Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	Propagation of 5.3 GHz through the Urban Foliated Environment: Summary of Propagation Path Loss and Signal de-Polarization Data
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Re:	IEEE 802.16.3 Request for Channel Models
Abstract	A summary of Propagation Path Loss exponent and De-Polarization measurements taken in an urban environment at 5 GHz. Study focussed on propagation through trees and above the roof lines of houses. Distances of the measurments in the study were 200-2500 meters.
Purpose	To provide the IEEE 802.16.3 (and the WirelessHUMAN) committees with some measured data on which to base propagation models and link budgets.
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Propagation of 5.3 GHz through the Urban Foliated Environment Summary of Propagation Path Loss and Signal de-Polarization Data

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Introduction

This contribution to the IEEE 802.16.3 summarizes propagation path loss (PLE) and polarization isolation measurements that were taken at 5 GHz. This data was gathered specifically to quantify the propagation characteristics of the "Last Mile". Though the data is taken at 5.3 GHz, we feel that it is representative of effect that occur within +/- 500 MHz of 5300 MHz.

Summary of Test Set-Up

In the summer of 1998 the Communications Research Centre conducted a series of tests that quantified the propagation of 5.3 GHz over the roof tops of houses and through the trees surrounding the houses (the urban canopy). Three transmitter sites were set up spaced apart by 1.5-2 Km. These sites were:

Glebe High School (Hub1) : height at 21 meters above street level
Super Eight Motel (Hub2) : height at 27 meters above street level
Riverside Hospital (Hub 3): height at 28 meters above street level

Each site transmitted Vertical polarization, Horizontal polarization and LHCP from highly directive antennas. The anechoic chamber measurements of these antennas is shown in Figures 1-3.

A test van equipped with an adjustable mast which could be raised to 11 and 16 meters above street level spent the summer taking measurements of propagation path loss, cross-polarization degradation, and antenna side-lobe degradation. Measurements were taken at over 90 sites in a 6 kilometer square area.

The van was equipped with 4 antennas which could be rotated and pointed toward the source sites. The van antennas were VP, HP, LHCP, and RHCP. The antenna patterns and cross polarization are shown in Figures 1-4.

Each antenna would be pointed to the source site and measurements would ensue. For example, at any site in the test area, the van would point its VP antenna toward Hub 1 and measure the signal being transmitted from that site's VP antenna, HP antenna, LHCP, and RHCP antenna. All the hub site's antennas would be directed with their boresites pointing toward the van site. This procedure was repeated for each of the 4 van antennas, for each of the 3 hub sites, and at heights of 11 and16 meters. Each measurement was average for 1-2 seconds. These were not long term temporal measurements. The measurements were only conducted on days when there was no significant wind (<20 km/hr) and when the leaves were not soaked with rain. The measurements were taken between May and October, when the trees still had leaves.

The areas in which the measurements were taken are neighborhoods in Ottawa, Canada and are typified by 1-3 story brick and wood frame houses, tall maple, oak, and elm trees (mature trees with heights of 10-25 meters). This neighborhood is typical of many found in the older sections of North American cities.

Propagation Path Loss Exponent

Figures 5 and 6 summarize the propagation path loss exponent that was calculated for all the data. As can be seen, the path loss exponent varies with distance, becoming higher as separation increases. Furthermore, there is also a

noted dependency on height of the receiving station. In free space the path loss exponent would be 2.0. In the measurements it varies between 2.4 and 3.5 over distances of up to 2.5 km.

Polarization Isolation

Figures 7-12 show the depolarization isolation between VP/HP and LHCP/RHCP antennas once the signal has traveled through the urban canopy. Polarization loss in the graphs is defined as the amount of excess signal loss for the signal once all other propagation factors, such as Path Loss Exponent, varying EIRP, cable loss, etc., have been factored into the link equations. Ideally, if there were no environmental degradation, the polarization loss would equal that measured in the anechoic chamber (Figures 1-4)

Conclusion

Propagation of 5 GHz through the urban canopy is affected by foliage and obstructions in the link path. These effects are dependent on the separation and height of the antennas supporting the link.

