

# Airport Noise Tech Challenge Overview

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- The Supersonics Project, operating under NASA Aeronautics Mission Directorate's Fundamental Aero Program, has been organized around the Technical Challenges that have historically precluded commercial supersonic flight. One of these Challenges is making aircraft that are capable of such high aerodynamic performance quiet enough around airports that they will not be objectionable. It is recognized that a successful civilian supersonic aircraft will be a system where many new technologies will come together, and for this to happen not only will new low noise propulsion concepts be required, but new engineering tools that predict the noise of the aircraft as these technologies are combined and compromised with the rest of the aircraft design. These are the two main objectives of the Airport Noise Tech Challenge.
- As a Project in the Fundamental Aero Program, we work at a relatively low level of technology readiness. However, we have high level milestones which force us to integrate our efforts to impact systems-level activities. To keep the low-level work tied to delivering engineering tools and low-noise concepts, we have structured our milestones around development of the concepts and organized our activities around developing and applying our engineering tools to these concepts. The final deliverables in these milestones are noise prediction modules validated against the best embodiment of each concept. These will then be used in cross-disciplinary exercises to demonstrate the viability of aircraft designs to meet all the Technical Challenges. Some of the concepts being developed are shown: Fan Flow Diverters, Multi-jet Shielding, High-Aspect Ratio Embedded Nozzles, Plasma Actuated Instability Manipulation, Highly Variable Cycle Mixer-Ejectors, and Inverted Velocity Profiles. These concepts are being developed for reduced jet noise along with the design tools which describe how they perform when used in various aircraft configurations. Several key upcoming events are highlighted, including tests of the Highly Variable Cycle Mixer-Ejectors, and Inverted Velocity Profiles. Other key events are milestones to be delivered within the next calendar year.



# Fundamental Aeronautics Program

## *Supersonics Project*

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Airport Noise Tech Challenge Overview  
James Bridges, Tech Lead  
NASA Glenn/Acoustics Branch



2011 Technical Conference  
March 15-17, 2011  
Cleveland, Ohio  
[www.nasa.gov](http://www.nasa.gov)

# Supersonic Project Technical Challenges



**Sonic Boom Community Response**

**Airport Noise**

- Improved prediction techniques for supersonic propulsion noise
- Innovative nozzle designs for highly integrated propulsion systems

**High Altitude Emissions**

**Supersonic Cruise Efficiency**



**Light Weight, Durable Engines/Airframes**

**Aeroservoelastic Analysis and Design**

**Integrated Multi-Discipline System Design**

- **Integration of Supersonic Aircraft in NextGen System (with Airspace Program)**

# Technical Challenge: Airport Noise

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## What are we trying to do?

- Allow supersonic aircraft to be acoustically acceptable around airports.
- Develop low noise concepts and the ability to engineer them on supersonic aircraft.

## What is our approach?

- Develop and use physics-based codes more and experiments less.
- Couple both code and concept development to delivery of systems-level noise prediction modules

## What are the payoffs if successful?

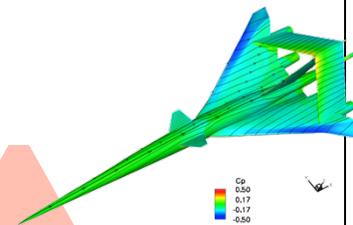
- Documented noise reduction technologies with ability to trade design parameters against other design goals.
- Detailed, physics-based jet noise prediction tools applicable to the design of all aircraft classes.

# Technical Challenge: Airport Noise



## Technical Challenge Validated

- National R&D plan (Mobility Goal 5, Nat'l Security Goal 2, E & E Goal 3)
- NASA System Studies
- Input from OGA stakeholders
- Input from Industry
- NRC 2006 Decadal Survey (A2, A9)



## Benefits of Successful Completion

- Fast, accurate, robust design process for configurations with low boom / low drag.
- Optimized propulsion systems.
- Meet airport noise requirements.

## Discipline Capabilities

- Assess empirical noise prediction codes against validated database.
- Develop CFD-based acoustic prediction codes for complex nozzles.
- Study and validate low-noise nozzle concepts.
- Validate CFD-based thrust prediction capabilities for low-noise nozzles.

