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Conceptual Evaluation for a Novel Green Aircraft Powered by Liquid Hydrogen and Fuel Cells

Diego Giuseppe Romano[a,1], Mattia Barbarino[a], Giovanni Fasulo[a], Etienne Guillame Behar[b], Ondrej Kotaba[b]

[a]C.I.R.A. SCpA – Italian Aerospace Research Centre, Via Maiorise SNC, Capua (CE) 81043, Italy
[b]Pipistrel Vertical Solutions d.o.o., Goriška Cesta 50◦, SI-5270 Ajdovščina, Slovenia
[b]Honeywell International s.r.o., Tuřanka 1387/100, 627 00 Brno

Abstract

Aviation decarbonization is one of the greatest challenges in the pursuit of sustainable mobility. While incremental improvements in aerodynamics, structures, and propulsion have led to sensible efficiency gains over the last years, the transition toward zero emission aircraft configurations requested by international guidelines needs disruptive technologies. Liquid hydrogen propulsion systems coupled with fuel cells are one of the most promising solutions to be investigated, since they offer high energy density, clean exhaust, and compatibility with regional aircraft missions. This study presents a novel configuration for a regional aircraft propelled by liquid hydrogen and fuel cells, based on conceptual design. The proposed configuration is a high-wing aircraft with T-tail. Unlike kerosene, liquid hydrogen requires specialized tanks and insulation, which significantly influence aircraft geometry and weight distribution. To address these challenges, the proposed configuration adopts a fuselage integrated cryogenic tank system installed in the aircraft rear cone, to minimize aerodynamic penalties while ensuring safety and operational feasibility. The fuel cell system is distributed to optimize redundancy and thermal management, enabling efficient power delivery to electric propulsors. The study contributes to the growing body of literature on hydrogen aviation by providing a system level configuration tailored to regional aircraft, a segment particularly suited for early adoption of hydrogen technologies due to shorter ranges and frequent operations. The findings underline the technical feasibility of liquid hydrogen–fuel cell systems, offering insights for future certification frameworks, infrastructure development, and industrial implementation. In conclusion, this work presents a feasible configuration of a novel green regional aircraft powered by liquid hydrogen and fuel cells. The results provide a foundation for further experimental validation and pave the way for the next generation of environmentally responsible regional aircraft.

Keywords

aircraft electrification, fuel cells integrations, green aviation, hydrogen, regional aircraft

1 Introduction

The aviation sector has played a crucial role in the global transportation industry, allowing efficient long-range movements of both cargo and passengers. However, it represents a non-negligible source of pollution, impacting on climate change: the aeronautical sector is responsible for about 2.5% of global Carbon Dioxide (CO_2) emissions and nearly 4% of overall global warming when considering non-CO_2 effects such as nitrogen oxides and contrail induced cloudiness [1]-[4].

[1]Corresponding author.
E-mail address: d.romano@cira.it (D. Romano)
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For these reasons, aviation sector is evolving to reduce its environmental footprint, aligning with the ambitious requirements set by international organizations, such as the Advisory Council for Aviation Research and Innovation in Europe (ACARE) that, through its Flightpath 2050 vision, and the European Union's climate policies, have set a 75% reduction in CO_2 emissions per passenger kilometre, a 90% reduction in Nitrogen Oxides (NO_x) emissions, and a 65% reduction in perceived noise levels by 2050 [5]-[7].

To respect these targets, disruptive technologies covering all aeronautic fields (aerodynamics, aircraft systems, including propulsion, structures and infrastructures) are needed. Propulsion system plays a crucial role in the reduction of emissions.

Among the various solutions currently under investigation, hydrogen Fuel Cells (FCs) represent a promising pathway for aviation decarbonization, since FCs generate electrical power through an electrochemical reaction using hydrogen, producing only water vapor as a by-product [8]. Consequently, FC powered aircraft have the potential to operate with zero in flight emissions, respecting stringent performance and operational requirements. Although several small-scale demonstrators (e.g. Boeing Fuel Cell Demonstrator [9], DLR HY4 [10], ZeroAvia's Piper M Class [11]) have successfully validated the feasibility of hydrogen electric propulsion, scaling these technologies to commercial aviation remains a significant challenge [12].

The present paper summarizes the conceptual study of an 80-passenger aircraft powered by fuel cells, designed to achieve sustainable and emission-free aviation. The activities have been carried out within the European Union (EU) co-funded research Project NEWBORN (NExt generation high poWer fuel cells for airBORNe applications) [13].

2 Fuel Cells Powered Aircraft State of the Art

2.1 Overview of sustainable aviation efforts

Aircraft decarbonization has become a central priority [14] for both the scientific community and the aviation industry, since air transport continues to be one of the fastest-growing sources of greenhouse gas emissions [15], [16]. Considering the ambitious objectives established by the European Green Deal [17], the aviation sector is now confronted with considerable challenges that cannot be addressed without a strong commitment to Research and Innovation (R&I). A comprehensive overview of the current state of R&I activities in Europe is provided in [18], where special attention is given to emission reduction in aviation by means of a thorough review of ongoing and past research projects. This assessment not only highlights major technological efforts but also offers a detailed examination of specific research areas that contribute to lowering aviation emissions.

A wide range of strategies has been explored in the literature to mitigate the environmental impact of aviation. Among these, the adoption of electric propulsion systems, the introduction of hydrogen-based technologies and the development of sustainable biofuels stand out as some of the most promising solutions [19], [20]. Each of these approaches presents distinct advantages and challenges; however, propulsion systems based on fuel cells appear particularly attractive due to their potential to enable zero-emission operations while maintaining high levels of energy efficiency [21]-[23].

Within the context of the EU co-funded research project NEWBORN project, a strategic decision has been made to concentrate on FC propulsion technology, specifically targeting its application to an 80-passenger regional aircraft, with the aim of advancing cleaner and more sustainable aviation solutions.

