Federal Aviation Administration

FAA / CAAs “Composite Meeting”

Overview - FAA Composite Plan

- Composite Safety & Certification Initiatives -

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FAA Composite Team

Singapore, Singapore
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Composite Safety & Certification Initiatives
- AVS Composite Plan -

Objectives

1) Work with industry, other govt. agencies and academia to ensure safe and efficient deployment of composite technologies used in existing & future aircraft
2) Update policies, advisory circulars, training, and detailed background used to support standardized composite industry practices

Composite Safety & Certification Initiatives
- AVS Composite Plan -

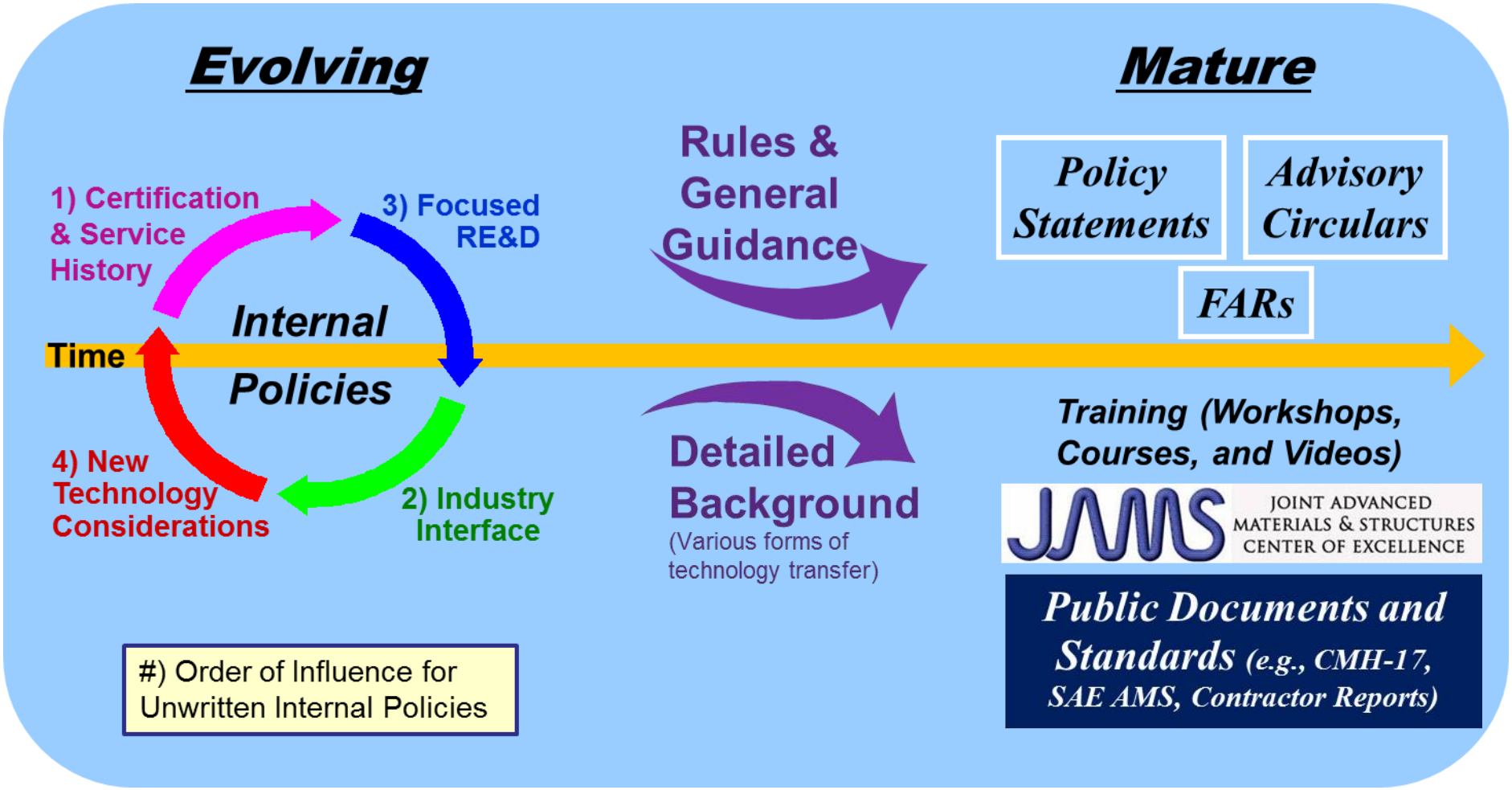
- **Background (CS&CI) (1999-2014)**
- **AVS Composite Plan (2014-)**
  - Fundamentals - Guideline
  - Overview - Plan Areas/Elements
- **High Priority (Current) Efforts**
  - COS A: Bonding Initiatives (BI)
  - COS B: HEWABI
  - CE: A, D, E, F (CMH-17 Rev. H)
  - WE: A, B, C
- **Summary and Closure**

