CMH-17 Support to CLEEN CMC Initiatives

Outline

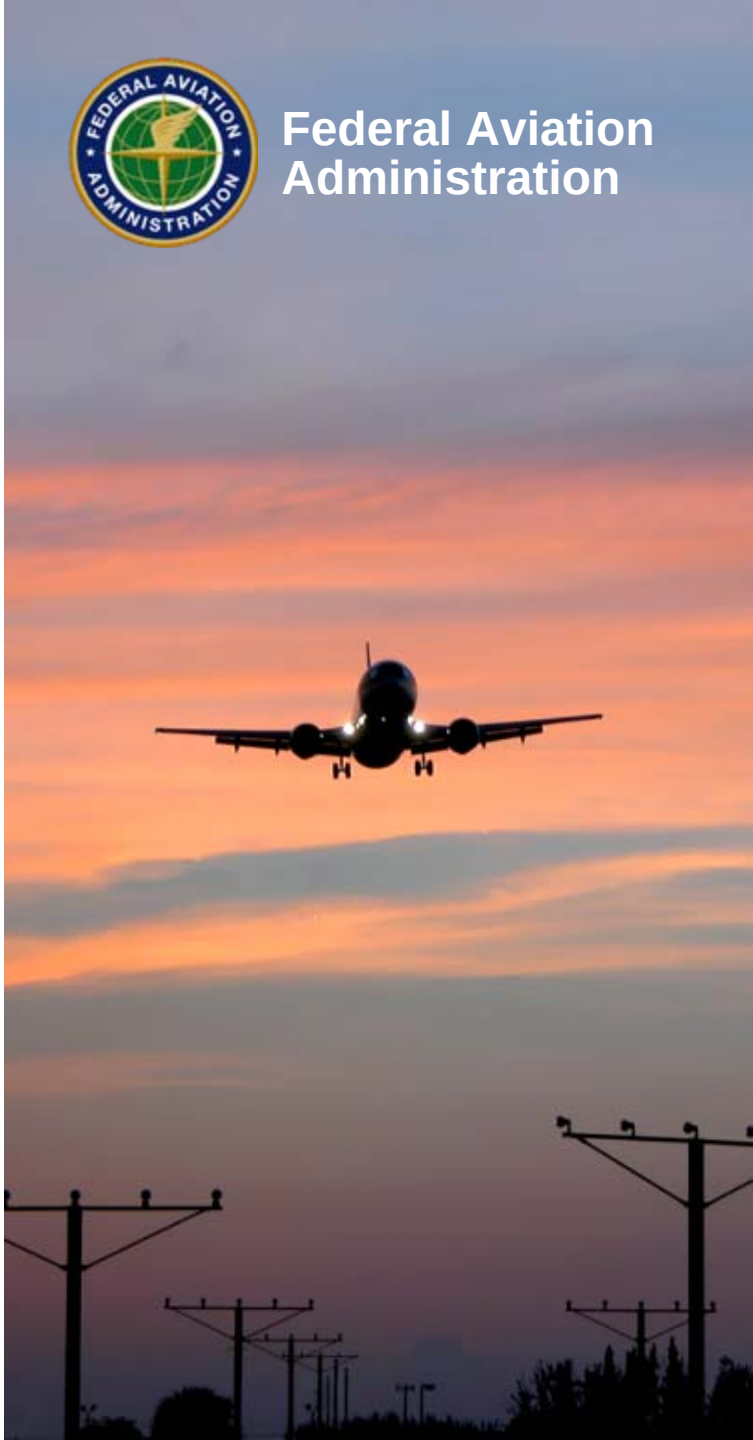
1) FAA Composite Education Strategy
2) CMH-17, Volume 3/Chapter 3
3) Perspectives on Stages of Product Development through Certification
4) Summary

