FAA Composite Safety and Certification Initiatives (with emphasis on support from JAMS research and development)

Presented to: Spring 2010 JAMS Conference

By: Larry Ilcewicz FAA

Date: May 19, 2010

Outline

- **Composite Safety & Certification Initiatives (CS&CI)**
  - Background
  - Expanding FAA composite team
  - Industry interface
  - Role of research
  - How we identify/select/prioritize research projects?
- **Selected CS&CI progress of relevance to JAMS**
- **Future CS&CI plans of relevance to JAMS**
  - Technical issues addressing safety problems
  - Training initiatives
- **Review of JAMS Progress and Plans**

Background on State of the Industry

- **Situation**
  - Composites have traditionally offered advantages due to fatigue & corrosion resistance, weight savings and other aircraft performance advantages (aero shape, larger cutouts)
  - More recently, the additional advantages from manufacturing cost savings, customer comfort interests & damage tolerance are driving more applications
- **Composite applications are expanding faster than the qualified workforce involved in structural engineering, manufacturing and maintenance functions.**
- **Motivation driving FAA CS&CI Safety Management:**
  - Composites are a non-standard technology
  - Limited shared databases, methods, guidance
  - Small companies have limited resources and certification experience
  - "Big-brother" expectations by industry (non-existent in today's military)

Ongoing FAA Composite Safety & Certification Initiatives

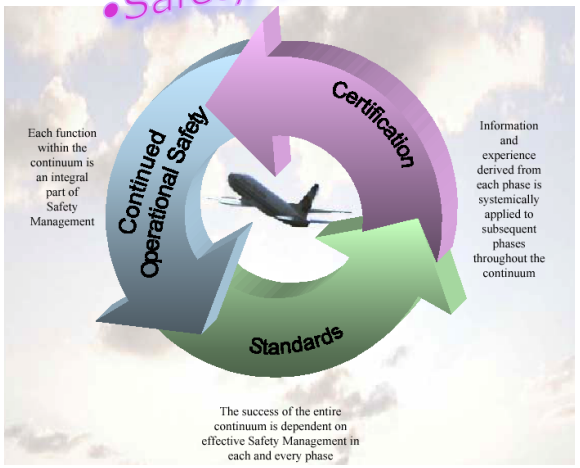
- **Actively working with industry since 1999**

Objectives

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

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

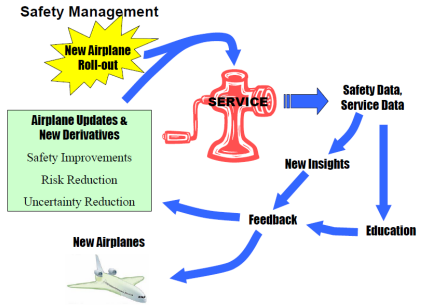
- Approach Following
- Principles of
- Safety Management



- **Safety management (airworthiness) Task Groups initiated within composite standards organizations**

CMH-17 COMPOSITE MATERIALS HANDBOOK

COMMERCIAL AIRCRAFT COMPOSITE REPAIR COMMITTEE (ata, IATA, SAE)



- **Future work underway to educate regulatory personnel**

How Can FAA Reduce Composite Concerns?

- **Promote standardization**
- **Develop guidance that recognizes safety concerns with industry push to minimize costs**

- **Establish safety awareness education for FAA Workforce (FSDO, ACO, MIDO, industry designees)**
- **Continue to benchmark the industry groups and members showing leadership for safe composite applications**
  - Standards organizations (CMH-17, CACRC, ASTM)
  - Applicants that portray leadership as “Model Citizens”
  - FAA/EASA/Industry Workshops

Presentations, recaps and breakout session summaries at:
http://www.niar.wichita.edu/niarworkshops/

