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Ares I Scale Model Acoustic Test
Liftoff Acoustic Results and Comparisons

Noise and Physical Acoustics: Launch Vehicle Noise II
Session 4pNS
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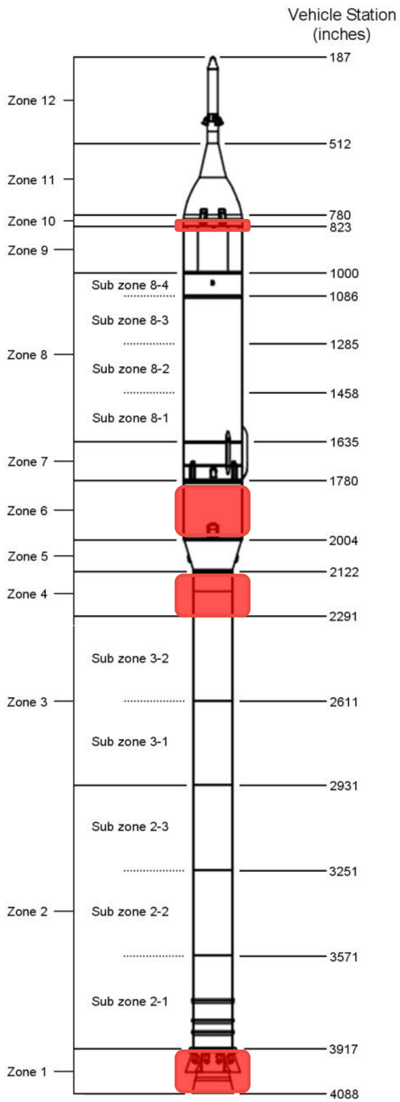
Introduction: Liftoff Acoustics

- ***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.**

Ares I at Kennedy Space Center Launch Complex

- **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



Ares I - Databook

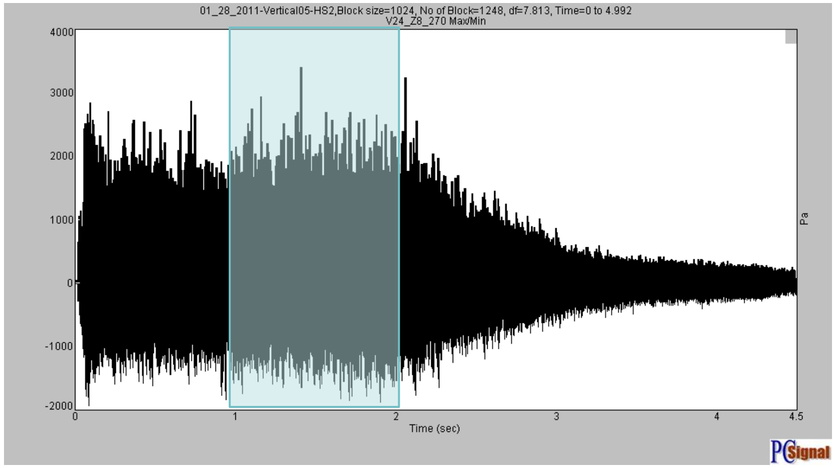
Ares I-X Flight Vehicle at Kennedy Space Center Launch Complex-39B

