ABSTRACT: Technologies for Aircraft Noise Reduction

By Dennis Huff
NASA Glenn Research Center

Technologies for aircraft noise reduction have been developed by NASA over the past 15 years through the Advanced Subsonic Technology (AST) Noise Reduction Program and the Quiet Aircraft Technology (QAT) project. This presentation summarizes highlights from these programs and anticipated noise reduction benefits for communities surrounding airports. Historical progress in noise reduction and technologies available for future aircraft/engine development are identified. Technologies address aircraft/engine components including fans, exhaust nozzles, landing gear, and flap systems. New "chevron" nozzles have been developed and implemented on several aircraft in production today that provide significant jet noise reduction. New engines using Ultra-High Bypass (UHB) ratios are projected to provide about 10 EPNdB (Effective Perceived Noise Level in decibels) engine noise reduction relative to the average fleet that was flying in 1997. Audio files are embedded in the presentation that estimate the sound levels for a 35,000 pound thrust engine for takeoff and approach power conditions. The predictions are based on actual model scale data that was obtained by NASA. Finally, conceptual pictures are shown that look toward future aircraft/propulsion systems that might be used to obtain further noise reduction.

Technologies for Aircraft Noise Reduction

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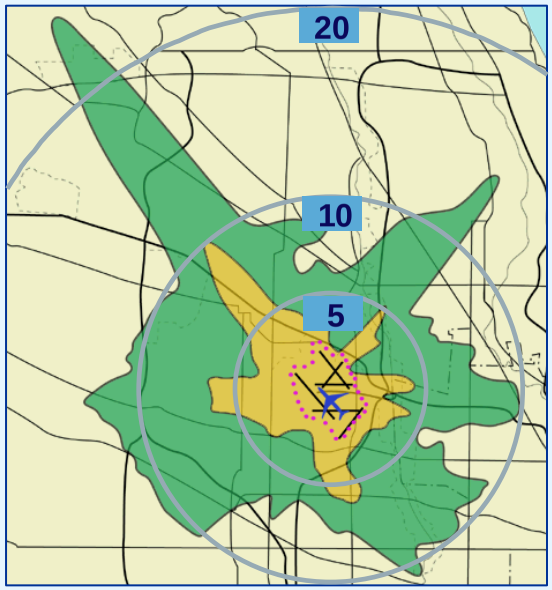
West Park Airport Committee Meeting
February 16, 2006

Technology Benefit: Reduced Noise Exposure



1997 Baseline

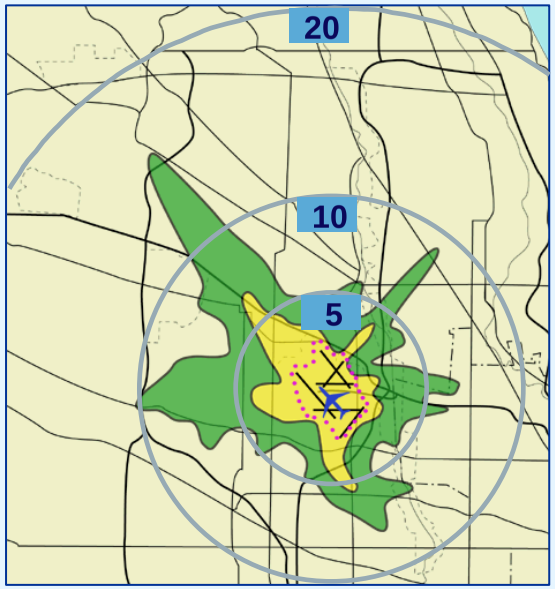
Key

55 dB

65 dB

Airport

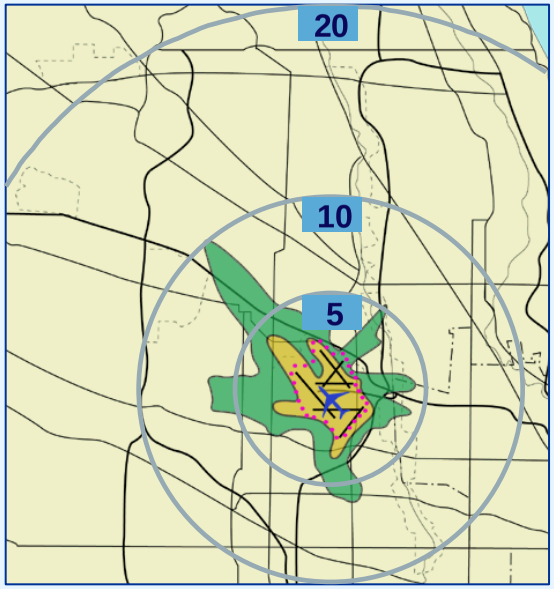
0 Miles 10



AST Technology Benefit

(Advanced Subsonic Technology)

- 5 dB Reduction (TRL 6)
- Doesn't meet public expectations
- Constrained growth

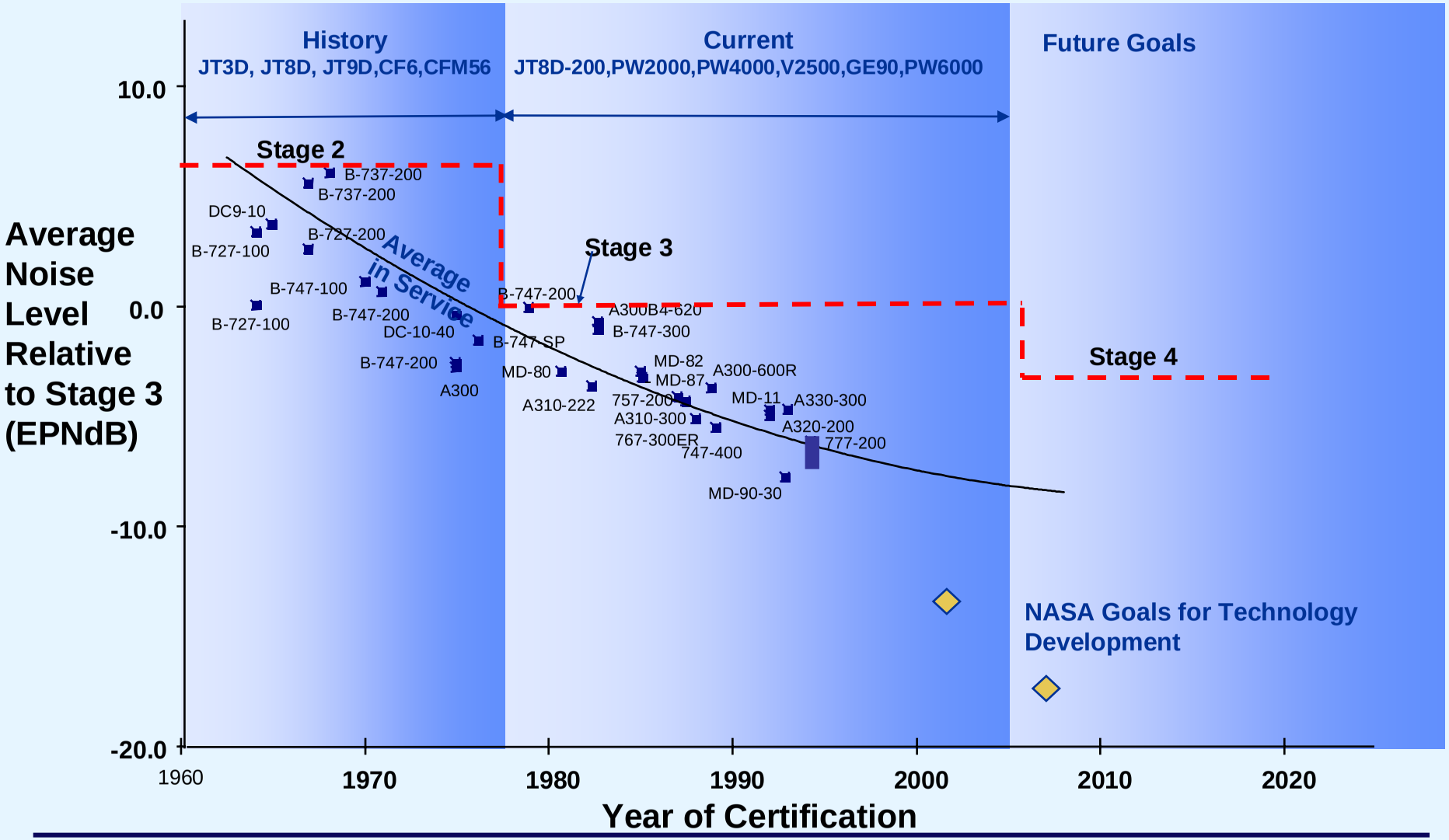


QAT Technology Benefit

(Quiet Aircraft Technology)