Presented to: CLEEN CMC Materials Workshop

By: Larry Ilcewicz, FAA

Date: November 8, 2012

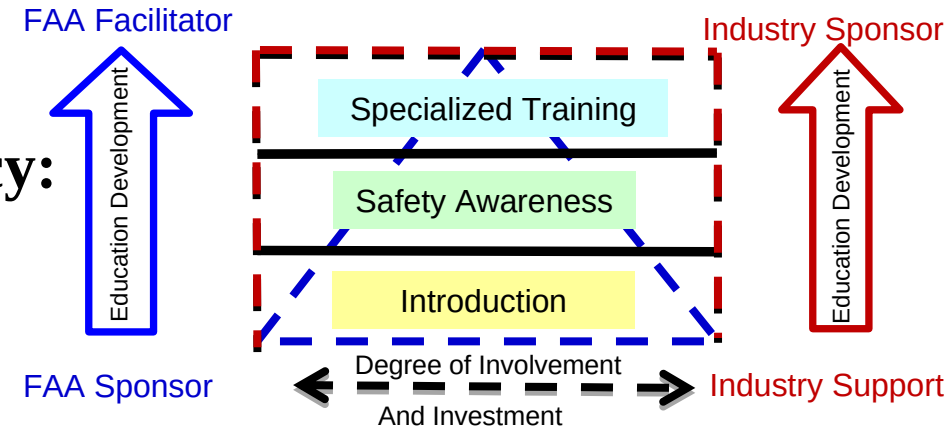
Federal Aviation Administration



Composite Educational Initiatives

FAA AVS Composite Training

- **FAA composite training strategy using existing courses, FAA COE & industry support** [Sept., 2009]
  - Courses to support airframe engineering, manufacturing and maintenance functional disciplines



- **Incl. three levels of competency:**

I) Introduction (common to all functional disciplines)
- Self-study intro content for composite basics/terminology
- CMH-17 Tutorial for composite certification & compliance [Aug, 2008]

II) Safety Awareness (courses for each functional discipline)
- Skills needed for FAA workforce supporting composite applications
- FAA development status summarized on the following charts

III) Specific Skills Building (most courses developed by the industry)
- Specialized skills needed in the industry & some FAA experts

Composite Educational Initiatives

Composite Level II Course Development Status

- Composite Safety Awareness for Maintenance/Repair [CACRC AIR5719]
  - FAA-led course development completed [Sept., 2008]
  - AFS-500 class-room version available to FAA [since 2009]
    - *~ 400 AFS ASI trained to date through FAA contract with ABARIS*
  - On-line version is also available to the industry thru WSU NIAR
- Composite Safety Awareness for Structural Engineering – *In work*
  - Development sponsored by FAA R&D COE & AIR-520
  - Detailed outline and Material & Process Control module [Sept., 2010]
  - Course content completed [Sept., 2012] and available in 2013
- Composite Safety Awareness for Manufacturing – *In work*
  - Development sponsored by FAA R&D COE & AIR-520
  - Detailed outline and key contractors [Sept., 2011]
  - Course content to be completed [Sept., 2013] and available in 2014
- Industry experts support course development and delivery

CMH-17 Volume 3, Chapter 3 (Revision G): Aircraft Structure Certification and Compliance

- **Motivated by several factors**
  - Provide CMH-17 with introductory composite certification roadmaps
  - Coordinate international harmonization on general composite guidance before updating AC 20-107A
- **Joint development under Airworthiness Task Group**
  (Lester Cheng & Angie Kostopoulos, FAA and Simon Waite, EASA)
  - TCCA and industry support in review
- **Top-level outline**
  - **3.1 Introduction**
  - **3.2 General certification discussions**
  - **3.3 Regulations**
  - **3.4 Design substantiation**
  - **3.5 Production**
  - **3.6 Maintenance**
  - **3.7 Guidance and reports**

Composites Education

CMH-17 Composite Certification Basics (*6-hour Tutorial)*

- **Based on New CMH-17 Volume 3, Chapter 3**
- **Available through CMH-17 at start of meetings**
  mj@materials-sciences.com (215) 542-8400
- **Content**
  - Initial airworthiness (design and production certification)
  - Continued airworthiness (maintenance and modifications)
- **Development process and implementation**
  - Course objectives based on CMH-17 content
  - Input from subject matter experts, with focus on structural substantiation
    - Larry Ilcewicz: FAA
    - Simon Waite: EASA
    - Hank Offermann: FAA (retired)
    - Charles Seaton: Wichita State University
- **Offered publically since 2008**

