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SMART SENSORS FOR ROBOTIC PANEL ASSEMBLY

SAMPE Europe 2022 – Dr.-Ing. Alfons Schuster

DLR

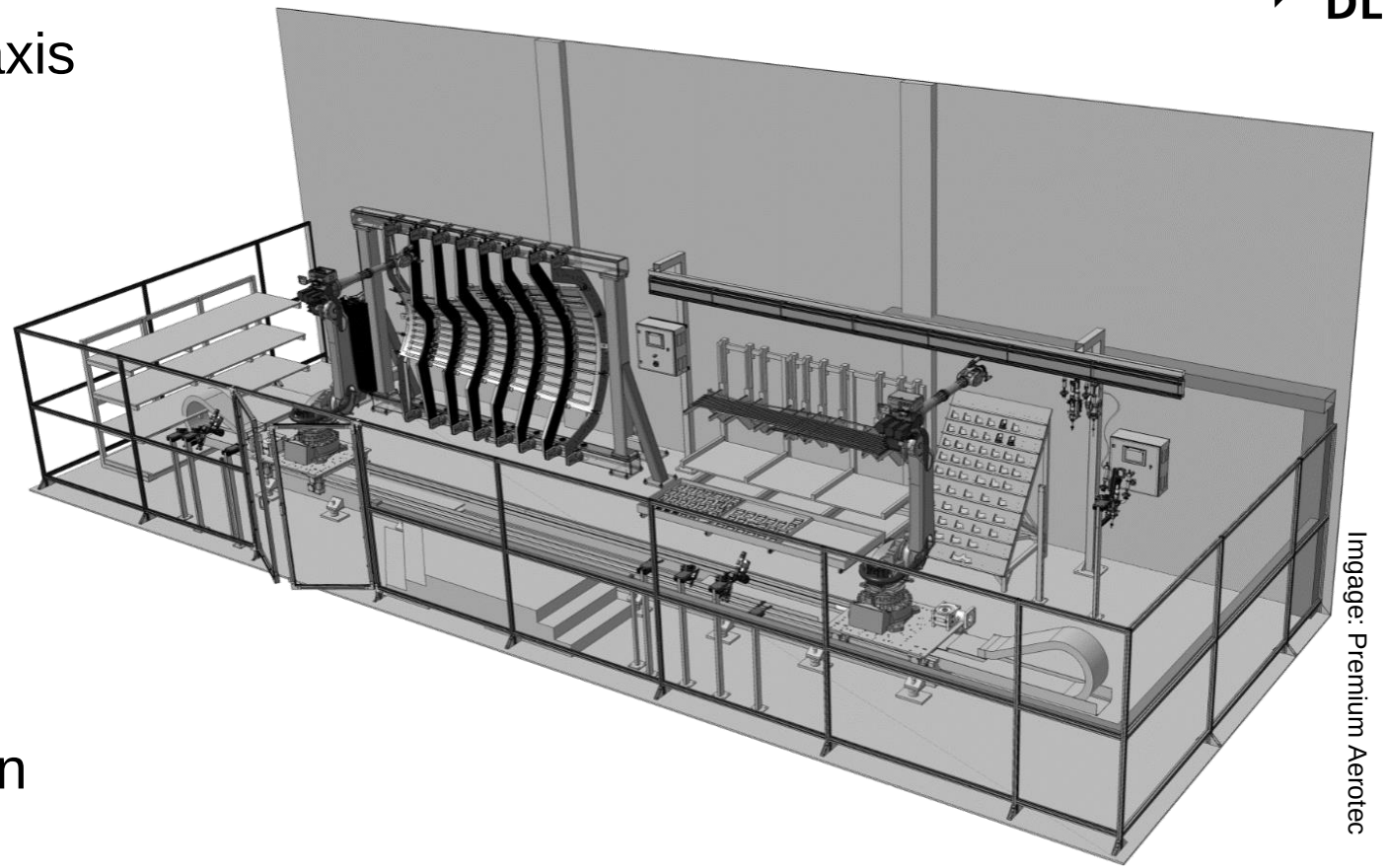
TOWARDS AUTOMATED PRODUCTION

Image: Airbus

Dr. Alfons Schuster, Institute of Structures and Design, 16. 11. 2022

Robot cell for autonomous assembly

- Two Comao-Robots on a linear axis
- Jig for skin and mounted parts
- Endeffectors for
  - Cleaning
  - Activating
  - Sealing
  - Clip handling
  - Stringer handling + riveting
- Tool changer + gripper storage
- Material supply
- Storage for resting after activation



Imgage: Premium Aerotec

- Sinumerik 840 D, OPC-UA communication
- Offline programming with VNCK and VZM simulation
- Process specific deviations are compensated by cameras

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picture source Premium AEROTEC

