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Variation of Digital Terrestrial Television Signal with Altitude

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ABSTRACT: *This study investigates the variability in the values of DTTV signal strength with the altitudes of the study areas using two receiver antenna heights. The signal of a Digital Terrestrial Base Station (DTBBS) in Akure (Latitude 7°15'09''N and Longitude 5°07'53'' E) South West, Nigeria was measured at intervals of 1km along three selected radial routes around the base station for both dry and wet seasons using a Digital Satlink Signal Meter Model WS-6936 with a DTT UHF receiving antenna connected. A GPS receiver (Garmin Map 78s) was used to monitor the line of sight with the station as reference and was equally used to measure the geographic coordinates and the altitudes of data locations. The variability of the signal strength with distance and elevation was plotted and analyzed. Result showed that higher values of elevation of data points enhance Quality of Reception (QoR) in the study areas whereas low values degrade the QoR. Furthermore an average value of **0.53,** positive correlation coefficient was determined between elevation and Received Signal Strength (RSS) in this work. Ipso-facto, for subscribers to enjoy optimum Quality of Service in the study areas a minimum of 3.0m receiver antenna height is recommended for use especially at the macro cell (> 1km LoS) from the base station. This is because the use of higher receiving antenna height of 3.0m does not have a significant difference in results with that of 1.5m at the micro cell (0-1.0km) along the routes. Also, for those who are resident within the fringe coverage area of the station, 10km-17km away from the DTTBS their receiver antenna height should be raised up to 4m for them to have quality of service. The overall result is useful for DTTV transmission and reception in the study areas and other similar terrain in Nigeria.*

Keywords: *Digital Terrestrial Television, Variation, Altitude, Propagation and Signal Strength*

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I. INTRODUCTION

Over the years, terrestrial television broadcasting has been on the analogue transmission and reception technology until the last few years that Digital Terrestrial Television (DTT) technology was proposed by the International Telecommunications Union (ITU). This was due to the quest to maximize the UHF band by releasing the upper UHF for other services and still ensure access to quality of service. The medium of propagation for both analogue and digital terrestrial television is the troposphere, where most weather phenomena occur (Bothias, 1987; Kenedy and Bernard, 1992). It has therefore become necessary to carry out researches on digital terrestrial television transmission and reception with a view of improving the Quality of Service (QoS) on the DTT network in Nigeria. This study investigates the variability in the values of DTTV signal strength with the altitudes of the study areas and receiver antenna. The ultimate goal is to determine the enhancements and degradation of signal as a result of the elevation profile of the study areas and as well determine the suitable receiver antenna heights for optimum signal reception.

Study Areas and the Experimental Station

A Digital Terrestrial Broadcast Station (DTTBS) belonging to the NTA-Star Times in Akure, was used for the field work. Akure is the Capital City of Ondo State with about 800,000 people living within the metropolis comprising of Akure South and Akure North Local Council Areas. Table 1 indicates the details about the DTTBS.

Table 1.1: Transmission Characteristic of the experimental DTTBS Station

S/N	Parameter	Value /definition
1	Base station's location	Lat. 7^{0}15' 08" N, Long. 5^{0}07' 53" E
2	Base station transmitted power (kW)	2.40
3	Base station's frequency(MHz)/ Channel	722 / 52
5	Height of transmitting mast (m)	250
6	Height of transmitting antenna(m)	2.5
7	Transmitting antenna gain (dB)	1
8	Height of receiving antenna (m)	1.5, and 3.0 (Variable)

II. METHODOLOGY

Instrumentation

A digital Satlink WS-6936 model field strength meter was used for the DTT signal strength measurement by connecting the terrestrial input signal received by the Star Times DTT UHF receiving antenna attached to a variable antenna stand to it. Whereas a Global Positioning System receiver (GPS Map 78s personal navigator) was used for the measurement of elevation, geographic coordinates and the line of sight of the various data locations from the base station. A field vehicle was used for the field campaign. Figures 1a and 1b present the digital Satlink field strength meter and the GPS used in this work.

