ULA
America's Ride to Space

ULA Rideshare Overview

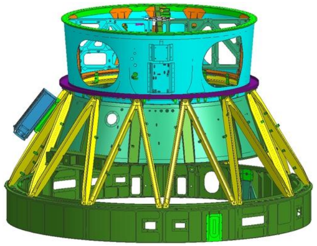
September 2015

Keith Karuntzos
Business Development
United Launch Alliance

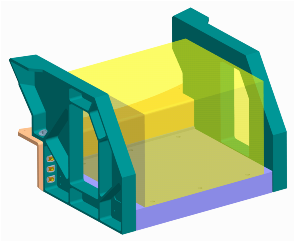
Copyright © 2015 United Launch Alliance, LLC.
All Rights Reserved.

Rideshare - A Low-Cost Solution For Space Access

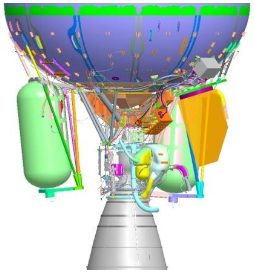
- What is Rideshare?
  - The approach of sharing available performance and volume margin with one or more spacecraft that would otherwise go underutilized by the spacecraft community
- Advantages of ULA Rideshare
  - Provides the payload community a cost-effective and reliable method to get capability on-orbit via Atlas and Delta launch vehicles
    - Cost-savings are realized by ridesharing with one or more payloads
    - Allows more funding to be applied to the spacecraft and mission operations



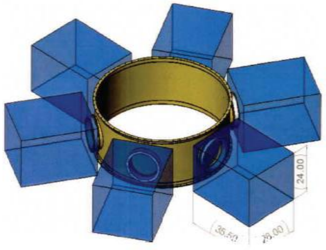
P-POD
10 kg



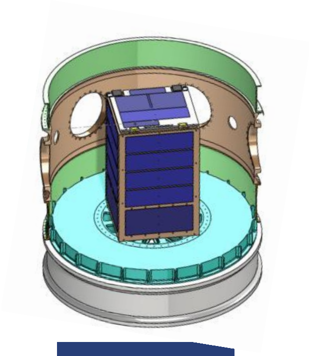
CAP
50 kg



ABC
80 kg



ESPA
200 kg



AQUILA
500+ kg

DSS
2,200+ kg

Rideshare Definitions

- Rideshare
  - A general term applicable to a launch service that launches more than one spacecraft or payload to orbit
- Auxiliary Payload (AP or APL)
  - A payload launched to orbit that is not a primary payload
- Hosted / Piggyback Payload
  - An APL launched as part of the spacecraft
- Secondary Payload (SP)
  - An APL launched as part of the launch vehicle
- Co-Manifest
  - General term for two or more primary payloads manifested together
- Multi-Manifest
  - Multiple spacecraft of the same design launched to orbit
  - Does not include multiple spacecraft launched as a single payload stack
- Dual Manifest (DM) or Dual Launch (DL)
  - Two primary payloads (of either a different design or the same design) sharing a launch to orbit using dedicated dual manifest hardware

America's Ride to Space

ULA Rideshare Mission History

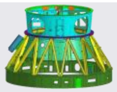
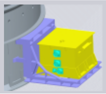
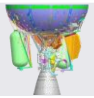
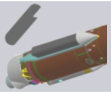
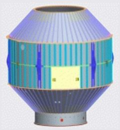
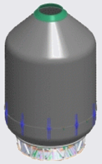
MISSION	VEHICLE	LAUNCH DATE	RIDESHARE TYPE	# OF RIDESHARE PAYLOADS	RIDESHARE HARDWARE USED
STP-1 (Orbital Express/ESPA)	Atlas V 401	3/8/2007	Secondary	4	ESPA
LRO/LCROSS	Atlas V 401	6/18/2009	Secondary	1	ESPA
NPP/ELaNa III	Delta II 7920	10/28/2011	Secondary	6	Delta II P-POD
NROL-36/OUTSat	Atlas V 401	9/13/2012	Secondary	11	ABC
NROL-39/GEMSat	Atlas V 501	12/5/2013	Secondary	12	ABC
AFSPC-4/ANGELS	Delta IV M+(4,2)	7/28/2014	Secondary	1	ESPA
SMAP/ELaNa X	Delta II 7320	1/31/2015	Secondary	4	Delta II P-POD
AFSPC-5/ULTRASat	Atlas V 501	5/20/2015	Secondary	10	ABC
				49	

UPCOMING ULA RIDESHARE LAUNCHES					
NROL-55/GRACE	*Atlas V 401*	*2015*	*Secondary*	*13*	*ABC*
InSight/MarCO	*Atlas V 401*	*2016*	*Secondary*	*2*	*ABC*
JPSS-1/ELaNa	*Delta II 7920*	*2016*	*Secondary*	*TBD (Up to 9U)*	*Delta II P-POD*
ICESat II/ELaNa	*Delta II 7420*	*2017*	*Secondary*	*TBD (Up to 9U)*	*Delta II P-POD*

ULA is the most experienced US rideshare launch service provider

ULA America's Ride to Space

ULA Rideshare Capability Overview

	CAPABILITY		LV			STATUS	INTERFACE	MAXIMUM # PER LAUNCH		MAXIMUM MASS PER PAYLOAD	VOLUME PER PAYLOAD
			DII	DIV	AV						
RIDESHARE	**Delta II Second-Stage Mini-Skirt**		•			Operational	P-POD	3 P-PODs		1.33 kg (2.9 lb)	10 cm^3 (4 in^3)
RIDESHARE	**CAP (C-Adapter Platform)**			•	•	First launch TBD	8-in Clampband	4 CAPs		45 kg (100 lb)	23 cm x 31 cm x 33 cm (9 in x 12 in x 13 in)
RIDESHARE	**ABC (Aft Bulkhead Carrier)**				•	Operational	15-in Bolted	1 ABC		80 kg (176 lb)	51 cm x 51 x 76 cm (20 in x 20 in x 30 in
RIDESHARE	**ESPA (EELV Secondary Payload Adapter)** ***(Moog CSA Engineering)***			•	•	Operational	15-in Bolted	Up to 6 S/C per ESPA		181 kg (400 lb)	61 cm x 71 cm x 96 cm (24 in x 28 in x 38 in
RIDESHARE	**AQUILA** ***(Adaptive Launch Solutions)***			•	•	CDR 4/2012	Variable	Up to 3 S/C per AQUILA		1,000 kg (2,200 lb)	142-cm dia. x 152 cm (56-in dia. x 60 in)
RIDESHARE	**XPC (External Payload Carrier)** ***(Special Aerospace Services)***				•	PDR 12/2010	Variable	1 XPC		1,810 kg (4,000 lb)	21.2 m^3 (750 ft^3)
DUAL-MANIFEST	**DSS-4 (Dual Spacecraft System, 4-m)**			•	•	CDR 12/2009	62-in Bolted	1 DSS-4	Forward	2,270 kg (5,000 lb)	365-cm-dia. x 658 cm (144-in-dia. x 259 in) (3-plug)
									Aft	9,000 kg (19,800 lb)	254-cm-dia. x 445 cm (100-in-dia. x 175 in) (3-plug)
DUAL-MANIFEST	**DSS-5 (Dual Spacecraft System, 5-m)**				•	CDR 12/2014	62-in Bolted	1 DSS-5	Forward	5,440 kg (12,000 lb)	457-cm-dia. x 762 cm (180-in-dia. x 300 in)
									Aft	9,000 kg (19,800 lb)	375-cm-dia. x 487 cm (148-in-dia. x 192 in)

