Automation of Production Processes for CFRPs and Hybrids in Aerospace

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Outline

Intro: Center for Lightweight Production Technology, Augsburg

1. Fiber Metal Laminates for a fuselage side shell

2. Examples for robotic lay-up systems
   a. Gripper systems
   b. Lightning Strike Protection - Tapelaying for 90 cm multilayer tapes
   c. Autonomous cut-piece detection and path planning

3. Manufacturing and assembly of thermoplastic components

Summary

German Aerospace Center (DLR)
Locations and employees

About 8000 employees at
32 institutes and facilities at
16 sites.

Offices in Brussels,
Paris and Washington.

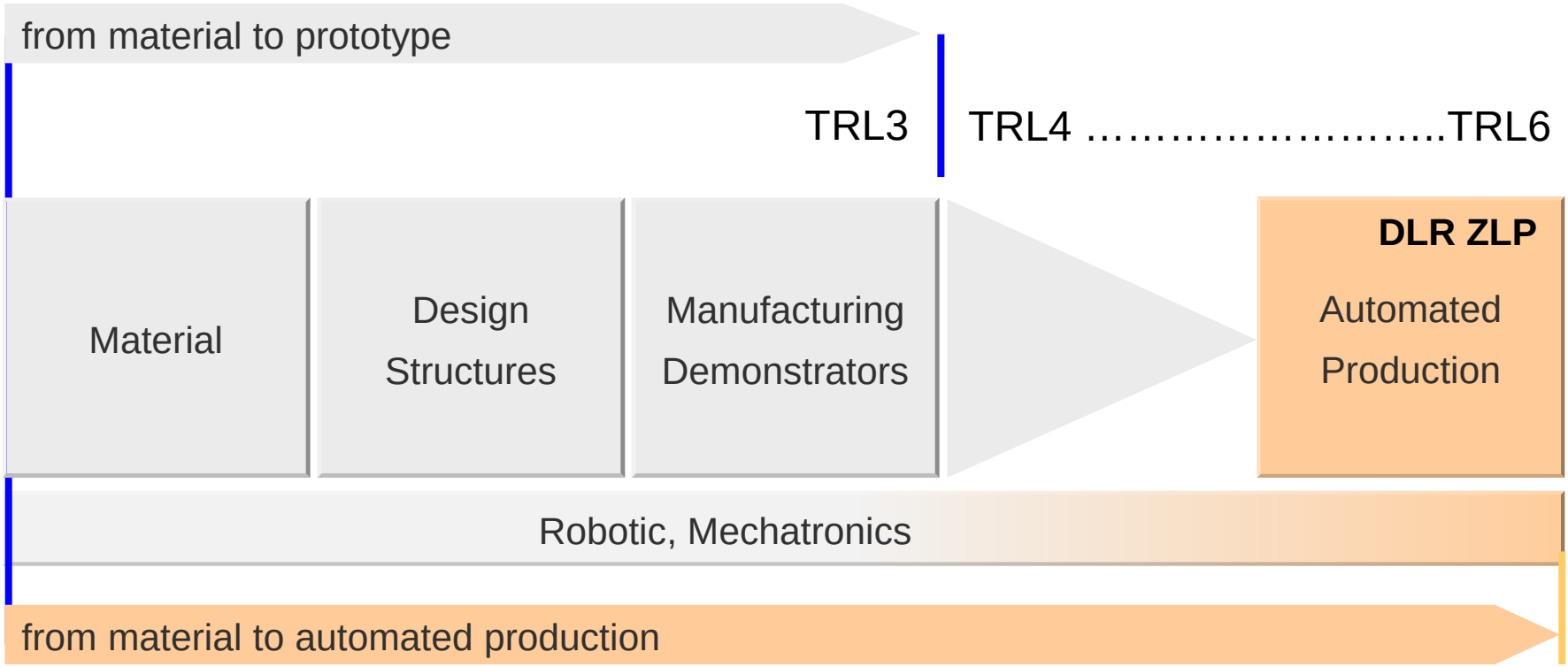
Institute of Structures and Design
Augsburg

Center for Lightweight Production Technology

Employees: 51
Turn over: 7 M€

Center for Lightweight Production Technology

Technology Readiness for Industrialisation



For integrated production development, industrialisation topics become more important

Flexible Automation Systems at ZLP Augsburg (1/2)

- High accuracy manipulation and calibration
- Simulation and offline-programming
- Reconfigurable and multi-functional systems
- Autonomous process guidance and manufacturing execution systems
- Various independent work cells, linkable to flexible cutter and logistics system

Flexible Automation Systems at ZLP Augsburg (2/2)

- Wickert 4400 S Composite Press
  - 1800 x 1200 mm²
  - 450°C
  - 100 - 4400 kN
- Krelus Infrared Heating System
  - 2000 x 1500 mm²
  - 20 – 800°C
- Kuka Robot KR210 R3100 Ultra F
  - Range 3100 mm
  - Payload 210 kg
  - Linear axis 5,4 m

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Summary

1) Fiber Metal Laminates for a fuselage side shell

Status quo:

- Manual manufacturing process of a FML layup
- Post-manufacturing QA

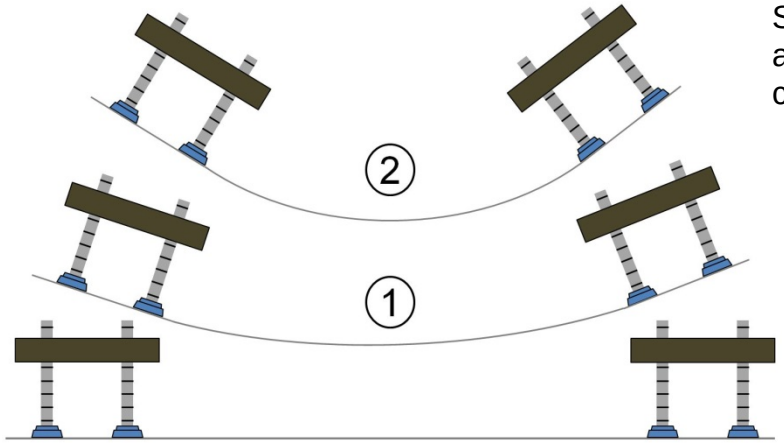
Targets:

