OLYMPUS

Your Vision, Our Future

Eddy current array technology for the inspection of aircraft and engine during maintenance

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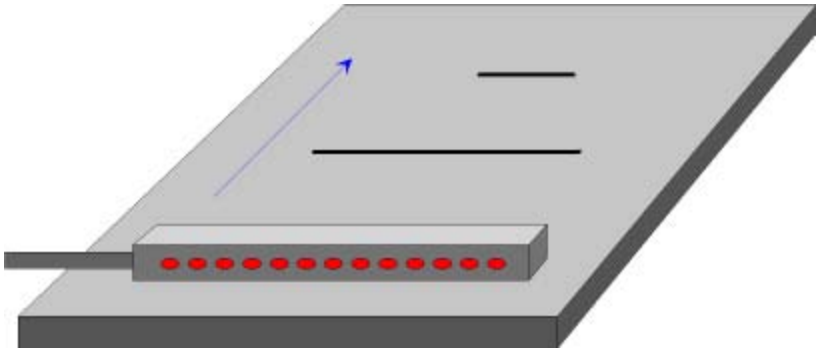
Innovation in NDT™

Presentation plan

- Eddy current array (ECA) technology
- ECA equipment
- High-frequency applications
  - 757 lap splice
  - Scribe mark (lower skin)
  - GE90 disk 1 and 2 HP
- Low-frequency applications
  - 737 Doubler edge
  - A330 Corrosion
- Conclusions

Eddy Current Array – Basic Concept

- In ECA, several eddy current coils are placed in the same probe assembly to:
  - Allows larger coverage in a single probe pass while maintaining a high resolution.
  - Reduces the need for complex robotics to move the probe; a simple manual scan is often enough.
  - Improves flaw detection and sizing with C-scan imaging.
  - Inspect complex shape with a probe made with to the profile of the parts

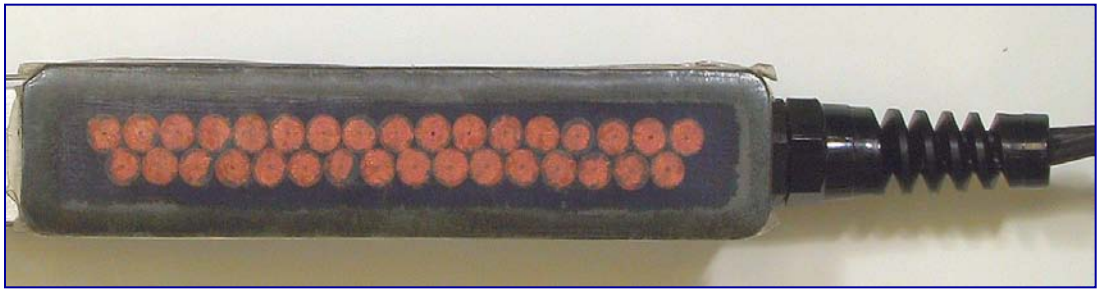


What is Eddy Current Array?

- Eddy current array technology is the ability to ***electronically drive several eddy current sensors*** placed side-by-side in the same probe assembly.

- Data acquisition is performed by ***multiplexing the eddy current sensors*** in a special pattern that will ***avoid mutual inductance*** between the individual sensors.

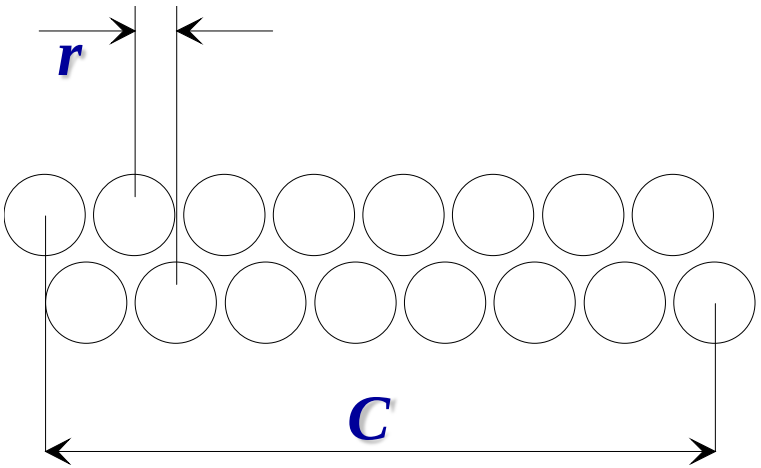
- Most eddy current probes and techniques for flaw detection can be used with eddy current array probes.



ECA – Probe Parameters

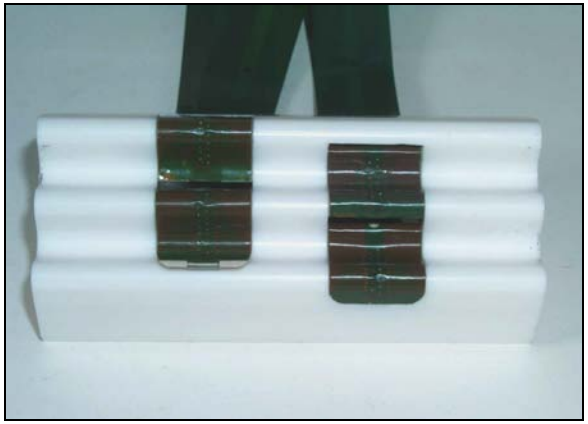
- Frequency (*f*)
- Number of elements (*n*)
- Resolution (*r*) (depends also on the coil configuration)
- Coverage (*C*)

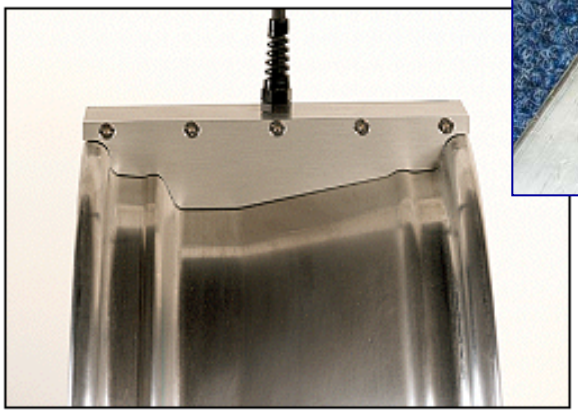
Example for absolute bridge probe

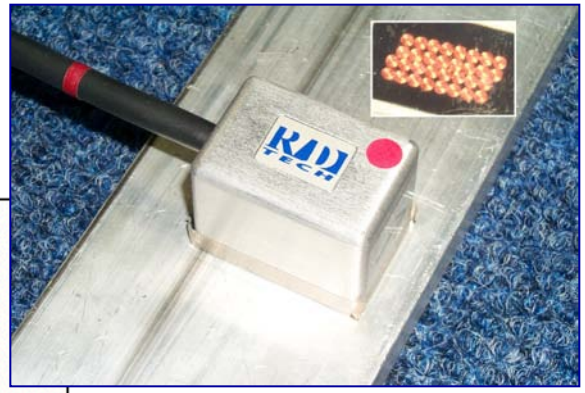


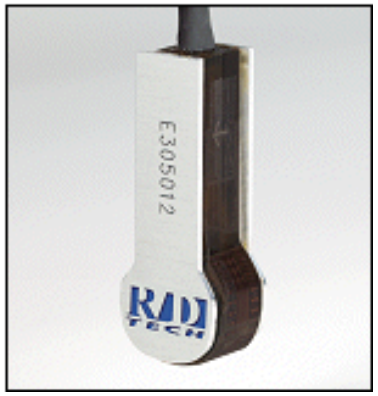
ECA - Probe

- Can be optimized for different applications.
- Can be shaped to follow the part to inspect.

