Transformative Aeronautics Concepts Program

Adaptive Aerostructures for Revolutionary Civil Supersonic Transportation

Active Technology Project (2017 - 2022)

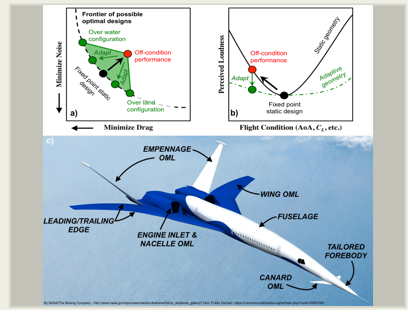
Project Introduction

To enable commercially viable civil supersonic transport (SST) aircraft, innovative solutions must be developed to meet noise and efficiency requirements for overland flight. This research effort consists of a multi-disciplinary team of academic and industrial experts exploring for the first time the potential of small real-time geometric outer mold line (OML) reconfigurations to minimize sonic boom signatures and aircraft drag in response to changing ambient conditions, thereby enabling noise-compliant overland supersonic flight. The team utilizes recent advances in supersonic computational fluid dynamic (CFD) methods, new noise prediction tools, and new design approaches to consider embedded highly energy-dense shape memory alloy (SMA) actuators for local shape modifications to an SST aircraft leading to optimal low boom signature and low drag in different environments. This university-led program will provide strategic leadership toward technology convergence that advances NASA's Aerospace Research Mission Directorate's (ARMD) research objectives with regard to Thrust 2: “Innovation in Commercial Supersonic Aircraft” by exploring for the first time enabling low-boom operation across a range of flight conditions via structural adaptivity, and will promote education of the next generation of engineers.

The overall research strategy is to pursue three critical areas: the design of configurations for reducing boom, SMA material development and modeling, and technology feasibility demonstration in a relevant environment. Initially, the team will identify potential applications where structure or geometry adaptivity provides a benefit in noise or drag across the entire flight envelope. For selected applications/structural locations, required OML geometry changes will be determined based on analysis of sonic boom ground signature and drag reduction using new design tools, trade studies, and atmospheric sensing techniques. Designs will be developed and evaluated against requirements on loading, stroke length, and operational temperature. New alloy formulations will be developed tailored for both autonomous and controlled actuation modes. As the SMA material development matures, integrated system-level factors will be investigated. Optimized designs for small-scale distributed adaptivity applications of maximum benefit will then be matured and tested, moving toward demonstration of the innovative technology approaches at a TRL 4-5 and showing that sonic booms can be reduced by reconfiguration on demand.

Anticipated Benefits

Adapting supersonic aircraft geometry in real-time in response to changing environmental or flight conditions will enable satisfaction of sonic boom and efficiency requirements across a much wider operating range than current static designs allow. This directly supports ARMD's Strategic Thrust 2 research focus on enabling vehicle designs that meet the Near-term Outcome of acceptable sonic boom noise as well as Mid-term Outcomes such as improved



Concept behind the Texas A&M led NASA ULI project: a) illustrates possible optimal adapted aircraft configurations in response to an off-condition performance, b) illustrates the benefit of continuous adaptivity for supersonic flight to sonic…

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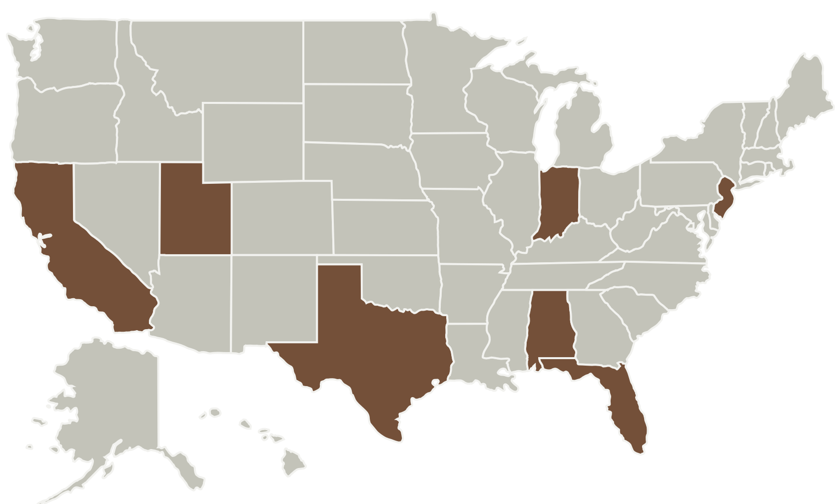
efficiency. This project uses a high level of technology convergence combining aerodynamics, noise, structures, sensing and control, and materials technologies. Validated and integrated tools for evaluation and optimization of adaptive geometries to minimize boom and increase efficiency will be developed. New shape memory alloy formulations and processing methods will be developed that meet the specific in-service requirements of supersonic platform integration. Potential adaptive geometry applications for supersonic aircraft will be identified. The design and analysis tools will be used to evaluate the benefits of and develop design solutions for selected embodiments. Key components will be built and demonstrated in the lab and wind tunnel. In addition, the practicality of using this technology for adaptive hardware and components for wind tunnel models test hardware will also be shown.

The team takes primary responsibility for maintaining high levels of technical quality throughout the project. Publication across a diverse range of peer-reviewed journals and organized special sessions/symposia at applicable conferences are available forums being considered for dissemination of the result and allow peer assessment of team progress. Further, a workshop with external invitees is being planned for Year 3 to allow critical review of progress.

