FAA Composite Safety and Certification Initiatives (with emphasis on support from JAMS research and development)

Presented to: Spring 2010 JAMS Conference
By: Larry Ilcewicz FAA
Date: May 19, 2010
Outline

• Composite Safety & Certification Initiatives (CS&CI)
  – Background
  – Expanding FAA composite team
  – Industry interface
  – Role of research
  – How we identify/select/prioritize research projects?

• Selected CS&CI progress of relevance to JAMS

• Future CS&CI plans of relevance to JAMS
  – Technical issues addressing safety problems
  – Training initiatives

• Review of JAMS Progress and Plans
Background on State of the Industry

• Situation
  – Composites have traditionally offered advantages due to fatigue & corrosion resistance, weight savings and other aircraft performance advantages (aero shape, larger cutouts)
  – More recently, the additional advantages from manufacturing cost savings, customer comfort interests & damage tolerance are driving more applications

• Composite applications are expanding faster than the qualified workforce involved in structural engineering, manufacturing and maintenance functions.

• Motivation driving FAA CS&CI Safety Management:
  – Composites are a non-standard technology
  – Limited shared databases, methods, guidance
  – Small companies have limited resources and certification experience
  – “Big-brother” expectations by industry (non-existent in today’s military)
Ongoing FAA Composite Safety & Certification Initiatives

• Actively working with industry since 1999

Objectives

1) Work with industry, other government agencies, and academia to ensure safe and efficient deployment of composite technologies used in existing and future aircraft

2) Update policies, advisory circulars, training, and detailed background used to support standardized composite practices

• Safety management (airworthiness) Task Groups initiated within composite standards organizations

• Future work underway to educate regulatory personnel
How Can FAA Reduce Composite Concerns?

- Promote standardization
- Develop guidance that recognizes safety concerns with industry push to minimize costs
- Establish safety awareness education for FAA Workforce (FSDO, ACO, MIDO, industry designees)
- Continue to benchmark the industry groups and members showing leadership for safe composite applications
  - Standards organizations (CMH-17, CACRC, ASTM)
  - Applicants that portray leadership as “Model Citizens”
  - FAA/EASA/Industry Workshops

Presentations, recaps and breakout session summaries at: [http://www.niar.wichita.edu/niarworkshops/]
Composite Technical Thrust Areas

Advancements depend on close integration between areas

Material Control, Standardization and Shared Databases

Progress to Date
- AC 20-107B (9/09)
- 2 other Advisory Circulars
- 6 Policy Memos
- 11 Workshops
- 3 Training Initiatives
- 2 Technical Documents
- CMH-17 Updates
- SAE CACRC Standard
- ~60 FAA R&D Reports

Structural Substantiation
- Advances in analysis & test building blocks
- Statistical significance
- Environmental effects
- Manufacturing integration

Crashworthiness & Flammability
Support to cabin safety research groups

Damage Tolerance and Maintenance Practices
- Critical defects (impact & mfg.)
- Bonded structure & repair issues
- Fatigue & damage considerations
- Life assessment (tests & analyses)
- Accelerated testing
- Structural tear-down aging studies
- NDI damage metrics
- Equivalent levels of safety
- Training standards

Bonded Joint Processing Issues

Advanced Material Forms and Processes

Significant progress, which has relevance to all aircraft products, has been gained to date
FAA Approach to Composite Safety and Certification Initiatives

1) Certification and Service History
2) Industry Interface
3) Focused RE&D
4) New Technology Considerations

Evolving

Time

Internal Policies

Mature

Rules & General Guidance

FARs

Advisory Circulars

Policy Statements

Training (Workshops, Courses, Videos)

Detailed Background (various forms of technology transfer)

Public Documents and Standards (e.g., CMH-17, SAE AMS, Contractor Reports)

#) Order of influence for unwritten internal policies
FAA Update of Selection Process for Composite Research Projects

