ORBCOMM Generation 2 Access to LEO on the Falcon 9 using SoftRide, A Case History



Raman Johal – Moog CSA Engineering

Jim Christensen – Sierra Nevada Corporation

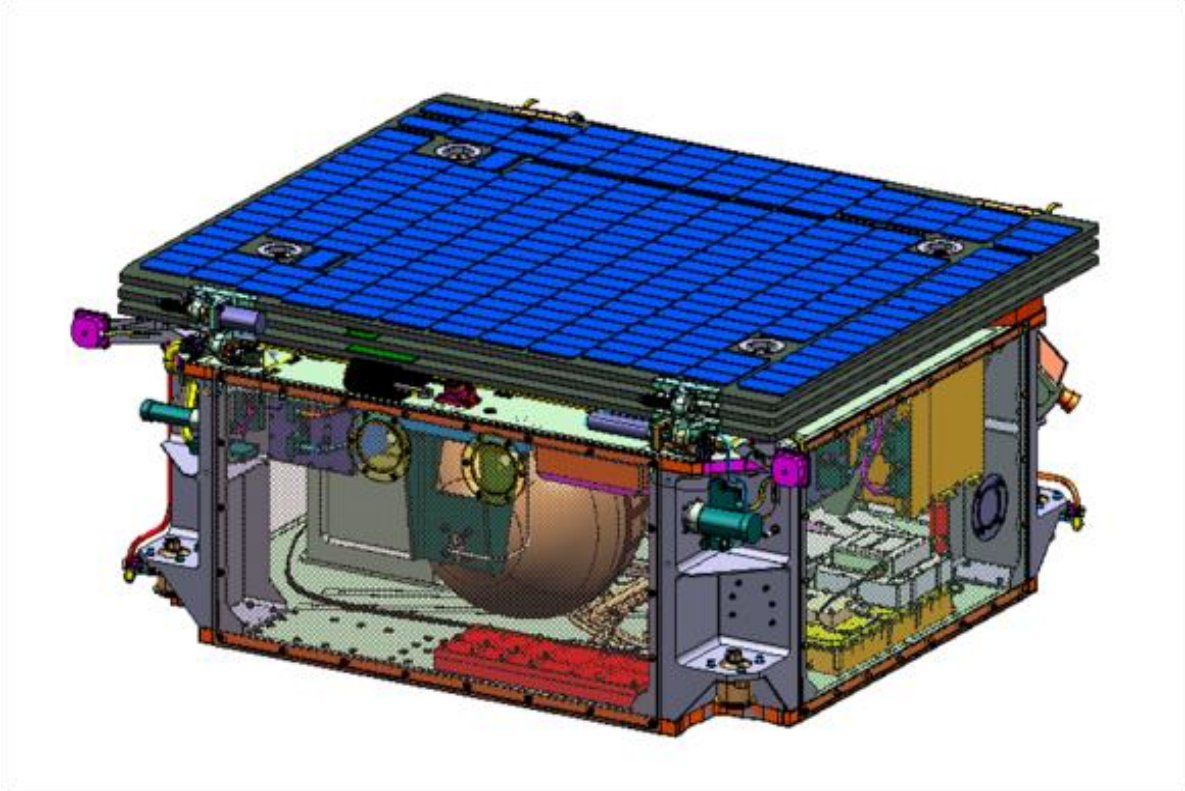
Dustin Doud – Space Exploration Technologies

AIAA/USU Conference on Small Satellites

Logan, Utah
August 13th-16th, 2012

MOOG
CSA Engineering

ORBCOMM Gen 2 (OG2)



- OG2 is a 160 lb spacecraft built by Sierra Nevada for ORBCOMM
- New set of 18 spacecraft will replace existing fleet which have been in operation since 1993

Random Environment used for Design

- OG2 was designed long before launch vehicle was known
- No two launch vehicle dynamic environments are identical
  - Some are fairly benign to the spacecraft
  - Most offer a **VERY** rough ride to orbit
- SNC made conservative estimates in random environment during bus design and component selection
  - Two potential launch vehicle random environments combined
  - Seemingly conservative environment for design purposes
- Falcon 9 with Dragon capsule was selected
  - "Trunk" has enough space for small payloads
  - Dynamic environment was higher than conservative envelope used by SNC

