

Zodiac Aerospace



HYCARUS: Hydrogen powered Fuel Cell systems for non-essential cabin applications

Workshop on aeronautical applications of fuel cells and
hydrogen technologies.
DLR, Lampoldshausen,
15/09/2015

Franck MASSET

Zodiac Aerospace at a glance

- Zodiac Aerospace belongs to World's top 10 equipment manufacturers
- €4,1 bn sales in 2013/14 / 28 000 employees worldwide
- 3 Business areas: 5 segments + 1 aftermarket organization

AIRCRAFT INTERIORS



■ ZODIAC CABIN & STRUCTURES

Overall design and implementation of cabin layout:

Turnkey Interiors (« floor-to-floor » interiors, walls, side protection panels, luggage bins), retrofit...

■ ZODIAC GALLEYS & EQUIPMENT

Innovation for optimisation of space aboard:

Galleys, inserts, trolleys, cargo containers...

■ ZODIAC SEATS

The widest and most efficient product line:

First Class, Business Class and Economy Class passenger seats, pilot and crew seats...

ZODIAC AEROSAFETY



Complete systems for enhanced safety:

Evacuation slides, life rafts, emergency arresting systems, electrical harnesses, parachutes, fuel tanks...

ZODIAC AIRCRAFT SYSTEMS



High-Technology equipment and systems for essential aircraft functions:

Power management and distribution systems, oxygen systems, fuel and inerting systems, cockpit systems, actuators, hydraulics, lighting solutions, IFE...

