

Moog SL-OMV: Enhancing Small Launch Vehicles for Rapid CubeSat Constellation Deployment

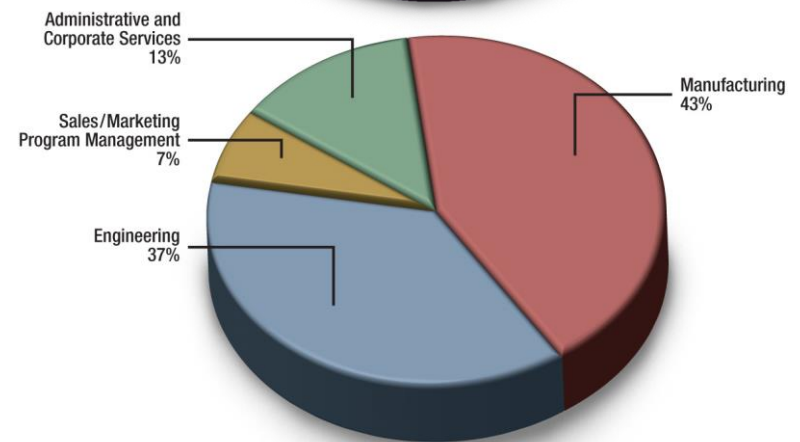
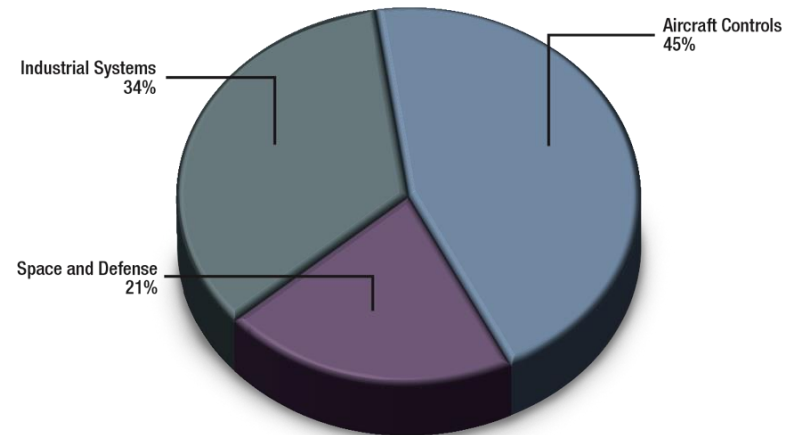
15th Annual CubeSat Developer's Workshop

