SLS
Space Launch System

National Aeronautics and Space Administration

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Scale Model Acoustic Test Overview

164th Acoustical Society of America
Noise ,Physical Acoustics, and Structural Acoustics and Vibration:
Launch Vehicle Acoustics
Session 3aNS
October 24, 2012

Introduction: Rocket Liftoff Environments

Ignition overpressure (IOP) is a significant transient low-frequency pressure event caused by the rapid pressure rise rate of the solid rocket motor.

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.

SLS 1000x at Kennedy Space Center Launch Complex

- Challenges for determining SLS 1000x rocket liftoff environments
  - 2 Reusable Solid Rocket Motor (RSRMV) boosters
    - Motor sound sources
  - 4 Space Shuttle Main Engine (SSME) heritage engines
    - Engine sound sources
  - New Mobile Launcher (ML)
    - One large shared exhaust hole
      - All 6 plumes interact: combined noise source
    - Launch pad deflector effects
      - Non-legacy deflector
    - New water sound suppression system
  - Tower
    - Plume sound reflections off of launch pad
- Verify environments with scale model test

SMAT Objectives

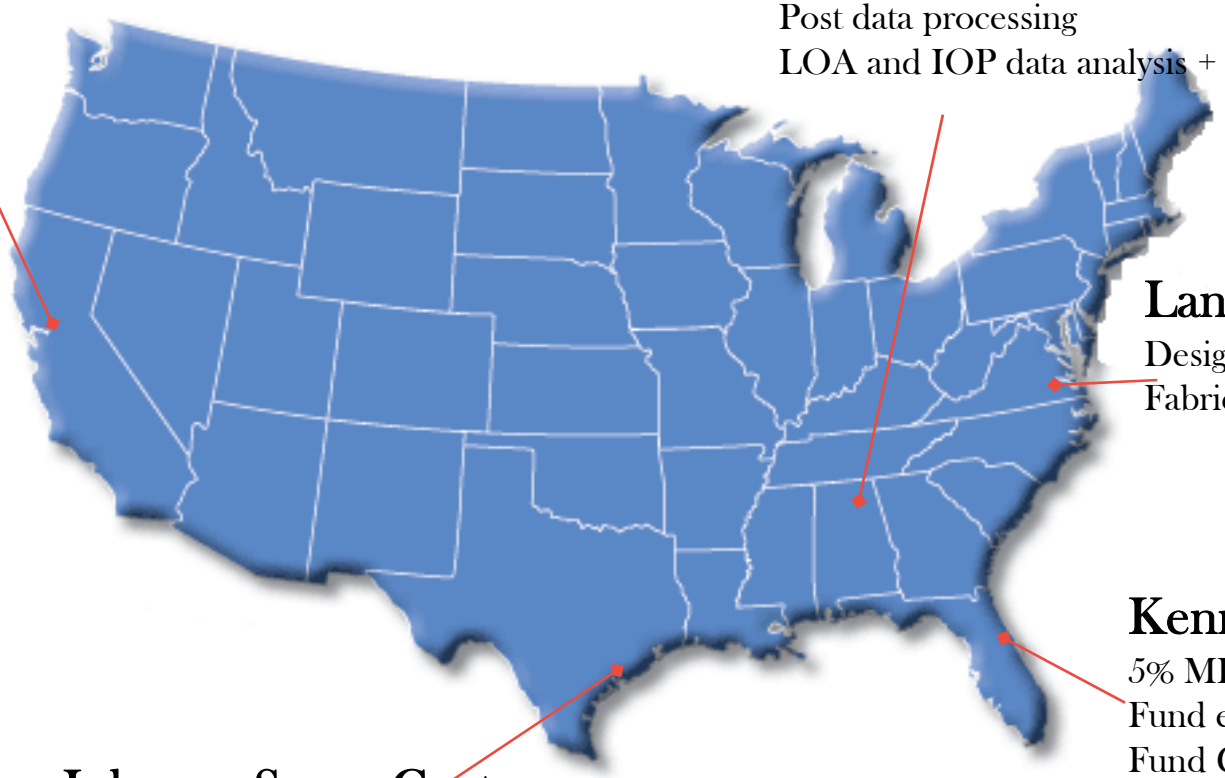
- Scale Model Acoustic Test (SMAT) objectives
  - Verify predicted LOA environments
    - Obtain data to update the liftoff acoustic environments
  - Verify predicted IOP environments
    - Obtain data for use in IOP analytical models for updated environments
    - Improve IOP analytical models
  - Verify SLS deflector design
  - Characterize Ground Acoustic (GA) environments
    - Provide data to support GA environment predictions
  - Obtain Spatial Correlation (SC) data for use in vibro-acoustic models
  - Obtain data for Computation Fluid Dynamics (CFD) validation