These results are provided to give some indication as to the effects the environment has on 5 GHz propagation through the urban canopy. The results can be used to test general models that may be developed to characterize this environment.

CRC has compiled a comprehensive file and conducted much analysis on then 5 GHz propagation program. Some of this work will be published shortly.

The raw data base for the testing program is available on CD ROM and includes a high resolution map of the test area that has a position accuracy of +/-0.3 meters and includes the location of all large vegetation, such as trees, in the test area.

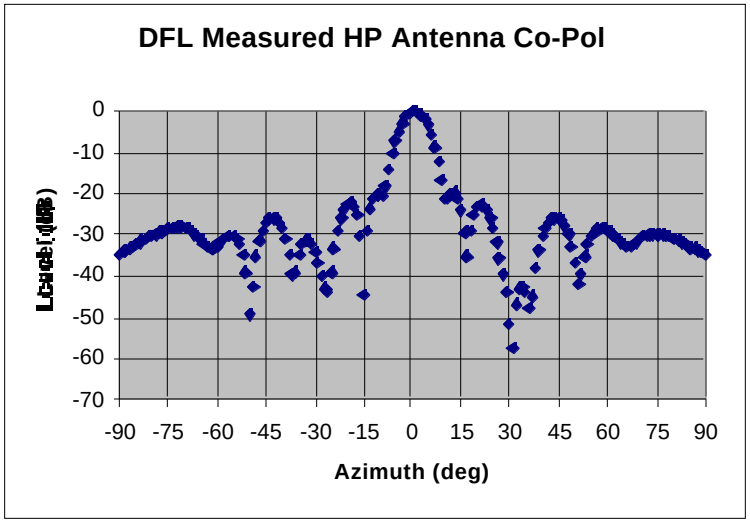

Figure 1. Anechoic Chamber Measurement of HP antenna used in the propagation study Cross polarization at –4 to 4 Degrees Azimuth was approximately –48 dBR

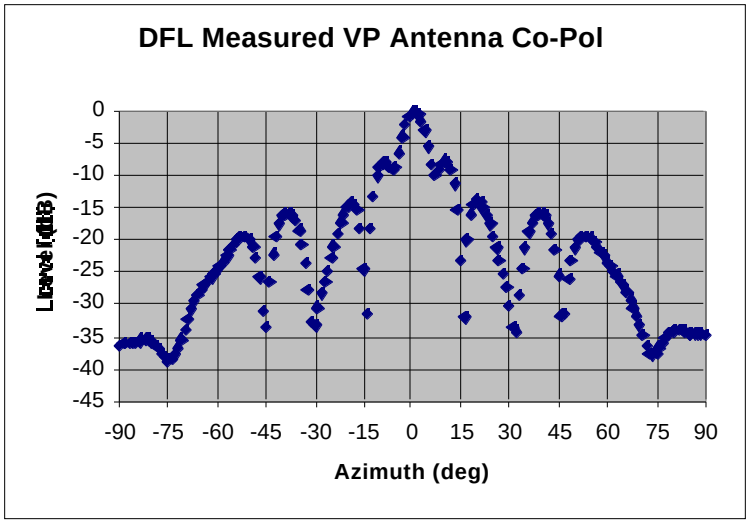

Figure 2. Anechoic Chamber Measurement of VP antenna used in the propagation study
Cross polarization at –4 to4 Degrees Azimuth was approximately –48 dBR

