

FAA R&D Inspection Program

Presented to: A4A NDT Forum
By: Paul Swindell, Danielle Stephens
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Federal Aviation
Administration



R&D Inspection Program

- **NDI: 1990-2015**
 - AANC: Validation of NDI
 - ISU: Provide knowledge of NDI
 - Provide support to FAA material testing program
 - Provide information to FAA certification sponsors
- **SHM: 2011- present**
 - AANC: Provide knowledge of SHM
 - Provide support to FAA material testing program
 - Provide information to FAA certification sponsors



Success

- **NDI**

- 1990's researchers provided many papers at A4A forum
- FAA and SAND reports published on numerous topics
- Characterized metal and composite specimens and developed POD experiments
- AANC specimen library used to support NDI aviation industry
- Far too many to document here from both AANC and ISU

- **SHM**

- Participate with SAE AISC since 2011
- AANC program provided data for first approved SHM use and development of generic Issue Paper
- Developed FAA online training course



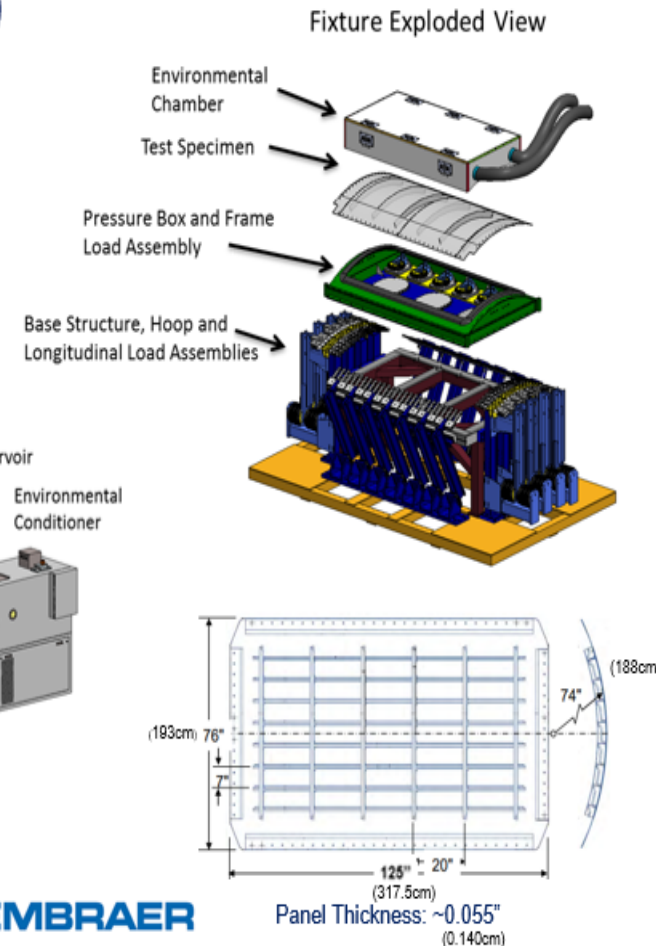
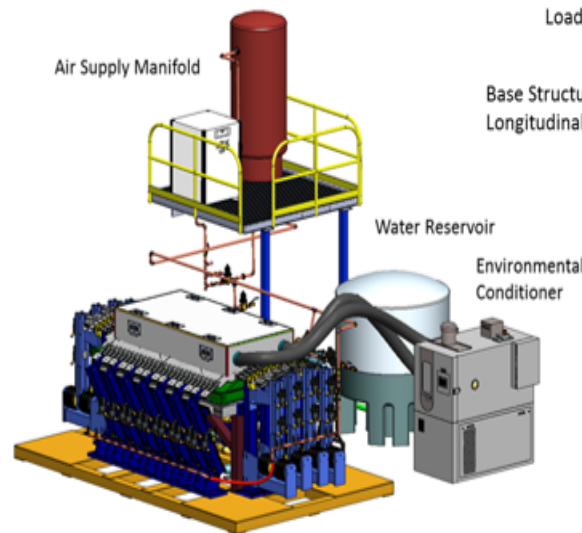
FAA Material Test Program

- **FASTER**
- **ABST**
- **MTS machines**
- **LAWS**
- **Main Rotorblade Test Fixture**