2.2 Recent developments in fuel cell technology for aviation

In recent years, FC technology has undergone substantial progress, largely driven by advances in electrochemistry, materials science, and system engineering. Significant improvements have been achieved in Proton Exchange Membrane Fuel Cells (PEMFCs), which are widely recognized to be especially suitable for aviation applications due to their high-power density, rapid start-up capabilities, and relatively low operating temperatures [24], [25]. These features make PEMFCs particularly attractive for integration into aircraft propulsion systems, where operational flexibility and performance reliability are essential.

Alongside the evolution of fuel cell technology, notable developments have also been made in hydrogen storage solutions. In particular, the design and optimization of lightweight storage systems — such as compressed and liquid hydrogen tanks — have played a crucial role in enabling feasibility studies for the integration of FC-based propulsion architectures into future regional and commuter aircraft [26]-

[28]. These advancements have contributed to improve the overall energy density at system level, while addressing some of the weight and volume constraints typical of aviation platforms.

Moreover, several demonstration projects have provided valuable validation in real-world conditions. Initiatives such as the HY4 aircraft and the H2Fly program [29] have successfully showcased the potential of hydrogen-powered fuel cell systems, offering important insights into both the operational benefits and the technical challenges associated with their deployment. These experimental efforts have helped bridge the gap between laboratory-scale innovation and practical aviation applications, highlighting key aspects such as system integration, safety considerations, and performance under realistic flight conditions.

2.3 Challenges in implementing zero-emission aircraft

Despite the promising advancements achieved so far, significant challenges still hinder the widespread adoption of fuel cell-powered aircraft. One of the primary obstacles lies in the development of a comprehensive hydrogen infrastructure, including efficient production, refuelling system, storage, and transportation [30], [31]. The transition to hydrogen as an aviation fuel requires large-scale investments and coordination across multiple sectors, making it a complex and long-term endeavour.

In addition, the integration of fuel cell systems into aircraft architecture presents several engineering challenges. These include issues related to system weight, volumetric constraints, thermal management, and reliability over extended operational cycles [32]. Maintaining optimal operating temperatures and ensuring consistent performance under varying flight conditions remain critical aspects that require further research and technological refinement. Furthermore, hybridization with batteries or other energy storage systems is often necessary, adding another layer of complexity to system design and control strategies.

Finally, regulatory and certification frameworks for hydrogen-powered aviation are still in their early stages of development. Establishing clear safety standards, certification procedures, and operational guidelines is essential to enable the commercial deployment of zero-emission aircraft. This process involves rigorous testing, risk assessment, and collaboration between industry stakeholders and regulatory bodies to ensure that hydrogen-based aviation systems meet stringent safety and performance requirements [33], [34].

3 Aircraft Specification and Mission Data

The NEWBORN Project studies both a 19-passenger (pax) Certification Specifications 23 (CS-23) [35] and an 80-pax Certification Specification 25 (CS-25) [36], that is the configuration described in the present paper.

The proposed configuration is a high-wing mounted aircraft, with a T-tail configuration, featuring four under-wing mounted nacelles (two per half-wing), housing propellers, electric motors with inverters, gearbox, and the propulsion lubrication and thermal management system (TMS) (see Figure 1).

Table 1 summarizes aircraft’s main characteristics, while Table 2 and Figure 2 depict the aircraft design mission in terms of the mission profile, power source usage, reserves, and efficiency.

Aircraft dimensions	Value
Wing span (without winglets)	35.2 m
Wing area	72.3 m^2
Fuselage length	30.7 m
Fuselage height	3.5 m
Horizontal tail plane surface	11.5 m^2
Vertical tail plane surface	14.5 m^2
Propeller diameter	3.5 m
Propeller blades	8

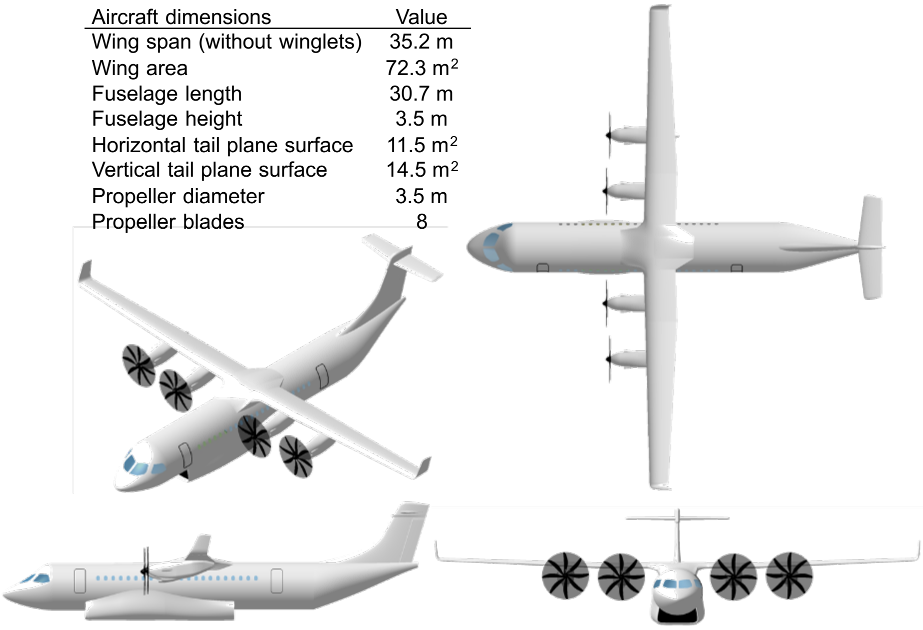

Figure 1. Aircraft view and main dimensions.

Table 1. Aircraft main characteristics.

