SMD Rideshare 101

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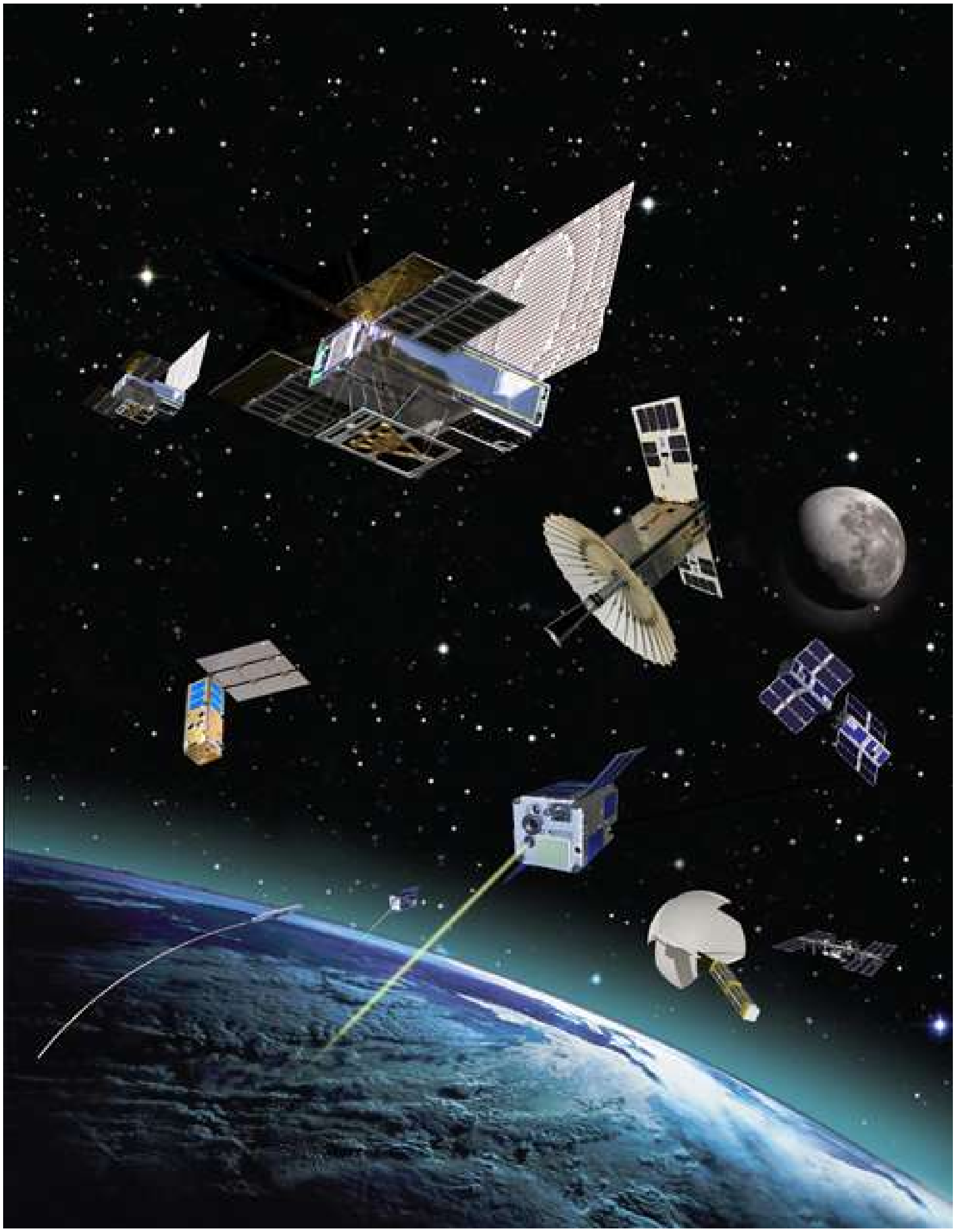

CONFIGURATION MANAGEMENT

This document is a Science Mission Directorate (SMD) Configuration Management (CM)-controlled document. Changes to this document require approval of the SMD Rideshare Lead. Changes to this document will be made by complete revision. Questions or comments concerning this document should be addressed to:

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VERSION HISTORY

Version	Description of Change	Rationale for Change	Author/POC	Effective Date
A	Initial Release		Bruce Yost	

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I. Purpose and Background

Rideshare 101 is intended as an informational source for mission developers and investigators to help delineate the framework of the NASA SMD's philosophy and general information that is useful to manifest and launch small spacecraft on NASA launch vehicles using a method generally termed as rideshare.