ASMAT Model at Marshall Space Flight Center Test Stand 116

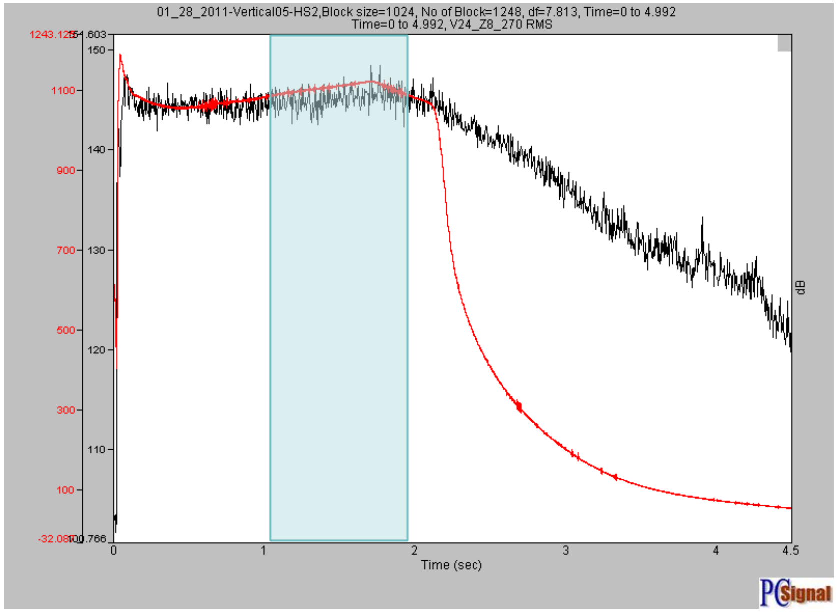
METHODOLOGY

ASMAT Acoustic Analysis

- **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/m^2
    - N Average: 7



Typical Time History of ASMAT Solid Motor



Analysis Window Overlaid on Chamber Pressure Measurement

ASMAT Data Corrections

- **ASMAT data shown in the following slides not corrected for**
