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Optimization of Radiowave Propagation in Ultra High Frequency Band for Ait Port Harcourt Nigeria

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Abstract- Viewer dissatisfaction predisposed by attenuated radio waves within propagating paths constitute a major viewers-depopulating factor of competing UHF structured broadcast television stations. This phenomenon often gives rise to viewers switching from stations challenged by attenuation to ones that have mitigated this untoward factor. Consequently, this study examines the dynamics of path loss related attenuation and how best optimization could be achieved in eight specified heights at the Choba axis of our experimental location. The findings revealed higher path loss values at the specified heights of 0.8m, 1.2m and 1.4m, when the Wire-Type Dipole antenna was used at the ground floor level of the one-storey building. Lesser path loss values were recorded at 5m, 5.4m and 5.7m, when both the Wire-Type Dipole and the Yagi antennas were used at the first floor. Negligible, path loss was, however, the case at 6.1 and 6.7m, when the Yagi antenna was exclusively used at the first floor. Thus, giving credence to the fact that optimization could best be achieved in UHF bands where the transmitting and receiving antennas have a fairly unobstructed path between them. Hence, their designation as line-of-sight communication system which peculiar straight line trajectory could as a result of being subject to mediums amenable to refraction still make for enhanced communication.

Keywords Optimization, UHF Band, Path loss, Radio wave Propagation Model, Matlab GUI.

1. Introduction

[1,2] defined optimization as a function of an observed deficiency in a given system. Optimization of radio wave propagation in UHF bands presupposes that measure could be taken to mitigate the attenuating factors and pave way for an improved frequency range resolution.

[3]defined Ultra High Frequency (UHF) band as a region of radio spectrum from 300MHz to 3GHz. UHF band lack the potential for ionospheric bounce and are mostly limited to LOS communication.

Several attenuating factors are prevalent in radio wave propagation. The establishment of communication outfits on locations that facilitate "ducting" and increased height of either (or both) transit or receive antennas to make for

Our focus for this study is the Path loss as an attenuating factor. [4] sees path loss as a major component of the analysis and design of the link budget of a telecommunication system. It is the attenuation undergone by an electromagnetic wave in transit between a transmitter and a receiver in a communication system.

The frequency of a radiowave is a function of its propagating characteristics through various media. UHF band has its propagation characteristics hinged on space wave exclusively. It can be applied in Global Positioning System (GPS), Microwave links, Wireless Personal Communication Systems, etc.

Myriads of problems have consistently burdened the optimization of radio waves propagation such as the attenuating effects of local area topography-cum-atmospheric conditions, man-made structure and frequency spectrum trajectory disposition in UHF ranges. Enhanced optimization of radio waves propagation can only be recorded by communication outfits that seek to degrade the incidence of the attenuating factors.

The aim of the study is to optimize radio wave propagation in UHF bands by mitigating path loss as an attenuating factor.

Accordingly, the study seeks to meet the following objectives, viz:-

To ensure a prior determination of the existence of attenuating factors at the "ex ante stage" of any radio propagation project with a view to having them mitigated before the "ex post stage".

To ensure the entrenchment of a hitch-free propagation channel in AIT Port Harcourt. AIT Port Harcourt operates on a UHF band.

The significance of the study is its potential to circumvent the attenuating influence of weather conditions, man-made structures, frequency spectrum trajectory disposition and topography in radio waves propagation. The innovation of adopting the appropriate models, facilitating frequencies, wave bands and broadcast friendly topography for areas designated for transmitting and receiving antennas enables the communication outfit to overcome the phenomenon of attenuation. The scope of the study exclusively entails the "path loss" deficiencies suffered by AIT Port Harcourt.

Radiowave propagation consists of two types: the "guided" as well as the free(unguided); with the latter(free) occurring in corresponding antennas in underwater, earth's atmosphere or in a free space [5], while the former(guided) takes place in man-made guiding systems such as wirelines, coaxial cable, waveguides and optical fiber[6]. UHF bands belong to the free (unguided) category. [7]sees this characteristic as reminiscent of the UHF bands, where radio signals can travel in a direct path from the transmitter to the receiver under conditions of both antennas being visible to each other devoid of obstructions such as buildings and mountains.

There has been a drought of receiver-antenna reconnaissance initiated by broadcast television stations in their coverage area. In times past, this had boosted optimization of radio waves propagation in areas where path loss attenuation was relatively predominant. At present this knowledge is either to no avail among the current wireless and communication engineers of propagating VHF and UHF structured broadcast television stations or they know about it, but are merely turning deaf ears to it. Nevertheless, the need for a rejuvenation of this informed error determination and corrective measures aimed at optimization of the radio waves being propagated by broadcast television stations cannot be overemphasized. This study, which constitutes a replication of this age-old –practice could serve as a point of departure for this exercise to be approximated by all broadcast television stations engaged in free (unguided) radio wave propagation.

