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ELECTROMAGNETIC PLATFORM FOR LIGHTWEIGHT INTEGRATION/INSTALLATION OF ELECTRICAL SYSTEMS IN COMPOSITE ELECTRICAL AIRCRAFT

PROJECT OUTCOMES FOR END-USERS

OFFICE NATIONAL D'ETUDES ET DE RECHERCHES AEROSPATIALES (ONERA)

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INTRODUCTION
EXPLOITATION PLAN - DEFINITION

- EPICEA's ambition is to provide an open EMC simulation framework for composite electric aircraft to enable collaborative EMC design by Aircraft Integrator and Electrical (Wiring) Systems suppliers
- The exploitation plan will define all activities at the appropriate level of detail to achieve this ambition
- Stakeholders
  - Solution providers (ONERA, AXE, IDS …)
  - End users (BA, FE …)
  - Certification authorities (…)

INTRODUCTION
EXPLOITATION PLAN IS INTEGRAL PART OF THE PROJECT

- EPICEA project proposal activities have a strong solution provider perspective
  - p. 14: The exploitation plan will be developed and will organize all the necessary dissemination actions to
    - Raise the awareness of the stakeholders to access and use the results (airlines, certification authorities, airframers, systems providers, equipment providers, academic, research centers, etc.)
    - Widely inform the scientific and technical community on project achievements to access and use the knowledge gained *(dissemination)*
  - p. 24: The partners' exploitation plan includes the design of training courses based on the ongoing collect of knowledge generated by the project to be integrated in educational material.
  - p. 27: Table 6: Exploitation plan for education and training of all partners
  - p. 31: To support the exploitation plan and secure the strengthening of the industrials competitiveness and the reinforcement of Research and Education, IPR must be well managed since the beginning of the project.
  - p. 52: WP6 Exploitation plan written from solution provider point of view (AXED)
- And is complemented and completed with a end user perspective
  - p. 53: D6.4; Business case with final exploitation plan. Decision document and plan for the future that projects the likely financial results and other business consequences of the project; AXES; CO; T6.1; M30

INTRODUCTION
OBJECTIVE AND SCOPE (END USER POINT OF VIEW)

- Objective end user point of view
  - Extend EMC models with composite structure material behaviour
  - Investigate how to add value with collaborative EMC design using EPICEA's methodology and tools and explore cosmic radiation
  - Secure a safe and sound design enabling weight and cost reduction

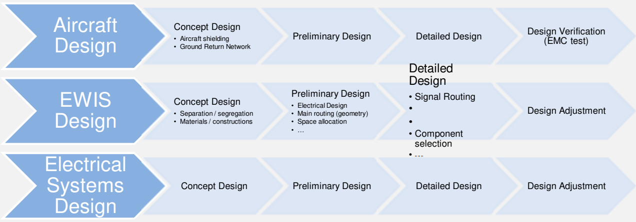
- EPICEA scope
  - Provide a simulation platform that supports assessment of EMC concepts at multiple levels (architecture/topologies, materials, constructions, finishing, shields …)
  - EMC concepts and the development of them is outside the scope

APPROACH

- Vision
  - Collaborative EMC design process between aircraft OEM, EWIS supplier and electrical system suppliers supported by an open simulation platform that can be jointly operated
- Define high level future state design process
- Analyze benefit that can be achieved
- Determine if/how EPICEA support this and what is missing
- Determine way forward towards exploitation (roadmap)

CURRENT PROCESS

- Determine acceptable EMI levels (emission and susceptibility)
- Define aircraft structure and EWIS concepts (architecture / topology / material / shielding …)
- Simulate/calculate/analyse concept
- Trade off and select concepts to be applied
- Make detailed aircraft design and build test aircraft
- Perform aircraft level EMC tests
- Rework the non conformities