Composite Technical Thrust Areas

Advancements depend on close integration between areas

Material Control, Standardization and Shared Databases

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

Structural Substantiation

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

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

Crashworthiness & Flammability

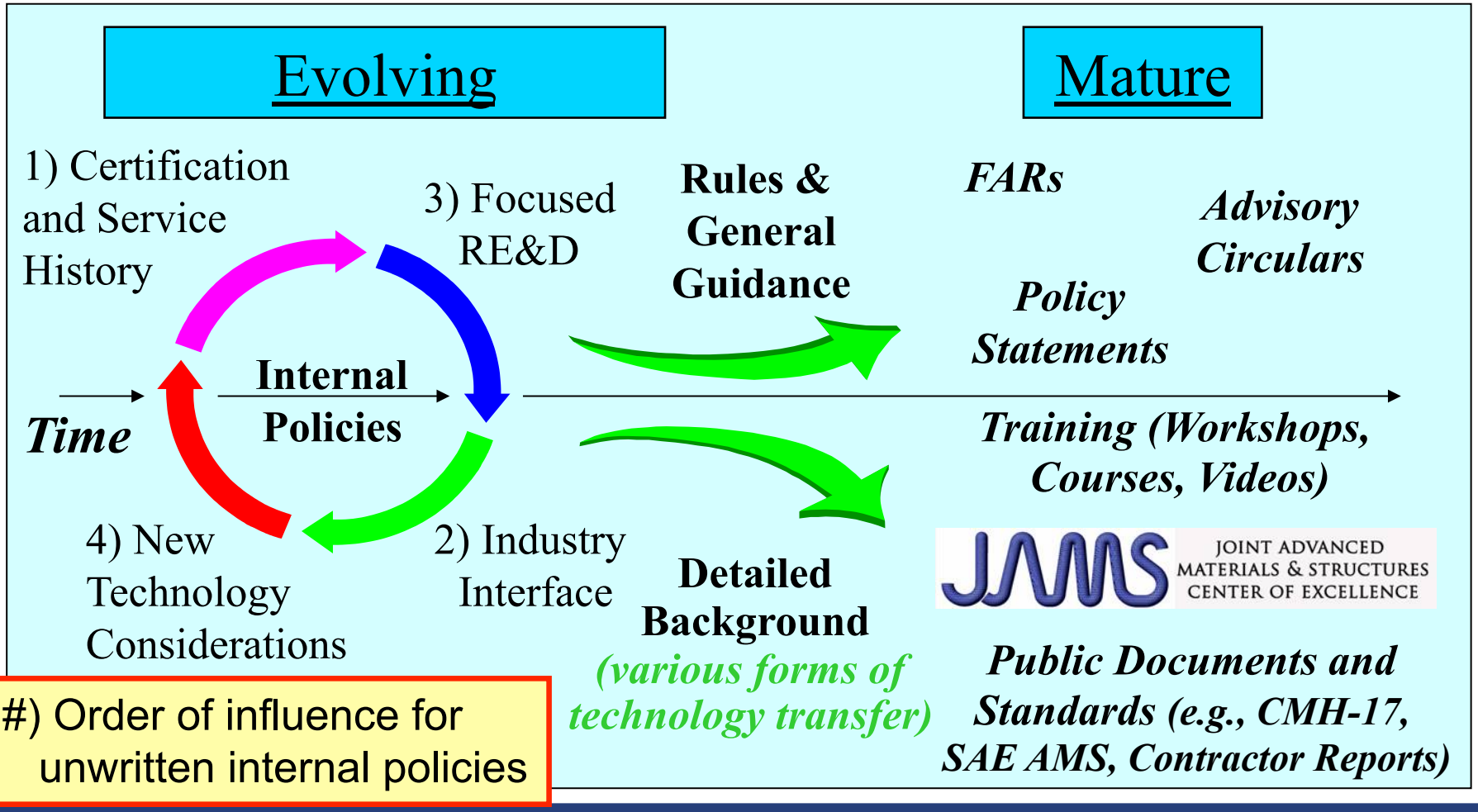
Support to cabin safety research groups

Bonded Joint Processing Issues

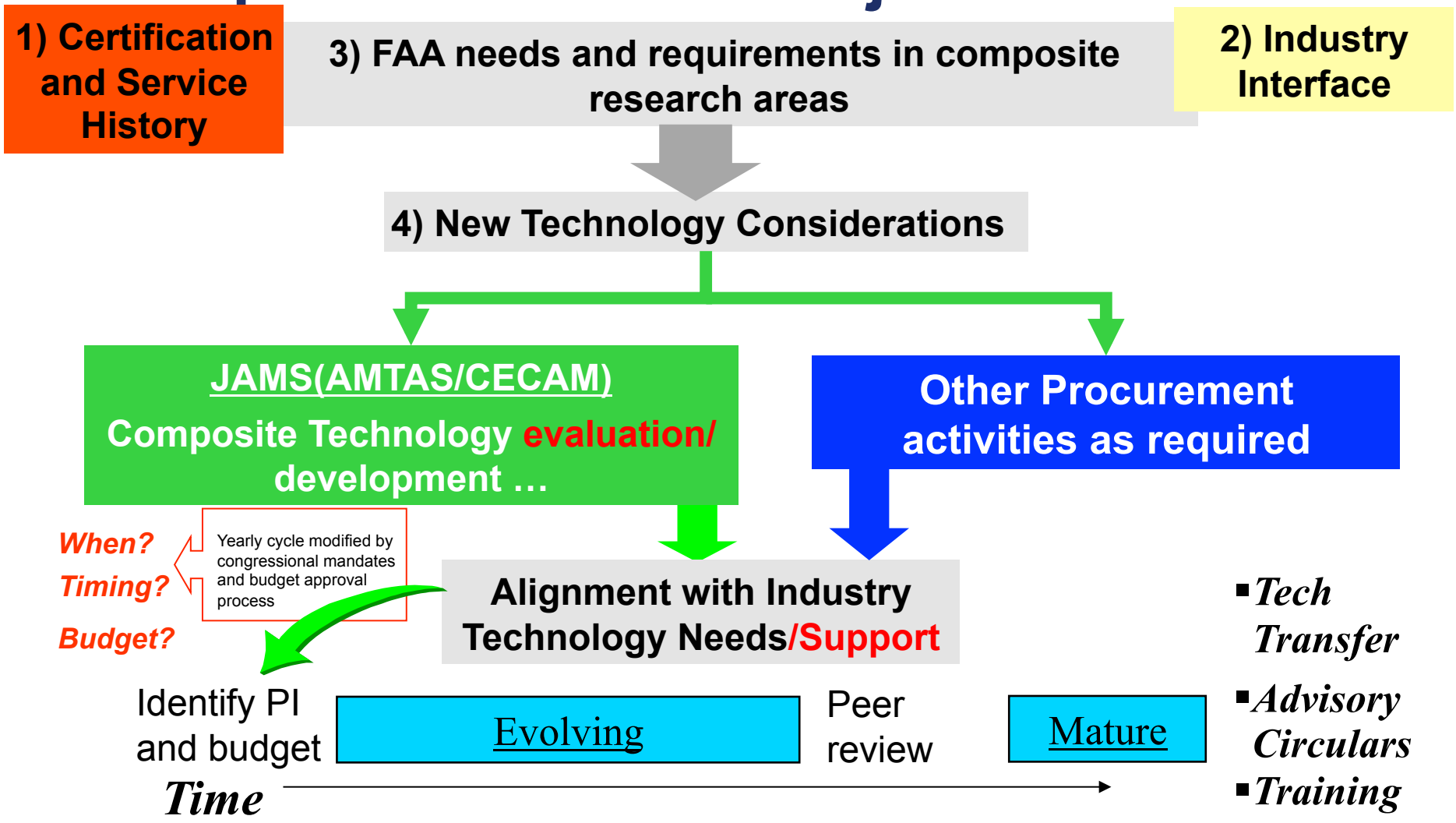
Advanced Material Forms and Processes

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

FAA Approach to Composite Safety and Certification Initiatives



FAA Update of Selection Process for Composite Research Projects



FAA Composite Team Members

Represented Group	Team Member Name	FAA Organization Number & Routing
FAA Technical Center	*Curtis Davies*	*AAR-450 (FAA Technical Center)*
	Michael Shiao	*AAR-450 (FAA Technical Center)*
	Lynn Pham	AAR-450 (FAA Technical Center)
	David Westlund	AAR-450 (FAA Technical Center)
Directorates	*Lester Cheng*	*ACE-111 (Small Airplane Directorate)*
	Bob Stegeman	ACE-111 (Small Airplane Directorate)
	Sharon Miles	ASW-110 (Rotorcraft Directorate)
	Mark Freisthler	*ANM-115 (Transport Airplane Directorate)*
