



**Emerging NDE Technology for  
Aging Aircraft – Large Area Scanning  
To Small High Resolution Systems  
Maintenance Planning Tools**

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# FAA Airworthiness Assurance NDI Validation Center

- Initiated in 1988 under the Aviation Safety Act
- Provides a mechanism to develop, evaluate, and assess new inspection technologies
- Partnerships with industry, academia, and government





# What We Do

- Aid in the development of new maintenance inspection techniques, validate improved structural repairs and advanced aircraft designs
- Perform inspection reliability studies
- Provide our customers with comprehensive, independent, and qualitative evaluations of new and enhanced inspection, maintenance, and repair techniques
- Facilitate the transfer of effective technologies into the aviation industry and develop inspection methods on a non-competitive basis





# **What We Deliver (*Information*)**

**Validation, technology transfer, and deployment**

**Information for inspection improvement (SBs, ADs,  
alternate-means-of-compliance requests, procedures)**

**Workshops, meetings, projects to promote technology transfer**

**Information to improve industry maintenance practices by  
conducting reliability studies**

**Support development of new inspection technologies**

**Ongoing comparisons of conventional & emerging technology**





# Validation Experiments

*A series of focused experiments that quantitatively & qualitatively evaluate NDI techniques through the use of blind testing & specific protocols to arrive at uniform comprehensive assessments.*

Consider all factors that affect reliability including inspector, equipment, procedures, and environment – accuracy, sensitivity, repeatability, human factors, versatility, portability, scan rate, cost.

- *Disbond Inspection between lap joints*
- *Corrosion Detection in thin and thick, Multi-Layered Joints*
- *Surface Crack Detection (lap joints)*
- *Interlayer Crack Detection (lap joints)*
- *Widespread Fatigue Damage – 2<sup>nd</sup> layer cracks in WFD scenario*
- *Corrosion Detection in Aircraft Joints*
- *Composite Honeycomb Flaw Detection*
- *Crack Detection Under-Raised Head Fasteners (1<sup>st</sup>/2<sup>nd</sup> layer; Rotorcraft)*





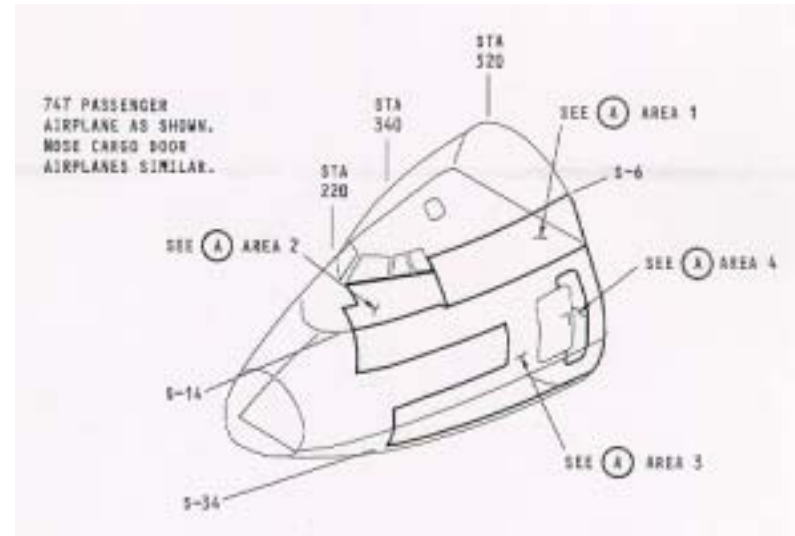
# Large Area Inspections

- **Disbond Inspection** Infrared Techniques
- **Corrosion Detection** Scanners (UT, ET)
- **Crack Detection** Scanner (UT, ET)  
subsurface and first layer
- **Composite Repair and Inspection** new  
equipment and inspection techniques



# Fuselage Disbond Inspection Procedure Using Thermography

Disbonds can be precursors to crack initiation

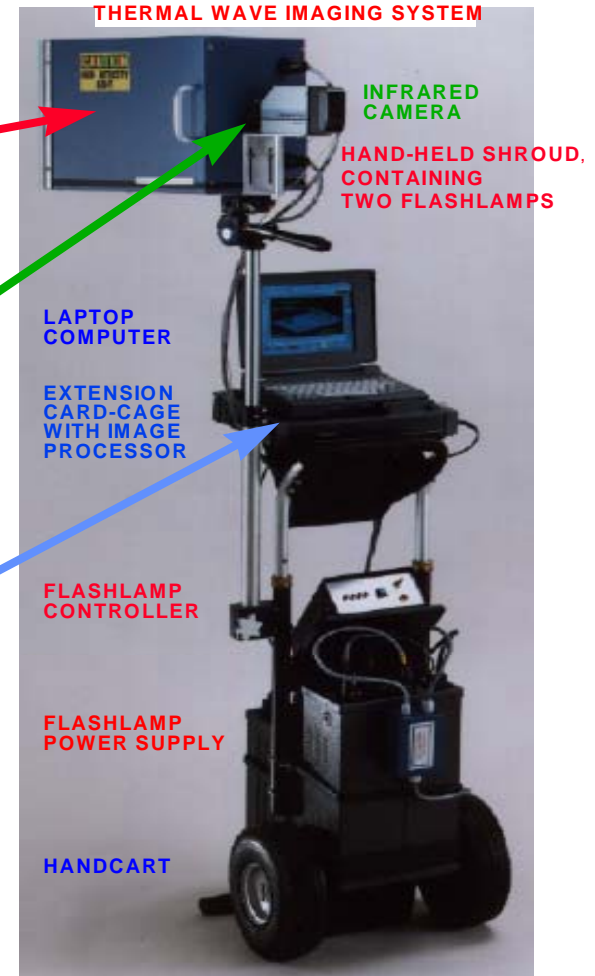


- Boeing Service Bulletin 747- 53A2409 - find disbonds between 1st and 2nd layer
- Can be used to detect 1" x 1" disbonds under 0.10" of skin or less
- Approved in Boeing NDT manuals as a general procedure for all model aircraft



# IR Thermography

- Flash lamps heat the inspection surface
- Infrared camera follows the surface cooling
- Computer & image processor make qualitative and quantitative images and plots of the subsurface structure