Fig. 1a: Digital Satlink WS-6936 model

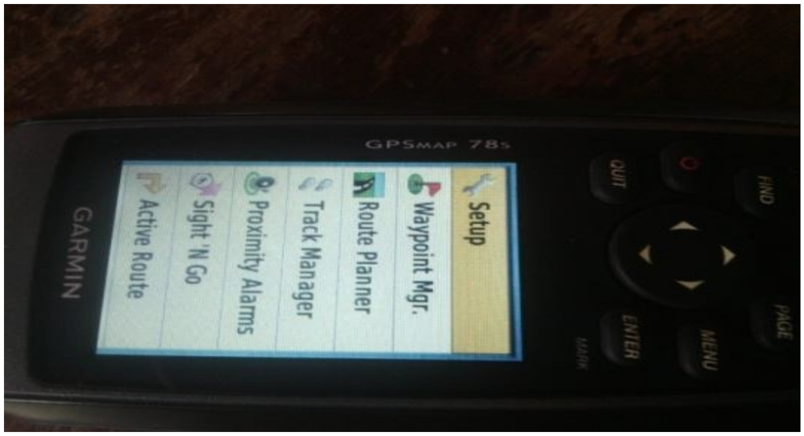

Fig. 1b: GPS Map 78s personal navigator

Data Collection

Measurement of the Signal Strength of the Digital Terrestrial Television Base Station, (DTBBS) in Oke Isikan Akure, was carried out radially from the base Station along three different routes in the State using a DTT UHF antenna connected to a digital Satlink WS-6936 signal meter. Two sets of data were obtained for the Signal Strength at two antenna receiver heights of 1.5m and 3.0m for each data location. This is to give room for comparison in the strength of signal received for the two heights. The station's transmitting antenna located at Oke Isikan, Akure was logged and used as the reference point by the GPS receiver for all the routes. The line of sight from the base station was monitored during the drive using the GPS, which equally measures the location's longitude, latitude, and the elevation. A field vehicle was used as a means of movement along the routes during the field work. The research crew usually stops at an interval of 1km LOS for measurement to be taken at each point of data collection. The exercise usually takes about 20minutes for each point before moving to another point usually 1km LOS. About sixteen data points were taken for each of the three radial routes around the transmitter. Detail of the routes categorization is as presented in Table 2.1. Data were collected for both dry and wet seasons for comparative studies in the study area. Transmission parameters of the (DTBBS) were relatively constant throughout the period of measurement as confirmed by the records of transmission in the station. Figures present

Table 2.1: Route definition for the field work

Route	Direction/ Definition
A	DTTBS in Akure towards Arakale-Oda Town (0-15km LOS)
B	DTTBS in Akure towards -Igoba- Ita Ogbolu (0-15 km LOS)
C	DTTBS in Akure towards – Ilaramokin - Igbara Oke (0-12km LOS)

III. RESULTS AND DISCUSSIONS

In this section, the variation of DTTV signal with elevation above sea level of data locations were analyzed using Mat lab and excel software. Also analyzed is the variation of the signal with the two receiver antenna heights (RxHt) of 1.5m and 3.0m along the routes of measurement for both dry and wet seasons of data collection. Observation on the influence of elevation of locations on the received DTTV signal strength during dry seasons Figures 2 and 3 depict the variation of the signal with altitudes of the study areas along route A during the dry seasons. It was observed that higher Signal Strength values were recorded for higher elevation values of location. At Lower elevation values of 340-350m, and line of sight of 2.0km and 2.5 km range, the signal received was between –55dBm and –60dBm for antenna height of 1.5m. Whereas, on the same line of sight range, signal strength values between –35dBm and –45dBm were recorded for the receiving antenna height of 3.0m. Secondly, the Received Signal Strength (RSS) was generally enhanced when higher receiving antenna height of 3.0m was used compared to the values of RSS recorded when receiving antenna height of 1.5m was used. This implies that for better signal quality, higher receiving antenna heights of not less than 3.0m are required for enhanced DTTV reception in the study areas. Whereas most Star Times customers in Akure make use of indoor antenna by placing it on the table or television set whose height can be less or equal to 1.5m. They must be encouraged to use outdoor antenna of about 3.0m to enjoy better quality of service.

