Recent Advances in Propulsion
Airframe Aeroacoustics

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NASA
Boeing
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Outline

• What is Propulsion Airframe Aeroacoustics (PAA)?
  – Definition
  – PAA in Action
  – Approach

• A recent PAA Experiment
  – Setup
  – Effects investigated

• Use of PAA Results
  – Prediction of System Noise

• Conclusions
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Propulsion Airframe Aeroacoustics (PAA)

• Definition: Aeroacoustic effects associated with the integration of the propulsion and airframe systems.

• Includes:
  – Integration effects on inlet and exhaust systems
  – Flow interaction and acoustic propagation effects
  – Configurations from conventional to revolutionary

• PAA goal is to reduce interaction effects directly or use integration to reduce net radiated noise.
Configuration Examples

[Images of various aircraft configurations]
PAA in Action

Lab experiments in 2004 led to PAA chevrons on QTD2 flight test in 2005

QTD2 success resulted in PAA chevrons on 747-8

Photos courtesy of Boeing
Technology Development

- **Large-Scale Aeroacoustic Experiments**
  - Lab
  - Flight

- **Multidiscipline Aircraft Concept Design**

- **Aircraft System Noise Prediction Methods**
  - ANOPP with PAA data
  - ANOPP 2 - direct
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Overall Experimental Setup (LSAF)
PAA Experiment
Some PAA Effects Investigated

Basic Shielding – Nozzle moved upstream

Impact of Chevrons and specific Pylon contributions
Chevrons move Jet Sources Upstream
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System Calculations

- Use NASA tools to generate ‘SOA’ and ‘HWB’ aircraft sized for same payload and 7500 NM mission
- Equivalent technology level and same engine family
Aircraft ‘flown’ for FAA cert. trajectory

Approach

Takeoff / Cutback

Sideline

Populated Areas

120 m

2000 m

6500 m

450 m
Progress towards Goal

dB Below Stage 4

- SOA: 10.3
- Baseline HWB: 22.0
- Simple Shielding: 31.6
- Chevrons: 35.1
- Active Pylon: 36.6
- Crown Pylon: 39.2
- Lined Pylon: 40.0
- Projection: 42.4
Sound Exposure Level (SEL) Contour

- For simulated Arrival and Departure (aircraft flying right to left)

66% Reduction in ground contour area
Conclusions

• PAA effects provide a powerful enabler for aircraft noise reduction

• Shielding of jet noise sources is feasible

• Aircraft noise is a system-level problem requiring system-level solutions
References

• Flight Test Results for Uniquely Tailored Propulsion-Airframe Aeroacoustic Chevrons: Community Noise AIAA-2006-2438

• Flight Test Results for Uniquely Tailored Propulsion Airframe Aeroacoustic Chevrons: Shockcell Noise AIAA-2006-2439

• Hybrid Wing Body Aircraft System Noise Assessment with Propulsion Airframe Aeroacoustic Experiment AIAA-2010-3913

• Propulsion Airframe Aeroacoustic Integration Effects for a Hybrid Wing Body Aircraft Configuration AIAA-2010-3912