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Full Length Research Paper

Comparative Evaluation on the Accuracies of Differential GPS and Total Station

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ABSTRACT: Control points include both horizontal and vertical control points, and they serve as the foundation for a variety of surveying tasks such as route surveying, topographic surveying, traversing, leveling, mapping and map revisions, property boundary surveys, construction projects, and so on. This serves as the foundation for further geomatics and engineering operations focused toward development. The purpose of this research is to use dual frequency to determine the coordinates of the existing control point network along Ibrahim Shehu Shema route. Hello, target. V90 with Differential GPS and Leica TCR 409 Total Station were used to compare the accuracies of DGPS and Total Station using statistical analysis to determine which was more accurate. The study's objectives are to observe existing spots using DGPS and Total station, process/compute the final coordinates, and compare the findings using statistical analysis. Satellite Positioning Technology using Differential Global Positioning System (DGPS) and Total Station are the methodologies used for this project. Existing control point data were collected from the surveyor general's office in Katsina State, and these control points were observed using both DGPS and Total Station. The data collected was then processed and examined. According to the results, DGPS observation is more accurate and requires less time. As a result, the study ended by advising that DGPS observation be used for establishing control surveys.

Keywords: Control point, differential GPS

INTRODUCTION

Surveying is defined as any means of measuring and gathering information about the physical earth and our environment, processing that information, and disseminating a variety of generating products to a wide range of clients. Surveying has been essential since the dawn of civilization. Its first applications were in measuring and identifying property ownership borders. With the growing need for a range of maps and other spatially connected types of information, as well as the expanding necessity for establishing correct line and grade to guide building operations, its importance has continuously expanded over the years (Tijani, 2021).

Throughout surveying history, many surveying devices have been used to acquire data from field measurements for diverse applications with varying precision capabilities and requirements. Thus, understanding these factors on any instrument is critical in constructing any surveying project. The required precision is determined by the deliverable result (Tijani, 2021). These data are collected for a variety of purposes, including route surveying, layout surveying, topographic surveys, and so on. All of these required control points will serve as the foundation for the survey.

The total station measures horizontal and vertical angles as well as slope distances to each prism, from which easting, northing, and height values are computed, as well as displacements. Total station coordination monitors building deformation by varying the coordinates of monitored sites. This approach provides adequate precision without requiring high visibility or a substantial workload. The use of total station surveying tools for tracking the movement of structures yields accurate and good findings.

For the EDM signal, most Total Stations use custombuilt glass prism reflectors. A standard total station can measure lengths up to 1,500 meters (4,900 feet) with an accuracy of 1.5 millimetres (0.0049 ft) + 2 parts per million (Leica Geosystems, 2008).

As a monitoring tool, GPS techniques have various advantages. The unusually high accuracy of relative GPS measurements is finding use in monitoring surveys in locations where stations must be visible and meteorological conditions must be met.

Continuous and automatic monitoring using GPS will become increasingly practicable and cost-effective once the whole satellite constellation is deployed. As a result, the capabilities of GPS as a super locating tool breathed new life into the field of monitoring surveys, particularly in situations where speedy findings may save lives and property (Aziz et al., 2001).

Differential Global Positioning Systems (DGPS) are improvements to the Global Positioning System (GPS) that improve location precision in the area of operations of each system, from the nominal GPS accuracy of 15 meters to roughly 10 cm in the best cases (Wikipedia, 2018).

A reference station calculates differential corrections for time and location. Operators can be up to 370 kilometers distant from the reference station, albeit some adjusted errors vary with space. Ionospheric and tropospheric distortions, as well as satellite ephemeris inaccuracies, are examples of these mistakes. As a result, DGPS accuracy falls as one moves away from the reference station. However, if the station lacks "intervisibility" (the inability to observe the same satellite), the situation will be severe (Wikipedia, 2018).

The aim of the paper is to compare and examine the accuracy of total station and differential GPS in establishing control points.

METHODOLOGY

Study area

The study area is along Ibrahim Shema Road, Katsina metropolis, Katsina local government in Katsina State of Nigeria. It is located 12.989065 Lat and 7.622504 Long (Figure 1).