2. Literature Review

Radiowave Propagation Models is an empirical mathematical formulation for characterization of radiowave propagation as a function of frequency, distance and other conditions [8]. It is used in optimization of radio network and planning analysis. Propagation models are categorized into three namely [9]:

i. Statistical Models
ii. Deterministic Models/Geometrical Propagation Models
iii. Empirical Models

i. Statistical Propagation Models.

It provides estimations of signal field strengths (or signal power) in cases where there is insufficient knowledge of the terrain profile.

ii. Deterministic (Geometrical) Propagation Models.

It makes use of the laws governing electromagnetic wave propagation with a view to estimating the field strength (or signal power) directly from the path profile (which has to do with terrain and clutter between the transmitter and receiver). They are usually site specific and can be associated with indoor or outdoor propagation environments.

iii. Empirical Propagation Models.

It incorporates the benefits of deterministic and statistical models. It is used for the planning and optimization of cellular networks. This model takes all environmental influences implicitly regardless of whether they could be separately recognized or not. Wireless, Propagation and Network Engineers sees the simplicity and computational efficiency of this model as its main advantage.[10,11]sees the possibility of splitting empirical models into two subcategories namely, time dispersive and non-time dispersive; with the time dispersive models providing information about time dispersive characteristics of the channel such as delay spread of the channel during multipath. Examples includes: Free space, Okumura-Hata, Cost 231 Hata, Okumura, Egliand Dual-slope, etc. Our focus for this study is on Okumura Hata Model and COST 231 Hata Model.

1. Okumura-Hata Model

It is a furtherance of the Okumura model in a variant referred to as Okumura Hata model which is the most widely used radio frequency propagation model for predicting the behavior of broadcast transmission, cellular transmissions in built up areas, point-to-point and it is based extensively on the empirical measurements taken [12].

The model can be represented mathematically as[14]]:

$$PL = 69.55 + 26.16\log f - 13.82 log h_T - a(h_R) + [44.9 - 6.55 log h_T]\log d \quad (1)$$

Where
PL is the pathloss in dB
f is the frequency of transmission in MHz
h_T is the height of transmitting antenna in meters
h_R is the height of the receiving antenna in meters
a(h_R)is the receiving antenna height correction factor
and d is the distance between the transmitting and the receiving antenna in kilometres

For large city with the frequency of transmission, $f \geq 400MHz$

$a(h_R) = 3.2[\log(11.75h_R)]^2 - 4.97$ (2)

For large cities with frequency of transmission f≤400MHz

$$a(h_R) = 8.2[\log(1.5h_R)]^2 - 1.1 \quad (1.2)$$

For suburban environments (150MHz≤f≤1500MHz)

$a(h_R) = (1.1\log f - 0.7)h_R - (1.56 log f - 0.8)$ (3)

Okumura Hata Model specification can be represented below as:

Carrier frequency: 150MHz≤f≤1500MHz

Transmitting antenna height: 30m≤$h_T \leq 200m$

Receiving antenna height: 1m≤h_R ≤10m

And distance between the transmitting and receiving antennas: 1km≤d≤20km.

2. COST-231 Hata Model

COST is defined as the European Cooperative for Scientific and Technical research; which is widely used for predicting path loss in mobile wireless systems [13,14]. COST-231 Hata model is an extension of the Okumura-Hata model designed to be used in frequency ranging from 500MHz to 2000MHz [Anderson [15]].It is also used for prediction of path loss in different environments such as rural, urban and sub-urban. A basic path loss equation in dB for COST-231 Hata model can be represented as:

$$PL = 46.3 + 33.9log_{10}(f) - 13.82log_{10}(h_T) - a_{hm} + \left(44.9 - 6.55log_{10}(h_T)\right)log_{10}d + C_m \quad (4)$$

Where

PL is the pathloss in decibel

f is the frequency in MHz

d is the distance between the transmitting and the receiving antennas in kilometres

h_T is the transmitting antenna height above ground level in metres

a(h_m) is the correction factor in dB

Cm is defined as 0db for suburban and 3dB for urban environment

a(h_(m))is represented mathematically for urban environment and suburban or rural(flat)environmentas:

For urban environment with f ≥ 400MHz

$a(h_m) = 3.20(log_{10}(11.75h_R))^2 - 4.97$ (5)

For urban environment with frequency of transmission f≤400MHz

$a(h_m) = 8.2[\log(1.5h_R)]^2 - 1.1$ (6)

For suburban or rural environment (150MHz≤f≤1500MHz)

$a(h_m) = (1.1log_{10}f - 0.7)h_R - (1.56log_{10}f - 0.8)$ (7)

where

h_R is the receiving antenna height above ground level.

