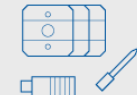
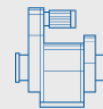
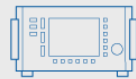


CONTACTLESS ROBOTIC EDDY CURRENT ARRAY INSPECTION

Dietmar Griem – Rohmann LLC
A4A Symposium 2024 Nashville



Robot Based Eddy Current Inspection Systems

Applications

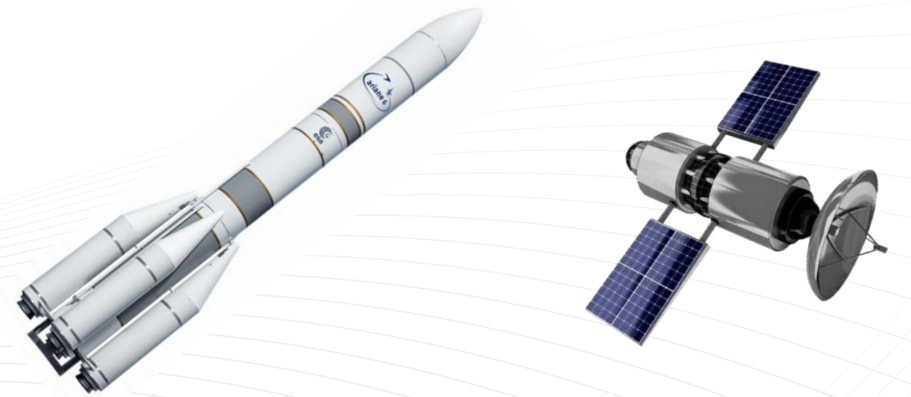
- Aircraft engines for civil and military uses need to be inspected by NDT methods during the overhaul process. Automatic eddy current inspection is required for defined areas of the different engine discs/stages.

Typical use in MRO shops

- Aeronautic and aerospace component manufacturers are conducting NDT inspections at different stages of the manufacturing or assembly process on various aerospace components



Source: <https://www.mtu.de/de/engines/zivile-triebwerke>



ELOSCAN Robot Based Eddy Current Inspection System

Requirements

Requirements and Reasons for Automated Aeronautic and Aerospace Components

- Reduced inspection time
- Reliability and
- Accuracy and Repeatability
- Automatic evaluation and self-monitoring for a reduced human factor
- Automatic documentation and storage of inspection data
- Flexibility
- Low total costs of ownership



Source: <http://www.finnair.com>



Spaceship in Space Center in Florida, USA

ELO\SCAN Robot Based Inspection System

Concept

First systems for engine disc inspection (ELO\SCAN)

The first designs for robot systems were made by Rohmann beginning to mid 90ties, transferring handheld tools for robotic use



ELO\SCAN Robot Based Inspection System

Components

ELO\SCAN – New system setup and components

- Eddy current instrument PL650R

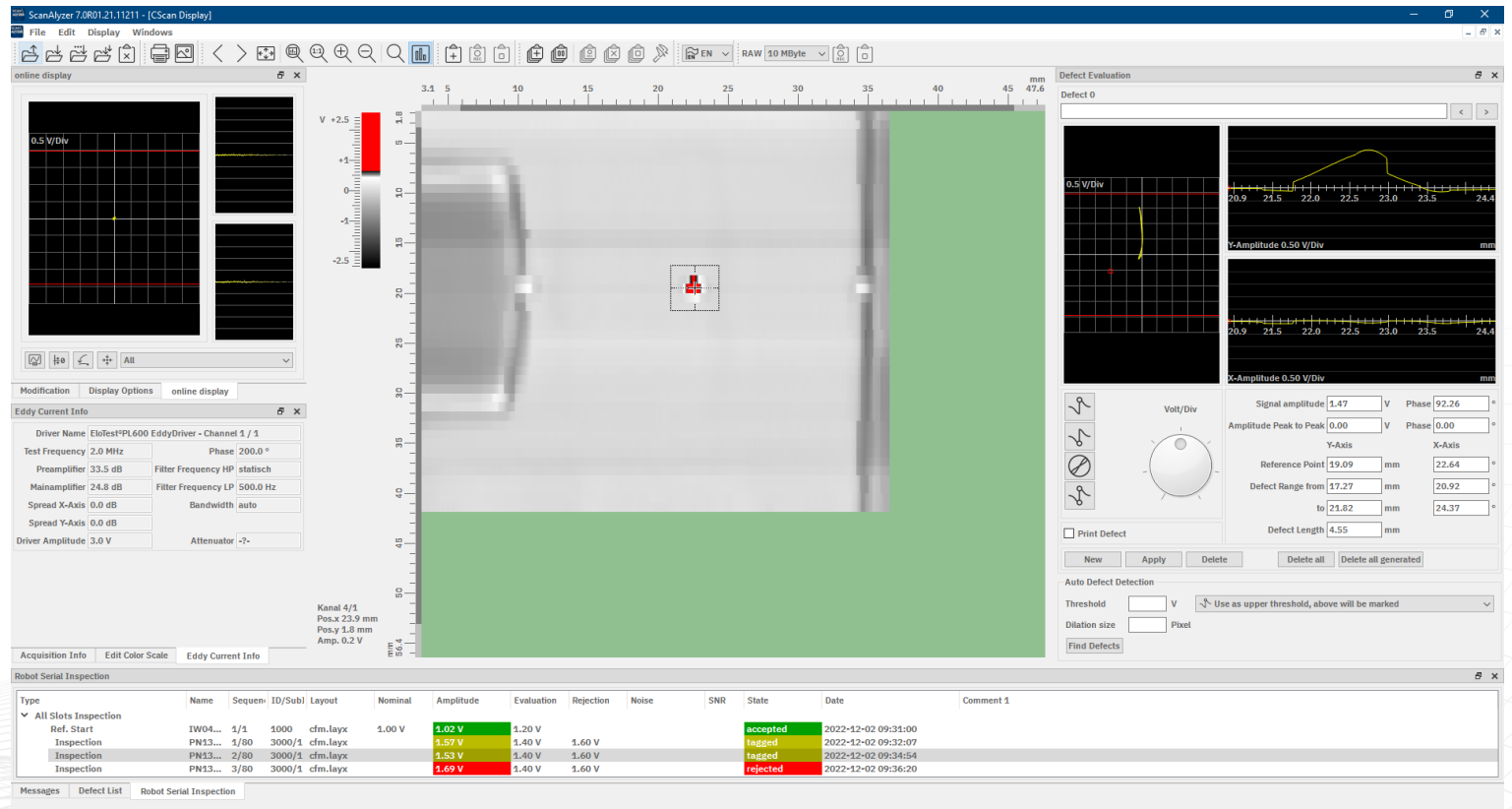


ELO\SCAN Robot Based Inspection System

Components

ELO\SCAN – New system setup and components

- Eddy current instrument PL650R
- Scanalyzer 7.0 C-Scan software



ELO\SCAN Robot Based Inspection System

Components

ELO\SCAN – New system setup and components

- Eddy current instrument PL650R
- Scanalyzer 7.0 C-Scan software
- KUKA Iontec KR30 with path mode
- KUKA control KR C5 newest generation



