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Performance Comparison of Okumura and Hata Model for UHF Signal Propagation in the City of Warri, Nigeria

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ABSTRACT

This paper is aimed at determining the performance of the renowned Okumura and Hata propagation models for propagation path loss prediction in the City of Warri, Delta state region of Nigeria. The work was carried out through a quantitative measurement of the signal strength of Delta Broadcasting Service which transmits TV signals in the ultra high frequency band at a frequency of 636MHz. The results obtained using the root mean square error RMSE performance metrics shows that the Hata propagation model gave a better pathloss prediction compared to the measured pathloss even though some modification are still required to enable it explain for the pathloss situation in the city of Warri, Delta State Nigeria.

Keywords: Hata, Okumura, propagation models, signal strength, UHF, VHF, Pathloss, Prediction,

INTRODUCTION

The television broadcasting stations in Nigeria predominantly occupy the ultra high frequency UHF band of the RF spectrum although some other stations like the Nigeria Television Authority (NTA), broadcast in the Very High Frequency VHF band. Whether a television station operates in the UHF or VHF, proper planning must be carried out to guarantee effective signal coverage. The television broadcast industry is dependent upon reaching people; therefore quality coverage is a key requirement in assessing a given station. Coverage assessment is important as it provides both government and broadcasters with information on television coverage which will enable them to ascertain the portion of the population that have access to television services.

Information obtained from such coverage assessment could also be used for planning other television broadcasting stations especially as the analogue to digital transmission switch over approaches.

Ensuring that all of the world's population has access to television services is one of the targets set by world leaders in the World Summit on the Information Society. Television is important for enhancing national identity, providing an outlet for domestic media content and getting news and information to the public, which is especially critical in times of emergencies.

[1]. Assessment of television coverage can be carried out using a combination of field survey measurements and/or modeling techniques [2]. Measuring received signal level over an area makes the radio broadcast engineer to properly gauge signal receivability. This allows the engineer to be certain of the transmitted signal. According to [3], analogue television signals cannot be successfully received when the reception level is less than -94dBm (equivalent to signal level of 14dBμV) for analogue television.

Propagation modeling techniques can also be deployed for signal prediction during the planning stage of a broadcast station or for optimizing already existing ones.

A good model can accurately predict signal strength at various frequencies over distances influenced by terrain. The propagation models we have today were developed and tested over a period of time with some been empirical and others deterministic in nature.

Since most of the radio signal strength prediction models like the Okumura-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 to ascertain their suitability in radio propagation in city like Warri, Nigeria. Development of model becomes imperative when existing models cannot suitably predict radio propagation in a given environment. Such models are of great value to radio engineers. Previous studies has shown that the Hata model needs modification before it could be used for radio planning in Benin City [4]
As the June 2015 deadline approach for Nigeria to switch from analogue television broadcasting to digital television broadcasting and as more broadcasting continue to spring forth, there is every need to have propagation data on hand. According to [5], 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.

Propagation Models

Path loss prediction is normally carried 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 [6]. The simple modeling of path loss is still dominated by the Hata empirical model [7] 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 [8]. 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,

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

Where L_U is the path loss in urban areas in dB, h_{te} 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 $a(h_{re})$ is the receiver antenna correction factor expressed as:

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

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 [9].

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 [10]. 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, [10].