Composite Safety & Certification Initiatives
- AVS Composite Plan -

- **Background (CS&CI) (1999-2014)**

  - Lessons learned – Lancair/Cirrus/Premier I (1998)
  - Requirements/Strategies/Team Building (1999)
  - “National Composite Plan” BP (Part 23) (2000)
  - CS&CI (FAA/EASA/Industry/Mil-17 ---) (2001)

FAA Approach to Composite Safety & Certification Initiatives



Important Teammates

- Partnerships with industry have been essential, including working groups & standards org. (**e.g., CMH-17, SAE P-17, CACRC, ASTM, SAMPE, AGATE, SATS, RITA, SAS/IAB/AACE)**

Training
Databases
Standardizatio
Engineering guidelines

- EASA, TCCA and other foreign regulators
- 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

FAA Joint Advanced Materials and Structures (JAMS) Centers of Excellence

FAA JAMS Centers of Excellence to provide research and training in support of expanding composite applications

Wichita State University
Northwestern University
Purdue University
Tuskegee University
University of California at Los Angeles
University of California at San Diego
University of Delaware

University of Washington
Edmonds Community College
Oregon State University
Washington State University
University of Utah
Florida International University

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 2012

- AC 20-107B (9/09)
- 3 other Advisory Circulars
- 7 Policy Memos/Statements
- 16 Workshops
- 4 Training Initiatives
- 2 Technical Documents
- CMH-17 Updates
- SAE CACRC Standards
- ~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)
- Structural test & analysis protocol
- 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

Milestones Achieved via CS&CI

- FAA policy/training for base material qualification & equivalency testing for shared databases (update 2003)*
- Policy/training for static strength substantiation (2001)
- New rule & AC for damage tolerance & fatigue evaluation of composite rotorcraft structure (2002, 2005 & 2009 releases)
- AC for material procurement & process specs (2003)*
- Tech. document on composite certification roadmap (2003)
- Policy on substantiation of secondary structures (2005)
- Policy for bonded joints & structures was released (2005)*
- Tech. document on composite maintenance & repair (2006)
- Composite maintenance & repair awareness training (2008)*
- AC 20-107B (Composite Aircraft Structure) (2009)*
- National Center for Advanced Material Performance Policy (2010)
- Revision G to CMH-17 (2012)

* FAA Technical Center reports exist for detailed background on engineering practices

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General - 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
  - Focused Research
  - Technological Advances in Aircraft Structures
- **Priority is given to structural engineering issues, related manufacturing procedures & 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)**

Overview of AVS Composite Plan

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COS A: Bonding Initiatives - Bonded Repair	*CE A:* Hybrid F&DT Substantiation	*WE A:* Composite Manufacturing Technology
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- Sandwich Disbond Growth	*CE C:* Composite Structural Modifications	*WE C:* Composite Maintenance Technology
COS B: HEWABI	*CE D:* Composite Quality Assurance	Composite Basics
COS C: Failure Analysis of Composites Subjected to Fire	*CE E:* Bonded Structure Guidance	Composite DER
	CE F: General Composite Structure Guidance	
Support to future COS Initiatives Aging Composite Aircraft Teardown	Transport Crashworthiness	
	Lightning Protection	
	CMH-17 Revision H	

Continued Operational Safety (COS)

- **Continued Operational Safety is always the number one priority!**
- **Priority will be assigned to tasks based on an assessment of those that pose the greatest safety threat.**
- **We are actively involved with industry and research organizations to identify, understand and mitigate future COS issues.**

Certification Efficiency (CE)

- **Certification efficiency initiatives promote safety by documenting:**
  - Best industry practices
  - Regulatory guidance
  - Industry standards documents
- **Actively support other FAA initiatives:**
  - Transport crashworthiness
  - Fuel tank lightening protection
  - Composite flammability testing

Workforce Education (WE)

- **Comprehensive Educational Development Program [White Paper – 2009]**
  - Requirements of Workforce Education
  - Definition of Education/Course Levels (I, II & III)
- **Safety Awareness Courses (Level II) for Three Main Functional Disciplines**
  - Structural Engineering Technology (CSET)
  - Manufacturing Technology (CMfgT)
  - Maintenance Technology (CMT)

