Human Aided Automation – a Game Changing Chance for the Aerospace Industry

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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

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

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.

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.

4 ADDITIVE MANUFACTURING

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

1 HUMAN-ROBOT COLLABORATION

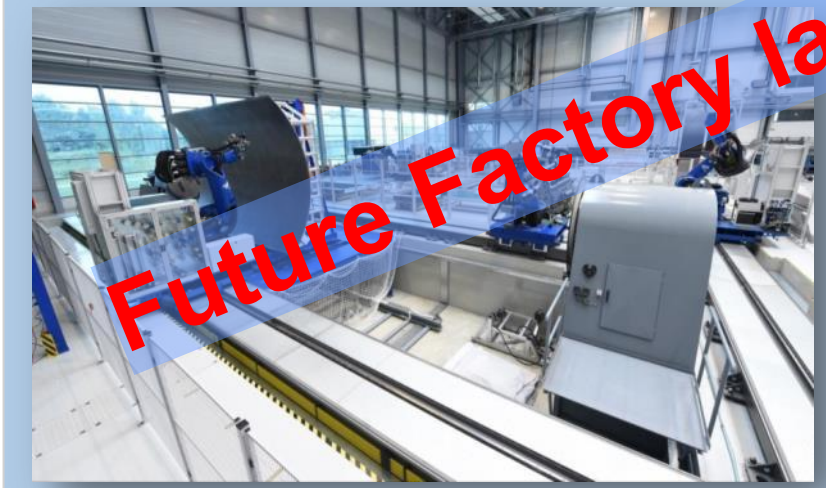
Intelligent robotic assistants and their human co-workers interact via intuitive, multimodal programming interfaces and share their workspace in safe and efficient industrial applications.

Factory of the Future

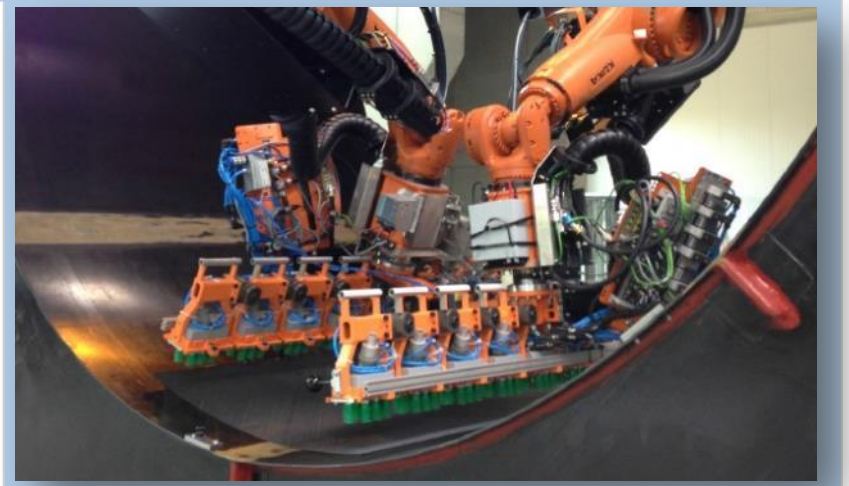
The DLR Center for Lightweight Production Technology (ZLP)

Objectives: Maximum floor-to-floor efficiency by high placement rate and robust placement devices
Placement rate: > 100 kg/h → industrial scale up to TRL 6

Stade
Multi-robot automated fiber placement
Autoclave technology
Fully automated preforming and RTM



Augsburg
Robot based dry placement of multi-axial fabrics
Vacuum infusion (VARI, VAP), oven curing

