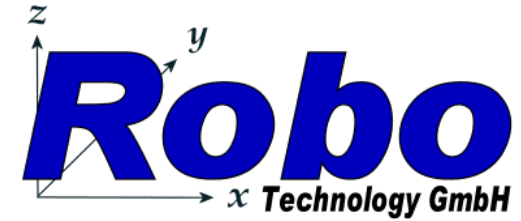
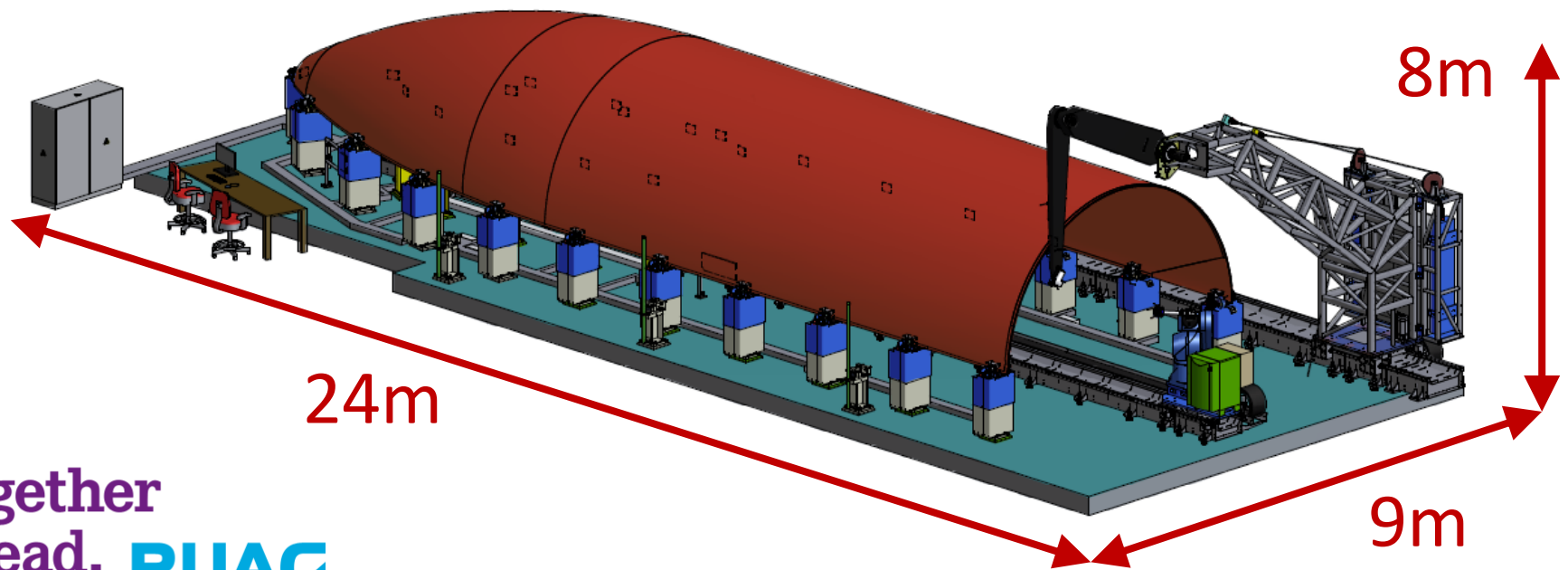


Space Tech Expo 2015 Bremen



Robotic Systems for Non-Destructive Ultrasonic Inspection of Large Carbon-Fiber Components



