Summary

Overview of the Jet / Surface Interaction Test (JSIT1)

This material was presented at the Acoustics Technical Working Group Meeting on April 22, 2011. It provides an overview of an experiment called the Jet / Surface Interaction Test which was conducted to expand the database available regarding how a planar surface interacts with a jet to shield and/or enhance the jet noise. This presentation focuses on data obtained during Phase 1 of the test, JSIT1, which was conducted using the Small Hot Jet Acoustic Rig located in the Aeroacoustics Propulsion Lab at NASA GRC during January and February, 2011. A second phase of the test, JSIT2, is planned for 2012.

There were two parts of the phase 1 test. In part 1, known as the shielding surface part of the test, a planar surface was placed between the jet and the microphones. In part 2, the reflecting surface part of the test, the surface was placed on the opposite side of the jet so that the jet noise was free to reflect off the surface toward the microphones. Phased array, pressure sensitive paint, and far field acoustic data obtained during JSIT1 are presented. The phased array data illustrate how the jet noise is blocked by the shielding surface. It also shows that the low frequency scrubbing noise generated when the surface is impacted by the jet comes predominantly from the surface trailing edge. The far field data show the trailing edge noise to be a dipole source. The pressure sensitive paint data show how the pressure distribution on the surface varies as the surface is traversed toward jet.
Overview of the Jet / Surface Interaction Test (JSIT1)

Gary Podboy
Cliff Brown
Tim Bencic

Support Provided by the Subsonic Fixed Wing Program
Purpose of JSIT1

Parametric study to expand the database available regarding how and where a planar surface can 1) shield and/or 2) enhance jet noise
Shielding Surface
Shielding Surface
Jet / Surface Interaction Test (JSIT1)

Phase 1: Jan – Feb 2011

Reflecting Surface
Parameters

1) Axial Dimension of Surface
2) Radial Location of Surface
3) Jet Operating Condition
4 Types of Data Acquired

1) Far field
2) Unsteady Surface Pressure
3) Phased Array
4) Pressure Sensitive Paint
4 Types of Data Acquired

1) Far field
2) Unsteady Surface Pressure
3) Phased Array
4) Pressure Sensitive Paint
4 Types of Data Acquired

1) Far field
2) Unsteady Surface Pressure
3) Phased Array
4) Pressure Sensitive Paint
4 Types of Data Acquired

1) Far field
2) Unsteady Surface Pressure
3) Phased Array
4) Pressure Sensitive Paint
Shielding Test – Surface Between Jet and Far Field Array
Shielding Test Using Longer Surface
Baseline Round Convergent Nozzle, smc000

Shield TE @ 2 Diams
Baseline Round Convergent Nozzle, smc000    Shield TE @ 4 Diams
Baseline Round Convergent Nozzle, smc000    Shield TE @ 6 Diams
Baseline Round Convergent Nozzle, smc000  Shield TE @ 10 Diams
Baseline Round Convergent Nozzle, smc000  Shield TE @ 15 Diams
Baseline Round Convergent Nozzle, smc000   Shield TE @ 20 Diams
Baseline Round Convergent Nozzle, smc000    Shield TE @ 10 Diams

For Each Shield, Far field and Phased Array Data Were Acquired at 17 Radial Locations
### Shielding Test

#### Baseline Round Convergent Nozzle, smc000

![Baseline Round Convergent Nozzle](image)

6 Axial X 17 Radial X 5 Set Points = 510

<table>
<thead>
<tr>
<th>Setpoint</th>
<th>NPR $P_j_{\text{total}}/Pa$</th>
<th>NTR $T_j_{\text{static}}/T_a$</th>
<th>Ma $V_j/ca$</th>
<th>Mj $V_j/c_{\text{local}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>1.197</td>
<td>0.95</td>
<td>0.5</td>
<td>0.51</td>
</tr>
<tr>
<td>7</td>
<td>1.86</td>
<td>0.835</td>
<td>0.9</td>
<td>0.98</td>
</tr>
<tr>
<td>27</td>
<td>1.36</td>
<td>1.764</td>
<td>0.9</td>
<td>0.68</td>
</tr>
<tr>
<td>46</td>
<td>1.227</td>
<td>2.7</td>
<td>0.9</td>
<td>0.55</td>
</tr>
<tr>
<td>9010</td>
<td>3.182</td>
<td>0.74</td>
<td>1.18</td>
<td>1.40</td>
</tr>
</tbody>
</table>
Shielding Test

