# Automated net-shape preforming of MAAXIMUS C73 frames

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# Agenda

- Overview – MAAXIMUS project (DLR activities)
- Overview – MAAXIMUS work package C73 frames
- C73 frame: RTM process chain
- Automated net shape preforming process
- Achievements
- Conclusions & Outlook

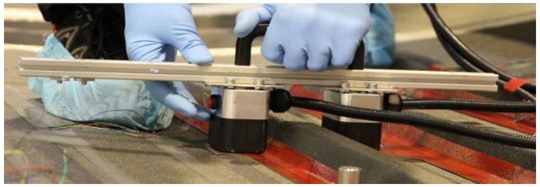
# Overview – MAAXIMUS project (DLR activities)

**MAAXIMUS** (**M**ore **A**ffordable **A**ircraft through e**X**tended, **I**ntegrated and **M**ature n**U**merical **S**izing)

- Automated tape laying of shell on vertical tool

- Manual manufacturing of all stringers

- Co-bonding of cured stringers with a new inductive heating device



- Automated preforming of two C73 frames

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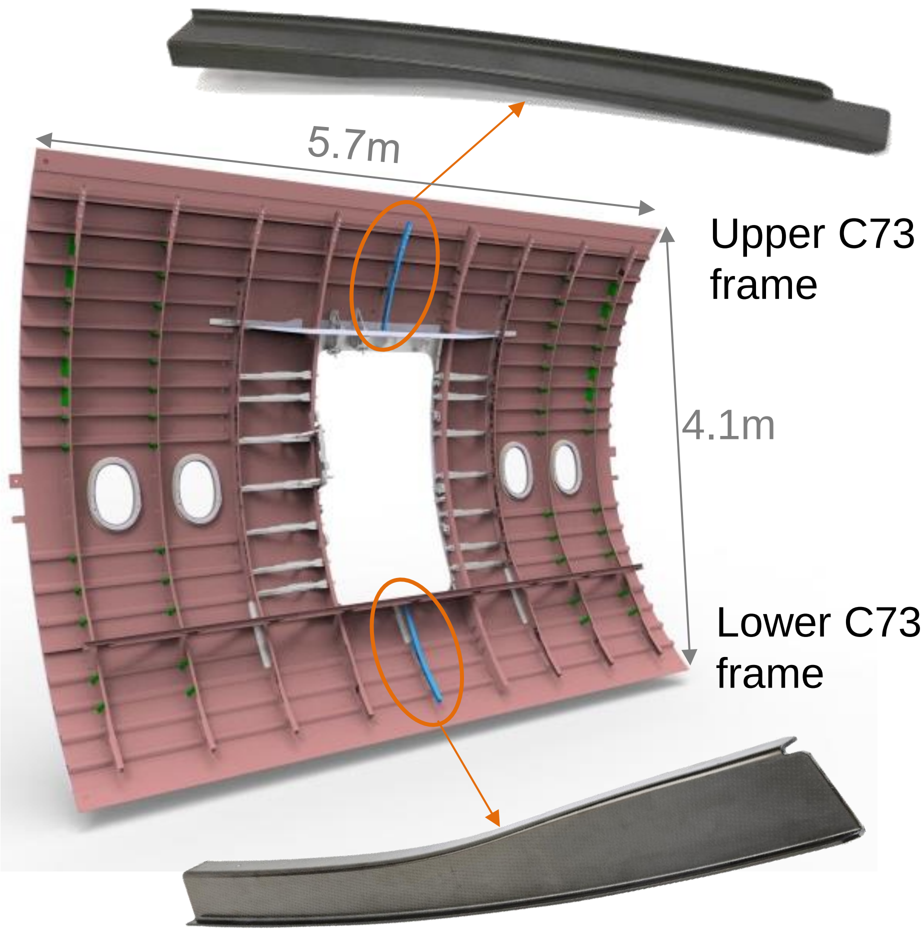
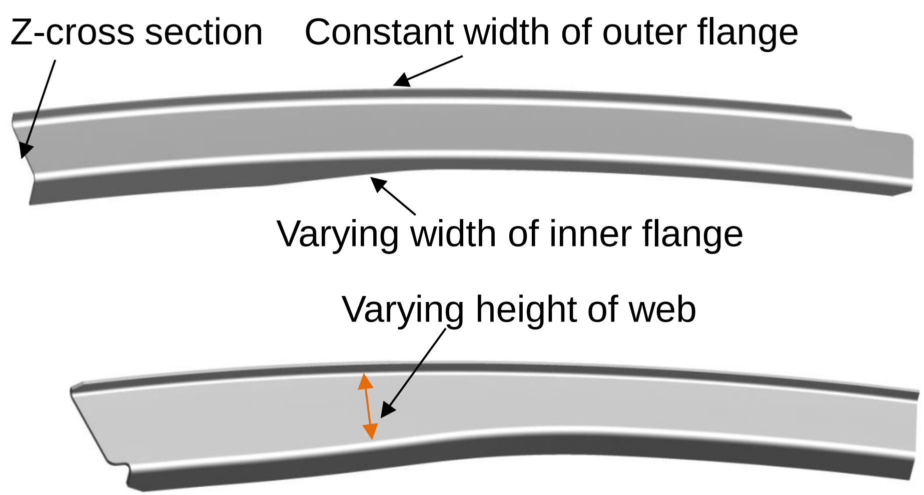
# Overview – MAAXIMUS work package C73 frames




