Composite Structure Engineering Safety Awareness Course

FAA Composite Initiatives: Perspectives on Material & Process Control

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Outline

- Composite Safety & Certification Initiatives
  - Background
  - Safety awareness training development plans
  - Structural engineering course development
- Composite material & process control
  - Importance to all phases of certification
  - Related composite guidance
  - Advances towards composite shared databases
- Workshop objectives

Ongoing FAA Composite Safety and Certification Initiatives

- Actively working with industry since 1999

- Composite educational strategies link to future initiatives
  - Justified to support training needs and help mitigate the risk of resource dilution with expanding applications
  - Pursuing effective ways to gather working knowledge by involving subject matter experts (SME) in training development

Composite Technical Thrust Areas

Advancements depend on close integration between areas

Material Control, Standardization and Shared Databases

Structural Substantiation

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

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

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

Flammability & Crashworthiness

Support to future cabin safety initiatives

Bonded Joint Processing Issues

Advanced Material Forms and Processes

Significant progress, which has relevance to all aircraft products, has been gained to date

Important Teammates

- NASA has been a leader for composite applications
  - Significant research support since 1970/1980s
  - AA587, A300-600 accident investigation
  - NCAMP * support to material standardization
- Partnerships with industry have been essential, **e.g., CMH-17, SAE P-17, CACRC, ASTM, SAMPE, AGATE, SATS, RITA, SAS/IAB/AACE**

Training
Databases
Standardization
Engineering guidelines

- DOD and DARPA research
- EASA and other foreign research/standardization

** Currently under the direction of Wright Patterson Air Force Base*

Safety Awareness Training Development Plans

- Three levels of composite training

Level III: Specialized Training	➢ Skill building in specialized areas ➢ Currently dominated by on the job training ➢ Industry leadership needed for future course development
Level II: Safety Awareness	➢ Understanding needed for safety & certification oversight ➢ FAA course development planned in 3 functional areas 1) Structural engineering 2) Maintenance 3) Manufacturing
Level I: Introduction to Composites	➢ Certification and composite technology application basics ➢ Intro to roles & responsibilities ➢ FAA developed CMH-17 certification tutorial

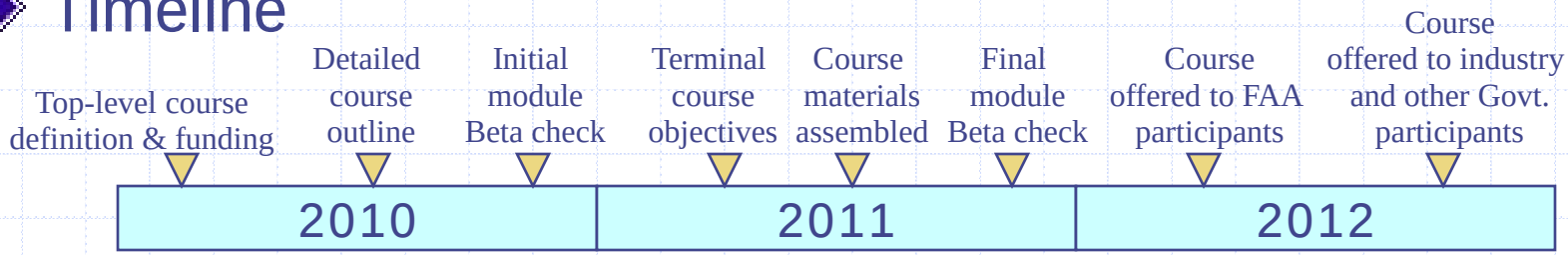
- Composite maintenance safety awareness course developed by the FAA and industry from 2005 to 2008
- Composite structural engineering & manufacturing safety awareness courses are currently under development
  - Current workshop to review composite material & process control module and some lab content for structural engineering course

Structural Engineering Course Development

- Top-level outline follows AC 20-107B (~60 classroom hr.)
  - Challenges with composite applications (2 hr)
  - 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 hr)
  - Manufacturing interface issues (1/2 day)
  - Maintenance interface issues (1/2 day)
  - Other: crashworthiness, fire safety & lightning strike protection (1/2 day)
- Course content/delivery options
  - Safety awareness level of training intended to provide balanced coverage of technical issues for composite structural certification and examples of *best* industry practice used to show compliance (not specific skill building)
  - Course supports the professionals in safety oversight positions
  - Online options appear to facilitate affordable/practical use of SME
  - Regional labs allow enough hands-on exposure to better understand composite technical issues

Structural Engineering Course Development

- Timeline



- Approach to course development
  - FAA is working with Wichita State University for course development
  - Plans to use SME to develop course materials and during case studies or practical problems used to assess student competency at the end of each module
  - Course materials will include documented references, lecture materials, expert testimonials, videos (demonstrations, SME discussion of the technical issues)
  - Terminal course objectives, “teaching points” and instructor’s manuals will be defined and made public to promote adoption by public teaching institutions
  - Workshops/beta course sessions involving SME and novice students will be used to evaluate course and lab content
  - Practitioners will review the course for relevance to industry applications
  - FAA will select the organization best suited to teach our workforce

