FAA Composites Safety Activities Overview

By: Curtis Davies
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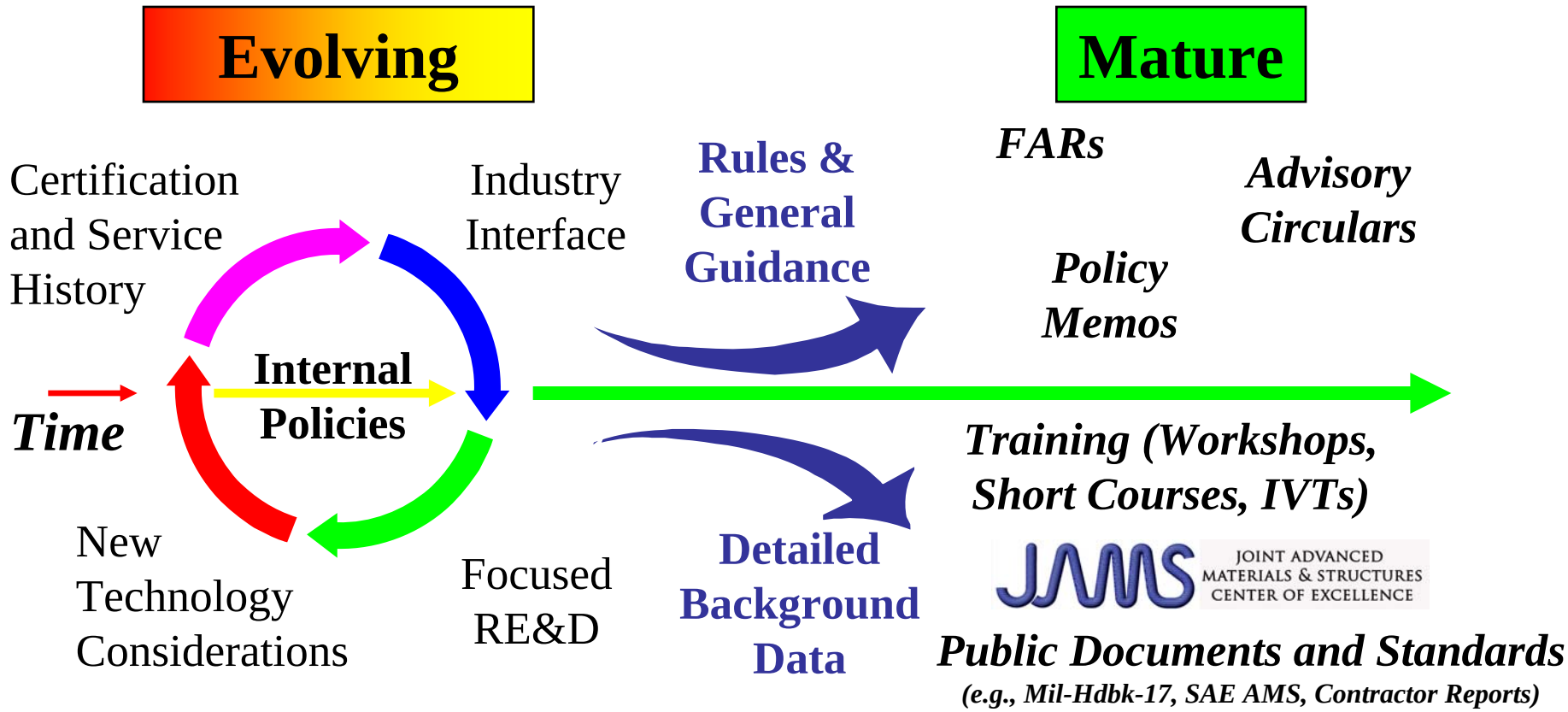
Center of Excellence

Date: November 15, 2007

FAA Approach to Composite Safety and Certification Initiatives



Advanced Materials and Structures
•FAA R&D Composites Focal Areas

4) Environmental and Aging Effects
- Environmental effects
- Reliability assessment
- Aged Structure Destructive Evaluation