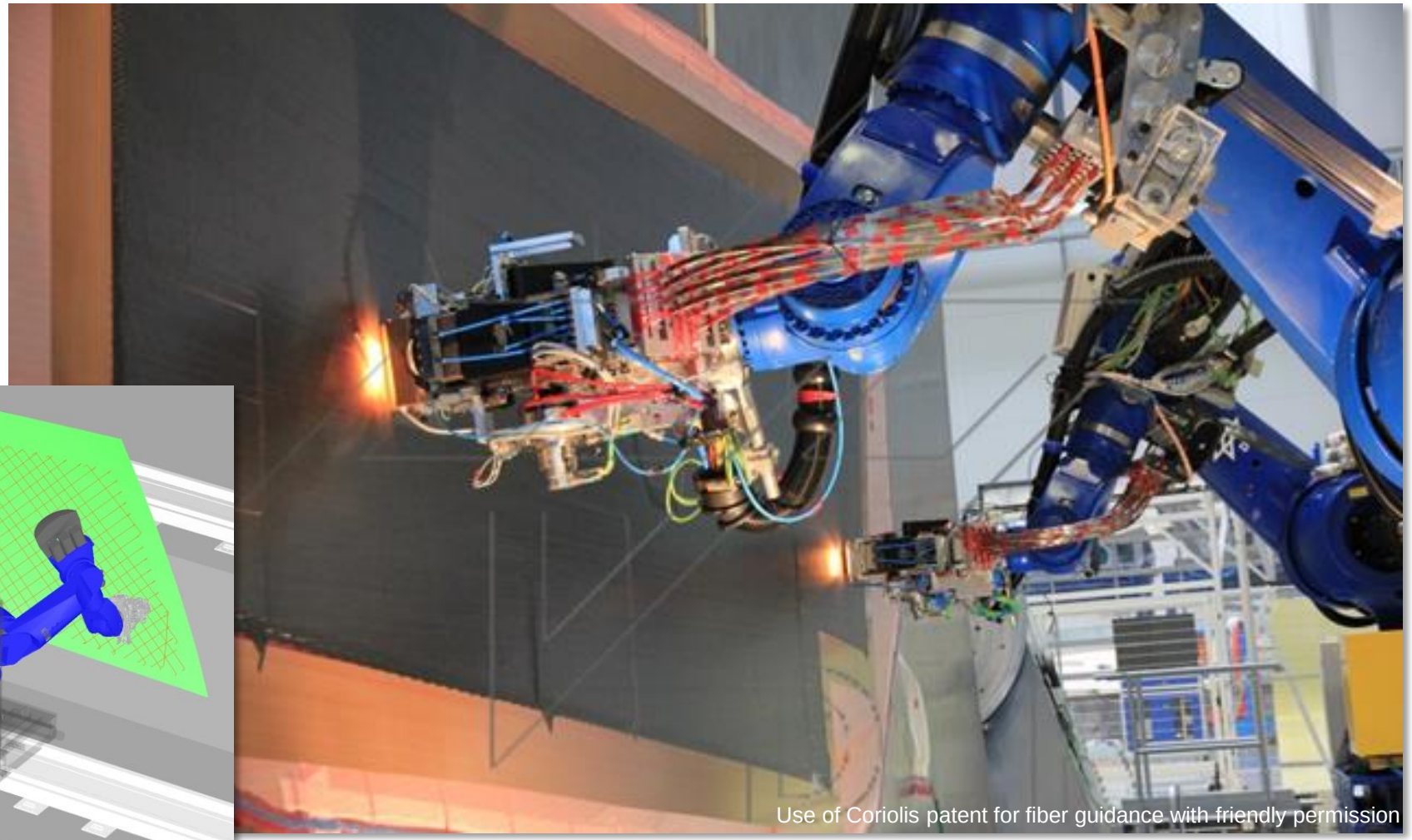


Future Factory labs for Composites

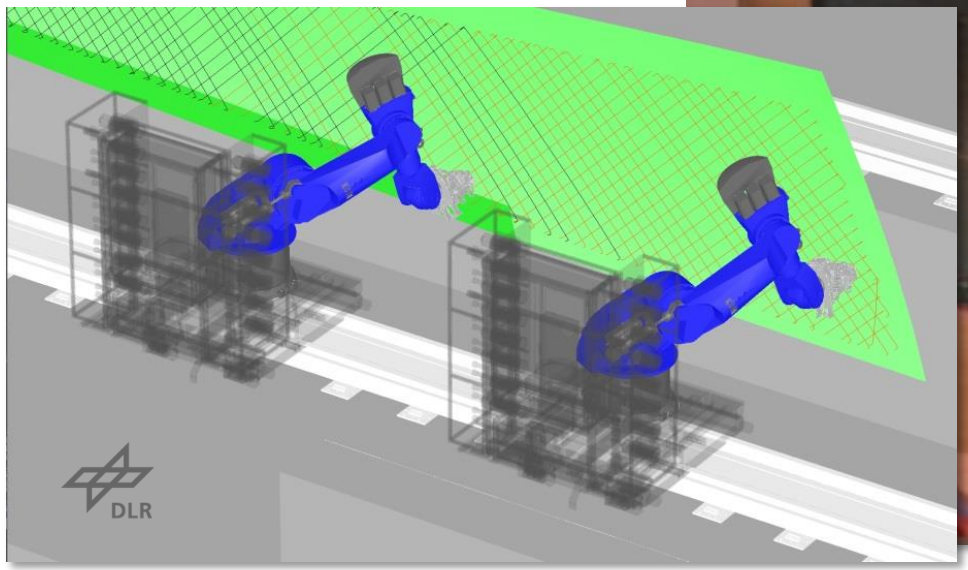
Future Factory for Composites

How does it look like?

