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ENGINEERING SURVEYING OF ELECTRIC POWER LINES: PLAN AND ROUTE PROFILES PLOTTING IN ELECTRICAL POWER SYSTEMS

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Abstract

This paper examines the engineering surveys of electric power lines and the under-laying principles of route profile in electrical power systems. The techniques and procedures of carrying-out the practical implementation of line surveying in relation to electric power lines are outlined in details in this work taking standard regulations into consideration. The method of data acquisition, computation, processing and storage were dearth with in this article. Then the paper exposes some shortcomings in the network and the tolerance limit of conductors sagging and power lines crossing buildings and hills etc. both for vertical and horizontal distances for the 330kV, 132kV and 33kV power lines.

Keywords: Engineering surveys, route profile, right-of way, power lines, reconnaissance, data acquisition

1.0 Introduction

Electrical Power Systems are one of the most complex system ever built by man. Its complexity and reliability cannot be overemphasized, if power supply from it to consumers must be reliable. It is worth knowing that a good power system design will give a reliable power output to its consumers. Hence, a reliable supply is a hallmark of a good design. Then a good engineering surveying during electric power design cannot be underestimated. Presently, the Nigeria complex transmission and distribution systems supply the vast needs of electrical power to their citizenry [1] and in Nigeria today, the power system is characterized with erratic, inadequate and inefficient power supply, voltage drop, under voltage and high-power losses, especially in the distribution network [2&3]which is due to long distribution and transmission lines which may be caused by non-optimal route profile selection during design. It is worthwhile knowing that the existing utility facilities are ageing and they are being overstretched due to increase in loads and high losses in the system without commensurate improvement and overhauling of the power network facilities to match the increasing loads for several past decades to improve consumers' satisfaction and reliability [4].One of the ways to minimize high losses in the network is optimal route selection for power lines and a good design should do so.

"A good design involves a good Right-of Way (ROW) and effective management of the electric power lines (transmission and distribution lines). Right-of Way (ROW) is a corridor of land over which electric power lines are located. Electric power lines owners my own the land in fee, own an easement; or have certain license or franchise rights to construct and maintain power lines" [3]. The importance of ROW in electric power lines design cannot be overemphasized, since "utility companies seek to locate power line in sites that are technically optimal, economically and environmentally acceptable to accommodate required facilities." Designing the Right-of Way is a significant factor when developing an electrical power systems" [5] because it gives the various optimal route profile and location that should be harness. Hence, "Power Systems is an interconnected network of generating plants, transmission lines and distribution facilities." The transmission lines evacuate (transport) the generated electric energy to the consumers at the point of utilization. The path the electric power lines follow to transport the energy generated to consumer is known as the power line route or Right-of Way (ROW); proper engineering survey is a key to a good route profile of electric power lines. Consequently, this paper x-ray engineering survey of electric power lines and route profile plotting in electric power systems.

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1.1 Engineering Survey

Engineering surveying may be regarded as a specialty within the broader professional practice of engineering and, it includes all surveying activities required to support the conception, planning, design, construction, maintenance and operation of engineered projects [6]. Furthermore, engineering surveying can be broadly described as a term used to describe the work of surveyors on engineering projects or works. The engineering surveys are broadly divided into two categories namely [7]: i. design-data surveys and ii. construction surveys.

1.1.1 Design Data Surveys

"A design-data survey is an orderly process of obtaining data that is needed for the planning and design of an engineering project. The activities involved in design-data surveying vary according to the type and complexity of the engineering or construction project it involves. For example, the activities might include simply obtaining topographic data for a proposed building site, or they may include extensive route surveying and soils investigation for a highway" [7].

1.1.2 Construction Surveys

"Construction surveying is further divided into two categories: (1) the layout, or stakeout survey and (2) the as-built survey. The layout, or stakeout survey consists of locating and marking (staking) horizontal and vertical control points to guide construction crews and giving line and grade as needed to establish additional control points and to reestablish disturbed stakes. The as-built survey includes making measurements to verify the locations and dimensions of completed elements of a new structure and to determine the amount of work accomplished up to a given date" [6].

1.2 Route Surveys

A route survey is a topographic survey of predetermined existing or proposed corridor [8]. This corridor may be described as road, right-of way, utility easement, etc. [8]. "The route survey details the route or course a highway, road, or utility line will follow. While the end product of a route survey for a highway differs from that of utility line, it may nevertheless be said that the purpose of any route survey is [7]:

a. to select one or more tentative general routes for the roadway or utility
b. to gather enough information about the general route to make it possible for designers to select the final location of the route
c. to mark the final location

1.3 Route surveys of Electrical Power Lines (Right-of Way Surveys)

Overhead power lines are the infrastructures for electric power transmission and distribution for some distance. It consists of conductors suspended by towers or utility poles such as wooden poles, steel poles and RCC poles (Reinforce Concrete Cement) mainly refer to as line supports. The overhead power lines are generally the lowest cost method of power transmission and distribution for a large amount of electric energy since most of the insulations are provided by air. The line supports are of high mechanical strength to withstand the weight of the conductor and any force, long life span, light in weight, cost effective and stress-free accessibility of conductors for maintenance.The choice for any kind of line support is dependent on the span length, cross-sectional area, line voltage, cost implications and local conditions. Therefore, for a better, desirable and reliable placement of line supports, surveying principle is applied in the transmission and distribution lines Right of Way.

