Propagation Model Development for Short-Range Mobile-to-Mobile Applications

Institute for Telecommunication Sciences (ITS)

- Analysis effort for developing radio-wave propagation models to assist electromagnetic compatibility analysis and spectrum management efforts of mobile wireless devices
- Measurement program to support analysis effort and refine propagation models in different scenarios

With the tremendous growth in the demand for licensed and unlicensed mobile wireless devices, it is necessary to perform electromagnetic compatibility analyses to address the problems of interference between users of the electromagnetic spectrum to accommodate the increasing number and type of these new mobile devices. The evolution of our communications infrastructure depends heavily on these mobile communication devices, and the successful operation of these devices in a crowded electromagnetic spectrum has a very profound impact on our economy. An accurate and flexible radio-wave propagation model is essential for meeting the needs of both the spectrum management process and the electromagnetic compatibility analysis process.

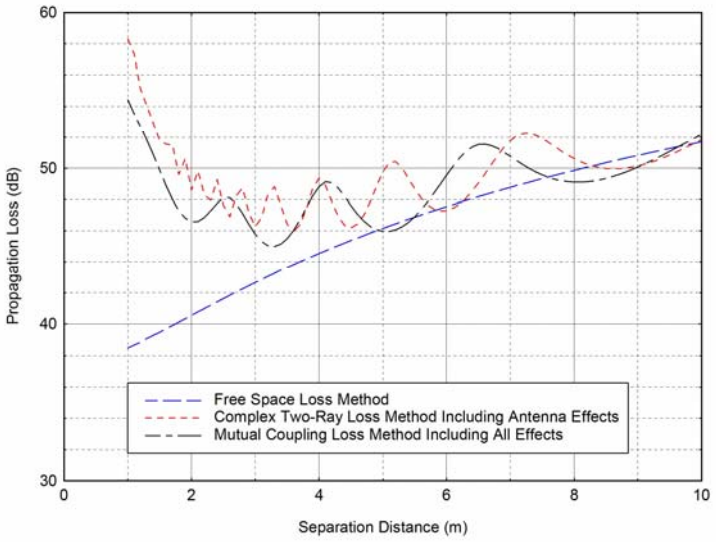
In an Executive Memorandum from the President dated November 30, 2004, the Department of Commerce was requested to submit a plan to implement recommendations that would ensure that our spectrum management policies are capable of harnessing the potential of rapidly changing technologies. These recommendations included providing a modernized and improved spectrum management system for more efficient and beneficial use of the spectrum. In addition, these recommendations included developing engineering analysis tools to facilitate the deployment of new and expanded services and technologies, while preserving national security, public safety, and encouraging scientific research and development of new technologies. In meeting these recommendations in the area of engineering analyses and technology assessments, it will be necessary to determine the best practices in engineering related to spectrum management, and also address the electromagnetic compatibility analysis process.

ITS was tasked by NTIA/OSM to review and evaluate the currently available propagation models and ITU-R Recommendations to determine where they would have applicability for performing the propagation analyses to facilitate electromagnetic compatibility analyses of mobile wireless devices. After performing an exhaustive review of currently available radio-wave propagation models, ITS determined that none of them were suitable for use in analyzing mobile-to-mobile interference interactions. Even though the models that were examined have their own regions of validity with respect to frequency, separation distance, and antenna heights, they were all found to be inadequate for the short-range mobile-to-mobile model requirements of one meter to two kilometer separation distances, one to three meter antenna heights, and a frequency range of 150 MHz to 3000 MHz. Existing radio-wave propagation models are valid only for much higher antenna heights (four meters or greater) and larger separation distances (greater than one kilometer). It was therefore necessary to initiate an analysis effort to develop new models that would be valid in this parameter range.

ITS performed an initial analysis effort and has determined that the development of a model that will provide propagation loss predictions for close-in distances as short as one meter and low antenna heights, requires the use of mutual coupling predictions and should also include the effects of the surface wave, and the near-field effects of the antennas for these frequencies. The antenna patterns or gains of the antennas may not be valid at close separation distances, since they may not be in the far field of the antennas. In addition, the analysis determined that for low antenna heights, the effects of the close proximity of the Earth to the antenna produces a strong interaction of the antenna with ground changing its impedance and thus affecting the efficiency and gain of the antennas.

Investigations of different propagation modeling techniques and the special considerations of a short-range propagation model with low antenna heights have resulted in the development of new approaches to be

taken to accurately model propagation loss in a mobile-to-mobile environment. This initial analysis addressed the line-of-sight propagation environment in an open scenario for vertical polarization. Horizontal polarization will be addressed in future efforts. A hierarchy of approaches was utilized to develop the short-range MTOM model that would account for different levels of complexity from very simplistic models where not much information about the scenario was known, to increasingly more sophisticated models that include all of the above mentioned effects for scenarios where more site-specific information would be available. The Figure shows a comparison of propagation loss versus distance predicted by three analysis methods of increasing complexity and accuracy. Free-space loss is the least complex and least accurate method, and a mutual coupling method including all effects is the most complex and most accurate method. A method of intermediate complexity is the complex two-ray theory with complex reflection coefficient and antenna effects included.



Three Propagation Loss Prediction Methods at 900 MHz for a Transmitter and Height of 3 meters and a Receiver Height of 1 meter.

An initial radio-wave propagation measurement program was also performed in support of the model analysis and development effort to validate and refine the mobile-to-mobile propagation models. Simultaneous wideband (~10 MHz bandwidth) measurements were made over the 150 to 5800 MHz band in various scenarios of antenna-height combinations and separation distances for comparison to propagation loss predicted by the analysis models. The measurement program uses a newly outfitted van for the receiver van with data collection instrumentation, and the RSMS-3 van as the pseudo-mobile transmitter vehicle. The initial testing for a concept demonstration was performed in an environment where it was possible to make measurements at distances ranging from a few meters up to one kilometer. The measurements were performed in two very large parking lots for different filling conditions ranging from empty or sparse vehicle population (approximating a two-ray line-of-sight (LOS) condition) to completely full of vehicles (approximating a heavy traffic LOS and diffraction condition). The measured data from these test results is currently being processed.

Contact: Paul M. McKenna
303-497-3474
pmckenna@its.bldrdoc.gov

Institute for Telecommunication Sciences
325 Broadway, Boulder, Colorado 80305
http://www.its.bldrdoc.gov, **303-497-5216**

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