National Aeronautics and Space Administration

Aircraft Noise Reduction Subproject Overview

Aircraft Noise Reduction Subproject
Advanced Air Transport Technology Project

Subproject Manager: Hamilton Fernandez (LaRC)
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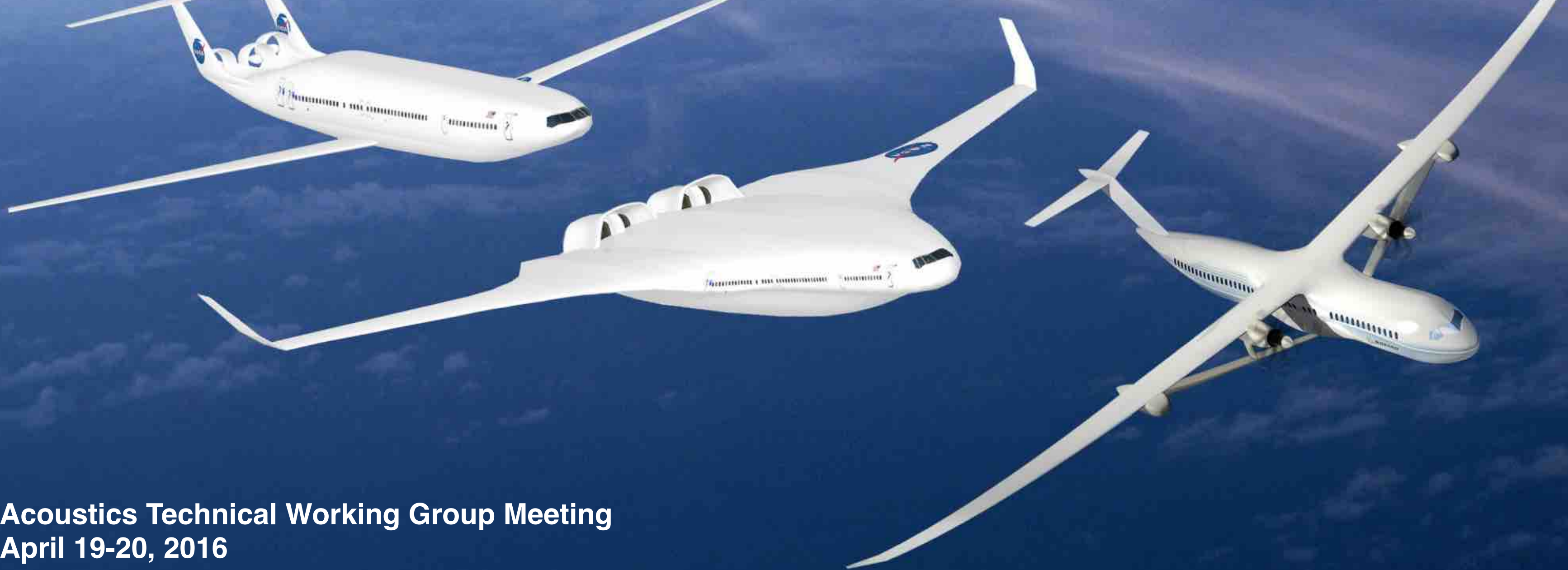


Acoustics Technical Working Group Meeting
April 19-20, 2016
NASA LaRC, Hampton, VA

Outline

- Background/Motivation
  - Objective
  - Technical Areas
  - Benefit/Pay-off
- Noise Reduction Concepts
  - Quiet High Lift
  - Multi-Degree of Freedom (MDOF) Liners
  - Additional Noise Reduction Concepts
  - System Noise Assessments
- Concluding Remarks and Future Plans

NASA Subsonic Transport System-Level Metrics

Strategic Focus

1. Energy Efficiency

2. Environmental Compatibility

v2013.1

TECHNOLOGY BENEFITS*	TECHNOLOGY GENERATIONS (Technology Readiness Level = 4-6)		
	N+1 (2015)	N+2 (2020**)	N+3 (2025)
Noise (cum margin rel. to Stage 4)	-32 dB	-42 dB	-52 dB
LTO NOx Emissions (rel. to CAEP 6)	-60%	-75%	-80%
Cruise NOx Emissions (rel. to 2005 best in class)	-55%	-70%	-80%
Aircraft Fuel/Energy Consumption ‡ (rel. to 2005 best in class)	-33%	-50%	-60%

* Projected benefits once technologies are matured and implemented by industry. Benefits vary by vehicle size and mission. N+1 and N+3 values are referenced to a 737-800 with CFM56-7B engines. N+2 values are referenced to a 777-200 with GE90 engines.

ERA's time-phased approach includes advancing "long-pole" technologies to TRL 6 by 2015

** CO_2 emission benefits dependent on life-cycle CO_2e per MJ for fuel and/or energy source used

‡

N+3 values are referenced to a 737-800 with CFM56-7B engines

Research addressing revolutionary far-term goals with opportunities for near-term impact

Aircraft Noise Reduction (ANR) Technologies

Objective

Explore and develop aero-structural-acoustic technologies to directly reduce perceived community noise without impacting performance

Technical Areas and Approaches

Acoustic Liners and Duct Propagation

- Advanced, low-drag liner concepts

Airframe Noise

- Flap/Slat and landing gear noise reduction

Propulsion Noise

- Fan and core noise reduction

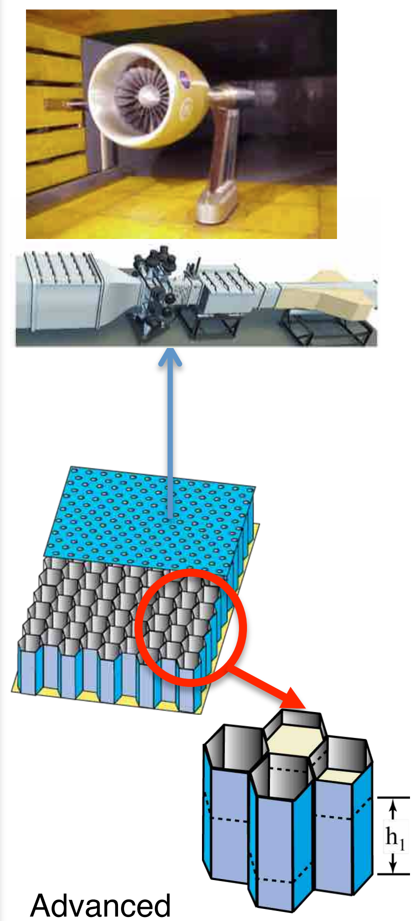
Propulsion Airframe Aeroacoustics (PAA)

- Installation effects on perceived noise

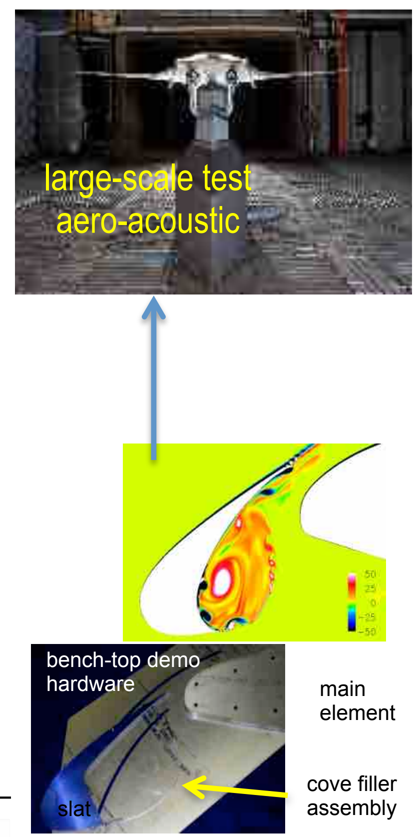
Benefit/Pay-off

Component noise reduction with minimal impact on weight and performance

- Direct contribution to Ultra-Efficient Commercial Vehicles Strategic Thrust
- Liner and non-active-flow-control high-lift system technology may have early insertion potential



Advanced Liner Concepts



High Lift System Noise Reduction

Aircraft Noise Reduction Technical Areas

Airframe
- Lifting components
- Landing components

Propulsion
- Propulsor
- Core (combustor & turbine)

Propulsion/ Airframe Aeroacoustics (PAA)
- Installation Effects on Noise Sources
- Shielding/Scattering

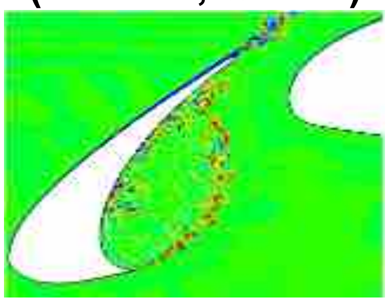
Liners

System Noise Impact Assessments

Quiet High-Lift

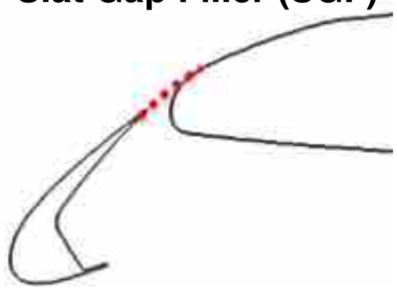
Aero-Structural-Acoustic High-Lift System Test (14x22)

LE Slat Noise (3D CFD, α=5.5°)

