

# FAA Composite Safety

Presented to: AMTAS

By: Cindy Ashforth, Larry Ilcewicz

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Federal Aviation  
Administration



# Outline

- **Summary of FAA's AVS Composite Plan**
  - Showing AMTAS research links with AVS Plan initiatives
  - Note those initiatives associated with continued operational safety and certification efficiency
  - Provide thoughts on technical links with the content of AVS deliverables

# AVS Strategic Composite Plan

- **The FAA’s mission is to “provide the safest, most efficient aerospace system in the world.”**
  - Safety is always our first priority
- **Aircraft certification, manufacturing and operational oversight is performed by the Aviation Safety Office (AVS) of the FAA**
  - AVS is comprised of 7 offices, including Aircraft Certification (AIR) and Flight Standards (AFS)

# AVS Composite Plan

- **The FAA has created an AVS Composite Plan to retain leadership of international safety and certification initiatives for composite airplane structures**
  - Seven-year plan updated annually
  - Depends on industry deliverables (e.g., CMH-17 and SAE)
  - Includes FAA research
- **Three focus areas**
  - Continued Operational Safety (COS)
  - Certification Efficiency (CE)
  - Workforce Education (WE)
- **Priority is assigned to tasks based on issues that pose the greatest safety threats**

# Overview FY2017

Continuous Operational Safety (COS)	Certification Efficiency (CE)	Workforce Education (WE)
COS A: Bonded Structure	CE A: Hybrid F&DT Substantiation	WE A: Composite Manufacturing Technology
COS B: HEWABI (High-Energy, Wide-Area Blunt Impact)	CE B: Advanced Composite Maintenance	WE B: Composite Structures Technology
COS C: Failure Analysis of Composites Subjected to Fire	CE C: Composite Structural Modifications	WE C: Composite Maintenance Technology
	CE D: Composite Quality Assurance	
	CE E: Bonded Structure Guidance	
	CE F: General Composite Structure Guidance	
	CE G: Engine Guidance	

# COS Initiatives

- **Three COS items in the Composite Plan:**
  - A. Bonded Structure
    - Bonded repairs
    - Bond quality control
    - Sandwich disbond growth
  - B. HEWABI (high-energy, wide-area, blunt impacts)
  - C. Failure analysis of composites subject to fire

# COS A, Bonding

- **The Bonding initiative encompasses three distinct sub-subjects**
  - Bonded Repairs
  - Bond Quality Control
  - Sandwich Disbond Growth
- **Background, Bonded Repairs**
  - The bonded repair process for both composites and metals is operator and process dependent, cannot be fully inspected after the fact, and is highly individualized due to lack of standard materials, processes and structural details. In addition, field data indicates potential problems in un-substantiated material & process substitutions, poor workmanship and unacceptable processing defects.

# COS A, Bonding

- **Background, Bond Quality Control**

- The NTSB has cited metal bond processes, environmental durability and weak bonds as contributing factors in multiple incidents and accidents, including the Aloha Airlines accident in 1988 and rotor blade failures of several helicopter accidents. Efforts are underway to benchmark best industry practices, update testing standards for both metal and composite bonding for environmentally driven degradation, and to publish corresponding industry guidelines.

- **Background, Sandwich Disbond Growth**

- A lost-rudder incident of an Airbus A310 aircraft that occurred in 2005 led to an emergency AD and other methods to mitigate corresponding safety risks. Forces generated from the rudder going into flutter overloaded the vertical fin to near failure. A NASA, FAA, and Industry effort is underway to develop standards and guidelines to control disbond growth for sandwich structures.



# COS A, Bonding

- **FAA Deliverables**

- Revise Advisory Circular (AC) 65-33, “Development of Training/Qualification Programs for Composite Maintenance Technicians” to include specific guidance on bonded structure FY2017
- Short Course for Bonded Repair Design, Substantiation, and Approval FY2018
- AC for Bonded Structure FY2020
- AC for Sandwich Structure FY2020

# COS A, Bonding

- **Prerequisite Industry Deliverables and Research**
  - Publication of the AC is dependent on successful completion of the following documents by industry groups: Best Practices in Bonded Repair (SAE), CMH-17 Repair Substantiation (CMH-17 Rev H), Standards for Metal Bond Process QC (ASTM D3762), Test Standards for Disbond Growth (ASTM) and CMH-17 Bonded Structure and Related Safety Risk Mitigation Guidelines (CMH-17 Rev H)
  - Numerous FAA research projects on bonded structure are underway and planned for the next few years
  - FAA also researching current maintenance instruction practices