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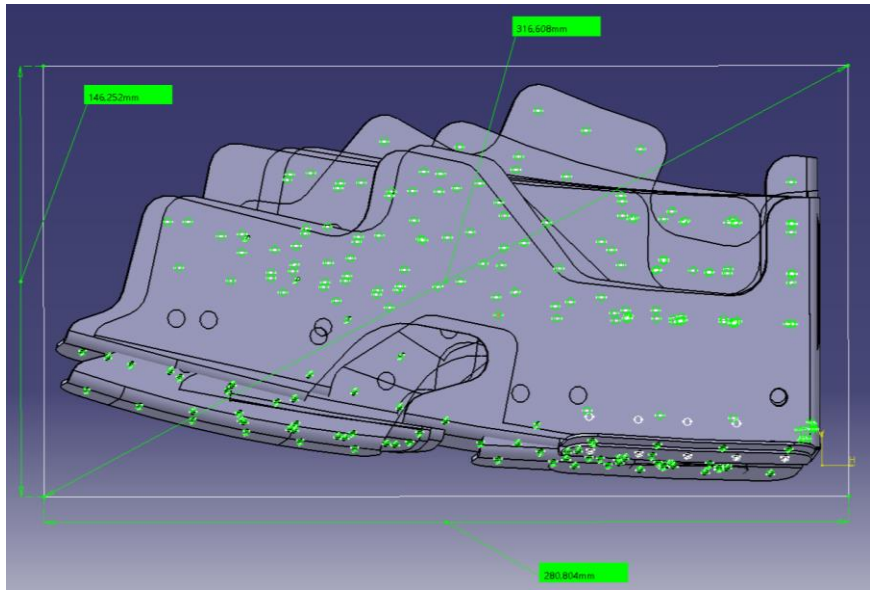
Assembly of both stringers and clips

Clips

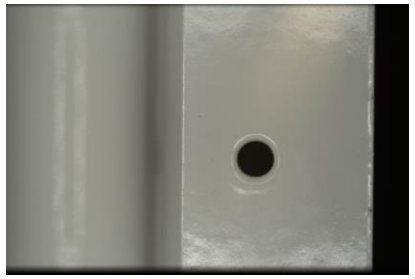
- Variety of different clips
- Different drill hole patterns
- ***Is it the right clip?***
- ***How can we identify it?***
- ***How do we grip it?***

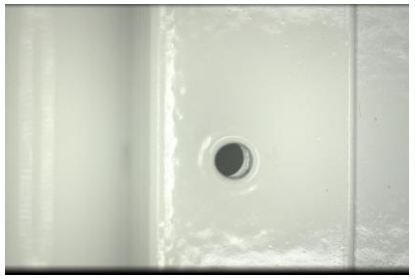


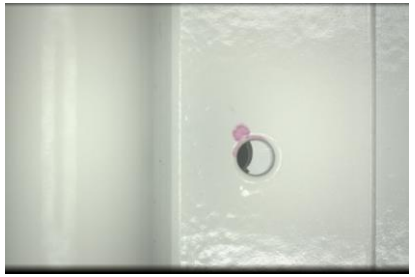
→required field of view ≈ 250x300 mm
resolution ≈ 0,06 mm

Stringer

- Identical drill holes, different overlap
- Different lighting conditions
- ***How to avoid ambigous situations?***
- ***Where to accurately put the rivet?***