Chris Loghry

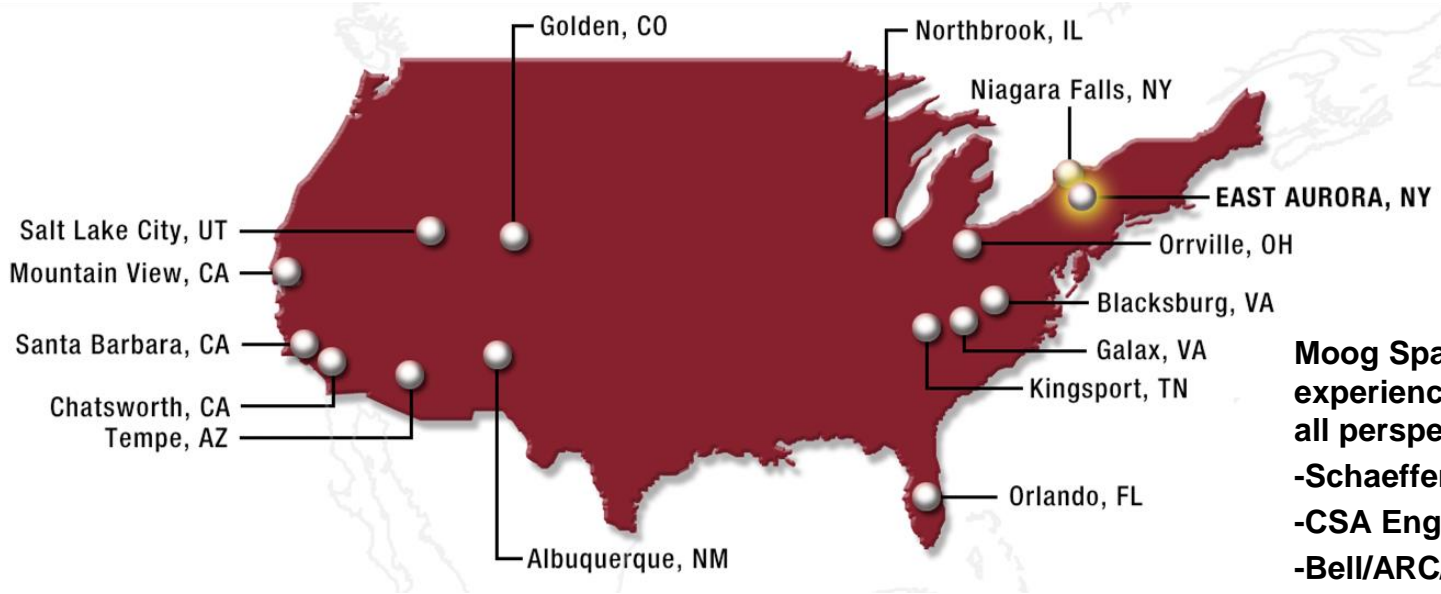
30 April 2018

Company Background

- **Founded in 1951 by Bill Moog**
- **Headquarters in East Aurora, NY**
 - Over 300 Acre Facility
- **Global Company**
 - 25 Countries
- **~11,000 Employees Worldwide**
- **\$2.50 Billion in Revenue (FY 2017)**
- **Aerospace, Defense, Industrial**
- **Precision Control Systems Solutions and Component Provider**



Moog Space and Defense Group Information

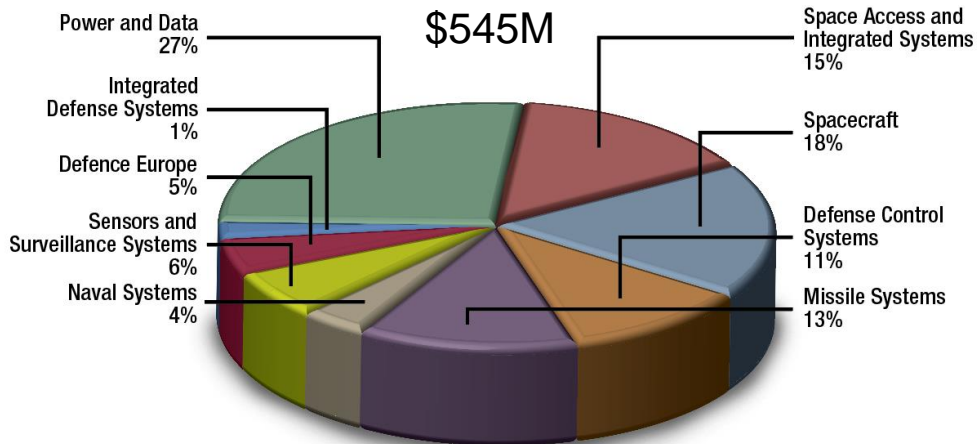


Moog Space leverages the unique experience from acquisitions to include all perspectives in the Space market

- Schaeffer Magnetics
- CSA Engineering
- Bell/ARC/AMPAC In-Space Propulsion
- Broad Reach Engineering

