Ares I Scale Model Acoustic Test Above Deck Water Sound Suppression Results

The Ares I Scale Model Acoustic Test (ASMAT) program test matrix was designed to determine the acoustic reduction for the LOA environment with an above deck water sound suppression system. The scale model test can be used to quantify the effectiveness of the water suppression system as well as optimize the systems necessary for LOA noise reduction. Several water flow rates were tested to determine which rate provides the greatest acoustic reductions. Preliminary results are presented.

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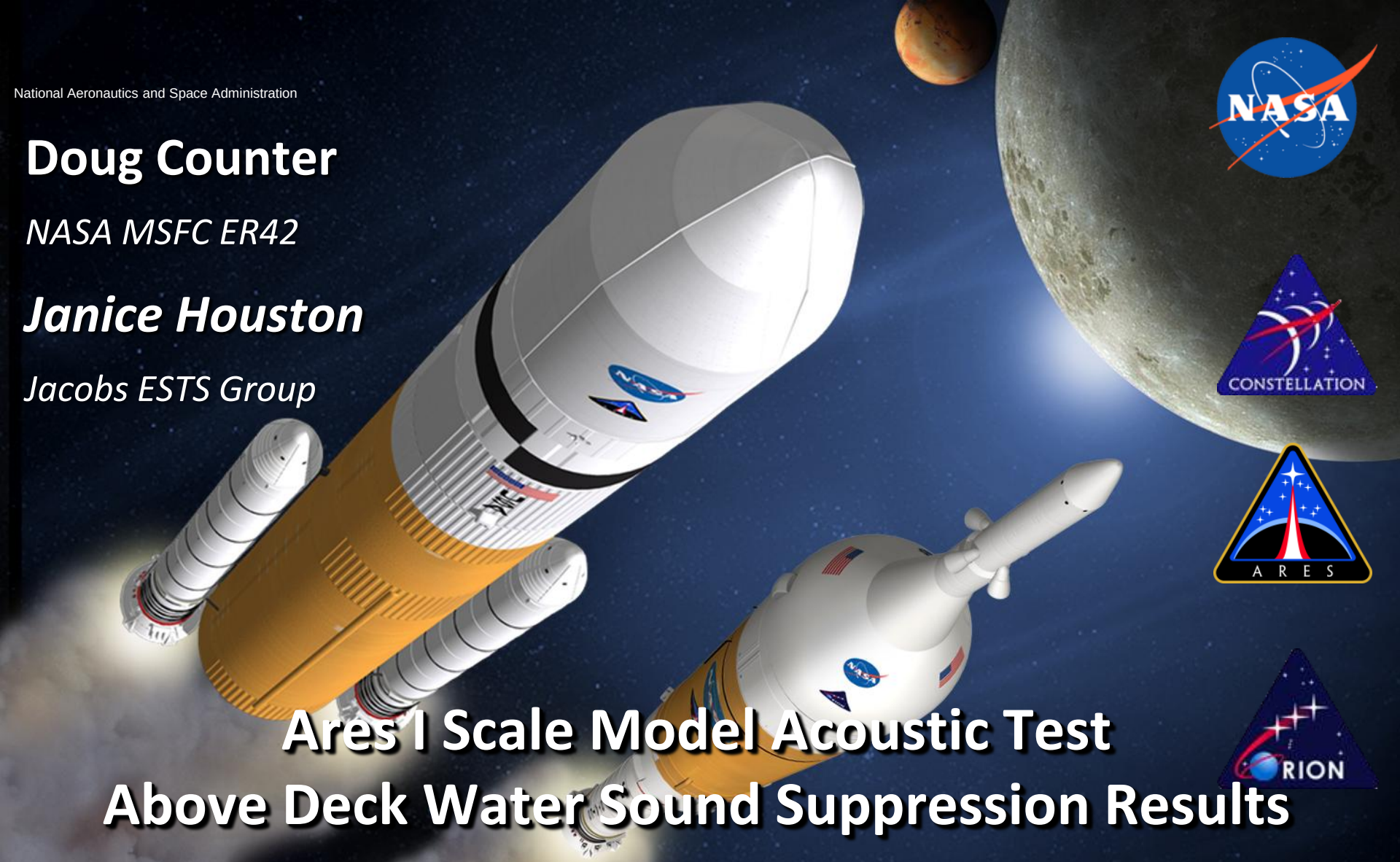
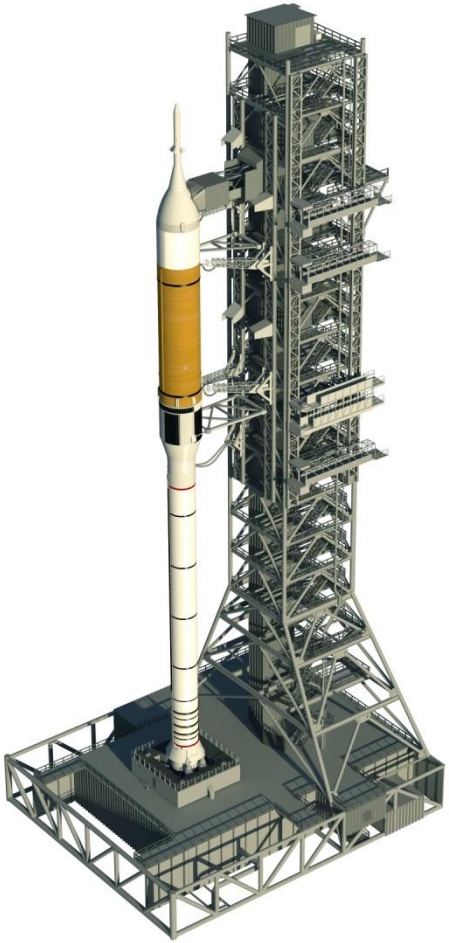