6) Standardization
- Shared Databases
- Test Methods
- Material and Process Control

1) Structural Substantiation and Damage Tolerance
- Advances in analysis & test building blocks
- Critical defects
- Fatigue & damage considerations
- Life assessments (tests & analysis)
- Manufacturing defects

FAA R&D is currently active in all these areas

8) Advanced Materials Forms and Processes
- Braiding
- Stitching
- Liquid Resin Molding

9) CMH-17 (MIL-HDBK-17)

3) Composite Maintenance Practices
- Bonded structure & repair issues
- Accelerated testing
- Impact damage effects
- Quantitative NDE/service POD
- Equivalent levels of safety

2) Structural Integrity of Bonded Joints
- Processing Issues
- Analysis Methods

5) Cabin Safety Unique to Composites

7) Fatigue & Damage Tolerance for Dynamic Composite Structural Applications

JAMS

JOINT ADVANCED MATERIALS & STRUCTURES CENTER OF EXCELLENCE

JOINT ADVANCED MATERIALS & STRUCTURES CENTER OF EXCELLENCE

Member Schools

- **The center has proven invaluable to performing our research**
- **The joint center consists of two groups and includes ten institutions**
- **AMTAS (Advanced Materials for Transport Aircraft Structures)**
- **CECAM (Center for Composite and Advanced Materials)**

Industry Involvement in Composites Safety Research

- **Forms of Industry Involvement**
  - Traditional (ARAC, Comment on Policy)
  - Workshops
  - Working Groups
  - Close working relationship with Specification Development Organizations (e.g., ASTM, SAE), and handbooks (e.g., CMH-17)
  - Direct involve
    (CoE match ects have
    industry prov this)

Industry Involvement in Composites Safety Research

- **Direct Involvement in the Research**
  - Most research is done with industry partner who provides funding and provides industry viewpoint on research.
  - Typically the industry partner carries forward the research and incorporates it into practice at their company and then other companies start to use it to maintain capabilities.
  - Overall industry involvement in Advanced Materials and Structures research ~ 2:3 (FAA:IND)

Examples of companies involved in research activities

Advanced Materials and Structures

•R&D Technical Focus areas and Individual Supporting Tasks

- **1) Damage Tolerance of Composite Structures**
  - Full-Scale Damage Tolerance of Structures (Wichita State University)
  - Damage Tolerance Testing and Analysis Protocols for Full-Scale Composite Airframe Structures under Repeated Loading (Wichita State University)
  - Fluid Ingression Damage Mechanism in Composite Sandwich Structures (Wichita State University)
  - Combined Global/Local Variability and Uncertainty in Integrated Aeroservoelasticity of Composite Aircraft (University of Washington)
  - Development of Reliability Based Damage Tolerant Structural Design Methodology (University of Washington)
- **2) Structural Integrity of Adhesive Joints**
  - Damage Tolerance and Durability of Adhesively Bonded Composite Structures (Purdue University)
  - Improving Adhesive Bonding of Composites through Surface Characterization (University of Washington)
  - The Effect of Surface Treatment on the Degradation of Composite Adhesives (Washington State University)
  - Methods for the Evaluation of the Fitness of Fiber Reinforced Composite Surfaces for Subsequent Adhesive Bonding (Wichita State University)
  - Identification and Validation of Analytical Chemistry Methods for Detecting Composite Surface Contamination and Moisture (Florida International University)
- **3) Composite Maintenance Practices**
  - Course Development: Maintenance of Composite Aircraft Structures (Edmonds Community College)
  - Effect of Repair Procedures Applied to Composite Airframe Structures (Wichita State University)
  - Structure Health Monitoring for Life Management of Aircraft (Northwestern University)