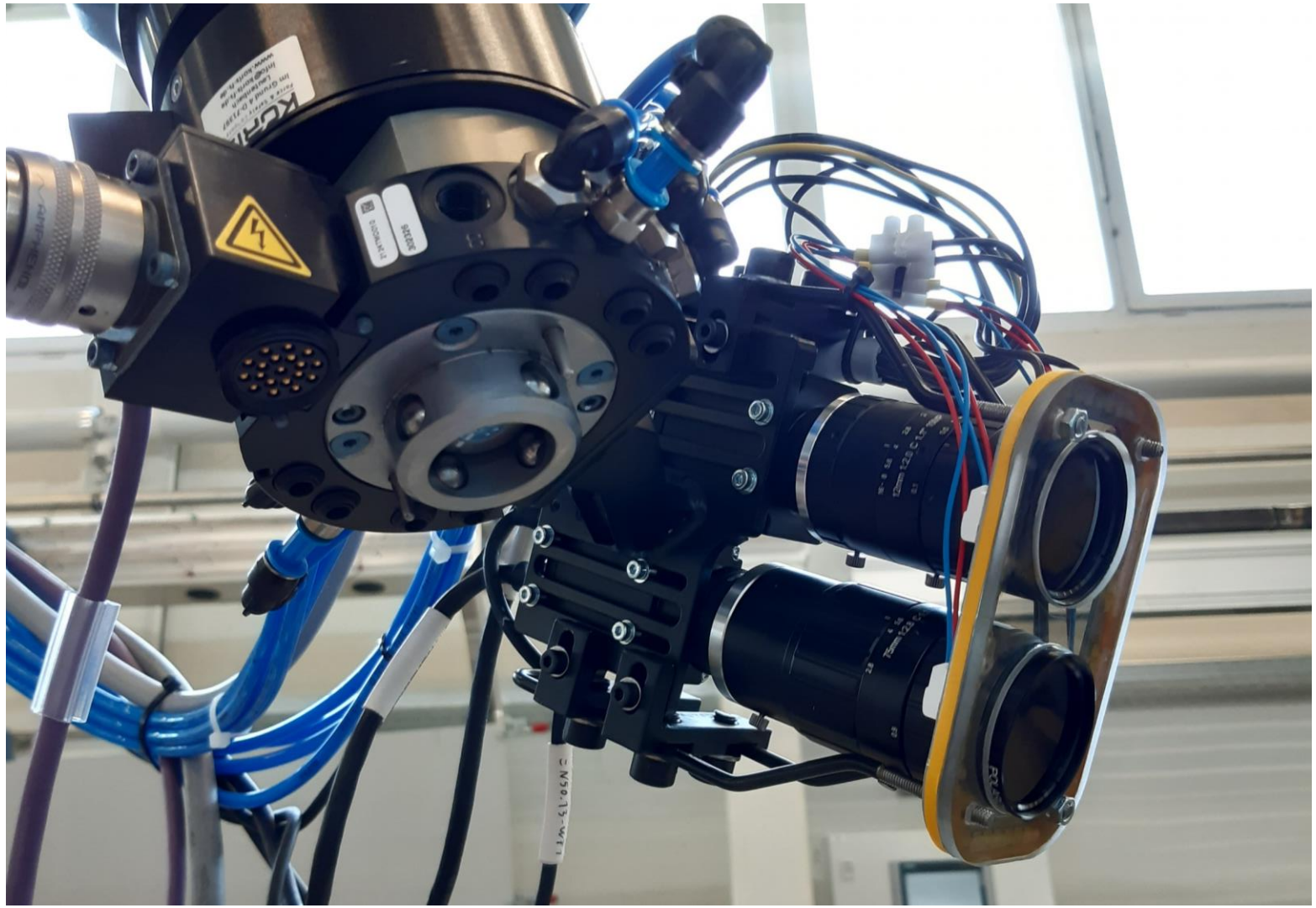


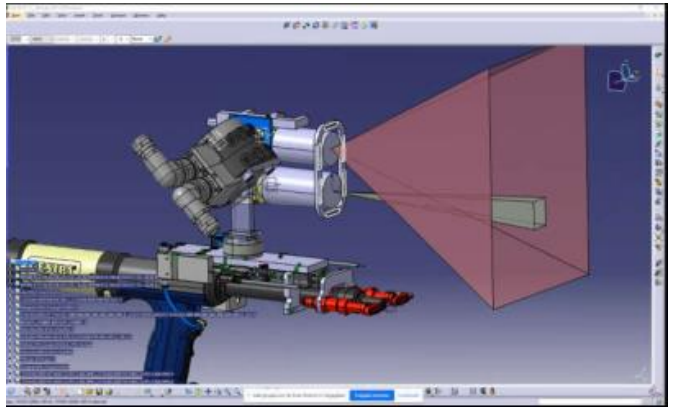


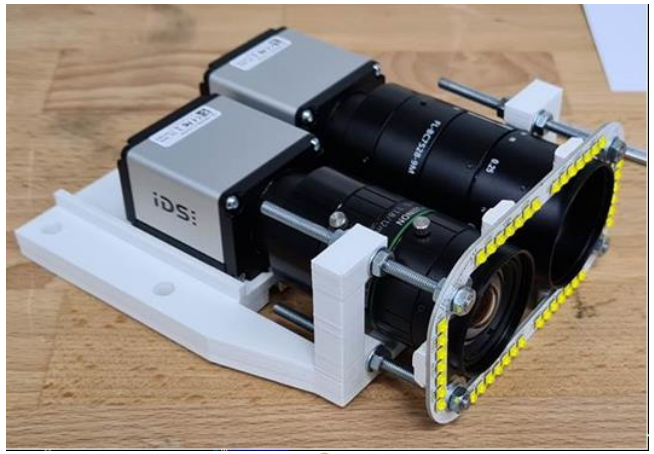


→required field of view ≈ 25x30 mm
resolution ≈ 0,006 mm

Solution: Dual camera system fixed to robot





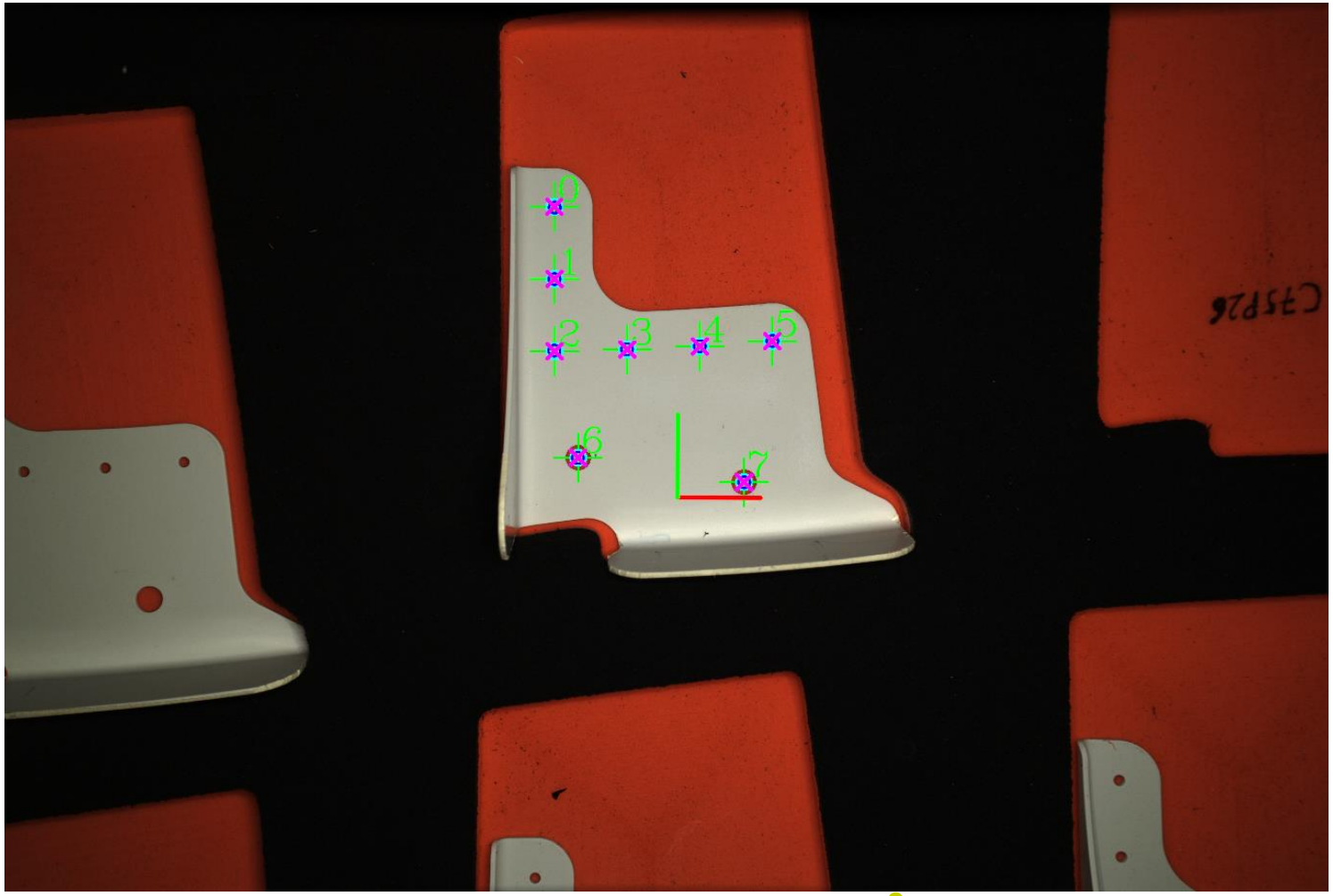


Clip Detection

- Clips are provided in shadow board (red ore blue)
- Position camera above clip
- Initial calibration assures that origin 0/0 is in the image center
- Take Camera image (flash)
- Optimize contrast
- Use blob detector to detect the bore holes
- Filter by size and circularity

