Evaluation of ITU-R Recommendation P.1546 and Consideration for New Correction Factor

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Abstract

ITU-R recommendation P.1546 models is representative path loss model in the frequency range 30~3000MHz over expended area (1~1000 km). It is mainly based on the propagation curves and correction factors are added on that.

In this paper, we compare measurements and prediction and propose several considerations to enhance the prediction accuracy of ITU-R P.1546 model.

1. Introduction

Broadcasting service has to cover over expanded area so it is difficult to predict exact the field strength over the entire service area. Okumura-Hata, COST231-hata and COST231-WI models are known as representative path loss models. ITU-R P.1546 model which is recently developed includes properties of these existing models. But a lot of measurement results showed that error of prediction was still large. In this paper, new correction factor for ITU-R P.1546 model is suggested, which results in the improvement of prediction accuracy

2. Recommendation ITU-R P.1546

This is the for point-to-area prediction of field strength for the broadcasting, land mobile, maritime mobile and certain fixed services (e.g. those employing point-to-multipoint systems) in the frequency range 30 MHz to 3 000 MHz and for the distance range 1 km to 1 000 km. The propagation curves represent field-strength values for 1kW effective radiated power (e.r.p) at nominal frequencies of 100, 600 and 2000 MHz, respectively, as function of various parameters. The field strength can be expressed as

$$E = E_{inf} + \left(E_{sup} - E_{inf}\right)\frac{\log\left[\frac{(d, f, h_1)}{(d_{inf}, f_{inf}, h_{inf})}\right]}{\log\left[\frac{(d_{sup}, f_{sup}, h_{sup})}{(d_{inf}, f_{inf}, h_{inf})}\right]} + C_1 + C_2 \ (dB\ \mu V/m) \quad (1)$$

C_1, C_2 are corrections for receiving antenna height and terrain clearance angle.

$$C_1 = \begin{cases} 6.03 - J(v) \ \ dB & for\ h_2 \le R' \\ K_{h_2}\left(\log h_2 - \log R'\right) \ \ dB & for\ h_2 > R' \end{cases} \quad (2)$$

$$C_2 = J(v') - J(v) \ \ dB \quad (3)$$

$$J(v) = 6.9 + 20\log\left(\sqrt{(v-0.1)^2 + 1} + v - 0.1\right) \ \ dB \quad (4)$$

In this paper, we focus on the C_1 which correction with regard to receiving/mobile antenna height. The field strength values given by the curves are for a reference receiving antenna at height R representative of the height of the ground cover surrounding it. The minimum height is 10 m. Examples of reference heights are 10 m for suburban areas, 20 m for urban areas and 30 m for dense urban areas. A correction depending on the ground cover should be applied if the receiving/mobile antenna height is different from the surrounding ground cover R.[1] Figure 1 is the example of Korean path profiles extracted using self-made GIS in other to produce the predictions. Resolution distance is 50m.

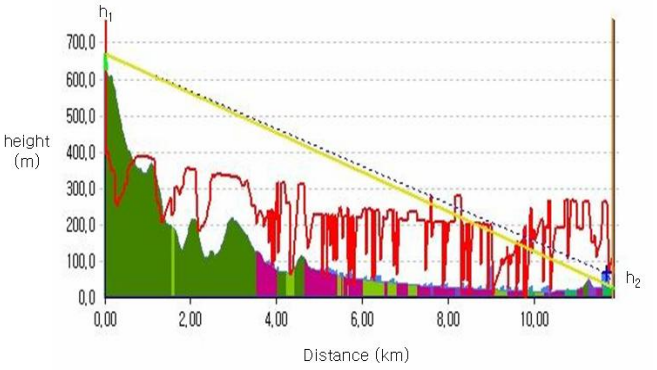

Figure 1 Path profile

3. The comparison of measurements with prediction

We had measured from several reference site; high rise dense urban and urban area. Seoul is represented in high rise dense urban. Urban areas are represented in Busan, Daegu, Daejeon and Gwangju. Table 1 shows measurement results. The mean of the prediction error, e, positive max error, e_p, negative max error, e_n, and its standard deviation, σ_e, are first order statistics traditionally used for evaluating the

accuracy of prediction models. Here, e is defined as the difference between measured values, m_i, and the prediction curve, p_i, on a logarithmic [dB] scale, i.e. assuming that the measured values are exactly correct. The correlation coefficient, r_e, provides a measure of the degree of linear relationship between two random variables and is calculated as

$$r_e = \frac{\sum_i^n (m_i - \overline{m})(p_i - \overline{p})}{\sqrt{\sum_i^n (m_i - \overline{m})^2 \sum_i^n (p_i - \overline{p})^2}} \quad (5)$$

where $\overline{m}$ and $\overline{p}$ are the means of the measured and predicted values, respectively, and N_s is the number of samples. A correlation coefficient close to one indicates a strong linear relationship. Figure 2 represents the CDF of shifted error distribution, which each error distribution curve is shifted as much as mean error.

