Summary

- ESPA 6U Mount (SUM) overview
- SUM qualification status
- Future SUM enhancements
- Moog CSA adapters and ESPA family

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ESPA Six-U Mount – SUM

- Adapter with ESPA standard interface for CubeSat launch
  - Compatible with standard ESPA port interface, Athena II Rideshare Adapter, CubeStack, Atlas V Aft Bulkhead Carrier
  - Prototype developed 2009

- Mounts two PPODs or one 6U dispenser
  - Inboard or outboard mounting on ESPA port
  - Inboard mount shares port with exterior mounted ESPA-sat

- Enables increased capacity for ESPA
 - Six 400-lb satellites and twelve 3U satellites
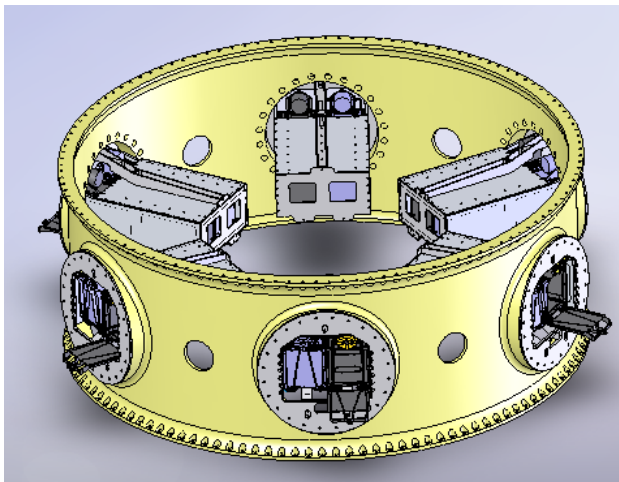
Prototype SUM with one PPOD

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ESPA SUM Status

- Stiffness driven design complete
  - 1st mode at 150 Hz to minimize launch dynamics
  - Predictions with maximum weight CubeSats
- August 3 Critical Design Review
- Manufacturing in progress
- Qualification program for NASA Launch Services Program
  - Environment requirements for ESPA payloads defined in Rideshare User's Guide (RUG)
  - Testing in October

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ESPA Inboard and Outboard Mounting

- ## SUM mounts CubeSats internally or externally on ESPA
  - Inboard configuration utilizes ESPA interior
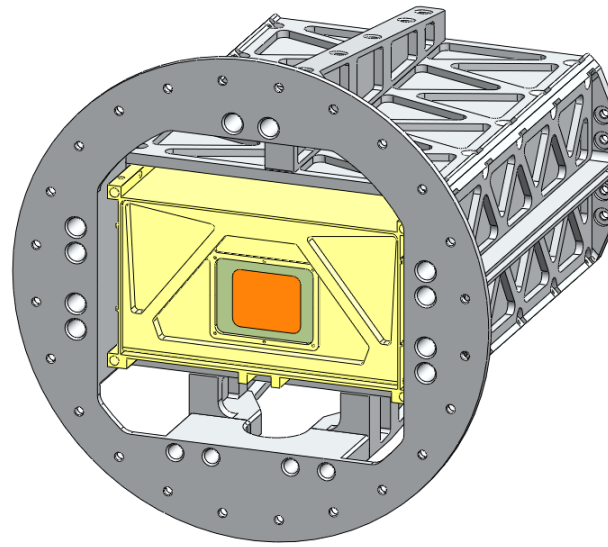 - Outboard configuration mounts to port
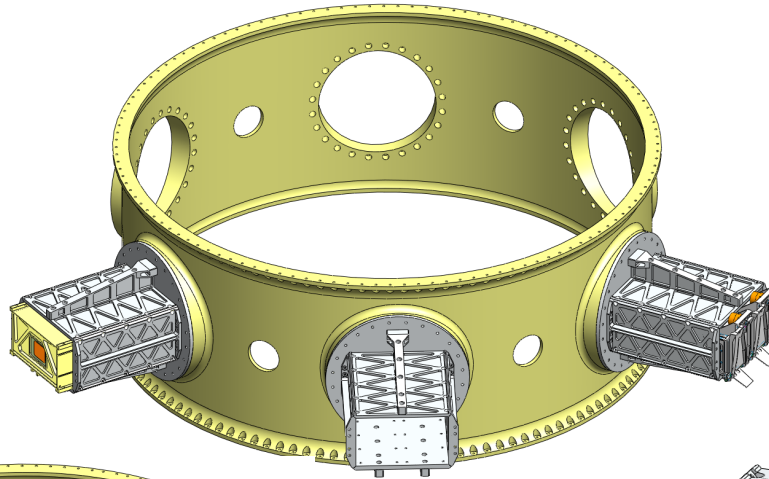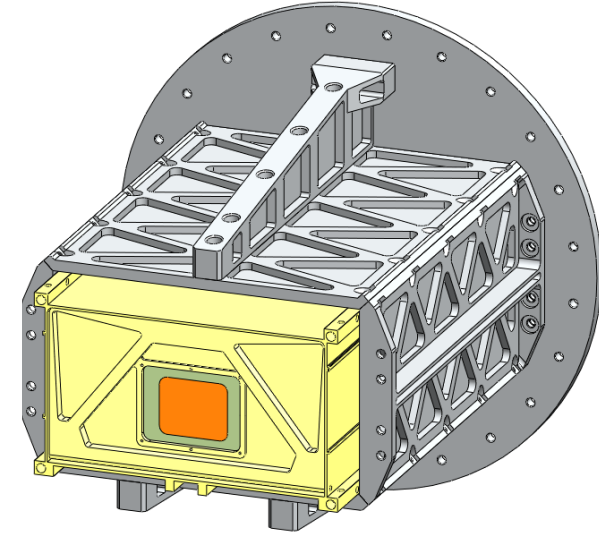

