Towards the Optimal Use of Telecommunication Mast Locations as a Platform for Survey Control Densification in Rivers State of Nigeria

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ABSTRACT

In the past, survey controls were established in major towns and cities which were used for cadastral and engineering surveys. In the light of the need for increased survey controls, most of the major towns and cities have expanded beyond the boundaries that existed at the time of control establishment. This is more critical as the extension of survey controls to the new areas has not kept pace with the rate of expansion in the study area. Moreover, the current survey controls are neither comprehensive nor adequate. This paper seeks to bring to the fore the option of optimal utilization of existing telecommunication mast locations as platform for survey control densification in Rivers State of Nigeria. This research adopted the mapping of the telecommunication mast location and producing a thematic map in addition to the attribute information of these facilities. The Map76Cs handheld GPS receiver and the ArcGIS 10.1 Software were used in data acquisition and analyses. The study obtained the coordinates of 251 telecommunication mast locations in Port Harcourt, Obio Akpor and 34 in Bori all in Rivers State. The coordinates of existing control stations as established by various agencies were obtained for analysis. The result of the buffering operation of 2km and 5km radius revealed a ratio of 1:19 (5%) and 8:28 (28.6%) for Rumukwurushi and East-West road axis of the study area respectively in terms of existing control stations and telecommunication mast locations. Besides, the nearest distance of control station to telecommunication mast is 240 meters and the farthest is 1.9km in Rumukwurushi axis. Similarly, the nearest distance of control station to telecommunication mast is 1.2km and the farthest is 4.3km along the East-West Road axis The use of these mast location that are spread all over the study area will reduce the challenge of identifying suitable location for citing higher order survey controls. Also, the removal and destruction of existing controls due to construction activities will be highly minimized considering their secured position. It will further enhance survey control network planning for the urban areas thereby providing quick information regarding proximity of available control points. These spatial information will therefore provide the necessary platform to locate a monument or any permanent mark of which their coordinates will be accurately determined to serve as survey controls for cadastral and engineering surveys.

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1.0 INTRODUCTION

A fixed (control) point is a surveyed point with known coordinates and/or height which is permanently marked by means of a stone monument or a bolt (sometimes covered by a manhole). These fixed control points form the basis for all spatially referenced data. Control points are reference stations that are also used to determine the coordinates of new points based on the reference point network. The reference of the position is one of the most basic infrastructure of human activities such as official cadastral survey data, public works, national topographic mapping, construction, navigation, utilities' asset registers and mapping, geographical information system (GIS) data, building zoning plans, engineering surveys, etc. The unique networks of control points provides veritable platform for precise referencing in all spatial related activities. They are also essential as a reference framework for giving locations of data entered into Land Information System (LISs) and Geographical Information System (GIS) (Ghilani & Wolf, 2008). There are two general types of fixed points: planimetric and vertical control points. The planimetric fixed points are generally based on geodetic latitude and longitude for very large areas. The corresponding plane rectangular coordinates may be computed directly without obtaining geodetic latitude and longitude, this is applicable in smaller areas.

Geospatial Scientist and allied professionals depend on accurate control points for their work. Geodetic and control surveying are of the most demanding applications for precision. The cost to perform regular geodetic control surveys has increased, and surveyors have begun to rely more heavily on GNSS solutions for surveying to optimize their field work and reduce the necessity to re-survey the ground marks. Positions on the ground are measured in longitude, latitude, and height on the chosen ellipsoid. For convenience to measure the three dimensional values, a lot of monuments whose coordinates are known are settled as reference point all over the study area. Elevations are expressed as distances above or below a vertical datum such as mean sea level, or an ellipsoid such as Clarke 1880, GRS 80 or WGS 84, or a geoid (in the case of classical techniques). Doyle (1994) points out that horizontal and vertical reference systems coincide by less than ten percent. This is because horizontal stations were often located on high mountains or hilltops to decrease the need to construct observation towers usually required to provide line-of-sight for triangulation, traverse and trilateration measurements. Vertical control points however, were established by the technique of spirit leveling which is more suited to being conducted along gradual slopes such as roads and railways that seldom scale mountain tops (Doyle, 2002, p. 1).

