GERMAN AEROSPACE CENTER (DLR) – HAP-ALPHA

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Stratospheric Operations & Research Symposium (SOaRS): 21/22 March 2023

DLR

The German Aerospace Center – DLR

Deutsches Zentrum für Luft- und Raumfahrt e.V





- **DLR as large scale research facility:**
  - is the largest **Science Center for Aerospace** in Germany with the main research areas: aviation, space, transport, energy and security
  - is the **German Space Agency**. In this role DLR manages the German space program on behalf of the government
  - Is one of the largest **Project Administration** for publicly founded projects in Germany
- **DLR has about 10.000 employees in 54 institutions at 27 locations**

DLR's research goals in the area of high altitude solar platforms

- DLR is developing a full scale technology demonstrator for high altitude solar platforms involving the program areas of aviation, space and security

- Goals of the development are:

  - ***Development of novel system concepts and technologies for the realization of robust and cost-efficient high altitude solar platforms***

  - ***Development and testing of innovative sensor systems for earth observation. In particular high performance is combined with highly sophisticated lightweight construction***

  - ***Development of operational strategies and mission scenarios to demonstrate the performance of high altitude solar platforms***

  - ***Demonstration and flight testing of novel technologies, processes and sensor systems under real environmental conditions***

DLR Project HAP-alpha

Project initiated in 2018 with a budget of around 30 M€

Currently 16 DLR Institutes all over Germany are involved:

Flight Systems FT,

Systemhaus Technik SHT,

Aeroelasticity AE,

Flight Guidance FL,

Remote Sensing Technology MF,

Atmospheric Physics PA,

Microwaves and Radar HR,

Networked Energy Systems VE,

Software Technology SC,

Aerodynamics and Flow Technology AS,

Communications and Navigation KN,

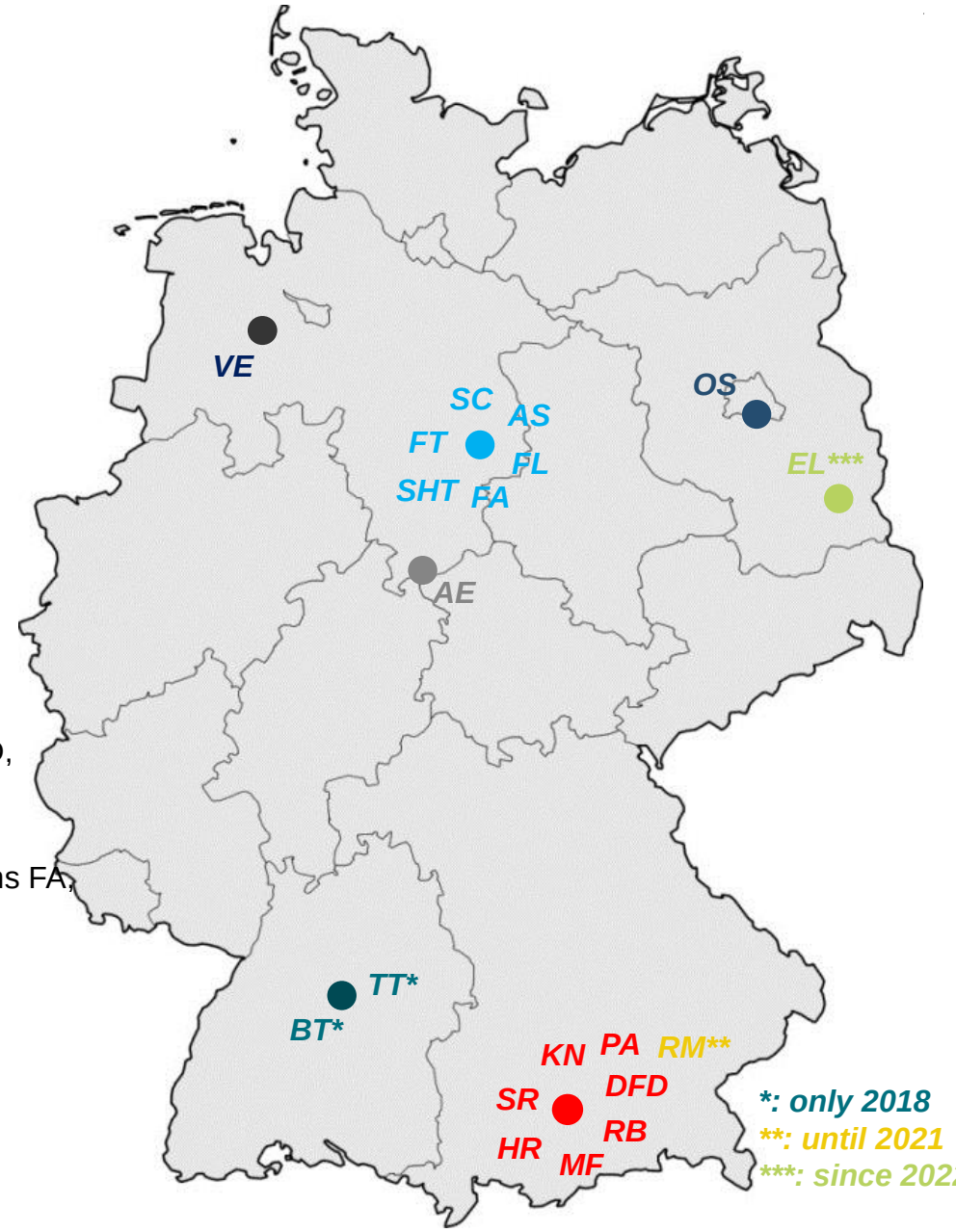
Optical Sensor Systems OS,

German Remote Sensing Data Center DFD,

Electrified Aero Engines EL,

Composite Structures and Adaptive Systems FA,

