Book of Abstracts

MEA'24

MORE ELECTRIC AIRCRAFT CONFERENCE

Toulouse, France

2024, February 7-8

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MEA'24 | FEB. 7 > FEB. 8 TOULOUSE - FRANCE

Welcome to MEA'24

It is with great pleasure that we welcome you to Toulouse for the new edition of the More Electric Aircraft conference.

Ongoing research and investment in air transport is driven by the ambition to increase the efficiency of aircraft, thereby reducing fuel consumption and carbon emissions. Another goal is to reduce operating costs and increase reliability. Given the economic and societal context, these challenges are of major importance. Developments to address these critical requirements rely on the design of innovative aircraft propulsion systems (all-electric, hybrid or turboelectric, potentially distributed), which will significantly increase the electrical power requirements and impact the aircraft power architecture...

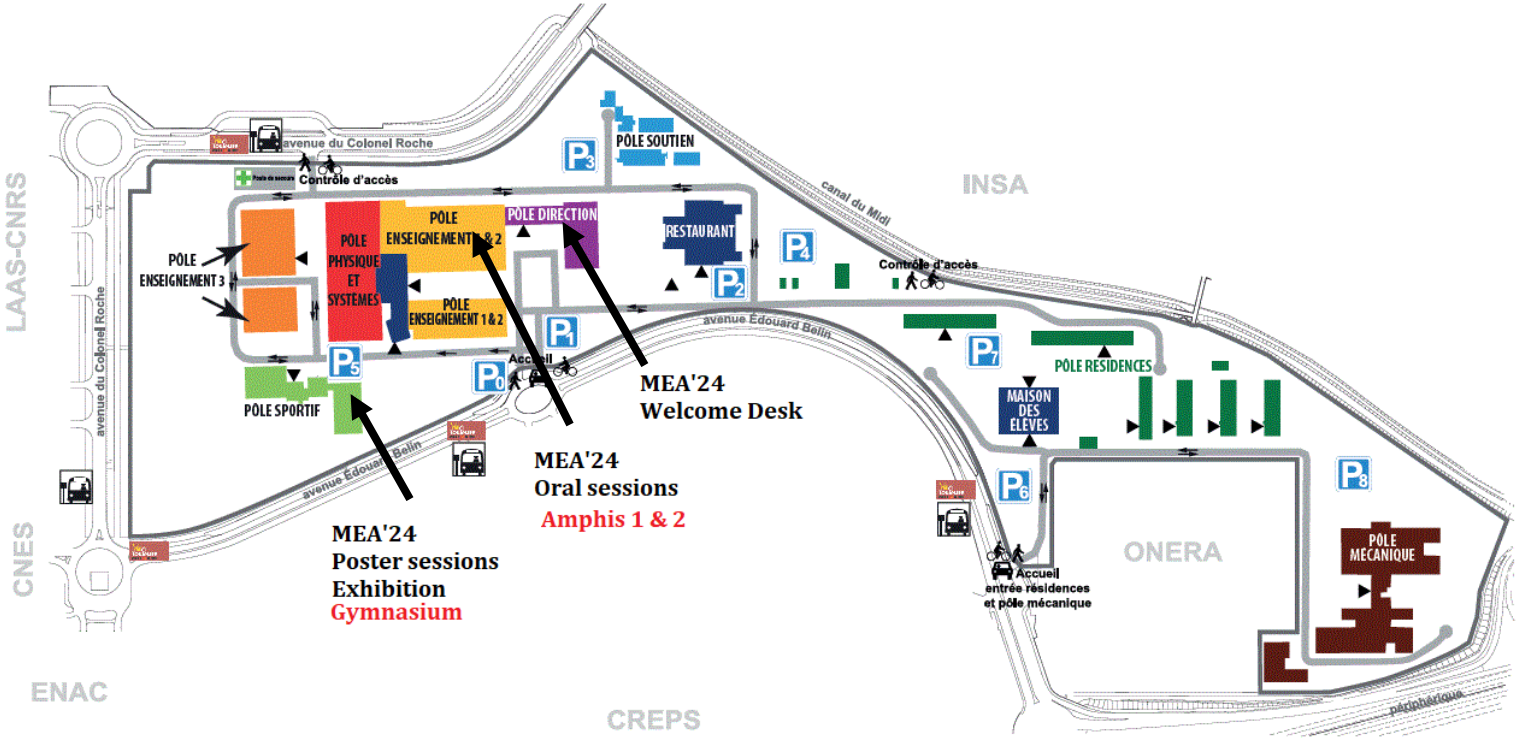
For this new edition, which follows on from the successful More Electric Aircraft Conference held in Bordeaux in February 2021, we have a wide range of plenary sessions and speakers from industry, institutions and academia. This conference reflects the growing interest in more electric aircraft, sustainability, reliability and certification issues. Oral presentations will be complemented by posters covering a wide range of topics related to more electric aircraft, including storage, power generation and distribution, thermal management, high voltage components, electric air conditioning and ice protection systems, more electric actuation systems, electric flight control, ...

The organizing committee has done its best to provide a pleasant working environment for the conference attendees and to facilitate networking among colleagues from industry and academia. The conference exhibition will provide an opportunity for the audience to visit booths where laboratories and industry will present their latest MEA achievements.

The Organizing Committee would like to thank the Program Committee, in particular the two chairs Regine Sutra-Orus from Safran Tech and Andre Thess from DLR and University of Stuttgart, for their strong commitment in the preparation of this conference. The Organizing Committee also thanks ISAE-SUPAERO and the industrial and institutional sponsors for their support.

Francis GUIMERA, chairman of the Organizing Committee

ISAE-SUPAERO MAP



Keynotes and plenary sessions in Amphis 1 & 2.

Posters sessions and industrial exhibition in the Gymnasium

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International Program Committee

Co-chairs: Régine SUTRA-ORUS (Safran Tech) & Andre THESS (DLR, University of Stuttgart)

With the assistance of Valerie Budinger (ISAE-SUPAERO, SEE), Stephane Henry (3AF) & Carsten Doll (ONERA, 3AF)

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Program Overview

Wednesday, Feb.7, 2024					
08:00	09:00	**Registration -** Welcome Coffee			
09:00	09:30	**Opening** Amphi 1 & 2 (video)	Welcome address and institutional support to cleaner aviation		
09:30	10:00	**Keynote 1** Amphi 1 & 2 (video)	Florent Nierlich - Safran		
10:00	10:30	**Keynote 2** Amphi 1 & 2 (video)	Andrew Murphy - Pratt & Whitney Todd Spierling - Collins Aerospace		
10:30	11:10	**Break - Exhibition** Gymnasium			
11:10	12:25	**Oral session 1a** 3 papers Amphi 1	Aircraft Architecture - Part 1	**Oral session 1b** 3 papers Amphi 2	Thermal management
12:25	14:00	**Lunch break** **Exhibition** Gymnasium			
14:00	14:30	**Keynote 3** Amphi 1 & 2 (video)	Michael Augello - Airbus Upnext		
14:30	15:00	**Keynote 4** Amphi 1 & 2 (video)	Clement Dinel, Ascendance Fllght Tech.		
15:00	16:15	**Oral session 2a** 3 papers Amphi 1	Propulsion systems	**Oral session 2b** 3 papers Amphi 2	Non propulsive systems
16:15	17:30	**Break - Exhibition - Poster session 1** Gymnasium			
17:30	18:20	**Oral session 3a** 2 papers Amphi 1	Power generation	**Oral session 3b** 2 papers Amphi 2	Certification
	19:30	**GALA DINNER Downtown** (Gare Matabiau - Hall M) Shuttle bus between ISAE Supaero and gala dinner (no bus for travel back after dinner)			

Thursday, Feb.8, 2024					
09:00	09:30	**Keynote 5** Amphi 1 & 2 (video)	Denis Deschmaeker - IRT St Exupery		
09:30	10:00	**Keynote 6** Amphi 1 & 2 (video)	Philippe Novelli - ONERA		
10:00	11:15	**Break - Exhibition - Poster session 2** Gymnasium			
11:15	12:55	**Oral session 4a** 4 papers Amphi 1	Aircraft Architecture - Part 2	**Oral session 4b** 4 papers Amphi 2	Power conversion - Part 1
12:55	14:00	**Lunch break** **Exhibition** Gymnasium			
14:00	15:40	**Oral session 5a** 4 papers Amphi 1	Hydrogen on board	**Oral session 5b** 4 papers Amphi 2	Power conversion - Part 2
15:40	16:00	Quick Break			
16:00	17:15	**Oral session 6a** 3 papers Amphi 1	Electromagnetic compatibility		

Note: each oral presentation is 25 min, questions included

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Detailed Program

Wednesday, Feb. 7

Opening & keynotes - 9h00 - Amphi 1 & Amphi 2 (video)

-	Welcome address and institutional support to cleaner aviation	Institutions and Authorities	
KN1	More Electrical Systems for Next Generation Platforms	Florent Nierlich	Safran
KN2	Electrification and sustainability	Andrew Murphy	Pratt & Whitney
		Todd Spierling	Collins Aerospace

Session S1a: Architecture - part 1 - 11:10 - Amphi 1

O1	The Distributed Electric Propulsion Scaled Flight Demonstrator DEP-SFD as a flying test bench for electrical architectures	Carsten Döll	ONERA
O2	High Power, High Scalability, Hybrid Powertrain (H3PS) Aircraft Demonstrator	Gergely Deak	Rolls Royce Hungary Kft.
O3	EcoPulse – Hybrid Demonstrator with Distributed Electric Propulsion	Didier Simeon	Daher

Session S1b: Thermal management - 11:10 - Amphi 2

O4	Characterization of local thermal resistances along electrical harnesses connectors	Alexandre Marie	ICAM, Toulouse Campus
O5	Development of a bi-directional modular converter and its thermal management system for a future much more electric aircraft	Salvatore Ameduri	CIRA
O6	How to assess and minimize the impact of occupants' thermal comfort on aeronautic vehicles energy management	Nicoletta Sanguini	Leonardo Helicopters

Keynotes - 14:00 - Amphi 1 & Amphi 2 (video)

KN3	Making the Unthinkable Real - Some lessons learned on how to accelerate innovation	Michael Augello	Airbus Upnext
KN4	Hybrid Electric Technology: A Key Enabler for Low Carbon Aviation	Clément Dinel	Ascendance Fllght Tech.

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Wednesday, Feb. 7

Session S2a: Propulsion systems - 15:00 - Amphi 1

O7	Alternative propulsion system for helicopter	Stephane Beddok	Safran Helicopter Engines
O8	A turboelectric distributed propulsion concept for hydrogen-powered blended-wing body aircraft architectures	Pavlos Rompokos	Cranfield University
O9	Cryogenic electric propulsion system: ASCEND main results and perspectives	Ludovic Ybanez	Airbus

Session S2b: Non-propulsive systems - 15:00 - Amphi 2

O10	Resonant Electromechanical Ice Protection Systems: Test Results on NACA Profiles	Younes Rafik	INSA Toulouse
O11	Innovative Electrical Wing Ice Protection System: key enabler towards 'More Electrical Aircraft'	Guillaume Fievez Olivier Prin	SONACA LTS
O12	Preparing Electric Actuation Technology for Upcoming Applications	Nilolaus Dreyer	Liebherr Aerospace

Session S3a: Power generation - 17:30 - Amphi 1

O13	Reliability-Oriented Optimization of High Performance SiC-Based Power Drive Systems for Aircraft Applications	Bernardo Cougo	IRT Saint-Exupery
O14	Contribution of machine learning techniques for the recognition of arc faults in aviation: Case of DC serial arcs	Raul Carreira Rufato	LPEM, ESPCI Paris - PSL, CNRS, Sorbonne Université

Session S3 : Certification - 17:30 - Amphi 2

O15	Hydrogen Aircraft Certification: Determination of Regulatory Gaps	Joël Jézégou, Robert André	ISAE-SUPAERO, Airbus
O16	Electrical Propulsion & Certification Challenges	Christophe Maury	Safran

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Wednesday, Feb. 7, 16:15-17:30 - Poster session 1

P1-1	Multi-Fidelity Approach for Aerodynamic Optimization of Propeller Blades in VTOL UAVs	Nina Moëllo	ISAE-Supaero
P1-2	Soft defects detection and localization on aeronautic wire harness by MCTDR reflectometry	Marc Olivas	WiN MS
P1-3	eVTOL electrical architecture wide band frequency modeling for network quality specification	Mariem Jday	Capgemini Engineering
P1-4	Sizing of a Spherical Hydrogen Tank for an eVTOL electrical power supply	Anis Idir	Capgemini Engineering Toulouse
P1-5	Methodology of robustness analysis using little gain theorem applied to aeronautical HVDC networks	Ugo Ginestet	Safran Tech
P1-6	Analytical Models for Magneto-Mechanical Sizing of a High-Speed Induction Machine for Aircraft Electric Generation	Larbi Dahnoun	Safran Tech
P1-7	TSAR – numerical LH2 tank simulation tool	Eszter Dudás	CT Ingénierie
P1-8	Dual Active Bridge converter Transformer flux balancing	Michel Jamot	Airbus Helicopters
P1-9	Sensitivity Analysis and Optimization of a Liquid Cooling Thermal Management System for Hybrid Fuel Cell Aircraft	Valentine Habrard	ISAE-Supaero
P1-10	Avionic Piezoelectric Deicing System: Numerical and Experimental Investigation of the Use of Extension Modes for Deicing	Modar Jomaa	ENS Paris-Saclay
P1-11	Control design and flight simulation for a DEP aircraft using differential thrust allocation	Rodrigo Casajus	ISAE-Supaero
P1-12	Lattice Boltzmann Method for Under Hood Hydrogen Leakage Numerical Simulation	Thomas Lafarge	CS group
P1-13	Thrusting MEA by Trusting SiC based power electronics	Olivier Perrotin	Alter Technology France
P1-14	Full instantaneous electromechanical de-icing using extensional modes	Giulia Gastaldo	ISAE-Supaero
P1-15	Mobile charging system for flexible and convenient charging of electric aircraft	Daniel Buvarp	Uppsala University
P1-16	An insight on the DC-side differential mode power quality requirement in a battery driven motor drive systems for an aerospace application assisting the component sizing.	Subhadra Tiwari	Rolls-Royce Electrical Norway

