Rideshare –
A Low-Cost Solution For Space Access

- **What is Rideshare?**
  - The approach of sharing the available performance and volume margin with one or more spacecraft that would otherwise go unused by the launch vehicle

- **Advantages to Rideshare**
  - Provides the payload customer the opportunity to get their spacecraft to orbit in an inexpensive and reliable manner
    - Cost-savings are realized by sharing a ride with the primary
      - Allows more funding to be applied to the rideshare mission
    - Rideshare payload receives the benefits of full-up launch service
    - Payload is launched on a highly reliable launch vehicle

- **Such an approach was demonstrated in 2009, when the Lunar Crater Observation and Sensing Satellite (LCROSS) was successfully flown as a secondary payload on an Atlas V that launched the Lunar Reconnaissance Orbiter (LRO) mission to the Moon**
## ULA Rideshare Missions Since 2000
### (Current Launch Vehicles)

<table>
<thead>
<tr>
<th>MISSION</th>
<th>VEHICLE</th>
<th>LAUNCH DATE</th>
<th>RIDESHARE TYPE</th>
<th>RIDEHARE HARDWARE USED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Globalstar 7</td>
<td>Delta II 7420</td>
<td>2/8/2000</td>
<td>Multi</td>
<td>Post Dispenser</td>
</tr>
<tr>
<td>EO-1/SAC-C/Munin</td>
<td>Delta II 7320</td>
<td>11/21/2000</td>
<td>Dual + Secondary</td>
<td>DPAF</td>
</tr>
<tr>
<td>Jason-1/TIMED</td>
<td>Delta II 7920</td>
<td>12/7/2001</td>
<td>Dual</td>
<td>DPAF</td>
</tr>
<tr>
<td>Iridium-12</td>
<td>Delta II 7920</td>
<td>2/11/2002</td>
<td>Multi</td>
<td>Platform Dispenser</td>
</tr>
<tr>
<td>ICESat/CHIPSAT</td>
<td>Delta II 7320</td>
<td>1/12/2003</td>
<td>Dual</td>
<td>Reduced-Height DPAF</td>
</tr>
<tr>
<td>GPS IIR-8/XSS-10</td>
<td>Delta II 7925</td>
<td>1/29/2003</td>
<td>Secondary</td>
<td>Delta II Guidance Section</td>
</tr>
<tr>
<td>Delta IV Heavy Demo/Nanosat-2</td>
<td>Delta IV Heavy</td>
<td>12/20/2004</td>
<td>Piggyback</td>
<td>Mission-unique bracket</td>
</tr>
<tr>
<td>CALIPSO/CloudSat</td>
<td>Delta II 7420</td>
<td>4/28/2006</td>
<td>Dual</td>
<td>DPAF</td>
</tr>
<tr>
<td>LRO/LCROSS</td>
<td>Atlas V 401</td>
<td>6/18/2009</td>
<td>Secondary</td>
<td>ESPA</td>
</tr>
<tr>
<td>NPP/ELaNa III</td>
<td>Delta II 7920</td>
<td>10/28/2011</td>
<td>Secondary</td>
<td>Delta II P-POD</td>
</tr>
<tr>
<td>NROL-36/OUTSat</td>
<td>Atlas V 401</td>
<td>9/13/2012</td>
<td>Secondary</td>
<td>ABC</td>
</tr>
<tr>
<td>AFSPC-4/ANGELS</td>
<td>Delta IV M+(4,2)</td>
<td>2014</td>
<td>Secondary</td>
<td>ESPA</td>
</tr>
</tbody>
</table>

**ULA is the most experienced US rideshare launch service provider**
Rideshare Spectrum of Capabilities

A range of capabilities address differing size, mass, and other Requirements, while providing individual operational advantages.

