Propulsion Airframe Integration

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Ames Research Center

High Speed Research Program Review

Lewis Research Center
September 23, 1992
Propulsion Airframe Integration

FY 1992

Accomplishments

<table>
<thead>
<tr>
<th>PAIT Inlet Concept Studies (LeRC)</th>
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<tbody>
<tr>
<td>Wing/2-D Mixer-Ejector Nozzle Interactions Test (LeRC)</td>
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<tr>
<td>SA 1150 Model Prep (ARC)</td>
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</table>

Significance

- Defined Relative Merits of Candidate Concept
- Identified PAI Issues as Critical
- No First-Order PAI Effects on Aero Performance Of Nozzle
- Extensive Pressure Data
- Wing-Body & Nacelle Support System Refurbished and Operational
- Remote Control of Vertical Nacelle Position
- Captive Nacelles and Diverters Fab'd
- Shake Down Run - July 10, 1992
## Propulsion Airframe Integration

### FY 1993

#### Planned Accomplishments

<table>
<thead>
<tr>
<th>Activity</th>
<th>Significance</th>
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</table>
| SA 1150 NAI Test (ARC) | • Supersonic Force, Moment & Cp Data Base  
| | • Supersonic Spillage Effects  
| | • Diverter/Pylon Data |
| Ref. H NAI Test (ARC) | • Integration Aspect of Advanced Nacelle Concepts  
| | • Critical Element in Inlet Selection Process |
| Generic Nacelle on a Balance Test (LaRC) | • Detailed Nacelle/Diverter Performance  
| | • Shock/Boundary Layer Separation Criteria |
| Refined Inlet Unstart Study (LeRC, Lockheed) | • Define Dynamic Forces & Moments  
| | • Assess Structural Response  
| | • Define Inlet Control Criteria |
| Atmospheric Disturbances (LeRC, Boeing) | • Assess Current Data Bases  
| | • Define Anticipated Flt. Environment  
| | • Develop Math Model of Environment  
| | • Basis for Design of Inlet Control System |
Program Objectives

Independently Supported Nacelles

- Expand NAI experimental database to $M = 2.4$
  * Simple, existing, axisymmetric N1 nacelles
  * Nacelle position
  * Mass flow effects, Steady state unstart loads
  * $M = 1.6, 2.0, 2.4$

- Assess the interference characteristics of supersonic spillage
  * Axisymmetric Centerbodies for $M =$ Subsonic, 1.6, 2.0, 2.4

Captive Nacelles

- Assess the integration characteristics for nacelles & diverters derived from NASA Lewis PAIT tasks with Boeing & Douglas
  * Circular Nacelle Shapes
    - Boeing: TBE
    - Douglas: FLADE
  * Diverters
    - Boeing: 3 Configurations
    - Douglas: 2 Configurations
PARAMETRIC NACELLE MODEL

Metric Nacelle / Diverter Model

Plate

Pallet

Balance

Section A-A

30.0 in.
DESIREABLE FEATURES OF NACELLE ON FLAT PLATE TESTING

• Low cost technique to address various NAI issues in a generic (ie non configuration dependent) manner

• Geometry provides ideal initial case for NAI code validation studies
  - Simplifies geometry and grid generation
  - Reduced solution time

• Accurate nacelle/diverter drag measurement

• Provides detailed surface pressure measurement capability

• Model exists (low cost)
MULTIPHASE PROGRAM

• Phase I
  - Conical axisymmetric forecowl
  - Diverter height effects
  - Diverter geometry effects
  - Aft-cowl effects
  - Drag and flow visualization measurements
• Phase II (Phase I geometries and measurements included)
  - Nacelle geometries (kinked axi, 2D bifurcated, 2D)
  - Diverter off/on effects
  - Nacelle angle effects
  - Surface pressure measurements
• Phase III
  - Mutual interference effects (with/without diverter)
  - Spillage/unstart effects
• Phase IV
  - Compression spike/ramp effects
  - Aft-cowl effects
HSCT Inlet Unstart Study

Objectives:
- Impact on:
  * Vehicle Dynamics
  * Structural Response
  * Passenger Safety & Comfort
- Define Requirements for Inlet & Vehicle Controls
- Viability of Mixed Compression Inlet Systems

Approach
- Impact of:
  * Flight Conditions
  * Disturbance Type
  * Inlet Type
  * Structural Stiffness
  * A/C Control Modes
  * Inlet Control System

Level of Effort
- 3700 Man Hours
- 12 Months
Atmospheric Disturbance Environment

Objectives
- Data Base of High Altitude Atmospheric Disturbances
- Requirements for Control System Design