OUTBOARD MOUNT
28.3 lbs
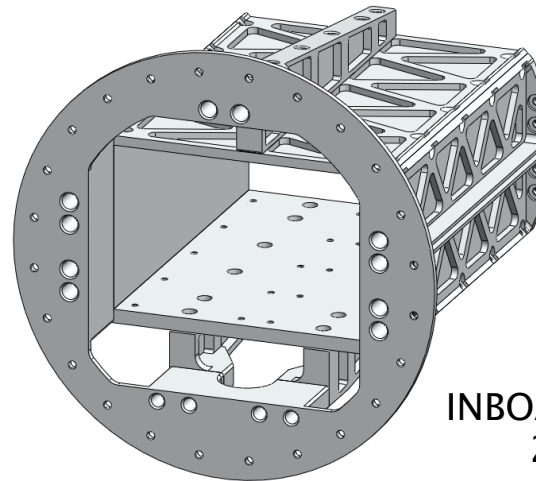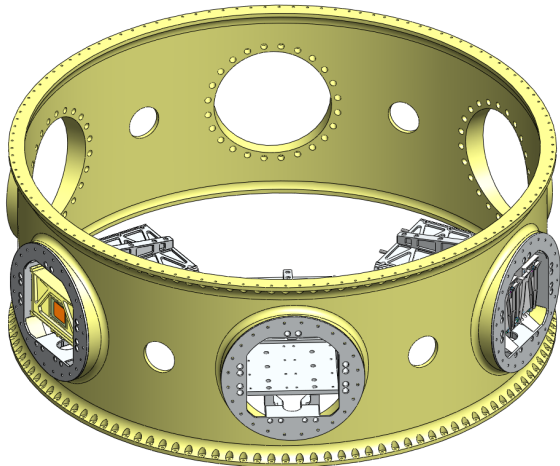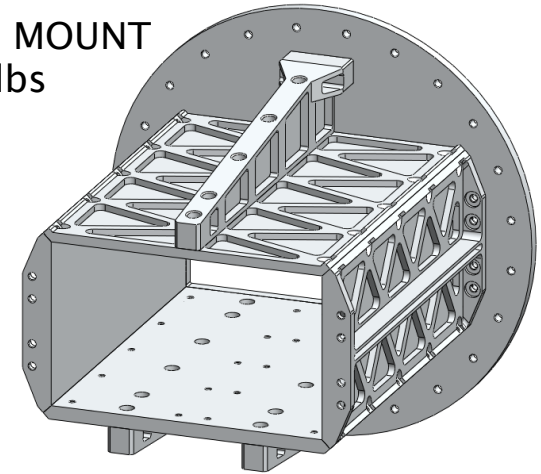
INBOARD MOUNT
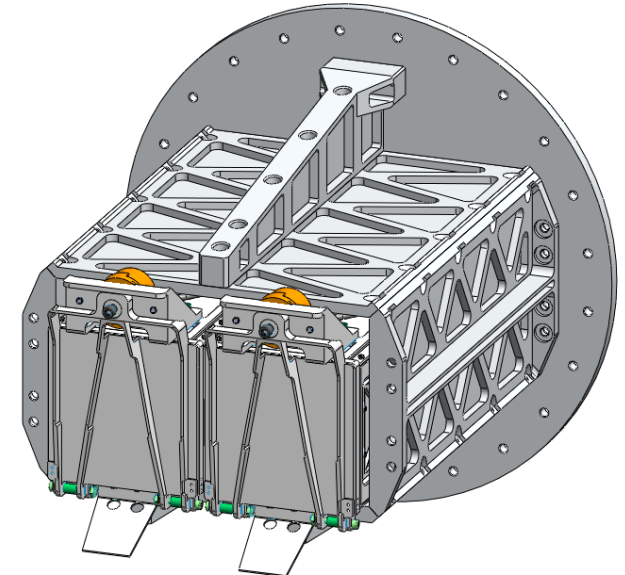29.0 lbs

