Center for Advanced Materials in Transport Aircraft Structures (AMTAS)

Summary of the AMTAS/JAMS Center of Excellence

prepared by

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Background – FAA Centers of Excellence

FAA Centers of Excellence (COE's):

- Funded through cooperative agreements among academic institutions, their affiliate industrial partners, and the FAA
- FAA provides funds that must be matched 1:1 by non-federal sources
- Funded in three phases over a total period of 3-10 yrs
- Expected to be self-supporting thereafter
- Six FAA COE's currently exist:

  http://www.coe.faa.gov/

The FAA Joint Advanced Materials & Structures (JAMS) Center of Excellence

Dec. 2003: FAA announced Phase I funding for a new Joint Advanced Materials & Structures (JAMS) Center of Excellence; University of Washington (UW) and Wichita State University (WiSU) are co-lead universities

Both UW and WiSU have since established their respective programs:

- UW: Center for Advanced Materials in Transport Aircraft Structures (AMTAS)
- WiSU: Center of Excellence for Composites and Advanced Materials (CECAM)

The FAA Joint Advanced Materials & Structures (JAMS) Center of Excellence

AMTAS and CECAM activities are coordinated by JAMS Program Manager Curt Davies (W.J. Hughes Research Center, Atlantic City, NJ)

- AMTAS/JAMS: http://depts.washington.edu/amtas/
- CECAM/JAMS: http://www.niar.twsu.edu/newniar/coe/cecam.asp
- JAMS: http://www.jams-coe.org/mx/hm.asp?id=home

AMTAS Participants

- AMTAS currently consists of:
  - Six academic partners
  - Twelve industrial partners
- Industry partner most actively involved is The Boeing Company

AMTAS Participants
Academic Partners

- University of Washington, lead (UW)
  - main campus in Seattle, WA
- Washington State University (WaSU)
  - main campus in Pullman, WA
- Oregon State University (OSU)
  - main campus in Corvallis, OR
- Edmonds Community College (EdCC)
  - campus in Lynnwood, WA
- Florida International University (FIU)
  - campus in Miami, FL
- University of Utah (UoU)
  - campus in Salt Lake City, UT

AMTAS Participants

Current Industry Partners

AMTAS Participants

Administered by the UW

- Prof. Mark Tuttle, Director
  206-685-6665
  tuttle@u.washington.edu

- Prof. Kuen Lin, Co-Director
  206-543-6334
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- Ms. Ellen Barker, Assistant to the Director
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  nelle@u.washington.edu

Some administrative activities

- Website established and updated regularly:
  http://depts.washington.edu/amtas

- AMTAS "news" - updates on AMTAS/JAMS e-mailed to interested persons every 1-2 months (about 650 persons, presently)

- AMTAS & JAMS meetings

AMTAS-JAMS
Meetings

- Semi-Annual AMTAS meetings:
  - Six held since initiation (nominally Oct & April; typically 50-70 attendees)
  - Usually (but not always) on UW campus
  - Autumn 2007 AMTAS Meeting:

    Thursday 25 October

    8:30am-4pm, HUB Rm 310, UW campus
    You are all invited (but please register)!
- Annual JAMS meetings
  - Three held since initiation (WiSU→ UW →Hughes Res Ctr)
  - Typically ~100 attendees, representing 12 universities plus many industrial partners
  - 2008 JAMS Meeting:
    Tues-Thurs, 17-19 June
    Future of Flight (Everett)

AMTAS-JAMS
Educational Activities

- 5-day, 40 hour short course
  - Offered every six months (September/March)
  - Introductory composites course for practicing engineers
  - ~10 instructors (5 from academia, 5 from industry or FAA)
  - Focus: composite material science, mechanics, manufacturing processes, structural design
- Additional specialty short courses under development
- AMTAS faculty @ UW also developed a Boeing Composite Certificate Program; ~150 have completed

AMTAS- JAMS
Research Projects

- Damage Tolerant Composite Design (K. Y. Lin, UW)
- Aeroservoelasticity of Composite Aircraft Structures (E. Livne, M. Tuttle, UW)
- Adhesive Bonding of Composites through Surface Characterization (B. Flinn, UW)
- The Effects of Surface Pretreatment on the Degradation of Composite Adhesive Bonds (L. Smith, WaSU)
- Analytical Chemistry Methods for Detecting Surface Contamination and Moisture (R. Burton, FIU)
- Composite Crashworthiness (P. Feraboli, UW)
- Maintenance/Repair of Composite Aircraft Structures (C. Seaton, EdCC)
- Out-of-Plane Loading of Thick Laminates (T. Kennedy, OSU)
- Shear Characterization of Composite Laminates and Adhesives (D. Adams, UoU)

