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

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• 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 – 2nd layer cracks in WFD scenario
- Corrosion Detection in Aircraft Joints
- Composite Honeycomb Flaw Detection
- Crack Detection Under-Raised Head Fasteners (1st/2nd layer; Rotorcraft)

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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

MATERIAL LOSS INDICATIONS

G - 8% MATERIAL LOSS

H - 10% MATERIAL LOSS

I - 5% MATERIAL LOSS

J - 5% MATERIAL LOSS
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- 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
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 $1^{\text{st}}$ and $2^{\text{nd}}$ 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

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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
Interlayer Crack Detection with JENTEK MWM GridStation

- Reliability of conformable probe system to detect cracks around fasteners of 3rd 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 = 2nd layer; Blue = 1st layer

Bottom of probe showing two coils

Rotation Head

Rotation Guide

Probe Carriage

Test Panel
Composite Inspection

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

Embedded Disbond and Delamination Flaws

6 PLY LAMINATE

72 ply composite laminate

Transducer in Weeper Water Column Housing

Gimbal Rotates About X and Y Axis

Water Supply

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Advanced Systems for Composite Inspection

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New Inspection Technologies
• 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

![Image of phased array](ultrasonic-wheel-array-sensor-instrument-NYT-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/