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Comparative Analysis of Total Station and GPSPROMAX 3 in Carrying Out Topographic Mapping.

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ABSTRACT
This work involves topographic mapping of permanent complex of School of Engineering, Modibbo Adama University of Technology, Yola. Global Positioning System (GPS) Promark3 and Total station instruments were used to obtain survey data. The observations by Total Station instrument was done using coordinate mode method to get XYZ coordinates of stations. The procedure was used for the boundary and detailed observations. A real time survey was carried out with the Promark 3 using the master and slave mode of the GPS. The slave was used to pick coordinates at all stations round the perimeter and consequently used to survey all the details in the study area. The data obtained by Promark3 GPS was copied into the computer using SD Card and later post processed using GNSS solution software while that of the Total station was adjusted using Least squares adjustment. A statistical test was carried out to test the reliability of the result obtained. The test found the result to be reliable at 0.01 level of significance. The adjusted coordinates and the detailed survey were plotted using AUTOCAD 2007. The contour lines were created by the use of Surfer 7 software using the data from the two instruments. The results of both methods were compared to get the variations produced by the two methods. It was concluded that, the two methods yielded good results under the same observation conditions. It was also recommended that, either of the methods can be used for topographic surveying especially the one whose instruments are readily available. However, based on the values of their variances, it can be inferred that, the results of that of Total station instrument looks better than that of GPS instrument.

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I. INTRODUCTION

Topographical survey is a survey that constitute a very important activity or process upon which the design, and implementation of most physical and infrastructural development on the surface of the earth were based.The production of topographical maps/plans as a type of geographical document is characterized by small or large scaled detailed and qualitative representation of relief using contour line. Hence both man-made and natural feature can be properly and adequately depicted in a topographical plan [1].

The increased advancement in digital surveying technology based on the use of modern sophisticated computers and digital survey equipment such as Total station, GPS, Terrestrial laser Scanners,Remote sensing satellites and the availability of new tools had transformed topographical map production from the traditional and conventional techniques into digital techniques. Currently, the availability of fast computer and digital data acquisition technology and digital data processing along with information presentation technology have brought a revolution into map making through the GIS application. And these make decision making easy and fasteras the topographical maps has become intuitive and versatile [2].

The distinctive characteristic of a topographic map is the use of elevation contour lines to show the shape of the Earth's surface. Elevation contours are imaginary lines connecting points having the same elevation on the surface of the land above or below a reference surface, which is usually the mean sea level. Contours make it possible to show the height and shape of mountains, the depths of the ocean bottom, and the steepness of slopes [3].

USGS topographic maps also show many other kinds of geographic features including roads, railroads, rivers, streams, lakes, boundaries, place or feature names, mountains, and much more. Older maps (published before 2006) show additional features such as trails, buildings, towns, mountain elevations, and survey control points which are added to more current maps over time[4].

Topographic maps are differentiated from other maps in that, they show both the horizontal and vertical positions of the terrain. Through a combination of contour lines, colors, symbols, labels, and other graphical representations, topographic maps portray the shapes and locations of mountains, forests, rivers, lakes, cities, roads, bridges, and many other natural and man-made features. They also contain valuable reference information for surveyors and map makers, including bench marks, base lines, meridians, and magnetic declinations [5].

Topographic maps are used by civil engineers, environmental managers, and urban planners, as well as by outdoor enthusiasts, emergency services agencies, and historians to solve different environmental problems. Topographic maps use a wide variety of symbols to represent human and physical features including the topography or terrain of the area with the aid of contour lines representing elevation by connecting points of equal elevation [6].

Topographic maps are maps that show locations and elevations of natural and cultural features of a given area. Standard colors and symbols have been designated for use on these maps by the United States Geological Survey. Topographic maps are generally oriented to show north at the top. Scales and contour intervals vary on topographic maps depending on the series of the map and the relief (the variation in elevation) of the topography. Using the Internet students can create topographic maps for any area in the United States. Students need to input the latitude and longitude or the zip code to create a map of their choice [7].

Newer technologies available include robotic total stations, Global Positioning Systems (GPS) and laser systems combined with GPS, which may offer economic alternatives. Dual-frequency GPS receivers are available from producers who claim they have high accuracy kinematic capabilities for obtaining positional information from a moving vehicle. Therefore, this study tends to examine the manufacturer's claim by determining if dual-frequency, high-precision GPS receivers in kinematic mode with real-time differential corrections could collect ground surface three-dimensional position data to produce a topographic map that is more accurate than that produced using Total station.

Statement of the Problem

Topographic map is essential in all spheres of our day-to-day activities. It provides fast and accurate method of solving geo-spatial problems, hence, the need to have one.

In the past, topographical maps are mainly produced by the analogue methods of surveying. This result to situations where most of the details supplied for such maps hardly appears in the correct positions. Also, the methods adopted in the past are tedious and rigorous because it involves a lot of computations. Furthermore, these processes take a longer time before such maps are produced. The instruments used for acquisition of these data are analogue i.e. (theodolite, leveling instrument, chain etc.) there by making the process to be very cumbersome. The way and manner in which maps are kept expose it to damage and lost, thereby rendering planning and development difficult because of non-availability of such maps. These have contributed to inability of MAUTECH authority to secure various maps such as topo map that would have been used for setting out the location of permanent site of engineering complex.

Aim and Objectives

The aim of this project is to compare the accuracy of Total Station and Global Positioning System (GPS) Instruments in carrying out a topographic mapping of an area. These would be accomplished through the following objectives:

1. Field and office reconnaissance of the study area.
2. Observation of spatial location of both natural and artificial feature within the project area using Total Station and GPS Instruments.
3. Processing of field observations to produce topographic maps.
4. Make recommendation based on the results obtained.

The Study Area

The study area of the project is in ModibboAdama University of Technology Yola which is located inGireiLocal Government area of Adamawa state, Nigeria. The area is located geographically between latitude 9^0 21' 18'' N and 9^0 21' 35'' N and longitude 12^0 30' 30'' E and 12^0 30' 36'', as shown in the figures 1.1 to 1.5 below.