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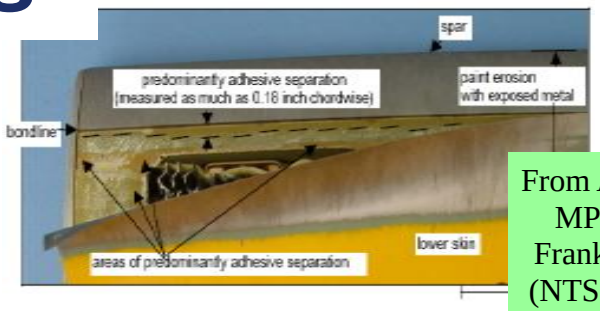
Bonding Field Difficulties

- Helicopter main rotor blade metal bonding problems
  - 2008 NTSB Safety Recommendations
  - Possible metal bond processing problems *(FAA R&D to help update wedge test standards & training)*



From Air Force MP3 Mtg. Frank Zankar (NTSB, 2008)

- Rudder debonding
  - NDI to control current field problems
  - OEM shared technical solutions & design concerns with industry in FAA 2009 Tokyo Workshop *(standards to be adopted by CMH-17)*

In-flight Rudder Failure (Large damage causing flutter) Air Transat Flight 961 [3/6/05]

- Extensive repair deficiencies *(resulted in COS A)*
  - DER-approved *repair design and processes* without supporting data
  - Inappropriate material substitutions, poor workmanship & inadequate tooling
  - Discovered when rigging on aircraft *(case studies documented with CACRC)*

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AVS Plan: Continued Operational Safety (COS) - Bonding Initiatives (BI) -

- **Bonded Repair**
  - BRSL Policy (FY 13-14)
  - Metal & Composite Bonding Best Practices
  - Repair Substantiation & M&P Control
  - Research Support
- **Bonding Quality Control**
  - Standards for Metal Bonding QC (FY 11-15)
  - Standards for Composite Bonding QC (FY 13-)
  - Research Support (e.g., Test Standards Development)
- **Sandwich Disbond Growth**
  - Document Best Practices
  - Standards for Sandwich Disbond Crack Growth
  - Research Support

AVS Plan: Certification Efficiency (CE) and Workforce Education (WE) Relevant to BI

- **Composite Quality Assurance (CE)**
  - Update AC 21-26 "Quality System for Manufacture of Composite Structures"
  - Update online job aid for audit & surveillance of composite repair facilities.
- **Bonded Structures Guidance (CE)**
  - Part 21 AC for Bonded Structure including Bonded Repair Best Practices
- **Workforce Education (WE)**
  - Composite Manufacturing Technology
  - Composite Structures Technology
  - Composite Maintenance Technology

Relevant Background – Requirements & Efforts

- NTSB has cited metal bond processes, environmental durability and weak bonds as contributing factors in multiple incidents and accidents, including the Aloha Airlines accident in 1988, rotor blade failures of several helicopter accidents, and other incidents thought to pose a safety threat.

- FAA Bonded Structures Workshops (2004) established an understanding that bonding needs to address long-term durability and reliable quality control is critical for the process. Development of durability test methods/standards has been well shared.

- FAA & the "Joint Advanced Materials & Structures (JAMS) Center of Excellence at U of Utah (SLC)" have initiated a R&D program to develop test method/standard for environmental durability of metal/composite bonding.

FAA Bonded Structure Workshops (2004) - Knowledge Database -

- **In 2004: FAA conducted two workshops, collecting best industry practices (operators & manufacturers), certification & field experiences, and research studies pertinent to bonded aircraft structures -**
  - Bonded Structures Workshop @ Seattle/WA, USA (6/16-18/2004)
  - Bonded Structures Workshop @ Sussex/London, UK (10/26-27/2004)

  [http://www.niar.wichita.edu/niarworkshops/Workshops/]

- **Building on above knowledge database: FAA established and issued a guidance (Policy Statement) -**

  "Bonded Joints and Structures – Technical Issues and Certification Considerations" (PS-ACE100-2005-10038) [9/2005]

  [Note: Essence has been contained in AC 20-107B / AMC 20-29]

  [http://rgl.faa.gov/Regulatory_and_Guidance_Library/rgPolicy.nsf/]

Further: A Bonded Structures Working Meeting was conducted in Salt Lake City (July/14).

