Launch Vibration Isolation for CubeSats

David Pignatelli
Aerospace Engineer – CubeSat Program
California Polytechnic State University, San Luis Obispo

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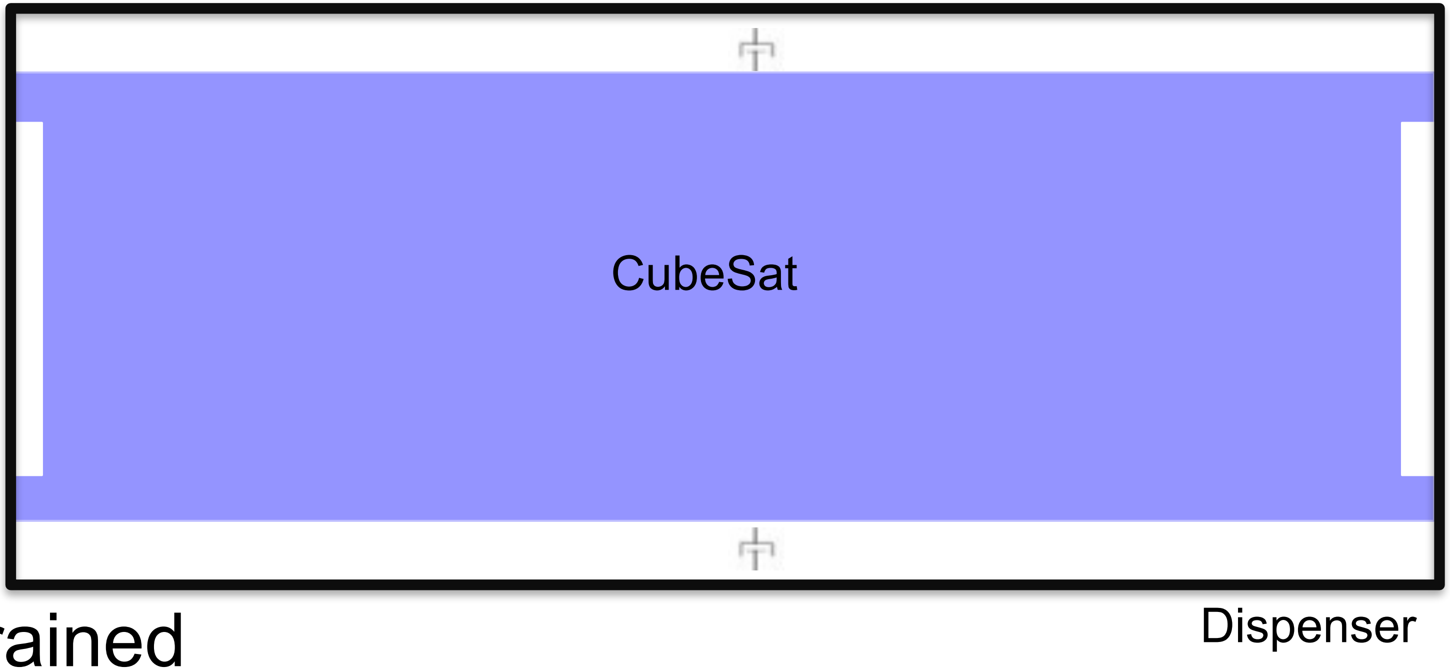
Motivation

- Launch vehicle environments are very severe
- Industry desire to rigidly constrain payloads to allow for analyzable environments
- Ideal dispenser provides isolation and an analyzable load path
  - No effect on launch vehicle mounting interface or static envelope requirements
  - No effect on CubeSat Design Specification

