Hydrogen Research & Innovation Days
24-25 November 2025

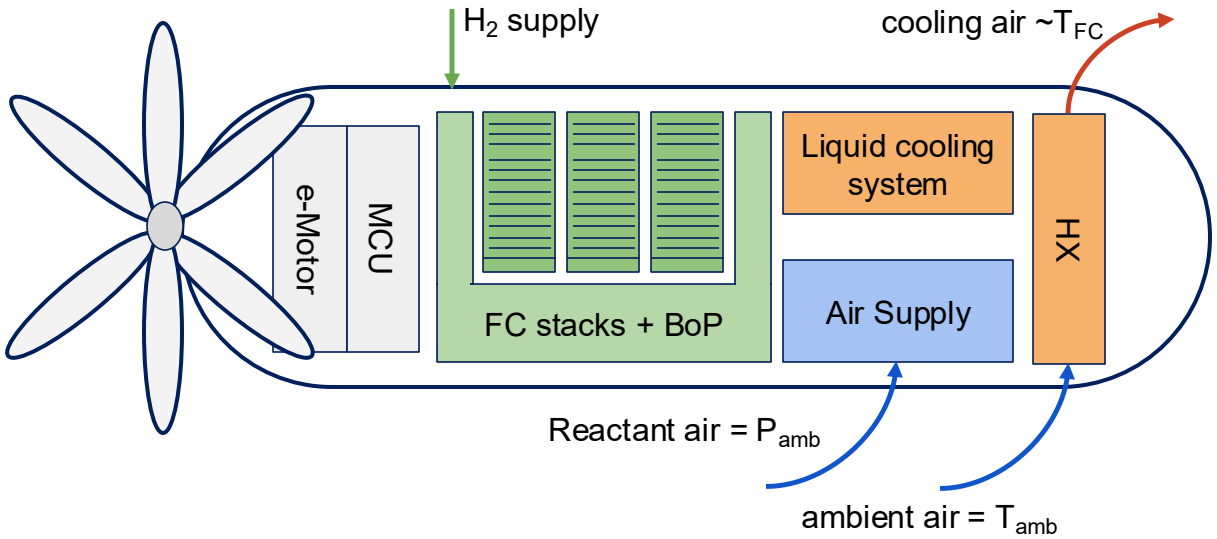
BRAVA - Fuel Cell Systems for main propulsion within Airbus ZEROe