Full-Scale Aircraft Structural Test Evaluation and Research (FASTER)

- Purpose: Assess damage tolerance of emerging metallic structures technologies for fuselage applications
- Partners: Arconic/Embraer
- Test emerging technologies
 - Al-Li skins/frames/stringers
 - Fiber Metal Laminate Reinforced
 - Bonded stiffeners
 - Multisite damage
- Panels 1, 2 and 3 completed
- Panels 4 and 5 will be last panels for this phase of testing



ARCONIC

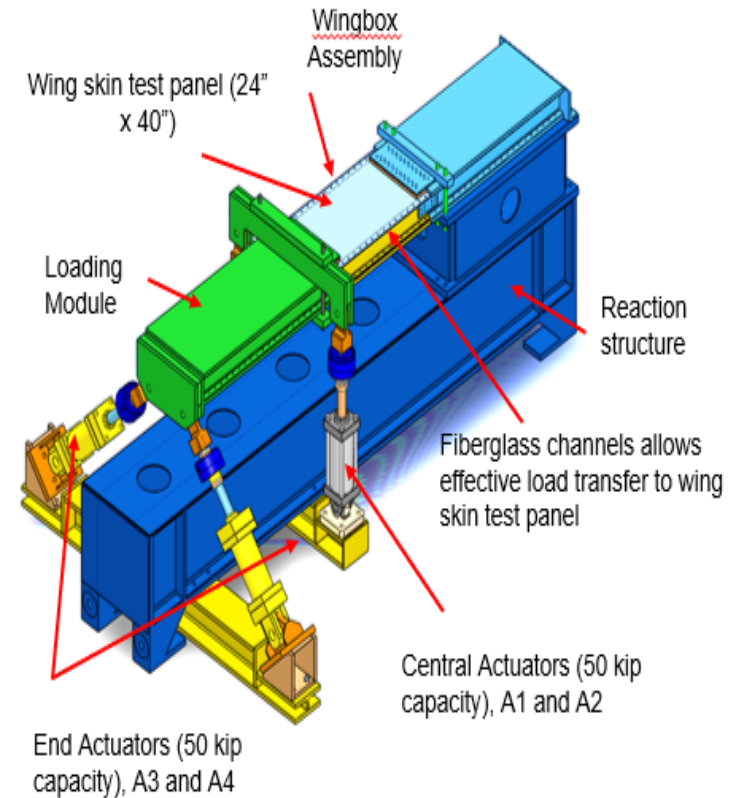


EMBRAER



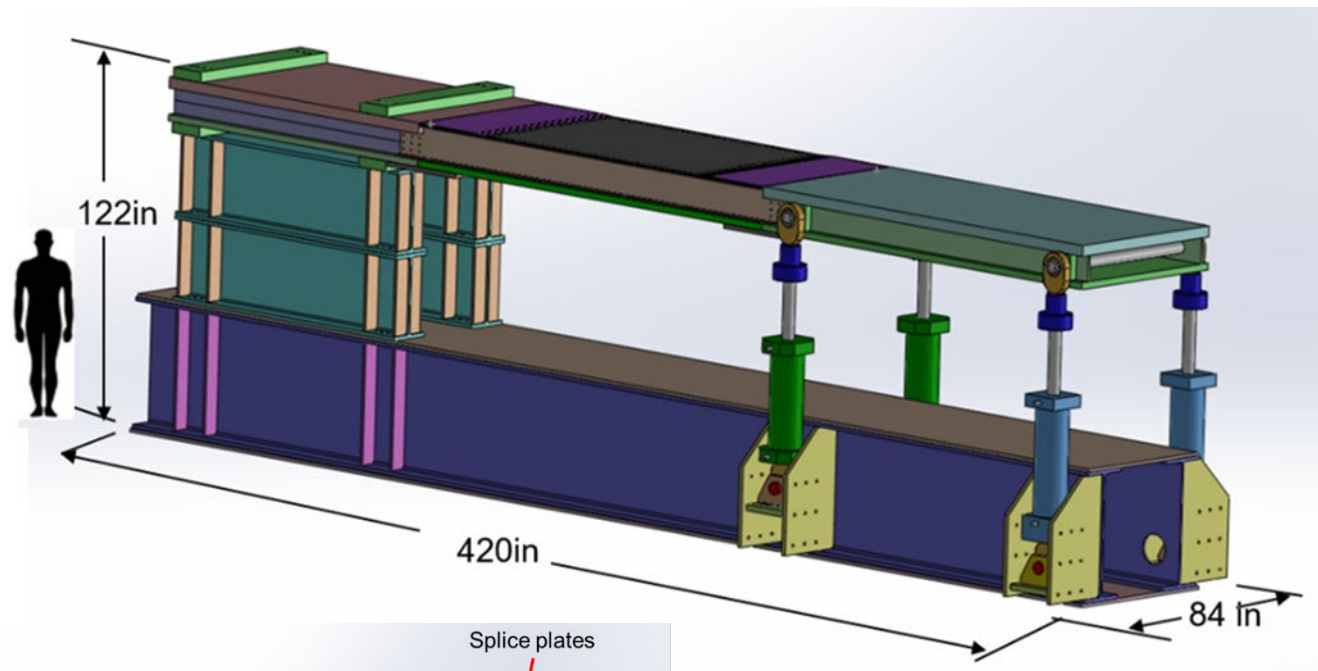
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- **Airframe Beam Structural Test (ABST) Fixture:** Wing Panel Test
- **Background:** Commissioned May 2018 through partnership with Boeing
- **Description:** Applies major modes of loading to structure representative of wing or stabilizer
- **Testing Activities:** Assessment of Bonded Repairs of Composite Wing Panels

