COMPARATIVE ANALYSIS OF THE ACCURACIES OF DGPS AND TOTAL STATION INSTRUMENT IN PRECISE LOCATION OF GEOSPATIAL INFRASTRUCTURE

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ABSTRACT

Several techniques are employed in the determination of spatial position of infrastructures. Some of these techniques range from traditional method of Surveying such as trilateration, triangulation, traversing to the use of Differential Global Positioning System (DGPS). Most often, Surveyors are faced with the challenges of choosing the appropriate technique or instrument in acquiring spatial data. Questions are often asked about the best instrument among DGPS and Total Station in determining precise location of geospatial infrastructure. This study attempts to analyze and compare the accuracies of DGPS and Total Station in acquiring spatial data. Nine points were marked and beaconed. The area chosen was divided into two loops. DGPS and Total Station were used to obtain the Northing and Easting coordinates of the nine points. All the necessary checks were carried out. Efforts were made to ensure that the observations were done according to Surveyors Council of Nigeria (SURCON) Specifications. The results obtained were processed and comparatively analyzed. The result of the regression analysis shows that the coordinates obtained from Total Station compares favorably with those of the DGPS. Also, the total distance computed from DGPS and Total Station was compared. The total distance covered using DGPS and Total Station is 1998.916m and 1998.908m respectively. The variation between the distances gives 0.008m. The result of the analysis revealed that the linear accuracy of 1: 20,000 (loop 1) and 1: 24,000 (loop 2) were obtained using Total Station, while that of the DGPS is 1/150,000. The areas of the traverse network polygon as computed from DGPS and Total Station was also compared, the area covered by these networks is 84737.55sq.mtrs and 84713.024sq.mtrs respectively. The variation of average area from DGPS data with reference to Total Station data is 24.526sq.mtrs. It can be concluded that DGPS is more accurate than Total Station under normal environmental and atmospheric condition.

Keywords: DGPS, Total Station, Accuracy, Geospatial Infrastructure, Analysis

INTRODUCTION

The conventional techniques of obtaining spatial data through the use of theodolite, total station etc has proven to be tedious and time consuming. The use of theodolite and total station have longed been used for obtaining spatial data. The theodolite was developed in the 16th century and the modern Total Station Theodolite is its latest incarnation (Abdelrahim and Mohamed, 2013). The accuracy of these instruments in acquiring data is mostly affected by wide range of factors such as centering error, personnel error at different order of survey.

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The emergence of Global Positioning System (GPS) has revolutionized the conventional method of position determination and the science of navigation (Okorocha and Oluropo, 2014). GPS is a satellite positioning system based on one-way ranging in which the measurement of travel time of a signal from transmitter to receiver is achieved by the application of separate clocks; the transmitter (GPS satellites in space) and the receiver clock (GPS receivers on the earth's surface). The two clocks must be properly synchronized as a deviation in 1nanosecond is equivalent to 30cm in distance (Okorocha and Oluropo, 2014 citing Rizos, 1999).

The introduction of DGPS has improved the accuracy of positioning, but the fact still remains that these methods of acquiring data are highly affected by a number of parameters that limit their measurement quality. For instance: multipath, the inherent satellite signal accuracy, signal transmission delay, receiver hardware and software limitations, satellite signal obstruction are some of the problems associated with GPS measurement (Chekole, 2014). DGPS has the advantage of speed, cost effectiveness, fixes positions accurately with greater flexibility and has accessibility to remote areas (Boye and Issaka, 2009). In the traditional method of Surveying, inter-visibility of points is required and calls for clearing to achieve the necessary line of sight. Because of earth's curvature, the accuracy of Total Station measurement can also be affected by distance limit (the accuracy will decrease when increasing the distance).

In some locations such as urban areas, DGPS are affected by non availability of satellite due to the presence of high rise buildings, blocking the signal. This in turn degrades the required accuracy. For Total Station, the accuracy is affected by weather condition, curvature of the earth and the operator handling the instrument. The differences in the Survey techniques of using these instruments as well as the factors affecting their accuracies necessitated the need for carrying out a comparative analysis of the traditional surveying techniques using Total Station and DGPS.

Study Area

The nine sample points selected for this analysis is located within Nnamdi Azikiwe University, Awka in Anambra state. The school lies between coordinates 6°14'N and 6°16'N and Longitudes 7°05'E and 7°08'E (WGS84). The geographic description of the study area is shown in figure (1a, 1b and 1c).