Approach
- Identify, Review & Categorize Existing Data Bases
- Define Anticipated Disturbance Environment
- Development of a Statistically based Math Model of Environment

Level of Effort
- 1200 Man Hours
- 12 Months
Propulsion ↔ Aerodynamic Interactions

High-Lift System and Wing Aerodynamics Influence
- Nozzle Entrainment and Installed Performance
- Mixer/Ejector Inflow Distortion
- Acoustic Signature

Nozzle Mixer/Ejector Entrainment Influences
- L.E. Vortex Trajectories and Wing Pressures
- T.E. Flap Flow Attachment and High-Lift System Performance

HSR High-Lift/Engine Aeroacoustic Technology
HIGH-LIFT/ENGINE AEROACOUSTIC TECHNOLOGY
NFAC WIND TUNNEL TEST

Objectives:
1.) Aerodynamic effects on installed noise suppressor performance.
2.) Suppressor entrained flow effects on high-lift.

Approach:
Level I: Test a 1/8th scale semi-span model of the Boeing HSCT reference geometry in the 40 x 80-Foot Wind Tunnel. The model will be powered by a Boeing propane jet simulator and mounted on an acoustic plane of symmetry.
Level II: More instrumentation, twin jet simulation and isolated nacelle/jet testing.

Primary Research Goals:
Acquire high quality far & near field noise measurements of a HSCT jet suppressor in forward flight with the associated forces, moments and pressures.

Deliverable:
Document significant design sensitivities related to high-lift/engine aeroacoustic installation effects.

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<th>Level</th>
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<th>FY 95</th>
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# Propulsion Airframe Integration Activities

## Fiscal Year Activities

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# Propulsion Airframe Integration - ARC

## Resource Summary

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PAI Working Group

Plans
• PAI Needs vs Aero & Propulsion Plans
• One Page Test Summaries
• CFD Subgroup

Issues
• Support for LaRC Nacelle Integration Tests in FY 93
• Initiate Inlet Controls Funding in FY 94 vs FY 95
• Engine/Inlet Dynamic Simulations Needed Early in Phase II to Support Inlet Design Activities and Planned Wind Tunnel Tests
  * LAPIN Refinements and 2-D Bifuracted Inlet Model
  * J-85 & HSR Scale Engine Models
Task Title: HEAT I 12% Semispan performance (40 x 80) [phase I]

Objective: Determine integrated nozzle performance increments due to interactions between the high-lift system and jet suppressor.

Technical Approach: A 12% scale semispan model of the HSCT reference 'H' geometry will be tested in the 40- by 80-Foot Wind Tunnel. The model will be powered by a single Boeing propane jet simulator and mounted on an aeroacoustic plane of symmetry. A second dummy nacelle will simulate blockage effects. The investigation will measure directional noise, forces and moments for a range of jet pressures and temperatures. The noise field measurements will be scaled to flight conditions and extrapolated to the far field to predict sideline and flyover noise. Limited wing surface pressures (24) with tuffs and smoke will be employed to approximately define the dominate wing flow patterns. The primary test parameters will be forward flight velocity, wing angle of attack, trailing edge flap deflections, jet total pressure, jet temperature, and nozzle axial position. The wing leading edge flap will be fixed at one deflection angle.

Cost Estimates:  
92       93       94       95  
$250K   $500K   $400K   $100K

Cost Assumptions:
1. A propane burner will be provided by Boeing at no cost.
2. Funding for acoustic instrumentation and the facility propane plumbing mod will be provided by the HSR source noise element (537-02-22).
3. Suppressor nozzles will be existing hardware developed and fabricated by NASA Lewis and/or U.S. industry as part of the HSR program.
4. Potential effectiveness of suppressors in climb to cruise is not addressed.

Deliverables:
1. High quality near & far field noise measurements of a generation II HSCT jet suppressor in the presence of a wing and high lift system in forward flight.
2. Longitudinal aerodynamic forces and moments, with and without power effects, and limited surface pressure data.
3. Compare measurements with isolated nozzle test data to determine propulsion and aeroacoustic performance increments and check available design methods.


Interconnectivity:
Prerequisites: Suppressor nozzle development.
Isolated suppressor nozzle thrust and noise measurements tests in the 40 x 80, the Boeing LSAF and the G.E. Cell 41.

Supports:
HEAT II 12% Semispan Flow Physics (40 x 80)
HEAT 12% Full span Advanced Configuration (40 x 80)
Large-scale High-lift Propulsion Interactions (40 x 80)
Industry configuration definition feedback for isolated suppressors.