Inspection Task Group

Task Group Mission Statement:
ITG goal is to enhance aircraft safety by assessing & improving NDI flaw detection performance in composite aircraft structure.

Deliverables:
- Information on NDI application, performance & optimization
- Authoring Aerospace Recommended Practice guidelines and AIRs
- Information for FAA advisory material
- Assisting associated NDI integration efforts with OEMs & airlines
- Relating results, as appropriate, to other CACRC task groups

Methods – Procedures – NDI Training

Optimized Inspections
Industry-wide Composite NDI Reference Standards - Complete (SAE ARP5506 & 5507; DOE report completed)

Composite Repair NDI Handbook - Complete (SAE ARP5089); update to include more solid laminate NDI guidance

Quantify NDI Performance – Complete; Solid Laminate POD & Honeycomb POD programs; info for composite NDI training module; NDI deployment improvements; DOT reports completed; (add to SAE ARP5089)

NDI for Impact Damage in Composites – Complete; impact detection & characterization from hail, hardened, and bumper; (add to SAE ARP5089)

Composite NDI Training – Complete; focused course to improve inspector proficiency in composite laminate NDI; (add to SAE AIR7491)

Composite NDI Proficiency Specimens (Training Aids) – Complete; realistic, challenging NDI specimens to facilitate inspector training, feedback & repetitive laminate NDI exposure (add to SAE AIR7491)

Composite Bond Integrity Assessment and Composite Repair Inspection (SOBR) - use engineered & actual, aged repairs to relate NDI capabilities with structural response
Expected Output of ITG Tasks for Adoption by Industry:

Quantify NDI Performance – Database on NDI performance, method optimization with limitations & personnel qualifications; dissemination & industry adoption via DOT reports and modification of ARP5089 (Composite NDI Handbook)

Composite NDI Training and Training Aids – Produce a new composite NDI training AIR7491 and determine an appropriate way for it to be referenced by ATA-105, NAS410/ASNT, EN4179 (coordinate activity with these groups)

FAA Advisory Material - Placement of appropriate information into FAA ACs was noted as a good way to facilitate adoption of best NDI practices at aircraft maintenance facilities (TBD)
Modification/Update of ARP5089 (Composite NDI Handbook)

- Currently concentrates on honeycomb structures
- Does not include solid laminate NDI – including ramp damage check devices
- Does not address NDI performance levels and limitations – both honeycomb and solid laminate
- Does not address performance enhancement options
- Material to be edited from 4 primary documents

Document Owner, Support Team and Approach

- Document Owner: Walt Jarecki (Boeing)
- Other team members – Holger Speckmann (Testia), Helge Hicken (Airbus), Dennis Roach (Sandia AANC), Piotr Synaszko (AFIT), Feedback (entire ITG)
A Quantitative Assessment of Advanced Nondestructive Inspection Techniques for Detecting Flaws in Composite Laminate Aircraft Structures

Dennis Roach
Tom Rice
Kirk Rackow
FAA Airworthiness Assurance Center
Sandia National Laboratories
Albuquerque, NM 87185

March 2016
Final Report

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U.S. Department of Transportation
Federal Aviation Administration

270 pages

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Federal Aviation Administration

300 pages
A Quantitative Assessment of Conventional and Advanced NDI Techniques for Detecting Flaws in Composite Honeycomb Aircraft Structures

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January 2017
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Detection and Characterization of Hail Impact Damage in Carbon Fiber Aircraft Structures

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Tom Rice
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Albuquerque, NM 87185

September 2017
Final Report

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Experiments to Assess Flaw Detection Performance in Composites-Honeycomb & Laminate Structures

Purpose

• Determine in-service flaw detection capabilities: 1) conventional NDT methods vs. 2) improvements through use of advanced NDT.
• Optimize honeycomb & laminate inspection procedures.
• Provide additional information on laminate inspections for the “Composite Repair NDT/NDI Handbook” (ARP 5089).
Results Compiled from Worldwide Aviation Industry
Performance of NDI for Various Composite Inspections

Performance of Single Device (Woodpecker) Over Range of Composite Configuration

Comparison of NDI Methods for a Single Composite Configuration
Comparison of Advanced Inspection Techniques with Best Conventional NDI Result on 9 Ply Carbon

<table>
<thead>
<tr>
<th>False Calls</th>
<th>Thermography</th>
<th>MAUS IV</th>
<th>Shearography</th>
<th>CATT</th>
<th>S.A.M.</th>
<th>Wichitech DTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>74</td>
<td>4.4</td>
</tr>
</tbody>
</table>

Flaw Size (Dia. in Inches) vs. Probability of Detection
Improvements from Methods to Ensure Proper Coverage
Use of Go/No-Go Devices at the Ramp