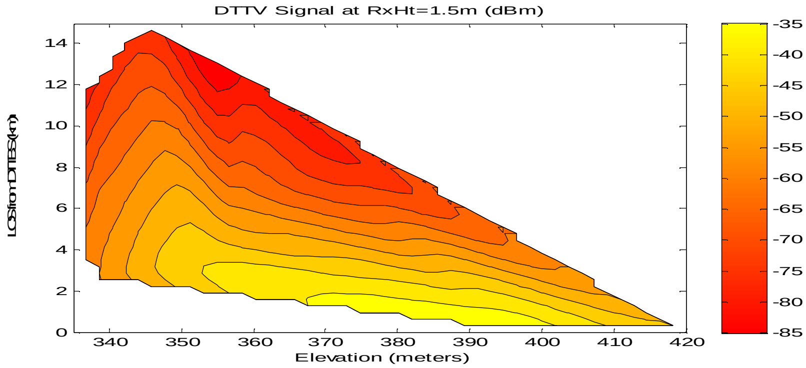

Fig.2: Relationship Between Elevation And Signal Strength Received At Receiving Antenna Height of 1.5m for Route A, during dry seasons

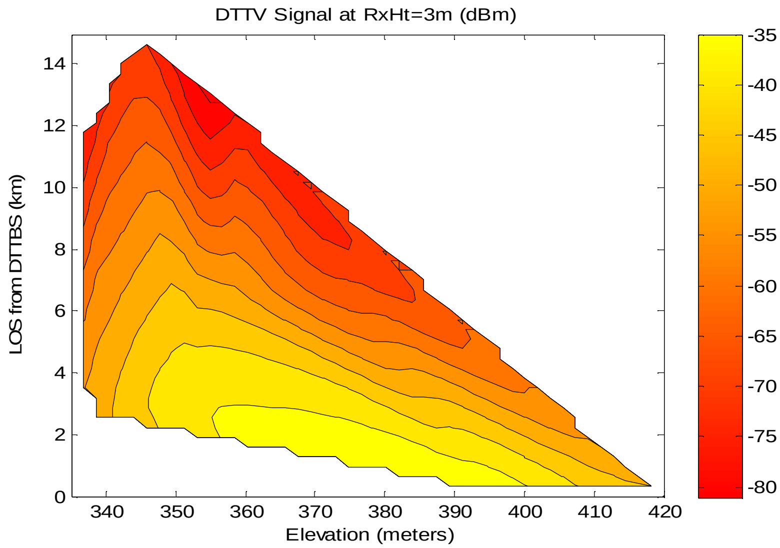

Fig.3: Relationship between elevation and signal strength received at receiving antenna height of 3.0m for Route A, during dry seasons

Also for route B during the dry seasons; It was observed from figures 3 and 4, that higher elevation values of location also enhance as it is the case for route A. Secondly, RSS was generally enhanced when higher receiving antenna height of 3.0m was used compared to the values of RSS recorded when receiving antenna height of 1.5m was used. This further confirms that better signal quality reception in the City of Akure, requires higher receiving antenna heights of not less than 3.0m.

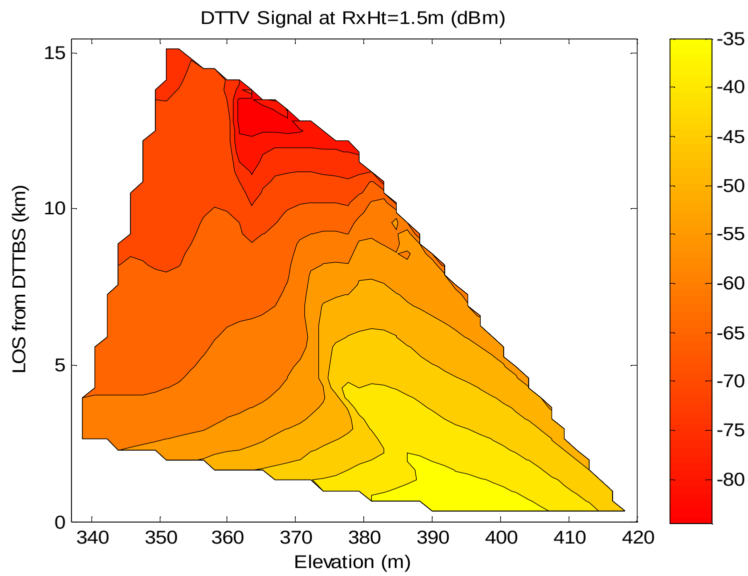

Fig. 4: Relationship between elevation and signal strength received at receiving antenna height of 1.5m for Route B during dry seasons

