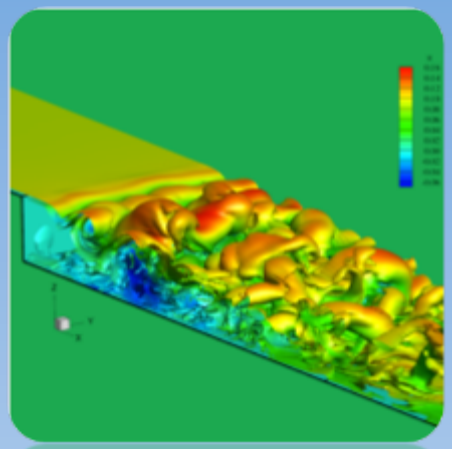
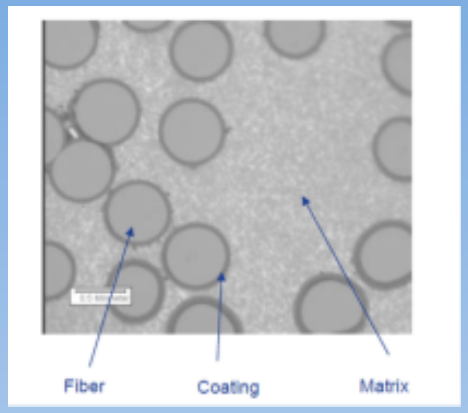
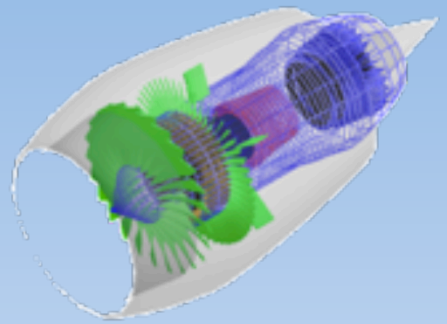
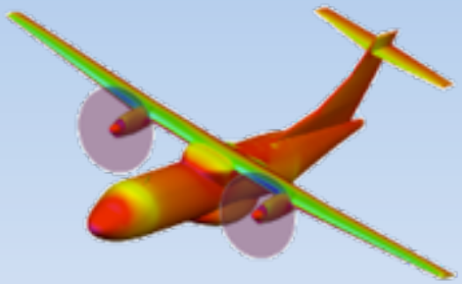
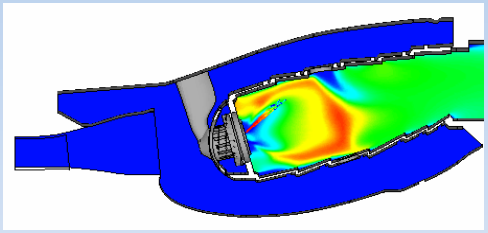






NARI Seedling Seminar
Materials Session
February 19-20, 2014





Dr. James D. Heidmann, Moderator

NASA Aeronautics Programs



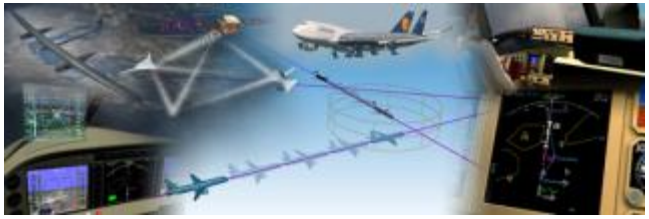

Fundamental Aeronautics Program

Enables innovative concepts, tools, and technologies and revolutionary changes for vehicles that fly in all speed regimes.

Integrated Systems Research Program

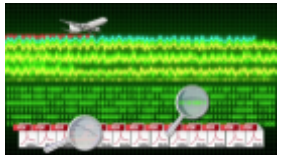
Conduct research at an integrated system-level on promising concepts and technologies and explore/assess/demonstrate the benefits in a relevant environment





Airspace Systems Program

Directly address the fundamental ATM research needs for NextGen by developing revolutionary concepts, capabilities, and technologies that will enable significant increases in the capacity, efficiency and flexibility of the NAS.




Aviation Safety Program

Conduct cutting-edge research that will produce innovative concepts, tools, and technologies to improve the intrinsic safety attributes of current and future aircraft.



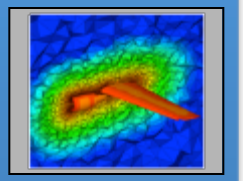
Aeronautics Test Program

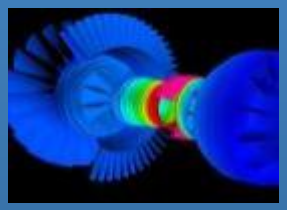
Preserve and promote the testing capabilities of one of the United States' largest, most versatile and comprehensive set of flight and ground-based research facilities.