Surveying is defined as (1) The science and art of making all essential measurements in space to determine the relative positions of points and/or physical and cultural details above, on, or beneath the earth's surface and to depict them in usable forms, or to establish the position of points and/or details. Also, the actual making of a survey and recording and/or delineation of dimensions and details for subsequent use, (2) the acquiring and/or accumulation of qualitative information and quantitative data by observing, counting, classifying and recording according to need. *(1978 ASCE Manual No. 34 Definitions of Surveying and Associated Terms prepared by a joint committee of the ASCE and ACSM).* Route surveying is an aspect of surveying made along a defined belt of a territory for location, design and eventual construction of routes for transportation and infrastructures such as highways, railways, canal, pipeline for water, sewage and transmission and distribution lines for power and; telecommunication systems.

The Right of Way survey comprises the preliminary route design, setting out of proposed transmission and distribution lines supports, As-built survey of set out points and detailing of features within the confines of right of way.The route profile survey of electrical power lines can be classified into two categories: a. *Route Surveys of Overhead Electrical Power Distribution and Transmission lines* and b. *Route Survey of Underground Piping and Power Lines.*

1.3.1 Route Surveys of Overhead Electrical Distribution and Transmission lines

The reconnaissance survey for electrical power lines employs many of the same principles and practices used for highway work [7]. Hence, the method of surveying as applied to distribution and transmission lines are on stages as follows:

1.3.2 Recconnaisance and Route Alignment Survey: A provisional route of transmission line is initially spotted on survey maps and a recconnaisance is carried out with the available map to ascertain the topography of the terrain and the best method to employ in carrying out the obligations. This is essential to fix up angle tower position tentatively since many of the physical features on the ground may not be clearly available on the survey maps due to the development that might have taken place subsequent to the preparation of the map.The recconnaisance survey is essential to be carried out, to collect the first hand information of various important field data required for transmission line work. It is of this stage that every military installation, land owners through which the transmission lines will pass are determine in order to obtain permission to run through the proposed transmission lines route(s). It is also of paramount importance to make use of existing utility maps to examine if there are natural or artificial features that may pose a hindrance or assist the construction of the transmission lines within the Right of Way. For power lines, the design engineer considers the principles of Horizontal Control and Direct Leveling to select one or more tentative routes over which the line will pass [7]. The under listed are the general consideration to be kept in recconnaisance survey with regards to preliminary route-

a. The route should be as short and straight as much as posible.
b. Minimize the crossing of permanent objects such as railway lines, roads, rocks, buildings etc
c. The direction of highways and roads should be followed and possibly, should be at right angle to the route
d. Go along with the farmers property or section lines
e. Avoid hilly terrain having sharp rise and falls on the ground profile and if by peradventure the hilly terrain is come across, it is necessary to conduct detail survey and locate the lower positions. The proposition should be most economical and safe.
f. Avoid disrupting the environment
g. Avoid marshy areas, low lying land, river beds, earth slippery zones e.t.c. involving risk to stability of foundation.
h. Avoid areas subject to flood, ponds, lakes, hurricane or having extreme climatic condition that can subject it to natural hazards.
i. Avoid areas, which will create problems for right of way and wayleaves.

Recconnaissance is usually an essential aspect of any survey operation that helps in decision making and facilitates proper planning vis a vis:-

i. Accuracy specified
ii. Determine the most suitable and profitable points and methodology in data acquisition.
iii. Type of instrument that will be used for the project
iv. Cost of project
v. Personnel to execute the project
vi. Type of vehicle to be used
vii. Type of safety equipment needed to use during the execution of the job.
viii. Duration of the field work

Bye and large, d**ata search** and **field reconnaisance** are always employed in the Right of Way survey.

1.3.3 Data Search: Thisentails all office preparations made which includes all necessary information about the control pillars near the project site, type of instrument needed to execute the job, the right personnel and all other documents which would assist in a thorough and acceptable result.

1.3.4 **Field Reconnaissance:**This is the act of visiting the project site for the adoption of the best procedural method for fast and cost-effective execution. The Tower Schedule of the tower spotting which contains the coordinates of the Tower Points of the proposed route for Transmission line should be taken along for the field reconnaissance. With the aid of a handheld GPS, the proposed route can be located using the provided coordinates of the tower points. This is to familiarise with the terrain and routes by which access could be gained to the site. The feasibility study made on site will afford the opportunity of choosing a baseline which should be marked out to facilitate operation.