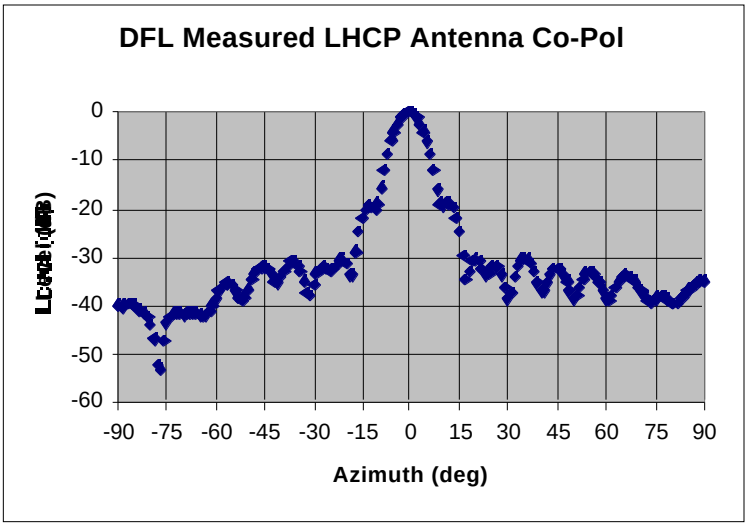

Figure 3. Anechoic Chamber Measurement of LHCP antenna used in the propagation study
Cross polarization at –4 to 4 Degrees Azimuth was approximately –28 dBR

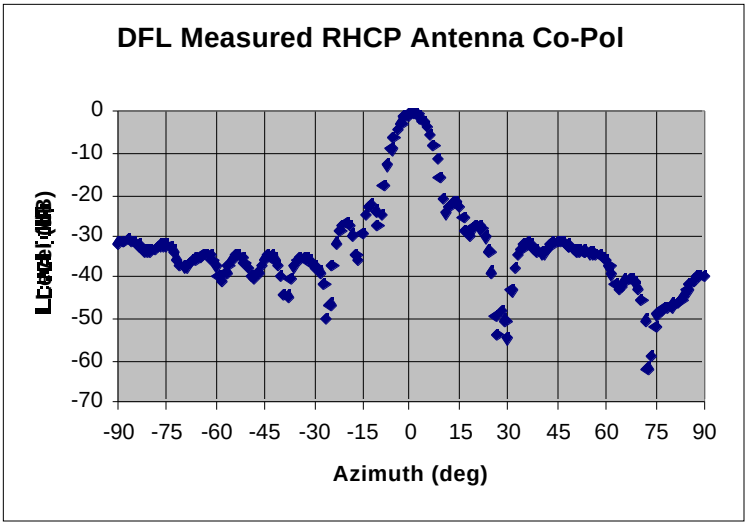

Figure 4. Anechoic Chamber Measurement of RHCP antenna used in the propagation study
Cross polarization at –4 to 4 Degrees Azimuth was approximately –31 dBR

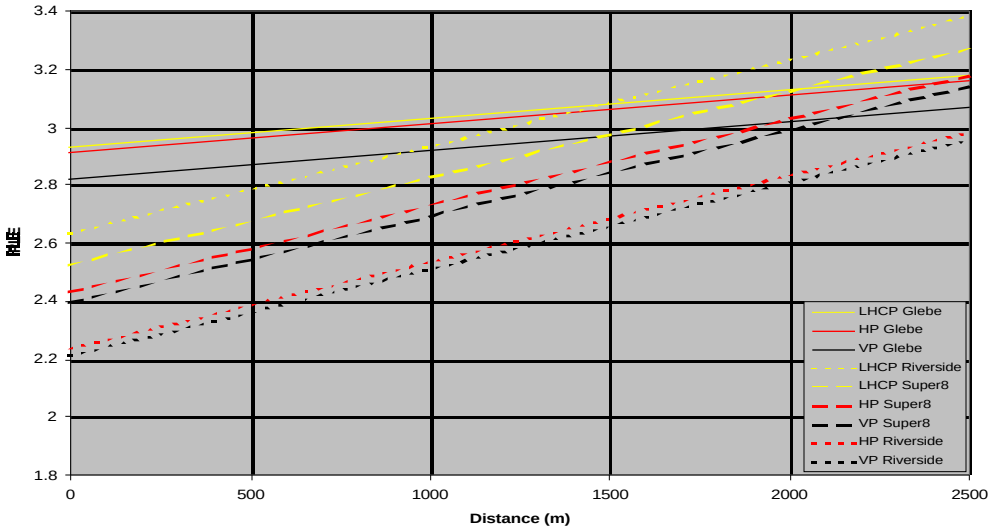

Figure 5. Propagation Path Loss Exponent Variation through the Urban Canopy;
Height of Receiving antenna is 11 Meters

