Eddyfi Technologies

DEPTH-ENCODED EDDY CURRENT INSPECTION
FOR BOLT HOLES IN MULTI-LAYER AIRCRAFT STRUCTURES

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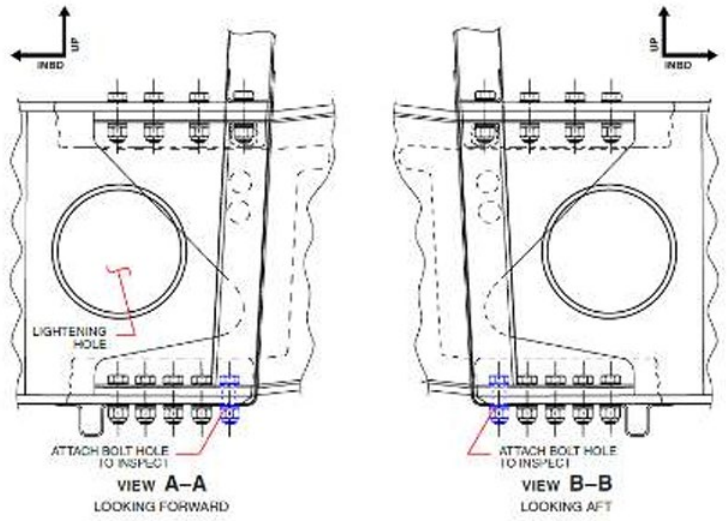
EDDY CURRENTS FOR BOLT HOLE INSPECTION

ROTATING ECT PROBES

EDDY CURRENTS FOR BOLT HOLES

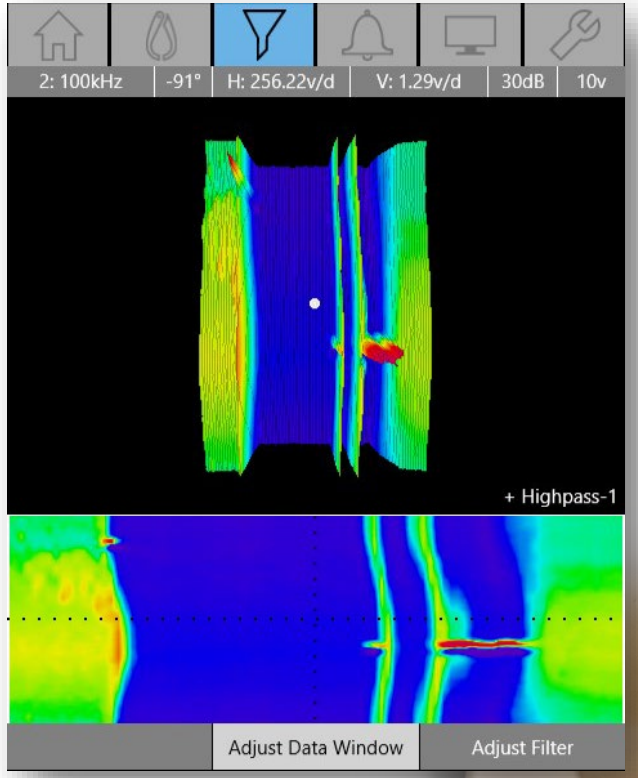
- Technique widely used for detecting cracks in critical aircraft structures
- Commonly applied to high-stress areas: wing spars, landing gear, engine mounts
- Uses rotating EC probes with signals shown on an impedance plane
- Detects presence of flaws but does **not indicate position** around the hole or through multiple layers
- Inspectors must infer flaw location, adding complexity to maintenance decisions

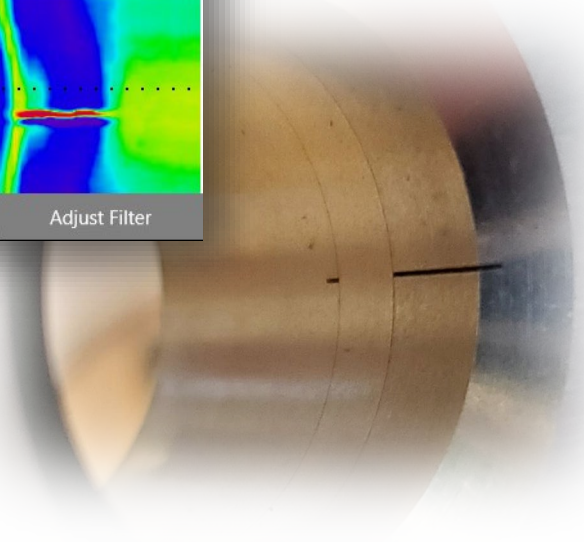
MIZ-21C detector and ZM-5 rotating scanner



EDDY CURRENTS FOR BOLT HOLES

- Conventional method: effective at detecting flaws, but positional ambiguity remains
- Challenge: no clear circumferential location or depth info in multi-layer joints
- Solution: introduce **circumferential encoding + C-scan displays**
- Provides a 2D color map of defect signals around the hole
- Benefits:
  - ✓ Displays flaw position in degrees around circumference
  - ✓ Easier to judge length, orientation, and relevance
  - ✓ Creates intuitive inspection records and improves team communication