FA Program Organization Structure

Fundamental Aeronautics Program Office

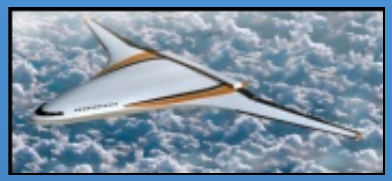
Aeronautical Sciences Project





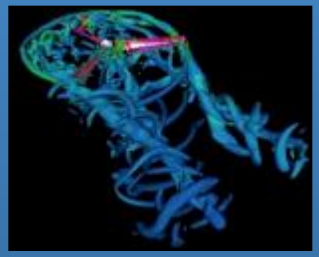
Aeronautical Sciences (AS)
Enable fast, efficient design & analysis of advanced aviation systems by developing physics-based tools and methods for cross-cutting technologies.

Fixed Wing Project



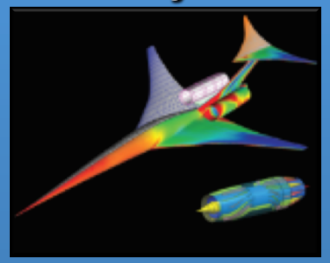
Fixed Wing (FW)
Explore & develop technologies and concepts for improved energy efficiency & environmental compatibility of fixed wing, subsonic transports

Rotary Wing Project



Rotary Wing (RW)
Develop and validate tools, technologies and concepts to overcome key barriers for rotary wing vehicles

High Speed Project



High Speed (HS)
Enable tools & technologies and validation capabilities necessary to overcome environmental & performance barriers to practical civil supersonic airliners.

Aeronautical Sciences Project

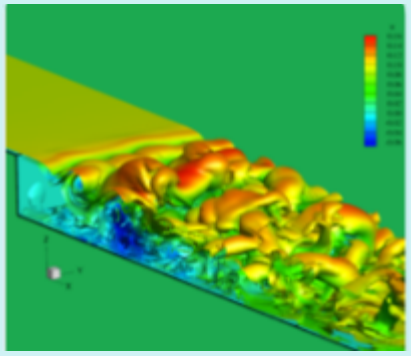
Enable fast, efficient design & analysis of advanced aviation systems from first principles by developing physics-based tools/methods & cross-cutting technologies, provide new MDAO & systems analysis tools, & support exploratory research with the potential to result in breakthroughs

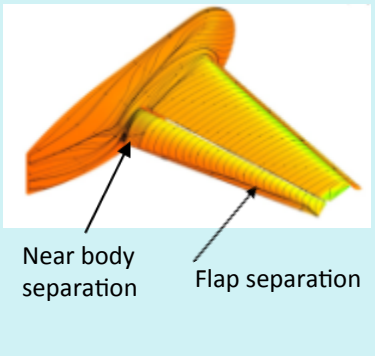
Vision

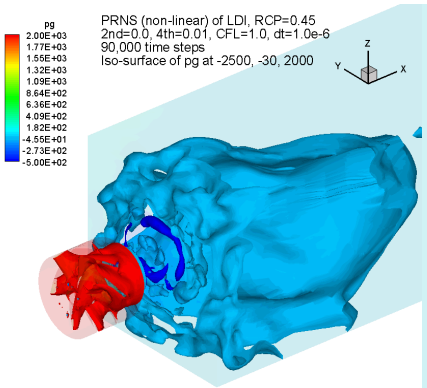
- Physics-based predictive methods for improved analysis and design
- Leverage improved understanding and discipline integration toward improved future air vehicles

Scope

- Foundational research and technology for civil air vehicles
- Discipline-based research and system-level integration method development







AS Research Themes & Technical Challenges

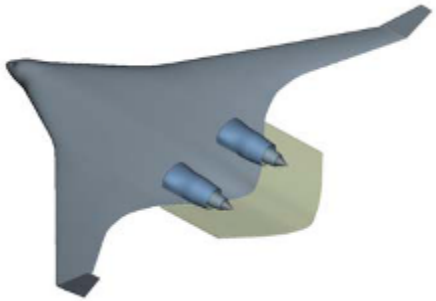
Research Themes	Technical Challenges 2013-2017
Revolutionary Computational Aerosciences	Identify and downselect critical turbulence, transition, and numerical method technologies for 40% reduction in predictive error against standard test cases for turbulent separated flows, evolution of free shear flows and shock-boundary layer interactions on state-of-the-art high performance computing hardware.
Structures and Materials	Develop high-temperature materials for turbine engines that enable a 6% reduction in fuel burn for commercial aircraft, compared to current state-of-the-art materials.
	Additional Focus Areas 2013-2017
Structures and Materials	Development of improved multi-functional airframe and engine structures and materials and computational design and optimization capability.
MDAO and Systems Analysis	Tool development at multiple levels of fidelity for air vehicle design and analysis.
Combustion	Combustion physics-based modeling and fundamental experiments. Investigation of new combustor technologies.
Controls	Advanced control technologies to enable new capabilities for efficient and autonomous operation of aircraft and propulsion systems.
Innovative Measurements	New measurement technologies that support a range of other fundamental research needs.