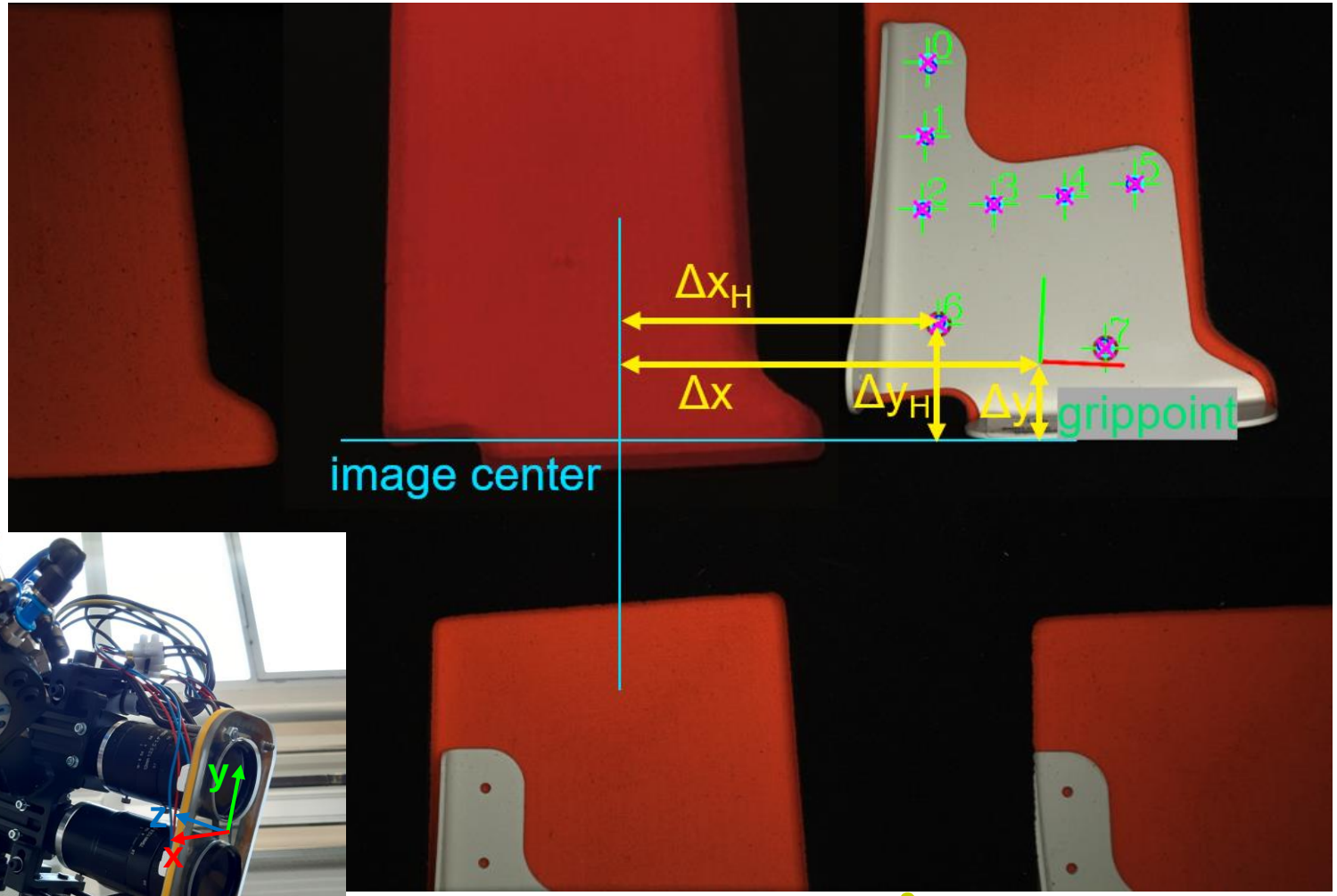
Clip Detection

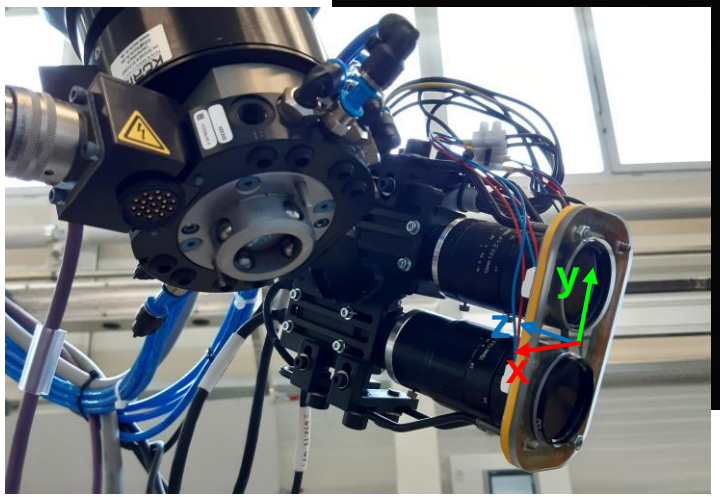
- Use CAD data with bore hole positions
- Every clip has a local coordinate system
- Sort bore holes linewise
- Perform least squares fit with free parameters
  - Shift Δx, Δy
  - Rototation φ
  - Scale s
- Introduction of scale greatly improves accuracy of shift



Grip the Clip

- Shift and rotation with respect to the image center are now known
- Switch the tool from camera to Gripper (not shown)
- Move to detection position
- Adjust x and y, then φ
- Advance in z direction and grip





