Advanced Production Technologies for High Performance FML Parts

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Presented by

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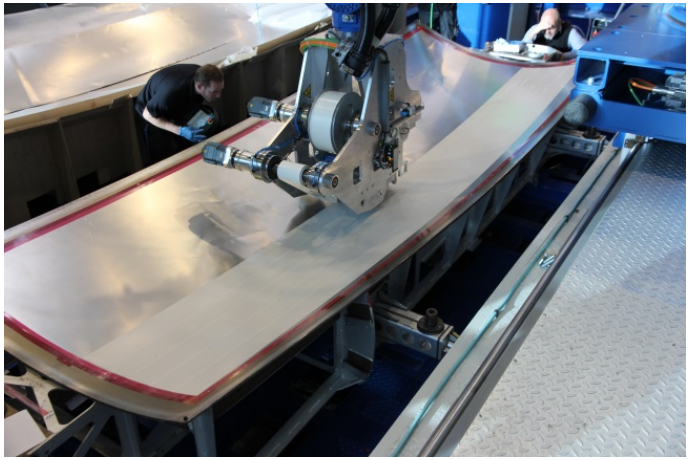
Overview

- Motivation
- Aluminium lay-up
  - 2D-trials
  - 3D-trials
  - Inline QS
- Glasprepreg lay-up
  - 2D-trials on vertical plate
  - 3D-trials on 2x2 m tool (TRL3)
  - 3D-trials on 2x5 m tool (TRL4)
- Summary and outlook



Motivation – Status Quo

Status Quo in serial production

- Manual lay up of
  - o aluminium foils
  - o glasprepreg
  - o adhessive film

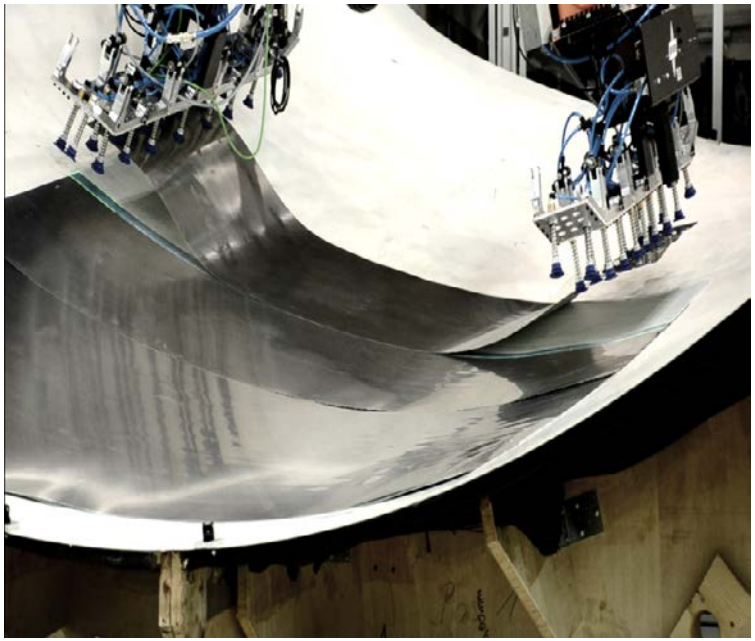
- Multi Shot Bonding
- Subsequent part inspection