Certification and Continued Airworthiness

- **Certification**
  - Step 1: components of a product's design are qualified, conformed, and substantiated to get a ***Type Certificate*** (extensive FAA oversight)
  - Step 2: approval of the quality control system that ensures every product produced conforms to its type design leads to a ***Production Certificate***
  - During aircraft production and beyond, special design and production approvals are sought for changes, modifications, repairs, or improvements
  - Step 3: each aircraft must also have an ***Airworthiness Certificate***, which certifies it conforms to type design and is in safe operating condition
- **Service problems are addressed with industry during the aircraft's life**

Data, analysis & procedures defining the aircraft product and demonstrating it meets Federal Regulations

Repeatable production of certified aircraft products

Additional info may be needed for changes occurring during production or the product life cycle

Note: FAA doesn't certify supporting technology (e.g., test & analysis methods)

6-hour Tutorial Based on New CMH-17 Chapter Aircraft Structure Certification & Compliance

- **Module 2 Certification (Section 3.2)**
  - Initial airworthiness
  - Continued airworthiness
  - Production modification
  - Qualified workforce and teamwork
- **Module 3 Regulations (Section 3.3)**
  - Structure, design & construction
  - Production approval
  - Maintenance and repair
- **Module 4 Design Substantiation (Section 3.4)**
  - Design & process documentation
  - Materials & adhesives qualification
  - Environmental exposure
  - Structural bonding
  - Tooling & part cure processes
  - Defect detection overview
  - Structural conformity
  - Flutter substantiation (aero stability)
  - Thermal issues (incl. fire safety)
  - Structural substantiation (static, fatigue & damage tolerance)
  - Lightning strike protection
  - Crashworthiness

Green text important to initial CMC applications

Emphasized in current tutorial

6-hour Tutorial Based on New CMH-17 Chapter Aircraft Structure Certification & Compliance

- **Module 5 Production Essentials (Section 3.5)**
  - Fabrication and production substantiation
  - Production implementation issues
  - Manufacturing quality control
  - Defect disposition requirements
  - Modifications in the production process
- **Module 6 Maintenance (Section 3.6)**
  - Continued airworthiness
  - Substantiated repair designs
  - Importance of teamwork
  - Damage detection and characterization
  - Bonded and bolted repair processes
- **Guidance and reports by regulatory bodies**

Green text important to initial CMC applications

Importance of Standards Organizations

- **Primary organizations currently active**

CMH-17
COMPOSITE MATERIALS HANDBOOK

ASTM INTERNATIONAL

Some Existing Standards
Databases
Test Methods
Engineering Guidelines
Analysis Protocol
Process Methods
Training

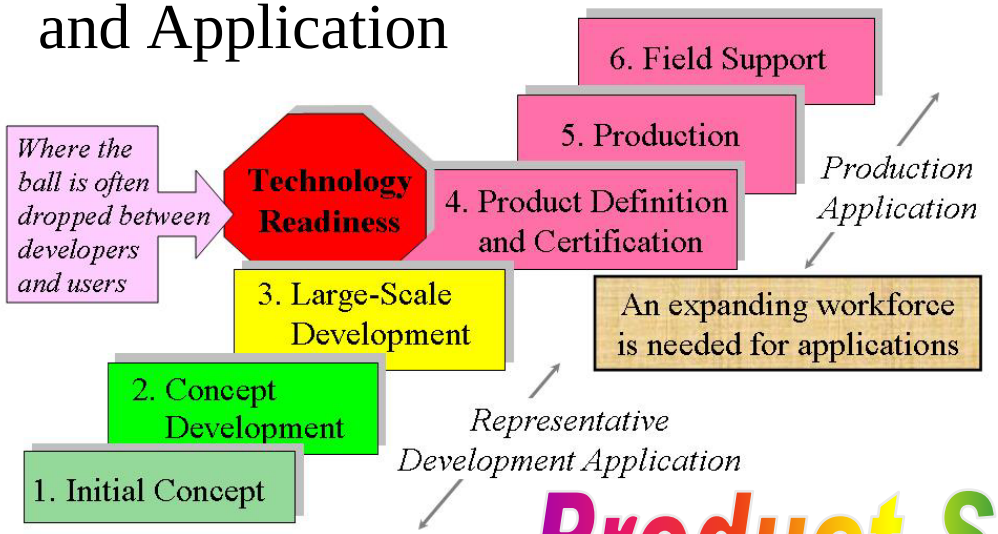
SAE INTERNATIONAL

COMMERCIAL AIRCRAFT COMPOSITE REPAIR COMMITTEE
ata
IATA
SAE

- **Current cost model for these organizations relies on volunteer technical support**
  - Some reluctance to accelerate efforts for several reasons (e.g., proprietary investments, job security, technical disagreement)
  - FAA has maintained a direct leadership role in CMH-17/SAE P-17 and indirect leadership role in SAE CACRC

