Susan Cliff
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Atlanta, GA
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Sonic Boom Analysis

CFD Domain

Near-field Signal

Altitude

Atmospheric Propagation

Ground Signal
Validation Geometry Selection
(experimental models)

• 6.48 degree Cone-Cylinder
  – Finite rise pressure signature

• Parabolic body of revolution
  – Representative of a typical transport vehicle fuselage

• Quartic body of revolution
  – Large bow shock simulation and low boom shape

• 69 degree swept Delta-Wing-Body
  – Simple lifting configuration

• Ames Low Boom Wing-Body-Tail with nacelles and B.L. diverters (LBWT)
  – Representative of low sonic boom complete configuration
Low Boom Wing Tail
## Experimental Validation Cases

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Mach</th>
<th>AoA</th>
<th>h/l</th>
<th>Report no.</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.48° Cone-Cylinder; L=8.6 units</td>
<td>1.68</td>
<td>0.0</td>
<td>10.0</td>
<td>NASA TM X-2219</td>
</tr>
<tr>
<td>Parabolic Body of Revolution; r=f(x**0.5); L=2.0 units</td>
<td>1.41</td>
<td>0.0</td>
<td>10.0</td>
<td>NASA TN D-3106</td>
</tr>
<tr>
<td>Quartic Body of Revolution; r=f(x**0.25); L=2.0 units</td>
<td>1.41</td>
<td>0.0</td>
<td>10.0</td>
<td>NASA TN D-3106</td>
</tr>
<tr>
<td>69° Swept Delta-Wing-Body; L=17.52 units</td>
<td>1.68</td>
<td>4.74</td>
<td>3.6</td>
<td>NASA TN D-7160</td>
</tr>
<tr>
<td>Ames Low Boom Wing-Body-Tail (LBWT) with 4 nacelles, L=12.0</td>
<td>2.0</td>
<td>2.0</td>
<td>1.167</td>
<td>NASA CP-1999-209699</td>
</tr>
</tbody>
</table>
Computational Study of Near Field Signatures
For the $69^\circ$ Swept Delta-Wing Body
Experimental Data

• NASA Ames 9x7 Unitary Plan Wind Tunnel (UPWT)
  – Cone-Cylinder
  – 69° Swept Delta-Wing-Body
  – Ames Low Boom Wing-Body-Tail (LBWT)

• NASA Langley 4x4 UPWT
  – Parabolic Body of Revolution
  – Quartic Body of Revolution
The Experimental Setup in 9x7 UPWT

- on-track probe
- AoA mech
- balance
- LBWT
- linear actuator
- strut
- ref. probe
- floor / nozzle block
The Experimental Setup in 4x4 UPWT

- Quiet Spike
- on-track probe
- floor / nozzle block
- model traverse
- strut
- AoA mech
- blade sting
- reference probe
## Experimental and Computational Considerations

<table>
<thead>
<tr>
<th>Wind Tunnel</th>
<th>CFD</th>
</tr>
</thead>
<tbody>
<tr>
<td>CN may vary by 10-20% due to sting/ram deflection ((\alpha) variation on large lifting models) and stream angle</td>
<td>Alpha and CN are constant</td>
</tr>
<tr>
<td>Flow is unsteady in Tunnel (model vibrates with turbulence)</td>
<td>Flow is steady / model is steady</td>
</tr>
<tr>
<td>Tunnel conditions (temperature and humidity) change during signature taking (~30 – 60 mins)</td>
<td>No change in flow conditions</td>
</tr>
<tr>
<td>Reference probe in different location than overpressure probes</td>
<td>(P_{\text{inf}}) is computed</td>
</tr>
<tr>
<td>Viscosity effects captured B.L not tripped</td>
<td>No viscous effects for Euler computations</td>
</tr>
<tr>
<td>Model base/sting cavity on lifting models has proper physics</td>
<td>Model base/sting geometries as solid ramps or steps</td>
</tr>
<tr>
<td>Geometry as built</td>
<td>Geometry as designed</td>
</tr>
</tbody>
</table>

Differences in computational and experimental data are expected
Computational Methods Assessed

AIRPLANE - Euler tetrahedral cells
CART3D - Euler Cartesian cells
FUN3D - Navier-Stokes (Euler mode) tetrahedral cells
USM3D - Navier-Stokes (Euler mode) tetrahedral cells
Agenda

8:00 - 8:15  Introduction and Case Descriptions for the Sonic Boom Prediction Workshop - Ms. Susan Cliff, NASA-Ames

8:15 - 9:00  Assessment of Unstructured Euler Methods for Sonic Boom Pressure Signatures Using Grid Refinement and Domain Rotation Methods - Ms. Susan Cliff, Mr. Scott Thomas, Mr. Matt McMullen, Mr. John Melton and Mr. Don Durston, NASA-Ames

9:00 - 9:30  Output-Adaptive Tetrahedral Cut-Cell Validation for Sonic Boom Prediction - Dr. Michael Park and Dr. Eric Nielsen, NASA-Langley

9:30 - 10:00  Sonic-Boom Prediction with Output-Based Adaptation and Cart3D - Mr. Michael Aftosmis, Mr. Marian Nemec, Mr. Mathias Wintzer, NASA ARC

10:00 - 10:30  BREAK

10:30 - 11:00  A Method for Shearing and Stretching Unstructured Grids for Improved Sonic Boom Prediction - Mr. Richard Campbell and Ms. Melissa Carter, NASA LaRC

11:00 - 11:30  Summary and Comparison of NASA's Supersonic Boom Prediction Methods - Ms. Melissa Carter, NASA LaRC