Convergent Divergent Nozzle, smc016

6 Axial X 17 Radial X 3 Set Points = 306

<table>
<thead>
<tr>
<th>Setpoint</th>
<th>NPR</th>
<th>NTR</th>
<th>Ma</th>
<th>Mj</th>
<th>Vj/c_local</th>
</tr>
</thead>
<tbody>
<tr>
<td>11606</td>
<td>2.748</td>
<td>0.761</td>
<td>1.128</td>
<td>1.29</td>
<td>1.128</td>
</tr>
<tr>
<td>11610</td>
<td>3.670</td>
<td>0.706</td>
<td>1.31</td>
<td>1.5</td>
<td>1.31</td>
</tr>
<tr>
<td>11617</td>
<td>4.324</td>
<td>0.671</td>
<td>1.41</td>
<td>1.61</td>
<td>1.61</td>
</tr>
</tbody>
</table>

- Overexpanded
- Design
- Underexpanded
No Shield, Convergent Divergent Nozzle
Shielding at 2 Diameters, Convergent Divergent Nozzle
Shielding at 4 Diameters, Convergent Divergent Nozzle
Shielding at 6 Diameters, Convergent Divergent Nozzle
Shielding at 10 Diameters, Convergent Divergent Nozzle
Shielding at 15 Diameters, Convergent Divergent Nozzle
Shielding at 20 Diameters, Convergent Divergent Nozzle
Shielding Test

Convergent Divergent Nozzle, smc016

6 Axial X 17 Radial X 3 Set Points

<table>
<thead>
<tr>
<th>Setpoint</th>
<th>NPR</th>
<th>NTR</th>
<th>Ma</th>
<th>Mj</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pj_total/Pa</td>
<td>Tj_static/Ta</td>
<td>Vj/ca</td>
<td>Vj/c_local</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11606</td>
<td>2.748</td>
<td>0.761</td>
<td>1.128</td>
<td>1.29</td>
<td>Overexpanded</td>
</tr>
<tr>
<td>11610</td>
<td>3.670</td>
<td>0.706</td>
<td>1.31</td>
<td>1.5</td>
<td>Design</td>
</tr>
<tr>
<td>11617</td>
<td>4.324</td>
<td>0.671</td>
<td>1.41</td>
<td>1.61</td>
<td>Underexpanded</td>
</tr>
</tbody>
</table>
Example Shielding Data

<table>
<thead>
<tr>
<th>Setpoint</th>
<th>NPR</th>
<th>NTR</th>
<th>Ma</th>
<th>Mj</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pj_total/Pa</td>
<td>Tj_static/Ta</td>
<td>Vj/ca</td>
<td>Vj/c_local</td>
<td>Overexpanded</td>
</tr>
<tr>
<td>11606</td>
<td>2.748</td>
<td>0.761</td>
<td>1.128</td>
<td>1.29</td>
<td></td>
</tr>
</tbody>
</table>
# Example Shielding Data

<table>
<thead>
<tr>
<th>Setpoint</th>
<th>NPR</th>
<th>NTR</th>
<th>Ma</th>
<th>Mj</th>
<th>Expansion</th>
</tr>
</thead>
<tbody>
<tr>
<td>11617</td>
<td>4.324</td>
<td>0.671</td>
<td>1.41</td>
<td>1.61</td>
<td>Underexpanded</td>
</tr>
</tbody>
</table>