- Evaluate water sound suppression systems
  - Determine water suppression attenuation

Teaming Across NASA

Marshall Space Flight Center
Managed SMAT
Design & fabricate ML & Launch Pad Trench (LPT)
Design & fabricate liquid engines
Execute test
Data acquisition
Post data processing
LOA and IOP data analysis + SLS SC data analysis

Ames Research Center
Install & calibrate SC sensors

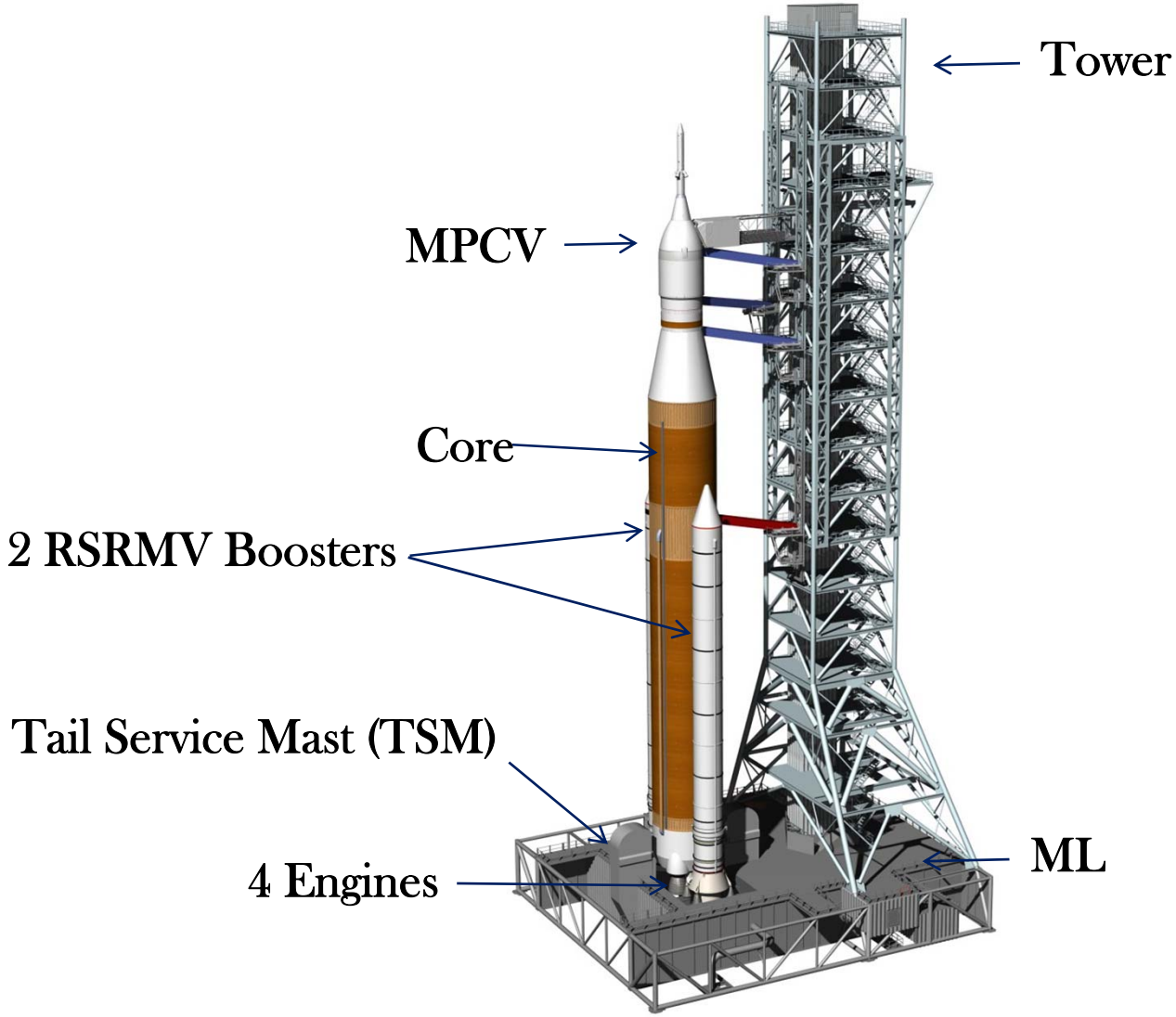


Langley Research Center
Design & fabricate SMAT vehicle
Fabricate nozzle extension

Kennedy Space Center
5% MLPro/E Model
Fund engine thruster development
Fund Ground Acoustic (GA) sensors
GA data analysis
Deflector design

Johnson Space Center