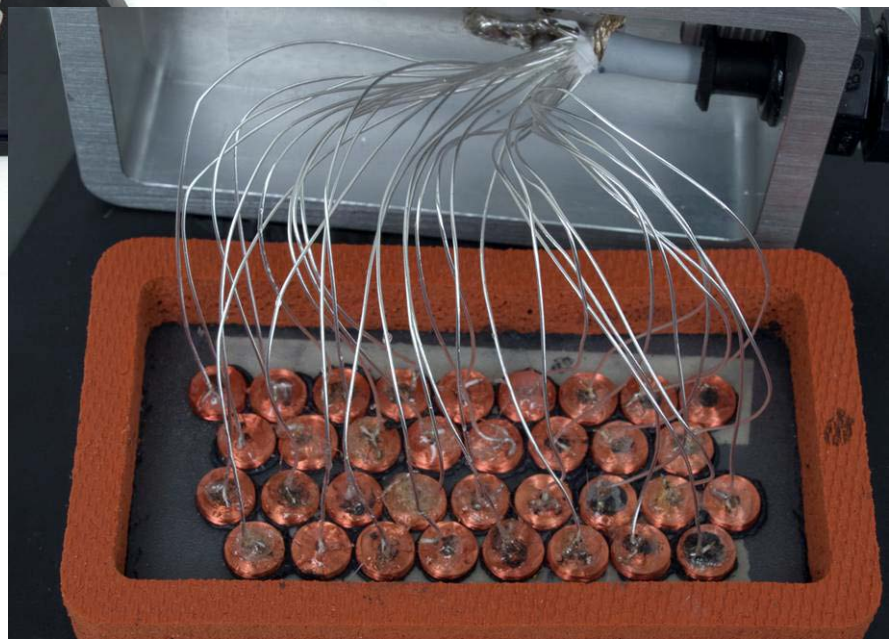






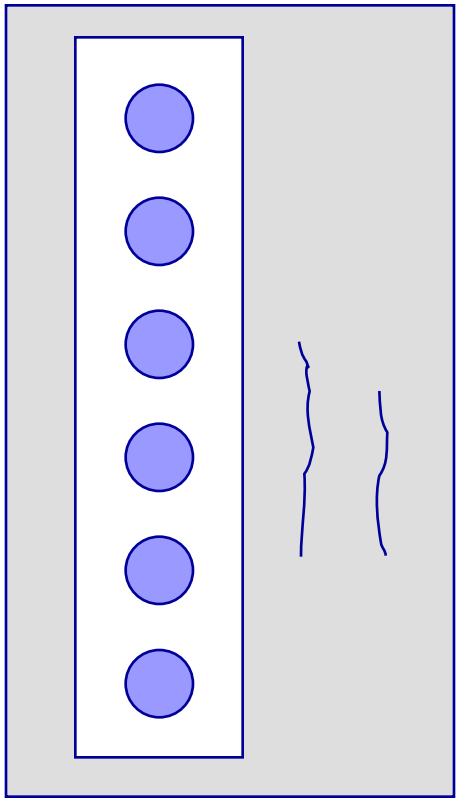


Inside an ECA probe

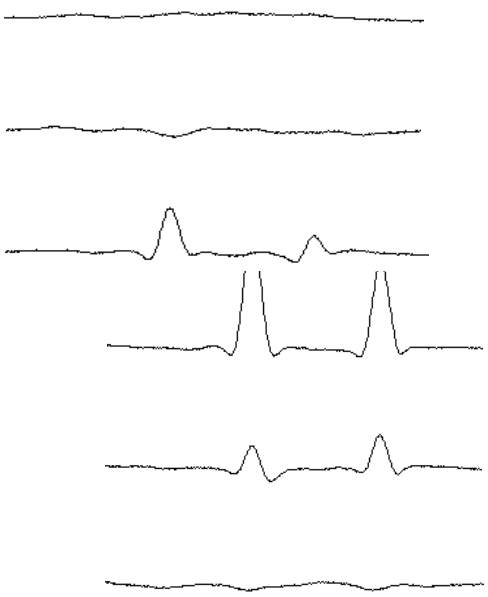


ECA – Signal Representation

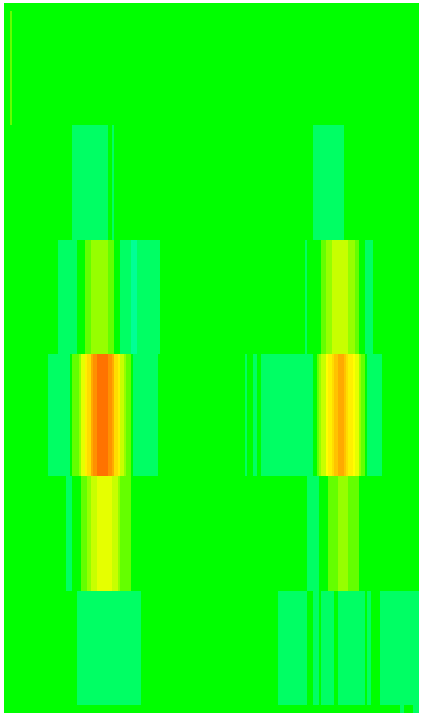
ECA probe over a flaw



Each coil produces an signal

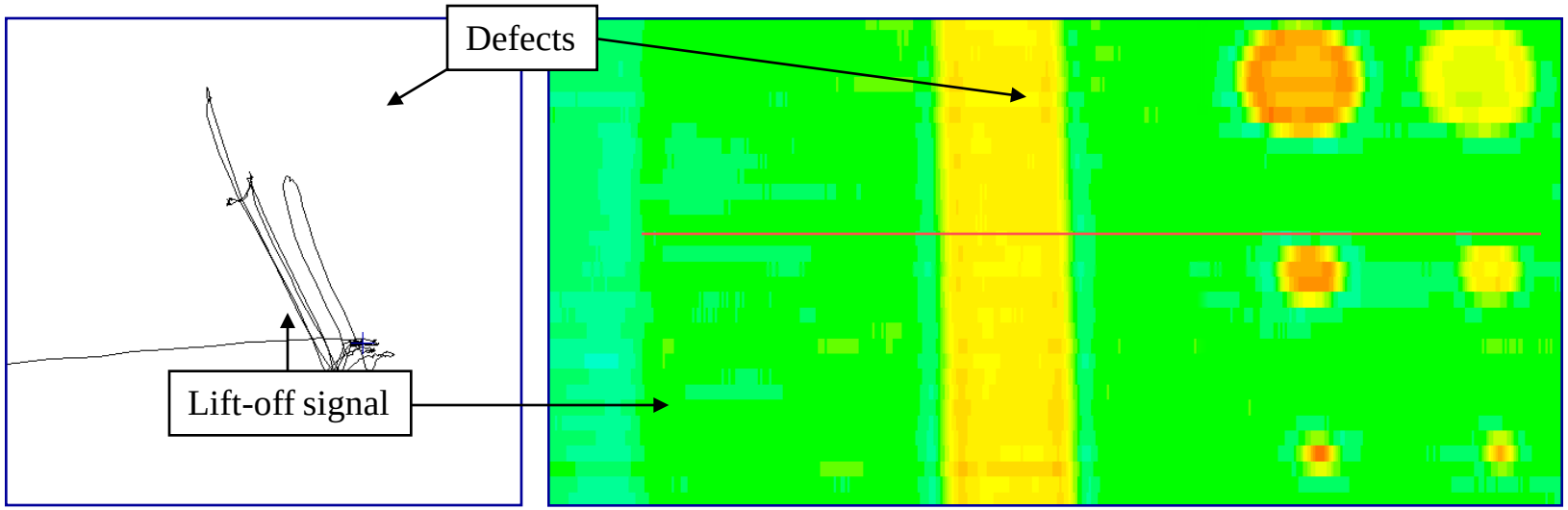


The amplitude of the signal is color-coded into a C-scan view



ECA – Signal Representation

- The C-scan can only show one component of the signal at a time (X or Y component).
- In the example below, the C-scan shows the vertical component of the signal (Y axis) and this is why the lift-off, which has been rotated horizontally, is almost not visible.