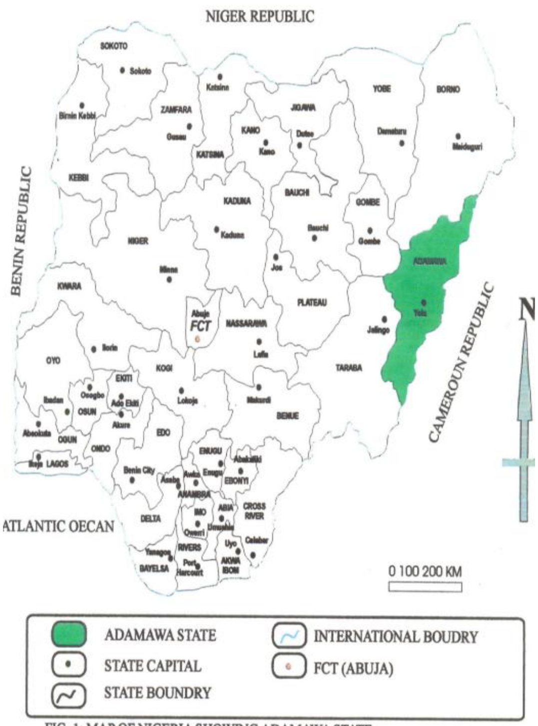

FIG. 1: MAP OF NIGERIA SHOWING ADAMAWA STATE
SOURCE: Adamawa State Ministry of Land and Survey

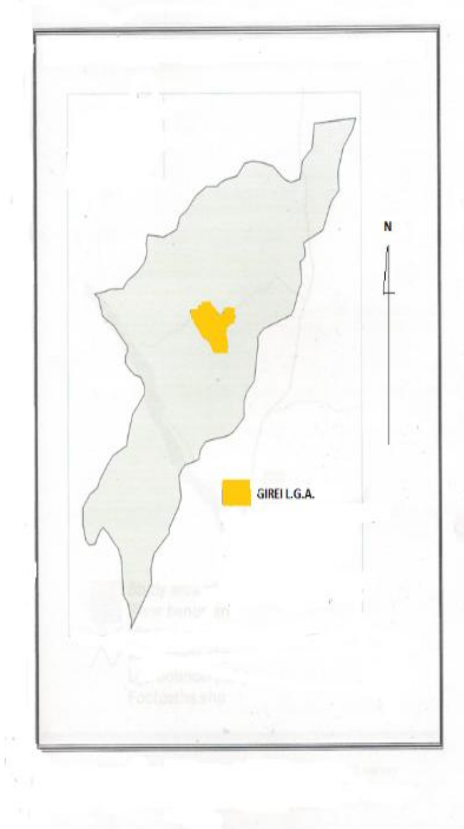

Fig 1.1 Map of Nigeria Showing Adamawa State.
Source: Ministry of Land and Survey, Yola. (2012)

Fig 1.2 Map of Adamawa State Showing Girei L.G.A.
Source: Ministry of Land & Survey Yola. (2012)

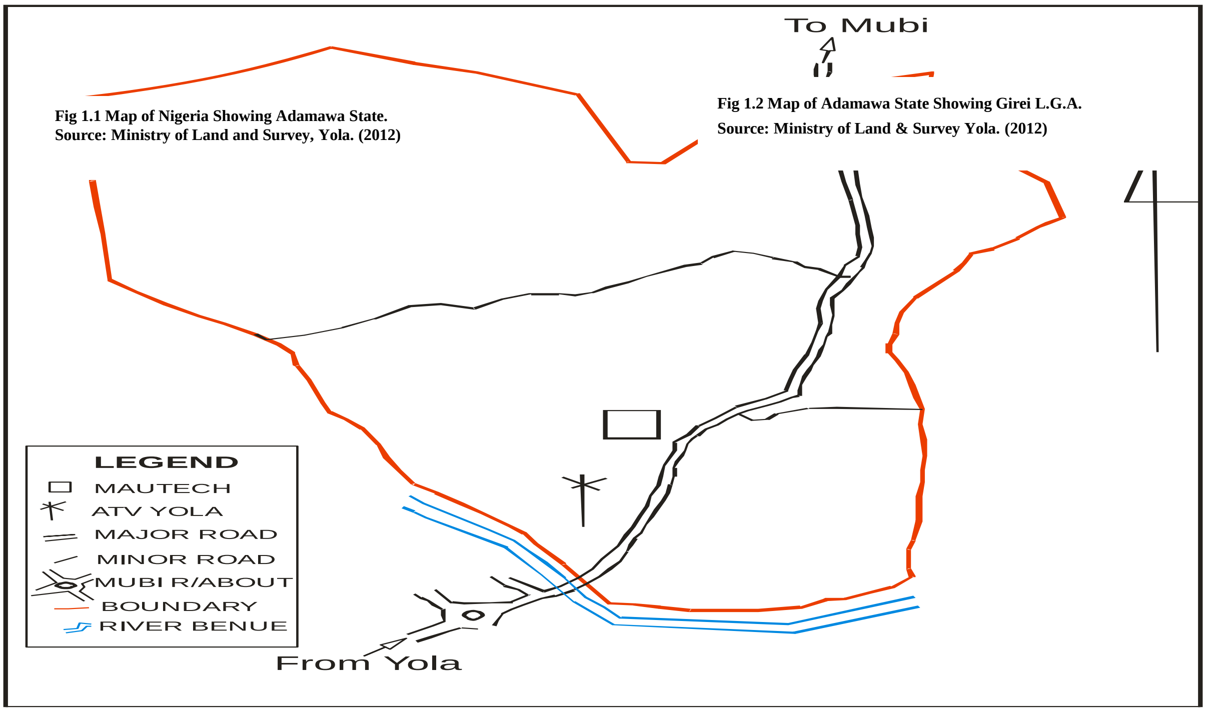

FIG 1.3: MAP OF GIREI L.G.A SHOWING MAUTECH
SOURCE: Laboratory work (2012)