## Multi-Discipline Capabilities

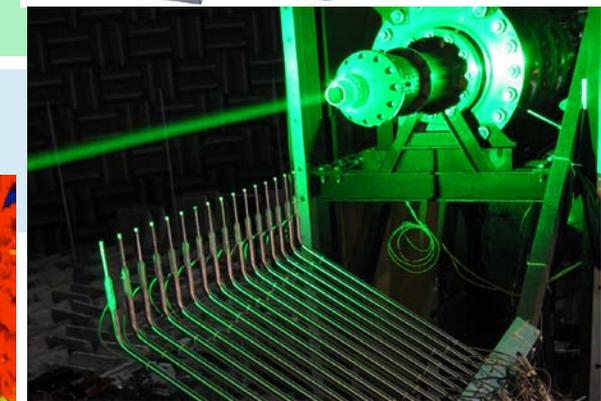
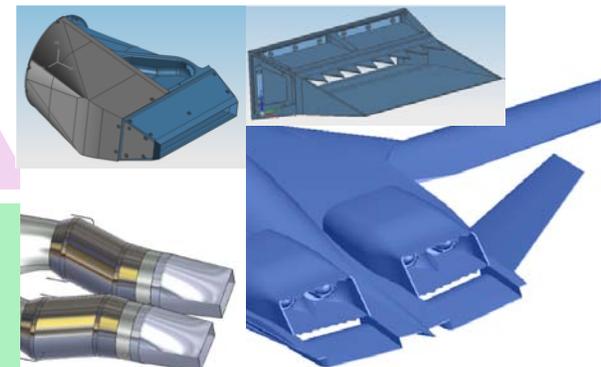
- Create systems analysis modules documenting performance of low-noise concepts.

System Design

Multi-Discipline Capabilities

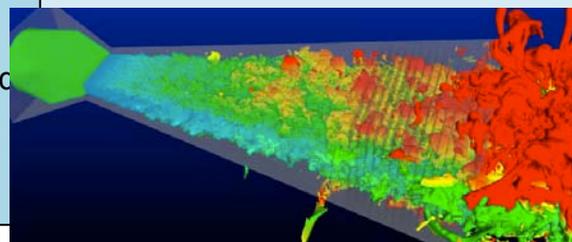
Discipline Level Capabilities

Foundational Physics & Modeling



## Foundational Research

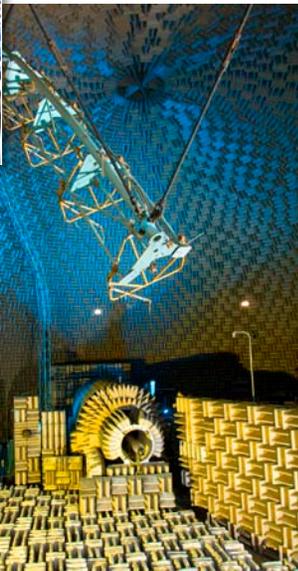
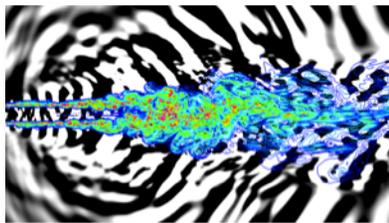
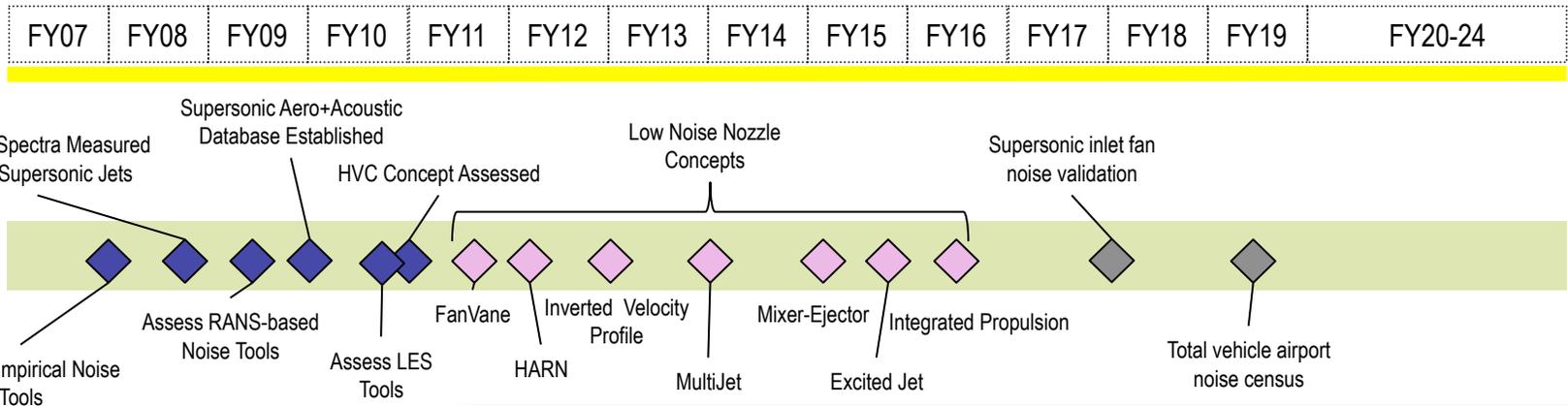
- Compile modern database of turbulent flow and acoustic data for relevant jets.
- Develop innovative measurement capabilities for jet noise.
- Obtain esoteric turbulence measurements key to aeroacoustic theory and modeling.
- Validate CFD codes for jet noise prediction.
- Develop and validate LES for jet plumes and noise prediction.
- Develop dynamic jet control actuators and their impact on jet noise.