1) Certification and Service History

2) Industry Interface

3) FAA needs and requirements in composite research areas

4) New Technology Considerations

JAMS(AMTAS/CECAM)
Composite Technology evaluation/development …

Other Procurement activities as required

- Tech Transfer
- Advisory Circulars
- Training

Identify PI and budget Evolving Peer review Mature

Time

Yearly cycle modified by congressional mandates and budget approval process

Federal Aviation Administration

FAA Composite Safety & Certification Initiatives
Spring 2010 JAMS Meeting (Seattle, Washington), May 19, 2010
# FAA Composite Team Members

<table>
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<tr>
<th>Represented Group</th>
<th>Team Member Name</th>
<th>FAA Organization Number &amp; Routing</th>
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<tbody>
<tr>
<td>FAA Technical Center</td>
<td>Curtis Davies</td>
<td>AAR-450 (FAA Technical Center)</td>
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<td>Michael Shiao</td>
<td>AAR-450 (FAA Technical Center)</td>
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<td>Lynn Pham</td>
<td>AAR-450 (FAA Technical Center)</td>
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<td>David Westlund</td>
<td>AAR-450 (FAA Technical Center)</td>
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<td>Directorates</td>
<td>Lester Cheng</td>
<td>ACE-111 (Small Airplane Directorate)</td>
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<td>Bob Stegeman</td>
<td>ACE-111 (Small Airplane Directorate)</td>
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<td>Sharon Miles</td>
<td>ASW-110 (Rotorcraft Directorate)</td>
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<td>Mark Freisthler</td>
<td>ANM-115 (Transport Airplane Directorate)</td>
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<td>Allen Rauschendorfer</td>
<td>ANM-115 (Transport Airplane Directorate)</td>
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<td>Jay Turnberg</td>
<td>ANE-110 (Engine &amp; Propeller Directorate)</td>
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<td>DC Certification</td>
<td>Dale Hawkins</td>
<td>AIR-120 (Aircraft Standards Division)</td>
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<td>Flight Standards</td>
<td>Otto Hill (&amp; Rusty Jones)</td>
<td>AFS-320 (Aircraft Maintenance Division)</td>
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<td>Gary Goodwin</td>
<td>ANM-200 (Seattle AEG)</td>
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<td>ACOs, and MIDOs,</td>
<td>Roger Caldwell</td>
<td>ANM-100D (Denver ACO)</td>
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<td>Hassan Amini</td>
<td>ACE-117A (Atlanta ACO)</td>
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<td>Fred Guerin</td>
<td>ANM-120L (Los Angeles ACO)</td>
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<td>Ken Paoletti</td>
<td>ANM-120S (Seattle ACO)</td>
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<td>Angie Kostopoulos</td>
<td>ACE-116C (Chicago ACO)</td>
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<td>Richard Noll</td>
<td>ANE-150 (Boston ACO)</td>
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<td>John Harding</td>
<td>ANM-108B (Seattle CMO)</td>
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<td>CS&amp;TA</td>
<td>David Swartz</td>
<td>ACE-115N (Anchorage ACO)</td>
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<td>Larry Ilcewicz</td>
<td>ANM-115N (CS&amp;TA, Composites)</td>
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**Those shown in Blue Italics are most active in CS&CI.**
(Many names in black joined for educational purposes. Training has been a priority since recent meeting with AVS management and CAST.)

**CSTA Advisors:**
Al Broz, Robert Eastin, Terry Khaled, Dave Walen, Chip Queitzsch
Important Teammates

- Partnerships with industry have been essential, e.g., CMH-17, SAE P-17, CACRC, ASTM, SAMPE, AGATE, SATS, RITA, SAS/IAB/AACE

- NASA research and other support
  - Significant research support since 1970/1980s
  - AA587, A300-600 accident investigation

- DOD and DARPA research
  - NCAMP support to material standardization

- EASA and other foreign research/standardization
Past Milestones for Composite Safety & Certification Policy, Guidance & Training

Material & Process Control and Shared Databases
- AGATE Shared Database Workshop
- Italian Industry Shared Database Workshop
- Static Strength Substantiation Policy and Workshop
- FAA/NASA/Industry Structures Workshop
- UCSB Peel Ply Research
- TTCP Bonded Structures Certification Document
- FAA/Industry Prepreg M&P Spec. Workshop
- FAA/Industry LRM M&P Spec. Workshop
- FAA/Industry Bonded Structures Workshop I
- FAA/EASA/Boeing/Airbus DT & Maintenance WG