1.1 Statement of the Problem

A good number of survey controls were established in urban and semi urban locations of Rivers State. However, with development and expansion of these areas, establishment of controls are not at par with the corresponding rate of urban growth. Also, the density of controls in our study area (Port Harcourt, Rivers State) is not adequate in the light of numerous mapping and construction activities. In addition, survey controls (planimetric and vertical points) were established along the arterial access roads towards the urban centers. Due to the conversion of these roads to multi-lane carriageways most of the controls (permanent marks) were destroyed as they were replaced with utility lines and features. Furthermore, when the control points were established, the configuration were in groups of intervisible three (3) points, which some may have lost their relevance in new surveys orientation.

From the forgoing, the need to provide and densify accurate survey control stations in the study area underscore the usefulness of telecommunication mast locations that are cited throughout the area. Furthermore, the advocacy for the use of these existing mast locations will minimize the cost and inconvenience of erecting survey monuments. In addition, they are visible, accessible and stable which are essential basis for selecting a location for the establishment of control stations.

1.2 Aim of the Study

This paper aims to highlight the need for the optimal utilization of telecommunication mast locations as platform for survey control densification in Rivers State of Nigeria.

1.3 Field Procedure for Survey Control Establishment and Network Costs

A typical procedure in horizontal control surveys involves the classical methods of triangulation, precise traversing and trilateration and/or a combination of these methods depending on the accuracy and configuration of the area. Also, appropriate celestial observations can be made to determine latitudes and longitude of stations. The use of Global Positioning System (GPS) has further provided increased frequency in horizontal control densification especially as it relates to very large areas. Nonetheless, the ease of usage, speed and high accuracy capability of GPS for very long distances underscore its advantage. This is besides adoption of rigorous photogrammetric and remote sensing techniques. In this same vein, vertical control surveys provides elevations for a network of reference permanent marks referred to as benchmarks. They are established by differential levelling or trigonometrical levelling depending on the accuracy required.

The cost of execution of a particular horizontal network design is an extremely complex problem. Equipment cost and depreciation, field procedures, labour, transportation, communication, support, and administrative cost all contribute to the final cost of a particular network design. As a result of the complexity of the economics, examination of some crude approximations to this problem is instructive.

The standard for the establishment of horizontal control stations are based upon the distance relative accuracy between directly connected adjacent points. In the current situation, accuracy requirements for a horizontal control network locations are established in response to geospatial user needs. The spatial location of the horizontal controls is a reflection of user requirements.

Fig 1.0: Specimen of a Typical Monuments as Survey Control Point RVOSG X1 (Source: Rivers State Office of the Surveyor General)

1.4 Study Area

The study area covers the entire Port Harcourt and Obio Akpor Local Government Areas popularly referred to as Port Harcourt City. The Port Harcourt City is situated between Latitudes $4°30'$ north and $4°45'$ north and Longitudes $7^{\circ}00'$ east and $7^{\circ}15'$ east. The Study area is approximately four hundred and seventy square kilometers 470.00sq km, (Okoye, 1975). According to the National Population Commission 2006 census, the population of the study area (i.e. Port Harcourt and Obio Akpor Local Government Area) is 1,000,908 persons.

Fig. 1.1 Map of Rivers State Showing Study Area (Source: Rivers State Office of the Surveyor General)

Table 1.0: Survey Controls by Shell Petroleum Development Company (SPDC) (WGS84 Curvilinear Coordinates)

S/No	Station	WGS84(ITRF93) Ellipsoid		Ellipsoidal Height h(m)
		Latitude	Longitude	
		d m s	d m s	
1.	ZVS 3003	04 50 52.703	07 02 52.158	37.783
2.	OBIGBO	04 53 27.527	07 07 26.646	48.272
3.	AGBADA	04 55 54.848	07 01 13.202	41.715
4.	IMO-RIVER	04 58 55.036	07 11 11.662	42.317

