Moog CSA Engineering
6U Mount for CubeSats on ESPA

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Summary

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

Cal Poly PPODs

INBOARD MOUNT

OUTBOARD MOUNT
Dispensers Mounted in ESPA with SUM

- Inboard mounting
  - PSC 6U Dispenser
- Outboard mounting
  - Cal Poly PPODs
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
Outboard Configuration Vibration Modes

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

Mode 1: 205 Hz
Mode 2: 206 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: $F_{S_y} = 1.25; F_{S_u} = 1.4$
- All stress margins positive due to RUG loads
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
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
Moog CSA Payload Adapters

ESPA

Flat Adapter

CASPAR

CubeStack

ESPA as Bus: LCROSS

ESPA with secondary payloads and propulsion system

ESPA Variations
CubeSat Deployment Sequencer

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

• Redundant high-current output signals to drive eight spacecraft release mechanisms

• Prototype at Moog Small Satellite exhibit

• In progress
  – Circuit and code development
  – Battery testing

• Next
  – Board iteration w/flight-capable parts and testing
Athena Commercial Rideshare

• 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
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
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