General Hardware Features

OMNI-P-ECT4

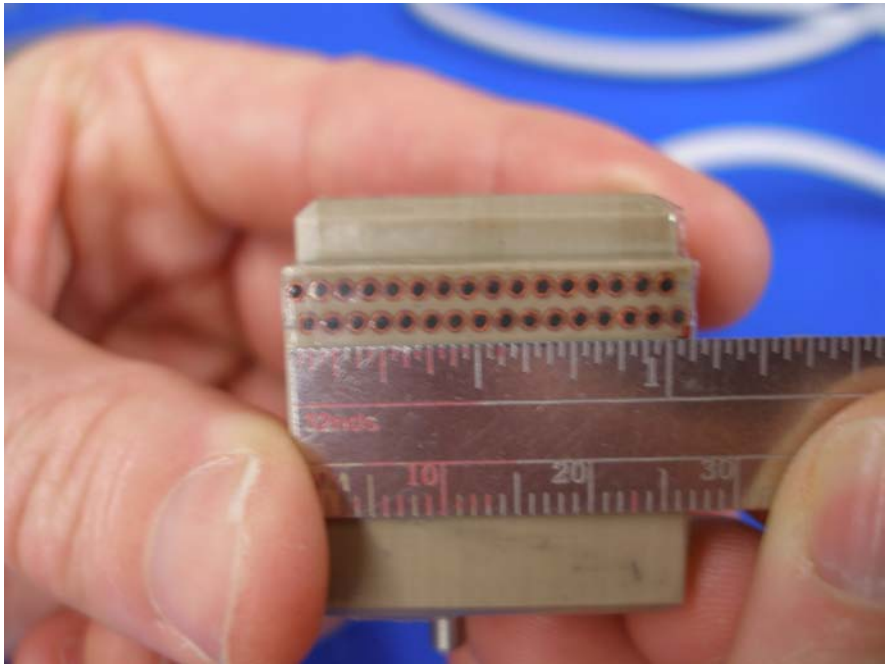
- Conventional ECT only
- 4 input channel
- Frequency range from 20Hz to 6MHz
- Dual Frequency operation
- 2-Encoder input
- 3-Alarms output
- 1-Analog output

OMNI-P-ECA4-32

- Conventional and **Array ECT**
- 4 input channel
- **32 channels**
- **64 channels with external multiplexer**
- Frequency range from 20Hz to 6MHz
- Dual Frequency operation
- 2-Encoder input
- 3-Alarms output
- 1-Analog output

High-frequency eddy current array probe

Probe coverage: 27 mm
Probe resolution: 0.8 mm
Coil diameter: 1.5 mm
Frequency range:
100 kHz to 1 MHz
Number of elements: 32
Operation mode: absolute



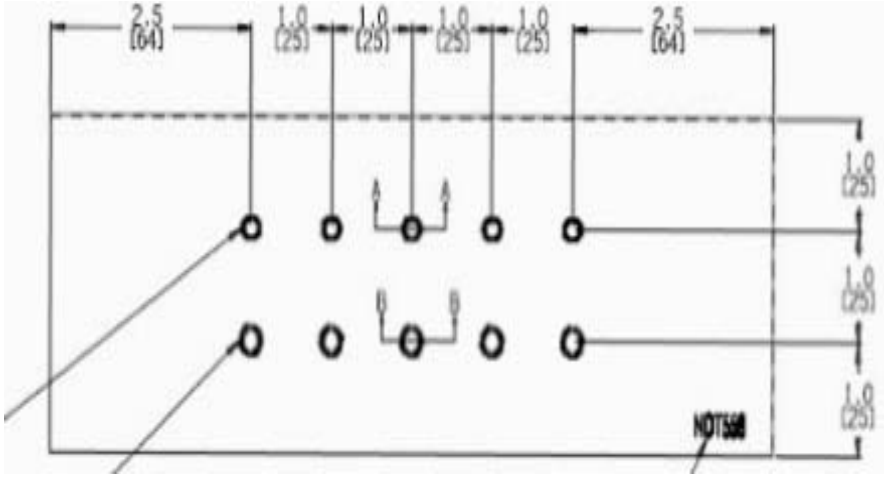
Probe SBBR-026-300-032

BOEING 757
LAP SPLICE C-SCAN INSPECTION AT THE UPPER ROW OF FASTENERS IN THE OUTBOARD SKIN

- Optional inspection procedure to Part 6, 53-30-06. Released in January 2008
- Has at least a 32 channel probe head that can scan an area greater than 0.87 inch (22 mm) but less than 1.5 inches (37 mm) in width. Probe SBBR-026-300-032
- Operates at a frequency range of 200 kHz to 400 kHz.
- Has a linear position encoder.
- Has a C-Scan display mode
- Not for magnetic fasteners