Bonded Joints & Structures
- CS&CI 7-Year Plan
- NTSB/FAA/WSU SH Nimbus Accident Investigation
- CMH-17 Revision F
- FAA/Industry Prepreg M&P Spec. Workshop
- FAA/Industry Bonded Structures Workshop I
- FAA Bonded Structures Policy
- FAA/Industry Bonded Structures Workshop II
- TSB/NTSB/FAA/Airbus Rudder Investigation
- FAA/Industry Composite Maintenance Training Workshop I

Other CS&CI Initiatives
- Initial material qualification and equivalency policy
- Initiated sandwich damage tolerance studies
- Policy on material selection guideline (ΔT rule)
- FAA/EASA/Boeing/Airbus Prepreg M&P Spec. Advisory Circular
- Update material qualification and equivalency policy
- FAA/Industry Composite Maintenance Training Workshop II
- FAA/Industry Bonded Structures Workshop II

1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005

FAA Composite Safety & Certification Initiatives
Spring 2010 JAMS Meeting (Seattle, Washington), May 19, 2010
Composite Material & Process Control and Shared Databases

• DOD, NASA & FAA have been working together to allow industry self-regulation for shared databases, which support efficient M&P control and generic design data
  – NASA AGATE initiated the efforts in 1995, with FAA help
  – Related FAA policy and guidance exists in this area (since 2003)
  – ASTM international test standards (many supported by FAA R&D)
  – CMH-17 shared test databases for simple, non-product specific M&P control and design properties (in work for 30+ years)
  – AMS P-17 Specifications for material procurement and processing information (in work for 10+ years)

• NCAMP program has demonstrated an acceptable path forward (to be recognized in 2010 FAA policy memo)
  – Conducting FAA 2010 safety awareness workshop in this area
Recent Milestones for Composite Damage Tolerance and Maintenance Initiatives

- **FAA/NRC Workshop (5/04)** Composite Maintenance Overview
- **FAA Seattle Workshop (11/04)** Initiate Composite Maintenance Training (CMT)
- **JAMS CMT Develop. (11/04-7/05)** Draft Course Objectives/Modules
- **FAA/Industry CMT Workshop (9/05)** Detailed CMT Review

**Airbus/Boeing FAA/EASA Composite Damage Tolerance and Maintenance WG**
- **Toulouse (9/05)** Seattle (3/06)

**JAMS CMT Develop. (7/06-10/09)**
- SAE CACRC Course Standard

**FAA/EASA/Industry Damage Tolerance and Maintenance Workshops**
- **Chicago (7/06)**
- **Amsterdam (5/07)**
- **Tokyo (6/09)**

**FAA/EASA/TCCA WG Draft CMH-17 Certification and Compliance Chapter, V3C3 (9/07)**

**Workshop presentations, recaps and breakout session summaries at:** [http://www.niar.wichita.edu/niarworkshops/](http://www.niar.wichita.edu/niarworkshops/)

**FAA/EASA/TCCA WG Draft CMH-17 Certification and Compliance Chapter, V3C3 (9/07)**

**White Paper on High-Energy, Blunt Impact (9/08)**

**New content in AC 20-107B (9/09)**

**Ongoing CMH-17 Revision G Developments (2005-2009)**

<table>
<thead>
<tr>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
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FAA Composite Safety & Certification Initiatives
Spring 2010 JAMS Meeting (Seattle, Washington), May 19, 2010
Composite Maintenance Awareness Course

Purpose: Course is intended to address aircraft safety & certification issues as opposed to building specific skills among team members

Main Course Structure

Initial Module: Understand the roles & responsibilities of teammates

Modules 2 & 3: Recognize composite damage types & sources + describe related damage and repair inspection procedures (2 labs)

Module 4: Identify & describe information contained in approved documentation

Modules 5 to 8: Describe composite laminate fabrication, bonding, & bolted assembly methods + perform bonded & bolted repairs (2 labs)