Rideshare indicates that additional and suitable spacecraft can participate on the same launch as another larger NASA spacecraft on missions that possess similar launch profiles. This opportunity occurs as occasionally the larger spacecraft, or primary payload, does not require all of the available launch performance capability of the launch vehicle. This excess performance, or margin, can therefore be used to carry secondary spacecraft that are compatible with the primary launch/mission profile. This process of sharing launch opportunities results in lower costs for NASA SMD and an increase in available launch opportunities. The expected end result is a more efficient use of existing resources to enable increased opportunities for launch accommodations for Evolved Secondary Payload Adapter (ESPA)-class payloads that address various science, technology, and exploration goals.

However, in order to allow a number of spacecraft to share a specific launch opportunity, some critical considerations must be observed to limit any additional risk to the primary mission and the overall launch campaign. This document describes and references these considerations, and is intended to serve as a planning resource for mission designers with the desire to use a rideshare arrangement for their mission.The SMD Rideshare Office (SRO) will serve as the single point of contact in SMD for coordinating the sharing of launch vehicles between compatible payloads.

This document is not intended to be a requirements document, but rather a general guide for mission designers and developers to help navigate through the NASA ESPA-class rideshare process. Mission designers should refer to launch campaign requirements documents and resources for detailed information related to specific launch opportunities.

This document is developed, maintained, and published by the SRO. It is applicable to any SMD solicitation that provides or allows for the use of rideshare as a method to access space on SMD-funded missions. NASA-sponsored missions funded by other mission directorates, such as the Space Technology Mission Directorate or the Human Exploration and Operations Mission Directorate, may employ different processes for rideshare accommodations.

This document also does not address CubeSats, also often launched as rideshare payloads. These spacecraft are mostly addressed and accommodated in NASA's CubeSat Launch Initiative.[1]

[1] CSLI website, Cubesat 101, (https://www.nasa.gov/directorates/heo/home/CubeSats_initiative)

II. Introduction

The use of small spacecraft for scientific discovery is rapidly gaining acceptance within NASA and related science communities. NASA science missions intend to utilize available launch performance margin to launch and deploy SMD missions.[2] NASA SMD regularly funds and sponsors a number of launch campaigns for a variety of primary spacecraft missions to both Earth orbital and deep space destinations. These missions may have available launch performance margin, which will be made available to other NASA-sponsored missions.

Smallsats are central to NASA's technology development, maturation, and demonstration missions. Further, in a 2016 National Research Council (NRC) study,[3] a strong case was presented for the use of smallsats to achieve NASA's science objectives. Currently, there are robust programs in SMD's Earth Sciences, Planetary Sciences, Astrophysics, and Heliophysics programs that exploit a number of smallsat form factors.

III. What is Rideshare?

Spacecraft often share launch services to achieve access to space. This approach has been used to support spacecraft much smaller than the primary payload. By utilizing launch services in this manner, spacecraft operators were able to deliver more payloads to orbit for a fraction of the cost when compared to dedicated launch opportunities.

Rideshare, the method of launching multiple payloads into orbit on a single launch vehicle, has been used over the past 50 years. While its use has not always been consistent, the number of rideshare missions launched to orbit has increased, beginning in the 1990s with the development of more standardized mechanical interfaces for attaching payloads to launch vehicles. This continual improvement in rideshare capabilities has allowed 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. Rideshare opportunities currently exist on NASA, U.S. Space Force (USSF), and commercial launch vehicles.

[2] Thomas Zurbuchen, 2018 Smallsat Conference Keynote Address

[3] Thinking Inside the Box, NRC, Zurbuchen, et al. 2017

IV. Advantages of Rideshare

The most obvious advantage of using the rideshare concept for launching payloads to orbit is the decreased cost to the mission developer. Instead of procuring a dedicated launch vehicle to launch a single payload, the mission can acquire the same delivery to orbit by launching as a secondary payload for significantly lower cost. This cost savings can be applied to the payload, or to other parts of the overall space mission's architecture.