- Automation of aluminium layup
- Integration of glas prepreg and adhesive layup
- Integrated QA and automated assessment

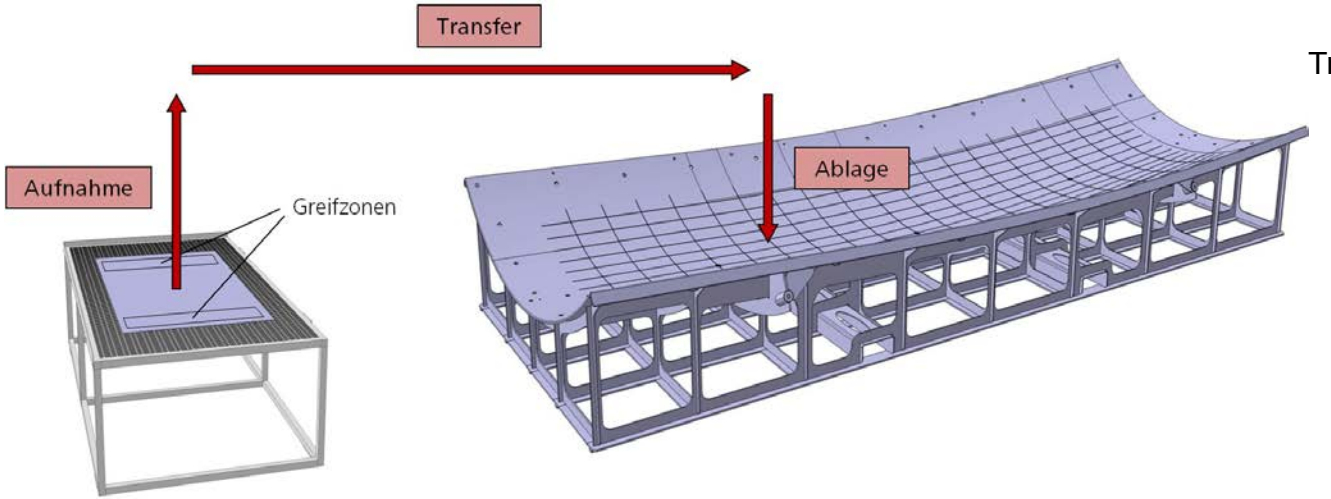
Quelle: PAG

1) Fiber Metal Laminates for a fuselage side shell

Aluminium layup



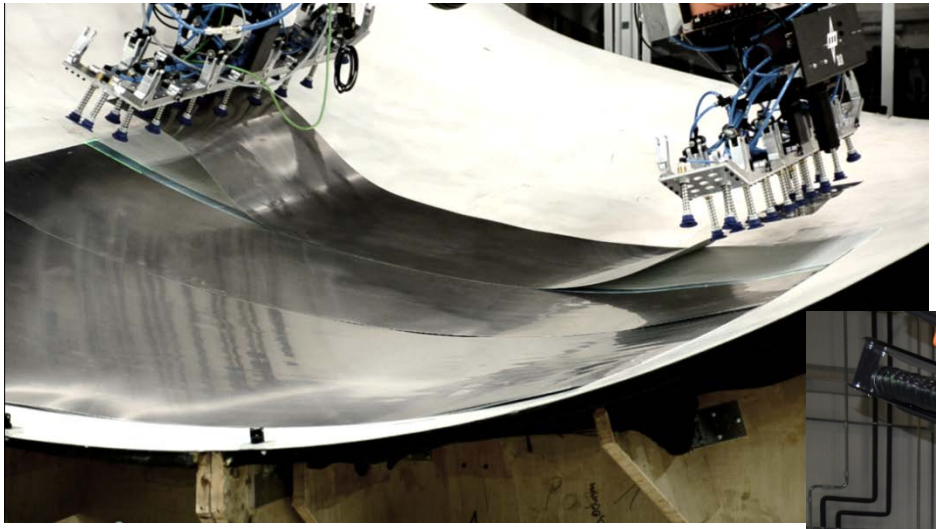
Schematic of gripper positions and movements for cooperating robots