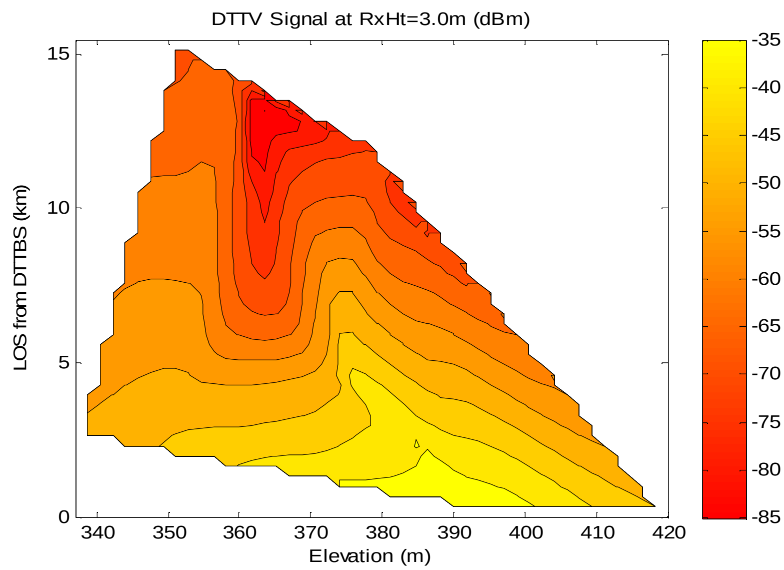

Fig. 5: Relationship between elevation and signal strength received at receiving antenna height of 3.0m for Route B during dry seasons

Observation on the influence of elevation of locations on DTTV signal strength during the Wet easons The signal strength variation for the rainy seasons was also analyzed. Figures 5 and 6 depict the signal's variation for antenna heights of 1.5m and 3.0m respectively for route A whereas figures 7 and 8 depict the signal's variation for antenna heights of 1.5m and 3.0m respectively for route B. As observed from figures 5 and 6, higher elevation values of location enhance RSS. At Lower elevation values, below 350m, and line of sight of 1km and 2 km range, the signal received was between –55dBm and –60dBm for antenna height of 1.5m. Whereas, on the same line of sight range, signal strength values between –50dBm and –55dBm were recorded for the receiving antenna height of 3.0m. This implies that for better signal quality, higher receiving antenna heights of not less than 3.0m are required in DTTV reception in the study areas.

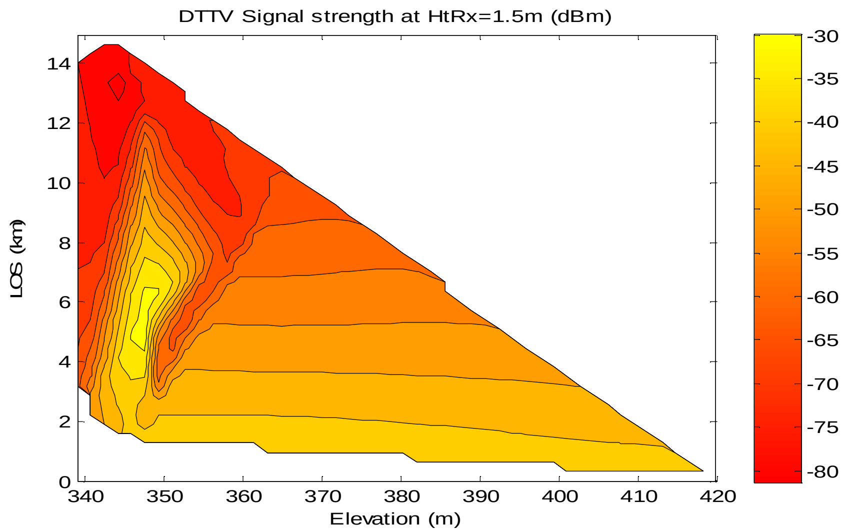

Fig 6: Relationship between Elevation and signal strength received at receiving antenna height of 1.5m for Route A during wet seasons

