Composites Technology

Training Strategy

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Ongoing FAA Composite Safety and 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

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
- ~50 FAA R&D Reports

- Educational strategies for composite technology transfer are a major part of future initiatives
  - Effective ways to gain working knowledge
  - Involvement of subject matter experts

Objectives for Fall AMTAS Meeting

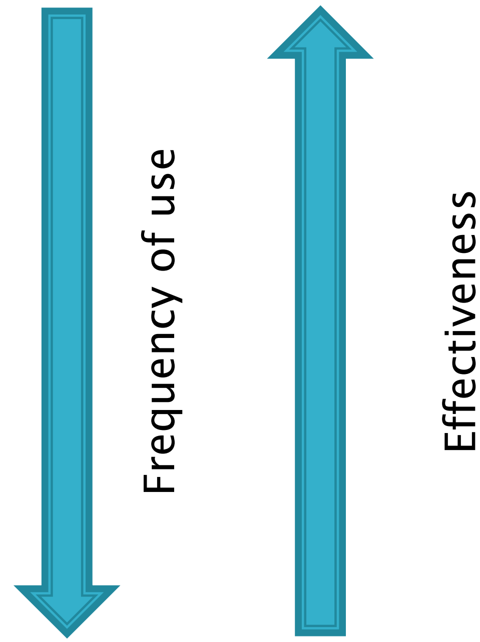
- Share progress in composite education plans and strategies derived to date
  (Supported by an Edmonds CC Cooperative Agreement)
- Solicit feedback on:
  - How to facilitate the most effective means of technology transfer
    e.g., educational courses/forum, internships
  - Discuss different ways to enhance learning effectiveness, e.g.,
    Involvement of subject matter experts
    Use of case studies (problems/applications)

Educating Practitioners through Technology Knowledge Transfer

- Technology knowledge base consists of:
  - Databases. Handbooks, Manuals
  - Industry practices
  - Practical insights
  - Training which is relevant to industry practices and common understandings
  - Research which is relevant to industry practices