Module 9: Participate in team case studies

Pre-requisite: Knowledge needed before taking main course

Base Knowledge

Teamwork & Disposition

Damage Detection & Characterization

Repair Processes

Total Costs ~ $1500K

Training Development Costs: $900K

- Industry Match (JAMS COE R&D)
- FAA JAMS COE R&D ($)
- FAA Development Manpower ($)
- Industry/EASA Review Manpower ($)
- Industry/EASA Workshop Manpower & Travel ($)
- FAA Workshop Manpower+Contracts+Travel ($)

11/04 & 9/05 Workshop Costs: $525K

FAA Composite Safety & Certification Initiatives
Spring 2010 JAMS Meeting (Seattle, Washington), May 19, 2010
Background for WG Initiative on Damage Tolerance & Maintenance Guidance

- FAA/EASA/Airbus/Boeing Working Group chartered in 2005 to discuss safety issues for expanding application of composites to transport aircraft
  - Focus on industry practices for damage tolerance & maintenance

- Expanded to include other (~380) industry technical focal in three FAA/EASA/Industry DT and Maintenance Workshops
  - Chicago, IL (150, July 19-21, 2006)
  - Amsterdam, Netherlands (110, May 9-11, 2007)
  - Tokyo, Japan (120, June 4, 5, 2009)

Total Costs = $1500K (est. thru FY08)
Summary of 2006, 2007 & 2009 Workshops

• Critical safety data shared in unique forum of practitioners
  – Captured in web files, new CMH-17 content and FAA course

• Five *categories of damage* were proposed for damage tolerance and maintenance consideration
  – Integrated efforts in structural substantiation, maintenance and operations interface help ensure complete coverage for safety

• Coordinated inspection, engineering disposition and repair is needed for safe maintenance
  – Reporting by operations is essential for detection of critical damage from anomalous events

• FAA is committed to CS&CI with industry, academia and government groups (~380 participants in three workshops)
  – Damage tolerance and maintenance initiatives are active
  – Principles of safety management will continue to be used in future developments (policy, guidance and training)

*Presentations, recaps and breakout session summaries at:*
http://www.niar.wichita.edu/niarworkshops/
FAA Technical Paper on Awareness & Reporting of Significant Impact Incidents Involving Composite Airframe Structures

(not effort initiated by FAA/EASA/Airbus/Boeing WG)

Not all damaging events (e.g., severe vehicle collisions) can be covered in design & scheduled maintenance

- Safety must be protected for severe accidental damage outside the scope of design (defined as Category 5 damage) by operations reporting
- Awareness and a “No-Blame” reporting mentality is needed
- Category 5 damage requirements:
  a) damage is *obvious* (e.g., clearly visual) and *reported* &/or
  b) damage is *readily detectable* by required pre-flight checks &/or
  c) the *event* causing the damage is otherwise *self-evident* and *reported* e.g., obvious, severe impact force felt in a vehicle collision
Solution Path for Vehicle Collisions Classified as Category 5 Damage

Layers of Safety Management are also needed

- Damaging events outside the scope of those considered in design must be of a magnitude that ensures reporting (i.e., design to sufficient impact damage resistance and damage tolerance)
- Simple training is needed to ensure the essential “reporting” role of operations and aircraft service personnel without blame
- Source documentation and training for line maintenance, inspectors and structural engineers needed to disposition such events to ensure proper application of conditional inspection and repair procedures
- Practical NDE methods should be able to detect critical levels of damage

<table>
<thead>
<tr>
<th>1) Impact Event is Reported</th>
<th>Awareness by ground crews, service crews, air crews, and/or ramp personnel</th>
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<tbody>
<tr>
<td>2) Line Maintenance Ensures Proper Evaluation</td>
<td>Line and Dispatch personnel trained to seek skilled disposition assistance</td>
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</table>
| 3) Engineering Evaluation & Repair (if necessary) | a. Engineers, OEM, technicians, inspectors with proper training  
  b. Allowable Surface Damage Limits do NOT apply  
  c. Initial inspection is to detect MAJOR internal damage |
FAA/Industry Research at University of California, San Diego (UCSD)