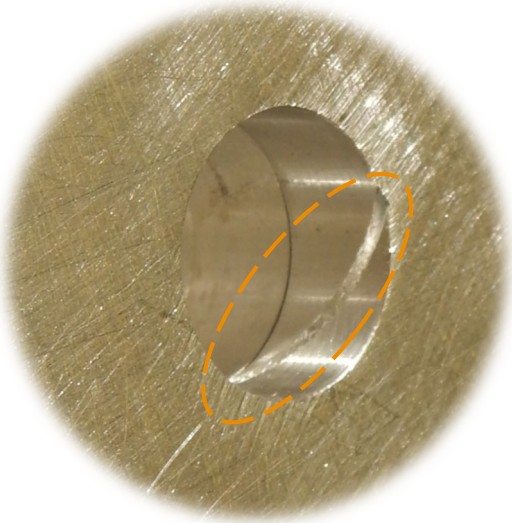




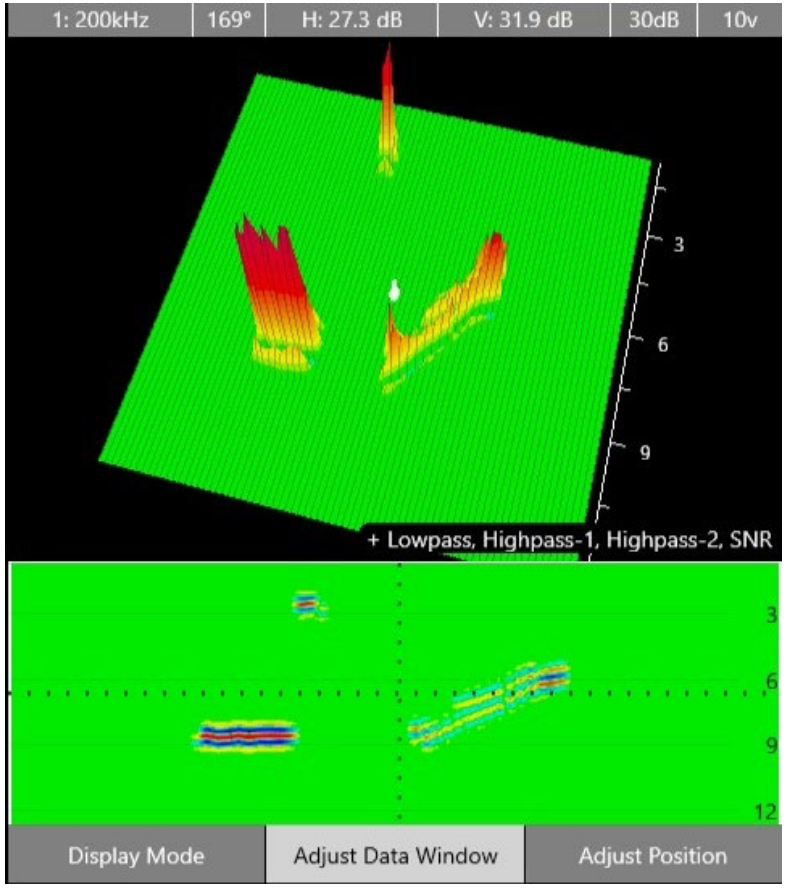
EDDY CURRENTS FOR BOLT HOLES

Bolt holes inspection

- Two EDMs starting from same interface
  - Layer 3, thru thickness notch, 9 o'clock
  - Layer 3, upper corner notch, 3 o'clock
- Helical gouge
  - Layer 1, from 6 to 9 o'clock