Facts of both C73 frames of the MAAXIMUS panel

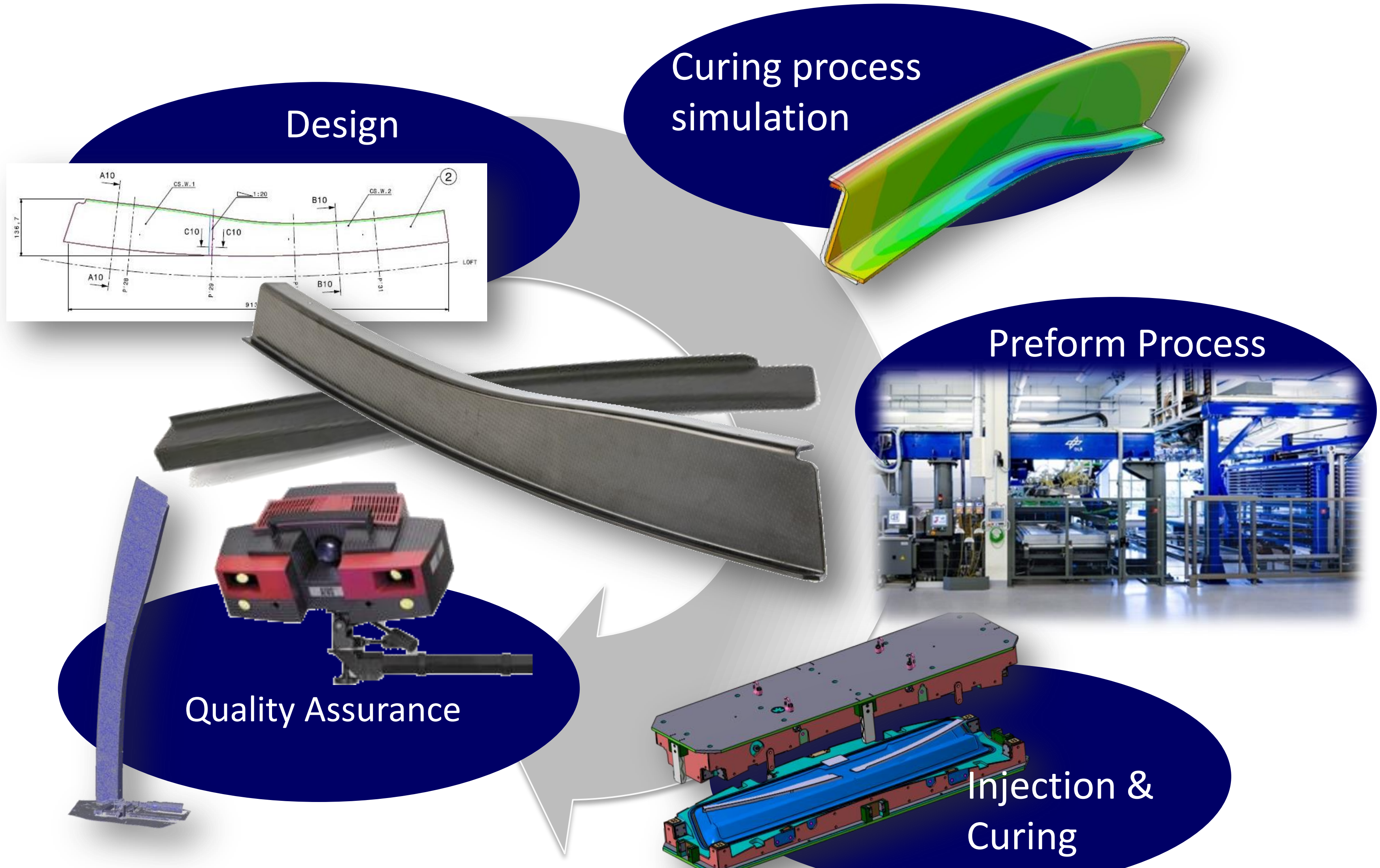
- Z-profile cross-section, approx. 1 m length
- Varying web height, varying flange width, several patches in inner flange and web
- Dry carbon and glass fiber woven fabric



