Trends in the manufacturing of Composite Aerospace Components and resulting demands for Machining Technologies

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Machining Innovations Conference 2019
Hannover, 28th of November 2019

DLR

DLR – German Aerospace Center

Tasks

Publicly funded non-profit organisation

- Research Institution
- Space Agency
- Project Management Agency

Research Areas and Cross-link-fields

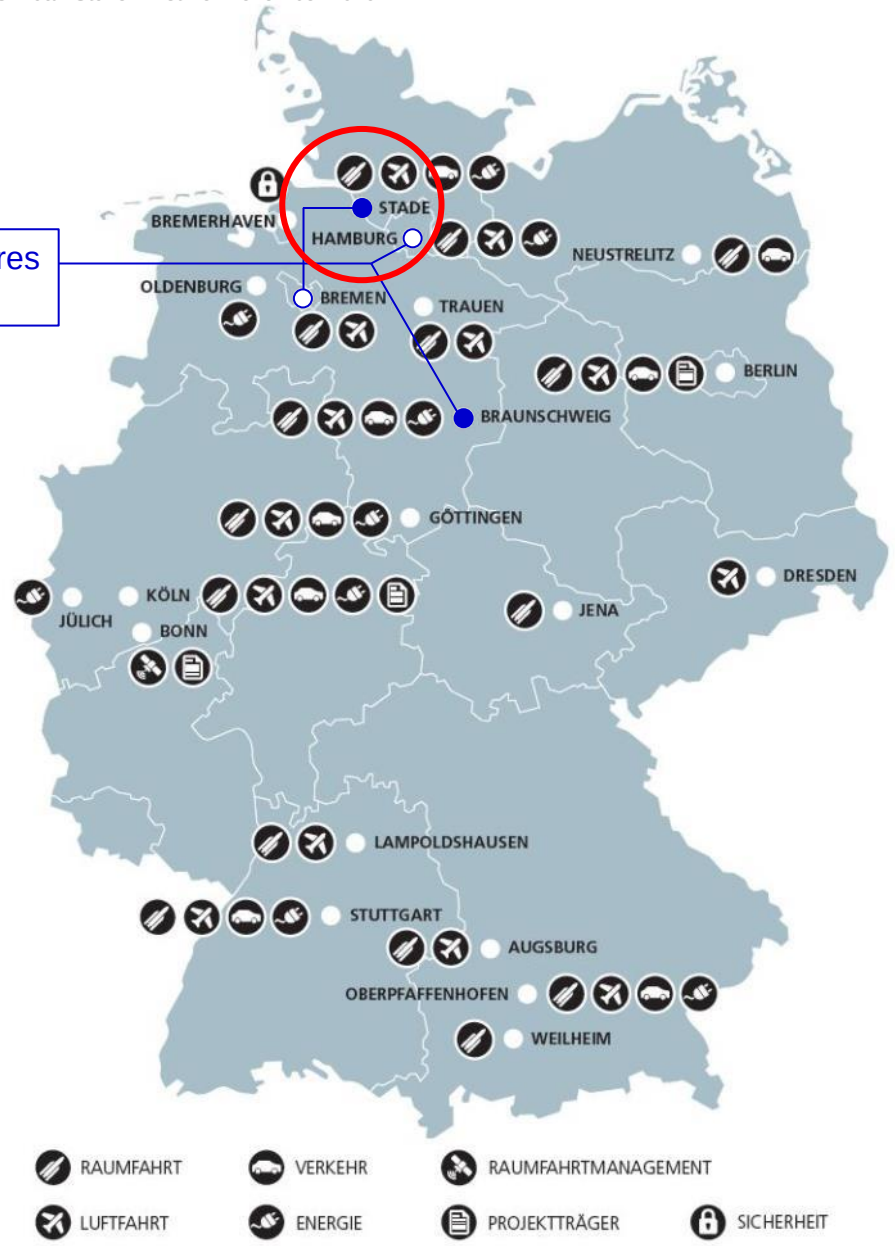
- Aerospace
- Space Research and Technology
- Energy
- Transport
- Security
- Digitization (e.g. „Factory of the Future“, „Condition Monitoring“)

Motivated by the Digitization Initiative of the German Government

DLR – German Aerospace Center

Sites and Staff

- Approx. 8.500 employees
- 42 Institutes and Institutions
- 20 Sites
- Offices in Brüssel, Paris, Tokio and Washington.



DLR – German Aerospace Center

Center for Lightweight-Production-Technology (ZLP®) in Research Center „CFK Nord“

DLR

- **ProductionTechnology Single Components**
- **Virtual Composite Product Development**

Fraunhofer IFAM

- **Assembly Technology**
- **Joining Technology**
- **Machining Technology**

FFT

- **Technology Development, Customer Service**

Olin

- **Fundamental Materials Research (e.g. novel resins)**

HP-CFK

TECHNISCHE UNIVERSITÄT CAROLO-WILHELMINA ZU BRAUNSCHWEIG

TU Clausthal

Leibniz Universität Hannover

20.000 qm for cooperation and innovation

DLR

The R&D-environment of the CFK-Valley Stade

Trend No. 1 in the manufacturing of Composite Aerospace Components

Source: https://www.alexanderthamm.com/de/artikel/digitalisierung-des-mittelstands/

6 DIGITAL GUIDANCE

Mass customization is a cornerstone in future manufacturing. Digital Guidance helps to minimize set-up-times by autonomously adapting facilities and controlling workflows.

5 DIGITAL TWINS

Accurate digital models represent both the product and the optimized production processes, saving costs, time and engineering efforts.

3 AUTONOMOUS ASSEMBLY

Intelligent autonomous robots assemble individually customized products using advanced planning algorithms, sensors and modular adaptive robotic skills.

4 ADDITIVE MANUFACTURING

Data analysis and digital tools improve manufacturing methods resulting in complex and individual parts with optimized geometries and improved component properties.

2 MOBILE MANIPULATION

Mobile autonomous production units fitted for carrying out a variety of back-work like tasks help to overcome static shop floor layouts.