2017 Sales

\$545M



Solutions for Every Stage of a Space Mission



REVOLUTIONIZING THE WAY TO SPACE

Propulsion

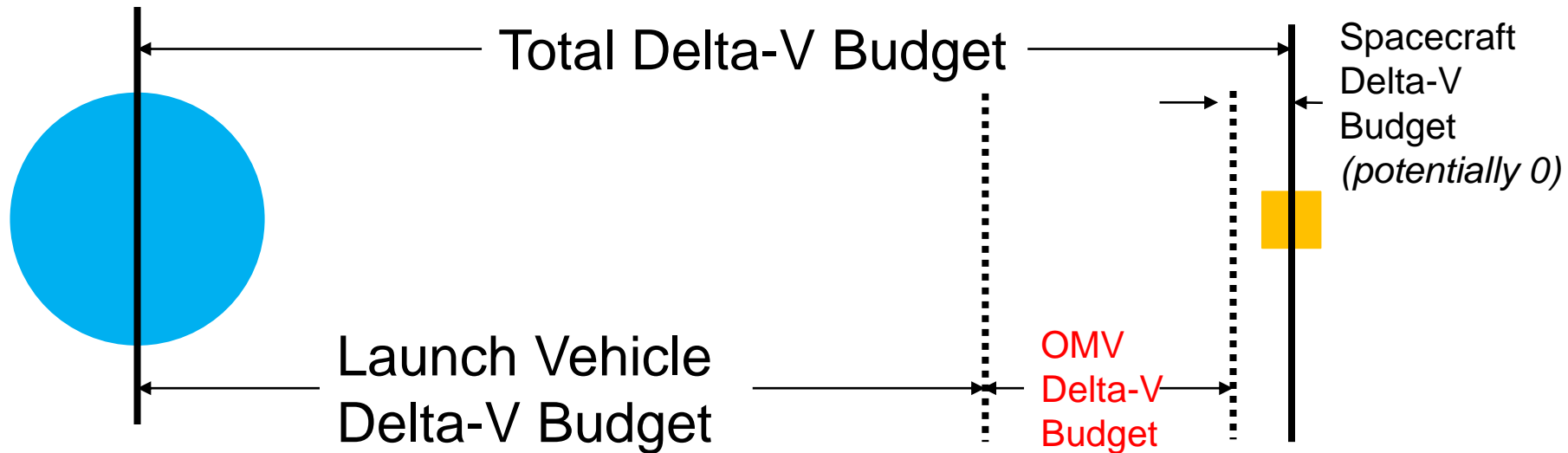
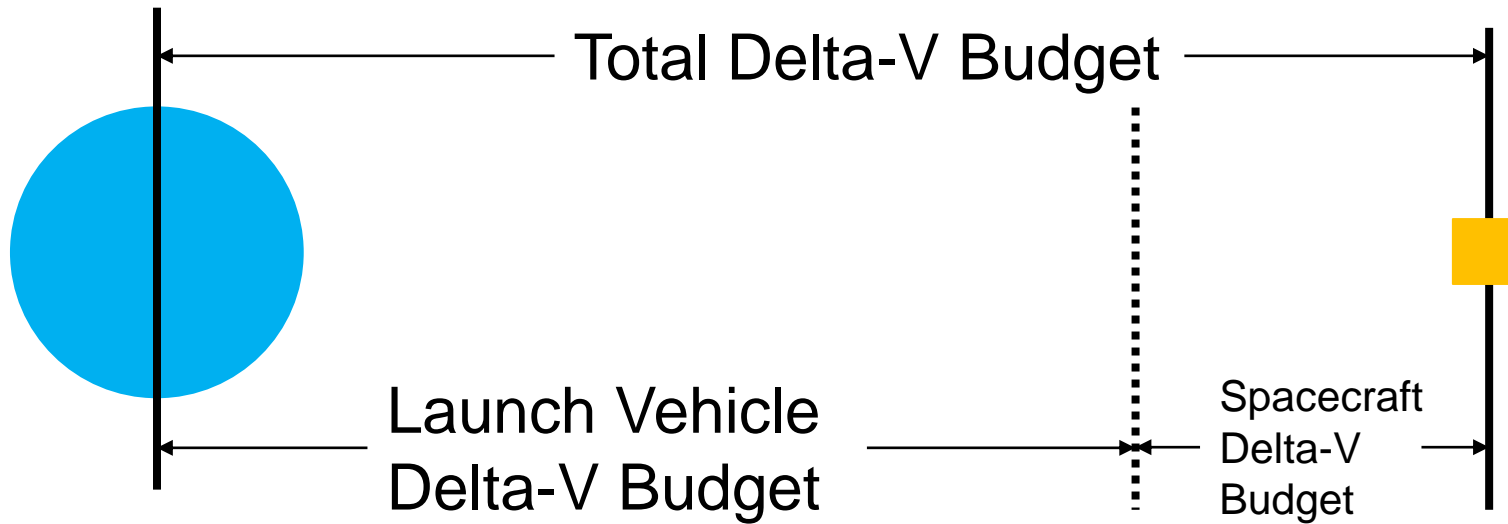
Actuation

