United Launch Alliance Rideshare Capabilities for Providing Low-Cost Access to Space

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Abstract—**United Launch Alliance (ULA) has a long history of providing launch services to high-value payloads for a variety of customers, including the US Department of Defense, the National Reconnaissance Office, NASA, and commercial customers. These missions have deployed a wide variety of capabilities into Earth orbit and beyond, such as navigation, communication, R&D, observation, and science, all which have provided us with a tremendous amount of knowledge about Earth and our solar system. The majority of these spacecraft has been launched as primary payloads, and used the full capability of the launch vehicle; yet there is a lower-cost alternative for achieving similar mission objectives: rideshare.**

Rideshare is the approach of sharing available launch vehicle performance and volume margins with two or more spacecraft that would otherwise go underutilized by the spacecraft community. This allows spacecraft customers the opportunity to get their spacecraft to orbit and beyond in an inexpensive and reliable manner. This concept has been regularly demonstrated since the 1960s, and these rideshare launches have proved that alternative ways to delivering important payloads to orbit in a cost-effective manner can be successfully achieved. Rideshare missions will become even more commonplace as newer launch service capabilities become available and the spacecraft customers choose to take advantage of them.

The ULA family of launch vehicles - the Atlas V, the Delta II, and the Delta IV - all have rideshare capabilities that can be used by the community to launch payloads to orbit for a much lower price than a dedicated single-manifest mission. These capabilities support a wide range of spacecraft sizes, from the smallest Cubesats, to the largest dual-manifest payloads. This presentation will provide a technical overview of current and future rideshare capabilities available, including Delta II P-POD dispensers, the C-Adapter Platform (CAP), the Atlas V Aft Bulkhead Carrier (ABC), the EELV Secondary Payload Adapter (ESPA), the AQUILA, the eXternal Payload Carrier (XPC), and the Dual Spacecraft Systems (DSS-4 and DSS-5). Additionally, programmatic considerations for designing, manifesting, and integrating rideshare missions will be discussed.

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1. WHAT IS RIDESHARE?

Since the dawn of the space age, spacecraft have often shared launch services with one another while being delivered into space. This approach has normally been done to support spacecraft much smaller than the primary payload it is launching with. By designing launch services in this manner, spacecraft operators were able to deliver more payloads to orbit for a fraction of the cost of a full-up launch service.

This method of launching multiple payloads into orbit on a single launch vehicle is called *rideshare*. The use of rideshare over the last 50 years has not always been consistent, but since the 1990s, with the development of more standardized mechanical interfaces for attaching the payload to the launch vehicle, the number of rideshare missions launched to orbit have increased. This continual improvement in rideshare capabilities is allowing more and more organizations to successfully design, produce, and launch payloads to orbit, increasing the amount of operational capability and scientific knowledge gained from these space-based payloads.

Advantages of Rideshare

The most obvious advantage to using the rideshare concept for launching payloads to orbit is the decreased cost to the customer. Instead of having to procure a dedicated launch vehicle to launch their single payload, the customer can get the same delivery to orbit by launching as a secondary or co-manifest payload for a price much lower than a full-up launch service. The cost savings can then be applied to the payload, or to other parts of the overall space mission's architecture.

In the case of dual manifest, the cost savings can be enormous. For example, for the GPS III program, by transitioning from single-manifest to dual-manifest launches for the last 26 of 32 total spacecraft, the cost savings are anywhere from $750M to $1B over the life of the program. Smaller constellations will not see as large a savings, but even manifesting two spacecraft together onto a single launch vehicle will provide almost $50M in savings.

Rideshare Definitions

There are a number of terms used within the space community to define the various types of rideshare approaches available. Not all terms are completely standardized across the board; however, the following are the terms used by ULA when discussing launch opportunities.

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 primary payload, and usually permanently attached.

Secondary Payload (SP)—An APL launched as part of the launch vehicle, and usually designed to separate.

Co-Manifest—General term for two or more primary payloads manifested together.

Multi-Manifest—Multiple spacecraft of the same design launched to orbit (This does not include multiple spacecraft launched as a single payload stack).

Dual Manifest (DM)—Two primary payloads (of either a different design or the same design) sharing a launch to orbit using dedicated dual manifest hardware.

2. Rideshare Launch History

ULA's launch systems have a long history of providing access to space to auxiliary, multi-manifest and dual-manifest payloads through the Atlas and Delta families of launch vehicles. Since the 1960s, these rideshare launches have benefited customers of diverse mission areas including commercial communications, Earth science, military research and development and education.

The approach of sharing available performance margin that would otherwise go unused by the primary payload has provided satellite customers the opportunity to get their spacecraft to orbit in an inexpensive and reliable manner. ULA remains committed to the rideshare community by developing new capabilities and solutions that allow for the launch of rideshare satellite customers for years to come. A list of Atlas and Delta rideshare missions launched since 2000 and scheduled out to 2016 are shown in Table 1.

