

H_2 & Fuelcell testing technologies

Systemtechnische Methodik auf einer Multi-Integration-Testumgebung für Brennstoffzellen-Flugantriebssysteme

Gernot Hacker

We Owe It to the Planet

Two organizations

DLR Institute of Engineering Thermodynamics

AVL

DLR

55
Research Institutes

10,000
Employees

1959
Founding year

DLR's work is diverse and geared towards the needs of society. It focuses on research in the areas of mobility, energy, communications, security, digitalisation and, of course, aeronautics and space, which gave DLR its name 60 years ago.



AVL

45
Tech & Engineering Center

10,700
Employees

1948
Founding year

AVL is the world's largest independent company for development, simulation and testing in the automotive industry, and in other sectors. Drawing on its pioneering spirit, the company provides concepts, solutions and methodologies to shape future mobility trends.

Pathways to meet 50% CO2 emissions by the year 2050[1]



urban air mobility



small aircrafts



commuter aircrafts



regional aircrafts



wide-body aircrafts [2]

Battery electric

Hybrid Electric
(GT with SAF combustion & Battery)

Fuel Cell Electric

GT with Fuel Cell

GT with H2 combustion

GT with SAF combustion

GT … gas turbine
SAF … sustainable aviation fuel

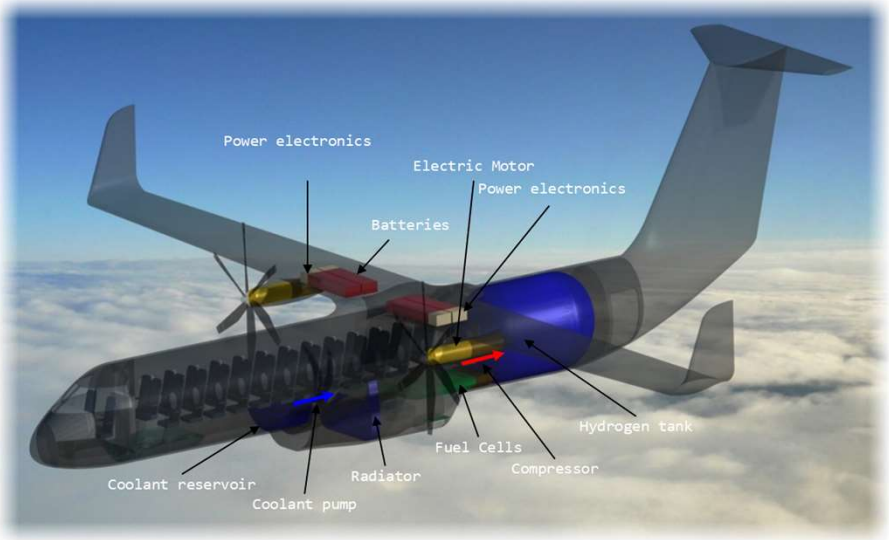
[1] International Air Transport Association (IATA), *Aircraft Technology Roadmap to 2050*, Geneva, 2019.
[2] German Aerospace Centre e.V. (DLR), *Zero Emission Aviation – Emissionsfreie Luftfahrt, White Paper der deutschen Luftfahrtforschung,* Köln, 2020.

Towards electric propulsion of commercial aircrafts

Vision

Implementation of an emission-free multi-megawatt propulsion for regional to short-haul aircraft