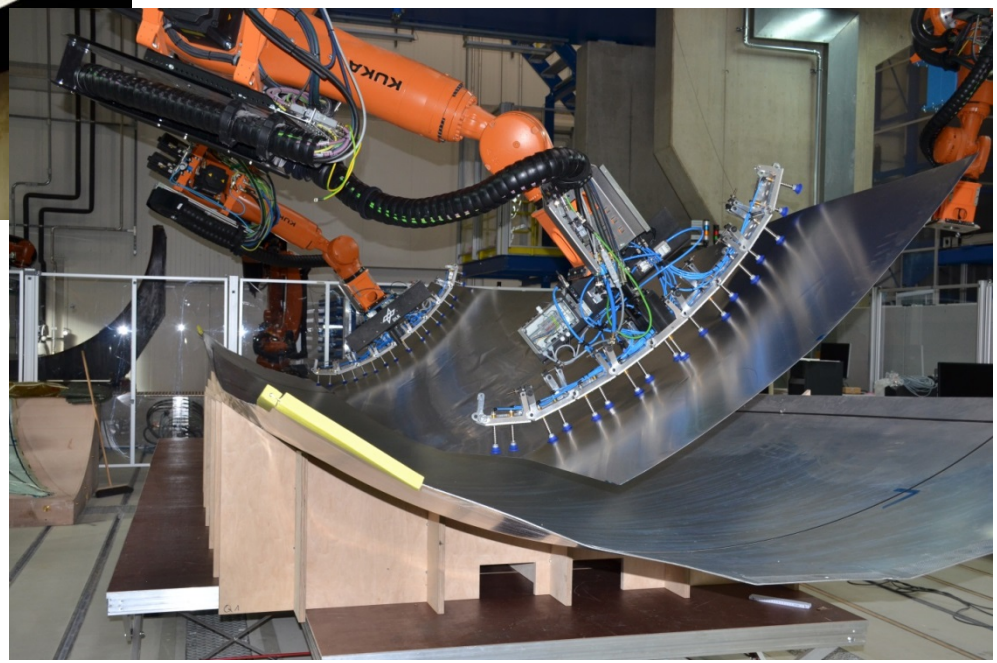


Transfer strategy

1) Fiber Metal Laminates for a fuselage side shell

Aluminium layup





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   - **a. Gripper systems**
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3. Manufacturing and assembly of thermoplastic components

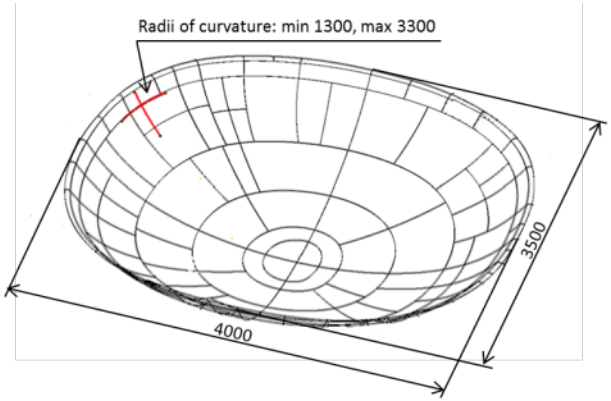
Summary

2a) Examples for robotic lay-up systems

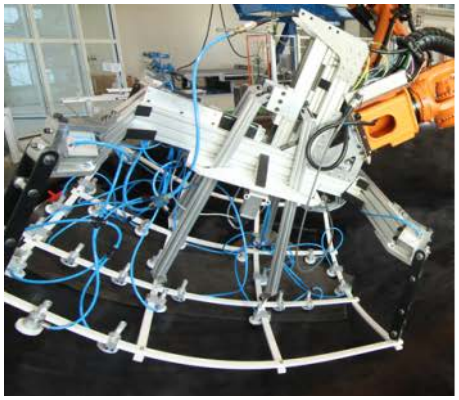
Gripper systems and draping strategies

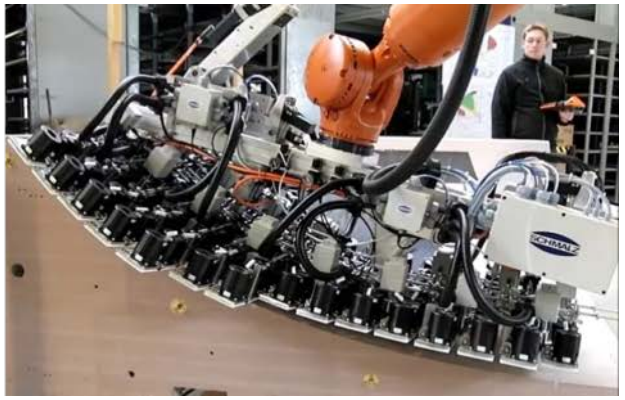
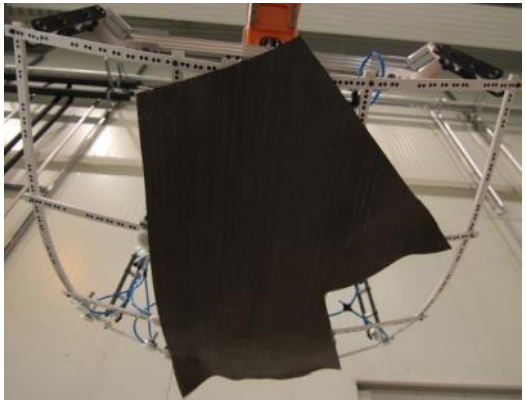
- Target component: pressure bulkhead
  - Double curvature with radii 1.3 – 3.3 m
  - Overall dimensions 3.5 x 4.0 m

- Thermoset part
  - Female Tooling
  - Preform made of dry textiles & stiffeners
  - 25 cut-pieces vary in size & geometry