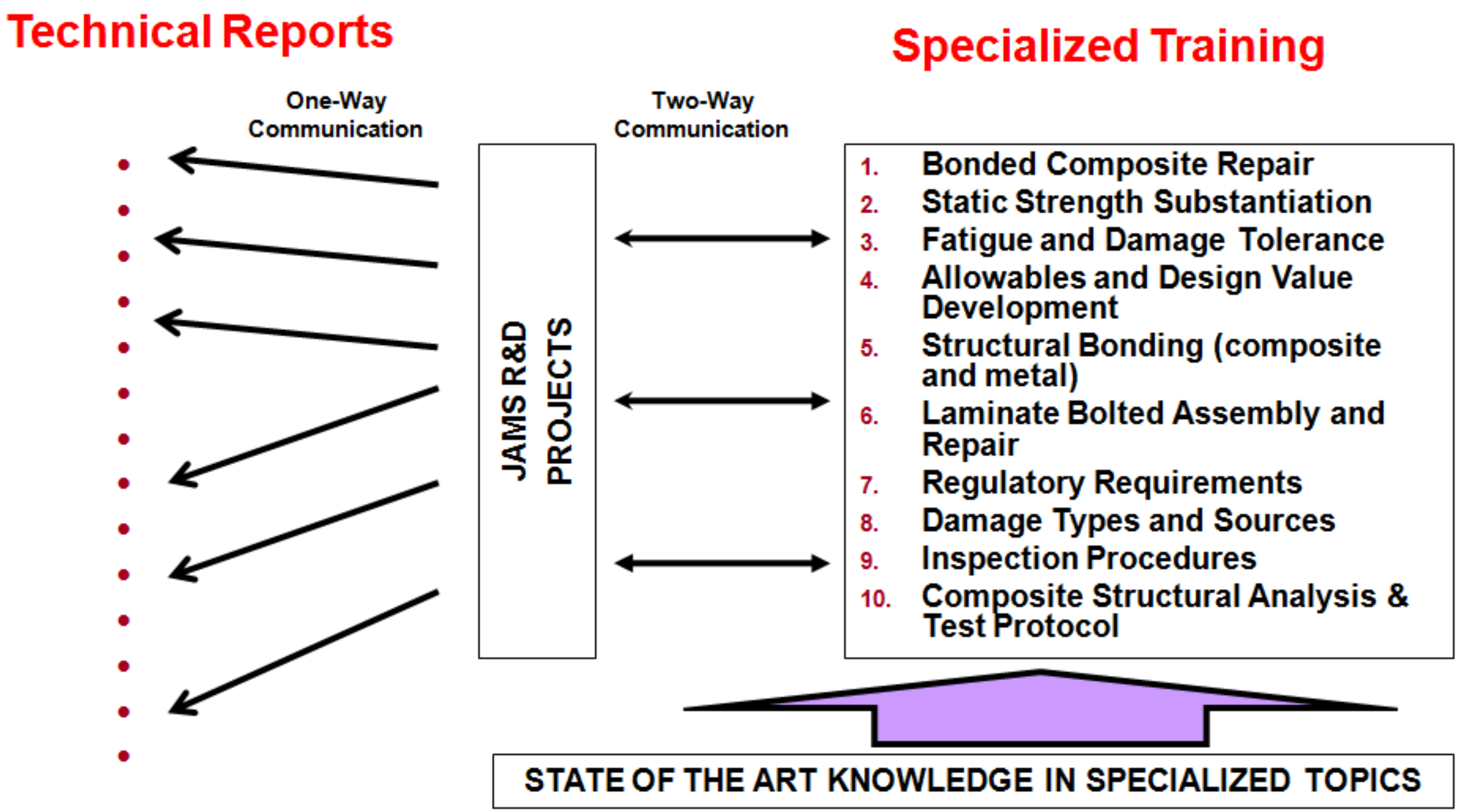
Educating Practitioners through Technology Knowledge Transfer Methods

- Education courses (Case Studies, SMEs)
- Internships (industry, faculty and student coops associated with R&D)
- Composite handbooks
- Workshops
- Technical research reports



Knowledge transfer can be more effective with increasing reliance on education and training

Internships and R&D have a Role in Knowledge Transfer while Increasing Research and Education Relevance



