Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Additional enhancements to Interim Channel Models for G2 MMDS Fixed Wireless Applications (IEEE 802.16.1c-00/49)**
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Re:	Response to 802.16.3 Call for Contributions (IEEE 802.16.3-00/13) sent September 15, 2000
Abstract	This document provides a list of proposed enhancements to the channel model submitted by K.V.S Hari and Carl Bushue (IEEE submission IEEE 802.16.1c-00/49) on Oct. 30, 2000.
Purpose	For use by the Task Group to consider channel models for comparing PHY proposals against.
Notice	
Release	
Patent Policy and Procedures	

Proposed Extensions to IEEE 802.16 submission "Interim Channel Models for G2 MMDS Fixed Wireless Applications" (IEEE 802.16.1c-00/49) for the 802.16.3 Air Interface Standard

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Introduction:

IEEE submission IEEE 802.16.1c-00/49 provides a good baseline for a channel propagation model. This contribution proposes additional extensions to that model in order to produce a better, more accurate, and more robust model.

The proposed enhancements, with supporting documentation, consist of the following:

Proposed extensions to the model.

1. Scenario / path loss model

Enhancements: Higher CPE antenna cases
Higher base antenna cases

Enhancements: Cost 231 Walfisch-Ikegami model for suburban or urban cases, with examples of parameters to use.

Enhancements: Use of a flat terrain model + terrain diffraction, as an alternative for hilly + light tree density.

Why these enhancements are recommended

MMDS / WDSL deployments could be made with various combinations of BTS and CPE antenna heights. Erceg et al's model [1] concentrates on low heights for both BTS and CPE. To cover a wide range of heights at either end of the link, other models are considered here. It has been found that Erceg's model for his category C (flat, light tree density) is in reasonable agreement with the model recommended below for suburban areas, providing continuity between the alternative models.

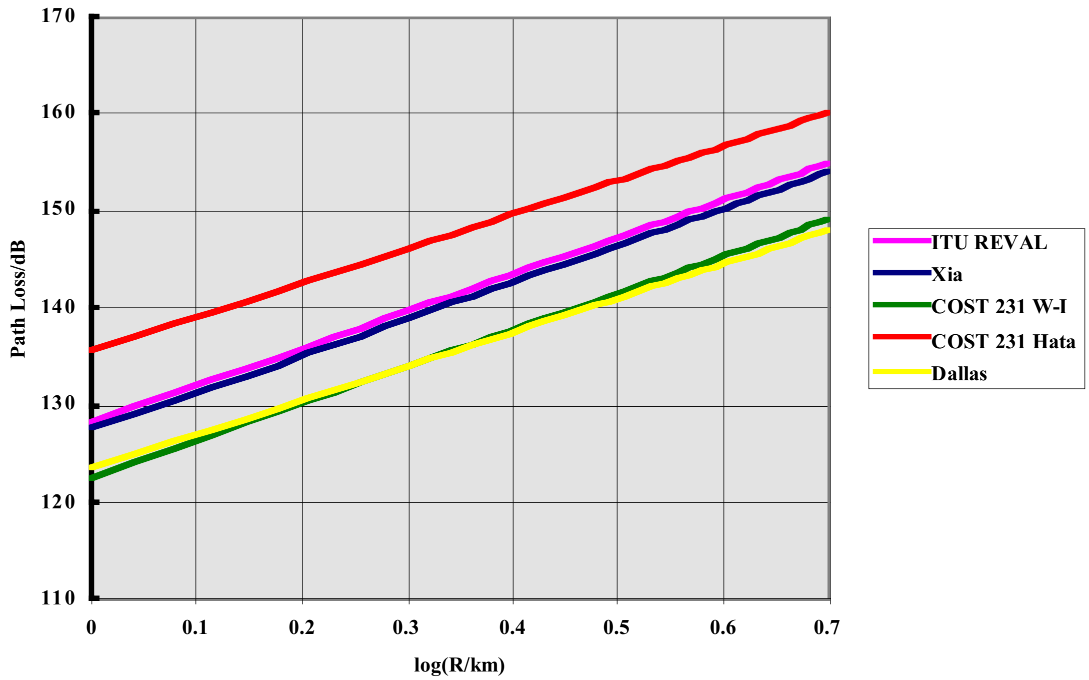


Figure 1. Comparison of suburban path loss models [5].