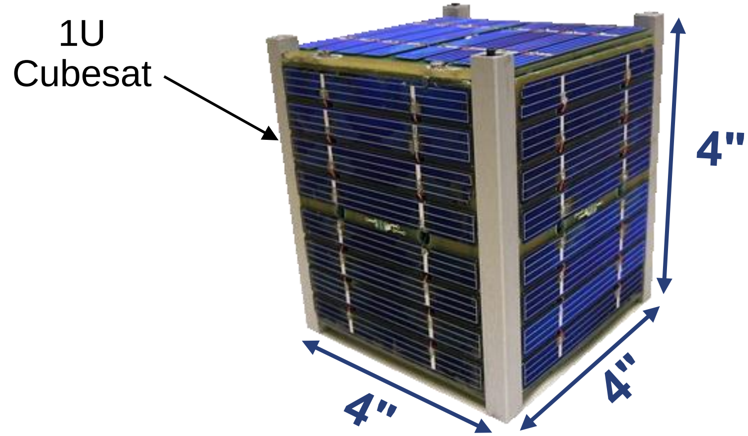
As of 2-2015

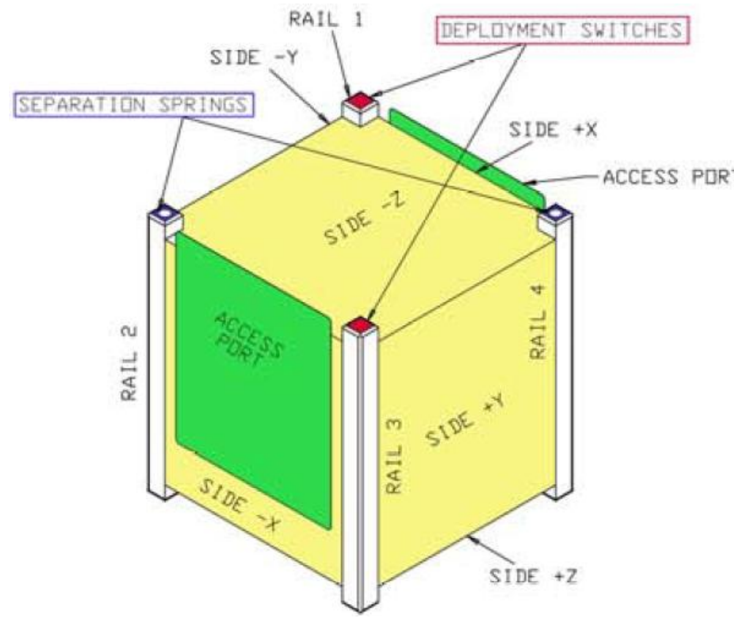
Cubesats

America's Ride to Space

Cubesat Nano-Satellite	
Description	A miniaturized satellite originally designed for use in conjunction with university educational projects
Interface	P-POD Dispenser
Mass	1.33 kg (2.9 lb) per 1U Cubesat
Volume	10 cm^3 (4 in^3) per 1U Cubesat
Status	Operational; nearly 100 Cubsats launched to date
Developer	Cal Poly San Luis Obispo & Stanford *(Jordi Puig-Suari, jpuigsua@calpoly.edu)*

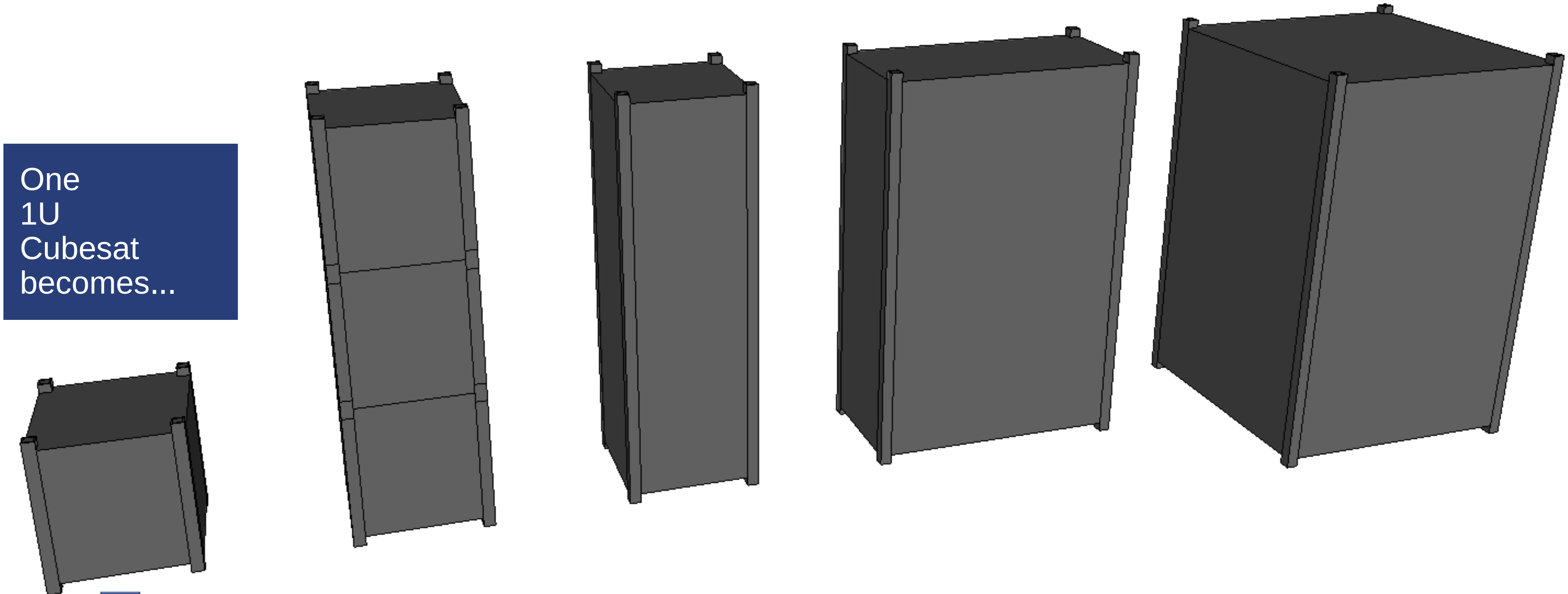
Cubesats have minimal impact to the LV: they have a long shelf-life, have no need for charging prior to launch, and are inactive during launch





1U Cubesat Volume Can Be Combined To Create Larger Cubesats

America's Ride to Space



One 1U Cubesat becomes...

Three 1U Cubesats
3 x (4" x 4" x 4")
~ 4 kg (9 lb)

One 3U Cubesat
(4" x 4" x 12")
~ 4 kg (9 lb)

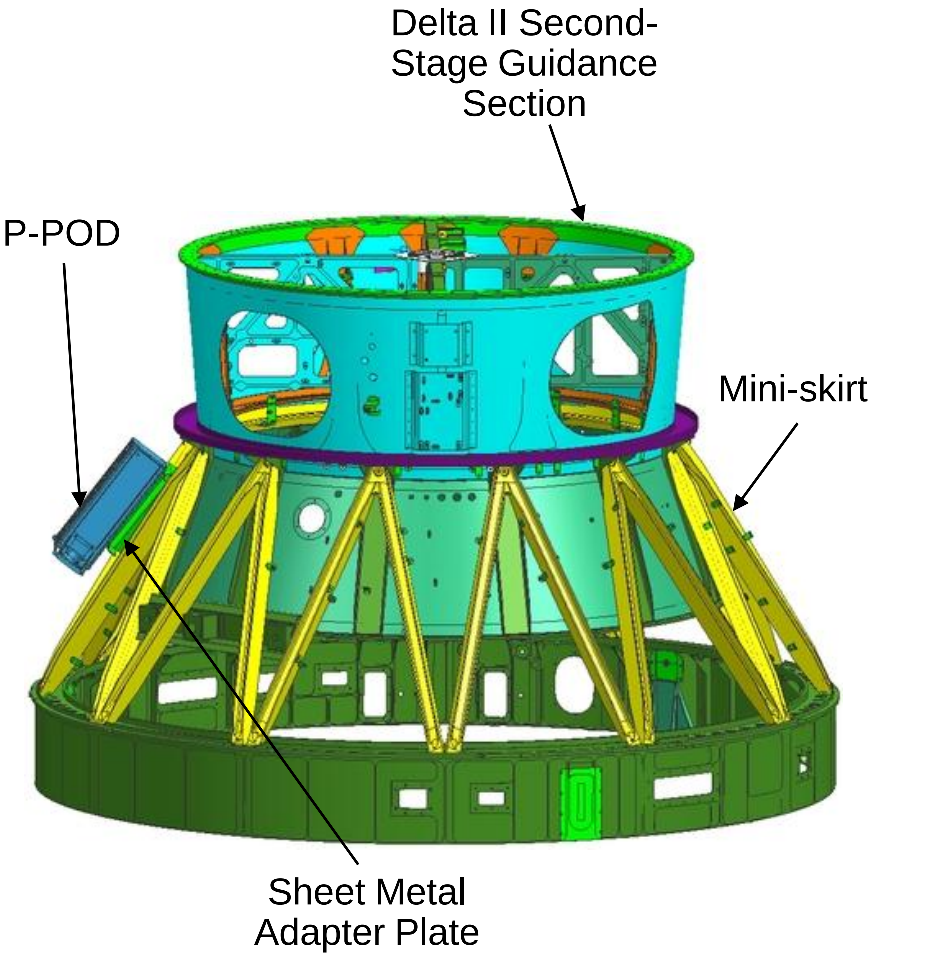
One 6U Cubesat
(4" x 8" x 12")
~ 8 kg (17 lb)

One 12U Cubesat
(8" x 8" x 12")
~ 16 kg (35 lb)

Delta II P-POD

Delta II P-POD	
Description	A Cubesat P-POD dispenser attached to the Delta II second-stage mini-skirt
Vehicle	Delta II
Capacity	3 P-PODs (9 Cubesats)
Interface	P-POD Dispenser
Mass	1.33 kg (2.9 lb) per 1U Cubesat
Volume	10 cm^3 (4 in^3) per 1U Cubesat
Status	Operational; first launch 10-2011 on NASA NPP

Three additional Delta II P-POD opportunities will be available through the NASA Educational Launch of Nanosatellites (ELaNa) program

