Clean Sky is the most ambitious aeronautical research program ever launched in Europe. Its mission is to develop breakthrough technologies to significantly increase the environmental performances of airplanes and air transport, resulting in less noisy and more fuel efficient aircraft, hence bringing a key contribution in achieving the Single European Sky environmental objectives.

The Clean Sky JTI (Joint Technology Initiative) was born in 2008 and represents a unique Public-Private Partnership between the European Commission and the industry. It is managed by the Clean Sky Joint Undertaking (CSJU) until 31 December 2017.

The CSJU will deliver demonstrators in all segments of civil air transport, grouped into six technological areas called 'Integrated Technology Demonstrators' (ITD).

ITD Leaders

Each ITD is led by two industry leaders that are committed for the full duration of the CSJU. They are the founding members (with the European Union) of the CSJU.

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Clean Sky JTI
(Joint Technology Initiative)
http://www.cleansky.eu

European Commission
http://ec.europa.eu

Labinal Power Systems
http://www.labinal-power.com

Arrow Project Workshop

Consortium

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ONERA – TOULOUSE CENTER

March 4th, 2015 – 10.00 a.m.

The Arrow Project

The Problem

The metallic bodies of "standard" aircrafts are commonly used as conductive electrical pathways for the return of direct and alternating currents, faults currents, lightning currents… and also other functions related to voltage differentials, electrostatic charge draining, electromagnetic shielding etc. Metallic body solutions are not applicable in composite aircrafts because they don't assure the necessary conductivity, and a dedicated conductive electrical pathway has to be integrated into the aircraft body for this specific electrical pathway function. This network can never be an ideal ground for installed cable-harnesses but also it cannot be as protective as a metallic body respect to the lightning aggression. In this frame, not only the compatibility of the critical/essential electrical and electronic systems with respect to indirect effects of lightning has to be assured, but also the aircraft-structure, the dedicated conductive electrical pathway, the cable-harness configuration and the cable-harness protection must be considered as a whole in order to optimize the overall wiring design and therefore to avoid over-dimensioning which could lead to undesired mass increase.

The Project

A numerical methodology and a CAE tool suited to model user defined cable-harness configurations installed aboard an aircraft made of composite and conductive materials, equipped with an Almost Equipotential Electrical Network is the output of the project.
In particular the **Tool** has to be suited to evaluate the Open Circuit voltage and Short Circuit current waveforms at equipment loads, induced by lightning strikes on the aircraft, in order to allow the verification of their compatibility with the design and qualification values.
The Arrow consortium members strictly collaborated with the ITD Topic Manager Labinal Power Systems.

URL: http://arrowproject.univaq.it

Program

10:00-10:15	*Opening remarks – Scope of the Workshop* **Aldo Bonsignore (IDS)**
10:15-10:45	Introduction to the ARROW Project: *Aircraft lightning thtRreat Reduction thrOugh Wiring optimization* **Jerome Genoulaz (Labinal Power Systems)**
10:45-11:00	Challenges of the Arrow Project **Mauro Bandinelli (IDS)**
11.00-11.30	Coffee-break
11:30-12:00	ARROW -Tool description **Gian Marco Sammarone (IDS)**
12.00-12.30	Application of field-to-TL at low frequency **Jean-Philippe Parmantier, Isabelle Junqua (ONERA)**
12.30-13.30	Lunch
13:30-14:00	Preconditioning and Adaptive Frequency Sampling Techniques **Giulio Antonini (UNIVAQ)**
14.00-14.20	Multi-resolution Method of Moment **Francesca Vipiana (POLITO)**
14:20-14:40	Formulation and Electromagnetic Solver Issues **Alessandro Mori (IDS)**
14:40-15:00	Validation test results **Gianmarco Sammarone (IDS)**
15:00-15:30	Arrow further development **Mauro Bandinelli (IDS)**
15:30-16.00	*Final discussion*

ALEEN modeling

Modeling Tool

The E-MIND electromagnetic CAE Tool (http://www.idscorporation.com/images/aeronautical/homepage/BRO_AERO_EMIND.pdf) has been updated with a new procedure dedicated to ALEENs modeling. The Tool is able:

- to input aircraft and ALEEN geometries and material properties from CAD (e.g. CATIA)
- to evaluate the equivalent impedance matrix at ALEEN terminals in the DC-MHz frequency range, also considering the EWIS and the electromagnetic interaction with aircraft body
- to visualize induced current and voltage distribution on the aircraft/ALEEN.

Methods

A 3D full-wave modeling procedure based on the S-PEEC (Surface - Partial Element Equivalent Circuit) has been developed. This method has special "**low-frequency stability**" and "**high-fidelity modeling**" features. The BLT algorithm already available in CRIPTE (Calcul sur Réseaux des Interactions Perturbatrices en Topologie Electromagnétique) has been also integrated for wiring response.

No "a-priori simplifications" of the geometry (which moreover are scarcely manageable to obtain accurate results in wide band analyses) are required to reduce the condition number. **DC resistance**, **skin-effect**, **inductive and capacitive effects** are represented. Modeling of **composites** through physical and equivalent parameters and modeling of **bonding resistances** are allowed.

An **acceleration method** based on ACA algorithm (Adaptive Cross-Approximation) preconditioned with the Multi-Resolution basis, and **parallel coding** have been applied to allow effective analysis of large structures in a limited amount of time, with currently available HW resources (i.e. no expensive HPC resources are required).

Validation

The numerical models and the Tool have been validated by comparing simulation results with data measured by Labinal Power Systems on an aircraft fuselage mock-up.