# **AMTAS Research Supporting COS A, Bonding (includes sandwich structure)**

- **Improving Adhesive Bonding of Composites through Surface Characterization**
- **Development and Evaluation of Environmental Durability Test Methods for Composite Bonded Joints**
- **Effect of Surface Contamination on Composite Bond Integrity and Durability**
- **Durability of Adhesively Bonded Aerospace Structure**

# **AMTAS Research Supporting COS A, Bonding (includes sandwich structure)**

- **Evaluation of Notch Sensitivity of Composite Sandwich Structures\***
- **Effects of Moisture Diffusion in Sandwich Composites**
- **Delamination/Disbond Arrest Features in Aircraft Composite Structures\***

**\*Also supports CE A, Hybrid F&DT**

# Certifying a Bonded Joint

- **More than just adhesive characterization and qualification**
- **A bonded joint is made up of at least 5 elements – change any of them and you’ve changed the bonded joint design and certification**
  - Adhesive Material
  - Substrate Material
  - Surface Preparation
  - Cure Process
  - Joint Design

# Bonding AC Sections

- **Base Material and Process Selection / Screening**
- **Design, M&P Development**
- **Structural Substantiation**
- **Manufacturing**
- **Repair**

# Bond Material and Process Selection (M&P Screening)

- **Initial Evaluation of a Bonded Joint**
  - Processing Envelope Development
  - **Substrate Material Selection**
  - **Bond Process Screening / Design Detail Considerations**
  - Operating Envelope Development
- **More of a best practice in design and development / FAA expectations before approaching us**
- **Prefer to reference industry documentation**

# Advancing Design and M&P Development to Qualification

- **Start of “For Credit” Work**
  - Material Qualification and Specification Development
  - Process Qualification and Specification Development
  - Bond Inspection Considerations
  - Bond Design Detail Definition
  - Other Bond Design Considerations
- **A combination of certification and best design practices – still an opportunity for industry standardization**



# Structural Substantiation

- **Addressing Rules on Proof of Structure**
  - Building Block Overview
  - Certification Means of Compliance
  - **Element, Structural Detail and Subcomponent Levels of Testing**
  - Full Scale Testing
  - Guidance on Post-TC Change Certification
- **Based heavily on existing policy statement, with additional detail when possible**

# Manufacturing Implementation

- **Production and Scaling Considerations**
  - Overview / Process Control Mentality
  - Tooling
  - Process Verification
- **Best practices during design; some regulatory requirements for production approval**
- **Prefer to refer to industry documentation**

# Repair

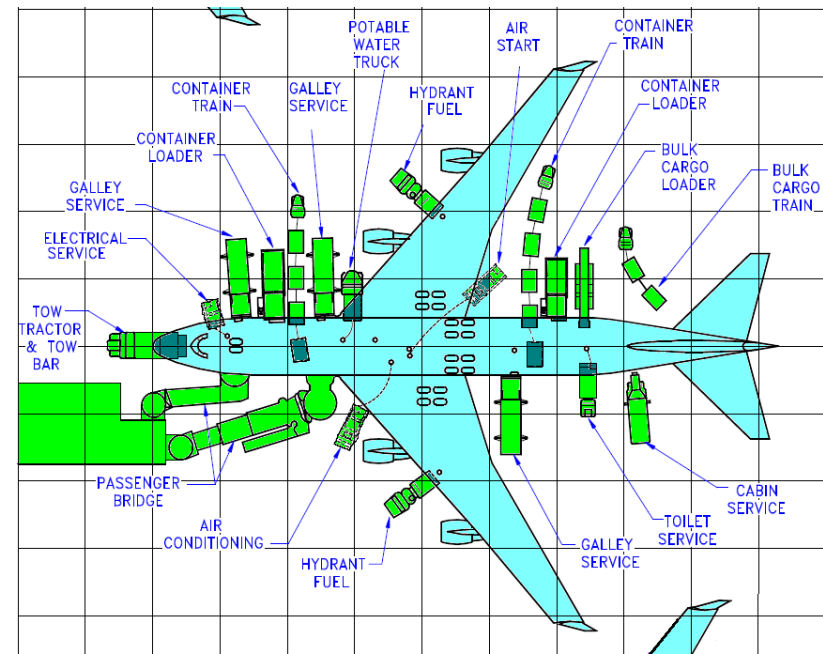
- **Repair Considerations *during the design and certification phase***
  - Types of repair
  - Design requirements
  - Substantiation
  - Considerations
- **Engineering substantiation expected in CMH-17**
- **Methods expected from SAE CACRC**

# COS B, HEWABI

- **Background**

The FAA is concerned with damage that occurs after part inspection when it is not visible to the naked eye. High-energy wide-area blunt impacts (HEWABI) are a type of this damage.