Importance of Composite M&P Control for Certified Composite Products

- Composite M&P control starts by stabilizing the materials and processes used to make aircraft parts
  - Data collection to qualify materials & processes ("fingerprint" the variation in key properties and define related material & process controls that ensure part structural performance)
  - Control key material characteristics & process parameters to ensure part structural performance is maintained over time
  - Thorough documentation of acceptable material and process variations for repeatable product
- Standard (reliable & repetitive) test procedures are needed to avoid un-desired sources in variation
- CMH-17 statistical procedures form a basis to bound practical M&P controls

Importance of Composite M&P Control for Certified Composite Products

- Material and process specifications document the basic controls needed for reliable production
  - Material specifications are intended to ensure a reliable and repeatable source of raw materials
  - Process specifications help control the key characteristics, processing parameters and limits in anomalies that have been substantiated during product certification
- Manufacturing control of part processing steps, tooling, equipment and facilities further ensure the production of parts representative of those used in structural substantiation for product certification
- Unique M&P controls for some advanced material forms and emerging processing technologies require special considerations

Importance of Composite M&P Control for Certified Composite Products

- Structural building blocks include:
  - Strong links with material and process specifications
  - Lower level properties used to control materials & processes (other statistical parameters control M&P better than allowables)
  - Higher level structural design values linked with analysis supported by tests to cover all sources of variability in meeting requirements, objectives and design criteria
- Available composite shared databases acceptable to the FAA and other regulatory agencies have operating procedures linked to composite standards org.
  - Composite Material handbook 17 (CMH-17)
  - SAE P-17 and CACRC
  - ASTM D-30 (+ other test standards committees, e.g., ASTM D-14)
  - National Center for Adv. Material Performance (NCAMP)

Background in Shared Composite Material Databases & Related Guidance

- Mil-Handbook-17 (now CMH-17) has been pursuing composite material standardization and shared databases for some time
  - First PMC data set approved in 1990
- NASA/FAA/Industry efforts under AGATE accelerated the need for FAA policy on shared databases - 2000 *

1. Multi-batch material qualification to generate the database & set specs.
2. Equivalency ("mini-qualification") to sample and show you process the material to fall within the database population and, if desired, update specs. per your specific use of material as allowed within guidelines
3. Apply database to your product and continuously control the material

* Updated and officially released by Small Airplane Directorate in 2003 (contact Lester Cheng: 316-946-4111, lester.cheng@faa.gov)

- Mil-Handbook-17 Data Utilization WG initiatives in early 2000s and AGATE led to a need for FAA guidance on M&P specs, which are closely linked with material control for shared databases - 2003

Related Composite Guidance on M&P Specs: AC 23-20 (released in 2003)

To provide acceptance guidance on what should be included in material procurement and process specifications, or other documents, to ensure sufficient control of composite prepreg materials

- It helps *control and stabilize raw material,* which is needed for continued safe & reliable use of composites in aircraft products
  - Expanding applications, including the use of composites in other industries, is driving material supplier developments
- It promotes *consistent engineering practices,* which support requirements essential for base material control
- It prepares the FAA for *composite databases and specs shared throughout industry,* with the end result being the improved efficiency of suppliers, users and regulators

Technical Scope of the Bonded Structures Workshops in 2004

Material & Process Qualification and Control

Bonding applications where at least one side of the joint is metal or pre-cured composite

Manufacturing Implementation and Experience

Regulatory Considerations

- Proof of structure: static strength
- Fatigue and damage tolerance
- Design and construction
- Materials and workmanship
- Durability
- Material strength properties & design values
- Production quality control
- Instructions for continued airworthiness
- Maintenance and repair

General aviation, rotorcraft and transport aircraft

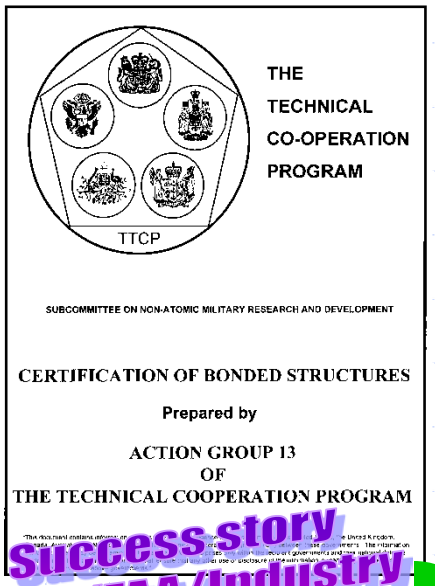
Design Development and Structural Substantiation