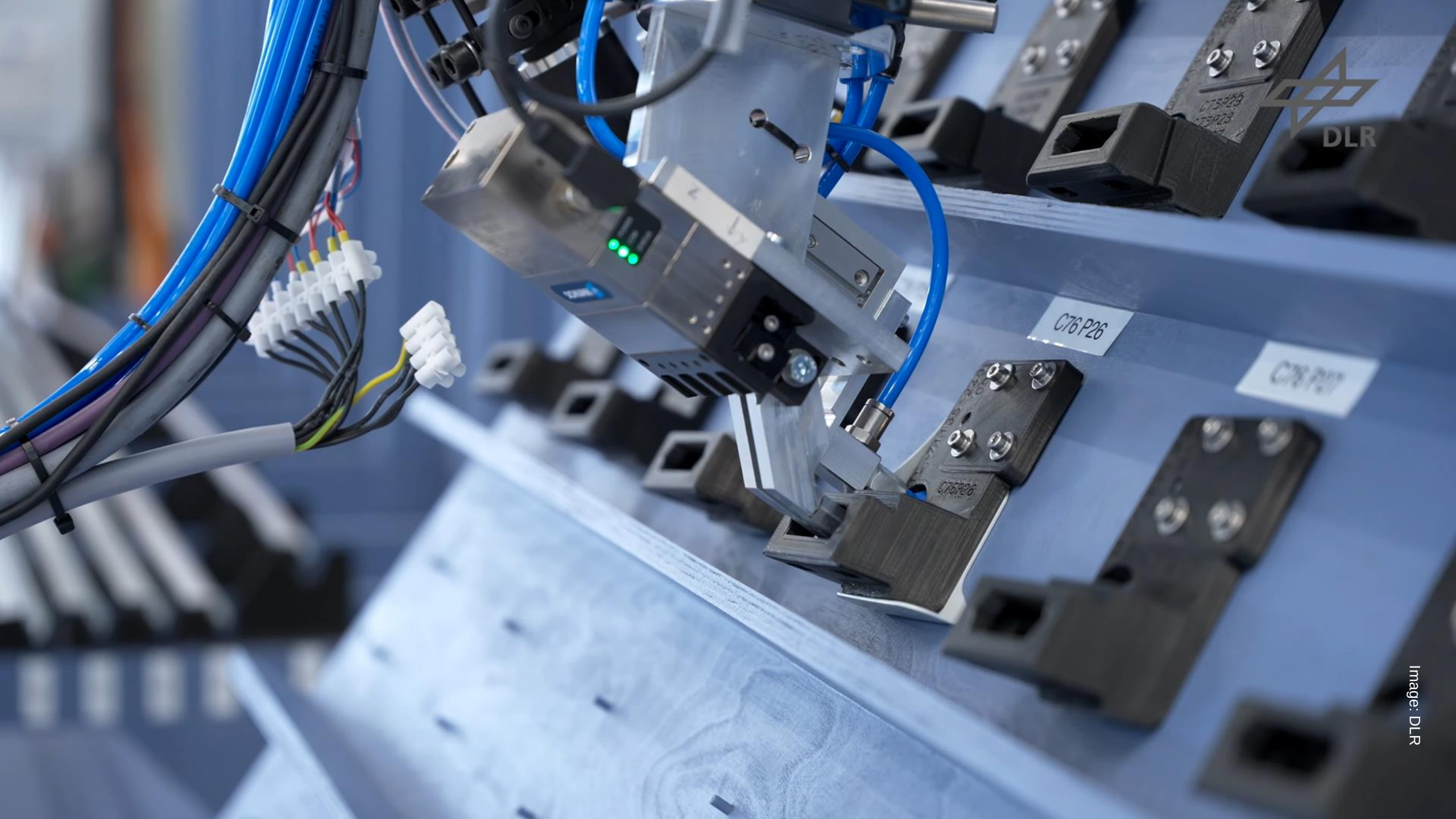


Image: DLR

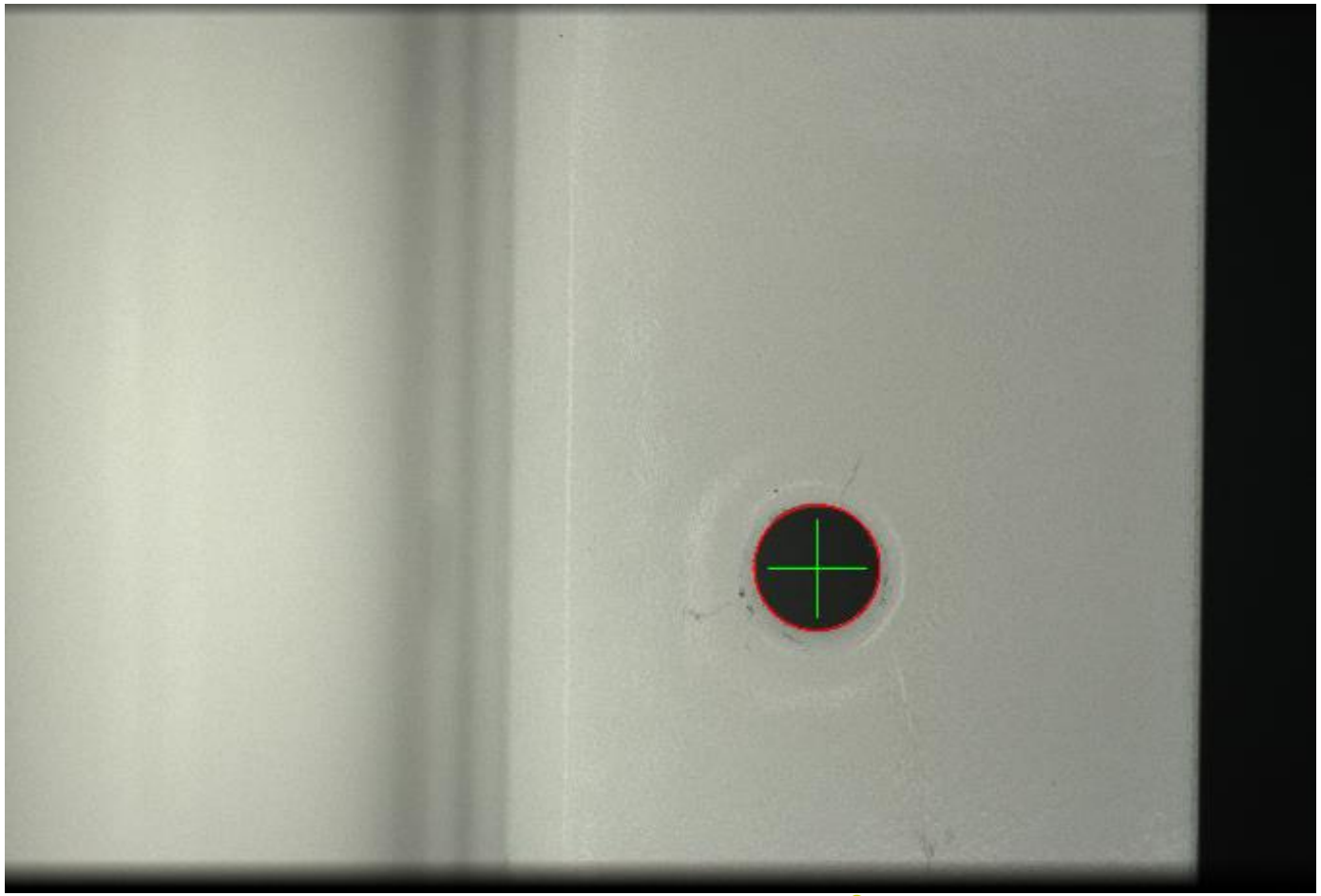
Stringer assembly

Six step process

- Detect and store every hole in the skin
- Detect left- and rightmost hole in stringer
- „Catch“ the stringer with two rivets in riveting tools
- Place stringer on skin at predetermined positions and set the first two rivets
- Detect next stringer holes midwards and tip them with the rivets
- Move to previously measured positions and set the rivets …

Detection

- Must be able to find „upper“ hole only
- May not be influenced by sealant



Stringer assembly

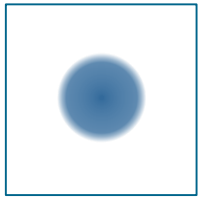
