INTERNATIONAL LASER SYMPOSIUM &
INTERNATIONAL SYMPOSIUM »TAILORED JOINING« 2016

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New Concepts for Friction Stir Welding of 3D Shells

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DRESDEN concept

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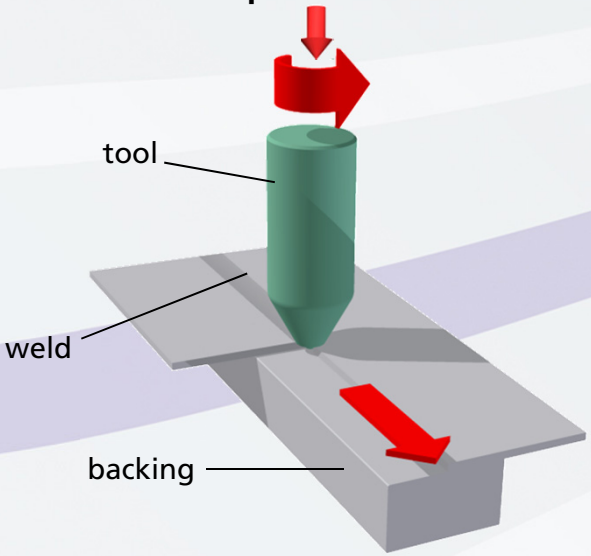
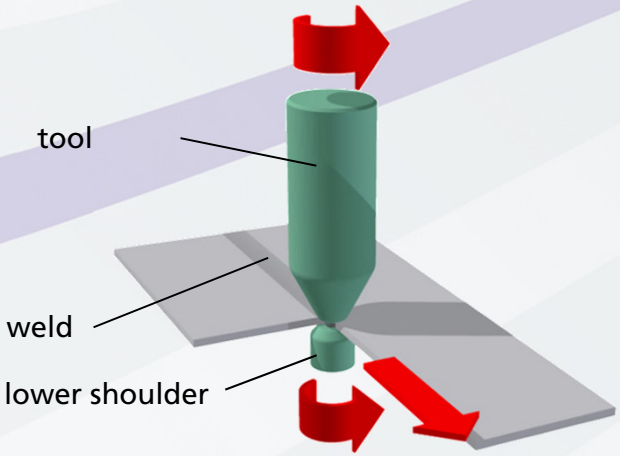
Motivation

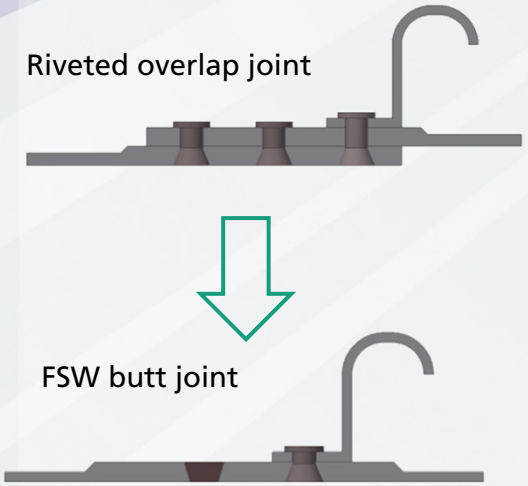
- State of the art: Riveting common joining technology of aircraft fuselages parts
- This leads to larger structural masses and cycle times…
- Number of overlap joints ↓ → structural mass ↓ → costs ↓
- Welding of fuselage parts by using friction stir welding has great potential



Standard - FSW principle



Bobbin tool - FSW principle



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Challenges

- Long welds
- Accessibility only from outer side
- Welds can have cylindrical and spherical curvatures
- High accuracy necessary (butt joint)

To reach the goal:

- Machine and clamping concept suitable for long welds
- Clamping mainly from outer side
- 3D capability of machine concept
- Performance of every process step within one fixture

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Development of a New Joining Concept

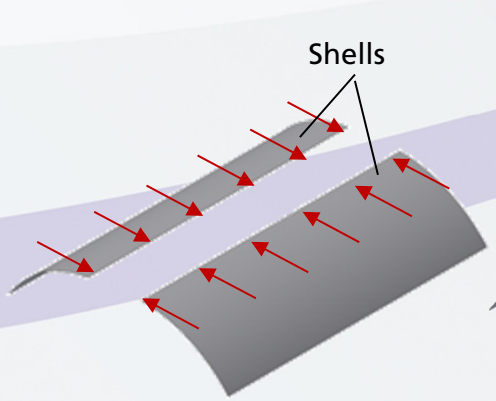
- Development of a 3D-capable machine concept comprising a trolley and a stiffening system as well as a clamping system