1 HUMAN-ROBOT COLLABORATION

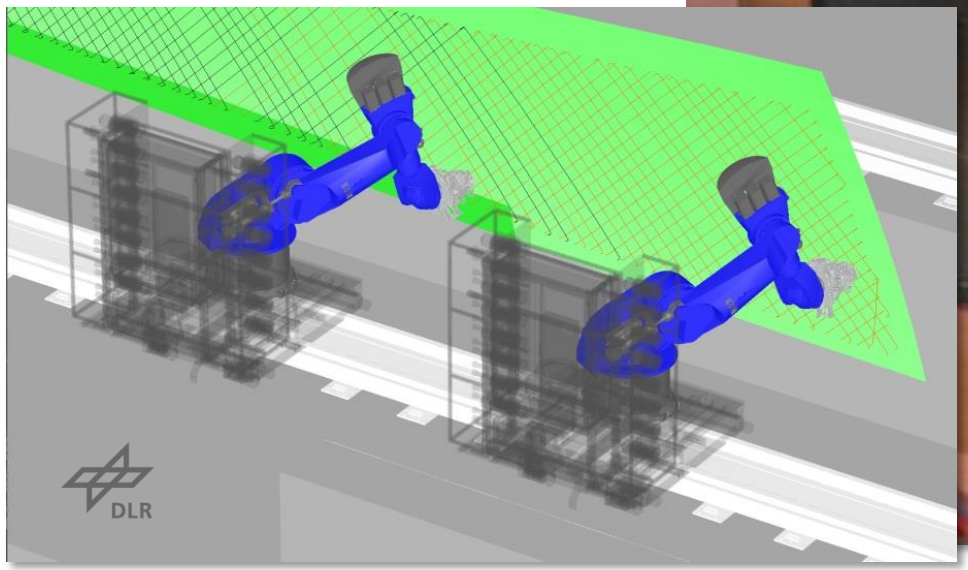
Intelligent robotic assistants and their human co-workers interact via intuitive, multimodal programming interfaces and share their workspace in safe and efficient industrial applications.

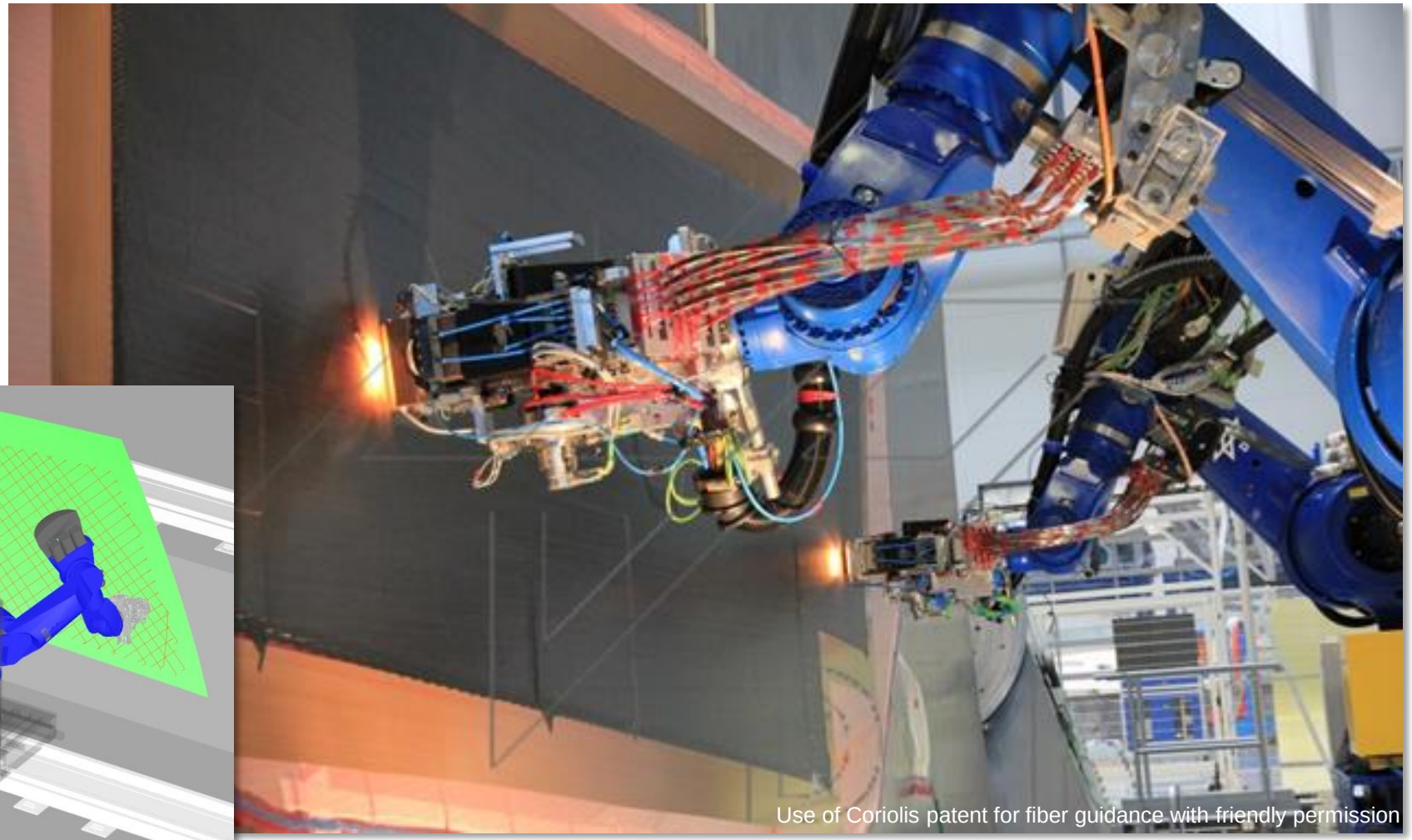
Factory of the Future

Future Factory for Composites

How does it look like?