Falcon 9 Trunk

Nose cap

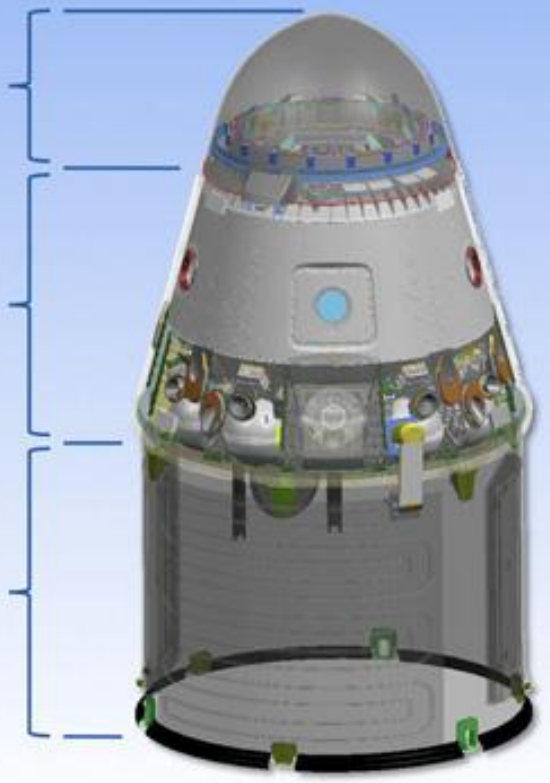
Jettisoned after stage separation.

Pressurized section

Contains pressurized cargo, experiments or crew, as well as hatches, windows, thrusters & propellant tanks, parachutes and heat shield.