2a) Examples for robotic lay-up systems
Gripper systems and draping strategies

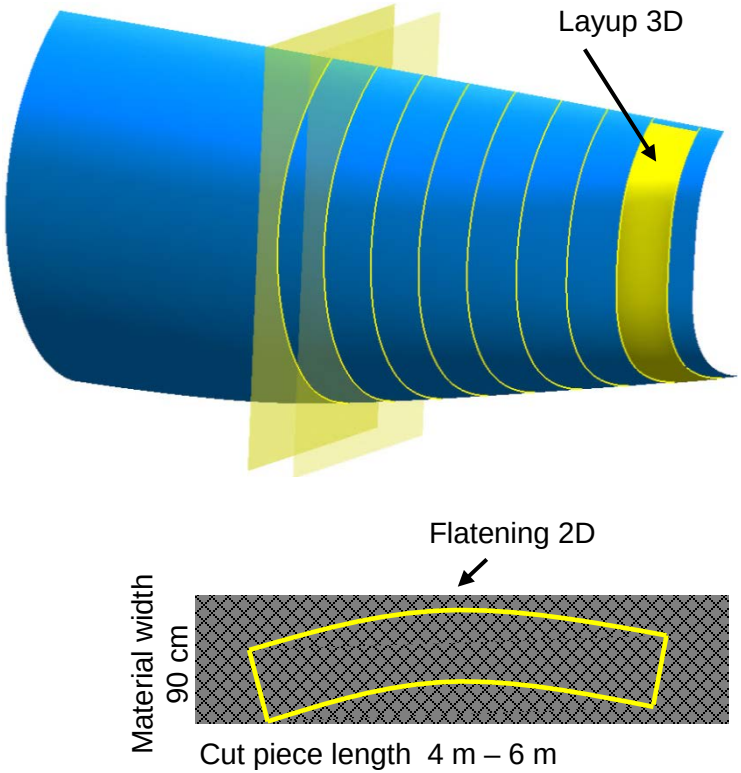


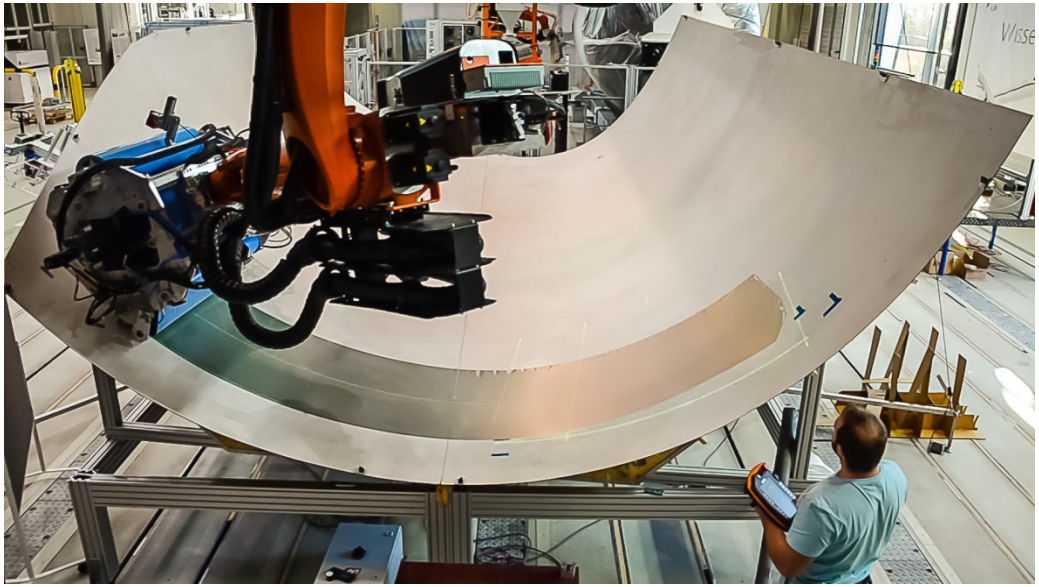



Partners: Fraunhofer IWU-RMV, Schmalz GmbH

2b) Examples for robotic lay-up systems

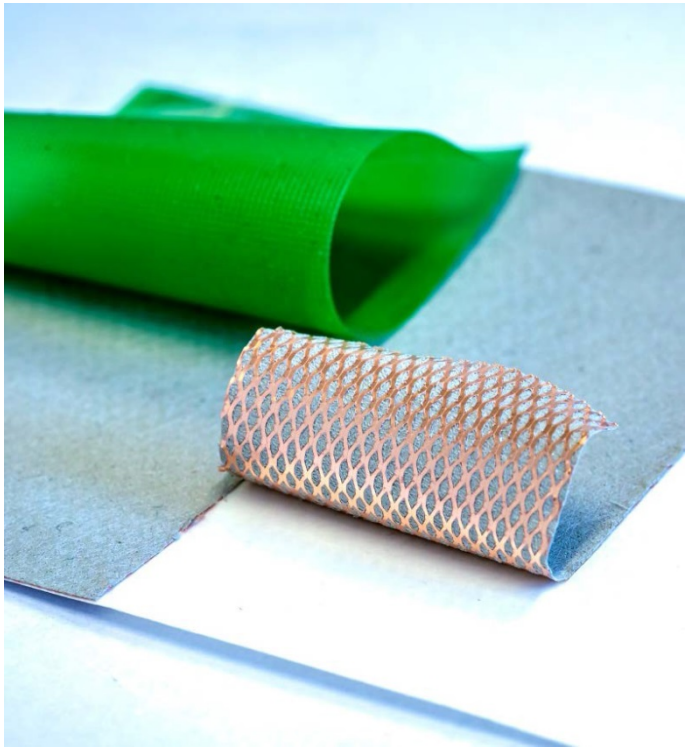
Tapelayer for 90 cm lightning strike protection





2b) Examples for robotic lay-up systems

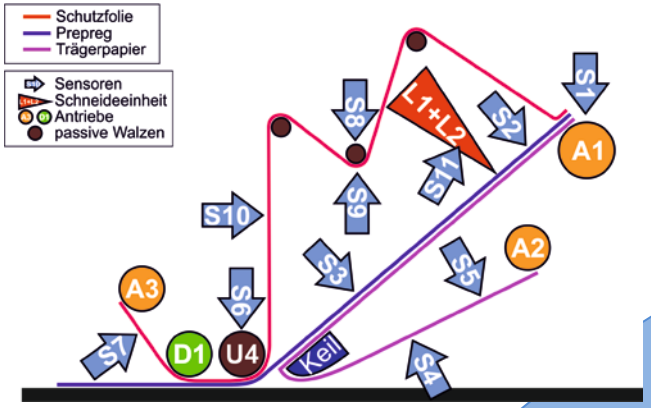
Tapelayer for 90 cm lightning strike protection