Measurement		N_s	e	σ_e	e_p	e_n	r_e
Total	R=20	6453	-0.45	13.09	55.01	-34.02	0.824
	R=30	6453	4.47	13.04	21.17	-21.83	0.828
Pusan	R=20	3781	-0.11	14.77	55.01	-27.17	0.775
	R=30	3781	5.14	14.74	60.16	-21.83	0.774
Daegu	R=20	466	-2.58	8.44	13.42	-22.25	0.835
	R=30	466	2.8	10.22	23.45	-34.02	0.765
Daejeon	R=20	1440	0.45	8.34	16.75	-17.87	0.87
	R=30	1440	5.8	8.35	22.04	-12.43	0.869
KwangJu	R=20	769	-5.76	11.69	15.69	-31.82	0.648
	R=30	769	-0.3	11.62	21.17	-26.29	0.651

Table 1 Statistical analysis summary

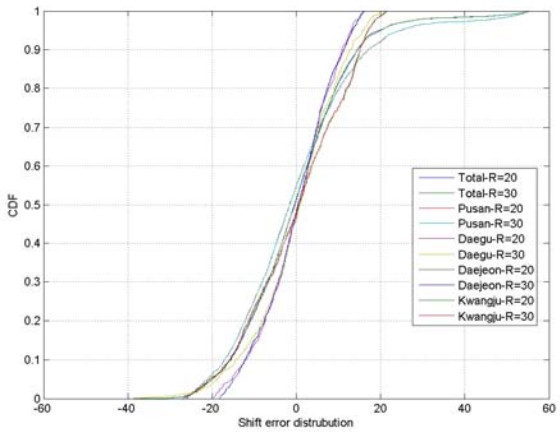

Figure 2 CDF of Shifted Error

4. Conclusions

Like as above equation (1)~(3), correction factors can be categorized two part; C_1 is coupled with receiving/mobile antenna height and receiving environment height and C_2 is related with terrain clearance angle (TCA) which can be derived from the terrain profile between transmitting and receiving antennas. To predict exact the field strength using ITU-R P.1546, we should determine the exact R value. To develop reliable prediction model, more consideration should be taken about the determination of correction with regard to R. Figure 3 shows correction variance with regard to R. It can be changed about to the 25dB. Wrong decision of R make amplitude of error bigger.

In the equation (2), we should insert new correction factor whether the receiving environment is LOS or not. If receiving environment is LOS, correction value much less than that of nLOS environment. So equation (2) should be changed as equation (6). New correction factor, ©, represents environment of receiving antenna and It can enhance the accuracy of ITU-R P.1546. In my next paper, I'll suggest proper value of new correction factor, ©, through ray-tracing simulation and measurement result.

$$C_1 = \begin{cases} 6.03 - J(v) + \alpha \ dB & for\ h_2 \le R' \ \text{(LOS)} \\ 6.03 - J(v) \quad dB & for\ h_2 \le R' \ \text{(nLOS)} \\ K_{h_2}\left(\log h_2 - \log R'\right) dB & for\ h_2 > R' \end{cases} \quad (6)$$

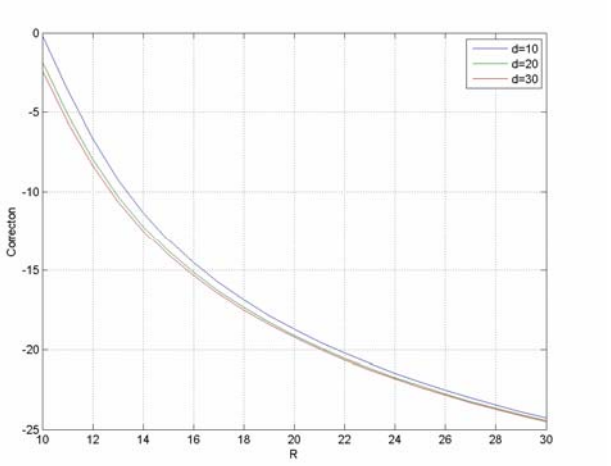

Figure 3 Correction vs R

5. Acknowledgements

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References

[1] ITU-R Recommendation P.1546-2, "Method for point-to-area predictions for terrestrial services in the frequency range 30 MHz to 3000 MHz," Oct., 2001