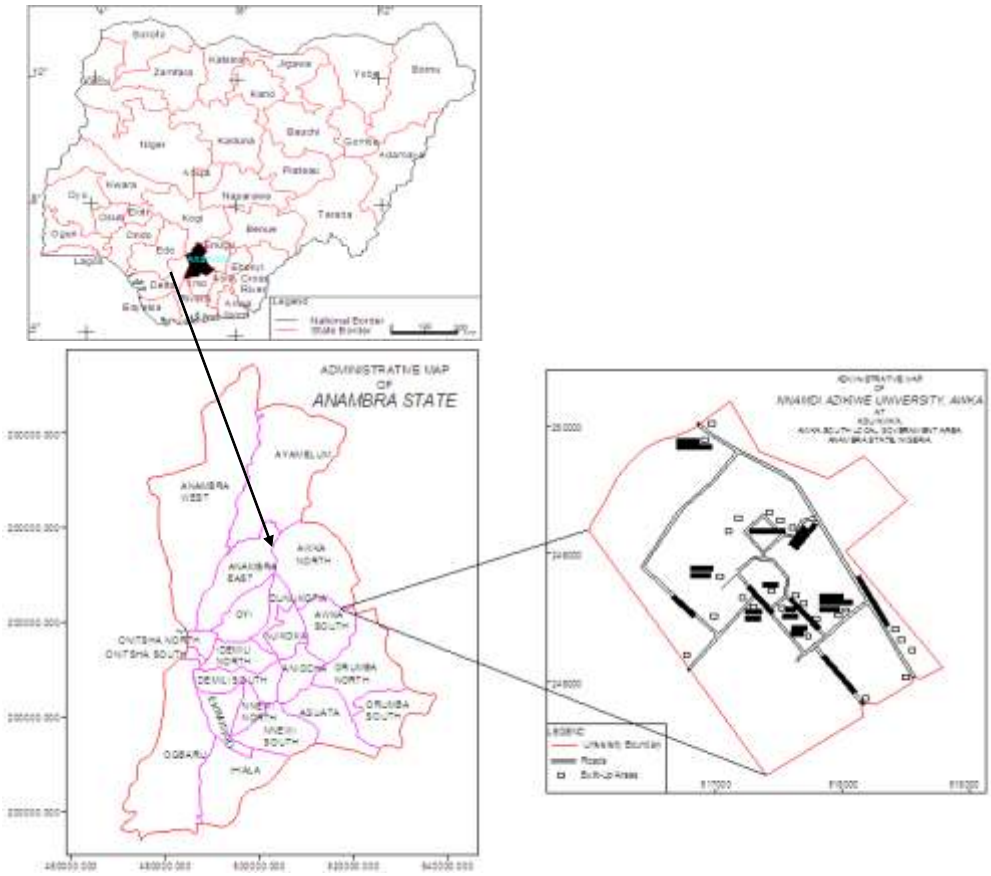


Fig 1a: Map of Nigeria showing Anambra State. Fig 1b: Map of Anambra State, showing Awka South and Fig 1c: Map of Nnamdi Azikiwe University, Awka.
Source (Onwuzuligbo, 2012)

Nnamdi Azikiwe University, Awka is in the tropical rainforest zone of Nigeria and experiences two distinct seasons brought about by the two predominant winds that rule the area: the south-western monsoon winds from the Atlantic Ocean and the north-eastern dry winds from across the Sahara desert. The monsoon winds from the Atlantic creates seven months of heavy tropical rains, which occur between April and October and are followed by five months of dryness (November - March). The Harmattan season is a particularly dry and dusty wind which enters Nigeria in late December or in the early part of January. The temperature in Awka is generally 27-30 degrees Celsius between June and December but rises to 32-34 degrees between January and April, with the last few months of the dry season marked by intense heat.

