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Comparative Analysis of Empirical Path Loss Models for Signal Propagation in Urban Area of Edo State, Nigeria

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Abstract − This paper is aimed at comparing the applicability of Okumura and Hata path loss model for VHF signal propagation in the urban area of Edo State, Nigeria using data obtained from empirical measurements. Path loss models are propagation tools used for estimating path loss during radio system planning. Although the Okumura model is been recommended by the International Telecommunication Union (ITU) for radio system planning, its applicability for Very High Frequency VHF television broadcasting planning in Edo State has not been ascertained. To satisfy this objective, a quantitative measurement of the signal strength of a VHF Television Broadcasting Stations in Edo State known as the Nigeria Television Authority (NTA) monitored on 189.25MHz was carried out. The results obtained on analysis shows that the Hata model performed better than the Okumura model for television signal propagation in Edo State as the prediction obtained from the Hata model gave a closer fit to the measures pathloss in the graphical plots.

***Keywords* – Okumura Model, Hata Model, Predict, Path Loss, Propagatio, Signal Strength.**

I. INTRODUCTION

Most of the radio signal strength prediction models like the Okumura and the Hata model (measurements done in Tokyo city) as well as other models are based on the measurements in temperate climate and are sometime not applicable to other environments. Such models need to be compared with measurements and necessary correction applied to compensate for imperfections of the model.

Propagation models can be used to plan the location of broadcasting stations, it can also be used to determine the antenna height and transmitting power of a new broadcast transmitter when a certain coverage area is to be served. They also can be used to calculate possible interference on the coverage area of another transmitter that is already on air. For example, when a country is planning to operate a new television broadcasting station there is need to follow certain rules and procedures to ensure that no interference is caused to existing broadcasting stations in adjacent countries. These rules and procedures generally prescribe the use of a specific propagation model.

As the June 2015 deadline approach for Nigeria to switch from analogue television broadcasting to digital television broadcasting station and as more broadcasting continue to spring forth, there is need to have propagation data on hand. According to [1] before implementing designs of any wireless communication (e.g broadcasting transmitting stations), accurate propagation characteristics of the environment should be known. The signal strength measurement campaign will be most valuable in achieving these objectives.

II. PROPAGATION MODELS

Path loss prediction is normally carry out using path loss models which are vital to any radio communication system. In this article the Okumura model and the Hata empirical model is described.

Hata Model

The Hata model is a popular propagation tool for radio propagation planning. The model is based on an empirical relation derived from Okumura's report on signal strength variability measurements [2]. The simple modeling of path loss is still dominated by the Hata empirical model [3] where the propagation results are fitted to a simple analytical expression, which depends on antenna height, environment, frequency and other parameters . Hata's method is basically an extension of Okumura's method (which is somewhat cumbersome due to numerous correction factors) and employs propagation curves instead of parametric equations [4]. It is applicable to frequencies between 150MHz and 1500MHz, transmitter-receiver separation distance from 1Km to 20Km, transmitter antenna height between 30m and 200m and the height of receiver antenna from 1m to 10m. Hata's model for urban area is expressed for urban area as,

$$L_U = 69.55 + 26.16\log f - 13.82\log h_{te} - a(h_{re}) + (44.9 - 6.55\log h_{te})\log d \quad (1)$$

where L_U is the path loss in urban areas in dB, hte is the height of the transmitter antenna in *m*, h_{re} is the height of the receiver antenna in *m*, *f* is the transmission frequency in *MHz*, *d* is the transmitter-receiver separation distance in *km* and *a(hre)* is the receiver antenna correction factor expressed as:

$$a(h_{re}) = 8.29(\log(1.54\, h_{re}))^2 - 1.1 \text{ for } f \leq 300\text{MHz} \quad (2)$$

Since the model only requires four parameters for the computation of path loss, the computation time is very short. This is the primary advantage of the model. However, the model neglects the terrain profile between transmitter and receiver, i.e. hills or other obstacles between the transmitter and the receiver are not considered [5].