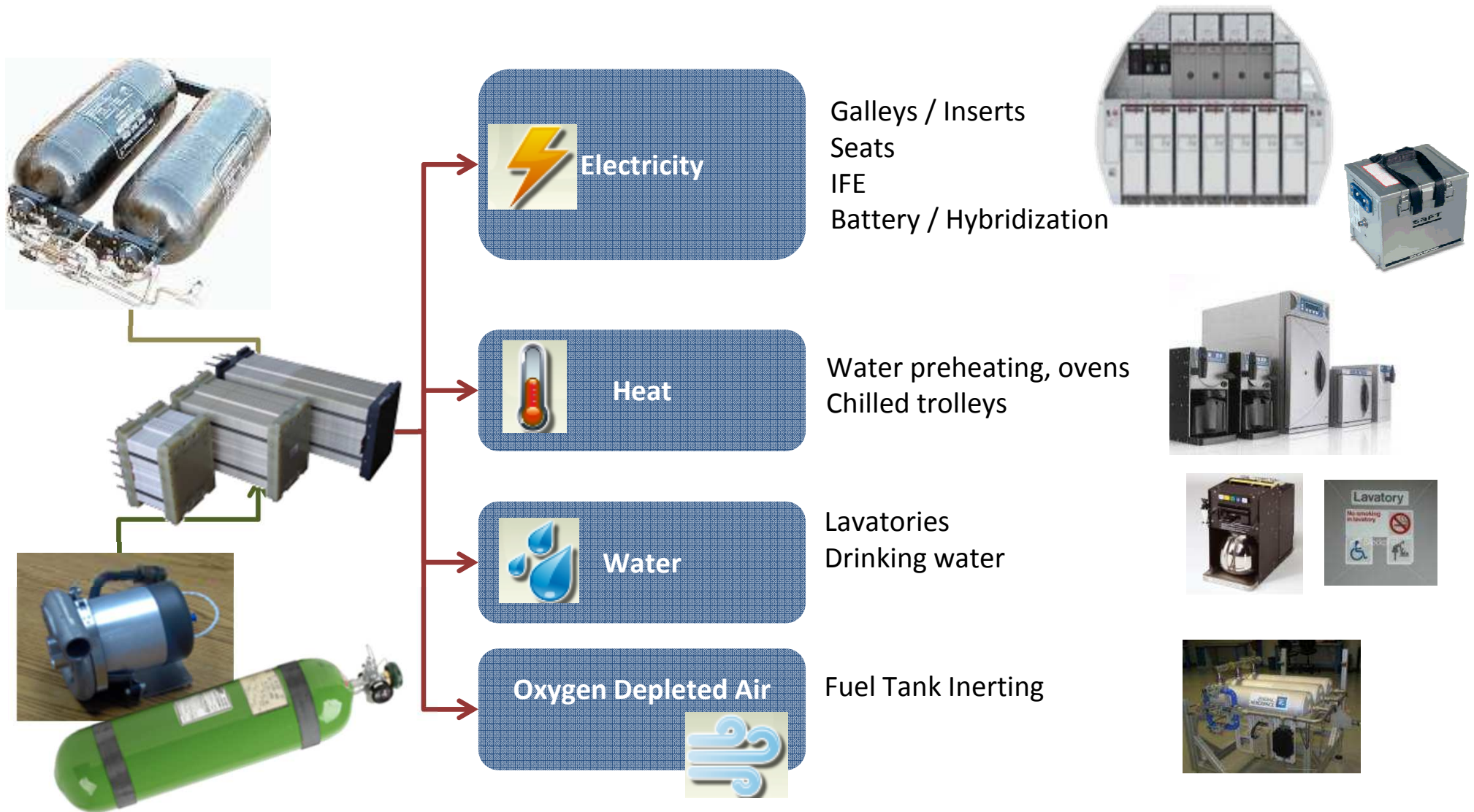
Context & market challenges

Goal	Vision 2020	ACARE 2050
CO ₂ Emission Reduction	50%	75%
NO _x Emission Reduction	80%	90%
External Noise Reduction	50%	65%
Fuel Consumption Reduction	50%	-

- Fuel cell technology has potential to contribute meeting ACARE objectives:
 - Draws less power from the mainline
 - Contributes to CO₂ + NO_x reduction
 - Enhances flexibility of power availability



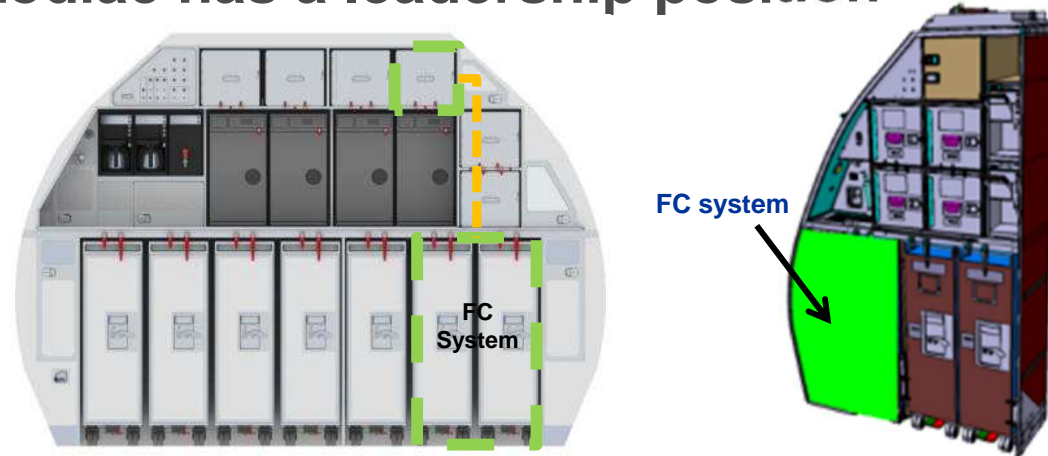
Zodiac Aerospace interest in FC technology



Zodiac Aerospace market approach

- **Zodiac is committed to develop fuel cell as alternative power source in systems where Zodiac has a leadership position**

- Galley and Lavatories
- Secondary Power generation



- **Primary focus on non-essential applications to address successful market introduction**

- Target market introduction of technology with retrofitable solutions
- at a stepping stone to essential applications

- **Certification**

- Actively involved in Working Group preparing future standards (EUROCAE/SAE WG80, FAA Advisory Rulemaking Committee)

HYCARUS Project

« Hydrogen Cells for Airborne Usage »

Project Leader	Zodiac Aerospace
Start-Date	01 May 2013
End-Date	30 April 2016
Total Budget	10 113 798,20€
FCH JU Contribution	5 219 265,00€



10 Partners from 5 countries

HYCARUS Project



Source : Dassault Aviation



Generic Fuel Cell System

Power Range : 20-25 kWe
H₂ Storage : 350 bars (1,5 kg)
Supplied Voltage : AC or DC

Design, develop and test a Generic Fuel Cell System (GFCS) in order :

- ☐ To power **non-essential aircraft applications** such as a galley in a commercial aircraft
- ☐ To be used as a **Secondary Power Source** on-board business jets (APU and RAT could be partially or completely substituted by a Fuel Cell System)

Demonstrate GFCS performances in relevant and **representative cabin environment (TRL 6)** through flight tests on-board a Dassault Falcon aircraft.

Assess how to valorise the by-products (especially heat and Oxygen Depleted Air - ODA) produced by the fuel cell system to increase its total efficiency.