Methodology

The methodology adopted in this study is presented in figure 2.1

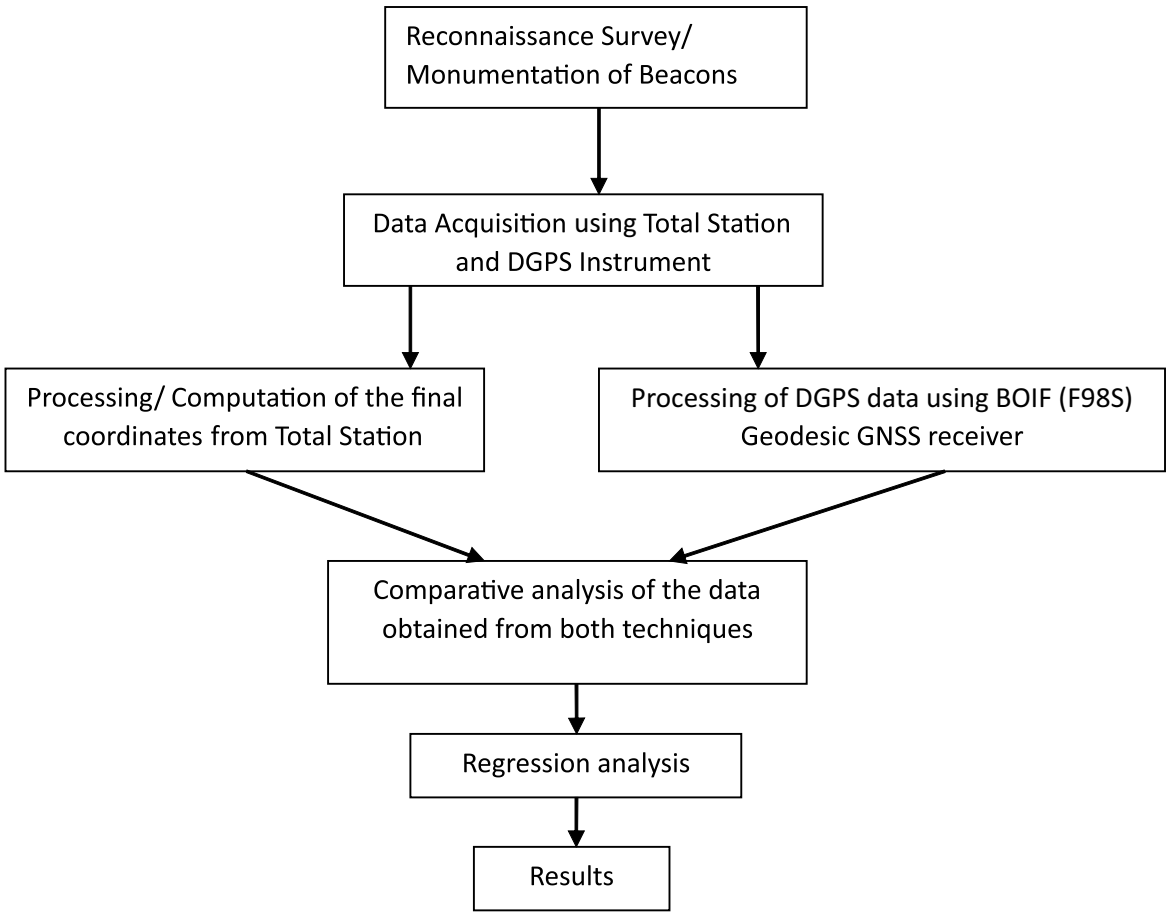


Figure 2.1: Methodology adopted

Field visit otherwise known as reconnaissance survey was carried out. The following factors were considered during the reconnaissance.

i. Location of control points to be used for the traversing.
ii. Identifying suitable positions to establish monuments.
iii. Intervisibility between successive points.
iv. Monuments were placed far away from objects that will disturb the satellite signals such as buildings, trees and electric poles.

Nine (9) stations were selected and monumented for further comparison. Permanent and temporary test was carried out on the Total Station instrument. The DGPS was calibrated on an existing first order control baseline. Zero baseline test also carried out. The project area was divided into two loops in order to control angular errors. The Total station traversing started from an existing control points (NAU 3P). The total station was mounted on its tripod stand which was stuck into the ground and set up over the controls (NAU 3P). Temporary adjustment (centering, levelling and focusing) was performed. Observation was made using angle and distances measuring mode. The angular and distance observation involves bisecting the reflector that was mounted on the reference control (NAU 2P) on face left, the instrument was then turned to the reflector that is mounted on the first unknown point (foresight) still on the same face to take the horizontal angular readings. The instrument was then transited to be on face right and the horizontal angular readings of the foresight and back sight reading were

recorded in the field book. This observational procedure continued until all the points were traversed and a closed loop was obtained by closing on the starting control (NAU 3P). Distances from one point to the other were measured using the total station EDM. A two loop traverse was carried out, observing on five sets over each set up in line with the specification of the project. The angles obtained were reduced to get average mean horizontal angle between stations. The average mean horizontal angles and distances obtained were used alongside the coordinate of the controls to calculate for the coordinates of the unknown points. Similarly, the DGPS was used to obtain the coordinates of the 9 control points in static mode. The data was processed and analyzed to obtain the final coordinates.