  - Mass Flow Differences

$$\frac{I_2}{I_1} = \left(\frac{13{,}500}{39.3}\right)\left(\frac{8{,}200}{8{,}400}\right)^2 \left(0.05\right)^2 = 0.818$$

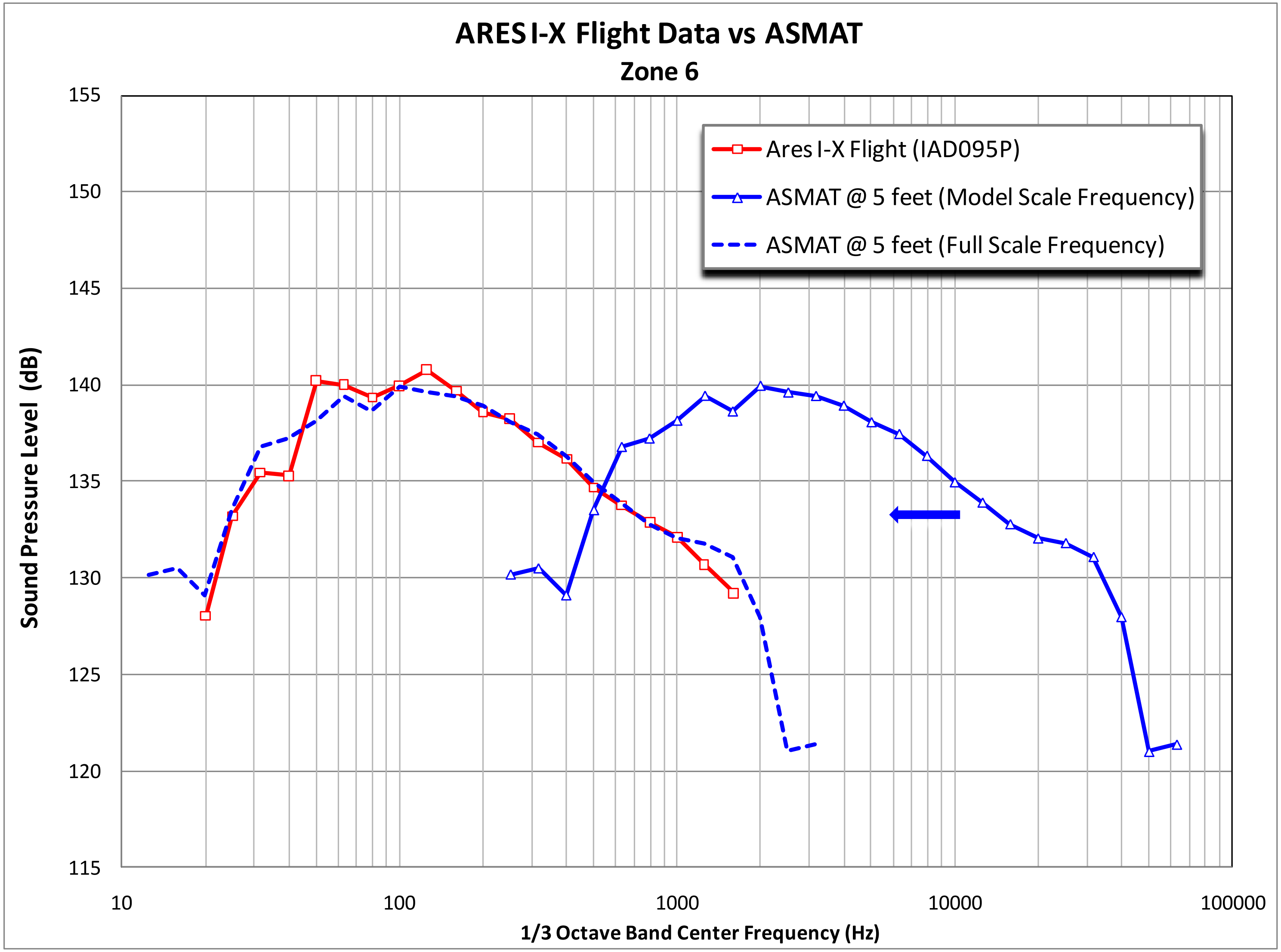
$$SPL_2 = 10\log\left(10^{\frac{SPL_1}{10}}\left(\frac{I_2}{I_1}\right)\right) = 10\log\left(10^{\frac{SPL_1}{10}}\left(0.818\right)\right) = \boxed{SPL_1 - 0.87\ \text{dB}}$$