Table 1. ULA Rideshare History, 2000-2016

MISSION	VEHICLE	LAUNCH DATE	RIDESHARE TYPE	RIDESHARE HARDWARE USED
Globalstar 7	Delta II 7420	2/8/2000	Multi	Post Dispenser
EO-1/SAC-C/Munin	Delta II 7320	11/21/2000	Dual + Secondary	DPAF
Jason-1/TIMED	Delta II 7920	12/7/2001	Dual	DPAF
Iridium-12	Delta II 7920	2/11/2002	Multi	Platform Dispenser
ICESat/CHIPSAT	Delta II 7320	1/12/2003	Dual	Reduced-Height DPAF
GPS IIR-8/XSS-10	Delta II 7925	1/29/2003	Secondary	Delta II Guidance Section
Delta IV Heavy Demo/Nanosat-2	Delta IV Heavy	12/20/2004	Piggyback	Mission-unique bracket
CALIPSO/CloudSat	Delta II 7420	4/28/2006	Dual	DPAF
STP-1	Atlas V 401	3/8/2007	Secondary	ESPA
LRO/LCROSS	Atlas V 401	6/18/2009	Secondary	ESPA
NPP/ELaNa III	Delta II 7920	10/28/2011	Secondary	Delta II P-POD
NROL-36/OUTSat	Atlas V 401	9/13/2012	Secondary	ABC
NROL-39/GEMSat	Atlas V 501	12/5/2013	Secondary	ABC
AFSPC-4/ANGELS	Delta IV M+(4,2)	7/28/2014	Secondary	ESPA
SMAP/ELaNa X	*Delta II 7320*	*2015*	*Secondary*	*Delta II P-POD*
AFSPC-5/ULTRASat	*Atlas V 501*	*2015*	*Secondary*	*ABC*
NROL-55/GRACE	*Atlas V 401*	*2015*	*Secondary*	*ABC*
ICESat II/ElaNa	*Delta II 7420*	*2016*	*Secondary*	*Delta II P-POD*
JPSS-1/ELaNa	*Delta II 7920*	*2016*	*Secondary*	*Delta II P-POD*

3. Rideshare Capability Overview

To date, ULA has completed development or is continuing to develop a large number of rideshare capabilities and hardware, each with its own set of mass, volume, and interface parameters that can support a multitude of payload shapes and sizes. Each of the capabilities is at different stages of development, but all are expected to be completed in order to support launch opportunities by the middle of this decade. An overview of the technical specifications and development status of each individual capability is shown in Table 2. Immediately following is a detailed technical overview of each one, and is provided to support future mission planning for the entire rideshare community.

Table 2. ULA Rideshare Capability Overview

Capability	Launch Vehicle			Status	Mechanical Interface	Maximum # Per Launch		Maximum Mass Per Payload	Volume Per Payload
	DII	DIV	AV						
Delta II Second-Stage Mini-Skirt	●			Operational	P-POD	3 P-PODs		1.0 kg (2.2 lb)	10 cm^3 (4 in^3)
CAP (C-Adapter Platform)		●	●	In Development	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)
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)
ESPA (EELV Secondary Payload Adapter)		●	●	Operational	15-in Bolted	Up to 6 SC per ESPA		181 kg (400 lb)	61 cm x 71 cm x 96 cm (24 in x 28 in x 38 in
AQUILA		●	●	CDR 4/2012	Variable	Up to 3 SC per AQUILA		1,000 kg (2,200 lb)	142-cm dia. x 152 cm (56-in dia. x 60 in)
XPC (eXternal Payload Carrier)			●	PDR 12/2010	Variable	1 XPC		1,810 kg (4,000 lb)	21.2 m^3 (750 ft^3)
DSS-4 (Dual Spacecraft System, 4-m)		●	●	CDR 12/2009	62-in Bolted	1 DSS-4	Fore	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)
DSS-5 (Dual Spacecraft System, 5-m)		●	●	CDR 12/2014	62-in Bolted	1 DSS-5	Fore	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)

CubeSats/Poly Picosatellite Orbital Deployer (P-POD)

CubeSats are the smallest spacecraft that can be accommodated on ULA vehicles. The common dispenser for this class of spacecraft is the Poly Picosatellite Orbital Deployer (P-POD) developed by California Polytechnic University, San Luis Obispo. An individual P-POD can accommodate up to 3 CubeSats. ULA has pursued a number of P-POD interface solutions for the Atlas and Delta vehicles. The first launch of P-PODs on a ULA vehicle occurred on a Delta II in October 2011. Three P-PODs were attached around the circumference of the Delta II second-stage, as shown in Figure 1.