# Motivation

- Automated manufacturing of frames in an industrial environment
- Demonstration of a reproducible and robust process
- Flexible production line regarding different frame geometries
- Improved dimensional fidelity (spring-in compensated toolings)
- Less material waste (net-shape approach)

# C73 frame: RTM process chain



# Video – Automated net shape preforming

If you are interested in the video please write me an email

# Achievements - Preforming

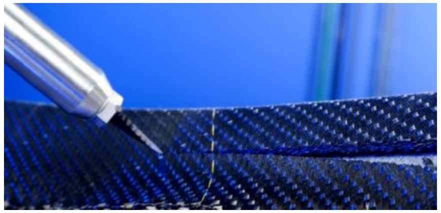
- Successful manufacturing of 20 CFRP frames with one production line

- Process times
  - Ply preparation (one nesting) : 5 min
  - Preforming (one ply) : 4,5 min
    (Draping+QA+binder activation+QA)
  - Consolidation (whole preform) : 20 min
  - Fine trimming : 7 min

92 min for upper C73 (9 plies)

118 min for lower C73 (16 plies)

- Net shape fine trimming
  - Precise cutting edges, no fiber delamination
  - Local optimization of contour trimming could be realized



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# Achievements - Preforming

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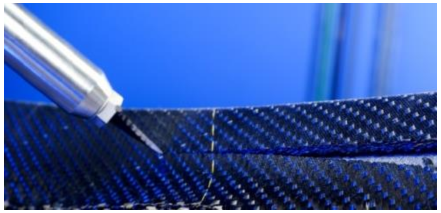
…min for upper C73 (9 plies)

118 min for lower C73 (16 plies)