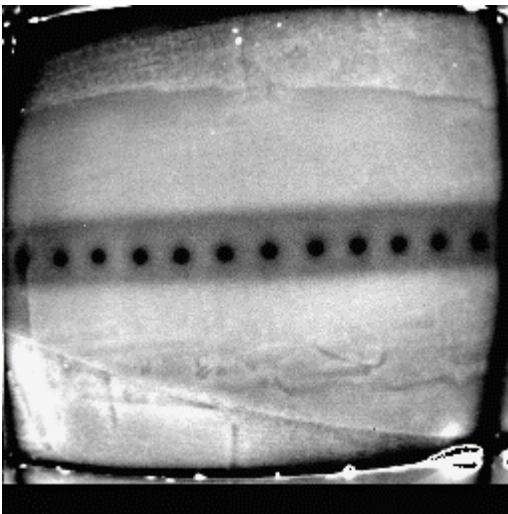
# B747 Experiments



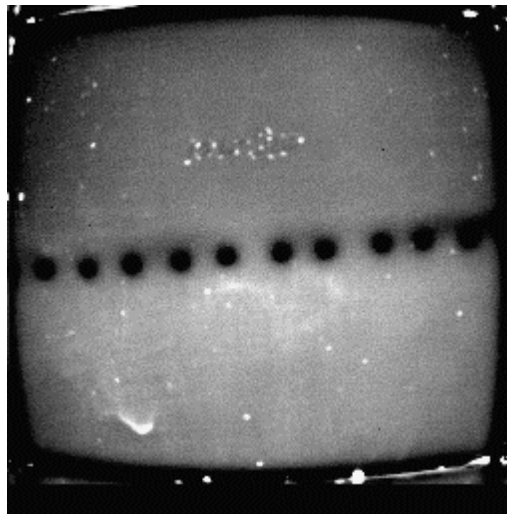
Ultrasonic Inspection



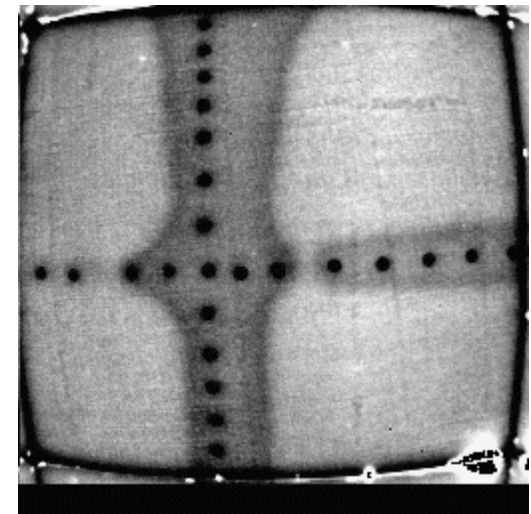
Thermography Inspection



Bonded Doubler



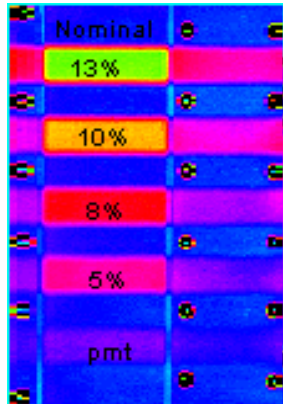
Disbonded Doubler



Disbonded/Bonded  
Doubler



# Corrosion Detection System I



2120

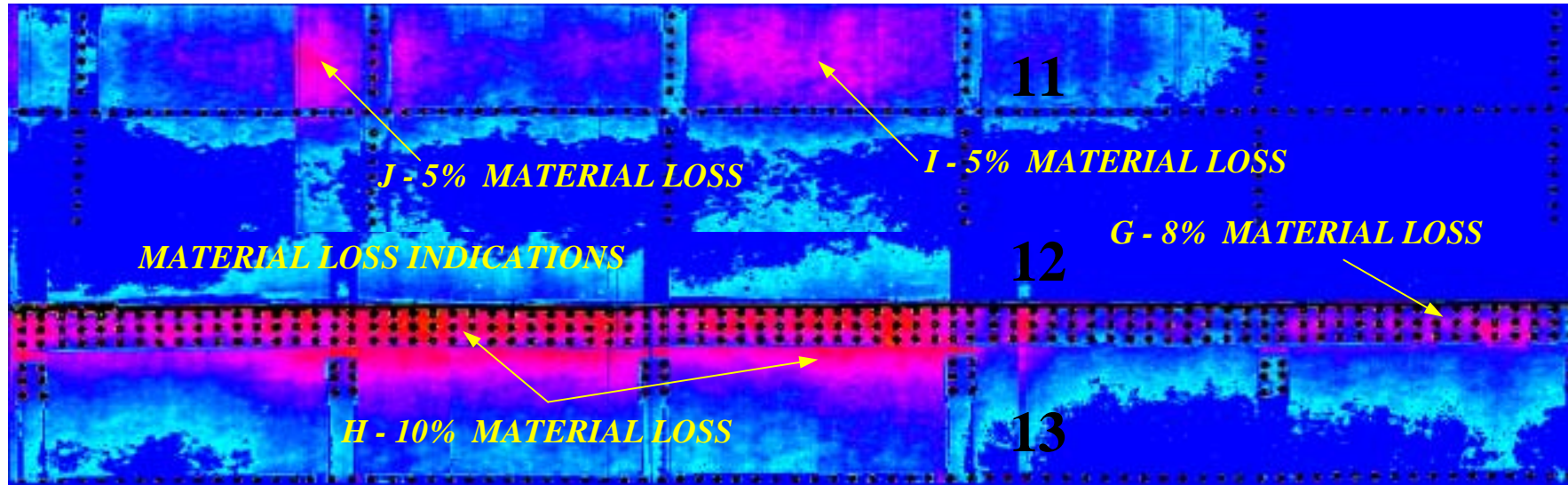
2100

2080

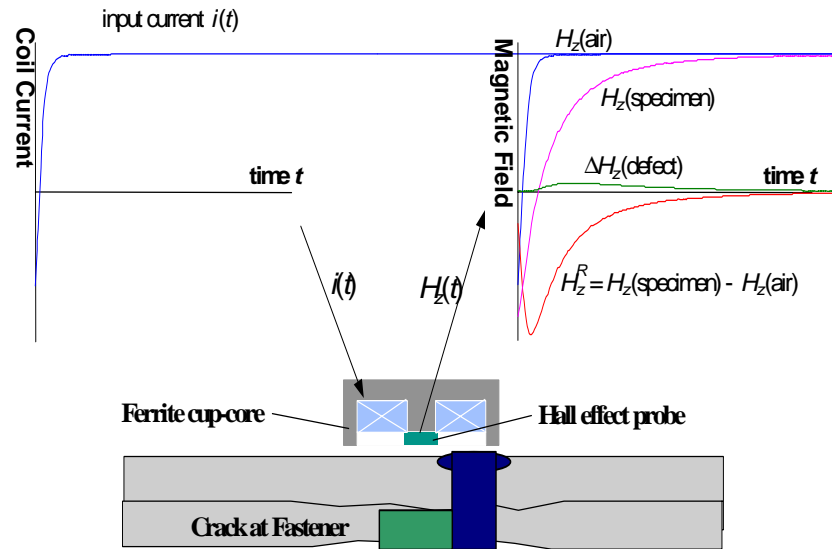
2060

2040

2020



# Corrosion Detection System II

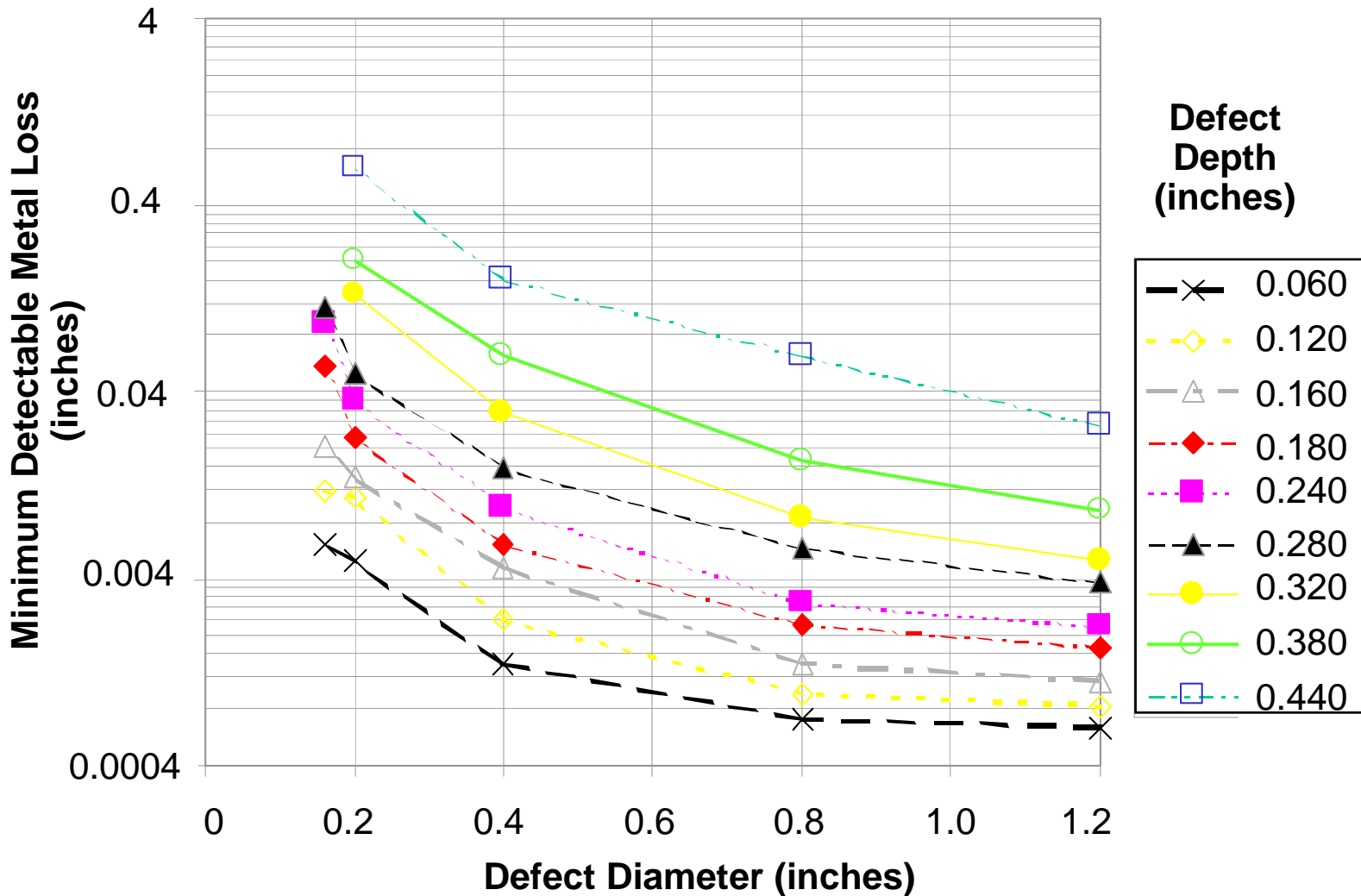


