FAA Perspectives on Future R&D Requirements for Structural Integrity - Composites

Presented to: AMTAS Industry Meeting
By: Larry Ilcewicz
Date: March 16, 2010
Outline

• Composite Safety & Certification Initiatives
  – Background
  – Selection process for R&D projects
  – FAA Teammates and industry interface

• Progress and plans linking to research
  – 2005 to present
  – Future plans (incl. FY12 composite research requirements)
    ➢ Damage tolerance of composite structures
    ➢ Structural integrity of adhesive joints
    ➢ Composite maintenance practices
    ➢ Environmental & aging effects for composite structures
  – Open discussion
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

- Significant efforts underway to educate FAA personnel
Challenges for Composite Applications

- Lack of qualified resources for expanding applications
- Lack of practical standards and educational materials of relevance to industry applications
- Pressure to apply composites to new applications due to potential cost and weight savings
- Relatively high development costs not shared within the industry, putting pressures on some segments

A combination of the above issues pose safety risks that must be mitigated through pro-active efforts

- Recent FAA focus areas have been in areas of damage tolerance, maintenance and structural bonding
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

**Advanced Material Forms and Processes**

**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**

**Crashworthiness & Flammability**

Support to cabin safety research groups

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

Time

Internal Policies

Evolving

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
Outside (Ref: M. Rassaian, Boeing) View of Selection Process for Composite Research Projects

FAA needs and requirements for the next funding cycle focus in composite research areas

New Technology Considerations

AMTAS
Composite technology development....

JAMS
Composite Technology development ...

Alignment with Industry Technology Needs

Identify PI and budget

Evolving
Peer review

Mature

Is there one for AMTAS?

Just received one from JAMS?

Timing?
Budget?

\[\text{Tech Transfer}\]
\[\text{Advisory Circulars}\]
\[\text{Training}\]
FAA Update of Outside View of Selection Process for Composite Research Projects

1) Certification and Service History

3) FAA needs and requirements for the next funding cycle focus in composite research areas

2) Industry Interface

4) New Technology Considerations

AMTAS
Composite technology evaluation/development….

JAMS
Composite Technology evaluation/development …

Alignment with Industry Technology Needs/Support

Evolving
Peer review

Mature

• Tech Transfer
• Advisory Circulars
• Training

Identify PI and budget

Timing?

Budget?

Is there one for AMTAS?

Just received one from JAMS?

Structural Integrity of Composites
SAS, March 10, 2010
Answers to Questions and the Complexities of FAA R&D

• Key FAA Focal (research sponsors and providers)
  – Larry Ilcewicz (Chief Scientific & Technical Advisor, Composites), lead directorates & field offices to define research requirements (i.e., as related to field problems and certification challenges) and combine the research outputs with other factors affecting safety and certification to develop outcomes (rules, guidance and training)
  – Curt Davies (Advanced Materials Research Program Manager), lead the FAA advanced materials research to meet sponsor requirements and deliver outputs to support the sponsor outcomes

• AMTAS & JAMS have the same research requirements

• Much of our research has focus on safety concerns from field problems and certification issues
  – Rarely linked with technology development
  – More likely linked to the evaluation of technology having interest to industry (as related with application to actual parts on aircraft)
Answers to Questions and the Complexities of FAA R&D, cont.

- **Alignment with industry technology needs and support currently comes through an ad-hoc interactive process**
  - Industry cost-share partners have a strong influence
  - Earmarks to specific university groups will ID some research providers
  - Base FAA research budget allows freedom in selecting other research providers per government grant & contract allocation processes

- **Scheduling issues**
  - Three year budget cycle (i.e., new research requests are linked to a congressional cycle that is three years in the future)
  - Budgets in any given year are subject to change during the allocation process --- *This can be a problem but it can also give some freedom to move research projects to an earlier date through “pop-ups”, earmarks, or updated plans*

- **Significant FAA efforts needed to “integrate research”**
  - Attempts to parse out “different pieces of requirements” to different research providers requires considerable FAA efforts
### FAA Composite Team Members

<table>
<thead>
<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>
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<td>Michael Shiao</td>
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<td>Lynn Pham</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>
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<td>Sharon Miles</td>
<td>ASW-110 (Rotorcraft Directorate)</td>
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<td>Mark Freisthler</td>
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<td>Allen Rauschendorf</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 (Rusty Jones)</td>
<td>AFS-320 (Aircraft Maintenance Division)</td>
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<td>Gary Goodwin</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>
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<td>Ken Paoletti</td>
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<td>Angie Kostopoulos</td>
<td>ACE-116C (Chicago ACO)</td>
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<td>Richard Noll</td>
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<td>John Harding</td>
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<td>David Swartz</td>
<td>ACE-115N (Anchorage ACO)</td>
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<tr>
<td>CS&amp;TA</td>
<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
Progress in Composite Safety and Certification Initiatives