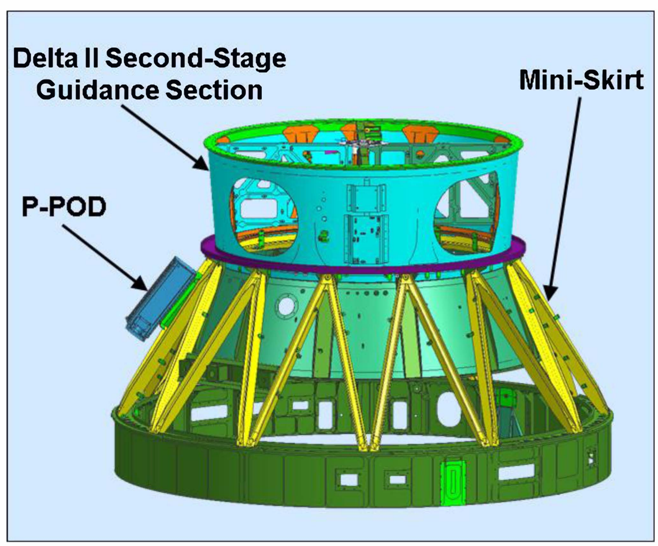

Figure 1. Delta II P-POD Interface

Another system for launching P-PODs is the Naval Post Graduate School (NPS) CubeSat Launcher (NPSCuL), as shown in Figure 2. The NPSCuL hosts eight P-PODs for a total of 24 CubeSat slots. This launcher was first flown on an Atlas V in September 2012, with a second launch in 2013, and two more scheduled in the coming years. The NPSCuL is launched with an avionics box attached to its side. This box receives the individual separation signals from the Atlas Centaur second-stage Ordnance Remote Control Assemblies (ORCA) and routes them to each P-POD, allowing the CubeSats to be released on a pre-determined schedule.

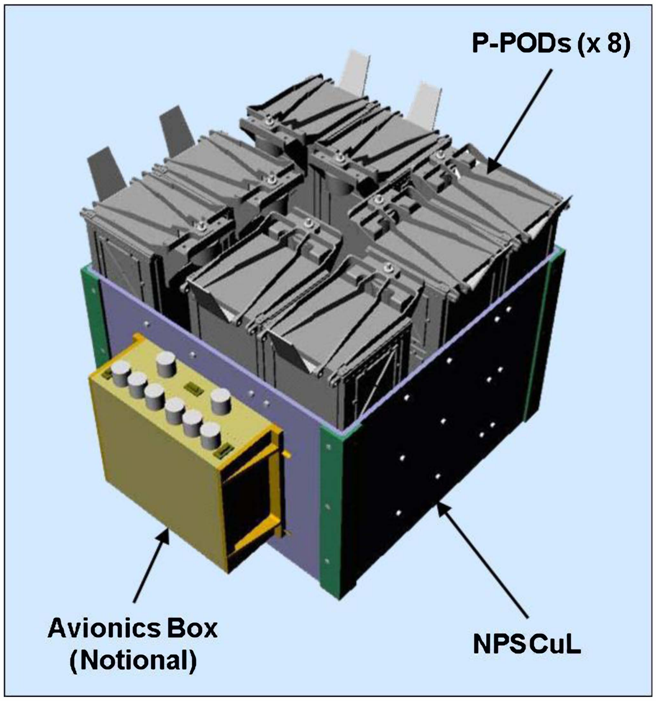

Figure 2. NPSCuL P-POD Interface

C-Adapter Platform (CAP)

The C-Adapter Platform (CAP) is a cantilevered platform that is located within the payload fairing and is attached to the side of a C-adapter. It can carry an auxiliary payload with a mass up to 45 kg (100 lb). With additional qualification, it may be possible to increase this mass limit. Figure 3 shows the basic configuration of a typical CAP. The number of CAPs and the positioning of the CAPs around the circumference of the C-adapter are subject to available mission margins and mission requirements, but up to four CAPs could be accommodated on a single flight. The CAP can accommodate various deployment options, and it is large enough to accommodate an 8-inch Motorized Lightband, which can be mounted on either the base of the CAP or on the back wall. The CAP is compatible with both the Atlas V and the Delta IV.

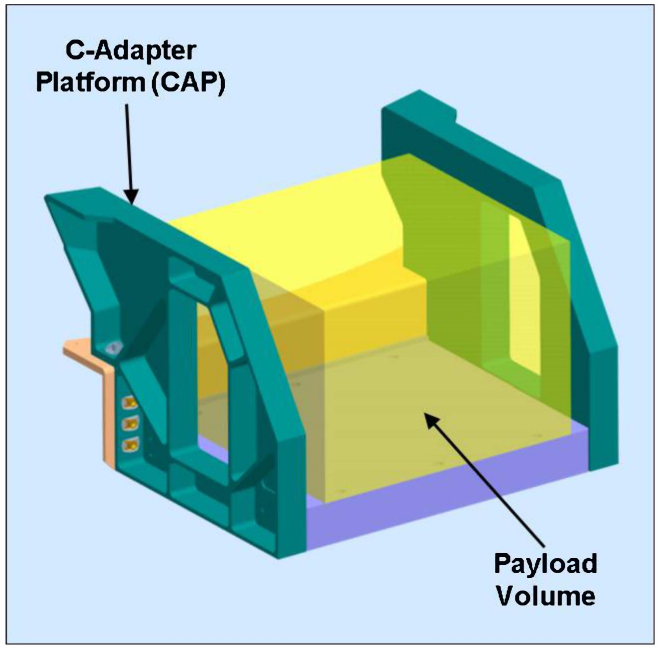

Figure 3. C-Adapter Platform (CAP)

Aft Bulkhead Carrier (ABC)

The Aft Bulkhead Carrier (ABC) utilizes volume on the Atlas V Centaur aft bulkhead previously occupied by a helium bottle that is no longer required. The ABC can carry an auxiliary payload with a mass of up to 80 kg (176 lb). Located on the aft-end of the Centaur second-stage near the RL10 engine area, and using mounting attachment points that use the existing tank doublers, the ABC provides a usable volume as shown in Figure 4. The ABC can accommodate both separating and non-separating payloads, with a volume that is slightly larger for non-separating payloads. The ABC is large enough to accommodate a 15-inch Motorized Lightband separation system.