	Allen Rauschendorf er	*ANM-115 (Transport Airplane Directorate)*
	Jay Turnberg	ANE-110 (Engine & Propeller Directorate)
DC Certification	*Dale Hawkins*	*AIR-120 (Aircraf t Standards Division)*
Flight Standards	*Otto Hill (& Rusty Jones)*	*AFS-320 (Aircraf t Maintenance Divisin)*
	Gary Goodwin	ANM-200 (Seattle AEG)
ACOs, and MIDOs,	Roger Caldwell	ANM-100D (Denver ACO)
	Hassan Amini	ACE-117A (Atlanta ACO)
	Fred Guerin	ANM-120L (Los Angeles ACO)
	Ken Paoletti	*ANM-120S (Seattle ACO)*
	Angie Kostopoulos	*ACE-116C (Chicago ACO)*
	Richard Noll	ANE-150 (Boston ACO)
	John Harding	ANM-108B (Seattle CMO)
	David Swartz	*ACE-115N (Anchorage ACO)*
CS&TA	*Larry Ilcewicz*	*ANM-115N (CS&TA, Composites)*

Those shown in Blue Italics are most active in CS&CI.
(Many names in black joined for educational purposes. Training has been a priority since recent meeting with AVS management and CAST.)

CSTA Advisors:
Al Broz, Robert Eastin, Terry Khaled, Dave Walen, Chip Queitzsch

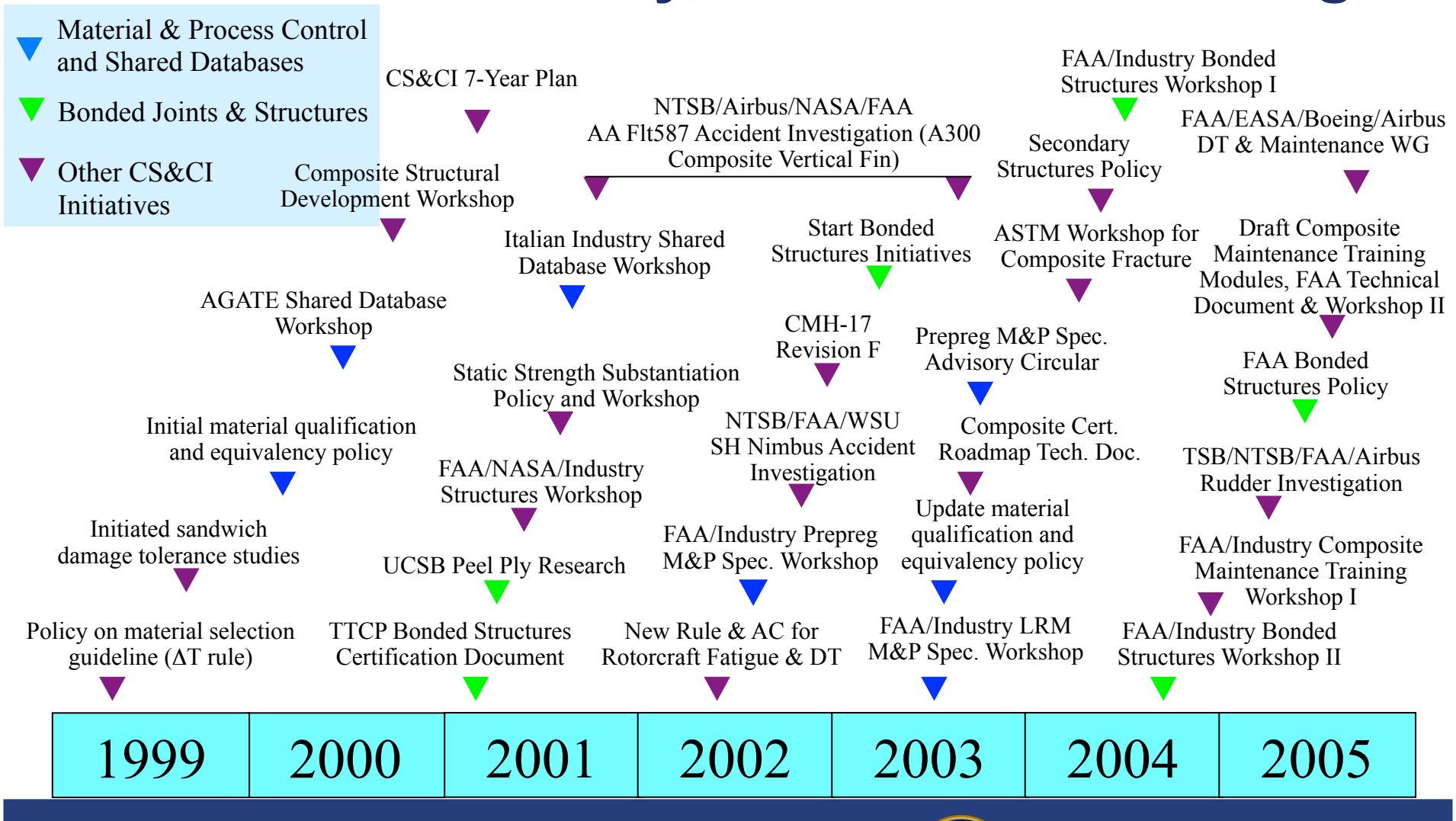
Important Teammates

- 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

- NASA research and other support
  - Significant research support since 1970/1980s
  - AA587, A300-600 accident investigation
- DOD and DARPA research
  - NCAMP support to material standardization
- EASA and other foreign research/standardization

