Welcome to the JTEG Monthly Teleconference

Topic: Composite Material Repair

15 December 2015
AGENDA

1300-1309: Welcome and Overview - Greg Kilchenstein (OSD-MPP)

1309-1310: Administrative Notes – Debbie Lilu (NCMS)

1310-1330: USCG Aviation Bonded Material Inspection System
– Rusty Waldrop (USCG)

1330-1400: Army Composite Repair & Support Activities
– Kimberly Cockrell (AMRDEC)

1400-1420: NAVAIR Composite Material Repair Projects
– Dave Motley (FRC-E)

1420-1435: Composite Materials Components for Reduced Maintenance
and Total Ownership Cost – Scott Bartlett (NSWCCD)

1435-1450: Composite Patch Repair of Cracked Aluminum Plates
– Dan Hart (NSWCCD)

1450-1500: Wrap-up and JTEG Principals Comments
Joint Technologies Exchange Group (JTEG)

- Provide a forum for the exchange of information on new technology, processes, and equipment developments
- Collect, analyze, and disseminate depot maintenance requirements for new technology, processes and equipment
- Advocate for new technology or equipment with cross-service potential to increase efficiency
- Facilitate joint service technology development
Technology Forum Protocol

• Please keep your phones on mute unless you are presenting. Do *NOT* put your phone on hold. Should you have to temporarily drop off please hang up and call back.

• Questions will be addressed via “Private Chat” on DCS. Send questions to “Langlais, Raymond R Jr”.

• Presenters - slides will be advanced by Ray

• This is an open forum. Briefs and Q&A will be posted on the JTEG website once approved for public release.

http://jteg.ncms.org
USCG Aviation Composite
“Bonded Material Testing”

Rusty Waldrop  NDI Program Manager  USCG
rusty.g.waldrop@uscg.mil
Problem

Training, Tap Testing (TT) and Ultrasonic's (UT).

- **Training**: Attentiveness and knowledge of structures and technical documents. (Historical observations)
- **TT** is an inconsistent method to determine serviceability on metallic and nonmetallic composite constructions.
- **TT** leads to conflicting results leading to interpretational dialogue between inspectors and maintenance managers.
- **UT** can be time consuming and be difficult set up and to interpret. (Signals with poor resolution \ Signals with poor return properties)
This is half of the inspection and it shows the thermal image obtained for review. The areas are mapped out using the C-C cross section slice.
Discerning the difference in the ply thickness.
These screen captures show the resolution of the separation in plies.
The BMT resonance method clearly would be an easier interpretive skill.
Discerning the difference in the ply thickness. These screen captures show the resolution of the separation in plies. The BMT resonance method clearly would be an easier interpretive skill.
• Plies of bidirectional (quasi-isotropic) laminates can cause a loss of UT signals.

• This condition can be mistaken for internal structure damage of carbon fiber laminates, making difficult to properly interpret.
**USCG Aviation Composite**

**“Bonded Material Testing”**

<table>
<thead>
<tr>
<th>Specific Technique Applied with</th>
<th>Type of Inspection:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tap Test</td>
</tr>
</tbody>
</table>

**Equipment Settings:**

- **Using a Tap Tester to Listen for Discontinuity of Blanks:**
  - **Tap Test Induced Test on Tension Edge of Blank with Converging Cone:**
  - **Drilled 2 Inches from Blank.**

**Aircraft Type:**

- □ HU25
- □ C130
- □ H60
- □ HN65
- ✔ Other

**Location:**

- ALC
- Other: NPS PDS-0041

**Technical Directive Applied:**

**Results:**

<table>
<thead>
<tr>
<th></th>
<th>Acceptable</th>
<th>Rejected</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>✔</td>
</tr>
</tbody>
</table>

**Disposition Report: Geometric and Material Property Characteristics:**

- **Gage Size of Blank:** 3.4 inches at 3-4 inches from the trailing edge.
- **Concave Side Has Delamination 3.4 inches from Blank Root:**
  - 3 inches from trailing edge. Trains off center as it gets to tip.
- **Blade Leaking:**
  - **Gage Size:**
  - **Shaded Area Delaminated.**

**Signature:**

- [Signature]

**Stamp Impression:**

Accept | Reject

- [Circled]
**Solution**

- Training / certification program that teaches various engineered material constructions, theory and application of BMT.
  - Validated through testing.
- Bonded Material Testing instrument (BMT). A portable instrument designed to detect unbonded conditions in laminate plies and in sandwiched constructed materials.
Solution

- BMT details a positive output to a situation that is an electronic signal and is audio. Both methods eliminate interpretational debate.