Thursday, Feb. 8

Keynotes - 9:00 - Amphi 1 & Amphi 2 (video)

KN5	FILAE: R&T emblematic project on electrical aircraft carried by French Institutes of Technology	Denis Deschmaeker	IRT St Exupery
KN6	Perspectives of hybridization for commercial aircraft: the lessons learned from the IMOTHEP project	Philippe Novelli	ONERA

Session S4a : Architecture - Part 2 - 11:15 - Amphi 1

O17	Testbed for evaluation of Electric propulsion Architectures	Samuel Bonnard	ONERA
O18	Review and comparative analysis of various hybridization strategies for energy management in eVTOL aircraft	Afef Najjar	Capgemini Engineering
O19	Climate and energy impact analysis of hybrid-electric aircraft in prospective scenarios for air transport	Scott Delbecq	ISAE-Supaero
O20	Powering Airbus Future Ambitions	Gabriel Beulaguet	Airbus

Session S4b : Power conversion - Part 1 - 11:15 - Amphi 2

O21	A new SSPC family: an example with the HVDC SSPC	Rodolphe De Maglie	Liebherr-Electronics and Drives GmbH
O22	Fault-tolerant magnetic coupling topology for network parallel multilevel inverters	Rita Mattar	Safran Tech
O23	Arc tracking power balance: Method for determining fusion and vaporization power	Flavien Valensi	LAPLACE - Université Paul Sabatier
O24	High Frequency modelling to predict inter-turn voltage distribution in electrical machines for aeronautical application	Helena Gressinger	Safran Tech

Session S5a : Hydrogen on board - 14:00 - Amphi 1

O25	Digital Twin of complete Fuel cell demonstrator	Matthieu Ponchant Jan Belak	Siemens Industry Software SAS Honeywell International S.R.O
O26	Hydrogen on board – Lessons learned from Space Launchers – Challenges and Opportunities	Simon Menager	ArianeGroup

O27	HOPE Project: Hydrogen Fuel Cell System Technologies for zero Emission Aircraft Propulsion	Guillaume Hubert Christophe Maury	Safran Power Units Safran Tech
O28	Thermal stratification for various design of the LH2 tank	Thibaut Dochy	CT Ingénierie

Session S5b : Power conversion - part 2 - 14:00 - Amphi 2

O29	Superconducting flux modulation machine for aircraft applications	Rémi Dorget	Safran
O30	Design guidelines of a battery-to-HVDC power converter for hybrid electric regional aircraft	Alejandro Llop	Tecnalia, Basque Research and Technology Alliance (BRTA)
O31	Parallel multilevel inverter for a deported electrical motor drive: Studies & Developments	Rita Mattar	Safran Tech
O32	Interactions between a fuel cell and its associated power converter : recommendations for the design with regard to the state of the art	Christophe Turpin	LAPLACE - Université Paul Sabatier

Session S6a: Electromagnetic compatibility - 16:00 - Amphi 1

O33	New EMC shielding harness characterization up to 9GHz	Charles Jullien	Safran Electrical and Power
O34	Enhancing Power Density in Medium Power Inverters for Electric and Hybrid Aircraft Propulsion: Addressing Thermal and EMC Challenges	Victor Dos Santos	Safran Tech
O35	Crash testing lithium-ion battery for helicopters	Séverin Halbout	Airbus

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Thursday, Feb. 8, 10:00 – 11:15 - Poster session 2

P2-1	Concept and Control of a Resonant Power Processor for a Permanent Magnet Synchronous Motor	Jean-François Bisson	École de technologie supérieure
P2-2	Low frequency design criteria for carbon fibre composite casings for aircraft power electronic converters	Mark Higgins	University of Strathclyde
P2-3	Aircraft passenger door optimized by electrifying its energy system	Gregoire Le Goff	LAAS, Université de Toulouse, CNRS
P2-4	Electrical Power Transportation for Electrical propulsion Systems	Charles Jullien	Safran Electrical and Power
P2-5	Techno-economic analysis of green hydrogen production for Toulouse-Blagnac airport	Badr Eddine Lebrouhi	Capgemini Engineering
P2-6	A Comparative Study between Immerged Slots and Hollow Conductors for AC Losses of PM Electrical Machines	Sulivan Kuttler	Safran
P2-7	Experimental and numerical investigation of direct two phase cooling for semiconductors	Antoine Loehrmann	Airbus SAS
P2-8	Pressure's Impact on Load Current Decrease in Series Arc Faults	Yousra Aichoun	Université de Paris-Saclay, Laboratoire GeePs Paris
P2-9	Direct Coupling of Parallel Hybrid Propulsive System and Vehicle-Level Integrated Mission Performance Aircraft Sizing Models	Aleksandar Joksimović	ISAE-Supaero
P2-10	Supporting Aircraft Electrification Technology Development with Modelling and Simulation	Maria Fernandez Jimenez	MathWorks
P2-11	Modeling and simulation of PEM fuel cell behavior for aircraft propulsion under steady-state and dynamic conditions	Marco Avila Lopez	Capgemini Engineering
P2-12	Analysis of the effects of partial discharges in a power cable for aeronautical applications	Vladimir Ricardo Pineda Bonilla	Airbus Helicopters ; Laboratoire GeePs Paris
P2-13	Design and simulation of a high fault-tolerant Electro Hydrostatic Actuator for helicopter swashplate control	Mingwei Sun	Beihang University
P2-14	Aeroelastic Behaviour of Urban Air Mobility Aircraft with Distributed Electric Propulsion Subjected to Urban Wind Gusts	Antoine Boissinot	Concordia University
P2-15	From towing to take-off assistance, the U-shaped linear induction motors to reduce consumption and emissions of aircraft	Gerard Coquery	TACV Lab
P2-16	An ultra long-range electric drone powered with liquid hydrogen	Sofia Mertika	ISAE-Supaero

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KEYNOTES

WEDNESDAY FEB. 7, 9:30 a.m.

More Electrical Systems for Next Generation Platforms
Florent Nierlich, Technical Director at Safran Electrical and Power
Wednesday, Feb. 7, 9:30 am, Amphi 1

Part of SAFRAN strategic vision is clearly focus to decarbonize our aerospace industry. Both ultra-efficient next generation of thermal engine and new air mobility market will require enhanced electrical systems for propulsive and non-propulsive applications. Those systems will host high voltage DC power sources combined with more traditional rotating machine generation channels. Improved protection components, power and energy management control and conversion systems, powerful motor drives will be at the heart of this new journey for electrical engineers. The presentation will introduce those new technologies, electrical products and systems in the context of a first in progress electrical motor certification and flight test campaigns.

Electrification and sustainability
Andrew Murphy - Chief Engineer, Advanced Commercial Engines at Pratt & Whitney
Todd Spierling, Principal Technical Fellow - Electrification, Collins Aerospace
Wednesday, Feb. 7, 10:00 am, Amphi 1

Around the world, all sectors of industry are strategizing on how to reduce greenhouse gas emissions to mitigate their effects on global warming. The aviation sector in general, and RTX in particular, has committed to achieve net zero by 2050 through a series of measures to reduce CO2 emissions, including Electric/Hybrid Electric Propulsion and Aircraft Systems Improvements, which are of particular interest at this More Electric Aircraft '24 conference.

One of the key approaches that the industry is working on to improve the fuel efficiency of engines and aircraft is electrification, with full electric concepts for small aircraft, and hybrid electric concepts for regional and larger aircraft. The maturation of electric propulsion architectures depends on the development progress of key constituent technologies, including rotating electrical machines, power electronics, energy storage, protection and

distribution systems, and synergies with more electric aircrafts, with both near-term targets and longer-term technologies that promise even further impact.

This presentation will outline challenges, approaches, technologies, and demonstrator programs being executed across RTX in support of this Electrification initiative. It will highlight component, propulsion system, and aircraft level initiatives that are currently underway in both Europe and North America in support of these sustainability goals.

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ORAL SESSION 1a

WEDNESDAY FEB. 7, 11.10 a.m.

Aircraft Architecture – Part 1

The Distributed Electric Propulsion Scaled Flight Demonstrator DEP-SFD as a ying test bench for electrical architectures

Carsten Doll, Henk Jentink, Pierluigi Iannelli, Maurice F.M. Hoogreef, Daniel Kierbel
ONERA / DTIS, University of Toulouse, France & NLR The Netherlands & CIRA / Fluid Dynamics Department, Italy & TU Delft / Faculty of Aerospace Engineering, The Netherlands & Airbus, France
Wednesday, Feb. 7, 11:10 am, Amphi 1

Within the work package radical new aircraft configuration of Cleansky2 Large Passenger Aircraft, a benefit of more than 20% in fuel consumption and CO2 emission (one of CS2 top level objectives) could be achieved by using various Distributed (hybrid) Electric Propulsion DEP architectures on different more or less radical aircraft configurations. It has therefore been identified as a disruptive technology which shall be de-risked in terms of achievable performance during wind tunnel tests and in terms of handling qualities during flight tests. The electric architecture with typical magnitudes shall also be studied in more detail. As already presented during AIAA SciTech Forum and Exhibition 2023, the D08 Distributed Electric Propulsion DEP version of the D03 Scaled Flight Demonstrator has been designed, manufactured and ground tested from 2020 to May 2023. An incident during the last ground test in May 2023 caused the total loss of this demonstrator. After its analysis, it was decided to robustify the electric architecture by improving the batteries, the wiring, the protections and the monitoring. These changes in the electric architectures lead to structural changes like the shift of the emergency parachute and bigger access hatches. The remanufacturing of the DEP-SFD2 has started in September 2023 for an exhaustive integration test campaign and taxi tests in January and February 2024. At the moment, the qualification flight tests will take place in April 2024 and the mission flight tests in May 2024.

High Power, High Scalability, Hybrid Powertrain (H3PS) Aircraft Demonstrator

Gábor Bihari
Rolls-Royce, Hungary
Wednesday, Feb. 7, 11:35 am, Amphi 1

H3PS (acronym for "High Power High Scalability Aircraft Hybrid Powertrain") was a project funded under the European Union Horizon 2020 research and innovation programme, Grant Agreement No. 769392. Tecnam Aircraft, in collaboration with Rolls-Royce and Rotax specialized teams, successfully flew the new P2010 H3PS hybrid aircraft for the first time on December 21st, 2021. The Permit to Fly was issued by ENAC, the Italian Civil Aviation Authority. Tecnam P2010 H3PS was powered by a 104kW Rotax 915 IS engine coupled with a 30kW Rolls-Royce electric motor, totalling a 134kW (180hp) powertrain in a fully integrated parallel hybrid-electric configuration. As such, this four-seat aircraft was a first of its kind. Bringing propulsion systems for hybrid-electric aircrafts required reconsidering several aspects of the design e.g., energy storage, health monitoring and flight safety [3]. The project has successfully tackled the challenges presented by parallel hybrid-electric architecture by de-risking a technology that is novel to aerospace propulsion applications. Through this paper, we present our activities and the lessons learned we gained from this project during maturing the hybrid parallel powertrain towards a commercially viable solution.

EcoPulse – Hybrid Demonstrator with Distributed Electric Propulsion

Didier Simeon, Pierre-Luc Regaud, William Llobregat, Vincent Chaperon, Sebastian Kauertz
Daher& Safran & Airbus, France

Wednesday, Feb. 7, 12:00 am, Amphi 1

EcoPulse is a hybrid-electric aircraft demonstrator, based on a TBM platform. A complete hybrid electric propulsion system is installed in order to test distributed propulsion benefits. The advantage of this flying test bench is that it can quickly obtain flight authorizations and ensure perfect flight safety thanks to the legacy turbine, with the possibility of switching very quickly from a hybrid mode and one test configuration (acoustics, aircraft control, aerodynamic performances) to thermal propulsion mode only.

The tests carried out on this demonstrator will allow to verify the proper functioning of the equipment specifically developed, to verify the compatibility of the fuel and electrical systems with the integration rules implemented, and to characterize the high-voltage electrical system, particularly at altitudes up to 12000ft. Particular attention will be paid to the thermal and electromagnetic behaviours that will define the constraints of integration of a high-voltage electrical system. An assessment of the performance of distributed propulsion (blown wings and wingtip propellers), steerability based on differential thrust, and acoustics (cabin noise and external noise) will also be a key deliverable of the project. The flight test data will also permit to fine-tune some models, for more accurate predictions based on simulations.

Through this partnership between Daher, Airbus and Safran, made possible by DGAC (the French Civil Aviation Authority) through France Relance (the French government's economy recovery plan) and NextGeneration EU, this project develops the key architectural principles of tomorrow's hybrid aircraft and paves the way to future aircraft with reduced carbon footprint and noise optimisation.