**Time reduction of >25% can be realized by further optimization**

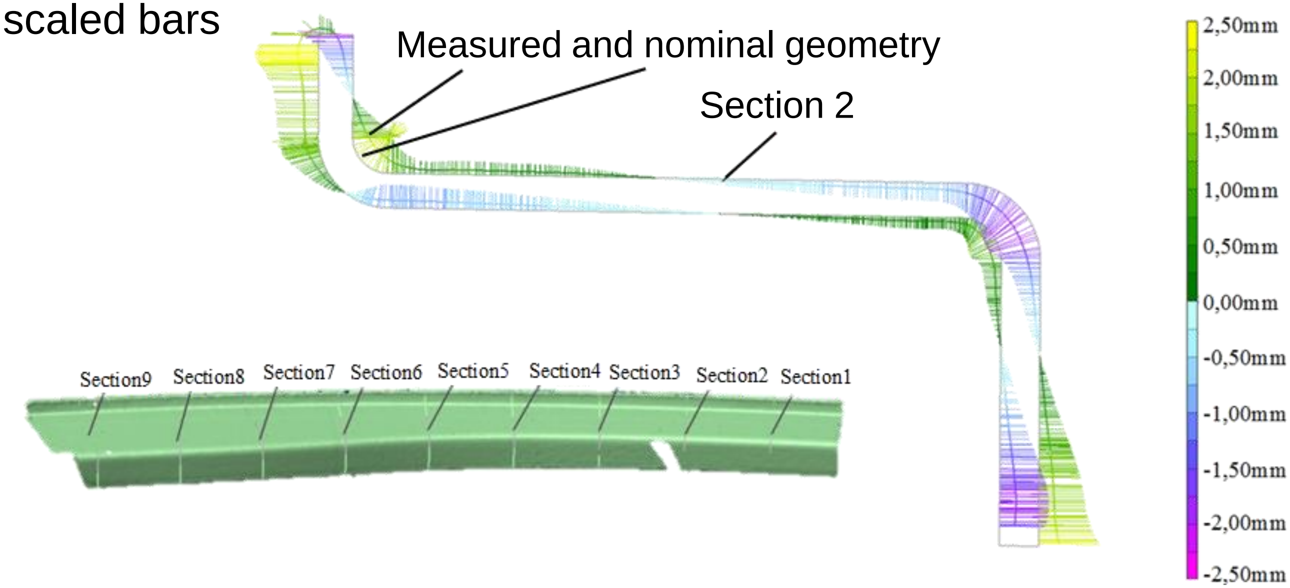
- Net shape fine trimming
  - Precise cutting edges, no fiber delamination
  - Local optimization of contour trimming could be realized

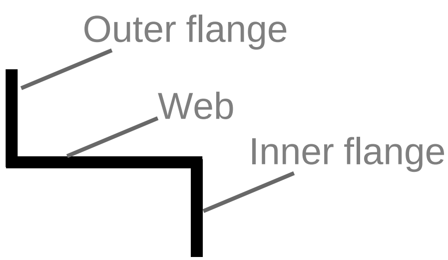


# Achievement - Preforming

Laser scan of the preform topology

- Target-performance comparison
- Deviations visualized by scaled bars




| | Angle in [°] *(Inner flange to web)* | Angle in [°] *(Outer flange to web)* |
|---|---|---|
| Upper C73 (target: 90,7°) | 100,5 | 109,8 |
| Lower C73 (target: 90,7°) | 99,0 | 104,1 |