AMTAS- JAMS
Details of Selected Projects

Aeroservoelasticity of Composite Aircraft Structures

- "Aeroservoelasticity" = study of interactions between a/c control systems, structures, and aerodynamic-inertial-structural forces during flight
- For example, aeroservoelastic analyses are used during design of modern aircraft control systems to insure that "flutter" conditions are never encountered during flight
- "Flutter" = uncontrolled structural vibrations due to airflow over a surface; can lead to catastrophic structural failure

AMTAS- JAMS
Details of Selected Projects

Aeroservoelasticity of Composite Aircraft Structures

- Typical research question: Can various forms of damage in composite control surfaces lead to unanticipated flutter conditions?
  - "damage" = delaminations, matrix cracking, weight increase/decrease, change in stiffness, broken hinge...)

- Objectives:
  - (Livne): Develop aeroservoelastic computational tools for nonlinear analysis of composite structures and control systems subject to multiple forms of damage
  - (Tuttle): Validate computations via experiments using simple structures in wind-tunnel testing

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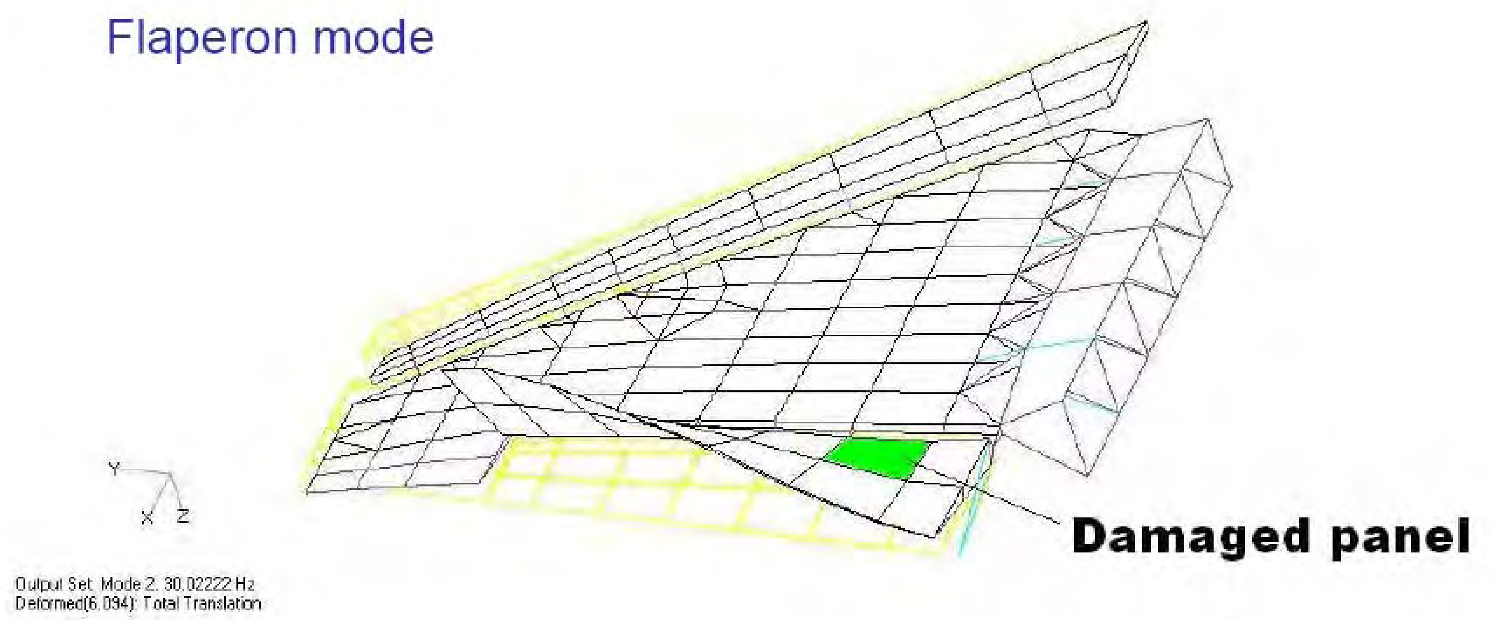
Details of Selected Projects

Aeroservoelasticity of Composite Aircraft Structures



- For fighter-jet type wing: Panel damage predicted to result in 7% reduction in critical flutter speed

