CFK VALLEY STADE CONVENTION™

DLR - Institute of Composite Structures and Adaptive Systems

„SAGITTA – Unmanned Aerial Vehicle with innovative CFRP airframe “

M. Kleineberg
J. Schmidt
M. Hanke

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Outline

- DLR - Institute of Composite Structures and Adaptive Systems
- The „SAGITTA“ Project
- Concept and Design
- Airframe Component Manufacturing
- Airframe Integration
- SAGITTA Flight Test
- Lessons Learnt

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DLR – German Aerospace Center

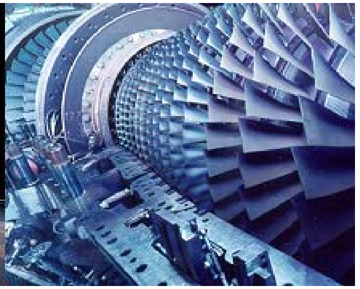
Sites and Employees

- 8.000 Employees
- 42 Institutes and Facilities
- 20 Locations, Offices in Brussels, Paris, Tokyo and Washington.

Institute of Composite Structures and Adaptive Systems

Aeronautics

Space

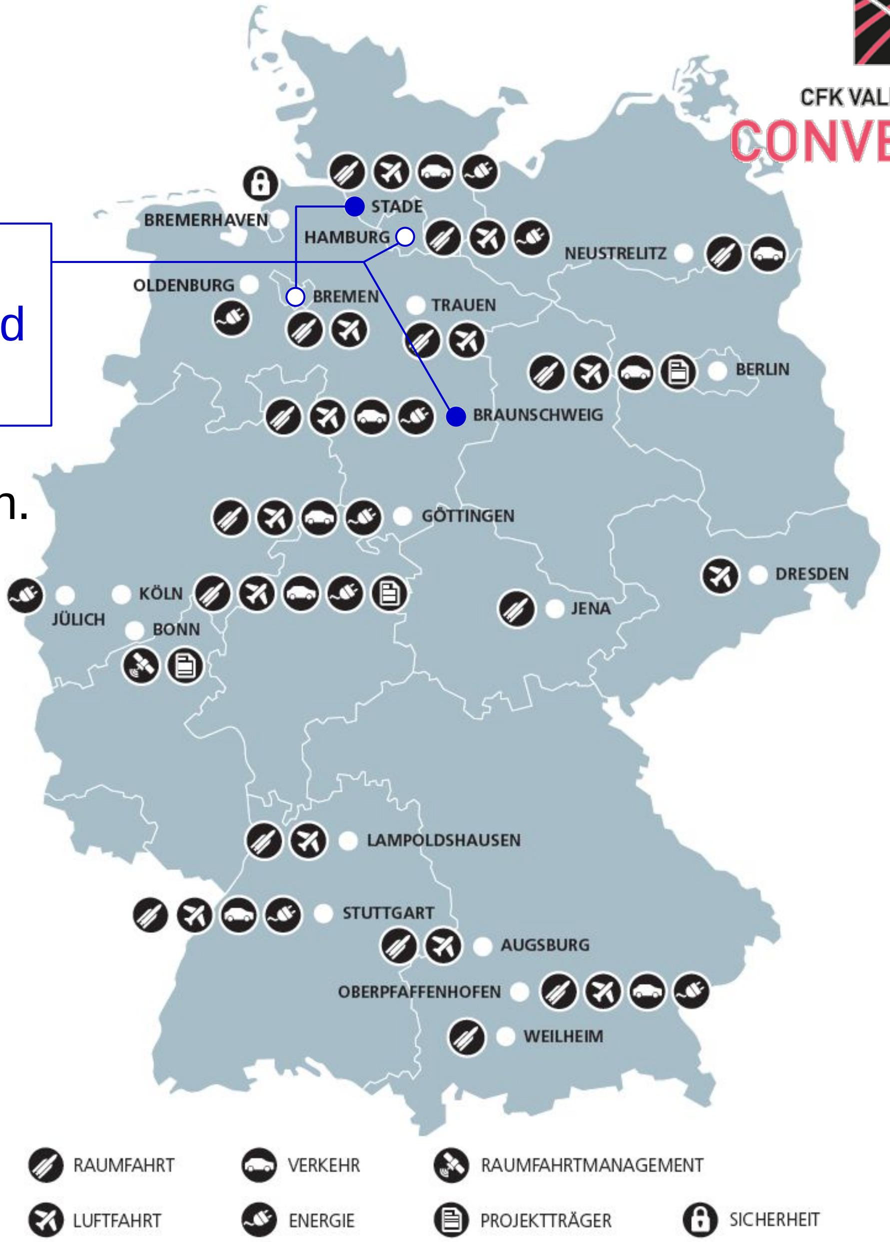


Energy

Transportation

Security

Digitalisation



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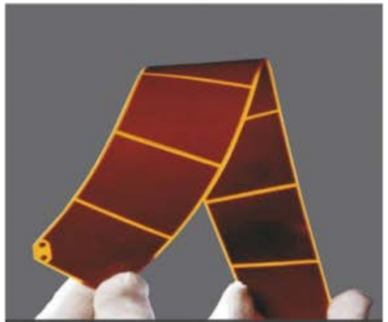
DLR – Institute of Composite Structures and Adaptive Systems

Director: Prof. Dr.-Ing. Martin Wiedemann
Dep. Director: Prof. Dr.-Ing. Peter Wierach

Multifunctional Materials

Prof. P. Wierach

We increase the ability of the materials!



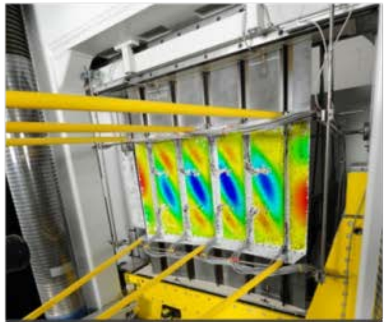
From materials to intelligent composites

- Fiber- and nanocomposites
- Smart materials
- Structural health monitoring
- Material characterization

Structural Mechanics

Dr. T. Wille

With high fidelity to virtual reality for the entire life cycle!