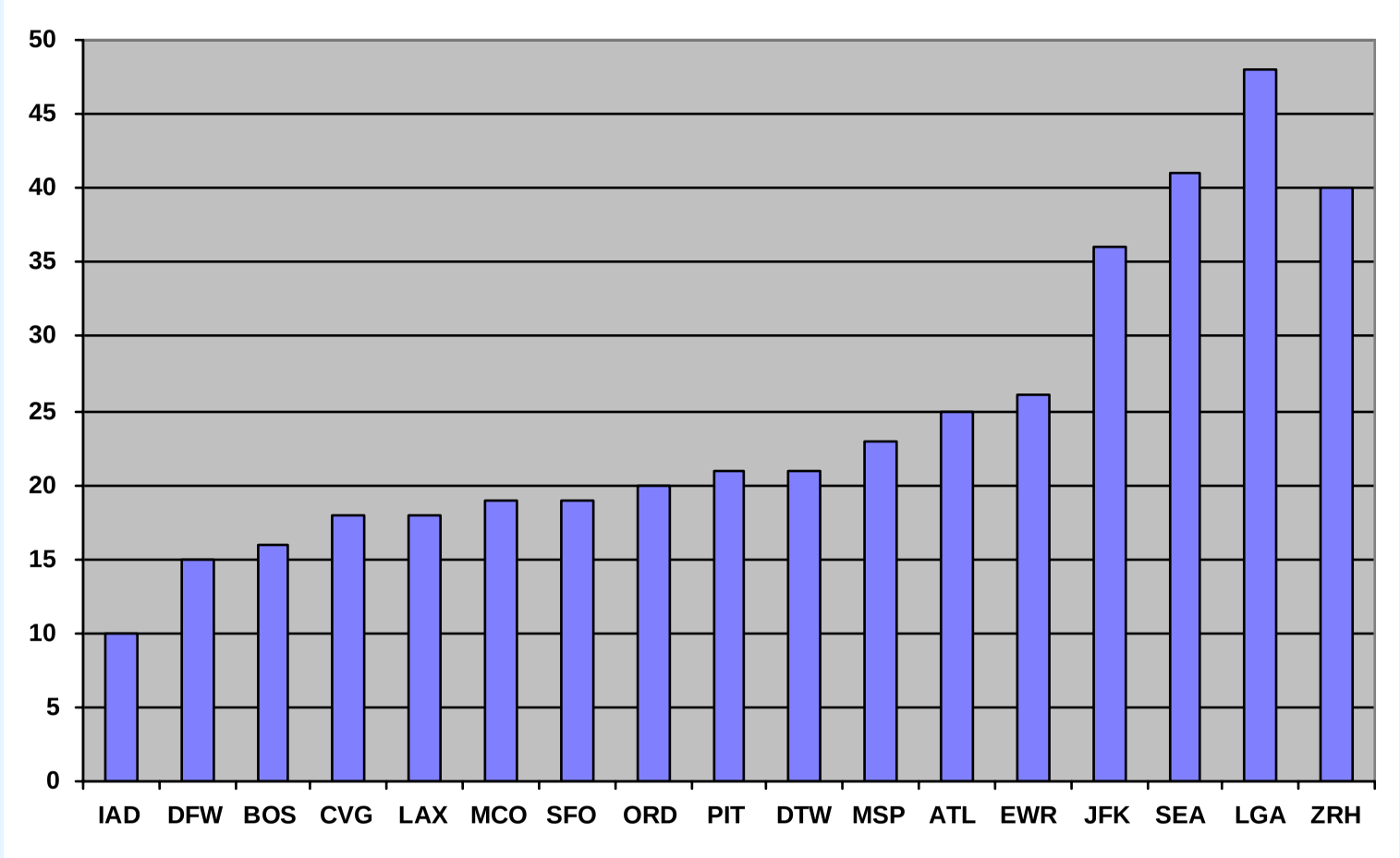
- 10 dB reduction
- 65 dB contour is within airport
- Enables projected air travel growth
- Reduces community noise impact

New Technology Enables Aircraft To Meet Future Requirements



Aircraft Fleet Noise Reduction Needed For 55 LDN Noise Contours Within Airport Boundaries

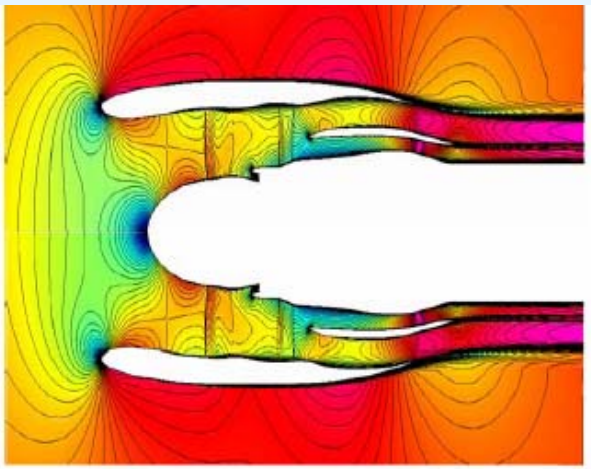
According to a document from the U.S. Environmental Protection Agency (EPA) published in the 1970's, 55 LDN is the outdoor noise exposure level "requisite to protect the public health and welfare with an adequate margin of safety". The phrase "health and welfare" is defined as "complete physical, mental and social well-being and not merely the absence of disease and infirmity".



Analysis by Don Garber, NASA Langley, using NoiseMap

NASA's Noise Reduction Research Programs

Airframe
Landing Gear
High-lift system
Integrated Propulsion



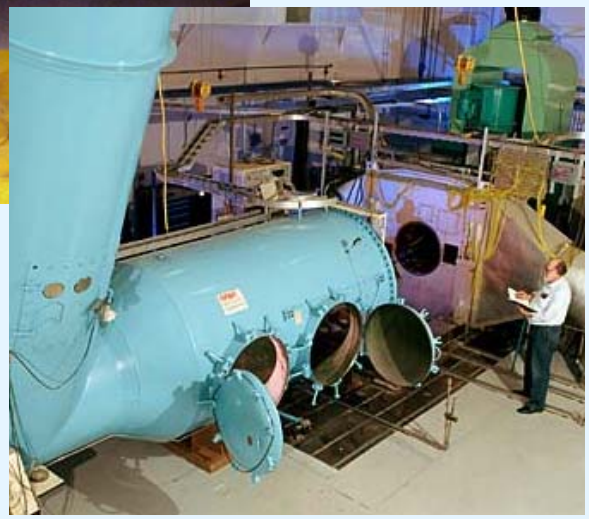
Engine
Fan
Jet
Core

Aircraft operations

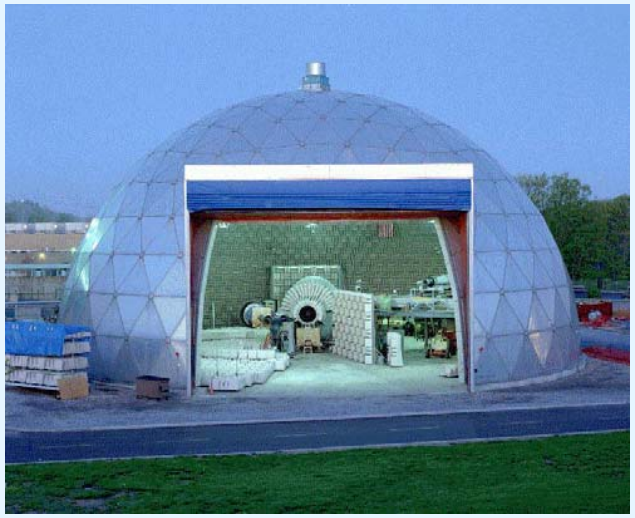
Aircraft Goal: 10 dB Quieter than 1997 Technology