**Pulsed (Transient) Eddy Current (PEC) applies a broadband pulse to a coil and generates a pulse magnetic field.**

- Sensor watches decay of the reflected field
- Range of interrogating frequencies to cover surface to deep flaws
- Monitor response by time slice depending on inspection area

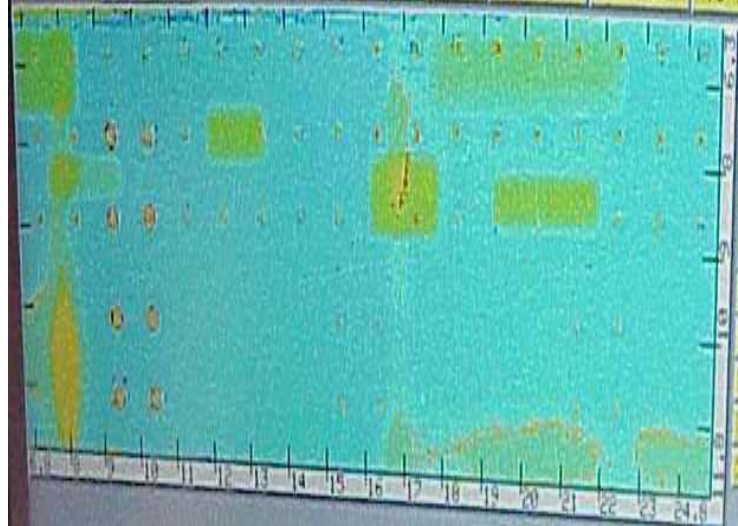


# Corrosion Detection with Pulsed EC Trecscan System



# Corrosion Detection- System III

- **Well developed system fielded for Air Force applications**
- **Uses commercial ultrasonic transducer**
- **ACES coupling system is truly dripless**
- **Accommodates raised fasteners and surface distortions**
- **Durable and accurate X-Y Scanner**