Fund SC sensors
Multi Purpose Crew Vehicle (MPCV) SC data analysis

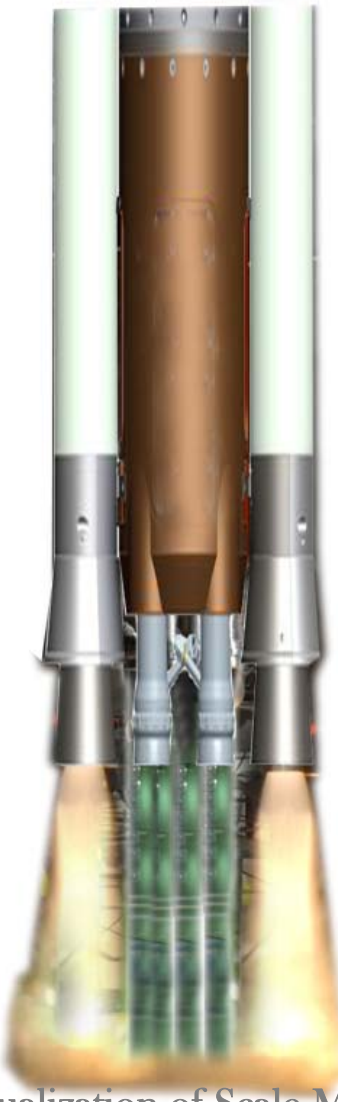
SMAT Configuration



Scale Model Acoustic Test Configuration

SMAT Propulsion Systems

- **Two Propulsion Systems for SMAT**
  - Two solid rocket motors for boosters
    - Rocket-Assisted Take Off (RATO) motors will simulate SLS RSRMV boosters
    - Test requirement that motors ignite simultaneously
    - Will be procured from manufacturer
  - Four liquid engines for core engines
    - Modified from 6.4% Shuttle scale test
    - Simulate SLS core engines
    - SMAT engine start time will not match SLS staggered engine start time
    - Will be developed in-house