Since the ABC is on the aft-end of the Centaur, it has the advantage of not interfering with the primary payload environment. It also has the ability to be deployed into low-Earth orbit during the Centaur first-coast portion of the mission, although the risk of doing so prior to primary payload separation would need to be assessed. The separation plane of the ABC is tilted 17 degrees relative to the longitudinal axis of the Centaur, providing clearance and no re-contact with the Centaur. To avoid contamination or plume impingement, the Centaur inhibits the normal settling thrusters during the period of deployment.

More information is available in the Aft Bulkhead Carrier Auxiliary Payload User's Guide, available for download from ULA [1].

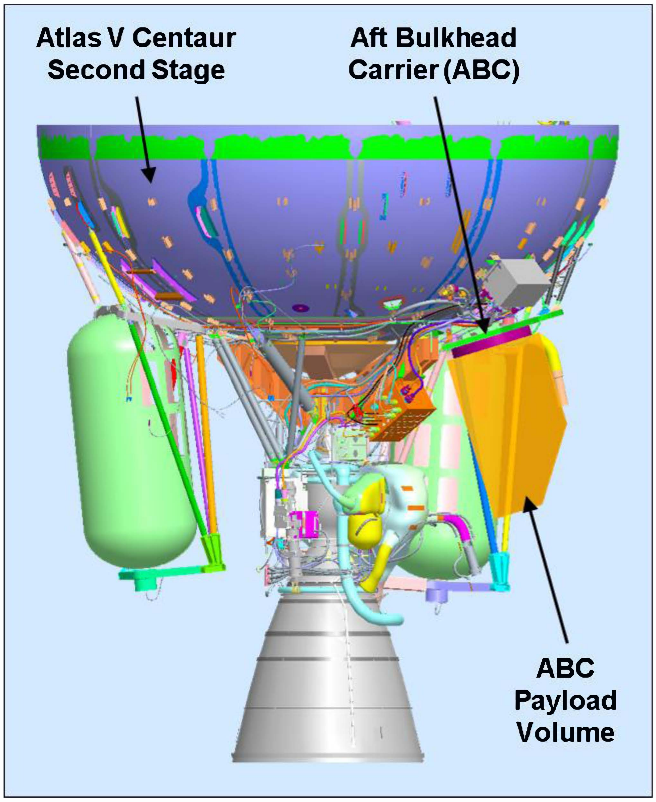

Figure 4. Aft Bulkhead Carrier (ABC)

EELV Secondary Payload Adapter (ESPA)

For missions with excess volume within the fairing, larger auxiliary payloads can be launched using the EELV Secondary Payload Adapter (ESPA), a 1.5-m-dia (62-in diameter), 61-cm-tall (24-in-tall) ring structure that can support up to six auxiliary payloads around its circumference. Developed by Moog CSA Engineering, the ESPA is mounted between the top of an Atlas V or Delta IV second-stage and the bottom of the primary payload's spacecraft adapter, duplicating the EELV standard interface plane (SIP), and passing the electrical interfaces through to the primary payload (Figure 5). The first launch of an ESPA occurred on the Department of Defense Space Test Program launch STP-1 in March 2007.

The auxiliary payload may be attached to the ESPA with a ULA-supplied separation system or directly through a customer-provided adapter. The ESPA ring includes six 381-mm-dia (15-in-dia) bolt circle interfaces, with each being able to accommodate a single auxiliary payload of up to 180 kg (400 lb) in mass, and a volume of 61.0 cm x 71.1 cm x 96.5 cm (24 in. x 28 in. x 38 in.). This total volume includes a 5.33 cm (2.1 inch) separation system operational envelope. Only the separation system, its mounting hardware and its harness are permitted inside the separation system operational envelope. Detailed information on the standard ESPA and its mission integration requirements are documented in the ESPA Rideshare User's Guide, available for download from ULA [2].

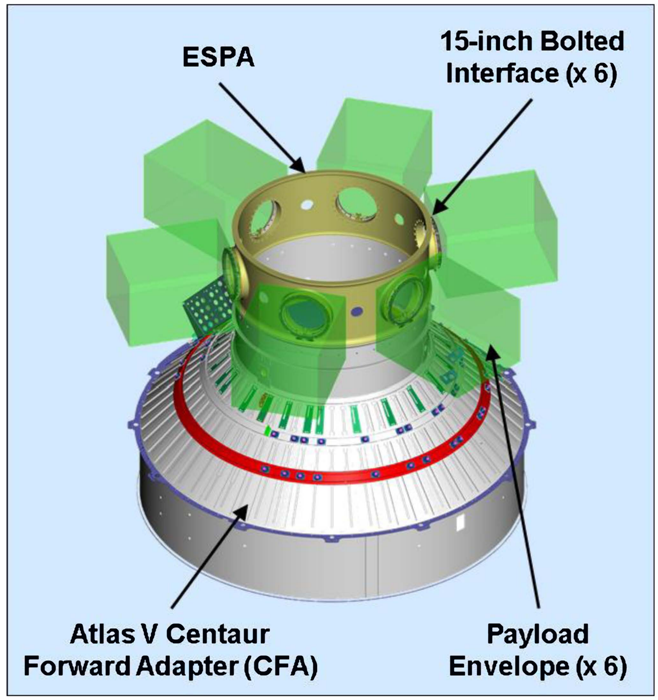

Figure 5. EELV Secondary Payload Adapter (ESPA)

