Comparison of Channel Models for Devices with Low-Height Antennas

Date: 2013-03-20

Name	Company	Address	Phone	email
Gabriel Villardi	NICT	3-4 Hikarion-Oka, Yokosuka, Japan	+81-46-847-5438	gpvillardi@nict.go.jp
Hiroshi Harada	NICT	3-4 Hikarion-Oka, Yokosuka, Japan		harada@nict.go.jp

Abstract

- **We provide a comparison between channel models for links determined by devices with low height antennas, i.e., H-CPE ←→ L-CPE.**
- **The comparison intends to indicate the most appropriate channel model in order to calculate such link budgets for IEEE 802.22b.**
- **Extended-Hata model [4] and the low-height antennas model in [1], [2], were compared with radio propagation measurements of low positioned devices [5], [6].**

Motivation

- **Hata [3] and Extended-Hata [4] models were derived specifically for propagation of highly positioned antennas. In the IEEE 802.22b context, extended Hata models can be useful for link budget analysis of**
  - BS ←→ H-CPE, BS ←→ L-CPE,
  - H-CPE ←→H-CPE, provided that at least one H-CPE ≥ 30m
- **Often, both H-CPE and L-CPE will be placed bellow 30 meters, thus rendering extended-Hata models useless in many circumstances.**

Measurements

- Measurements in [5], [6] present signal levels within suburban houses measured in the 800MHz band. The measurements were made with dipole antennas; the receiver positioned at 9.1 meters while the transmitter positioned at 1.8 meters above ground.
- The height dependence in the data is found to be consistent with the simple model of reflection from the ground.
- Interestingly, these experiments have demonstrated that low-height antennas links have very low frequency dependence.

Propagation Models being Compared

ITU-R P529-3 Extended Hata Model [4]

Correction factor for city size: medium to small
Area type: suburban

b = 1;
a = (1.1*log10(fc) - 0.7)*Hr - (1.56*log10(fc) - 0.8);
Lp = 69.55 + 26.16*log10(fc) - 13.82*log10(Ht) - a + (44.9 - 6.66*log10(Ht))*(log10(d)).^b - 2*(log10(fc/28))^2 - 5.4;

Pr = 10 log(Pt) + 10 log(Gt) + 10 log(Gr) – Lp – B;

Obs: 'Pt' in Watts, 'd' in kilometers, 'Ht' in meters, 'Hr' in meters, 'fc' in MHz, Pr in dB ; 'B' = 5.4 dB, 'Gt' = 'Gr' = 1.65;

Low-Height Antennas Model [1], [2]

Area type: suburban

Pr = 10 log(Pt) + 10 log(Gt) + 10 log(Gr) + 20 log (Ht) + 20 log(Hr) – 43.36 log(d) – A – B;

Obs: 'Pt' in Watts, 'd' in meters, 'Ht' in meters, 'Hr' in meters, Lp in dB; 'B' = 5.4 dB, 'A' = 19.26 dB, 'Gt' = 'Gr' = 1.65;

Considerations – part 1

For Measurements in [5]

Suburban area of small city;