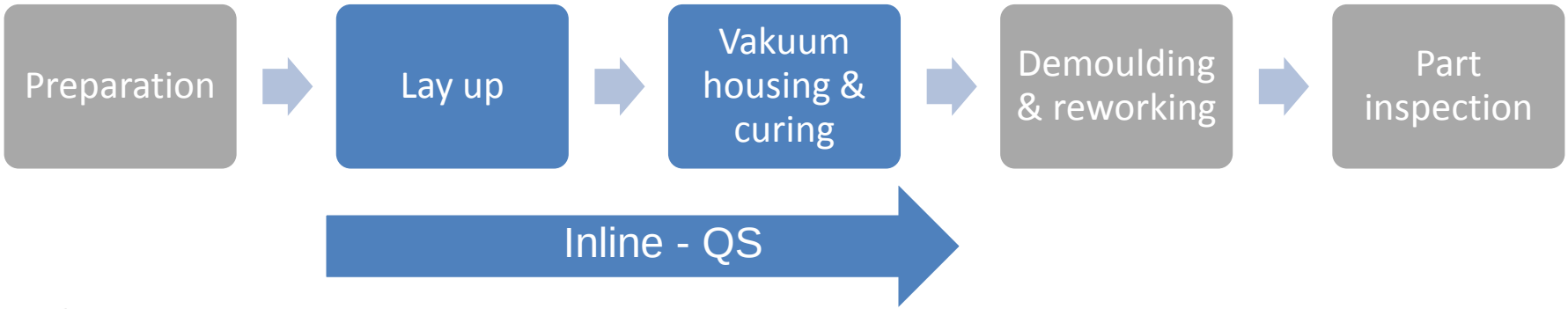
Source: PAG

Motivation – Project goals

Project goals in AutoGlare (LuFo V2)

- Automated handling and layup of
  - o aluminium sheets
  - o glasprepreg
  - o adhesive film
- One-Shot-Bonding
- Integration of Inline-QS





Motivation – DLR sites in project AutoGlare

Augsburg **Stade** **Braunschweig** **Köln**



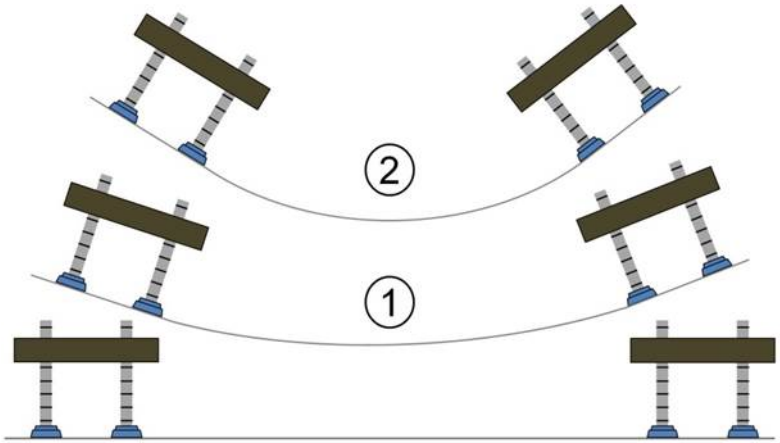




DLR

Automated layup of aluminium 2D layup

- Strategy:
  - Use of two cooperating robots
  - Plain gripping
  - Transport in a funicular curve



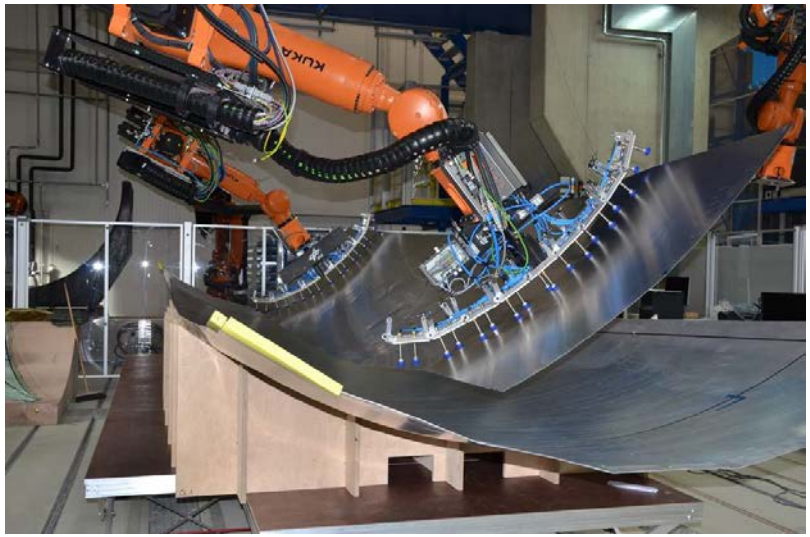
- Results:
  - Handling and layup perfectly possible
  - Transport without damage
  - No air inclusions
  - Bottom layers not damaged