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ORAL SESSION 1b

WEDNESDAY FEB. 7, 11.10 a.m.

Thermal management

Characterization of local thermal resistances along electrical harnesses connectors

Alexandre Marie, Jean-Pierre Fradin, Yves Fardel, David Thomasse

Icam school of engineering, Toulouse campus & IRT Saint-Exupery, France

Wednesday, Feb. 7, 11:10 am, Amphi 2

The aim of the study presented in this paper is to propose an approach for the thermal characterization of power cables and electrical connectors assemblies, referred thereafter as electrical harnesses. To this end, an experimental setup allowing to measure the heat flow and temperature profiles along different electrical harnesses is developed along with 3D thermal models in order to evaluate local contact thermal resistances within the connectors. On one hand, the results presented in this paper show that, for the connectors under consideration, the thermal resistance associated with the hexagonal crimps considered here is negligible compared to the conduction resistances along the cables. On the other hand, it has been possible to identify a significant thermal resistance induced by the electrical connection system of a removable connector attached to copper bars. In the future, the approach developed in this work could be adapted to study the coupling between electrical and thermal contacts of such assemblies.

Development of a bi-directional modular converter and its thermal management system for a future much more electric aircraft

Diego Giuseppe Romano, Salvatore Ameduri, Antonio Carozza, Bernardino Galasso, Gianluca Marinaro, Edson Lima Junior Manuel Lagares, Carmen Bejarano Espada, María Dolores Jiménez Sánchez

CIRA, Italy & Skylife, Spain

Wednesday, Feb. 7, 11:35 am, Amphi 2

Global warming concern is pushing aviation to introduce innovative technologies for greener flights, since aviation stakeholders committed to ambitious targets of reducing global net aviation carbon emissions by 50% by 2050 compared to 2005. Hybrid-electric propulsion is one of the solutions proposed to reach this ambitious goal. The introduction of such solution opens new opportunities and originates new challenges as well, such as the need for dedicated thermal management systems (TMS) to cool-down electric machines. European Union has co-funded ORCHESTRA (Optimised electric

network aRCHitEctures and SysTems for moRe-electric Aircraft) Project to design new technologies allowing 10% efficiency increase and 25% weight reduction of electric power system (EPS) compared to state-of-the-art. Within ORCHESTRA Project, Skylife Spanish Partner developed a Dual Active Bridge (DAB) bi-directional modular converter to manage the power transfer between Kilo-Voltage Direct Current (KVDC) bus (1-3KV) and High Voltage Direct Current (HVDC) bus (540V). Based on the DAB developed by Skylife, CIRA (Centro Italiano Ricerche Aerospaziali) Italian Partner developed an optimised TMS for lightweight solutions enabling hybrid/electric flights. Moreover, feasibility studies of the introduction of Shape Memory Alloy (SMA) materials into designed TMS to improve off-design conditions has been performed.

How to assess and minimize the impact of occupants' thermal comfort on aeronautic vehicles energy management

Nicoletta Sanguini, Luca Patricelli
Leonardo Helicopter Division, Italy, & Siemens Industry Software

Wednesday, Feb. 7, 12:00 am, Amphi 2

Increasing payload reducing fuel consumption is always the challenge every aeronautic design team has to face. New vehicles, like EVTOL, are making this challenge even harder, so it is important to find efficient methods to reduce the energy consumption of the most expensive systems, such as Environmental Control Systems. Leonardo, as a global company in the Aerospace, Defence and Security sector, is engaged in finding solutions that are more effective, maintaining the focus, at the same time, on human well-being on board aircraft.

In this presentation, we introduce a statistical climate-based methodology to select the external environmental conditions for sizing the system. Then, we show how to move from standard design methodologies to a more use-oriented and thermal comfort-oriented methodology, highlighting and quantifying the benefit of this change and presenting the impact of different technical solutions on the occupants' thermal comfort and on vehicle energy management.

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KEYNOTES

WEDNESDAY FEB. 7, 2:00 a.m.

Making the Unthinkable Real - Some lessons learned on how to accelerate innovation
Michael Augello, CEO of Airbus Upnext
Wednesday, Feb. 7, 2:00 pm, Amphi 1

Airbus is a leader and pioneer in aviation, space and related services. Within Airbus a small subsidiary called "Airbus UpNext" is dedicated to technologies and innovations that will shape the future of aviation.

At Airbus UpNext, we experiment with daring technologies and concepts to prove they can contribute to a future improvement in aviation and space. Projects at UpNext known as "Demonstrators" bring these to life by integrating them to aircraft or test beds. Experiments range from modifying a helicopter to be flown via a tablet, to having wings that move inflight, and having automatic mid-air refuelling or multiple aircraft. UpNext pushes the boundaries of what we know about flight and what can be radically different.

Each demonstrator lasts from 24 to 36 months, with a high focus on the technology maturation objective, creating the condition to allow maximum focus and success. In this presentation, you will discover some of UpNext's most important projects and how UpNext connects to the larger group while executing its projects in an as independent as possible manner in order to execute on (insane/crazy) timelines.

Discover in this session, these demonstrators and observe how we make the unthinkable real!

Hybrid Electric Technology: A Key Enabler for Low Carbon Aviation
Clément Dinel – Co-founder & Hybrid Product Director at Ascendance flight technologies
Wednesday, Feb. 7, 2:30 pm, Amphi 1

As the world grapples with the effects of climate change, we all need to act together. With two innovative products, a hybrid electric propulsion system and a unique VTOL aircraft, Ascendance Flight Technology aims to contribute to the decarbonization of aviation. Hybrid Electric is the key enabler to cleaner connections. It works today and prepares for tomorrow.

This presentation aims to detail the impact of hybridization and explain the benefits of this technology in a wide range of applications, thanks to a variable degree of hybridization.

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ORAL SESSION 2a

WEDNESDAY FEB. 7, 3:00 p.m.

Propulsion systems

Alternative propulsion system for helicopter

Stéphane Beddok, Jean-Baptiste Jarin, Fabien Mercier-Calvairac, Alexis Patin, Frédéric Pousse, Quentin Vincenzotto

Safran Helicopter Engines & University of Pau and Pays de l'Adour, France

Wednesday, Feb. 7, 3:00 pm, Amphi 1

The aviation sector is now facing one of its biggest challenges as it aims to reduce its carbon emissions close to zero. Several technologies are potential candidates both at aircraft level, including configuration and at propulsion system level, including architectures and energy sources.
This study focuses on helicopter aircraft and on propulsion system by looking at the six main propulsion systems known as conventional turboshaft engine with either standard jet fuel, sustainable aviation fuel or electro fuel issued from hydrogen or direct hydrogen combustion, full electric supplied by batteries and full electric supplied by fuel cell and hydrogen. The aircraft will be sized for a given mission, depending on the propulsion system weight and efficiency and each solution will be compared with respects to energy consumption.

A turboelectric distributed propulsion concept for hydrogen-powered blended-wing body aircraft architectures

Pavlos Rompokos1, Andrew Rolt2, Ioannis Roumeliotis3, Devaiah Nalianda4

Cranfield University, Centre for Propulsion and Thermal Power Engineering, UK

Wednesday, Feb. 7, 3:25 pm, Amphi 1

Aircraft using liquid hydrogen fuel (LH2) have the potential to decarbonise commercial aviation almost completely and greatly reduce aviation's contributions to global warming. Whereas slower-flying regional aircraft may use batteries, hydrogen fuel cells and electrically-driven propellers, larger longer-range and faster-flying aircraft will continue to need more power-dense propulsion systems that will burn the fuel to generate power via turbomachinery. Such systems may offer comparable energy conversion efficiency to hydrogen fuel cell systems at significantly higher power to weight ratios. Nevertheless, the energy demands of the long-range aircraft may be further reduced by integrating novel airframe, propulsion, and fuel system architectures. One highly-efficient concept that may be realised in next few decades is the LH2-fuelled blended wing body (BWB) passenger aircraft with

superconducting turbo-electric distributed propulsion (TeDP) and boundary layer ingesting (BLI) ducted fans. This paper presents a preliminary design methodology that aims to maximise the synergistic performance benefits from combining these new technologies by optimally sizing the major propulsion system components. By way of example, the methodology is applied to the long-range BWB aircraft studied in the recent Horizon 2020 ENABLEH2 project.

Cryogenic electric propulsion system: ASCEND main results and Perspectives

Ybanez Ludovic, Boukayoua Souhaib, Emelie Nilsson, Matteo Tassisto, Swapnil Kharche, Jean-François Rouquette, Timin Jacob, Surapaneni Ravi-Kiran, Galla Gowtham, Frederick Berg
Airbus UpNext, France, & Airbus UpNext GmbH, Germany & Airbus X-Labs, Germany

Wednesday, Feb. 7, 3:50 pm, Amphi 1

To reduce the carbon footprint of aviation, Airbus is proposing to develop a liquid hydrogen aircraft over the next decade. Liquid hydrogen must be stored at 22K (-250°C), and if such a cold source is available on board, cryogenic cooling of conventional electrical components and the use of high-temperature superconducting technologies promise to revolutionise electric propulsion systems. This pioneering development is pursued with a pragmatic approach, from the exploration activities of Airbus CRT (Central Research & Technology) to the launch in 2021, as part of Airbus UpNext, of the ASCEND project (Advanced Superconducting and Cryogenic Experimental powertraiN Demonstrator). It has been focused on the development of an integrated 500 kW cryogenic propulsion system, comprising superconducting cables, cryogenic power electronics, a superconducting motor, a control and monitoring unit and a cryogenic cooling system. All these components have been integrated and tested on a dedicated test rig at Airbus X-Labs (Ottobrunn, Germany) from January 2023.
This project demonstrates the potential of cryogenic propulsion in terms of components and equipments figure of merits improvements, as well as a significant value for high-power electric propulsion of future Airbus products.

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ORAL SESSION 2b

WEDNESDAY FEB. 7, 3:00 p.m.

Non-propulsive systems

Resonant electromechanical ice protection systems: test results on NACA profiles

Younes RAFIK, Marc BUDINGER, Valerie POMMIER-BUDINGER, Valerian PALANQUE
Institut Clément Ader (ICA), Université de Toulouse, INSA, ISAE-SUPAERO, MINES ALBI, UPS, CNRS & ISAE-SUPAERO, Université de Toulouse, France

Wednesday, Feb. 7, 3:00 pm, Amphi 1

Electro-mechanical de-icing systems are low-energy ice protection solutions based on ice fracture mechanisms. This article focuses on resonant electro-mechanical de-icing systems actuating flexional or extensional modes. The principle of these systems is to apply vibrations that create high-level stresses to crack and delaminate the ice accumulated on the structure. Key performance indicators to analyze the performances of such systems with respect to levels of energy, force, and power required for de-icing are described in this paper and computed from Finite Element simulation and making assumptions on two values: the ice adhesion strength and the critical strain energy release rate. These indicators allowed the sizing of two resonant piezoelectric de-icing systems for NACA profiles. Test results on a metallic NACA profile tested in extension and a NACA profile of CRFP substrate tested in flexion are presented and validate the analysis thanks to key performance indicators.

Innovative Electro thermal Wing Ice Protection System: key enabler towards 'More Electrical Aircraft'

C. Lenoir O. Prin, C. Leroi, G. Fiévez
Liebherr Aerospace, France & Sonaca Group Belgium

Wednesday, Feb. 7, 3:25 pm, Amphi 1

Liebherr Aerospace Toulouse SAS (Liebherr) and Sonaca Gosselies (Sonaca) have been collaborated for several years to develop an innovative Electro thermal Wing Ice Protection System (eWIPS). Current WIPS being considered as one of the main power consumers, the eWIPS technology is a key enabler towards the development of 'More Electrical Aircraft' (MEA) in the future. This innovative electrical system is also acknowledged as a potential solution for conventional aircraft, thanks to advantages offered in terms of cost, reliability and performance. eWIPS system developed by Liebherr and Sonaca is based on an electrothermal approach with a smart power regulation using Power Electronics and dedicated technologies (Heater mats, Power transfer assembly (PTA), harnesses) integrated within the wing structure.
The main challenges consist in designing the best possible architecture allowing:

• An optimal sizing of the power generator supplying the Power Switch Bay (mass)
• An efficient protection against icing conditions in CS-25 both Appendices (O and C) (aerodynamic performances)
• Smart control laws and power modulation delivering the right power at the right time (consumption)
• Flexible integration strategies, with metallic or composite structure compatibility as well as with HVAC or HVDC voltage (cost / mass / reparability)
In 2023, an Icing Wind Tunnel test campaign has been performed on a full scale demonstrator and gave already very promising outlook for the future.

Preparing Electric Actuation Technology for Upcoming Applications

Guido Weber, Nikolaus Dreyer, Thomas Immler
Liebherr-Aerospace Lindenberg GmbH, Germany

Wednesday, Feb. 7, 3:50 pm, Amphi 1

Resulting from the demands of more electric or all electric aircraft (MEA) concepts, new requirements for electrically powered flight control actuation equipment have emerged. In addition to the continuing electrification trend in the traditional commercial aviation, new markets have been developing that require electric actuation technology. These applications include flight control and thrust tilting systems for advanced air mobility (AAM) vehicles or various unmanned aerial vehicles (UAVs).
The wide application of electric actuation technology for all kind of flight control surfaces, including full-time primary flight control, introduces new challenges and technology demands for such actuation systems. Based on the in-house electric actuation experience in the field of high lift and electrical back-up actuation for primary flight controls, Liebherr-Aerospace Lindenberg GmbH is improving existing electric actuator concepts and developing new approaches to meet new demanding requirements.

