HYCARUS

HYdrogen Cells for AiRborne USage

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Programme Review Days 2018

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PROJECT OVERVIEW

- **Call year:** 2012
- **Call topic:** SP1-JTI-FCH.2012.1.6: Fuel cell systems for airborne application
- **Project dates:** 01/05/2013 – 31/12/2018
- **% stage of implementation 01/11/2017:** 97 %
- **Total project budget:** 12 064 474 €
- **FCH JU max. contribution:** 5 219 265 €
- **Other financial contribution:** None
- **Partners:** Zodiac Aerotechnics (ZAET); Zodiac Aero Electric (ZEL); Zodiac Galleys Europe (ZGEU); Zodiac Cabin Controls (ZCC); Commissariat à l'Energie Atomique et aux Energies Alternatives (CEA); Dassault Aviation (DA); Air Liquide Advanced Technologies (ALAT); Joint Research Centre (JRC); National Institute for Aerospace Technology (INTA); ARTTIC France

PROJECT SUMMARY

“HYCARUS”: “HYdrogen Cells for AiRborne USage”

Source : Dassault Aviation

Generic Fuel Cell System

Power Range : 20-25 kWe
H_2 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)

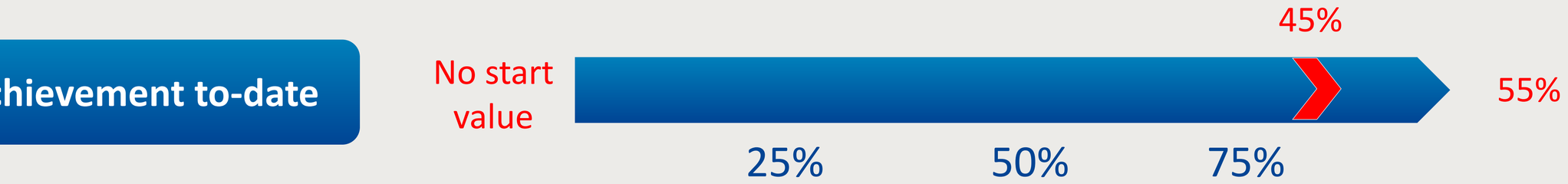
Demonstrate GFCS performances in relevant and **representative cabin environment (TRL 6)** through flight tests on-board a Dassault Falcon aircraft.

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.

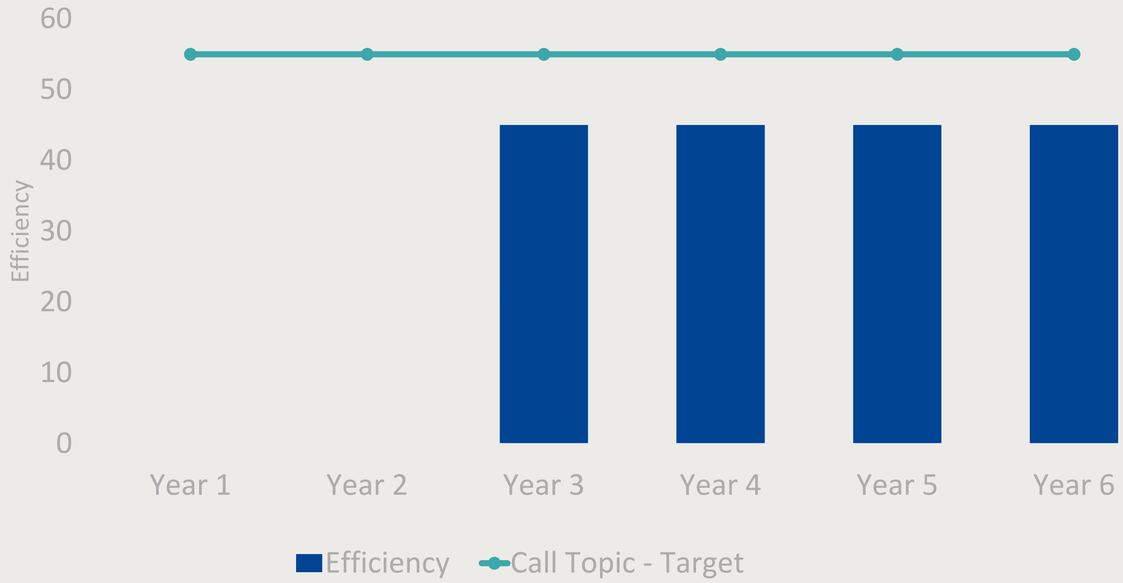
World first-ever
Fuel Cell system demonstration
in a pressurized aircraft cabin