Multi-Head Automated Fiber Placement

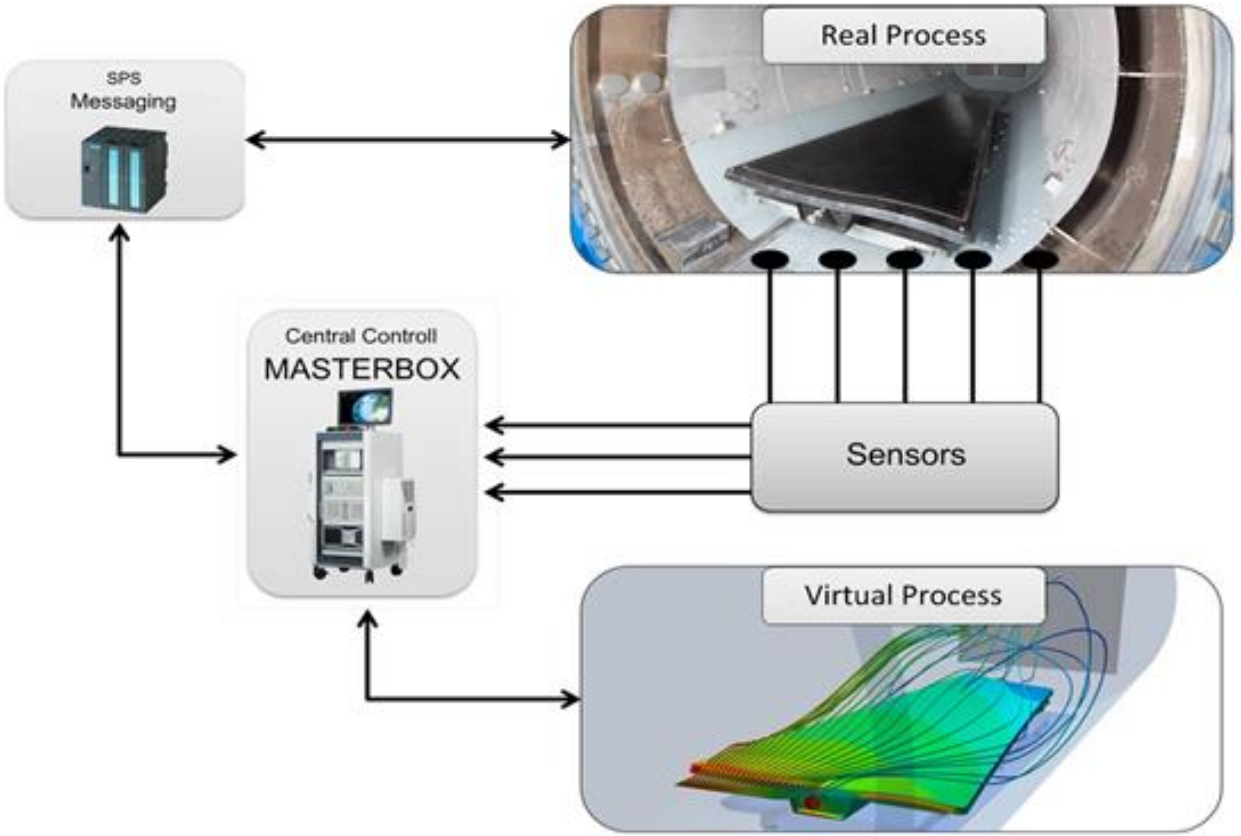


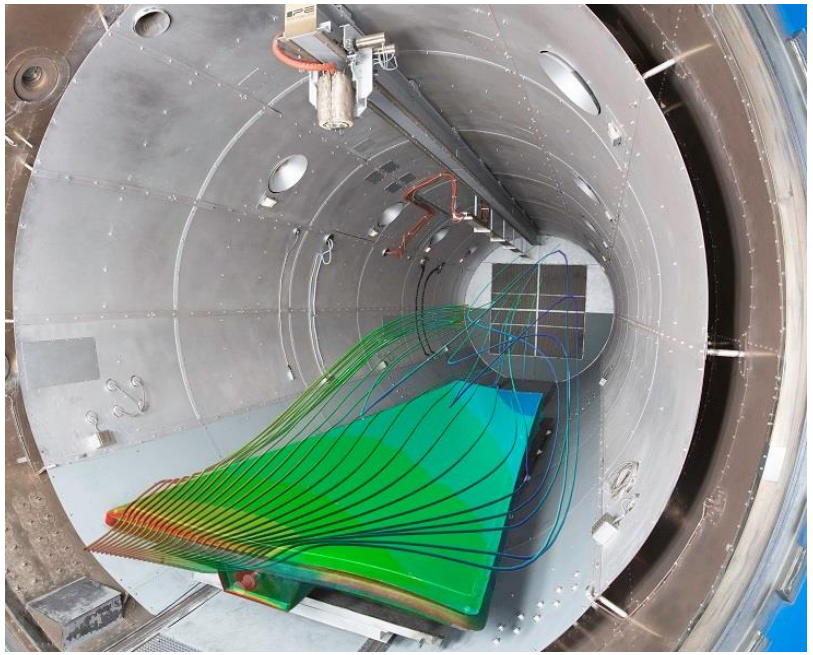
Use of Coriolis patent for fiber guidance with friendly permission



Smart and efficient autoclave processing

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





Simulation of heat flow inside the autoclave

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