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POSTER SESSION 1
WEDNESDAY FEB. 7
4:15 a.m. – 17:30 a.m.

Multi-Fidelity Approach for Aerodynamic Optimization of Propeller Blades in VTOL UAVs

Nina Moëllo, Jonathan Liscouët
ISAE Supaero, Université de Toulouse, France & Concordia Univ., Canada

Unmanned aerial vehicles (UAVs) require innovative designs to meet the diverse needs of various sectors, from precision agriculture and environmental monitoring to emergency response. This research focuses on the conceptual design of vertical take-off and landing (VTOL) UAVs, with an emphasis on optimizing propeller aerodynamics for small-scale designs. Due to the limited dimensions of small VTOL UAVs operating in low Reynolds number aerodynamic flow conditions, high-fidelity numerical methods, such as computational fluid dynamics (CFD) simulation, are essential for accurately evaluating their aerodynamic performance. Multidisciplinary design optimization (MDO) plays a critical role in the conceptual design of UAVs. However, MDO's high number of optimization iterations is incompatible with the computation times needed for CFD simulations. To tackle this challenge, we propose a multi-fidelity methodology that integrates computational fluid dynamics (CFD) simulation with blade element momentum theory (BEMT) optimization for propeller geometry, aiming to minimize the number of optimization iterations involving CFD simulation. A case study demonstrates the advantages of the proposed methodology, achieving approximately 40% to 50% in computation time reduction. The multi-fidelity method demonstrates promising results in reducing the number of CFD optimization iterations. This advancement marks a significant first step towards the practical integration of CFD optimization into VTOL UAV MDO and the efficient exploration of innovative UAV designs.

Soft defects detection and localization on aeronautic wire harness by MCTDR reflectometry

Soumaya SALLEM, Marc OLIVAS
WiN MS, France

The security of wired networks, which are becoming increasingly complex particularly in the on-board sectors is of increasing concern. In the field of aeronautic wire diagnosis, our expertise extends to most specific defects such as electric arcs (serial and parallel), hot spots in thermosensitive cables, soft faults (chafing, crushing, bending...) and connector defects (corrosion, crimping defects, and manufacturing

defects), ... These kinds of fault cause small local modifications of the propagation characteristics of the cable. MCTDR (Multi-carrier Time Domain reflectometry) is a non-destructive method that helps solving most industry's wiring problems and has the potential to detect and locate very small changes in impedance like those caused by soft faults. It enables live monitoring of the wires (for example in aircraft during flight) and without interfering with existing signals. The MCTDR reflectogram shows the wire faults as peaks due to impedance changes. The fault location and characteristics are calculated, by analyzing these peaks. With specific post-processing algorithms, it's possible to determine the severity of the deterioration, and assess the wire harness state to plan its repair or replacement. This prognosis permits to reduce repair costs and offers a better maintenance management.

Evtol electrical architecture wide band frequency modeling for network quality specification

Mariem JDAY, Abderrahmane BOULARAS, Michel BAREILLE
Capgemini Engineering, France

The aim of this article is to define and model the electrical architecture of an electric Vertical Take-off and Landing (eVTOL) aircraft to establish a list of requirements for the eVTOL network quality. eVTOLs represent a fast-growing aeronautical market which seeks to revolutionize intra-urban and inter-city mobility, thanks to an air transport system based on safety and efficiency. The typical application studied in this work is a search and rescue flight, for which the eVTOL must be able to transport a pilot, a doctor, and a patient. The aircraft studied is powered by fuel cells and batteries. At the core of each aircraft architecture, power electronics plays a crucial role in the new generation of transport. Design stakes include DC-DC power conversion choice, the composition of the filters associated to each power converter, the control strategies used to balance current supply distribution and the interactions between all these elements. Based on existing aeronautic specifications and specific simulations, the results of the wide-band frequency model are used to define a set of requirements for the HVDC eVTOL voltage system.
In this paper, the wide-band frequency model and its simulation results in OpenModelica are presented. Outcomes are discussed to improve the efficiency of the proposed architecture and to deduce a set of requirements ensuring the interoperability of the electrical network pieces of equipment.

Sizing of a Spherical Hydrogen Tank for an eVTOL electrical power supply

Aymen SENDI, Anis IDIR, Abderrahmane BOULARAS, Michel BAREILLE
Capgemini Engineering, France

The electric Vertical Take-Off and Landing (eVTOL) aircraft presents nowadays an essential main development direction in the aeronautical sector. Regarding the use case considered in this paper, the main energy source of the eVTOL is the PEMFC powered by hydrogen to produce electrical energy. The storage of hydrogen in cryogenic state (Liquid Hydrogen (LH2) at 20K at low pressure) or in gaseous state at high pressure at 700 bars, as well as the choice of its state presents a real challenge to optimize

the mass of hydrogen tanks. In this paper, we present the sizing of two types of LH2 tanks at low-pressure: the first one is the LH2 cryogenic tank with Multi-Layer-Isolation (MLI) using Polyurethane thermal insulation, the second one is the LH2 cryogenic tanks with inter-wall vacuum insulation. A 700 bars Gaseous Hydrogen (GH2) tank will also be designed for the same application. This study will compare the mass impact of these three technologies and their mechanical integrability in the fuselage of the eVTOL. The mass calculation results are given and discussed to highlight the relevance of the proposed approach and show the different limits and thresholds of these three hydrogen storage technologies.

Methodology of robust stability analysis using small gain theorem applied to aeronautical HVDC network

U. Ginestet, F. Rougier, N. Roux, H. Piquet
Safran TECH & LAPLACE Université de Toulouse, CNRS, INPT, UPS, France

The air transport is undergoing a period of transition, responding to recommendations aimed at drastically reducing its polluting emissions. As a result, the electrical energy vector is taking an increasingly important part on board of aircraft, requiring significant changes to the electrical network. The trend is to develop High Voltage Direct Current (HVDC) networks 540VDC / 800VDC to replace the traditional 115VAC / 230VAC electrical system (ATA24) and support the synergy between non-propulsive and propulsive functions. These new aeronautical HVDC architectures may be subject to network quality issues due to the interconnection of many devices driven by power electronics. In particular, instabilities can occur under certain operating conditions, which needs to be anticipated and avoided. This is the purpose of the network specification step, carried out by the aircraft manufacturer. This paper explores the use of Small Gain Theorem to tackle stability issue and to specify the different stakeholders in such a way as to achieve an optimum sizing of the system's components. The proposed methodology tries to provide a relevant response to this subject by linking potential network uncertainties (variable parameters, etc…) to the formulation of the requirement.

Analytical Models for Magneto-Mechanical Sizing of a High-Speed Induction Machine for Aircraft Electric Generation

L. Dahnoun, J. Fontchastagner, C. Viguier, N. Takorabet
Safran Tech and Université de Lorraine, France

Electrical machines that can run at high speeds are more and more studied as they can respond to the increasing need of power onboard of aircrafts. However, to allow high-speed operability mechanical handling of the rotating parts need to be insured. In this paper an analytic design process of a novel high-speed induction machine is presented. The analytical magnetic and mechanical models developed are presented and validated thanks to finite element simulations. The magnetic model is based on a classic equivalent electrical diagram of the induction machine with a specific adaptation for the rotor leakage inductance as the squirrel cage is buried. The mechanical model is based on a field

displacement approach leading to the stress tensor in all the rotating part. A four degrees of freedom vibration analysis model considering gyroscopic effects based on Euler-Lagrange equation allows to identify the critical speeds of the system. It is shown that some geometrical parameters will have opposed effects on the two physics. Thus, an optimization-based coupling between the different physics allows to design rapidly the desired machine regarding any technical specifications as analytical models are being used.

TSAR – Numerical LH2 tank simulation tool
Eszter Dudás, Thibaut Dochy
CT Ingénierie, France

The RUBHY (Responsible Unmanned Bird with HYdrogen) project was established at CT Ingénierie with the dual objectives of promoting sustainable alternatives in aviation and reducing the industry's carbon footprint. Introducing liquid hydrogen (LH2) as aviation fuel presents new challenges on-board the planes as well as on the ground. An in-house research project is being developed in our company to understand and regulate physical parameters of the cryogenic fluid throughout the various flight stages of fuel cell powered lightweight unmanned aerial vehicles. TSAR (Thermal Stratification in A Reservoir) is a numerical tool simulating the operation of a cryogenic hydrogen tank. The model accounts for the physics of liquid hydrogen in equilibrium with its vapour inside a cryogenic tank subjected to external heat flux. Using the REFPROP database the code incorporates real gas effects and a special study is being carried out regarding the discretization of the tank in a horizontal position. The presentation emphasises the key challenges related to fuel storage and their simulation in our numerical model.

Dual Active Bridge converter - Transformer flux balancing
Michel JAMOT
AIRBUS HELICOPTERS, France

Hybridization and electrical propulsion of next aircraft trend leads to introduce new electrical architectures including energy storage as batteries and fuel cells.
Insulated DC-DC converters are more and more demanded to transfer energy between electrical networks, especially between “high voltage” DC networks and the conventional 28Vdc network. When bidirectional power transfer is needed, the Dual Active Bridge (DAB) converter is an interesting candidate due to its well-adapted symmetrical architecture. The transformer, part of the DAB topology, allows adaptation of voltage and current and is the insulation barrier. Uncontrolled transformer flux dc bias may affect the converter reliability and at least its efficiency. The aim of this paper is to remind or explain the phenomena and to present solutions preventing uncontrolled dc bias current within the transformer.

Sensitivity Analysis and Optimization of a Liquid Cooling Thermal Management System for Hybrid Fuel Cell Aircraft

Valentine Habrard, Ion Hazyuk, Valérie Pommier-Budinger, Joël Jézégou, Emmanuel Benard
ISAE-SUPAERO, Université de Toulouse & ICA/INSA/Université de Toulouse, France

The objective of this work is to perform a comprehensive system analysis of a liquid-cooling thermal management system for a hybrid-electric aircraft using fuel cells for general aviation by sizing and optimizing the system with respect to a given objective. A sensitivity analysis on the different design parameters and model assumptions present in the system is also performed. The system and its design parameters will be evaluated based on their impact on the aircraft and its performances. Firstly, the case study is defined and an optimization is run with some initial assumptions leading to a feasibility study for the implementation of this system. The sensitivity analysis is then undergone for the chosen coolant type and fuel cell stack temperature selected after the first optimization. Incorporating the findings of the sensitivity analysis, a second optimization is run on the thermal management system with improved inputs in order to demonstrate a scenario with reduced penalty on the aircraft. Preliminary results show that implementing this hybrid propulsion system along with its thermal management system is feasible without a detrimental reduction in payload and range. In addition, it can be concluded that initial assumptions and system design choices are shown to have a significant impact on the system's sizing and should be considered in aircraft sizing design loops.

Avionic Piezoelectric Deicing System: Numerical and Experimental Investigation of the Use of Extension Modes for Deicing

Modar JOMAA, Pierre-Etienne LÉVY, Dejan VASIC, François COSTA and Marwan ALI4
Université Paris-Saclay, ENS Paris-Saclay, CNRS, SATIE & Université de Cergy-Pontoise & Safran Tech, France

A proof of the concept of utilizing lightweight piezoelectric actuators for deicing aircraft's leading edges with minimal power needs is proposed. This type of deicing applies vibration to the structure by activating its own resonant frequencies to generate sufficient stress to break the ice and detach it from the substrate. The deicing mechanism depends strongly on the chosen excitation mode, whether it's flexural (bending) mode, extension (stretching) mode, or a combination in between, hence affecting the efficiency and effectiveness of the deicing process. Using extensional modes generates shear stresses at the interface leading edge/ice great enough to delaminate the ice. Deicing was demonstrated with a power input density of 0.074 W/cm² and a surface ratio of 0.07 piezoelectric actuators per cm². First, a numerical method for positioning piezoelectric actuators and choosing the proper resonance mode was validated to assist in the system's design. Then, the numerical method was used to implement piezoelectric deicing on a more representative structure of an aircraft wing or nacelle. Finally, a converter topology adapted for deicing application was proposed.

Control design and flight simulation for a DEP aircraft using differential thrust allocation

Rodrigo CASAJUS, Devaki KOTHANDA RAMAN, Joël JEZEGOU, Philippe PASTOR
ISAE-SUPAERO, Université de Toulouse, France

The evolving global market for aircraft electrification has spurred organizations to develop aircraft that harness the advancements in Distributed Electric Propulsion (DEP) technology. This paper considers as a use-case the ECOPULSETM, a hybrid demonstrator for DEP technology featuring six electric propellers positioned along the leading edge of the wing, jointly developed by Airbus, Daher, and Safran. This serves as the reference aircraft to develop longitudinal and lateral-directional control laws that leverage the electric propulsors to enhance the aircraft's lateral directional controllability and stability by effectively managing the additional lift they generate. Part of the work involved establishing a platform that is used to simulate and visualize the flight of the DEP aircraft. This platform facilitates the seamless implementation of longitudinal and lateral control laws adhering to the fly-by-wire concept. Subsequently, the authors propose a control architecture that integrates thrust allocation while adhering to the conventional piloting principles. Ultimately, this study provides pertinent findings concerning the aircraft's flying characteristics under the proposed flight control laws. Finding a feasible and dependable allocation scheme, capable of decreasing the actuation requirements for aerodynamic surfaces, it would pave the way for resizing such surfaces in future DEP aircraft designs. This reduction in actuators and surfaces weight could potentially lead to further reduce emissions.

