

## Marshall Space Flight Center

# Structural Dynamics Testing

Engineering Solutions for Space Science and Exploration

Vibration test of roll  
control thruster moduleOrthogrid panel  
vibroacoustic  
testDynamic test of Reusable  
Solid Rocket Booster  
PlungerModal Test of the ISS  
P3/P4 Truss

Lateral slosh test

**Structural Dynamics Testing** comprises a wide range of testing techniques to characterize the dynamic behavior of a variety of structures. Dynamic testing may be required for a number of reasons. Testing may simulate the expected launch environment to ensure the successful performance of the flight article, it may be required for troubleshooting, or it may be conducted to validate structural models used in a variety of analyses. The Structural Dynamics Test Branch has extensive experience in many types of testing, including vibration, vibro-acoustic, pyrotechnic shock, fluid slosh, and modal testing. Unique facilities and test equipment, along with the expertise of the personnel, provide a flexible and efficient option for both large and small test articles. Customized vibration fixture design and fabrication can be provided through in-house organizational resources.

## Vibration Testing

Vibration testing is conducted utilizing two separate test cells located adjacent to high-bay structures. A total of six electrodynamic exciters are dedicated to development and certification vibration testing of flight and ground support hardware. Dynamic excitation controlled up to 40K lbf is available using multiple digital vibration control systems. These control systems provide sine sweep, broad-band random, sine-on random, random-on random, classical shock, and shock response spectrum (SRS) control functions. Other control features include 80 dB dynamic range, real time 32 channel control, tolerance limited spectra, test article response limitation, and real time signal analysis. Shaker head expanders allow mounting surfaces up to 5 ft by 5 ft. Acceleration data can be acquired in real time up to 64 channels in both time and frequency domains and formatted to conventional and specified test requirements. An additional signal conditioning and digital recording capability can be utilized for post processing of dynamic response data. Its recording capability can accommodate up to 72 channels of accelerometers or 80 channels of strain gages.

## Acoustic Testing

Vibro-acoustic testing is conducted utilizing a reverberation chamber and a progressive wave tube. Vibro-acoustic development and certification testing is performed in a 5K ft<sup>3</sup> concrete chamber with the capability of up to 200K-acoustic W input using air-stream modulators yielding up to 172 dB overall (OA) sound pressure

level (SPL) in a progressive wave tube and 163 dB OA SPL in a diffuse field. Test articles up to 500 ft<sup>3</sup> can be placed in the diffuse field. Electrodynamics drivers are available for noise levels up to 139 dB OA SPL. An adjacent 3K ft<sup>3</sup> anechoic chamber provides the capability for transmissibility and absorption studies, as well as acoustic emission measurements. Up to eight microphones can be multiplexed for acoustic level control and 32 channels of acceleration response can be analyzed online. Control tolerances are  $\pm 2$  dB per one third octave and  $\pm 2$  dB overall from 50 to 10 KHz.

## Pyrotechnic Shock Testing

Pyrotechnic shock testing is conducted in an area equipped for generating dynamic transients with explosive materials. Detonating cord and blasting caps are used to generate flight input transient shock simulation to test hardware commonly mounted on a suspended plate. Shock levels up to 50,000 g's SRS and 10 KHz can be generated. Pyrotechnic devices used in aero-space flight applications can be evaluated and characterized as to the SRS response resulting from detonation. Sixteen channels of transient pyrotechnic response data can be acquired real-time and post processed in the time domain or SRS for one pyrotechnic event. Up to 40 additional channels can be conditioned and digitally recorded.

## Modal Testing

The MSFC modal test facility is equipped to conduct modal and other related dynamic testing on a variety of hardware, including flight systems, payloads, and components. Testing may be conducted in the MSFC Test facility or at a customer facility. Fixed, free-free, or hybrid boundary conditions may be accommodated. Excitation may be provided by a variety of impulse hammers or electromagnetic or hydraulic shakers using transient, sinusoidal, or random inputs. A broad range of shakers are available from 2-lb to 1,000-lb output electromagnetic shakers to 1,500-lb output hydraulic shakers. The MSFC modal test facility also has several dynamic signal analyzers providing over 500 channels of simultaneous data acquisition. The modal team also has expertise in non-conventional modal testing and data acquisition techniques, including the development of several slosh test beds and non-contacting, full-field measurement capabilities. These capabilities include laser vibrometry and photogrammetry.