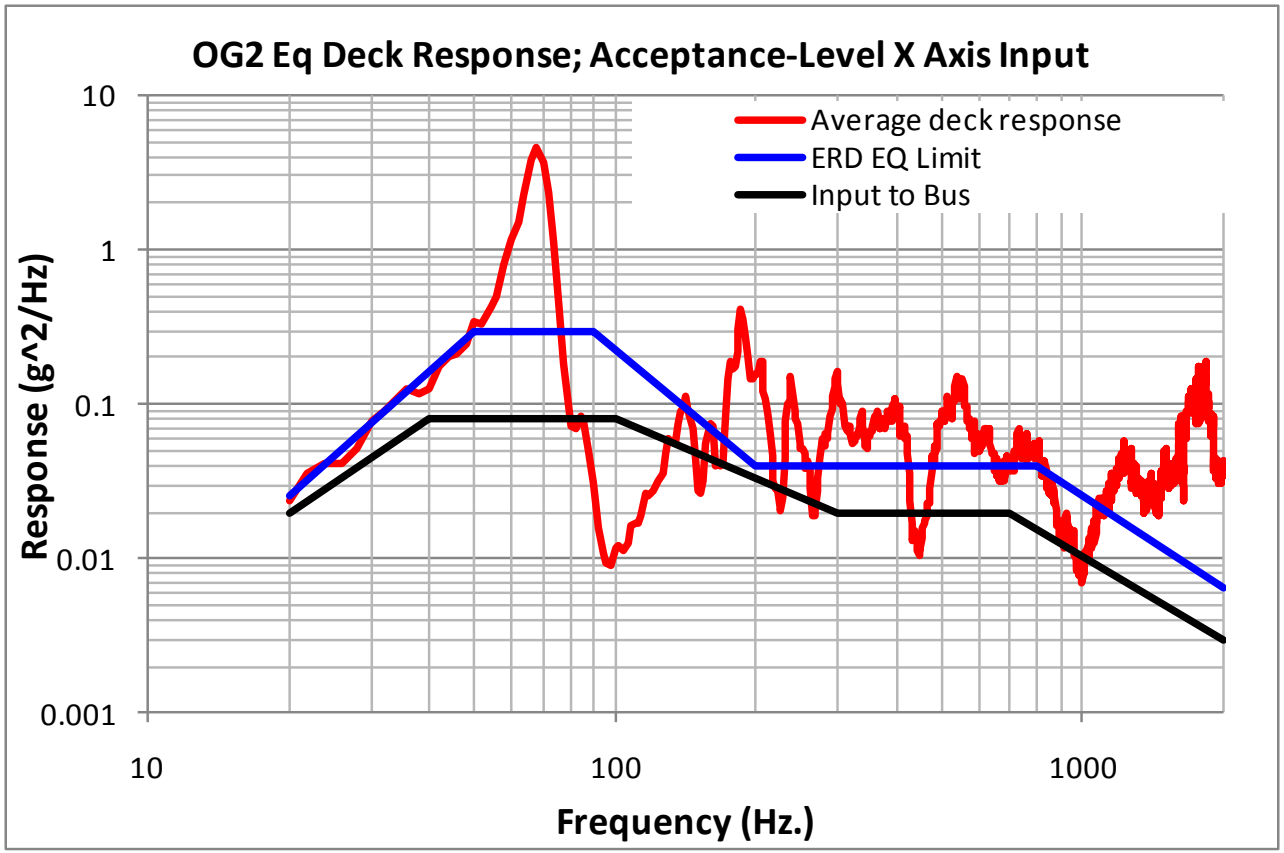
Trunk section

Supports solar panels, thermal radiator and contains unpressurized cargo, and small deployable satellites. Jettisoned before reentry.



Dragon Trunk supports secondary payloads for orbital insertion

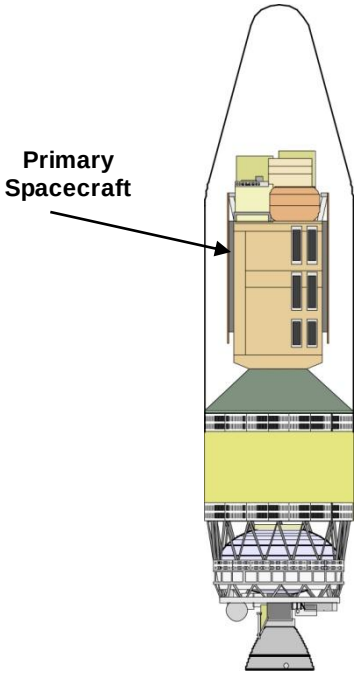
OG2 Equipment Responses



OG2 preliminary analysis showed average of responses due to expected Trunk random environment would exceed many of the components' qualification levels

SoftRide as a Solution

Standard Mounting

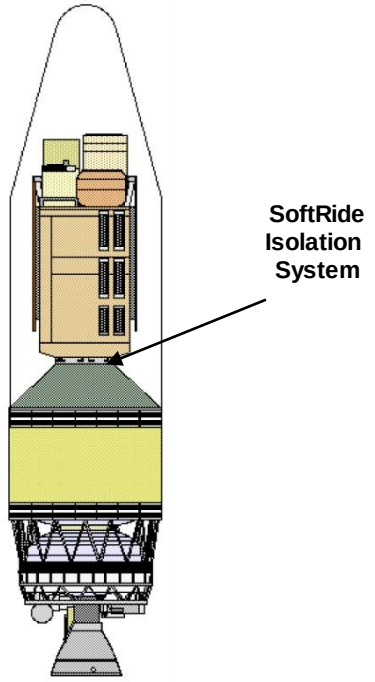


- Spacecraft hard-mounted to launch vehicle
- Vibrations from launch vehicle transmitted directly to spacecraft

Benefits for Spacecraft:

1. Lower risk on launch
2. Lighter structures
3. Less launch costs
4. Higher reliability
5. Lower qual testing requirements
6. Launch on multiple launch vehicles

