FAA Composite Safety Awareness Course Developments

Outline

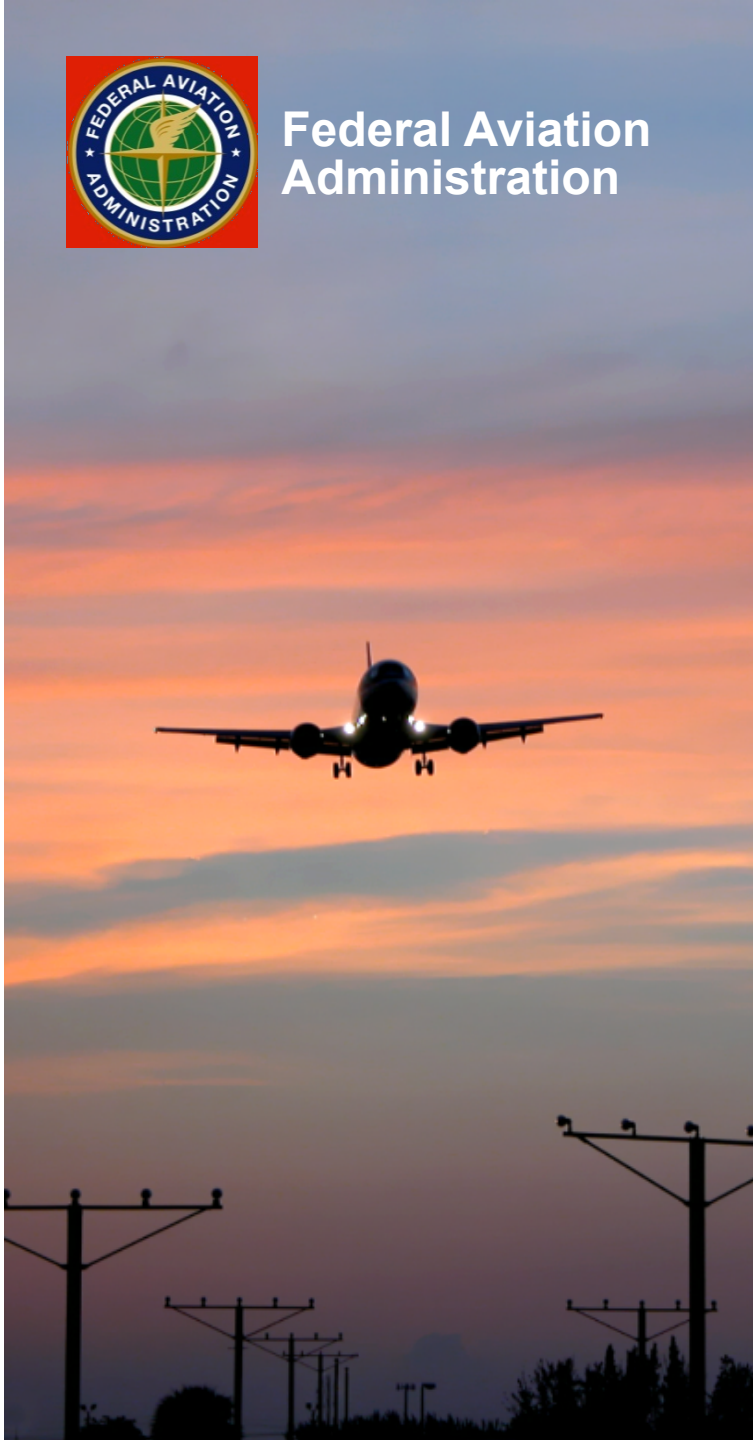
- Overall strategies
- Structural engineering safety awareness course
- Manufacturing safety awareness course

Presented to: Fall 2013 AMTAS Meeting

By: Larry Ilcewicz and Cindy Ashforth FAA

Date: November 14, 2013

Federal Aviation Administration



Overview of AVS Composite Plan

- **AVS Composite Plan Consists of a Strategic Management Plan and a Working Plan**
  - These plans are linked through AVS Business Plan Items
  - Both plans will be updated annually
- **Based on safety management approach**
- **The Plans are linked to:**
  - Best Industry Practices
  - Certification and field experiences
  - Research
  - Projected technological advances in aircraft structure
- **Priority is given to structural engineering issues, related manufacturing procedures and maintenance practices resulting from service experience and industry input.**

