On The Study Of The Comparative Error Bounds Of Hata And Egli Empirical Prediction Models At Uhf Bands In Edo State

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Abstract- The work presented is aimed at studying the comparative error bound of Hata and Egli radio pathloss prediction model to determine which of the model will better suit television planning in the UHF band of Edo state. Signal strength measurement campaign of selected television stations in the Ultra high frequency UHF band in Benin City was conducted across some selected routes using a hand held spectrum analyzer. The results revealed that for all scenario, both the Egli and Hata pathloss models could not be relied on for effective radio planning in the region as both models exceeded the root mean square error RMSE of 6-7 dB acceptable for the adoption of existing radio propagation models for the planning of new radio communication systems. However the Hata pathloss model prediction gave a better fit to the measured pathloss.

Keywords Pathloss, Signal strength, Egli model, Hata model, UHF.

1. Introduction

Authors should any word processing software that is The starting point in the deployment of radio communication system is to plan how well signals are received within the determined area of coverage. Radio propagation models also called pathloss models are the important tools deployed during such planning stage of a radio communication system. When a signal is transmitted from a given point, it experiences losses which are due to a number of physical factors of the environment through which the signal propagate for example there could be multipath induced fading, Shadowing from tall building, thick vegetation, and even losses due to physical distance of receiver from the transmission the stations. Such losses associated with these phenomenon for a given signal transmission is referred to as the Pathloss. During the planning stage, radio engineers use radio propagation models to gauge the signal levels at determined distances from the transmission end. Radio models are mathematical tools used for the planning, design and implementation of wireless mobile networks (Abhayawardhana 2005). Radio propagation models predicts the acceptable signal levels for a given transmitter-receiver separation distance. They are also very useful for performing interference studies for radio communication system during deployment (Faruk et al, 2013). These models can be broadly categorized into three types; empirical, deterministic and stochastic (Govind 2014). Empirical models are those based on observations and measurements alone (Faruk et al, 2013). The deterministic models make use of the laws governing electromagnetic wave propagation to determine the received signal power at a particular location (Yahia, 2014). Stochastic models, on the other hand, model the environment as a series of random variables, these models are the least accurate but also require the least information about the environment and use much less processing power to generate predictions (Thomas et al, 2001). These models predict the path loss as a function of various parameters like distance, antenna heights frequency of tranmission etc. However to deploy such empirical models, they will need to be tested first so as to determine their suitability. An empirical model of RMSE between 6 and 7 dB is considered acceptable for urban areas (Gupta et al, 2009)

In previous works (Ogbeide et al, 2013, Ogbeide et al, 2014, Ogbeide et al, 2017) the applicability of different empirical models have been investigated for signal propagation in the very high frequency VHF band, however, the current work is aimed at testing the comparative error bounds of the Egli and Hate pathloss models for prediction in the Ultra High Frequency UHF band in Edo State.

2. Materials and Methods

This section comprises of the measurement procedure adopted for the work and a brief review of the Egli pathloss model.

2.1. Measurement procedure for the investigation

The investigation was carried out in Edo state within the south- south region of Nigeria which mainly falls within the tropical climatic zone of west Africa. Edo State lies roughly between longitudes 05° 04'E and latitudes 05°44'N and 07°34'N with an area of about 19,794 square kilometres. Figure 1 shows the digitized map of Edo state and the routes taken in the course of the measurement campaign.