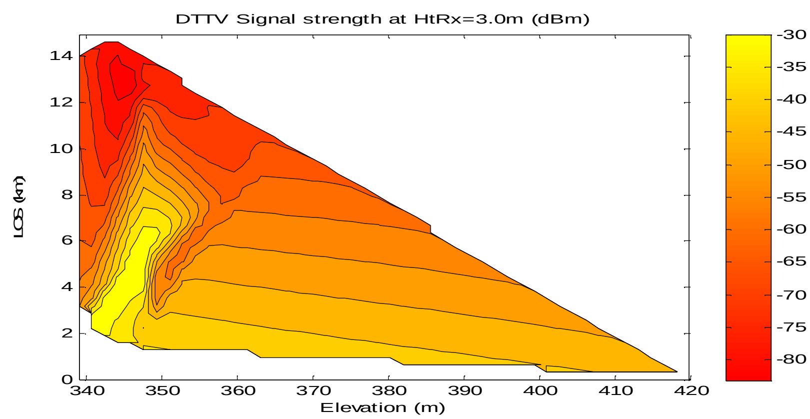

Fig 7: Relationship between Elevation and signal strength received at receiving antenna height of 3.0m for Route A during wet seasons

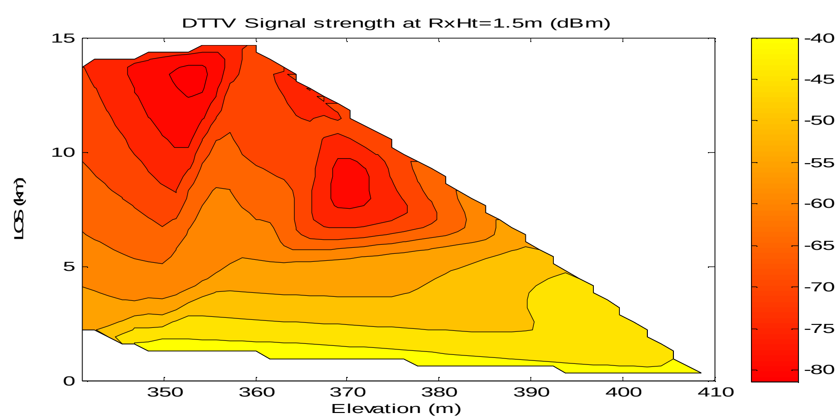

Fig. 8: Relationship between Elevation and signal strength received at receiving antenna height of 1.5m for Route B during wet seasons

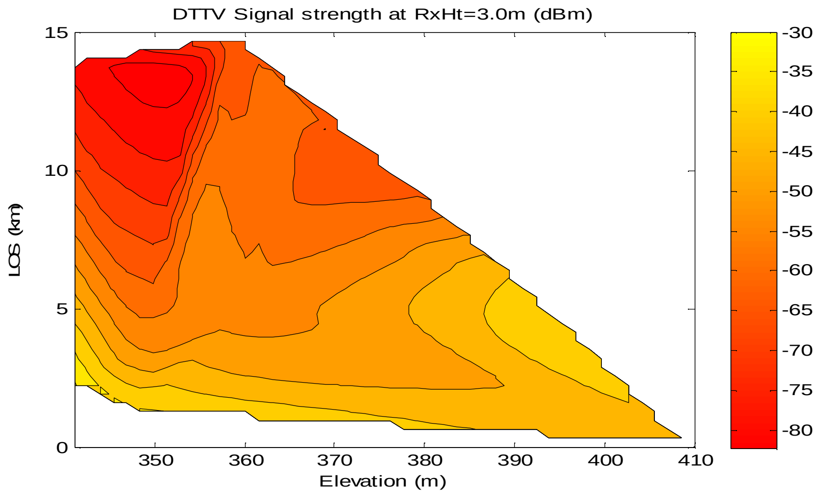

Fig. 9: Relationship between Elevation and signal strength received at receiving antenna height of 3.0m for Route B during wet seasons

Propagation Curves and Analysis along Routes of Measurement: Propagation Curve is the decay of signal strength with distance (Akinbolati, et al., 2016). The propagation curves for the DTTBS under study were plotted for the routes of measurement for both wet and dry seasons for the two receiving antenna heights of 1.5m and 3.0m. Figures 10 and 11 present the curves for route A and route B for the dry seasons respectively. It is observed that the signal reduces as distance increases, however the inversely proportional relation that is expected is not generalized due to the fact that there are some locations that recorded higher values than expected and vice versa. This can be connected with the positive or negative influence of the elevation and meteorological parameters of such locations. Another finding is that higher signal values were recorded while using the receiving antenna height of 3.0m compared to the values recorded while using antenna heights of 1.5m (this is due to reduction in multipath effects with the use of higher antenna). Other finding is that the use of higher receiving antenna height of 3.0m does not have a significant difference in results with that of 1.5m at the micro cell (0-1.0km) along the routes.