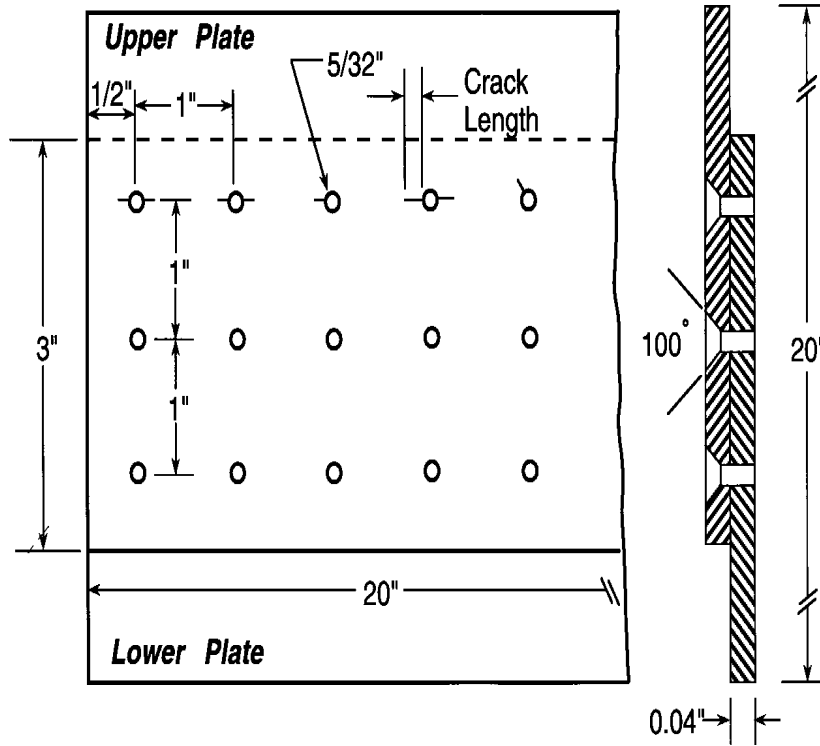
# Corrosion Detection

- **Most of the techniques considered have no problem detecting 14% corrosion in .04 to .1 inch thick aluminum panels.**
- **Two ultrasound techniques have estimated 90% detection rates at approximately the 3% corrosion level.**
- **One eddy-current automated dual frequency technique has an estimated 90% detection rate at approximately the 2% corrosion level.**
- **System II not included in this study.**



# Crack Detection 1<sup>st</sup> and 2<sup>nd</sup> Layer

- Fatigue crack specimens with comparison to industry baseline for conventional techniques deployed at airlines
- Small cracks under fastener heads (0.050") were stressed
- Improvements accompanied by increased training for optimized signal interpretation



# Magneto Optic Imager Device

- Magneto-optic sensor images the perturbations in the magnetic field on a video display
- MOI 308 (1.5-200kHz) with 303 and 307 imager; rotating MOI (circular mag. field)
- Applications corrosion, surface and subsurface fatigue crack detections (transport to GA categories) in commercial and military
- Turbo MOI (prototype) - higher power and better eddy-current excitation for improved depth of penetration



Standard MOI  
High Power



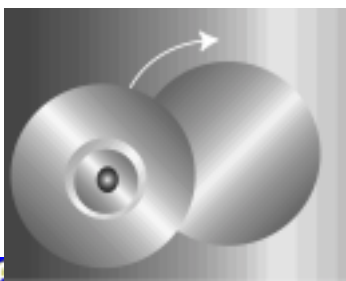
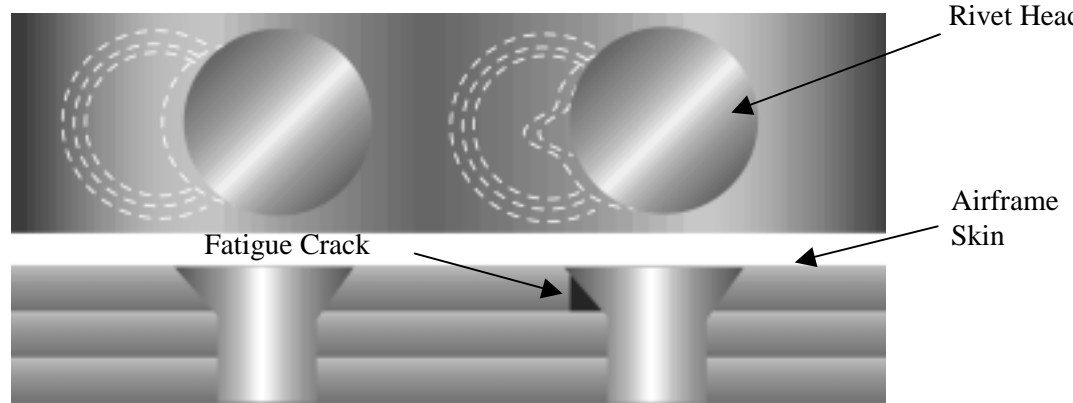
Turbo MOI  
High Power (2X Standard)



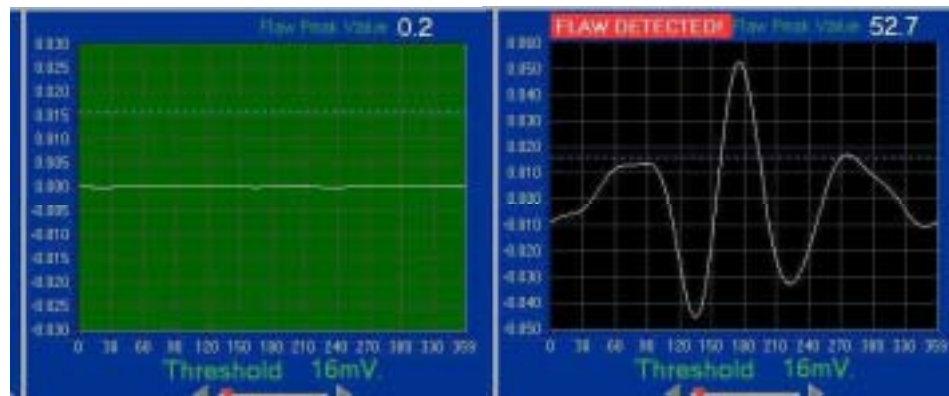
# Rivet Check



- EC distribution based on Self Nulling Probe (NASA)
- Eliminates signal variations associated with probe deployment & rivet misalignment – missed cracks
- Centering display (constant voltage) used to optimize probe position