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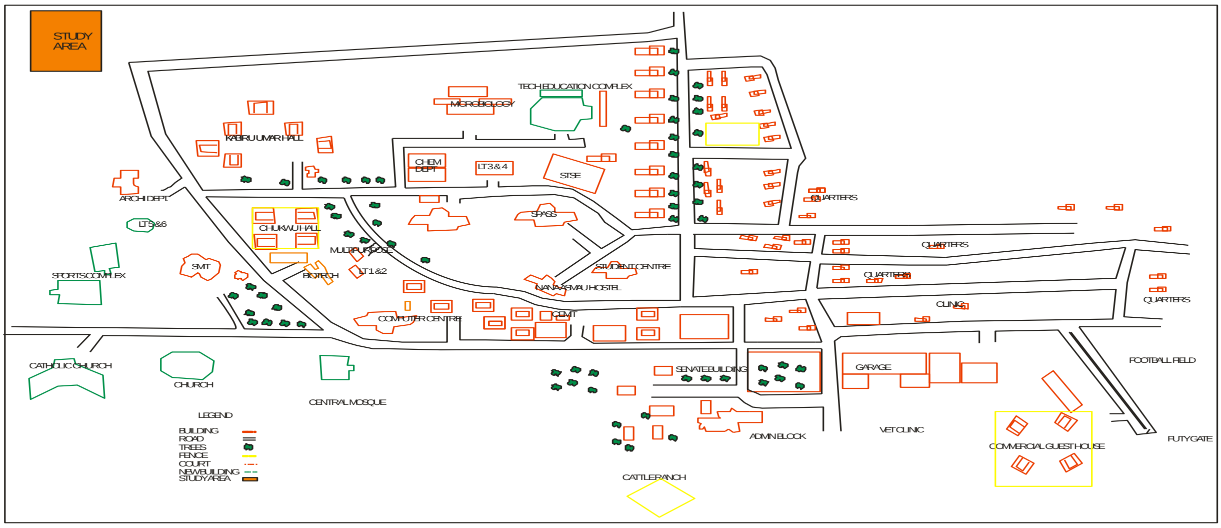

FIG 1.4: MAP OF BUILT UP AREA OF MAUTECH SHOWING THE STUDY AREA
SOURCE: Laboratory work (2012)

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FIG 1.4 MAP OF BUILT UP AREA OF MAUTECH SHOWING THE STUDY AREA SOURCE:

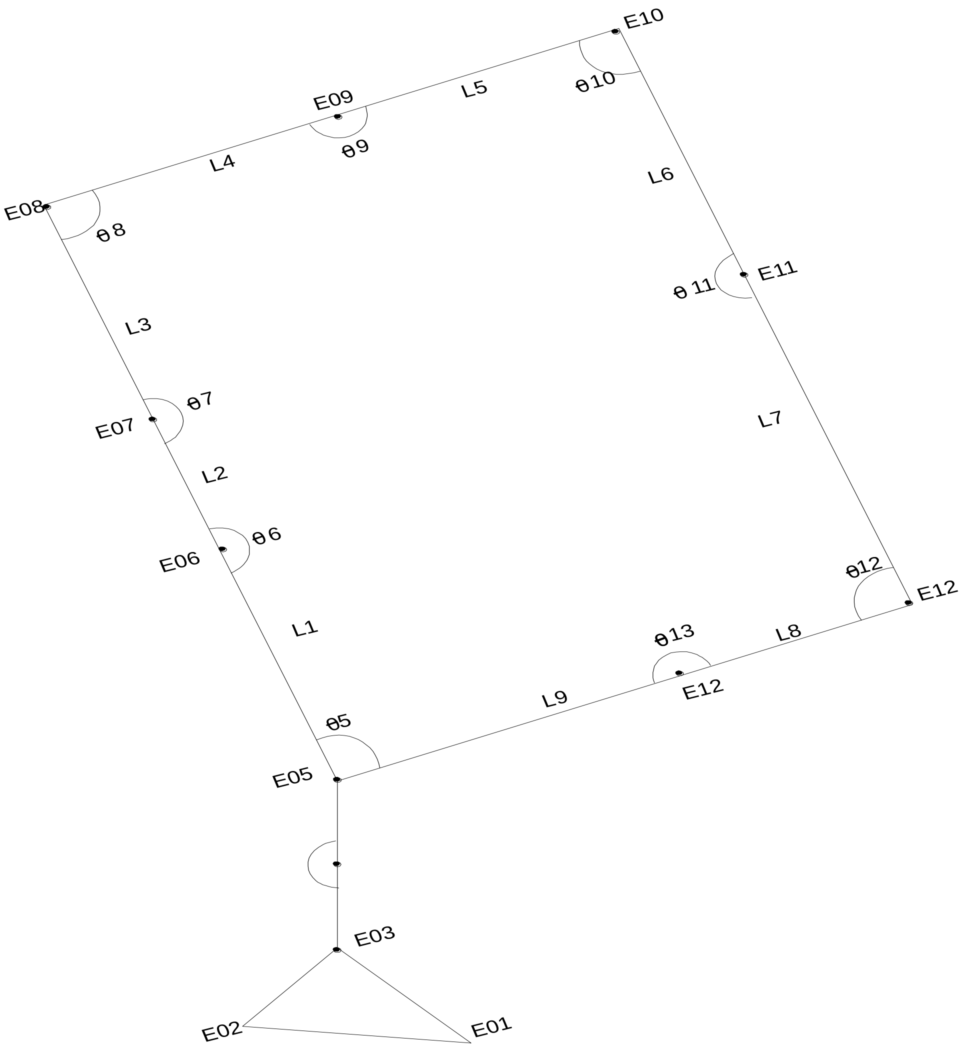


Fig 1.5 Diagram showing the sketch of the boundary.

II. The Role of Topographic Mapping in Civil Development

According to Scherer [8], topographic maps are based on topographical surveys. Performed at large scales, these surveys are called topographical in the old sense of topography, showing a variety of landmark and landscape information.

In the olden days, topographic surveys were prepared by the military to assist in planning for battle and for defensive emplacements. As such, elevation information was of vital importance. As they evolved, topographic map series became a national resource in modern nations in planning infrastructure and resource exploitation. In the United States, the national map-making function which had been shared by both the Army corps of engineers and the department of interior migrated to the newly created United States Geological surveys in 1879, where it has remained since and producing the first multi-sheet topographic map series of the entire country. But recent advances in technology has provided the ability to produce topographic maps through digital mapping process that are versatile in nature.

According to Husby [9], digital mapping is the process by which a collection of spatial data from a location is compiled and formatted into a virtual image. Primary function of this technology is to produce maps that give accurate representations of a particular area and detailing all features of interest that would be valuable to a user.

