Aircraft Noise Reduction Subproject Overview

Aircraft Noise Reduction Subproject
Advanced Air Transport Technology Project

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

- **System Noise Impact Assessments**
Quiet High-Lift

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

- 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

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

Attenuation Spectra, 80% RPM

Sideline OASPL Attenuation at 80% RPM

Multi-Degree of Freedom (MDOF)
Single-Degree of Freedom (SDOF)

Nacelle Liner
Hub Liner – 1
Hub Liner - 2

Broadband Benefit Demonstrated

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Additional Concepts

Soft Vane

Over-The-Rotor Acoustic Treatment

Notable benefits possible: Need further development

Lean nine-point fuel injector (LDI)

Swirler

Fuel injector tip

Understand combustor-design change impacts

Advanced Air Transport Technology Project
Advanced Air Vehicles Program
Low-Drag Liner Concepts

**Objective**
- Reduced liner drag for internal/external applications

**Technical Areas and Approaches**
- Acoustic benefits and improved aerodynamic performance (fuel burn)
**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
**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.
- Test repeated at DLR and ONERA

**Status**

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**Source Shielding/Scattering**
Acoustically Treated Tail (External Liners)

**Jet-Surface Interaction Test (JSIT)**

**Preliminary Prediction of Shielding Impact**

- 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
Backup Slides
Flight Demo Plan

Hybrid Electric Propulsion Demonstrators

Ground Test Risk Reduction

Design & Build

Flight Test

Preliminary Design

Design & Build

Flight Test

Total Demonstration Cost: $700M

“Purpose-Built” UEST Demonstrators

Ground Test Risk Reduction

Preliminary Design

Design & Build

Flight Test

Potential Candidates

Life Cycle Cost: $400-500M

Preliminary Design

Design & Build

Flight Test

Life Cycle Cost: $430M

Fully integrated UEST Demonstrator

Design & Build

Flight Test

Life Cycle Cost: $400-500M

Life Cycle Cost: $850M

Design & Build

Flight Test

Life Cycle Cost: $430M

FY17  FY18  FY19  FY20  FY21  FY22  FY23  FY24  FY25  FY26
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

**EPNL**

- **D8 - Baseline**
  - Fan (In.)
  - Fan (Ex.)
  - Core
  - Jet
  - Gear
  - Flaps
  - Trailing Edge
  - Total

  - Approach
  - Sideline
  - Cutback

- **N3-X**
  - Fan (In. + Ex.)
  - Core
  - Jet
  - Main Gear
  - Nose Gear
  - Slats
  - Flaps
  - Trailing Edge
  - Total

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**“dB Math”**

- 2x Source Acoustic Power = 3 dB Increase
- 10x Source Acoustic Power = 10 dB Increase
Propulsion Noise: Possible Concepts

Concepts for Study

- Shrouded Open Rotor
- Distributed Fans
- Counter-Rotating Fans
- Over-the-Rotor acoustic treatment fan case

Graph:
- Efficiency vs. Fan Pressure Ratio
- Open Rotor
- NextGen narrow body
- Ducted fan limited by nacelle weight and installation drag
- CFM56-7B
Propulsion Airframe Aeroacoustics

Source Shielding/Scattering
Acoustically Treated Tail (External Liners)

Jet-Surface Interaction Test (JSIT)
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

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<th>D8.5-2015-FSC</th>
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NASA Team: Berton, Burley, Guynn, Nark, Welstead

52 dB