FAA Joint Centers of Excellence for Advanced Materials (JAMS)

Federal Aviation Administration

Presenter:

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Aviation Research Division
FAA Technical Center

Presented to SAS REDAC

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Background

- FAA Office of NextGen (ANG) has two grant programs for research and development funding
  - Aviation Research Grants
  - FAA Centers of Excellence

	FY21	
	# of Grants	Total Award
Aviation Research	20	$7.3M
COE	142	$56.1M

- The FAA has entered into six cooperative agreements with competitively selected Centers of Excellence (COE) established with academic institutions and their industry affiliates throughout the United States:
  - ASCENT: Center of Excellence for Alternative Jet Fuels and Environment
  - ASSURE: Center of Excellence for Unmanned Aircraft Systems
  - CST: Center of Excellence for Commercial Space Transportation
  - **JAMS: The Joint Centers of Excellence for Advanced Materials**
  - PEGASAS: Center of Excellence for General Aviation Safety
  - TTHP: Center of Excellence for Technical Training and Human Performance

FAA Joint Centers of Excellence for Advanced Materials (JAMS)

- **JAMS was established by the FAA as a Joint Centers of Excellence in 2004**
  - COE for Composites and Advanced Materials (CECAM)
  - COE for Advanced Materials in Transport Aircraft Structures (AMTAS)
- **9 Core Member Universities**
- **H.R. 302 (P.L. 115-254), FAA Reauthorization Act of 2018,**
  - It extended FAA's funding and authorities through Fiscal Year 2023.

SEC. 762. ADVANCED MATERIALS CENTER OF EXCELLENCE.

(a) IN GENERAL.—Chapter 445 of title 49, United States Code, is amended by adding at the end the following:

"§ 44518. Advanced Materials Center of Excellence

"(a) IN GENERAL.—The Administrator of the Federal Aviation Administration shall continue operation of the Advanced Materials Center of Excellence (referred to in this section as the 'Center') under its structure as in effect on March 1, 2016, which shall focus on applied research and training on the durability and maintainability of advanced materials in transport airframe structures.

"(b) RESPONSIBILITIES.—The Center shall—

"(1) promote and facilitate collaboration among academia, the Transportation Division of the Federal Aviation Administration, and the commercial aircraft industry, including manufacturers, commercial air carriers, and suppliers; and

"(2) establish goals set to advance technology, improve engineering practices, and facilitate continuing education in relevant areas of study.".

JAMS
JOINT ADVANCED MATERIALS & STRUCTURES CENTER OF EXCELLENCE

CECAM
center of excellence for composites and advanced materials

- **Wichita State University**
- University of California San Diego
- Auburn University
- Mississippi State University

A Center of Excellence
AMTAS
Advanced Materials in Transport Aircraft Structures

- **University of Washington**
- University of Utah
- Oregon State University
- Washington State University
- Florida International University

FAA Joint Centers of Excellence for Advanced Materials (JAMS)

Benefits

- Access to a large pool of subject matter experts and specialized laboratories from member universities
- 1:1 in-kind or matching contributions from a non-federal source
- Thriving research community
  - Improved coordination and awareness among member universities and affiliates
  - Strong connections with industry as contributing research partners,
  - Partnerships with other government agencies to leverage resources and coordinate efforts.
  - Connections with international industry standards organizations
- Workforce education and knowledge transfer
  - JAMS graduates are employed by government agencies and industry partners
  - Publically available data and technical publications

JAMS Funding Source

- Congress is providing directed funding for JAMS through the FAA research and development budget
- JAMS funding is primarily provided through the FAA **Advanced Materials/Structural Safety** research program and associated budget line item (**A11C**)
    - In FY19 and FY20 Continued Airworthiness program (A11E) included additional direction for JAMS
- Congressional direction is outlined in a Joint Explanatory Statement that refers to applicable House/Senate Report for that Fiscal Year
- FY21 research budget direction for A11C is provided in **116HR-133 Joint Explanatory Statement Division L Transportation-HUD** (December 21, 2020):

> *Advanced materials/structural safety.*—The agreement includes $14,720,000 for advanced materials/structural safety, of which: (1) $6,000,000 is to advance the use of these new additive materials (both metallic and non-metallic based additive processes) in the commercial aviation industry; (2) $4,000,000 is to advance the use of fiber reinforced composite materials in the commercial aviation industry through the FAA Joint Advanced Materials and Structures Center of Excellence; and (3) $2,000,000 is for the FAA to continue its work with existing public-private partnerships that provide leading-edge research, development, and testing of composite materials and structures.