Early digital maps had the same basic functionality as paper maps that is, they provided a "virtual view" of the terrain encompassing the surrounding area. However, as digital maps have grown with the expansion of G.P.S. technology in the past decade, live traffic updates, points of interest and service locations have been added to enhance digital maps to be more "user conscious". Digital maps heavily rely upon a vast amount of data collected over time ranging from land observation data to remotely sensed data and satellite imageries. Maps must be updated frequently to provide users with the most accurate reflection of a location.

According to Ram and Dupain [10],the concept of topographic map is to show different elevations on a map developed to allow the accurate depiction of land features on a flat two-dimensional map.

Musa [11] lamented that, topographic maps are now three dimensional in nature due the introduction of the computer and other several digital equipment that emerged like the digital theodolite, terrestrial laser scanner and the total station etc. However, none could be compared with the Global Positioning System (GPS). The GPS is a space-based radio Navigation system, consisting of 24 satellites and ground support that provide accurate, three dimensional velocity, and 24 hours a day.

Ndukwe [12] also opined that, the Global positioning system (GPS) was developed to replace the Transit System to overcome the problem inherent in the Transit System. GPS can provide 24 hours a day instantaneously Global Navigation to positioning occurrences of a few meters. The GPS has been adopted for surveying application (High accuracy GPS surveying). The GPS satellite system is also called NAVSTAR satellite system.

Michael [13] produced the Digital Topographic map of the city of Lakewood. The map showed some infrastructure layers developed and maintained by Lakewood's GIS. Some layers such as waterlines, sewage lines, manholes, and curbs were digitized using a variety of sources that included as builds and substructure maps, individual feature layers such as fire hydrants and water valves were captured in the field by water department staff using GPS equipment. Building foot prints, transmission towers, and transmission lines were digitized using four inch colour aerials and parcel data. Annotation layers such as addresses and street names were created using address point and street Centre-line layers. But the accuracy at which those maps were produced is still questionable. However, many researchers focused their studies on the accuracy of mapping topography using GPS and Total station.

According to Lin, [14], accuracy test was made between GPS RTK and total station. The results showed that a positional accuracy of 14 mm has been achieved using GPS RTK while using total station it was possible to determine 16 mm positional accuracy. Similarly, Borgelt *et al*, [15] compared the accuracy of RTK with total station on the free area and they reported a standard deviation of 12 cm in a vertical position with RTK. But in the case of total station, better results (below 5 mm) have been achieved. In another vain, Ahmed, [16] tested RTK and total station measurements on an existing network through repeatability assessment by comparing the coordinates of points with that of independently precisely determined using a total station and the result revealed that, the difference between the coordinates of total station and RTK was 2 cm for the horizontal and 3 cm for the vertical coordinates.

Several methods are used to show accurately the configuration of the land surface on topographical plans or maps, the method of showing relief are however inadequate because they do not tell the reader of the elevation above the sea level of all points on the map or how the shape are but topographical contour gives these information through different types of topographical maps.

III. MATERIALS AND METHOD

Data Acquisition

The data used for this project work was obtained from two different sources: The primary data source and Secondary data source. The primary data was obtained from the site by means of direct field observation using the Total Station and Promark 3 GPS receivers to obtain the spatial data of all the natural and artificial features (i.e. Northings, Easting's, and Heights) on the topography of the project area. This included mounting a GPS antenna on a vehicle driven over a surface to minimize data collection time while optimizing data precision. For comparison, data was also collected with an antenna on a tripod to get maximum accuracy from antenna height using the stop-and-go mode. While Secondary data was obtained from the existing maps and plans of the area of concern and the coordinate of existing controls. During the field work, the observations by Total Station instrument was done using coordinate mode method to get XYZ coordinates of stations. The procedure was used for the boundary and detailed observations. A real time survey was carried out with the Promark 3 using the master and slave mode of the GPS. The slave was used to pick coordinates at all stations round the perimeter and consequently used to survey all the details in the study area. The data obtained by Promark3 GPS was copied into the computer using SD Card and later post processed using GNSS solution software while that of the Total station was adjusted using Least squares adjustment.

Instruments used

The various instruments that were involved in the execution of this project are here under listed:

1. Total Station Instrument (NTS 350 South)
2. Promark 3 GPS
3. Two External low Cost Antenna
4. Computer System (HP Pavilion dv5)
5. Software: Surfer 7 and Auto CAD 2007

Table 3.1: Coordinate Of Existing Controls

STATION	NORTHING (M)	EASTING (M)	HEIGHT(M)
E01	1034553.811	224957.646	215.901
E02	1034541.964	224917.052	219.960
E03	1034595.396	224946.123	217.468

Angular check

The bearings of various lines joining the three stations were computed from the above coordinates and to further deduce the angles between the lines.

The total station was used on the field to measure the angle between the ground stations. Comparing the computed and measured angles gave a permissible discrepancy and thus the angles are in-situ. See computation below.

Linear check

The distances of the various lines joining the three stations were computed from the above coordinates and the total station was used on the field to measure the distances between the ground stations. Comparing the computed and measured angles gave a permissible discrepancy and thus the distances are in-situ. See computation below.

Fig. 3.1 Diagram Showing Existing Controls

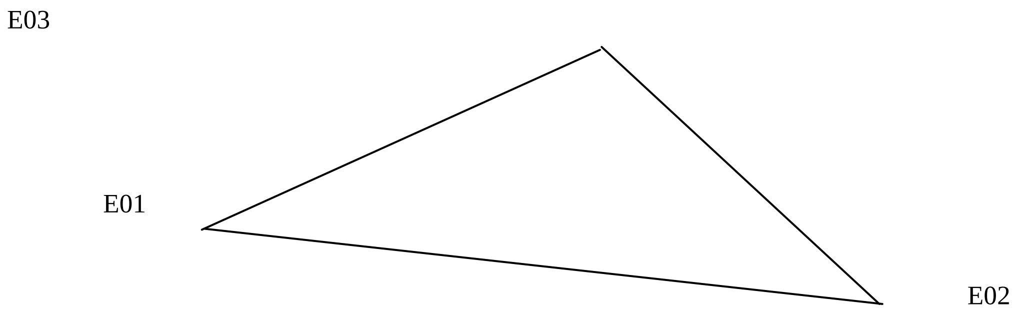


Table 3.2: Angular Comparism.

