FAA/EASA/Boeing/Airbus Damage Tolerance and Maintenance Working Group

Damage Tolerance and Maintenance Workshop

Chicago, IL
July 19, 2006

Tom Walker – NSE Composites

Outline

- Overview
- Progress to Date
- Future Plans
- Day 1 Wrap-up

Working Group Charter: Background

- Use of composite materials in transport aircraft is rapidly expanding.
- Damage tolerance and maintenance practices are key aspects of safety for composite primary structure
- Approaches are not standardized, with OEMs often using different design criteria, structural substantiation methods, and maintenance practices
  - An understanding of composite behavior is still evolving
  - Service history is limited
  - Composites have some substantially different attributes than metal, requiring unique considerations and procedures
- Different approaches are acceptable, but they should not lead to confusion and inconsistent field practices by operations and maintenance personnel.
- OEM coordination is needed to facilitate consistent communication with regulatory agencies, airline customers, and maintenance organizations.
  - Necessary to ensure that safety issues are well understood and adequate training is achieved

Working Group Charter: Objectives

1. Agree on the critical technical issues and areas of safety concern for transport aircraft with composite structure related to damage tolerance and maintenance
2. Identify key similarities and differences in methods used to substantiate damage capability for transport aircraft composite structures.
3. Identify the key elements necessary to substantiate maintenance inspection and repair procedures for composite aircraft structures.
4. Identify related content needs for appropriate approved source (OEM) documentation (MPD, SRM, etc.) focused on field safety issues.
5. Identify related content needs for the Mil-17 Damage Tolerance, Supportability, and Structural Safety chapters and the FAA composites maintenance training standards.
6. Identify areas for safety-related standardization of composite damage tolerance and maintenance approaches to be addressed by future working groups.