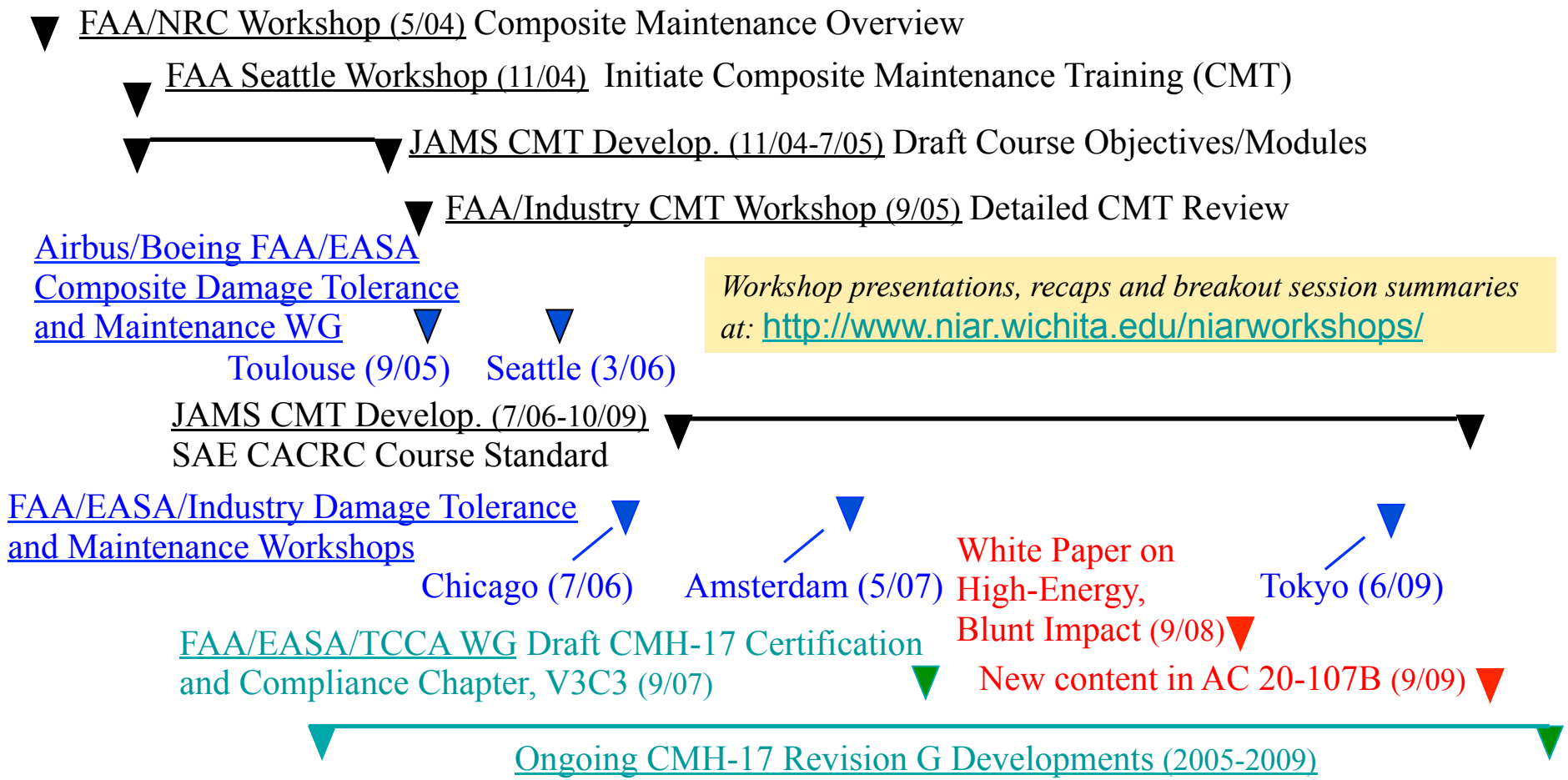
Past Milestones for Composite Safety & Certification Policy, Guidance & Training



Composite Material & Process Control and Shared Databases

- **DOD, NASA & FAA 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

Recent Milestones for Composite Damage Tolerance and Maintenance Initiatives



Composite Maintenance Awareness Course

Purpose: Course is intended to address aircraft safety & certification issues as opposed to building specific skills among team members

Base Knowledge

Teamwork & Disposition

Damage Detection & Characterization

Repair Processes

Pre-requisite: Knowledge needed before taking main course

Main Course Structure

Initial Module: *Understand the roles & responsibilities* of teammates

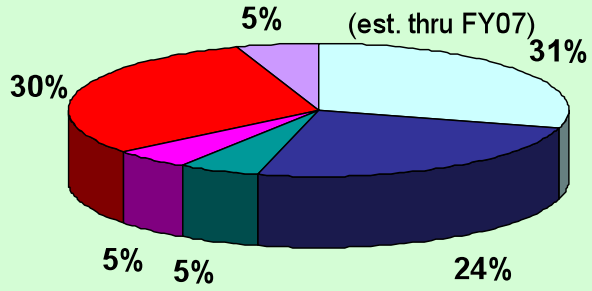
Modules 2 & 3: *Recognize composite damage types & sources + describe related damage and repair inspection procedures (2 labs)*