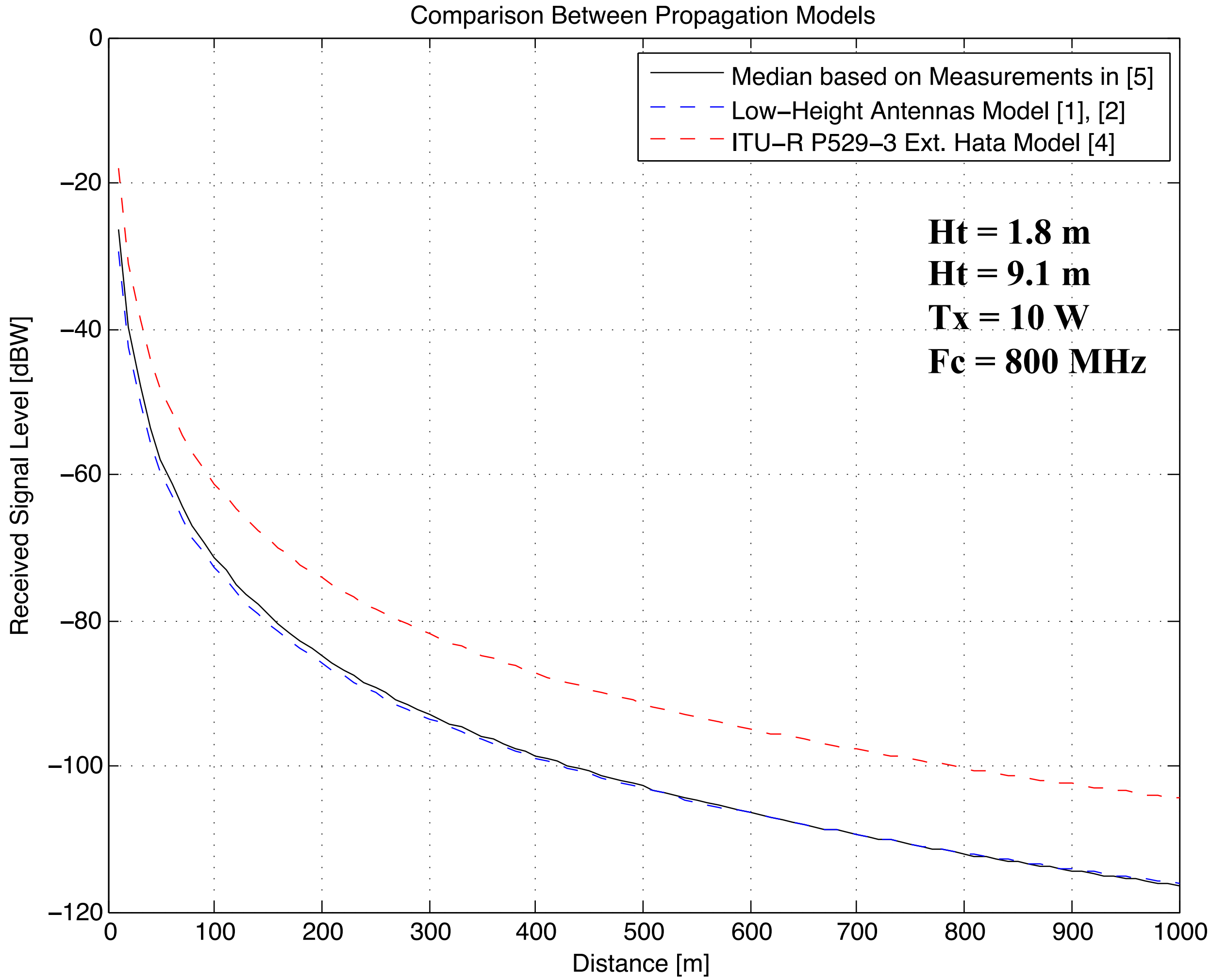
Tx @ 1.8 m (located indoors) is half-wave dipole