Smart machine control for Multi-Head Automated Fiber Placement

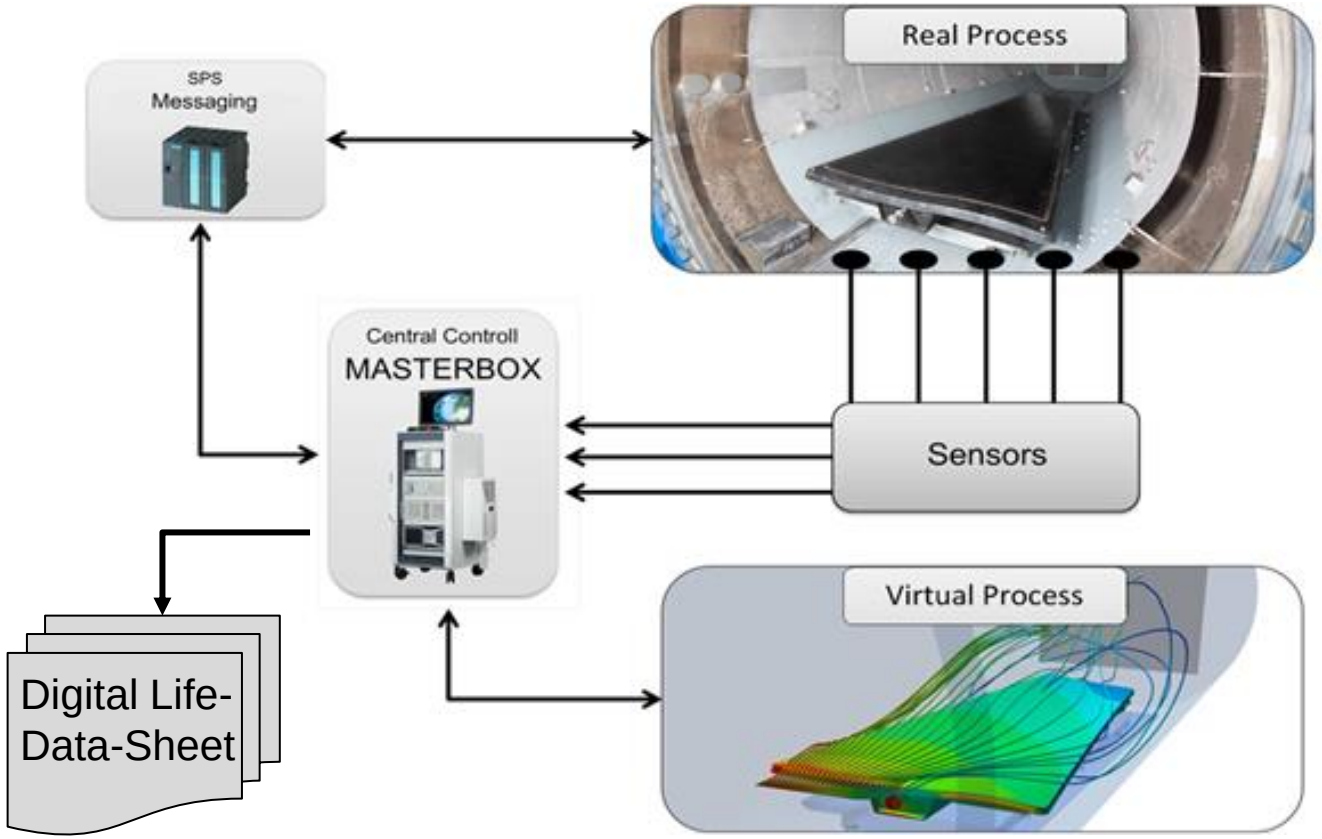


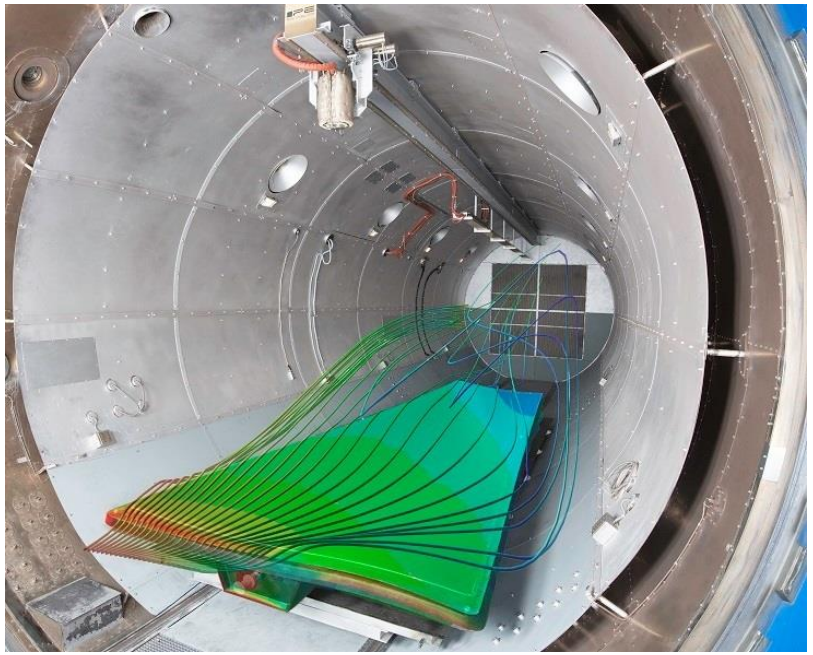


Use of Coriolis patent for fiber guidance with friendly permission

