Ares I Scale Model Acoustic Test
Liftoff Acoustic Results and Comparisons

Noise and Physical Acoustics: Launch Vehicle Noise II
Session 4pNS
November 3, 2011
Introduction: Liftoff Acoustics

- *Liftoff acoustics (LOA)* noise is caused by the supersonic steady jet flow interaction with surrounding atmosphere and launch complex, persisting for 0-20 seconds as the vehicle lifts off.

- **Challenges for determining Ares I Rocket Liftoff Environments**
  - New Solid Motor
    - Motor Sound Sources
  - New Mobile Launcher
    - Launch Pad Deflector Effects
  - New Tower
    - Plume Sound Reflections off of Launch Pad

- **Ares I LOA Environments**
  - Documented in Ares I Acoustics Databook
  - Validate LOA environments
    - Ares I-X flight
  - Verify LOA environments
    - Ares I Scale Model Acoustic Test
Ares I LOA Validation and Verification Comparisons

Oct 28, 2009

Nov 2010 – July 2011

Ares I - Databook

Ares I-X Flight Vehicle at Kennedy Space Center Launch Complex-39B

ASMAT Model at Marshall Space Flight Center Test Stand 116
METHODOLOGY
The goal is to find maximum sound response and the corresponding steady state time window.

This max sound corresponds to when the solid motor’s chamber pressure reaches steady state.

Data Processing:
- Data File Sample Rate: 256,000 sps
- Data post-processing using PCSignal
- 1/3 Octave Band Frequency analysis
  - 1/3 Octave Band Range (Center Frequency): 250 to 63,000 Hz
  - Analysis Window: 1 to 1.9 seconds
  - Window Type: Rectangular
  - Reference Pressure: 0.00002 N/m²
  - N Average: 7
ASMAT Data Corrections

♦ ASMAT data shown in the following slides not corrected for
  • Mass Flow Differences
    \[ \frac{I_2}{I_1} = \left( \frac{13,500}{39.3} \right) \left( \frac{8,200}{8,400} \right)^2 \cdot 0.05 \approx 0.818 \]
    \[ \text{SPL}_2 = 10 \log \left( 10^{\frac{\text{SPL}_1}{10}} \left( \frac{I_2}{I_1} \right) \right) = 10 \log \left( 10^{\frac{\text{SPL}_1}{10}} \cdot 0.818 \right) = \text{SPL}_1 - 0.87 \text{ dB} \]
  • Grid response, Frequency response, Atmospheric Absorption
    – Impacts 500 hertz and above for full scale frequencies
  • Frequency spectra are scaled using Strouhal number
    \[ f_2 = \left( \frac{V_2}{V_1} \right) \left( \frac{d_1}{d_2} \right) f_1 \]
    \[ f_2 = 0.0488 f_1 \quad f_2 \approx 0.05 f_1 \]
**ASMAT Results Scaled to Ares I-X Full Scale**

**ARESI-X Flight Data vs ASMAT**

*Zone 6*

- **Ares I-X Flight (IAD095P)**
- **ASMAT @ 5 feet (Model Scale Frequency)**
- **ASMAT @ 5 feet (Full Scale Frequency)**

*Scaling process primarily driven by frequency scaling*
DATA RESULTS
Validation: ASMAT vs. Ares I-X (Zones 1 and 4)

**ARES I-X Flight Data vs ASMAT**

- Ares I-X AAD158P (0 degrees, Aft Skirt)
- ASMAT (Zone 1)
- Ares I-X (AAD155P)
- Ares I-X (AAD157P)
- ASMAT (Vert#5)
- ASMAT (Vert#7)
- ASMAT (Vert#11)
Validation: ASMAT vs. Ares I-X (Zones 6)

ARES I-X Flight Data vs ASMAT

Sound Pressure Level (dB)

1/3 Octave Band Center Frequency

- IAD098P (0 degrees)
- IAD097P (45)
- IAD095P (80)
- Vert #5 (5 feet)
- Vert #7 (5 feet)
- Vert#11 (5 feet, No LM)
Validation: ASMAT vs. Ares I-X
(Zone 10)

Ares I-X Flight Data vs. ASMAT

- OAD838P (5)
- OAD839P (45)
- IAD915P (0 degrees)
- IAD619P (45)
- Vert #5 (5 feet)
- Vert #7 (5 feet)
- Vert #11 (5 feet, No LM)
Verification and Validation of Overall Sound Pressure Levels
ASMAT vs. Ares I-X

Results Summary:
- ASMAT OASPL compares well to Ares I-X OASPL
- Scaling methodology works
- Frustum has higher OASPL than zones below and above
Verification of Frustum Sound Pressure Levels

ASMAT vs. Databook

Results Summary:

- The ASMAT P95/50 environment is significantly higher than Ares I Acoustics Databook LOA environment for the Frustum.
- Recommend increasing the Databook environment for Zone 5.
Conclusions and Recommendations

♦ Conclusions

- Ares I-X flight data validated the ASMAT LOA results
- Ares I Liftoff acoustic environments were verified with scale model test results
  – Results showed that databook environments were under-conservative for Frustum (Zone 5)

♦ Recommendations

- Databook environments can be updated with scale model test and flight data
- Subscale acoustic model testing useful for future vehicle environment assessments