Parameter	Unit	Value
MTOW (Max Take-Off Weight)	kg	39,842
Airframe mass	kg	19,523
FCPSS (Fuel Cell Power Supply System) mass	kg	6000
Battery mass	kg	1317
Power electronics mass	kg	2368
LH2 (Liquid Hydrogen) tank mass	kg	1389
LH2 (fuel) mass	kg	845
Wing surface area	m^2	113.8
FCPSS power available @ MSL (Mean Sea Level)	kW	7200
Battery power available	kW	1976
Shaft power available @ MSL	kW	7969
Technology		
FC specific power	kW/kg	1.200
Battery-specific power	kW/kg	1.500
Battery-specific energy	kWh/kg	0.250
LH2 tank GI (Gravimetric Index)	/	0.378
Power electronics specific power	kW/kg	3.360
Power electronics efficiency	/	0.918

Table 2. CS-25 80-pax aircraft mission data.

Phase number	Segment	Duration [mm:ss]	alt_{final} [m]	CAS [m/s]	RoC [m/s]	L/D [-]	P_{FCS} [kW]	P_{bat} [kW]	P_{shaft_tot} [kW]	SoC_{final} [%]
FLIGHT TO DESTINATION AERODROME										
0	Taxi-out	10:00	0	0.0	0.00	-	1025	0	899	95.0
1	Take-off	00:40	0	0.0	0.00	-	7200	1877	7969	88.3
2	Fast climb	04:10	3048	72.0	12.19	15.0	7200	1791	7893	48.6
3	Slow climb	09:22	7620	72.0	8.13	15.0	7200	264	6553	35.4
4	Cruise	78:42:00	7620	105.5	0.00	12.8	6181	0	5426	35.4
5	Descent	16:40	0	102.9	-7.62	12.9	1563	-461	968	76.3
GO-AROUND & DIVERSION										
6	Fast climb	06:40	3048	72.0	7.62	15.0	6619	0	5810	76.3
7	Diversion cruise	15:32	3048	105.5	0.00	12.5	4990	0	4380	76.3
8	Descent	05:40	457	92.6	-7.62	14.1	461	-461	0	90.2
9	Loiter	30:00:00	457	72.0	0.00	15.0	2758	-30	2395	95.0
10	Descent	01:00	0	102.9	-7.62	12.8	291	0	256	95.0
11	Landing	00:00	0	0.0	0.00	-	0	0	0	95.0
12	Taxi-in	05:00	0	0.0	0.00	-	1025	0	899	95.0

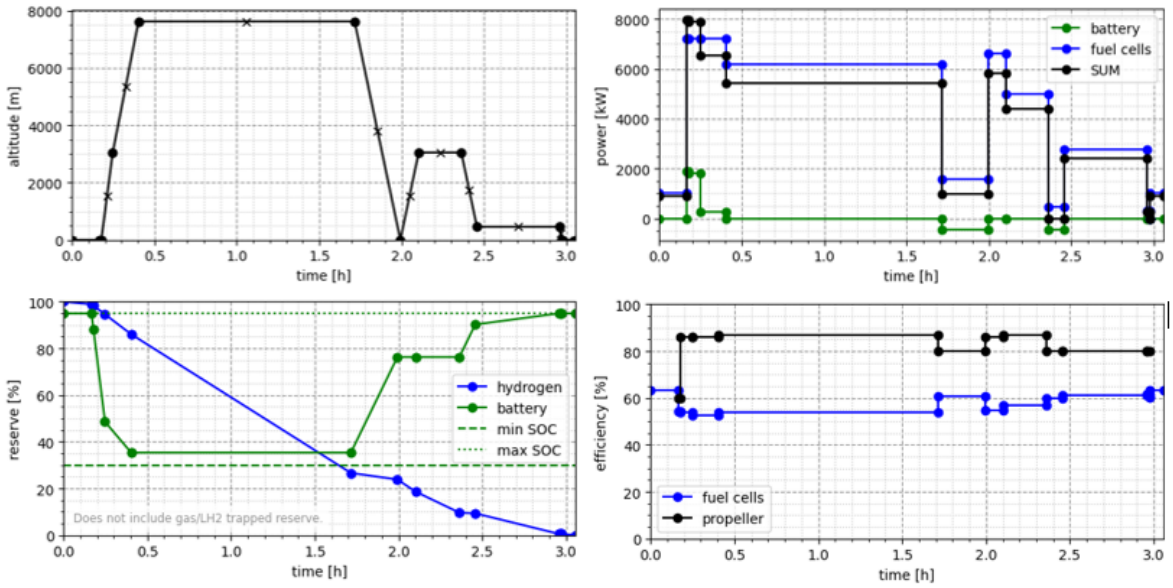

Figure 2. Aircraft design mission.

4 Results and Discussion

This section shows the final design of the 80-pax aircraft, focusing on the main systems and subsystems installed.

4.1 Propulsion system

The aircraft is equipped with a distributed electric propulsion system consisting of four nacelles, with two units installed under each half-wing – see Figure 3 –. This configuration has been selected to provide an optimal balance between thrust distribution, redundancy, and aerodynamic integration. The use of multiple propulsion units enhances overall system reliability, as the aircraft can tolerate the loss or degradation of a single propulsion unit without compromising flight safety.

Each nacelle integrates the main components of the propulsion system, including an electric motor, power electronics units (inverters), gearbox, a propeller, and a dedicated lubrication and TMS for the electric drive, see Figure 4. The electric motor dimensions are derived by the ones designed for the CS23 aircraft by applying the Vogt formula [37]:

$$P = C_m \omega_r d_r^2 l_r \tag{1}$$

where P is the motor's power, C_m is the utilization factor, ω_r is the rotational speed, d_r is the rotor diameter, and l_r is the rotor length.

The inverter ensures proper conversion and control of the electrical power supplied by the onboard energy system. The integration of a localized TMS within each nacelle allows for efficient dissipation of the heat generated by both the motor and the power electronics, contributing to improved performance, and especially system reliability thanks to its physical and functional independence from the fuel cell stack and battery thermal management systems.