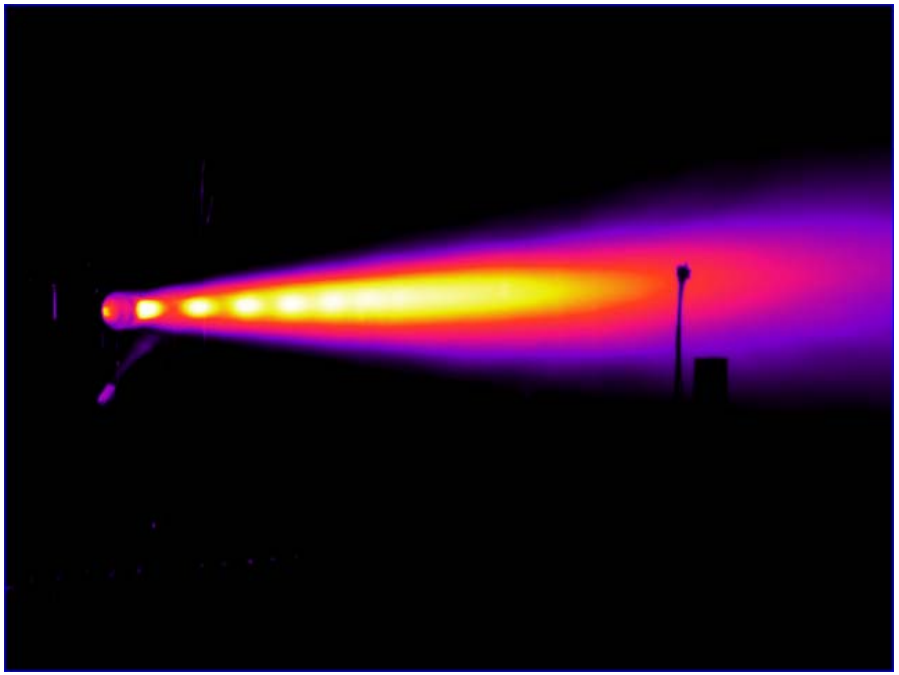


Visualization of Scale Model
Acoustic Test Boosters and Engines

Developing SMAT Liquid Engines

- Show movie

Scale Model Acoustic Test single thruster engine at MSFC East Test Area Test Stand 115.



Infrared image of Scale Model Acoustic Test single thruster during operation.

Designing Water Sound Suppression Systems

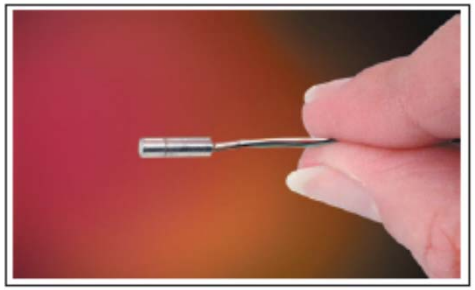
- Two water sound suppression systems
  - Below deck: exhaust hole & trench water
    - Exhaust hole water has three subsections: one for each booster and core
  - Above deck: rainbirds
- Show movie of development of exhaust hole water

Instrumentation Suites

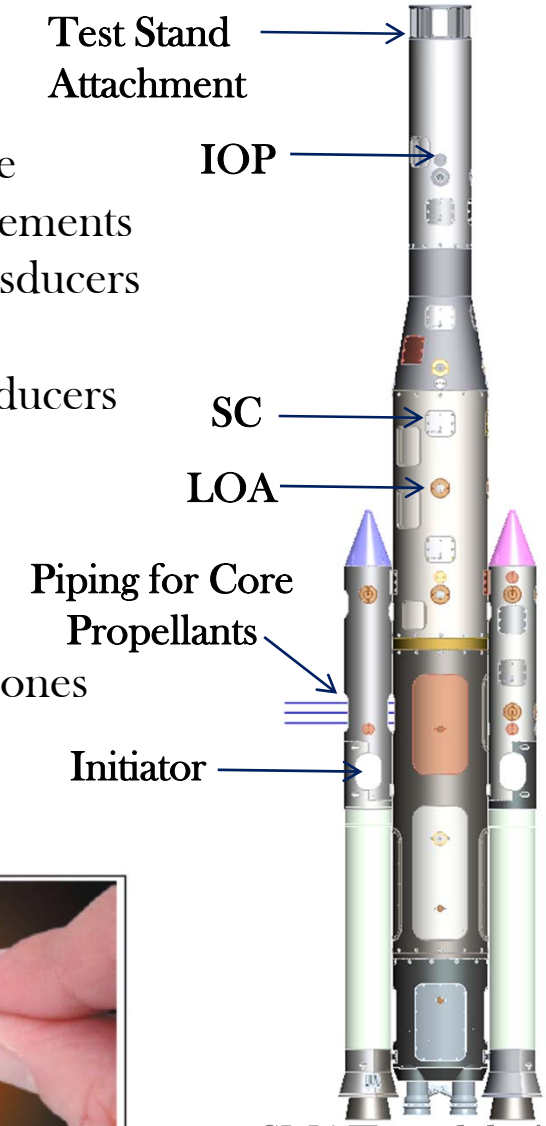
- Five primary instrumentation suites with over 325 sensors
  - **LOA:** B&K 4944-B microphones on vehicle
  - **GA:** B&K 4944-B microphones and PCB 112A22 pressure transducers on the tower, mobile launcher, far field measurements
  - **Spatial Correlation:** Kulite XCEL-12-100-2D pressure transducers on the vehicle
  - **IOP:** Kulite XTL-123B-190-30SG & -65SG pressure transducers on the vehicle, tower, mobile launcher
  - **Health & Monitoring:**
    - Accelerometers on vehicle
    - Strain gages on vehicle
    - Thermocouples on vehicle and co-located with microphones
    - Flow meters
    - Chamber pressure

