Automated Spot Weld Testing using a Smart Robotic System

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Agenda

- Motivation
- Requirements for an autonomous system
- Implementation of the requirements
- Reliability and reproducibility considerations
- Implementation opportunities into body-in-white assembly lines
- Summary and outlook

Motivation

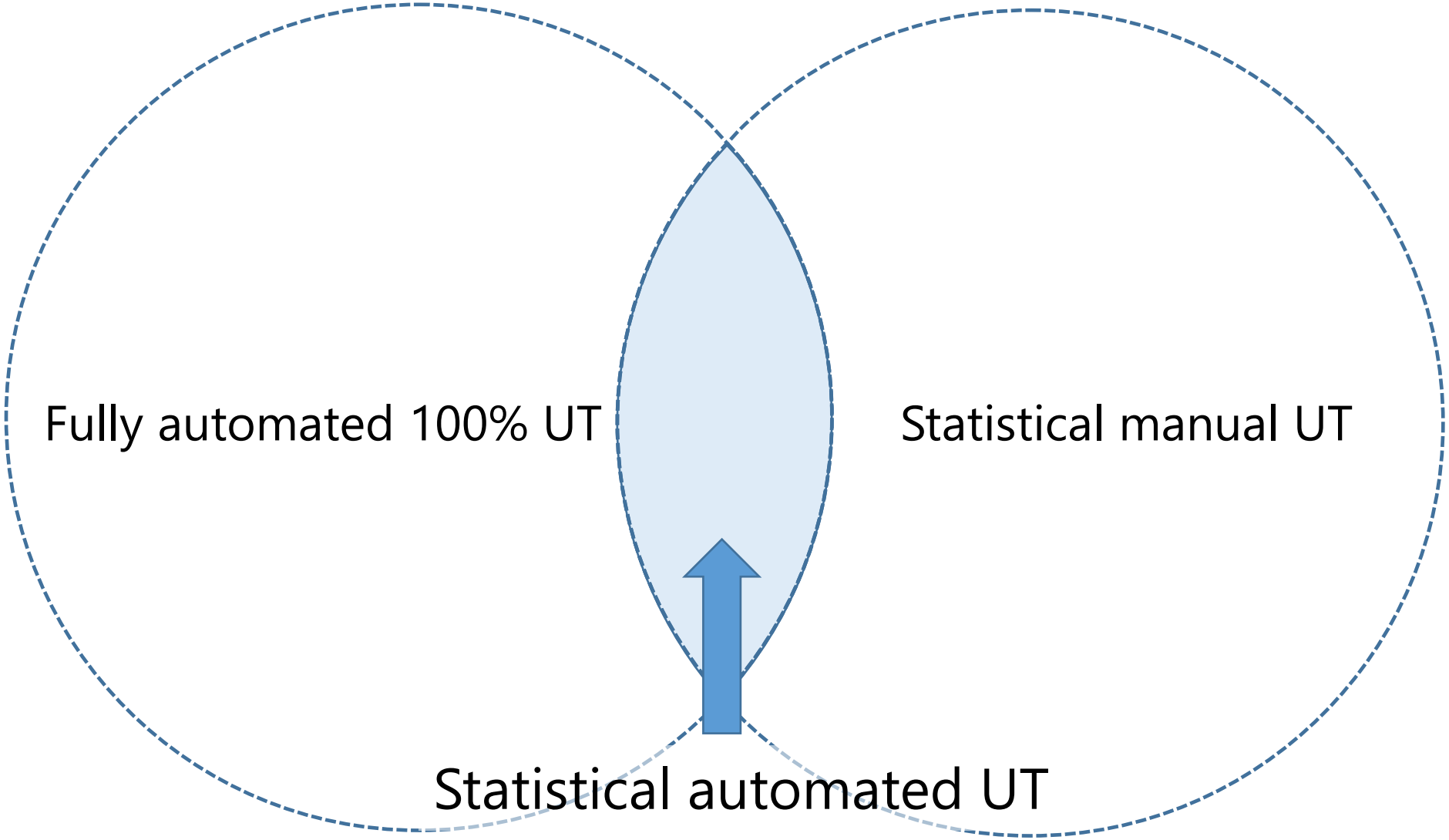
Motivation

- Generally…the quest for increased productivity in the automotive industry
- To become independ from external influences (e.g. pandemics)
- Move quality control closer to actual production