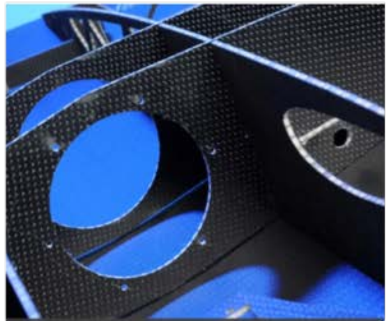
From the phenomenon via modeling to simulation

- Global design methods
- Stability and damage tolerance
- Structural dynamics
- Thermal analysis
- Multi-scale analysis
- Process simulation

Composite Design

Prof. C. Hühne

Our design for your structures!



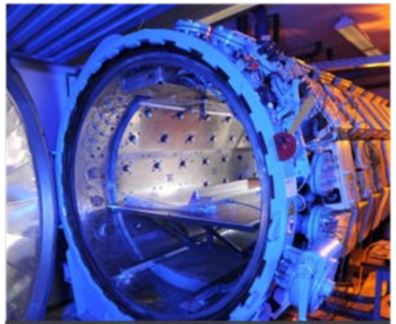
From requirements via concepts to multi-functional structures

- Design and Sizing
- Structure concepts and assessment
- Multi-functional structures
- Shape-variable structures
- Hybrid structures

Composite Technology

Dr. M. Kleineberg

Tailored manufacturing concepts



From the idea via processes to prototypes

- Tolerance Management
- Process Simulation
- Functional Demonstrators
- Digital Production Network
- Online Process Assessment
- Design to Cost Modelling

Adaptronics

Prof. H. P. Monner

The adaptronics pioneers in Europe

From functional composites to adaptive systems

- Simulation and demonstration of adaptive systems
- Active vibration control
- Active noise control
- Active shape control
- Autarkic systems

Composite Process Technology

Dr. J. Stüve

Research with industrial dimension

For sustainable processes

- Automated FP und TL
- Online QA within autoclaves
- Automated manufacturing for mass-production
- Simulation methods for maximum process reliability and process assessment

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- **The „SAGITTA“ Project**
- Structural Concept
- Airframe Component Manufacturing
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- SAGITTA Flight Test
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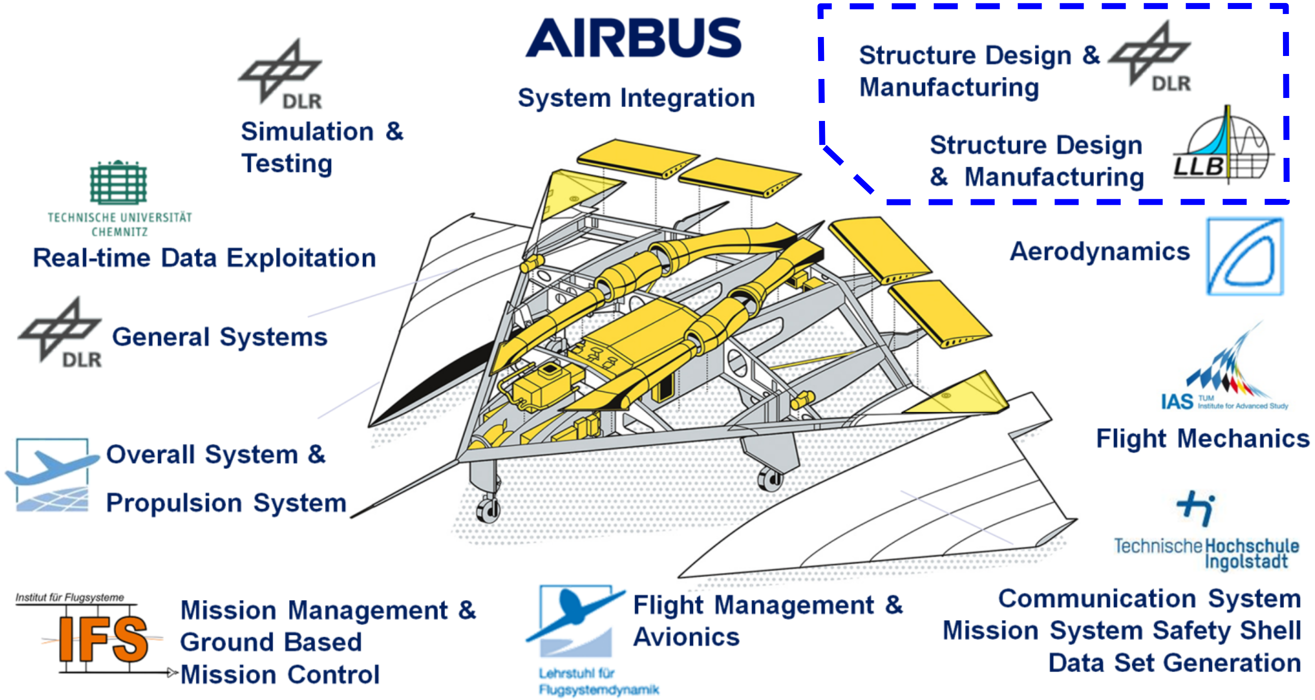
The „SAGITTA“ Project

Basics

Time: 2010 – 2017

Project : Open Innovation Initiative

Partners: Airbus, DLR, THI, TUC, TUM, UniBw u.a



High Level Objective:

- **Scouting** for new **ideas** and solutions for selected technology gaps with qualified academic partners
- **Recruiting** and **training** of highly qualified **engineers** for Airbus
- **Concentration** of the German **academic community** behind the key technology **areas of interest**
- Provide the **Sagitta Demonstrator** as experimental platform to demonstrate selected technology experiments

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The „SAGITTA“ Project

Strategic Approach:

- VLO (Very Low Observability) UAV with ambitious „Diamond“ configuration

- “Inverted flight” based VLO Concept
  - Symmetric profile (UAV turns upside down for the mission)
  - Seamless upper cover (lower cover inflight configuration)

- Concept without vertical stabilisers (just for maiden flight)

- VLO compatible integration of jet engines and ducts

- Scale of 1:4 to stay below 150kg (certification requirement)