SUM with CubeSat Dispensers

PSC 6U Dispenser

INBOARD MOUNT

OUTBOARD MOUNT

Cal Poly PPODs
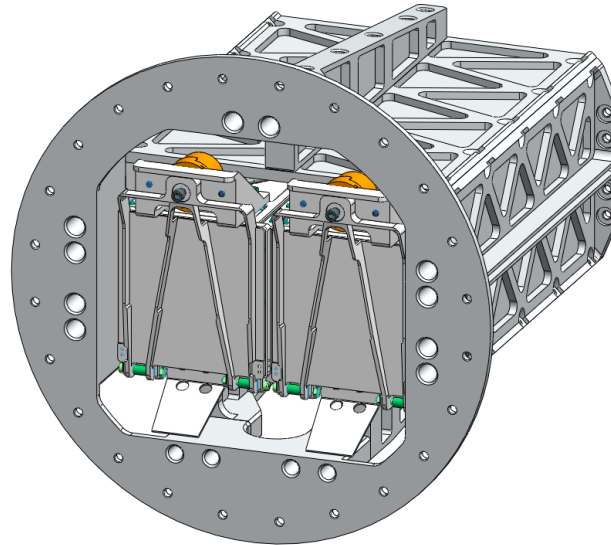
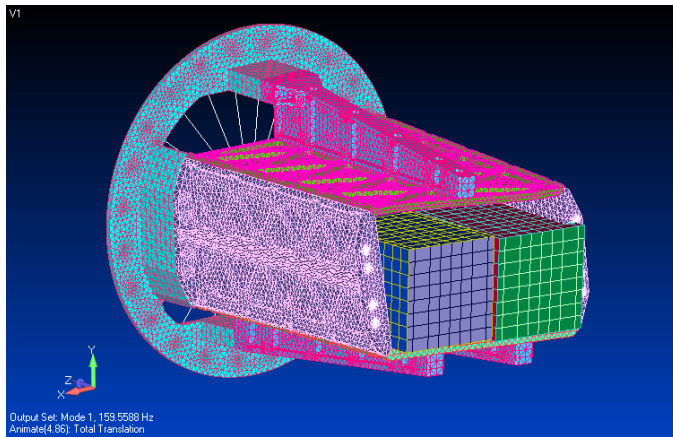# Dispensers Mounted in ESPA with SUM

PSC 6U Dispenser

Inboard mounting

Cal Poly PPODs

Outboard mounting

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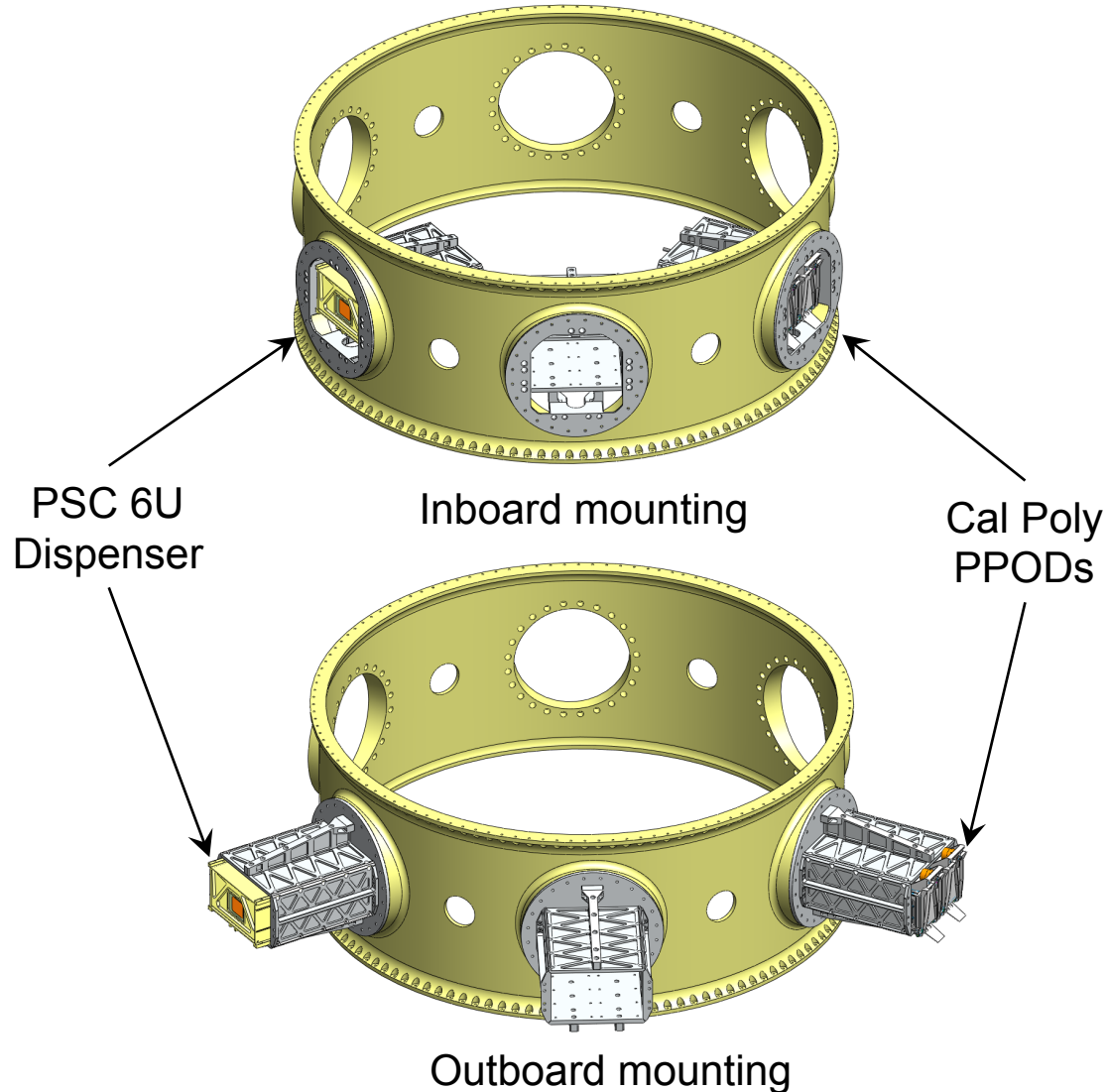
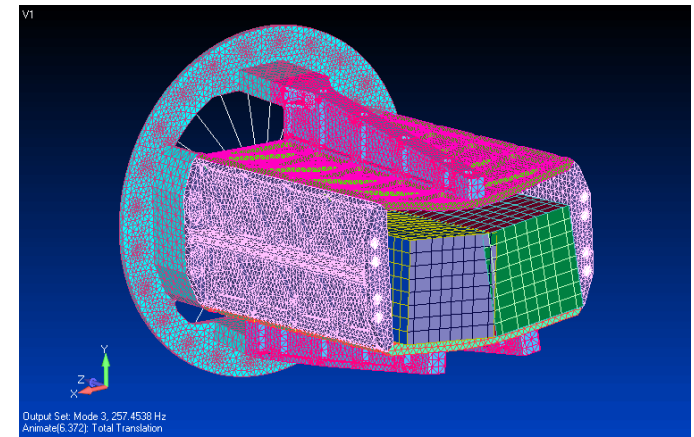# Inboard Configuration Vibration Modes

