Superconducting motor associated with a superconducting power train

Christophe Viguier[1], Abdelrahman El-Wakeel[2], Min Zhang[2], Ghazi Hajiri[3], Yanis Laïb[3], Kévin Berger[3], Jean Lévêque[3]

[1]SAFRAN TECH, Blagnac, [2]University of Strathclyde, Glasgow [3]Université de Lorraine, GREEN, F-54000 Nancy, France

Imothep Project : "Investigation and Maturation of Technologies for Hybrid Electric Propulsion"

H2020 project ("Mobility for Growth" - "towards a hybrid/electric aircraft") **Coordinated by ONERA**

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 875006

29 partners - 9 European countries + international partners from Canada - 10.4 M€ EC funding

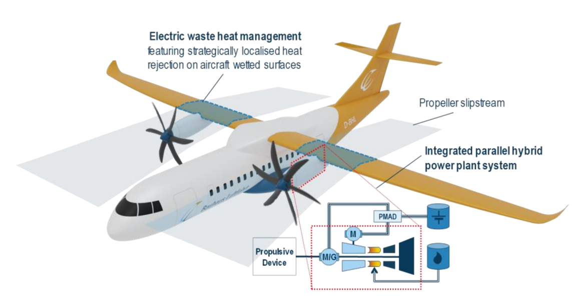
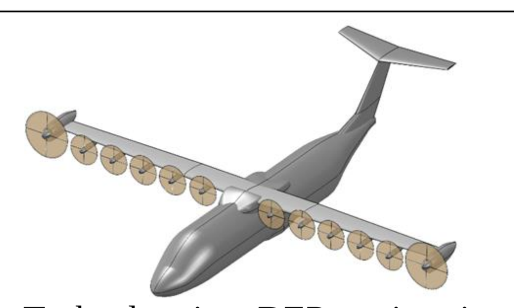
Key step in assessing potential benefits of HEP for emissions reductions of aircraft

First level objectives

- Identifying propulsion architecture & aircraft concepts benefiting from hybrid electric propulsion
- Investigating technologies for HE power train architecture and components
- Analysing required tools, infrastructures, demonstrations and regulatory adaptations for hybrid electric propulsion development
- Synthesising results through the elaboration of the development roadmap for hybrid electric propulsion

Reference missions

Short/medium range: minimum segment for a significant impact on aviation emissions
Regional: more accessible, potential intermediate step toward small and medium range aircraft