![Graph and Image](image-url)
Surface Moved to Opposite Side of Jet for Reflecting Surface Test
Baseline Round Convergent Nozzle, smc000    Surface TE @ 5 Diams
Baseline Round Convergent Nozzle, smc000 Surface TE @ 15 Diams
Baseline Round Convergent Nozzle, smc000    Surface TE @ 20 Diams
Reflecting Surface Test

Baseline Round Convergent Nozzle, smc000

5 Axial X 17 Radial X 3 Set Points

<table>
<thead>
<tr>
<th>Setpoint</th>
<th>NPR</th>
<th>NTR</th>
<th>Ma</th>
<th>Mj</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pj_total/Pa</td>
<td>Tj_static/Ta</td>
<td>Vj/ca</td>
<td>Vj/c_local</td>
</tr>
<tr>
<td>3</td>
<td>1.197</td>
<td>0.95</td>
<td>0.5</td>
<td>0.51</td>
</tr>
<tr>
<td>7</td>
<td>1.86</td>
<td>0.835</td>
<td>0.9</td>
<td>0.98</td>
</tr>
<tr>
<td>9010</td>
<td>3.182</td>
<td>0.74</td>
<td>1.18</td>
<td>1.40</td>
</tr>
</tbody>
</table>
Reflecting Surface Test
Convergent Divergent Nozzle, smc016

4 Axial X 17 Radial X 3 Set Points

<table>
<thead>
<tr>
<th>Setpoint</th>
<th>NPR Pj_total/Pa</th>
<th>NTR Tj_static/Ta</th>
<th>Ma Vj/ca</th>
<th>Mj Vj/c_local</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>11606</td>
<td>2.748</td>
<td>0.761</td>
<td>1.128</td>
<td>1.29</td>
<td>Overexpanded</td>
</tr>
<tr>
<td>11610</td>
<td>3.670</td>
<td>0.706</td>
<td>1.31</td>
<td>1.5</td>
<td>Design</td>
</tr>
<tr>
<td>11617</td>
<td>4.324</td>
<td>0.671</td>
<td>1.41</td>
<td>1.61</td>
<td>Underexpanded</td>
</tr>
</tbody>
</table>
Reflecting Surface Test

Baseline Round Convergent Nozzle, smc000

5 Axial X 17 Radial X 3 Set Points

<table>
<thead>
<tr>
<th>Setpoint</th>
<th>NPR</th>
<th>NTR</th>
<th>Ma</th>
<th>Mj</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pj_total/Pa</td>
<td>Tj_static/Ta</td>
<td>Vj/ca</td>
<td>Vj/c_local</td>
</tr>
<tr>
<td>3</td>
<td>1.197</td>
<td>0.95</td>
<td>0.5</td>
<td>0.51</td>
</tr>
<tr>
<td>7</td>
<td>1.86</td>
<td>0.835</td>
<td>0.9</td>
<td>0.98</td>
</tr>
<tr>
<td>9010</td>
<td>3.182</td>
<td>0.74</td>
<td>1.18</td>
<td>1.40</td>
</tr>
</tbody>
</table>
Baseline Round Convergent Nozzle, smc000  Surface TE @ 5 Diams

top view

4 diam from CL
Baseline Round Convergent Nozzle, smc000    Surface TE @ 5 Diams
Trailing Edge Source
Far-Field Acoustic Data – \( x/D_j = 6.0, \theta = 90^\circ \)

- **Shield Reflect Baseline**

  \( r/D_j = 1.0 \)

  Trailing edge noise – same for shield and reflect configurations

- **Surface out of the jet flow – no trailing edge noise**

  \( r/D_j = 3.0 \)