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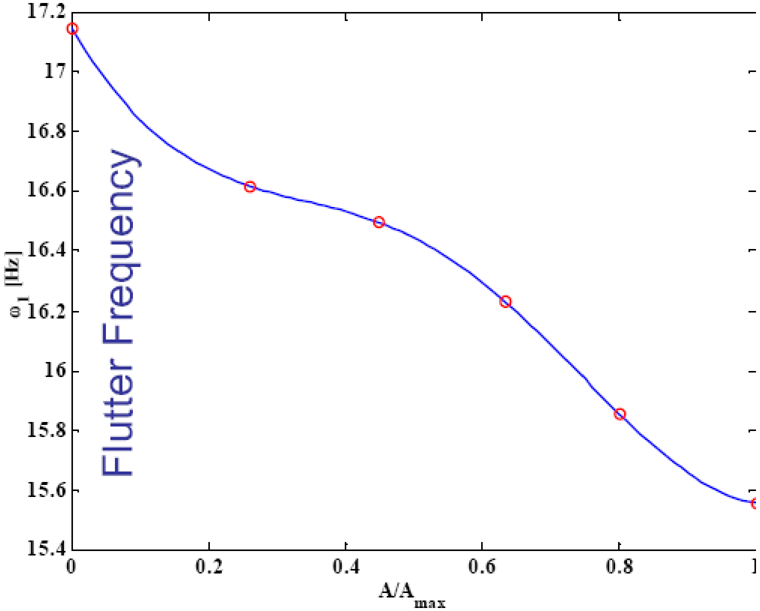
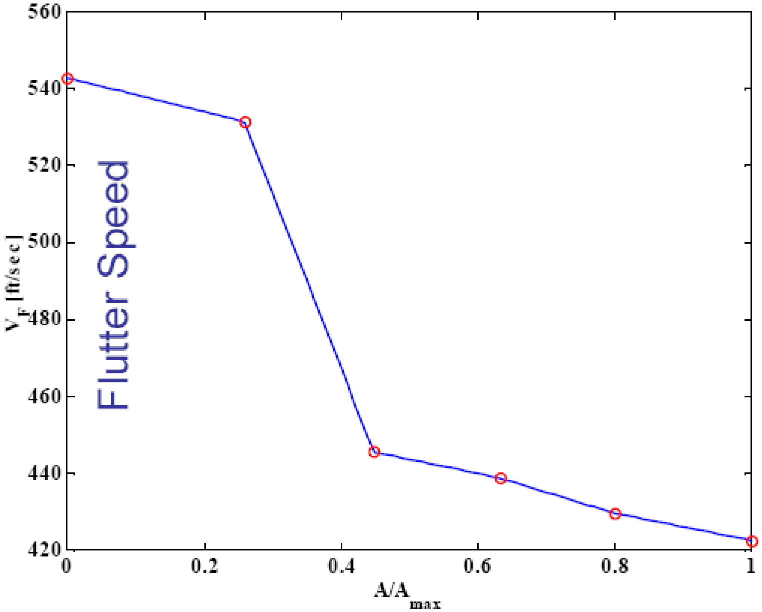
Aeroservoelasticity of Composite Aircraft Structures





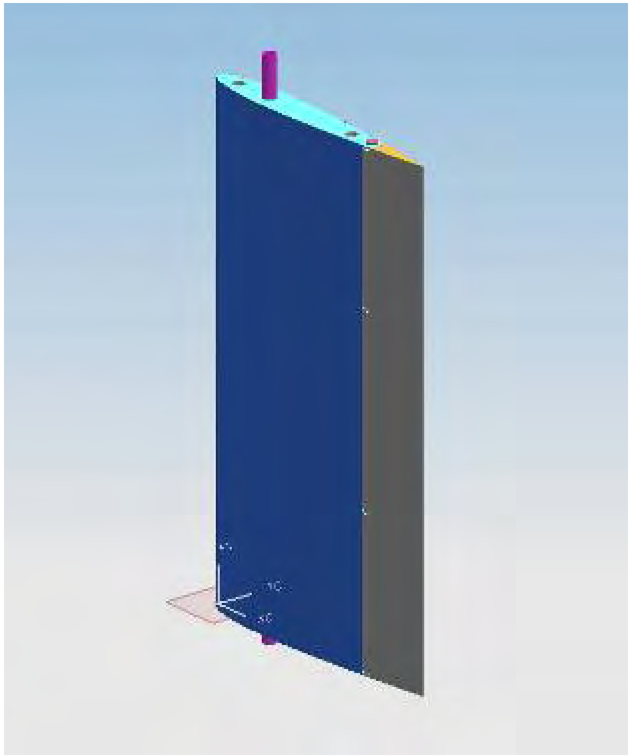
- For supersonic all-composite UAV: Delamination over 40% of aileron surface predicted to reduce flutter frequency and speed by about 35% and 13%, respectively