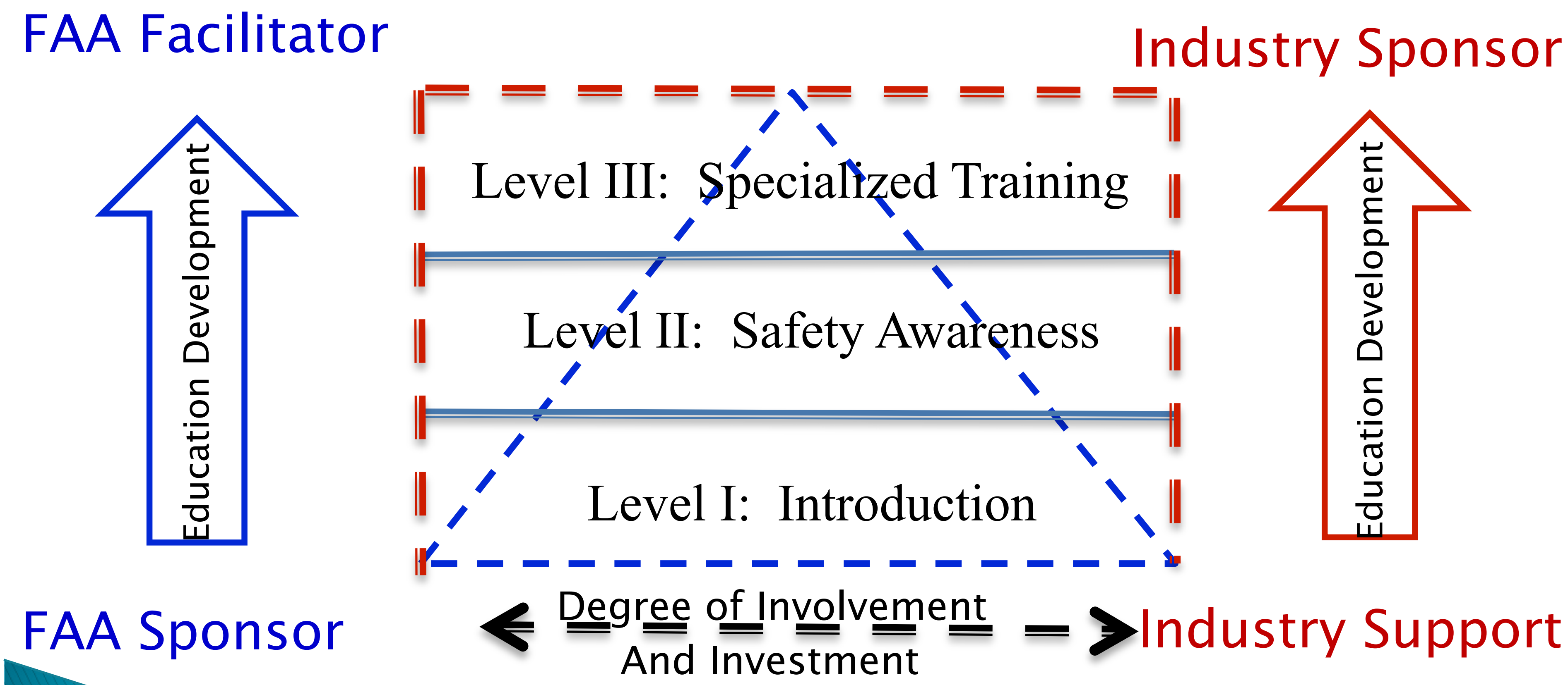
Education Progresses through Three Levels

Increasing Specialization

Specialized Training (Level III)	→	1. Skill building in specific areas 2. Institutions responsible for training which have subject matter expertise 3. "Go-to" skills needed for successful applications
Safety Awareness (Level II)	→	**1. Composite safety focus, including hands-on laboratory** **2. More details of regulatory guidance and industry practice** **3. Highest level where most standards are currently possible**
Introduction to Composites (Level I)	→	1. Basics of composite technology 2. Intro to job roles & responsibilities (understand "what you don't know") 3. Certification basics

Courses Progress from Awareness to Specialized Levels of Training

Training Development is a Team Effort between Industry, Academia, and Regulatory Organizations



Level I and Level II Course Development Initiatives

- Introductory courses (Level I)
  - CMH-17 Composite Certification and Compliance Tutorial developed in 2008, based on Chapter 3, Volume 3 (CMH-17)
  - Online course on composite basics developed as a prerequisite to Level II maintenance course (described below) in 2007
- Safety awareness courses (Level II)
  - Composite maintenance course developed from 2004 – 2007
  - Customization of the composite maintenance course developed in 2008 for FAA inspectors
  - Industry standard for teaching composite maintenance published through the Society of Automotive Engineers (2009): AIR 5719

<u>Lessons Learned</u>

Need more efficient approach (Don't include "masses" until end)

Educational partners must become self-sufficient

Level III Training Topics (used in industry surveys)

Crash dynamics and energy absorption of composite airframe structures	Composite Structural Analysis & Test Protocol
Safety risk management	Tooling
Emerging material forms and processes (e.g., VARTM, RTM, Chopped Fiber, etc.)	Flammability and composite high temperature performance issues
Damage Types and Sources	Lamination Processes
Source Documentation	Resin Transfer Molding
Regulatory Requirements	Mechanical Assembly
Conformity Guidelines	Static Strength Substantiation
Bonded Composite Repair	Fatigue and Damage Tolerance
Inspection Procedures	Material Qualification
Laminate Bolted Assembly and Repair	Allowables and Design Value Development
Structural Bonding (composite and metal)	Material and Process Specifications
Environmental protection incl. lightning strike	Manufacturing Automation