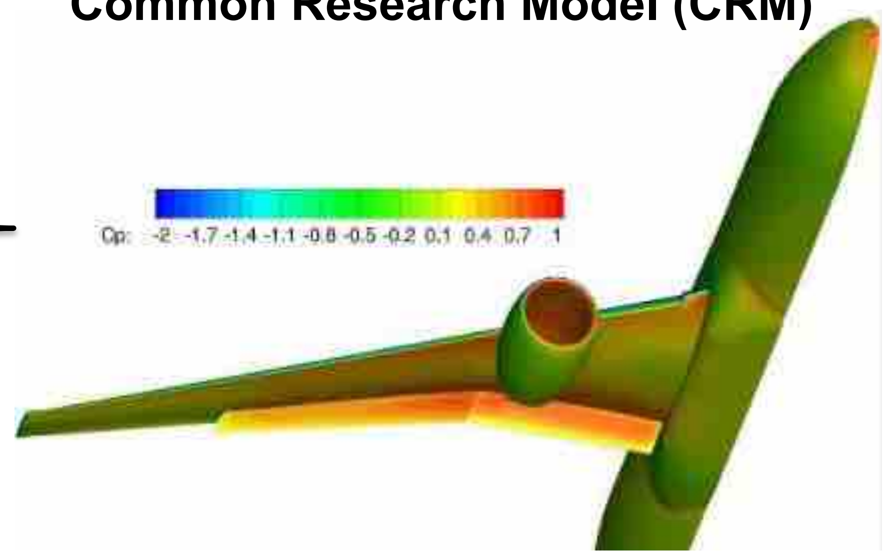


Slat Cove Filler (SCF)

Slat Gap Filler (SGF)



Conventional High-Lift (CHL) Common Research Model (CRM)



- CHL/CRM: Open geometry high-lift configuration based on the high-speed CRM
- Testbed for slat, flap side-edge, and landing gear noise reduction technology
  - SCF and SGF will be tested in the 14x22 in FY18
  - Modified slats fabricated using realistic materials, but non-articulating

Quiet High-Lift

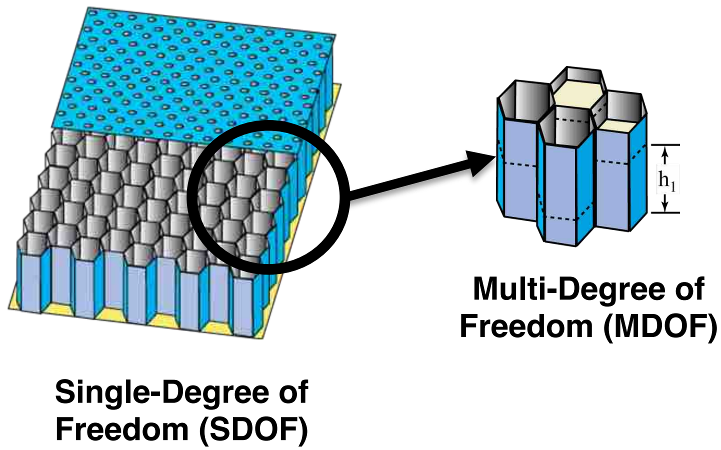
CHL/CRM V2.0 Wind Tunnel Model

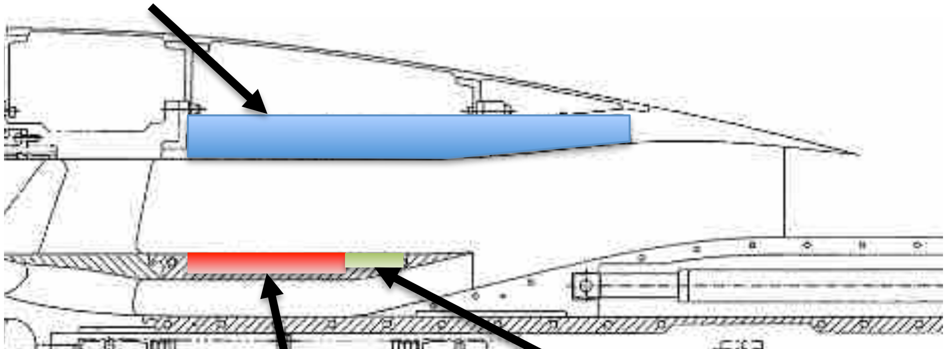
AEROSPACE ENGINEERING
TEXAS A&M UNIVERSITY

- 6.25% scale model of a section at mid-span of the CRM outboard slat
- Lift and drag measurements at various angles of attack and flow speeds
- Deployable slat and flap via embedded actuators
- Study fluid-structure interaction (FSI) of slat treatment during articulation
- Risk reduction for 14x22 test and beyond
    - Validation of computational models and overall design process

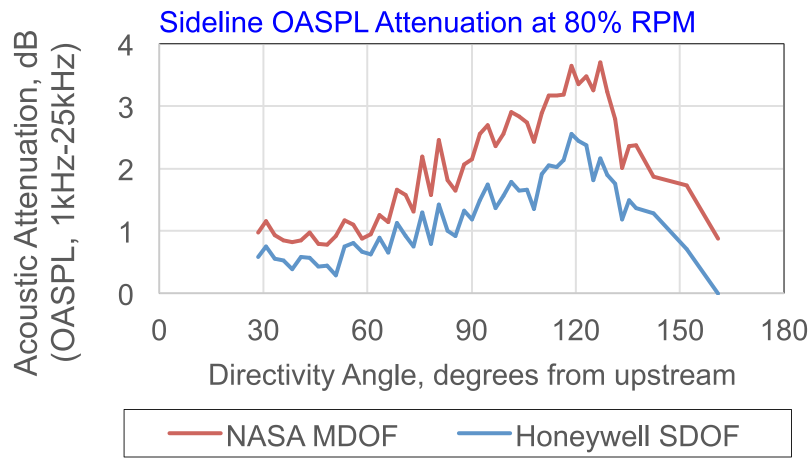
MDOF Liner Concept

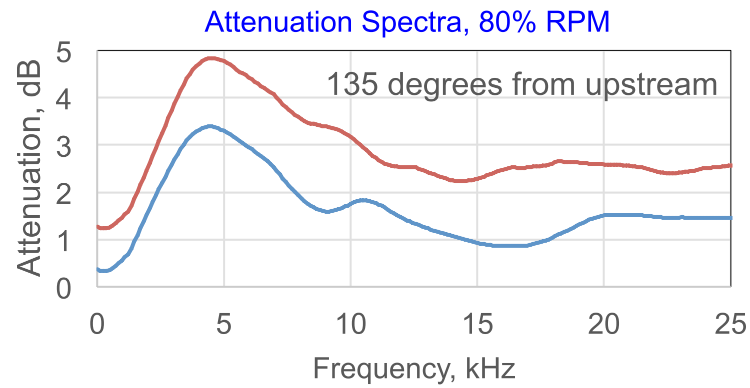
NASA/Honeywell 9x15 Test





Broadband Benefit Demonstrated

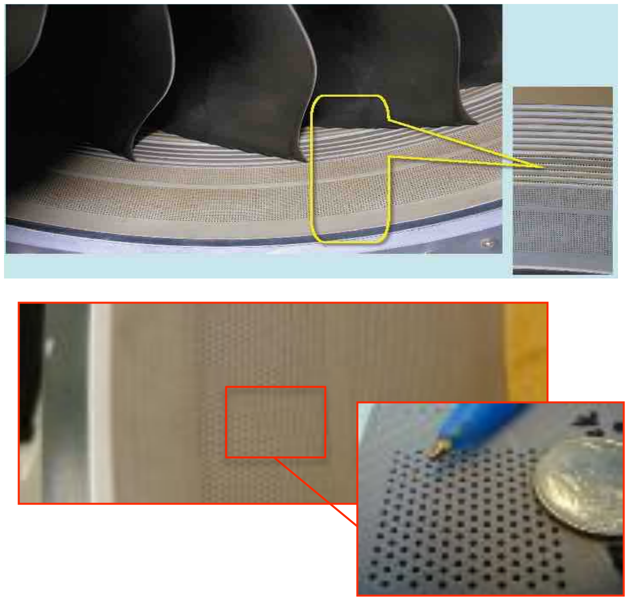




Additional Concepts

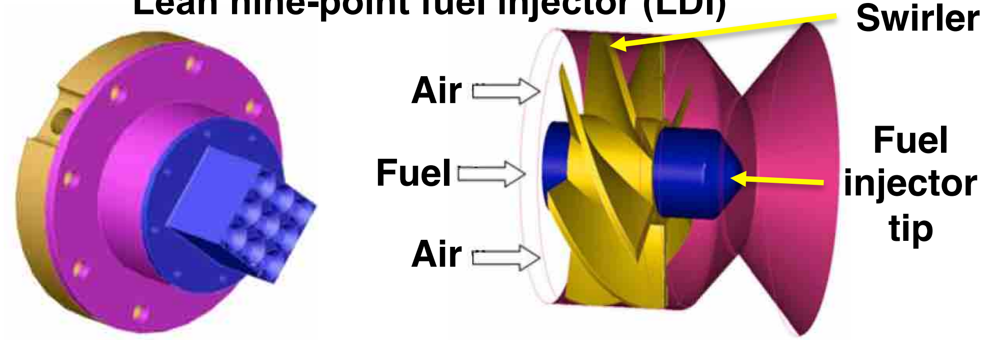
Soft Vane

Over-The-Rotor Acoustic Treatment



Notable benefits possible: Need further development

Lean nine-point fuel injector (LDI)

