JTEG
Joint Technology
Exchange Group
Joint Solutions for Depot Maintenance

COMMERCIAL TECHNOLOGIES for MAINTENANCE ACTIVITIES
NCMS • DoD
CTMA

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

2015 DoD Maintenance Innovation Challenge

USCG Aviation Composite “ Bonded Material Testing”

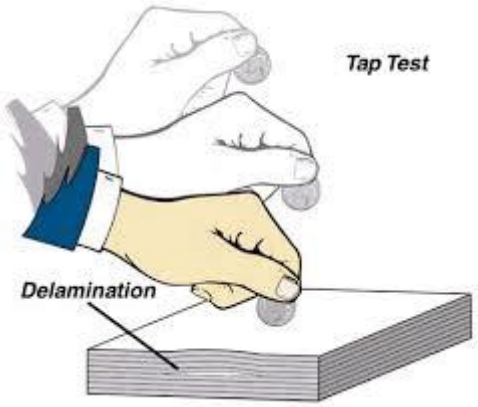
Rusty Waldrop NDI Program Manager USCG
rusty.g.waldrop@uscg.mil

USCG Aviation Composite " Bonded Material Testing"

Problem

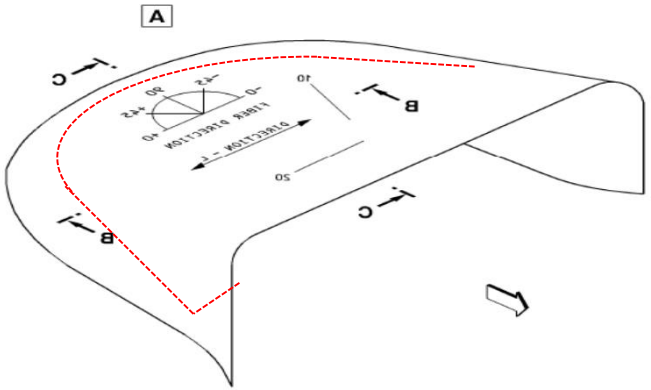
Training, Tap Testing (TT) and Ultrasonic's (UT).

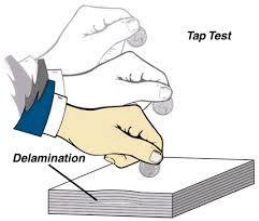
- Training: Attentiveness and knowledge of structures and technical documents. (Historical observations)
- TT is an inconsistent method to determine serviceability on metallic and nonmetallic composite constructions.
- TT leads to conflicting results leading to interpretational dialogue between inspectors 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)

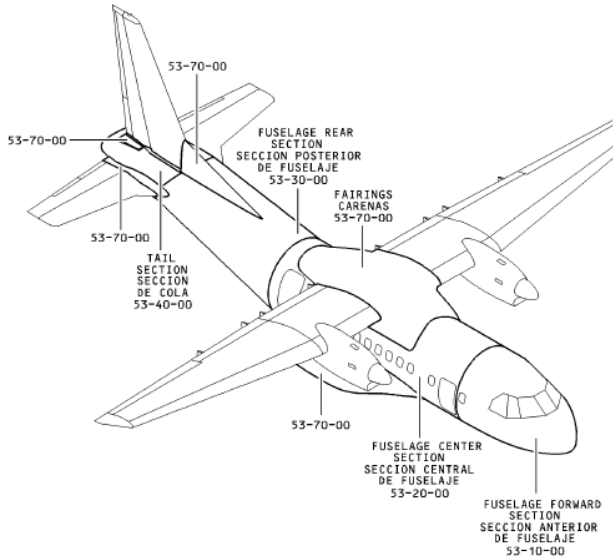


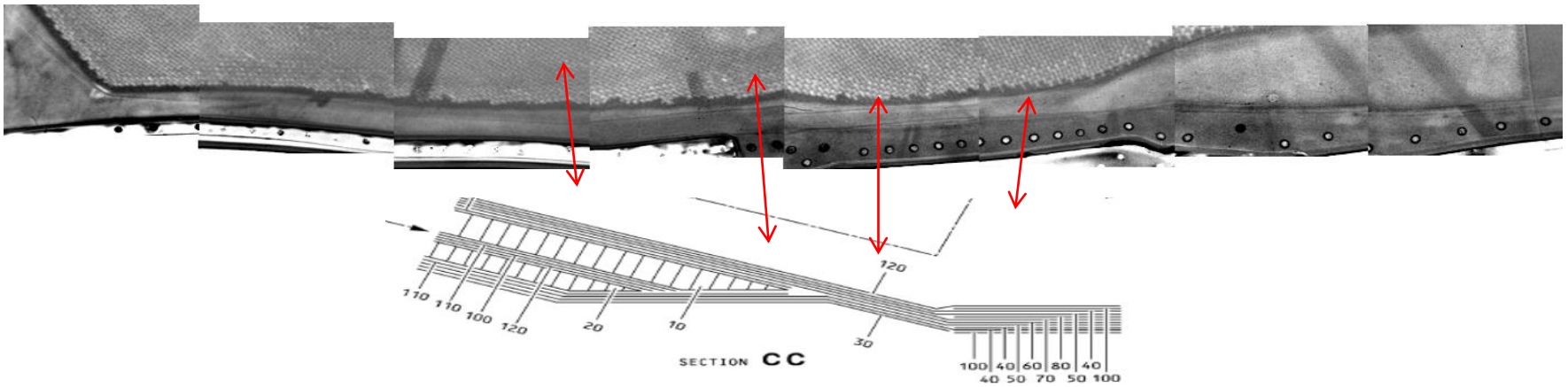
USCG Aviation Composite “ Bonded Material Testing”

Incipient Event









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.

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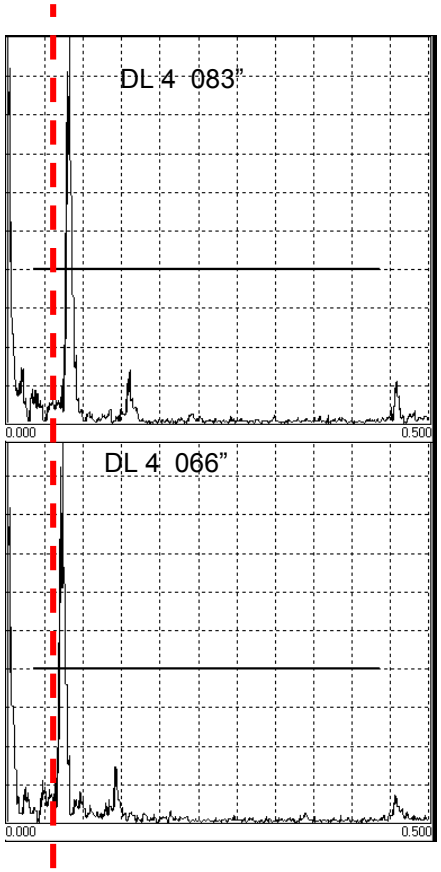
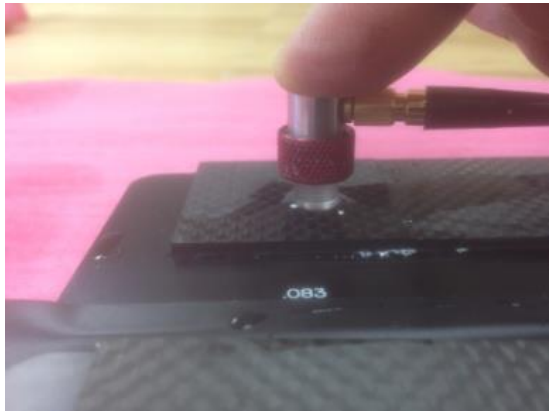
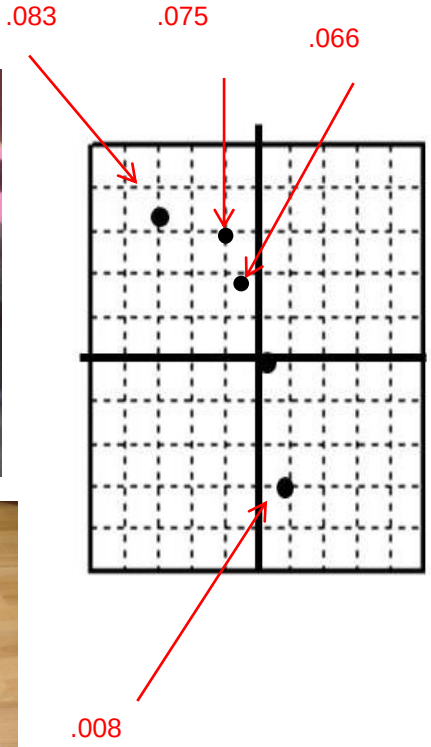
USCG Aviation Composite “ Bonded Material Testing”