Major Engine Noise Test Facilities at NASA Glenn

9x15 Wind Tunnel



W8 Fan Rig

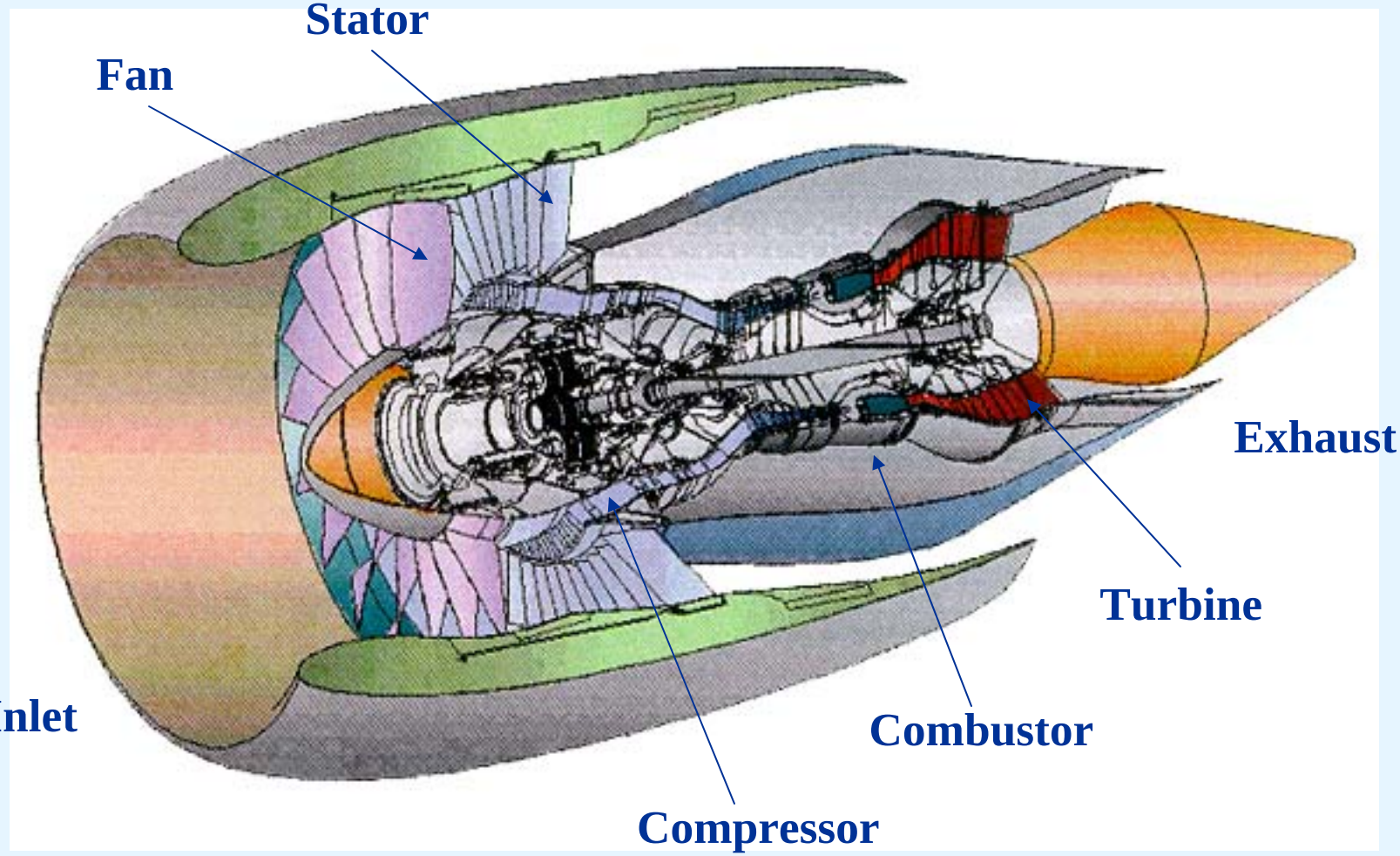


AeroAcoustic Propulsion Lab

Test Facilities Provide Component-Level Noise Assessments

Engine Noise Sources

(P&W PW8000 Engine, Conceptual)