Rx @ 9.1 m (located outdoors) is half-wave dipole

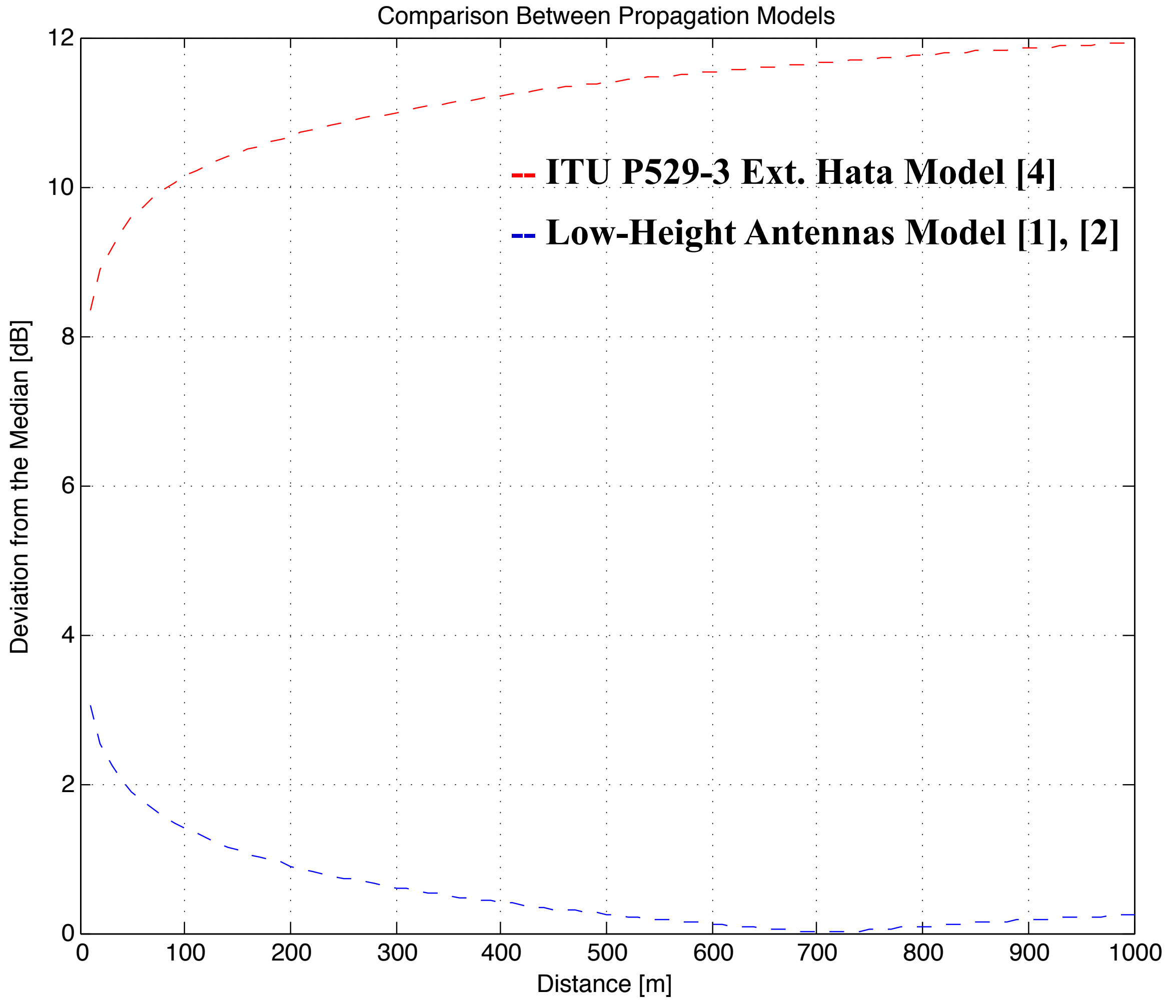
Fc = 800 MHz band

- **Low-Height Antennas Model [1], [2]**
  - Area Type: Suburban
  - Transmitter indoors
  - Receiver Outdoors
  - Tx and Rx antennas gains are 2.15 dBi each;
- **ITU-R P529-3 Extended Hata Model [4]**
  - Area Type: Suburban
  - Correction factor for city size: Medium to Small
  - Transmitter indoors
  - Receiver outdoors
  - Tx and Rx antennas gains are 2.15 dBi each;
  - Frequency is 800 MHz;

Model vs. Measurement – part 1



Model vs. Measurement – part 1



Considerations – part 2

For Measurements in [6]

Suburban area of small city;