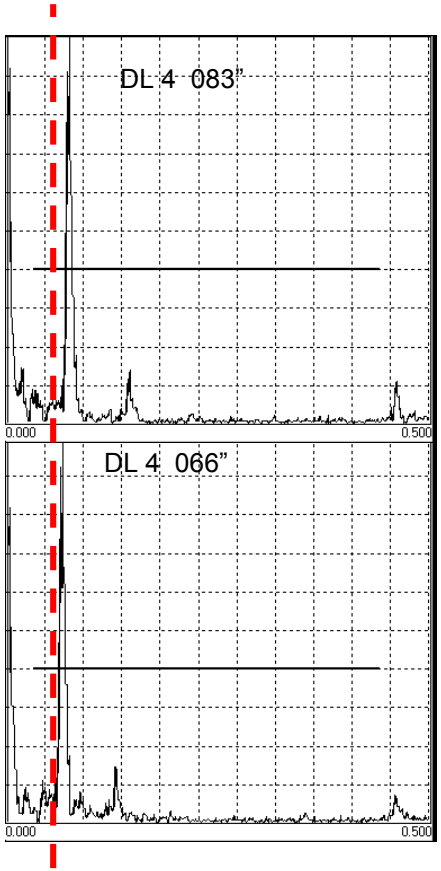


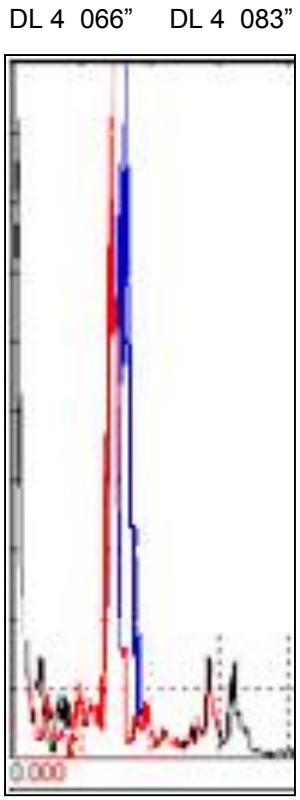


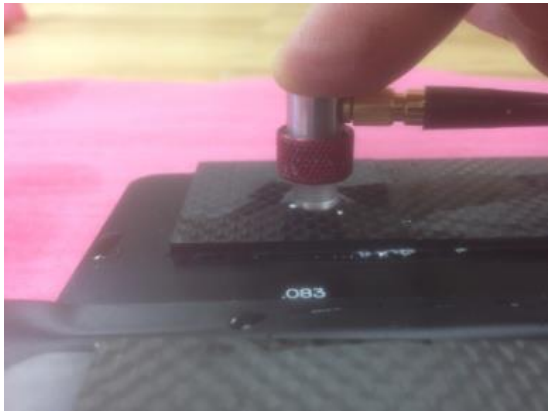
Discerning the difference in the ply thickness.
These screen captures show the resolution of the separation in plies.
The BMT resonance method clearly would be an easier interpretive skill.

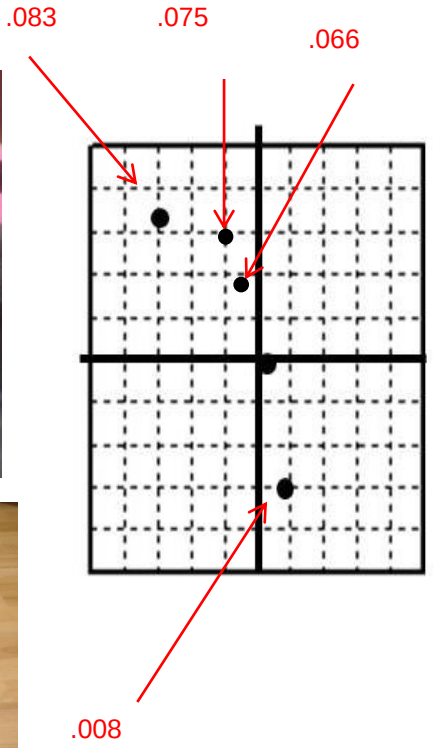
2015 DoD Maintenance Innovation Challenge

USCG Aviation Composite “ Bonded Material Testing”









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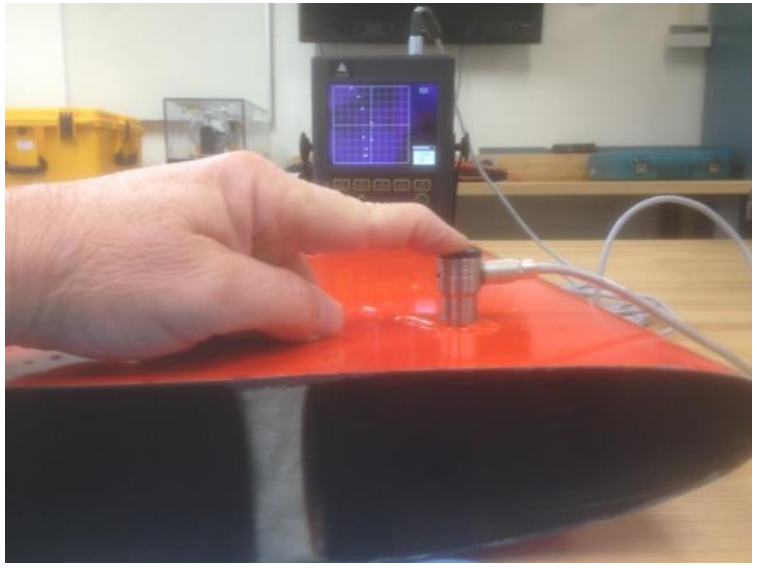
USCG Aviation Composite " Bonded Material Testing"



- 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.