1.3.5 Detailed Survey:with the tentative route(s) selected, a preliminary or detailed survey is carried out to prepare Plan and Profile design showing details of deviation angles along with important objects falling within the right of way (ROW). In the course of detailing, all pertinent topographic information and overheads and underground lines should be captured indicating individual properties whether it's of power or communication lines. Work of detailed survey is distinctly done in two stages:

a. Actual field observations for Cadastral and Topographical data acquisition.
b. Plotting of plan and profile on which the plan depicts the route the transmission line will pass through with the significant topography adjacent to the route and the profile exhibiting the existing ground elevations along the route and the top elevations of the poles/towers which are set in accordance with the minimum allowable clearance specified in the National Electrical Safety Code (NESC).

1.3.6 Tower Spotting

The tower spotting operation is clearly divided into six operations and which are as follows:

i. Sag tension calculation.
ii. Preparation of sag template
iii. Application of sag template to decide the optimum tower position on survey charts.
iv. Preparation of structure limitation charts.
v. Deciding tower types and preparation of tower schedule
vi. Setting out the positions of the tower legs on ground.

In designing an overhead transmission line, attention is paid to the tension force in order not to exceed in any case the limit of the mechanical strength of the conductor. For distibution lines, poles are placed by the sides of the streets that is most free of other lines and trees. The transmission lines are kept on the same side of the road of the entire length of the power line if possible. The span of the line supports of transmission lines is dependent on the type of the supporting structure for the overhead conductors. There are various types of line support such as wooden poles, steel poles, Reinforced Concrete Cement (RCC) and the Towers. Wooden poles are limited to low voltage up to 11kV and suitable for lines of relatively short spans up to 38.10m meters (30.48m minimum and 45.72m maximum). Steel poles are used in place of wooden poles with span of 50 meters. The RCC poles usually refer to concrete poles are used for low voltage and high voltage distribution lines up to 33kV. It has a greater mechanical strength, durable and permit longer span than steel poles. It can be used for longer span between 50 to 80 meters. Steel towers also known as Lattice steel towers has a greater mechanical strength and are used for higher voltage distribution lines. It allows a longer span from 80 to 200 meters. They are of two types, The Narrow base lattice steel tower used for distribution lines between 11kVand 33kV, and the Broad base lattice steel tower used for Transmission lines of 132kV and 330kV.

Whenever the line support comes in line with property or fences alongside with road, the span is adjusted. The poles should be place at safety distance from ground to transmission line and scissors crossing as follows:

Where the transmission line crosses a railway

1) There should be no joints in the conductor or ground wire within the crossing span length
2) The minimum vertical distance from the tread to the conductor should be not less than 7.6 meters and 8.5 meters for 33kV to 132kV and 330kV respectively.

Where the transmission line crosses a public road, there should be no joints in the conductor within the crossing span length and second-class circuit. The minimum vertical distance from the ground to the conductor should be 7 meters for 33kV to 132kV and 8 meters for 330kV. The minimum horizontal distance from railway or a public road to the conductor should not be less than as stated below:

a. From the pole to the railway edge, where the transmission lines are at right angle with the railway; the 33kV to 132kV = Pole height + 3 meters and where the transmission lines are crossing the railway, 33kV to 330kV lines support should be place at 5 meters to the edge of railway.
b. From pole to roadbed edge, it should be place at 5 meters for 33kV to 330kV.

Where the transmission lines cross weak current circuit, there should be no joints in the conductor within the crossing length of first class and second-class weak circuit and a minimum vertical and horizontal distances are stated in Table 1below:

Table 1: Minimum Vertical and Horizontal Distance of Power Line Crossing

Voltage	**Distance in Meters**
Minimum Vertical Distance	
33kV to 132kV	3m
330kV	4m
Minimum Horizontal Distance	
33kV to 132kV	4m
330kV	5m

Where the transmission lines cross a weak current circuit, the crossing angle to the ground and second-class weak current circuit should be more than 45^0 and 30^0 respectively. The minimum height from the ground to conductor at maximum sag should not be less than as listed in Table 2 below:

Table 2: Minimum Height from the Ground to Conductor at Maximum Sag

Voltage	33kV to 132kV	330kV
Residential area	7 Meters	7.5 meters
Non-Residential Area	6 Meters	6.5 Meter
Road-Block Area	5 Meters	5.5 Meters

Minimum space distance from hillside, precipice or rock to the conductor should be as stated in Table 3 below:

Table 3: Minimum Space Distance on Hillsides

Voltage	33kV to 132kV	330kV
Hillsides which can be access by foot	5 Meters	5.5 Meters
Hillsides, precipice of rock that cannot be access by foot	3 Meters	4 meters

The supposed vertical distance from building to the conductor at maximum sag should not be less than the values stated in Table 4 below:

Table 4: Vertical Distance from Buildings to Conductor at Maximum Sag

Voltage	**Distance in Meters**
33kV	4
132kV	5
330kV	6

The horizontal distance from building to the conductor at maximum sag calculated or windage yaw should not be less than the value in Table 5 below:

Table 5: Horizontal Distance from Buildings to Conductor at Maximum Sag

Voltage	Distance in Meters
33kV	3
132kV	4
330kV	5

Where the transmission line crosses a bush/forest, a path should be cut out to give way to every tree and plants at distance between the phases conductors of the sides of the transmission line. The high trees around the path should also be cleared. Safety distance to be adopted from the plants/trees/crops to the conductor at maximal sag or maximum windage yaw shall be as stated in Table 6 below:

Table 6: Safety Distance to be adopted from Plants to Conductor at Maximum Sag

Voltage	33kV to 132kV	330kV
Vertical Distance at Maximum Sag	4 Meters	4.5 Meters
Space Distance at Maximum Sag or Calculated Windage Yaw	3.5 Meters	4 meters

Note that the flashover often accompanies strong wind and rain that makes the rate of re-closure low when the transmission line trip and is caused by windage yaw which affects the security and reliability of the power system. However, in open roadways or highways, poles should place at 46cm from the outside of the fence. For transmission lines, poles should be positioned on elevated areas so that the shorter poles may be used and keeps the proper ground clearance at the middle of the span. Locating of poles at the edges of embankments and streams where there is possibility of washout should be avoided. Tower spotting commence with the establishment of control points along the proposed transmission lines followed by Line Route using differential GPS or Total station and lastly the Setting out the center of line supports / tower positions. In the course of tower spotting, it is also imperative to provide the three Pegs at ten meters interval longitudinal to the Transmission line at every Tower position using Total station instrument with the center peg indicating the Tower Position and other pegs showing the Right of Way. For example, the recommended right of way for 132kV/dc transmission line is not less than 27meters.

1.4 Route Survey of Underground Power Lines and Piping

Underground power line is the replacement of overhead lines or cables providing power or telecommunication lines with underground routes. This is not typically done for aesthetic purposes only, but it is carried-out in an area(s) where overhead lines will not be possible or save to implement. Hence, underground power lines routing serves additional significant purpose of making the power lines less susceptible to power outages during high wind thunderstorm or heavy rain fall. The underground power line routing, which is term undergrounding can increase the initial capital cost of electric power lines (transmission and distribution) but the running or operational costs may decrease over the lifetime of the cables. This technique of undergrounding is highly advantageous across densely populated or areas where land is costly or environmentally or aesthetically sensitive [9].Underground utility structures such as pipe and conduit systems are expected to withstand induced stresses from live and dead loads, have a robust system of joints and connections, and be somewhat chemically inert with respect to soil and water to serve the expected service life. There are various techniques deploy to carried-out underground power lines routes and piping but one them is the high resolution of geophysical techniques. The various geophysical tools including: the electromagnetic induction techniques and ground penetrating radar technology.

The low frequency electromagnetic induction devices are commonly referred to simply as 'electronic pipe and cable locators. The method of route profile for overhead and underground and the same except locating the existing pipes and cables underground to avoid damage when excavating the soil for the underground route profile.

1.4.1 Electromagnetic Locating Survey[10]

Electromagnetic location instruments (Cable/Pipe Locator) is used to locate metallic pipes and trace wires that laid for non-metallic pipes and drains where there is an access point within a reasonable distance (say 20 meters) from the site or on the route being surveyed. All surface features relating to underground utilities, such as manholes, draw pits, inspection chambers and gullies, including all street furniture connected to pipes and cables such as lamp posts, illuminated road signs and bollards, telephone kiosks etc. will be recorded during the survey process. Underground utilities will be located continuously and recorded in three dimensions at reasonable intervals and at each surface feature, change of direction. Where bands of cables/ducts are identified, the upper and lower outer cables/ducts will be traced in order to provide a cross section of the cable/duct band.

Direct connections will be made to gas and water valves without any damage to the utilities. All electrical utilities (lampposts, traffic lights, low / medium / high voltage electric cables and telecom cables) will be located by either inductive methods or where necessary the use of a signal clamp which makes no contact with any conducting material. Sewer manholes will never be accessed internally but rather examined by use of torches thus not requiring confined space entry and greatly reducing any chance of injury from harmful gases, rats, snakes, etc.All known and all other recordable underground services within the site will be surveyed. However, the condition of services should not be surveyed.

1.5 Monumentation

Emplacement of beacons are done before any survey activity is executed. The beacon should be casted in-situ. Below is a beacon casted in-situ where ground was dug within the dimensions of 30cm x 30cm to a depth of 75cm. A $3^{1/4}$ inch galvanized pipe cut to a length of

1.2 metresdriven into the dug hole and further driven into the ground to a depth of 15cm. The hole is filled with concrete to a height of 15cm above the ground with concrete mixed at a ratio 3:2:1 of sharp sand, gravel and cement. The pipe is also filled with the concrete and a nail is inserted at the center of the pipe indicating the station point.