First structural mode for inboard configuration is 159 Hz
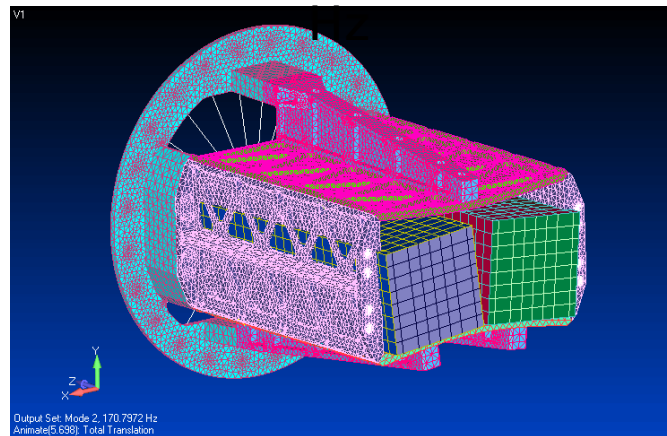
Mode shape deformations are greatly exaggerated

Mode 1: 159 Hz

Mode 2: 171 Hz
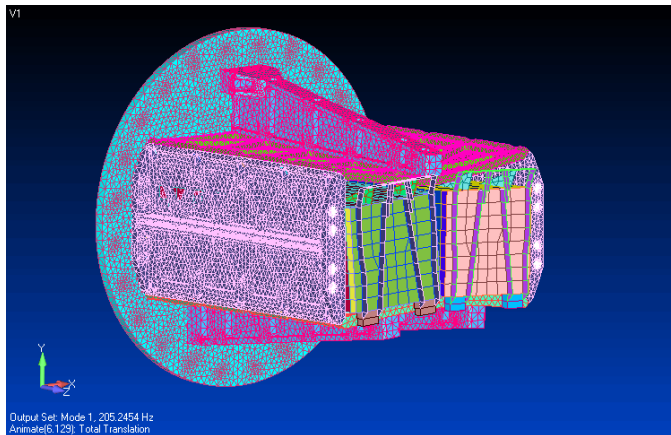

Mode 3: 257 Hz

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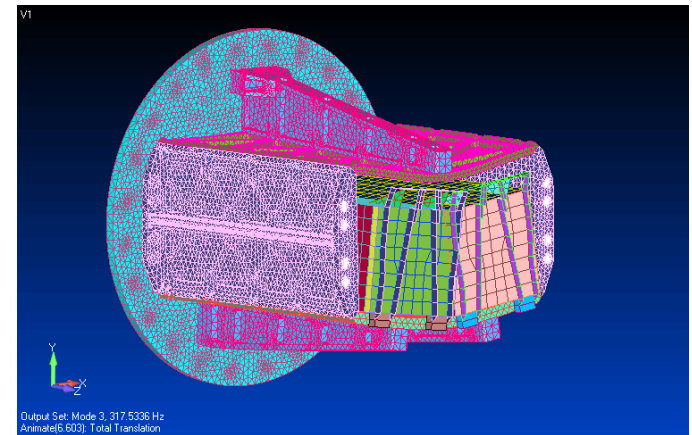# Outboard Configuration Vibration Modes

