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Scalable Modeling Strategy for EM Interactions in Composite Electric Aircrafts

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Modern aircrafts massively made of composite non-metallic materials are the subject of the EPICEA collaborative project started in 2016 and gathering partners from Canada and Europe for analyzing the interactions of those aircrafts with electromagnetic (EM) waves from both natural and artificial sources [1]. The target of this study is to develop a scalable model to facilitate the design process of various electric systems mounted on such aircrafts. This model should account for different physical phenomena ranging from EM environment, such as lightning indirect effects (LIE) and High Intensity Radiated Fields (HIRF), and cosmic radiations to onboard systems. In this presentation, few aspects of this study are highlighted for EM coupling aspects in regard to the analytical and practical procedures applied to tackle such a sophisticated problem, as explained below.

Full-wave numerical simulation of complex aircraft indoor environments is computationally very expensive to a limit that makes it unsuitable for practical design and optimization tools. A possible solution lies in what we call "macro-modeling". A first application of macro-modeling, consists in ignoring the small size geometric details of the environment (the inside details of an aircraft, for example). For example, for materials, the electric and magnetic parameters of the details are averaged to represent a simpler combination of effective homogeneous media. Another application consists in decomposing the calculation in such a way that a first calculation is made at large scale and provides input sources to a second modelling problem. For example, for EM coupling on cables, the Field-to-Transmission-Line (FTL) theory is appropriate. Such a macro-modelling strategy has two main advantages. First, it is not as computationally expensive as full-wave electromagnetic numerical simulations. Second, it is based on a deep understanding of the electromagnetic phenomena that appear in media with arbitrary imperfect parameters, providing the necessary calculation mechanisms to EM design and optimization tools at reasonable and practical computational costs.

Current state of the art of metallic aircraft modelling shows that EM simulation based on full-wave simulation techniques, combined to FTL, offer precise simulation of EM interaction on electrical systems for frequencies up to few GHz. At higher frequencies, combination of Power Balance techniques for the inside and asymptotic methods for the outside begin to be used at industry level as an appropriate approach to account for the high sensitivity of EM responses inside aircraft. In all those approaches, non PEC models of materials are already introduced in macro-models of the various solvers used in these scalable approaches in order to describe locally EM losses, EM absorption, and EM transmission.

As far as massively composite aircraft becomes concerned, the weight of material modelling significantly increases to such a point that previously mentioned scalable techniques can be questioned. Controlling the return of currents, the quality of grounding of the electrical system and the bonding between structural parts becomes a much more stringent issue than for metallic aircraft. Massive use of composite materials questions their contribution to current distribution on cables, EM field scattering and antenna sitting. From a numerical modelling point of view all those issues give raise to the main scientific challenges of the EPICEA project which will implement those models and numerical solvers inside the EPICEA modelling platform allowing playing the various modelling scenarios required for this scale modelling strategy.

In this project, the validity of the model is then examined against full wave simulations, and ambitiously against measurement results as well. The simulations are done on commercial EM software packages as well as special purpose codes plugged in the EPICEA platform. The measurements are done by Bombardier Aerospace from Canada, and ONERA from France. The first-year preliminary results of such models will be shown in the presentation.

References

1. Electromagnetic Platform for Lightweight Integration/ Installation of Electrical Systems in Composite Electric Aircrafts, EPICEA, http://epicea-env714.eu/

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