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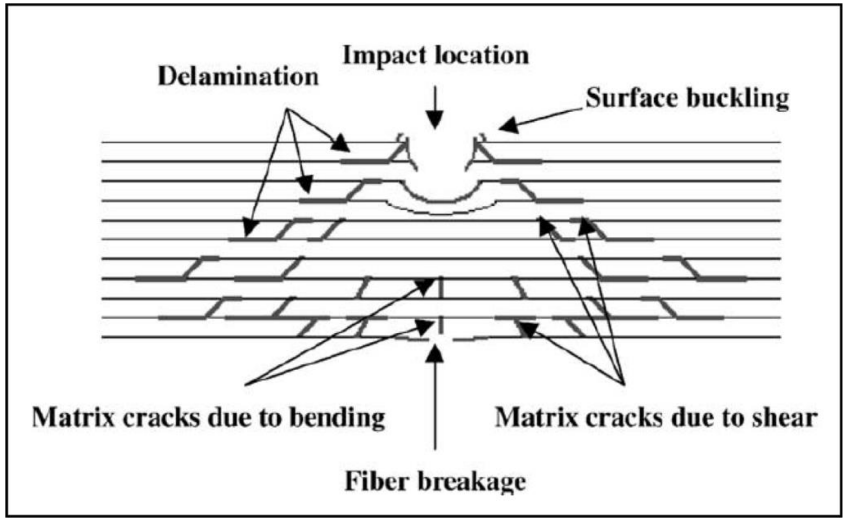

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USCG Aviation Composite “ Bonded Material Testing”

Specific Technique Applied with Type of Inspection: TAP TEST

Equipment Settings: USING A TAP TESTER TO LISTEN FOR DELAMINATION OF BLADE. TAP TEST INDICATED THAT ON TRAILING EDGE OF BLADE BOTH CONVEX AND CONCAVE SIDES DELAMINATED 2 INCHES FROM EDGE.

Aircraft Type:	☐ HU25	☐ C130	☐ H60	☐ HH65	☑ Other

Other Type: HC-144

Location: ALC ☐	Other: NAS PENSACOLA

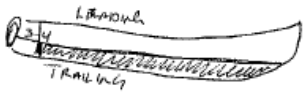
Technical Directive Applied:

Results:	☐ Acceptable	☑ Rejected

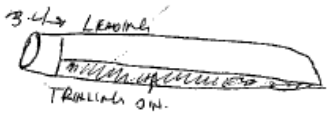
Desposition Report: Geometric and Material Property Characteristics:

for convex

CONVEX SIDE OF BLADE 3-4 INCHES IN, 2-3 INCHES FROM THE TRAILING EDGE

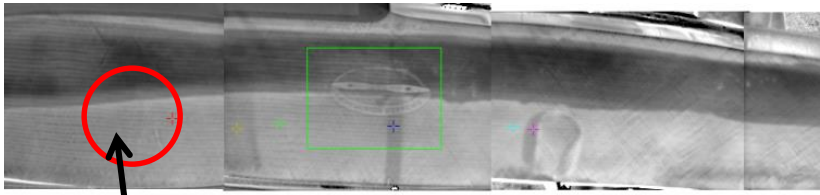


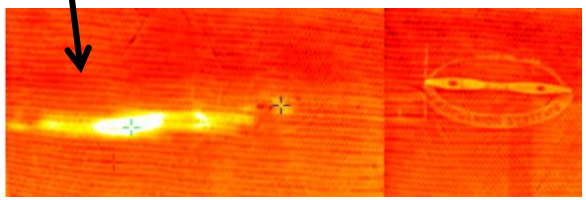
CONCAVE SIDE HAS DELAMINATION 3-4 INCHES FROM BLADE ROOT 2-3 INCHES FROM TRAILING EDGE. TAPERS OFF DELAM AS IT GOES TO TIP.



= SHADED AREA DELAMINATED.

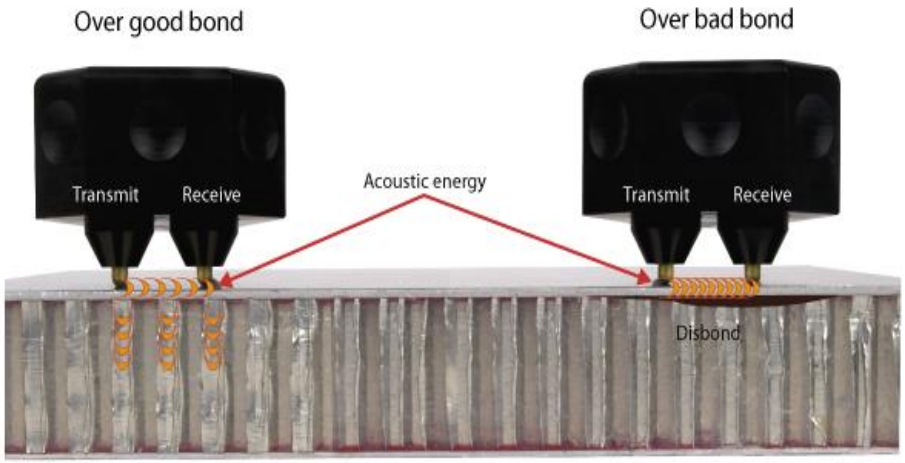
Signature: [signature] 18 Stamp Impression ☐ Accept ○ Reject ◉

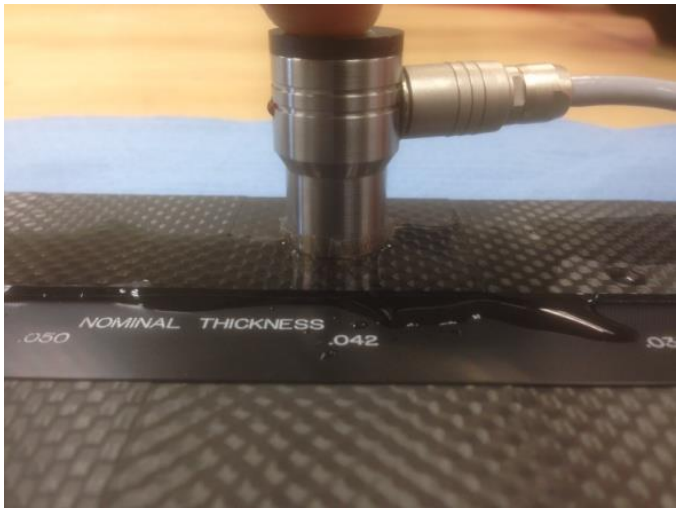




Solution

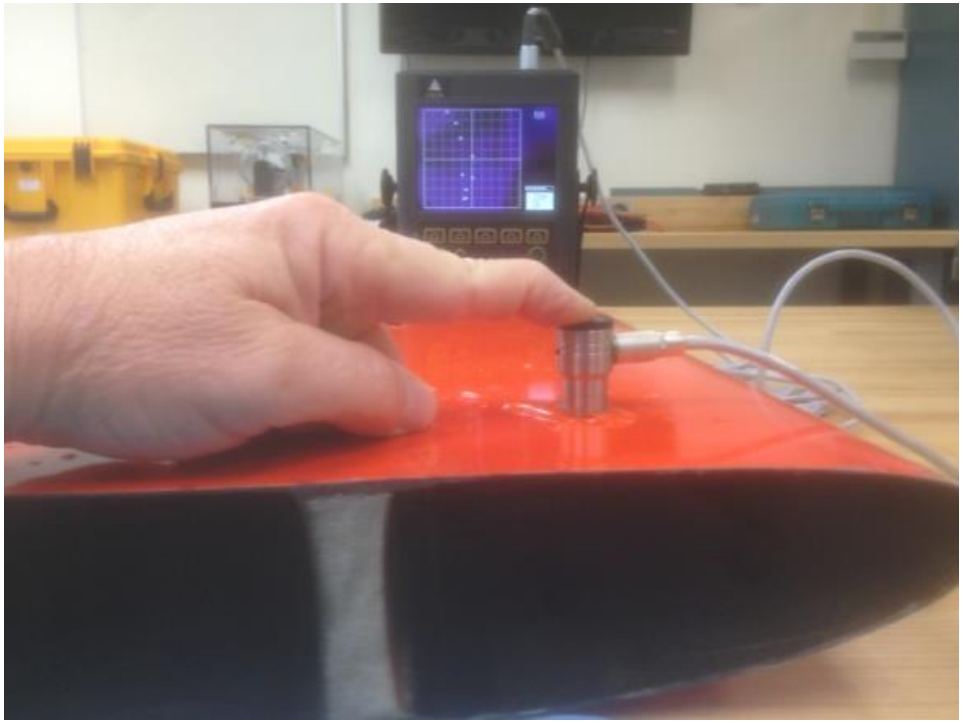
- Training / certification program that teaches various engineered material constructions, theory and application of BMT.
  - Validated through testing.
- Bonded Material Testing instrument (BMT). A portable instrument designed to detect unbonded conditions in laminate plies and in sandwiched constructed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