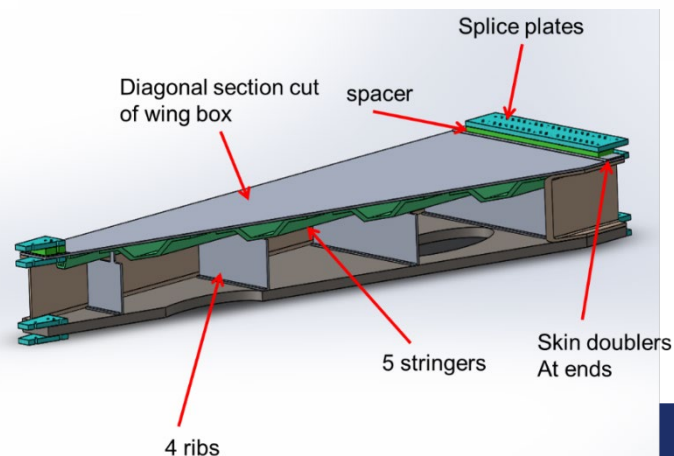


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Large Area Wing Structure (LAWS)



Estimated test program to start late 2026



LAWS fixture
5 Stringer Panel
152-inch x 60-inch



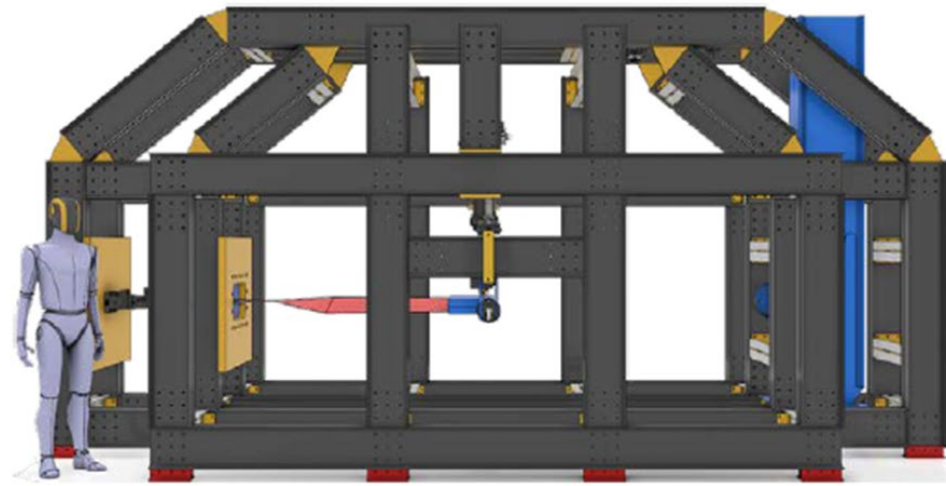
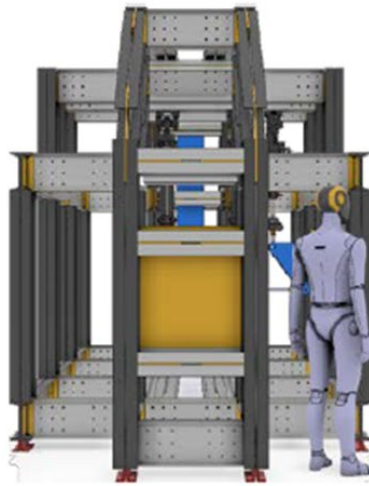
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Main Rotor Blade (MRB) Test Fixture