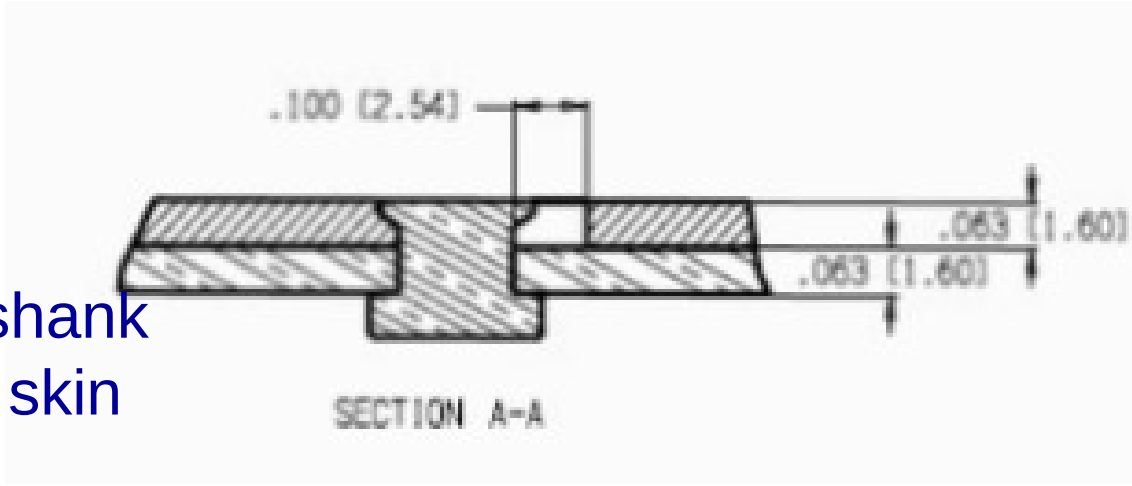
Calibration sample

NDT 588
5/32 and 6/32 rivet hole

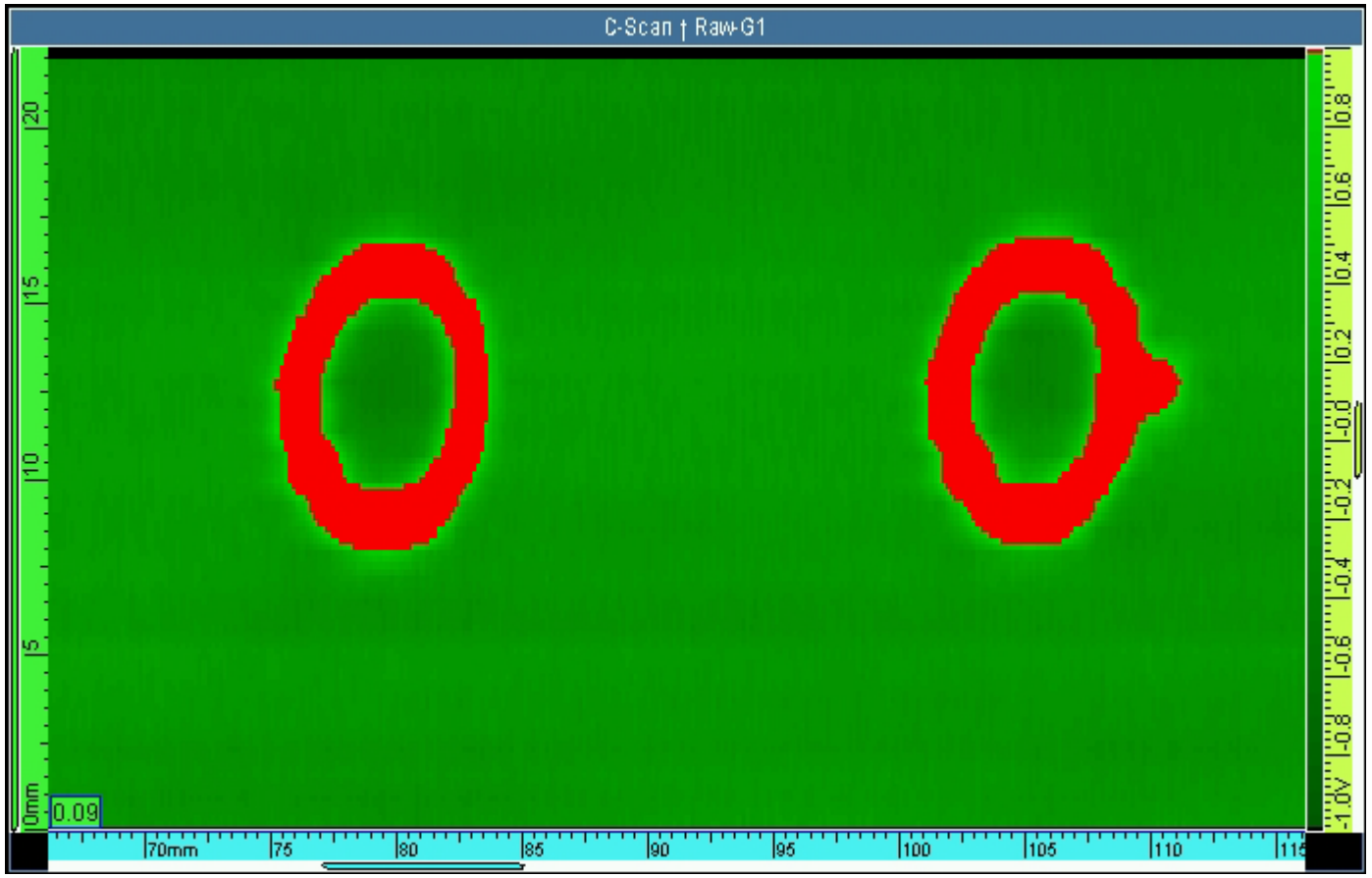


Typical cross-section

EDM notch:
length .1 in from rivet shank
Thickness: through 1st skin



Results



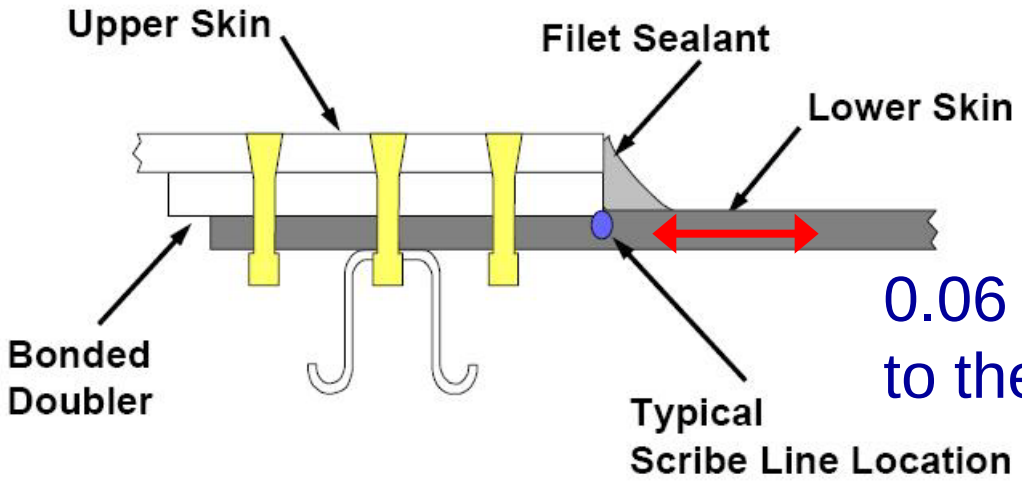
Good rivet hole

Rivet hole with notch

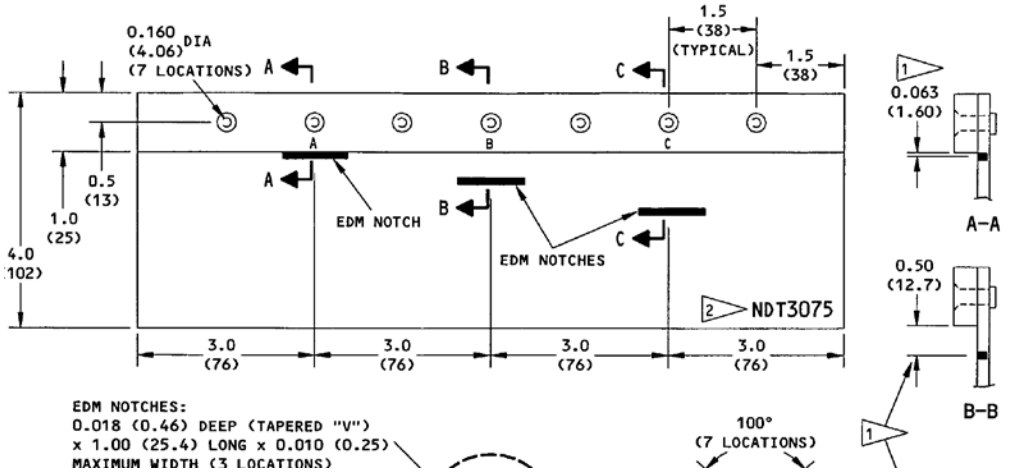
Advantages

- Positionning not critical (compared to EC sliding probe)
- Can detect notches in any direction (absolute coil)
- Fast
- Reliable (full coverage)
- Easy to interprate (Cscan image)

Proposed Method of ECA High-frequency inspection of the lower skin for scribe mark

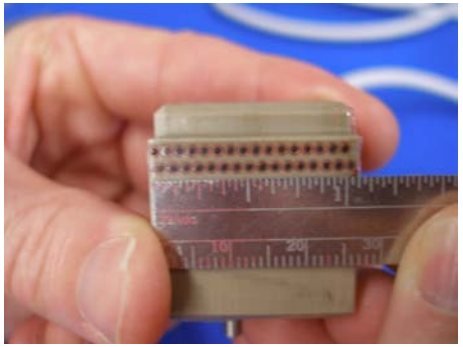


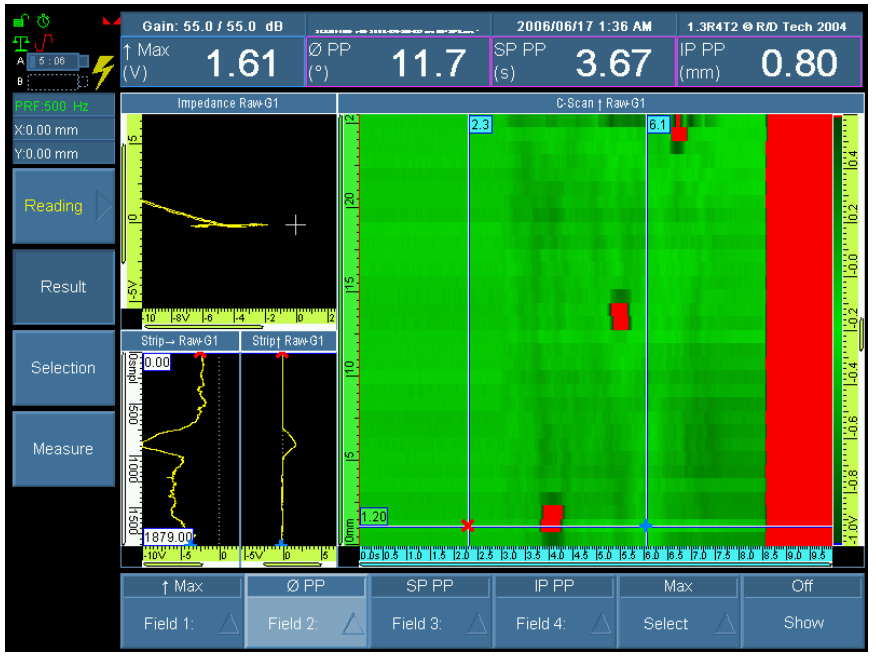
0.06 in to 1 in to the edge



Proposed method of ECA high-frequency inspection of the lower skin for scribe mark