The propellers have eight blades, a diameter of 3.5 m and have been designed to operate efficiently within the expected flight envelope of the aircraft, ensuring adequate thrust generation during all flight phases. The distributed arrangement of the propulsion units also offers potential aerodynamic benefits, such as improved lift distribution along the wing and enhanced control authority, particularly in low-speed conditions.

From a structural standpoint, each propulsion unit is supported by a dedicated engine mounting system, designed on the basis on previous experience gained from other projects. Engine mounting consists of a tubular structure composed of struts and tie-rods. This configuration provides an effective load path for transmitting thrust, weight, and aerodynamic loads from the nacelles to the wing structure, while maintaining structural efficiency and minimizing weight. Additionally, the tubular architecture allows for ease of inspection, maintainability, and adaptability to different propulsion layouts.

Overall, the proposed propulsion system architecture combines the advantages of distributed electric propulsion with a modular nacelle design, enabling high levels of redundancy, scalability, and integration with advanced fuel cell-based energy systems.

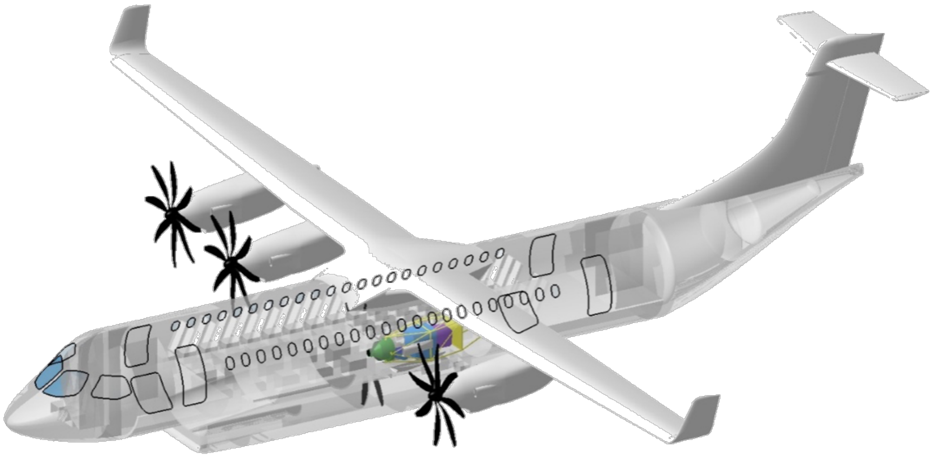

Figure 3. Propulsion unit integrated into the 80-pax aircraft.

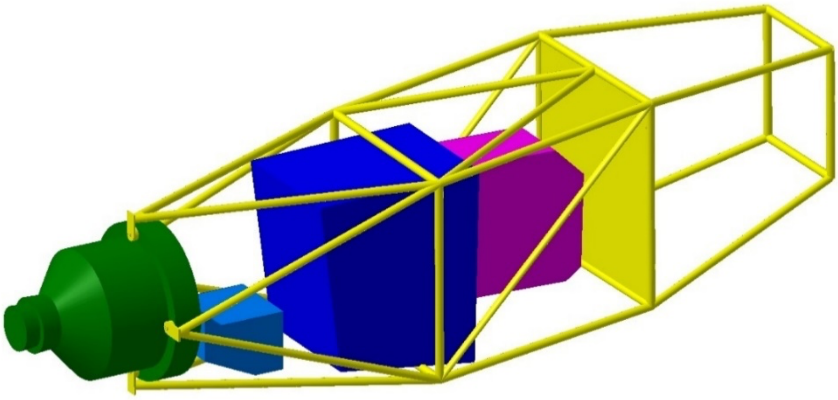

Figure 4. Engine nacelle components: electric motor (green), TMS (light and dark blue), inverter (violet) and engine mount (yellow).

4.2 Battery system

The aircraft is equipped with an onboard battery system installed in the lower fuselage, in close proximity to the Fuel Cell Power Source System (FCPS). This configuration has been selected to minimize power transmission losses, reduce cabling complexity, and ensure an efficient integration between the primary energy generation and storage subsystems. The location within the belly section also facilitates thermal management and structural integration while maintaining accessibility for maintenance operations.

The battery system serves multiple functions within the overall propulsion architecture. First of all, the battery system provides supplementary power during high-demand flight phases, such as take-off and climb. It also supports peak shaving and load levelling of the fuel cell system, thus improving its efficiency and operational lifespan. Next, the batteries enable transient response capabilities, compensating for the slower dynamic behaviour of the fuel cell stacks and ensuring stable and reliable power delivery to the propulsion units. Last, the batteries provide energy for the fuel cell system pre-conditioning, start, and re-start functions.

From a technological standpoint, the battery packs are designed based on Lithium-ion (Li-ion) technology, with power density of 1.5 kW/kg and an energy density of 0.25 kWh. The system is equipped with a dedicated Battery Management System (BMS), responsible for monitoring cell voltage, temperature, and state of charge, as well as ensuring safe operation through active balancing and fault detection mechanisms.

The battery TMS represents a critical aspect of the battery system design. Given the proximity to the FCPS and other heat-generating components, a dedicated TMS is installed to maintain the batteries within their allowable operating temperature range, thanks to efficient heat dissipation under all operating conditions, see Figure 5. The battery TMS is designed as functionally independent from the fuel cell systems TMS to further increase power provision redundancy. Figure 6 shows the battery system installed inside the aircraft belly fairing.

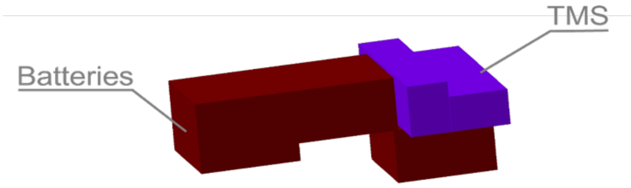

Figure 5. Aircraft modular battery system (brown) and TMS (violet).