Table 1.1: A Specimen of Survey Controls Established By Greater Port Harcourt Development Authority (Source: GPHDA)

Station Name	Easting (meters)	Northing (meters)
GPS 001	504542.265	115038.4
GPS 002	504830.214	109493.3
GPS 003	498661.535	108710.3
GPS 004	498807.887	107726.9
GPS 005	499754.335	109485.5
GPS 006	498736.39	108238.6
GPS 007	498760.853	107303.7
GPS 008	498605.016	105938
GPS 009	498348.683	105815.3
GPS 010	498038.123	105686.7
GPS 011	500777.12	108360.6
GPS 012	500937.42	108205.8

1.5 Review of Status of Survey Control Stations in Rivers State

The colonial administration established survey controls in all the major towns and district headquarters of the old River State. These towns and cities include but not limited to the following: Degema, Bori, Ahoada, Port Harcourt, Isiokpo, Bonny, etc. these controls are based on local origin for the location. Each of these towns/cities are independent of each other with respect to their coordinate system. To this end, the control stations are confined to the location, which makes trans-city surveys not possible. In addition, the integration of mapping activities and data across the various towns in Rivers State was quite difficult as these survey stations are not referenced to national and/or global coordinate reference system. Though many cadastral and engineering surveys were done based on this local origin survey stations, their physical position cannot be located.

Recently, some International Oil Companies established second order survey controls around their onshore facilities for their use in mapping and positioning as shown in table 1.0 (Fubara, 1995). The procedure of establishment and the accuracy of these stations are not stated. However, their coordinates are used by surveyors carrying out geospatial operations within their vicinity.

In the same vein, table 1.1 shows a sample of GPS control stations established by the Greater Port Harcourt Development Authority, Rivers State within the study area. The authority established a total of sixty three (63) control stations. These stations are proximally located with no location attribute as there are few stations in the center of the study area.

1.6 GSM Telecommunication Mast

Typical telecommunication mast tower consists of a body structure of steel beams and materials with a concrete base of an approximate height of between 25 and 55meters. Antennae, transmitters and receivers are mounted on the body of the structure. These antennae receive high frequency radio waves from cell phones. The ranges of these antennas vary from distances as short as 1.5 to 2.4km to distances as long as 48 to 56km. A power source is provided with other accessories, all fenced either by block wall or steel poles and wire depending on the service providers. The area covered by each mast location is approximately 144m^2 (12m x 12m) (Hart, L. et.al 2012).

The authors obtained the spatial and attribute data of these telecommunication mast location using Garmin 76s handheld GPS receiver. A total of 251 mast locations were identified (table 1.2). This number has increased due to network expansion and construction of mast locations by telecommunication service providers. Tables 1.3 to 1.6 shows samples of various telecommunication mast locations as developed by different service providers. However, their structural attributes are similar in terms of size and infrastructure.

Fig 1.2: A Typical GSM Telecommunication Mast Facility (Source: Hart L. & Jackson K.P, 2006)

Table 1.2: The Breakdown of Service Providers in Port Harcourt (Source: Hart, L. & Jackson, K.P, 2006)

S/N	SERVICE PROVIDERS	NUMBER OF CELL MAST
1	MTN	125
2	GLOBACOM	48
3	AIRTEL	40
4	MOBITEX	1
5	M-TEL	4
6	REITEL	6
7	STARCOMMS	10
8	BOURDEX	3
9	NITEL	4
10	INTERCELLULAR	3
11	MOTOFONE	1
12	G.S. TELECOM	1
13	RADIORIVERS MAST	1
14	RHYTHM 93.7 MAST	1
15	SPDC MICROWAVE MAST	1
16	TELEPHONICS	1
17	TELECOM MAST	1
	TOTAL	251

Table 1.3: The Breakdown of Control Stations in Port Harcourt (Source: Hart, L. & Jackson, K.P, 2014)

S/N	**DESCRIPTION OF PROVIDERS**	**CONTROL STATIONS**
1	GPHDA	63
2	RSG OFFICE OF THE SURVEYOR GENERAL	15
3	SPDC	4
	TOTAL	82

