Foliage Attenuation Model for the Calculation of Forest Path Loss

Mark D. Casciato* *Member, IEEE* and Kamal Sarabandi *Fellow, IEEE*

Radiation Laboratory
Department of Electrical Engineering and Computer Science
University of Michigan
Ann Arbor, MI 48109-2122 USA
email: casciato@eecs.umich.edu, saraband@eecs.umich.edu

The ability to predict attenuation or path loss in a forest in a simple, and yet accurate and more general fashion, is greatly desired by the systems engineer. Physics-based computer models for forest propagation are accurate and more generally applicable, however they involve complicated mathematics and in order to capture the statistical nature of the propagation channel, time consuming Monte Carlo simulations are required. Other commonly used attenuation models are heuristic, based on measured data, and in some cases overly simplified electromagnetic formulations, with little correlation to the physics of the problem. Thus, while simple to implement, these models lack the desired accuracy and generality, in part due to the fact that they are based on a limited measured data set. An example of this is the Weissberger Foliage attenuation model. A heuristic model, based on measured data, the Weissberger model predicts path loss by using an exponential model, which is a function of frequency and distance through foliage in a forest. This model is limited to ranges under 400 m and uses a slightly different formulation for distances under 14 m. It is assumed to be accurate at frequencies through 95 GHz, however, it does not account for the effects of the tree structure, tree density or type, moisture content of leaves, branches, etc., or wave polarization. Also the accuracy of the Weissberger model has been questioned at higher frequencies (11.2 - 20 GHz). (A Generic Model of 1-60 GHz Radio Propagation through Vegetation-Final Report, Rogers, et. al, *Document produced by QinetiQ for the UK Radiocommunications Agency*, May 2002)

In order to significantly improve and expand upon heuristic models like the Weissberger model, while retaining their desired simplicity, a more complete data set is required, however the time and cost required to gather such an extensive data set by a field campaign is impossible. Recent accomplishments in physics-based computer modeling at the University of Michigan's Radiation Laboratory however, allow for the generation of a much more extensive data set, using computer simulations, based upon which, a simple, and more accurate and general macromodel of the mean power attenuation, for point to point propagation in a forest can be developed. The Michigan models, which have had significant validation, are as mentioned, physics-based models, and account for the effects of tree structure, frequency, polarization, distance, and tree density, on the propagating radio wave. These models include near-field effects, which are essential for accuracy, when the radio receiver is near a tree trunk or branch.

It is proposed in this work to develop an improved macromodel for path loss (power) in forested environments, with parameters which allow users to change tree density, and tree height. The model will be developed in a "heuristic" fashion, from data generated by the Michigan physics-based forest models. The proposed macromodel will be more complete than the Weissberger model and will account for polarization effects, tree density, range, and frequency, as well a tree type. Results from the macromodel will be shown and compared to the Weissberger model, measured data, as well as the simulated data set.