- Precise output of material integrity. The output material condition eliminates production scrutiny.
USCG Aviation Composite
“Bonded Material Testing”

Training
(Knowledge)

DISBOND
Core Damage
DELAMINATION
LAMINATED STRUCTURE
SUBSURFACE POROSITY
LAMINATED STRUCTURE
Training
(Applications)
Training
(Applications)

Spar in horizontal Stab.
Horizontal Stab Skins
9 plies of CFRP.

Delamination between stringer and skin
Delamination between CFRP plies 5 & 6 in the skin
Challenges & Risks

• Innovation Immaturity: This is a proven application. The method has been used for approximately 30 years in various industries but the knowledge of the concept and its application has always been on back burner. USCG has dedicated this program for success through knowledge, applications and personnel certification.

• DoD Community Awareness/Exposure: Success through awareness, the more it is used the more success it will have and the blue collar fleet personnel will find ways to use it that white collar engineers can't think of. Provide the knowledge and they will it will be used. (INNOVATION GROWTH)

• Transition to a Program: USCG has a natural smooth transition into a program that holds promise in reliability, proficiency and accomplished in a reasonable amount of time.

• What are the risks?
  – Lack of knowledge will lead to lack of acceptance.
  – The task of inspection will now rest on the shoulders of the few that are trained and certified verses the mass of personnel in the maintenance departments.
  – Old school maintenance methods and practices.

• This will require me to maintain diligence in open discussions about the system concept. The NDI program manager must be vocal about the successes and be vigilant in solving hurdles.
Innovation Status

• Where is the technology in the Life-Cycle Continuum?
  – This is a demonstrated capability. Current use is minor but it is in an industrial strategically growth state.

• What are the most probable applications and locations for the technology?
  – Will be accomplished with nonmetallic components and structures.
    • Fleet in-service components.
    • Depot level in-service and secondary processing stages of structures and components.

• What are the possible obstacles?
  – Lack of production managers and engineers to demand its use to provide a quality consistent inspection.
  – The battle between the few trained certified individuals verses the mass performing the inspections.
  – Managers will need to better plan personnel work shifts and hours to ensure a timely inspection.

• What is the likely outcome that we should expect?
  – Slow but steady growth and acceptance over a careful implementation strategy
Benefits

- **Engineering Benefits**: BMT offers more accurate results and exact measurement of defects compared to TT.

- When the UT delay line is used the beam spread inhibits an exact measurement and is never consistent between inspectors. Return signals can be difficult to interpret.

- Increase repair quality and potentially reduce repairs and size. Most defects when tapped are generally marked larger then actual size.
  - Repairs can be evaluated for quality.

- **Reduced Repetitive Tasks**: The discovery of defects with tapping will usually involve seeking second and third opinions.

- Reduce maintenance production scrutiny in rejected indications or acceptable conditions.
Vision / Final Thoughts

• How can the innovation be integrated into DoD maintenance processes?
  – DOD aviation has begun implementation but the DOD community has not inserted a vigorous specific training for the technology with specific testing.
  – USCG has incorporated the process into the training program for inspectors which includes written examination and proficiency applications testing.

• What further development is required?
  – Repairs and far side inspection procedures.