Structures and Materials
Overarching Goals

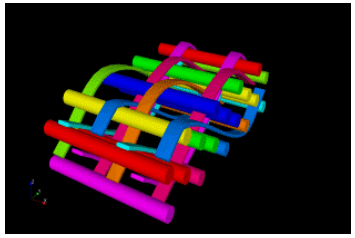
- Develop ***high temperature engine materials*** and associated design and life prediction tools to reduce or eliminate the need for turbine cooling

- Develop ***multifunctional structures and materials*** that reduce weight and enable innovative components by meeting multiple airframe or engine requirements simultaneously

- Develop physics-based ***computational design and analysis tools*** for airframe and engine materials and structures to enable more optimized component designs with greater confidence

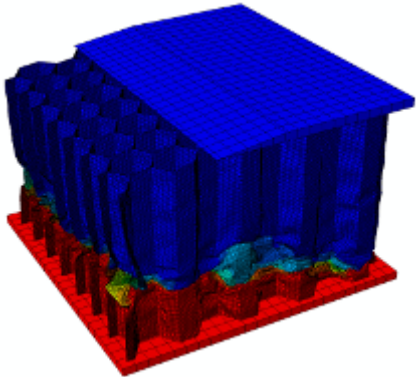


Extreme environment structures



Advanced 3D fiber architecture

EBC-coated CMC vane



Analysis tools simulate failure process

Structures and Materials
R&D Portfolio

- **High Temperature Engine Materials**
  - Ceramic Matrix Composites
  - Environmental Barrier Coatings
- **Multifunctional Structures and Materials**
  - Exhaust Washed Structures
  - Shape Memory Alloys
- **Computational Design and Analysis Tools**
  - Integrated Computational Materials Engineering
  - Multiscale Deformation and Life Modeling
  - Damage Tolerant Composite Structures

Discontinued in FY14

- **NASA Research Announcement Awards**
  - "Modeling of Nanostructured Multifunctional Materials for Light Weight Aircraft Structures" (U. of Alabama, Prof. Samit Roy)
  - "Multiscale Model Development and Validation of Graphene/ULTEM Composites for Structural and Noise Reduction Applications" (Michigan Tech U., Prof. Gregory Odegard)

Structures and Materials

Technical Challenge – High Temperature Engine Materials

Objective

Develop high temperature engine materials for turbine components that enable a 6% reduction in fuel burn for commercial aircraft, compared to current SOA materials.

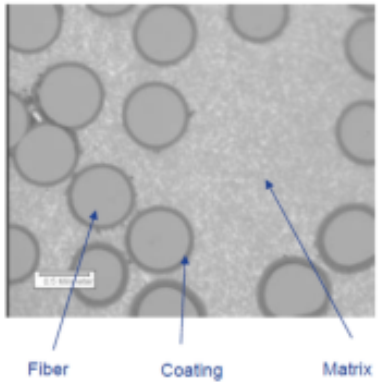
Technical Areas and Approaches

- Ceramic matrix composite (CMC) materials and the required environmental barrier coatings (EBCs) are investigated and developed.
- Modeling and lifing tool development

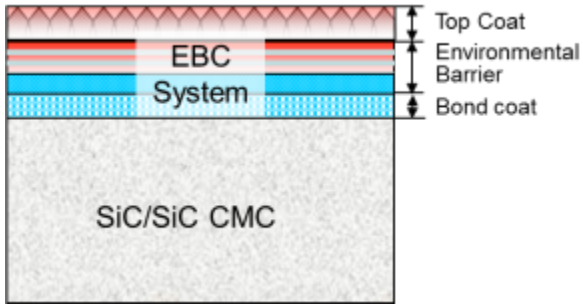
Benefit/Pay-off

- Enables increase in engine operating temperature, and/or reduced cooling for turbine components
- Improves efficiency and helps reduce emissions