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

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

$$G(h_r) = 20\log\frac{h_r}{3} \qquad 10m > h_r > 3m \tag{5}$$

DATA COLLECTION

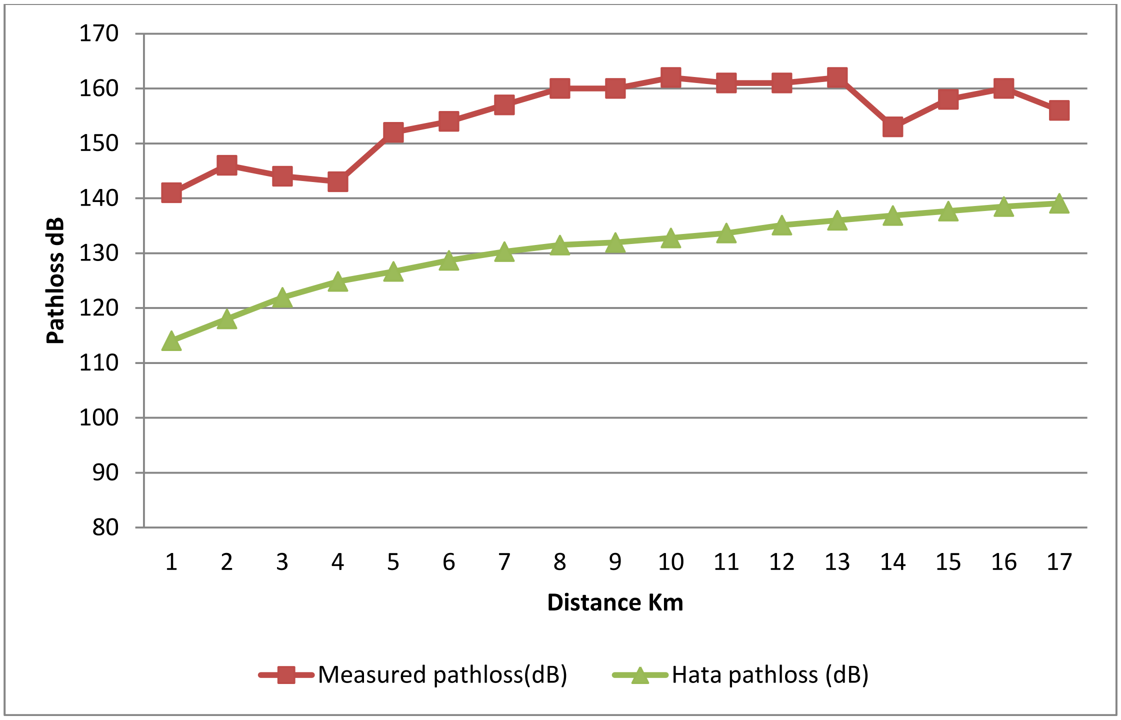
The measurement of the UHF signal strength was taken along various routes starting at the transmission base station. A drive test was taken round Warri/Effurun area of Delta state Nigeria. Devices used where a GPS device, a vehicle for movement and a field strength analyzer capable of measuring field strength of frequencies reaching 2GHz. In each test, the field strength analyzer was set to the frequency of the television station to be monitored (Delta Broadcasting Service) and the field strength is then measured at intervals. Each measurements location is also geo-referenced. Figure 2 shows the Google map of the City of Warri where the measurements was carried out.

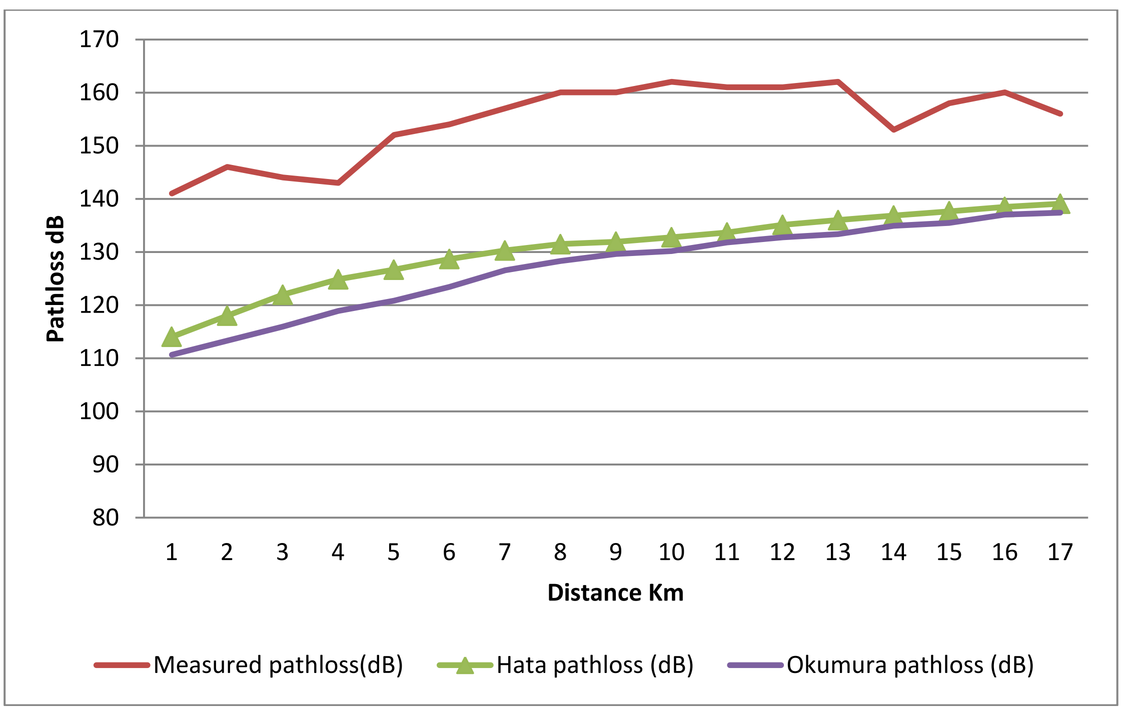
Figure 2: Map of Warri showing the measurement routes.