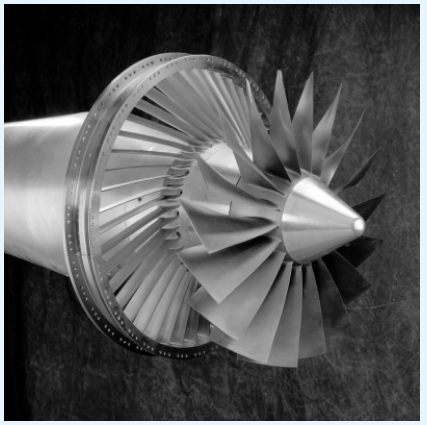
Engine Noise Reduction Technologies

Higher Bypass Ratio

Scarf Inlets

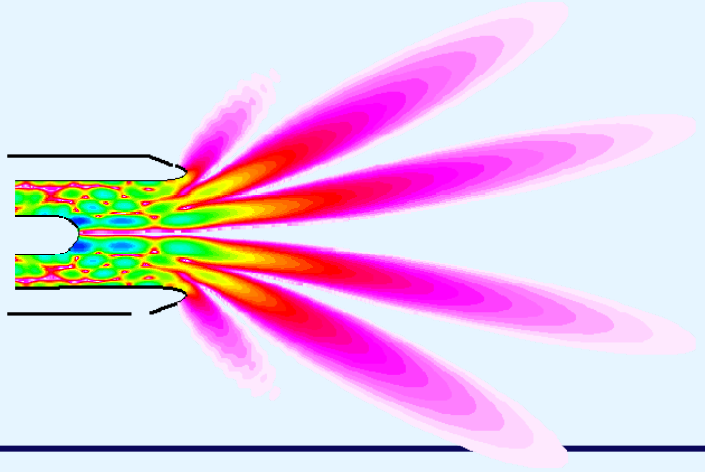
Forward-Swept Fans

Swept/Leaned Stators

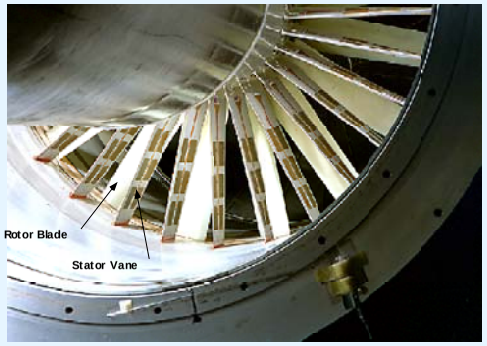


Chevron Nozzles

Noise Prediction



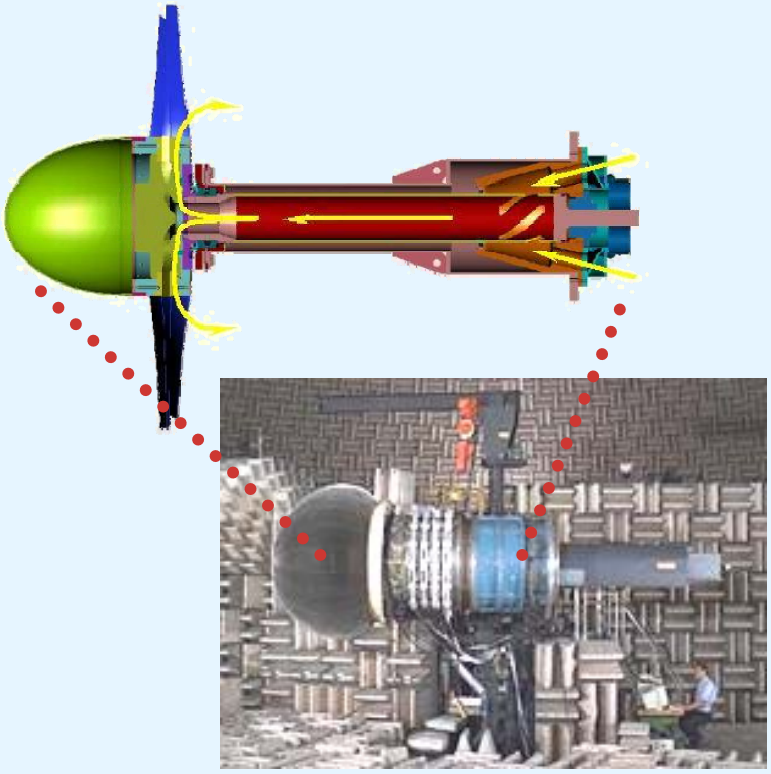
Active Noise Control

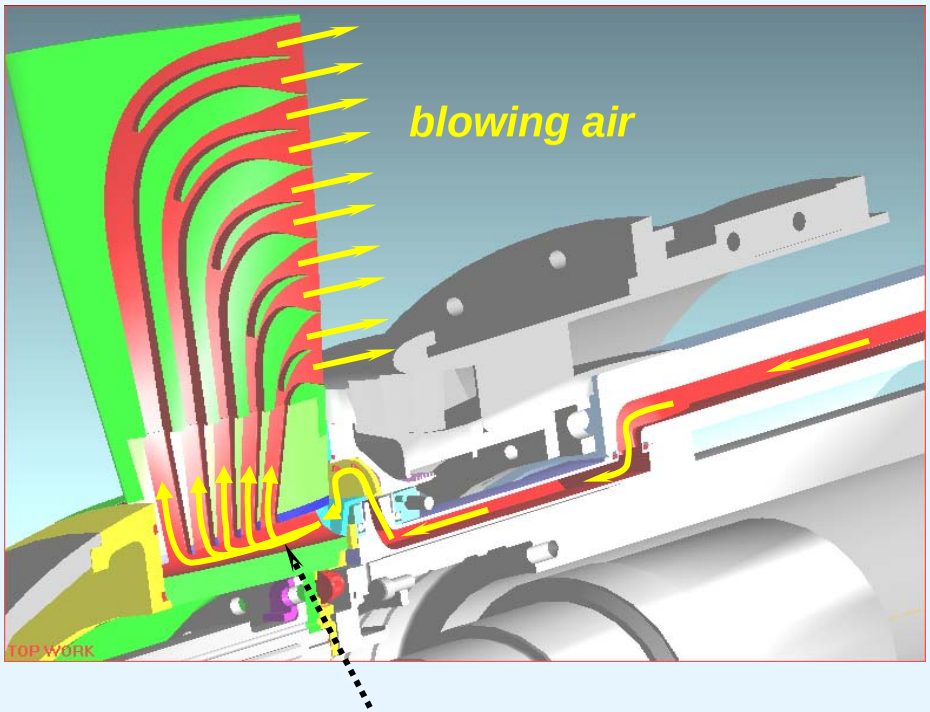


Trailing Edge Blowing

Benefits:

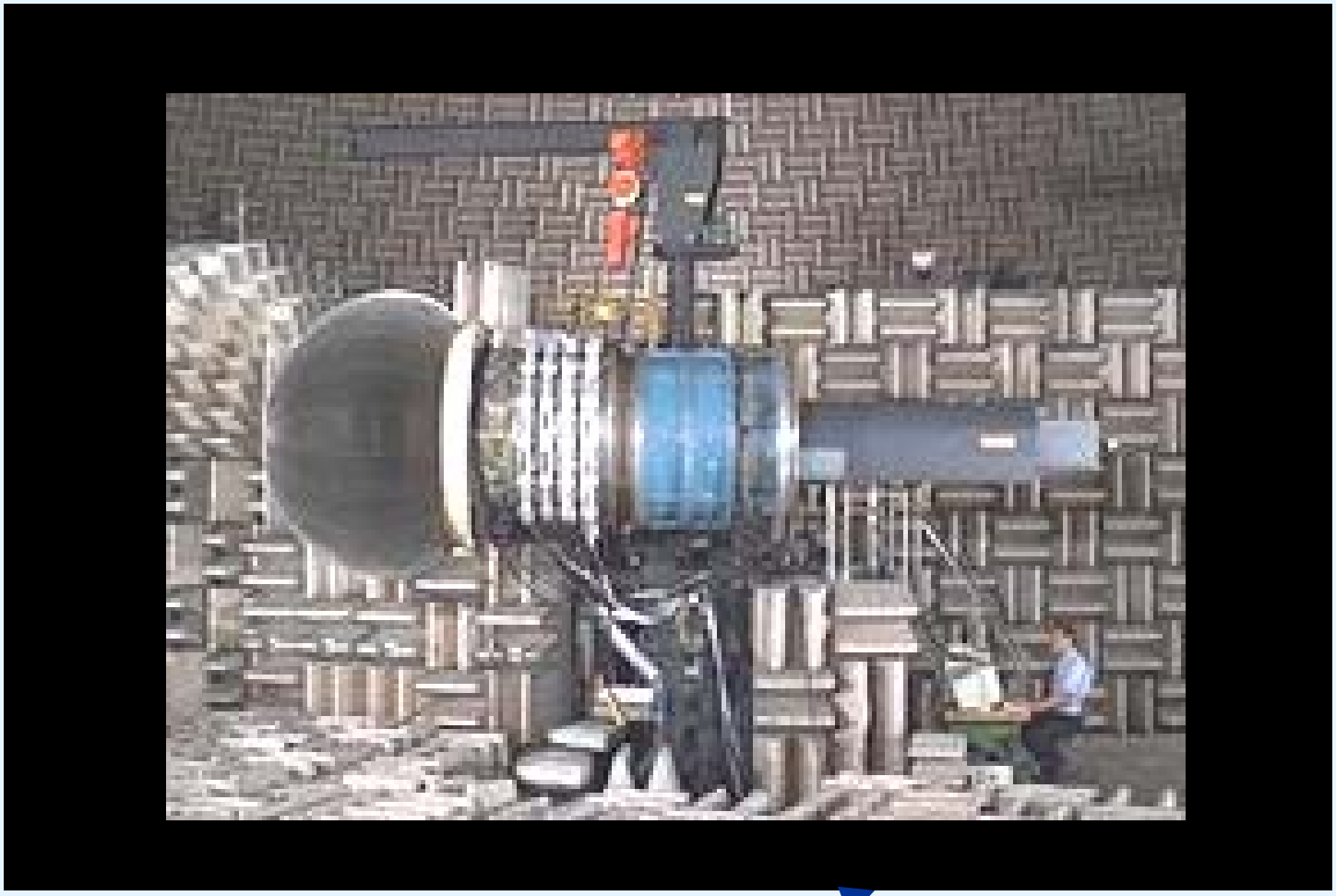
- Reduced Fan Noise





Testbed**: 9x15 Wind Tunnel**

Trailing Edge Blowing – ANCF Demo



Click Here for Audio Demo

Jet Noise Reduction With Chevron Nozzles

Engine Noise Diagnostic Testing at Honeywell

Engine:

Honeywell HTF7000

2005/06 Engine Tests Include:

- Internal flow measurements
- Microphone arrays to map engine acoustic field
- Fan noise modal measurements
- In-situ impedance measurement

Noise Reduction Technologies:

- Forward-Swept Fan
- Advanced acoustic liners

Small Engine Test Supports Business & Regional Jet Applications

Design of Low Noise Engine Initiated at P&W

Ultra-High Bypass “Advanced Geared Turbofan”