Credit: ULA

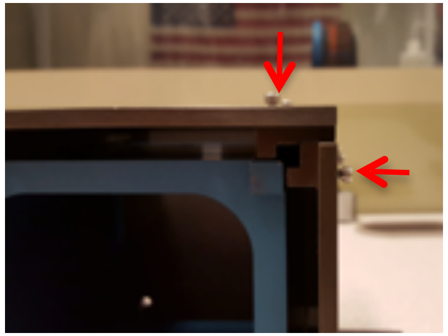
Current Constraints in P-POD

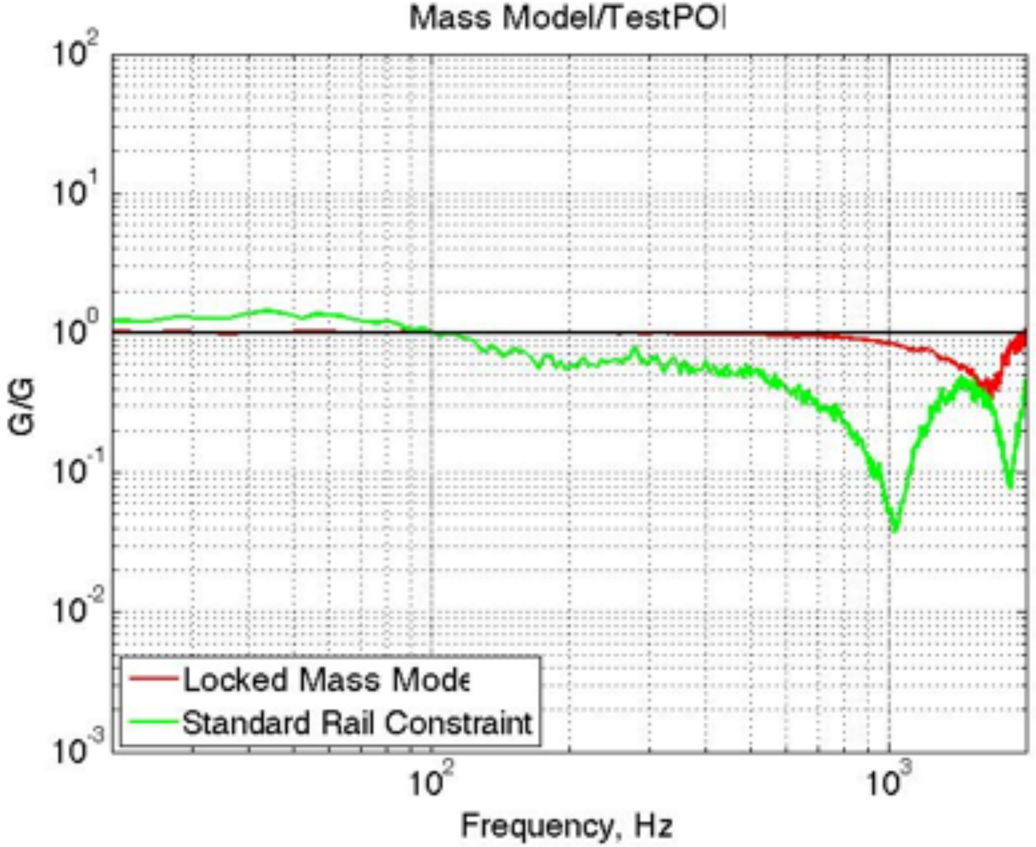


- Z-axis constrained
  - Results in P-POD dynamics driven into CubeSats
- X/Y-Axis unconstrained
  - Results in isolated, damped “rattle” inside the P-POD
  - Difficult to analyze

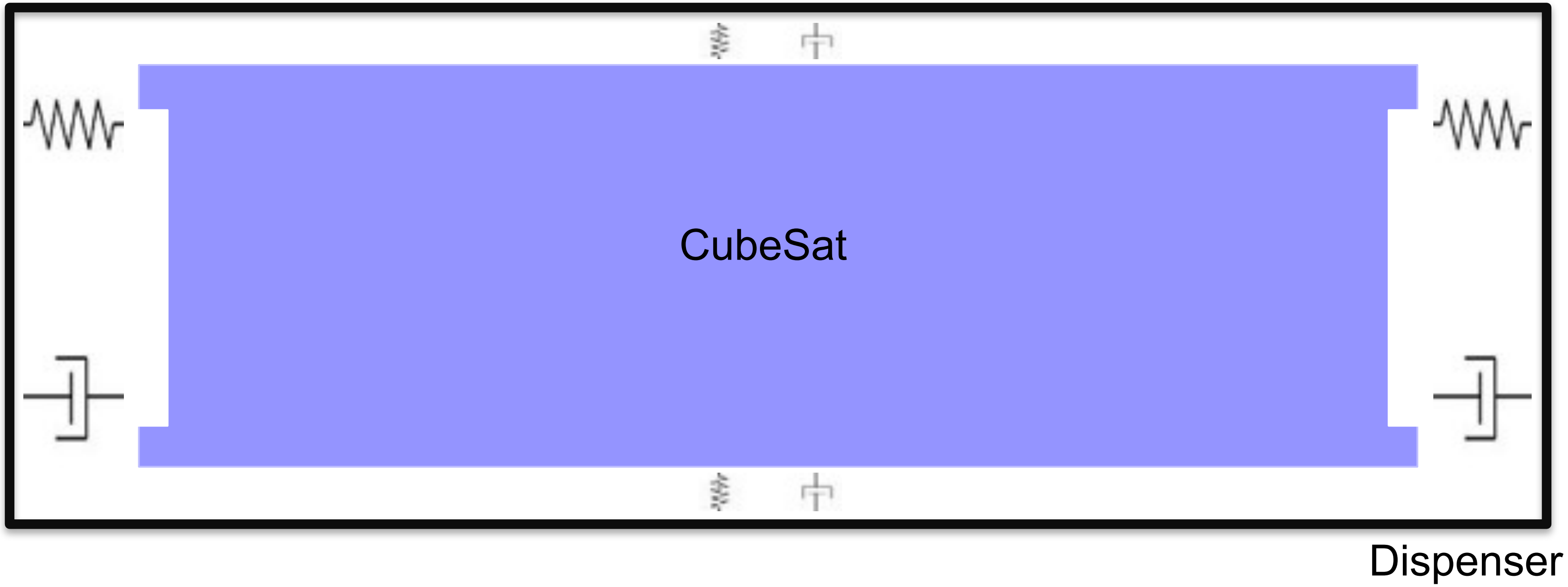
Rigid Constraint vs. Loose Environment

- Modified 1U Test-POD to rigidly constrain 1U Aluminum Mass Model
- Test-POD transmits significantly less energy in the loose case
- Input: 13.89 G_{rms}
  - **Rigid: 37.5 G_{rms}**
  - **Loose: 8.5 G_{rms}**