Durability of Adhesively Bonded Structure & Test Methods - Research Progress & Results (2010-2014)

- **FAA Research Program (2010 - TBD)**
  - Institute: U of Utah @ Salt Lake City, UT
  [Joint Advanced Materials & Structures (JAMS) Center of Excellence]
  - Principal Investigators: Dr. Dan Adams, Dr. Larry Devries
- **Research Progress & Results Have Been Presented Yearly in JAMS Annual Technical Review/Meeting (2011-2015).**
  - "Durability of Adhesively Bonded Joints for Aircraft Structures" [Dan Adams & etc. (U of Utah), San Diego, Apr/2011 & Baltimore, Apr/2012]
  - "Test Method Development for Environmental Durability of Bonded Joints" [Dan Adams & etc. (U of Utah), Everett, Apr/2013; Seattle, Mar/2014 & Baltimore, Mar-Apr/2015]
- **Results Have Been Shared/Reviewed via Various Meetings**
  - SAMPE, CMH-17, SAE/CACRC

Policy Content: *Bonded Repair Size Limits*

- *The size and extent of a bonded repair is first constrained by the limits of substantiating data* used to meet appropriate rules
  - Repair processes must produce consistently sound structure (performed using approved/qualified materials and processes)
  - Repair design must have structural substantiation needed for the structure (tests or analyses supported by tests)
  - Service inspections of bonded repair should be capable of finding complete or partial failure of the bondline. Inspection intervals must consider criticality of the structure and residual strength with the repair failed.
- *Critical structure will have an additional repair size limit to be no larger than able to yield Limit Load residual strength capability with the repair failed* within arresting design features
  - Note that this requirement may not control depending on the repair size limit coming from the first constraint
  - Residual strength with the repair failed should be shown by tests or analysis supported by tests

Work Flow – Other Bonding Initiatives

Example of Working Plan Details

FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018

***Revised Metal Wedge Crack Durability Test**: Develop an update to the existing ASTM test standard and acceptance criteria for environmentally –driven crack growth and failure mode.*

Test Standards for Sandwich Disbond Crack Growth (Modes I, II, and III): Develop ASTM standards for composite sandwich disbond testing, including instructions for fracture toughness and growth measurements with environmental and aviation fluid exposures..

***CMH-17 Design, Proof of Structure and Process Guidelines** to Mitigate Safety Risks for Composite Sandwich Disbonding : Document best practices for M&P control, design, fabrication, inspection, repair and structural substantiation, with special considerations for the phenomena of sandwich panel disbonding in a service environment and controlling related aircraft safety (certification and continued airworthiness).*

***CMH-17 Revision H:** Document best practices for metal & composite bonding (incl. sandwich) as related to M&P control, design, fabrication, inspection, repair and structural substantiation to support new AC.*

FAA/EASA/CAA/Industry Workshop to review above Advances

***Part 21 AC for Bonded Structure**: Build on industry guidelines, informational reports, standards and AIR-100 policy to create comprehensive guidance supporting Part 23, 25, 27, 29, 33 and 35 bonding applications, considering new technology for modern aircraft (to be completed in FY20).*

Research Support to Sandwich Disbond Initiatives: Benchmark industry practices and field findings on the root cause of sandwich disbond growth, while standardizing analysis and test evaluation protocol.

Test Standards Research and Development: Perform research to support industry quality control and structural test standards development.

Research Support to Bonded Structure Initiatives, Including Bonded Repair: Benchmark industry practices and identify potential safety problems to support the development of regulatory policy, guidance and training that mitigate risks. This research will also include inspection method and other maintenance technology evaluations.

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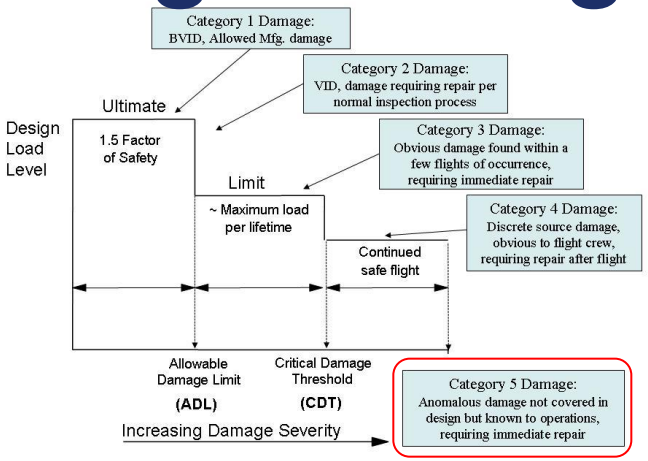
Safety Awareness: Engineering