LOA & GA microphone

IOP pressure transducer



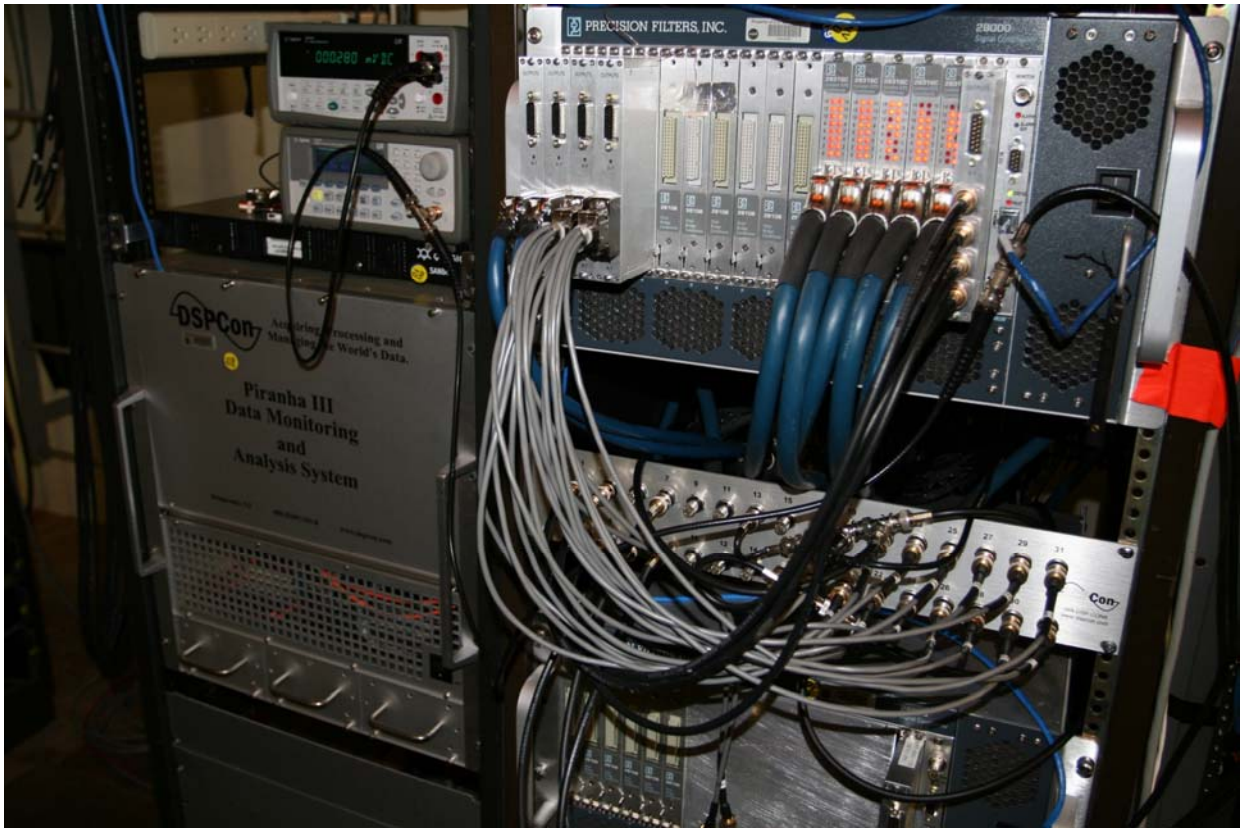
SC pressure transducer



SMAT model with instrumentation plates

Data Acquisition Systems

- Two data acquisition systems required
  - Low speed system (100 sps)
  - Medium & high speed system (4000 & 256,000 sps)



DSPcon Piranha III data monitoring and analysis system

Forward Work

- SMAT is in development
- Testing will begin in Fall 2013
- Results available Fall 2014