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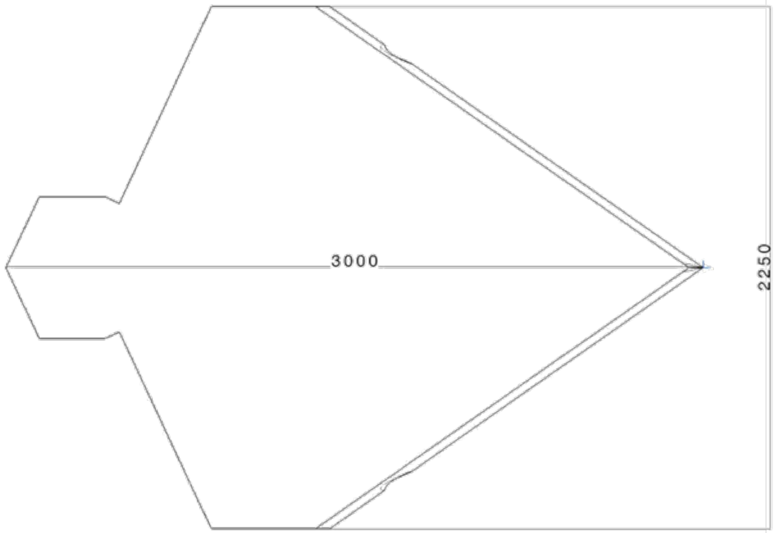
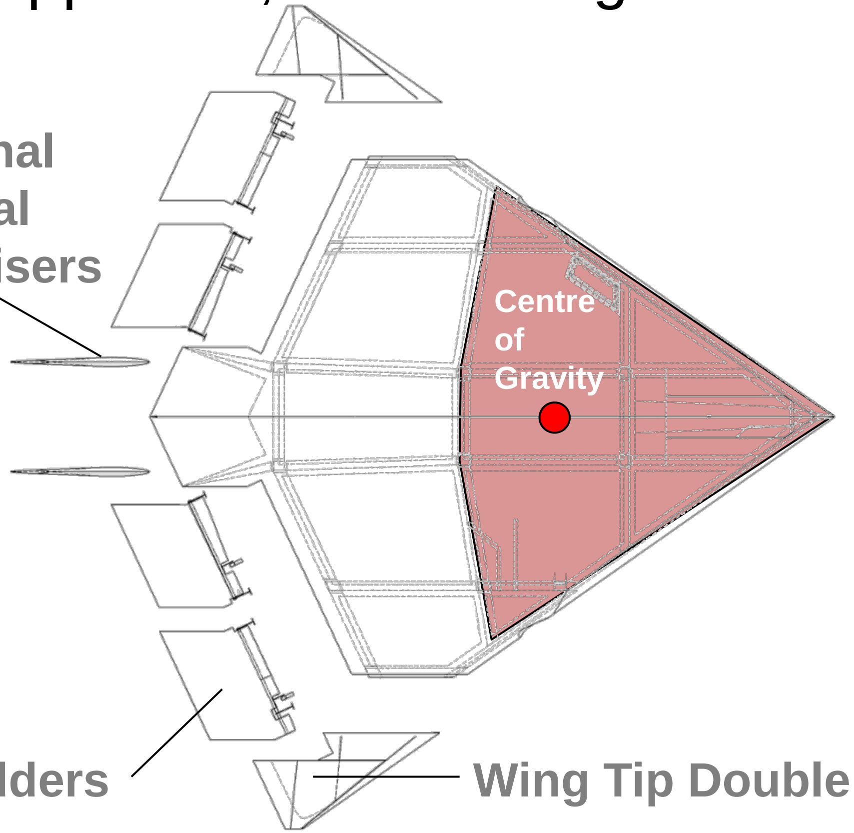
Structural Concept

Basic Layout

structural concept, provisional system allocation, integration and accessibility, centre of gravity, assembly/joining approach, ensure longitudinal stability





Weight Limit: 150kg MTOW

Maximum Take Off Weight

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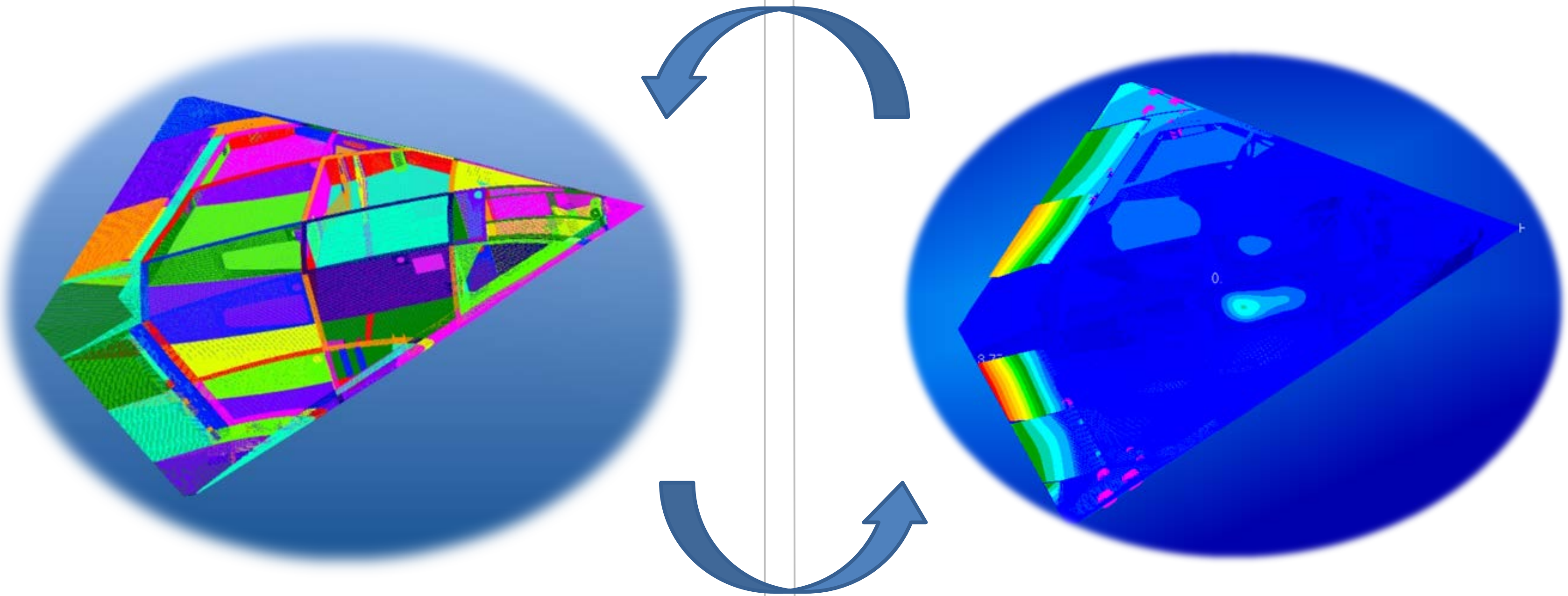
Structural Concept