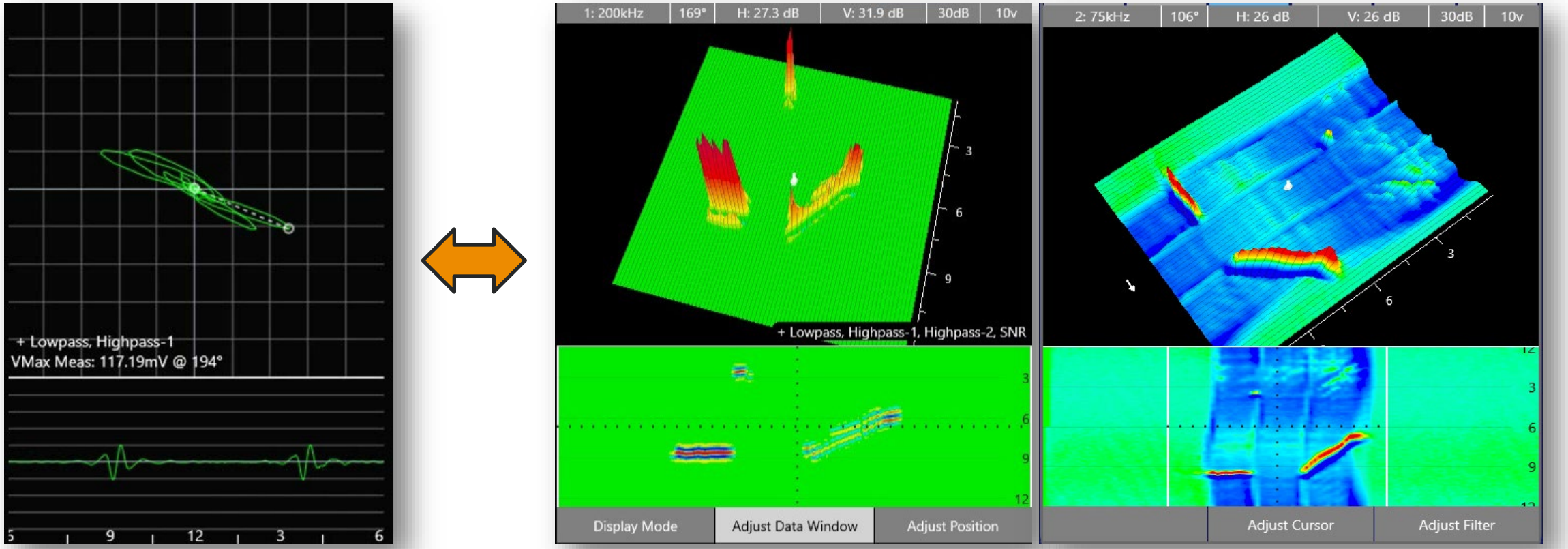
C-scan flaw detection



EDDY CURRENTS FOR BOLT HOLES

Bolt holes inspection

- Data interpretation of conventional impedance display vs rotating probe C-scan:



EDDY CURRENTS FOR BOLT HOLES

MIZ-21C in inspection procedures:

- Boeing service bulletins:
  - 737 models, including the MAX
  - 777 models
  - 777X fatigue tests
- Airbus service bulletins
- US Air Force and French Air Force
- GE Engines procedure: *“High speed eddy current inspection of circular holes in aircraft engine hardware”*

DUAL ENCODING: CIRCUMFERENCE & DEPTH

ROTATING ECT PROBES

DEPTH ENCODING

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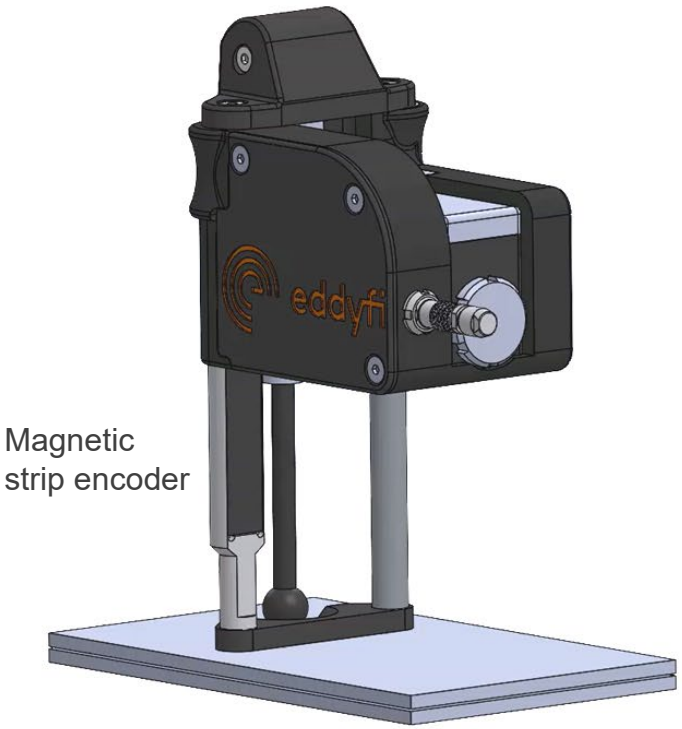
Limitations of Circumferential-Only Encoding

- C-scans solved the **circumference challenge** but not the **depth challenge**
- In multi-layer joints, flaws can exist in different structural layers
- **Current limitation**: cannot precisely measure flaw length in a specific layer
- Critical maintenance decisions can depend on flaw length and on which layer is affected
- Need: a **dual-encoded method** (circumference + depth) for full 3D defect positioning
- **User dependence**: speed of scan affects filters

DEPTH ENCODING

Axial Encoder for standard rotating probe

- Unlock axial flaw length sizing in a specific layer
- Differentiate types of layer material, thickness or potential detachment
- In combination with circumferential information, the flaw footprint can be defined
- Compatible with any rotating probe type (even if not provided by Eddyfi or Zetec)
- User independence, apply filters based on encoder information
- **Extra**: Customization options are possible if needed