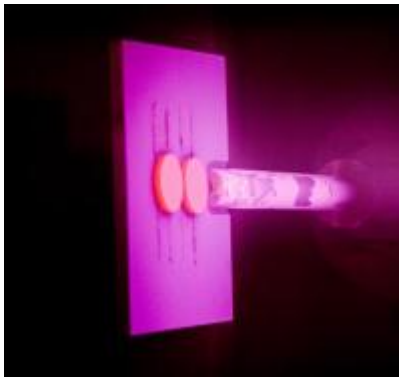
EBC-Coated CMC Turbine Vane



Fiber/Coating/Matrix Development



EBC Multilayered Architecture



PS-PVD Coating Technique

Structures and Materials

Shape Memory Alloy Characterization and Development

Long-term Objective and Approach: Develop and mature advanced high-temperature shape memory alloys (HTSMA) based on the NiTiHf and NiTiZr systems for stable, high-strength actuator applications.

Future efforts will focus on maturing the HTSMA technology in collaboration with Industry Partners including:

- Development of torque actuators for future flight demonstrations. Preliminary results indicate that the performance (recoverable strain and strength) of these alloys in torsion is superior to any known SMA.
- Reproducible scale-up of the processing of a NiTiHf alloy for commercial aerospace applications (Figure 2).
- Development of a 200°C alloy variant for supersonic applications and thermal safety switches (Figure 3).
- Evaluation of the life and durability of HTSMA systems.

Figure 1. SMA-based adaptive Trailing edge flown on recent Boeing Eco Demonstrator

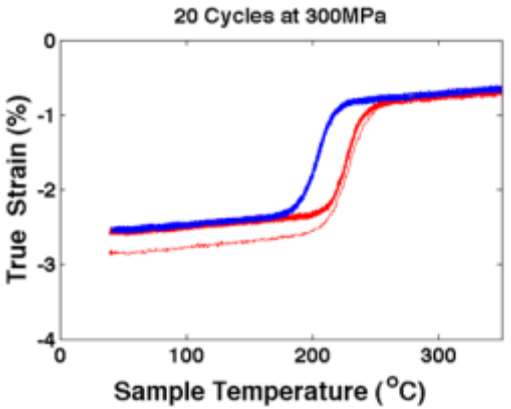


Figure 3. Development of a higher temperature variant of the NiTiHf alloy.

Figure 2. Initial scale-up of the processing of the NiTiHf alloy.

Aeronautical Sciences Partnerships & Collaborations
NASA Research Announcement (NRA) Awards

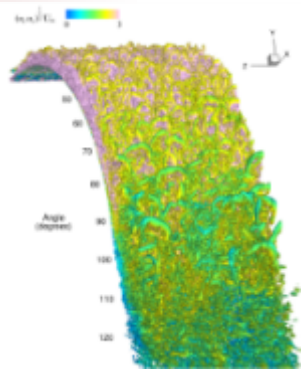
- **Revolutionary Computational Aerosciences (13)**
  - Stanford University (2), U. of Wyoming, North Carolina State University, Texas A&M University, Iowa State University, MIT, U. of New Mexico, U. of Michigan, U. of Illinois at Urbana-Champaign, Brown University, U. of Kansas, The Boeing Company
- **Structures and Materials (2)**
  - U. of Alabama, Michigan Technological University
- **MDAO and Systems Analysis (5)**
  - U. of Michigan, MIT, Georgia Institute of Technology, California Polytechnic State, Old Dominion University
- **Combustion (2)**
  - Georgia Institute of Technology, Purdue University
- **Controls (1)**
  - Rolls-Royce North American

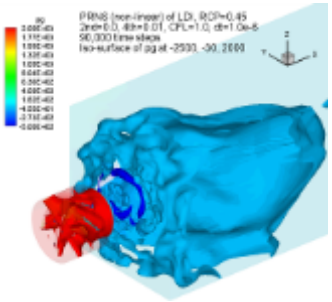
Total of 23 NRAs with an annual investment of over $4M*

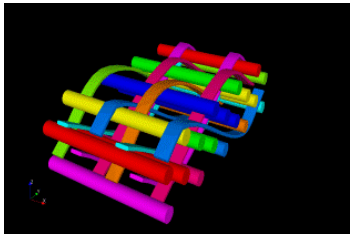
* Full annual award level

Aeronautical Sciences Project Summary

- Exciting suite of fundamental cross-cutting research focused on foundational model and tool development
- Well-integrated with other NASA Aeronautics Projects and across NASA Aero Centers.
- Interested in potential for NARI seedling and LEARN efforts to transition to direct project support in future
- Aeronautical Sciences is the steward of NASA aero cross-cutting fundamental research and methods development – the lifeblood of NASA Aeronautics







Challenges ahead with great technologies on the horizon!


NASA