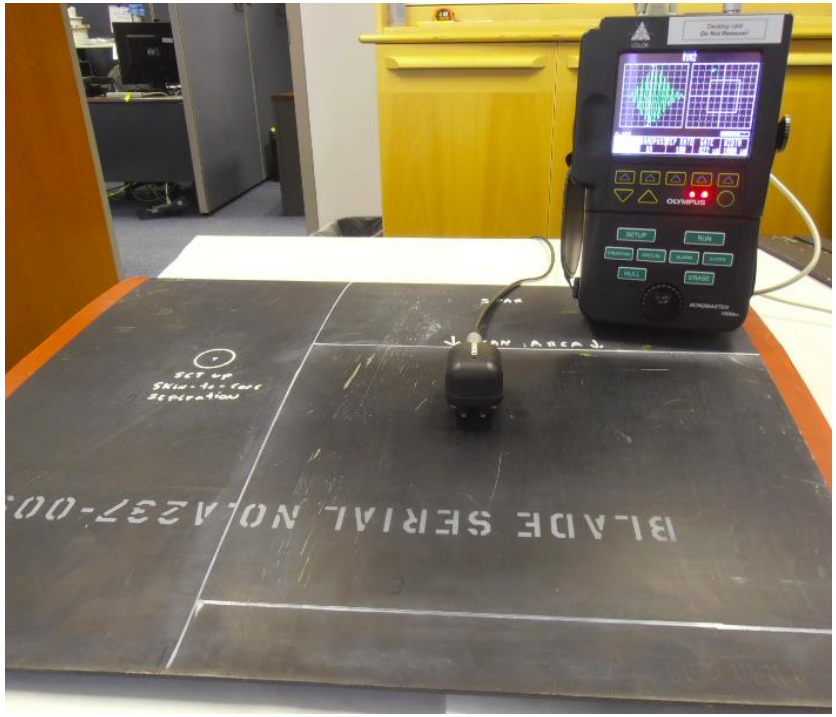




Solution

- 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.



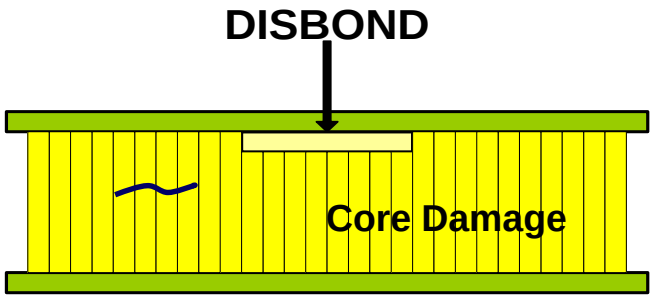


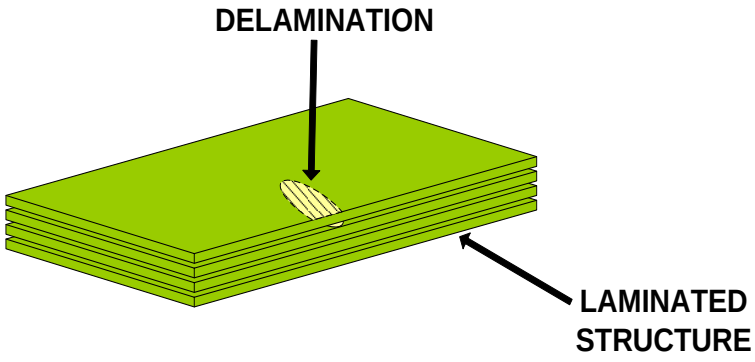
2015 DoD Maintenance Innovation Challenge

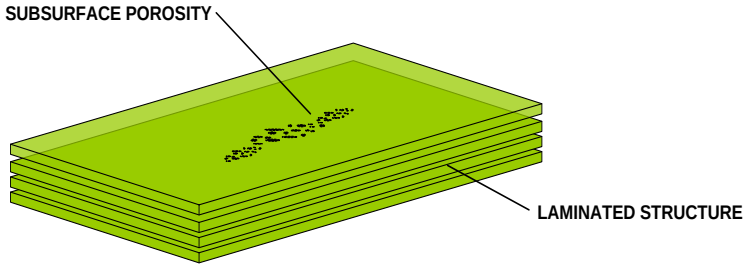
USCG Aviation Composite “ Bonded Material Testing”

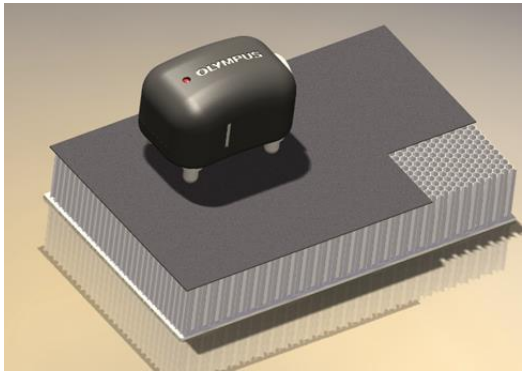
Training

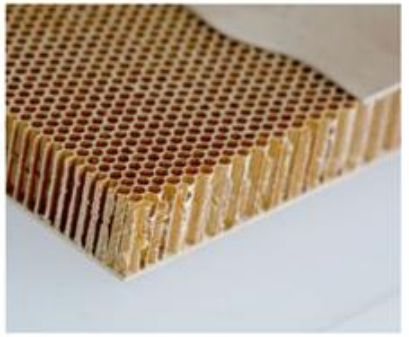
(Knowledge)

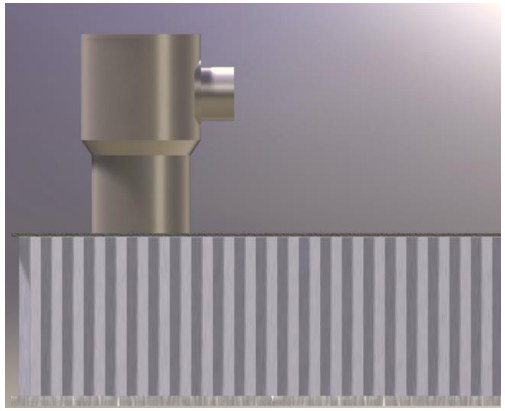


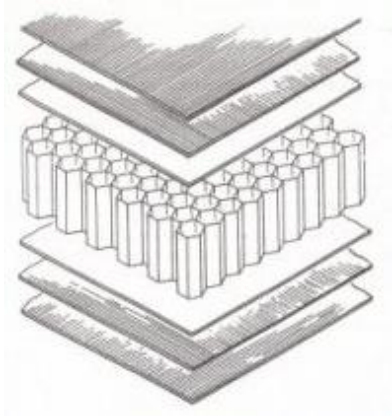






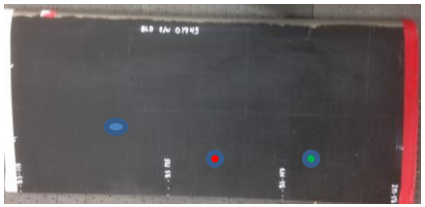


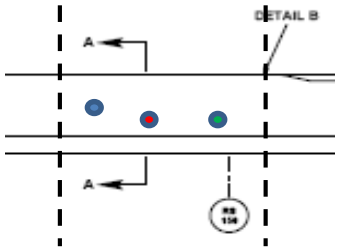




2015 DoD Maintenance Innovation Challenge

USCG Aviation Composite “ Bonded Material Testing”