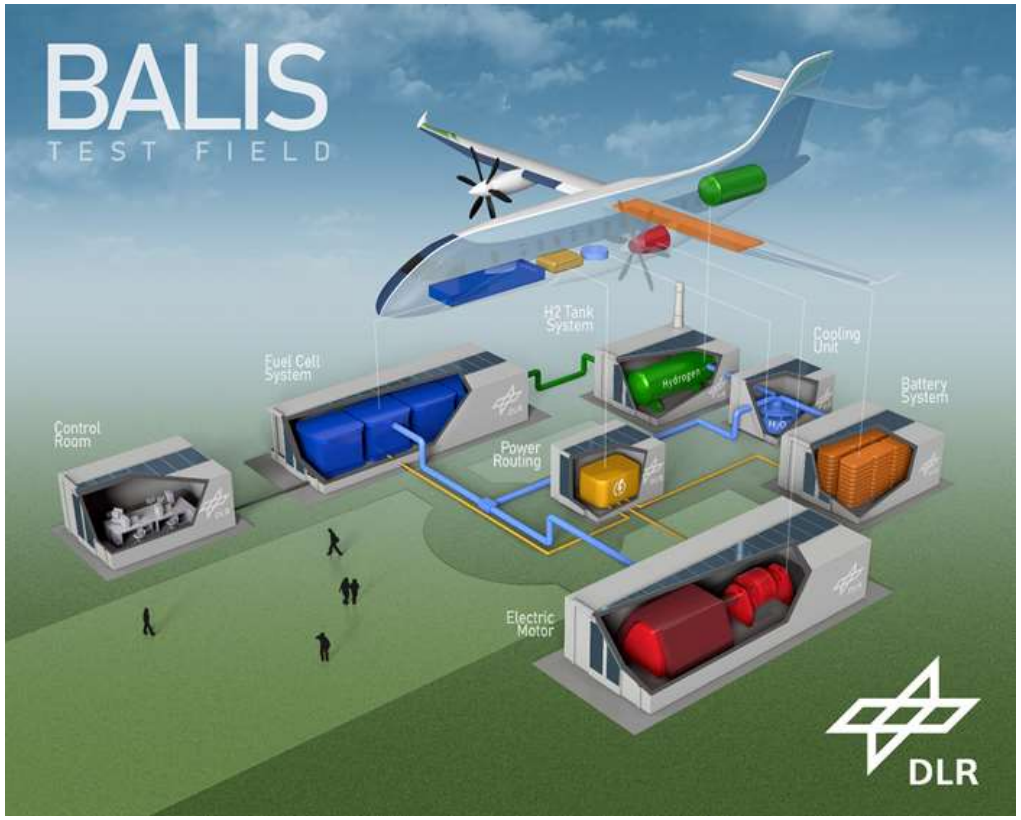




BALIS Project objective

World's first test environment for megawatt fuel cell-based powertrains for aviation propulsion systems

The BALIS Project



Test fields for components and systems:

- **LH2 tank system** 200 kg max.
- **PEMFC** 1500 kW max.
- **Battery** 500 kW max.
- **Electric drive** 1500 kW max.
- Flexible power routing & control system
- LH2 infrastructure with storage and refueling unit

- Development, optimization and coupling of powertrain components
- Cooperation with component and system developers from industry

The BALIS project is funded by the Federal Ministry of Digital and Transport (BMDV) as part of the National Hydrogen and Fuel Cell Technology Innovation Programme (NIP) and financed via the Energy and Climate Fund. The funding guideline is coordinated by NOW (National Organisation Hydrogen and Fuel Cell Technology) and implemented by Project Management Jülich (PtJ).

Many firsts…

1.5 MW Fuelcell System

World's first hydrogen fuel cell based 1.5MW test field for aviation applications

Hybrid Propulsion

Integration of the entire electric propulsion system for aviation applications.

Liquid Hydrogen

The necessary peripherals to integrate an aerospace liquid hydrogen tank are not yet state of the art.

Complex Use Cases

Execute application-oriented load profiles (use cases) requires newly developed hardware.