- **Fixture Dimension**
 - 20' L x 8' W x 10' H
- **Fixture Design Limits**
 - Lift Force: 44-kip Tension
 - Drag Force: 12-kip Compression
 - MR Damper Force: 10-kip Compression
 - Centrifugal Force: up to 120-kip

Est completion end of 2025

Bonded joint strength testing



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MTS Testing

- **4 test fixtures**
- **Test specimens of a variety of widths and lengths**
- **Preliminary testing of materials to determine crack growth rates and other material parameters determination**
- **Ability to perform NDI and SHM and use of electronic microscope for crack measurement**
- **Ability to perform hot/cold testing on one test fixture**



Testing

- **Multiple test panels (real aircraft components) for SHM/NDI testing**
- **Data useful for support of SAE documents**
- **Research is currently focused on collaborative R&D programs with focus on identification and prioritization of gaps**
- **Data from FAA R&D test programs reported to FAA Sponsors**
- **Output:**
 - Data and tools that support rulemaking, policy and guidance development, aircraft certification, continued airworthiness, education and training.



Airworthiness Assurance NDI Validation Center (AANC) A Unique FAA Facility



**Albuquerque International Airport
Operated for the FAA by Sandia National Laboratories
Dedicated in February 1993**

AANC Role and Services

- **NDI Inspection Validation, technology transfer, and deployment**
- **Ongoing comparisons of conventional & emerging NDI technologies**
- **Develop and perform NDI reliability studies**
- **Rapid response to airworthiness issues**
- **Perform structured validation experiments**
- **Consult on maintenance technique applications**
- **Support development of new technology**
- **Provide access to other resources within SNL**



SAMPLES OF PAST AANC PROJECTS

Industry wide NDI Reference Standards

NDI Assessment: Honeycomb Structures

NDI Assessment: Solid Laminate Structures

Composite Heat, UV, and Fluid Ingress Damage

Composite Repairs and Porosity

Composite NDI Training and NDI Proficiency Specimens

Visual Inspection Reliability

NDI Capability Characterization

NDI Structured Experiments (POD)

- **Surface Cracks**
- **Faying Surface Corrosion**
- **Interlayer Crack Detection Program**
- **Composite Laminate Flaw Detection Program**
- **Composite Honeycomb Flaw Detection Program**