COMPUTED	MEASURED	DISCREPANCY
90^0 46' 53.9"	90^0 46' 28.6"	00^0 00' 25.3"
45^0 10' 51.82"	45^0 10' 31.7"	00^0 00' 20.12"
44^0 02' 14.28"	44^0 02' 13.3"	00^0 00' 0.98"

Table 3.3: Linear Comparism

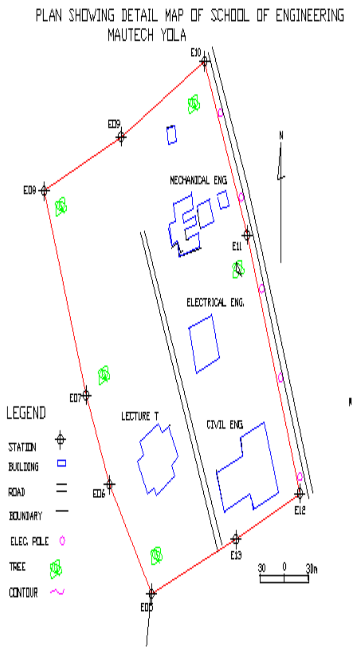
COMPUTED	MEASURED	DISCREPANCY
42.287m	42.283m	0.004m
60.828m	60.825m	0.003m
43.154m	43.149m	0.005m

Table 3.4: Height Comparism

GIVEN	MEASURED	DISCREPANCY
215.901m	215.899m	0.003m
219.960m	219.949m	0.011m
217.468m	217.460m	0.008m

IV.Data Processing

Two sets of data are involved in this work: the one obtained by GPS instrument and the one obtained by Total Station instrument. The data obtained by GPS instrument was post process using GNSS solution software and the final coordinates of the boundary of the study area determined as shown in table 4.2. On the other hand, the data obtained using Total Station instrument are the angles, bearings and distances between stations and also the preliminary coordinates of the perimeter stations as shown in table 3.5 and 3.6(see appendix I) as well as the field observed data using the two instruments .The data was further adjusted to obtain the final coordinates of the perimeter stations using Least Squares adjustments. The boundary coordinates and details were plotted using the Auto CAD software and the contour lines were produced with surfer 7 software.



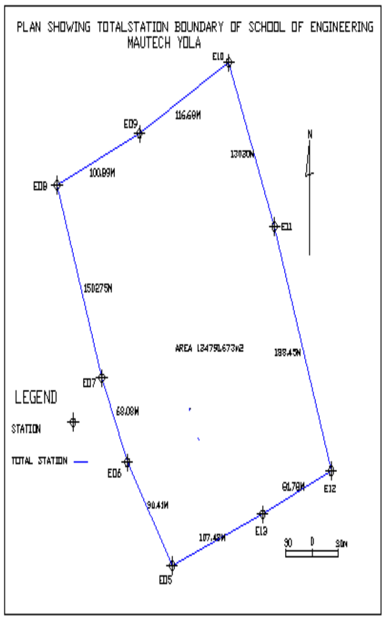
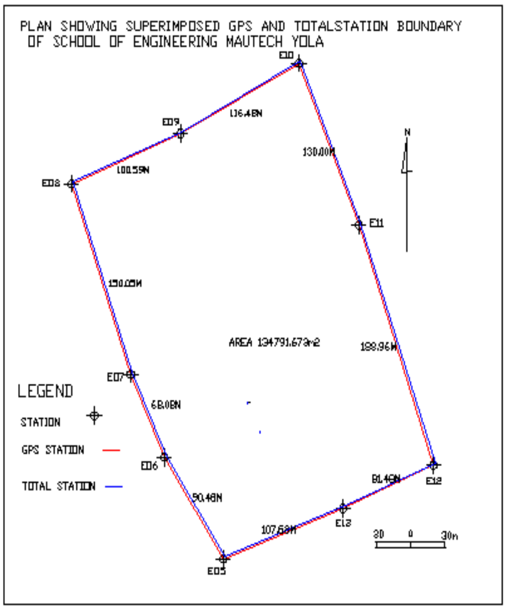


FIG 4.1 PLAN SHOWING GPS BOUNDARY OF THE STUDY AREA
FIG 4.2 PLAN SCHOWING TOTAL STATION BOUNDARY OF THE STUDY AREA



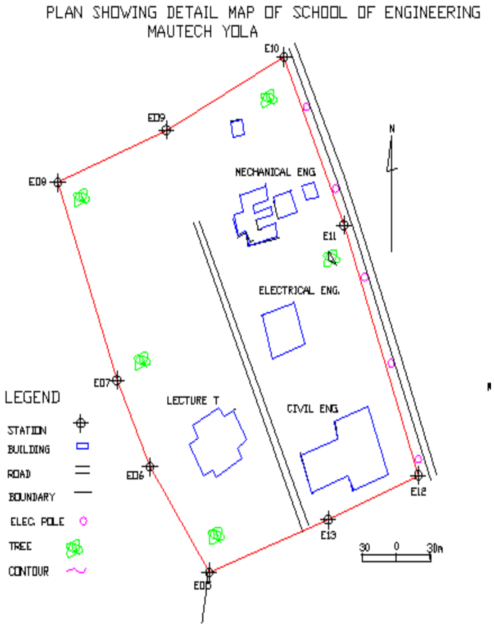
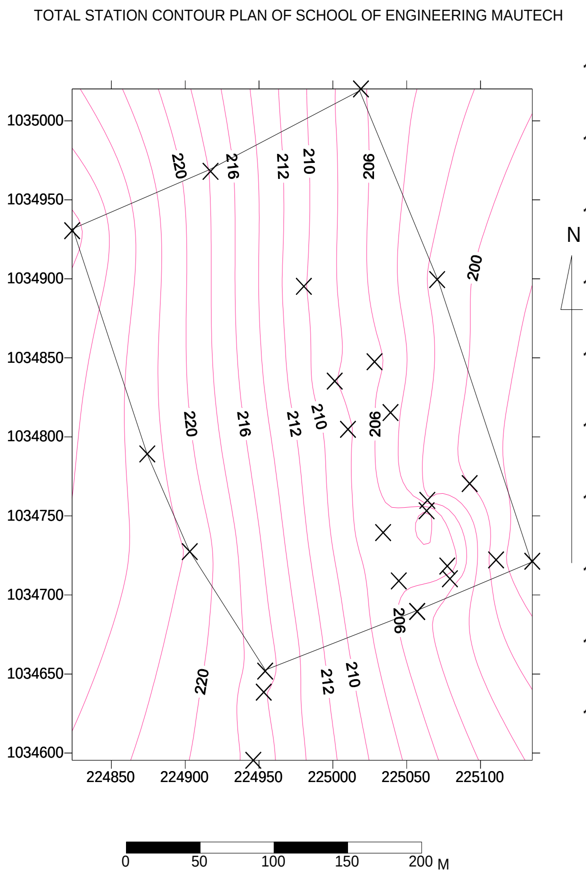