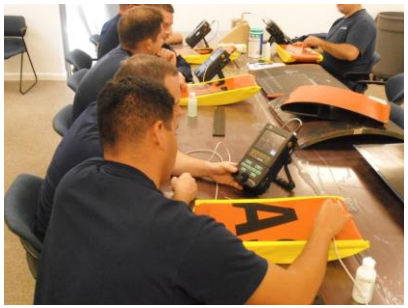


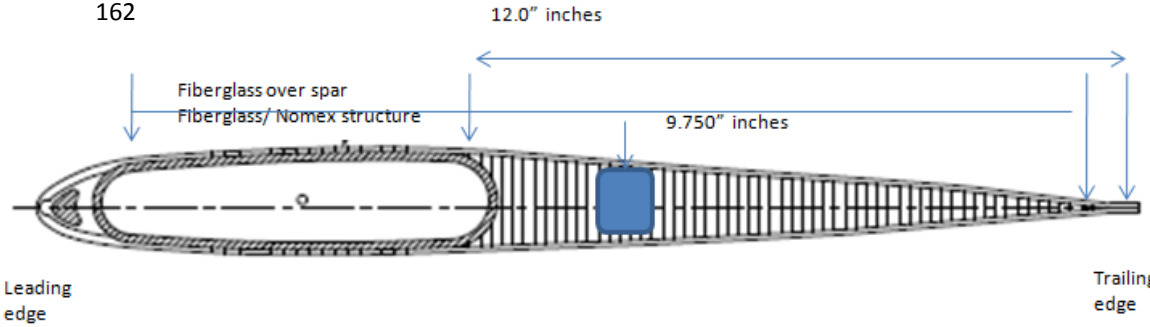


BS115 BS 162

Training

(Applications)



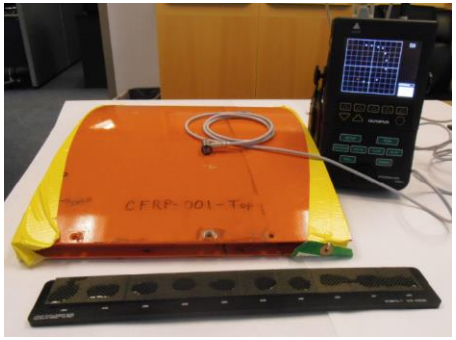


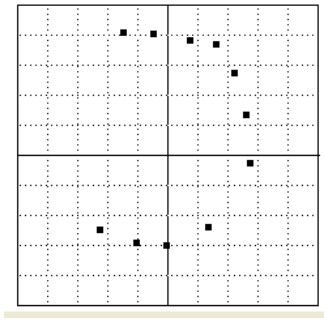
2015 DoD Maintenance Innovation Challenge

USCG Aviation Composite “ Bonded Material Testing”

Training

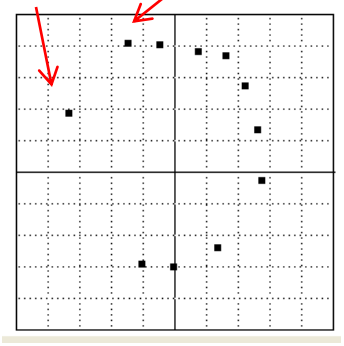
(Applications)



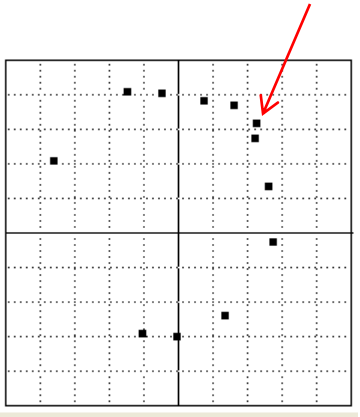


Spar in horizontal Stab.

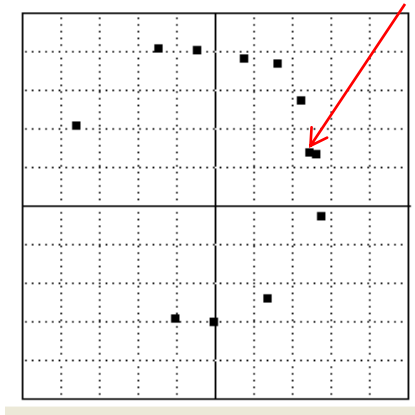
Horizontal Stab Skins
9 plies of CFRP.



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 cant 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

USCG Aviation Composite " Bonded Material Testing"

<u>If there is time the next slides are more application examples</u>

2015 DoD Maintenance Innovation Challenge

USCG Aviation Composite " Bonded Material Testing"

Specific Technique Applied with Type of Inspection: TAP TEST

Equipment Settings: N/A

Aircraft Type:	☐ HU25	☐ C130	☐ H60	☐ HH65	☑ Other

Other Type: HC-144

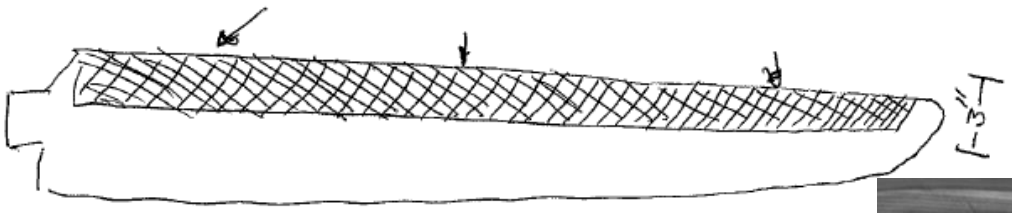
Location:	ALC ☐	Other:

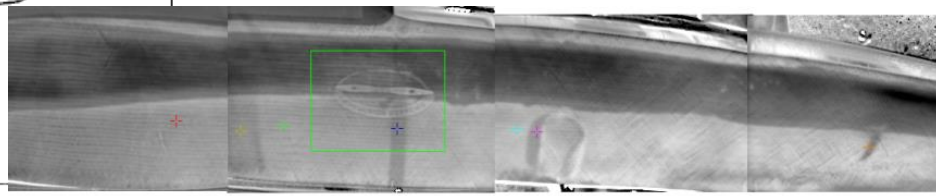
Technical Directive Applied:

Results:	☐ Acceptable	☐ Rejected

Desposition Report: Geometric and Material Property Characteristics:

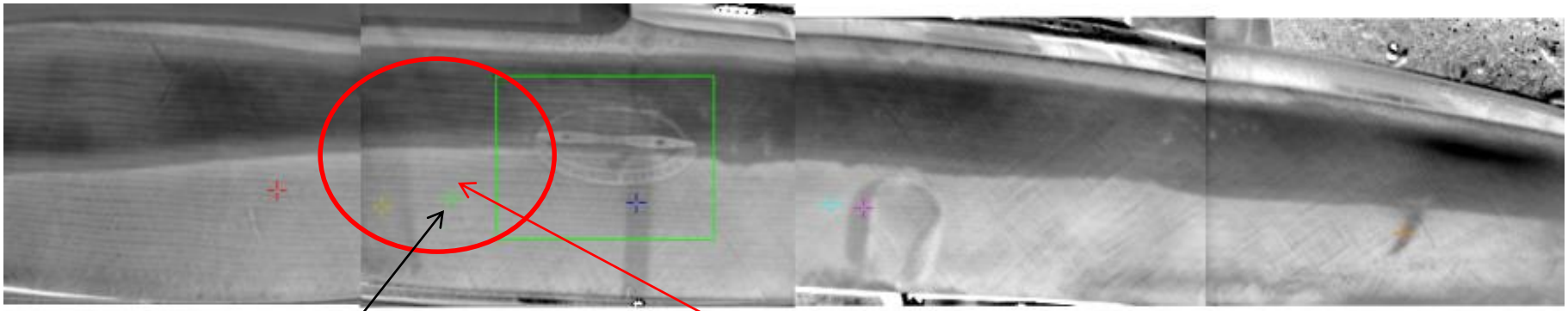
FIBERGLASS SKIN DELAMINATING FROM TRAILING EDGE TO 3 INCH UP BLADE, ENTIRE LENGTH OF BLADE ON BOTH SIDES.