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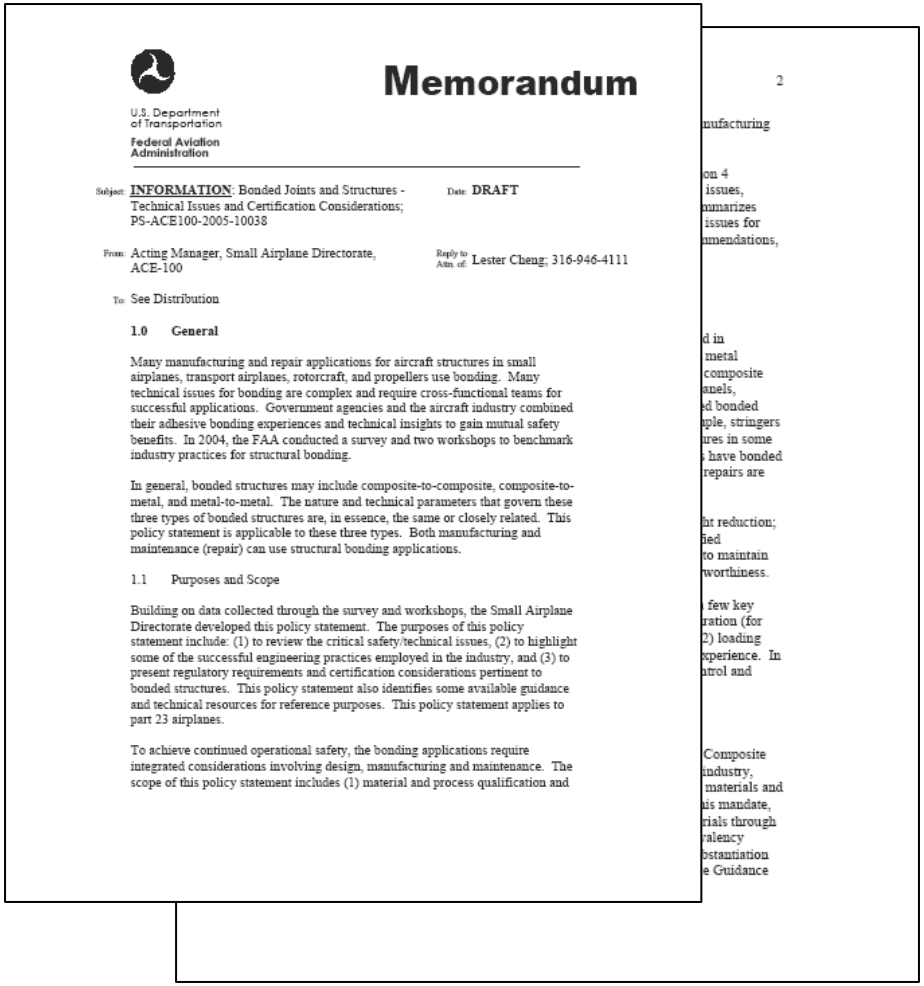
•R&D Technical Focus areas and Individual Supporting Tasks (continued)

- **4) Aging Effects for Composite Structures**
  - Aging of Composite Aircraft Structures- Teardown of a Beechcraft Starship & a 737 Stabilizer (Wichita State University)
- **5) Cabin Safety Issues Unique to Composite Materials**
- **6) Specifications for Material Control and Test Standards for Advanced Materials**
  - Production Control Effect on Composite Material Quality and Stability (Wichita State University)
  - Shear Characterization of Composite Laminates and Adhesives (University of Utah)
- **7) Fatigue and Damage Tolerance of Dynamic Composite Structure Applications**
- **8) Advanced Materials and Processes**
  - VARTM Variability and Substantiation (University of Delaware)
  - Damage Tolerance and Durability of Fiber Metal Laminates for Aircraft Structure (University of California at Los Angeles)
  - Evaluation of Friction Stir Weld Process and Properties for Aerospace Application (Wichita State University)
- **9) Composite Material Handbook-17 (CMH-17)**
  - Supported through specific research projects and active participation of R&D personnel