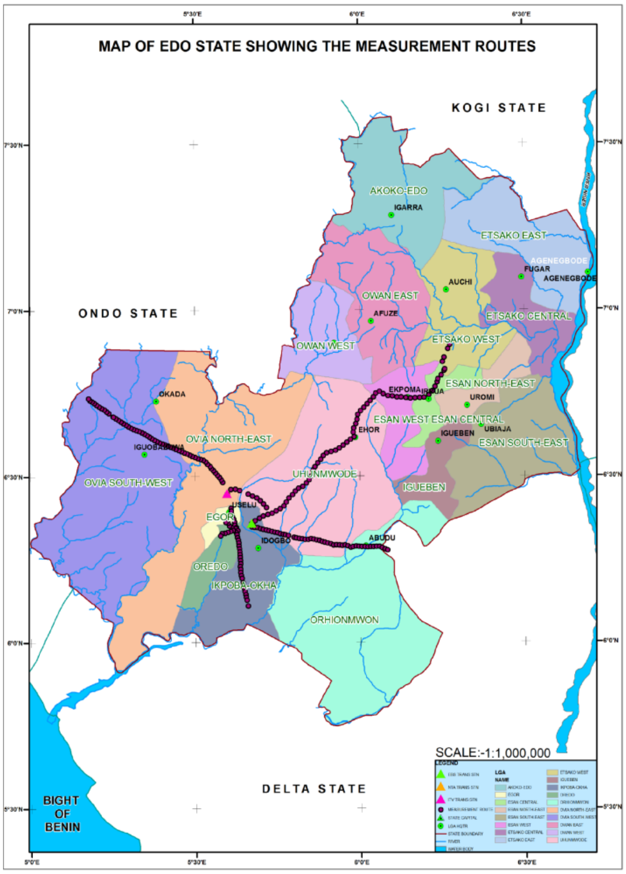


Fig. 1. Digitized map of Edo Sate showing measurement routes

To measure the signal strength of the television broadcasting stations, a portable spectrum analyzer (Sefram 7806 analyzer) was used. It is a battery operated hand-held RF field strength meter capable of measuring radio frequency levels. The instrument provides a reliable measurements across a wide reception range of 45 to 865MHz. The characteristics of the Television station used for the investigation is as shown in Table 1

Table 1. Characteristics of Broadcasting station.

Station	Transmit Frequency (MHz)	Transmitter Height (m)	Channel	Transmitter Power (kW)	Frequency Band
ITV BENIN	479.25	300	22	10	UHF

A handheld global positioning system (GPS) –Garmin GPS 76CS receiver was used for obtaining the spatial coordinates of the various measuring points in angular degrees

2.2. Egli Model

The Egli Model is an example of an empirical radio propagation model for path loss prediction. This prediction model was first introduced by John Egli in 1957 (Egli 1957). This propagation model can be applied at frequencies ranging from 40 MHz to 900 MHz and for distances less than 60 km. The model was developed from measurement data on the Ultra High Frequency and Very High Frequency television transmissions in several large cities and It predicts the total path loss for a point-to-point link (Mardeni et al, 2010). The Egli model is formally expressed as equation 1

$$P_R = G_B G_M \left[\frac{h_B h_M}{d^2}\right]^2 \left[\frac{40}{f}\right]^2 \quad (1)$$

Where:

PT = Transmitted power [W]

GB = Absolute gain of the base station antenna.

GM = Absolute gain of the mobile station antenna.

hB = Height of the base station antenna. [m]

hM = Height of the mobile station antenna. [m]

d = Distance from base station antenna. [m]

f = Frequency of transmission. [MHz]

Equation 1 presented in the logarithm form is shown in equation (2) and (3) for different height of mobile receiver

For hm<10m,

$$Lt(dB) = 20Log(fc) + 40Log(R) - 20Log(hb) + 76.3 - 10log(hm) \quad (2)$$

for hm>10m

$$Lt(dB) = 20Log(f\_c) + 40LogR - 20Log(hb) + 85.9 - 10Log(hm) \quad (3)$$

Since the model typically suitable for communication scenarios for frequency in the range of 40MHz - 900MHz (Mardeni et al, 2010). This the model applies to coverage frequency in the VHF and UHF spectrum transmissions

2.3. Hata Model

Hata model for urban areas, also known as the Okumura–Hata model is a more developed version of the Okumura model, is the most widely used radio frequency propagation model for predicting the behaviour of cellular transmissions in built up areas (Ogbeide et al, 2013). This model incorporates the graphical information from Okumura model and develops it further to realize the effects of diffraction, reflection and scattering caused by city structures. This model also has two more varieties for transmission in suburban areas and open areas.

