FAA Initiatives Relative to CACRC

Objectives

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

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

• 2018 AVS Composite Plan Update
  – Overview of progress and plans

• ARAC – 14 CFR 25.571 Damage Tolerance, Overview
  – Eric Chesmar will provide additional details

• ARAC - Part 145 Repair Station Certification and Oversite

• CMH-17 Substantiation of Bonded Repairs (SOBR) Update

• CMH-17 Double Vacuum bag Debulking (DVD)

• Discussion
Our World of Composites

- **COS**
  - **Continued Operational Safety**
    - Most critical/Defined by Field
    - Has high priority because it can change composite applications (CE and WE game changer)
    - All WG Members work together to avoid any potential problems

- **CE**

- **WE**
  - Workforce Education
    - Engineering
    - Manufacturing
    - Maintenance
    - Related integrations
    - Out-reach efforts for future needs

- **Certification Efficiency**
  - Complex for non-standard world
  - Must have functional integration
  - Product-specific relief
  - Evolving technology
  - Conservative practices for complex behaviors
## Overview FY2018

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Blue of interest to CACRC

Red – Small Change from Minneapolis
COS A, Bonded Structure

• The Bonding initiative encompasses three distinct sub-subjects
  – Bonded Repairs
  – Bonding Quality Control
  – Sandwich Disbond Growth

• FAA Deliverables
  – Short Course for Bonded Repair Design, Substantiation, and Approval FY2018
  – AC for Bonded Structure that includes Bonded Repair Best Practices FY2021
  – AC for Sandwich Structure FY2020
COS A, Bonded Structure

• Industry Deliverables and Research
  – Publication of the ACs 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 Risk Mitigation Guidelines (CMH-17 Rev H)
  – FAA research projects on bonded and sandwich structure are underway and planned for the next few years
    • FAA Tech Center: Bonded Repair Teardown – Access aging of bonded structure
    • NIAR researching current maintenance instruction practices.
      – Phase II, Task 1 – Data Review and Final Report Released 3/18
        » DOT/FAA/TC-17/63 Round Robin Evaluation of CACRC Bonded Repairs- Publicly Available
        » Brandon Saathoff POC replacing Dr. Lamia Salah
COS B, HEWABI

• FAA Deliverables
  – Policy requiring HEWABI evaluation during the certification of aircraft structures - released 8/2016
  – Internal FAA webinar FY2017 – Completed (to be presented in 2018)

• Industry Deliverables and Research
  – FAA has funded research - additional risk mitigation in this area
  – 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

• With the presentation of webinar, this initiative will be closed
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
  – Updated maintenance technician training requirements May 2017
  – Updated chapter in Order 8900.1, “Flight Standards Information Management System” outlining minimum curriculum requirements.
    • Delivered to AFS-300 in May 2017 but will not be added as an appendix to AC 43-3 due to the fact that new part 147 rulemaking has been put on hold indefinitely. Portions of the training requirements have been incorporated in AC 65-33, which was revised under COS A Bonded Structure.
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.

• **Deliverables**
  – AC outlining best practices approving modifications to composite structure 12/2018
  – Draft due 12/2017
    • Delivered to FAA Process on 2/2/2018
    • AC has sections for Modified Structure, New Parts, Interface Issues plus Appendix of Examples
    • About 75 pages long

• **Industry Deliverables and Research**
  – None
CE C: AC for Composite Modifications
(Most active AVS Composite Plan Initiative)

• New applicants to modify critical composite structures, such as with installation of antennas on 787 or A350 aircraft
• Safety risk with 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 (all product types)

• AC outlining best practices approving modifications to composite structure 12/2018
  ➢ Covers modifications to composite structure and/or installation of composite parts
  ➢ Teamed with TCCA (Future EASA help likely)
  ➢ FAA sponsored workshops in FY2016 – 2018
  ➢ Significant Industry participation by providing their best practices
  ➢ Four “risk levels” in work
Four Risk Levels (Draft sent to FAA AIR)

In order to assist a modifier with defining the appropriate regulatory requirements, this AC will use “Risk Levels”. These Risk Levels use the existing FAA risk-based approach, but are only for use with this AC. These definitions are not to be applied outside of this AC.