FIG 4.3 PLAN SHOWING SUPERIMPOSED GPS AND TOTAL STATION BOUNDARY OF THE STUDY AREA

FIG 4.4 PLAN SHOWING DETAIL MAP OF THE STUDY AREA



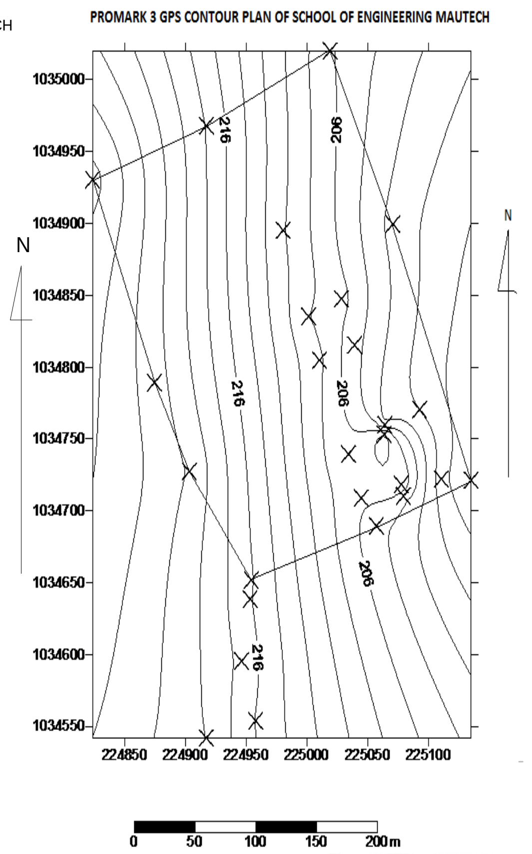


FIG 4.5 TOTAL STATION CONTOUR PAN FIG 4.6 GPS PROMAX 3 CONTOUR PLAN OF THE STUDY AREA
OF THE STUDY AREA

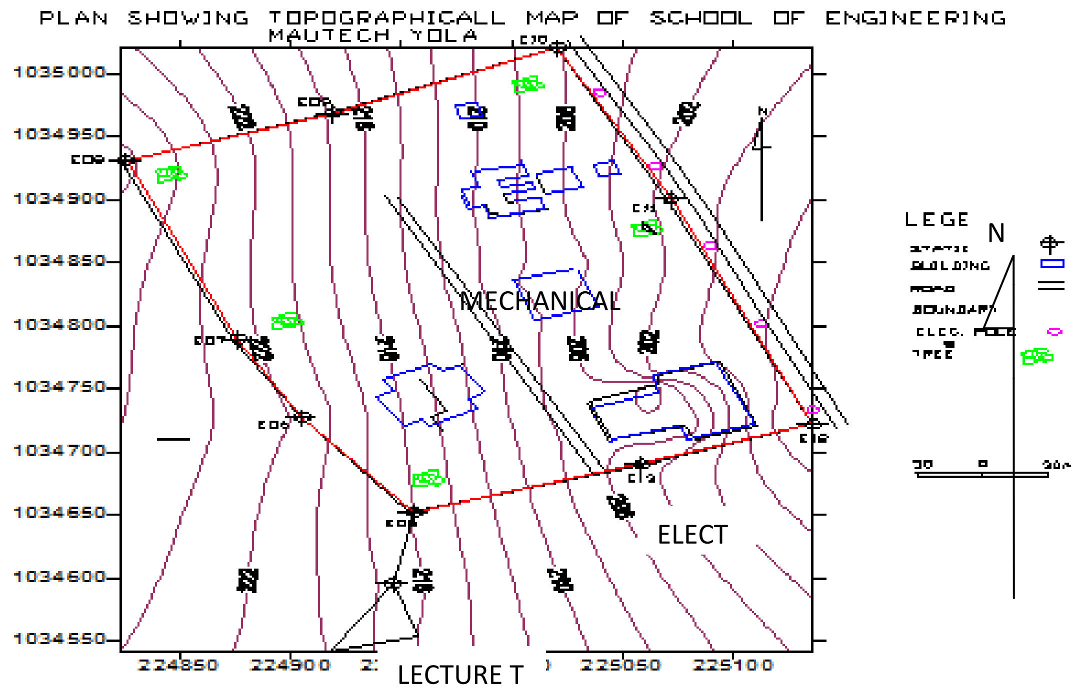
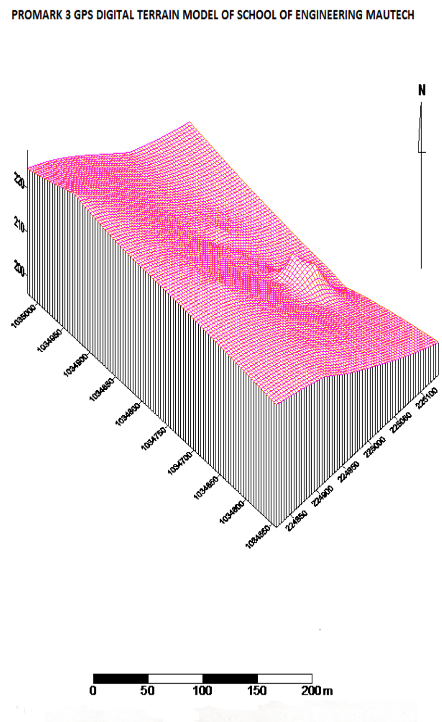