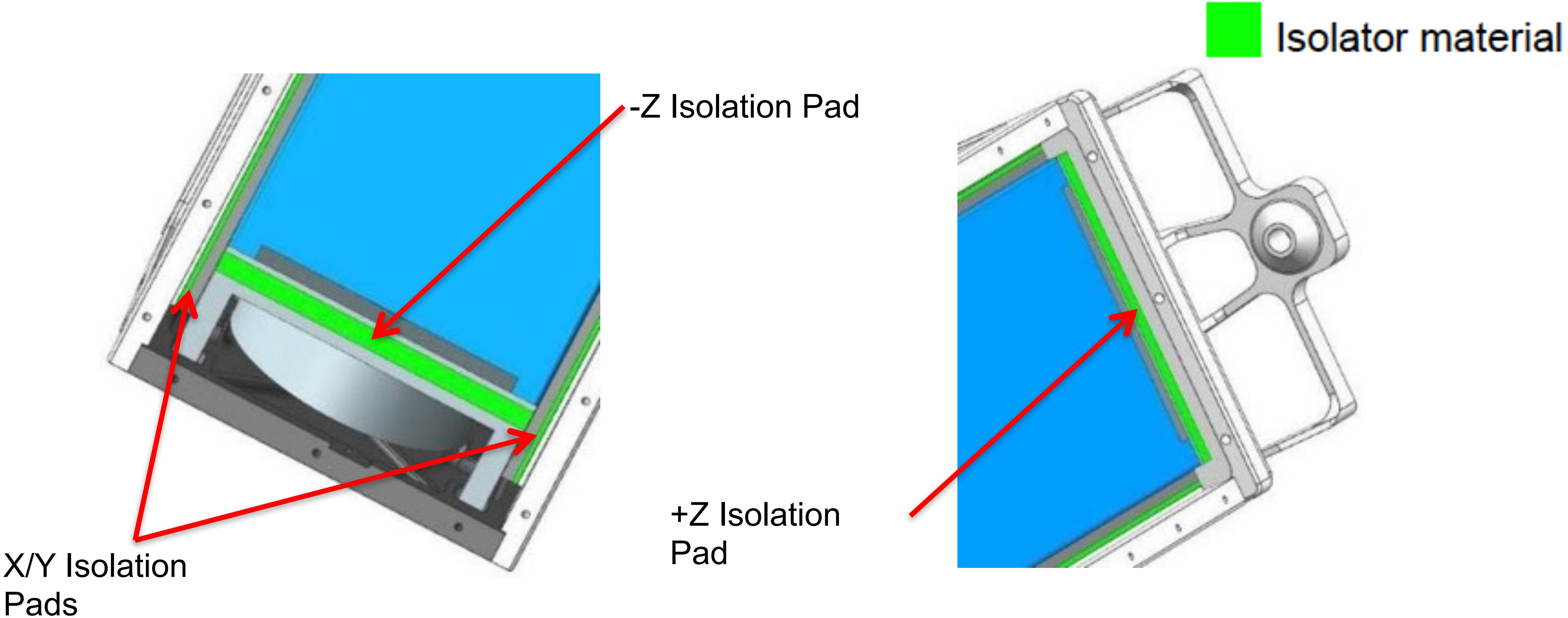


Conceptual Design for Isolation (1)



- Fixed Z-Axis constraint replaced with damped isolator
- Isolation material can be incorporated into dispenser rails to mitigate the impact of the CubeSat rattling
  - Results in truly isolated system

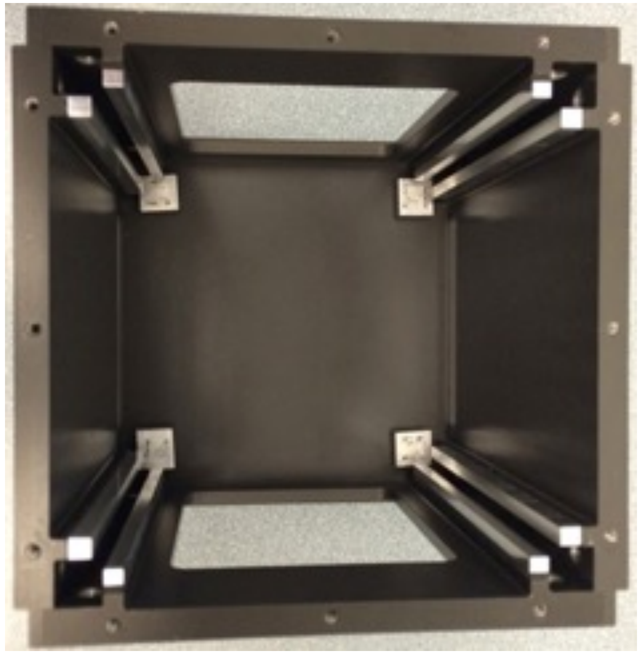
Conceptual Design for Isolation (2)