This particular version of the Hata model is applicable to the radio propagation within urban areas. It is suited for both point-to-point and broadcast transmissions and it is based on extensive empirical measurements.

The Hata model for is formulated as follows (Hata, 1980):

$$LU = 69.55 + 26.16log\ f - 13.82log\ the - a(hre) + (44.9 - 6.55log\ hte)log\ d \quad (4)$$

where LU is the path loss in urban areas in dB, hte is the height of the transmitter antenna in m, hre 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,

$$a(hre) = 3.2(Log10(11.7554hm))2 - 4.97 \quad \text{for } fc \geq 300MHz \quad (5)$$

The pathloss computed from the Egli model equation given in equation 2 is compared with the pathloss obtained from the measurement campaign using equation 4.

$$Pathloss(dB) = Power\ transmitted - Power\ received \quad (6)$$

3. Results and Discussion

The measured path loss and the models Path loss values were computed for the Egli and Hata propagation models and the results are shown in Figures 2 to 7.

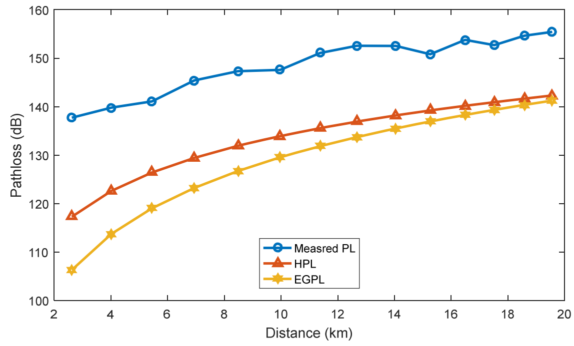


Fig. 2. Measured and models predicted pathloss for route 1

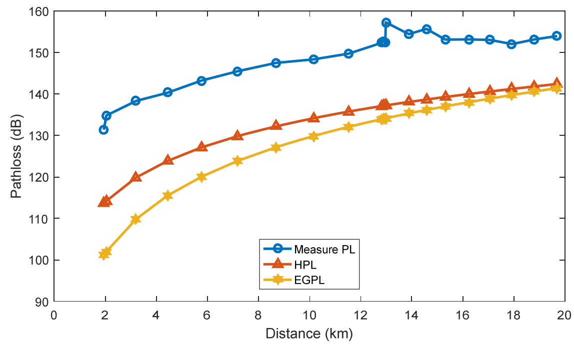


Fig. 3. Measured and models predicted pathloss for route 2

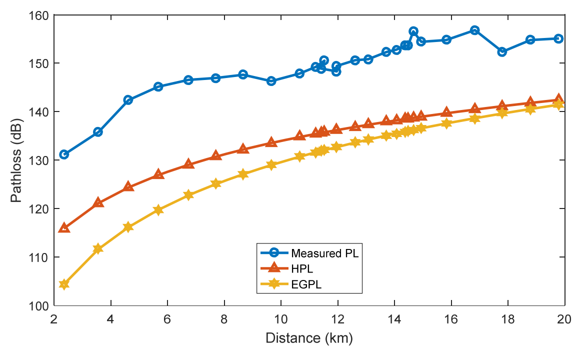


Fig. 4. Measured and models predicted pathloss for route 3

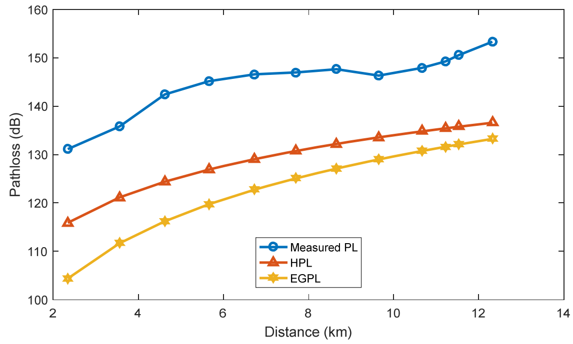
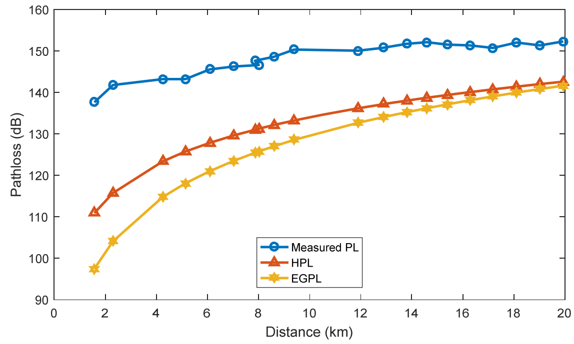


Fig. 5. Measured and models predicted pathloss for route 4



g. 6. Measured and models predicted pathloss for route 7

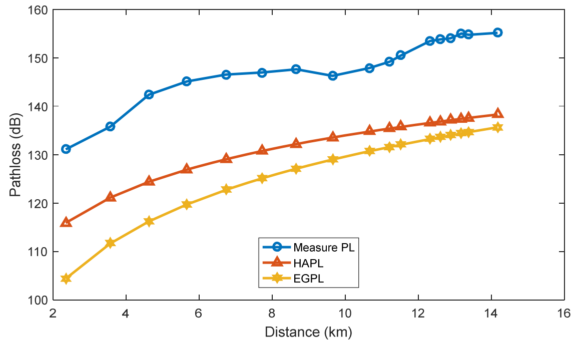


Fig. 6. Measured and models predicted pathloss for route 5

Correlation coefficients are used to assess the strength and direction of the linear relationships between the measured pathloss, Hata and the Egli pathloss prediction using equation 7 and the root mean square error value is determined using the equation 8 .