  (control circuit 2 → 1, from „out-of-the-line“ to „inline“)

⇒ From “hand-held UT probe” to “robot guided UT probe”

Motivation


Fully automated 100% UT
Statistical manual UT
Statistical automated UT

Requirements for an autonomous system

Requirements for an autonomous system

Target: From “hand-held UT probe” to “robot guided UT probe”

- Transfer all manual/human operations to a smart robotic system
  - Find spot weld
  - Apply couplant
  - Set up transducer and optimize coupling
  - Do the actual measurement
  - Compare with requirement and make decision
  - Record data
  - Remove couplant
- Full depth of UT information
- Communication with robot controller and QM system
- Small form-factor to access maximum number of spot welds

Requirements for an autonomous system

- Qualified personnel still needed: e.g. DGZfP recommends UT2-certified supervisor

Implementation of the requirements

Implementation of the requirements

- Implementation done in collaboration with Chropynska (Chropyne, C
- Fully functional robot test cell available for demonstrations
- Small Tessonics SRS (Smart Robotic System) for mounting on a robot
- Ruggedized design for industrial use

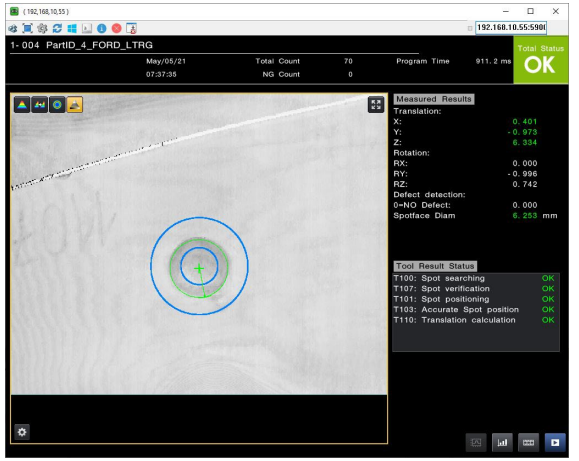
Implementation of the requirements

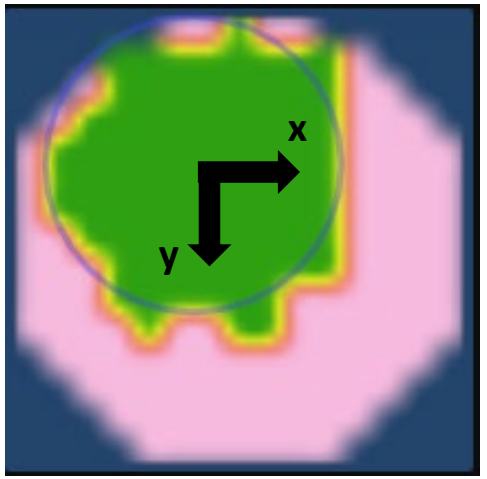
Find spot welds

- Locations known from engineering drawings
- However, up to 15 mm deviation in real life

Solution:

- Use digital camera to find right position
  → feedback to robot
- Last deviations can be corrected
  through the C-scan image





Implementation of the requirements

Apply couplant

- Couplant must me applicable through a nozzle

Solution:

- Water or oil together with a flexible delay line

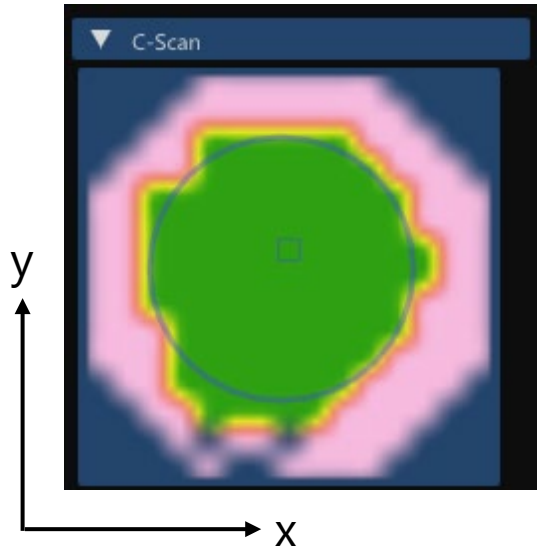
Implementation of the requirements

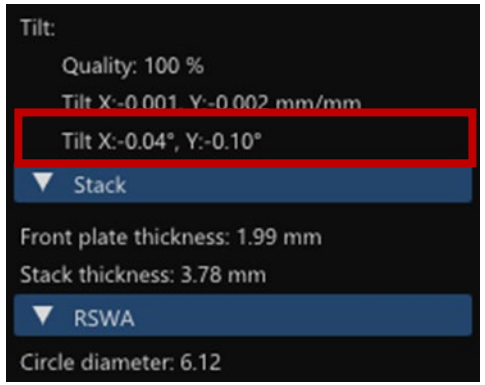
Set up transducer and optimize coupling

- correction of displacement already done in previous step
- Possibility of tilt

Solution:

- Use elements of transducer matrix to measure tilt angle → feedback to robot





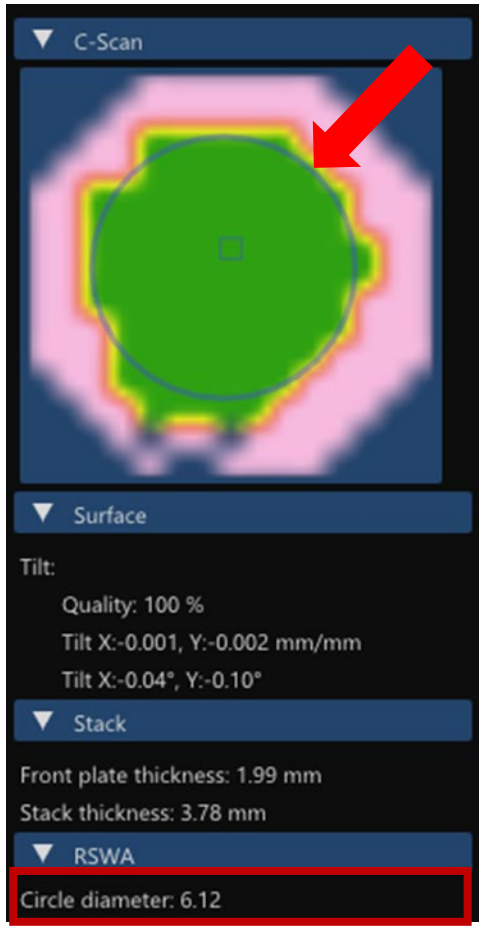
Implementation of the requirements

Do the actual measurement

- Take C-scan and evaluate nugget diameter

Solution:

- Re-use well-established evaluation algorithms from manual testing



Implementation of the requirements

Compare with requirement and make decision

- …

Solution:

- Store requirements in a part-specific test procedure (as done in manual inspection)
- Program robot to communicate weld-ID
- Compare measurement with requirement