Digital twins as enabler for efficient composite processing

- The Virtual Autoclave – a digital twin of the real process

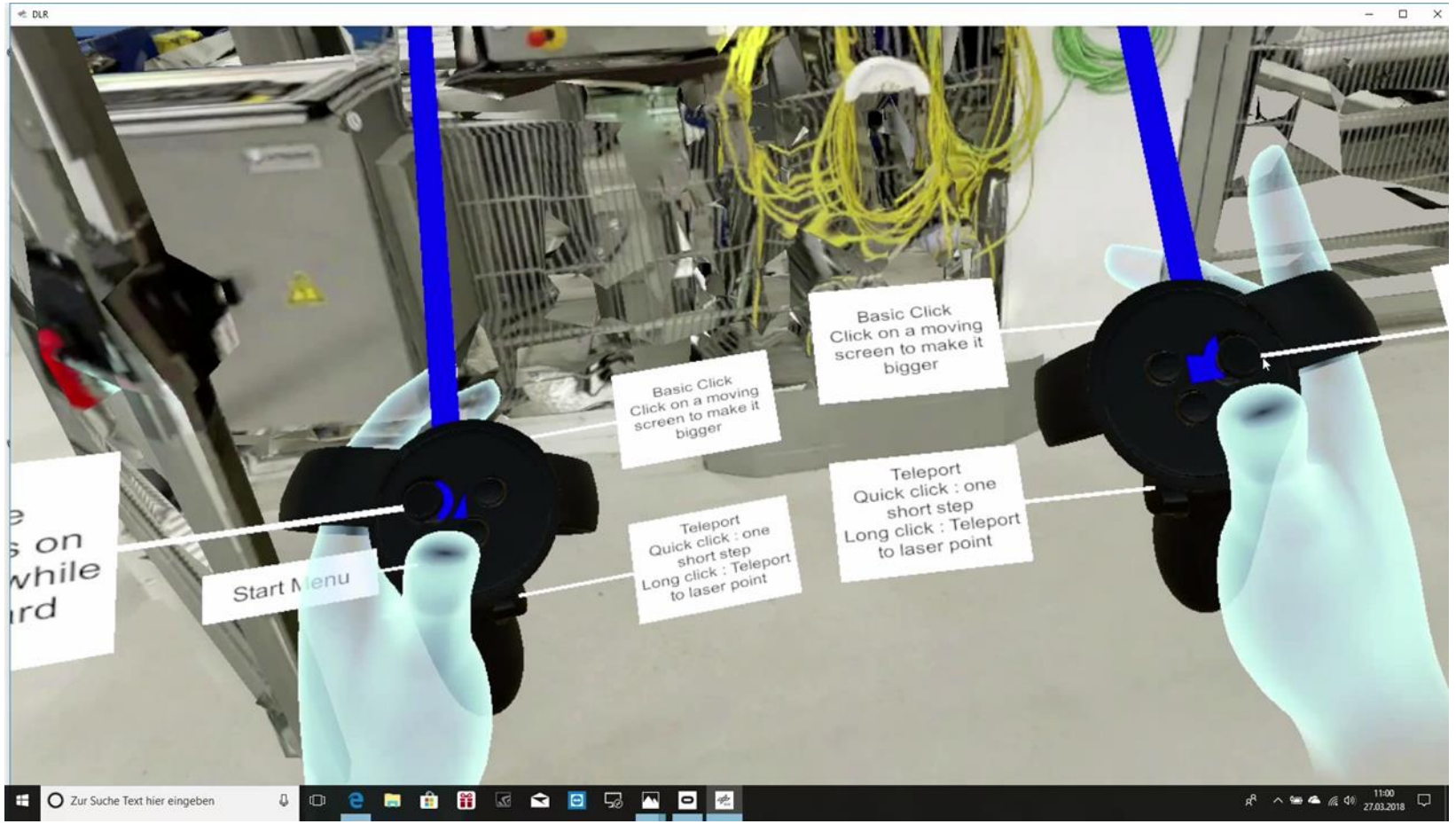




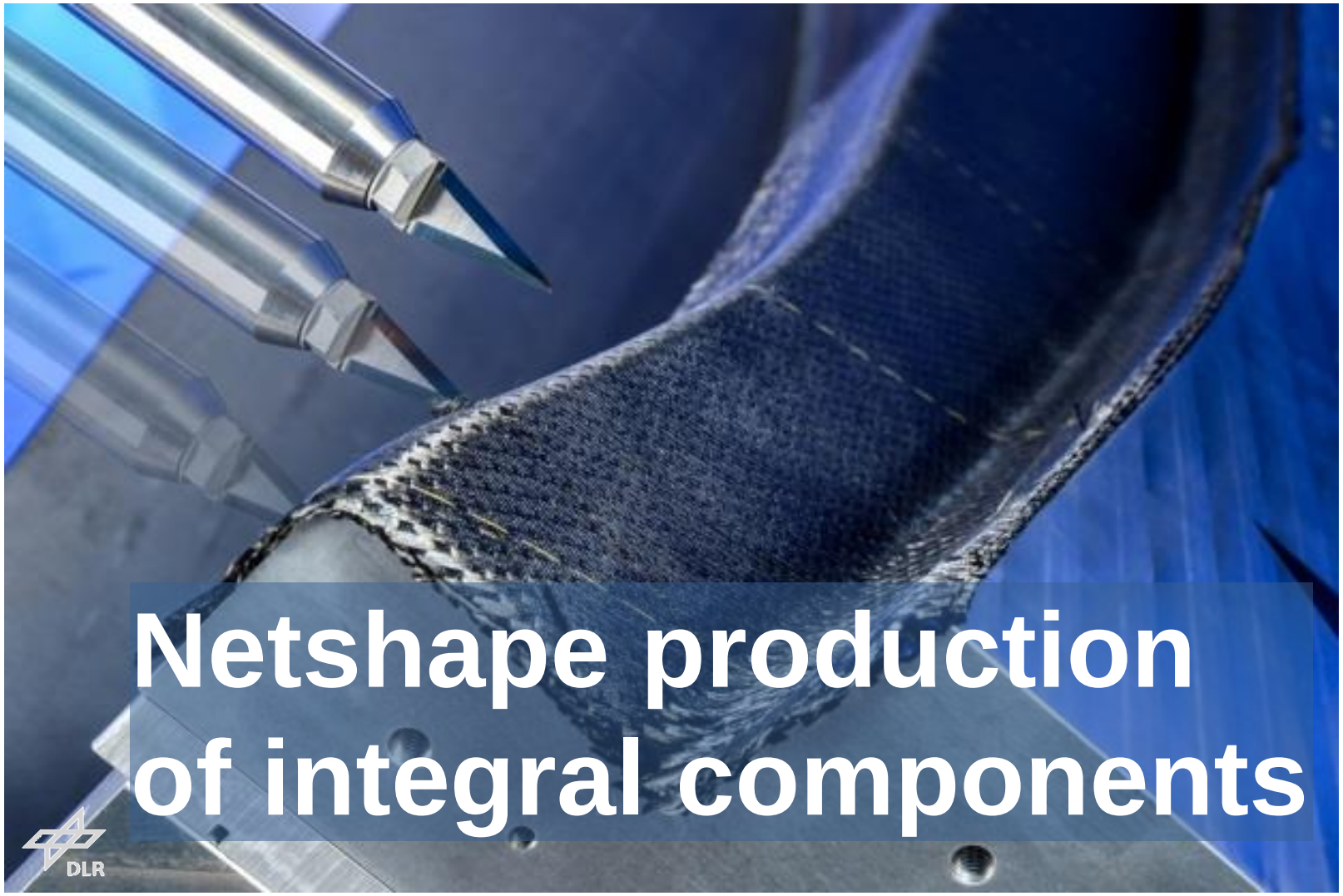
Simulation of heat flow inside the autoclave