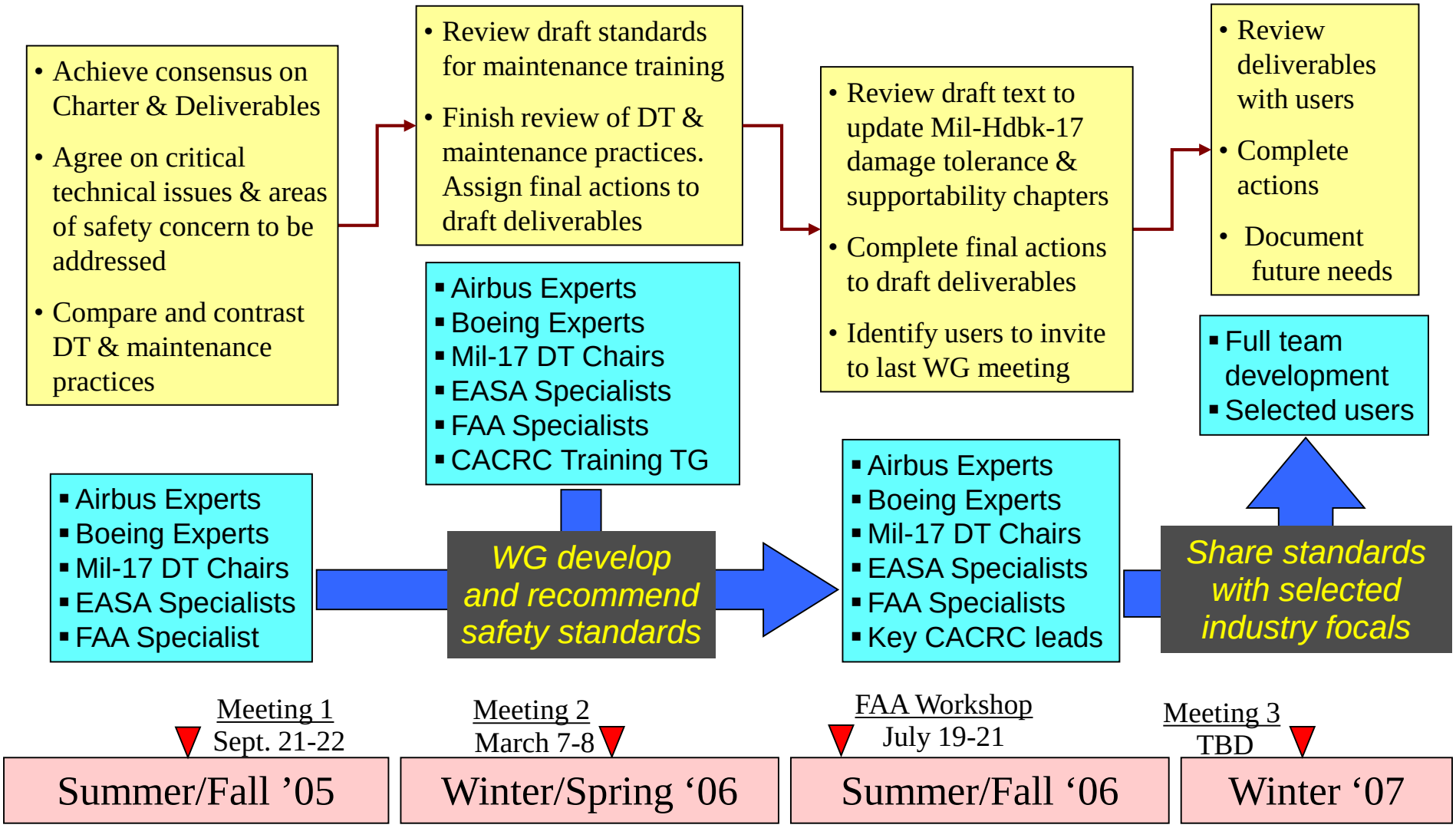
Key Participants

- FAA
  - Larry Ilcewicz
  - Angie Kostopoulos
  - Tom Walker (NSE)
- Airbus
  - Christian Beaufils
  - Chantal Fualdes
  - Roland Thevenin
  - François Smal
  - José-Carlos Gomez-Lopez

Mil-Handbook-17 Damage Tolerance Task Group Co-Chairmen

- EASA
  - Simon Waite
  - Jean Rouchon
  - Wim Doeland
- Boeing
  - Al Fawcett
  - David Polland
  - Gary Oakes

Approach and Timelines



Progress to Date

- Held two working group meetings
  - September 2005, Toulouse
  - March 2006, Seattle

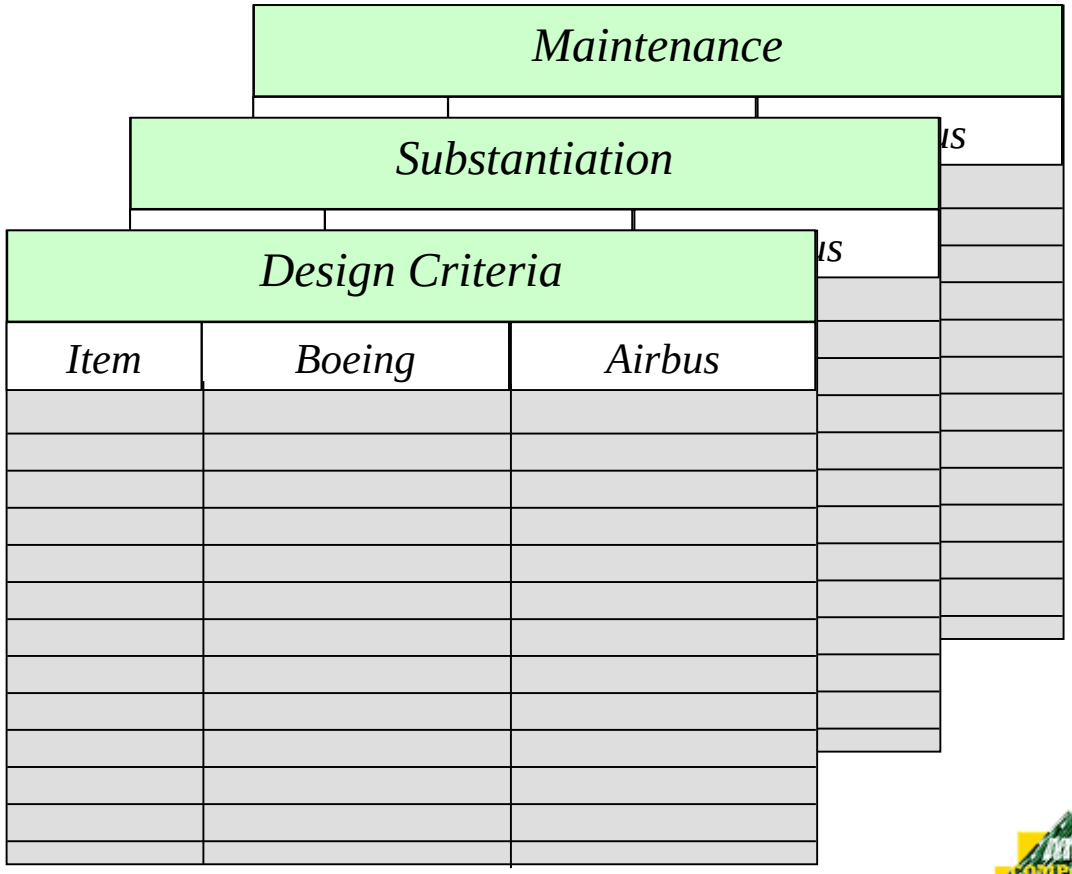
- Boeing and Airbus presented their practices in 3 major areas related to damage tolerance and maintenance
  - Damage tolerance requirements and design criteria
  - Engineering practices for structural substantiation
  - Maintenance practices