ELO\SCAN Robot Based Inspection System

Components

ELO\SCAN – New system setup and components

- Eddy current instrument PL650R
- Scanalyzer 7.0 C-Scan software
- KUKA Iontec KR30 with path mode
- KUKA control KR C5 newest generation
- High precision turntable and 700mm three-jaw-chuck
- Tool magazine with extension option



ELO\SCAN Robot Based Inspection System

Components

ELO\SCAN – New system setup and components

- Eddy current instrument PL650R
- Scanalyzer 7.0 C-Scan software
- KUKA Iontec KR30 with path mode
- KUKA control KR C5 newest generation
- High precision turntable and 700mm three-jaw-chuck
- Tool magazine with extension option
- Centralized Control console with user friendly GUI



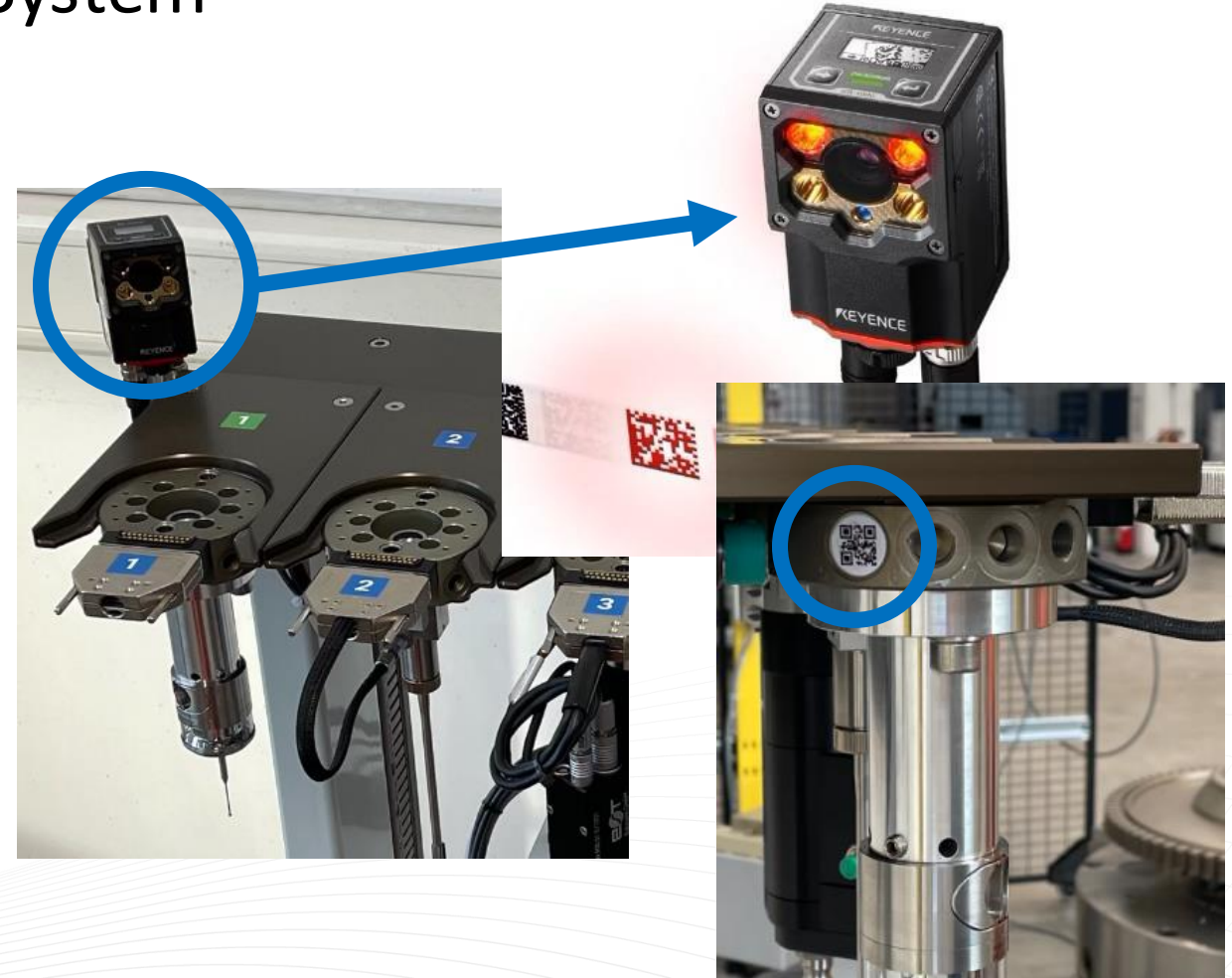
ELO\SCAN Robot Based Inspection System

Components

ELO\SCAN – New system setup and components

- Eddy current instrument PL650R
- Scanalyzer 7.0 C-Scan software
- KUKA Iontec KR30 with path mode
- KUKA control KR C5 newest generation
- High precision turntable and 700mm three-jaw-chuck
- Tool magazine with extension option
- DMC code reader for tool identification

Source: <https://www.keyence.de>

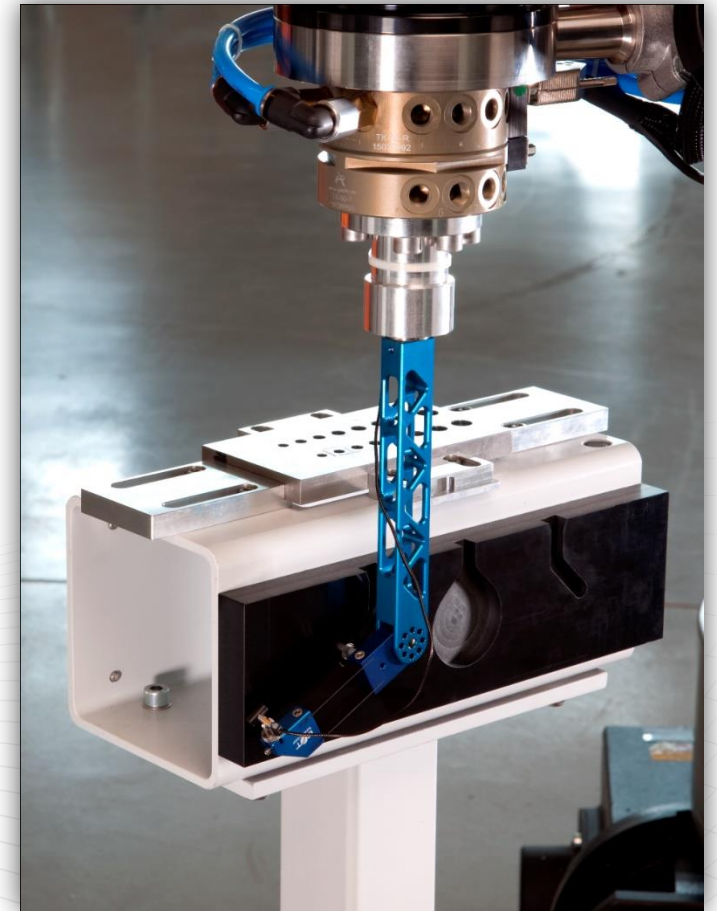


ELO\SCAN Robot Based Inspection System

Components

Blue Tool Different probe types available

- Automated angle adjustment
- Used for bore and web inspection
- Flat surfaces
- Available in different length and sizes