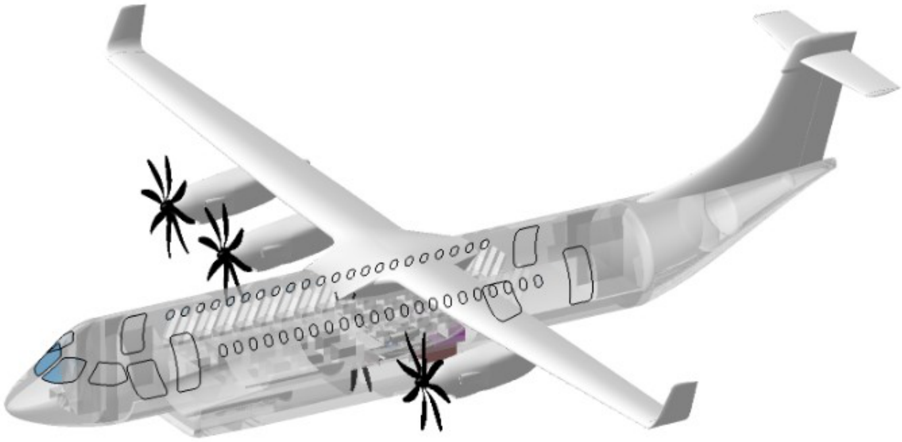

Figure 6. Batteries installation into 80-pax aircraft belly.

4.3 Fuel cells power system

The aircraft is powered by a FCPS installed in the lower fuselage, within the belly fairing section of the aircraft. This location has been selected to minimize the system encumbrance enabling an efficient integration with the battery packs, while also contributing to a balanced mass distribution along the longitudinal axis of the aircraft.

The FCPS represents the primary source of electrical power for the propulsion system. It is based on PEMFC technology, which converts the chemical energy of hydrogen into electrical energy through an electrochemical process, producing water and heat as byproducts. The system is installed in aircraft belly and is composed by 30 stacks grouped in 10 superstacks, 5 installed in the left-hand side of the aircraft and 5 on the right-hand side, allowing scalability, fault tolerance, and ease of maintenance, and several instantiations of the Balance of Plant (BoP), including air supply subsystems, anode recirculation loop (ARL), DC/DC (Direct Current/Direct Current) converter, control system, High Voltage Junction Box (HVJB), TMS (excluding ram air Heat Exchangers (HXs) – see Figure 7).

From a functional standpoint, the FCPS is designed to operate as the main steady-state power provider, supplying the base load required during the various flight conditions. Due to the relatively slow dynamic response of fuel cells to rapid load variations (in the order of seconds), the FCPS operates in conjunction with the onboard battery system, which provides additional power during rapid power transient conditions and high-demand phases. This hybrid architecture enables efficient load sharing and enhances the overall responsiveness and stability of the propulsion system.

Thermal management is a critical aspect of the FCPS design, as a significant portion of the chemical energy is dissipated as heat. The FCPS is therefore thermally coupled with the aircraft cooling system, which includes the heat exchangers integrated within the belly fairing. Dedicated cooling circuits ensure that the fuel cell stacks operate within their optimal temperature range, preserving efficiency, durability, and safety.

The structural integration of the FCPS within the fuselage has been carefully designed to meet airworthiness requirements related to crashworthiness, containment, and system protection. The system is enclosed within a protected bay, incorporating appropriate shielding, ventilation, and isolation features to mitigate potential hazards such as hydrogen leakage or component failure. Additionally, the proximity to other key subsystems, such as the batteries and power electronics, allows for a compact and efficient layout, minimizing electrical losses and simplifying system routing.

Overall, the FCPS installation within the belly fuselage provides a well-balanced solution in terms of performance, safety, and integration, enabling the effective implementation of a fuel cell-based propulsion architecture for regional aircraft applications.

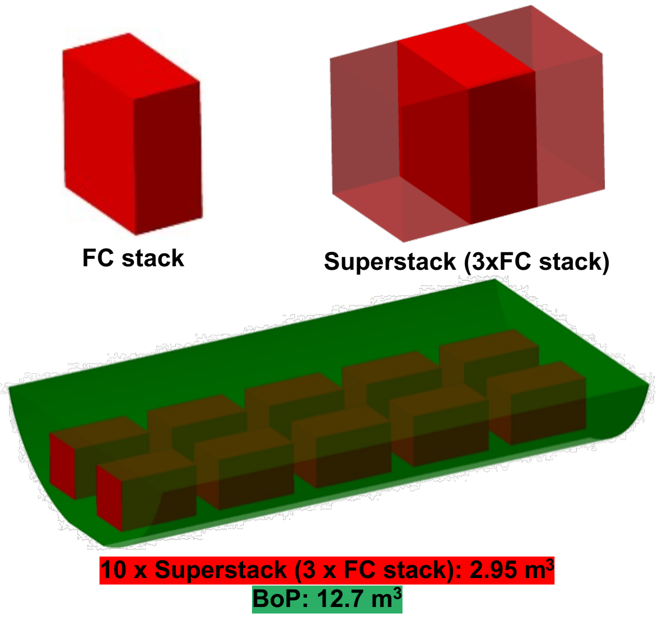

Figure 7. FCPSS volume and layout.