HyperSizer

Sizing section:

Objectives: Definition of property sections, optimization of property, model update
Input: Load distribution (element forces)
Results: Sizing according to current load distribution

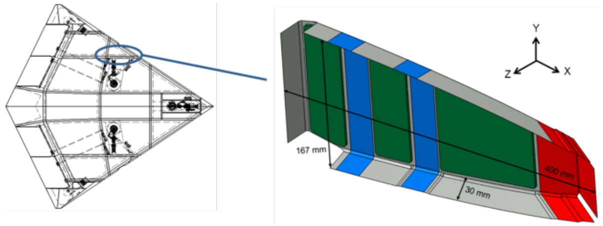


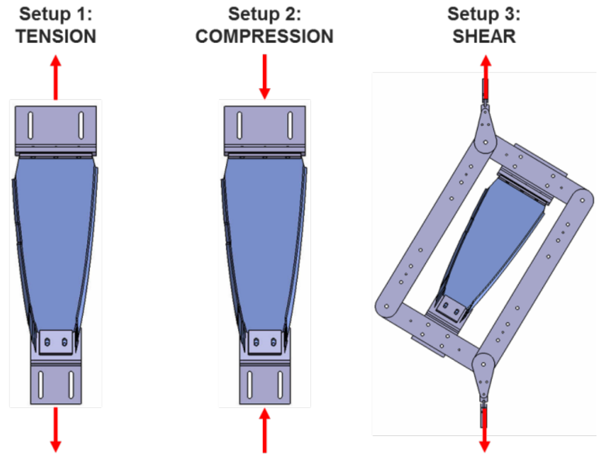
FEM section:

Objectives: Solving of FEM-model, computation of load distribution
Input: Geometry and mesh, load and boundary conditions, properties
Results: Load distribution