Avionics

Structures

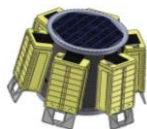
Power

Delta-V Budget Sharing (aka $dV \propto \text{Time} \propto \$\$$)



Moog OMV Family

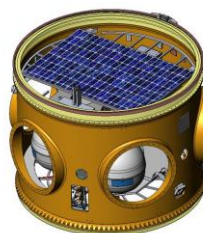
SL-OMV



M-OMV



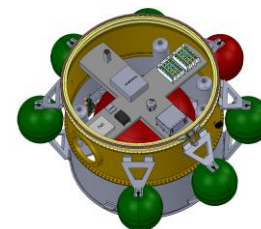
COMET



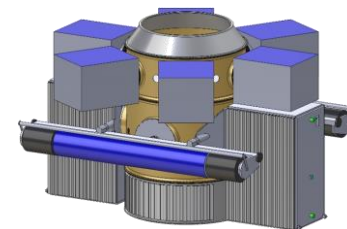
HELIOS



ASTRO



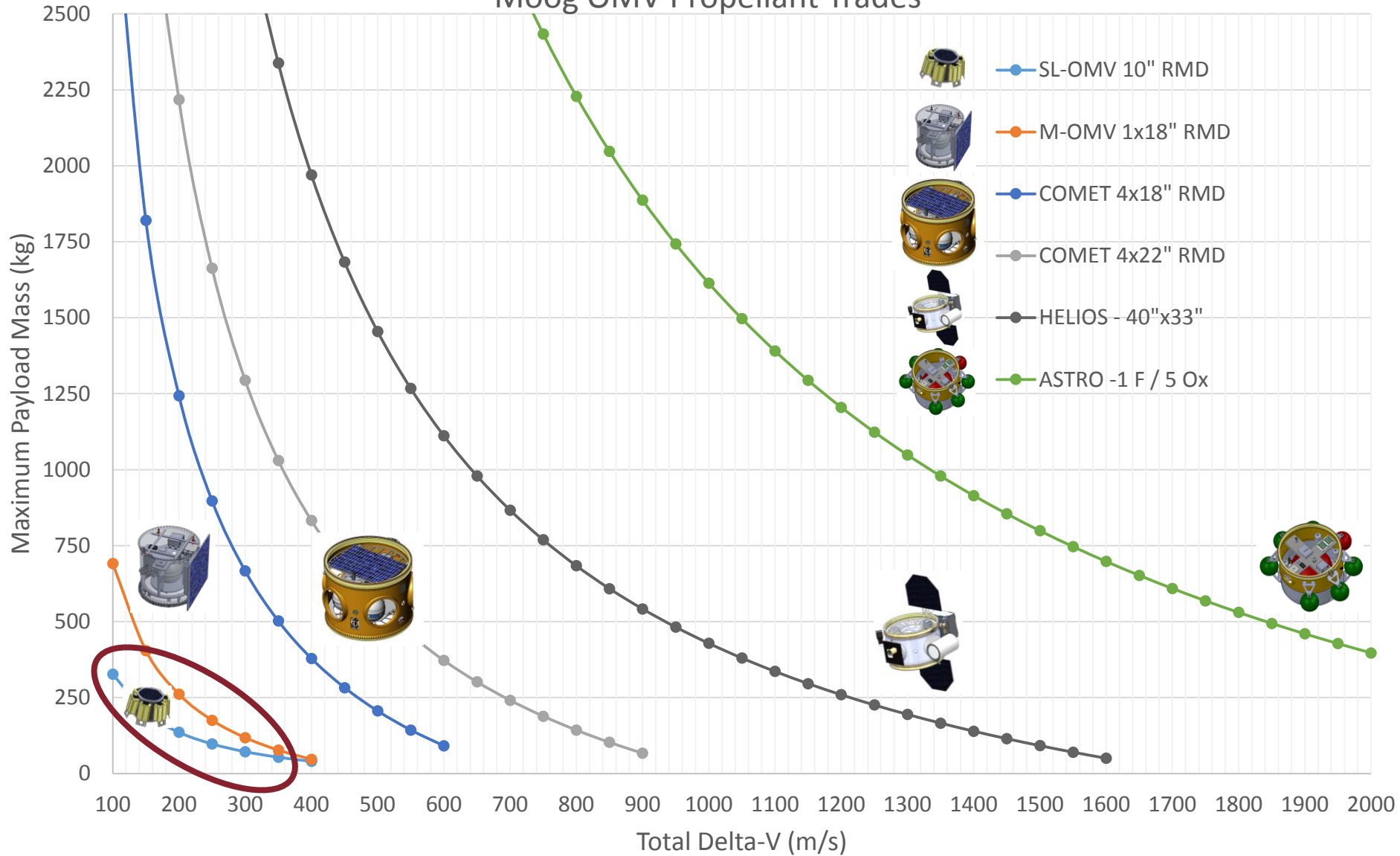