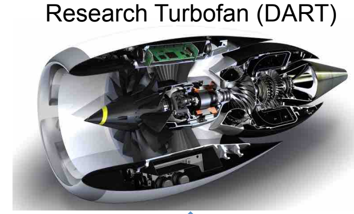


Understand combustor-design change impacts

Integrated Tests

Isolated Rig Tests

DGEN Aero-propulsion Research Turbofan (DART)

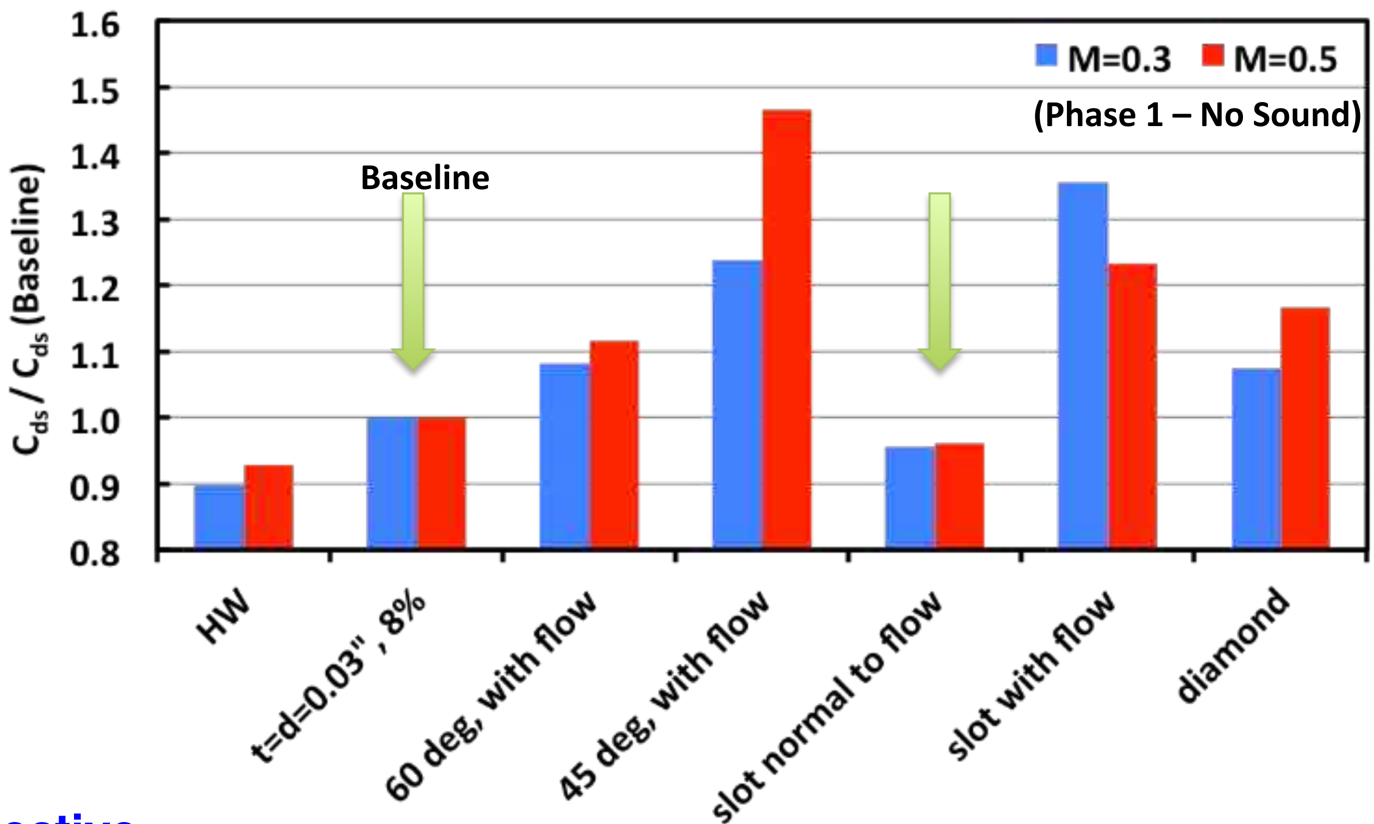


Liner Test Facility (LTF)

TRL

Low-Drag Liner Concepts

Grazing Flow Impedance Tube (GFIT) Test



Objective

- Reduced liner drag for internal/external applications

Technical Areas and Approaches

- Acoustic benefits and improved aerodynamic performance (fuel burn)

Fan Acoustic Casing Treatment

Objective

Evaluate fan acoustic casing treatments noise reduction potential of up to TRL 3

Technical Areas and Approaches

Series of progressively higher TRL testing

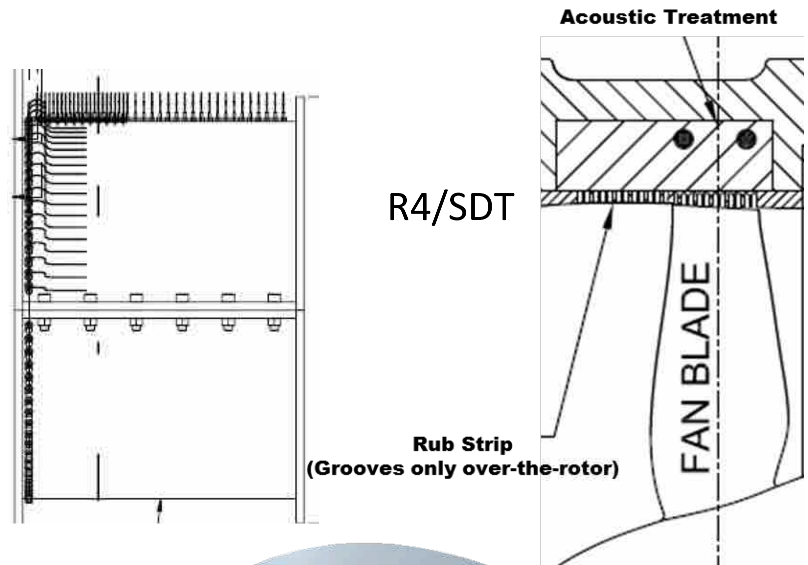
- Normal Incidence Tube Testing (LaRC)
- Low Speed Fan Testing (ANCF, GRC)
- Scaled UHB Fan Testing (W-8, GRC)

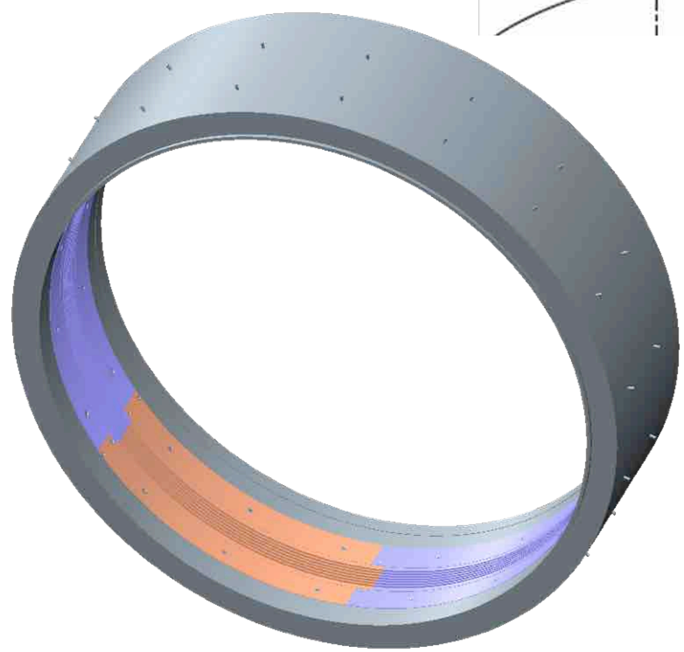
Acoustics: In-duct array testing

Aero: Determine aerodynamic impact

Benefit/Pay-off

- Benefits up to 4-5dB reduction have been demonstrated in previous testing





Soft Vane Technology

Objective

Evaluate soft vane broadband noise reduction

Technical Areas and Approaches

Series of progressively higher TRL testing

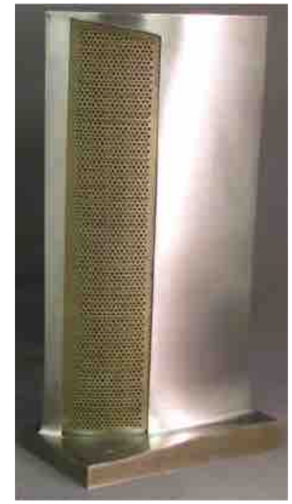
- Generate and characterize noise generated by interaction with upstream turbulence