Human Aided Automation by Virtual and Augmented Reality

- Reinvolve Human into Automation
- Smart Remote Maintenance
  - VR-login for service provider
  - AR for on-site worker
- Process Monitoring
  - Process data displayed in the right context
- Colaborative Troubleshooting
  - Multi User VR/AR
- „Replay“ as process documentation
  - Review process as happened
  - Walk through instead of one-perspective video



Trend No. 2 in the manufacturing of Composite Aerospace Components



Fully automated textile preforming and RTM-production

9. curing

8. isothermal 2C injection

7. loading/ 10. demoulding

production flow

RTM

preforming

cutting

6. trimming to net shape

5. compressing

4. draping

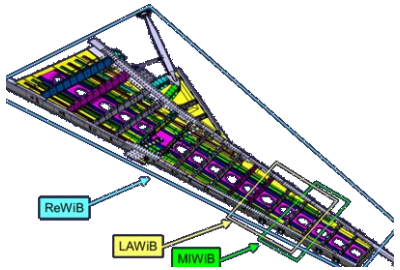
1. textile storage

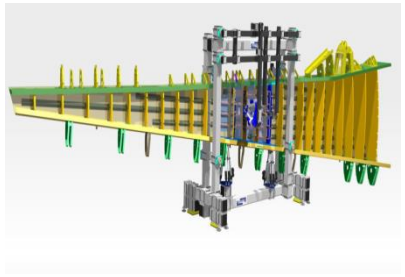
2. textile cutting

3. textile handling

Example for application of netshape composite production: Competitive Composite Rib - LOCOMACHS

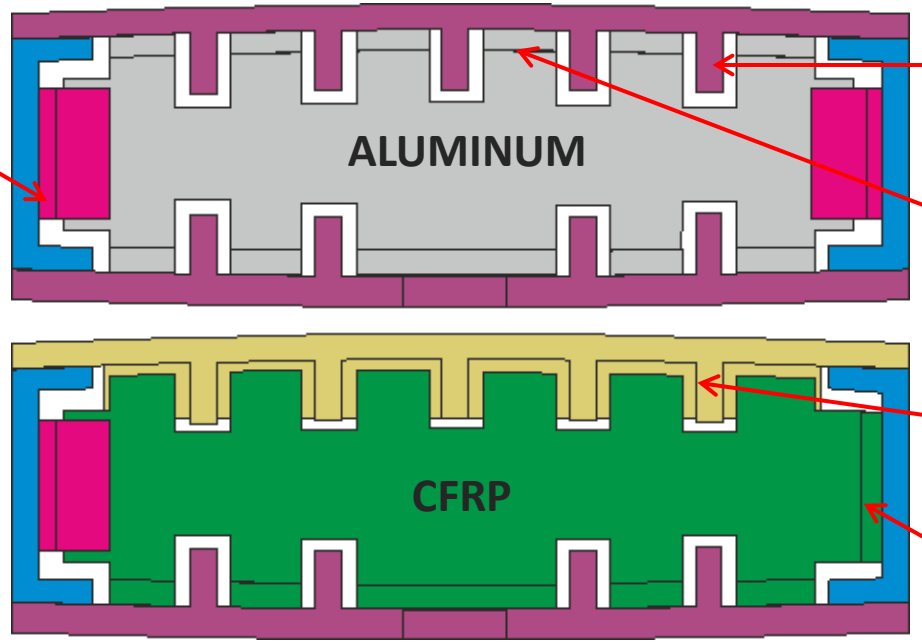
Global Wing Box Design Modification





Former Box Design

Separated
Rib Posts



Stringer Integrated
Upper Cover

Rib Integrated
Rib Feet

Stringer and Rib Cap
Integrated Upper Cover

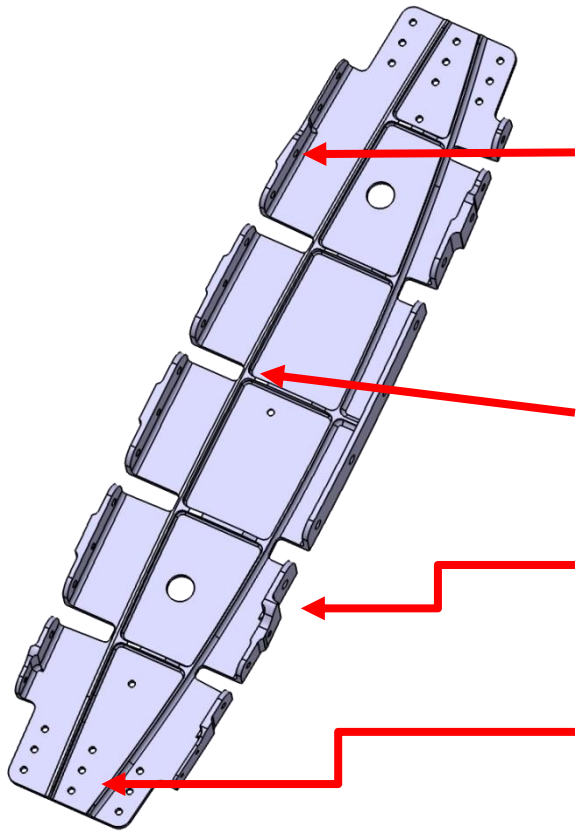
Rib Integrated
Rib Post

LOCOMACHS Box Design

The research leading to these results has received funding from the European Union's Seventh Framework Programme (FP7/2007-2013) under grant agreement n°314003.