JUPITER



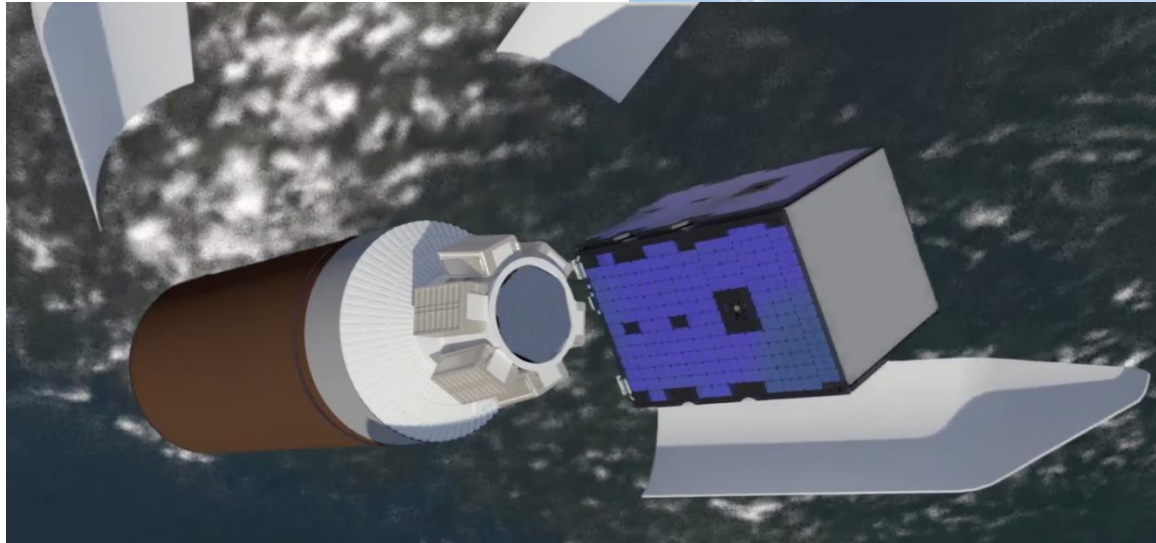
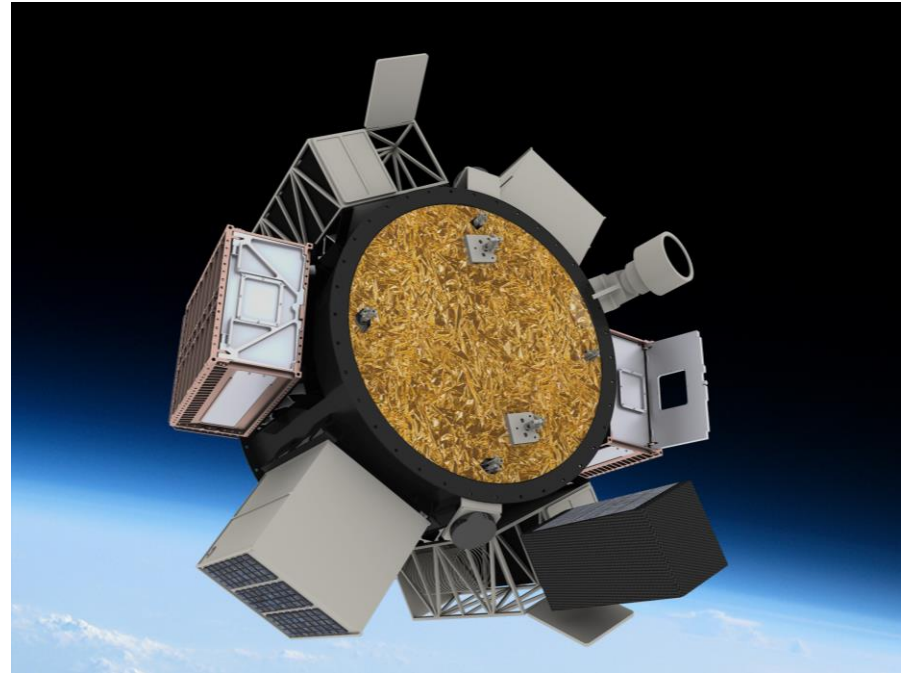
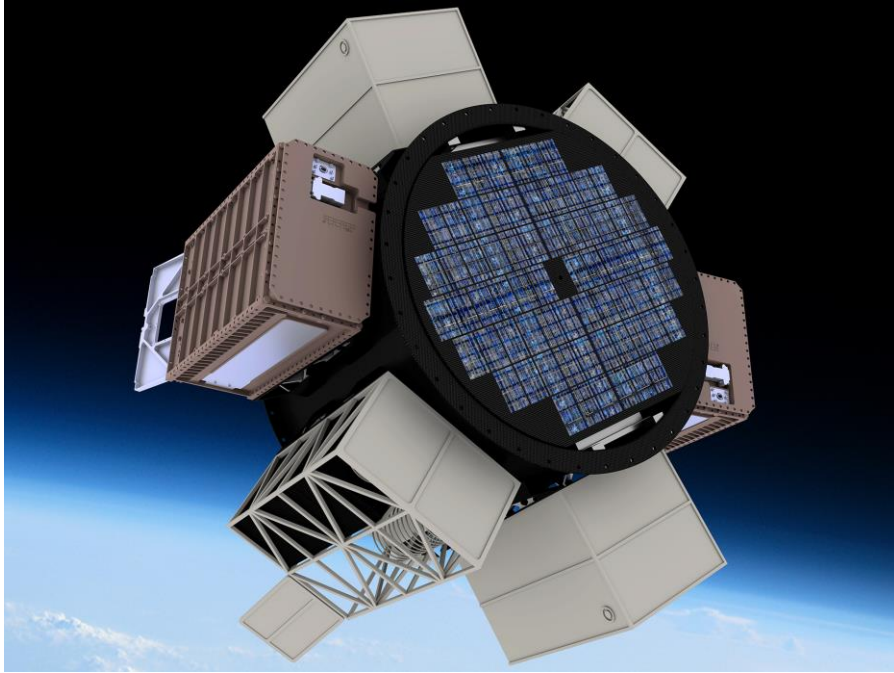
Parameter		Monopropellant			Bipropellant	Electric
Propellant	LMP-103S	Hydrazine			Hydrazine/NTO dV + Hydrazine ACS	SEP: Xenon Cold Gas ACS
dV Thrust	4N	140 N		540 N	176 N	1.2 N
ACS Thrust	1 N each	1 N or 5 N each			5 N each	4 N each
Prop Volume	13.7 liters	38 liters	153 liters (245 liter option)	454 liters	700 liters (total)	>130 liters
100 m/s	327 kg	691 kg	2975 kg	N/A	N/A	Designed for 5000 kg to 6000 m/s
200 m/s	136 kg	261 kg	1243 kg	4552 kg		
400 m/s	40 kg	47 kg	378 kg	1970 kg	5319 kg	
1000 m/s	N/A	N/A	N/A	428 kg	1616 kg	
1600 m/s				50 kg	700 kg	
2000 m/s				N/A	400 kg	