3. Methodology

This study sought to determine the degree of “path loss” related “attenuation” suffered by radio waves propagating at eight consecutive heights from the UHF bands respectively. It also sought to ascertain the corresponding heights wherein the optimization objective could best be achieved. The work was executed with reception antennas at the Choba axis of Obio/Akpor Local Government Area of Rivers State using Africa Independent Television, Port Harcourt (AIT, PH)) as source of broadcast signal and transmitting antennas.

Prior to carrying out the work, the transmitting parameters of the broadcast station such as the operating frequency, maximum transmitter power, actual transmitter power, transmitter type, antenna type/model, antenna height, station coordinates and antenna gain were sourced and obtained. This is as shown in Table 1

The methodology adopted for this study is the empirical propagation models with a bias for the Okumura-Hata Model and the COST-231 Hata Model. It involves eleven stages as shown in Figure 1.

Table 1. Television Broadcast Station Parameters sourced and obtained from AIT PH

	Parameters	***Value***
1.	*Station Location*	*Ozuoba, Port Harcourt*
2.	*Station Coordinates*	*Latitude- 4.8712834°N,* *Longitude- 6.9386575°E*
3.	*Frequency Band*	*Ultra High Frequency*
4.	*Operating Frequency*	*535.25MHz*
5.	*Transmitter Power(Maximum)*	*10kw*
6.	*Transmitter Power(Actual)*	*3Kw*
7.	*Antenna Type/model*	*Jampro(Yagi)/TCBI-UP-01*
8.	*Antenna height*	*260m*
9.	*Antenna gain*	*1dBi*
10.	*Tx-Rx Seperation*	*13km*

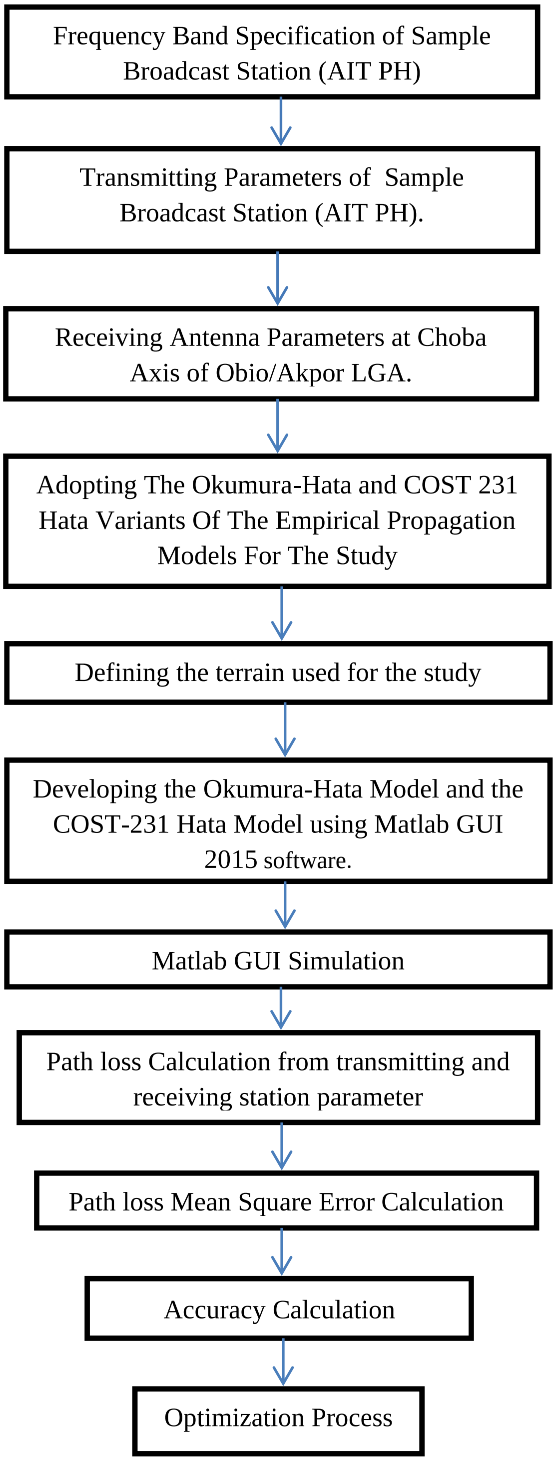

Fig 1. Block Diagram showing the Procedure used to carry out the Research Design.

Six of the eleven stages represented in Figure 1 are expatiated in the methodology, while the remaining five are fully deliberated upon in results and discussion. The following sub-sections comprise details of each of the first six stages compartmentalized above in the block diagram.

i. Frequency Band Specification of Sample Broadcast Television Station.

This stage, like the two others that follow has to do with data collection. It entails the choice of a sample broadcast television station reminiscent of the UHF band. In this respect, AIT, Port Harcourt was sampled as a UHF band, it transmits on a frequency specification of 535.25MHz.

ii. Transmitting Parameters of Sample Broadcast Television Station.