Together
ahead. **RUAG**

Robotic NDI of CFRP components

Eugen Ostertag GmbH & Co. KG

Payload Fairing of Ariane5 and similar LV



DR. HILLGER
Ingenieurbüro

Today:
14 segments

Future:
2 half-shells

↓

- Less weight
- Higher stiffness
- Faster assembly
- Cost reduction

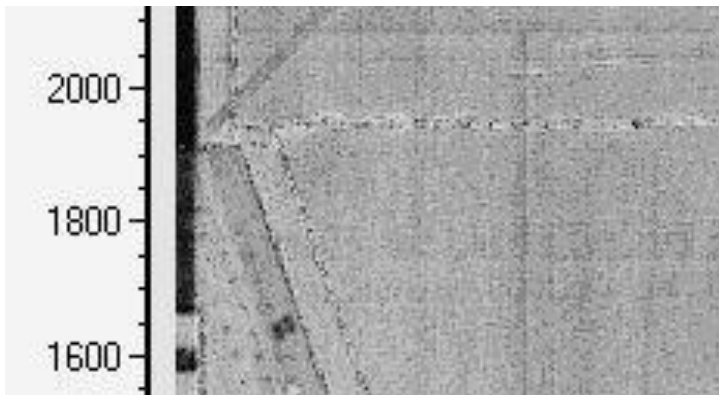
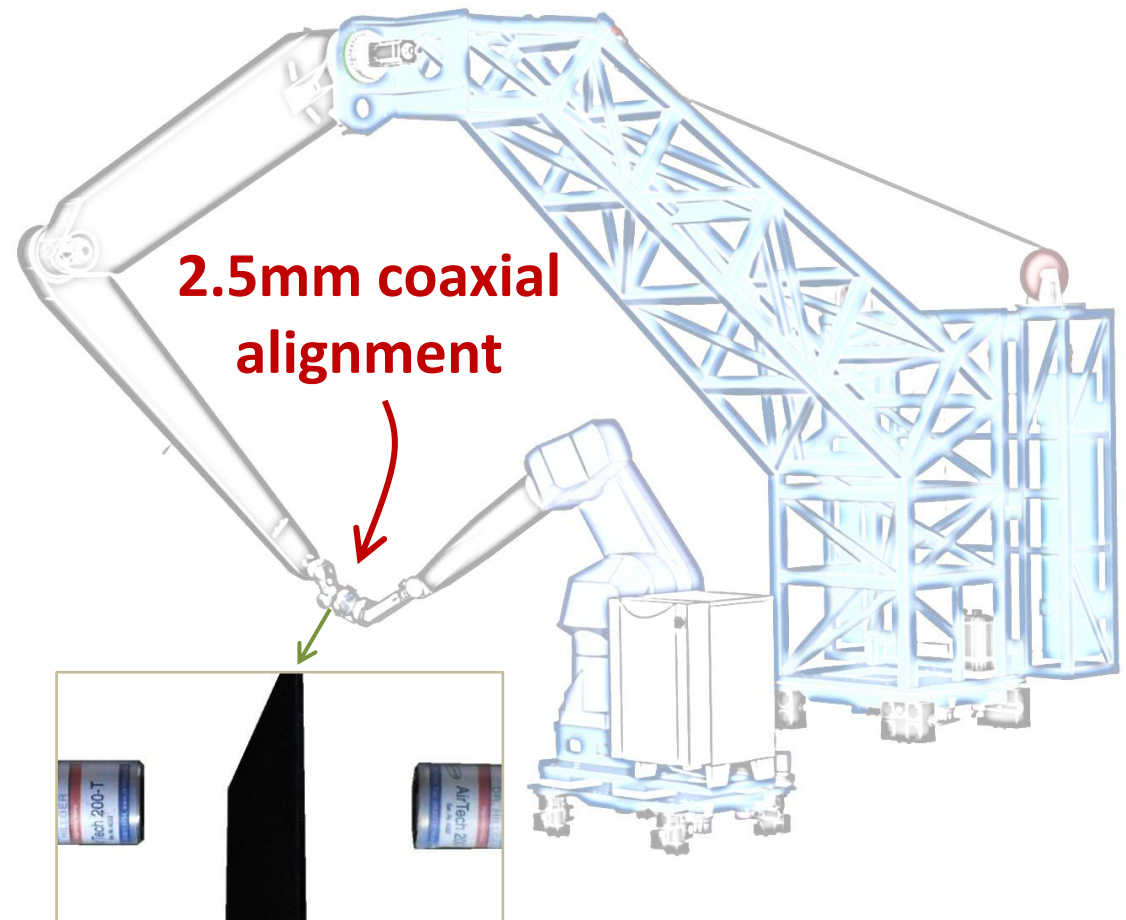
Picture: ESA

