Combining Asymptotic Methods and Power Balance Approaches to simulate HIRF HF scenarios

N. Douchin, N. Moreau, G. Moura
OKTAL Synthetic Environment
Toulouse, France
nicolas.douchin@oktal-se.fr

I. Junqua, J-P. Parmantier
ONERA – The French Aerospace Lab, F-31055,
Toulouse, France
isabelle.junqua@onera.fr

***Abstract*— This paper describes the cooperative work achieved in the frame of the HIRF SE European FP7 project to combine a 3D asymptotic software and a Power Balance software. The objective is to assess high frequency EM coupling constraints in a complex system. Each code is briefly described along with its function in the combination scheme. This method has been applied to several HIRF scenarios and validated in the HIRF SE project.**

Keywords-HIRF; software computation; asymptotic methods; shouting and bouncing rays; Power Balance approach

I. Introduction

ONERA and the OKTAL-SE groups have been cooperating for more than 10 years in the development of numerical simulation tools with the ambition to calculate scattered electromagnetic fields at high frequency (the size of the objects is supposed to be large compared to the wavelength) in a complex modelled 3D scene including the environment. This cooperative work has first focused on radar applications [1] and extended to antenna radiation simulation. As illustrated hereafter, more recently both entities have initiated a cooperation on EMC issues in the HIRF SE project. This project aims at providing to the aeronautic industry a numerical modelling computer framework for HIRF aircraft/rotorcraft (A/C) certification purposes.

II. Description of SE-RAY-EM software

The SE-RAY-EM software is based on a combination of Shooting and Bouncing Rays (SBR) technique, that has been optimized to calculate efficiently the intersections between rays from the transmitter towards the 3D database and back to a receiving point, and EM models for computing propagation, reflection and diffraction. These models are the formulations of Geometrical Optics (GO), Physical Optics (PO) and Equivalent Current Method (ECM). An operating strategy enables unified calculation for the near or far EM scattered fields from the scenes. The “forward scattering” approach based on the equivalence principle is also used to compute EM fields in the shadow region. Since it relies on asymptotic methods SE-RAY-EM is well suited for computing the EM interactions of an incident wave with a complex object at high frequencies typically in the 1 – 100 GHz range. In the HIRF SE project SE-RAY-EM is used for computing the EM field on the external surface of the A/C, at the points of entry up to 40 GHz.

The research leading to these results has received funding from the European Community’s Seventh Framework Programme [FP7/2007-2013] under grant agreement no 205294.

III. The Power Balance Method

At high frequency, system cavities as in A/C are electrically oversized. Their geometry and constitution are not fully controlled. Therefore, EM environment in such a system can be characterized by a probabilistic model for which the relevant parameters are the mean power densities, the mean dissipated or the transmitted powers. These relevant parameters are evaluated by the Power Balance (PWB) method, developed by ONERA [2]. The resulting PWB computer code is based on a network representation of EM interactions in oversized cavities, taking into account energetic budgets, such as dissipative effects and transfer of energy between cavities

IV. Combining SE-RAY-EM and PWB

Since the initial problem of EM HIRF HF coupling in complex oversized structure cannot be modelled as a whole, it is split into 2 elementary independent problems:

- The “*external EM problem*”. It consists in solving with SE-RAY-EM the EM interaction between the incident EM interference with the external surface of the A/C.
- The “*internal EM problem*” is solved by the PWB approach to obtain derive internal EM interference. The excitation terms are deduced from the incident EM environment at POE level, previously evaluated.

V. Application Examples

An example of application and validation in HIRF-SE of the methodology will be illustrated on a Piaggio P180 nose cone (Fig.1).

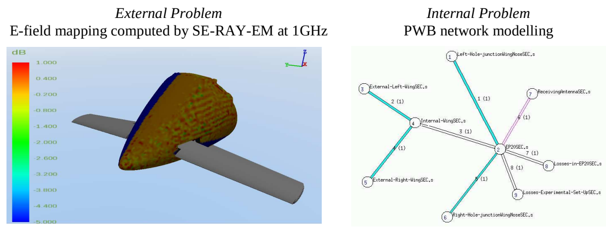

Figure 1. Computed E field on the nose of an aircraft & PWB model.

References

[1] H.J. Mametsa, S. Laybros,& Co, “FERMAT: A high frequency EM scattering code from complex scenes including objects and environment” Progress in Electromagnetic Research Symposium (PIERS 04), Pisa, Italy 28-31 March 2004.

[2] J-P. Parmantier, I. Junqua, “EM topology from theory to application”, In UWB, short-pulses Electromagnetics 7, Volume 7, pp 3-11, Oct 2006.