Adhesively Bonded Structures Policy Development

- **FAA Benchmarked the Bonded Structures Industry**
  - Document critical safety issues and certification considerations
  - Document examples of proven engineering practices
  - Identify needs (databases, standards, focused research)
- **Industry Survey**
  - ~60 respondents from 100 mailings
  - Provided a broad range of industry
    - Bonded structure manufactures
    - Material producers
    - Regulators
  - Provides a searchable database for future
- **Bonded Structures Workshop - US**
  - June 2004
  - Held in Seattle to gain additional large transport participation
  - Allowed additional input and discussion on the issues
- **FAA workshop - Europe**
  - October 2004
  - European industry and regulator perspectives
- **Bonded Joints and Structures - Technical Issues and Certification Considerations; PS-ACE100-2005-10038**
  - Technical Issues
    - Material and Process Qualification and Control
    - Design Development and Structural Substantiation
    - Manufacturing Implementation
    - Repair Implementation
    - Service Experience
  - Certification Considerations
    - Design and Construction
    - Structural Substantiation
    - Production
    - Continued Airworthiness
    - Other Elements



Memorandum

U.S. Department of Transportation
Federal Aviation Administration

Subject: **INFORMATION**: Bonded Joints and Structures - Technical Issues and Certification Considerations; PS-ACE100-2005-10038

Date: **DRAFT**

From: Acting Manager, Small Airplane Directorate, ACE-100

Reply to Attn. of: Lester Cheng; 316-946-4111

To: See Distribution

1.0 General

Many manufacturing and repair applications for aircraft structures in small airplanes, transport airplanes, rotorcraft, and propellers use bonding. Many technical issues for bonding are complex and require cross-functional teams for successful applications. Government agencies and the aircraft industry combined their adhesive bonding experiences and technical insights to gain mutual safety benefits. In 2004, the FAA conducted a survey and two workshops to benchmark industry practices for structural bonding.

In general, bonded structures may include composite-to-composite, composite-to-metal, and metal-to-metal. The nature and technical parameters that govern these three types of bonded structures are, in essence, the same or closely related. This policy statement is applicable to these three types. Both manufacturing and maintenance (repair) can use structural bonding applications.

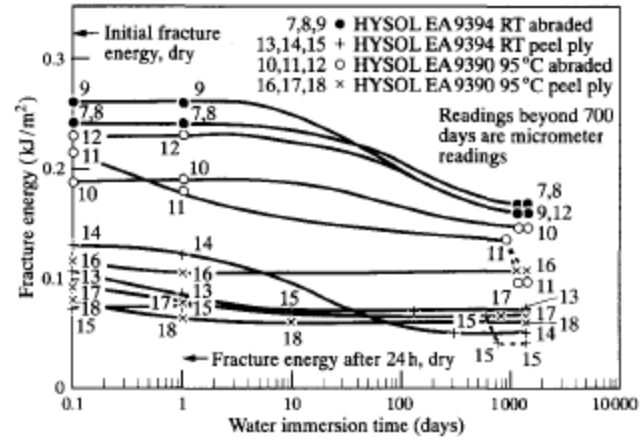
1.1 Purposes and Scope

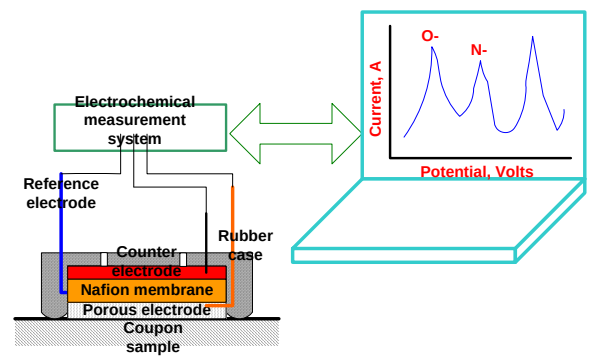
Building on data collected through the survey and workshops, the Small Airplane Directorate developed this policy statement. The purposes of this policy statement include: (1) to review the critical safety/technical issues, (2) to highlight some of the successful engineering practices employed in the industry, and (3) to present regulatory requirements and certification considerations pertinent to bonded structures. This policy statement also identifies some available guidance and technical resources for reference purposes. This policy statement applies to part 23 airplanes.