Picture: RUAG Space

Air coupled ultrasonic inspection



- Two robots on rails move an ultrasonic transmitter and a receiver along the surface of the specimen.
- The recorded signal shows the quality of the bonding process inside the composite



Tasks and Challenges



Mapping
of linear
rails

Absolute calibration of robot arms

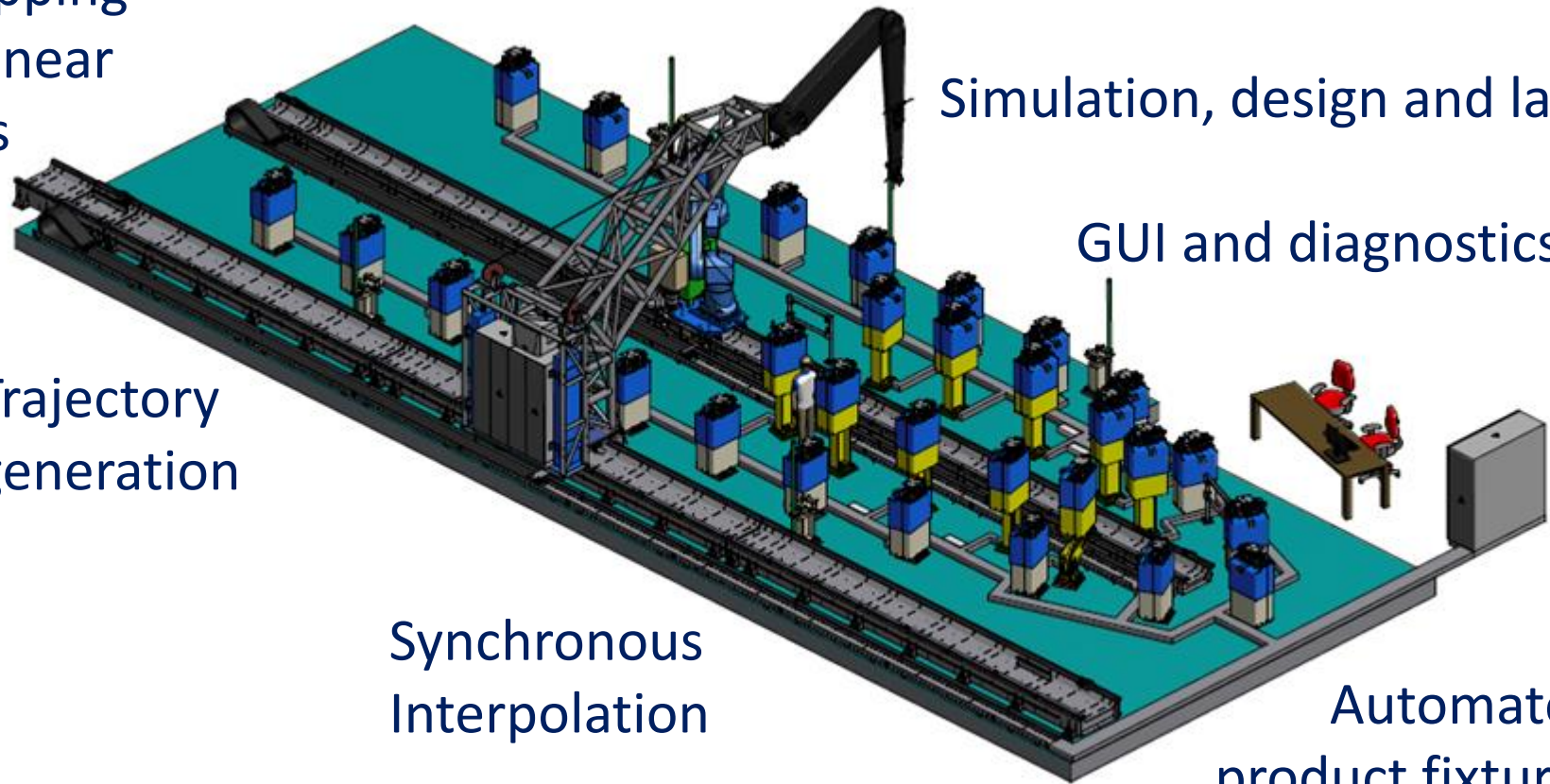
Simulation, design and layout

GUI and diagnostics

Trajectory
generation

Synchronous
Interpolation

Automated
product fixtures