System Dynamics and Control SR

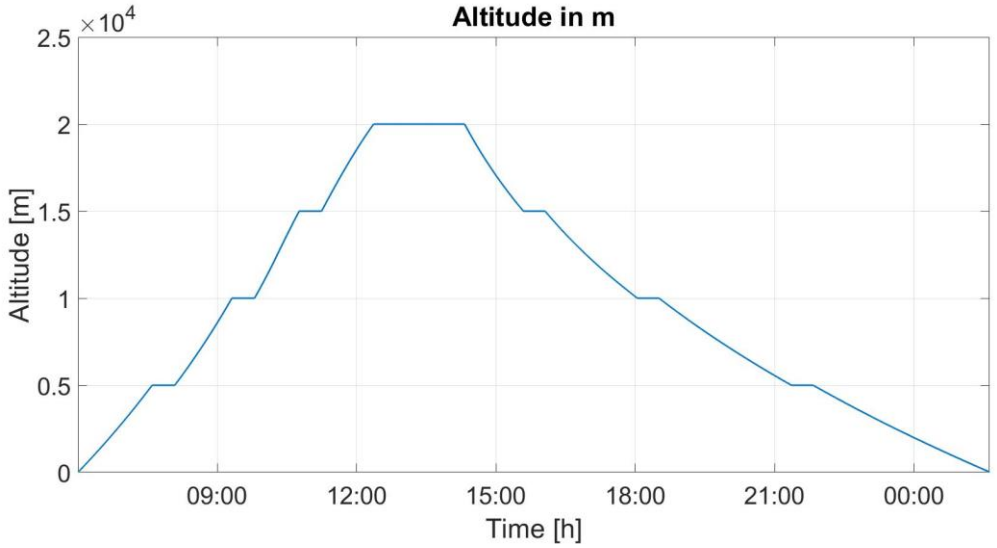


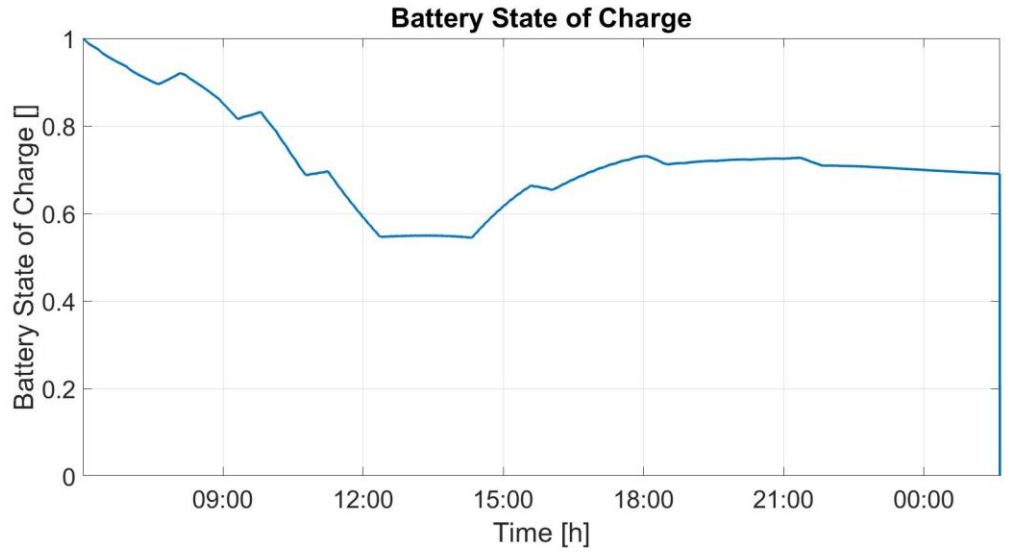
Technology Demonstrator HAP alpha

- Wing span 27 m
- Mass 136 kg
- Service Ceiling >22 km
- 5 kg payload
- Developed Payloads: High resolution camera system and a radar with synthetic aperture

Research Mission Design

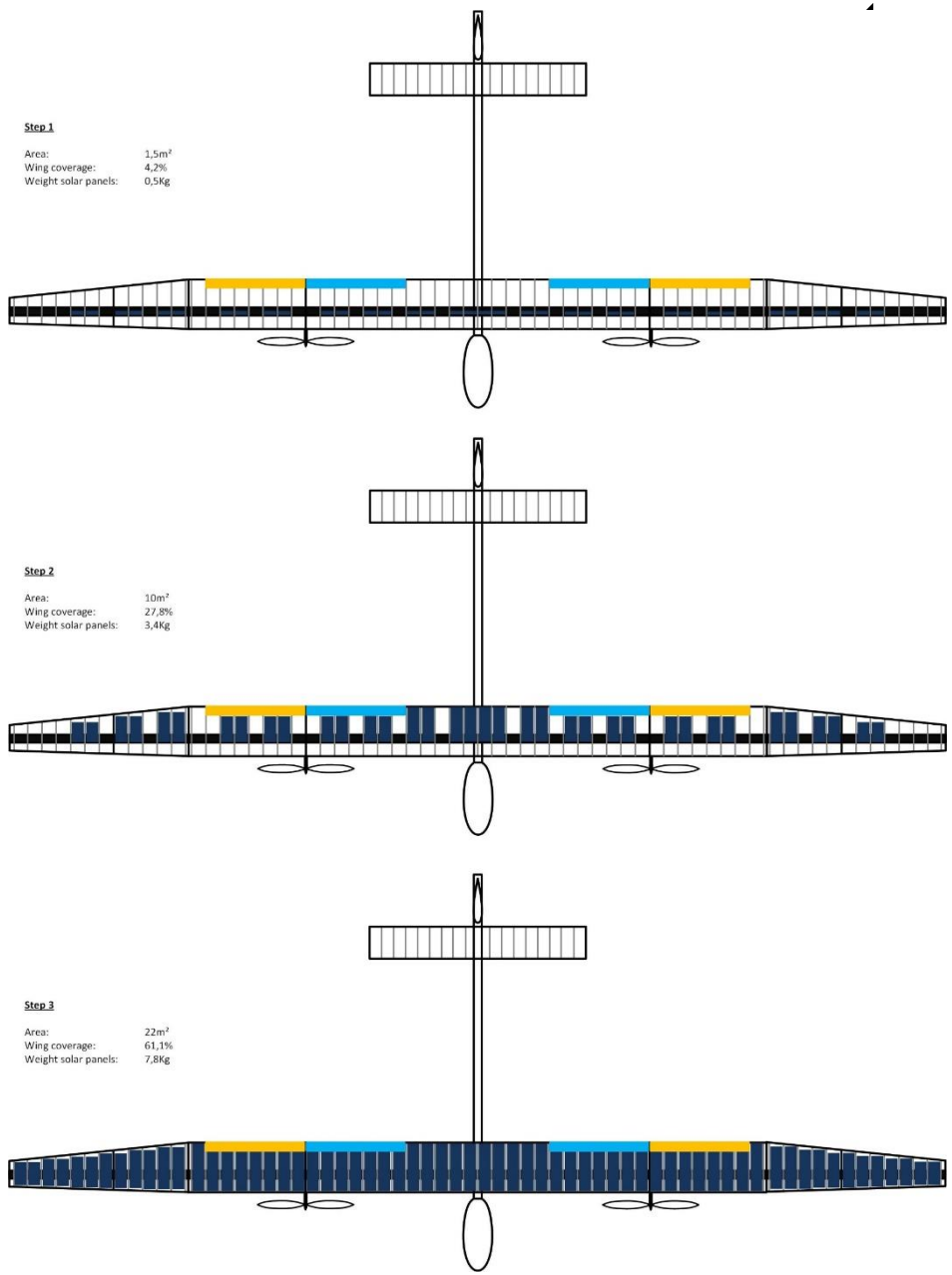
- We aim to operate the aircraft under real flight conditions
- The goal is to reach an altitude of 20 km and remain there for at least 2 h
- The aircraft is designed for several landings
- The aircraft is designed according to modified CS25 gust loads
- The aircraft shall serve as a testbed for critical system technology
- We want to operate payload systems at the target altitude
- We want to built up and advance our capabilities to conduct long term flight test
- We do not aim to develop a commercial product