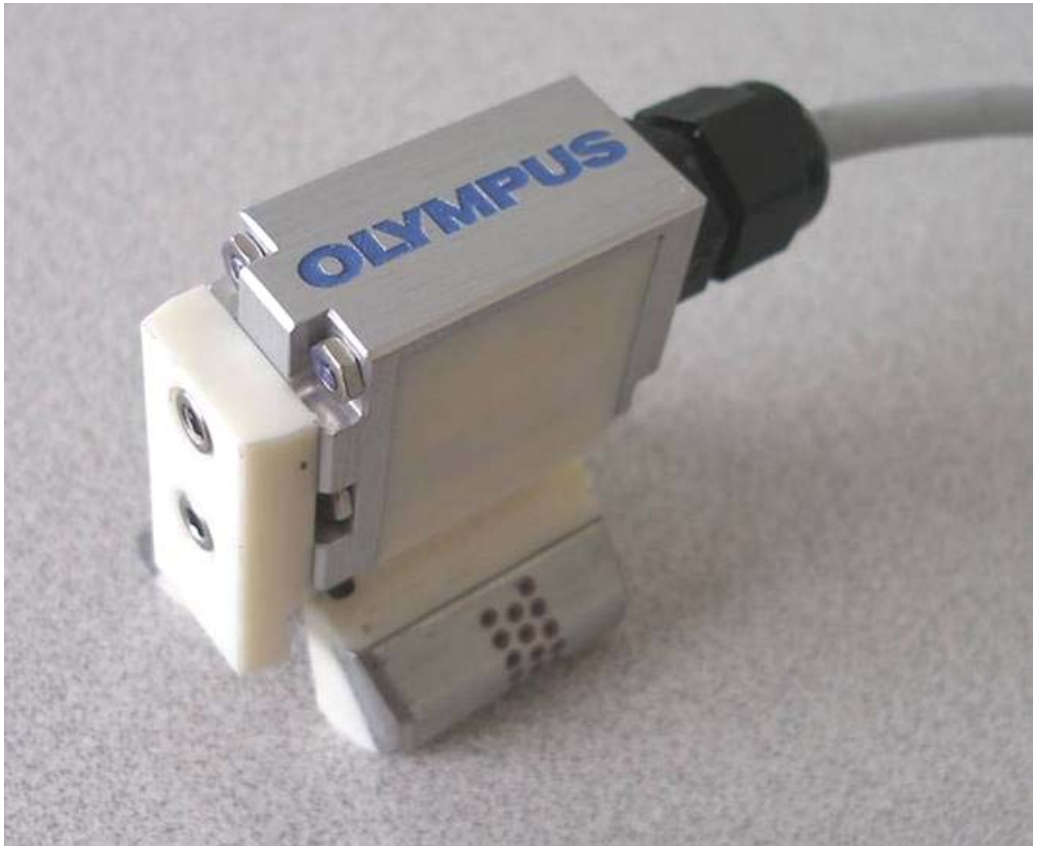
- One pass inspection
- Notch detection from 0.06 to 1 in to the edge
- Reliable inspection (100% full coverage)
- Easy interpretation on Cscan
- No need for encoder
- General procedure to be issued soon





movie

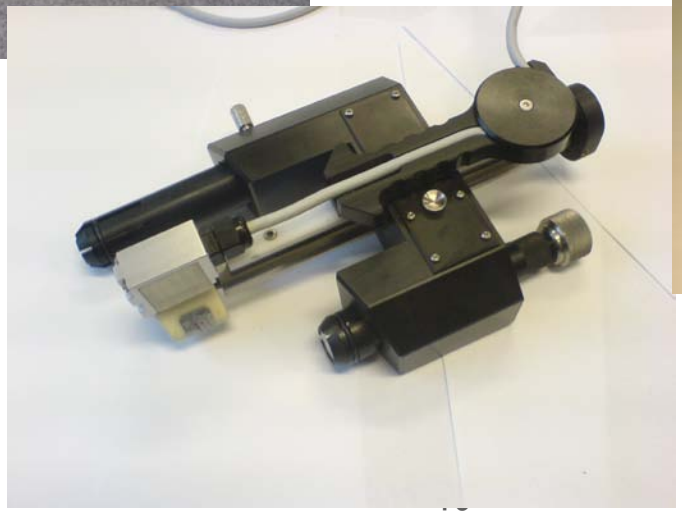
ECA HF Inspection method for the GE90 HP disk 1 and 2

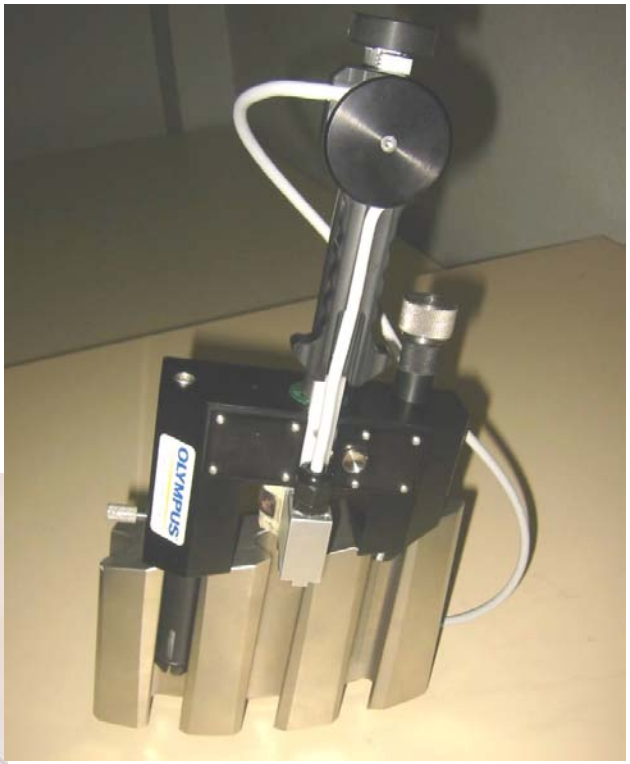


- ECA probe
- 32 elements (2 x 16)

GE90 Engine disk dovetail slot Inspection

32 coils



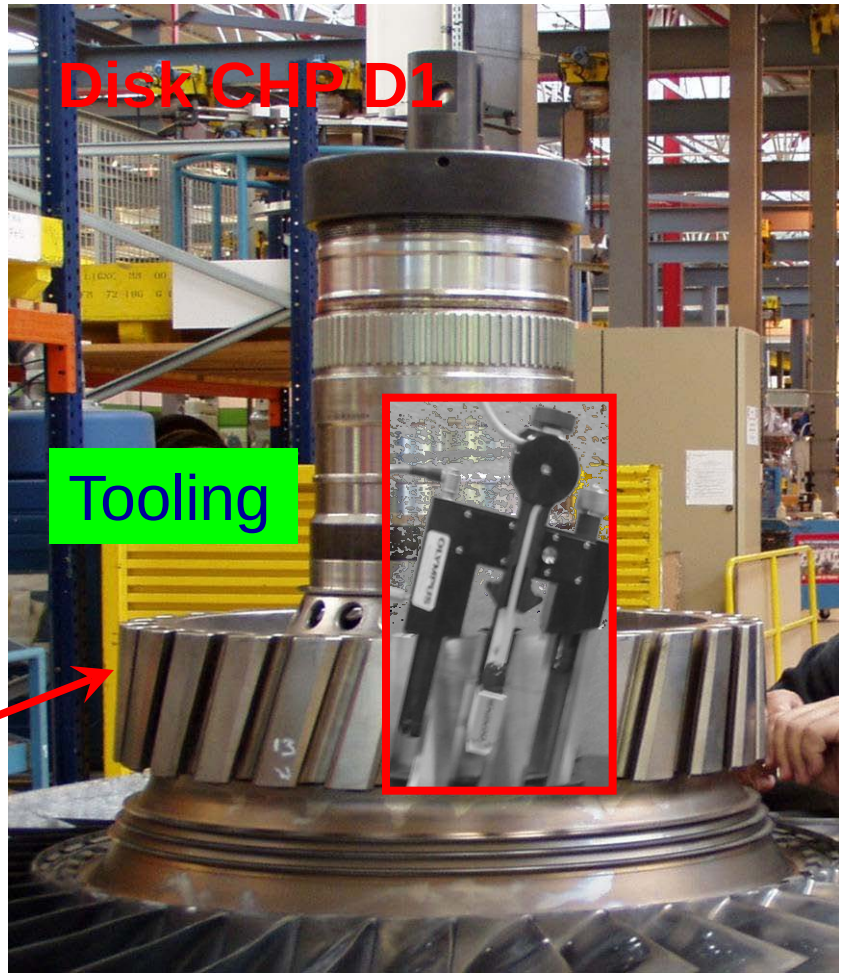


Dovetail Slot Inspection Current Method

- CFMI tooling
- Scanner with pencil probe
- The operator must perform 40 line scan
- Is reported to be time consuming
- Operators complain about pain