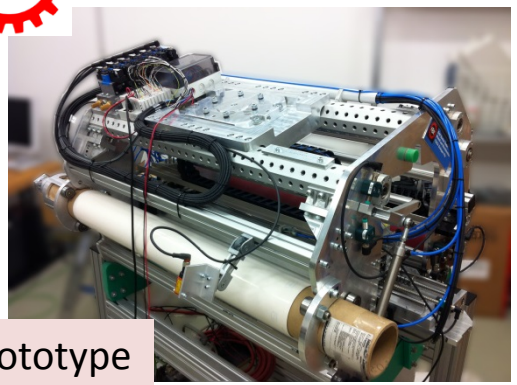


- 3 layer material (carrier, prepreg, foil cover)
- Prepreg made of copper mesh and thermoset matrix
- High draping forces required on doubly curved surfaces
- Compression results in waviness or even folds

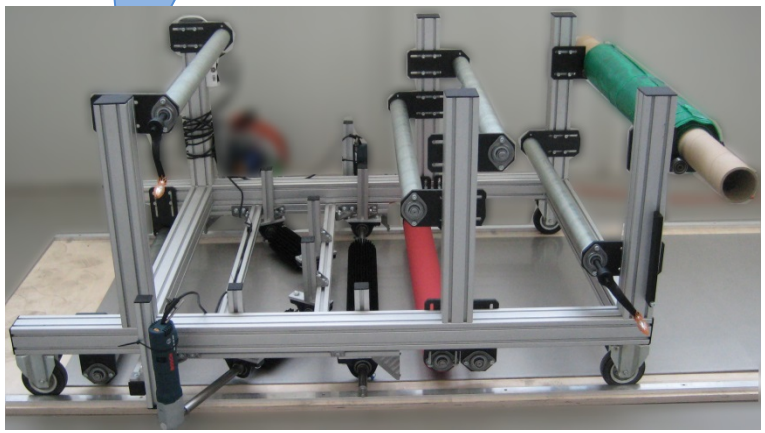
2b) Examples for robotic lay-up systems

Tapelayer development

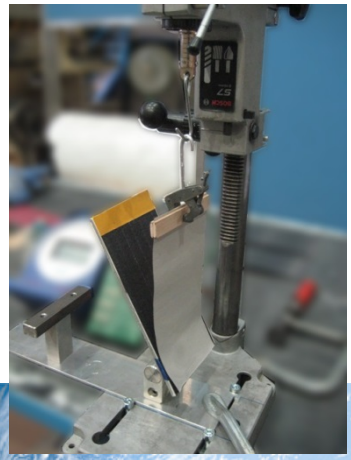




Prototype



Test vehicle



Material properties

Process analysis

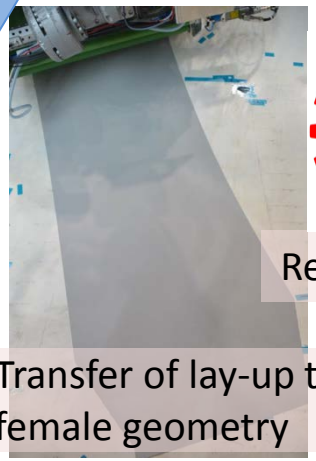
2b) Examples for robotic lay-up systems

Tapelayer development

Implementation in robotic cell and pre-testing

Lay-up on male geometry

Validation on full-scale female demonstrator

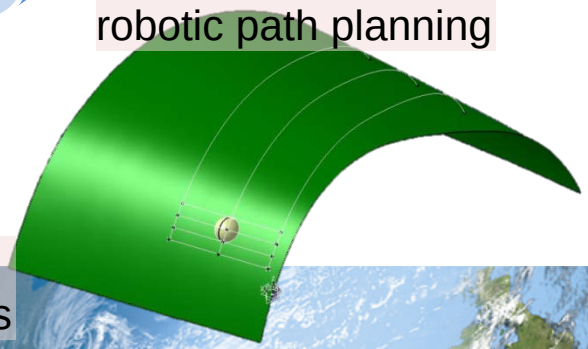


Transfer of lay-up to female geometry

EBE

Reconfiguration

Implementation of sensors and controls



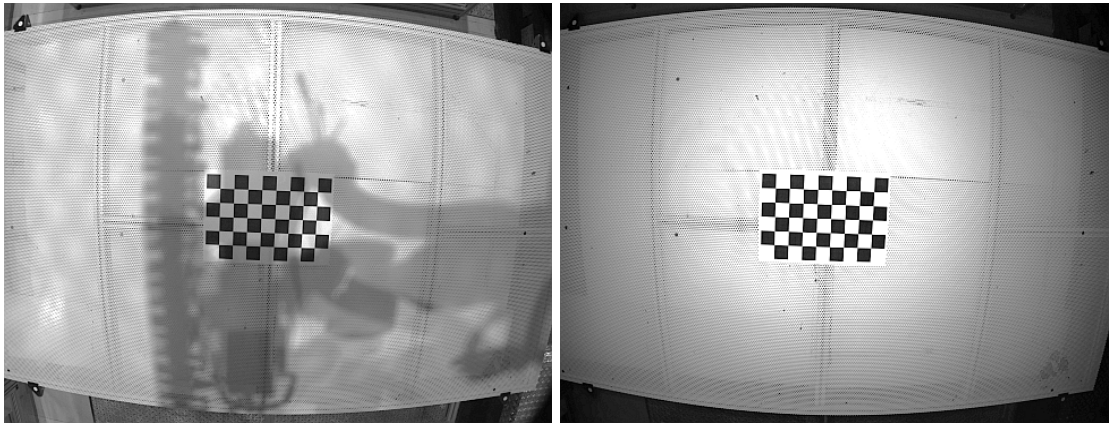
Development of robotic path planning

2c) Examples for robotic lay-up systems
Autonomous Gripper

Challenge:
- Process chains not fully automated
- Provide textile cut-pieces with high accuracy
- Robust pick-and-place process