Different Types of Scaling to Support Applications

Six Stages of Technology Development and Application



Size Scaling

Efforts to apply information at one scale of study to predict the behavior at a larger, more complete level

Product Scaling

Efforts to verify a technology basis, which links design components, factory process cells, maintenance procedures, and cost evaluations

References for charts 32 through 36

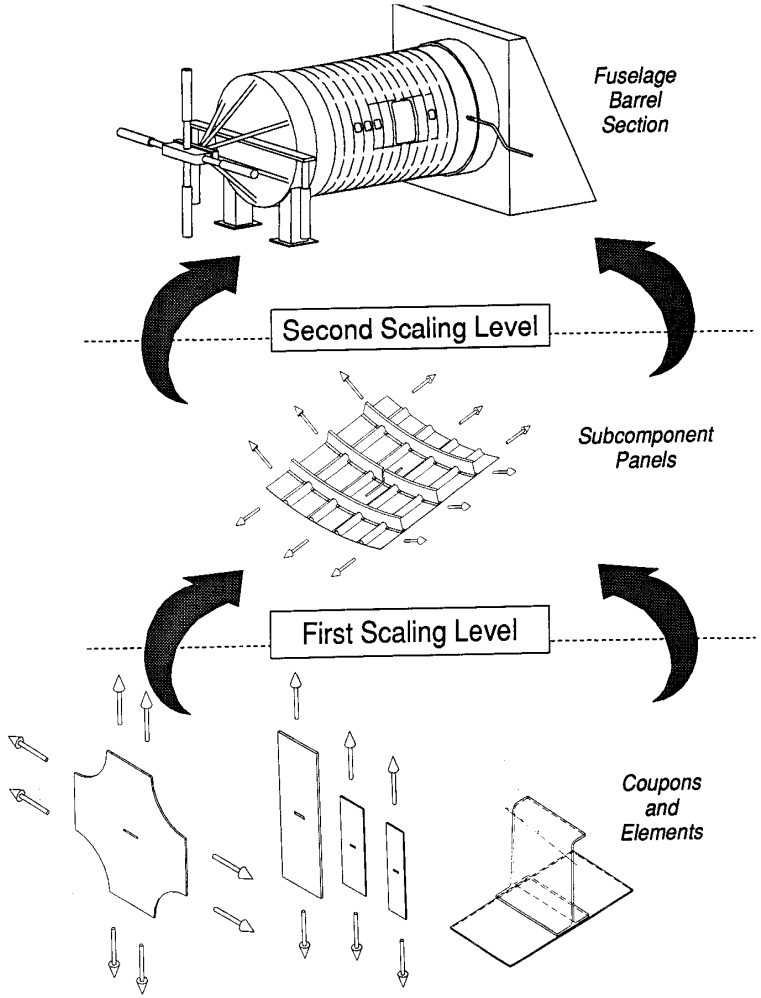
a) "Composite Technology Development for Commercial Airframe Structures," L.B. Ilcewicz, Chapter 6.08 from *Comprehensive Composites* Volume 6, published by Elsevier Science LTD, 2000

b) "Composite Applications in Commercial Airframe Structures," L.B. Ilcewicz, D.J. Hoffman, and A.J. Fawcett, Chapter 6.07 from *Comprehensive Composites* Volume 6, published by Elsevier Science LTD, 2000

Examples of Size Scaling

- **Manufacturing**
  - Process development
  - Tooling trials
  - Material & process control
- **Structures**
  - Design criteria, requirements and objectives
  - Building block tests & analysis, including the effects of environment and damage
- **Maintenance**
  - Inspection procedure development
  - Repair process development
  - Repair building block tests & analysis
- **Manufacturing, structures and maintenance methods & procedures**