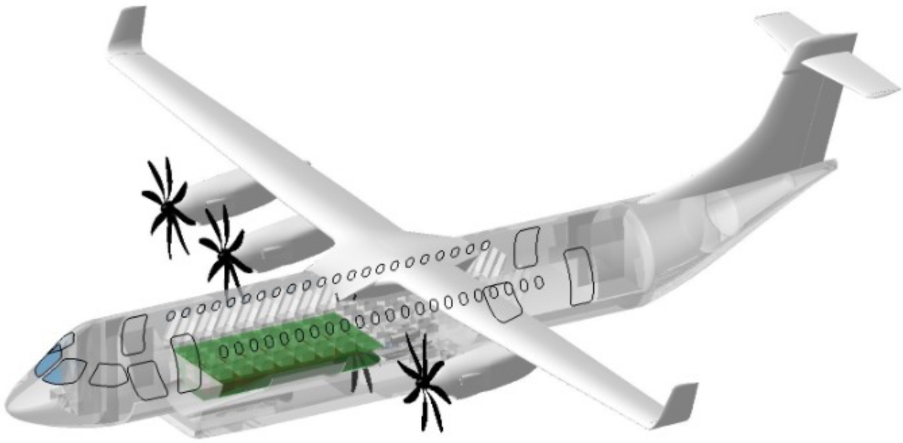

Figure 8. Integrated representation of FCPSS within NEWBORN 80-pax aircraft.

4.4 Heat exchangers

The TMS providing cooling to the FCPS relies on a set of partitioned heat exchangers installed inside the aircraft belly fairing, which has been specifically designed and shaped to support the cooling requirements of the fuel cell propulsion system. The belly fairing geometry is optimized to ensure an adequate airflow through the heat exchangers, allowing ambient air to be efficiently captured from the external flow and directed into the cooling system. The incoming air is then channelled through the heat exchanger cores, where it absorbs the excess heat generated by the FCPS, before being discharged through dedicated outlet located in the aft section of the fairing.

The chosen cooling solution is based on a ram-air cooling concept: the external airflow induced by the aircraft motion provides the primary cooling mechanism. The sizing of the heat exchangers has been performed by considering the thermal loads associated with the fuel cell stacks and auxiliary systems, which can reach several hundreds of kilowatts under high-power operating conditions. In particular, the heat exchangers total surface is equal to 21.6 m^2, split into two forward and two after radiators – see Figure 9. The ram air effect will be further assisted by fans (not depicted), supporting ground operations.

The analysed operating envelope includes ground-operation conditions characterized by reduced airflow through the heat exchanger. Therefore, the present results also provide an indication of system behaviour during turnaround, refuelling, loading/unloading, and other idling phases on the ground

A preliminary trade-off between cooling performance and aerodynamic penalties has been carried out to design the final system shape, as increased airflow requirements may lead to higher drag contributions.

The configuration enables effective thermal control while minimizing aerodynamic penalties, as the fairing is contoured to reduce drag and ensure smooth flow interaction with the fuselage. The positioning of the 2.16 m^2 inlet and a 2.6 m^2 outlet has been preliminary designed to maintain stable cooling performance across a wide range of operating conditions, including low-speed phases such as climb and approach, where ram-air availability is reduced.

The belly fairing is used to house the main landing gear as well, see Figure 10. To prevent any adverse thermal interaction between the landing gear and the heat exchange system, the landing gear is appropriately shielded, and thermally insulated insulation by means of a dedicated canopy installed inside the belly fairing. These solutions ensure that the landing gear components are protected from elevated temperatures, while simultaneously preserving the efficiency and reliability of the heat exchangers. Moreover, the structural and thermal interfaces between the landing gear bay and the cooling ducts have been designed to avoid unwanted heat transfer and to guarantee safe operation under all conditions.

Overall, the integration of the heat exchangers within the belly fairing represents a compact, thermally efficient, and aerodynamically integrated solution, enabling the effective dissipation of the significant thermal loads associated with fuel cell propulsion systems without compromising structural integrity, safety, or overall aircraft performance.

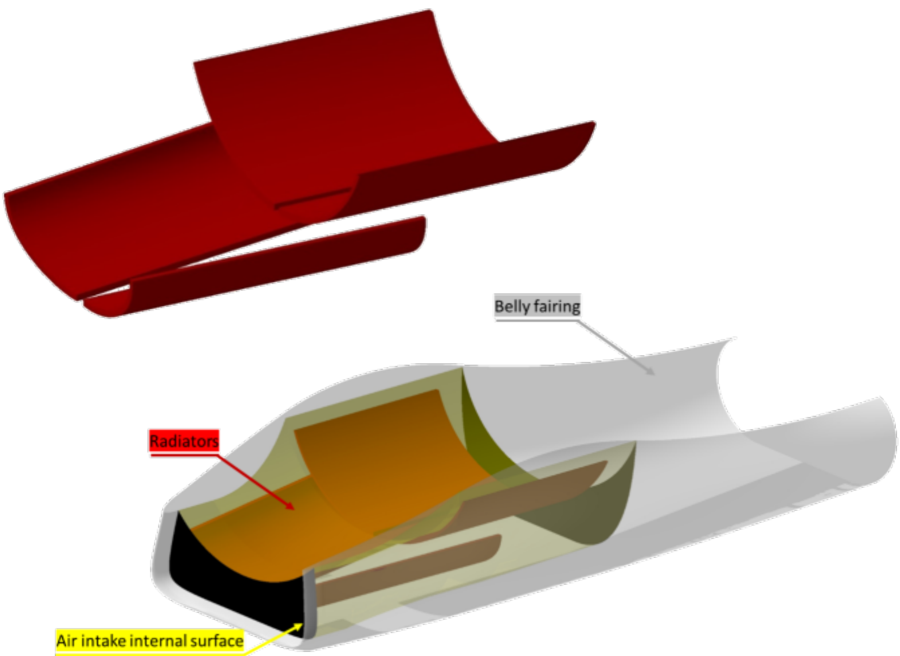

Figure 9. Belly fairing with radiators and air intakes.

Figure 10. 80-pax aircraft with installed HXs and landing gear bay.