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

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

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

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

- **IPC / A-Deck**
  - Integrated Payload Carrier
  - 500+kg
  - Mix and Match H/W Internal and External P/L
  - SP to 60 in. diameter
  - Last Flight LRO/LCROSS

- **DSS**
  - Dual Satellite System
  - 5000 kg
  - 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

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>
</tr>
</thead>
<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>
</tr>
<tr>
<td>Delta IV Equipment Shelf</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</td>
<td>Concept Development</td>
</tr>
<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</td>
<td>Concept Development</td>
</tr>
<tr>
<td>CAP (C-Adapter Platform)</td>
<td>45 kg (100 lb)</td>
<td>23 cm x 31 cm x 33 cm</td>
<td>15” clampband</td>
<td>4</td>
<td>x</td>
<td>ILC 2012</td>
</tr>
<tr>
<td>ABC (Aft Bulkhead Carrier)</td>
<td>77 kg (170 lb)</td>
<td>51 cm x 51 x 76 cm</td>
<td>15” clampband or P-POD</td>
<td>1</td>
<td>x</td>
<td>ILC 2012</td>
</tr>
<tr>
<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</td>
<td>ILC 2012</td>
</tr>
<tr>
<td>ESPA (EELV Secondary Payload Adapter)</td>
<td>180 kg (400 lb)</td>
<td>61 cm x 71 cm x 96 cm</td>
<td>15” bolted</td>
<td>6</td>
<td>x</td>
<td>Operational</td>
</tr>
<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>
<td>1</td>
<td>x</td>
<td>Operational</td>
</tr>
<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>
<td>1</td>
<td>x</td>
<td>PDR 12/2010</td>
</tr>
<tr>
<td>DSS-4M (Dual Spacecraft System - 4M)</td>
<td>2,270 kg (5,000 lb)</td>
<td>254-cm dia. x 127 cm</td>
<td>37” clampband</td>
<td>1</td>
<td>x</td>
<td>ILC 2012</td>
</tr>
<tr>
<td>DSS-5M (Dual Spacecraft System - 5M)</td>
<td>5,000 kg (11,000 lb)</td>
<td>4-m dia. x 6.1 m</td>
<td>62” bolted</td>
<td>1</td>
<td>x</td>
<td>Concept Development</td>
</tr>
</tbody>
</table>
Delta II P-POD

**Delta II P-POD**

<table>
<thead>
<tr>
<th>Description</th>
<th>A Cubesat P-POD dispenser attached to the Delta II second-stage mini-skirt</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle</td>
<td>Delta II</td>
</tr>
<tr>
<td>Capacity</td>
<td>3 P-PODs (9 Cubesats)</td>
</tr>
<tr>
<td>Interface</td>
<td>P-POD Dispenser</td>
</tr>
<tr>
<td>Mass</td>
<td>1.0 kg (2.2 lb) per 1U Cubesat</td>
</tr>
<tr>
<td>Volume</td>
<td>10 cm³ (4 in³) per 1U Cubesat</td>
</tr>
<tr>
<td>Status</td>
<td>Operational; first launch 10-2011 on NASA NPP</td>
</tr>
</tbody>
</table>

Additional P-POD opportunities are expected to available on the four upcoming NASA Delta II launches between now and 2016.
ELaNa III P-PODs Installed On NPP – Delta II Second-Stage Mini-Skirt
C-Adapter Platform (CAP)

<table>
<thead>
<tr>
<th>Description</th>
<th>A cantilevered platform attached to the side of a C-adapter to accommodate secondary payloads</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle</td>
<td>Atlas V, Delta IV</td>
</tr>
<tr>
<td>Capacity</td>
<td>4 CAPs per C-adapter</td>
</tr>
<tr>
<td>Interface</td>
<td>8-in Clampband</td>
</tr>
<tr>
<td>Mass</td>
<td>45 kg (100 lb)</td>
</tr>
<tr>
<td>Volume</td>
<td>23 cm x 31 cm x 33 cm (9 in x 12 in x 13 in)</td>
</tr>
<tr>
<td>Status</td>
<td>First launch TBD</td>
</tr>
</tbody>
</table>

The CAP was originally designed to accommodate batteries that are part of the Atlas V extended-mission kit hardware

Hosted experiments?
CAP/GSO Battery Test Installation Photos

Entering 5.4-m PLF BM door

Positioning ABP using GSE

ABP fastener installation

Maneuvering GSE scoop

Battery-only installation/removal

Rear battery fastener installation
Aft Bulkhead Carrier (ABC)

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

- **Capabilities**
  - Mass: **96 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 L-36 9/2012
  - ABC Users Guide available

- **Why?**
  - Sep from primary – release any time, no contamination, no re-contact, no security
ABC Installed on Centaur