Another advantage to rideshare is potential access to a larger number of launch opportunities for the secondary spacecraft. Since many launch campaigns possess excess margin, rideshare opens up a number of launch options.

V. Rideshare Challenges and Developments

While rideshare launches have successfully supported and enabled low-cost missions, there are some considerations associated with launching spacecraft together that mission designers should acknowledge. The original tenet of rideshare was that all "riders" or spacecraft are delivered to approximately the same orbit. This has restricted launch vehicles from accommodating spacecraft with varying orbital requirements on the same launch campaign. In addition, a number of vendors are developing and testing unique upper stage concepts, sometimes called "space tugs," that can deploy spacecraft at different orbits from the launch insertion.

Another limitation of rideshare launches is that the secondary spacecraft typically cannot influence the date and time of the launch. The milestones and schedule for integration and launch are dictated largely by the primary spacecraft or mission. However, if a rideshare payload includes common and industry-established interfaces and follows the Do No Harm[4] requirements, it may be possible for a secondary payload to switch to a different launch vehicle and schedule. For instance, the United States Space Force (USSF)/Department of Defense (DoD) has annual launches to low-Earth orbit (LEO), geostationary transfer orbit/geosynchronous orbit (GTO/GEO), and medium Earth orbit (MEO). Industry offers annual flights to LEO and GTO/GEO. However, if the secondary payload does not conform to the interfaces and Do No Harm requirements, these opportunities become limited and expensive.

[4] See the Rideshare Do No Harm Requirements document for more information.

VI. Rideshare Definitions

There are a number of terms used within the space community to describe elements of the rideshare opportunity. Not all terms are completely standardized. However, the following terms are generally used by the smallsat and rideshare communities when discussing these opportunities. Rideshare standard definitions appear first in order and are followed by definitions from NASA Policy Directive (NPD) 8610.12, Office of Space Operations (OSO) Space Transportation Services for NASA and NASA-Sponsored Payloads, NPD 8610.12 definitions are are designated by a preceeding identifier.

Primary Payload

The primary spacecraft, or payload, is the spacecraft for which the launch service is initially procured.The primary payload typically dictates launch requirements including launch schedule, time of launch, orbit inclination and destination, and orbit insertion accuracy.

NPD 8610.12: A payload that justifies its own launch. Specific characteristics: A primary payload typically defines the orbital placement/trajectory, flight design, critical path of the mission integration, including launch preparation process, and mission operations.

Secondary Payload

A secondary payload is typically a smallsat that is usually designed to separate after the primary payload or satellite has been deployed into its orbit or trajectory. There can be a number of secondary smallsats on any launch campaign.

Often payloads are launched with excess performance capability due to large spacecraft being volume limited rather than mass limited. To utilize this excess capability, secondary payloads may be launched along with the primary, providing a means to economically launch small spacecraft. These are generally independent missions that minimally impact the primary payload.

NPD 8610.12: A payload that is manifested subordinate to a primary payload and, therefore, is subordinate in launch date and orbit selection. *Specific characteristics*: A single secondary payload does not justify a dedicated launch; however, a launch could be justified for the flight of multiple secondaries. A secondary payload is usually independent of the primary payload, providing its own power and communication system, but is dependent on a primary payload's launch vehicle to achieve orbit/desired trajectory. A secondary payload can be manifested on a mission where excess performance margin allows such an addition. A secondary payload does not drive the launch mission's orbit selection, flight design, or mission integration critical path without agreement from the primary payload. The secondary payload does not cause a launch delay without agreement from the primary payload. Currently, the launch vehicle contractor will create an appropriate fidelity mass simulator for the secondary payload to meet the schedule needs of the primary payload should the secondary be unable to support the launch date. There can be more than one secondary payload on a launch mission. The primary payload's organization typically pays the majority of, if not the entire, space transportation service costs; however, a secondary payload provider typically pays for any mission unique integration costs.

Tertiary (Auxiliary) Payload

A tertiary payload is a small satellite (e.g., CubeSats, Nanosatellites, Picosatellites) that does not interfere with the primary payload mission.

