The ARROW Project

Modelling of Lightning Indirect Effects on Composite Aircraft equipped with Current Return Networks

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***Abstract*— The ARROW project (Aircraft lightning thReat Reduction thrOugh Wiring optimization) is a research project, funded by the European Community in the framework of the CleanSky program. The project aims at the development of an accurate and reliable modelling method of the indirect effects of lightning on cable-harness configurations installed aboard aircraft of today's technology, including composite materials and current return networks. The proposed numerical methodology links a three-dimensional full wave electromagnetic solver with a MLTN, which allows design as well as optimization of the wiring itself. This contribution reports about the modelling procedure, the mathematical formulation and some validation results of the developed numerical code.**

Keywords - Electromagnetic modelling, Indirect effects of lightning, Method of Moments, Multiconductor Transmission Lines.

I. Introduction

Modelling of the effect of lightning on cables installed on an aircraft can lead to challenging problems, due to the complexity of the environment and due to the necessity of modelling all the involved electromagnetic phenomena (ohmic losses, skin effect, reactive and radiative coupling, …). Even if it is theoretically possible to carry out an electromagnetic analysis on a model comprising the structures and the wires present in an aircraft, a hybrid field-to-wire coupling procedure [1] can advantageously be employed in order to lighten the models and to make easier parametric analysis on the internal cabling.

In such a hybrid procedure, the 3D EM model of the structural parts is solved through a full wave method without explicitly considering the cables. The Multiconductor Transmission Network analysis (MTLN) is then carried out, by considering a distributed excitation term given by the incident electric field produced by the structural parts onto cable routes. In case of non-fully low-impedance metallic structures (e.g. composite fuselages and/or aircraft equipped with a current return network), the application of such a hybrid method must be validated specifically in the low frequency part for lightning problems. Briefly summarizing, the impedance of current paths on structures and common mode voltages induced by the lightning current on to the non perfectly conducting surface have to be considered; finally, the interaction between the cables and the aircraft (i.e. the p.u.l. [C], [L] parameters) is not evaluated anymore by referring to a return path directly located under the cable. In the following we briefly list the main characteristics of the procedure, and we show a small example of application. A more detailed description of the methods employed in the modelling procedure and examples of its application will be presented at the time of the conference.

II. Characteristics of the Modelling Procedure

The modelling procedure is going to be integrated in the electromagnetic CAE Tool E-MIND [2], devoted to support the user in all the phases of the lightning threat analysis, from the input data import to the advanced output data post processing. The main functions implemented by the integrated tool are briefly summarized in the following:

1. Import of the platform geometry and material properties from CAD and the cable Harness representation from Harness Design Electric CAD;
2. Three-dimensional frequency domain Method of Moments full wave electromagnetic solver (MultiResolution and S-PEEC) reliable from the very-low frequency range;
3. MTLN solver able to consider a not perfect ground by means of a common mode impedance and/or a common mode voltage;

A pictorial representation of analysis environment is shown in Figure 1.

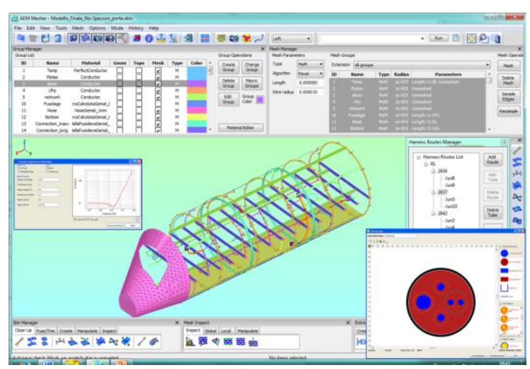

Figure 1. Pictorial representation of analysis environment. Mock up structure built by DEMLAB (Labinal Power Systems)

References

[1] A.K. Agrawal et al "Transient Response of Multiconductor Transmission Lines Excited by a Nonuniform Electromagnetic Field", IEEE Trans. On Electromagnetic Compatibility, Vol. n. 22, 1980.

[2] E-MIND Electromagnetic Multicode Integrated Design Framework, https://www.idscorporation.com/aeronautical/