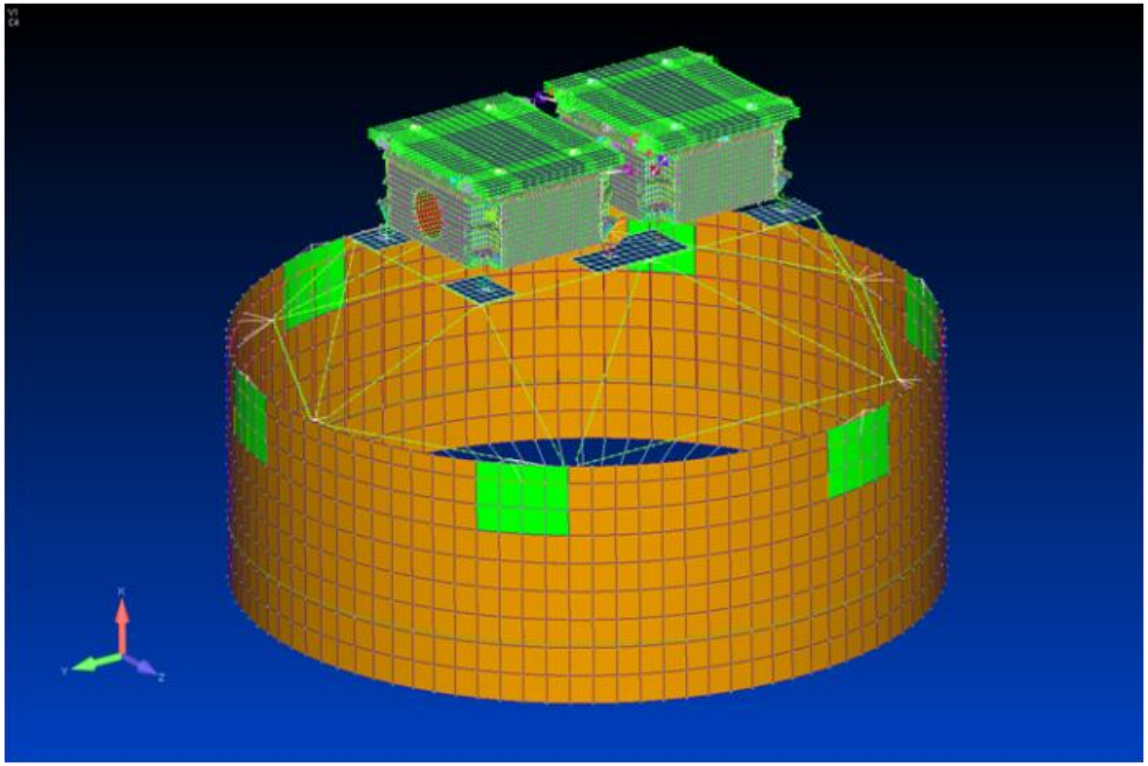
SoftRide Mounting



- **Spacecraft mounted to launch vehicle by isolation system**
- **Vibrations transmitted to spacecraft greatly reduced**

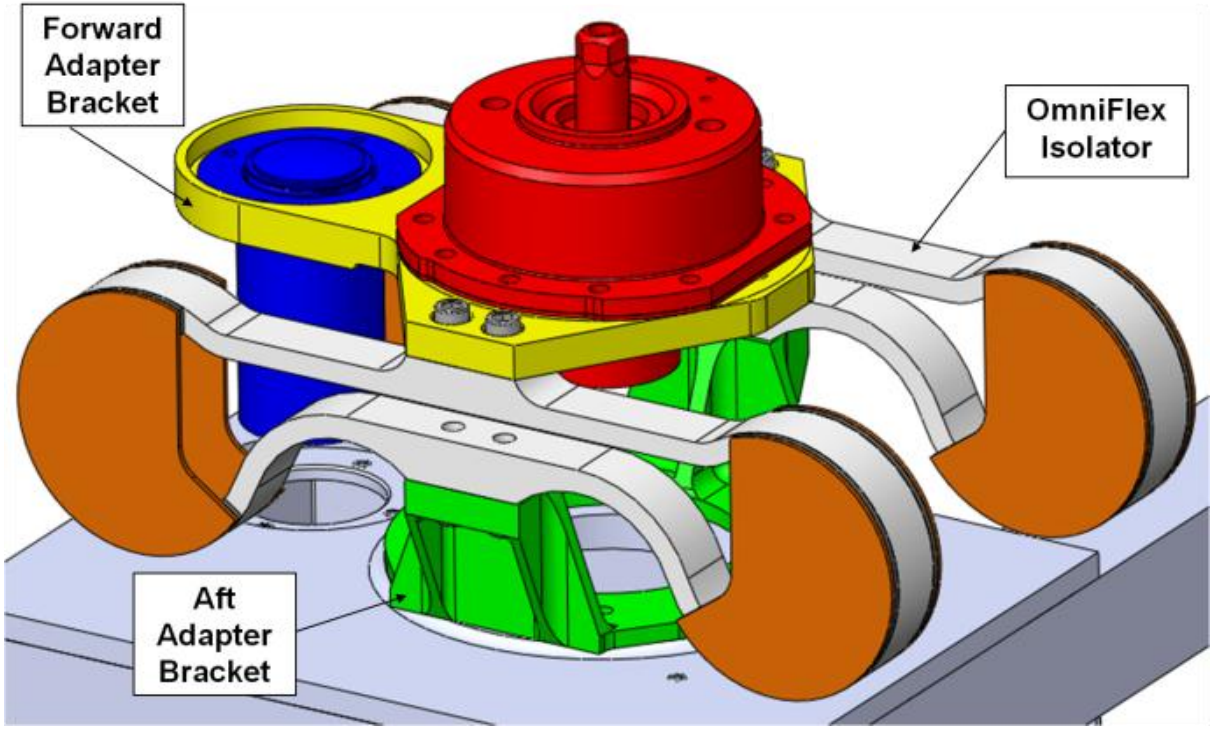
SoftRide Systems can greatly reduce spacecraft dynamic responses, significantly saving time and money