GE90 : ECA HF Inspection method

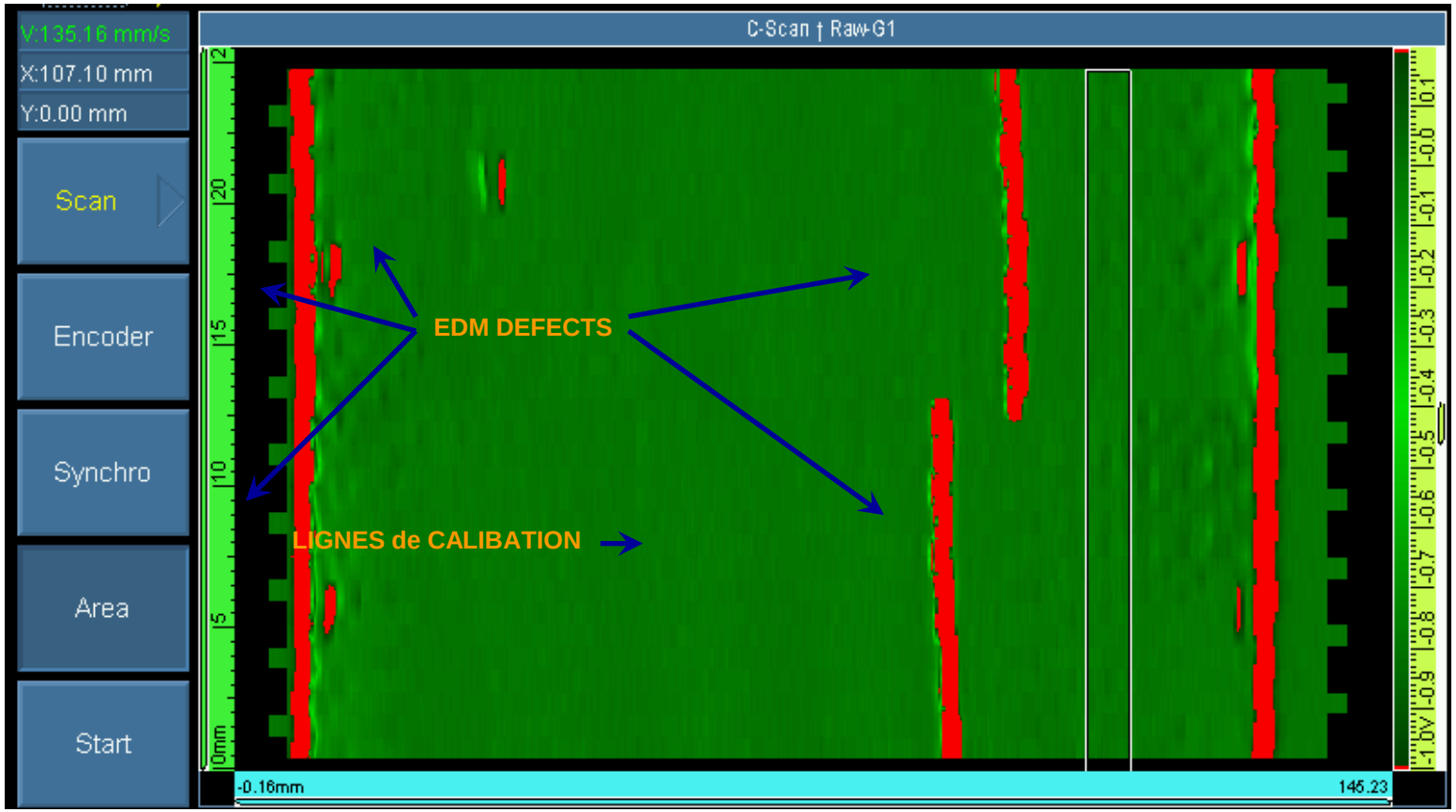
Inspection in the maintenance shop



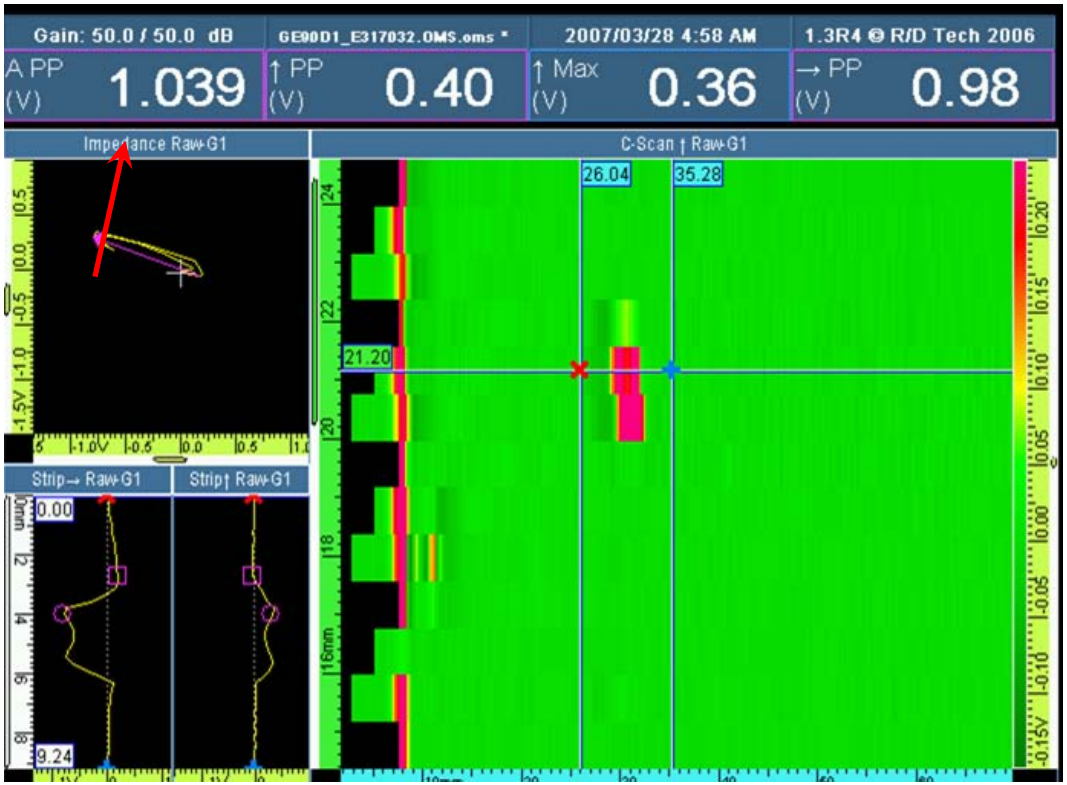
movie

GE90 : ECA HF Inspection method

- Cscan with EDM notches and calibration notches in the calibration sample



GE90 : ECA HF Inspection method



Cscan of a EDM notch:(1.5 x 0.7 x 0.1 mm)

GE90 : ECA HF Inspection method

- 100% critical zone coverage
- Inspection time reduced by 70%
- Reliability improvement
- Data saving

- Users:
  - AIR FRANCE
  - SNECMA SERVICES
  - SNECMA
  - GE Walles

Low-frequency eddy current array probe: SAB-067-005-032

- Probe specifications
  - Probe coverage: 67 mm (2.64 in.)
  - Probe resolution: 2.1 mm (0.082 in.)
  - Frequency range: 2 kHz to 20 kHz
  - Number of elements: 32
  - Operation mode: Transmit/receive on two rows and about 30° orientation.