$12M directed to JAMS research in FY21 budget

JAMS Funding

- JAMS historical funding trends

A11C - Advanced Materials/Structural Safety Program Budget

	FY 2021	FY 2020	FY 2019	FY 2018
Request	$ 1,003,000	$ 1,799,000	$ 2,300,000	$ 4,338,000
** Enacted	$ 14,720,000	$ 14,720,000	$ 14,720,000	$ 10,500,000
Directed to JAMS	**$ 12,000,000**	**$ 12,000,000***	**$ 12,000,000***	**$ 6,000,000**

* Includes $2,000,000 from A11E

** Includes ~$1.3M for PC&B

- JAMS uses RED funding which is available for obligation three years including year of appropriation (e.g., if not awarded, FY21 funds will expire at the end of FY23, or on Oct 1, 2023).

Dollars Committed to JAMS

Fiscal Year	Commitments to Date
FY18	$ 8,898,588
FY19	$ 14,462,749
FY20	$ 13,039,190
FY21*	$ 5,849,883

* awards are pending final approval from OST

FAA Advanced Materials Research

JAMS Program Drivers

- The FAA's mission is to "provide the safest, most efficient aerospace system in the world." Safety is always our first priority

- **Continued operational safety of advanced material technologies currently used in aviation products**
- **Knowledge base for certification of new and emerging materials:** New manufacturing techniques, such as 3D printing, and new materials, such as polymer and ceramic matrix composites, are being incorporated into aircraft design. These techniques and materials must be certified as safe for their intended application and may have other implications that need to be understood.

- FAA-funded research on advanced materials and structural safety helps AVS-AIR Cert. Office to identify and manage safety risks, opportunities to standardize means of compliance, and promote workforce education.

"… from 1933 up until the Boeing 787, they've been building aircraft the same way."
Robert van der Linden, Curator, Commercial Aviation, National Air and Space Museum

FAA Advanced Materials Research

JAMS Program Focus

A11C BLI Focus Areas	Research Topics
Guidelines for characterizing new material forms and assessing manufacturing maturity	• Develop new material database protocols • Evaluate equivalence for changes to materials and processes relative to an existing database • Evaluate key process parameters and key characteristics for selected new materials and processes, as well as effectiveness of manufacturing control and inspection methods including in-situ monitoring and NDI
Long-term material and structural behavior and associated maintenance activities	• Evaluate aging effects on selected material or structural detail. • Evaluate fatigue and damage tolerance behavior of bonded joints
Dynamic behavior of advanced structures	• Evaluate analytical methods for evaluating composite seat performance • Evaluate analytical methods for modeling bird strike of composite structure • Investigate dynamic behavior of composites and other advanced materials/processes
Methods for characterizing composites to tie to best practice design and certification principles	• Develop standards and supporting data evaluation protocols for characterizing/testing mid-level composite building block configurations • Develop standards and supporting data evaluation protocols for characterizing/testing mid-level additive manufacturing building block configurations

FAA Advanced Materials Research

JAMS Program Scope

- Ongoing JAMS projects supports the following research requirements under A11C BLI

A11C	Requirement Title
SIC.1	Fatigue and Damage Tolerance of Composite Structures*
SIC.2	Composite Maintenance Practices
SIC.3	Crashworthiness Issues Unique to Composites
SIC.5	Structural Integrity of Adhesive Joints
SIC.12	Continued Operational Safety (COS) and Certification Efficiency (CE) for Emerging Composite Technologies*
SIC.13	Advanced Materials Standardization Development*
SIC.14	Certification and Maintenance Protocols for Bonded Joints
SIM.1	Advancement of Metal Additive Manufacturing Materials*

* funded by the FY21 budget

COE JAMS – Research Portfolio

- FAA awarded 75 grants to JAMS Universities since 2017
- Current JAMS research portfolio includes 40 active projects

Project Title (University)

Impact Damage Formation on Composite Aircraft Structures **(UCSD)**
Impact Damage Tolerance Guidelines for Stiffened Composite Panels **(UCSD)**
DT for Full-Scale Composite Structures under Repeated Loading **(WiSU)**
Failure of Notched Laminates Under Out-of-Plane Bending **(OSU)**
Evaluation of Parameters Used in Progressive Damage Models **(OSU)**
Environmental Factor Influence on Composite Design and Certification **(WiSU)**
Fracture Mechanics Test Methods for Sandwich Composites **(UU)**
Moisture Diffusion in Sandwich Composites **(UW)**
Safety Management of Composite Certification Guidance **(WiSU)**
FAA CSET, CMT, CMfgT and Adhesive Online Courses **(WiSU)**
Certification by Analysis – Structural Crashworthiness **(WiSU)**
A Building Block Approach for Crashworthiness Testing **(UU)**
Effect of Surface Contamination on Composite Bond Durability **(FIU)**
Durability of Adhesively Bonded Joints for Aircraft Structures Project **(UU)**
Durability of Bonded Aerospace Structures **(WSU)**
Improving Adhesive Bonding Through Surface Characterization **(UW)**
Nanomechanical Characterization of Adhesive Bondlines **(UW)**
Evaluation of aged bonded rotor blades **(WiSU)**
Lightning Strike of Composite Structures **(WiSU)**