Transmitting parameters of the Sample Broadcast Television Station, such as operating frequency, transmitter power(maximum), transmitter power(actual), antenna type/model, antenna gain, frequency band and station coordinates(Longitude and Latitude) were sourced and obtained.

The Broadcast Television Station coordinates were sourced through google earth software, while the topographical map was used to determine the line of sight (LOS) distance between both transmitters and the chosen receiver antenna location.

iii. Receiving Antenna Parameters at Choba Axis of Obio/Akpor LGA.

At the storey-building location in Choba, where the study was carried out, two antenna types namely: wire-type dipole antenna and yagi antenna were used, with the former acting as an error determinant, while the latter served as correction at various heights.

Table 2 shows eight measured receiver antenna heights and type of receiver antenna used respectively for both broadcast television stations in the study.

Table 2. the Receiver Antenna Heights Measured and the Receiver Antenna Type used respectively for both Broadcast Television Stations in the study**.**

Receiver Antenna Height Measured	Receiver Antenna Type Used
0.8m	Wire-Type Dipole Antenna
1.2m	Wire-Type Dipole Antenna
1.4m	Wire-Type Dipole Antenna
5m	Wire-Type Dipole Antenna and Yagi Antenna
5.4m	Wire- Type Dipole Antenna and Yagi Antenna
5.7m	Wire-Type Dipole Antenna and Yagi Antenna
6.1m	Yagi Antenna
6.7m	Yagi Antenna

i. Adopting the Okumura-Hata Model and COST 231 Hata Model Variants of the Empirical Propagation Models for the Study.

Subscription for the aforesaid variants of the empirical propagation models is based on their being applicable to urban, suburban/rural environments [13,16]. Table 3 shows a summary of the path loss expression and correction factor of the Okumura-Hata Model and COST 231 Hata Model.

Table 3. a summary of the path loss expression and correction factor of the Okumura-Hata Model and COST 231 Hata Model.

MODEL USED	PATH LOSS EXPRESSION	CORRECTION FACTOR (a_{hr})
Okumura Hata Model	PL=69.55+26.16log(f)-13.82log$h_T - a_{hr}+$ [44.9-6.55logh_T]$log\ d$.	$a_{hr} = (1.1log(f) - 0.7)h_r - (1.5log(f)$-0.8)
COST-231 Hata Model	PL=$46.3 + 33.9log(f) - 13.82log(h_T) - a_{hm} + (44.9 - 6.55log(h_T)log\ d + Cm$	$a_{hm} = (1.1log(f) - 0.7)h_r - (1.5log(f)$-0.8)

i. Defining the terrain used for the study.

A proper delineation of the "Receiving Antennas Location" on a storey building at the Choba Axis of Obio/Akpor Local Government Area (the experimental location of the study) afforded the study the reality of designating it as a sub-urban/rural environment surrounded by farmlands, tall storey buildings and the east-west road to its left. Hence, its applicability to the Okumura-Hata Model and the COST-231 Hata Model.

ii. Developing the Okumura-Hata Model and the COST-231 Hata Model using Matlab GUI 2015 software.

The software by which the Okumura-Hata model and the COST-231 Hata Model path loss analysis were developed was the Matlab GUI 2015 Software.

4. Result and Discussion

4.1 Presentation of Data

Figure 2 and 3 shows the developed model interface of Okumura-Hata and COST-231 Hata for path loss analysis in the sample broadcast television station using the Matlab GUI 2015 software.