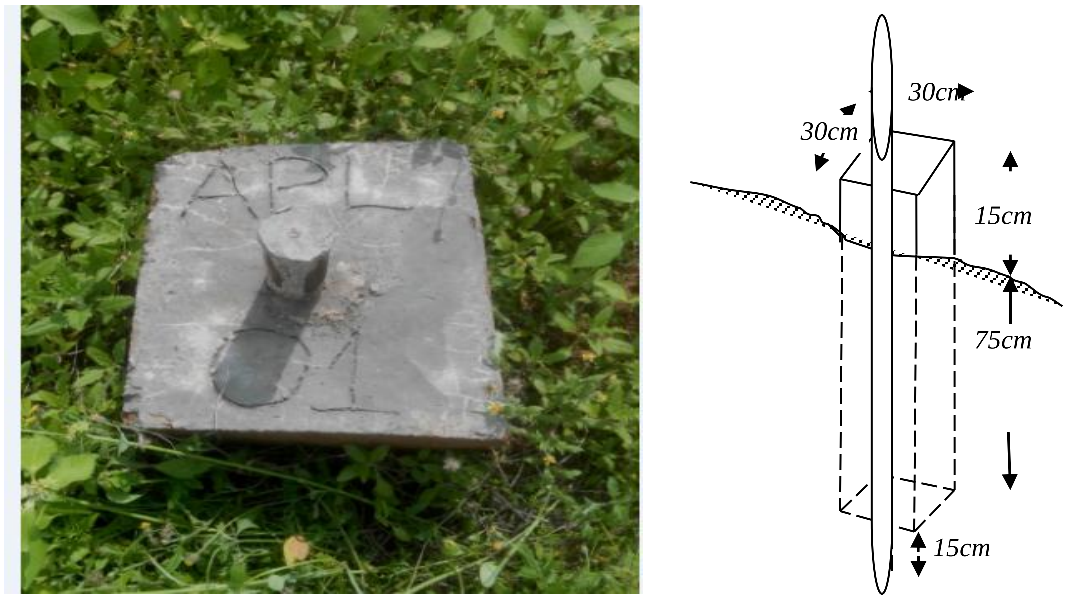

Figure1: Picture Showing Schematic Diagram with Dimension(not drawn to scale).

1.5.1 Data Acquisition

Data acquisition involved the following:

1. Acquisition of satellite imagery and attribute data acquisition.
2. Geometric or Locational data acquisition with Differential Global Positioning System (DGPS) and Total Station Equipment.

1.5.2 Data Acquisition from Satellite Imagery

This involves the following:-

i. Extraction of the satellite imagery of the study area.
ii. Geo-referencing and digitizing of map features.
iii. Attribute data acquisition.

1.5.3 Acquisitionof Imagery of Study Area

Ssatellite imagery of the study area should be extracted in portionsin such a way that all the portions should have a common overlapping area. The below sample of satellite imagery was obtained through Google Earth. From the google earth the landmark features that are closer to the route were fixed and every other prominent features such as highwaya, access roads, rivers and streams were also fixed on google earth. The extracted images were saved in a folder in Local Disk C (c/:) of the computer system in a JPEG file format, for digitizing. Figure 2, 3 and 4. shows the extracted portions of the imagery.

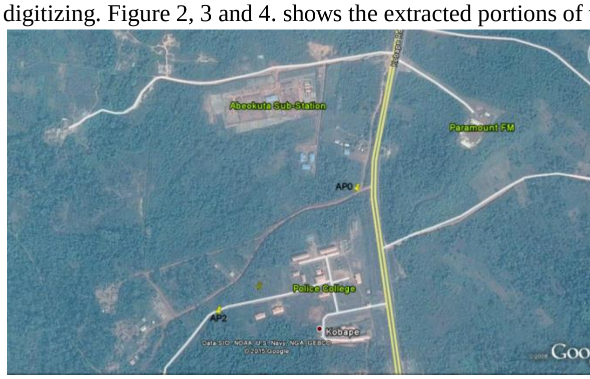

Figure 2: Slide 1 of the Satelite imagery showing some prominent features and AP0 to AP2

Figure3: Slide 2 of the Satelite Imagery showing AP2 to AP3

Figure 4: Slide 3 of the Satelite Imagery showing AP3 to AP4

The following are the metadata of the imagery:

i. Purpose of Procurement: 132kV/dc Transmission lines route planning
ii. Scene dimension: 2km by 5km
iii. Pixel size (resolution): 950m
iv. Latitude and longitude of the area: It lies between latitude 786’ 6.84” and 7817’ 12.84” and longitude 3823’ 36.24” and 3820’ 22.56”.
v. Digitizing method: Screen Mode
vi. Digitizing technique: On-screen
vii. Method of Geospatial data acquisition: Land Surveying and GIS method using GPS and ArcGIS 9.3.