# Capabilities

## Vibration Test



Vibration test of an Environmental Control and Life Support Systems Component

- 6 electromagnetic shakers (up to 40,000 lbf)
- Accelerometers with capability up to 5,000 g's
- Test article accommodation up to 5 ft × 5ft
- Signal conditioning and data acquisition and control systems with up to 64 channels
- Vibration spectra including: Sine, random, sine on random, random on random, classical shock, and Shock Response Spectrum (SRS)

## Acoustic Test



Acoustic test of mounting plate

- Vibro-Acoustic environments
  - Diffuse field to 163 dB
  - Progressive wave to 172 dB
- Acoustic Characterization
  - Transmissibility – reverberation to anechoic
  - Acoustic emission testing
- 8 microphone channels of excitation control
- Acoustic excitation up to 200 K-acoustic W
- Test article accommodation up to 500 ft<sup>3</sup>
- Chamber access doors 8 ft × 8 ft

## Pyrotechnic Shock Test



Panel separation test

- Pyrotechnics that generate up to 50,000 g's SRS and 10,000 Hz
- Accelerometers capable up to 50,000 g's
- Limited thermal conditioning
- 16-channel system for real-time response data
- 11 ft × 9 ft exterior blast room door
- Signal conditioning and digital recording for up to 40 additional channels
- Time and shock response spectrum (SRS) analysis

## Modal Test



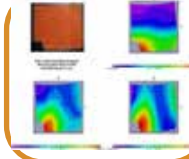
Modal test of ETM-3 Motor at ATK

- Excitation Sources
  - Instrumented hammers (mlbf – 1,000's lbf)
  - Electromagnetic shakers from 2 lbf to 1,000 lbf
  - Hydraulic shakers up to 1,500 lbf
- Large inventory of accelerometers (DC – 20 kHz)
- Signal conditioning and data acquisition over 500 channels simultaneously
- Mobile equipment

## Non-contacting Optical Measurement Capability



High-speed video camera



Full-field strain measurement using Photogrammetry

- Photogrammetry
  - 3D dot/marker tracking
  - 3D full-field motion/displacement measurement
  - 3D transient strain measurement
- High-speed digital video cameras
  - 7 v7 Phantom cameras
  - 3 v9 Phantom cameras
  - 100 – 160,000 frames per second video
  - 3 minutes of video at 1,000 frames per second
- Electronic Speckle Pattern Interferometry
  - Full-field displacements (DC – 40,000 Hz)
  - 50 nm displacement resolution
- Scanning laser vibrometer

## Fluid Slosh



Transducer Embedded Slosh Test

- Numerous vertical and lateral test beds with embedded transducers.
- Slosh parameter measurement and estimation.

# Key Benefits

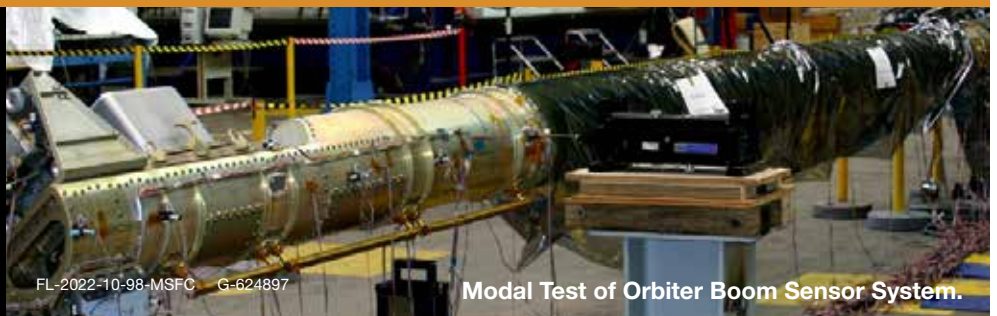
- Experienced team dedicated to structural dynamic testing
- Existing labs and test equipment, along with in-house design and fabrication capability, allow for rapid test planning and build-up
- Broad range of expertise in all facets of structural dynamic testing for hardware development and qualification
- Mobile capabilities for some testing

Thermally-conditioned vibration test



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Modal Test of Orbiter Boom Sensor System.