First structural mode for outboard configuration is 205 Hz
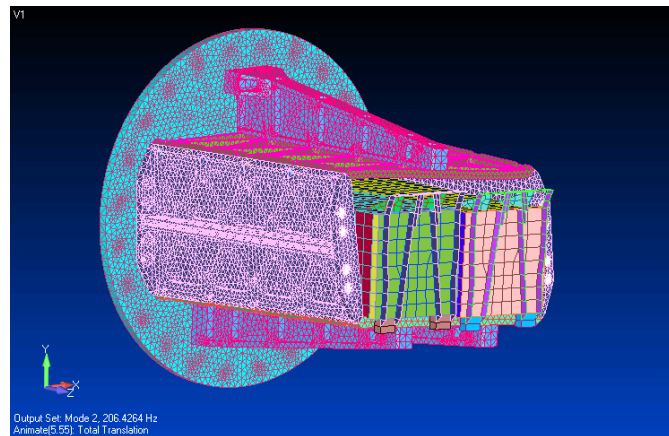
Mode shape deformations are greatly exaggerated


Mode 2: 206 Hz

Mode 1: 205 Hz

Mode 3: 318 Hz

Strength Analysis

- Analysis performed with maximum weight CubeSat simulators inside PPOD models

- Static analysis with ESPA Rideshare User's Guide (RUG) quasi-static load factors
    - 8.5g in thrust axis and 8.5g lateral
    - No-test factor of safety = 2.0

- Random vibration analysis with RUG maximum predicted environment + 3 dB (16.2 grms)
    - Crest factor of 3.0 applied to stress RMS levels to predict peak Von Mises stresses
    - 2% critical damping used for analysis
    - Test safety factors: FS_y =1.25; FS_u = 1.4

- All stress margins positive due to RUG loads

PPOD configuration allows bending of baseplate
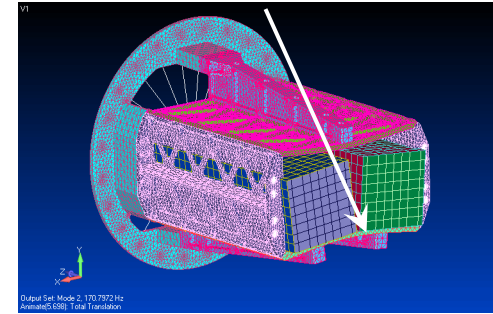
6U dispenser stiffens SUM in this region

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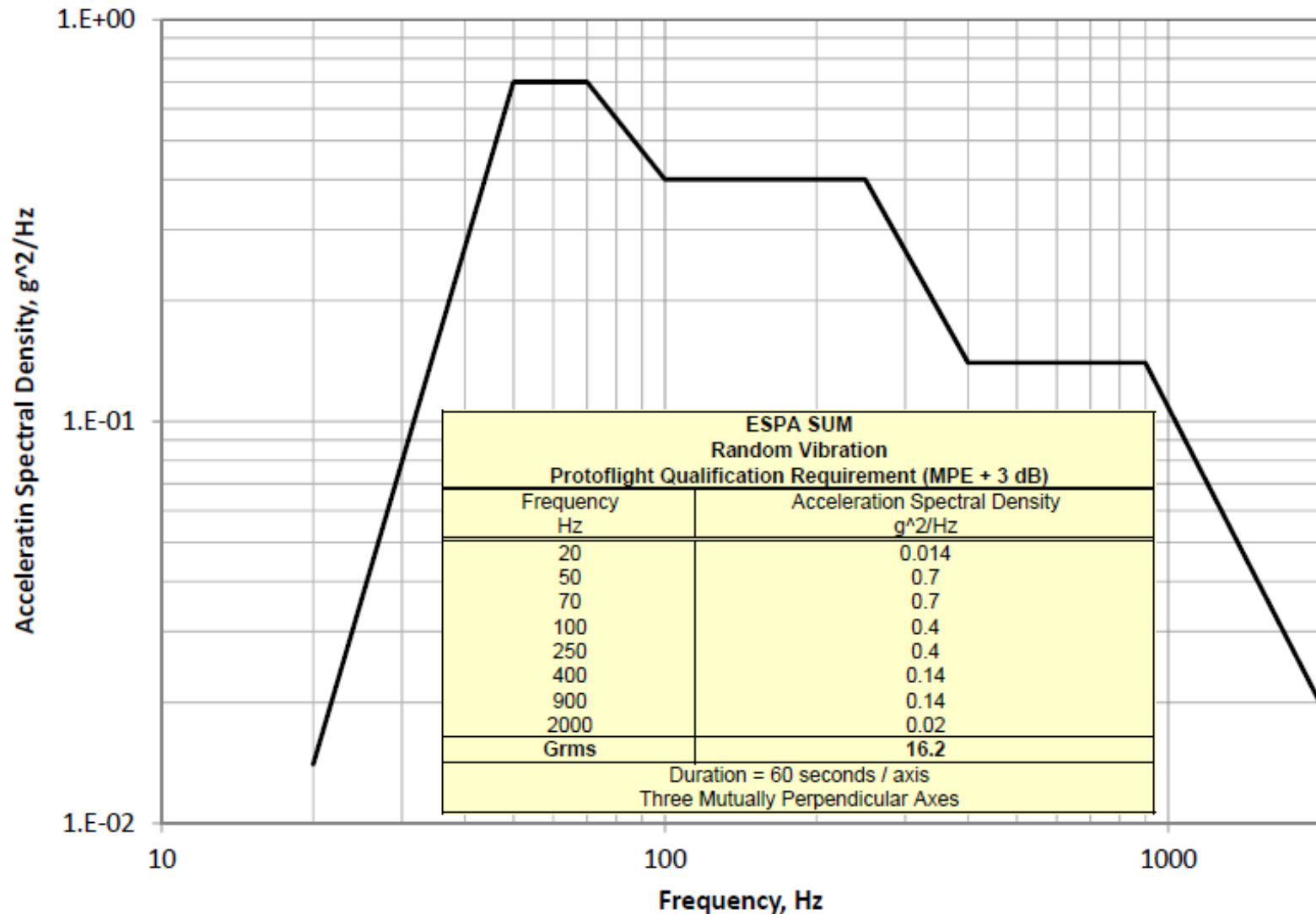
RUG Static Loads Analysis