Magnetic strip encoder

DEPTH ENCODING

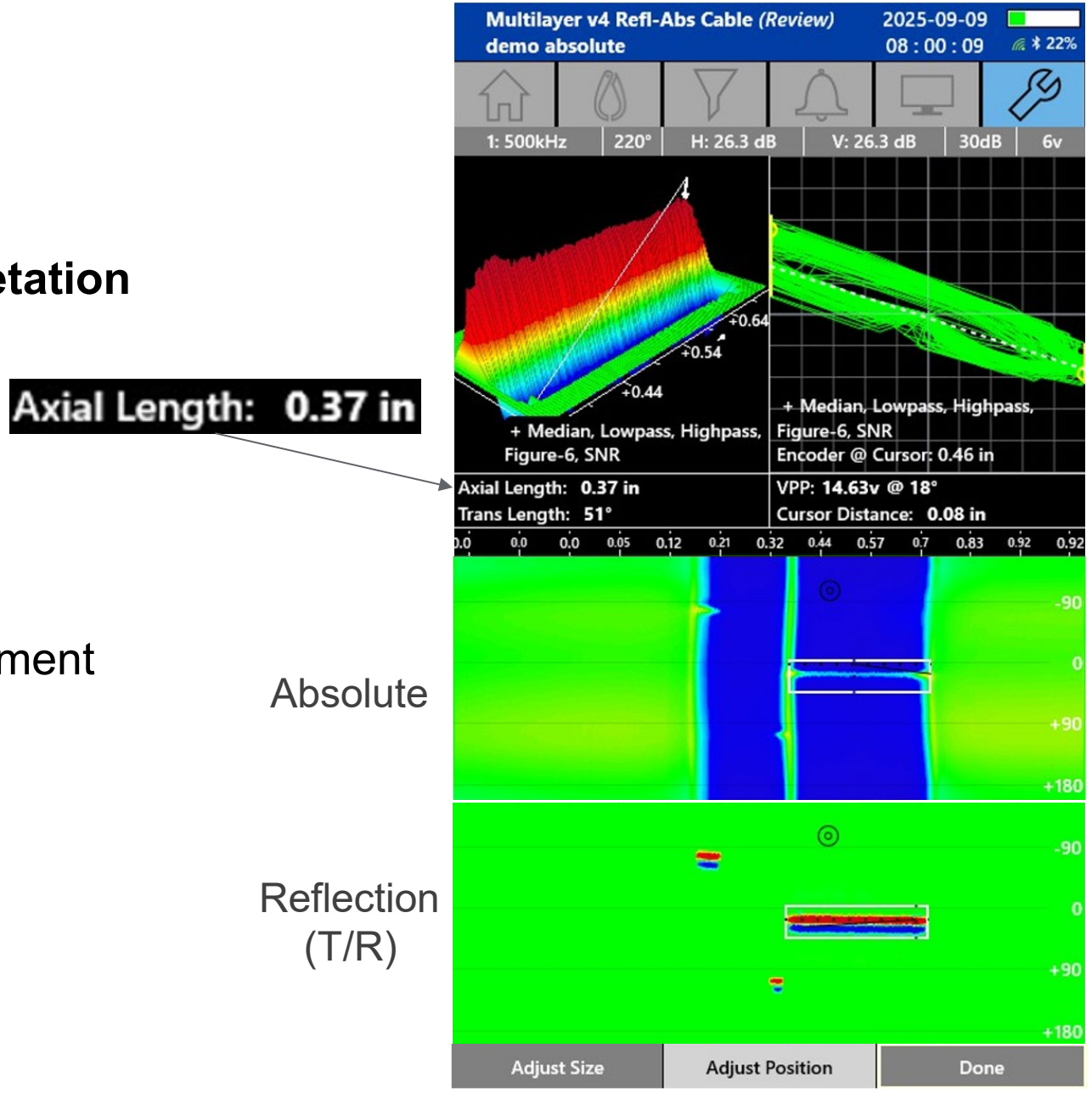
Two Topology mode for optimal data interpretation

Absolute:

- Raw and unfiltered data
- Identify different layers
- Measure layer thickness and potential detachment

Reflection (T/R):

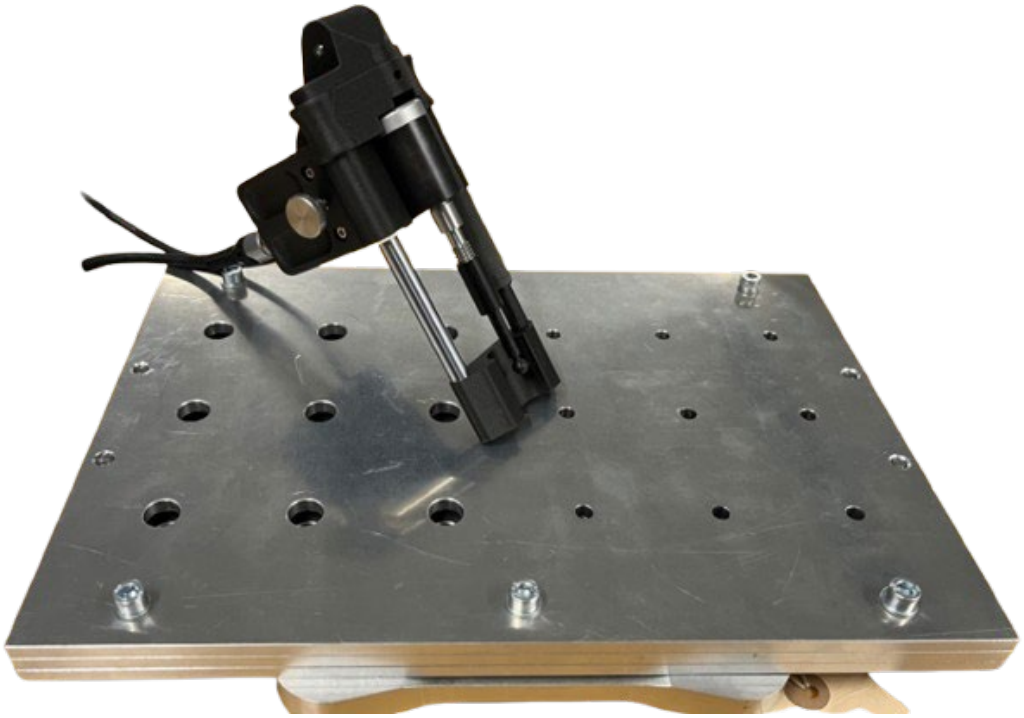
- Filtered data → find flaws easily
- Measure crack length
- Locate circumferential position