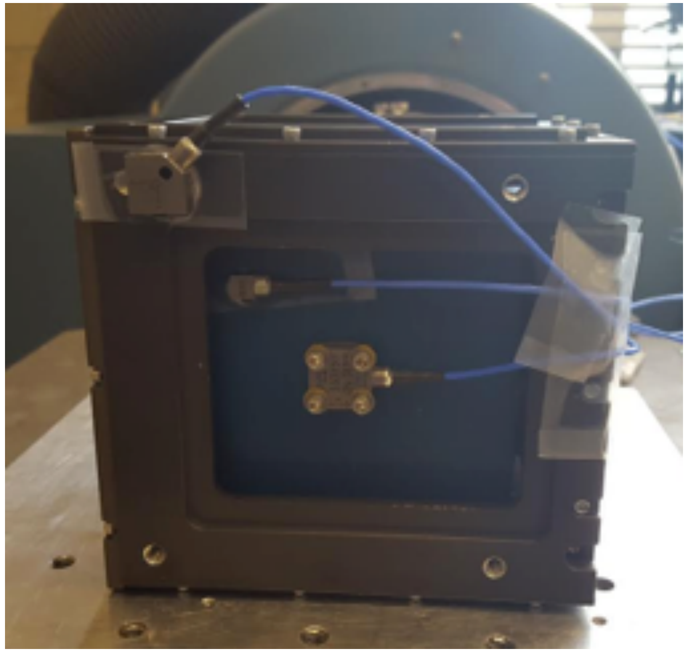
- Isolation Pads are laser cut to size and adhered to the P-POD with low outgassing adhesive
- CubeSat contacts anodized aluminum on all 4 sides
- System can be adapted to fit any rail-type dispenser

Low Outgassing Foam X/Y-Axis Test Setup

- 1 kg 1U Aluminum Mass Model integrated into 1U Test-POD
- Shock accelerometer hard-mounted to 1U Mass Model
- Vibration Response accelerometers mounted with super-glue to the 1U Test-POD and 1U Mass Model