- Two static load environments applied to SUM with two P-PODs
  - -8.5g in Y direction and 8.5g in Z direction
  - -8.5g in Y direction and 8.5g in X direction
- Body loads applied in Nastran
  - GRAV feature with appropriate scale factors

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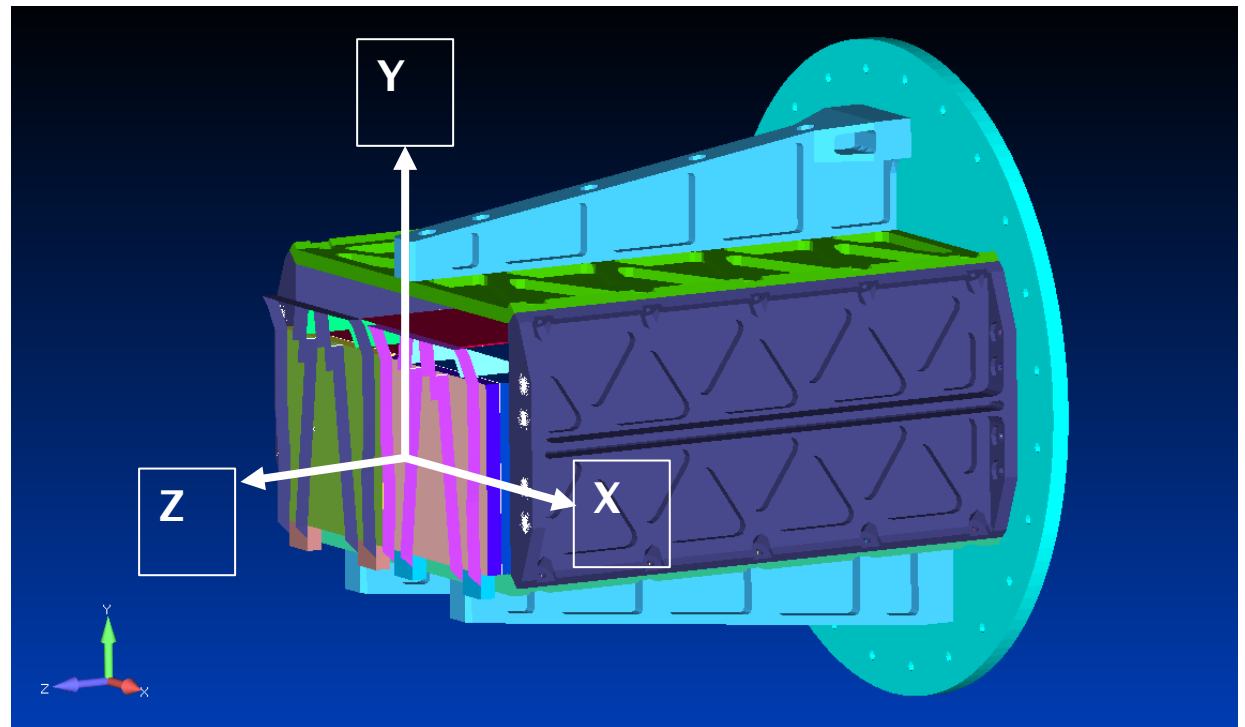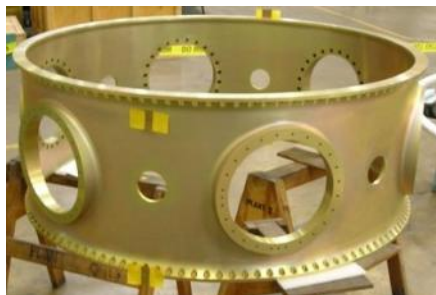
RUG Random Vibration Protoflight Profile

