Effects of Trees on Slant Propagation Paths

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Abstract: Limited fade margins on mobile satellite links make communications susceptible to failure when the line-of-sight between the satellite and mobile unit is not free of obstructions. For mobile users in suburban or rural environments, fading caused by trees is the most prevalent situation encountered. In non-arid regions of the world, roads are often lined with trees or pass through forests. Consequently there is a significant probability that the signal to and from a vehicular mobile user has to penetrate through one or more roadside tree crowns, depending on road direction, satellite look angles, and environment. Even a cooperative pedestrian user with a hand-held terminal for a Low-Earth-Orbit (LEO) satellite system can hardly avoid tree shadowing as look angles change continually. The same problem will affect proposed wideband LEO systems at K_a-Band when providing service to single-family residences, as trees adjacent to houses are a desirable aesthetic and energy-saving feature. The wideband signals are also more susceptible to channel distortions in the time and frequency domains. It is therefore necessary to quantify the spatial, temporal and frequency signal variations of slant propagation paths through trees.

In this presentation, we will review measurements and models of slant-path tree attenuation for frequencies from 50 MHz to K_a-Band. The difference between propagation mechanisms applicable to horizontal paths vs. elevated paths will be discussed. Pertinent results include the polarization dependence of both loss and fading on frequencies up to about 600 MHz. For example, the average attenuation due to a single tree is approximately 10.5, 11, and 23 dB at UHF, L-Band and K-Band. Measured median attenuation constants for slant paths through the vegetation vary from approximately 0.05 to 0.5 dB/m from 50 MHz to 400 MHz, 1 to 2 dB/m at 1 to 4 GHz, and 2.5 to 4.5 dB/m at 20 GHz. The possible influence of the measurement geometry on the results will be discussed. The effect of leaves increases with frequency, adding 35% to the dB attenuation at UHF and doubling or tripling it at K-Band. A frequency-scaling relationship will be given.