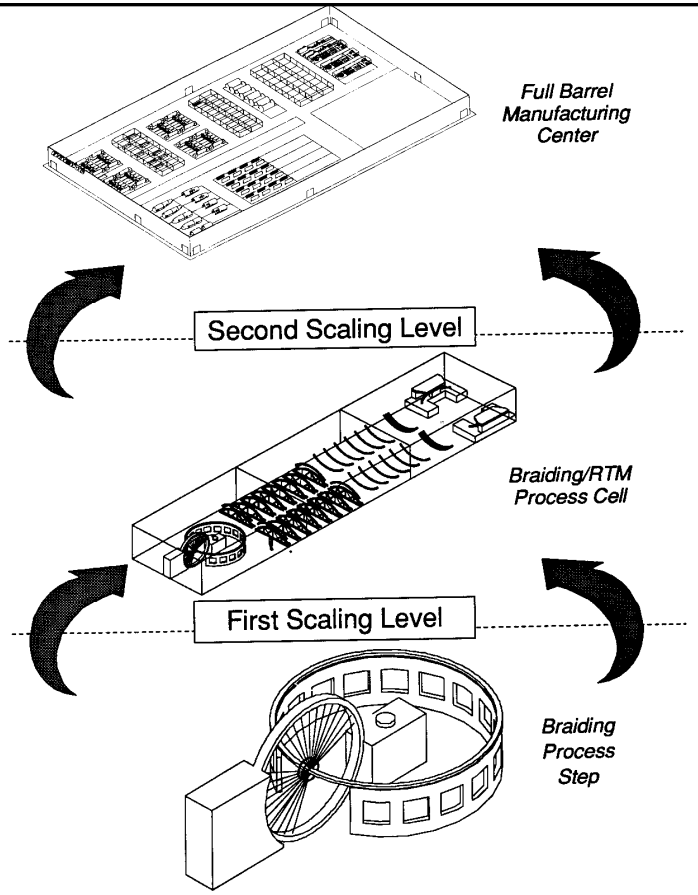
Example: Fuselage Damage Tolerance



Examples of Product Scaling

- **Product Viability**
  - Direct operating costs (acquisition, fuel, maintenance)
  - Performance (range, payload, speed)
  - Market (# aircraft, timing, external factors)
- **Factory Definition**
  - Floor space and process flow
  - Quantity of equipment and tools
  - Quality and process controls
  - Staffing needs
- **Certification**
  - Design, manufacturing, and maintenance definition/documentation
  - Design, manufacturing, and maintenance verification (material qualification, mfg. conformity and structural substantiation)

Example: Braided/RTM Fuselage Frames

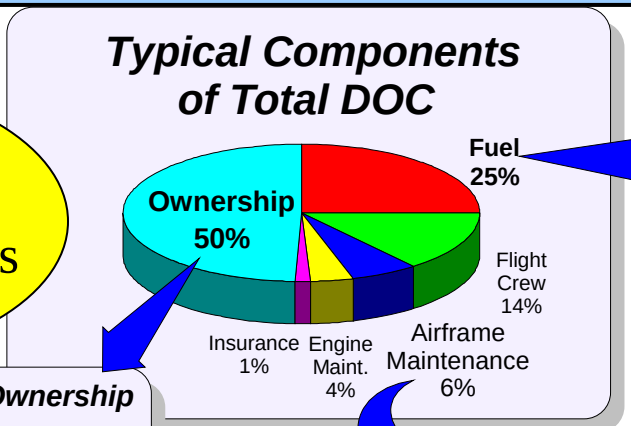


Product Value Assessment of New Technology (1995 calculations)

Composite technology is of interest in new aircraft products of all types because it can help decrease total direct operating costs (DOC) in 3 key areas (see example below from transport aircraft)

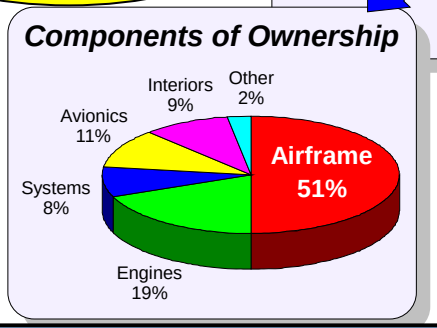
Note % fuel costs based on 1995!!