OG2 Configuration in Trunk



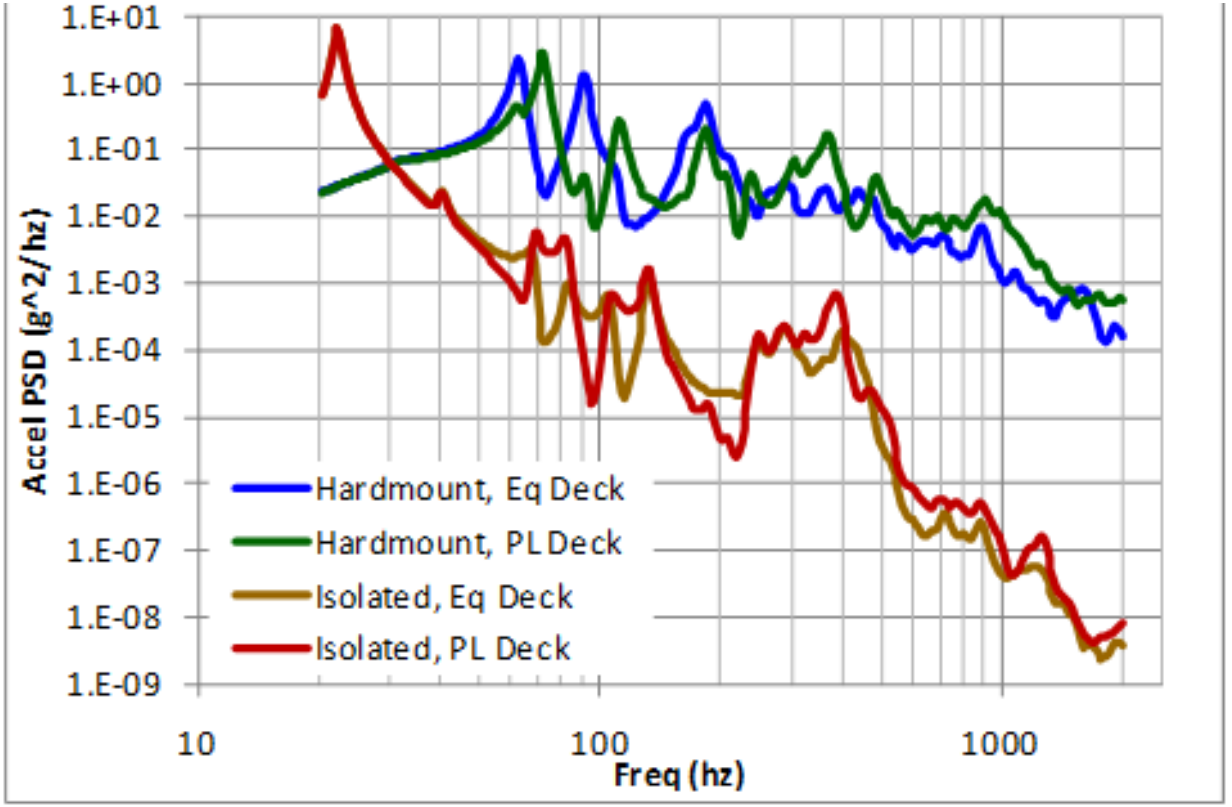
- FE model of original concept
  - Two OG2 spacecraft on truss within Trunk
- To implement SoftRide system, two locations were considered
  - Base of truss system to isolate both payloads simultaneously
  - Discrete 4-point mount under each spacecraft