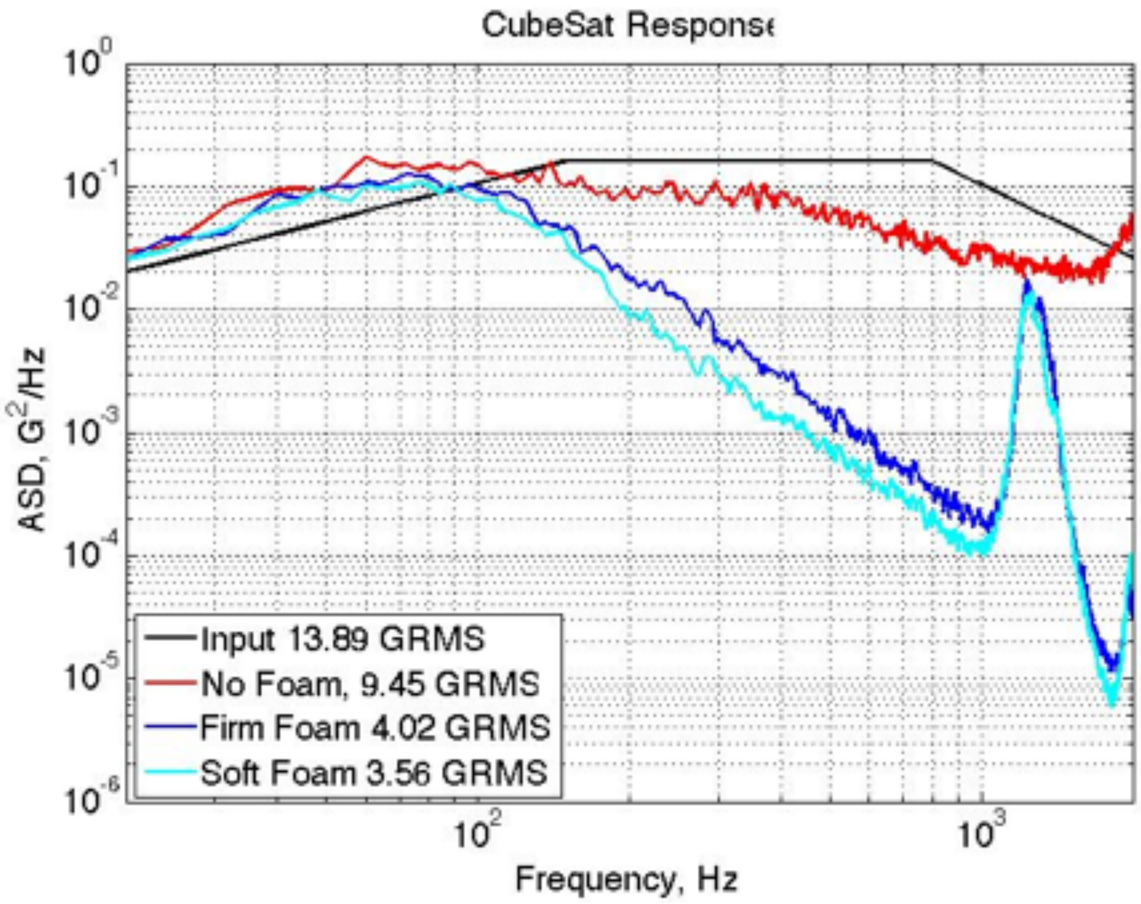
1U Test-POD with soft rails



1U Test-POD Setup

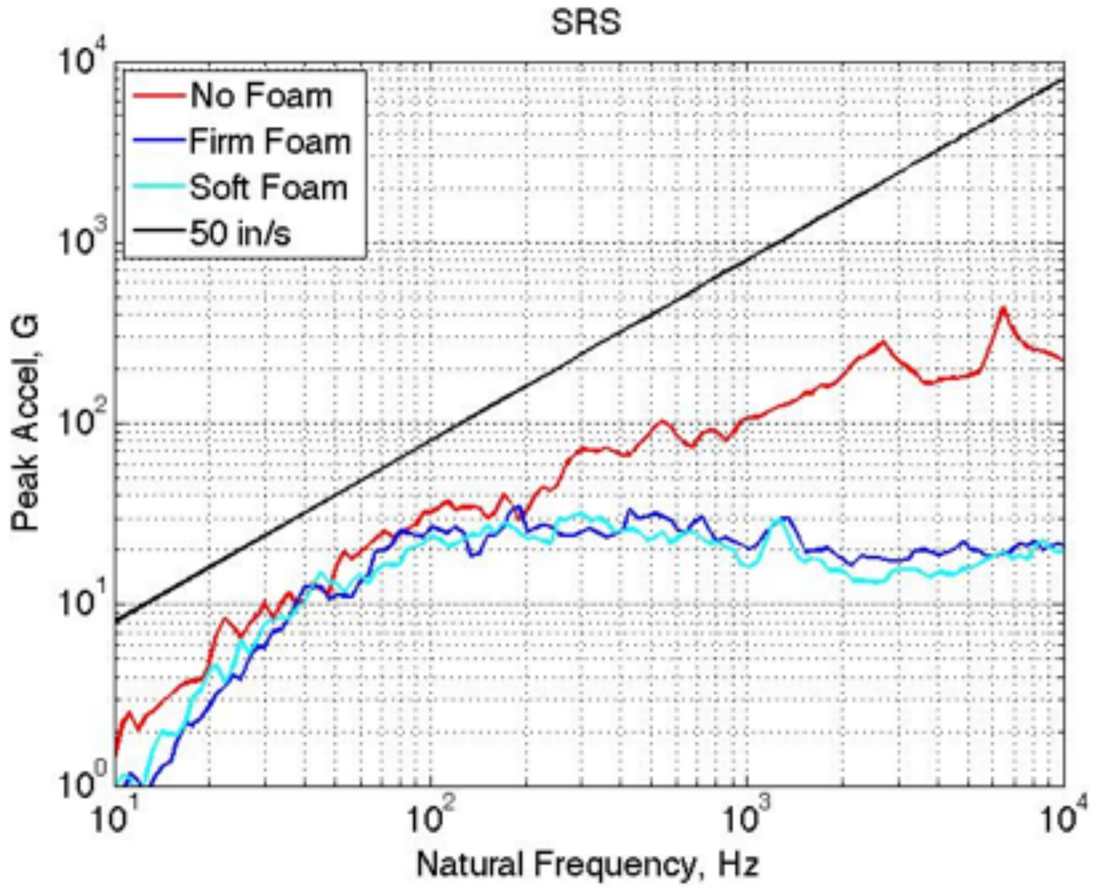
X/Y-Axis Random Vibration Mass Model Response

- Significant isolation observed from implementing foam rails
- Both foams exhibit isolated roll-off
- Test-POD mode is transmitted to the Mass Model with the foam, but not without
  - Foam allows additional degrees of freedom



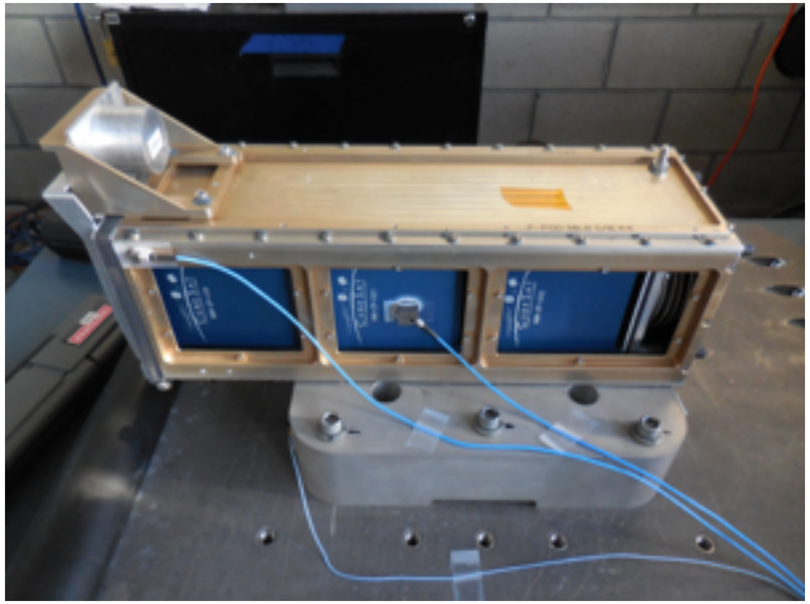
X/Y-Axis Shock Mitigation

- Foam provides significant shock attenuation above ~1000 Hz
- Firm foam performs similarly to the softer foam in shock mitigation
  - Less impact on design to maintain payload dynamic envelope with firm foam