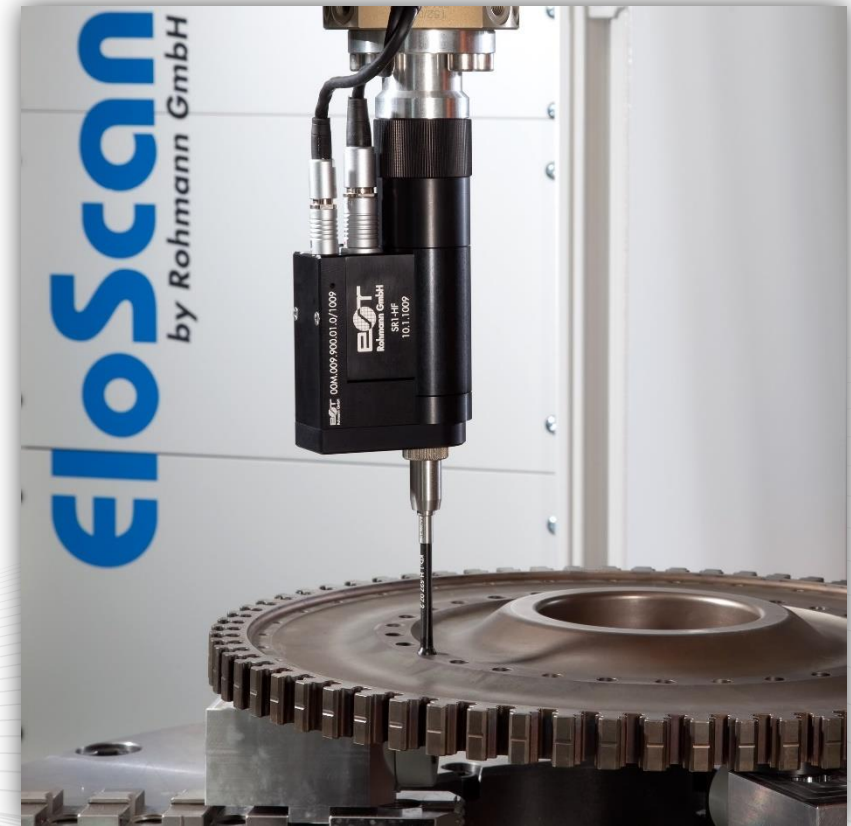


ELO\SCAN Robot Based Inspection System

Components

Rotor Tool – The rotating probe for automatic bolt hole inspection

- Rotor for different probe diameter
- Serial inspection mode for one cycle turn
- Integrated calibration procedure
- Incremental function for C-Scan generation
- Automatic bore hole identification function by using the touch probe
- Used for bolt hole inspection

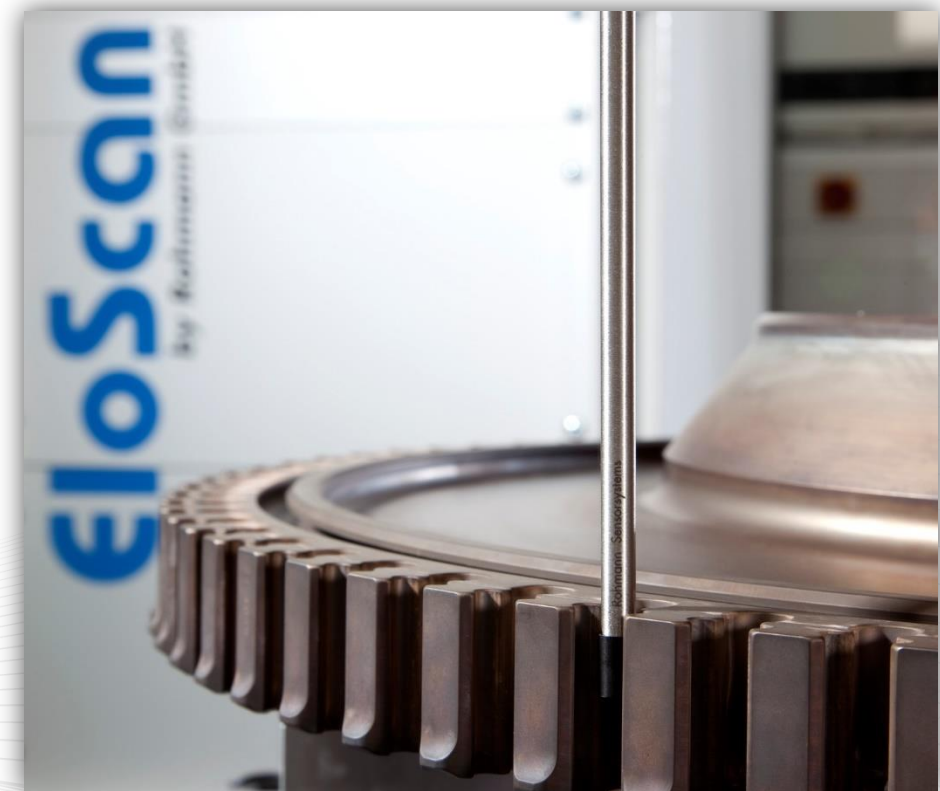


ELO\SCAN Robot Based Inspection System

Components

Precision inspection for contoured areas

- Program generating based on simple CAD/CAM functions
- Serial inspection mode for one cycle turn
- Integrated calibration procedure
- Fully integration of the touch probe
- Monitoring of Teflon wear
- Used for dovetail inspection or complex contours



ELO\SCAN Robot Based Inspection System

Components

The ELO\SCAN robot cell



ELO\SCAN Robot Based Inspection System

Components

Why are array applications also becoming more and more important for robot systems?