Compact Solution

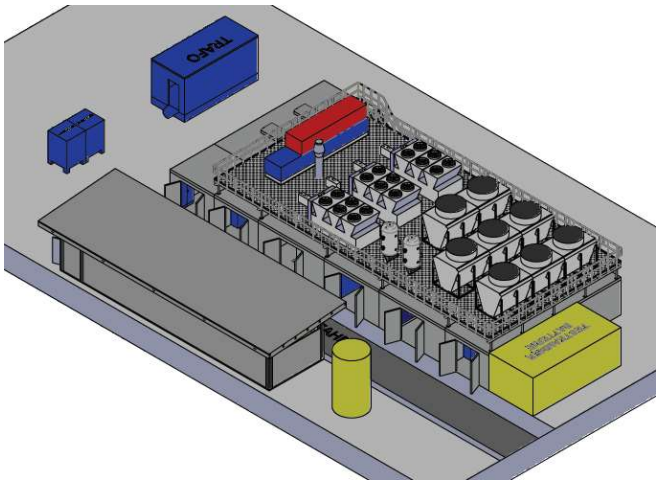
Optimized container strategy with minimized footprint

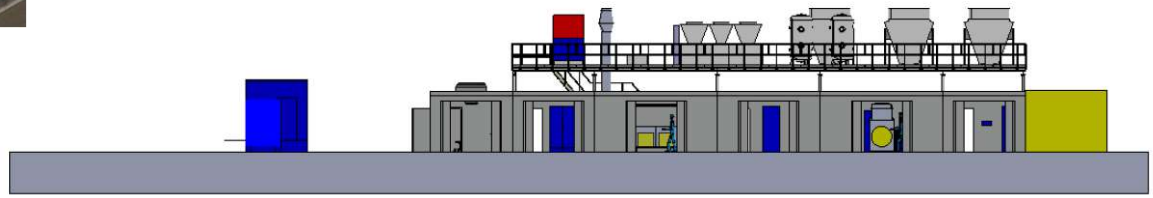
Control Technology

Comprehensive infrastructure for development of control technology (no master controller)