FIG 4.7 PLAN SHOWING TOPOGRAPHICAL MAP OF THE STUDY AREAR



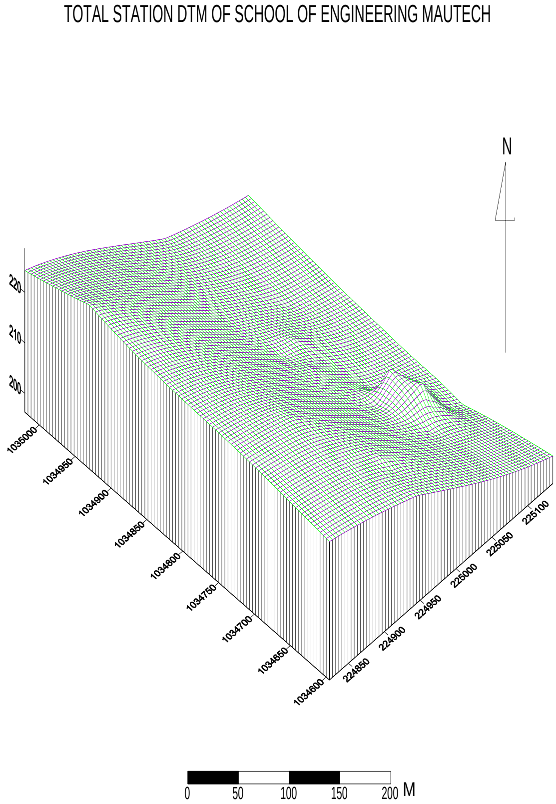


FIG 4.8 PROMARK 3 GPS DIGITALFIG 4.9 TOTAL STATION DIGITA TERRAIN MODEL OF THE STUDY AREAR OF THE STUDY AREAR

Analysis of the Results

The adjusted coordinates obtained from the two instruments are shown on table 4.1 and 4.2. The adjustment for coordinates obtained by Total Station instruments was done by Least squares adjustment and the process of the adjustment was tested. This was tested by chi squares distribution, a two tailed test at 0.01 level of significance. It was found from the test that processed of adjustment adopted did not distort the final result obtained. On the other hand, the coordinates obtained from GPS instruments were post processed by the GNSS solution software and the final adjusted coordinates presented. The result of the analysis shows that, at a degree of freedom 2 and 0.05 level of significance, the adjustment procedure was found worthy. Coordinates obtained from the two methods were also compared and was found that the result did not show any significant difference as can be seen on table 4.3 in appendix II.

The figures of the surveyed area were also plotted from the two boundary coordinates. The figures did not differ from each other by any significant measure. The two figures were also superimposed, the result shows that the two superimposed precisely without any significant difference. Although the two methods can be recommended under the same working conditions, the variances of the two instruments 4.546791 for GPS instrument and 3.9775 for Total station instrument shows that, that of Total station instrument is lower and can therefore be preferred to the GPS instrument.

V.Conclusion

Total Station and GPS instruments were used in surveying the permanent complex of School of Engineering, Modibbo Adama University of Technology Yola, for the production of topographic map of the area. Both instruments used were found to produce reliable data under similar conditions for the production of topographic map. The final adjusted boundary coordinates determined by the two instruments yield good result on the bases of precision. The two coordinates shows no significant difference as shown on table 4.3. The topographic maps produced by the data obtained from the two instruments were superimposed. The superimposed maps show no significant difference on the bases of position of details and the boundary stations.

Recommendation is hereby made, that the use of Total Station and GPS instruments are both good in the production of Topographic Map. The most suitable method at a time is the one that its instruments are readily available. Although the two methods can be recommended under the same working conditions, the variances of the two instruments 4.546791 for GPS instrument and 3.9775 for Total station instrument shows that, that of Total station instrument is lower and can therefore be preferred to the GPS instrument.

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Appendix I

TABLE 3.5 Observed angles and distances using Total Station

STATION	ANGLES	DISTANCES
E01	$185^0 08' 57''$	
E02	$99^0 54' 26''$	91.219
E03	$170^0 56' 17''$	68.209
E04	$174^0 50' 41''$	150.090
E05	$86^0 52' 08''$	101.014
E06	$185^0 15' 24''$	114.410
E07	$86^0 04' 27''$	131.186
E08	$176^0 41' 54''$	189.490
E09	$92^0 18' 25''$	84.192
E10	$177^0 56' 59''$	109.640

Table 3.6 Observed boundary coordinate using Total Station

S/N	X(m)	Y(m)	Z(m)
E01	224946.123	1034595.396	217.468
E02	224953.186	1034638.517	216.156
E03	224954.152	1034651.822	216.984
E04	224903.098	1034727.412	221.753
E05	224874.300	1034789.244	222.922
E06	224823.414	1034930.445	228.745
E07	224917.177	1034968.028	217.884
E08	225019.029	1035020.146	206.245
E09	225070.652	1034899.544	201.326
E10	225135.063	1034721.335	196.231
E11	225057.100	1034689.553	204.554

Table 3.7 Observed detail coordinate using Total Station

S/N	X(m)	Y(m)	Z(m)	REMARK
1	225014.766	1034892.154	206.000	B1
2	225013.444	1034901.155	205.980	B2
3	225000.344	1034897.910	205.779	B3
4	224996.036	1034903.335	205.001	B4
5	225010.170	1034907.682	206.011	B5
6	225009.086	1034913.111	205.913	B6
7	224994.945	1034908.759	205.003	B7
8	224991.866	1034914.198	207.013	B8
9	225006.911	1034918.533	207.143	B9
10	225004.722	1034930.493	207.255	B10
11	224981.911	103494.805	210.156	B11
12	224985.122	1034909.850	209.322	B12
13	224977.505	1034907.682	210.722	B13
14	224980.822	1034891.390	213.220	B14
15	225025.309	1034927.233	205.001	B15
16	225011.244	1034918.545	205.501	B16
17	225015.601	1034904.424	205.702	B17
18	225031.900	1034909.859	204.922	B18