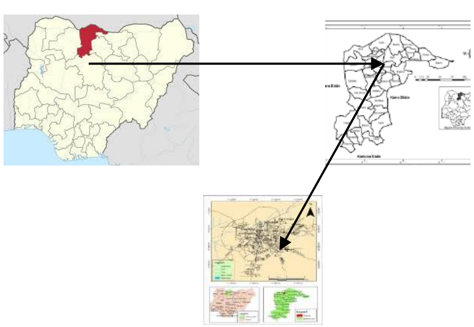

Figure 1: Map of the study area.

Materials used

The materials used are software, hardware and datasets.

The hardware and Software used are:

Laptop computer
Hi target V90 plus Differential GPS
Total Station
Microsoft Excel
Microsoft word

After reviewing numerous studies on the densification of control points and various methodologies used, and taking into account the gaps discovered, this study will be carried out to produce a better outcome.

The following is the methodology that was used:

Location of the existing control point to be used for the traversing.
Inter-visibility between the points.
Government agencies in any selected government properties will be enlightened about the importance of control points and about their duty in the protection of the control points located in their office premises.
Redundancy observations will be incorporated in to the observations for quality control and to guard against gross errors.
Dual frequency GPS and Total Station will be used for the observations. The acquired data will be processed and adjusted. Finally, Comparing the results of DGPS and Total Station using statistical analysis
Presentation of final results

Twelve control points were selected for the exercise and the uses of DGPS and Total station to obtain the Northing and Easting coordinates (Figure 2).

RESULTS AND DISCUSION

Reconnaissance

Office Reconnaissance

The office planning stage involved collection of necessary information such as the co-ordinates of existing controls. These were obtained from the survey department already densified second order Controls along the road. The survey method to be adopted, type of equipment, other-materials and number of staff required for the job were determined.

