TRIATHLON

Press release

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Advancing hydrogen-electric aviation in Europe

TRIATHLON highlights two years of progress toward integrated hydrogen-electric aviation technologies

TRIATHLON partners at the Month 24 progress meeting in Florence, Italy, November 2025.

After two years of research and testing, the European project TRIATHLON is reporting significant progress toward enabling **hydrogen-electric propulsion for aviation**. Funded by **Horizon Europe**, the consortium brings together universities, research centres, and industry partners to develop and validate integrated technologies that **reduce emissions** and i**mprove efficiency in future aircraft**.

At its **Month 24 milestone**, the project has advanced key building blocks across hydrogen combustion, storage, thermal management, and full powertrain integration — laying the technical foundations for low-emission regional and short-haul aviation.

Technical highlights

- Validated LES/ESF simulations of hydrogen RQL–TVC combustion
- Stable operation demonstrated with cooled H_2–air mixtures down to 150 K
- Cryogenic test rig achieving 12 K for composite permeability testing
- Aluminium nitride ceramic heat exchanger coupons tested for high-temperature operation

Project Milestones and Research Highlights

WP1 – Progress on Hydrogen Combustion

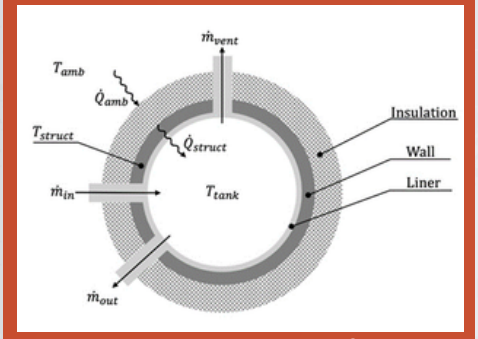
Led by Delft University of Technology, the team designed and analysed a **100% hydrogen-fuelled combustor** concept tailored for aviation applications. Using detailed simulations, validated on benchmark configurations, researchers studied how cryogenic hydrogen injection and fuel temperature affect flame behaviour and emissions. Results demonstrate that stable combustion with **well-controlled nitrogen oxides emissions** is possible at different operating conditions, confirming that hydrogen combustors can achieve both safety and environmental performance — a key step toward next-generation hydrogen-powered aircraft engines.

Complementing the combustion research, Ergon Research contributes to WP1 through **fuel cell system modelling**. The work supports system sizing and the assessment of performance under key flight conditions such as take-off and cruise, while evaluating synergies with hydrogen combustion, including the use of fuel cell–produced water for injection into the fuel cell.

WP2 – Optimising Multi-State Hydrogen Storage

Work Package 2 develops safe, lightweight hydrogen storage solutions for aviation. The team at Dresden University of Technology is working together with the team at Delft University of Technology and Cryomotive GmbH to advance a novel **multi-state storage concept** combining **gaseous, liquid, and cryo-compressed hydrogen** to maximise energy density while reducing system weight. A dedicated cryogenic test facility characterises advanced carbon-fibre-reinforced composites at extremely low temperatures, measuring thermal conductivity and hydrogen permeability. In parallel, a flexible modelling tool compares conventional and multi-state storage configurations at aircraft level, supporting the optimisation of lighter, safer, and more efficient hydrogen storage systems.

Cryogenic test rig with periphery



Tank layout with hydrogen flow and heat transfer paths

> *"We are at the halfway point of the TRIATHLON project and all the separate building blocks are really starting to come together. I am confident that the technologies developed in TRIATHLON will contribute to the realization of a disruptive hybrid hydrogen-electric powertrain for megawatt class aircraft." Dr.ir. Julien van Campen, Project Coordinator*

WP3 – Ceramic Heat Exchanger Development

Work Package 3 (WP3), Lithoz, Ergon Research, and Sabancı University are focusing on the design, manufacturing, and testing of a **ceramic heat exchanger coupons** to increase the temperature of hydrogen using waste heat from the fuel cell. Unlike conventional metal components, ceramic materials enable higher operating temperatures, lower thermal expansion, and reduced weight — key advantages for aviation.

Coupon gyroid - 65% porosity, aluminum oxide, sintered

The team is designing and testing advanced internal geometries and comparing aluminium nitride and aluminium oxide ceramics to optimise heat transfer, pressure drop, and overall performance. These developments support more compact and efficient thermal management for hydrogen-electric aircraft.

WP4 – System-Level Powertrain Integration

Work Package 4 is led by Ergon Research and brings together the technologies developed across the project into a complete **hydrogen-electric propulsion system**, integrating hydrogen storage, fuel cells, thermal management, power electronics, and turboprop propulsion. Using an integrated virtual model, the team evaluates performance across the full flight envelope to assess efficiency, operability, and system-level trade-offs. This whole-system approach ensures that individual component innovations work together reliably and provides a clear **technology roadmap** to support future industrial deployment of hydrogen-electric aircraft.

Dissemination and Outreach

Alongside its technical developments, TRIATHLON actively disseminates its results through major international aerospace events, engaging researchers, industry leaders, and policymakers across Europe. The project contributes to European clustering initiatives, including the **ClimAvTech** network, fostering collaboration with complementary EU projects and accelerating knowledge exchange.

Why This Progress Matters

After two years of research, TRIATHLON is advancing the practical foundations for hydrogen-powered aviation. By addressing challenges across combustion, thermal management, storage, and system integration, the project is demonstrating how these technologies can be designed and evaluated within realistic aircraft constraints.

Beyond scientific insight, the consortium is delivering validated models and experimental data that help reduce technical risk and inform future development. These advances support **safer combustion**, **more efficient energy use**, and **lighter**, **more reliable hydrogen storage** — important steps toward enabling hydrogen-electric flight.

By combining component innovation with system-level assessment, TRIATHLON strengthens the pathway from research to future industrial application and contributes to Europe's broader ambition for **climate-neutral aviation**.

About the project

TRIATHLON (THERMODYNAMICS-DRIVEN CONTROL MANAGEMENT OF HYDROGEN-POWERED AND ELECTRIFIED PROPULSION FOR AVIATION) is a collaborative European research project focused on advancing disruptive design approaches for safer, lighter, more reliable, and highly responsive megawatt-class hydrogen-electric aircraft propulsion systems.

The project started on January 1st, 2024, and will run for 48 months, coordinated by Stichting Materials Innovation Institute (M2i).

Consortium partners: STICHTING MATERIALS INNOVATION INSTITUTE (M2I), TECHNISCHE UNIVERSITEIT DELFT, TECHNISCHE UNIVERSITAET DRESDEN, ERGON RESEARCH SRL, SABANCI UNIVERSITESI, CRYOMOTIVE GMBH, LITHOZ GMBH, AMIRES SRO.

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Project Information and Media Channels

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Website: https://triathlon-project.eu

LinkedIn: TRIATHLON project