Approach:

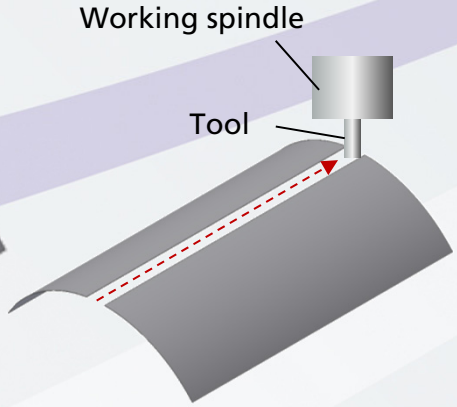
- "Lean FSW Tooling", costs ↓
- Concept: "**M**ulti **U**se **V**acuum **A**ssisted e**X**oskeleton

Process Steps:

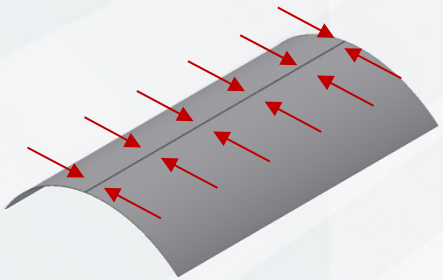
Clamping and positioning



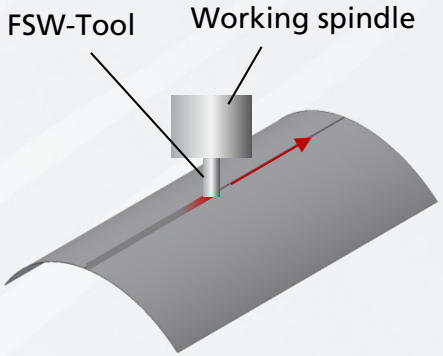
Milling of the edges



Gap adjustment



Friction Stir Welding



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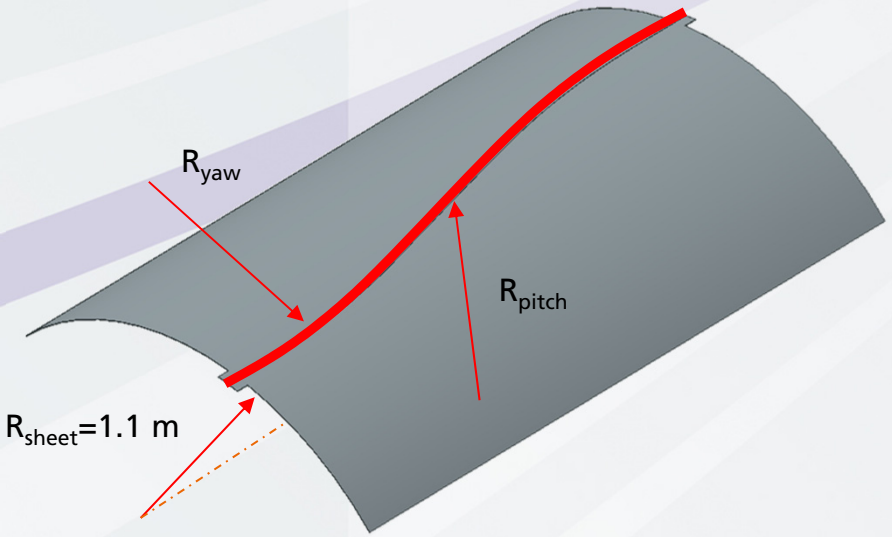
Development of a New Joining Concept
MUVAX – 3D Demonstrator

Challenge:

- Representation of all relevant curvatures within one demonstrator

Evaluation of all functionalities:

- Clamping of welding parts
- Milling for joint preparation
- Friction stir welding of the demonstrators
- Unclamping the welded part