# Measuring Progress: Airport Noise Technical Challenge



- ◆ Complete
- ◆ Funded
- ◆ Unfunded



## What are the intermediate and final exams to check for success?

- Suite of noise prediction codes.
- Systems analysis tools used in cross-challenge design exercise.
- Concepts and physics-based tools demonstrated on detailed design of integrated nozzle validation test.

## Recent Progress Toward Meeting Technical Challenge

- Tool Development
  - Developed RANS-based broadband shock noise code.
  - Method for creating MDOE-based empirical modules developed
- Concept Development
  - Assessed HVC mixer-ejector concept with intensive flow diagnostics.
  - FanVane concept captured in MDOE database.
  - Extensible Rectangular Nozzle models designed, tested.
  - Exploratory MultiJet experiments completed.
  - Model hardware for GE & RRLW low-noise concept validation designed.

# FY11-15 Airport Noise Activities



Concepts	Tools			
	Experimental	Empirical	RANS-based	LES
•Offset stream				
•Inverted velocity profile				
•High aspect ratio nozzles				
•Multiple Jets				
•Mixer-ejector				
•Jet Excitation				
•Integrated Propulsion				

Tool Development Scale

Needs Development

Ready

# FY11-15 Airport Noise Activities



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**New  
Accomplishment**

Tool Development Scale

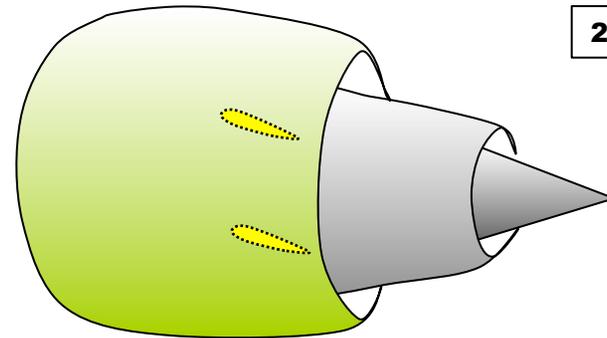
Needs Development

Ready

# Research Elements



- Offset Stream Concept
  - Modification of shear layer instabilities
  - Small scale parametric testing complete
  - Empirical noise model complete
  - Thrust evaluation via RANS CFD
  - RANS acoustic code lacks asymmetric Green's function



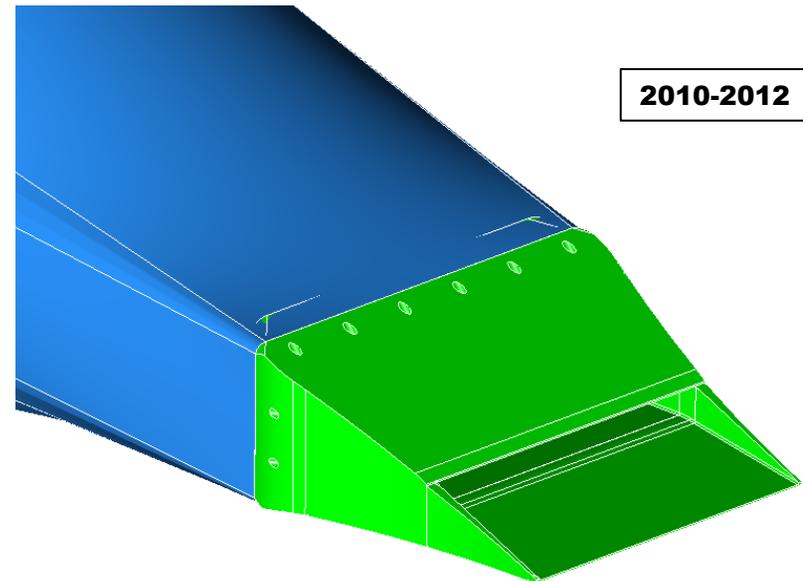
- Noise Modeling of Multiple Jets
  - Impact of jet-by-jet shielding
  - Source change by enhanced mixing
  - Initial twin jet experiments completed for jet spacings from 2–5D
  - Significant noise reductions observed
  - RANS acoustic code lacks 3D Green's function