Figure 1 compares a number of published path loss models for suburban morphology with an empirical model based on drive tests in the Dallas-Fort Worth area [2]. The best agreement is found with the Cost 231 Walfisch-Ikegami model [3], with the following parameter settings:

Building spacing:	50 metres
Street orientation:	90 degrees
Average rooftop height:	8 metres
Mobile antenna height:	2 metres
Base antenna height	30 metres (for the particular comparison above)

It has also been found that the Cost 231 W-I model agrees well with measured results for urban areas, provided the appropriate building spacing and rooftop heights are used. It can therefore be used for both suburban and urban areas, and can allow for variations of these general categories between and within different countries.

The Cost 231 Walfisch-Ikegami model is a ‘flat terrain’ model, and it is therefore recommended that it is used in conjunction with terrain diffraction modeling for hilly areas. In [2] it was found that the weighting term for knife edge diffraction should be set to 0.5 to minimize the log normal standard deviation of the path loss.

(N.B. The Cost 231 Hata model for ‘suburban’ is effectively an urban category.)

2. Multipath Delay Spread

No additional enhancements

3 . K-factor

No additional enhancements

4 . Temporal fading characteristics

Enhancements: Fading cdfs for various K factors. (This shows that deep fades occur for moderate K factors as well as Rayleigh.)

Why these Enhancements are Recommended

Figure 2 shows fading cdfs for various K factors. For example, for K=0 dB (linear K=1) a 30 dB fade occurs 10^{-3} of the time, very similar to a Rayleigh fading case (linear K=0). For a K factor of 6 dB, the probability of a 30 dB fade drops to 10^{-4}. The significance of these fade probabilities depends on the WDSL system design, for example whether diversity or ARQ is provided, and the QoS being offered.