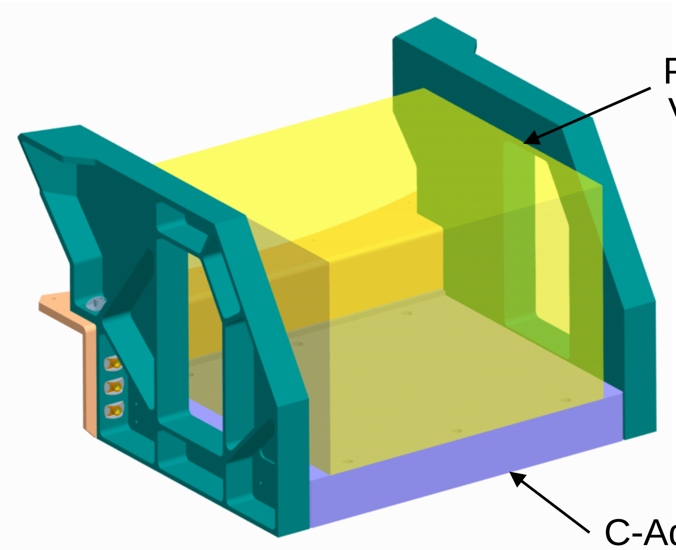


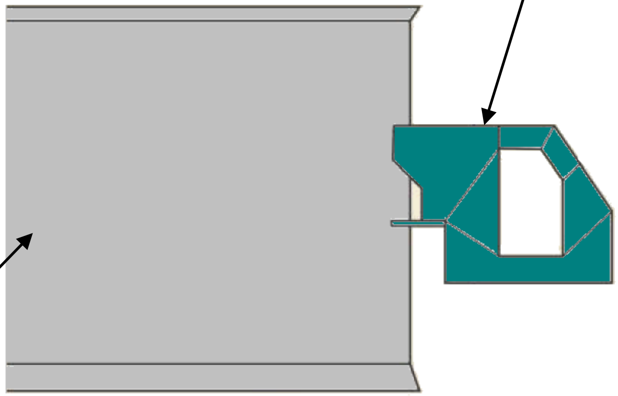
ELaNa III P-PODs Installed On NPP - Delta II Second-Stage Mini-Skirt

C-Adapter Platform (CAP)

C-Adapter Platform (CAP)	
Description	A cantilevered platform attached to the side of a C-adapter to accommodate secondary payloads
Vehicle	Atlas V, Delta IV
Capacity	4 CAPs per C-adapter
Interface	8-in Clampband
Mass	45 kg (100 lb)
Volume	23 cm x 31 cm x 33 cm (9 in x 12 in x 13 in)
Status	Qualified for GSO battery

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

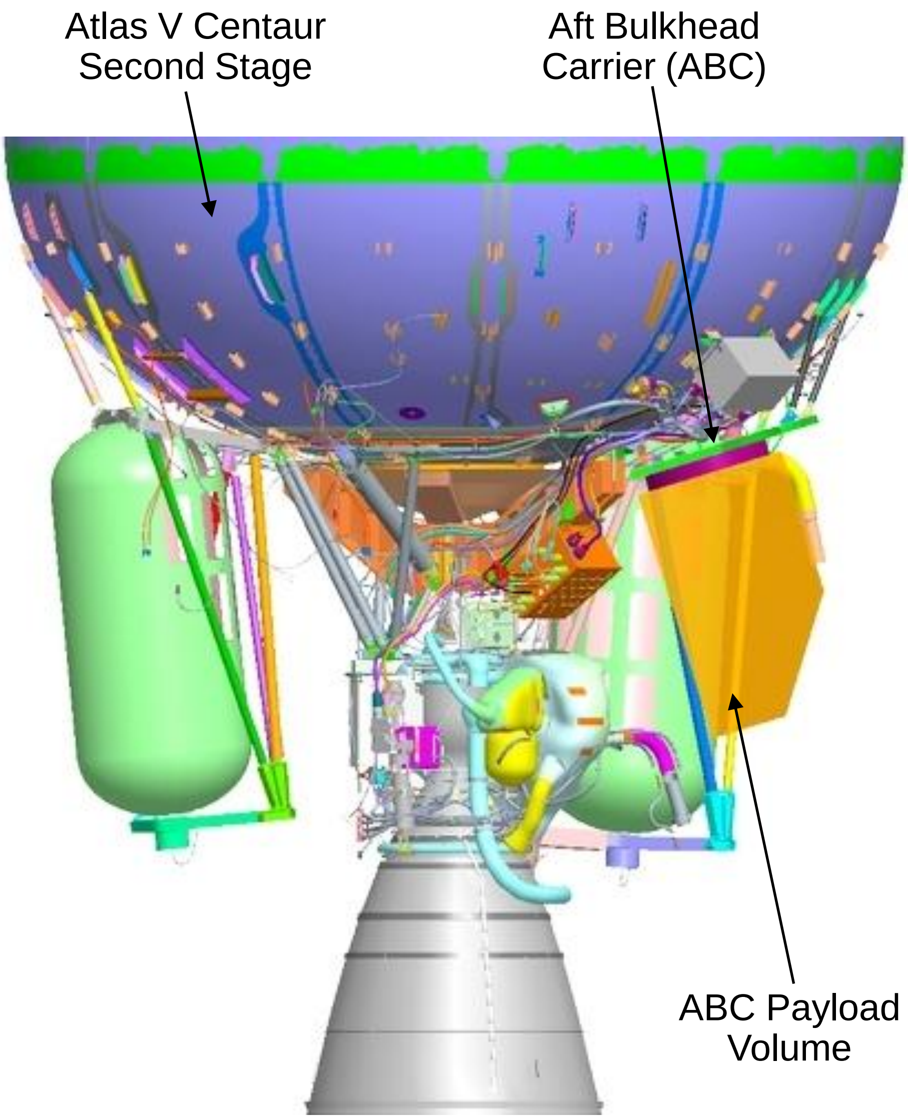




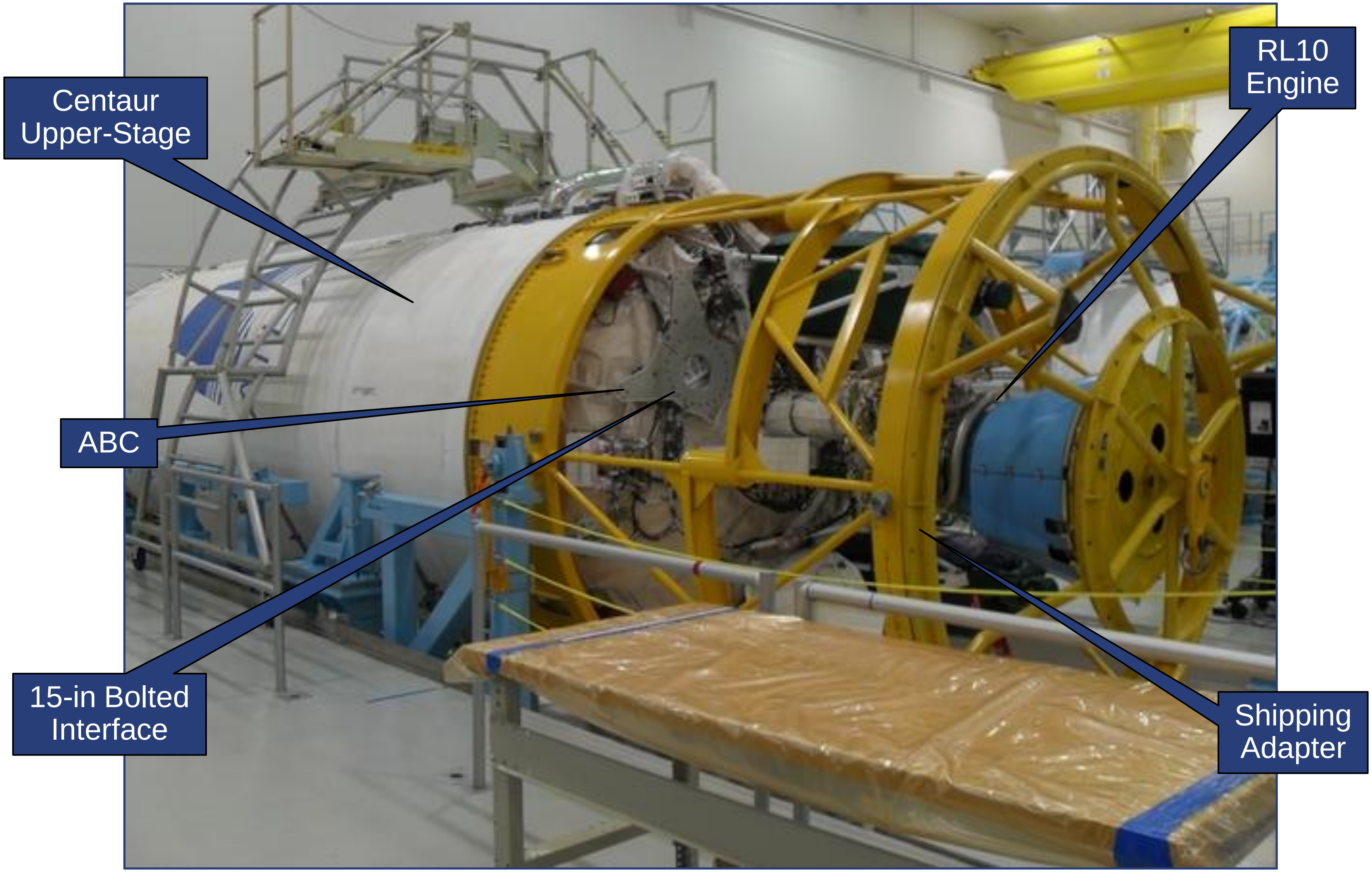
Aft Bulkhead Carrier (ABC)