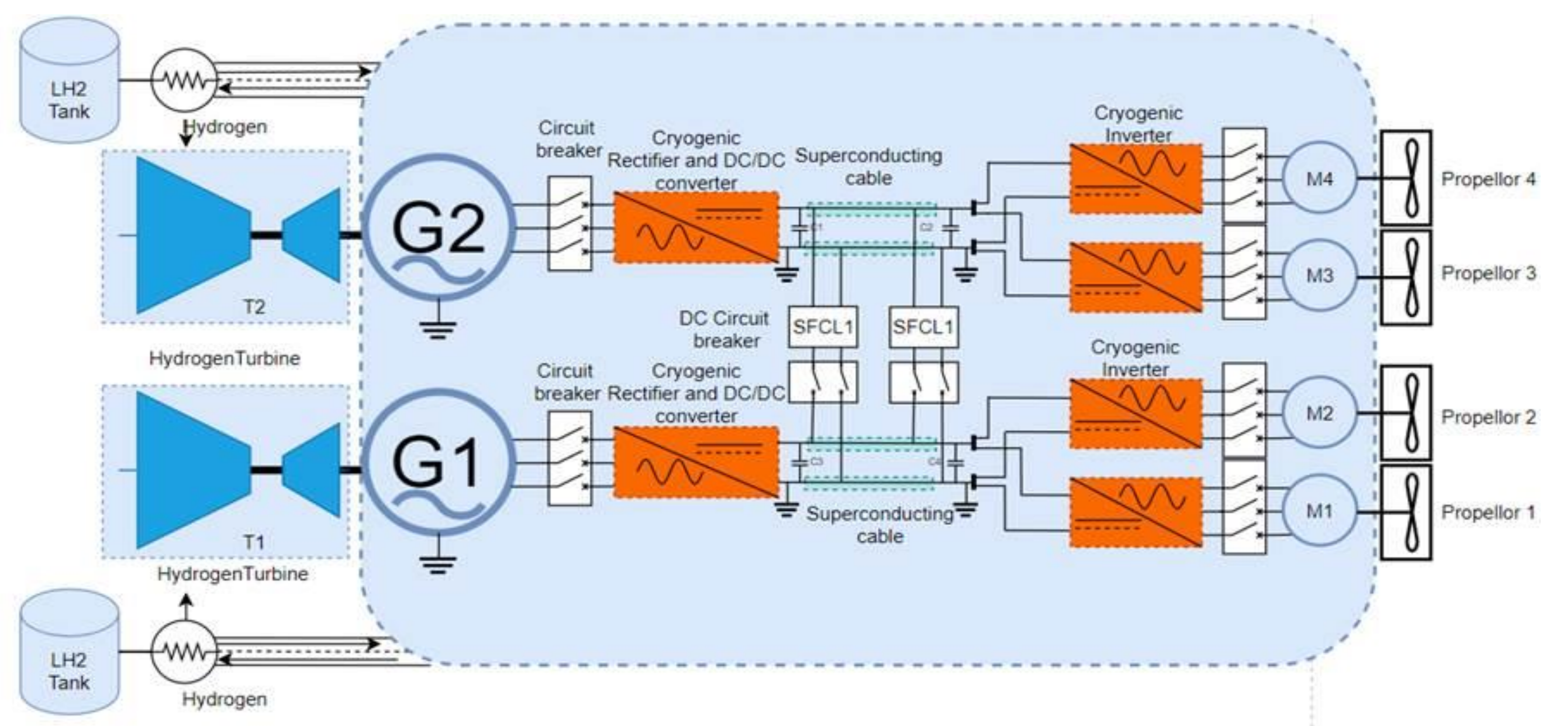
	Conservative	Radical
Regional	 Electrically assisted turboshaft	 Turboelectric + DEP + wing-tip propeller
SMR	 Tube & wing, turboelec, DEP (from CS2)	 BWB, turboelectric, DEP, BLI

Technological scope

Central focus on thermal hybrid with drop-in fuel
some investigations on fuel cells at conceptual level (aircraft + fuel cell)
Main focus on conventional conductivity
Exploration of superconductivity as a potential enabler

Ambition

Reaching 10% more emissions reductions than Clan Sky 2 targets with conventional technologies



Overall description of the approach and hypothesis

Elecromagnetic Hypothesis

The operating temperature is 20K ➔ liquid hydrogen.

Full superconducting synchronous motor is considered to provide best performances.

Power Electronics Hypothesis

The operating temperature is between 50 K to 70 K.

Semi-conductor technology: IGBTs have sufficient ratings and good performance at cryogenic temperatures.

Specifications

Parameters	Value
Power rating (MW)	2,3
Speed (rpm)	2700
Input Voltage (DC Bus) V	3000
Output voltage (AC), V	1200
Output current (A)	1200

Results

		Devices	
		Diode	IGBT
Characteristic	Forward Voltage	Increases by 20-260% for all devices but GaAS which decreases by 20%	Decreases by 5-30%
	Gate-source threshold voltage	-	Increases by 20%
	On-state resistance	Decrease for (20-70%): Silicon diode Increased for (20-80%) : Silicon Ultrafast	Decreases by 30-70%
	Breakdown Voltage	Increased by 5% : SiC Schottky Decreased by 20% : MBRS Schottky	Decreases by 20-70%
	Switching Time	Reverse recovery time decreases by 30%	Decrease by 60-80%

Design of a Synchronous full superconducting motor

Parameters	Value
Length (mm)	200
Radius (mm)	140
Power (MW)	2,6
Power to Mass ratio (kW/kg)	51
Efficiency	0,97

Overall goals

Evaluation of the **benefits of superconductivity** technology for **HEP architecture**
Trade-off between liquid cooling and cryocooler approach for superconductive component cooling