- Centaur Upper-Stage
- RL10 Engine
- ABC
- 15-in Bolted Interface
- Shipping Adapter
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
The Operationally Unique Technologies Satellite (OUTSat) launched 8 P-PODs via the Naval Postgraduate School Cubesat Launcher (NPSCuL).
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
### AQUILA

<table>
<thead>
<tr>
<th>Description</th>
<th>A flat deck and cylindrical spacers, located between the forward-end of the second stage and the primary payload</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle</td>
<td>Atlas V, Delta IV</td>
</tr>
<tr>
<td>Capacity</td>
<td>Multiple payloads per AQUILA</td>
</tr>
<tr>
<td>Interface</td>
<td>Variable</td>
</tr>
<tr>
<td>Mass</td>
<td>1,000 kg (2,200 lb)</td>
</tr>
<tr>
<td>Volume</td>
<td>142-cm dia. (56-in dia.) x 152 cm (60 in)</td>
</tr>
<tr>
<td>Status</td>
<td>In development; CDR 04-2012</td>
</tr>
<tr>
<td>Developer</td>
<td>Adaptive Launch Solutions (ALS) (Jack Rubidoux, <a href="mailto:jrubidoux@adaptivelaunch.com">jrubidoux@adaptivelaunch.com</a>)</td>
</tr>
</tbody>
</table>

Graphics courtesy of ALS

AQUILA modular adapters are rated to support a primary payload mass up to 6,350 kg (14,000 lb)
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
**EELV Secondary Payload Adapter (ESPA)**

<table>
<thead>
<tr>
<th><strong>EELV Secondary Payload Adapter (ESPA)</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td><strong>Vehicle</strong></td>
</tr>
<tr>
<td><strong>Capacity</strong></td>
</tr>
<tr>
<td><strong>Interface</strong></td>
</tr>
<tr>
<td><strong>Mass</strong></td>
</tr>
<tr>
<td><strong>Volume</strong></td>
</tr>
<tr>
<td><strong>Status</strong></td>
</tr>
<tr>
<td><strong>Developer</strong></td>
</tr>
</tbody>
</table>

ESPA hardware will be used to launch a rideshare mission in 2014, and additional missions are being evaluated.
ESPA Flight Hardware Configuration - Atlas V

- **Description**
  - 4-m stack
    - SIS-compliant C-22 adapter on Centaur Forward Adapter (CFA)
  - 5-m/5-m GSO stack
    - SIS-compliant C-29 adapter on CFA
    - SIS-compliant C-9 above C-29

- **Summary**
  - Two configurations for Atlas
  - Common C-9 adapter between Atlas and Delta
  - New engineering for C-22
  - New engineering for C-9
Avionics Flight System Design Overview
Common Routing Scheme for ESPA Chassis

- Same panels used on Atlas and Delta
- Harnesses forward of panels are common for any mission

**MLB Separation Panel**
- Houses 4 connectors with common forward harness routing:
  - 2 Connectors for routing to MLB Motors (Shell size 17)
  - 1 Connector for routing Sep Signal (part of APL Servicing Harness) (Shell size 15)
  - 1 Atlas Bussing Connector (Shell size 15, used for Atlas only)
- Aft harness routing is dependent upon vehicle:
  - Atlas 4-m: Aft harness routes through boat-tail door (disconnected before flight)
  - Atlas 5-m: Aft harness routes through base module door (disconnected before flight)
  - Delta: Aft harness routes to Delta Fairing Connector Panel located on PAF (in-flight harness)

**APL Servicing Panel**
- Houses 6 connectors (Shell size 25) each with a different clocking to prevent miss-mate
- Forward harnessing routes to all 6 ESPA portals in order to charge APLs before flight
- Aft harness routing is dependent upon vehicle:
  - Atlas 4-m: Aft harness routes through boat-tail door (disconnected before flight)
  - Atlas 5-m: Aft harness routes through base module door (disconnected before flight)
  - Delta: Aft harness routes to Delta Fairing Connector Panel located on PAF (in-flight harness)
Separation Systems

- MLB (MkII Motorized Lightband)
  - Risk Reduction Testing on-going
    - Thermal test completed - nominal
    - Vibration test completed – some degradation in current signature
    - Vibration data evaluated proceeding on to shock testing
    - Shock Test pending
STP-1 Mission Overview

