Satellite-Indoor Channel Modelling by ABT and Reciprocity

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Urban and indoor environments as well as Land Mobile Satellite (LMS) environments has been deeply investigated in order to achieve accurate propagation models and channel characterization. Outdoor to indoor propagation has been also considered in published papers. Nowadays, the research interest is moving toward satellite-indoor propagation because future satellite mobile communication and navigation systems (S-UMTS, Galileo) will need reliable propagation data and models in order to achieve an optimum performance in various kinds of environment. The satellite-indoor environment is characterised by severe attenuation of the signals and strong multipath effects due to reflection and diffraction, which make this environment more stringent than most other typical LMS environments. Even though deterministic electromagnetic models (ray-tracers) based on Geometrical Optics (GO) and Geometrical Theory of Diffraction (GTD) are suitable for this kind of environment their application is rather tangled because of the different computational and algorithmic requirements to model indoor and outdoor environments.

The joined modelling of indoor and outdoor environments is not suitable to put into practice for electromagnetic and computational reasons. From the electromagnetic point of view the typical indoor problem involves a large number of interactions (reflections and diffractions), moreover it may behave like a cavity while outdoor scenarios could require only few interactions especially in rural or suburban propagation. Outdoor and indoor propagation models require different geometrical and morphological details for accurate electromagnetic prediction, e.g. an accurate description of material loss variation with thickness and frequency is required for appropriate modelling of walls and furniture. Urban models frequently neglect some macroscopic architectural details like windows, balconies, verandahs which instead are important for indoor propagation. From the computational point of view it is difficult to obtain a sufficient ray density inside both indoor and outdoor to be sure that at least the main contributions to the field at a given point have been considered. Ray-tracing easily becomes excessively time consuming. Moreover, not all contributions calculated for the outdoor (indoor) environment are necessary to determine the electromagnetic field at some specific indoor (outdoor) locations. Finally, when only either scenario is changed a new complete ray tracing should be launched (J.P.T.Faria and G.L Siqueira, Proceedings SBMO/IEEE MTT-S IMOC, 1, 209-212, 2003).

In this paper we propose a tool that exploits the reciprocity theorem for the electromagnetic coupling between the two environments which are separately modelled by ABT (E.Di Giampaolo and F. Bardati, JEWA 15, 4, 439-460, 2001). The tool avoids the over mentioned computational inefficiencies and electromagnetic inaccuracies of the joined modelling. Numerical examples are provided.