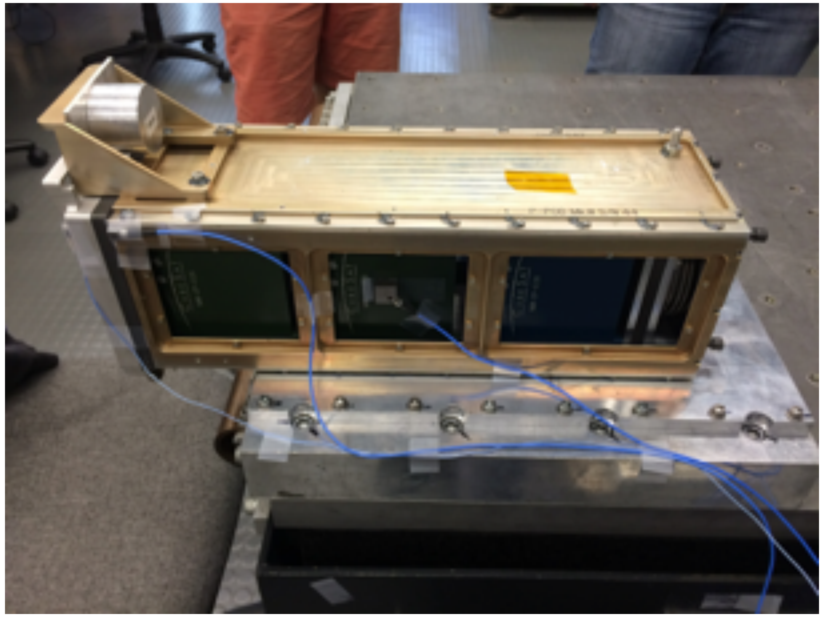


Low Outgassing Foam Z-Axis Test Setup

- P-POD Mk. III Rev. C Integrated with 3 1U Aluminum Mass Models
  - Thicker foams required modified pocketed door
  - -Z Back Panel Screws were used to control initial foam compression
- Foam placed on P-POD door and P-POD Pusher-Plate
  - On +/-Z interfaces of CubeSats
- Measurement accelerometer on P-POD and Middle 1U Mass Model