Absolute calibration of the robot arms



Outer robot (RMS values):

- FEA-optimized steel frame
- CFRP arms, 5.1m reach
- Bidir. repeatability: 0.03mm
- Absolute accuracy: 0.40mm

Inner robot (RMS values):

- Stäubli industrial robot
- CFRP forearm, reach 2.4m
- Bidir. repeatability: 0.28mm
- Absolute accuracy: 0.39mm

Linear rails (RMS values):

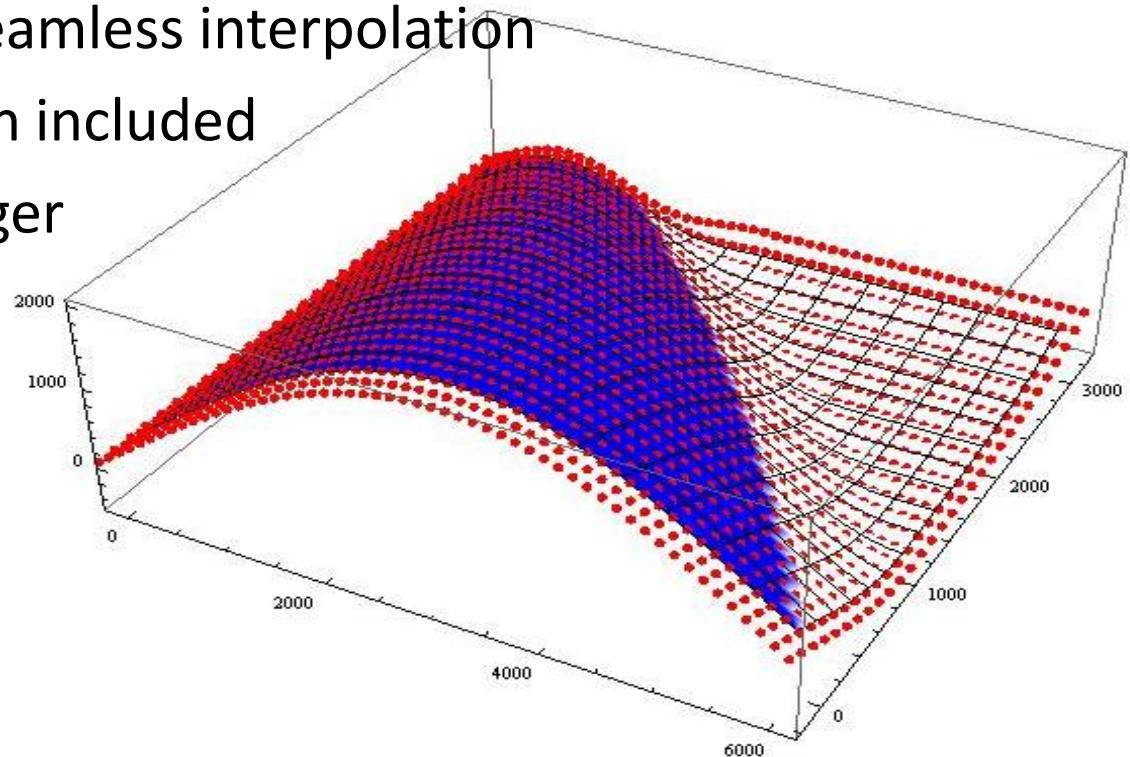
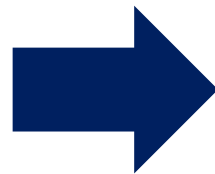
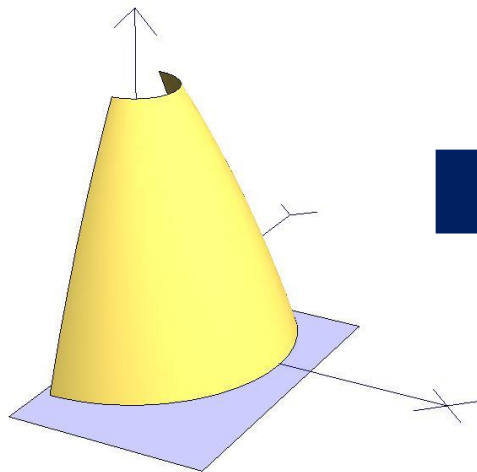
- Bidir. repeatability: 0.03mm
- Absolute accuracy: 0.15mm