Jörg Tappermann, Head of Fuel Cell Systems, Airbus in Hamburg
24 Nov 2025

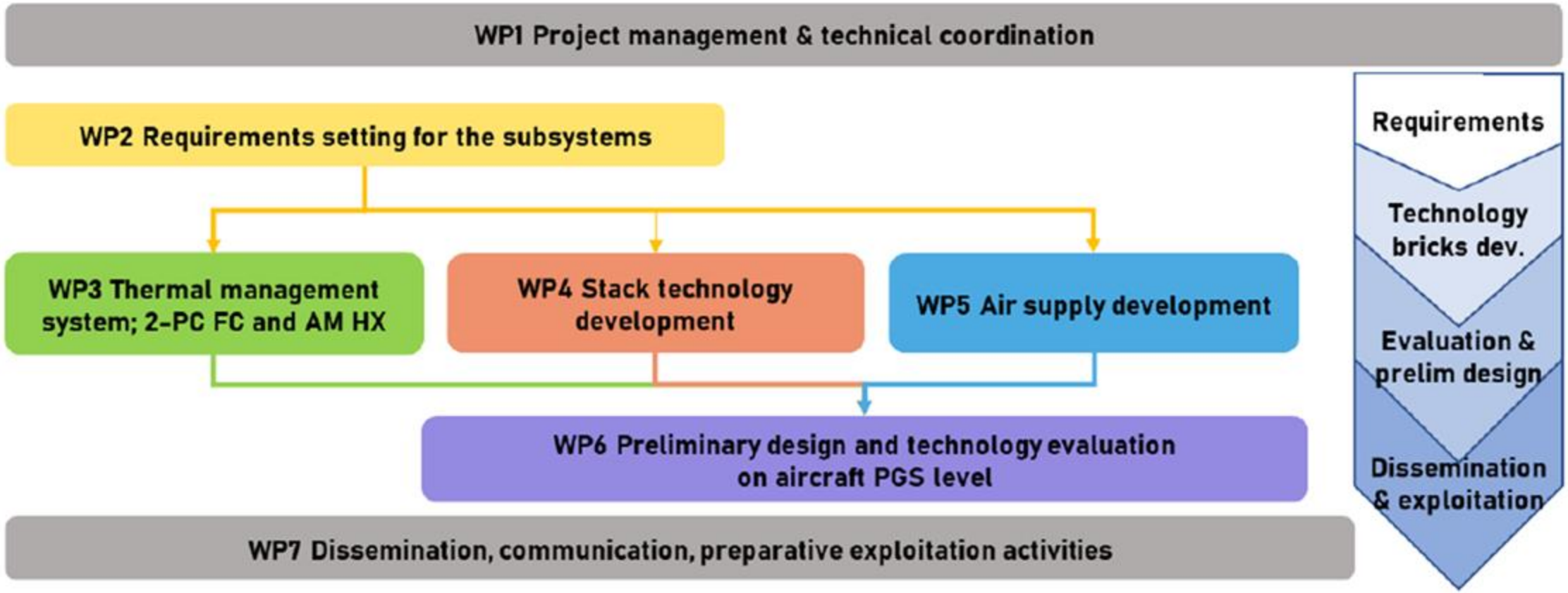
Clean Hydrogen Partnership

Co-funded by the European Union

Airbus ZEROe revisited

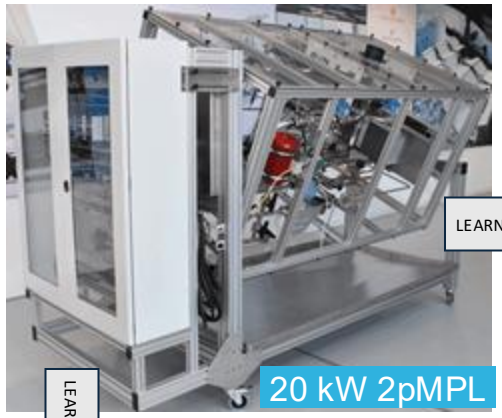


BRAVA outline

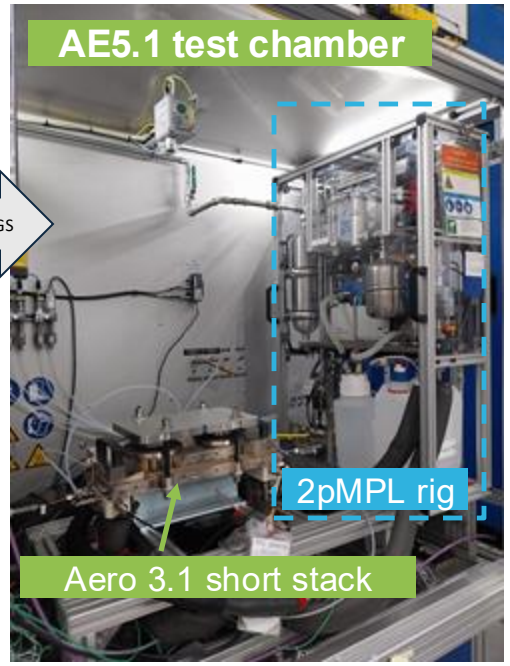


WP3 - Thermal Management System: 2-phase cooling

Tests at NLR



Tests at Aerostack



Achievements within BRAVA:

Liquid cooling system (= heavy) successfully replaced by a novel **2-p**hase **M**echanically **P**umped **L**oop w/o accumulator (= lightweight). The LT-PEM fuel cell system shows full functionality:

- Test setup with 20 kW cooling capacity to test different concepts and control methods[1]. Upscaled to a 200 kW demonstrator
- Fuel Cell short stack (9 cells) test system integrated with 2pMPL and tested. Stable flow-boiling operation with a short stack → normal performance & voltage homogeneity.

Benefits / Innovations:

- Lower fluid and equipment mass (up to -58 %[2]);
- lower pump parasitic loads (up to -88 %[2]) with positive snowball effects.
- World's first aeronautic fuel cell stack operated with 2-phase cooling approach

Clean Hydrogen Partnership

nlr

Aerostack GmbH

AIRBUS

Co-funded by the European Union

[1] see paper https://www.mdpi.com/2226-4310/12/3/188
[2] see paper https://doi.org/10.3390/en18040849

WP3 - Thermal Management System: metal 3D printed Heat Exchangers

Achievements within BRAVA:

- Additive manufactured a mid-scale HX in Aluminum with integrated liquid manifolds
- Analytical improvement of project targets by:
  - > 20% lower mass → 24% ✅
  - > 15% lower drag → 40% ✅
  - > 30% smaller volume → 13% ❌
- Manufactured thin wall specimens (0.5, 0.75 and 1 mm) for tensile and fatigue testing; evaluate how the HX primary walls will perform under stress
- Vibration and Operational Shock test at mid scale HX at NLR done.

Benefits / Innovations:

- Potentially decrease mass and drag of the HX might positively impact the A/C performance.
- HX Volume might be reduced by studying the HX integration in the Ram Air Channel → activity to be started.