Three Main Areas of Coverage in the AVS Composite Strategic and Working Plans

- **Continued Operational Safety (COS)**
- **Certification Efficiency (CE)**
- **Workforce Education (WE)**

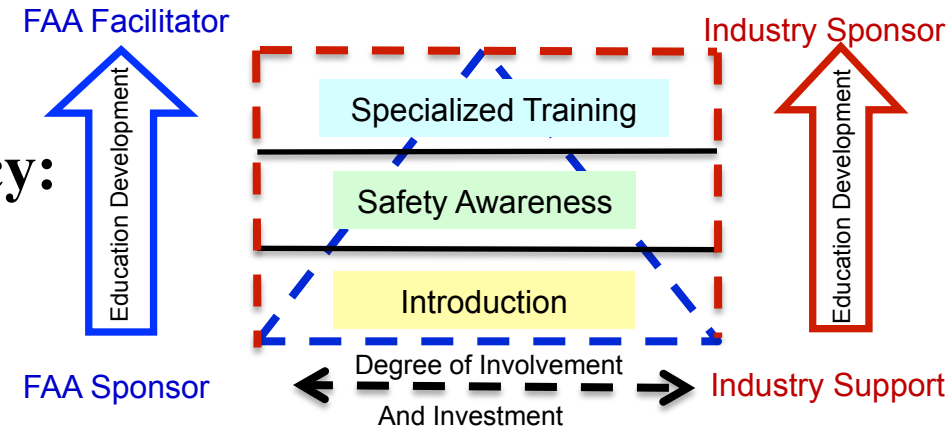
Workforce Education (WE):

- **Comprehensive educational development program**
- **Safety awareness courses for three main functional disciplines:**
  - Structural engineering
  - Manufacturing
  - Maintenance

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 and some FAA experts

Status - Level II Courses Development

- **Maintenance Safety Awareness (CMT)**
  [International Standard: CACRC AIR5719]
  - FAA-led course development completed [9/2008]
  - AFS-500 class-room version available to FAA [Since 2009]
    - *~ 350+ AFS Inspectors trained to date through FAA contract with ABARIS*
  - On-line version available to the industry through WSU
- **Structural Engineering Safety Awareness (CSET)**
  [Completed - Sponsored by FAA R&D, AIR-520]
  - FAA "M&PC" Workshop and Module [2010]
  - Content Development [4/2012]
  - Beta Course [6/2012]
  - Content Completion [8/2012]
  - Teaching points & Assessments [9/2012]
  - First course offering through Wichita State Univ. (WSU) [4/2013]
  - Current WSU course offering Oct., 2013 through Jan., 2014

Status - Level II Course Development (cont.)

- **Manufacturing Safety Awareness (CMfgT)**
  [In Work - Sponsored by FAA R&D, AIR-520]
  - Detail Outline [12/2011]
  - Content Development [12/2013]
  - Beta Course [Spring, 2014]
  - Content Completion, Teaching points & Assessments [9/2014]
  - First course offering through Wichita State Univ. [Fall, 2014]

CMT – Target Audience: FAA Flight Safety Inspectors [Content: 64 Hours]
CSET – Target Audience: FAA Airframe Engineers & Delegations [Content: 80 Hours]
CMfgT – Target Audience: FAA Manufacturing Inspectors [Content: 64 Hours]

Contributors - Level II CSET Course

- **FAA Composite Team** (led by Larry Ilcewicz, Lester Cheng & Charlie Seaton)
  - Structures Specialists: Dave Walen (Lightning Protection CSTA), Mark Freisthler (Transport Directorate Standards), Cindy Ashforth (Transport Directorate International Branch), Angie Kostopoulos (Chicago ACO), Allen Rauschendorfer, Melanie Violette and Nathan Weigand (Seattle ACO)
  - Cabin Safety Experts: Joseph Pellettiere (Crash Dynamics CSTA), Dick Hill, Robert Ochs & Alan Abramowitz (FAA Technical Center), Jeff Gardlin (Transport Directorate Standards),
- **Key subject matter experts (SME)**
  - Peter Smith (retired Boeing)
  - Keith Kedward & Steve Keifer, UCSB (incl. composite design/analysis textbook)
  - Steve Ward (M&P control, design/analysis and proof of structure)
  - Tom Walker and D.M. Hoyt, NSE Composites (fatigue & damage tolerance)
  - Wichita State University (Yeow Ng, Waruna Senevertine, Beth Clarkson, lab development)
  - Delft University (Christos Kassapoglou)
  - Other SME (contractors and volunteers)
    - Michael Niu (UCLA, composite design)
    - Max Davis (Adhesion Associates, metal-bonding)
    - Michael Borgman (Spirit Aero, repair substantiation)
    - FAA JAMS (Paolo Feraboli, Hyonny Kim, Dan Adams)
    - John Halpin (retired Air Force)
    - Will McCarvill (retired Hexcel)
    - John Adelmann (retired Sikorsky)
    - Dan Ruffner (Boeing, Mesa)
    - Convergent Manufacturing Technologies (Univ. of British Columbia composite manufacturing experts)
    - Heatcon (Field and Production repairs, including those performed on-airplane)
    - Workshop participants: presentations, discussions, testimonials (M&P control, fatigue & damage tolerance, crashworthiness)