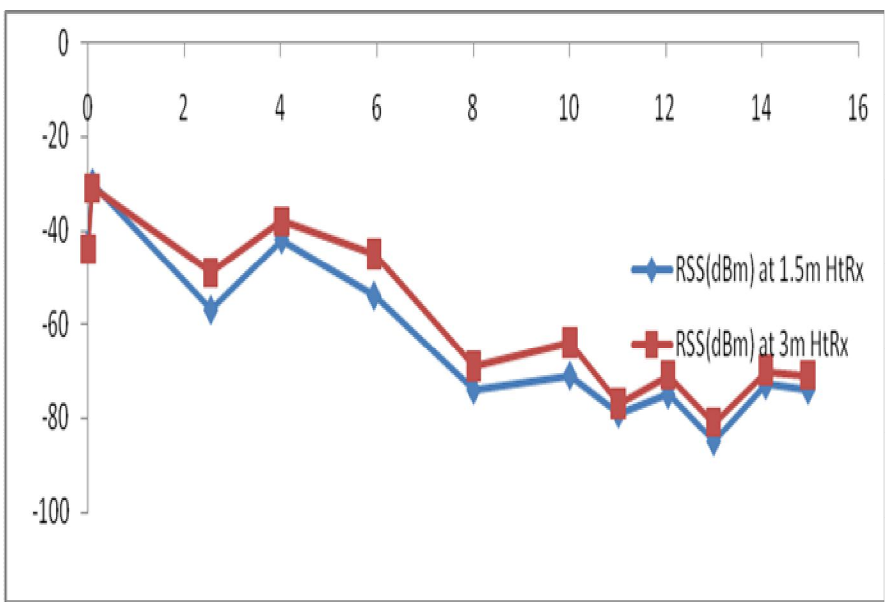

Fig.10: Propagation curves at various Heights of receiver antenna along RA during dry season in Akure

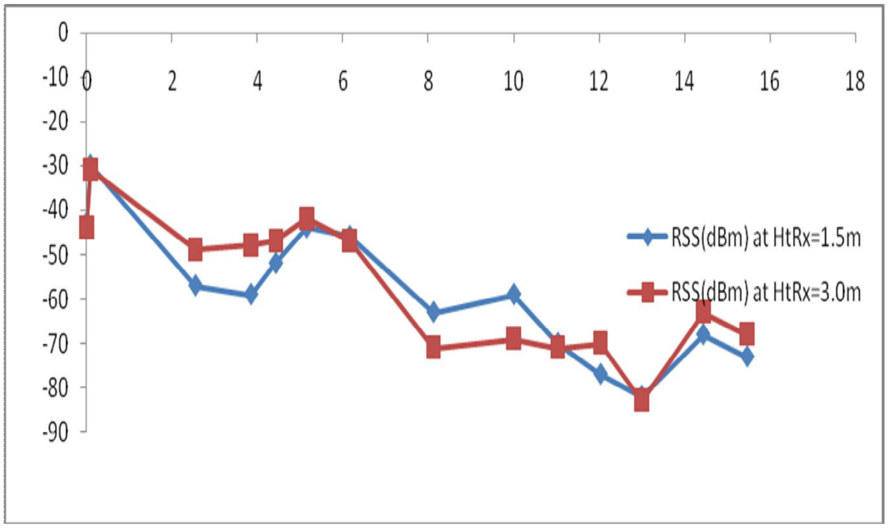

Fig. 11: Propagation curves at various Heights of receiver antenna along RB during dry season in Akure

For the rainy seasons propagation curves, (figures 12 and 13) the observations were the same for the dry seasons with few exceptions. It was observed that RSS recorded for receiving antenna height of 3.0m were more significant compared to the values recoded for the same height during dry seasons.