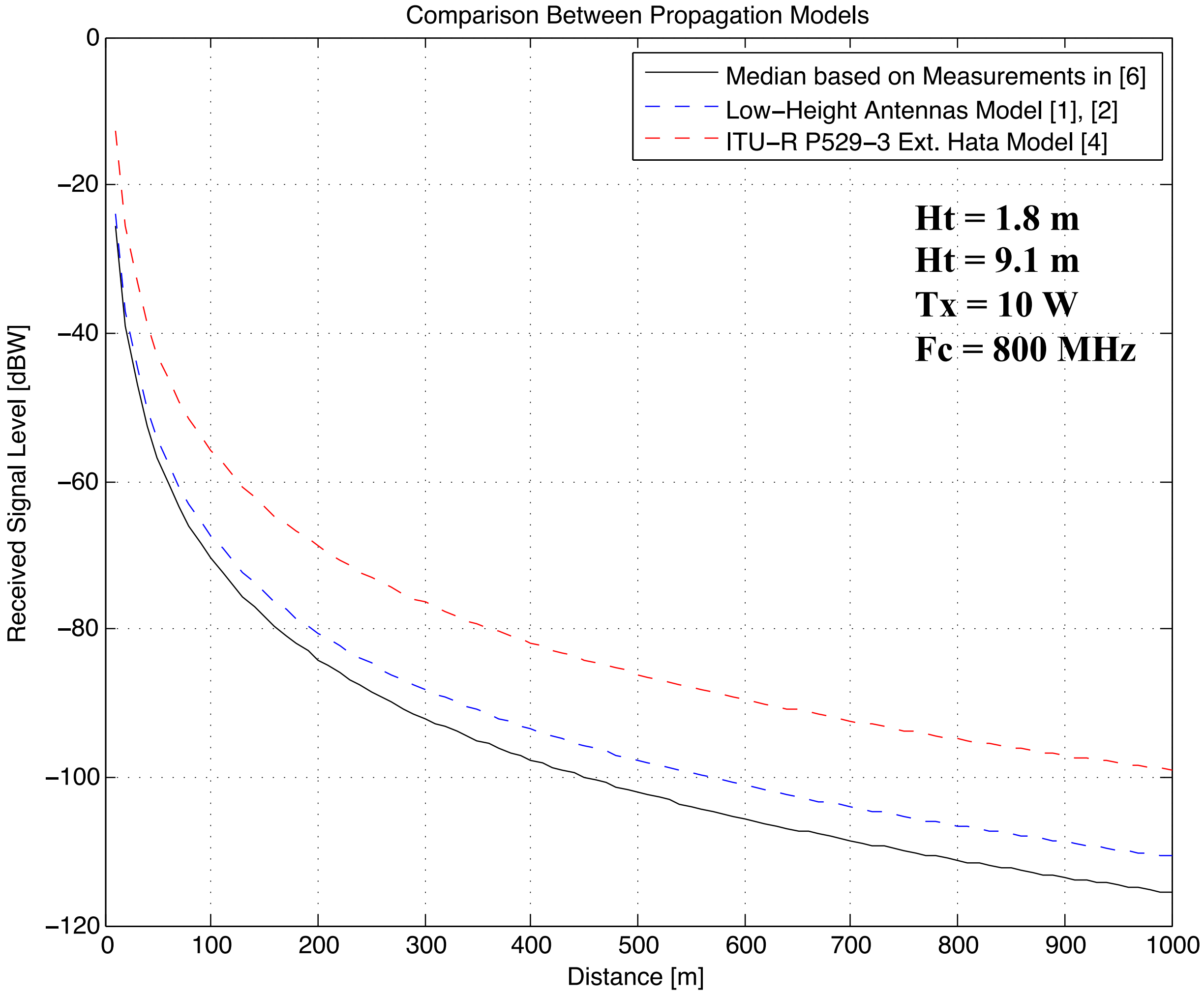
Tx @ 1.8 m (outdoors) is half-wave dipole