Aft Bulkhead Carrier (ABC)	
Description	An interface located at the aft-end of the Atlas V Centaur second-stage
Vehicle	Atlas V
Capacity	1 ABC per Atlas V
Interface	15-in Bolted Interface
Mass	80 kg (176 lb)
Volume	51 cm x 51 cm x 86 cm (20 in x 20 in x 34 in)
Status	Operational; first launch 09-2012 on NROL-36 (OUTSat - NPSCuL box with 8 P-PODs)

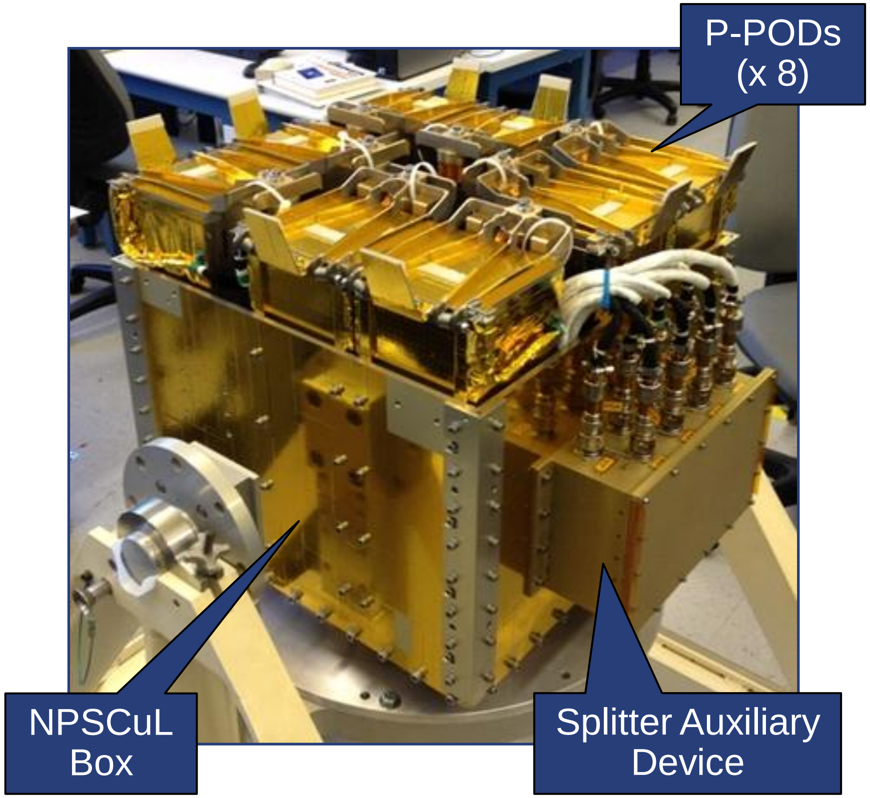
A second ABC mission, GEMSat, launched in Dec 2013, and two additional missions are currently on contract for launch by ULA



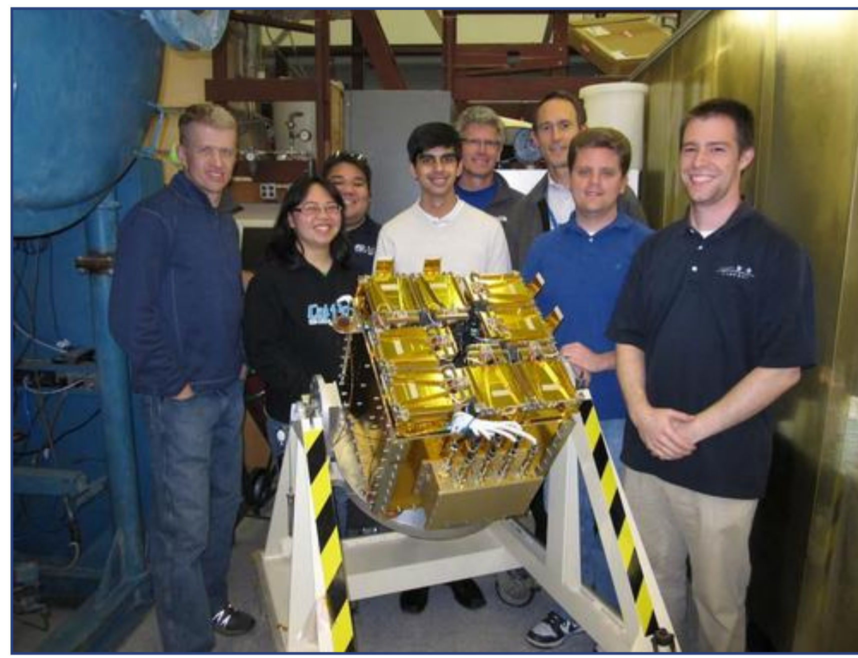
ABC Installed on Centaur



ABC/NROL-36 - OUTSat & Naval Postgraduate School Cubesat Launcher (NPSCuL)



The Operationally Unique Technologies Satellite (OUTSat) launched 8 P-PODs via the Naval Postgraduate School Cubesat Launcher (NPSCuL)

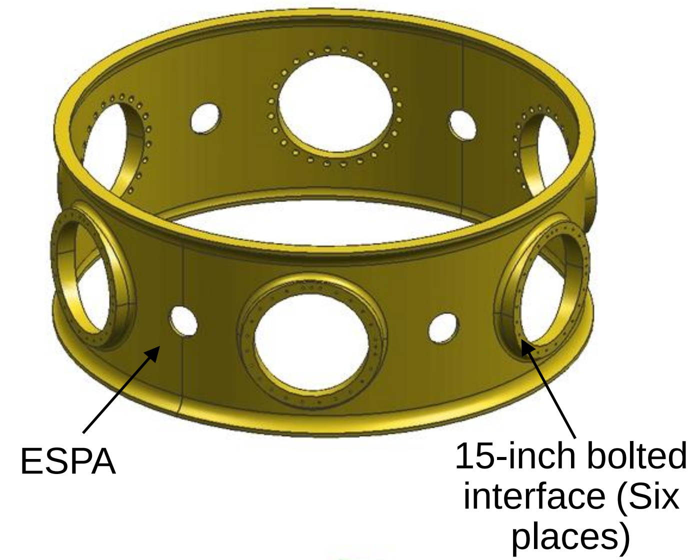


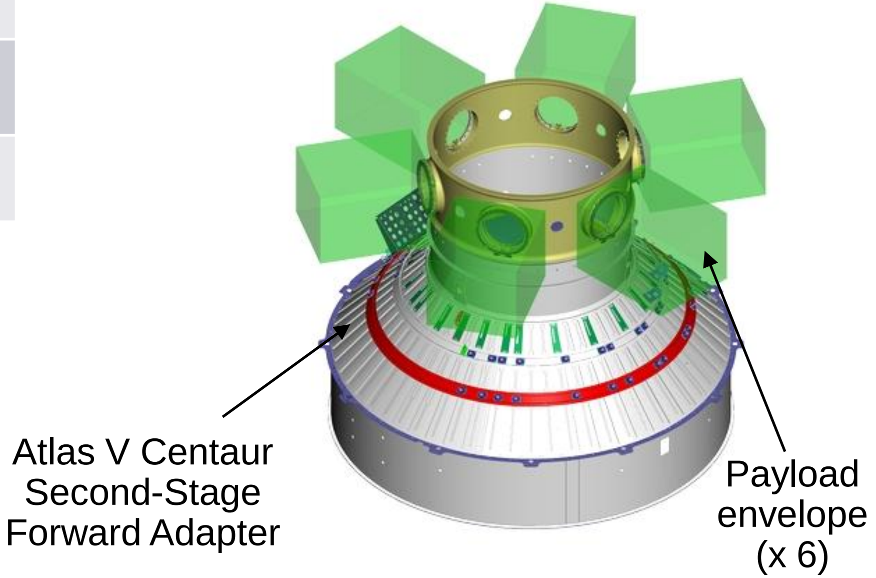
Photos courtesy of NRO/OSL

EELV Secondary Payload Adapter (ESPA)

EELV Secondary Payload Adapter (ESPA)	
Description	An adapter located between the second-stage and the primary payload, which can accommodate up to six secondary payloads
Vehicle	Atlas V, Delta IV
Capacity	6 payloads per ESPA
Interface	15-in Bolted Interface
Mass	181 kg (400 lb)
Volume	61 cm x 71 cm x 96 cm (24 in x 28 in x 38 in)
Status	Operational; first launch 03-2007 on STP-1
Developer	Moog CSA Engineering *(Joe Maly, jmaly@csaengineering.com)*

ESPA hardware will be used to launch ANGELS on AFSPC-4 in 2014, and additional missions are being evaluated