Ares I Scale Model Acoustic Test Above Deck Water Sound Suppression Results

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

Introduction: Reducing Liftoff Acoustics

- ***Liftoff acoustics (LOA)*** **noise is caused by the supersonic jet flow interaction with surrounding atmosphere and occurs at ignition and persists for 0-20 seconds as the vehicle lifts off.**



Ares I and Mobile Launcher

- **Vehicle Design**
  - LOA - input for vibro-acoustics
- **If responses are high…**
  - Mitigate at component or vehicle
- **Vehicle mitigation is accomplished with a water sound suppression system provided by the Kennedy Space Center Launch Complex**
  - Mobile Launcher baseline configuration includes Below Deck Water
  - Above Deck Water not baselined
    - Technical, cost and schedule risks
- **Mitigation Pathfinder - scale model test**
  - 5% Ares I Scale Model Acoustic Test (ASMAT)

Above Deck Water: Rainbirds

KSC Rainbirds for Shuttle
(W_w/W_p = 3.0)

ASMAT Rainbirds
(W_w/W_p = 4.5)

- ASMAT Rainbird design based upon Shuttle design
- Flow rates are ratios of water to propellant (W_w/W_p)

Rainbird Flow Rate Ratio W_w/W_p	Ares I Flow Rate (GPM)	ASMAT Flow Rate (GPM)
2.0	243,000	566
3.5	340,000	991
4.5	438,000	1275

ASMAT Matrix

- **Test matrix designed to determine liftoff acoustics**
  - **Quantify acoustic reduction with Above Deck Water/Rainbirds**
  - **Optimize Above Deck Water/Rainbirds flow rate ratio**

Relevant ASMAT Cases
VERT5: 5 ft + Drift + Launch Mount + Below Deck Water
VERT7: 5 ft + Drift + Launch Mount + Below Deck Water
VERT11: 5 ft + Drift + Below Deck Water
VERT8: 5 ft + Drift + Launch Mount + Below Deck Water + Rainbird Water at 2 flow rate
VERT9: 5 ft + Drift + Launch Mount + Below Deck Water + Rainbird Water at 3.5 flow rate
VERT10: 5 ft + Drift + Below Deck Water + Rainbird Water at 3.5 flow rate
VERT12: 5 ft + Drift + Below Deck Water + Rainbird Water at 4.5 flow rate