PROJECT PROGRESS/ACTIONS – Fuel Cell system efficiency

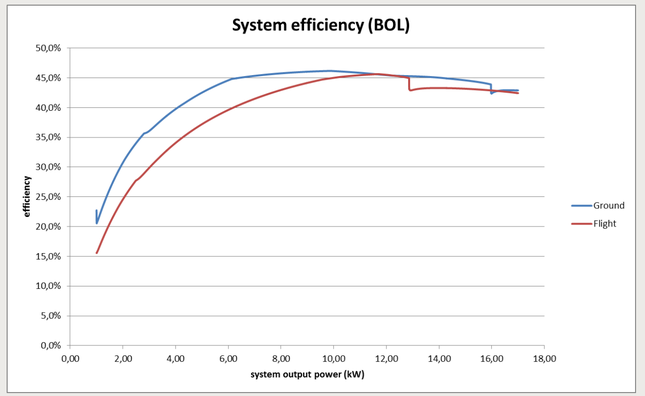
Achievement to-date



Status at month 66 of 68 project months at date 01/11/2018

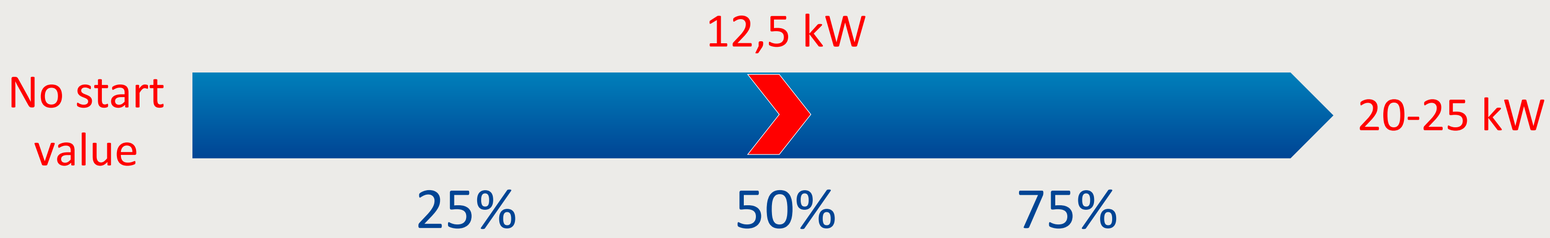


- ✓ **For our target application (Generic Fuel Cell System), maximum efficiency operating point is 55% of rated power. Corresponding target efficiency is 46% under airborne operating conditions (low ambient pressure for example).**
- ✓ **Due to specific system architecture and rated power (20-25 kW), achievement of this objective is very challenging.**