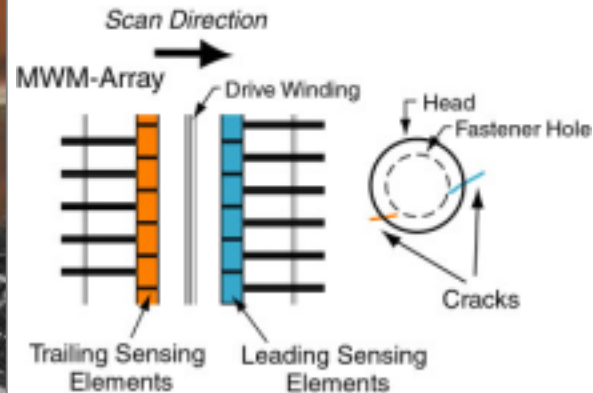
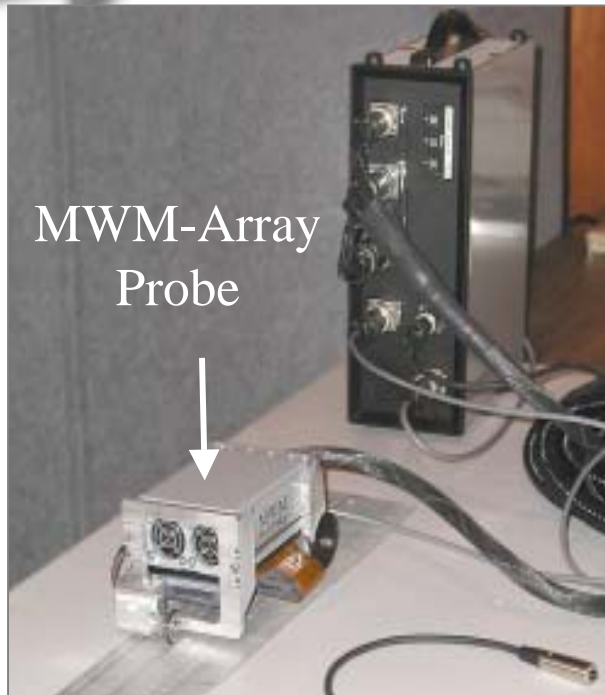
Probe Positioning



Unflawed and Flawed Rivet Signals



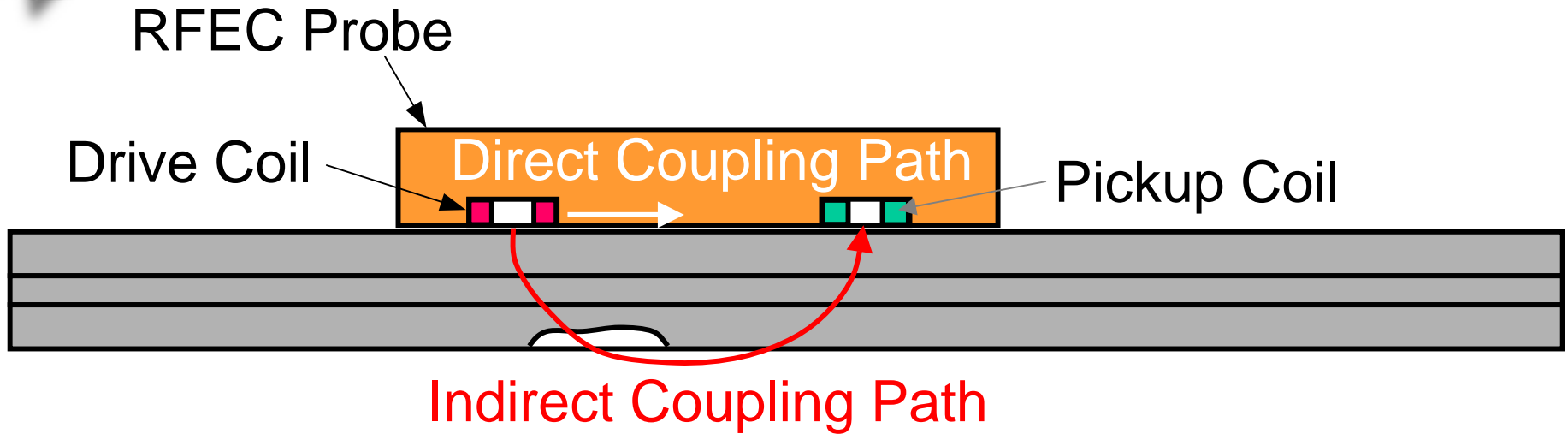
# Interlayer Crack Detection with JENTEK MWM GridStation



- Reliability of conformable probe system to detect cracks around fasteners of 3<sup>rd</sup> layer
- POD improvements over existing sliding probe procedures, with low false call rates. (0.9 PoD = .125" vs. 0.20+" for conventional NDI)



# RFEC Technique for Flat Geometries

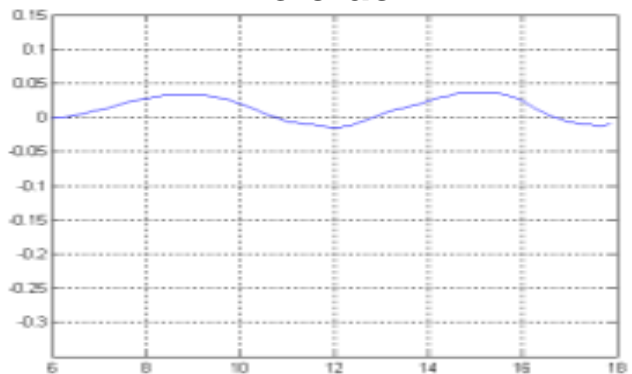


- The RFEC probe is designed to focus on the indirect coupling path, so that the signal measured by the pickup coil carries the information of the whole wall-thickness.
- Deeper penetration in detection deep flaws; higher S/N than LFEC
- Higher sensitivity and resolution to small defects
- Minimal signal interpretation is needed