AMTAS- JAMS

Details of Selected Projects

<u>Aeroservoelasticity of Composite Aircraft Structures</u>

- Model based on NACA 0012 airfoil
- Nominal dimensions: 36 in tall, 20-in chord
- Aluminum wing w/composite sandwich rudder
- Several composite rudders will be fabricated/tested (both "pristine" and rudders with well-defined damaged regions); flutter speeds measured using UW low-speed wind tunnel
- Measurements compared to predictions



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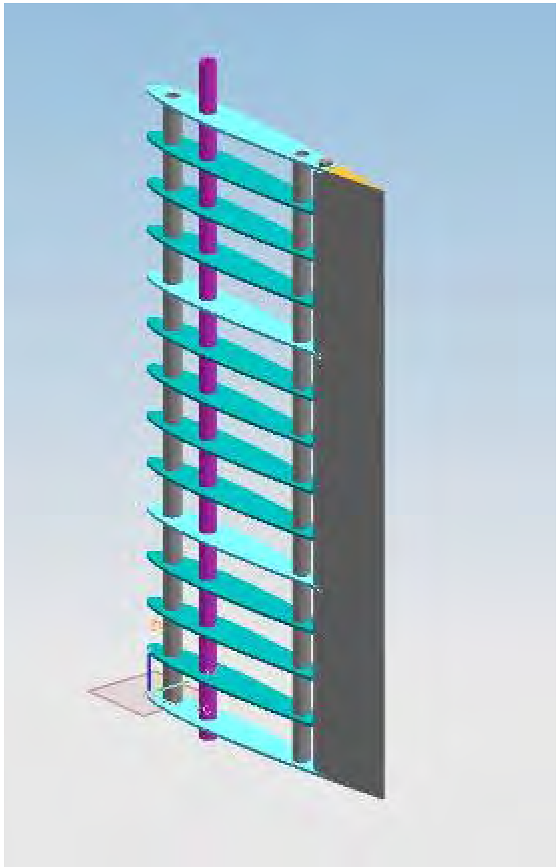