3.1 Results and analysis

The coordinates (Northing and Easting) of the nine points obtained using the Total station was compared to those obtained using the DGPS. Table 1.1 shows the difference between coordinates obtained using Total Station and DGPS. The difference between the bearing and distances computed from Total Station and DGPS is shown in table 1.2a and 1.2b for loop1 and loop2 respectively

Table 1.1: The coordinate's difference between DGPS and Total Station collected field data (Northings and Eastings)

DGPS			TOTAL STATION		DISCREPANCIES	
POINT ID	NORTHINGS	EASTINGS	NORTHINGS	EASTINGS	?N	?E
SVI15/01	248369.175	518352.629	248369.182	518352.597	-0.007	0.032
SVI15/02	248255.489	518427.638	248255.470	518427.550	0.019	0.088
SVI15/03	248168.688	518334.068	248168.649	518334.000	0.039	0.068
SVI15/04	248100.538	518241.423	248100.432	518241.396	0.106	0.027
SVI15/05	248244.125	518238.819	248244.017	518238.820	0.108	-0.001
SVI15/06	248528.101	518251.487	248528.077	518251.293	0.024	0.194
SVI15/07	248163.959	518146.090	248163.868	518146.089	0.091	0.001
SVI15/08	248258.593	518060.403	248258.521	518060.496	0.072	-0.093
SVI15/09	248371.295	518112.118	248371.242	518112.203	0.053	-0.085

Table 1.2a: The DGPS and Total Station collected field data (Distance, Bearing) for loop1.

DGPS			TOTAL STATION		DISCREPANCIES	
DRAFT	DIST. (m)	BEARING	DIST. (m)	BEARING	DIST. (m)	BEARING
01 – 02	136.202	146° 35’ 01’’	136.192	146° 36’ 33’’	0.010	00° 01’ 32’’
02 – 03	127.632	227° 08’ 58’’	127.630	227° 08’ 11’’	0.002	00° 00’ 47’’
03 – 04	115.011	233° 39’ 42’’	115.018	233° 37’ 22’’	-0.007	00° 02’ 20’’
04 – 05	143.611	358° 57’ 40’’	143.608	358° 58’ 20’’	0.003	-00° 00’ 40’’
05 – 06	283.258	02° 33’ 15’’	283.334	02° 30’ 51’’	-0.076	00° 02’ 24’’
06 – 01	188.380	147° 31’ 37’’	188.441	147° 28’ 49’’	-0.061	00° 02’ 48’’

Table 1.2b: The DGPS and Total Station collected field data (Distance, Bearing) for loop 2.

DGPS		TOTAL STATION		DISCREPANCIES		
DRAFT	DIST. (m)	BEARING	DIST. (m)	BEARING	DIST. (m)	BEARING
06 – 05	284.258	182° 33’ 15’’	284.334	182° 30’ 51’’	-0.076	00° 02’ 24’’
05 – 04	143.611	178° 57’ 40’’	143.608	178° 58’ 20’’	0.003	-00° 00’ 40’’
04 – 07	114.502	303° 38’ 03’’	114.488	303° 38’ 51’’	0.014	00° 00’ 48’’
07 – 08	127.663	317° 50’ 26’’	127.614	317° 52’ 39’’	0.049	-00° 02’ 13’’
08 – 09	124.001	24° 38’ 55’’	124.015	24° 38’ 30’’	-0.014	00° 00’ 25’’
09 – 06	209.790	41° 37’ 50’’	209.626	41° 34’ 06’’	0.164	00° 03’ 44’’

The coordinates were used to plot the location of the points. The result is shown in figure 3.1a and 3.1b for coordinates obtained using DGPS and Total station respectively. Their respective areas were also computed and compared.