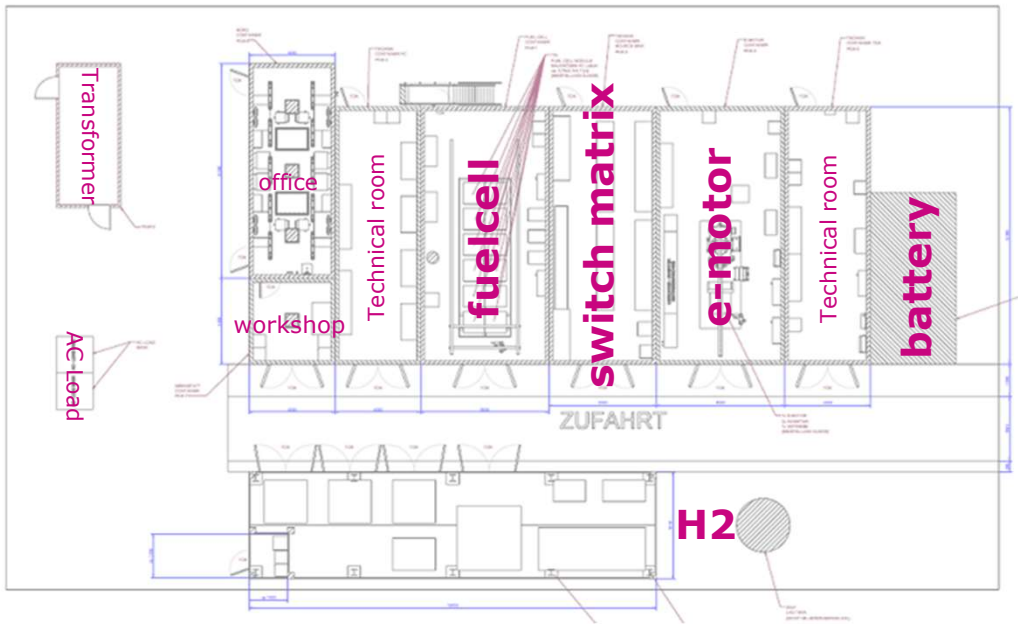
Containerized bundle solution





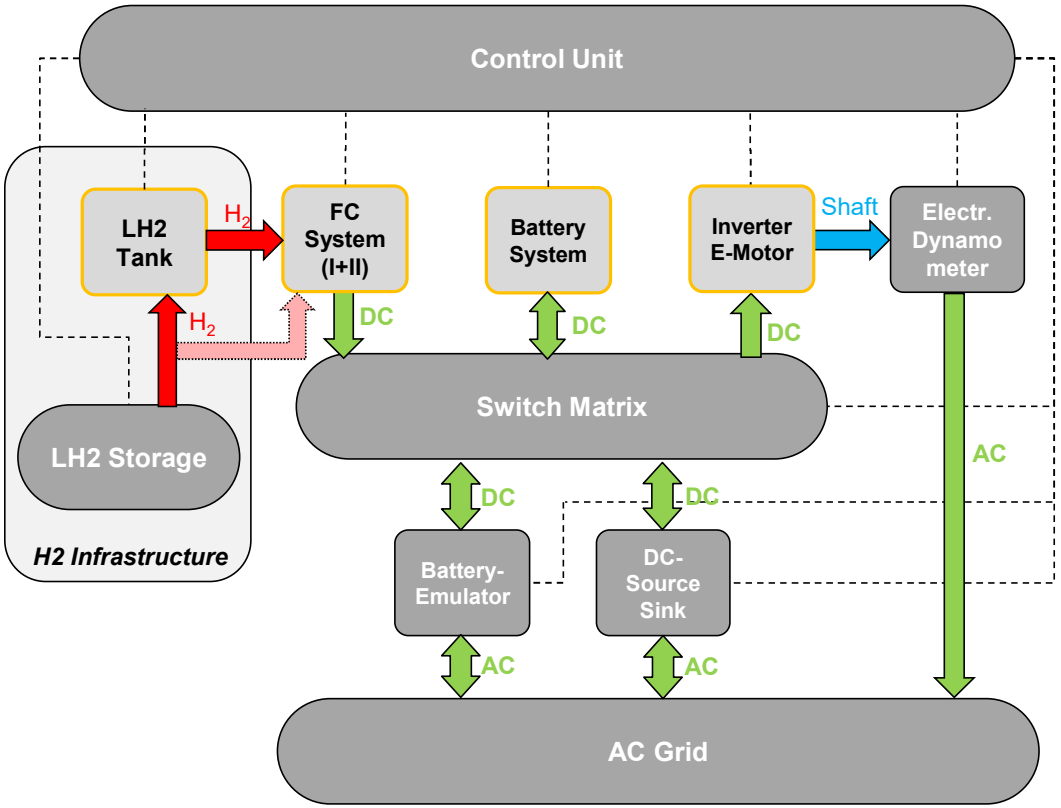


Compact and modular design



The container solution allows flexible integration of different technologies into the test environment.