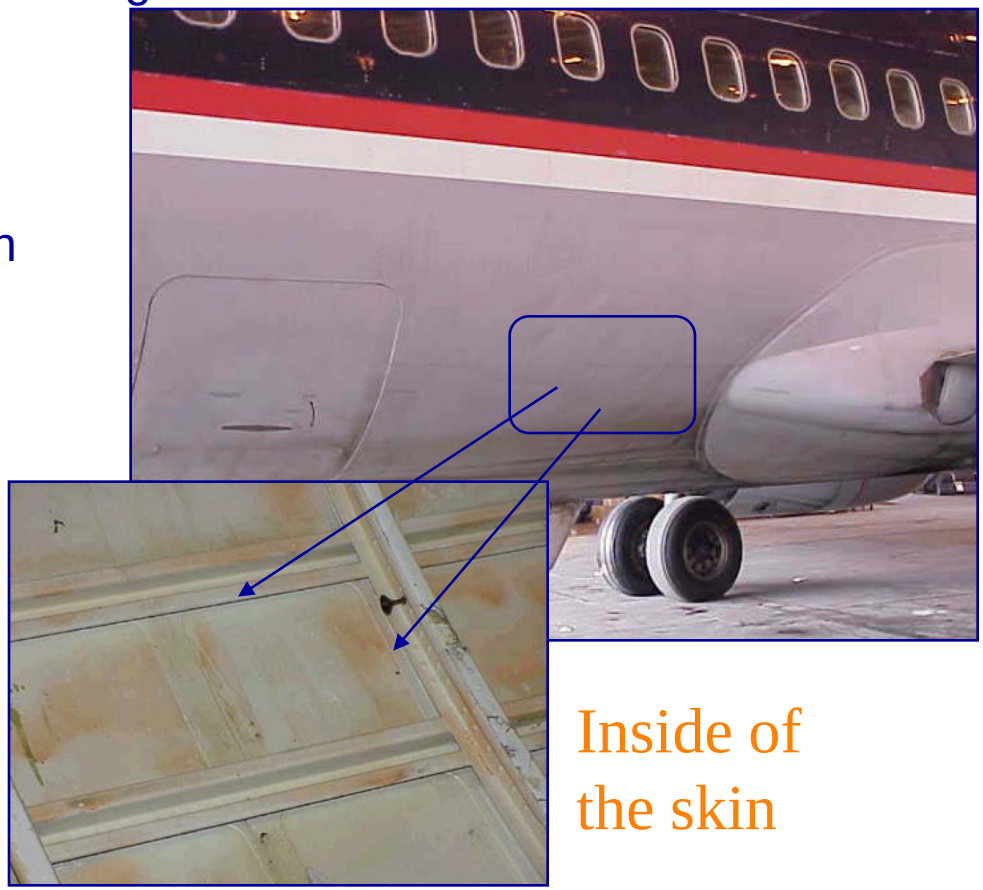
- General performances
  - Penetration in aluminum: 1.0 mm to 3.5 mm (0.040 in. to 0.140 in.)
  - 3.8 mm (0.150 in.) long second layer crack at fastener. The first layer can have a thickness up to 2 mm (0.080 in.) of aluminum,
  - 5 % Corrosion under 2 mm (0.080 in.) with a diameter of 6 mm (0.25 in.), 10 % Corrosion under 3 mm (0.120 in.) with a diameter of 6 mm (0.25 in.).

Low-frequency EC array application: Boeing 737 Skin crack detection at doubler edge (chem mill)

- Probe SAB-067-005-032 referenced in the NTM737 NDT 53-30-25 part 6, dec 2004.
- Description of the application:
  - Shear and compression loading cause cracking at the doubler edge.
  - Cracks need to be detected at their initial stage during the "C" Check, unless they will grow in length and depth to the point that, they can be visually seen on the fuselage skin outer surface.
  - If the crack reach the surface, the aircraft must be removed from service to perform the repair and the cost involved is enormous.

Boeing 737 Skin crack detection at doubler edge

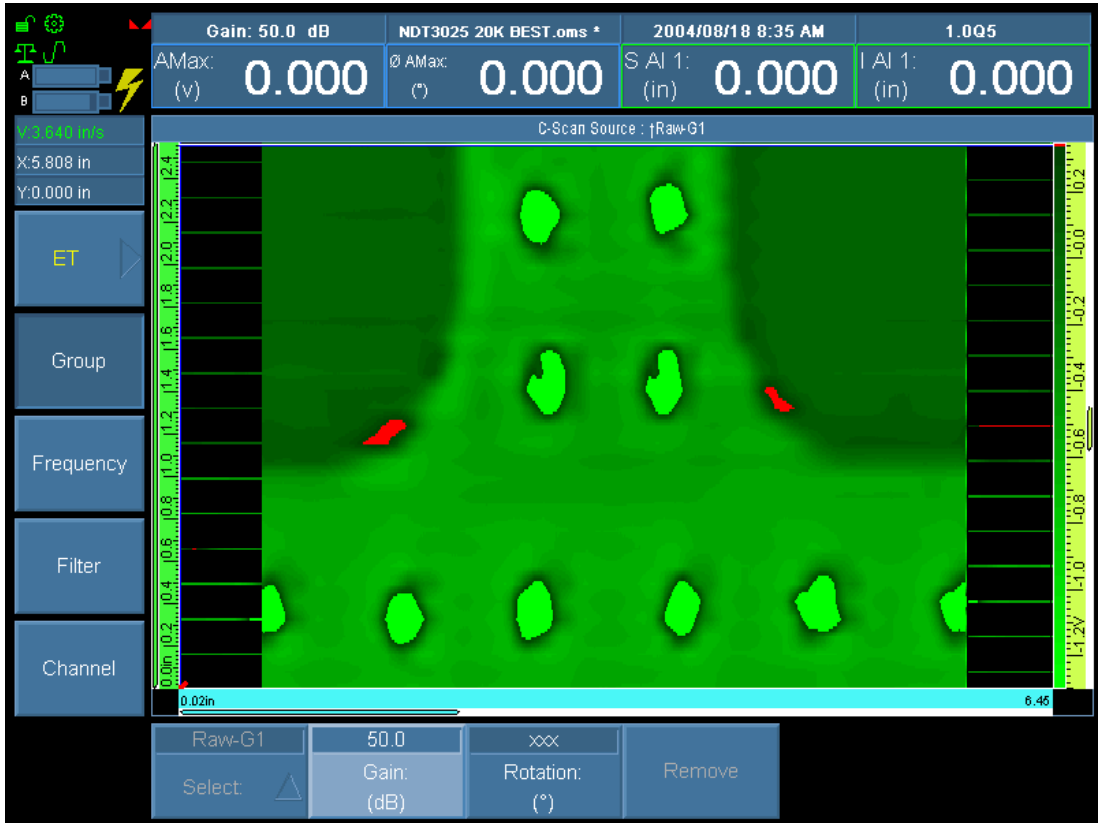
- The inspection is done from the outside and crack as small as 0.240” long by 0.010” deep located at the edge of the doubler need to be detected.
- Benefits:
  - Simple manual inspection
  - C-Scan allows easy location of the doubler edge for fast and simple detection of the initiating cracks
  - Better reliability
  - Better reproducibility
  - Time saving:
    - » Normal time: 200 hours
    - » With ECA: 48 hour



Inside of the skin

Boeing 737 Skin crack detection at doubler edge

- During acquisition, the user can see very well the doubler edge represented by the light to dark green color transition.
  - Fastener will show up in light green.
  - Defect above the rejection level are in red like shown in this picture
  - Detect subsuface crack at doubler edge, 6mm (0.25”) long by 0.25mm (0.010”) deep



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Boeing 737 Skin crack detection at doubler edge

- Standard Crack probe – SAB-067-005-032
  - Probe coverage of 67 mm (2.64in.) in one pass
  - Penetration in aluminium of 1.0mm to 3.5mm (0.040in. to 0.120in.)
  - Detection capability
    - » Subsurface at crack at doubler edge, 6mm (0.25”) long by 0.25mm (0.010”) deep

Equipment listing

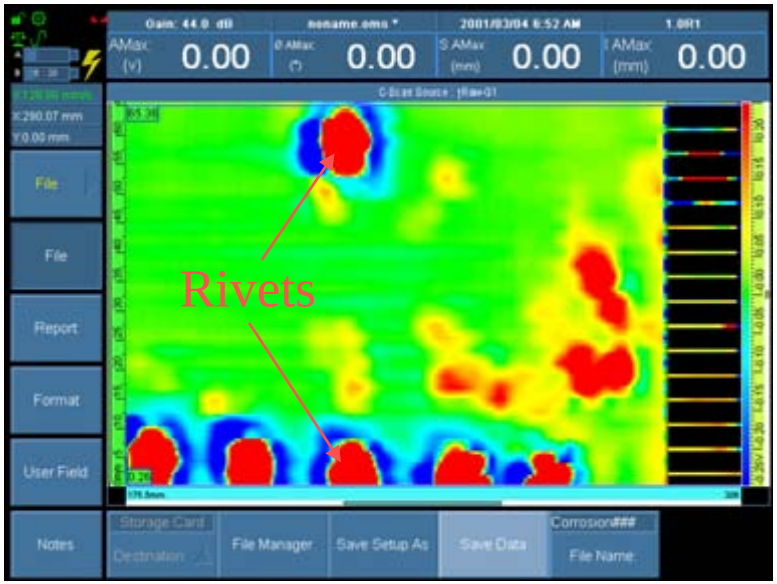
- Omniscan ECA: OMNI-ECA4-32
- Probe: SAB-067-005-032
- Encoder: SXA-270