- STP-1 program consists of multiple satellites integrated into one payload stack.
- Baseline design: 2 spacecraft separation orbits
  - Orbit 1: 492 km circular; 46.0° inclination
    - Orbital Express (sun-relative separation)
    - MidSTAR-1
  - Orbit 2: 560 km circular; 35.4° inclination
    - NPSAT1 (sun-relative separation) [Mass Simulator]
    - NPSAT1 mass simulator will not be deployed
    - STPSat-1
    - CFE
    - FalconSAT-3
<table>
<thead>
<tr>
<th>TIME</th>
<th>EVENT</th>
<th>BASIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Liftoff (L/O)</td>
<td>Thrust/Weight &gt; 1</td>
</tr>
<tr>
<td>17.9</td>
<td>Begin Pitch/Yaw/Roll Program</td>
<td>Rise of 786 ft</td>
</tr>
<tr>
<td>57.4</td>
<td>End Pitchover/Begin Zero Total-Alpha</td>
<td>12,445 ft Altitude (Optimized)</td>
</tr>
<tr>
<td>244.1</td>
<td>Booster Engine Cutoff (BECO)</td>
<td>Fuel/LO2 Depletion</td>
</tr>
<tr>
<td>250.1</td>
<td>Atlas/Centaur Separation (AC_SEP)</td>
<td>BECO + 6.0 sec</td>
</tr>
<tr>
<td>260.1</td>
<td>Main Engine Start 1 (MES1)</td>
<td>AC_SEP + 10.0 sec</td>
</tr>
<tr>
<td>268.1</td>
<td>Payload Fairing Jettison (PFJ)</td>
<td>t &gt; MES1 + 8.0 sec &amp; 35 qv &lt; 360 BTU/ft²/hr</td>
</tr>
<tr>
<td>867.4</td>
<td>Main Engine Cutoff 1 (MECO1)</td>
<td>Park Orbit (Guidance)</td>
</tr>
<tr>
<td>1086.4</td>
<td>Separate Orbital Express Spacecraft</td>
<td>MECO1 + 219 sec</td>
</tr>
<tr>
<td>1341.4</td>
<td>Separate MidSTAR-1Spacecraft (Command)</td>
<td>MECO1 + 474 sec</td>
</tr>
<tr>
<td>1987.7</td>
<td>Main Engine Start 2 (MES2)</td>
<td>Guidance</td>
</tr>
<tr>
<td>2070.6</td>
<td>Main Engine Cutoff 2 (MECO2)</td>
<td>Guidance</td>
</tr>
<tr>
<td>2788.8</td>
<td>Main Engine Start 3 (MES3)</td>
<td>Guidance</td>
</tr>
<tr>
<td>2899.8</td>
<td>Main Engine Cutoff 3 (MECO3)</td>
<td>Guidance</td>
</tr>
<tr>
<td>3024.8</td>
<td>Separate NPSAT-1 Spacecraft (Command)</td>
<td>MECO3 + 125 sec</td>
</tr>
<tr>
<td>3367.8</td>
<td>Separate STPSat-1 Spacecraft (Command)</td>
<td>MECO3 + 468 sec</td>
</tr>
<tr>
<td>3700.8</td>
<td>Separate CFE Spacecraft (Command)</td>
<td>MECO3 + 801 sec</td>
</tr>
<tr>
<td>3938.8</td>
<td>Separate FalconSat Spacecraft (Command)</td>
<td>MECO3 + 1039 sec</td>
</tr>
</tbody>
</table>

(Jettison event in boldface text)
MULE Delivery System

Stowed Configuration

Deployed Configuration

Internal: Propellant tanks, reaction wheels, torque rods

3X Free Flyer Spacecraft

Stowed Solar Array Wing

s/c Propulsion

Avionics Module

ESPA Ring

Solar Arrays

Telescope

HET Electric Propulsion

MULE Delivery System

(1)

(2)

(3)
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:**
  - Oakman Aerospace (Avionics)
  - Busek Space Propulsion (Hall Thrusters)
  - Adaptive Launch Solutions (S/C Integration)