4.5 Liquid hydrogen tanks

In accordance with the airworthiness requirements defined by the CS-25 certification specifications, particular attention must be given to the design of the fuel system to ensure adequate levels of fault tolerance, reliability, and safety. In fact, although CS-25 does not explicitly prescribe a minimum number of fuel tanks to be installed in the aircraft, the regulation establishes general principles requiring the fuel system to guarantee continuous fuel supply under all expected operating conditions, while preventing hazardous conditions in the event of component failures.

Specifically, the certification framework emphasizes the need for system independence and the mitigation of single points of failure, as well as the capability to withstand structural loads and minimize the risk of fuel leakage or fire hazards. These requirements inherently drive the design toward redundant and segregated fuel storage and distribution architectures.

In addition to integration and packaging constraints, the proposed tank arrangement was also informed by preliminary safety considerations. These included qualitative attention to tank location, separation from critical aircraft systems, and potential abnormal operating or impact-related scenarios. However, no dedicated crashworthiness analysis was performed in the present study. Therefore, the current work does not provide a detailed assessment of tank behaviour under hard landing, tail strike, or rupture scenarios, which would require a dedicated aircraft-level safety and structural investigation.

On this basis, the adoption of two distinct liquid hydrogen (LH2) storage tanks has been selected for the present aircraft configuration. , This design choice allows for an improved level of system redundancy, ensuring that the failure of one tank – or associated subsystem – does not compromise the overall aircraft fuel supply. Moreover, the use of multiple tanks facilitates better management of fuel distribution, enhances operational flexibility, and contributes to meeting safety objectives related to containment, isolation, and crashworthiness.

The fuel tanks are installed in the rear aircraft cone and consist of two cryogenic low-pressure double-insulation layer composite tanks for weight savings and mechanical resilience. The two tanks have a total capacity of 22.1 m^3: the rear tank provides 3.7 m^3 of hydrogen, while the forward one 18.4 m^3.

Since the LH2 storage tanks are in the tail section of the aircraft and are characterized by different volumes, an appropriate fuel management system is required The potential longitudinal CG shift associated with the aft tank installation is mitigated through an onboard tank-management strategy that controls the depletion sequence of the two hydrogen tanks during flight. The adopted logic is intended to constrain CG migration within the target operating envelope and was also defined considering abnormal cases in which one tank becomes unavailable. Because the two tanks have different capacities, the depletion schedule preserves a residual amount of hydrogen in the smaller tank to support continued safe operation under the considered fault scenario.

Such a system is essential not only to optimize the overall performance, but also to mitigate potential safety issues associated with uneven fuel depletion or, in worst-case scenarios, the leakage or failure of one of the tanks. By properly managing the fuel flow, the software, in fact, can ensure that the propulsion system continues to operate safely and efficiently, even in the presence of partial system degradation.

Figure 11 shows the two LH2 tanks installed in the rear aircraft cone, while Figure 12 shows the fuel tanks and their venting system.

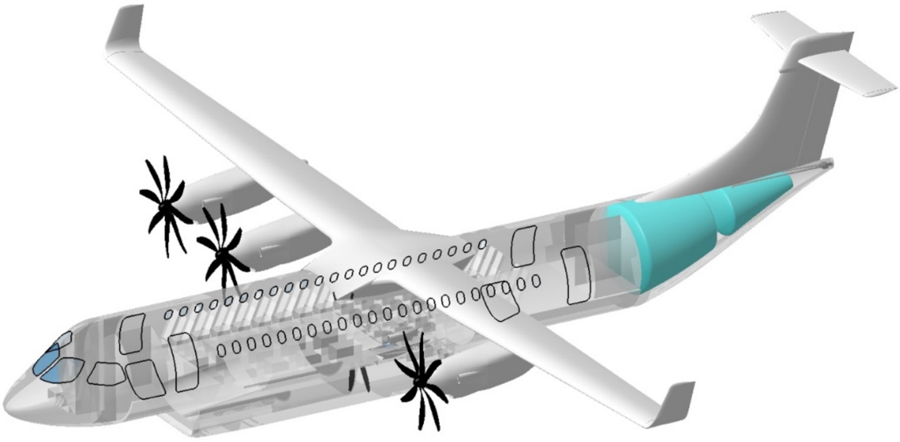

Figure 11. Tanks installation within the NEWBORN 80-pax aircraft.

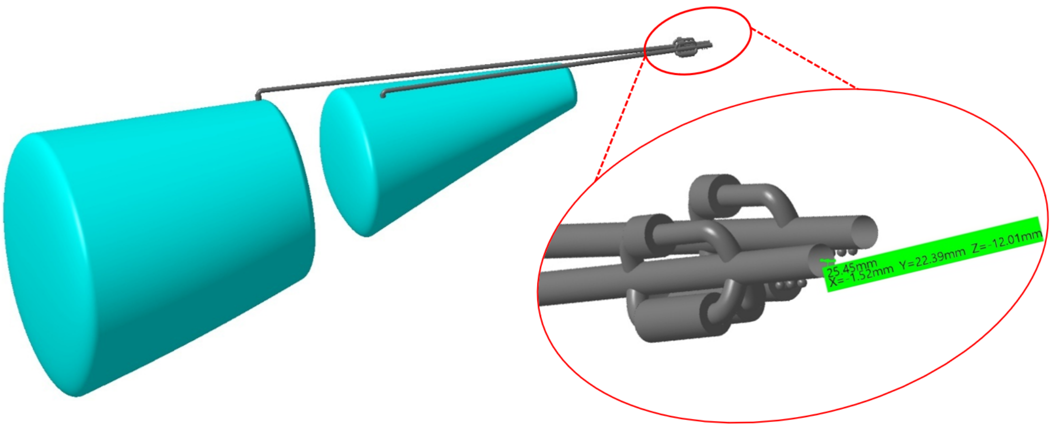

Figure 12. Hydrogen fuel tank and venting system design.