Pulsed Eddy Current

Liquid Penetrant Technology

Composite Inspection & Reference Standards

Structural Health Monitoring Research/Mock Certification

Published Reports

- ❖ Roach, D., Rice, T. "Performance Evaluation of Comparative Vacuum Monitoring and Piezoelectric Sensors for Structural Health Monitoring of Rotorcraft Components," Dept of Energy SAND2021-7984, July 2021.
- ❖ Roach, D., Rice, T. "Application and Certification of Comparative Vacuum Monitoring Sensors for Structural Health Monitoring of 737 Wing Box Fittings," Dept of Energy SAND2020-9184, September 2020.
- ❖ Roach, D., Rice, T., Ely, R., "Probability of Detection Study to Determine Inspection Method and Assess Subsurface Crack Detection in E1 and E2 Wing Joints," Dept of Energy SAND Report SAND2019-6476, June 2019.
- ❖ Neidigk, S., Roach, D., Rice, T. "FAA Composite Inspector Training Course to Enhance Proficiency and Improve Reliability," Dept. of Transportation Report DOT/FAA/TC-18/12, June 2019.
- ❖ Ely, R., Roach, D., Falls, J., Montoya, G., Newton, C., Rice, T., "Analysis of Sensors for a Drone- Deployed Wind Turbine Blade Nondestructive Inspection System," Dept of Energy SAND Report SAND2019-3933, April 2019.
- ❖ Neidigk, S., Roach, D., Duvall, R., Rice, T. "Detection and Characterization of Hail Impact Damage in Carbon Fiber Aircraft Structures," Dept. of Transportation Report DOT/FAA/TC-16/8, September 2017.
- ❖ Roach, D., Rice, T., "Design and Assessment of Comparative Vacuum Monitoring and Piezoelectric Transducer Systems for Certified Use in Aircraft Structural Health Monitoring Solutions," Sandia Dept of Energy Report, SAND2017-6401, July 2017.
- ❖ Roach, D., Rackow, K., "A Quantitative Assessment of Conventional and Advanced NDI Techniques for Detecting Flaws in Composite Honeycomb Aircraft Structures," Dept. of Transportation Report DOT/FAA/TC-15/63, January 2017.
- ❖ Roach, D., Rice, T., "A Quantitative Assessment of Advanced Nondestructive Inspection Techniques for Detecting Flaws in Composite Laminate Aircraft Structures," US Dept. of Transportation Report DOT/FAA/TC-15/4, March 2016.
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- ❖ Roach, D., Neidigk, S., Smith, B., "Utilization of Structural Health Monitoring Solutions and Recommendations for the Federal Aviation Administration's SHM Research and Development Program," Dept. of Transportation Report DOT/FAA/AR-14/92, November 2014.
- ❖ Bond, R., Adams, D., Roach, D., "Structural Health Monitoring for Impact Damage in Composite Structures," Sandia DOE Report, SAND2014-16965, September 2014.
- ❖ Roach, D., Rice, T., "A Quantitative Assessment of Conventional NDI Techniques for Detecting Flaws in Composite Laminate Aircraft Structures," Dept of Transportation Report DOT/FAA/AR-13/23, May 2013.
- ❖ Roach, D., Nelson, C., DeLong, W., "Accident Investigation of the December 2008 Fiji Island Rotorcraft Accident and Suggested Methods to Preclude Future Failures in Main Rotor Blades," Sandia Labs report to National Transportation Safety Board, June 2009.

Published Reports

- Roach, D., DeLong, W., Rackow, K., Yepez, E., Reedy, D., White, S., "Use of Composite Materials, Health Monitoring, and Self-Healing Concepts to Refurbish Our Civil and Military Infrastructure," Dept of Energy SAND Report SAND2007-5547, September 2007.
- Roach, D., and Rackow, K., "Development and Validation of Bonded Composite Doubler Repairs for Commercial Aircraft," Dept of Energy SAND Report SAND2007-4088, July 2007.
- Roach, D., Walkington, P. and Rackow, K., "Pulse-Echo Ultrasonic Inspection System for In-Situ Nondestructive Inspection of Space Shuttle RCC Heat Shields," Dept of Energy SAND Report SAND2005-3429, June 2005.
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- Roach, D.P., "Damage Tolerance Assessment of Bonded Composite Doubler Repairs for Commercial Aircraft Applications," Sandia National Laboratories/ Dept. of Energy Report No. SAND98-1016 , August 1998.
- Roach, D., Walkington, P., "Development and Validation of Nondestructive Inspection Techniques for Composite Doubler Repairs on Commercial Aircraft", Sandia National Laboratories/ Dept. of Energy Report No. SAND98-1014, May 1998.
- Roach, D., and Graf, D., "NDI and Structural Mechanics Tests to Support the Evaluation and Development of RAPID Aircraft Repair Design Software", Dept of Energy SAND Report SAND96-9775, November 1996.
- Jeong, D.Y., Roach, D.P., Canha, J., Brewer, J., Flournoy, T., "Strain Fields in Boeing 737 Fuselage Lap Splices: Field and Laboratory Measurements with Analytical Correlations", Dept. of Transportation Report No. DOT/FAA/CT-95/25, June 1995.
- Beattie, A., Dahlke, L., Gieske, J., Hansche, B., Phipps, G., Roach, D., Shagam, R., and Thompson, K., "Emerging Nondestructive Inspection for Aging Aircraft", Dept. of Transportation Report No. DOT/FAA/CT-94/11, October 1994.
- Roach, D., Beattie, A., Dahlke, L., Gieske, J., Hansche, B., Phipps, G., Shagam, R., and Thompson, K., "Emerging Nondestructive Inspection Methods for Aging Aircraft"; Dept. of Energy SAND Report 92-2732, March 1994; Dept. of Transportation Report No. DOT/FAA/CT-94/11, October 1994.
- Spencer, F., Borgonovi, G., Roach, D., Schurman, D., Smith, R.; "Reliability Assessment at Airline Inspection Facilities, Volume I: A Generic Protocol for Inspection Reliability Experiments"; Dept. of Transportation Report, DOT/FAA/CT-92/12-I, March 1993.