Project Title (University)

Airframe Crashworthiness Testing and Simulation **(WiSU)**
Resin Infused Fiber Reinforced Materials Guidelines **(WiSU)**
Ceramic Matrix Composite (CMC) Materials Guidelines **(WiSU)**
Polymer-Based Additive Manufacturing (PBAM) Guidelines **(WiSU)**
Surface Integrity of Additively Manufactured Ti-6A1-4V Parts **(AU)**
Factors Affecting Qualification/Certification of Metal AM parts **(AU)**
Certification of Discontinuous Fiber Composite Material Forms **(UW)**
Post-Crash Fire Forensic Analysis on Aerospace Composites **(MSU)**
Development of Higher Level Building Block Testing Standards **(WiSU)**
Inspection and Teardown of In-Service Bonded Repairs Project **(WiSU)**
Composite Repair Materials Guidance for Aircraft Safety Assurance **(WiSU)**
Advanced Fiber Reinforced Polymer Composite Materials Guidance **(WiSU)**
Adhesive Qualification Guidance for Aircraft Design and Certification **(WiSU)**
Adhesive Bond Qualification Guidance for Aircraft Design and Certification **(WiSU)**
Development of a Technical Standard Order (TSO) for Composite Materials **(WiSU)**
Core Materials Qualification Guidance for Aircraft Design and Certification **(WiSU)**
Process Control Documents and Process Specifications for Advanced Materials **(WiSU)**
Static Strength Variability Between Composites and Metallic w/rto Overload Factors **(WiSU)**
Thermoplastic Joining Process Qualification Protocols for Design and Certification **(WiSU)**
Correlation Between Effects of Defects on Static and Dynamic Strength Behavior **(WiSU)**
Effects Disinfecting Materials and Methods on Cabin Interiors **(WiSU)**

COE JAMS - Program Management

FAA Team

FAA Administrator (AOA)

5 Lines of Business

- Aviation Safety (AVS)
  - Air Certification (AIR)
    - Policy & Innovation (AIR-600)

Larry Ilcewicz, PhD - Chief Scientific and Technical Advisor (CSTA) for Composites
Cindy Ashforth – Senior Technical Specialist (STS) for Composites
Joseph Pellettiere, PhD - CSTA for Crash Dynamics

Sponsors
Develop Research Requirements

9 Staff Offices

- NextGEN Next Generation Air Transportation System (ANG)
  - William J Hughes Technical Center (ANG-E)
    - Aviation Research (ANG-E2)
      - Structures & Materials (ANG-E281)

Performers
Manage Program Funds & Research Project

Ed Weinstein, PhD – Section Manager
Ahmet Oztekin, PhD – JAMS PM
Curt Davies
Danielle Stephens
Dave Stanley
Kevin Stonaker
Lynn Pham
Burak Kumas

FAA Advanced Materials Research

JAMS Research Lifecycle – Before Award

- FAA program sponsors develop research requirements
- FAA Tech Center team outlines research tasks and develops cost estimates
- AVS RED MT rates proposed requirements and determines research priorities

Congress passed the budget & President signed it into law

- FAA confirms the intent of the budget language through congressional liaison
- Develop detailed Research Execution Plans per actual budget including any plussed-up amount and congressional direction (Sponsors and Performers)
  - Identify specific research tasks and associated projects
  - Request research dollars

- Research Execution Plans are reviewed and approved by the ANG & AVS management
- Funds are released by AFN

FAA Tech Center team develops projects with JAMS schools in close coordination with AVS sponsors

JAMS schools submit final proposals through grants.gov

FAA review panel provides technical and cost evaluation for each JAMS submission

Approved and fund certified proposals are bundled in a request package for JAMS and submitted to the FAA Grant Management Office

5-8 months

- Grant management office coordinates FAA-OST review process.
- During this process each grant is reviewed by the FAA legal office and signed by the FAA Administrator.
- Subsequently OST reviews the JAMS package
- Secretary of Transportation signs on the grant package
- Awards are issued