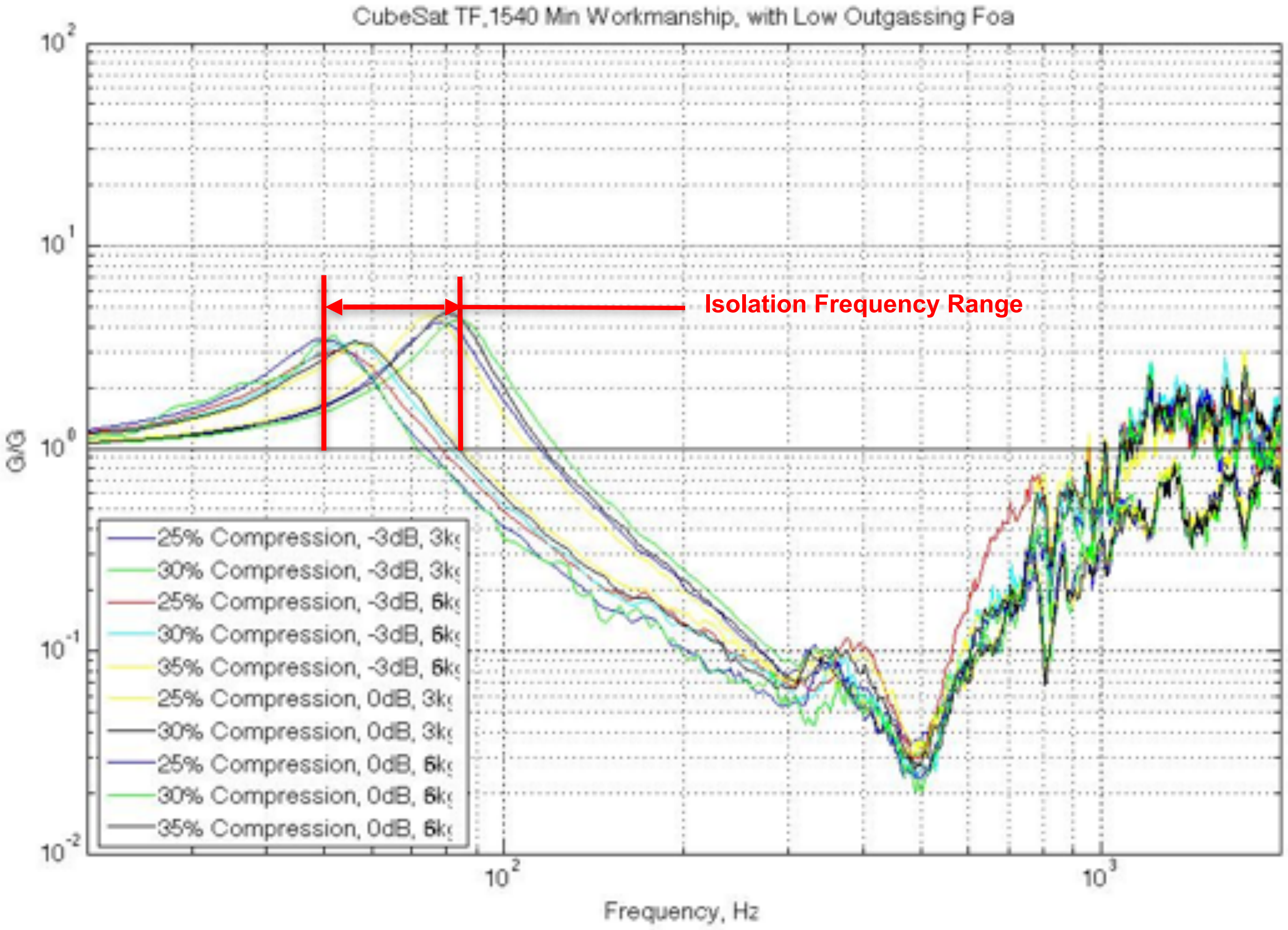
Z-Axis Test Setup



Z-Axis Test Setup with Modified Door

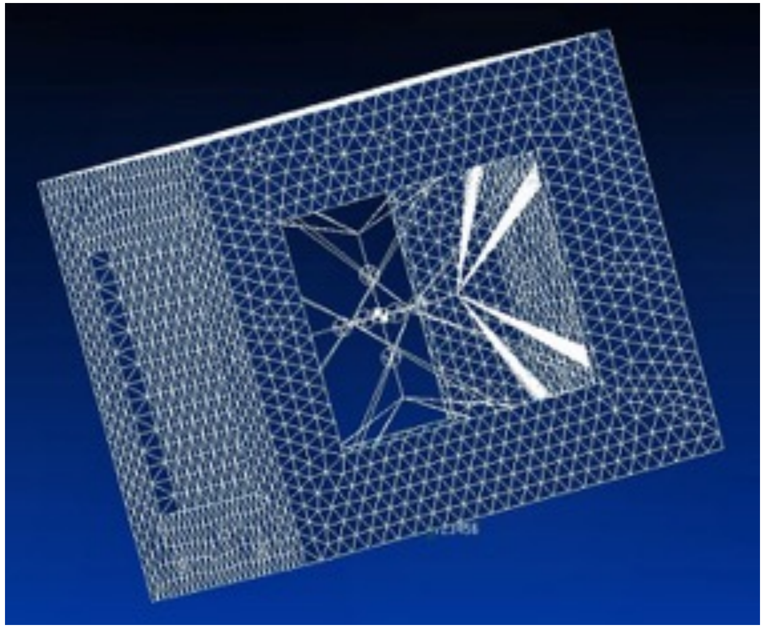
Z-Axis Random Vibration Mass Model Response

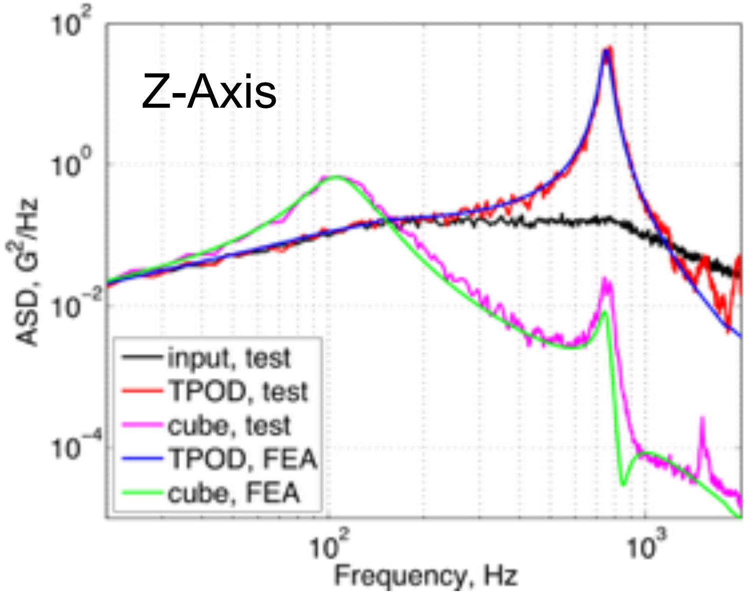
- Significant attenuation of loads beyond isolation frequency
- Isolation frequencies range from 50-82 Hz, depending on:
  - Payload mass
  - Environment magnitudes
  - Initial compression of foam
- Objective is to envelope likely range of levels