Updated Status:

FAA Contract ended, AANC Closed

**AANC specimen library, equipment and other assets at
FAA Tech Center NJ**

Performing Inventory (Dennis to visit first week of Oct)

Developed process/procedures for assets use

Inventory: Metal and composite structure that are representative of actual aircraft structure and contain characterized flaws, Feedback Specimens, POD Experiments

Material will be available for Industry Use

- **Test NDI new equipment**
- **Industry NDI training**
- **POD Experiments**

Loaned weak bond and other composite specimens to Kratos (paper at 2024 A4A Forum)

Loaned composite specimens to Alaska Airlines

AANC Test Specimen Library

Test Specimen Library

Confirmed

composite bonded doubler
Rotorcraft test specimens
EC Inspection Reliability POD Set
Corrosion POD set
Interlayer Crack POD Experiment
Wing crack POD
Solid Composite Laminate POD
Honeycomb POD
Assorted composite laminate NDI specimens
Honeycomb NDI specimens
Composite Impact NDI specimens
NDI ref stds/composite corrosion NDI specimens
composite weak bond specimens (USCAR)

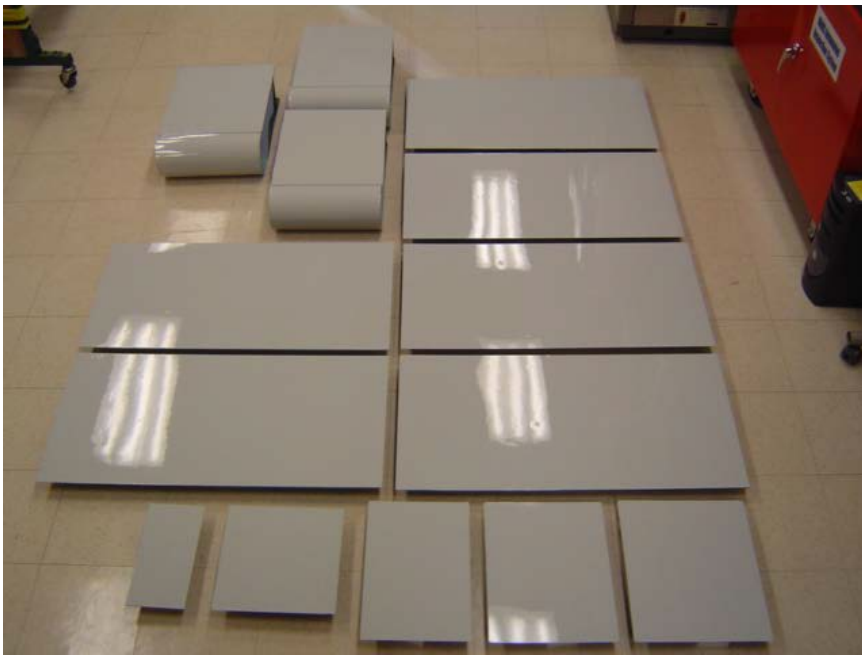
scarfed composite specimen
FTIR and NASA contamination
composite honeycomb impact damage
Cessna wing crack specimen
Bell damage detection/Robinson accident
microcrack specimens for penetrant/mag particle
Rotor CVM and PZT specimens
PZT specimens
Embraer PZT specimens
NDT reference standards-cracks and thickness metals
Composite specimens