Test Article Configuration Change

- **Removed Launch Mount after VERT9**

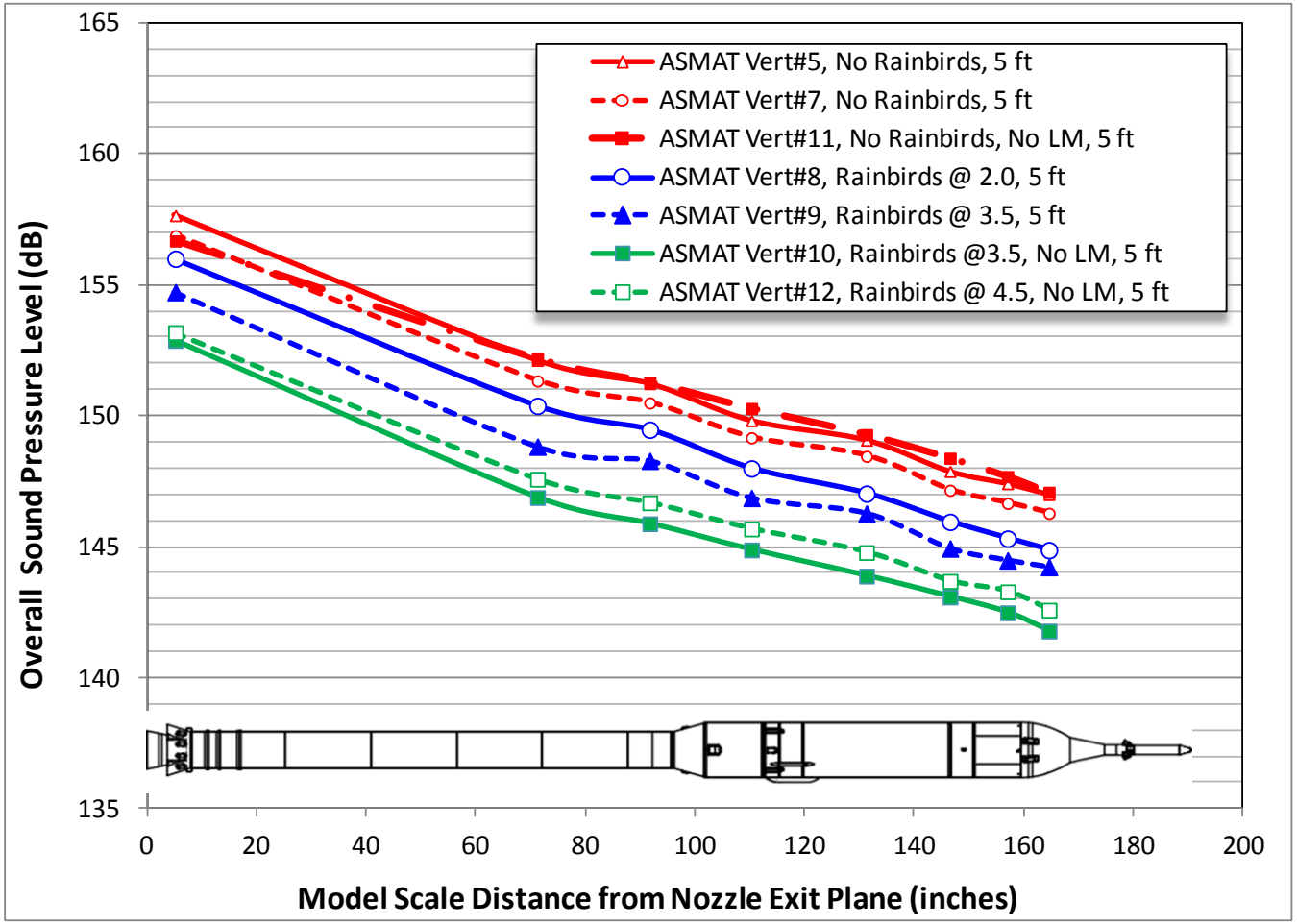
VERT9 flow pattern with Launch Mount

VERT10 flow pattern without Launch Mount

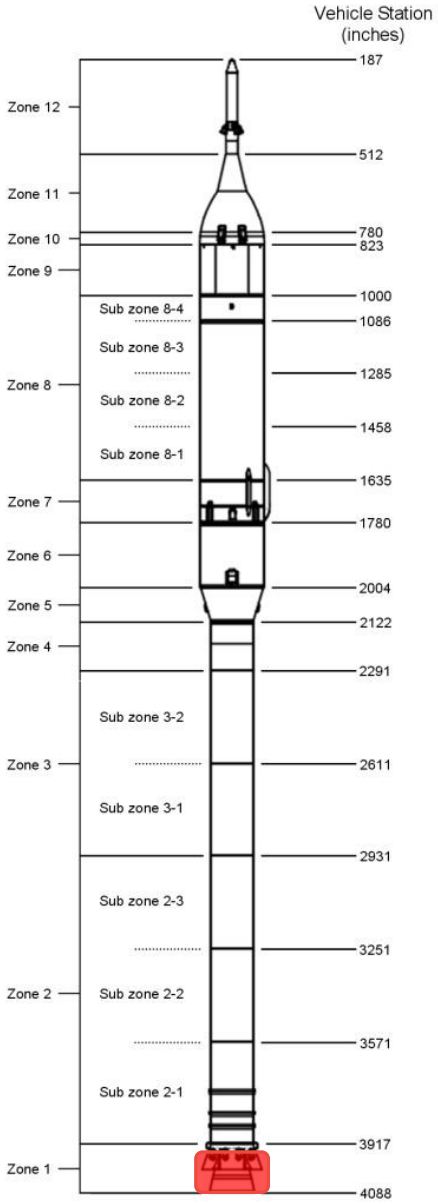
DATA RESULTS

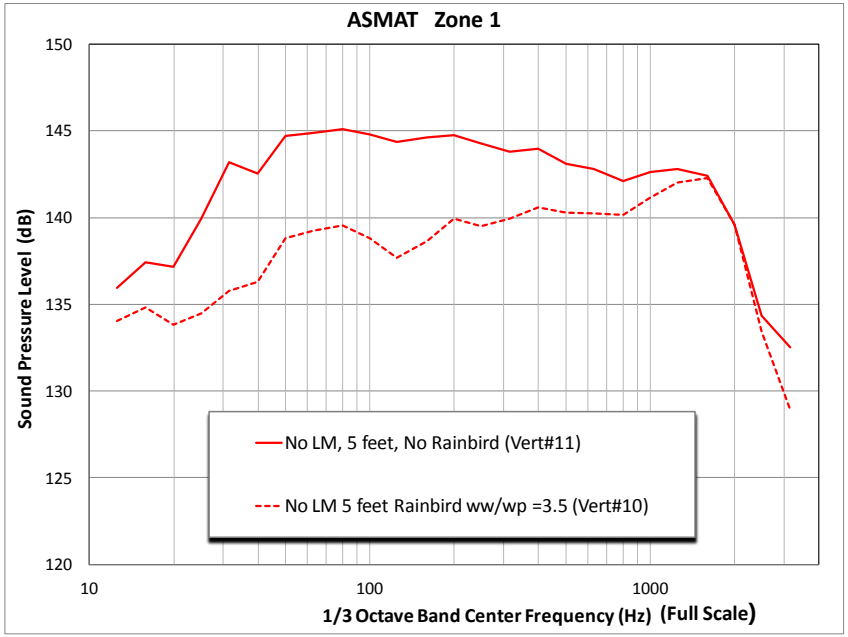