HYCARUS Project



Source : Dassault Aviation

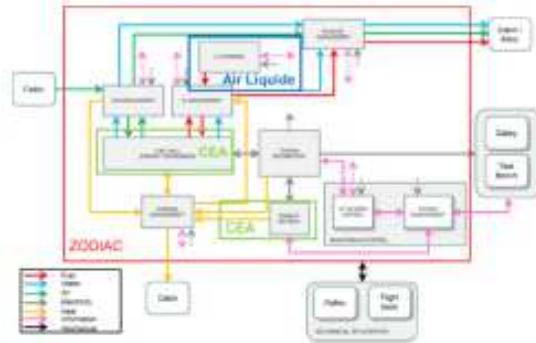
GFCS for Flight Tests



GFCS integrated in Galley Ground demonstration

- GFCS Specification
- System Architecture / FHA
- Detailed Design / Component Specification
- Fault Trees / Preliminary System Safety Assessment (PSSA)
- Component Development / Procurement
- System integration
- Subsystem verification (Test)
- System functional verification (Test) / System Safety Assessment (SSA)
- Environmental Tests
- Permit to Fly / Flight Tests

HYCARUS Project - Status



GFCS PID



GFCS Fault Tree

- GFCS Specification ✓
- System Architecture / FHA ✓
- Detailed Design / Component Specification ✓
- Fault Trees / Preliminary System Safety Assessment (PSSA) ✓
- Component Development / Procurement
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HYCARUS Project - Status



Air cooler



Controller



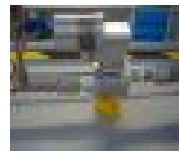
Heat exchanger



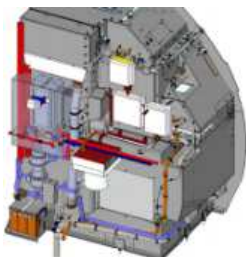
28DC/DC converter



Hydrogen Low Pressure Sub system test set up



H2 Low Pressure regulator



GFCS Galley integration



GFCS Flight test integration

• GFCS Specification ✓

• System Architecture / FHA ✓

• Detailed Design / Component Specification ✓

• Fault Trees / Preliminary System Safety Assessment (PSSA) ✓

• Component Development / Procurement

• System integration

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• Environmental Tests

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HYCARUS Project - Status



Source : Dassault Aviation

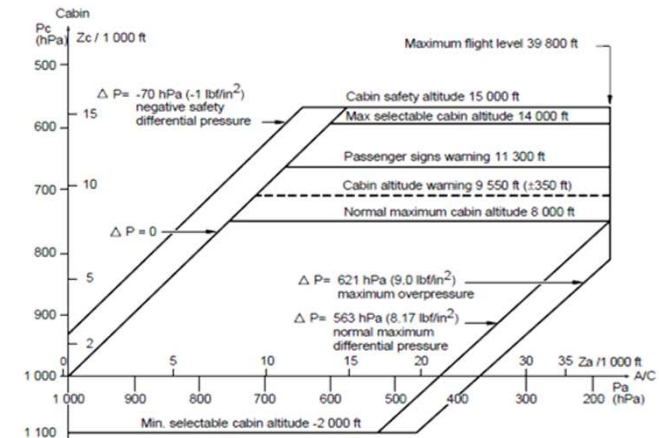
Challenges for aerospace fuel cell developments

■ Operational conditions impacting design

- Variable conditions (P, T) with altitude
- System thermal integration
- Closed and confined environment

■ Certification, Regulatory

- Certification and Qualification Requirements (CS25, DO178, DO254, DO160, MIL-STD-704-F, ...)
- Safety: new risks to be assessed (hydrogen, DC High voltage, ...)



■ Need for further developments to reach airworthiness of fuel cell systems:

- Fuel Cell Stack and Balance of Plant equipments (Compressor, pump, valves, H₂ sensors,
- Dedicated and specific Integration and layout
- Control & monitoring

■ Hydrogen Logistics

- H₂ distribution at and on airport to be implemented
- Develop synergies with ongoing deployment initiatives



Challenges for aerospace fuel cell developments



Zodiac Aerospace committed to fuel cell technology developments for aerospace



Zodiac Aerospace committed to fuel cell technology developments for aerospace



IMACS
2019 – TRL6 Fuel Cell
Galley

 Clean Sky 2



2014 – H2 & FC
Lab. Facility

2016 – HYCARUS Flight tests
Secondary Power Source
Galley Ground Demonstration



2013 – TRL3 Demonstrator



Thank you for your attention



Contributing to Aerospace Legend since 1896

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