- Time savings during inspection - Larger parts and inspection areas
- Inspection of complex geometries
- Significantly less SNR loss with the new electronics
- Possibilities of different patterns for element combinations
- Higher acceptance and requests for array applications
- Simulation und Programmerstellung via CAD/CAM

ELO\SCAN Robot Based Inspection System

Components

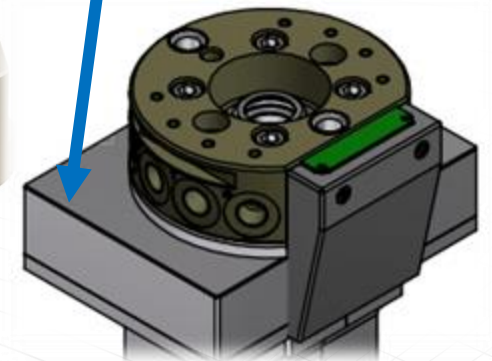
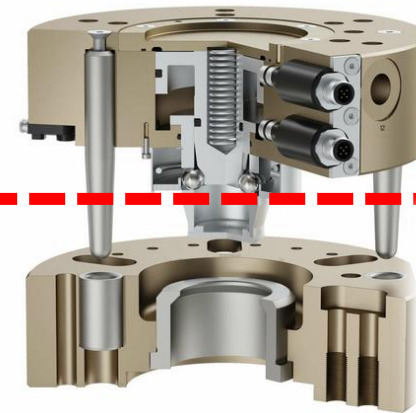
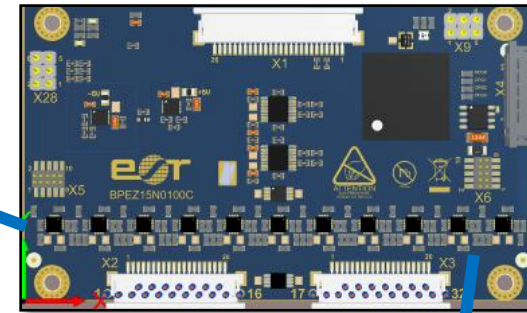
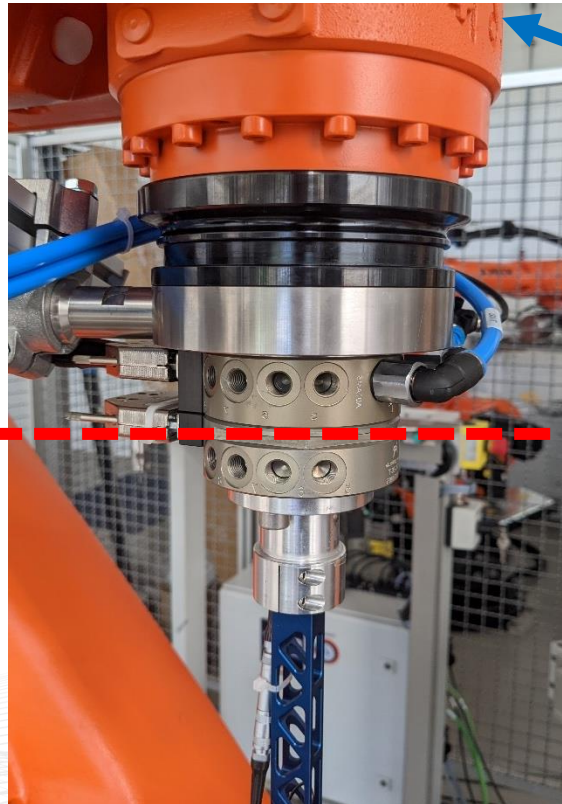
Where should the Multiplex electronics be placed?

On the robot side

- + One multiplexer for all tools
- Limited number of sensor elements
- Wiring harness and a reduces SNR

On the tool side

- + High SNR
- + Flex-print PCB for the sensors
- + High number of sensor elements
- More space required for the PCB
- /+ Higher costs for sensor tools