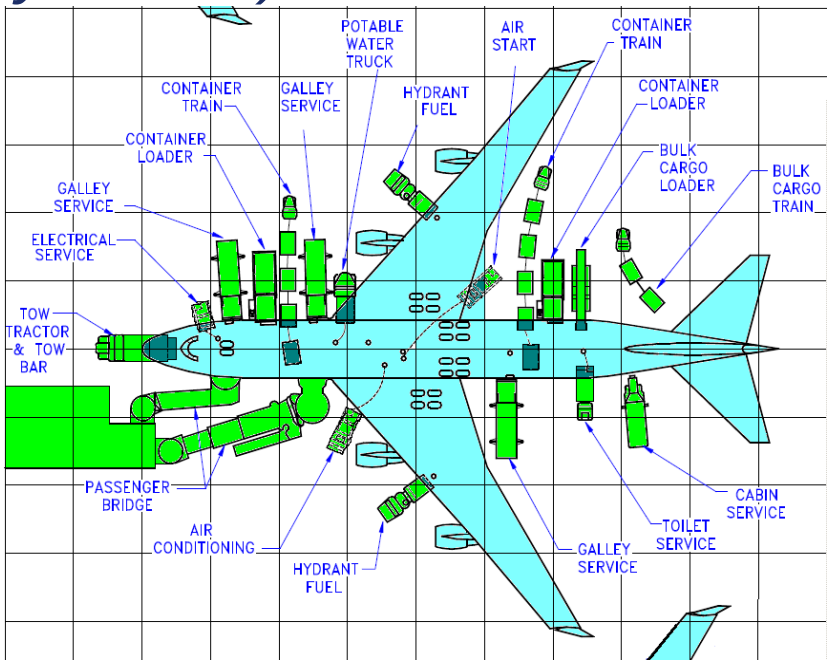
- **Category 5 Damage**
  - Severe damage
  - Rare event
  - Capability is below limit load
  - Beyond design considerations
  - Unbounded
  - Examples: severe collisions with service vehicles or other aircraft, flight overload conditions, very large bird strike



- **Composite Initiatives Covering Category 5 Damage**
  - Damage Tolerance Working Group (Industry & Regulatory)
  - FAA/CMH-17 Workshop, Chicago, IL (2006)
  - FAA/CACRC Workshop, Amsterdam, Netherlands (2007)
  - FAA/CACRC Workshop, Tokyo, Japan (2009)
  - AC 20-107B (Sep. 2009)
  - FAA/EASA Research

Safety Awareness: Reporting of Significant Impact Events on Composite Airframe Structures

(Efforts Initiated by DTWG)



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

AVS Plan: Continued Operational Safety (COS) - High Energy Wide Area Blunt Impact (HEWABI) -

- **TAD Policy for Airport Vehicle Collisions (HEWABI)**

  Activity: **Issue policy for transport aircraft to mitigate safety risks associated with service vehicle collisions with critical composite structure.**

  Outcome: ANM Policy Statement (FY 14-15)

- **Research Support to Policy & Industry Guidance**

  Activity: **Perform structural tests & supporting analyses to bound technical issues and identify design guidelines & evaluation protocols.**

  Outcome: Support Policy and Standards (FY 10-18)

- **CMH-17 Chapter(s) on HEWABI Phenomena**

  Activity: **Document HIWABI damage threats and safety management principles (e.g., design guidelines, structural evaluation, conditional inspections, maintenance training, operations safety awareness).**

  Outcome: CMH-17 Vol. 3 for Rev. H (FY 14-18).

- **Methods for Blunt Impact Damage Inspection (2014-TBD)**

  Activity & Outcome: **Establish NDE methods finding presence of major subsurface damage to internal composite fuselage structural members, and relate NDE measurements with damage location, mode, size/severity.**

High Energy Wide Area Blunt Impact (HEWABI) Research Strategy & Approach

- **FAA Research Program (2008 -)**
  - Institute: U of California @ San Diego, CA
  [Joint Advanced Materials & Structures (JAMS) Center of Excellence]
  - Principal Investigator: Prof. Hyonny Kim
  - FAA: Larry Ilcewicz (SIC), Rusty Jones (M&I)
  - Program Administration: FAA Tech Center
  - Industry Participation: Airlines, OEMs, and Others.
- **Objectives -**
  - To identify commonly occurring wide-area blunt impact scenarios of major concern to operators & OEMs.
  - To develop methodology for blunt impact threat characterization & modeling.
  - To experimental identify key phenomena & parameters governing blunt impact damage formation
  - To establish major sub-surface damage detection methods.

