AEROCOUSTIC ANALYSIS AND EXPERIMENTS

537-03-20

Presented By

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Aeroacoustics Branch, Acoustics Division, LaRC

on

September 23, 1992

at

Lewis Research Center, Cleveland, Ohio
# 1992 Program Review

## Community Noise Activities / Major Milestones

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### 537-03-20 Aeroacoustic Analysis & Experiments

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### $K$

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### Manpower

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<td>1CS/4SSC</td>
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1. Initial ANOPP Update
2. Broadband Shock Noise Update
3. Jet Noise Module Update
4. Engine Cycle Downselect
5. Interim FAR 36 Assessment
6. Turbomachinery Noise Module
7. ANOPP Code Updated
8. Initial Jet Noise Update Completed
9. Propulsion Concept Select
10. FAR 36 Assessment
AEROACOUSTIC ANALYSIS AND EXPERIMENTS

- CLIMB-TO-CRUISE FLIGHT TEST RESULTS
- IMPLEMENTATION / VALIDATION OF NEW TAM BROADBAND SHOCK NOISE THEORY
CLIMB-TO-CRUISE FLIGHT TEST

- Dryden Flight Research Center
- November, 1991
- 120 recorded fly-overs of a 28 microphone array
CLIMB-TO-CRUISE / ANOPP VALIDATION FLIGHT TEST

Flight test - November, 1991

Data Reduction

LaRC / DFRF

Tracking

Weather data

Ambient acoustic data

Engine data

Acoustic data

LaRC Analysis
Ensembled Average Spectra

F-18 Data Base Distribution

Code validation & update

Source noise understanding

Further data analysis

Boeing
DAC
GE
P & W
LeRC
LaRC

Ambient acoustics

Weather

Engine data

Tracking

Acoustic spectra

F-18 & F-16XL Data Base
CLIMB TO CRUISE FLIGHT TEST F-18 SPECTRA
Mach 0.3 at 1500 Feet

Single microphone spectra

\[ \theta = 35^\circ \]

\[ \theta = 90^\circ \]

\[ \theta = 135^\circ \]

Ensemble averaged spectra

\[ \theta = 35^\circ \]

\[ \theta = 90^\circ \]

\[ \theta = 135^\circ \]
F-18 FLIGHT TEST DATA SCALED TO HSCT AIRCRAFT SIZE.

Distance from brake release, NMi
CLIMB-TO-CRUISE NOISE ISSUE

SUMMARY

- Noise problem quantified
- Data indicates less climb-to-cruise suppression required than earlier predicted by industry
- Data base calibrates existing codes and will be used to improve prediction capability
- Results must be incorporated into studies to guide:
  - HSCT engine selection
  - Design and operation of suppressors
  - Aircraft climb-out procedures
FLIGHT EFFECTS ON SHOCK NOISE
THEORY DEVELOPED

$M_j = 1.4; \theta = 90^\circ; 2''$ dia conic jet

Turbulence/shock cell interactions generate intense broadband shock noise

Theory validated: Forward flight increases shock noise levels and decreases peak frequency
FLIGHT VALIDATION OF PREDICTED HIGH SPEED FLIGHT EFFECTS ON SHOCK NOISE

Frequency, kHz

OASPL, dB

Classical theory

Flight data

Tam theory

Emission angle, θ_e, deg

Emission angle, θ_e, deg

M_∞ = 0.8

1500 ft.

Observer

F-18 at Dryden
AEROCOUSTIC ANALYSIS AND EXPERIMENTS

- AA&EP RELATIONSHIP TO MAJOR PROGRAM MILESTONES
- PROPOSED OVERGUIDELINES
- FY93/94 PLANNED ACCOMPLISHMENTS AND SIGNIFICANCE
- ISSUES AND CONCERNS
# Aeroacoustic Analysis and Experiments Element Relationship to Major Program Milestones