To achieve continued operational safety, the bonding applications require integrated considerations involving design, manufacturing and maintenance. The scope of this policy statement includes (1) material and process qualification and

Bonding Preparation Surface Assessment

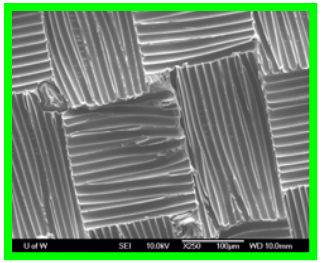
- **Characterization of surface condition**
  - Moisture
  - Contaminates
- **Analytic chemistry techniques to assess surface condition**
- **Investigate methods for application to factory, FBO and field inspection**

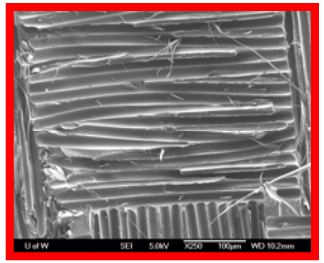


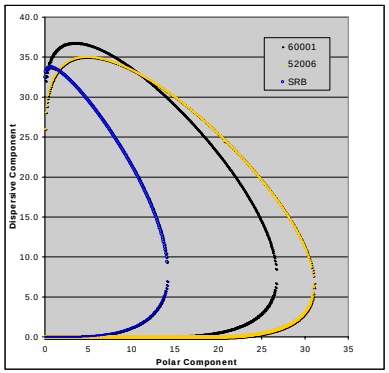


Bonding Preparation Surface Assessment

- **Characterization of various surfaces**
- **Peel Ply characterizations**
- **Wetability envelop determinations**
- **Other laboratory surface characterization methods**

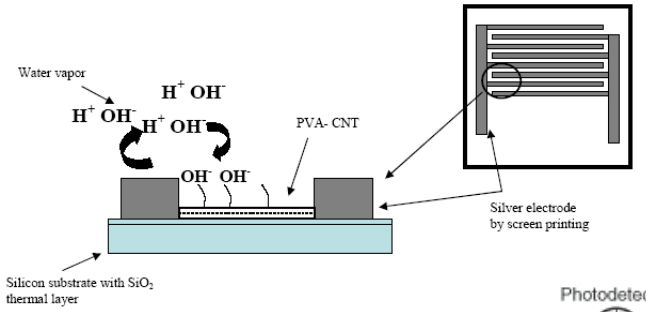


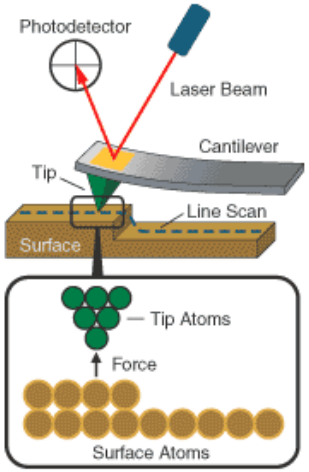




Bonding Preparation Surface Assessment

- **Conventional analysis methods**
- **Near Infrared Diffuse Reflectance Spectroscopy**
- **Carbon Nanotube Humidity Sensor**
- **Atomic Force Microscopy**