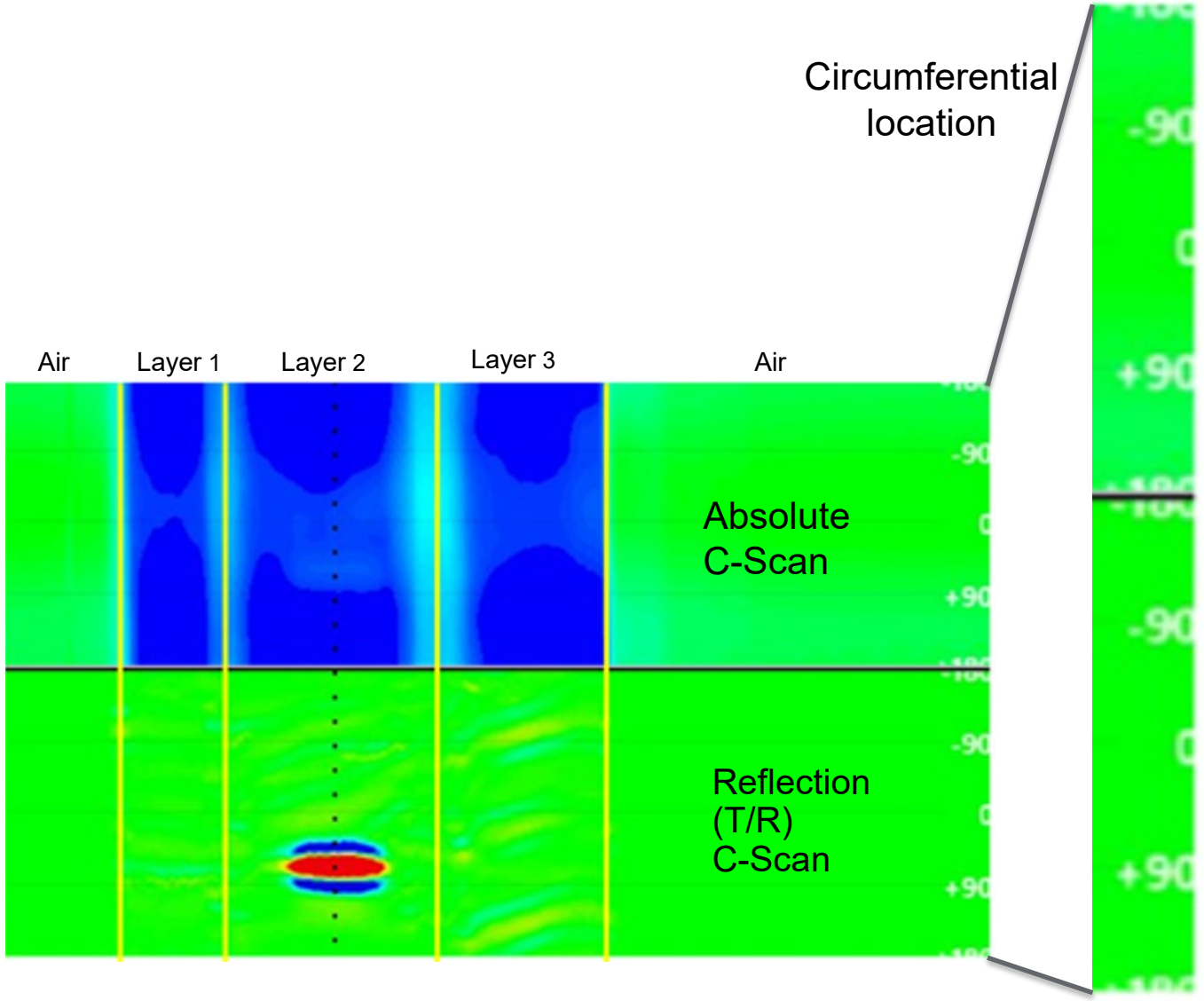


DEPTH ENCODING

Example C-Scan data:

- calibration block with real life cracks
- 3 Different layers

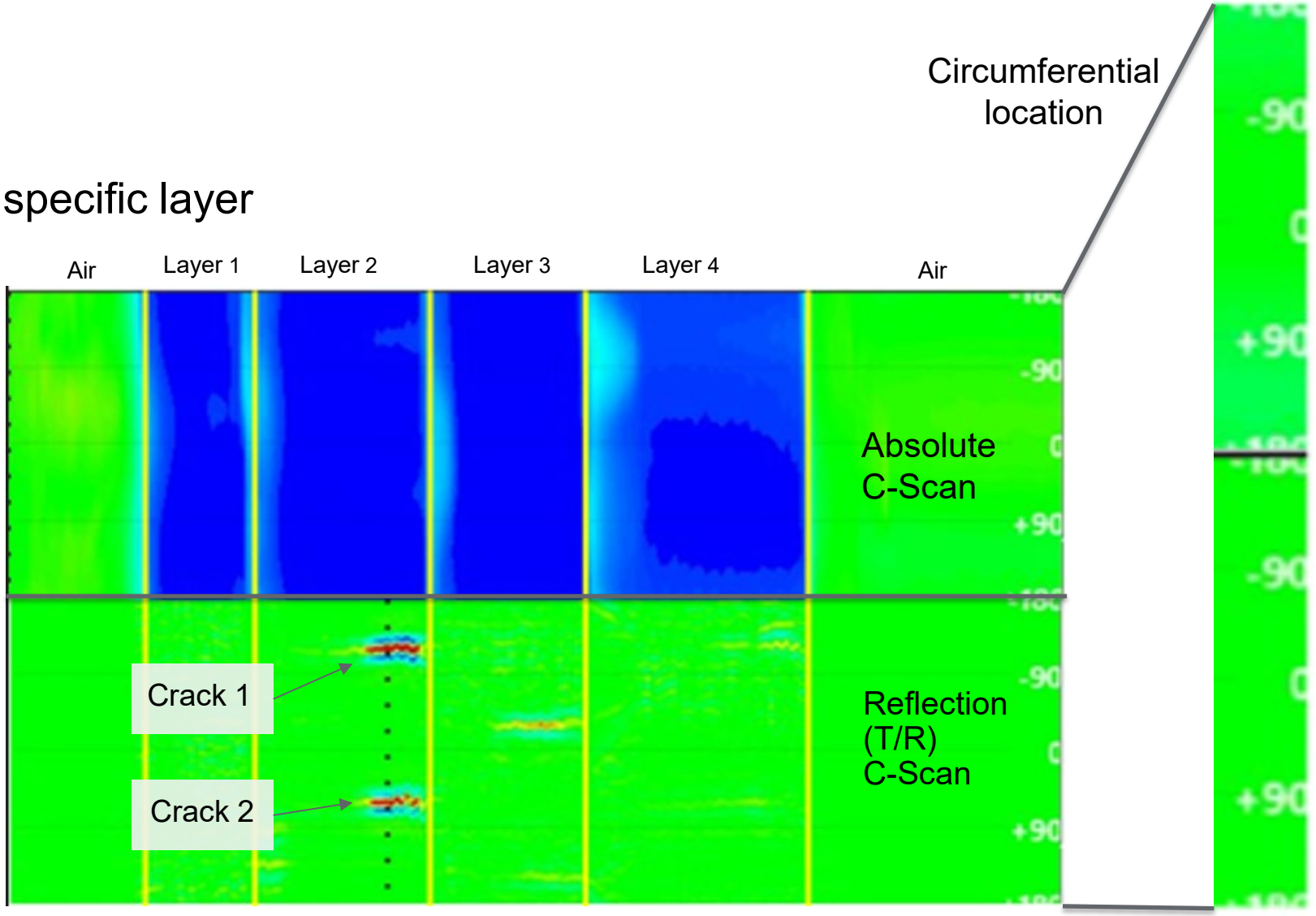




DEPTH ENCODING

Example C-Scan data:

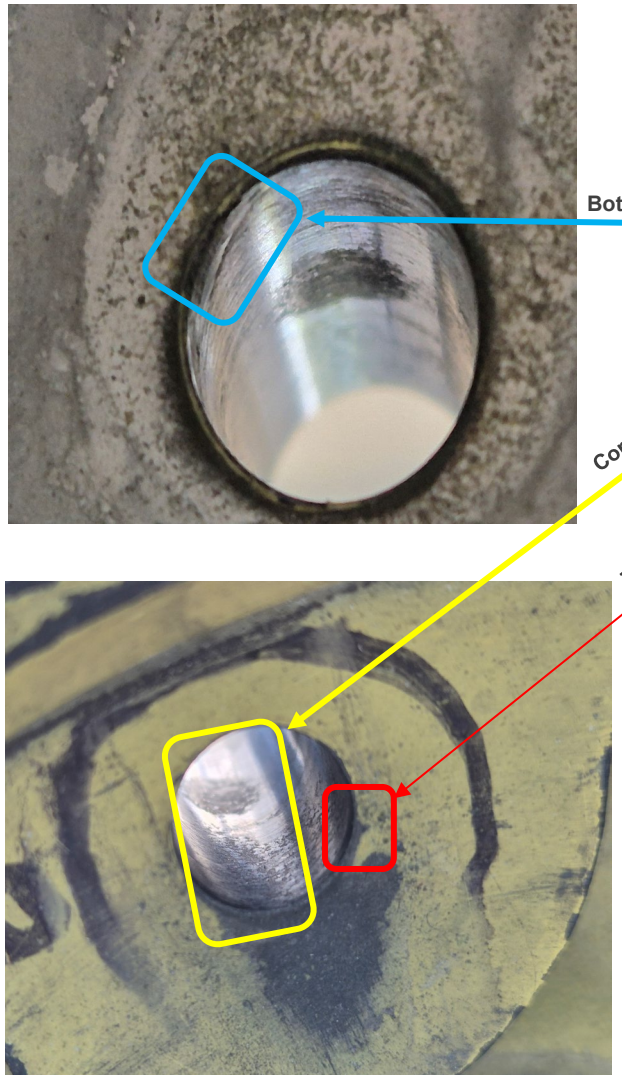
- Understand crack quantity in specific layer