NPD 8610.12: A payload that is lower in priority than a secondary (a third-order payload), e.g., a CubeSat. *Specific characteristics*: A tertiary payload has all the same characteristics as noted above for a secondary.

CubeSat

For NASA missions, a CubeSat is a small spacecraft, (usually less than 25 kg mass) that is compatible with the NASA Launch Services Program, Program Level Dispenser and CubeSat Requirements Document.[5] CubeSats are built in units (U) with a 1U being 10 cm x 10 cm x 10 cm. CubeSats are typically accommodated in enclosed dispensers which are also used to deploy the CubeSat. To date, 1U, 3U, 6U and now 12U CubeSats have been launched as payloads.

Hosted or Piggyback Payload

A hosted or piggyback payload is launched as part of a primary payload, and is usually permanently attached to the host spacecraft (non-deployed). In addition to containing the hosted or piggyback payload, the host spacecraft typically provides resources such as power, thermal management, and communications to the hosted or piggyback payload.

NPD 8610.12: A payload comprised of one or more sensors or instruments that is attached and/or integrated into a host space vehicle for the purpose of obtaining one or more ongoing resources from the host for the life of the hosted payload. *Specific characteristics*: A hosted payload's objective is typically independent of its host's objective, but is dependent on the host space vehicle for one or more resources (e.g., volume, mass, power, communications). A hosted payload typically does not drive the launch schedule or orbital placement/trajectory. The host space vehicle provider or owner is the lead for the space transportation service agreement. Terms are negotiated, but the hosted payload typically pays for its own integration onto the host space vehicle and/or the marginal costs of the hosted payload's share of ongoing mission operations (resources used, e.g., power, thermal, data processing, and communications).

ESPA-Class Spacecraft and Adapters

Multi-payload missions typically utilize specific adapter hardware systems to safely accommodate and then deploy rideshare payloads. ESPA-class spacecraft, therefore, are vehicles that are

[5] LSP-REQ-317.

compatible with and able to utilize the suite of ESPA-class hardware. These spacecraft are typically not containerized like CubeSats.

Table 1 – ESPA-Class Spacecraft Adapter/Carrier Options

Rideshare Carrier	**Max S/C Mass (kg)**	**Volume Available**	**S/C interface**	**Comment**
ESPA Ring	220*	24”x28”x38” 24”x28”x56”	8/15” dia	S/C mass driven by fastener (1/4 v. 5/16”) *up to 450kg with Heavy ESPA variant plus use of larger fasteners and non-heritage load factors
ESPA Grande Ring	465**	42”x46”x38” 42”x46”x56”	15/24” dia	S/C radial dim driven by fairing diameter (4m x 5m) **up to 700kg with larger fatseners & non-heritage load factors
A-Deck	`1,000	56” dia x 60” h	24/38” dia	A dual spacecraft adaptor for taller/larger S/C
Propulsive ESPA	~180-450***	4m dia x 24”h	15/24” dia	4-6 Ports for Rideshare P/L or Hosted P/L ***Total S/C mass dependent on delta-v required
Propulsive ESPA Grande	up to 700***	5m dia x 42”h	24” dia	4-5 Ports for Rideshare P/L or Hosted P/L ***Total S/C mass dependent on delta-v required
Airbus Multi-Payload Carrier (MPC) (also referred to as ASAP-S)	120	26”x31”x 41”	11.7” dia	Multiple attach locations for up to 4 S/C externally with an internal microsat or free-flyer volume. (SSO-A mission)
Airbus Hub	~400	24”x28”x38” 42”x46”x56”	24” dia	6-ports. Composite adapter similar to the ESPA Grande (SSO-A mission)

ESPA-class secondary payload adapters may accomodate can-type structures where one satellite is mounted internal to the structure and the other on top, or they can be frame-type structures where various rideshare payloads are mounted together on external frames or strongback structures. There are several new containerized adapters for ESPA-class or other smallsats that allow integration with a ring-type separation system, but provide a structure holding the satellite inside.