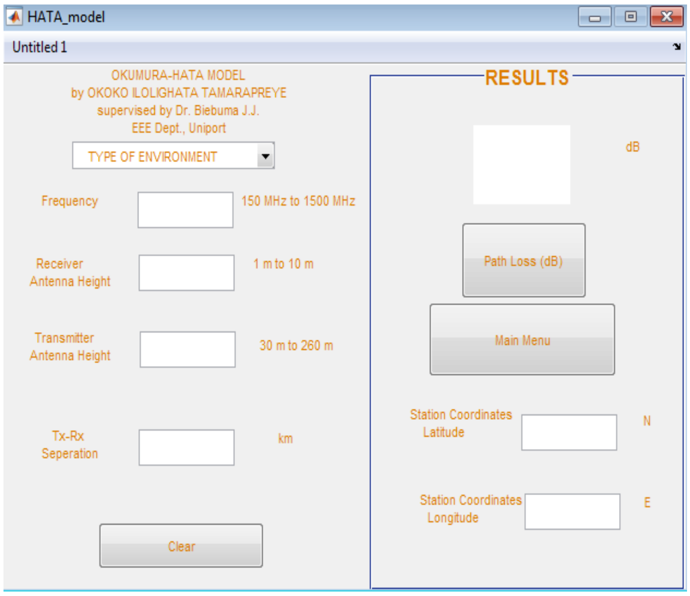

Fig. 2. the Developed Model Interface of Okumura-Hata for path loss analysis

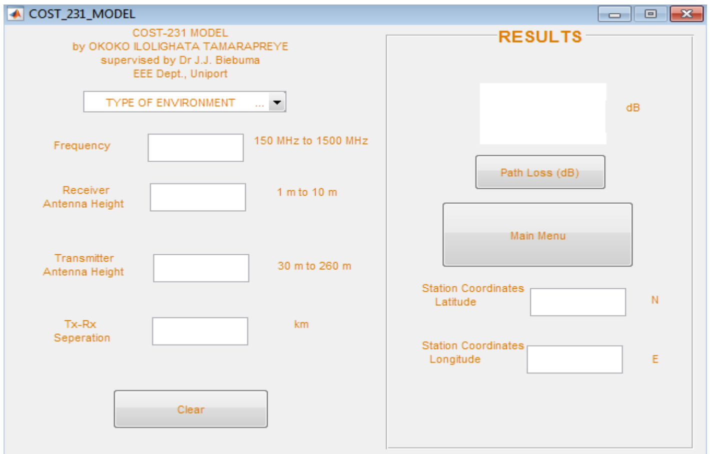

Fig. 3. The Developed Model Interface of COST-231 Hata for path loss analysis.

Table 4 shows the simulated results of path loss analysis for the Okumura-Hata Model and the COST-231 Hata Model vis-à-vis the receiving antenna-type used, their identifiable heights, their respective distance from the transmitting antenna of the sample broadcast television station, their operating frequency and transmitter height.

Table 4. Showing the simulated results of path loss analysis for the

Receiving Antenna Height	Simulated Path loss Results of Okumura-Hata Model for AIT PH(535.25MHz)	Simulated Path loss Results of COST-231 Hata Model for AIT PH(535.25MHz)
0.8m	141.5651	139.4342
1.2m	140.6446	138.5136
1.4m	140.1843	138.0533
5m	131.8992	129.7682
5.4m	130.9786	128.8477
5.7m	130.2882	128.1573
6.1m	129.3677	127.2367
6.7m	127.9868	125.8558

Okumura-Hata Model and COST-231 Hata Model.

Figure 4 and 5 are graphs representing the simulated results of the path loss against the distance between the transmitting and receiving antenna using Matlab.