- Challenge:
  - Fixiation of the first layer
  - Wrinkle development in spherical contour

DLR

Automated layup of aluminium 3D layup

- Strategy:
  - Use of two cooperated robots
  - Gripping in curved configuration
  - Transport with constant distance between the grippers
  - Layup from one end to the other



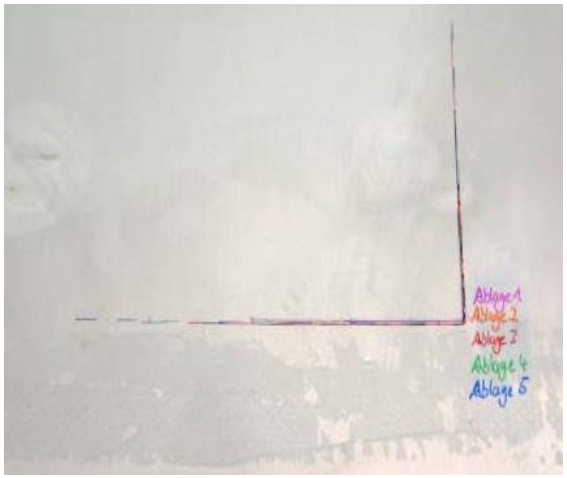
- Results:
  - Handling and layup perfectly possible
  - Transport without damage
  - No air inclusions

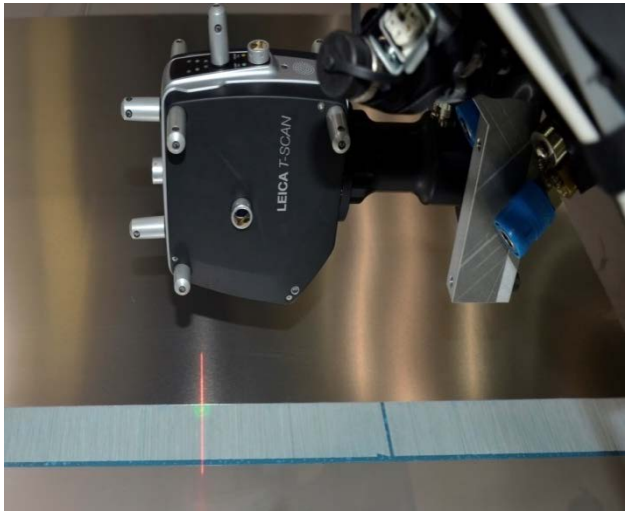
- Challenges:
  - Transport concept dependent from the stability of the sheets

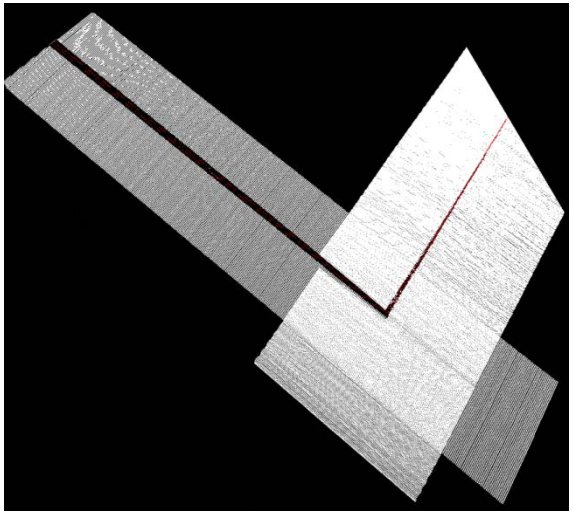
DLR

Inline QS in aluminium lay-up
Edge detection

- Examination of laid up sheets in terms of positioning accuracy
- Integration in running process possible
- Resolution sufficient for aluminium, glass prepreg and adhesive film