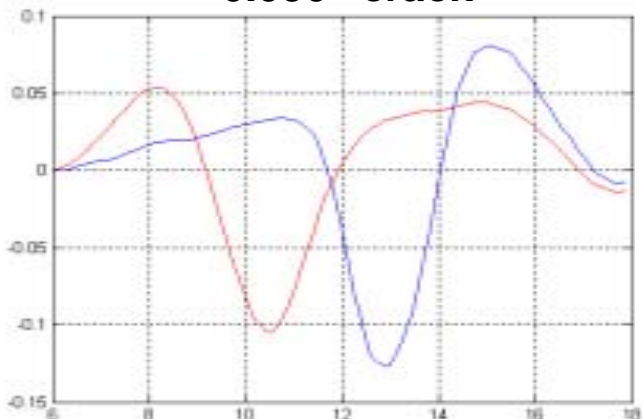




No crack



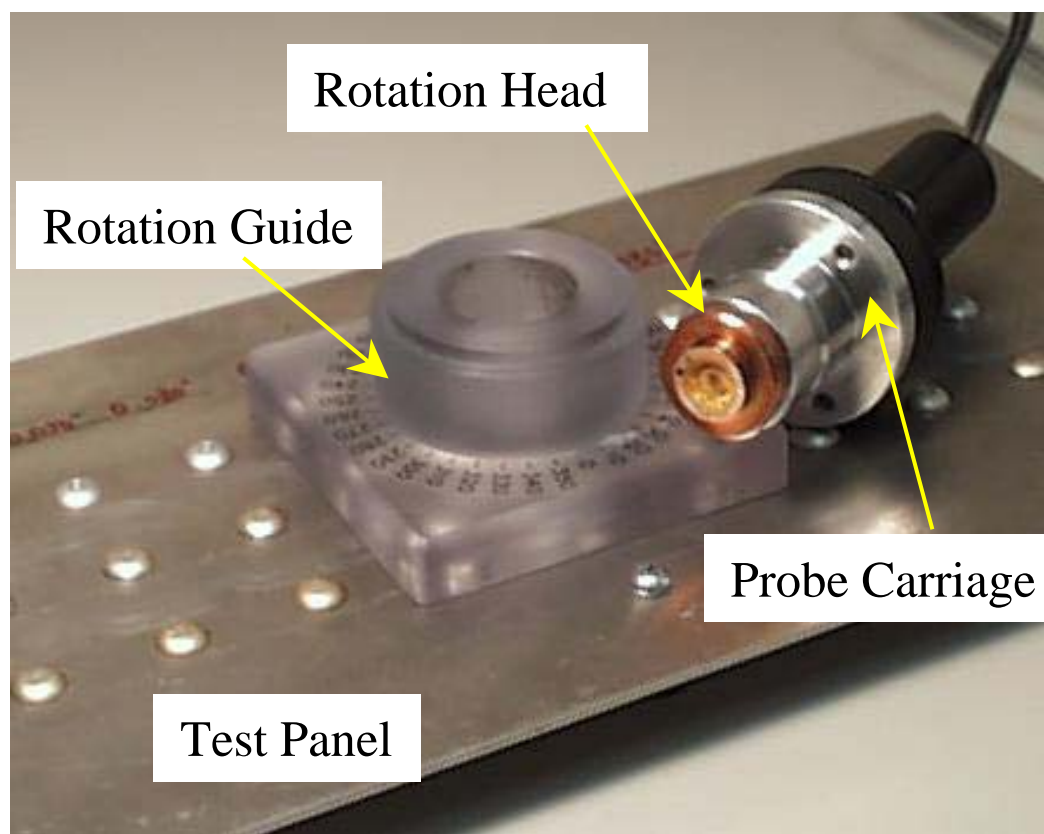
0.050" crack



Red = 2<sup>nd</sup> layer; Blue = 1<sup>st</sup> layer



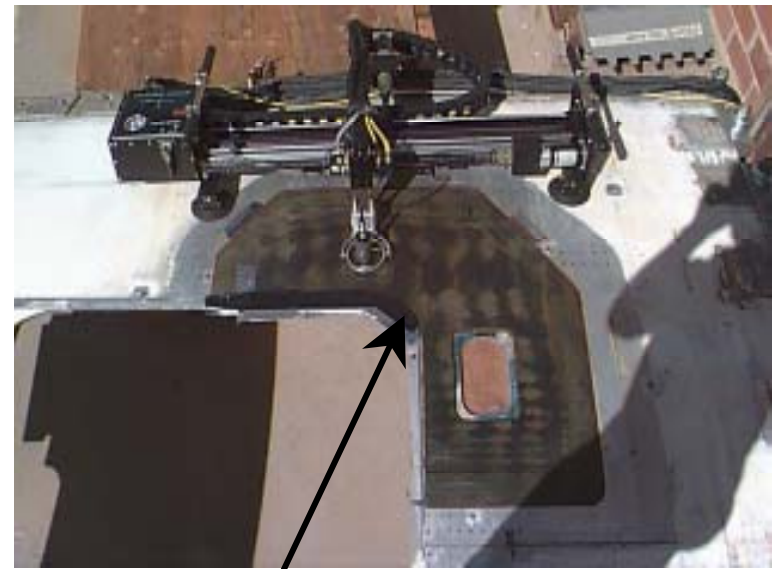
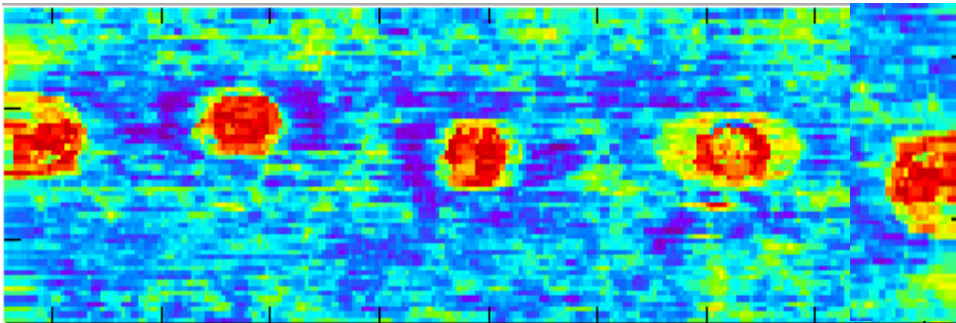
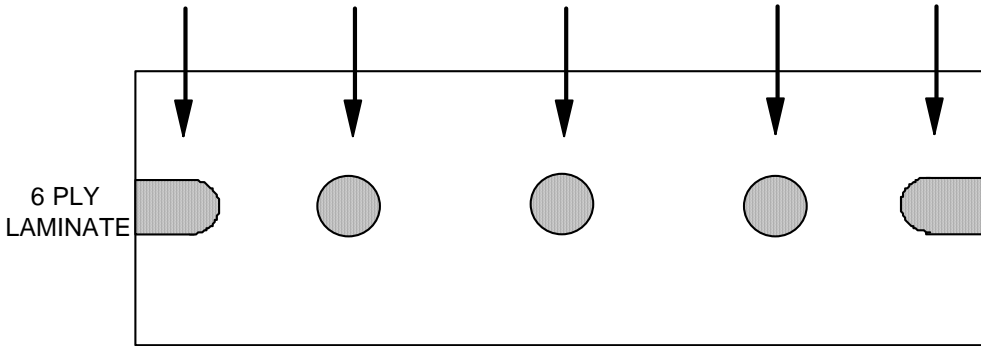
Bottom of probe showing two coils