Table 1.4: A Specimen of GLO Telecommunication Mast Location in Port Harcourt

S/N	**CELL-TYPE**	**EASTINGS(m)**	**NORTHINGS(m)**	**LOCATION**
1	GLO PR 001	504971.55	88940.545	2 AGUDAMA STREET, D/LINE
2	GLO PR 002	504097.391	87454.996	62 NSUKKA STREET, MILE 1 DIOBU
3	GLO PR 006	504382.027	92155.78	PEOPLES CLUB COMPOUND, RUMUOLA ROAD
4	GLO PR 014	507225.032	89580.753	APEX MILL LTD. TRANS AMADI INDUSTRIAL AREA
5	GLO PR 025	503014.371	92410.726	EJOVINA ESTATE, RUMUOKWUTA, MILE 5
6	GLO PR 034	501278.34	94654.151	By LINSOLOA EYE CLINIC, 180 NTA ROAD, MGBOUBA
7	GLO PR 036	501996.61	92038.215	RUMUPIRIKOM VILLAGE, OWABIE CLOSE
8	GLO PR 037	496872.068	89469.317	COLLEGE OF EDUCATION ROAD, RUMUOLEMENI
9	GLO PR003	505678.527	84989.028	NPA BY INDUSTRY ROAD, CONOIL FILLING

				STATION
10	GLO PR007	503020.163	88085.294	50 ABEL JUMBO STREET, DIOBU, PHC

Table 1.5: A Specimen of MTN Telecommunication Mast Location in Port Harcourt

S/N	CELL-TYPE	EASTINGS(m)	NORTHINGS(m)	LOCATION
1	MTN T 133	508867.676	93366.782	21122 OLD ABA ROAD, ARTILLERY, RUMIOGBA, PORT HARCOURT
2	MTN T 135	506350.236	84355.361	ST MARY'S CATHOLIC CHURCH BY LAGOS BUS STOP
3	MTN T 188	502756.96	88909.182	CHINDAH ESTATE, UST, PORT HARCOURT
4	MTN T 2151	507710.324	96781.025	RUMUDURU OROIGWE VILLAGE, ELIOHANI
5	MTN T 2165	510090.631	97199.784	BY KING PETROL STATION, ENEKA
6	MTN T 2218	507807.73	102404.375	ABOUT 20M AWAY FROM ASPHALT&CONST. LTD, ENEKA-IGWURUTA ROAD
7	MTN T 2222	503085.76	87368.752	23 DICK TIGER, STREET, DIOBU
8	MTN T 341	503971.878	87556.649	MILE ONE POLICE STATION
9	MTN T 344	504282.722	90447.959	157 KING PEREKULE STREET
10	MTN T2020	509557.044	94961.483	GOLF COURSE ESTATE

Table 1.6: A Specimen of REITEL & STARCOMS Telecommunication Mast Locations in Port Harcourt

S/N	CELL-TYPE	EASTINGS(m)	NORTHINGS(m)	LOCATION
1	REI TEL	504901.854	89198.746	14 CHOBA STREET, D/LINE
2	REI TEL	508473.599	93244.141	2 TEMPLE EJEKWU CLOSE 2ND ARTILLERY JUNCTION, RUMUOGBA, PH-ABA EXPRESS WAY
3	REI TEL	506524.6	84609.346	24 HOSPITAL ROAD, CLOSE TO STATION BUS STOP
4	REI TEL	493887.732	99419.273	4, WOKEMS STREET, CHOBA
5	REI TEL	507170.833	89313.608	79 GANI INT'L NIG. LTD, CLOSE TO UNION BANK (AREA BRANCH)
6	REI TEL	500376.193	108336.148	ALONG AIRPORT ROAD
7	RHYTHM 93.7 COM	505379.502	86084.536	10 FORCES AVENUE OLD GRA
8	SPDC MICROWAVE	511958.502	94880.775	PH-ABA EXPRESS WAY, BY GOMAN INT'L SEC. SCHOOL
9	STARCOMMS	504358.018	87413.873	27 IKWERRE ROAD MILE ONE, DIOBU
10	STARCOMMS	504953.678	89222.594	6 CHOBA STREET D/LINE