Main Instructors in red, FAA support instructors in green

Composite Structural Engineering Technology (CSET) Course

- **Top-level Course Objectives**
  - Students will describe essential safety awareness issues associated with composite structural engineering important to safe composite aircraft product applications
  - Students will describe engineering principles of composite airframe substantiation during all stages of aircraft product certification
- **Course Outline**

1.0 Introduction
2.0 Challenges of Composite Applications
3.0 Design, Material and Fabrication Development
4.0 Proof of Structure
5.0 Quality Control of Composite Manufacturing Process
6.0 Maintenance Interface Issues
7.0 Additional Considerations
  7.1 Proof of Structure – Flutter +
  7.2 Crashworthiness
  7.3 Fire safety and fuel tank issues
  7.4 Lightning protection

Composite Structural Engineering Course Syllabus
(April to June, 2013)

Course Schedule	WEEK	TOPICS	DISCUSSION BOARD (20 topics) 400 points	EXAMS
	First Week TCO A April 1-7	Basic Knowledge of Composite Materials and Structures Technology	Not Applicable (self-study)	Prereq. Exam (Score >= 80%)
	ONE TCO 1, 2, 3, 4, 5 April 8-14	Introduction, Challenges, and Material and Fabrication Development	1: Top ten issues from the introduction module 2: Functional inter-relationships through Integrated Product Teams in support of safety management principles and ensuring the existence of stable materials	
	TWO TCO 6, 7, 8, 9 April 15-21	Design, Material and Fabrication Development	1: Importance of establishing a stabilized manufacturing process, including schedule considerations 2: Structural design details and consideration of environmental effects, including sandwich moisture ingression	
	THREE TCO 9, 10 April 22-28	Design, Material and Fabrication Development	1: Analysis methods and considerations for FEM 2: Material allowables and knockdown factors	
	FOUR TCO 10, 11, 12, 13 April 29-May5	Design, Material and Fabrication Development	1: Bonded and bolted considerations for designing a front wing spar 2: Designing for ease of manufacture and maintenance	
	FIVE TCO 14, 15, 16, 17, 18 May 6-12	Statistics and Proof of Structure	1: Contrasting environmental approaches for calculating A- and B- values 2: Damage in fatigue and static strength substantiation using analysis supported by test evidence	Mid-term (50 points)

Composite Structural Engineering Course Syllabus,
(April to June, 2013) *continued*

SIX **TCO 19, 20, 21, 22, 23** **May13-19**	Proof of Structure	1: Implications of high energy, low velocity impact events 2: Reliability for composite fatigue and damage tolerance assessments	
SEVEN **TCO 24, 25, 26, 27** **May20-26**	Proof of Structure	1: Reasons for more reliance on testing for composite structure 2: Managing 'significant changes' related to materials and processes	
EIGHT **TCO 28** **May28-June 2**	Maintenance	1: Roles and responsibilities of the repair team 2: Issues associated with repairing composites having complex geometry with different thermal environments	
NINE **TCO 33, 34, 35, 36** **June 3-9**	Laboratory (2.5 days)	Hands-on reinforcement of teaching points	
TEN **TCO 29, 30, 31, 32** **June 10-16**	Additional Considerations	1: Evaluate the effect of large damage and environment on flutter, and repair to reestablish lightning protection 2: Evaluate design options for accommodating crashworthiness and fire safety	Final (50 points)