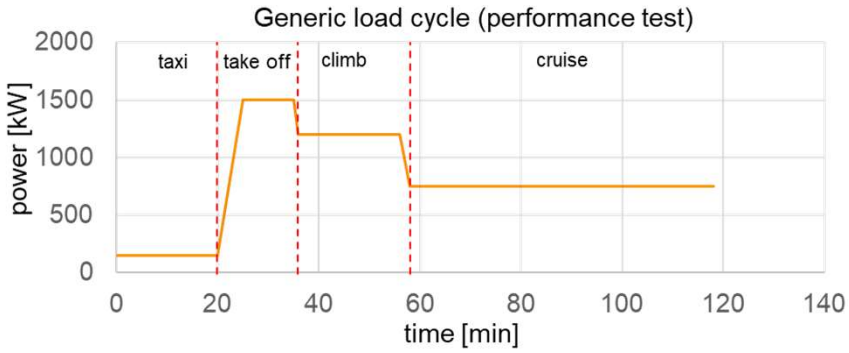
Flexibility due to Modular Approach



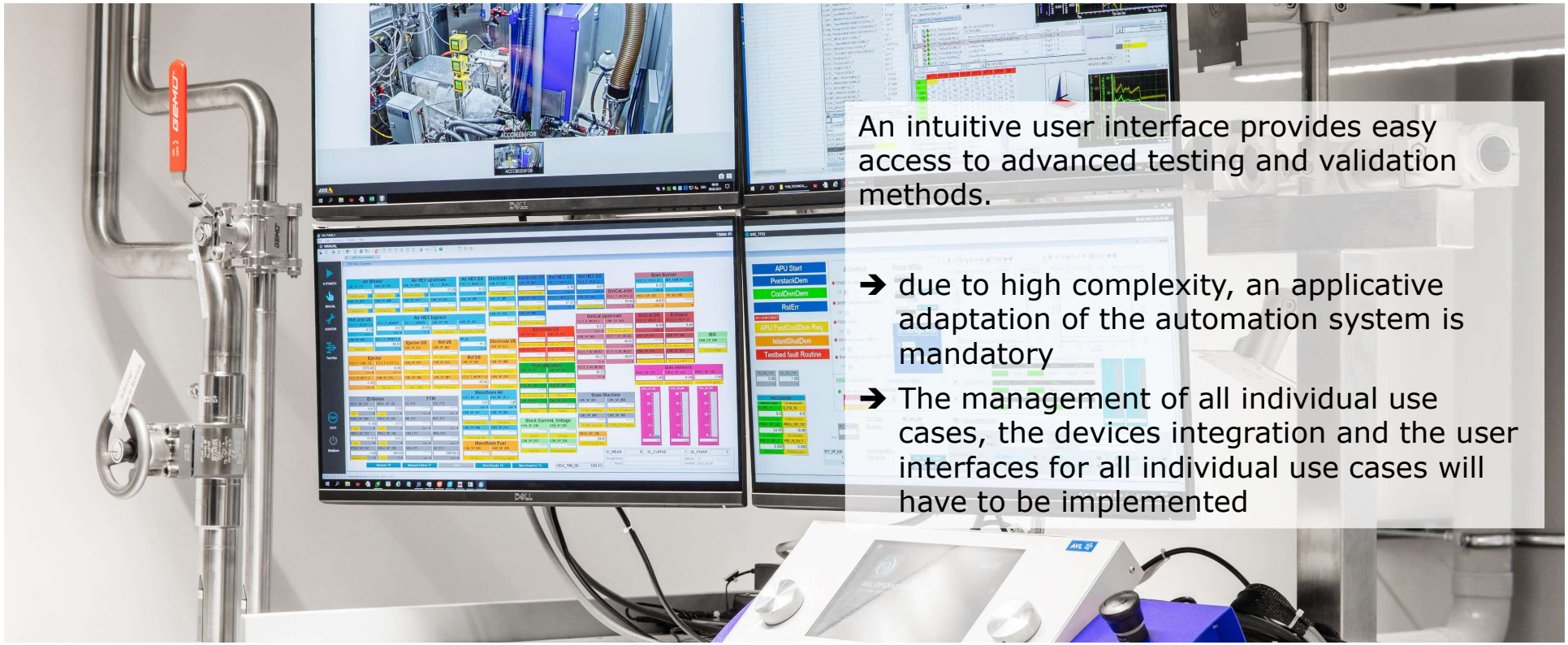
BALIS Tasks and Focus

- Test of components under real load cycles
- Flexible interconnection of components to investigate the coupling behavior
- The switch matrix allows realization of multiple electric architectures