Record data

- …

Implementation of the requirements

Remove couplant

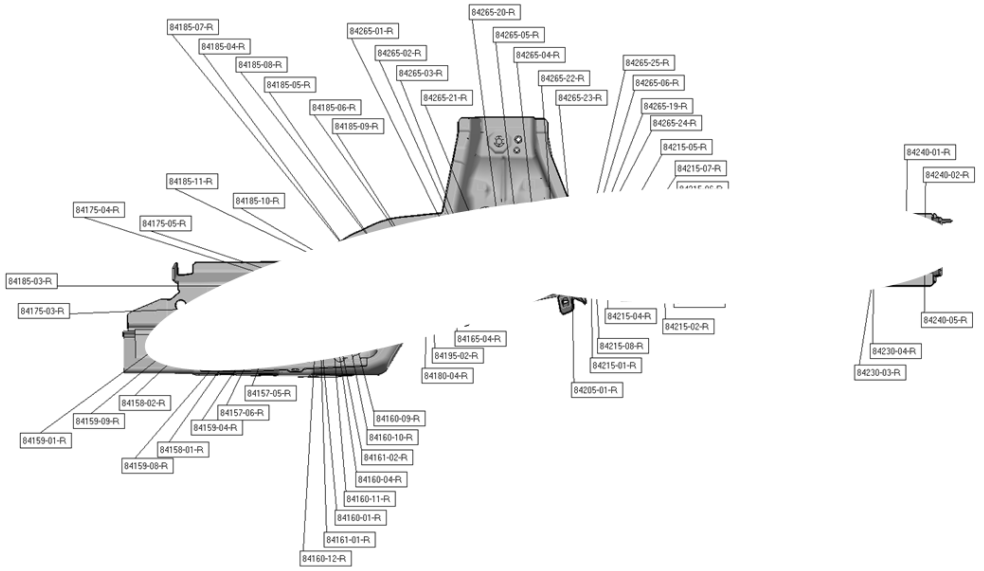
- With water and oil not really an issue

Implementation of the requirements

Reliability and reproducibility considerations

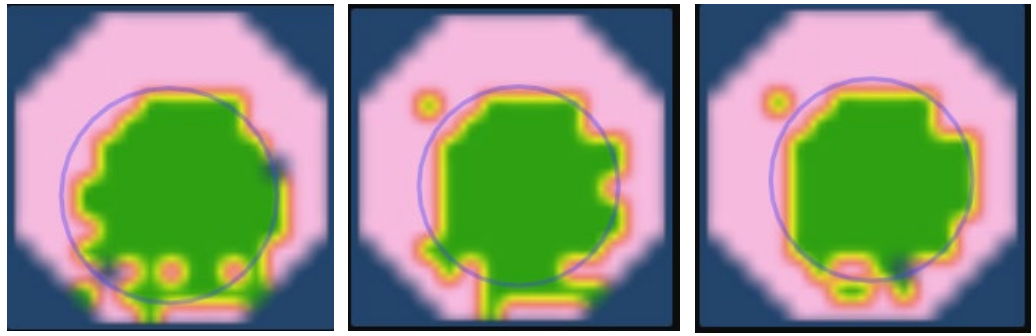
Reliability and reproducibility considerations

- Tests have been carried out on cross-beam with 63 spot welds
- 2T and 3T combinations
- Part has been completely tested 3 times
- C-scans show good repeatability



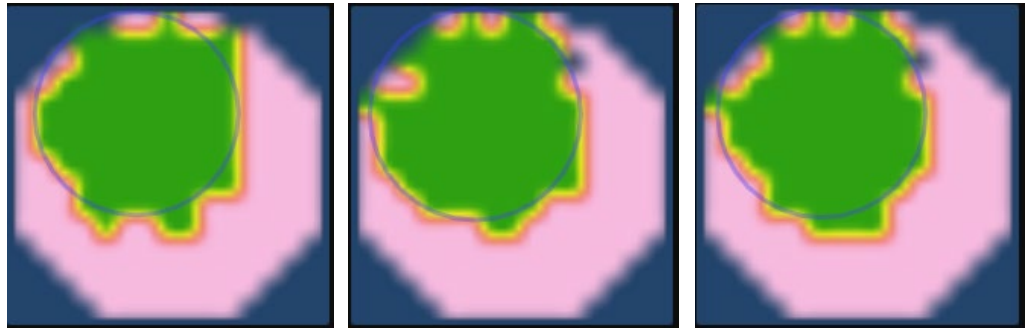
Reliability and reproducibility considerations