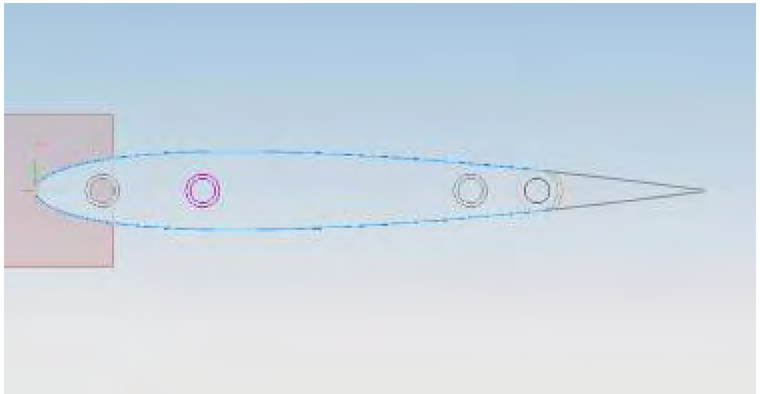

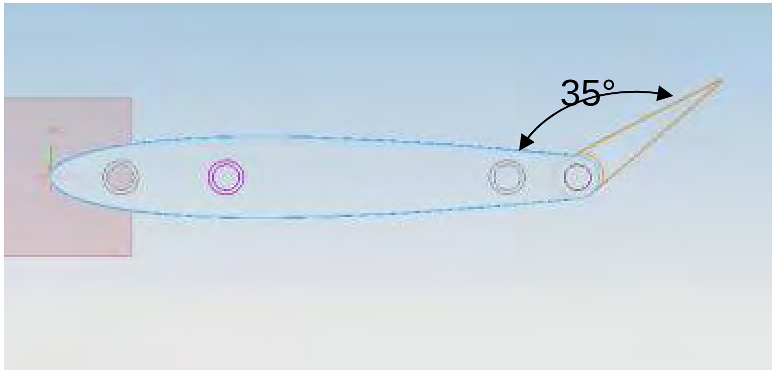

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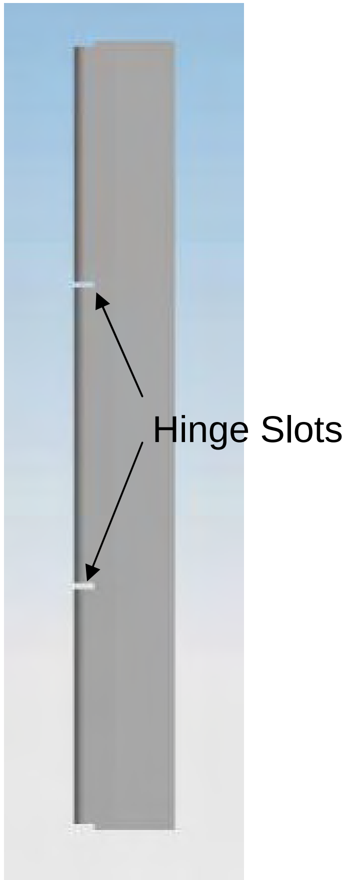

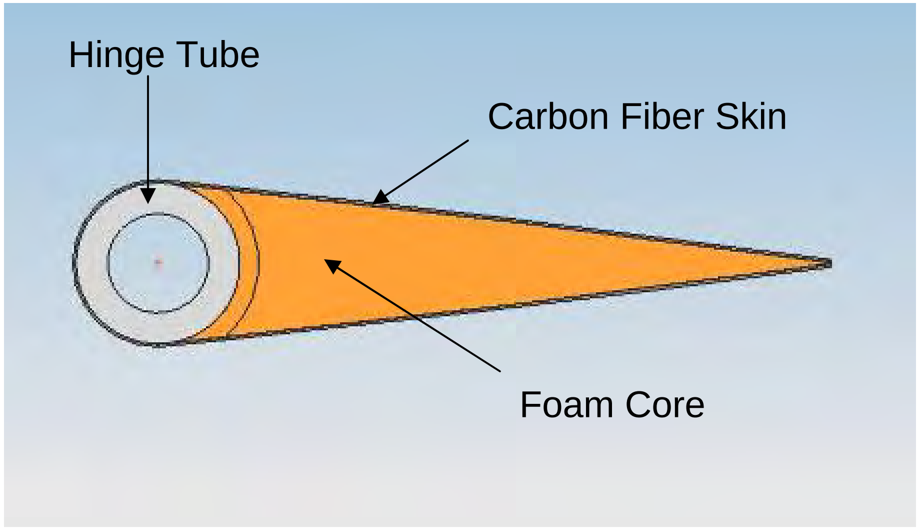

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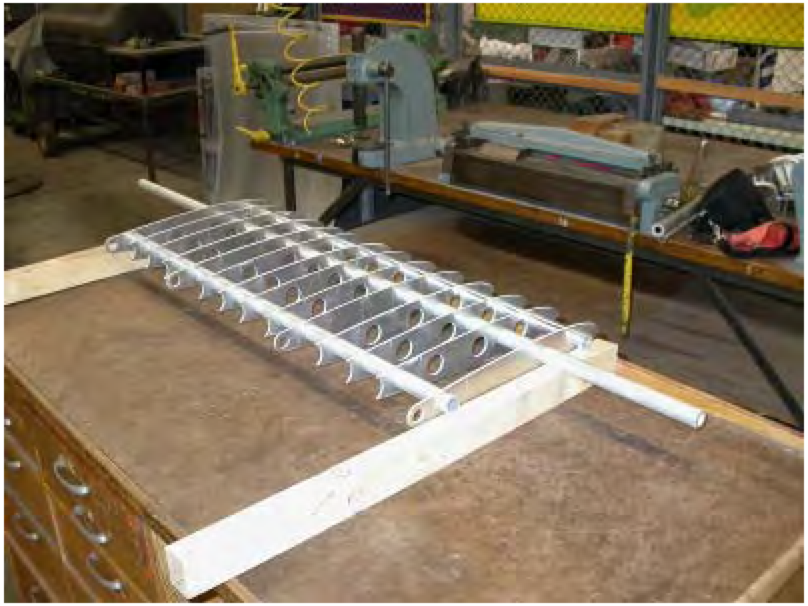
Aeroservoelasticity of Composite Aircraft Structures



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Details of Selected Projects