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Okumura model

Okumura model is valid for radio predictions between the range of 150 to 1920MHz,, transmitter-receiver separation distance up to a 100km and transmitter antenna height of between 30-1000m [5]. The Okumura's model takes into account some propagation parameters such as the type of environment and the terrain irregularity .The Okumura's model is expressed as:

$$L\,(dB) = L_F + A_{mu}\,(f,d) - G\,(ht) - G\,(h_r) - Garea \qquad (3)$$

where:

L (dB) is the propagation path loss,
L_F is the free space path loss,
A_{mu} is the free space attenuation,
G (h_t) is the base station antenna height gain factor,
G (h_r) is the mobile antenna height gain factor, and
G_{area} is the gain corresponding to specific environment
A_{mu}(f; d) and G_{AREA} are determined by looking up Okumura curves
G(h_t) and G(h_r) are calculated as, [6] [7].

$$G(h_t) = 20\log\left(\frac{h_t}{200}\right) \quad 1000m > h_t > 30m \qquad (4)$$

$$G(h_r) = 10\log\left(\frac{h_r}{3}\right) \quad h_r \leq 3m \qquad (5)$$

$$G(h_r) = 20\log\left(\frac{h_r}{3}\right) \quad 10m > h_r > 3m \qquad (6)$$

III. Field Strength Measurements

The measurement of signal level of a VHF broadcasting station was taken radially along selected routes starting at the transmission stations using handheld RF field strength spectrum analyzer (Sefram 7808) and a Germain 78CX GPS receiver. Data were collected in the month of September 2012. Route 1 is the Aduwawa-Ehor road, route 2 is the Aduwawa-Abudu road and route 3 is the Aduwawa-Ologbo road.

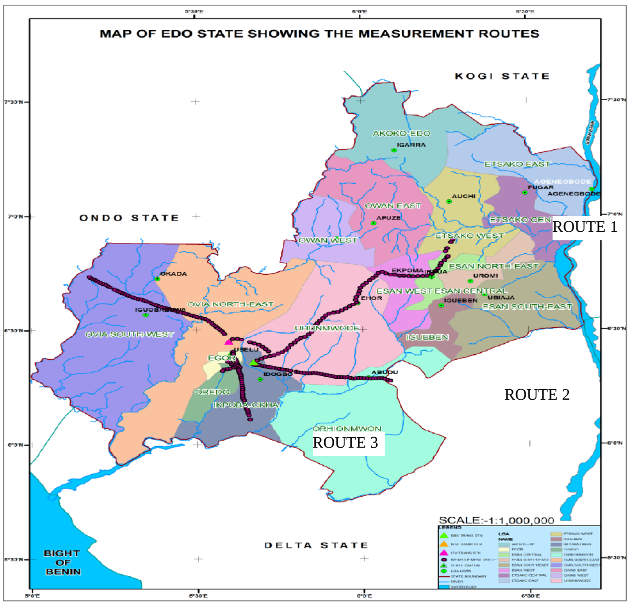

Fig.1. Map of Edo State showing the measurement Locations

A drive test was employed for the measurement of signal level of a VHF broadcasting stations located in the Ikpoba hill axes of Edo state. In each measurement sessions, field strength meter is set to the desired frequency of the television station to be monitored and field strength measurements is carried out at intervals starting from the transmitting stations. The spatial information (Latitude and Logitude) are taken at each measurement location. The drive test was facilitated by a route map of Edo State obtained from the Ministry of Lands and Survey, Edo State. Figure 1 shows the various measurements locations.

IV. Results and Discussion

The field strength values measured along these three paths are converted into a path loss value called 'measured path loss'. Path loss values were computed for the Hata and Okumura prediction model using combinations of equations 1 to 6. The obtained path loss is compared to that of the measured path loss and the results is presented as in Tables 1 to 3 and Figures 2 to 4

Table 1: Measured and Predicted path loss along route 1

Distance (km)	Measured Pathloss	Okumura Model	Hata model
1.46	136.27	90.10	104.69
3.10	139.83	99.64	114.79
4.60	142.87	104.06	120.08
6.16	146.83	107.10	123.99
7.67	147.20	109.49	126.92
9.24	147.37	112.11	129.42
10.82	146.93	114.48	131.55
12.33	148.40	116.62	133.30
13.66	148.77	118.01	134.67
15.16	149.43	119.41	136.07
16.74	148.23	120.78	137.41
18.19	151.53	122.00	138.52
19.68	150.60	123.18	139.58