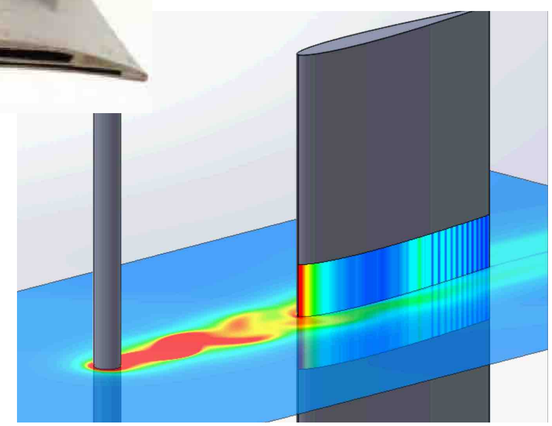
Acoustics: Improve acoustic benefit

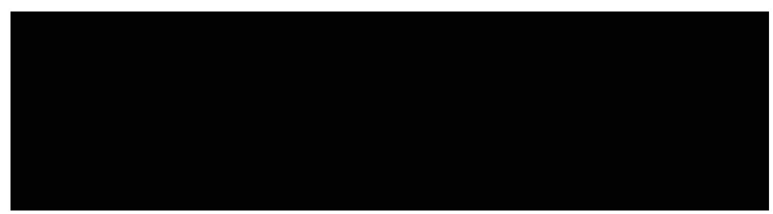
Aero: Quantify and reduce aerodynamic impact

Benefit/Pay-off

- Soft vanes have shown a significant noise reduction potential on the Source Diagnostic Test hardware.
- ERA assessments predict potential 1.5 EPNdB system noise reduction







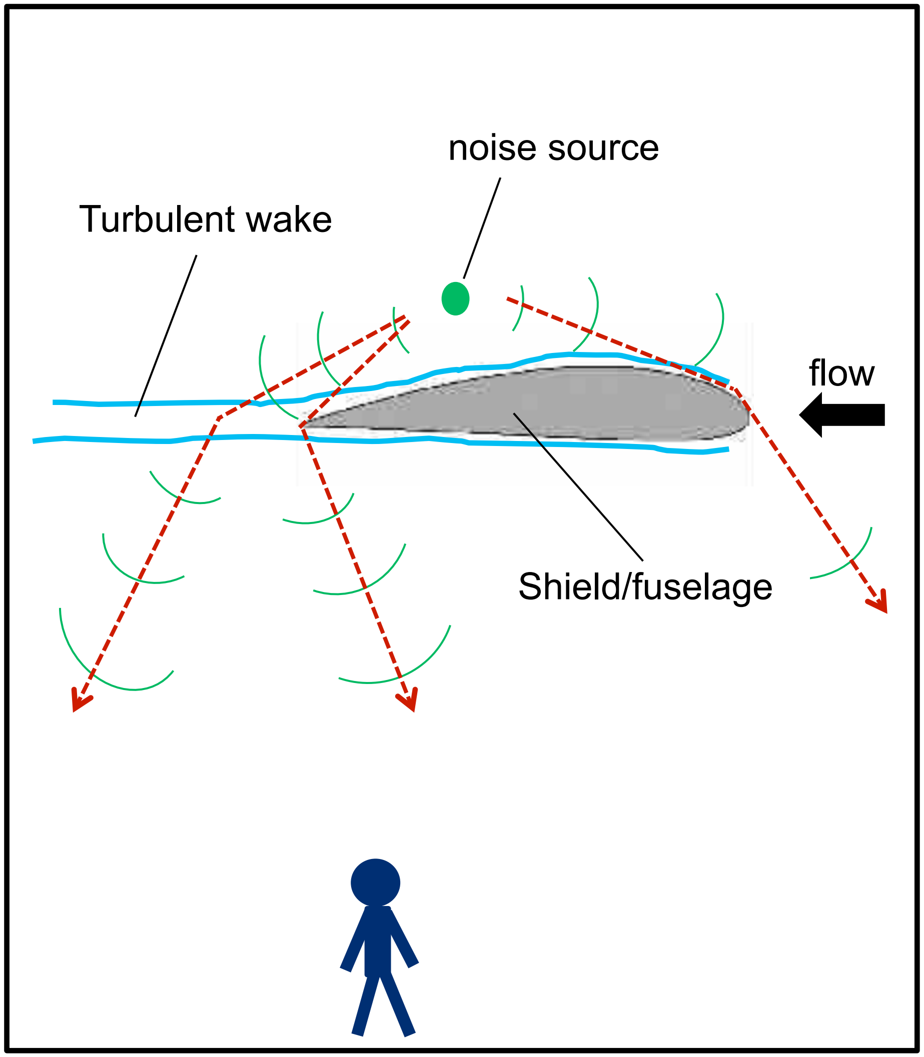
Objective

Further validate and improve acoustic scattering prediction capabilities

- Employ well-defined sound source
- Utilize open, generic geometry

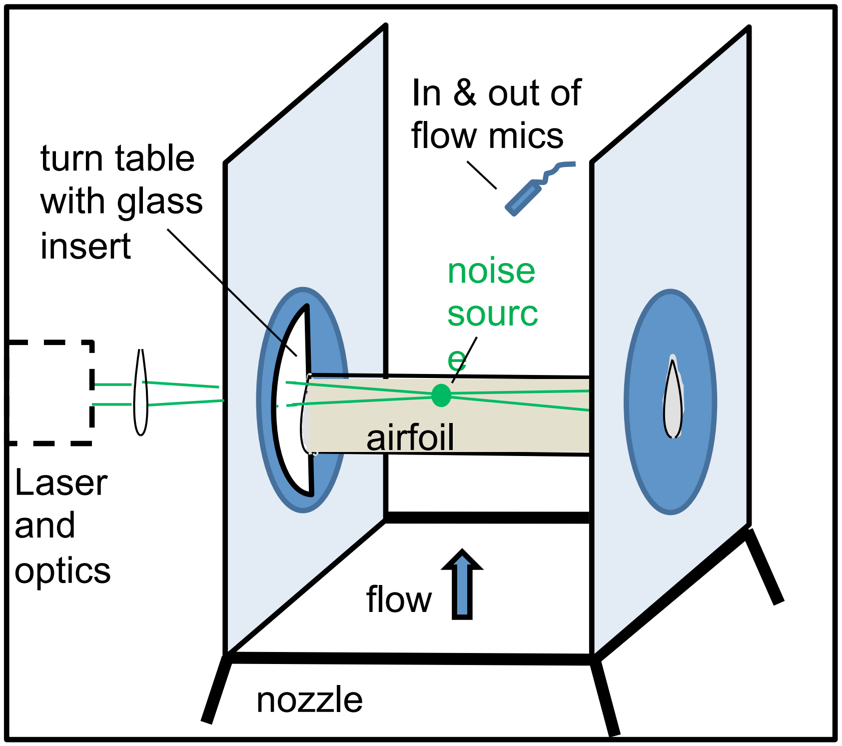
Benefit/Pay-off

- Establish validation database
- Characterize effect of flow, model wake, and source location



Scattering of sound by an aircraft fuselage

Laser-induced noise source - bench test



Quiet Flow Facility (QFF) test set-up

Technical Areas and Approaches

Acoustic scattering test to be performed in QFF

- with 2-D NACA0012 airfoil
- using non-intrusive, laser-induced, monopole source.
- Test repeated at DLR and ONERA

Status: **Test preparations are on-going**

- Test hardware fabrication is nearly complete.
- Laser and optics set-up needed to meet test requirements has been established.
- Traverse systems for the microphones and laser/optic assembly have been developed and controls integrated in the QFF data acquisition system.
- Data acquisition expected to run May-June.

Technical Areas and Approaches

QFF acoustic scattering test

- 2-D NACA0012 airfoil
- Non-intrusive, monopole source.
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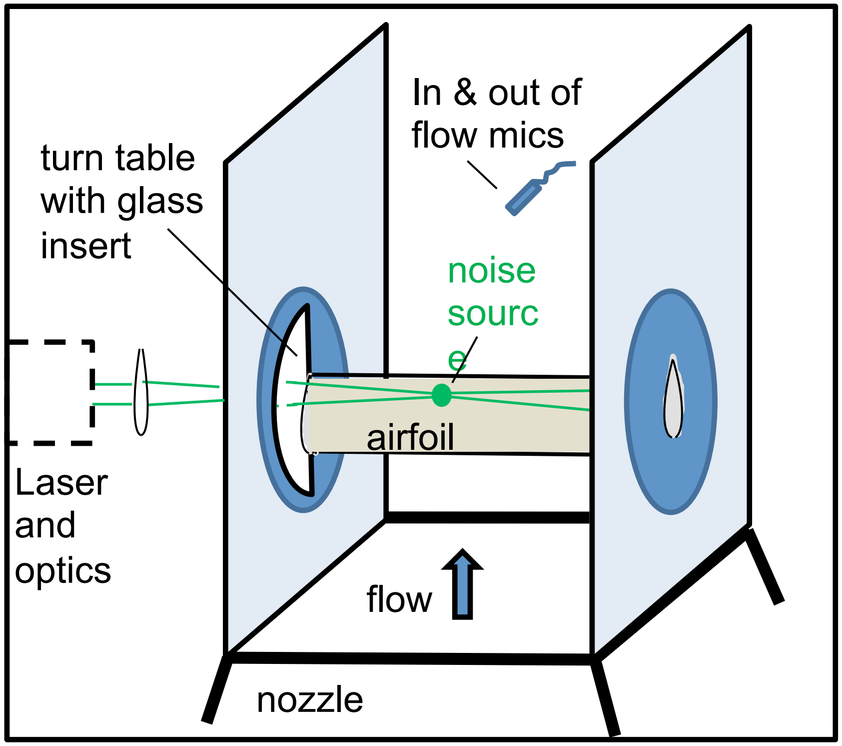
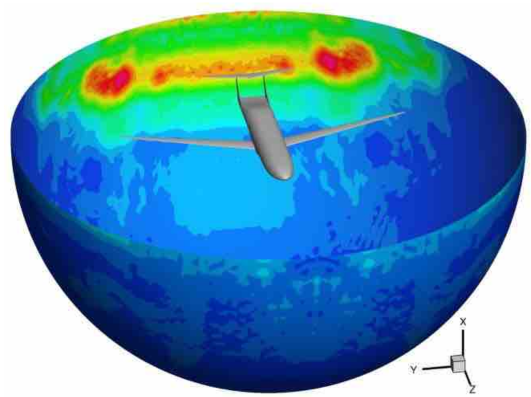
Laser-induced noise source - bench test