- Composite airframe structures may not show damage as readily as traditional metallic structures (less prone to plastic deformation / dents)
- In-service characteristic of transport airplanes where they are impacted by baggage carts and other service vehicles
- Also possible from damage in the factory or in production flight line
- In either case, reporting is essential for safety



# COS B, HEWABI

- **FAA Deliverables**
  - Policy requiring HEWABI evaluation during the certification of aircraft structures released 8/2016
  - Internal webinar FY2016
- **Prerequisite Industry Deliverables and Research**
  - The FAA will participate in the development of a chapter in CMH-17 specific to HEWABI to be used as future guidance for composite aircraft certification
- **The FAA is researching what additional risk mitigation activities can be taken**

# COS C, Failure Analysis of Surfaces Subjected to Fire after Part Failure

- **Background**
  - Composite structure that failed in an accident may be subjected to fire, changing failure surfaces and potentially masking clues that could identify the root cause for part failure or the extent of damage
- **FAA Research beginning this FY**



- **FAA Deliverables**
  - Failure Analysis Handbook FY2021

# Certification Efficiency Initiatives

- **Certification Efficiency (CE) initiatives capture best industry practices via regulatory guidance and industry standards documents.**
- **Goal is to standardize methods to certify composite structures and repairs which will address the current industry practice of using proprietary databases and advanced procedures.**

# Certification Efficiency Initiatives

- **Seven CE initiatives**
  - A. Hybrid Metallic/Composite Structure Fatigue and Damage Tolerance Substantiation
  - B. Advanced Composite Maintenance
  - C. Composite Structural Modification
  - D. Composite Quality Control
  - E. Bonded Structure Guidance
  - F. General Composite Structures Guidance
  - G. Engine Guidance
- **Additional standardization activities in the area of transport crashworthiness, fuel tank lightning protection, and composite flammability**



# CE A, Hybrid Structure

- **Background**

- Fatigue and damage tolerance (F&DT) engineering protocol for composite aircraft structures differ significantly from metal engineering practices. These issues must be considered for the substantiation of most modern structures that include a combination of composite and metallic parts and assemblies.

# CE A, Hybrid Structure

- **Deliverables**

- Policy on interpretation of existing amendment 25.571 for composite structure (timing to be coordinated with ARAC)
  - FAA “White Paper” 9/2016
- A new rule defining fatigue and damage tolerance requirements for the certification of composite transport aircraft FY2020
- Associated guidance for new part 25 rule FY2020

- **Prerequisite Industry Deliverables and Research**

- Publication of the policy is dependent on CMH-17 Rev H F&DT updates and ASTM test standards for laminate damage propagation
- All deliverables linked to the three-year ARAC Tasking formed 1/26/2015 under the Transport Airplane Metallic and Composite Structures Working Group

# AMTAS Research Supporting CE A, Hybrid Structure F&DT

- **Failure of Notched Laminates under Out-of-Plane Bending**
- **Delamination/Disbond Arrest Features in Aircraft Composite Structures\***
- **Evaluation of Notch Sensitivity of Composite Sandwich Structures\***

**\*Also supports COS A, Bonding**

# CE B, Advanced Composite Maintenance

- **Background**

- Title 14 CFR part 147 appendix B requires that composite materials be included in the curriculum, however, no guidance exists to define the level of detail or application

- **Deliverables**

- Update maintenance technician training requirements FY2017
- Update chapter in Order 8900.1, “Flight Standards Information Management System” outlining minimum curriculum requirements FY2017

- **Prerequisite Industry Deliverables and Research**

- The FAA is researching current maintenance instruction practices

# CE C, Composite Structural Modifications

- **Background**

- Non-OEM companies are applying to the FAA to modify critical composite structures, such as with installation of antennas on 787 or A350 aircraft. Many of these new applicants do not have experience in modifying critical composite structure, and assume their standard practices of reverse engineering can be applied. FAA offices have requested guidance on how to approve modifications to critical composite structure.