Moog OMV Family – Mass/Delta-V Performance

Moog OMV Propellant Trades



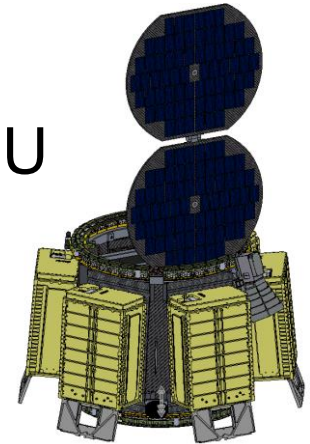
SL-OMV: Pretty Space Graphics



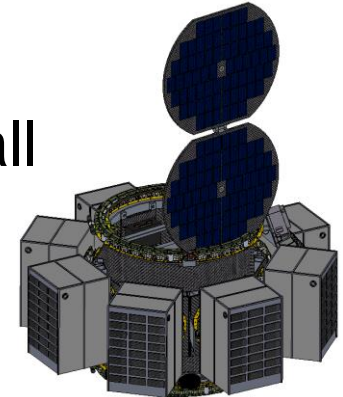
Leveraging Low Cost Launch for Resilient Constellations

- Adapter designed for “light” primary payload (<300 kg) and smaller diameter LV fairing
 - 24” Bolt Circle interface, 20” Height
- Minimal mass and maximum payload capacity
 - Composite cylinder adapter
 - Simplified Cubesat-Class Avionics and EPS
 - Fixed or simple deployable array
- 12 month mission duration
- Compatible with multiple CubeSat dispensers
 - Tyvak RailPOD and NLAS
 - FANTM-RAIL
 - Teton Aerospace dispenser
 - Planetary Systems CSD (shown, upper)
 - Non-Containerized (shown, middle/lower)
- Modularity
 - Flexible adapter diameter and height
 - Customizable quantity of dispensers
- Targeting late 2019 flight readiness
- Single Recurring unit <\$3M (quantity discounts)

6x6U



8 Small Sats

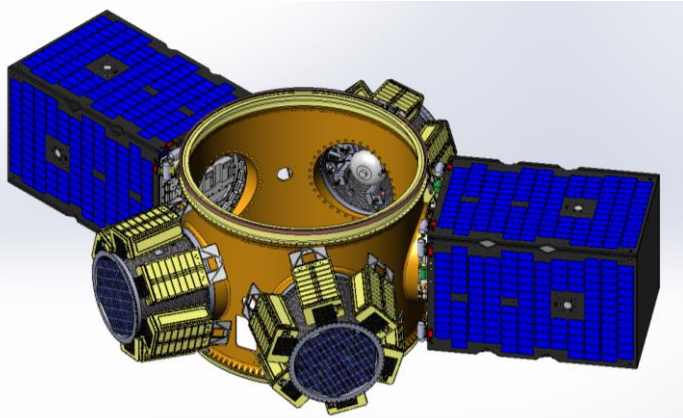


2x12U+
2x6U
(on top)