- Information summarized in an Excel spreadsheet to directly compare and contrast approaches

Compare & Contrast Spreadsheet

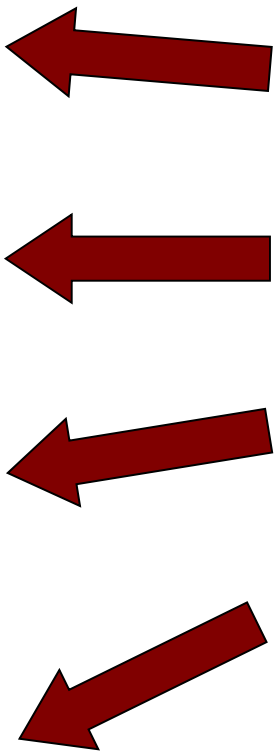
- One sheet for each major subject area

- Address major aspects of approaches
  - Not all-inclusive



Requirements and Design Criteria

- Damage Threat Assessment
- Ultimate Load Residual Strength
  - Explicit Considerations
  - BVID Implementation Details
- Limit Load Residual Strength
  - Explicit Considerations
  - VID Implementation Details
- Fail Safe & Obvious Damage
  - Large Damage Capability
  - Fail Safe Assessments
  - Bonded Joints
  - Attachments
- Continued Safe Flight and Landing
  - Explicit Considerations
  - Damage Details



Category 1: Damage that may go undetected by field inspection methods
Category 2: Damage detected by field inspection
Category 3: Obvious damage detected within a few flights by operations
Category 4: Discrete source damage and pilot limits flight maneuvers
Category 5: Severe damage created by anomalous ground or flight events

Engineering Practices for Structural Substantiation

- Strength Substantiation
  - Acceptable Manufacturing Anomalies
  - BVID
  - VID
  - Discrete Source Damage
  - Large-Scale Repeated Load Demonstration

- Repair Substantiation
  - Building Block Tests
  - Repair Analysis Correlation
  - Repeated Load Demonstration

Maintenance Practices

- Visibility / POD Approach
- Inspection Procedures
- Guidelines for ADL and Repair Limits (bonded and bolted)
- Fleet Leader Programs
- Inspection interval = f(damage criticality)
- Unsubstantiated maintenance repair/rebuilding in the field
- Engineer, Inspector, & Technician Training

Link with Mil-Handbook-17

- A major deliverable is to provide related content for Mil-17, Volume 3

- Content will be approved for public release by WG members
  - Details will probably be generalized and presented as “typical approaches” or “an example approach”

Mil-Handbook-17 Revised Volume 3 Outline (Rev. G)

1. General Information
2. Introduction to Composite Structure Development
3. Structural Certification and Compliance
4. Building Block
5. Materials and Processes
6. Quality Control of Production Materials
7. Design of Composites
8. Analysis of Laminates
9. Structural Stability Analyses
10. Bonded Joints
11. Bolted Joints
12. Damage Resistance, Durability and Damage Tolerance
13. Crashworthiness
14. Supportability
15. Thick Section Composites
16. Structural Safety
17. Environmental Management