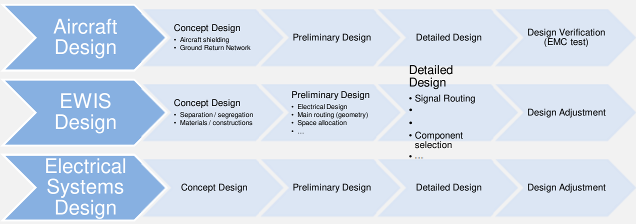


FUTURE STATE PROCESS

TO INCREASE ROBUSTNESS, AFFORDABILITY AND TO REDUCE WEIGHT

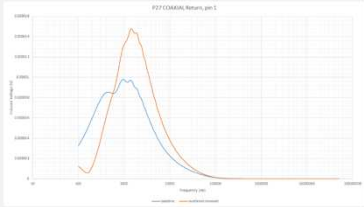
- Determine acceptable EMI levels (emission and susceptibility)
- Define aircraft structure and EWIS concepts (architecture / topology / material / shielding …)
- Simulate/calculate/analyse concepts *of the complete installation and collect more in depth understanding of EMC phenomena to support*
- Trade off and select concepts to be applied
- Make detailed aircraft design and build test aircraft
- *Perform simulation of detailed design*
- *Check margins and increase/decrease protection where margins are low/high Adjust EMC test plan to put more focus*
- Perform aircraft level EMC tests
- Rework the non conformities

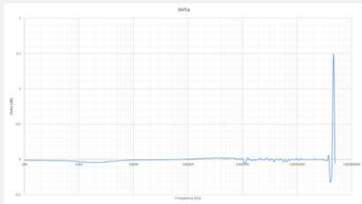
EPICEA added value



FINDINGS

- Experienced simulation abilities
  - Change cable shielding and determine impact
- Integrating EWIS is a tedious job
  - Needs interface to design systems
  - Key figures for single aisle: 50 km cable, 8700 signals, 17500 cables, 48500 pins, 24000 interconnections
- There is more to it than simulation only …





HARNESSES WEIGHT REDUCTION

INTRODUCTION

- Wirings, their shielding and related connectors contribute a lot to weight increase onboard planes.
- In order to reduce energy consumption while flying long distances, aircraft manufacturers are hunting for weight due to cable shields and overbraid
- We cannot reduce cabling weight without first getting back to cables or harnesses main missions on board the planes which are:
  - *To transmit the signal*
  - *To provide the cable core a good shielding effectiveness* in order to avoid the signal to be modulated by electromagnetic unwanted energy

HOW SIGNAL & FREQUENCY

LEAD THE CABLE TYPE CHOICE

- The equipment signal is governed by its frequency the range of which dictates the nature of the box equipment
  - *common mode*
  - *differential mode system*
  - *Non specific mode*
- The frequency range and the nature of the LRU (equipment) will dictate the type of cable
- Single wire → for non specific systems — low and very Low Frequency
- Twisted pair,
- Multiconductors

  → for differential mode systems — *low and* very Low Frequency
- Coaxial cable. → for common mode systems — High Frequency

The frequency and type of system governs the component of the predominant electromagnetic field at which the system will be more sensitive and therefore against which protection is required; Magnetic field? Electricity field?

WHAT THREAT TO WHICH SYSTEM?

- The frequency and type of system govern the component of the predominant electromagnetic field at which the system will be more sensitive and therefore against which protection is required; Magnetic field? Electricity field?

Magnétique field

1. Very Low Frequency systems
2. Low Frequency systems ⟷ H, E field
3. High Frequency systems ⟷ E field

Impedance transfer of cabesl to be determined by the SOFWARE EPICEA and the electromagnetic threat determined in the specifications of the aircraft manufacturer SURBL

OPTIMISATION OF SIGNAL IMMUNITY
AND CABLE WEIGHT REDUCTION

A. Very low frequency link: *Avoid magnetic flux and avoid mass loops*

B. Low frequency link: *Connected at both ends with pigtails*

C. High frequency link : *Terminated at both ends with 360 degree*

Cable shield transfer impedance will be determined with EPICEA Software from electromagnetic threat determined in the aircraft manufacturer specifications