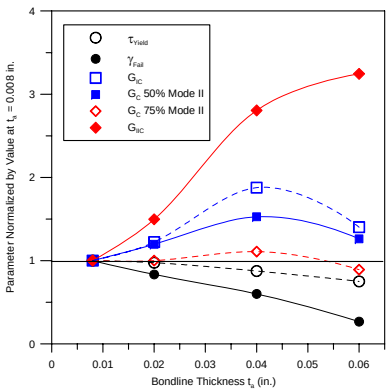


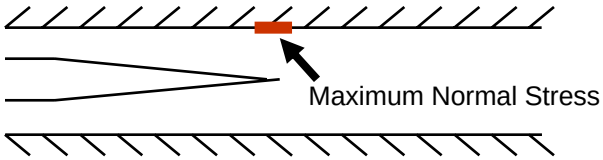


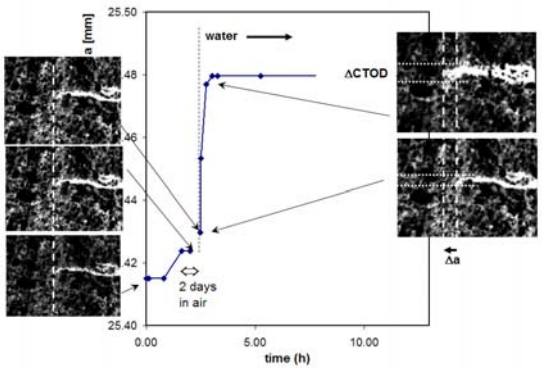
Analysis of Bonded Joints

PURDUE UNIVERSITY

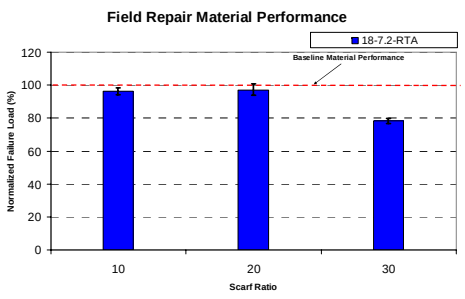
- Adhesive constitutive behavior for use in bonded joint analyses
- Effect of adhesive thickness on mixed mode fracture of joints
- Effect of bondline thickness on strength of adhesively bonded joints – CTOA approach
- Influence of moisture, cyclic loading and time dependence on joint fracture – Cohesive zone model approach



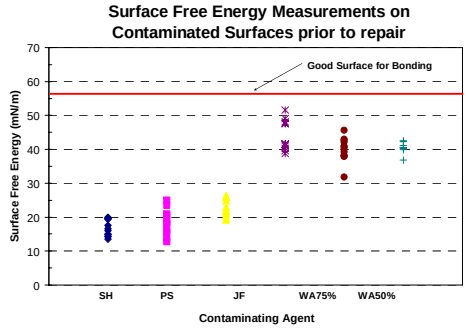


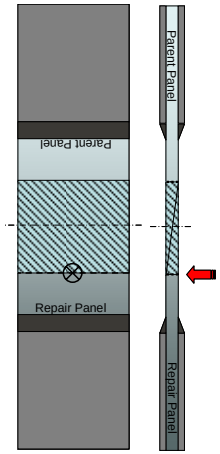


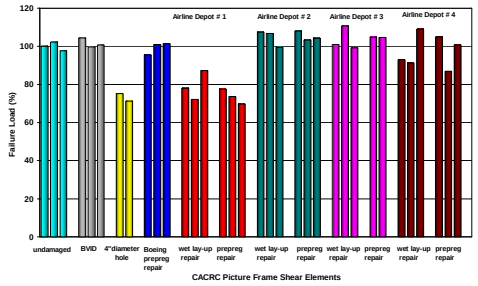
Performance of Repairs Applied to Laminate and Sandwich Structures