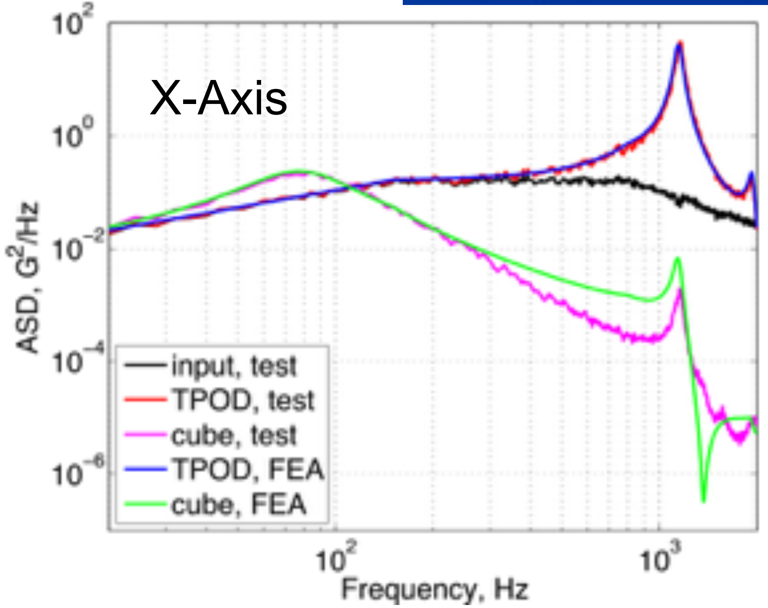


System Analyzability

- 1U Test-POD FEM with mass element payload
  - RBE3 and CBUSH elements used to constrain payload
  - Damping and CBUSH stiffness values derived from test data
- 1U Test-POD integrated with 1kg Mass Model
  - Foam attached to rails

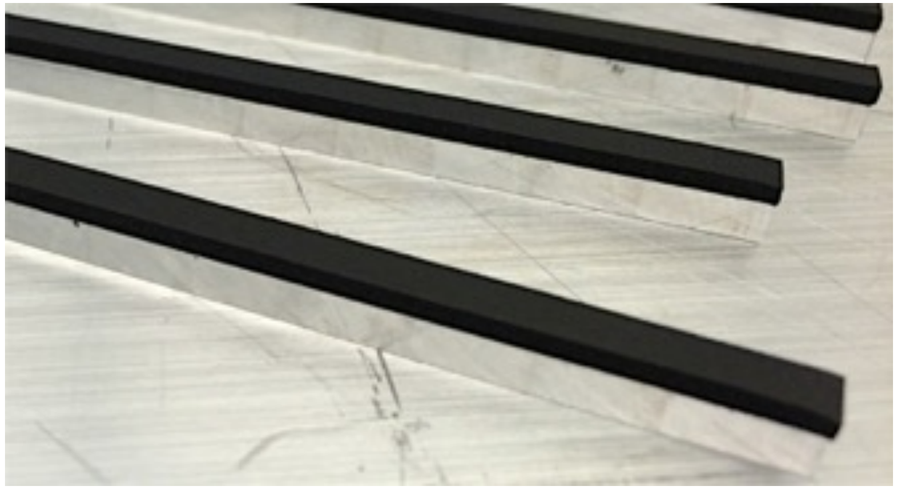


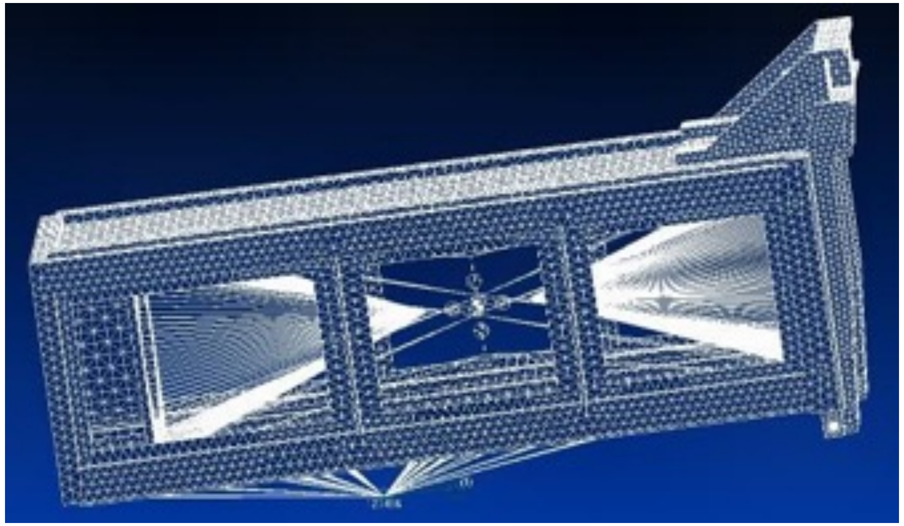




Looking to the Future

- Analysis to predict levels for specific launch vehicle environments
- Implementation in Tyvak 6U Dispenser
- Design qualification and deployment testing
- Flight





Conclusion

- Not pursuing a locked-down constraint on the P-POD
- System builds upon the isolation currently provided
- Isolation design requires no changes to the LV interface
  - Ready for implementation now!