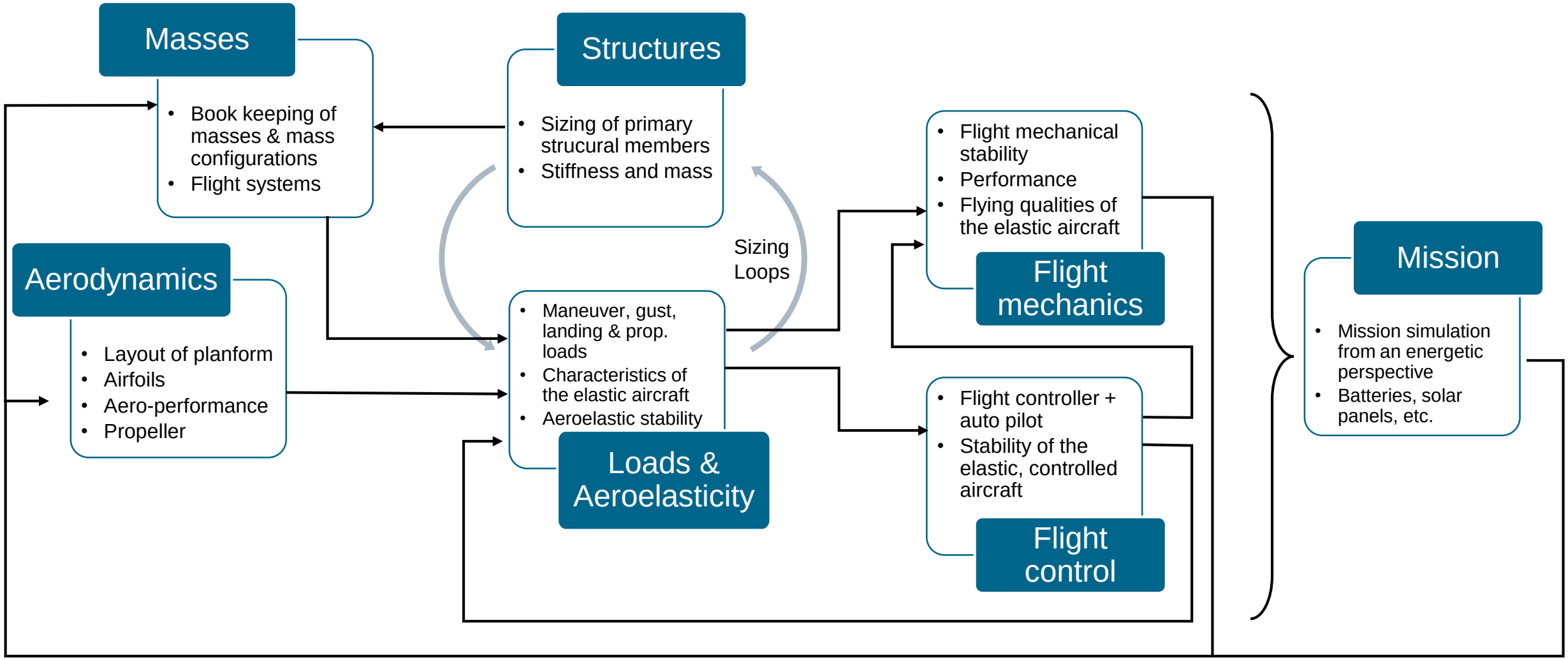


HAP alpha Variants

- As cost reduction we apply in the first steps only a small area of solar panels on the wing
  - *Variant 1: ~ 1.5 m² Solar panels*
  - *Variant 2: ~ 12 m² Solar panels*
  - *Variant 3: ~ 22 m² Solar panels (at the moment no further consideration)*
- Each variant differs in the area of applied solar panels only



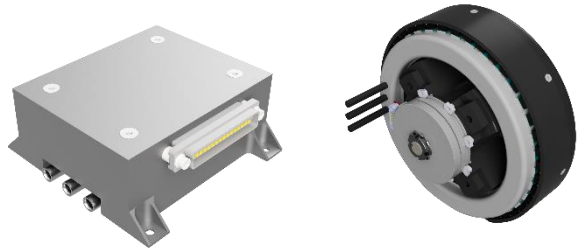
Aircraft Design Loop



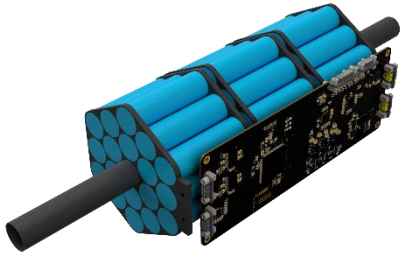
Drive Train

Solar Arrays

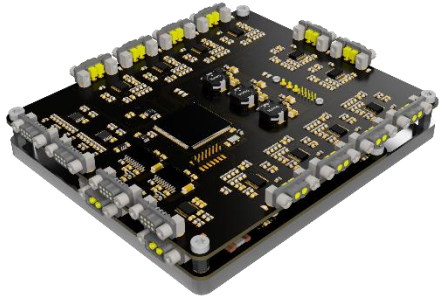
- Redundancy achieved via twice instantiation on aircraft level to satisfy system reliability and availability requirements
- Applied design principles of high cohesion and loose coupling to reduce system complexity
- Tailored to the special requirements in-house developments
  - Engine Control Unit
  - Power Distribution Unit
  - Battery System
  - Solar Power Tracker
- Distributed battery system throughout the wingspan utilizing standard cell geometry
- Engine is a modified COTS component



Propulsion System



Battery Unit



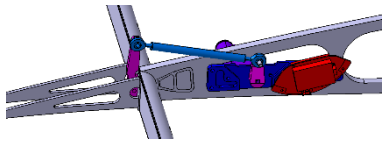
Power Distribution Unit

Avionics

Sensors & Actuation

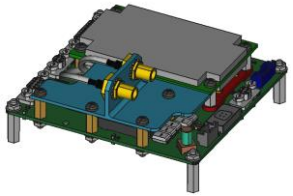
Actuation System

- 6 control surfaces
- Special actuators with wide temperature range
- Low-EMI adaptation



Position Sensorics

- High-Performance INS for payloads developed by DLR
- Redundant INS integrated into Flight Control Computer



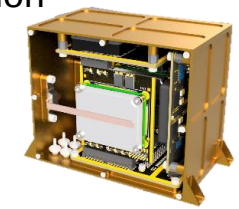
Air Data System

- High precision, low weight
- Power redundancy
- Cooperation with industry partner