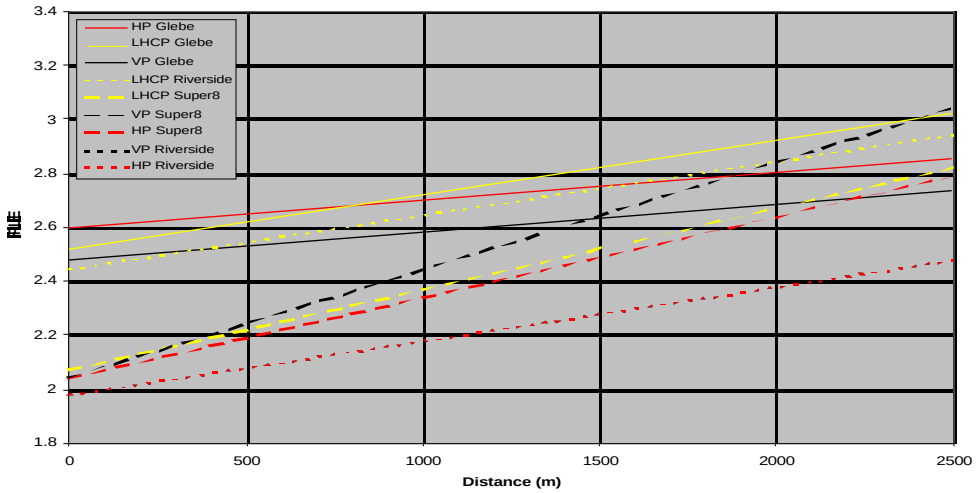

Figure 6. Propagation Path Loss Exponent Variation through the Urban Canopy, RX Antenna at 16 Meter Height

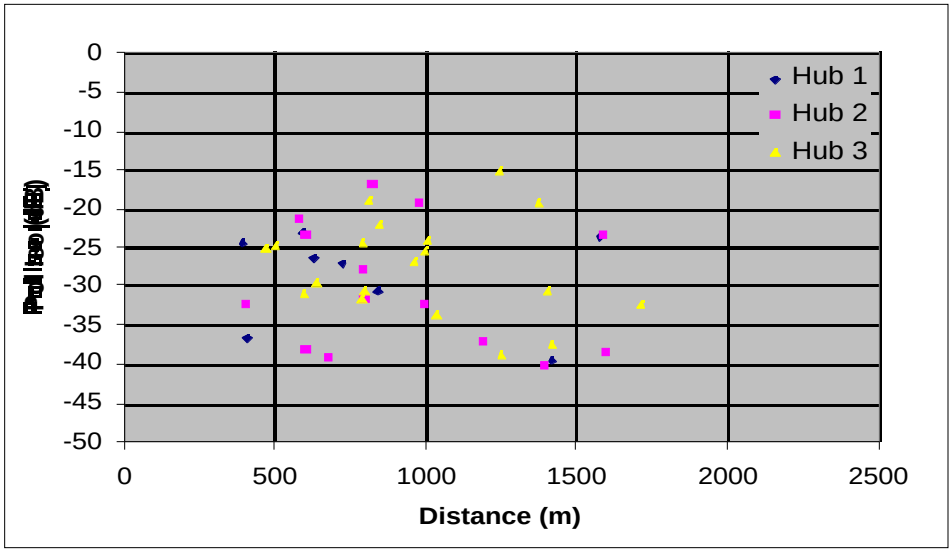

Figure 7. Horizontal (Tx) to Vertical Antenna (Rx) Polarization Isolation; RX Antenna at 11 Meters