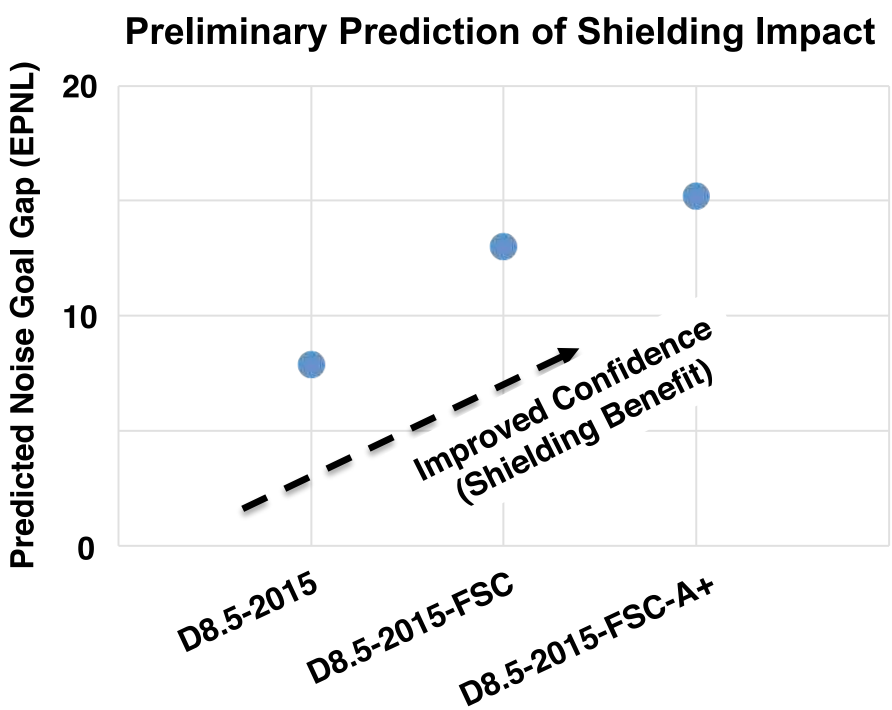
Quiet Flow Facility (QFF) test set-up

Propulsion Airframe Aeroacoustics

Source Shielding/Scattering
Acoustically Treated Tail (External Liners)

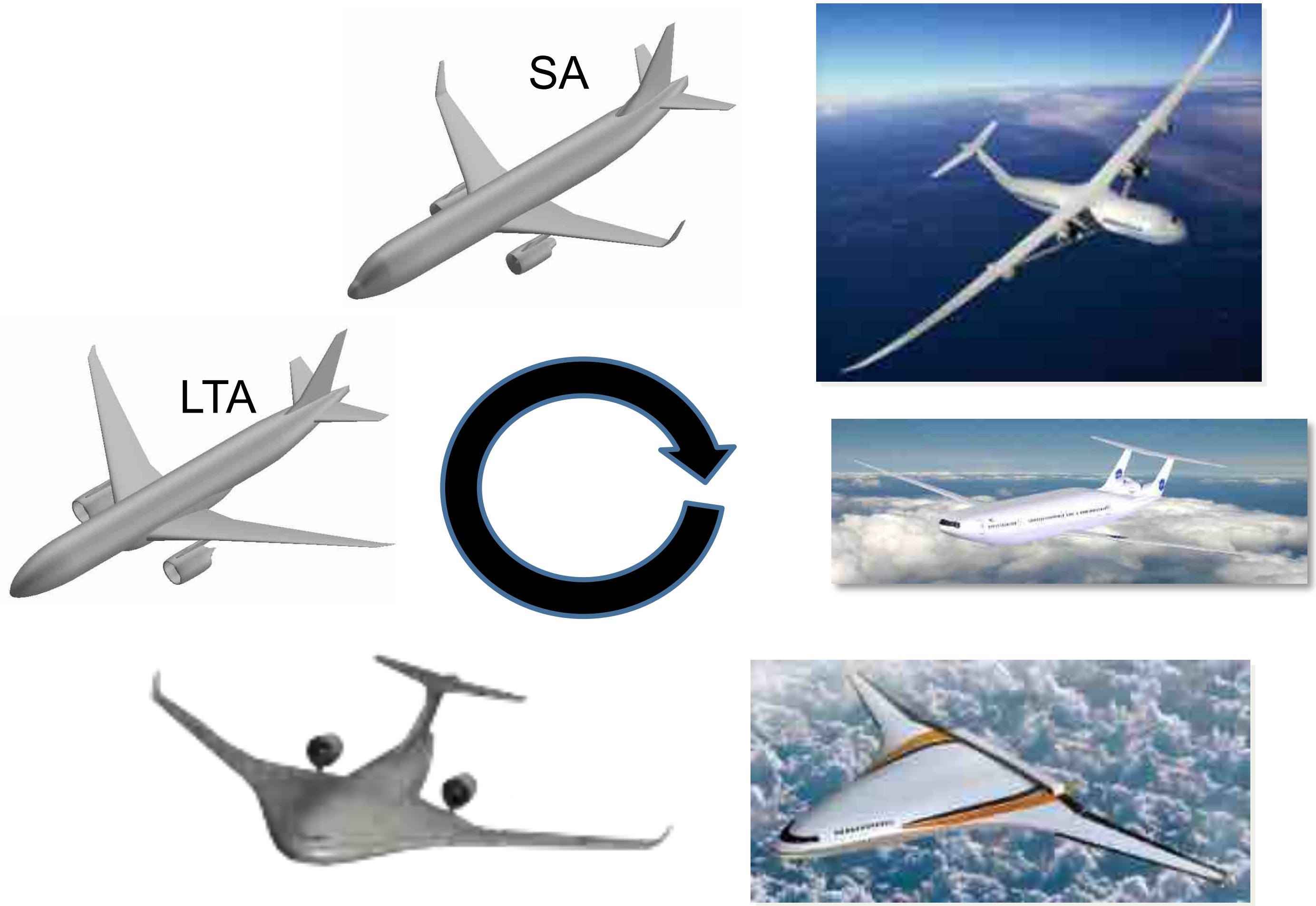


Jet-Surface Interaction Test (JSIT)



- Conceptual Stage (Initial Feasibility Study)
- No N+2/N+3 Noise Technologies Applied
  - FSC: Improved Shielding Model
  - FSC-A+: Refined Fan Prediction

System Noise Impact Assessment



Overall system noise impacts of various component technologies assessed through periodic system noise studies for baseline and unconventional aircraft configurations.

Concluding Remarks and Future Plans (1/2)

ANR Subproject is well poised within the AATT Project to support Ultra-Efficient Commercial Vehicles Strategic Thrust

- **Technical Challenge, TC 3.1, to be concluded in FY18 with results from MDOF Liners and Quiet High-Lift Test in 14x22**
- **Technical Challenge, TC 3.2, to be formulated and proposed with technical investments to close current predicted noise goal gap with associated impact/benefits to performance goals**
  - Acoustic Liners and Duct Propagation: Low-drag advanced liners
  - Airframe Noise: High-lift system/gear interaction
  - Propulsion Noise: Fan and core noise reduction
  - PAA: Installation effects on sources
  - System Noise Impact Assessments

Integrated PAA Test

Concluding Remarks and Future Plans (2/2)

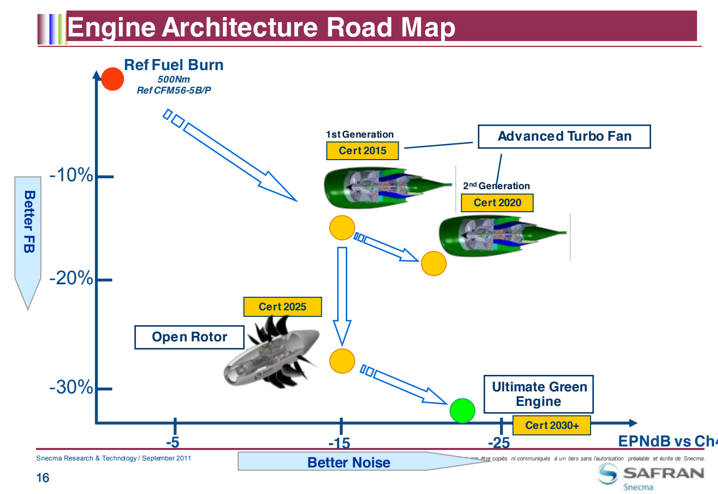
Technical Challenge, TC 3.3, to be formulated and proposed with technical investments in propulsors for FY18-22 within the AATT Project.

Background:

- At the conclusion of ERA, there was still a need for higher TRL, advanced propulsor research.
- The new TC 3.3 is intended to have significant partner cost share and to focus on maturing propulsor technologies for N+3 systems.