Level III Training Topics Preferences (200 responses)

Bonded Composite Repair	68%
Static Strength Substantiation	66%
Fatigue and Damage Tolerance	63%
Allowables and Design Value Development	59%
Structural Bonding (composite and metal)	51%
Laminate Bolted Assembly and Repair	47%
Regulatory Requirements	43%
Inspection Procedures	36%
Damage Types and Sources	35%
Material and Process Specifications	33%
Composite Structural Analysis & Test Protocol	32%
Material Qualification	32%

Level III Teaching Format Preferences

Online Teaching	85%
Laboratory	52%
Classroom	42%

Note: Respondents generally indicated that the content might dictate teaching format (e.g. inspection procedures best taught in laboratory; Level II courses most suitable for online)

Education Challenges

- Demand for practitioners with composites expertise exceeds the supply
- Proprietary nature of composites conflicts with the adoption of standard practices – education focuses on standard practices
- Cost and student availability of training
- Negative implications
  - Increased competition for practitioners
  - Dependence on OJT ⟶ Narrow knowledge base
  - Limited availability of experienced teachers
  - Limited training budgets

Education Needs

- Awareness of safety implications for decision-makers (Level II)
- Specialized training, utilizing the resources of multiple learning institutions (Level III)
  - Connecting R&D and education increases relevance of both
  - Interactions among coop students, professors, and industry provides depth and balance to content
- Training resources
  - SMEs, Multimedia, low-cost and accessible formats
  - Case studies

Learning Effectiveness

Increasing learning effectiveness and retention by adding meaning to content in courses includes:

- Subject matter experts (SMEs) involvement brings relevance to classroom. SMEs can:
  - Approve content during course development
  - Participate in online discussions and case studies
  - Assess course effectiveness
  - Assist in laboratory experience
- Case studies for online/classroom discussions
  - Students learn by ‘self-discovery’
  - Based on actual experiences
  - Interaction with SMEs enhances learning experience

Case Study Example: Transport Flap Assembly

An airline received an overhauled flap assembly and observed that the assembly would not properly fit due to contour, requiring further investigation

Weighted on one side, contour had 1.5 inch gap

Case Study Example: Transport Flap Assembly

Further investigation after removing lower skin and honeycomb revealed improper practices

250°F film adhesive well over 6" diameter

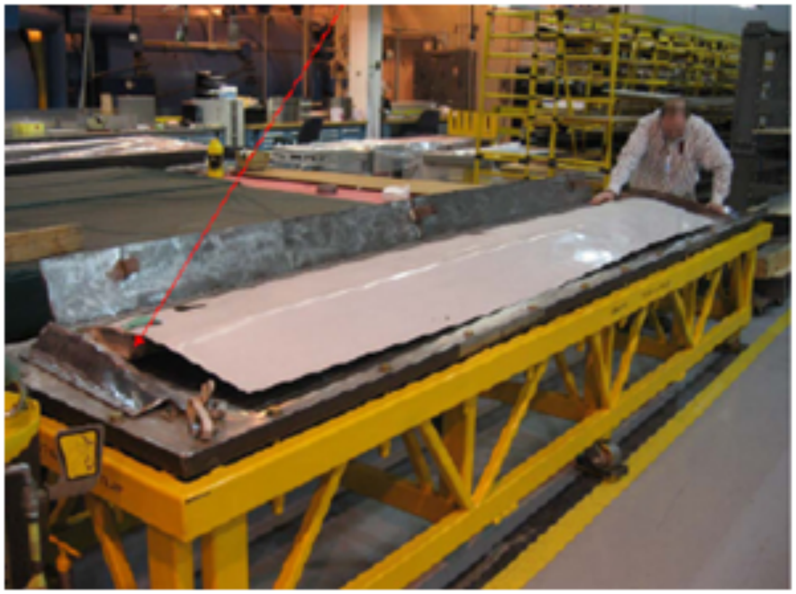
Incorrect film adhesive (SRM limits to 6 inches)