Table 2: Measured and Predicted path loss along route 2

Distance (km)	Measured Pathloss	Okumura Model	Hata Model
1.26	138.33	88.80	102.68
3.48	146.13	99.12	116.31
5.37	146.47	106.40	122.14
6.34	144.80	108.34	124.38
7.43	147.93	110.21	126.50
8.32	148.53	111.70	128.02
9.31	150.33	113.18	129.53
10.18	149.60	114.96	130.73
13.03	151.83	117.80	134.04
15.02	150.83	119.14	135.95
16.87	152.30	120.34	137.51
17.88	152.67	121.25	138.29
18.89	151.90	122.13	139.03

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Table 3: Measured and Predicted path loss along route 3

Distance (km)	Measured Pathloss	Okumura Model	Hata Model
1.27	136.67	88.90	102.83
4.52	141.60	102.39	119.82
5.91	146.00	107.34	123.44
7.28	151.63	109.84	126.22
8.74	152.63	112.03	128.68
10.40	152.57	115.14	131.01
11.26	153.23	116.03	132.08
12.11	152.63	116.96	133.06
13.03	152.80	117.70	134.04
14.02	153.30	118.54	135.03
15.21	153.00	119.29	136.12
16.87	155.93	120.34	137.51
18.66	155.23	121.82	138.86

Using Microsoft Excel software, the data presented in Table 1 to 3 are graphically depicted as shown in the Figures 2 to 4.

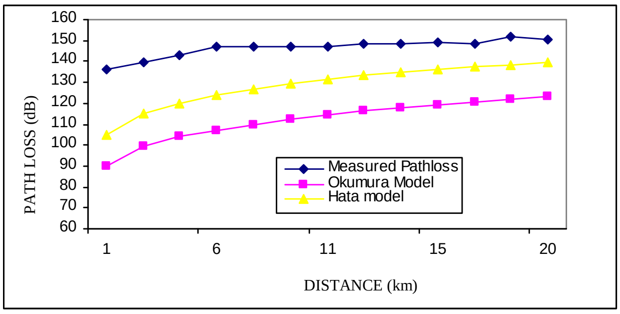

Fig. 2. Measured and Predicted pathloss versus distance (route 1)

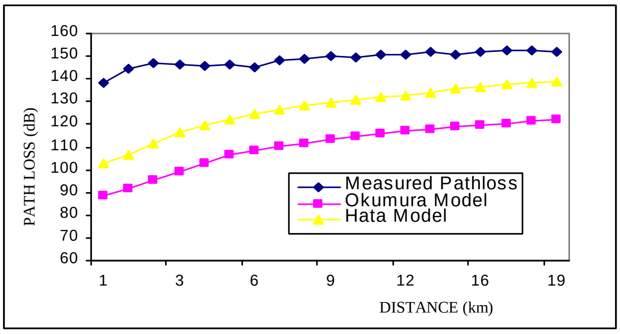

Fig.3. Measured and Predicted pathloss versus distance (route 2)

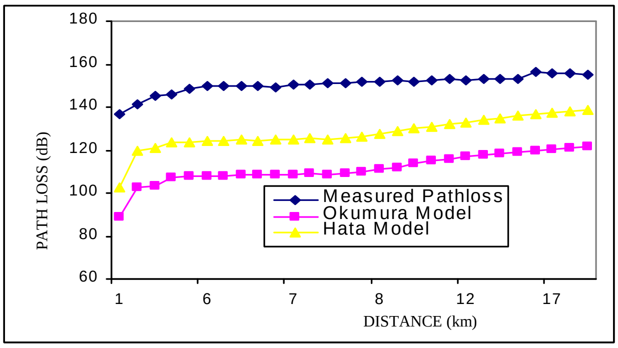

Fig.4. Measured and Predicted pathloss versus distance (route 3)

Figures 2-4 depicts the variation of these path losses as a function of the propagating distance for both the empirically measure path losses and the predicted path losses for the three routes under investigation. The Figures clearly shows that propagation mechanism is the same in every direction irrespective of the different terrain transversed. However it is seen that the Hata model prediction fit better to the empirically determined pathloss when compared to that of the prediction of Okumura.

V. Conclusion

The research work has focused on comparative analysis of the renowned Okumura and Hata path loss models using empirical data obtained form measurements in the urban area of Edo State. It is observed that both models do not fit exactly the path loss situation in the urban area of Edo State as seen in the Figures 2 to 4. This is due to differences in the terrain profile between where both the Okumura and Hata model was developed and where it is been applied. However the Hata model performed better in explaining the path loss variability as compared to the Okumura pathloss model. The Hata model is therefore better for VHF signal prediction in Edo State..

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