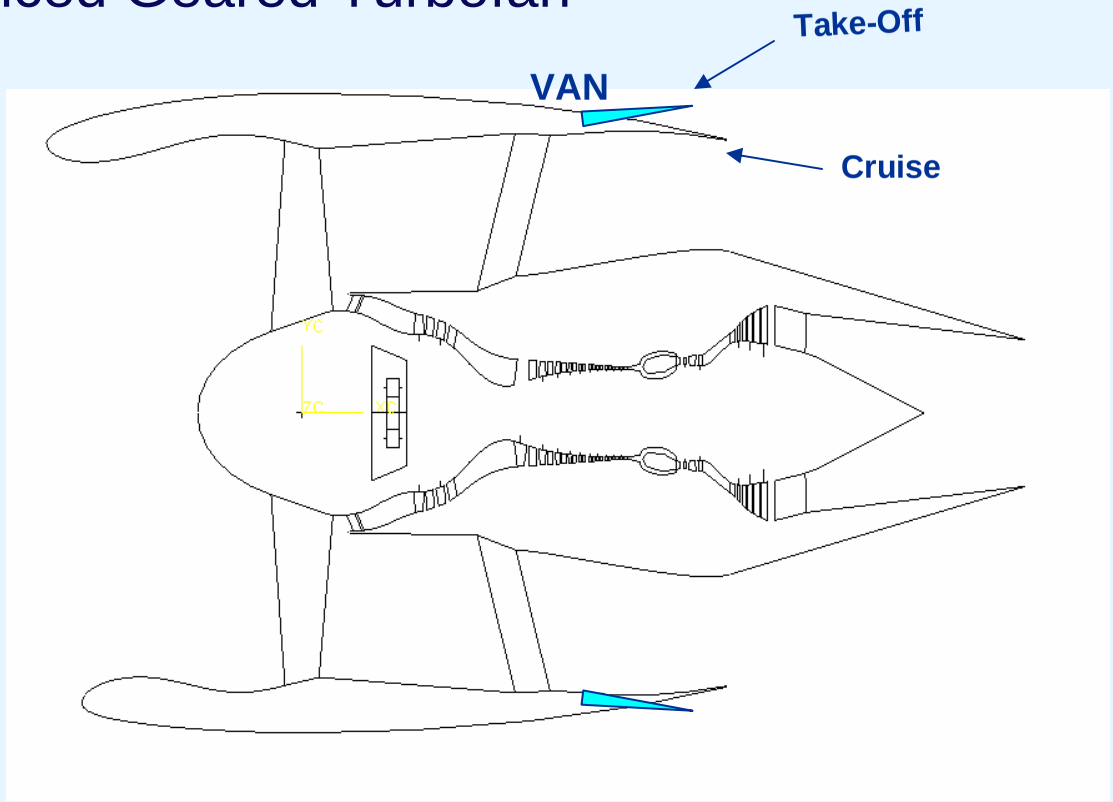
Low Noise Because of:

- Low fan tip speed
- Low jet exhaust velocity

Enabling Technologies:

- Fan drive gear system
- Variable area fan nozzle

Additional Noise Reduction Advanced Technologies

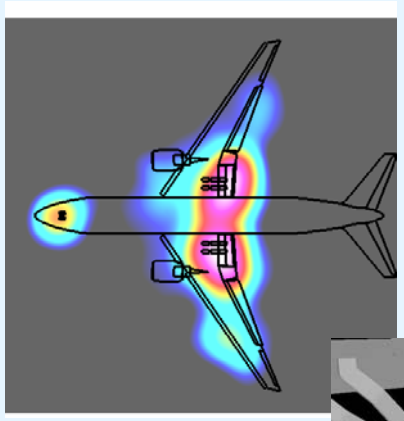


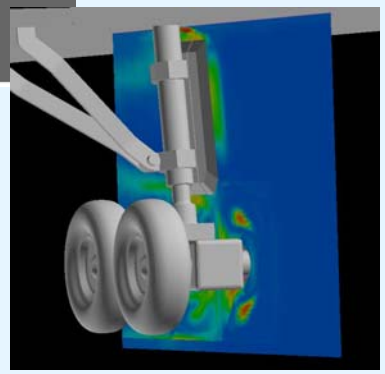
Wind Tunnel Fan Operability Test Planned for 2006

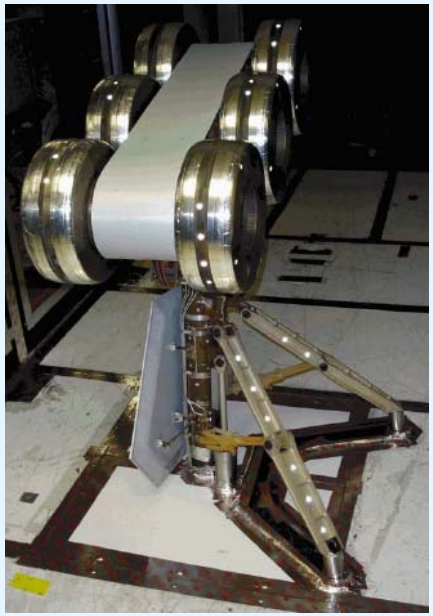
“Toboggan” Landing Gear Fairings

Benefits:

- Reduced Gear Noise



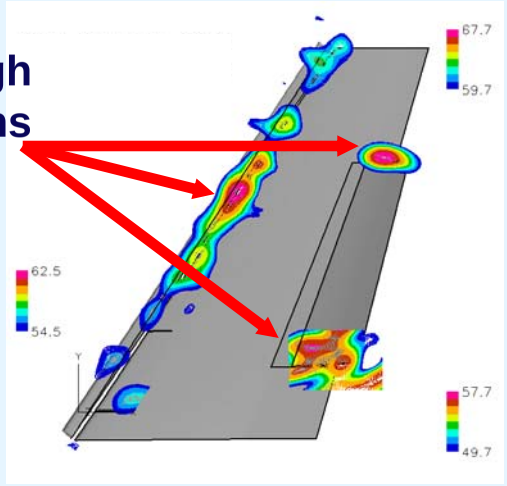




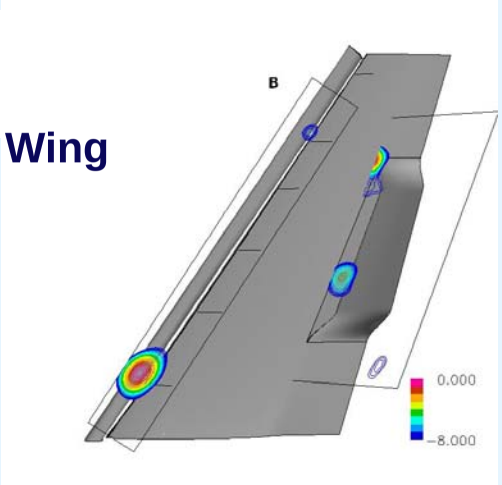
Flight Test In August 2005

Continuous Line Mold Flap & Slat Cove Filler

Baseline: High Noise Regions



Low-Noise Wing



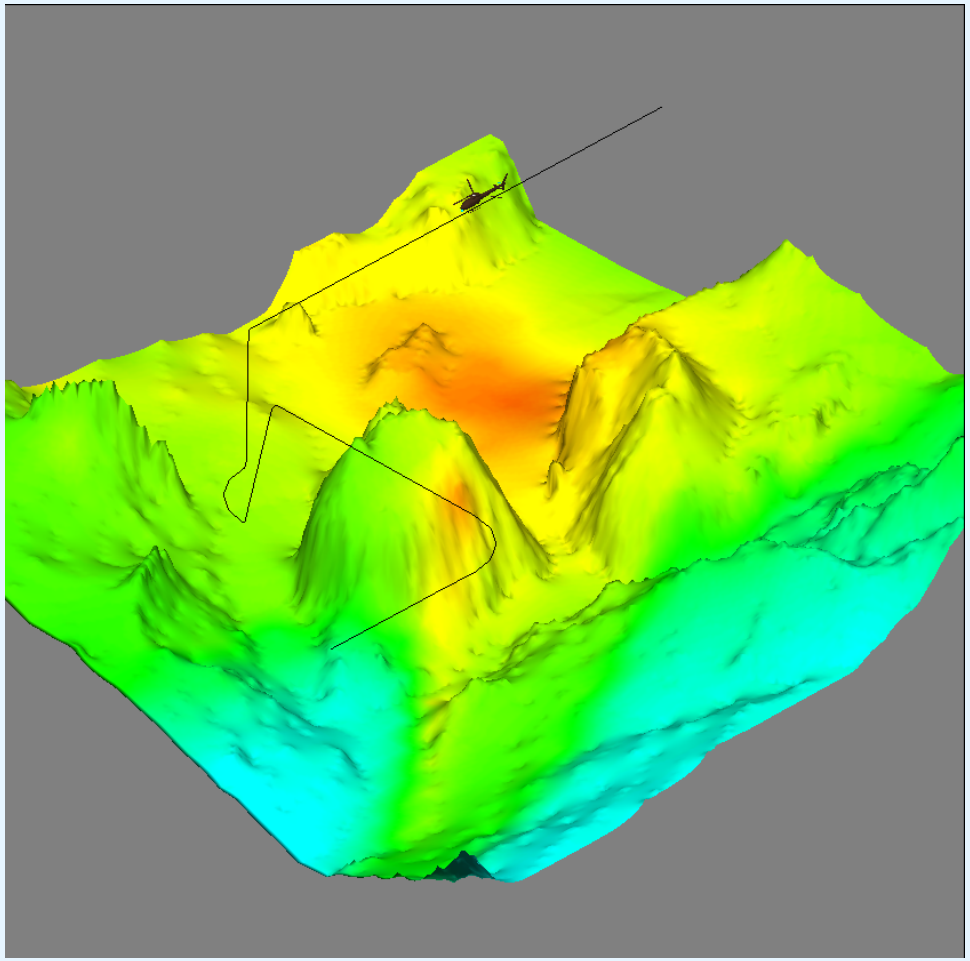
Benefits:

- Reduced Flap and Slat Noise

Simulation of Sound Propagating to Ground

Movie shows propagation of sound to grid of ground receiver locations

- **Rotorcraft (CH53E) flight description:**
  - **Begins traveling south at 2000' altitude in level flight, 110kts**
  - **Slows to 50kts, and then descends at 50kts to 100'**
  - **Performs 90° CCW turn while moving eastward at 50kts**
  - **Accelerates to 110kts while climbing to 2000'**
  - **Travels east at 110kts, then turns 90° to south and then accelerates to 180kts**



Hear the Quiet Airplanes of the Future

- A major airframe/engine opportunity is a Boeing 737 replacement that will require ~ 35,000 lb thrust engines.
- Using the best noise reduction technologies under development now, what are the predicted noise levels for a new engine?
- This audio demonstration contains projected noise levels for an engine for simulated takeoff and approach power conditions. It is based on actual model scale jet and fan data taken in NASA's wind tunnels.

Quiet Airplanes of the Future

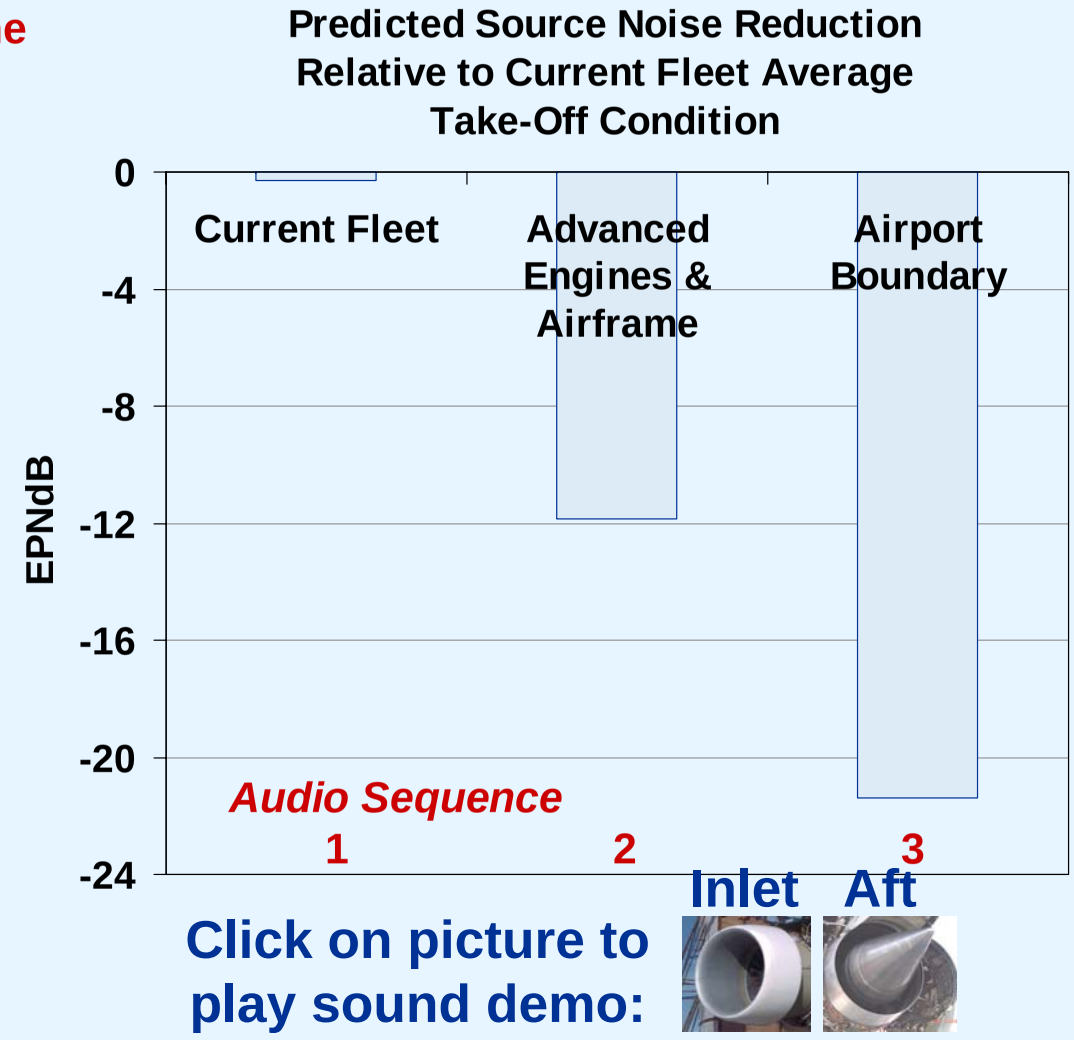
Advanced Engines & Airframe

Lower Fan Tip Speeds

- **Lower Jet Exit Velocities**
- **Variable Area Nozzle**
- **"Soft" Fan Stator Vanes**
- **Fan Trailing Edge Blowing**
- **Bypass Acoustic Splitter**
- **"Toboggan" Landing Gear Fairings**
- **Continuous Mold Line Flap**
- **Slat Cove Filler**

Airport Boundary

Projected level required for objectionable noise to be contained within airport boundary.