Various electric use cases



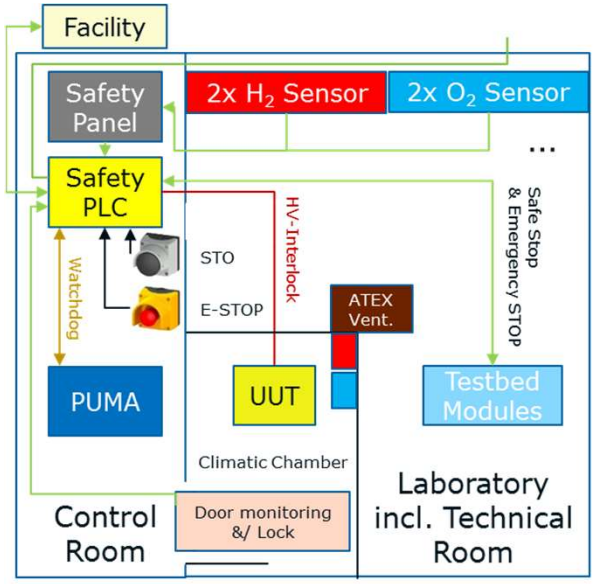
Automation & Control



An intuitive user interface provides easy access to advanced testing and validation methods.

- ➔ due to high complexity, an applicative adaptation of the automation system is mandatory
- ➔ The management of all individual use cases, the devices integration and the user interfaces for all individual use cases will have to be implemented

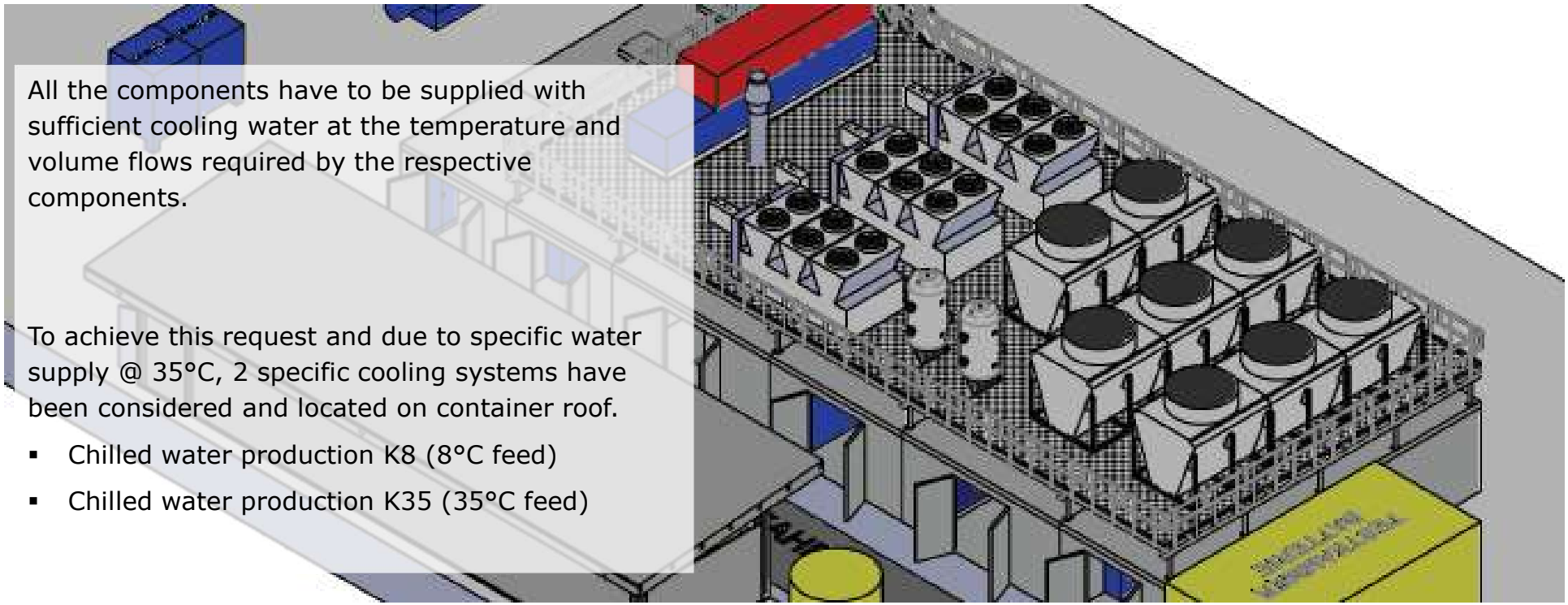
Safety 1st



The entire test field is equipped with a higher-level safety system that monitors the lower-level safety systems of the individual test beds.
The **central safety PLC** monitors all safety-relevant functions such as emergency stop buttons, door switches, gas sensors, etc.