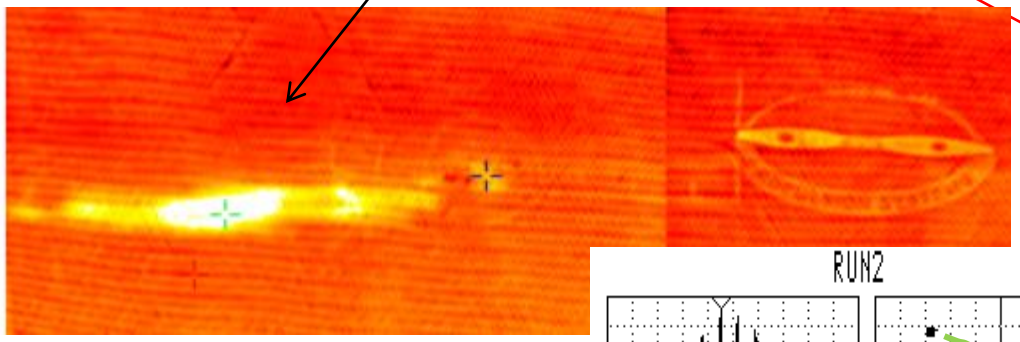


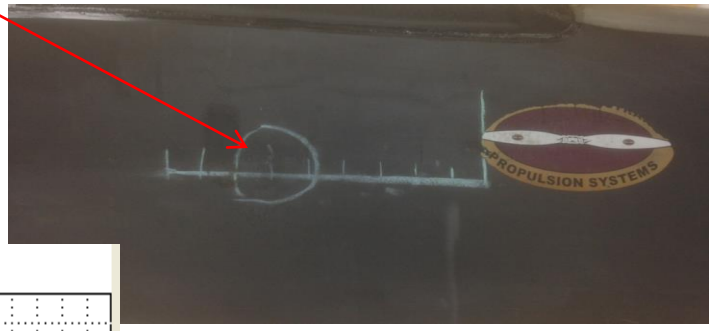


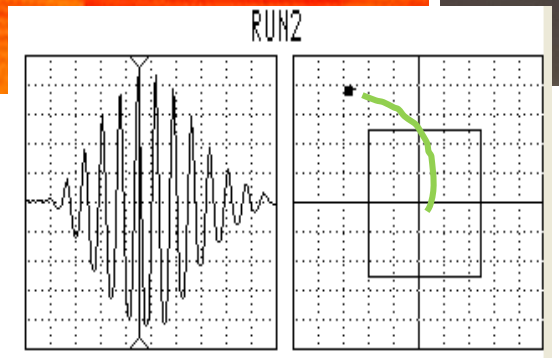
Signature: _____ Stamp Impression ☐ Accept ○ Reject ○

HC 144 Prop Blade
S/N : 2005040643 Convex Side
Pre-Induced Defect









2015 DoD Maintenance Innovation Challenge

USCG Aviation Composite " Bonded Material Testing"

Specific Technique Applied with Type of Inspection: TAP TEST

Equipment Settings: N/A

Aircraft Type:	☐ HU25	☐ C130	☑ H60	☐ HH65	☐ Other

Other Type:

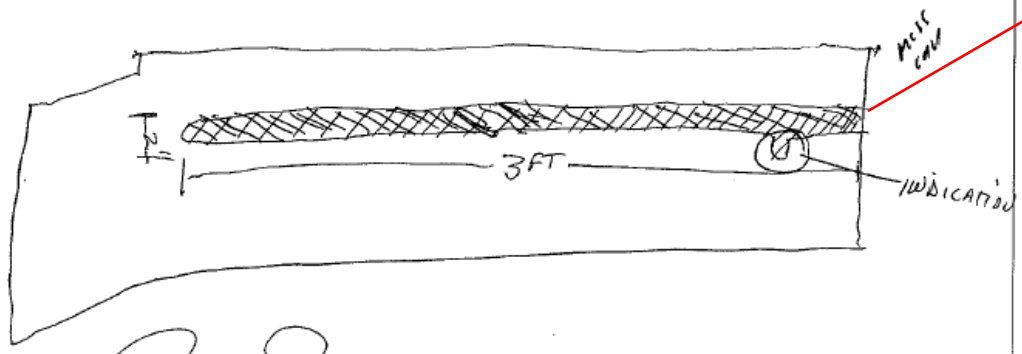
Location: ALC ☐	Other:

Technical Directive Applied:

Results:	☐ Acceptable	☑ Rejected

Desposition Report: Geometric and Material Property Characteristics:

#1 MAIN ROTOR BLADE HAS ~~2 FOOT~~ 2 INCH BY 3 FOOT VOID RUNNING LENGTH WISE IN MIDDLE OF BLADE.

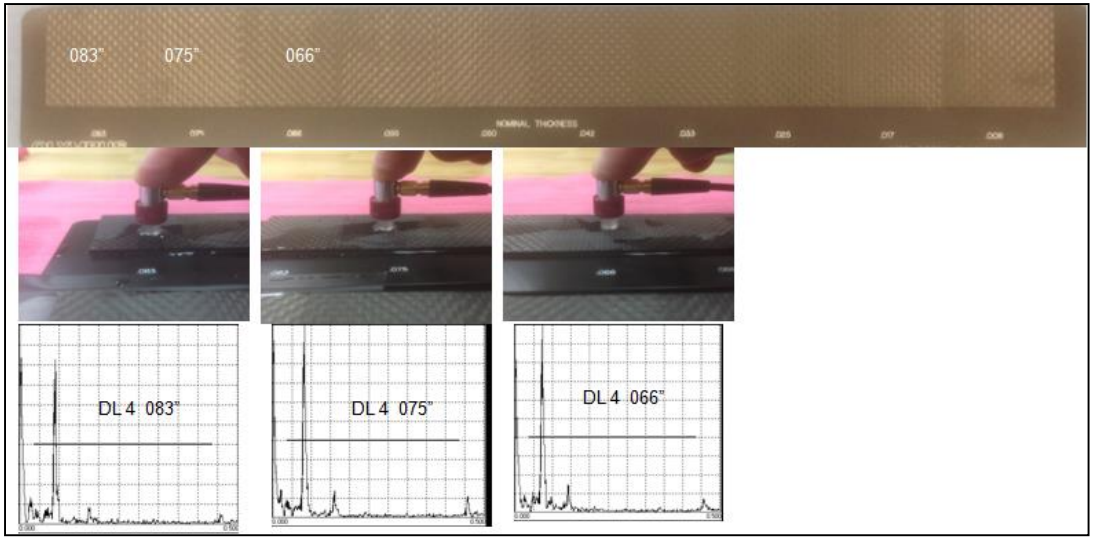


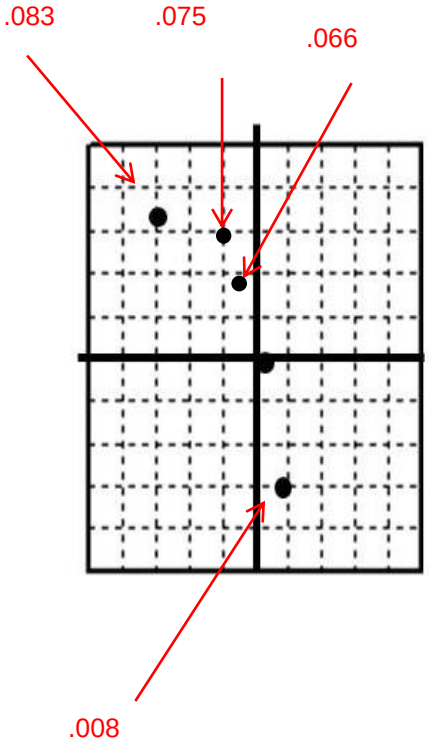
Signature: _____ Stamp Impression ☐ Accept ○ Reject ○