Overall Sound Pressure Level Comparisons of ASMAT Flow Rate Ratios

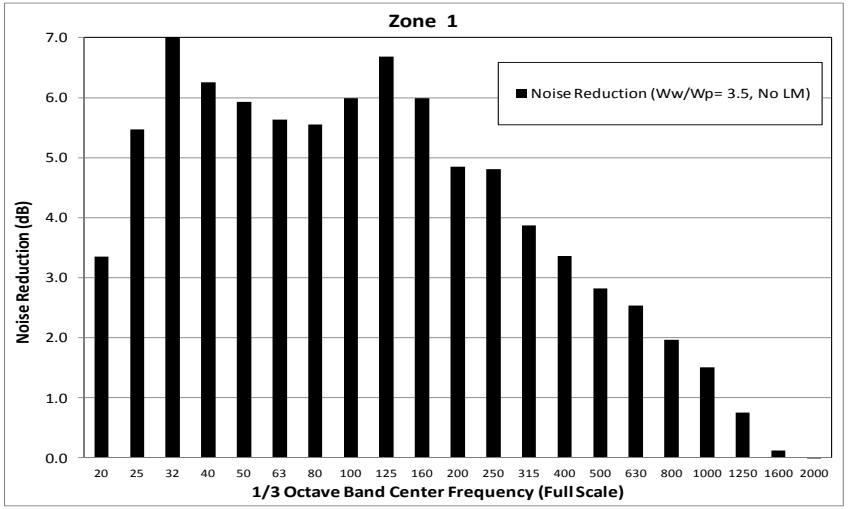
- The greatest noise reduction was achieve at a 3.5 flow rate ratio
- No improvement in noise reduction when flow rate ratio was increased to 4.5



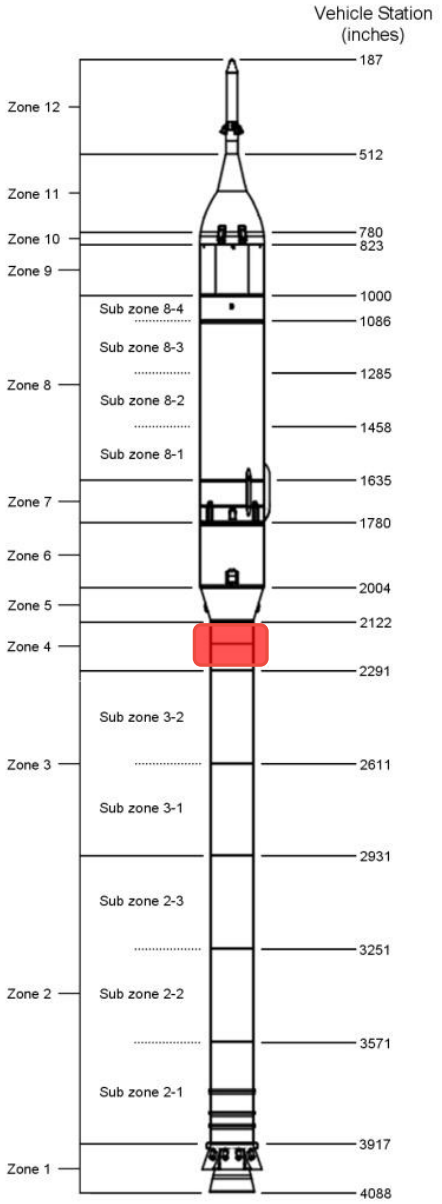
Sound Pressure Levels and ΔdB Reduction at Zone 1