SL-OMV Performance Summary

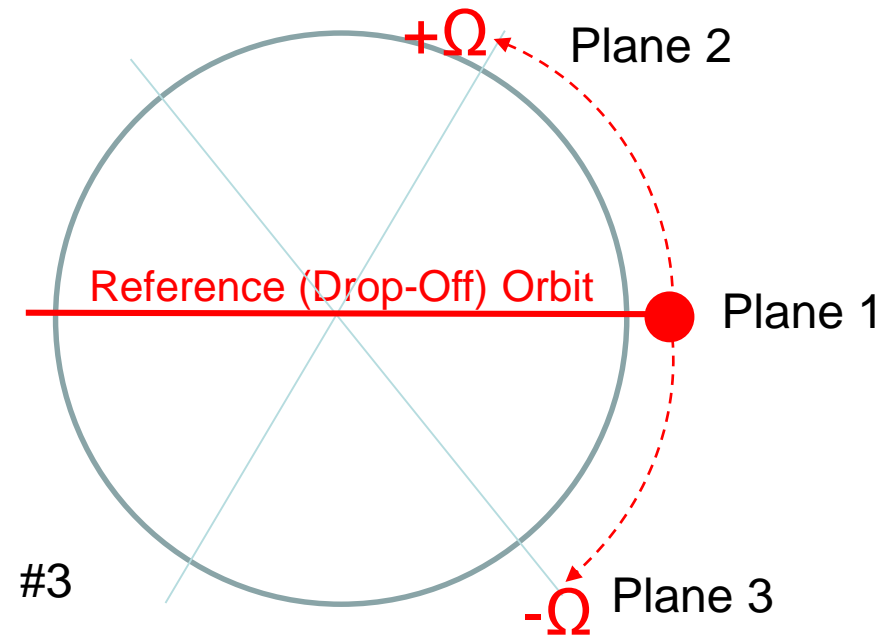
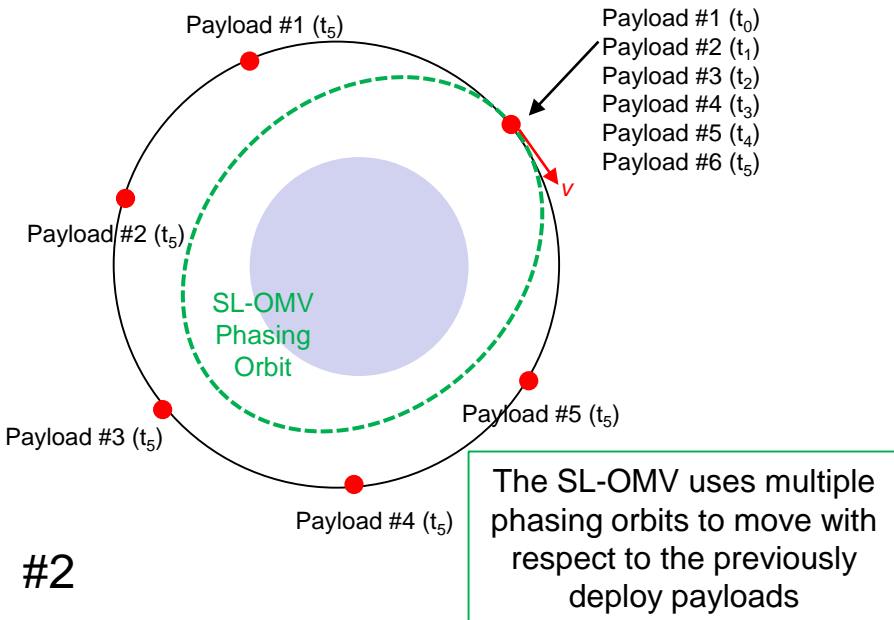
- No services provided to Cubesats (i.e. power or communication)
- 6x6U CSD within 42" PLF
 - Electron
- 8x12U on 8" MLBs in 49" PLF
 - LauncherOne
 - Firefly Alpha
- Can be used on PegasusXL or Minotaur class vehicles
- Can be ESPA Grande launched



SPECIFICATIONS	
Parameter	Performance
Total Impulse	38.3 kN-sec (8,600 lb _f -sec)
Thrust (Nominal)	6 x 1 N
Propellant Type	LMP-103S (4:1 Blowdown)
Attitude Control	3 DOF
Orbital Lifetime	12 months or more in LEO
Dry Mass (w/out Payloads)	48 kg
Wet Mass (w/out Payloads)	65 kg
Wet Mass (w/ Payloads)	155 kg for 6 x 6U
Payload Mass	Up to 12 x 3U or 6 x 6U Payloads
Nominal LV Adapter Interface	Ø24" (up to Ø38.81") or 4-point Mount
Nominal Adapter Height	20"
Payload Interface	3U RailPod/P-POD/CSD/ISIPOD, 6U CSD, 3U/6U NASA NLAS
Example Configuration #1	12x3U Cubesats > 260 m/s Delta-V
Example Configuration #2	6x6U Cubesats > 115 m/s Delta-V
Example Mission Scenario	500 km SSO deployment, Deploy 6x6U Cubesats evenly spaced around a plane, Deorbit

Example Mission CONOPS and Potential Users

CONOPS	Type	Potential Users
#1	Change Altitude/Inclination, several different orbital planes on one launch	SLV providers, Commercial Rideshare Brokers, Multi-Mission Manifest offices, Nested Constellations
#2	In-Plane Phasing	“String of Pearls” Constellation, Large Constellation refresh, Propulsion-less CubeSats
#3	Multi-Plane Deployment (>1 SL-OMV)	Constellations of several planes on a single launch
#4	Liquid Insertion Stage	SLV providers
#5	On-Orbit Loiter and Deploy	Defense Applications, immediate call up missions



Contact Info

Please contact us with any questions or potential applications you would like to discuss

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