- **Deliverables**

- AC outlining best practices approving modifications to composite structure FY2018

- **Prerequisite Industry Deliverables and Research**

- None identified

# CE D, Quality Assurance Guidance

- **Background**

- Material and process control is essential to composite certification and continued airworthiness. The aviation industry continues to explore advanced design options which may not be able to utilize traditional quality controls, analyses, and accelerated test methods.

- **Deliverables**

- Write new AC to replace AC 21-26, “Quality System for the Manufacture of Composite Structures” and AC 21-31, “Quality Control for the Manufacture of Non-Metallic Compartment Interior Components”
- Revision to online job aid for audit and surveillance of composite repair facilities FY2018 (taking best practices from mfg oversight)

- **Prerequisite Industry Deliverables and Research**

- **AMTAS research advancing QA test methods may support this AC**

# CE E, Bonded Structure Guidance

- **Background**

- There is an existing part 23 policy memo covering bonded structure material and process, control, design, analysis, testing, manufacturing, and repair techniques. The policy will be expanded into an AC for all product types and there will be a companion AC for sandwich structure.

- **Deliverables**

- AC for Bonded Structure that includes Bonded Repair Best Practices FY2020 (Note this is the same deliverable as COS Initiative A)
- AC for Sandwich Structure FY2020 (Note this is the same deliverable as COS Initiative A)
- Other FAA guidance will be reviewed to determine effects from loss of prescriptive rule 23.573 in the part 23 rewrite

# CE F, General Composite Structure Guidance

- **Background**
  - With the evolving/advancing composite technology and expanding composite applications, AC 20-107 “Composite Aircraft Structure” will require revision
- **Deliverables**
  - Revision to AC 20-107, “Composite Aircraft Structure,” to incorporate advanced composite technologies and lessons learned FY2020
- **Prerequisite Industry Deliverables and Research**
  - Will incorporate latest information from industry documentation and FAA research



# AMTAS Research Supporting CE F, General Composite Guidance

- Safety and Certification of Discontinuous Fiber Composite Structures

***Since this is general guidance, AMTAS research that supports any of the other composite guidance will also have an influence on updates to AC 20-107C***

# CE G, Engine Installation Guidance

- **Background**

- Polymer matrix composite (PMC) materials have been approved in several engine applications and now ceramic matrix composite (CMC) materials are being approved as well. These approvals have been managed on a case-by-case basis, adapting existing composite guidance for composite aircraft structure. Unique concerns with engine applications would benefit from documenting standardized means of compliance for both PMC and CMC materials

- **Deliverables**

- New AC on certification of composite materials (PMC and CMC) in engine applications FY2019

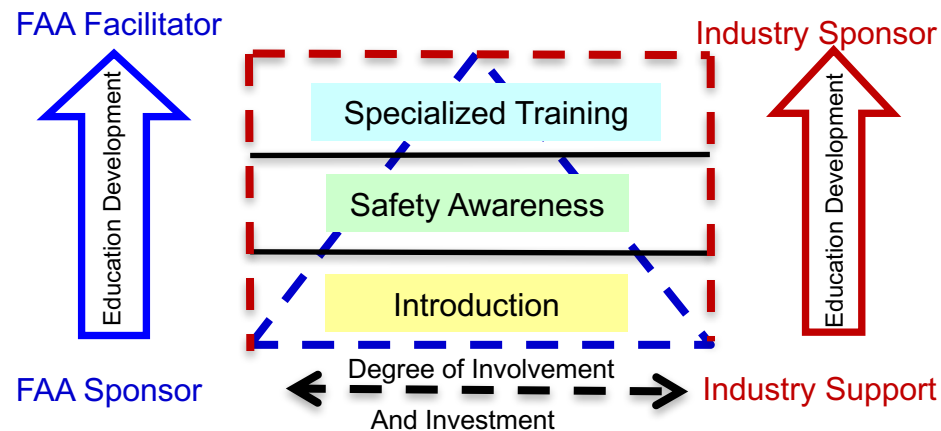
- **Industry Deliverables and Research**

- TBD

# Workforce Education Initiatives

- **An essential component for COS and CE is a comprehensive educational development program**
- **Successful composite safety and certification oversight is dependent upon our workforce being knowledgeable of both basic and advanced composite technologies and terminologies**
- **Availability of WE courses to industry helps ensure composite aviation safety awareness is considered for product research, development and implementation**

# Workforce Education Initiatives



- **FAA composite training strategy uses FAA Centers of Excellence & industry support**
- **Define three levels of competency:**
  - **Introduction** (“Composites 101”)
  - **Safety Awareness** (courses for each functional discipline)
    - Skills needed for FAA workforce supporting composite applications
  - **Specific Skills Building** (most courses developed by the industry)
    - Specialized skills needed in the industry and some FAA experts