The ESPA can also be used as a separating spacecraft bus structure of the actual secondary payload. This was first achieved on the NASA Lunar Crater Observation and Sensing Satellite (LCROSS) mission (Figure 6), which launched as a secondary payload on the Lunar Reconnaissance Orbiter (LRO) mission in 2009. After LRO spacecraft separation, the ESPA-based LCROSS spacecraft stayed attached to the Centaur second stage, and sheparded it for three months, at which time it released the Centaur towards the Moon to act as an impactor, LCROSS following shortly afterward.

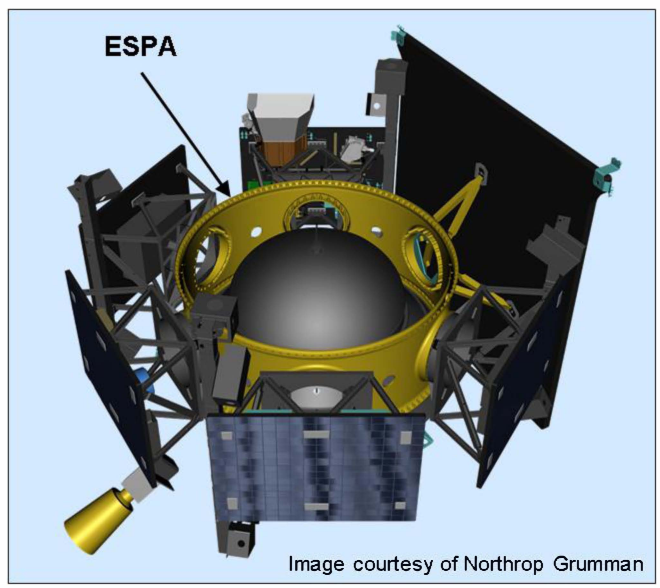

Figure 6. Lunar Crater Observation and Sensing Satellite (LCROSS)

Other ESPA solutions, such as the 122-cm-tall (48-in-tall) ESPA Grande, with 60.9-cm-dia (24-in-dia) ports and an increased capability of up to 318 kg (700 lb), can also be flown atop Atlas V and Delta IV launch vehicles.

AQUILA

The AQUILA is a flexible stack of ring adapter segments that provide an interior volume below the primary payload (Figure 7), and is designed to accommodate various auxiliary payload types within its volume. The entire stack can be configured to accommodate a variety of spacecraft volumes, depending on the particular needs of the mission. It consists primarily of a mix of C-adapters of various heights (13, 24, or 25 inches). Additionally, a separation system can be added in order to separate the upper portion of the AQUILA from the lower portion. Also, an ESPA ring can be added in place of a C-adapter in support of multi-manifest missions. The AQUILA has been developed by Adaptive Launch Solutions (ALS).

The AQUILA uses an isogrid or aluminum flat-deck called the A-Deck at the bottom of the structure as the spacecraft interface, which allows for the deployment of one or multiple auxiliary payloads from within the internal volume of the AQUILA. The internal envelope diameter of a C-Adapter segment can accommodate auxiliary payloads diameters of up to approximately 56 inches. The height available to the auxiliary payload can vary by the types and number of adapters used.

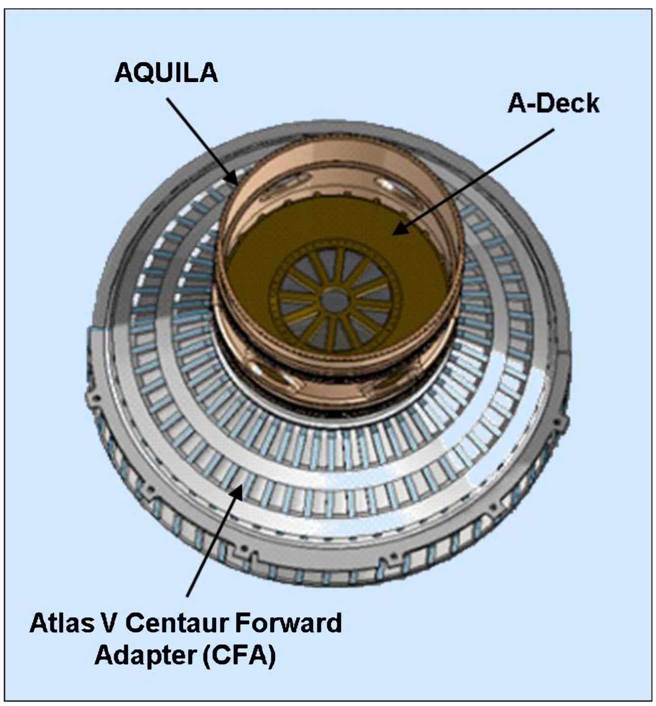

Figure 7. AQUILA

eXternal Payload Carrier (XPC)

An atypical approach to rideshare, the eXternal Payload Carrier (XPC) is a payload carrier external to the Atlas V first-stage. Appearing as an existing solid rocket booster (SRB) (Figure 8), the XPC will attach to the first stage like any other SRB, and ride with the first-stage booster up through booster separation. At this point in the ascent, the XPC would be flying at a velocity of Mach 14 at an altitude of 700,000 ft. The XPC cover will jettison, allowing the internal payloads to be released into a hypersonic suborbital trajectory.