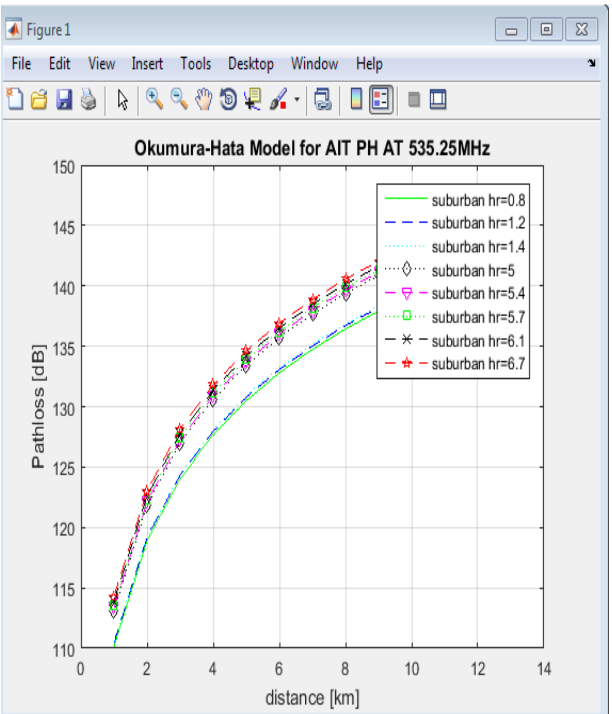

Fig 4. Path loss vs distance for AIT PH @ 535.25MHz using Okumura-Hata Model

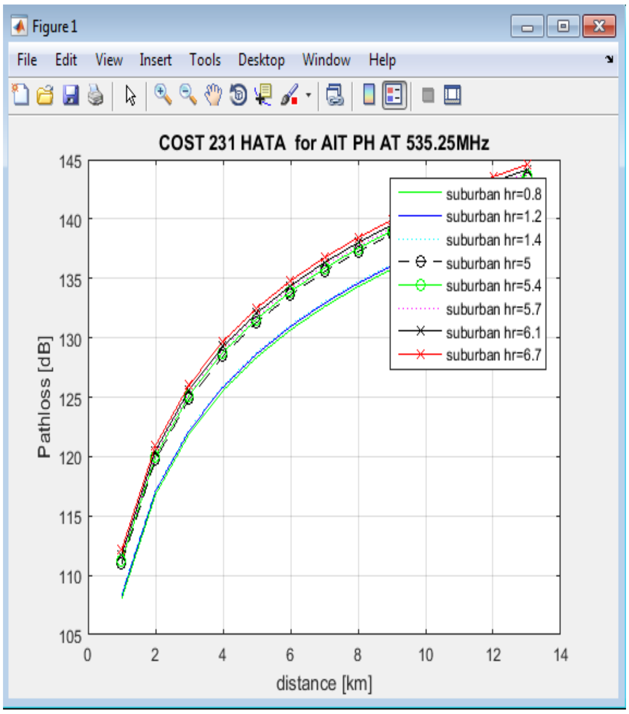

Fig 5. Path loss vs distance for AIT PH @ 535.25 MHz using COST-231 Hata Model

Equations 1 and 2 are Okumura-Hata Model and COST-231 Hata Model path loss formulas used to calculate / predict the path loss along the eight exclusive antenna heights, frequency of the sample broadcast television station, distance from the transmitting to the receiving antenna and the transmitter height of both stations.

Okumura-Hata model represented mathematically as:

$$PL = 69.55 + 26.16\log_{10} f - 13.82\log_{10} h_T - a_{hr} + (44.9 - 6.55\log_{10} h_T)\log_{10} d \qquad (8)$$

Where f=sample broadcast television station frequency
h_T is the height of the transmitting antenna
h_R is the height of the receiving antenna
d is the distance between the transmitting and the receiving antenna
a_{hr} is the correction factor.
For suburban environment a_{hr} is represented mathematically as:

$$a_{hr} = (1.1\ \log_{10} f - 0.7)h_R - (1.56\log_{10} f - 0.8) \qquad (9)$$

COST-231 Hata model represented mathematically as:

$$PL = 46.3 + 33.9\log_{10} f - 13.82\log_{10} h_T - a_{hm} + (44.9 - 6.55\log_{10} h_T)\log_{10} d \qquad (10)$$

$$a_{hm} = (1.1\ \log_{10} f - 0.7)h_R - (1.56\log_{10} f - 0.8) \qquad (11)$$

Table 5 and 6 shows the calculated results of path loss analysis for the Okumura-Hata Model and the COST-231 Hata Model vis-à-vis the receiving antenna-type used, their identifiable heights, their respective distance from the transmitting antenna of the sample broadcast television station, their operating frequency and transmitter height.

Table 5. Showing the calculated results of path loss analysis for the Okumura-Hata Model (AIT PH)

Receiver Antenna Height	Receiver Antenna Type	Sampled Broadcast Television Station Frequency/ Station Name	Distance from the transmitting station to the receiving station	Transmitter Height	Correction Factor(a_{hr})	Path loss (dB)
0.8m	Wire-type Dipole Antenna	535.25MHz AIT PH	13km	260m	-1.615	141.56
1.2m	Wire-type Dipole Antenna	535.25MHz AIT PH	13km	260m	-0.695	140.64
1.4m	Wire-type Dipole Antenna	535.25MHz AIT PH	13km	260m	-0.235	140.18
5m	Wire-type Dipole & Yagi Antenna	535.25MHz AIT PH	13km	260m	8.051	131.90
5.4m	Wire-type Dipole & Yagi Antenna	535.25MHz AIT PH	13km	260m	8.971	130.98
5.7m	Wire-type Dipole & Yagi Antenna	535.25MHz AIT PH	13km	260m	9.662	130.29
6.1m	Yagi Antenna	535.25MHz AIT PH	13km	260m	10.582	129.37
6.7m	Yagi Antenna	535.25MHz AIT PH	13km	260m	11.963	127.99

Table 6. Showing the calculated results of path loss analysis for the COST-231 Hata Model (AIT PH)

Receiver Antenna Height	Receiver Antenna Type	Sampled Broadcast Television Station Frequency/ Station Name	Distance from the transmitting station to the receiving station	Transmitter Height	Correction Factor(a_{hr})	Path loss (dB)
0.8m	Wire-type Dipole Antenna	535.25MHz AIT PH	13km	260m	-1.615	142.43
1.2m	Wire-type Dipole Antenna	535.25MHz AIT PH	13km	260m	-0.695	141.51
1.4m	Wire-type Dipole Antenna	535.25MHz AIT PH	13km	260m	-0.235	141.05
5m	Wire-type Dipole & Yagi Antenna	535.25MHz AIT PH	13km	260m	8.051	132.77
5.4m	Wire-type Dipole & Yagi Antenna	535.25MHz AIT PH	13km	260m	8.971	131.85
5.7m	Wire-type Dipole & Yagi Antenna	535.25MHz AIT PH	13km	260m	9.662	131.16
6.1m	Yagi Antenna	535.25MHz AIT PH	13km	260m	10.582	130.24
6.7m	Yagi Antenna	535.25MHz AIT PH	13km	260m	11.963	128.86

Mean Square Error (MSE) was used to measure the average of the errors showing the difference between the simulated and calculated results of the path loss analysis.