1.6 Geo-Referencing

Georeferencing is the process of assigning the real-world coordinates to each pixel of imagery. The coordinates are usually acquired by ground truthing with GNNS tools on few features that are easily identify in the image or map. The georeferencing is done using prominent features on imagery that can be easily identified on ground to enable obtain the feature’s coordinates through ground truthing using GPS or Total station.The accuracy of the project depends on the accuracy of the geo-referencing. The aim of geo-referencing is to convert non-spatial imagery into spatial Rasta data for multipurpose use

Therefore, the georeferencing of the sample was done using three ground controls that were easily identified on the imagery.

The three controls used are ATCS 16S, APL 2 and APL 7. The under listed are the steps followed to geo-reference the downloaded imagery:

Step 1: ArcGIS was launched, ArcCatalog was selected on the toolbox and the file [satellite imagery] directory was located on a folder in Local Disk (C :) and selected.

Step 2: The imageto be geo-referenced was projected to UTM Zone 31N where the study area is located in the co-ordinates system.

Step 3: The image was loaded on ArcGIS; geo-referencing tool was clicked on the toolbox and ‘AUTO ADJUST’ was selected. The image was zoomed to layer and the X & Y co-ordinates of the three [3] known points were added one after the other using the ‘ADD CO-ORD’ tool.

Step 4: Geo-referencing tool was clicked and ‘UPDATE GEO-REFERENCING’was selected to update the geo-referencing process.

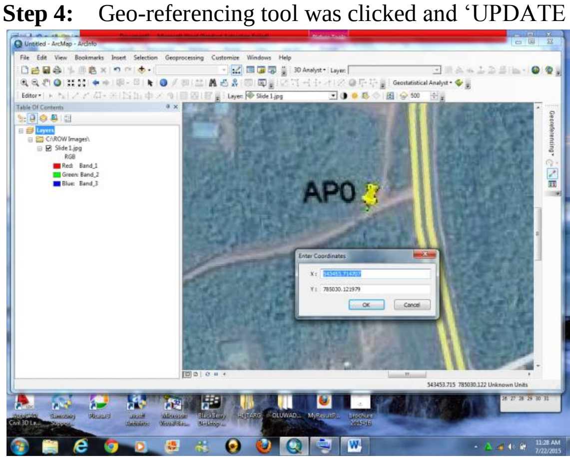

Figure 5: Geo-referencing using ArcGIS 9.3 Software

1.7 Digitizing of Map Features

Digitization is the process of converting information into a computer readable format (refer to as digital format). The prominent features such as access roads, rivers and streams are extracted from the imagery should be digitized and features such as buildings are directly capture through ground truthing with instrument of high precision.

1.8 Attribute Data Acquisition

Attribute data are simply observed facts about objects in space. For the purpose of the right of way survey, names of roads, villages, riversand so on,should be acquired.

1.8.1 Data Acquisition using DGPSand Total Station

DGPS (Differential Global Position System) and Total Station are usually employed for data acquisition. The following steps should be undertaken in the course of observations.in the right of way survey.

1. GPS observation for control establishment.
2. Traversing, detailing and setting out of Tower points with its directional pegs.

The observational procedure for the field observations commences with the establishment of three-dimensional coordinatesusing DGPS. The traversing, detailing and setting out of the Tower Center Points are preferable establish with Total station instrument. The setting-out of points are later re-coordinated to check the accuracy of the work at every point

Table 7: Specifications for GPS Data Collection

S/NO.	SPECIFICATIONS	STANDARD
1	Spatial accuracy standard	5mm + 2ppm
2	Maximum PDOP (Position Dilution of Precision)	5
3	Minimum mask angle	15^0
4	Minimum number of satellites	5
5	Number of independent antenna measurement	2
6	Maximum centering error	3mm
7	Maximum height error	5mm
8	Mode of observation	Differential
9	Repeated station observation	2
10	Independent Plumb line centering	Yes
11	Period of time of observation at a station for second order control	Not less than 30minutes

Table 8: Specifications for the Total Station (Leica Tc 407) data Collections

S/NO.	SPECIFICATIONS	STANDARD
1	Contrast	50%
2	Tilt correction	2 axis
3	Horizontal correction	On
4	HZ	Left
5	Vertical setting	Zenith
6	Face/Deft	V- setting
7	Language	English
8	Angle unit	0 ' "
9	Min reading	1"
10	Dist. Unit	Meter
11	Dist. Decimal	3
12	Temp. unit	0C
13	Pressure unit	Hpa
14	Grad unit	v:h
15	Data output	Internal memory