Improve Detection

- Blob detection could not handle all cases
- ***What part of the image is always the same?***

Solution

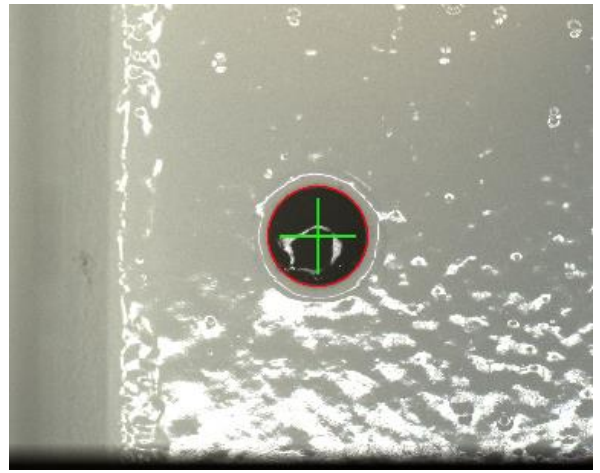
- Use template matching with mask
- Template is a completely covered drill hole
- Mask is a gaussian proflie so that the edge is taken into account and the interiour part is weighted less and less to the middle
- The blueish part is not considered
- Good results for all measurements (≈400 images)

template



mask

result



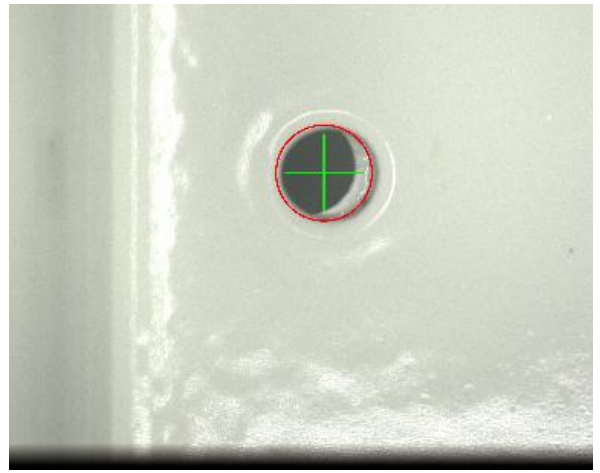
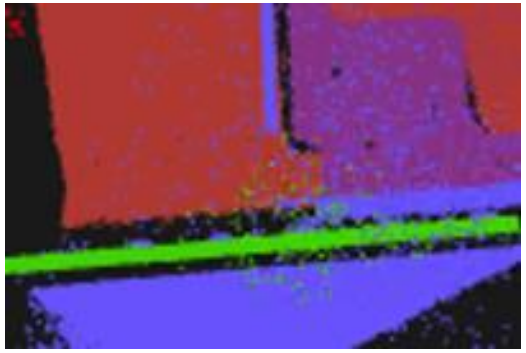
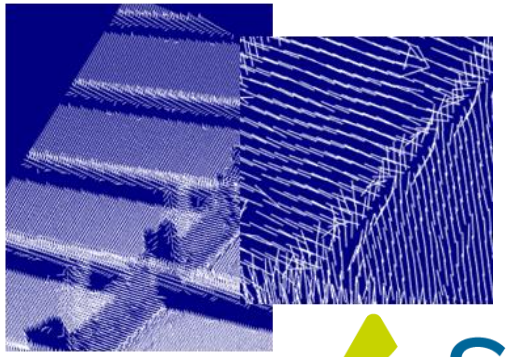