Aeroservoelasticity of Composite Aircraft Structures




AMTAS- JAMS

Details of Selected Projects

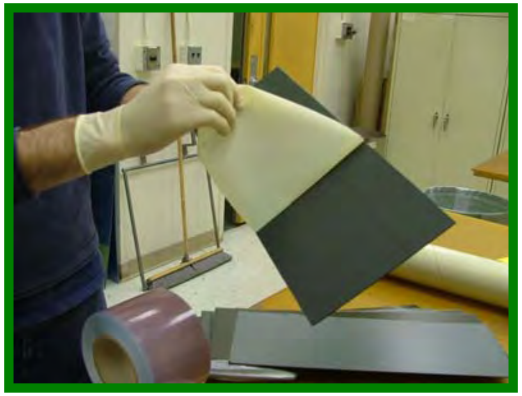
<u>Aeroservoelasticity of Composite Aircraft Structures</u>

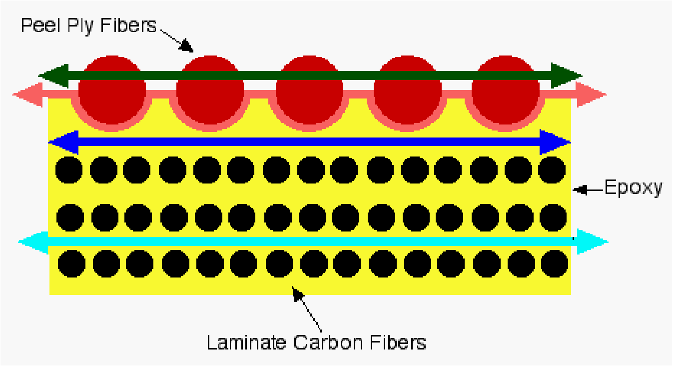
- Aluminum wing completed
- Composite rudders currently being fabricated
- Wind tunnel testing begin in November-December

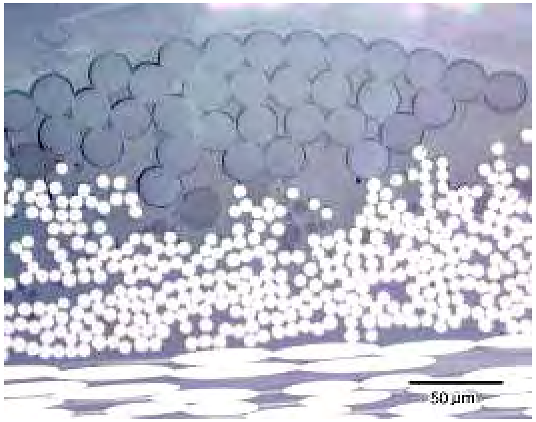
AMTAS-JAMS
Details of Selected Projects

Projects Involving Adhesive Bonding (UW, WaSU)

- Surface preparation is critically important in any adhesive bond
- The use of “peel-ply” is popular with composite structures (insures surface cleanliness)







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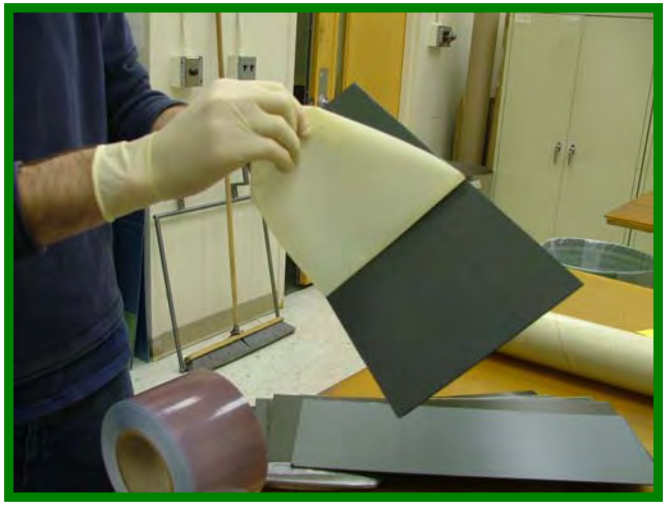
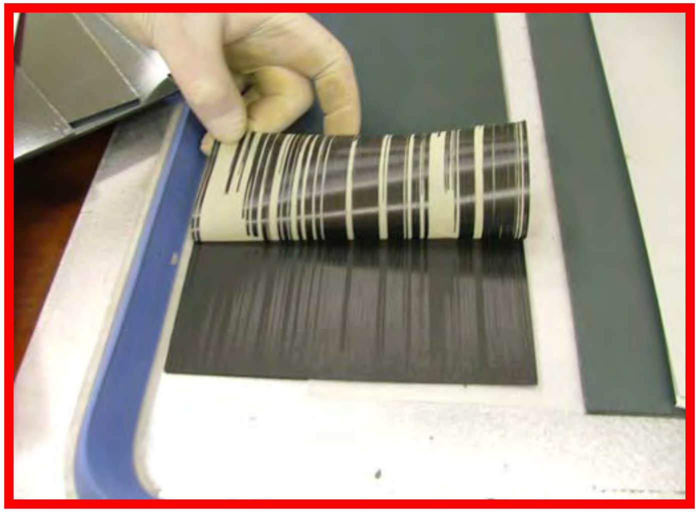
Projects Involving Adhesive Bonding (UW, WaSU)