Olympus – “Ramp Damage Checker”

General Electric – “Bondtracer”

![Graph showing probability of detection for flaw size]
Multiple impact parameters must be studied – hardness of impactor, low mass-high velocity impact, high mass-low velocity impact, angle of impact, surface demarcations & visual clues, panel stiffness

- Identify which impact scenarios of major concern
- Identify key parameters governing impact damage formation
- Relate damage threat & structural integrity to capabilities of NDI to detect hidden impact damage
Summary of Inspection Data from Composite Impact Studies

Laminate Impact Damage from Hail, Solid Items & Ground Handling Equipment

Laminate & Full-Scale Fuselage Test Panels

Side-by-Side Comparisons of NDI Techniques
Composite Impact Damage – Sample Inspection Methods Deployed

Damage Check Device (Pulse-Echo UT)

V-95 (Mechanical Impedance Analysis)

MAUS LFBT

MAUS PE

MAUS Resonance

Thermography

Omniscan Phased Array UT
**Example Result**

**TC-24-19**  
Impact Energy (J) - **1,268.1**

<table>
<thead>
<tr>
<th>Flaw Size MAUS PE (mm²)</th>
<th>Flaw Size Omniscan PE (mm²)</th>
<th>Flaw Size TTU UCSD (mm²)</th>
<th>Impact Velocity (m/s)</th>
<th>Projectile Size (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>9,413</strong></td>
<td><strong>9,439</strong></td>
<td><strong>8,022</strong></td>
<td><strong>153.46</strong></td>
<td><strong>61</strong></td>
</tr>
</tbody>
</table>

**Picture**  
**TTU**  
**MAUS PE**  
**Omni PE**  
**Ramp Damage Checker** (flaw indicated)

**IR**  
**MAUS Resonance**  
**Omni PA**  
**Good area**  
**Imp. area**
Status, Contents and Process

- Original document to be provided by SAE
- Largely an editing process on recent DOT reports
- Describe & identify usage of composites in primary structure
- Description of techniques, performance, recommended usage areas, limitations
- Conventional vs advanced NDI
- Describe use by non-NDT people (direct read-out equipment, deployment)
- Add “Line Sizing Tool” from Airbus
- Guidelines to optimize performance
- Need to determine effect of SAE publication on existing public domain documents (they will not be exact duplicates)
Produce a new AIR on Composite Inspector Training

• Tailoring training to meet airline needs
• Expected audience – inspectors & maintenance engineers
• Composite NDI training and training aids (NDI Proficiency Specimens)
• Increase exposure to solid laminate NDI
• Teach NDI optimization (performance enhancement options) and inspection challenges
• Provide lessons learned from industry
• Material to be edited from one primary document

Document Owner, Support Team and Approach

• Document Owner: Helge Hicken (Airbus)
• Other team members – Walt Jarecki (Boeing), Holger Speckmann (Testia), Chris Dragan (AFIT), Dennis Roach (Sandia AANC), Feedback (entire ITG)
FAA Composite Inspector Training Course to Enhance Proficiency and Improve Reliability

Stephen Neidigk
Dennis Roach
Tom Rice

FAA Airworthiness Assurance Center
Sandia National Laboratories
Albuquerque, NM 87185

June 2018
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270 pages
Objective - The Composite NDI Training class will be used by airlines and MROs to enhance an inspector’s preparation and training by focusing on the unique challenges associated with composite laminate inspections.
Class Modules
1. Introduction, Motivation, Objectives & Expected Outcome from Class
2. Composite Awareness – Materials, Design, Fabrication and Use
3. Composite NDI – Theory and Practice
   • Review procedures; use of available guidance; signal interpretation (e.g. lightning strike, porosity, repairs, substructure, impact); flaw characterization; POD
4. Special Cases - Challenges & Lessons Learned
   • HEWABI, damage assessment & repair process/NDI, lightning strike incidents, signal complexities → airline experiences
5. NDI Proficiency Specimens
6. Composite NDI – Hands-On Exercises
   • Selection of transducer, proper use of NDI Ref Stds, highlight lessons learned with lab exercises; use of TCG curves
Example: Uniform thickness skin, pads, fastened shear tie flanges, co-cured stiffeners, sealant