- **Status** – proposal development
Mars “TDRSS-lite” Delivery

**Con-Ops**
- Rideshare Earth escape
- MULE Mars Rendezvous
- Deploy ea free-flyer s/c
- Move MULE to high orbit
- Deploy High-gain antenna

**Operations**
- Mother-ship in areostationary (ASO) orbit (11,000 mi above surface)
- MULE Stage switches power to high-gain
- Permits comm links:
  - Surface to Surface
  - Surface to Earth
  - Continuous surface observation
  - Internet-like service
Thrust vs. Isp (BHT-20K, Xe)

- T>1 N measured at 20-kW.
- Peak T/P~ 70 mN/kW at 200 V and 5 kW.
- Isp from 1430 s (200 V, 5-kW) to 2630 s (500 V, 20-kW).

\[
\left(\frac{\sigma_{I_{sp}}}{I_{sp}}\right)^{2} = \left(\frac{\sigma_{T}}{T}\right)^{2} + \left(\frac{\sigma_{m}}{m}\right)^{2}
\]
- Busek has 20 kW thrusters
- ULA 20 KW array stowed config.
Delivery of a Rideshare P/L to GSO

A. Atlas V 551 can deliver 19,620 lbs (8,900 kg) to a GTO orbit. A 5M fairing is required for a GSO type mission

B. To deliver a rideshare P/L to GSO: requires an extended-mission-kit, a 5M fairing, a long coast, an additional burn to achieve GSO orbit.

C. To enable a 2,200 lbs (1000 kg) Rideshare mission, the Primary would be restricted to 10,700 lbs
MULE Rough Specs Summary

- MULE stage built on ESPA ring and standard ULA separation system
- Total mass of the MULE stage with 14,055lb SV is ~19,500lb
- ~4kW solar array on board (SS/L is flying them now)
- 4 of Busek 2kW thrusters on 2 gimbals
- GTO to GEO transit time <140 days
- Mars transit 3 years
- ULA has been working w/ Busek Propulsion on the Hall Effect thruster
  - Xenon  $I_{sp} = 1544$ for Xe at 250 V, 200 W
- New solution launches with lite-wt composite tank to eliminating the need for heavy pressurized tanks
- Minimum delivery time first unit ~3 years
- EP Upper stage cost with all NRE ~$50-60M
- Re-flight unit ~$30-40M
- No significant technical challenge
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
Potential Rideshare Opportunities

- Some of these missions are pending contract ward – must check current status.
- All potential mission opportunities will need to be:
  - Assessed for technical compatibility
  - Coordinated and approved by the primary payload customer