Example 1
(1.5 mm / 1.2 mm)



6.45 mm | 6.09 mm | 6.09 mm

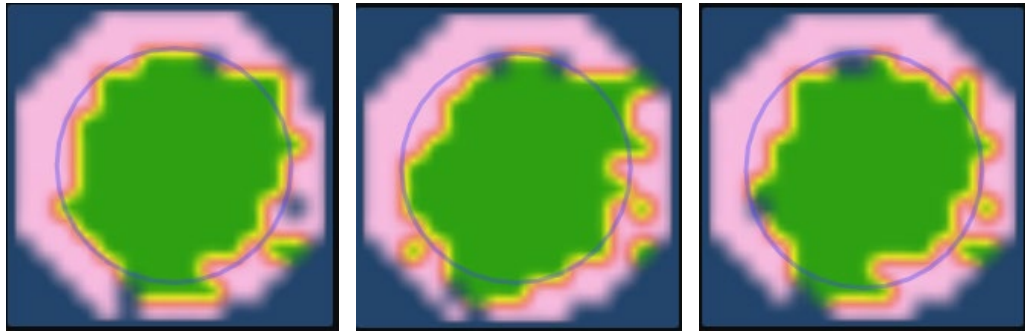
Example 2
(1.5 mm / 1.5 mm)



6.20 mm | 6.44 mm | 6.34 mm

Reliability and reproducibility considerations

Example 3
(1.4 mm / 1.8 mm)