Technical investment areas:

- Benchmark low PR fan test case (aero/acoustic/aeromechanic)
- Advanced ducted and/or unducted propulsor systems (To duct or not to duct?)
- Propulsion Airframe Installation/Aeroacoustics for low PR fan systems



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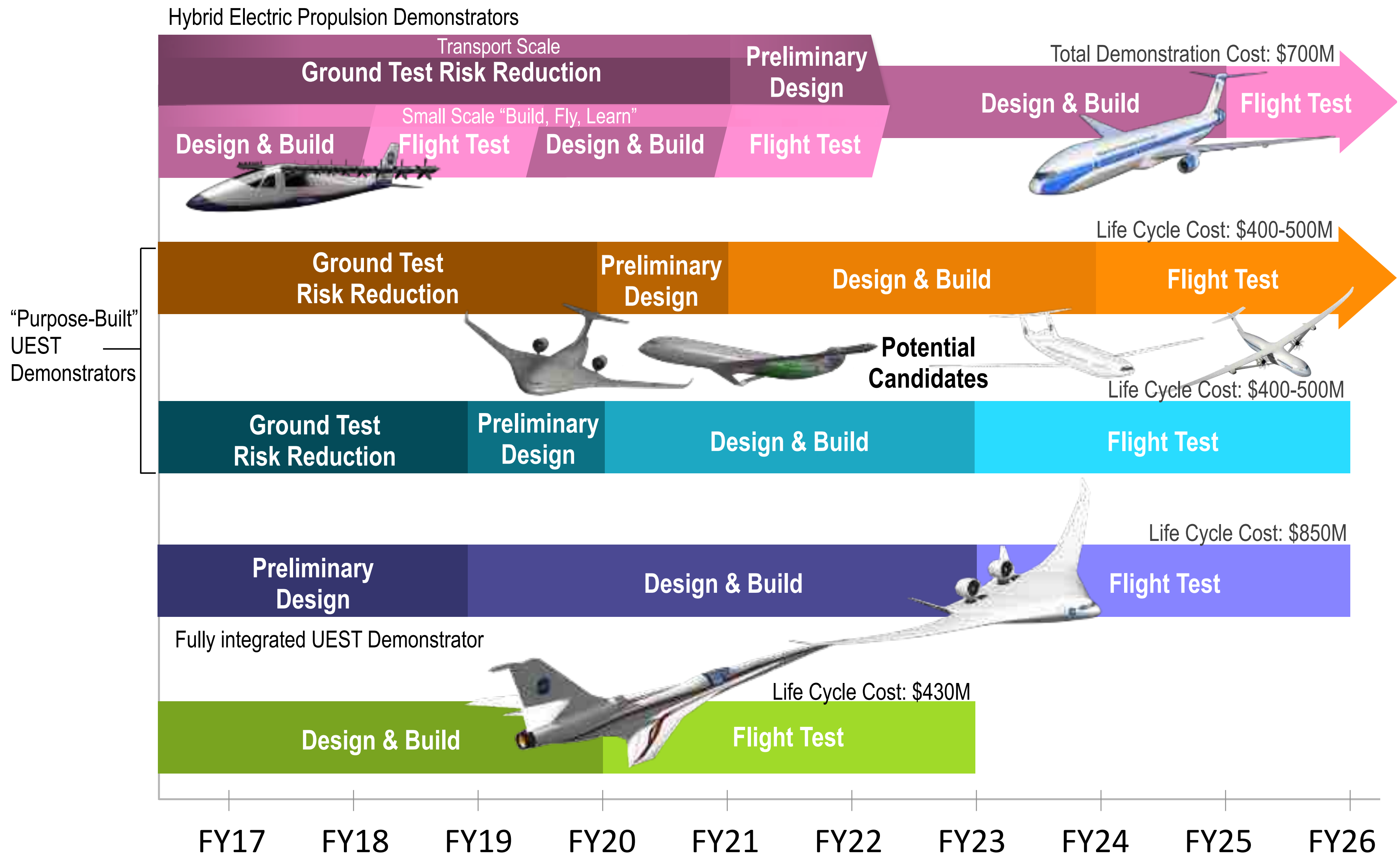
Backup Slides

Flight Demo Plan



Aircraft Noise Reduction (ANR)

AATT TC3.1 (FY18) Fan & High-Lift Noise

Reduce fan (lateral and flyover) and high-lift system (approach) noise on a component basis by 4 dB with minimal impact on weight and performance (TRL5)

TC3.1 Investment

- Acoustic Liners & Duct Propagation – Multi-Degree of Freedom (MDOF)
- Airframe Noise – High-Lift System

AATT eTC3 Quieter Low-Speed Performance

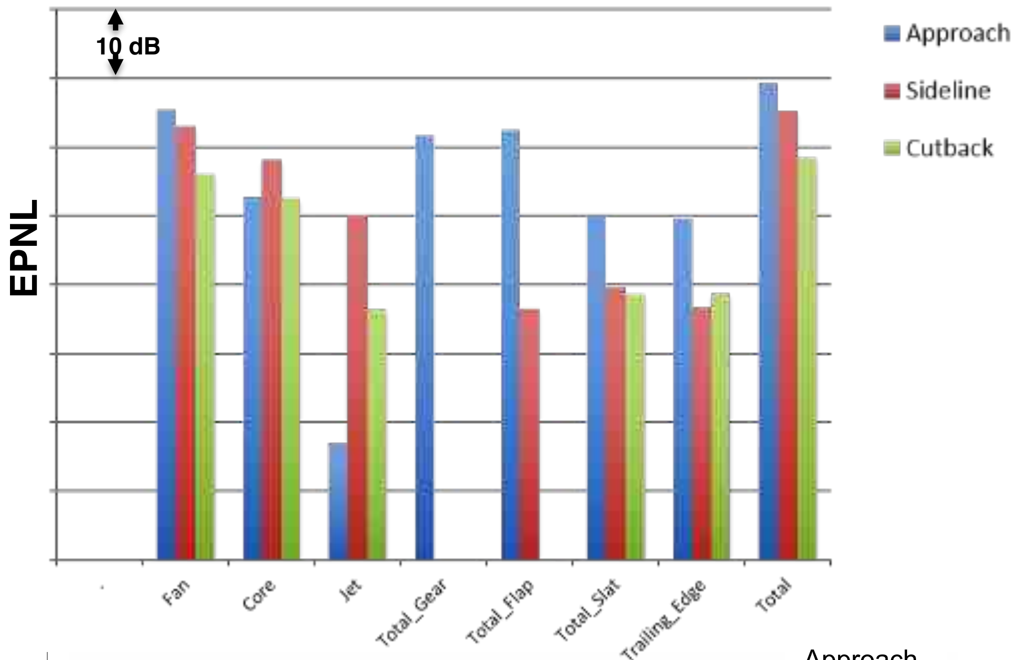
Develop, quantify and assess the impact of component noise reduction technologies across the airframe noise, acoustic liner technology, propulsion noise, and propulsion airframe aeroacoustics technical areas. Overall system noise impacts of various component technologies will also be assessed through periodic system noise studies for candidate conventional and unconventional aircraft configurations.

eTC3 Investment

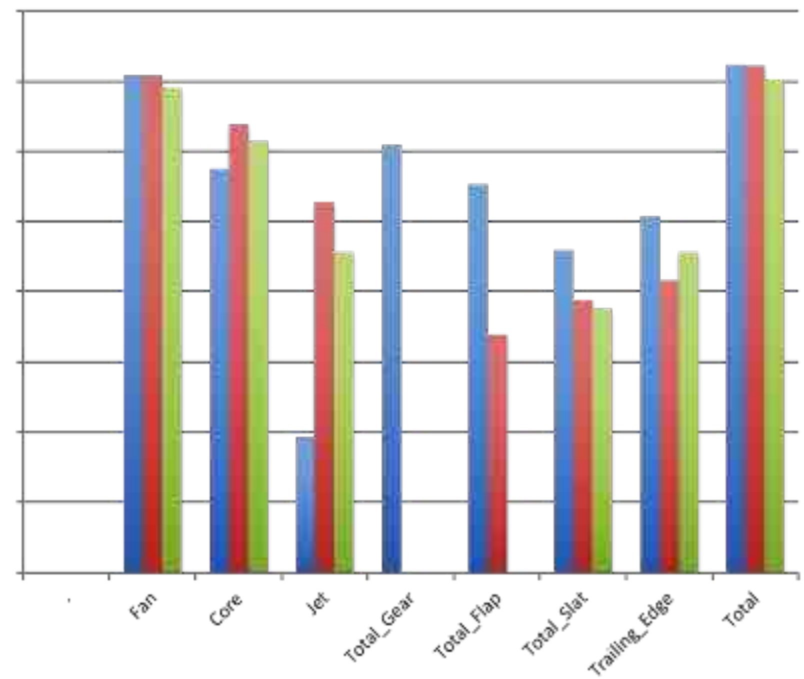
- Acoustic Liners & Duct Propagation – Low-Drag Advanced Liners
- Airframe Noise -
- Propulsion Noise
- Propulsion-Airframe Aeroacoustics (PAA)

