TWIN JET

Many subsonic and supersonic vehicles in the current fleet have multiple engines mounted near one another. Some future vehicle concepts may use innovative propulsion systems such as distributed propulsion which will result in multiple jets mounted in close proximity. Engine configurations with multiple jets have the ability to exploit jet-by-jet shielding which may significantly reduce noise. Jet-by-jet shielding is the ability of one jet to shield noise that is emitted by another jet. The sensitivity of jet-by-jet shielding to jet spacing and simulated flight stream Mach number are not well understood. The current experiment investigates the impact of jet spacing, jet operating condition, and flight stream Mach number on the noise radiated from subsonic and supersonic twin jets.
TWIN JET

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Rick Bozak
May 2010

Acoustics Technical Working Group
October 21-22, 2010

Funded by the Supersonics Project
Range of Aircraft
Twin Jet Configurations

Y-Duct
S-Duct
Nozzle

Single Jet
Nozzles

Conical Nozzle

Contoured CD Nozzle
Md = 1.51

(Bi-conic CD Pictured)
Twin Jet Spacing Effects

- Shielding
  - Effect of Heating
  - Free Jet Effects
  - Supersonic

- Interaction

<table>
<thead>
<tr>
<th>Spacing</th>
<th>S/D</th>
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<tbody>
<tr>
<td>S1</td>
<td>2.625</td>
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<tr>
<th>NPR</th>
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<tbody>
<tr>
<td>1.89</td>
<td>1.00</td>
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</tr>
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<td>1.88</td>
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Twin Jet Spacing Effects

- Shielding
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<table>
<thead>
<tr>
<th>Nozzle Pressure Ratio</th>
<th>Nozzle Temperature Ratio</th>
<th>Free Jet Mach Number</th>
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</thead>
<tbody>
<tr>
<td>NPR</td>
<td>NTR</td>
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</tr>
<tr>
<td>3.50</td>
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Effect of Spacing on Shielding

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NPR 1.88
NTR 2.37
Mfj 0.1
90°

In-plane – 0°

S1
S3
S5
S8

Freq (Hz)
SPL (dB)

10^2 10^3 10^4 10^5
# Effect of Spacing on Shielding

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The diagram shows the SPL (decibels) versus frequency (Hz) for different spacings (S1, S3, S5, S8). The text box in the image provides the NPR, NTR, and Mfj values.

NPR 1.88
NTR 2.37
Mfj 0.1
140°
Shielding – Low Speed

Spacing S/D
S1 2.625

NPR 1.52
NTR 1.95
Mfj 0.1
90°
Shielding – Low Speed

Spacing S/D
S1 2.625

NPR 1.52
NTR 1.95
Mfj 0.1
140°
Shielding – Middle Speed

Spacing | S/D
---------|------
S1       | 2.625

NPR 1.88
NTR 2.37
Mfj 0.1
140°

In-plane – 0°

SPL (dB)

Freq (Hz)

S1
Single Jet
Single Jet +3dB
Heating Effects

Spacing S/D
S1 2.625

NPR 1.893
NTR 1.000
Mfj 0.1
140°

In-plane – 0°

SPL (dB)
Freq (Hz)

Single Jet
Single Jet +3dB
Heating Effects

NPR 1.880
NTR 2.369
Mfj 0.1
140°
Heating Effects

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NPR 1.867
NTR 3.115
Mfj 0.1
140°
Free Jet Effects

Spacing | S/D
---|---
S1 | 2.625

NPR 1.70
NTR 3.11
Mfj 0
140°
Free Jet Effects

Spacing S/D
S1 2.625

NPR 1.867
NTR 3.115
Mfj 0.1
140°

In-plane – 0°
Free Jet Effects

Spacing | S/D
---|---
S1 | 2.625

NPR 1.867
NTR 3.115
Mfj 0.3
140°
Supersonic Shielding

Spacing S/D
S1 2.625

In-plane – 0°

NPR 3.50
NTR 3.00
Mfj 0.1
140°
Supersonic Shielding

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NPR 3.50
NTR 3.00
Mfj 0.3
140°

In-plane – 0°

SPL (dB)

Freq (Hz)

S1
Single Jet
Single Jet +3dB
Interaction

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NPR 1.88
NTR 2.37
Mfj 0.1
90°
Interaction

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Out-of-plane — 90°

NPR 1.88
NTR 2.37
Mfj  0.1
140°
### Interaction

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- **Out-of-plane – 90°**

**Graph:**

- NPR 1.87
- NTR 3.12
- Mfj 0.3
- 140°

**SPL (dB)**

**Freq (Hz)**

**Legend:**
- S1
- S3
- S5
- S8
- Single Jet +3dB
Supersonic Interaction

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NPR 3.50
NTR 3.00
Mfj 0.1
140°

Out-of-plane – 90°
### Supersonic Interaction

#### Spacing, SID

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#### NPR 3.50

- **NTR 3.00**
- **Mfj 0.3**
- **140°**

#### Out-of-plane – 90°

![Graph showing SPL vs. Freq (Hz)](image_url)

- **S1**
- **S3**
- **S5**
- **S8**
- **Single Jet +3dB**

![Graph parameters](image_url)
Summary

Shielding

• Most effective in the peak jet noise direction
• Most sensitive to flight speed, less sensitive to jet conditions

Interaction

• For peak jet noise, secondary peak grows with increasing spacing

Further investigation needed: Acoustics (Langley JNL), PIV, Phased Array
Backup Slides
Free Jet Effects

Spacing | S/D
---|---
S1 | 2.625

NPR 1.70
NTR 3.11
Mfj 0
140°
Interaction – Effect of Spacing

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NPR 1.88
NTR 2.37
Mfj 0.1
140°

Out-of-plane – 90°