Example for application of netshape composite production: Competitive Composite Rib - LOCOMACHS

Detailed Rib Design Modification

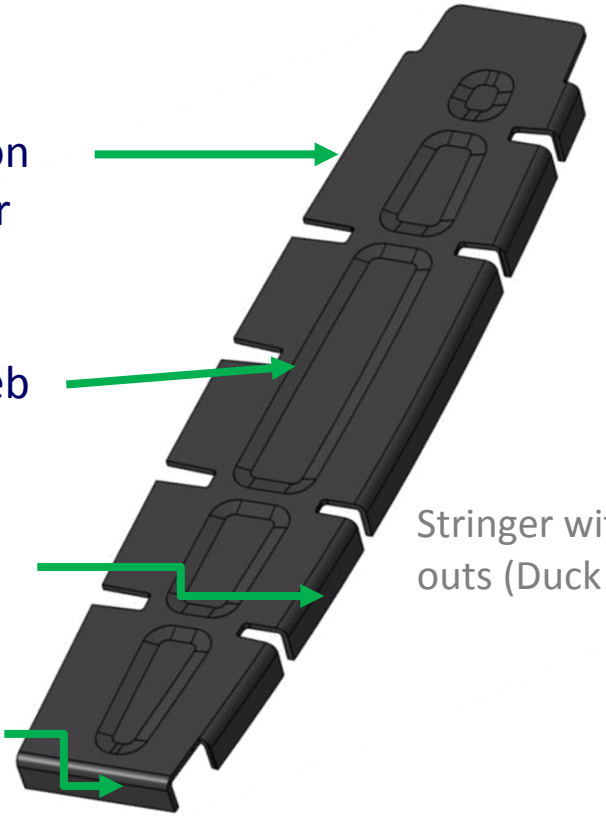


Tolerance compensation option at joint to upper cover

Composite adapted web reinforcement

Reduced complexity at joint to lower cover

Integration of rib post on one side



Stringer with local grow outs (Duck Feet) required

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Example for application of netshape composite production: Competitive Composite Rib - LOCOMACHS

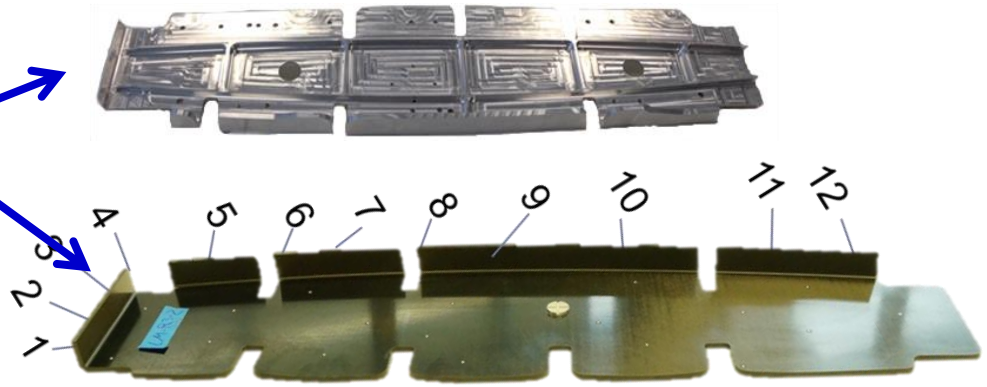
Geometrical Accuracy and Weight

Flange Angle

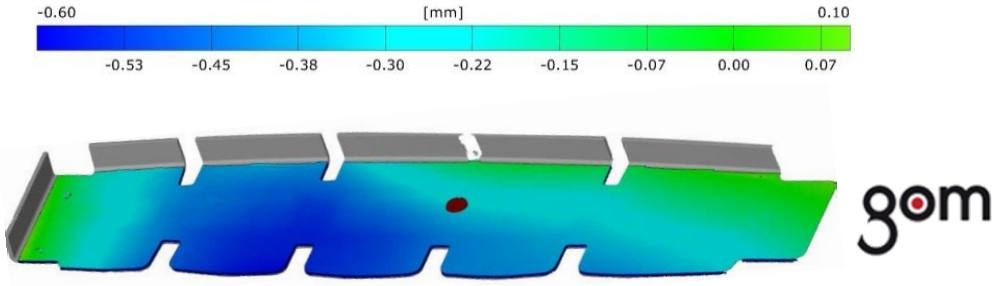
	Nominal	Measured	Delta
Angle 1	90,00	89,95	**-0,05**
Angle 2	90,00	90,08	**0,08**
Angle 3	90,00	90,07	**0,07**
Angle 4	90,00	90,08	**0,08**
Angle 5	88,88	88,99	**0,11**
Angle 6	88,86	88,92	**0,06**
Angle 7	88,81	88,90	**0,09**
Angle 8	88,72	88,72	**0,00**
Angle 9	88,66	88,67	**0,01**
Angle 10	88,55	88,58	**0,03**
Angle 11	88,53	88,56	**0,03**
Angle 12	88,52	88,59	**0,07**