*Milestones achieved to date*

- FAA policy/training for base material qualification & equivalency testing for shared databases (update 2003)*
- Policy/training for static strength substantiation (2001)
- AC for material procurement & process specs (2003)*
- Policy on substantiation of secondary structures (2005)
- Policy for bonded joints & structures was released (2005)*
- Composite maintenance & repair awareness training (2008)*
- AC 20-107B (Composite Aircraft Structure) updates (2009)*
- Revision G to CMH-17 in work (2010)

* FAA Technical Center reports exist for detailed background on engineering practices
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)

**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)**

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<th>2006</th>
<th>2007</th>
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## FAA Composite Damage Tolerance & Maintenance Workshops

### Chicago, IL, USA July 19-21, 2006

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### Amsterdam, Netherlands May 9-11, 2007

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### Tokyo, Japan June 4 & 5, 2009

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### Candidate Ratings

- **120 Participants**
- **110 Participants**

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**Federal Aviation Administration**

**Structural Integrity of Composites**

SAS, March 10, 2010
AC 20-107B Outline (released in 9/09)

1. Purpose
2. To Whom This AC Applies
3. Cancellation
4. Regulations Affected
5. General
6. Material and Fabrication Development
7. Proof of Structure – Static
8. Proof of Structure – Fatigue and Damage Tolerance
9. Proof of Structure – Flutter
10. Continued Airworthiness
11. Additional Considerations

Appendix 1
Appendix 2
Appendix 3 (updates to EASA CS 25.603, AMC No. 1, Para. 9 and No. 2: Change of Material & Process)

AC 20-107A 11 pages
AC 20-107B 37 pages
Harmonized AMC 20-29
(new sections highlighted by blue)
FAA Technical Paper on Awareness & Reporting of Significant Impact Incidents Involving Composite Airframe Structures

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
FAA/Industry Research at University of California, San Diego (UCSD)

- New R&D started 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 M&I TCRG)

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 research to study:
  – 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

• Research needs
  – 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

• Research needs
  – 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

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

Improper fit and considerable warp suggested a repair problem
## Composite Education Initiatives

*Proposed education progression through three levels*

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

Some additional focus for functional disciplines (e.g., structural engineering, manufacturing and maintenance) for levels II and III.
Composites Education Initiatives
Joint FAA and Industry Development

FAA Sponsor

FAA Facilitator

Industry Sponsor

Industry Support

Education Development

Specialized Training

Safety Awareness

Introduction

Degree of Involvement And Investment
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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<th>2009</th>
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<th>2012</th>
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Structural Integrity of Composites
SAS, March 10, 2010
• Remaining Charts Include
• FY12 Requirements Sent in
• 3/24/10 from C. Davies and
• the 4 Priorities "Funded" by
• Current FAA Base Budget Process

• Open Discussion
Priority 1: Damage Tolerance of Composite Structures

- Study critical defects (e.g., disbonding and other defects) and service damage threats (e.g., impact damage, fluid ingression) to understand the damage tolerance of airframe structures (e.g., sandwich and laminated).
- Support large-scale structural substantiation by establishing structural test protocol, load enhancement factors to cover reliability, analysis limits and test/analysis methods to simulate damage.
- Address safety concerns from expanding composite applications such as transport wing and fuselage structure.
- Understand damage threats (damage detectability, residual strength, and growth potential) from high energy blunt impact.
- Determine the probability of critical damage threats (e.g. in-flight hail, bird strike) and realistic analysis & test simulations along with deterministic engineering assessment to create practical design criteria.
- Identify laminated skin design parameters that affect large notch/penetration residual strength.
- Develop a fatigue and damage tolerance module for the structural safety awareness course.
**Damage Tolerance of Composites, SIC-12-01**

### Drivers/Rationale
- Study the effects of critical defects and service damage on representative composite airframe structure
  - Potential sources of impact damage, disbonding, fluid ingress, and heat-induced damage
- Damage tolerance design principles and related maintenance practices used by the industry have not been standardized for many damage threats
  - Evaluate industry design criteria and certification test & analysis protocol for critical damage threats
- Identification of emerging risks (see 2/5/09 CAST review of severe blunt impact, e.g., service vehicle collisions)
- Enabling insertion of new composite technologies

### Outputs
- Damage tolerance evaluations for composite structure currently in service and near-term applications
  - Identify critical damage and evaluate analysis & test protocol for sandwich & skin-stiffened designs
- Bound threats/risks associated with severe blunt impact, including key parameters affecting damage severity
- Sandwich panel degradation mechanisms due to disbond growth, fluid ingression and freeze/thaw failures
  - Quantify growth rates and the effects on residual strength, stiffness and flutter
- Effect of fasteners in arresting delamination & debonds
- Related safety awareness course developments