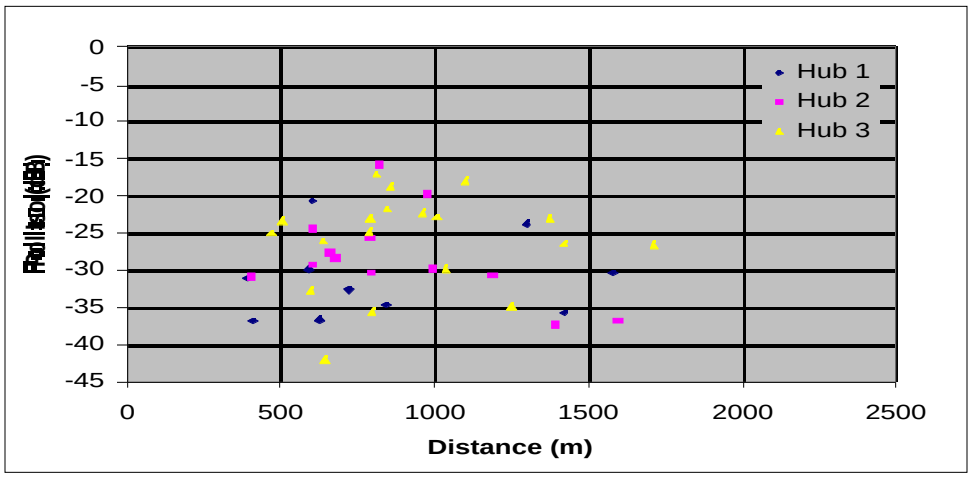

Figure 8. Vertical (TX) to Horizontal (Rx) Antenna Polarization Isolation
RX Antenna at 11 Meters

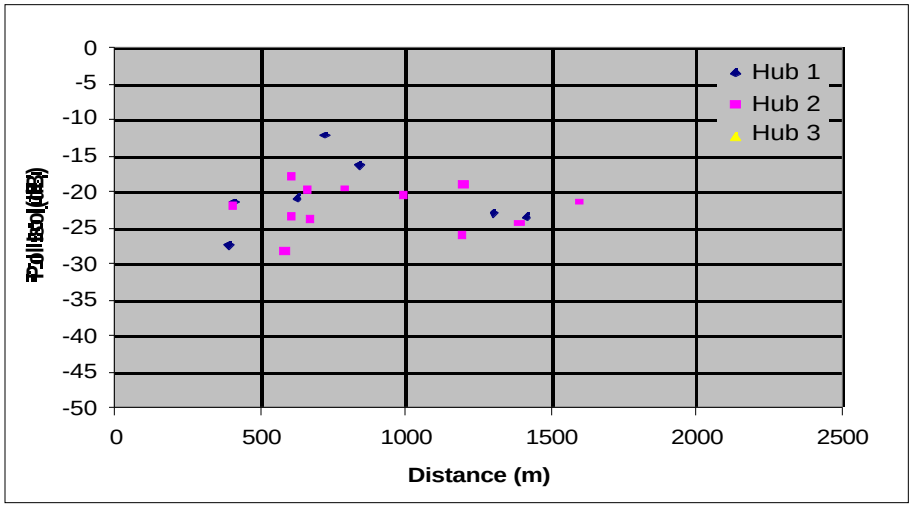

Figure 9. LHCP(TX) to RHCP(Rx) Antenna Polarization Isolation;
RX Antenna at 11 Meters

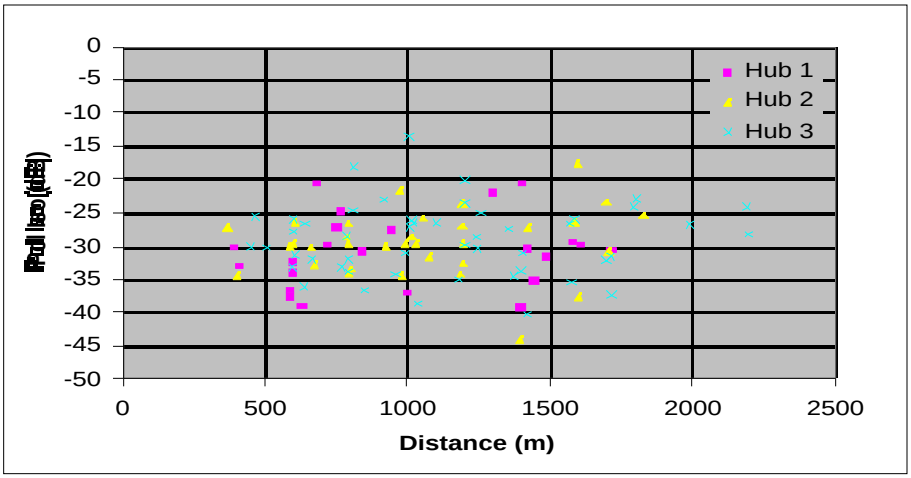

Figure 10. Horizontal Polarization (TX) and Vertical Polarization (RX)
At 16 Meters Height