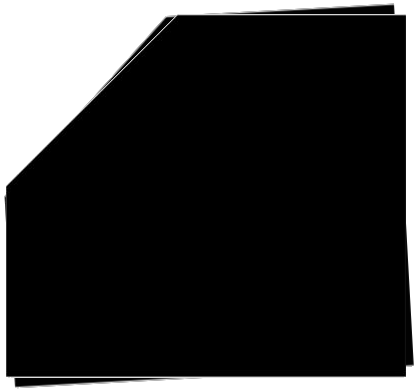
Goal:
- Flexibility and robustness in an intelligent system

Requirements:
- No obstacles
- Wide field of view
- Independent from ambient light
- Independent from reflections on cut-piece surface
- Closed casing to protect from carbon fibers

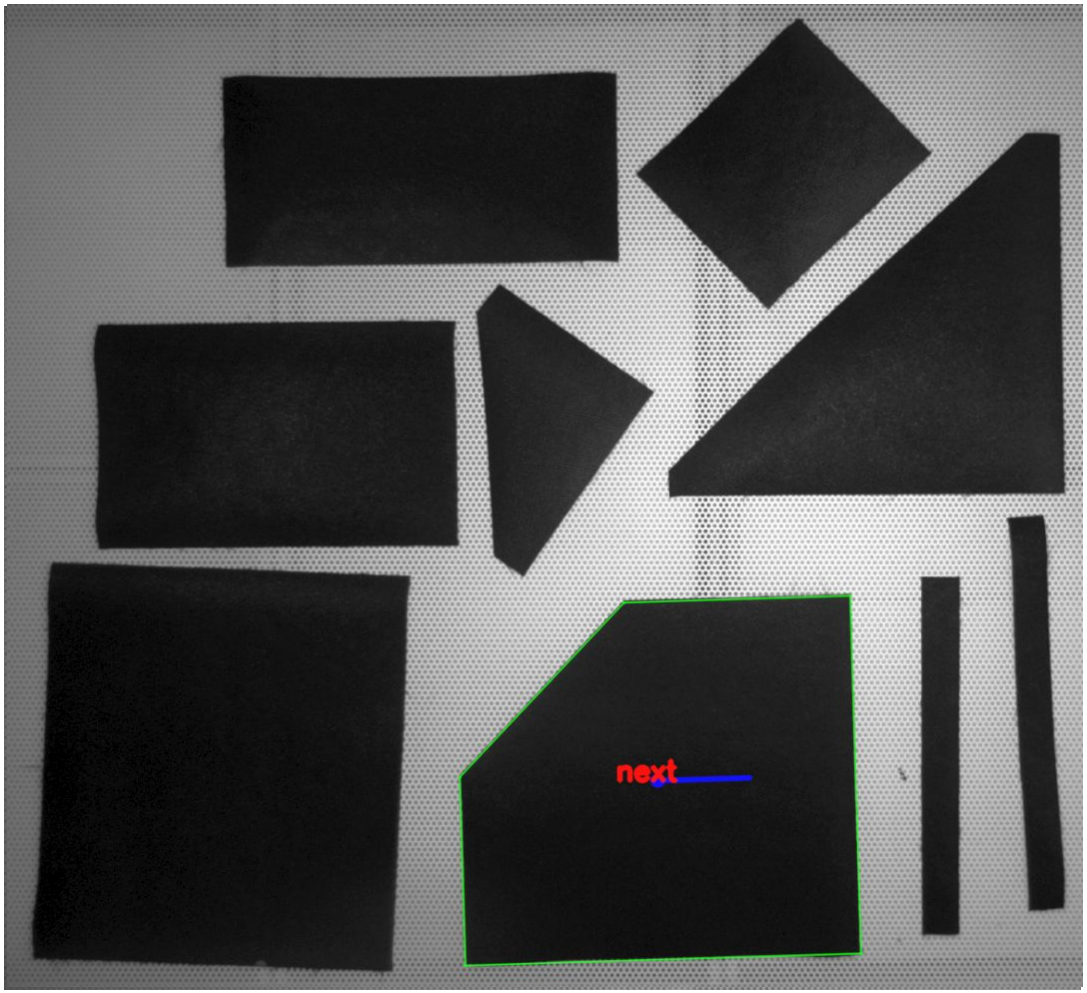


2c) Examples for robotic lay-up systems
Template-Matching for rotating Objects

- Produce rotating bitmaps from CAD-data (plybook)
- Comparison to camera view

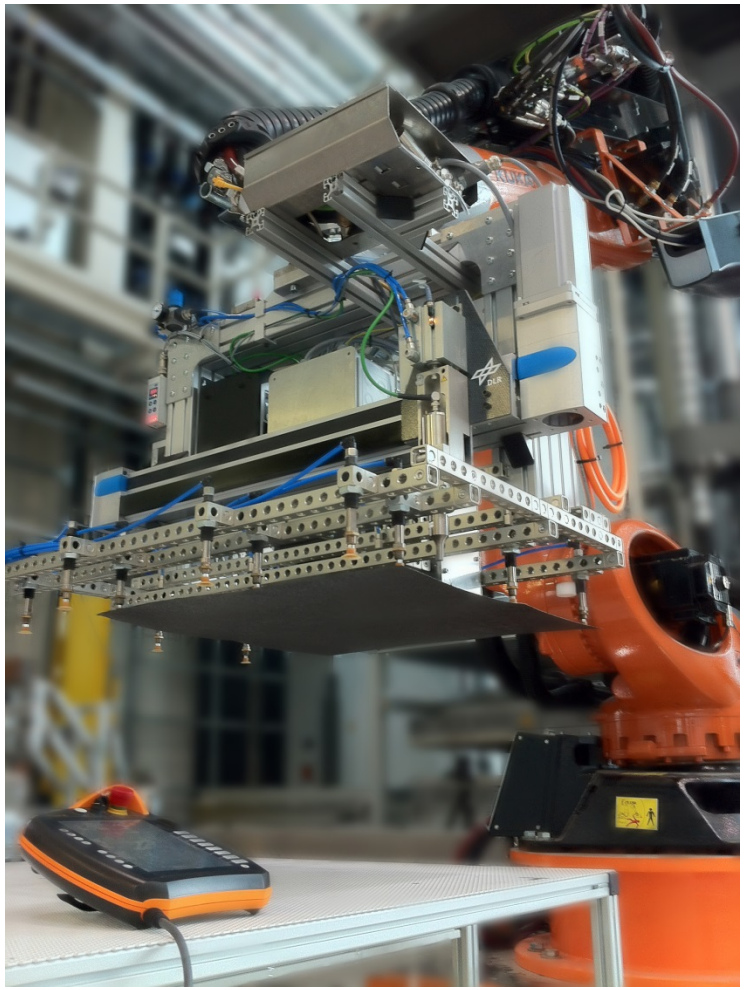


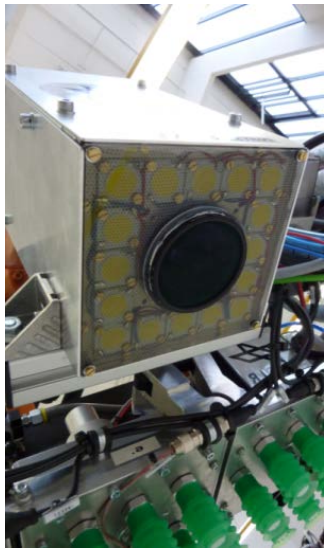
MATCH



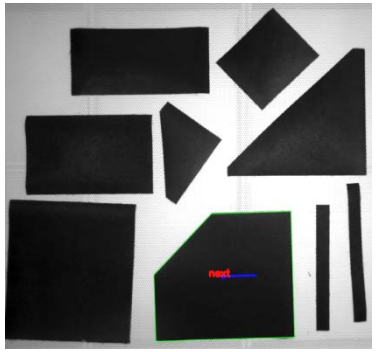
- Advantage: Robustness regarding waviness and reflections