### Outcome
- Research helps study critical composite damage threats, evaluate industry practices & standardize as appropriate
- Key outcomes include regulatory guidance, industry standards, workshops and related course content
- New composite damage tolerance standards & guidance
  - Shared databases on reliability factors (2012)
  - Severe blunt impact policy (2012)
  - Advance beyond the general AC 20-107B guidance that was just released (2014)
- Composite detailed standards document updates (e.g., CMH-17), training materials & workshops, including SIC research areas (2011, 2014)
- Structural Eng. Safety Awareness Course Module (2012)

### Funding
Priority 2: Structural Integrity of Adhesive Joints

- Evaluate the effects of adhesive joint design, process and tooling issues on the integrity of bonded structure (e.g., static strength, fatigue, environmental resistance, aging, and damage tolerance)
- Ensure reliable bonded structure by documenting engineering guidelines and process acceptance criteria; establishing environmental durability testing of metal-bonded aircraft structures and composite bonded joints
- Study bonded stiffening attachments to ensure sufficient process control, certification test and analysis protocol
- Consider combined load conditions, environmental and aviation fluid resistance, long-term aging and damage to support structural joint substantiation protocol
- Develop a bonding module for structural safety awareness course
## Drivers/Rationale
- Evaluate the effects of adhesive joint design, process & tooling issues on the integrity of bonded aircraft structure
- Bonding practices used by industry are not standardized
  - ID reliable bonded structural design details
  - ID key characteristics & process parameters
- Address NTSB Safety Recommendations A-08-25 to -29, including a need for updates in guidance to address long-term durability testing of metal-bonded joints
  - Also needed for composite bonded joints
- Identification of emerging risks for expanding structural applications of bonding (guidance & training needs)
- Enabling insertion of new composite technologies

## Outcome
- Research helps characterize bonded joint integrity, evaluate industry practices & standardize as appropriate
- Key outcomes include regulatory guidance, industry standards, workshops and related course content
- New bonded composite standards & guidance
  - Metal-bonded joint durability test standard (2013)
  - Update composite guidance in AC 21-26 (2014)
- Composite detailed standards document updates (e.g., CMH-17), training materials & workshops, including other SIC research areas (2012 - 2014)
- Structural Eng. Safety Awareness Course Module (2012)
- Manufacturing Safety Awareness Course Module (2014)

## Outputs
- Evaluations of bonding practices for composite structure currently in service and near-term applications
  - Evaluate in-process quality control procedures to mitigate risks of “weak bond” conditions, which can not be reliably detected by post-process NDI
- Update guidelines and standards for environmental durability tests of metal- & composite-bonded joints
  - Evaluate accelerated versus real-time testing
  - Study surface preparation and processing parameters known to affect bond quality
- Bonded joint fatigue and damage tolerance test protocol
- Related safety awareness course developments

## Funding
Priority 3: Composite Maintenance Practices

- Study process variables and human factors contributing to repair process variability in both bonded and bolted repairs
- Resolve the effects of surface moisture exposure and drying of bonded repairs
- Identify inconsistencies and problems in other maintenance practices as well as control key process parameters and characteristics
- Focus on repair processing and proof of structure to reduce poorly performed major repairs with insufficient structural substantiation
- Consider repairs performed on pressurized shell structure to ensure structural integrity
- Evaluate the potential of new technology in health monitoring to support maintenance and mitigate safety risks
- Develop training standards including distance learning
## Composite Maintenance Practices, SIC-12-03

### Drivers/Rationale
- Study process variables and human factors affecting the reliability of representative field repairs for composite aircraft structure
  - Identify sources of repair defects and repair key characteristics & process parameters to control
- Field problems with composite repair are known to exist and industry practices have not been standardized
  - Evaluate repair processing mistakes found in the field and seek long-term solutions with industry
- Identification of emerging risks (see 2/5/09 CAST review of risks associated with workforce guidance & training needs for expanding composite applications)
- Enabling insertion of new composite technologies

### Outcome
- Research helps characterize field repair problems, evaluate industry practices & standardize as appropriate
- Key outcomes include regulatory guidance, industry standards, workshops and related course content
- New composite maintenance guidance
  - Composite repair structural substantiation (2013)
  - Updates to AC 145-6 (2015)
- Composite detailed standards document updates (e.g., SAE CACRC), training materials & workshops, including SIC research areas (2012-2015)
- Update Maintenance Safety Awareness Course Standard AIR 5719 & include case studies of field problems (2012)
- Structural Eng. Safety Awareness Course Module (2012)