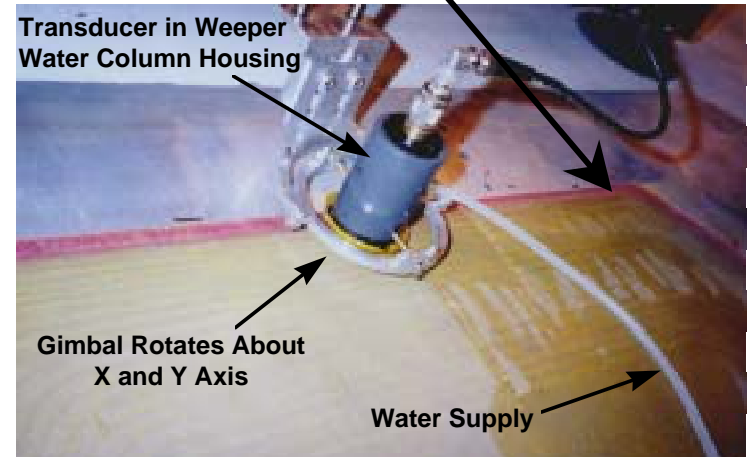
# Composite Inspection

Validation of Ultrasonic Inspections  
Six Ply Boron-Epoxy Test Specimen with  
Engineered Flaws