Clean Hydrogen Partnership

Morpheus Design

MADIT

Co-funded by the European Union

WP4 - Fuel Cell Stack MEA development

PAI Torlon® reinforcement membrane made by CNRS

Achievements within BRAVA:

- Membrane durability on operation > 20,000 hours (extrapolated)
- Membrane conductivity > 20 mS/cm at > 105 °C and < 20% RH
- Status: MEA performance → 0.8 A/cm^2 at 0.74 V at low humidity (RH < 20%), higher temperature (T > 100 °C); durability measurements are ongoing, simulations indicate high durability
- MEA size produced 35x20cm = sufficient to enable high power stack active area
- High durability membrane with low H2 crossover

Benefits / Innovations:

- PAI Torlon® reinforcement membrane → fluorine free
- Low H2 crossover + high conductivity = higher efficiency, lower degradation, improved anode dead-end operation
- High durability as key requirement for aviation applications wrt operating cost and safety

Clean Hydrogen Partnership
Aerostack GmbH
SYENSQO ADVANCING HUMANITY
cnrs
Heraeus Precious Metals
TECHNISCHE UNIVERSITÄT BERLIN

Co-funded by the European Union

WP5 - Air Supply System: MTC

compressor

turbine

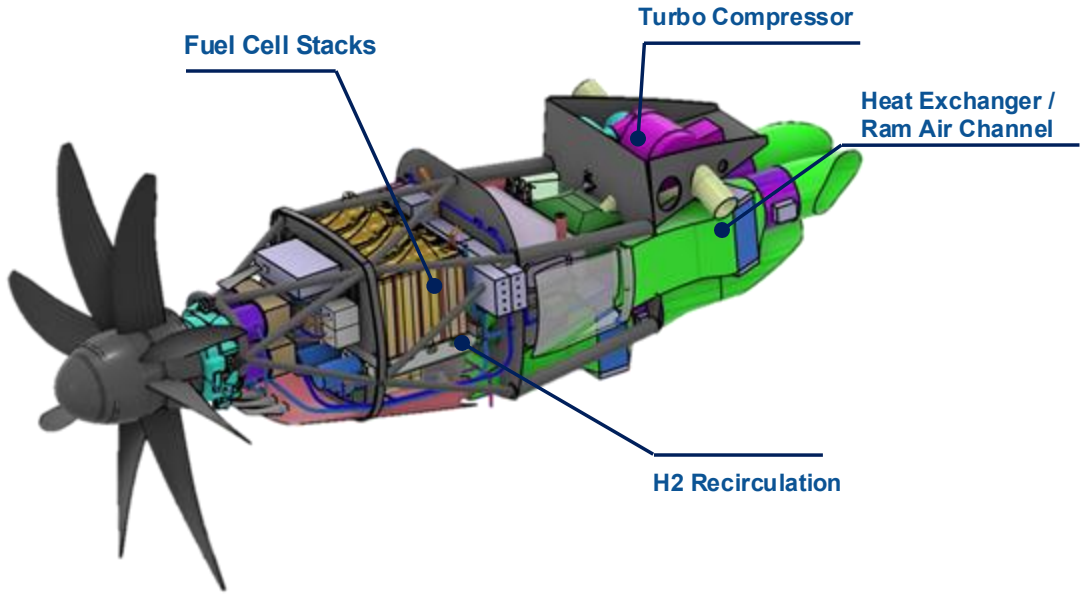
Achievements within BRAVA:

- Design/build first ASP System to feed a 2,4MW FCS. Including 1 stage Motorized Turbo Compressors with pressure ratio of 5 and single stage turbine.
- Lightweight MTC design (gravimetric power density:5,7 kW_{FCelec}/kg)
- Core component of Air Systems Line for Fuel Cell propulsion
- Most powerful flight worthy MTC available to date for FC systems
- Start of testing the prototype planned for Jan 2026 at LTS
- Maturity at TRL 5 (mid 2026)

Benefits / Innovations:

- Compression ratio 5 and power density 5,7 with single stage unit
- Covers all aviation relevant environmental conditions (FL250)
- Scalable ASP System architecture to fit FCS aviation needs
  - Mass flow up to 800g/s per MTC

WP6 - design and evaluation via system integration



Optimized Power Generation System (PGS) integrated into a FC engine

Achievements within BRAVA:

- Elements considered in analysis of system architecture simplification
  - Need for reactant air filtration
  - Anode path optimization - active vs passive
  - H2 exhaust management
  - Idle operation = high voltage operation management
  - Air humidification options - evap cooling, cathode recirc or no humidification
- Trades performed and impact on system/engine level understood

Benefits / Innovations:

- Significantly simplified system architecture
- Component removal - reduce weight, minimize failure cases
- PGS weight reduction -30% vs requirements, increase power density
- Durability requirements expected to be achieved (3% degradation)
- Significant improvement (-50 %) in operations and maintenance cost

Clean Hydrogen Partnership
AIRBUS
Co-funded by the European Union

Hydrogen Research & Innovation Days

24-25 November 2025

Clean Hydrogen Partnership

Co-funded by the European Union