FAA Advanced Materials Research

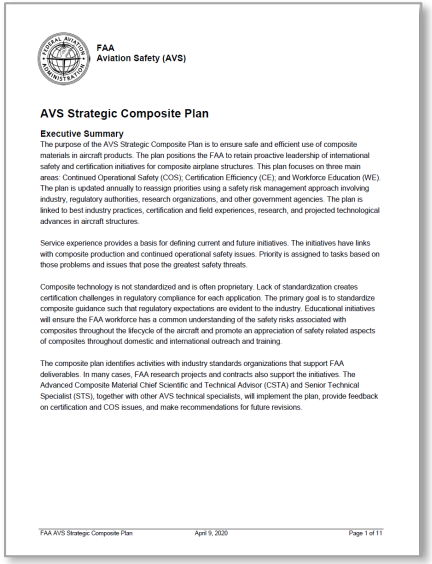
JAMS Research Lifecycle – After Award

- FAA Tech Center team manages JAMS projects to make sure they align with FAA mission and industry priorities
- Monthly meetings with the PIs and FAA sponsors as well as industry partners to review status
- Public technical exchange meetings with participation from industry and research community to hear feedback
- Annual JAMS technical review meetings with all stake holders to culminate synergy and situational awareness among funded projects and research teams

Impact of JAMS Research

Internal to FAA

- **A11C BLI program activities and JAMS research are aligned with key initiatives and deliverables identified by the FAA Composite Plan**
- **FAA Composite Plan**
  - In use since FY14
  - A short (<10 page) document that summarizes potential safety risks and opportunities for standardization associated with the use of composites in aviation products
    - Aviation Safety (AVS)-level plan (implemented by flight standards, aircraft certification and manufacturing inspection offices)
    - (up to) 7-year plan, updated annually
    - Safety management principles used to select subjects and prioritize deliverables
  - Defines mitigating actions for the FAA -rulemaking, policy, guidance, and training materials
    - Identifies prerequisite industry and research activities
  - Divided into subjects under **Continued Operational Safety**, **Certification Efficiency** and **Workforce Education**



FAA
Aviation Safety (AVS)

AVS Strategic Composite Plan

Executive Summary

The purpose of the AVS Strategic Composite Plan is to ensure safe and efficient use of composite materials in aircraft products. The plan positions the FAA to retain proactive leadership of international safety and certification initiatives for composite airplane structures. This plan focuses on three main areas: Continued Operational Safety (COS); Certification Efficiency (CE); and Workforce Education (WE). The plan is updated annually to reassign priorities using a safety risk management approach involving industry, regulatory authorities, research organizations, and other government agencies. The plan is linked to best industry practices, certification and field experiences, research, and projected technological advances in aircraft structures.

Service experience provides a basis for defining current and future initiatives. The initiatives have links with composite production and continued operational safety issues. Priority is assigned to tasks based on those problems and issues that pose the greatest safety threats.

Composite technology is not standardized and is often proprietary. Lack of standardization creates certification challenges in regulatory compliance for each application. The primary goal is to standardize composite guidance such that regulatory expectations are evident to the industry. Educational initiatives will ensure the FAA workforce has a common understanding of the safety risks associated with composites throughout the lifecycle of the aircraft and promote an appreciation of safety related aspects of composites throughout domestic and international outreach and training.

The composite plan identifies activities with industry standards organizations that support FAA deliverables. In many cases, FAA research projects and contracts also support the initiatives. The Advanced Composite Material Chief Scientific and Technical Advisor (CSTA) and Senior Technical Specialist (STS), together with other AVS technical specialists, will implement the plan, provide feedback on certification and COS issues, and make recommendations for future revisions.

FAA AVS Strategic Composite Plan April 9, 2020 Page 1 of 11

Impact of JAMS Research

Internal to FAA – Past Accomplishments

- **Some key initiatives and deliverables of the FAA Composite Plan directly supported by JAMS research**
  - Policy Statement on Bonded Repair Size Limits PS-AIR-20-130-01 (released 11/2014)
  - Chapter in Order 8900.1 “Flight Standards Information Management System” outlining Bonded Repair Size Limits
  - Advisory Circular (AC) 65-33, “Development of Training/Qualification Programs for Composite Maintenance Technicians” to include specific guidance on bonded structure
  - Policy Statements PS-ANM-25-20 requiring HEWABI evaluation during the certification of aircraft structures (released 8/2017). Internal FAA webinar (5/2018)
  - FAA “White Paper” outlining draft policy on interpretation of existing amendment 25.571 for composite structure (9/2016)
  - Deliverable to complete minimum curriculum requirements for maintenance school (5/2017). Portions of the training requirements have been incorporated in AC 65-33
  - FAA Chief Scientific and Technical Advisor (CSTA) workshop on engine applications to identify scope of engine AC (9/2019)
  - Composite Structural Engineering Training (CSET) was updated with significant reorganization and content changes. It was offered for the first time in March 2020
  - Data and technical content for planned revisions to the Composite Materials Handbook (CHM-17)