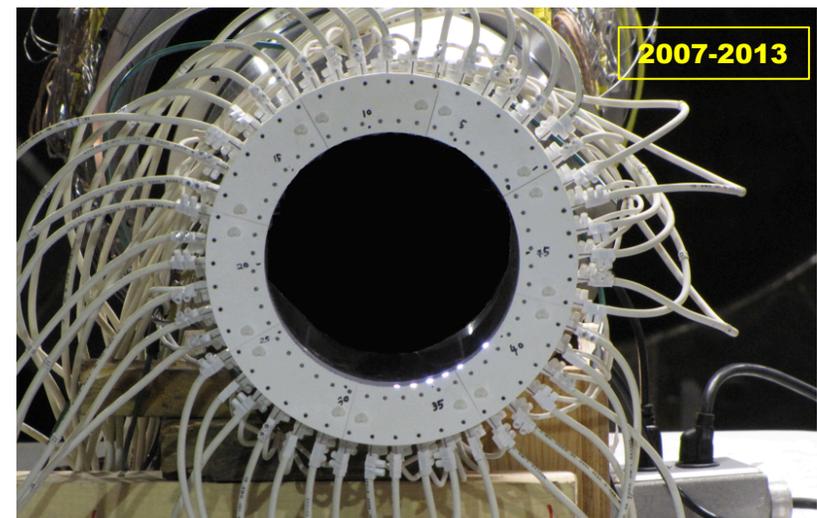


# Research Elements

- High Aspect Ratio Nozzles
  - Highly integrated propulsion
  - Small scale parametric testing complete
  - Empirical noise model near complete
  - Thrust evaluation via RANS CFD
  - RANS acoustic code uses elliptic Green's function approximation



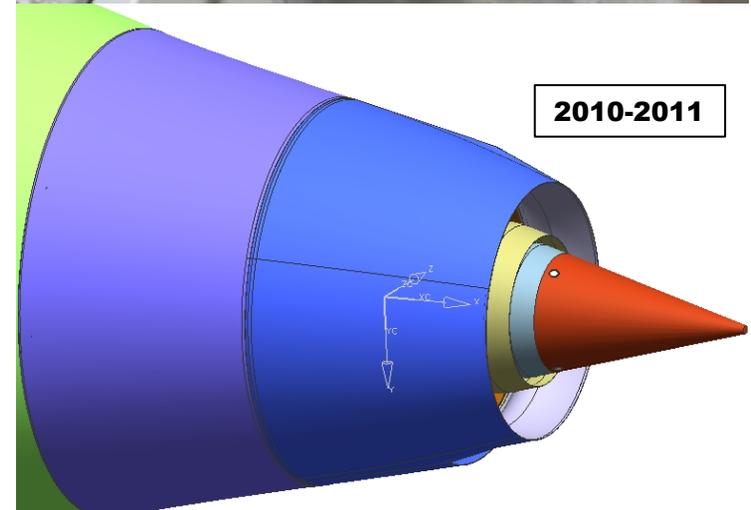
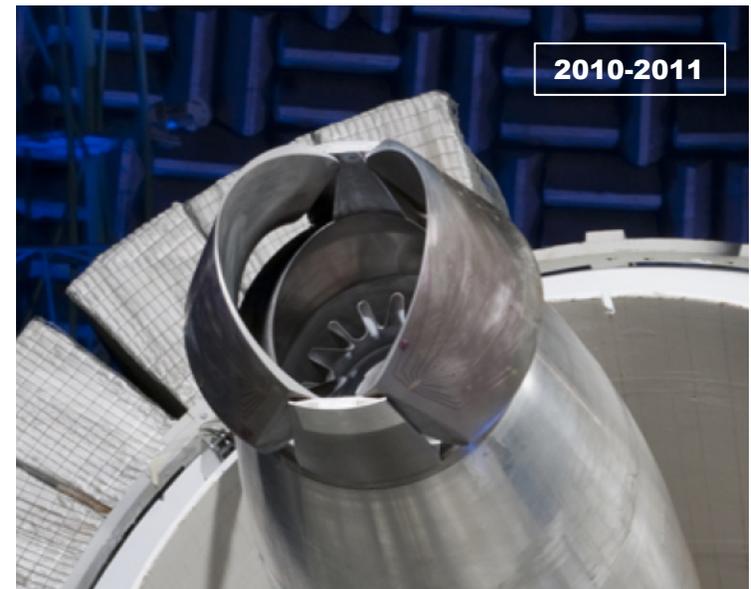
- Jet Instability Manipulation for Noise Reduction
  - High-energy plasma actuators at nozzle lip
  - Azimuthal modes/ frequencies excited
  - Test of scaleup underway at NASA
  - Previous LES and adjoint methods show role of instabilities in noise production