Field reconnaissance

Field reconnaissance involved the preliminary inspection

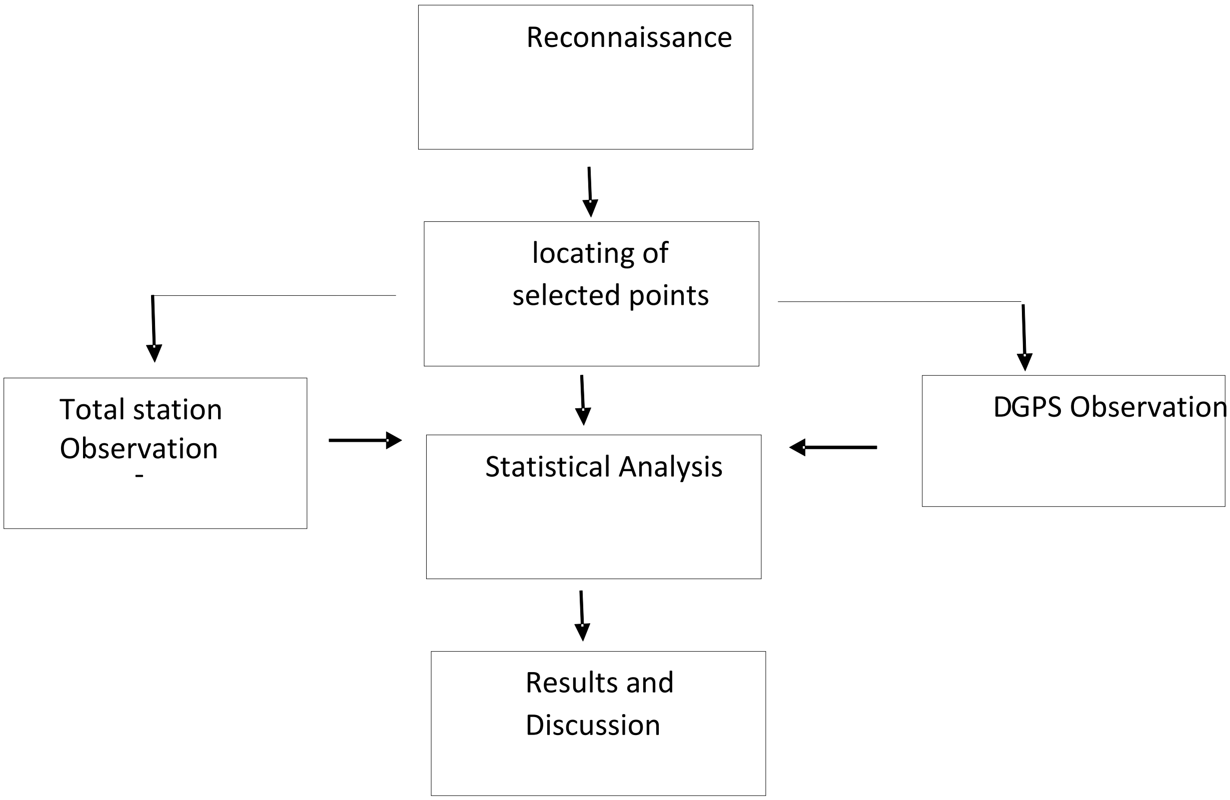

Figure 2: A flow diagram of the steps used in carrying out the research**.**

Table 1: Existing coordinates.

Point ID	Easting(m)	Northing(m)
SEMS01	348564.051	1430774.503
SEMS02	348887.041	1430807.502
SEMS03	349182.04	1430826.502
SEMS04	349504.091	1430857.506
SEMS05	349793.186	1430937.533
SEMS06	350103.281	1431102.583
SEMS07	350295.33	1431263.624
SEMS08	350533.345	1431482.638
SEMS09	350736.349	1431683.642
SEMS10	350955.364	1431894.656
SEMS11	351226.379	1432209.674
SEMS12	351459.379	1432480.674

of the site and verification of the locations of the GPS controls available around the project area. The search for the controls was carried out using hand held GPS receiver (Garmin GPS map 62s) in navigation mode. The second order controls around the project area shown in (Table 1).

Instrument test

The instrument test was carried out to ascertain the integrity and reliability of the instruments. To start, the instruments were physically inspected to ensure that all

Table 2: Total Station EDM Calibration Test.

SECTION		AE (1)	AB (2)	BC (3)	CD (4)	DE (5)	EA (6)
Distance (m)	1	400.009	100.002	100.001	99.999	100.001	400.005
	2	400.008	100.003	99.998	100.001	100.003	400.006
	3	400.007	100.001	99.997	100.003	100.002	400.005
Total		1200.024	300.006	299.996	300.003	300.006	1200.016
MEAN		U=400.008	V=100.002	W=99.999	X=100.001	Y=100.002	Z=400.0053

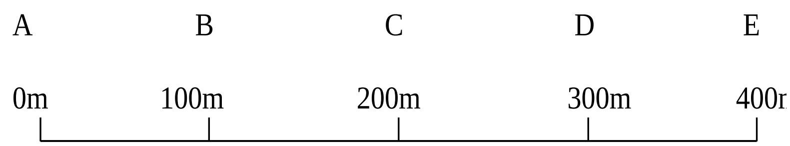

Figure 3: EDM standardization base.

Table 3: GPS receiver test/verification of controls.

Point ID	Existing E (m)	Total station E(m)	Diff E(m)	Existing N(m)	Total station N(m)	Diff N(m)
KT011	348341.326	348341.332	-0.006	1430834.154	1430834.147	0.007
KT013	348438.041	348438.033	0.008	1430894.338	1430894.343	-0.005
KT005	349032.021	349032.012	0.009	1430748.553	1430748.557	-0.004

components were intact and the batteries were fully charged. The following instrument tests were then conducted to confirm that the instruments are in good working condition:

Total Station EDM Calibration test
Collimation and Index test.
GPS Receivers test

Total station EDM calibration test

For the purpose of this test, a base of 400m long divided into four segments of 100m long each was used. The total station and target were set up, centered and leveled at points A to E respectively. The target was sighted, bisected and linear measurements made three times and booked. In the same manner the distances AB, BC, CD, DE and EA were measured. The result of the test is shown in (Table 2 and Figure 3).

(U + Z)/2 = V + W + X +Y

Ideally, {(U + Z)/2} – {V + W + X +Y} = 0 but this is normally not the case in real practice. The deviation from zero is the standardization correction.
Therefore, standardization correction = (U + Z)/2 = V + W + X +Y
= {(400.0080 + 400.0053)/2} – {100.002+ 99.999 + 100.001 + 100.002}
= 400.007 – 400.004 = 0.003m

After the test, the results showed a discrepancy of **0.003m**; this discrepancy is negligible for a third order job hence was ignored.