Image: DLR

Quality control: positional and angular accuracy

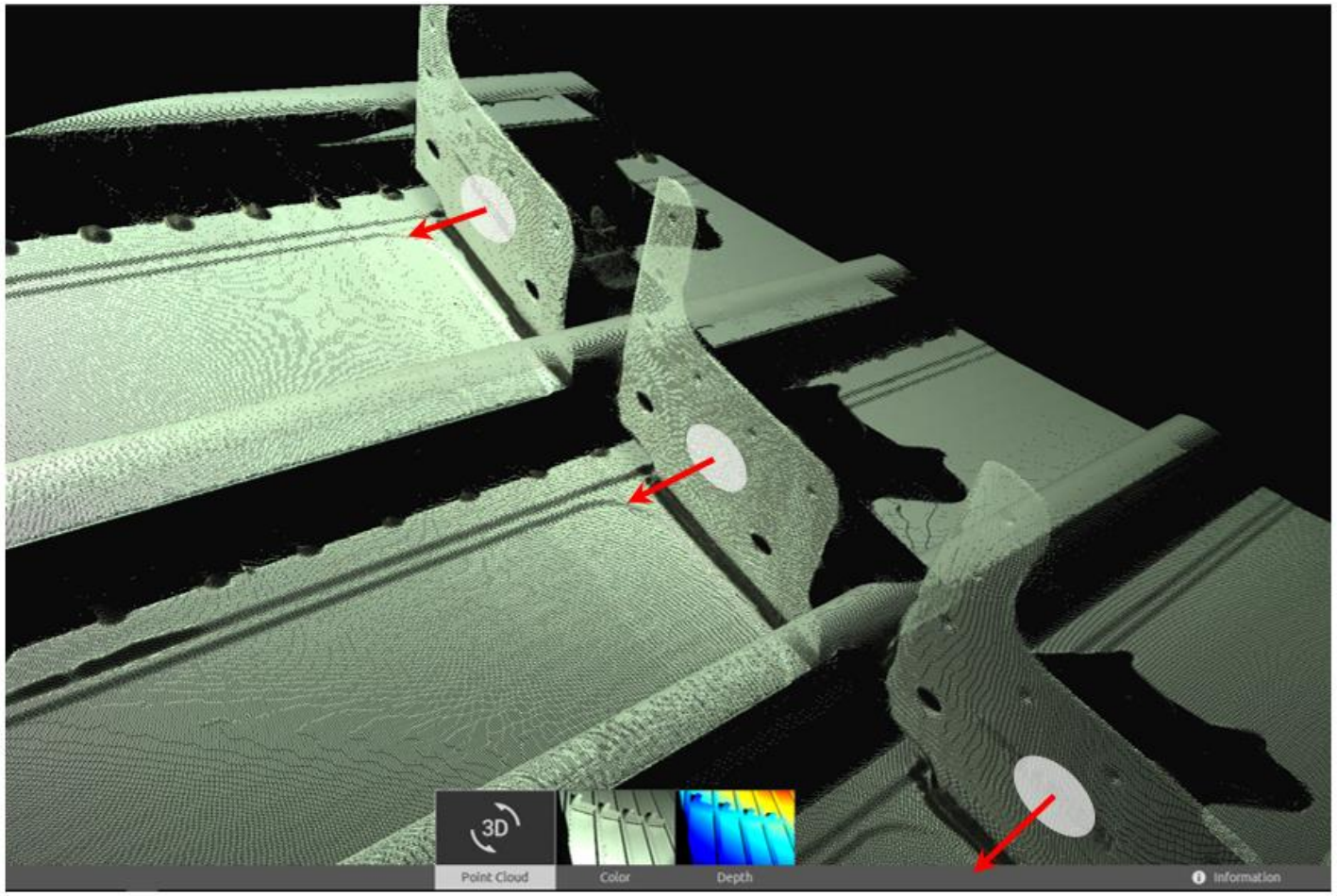
- Measure poincloud by a 3D structured light camera (here: Zivid One)
- Determine object surfaces
- Separate the clips from the rest
- Determine surface normals





Quality control: positional and angular accuracy

- Process still under construction
- Semi-Automated
- Next step: full automation with camera mounted on a robot



Conclusion

- Reliable sensor guided process for aerospace panel assembly demonstrated
- Continuous digital process chain from CAD to the robot system with simultaneous process simulation and integrated smart sensors proved to be a viable concept for flexible automation
- The developed process and the integrated detection systems will be an essential enabler for future production concepts
- Most important is the flexibility to adapt to various tasks in order to enhance production flow and to reduce downtimes
- Future work should include the integration and automation of the quality control by 3D imaging as well as a database for measurement documentation

Watch the movie

https://www.youtube.com/watch?v=wVorUo0YROE

Thank you! Questions?

Image: DLR