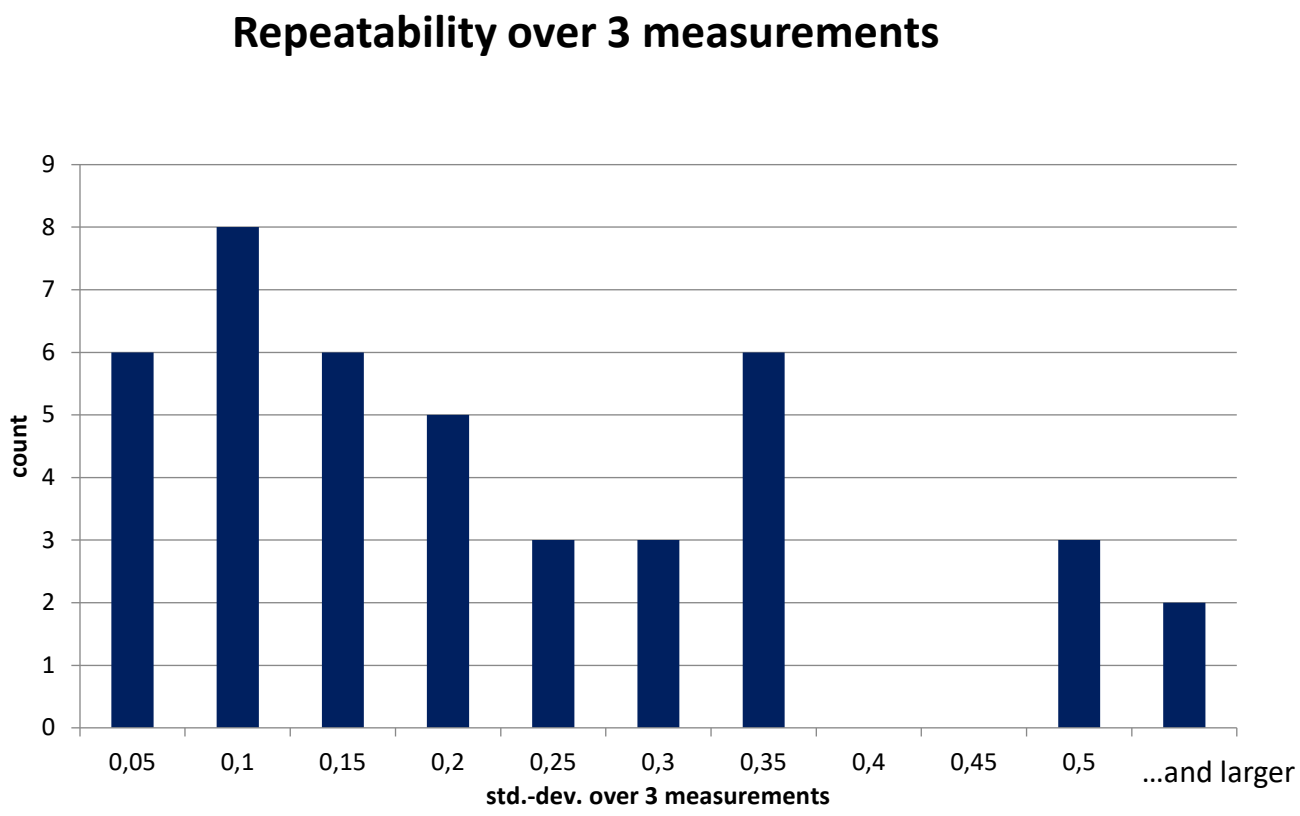
7.07 mm

6.96 mm

7.20 mm

Reliability and reproducibility considerations

- On this part, 44 out of the 63 spot welds were accessible
- Statistics over 3 measurements show only very little deviation between 3 measuremer



Implementation opportunities into body-in-white assembly lines

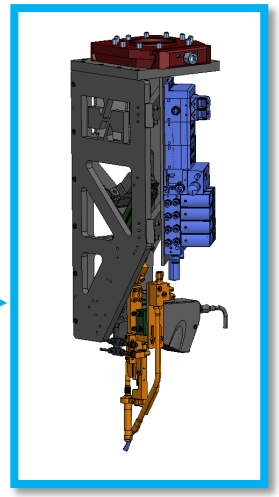
Implementation opportunities into body-in-white assembly lines

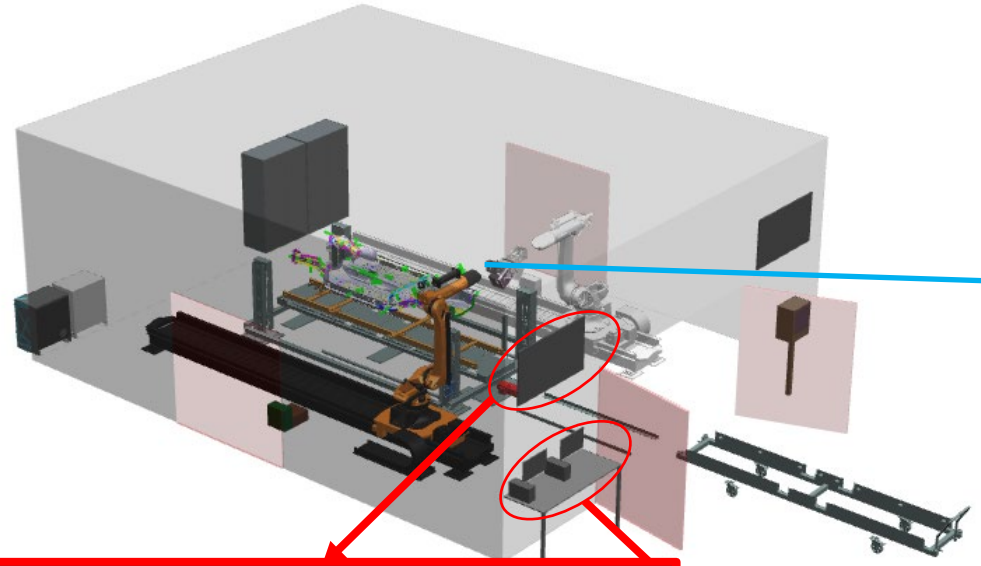
- Modular concept enables multiple implementation opportunities
  - In-line or out-of-line
  - “UT on the robot” vs. “part on the robot”
  - part handling
  - …