  - Grid response, Frequency response, Atmospheric Absorption
    - Impacts 500 hertz and above for full scale frequencies

  - Frequency spectra are scaled using Strouhal number

$$f_2 = \left(\frac{V_2}{V_1}\right)\left(\frac{d_1}{d_2}\right)f_1 \qquad \boxed{f_2 = 0.0488 f_1} \qquad f_2 \approx 0.05 f_1$$

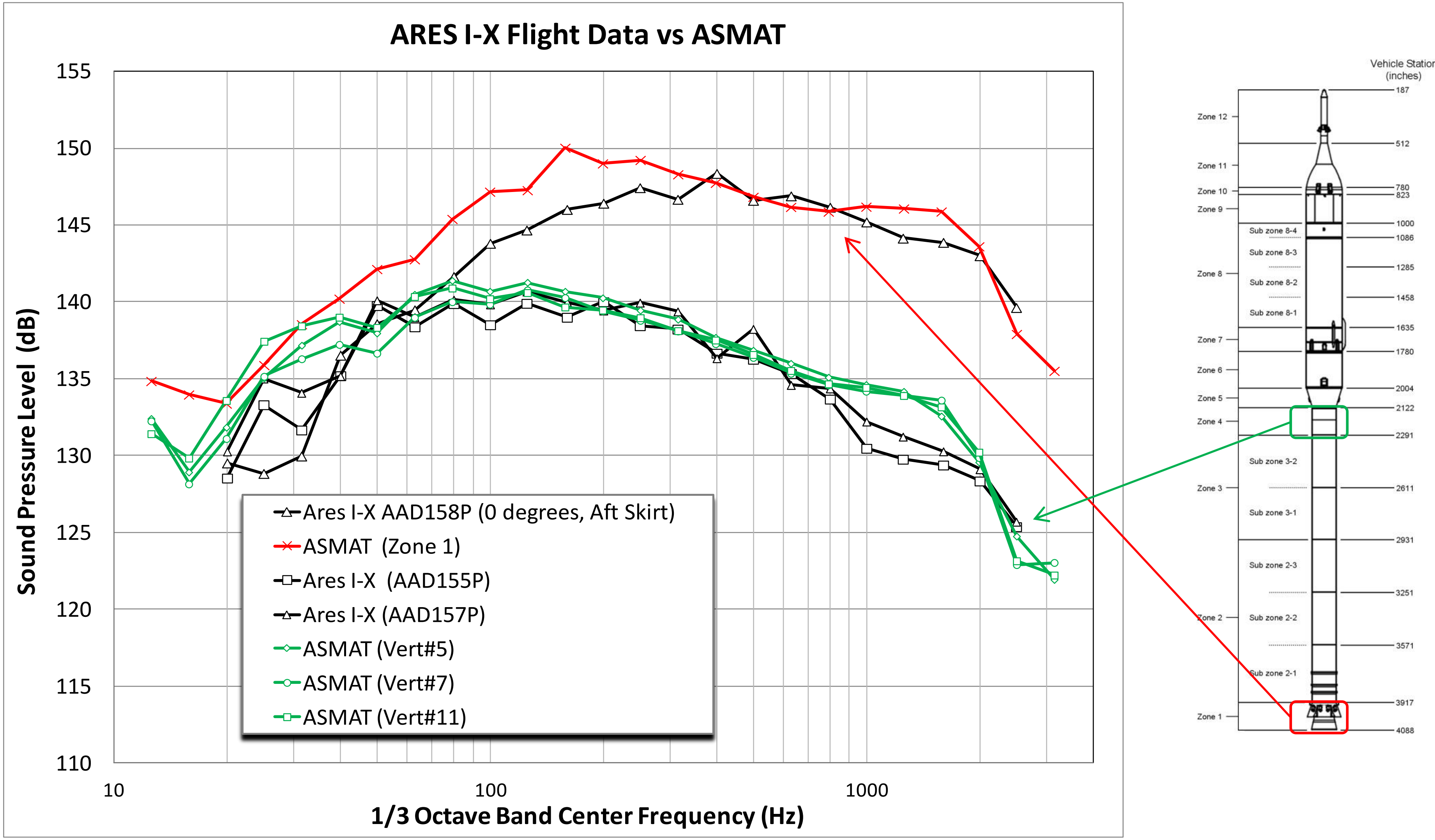
ASMAT Results Scaled to Ares I-X Full Scale



