1st Interplanetary Cubesat Workshop
MIT Cambridge, MA

ULA Rideshare CubeSat Missions for Lunar & Inter-Planetary Exploration

Jake Szatkowski
gerard.p.szatkowski@ULAlaunch.com
May 29-30, 2012
ULA's family of expendable launch vehicles has a long history of providing high-value payload accommodations for a variety of customer spacecraft & missions throughout the solar system.

**ULA PLANETARY MISSIONS (Since 2001)**

<table>
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<tr>
<th>Mission</th>
<th>Vehicle</th>
<th>Launch Date</th>
<th>Destination</th>
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<td>4/7/2001</td>
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<td>CONTOUR</td>
<td>Delta II 7425</td>
<td>7/3/2002</td>
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<td>Mars Rover B (Opportunity)</td>
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<td>MESSENGER</td>
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<td>Deep Impact</td>
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<td>Mars Reconnaissance Orbiter</td>
<td>Atlas V 401</td>
<td>8/12/2005</td>
<td>Mars</td>
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<td>New Horizons</td>
<td>Atlas V 551</td>
<td>1/19/2006</td>
<td>Pluto</td>
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<td>Delta II 7925</td>
<td>10/25/2006</td>
<td>Sun (Earth orbit)</td>
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<td>Lunar Reconnaissance Orbiter</td>
<td>Atlas V 401</td>
<td>6/18/2009</td>
<td>Moon</td>
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These missions were launched as primary payloads and used the full capability of the launch vehicle, but there are lower-cost alternatives for achieving these science objectives.
Rideshare Concept

- **What is Rideshare?**
  - Sharing available performance and volume margin that would otherwise go unused by the primary payload

- **Advantages to Rideshare**
  - Provides an inexpensive and reliable solution
    - Cost-savings allows more funding to be applied to the science mission
    - Rideshare payload receives the benefits of full-up launch service

- **Successfully demonstrated in 2009, with LCROSS was flown as a secondary payload on an Atlas V that launched the LRO**

- **Difficulties:**
  - 1. ownership of the mission margin
  - 2. ULA reluctance to have more than a single contract per mission
Rideshare Spectrum of Capabilities

A range of capabilities address differing size, mass, and other requirements and provide individual operational advantages.

- **P-Pod**: Poly PicoSat Orbital Deployer
  - Size: 10 kg
  - Features: R&D Development, Dynamically Insignificant, First flight ILC 2011

- **ABC**: Aft Bulkhead Carrier
  - Size: 80 kg
  - Features: Releasable in LEO, Isolated from Primary S/C, First flight ILC 2010

- **CAP**: C-Adapter Platform
  - Size: 100 kg
  - Features: 2-4 Slots per Launch, Less obtrusive than ESPA, First flight Fist Flight 2010

- **ESPA**: EELV Secondary P/L Adapter
  - Size: 200 kg/ea.
  - Features: ESPA Way Fwd Progress, STP-1 Flew 2007, First flight Fist Flight 2010

- **IPC / A-Deck**: Integrated Payload Carrier
  - Size: 500 kg
  - Features: Mix and Match H/W Internal and External P/L, SP to 60 in. diameter, Last flight LRO/LCROSS, First flight ILC 2010

- **DSS**: Dual Satellite System
  - Size: 5000 kg
  - Features: All Flight Proven H/W, Sp to 100 in diam., CDR 4Q 2009 ILC 2011

Delivering a Wide Range of Small Spacecraft with the Appropriate Conops and Technical Accommodations

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1 ESPA Graphic courtesy of CSA Engineering, Inc
2 COTSAT courtesy of NASA/AMES
3 NPSCuL courtesy of NPS
4 A-Deck courtesy of Adaptive Launch Solutions
# ULA Rideshare Capability Overview