Lattice Boltzmann Method for Under Hood Hydrogen Leakage Numerical Simulation

LAFARGE Thomas, RICOT Denis, ZHAO Song, BOIVIN Pierre, MANAI Sakreddine, HUANG Zhangchen
CS Group & M2P2 & HYVIA, France

Motivated by the growing interest for hydrogen airplane and on-board fuel-cell electricity production, a lattice Boltz-mann method under hood hydrogen leakage numerical simulation is leaded. A multi-species flow simulation model was developed within the ProLB solver. In this study, ProLB capability to simulate hydrogen mixtures is assessed by comparing LBM simulation results on an academical testcase, the double shear layer, to results provided by a DNS solver. Both solvers velocity, temperature and hydrogen mass fraction profiles show a good agreement which underlined LBM capability to simulate hydrogen flows efficiently with a low dissipation rate.
In the meantime, HYVIA provided a hybrid fuel cell/battery architecture mounted on a utility vehicle. A under hood stack and a pipe hydrogen leakage scenario were experimentally investigated. A vehicle with an inside hydrogen leak was exposed to an incoming flow, heat transfer with the radiator and hydrogen mass fraction was measured. ProLB capability to reproduce experimental results is assessed.

Thrusting MEA by Trusting SiC based power electronics

O. Perrotin, F. Coccetti
Alter Technology & IRT Saint Exupéry, France

Endowed with superior performances such as high switching speed, energy efficiency voltage and temperature handling capability, Silicon Carbide (SiC) based MOSFETs are introducing a paradigm shift in next generation of embedded power electronics. Dependable, efficient and lightweigh solutions are indeed key enabling attributes of next generation of power electronic converters for MEAs. Although SiC represents a promising alternative to its silicon counterparts, largely in use today, shortcoming in the full understanding of the underlying physics-of-degradation and –failure represents a major hurdle for meeting the demanding aeronautic reliability standards. Particularly needed for gaining trust in this technology are "SiC adapted" testing and qualification protocols along with reliability models and "safety-margin" aware design rules. In fact, "test-for-SiC" and "design-for-SiC" guidelines and methodologies are essential to bring confidence in the deployment of the MEA value chain. This is the focus of the public-private funded "SiC (MOSFET) Reliability Evaluation for Transport" (SICRET) project, which main outcomes are presented hereafter.

Full instantaneous electromechanical de-icing using extensional modes

G. Gastaldo, Y. Rafik, M. Budinger, V. Pommier-Budinger, V. Palanque
ISAE-SUPAERO & Institut Clément Ader (ICA), University of Toulouse, INSA, ISAE-SUPAERO, MINES ALBI, UPS, CNRS, France

New programs at Airbus and Boeing that could lead to high aspect ratio wings with large areas to protect from ice, along with advances in electric propulsion that could make conventional de-icing methods (pneumatic or hot air) obsolete, are driving research into efficient electric de-icing systems. Ultrasonic de-icing systems are one of the promising solutions to meet the requirements of such systems. They generate high levels of stress in the ice by inducing vibrations in the substrate, resulting in bulk or adhesive ice failure and, ultimately, ice removal. Two types of resonant modes can be excited for this purpose: flexural and extensional modes. The first should be chosen if low power consumption is required, knowing that the area that can be protected is limited. Contrarily, extensional modes require higher power, but they are more suitable for completely de-icing the surfaces to be protected. However, when the extensional mode is not pure and interfere with flexural modes, the ability of extensional modes to de-ice substantial areas is reduced. The article shows how multilayered materials can be used to design piezoelectric resonant de-icing systems with pure extensional modes, leading to efficient de-icing of large areas.

Mobile charging system for flexible and convenient charging of electric aircraft

Daniel Buvarp, Jennifer Leijon
Division of Electricity, Department of Electrical Engineering, Uppsala University, Sweden

The advent of battery electric aircraft represents a ground-breaking shift in the aviation landscape, promising a future characterized by sustainable air travel. However, the realization of this vision hinges on the establishment of a robust charging infrastructure. Striking the right balance between widespread accessibility and the flexibility and safety demands of airports poses a considerable challenge. In this study, an innovative strategy is proposed and designed to overcome the identified hurdles associated with charging electric aircraft at airports. The idea investigated includes a mobile charging system equipped with advanced energy storage capabilities, complemented by the integration of a megawatt-level charging station. This multi-component mobile system not only addresses the current challenges but also anticipates the dynamic needs of future electric aircraft. By providing both flexibility and scalability, the solution emerges as a pivotal step in shaping the trajectory of aviation electrification, fostering a sustainable and efficient future for air travel.

In insight on the DC-side differential mode power quality requirement in a battery driven motor drive system for an aerospace application assisting the component sizing.

Subhadra Tiwari
Rolls-Royce Electrical Norway AS, Norway

An aerospace application demands high volume and weight density solution. However, the current stringent DC-side differential mode power quality requirement entails in a large DC-filter and is not in favour of the above-mentioned aerospace demands. Moreover, the definition of the maximum voltage ripple in the DC-link exists for 270 V DC-system only. To support for future high voltage DC-system, an addition, or an update of DO160 document with a requirement addressing such system would be useful for component sizing. This paper provides an insight into what the impact of current requirement is on the component sizing via simulation in MATLAB. Further the paper opens the discussion on the possibility to address the issue by understanding the existing requirements and setting a new standard via a trade-off between weight, volume, and power quality concerns.

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ORAL SESSION 3a

WEDNESDAY FEB. 7, 5:30 p.m.

Power generation

Reliability-Oriented Optimization of High Performance SiC-Based Power Drive Systems for Aircraft Applications

Bernardo Cougo, Hans Hoffmann Sathler, Marco Andrade, Alice Teixeira, Fabio Coccetti
IRT Saint-Exupery, France

Wednesday, Feb. 7, 5:30 pm, Amphi 1

Three-phase inverters are one of the most common applications of power converters in More Electrical Aircrafts. In order to significantly reduce weight, size and losses of these converters, disruptive technology such as Wide Bandgap (WBG) components (e.g., SiC and GaN transistors) should be used. Projects at IRT Saint-Exupery have already shown how to optimize and design inverters using SiC and GaN devices to obtain high efficiency and power density. However, reliability and lifetime of such converter (specifically of WBG semiconductors inside the converter) is nowadays the most critical criterion to achieve. For that reason, this paper shows the approach at IRT to optimize SiC-based inverters considering the converter lifetime, based on very precise models internally developed. Models to estimate converter lifetime are focused on the SiC power module, which is the most critical component. With a fast thermal camera, we obtain precise thermal models that are coupled with devices loss model to estimate thermal cycles in the die at the frequency of the fundamental current flowing through the component. This is extremely important for SiC components, contrarily to classical IGBT technology. These thermal cycles will then be used with SiC lifetime models to estimate the converter lifetime. SiC lifetime models will be specifically created at IRT projects for this specific stress on the device: power cycle for high frequency (10 to 100Hz) and low amplitude temperature swing (10 to 40°C).

Contribution of machine learning techniques for the recognition of arc faults in aviation: Case of DC serial arcs

R. Carreira Rufato, T. Ditchi, C. Van de Steen, T. Lebey, Y. Oussar
Safran Tech & LPEM, ESPCI Paris -PSL, CNRS, France

Wednesday, Feb. 7, 5:55 pm, Amphi 1

Arc fault detection represents one of the major challenges for protection systems used in aeronautical applications due to the high demand in terms of security and redundancy. This requirement becomes harder to meet with the increase of voltage levels expected in More Electric Aircraft (MEA) and for all electric or hybrid propulsion, pushing studies to consider more carefully the phenomenon of arc faults. Currently, there is no robust and reliable device in an aircraft capable of recognizing arc faults, hence, this study proposes a machine learning approach to help detect DC serial arcs, which is a challenge in terms of recognition. The analysed database contains current signal measurements of arc faults and nominal behaviours. A linear classifier is implemented based on the extraction of relevant features from the conventional current signals. Thereafter, a feature ranking is performed using the Gram-Schmidt orthogonalization procedure and a feature selection method is applied using the wrapper approach. The described methodology is able to achieve 98% recognition rate in a real time simulation.

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ORAL SESSION 3b

WEDNESDAY FEB. 7, 5:30 p.m.

Certification

Hydrogen Aircraft Certification: Determination of Regulatory Gaps

Joël Jézégou, Robert André, Yves Gourinat

ISAE-SUPAERO, Université de Toulouse, & Airbus, France

Wednesday, Feb. 7, 5:30 pm, Amphi 2

Hydrogen is an energy vector identified as a promising candidate to replace fossil fuel on aircraft, used in a gaseous or cryogenic liquid form, either through direct combustion or through reaction in fuel cells. Hydrogen comes with intrinsic properties that lead to hazards and safety risks. The objective of this work, conducted under the Clean Aviation CONCERTO research project, is to perform a regulatory gap analysis and a risk assessment to prepare future rulemaking activities for the timely certification of hydrogen-powered aircraft. The existing EASA certification regulation will be evaluated to determine its relevancy for hydrogen aircraft architecture and the adaptations that will be needed. Firstly, a synthesis of hazards is determined from hydrogen properties and related research. Through a proposed methodology, a gap analysis is then conducted to cross-evaluate hydrogen hazards, generic concepts of hydrogen aircraft and existing certification regulations. The preliminary results of this analysis show that multiple requirements related to fire protection and cabin safety/emergency evacuation are affected due to the flammability properties of hydrogen. It can be concluded that hydrogen hazards challenge some existing certification assumptions, and that further regulatory evolutions will be needed, with a still on-going analysis that raises significant gaps in existing requirements and means of compliance.

Electrical propulsion & Certification challenges

RENOTTE Alexis, MAURY Christophe, MEUNIER René, PRADIER Jean-Clair

SAFRAN SA, & SAFRAN Electrical & Power, France

Wednesday, Feb. 7, 5:55 pm, Amphi 2

In current aircrafts, there are two distinct certification perimeters: the Engine, ruled by CS-E and the aircraft itself ruled by either CS25/CS23, or CS27/CS29. In the growing activity of the electrical propulsion, a new concept has emerged in term of certification perimeter: Electric and Hybrid Propulsion System (EHPS). This new certification perimeter shall address new technologies, associated to new undesired events, as well as new interfaces with the aircraft (such as grounding strategy or new HV EWIS rules to define). Currently, these new risks are only assessed by safety of flight requested tests. Aeronautic industry needs to complete the way toward production and entry into service and continued airworthiness of the hybrid/electric aircraft.

MEA'24 | FEB. 7 > FEB. 8 TOULOUSE - FRANCE

KEYNOTES

THURSDAY FEB. 8, 9:00 a.m.

FILAE: R&T emblematic project on electrical aircraft carried by French Institutes of Technology

Denis Descheemaeker - Chief Executive Officer at IRT AESE Saint Exupéry

Thursday, Feb. 8, 9:00 am

The emblematic FILAE project "FILière Aéronautique Electrique" aims to contribute to positioning France and Europe at the forefront of the electrification of aviation by tackling key technological locks.

This program of 60M€, starting in 2023 and ending in 2030, is intended to:

- Support development of technologies for electrified light aircraft (CS23),
- Prepare reusable innovative technologies on the commercial aviation of tomorrow (CS25),
- Maximize synergies between different industrial sectors and ranges of aircraft.

FILAE is based on a scientific program that has been initiated by IRT Saint Exupéry, ONERA and ISAE-SUPAERO to which key players in the French research landscape have joined, such as the CEA, LAPLACE and LAAS. Competitiveness, resourcing and cooperation are the main objectives of this program. The presentation will outline the main activities and expected outcomes of the program.

MEA'24 | FEB. 7 > FEB. 8 TOULOUSE - FRANCE

Perspectives of hybridization for commercial aircraft: the lessons learned from the IMOTHEP project

Philippe Novelli – Program Director for Aeronautic. Propulsion and Environment at ONERA

Thursday, Feb. 8, 9:30 am

Facing the challenge to drastically reduce and even cancel its greenhouse gas emissions, aviation is exploring a large panel of technologies, amongst which introducing some electrification in the main propulsion is seen as a disruptive way to reduce fuel consumption. Many architectures have been proposed to date. Parallel hybrid power chains, thanks to energy storage in batteries and electric assistance to thermal engines, provide the opportunity to substitute some decarbonized electricity to fossil fuel in the energy used by the aircraft, as well as some possibilities to better optimise the global propulsion system. On the contrary, series hybrid, or turboelectric, produces all the electricity on board from thermal machines but offers some perspective for optimising the efficiency of the whole propulsion system, in particular through distributed propulsion. Combination of parallel and series are also explored. Obviously, this implies introducing in aviation electric technologies that represent a disruptive step compared to the level of power of the current electric systems on board aircraft. These technologies raise challenges in terms of energy and power density of electric systems, power bus voltage, protection against partial discharges and electromagnetic interference or thermal management.

The IMOTHEP European project was initiated to get a better view of the potential of hybridization for reducing fuel consumption and CO2 emissions of aircraft and to explore the required electric technologies. For this, IMOTHEP has assessed the benefit of hybridization on four different configurations of hybrid aircraft covering regional and SMR missions and representing different levels of disruption in aircraft design. This assessment was performed in close connection with the investigation of the electric components and the architecture of the hybrid power train, the specifications of which were derived from the configuration studies.

