Propagation and Coverage Analysis over Terrain Profiles comparing Empirical Approaches with Exact Solutions

Celal Alp Tunç*, Ayhan Altıntaş, Vakur B. Ertürk
Dept. of Electrical-Electronics Engineering
Bilkent University, TR-06533, Bilkent, Ankara, Turkey

Mobile radio planning requires the accurate prediction of electromagnetic field strengths over large areas and in a wide variety of environments. There are empirical, intuitive and deterministic approaches for predicting field patterns such as ITU curves, diffraction loss methods, UTD, GTD and parabolic wave equation method. All approaches to the radio propagation prediction present a similar behavior, although they do not give numerically or analytically exact results. In this regard, the problem is concerned with finding solutions and direct approaches to Maxwell's equations, such as integral equation based approaches. Since the numerically exact propagation models could be used to check solutions as a reference, integral equation based methods become desirable. The Forward-Backward method is a powerful numerical technique which is proposed by Holliday *et al.* (*IEEE Trans. Antennas and Propagat.*, vol. 44, pp. 722-729, May 1996) for ocean-like surfaces. Although the Forward-Backward method obtains very accurate results after few iterations, the computational cost for the method is $O(N^2)$. A spectral acceleration algorithm was proposed by Chou and Johnson (*Radio Science*, vol. 33, no. 5, 1277-1287, 1998) for perfectly electrical conducting and impedance ocean-like rough surfaces reducing this cost to $O(N)$. Since the original acceleration becomes not suitable for very undulating geometries, it is modified and adapted to the wave propagation over very undulating surfaces such as terrain profiles by López et al. (*J. of Electrmagn. Waves and Appl.*, vol. 15, No. 8, pp. 1049-1074, 2001). The operational count is reduced to $O(N)$ for undulating surfaces by this modified acceleration algorithm.

In this paper different radio propagation prediction approaches will be compared with reference solutions for larger distances at UHF frequencies. Propagation prediction models are applied over terrain profiles with the help of a computer tool developed at the Bilkent University Communications and Spectrum Management Research Center. The tool is an integrated spectrum engineering and planning software for the simulation, planning and analysis of radio spectrum from 10 kHz to 40 GHz. The coverage analysis of any terrain profile can be made due to empirical, heuristic and deterministic techniques. Various propagation models can be employed for different frequency bands. In the VHF and UHF bands, ITU propagation curves, Okumura–Hata, Walfish-Ikegami or ITU Rec. 529 and 1146 models can be readily employed. Diffraction correction to some of these models can also be chosen. Epstein–Peterson, Deygout and Vogler methods are available for the diffraction correction. The studies are done on a circular sector around the transmitter which is formed by radial paths. In order to improve the accuracy of these propagation models, propagation and coverage analysis results over different terrain profiles will be compared with reference solutions obtained using FB/SA. For certain terrain profiles which this method can not handle, the Generalized FB/SA method will be used.