PROJECT

CELINA

Fuel Cell Application in a New Configured Aircraft

Funding: European (6th RTD Framework Programme)
Duration: Jan 2005 - Jun 2008
Status: Complete with results
Total project cost: €8,129,882
EU contribution: €4,497,400

Call for proposal: FP6-2003-AERO-1
CORDIS RCN: 75784

Background & policy context:
The application of fuel cell systems is a step towards more electric aircraft configuration. The expected improvements for fuel cells applied in power supply are a reduction of fuel consumption, noise and gas emissions and significantly higher aircraft efficiency. This efficiency improvement is due to a more efficient fuel conversion in comparison to the current APU.

The CELINA project met the goals of 'Vision 2020' with respect to:

- more efficient aircraft;
- improving passenger comfort;
- less negative environmental impact.

Objectives:
The objectives for the project were the following:

- generation of basic aircraft requirements for a fuel cell power system regarding safety and certification, including safety assessment;
- generation of emergency power supply network requirements, including power conversion;
- investigation of the technical capabilities of an existing fuel cell system under aircraft operating conditions and identification of the needs for aircraft design;
- investigation of the behaviour and limiting conditions of the fuel cell system in terms of different system parameters, such as performance output, electrical, thermal and mass flow management, and air supply;
- definition of a controller and fuel cell control laws based on airworthiness requirements;
- generation of aircraft integration strategies and simulation within the aircraft environment.

Methodology:
Fuel cell systems allow converting a variety of fuels used in aviation such as hydrogen, natural gas or Jet A fuel into electrical power. This makes them cleaner and quieter than most other power supplies. Fuel cell systems are an ideal alternative for conventional on-board power sources used in airplanes such as auxiliary power units or ram air turbines. In fact, they are considered as ideal power source for the all-electric aircraft of the future. However, before fuel cell systems can be installed into aircraft, a number of technological challenges remain to be solved.

Early in the project it became obvious that commercially available fuel cell system components are not suitable for aircraft application because e.g. of their present power-to-weight ratio. This finding required CELINA to place an extra effort into changing of objectives regarding to installation concept definition.

CELINA demonstrated that fuel cell systems are suitable for airborne use if properly integrated into the aircraft's electrical network and if safety and cooling aspects as well as the power management are organised appropriately.
The investigation of the fuel processing showed that kerosene reforming onboard aircraft is a long-term research topic. Today, all known reformer projects in Europe are running only on laboratory level requiring a significant financial investment and time for reaching airworthiness levels.

Similarly, Solid oxide fuel cells (SOFC) are at present operated only on laboratory level. Application to flight conditions requires huge investments and technical solutions for safely managing the up to 800 degrees Celsius of operating temperature onboard of an aircraft.

Originally, a 50 kWel system architecture as replacement for the ram air turbine was designed and simulated as intermediate step for 500 kWel system as future auxiliary power unit replacement.

However, it became obvious that in the near to mid-term such complex fuel cell system architecture would not be suitable as standard design and that based on state-of-the-art technology it would be far beyond what is acceptable in commercial aircraft.

The major obstacles are the high specific system weight, the high space requirements of cooling equipment and the complex fuel processing technology. As a consequence, pure hydrogen might be the preferred fuel for the first commercial in-flight application of fuel cells.

In order to optimise the system efficie

**Parent Programmes:**
FP6-AEROSPACE - Aeronautics and Space - Priority Thematic Area 4 (PTA4)

**Institute type:** Public institution

**Institute name:** European Commission

**Funding type:** Public (EU)

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**EU Contribution:** €0

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Key Results:

The consortium faced many challenges and finally had to re-adjust several objectives with respect to the application readiness of fuel cell systems. But many lessons have been learned. The difficulties have been in definition of consistent interfaces between the corresponding modules between different partners while on the other hand the fuel cell system models were modelled partly too detailed.

In general, the original envisaged improvements were validated with the potential benefits which are depending on the respective type of aircraft.

Future fuel cell research for flight applications should consider the following recommendations:

- Main off-the-shelf fuel cell system components need to be modified and re-designed for aircraft application
In order to reach maximum efficiency all by-products (heat, water, exhaust gas) have to be utilised aboard the aircraft allowing the fuel cell system to take over additional services on ground and during flight in addition to ram air turbine and auxiliary power unit replacement.

- The power-to-weight ratio and the structural volume of present fuel cell systems need to drop below today's standards given by conventional auxiliary power units and ram air turbines.
- The reliability and durability of system components under all flight conditions including vibrations over long operating live times need to be investigated with respective aircraft requirements to be specified.
- Redundant fuel cell system architectures have to be developed to guaranty reliable and safe operation in major failure scenarios.
- To improve the long-term performance of the SOFC running on commercial hydrocarbon fuels, research should address the development of kerosene/diesel reformer and the development of advanced sulphur and carbon tolerant anode materials with superior catalytic and electrical properties.

Documents:
- Publishable Project Report (Final report)
- STRIA Roadmaps: Transport electrification, Vehicle design and manufacturing

Transport mode: Air transport
Transport sectors: Passenger transport, Freight transport
Transport policies: Decarbonisation, Societal/Economic issues, Environmental/Emissions
Geo-spatial type: Infrastructure Node