Vibration spectrum for analysis and demonstration test

Planned SUM Enhancements

- ESPA 24" port version, 12U capability
- Compatibility with NASA Ames and NASA GSFC/Wallops dispensers
- SoftRide interface for loads mitigation

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Moog CSA Payload Adapters

ESPA

Flat Adapter

CASPAR

CubeStack

LCROSS ESPA

DSX ESPA
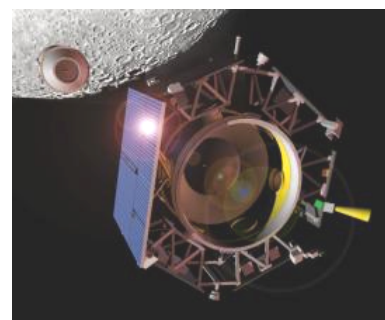
ESPA as Bus: LCROSS

ESPA Grande 42

SepESPA Saab

ESPA Variations

ESPA with secondary payloads and propulsion system
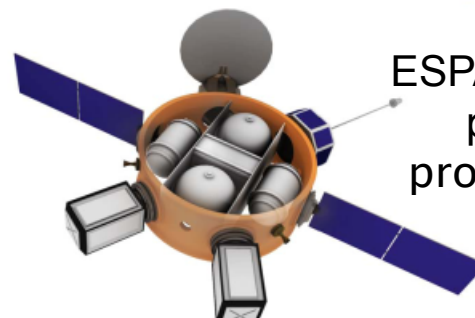
CubeSat Deployment Sequencer

- Moog IRAD multi-payload sequencer
  - Modular architecture
  - Compatible with PPOD, PSC, SNC, RUAG systems
- Moog IRAD multi-payload sequencer
  - Modular architecture
  - Compatible with PPOD, PSC,

- Prototype at Moog Small Satellite exhibit
- In progress
  - Circuit and code development
  - Battery testing
- Prototype at Moog Small
  -

Next

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Athena Commercial Rideshare

LOCKHEED MARTIN
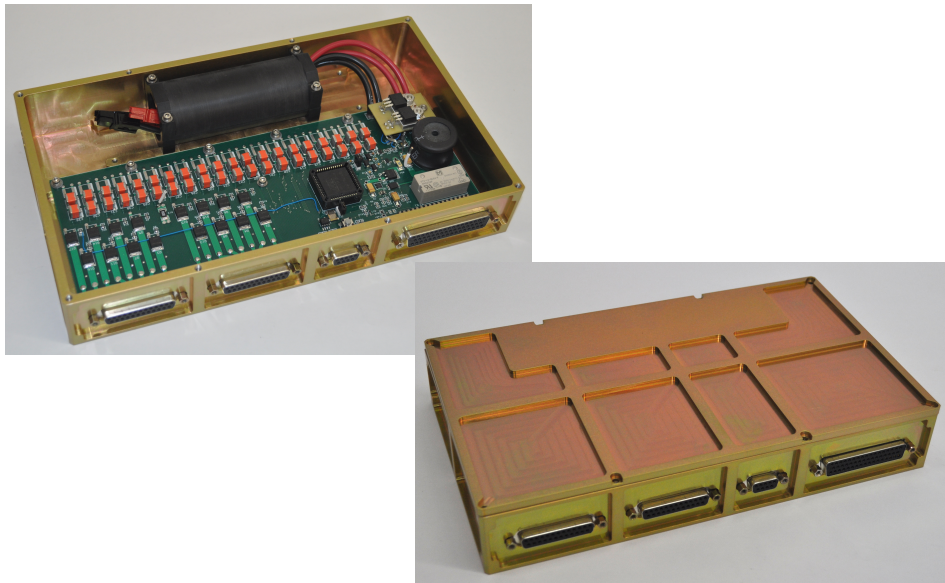
- Athena IIc annual launches for small satellites
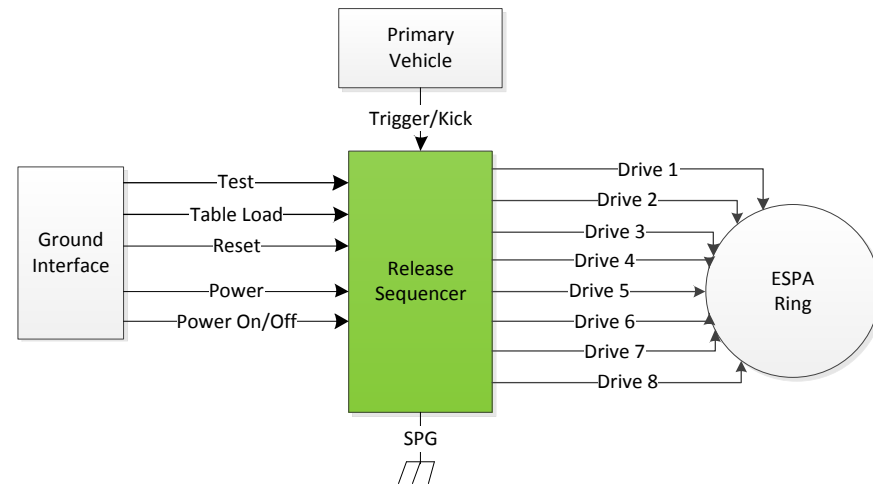 - STPSat3 Feasibility Assessment completed for DoD Space Test Program