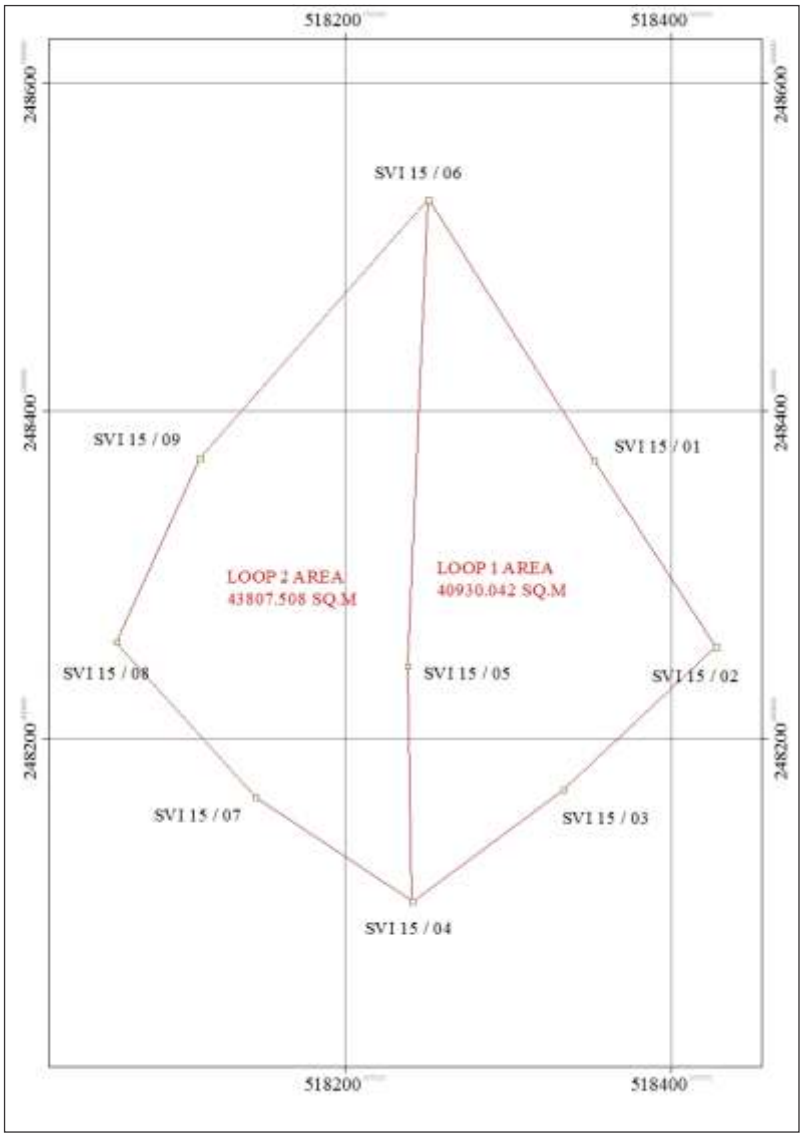


Figure 3.1a: Traverse network developed in grid system by using DGPS data showing area of each loop.

