Initial Results from Exhaust Noise Tests of Three Streams

Supersonics Project

Brenda Henderson, Rick Bozak
NASA Glenn Research Center

2011 Acoustics Technical Working Group
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Model

Lobed Mixer

Axi-symmetric Splitter

Core Stream
Bypass Stream
Third Stream

Hardware designed and manufactured under SUP NRA NNC10CA02C – N+2 Supersonic Validation, Lockheed Martin
Third Stream Upgrade - Capabilities

- Mass flow rate – 0.5 to 6.0 lbm/sec
- Temperature range – 70° to 250° F (no independent temperature control)
- Controllable plenum outlet pressure – 14 to 30 psia
- Evenly distributed flow (circumferentially) – accomplished with choke plate and Dynapore screens
- Instrumentation
  - plenum static pressure, total pressure, total temperature
  - mass flow - venturi meter
Studies

- Far-field acoustics
- PIV
  - cross-stream stereo
  - streamwise
Acoustic Results – Mixer vs. Splitter

$M_f = 0.3$

![Graphs showing acoustic results for Core Lobed Mixer and Core Splitter at different frequencies and peak directions.](image)
Acoustic Results – Core Splitter

<table>
<thead>
<tr>
<th>NPR_c</th>
<th>NPR_b</th>
<th>NPR_t</th>
<th>W_c (lbm/s)</th>
<th>W_b (lbm/s)</th>
<th>W_t (lbm/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.8</td>
<td>1.8</td>
<td>1.3</td>
<td>3.5</td>
<td>16.1</td>
<td>3.2</td>
</tr>
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<td>1.8</td>
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<td>1.7</td>
<td>1.8</td>
<td>1.5</td>
<td>2.8</td>
<td>16.9</td>
<td>4.2</td>
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M_fj = 0.3

Peak Direction

90°
Acoustic Results – Core Lobed Mixer

<table>
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<tr>
<th>NPRc</th>
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<th>Wc (lbm/s)</th>
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\[ M_{fj} = 0.3 \]

Peak Direction

Freq (Hz) | PSD (dB)
---|---
60^2 | 10^3 |
10^4 | 10^5 |

- NPRc, b, t: 1.8, 1.8, 1.3 NTRc, b: 3.2, 1.25
- NPRc, b, t: 1.8, 1.8, 1.4 NTRc, b: 3.2, 1.25
- NPRc, b, t: 1.8, 1.8, 1.5 NTRc, b: 3.2, 1.25
## Acoustic Results – Core Lobed Mixer

\[ M_f = 0.3 \]

<table>
<thead>
<tr>
<th>NPR(_c)</th>
<th>NPR(_b)</th>
<th>NPR(_t)</th>
<th>( W_c ) ((\text{lbm/s}))</th>
<th>( W_b ) ((\text{lbm/s}))</th>
<th>( W_t ) ((\text{lbm/s}))</th>
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- **Freq (Hz)**
  - 120
  - 110
  - 100
  - 90
  - 80

- **PSD (dB)**
  - 120
  - 110
  - 100
  - 90
  - 80

- **Peak Direction**: 90°
# Velocity and Thrust

<table>
<thead>
<tr>
<th>NPR(_c)</th>
<th>NPR(_b)</th>
<th>NPR(_t)</th>
<th>(V_b/V_c)</th>
<th>(V_t/V_b)</th>
<th>(V_{fi}/V_t)</th>
<th>Thrust Increase (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.8</td>
<td>1.8</td>
<td>1.3</td>
<td>0.63</td>
<td>0.68</td>
<td>0.45</td>
<td>3</td>
</tr>
<tr>
<td>1.8</td>
<td>1.8</td>
<td>1.4</td>
<td>0.63</td>
<td>0.76</td>
<td>0.40</td>
<td>5</td>
</tr>
<tr>
<td>1.8</td>
<td>1.8</td>
<td>1.5</td>
<td>0.63</td>
<td>0.83</td>
<td>0.36</td>
<td>3</td>
</tr>
<tr>
<td>1.7</td>
<td>1.8</td>
<td>1.5</td>
<td>0.66</td>
<td>0.84</td>
<td>0.36</td>
<td>3</td>
</tr>
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</table>
Current Three-stream Experiments

- Experiments conducted October 2011
- Hardware includes core splitter and core lobed mixer
- Experiments include
  - Far-field acoustics
  - PIV
    - Two-component streamwise
    - Cross-stream stereo
Conclusions

• Increase in thrust achieved with addition of third stream without increase in noise
• Database needs to be expanded to understand potential of third-stream for noise reduction