Table 1.7: A Specimen of AIRTEL Telecommunication Mast Location in Port Harcourt

S/N	CELL-TYPE	EASTINGS(m)	NORTHINGS(m)	LOCATION
1	AIRTEL PHC	507480.507	81973.387	PLOT 114 BOROKIRI, EXT. NEW LAYOUT OR NEW ROAD
2	AIRTEL PHC	507431.249	92590.229	RUMUOBIAKANI (NWOGU STREET) CLOSE TO SHELL I.A
3	AIRTEL PHC	497969.245	97521.845	SALVATION WAY BY PROPHECTIC DELIVERANCE CHURCH
4	AIRTEL PHC	505316.996	95514.489	OPP.ALO-ALUMINIUM EAST-WEST ROAD
5	AIRTEL PHC	509507.979	92781.117	OBADIAH AVENUE, WOJI TOWN
6	AIRTEL PHC 003	502929.979	89108.48	CHINDAH PETROL STATION BY UST ROUND ABOUT
7	AIRTEL PHC 006	509711.803	93849.718	ALONG PH-ABA EXPRESS WAY,BY RUMUIBEKWE JUNCTION
8	AIRTEL PHC 007	503130.93	92167.775	48/49 PIXY AVE., ORAZI NEW LAYOUT

9	AIRTEL PHC 008	505180.037	87041.591	FIRST BANK PREMISES FORCES AVENUE, OLD GRA
10	AIRTEL PHC 010	514000.53	90902.66	BEHIND AKPAJO PRIMARY SCHOOL, ALONG OLD REFINERY ROAD, AKPAJO-ELEME

1.7 Analysis and Discussion on Data

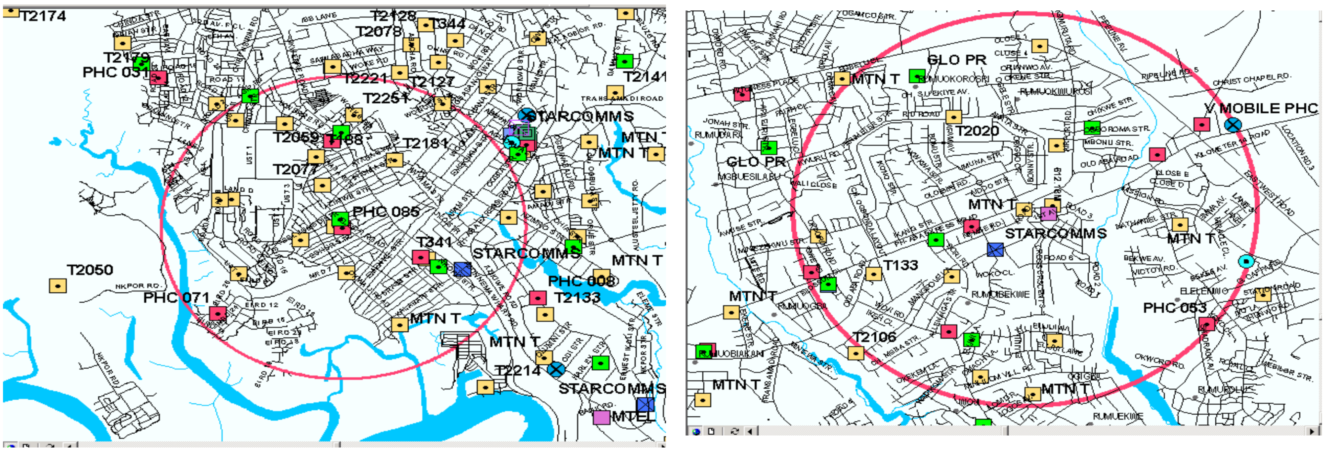

Fig.1.3: Buffering Analyses of Tower Sites in Rumukwurushi and Diobu Areas, Port Harcourt, Rivers State