Logic

Flight Control Computer

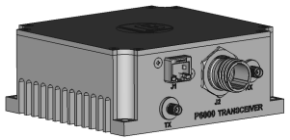
- In-house hardware and software
- Duplex system (COM/MON)
- Integrated INS and air data
- RTOS running Flight Control & Management
- HIL testing through ethernet connection



Communication

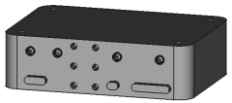
Command & Control Link

- COTS Components
- High-range S-Band link
- Up-/download



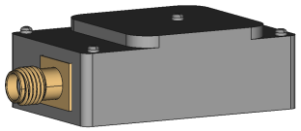
Payload Link

- High-rate downlink for observation data
- Flow control through C2 Link
- COTS hardware

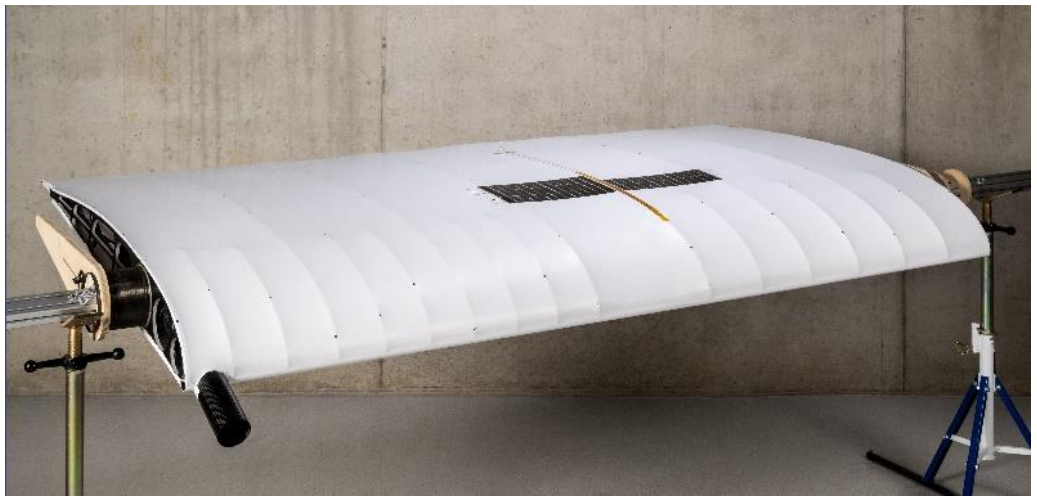


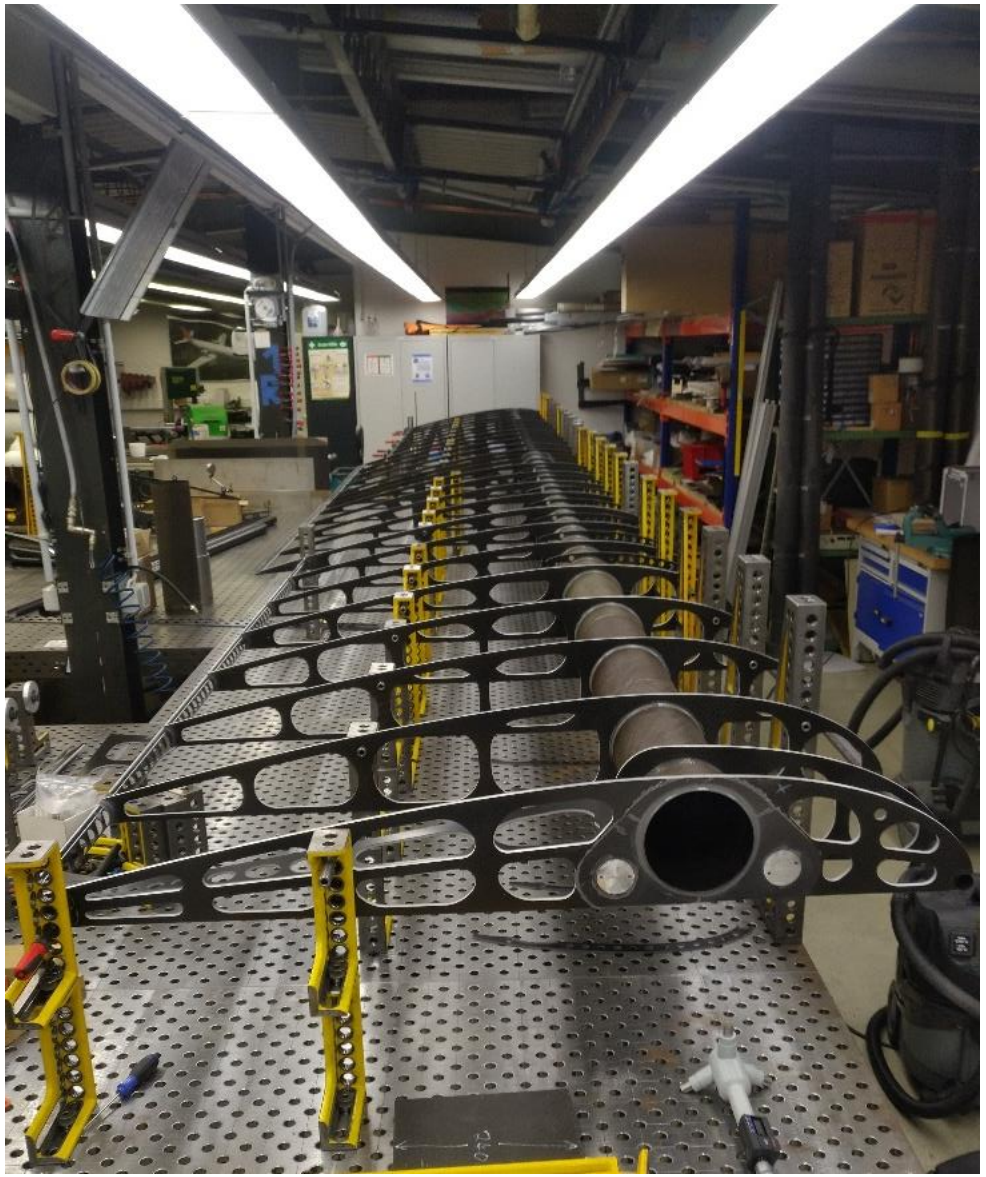
Transponder System

- Custom UPS
- ADS-B transponder



Impressions of the realization of the structure



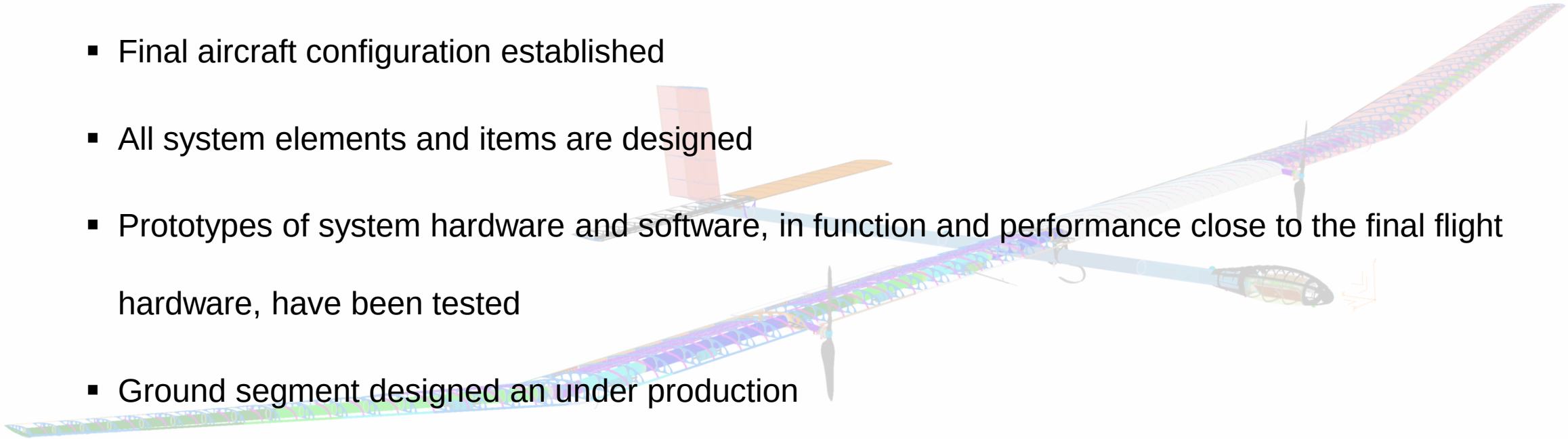


HAP alpha prototype hardware testing