MSC Nastran

Coupon and sub structure tests

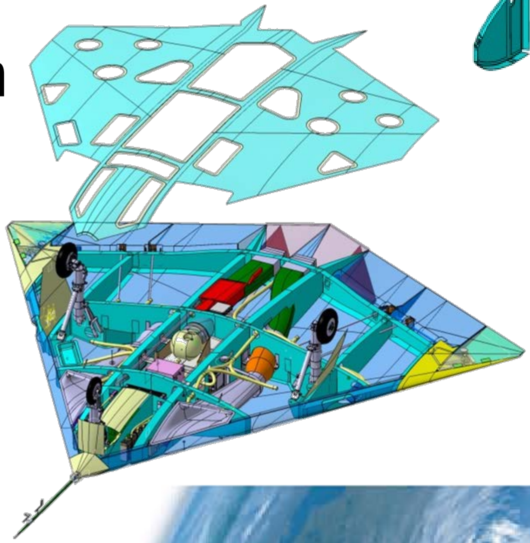


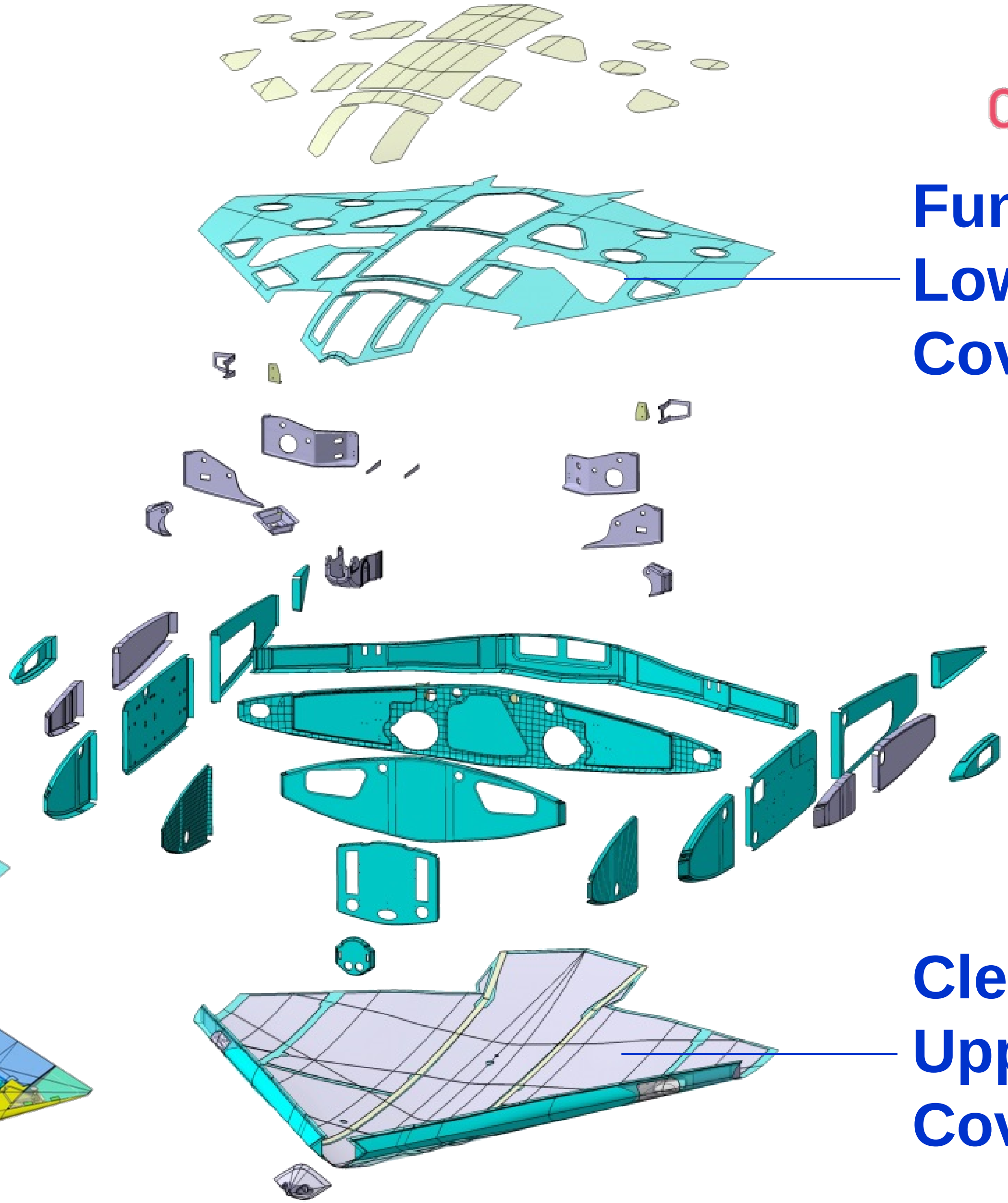


Structural Concept

Detailed design

- All subcomponents
- Propulsion/fuel system
- Landing gear
- Termination system
- Flight control system
- Power Supply
- Data Link
- Sensors





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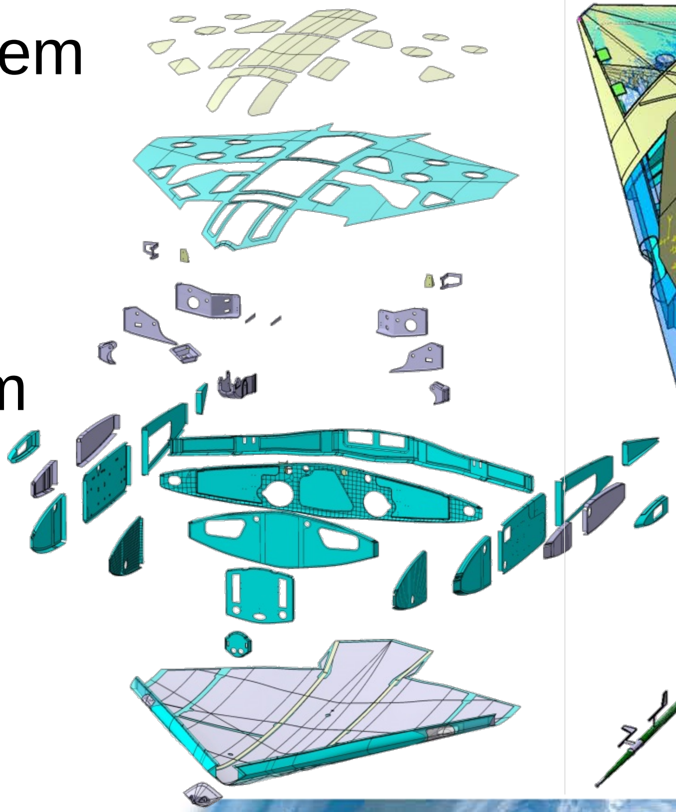