Risk Level 1 (high criticality) – Structure whose failure poses a direct risk to continued safe flight and landing. Referred to as “critical structures” in AC 20-107B, these load-bearing structures are essential in maintaining the structural integrity of the aircraft. This risk level includes “principal structural elements” as defined in several 14 CFR parts. These structures may or may not be subject to fatigue and damage tolerance requirements, as defined in each part.

Risk Level 2 (medium/high criticality) – Structure or parts whose failure poses an indirect risk to continued safe flight and landing, or a risk to passengers or crew.

Risk Level 3 (medium/low criticality) – Structure whose failure does not pose a risk to continued safe flight and landing, or to passengers or crew. Failure of these parts would be inconsequential from a structural perspective, but may have other performance requirements.

Risk Level 4 (low criticality) – Parts whose failure does not pose a risk to continued safe flight and landing, or to passengers or crew. Commonly referred to as “non-structural parts,” these parts do not carry primary flight, ground, crash, or pressurization loads (excluding inertial loads for carrying their own weight or typical flight vibration). Failure of these components would be inconsequential from a structural perspective but may have other performance requirements.
CE E, Bonded Structure Guidance

• **Background**
  – There is an existing part 23 policy memo (PS-ACE100-2005-10038) 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 FY2021 (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 14CFR 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 FY2022

• Industry Deliverables and Research
  – Will incorporate latest information from industry documentation and FAA research
WE B, Composite Structures Technology (CSET)

• Background
  – The Composite Structural Engineering Technology (CSET) course will be updated every four years.
  – Update the structural DER seminar content on a recurring basis
  – Class currently being taught. Started February 2018 through NIAR

• Deliverables
  – Updated CSET course with revised content, lesson plans and a job aid Fall FY2018
WE C, Composite Maintenance Technology (CMT)

• **Background**
  - Revise Flight Standards Service’s course “Composite Awareness for the Aviation Safety Inspector,” on a five year basis (was last updated in 2015)
  - Additional directed training necessary for repair facility oversight

• **Deliverables**
  - Course development request FY2019
  - Developed a computer-based short course for Aviation Safety Inspectors that have oversight responsibilities for complex composite repair facilities
    - Milestone met, but training is on hold due to AFS reorganization training priorities
Activity Related to Composites:

- FAA revised parts 23, 27, and 29 and related guidance material, including AC 20-107
- In June of 2009, FAA sought public comments on whether future rulemaking is needed related to composites
  - Need for improved guidance material and possible rulemaking
- FAA tasked ARAC on January 26, 2015, to provide recommendations on DT and fatigue requirements
  - Rules are metal-centric
  - Composites have been used since 1980s, but today more PSEs are made from composite materials
  - Testing of composites poses technical and economic concerns
Tasking to TAMCSWG (Transport Airplane Metallic and Composite Structures Working Group)

- Determine if changes are necessary based on an evaluation of parts 23, 27, and 29 (Task 1)
- Provide rule and guidance recommendations (Tasks 2, 3, and 4)
- Provide recommendations on costs and benefits (Task 5)
- Write a report (Task 6)
- Address any FAA questions on report (Task 7)
Summary

• § 25.571 is a metal-centric rule
• TAMCSWG recommends some strategic rule changes
  – Remove metal-centric characteristics
  – Revise threat assessment
  – Revise inspection threshold requirement
  – Revise full-scale fatigue test evidence requirement
  – Revise requirement for establishing LOV
• Enhance guidance to reflect industry practice
  – Allow engineering freedoms with limited guidance constraints
• Recommend new tasking to address single load path structure
• Report expected in summer of 2018
ARAC - Part 145 Cert and Oversight

• SUMMARY:
  – The FAA has assigned the Aviation Rulemaking Advisory Committee (ARAC) a new task to provide recommendations regarding the agency's guidance on the certification and oversight of all part 145 repair stations. This notice informs the public of the new ARAC activity and solicits membership for the new Part 145 Working Group.