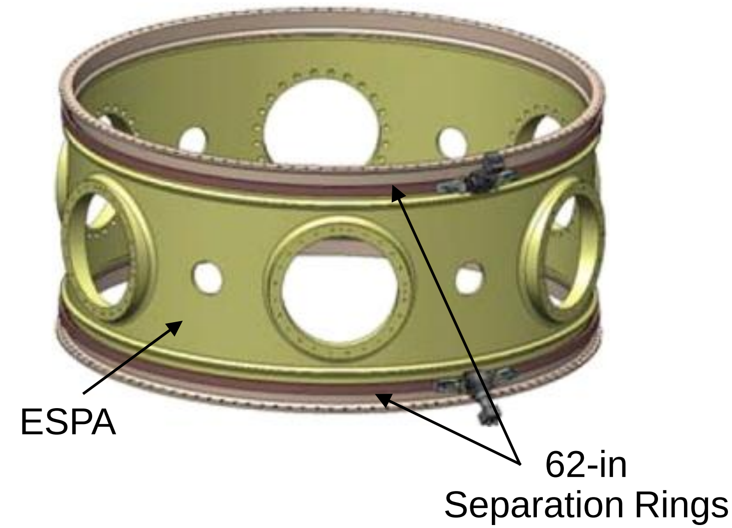


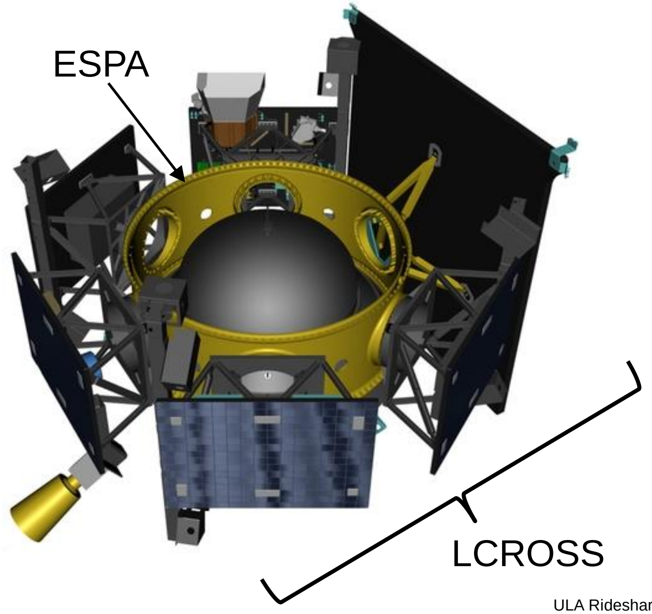


Separating ESPA

Separating ESPA	
Description	A separating rideshare payload that uses the ESPA ring as the structural bus of the satellite
Vehicle	Atlas V, Delta IV
Capacity	Variable
Interface	62-in Bolted Interface
Mass	1,360 kg (3,000 lb)
Volume	350-cm dia. x 61 cm (138-in dia. x 24 in)
Status	Operational; first launch 06-2009 on LRO/LCROSS
Developer	Moog CSA Engineering *(Joe Maly, jmaly@csaengineering.com)*

A separating ESPA can use various separation ring hardware solutions from a number of vendors to separate from the ULA launch vehicle





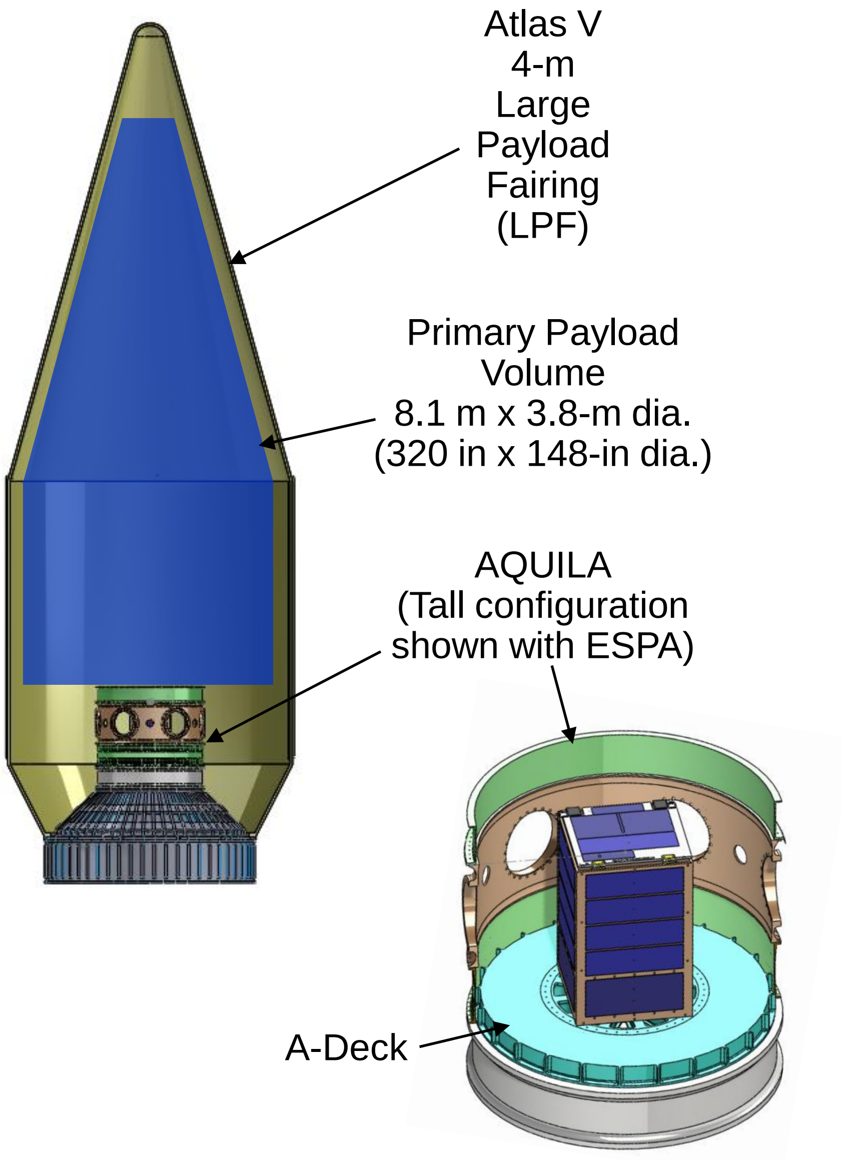
America's Ride to Space

LRO/LCROSS Overview

- In 2009, an Atlas V 401 launched the NASA Lunar Reconnaissance Orbiter (LRO), with the Lunar CRater Observation and Sensing Satellite (LCROSS) as a secondary payload
  - LCROSS' mission was to determine the presence of ice water in a permanently shadowed crater on the Moon
- Designed around an ESPA, LCROSS stayed attached to the Centaur for 4 months, providing command and control to Lunar orbit
- Prior to Lunar impact, LCROSS separated from Centaur, allowing Centaur to act as a heavy impactor that created a debris plume for LCROSS to fly through
  - Centaur and LCROSS successfully impacted Moon on 10/9/2009