Damage Tolerance Chapter Outline

12.1 Overview & General Guidelines

12.2 Aircraft Damage Tolerance

12.3 Types, Characteristics and Sources of Damage

12.4 Inspection for Damage

Most of changes will probably occur here

12.5 Damage Resistance

12.6 Durability (Damage Initiation)

12.7 Damage Growth under Cyclic Loading

12.8 Residual Strength

- 12.X.1 Influencing Factors
- 12.X.2 Design Issues and Guidelines
- 12.X.3 Test Issues
- 12.X.4 Analysis Methods

12.9 Applications/Examples

12.10 Supporting Discussions

Supportability Chapter Outline

14.1 Introduction

14.2 Design for Supportability

- 14.2.1 In-service experience
- 14.2.2 Inspectability
- 14.2.3 Material selection
- 14.2.4 Damage resistance, damage tolerance, and durability
- 14.2.5 Environmental compliance
- 14.2.6 Reliability and maintainability
- 14.2.7 Interchangeability and replaceability
- 14.2.8 Accessibility
- 14.2.9 Repairability

14.3 Support Implementation

- 14.3.1 Part Inspection
- 14.3.2 Damage assessment for composite repairs
- 14.3.3 Repair design criteria
- 14.3.4 Repair of composite structures

14.4 Composite Repair of Metal Structure

14.5 Logistics Requirements

- 14.5.1 Training
- 14.5.2 Spares
- 14.5.3 Materials
- 14.5.4 Facilities
- 14.5.5 Technical data
- 14.5.6 Support equipment

Mil-17 Updates: Key Additions

- Safety is achieved through the combined effort of design, manufacturing, maintenance, operations, and regulatory agencies
  - Each must understand the roles and responsibilities for all areas
- Each application must develop its own plan to achieve safety over the aircraft's lifetime, considering its unique aspects (design, threats, etc.)
  - Details associated with demonstrating compliance are not standardized
  - Damage threats and responses are not fully understood, so regulatory guidance material is necessarily general in nature, and must be interpreted for the specific application.
- All possible damages and their related requirements must be addressed
  - In general, 5 categories of damage exist. Their attributes are …
  - Strategies for addressing damage not considered during design (i.e., Category 5) are very important
  - Details associated with addressing different damage categories are interrelated
    - *e.g., considering more severe damage states for large damage may allow less conservatism in small damage*

Mil-17 Updates: Key Additions (con't)

- Areas of safety concern that are beyond what is included in current design and certification practice are …
- Typical industry practice for design criteria and demonstrating compliance is …
- To ensure safety, OEMs should be involved in the substantiation of all significant repairs
  - Significant amounts of data are needed for repair substantiation
  - OEMs are generally reluctant to share supporting databases
    - *loads, allowables, etc*

Mil-17 Updates: Other Needs

- Inspection
  - Clarification that “non-visible” does not imply “no action required”. Directed inspections are needed when “rogue” events occur (i.e., those beyond what was considered during design).
  - Need for inexpensive, quick methods to find non-visible damage that threatens Limit Load capability between flights
- Criteria and Compliance Issues
  - Additional emphasis on need to identify and address impact events that cause severe damage with low detectability … and some thoughts on what types of events might cause this (e.g., high-energy blunt impact)
- Training
  - Necessity for awareness training for operations and maintenance personnel

Mil-17 Updates: Other Needs (con't)

- Repair Sizing & Substantiation
  - Necessity for allowables (parent and repair materials) in repair design/substantiation
  - Clear description of requirements for test validation of repair materials, process, and concepts. It should address full spectrum of repairs (i.e., SRM to AOG), as well as practical compliance suggestions.
  - Desire / requirement to maintain Limit load capability if (bonded) repair departs the aircraft
- Structural Repair Manual
  - Clear explanation and/or example of process for determining ADLs, including zoning considerations
  - Description of the considerations in determining RSLs, including zoning

Comments & Discussion

Day 1 Wrap-Up

- FAA has two major research initiatives related to composites
  - Structural Integrity of Composites
  - Maintenance and Inspection
- Accomplishments have been summarized
- Remainder of workshop intended to expand the discussions on critical composite damage tolerance and maintenance issues
  - Thursday: Invited speakers on a range of applicable subjects
  - Friday: Breakout sessions allow for additional perspectives
  - “Categories of Damage” are good framework for discussions
- Input will help guide future FAA activities
  - Focus of existing research initiatives
  - Development of additional regulatory and guidance material