• The Tasks:
  1. Perform a comprehensive review of internal and external guidance material, in relation to the current laws and regulations, that pertain to certificating and overseeing all part 145 repair stations.
  2. Develop recommendations on improvements to Internal and external guidance material and provide oversight by the FAA's domestic and foreign workforce vis-à-vis the amount, type, scope, and complexity of work being performed and the certificate holders' size.
  3. Develop a preliminary and final report containing recommendations based on the analysis and findings.

• Schedule:
  – The preliminary report is to be submitted no later than 24 months from the first meeting of the Part 145 Working Group. The final report will be submitted no later than 12 months after the preliminary report is forwarded to the FAA by ARAC.
  – The FAA must receive all requests by February 20, 2018. The ARAC and the FAA will review the requests and advise you whether or not your request is approved.
CMH-17 Substantiation of Bonded Repairs (SOBR) – Volume 3, Chapter 14 Rev.H Update

- **Summary of SoBR-WG/TG Accomplishments**
  - Roughly 70% Complete
    - Proposed updates presented to Yellow Pages (YP)
    - Comments received, incorporated and re-submitted
    - Major focus on Ch.14.6-Repair Design and Substantiation
  - Ch. 14.7- Repair analysis TG
    - Meetings with a handful of participants ongoing
    - Strategy for placement of stress methods unique to repairs only.
    - Common analysis methods with Bonded Joint Design (Ch.10) and Bolted Joint Design (Ch11) will be referenced.
    - Coordination with Ch.10 & Ch.11 authors initiated.
# CHAPTER 14  SUPPORTABILITY, MAINTENANCE, AND REPAIR

14.1 INTRODUCTION – Previously submitted to Yellow Pages  
14.2 IMPORTANT CONSIDERATIONS – Previously submitted to Yellow Pages  
14.3 IN-SERVICE EXPERIENCE – Previously submitted to Yellow Pages  
14.4 INSPECTION – Previously submitted to Yellow Pages  
14.5 DAMAGE ASSESSMENT – Previously submitted to Yellow Pages  
14.6 REPAIR DESIGN & SUBSTANTIATION  
14.6.1 Introduction - Previously submitted to YP  
14.6.2 Prerequisites for Composite and Metalbond Structural Repair - Previously submitted to YP  
14.6.2.1 Approved data  
14.6.2.2 Material and Process Specifications  
14.6.2.3 Qualified materials  
14.6.2.4 Raw materials handling and storage  
14.6.2.5 Work space control  
14.6.2.6 Contact and non-contact materials  
14.6.2.7 Equipment calibrations  
14.6.2.8 Engineer/technician qualifications and training  
14.6.3 Repair Design - Previously submitted to YP except labeled In work  
14.6.3.1 Design Criteria  
14.6.3.2 Repair Design and Processing – In work (DVD Incorporation?)  
14.6.3.3 Sandwich Structural Repairs  
14.6.3.4 Repair Quality Assurance  
14.6.4 Repair Substantiation – Previously submitted to YP except labeled In work  
14.6.4.1 Introduction  
14.6.4.2 Building Block – In work  
14.6.4.3 Approved Data  
14.6.4.4 Test Program to Support Analysis  
14.6.4.5 Substantiation by Test Only  
14.6.4.6 Requirements  
14.6.4.7 Guidance and Policy Statements  
14.6.4.8 Structural Criticality Assessment  
14.6.4.9 Temporary Repairs  
14.6.4.10 Continued Airworthiness  
14.6.4.11 Interdependencies – In work  
14.7 REPAIR OF COMPOSITE STRUCTURE – Outlines submitted for YP  
14.7.1 Introduction  
14.7.2 Bolted Repair Analysis – In work  
14.7.3 Bonded Repair Analysis – In work  
14.8 COMPOSITE REPAIR OF METALIC STRUCTURE  
14.9 MAINTENANCE DOCUMENTATION  
14.10 DESIGN FOR SUPPORTABILITY  
14.11 LOGISTICS REQUIREMENTS  
14.12 BONDED REPAIR CASE STUDIES – In work  
14.12.1 Introduction
CMH-17 REV H, Ch14.7.2 Updates – Bolted Repair Outline