The Measurement parameters are as given:
Frequency-636MHz
Height of Base antenna- 195m
Power transmitted from basestation-2kw
Height of receiver-1.5m
Transmitter gain – 13dB

RESULTS AND DISCUSSION

The results obtained from the measurements and the prediction obtained from the Hata, and Okumura models in route 1 are shown in the Figures 1 to 3


170
160
150
140
130
120
110
100
90
80
Pathloss dB
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
Distance Km
Measured pathloss(dB)
Hata pathloss (dB)


170
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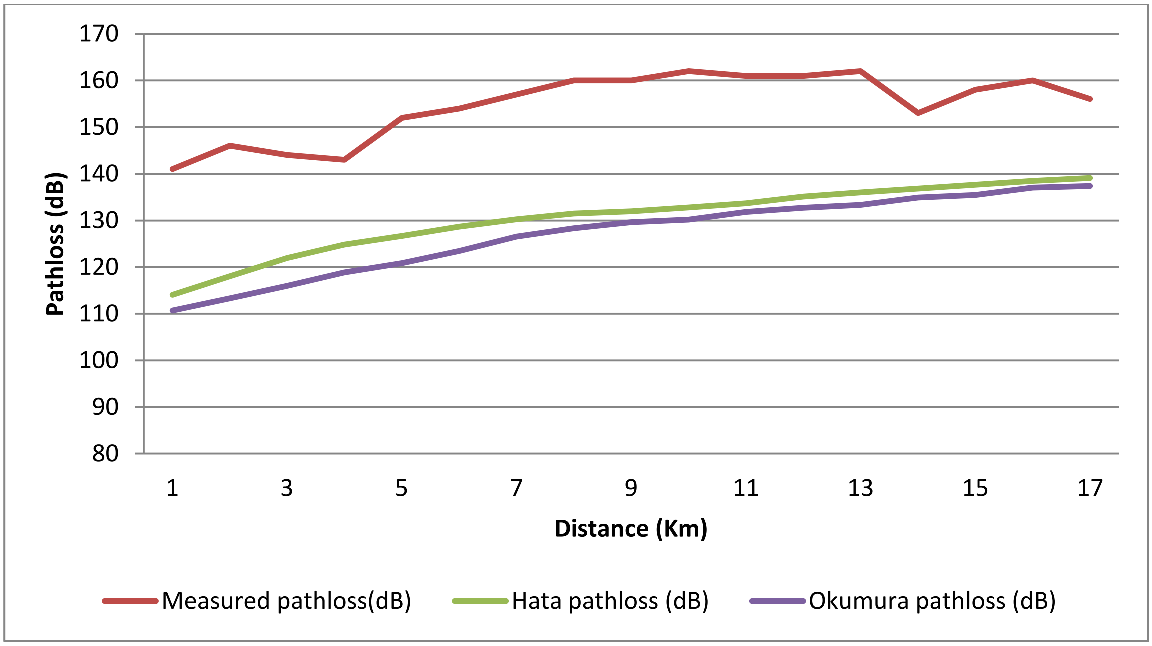
Pathloss dB
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
Distance Km
Measured pathloss(dB)
Hata pathloss (dB)
Okumura pathloss (dB)



A commonly used statistical tool for evaluating propagation models is the mean prediction error and the root mean square error as reported by [3,11,12].The RMSE of a model prediction with respect to the estimated variable X_{model} is defined as the square root of the mean squared error given as; [12]

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}(X_{obs,i} - X_{model,i})^2}{n}} \qquad (4.18)$$

$$MPE = \frac{\sum(X_{Obs,i} - X_{model})}{n} \qquad (4.19)$$

Where X_{obs} is observed values and X_{model} is modeled values at time/place *i*.

Using the equations 2 and 3, the RMSE is calculated to be 24.6dB for prediction from the Hata model why that obtained for the Okumura model is found to be 27.98dB

CONCLUSION

The paper has presented two popular propagation models for radio propagation planning in the coastal city of Warri, Delta state. As with other work carried out in Edo State, these propagation models do not predict the actual pathloss situation in Warri, Delta State as the resultant RMSE values obtained is far in excess of 6dB require for the adoption of a radio model in areas other than where they were developed. However, the Hata model marginally performed better when compared to the Okumura model as shown by the lower 24.6dB value of the RMSE with the Okumura having a RMSE value of 27.98db

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