$$r = \frac{1}{n-1}\Sigma\left(\frac{x-\bar{x}}{s_x}\right)\left(\frac{y-\bar{y}}{s_y}\right) \tag{7}$$

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}(X_{obs,i} - X_{model,i})^2}{n}} \tag{8}$$

The results of the correlation coefficient is as shown in the table 3. Furthermore, the RMSE value was calculated for each route and the results is as presented on table 4.

Table 2. Correlation coefficient of measured and Egli predicted pathloss.

	Route 1	Route 2	Route 3	Route 4	Route 5	Route 6
	Measured pathloss					
Egli model	0.8883	0.9112	0.9584	0.9774	0.9636	0.9177
Hata model	0.8989	0.9214	0.9623	0.9845	0.9765	0.9216

Table 3. RMSE statistical analysis for each route

	Route 1	Route 2	Route 3	Route 4	Route 5	Route 6
	Root Mean Square Error (RMSE) values					
Egli model	19.0835	24.1034	33.3583	55.8726	53.4538	19.5005
Hata model	16.6745	22.2107	30.1254	52.9874	51.3469	16.9768

From the Table 2 and 3, It can be seen that for all the routes investigated, that there was a strong correlation between the measured pathloss and pathloss predicted by both the Egli and Hata models, however the high RMSE values are far above the 0 – 7dB normally accepted for adopting a pathloss prediction models for an environment. However, it is also shown that the Hata model perfomed relatively better than the Egli model predictions for the environment investigated.

4. Conclusion

The comparative error bounds of the Egli and Hata pathloss models revealed that for all scenario, both the Egli and Hata pathloss models could not be relied on for effective radio planning in the region as both models exceeded the root mean square error RMSE of 6-7 dB acceptable for the adoption of existing radio propagation models for the planning of new radio communication systems. However the Hata pathloss model prediction gave a better fit to the measured pathloss.

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