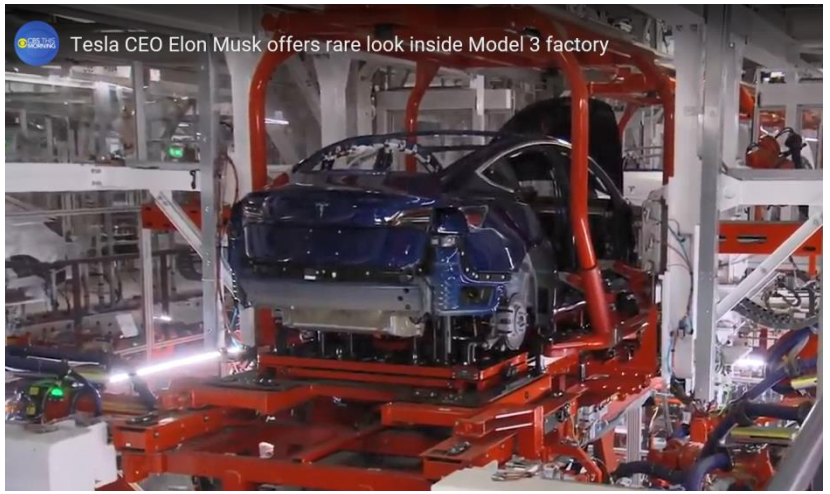
Fully automated textile preforming and RTM-production

- Example for demonstrator which has been produced by fully automated textile preforming and RTM-process: generic VTP-Rip

VTP-Rip

Today cycle time is limited to 25 min. due to curing time of qualified resin system

Over-automation: “Production Hell”