# Achievement - Preforming

Laser scan of the preform topology

- Target-performance comparison
- Deviations visualized by scaled bars

➢ Bulking analysis of different materials by different process parameters

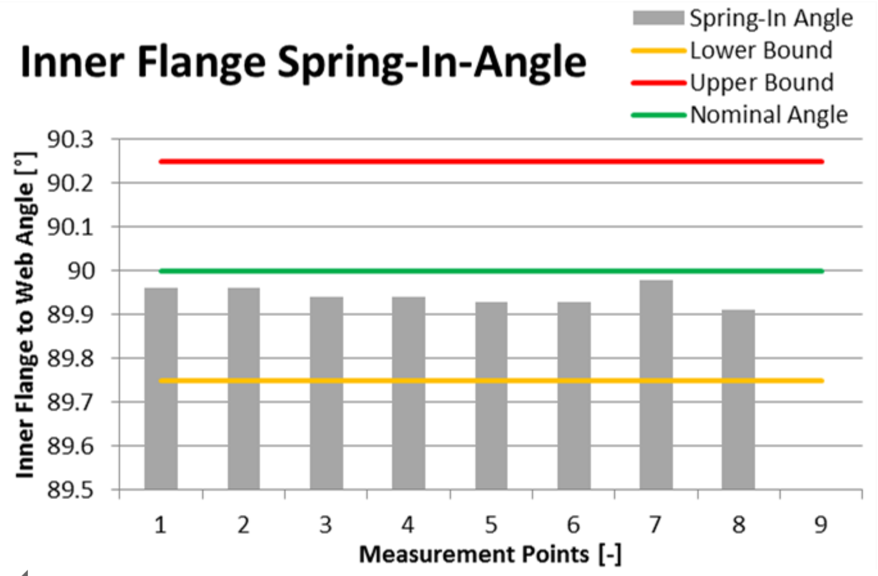
Force sensor

Laser distance measurement

Heating plate

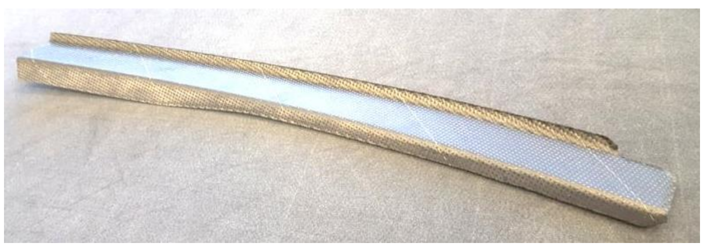
# Achievements – Injection and quality assurance

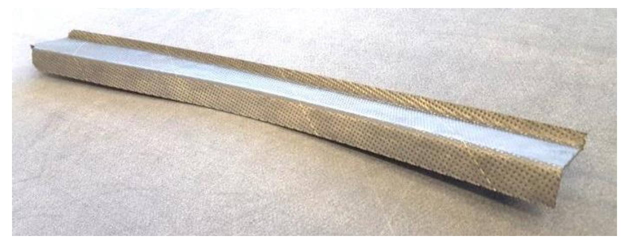
- Reduction of RTM process time by 60% by isothermal RTM process
- No findings in nondestructive testing (NDT) of all manufactured parts
- Geometrical shape verification of cured part in required space
- One set of C73 frames is installed in the test panel



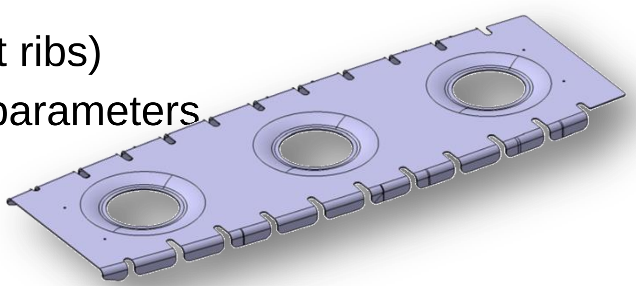

# Conclusions & Outlook

- Automated manufacturing of two different frames with one production line has been realized
- 20 net-shape preforms with no findings in NDT were manufactured
- Reduction of RTM process time by 60%
- Spring-in compensation strategy was successfully applied
  - Airbus tolerances were met for all frames





- Demonstration of the whole RTM production process (aircraft ribs)
- Bulking analysis of different materials with different process parameters