19	225038.423	1034916.368	204.801	B19
20	225049.322	1034922.887	204.212	B20
21	225046.055	1034930.491	204.820	B21
22	225034.091	1034926.145	205.345	B22
23	224986.677	1034982.344	210.250	SP1
24	224960.811	1034941.285	212.210	SP2
25	224934.900	1034829.522	214.315	SP3
26	224923.523	1034776.277	215.821	SP4
27	224925.711	1034704.810	214.982	SP5
28	224998.095	1034666.034	210.213	SP6
29	224893.845	1034910.873	218.347	SP7
30	224891.809	1034869.868	220.419	SP8
31	224874.801	1034794.536	222.126	SP9
32	224891.505	1034762.601	220.220	SP10
33	224851.211	1034888.811	223.201	SP11
34	224851.205	1034888.811	223.210	SP12
35	224845.877	1034935.010	226.578	SP13
36	224951.450	1034720.876	213.129	B23
37	224959.072	1034725.233	212.424	B24
38	224962.333	1034719.753	212.122	B25
39	224984.075	1034733.902	211.259	B26
40	224980.814	1034740.448	210.572	B27
41	224987.333	1034745.879	210.000	B28
42	224978.650	1034768.646	211.210	B29
43	224968.850	1034763.226	211.721	B30
44	224963.445	1034769.742	212.329	B31
45	224941.678	1034756.726	212.333	B32
46	224946.022	1034748.021	212.122	B33

Table 3.8 Observed boundary coordinate using Promark 3 GPS

S/N	X(m)	Y(m)	Z(m)
E01	224946.123	1034595.396	217.468
E02	224953.186	1034638.517	216.156
E03	224954.134	1034651.835	216.194
E04	224903.122	1034727.416	221.793
E05	224874.383	1034789.246	222.914
E06	224823.433	1034930.449	228.772
E07	224917.178	1034968.028	217.884
E08	225019.031	1035020.143	206.245
E09	225070.652	1034899.578	201.314
E10	225135.06	1034721.335	196.000
E11	225057.102	1034689.551	204.574

Table 3.9 Observed Detail Coordinate using Promark 3 GPS

S/N	X(m)	Y(m)	Z(m)	REMARK
1	225014.755	1034892.155	206.001	B1
2	225013.434	1034901.166	205.981	B2
3	225000.386	1034897.908	205.781	B3
4	224996.037	1034903.339	205.000	B4
5	225010.172	1034907.683	206.010	B5
6	225009.084	1034913.113	205.912	B6
7	224994.950	1034908.769	205.001	B7
8	224991.863	1034914.199	207.014	B8
9	225006.910	1034918.544	207.144	B9
10	225004.735	1034930.490	207.254	B10
11	224981.903	103494.802	210.157	B11
12	224985.165	1034909.855	209.325	B12
13	224977.554	1034907.683	210.721	B13
14	224980.816	1034891.392	213.228	B14
15	225025.393	1034927.232	205.000	B15
16	225011.259	1034918.544	205.502	B16
17	225015.608	1034904.425	205.701	B17
18	225031.917	1034909.855	204.923	B18
19	225038.441	1034916.371	204.802	B19
20	225049.313	1034922.888	204.219	B20
21	225046.052	1034930.490	204.825	B21
22	225034.092	1034926.146	205.345	B22
23	224986.680	1034982.345	210.254	SP1
24	224960.803	1034941.286	212.211	SP2
25	224934.926	1034829.513	214.316	SP3
26	224923.509	1034776.288	215.822	SP4
27	224925.793	1034704.811	214.983	SP5
28	224998.096	1034666.036	210.211	SP6

29	224893.827	1034910.871	218.345	SP7
30	224891.811	1034869.871	220.411	SP8
31	224874.800	1034794.537	222.124	SP9
32	224891.544	1034762.602	220.225	SP10
33	224851.206	1034888.821	223.217	SP11
34	224845.879	1034935.000	226.579	SP12
35	224951.459	1034720.879	213.125	B23
36	224959.070	1034725.223	212.423	B24
37	224962.332	1034719.793	212.123	B25
38	224984.077	1034733.912	211.257	B26
39	224980.816	1034740.428	210.571	B27
40	224987.339	1034745.859	210.001	B28
41	224978.641	1034768.666	211.211	B29
42	224968.856	1034763.236	211.722	B30
43	224963.449	1034769.752	212.324	B31
44	224941.674	1034756.716	212.332	B32
45	224946.023	1034748.031	212.121	B33
46	224938.412	1034743.687	213.211	B34

Appendix II

Table 4.1 Final Computed Coordinates Determined by Total station

S/N	X(m)	Y(m)
E01	224954.152	1034651.822
E02	224903.098	1034727.412
E03	224874.300	1034789.244
E04	224823.414	1034930.445
E05	224917.177	1034968.028
E06	225019.029	1035020.146
E07	225070.652	1034899.544
E08	225135.063	1034721.335
E09	225057.100	1034689.553

Table 4.2: Final Perimeter Coordinates Determined By GPS Instrument

S/N	X(m)	Y(m)
E01	224954.134	1034651.835
E02	224903.122	1034727.416
E03	224874.383	1034789.246
E04	224823.433	1034930.449
E05	224917.178	1034968.028
E06	225019.031	1035020.143
E07	225070.652	1034899.578
E08	225135.06	1034721.335
E09	225057.102	1034689.551

Table 4.3: Difference between the Coordinates Determined From the two Instruments

S/N	X(m) GPS	X(m) Total Stn.	Y(m) GPS	Y(m) Total Stn.	Diff in X(m)	Diff in Y(m)
E01	224954.134	224954.152	1034651.835	1034651.822	-0.018	0.013
E02	224903.122	224903.098	1034727.416	1034727.412	0.024	0.004
E03	224874.383	224874.300	1034789.246	1034789.244	0.083	0.002
E04	224823.433	224823.414	1034930.449	1034930.445	0.019	0.004
E05	224917.178	224917.177	1034968.028	1034968.028	0.001	0.000
E06	225019.031	225019.029	1035020.143	1035020.146	0.002	-0.003
E07	225070.652	225070.652	1034899.578	1034899.544	0.000	0.034
E08	225135.060	225135.063	1034721.335	1034721.335	-0.003	0.000
E09	225057.102	225057.100	1034689.551	1034689.553	0.002	-0.002