AQUILA

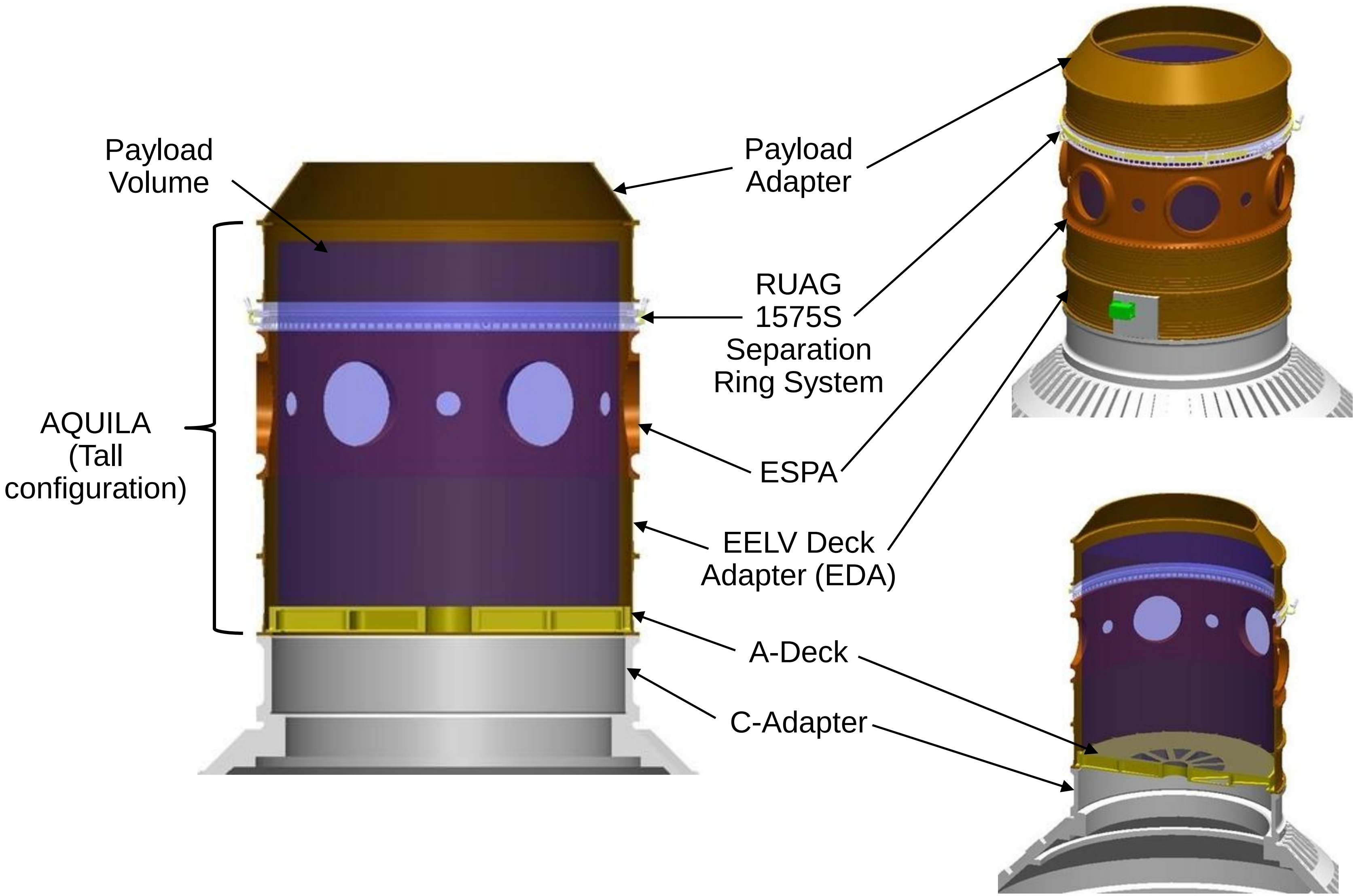
AQUILA	
Description	A flat deck and cylindrical spacers, located between the forward-end of the second stage and the primary payload, providing volume for rideshare payloads inside the AQUILA system
Vehicle	Atlas V, Delta IV
Capacity	Multiple payloads per AQUILA
Interface	Mission-unique bolted
Mass	1,000 kg (2,200 lb)
Volume	142-cm dia. (56-in dia.) x 152 cm (60 in)
Status	In development; CDR 04-2012, Qualification tests complete
Developer	Adaptive Launch Solutions (ALS) *(Jack Rubidoux, jrubidoux@adaptivelaunch.com)*



AQUILA modular adapters are rated to support a primary payload mass up to 6,350 kg (14,000 lb)

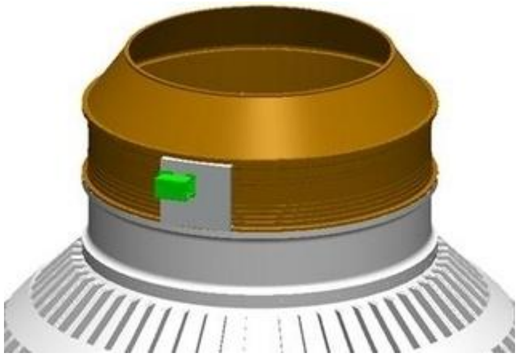
Images courtesy of ALS

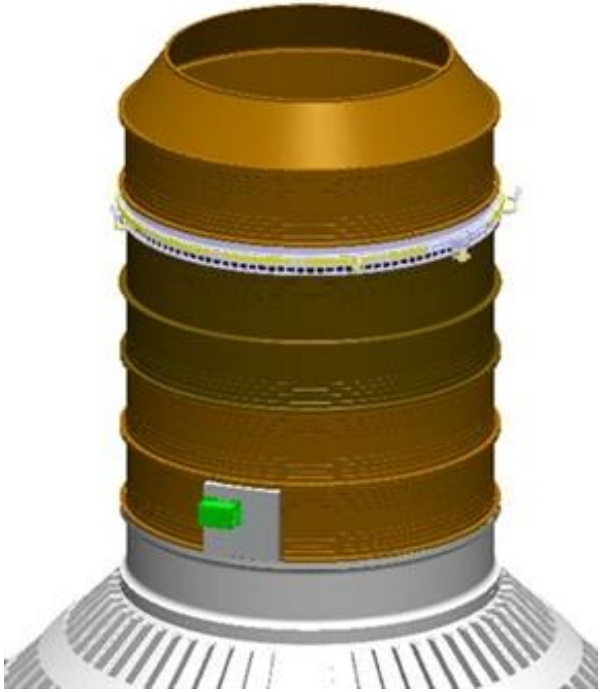
AQUILA Components

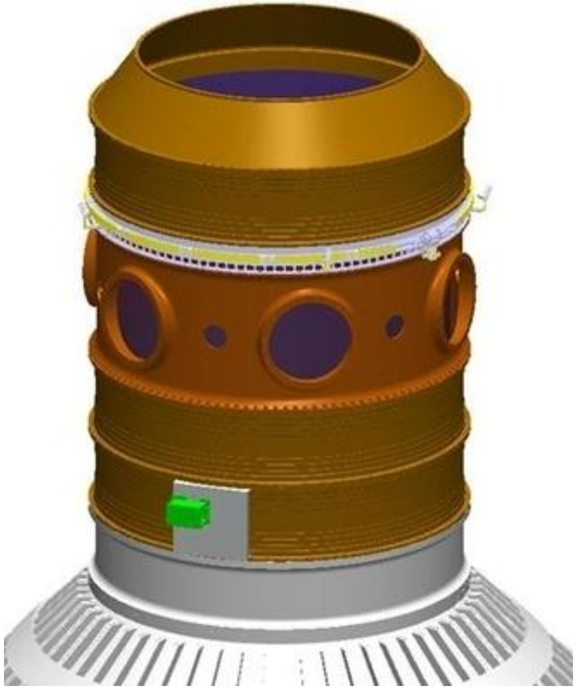


AQUILA Modular Configurations (Notional)

- AQUILA can support multiple heights and is available with various options (i.e. ESPA, isolation barrier) to accommodate customer needs







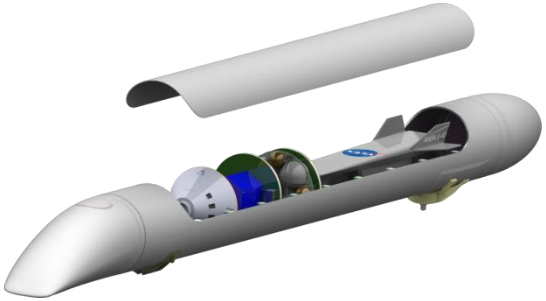
Short	Tall	Tall with ESPA
142-cm dia. (56-in dia.) x 58 cm (23 in)	142-cm dia. (56-in dia.) x 152 cm (60 in)	142-cm dia. (56-in dia.) x 152 cm (60 in)

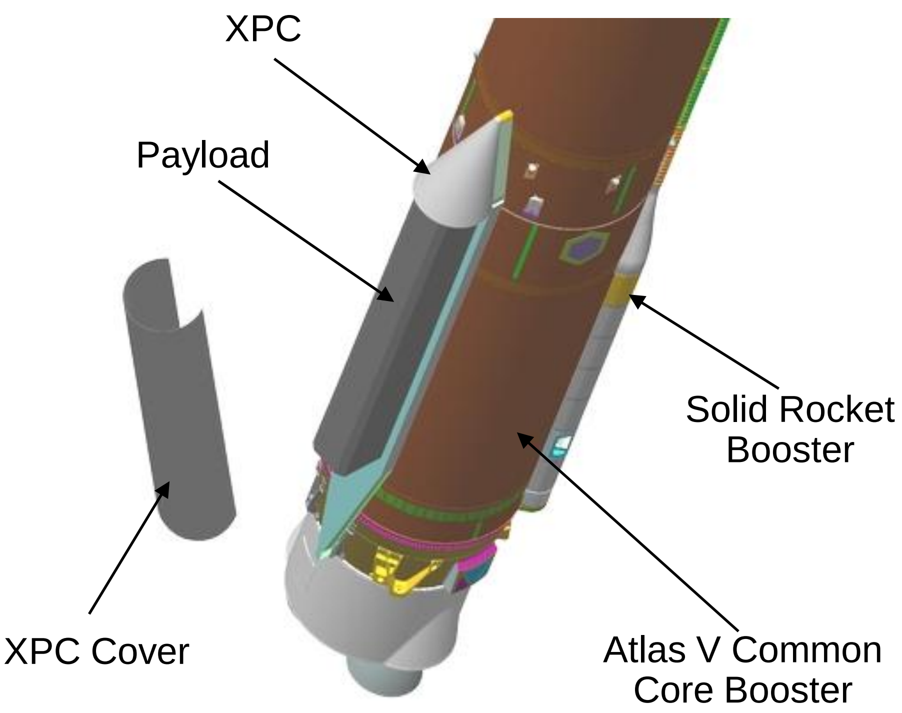
Graphics courtesy of ALS

eXternal Payload Carrier (XPC)