• Aircraft structures are changing to the lighter stronger bonded materials. Don’t be reactive be proactive. Get the knowledge of the materials and the tools in the tool box. Grow this knowledge and applications now to avoid from being behind the curve when its time to react.
Questions
If there is time the next slides are more application examples
### Specific Technique Applied with Type of Inspection:

- **TAP TEST**

### Equipment Settings:

- **N/A**

### Aircraft Type:

- [ ] HU25
- [ ] C130
- [ ] H60
- [ ] HH65
- [x] Other

### Other Type:

- H-144

### Location:

- ALC
- Other:

### Technical Directive Applied:

- [ ] Acceptable
- [ ] Rejected

### Disposition Report: Geometric and Material Property Characteristics:

Fiberglass skin delaminating from trailing edge to 3 inch up blade, entire length of blade on both sides.
HC 144 Prop Blade
S/N: 2005040643 Convex Side
Pre-Induced Defect
# 2015 DoD Maintenance Innovation Challenge

USCG Aviation Composite
“Bonded Material Testing”

<table>
<thead>
<tr>
<th>Specific Technique Applied</th>
<th>Type of Inspection:</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment Settings:</td>
<td></td>
<td>N/A</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Aircraft Type:</th>
<th>HU25</th>
<th>C130</th>
<th>NH60</th>
<th>HH65</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other Type:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Location:</td>
<td>ALC</td>
<td></td>
<td></td>
<td></td>
<td>Other</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Technical Directive Applied:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Results:</th>
<th>Acceptable</th>
<th>Rejected</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Deformation Report: Geometric and Material Property Characteristics:

Number 1 Main Rotor Blade has a 2 inch by 3 foot void running length wise in middle of blade.

Signature: [Signature]

Stamp Impression: [Stamp Impression]

Accept / Reject: [Accept / Reject]

[Spar Image]
USCG Aviation Composite
“Bonded Material Testing”
Army Composite Repair & Support Activities
FY15 Status Update

December 15, 2015

Presented by:
Kimberly Cockrell
Prototype Integration Facility (PIF)
U.S. Army Aviation and Missile Research, Development, and Engineering Center

“DISTRIBUTION STATEMENT A. Approved for public release. PR 1843”
Updates to Continuing Activities

- **Composite Maintainers Technical Interchange Meeting (TIM)**
  - Annual meeting of defense composite maintainers
  - Participation across DoD, Homeland Security, industry and academia

- **AMRDEC Composites Working Group**
  - Growing enterprise collaborations

- **National Composite Consortiums**
  - **DOE** Institute for Advanced Composites Manufacturing Innovation (IACMI)
Repair-based Training & Certification

1. **Repair Course:** 5-day hands-on class based on UH-60M stabilator, but applicable to any composite structure

2. **Technical Inspector Course:** 3-day hands-on class

3. **NEW** **Blade Repair Course:** 5-day hands-on class based on UH-60M Wide Chord Blade

4. **Basic Composites Certification from CertTec** *(recommended for contractors at maintenance sites)*
   - DoD “COOL” program and VA approved
   - Certifying Examiners

Engineering and Acquisition Training

**Fundamentals of Composites Course**

- Course for engineers and acquisition professionals
- Covers lifecycle support of composites, including design, production, sustainment (repair), safety, and quality inspection
Dry De-Paint Modernization Report (w/ USAF)

- Chemical Strippers don’t mix with composites and are generally unfriendly to the environment
- Automation key to reducing cost, improving safety
- Dry Depaint Technologies exist in various stages of technology readiness
  - Manual Abrasion (sanding)
  - Blasted Abrasion (plastic and organic media)
  - Cryogenics
  - Plasma (torch, dbd, corona and RF glow discharge)
  - Laser Ablation (including CO2, Fiber, and Nd:YAG)

**Enabling Technologies**
- Immersive Learning (virtual environment)
- Augmented Reality (digital overlay to real environment)
- Software tool for simulating & optimizing laser ablation
AATD Efforts

- Repaired IM8 solid laminate and sandwich structure using 2 separate techniques:
  - IM8/PMT F3G-HT pre-cured patches
  - IM8/Benzoxazine wet lay-up patches
- Integrity of the repaired structure validated through full-scale static ultimate / cyclic fatigue testing and NDI.

PIF Efforts

- Continue Propagating Common Repair Processes
  - Leveraged across many platforms:
    ✓ UH-60M Black Hawk
    ✓ MQ-1C Gray Eagle MAE UAS
    ✓ AH-64E Apache
    ✓ MH-47G Chinook
    ✓ UH-72 LUH ....and more!
Scope: Develop, substantiate and publish a Technical Manual for unit-level airframe repair leveraging common repair processes, tools and materials from manned rotorcraft platforms (UH-60M Black Hawk and AH-64E Apache).