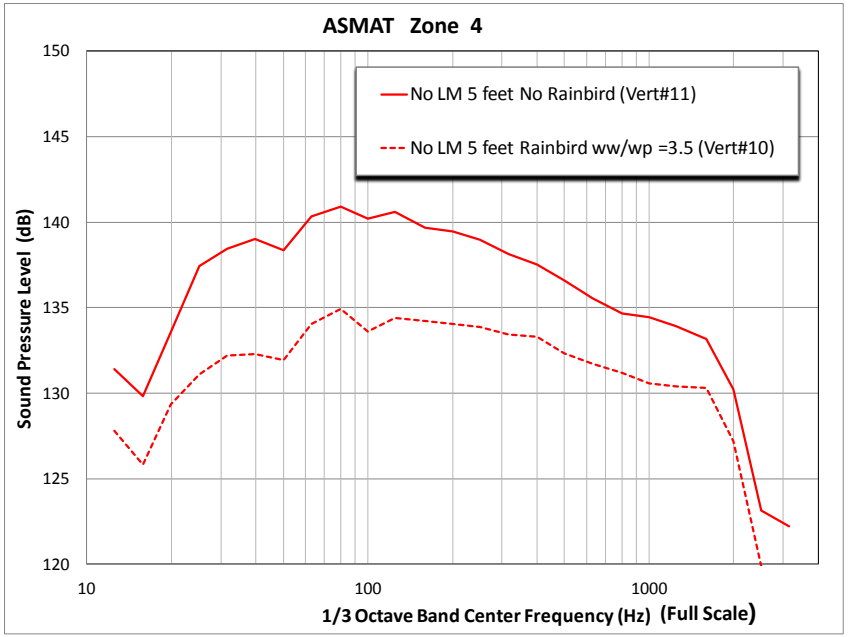


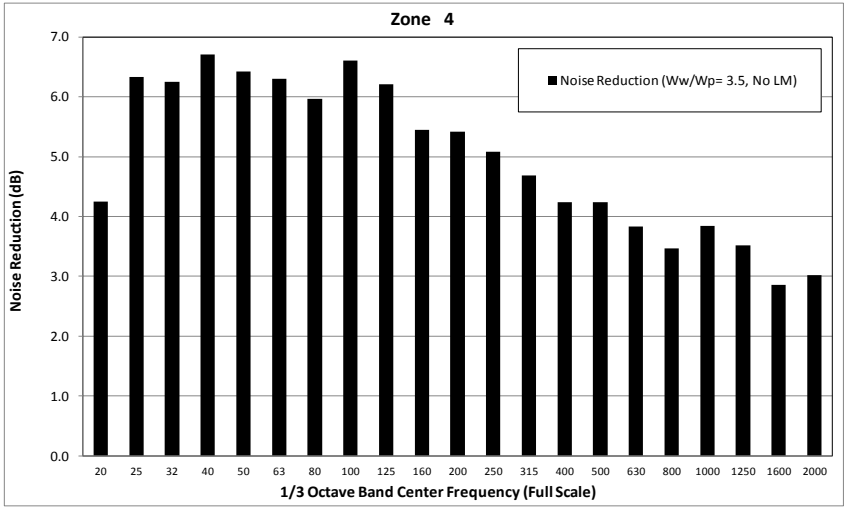




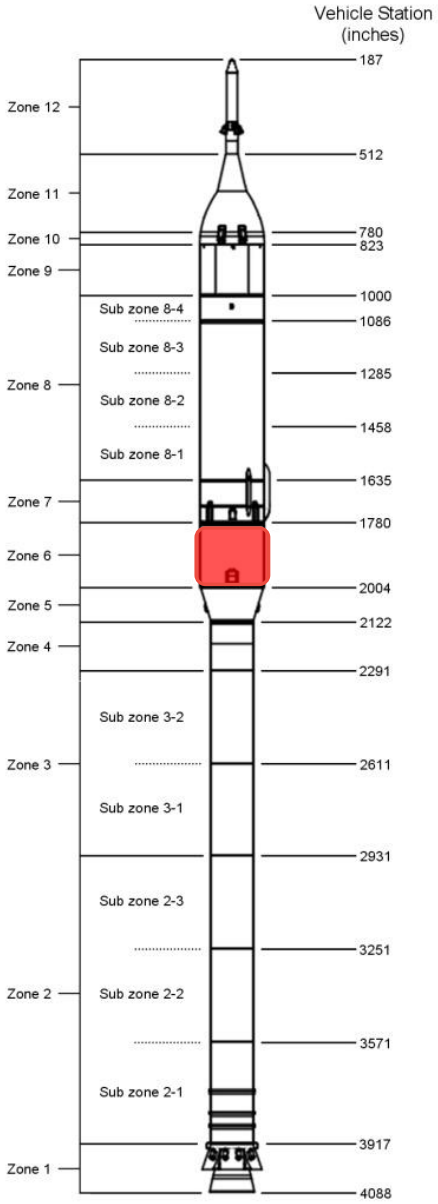
Sound Pressure Levels and ΔdB Reduction at Zone 4