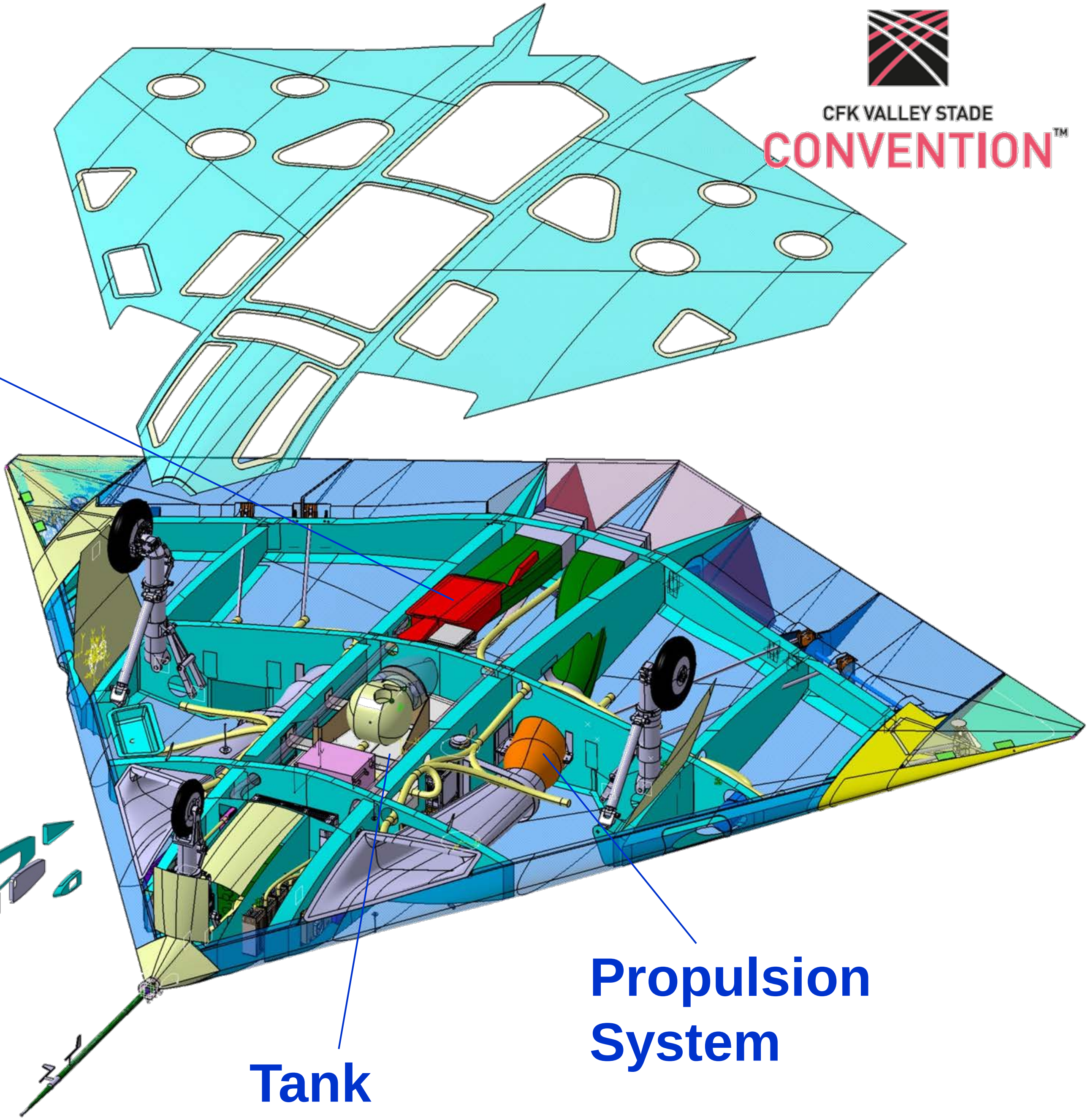

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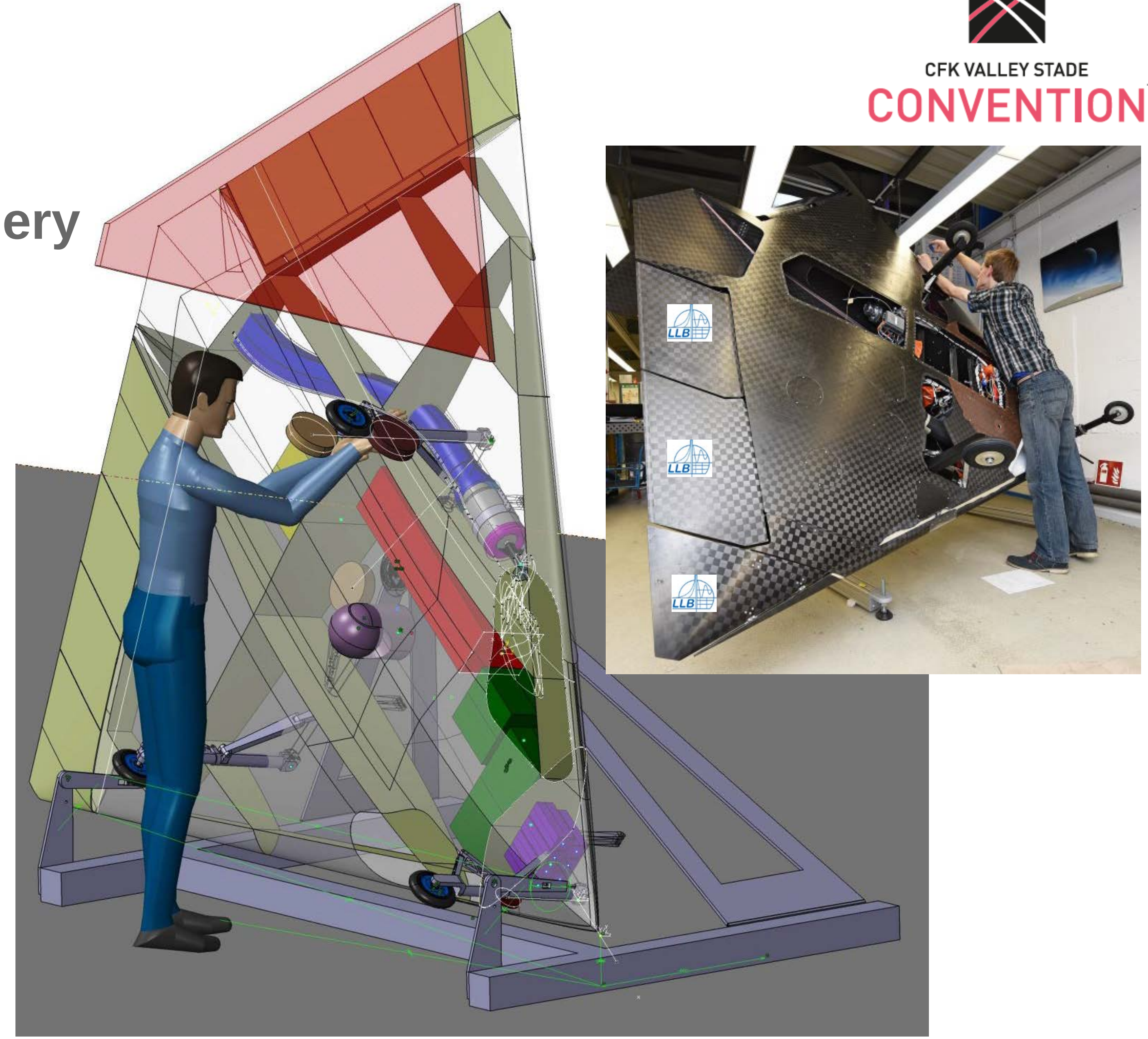
Structural Concept

Manufacturing / Assembly Periphery

- Tolerance Management
- Ergonomics
- Inspectability
- Maintenance strategy
- Jigs and Tools
- Quality Gates
- Process Documentation



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Airframe Component Manufacturing

SAGITTA Specific Challenges

Ambitious 150kg MTOW limit with less than 30kg for the compete airframe
→ Very thin, bonded micro sandwich laminates

High local load concentration (landing gear, termination system)
→ Critical ramping

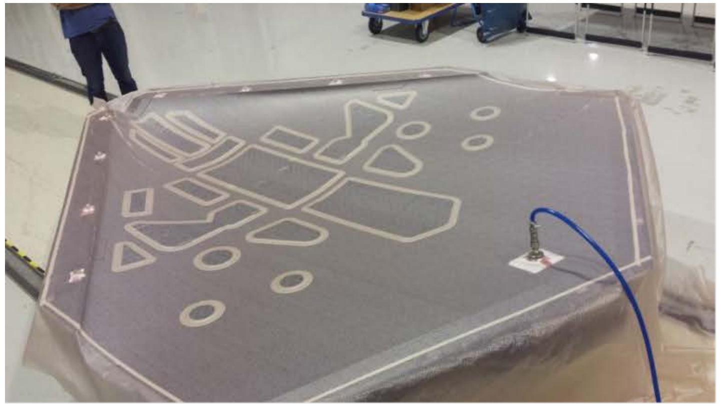
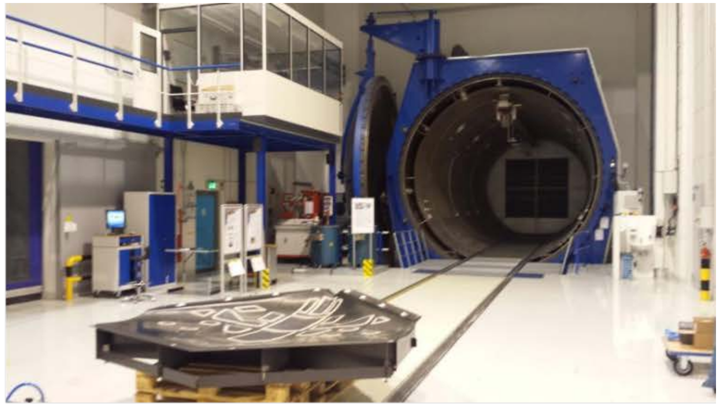
Complex structures with back cuts (integrated leading edge)
→ Complex, modular tooling