GPS receiver test/verification of controls (In-Situ Check)

Baseline In-situ check observation was executed for the purpose of testing the GPS receivers as well as verifying the integrity of the existing controls. The baseline check was carried out using control pillars whose coordinates were given (Table 3).

The check was per formed using the differential GPS static mode under a clear sky view. One receiver was set on KT 011 as the base while the other receiver was used as rover on KT 013 and KT 005.

The operation was repeated but in reverse order. The Registered/ known coordinates of the control pillars were compared with the observed ones.

The differences between the known values and their corresponding observed values indicated that the controls were in good state. The GPS baseline check performed also confirmed that the operation of the GPS receivers and data processing software were in good condition, hence the calibration of the equipment are in good order.

Observation using total station

The total station was set up over control station SEM01. The instrument was then turned on using the ON key. The instrument was centred, levelled and telescope focused to

Table 4: Coordinates obtained using DGPS.

Point ID	Easting(m)	Northing(m)
SEMS02	348887.061	1430807.511
SEMS03	349182.052	1430826.517
SEMS04	349504.079	1430857.518
SEMS05	349793.195	1430937.517
SEMS06	350103.263	1431102.565
SEMS07	350295.342	1431263.634
SEMS08	350533.360	1431482.656
SEMS09	350736.333	1431683.634
SEMS10	350955.377	1431894.670
SEMS11	351226.398	1432209.691
SEMS12	351459.359	1432480.689

Table 5: Coordinates obtained using Total Station.

Point ID	Easting(m)	Northing(m)
SEMS02	348887.058	1430807.504
SEMS03	349182.065	1430826.514
SEMS04	349504.108	1430857.493
SEMS05	349793.170	1430937.538
SEMS06	350103.254	1431102.587
SEMS07	350295.352	1431263.675
SEMS08	350533.376	1431482.673
SEMS09	350736.324	1431683.657
SEMS10	350955.391	1431894.653
SEMS11	351226.391	1432209.659
SEMS12	351459.356	1432480.662

Table 6: Difference between existing coordinates and Total Station coordinates.

Point ID	Existing E (m)	Total station E(m)	Diff E(m)	Existing N(m)	Total station N(m)	Diff N(m)
SEMS02	348887.041	348887.058	-0.017	1430807.511	1430807.504	0.007
SEMS03	349182.040	349182.065	-0.025	1430826.527	1430826.514	0.013
SEMS04	349504.091	349504.108	-0.017	1430857.518	1430857.493	0.025
SEMS05	349793.186	349793.170	0.016	1430937.517	1430937.538	-0.021
SEMS06	350103.281	350103.254	0.027	1431102.565	1431102.587	-0.022
SEMS07	350295.330	350295.352	-0.022	1431263.644	1431263.675	-0.031
SEMS08	350533.345	350533.376	-0.031	1431482.656	1431482.673	-0.017
SEMS09	350736.349	350736.324	0.025	1431683.634	1431683.657	-0.023
SEMS10	350955.364	350955.391	-0.027	1431894.678	1431894.653	0.025
SEMS11	351226.379	351226.391	-0.012	1432209.695	1432209.659	0.036
SEMS12	351459.379	351459.356	0.023	1432480.699	1432480.662	0.037

eliminate parallax. Then with the “job” menu of the total station, a new job was created and named “CONTROL SURV”. The parameters of the instrument station i.e. station name, height of instrument over the station mark, and the XY coordinates of the station were keyed into the memory of the total station using the orientation option in “Observation” menu. After inputting the parameters of the instrument station, the instrument requested the parameters of the reference station. The parameters of the reference control point KT007 i.e. station name, height of target over the station mark, and the XYZ coordinates of the station were keyed into the memory of the total station hence the orientation was set. The target at the reference station was accurately bisected and readings were taken and recorded into the internal memory of the instrument by pressing Measure and record soft keys. The method is repeated and other points observed and recorded as shown in (Table 5).

Observation Using DGPS

One of the DGPS receiver was set up over control station SEM01. The receiver was then turned on using the ON key. The instrument was centred and levelled. Then with the “job” menu of the receiver, a new job was created and named “CONTROL SURV”. The parameters of the instrument station i.e. station name, height of instrument over the station mark, and the XY coordinates of the station were keyed into the memory of the receiver. After synchronizing both receivers, the second rover is then used to observe other stations and the results are shown in (Table 4).

Data download, analysis and processing

The data obtained from both instruments were downloaded into the computer.