Rx @ 9.1 m (outdoors) is half-wave dipole

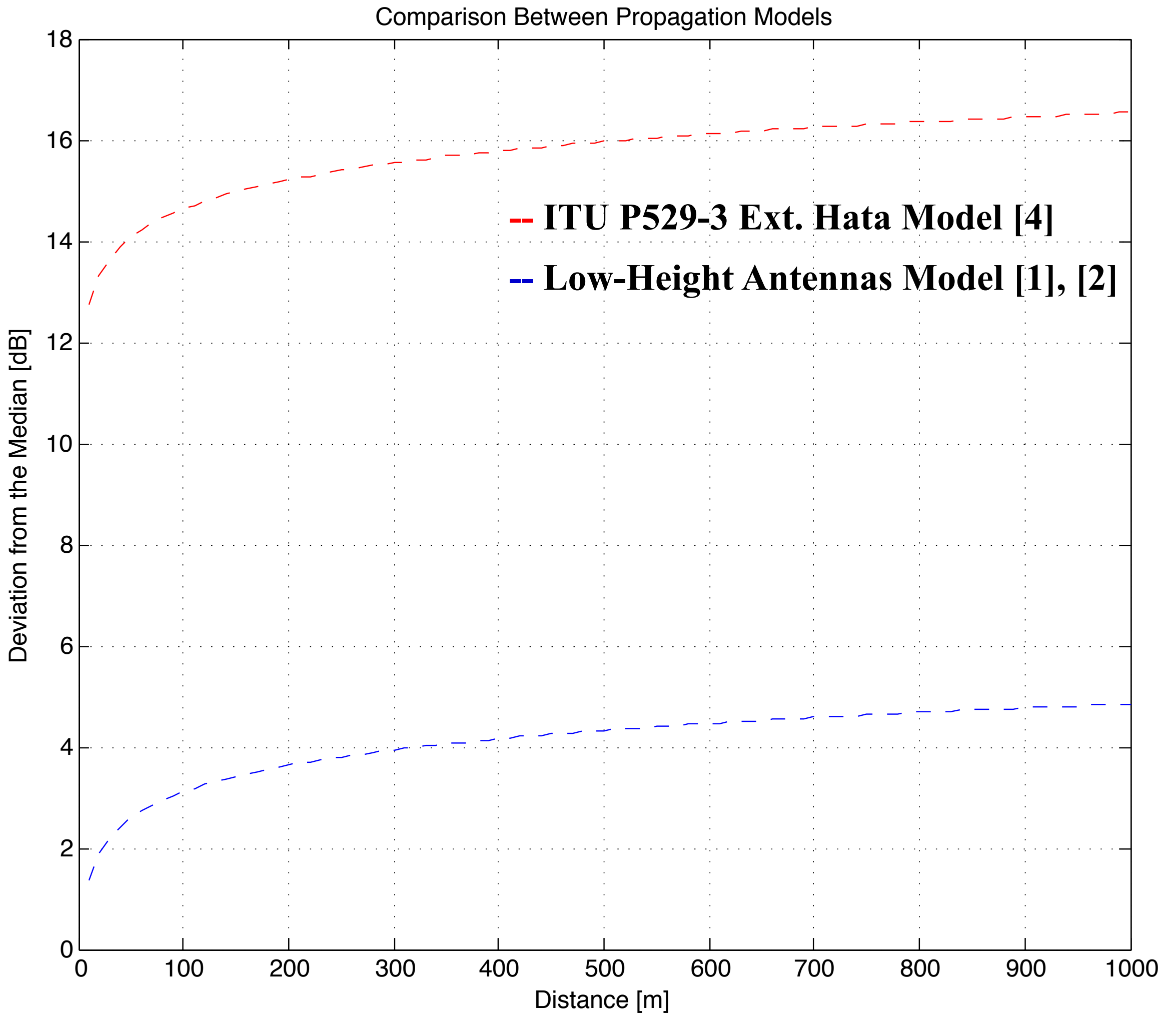
Fc = 800 MHz band

- **Low-Height Antennas Model [1], [2]**
  - Area Type: Suburban
  - Transmitter outdoors
  - Receiver Outdoors
  - Tx and Rx antennas gains are 2.15 dBi each;
- **ITU-R P529-3 Extended Hata Model [4]**
  - Area Type: Suburban
  - Correction factor for city size: Medium to Small
  - Transmitter outdoors
  - Receiver outdoors
  - Tx and Rx antennas gains are 2.15 dBi each;
  - Frequency is 800 MHz;

Model vs. Measurement – part 2



Model vs. Measurement – part 2



Conclusions

- Using models developed for broadcasting services, *i.e.*, Hata [3] and Extended-Hata models [4], can provide very conservative link range estimations for applications in which antennas heights are low. This is due to the fact that the predicted path-loss is smaller than the ones obtained through measurements of low positioned devices [5], [6].
- On the other hand, the model derived for low height antennas [1], [2], has provided path-loss estimation remarkably close the the ones obtained from measurements [5], [6]. It can, therefore, be expected that ranges of links such as H-CPE←→L-CPE will be shorter than previously predicted by the references [7], [8].

References

[1] G.P. Villardi, C.S. Sum, C. Sun, Y.D. Alemseged and H. Harada, "*Efficiency of Dynamic Frequency Selection Based Coexistence Mechanisms for TV White Space Enabled Cognitive Wireless Access Points*", IEEE Wireless Communications, Vol. 19, Issue 6, Dec. 2012.

[2] G.P. Villardi, C. Sun, Y.D. Alemseged and H. Harada, "*Coexistence of TV White Space Enabled Cognitive Wireless Access Points*," Wireless Communications and Networking Conference (WCNC 2012), Apr. 2012.

[3] M. Hata, "Empirical formula for propagation loss in land mobile radio services," *Vehicular Technology, IEEE Transactions on*, vol. 29, no. 3, pp. 317 – 325, Aug. 1980.

[4] "Recommendation itu-r p.529-3, prediction methods for the terrestrial land mobile service in the vhf and uhf bands," ITU-R (P.529-3), Tech. Rep., 1999

[5] Donald C. Cox, Roy R. Murray, A. W. Norris, "Antenna Height Dependence of 800 MHz Attenuation Measured in Houses", IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY, VOL. VT-34, NO. 2, MAY 1985

[6] D. Devasirvatham, "Radio propagation studies in a small city for uni- versal portable communications," in *Vehicular Technology Conference, 1988, IEEE 38th*, Jun. 1988, pp. 100 –104.

[7] Z. Xin, C.W. Pyo, C. Song, M. Zhou and H. Harada, "*Preliminary Link Budget Analysis for IEEE 802.22b*", doc.: IEEE 802.22-12/0055r4, May 2012.

[8] S. Shigenobu and B. Zhao, "*Link Budget Analysis for IEEE 802.22b*", doc.: IEEE 802.22-12/0054r0, May 2012.