Overbraids

Cables will only be over braided in the belly fairing or in the composite parts of the aircraft, the tail and wings
No overbraid in the metallic fuselage
Overbraid Shield Effectiveness will be determined by the EPICEA sofware

ROADMAP
OVERVIEW

Develop EPICEA and achieve TRL4

---------- End if project ---------- (2019)

Perform (business) case study and determine benefit at aircraft level
(2019-2020)
Increase simulation fidelity (maturation, 2020-2022)
Extend functionality (2020-2022)
Integrate simulation platform in design environment (interfaces, 2021-2023)

--------- Enter aircraft program – e.g. BA Challenger NG ---------- (2023)

Exploit

ROADMAP: CASE STUDY

- Define case that is agreed representative for next generation aircraft
- Apply future state design process
  - Define criteria
  - Define concepts
  - Simulate
  - Perform trade off concept
  - Analyze
- Substantiate benefit that can be achieved (robustness, weight, affordability, NRC/design effort)
  - Estimate/quantify benefit of better control on integrated EMC solutions, less EMC aircraft level EMC tests, shield reduction, manufacturing cost reduction for shielding, reduced rework …

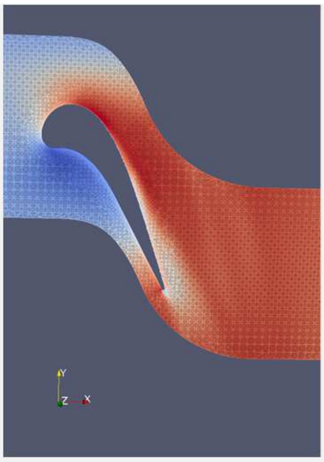
ROADMAP – INCREASE MODEL FIDELITY

- TRL5 and up required a higher or a more substantiated model fidelity
  - TRL3: Some experience of the analysis method within the company but verification data and design criteria are limited. Input data are estimates and of poor quality.
  - TRL4 and 5: Analysis method used for a period of time and the method is validated with a few measurements and tests. Input data are of reasonable quality.
  - TRL6: Analysis method used for a period of time and the method is validated by measurements and tests of relevant components in subsystem environment. Input data are of good quality. Deliverable Analysis report with TRL statement and supporting evidence. Design Practice Created and Signed off.
- EPICEA is at TRL4, FE is at TRL3 – need to have access to more input data
- To gain TRL: use measurements form previous and new projects
- To improve gaining TRL: shorten iteration loop between test – adjust model (EPICEA applied single loop, more agile approach is necessary)

Business readiness will be developed outside and aligned

ROADMAP – EXTEND FUNCTIONALITY

- To support operation
  - Interface between design systems and EPICEA applied AMELET HDF (to be done by end users)
  - Extend functionality to interface aircraft geometry and with intelligence (EMC relevant properties)
- To extend scope (opportunities)
  - To assess aircraft internal generate radiated emission caused by Hybrid Electric Aircraft enables (power electronics and multiphase power feeders, aircraft internal generated fields)
  - Applicability for transport sector? (automotive, ships, trains …)



SUCCESS CONDITIONS

- Open platform
  - You can keep using your tools
- Joint operation of solution eco-system
  - Solution provider, aircraft OEM, system suppliers for context
  - System integration design
- Keep momentum
  - Gain experience, evidence and confidence
  - Bridge the gap between end of project and successor research (HIRF SE < … > EPICEA)
- Willingness
  - Persistence
  - Part of the stakeholder strategy

CONCLUSIONS

- Challenges
  - Keep momentum
  - Get it in place for next generation aircraft

- Lessons learned:
  - Need an agile approach for platform verification

- EPICEA added value
  - Support to reduce weight and costs and to increase robustness
  - Support in developing insight

THANK YOU FOR YOUR ATTENTION!
ANY QUESTION?

THANK YOU

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