APUS i-2

Flight conditions and PtF for innovative products

World-class Engineering. Superior Economics.
Clean Aviation.

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APUS – Location

The headquarter of **APUS** is located 30 km east of Berlin. The offices and workshops are directly connected to the runway and taxiway of the highly developed airport EDAY.

APUS Zero Emission
Lilienthalstraße 2
15344 Strausberg
GERMANY

Facts – APUS Zero Emission

Founded	**2014**
Experience (Key Staff):	**20 Years+ (each)**
Approvals/Certificates:	**EASA 21J / 21G / ISO 9100**
Staff:	**70+**
Infrastructure:	**350 sqm Offices**
	1.300 sqm Work-Shop
	1.500 sqm Test-Area

Flight conditions and PtF for innovative products

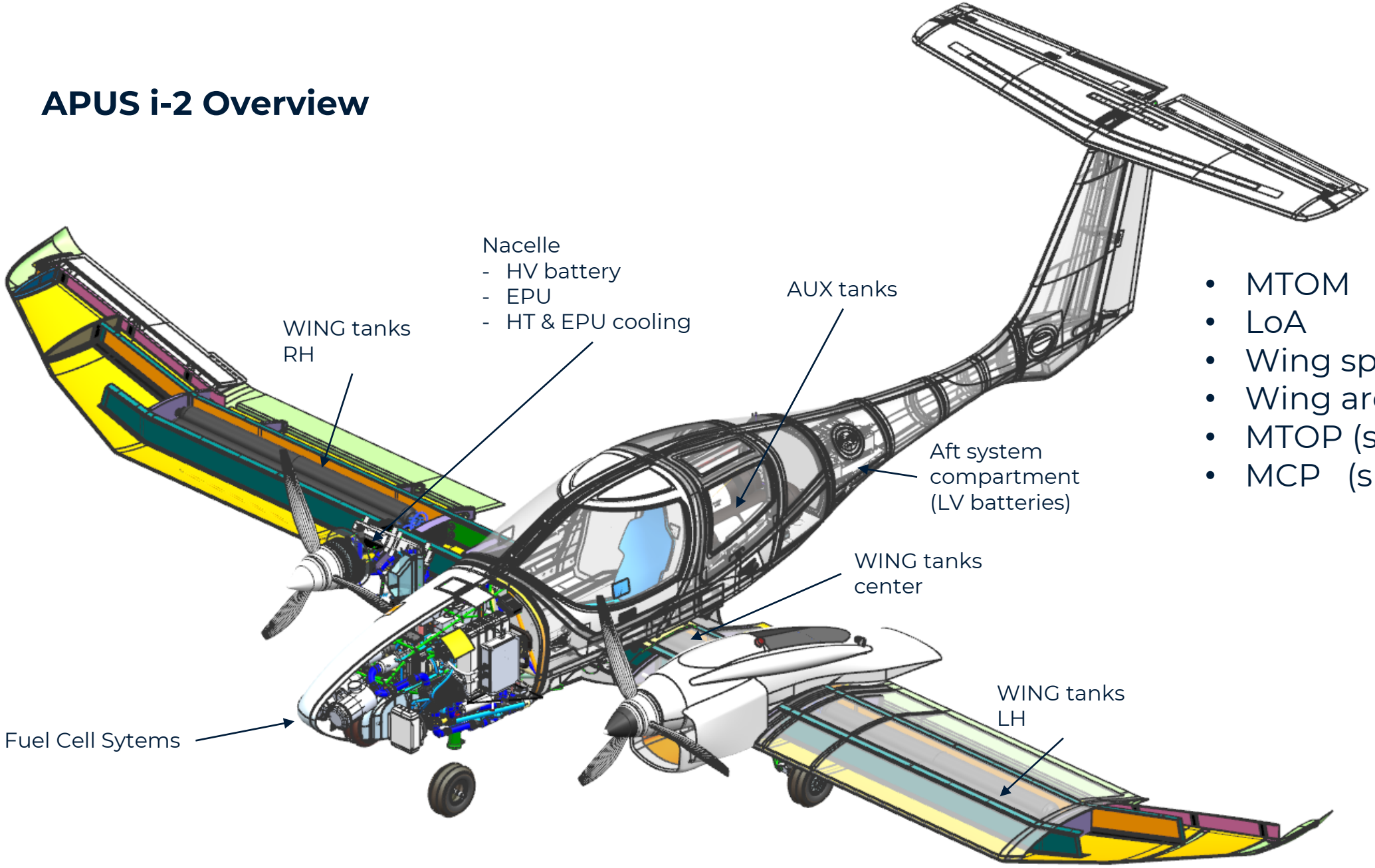
Overview of Key Points

- APUS i-2 Overview
- Hydrogen Components
- Hydrogen Safety
- Challenges and Outlook

APUS i-2 Overview

- MTOM 2,200 kg
- ~~LoA~~ 8.86 m
- Wing span 13.20 m
- Wing area 18.73 m²
- MTOP (shaft) 2 x 135 kW
- MCP (shaft) 2 x 95 kW

APUS i-2 Overview



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APUS i-2 PtF approach – Hydrogen System Components

- All hydrogen components are COTS or as close to existing COTS as possible.

- Example: 6 identical type IV vessels in wing
  - designed as standard type IV tanks for 350 bar NWP

  - Key requirements selected in acc. to established standards for type IV vessels (UNECE 134).

  - Reduced scope of testing comp. to full UNECE 134
    - PoC application with restricted conditions & service life!

  - But 100% tracing of quality recordings from supplier manufacturing!

- The originally envisaged wing with structurally integrated tanks had to be skipped to achieve PoC 1st flight within an acceptable time and cost frame

APUS i-2 PtF approach – Hydrogen Safey

- compared with kerosene, hydrogen has the disadvantages of a much wider flammability range and 1/15th the ignition energy
- advantage of a much higher Lower Flammability Limit (LFL 4.1% cf. 0.7%)
  - Exploiting the higher hydrogen LFL (cf. kerosene) is a key point to consider

- low ignition energy leads to the notion, that flammable H2 atmospheres tend to spontaneously combust and that H2 leaks lead to immediate ignition