Low-frequency EC array application:
Airbus A330 for corrosion

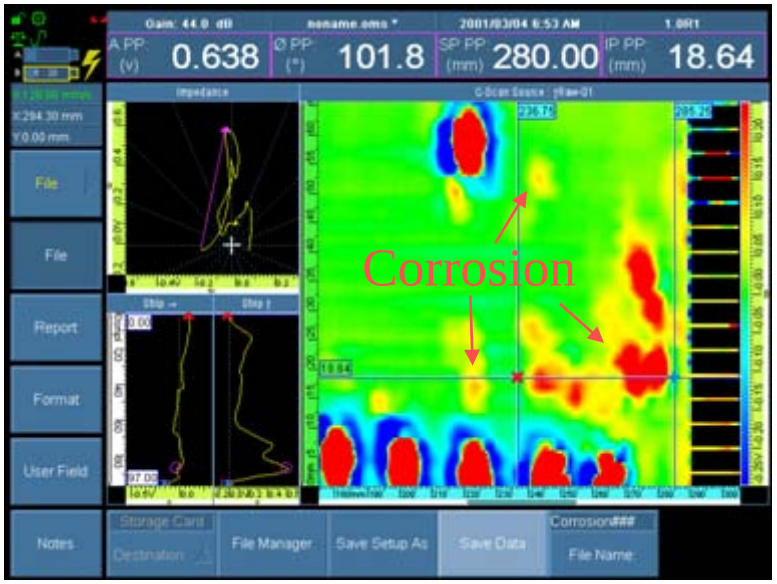
- Airbus used the OmniScan ECA to perform corrosion detection on the A330/340
- Corrosion in between the first layer and an internal acoustic panel.
- Benefits:
  - Simple manual inspection
  - C-Scan allows easier detection of small corrosion in large area
  - Better reliability
  - Better reproducibility
  - Time saving:
    - Area : 12 m²
    - Normal time: 9 hours
    - With ECA: 1 hour

Airbus A330 for corrosion

- In acquisition mode, a scrolling C-scan shows in real time the mapping of the part under inspection
- In analysis mode, selection cursors are used to show data in an impedance plane and a strip chart display to make detailed measurement.



Acquisition



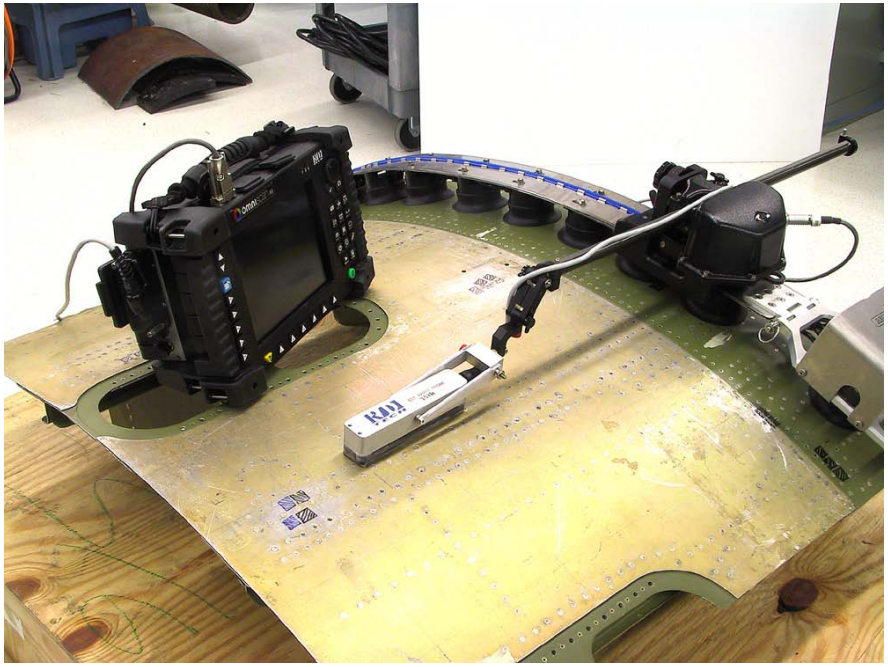
Analysis

Low-frequency eddy current array probe: SAA-112-050-032

- Probe specifications
  - Probe coverage: 128 mm (5 in.)
  - Probe resolution: 4 mm (0.016 in.)
  - Frequency range: 1 kHz to 20 kHz
  - Number of elements: 32
  - Operation mode: Transmit/receive on two rows and about 30° orientation.

- General performances
  - Penetration in aluminum: 3.0 mm to 6.0 mm (0.120 in. to 0.240 in.)
  - Detection capability: 10 % corrosion under 5 mm (0.200 in.) with a diameter of 12.5 mm (0.5 in.)

ECA large surface inspection

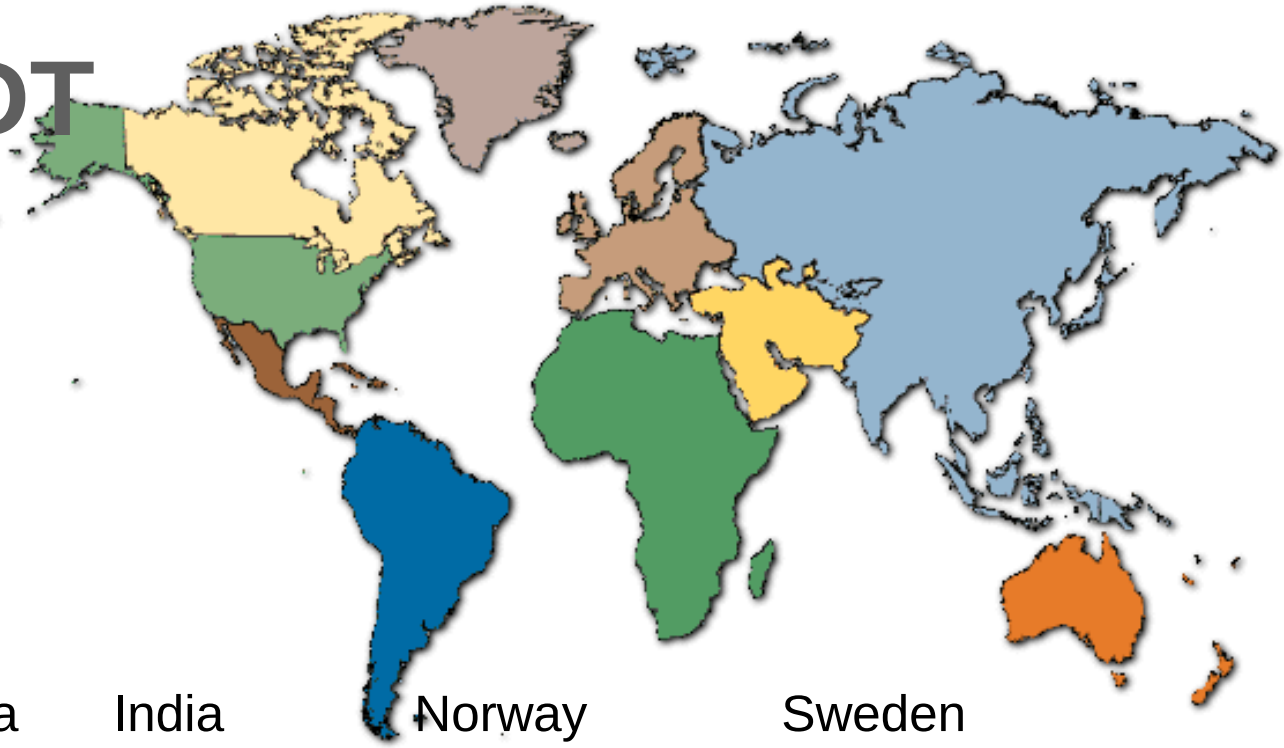


Compatible with 2D scanner for large area inspection

Conclusions about ECA

- Deployed in the field for many applications
- Referenced in procedures for aircraft and engine maintenance
- Fast (large area)
- Reliable (Full coverage and Cscan imaging)
- Omniscan ECA module compatible with Omniscan PA (economic)
- Many ECA standard probes
- More to come…

Olympus NDT in the world



Africa	Colombia	India	Norway	Sweden
Australia	Denmark	Indonesia	Peru	Taiwan
Austria	Finland	Ireland	Poland	Thailand
Brazil	France	Italy	Russia	Turkey
Canada	Germany	Japan	Singapore	United Arab Emirates
Central America	Greece	Korea	Slovakia	United kingdom
Chile	Greenland	Malaysia	South America	USA
China	Hungary	Netherlands	Spain	Venezuela

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