PANEL DISCUSSION II: Alternative Propulsion

Dr. Marcello Amato, *CIRA, Director of the Research Directorate*

Q1: RTOs made significant contributions to the success of Clean Sky, Clean Sky 2 and, currently, for the progress of Clean Aviation. As EU research aims to demonstrate the critical role of R&I in achieving clean and competitive outcomes, could you share the most impactful findings so far from the RTOs point of view that are crucial for implementing the European roadmap towards a more sustainable aviation?

CIRA and Research Technology Organisations - as partners and members of the CS1, CS2 and CA - largely participated in the programme both in terms of volume of research activities and achieved results contributing to answer the defined challenges reaching quantitative targets.

CIRA, together with many important RTOs contributed to all three Innovative Aircraft Demonstrators - nominally Large Passenger Aircraft, Regional Aircraft and Fast Rotorcraft – and to all Integrated Technology Demonstrators – nominally Airframe, Engines, Systems – as well as to transverse activities like Small Air Transport and last but not least Impact Monitoring.

Thus, CIRA and European RTOs were involved in a wide range of applied research topics ranging from aerodynamics, aerostructures, aeroacoustics, systems, engines, aircraft architectures, on board systems up to safety related approaches and analysis for different type of fixed wing and rotating wing aircraft.

It has not to be forgotten that RTOs operate strategic validation, qualification and certification experimental facilities, including flying test bed, that are essential for maturing technologies up to flying demonstration.

I can make some examples for Clean Sky 2 programme.

The Impact Monitoring project built an instrument integrating different tools to collect and assimilate research results and evaluate their potential benefits from technology development, through integration studies and up to large-scale demonstrations, to deliver the cumulated programme impacts versus the aviation sector’s trajectory towards climate neutrality.

Within the Large Passenger Aircraft platform - Airbus, the Dutch RTO NLR and the French RTO ONERA, CIRA - contributed to the development of a Scaled Flight Demonstrator technology to accelerate maturation and de-risking of disrupting technologies and configurations related to distributed electric propulsion. The Scaled Flight Demonstrator was flown in a very successful flight test campaign in Italy (Grottaglie) during year 2022 and in June-July 2024 collecting a large amount of flight data.

In the Fast Rotorcraft platform two streamlines were followed namely: Next Generation Civil Tiltrotor and the Racer Compound Helicopter; the two programmes delivered flying demonstrators positioning Europe in a leading role. In this context, CIRA coordinated two consortia that delivered two essential subsystems to both leaders (Leonardo Helicopters and Airbus Helicopters) for the

Next Generation Civil Tiltrotor and the Racer Compound Helicopter demonstrators. More specifically, the T-WING project designed and realized the innovative composite wing for the Tiltrotor demonstrator, while the ANGELA project designed and delivered the landing gear system. Both components were integrated and flown in the two flying demonstrators.

Other activities from RTOs in this context were, for example, wind tunnel testing, fuel tank drop tests, high-fidelity structural analyses, noise evaluations, aerodynamic assessments, vibration qualification testing, additive manufacturing of flight parts, life cycle assessment, and the design and installation of flight instrumentation.

In the Regional Platform as an example, I can mention the Air Green-2 project developed and demonstrated innovative technologies for wings like innovative wing box manufacturing processes, innovative materials, structural health monitoring, natural laminar flow technologies; morphing surface to improve aerodynamic efficiency, hyper lift generation and enable advanced load control. CIRA, in particular, designed and developed morphing winglets for a Regional aircraft configuration designed by Leonardo, ready for flight tests, capable to support load control strategies and improve climb performance.

In the Systems platform one specific example for the Small Air Transport (SAT) was the project named "Cost Affordable Avionic System" by designing and developing enabling technologies for Single Pilot Operations; these technologies were matured up to flight demonstration.

The realization of all the projects during Clean Sky 2 enabled the creation of new European supply chains for specific innovative technologies very important for the competitiveness and for matching the Green Deal challenges.

CIRA and many RTOs are founder members of Clean Aviation and are largely contributing with activities in all the pillars of the new partnership.

Let me make only one example related to new propulsion technologies. The AMBER project aims to develop a hybrid propulsion system combining a thermal engine with Proton-Exchange Membrane (PEM) fuel cell-powered electric motors. In this project, CIRA is building advanced test benches, to test innovative heat exchangers to improve cooling, and is engaged in certification activities to identify transformative technologies, assess their impact on current airworthiness standards, and propose tailored solutions to address the challenges of certification.

Q2: From the RTOs viewpoint, which are the main areas of research for the short-medium term related to Alternative Propulsion ensuring a competitive and sustainable future in aviation?

The difficulty of indicating the main areas of research is due that there is not a unique solution for different aircraft categories (passengers' seats, endurance) and we are going to face a real revolution for aviation including vehicles, operations and airports.

We should not only talk of vehicles but also of air traffic management and airports and we should have the perspective of the full transport systems with interconnected modes with maritime, rail and road transport. This perspective is important in terms of intermodal operations but also thinking to the energy and energy vectors needed for the overall transport systems and related climate impact.

Before making some examples of important research areas related to next generation of aircraft (N+1), it is important to highlight the RTOs point of view on the importance on not loosing momentum on medium-long term research and technology development in order to avoid the creation of technological gaps for the following generation of aircraft (N+2) for 2050 and beyond.

In addition, it is essential that Europe and Member States coordinate efforts for making available:

- large Research & Technology infrastructures to validate and certify innovative technologies for propulsion but also for all related technologies and demonstrators (e.g. European Flying testbeds; test benches and facility for testing fuel cells, hydrogen propulsion systems, crashworthiness of fuel thanks and of new aircraft architectures to ensure passengers survivability);
- ground test benches supporting the deployment of new aircraft powered with SAF, batteries, or hydrogen.