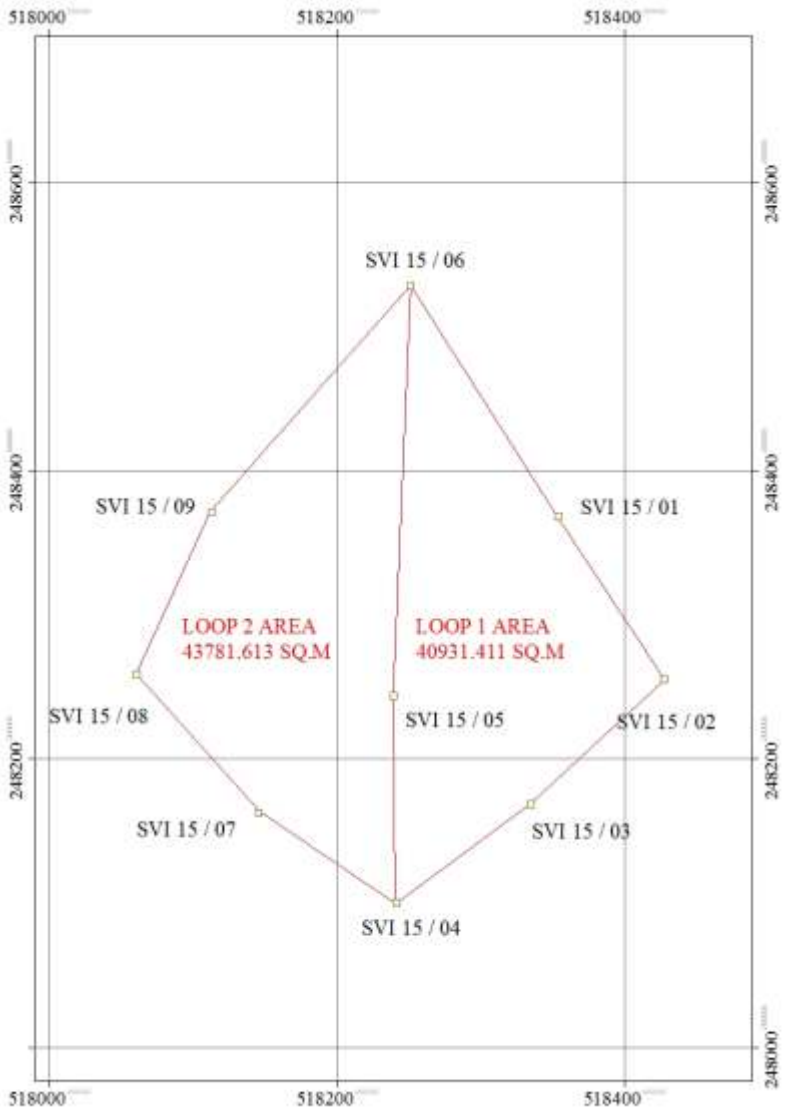


Figure 3.1b: Traverse network developed in grid system by using Total station data showing area of each loop.

`The result of the analysis revealed that the linear accuracy of the Total station is 1: 20,000 (loop 1) and 1: 24,000 (loop 2), while that of the DGPS is 1/150,000. The area covered using DGPS and Total Station is 84737.55sq.mtrs and 84713.024sq.mtrs respectively. The variation of average area from DGPS with reference to Total Station is 24.526sq.mtrs. Also, the total distance computed from DGPS and Total Station was compared. A total distance of 1998.916m was covered using DGPS while a distance of 1998.908m was covered using Total Station. The variation between the distances gave a distance of 0.008m.

`Linear regression analysis was applied to the scatter diagrams of the coordinates in order to test the degree of correlation between the Total station and DGPS coordinates. Figures 3.2a and 3.2b show the relationships established among the Northings and Eastings coordinates.

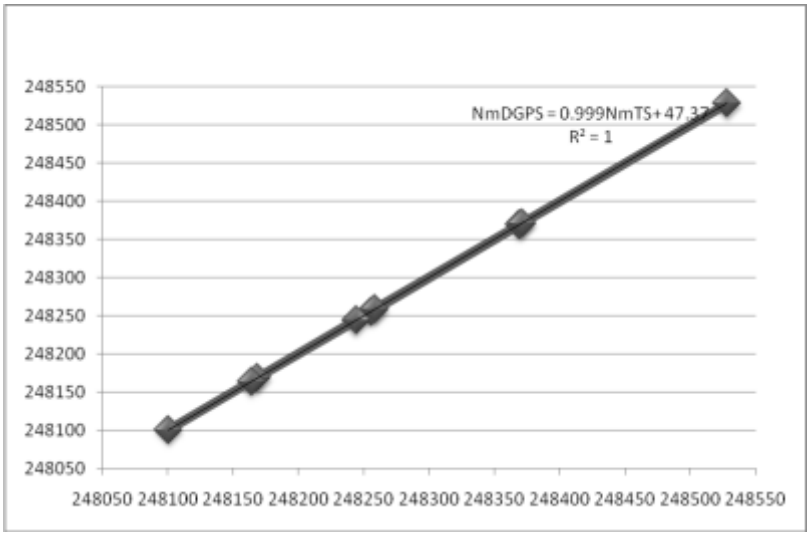


Figure 3.2a: Graph of the Northings of points by the DGPS (Y-axis) versus Total station (X-axis).