FAA Biz Plan (FY14-15): HEWABI

- **HEWABI Policy (ANM-100/115, FY14-15)**
  - Safety threat to composite transport aircraft in ground service operation
  - Technical study started a few years ago (2008)
  - Study conducted in UCSD (Prof. Kim) via FAA CoE
  - Data reviews have been conducted via various meetings (e.g., CMH-17, SAE/CACRC, FAA Workshops)
  - Need of guidance is a consensus of global community
  - Guidance (PS) will be developed via DTWG
  - A multi-year biz plan (FY14-15) to complete
  - Guidance will be harmonized (FAA/EASA/TCCA)

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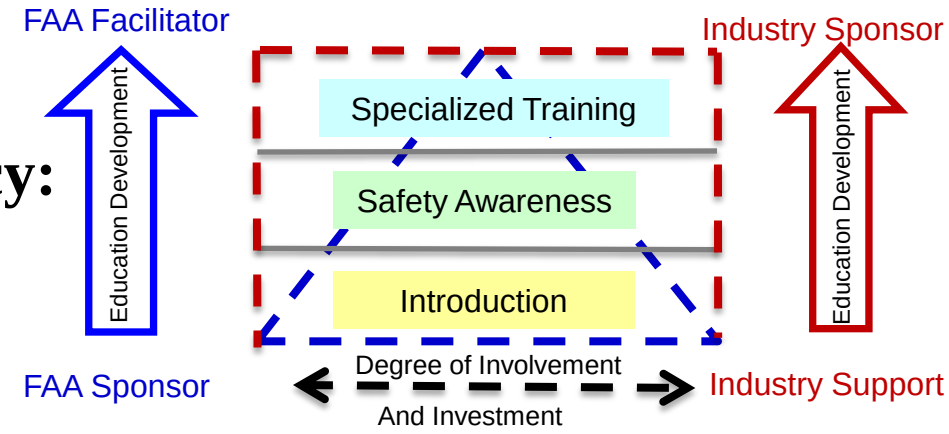
Workforce Educational Initiatives

FAA AVS Composite Training

- **FAA composite training strategy using existing courses, FAA COE & industry support** [White Paper – Sep/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

Level II Safety Awareness Courses

- **Maintenance Safety Awareness (CMT)**
  [International Standard: CACRC AIR5719]
  - FAA-led course development completed [9/2008]
  - FAA Audience: Flight Safety Inspectors [Content: 60 Hours]
  - 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
- **Structural Engineering Safety Awareness (CSET)**
  [Sponsored by FAA R&D, AIR-520]
  - First course offering through Wichita State Univ. (WSU) [4/2013]
  - FAA Audience: Airframe Engineers & Delegations [Content: 80 Hours]
  - Available to the industry through WSU.
- **Manufacturing Safety Awareness (CMfgT)**
  [Sponsored by FAA R&D, AIR-520]
  - Completion of course development [9/2014]
  - FAA Audience: Manufacturing Inspectors [Content: 60 Hours]
  - First course offer through Wichita State Univ. (WSU) in FY15.

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Summary and Closure

AVS Composite Plan Established to Guide FAA Initiatives

- **Continued involvement of industry, other agencies & institutions; and harmonization with foreign regulatory agencies (EASA & TCCA are active involved)**
- **Three (3) main areas: Continued Operational Safety (COS), Certification Efficiency (CE) and Workforce Education (WE)**
- **Active initiatives for composite guidance/standards**
  - Bonded repair size limits (BRSL) policy has safety priority
    (related bonded repair initiatives with help of CACRC & CMH-17)
  - HEWABI (service vehicle collision) is a safety concern requiring safety management approach
  - Plan to initiate effort of developing Hybrid F&DT Substantiation guidance in FY2016.
- **On-going active composite training initiatives**
  - Offer CMT, CSET & CMT courses for FAA staff and industry on a regular basis per needs.
  - Perform courses review/update on a regular basis per Update Cycle protocol.
- **AVS Composite Plan – A Living Plan (Update Annually)**
- **AVS Composite Plan – FAA Plan for Composite Safety** **[Thanks]**

Composite Safety & Certification Meeting - Overview: FAA Composite Plan -

- **Thanks for Opportunity.**
- **Questions and/or Thoughts?**
- **Further Discussion.**