Electromagnetic Wave Interactions Modelling and Uncertainties Management

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Abstract

The modelling of the electromagnetic wave interactions with the environment plays an important role in the analysis and design of complex structures involving radio sources. Antennas installed in their actual environment, platforms, vehicles, buildings, near field wave propagation or interactions with the human body are examples of such systems. Simulation plays then an integral part in the process, complementary to test and measurement. In the field of dosimetry, it is noted that the measurement of SAR (Specific Absorption Rate), i.e. locally absorbed power, is at the moment invasive. The development of numerical rigorous techniques such as FDTD (Finite Difference Time Domain) or asymptotic ones like ray-racing or ray-launching methods or physical optics have greatly contributed in the availability of simulation tools. The FDTD is widely used in the analysis of absorbed power in morphologically realistic phantom models. Asymptotic methods coupled to source models are ideally used for the electromagnetic wave interactions with the environment such as those involved in environmental human exposure to radiowaves.

Accuracy and reliability are key features related to modelling. From phenomena understanding to decision making, the uncertainty related to models has to be determined. Dealing with dosimetry, the quality is clearly not the same if compliance is dealt with or only qualitative results are looked for. Validation of the models is a first step. Comparisons to known solutions or measurements are needed to assess the uncertainty and to build trust in the application of a model. However, uncertainties may be found outside the model. A model can be accurate as long as input data are perfectly known. Unfortunately, the environment or human tissues are typically examples for variability of input data in terms of geometry and dielectric properties. On the other hand, the strength of simulation is to allow playing "what if" scenarios. Thus, modelling can help in the uncertainties management. Sensitivity analysis is such an example. Different techniques can be used : from perturbation theory to brute force Monte Carlo approach. The propagation of uncertainties through the model is a way to determine the statistics of output data, i.e. observables, knowing input data. Management of uncertainties is often already taken into account in worst case studies related to compliance assessment. For informational purpose, e.g. environmental human exposure, the accuracy of the simulations has to be related to the uncertainty of available input data.