Module 4: *Identify & describe information contained in approved documentation*

Modules 5 to 8: *Describe composite laminate fabrication, bonding, & bolted assembly methods + perform bonded & bolted repairs (2 labs)*

Module 9: *Participate in team case studies*

Total Costs ~ $1500K



- Industry Match (JAMS COE R&D)
- FAA JAMS COE R&D ($)
- FAA Development Manpower ($)

Training Development Costs: $900K

- Industry/EASA Review Manpower ($)
- Industry/EASA Workshop Manpower & Travel ($)
- FAA Workshop Manpower+Contracts+Travel ($)

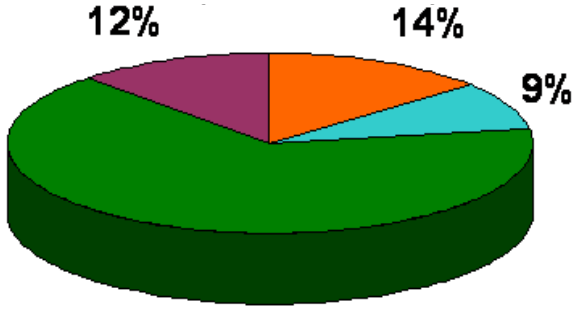
11/04 & 9/05 Workshop Costs: $525K

Background for WG Initiative on Damage Tolerance & Maintenance Guidance

- **FAA/EASA/Airbus/Boeing Working Group chartered in 2005 to discuss safety issues for expanding application of composites to transport aircraft**
  - Focus on industry practices for damage tolerance & maintenance
- **Expanded to include other (~380) industry technical focal in three FAA/EASA/Industry DT and Maintenance Workshops**
  - Chicago, IL (150, July 19-21, 2006)
  - Amsterdam, Netherlands (110, May 9-11, 2007)
  - Tokyo, Japan (120, June 4, 5, 2009)

Total Costs = $1500K

(est. thru FY08)



- FAA/EASA/Industry WG Manpower+Travel ($)
- FAA Manpower, Travel & Contracts ($)
- Industry/EASA 7/06 & 5/07 Workshop Manpower+Travel ($)
- FAA 7/06 & 5/07 Workshops Manpower+Contracts+Travel ($)

Summary of 2006, 2007 & 2009 Workshops

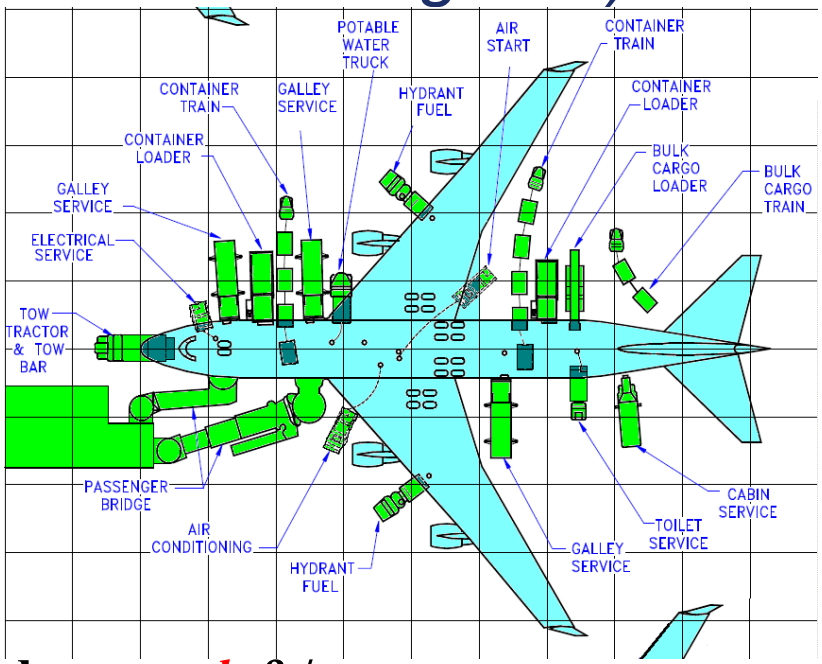
- Critical safety data shared in unique forum of practitioners
  - Captured in web files, new CMH-17 content and FAA course
- Five *categories of damage* were proposed for damage tolerance and maintenance consideration
  - Integrated efforts in structural substantiation, maintenance and operations interface help ensure complete coverage for safety
- Coordinated inspection, engineering disposition and repair is needed for safe maintenance
  - Reporting by operations is essential for detection of critical damage from anomalous events
- FAA is committed to CS&CI with industry, academia and government groups (~380 participants in three workshops)
  - Damage tolerance and maintenance initiatives are active
  - Principles of safety management will continue to be used in future developments (policy, guidance and training)

Presentations, recaps and breakout session summaries at:
http://www.niar.wichita.edu/niarworkshops/

FAA Technical Paper on Awareness & Reporting of Significant Impact Incidents Involving Composite Airframe Structures

(effort initiated by FAA/EASA/Airbus/Boeing WG)

Not all damaging events (e.g., severe vehicle collisions) can be covered in design & scheduled maintenance



- **Safety must be protected for severe accidental damage outside the scope of design (defined as Category 5 damage) by operations reporting**
- **Awareness and a "No-Blame" reporting mentality is needed**
- **Category 5 damage requirements:**
  a) damage is *obvious* (e.g., clearly visual) and *reported* &/or
  b) damage is *readily detectable* by required pre-flight checks &/or
  c) the *event* causing the damage is otherwise *self-evident* and *reported*
  e.g., obvious, severe impact force felt in a vehicle collision

