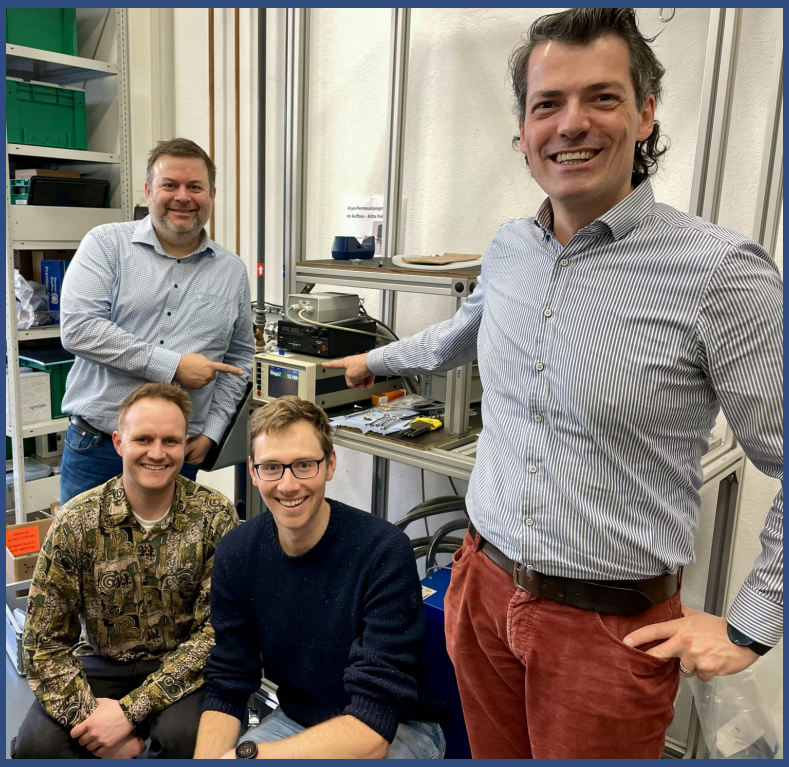
TRIATHLON

THERMODYNAMICS-DRIVEN CONTROL MANAGEMENT OF HYDROGEN POWERED AND ELECTRIFIED PROPULSION FOR AVIATION

Work Package 2 Update



WP2 Progress: From Concept to Cryogenic Testing

WP2 focuses on improving **hydrogen storage efficiency** by reducing **loss, weight and cost** for hydrogen-powered aviation. The work develops **multi-state storage** using **gaseous, liquid and cryo-compressed hydrogen** to achieve high storage densities and avoid the need for a cryopump. Advanced, **leak-tolerant composite materials** are used to enable **lighter** and s**afer storage systems**.

During the first year, key progress was made: **crucial boundary conditions** for the multi-state storage system were defined, and hydrogen discharge from a cryo-compressed tank was successfully simulated for a typical flight mission. A **generic wall design** for an **all-composite CcH2 vessel** was developed, with experiments on **crack formation** and **gas leakage** laying the groundwork for l**eak-tolerant composites**. **Test rigs for cryogenic material characterisation** were also conceptualised at the Institute of Lightweight Engineering and Polymer Technology (ILK), TU Dresden.

ACHIEVEMENTS SO FAR

Over the past year, major technical groundwork has been completed. **X-ray imaging of cryogenically cycled material** samples was successfully tested to study internal damage after thermal cycling. The **cryogenic test rig was fully assembled and commissioned**, and **thermal conductivity testing has now started**, enabling realistic material evaluation under cryogenic conditions.

PROGRESS AND MILESTONE

On December 16, 2025, **Milestone 4 was reached** with the **successful commissioning of the cryogenic test rig at ILK/TU Dresden**. During the first cooldown test, performed together with the project coordinator Julien van Campen from TU Delft, **a temperature of 12 K was achieved**.
This marked a key step toward testing materials under conditions relevant for cryo-compressed hydrogen storage.