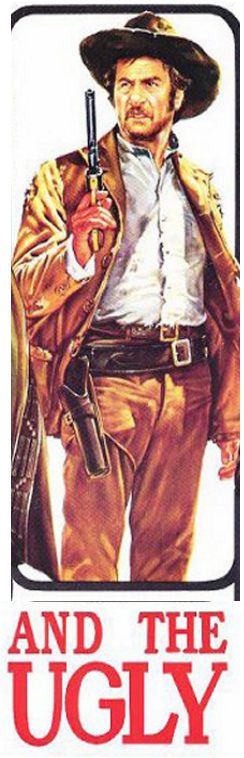
CSET Course Experience (Spring, 2013)

- **What students liked**
  - Syllabus & Prerequisite were great
  - Students loved all of the different subject areas
  - Blackboard was a great tool because students were able to participate when it was convenient for them (work schedule, vacation, time zones, etc.)
  - Classroom mix was great (FAA & Industry)
  - The 2 ½ day lab was a great hands-on learning tool

- **What Needs Work**
  - Time (course schedule is too ambitious)
  - Discussion Boards
  - Tests
  - Blackboard Structure (PDFs)
  - Minor Lab Improvements (content)
  - Testimonial

CSET Future Updates (Fall, 2013+)

- **Time**
  - Edit and reduce main content (optional charts)
- **Discussion Boards**
  - Make it more situational (mini case studies)
  - Structure of grading
- **Tests**
  - Review questions and improve wording
  - Have bi-monthly quizzes instead of 2 large tests
- **Blackboard Structure**
- **Course Structure (extend by 1 week)**
- **Testimonials (make optional?)**
- **Lab Improvements (Increase to 3 days)**
  - Long term goal to make more videos (e.g., A/B statistical)
  - Make Lab more consistent with course content



Level II Composite Manufacturing Technology (CMfgT) Course

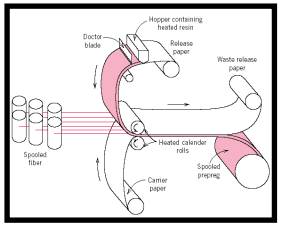
Under Development (to be available in late 2014)

Overall Objectives of CMfgT Course

- **Students will describe the essential safety awareness issues associated with composite manufacturing technologies & processes important to conformity of type design.**
- **Students will describe deficiencies on the factory floor that have safety implications.**