Solution Path for Vehicle Collisions Classified as Category 5 Damage

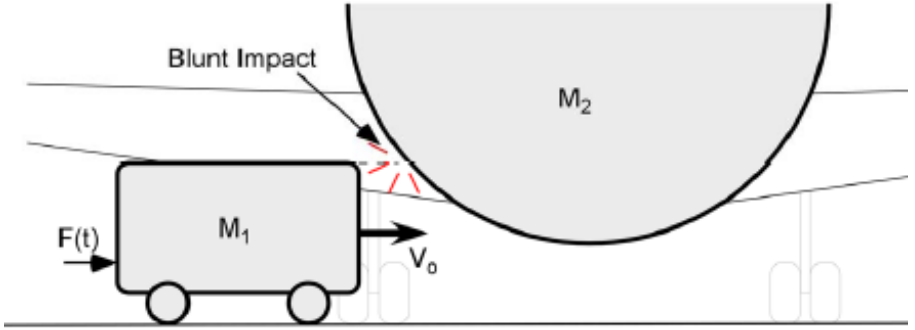
Layers of Safety Management are also needed

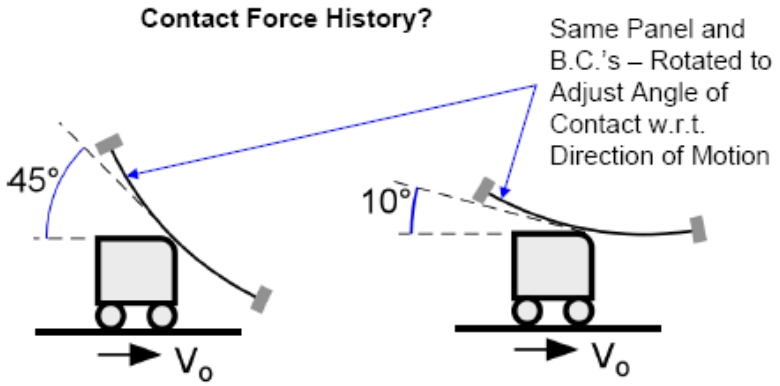
- **Damaging events outside the scope of those considered in design must be of a magnitude that ensures reporting *(i.e., design to sufficient impact damage resistance and damage tolerance)***
- **Simple training is needed to ensure the *essential "reporting" role of operations and aircraft service personnel without blame***
- **Source documentation and training for line maintenance, inspectors and structural engineers needed to disposition such events to ensure *proper application of conditional inspection and repair procedures***
- **Practical NDE methods should be able to detect critical levels of damage**

1) Impact Event is Reported	**Awareness by ground crews, service crews, air crews, and/or ramp personnel**
2) Line Maintenance Ensures Proper Evaluation	**Line and Dispatch personnel trained to seek skilled disposition assistance**
3) Engineering Evaluation & Repair (if necessary)	**a. Engineers, OEM, technicians, inspectors with proper training** **b. Allowable Surface Damage Limits do NOT apply** **c. Initial inspection is to detect MAJOR internal damage**

FAA/Industry Research at University of California, San Diego (UCSD)

- **R&D active to help bound important variables and worst case scenarios (i.e., most severe internal damage with least exterior visually detectable indications)**
- **Both analysis and test evaluations are planned**
  - Vehicle collision characteristics (e.g., speed, angle of incident, impactor geometry/material and structural location) important to:
    a) damage severity,
    b) details worth reporting,
    c) possible visual evidence and
    d) identification of inspection needs (coordinated with FAA NDI research)



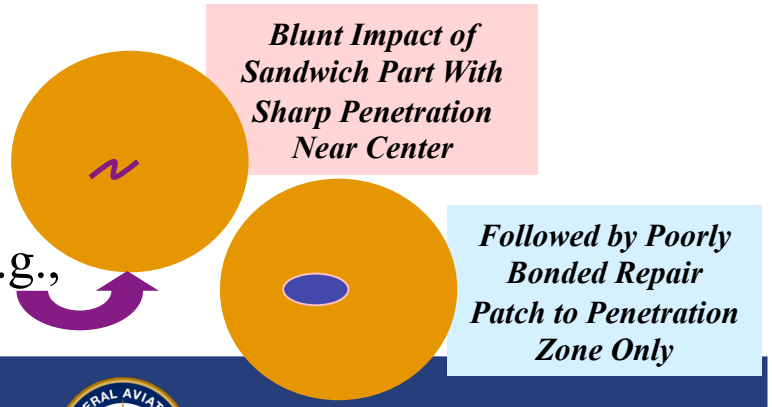


Dr. Hyonny Kim, UCSD

Aero-elastic Stability and Flutter of Damaged Control Surface Structure

- **Transport rudder lost during 2005 flight** (flutter event) **led to service bulletins and associated airworthiness directives**
  - Evidence from the investigation indicated large damage (e.g., extensive sandwich face-sheet disbonding) was needed to cause rudder flutter
  - Airbus presentations at FAA workshops shared key safety findings (e.g., sandwich design details susceptible to disbond growth in ground-air-ground cycling and supporting tests & analyses)
- **Active FAA initiatives:**
  - Effects of composite damage on flutter
  - Characterize sandwich damage growth mechanisms & document bad design details
  - Scenarios for damage initiation & growth, e.g.,
  - Standard test & analysis methods