<table>
<thead>
<tr>
<th>Year</th>
<th>Budget</th>
<th>Research Focus</th>
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<tr>
<td>FY92</td>
<td>$450K 1CS/4SSC</td>
<td>LaRC / LeRC System Studies (Noise Elements) - ongoing</td>
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<tr>
<td>FY93</td>
<td>$550K 1CS/4SSC</td>
<td>Engine Cycle Downselect</td>
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<tr>
<td>FY94</td>
<td>$550K 1CS/4SSC</td>
<td>Interim FAR 36 Assessment</td>
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<tr>
<td>FY95</td>
<td>$550K 1CS/4SSC</td>
<td>FAR 36 Assessment</td>
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**ANOPP CODE System Noise Prediction Updates - ongoing**

- Nozzle Studies
- Brdgd Shock Noise
- Jet Mixing Noise
- High Speed Flight Effects
- Airframe Noise
- Turbomachinery Noise
- Prop./Airframe Int. Noise
- Core & Turbine Noise

*Unfunded Phase 1*
AEROACOUSTIC ANALYSIS AND EXPERIMENTS

Proposed Overguidelines to Accomplish FAR 36 Assessment

<table>
<thead>
<tr>
<th>NOISE SOURCE</th>
<th>UNCERT. ESTIMATE</th>
<th>FY93</th>
<th>FY94</th>
<th>FY95</th>
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<tbody>
<tr>
<td>PROPULSION NOISE</td>
<td>±10dB</td>
<td>750</td>
<td>750</td>
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<tr>
<td>Inlet - <em>Interaction tones, sub/supersonic flow</em></td>
<td>?</td>
<td>250</td>
<td>250</td>
<td>250</td>
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<tr>
<td>Exhaust - mixing, brdbd shock, <em>core, turbine</em></td>
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<tr>
<td>AIRFRAME NOISE</td>
<td>±10dB</td>
<td>500</td>
<td>1000</td>
<td>1100</td>
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<tr>
<td>PAI NOISE</td>
<td>1-3dB</td>
<td>250</td>
<td>250</td>
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<tr>
<td>Jet shielding effects</td>
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<tr>
<td>High lift effects</td>
<td></td>
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<tr>
<td>Laminar flow control effects</td>
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<tr>
<td>PROPAGATION EFFECTS</td>
<td>?</td>
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<tr>
<td>Lateral attenuation</td>
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<td>OPERATING PROCEDURES</td>
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<td>Take-off</td>
<td>250</td>
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<td>Climb-to-cruise</td>
<td><em>community noise impact</em></td>
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Fiscal Year Budgets, $K
AEROACOUSTICS ANALYSIS AND EXPERIMENTS
FY93/94

Planned Accomplishments

• Complete Flight Test Data Analysis and Distribute to HSR Participants.

and

Continue Validation of Tam Broadband Shock Theory with Flight Data and Expand Validation with Wind Tunnel and Further Small Scale Flight Test.

• Additions to ANOPP for: rectangular nozzle predictions for shock noise, increasing jet mixing noise temperature validation to 2750 °F, Contour Package, Interactive Run Capability, and a glossary for User Friendliness.

• Empirical Turbomachinery Noise Prediction for P-Inlet.

• Participate in the Engine Cycle Downselect and Interim FAR 36 Assessment Processes.

Significance

• Validate and Update Prediction Codes for Greater Accuracy and Discrimination for Engine Cycle Downselect and FAR 36 Assessment.

• To Provide Government/Industry with a Benchmark Prediction Tool for the Engine Cycle Downselect and FAR 36 Assessment.

• To Reduce the Inaccuracy in the Prediction of Inlet Radiated Noise for Support of Engine Cycle Downselect and FAR 36 Assessment.

• To Help Assure Achievement of HSR Phase I Goals.
AEROA COUSTIC ANALYSIS AND EXPERIMENTS

ISSUES AND CONCERNS

Major Programmatic Changes:

Planning, execution, and data reduction and analysis for the Climb-To-Cruise flight test will have absorbed about 50% of the ANOPP code development manpower for about one year. This has resulted in a delay in the accomplishment of several planned activities/milestones.

Concerns:

Lack of efforts to develop and or refine inlet noise codes (turbomachinery/approach noise), jet-jet shielding codes, excess ground attenuation codes, airframe noise codes, etc. may result in a large uncertainty in the FAR 36 assessment.

Community noise impact assessments will be necessary to help determine a meaningful (necessary and sufficient) noise goal for the HSCT for both near-airport (certification) and climb-to-cruise operating conditions.