The keynote will present the performances achieved and the lessons learned from the exercise at both the electric components level and the aircraft level. It will highlight the main conclusions drawn from the project regarding the potential of hybridization for reducing commercial aircraft emissions and the roadmap for maturing the technology.

MEA'24 | FEB. 7 > FEB. 8 TOULOUSE - FRANCE

POSTER SESSION 2
THURSDAY FEB. 8
10:00-a.m. – 11:15 a.m.

Concept and Control of a Capacitive Boost Processor for a Permanent Magnet Synchronous Motor
Jean-François Bisson, Kamal Al-Haddad
École de technologie supérieure, Canada

This paper proposes a method to increase the power density of a flat-poles permanent magnet synchronous motor (PMSM) by adding the voltage of pre-charged capacitors to the motor phases in addition to the phase voltage of a 3-level PWM inverter. A capacitor being connected in series to each phase of the PMSM, each motor phase becomes a RLC circuit. The outcome of this concept is that the PMSM can be operated at its maximum rated torque over a wide speed range. The pre-charged capacitors have two main effects. First, the voltage boost offered by the pre-charged capacitors opposes the PMSM's Back-EMF, allowing to operate the PMSM in Zero d-axis current (ZDAC) even when the Back-EMF significantly exceeds the DC link voltage, therefore eliminating the need to use the field weakening current control technique. Second, the electrical dynamic of a RLC circuit intrinsically oscillates current and voltage. This supports the inverter in generating AC from a DC source. To pre-charge the capacitors, a converter named the Capacitive Boost Processor (CBP) has been designed. This paper presents the PMSM drive system architecture, the proposed topology of the CBP and the proposed control strategy of the PMSM drive. The simulation results of the proposed system are presented in conclusion.

Low frequency Design Criteria for Carbon Fibre Composite Casings for Aircraft Power Electronic Converters
Mark Higgins, Catherine E. Jones, Rafael Peña Alzola, Graeme Burt
University of Strathclyde, UK

Two key technologies supporting decarbonisation of aviation are the light-weighting of aircraft structures, and the electrification of on-board power and propulsion systems. Achieving the target high power densities required for electrical power system equipment, including power electronic converters (PEC) is extremely challenging. A modularised electrical power system (EPS) which exploits the use of carbon fibre reinforced polymer (CFRP), rather
than aluminium, for non-electrically active components (e.g., casings) for EPS equipment offers an opportunity for more compact, lightweight equipment design. However, existing knowledge of the

electrical response of CFRP at a component scale, and how this impacts on the design of systems where electrical and structural systems interact, is limited.
This paper provides a set of low frequency (<200 kHz), component scale models of a quasi-isotropic layup of CFRP, suitable for use with a behavioural simulation model of a 6-switch inverter to investigate the influence of casing on fault response, and enable capture of design criteria for resilient, low frequency design of CFRP casings for PECs. This includes investigation of key design interdependencies including influence of CFRP layup, design of electrical bonding points and interdependencies with wider system design considerations, including protection strategies.

Aircraft passenger door optimized by electrifying its energy system
Grégoire Le Goff, Sébastien Devillez, Jean-François Llibre, Carole Henaux
LAAS, Université de Toulouse, CNRS & LATECOERE & LAPLACE, Université de Toulouse, CNRS, INPT, UPS, & IES Institut d'Électronique, France

The electrification of aircraft passenger doors is technically feasible. It is already performed in large cargo doors because the size of the door prevents the direct use of a mechanism driven by human force. Passenger door size remains small enough to be compatible with human capacity except for emergency openings where assistance needs to be provided to guarantee the opening in some crash configurations (broken landing gear, wind). Since an attendant must be present for safety reasons, electrifying passenger doors does not bring direct value to the product. The feasibility of electrifying a passenger door has been demonstrated successfully through the NexGED research program, but it highlights the difficulty of achieving the main need of the market, which is the cost. Effectively saving on the mechanism is small, but implementing motors generates new costs. Using a functional approach and value analysis, new architectures with electric functions that are cost-effective are defined. Replacement of the hydro-pneumatic assistance is one of them. Dedicated research efforts have been carried out to optimize the electrical actuator for this function.

Electrical Power Transportation for Electrical propulsion Systems
Charles JULLIEN, Rami KAHOUL
Safran Electrical & Power, France

This article presents the aeronautical vision of electrical energy transport with a short-term vision. A global analysis of the electric energy on board will be made during the discussion on the issues introduced by electric and hybrid propulsion in the aeronautical field. A dedicated focus on EMC issues will be presented. This will highlight the importance and consideration of EMC at harness level in the overall electrical system to ensure the realization of hybrid or even all-electric aircraft.

Techno-economic analysis of green hydrogen production for Toulouse-Blagnac airport

Badr Eddine LEBROUHI; Kolthoum MISSAOUI, Melissa LOPEZ VIVEROS, Silvia DE LOS SANTOS, Pamela RAMIREZ VIDAL
Capgemini Engineering, France

Since the Paris Climate Agreement, numerous countries, including France, have committed to achieving carbon neutrality by 2050 by enhancing renewable energy capacity and decarbonizing various sectors, including aviation. In this way, the Occitanie region aspires to become a renewable energy pioneer and has focused on Toulouse's Blagnac airport—a prominent hub characterized by high-energy demands. As part of a holistic strategy to reduce the airport's energy dependency, green hydrogen has emerged as a promising alternative fuel, offering the potential to significantly enhance aviation's environmental sustainability. This study assesses the technical and economic aspects of green hydrogen production, particularly its potential to replace fossil kerosene in aviation at Toulouse-Blagnac airport. It analyzes future liquid hydrogen fuel demand, calculates energy requirements for electrolysis and liquefaction, considers diverse renewable energy scenarios, and assesses the Levelized Cost of Hydrogen (LCOH) for economic viability. The research also projects LCOH evolution from 2023 to 2050, offering a comprehensive view of green hydrogen's feasibility as a sustainable aviation fuel, aligning with the region's renewable energy and sustainable aviation objectives.
Keywords: Toulouse-Blagnac Airport, green hydrogen, aviation decarbonization, electrolysis, renewable energy, technical-economic feasibility.

A Comparative study for AC Losses of PM Electrical Machines between Submerged Slots and Hollow Conductors

Sulivan KÜTTLER, Sabrina AYAT, Rindrarivelo RAMAROTAFIKA, Julien LABBÉ
Safran Tech & Safran Electrical & Power, France

Future aircraft electrical systems will require high power density and high efficiency in electrical machines. Traditionally, to enhance compactness, a common approach is to increase the number of pole pairs, thereby operating at higher fundamental machine frequencies, typically between 1 and 2 kHz. However, at this frequency, AC losses in conductors may become significant and surpass DC copper losses, which are usually the primary copper loss component in an electrical machine. The objective of this paper is to investigate the optimization of copper loss components. Efficient cooling systems have a substantial impact on machine compactness. Various solutions for direct cooling exist, aiming to place the cooling liquid as close as possible to the heat sources. However, their implementation interacts with winding design, potentially affecting copper losses. These solutions should enhance thermal exchanges, enable operation at lower temperature ranges, and limit the winding's maximum temperature. The maximum temperature is critical in electrical machines as it directly influences wire insulation grade and transient operation duration. This paper, in the given context, compares the impact on copper losses of two direct cooling configurations: Submerged Slots and Hollow Conductors. Specifically, the study investigates the effect on generated AC losses of an increased external surface for hollow conductors. A 3D Finite Element model will be employed to

compare various excitation frequencies and conductor positions within the slot, resulting in a precise spatial loss decomposition. Conclusions drawn from this analysis will contribute to understanding design trends for integrating hollow conductors in electrical machines.

Experimental and numerical investigation of direct two-phase cooling for semiconductors

Antoine Loehrmann, Etienne Videcoq, Vincent Ayel, Sébastien Dutour, Stéphane Blanco, Benjamin Piaud, Vincent Forest, Olivier Crepel

Airbus SAS & Institut PPRIME, CNRS-ENSMA-Université de Poitiers & LAPLACE, UPS, INPT, CNRS, Université de Toulouse & Méso-Star, France

With this study, we focus on power converters intended for propelling future aircrafts. Currently commercially available power converters do not meet the aeronautical requirements. Even though robust they force designers to oversize the thermal systems. One of the main pain points are the heatsinks or baseplates associated with power modules. Here we propose to get rid of them all together and apply the coolant directly to the semiconductors. This simplifies the design and construction of the modules but, because heat fluxes are really high due to the small footprint of semiconductors, the use of liquid/vapor two phase cooling becomes a necessity. In order to cover this topic, a purposely built module and test loop will be the end target. Before that, more simplified versions of the module will be created to better understand the impact of discrete heat sources on two-phase flow and boiling process. With the same objective, a numerical approach including a Monte Carlo algorithm dealing with complex geometry is proposed.

Pressure's Impact on Load Current Decrease in Series Arc Faults

Yousra AICHOUN, Romaric LANDFRIED, Thierry LEBLANC, Philippe TESTE

Université Paris-Saclay, CentraleSupélec, CNRS, Laboratoire de Génie Electrique et Electronique de Paris, France

In recent decades, a significant shift towards the development of more electric aircraft (MEA) has gained momentum. This transition leads to the use of higher voltage distribution network, and to great reliance on direct current (DC) systems. However, utilizing DC power systems at high altitudes presents considerable challenges. One of them is the likelihood of arc faults occurrence. This research focused on series arc faults in DC aircraft power networks. specifically addressing variations in electrical current levels between normal operational load conditions and arc fault scenarios under diverse pressures [200 hPa - 1000 hPa]. To this end, an experimental setup enabling arc generation through controlled contact separation has been implemented within a law-pressure chamber. the latter enables the manipulation of pressure settings to encompass the different cruising altitudes. The experimental results indicate that pressure variations have slight influence on load current variation at the moment of arc ignition. And that this variation could be drowned out by the noise of the measurement.

Direct Coupling of Parallel Hybrid Propulsive System and Vehicle-Level Integrated Mission Performance Aircraft Sizing Models

Aleksandar Joksimović, Alberto Lourenco-Feio, Anna Occhipinti, Javier Domínguez Sanchez
ISAE-SUPAERO, Université de Toulouse, France & PACE Aerospace - IT GmbH, Germany & Empresarios Agroupados, Spain

This paper presents preliminary-design models of hybrid-electric propulsive system architectures in software PROOSIS™, and an example integration thereof into aeroplane mission sizing scheme in software Pacelab APD™. Firstly, an elaboration is provided on the development of hybrid-electric propulsive system architecture sizing/design capabilities. It relies on power-balance modelling that captures basic correlations between component power levels and power densities and efficiencies of the electrical machinery employed in the power train; the models handle steady-state operation alone. Subsequently, the paper explores integration of such models into aeroplane mission-sizing scheme based on direct information exchange between the two tools. An example trade study of parallel-hybrid performance system integrated in a short-medium range aeroplane model made accessible by such fully transparent coupled model is presented. The coupled framework is demonstrated as capable to provide trade-offs between whole aircraft mission performance and properties of the integrated hybrid system model. However, correct preliminary sizing of the propulsive system remains a challenge to be resolved. With subsequent rigorous validation and further development including comprehensive aeroplane-propulsive system information exchange, it will be capable to provide full fine-grained description of the design space, allowing robust concept comparison and decision making in conceptual design.

Supporting Aircraft Electrification Technology Development with Modeling and Simulation

Maria Fernandez Jimenez, Graham Dudgeon, Lachlan Jardine
MathWorks Spain, MathWorks Natick, MathWorks UK

Different engineering questions are asked at each stage of a technology development cycle. Effectively answering these questions requires mapping computational tools and techniques that provide a framework allowing different engineering disciplines to innovate with rigour and seamlessly transfer engineering information between various teams. Adjustable model fidelity and task-specific analysis are the key values for mapping at multiple stages of a technology development cycle. In this paper, we will consider a representative hybrid-electrical architecture that includes electrical, mechanical, and thermal components and moves incrementally from a low-fidelity system-level model to answer questions regarding architecture layout and component sizing to more detailed component models to answer questions regarding feedback control design and power electronic switching strategies. We will also answer questions regarding system-level energy accounting for energy efficiency calculation, fault analysis, and modeling considerations for real-time testing. Finally, we will show how to explore a large design space by running thousands of simulations in parallel and applying statistical analysis to the resulting large data sets.

Crash testing lithium-ion battery for helicopters

Jeremy CAMUS, Severin HALBOUT-
AIRBUS HELICOPTERS, France

Electrification is one of the promising lead for decarbonizing the aeronautics sector, which is highly dependent on fossil fuels.
Given the safety issues associated with propulsive lithium ion battery (thermal runaway, smoke, fire…), the European Aviation Safety Agency (EASA) plans to extend to these, the applicable drop tests used for helicopters fuel tanks certification.
Storage energy specialists from Airbus helicopters and EDF Company designed and initiated tests consisting of dropping a lithium ion battery from a height of 50 feet, a height covering the conditions of a survivable crash.
This innovative test, the second in the world and the first in Europe in the specific domain of VTOL, was to characterize the behaviour of a lithium-ion battery, with respect to the risk of fire or other harmful releases (gas, smoke, explosion …) in case of crash and then will allow to determine acceptance criteria to ensure safety of occupants. This knowledge makes it possible to anticipate battery design and helicopter installation for the next serial developments.