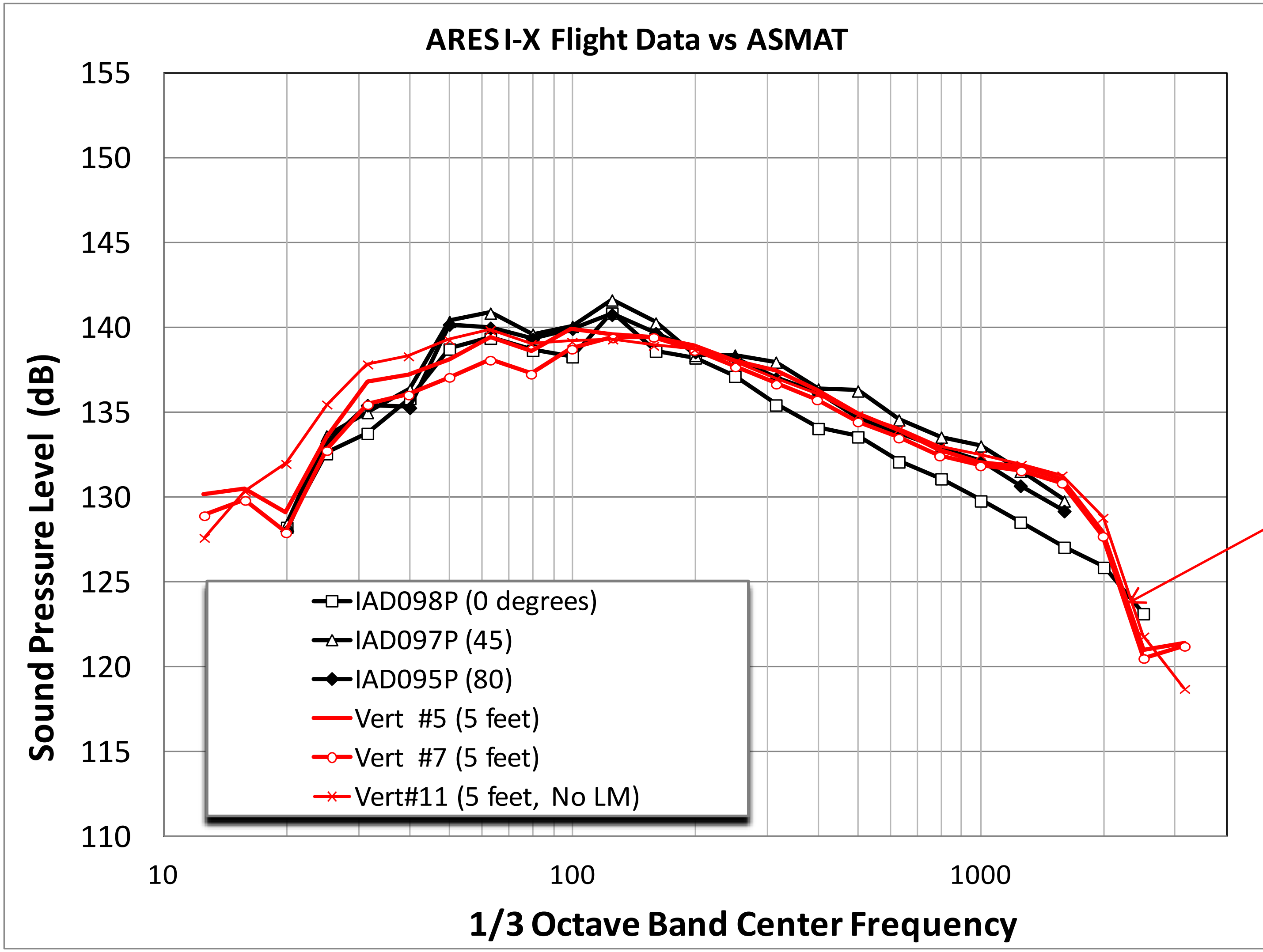
*Scaling process primarily driven by frequency scaling