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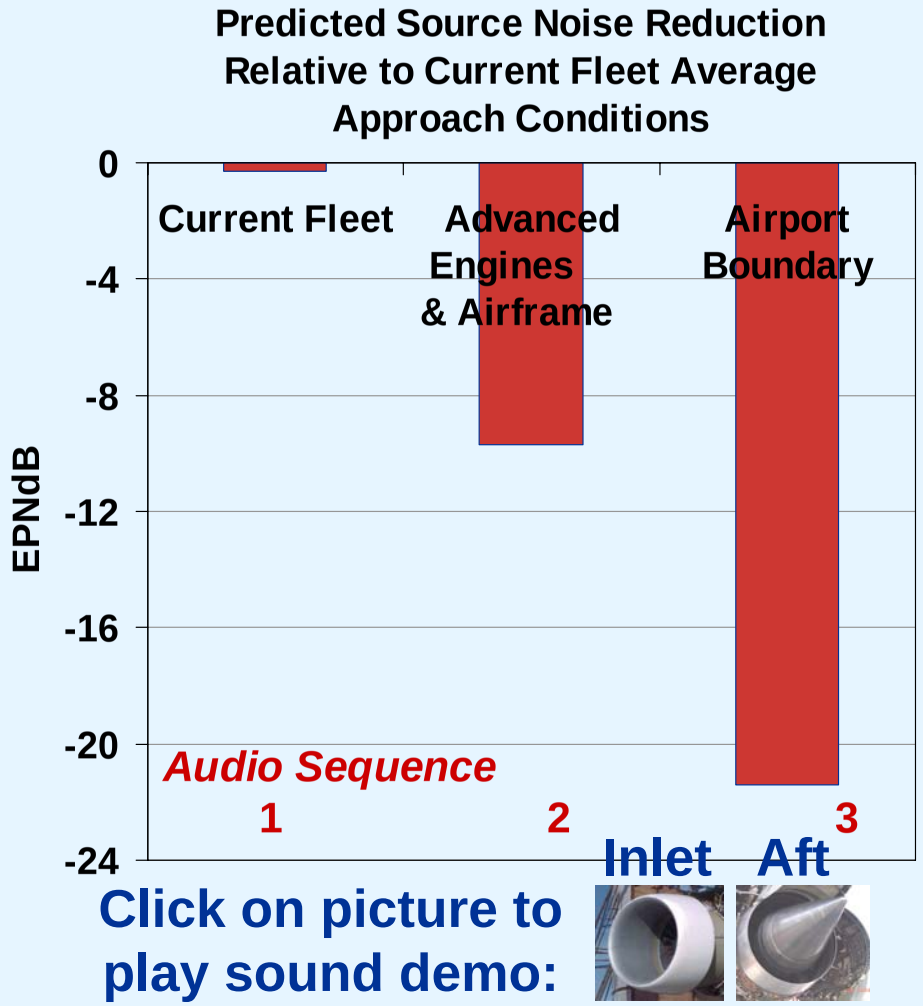
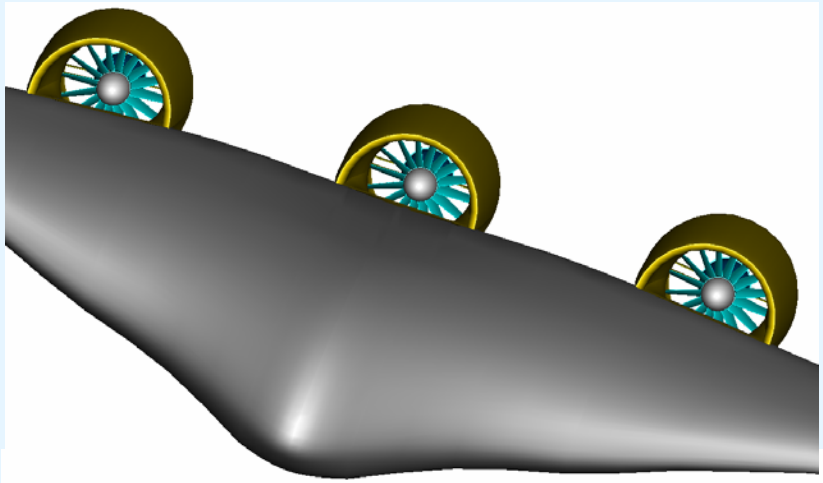
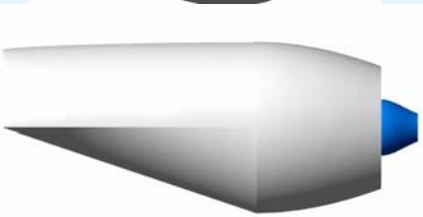


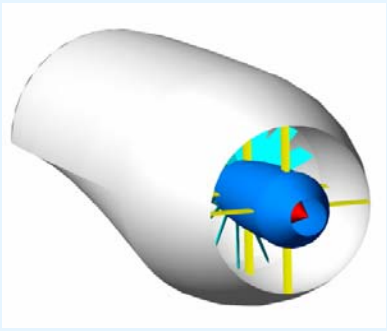
Click on picture to play sound demo:

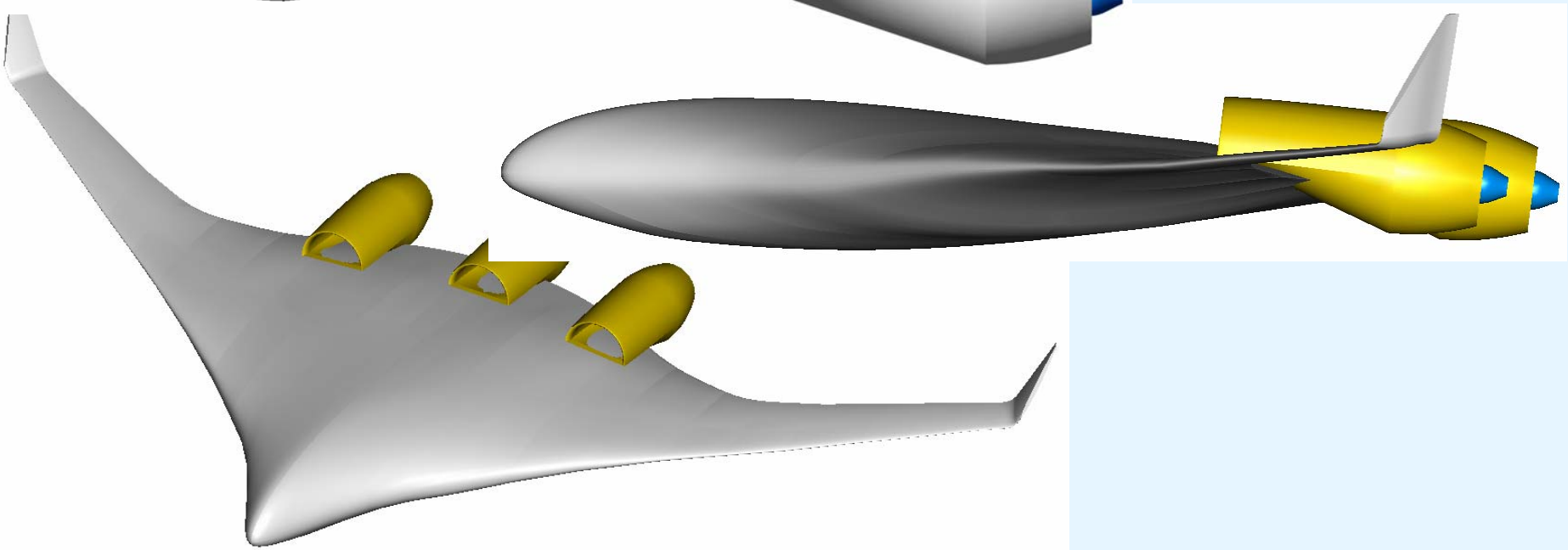
Single Fan On Blended Wing Body (BWB)

Fan Diameter	154.2”