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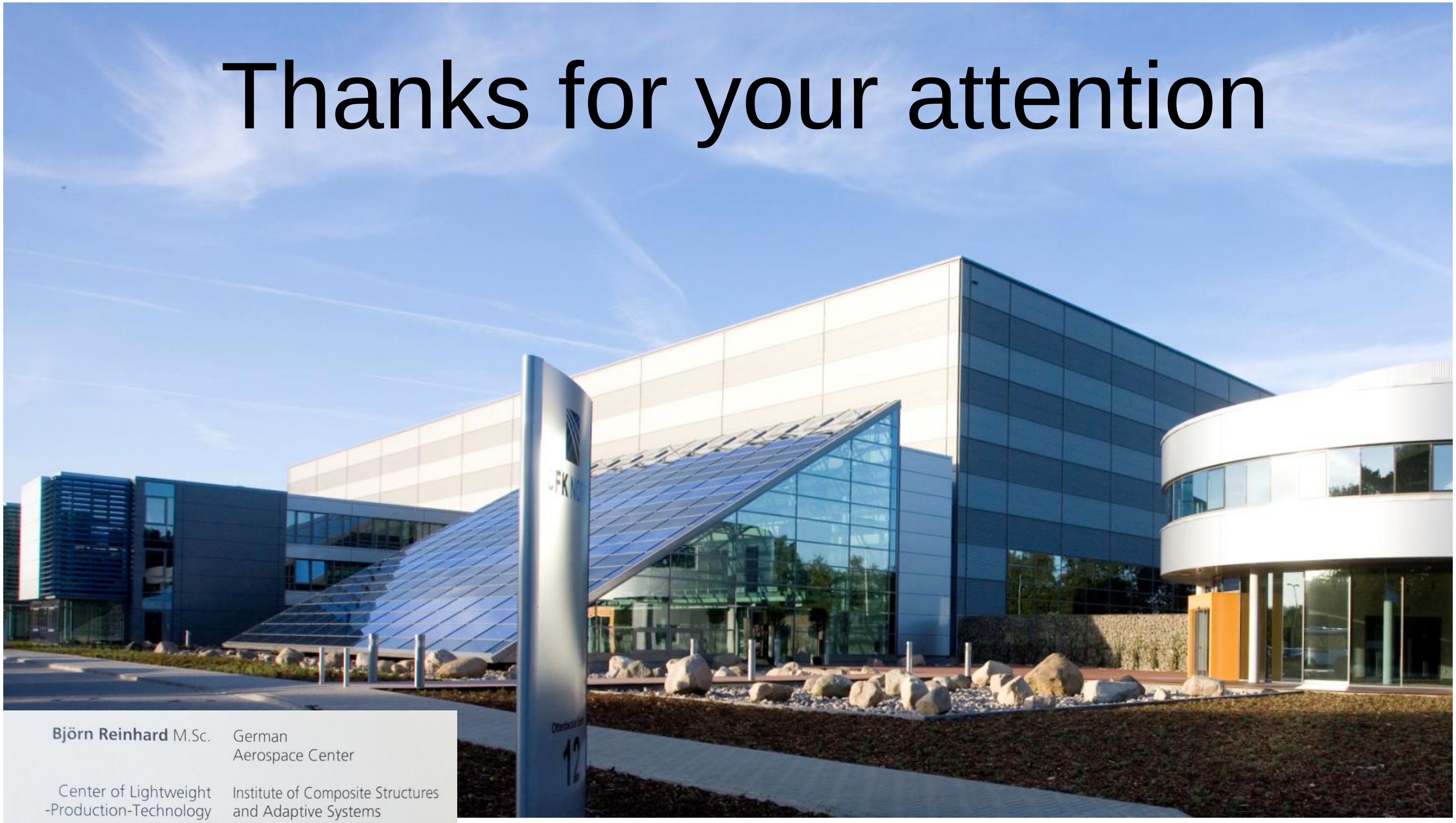
# Thanks for your attention



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- Martin Liebisch, Björn Reinhard: Automated, net shape preforming and isothermal injection process of spring in compensated frames. Springer. (will be published end of 2017)
- S. Torstrick, F. Kruse, M. Wiedemann: RTM-Processing for Net Shaped Parts in High Quantities. CFK Convention 2013, Stade, Germany
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