ALPHAJET WHEEL

Example C-Scan data:

- Corrosion and cracks



EDDY CURRENT ARRAY (ECA)

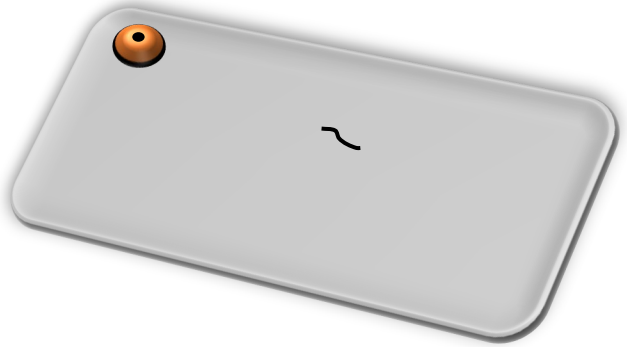
INSPECTION OF SURFACES

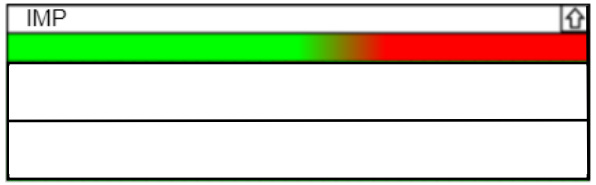
EDDY CURRENT ARRAY

Eddy current array (ECA) uses multiplexed coil sensors, allowing the inspection of large surfaces in a single linear scan.

Single-element (ECT):

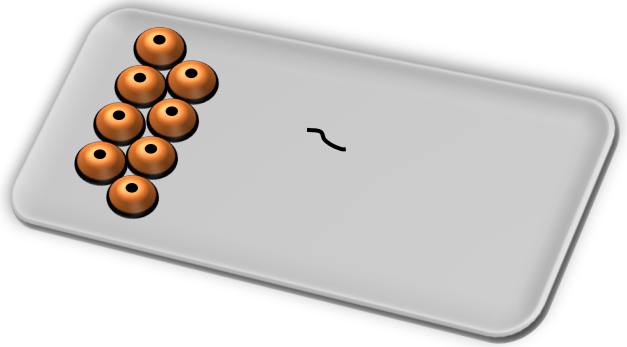
- Small footprint
- Slow inspection process
- Post-inspection analysis difficult

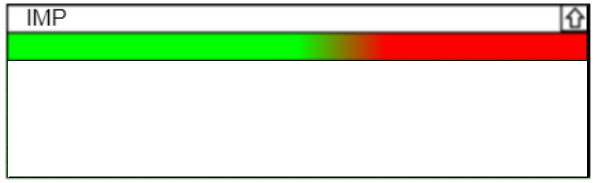




Array (ECA):

- Stable and repeatable scanning
- Fast inspection with wide coverage
- Intuitive surface visualization and post-inspection data analysis

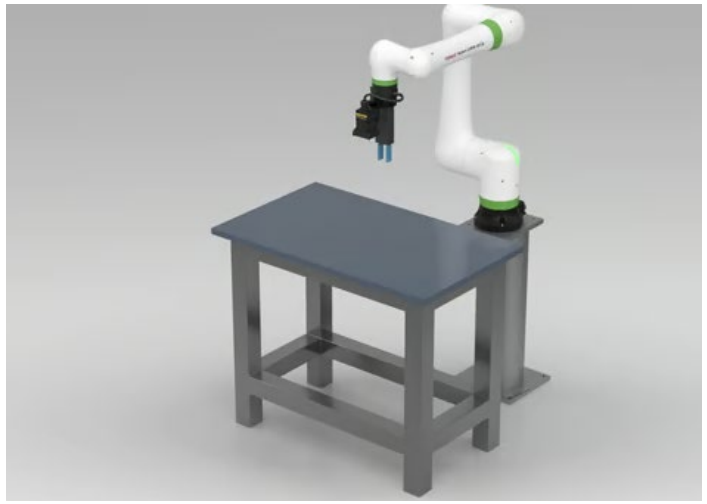




EDDY CURRENT ARRAY

Wheel inspection

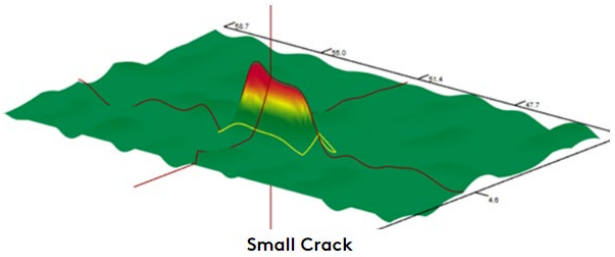
- Flexible tape probe for the detection of cracks in the wheel radius
- Highest flexibility allowing inspecting sharp radii curvatures and small wheel diameter
- Detection of 1-mm cracks in the wheel radius
- Manual or automated encoded scans for easy crack localization around the wheel circumference