Four-point Isolation with SoftRide OmniFlex



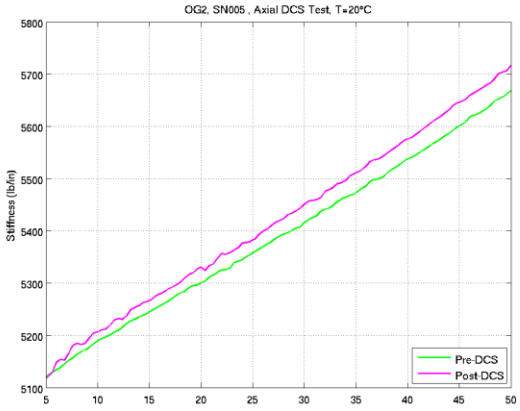
- Base of each OG2 was selected due to strict stay-out zones in truss
- Each spacecraft had plenty of “head-room” to accommodate SoftRide and required adapter brackets
- Push-off springs on truss were moved to forward bracket which also housed sep-nut
- Two OmniFlex isolators with high damping “float” payload above truss

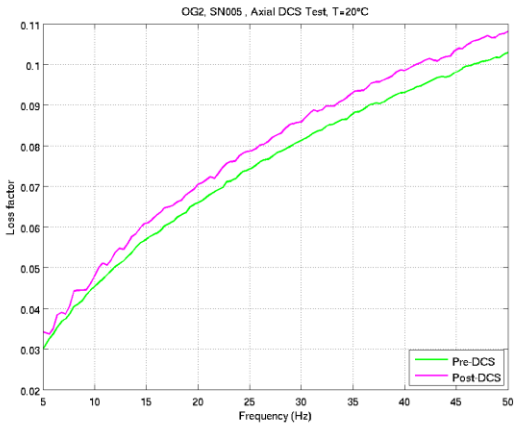
System Analysis with SoftRide

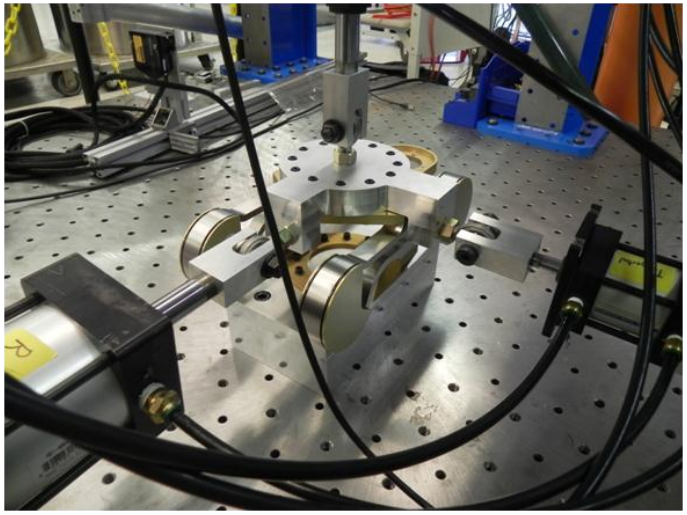


- Payload and equipment decks average responses compared
  - Hard-mounted and isolated
- Isolated case provides roll-off of vibration response
- Roll-off helps protect sensitive components on OG2 spacecraft
  - Especially in high frequency bands
- High response at 22 Hz is “bounce” mode of OG2 on isolators
  - Highly damped mode due to damping treatment on isolators