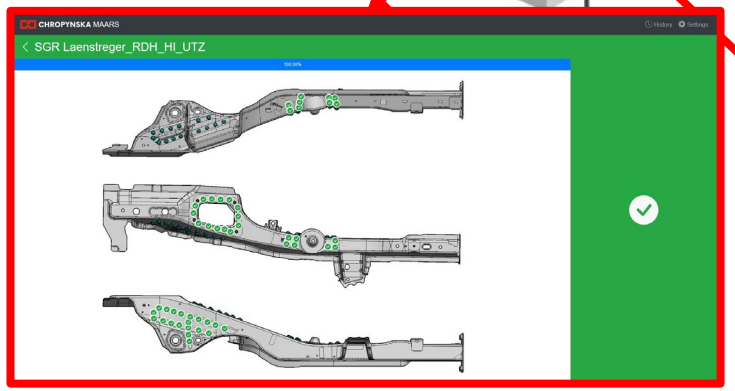
Implementation opportunities into body-in-white assembly lines

Concept A

Tool with ultrasound



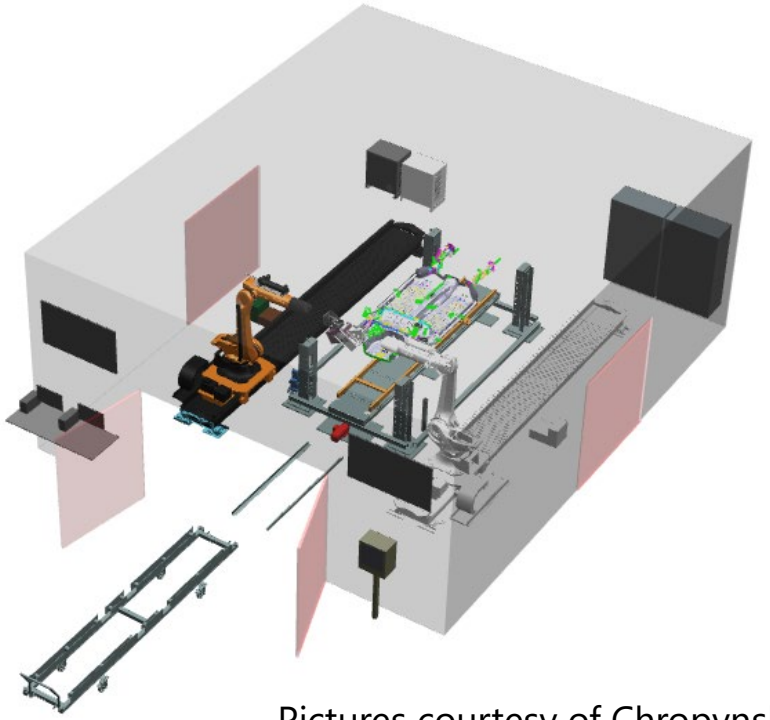




PC- SW - MAARS / LabIR

MAARS- ***M****odular* ***A****utomatic* ***A****udit* ***R****obot* ***S****ystem*