### Outputs
- Evaluations of maintenance procedures for composite structure currently in service and near-term applications
- Bonded repair assessments considering variables in field working conditions, technician skill levels, and processing parameters important to structural integrity
  - Structural data to evaluate bonded repair
- Bolted repair assessments considering variables in field working conditions, technician skill levels, and processing parameters important to structural integrity
  - Structural data to evaluate bolted repair
- Repair fatigue, durability & damage tolerance test protocol
- Related safety awareness course developments

### Funding

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**Structural Integrity of Composites**  
SAS, March 10, 2010
Priority 4: Environmental and Aging Effects for Composite Structures

- Identify environmental and aging factors affecting the performance and airworthiness of composite materials (e.g., study sensitivities to service environments and aircraft fluids including real-time interactions with loads).
- Support maintenance practices and establish criteria for structural retirement.
- Conduct tear down inspection and laboratory tests on retired aircraft structures.
- Evaluate control surfaces in sandwich and metal-bonded sandwich structures.
- Determine realistic structural temperature exposures and moisture contents in comparison to current worst-case assumptions.
- Evaluate the composite materials in high temperature locations to investigate the effects of exposure to possible heat damage and establish field inspection procedures to detect the level and extent of damage.
# Environmental & Aging Effects, SIC-12-04

### Drivers/Rationale
- Identify environmental and aging parameters affecting the long term performance of composite aircraft structure
- Investigate structural integrity of composite and bonded aircraft parts that have had significant time in service
  - ID dependency on design and process details
  - ID real-time and accelerated test differences
- Identification of emerging risks for expanding composite structural applications (guidance & training needs)
- Enabling insertion of new composite technologies

### Outcome
- Research helps characterize real-time environmental effects and aging threats to support more accurate accelerated test standards & design criteria
- Key outcomes include regulatory guidance, industry standards, workshops and related course content
- Composite guidance on environmental effects & aging
  - Advance beyond the general AC 20-107B guidance that was just released (2014)
- Composite detailed standards document updates (e.g., CMH-17), training materials & workshops, including SIC research areas (2012 - 2014)
- Structural Eng. Safety Awareness Course Module (2012)

### Outputs
- Perform nondestructive and tear-down inspections of composite & bonded aircraft structure retired from service
  - Contrast the environmental & aging resistance of sandwich and skin-stiffened design details
  - Perform mechanical tests when possible
  - Compare real-time degradation/property changes with that from accelerated test methods & industry design criteria for environmental exposure
  - Assess the quality and structural integrity of repairs mandated by airworthiness directives
- Assess parts subjected to high temp. for heat damage
- Document case studies for the safety awareness courses

### Funding
- Composite detailed standards document updates (e.g., CMH-17), training materials & workshops, including SIC research areas (2012 - 2014)
Priority 5: Cabin Safety Issues Unique to Composite Materials

- Investigate composites in airframe structures crucial to cabin safety under crash conditions which must not reduce the level of safety.
- Study composite materials and associated airframe structural details that may lead to changes in aircraft crashworthiness.
- Perform both analysis and test evaluations to seek in substantiating crashworthiness for new composite airframe designs.
- Assess crashworthiness effect of structural scale and boundary conditions for building block tests, including assessment of strain rate sensitivity for typical composite material properties and their resulting structural behavior.
- Evaluate existing analysis methods used to predict the crashworthiness of composite structures and develop test standards to measure the energy absorption of composite details.
Priority 6: Specifications for Material Control and Test Standards for Advanced Materials

- Establish information critical to composite material and process control such as specification requirements and reliable test standards.
- Focus on quality controls for material constituents and effectiveness of statistical process control procedures.
- Evaluate material and process control for chopped fiber composites and possible TSO applications to achieve in more efficient structural substantiation procedures.
- Develop a material and process control module for structural safety awareness course.
Priority 7: Fatigue & Damage Tolerance for Dynamic Composite Structure Applications

- Address fatigue and damage tolerance in dynamic service environments, damage conditions and loads.
- Identify damage growth mechanism for metal-bonded and composite rotorcraft parts and investigate control through damage tolerant design and maintenance practices.
- Define test and engineering protocol for damage growth and arrestment options.
- Conduct impact surveys to better understand the potential threat to dynamic rotorcraft parts.
Priority 8: Advanced Materials & Processes

- Study new structural materials (e.g. textile material forms, nano-particle enhanced resins, chopped fiber composites) and processes (e.g. resin-molding processes, stir friction welding, automated ply lay-up and machining processes) to identify the necessary quality controls and structural substantiation protocol.
- Study high temperature applications (e.g., ceramic matrix composites).
- Develop an advanced material and processes module for structural safety awareness course.