Impact of JAMS Research

Internal to FAA – Ongoing Support

- **Ongoing JAMS research supports the following key initiatives of the FAA Composite Plan.**
  - Continued Operational Safety
    - Bonding Safety Risks: bonded repairs, bondline durability (additional emphasis on rotorcraft applications), and sandwich disbond growth
    - Failure Analysis of Composites Subjected to Fire
  - Certification Efficiency
    - Fatigue and Damage Tolerance
    - Composite Quality Assurance
    - General Composite Guidance
    - Engine Guidance
    - Composite Technical Standards Order
  - Workforce Education
    - Periodic updates to composite training for ACO engineers, MIDO inspectors and FSDO inspectors
    - Industry training and international outreach

Congressionally Directed JAMS Research

@ Wichita State University

JOINT ADVANCED MATERIALS & STRUCTURES CENTER OF EXCELLENCE

FAA-funded Research:

- Additive Manufacturing (metal and non-metal)
- Aging Effects On Structural Bonds
- Thermoplastic Discontinuous Fiber Composites (DFC)
- Ceramic Matric Composite (CMC) Materials
- Building-Block Certification Of Sandwich Composite Structures
- Quality Assurance Of Automated Fiber Placement In Thermoset, Thermoplastic, and Dry Fiber Materials
- Resin Infused Fiber Reinforced Materials Guidelines for Design and Certification
- Technical Standard Order (TSO) for Composite Materials
- Electric Vertical Takeoff and Landing (eVTOL) Crashworthiness

National Center for Advanced Materials Performance (NCAMP)

- FAA and EASA accepts composite specification and design values developed using the NCAMP process.

Industry Partnerships:

- Spirit AeroSystems, Boeing, Airbus, Embraer, Bombardier, Textron Aviation, Lockheed-Sikorsky, Teijin Carbon, Solvay, Fiber Dynamics, Axiom Materials, MarkForged, Hexcel, Stratasys, EOS, Sekisui

Other Research Partnerships:

- Composite Materials Handbook (CMH-17)
- ASTM Center of Excellence for Additive Manufacturing
- Kansas Aviation Research & Technology (KART)
- America Makes - National Additive Manufacturing Innovation Institute
- NASA High-Rate Composite Manufacturing (HiCAM)
- Navy Composites Manufacturing Technology Consortium (CMTC)

NIAR Wichita State University National Institute for Aviation Research

Congressionally Directed JAMS Research
@ Auburn University

Metal Additive Manufacturing Research:

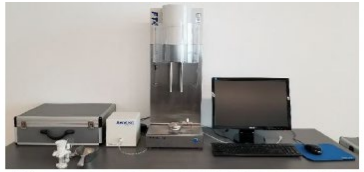
- Effect of Key Process Variable (KPV) Drift
- Criticality of Inherent Defects on Fatigue Behavior
- Surface Integrity of Metal AM Parts
- Joint Metals Additive Database Definition (JMADD)

Industry Partnerships:

- EOS, AP&C, ASTM, NASA, Army DEVCOM

Other Research Partnerships:

- (NCAME)
- ASTM AM CoE
- America Makes - National Additive Manufacturing Innovation Institute



Congressionally Directed JAMS Research
@ Mississippi State University

FAA-funded Research:

- Technology readiness assessment for stitched and unstitched resin infused composites.
  - The research includes thorough literature surveys; innovative Voice of the Market analyses; and targeted design, fabrication, testing and evaluation of scaled components based on validated industry needs and requirements for technology readiness of resin infusion

Industry Partnerships:

- Boeing Aurora, Stark Aerospace, Northrop Grumman, GE, Seemans Composites, MTorres, ElectroImpact, Ingersoll, RAMPF

Other Research Partnerships:

- Mississippi Development Authority,
- Center for Advanced Vehicular Systems (CAVS),
- FAA COE for Unmanned Aircraft Systems – The Alliance for System Safety of UAS through Research (ASSURE),
- Raspet Flight Research Laboratory
- NASA
- AFRL

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