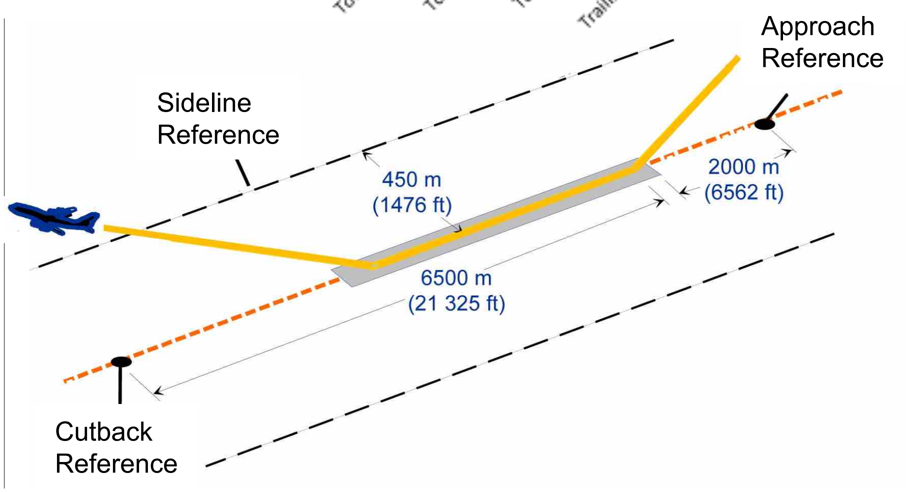
ANR Research Approach

Example: Single Aisle (SA) - Baseline



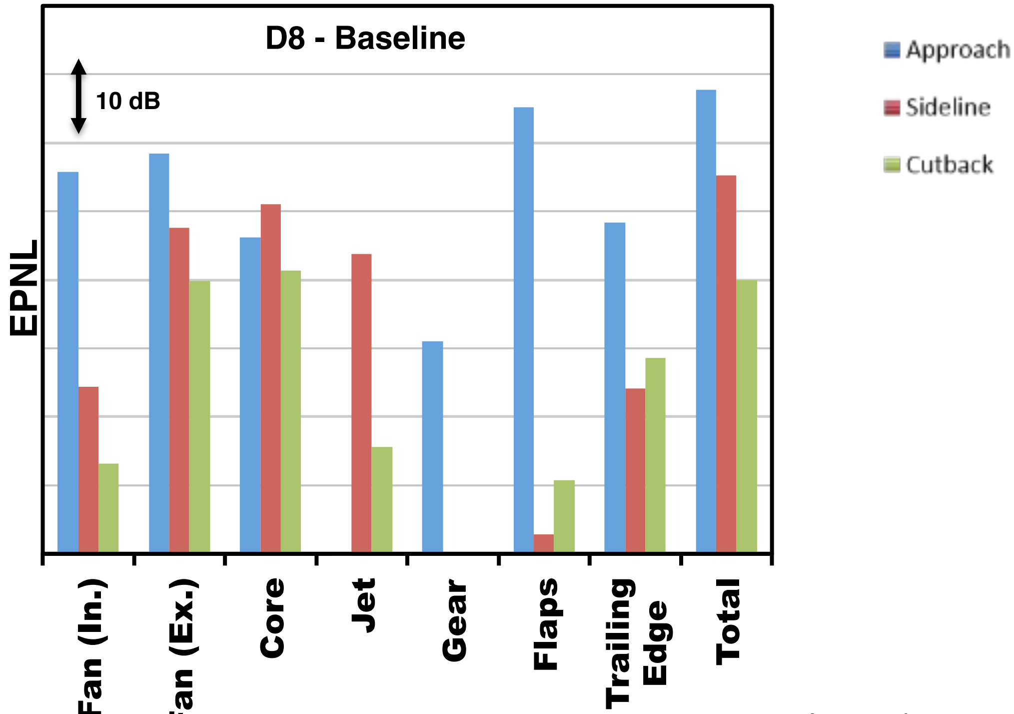
Example: Large Twin Aisle (LTA) - Baseline

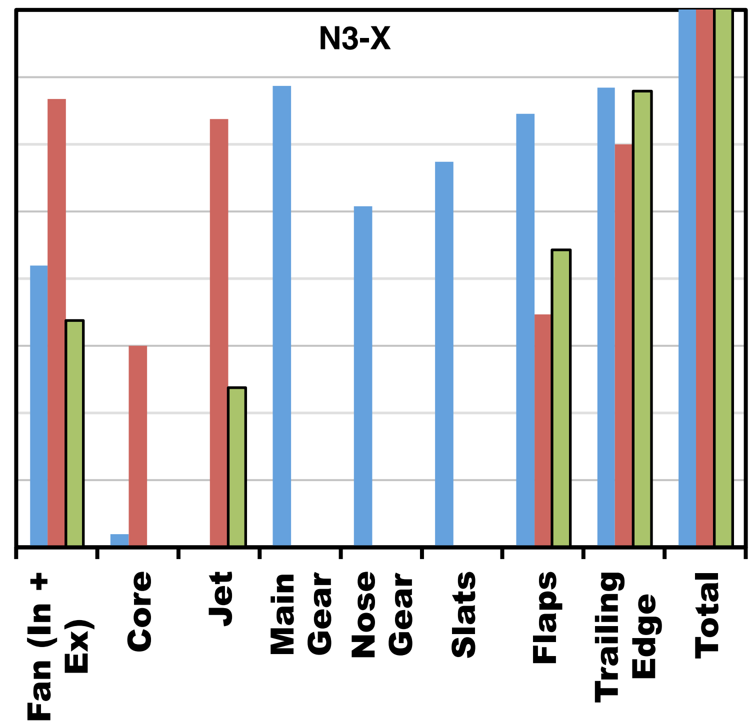


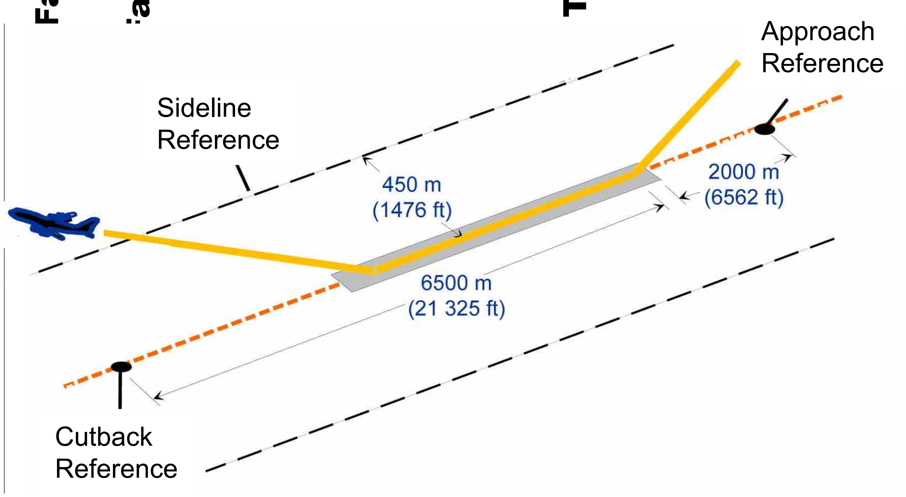


"dB Math"
2x Source Acoustic Power = 3 dB Increase
10x Source Acoustic Power = 10 dB Increase

ANR Research Approach







"dB Math"

2x Source Acoustic Power = 3 dB Increase

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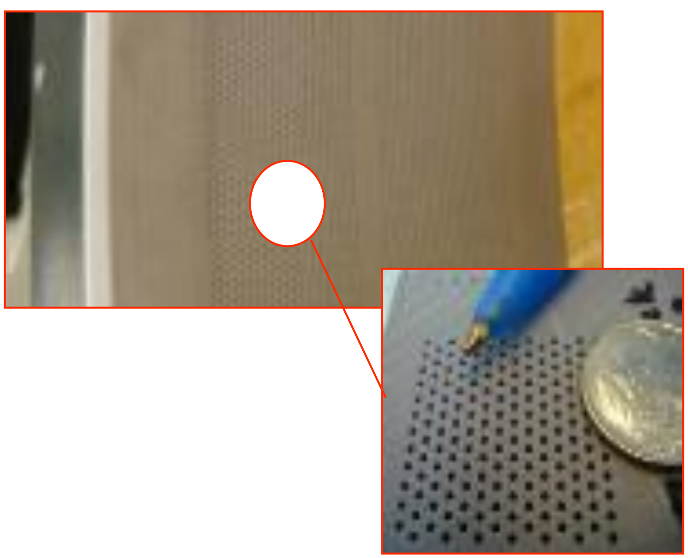
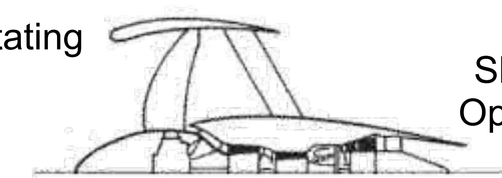
Propulsion Noise: Possible Concepts