Geometrical accuracy requirements of flanges met

Weight Saving of more than 40%



Deformation in mm

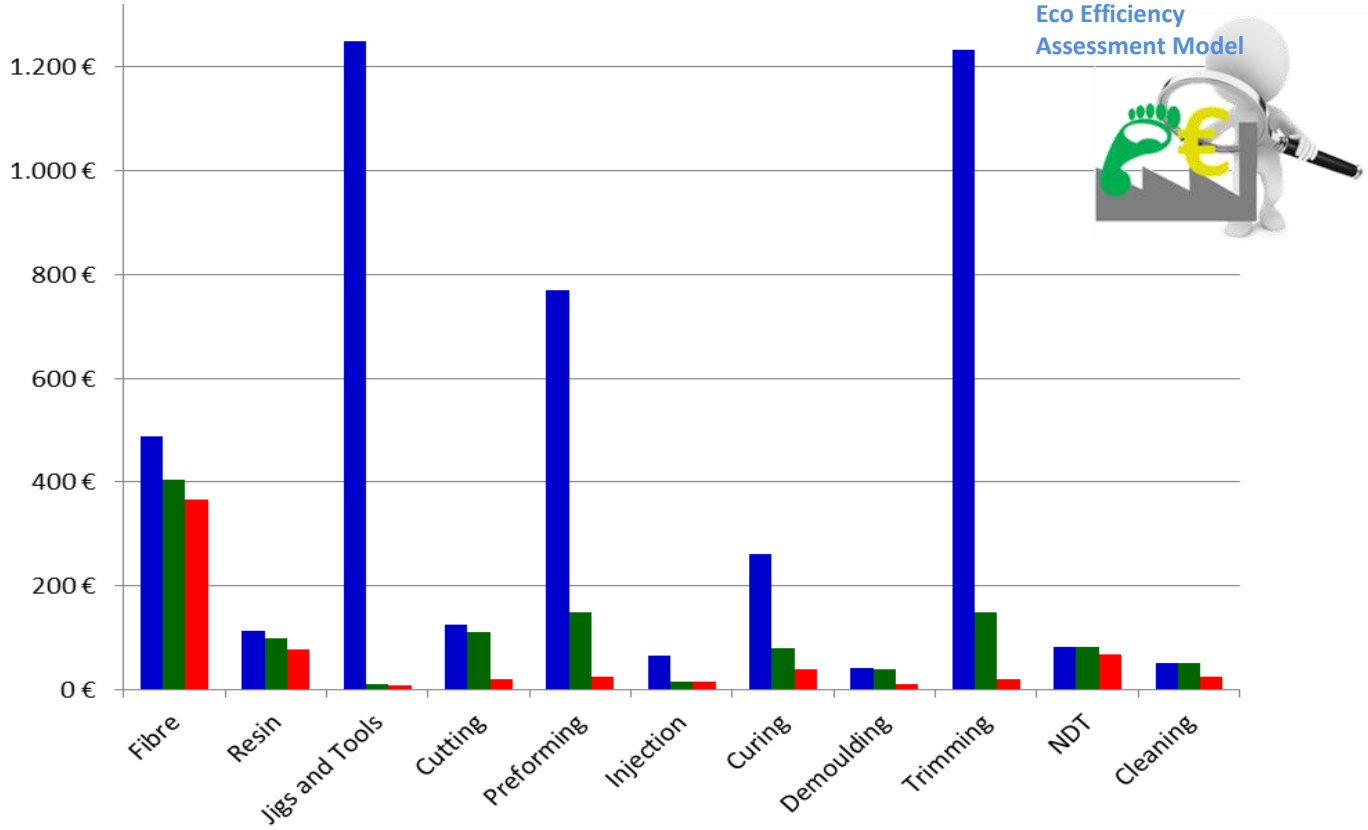


Global geometrical accuracy requirements met

The research leading to these results has received funding from the European Union's Seventh Framework Programme (FP7/2007-2013) under grant agreement n°314003.

Example for application of netshape composite production: Competitive Composite Rib - LOCOMACHS

Production Cost Estimation



Eco Efficiency Assessment Model

Assessment
8 Produced Prototypes
1280 €/kg
RMS 13%

Estimation
Typ. Aerospace Series
340 €/kg
RMS 43%

Outlook
High Rate Production
190 €/kg
RMS 66%
(net shape+ isotherm)

RMS: Raw Material Share

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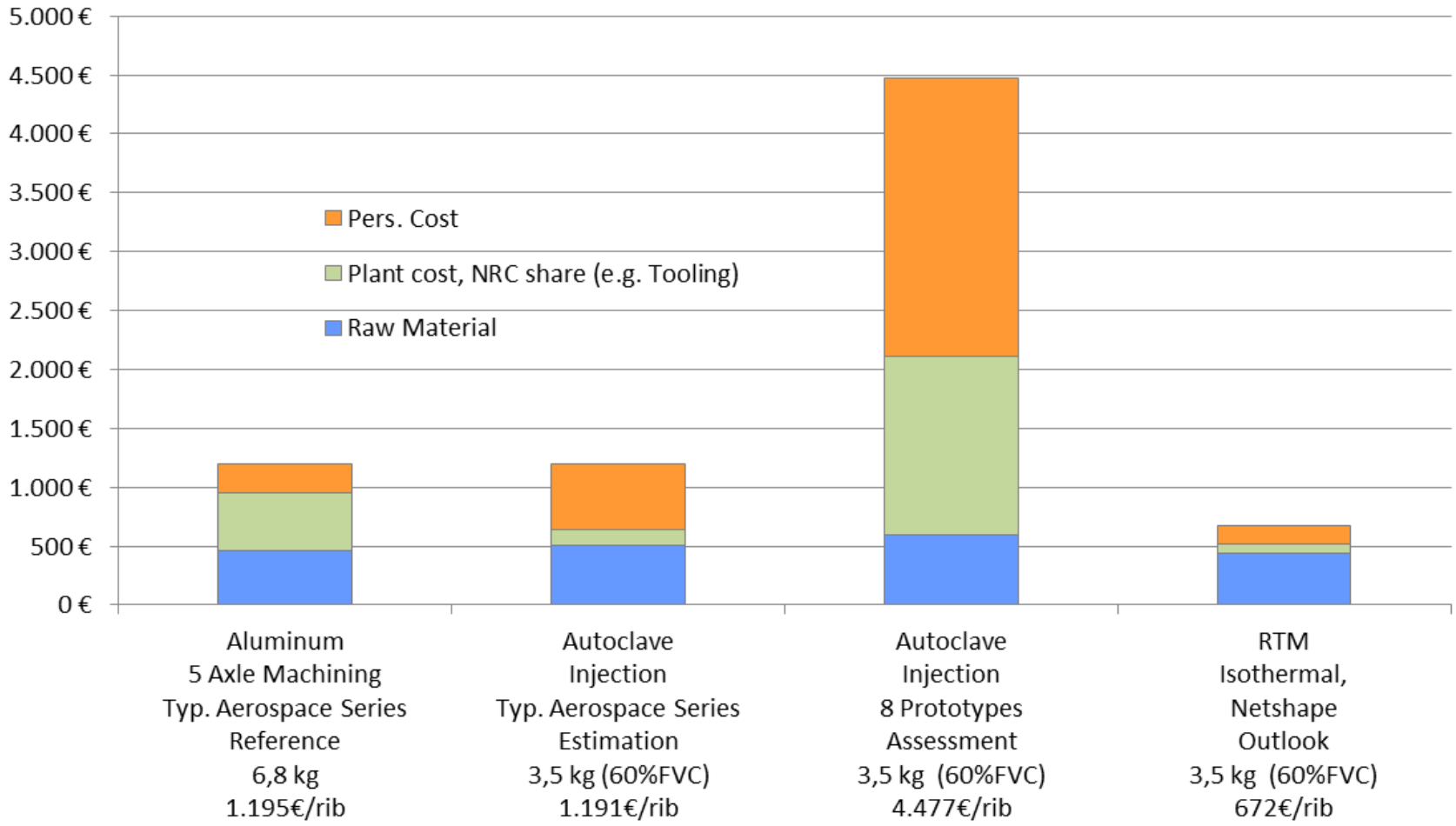
Example for application of netshape composite production: Competitive Composite Rib - LOCOMACHS