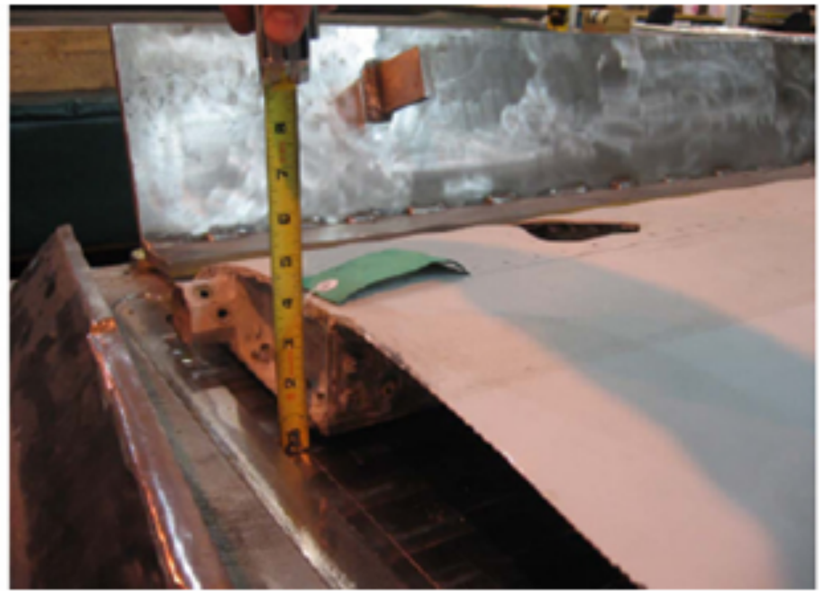
Burn marks on upper skin from overtemping during hot bond repairs.

Improper use/location of thermocouples resulted in overheating

Case Study Example: Transport Flap Assembly

Further investigation after removing lower skin and honeycomb revealed improper practices





Utilizing tooling with incorrect contours, during the repair, caused a warp condition on the spar

Discussion Topics involving SMEs

- **Roles and Responsibilities**
  - What can be the result of repairs made which are a) outside the limitations of the SRM and b) not properly substantiated?
- **Configuration Control**
  - How could the improper repairs have been detected aside from the lack of fit and function of the part on the aircraft?
- **Process Control**
  - Describe how the various prior repair discrepancies could have been prevented by proper process control during and after the repairs

Example of Application of AIR 5719
(To be integrated into case study for instructor)

SAE Aerospace
An SAE International Group

AEROSPACE INFORMATION REPORT

SAE 5719

Issued

Teaching Points for an Awareness Class on
"Critical Issues in Composite Maintenance and Repair"

4.1.2.5 Any available documentation must be reviewed for approved inspection techniques using, for example, NDI methods in the OEM's structural repair manual (SRM) or other approved repair instructions

4.2.1.4 The OEM's structural repair manual (SRM) or other authorized source documentation are used to:

4.2.1.4 .1 Define detection and inspection procedures needed to disposition the damage for a particular structural component.

4.2.1.4 .2 Define allowable damage limits and allowable repair sizes.

4.2.1.4 .3 Define acceptable repair designs and processes for the specified damage sizes and locations described for a given structure.

4.2.1.4 .4 Provide design and process details for time limited and permanent composite repairs, including specified limits for their use.

Summary

- Technology knowledge transfer of standard practices should emphasize education and training to complement workshops and reports
- R&D and education are closely related and add relevance to each
- Three levels of training are in various stages of development – The largest ‘gap’ is Level III
- Industry surveys have indicated topics of most interest and, when appropriate, a preference for on-line training
- Use of SMEs and Case Studies are proven methods of increasing learning effectiveness

Feedback and Discussion

- How to facilitate the most effective means of technology transfer
  e.g., educational courses/forum, internships

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