Composite Manufacturing Technology (CMfgT) Course Outline

Prepreg Production

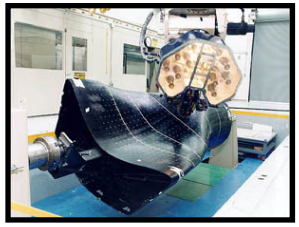


Transportation

Storage

Tooling Preparation

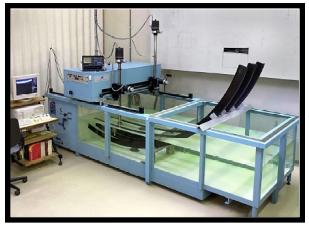
Layup



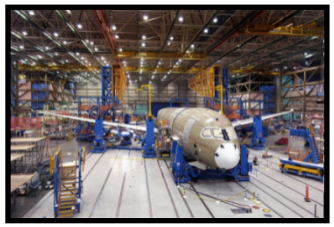
Debulking / Bagging

Cure

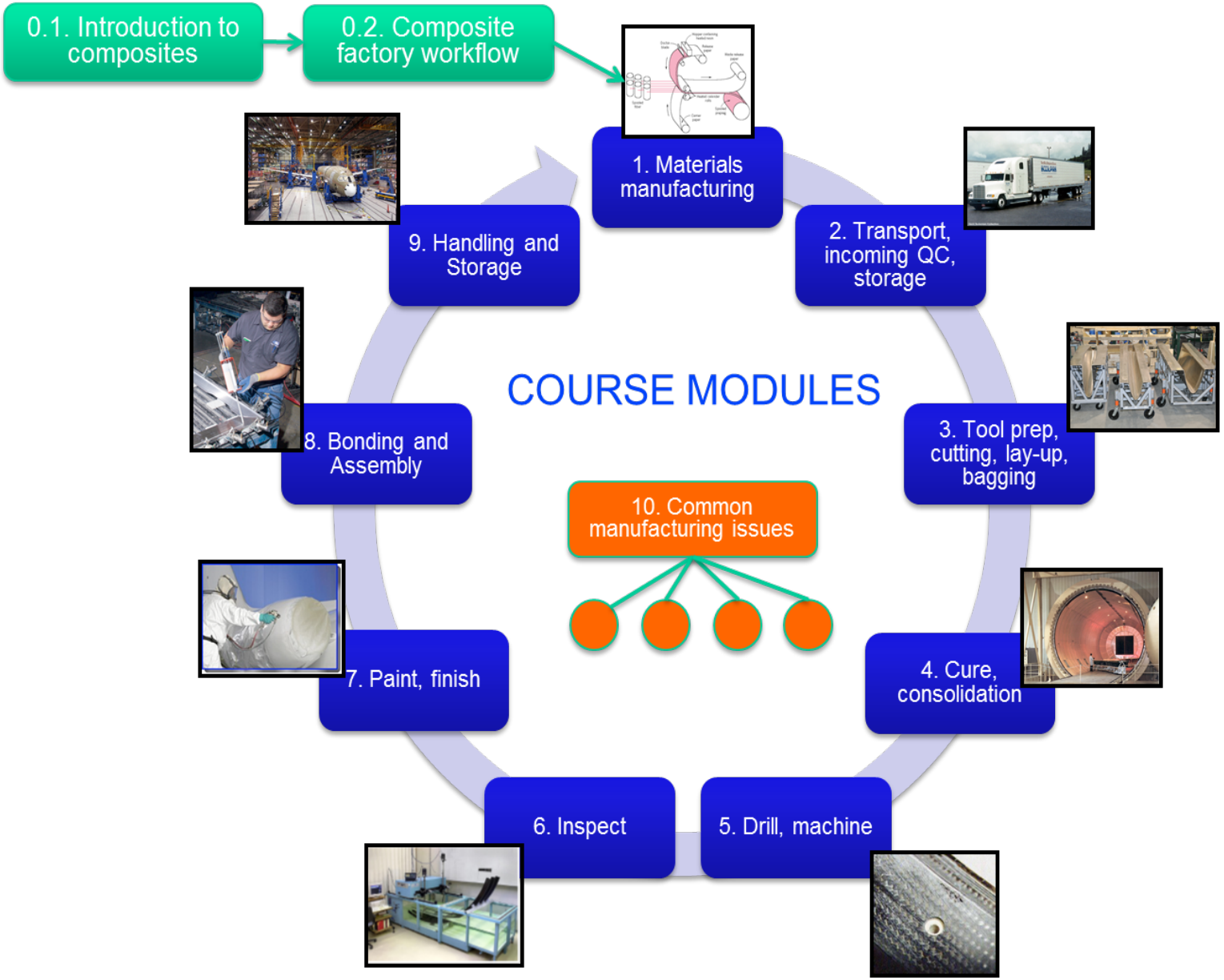
Inspection



Assembly



- Recommendations that course is presented from a factory perspective as experienced by a Manufacturing Inspection District Office (MIDO) Inspector
- At each step, discuss deviations (and defects), root causes, in-process and post-process controls
- Introduce information over a number of passes


0.1. Introduction to composites
0.2. Composite factory workflow
COURSE MODULES
1. Materials manufacturing
2. Transport, incoming QC, storage
3. Tool prep, cutting, lay-up, bagging
4. Cure, consolidation
5. Drill, machine
6. Inspect
7. Paint, finish
8. Bonding and Assembly
9. Handling and Storage
10. Common manufacturing issues

Overview – CMfgT Laboratory Session

- **Students will fabricate panels with intentional defects**
  - They will use NDI inspection techniques
  - They will test the panels to show effects of defects
- **Students will see various material forms and defects**
- **There will be optional tours of a prepreg manufacturing facility and composite structures manufacturing facility**

Summary

- **FAA composite training developments are focused on safety awareness (Level II)**
  - Industry has supported the efforts since 2005
  - Separate courses for maintenance, structural engineering and manufacturing functional disciplines
  - Learning enhancements include labs, testimonials, case studies and application discussion threads with experts
  - Composite maintenance course first taught in 2009
- **Two active composite training initiatives**
  - Composite Structural Engineering Technology (CSET) has been completed and is available through WSU
  - Composite Manufacturing Technology (CMfgT) is under development and scheduled to be available in 2014