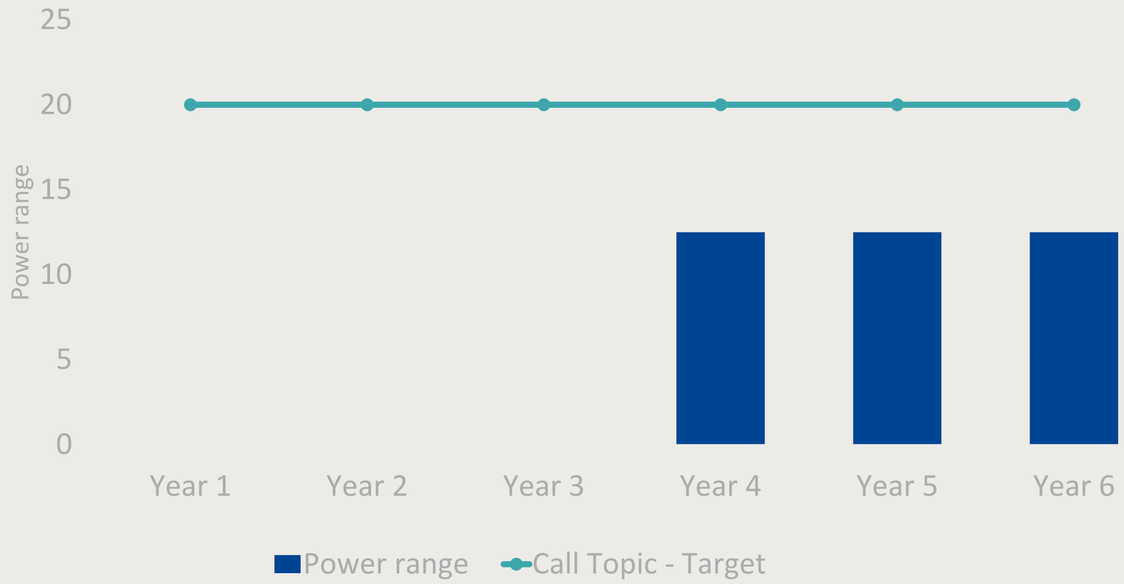


PROJECT PROGRESS/ACTIONS – Demonstrator in the 20-100 kW Power Range

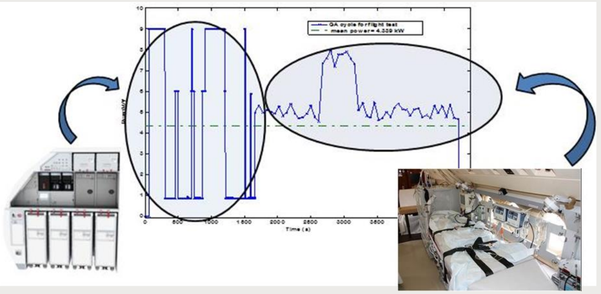
Achievement to-date



Status at month 66 of 68 project months at date 01/11/2018

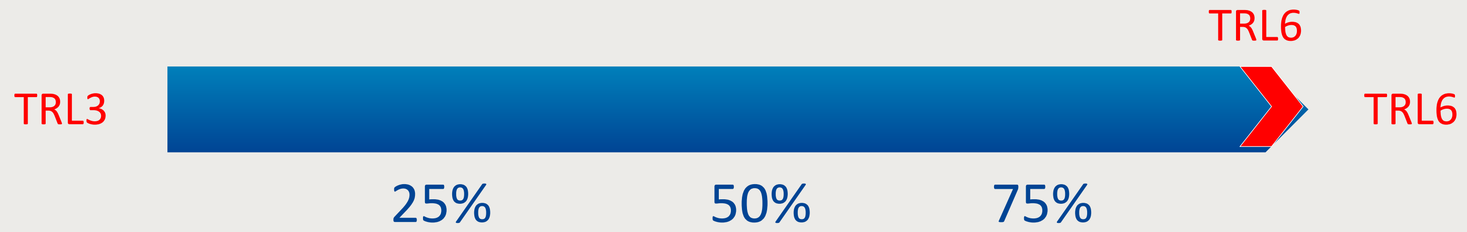


- ✓ **The most constraining figures (peak power for example) have been retained for system sizing**
- ✓ **20-25kW power range has already been demonstrated by simulation**
- ✓ **12,5kW has been reached during flight test configuration tests**
- ✓ **As the Galley configuration tests have been cancelled (priority to the flight test configuration), it will not be possible to demonstrate the 20-25kW power range in the framework of HYCARUS.**