4.6 Cabin and cargo compartments

The aircraft cabin has been designed to accommodate to 80 passengers adopting a single-aisle, five-abreast seating layout (3–2 arrangement). This configuration ensures an effective balance between passenger capacity and comfort, while maintaining efficient boarding and deplaning procedures and compliance with evacuation and safety requirements. Seat pitch, aisle width, and overhead storage volumes have been defined in accordance with typical regional aircraft standards, ensuring a satisfactory level of comfort for short- to medium-range operations.

The design accounts for the presence of fuel cell-based propulsion components, which are installed beneath the fuselage floor. Consequently, the cabin configuration has been optimized to maximize usable space while ensuring proper insulation, noise reduction, and environmental control, including pressurization and air conditioning systems.

At this preliminary design stage, the aft bulkhead was introduced as a safety-oriented measure to segregate the LH2 tank compartment from the occupied cabin. However, no dedicated crashworthiness or detailed structural analyses were performed in the present study to verify its integrity under crash or emergency-landing conditions.

The cargo compartment is located both in the lower fuselage and in the cabin, being designed to provide sufficient volume for passenger luggage as well as additional freight, in line with the operational requirements of regional transport aircraft. Total cargo volume is up to 36 m^3. Dedicated loading doors are used to access the cargo compartment with standard loading procedures, allowing for efficient ground handling operations. Structural reinforcements and fire protection systems are incorporated to ensure compliance with airworthiness regulations, particularly with respect to crashworthiness and fire containment.

Given the presence of hydrogen storage tanks in the aft section of the aircraft, special consideration has been given to the distribution of mass within the fuselage. The cargo layout has therefore been designed to support proper weight and balance management throughout the mission, providing additional flexibility to compensate for variations in fuel distribution and passenger loading conditions. Although a detailed loading diagram is not reported in the present study, the proposed configuration was informed by preliminary weight-and-balance considerations, including representative limiting loading conditions, to ensure conceptual compatibility with the intended longitudinal CG envelope.

Overall, the cabin and cargo compartment design results from a careful trade-off between passenger accommodation, payload capability, and the integration of innovative propulsion technologies, ensuring both operational efficiency and compliance with safety requirements. One front and one rear lavatory are available inside the aircraft, together with a service compartment installed in the forward fuselage section, close to cockpit. The final layout is shown in Figure 13.

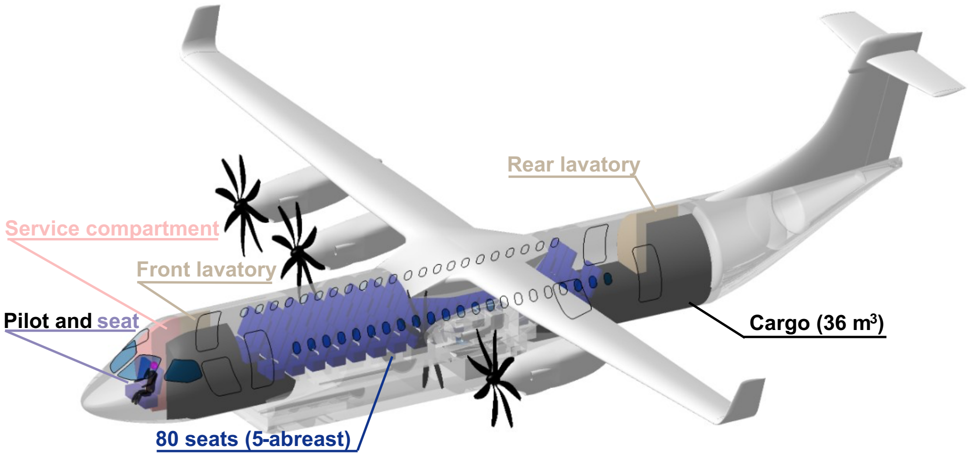

Figure 13. Cabin and cargo compartments.

5 Conclusions

The paper summarizes the results of activities aimed at the preliminary design of an innovative regional aircraft powered by LH2 and electric propulsion. The proposed configuration consists in a high-wing aircraft with T-tail, with four under-wing mounted nacelles. Each nacelle houses the propulsion system consisting of an electric motor and its thermal management system, an inverter, and a propeller. Fuel cell power system, made up of 10x3 FC stacks, with 5 super-stacks (1x3 stack) per side and BoP – which includes air line, ARL, DC/DC converter, control system, HVJB, TMS without HXs – is installed under fuselage passenger floor, where the battery system, based on Li-ion technology, is housed as well. Heat exchangers are installed in the aircraft belly fairing, properly designed with an inlet and an outlet, assuring required input air flow. Two cryogenic low-pressure double-insulation layer composite tanks for weight savings and mechanical resilience are installed in the rear aircraft cone, assuring system redundancy in case of failures.

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7 Nomenclature

ACARE	Advisory Council for Aviation Research and Innovation in Europe
ARL	Anode Recirculation Loop
BMS	Battery Management System
BoP	Balance of Plant
CO_2	Carbon Dioxide
CS-23	Certification Specification 23
CS-25	Certification Specification 25
DC/DC	Direct Current/Direct Current
DLR	Deutsches Zentrum für Luft- und Raumfahrt e.V.
EU	European Union
FC(s)	Fuel Cell(s)
FCPS	Fuel Cell Power System
FCPSS	Fuel Cell Power Supply System
GI	Gravimetric Index
HVJB	High Voltage Junction Box
HXs	Heat Exchangers
LH2	Liquid Hydrogen
Li-ion	Lithium-ion
MSL	Mean Sea Level
MTOW	Max Take-Off Weight
NEWBORN	NExt generation high poWer fuel cells for airBORNe applications
NO_x	Nitrogen Oxides
PEMFCs	Proton Exchange Membrane Fuel Cells
R&I	Research and Innovation
TMS	Thermal Management System

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