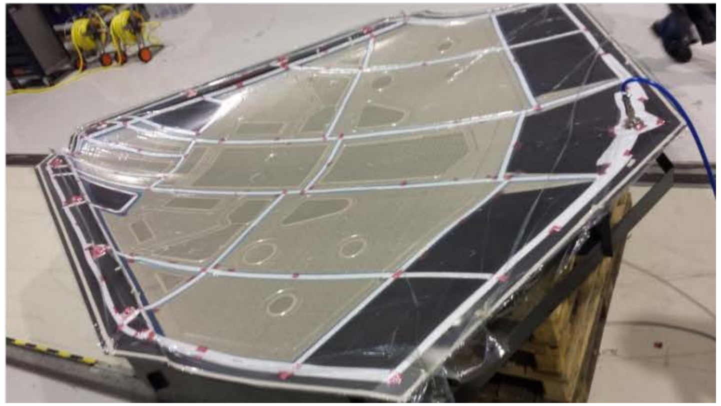
Numerus access panels on functional lower cover
→ Tolerances, Effort

Airframe Component Manufacturing

Manufacturing of upper and lower cover

- Common CFRP open mould for upper and lower cover (symmetric airfoil)
- Integrated manufacturing of access panels and doors
- “Thin Ply” Prepreg (less resin uptake than infusion laminate)
- Rohacell micro foam core
- Autoclave curing



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Airframe Component Manufacturing

Manufacturing of spars and ribs

- Machined female, aluminium open moulds for C-spars
- Machined female, polymer open moulds for C-rib components
- Low areal weight pepreg fabric
- Local Rohacell micro foam core
- Autoclave curing

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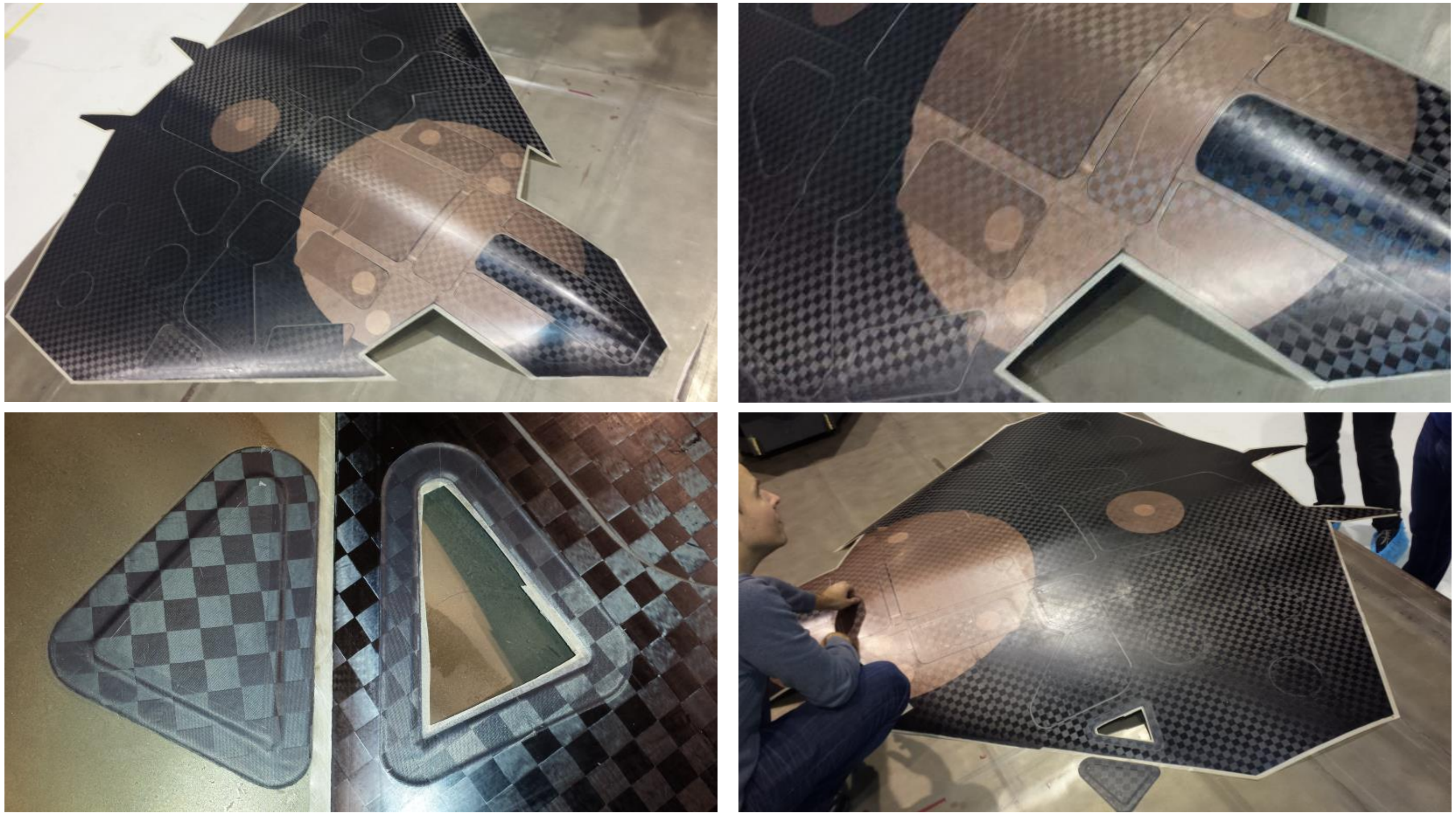
Airframe Component Manufacturing