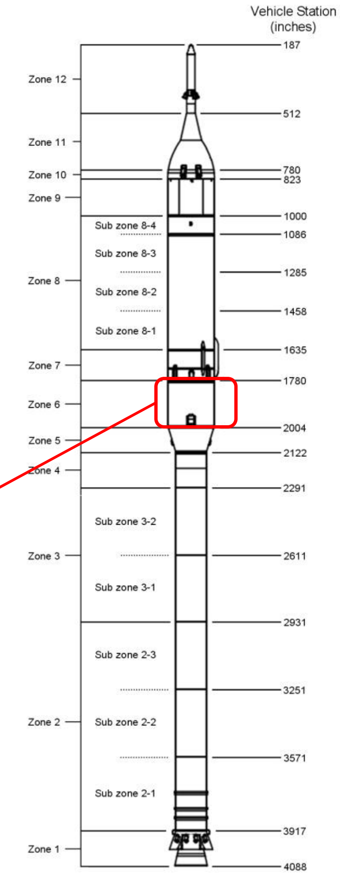
DATA RESULTS

Validation: ASMAT vs. Ares I-X (Zones 1 and 4)

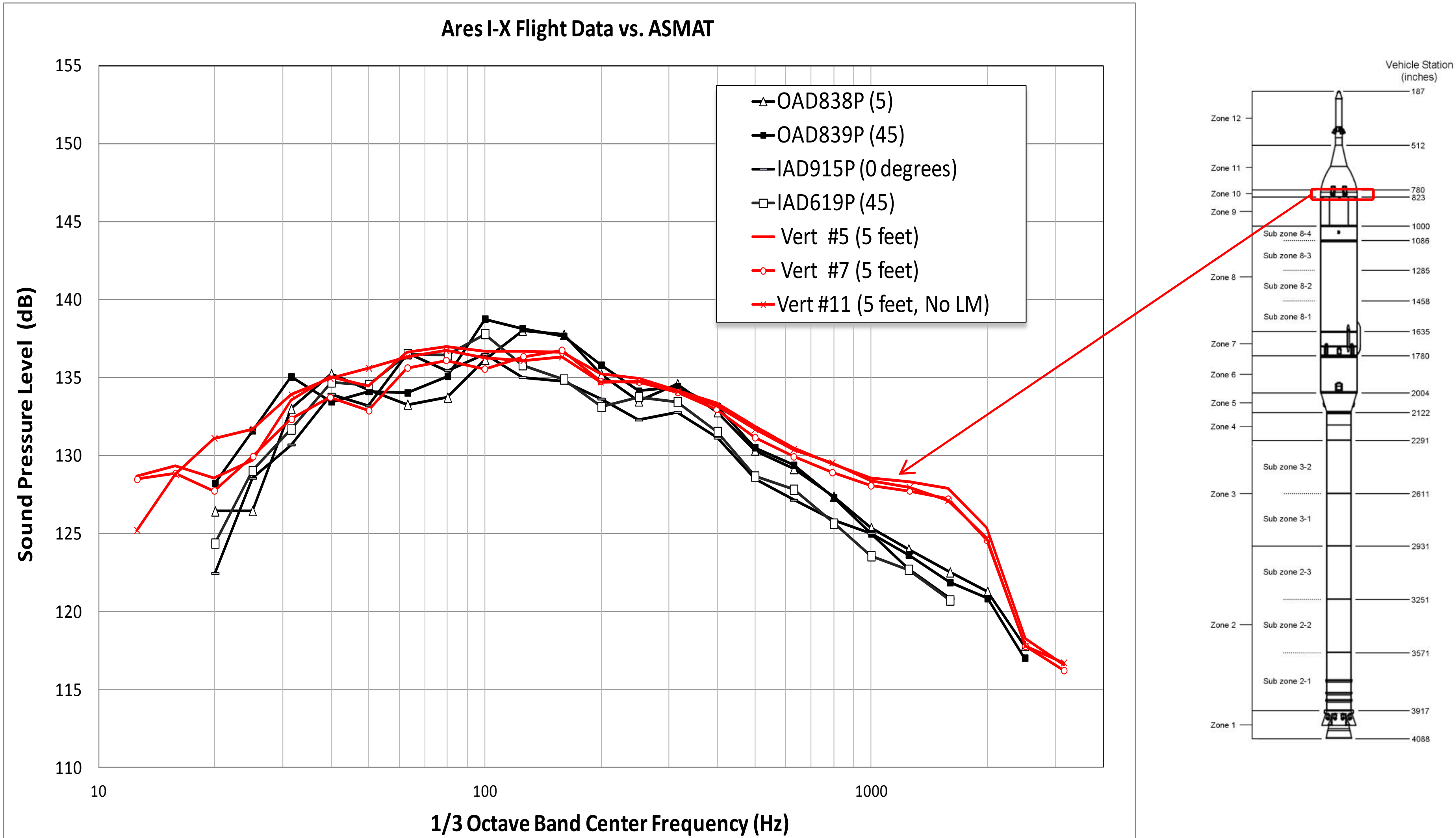


Validation: ASMAT vs. Ares I-X (Zones 6)