UPCOMING WORK

In **2026**, a full **test campaign** will measure the **thermal conductivity and gas permeability** of **carbon-fiber-reinforced LM-PAEK**, a promising material for **high-performance hydrogen storage**.
C**ryogenic cycling** and **CT scanning** will also be used to link **crack development** to **gas permeability**, supporting the design of more **reliable** and **leak-tolerant storage systems.**

Funded by the European Union

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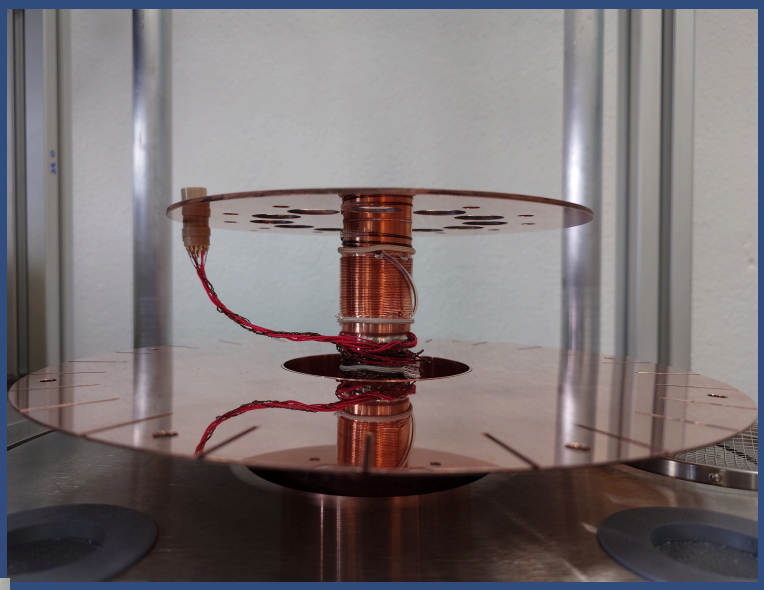
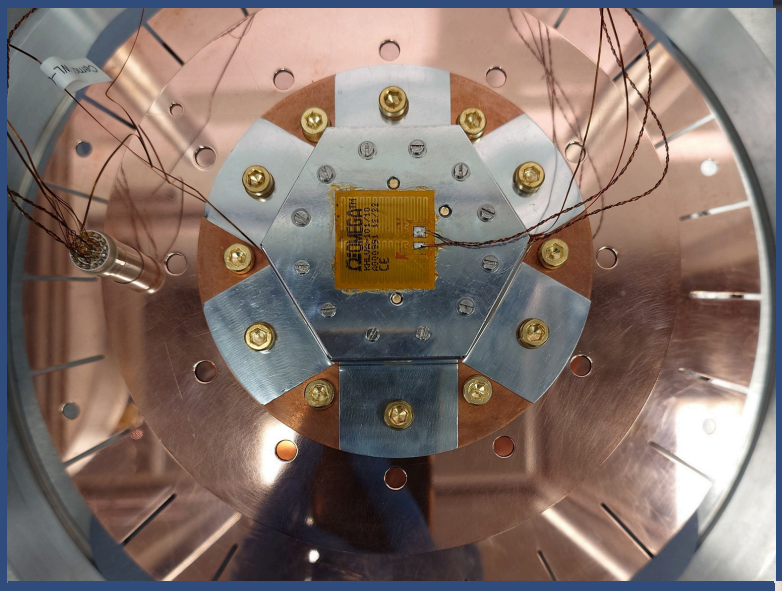
Cryogenic Test Rig – Stages 1 & 2

Stage 1 (thermal shielding) and Stage 2 (experimental platform) of the cryogenic test rig.





Inside the Cryogenic Test Rig

A view inside the cryogenic test rig with the thermal conductivity experiment mounted.

Cryogenic Test Rig with Periphery

Overview of the test rig architecture and associated peripheral devices.