Spar

2015 DoD Maintenance Innovation Challenge

USCG Aviation Composite “ Bonded Material Testing”





Presented to:

JTEG Technical Forum on Composite Repair

Army Composite Repair & Support Activities

FY15 Status Update

"DISTRIBUTION STATEMENT A. Approved for public release. PR 1843"

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

December 15, 2015

Presented by:

Kimberly Cockrell

Prototype Integration Facility (PIF)

U.S. Army Aviation and Missile Research, Development, and Engineering Center

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)

THE COMPOSITES iacmi INSTITUTE

Continued Efforts

Updates to Continuing Activities

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

CERTTEC®
Certifying Technical Employee Competence™
BASIC COMPOSITES CERTIFICATION

Engineering and Acquisition Training

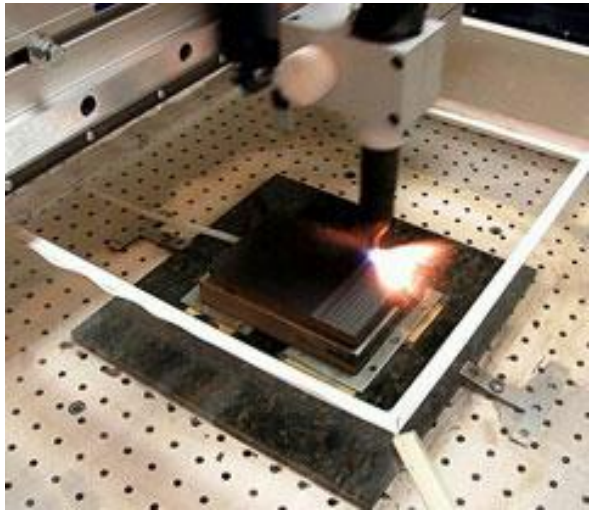
Fundamentals of Composites Course

- Course for engineers and acquisition professionals
- Covers lifecycle support of composites, including design, production, sustainment (repair), safety, and quality inspection

Continued Efforts

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



Composite Repair Development

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!*

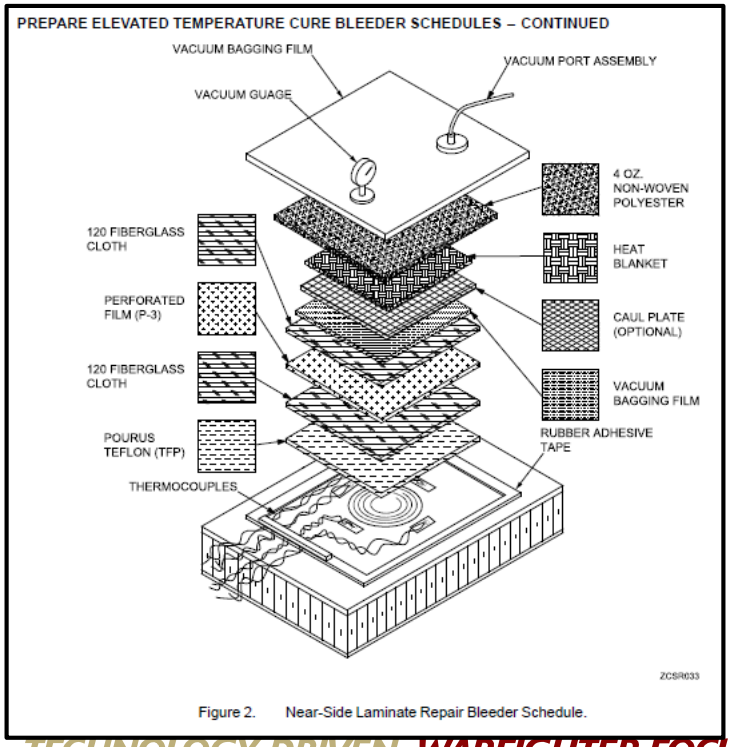
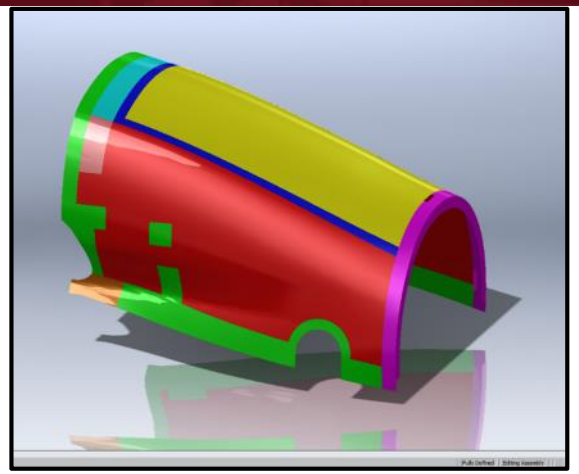


Figure 2. Near-Side Laminate Repair Bleeder Schedule.

UAS Effort



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

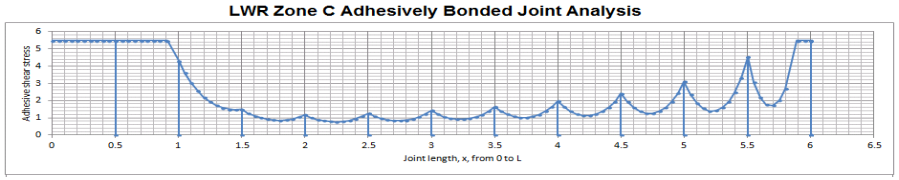
Step 6: Develop Repairs based on Army Aviation common set of tools and materials