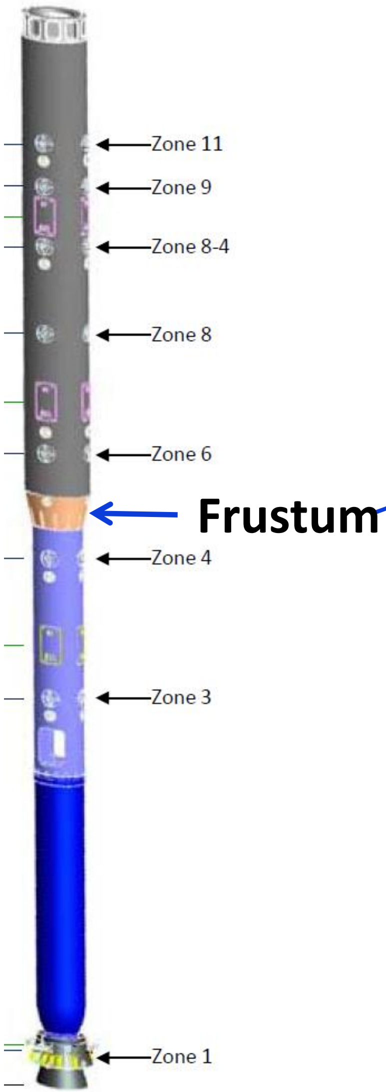


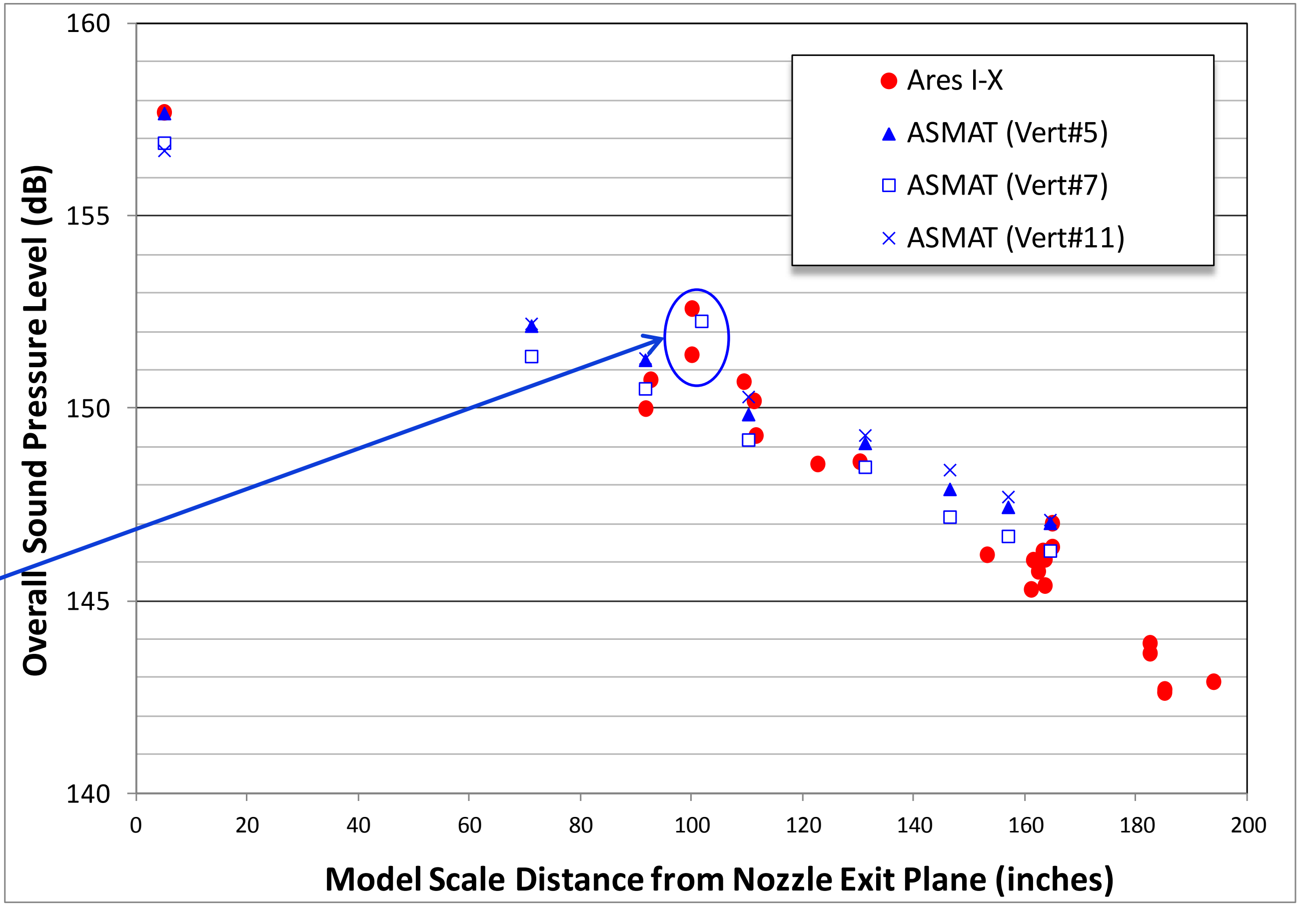
Validation: ASMAT vs. Ares I-X (Zone 10)



