CUBESAT LAUNCH TO HIGH ENERGY ORBITS

April 2019
VULCAN CENTAUR EVOLUTION

- Composite 5.4m PLF
- Common Avionics
- Upgraded Centaur Upper Stage
- 5M Class Booster Derivative
- Graphite Epoxy Motor Derivative
- Aerojet Rocketdyne Dual RL10 Upper Stage Propulsion Solution
- Blue Origin Dual BE-4 Booster Propulsion Solution
- GEM 63XL
MULTI-MISSION CAPABILITY OVERVIEW

### AFT BULKHEAD CARRIER (ABC)
- Interface located at the aft end of the Centaur upper stage

### SECONDARY PAYLOAD ADAPTER (ESPA)
- Adapter located between the upper stage and the primary payload

### MULTI-PAYLOAD CANISTER SYSTEM
- Load-bearing separating canister supporting forward traditional large satellite and enclosing aft small satellite

---

<table>
<thead>
<tr>
<th>CubeSats</th>
<th>CubeSats to Small Satellites</th>
<th>Small Satellites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity</td>
<td>Capacity 4-6 payload modules per ESPA ring</td>
<td>Capacity Canister and forward payload volume</td>
</tr>
<tr>
<td>Interface</td>
<td>Interface 15 in or 24 in bolted</td>
<td>Interface Fwd: 1575 standard interface Internal: 62 in bolted</td>
</tr>
<tr>
<td>Mass</td>
<td>Payload Mass 181-318 kg (400-700 lbs)</td>
<td>Payload Mass Small satellite masses exceeding ESPA capability</td>
</tr>
<tr>
<td>Volume</td>
<td>Volume (5-m PLF) ESPA: 61 cm x 71 cm x 96 cm (24 in x 28 in x 38 in) Grande: 100 cm x 115 cm x 125 cm (39 in x 45 in x 49 in)</td>
<td>Canister Volume 218 cm-dia x 195 cm (86 in-dia x 77 in)</td>
</tr>
</tbody>
</table>
VULCAN CENTAUR CUBESAT LAUNCH – AFT BULKHEAD CARRIER

- Equipment Shelf
- Aft Bulkhead Carrier
- 4 X 6U NLAS Mk. II
- RL10 Engines
CUBESAT LAUNCH SOLUTIONS TO HIGH-ENERGY ORBITS
MARCO - FIRST INTERPLANETARY CUBESATS

Launched on Atlas V May 5, 2018
Supported EDL of InSight

Photo from Marco-B cubesat, 1M km from Earth
CUBESAT LAUNCH
HIGH ENERGY ORBITS

• High energy orbits
  o MEO
  o GTO
  o GSO
  o Lunar
  o Earth Escape / Interplanetary

• Unique mission opportunities
  o Mission augmentation and support
  o Tech development
  o Science
  o Exploration

Requires high performance launch vehicle
LAUNCH MARKET COMPARISON

Dedicated Small Rockets

• High cost per kilogram
• Ability to choose launch window
• Capability limited to LEO orbits
• New entrants developing innovative solutions

Large Multi Launch

• Low cost per kilogram
• Launch timeline driven by primary spacecraft requirements
• Options for high energy orbits
• Providers enhancing capabilities to provide new and unique solutions

Trade-off between small and large launch vehicles
THANK YOU