Table 2 – MOOG ESPA Configurations

Name	Part # (n-d-h)	Port Diameter	# of Ports	ESPA Height	Interface Fastener Size	Port Payload Capacity	ESPA Mass
Standard ESPA	6-15-24	15″	6	24″	1/4″ Fasteners	567 lb * (257 kg)	293 lb (133 kg)
ESPA Heavy					5/16″ Fasteners	991 lb * (450 kg)	
ESPA Grande	4-24-42	24″	4	42″	1/4″ Fasteners	1543 lb * (700 kg)	465 lb (211 kg)
Grande Heavy					5/16″ Fasteners	1543 lb * (700 kg)	

Propulsive ESPA

A number of companies have added satellite functionality including propulsion systems and basic avionics to ESPA-type structures allowing multi-orbit insertions and in some cases extended on-orbit operations to support multi-missions. These upper stages, or "space tugs" can carry multiple satellites, burn to different orbits, and drop off satellites in separate locations. This capability enables a wide variety of spacecraft to be manifested on a single launch.

Figure 1 – Example ESPA-Class Spacecraft Adapter/Carrier Options

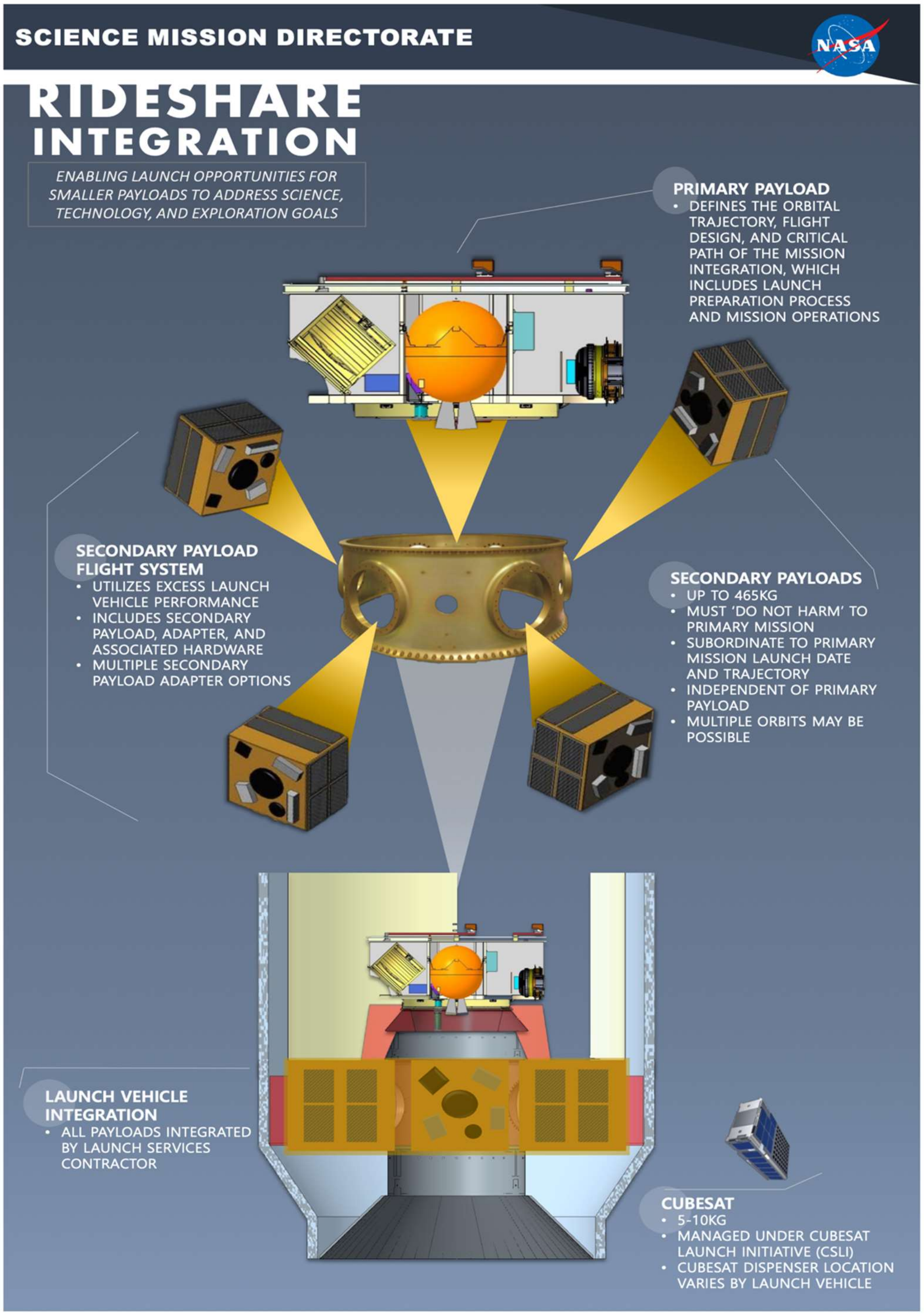

Figure 2 – Graphical Representation of Select Rideshare Definitions

VII. Science Mission Directorate Rideshare Documents

The following describes some of the relevant documents and resources pertaining to the rideshare process for NASA science missions.

Science Mission Directorate Rideshare Policy

The SMD Rideshare Policy, NASA-SPD-32: Evolved Expendable Launch Vehicle (EELV) Secondary Payload Adapter (ESPA) Secondary Payloads Rideshare defines the process for identifying and prioritizing secondary spacecraft on SMD-procured launch vehicles. It also specifies roles and responsibilities for implementing the SMD Rideshare Policy.

Do No Harm Requirements

As rideshare missions become more accessible and accepted in today's space and science industry, there is an increased need to mitigate risks from the rideshare spacecraft (secondary payload) to the primary mission and all other payloads on the mission. NASA SMD has developed its Rideshare Mission Assurance (RMA) process with the objective to provide all mission partners with a degree of certainty that all payloads included on a mission will do no harm (DNH) to each other, or to any operational aspect of the launch.

