The Current State of Radar and Communication Electromagnetic Propagation Models

Abby Anderson* [(1)]
(1) Naval Surface Warfare Center Dahlgren Division, Dahlgren, VA 22448

Numerous applications including communications, radar, and electronic warfare among others require an understanding of electromagnetic propagation and the mechanisms that influence it. Atmospheric conditions, terrain, and geometry all affect how electromagnetic (EM) waves propagate. If unaccounted for in system models, these factors can cause predicted field strength values to be tens of dBs different from actual field strength values, which can result in missed target detections or in communications failures. Propagation models attempt to account for these factors in a variety of ways. The most common methods are parabolic wave equations (PWEs) (e.g. TEMPER, APM, VTRPE), two-ray models (e.g. TIREM, ITM, ITU-R P.452), and empirical models (e.g. ITU-R P. 528, P.1546, Hata). Each of these methods is based on differing sets of principles and design trade-offs which affect the models' performances. PWE models are based on Maxwell's equations and require the most run-time. Two-ray models break the propagation region into three different zones (the line-of-sight zone, diffraction zone, and tropospheric scatter zone), which results in simpler math than PWE models. Empirical models are based on measurements yielding simple, easy-to-use models; however, the measurements can be contaminated for various reasons causing inaccurate results. Users of propagation models need to know the strengths and weaknesses of their particular model in order to understand whether or not results are reliable for a particular problem. A survey is presented to further understanding of the applicability and limitations of various commonly encountered EM propagation models. The survey differentiates between models developed for communications and radar purposes, which affects the appropriate situation in which to use the model. The methods used to model terrain, atmospheric conditions, etc. are compared, and the differences between PWE, two-ray, and empirical modeling principles are expounded. The survey gives the current state of the models and how they are relevant to predicting EM effects on Navy systems.