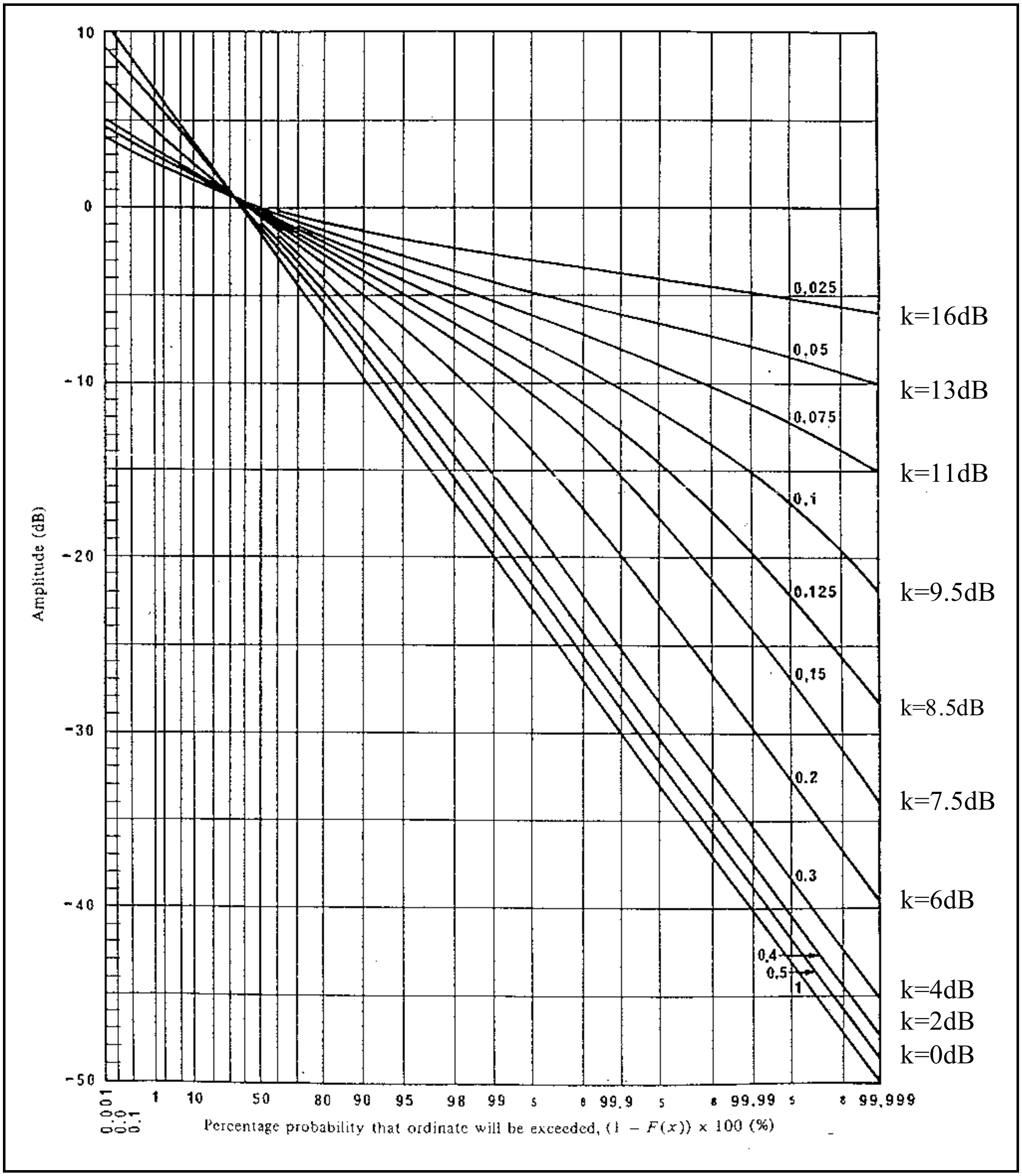


Figure 2. Rician fading distributions.

5 . Co-channel interference

Enhancements: Longer section, including discussion of fade margin, fade mitigation measures to reduce it, effect of these on reuse.

Why these Enhancements are Needed

C/I calculations use a path loss model that accounts for median path loss and log normal fading, but not for 'fast' temporal fading. In the example shown below, a (9,3) reuse pattern has been simulated with r^2 or r^3 propagation, with apparently better C/I for the latter. However for non-LOS cases, temporal fading requires us to allow for a fade margin, the value of which depends on the Rician K factor of the fading, the QoS required and the use of any fade mitigation measures in the system. Two ways of allowing for the fade margin then arise; either the C/I cdf is shifted left as shown below, or the C/I required for a non-fading channel is increased by the fade margin. For example, if QPSK requires a C/I of 11 dB without fading, this becomes 21 dB with a fade margin of 10 dB.