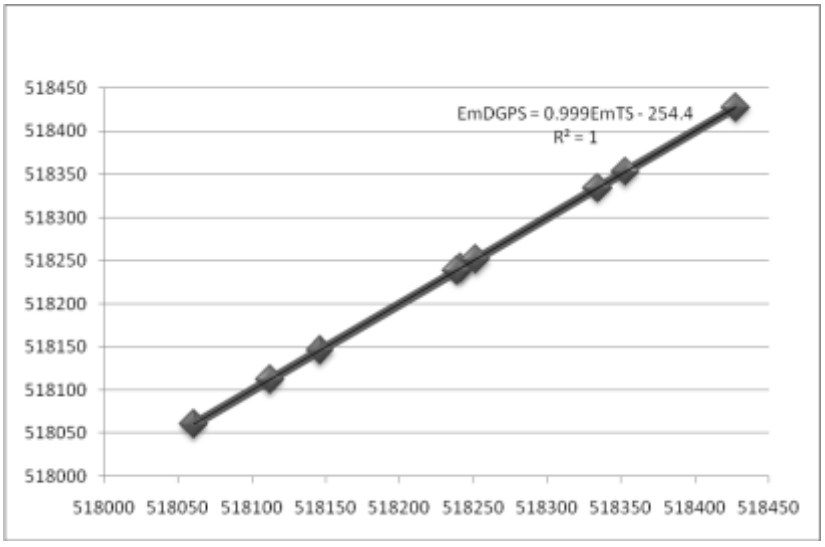


Figure 3.2b: Graph of the Eastings of points by the DGPS on the (Y-axis) versus Total station (X-axis).

The above graph in (Fig 3.2a and 3.2b) illustrations show good positive correlation between the DGPS coordinates and Total Station coordinates and the correlation is perfect in the proportion of variation in the dependent variable (goodness of fit) (**R**2) and correlation coefficient **R** between the observed and the predicted values of the dependent variables, which is an indication of the models compliant.

The deterministic coefficient (R^2) between the variables was calculated and the result is shown in Table 2.1. The coefficient of determination (R^2) is a criterion that is commonly used to measure the adequacy of the statistical prediction. The closer R^2 is to 1 the better the prediction. On the basis of the results, the R^2 values for relationship between DGPS Eastings plotted against the Total station Eastings is 0.999999658 and the Northings Coordinates of both instrument also gave the R^2

Table 2.1: regression analysis table R^2 data for Northings and Eastings

	DGPS EASTINGS COORDINATES AGAINST TOTAL STATION EASTING COORDINATE	DGPS NORTHINGS COORDINATES AGAINST TOTAL STATION NORTHINGS COORDINATE
R^2	0.999999658	0.999999931

Conclusion and Recommendations

There have been rapid and tremendous advancement in surveying instruments. Sophisticated instruments are being introduced for collection of accurate data in precise location of points. The introduction of DGPS and Total Station, has improve the accuracy of positioning information. But the fact still remains that these methods of acquiring data are highly affected by various factors. The average variations in the coordinates are 0.056m and 0.026m in the northings and eastings coordinates respectively. The average variation of computed area from DGPS with reference to Total Station is 24.526sq.mtrs. This variation may look insignificant, but could be a subject of land in dispute. The correlations between the scatter plots of the various coordinates of the control points are strong and the regression equations are linear.

DGPS and Total Station instrument are good for precise location of spatial infrastructure depending on the order of survey accuracy. Under ideal environmental and atmospheric condition for both instruments, DGPS may be preferred for high accurate job.

REFERENCES

Abdelrahim, E. M. and Mohamed A.N. (2013). Integration and Calibration Factor by Practical Comparison of GPS and Total Station Measurements. *International Journal of Technology Enhancements and Emerging Engineering Research*, 1(2) : 57-63

Boye, C.B and Issaka, Y (2009). Comparative Study on Position-Fixing with GPS to ascertain Positional Accuracy for Peaceful Socio-Environmental Management. LSD-Seminar- Conference Proceedings of Ghana Institution of Surveyors, Accra Ghana.

Chekole, S.D (2014). Surveying with GPS, total station and terrestrial laser scanner: a comparative study. *MSc Thesis*, School of Architecture and the Built Environment, Royal Institute of Technology, Stockholm.

Okorocha, C.V and Oluropo O. (2014). Comparative Analysis of Short, Medium and Long Baseline Processing in the Precision of GNSS Positioning. Proceedings of FIG Congress, Kuala Lumpur, Malaysia.

Onwuzuligbo, C.U (2012). Realization of the local Geoid model using the GPS/levelling method for Nnamdi Azikiwe University, Awka, Anambra State. *M.Sc Thesis*, Department of Surveying and Geoinformatics, Faculty of Environmental Sciences, Nnamdi Azikiwe University, Awka

Zarzoura F., Ehigiator I.R., Mazurov B. (2013). Investigating Accuracy Enhancement of Global Navigation Satellite System. British Journal of Earth Sciences Research, 1(1): 1-9