Step 5: Create ply tables and Zone Maps

Step 6: Develop Repairs based on Army Aviation common set of tools and materials

<table>
<thead>
<tr>
<th>Sample UAS Laminate Materials</th>
<th>Army Preferred Repair Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>8-harness satin 3K carbon fabric</td>
<td>IM7 plain weave 3K carbon fabric</td>
</tr>
<tr>
<td>With a Tencate resin system</td>
<td>EA 9396 laminating resin</td>
</tr>
<tr>
<td>120 Kevlar Fabric</td>
<td>120 E-glass / EA 9396</td>
</tr>
</tbody>
</table>

Step 7: Design and Substantiate Repairs

*Equivalent Strength Analysis Approach* compares original laminate to repaired laminate to establish:

- Repair Stiffness Margin
- Repair Strength margin of safety
- Bonded Joint margin of safety
Logistics Impacts of UAS Repairs
- 17 of 21 discrete work packages imported with little to no modification
  - NO new training requirements
  - NO new tools/equipment requirements
- Provisioning task minimized: only ONE (1) new material

UH-60 L/M Engine Cowling Doubler
- Minor field damage causes Engine Cowling to fail catastrophically in the maintenance platform position
- New carbon fiber doubler to be installed at Intermediate maintenance level that restores damaged cowlings to better-than-new strength
- 2 configurations: Flat Deck & Recessed Deck
- Production of doublers & repair kits in mid-FY16
• Whitepaper on Supportability Considerations for Advanced Composite Structures
• Follows the life cycle and provides recommendations ("Takeaways") for action or consideration today
  – Materials & Processes
  – Program Planning
  – Education & Training
• 10 case studies provide "Army Lessons Learned" and basis for Takeaways
• Opportunities for DoD collaboration:
  ❑ Software tools for analysis
  ❑ Standards for CDRL deliveries of 3D models that can be interrogated
  ❑ Material properties data for repairs
AMRDEC Prototype Integration Facility

E-mail: PIFcomposites@amrdec.army.mil

AMRDEC Web Site
www.amrdec.army.mil

Facebook
www.facebook.com/rdecom.amrdec

YouTube
www.youtube.com/user/AMRDEC

Public Affairs
AMRDEC-PAO@amrdec.army.mil
Back-up Slides
Why This is Important

• Composites are *constructed* differently than metals
  – The maintainer becomes the material manufacturer
  – Controlling the *process* (heat, cure times) is critical
    o Even in metals, 2024-0 is not the same as 2024-T3
    o The differences are often not visible to the naked eye

• Composites *fail* differently than metals
  – Under loads, metals become "plastic" and yield until they fail
  – Composites are elastic to a point, and then catastrophically fail
  – The various ply orientations will have different failure modes

• Composites are *designed* differently than metals
  – Fibers must be placed in the direction of the loads
  – Aluminum, cadmium, and steel will corrode against carbon fiber and must be isolated electrically

• Composites must be *supported* differently than metals
PIF Advanced Composites

Composite Repair Expertise
• Repair structural substantiation
• Procedure development (IETM or MWO)
• Illustrations and XML coding

Composite Design Expertise
• Composite component design
• Structural analysis and substantiation
• Test and qualification

Composite Fabrication Expertise
• Material and process (M&P) development
• Hand lay-up, resin infusion molding
• Master models and tooling

Composite Training Expertise
• 50+ years in composites instruction
• Repair of blades, solid laminates, and sandwich structure
• Manufacturing and adhesive bonding
FRC
Composite Material Repair Projects Update

David Motley
FRC-E
Current Navy FRC Projects

• Cyanate Ester high temp repair resin
  – Possible BMI repair resin
  – Possible use as fire retardation barrier on BMI

• FTIR heat damage detection
  – Approved for use on F18 – working on approval for other platforms

• StressCheck (ESRD) composite repair analysis tools
  – Goal is to make “templates” for composite repair analysis

• VARTM
  – Ongoing trials and material testing as a repair option
  – Magnolia 136-553 resin