SoftRide Component Testing

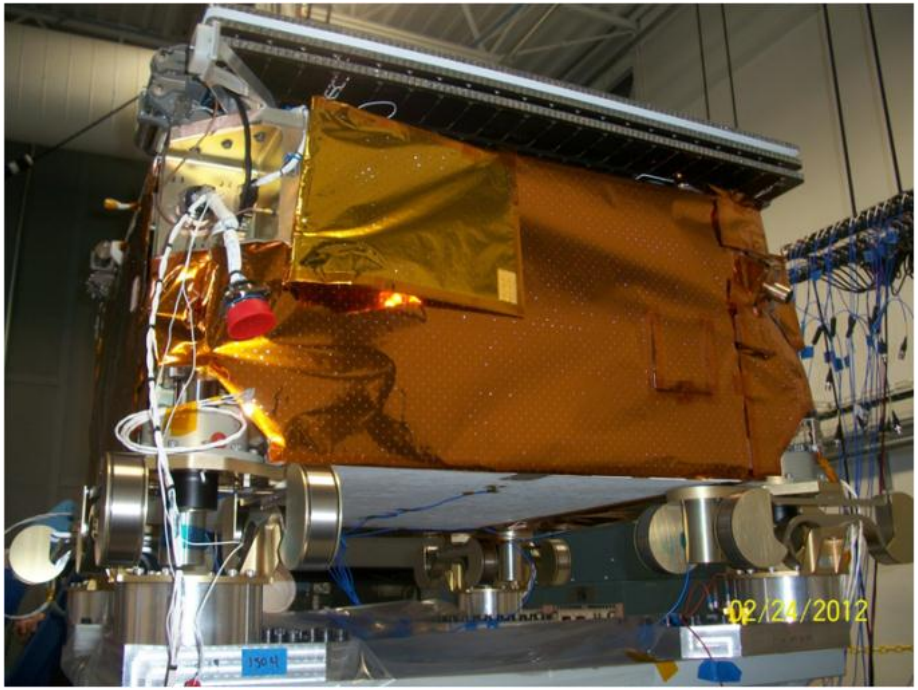


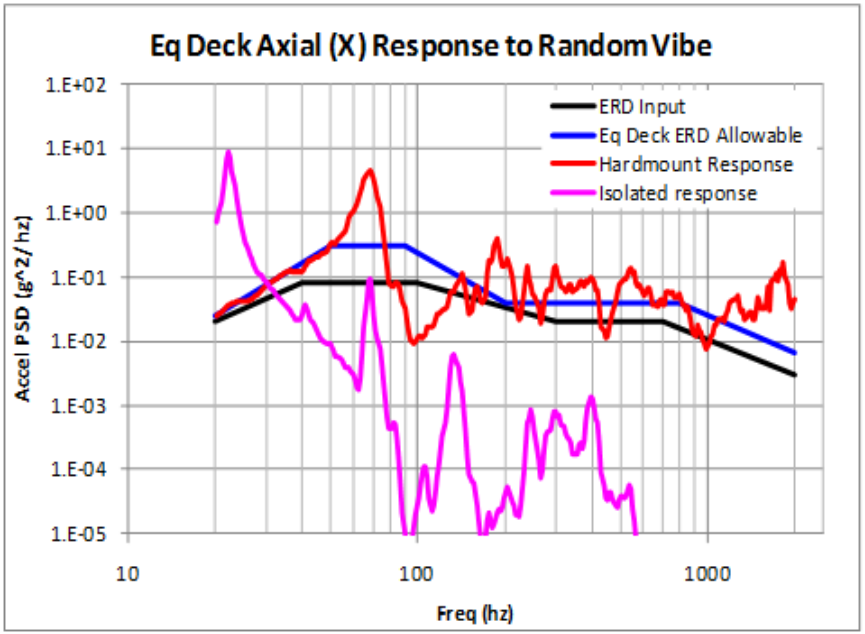




- All SoftRide isolators are characterized through testing to determine:
  - Stiffness of isolator as function of frequency
  - Loss factor (damping) of isolator as function of frequency
- Qualification isolator assembly was also subjected to three-axis (simultaneous) load test to ensure that spacecraft-to-launch vehicle connection would remain intact

OG2 System Testing on SoftRide





- SNC conducted tests of OG2 on shaker table early 2012
- Comparisons between hard-mounted test and SoftRide test are compared

Conclusion

- Falcon 9 LV can launch small spacecraft by utilizing excess capacity in Trunk
- Random vibration environment provided in Trunk could be more severe than expected
- SoftRide whole-spacecraft isolation system can solve these (and more) vibration problems