The RMA process mitigates risks by assessing each payload on a mission against a tailored set of criteria, known as Do No Harm (DNH) requirements. The primary concerns of the RMA process are to ensure that the payloads are robust enough to survive the launch environment; will not inadvertently power on, and will not perform functions that could be harmful to personnel or the mission. The DNH assessment also includes a review of any co-use of facilities during the launch campaign as well as a review of the critical function inhibit scheme utilized by the payload. The focus of this process is to ensure safety of flight for all mission partners. It is not to ensure mission success for individual secondary spacecraft. It is the responsibility of these spacecraft/missions to ensure their own mission success.

A NASA SMD DNH Requirements document was developed incorporating key elements of the DoD RMA process for the intended use in a mission's concept development phase leading up to vehicle procurement and final manifesting. Once the Launch Vehicle Contractor (LVC) is on contract, this process is formalized and a detailed mission specific set of DNH criteria will be developed and validated as part of the overall mission integration cycle.

Rideshare User's Guide

The NASA SMD Rideshare User's Guide (RUG) provides a step-by-step process to develop a rideshare concept and to generically formulate/implement a rideshare mission. The RUG includes details to explore and select a rideshare option, including NASA, DoD, and commercial rideshare opportunities. The RUG provides generic guidelines and information for preliminary spacecraft design, launch vehicle integration, and mission planning for rideshare payloads. The NASA RUG focuses on payloads that integrate to the ESPA-type ring, including: 1) CubeSats (when their deployer integrates to an ESPA port); 2) ESPA-class payloads; 3) ESPA Grande payloads; 4) propulsive ESPA-class payloads; 5) propulsive ESPA Grande payloads; 6) and A-Deck payloads (payloads that mount inside the ESPA ring). The NASA RUG is modeled after the DoD RUG allowing NASA payloads that implement the NASA RUG to be compatible with primary DoD missions and DoD Payloads that implement the DoD RUG, to be compatible with primary NASA missions.

VIII. References

1. Orbital Space Transportation Services (NPD 8610.12H, 9/23/15)
2. NASA SMD Do No Harm Requirements Document (TBD)
3. NASA SMD Rideshare User's Guide (TBD)
4. SMD Rideshare Policy (SPD-32) NASA-SPD-32: Evolved Expendable Launch Vehicle (EELV) Secondary Payload Adapter (ESPA) Secondary Payloads Rideshare
5. Launch Services Program, Program Level and Dispenser and CubeSat Requirements Document (LSP-REQ-317, 1/30/14)

For more information, please go to www.nasa.gov/smallsat-institute or contact HQ-SMD-Rideshare@mail.nasa.gov.