- Each **Safety PLC** of each testbed is supervising all safety relevant features like e-stop buttons, door switches etc. inside the container, exchanging information with central Safety PLC and sending e-stop command to the installed devices on this connection.
- The **Facility PLC** is exchanging information (like status, demand/actual temperatures and air flow) between the local ventilation system and the central PLC.

Cooling

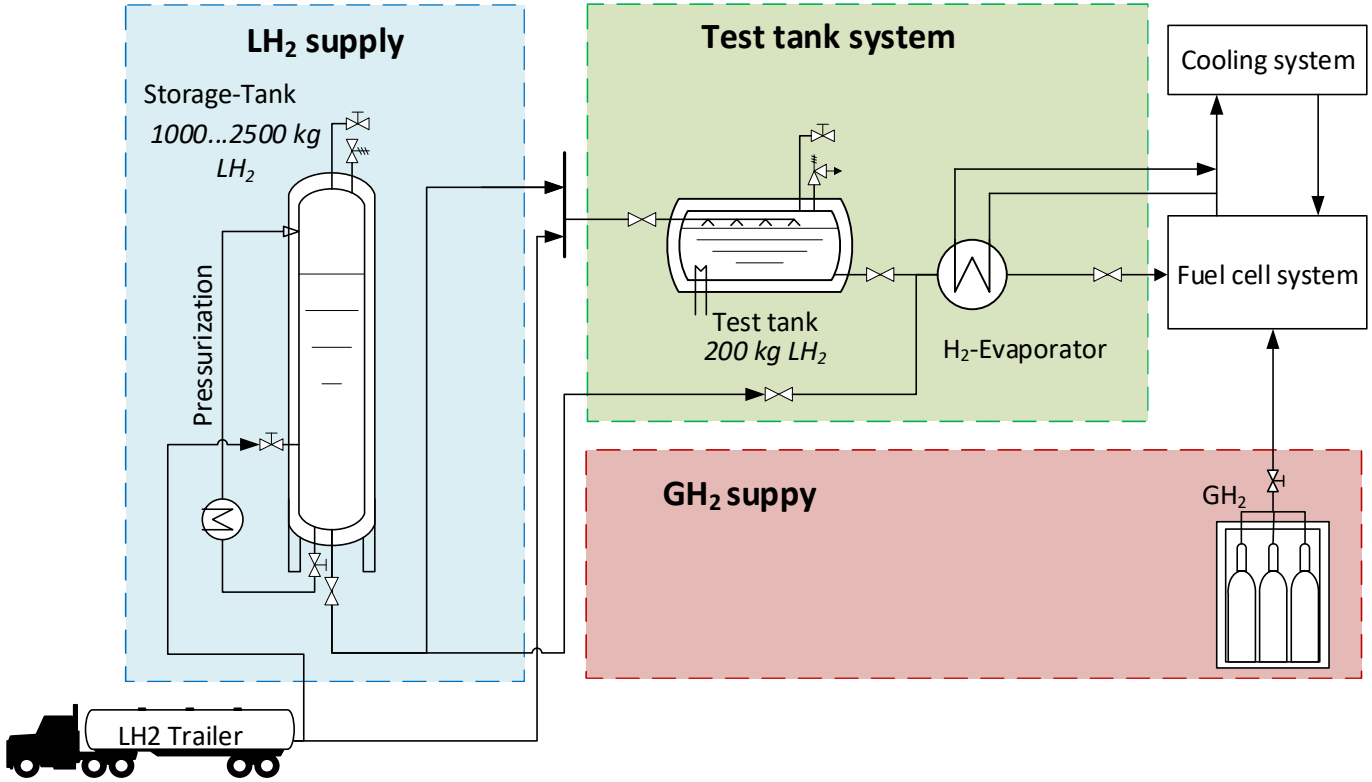


All the components have to be supplied with sufficient cooling water at the temperature and volume flows required by the respective components.