Over-the-Rotor acoustic treatment fan case

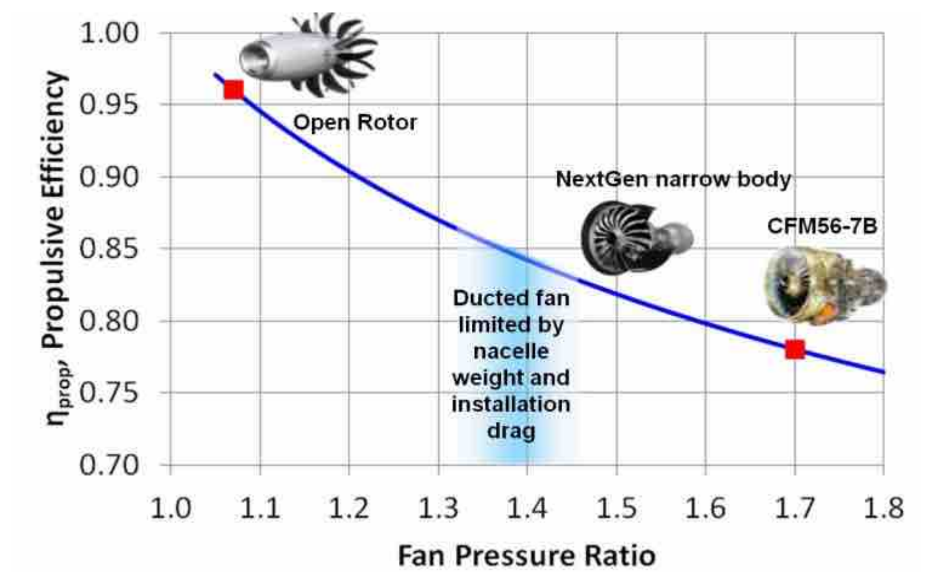


Concepts for Study

Counter-Rotating Fans

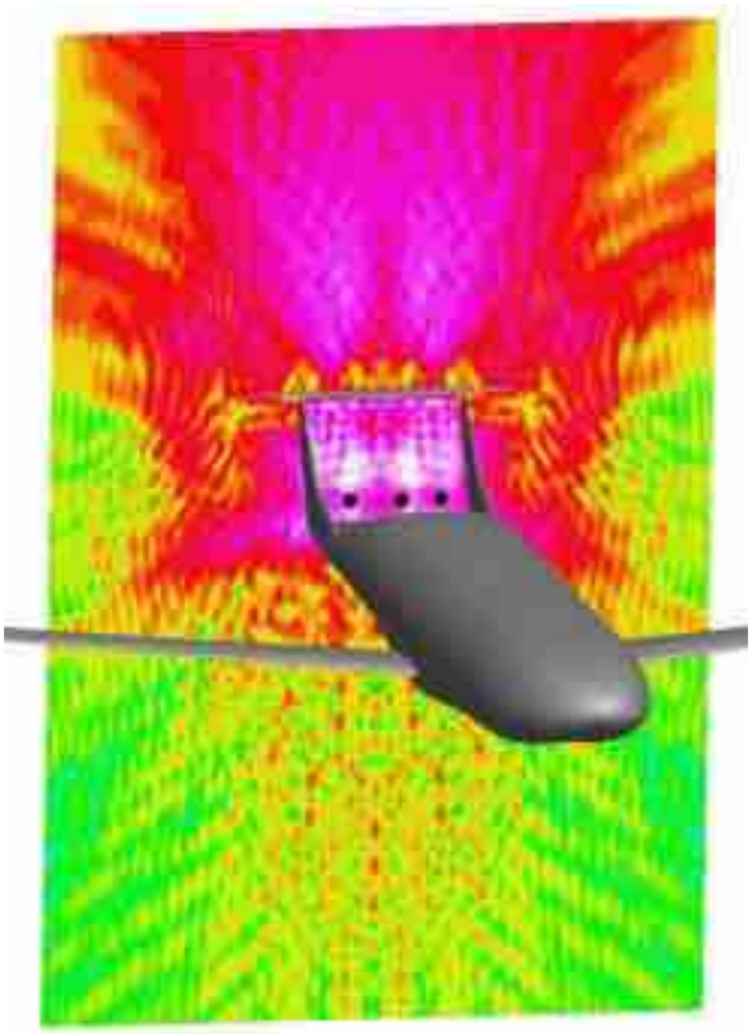


Shrouded Open Rotor

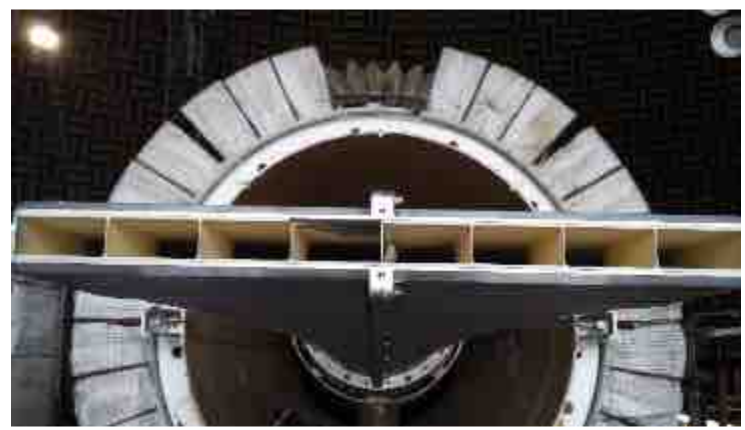


Propulsion Airframe Aeroacoustics

Source Shielding/Scattering
Acoustically Treated Tail (External Liners)



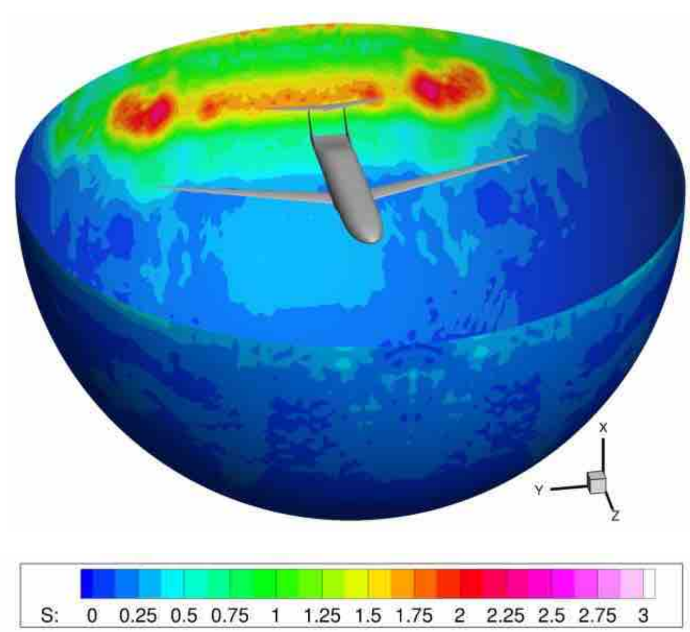
Jet-Surface Interaction Test (JSIT)

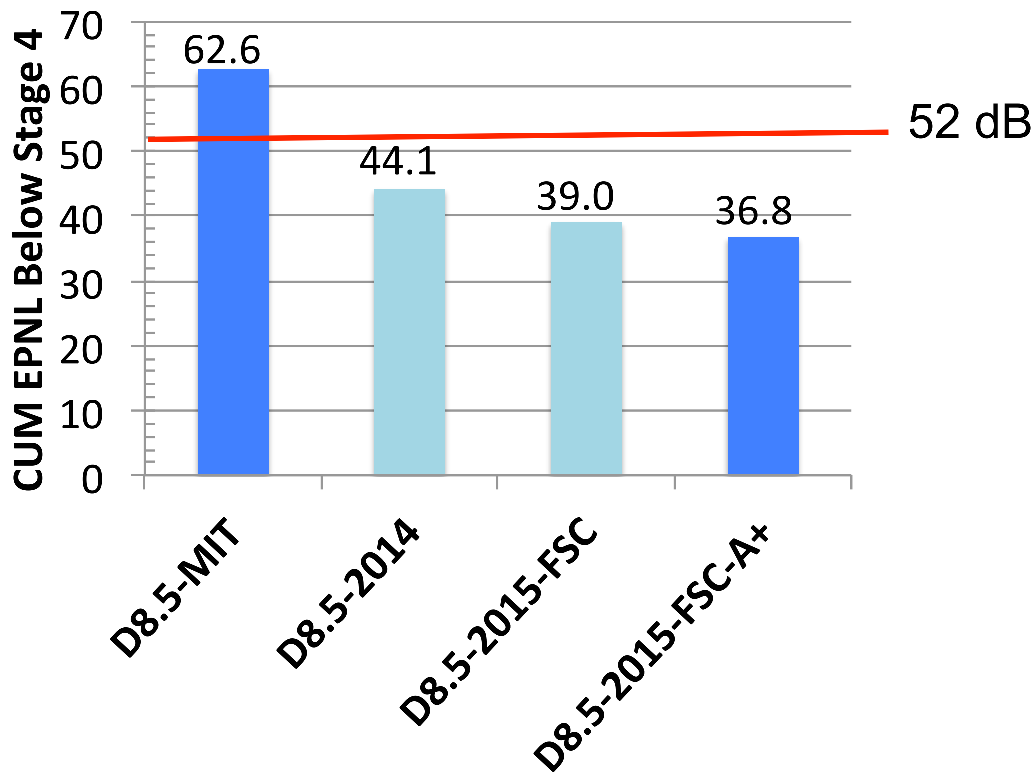


MIT D8.5 System Noise Assessment

NASA systems analysis on the MIT D8.5 configuration - update Sept 2015

- Fast Scattering Code (FSC) for shielding/scattering predictions
- Updated fan and airframe source level predictions





NASA Team: Berton, Burley, Guynn, Nark, Welstead