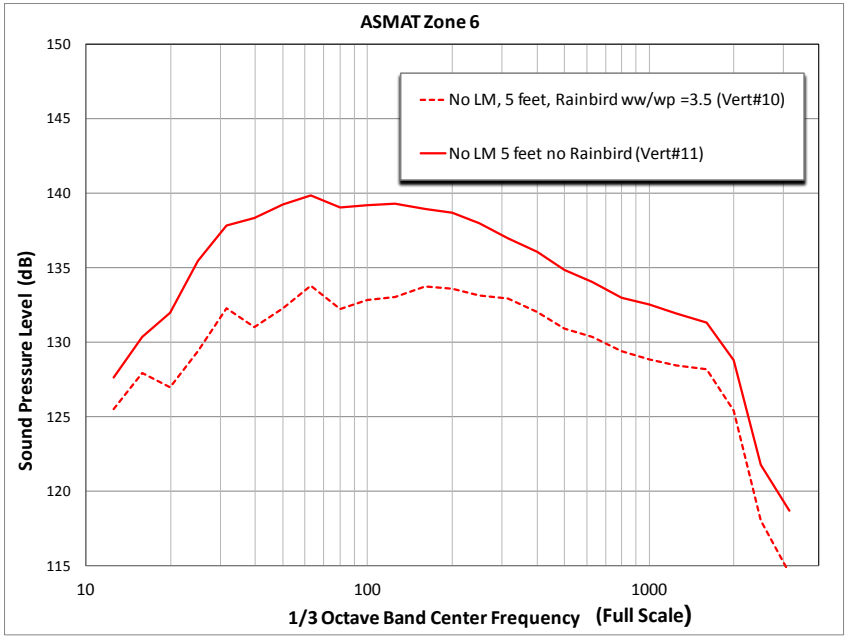


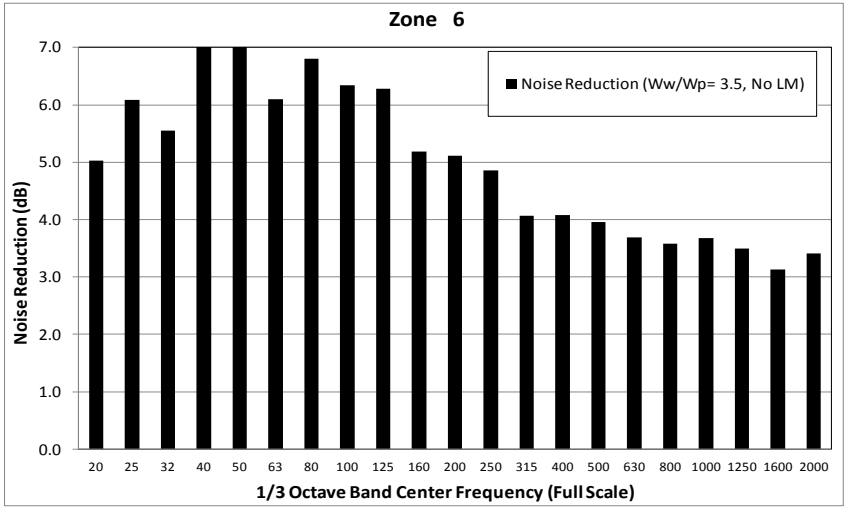




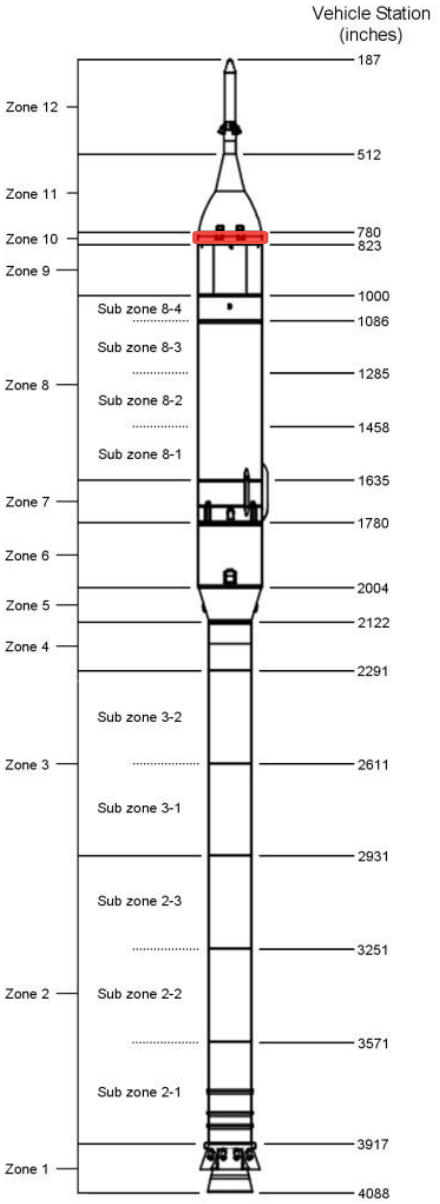
Sound Pressure Levels and ΔdB Reduction at Zone 6