Automated layup of glass prepreg material
Material analysis

tack behaviour

- release of backing paper
- on aluminium foils
- on glass prepreg
- variation compaction pressure
- change during shop life time

wrinkles

- curvature-dependent
- steering-dependent

process parameter

- necessary heating power
- necessary compaction pressure
- maximal layup speeds

process ability

- cut at course ends

DLR

2D layup trials
Process parameter

Analysis of material behaviour on 2D flat plate

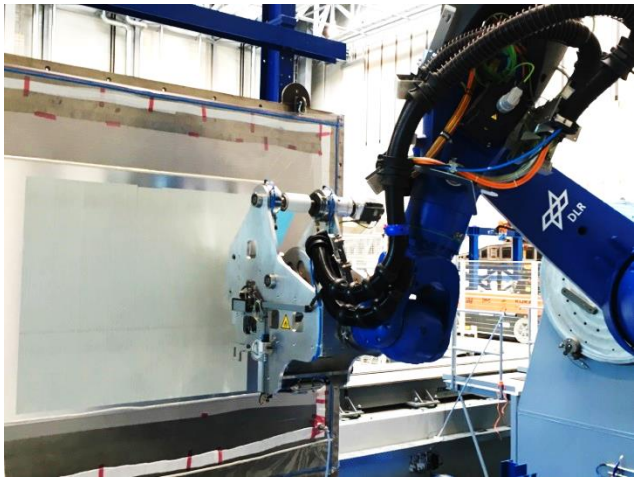
- Hexcel DLS 1611 material with 150 mm width
- 0,4 mm aluminium sheets (w/o primer)

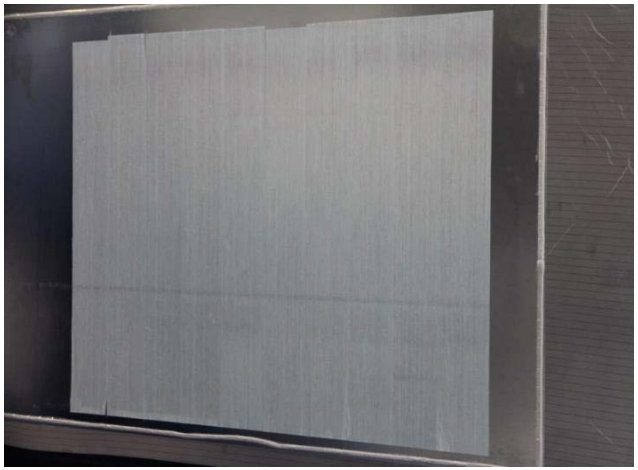
Results 2D – Glass prepreg on Aluminium

- Heating supports tack
- Compaction pressure of 1.200 N shows best results
- Cutting at end of course successful
    - Cutting speed = 10 m/min (US-knife)
- Layup speed at 1 m course length = 12 m/min

- **Layup of glass prepreg onto glass prepreg**
    - tack is much better

✓ **Successful analysis of process parameters**

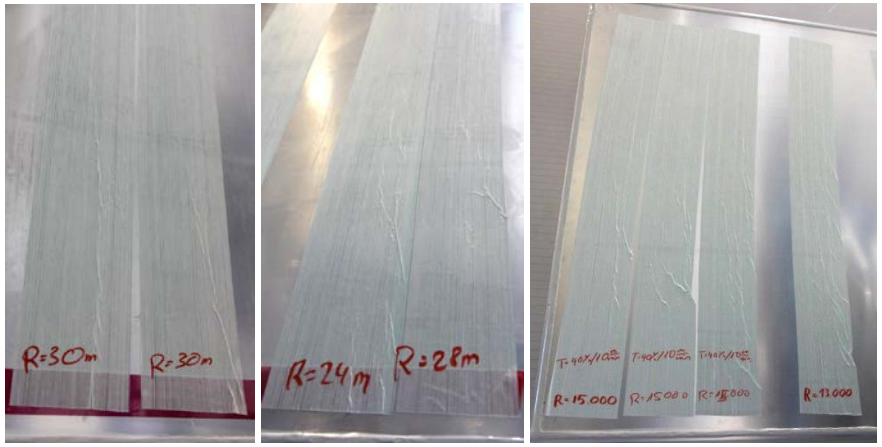




2D layup trials
Steering trials and accuracy measurements

- **Steering analysis**
  - Aim: 12 m Radius for CoFul²-tool (TRL4)
  - Wrinkles due to movements between prepreg and backing paper