Well-defined radii on the demonstrator

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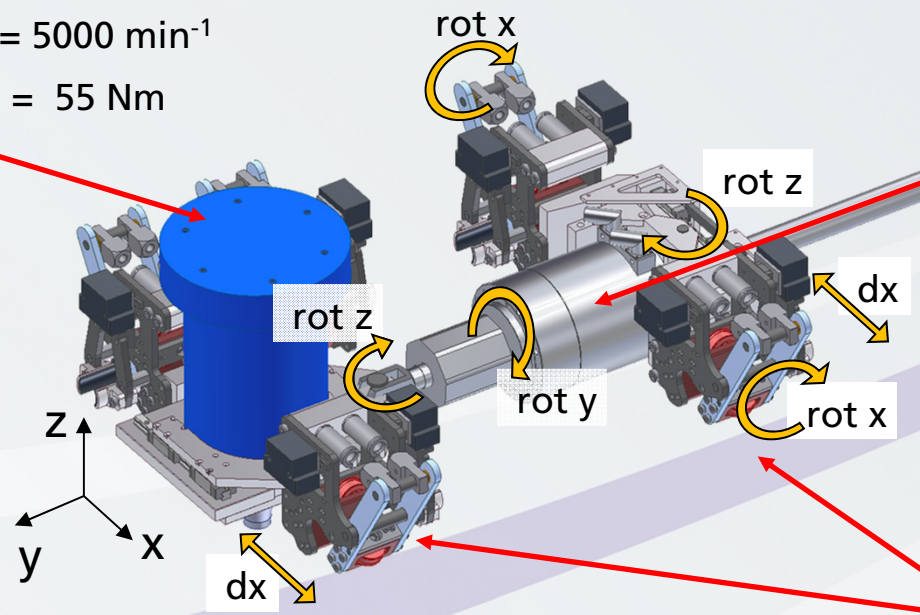
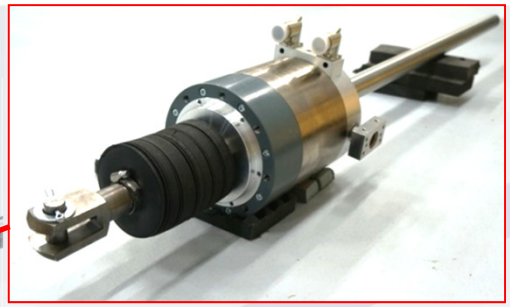
Development of a New Joining Concept
MUVAX – Trolley

Working spindle

n = 5000 min^{-1}

M = 55 Nm

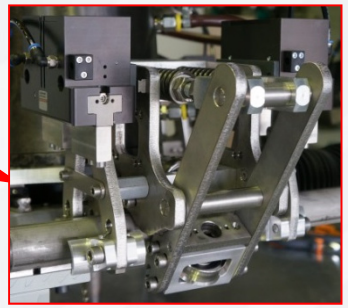




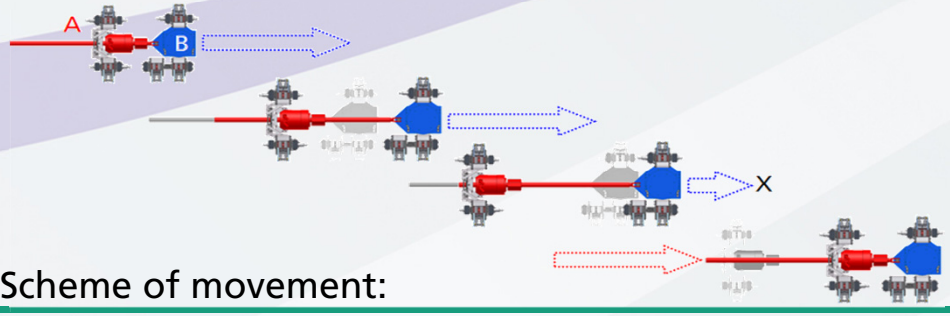
Ball screw motor

v_f = 1,2 m/min

F_{max} = 5 kN



Wheel set with integrated brake system



Scheme of movement:

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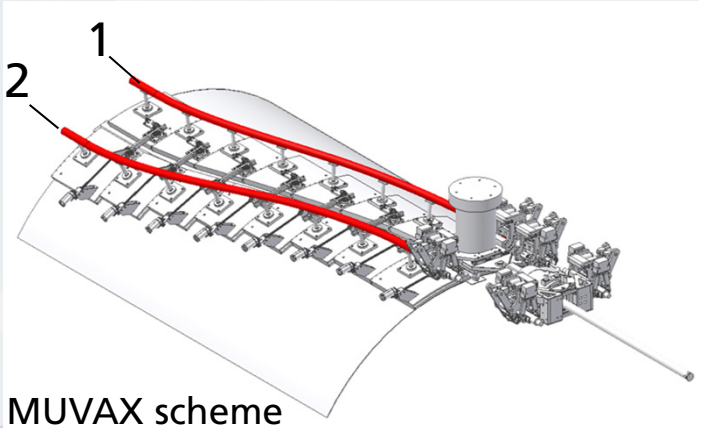
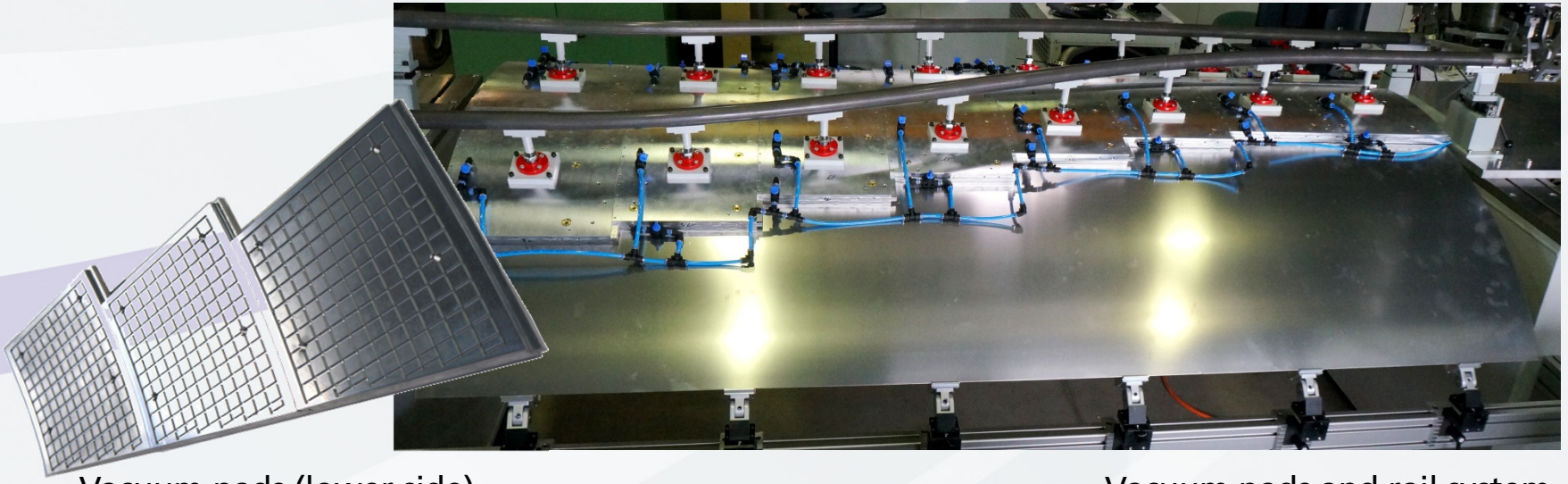
Development of a New Joining Concept
MUVAX – Rail and Clamping System

- Rail system: 3 D-bent tubes
  - **Rail 1:** reference rail → fixed
  - **Rail 2:** parallel movable to the demonstrators longitudinal axis
- Rails and vacuum pads mounted together



MUVAX scheme


Vacuum pads (lower side)

Vacuum pads and rail system

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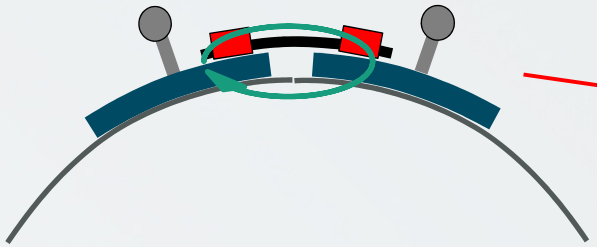
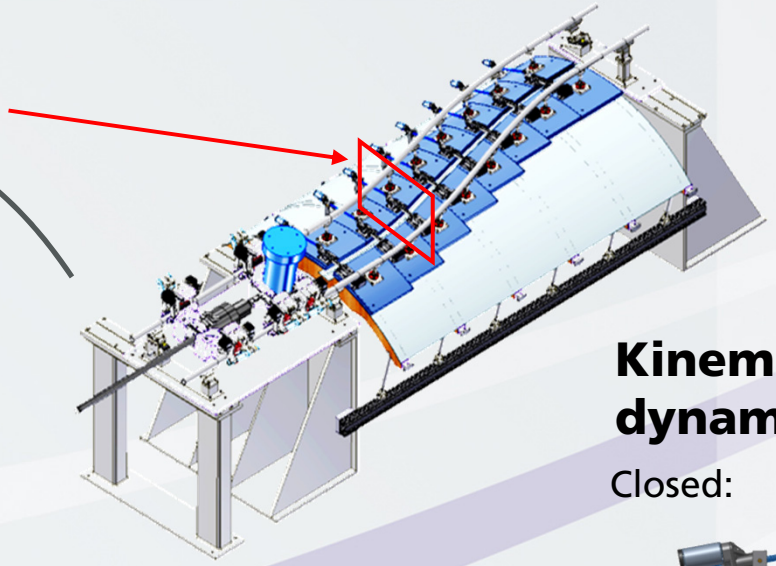
Development of a New Joining Concept
MUVAX – Dynamic Bolts