<table>
<thead>
<tr>
<th>A-Scan Exercises</th>
<th>Panels</th>
</tr>
</thead>
<tbody>
<tr>
<td>General A-Scan Inspection Procedure</td>
<td>All panels</td>
</tr>
<tr>
<td>1 - Calibration - Set Material Velocity and TCG Curve</td>
<td>Ref Std</td>
</tr>
<tr>
<td>2 - Mark substructure on surface</td>
<td>a, b, c, 2a, 2b</td>
</tr>
<tr>
<td>3 - Defect detection in uniform thickness skin</td>
<td>a, b, c, 3a, 3b, 3c</td>
</tr>
<tr>
<td>4 - Defect detection in tapered skin</td>
<td>a, b, c</td>
</tr>
<tr>
<td>5 - Inspection of bonded substructure</td>
<td>a, b, c</td>
</tr>
<tr>
<td>6 - Inspection of co-cured substructure</td>
<td>2a, 2b</td>
</tr>
<tr>
<td>7 - Defect detection around other aircraft elements</td>
<td>2a, 2b</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PA Exercises</th>
<th>Panels</th>
</tr>
</thead>
<tbody>
<tr>
<td>General C-Scan Inspection Procedure</td>
<td>All panels</td>
</tr>
<tr>
<td>1 - PA Calibration</td>
<td>Ref Std</td>
</tr>
<tr>
<td>2 - Set up TCG Curve</td>
<td>ST8872</td>
</tr>
<tr>
<td>3 - Setting gates</td>
<td>All panels</td>
</tr>
<tr>
<td>4 - Analyzing C-Scan results</td>
<td>All panels</td>
</tr>
</tbody>
</table>
First draft of AIR 7491 completed

- Class modules
- Case studies: lessons learned
- Proficiency specimen drawings and specifications
- Generalized A-scan and C-scan inspection procedures
- Hands-on exercises
- Grading and instructor materials
Status, Contents and Process

- Complete draft of AIR7491 under review by ITG
- Add “Line Sizing Tool” discussions to equipment & exercises
- Porosity/inclusions repair assessment criteria & examples
- Add latest from Boeing/Airbus classes
- Add information on NDI of composite-to-metal bonds
- Need to determine effect of SAE publication on existing public domain documents (they will not be exact duplicates)
- Composite NDI Training Adoption: Would like to set up a source for PPT files & CAD drawings for manufacturing NDI Proficiency Specimens (SAE)
- Goal: 2nd draft in Q1 CY20 & submittal for CACRC ballot in Q2 CY20

AIR 5279 Composite NDI Training – brief syllabus only
Substantiation of Bonded Repairs (SOBR) - composite bond integrity and assessment under Composite Repair Teardown program

Activity Owner, Support Team and Approach

Composite Repair Teardown – info for SOBR Program

• Team – Wichita State Univ (NIAR) & Sandia Labs (AANC)
• Comments & process:
  • Output from Repair Teardown (NDI vs Strength) may be added to SOBR documents
  • Inspection substantiation - OEMs/airlines confident with guidance criteria evolved for post repair NDI:
    – Attenuation of PE-UT; based on thickness
    – Proximity/grouping criteria
    – Size/location allowance
  • Topic to be revisited for future needs regarding repair substantiation from an inspection perspective

CACRC Inspection Task Group – Task 3
Ongoing Tasks & Future Work
Composite Repairs and Bonding

- Detection and quantification of weak bonds – co-cured, co-bonded & secondarily bonded configurations
- Effect of porosity & nonuniform/high resin flow on NDI of repairs (honeycomb & solid laminate)
NDI characterization of bonded structures – weak bonds

Activity Owner, Support Team and Approach

NDI Characterization of Bonded Structures
• Team – ITG members are assessing ability to provide in-kind support for activity
• Comments & process:
  • Needed to obtain credit for bonded repairs
  • Reproducible weak bond specimens are key
  • Round-robin consortium to support NDI testing & signal analysis

MAUS P-E UT scans produced by gating on Peak 3
Ongoing ITG Document Work:
• Update “Composite Repair NDT/NDI Handbook” (ARP 5089)
• “Composite Inspector Training Course to Enhance Proficiency and Improve Reliability” (AIR 7491)

Ongoing/Future ITG Work:
• NDI characterization of bonded structures
Current Membership

Chair: Dennis Roach FAA-AANC

Participants:
Eric Bartoletti – Southwest Airlines
Viswanath Dhanisetty – Tech Univ Delft
Jim Hofer – Boeing
Chris Dragan – Polish Air Force Inst of Tech
Rafik Hadjria – SAFRAN
Robert Hager – Delta Air Lines
Helge Hicken – Airbus
Walt Jarecki – Boeing
Fabrice Lambert – Air France
Francois Landry – Bell Helicopter

Robert Luiten – KLM Airlines
Adolfo José Martins – Embraer
Alex Melton – Delta Air Airlines
Marcos Miranda – Embraer
Charles Shepherd – American Airlines
Jez Hacket – Rolls-Royce
George Ray – UPS
Holger Speckmann – Testia
Piotr Synaszko - Polish Air Force Inst of Tech
Sam Tucker – United Airlines
Dennis von Seelen – Lufthansa Technik
Roy Wong – Bombardier