Realtime 2D-Interpolation of 13 servos



The 3D surface of the product is mapped to 2D coordinates:

- Continuous function with 3 continuous derivatives
- Fast to calculate, seamless interpolation
- Absolute calibration included
- Equidistant US trigger



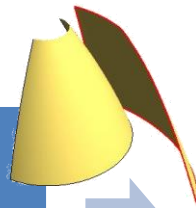
Robotic NDI of CFRP components

Eugen Ostertag GmbH & Co. KG

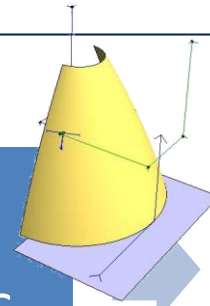
Toolchain



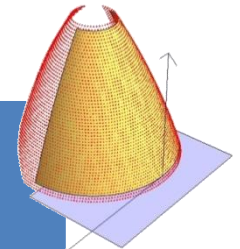
Surface
projection



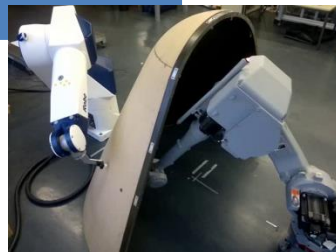
Inverse
Kinematics



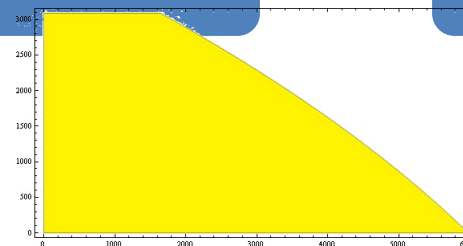
Spline
calculation



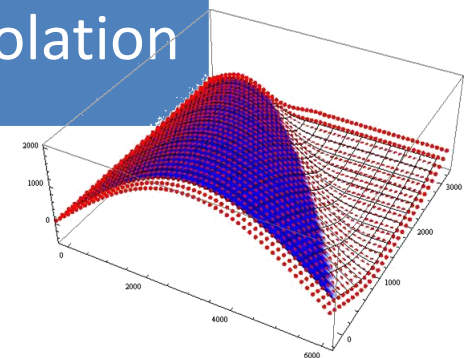
Synchronous
Movement



2D Scanner-
definition

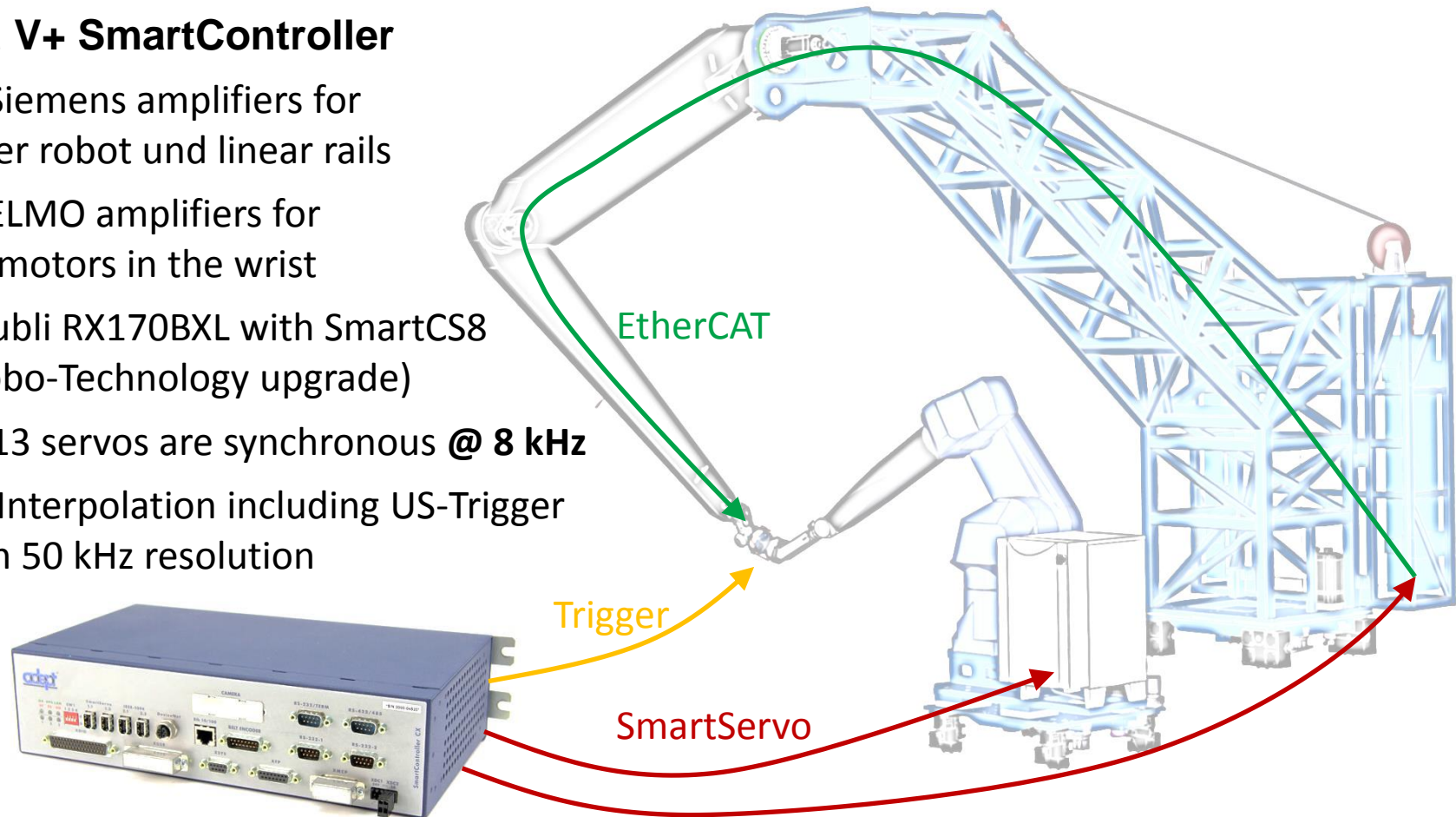


2D-
Interpolation



Adept V+ SmartController

- 4x Siemens amplifiers for outer robot und linear rails
- 3x ELMO amplifiers for TQ-motors in the wrist
- Stäubli RX170BXL with SmartCS8 (Robo-Technology upgrade)
- All 13 servos are synchronous @ 8 kHz
- 2D-Interpolation including US-Trigger with 50 kHz resolution