Prototype Tests include drive tests of motor and propeller as well as extensive temperature and pressure testing of all airborne hardware.

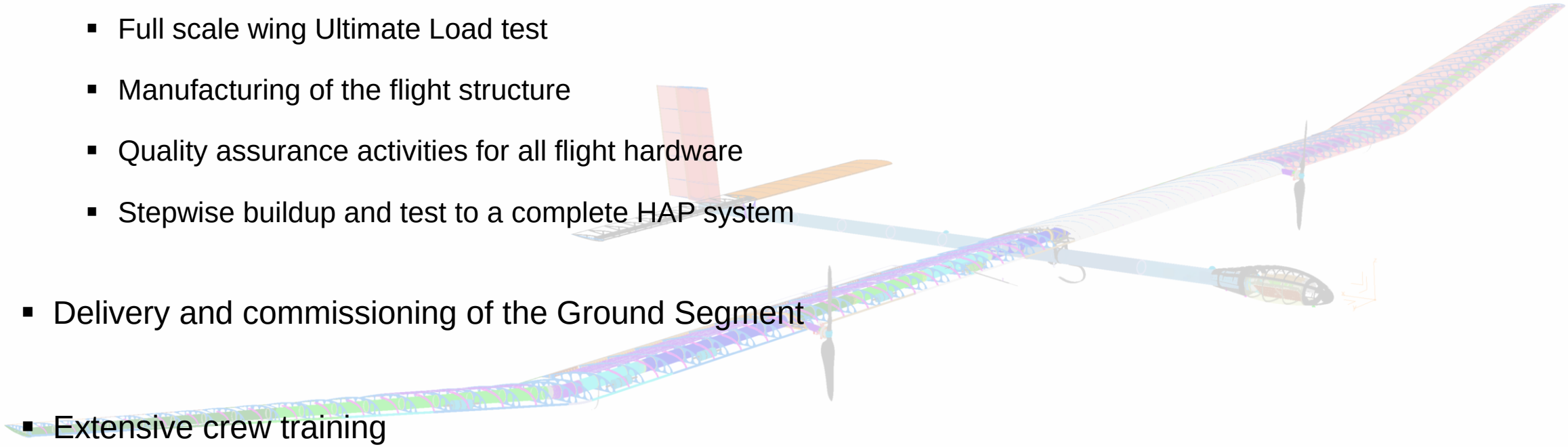
Where the Project is now

- By now the project is at the end of the detailed design phase:
  - Final aircraft configuration established
  - All system elements and items are designed
  - Prototypes of system hardware and software, in function and performance close to the final flight hardware, have been tested
  - Ground segment designed an under production
  - Critical Design Review planned for July in preparation



What to expect in 2023

- Transition to the overall system test phase:
  - Full scale wing Ultimate Load test
  - Manufacturing of the flight structure
  - Quality assurance activities for all flight hardware
  - Stepwise buildup and test to a complete HAP system
- Delivery and commissioning of the Ground Segment
- Extensive crew training
  - Remote pilot and safety pilot training with downscaled HAP alpha model aircraft
  - Overall crew training for flight operations



What to expect in the next 5 years

- First flight and low altitude flight tests in Cochstedt / Germany or Kiruna / Sweden in 2024
- Mid and high altitude flight testing with flight test instrumentation in Kiruna
- High altitude flight testing with the two co-developed payloads – a high resolution camera system (MACS-HAP) and a radar system with synthetic aperture (HAPSAR)
- Conducting of other lower Stratosphere scientific experiments

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