Air Transat Flight 961



Blunt Impact of Sandwich Part With Sharp Penetration Near Center

Followed by Poorly Bonded Repair Patch to Penetration Zone Only

Metal Bond Durability Test Standard and Related Guidance

- **Focus on bond durability problems occurring in service**
  - NTSB Safety Recommendations A08-25 to -29 for metal bond failures of helicopter rotor blades
  - Bond process qualification issues (e.g., surface preparation that doesn't provide sufficient long-term durability)
  - Issues of void development and hydration, leading to adhesion failures
- **New FAA initiatives, incl. R&D**
  - Detailed background for guidance/training on technical issues & proven industry practice
  - Level II safety awareness course development
  - Evaluation of real-time vs. accelerated test degradation mechanisms
  - Standard tests for qualification of long-term environmental durability

Taken from Fiji Accident Reports

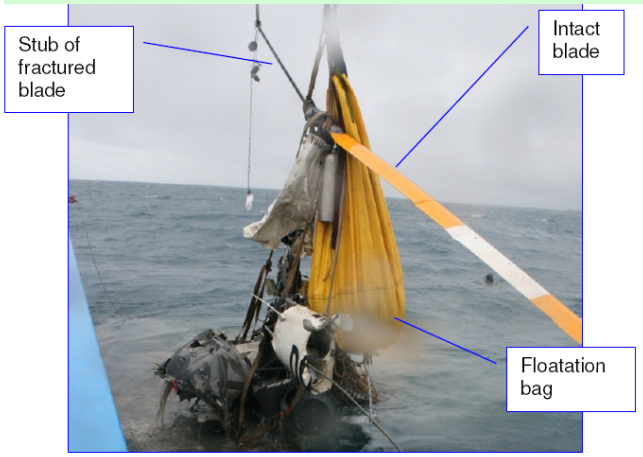


Fig A2 Lifting the main wreckage out of the water

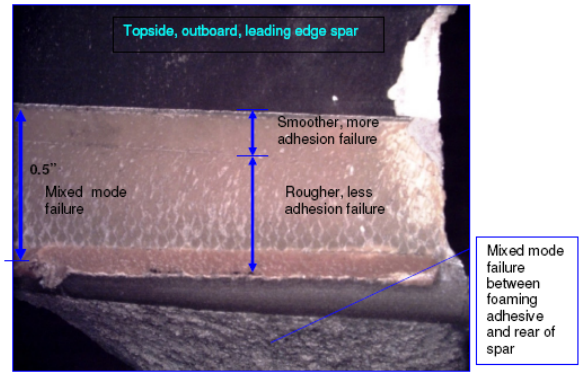


Fig A17 NTSB blade failure analysis

Service Problems With Extensive Repair of Metal-Bond & Composite Aircraft Structure

- **Airline members of the CACRC have been sharing case studies of improper composite repair found in the field**
  - Numerous cases of extensive bonded repairs that have some indication of a problem before destructive tear-down inspection reveals the likely root cause
  - Evidence of the the industry challenges of insufficiently trained resources and economic pressures

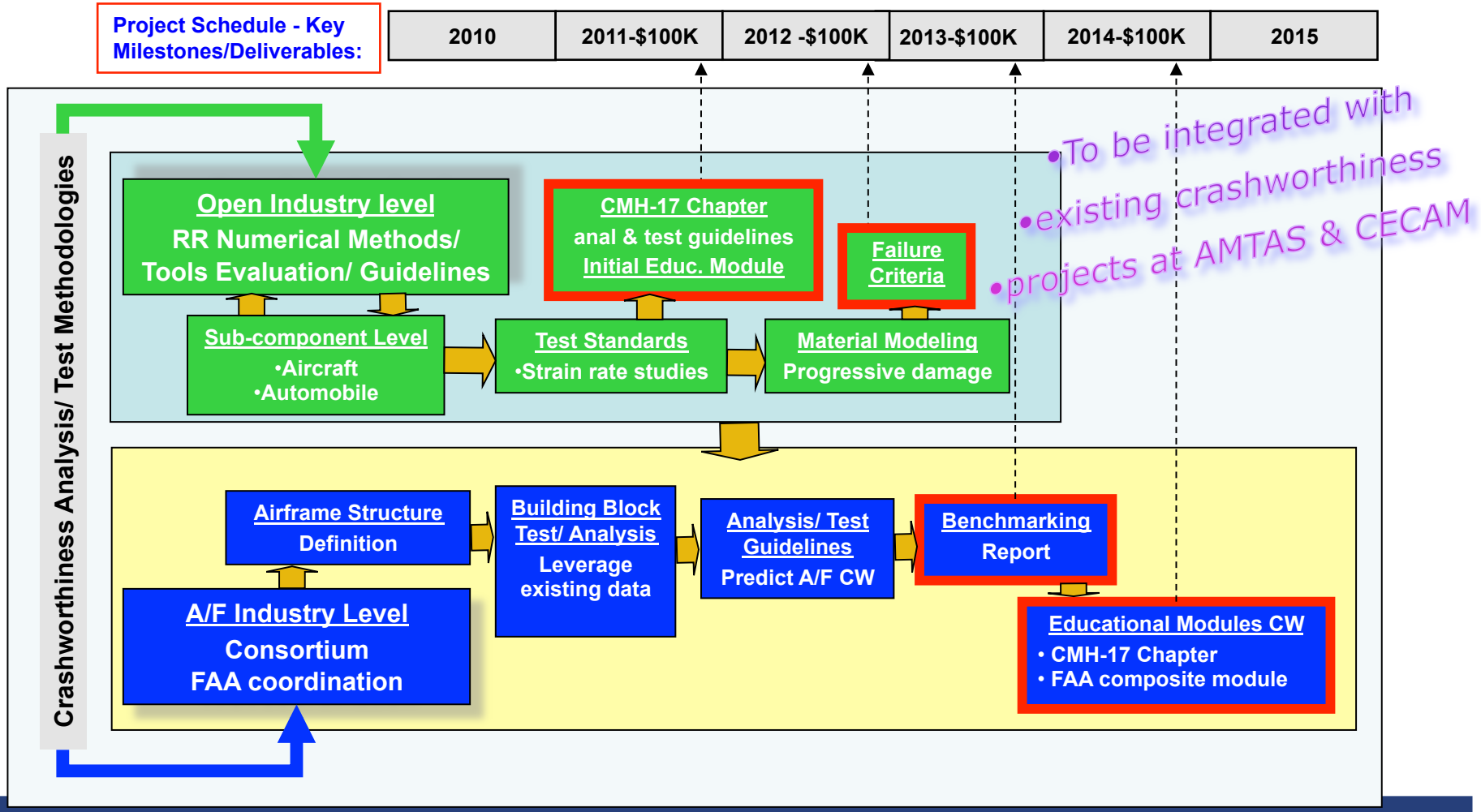
Example Case Study: Repaired TE Flap delivered to airline for installation