1.9 GPS Field Procedure for Control Establishment.

With reference to the sample above, the Base receiver was set up on control pillar ATCS 5S, centred and levelled accordingly. The mode of operation is set to static survey. The rovers were set on other controls with necessary informationkeyed in such as point Identification, Antenna height, mask angle, record interval, and track times at each receiver's station. The receivers were activated to track satellites for simultaneous data collection or receiving ephemeris data (satellite orbital information) for a minimum of preset observation time of 30 minutes. This duration ofobservation is based on the baselength of the two receivers (since the longer the baseline, the longer the observation time and vice versa.) This duration is also suitable for the ambiguity resolution of the GPS. At the expiration of the preset observation time of 30minutes, the rovers are stopped from collecting data. The data already collected are stored in the internal memory of the receivers. The roving unit is taken in turn to other station respectively for data collection following the same procedure until all the points are occupied and coordinated. The GPS master receiver maintained its original position throughout the period of the observation since the baseline was within the maximum GPS coverage length (20 kilometres). It is ensured that the correct antenna height reading is keyed in and the Geometric Dilution of Precision (GDOP), a function of the satellite vector (arrangement) must be good throughout the observations so as to obtain a reliable point positioning. The data should be downloaded and processed before the commencement of the traversing.

2.0 Setting Out of Tower Center Points and Offsets Points

To commence a setting out operation there must be a setting out data. The setting out data are obtained from the plan and profile design which resulted from the preliminary survey undergone earlier.. Setting out of points are carried out with the use of Total Station using setting out program.. The program computes the horizontal distance, elevation and the bearing to the setout points using coordinates keyed in manually or stored in the Total station memory. The coordinates of point of interest ot be set out are manually typed or uploaded into the Total Station through the computer using GNNS software. The coordinates should be arranged in the order that suit the file format of the Total station. Leica Tc407 is used as example and therefore data uploaded are arranged as follows: Point Id, Easting, Northing and elevation through the Coordinates Editor in Leica Geo Office Tools and thereafter, saved in index format.

The following procedures should be followed in setting out of the Tower points using Leica Tc407:

a. The instrument should be set on a coordinated points (e.g. APL2), switched on to carry out all temporary adjustment.
b. PROG button is pressed and SETTING OUT is selected from the Program list while the following settings are carried out.
   i. JOB – TOWER SPOTTING is entered
   ii. OPERATOR –Emesom
   iii. DATE and TIME the Job was created will automatically be registered by the instrument.
   iv. SET is selected by pressing Enter button.
c. Under SET STATION, Station Id of the occupied station (e.g. APL2) is keyed into the Total Station. The instrument automatically recall the uploaded coordinates of the point or ask for the information (if not found in the instrument's memory) to be provided manually.
d. Height of Instrument was measured from the trunion axis of the instrument to the tip of the nail on the pillar and input into the instrument.
e. Enter button is pressed on SET to save.
f. The reflector at the back station of a known station (APL3) is bisected.
g. SET ORIENTATION is activated, and orientation by COORD is selected. The backsight point Id (APL3) is keyed in and the instrument automatically recalled the uploaded coordinate of the orientation point displaying the backsight bearing.

2.1 Precaution

Ensure that enter button is pressed when the horizontal cross hair accurately bisects the lower part of the tracking pole and transit to the reflector vertically held at the back sight station point.

i. Enter button is pressed on START to begin Setting Out operation
ii. From the 2D Set out screen, Pt ID – point of interest is inputted. The instrument recalls the information as regards the station if stored in its memory or ask for the data if not found in the memory.
iii. The Total station automatically calculates the bearing and distance from the set-station to the point to be set out.
iv. The tracking pole is aligned in the direction the Total station points as it reads 00^0 00' 00" of the bearing.
v. Points are set out when the distance and bearing to the point data inputted reads 0.000m and 00^0 00' 00" respectively.

The pegging pegging of the set out location is usually done with a quarter inch pipe of 70cm length, paint with yellow colour with 40cm driven to the ground. The pipe is filled with concrete. Every Tower Pegs is embedded with the company name, tower number and tower type. The Right of Way (ROW) of 15m from the center line should also be establish using concrete pillars.

Figure 6: The Pegging of a Tower Center Point and its Offset Points

In areas where a tower point cannot be access directly from the last peg due to big trees or buildings, altermative peg should be introduce in a position good enough to access the tower points.

2.2 Traversing and Detailing

The Tower points and the Right of way beacons should be captured using a precise instrument such as total. In the sample given, Leica TC 407 Total Station was used to capture the locational data (x,y,z) of the buildings and other permanent features along the right of way.

Subsidiary traverse stations are created to capture details that cannot be access perhaps due to long distance from instrument station or obstacle on the line of collimation. The purpose of capturing the locational data of the set-out tower points is to check the positioning accuracy by comparing the set-out data generated from design with the As-built data. The fixed hard, soft and overhead details comprise of the roads, buildings, vegetation, power lines and other constructed features such as road intersection, are observed from control network extended to the study area by geometrically coordinating their edges or center as the case may be.

