„SAGITTA – Unmanned Aerial Vehicle with innovative CFRP airframe“

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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
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!

**Structural Mechanics**
- Dr. T. Wille
- With high fidelity to virtual reality for the entire life cycle!

**Composite Design**
- Prof. C. Hühne
- Our design for your structures!

**Composite Technology**
- Dr. M. Kleineberg
- Tailored manufacturing concepts

**Adaptronics**
- Prof. H. P. Monner
- The adaptronics pioneers in Europe

**Composite Process Technology**
- Dr. J. Stüve
- Research with industrial dimension

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

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

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

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

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

- 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

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
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
### Structural Concept

**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

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**MSC Nastran**

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**Coupon and sub structure tests**

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**Setup 1:** TENSION

**Setup 2:** COMPRESSION

**Setup 3:** SHEAR
Structural Concept

Detailed design

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

Clean Upper Cover

Functional Lower Cover
Structural Concept

Detailed design

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

Termination System

Propulsion System

Tank
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
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
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
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
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
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)
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
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”