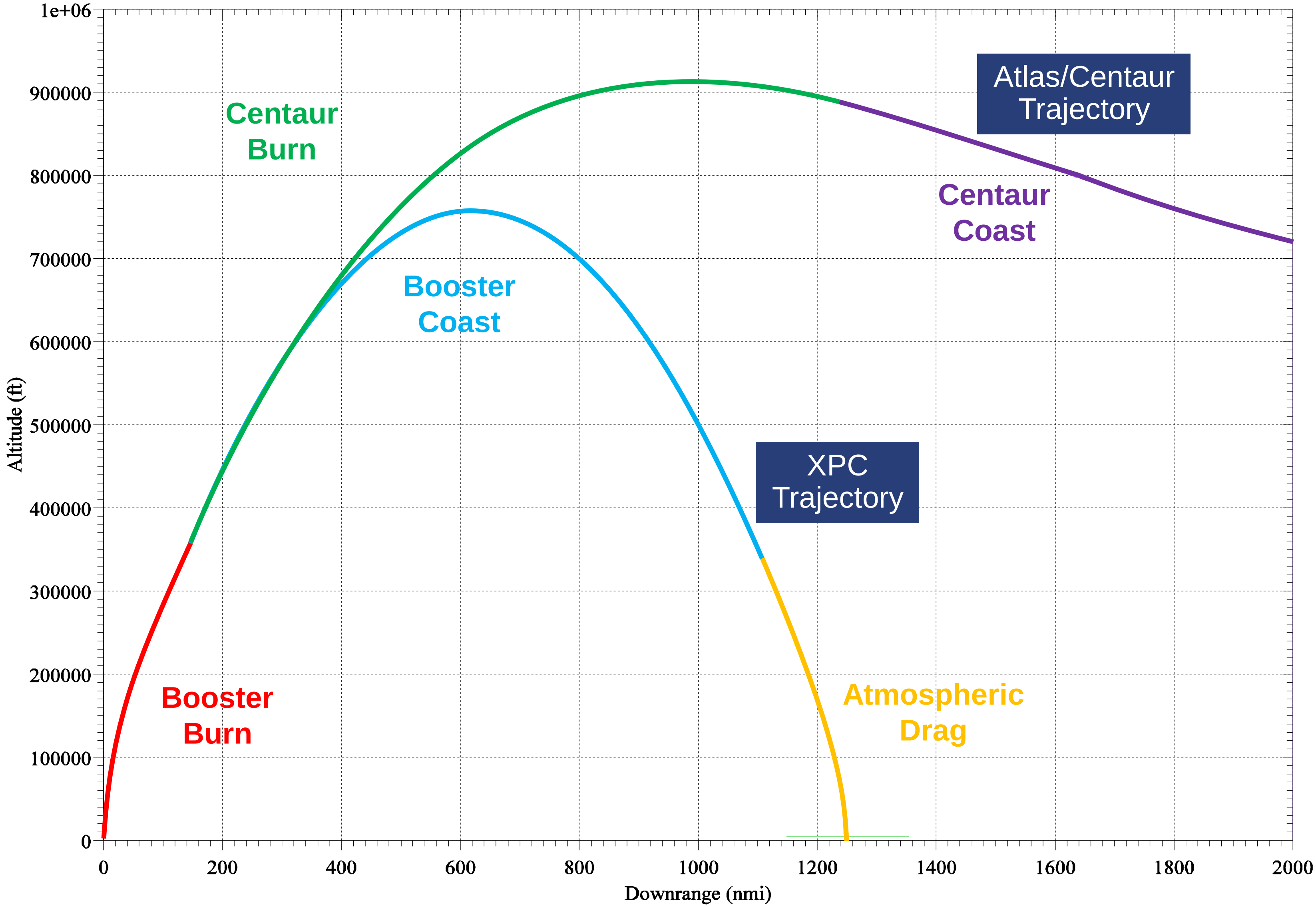
XPC	
Description	An inert solid rocket booster to hold small payloads for injection into a hypersonic suborbital trajectory
Vehicle	Atlas V
Capacity	1 XPC per launch
Interface	Variable
Mass	1,810 kg (4,000 lb)
Volume	21.2 m^3 (750 ft^3)
Status	Concept Development
Developer	Special Aerospace Services (SAS) (Tim Bulk, tbulk@specialaerospaceservices.com)

The XPC can accommodate one large payload, or a number of smaller payloads, and all are jettisonable during the sub-orbital trajectory of the first-stage





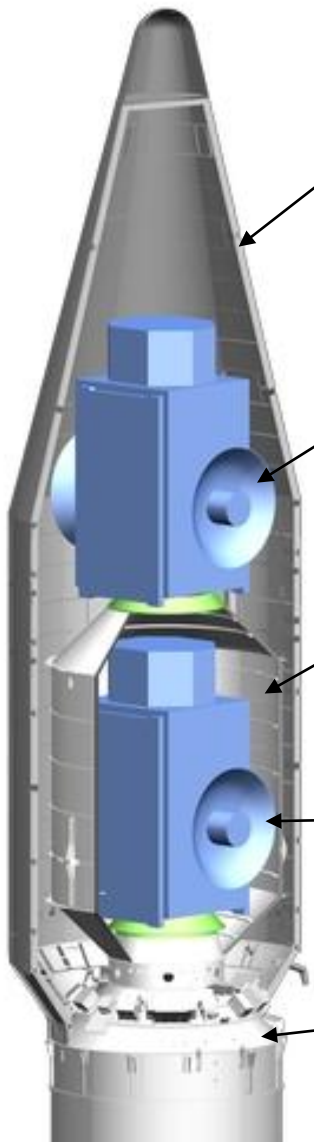
XPC Notional Trajectory



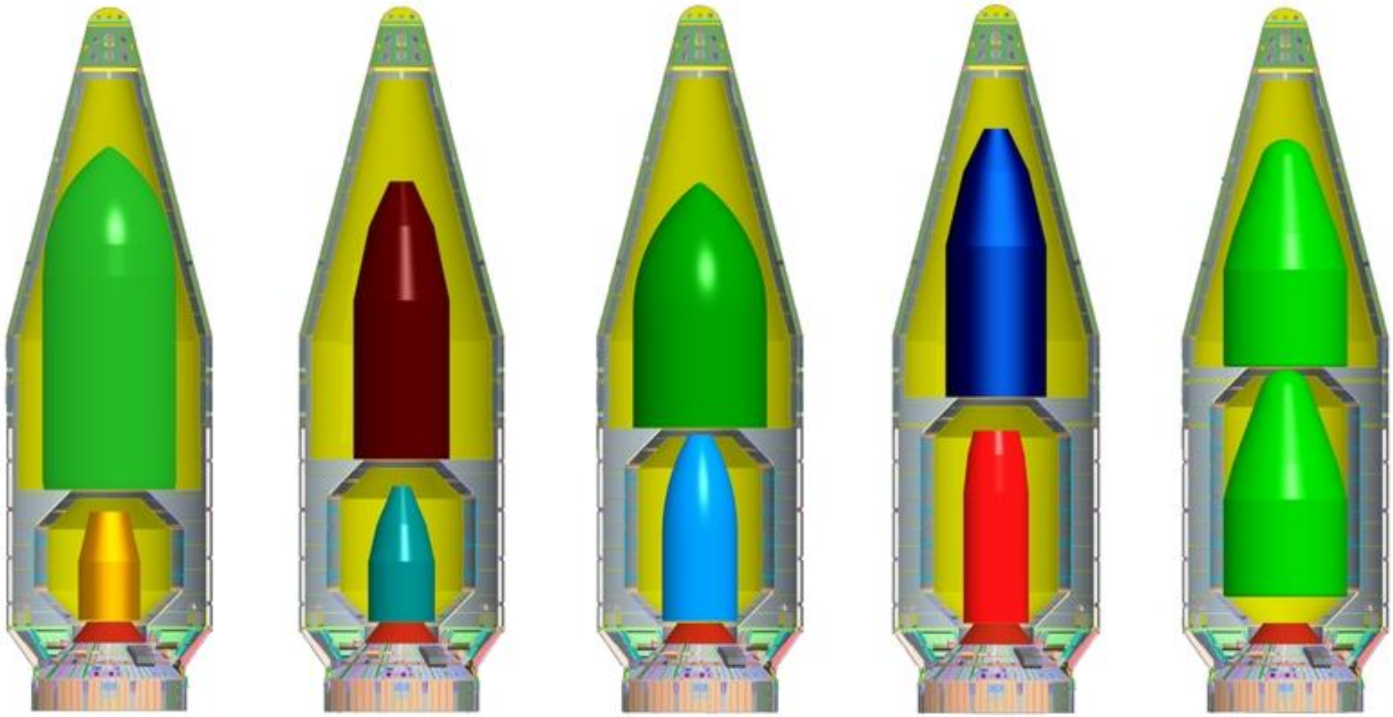
Dual Spacecraft System, 4-m (DSS-4)