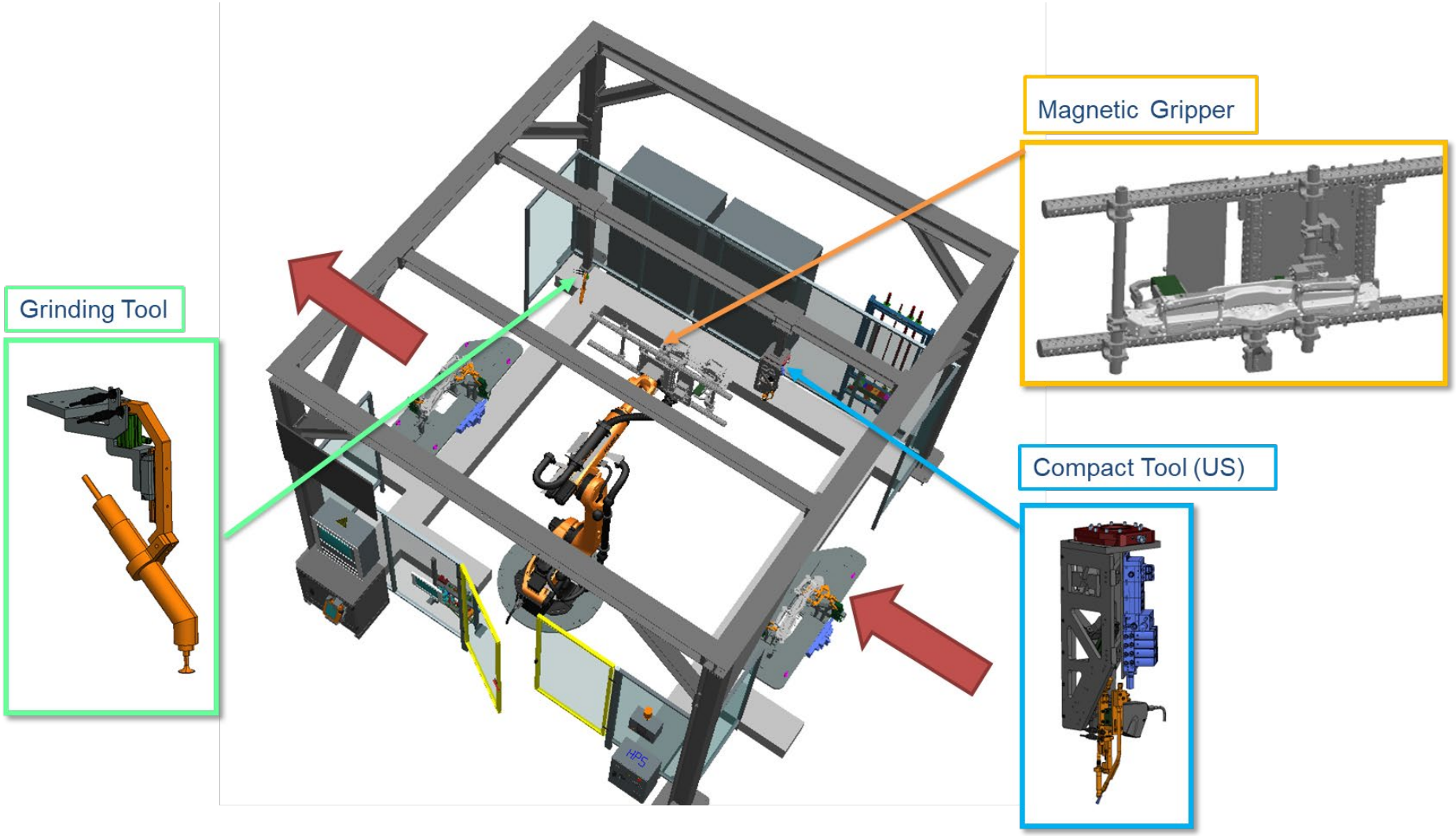
Vizualization



Pictures courtesy of Chropynska

Implementation opportunities into body-in-white assembly lines

Concept B



Pictures courtesy of Chropynska

Summary and outlook

Summary and outlook

- Introduction of automatized/robotized spot weld testing using Tessonics SRS-technol
- Manual spot weld testing can be mimicked with reliable results
- Modular concept give freedom in implementation
- Can potentially be used for other applications, e.g.
  - Adhesive bonds
  - Projection welds
  - Friction elements
  - …

Thank You for Your attention!