Verification and Validation of Overall Sound Pressure Levels ASMAT vs. Ares I-X

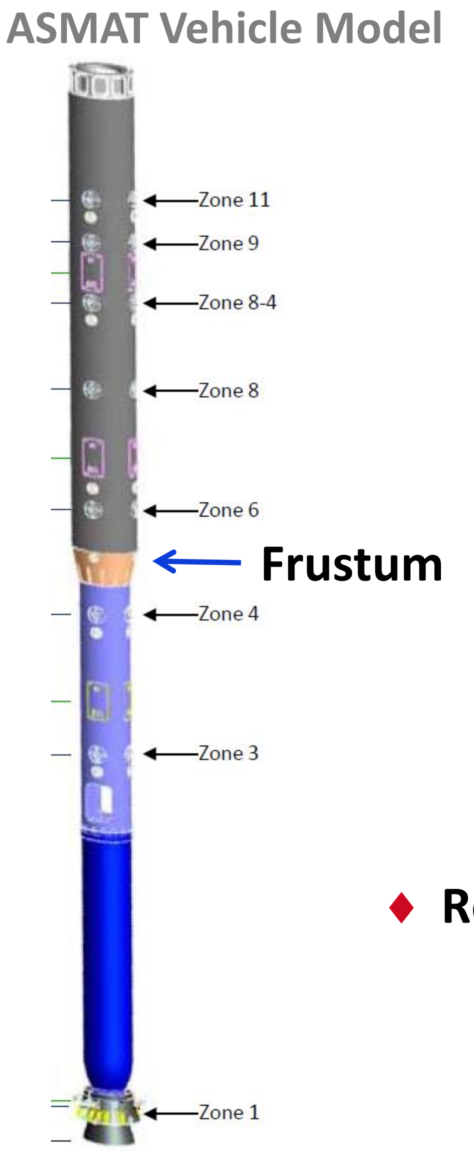
ASMAT Vehicle Model

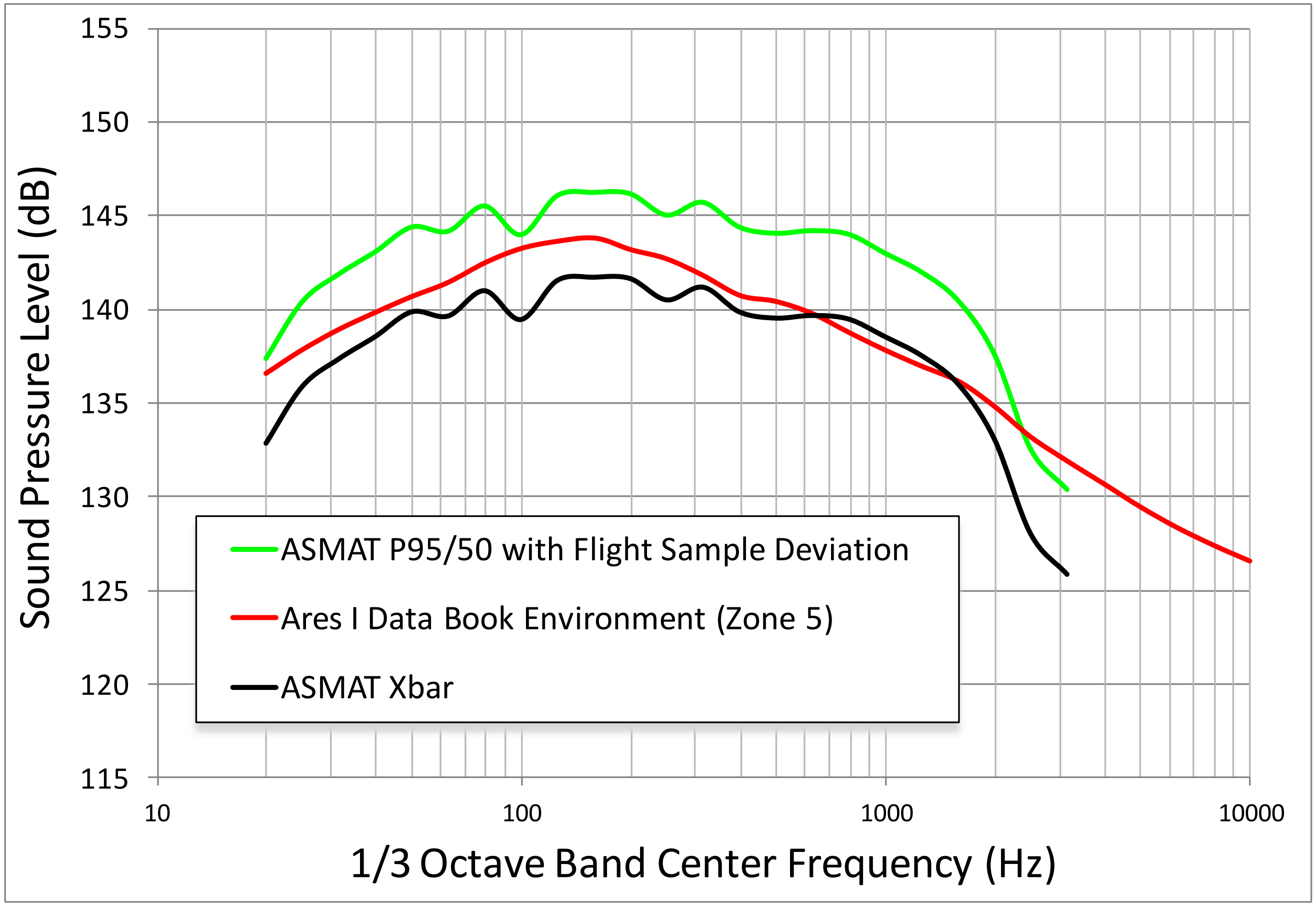




- **Results Summary:**
  - ASMAT OASPL compares well to Ares I-X OASPL
    - Scaling methodology works
  - Frustum has higher OASPL than zones below and above

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