Force distribution



Kinematics of the dynamic bolts:

Closed:

Mid position:

Opened:

Functional range:

- Direct force distribution
- Positioning the demonstrator for milling and welding
- Temporary opening for spindle passage
- Well-directed adjustment of the weld gap

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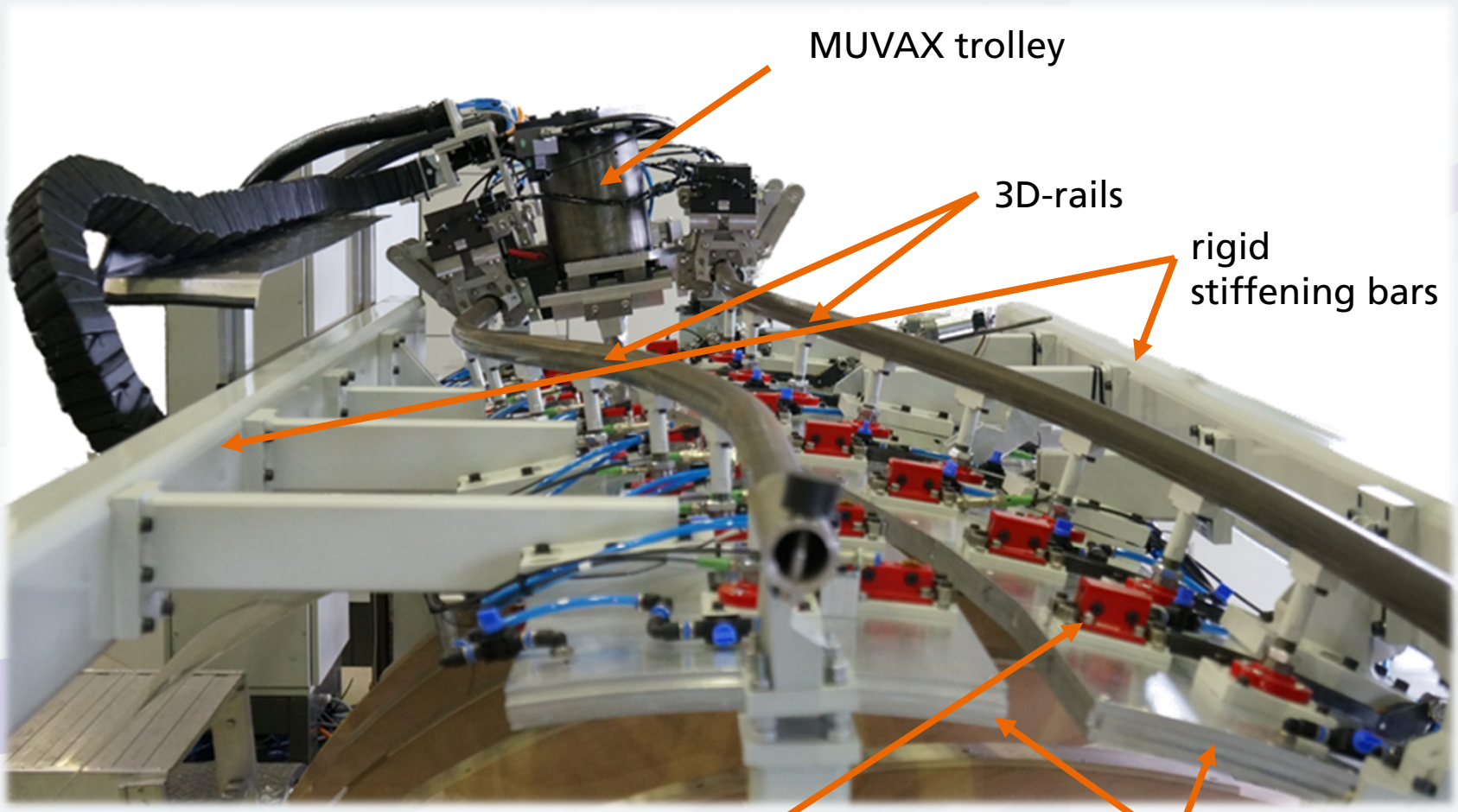
Conception of the Overall System