Production Cost Estimation



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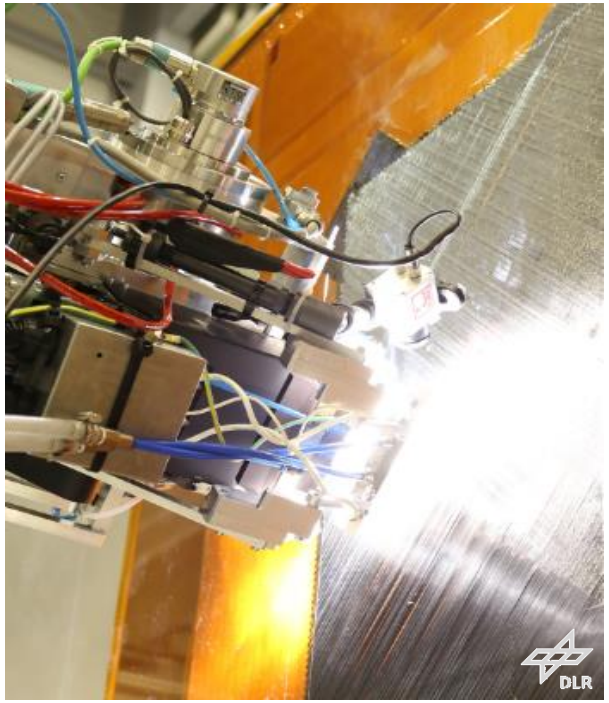
Trend No. 3 in the manufacturing of Composite Aerospace Components

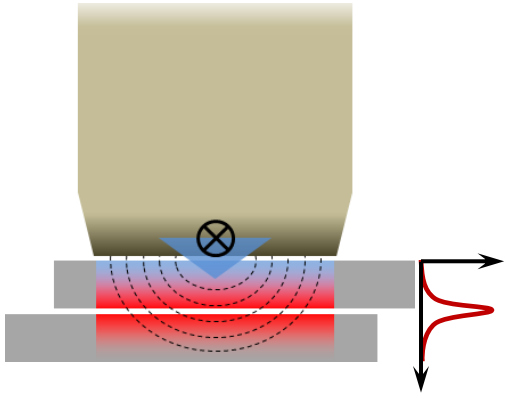
Carbon Fiber Reinforced Thermoplastic (CFRT) material for aerospace components

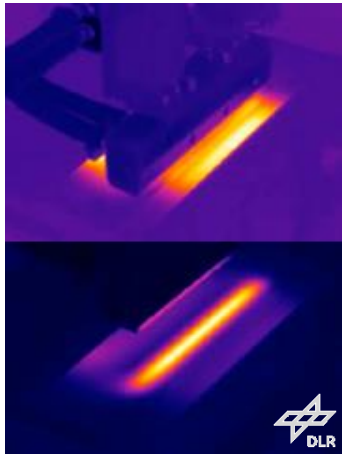
Faster processing of components

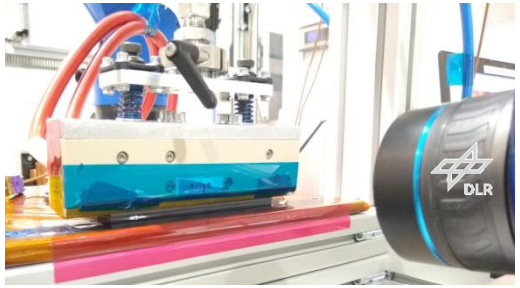


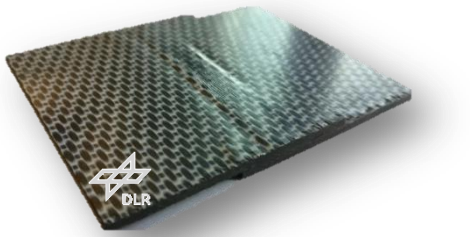
Automated Fiber Placement of CFRT using HUMM3-Flashlamp

and weldability for assembly without riveting









Induction welding of PEEK-CFRT as an example

Use Carbon Fiber Reinforced Thermoplastic (CFRT) material for aerospace components

Current product developments: Rear pressure bulkhead made of CFRT in automated production

Realized by DLR Center for Lightweight-Production-Technology Augsburg and Premium Aerotec GmbH, Augsburg

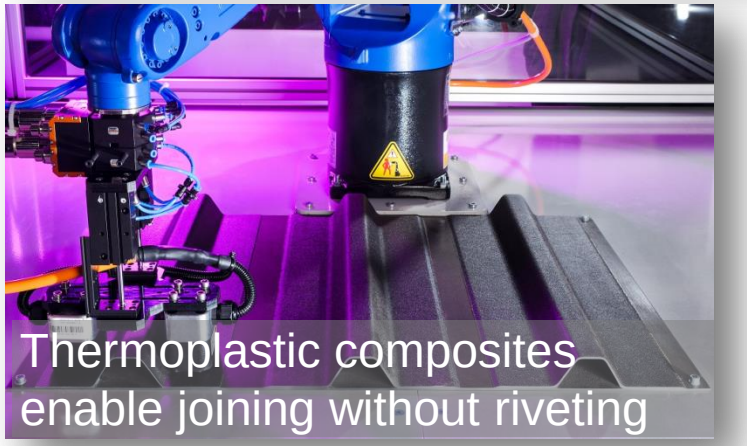
Source: https://www.compositesworld.com/blog/post/new-horizons-in-welding-thermoplastic-composites

Conclusion

Automation in composite production is needed to enable rate and constancy of quality

Digitization enables smart processing and the creation of digital Life-Data-Sheets

Netshape production avoids post processing and reduces waste



Thermoplastic composites enable joining without riveting

DLR


Thank you
for your attention!