Table 7: Difference between existing coordinates and DGPS coordinates.

Point ID	Existing E (m)	Total station E(m)	Diff E(m)	Existing N(m)	Total station N(m)	Diff N(m)
SEMS02	348887.041	348887.061	-0.020	1430807.502	1430807.507	-0.005
SEMS03	349182.040	349182.052	-0.012	1430826.502	1430826.517	-0.015
SEMS04	349504.091	349504.079	0.012	1430857.506	1430857.518	-0.012
SEMS05	349793.186	349793.195	-0.009	1430937.533	1430937.517	0.016
SEMS06	350103.281	350103.263	0.018	1431102.583	1431102.565	0.018
SEMS07	350295.330	350295.342	-0.012	1431263.624	1431263.634	-0.010
SEMS08	350533.345	350533.360	-0.015	1431482.638	1431482.656	-0.018
SEMS09	350736.349	350736.333	0.016	1431683.642	1431683.634	0.008
SEMS10	350955.364	350955.377	-0.013	1431894.656	1431894.670	-0.014
SEMS11	351226.379	351226.398	-0.019	1432209.674	1432209.691	-0.017
SEMS12	351459.379	351459.359	0.020	1432480.674	1432480.689	-0.015

Processing of the GNSS Observations and the Total Station Data

The DGPS observations were downloaded into a computer system folder. The total station data (bearings, distances, northings and eastings) were typed in Microsoft Excel 2016spreadsheet and saved in a computer folder. The data were processed, arranged and analyzed (Table 4). From (Table 6), the minimum and maximum difference in easting -0.012 and -0.031 respectively while the minimum and maximum difference in northing are 0.007 and 0.037 respectively. From the above (Table 7) the minimum and maximum difference in easting -0.009 and -0.020 respectively while the minimum and maximum difference in northing are -0.005 and 0.018 respectively. The data obtained using DGPS observation is closer to the known coordinates this reveals that the DGPS observation is more accurate.

Conclusion

Observation of existing control point network along Ibrahim Shema road using DGPS and Total Station was carried out to determine and compare the accuracy of the two horizontal methods so as to determine which of them is better in terms of accuracy which in turn will enable users to decide on the method to employ as regards the purpose of measurement. There has been advancement in surveying instruments such that accurate and precise instruments are being introduced for collection of data. The introduction of DGPS and Total Station, has improved the accuracy of positioning information and takes less time in making the observation. It is important to access which of these is instruments provide more accurate data in establishing control points. From the results obtained, both DGPS and Total Station instrument are good for precise location of spatial infrastructure depending on the order of survey accuracy since both differences are within acceptable limit depending on the order of survey. The difference obtained using DGPS is more accurate as it is closer to the known coordinate. The research concluded by recommending DGPS for high accurate job, larger area coverage and to reduced labour cost.

REFERENCES

Aziz, W. A., Othman, Z. and Najib, H. (2001): Monitoring High-Rise Building Deformation using Global Positioning System. Asian GPS Conference.

Leica Geosystems (2018). Americas.
http://www.leicageosystems.us/commom/shared/downloass/inc/downloader.asp?id=14376

Ono, M. N., Eteje, S. O., Oduyebo O. F (2018). Comparative Analysis of DGPS and Total Station Accura- cies for Static Deformation Monitoring of Engineering Structures. IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT), International Organization of Scientific Research (IOSR), 2018, 12 (6, Vers 1), pp.19-29. 10.9790/2402-1206011929. hal-02446368.

Tijani O., Igbokwe, J. I., Ono, M. N. (2021). "Comparative Evaluation of the Accuracies of Differential GPS and Total Station in Determining the Coordinates of Existing Controls", International Journal of Scientific Research in Science and Technology(IJSRST), Print ISSN: 2395-6011, Online ISSN: 2395-602X, Volume 8, Issue 3, pp.894-906, May-June-2021.

Wikipedia (2018). Total Station and Differential Global Positioning System. Retrieved from http://en.wikipedia/total_station/DGPS. Accessed on 15th July, 2018.

Wilson, J P, Spangrud D J, Nielsen G A, Jacobsen J S and Tyler D A (1998). Global positioning system sampling intensity and pattern effects on computing topographic attributes; *Soil Sci. Soc. Amer. J.* 62 1410–1417.