  \( r/D_j = 5.0 \)
## PSP Data

### Baseline Round Convergent Nozzle, smc000

<table>
<thead>
<tr>
<th>Setpoint</th>
<th>NPR (P_{j\text{total}}/P_a)</th>
<th>NTR (T_{j\text{static}}/T_a)</th>
<th>(M_a)</th>
<th>(M_j)</th>
<th>(V_{j/ca})</th>
<th>(V_{j/c_local})</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>1.197</td>
<td>0.95</td>
<td>0.5</td>
<td>0.51</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>1.86</td>
<td>0.835</td>
<td>0.9</td>
<td>0.98</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9010</td>
<td>3.182</td>
<td>0.74</td>
<td>1.18</td>
<td>1.40</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Convergent Divergent Nozzle, smc016

<table>
<thead>
<tr>
<th>Setpoint</th>
<th>NPR (P_{j\text{total}}/P_a)</th>
<th>NTR (T_{j\text{static}}/T_a)</th>
<th>(M_a)</th>
<th>(M_j)</th>
<th>(V_{j/ca})</th>
<th>(V_{j/c_local})</th>
</tr>
</thead>
<tbody>
<tr>
<td>11606</td>
<td>2.748</td>
<td>0.761</td>
<td>1.128</td>
<td>1.29</td>
<td></td>
<td>Overexpanded</td>
</tr>
<tr>
<td>11610</td>
<td>3.670</td>
<td>0.706</td>
<td>1.31</td>
<td>1.5</td>
<td></td>
<td>Design</td>
</tr>
<tr>
<td>11617</td>
<td>4.324</td>
<td>0.671</td>
<td>1.41</td>
<td>1.61</td>
<td></td>
<td>Underexpanded</td>
</tr>
</tbody>
</table>
SMC000 RC Nozzle  Set Point 7  $M_a=0.9$
SMC000 RC Nozzle  Set Point 7  \( M_a = 0.9 \)

3.5 diam from CL

Pressure Ratio

- 1.00
- 0.98
SMC000 RC Nozzle    Set Point 7    $M_a=0.9$

3.0 diam from CL
SMC000 RC Nozzle Set Point 7 $M_a = 0.9$

2.5 diam from CL

Pressure Ratio

1.00

0.98
SMC000 RC Nozzle  Set Point 7  \( M_a=0.9 \)

2.0 diam from CL
SMC000 RC Nozzle  Set Point 7  $M_a=0.9$

1.5 diam from CL
SMC016 CD Nozzle  Set Point 11606  \( M_{\text{jet}}=1.3 \)  \( M_d=1.5 \)

4.5 diam from CL

Pressure Ratio

0.95

1.01
SMC016 CD Nozzle  Set Point 11606  $M_{\text{jet}}=1.3$  $M_d=1.5$

4.0 diam from CL

Pressure Ratio

0.95  1.01
SMC016 CD Nozzle     Set Point 11606     \( M_{\text{jet}} = 1.3 \) \( M_d = 1.5 \)

3.5 diam from CL
SMC016 CD Nozzle  Set Point 11606  $M_{\text{jet}}=1.3$  $M_d=1.5$
SMC016 CD Nozzle  Set Point 11606  $M_{\text{jet}}=1.3$  $M_d=1.5$

2.0 diam from CL

Pressure Ratio

0.95 to 1.01
SMC016 CD Nozzle  Set Point 11606  $M_{jet}=1.3$  $M_d=1.5$

1.5 diam from CL

[Image: Diagram showing pressure ratio with color scale from 0.95 to 1.01]
SMC016 CD Nozzle  Set Point 11606  \( M_{\text{jet}}=1.3 \)  \( M_d=1.5 \)

1.0 diam from CL

Pressure Ratio

0.95 - 1.01
Plans for JSIT2

1) Unsteady surface pressure measurements very close to the surface TE
2) Hot jet data for reflecting surface configurations
3) Shielding surface phased array data with array in the peak noise direction
4) Reflecting surface phased array data both with and without the surface
5) PIV flowfield data near surface TE
6) Rectangular nozzles

Gary.G.Podboy@nasa.gov
Clifford.A.Brown@nasa.gov