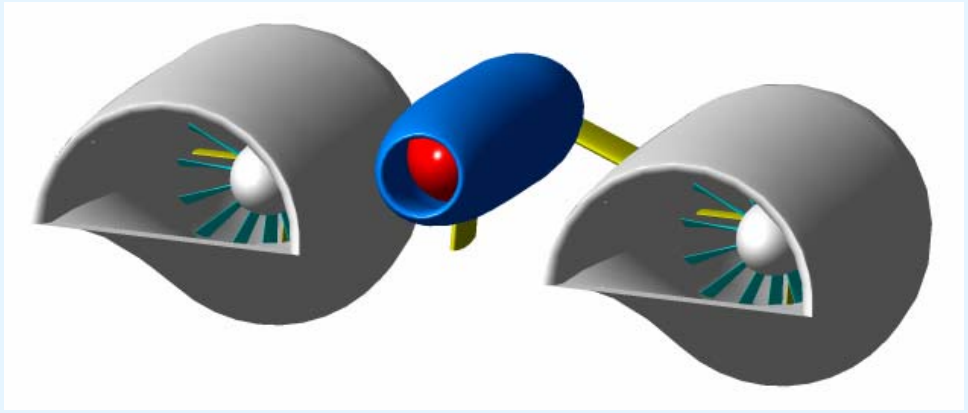


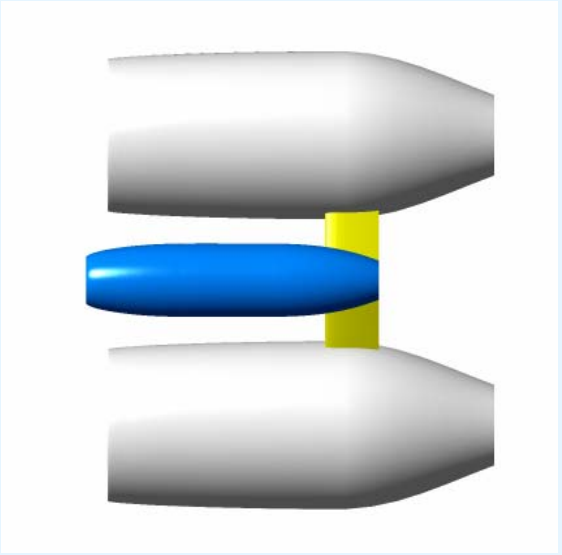


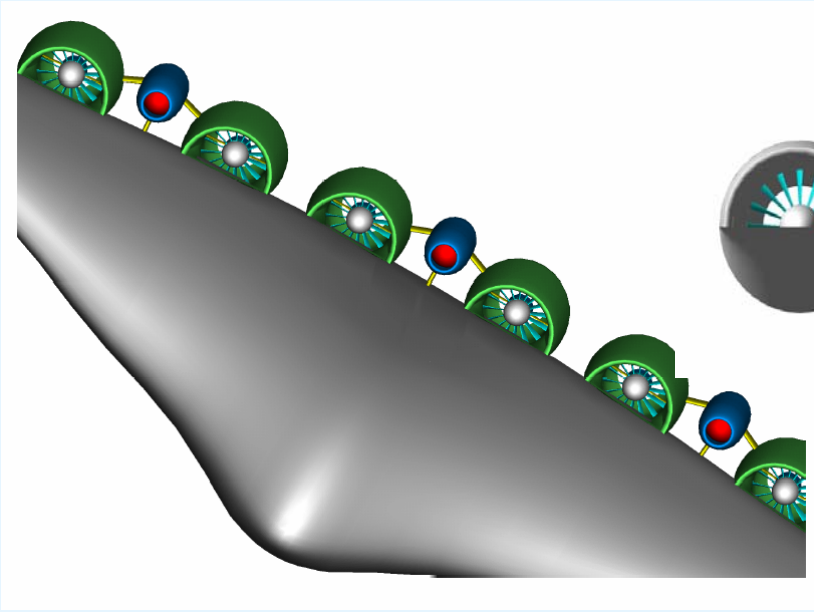


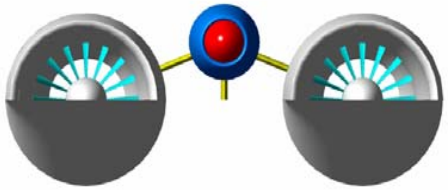
Dual Fan On Blended Wing Body (BWB)

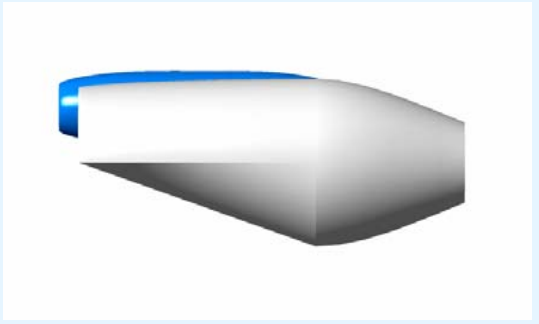
Fan Diameter	105.1”



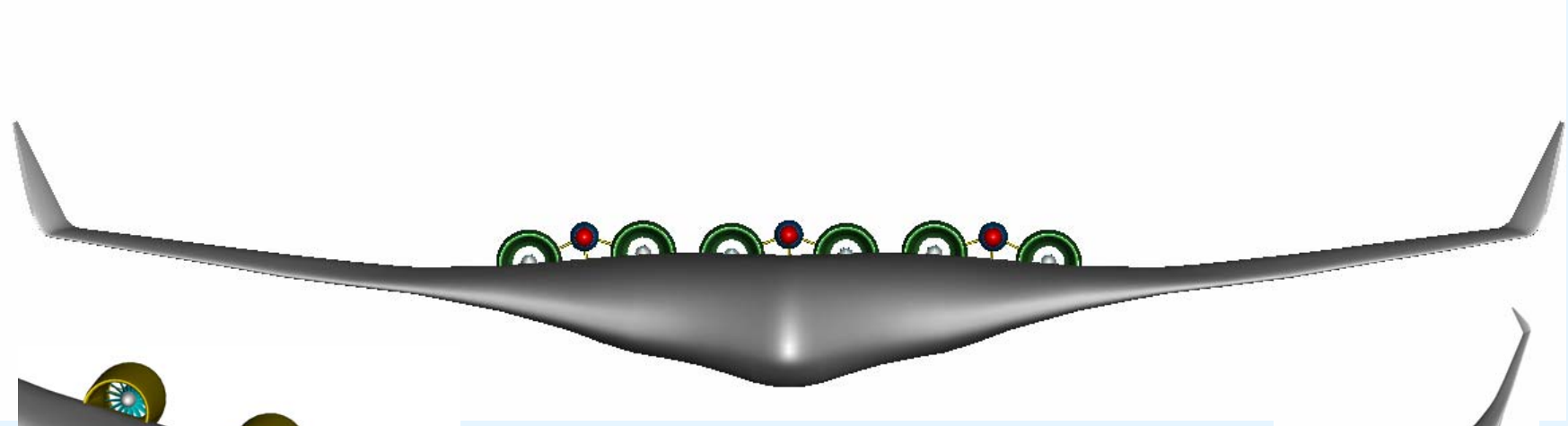


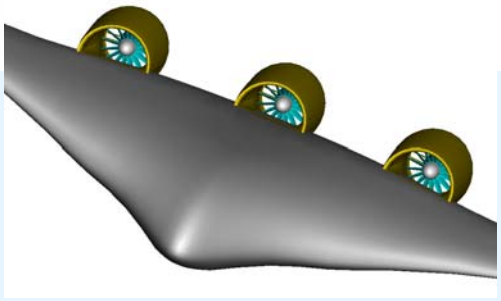


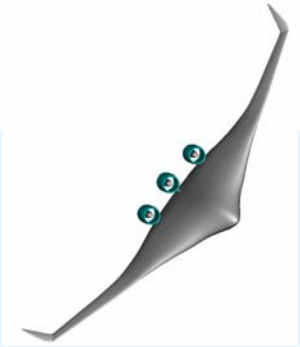




Dual Fan – Conceptual Applications







Summary

- Considerable progress has been made over the past 15 years developing technologies for aircraft noise reduction.
- NASA has been working closely with aerospace companies to identify opportunities to introduce new technologies into engines and aircraft.
- Limited technologies are retrofit-able, most will require development with new vehicles.
- Benefits near airports are incremental due to slow turnover from existing aircraft to newer aircraft with better noise reduction technologies.
- Technologies exist today to produce aircraft/engine combinations that can move the average 65 LDN noise contour near the airport boundaries if the entire fleet were replaced.