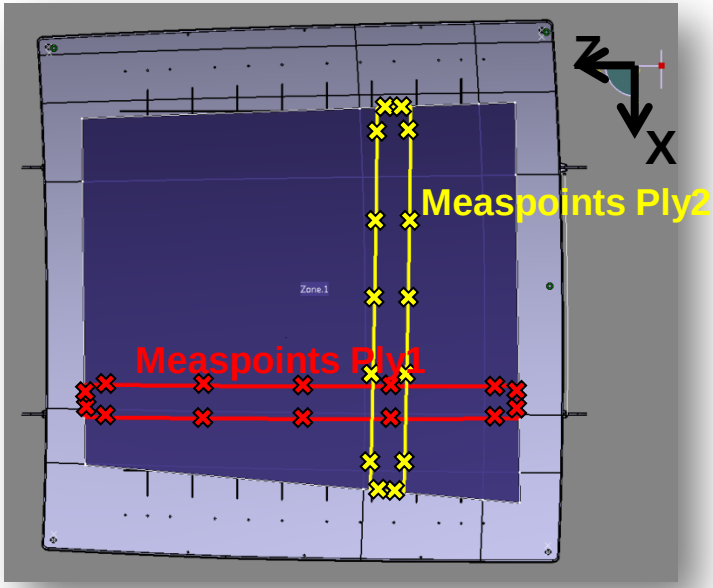
  No steering possible!

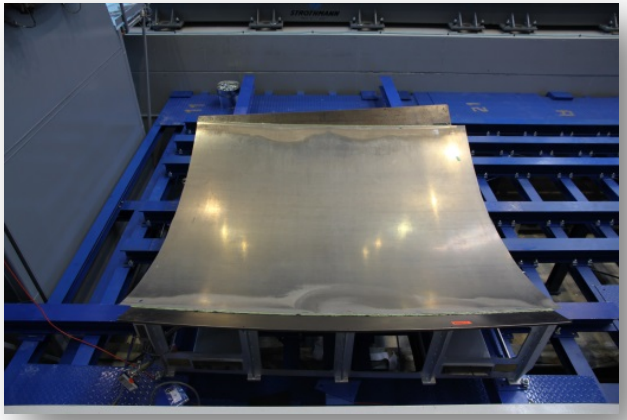


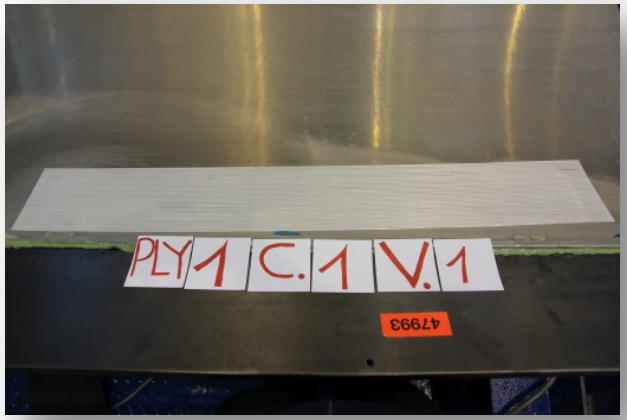
- **Analysis of layup accuracy (defined gaps)**
  - Measurements with a microscope
  - σ for 90°-Ply = 0,56 mm
  - σ for 0°-Ply = 0,21 mm
  - ➢ High controllability of course layup

  Accuracy within tolerances!