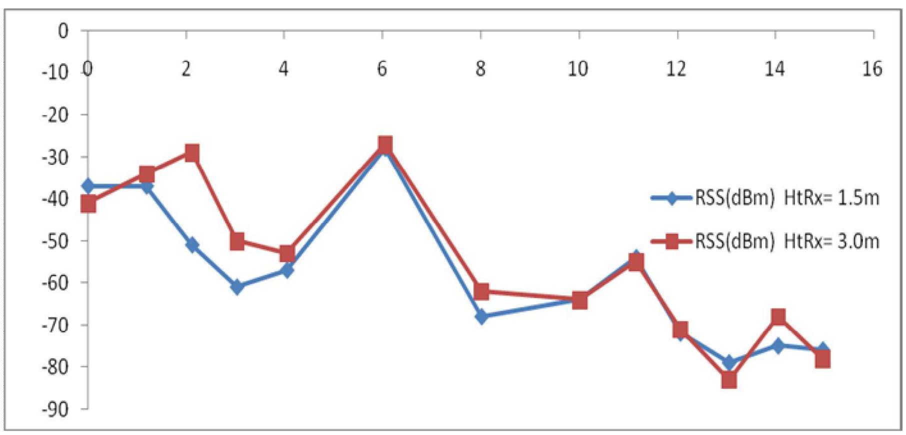

Fig. 12: Propagation curves at various Heights of receiver antenna along RA during raining season in Akure

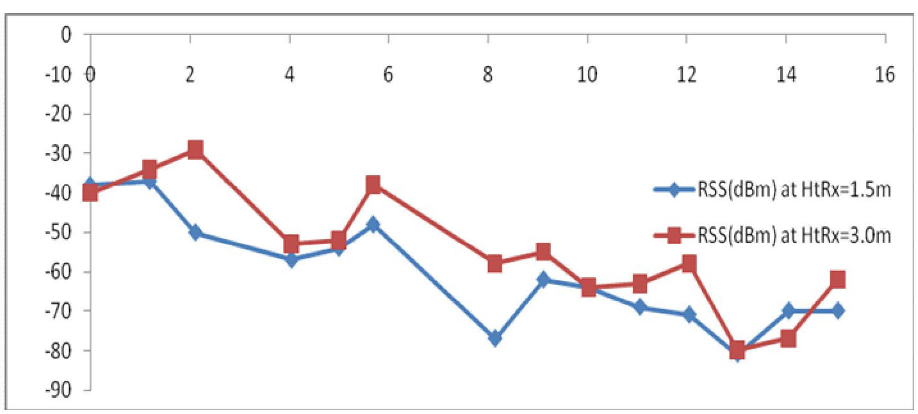

Fig.13: Propagation curves at various Heights of receiver antenna along RB during raining season in Akure

Signal decay and coverage areas; another key observation from the propagation curves (figures 10, 11, 12 and 13) for all the routes during the dry and rainy seasons is that beyond 10km LOS, RSS reduces to 50% of its value. The implication of this is that with the present transmission parameters of the station, both the primary and secondary coverage areas of the DTTBS lies within 0-10km radial distance. Whereas, areas beyond 10km LOS falls within the fringe coverage areas and as such the signal quality there should be enhanced for better Quality of Service.

IV. Conclusion

This study has successfully investigated the variation of DTTV Signal Strength with altitudes of the study areas (Akure metropolis) .The study was carried out for both wet and dry seasons with the following major findings; It is clearly revealed at all the routes and for the two seasons that the higher the altitudes of locations the better the Received Signal Strength (RSS). The use of 3.0 m receiving antenna height recorded better signal strength at the macro cell compared to the values recorded when 1.5m was used. This is due to the fact that the use of high receiving antenna heights reduces attenuation effects resulting from multi paths. This reduction is significant at the macro cell (distances $>$1.0 km from the base station) however at the micro cell (distances $\leq$1.0 km from the base station) there is no significant difference between the signal quality received when using 1.5m compared to 3.0 m receiving antenna heights. This was the trend for all the routes for both dry and wet seasons. In addition, it was observed that there is a greater difference in the quality of signal between the two antenna heights compared to the difference during the rainy seasons. The implication of this is that the attenuation effect due to multi paths is higher during the rainy seasons compared to the dry seasons. Based on this, a minimum of 3.0m receiving antenna height is strongly encouraged by subscribers of DTTV for use in the study areas and other similar cities in Nigeria for them to enjoy better Quality of Reception (QoR). For Subscribers who are resident within the fringe coverage areas of the station, around 10km-17km LOS from the DTTBS, it is advised that their receiver antenna height should range between 3.0km and 4km, for them to have better Quality of Reception (QoR). The overall findings of this work will be of immense benefits to all stake holders in DTT industry (The government in the area of policy making, DTT Service providers and subscribers in the study areas)

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