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

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

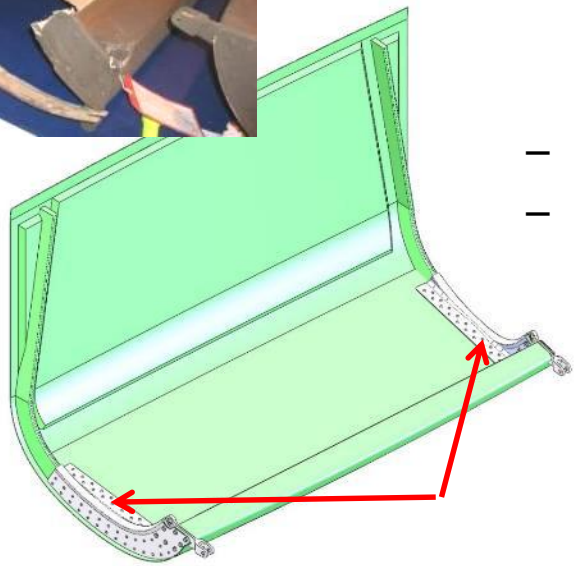


TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Repair Efforts

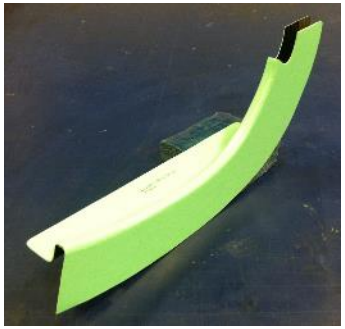
Logistics Impacts of UAS Repairs

- **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**



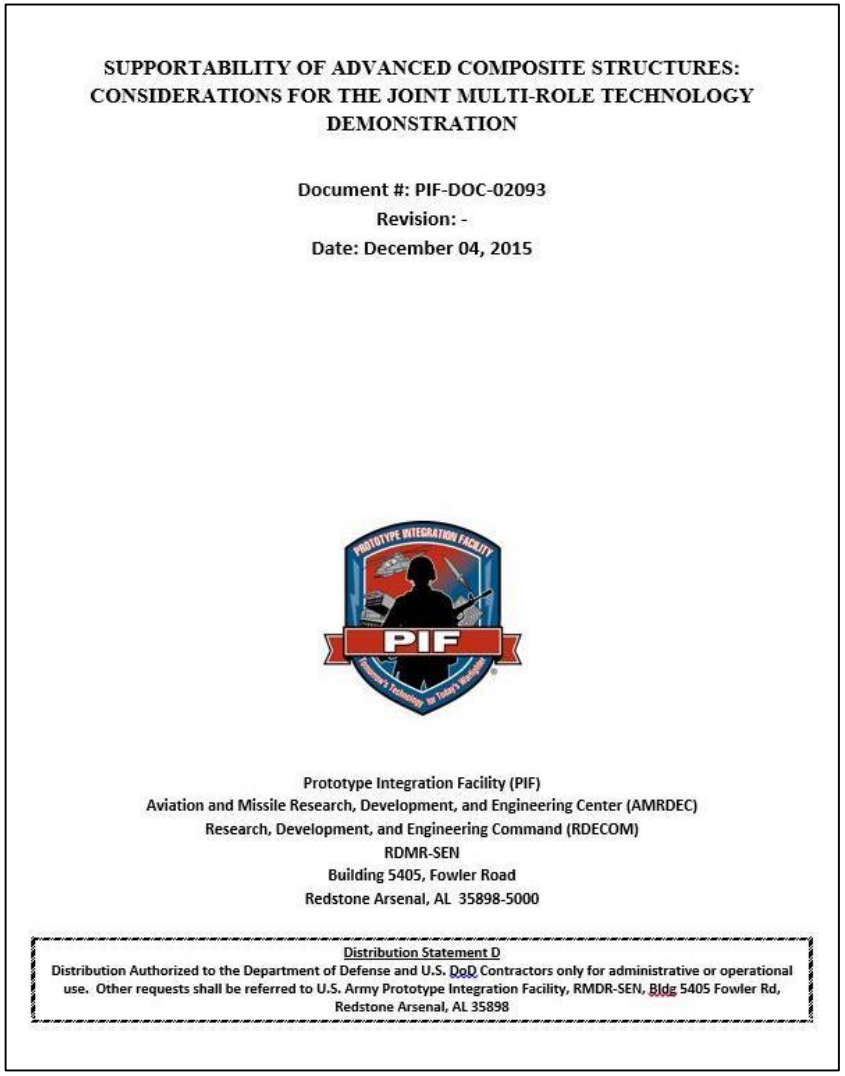
UH-60 L/M Engine Cowling Doubler

- 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 for JMR-TD / FVL

- **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



SUPPORTABILITY OF ADVANCED COMPOSITE STRUCTURES: CONSIDERATIONS FOR THE JOINT MULTI-ROLE TECHNOLOGY DEMONSTRATION

Document #: PIF-DOC-02093
Revision: -
Date: December 04, 2015

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Aviation and Missile Research, Development, and Engineering Center (AMRDEC)
Research, Development, and Engineering Command (RDECOM)
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Distribution Statement D
Distribution Authorized to the Department of Defense and U.S. DoD Contractors only for administrative or operational use. Other requests shall be referred to U.S. Army Prototype Integration Facility, RMDR-SEN, Bldg 5405 Fowler Rd, Redstone Arsenal, AL 35898

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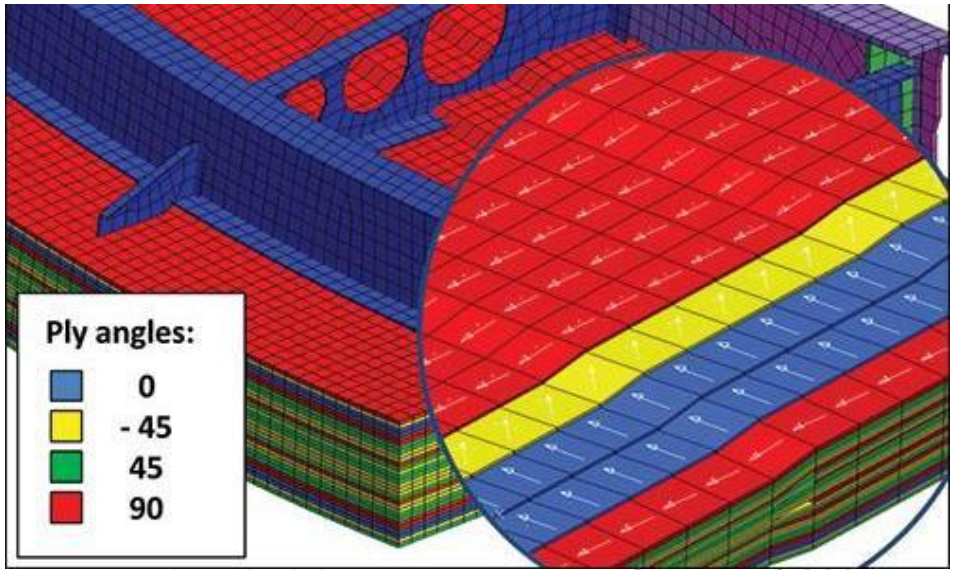
Back-up Slides

Why This is Important

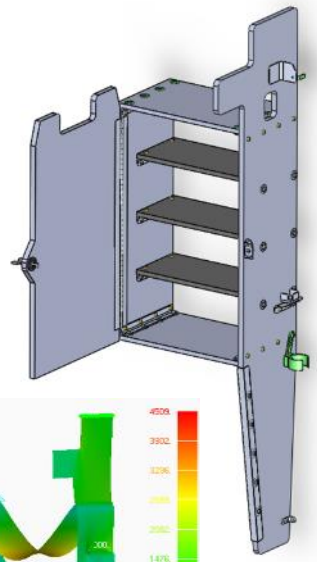
- **Composites are <u>constructed</u> differently than metals**
  - The maintainer becomes the material manufacturer
  - Controlling the *process* (heat, cure times) is critical
    - Even in metals, 2024-0 is not the same as 2024-T3
    - The differences are often not visible to the naked eye
- **Composites <u>fail</u> 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 <u>designed</u> 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 <u>supported</u> differently than metals**



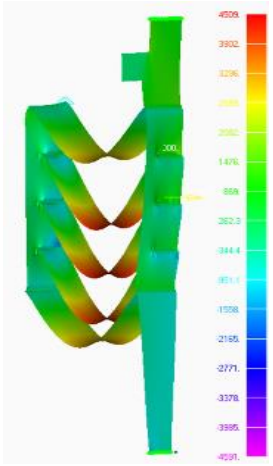
PIF Advanced Composites

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

JTEG Joint Technology Exchange Group

Joint Solutions for Depot Maintenance

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