Unconfirmed

Large A/C control surfaces
Large skin/structure panels
Robinson rotorcraft blades
787 composite panels with impact damage
Honeycomb panels
Skin panels with substructure
Assorted aircraft components
ECIRE frames POD experiment
ECIRE bolt hole POD experiment
cases of POD experiments
Engine Ti and Inconel specimens
NDT reference standards-composite

Rotorcraft composite Hub/composite doublers
Lap splice with corrosion
Goodrich hidden tire damage
NASA shuttle heat shield





Composite Laminate POD Experiment

Thickness Range:
12 – 64 plies

Simple Tapers

Complex tapers

Substructure Flaws

Curved Surfaces

Array of flaw types

NDI Ref. Stds.

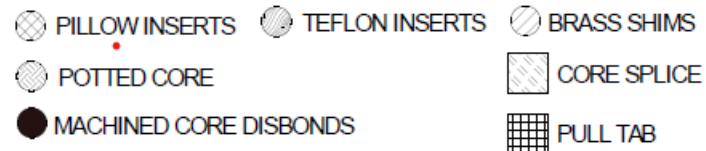
Inspection Area: 46 ft.²

Number of Flaws: 202

Composite Honeycomb test specimens



Qty 6 of each: 3, 6 and 9 ply carbon and fiberglass skins (18 total panels of each skin)



FAA AANC Small Panels For NDI Validation Studies

Allows quantitative assessments of NDI Methods



Small Crack/WFD Panels



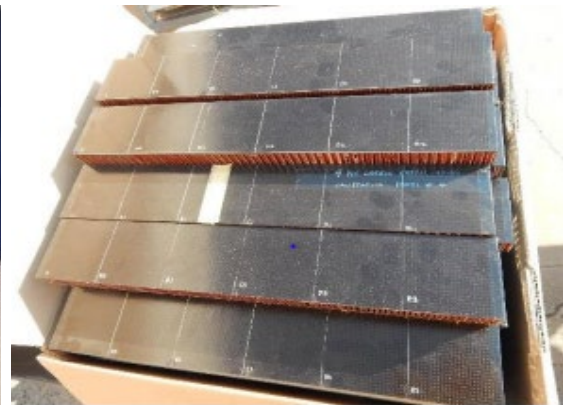
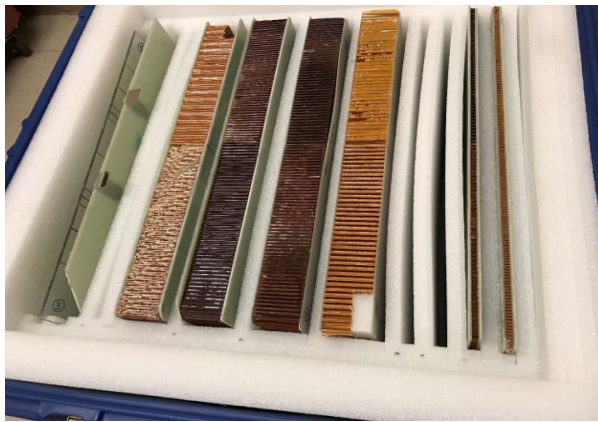
Solid Laminates



Lap Joint Corrosion



Composite Honeycomb



Specimen Loans:

- **FAA pays to ship to/Borrower pays to ship back to FAA**
- **Period of loan: 90 days**
- **Share data with FAA**

POD Experiments:

Prefer tests to be completed at FAA Tech Center

Pay for statistical analysis, test oversight

If test not on site, pay for test oversight (incl travel)

Contact Danielle Stephens or Paul Swindell/Dennis Roach

Contact info chart 25

Conclusions

Active test program of real aircraft components useful to NDI/SHM community

Offering partnerships for testing NDI/SHM methods

The FAA is offering the use of the various AANC feedback specimens and POD experiments to the NDI industry

The FAA R&D Inspection Program continues to provide valuable information to the FAA certification offices to further safety of the aviation industry

Please contact Danielle, Dennis or myself if you more information or use of the AANC material

QUESTIONS?

Danielle Stephens
danielle.stephens@faa.gov

Paul Swindell
Paul.E-CTR.Swindell@faa.gov

Dennis Roach
dpmroach@outlook.com



FAA