<table>
<thead>
<tr>
<th>CAPABILITY</th>
<th>MAXIMUM MASS PER PAYLOAD</th>
<th>VOLUME</th>
<th>INTERFACE</th>
<th>MAXIMUM # / LAUNCH</th>
<th>COMPATIBILITY</th>
<th>STATUS</th>
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<tbody>
<tr>
<td>Delta II Second-Stage Mini-Skirt</td>
<td>1.0 kg (2.2 lb)</td>
<td>10 cm³ (4 in³)</td>
<td>P-POD</td>
<td>6 Cubesats</td>
<td>X</td>
<td>ILC 2011</td>
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<tr>
<td>Delta IV Equipment Shelf</td>
<td>1.0 kg (2.2 lb)</td>
<td>10 cm³ (4 in³)</td>
<td>P-POD (NPSCuL)</td>
<td>24 Cubesats</td>
<td>x</td>
<td>Concept Development</td>
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<tr>
<td>ULA EELV P-POD</td>
<td>1.0 kg (2.2 lb)</td>
<td>10 cm³ (4 in³)</td>
<td>P-POD</td>
<td>24 Cubesats</td>
<td>x x</td>
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<tr>
<td>CAP (C-Adapter Platform)</td>
<td>45 kg (100 lb)</td>
<td>23 cm x 31 cm x 33 cm (9 in x 12 in x 13 in)</td>
<td>15” clampband</td>
<td>4</td>
<td>x x</td>
<td>ILC 2012</td>
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<tr>
<td>ABC (Aft Bulkhead Carrier)</td>
<td>77 kg (170 lb)</td>
<td>51 cm x 51 x 76 cm (20 in x 20 in x 30 in)</td>
<td>15” clampband or P-POD</td>
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<td>x</td>
<td>ILC 2012</td>
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<td>A-DECK (Auxiliary Payload Deck)</td>
<td>905 kg (2,000 lb)</td>
<td>152-cm dia. (60-in dia.)</td>
<td>15”, 23”, 37” clampband</td>
<td>1</td>
<td>x x</td>
<td>ILC 2012</td>
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<tr>
<td>ESPA (EELV Secondary Payload Adapter)</td>
<td>180 kg (400 lb)</td>
<td>61 cm x 71 cm x 96 cm (24 in x 28 in x 38 in)</td>
<td>15” bolted</td>
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<td>x x</td>
<td>Operational</td>
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<tr>
<td>IPC (Integrated Payload Carrier)</td>
<td>910 kg (2,000 lb)</td>
<td>137-cm dia. (54-in dia.)</td>
<td>8”, 15”, 37” clampband</td>
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<tr>
<td>XPC (External Payload Carrier)</td>
<td>1,590 kg (3,500 lb)</td>
<td>20.1 m³ (710 ft³)</td>
<td>60” diameter</td>
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<td>DSS-4M (Dual Spacecraft System - 4M)</td>
<td>2,270 kg (5,000 lb)</td>
<td>254-cm dia. x 127 cm (100-in dia. x 50 in)</td>
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<td>DSS-5M (Dual Spacecraft System - 5M)</td>
<td>5,000 kg (11,000 lb)</td>
<td>4-m dia. x 6.1 m (13.1-ft dia. x 20 ft)</td>
<td>62” bolted</td>
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<td>x x</td>
<td>Concept Development</td>
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Aft Bulkhead Carrier (ABC)

- **Description**
  - I/F located at the aft-end of the Atlas V Centaur second-stage

- **Capabilities**
  - Mass: **80 kg**
  - Volume: 51 cm x 51 cm x 76 cm (20 in x 20 in x 30 in)
  - Interface: 15-in clampband or P-POD dispenser
  - Capacity: 1 slot
  - Vehicle: Atlas V

- **Status**
  - First fight 2012
  - ABC Users Guide available 9/12

- **Why?**
  - Sep from primary – release any time, no contamination, no re-contact, no security
OUTSat Mission on L-36

- Integration onto Atlas completed
- Launch date Aug 2, 2012 (first-flight)
- Next flight, pending L-39

Photos courtesy Maj. Wilcox NRO/OSL
Integrated Payload Carrier (IPC)

- **Description**
  - A flexible *stack of ring segments*
  - Config: *conic adapter or A-Deck*