Analysis of the effects of partial discharges in a power cable for aeronautical applications

Vladimir Pineda Bonilla, Riantsoa Rabemarolahy, Françoise Foray, Michael J. Kirkpatrick, Philippe Molinié, Emmanuel Odic
Laboratoire de Génie Électrique et Électronique de Paris (GeePs -UMR8507 CNRS, CentraleSupélec, Université Paris-Saclay, Sorbonne Université & Airbus Helicopters, France

The objective of this study was to investigate the behavior of the electrical insulation system of a power cable in the presence of partial discharges (PDs). The cable was taped DH gauge 2 with PTFE insulation, currently used in aircraft. A PD aging chamber has been designed and constructed. The cable specimens were partially covered with grounded shielding braid. Thus, when a voltage exceeding the system partial discharge inception voltage (PDIV) was applied to the center conductor (~30 kHz AC sinusoidal voltage), the insulation system was subjected to partial discharges over a cable length delimited by the dimensions of the ground braid. Accelerated ageing was carried out at room temperature and atmospheric pressure. The conditions for the presence of external discharges (discharges initiated at the ground braid conductors in contact with the outer insulating face of the cable) and internal discharges (discharges initiated in the internal cavities of the insulation at the peripheral strands of the conductor) were identified based on the experimental conditions (amplitude of the applied voltage, geometry of the ground braid). For each aging condition, the mean power dissipated in the discharge was measured, and the delay to failure noted. During aging of certain specimens, PDIV was also measured.

Design and simulation of a power module for helicopter Electro-Hydrostatic Actuator

Mingwei SUN, Chao WANG, Jian FU
Beihang University, China

With the introduction of the concept of More Electric Aircraft (MEA), the Power-by-Wire (PbW) actuators of Electro- Hydrostatic Actuator (EHA) and Electro-Mechanical Actuator (EMA) are put into application recently. Both of them have been successfully used in the flight control systems of fixed-wing aircraft, launch vehicles, and other vehicles. With fast increase in the number of research projects about helicopter, it's obvious that the development of helicopters also pursues lightweight design and electrification. Therefore, the electrification of flight control systems (FCS) is an essential path toward more electric helicopter. However, due to the high reliability requirements of helicopter flight control systems, the application of power-by-wire actuators in helicopters has progressed more slowly. This communication aims to design a power module used in high fault-tolerant EHA architecture for swashplate control of helicopter. To enhance output forces and reduce installation space, a dual-redundant design with asymmetric and symmetric cylinders is employed in the EHA. Then, system simulation model is established to comparatively analyse the advantages of the proposed power module. Simulation results demonstrate the feasibility of the proposed approach, indicating that the use of this power module can reduce replenishment flow and decrease overall energy consumption in the operation of EHA.

Aeroelastic Behaviour of Urban Air Mobility Aircraft with Distributed Electric Propulsion

Antoine Boissinot, Mojtaba Kheiri
Department of Mechanical, Industrial and Aerospace Engineering, Concordia University, Canada

This project aims to conduct a parametric study on the aeroelastic behaviour of urban air mobility (UAM) vehicles with distributed electric propulsion (DEP) systems. The study focuses on the stability analysis of wings with distributed propellers. Despite the growing attention given to UAM vehicles, their aeroelastic behaviour remains poorly understood due to their DEP system complexities altering the force, mass, and moment of inertia along the wingspan. Failing to adequately consider those aspects can have a detrimental impact on the stability of the aircraft.

The study uses Euler-Bernoulli beam theory for wing bending-torsion dynamics and models the propellers as concentrated masses with thrusts as follower forces. The governing equations are transformed into a set of ordinary differential equations via Galerkin's method, and the aerodynamic loads are derived with a time-domain indicial aerodynamic theory based on Wagner's function. The stability analysis is then obtained with an eigenvalue analysis. Parameters like propeller count, propeller-wing mass ratio, and dimensionless thrust inputs are explored, offering insight to enhance UAM vehicle stability. Urban gust response and aerodynamics interaction effects between the propellers and wing are to be analysed in future works.

From towing to take-off assistance, the U-shaped linear induction motors to reduce consumption and emissions of aircraft

G. Coquery. M. Combette. J. Perrot, F. Daniel
TACV Lab & GROUPE CELDUC, France

Researchers and Engineers have to find greener solutions for the future of the aviation industry taking into account the requirements to satisfy the next regulation of the global CO2 emissions, as well as the "flight shame", or "flygskam" movement. French researches have delivered very high levels performances considering efficiency and power factor of the linear induction motor using a U shape reaction rail (U-LIM). This U-LIM system technology provides very compact support for traction and guidance forces. A similar LIM technology based on flat linear induction motor is use for Electro-Magnetic Launcher System (EMALS), installed on the new generation of aircraft carrier by the US Navy and recently by the Chinese Navy.

The present proposition is to apply such technology for towing civil aircraft until its assisted take-off. The principle is as follows, the two parts of the U-LIM are completely integrated into the aircraft taxiway in order to create a continuous loop from the taxiway to the runway. The traction force is relayed to the aircraft by a retractable mechanical arm under the runway.

U-LIM system has to be designed for low speed on the taxiway, and high speed on runway with the respect of limited acceleration stress for the passenger comfort.

By moving the airplane on the taxiway and producing the additional thrust for take-off acceleration, the benefits should be a reduction of consumption and polluting emissions, as well as a significant noise reduction for airport neighbourhood, thanks to a shorter take-off distance on the runway.

An ultra-long-range electric drone powered with liquid hydrogen.

Sofia Mertika, Nikola Gavrilović, Joshua Schimpf, Sebastien Duplaa, Christophe Turpin, Jean-Marc Moschetta
ISAE-SUPAERO, Université de Toulouse & Hylium Industries & Plasma and Energy Conversion Laboratory, France

Project Drone Mermoz is a collaboration between ISAE-SUPAERO and the company H3 Dynamics. It was created to design a long-endurance hydrogen-powered unmanned aerial vehicle that aims to cross the Atlantic Ocean. The drone is specifically engineered to incorporate the use of both gas and liquid hydrogen. This research introduces the development of a prediction tool for monitoring the drone's system response under various flight scenarios, facilitating optimization. This tool consists of modeling mathematically each individual component in the chain of the drone's propulsion system, including the electric motor coupled with a propeller, the fuel cell module, and the reservoir for gaseous and liquid hydrogen. These models have been determined from the literature and then validated and calibrated through experimental campaigns. This research signifies in addition the initial stages of integrating liquid hydrogen into Mermoz's flight mission.The experimental campaign for liquid hydrogen extends to include the ground testing of the UAV's propulsion system and the monitoring of the ice formation around the hydrogen's transfer line.

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ORAL SESSION 4a

THURSDAY FEB. 8, 11:15 a.m.

Aircraft Architecture - Part 2

Testbed for evaluation of Electric propulsion Architectures

M. Ridel, S. Bonnard

ONERA/DEMR, Université de Toulouse, France

Thursday Feb. 8, 11:15 am, Amphi 1

For some years now, the use of electrical energy for aircraft propulsion has been one of the ways to be explored to reduce the environmental impact of aviation. The total or partial electrification of propulsion systems means the introduction of additional electrical loads of much greater power than the non-propulsive electrical loads carried on board until now, on the order of a hundred kilowatts for a light aircraft and a megawatt for a commuter. The implementation of these high electrical powers, via a rise in voltage and current in an extremely constrained environment, questions current electrical architecture solutions and their installation rules. At the same time, the electrification of propulsion opens the way to new, more aerodynamically efficient distributed propulsion configurations, offering new reconfiguration capabilities for energy management and safety. ONERA's various conceptual studies on distributed electric propulsion (DEP) [1] [2] [3] have shown the need to master the integration of these electric propulsion chains, firstly from a functional point of view (static and dynamic), but also in terms of integration at aircraft level. This article describes the specifications of our new testbed, named TROPHEA (Testbed for Research On PHysics of Electrical Architectures), which will enable us to better understand the various physical phenomena associated with this type of architecture.

Review and comparative analysis of various hybridization strategies for energy management in eVTOL aircraft

Afef NAJJAR, Meryem TAGHBALOUT, Abderrahmane BOULARAS, Michel BAREILLE, Youssef HENNANE, Florian FRITZ

Capgemini Engineering, France.

Thursday Feb. 8, 11:40 am, Amphi 1

In recent years, new electric Vertical Take-Off and Landing (eVTOL) aircraft have emerged as one of the most dynamic fields in aeronautics. The Hybrid Power System (HPS) of the eVTOL requires an Energy Management Strategy (EMS) that guarantees optimal sharing of power flow between the

diverse sources, while meeting energy demands and adhering to the dynamics and limitations of each component. This HPS integrates batteries and Fuel Cells (FCs). In this work, we present the hybridization strategies for the eVTOL propulsion system proposed in the CAPGEMINI "VIABLE " R&I project. Four methods have been implemented for this purpose: the State Machine Control (SMC) approach, the Equivalent Consumption Minimization Strategy (ECMS), the frequency-separation approach, and the EMS with reinforcement learning strategy. These EMS approaches aim to ensure the best allocation of energy requirements between various sources, taking into account their limitations and specifications. Our objective is to study these methods and compare them based on predefined criteria, such as strategy efficiency, adherence to our study case constraints, hydrogen consumption and battery state of charge.

Climate and energy impact analysis of electric, hybrid-electric and hydrogen aircraft in prospective scenarios for air transport

Scott Delbecq, Thomas Planès, Valérie Budinger, Antoine Salgas, Félix Pollet
ISAE-SUPAERO, Université de Toulouse, France

Thursday Feb. 8, 12:05 am, Amphi 1

To meet climate impact reduction objectives, the aviation sector must both accelerate the improvement of the fleet efficiency and the deployment of low carbon energy carriers. This implies to develop new concepts of aircraft with a reduced climate impact than previous ones and possibly more energy efficient. One research direction is the investigation of electric and hybrid-electric aircraft concepts to possibly gain propulsive efficiency and ultimately aircraft efficiency. Some of these concepts also imply the direct usage of electricity or hydrogen from electrolysis which may be potential low carbon energy carriers. Evaluating the climate impact benefits and energy implications of the deployment of such aircraft architecture is intricate. This paper presents an analysis of different deployment and technological assumptions for these concepts. The analysis which consists in assessing the climate impact benefits of these new aircraft architecture in terms of CO2 and non-CO2 effects will be performed. The assessment of absolute kerosene and electricity consumption will also be achieved. This will enable the performance comparison between architectures and with other market segment not relevant for such technology.

Electrical Power Transportation for Electrical propulsion Systems

Charles JULLIEN, Rami KAHOUL
Safran Electrical & Power, France

Thursday Feb. 8, 12:30 am, Amphi 1

This article presents the aeronautical vision of electrical energy transport with a short-term vision. A global analysis of the electric energy on board will be made during the discussion on the issues introduced by electric and hybrid propulsion in the aeronautical field. A dedicated focus on EMC issues will be presented. This will highlight the importance and consideration of EMC at harness level in the overall electrical system to ensure the realization of hybrid or even all-electric aircraft.

MEA'24 | FEB. 7 > FEB. 8 TOULOUSE - FRANCE

ORAL SESSION 4b

THURSDAY FEB. 8, 11:15 a.m.

Power conversion – Part 1

A new SSPC family: an example with the HVDC SSPC
Rodolphe De Maglie, Yannick Laurent
Liebherr-Electronics and Drives GmbH, Germany & Liebherr Aerospace Toulouse, France
Thursday Feb. 8, 11:15 am, Amphi 2

This paper deals with the presentation of a new SSPC (Solid State Power Controller) dedicated to 540V HVDC system. Thanks to a family concept development, this SSPC is aimed to be competitive on the market targeting reduction of costs, high reliability and performances based on natural convection air-cooling. The family concept is introduced covering the main types of voltages and the main applications in term of currents: a generic and modular approach allows reuse of the core functions in all of the SSPC family members. Main features are described, commissioning and environmental tests results are presented and validate the maturity of the current HVDC SSPC design.

Fault-tolerant magnetic coupling topology for network parallel multilevel inverters
Rita MATTAR1, Marwan ALI1
Safran Tech, E&E France
Thursday Feb. 8, 11:40 am, Amphi 2

In view of the increase in electrical power levels in aircraft applications, the availability of high-power density of static converters is nowadays essential in electrical systems. However, if the converter's power density is a major challenge, so is its reliability. This paper is set in this perspective, and plans to study a fault-tolerant magnetic coupling topology for a network parallel multilevel inverter in aircraft applications. These structures allow to follow the rise in power of the converters, without drastically increasing the voltage level. The modeling, the sizing, and the design of the Secondary Loop coupling topology are developed for 15 kW/phase. Then, the experimental results are presented in an open-loop study. For the closed-loop study, a linear dynamic model of the inverter is discussed to ensure the balancing of the leg currents. In the last paragraph, this topology is tested in terms of fault tolerance due to the loss of an inverter leg.

Arc tracking power balance: Method for determining fusion and vaporization power

C. Gouze, F. Valensi, Ph. Teulet, T. André, M. El Khaiter, R. Causse
Université de Toulouse, UPS, LAPLACE & Airbus, France

Thursday Feb. 8, 12:05 am, Amphi 2

The energy balance for fault arcs in aeronautic conditions has been studied for copper and aluminium cables. A method based on high speed observation of melted droplets ejected from the electrodes has been developed for lost mass determination. This allows estimating the power needed for metal fusion and by considering the power transferred to the electrodes, the part responsible for vaporization can be estimated. This leads to more accurate determination of the power balance. In addition, this method allows study of the cables erosion as a function of time. Comparison between aluminium and copper cables has been made for various wire diameters. Results show that while the total power transferred to electrodes is lower in the case of copper, the part available for vaporization is greater. As expected, less metal is vaporized for larger cables at the same power. The droplets ejection shows high fluctuations over time but erosion becomes lower and more stable once the two cables are cut.