WICHITA STATE UNIVERSITY



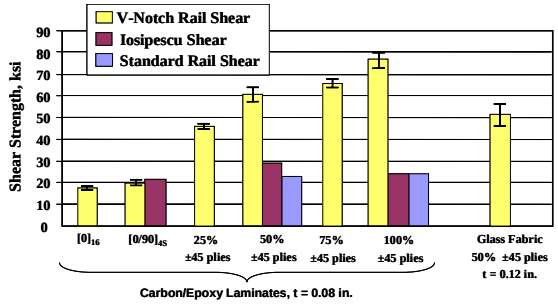


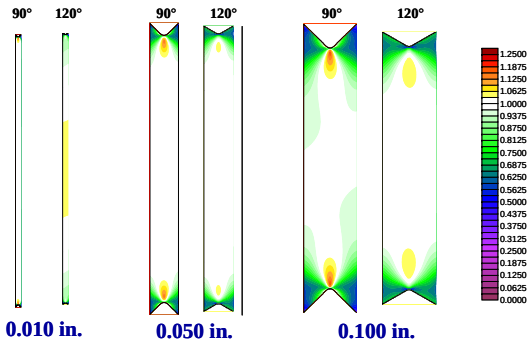


- To generate baseline repair data (static and fatigue) for both laminate/ sandwich configurations using OEM/ Factory but also field repairs
- To evaluate the strength/ durability of poorly bonded and/or contaminated repairs that passed NDI (Laminate/Sandwich)
- To evaluate the existing CACRC standards for repair and provide recommendations pertaining to process improvement to ensure repair bond repeatability and structural integrity
- To evaluate the damage tolerance of repairs subjected to BVID inflicted at three different locations on the repair (Laminate)

Shear Characterization of Adhesives

- **Concern**
  - Lack of consensus on whether mechanical properties of an adhesive are affected by bondline thickness
  - Need for shear response of adhesives for use in the design and analysis of adhesive joints
- **Approach**
  - Use of V-notched Iosipescu shear specimen developed for composite materials
- **Results**
  - Iosipescu shear test appears to be well suited for both bulk and in-situ shear testing
  - 90° notch angle for bulk adhesive testing
  - 120° notch angle for in-situ adhesive testing
  - Shear properties (modulus, strength) do not appear to be dependent on adhesive thickness
  - Apparent adhesive thickness effect in tensile strength is produced by differences in stress state within adhesive layer
  - Bulk adhesive properties may be applied to thin adhesive bondlines

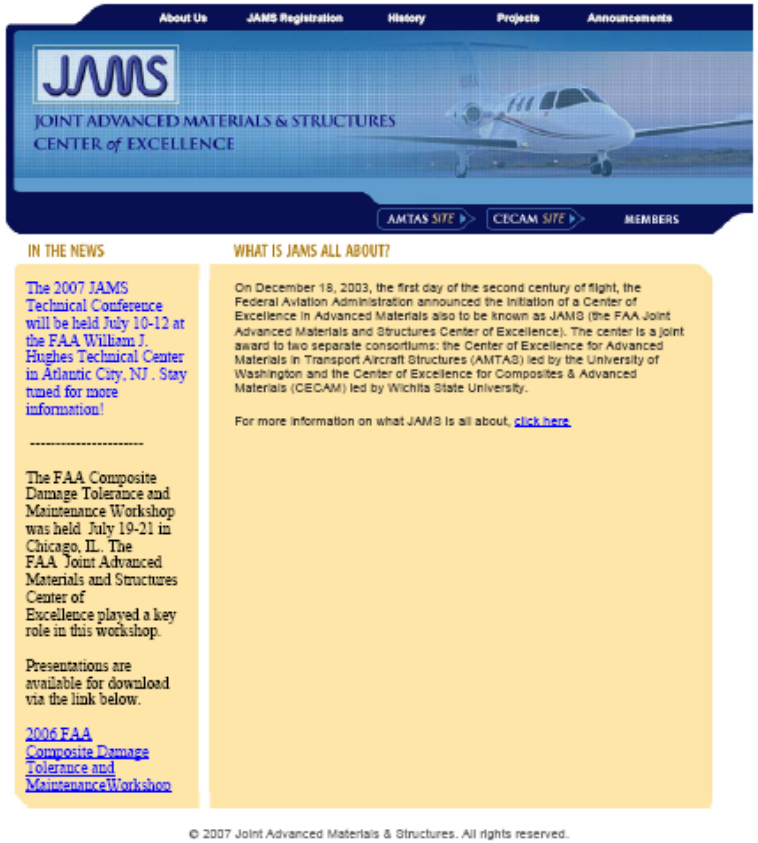




Websites

JAMS Presentations:

http://www.jams-coe.org



FAA Technical Reports:

http://actlibrary.tc.faa.gov