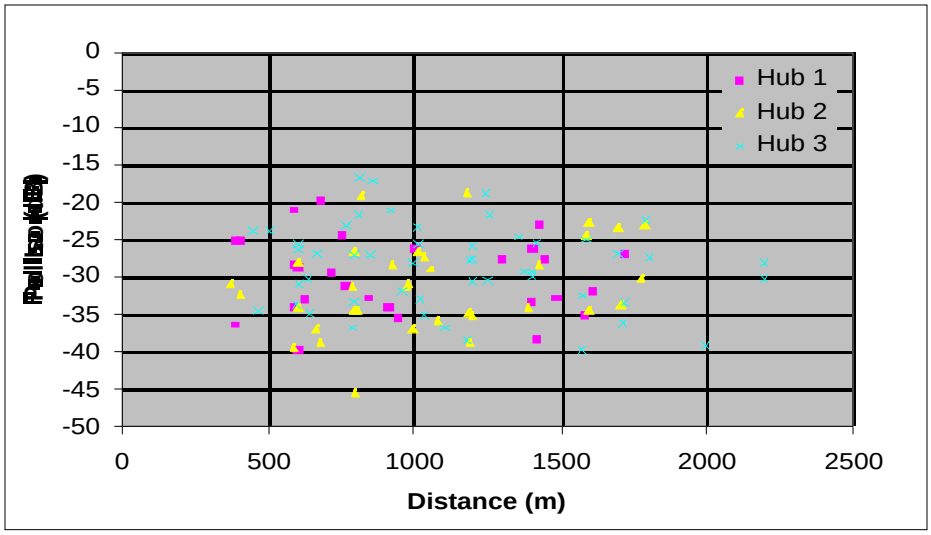

Figure 11. Vertical Polarization (TX) to Horizontal Polarization (Rx)
At 16 Meters Height

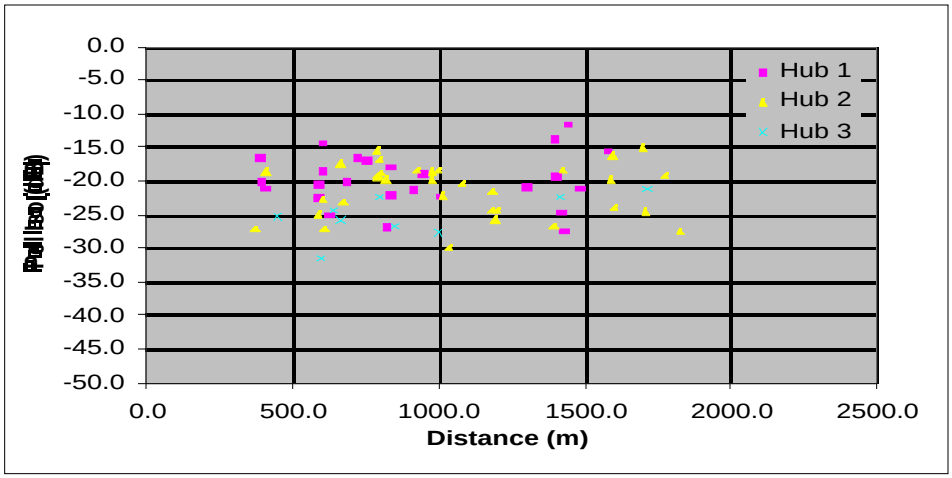

Figure 12. LHCP (Tx) to RHCP (Rx) at 16 Meters