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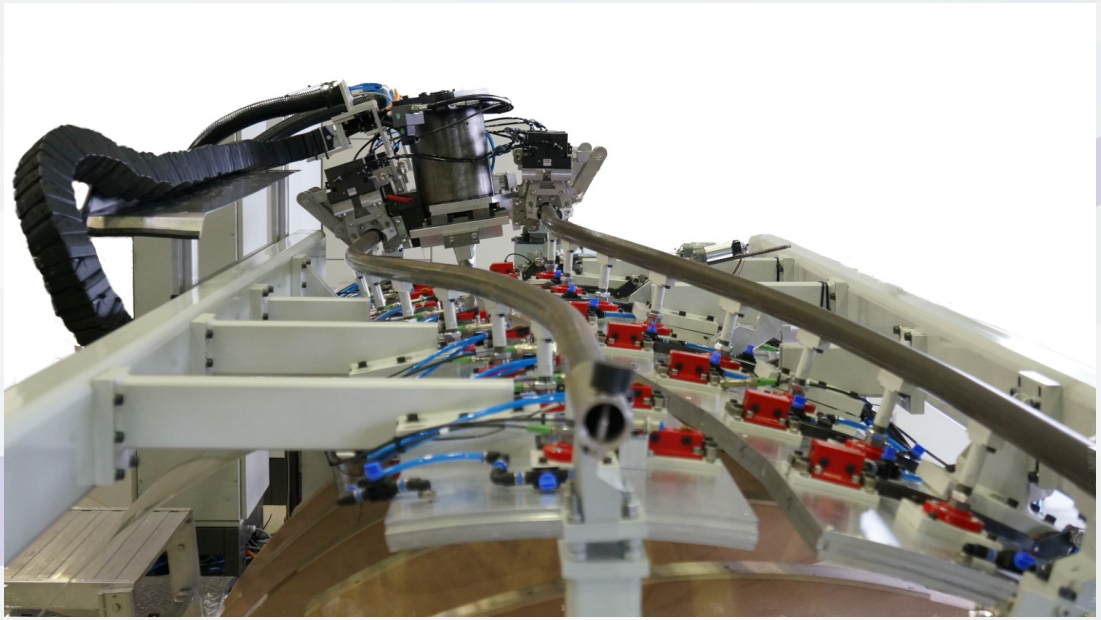
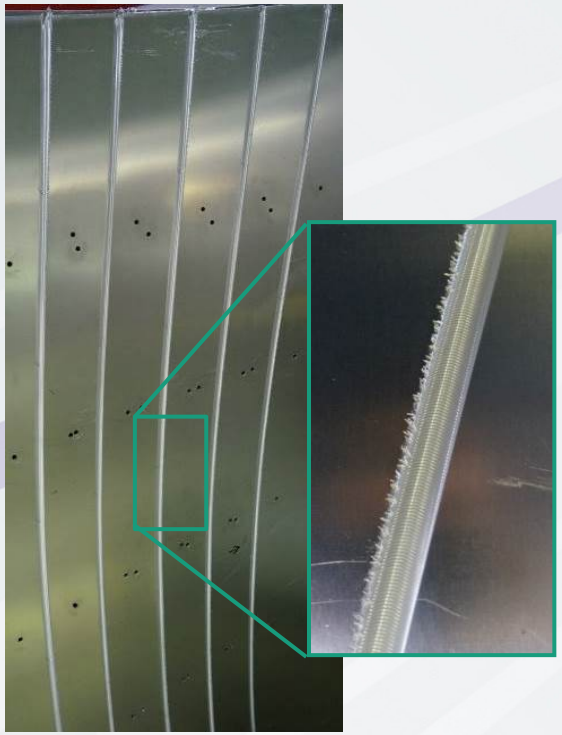
Conception of the Overall System