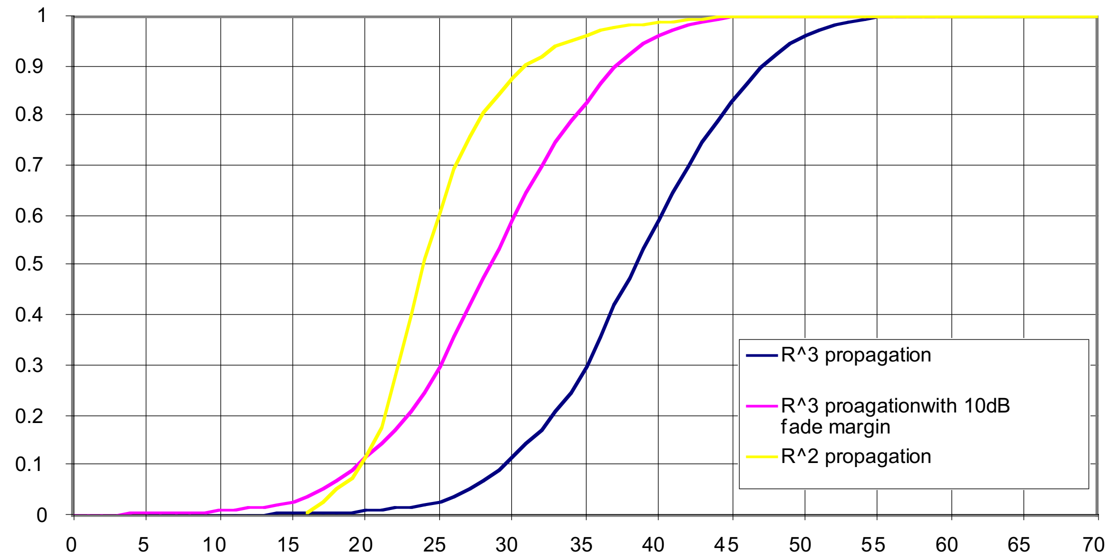


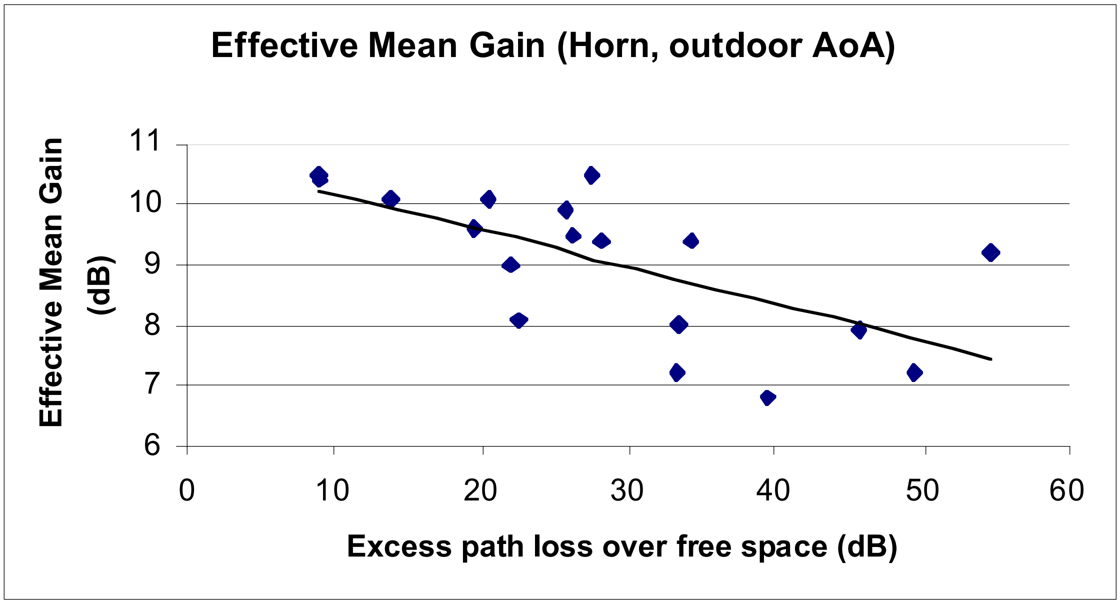
Figure 3. Effects of fade margin on C/I distributions.

6. Antenna gain reduction factor:

Enhancements: Results from our recent measurements showing the relation between gain reduction and excess path loss.

Why these Enhancements are Needed

Greenstein and Erceg [4] have investigated the effects of angle spread on the mean effective gain of the CPE antenna. For a 30 degree beamwidth antenna, they estimate a 4-5 dB gain reduction. However they consider low antenna heights at both ends of the link, and also cases with many trees. They do not investigate the relation between effective gain reduction and excess path loss, which is considered below.



A horn (30 deg. beamwidth) used at 18 suburban sites up to 2 Km range from the base trans mitter.

Figure 4. Effective mean (azimuth) gain for a 30 degree horn [8].

For the results in figure 4, a base antenna height of 22 metres was used, in a suburban area (Harlow, U.K.), in the summer. A 30 degree subscriber antenna was used, raised to gutter height as near as possible to houses being examined. The antenna was rotated in 15 degree steps, and the effective gain calculated from the maximum signal compared to the average signal (signals averaged through any temporal fading). The peak gain is 10.4 dB (this only accounts for azimuthal directivity). The median effective gain reduction was 1.0 dB, for the range of excess path loss seen, 10 to 55 dB. However there was a clear trend for the gain reduction to increase as the excess path loss increases. This is due to the indirect multipaths becoming relatively important when the direct path is heavily attenuated.

7. Multiple Antenna Channel Models (MIMO)

No additional enhancements

References:

[1] V. Erceg et al, 'An empirically based path loss model for wireless channels in suburban environments', IEEE JSAC, Vol. 17, no. 7, July 1999, pp 1205-1211.

[2] M.S. Smith, J.E.J. Dalley, 'A new methodology for deriving path loss models from cellular drive test data', Proc. AP2000 Conference, Davos, Switzerland, April 2000.

[3] EURO-COST-231 Revision 2, 'Urban transmission loss models for mobile radio in the 900 and 1800 MHz bands', Sept. 1991.

[4] L.J. Greenstein, V. Erceg, 'Gain reductions due to scatter on wireless paths with directional antennas', IEEE Communications Letters, Vol. 3, No. 6, June 1999.