Mean Square Error (MSE) can be expressed mathematically as:

$$\text{MSE}=\sqrt{\frac{1}{N}\sum_{I=1}^{N}(P_m - P_r)^2} \qquad (12)$$

Where
P_m is the measured/simulated path loss
P_r is the predicted/calculated path loss
N is the number of measured data point

Table 7 and Table 8 shows the mean square error result of Okumura-Hata Model and COST-231 Hata Model for the Sample Broadcast Television Station.

Table 7. Okumura-Hata Model Mean Square Error Result for the Sample Broadcast Television Station

Sample Broadcast Television Station Name	Mean Square Error Value
AIT PH @535.25MHz	0.002

Table 8. COST-231 Hata Model Mean Square Error Result for the Sample Broadcast Television Station

Sample Broadcast Television Station Name	Mean Square Error Value
AIT PH @535.25MHz	0.001

The accuracy of each of the two developed models of both sample broadcast television station were obtained using the mathematically expression:

$$Accuracy = 1 - Mean\ Square\ Error\ Value \qquad (13)$$

Table 9 and 10 shows the accuracy result of Okumura-Hata Model and COST-231 Hata Model for the Sample Broadcast Television Station.

Table 9. Okumura-Hata Model Accuracy Result for the Sample Broadcast Television Station

Sample Broadcast Television Station Name	Accuracy Result Value
AIT PH @535.25MHz	0.998=99.8%

Table 10. COST-231 Hata Model Accuracy Result for the Sample Broadcast Television Station

Sample Broadcast Television Station Name	Accuracy Result Value
AIT PH @535.25MHz	0.999=99.9%

The corresponding path loss of the sample broadcast television station signal for each signal field strength was calculated using eqn. 19 as obtained from [14].

$$E\left(\frac{V}{m}\right) = \sqrt{30\,\frac{P_T G_T}{d(LOS)}} \qquad (14)$$

Table 11 shows the signal field strength of the sample broadcast television station.

Table 11. Signal field strength of the Sample Broadcast Television Station.

Sample Broadcast Television Station Name	Signal Field Strength Value(decibel(dB))
AIT PH	0.73

4.2 Data Analysis

Data collected and presented from the sample broadcast television station (AIT Port Harcourt) showed a negligible path loss. The television station was observed to have suffered a path loss. Observable dimensions of the dynamics of this phenomenon were obtained through simulated Matlab GUI 2015 and calculated path loss models of Okumura-Hata and COST-231 Hata models sourced “horizontally” between the transmitting and receiving antennas as well as that recorded “vertically” at the eight consecutive heights of the experimental location at the choba axis of Obio/Akpor Local Government Area. This could be put in proper perspective when viewed against the background of observed “attenuation” and “optimization” vis-à-vis the output of the “Wire-Type Dipole” and “Yagi” antennas at their horizontal and vertical disposition.

4.2.1 Observable Attenuation from the Sample Broadcast Television Station at the Experimental Location Vis-À-Vis the Horizontal Disposition of Radio Wave Propagation.

[17] enabled this study to determine the “signal field strength” of the sample broadcast television station vis-à-vis the line of sight perspective from their transmitting antennas to the choba axis. Through the use of the formula:

$$E\left(\frac{V}{m}\right) = \sqrt{30\,\frac{P_T G_T}{d(LOS)}} \qquad (15)$$

The signal field strength of AIT Port Harcourt was found to be 0.73. Deductively, the path loss recorded by AIT, Port Harcourt was high as already established in the simulated and calculated results. Reminiscent of this is Table 4, 5 and 6.

4.2.2 Observable Attenuation From the Sample Broadcast Television Station Recorded at the Eight Consecutive Heights of the Wire-Type Dipole Antenna at the Choba Axis.

Using the “Wire-Type Dipole Antenna” as an error determinant, the study recorded six distinct values of path loss in its experimental location at Choba Axis, which shows that the higher the receiver-antenna height, the lower the path loss value and vice versa. Reminiscent of this is Table 4, 5 and 6.

4.2.3 Observable Optimization from the Sample Broadcast Television Station Recorded at Six of the Consecutive Heights Using the Yagi Antenna at the Choba Axis.

Using the Yagi antenna as an error correction measure, the study ascertained five respective heights at the experimental location where optimization of radio wave propagation could best be achieved. Table 4, 5 and 6 shows the peculiar optimization compliant receiver antenna placement heights of the location at choba axis.