(1)
Potential for lower manufacturing costs



Life-cycle cost related to structural weight savings

(3)
Proven weight savings reduce fuel costs



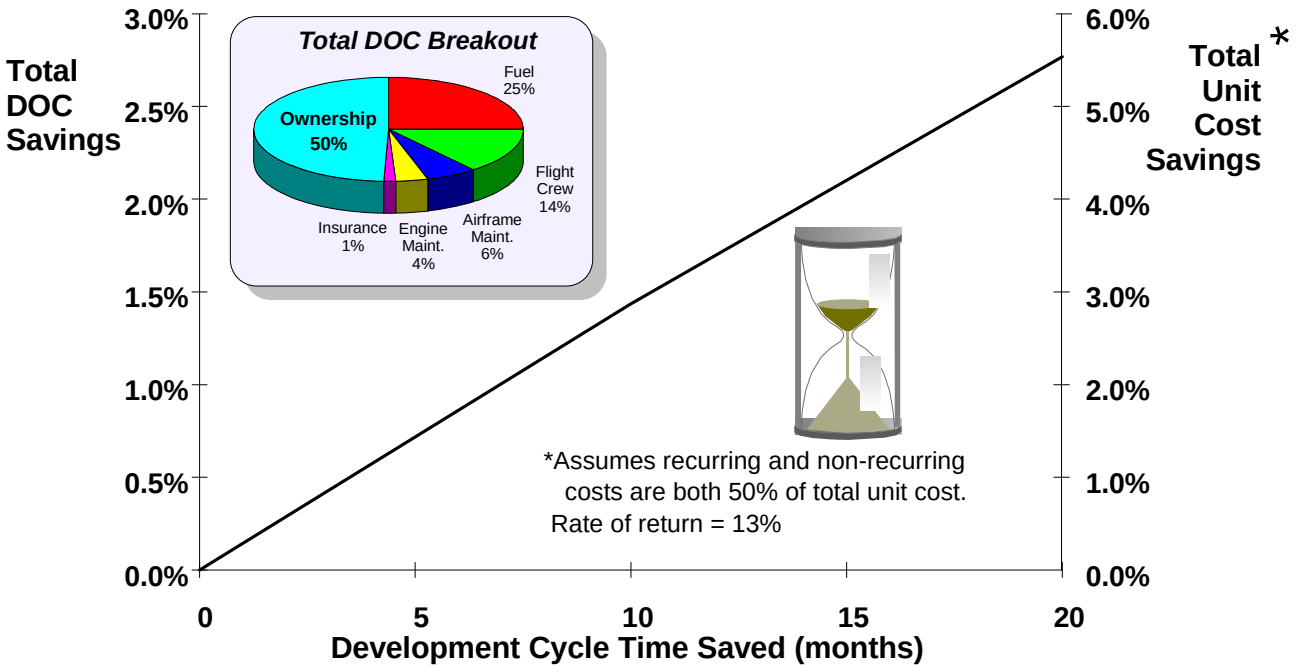
Life-cycle cost related to structural reliability, inspectability, and repairability

(2)
Potential for lower maintenance costs

Total DOC savings on the order of 5 to 8% appear possible with composites applied to both transport wing and fuselage

Reduced Cycle Time to Market is Equally Important to Increased Product Value

Unless new composites technology becomes as assessable to the engineering community as metals, Total DOC benefits are lost



Ilcewicz Opinion

Lack of composite standardization and engineering resource dilution pose serious safety & certification issues and limit aircraft product applications

Summary

- **CMH-17 Volume 3, Chapter 3 provides introductory thoughts on issues addressed during "composite certification"**
  - Not all areas need to be addressed for all parts in an aircraft or engine
  - A tutorial also exists for introductory training purposes
  - CLEEN Consortium focus on areas that can be shared independent of specific parts can be pursued through CMH-17 Vol. 5 development
- **New technology development is one of the biggest challenges approaching implementation of advanced parts in certification of an aircraft or engine**
  - Timing must be driven by practical developments to a scale that allows repeatable, reliable and safe implementation
  - Viable business strategies, including technical and financial benefits, must be considered for a successful product introduction