- Several types of peel-plies are commercially available
- Successful use with one composite material system does not guarantee success with another – why?





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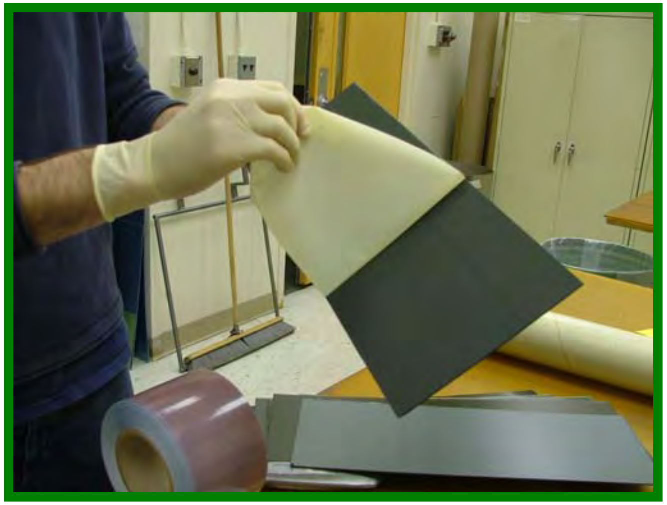
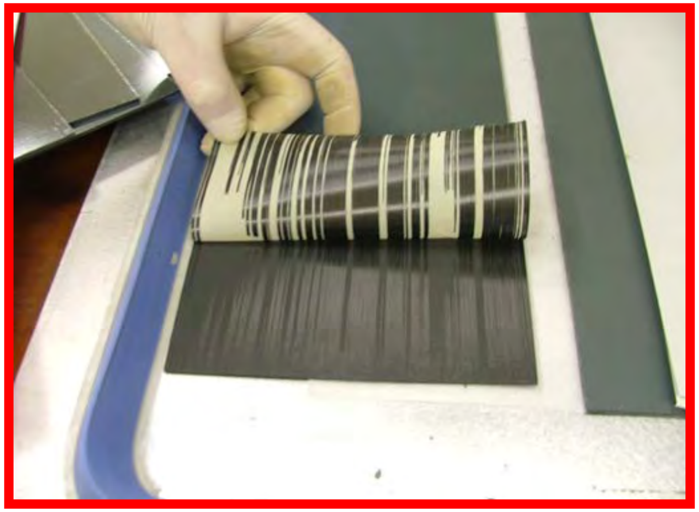
Details of Selected Projects

Projects Involving Adhesive Bonding

- Flinn (UW): Use modern surface characterization techniques to understand surfaces involved
- Smith (WaSU): Perform thermomechanical tests to evaluate impact of particular peel ply on performance