- R&D active to help bound important variables and worst case scenarios (i.e., most severe internal damage with least exterior visually detectable indications)

- Both analysis and test evaluations are planned
  - Vehicle collision characteristics (e.g., speed, angle of incident, impactor geometry/material and structural location) important to:
    a) damage severity,
    b) details worth reporting,
    c) possible visual evidence and
    d) identification of inspection needs (coordinated with FAA NDI research)

Dr. Hyonny Kim, UCSD
Aero-elastic Stability and Flutter of Damaged Control Surface Structure

- Transport rudder lost during 2005 flight (flutter event) led to service bulletins and associated airworthiness directives
  - Evidence from the investigation indicated large damage (e.g., extensive sandwich face-sheet disbonding) was needed to cause rudder flutter
  - Airbus presentations at FAA workshops shared key safety findings (e.g., sandwich design details susceptible to disbond growth in ground-air-ground cycling and supporting tests & analyses)

- Active FAA initiatives:
  - Effects of composite damage on flutter
  - Characterize sandwich damage growth mechanisms & document bad design details
  - Scenarios for damage initiation & growth, e.g.,
    - Standard test & analysis methods
Metal Bond Durability Test Standard and Related Guidance

- **Focus on bond durability problems occurring in service**
  - NTSB Safety Recommendations A08-25 to -29 for metal bond failures of helicopter rotor blades
  - Bond process qualification issues (e.g., surface preparation that doesn’t provide sufficient long-term durability)
  - Issues of void development and hydration, leading to adhesion failures

- **New FAA initiatives, incl. R&D**
  - Detailed background for guidance/training on technical issues & proven industry practice
  - Level II safety awareness course development
  - Evaluation of real-time vs. accelerated test degradation mechanisms
  - Standard tests for qualification of long-term environmental durability
Service Problems With Extensive Repair of Metal-Bond & Composite Aircraft Structure

- Airline members of the CACRC have been sharing case studies of improper composite repair found in the field
  - Numerous cases of extensive bonded repairs that have some indication of a problem before destructive tear-down inspection reveals the likely root cause
  - Evidence of the industry challenges of insufficiently trained resources and economic pressures

- New FAA initiatives, incl. R&D
  - Detailed background for regulatory guidance and training on the technical issues and proven industry practice
  - International safety standards on expectations for “approved repairs”
  - Level II safety awareness course updates
  - Possible regulatory rule-making and enforcement actions

Example Case Study: Repaired TE Flap delivered to airline for installation

Improper fit and considerable warp suggested a repair problem
Proposed Crashworthiness Project Plan

To address FAA needs for cabin safety issues unique to composite materials

Project Schedule - Key Milestones/Deliverables:

<table>
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<th>Year</th>
<th>2010</th>
<th>2011-$100K</th>
<th>2012-$100K</th>
<th>2013-$100K</th>
<th>2014-$100K</th>
<th>2015</th>
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Open Industry level
- RR Numerical Methods/Tools Evaluation/Guidelines

CMH-17 Chapter
- Anal & test guidelines
- Initial Educ. Module

Failure Criteria

Sub-component Level
- Aircraft
- Automobile

Test Standards
- Strain rate studies

Material Modeling
- Progressive damage

Airframe Structure
- Definition

Building Block
- Test/Analysis
- Leverage existing data

Analysis/Test
- Guidelines
- Predict A/F CW

Benchmarking Report

A/F Industry Level
- Consortium
- FAA coordination

Educational Modules CW
- CMH-17 Chapter
- FAA composite module

To be integrated with existing crashworthiness projects at AMTAS & CECAM

FAA Composite Safety & Certification Initiatives
Spring 2010 JAMS Meeting (Seattle, Washington), May 19, 2010
### Composite Education Initiatives

**Proposed education progression through three levels**

<table>
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<tr>
<th>Level</th>
<th>Focus Area</th>
<th>Details</th>
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</table>
| Level I | Introduction to Composites | 1. Basics of composite technology  
2. Intro to job roles & responsibilities  
3. Certification basics |
| Level II | Safety Awareness | 1. Composite safety focus, including hands-on laboratory  
2. More details of regulatory guidance and industry practice  
3. Joint FAA/industry leadership |
| Level III | Specialized Training | 1. Skill building in specific areas for existing & emerging applications  
2. Training for practitioners using experts with real-world experience  
3. Industry leadership needed |