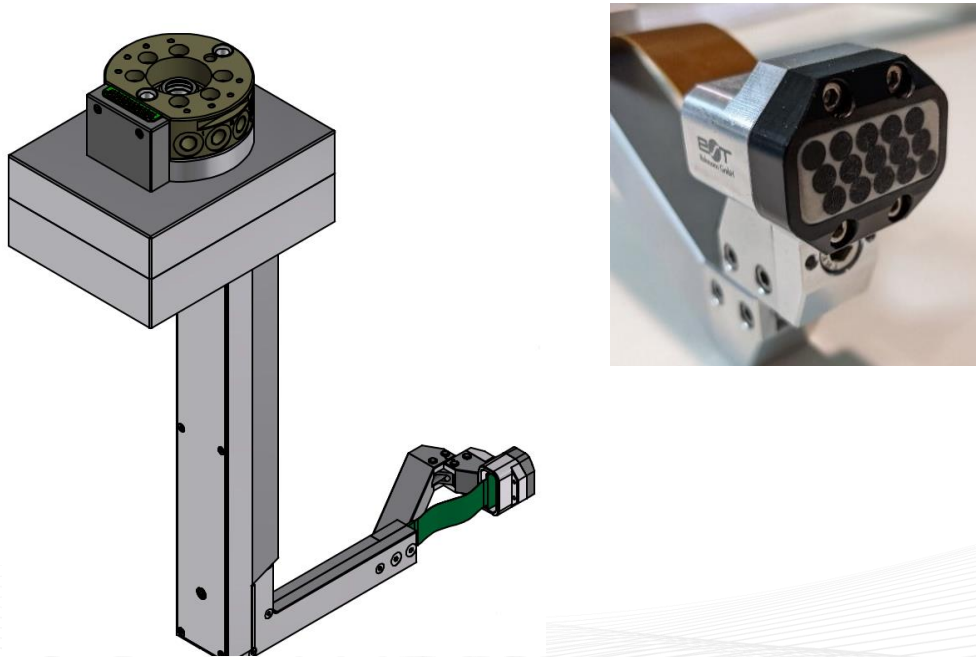


ELO\SCAN Robot Based Inspection System

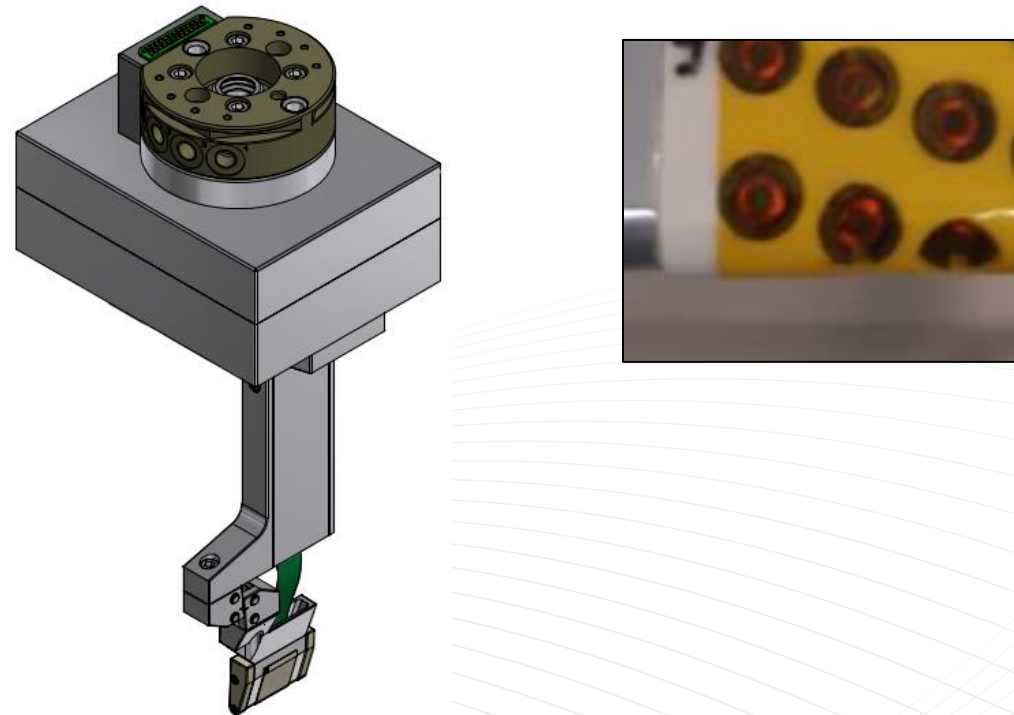
Components

Ariane 6 ring inspection customized probe arrays

15 element array for flat areas



16 element array for y-contour areas

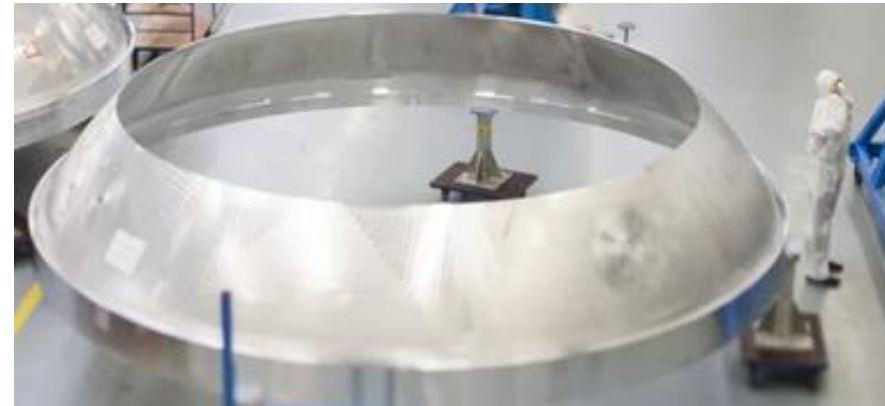


ELO\SCAN Robot Based Inspection System

Components

Ariane 6 ring inspection project requirements

- Testing with probe array
- C-Scan functionality with automatic evaluation
- Robotic inspection with CAD CAM functionality
- Possibility of probe/tool change
- Aluminum alloy
- 12 different components
- Ring diameter range 3.5 – 5.4 meter
 - Telescopic arm turntable
 - Additional linear axis for KUKA robot – linear movement



ELO\SCAN Robot Based Inspection System

Components

Ariane 6 ring inspection system setup



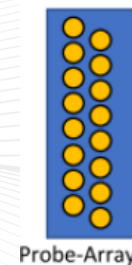
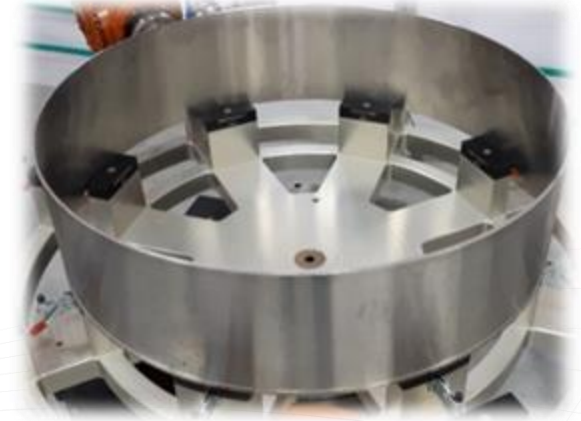
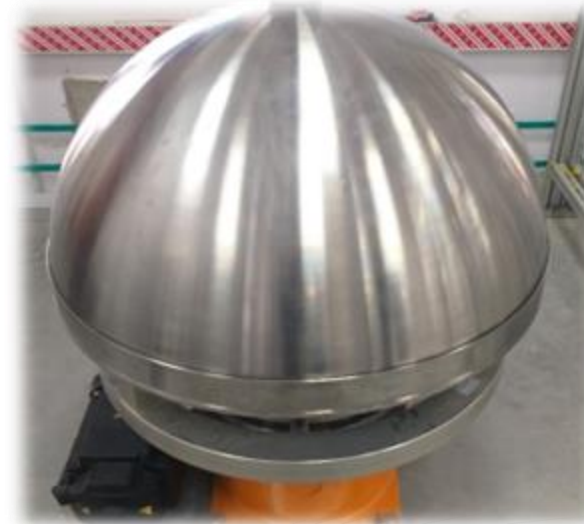
ELO\SCAN Robot Based Inspection System



Components

Satellite tank inspection with probe array and EMDC

- Testing with probe array (min. 8 sensors)
- C-Scan functionality with automatic evaluation
- Robotic inspection with CAD CAM functionality
- Possibility of probe/tool change
- ***Non-contact inspection***
- Defect definition 0.12mm deep / 1.2mm long
- Titanium alloy with 0.8mm wall thickness
- 8 different parts for testing
 - 4 Domes and 4 Rings



Probe-Array



ELO\SCAN Robot Based Inspection System

Components

Satellite tank inspection with probe array and EMDC

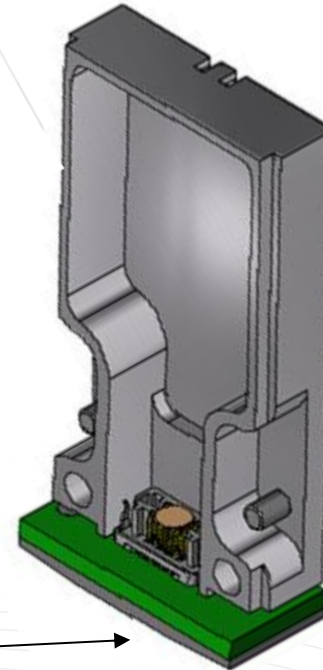
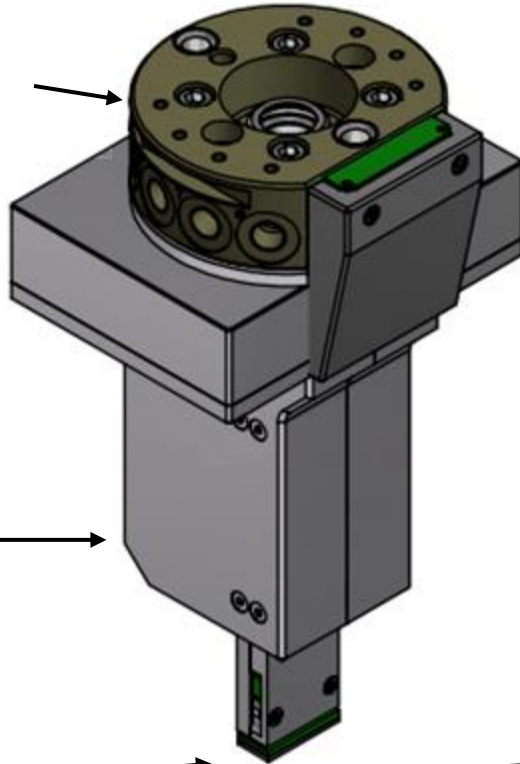