Improper fit and considerable warp suggested a repair problem

- **New FAA initiatives, incl. R&D**
  - Detailed background for regulatory guidance and training on the technical issues and proven industry practice
  - International safety standards on expectations for “approved repairs”
  - Level II safety awareness course updates
  - Possible regulatory rule-making and enforcement actions

Proposed Crashworthiness Project Plan

To address FAA needs for cabin safety issues unique to composite materials



Composite Education Initiatives
Proposed education progression through three levels

Increasing Specialization

Specialized Training (Level III)	→	1. Skill building in specific areas for existing & emerging applications 2. Training for practitioners using experts with real-world experience 3. Industry leadership needed
Safety Awareness (Level II)	→	**1. Composite safety focus, including hands-on laboratory** **2. More details of regulatory guidance and industry practice** **3. Joint FAA/industry leadership**
Introduction to Composites (Level I)	→	1. Basics of composite technology 2. Intro to job roles & responsibilities 3. Certification basics

Some additional focus for functional disciplines (e.g., structural engineering, manufacturing and maintenance) for levels II and III.

Summary of FAA Composite Training Strategy: Progress to date

- **Two introductory level courses are available**
  - 6-hour classroom tutorial on certification basics
  - Online training on the basics of composite technology
- **Work on safety awareness courses (status color-coded)**
  - Maintenance: AFS 500 converted FAA-sponsored industry standard (AIR 5719) into 6-7 day classroom course currently available through contractor (more than 200 inspectors to date).
  - Structural Engineering: Only a 7 hour module is currently available in the OK City airframe course.
  - Manufacturing: Nothing is currently available.
- **Specialty coursework is generally sparse & incomplete**
  - Some elements of a course for material qualification, equivalency sampling, statistics and M&P specs in work

Composite Structural Engineering Level II Safety Awareness Course Development

- **64-Hour course development started in 2010**
- **Draft top-level outline following AC 20-107B**
  - Difficulties faced in composite applications (2 hours)
  - 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 hour)
  - Manufacturing interface issues (1/2 day)
  - Maintenance interface issues (1/2 day)
  - Other: crashworthiness, fire safety & lightning strike protection (1/2 day)
- **2010 FAA Workshop*** (on Week of 9/13) **at Wichita State Univ. to "beta test" module on composite material & process control** (2 to 3 days)
  - Material & process qualification (test matrices, statistics)
  - Material & process specifications (material rqmts., process details, quality control)
  - Shared data (NCAMP/CMH-17/SAE P-17 & CACRC initiatives, equivalency sampling)
  - "Material allowables" versus design values

* Contact Lester Cheng, FAA ACE-111, lester.cheng@faa.gov, 316-946-4111

Recent/Future Milestones for Composite Safety & Certification Guidance & Training

Release CMH-17 Revision G

- *Advances in statistics, test methods and data reduction protocol*
- *Major Volume 3 re-organization*
- *New Volume 6 (Sandwich)*
- *New certification & compliance chapter*
- *New crashworthiness chapter*
- *New safety management chapter*
- *Updates to damage tolerance & maintenance*

Implement Composite Maintenance Awareness Course

High Energy Blunt Impact Awareness

Release AC 20-107B (Composite Aircraft Structure)

NCAMP shared databases and specifications (CMH-17, SAE AMS)

Composite maintenance guidance/policy for extensive repair

FAA/Industry composite education initiatives

Metal bond durability standards & guidance

Composite damage tolerance guidance

Crashworthiness guidance

2009	2010	2011	2012	2013

Review of Existing JAMS Projects

- Overall Grade
  - B
- Convertion of
- R&D Results
- to Practice
  - C+

Grading Considerations

- Quality of R&D performed to date: A-
- Relationship with safety issues: B
- Understands industry application needs & achieves tech. transfer: C+

Areas Needing Improvement

- Researcher involvement in process
  (e.g., CMH-17, CACRC, workshops, standards and course development)
- Proactive industry involvement
- Availability of FAA and industry resources for implementation
- Published results (Tech. Center Reports)

Challenges for JAMS - *Need More Industry, FAA & other Govt. Agency Involvement*

- **Help JAMS identify key R&D areas, realizing the need for a safety & certification emphasis**
  - Outline existing industry problems and near-term applications
  - Participate in FAA Safety Awareness Course developments
  - Cost sharing partners should have proactive involvement in project from start to finish (word about **Direct!** vs. **In-kind?**)
- **Actively participate in ongoing projects**
  - Provide advice/guidance to the PI and researchers
  - Interface with additional FAA personnel directing the project
  - Help convert results to practice (deliverables to support industry and FAA needs – avoid "throwing report over the fence")
- **Review JAMS detailed project descriptions, references and presentations**
  - Provide feedback and suggestions for improvement (feel free to "grade" the efforts)