Embedded Disbond and Delamination Flaws



72 ply  
composite  
laminate

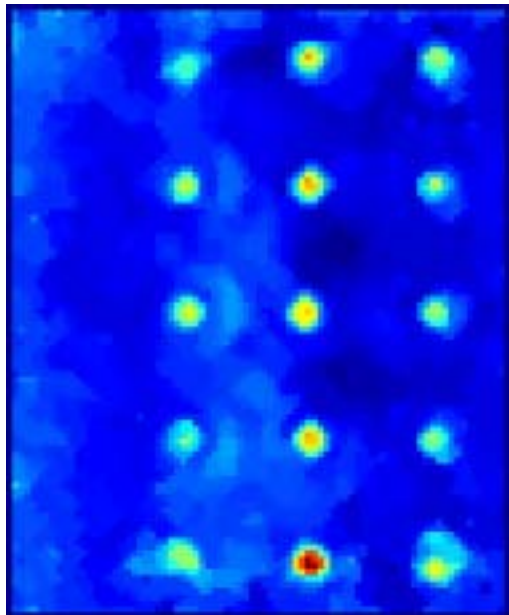


# Advanced Systems for Composite Inspection

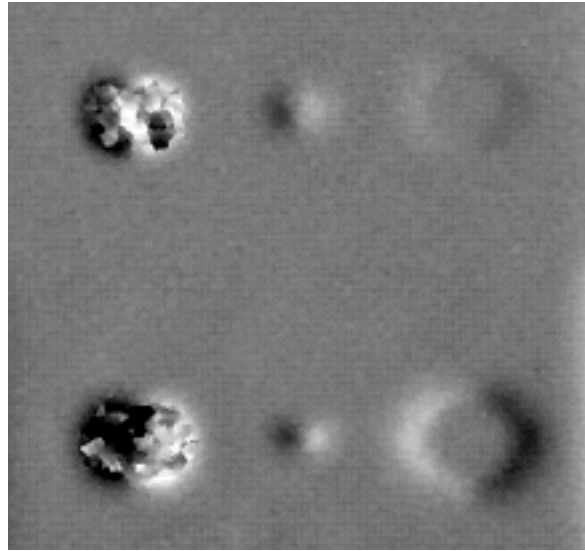




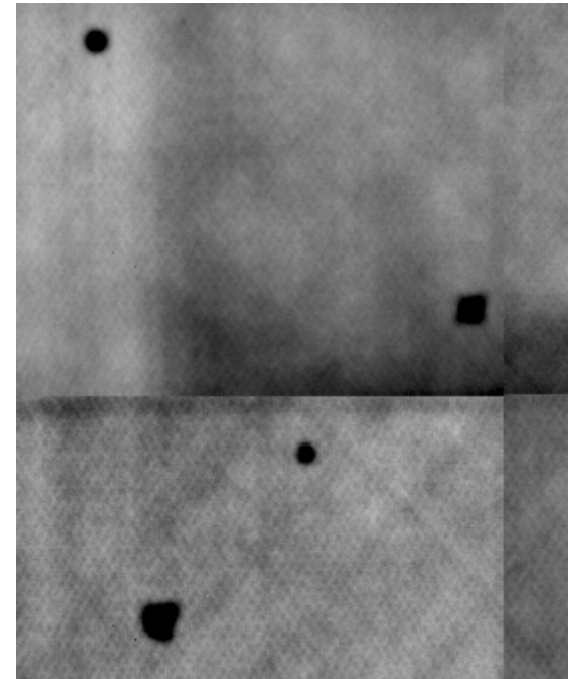
SAM Image



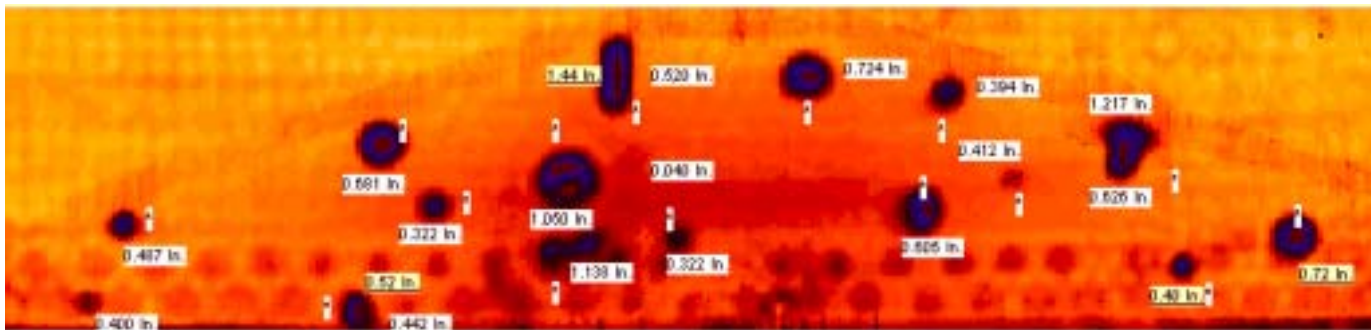
Shearography (LTI) Image



Thermography (TWI) Image



MAUS Image





# New Inspection Technologies



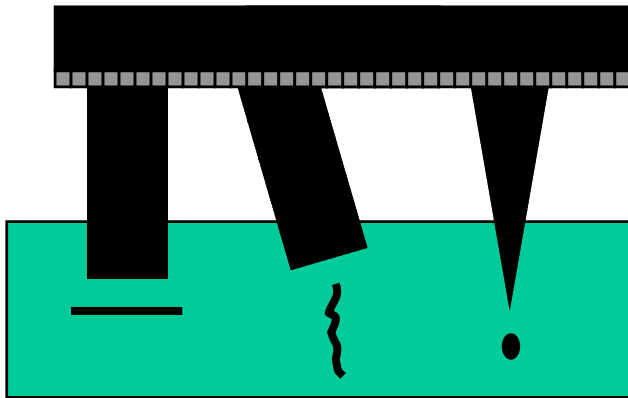
# RD Tech Array Eddy Current Hidden Corrosion Detection

- POD curves indicate detection capability comparable to other leading technologies currently in use by commercial and military maintenance facilities.



# UT Phased Array

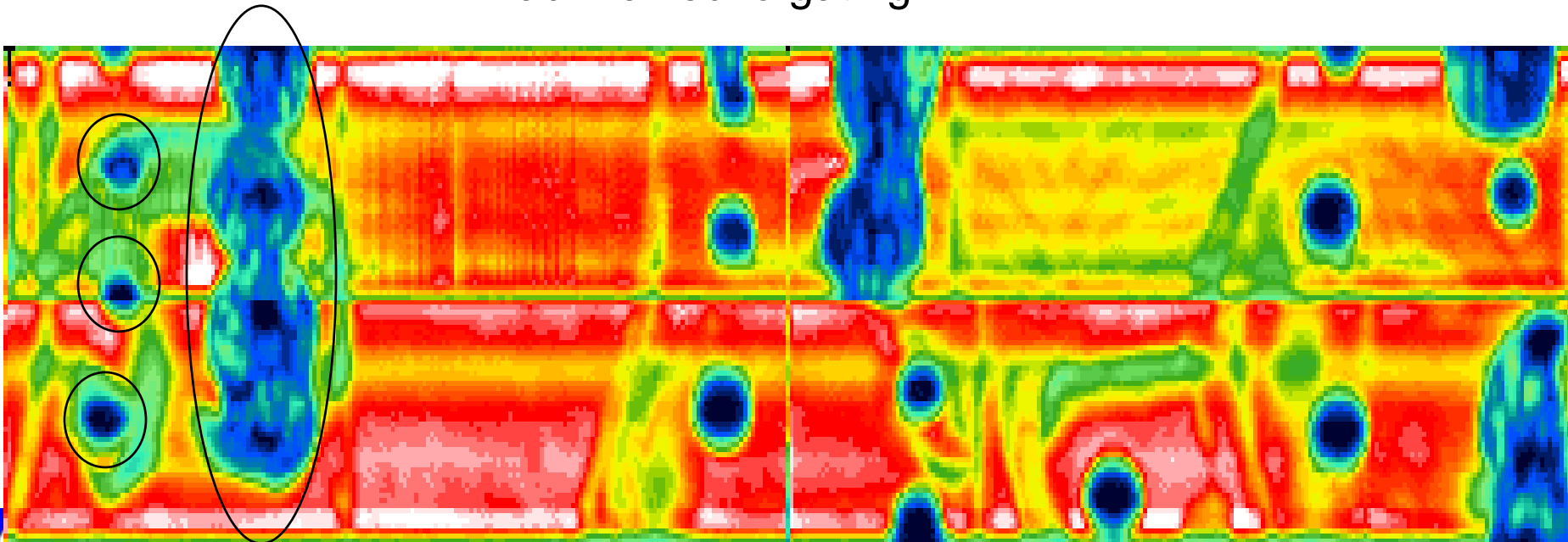
- **Phased array**
  - 128 element array with position encoder
  - Rubber coupled rotating tire over wet surface
  - Pulse-Echo mode
  - Initial application – disbonds in thick Airbus wing structure
- **Principle of operation**
  - Beam electronically configured and swept along array



Ultrasonic Wheel Array  
Sensor Instrument (NDT  
Solutions Ltd.)

# Results - wing (exfoliation corrosion)

- UWASI scan
  - 0.8 mm resolution
  - 100 mm x 400 mm area
  - Scan time 8 seconds
  - Pulse echo
  - Backwall echo gating





# Summary

- The AANC provides a focal point for FAA nondestructive evaluation activities related to assessing advanced aircraft maintenance technologies and transferring the technology to use.
- As these technologies mature, the Center will continue to evolve and assess new technologies in order to fulfill the long term commitment to the FAA and aviation industry.





# Questions?

<http://www.sandia.gov/aanc/AANC.htm>

<http://www.tc.faa.gov/>