14.7.2 Bolted Repair Analysis

14.7.2.1 Design of Bolted Joints
   a) Geometry
   b) Lay-up and Stacking Sequence
   c) Fastener Selection
   d) Shim Selection

14.7.2.2 Analysis of Bolted Joints
   a) Load Sharing in a Joint
      i) Fastener Flexibilities
      ii) Analysis Methods
   b) Bolted Joints Laminate Strength Analysis
      i) Failure Criteria
      ii) Bypass Loads
      iii) Bearing/Bypass Interaction
      iv) Influence of Bending
      v) Analysis of a Local Failure
   c) Fastener Strength analysis
      i) Shank Shear
      ii) Bolt Bending
      iii) Axial Tension and Tension/Shear Strength
      iv) Fastener Pull Through
      v) Hard Point Analysis and Guidelines

14.7.2.3 Fatigue Effects on Bolted Joints
   a) Influence of Loading Mode
   b) Influence of Joint Geometry
   c) Influence of Attachment Details
   d) Influence of Laminate Layup
   e) Influence of Environment
   f) Influence of Specimen Thickness
   g) Residual Strength

14.7.2.4 Test Verification

• Sections will contain only repair specific information. Methods common to Chapter 11 (Design and Analysis of Bolted Joints) will be referenced.
14.7.3 Bonded Repair Analysis

14.7.3.1 Design of Bonded Joints
   a) Geometry
   b) Lay-up and stacking sequence
   c) Materials

14.7.3.2 Load sharing in the repair
   a) Match original stiffness and strength or
   b) Does not match original stiffness and strength

14.7.3.3 Analysis of local failure
   a) Parent Structure
   b) Patch Structure
   c) Adhesive

14.7.3.4 Repair Analysis Approach- Factors
   a) Load Increase Factor (LIF)
   b) Finite Width Correction Factor (FWC)

14.7.3.5 Repair Analysis Approach – Solid laminate &
   Honeycomb, Away from fasteners
   a) Face sheet checks
     i) Original Panel Stiffness
     ii) Repair Laminate Stiffness
     iii) Repair Stiffness ratio check
   b) Laminate Strength, original part capability or
   c) Laminate Strength, applied internal loads

14.7.3.6 Analysis Approach – Solid laminate &
   Honeycomb, At fasteners
   a) Face sheet checks
     i) Original Panel Stiffness
     ii) Repair Laminate Stiffness
     iii) Repair Stiffness ratio check
   b) Laminate Strength, original part capability or
   c) Laminate Strength, applied internal loads

14.7.3.7 Test Verification

• Sections will contain only repair specific information. Methods common to Chapter 10 (Design and Analysis of Bonded Joints) will be referenced.
CMH-17 Rev H, Ch14.12 – Case Studies

Real world examples chosen:

• Case Study #1- Flap Wedge Damage, Metal Bond, Substitute Surface preparation
• Case Study #2 – Fuselage, Bonded Repair
• Case Study #3 – Horizontal Stab. Wet Layup
• Case Study #4 – Fuselage, Bolted Repair
Case Study #1- Flap Wedge Damage, Metal Bond, Substitute Surface Preparation

- Substantiation of Bonded Repair (SoBR) Working Group
  Proposed New Section §14.12 Case Studies