The XPC will provide a 5 ft diameter and 750 cubic feet of volume. Technology development programs that would find the XPC beneficial may include Mars re-entry, Scramjet technology, or micro-gravity fluid dynamics and aerosols.

Currently the XPC is under development by an industry team led by Special Aerospace Services (SAS).

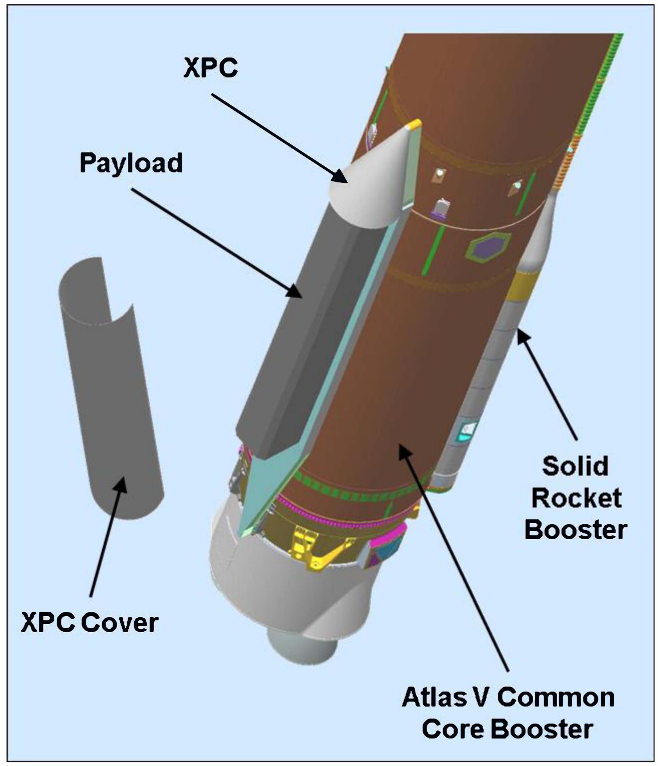

Figure 8. eXternal Payload Carrier

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

The Dual Spacecraft System, 4-m (DSS-4) is a capability designed and developed by ULA to enable the launch of two independent, small-to-medium class spacecraft within a single Atlas V or Delta IV 4-m launch vehicle fairing, as shown in Figure 9. The DSS-4 makes extensive use of existing components with well-understood capabilities. The launching of two similarly-sized dual spacecraft has already been demonstrated four times over the past decade on the Delta II Dual Payload Attach Fitting (DPAF). The launch processing and on-orbit concept of operations for the DSS-4 is very similar to the DPAF.

The DSS-4 structure consists of two back-to-back Centaur Forward Adapters (CFAs) with an optional addition of one, two, three, or four DSS-4 plug sections to provide flexibility in the heights of the forward and aft spacecraft volumes. The CFA is an assembly of one cylindrical stub adapter and a conical adapter attached by a common ring. In the DSS-4 application, the cylindrical parts of a lower, inverted CFA and an upper, non-inverted CFA mate together. This creates a canister which contains the lower spacecraft. The Atlas V or Delta IV 4-m-diameter payload fairing completely encloses the upper spacecraft and the DSS-4, while the DSS-4 itself encloses the lower spacecraft. The DSS-4 supports the upper spacecraft and therefore all the loads from the upper spacecraft are carried by the DSS-4 during vehicle flight.

The forward interface of the DSS-4 is the 62-inch Standard Interface Specification (SIS) payload interface, permitting use of existing payload adapters. The aft interface attaches to the Atlas launch vehicle using a standard C-13 cylindrical payload adapter. The DSS-4 can be flown within any Atlas V or Delta IV payload fairing as needed, based on the lengths of the two spacecraft and the DSS-4.