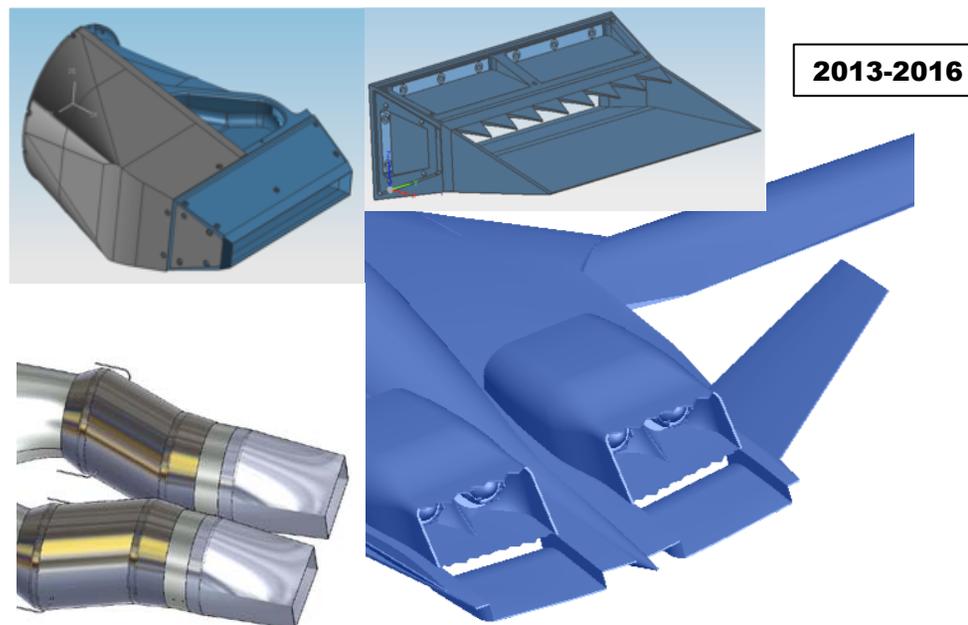
# Research Elements

- Three-Stream Mixer-Ejector
  - Lockheed/RR-Liberty Works N+2 Validation Test
  - Test hardware designed; test in April at NASA
  - Current empirical codes predict success
  - RANS design of ejector crucial
  - RANS acoustic code prediction coming
  
- Inverted Velocity Profile w/Fluid Shield
  - Lockheed/GE N+2 Validation Test
  - Test hardware designed; test in May at NASA
  - Current empirical jet noise codes outside range of validity
  - RANS acoustic code prediction coming
  - LES underway at GE



# Research Elements

- Integrated Multi-Discipline Propulsion System
  - Current configuration features highly integrated propulsion system
  - Thrust performance, low boom, and quiet airport operation factors
  - Uses system models being developed for multi-discipline optimization
  - Uses physics-based models being developed for detail design
  - Validated by integrated scale model tests





# Key Upcoming Events

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- N+2 System Validation Nozzle Tests
  - NASA GRC AeroAcoustic Propulsion Lab
  - RR-Liberty Works and GE concepts evaluated
  - April-August 2011
- Deliver Fan Vane Diverter Empirical Noise Module
  - Incorporate into ANOPP2 for systems-level optimization
  - June 2011
- Deliver High Aspect Ratio Empirical Noise Module
  - Incorporate into ANOPP2 for systems-level optimization
  - January 2012