Evaluation of the overall system:

- Clamping with vacuum
- Milling of the vacuum clamped parts
- Welding of the demonstrators



Principle of MUVAX kinematics



Welds in butt joint and bead on plate condition (v_f 200 … 900 mm/min)

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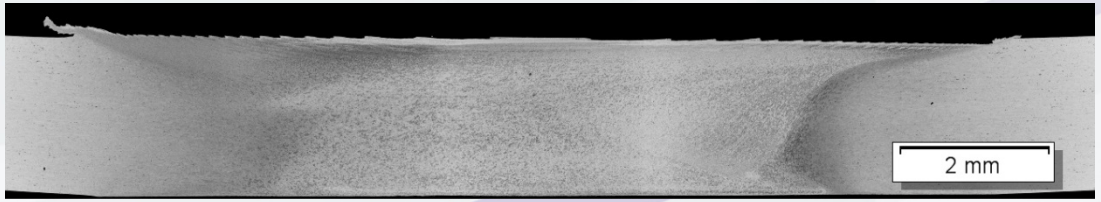
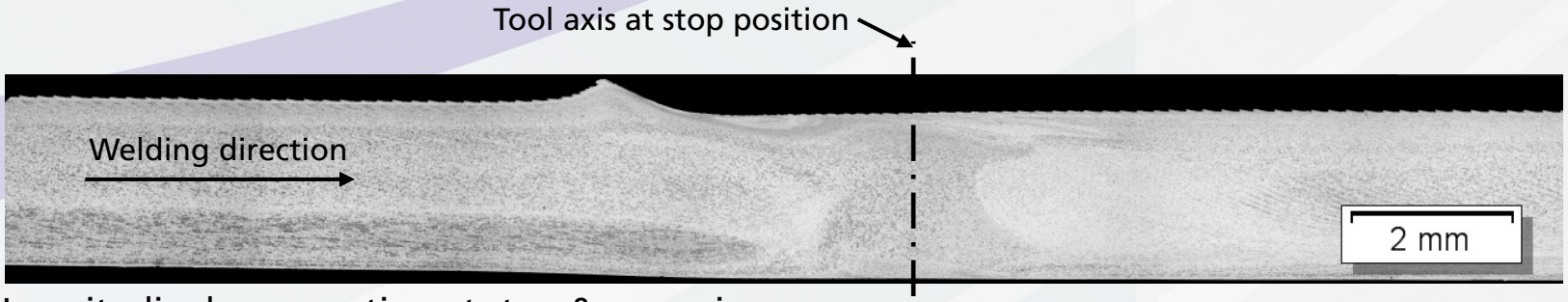
Welding Results - Details

- No lack of penetration
- Critical stop & go zone shows only a slightly changed texture
- At stop position: Characteristic weld flash behind the tool



Typical cross section of a MUVAX-welded joint



Longitudinal cross section at stop & go region

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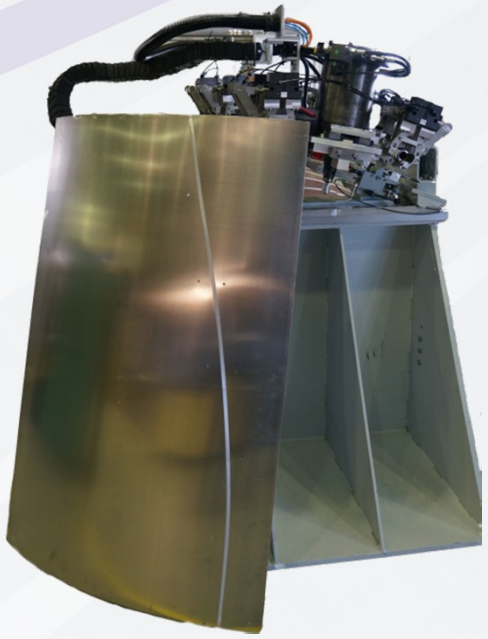
Summary

- Entirely new machine concept for welding (FSW) of large thin-walled structures developed
- 3D-capability of the system proved
- Dynamic bolt system successfully tested
- Welding of demonstrator panels successfully conducted



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Thank you for your attention!

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