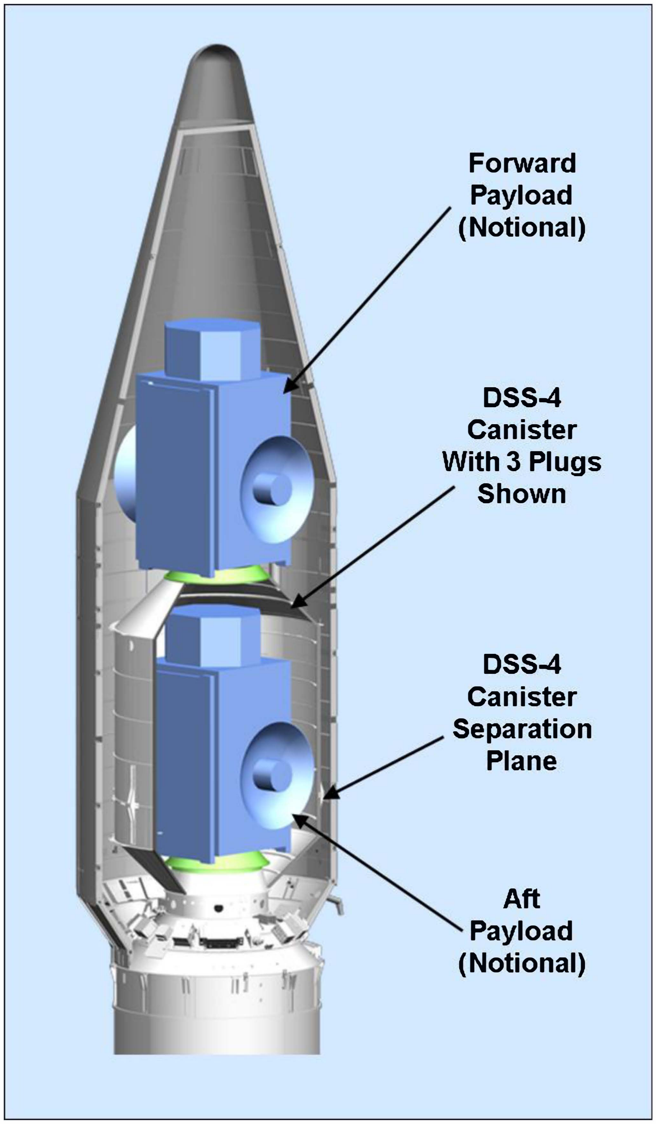

Figure 9. Dual Spacecraft System, 4-m Fairing (DSS-4)

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

Similar to the DSS-4, the DSS-5 is designed to dual-launch two medium-to-intermediate class payloads within an Atlas V or Delta IV 5-m payload fairing, as shown in Figure 10. The DSS-5 consists of a newly designed composite cylindrical canister and upper cone structure that encloses the lower payload and provides structural support for the upper payload. There is no change to the structural support of the lower payload. The DSS-5 is being developed by ULA and RUAG Space.

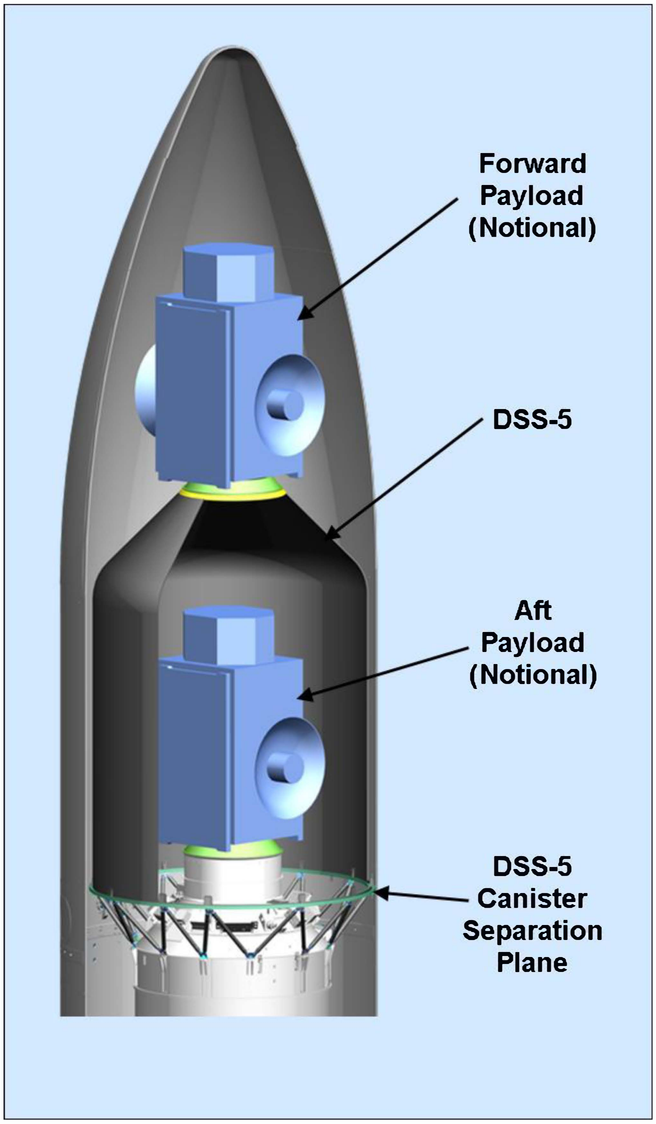

Figure 10. Dual Spacecraft System, 5-m Fairing (DSS-5)

A mission-unique adapter is used to attach the launch vehicle to the interface of the lower payload. The DSS-5 provides support for the ULA-provided electrical harnessing to the upper payload, instrumentation, and upper payload separation system.

The lower DSS-5 spacecraft volume is approximately 4-m dia. x 6.1 m (13.1-ft dia. x 20 ft), while the upper spacecraft volume is slightly larger. The DSS-5 is designed to fly on both the Atlas V and the Delta IV 5-m launch vehicles.