Robot tool
changing system

32x
Array multiplexer

EMDC

Changeable
Array Probe



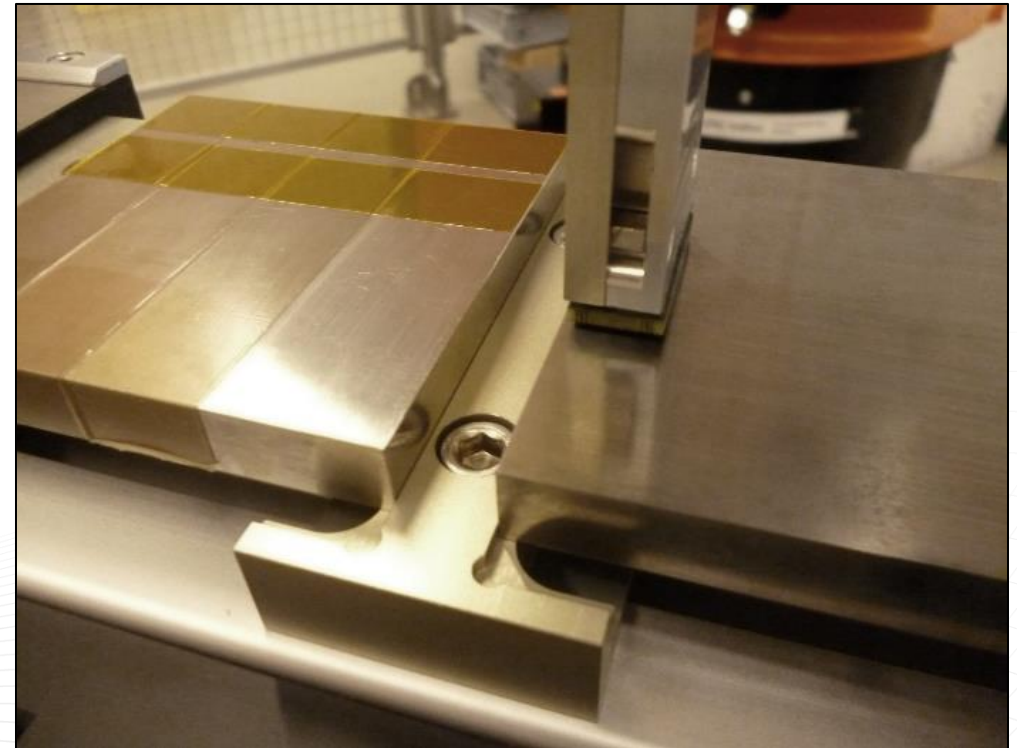
ELO\SCAN Robot Based Inspection System



ELO\SCAN Customized Inspection Task – Satellite Tank Inspection

Reference plate for adjustment and verification

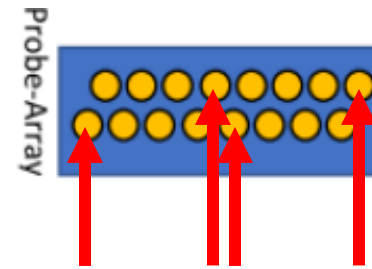
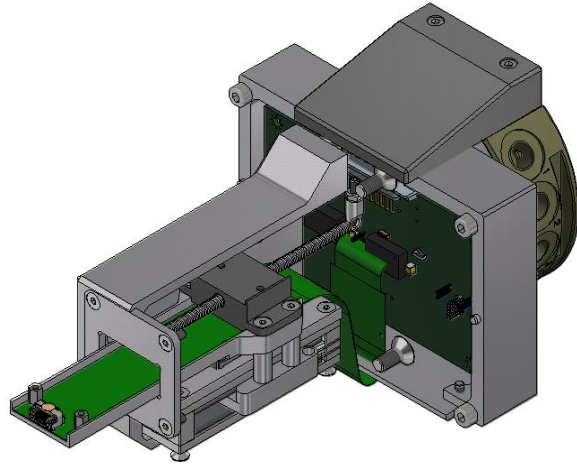
- Material: Titanium alloy
- Continuous notch for adjustment of the individual coils
- Reference defect (0,12mm x 1,2 mm) in different orientations (0°, 90°, 45°, 135°)
- Additional plate for the adjustment of the lift-off signal (EMDC) (0,5 / 1,0 / 1,5 mm / Lift-Off)
- Exchangeable reference plates



ELO\SCAN Robot Based Inspection System

ELO\SCAN Customized Inspection Task – Satellite Tank Inspection

EMDC – Electro Mechanical Distance Compensation



< Distance value from
4 defined coils



Calibration integrated in the test sequence:

- 0 mm „material“
- 0.05mm „too close“
- 0.1 mm „operating distance“
- 0.15 mm „too far“