3D-trials on 2x2m tool (TRL3)
Analysis of accuracy and repeatability







- For each ply, 4 courses were laid up five-times each and position measured at 14 measurement points
- Measuring device: tactile measurement with Leica AT960 and T-Probe

Good 3D repeatability was demonstrated (<= 1,1 mm)

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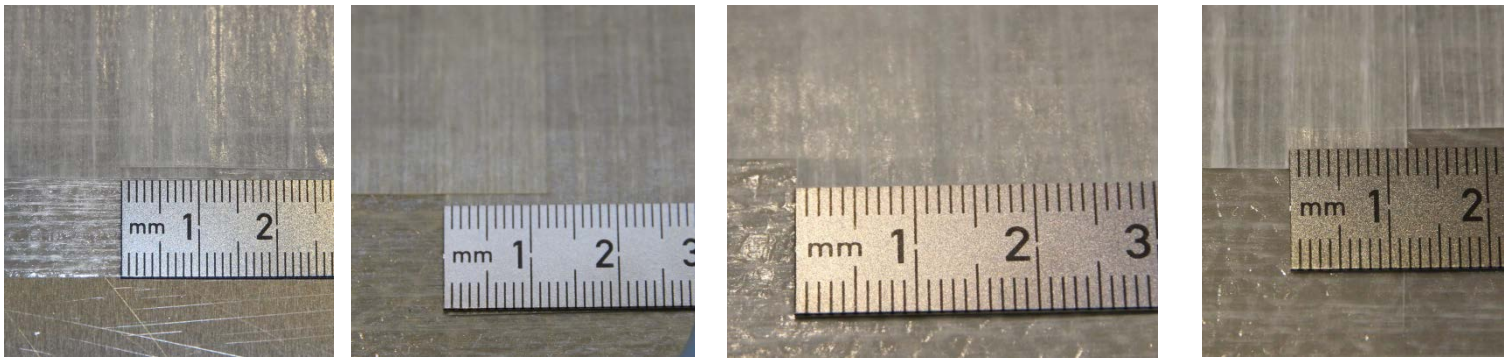
Manufacturing / technology demonstrator
Overlap measurements

0° plies:

- Defined overlap at start/end of 0° plies = 12,1 mm (simulation result)
- Measured overlaps = 12 ± 1mm



90° plies:

- Defined overlap at start/end of 0° plies = 2,2 mm (simulation result)
- Measured overlaps = 2 ± 1mm

Summary and outlook

tack behaviour

- release of backing paper ✓
- on aluminium foils ✓
- on glass prepreg ✓
- variation compaction pressure ✓
- change during shop life time ✓

wrinkles

- curvature-dependent ✓
- steering-dependent ✓

process parameter

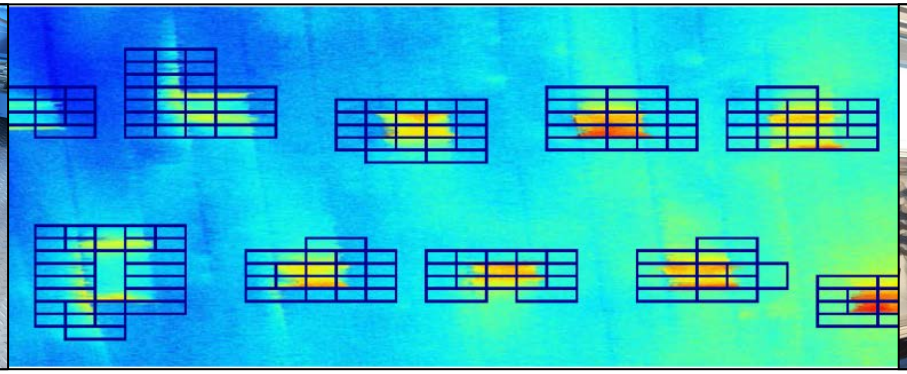
- necessary heating power ✓
- necessary compaction pressure ✓
- maximal layup speeds

process ability

- cut at course ends ✓

Summary and outlook

- Succesful handling of aluminium, layup of glass prepreg
- Continuation of the works concerning the aluminium handling and aluminium layup
- Tests with automated fiber placement technology to enable layup without overlap
- Integration of a sensor system for quality assurance
- Analysis of measured and simulated process induced deformations / stresses from layup to curing



Thank you for your attention!