To achieve this request and due to specific water supply @ 35°C, 2 specific cooling systems have been considered and located on container roof.

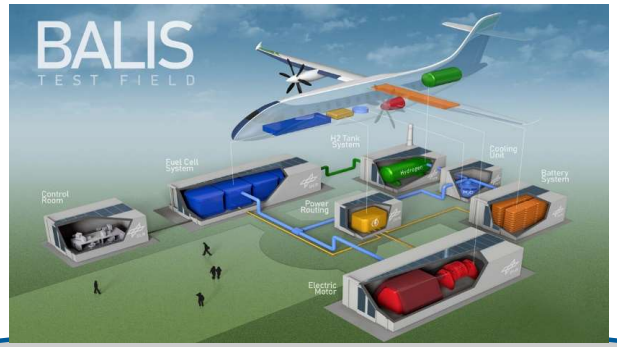
- Chilled water production K8 (8°C feed)
- Chilled water production K35 (35°C feed)

Hydrogen Supply



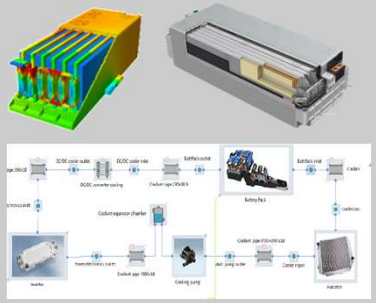
- Test environment for aviation-ready LH2 tanks
- Tank tests: handling, refueling, optimization
- H_2 flow rate up to 120kg/h
- System tests: fuel cell system operation with LH2 supply chain
- Direct GH2 supply from storage tank → Fuel cell testing independent of test tank availability

Model-based development: Simulation & virtualization
Frontloading & continuous integration platform

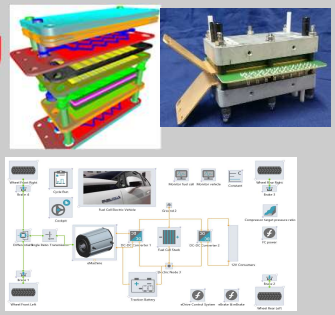


Electric and Hybrid-Electric Propulsion Concept Development

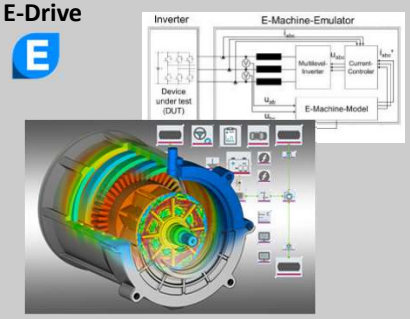
Battery



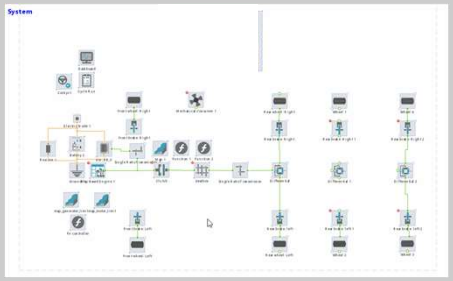
Fuel Cell & LH2 Tank System



E-Drive



Virtual Propulsion Concept



Digital Prototype

Electrochemistry Thermal Management Powertrain Integration	Electrochemistry Thermal Management Powertrain Integration	Powertrain and Component Acoustics & Dynamics	Performance Analysis

AVL eSUITE™ — 3D CFD | 3D MBS | 1D System Simulation

Status on side (01/06/2023)










Conclusion

Fuel Cell propulsion for aviation

Automotive & Aviation share similar challenges



Manage complexity with virtualization



Multi-integration test environment

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