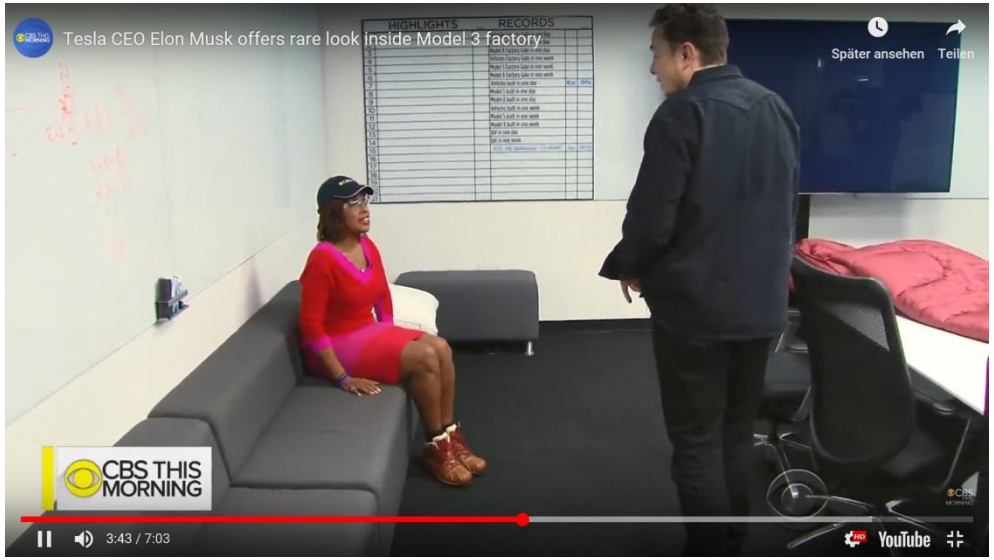


Elon Musk:

- Too many robots in the production process of the Model 3 led to
- "crazy, complex network of conveyor belts“.
- Robots slowed down production
- Start using more humans in the factory, to speed up production

Short way out:

- Take personally control over production line
- Sleep at the factory to keep it running



Learning element for Industry 4.0:

- **Where are human skills indispensable?**

Source: https://www.theinquirer.net/inquirer/news/3030277/elon-musk-admits-too-much-automation-is-slowing-tesla-model-3-production

Why does Human Aided Automation work for Composite Production?