- a distinctive ignition mechanism is always involved.
  - When all ignition mechanisms can be avoided, a hydrogen fire does not occur even in flammable atmospheres or in the case of (large) leaks..

APUS i-2 PtF approach – Hydrogen Safey

- The hydrogen storage and supply system and the fuel cell system (FCS) are rather complex systems, spread over several aircraft zones, that use a novel technology with a significant potential fire hazard associated.
  - → Mitigation by passive and active ventilation, monitoring of H2 concentration and control of ignition sources → FTA, ZSA

    - Testing is performed to understand hydrogen permeation and leaks
    - To understand how the hydrogen fuel systems “leaks”
    - and how hydrogen compartments ventilate,
    - from the first rig testing of system elements, through complete system testing and to experimental flight tests.

APUS i-2 PtF approach

- Mutually agreed TC application (instead of Annex I), though only proof-of-concept (PoC) test flights targeted.
  - Good learning experience for later certification activities
  - Possibility to be part of EASA rule-making

- CS-23 performance-based objectives allow manufacturers flexibility to meet the intent of the rules through innovative technologies
  - Also requires deep understanding of innovative technologies on both sides!

- Difficulties in understanding expectations and requirements on both sides.
  - e.g. scope and level of detail of reports
  - Lack of guidance material

- PoC activities within TC project introduce additional hurdles
  - TC application triggers DO scope extension at a very early stage of the PoC!

APUS i-2 outlook on type certification

- Type Certification (TC) is a complex and resource-intensive process even for conventional projects
- Novel technologies lead to ambiguities in how CS-23 applies, leading to lengthy discussions with regulators.
- Requirements due to complex system design often significantly above comparable CS 23 level.

- More **risk-based assessment** envisioned
  - especially in the technology development/prototype phase
  - proportionate to the A/C category

Thank you!