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

Brenda Henderson
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>
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<tbody>
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<td>S1</td>
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**Twin Jet Spacing Effects**

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

<table>
<thead>
<tr>
<th>Nozzle Pressure Ratio (NPR)</th>
<th>Nozzle Temperature Ratio (NTR)</th>
<th>Free Jet Mach Number (Mfj)</th>
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<tbody>
<tr>
<td>1.89</td>
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</tr>
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- Shielding
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In-plane – 0°
Twin Jet Spacing Effects

- **Shielding**
  - Effect of Heating
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<tr>
<th>NPR</th>
<th>NTR</th>
<th>Mfj</th>
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<tbody>
<tr>
<td>1.70</td>
<td>3.11</td>
<td>0</td>
</tr>
<tr>
<td>1.87</td>
<td>3.12</td>
<td>0.10</td>
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<tr>
<td>3.50</td>
<td>3.00</td>
<td>0.10</td>
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  - Effect of Heating
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Interaction

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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°
# Effect of Spacing on Shielding

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- **NPR**: 1.88
- **NTR**: 2.37
- **$M_fj$**: 0.1
- **Angle**: 140°
Shielding – Low Speed

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

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

**Spacing**

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NPR 1.88  
NTR 2.37  
Mfj 0.1  
140°  

In-plane – 0°

SPL (dB)

Freq (Hz)

S1  
Single Jet  
Single Jet +3dB
Shielding – High Speed

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

SPL (dB) vs. Freq (Hz)

![Graph showing SPL vs. Freq](image)

- NPR 2.00
- NTR 2.51
- Mfj 0.1
- 140°
Heating Effects

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

NPR 1.893
NTR 1.000
Mfj 0.1
140°

In-plane – 0°

SPL (dB) vs. Freq (Hz)

S1
Single Jet
Single Jet +3dB
Heating Effects

Spacing S/D
S1 2.625

NPR 1.880
NTR 2.369
Mfj 0.1
140°
Heating Effects

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

NPR 1.867
NTR 3.115
Mfj 0.1
140°
Free Jet Effects

- NPR 1.70
- NTR 3.11
- Mfj 0
- 140°

Spacing S/D
S1 2.625

In-plane – 0°
Free Jet Effects

Spacing
S/D
S1 2.625

NPR 1.867
NTR 3.115
Mfj 0.1
140°
Free Jet Effects

Spacing S/D
S1 2.625

In-plane – 0°

NPR 1.867
NTR 3.115
Mfj 0.3
140°
Supersonic Shielding

Spacing | S/D | S1 | 2.625

NPR 3.50
NTR 3.00
Mfj 0.1
140°
Supersonic Shielding

Spacing | S/D | S1 | 2.625

In-plane – 0°

S1

Single Jet

Single Jet +3dB

NPR 3.50
NTR 3.00
Mfj 0.3
140°
Interaction

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NPR 1.88
NTR 2.37
Mfj 0.1
90°

Out-of-plane – 90°

S1
S3
S5
S8

Single Jet +3dB

Freq (Hz)
SPL (dB)

Freq (Hz)

www.nasa.gov
**Spacing**

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**Out-of-plane** – 90°

**Interaction**

NPR 1.88  
NTR 2.37  
Mfj 0.1  
140°
Interaction

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- Out-of-plane – 90°

NPR 1.87
NTR 3.12
Mfj 0.3
140°

SPL (dB)
Freq (Hz)

- 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

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NPR 3.50
NTR 3.00
Mfj 0.3
140°
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
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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- Out-of-plane – 90°

- NPR 1.88
- NTR 2.37
- Mfj 0.1
- 140°

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![Diagram](https://www.nasa.gov)