# Workforce Education Initiatives

- **Three initiatives for FAA and industry to develop and update Level 1 and 2 training in:**
  - Composite Manufacturing Technology
  - Composite Structures Technology
  - Composite Maintenance Technology
- **AMTAS research indirectly affects updates to WE courses through advances in supporting standards and AVS deliverables**

# Detailed Links with AMTAS Research

- **Improving Adhesive Bonding of Composites Through Surface Characterization: Effect of Amine Blush, Peel Ply History, and Other Material or Process Key Issues on Bond Quality, UW**
  - Evaluate material and processing variables that lead to amine blush or peel ply challenges in a typical industry manufacturing production environment and identify key processing parameters and key characteristics that need to be controlled in materials and processes to avoid potential understrength or weak bonds
  - Document findings, together with past work on peel plies, to establish protocol for avoiding known bond surface phenomena that degrades structural performance
- **Development and Evaluation of Environmental Durability Test Methods for Composite Bonded Joints, University of Utah**
  - Investigate the potential for developing a composite bond standard for environmental durability testing that meets the needs of existing applications, ***integrating all other knowledge coming from other AMTAS researchers***
  - Document the key factors to control data analysis procedures and findings from tests performed with joints having different levels of structural bond integrity as reports that complement the international composite bond test standard

# Detailed Links with AMTAS Research

- **Effect of Surface Contamination on Composite Bond Integrity and Durability, Florida International University**
  - Understanding the factors leading to bond surface contamination, weak bonds, other undesirable bonding conditions, and the corresponding effects on structural performance and long-term durability (including the evaluation of cleavage mode bond failures with environmental exposures)
  - Documenting the industry best practices on process quality controls and other engineering measures that minimize the risk of structural weak bonds, with some emphasis of getting such information into CMH-17 (Rev. H)
- **Durability of Adhesively Bonded Aerospace Structures, Washington State University**
  - Investigate the various test and analysis methods that can be used to evaluate environmental effects and time-dependent static/durability performance of adhesives (with a range of toughness) used in existing aviation applications
  - Document key factors (design – bond-line thickness, temperature, ***stress level***) contributing to environment and time-dependent viscoelastic ratcheting effects in studying structural bond integrity, including ***screening test recommendations***

# Detailed Links with AMTAS Research

- **Evaluation of Notch Sensitivity of Composite Sandwich Structures, University of Utah**
  - Sandwich disbond test standards supporting the ongoing CMH-17 efforts for Rev. H
  - **Evaluation** of analysis used by industry for Category 2 and 3 large in-plane damage capability of *sandwich structures*, including complex structural loading
  - **Development** of building block test standards & related data analysis procedures to gain the structural data needed to support structural damage tolerance
- **Effects of Moisture Diffusion in Sandwich Composites, UW**
  - Perform analysis & tests to understand the moisture and liquid transport phenomena in sandwich composites as it affects loads, core degradation and properties
  - Document key factors (temp, MC) to be considered for loads causing disbond growth, changes in core material fracture properties, and sandwich design substantiation
- **Failure of Notched Laminates under Out-of-Plane Bending, Oregon State University**
  - **Evaluation** of industry analyses for Category 3 large damage capability of *discretely stiffened structures*, incl. complex structural loads & some matrix compression emphasis
  - **Development** of building block test standards and related data analysis procedures to gain the structural data needed to support structural damage tolerance



# Detailed Links with AMTAS Research

- **Delamination/Disbond Arrest Features in Aircraft Composite Structures, UW**
  - Current FAA guidance and best industry design practices used for bonded structures include structural redundancy. Perform tests and analysis to evaluate effectivity of mechanical fasteners to arrest disbond growth and the associated dependence on loads, design detail and process variables.
  - Document design/process guidelines, tests and analyses that help industry ensure that the intended use of fasteners meets the desired redundancy.
- **Safety and Certification of Discontinuous Fiber Composite Structures, UW**
  - Investigate the structural performance of discontinuous fiber material forms for applications selected by industry and document unique characteristics
  - Evaluate analysis and test procedures to quantify the effects of defects for such composite materials, documenting the strengths and limitations

# Summary

- **AMTAS research supports the FAA's AVS Composite Plan**
  - Detailed background for supporting industry standards and guidelines
  - Technical knowledge that supports industry compliance with regulations (e.g., process quality control, structural substantiation, design efficiency)