Primary U.S. Work Locations and Key Partners



Organizational Responsibility

Responsible Mission Directorate:

Aeronautics Research Mission Directorate (ARMD)

Lead Organization:

Texas A&M University

Responsible Program:

Transformative Aeronautics Concepts Program

Project Management

Program Director:

John A Cavolowsky

Project Manager:

Koushik Datta

Principal Investigator:

Dimitris C Lagoudas

Continued on following page.

Organizations Performing Work	Role	Type	Location
Texas A&M University	Lead Organization	Academic	College Station, TX
ATA Engineering, Inc.	Supporting Organization	Industry	San Diego, CA
Boeing	Supporting Organization	Industry	Chicago, IL
Florida International University	Supporting Organization	Academic	Miami, FL
Fort Wayne Metals Research Products Corp	Supporting Organization	Industry	Fort Wayne, IN
Princeton University	Supporting Organization	Academic	Princeton, NJ
University of Houston	Supporting Organization	Industry	Houston, TX
University of North Texas	Supporting Organization	Academic	Denton, TX
Utah State University	Supporting Organization	Academic	Logan, UT

Primary U.S. Work Locations	
Alabama	California
Florida	Indiana
New Jersey	Texas
Utah	

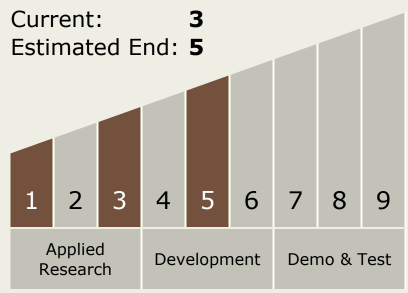
Project Management *(cont.)*

Co-Investigators:

Darren J Hartl
David S Lazzara
Theocharis Baxevanis
Eric Blades
Rodney D Bowersox
Paul Cizmas
George S Dulikravich
Doug Hunsaker
Ibrahim Karaman
James Mabe
Todd Magee
Richard Malak
Richard Miles
Helen Reed
Jeremy E Schaffer
Hao Shen
Edward V White
Marcus L Young

Technology Maturity (TRL)

Start: **1**
Current: **3**
Estimated End: **5**

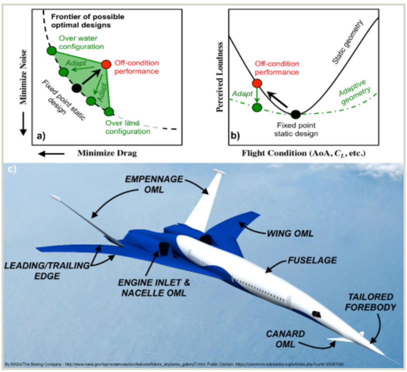


Technology Areas

Primary:

Continued on following page.

Images



Concept behind the Texas A&M led NASA ULI project

Concept behind the Texas A&M led NASA ULI project: a) illustrates possible optimal adapted aircraft configurations in response to an off-condition performance, b) illustrates the benefit of continuous adaptivity for supersonic flight to sonic boom noise levels, and c) identifies potential locations where small/distributed surface adaptions would occur in real-time throughout a flight to achieve the adaption benefits illustrated in a) and b). *(https://techport.nasa.gov/image/40912)*

Links

A Three-Dimensional Constitutive Modeling for Shape Memory Alloys Considering Two-Way Shape Memory Effect and Transformation-Ind *(https://doi.org/10.2514/6.2019-1195)*

Achieving Quieter Supersonic Flight Through Outer-Mold Line Modifications: An Optimization Study *(https://doi.org/10.2514/6.2019-3104)*

Characterization and Processing of High Temperature Shape Memory Alloys for Aerospace Applications *(https://doi.org/10.2514/6.2019-1196)*

Controlling Sonic Boom Loudness Through Outer Mold Line Modification: A Sensitivity Study *(https://doi.org/10.2514/6.2019-0603)*

Technology Areas *(cont.)*

- TX15 Flight Vehicle Systems
  - └ TX15.1 Aerosciences
    - └ TX15.1.6 Advanced Atmospheric Flight Vehicles

Other/Cross-cutting:

- TX15 Flight Vehicle Systems
  - └ TX15.1 Aerosciences
    - └ TX15.1.4 Aeroacoustics

Target Destination

Foundational Knowledge

Supported Mission Type

Push

Fluid-Structure Interaction Modeling of a Shape-Memory Alloy Actuated Supersonic Wind Tunnel Model Alloy
(https://doi.org/10.2514/6.2019-0602)

Off-Design Sonic Boom Performance for Low-Boom Aircraft
(https://doi.org/10.2514/6.2019-0606)

Shape Memory Alloy Actuation Technology for Adaptive Low Boom Supersonic Transports
(https://congress.cimne.com/smart2019/frontal/doc/EbookSMART2019.pdf)

Sonic Boom Performance of Low-Boom Aircraft in Non-Standard Atmospheres
(https://doi.org/10.2514/6.2020-0792)

Structurally Feasible Morphing of a Low-Boom Supersonic Transport
(https://doi.org/10.2514/6.2020-0791)

Temperature Profiling of the Atmosphere from an Airborne Lidar by Dispersed Filtered Rayleigh Scattering in Atomic and Molecular
(https://doi.org/10.2514/6.2019-3286)

Project Website:

https://supersonic.tamu.edu/