EDDY CURRENT ARRAY

Orbital weld inspection

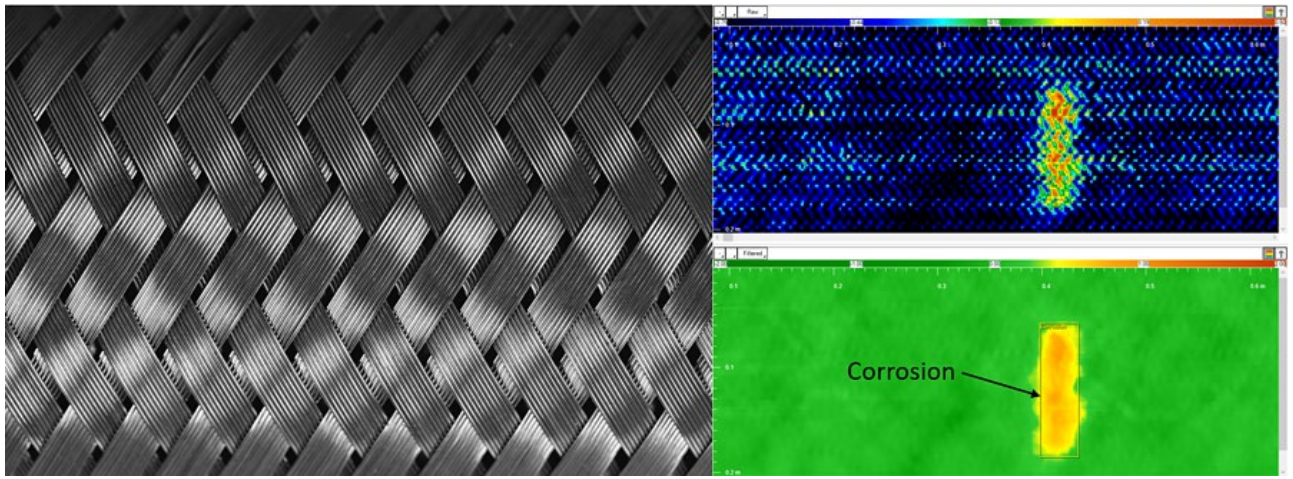
- Automated orbital welding used for small-diameter hydraulic lines / fuel lines
- Penetrant testing (PT) is the standard: up to 60 min of inspection per weld
- PT can be difficult and cumbersome due to restricted access to the welds
- Specialized ECA solution:
  - Small probe designed for restricted access
  - Scan time under 10 seconds
  - Detection of surface cracks 2 mm long (0.080 in)
  - Tight mechanical fit, encoding, and software interface make the solution user-friendly

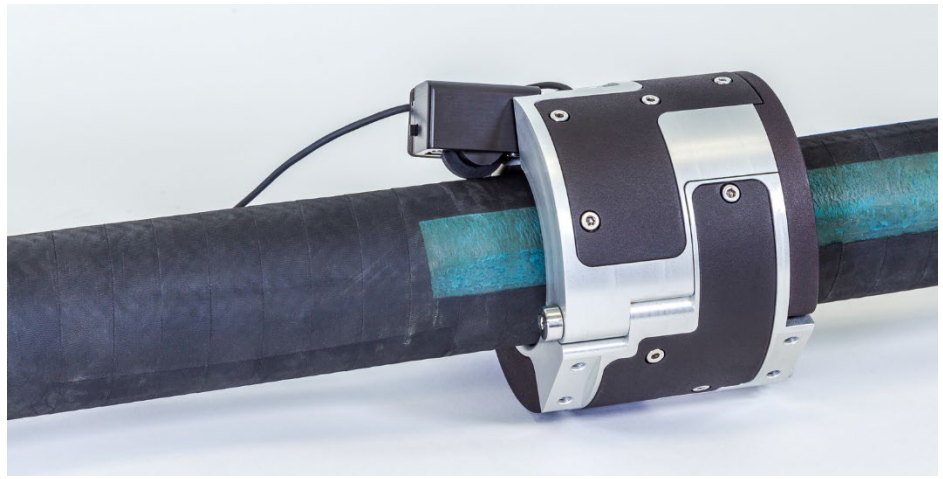


EDDY CURRENT ARRAY

Refueling hoses inspection

- Detection of corrosion in the carbon steel braid of in-flight refueling hoses
- Full 360° coverage in one pass, scan speed up to 2 ft/s (600 mm/s)
- Automated corrosion detection with go/no-go criteria





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CONCLUSION

BEYOND CONVENTIONAL EDDY CURRENTS

CONCLUSION

- EC bolt hole inspection is essential but historically limited by lack of spatial detail
- Advances in **circumferential** and **depth encoding** enable precise flaw measurement and 3D positioning within multi-layer structures
- This new capability sets a higher standard for accuracy, efficiency, and confidence in aviation maintenance
- New surface inspection capabilities enabled by eddy current array show immense potential for further improvement of conventional inspection procedures in aviation and aerospace