4.3 Discussion of findings

Field measurement data was obtained from a transmitting antenna at Ozuoba, the Jampro (Yagi)/TCBI-UP-01 antenna from AIT Port Harcourt. The antenna have their radio waves propagating to two antenna-types, namely: the Wire-Type Dipole antenna and the Yagi antenna, all placed at eight respective heights of the experimental location at Choba axis of Obio/Akpor Local Government Area. The distance covered by the propagating sample television station from their transmitting antennas to receiving antennas amounted to 13km from AIT Port Harcourt (Google Map Software). The sample transmitting antenna recorded an antenna gain of 1dB.The transmitting antenna of AIT Port Harcourt at Ozuoba, a suburb of Port Harcourt operates a transmitting power of 3kw and a transmitting frequency of 535.25MHz; with a transmitting antenna height of 260m. Table 11 shows the calculated field strength values of the sample broadcast television station with 0.73 dB for AIT Port Harcourt. Figure 2 and 3 shows the developed model interface of Okumura-Hata Model and COST-231 Hata Model for path loss analysis. The two developed models of the Okumura-Hata and COST-231 Hata Model were tested and then simulated. The simulated results were then compared with the calculated values evolved from the mathematical expression of the two models. The comparison predisposed a slight difference between the simulated and calculated result. Thus, prompting resort to using the “”Mean Square Error equation” in differentiating the “average error” between the simulated and calculated results of the sample broadcast station. Table 7 and 8 constitute the “mean square error” values of the sample broadcast television station. Table 9 and 10 shows the accuracy calculation results of Okumura-Hata and COST-231 Hata Model for the sample broadcast television station; with an approximate value of 1.0 or 100% accuracy recorded at the sample broadcast television station. The 100% accuracy recorded from the simulated and calculated results ascertain both models as fit for deployment for the study.

4.3.1 Path Loss Related Attenuation.

Table 4, 5 and 6 comprise the simulated and calculated results of path loss analysis for the sample broadcast television station using the Okumura-Hata and COST-231 Hata Models. The results from the transmitting and receiving antennas showed that AIT Port Harcourt with a UHF frequency band of 535.25MHz recorded high path loss values. The simulated and calculated results as per Table 4, 5 and 6 equally showed that the higher the receiving antenna height, the lower the path loss value and vice-versa.

4.3.2 Height at which Optimization could best be achieved at the Experimental Location.

Table 4, 5 and 6 comprise the simulated and calculated results of path loss analysis for the sample broadcast television station using the Okumura-Hata and COST-231 Hata Models. Using the Wire- Type Dipole antenna, at the experimental location, the results at the respective heights of 0.8m, 1.2m and 1.4m showed higher values of path loss. The path loss value however dropped at 5m, 5.4m and 5.7m with the application of the Wire-Type Dipole and Yagi antennas. Obviously the 5.7m height at the experimental location comprised the limit of the Wire-Type Dipole antenna, more so, as it was a one-storey building. But using the Yagi antenna alone at 6.1m and 6.7m, there was a total reduction of the value of the path loss. In other words optimization of radio wave propagation in the sample broadcast television station (UHF band) was best achieved using the Yagi antenna at 6.1m and 6.7m.

5. Conclusion

Free (unguided) radio wave propagation in UHF bands have a tendency of being beset by path loss related attenuation. The implication of this on the optimization objective of the UHF bands had over the years constituted a major concern of Wireless and Communication Engineers. This study, like this coterie of engineers ascertained and determined the resultant error such identifiable attenuation factors predisposed on the radio wave propagation at its experimental location as well as having such errors subjected to correction using Okumura-Hata and COST-231 variants of the empirical propagation models. The study showed the suitability of the two models in determining the path loss values suffered by the sample UHF broadcast television station with a Wire-Type Dipole antenna and empirically verified how best optimization could be achieved at the specified heights at the experimental location with a Yagi antenna. In the main, the dynamics of path loss related attenuation and efforts geared at mitigating its incidence with the Yagi antenna brought to the fore, the maximum role played by “height” of the transmitting and receiving antennas in fostering improved optimization to occur in UHF bands. Equally worthy of note is the advantage conferred upon higher frequencies in best approximating the optimization objective.

6. Recommendations

The study recommends both at the ex-ante and ex-post examination stages of the project that increased antenna height at both the transmitting and receiving ends of propagating channels be se as a standard yardstick for implementation. Hence, the primacy of establishing a fairly unobstructed path between the transmitting antennas of these VHF and UHF structured broadcast television stations and their receiving antennas to make for enhanced line of sight communication.

The study also recommends the primacy of carrying out path loss measurement during the installation of antennas at the transmitting and receiving ends of the propagation channels. This is to ensure prior determination of favourable antenna heights where path loss could be eliminated or reduced to the barest minimum.

The study also recommends a dynamic transmitter power at the transmitting station to boost signal strength at the receiver end. The imperative of this cannot be overemphasized, more so, with the fact that VHF and UHF waves attenuate with every mile of distance.

The study equally recommends that broadcast television stations that are fraught with inadequacies such as poor antenna height and reduced transmitter power should take advantage of an improved frequency band to mitigate path loss related attenuation. And as a corollary achieve enhanced optimization of radio wave propagation.

The study highly recommends the use of yagi antenna at the receiver end for enhanced optimization.

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