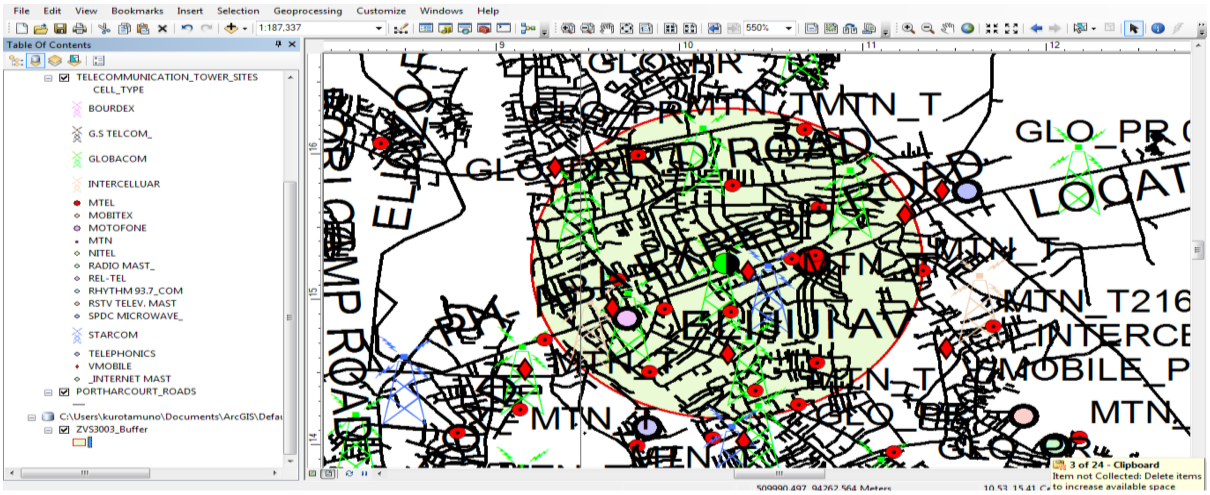

Fig.1.4: Buffering Analyses of Tower Sites and Control Stations in Rumukwurushi, Port Harcourt, Rivers State

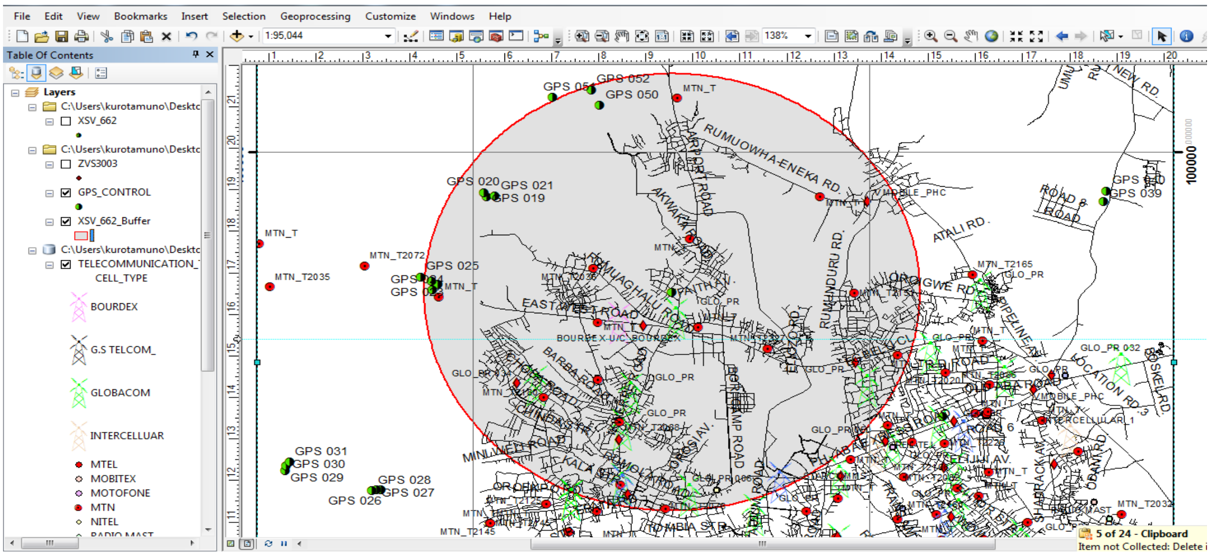

Fig.1.5: Buffering Analyses of Tower Sites and Control Stations in East-West Road, Port Harcourt, Rivers State