2c) Examples for robotic lay-up systems





- Automated camera based ply-detection
- End effector for the automated stacking of tailored laminates
- Ultrasonic spot welding of laminate stacks



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Summary

3) Manufacturing + Assembly of Thermoplastic Components

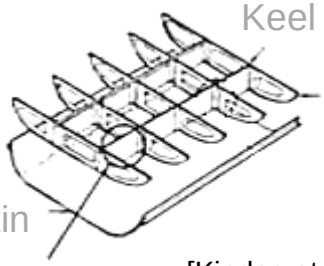
Use Case: Sine Wave Beam

- Sine wave beam as generic crash-absorber to demonstrate entire process chain from design to automated production

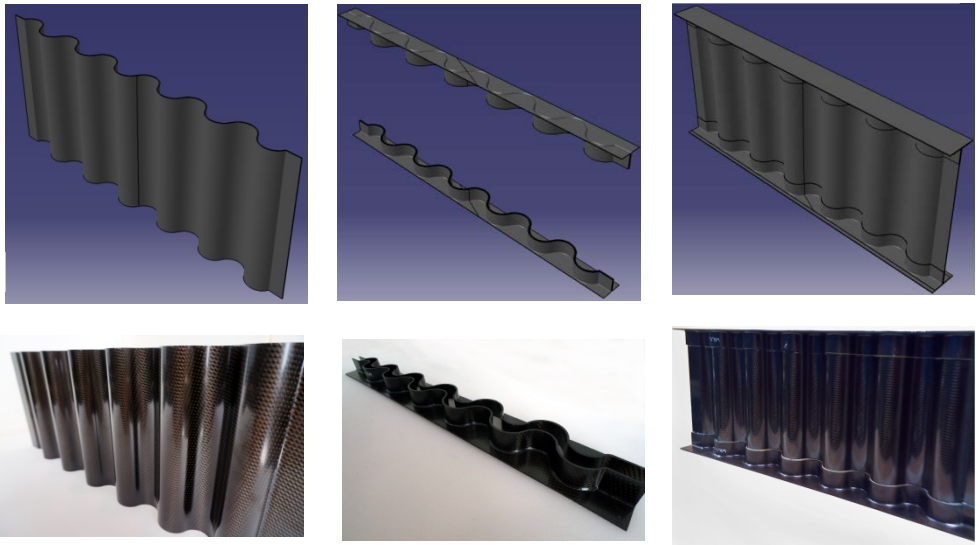
- Assembly of sine wave beam consists of 7 parts with 3 different geometries with high degree of deformation