Commercial and military applications were reviewed

Repair Implementation and Experience

Progress for Bonded Structures
Action Groups for Detailed Documentation

- Some guidance for bonded structures, which comes from military and commercial aircraft experiences, are documented in a TTCP report
  - Chairman: Jack Lincoln, WPAFB
  - Composite and metal bonding
  - Starting point for FAA bonding initiatives
- FAA policy for bonded joints and structures was released in September, 2005


THE TECHNICAL CO-OPERATION PROGRAM

TTCP

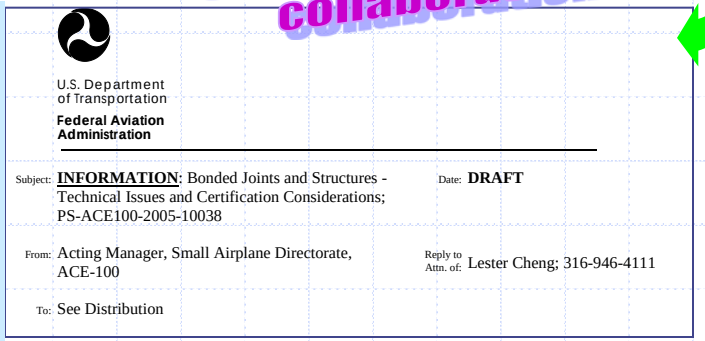
SUBCOMMITTEE ON NON-ATOMIC MILITARY RESEARCH AND DEVELOPMENT

CERTIFICATION OF BONDED STRUCTURES

Prepared by

ACTION GROUP 13
OF
THE TECHNICAL COOPERATION PROGRAM

Success story of DOD/FAA/Industry collaboration


U.S. Department of Transportation
Federal Aviation Administration

Subject: **INFORMATION**: Bonded Joints and Structures - Technical Issues and Certification Considerations; PS-ACE100-2005-10038

Date: **DRAFT**

From: Acting Manager, Small Airplane Directorate, ACE-100

Reply to Attn. of: Lester Cheng; 316-946-4111

To: See Distribution

Purpose

1. To review the critical safety/technical issues
2. To highlight some of the successful engineering practices employed in the industry
3. To present regulatory requirements and certification considerations pertinent to bonded structures

AC 20-107B*

Content increased from 0.5 to 4.5 pages

Para. 5: Material & Fabrication Development

- New subsection on material & process control
  (qualification, testing, equivalency sampling, shared data, M&P specifications, references to other FAA policy & AC 23-20)
  - Linking qualification data to spec requirements
  - Importance of environmental durability testing (e.g., metal bonding)
- New subsection on manufacturing implementation
- New subsection on structural bonding
  - Qualified materials and bonding processes (e.g., surface prep)
  - Critical bonding process steps to control
  - Review of options to ensure structural integrity of bonds
    i) structural redundancy ii) proof testing iii) advanced NDE
  - Action for adhesion failures noted in qualification tests or service
- Added thoughts on environmental durability testing
- Design values using parts from mature processes

* Published on Sept. 8, 2009

Advances Towards Composite Shared Databases

- FAA, NASA & DOD 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

2010 NCAMP AIR Policy Memo

- Acknowledges National Center for Advanced Material Performance (NCAMP) procedures as meeting FAR XX.603, XX.605 & XX.613 for basic material databases and M&P specifications
  - 15 years of experience under FAA oversight
  - Strong link to Composite Material Handbook 17 (CMH-17)
  - Strong link to SAE Committee P-17
  - Strong link to ASTM Committee D-30
- Promotes industry self-regulation thru NCAMP
  - Applicants must demonstrate equivalency in using NCAMP data and specs
    Primarily limited to lower levels of building block

Workshop Objectives

- To introduce FAA efforts to work with industry in safety awareness course development in areas of certified composite aircraft product applications
- To discuss critical issues in composite M&P control and benchmark related industry practices
- To review draft course and laboratory content in the M&P control module from the composite structural engineering safety awareness course
  - Including FAA personnel that developed related guidance
  - Including industry subject matter experts
  - Including candidate students with limited working knowledge of composite aircraft structures

9/16/10 Workshop Recap

- Workshop objectives were achieved
  - Draft development of M&P control module for Level II safety awareness course (structural engineering)
  - SME provided a good starting point for discussion of critical issues for composite M&P control
  - Further refinement of course content based on workshop discussions/survey/feedback
- Key content for composite safety awareness
  - Links with CFR and related guidance materials
  - Realization of current limits in composite standards as related to specific application needs
  - Awareness of real world problems and workable solutions to benchmark acceptable industry practice

9/16/10 Workshop Recap, cont.

- Next steps forward for structural eng. course
  - Refine M&P control module content based on workshop discussions/survey/feedback
  - Build additional course content based on *appropriate discussions from breakout sessions & labs* (several beyond M&P control module)
  - Development of detailed course objectives and content for other modules (most future beta course content reviews, without the benefit of workshops)
- Many thanks for your support to this effort
  - Each participant has brought unique background, ranging from very limited composite skills to *experts capable of Level III course development*