- **Capabilities**
  - Mass: 910 kg (2,000 lb)
  - Volume: 137-cm dia. (54-in dia.)
  - Vehicle: Atlas V, Delta IV

- **Status**
  - IPC is operational

- **Why?**
  - Large volume
  - on centerline
  - treated as single SC
  - height up to 7 ft
A-Deck Structure

- **Structural Component Approach**
  - Monolithic Aluminum Design
  - Spider Pattern Centered Drilled
  - CNC Machined
  - Designed for 1000 kg Load Bearing Capability
  - Mil Spec Drilling for Fasteners

* Slide courtesy of Lt Col Guy Mathewson. NRO and Adaptive Launch Solutions
A-Deck Structural Testing

A-Deck arrives at NTS Test Facility

A-Deck carried to EDA 330

A-Deck lowered in EDA 330

Mass Simulator on A-Deck

A-Deck Suspended in Acoustic Test Chamber

* Slide courtesy of Lt Col Guy Mathewson. NRO and Adaptive Launch Solutions
What does it mean for Interplanetary Missions?

- Some of our missions (particularly polar ones) do Earth-escape disposal of the upper stage
- Some of the missions have fairly large margins
- It is possible to raise the apogee to beyond L1 for a separation
- The primary will dictate the time of launch and the moon can be anywhere in its orbit.
- However, if a Lunar exploration s/c could loiter long enough it could sync with and be captured by Lunar gravity

Options:
- ABC can support 80 kg s/c
- ESPA can support (6) 200 kg s/c
- A-Deck can support up to 2000 kg s/c
MULE (Multi-payload Utility Lite Electric)  
Third Stage

- MULE stage provides high deltaV to perform delivery of ESPA class payloads to a variety of orbits and Earth Escape missions
  - Delivery to Earth Escape (Lunar, NEO, Mars)
  - Delivery of a constellation (3 or 4 ESPA S/C)
  - Delivery to GSO
  - High delta-V
  - Solar Electric propulsion
  - Based on the ESPA Ring
  - On-orbit operations multi-yr

- Co-sponsors:
  - Comtech AeroAstro (Avionics)
  - Busek Space Propulsion (Hall Thrusters)
  - Adaptive Launch Solutions (S/C Integration)

- Status – proposal development
MULE Stage Conops

- **Lunar Mission concept**
  - Atlas prime-S/C separation & CCAM
  - Atlas disposal to high-apogee or Earth-escape & MULE separation
  - MULE transfer orbit to high-apogee for Lunar capture
  - MULE deploys ESPA S/C, CCAM / disposal

- **Mars Mission concept**
  - Atlas prime-S/C separation & CCAM
  - Atlas disposal to high-apogee or Earth-escape & MULE separation
  - MULE deploys high-gain antenna from 4\(^{th}\) ESPA slot
  - MULE transfer orbit to Earth escape, Mars intercept trajectory
  - Transfer orbit for Mars capture
  - Lowers Mars orbit for S/C delivery
  - Positioning of constellation into Mars orbits
    - (3) TDRSS-lite, or (24) 3-U GPS-lite S/C
  - MULE moves to areostationary orbit to continual data relay to Earth using high-gain antenna
Potential Rideshare Opportunities

- All potential mission opportunities will need to be:
  - Assessed for technical compatibility
  - Coordinated and approved by the primary payload customer

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<th>Mission</th>
<th>Customer</th>
<th>Vehicle</th>
<th>Site</th>
<th>Orbit</th>
<th>Margin, Excluding Disposal (kg)</th>
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<td>&gt;4,000</td>
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Transfer orbits missions
Earth escape trajectories
LEO Missions Disposal TBD
Summary

- ULA does not broker rideshares with primary customers
- ULA can give you a POC for specific applications that may work
- ULA can suggest ways to approach selected primary customers for rideshare
- You are responsible for:
  - design rqts (SMC/STP - ESPA Rideshare users guide),
  - required gates for success (i.e. Range Safety)
  - way to perform the integration