The instrument should be setup at an established coordinated station where details to be captured are considerably visible and orienting to another reliable coordinated station. Thereafter, all necessary temporary adjustment has been carried-out, observations are made to the edges of the buildings, the two sides of the roads and other features of interest which are visible from the instrument station. The acquired data are usually stored in the internal memory of the total station. The features are label with different alphabets which served as their identifiers during data processing.

2.3 Attribute Data Acquisition

Oral interviews should be used in acquisition of attribute data of the various features that its description is unknown. Questions should be asked from people available so that a detailed information about the terrain is obtained. This is essential and informative for proper description of observed entity.

2.3.1 Data Downloading and Processing

This involves various computations and methods in which useful information that can aid decision making which are derived from the data acquired.

2.3.2 Data Downloading and Storage

The data stored in the internal memory of total station are downloaded from total station through Leica Geo-Office Software. The instrument downloading cable (an accessory accompanying the total station) is connected from the total station to the computer. "Leica Survey Office" (Leica downloading software) short cut on the computer's screen should be double checked and which will display a dialogue box. In the dialogue box, Data Exchange Manager is clicked on the computer with automatically recognize the instrument by putting it on and depicting the jobs contained in the total station folder. The job name (when observed data are stored) is selected, two files with be displayed namely fixed points and measurements point. Measurement points stands for stored data in the field observation while the fixed points are data typed manually or uploaded from computer into the internal memory of the total station. The measurement point should be highlighted and copied and paste into the local disk 'C' at right side of the window. The data will automatically download at the pasting of copied selected items. It should be save with file extension 'IDX' into the computer 'C' drive. The computer will return to the dialogue box and 'coordinate data editor' is now clicked. The saved file downloaded should be locatedto be open and data are copy into MS-excel file. From the MS-excel the data are process and save to format that will be recognize by the drafting software or draft man. The data in this case should be save as CSV (comma delimited) or PRN as preparation for further use in AutoCad application.

2.4 Conclusion

Having x-rayed the important of this paper and the under-laying principles of engineering surveys of electric power lines in electrical power systems as a critical aspect of electrical power design and development when carrying-out electrical power systems construction for a particular location or area.It is imperative to note that engineering surveys in the area of electric power lines is of a great importance in locating the optimal route profile for the network. The transmission and distribution systems are very important to an electrical utility because its optimal routing minimize power losses in the network. Hence, accurate line surveying in electrical power systems is a key to designing and developing optimal electrical power network or overhauling existing once.

References

[1] **Akpojedje, F.O., Onogbotsere, M.E., Mormah, E. C and Onogbostere, P.E.** "AComprehensive Review of Nigeria Electric PowerTransmission Issues and Rural Electrification Challenges," International Journal of Engineering Trends and Technology (IJETT) – Volume 31 Number 1 - January 2016. pp. 1 – 9.

[2] **Akpojedje, F.O., Okakwu, I.K., Onogbotsere, M.E and Egedi-Idu, S.O.** "Reliability Estimation of Injection Power Stations Based on Outages Scheduling in Nigeria Power System," Journal of the Nigerian Association of Mathematical Physics, Vol. 28, No. 2, November 2014. pp. 405 – 414.

[3] **Akpojedje, F.O., Abu, Y.O and Onogbotsere, M.E.** "Parametric Modeling of Undervoltage and Its Impact on Nigerian Electric Power Distribution Network: A case Study," Journal of Multidisciplinary Engineering Science and Technology (JMEST), Vol. 4, Issue 1, January 2017. pp. 6434 – 6441.

[4] **Akpojedje, F.O.** "Causes and Modeling of Power Losses on Electric Power Distributors and Its Effects on Household Appliances in the Nigerian Power Distribution Network," IJISET-International Journal of Innovative Science, Engineering & Technology, Vol. 4, Issue 6, June 2017. pp. 281 – 290.

[5] **Ahmed, W and Hafeez, K.** "A Right of Way Management of Electric Power Line using Global Positioning System and Spot-5 Satellite Image," Journal of Space Technology, Vol.1, No. 1, July 2012. pp. 23 – 27.

[6] www.asce.org/engineering Surveying. Accessed on the 6th of June, 2018. Time: 1:11pm

[7] **NAVEDTRA**"Engineering and Land Surveys," Retrieved from https://www.nap.edu/read/2227/chapter/4 on the 6th of June, 2018. Time: 1:30pm

[8] Route Survey, accessed on rapidsurveying.net/route-surveyss.php, date: 6th of June, 2018. Time:1:33pm.

[9] **The Free Encyclopedia.** Undergrounding, accessed onhttps://en.wikipedia.org/wiki/Undergrounding , 7th July, 2018. Time 12:07pm.

[10] **HKIUS-UTMS**, "Method Statement for Utility Mapping by Non-Destructive Method," Publishedby Utility Training Institute (UTI), April 2011. pp. 1 – 29.