HELICOPTER FUSELAGE

SUBFLOOR STRUCTURE



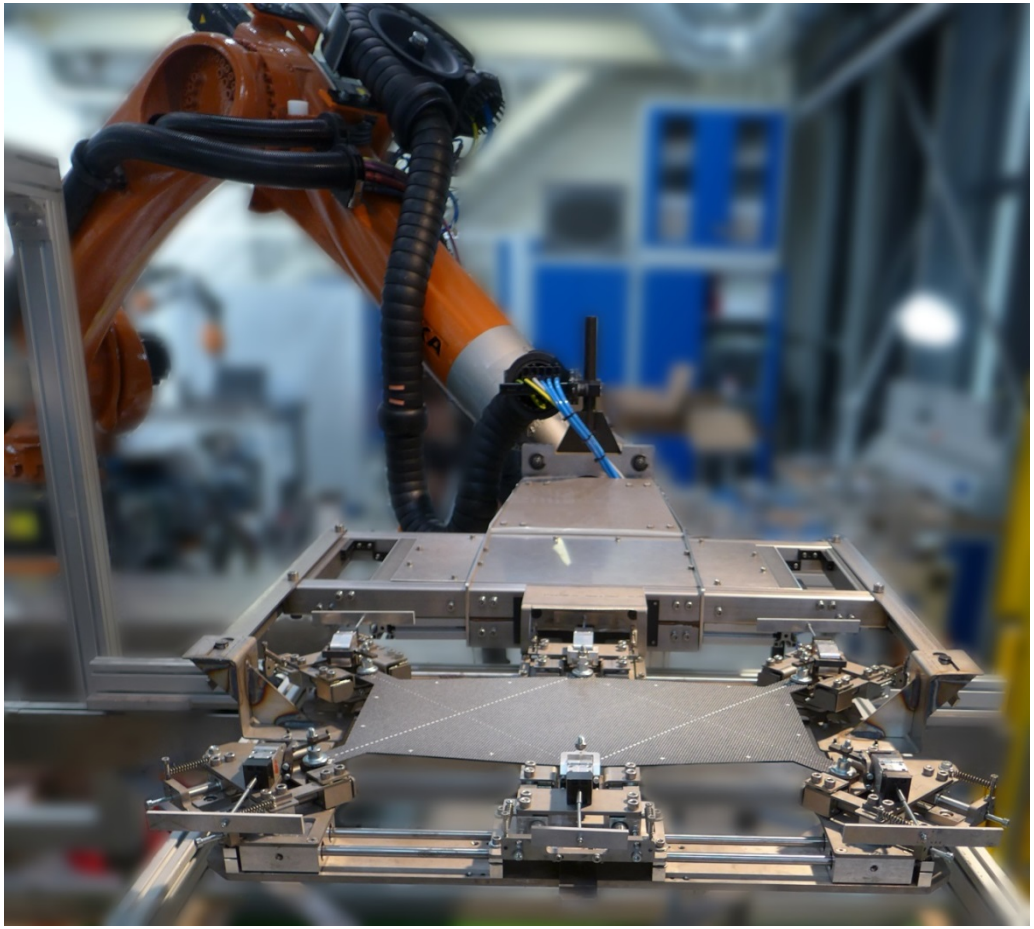
ENERGY ABSORBING BEAM



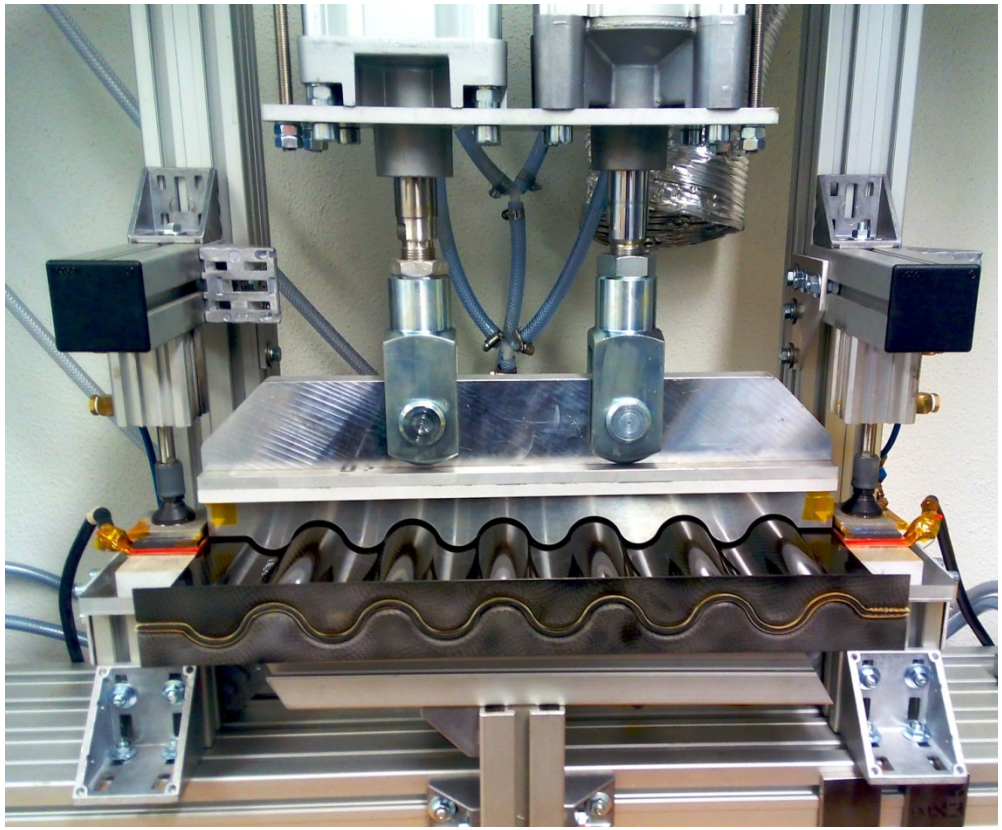
[Kindervater and Georgi, 1993]

3) Manufacturing + Assembly of Thermoplastic Components

Automated Clamping Frame



3) Manufacturing + Assembly of Thermoplastic Components
Resistance Welding



- Resistance welding of CF/PEI parts for the sine wave beam assembly
- Test stand to establish process parameters at the Institute of Structures and Design (DLR BT) in Stuttgart
- Welding element made of stainless steel glasfiber semipreg developed at DLR BT in Stuttgart

Summary

1. Automation of production processes in Aerospace
   a. Production rates of 10 – 60 per month
   b. Dimensions with variability 0.5 – 10.0 m
   c. Accuracy in layups regarding positions and fiber angles

2. Shown examples
   a. Fiber Metal Laminates for a fuselage side shell
   b. Draping systems for double curvature
   c. Tape layer for 90 cm multilayer tapes
   d. Autonomous cut-piece detection and path planning
   e. Manufacturing and assembly of thermoplastic components

Acknowledgements

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Stadt Augsburg

AUGSBURG INNOVATIONS PARK

Bundesministerium für Wirtschaft und Technologie

DLR