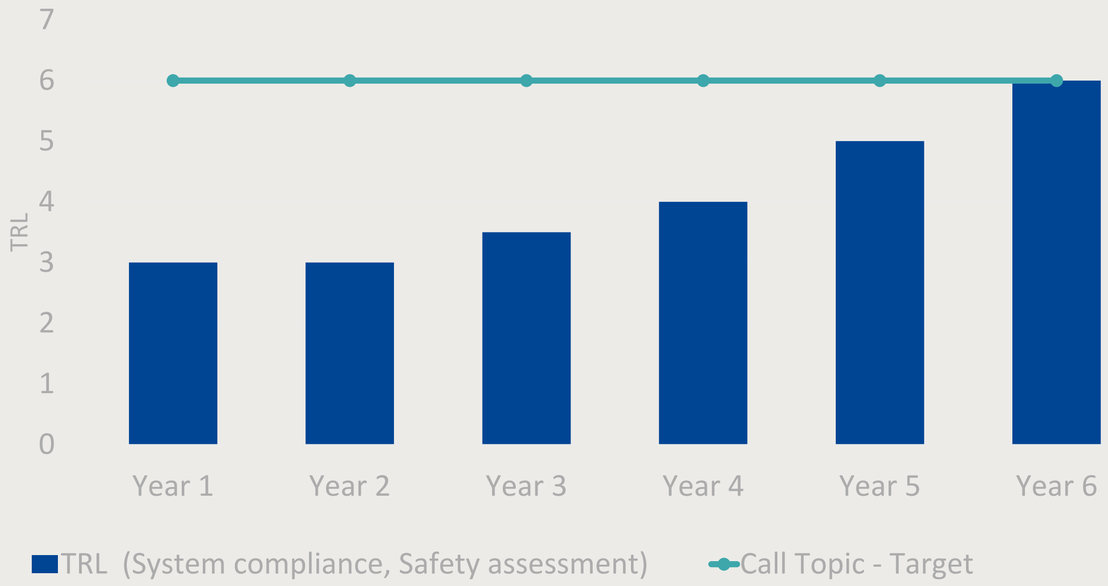


PROJECT PROGRESS/ACTIONS – TRL6 Demonstration

Achievement to-date



Status at month 66 of 68 project months at date 01/11/2018



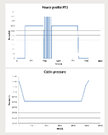
PROJECT PROGRESS/ACTIONS – TRL6 Demonstration

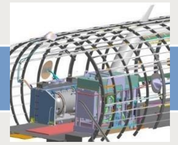
Achievement to-date

TRL3 → TRL6

TRL6

25% 50% 75%





Flight test

Readiness process

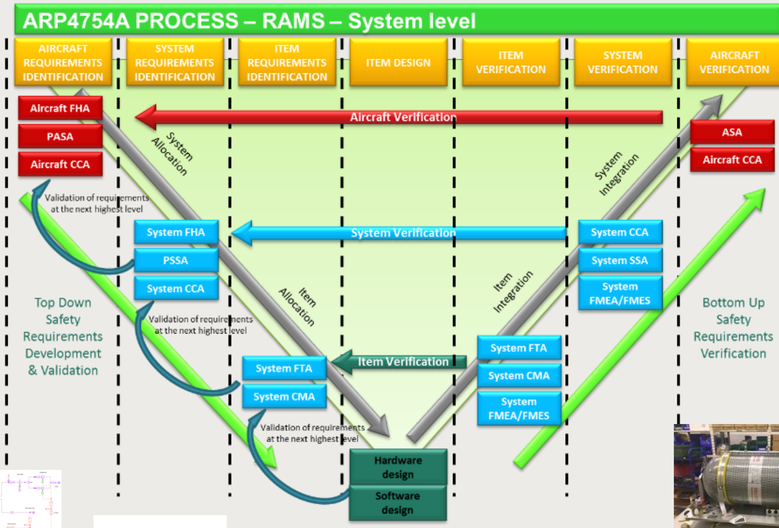
Permit To Fly

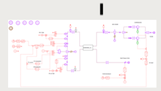
Flight tests

Environmental System tests

GFCS Specification

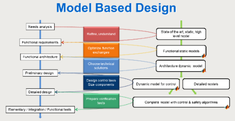
Qualification Plan





AMESim modeling

Safety Analysis



Model Based Design

Fuel Cell

H2 Low pressure regulator tests

Sub-system tests

System tests

Future steps:

- ✓Aircraft modification
- ✓Engine run tests
- ✓Flight tests

Risks and Challenges

Challenges encountered and mitigation measures taken:

- **Compliance with the environmental requirements (DO160):**
  - ✓ Several mechanical simulation and calculation iterations during the design of the system
  - ✓ Environmental tests performed at equipment level

- **Compliance with aerospace safety requirements including the safety aspect related to the management of pressurized hydrogen gas on-board the aircraft**
  - ✓ System Safety analysis made according to the ARP 4761
  - ✓ Several conceptual studies performed to find out how properly install the high pressure hydrogen venting line

- **Permit to fly obtaining:**
  - ✓ Demonstration of system performances and compliance with requirements
  - ✓ Demonstration of proper installation of the system on-board the aircraft for safe operation
  - ✓ Permit to fly documentation package elaboration

The main challenge now is to fly

AND

The main continuing risk is not to have the permit-to-fly

Dissemination and Communications Activities

❑ Since project start:

- ✓ **Public website** www.hycarus.eu
- ✓ **Project leaflets**
- ✓ **Press releases**
- ✓ **Attendances at** Le Bourget Air Show, Hannover Messe, World Hydrogen Energy Conference, Joint CleanSky2/FCH JU Workshop on aeronautical applications of fuel cells and hydrogen technologies, Electric & hybrid aerospace technology symposium, etc.).
- ✓ **Video** on YouTube presenting Zodiac's fuel cell activities

❑ Plans related to the flight tests and therefore the "TRL6" objective:

- ✓ **Invite the FCH-JU for flight test** and make this day an "event"
- ✓ **Issue press releases** when the flight tests will be performed
- ✓ **Communicate on the future prospects of the Fuel Cell technology** during the next Paris Airshow in 2019 by presenting the HYCARUS project results

EXPLOITATION PLAN/EXPECTED IMPACT

Exploitation

- ✓ HYCARUS outcomes are currently used for the **FLHYSAFE** project (FCH 2 JU) https://www.flhysafe.eu/

- ✓ Partners' exploitation plans:
  - ❑ **ZA**: to shift from the current demonstrator to the ready-to-certify industrial product level in the coming years (2025+) for aeronautical applications where Zodiac is already the leader.
  - ❑ **DAv**: to use a certified fuel cell in aircraft completion as an independent power source for business jet aircraft cabin
  - ❑ **ALAT**: to use the results of HYCARUS to optimize the hydrogen storage in term of gravimetric efficiency throw new funded project in the coming years (2019+)
  - ❑ **INTA**: to become a European/world-wide reference in environmental tests of fuel cell systems for A/C applications in the coming years (2020+)
  - ❑ **CEA**: to improve PEM Fuel Cell technology (lifetime, durability, power, weight, cost, etc.) and develop partnership with industrials for Fuel Cell production in the coming years (2020+).

Impact

- ✓ Demonstrate technical feasibility of operating a fuel cell system in an aircraft pressurized cabin environment (using 350bars hydrogen storage)

- ✓ Facilitate the introduction of the PEM Fuel Cell system applications on-board an aircraft

- ✓ Pave the way towards fuel cell powered non-essential applications in the next generation of aircraft

- ✓ Demonstrate feasibility of using Fuel Cell as an alternative source to power non-propulsive aircraft systems

- ✓ Address the need of the aerospace industry for more electrical aircraft and strong reduction of CO2 and NOX emissions

- ✓ Contribute to the development of guidelines for Hydrogen Fuel Cell Systems for airborne applications

- ✓ Change in public perceptions and acceptance of hydrogen on board an aircraft

FUEL CELLS AND HYDROGEN
JOINT UNDERTAKING

HYCARUS
AIRBORNE FUEL CELLS

Thank you for your attention!