Typically, this large infrastructures and ground test benches, to progress maturation of technologies, are developed and operated by RTOs but they are very costly. Thus, dedicated resources should be allocated to ensure availability of these infrastructures but coordination and synergies among European Union and MSs are essential.

Looking to new aircraft products for entry into service by 2035 and by 2050 the main focus is on three aircraft concepts for commercial aviation: ULTRA-EFFICIENT REGIONAL AIRCRAFT, HYDROGEN POWERED AIRCRAFT, ULTRA-EFFICIENT SHORT AND MEDIUM RANGE AIRCRAFT.

These concepts are mainly focusing on regional (50-100 passengers, range up to 500 Nautical Miles) and small and medium range (200-250 passengers, range up to 3000 Nautical Miles) segments; the hydrogen powered aircraft, probably, will be an intermediate segment.

For each concept the main areas of research are different and these poses some complexity.

I try to summarise some examples for each of the three concepts.

For Regional aircraft, aiming to hybrid propulsion with Sustainable Aviation Fuel and batteries some critical technologies are: new propellers for hybrid propulsion units, in flight thermal management, new aircraft configurations with aerodynamic and aero structural optimisation, advanced systems, energy and power management, energy storage and eventually high-performance fuel cells (if they satisfy specific requirements being the main concept only with batteries). If fuel cells will be adopted, technologies related to hydrogen storage and distribution will be an essential enabler in common with hydrogen aircraft but also specific technologies like thermal management have to be developed, demonstrated and certified.

For Small and Medium Range, aiming to adoption of thermal engines with drop-in (SAF) and eventually non-drop-in fuel (Hydrogen), the main critical technologies are: ultra-efficient engines both ducted or un-ducted; high aspect ratio wing - including laminarity, advanced and active technologies for flutter control and ice protection system - with competitive production processes and low cost of operation; new aerostructures for fuselage and empennages.

For the short term only SAF fuels and thermal engines will be adopted while for the medium term, possibly, hydrogen will be adopted for direct burn; in this case other technologies are relevant and are in common with the Hydrogen Powered aircraft.

For Hydrogen aircraft, aiming to the adoption of thermal engines directly burning hydrogen, main technologies are related to the propulsion system, aircraft configuration, fuel tanks (issues are mechanical, permeability, crashworthiness characteristics), hydrogen distribution control systems, hydrogen venting and thermal management systems, certification rules and specific means of compliance (both digital twins and experimental facilities). Clearly, an alternative is the adoption of electrical engines with highly efficient and high-power fuel cells and eventually some batteries; in this case fuel cell innovative technologies, high-efficient thermal management systems, and electrical related technologies are very relevant.

Q3: Research collaboration is key to creating new solutions and achieving better results in any scientific field. What type of partnerships with the industry do you foresee being crucial for ensuring future success in aviation innovation?

Aviation JUs, Clean Aviation and SESAR, are being very successful to define European roadmaps and implement them with R&I programmes with high impacts towards the entry into service of new vehicles and operations aiming to make a reality the Green Deal objectives. Both HE collaborative projects and public-private partnerships (PPP) are facilitators for real cross-border and cross-sectoral European cooperation in R&I, bringing together the best European stakeholders from industry, RTOs, academia, operators, and SMEs creating critical mass and achieving goals not possible with national programs alone. These instruments are creating the basis for a European Research Area (ERA) and a trustful cooperation between European R&I actors.

This European approach has to be preserved and improved for the future Framework Programme being crucial for the success of European aviation innovation process.

Looking forward to FP10, an unbalanced system and dominance of any single stakeholder group is undesirable and might create the risk of not preparing Europe for the medium-long term. RTOs advocate for a strong and well-balanced system, funded and with an appropriate governance, where all stakeholders should find their place to ensure balanced multi-annual R&I cycles.

A proper funding for Low to Mid TRL (TRL 2-5) research has to be ensured for developing disruptive technologies and to avoid the creation of technological gaps for the following generation of aircraft (N+2) for 2050 and beyond.

While acknowledging the Partnerships as a valuable tool to support strategic topics, the EU should preserve the Collaborative type of research activities we had so far in Framework Programmes focusing on Aviation or in alternative explore new avenues such as a dedicated pillar of a public-private partnerships focussing on medium-long term research and technology development, knowledge exchange, and infrastructure sharing.

European coordinated support to Research and Technology Infrastructures (both physical and digital like wind tunnels, European flying test bed infrastructure, simulators and propulsion test beds) should be ensured to increase European leadership and sovereignty in key technology developments. Defining new European strategic technology and test infrastructures facilities, maintaining and upgrading existing ones will help support European industries and the development of innovative products

Synergies with national and regional initiatives shall be strengthened to support the uptake and use of project results and generate new impulses for innovation and growth of the European Research and Innovation (R&I) ecosystem while fostering its competitiveness.

Considering the specific needs and different rules for data management (e.g. classified information) all stakeholders should push for maintaining civil and military R&I Programmes separate but promoting better synergies between the two.

All aviation stakeholders should foster synergies between EU programmes and at least some elements of national, regional R&I investments for a more efficient public spending and to make full use of research results by seeking a better alignment of funding schemes, strategies and priorities.

Another element is to work together for enhancing complementarity and synergies for aviation with other key European funding instruments (e.g. EU Innovation Fund) to accelerate the trajectory towards climate-neutral aviation by implementing a joint and coordinated effort to support the market uptake of innovative net-zero emission technologies.