Some additional focus for functional disciplines (e.g., structural engineering, manufacturing and maintenance) for levels II and III.
Summary of FAA Composite Training Strategy: Progress to date

• Two introductory level courses are available
  – 6-hour classroom tutorial on certification basics
  – Online training on the basics of composite technology

• Work on safety awareness courses (status color-coded)
  – **Maintenance**: AFS 500 converted FAA-sponsored industry standard (AIR 5719) into 6-7 day classroom course currently available through contractor (more than 200 inspectors to date).
  – **Structural Engineering**: Only a 7 hour module is currently available in the OK City airframe course.
  – **Manufacturing**: Nothing is currently available.

• Specialty coursework is generally sparse & incomplete
  – Some elements of a course for material qualification, equivalency sampling, statistics and M&P specs in work
Composite Structural Engineering Level II Safety Awareness Course Development

• 64-Hour course development started in 2010

• Draft top-level outline following AC 20-107B
  – Difficulties faced in composite applications (2 hours)
  – Design, material and fabrication development (3 days)
  – Proof of structure – static (1 day)
  – Proof of structure – fatigue & damage tolerance (2 days)
  – Proof of structure – flutter (1 hour)
  – Manufacturing interface issues (1/2 day)
  – Maintenance interface issues (1/2 day)
  – Other: crashworthiness, fire safety & lightning strike protection (1/2 day)

• 2010 FAA Workshop* (on Week of 9/13) at Wichita State Univ. to “beta test” module on composite material & process control (2 to 3 days)
  – Material & process qualification (test matrices, statistics)
  – Material & process specifications (material rqmts., process details, quality control)
  – Shared data (NCAMP/CMH-17/SAE P-17 & CACRC initiatives, equivalency sampling)
  – “Material allowables” versus design values

* Contact Lester Cheng, FAA ACE-111, lester.cheng@faa.gov, 316-946-4111
Recent/Future Milestones for Composite Safety & Certification Guidance & Training

Release CMH-17 Revision G
- Advances in statistics, test methods and data reduction protocol
- Major Volume 3 re-organization
- New Volume 6 (Sandwich)
- New certification & compliance chapter
- New crashworthiness chapter
- New safety management chapter
- Updates to damage tolerance & maintenance

Implement Composite Maintenance Awareness Course

High Energy Blunt Impact Awareness
Release AC 20-107B (Composite Aircraft Structure)
- NCAMP shared databases and specifications (CMH-17, SAE AMS)
- Composite maintenance guidance/policy for extensive repair
- FAA/Industry composite education initiatives
- Metal bond durability standards & guidance
- Composite damage tolerance guidance
- Crashworthiness guidance

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Federal Aviation Administration
Review of Existing JAMS Projects

**Grading Considerations**
- Quality of R&D performed to date: A-
- Relationship with safety issues: B
- Understands industry application needs & achieves tech. transfer: C+

**Areas Needing Improvement**
- Researcher involvement in process (e.g., CMH-17, CACRC, workshops, standards and course development)
- Proactive industry involvement
- Availability of FAA and industry resources for implementation
- Published results (Tech. Center Reports)
Challenges for JAMS - Need More Industry, FAA & other Govt. Agency Involvement

• Help JAMS identify key R&D areas, realizing the need for a safety & certification emphasis
  – Outline existing industry problems and near-term applications
  – Participate in FAA Safety Awareness Course developments
  – Cost sharing partners should have proactive involvement in project from start to finish (word about Direct! vs. In-kind?)

• Actively participate in ongoing projects
  – Provide advice/guidance to the PI and researchers
  – Interface with additional FAA personnel directing the project
  – Help convert results to practice (deliverables to support industry and FAA needs – avoid “throwing report over the fence”)

• Review JAMS detailed project descriptions, references and presentations
  – Provide feedback and suggestions for improvement (feel free to “grade” the efforts)