- Moog CSA payload accommodations
  - Modular multi-payload adapter
    - 4-9 rideshare satellites, 110-440 kg spacecraft
    - Options for CubeSats and heavier spacecraft
  - SoftRide isolation of adapter and payloads
    - Reduced launch environments
    - Vehicle has similar dynamics with various payload stacks
  - Coupled loads analysis for environment predictions

- Athena Rideshare Users Meeting 10am Monday Aug 13 Eccles Science Learning Center RM 046

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CubeStack
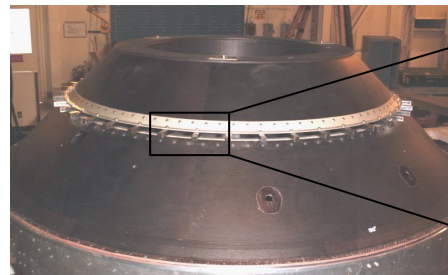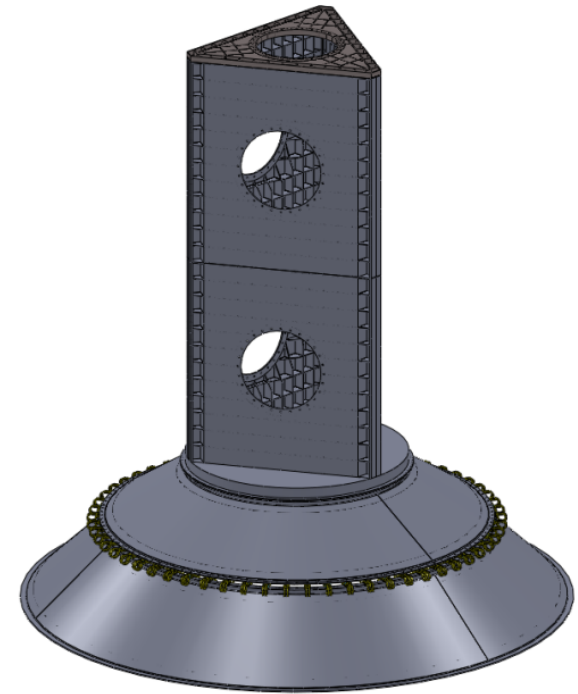
- CubeSat adapter by LoadPath and Moog CSA
  - AFRL Space Vehicles Directorate contract
- Satellites in 10-inch "wafer" between payload interface and primary
  - Primary interfaces at 24 and 38.8 inches
  - Eight 3U dispensers or combinations of 3U and 6Us
- Qualification program complete
  - Flight units available
- Two flight structures ready for delivery
  - Manifested on ORS 3 launch 3rd quarter 2013
- Second generation CubeStack design
  - Bulkhead configuration eliminates lower deck
  - Weight reduced by 15%-20%
  - Improved access for integration
- CubeStack propulsion module
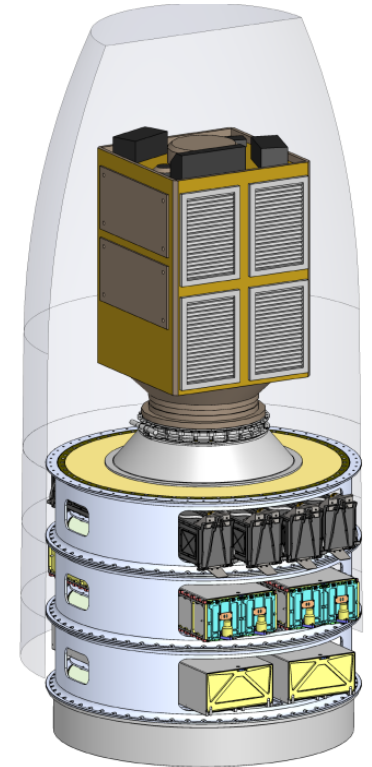
8-PPOD configuration

Conclusion

- SUM is one of several new adapters developed for or compatible with CubeSats
- SUM Critical Design Review complete, proceeding into manufacturing
- SUM flight units available 2012

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