In Composite Production possible sources of errors are very individual

In case-by-case decisions humans are superior to computers

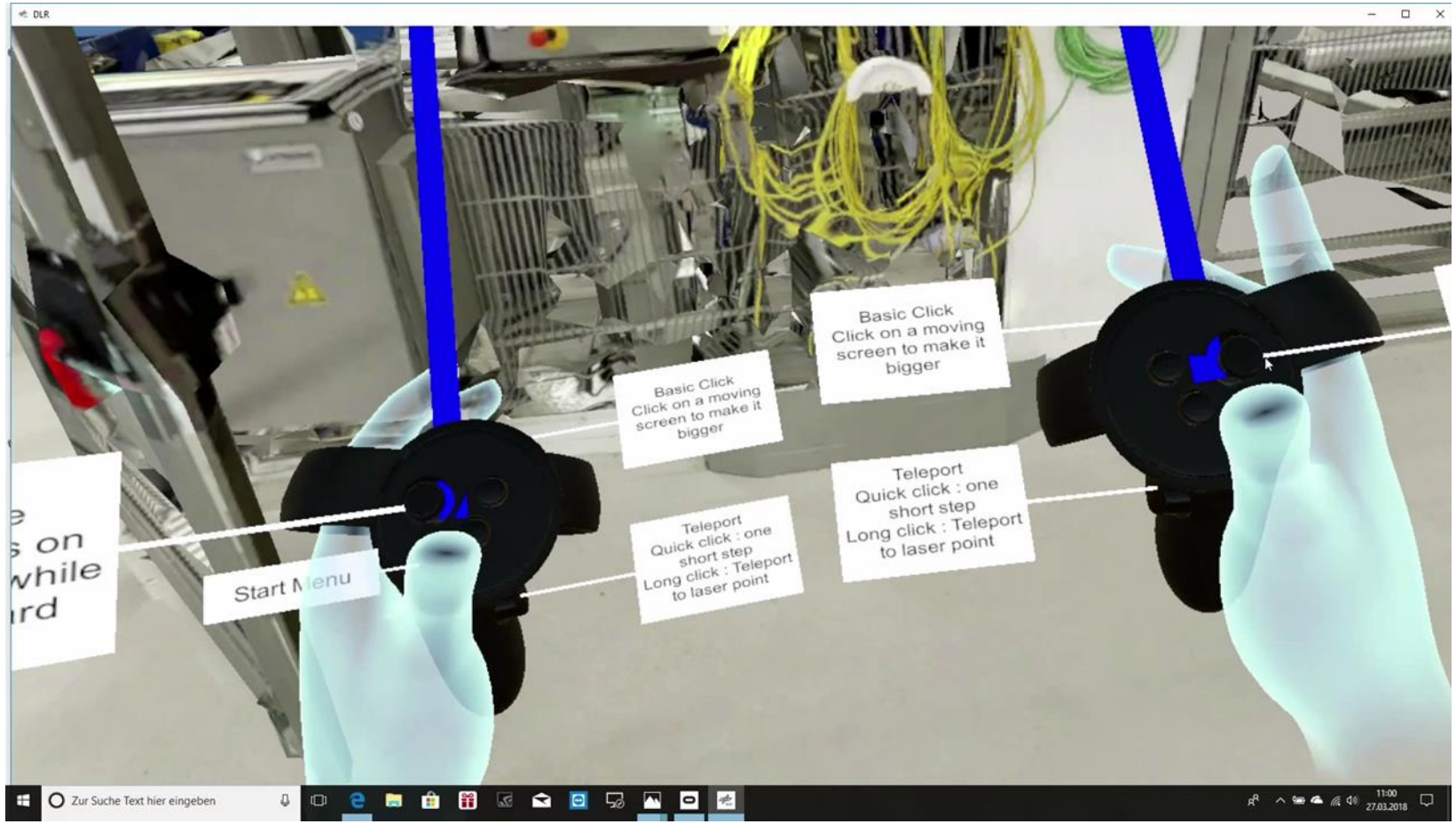
You can't step into fully automated processes physically to detect a problem…

… virtually, you can!

Automation suspends humans from interaction, digitization brings humans back to involvement

HR: Human Aided Automation

- 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



„*Human Centered Digitization*“ in lightweight construction

Manufactrue of substructures:

Individual correction of process- and material tolerances

Measurement of:
Fiber angle,
Flow front,
Part thickness,
Curing state,
…

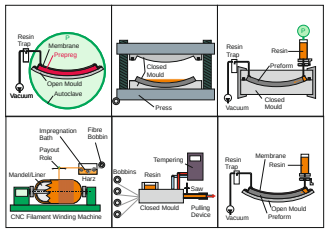
Actuation of:
Forming angles,
Pressures,
Temperatures,
Valves,
…

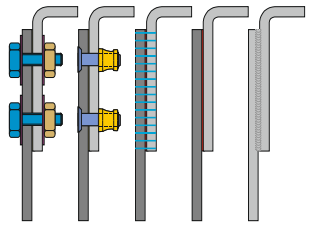
- Reduced process time
- Minimized scrap rate
- Inherent development
- Relaxation of specifications

Individual analysis of sustainability and productivity

Learning aptitude

production and assembly conform **Design** with weighted tolerance windows



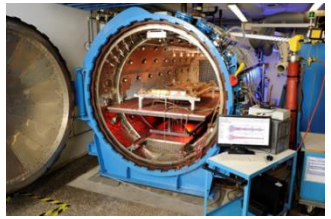


Feed-back

Interactive correction of processes

Interactive Joining of substructures

Feed-back



Assembly of substructures:

Usage of elasticity and plasticity for gap avoidance

Measurement of:
Surfaces,
Clearances,
Joining Forces,
Adhesive Distribution,
…

Actuation of:
Treatment,
Positioning,
Compression,
Dwell Time,
…

- Reduced correction efford
- Reduced Lead Times
- Scaling Options
- Adaptability due to Modularity

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Conclusion

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

Especially RTM offers many opportunities for automation

Digital twins and augmented reality methods re-involve humans in automated processes

Human Centered Digitization enables efficiency, traceability and quality control in composite manufacture

Thank you for your attention!