Example Case Study #1* – Flap Wedge Damage

  - Damage
    - Component: Outboard flap wedge
    - Sufficient damage to require full re-skin
  
  - Proposed repair - Replace skin and core per SRM except...
    - Substitute CCC in lieu of preferred PAA surface preparation
      - Scuff sand, chromate conversion coat (CCC), and adhesive prime in lieu of phosphoric acid anodize (PAA) was approved OEM process when PAA not practical
      - SRM instructions not component or assembly specific
      - Areas bonded consisted of entire spar to upper and lower skin
      - Repair procedure not approved by OEM for this scenario

- Case Study Origin: DOT/FAA/TC-14/20, Nonconforming Composite Repairs: Case Study Analysis, Nov. 2014
Case Study #2 – Fuselage-Bonded Repair

- **Component = composite fuselage**
  - Impact damage to fuselage side skin
    - Skin Thickness ≈ 3mm (0.12”)
    - Stringer thickness ≈ 2mm (0.08”)
  - Location visible on walk around
- **Damage description:**
  - Visible damage > SRM size limit
    - Delamination at up to 70% depth from OML
      - No skin penetration
    - Centered between stiffeners A and B
    - Mid frame-bay
    - Damage to skin only
      - No stringer or interface bond damage
Case Study #3 – Horizontal Stab. - Wet Layup

Final location:

Highly loaded area - relatively thick skin - no buckling prior to UL
10 – 13 ply skins - buckling of skin pockets between stringers allowed above LL

location of repair above stringer
Case Study #4 – Fuselage – Bolted Repair

- **Damage Description**
  - Component: Unpressurized Fuselage, Composite load carrying Structure
    - Co-cured Stringers, Metallic Frames
  - Damage:
    - VID Damage, larger than ADL
    - Between Frame A/B and Stringer 3/4
    - Damage to skin only
  - Visible at scheduled inspection (as well as walk around)

- **Available Procedure/Data**
  - SRM provides bolted repair guidelines in nearby bay
    - Metallic doubler (Ti Sheet) on composite skin
    - 130° shear head, Ti fasteners
  - No bolted repair procedures provided in SRM in bay of interest (@ VID damage)
• The double vacuum bag debulk (DVD) processing concept is one of several alternative approaches that has been investigated since the early 1980s in an effort to develop processes that would improve the overall quality of composite laminate repair patches for thicker laminates and wet lay-up laminates.

• The DVD wet layup process is a technique for removing entrapped air that causes porosity in standard wet layup laminates.
CMH-17 Rev H, Ch14.6 – DVD Process; Double Vacuum bag Debulking

• 14.6.3.2.4.3 Repair process:
Discussion:
Active Bonded Repair Initiatives

|---------|---------|---------|---------|---------|---------|---------|

**Bonded Repair Size Limits Policy:** Policy to mitigate bonded repair safety risks to critical structure (composites & metal) for all product types.

**CACRC Metal Bond and Composite Bonded Best Practices (AIRs):** Document best practices in metal bonding and composite sandwich bonded repair for previously substantiated repairs.

**CMH-17 Composite Repair Structural Substantiation (Vol. 3 Ch. 14):** Document recommended M&P specifications, qualification, design criteria, analysis and test protocol for bonded repair structural substantiation.

**AC 65-33 (Composite Maintenance Training Guidance) Updates:** Work with industry to update AC 65-33

**Best Practices in Bonded Repair:** Note to summarize and reference new international standards (SAE) and guidelines (CMH-17).

**Short Course for Bonded Repair Substantiation, and Approval:** Develop short course for training needed for regulatory and industry engineering designees involved in bonded repair design, structural substantiation, and approval.

**FAA/EASA/CAA/Industry Workshop** to review above Advances

**Research Support to Bonded Structure Initiatives, Including Bonded Repair:** Benchmark industry practices and identify potential safety problems to support the development of regulatory policy, guidance and training that mitigate risks. This research will also include inspection method and other maintenance technology evaluations.