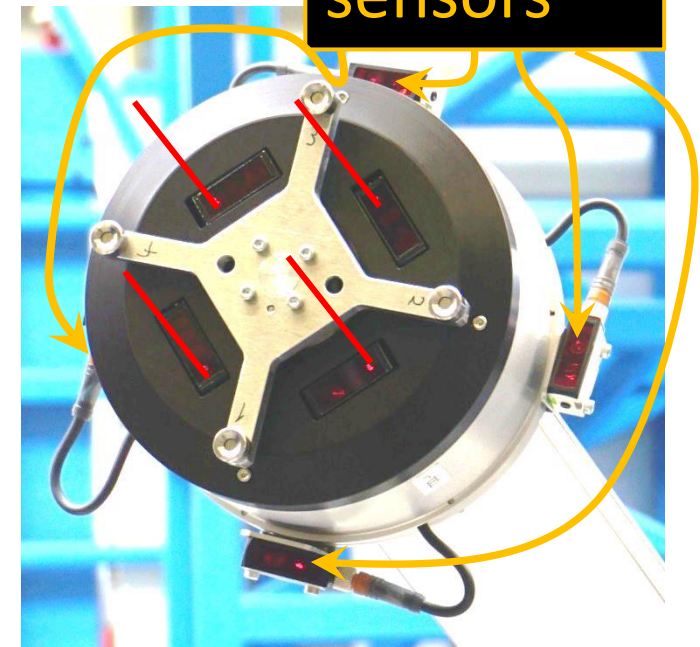
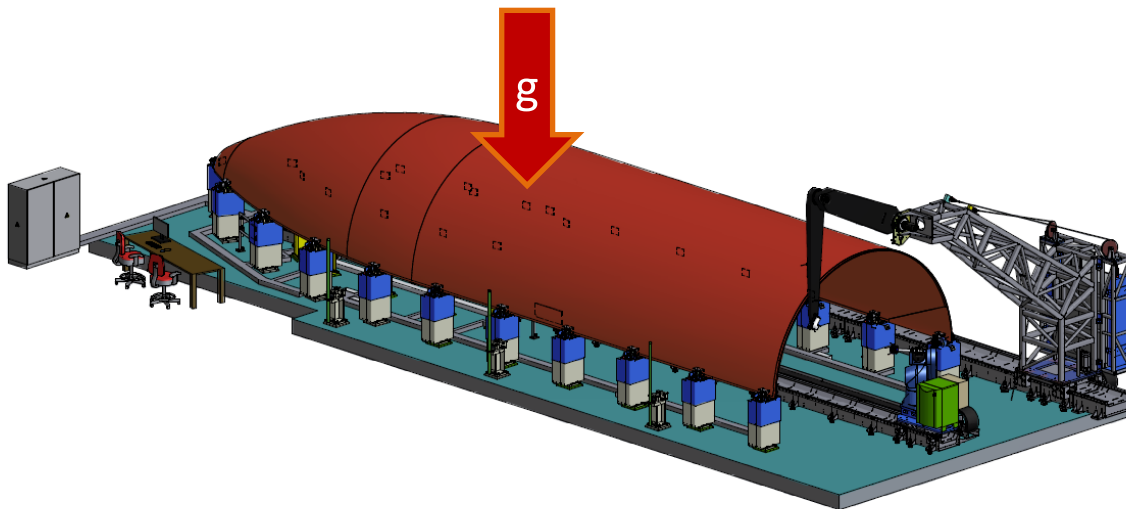


Distance measurement and control



- Product distorts under gravity, several mm at the top
- 4 laser sensors measure distance to surface
- Trajectory of both robots corrected in real-time
- Variable product thickness taken into account!

Collision protection sensors



Robotic NDI of CFRP components

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The system in action at RUAG Space



DR. HILLGER
Ingenieurbüro



Picture: RUAG Space

www.robotechnology.de

www.dr-hillger.de

www.eoster.de

Thank you for your attention! Questions?



Key facts for this system:

Booth H30

- Scan area: half-cylinder, length 21m, \varnothing 5.4m = 180 m²
- Robot velocity: up to 1m/s (0.5m/s nominal, 200 Hz trigger rate)
- Total inspection time: 20min/m² < 3 days for whole product
- Dynamic accuracy: < 2.5mm transmitter vs. receiver
- Dynamic distance control: +/- 1mm
- Ultrasonic trigger strictly equidistant in position
- 31 intelligent support fixtures for product
- Tablet-PC GUI to support loading/unloading
- Extensive US evaluation software

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