Time-Domain $(2D)^2$ modelling of UWB indoor propagation

G. Marrocco[1], C. Anelli[1] and D. Cassioli[2]

[1] DISP, University of Rome Tor Vergata ITALY

[2] RADIOLABS, University of L'Aquila, L'Aquila ITALY

Ultra-wideband (UWB) is envisaged to be one of the most promising wireless technology for very high data rate communications. The ultimate performance limits of a communications system are determined by the channel it operates in. Realistic propagation models are therefore of utmost importance for system design and testing. A number of UWB channel models and measurements for specific environments, have been recently proposed in the literature (D. Cassioli, M. Z. Win, and A. F. Molisch, IEEE J. Select. Areas Commun., 20, 1247–1257, 2002). However, most of the available models are statistical and strongly site-specific. In this context, numerical electromagnetic propagators could be used to both corroborate the measurements outcomes and to generate synthetic data in a variety of realistic scenarios. Although ray-based propagators, working in the frequency domain (F. Tehoffo-Talom, B. Uguen, E. Plouhinec, G. Chassay, in proc. of Int. Workshop on UWB systems, 61-65, 2004) are traditionally adopted for the indoor characterization, a local computational method such as the Finite-Difference Time-Domain (FDTD) is also attractive because of it offers a natural interface toward the time-domain extraction of channel data. Nevertheless, the involved large computational domain forbids a three-dimensional modeling of the scenario. To overcome this limitation, we propose a computational strategy based on multiple 2D FDTD simulations appropriately combined in the time domain by signal processing. For any given mutual position of the transmitter and receiver (say $\underline{r}_0$ and $\underline{r}_n$) the propagation is decomposed into the superposition of two 2D fields in the horizontal and vertical plane passing through $\underline{r}_0$ and $\underline{r}_n$. However, on moving from a real antenna to two 2D counterparts, the corresponding antenna impulse responses needs to be properly included in order to refer to the same radiator. It is demonstrated that the resulting overall received signal by the $(2D)^2$ approach is $v_{tot}(t) = \frac{w(t)}{\sqrt{ct}}[v^V(t) + \frac{1}{A}v^H(t) * h_z^{TR}(t)]$, where $v^V$and v^H are the received signals computed on the two orthogonal planes, h_z^{TR} is the free-space impulse response of the transmitting-receiving antennas, $w(t)$ is a windowing function, A is an attenuation, and $1/\sqrt{ct}$ is the cylindrical to spherical wave correction. The computational procedure has been validated through an accurate comparison with UWB experimental channel responses (W. Ciccognani, A. Durantini, D. Cassioli, IEEE Trans. Antennas Propagat., 53, 1542-1549, 2005) recorded in the buildings of our University (Fig.1). The electromagnetic simulation permits to reproduce, with reasonable accuracy, the time-domain received signals in LOS and NLOS and allows a correct estimate of the channel parameters such as the path loss and the time dispersion.

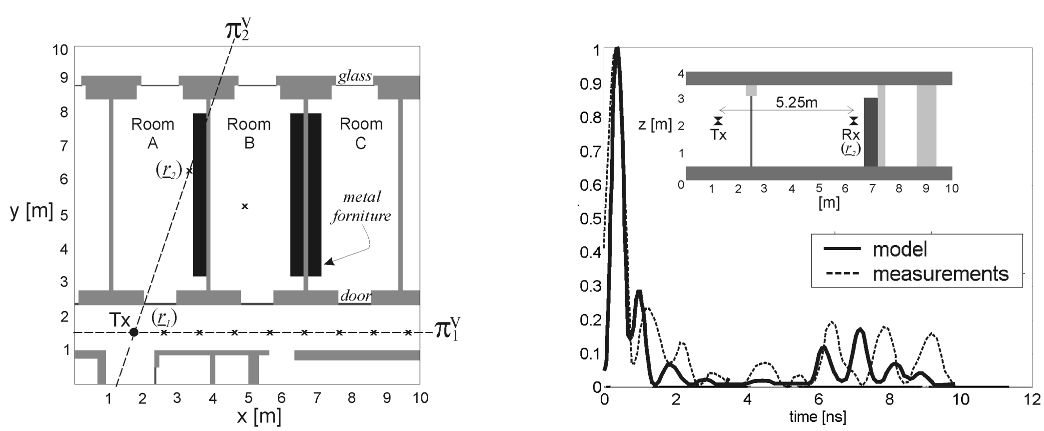

Figure 1: Example of UWB indoor modeling and NLOS prediction at location r_2.