# ENFICA-FC: Environmental Friendly Inter-City Aircraft. Design and Realization of 2-seat aircraft powered by Fuel Cells electric propulsion

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**Abstract (Topic: Aircraft Design)**

Rapidly emerging hydrogen and fuel cell power based technologies can now be exploited to initiate a new era of propulsion systems for light aircraft and small commuter aircraft. These technologies can also be developed for the future replacement of on-board electrical systems in larger 'more-electric' or 'all-electric' aircraft. The feasibility of the ENFICA-FC project (ENvironmentally Friendly Inter City Aircraft powered by Fuel Cells), funded by European Commission within the 6FP, is dependent on several key-enabling technologies including fuel cell stacks and integrated systems, hydrogen fuel storage and a safe airport based hydrogen-refuelling infrastructure [1].

Another important consideration is that it should demonstrate the path to future economic viability. The primary advantages of deploying these technologies are low noise and low emissions – features which are particularly important for commuter airplanes that usually takeoff and land from urban areas. The main objective of the ENFICA-FC project is to develop and validate the use of a fuel cell based power system for propulsion of more/all electric aircraft. The fuel cell system will be installed in a light sport aircraft which will be flight and performance tested as a proof of functionality and future applicability for inter city aircraft.

The ENFICA-FC consortium, coordinated by Prof. G. Romeo of Politecnico di Torino, consists of 9 partners representing the whole value chain with Aircraft manufacturers (IAI, Evektor and Jihlavan Airplanes), Fuel cells Power system producer (Intelligent Energy), Hydrogen distribution (Air Product), Research Institutes (Politecnico di Torino, Université Libre de Bruxelles and University of Pisa) as well as a SME in the field of administrative management (Metec). Within the course of the 3 years ENFICA-FC project, which was launched on October 2006, two key objectives will be realised:

**1) A feasibility study** is being carried out to provide a preliminary definition of new forms of Inter-City aircraft power systems that can be provided by fuel cell technologies (APU, Primary electrical generation supply, Emergency electrical power supply, Landing gear, De-icing system, etc); also Safety, certification & maintenance concepts are being defined.

In defining the Inter-City aircraft systems that can be powered by fuel cell technologies, the feasibility study is being take into account the performance improvements of future generation fuel-cells and will thereby show the technical (and performance) advantages that could be obtained in contrast to existing conventional systems. In addition, the feasibility of an all-electric propulsion inter-city aircraft (10-15 seats), completely powered by fuel cells, is being studied in order to assess the impact that a more silent and less polluting aircraft will have in being able to takeoff and land from congested urban areas using short airfields.

Several parameters have been taken in account: the storage efficiency of the H2 tank, the power density of the fuel cell stack, of H2 tanks, of electric devices, etc. The parametric sizing has been carried out considering a typical mission profile (take-off, climbing, cruise, descent). The results of this preliminary analysis affect three parameters: the volume occupied from the power plant (batteries, converter, inverter, FC stack and the electric engine), the payload and/or the cruise time improvement (endurance improvement).

Very interesting results have been obtained from the preliminary parametric sizing and analysis of a more-electric 32 passengers' regional jet aircraft fuelled by liquid hydrogen. The study has given better understanding of the practical meaning of transition from kerosene to hydrogen in transportation airplanes.

**2) A two-seat electric-motor-driven airplane powered by fuel cells is being completed and will be validated by flight-test in September 2009.**

The high efficiency existing, two-seat aircraft Rapid 200, manufactured by **Jihlavan Aircraft,** was selected over more than one hundred light sport aircrafts and will be used for the conversion from internal combustion engine.

All aerodynamic, geometric and performance characteristics have been preliminary defined. Also a new CFD analysis for better determining the aerodynamics characteristic and a flight mechanic simulation has been carried out (Fig. 1). Several configurations have been evaluated for installing on board the new energy and propulsion system in order to maintain the new Centre of Gravity within the limit of 20-25% m.a.c. The fuel cell system and the electric motor are being integrated on board. (Fig. 2 preliminary virtual lay-out). The RAPID 200 airplane has been acquired by POLITO and the structural conversion procedure is in progress (Fig. 3-4).

A fuel cell system has been designed, built and tested in laboratory ready to be installed on board for flying. The Hydrogen system has been realized and are being tested at 350 bar. A high efficiency brushless electric motors (Phase Motion) and power electronics apparatus for their control have been manufactured and tested in laboratory ready to be installed on board for flying tests.

The FC stack will be able to deliver 20 kW of maximum continuous power until there is hydrogen stored in the tank. The battery pack has to guarantee others 20 kW of maximum continuous power for a limited time period (15 minutes), during take-off, climb and, in case of emergency, for landing in safety. It has been manufactured and tested in laboratory ready to be installed on board for flying tests. Efficiency of about 90% is being obtained by an optimised aerodynamic propeller design and is being manufactured.

Flight test bed of the aircraft capable of remaining aloft for one hour will be the main goal of the project to validate the overall high performance of an all electric aircraft system.

The planned mission profile includes take-off, climb from the sea level to an altitude of 1000 m (with a medium climbing ratio of 2,5 m/s), level flight at 1000 m at about 144 km/h, descent and landing. The total mission time is about 1 h.

Several of these systems and subsystems are being assembled in the laboratory of University of Pisa for ground tests planned for March 2009. Also the aircraft Rapid 200-FC has been manufactured (Fig. 2) and realization of the new structural items have been completed.

**The ambitious results will be to present, in a public event within the scheduled time** the flight test bed of the aircraft capable of remaining aloft for one hour to validate the overall high environmental performance of an all electric aircraft system.

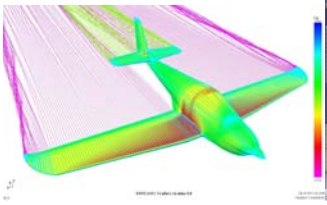

Fig. 1-

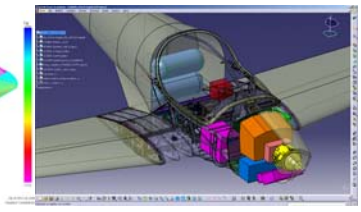

Fig. 2

Fig. 3

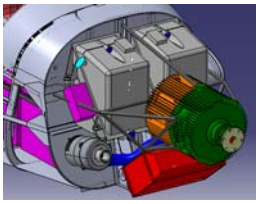

Fig. 4

**References**

[1] G. Romeo, C. Novarese, "ENFICA-FC: Preliminary Survey & Design of 2-Seat Aircraft Powered by Fuel Cells Electric Propulsion", **7th AIAA Aviation Technology, Integration and Operations Conference (ATIO)** – September 2007, Belfast, Northern Ireland, **AIAA-2007-7754**, pp. 15.