High Frequency modelling to predict inter-turn voltage distribution in electrical machines for aeronautical applications

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Thursday Feb. 8, 12:30 am, Amphi 2

Electrifying future aircrafts requires subsequent embedded electrical power. To reach this objective, the on-board voltage needs to be increased to levels higher than the reference values of 540V. Rotating electrical machines fed by PWM (Pulse Width Modulation) inverters are widely used in More Electrical Aircrafts (MEA) applications. The generated output voltage from the PWM source usually contains pulses with a high slew rate, resulting in overvoltages due to waveform reflections phenomena and non-uniform voltage distribution within stator windings. Consequently, there is a risk of Partial Discharges (PD) inception since the inter-turn voltage can reach values higher than the PDIV (Partial Discharge Inception Voltage). These phenomena are amplified with the use of Wide Gap Band (WBG) inverters, that allow reaching higher switching frequencies and faster voltage rise times. The combination of these factors, in addition to the environmental conditions (especially the altitude) raise the risk of partial discharge and insulation breakdown in the machine windings. This paper presents a high frequency (HF) model of a machine stator windings which aims to predict the turn-to-turn and turn-to-ground voltages. The proposed method is based on a two-scale model allowing to take into account the environment of the electrical machine and to predict the electrical stress distribution within the stator windings.

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ORAL SESSION 5a

THURSDAY FEB. 8, 2:00 p.m.

Hydrogen on board

Digital Twin of complete Fuel Cell System demonstrator
Matthieu Ponchant, Olivier Broca, Antoine Delacourt, Jan Belak, Pavel Trnka
Siemens Industries Software SAS & Honeywell International s.r.o, , France
Thursday Feb. 8, 2:00 pm, Amphi 1

In the context of the road of aircraft decarbonization, new propulsion concepts are designed and virtually assessed, especially by using carbon-free fuel like hydrogen thanks to the European research program Clean Aviation. Within the European-founded project NEWBORN, a consortium led by Honeywell International s.r.o is working on a Fuel cell (FC) system demonstrator with several partners. In parallel to the real demonstrator, a Digital Twin (DT) is necessary to support design at the preliminary stage until final control validation. For those purposes, multiple dedicated models for integrated multi-fidelity DT have been developed with Siemens software Simcenter Amesim,
resulting in a control calibration time reduction of approximately 50% and enabling a single prototype design iteration. Additional interest of such digital twins is also virtual testing in harsh conditions and assessment for scaling-up checking the relevancy of the proposed solution for bigger aircraft (regional). Several models will be developed from detailed physical models to reduced order one to tackle all simulation challenges, especially the overall physical consistency due to complex multi-physical modelling including all subsystems of a complete fuel cell system demonstrator. Finally, the DT will be able to connect with the hardware test bench for final control validation and to be sharable in the framework of the Clean Aviation European program.

Hydrogen on board – Lessons learned from Space Launchers – Challenges and Opportunities
Simon Ménager, Emmanuel Blanvillain
ArianeGroup, France
Thursday Feb. 8, 2:25 pm, Amphi 1

When considering a more electric aircraft, especially for propulsive purposes, the use of hydrogen (and especially liquid hydrogen) as an energy storage soon become a key candidate required to meet the performance requirement of a medium size airplane.
Designing an LH2 aircraft however requires an ambitious development and several technological leaps in order to meet current aircraft's reliability, safety and cost standards. To meet these ambitious targets and develop the technologies required to safely store LH2, raise its pressure and heat it up to the power plant required levels, the experience built on cryogenic space launchers over the past decades will be extremely valuable.

Furthermore, the introduction of LH2 as energy storage also offers opportunities to use more electric equipment and to develop more electric architectures.

HOPE Project: Hydrogen Fuel Cell System Technologies for zero Emission Aircraft Propulsion
Guillaume HUBERT, Christophe MAURY, Claude VALLEE, Yann FEFERMANN
Safran Power Units & Safran Tech, France
Thursday Feb. 8, 2:50 pm, Amphi 1

H2-based fuel cell systems are clearly a promising solution to power aircraft without emitting CO2 nor NOx and thus have the potential to strongly reduce aviation emissions and pave the way to climate neutrality.
In this context, the objective of this article is to present a collaborative project funded by the French DGAC and the European Union, led by Safran Power Units, and which allows the development of a H2-based fuel cell propulsive system and their associated technologies. The platform target, a derived concept of the DHC-6 Twin Otter, will be detailed and two technical focuses will be developed. Global optimization of this integrated propulsive system is key as compromises must be found between each component sizing. Moreover, the use of H2 introduces new challenges and carries some intrinsic issues that need to be resolved for a safe integration in an airplane. Specifically, the lack of standardized test for H2 fire is one of them. Finally, the HOPE (Hydrogen Optimized Propulsive Energy) project is a great opportunity to imagine the future hydrogen fuel cell engines and to develop their associated key technologies

Thermal stratification for various design of LH2 tanks
Thibaut Dochy, Eszter Dudás
CT ingénierie, France.
Thursday Feb. 8, 3:15 pm, Amphi 1

Hydrogen can be liquefied by cooling it to around 20 K (-253°C) at atmospheric pressure. The resulting temperature difference between the stored liquid volume and the surrounding environment ensures that heat inevitably penetrates the LH2, which can lead to evaporation.
The first challenge is to assess the evaporated vapour known as boil-off gases (BOG). BOG production leads to an increase in pressure within the storage tank, requiring venting of the tank to atmosphere and loss of H2.
The key objective is to understand the impact of BOG consumption on pressure rise.
For this purpose, an internal code, named Thermal Stratification in A Reservoir (TSAR), has been developed, for a static Dewar. The 'static' criteria meaning no mass transfer across the system boundary (such as refuelling) is considered. The results of these simulations are in good agreement with Daigle model.

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ORAL SESSION 5b

THURSDAY FEB. 8, 2:00 p.m.

Power conversion – Part 2

Superconducting flux modulation machine for aircraft applications
R. Dorget, P. Gning, W. Dirahoui, J. Lévêque, Adrien Cipriani
Safran Tech, & Université de Lorraine, France
Thursday Feb. 8, 2:00 pm, Amphi 2

Hybridisation and electrification of aircraft propulsion requires electrical component and especially electrical machines with high efficiency and specific power. Superconducting and cryogenic technologies have the potential to improve drastically the performances of an electrical powertrain but require a complex cryogenic cooling. However, there could be a strong synergy with the potential use of liquid hydrogen as fuel in future aircrafts. Indeed, liquid hydrogen is stored at about 20 K, a temperature at which high temperature superconductors have outstanding performances. In this paper, generalities about industrial high temperature superconductors are presented as well as the potential of these technologies for electrical machines. Then, the different prototypes of superconducting flux modulation machines realised or being built by the authors are exposed.

Design guidelines of a battery-to-HVDC power converter for hybrid electric regional aircraft
Alejandro Llop, Imanol Trapote, Alfredo Rubio, Kepa Mendibil, Igor Gabiola, Pablo Doña, Elena Trancho
Tecnalia, Basque Research and Technology Alliance (BRTA), Spain
Thursday Feb. 8, 2:25 pm, Amphi 2

Aviation needs to transition towards the hybrid-electric aircraft to meet European Green Deal targets. This can only be accomplished with power distribution networks that can safely handle the high power and voltage levels, of up to several MW. This paper aims to present the first design steps and guidelines of a battery-to-HVDC power converter, currently under development within the European Project HECATE, granted under the HORIZON-JU-CLEAN-AVIATION-2022-01-HER-03 call and kicked-off in January 2023. The manuscript includes the design guidelines adopted in the area of power electronics and control, providing an overview of the advancements on the development of this battery-to-HVDC power converter, which poses a significant increase in power density target without sacrificing efficiency. In this paper, the comparison between two topology candidates, dimensioning, sizing, component pre-selection and design guidelines have been addressed as a previous step of its implementation in a fully functional prototype, keeping in mind compliance with aero regulations.

Parallel multilevel inverter for a deported electrical motor drive: Studies & Developments
Rita MATTAR, Marwan ALI, Edson de Souza Lima Junior, María Dolores Jiménez Sánchez
Safran Tech, France & Skylife, Spain
Thursday Feb. 8, 2:50 pm, Amphi 2

The electrification of avionics systems is becoming a necessity in order to support the plan to reduce gas emissions. The electromechanical chain is the main lock to be optimized specifically for each application to be electrified. The electronic power converter is the main equipment in this chain, which can strongly impact its reliability and power density. In this paper, we present a theoretical and experimental study of an inverter topology intended for split electromechanical chains. Theoretical and experimental results of design and production are presented. This parallel multilevel topology will greatly reduce the constraints on the filters, which will increase the overall power density.

Interactions between a fuel cell and its associated power converter: recommendations for the design with regard to the state of the art
Christophe Turpin, LAPLACE, Université de Toulouse, CNRS, INPT, UPS, France
Thursday Feb. 8, 3:15 pm, Amphi 2

The fuel cell powered by hydrogen and air is a promising solution to decarbonize the power generation systems of future aircraft, at least for non-propulsive applications and even for propulsive purposes if the size of the aircraft is limited. A fuel cell is most often connected to the electrical consumer via power electronics. The operation of power converters results in current harmonics on the fuel cell side at different frequencies and amplitudes depending on their structure, their control and the operating point of the fuel cell. These harmonics are generally mitigated by introducing filters (based on reactive elements capacitors and inductors) between the fuel cell and the power converters. But the introduction of these filters increases the weight and the volume of the power interface. The challenge is then to optimize their sizing by minimizing the impact on the fuel cell lifetime. The literature offers few studies on this topic. After a detailed presentation of this state of the art in which LAPLACE's work plays an important role, some high-level recommendations will be proposed to electrical architecture designers.

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ORAL SESSION 6a

THURSDAY FEB. 8, 4:00 p.m.

Electromagnetic compatibility

New EMC shielding harness characterization up to 9GHz
Charles JULLIEN, Anca DIEUDONNE, Thomas COLLETER
Safran Electrical & Power, France
Thursday Feb. 8, 4:00 pm, Amphi 1

Localized injection is a method for measuring the transfer impedance (Zt) and could be used for a shielded cable connector assembly (CCA). The principle consists in generating via an injection probe a disturbing current which will circulate on the shielding itself creating a victim voltage between the shielding and the core. A second probe of the same type is necessary to measure the intensity of the injected current. The CCA under test (CUT) is short-circuited at the end in order to maximize the injected current and open-circuited at the other end, which makes it possible to measure the victim voltage. The interest of this method lies in its simplicity of implementation, the use of means already existing for other tests and adapts to any type of samples without being a destructive test. The transfer impedance measurement method with the localized injection method has two limitations: low level of injection to be able to disturb the cables at very low frequency and high frequency, The transfer impedance measurement will be limited by the length of the sample and/or the measurement probes used. For shielding efficiency, the limitation will be above all on the capacity of classic probes to measure and inject beyond the GHz. The high frequency limitation can be bypassed by using stripline type probes which can be used up to 9Ghz.

Enhancing Power Density in Medium Power Inverters for Electric and Hybrid Aircraft Propulsion: Addressing Thermal and EMC Challenges
Victor Dos Santos, Bernardo Cougo, Gilles Segond
Safran Tech, & IRT Saint Exupéry, France
Thursday Feb. 8, 4:25 pm, Amphi 1

This article explores a more recent assembly technique to enhance power density in medium power inverters designed for electric and hybrid aircraft propulsion systems. While TO-247 packaging serves as a conventional benchmark for power semiconductors, this study primarily focuses on the innovative approach of integrating these components directly into the printed circuit board (PCB). Given the imperative need for greater power density in aviation applications, driven by strict space and weight

constraints, this research contributes to the integration of components into the PCB. The article offers an overview of the preliminary design phase and presents design results for two 400..800V/60kW six-phase inverters. Study results reveal promising improvements in the compactness of the switching cells, highlighting the potential for more efficient and compact medium power inverters suitable for electric/hybrid aircraft propulsion and non-propulsive systems. This research contributes to the ongoing efforts to advance power electronics for aviation and aligns with the goal of electrifying aircraft propulsion systems.

Crash testing lithium-ion battery for helicopters
Jeremy CAMUS, Severin HALBOUT
AIRBUS HELICOPTERS, France
Thursday Feb. 8, 4:25 pm, Amphi 1

Electrification is one of the promising leads for decarbonizing the aeronautics sector, which is highly dependent on fossil fuels. Given the safety issues associated with propulsive lithium ion battery (thermal runaway, smoke, fire…), the European Aviation Safety Agency (EASA) plans to extend to these, the applicable drop tests used for helicopters fuel tanks certification. Storage energy specialists from Airbus helicopters and EDF Company designed and initiated tests consisting of dropping a lithium ion battery from a height of 50 feet, a height covering the conditions of a survivable crash. This innovative test, the second in the world and the first in Europe in the specific domain of VTOL, was to characterize the behaviour of a lithium-ion battery, with respect to the risk of fire or other harmful releases (gas, smoke, explosion …) in case of crash and then will allow to determine acceptance criteria to ensure safety of occupants. This knowledge makes it possible to anticipate battery design and helicopter installation for the next serial developments.