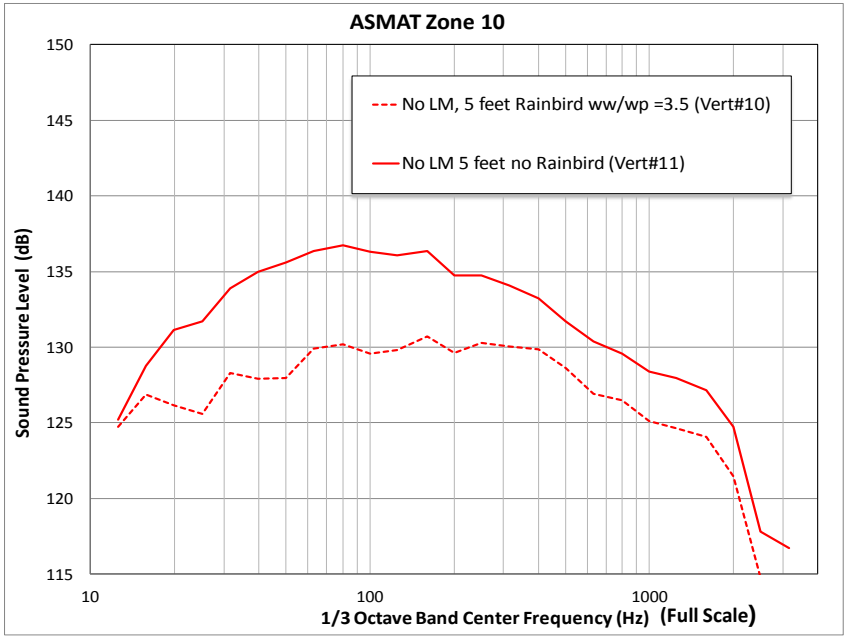


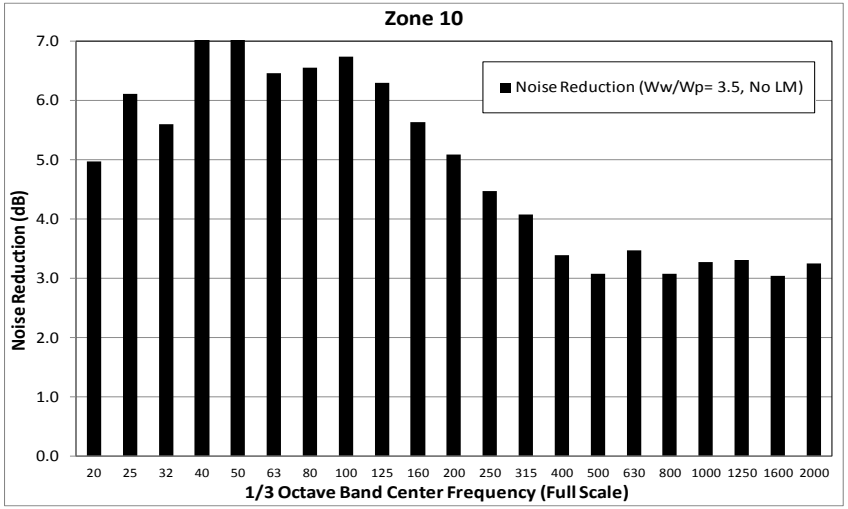




Sound Pressure Levels and ΔdB Reduction at Zone 10

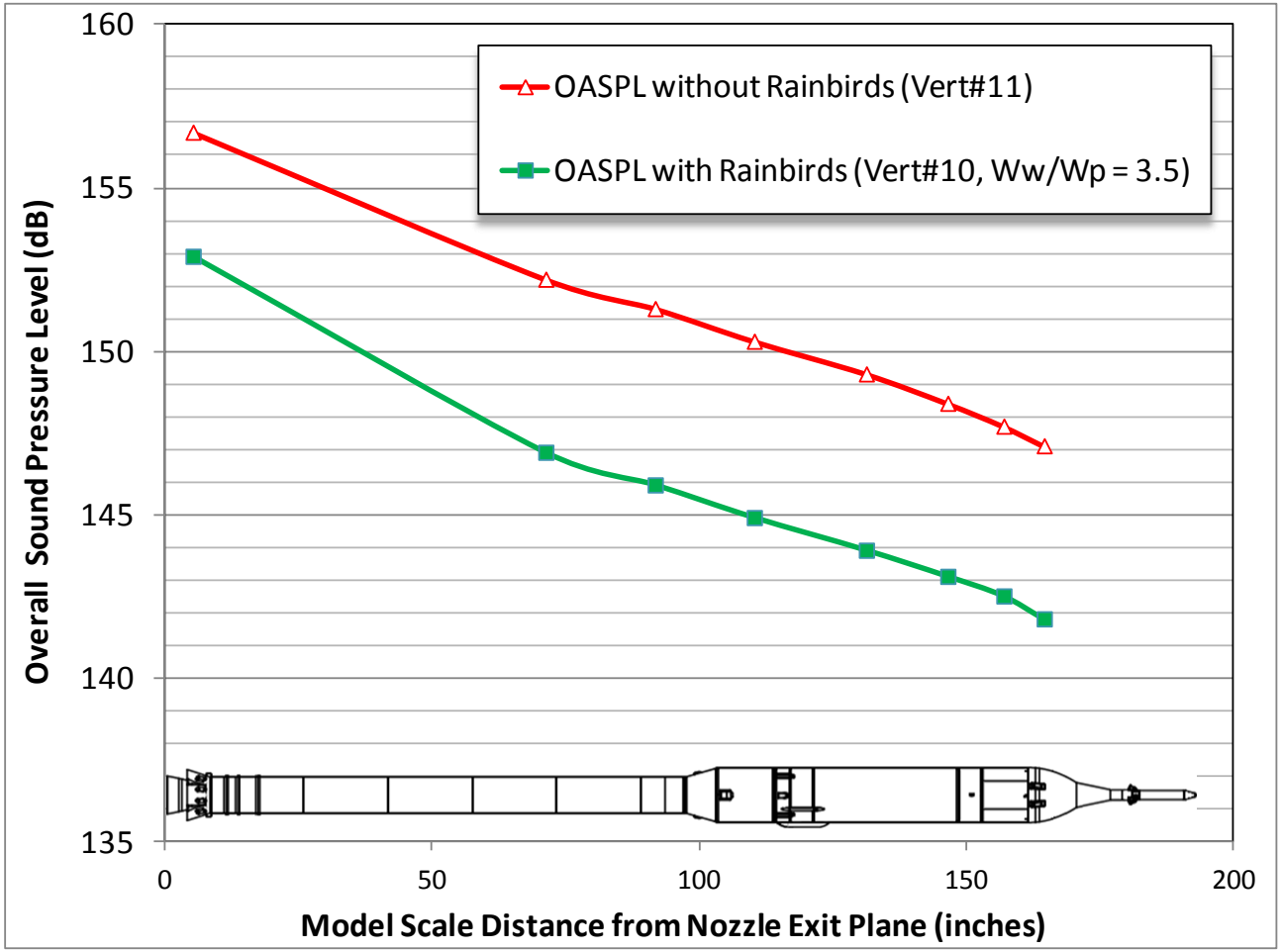






Overall Sound Pressure Level Comparisons: No Rainbirds to Rainbirds at 3.5 Flow Rate Ratio

- Comparing Vert10 and Vert11, both without the Launch Mount, the rainbirds effectively reduce the OASPL by 5 dB



ASMAT Findings and Recommendation

- **Removing Launch Mount resulted in an increased noise reduction**
- **Rainbird noise reduction quantification**
  - Reduced OASPL by 5 dB at $W_w/W_p = 3.5$
    - 5-6 dB reduction in the 20 to 200 Hz range
    - 3 dB reduction in the 250 to 2000 Hz range
  - Noise reduction appears to be consistent along the vehicle
- **Rainbird flow rate optimization**
    - Significant improvement in noise reduction from $W_w/W_p = 2$ to 3.5
    - No improvement in noise reduction from $W_w/W_p = 3.5$ to 4.5
- **Recommend Above Deck Water (Rainbird) on future launch systems**
  - Recommend water to propellant flow rate ratio of 3.5