As shown in fig 1.3, the Rumukwurushi axis of the study area was buffered at a radius of 2km (2000 meters) circumference. It was discovered that a total of 28 mast locations were identified in the buffered area. The minimum distance within the buffered area between masts was 236.30meters and the maximum distance within the buffered area between sites was 3556.38meters. Similarly, a total of twenty four (24) mast locations were identified within the diobu buffered area.

In determining the relationship between the telecommunication mast locations and control station established in the study area. It was discovered that for a buffer area of Rumukwurushi of 2000 meters radius the result is as shown in table 1.8

Table 1.8: Results of Buffering Operation in Rumukwurushi Axis of Study Area

S/N	DESCRIPTION	REMARKS
1	NO. OF GPS CONTROL STATIONS	1
2	NO. OF TELECOMMUNICATION MAST LOCATION	19
3	NEAREST DISTANCE OF CONTROL STATION TO TELECOMMUNICATION MAST	240 Meters
4	FARTHEST DISTANCE OF CONTROL STATION TO TELECOMMUNICATION MAST	1920 Meters

The operation revealed 1:19 of survey controls to telecommunication mast representing approximately 5%.

Table 1.9: Results of Buffering Operation along East-West Road Axis of Study Area

S/N	DESCRIPTION	REMARKS
1	NO OF GPS CONTROL STATIONS	8
2	NO OF TELECOMMUNICATION MAST LOCATION	28
3	NEAREST DISTANCE OF CONTROL STATION TO TELECOMMUNICATION MAST	1.2 Km
4	FARTHEST DISTANCE OF CONTROL STATION TO TELECOMMUNICATION MAST	4.3 Km

Furthermore, as shown in table 1.9, the operation revealed 8:28 of survey controls to telecommunication mast representing approximately 28.5%.

Using the geographical query capabilities of the ArcGIS software processing tool, we can find all of the telecommunication mast, GPS Control stations located within the study area. In Figures 1.3, 1.4, 1.5 each zone is of a fixed radius and it is also possible to vary the extent of the buffer zones according to the characteristics of the objects around which they are drawn, or to create multiple buffer zones around map features.

1.8 Conclusion and Reconmendation

From the foregoing, the number of telecommunication mast location situated in the study area affords a large platform for survey controls as indicated in the aforementioned results. In view of the fact that several bodies including the government are making efforts to provide survey controls in the ever changing urban area (such as our study area) the pace of establishment is not at par with the ever increasing need for these controls. This therefore underscore the objective of this paper for the optimal use of Telecommunication mast locations as a platform for survey control densification in Rivers State of Nigeria. The telecommunication mast locations being built on a securely and firm ground in addition to its visibility and accessibility. These features are essential requirement for choosing a location for survey control point establishment. Also, the removal and destruction of existing controls due to construction activities will be highly minimized considering their secured position. It will further enhance survey control network planning for the urban areas thereby providing quick information regarding proximity of available control points. Considering that we also store the locational attribute of the mast locations in the GIS database we can use this information to guide prospective surveyors on the nearest telecommunication mast survey control station available in his operational area. Similarly, buffer zones are very useful tools for determining spatial proximity and whether or not features fall within critical distances of one another. They can be used to model many diverse problems from zones of equal distance or travel time from a starting point to the catchment areas of mobile communication masts.

To this end, we make the following recommendations:

- That all spatial and attribute information of telecommunication mast locations be determined for an updated database of the facilities.
- That the citing of the telecommunication mast must be preceeded by a proper location analysis by relevant stakeholders.
- That point marks within the mast locations be coordinated appropraitely using GNSS technology to provide values for these points.
- The coordinates determined in (3) above be published and made accessible to Geospatial users.

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