4. Manifesting and Mission Integration of Rideshare

Development of mechanical interfaces for rideshare payloads is only half the battle; mission integration activities on both the primary and rideshare spacecraft must be successfully completed to ensure that all payloads are safely delivered to their orbit without damage to themselves or the launch vehicle. Yet these activities cannot begin until a rideshare is manifested onto a launch service alongside a primary payload. Rideshare missions can be manifested onto a launch service in one of two ways. First, they can be manifested as a rideshare onto an already-existing primary payload mission. Second, they can be co-manifested together with a companion rideshare payload early in the development process of both, allowing the payloads to be designed and integrated concurrently.

Adding Rideshare Payloads to Existing Missions

The first approach is the historical way that the majority of rideshare missions have been integrated and launched. However, this approach is more difficult to implement, as the primary payload has already been matched up with a particular launch vehicle configuration, including payload fairing size and number of solid rocket motors. Depending on the mass and volume of the rideshare payload, these parameters might need to be changed to physically accommodate the rideshare. If a change to the launch vehicle configuration is implemented, it could impact the schedule, as new hardware might need to be procured to meet the new requirements. An impact to mission cost will also occur, as the inclusion of a larger fairing or additional solid rocket motors will need to be paid for.

Additionally, depending on the complexity of the primary payload mission, mission integration efforts may have already begun at the time the rideshare payload is requesting to be co-manifested, meaning that a large portion of integration analyses may no longer be valid, causing these analyses to be performed again, and increasing overall costs.

ULA has been very successful in performing rideshare integration in this way. However, because of the potential impacts to the primary payload caused by the inclusion of a rideshare mission, this approach frequently leads to the rideshare not being able to be manifested onto the mission of its choice. More often than not, rideshare payloads have difficulty in finding the appropriate match, leading to schedule delays going beyond their preferred launch date.

Designing Rideshare Missions Concurrently

The second approach of integrating rideshares is the recommended method. Concurrent rideshare mission design has not occurred as often as the first method, but missions that have followed this approach have been very successful. The most recent example is NASA's LRO/LCROSS mission, described in Section 4. When the LRO launch service was competed, NASA knew they were going to launch with a secondary payload, although the specific spacecraft was unknown at that time. This allowed the launch service provider to appropriately plan for the mission ahead of time. Once the standard NASA 30-month mission integration effort began, the LCROSS payload had been identified, allowing both payloads to progress through the integration cycle together, greatly reducing the amount of additional work to integrate the LCROSS rideshare. This approach maximized mission capability and efficiencies between the primary payload and the rideshare payload.

Initial Assessment of Rideshare Manifesting

For either approach, there is a basic list of top-level parameters that need to be assessed to determine if a rideshare match is possible:

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?

Once these parameters are assessed, and assuming a positive result, then the primary and rideshare payloads can move forward on performing more detailed feasibility analyses to completely ensure rideshare compatibility with the primary. Upon successful verification of the feasibility, then the rideshare mission can begin the normal mission integration process with the launch service. ULA's standard mission integration services are documented in the Atlas V Launch Services User's Guide 2010 [3] and the Delta IV Launch Services User's Guide 2013 [4].

Performance Margin

Most primary payload mission parameters are set in stone and cannot be changed. However, the most critical factor when determining if a rideshare mission is possible - available launch vehicle performance margin - is one area where ULA has some flexibility. Missions already on the ULA manifest usually have most of their margin spoken for to support the primary payload and orbital disposal compliance requirements, but performance can usually be improved via the addition of solid rocket motors. Since both the Atlas V and Delta IV launch vehicles can accommodate a number of solid rocket motors, the adding of a large rideshare payload is not always a limiting factor. For example, on the Atlas V, the addition of a single solid can provide up to an extra 1,000 kg (2,200 lb) to GTO, or 2,000 kg (4,400 lb) to Polar LEO. The cost for flying with an extra solid would have to be covered by the rideshare payload customer, but is still lower than procuring a dedicated launch.

For missions that still have available performance margin beyond what is required for the primary and rideshare payloads, various mission trajectories can be assessed to provide flexibility in delivering the primary and rideshare payloads to their respective orbits.

5. SUMMARY

Rideshare is a flight-proven solution for achieving various mission objectives at low-cost. 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.

Rideshare customers must plan ahead when designing their mission concepts, and attempt to co-manifest their payloads with similar spacecraft prior to the start of mission integration activities. This maximizes their chances of successfully being delivered to orbit on schedule.

Multiple rideshare interface capabilities offer solutions to all mission types, with a mass range from 1 kg to 5,000 kg, and a dimension range from 10 cm to 5 m. ULA stands ready to evaluate concepts and provide low-cost rideshare launch opportunities to the spacecraft community.

REFERENCES

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BIOGRAPHY

Keith Karuntzos *received a B.S. in Aerospace Engineering from the University of Southern California, Los Angeles in 1992. He began his career as an officer in the U.S. Air Force where he held leadership and management responsibilities as an acquisition program manager in the Training Systems Program Office and the Delta II Program Office. In 2000, Keith joined Boeing Launch Services as a customer engineer, assessing technical requirements for U.S. government and industry customers on new launch opportunities. With the formation of United Launch Alliance in 2006, he transitioned to Business Development, responsible for generating DOD, NASA, NRO, and commercial customer launch service solutions on Atlas and Delta launch vehicles.*