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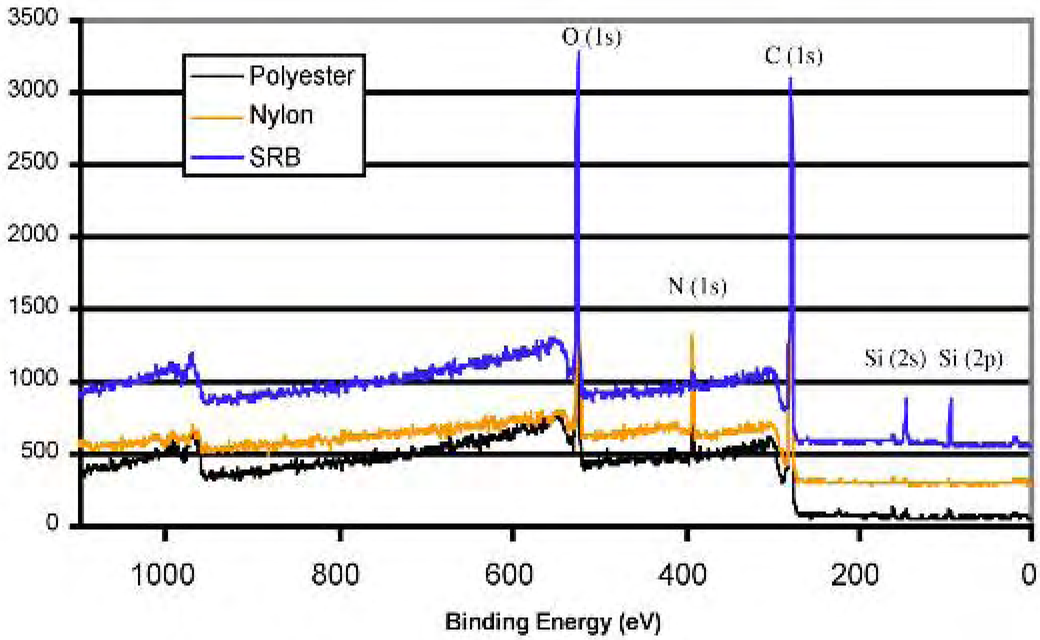
Details of Selected Projects

Projects Involving Adhesive Bonding

Flinn: X-ray Photoelectron Spectroscopy (XPS) surface scan reveals high Si concentration from SRB product



Laminate Surface Composition

Peel Ply	%C	%O	%N	%Si
Nylon	77.5	12.6	9.8	Tr.
Polyester	75.5	21.6	1.9	1.0
SRB	68	24.2	0.9	6.9

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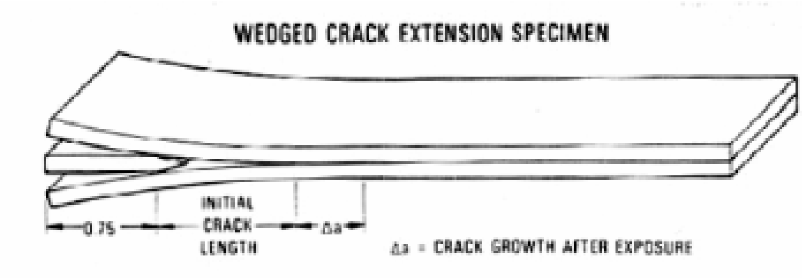
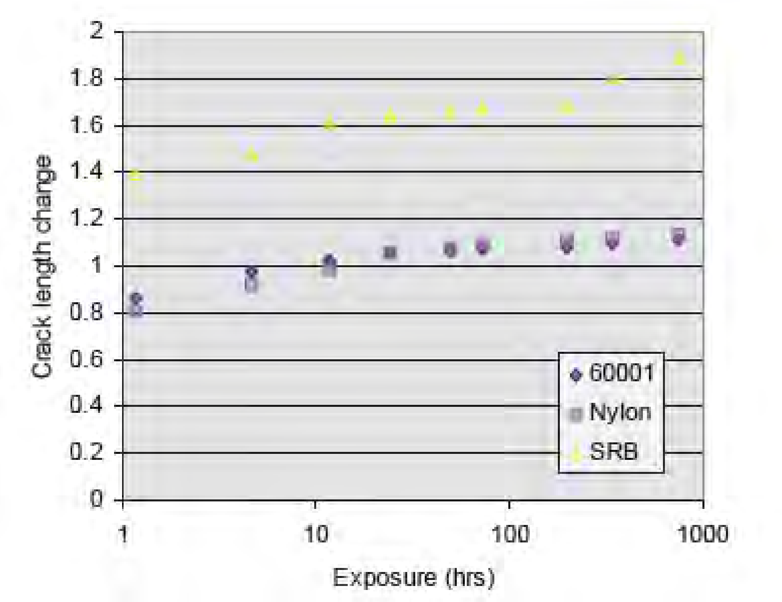
Details of Selected Projects

Projects Involving Adhesive Bonding

Smith: Wedge tests confirm poor performance of SRB product (although long-term crack growth rates comparable)





Concluding Comments

- AMTAS/JAMS provides an opportunity for industry to leverage R&D expenditures by utilizing 1:1 matching FAA funds
- Industry can also collaborate directly with AMTAS faculty/students (i.e., without FAA matching funds)
- Efforts to expand to a regional advanced materials and manufacturing center that supports multiple industrial segments are underway