DSS-4	
Description	A modular dual-manifest launch capability for 4-m fairings, using Centaur Forward Assembly hardware
Vehicle	Atlas V, Delta IV (4-m fairings)
Capacity	1 DSS-4 per launch, 2 payloads
Interface	62-in Bolted
Mass	Upper Payload: 2,270 kg (5,000 lb) Lower Payload: 9,000 kg (19,800 lb)
Volume	Upper Payload: 365-cm-dia. x 658 cm (144-in-dia. x 259 in) Lower Payload: 254-cm-dia. x 445 cm (100-in-dia. x 175 in) (3-plug)
Status	CDR 12-2009

The DSS-4 will have the same on-orbit concept of operations as the Delta II DPAF, delivering the two payloads to the same or similar orbits (Performance-limited)



DSS-4 Plug Options & Volumes



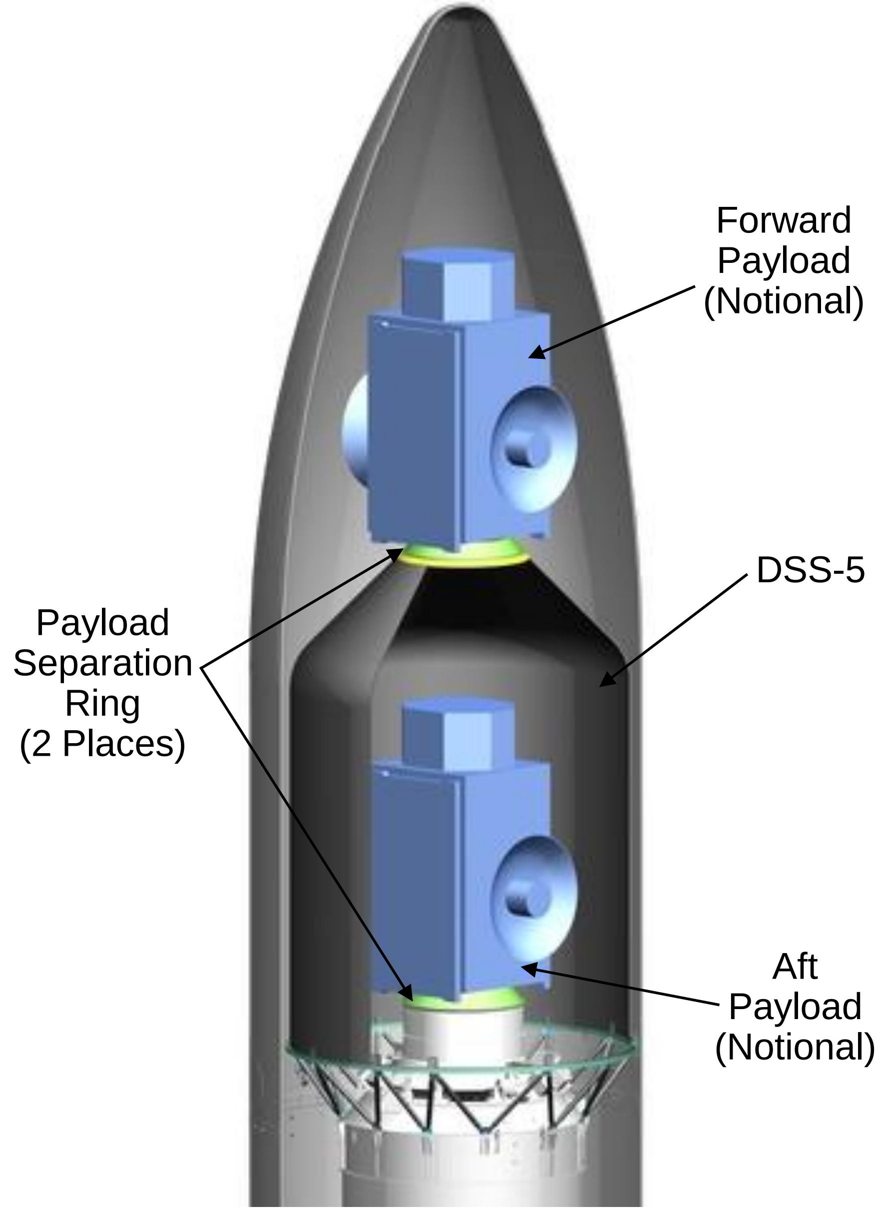
	0 Plug	1 Plug	2 Plugs	3 Plugs	4 Plugs
Forward Payload	Delta II 10-ft PLF	Taurus 92 PLF	Delta II 10-ft PLF	Minotaur IV 92	Delta II 9.5-ft PLF
Aft Payload	Pegasus 38	Falcon 1	Falcon 1E	Taurus 63	Delta II 9.5-ft PLF

Dimensioned drawings are available in the current Atlas V & Delta IV Users Guides

Dual Spacecraft System, 5-m (DSS-5)

DSS-5	
Description	A dual-manifest launch capability for 5-m fairings, using newly designed composite structure
Vehicle	Atlas V, Delta IV (5-m fairings)
Capacity	1 DSS-5 per launch, 2 payloads
Interface	62-in Bolted
Mass	Forward Payload: 5,440 kg (12,000 lb) Aft Payload: 9,000 kg (19,800 lb)
Volume	Forward Payload: 457-cm-dia. x 762 cm (180-in-dia. x 300 in) Aft Payload: 375-cm-dia. x 487 cm (148-in-dia. x 192 in) (Standard DSS-5)
Status	In development; CDR 12-2014

The DSS-5 is expected to be first used in support of the GPS III program, with a first-flight of a GPS III dual manifest mission in 2017/2018



ULA™

America's Ride to Space

Assessing Possible Rideshare Matches

- When determining if a rideshare match is possible, the following top-level parameters need to be assessed:
  - Launch Date - Are the primary and rideshare payloads launching at the same time?
  - Orbit - Are the primary and rideshare payloads going to the same or similar orbits?
  - Mass - Does the launch vehicle have enough mass margin to deliver all payloads to their respective orbits?
  - Volume - Does the fairing volume provide enough room for all payloads?
  - Schedule - Is there enough time to adequately integrate the mission?
  - Funding - Does the rideshare payload have enough budget to support both early feasibility studies and mission integration work?
- Upon assessing these initial parameters, and assuming a positive result, feasibility work can begin, which will ensure complete compatibility between the rideshare and the primary payload
  - Pre-coordination with the primary payload customer may be required, depending on launch service contract requirements
- The standard mission integration process will begin 18-30 months before launch, depending on the primary payload schedule

Manifesting and Integrating Rideshare Payloads - Two Basic Approaches

- Adding Rideshare Payloads To Existing Missions
  - This is the historical approach for many past rideshares; however, it is more difficult to implement due to impacts to the primary payload mission
    - The launch vehicle configuration is already determined, so depending on the rideshare mass/volume, there could be impacts to the fairing size, number of solid rocket motors, and other physical parameters
    - The rideshare manifest request may come after many months of mission integration work on the primary payload has been completed, requiring some design and analysis to be performed again
- Designing Rideshare Missions Concurrently
  - This approach identifies and manifests the primary and rideshare payloads together early in the mission integration process
    - Payloads are designed and integrated concurrently
    - Maximizes mission capability and efficiencies between the rideshare payloads
    - Prevents the need for changing launch vehicle configurations or redoing mission analyses

ULA recommends concurrent rideshare mission design to ensure rideshare mission success

Adding Performance Margin Via Solid Rocket Motors

- ULA's Atlas V and Delta IV launch vehicles have multiple configurations based on the number of solid rocket motors (SRMs) flown
- For both current missions, or when designing a new rideshare mission, the addition of an SRM can provide an appreciable amount of mass capability to orbit, as shown below

		All values are in kg					
ORBIT	**VEHICLE**	**0 SRMs**	**1 SRM**	**2 SRMs**	**3 SRMs**	**4 SRMs**	**5 SRMs**
GTO (35,786 X 185 km @ 27.0 deg)	**Atlas V 4-m**	- 4,750	*+ 1,200* 5,950	*+ 940* 6,890	*+ 810* 7,700		
	Atlas V 5-m	- 3,780	*+ 1,470* 5,250	*+ 1,230* 6,480	*+ 970* 7,450	*+ 840* 8,290	*+ 610* 8,900
	Delta IV 4-m	- 4,210		*+ 1,950* 6,160			
	Delta IV 5-m			- 5,080		*+ 1,810* 6,890	
LEO Polar (200 km circular @ 90 deg)	**Atlas V 4-m**	- 8,080	*+ 1,900* 9,980	*+ 1,160* 11,140	*+ 990* 12,130		
	Atlas V 5-m	- 6,770	*+ 2,200* 9,060	*+ 2,100* 11,160	*+ 1,720* 12,880	*+ 1,600* 14,480	*+ 1,280* 15,760
	Delta IV 4-m	- 7,690		*+ 2,840* 10,530			
	Delta IV 5-m			- 9,610		*+ 1,990* 11,600	

America's Ride to Space

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 5 m
- Designing and launching co-manifested missions is the best approach for maximizing mission capability to orbit, at a significant cost savings over a dedicated launch

United Launch Alliance stands ready to evaluate concepts and provide low-cost rideshare launch opportunities to the spacecraft community

America's Ride to Space