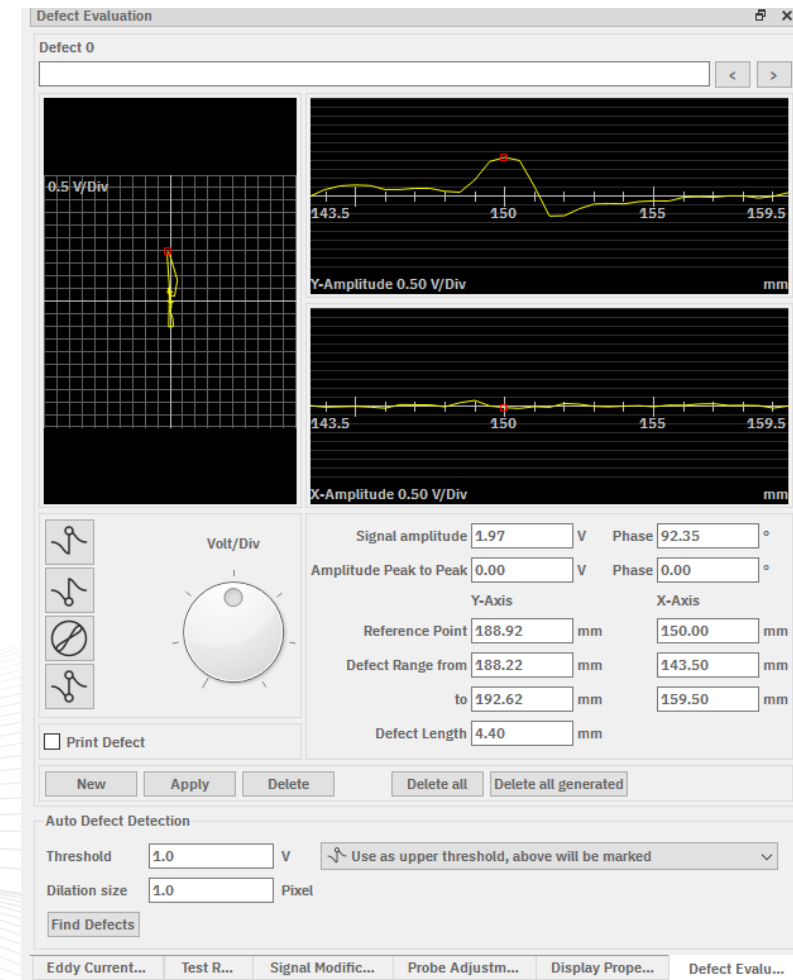
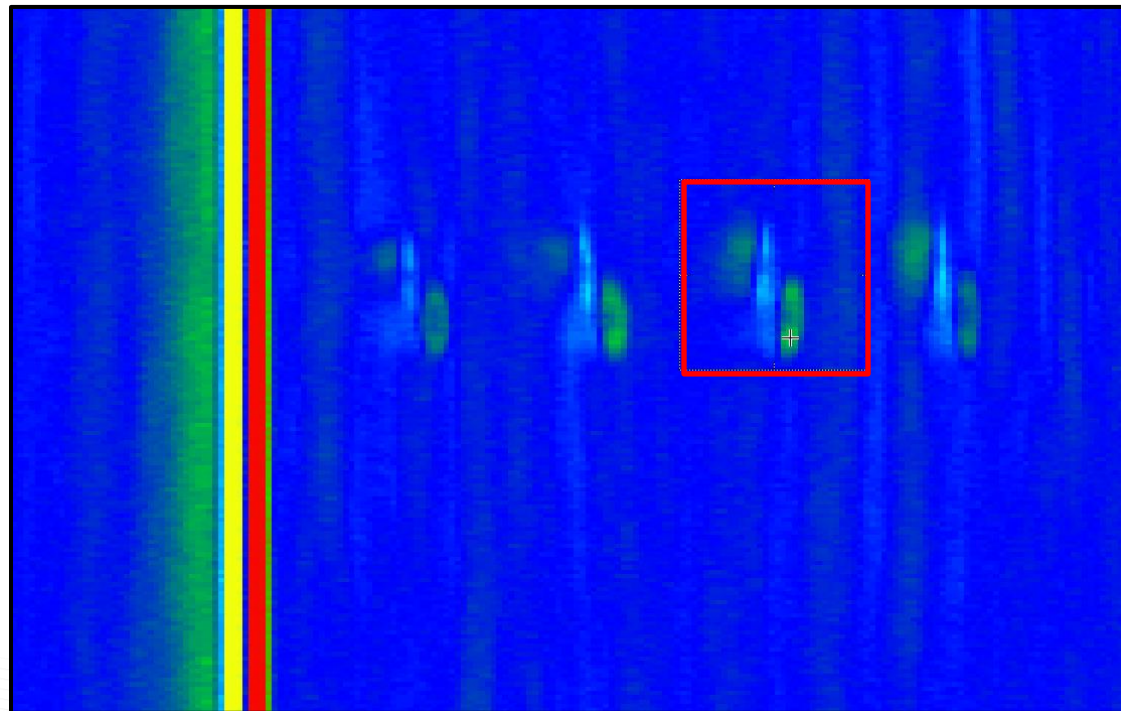
Solution for distance measurement:

Absolute signals as distance sensor in own multiplex cycle, coil with lowest distance value controls EMDC

ELO\SCAN Robot Based Inspection System

ELO\SCAN Customized Inspection Task – Satellite Tank Inspection

Reference plate for adjustment and verification



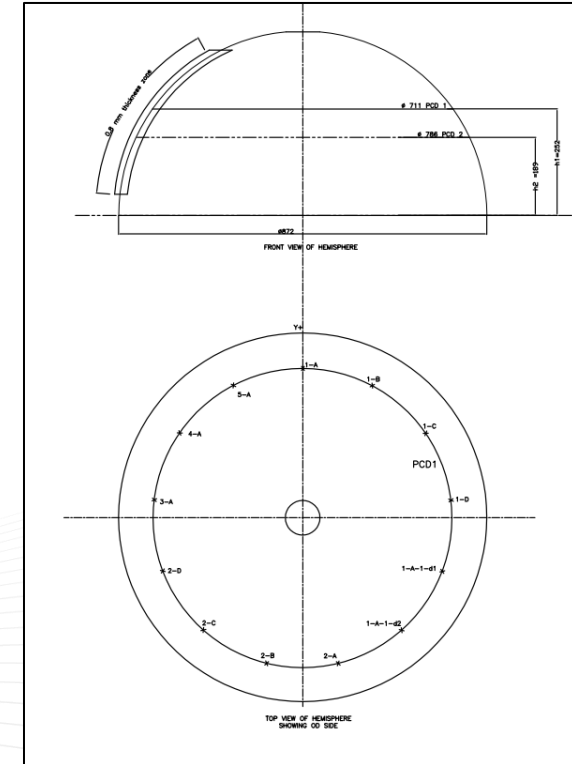
ELO\SCAN Robot Based Inspection System

ELO\SCAN Customized Inspection Task – Satellite Tank Inspection



Reference hemisphere with artificial defects

- Satellite Dome with diameter 872 mm
- Wall thickness 0,8mm - Titanium alloy
- 15 Reference EDM notches, ID and OD position
- Different Reference EDM sizes in length and depth
- 2x double reference EDM's each with 0.5 - 1.0 mm spacing
- EDM reference notches in different orientations 0/45/90deg



ELO\SCAN Robot Based Inspection System

ELO\SCAN Customized Inspection Task – Satellite Tank Inspection

Reference hemisphere with EDM reference notches



Name	Max. Amplitude	Max. Phase	PTP Amplitude	PTP Phase	Ref. Point to
1-A	2.06482V	92.0653°	0V	0°	321.922
1-A-1-d1	2.50519V	96.1291°	0V	0°	332.733
1-A-1-d2	3.04214V	93.579°	0V	0°	323.123
1-B	1.19568V	97.8832°	0V	0°	319.52
1-C	1.465V	95.1541°	0V	0°	326.727
1-D	1.45493V	99.0692°	0V	0°	317.117
2-A	0.478058V	95.3972°	0V	0°	326.727
2-B	0.587769V	98.1697°	0V	0°	314.715
2-C	0.611115V	101.461°	0V	0°	323.123
2-D (not visible)	0.113068V	93.0128°	0V	0°	313.514
3-A	2.25189V	94.7566°	0V	0°	323.123
4-A	2.00439V	90.567°	0V	0°	321.922
5-A	0.874023V	99.9224°	0V	0°	320.721

ELO\SCAN Robot Based Inspection System

ELO\SCAN Customized Inspection Task – CAD/CAM

CAD/CAM program generation for complex inspection tasks

Conventional robot programming:

- Too complex traverse paths for manual teaching (especially for hemispheres)
- Components only available on site after commissioning (high cost and time expenditure)
- No collision check with different tools (high risk and rework if necessary)

CAD-CAM robot program creation:

- Simulation and creation of all test programs with 3D data of the components
- On-site corrections possible at any time (e.g. base correction)
- Training of customers for future programming of new components
- Increases productivity, flexibility and reliability

Rohmann-Partner:

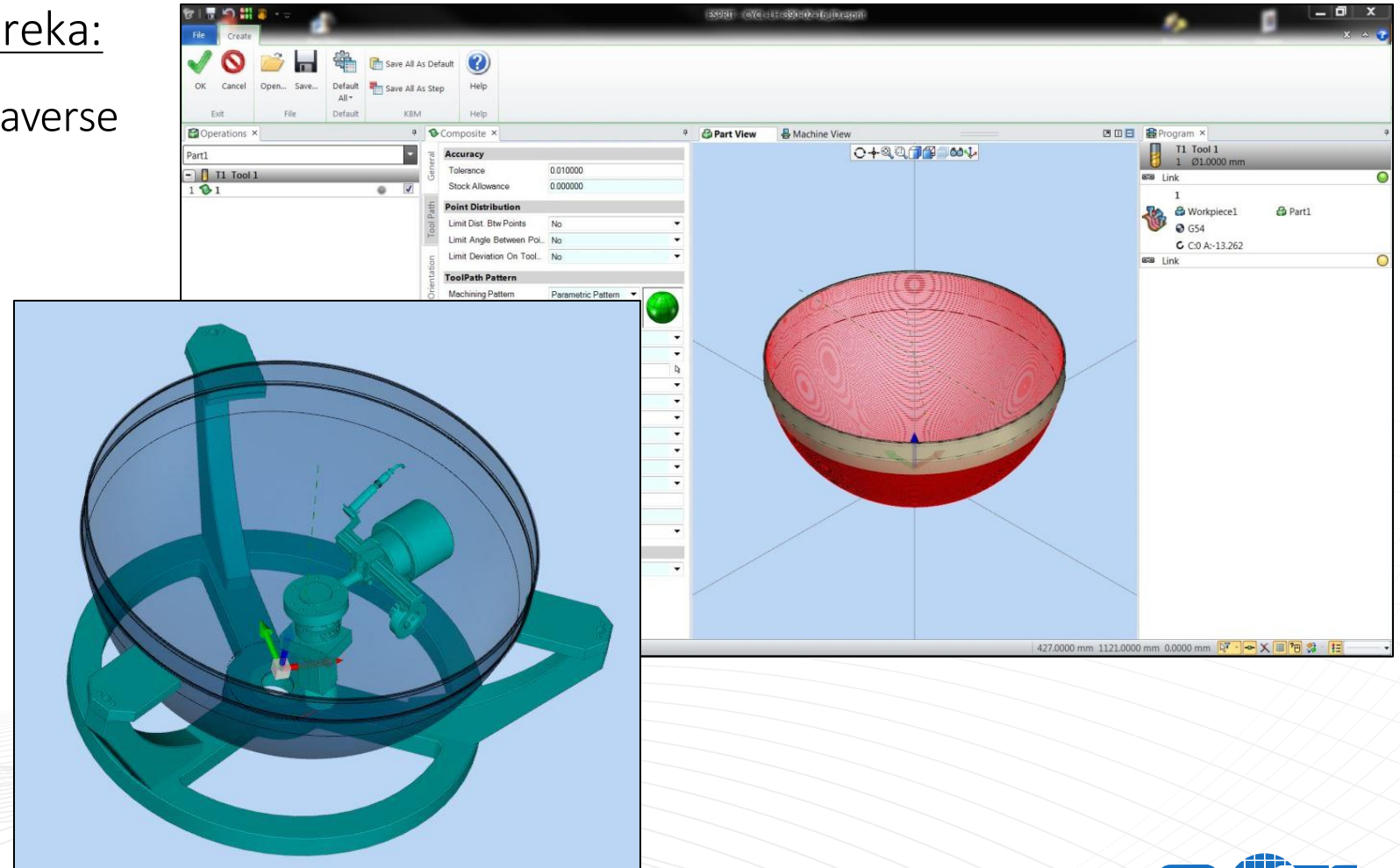


ELO\SCAN Robot Based Inspection System

ELO\SCAN Customized Inspection Task – CAD/CAM

Software combination **ESPRIT / Eureka:**

- Creation of tool coordinates and traverse paths
- Collision check between:
 - Test part
 - Part fixture
 - Tool

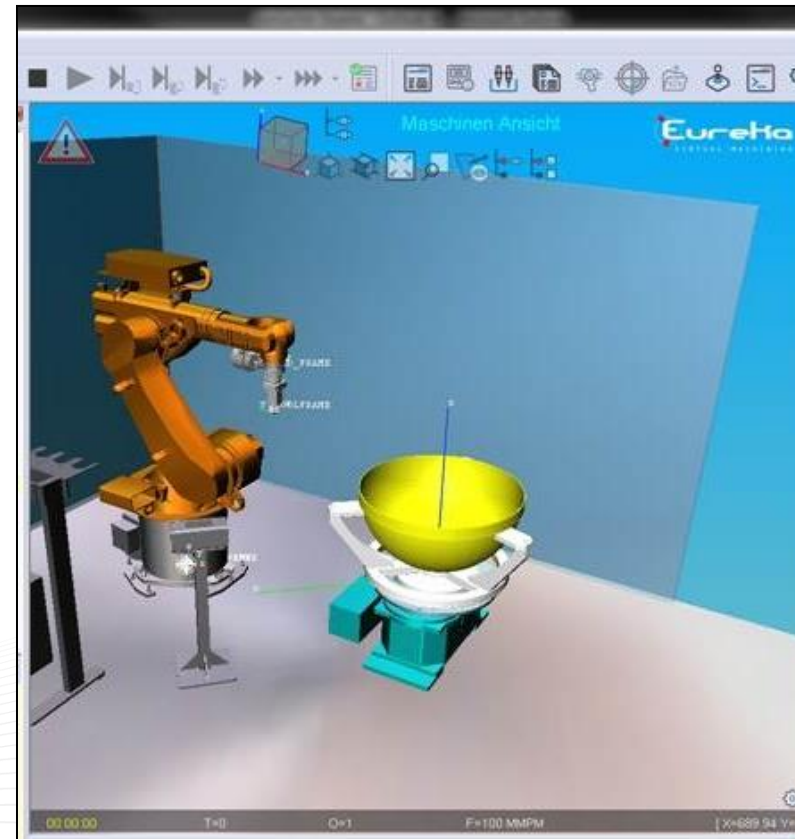


ELO\SCAN Robot Based Inspection System

ELO\SCAN Customized Inspection Task – CAD/CAM

Software combination ESPRIT / Eureka:

- Simulation of the robot cell
 - environment and equipment
 - components and mounts
- Checking the test positions for the accessibility of the robot
- Collision test sequence



ELO\SCAN Robot Based Inspection System

Thank you for your attention

Gregor Grzonkowski

Head of Projects and Systems
Dipl.-Ing. (FH)
Eddy Current Testing Level 3



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