<table>
<thead>
<tr>
<th>Mission</th>
<th>Customer</th>
<th>Vehicle</th>
<th>Site</th>
<th>Orbit</th>
<th>Margin, Excluding Disposal (kg)</th>
<th>FY15</th>
<th>FY16</th>
<th>FY17</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPS-IIF</td>
<td>USAF</td>
<td>401</td>
<td>ER</td>
<td>MEO - Direct</td>
<td>~600</td>
<td>IIF-4,</td>
<td>IIF-6</td>
<td>IIF-7, IIF-8</td>
<td></td>
</tr>
<tr>
<td>GPS-III</td>
<td>USAF</td>
<td>411</td>
<td>ER</td>
<td>MTO</td>
<td>(~1100)</td>
<td>IIIA-2</td>
<td>IIIA-5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SBIRS</td>
<td>USAF</td>
<td>401</td>
<td>ER</td>
<td>GTO</td>
<td>~100</td>
<td>GEO-3</td>
<td>GEO-4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AFSPC</td>
<td>USAF</td>
<td>401</td>
<td>ER</td>
<td>GTO</td>
<td>TBD</td>
<td>AFSPC-8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NRO</td>
<td>NRO</td>
<td>411</td>
<td>ER</td>
<td>GTO</td>
<td>TBD</td>
<td></td>
<td>L-61</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AEHF</td>
<td>USAF</td>
<td>531</td>
<td>ER</td>
<td>GTO</td>
<td>Performance Limited</td>
<td>AEHF-4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MUOS</td>
<td>USAF</td>
<td>551</td>
<td>ER</td>
<td>GTO</td>
<td>Performance Limited</td>
<td>MUOS-4</td>
<td>MUOS-5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GOES</td>
<td>NASA</td>
<td>541</td>
<td>ER</td>
<td>GTO</td>
<td>Performance Limited</td>
<td>GOES-R</td>
<td>GOES-S</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TDRS</td>
<td>NASA</td>
<td>401</td>
<td>ER</td>
<td>GTO</td>
<td>Performance Limited</td>
<td>TDRS-M</td>
<td>TDRS-N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MMS</td>
<td>NASA</td>
<td>421</td>
<td>ER</td>
<td>GTO</td>
<td>Performance Limited</td>
<td>MMS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discovery</td>
<td>NASA</td>
<td>401</td>
<td>ER</td>
<td>Hyperbolic</td>
<td>TBD</td>
<td>D-12</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ExoMars</td>
<td>NASA</td>
<td>421</td>
<td>ER</td>
<td>Hyperbolic</td>
<td>Performance Limited</td>
<td>EM</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Osiris Rex</td>
<td>NASA</td>
<td>401</td>
<td>ER</td>
<td>Hyperbolic</td>
<td>Performance Limited</td>
<td>OR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Europa</td>
<td>NASA</td>
<td>551</td>
<td>ER</td>
<td>Hyperbolic</td>
<td>Performance Limited</td>
<td>EO</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solar Orbiter</td>
<td>NASA</td>
<td>551</td>
<td>ER</td>
<td>Hyperbolic</td>
<td>Performance Limited</td>
<td>SO</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NRO</td>
<td>NRO</td>
<td>401</td>
<td>WR</td>
<td>TBD</td>
<td>TBD</td>
<td>L-79</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NRO</td>
<td>NRO</td>
<td>541</td>
<td>WR</td>
<td>TBD</td>
<td>Performance Limited</td>
<td>L-67</td>
<td>L-42</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NRO</td>
<td>NRO</td>
<td>401</td>
<td>WR</td>
<td>TBD</td>
<td>TBD</td>
<td>L-55</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>STP</td>
<td>USAF</td>
<td>401</td>
<td>WR</td>
<td>~700km 98 deg</td>
<td>&gt;5,000</td>
<td>STP-3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CLARREO</td>
<td>NASA</td>
<td>[Delta II]</td>
<td>WR</td>
<td>~600 km Polar</td>
<td>TBD</td>
<td>CLARREO</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ICESat</td>
<td>NOAA</td>
<td>[Delta II]</td>
<td>WR</td>
<td>Polar</td>
<td>TBD</td>
<td>ICESat-2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DMSP</td>
<td>USAF</td>
<td>401</td>
<td>WR</td>
<td>~800km 99 deg</td>
<td>~900</td>
<td>DMSP-19/DSX</td>
<td>DMSP-20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>JPSS</td>
<td>NOAA</td>
<td>[Delta II]</td>
<td>WR</td>
<td>~800km 98deg</td>
<td>&gt;4,000</td>
<td>JPSS-1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GeoEye</td>
<td>GeoEye</td>
<td>401</td>
<td>WR</td>
<td>~700km 98 deg</td>
<td>&gt;4,000</td>
<td>GEOEYE-2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WorldView</td>
<td>Digital Globe</td>
<td>401</td>
<td>WR</td>
<td>~700km 98 deg</td>
<td>&gt;4,000</td>
<td>WV-4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comm I-9</td>
<td>CLS</td>
<td>401</td>
<td>WR</td>
<td>TBD</td>
<td>&gt;4,000</td>
<td>Comm I-9</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Transfer orbits missions
Earth escape trajectories
LEO Missions Disposal TBD
Summary

- Rideshare is a flight-proven solution to achieving various mission objectives
- Multiple ULA rideshare capabilities offer solutions to all mission types
  - Mass range 1 kg to 5,000 kg
  - Dimension range 10 cm to 6 m
- Designing and launching co-manifested missions is a better approach for maximizing mission capability to orbit

United Launch Alliance stands ready to evaluate and provide low-cost rideshare launch opportunities to SMC and the US Air Force
ULA can assist in brokering rideshares with primary customers.
ULA can assist for specific applications that may work.
ULA can work with primary customers for rideshare opportunities.
You are responsible for:
- design rqts (ABC / ESPA Rideshare users guides),
- required gates (pre-mission design, PDR, CDR, Range Safety)
- perform the qualification and pre-integration