Trimming

- Manual diamond cutter trimming at moulded trim lines
- Removal of integrated access panels
- Optical inspection of all structural components
- Preparation of surfaces for structural bonding



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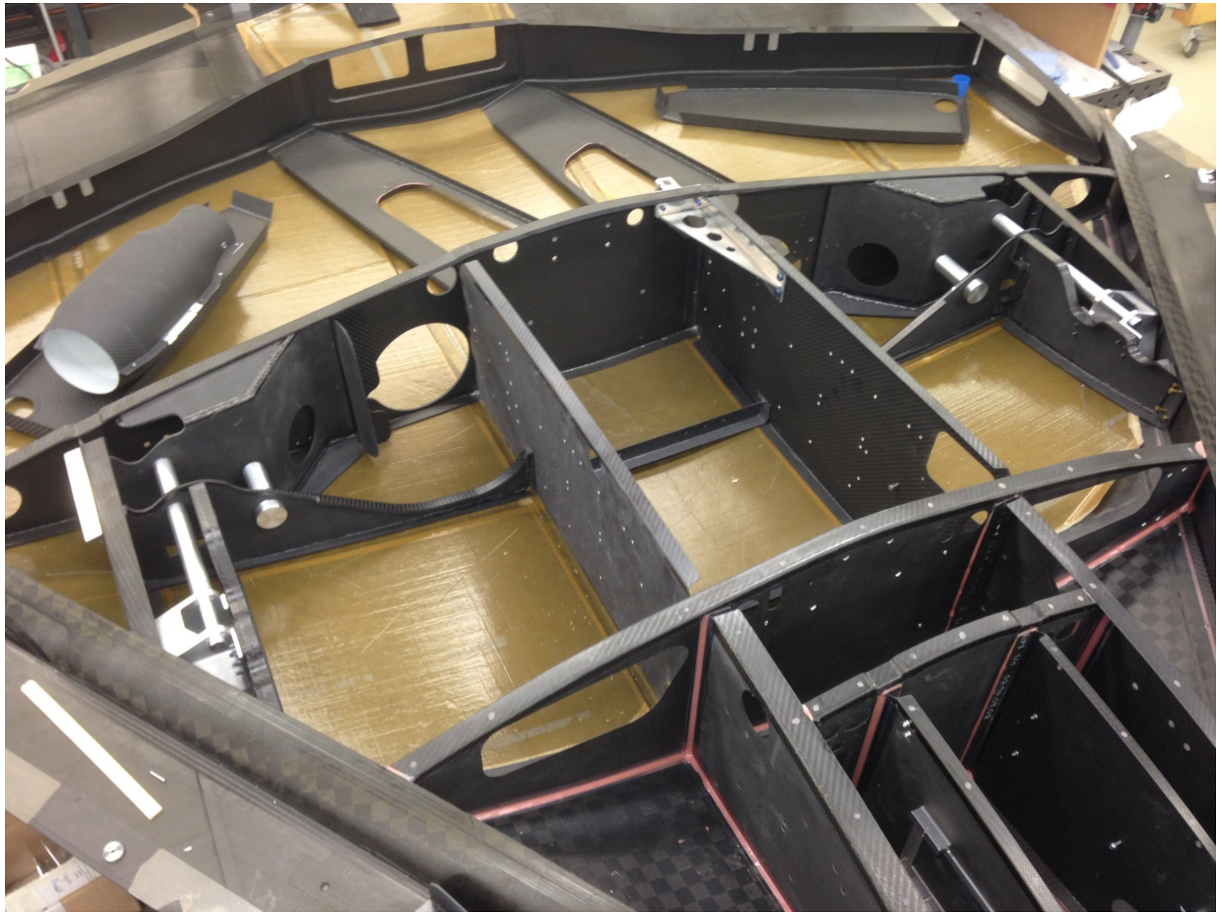
Airframe Integration

“Clean” Upper Cover + Spars + Ribs

- Global referencing and positioning of subcomponents
- Final joining of subcomponents starting with forward fuselage section (paste adhesive)
- Bolting of load introduction components for landing gear attachment and termination system



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Airframe Integration

System Installation

- Installation of wiring
- Integration of fuel system support structure
- Integration of engine support structure and air ducts
- Integration of kinematic elements for rudders/actuators

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Airframe Integration

Installation of Lower Cover

- Detailed planning of positioning, joining and pressing procedure
- Application of adhesive and final closing of the airframe structure
- Quality assurance of the bondlines based on boroscopy/video

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Airframe Integration

Functional Test

- Test of rudder positions
- Test of rudder dynamics
- Test of neutral position
- Test of long term behaviour
- Test of wing tip split flaps (air brakes / yaw control)

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Airframe Integration

Roll Out

- Completion of structure
- Closing of access doors
- First time on provisional landing gear
- Shipping to Airbus Defence and Space for system tests

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SAGITTA Flight Test

Brake Tests in Manching, Germany

„SAGITTA Project“

Fully Autonomous UAV
MTOW: 150 kg
Span: 3m
Length: 3m
Thrust: 2x300N

Projekt Manager: Andreas Kiefer
Chief Engineer: Jochen Dornwald

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SAGITTA Flight Test

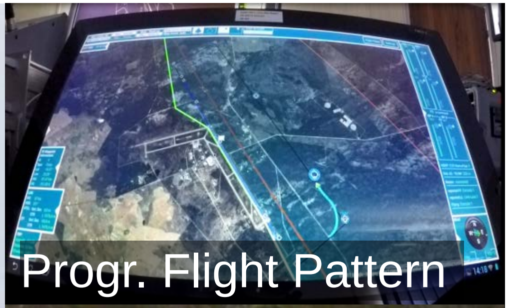
Flight Tests in Overberg, South Africa on July 5th, 2017


Preflight-Check


Ground Control


SAGITTA Camera


First Flight


Progr. Flight Pattern


Successful Landing


Flight Test Crew

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Lessons Learnt

- Iteration of ideas between all disciplines right from the start was time consuming but proved to be the major enabler for the **SAGITTA** success story

- Introduction of new manufacturing and assembly strategies was the only way to meet the ambitious target of 150kg MTOW

- Airbus Defence and Space managed the project in an open and comprehensive way, always leaving enough room for new ideas

“The Proof is in the Doing”