NASA's Mission Specific

Evolved Expendable Launch Vehicle Secondary Payload Adapter

System Interface Specifications

For

Heliophysics Missions of Opportunity

Revision 2
Effective Date: September 18, 2018

RECORD OF REVISIONS		
REV	**DESCRIPTION**	**DATE**
Basic	Basic Issue	
1	1. Update title of document	August 2, 2018
2	1. Add Record of Revision Log 2. 1.2 Scope Changed the term requirements to process guidelines 3. Term “Aggregator” has been replaced by “Integrator” throughout the document 4. Added acronym PSWG – Payload Safety Working Group 5. 1.3.2 Deleted definition of Multi Mission Payload 6. Updated 3.1.9 to reference section 5.2.3 instead of 3.2.5 7. Inserted new 3.6 to include support for PSWG 8. Inserted new 3.9 to include responsibilities to Department of Transportation 9. Inserted new text in section 4 to describe that NASA will develop a Do-No-Harm document in future. 10. Update 5.1 with new C3 trajectory information 11. Update Figure 5.1 to 5.2 12. Update Table 5.1 to 5.2 a. Updated Table 5.2 axes information b. Delete Note 2. The stay-out zone is no longer applicable when considering the width of the RUAG PAS 610S Separation System c. Added notes for separation system mass allocation 13. Remove Figure 5.2 RPL Volume Stay-Out Zone, no longer applicable 14. Remove 5.2.2.3 Ballast requirement 15. Update 5.3.1.1 to clarify allowable power on times 16. Add 5.3.1.2 RPL deadface requirement 17. Update 5.6.1 remove word “hard” mounted to allow option for isolation systems 18. Update 6.1.1 to ensure hazardous operations are dual fault tolerant 19. Update 6.3.1 and 6.3.2 to remove reference to DOT	September 18, 2018

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1 Introduction

1.1 Purpose

This document defines requirements and guidelines for a Rideshare Payload (RPL) for proposals submitted to the Heliophysics' Science and Technology Demonstration Missions of Opportunity that utilize the Evolved Expendable Launch Vehicle Secondary Payload Adapter (ESPA) Grande accompanying the Interstellar Mapping and Acceleration Probe (IMAP) mission.

This document was developed by NASA Science Mission Directorate (SMD) Heliophysics Division (HPD).

1.2 Scope

This document provides ground rules and assumptions for RPLs intended to launch on the IMAP ESPA Grande, as well as specific interface requirements and generic environment definitions that will not be formalized until the IMAP Launch Vehicle Provider has been selected and mission matures.

This document also includes Rideshare Mission Assurance (RMA)/Do No Harm (DNH) process guidelines that focus on ensuring safety of flight for the primary mission and other rideshare payloads.

Additional RPL requirements will be accommodated using the mission-specific or mission unique hardware processes, or services as specified by the Launch Vehicle to Payload Interface Control Document.

NOTE: For this document, the ESPA and the ESPA Integrator contractor are considered part of the Launch Vehicle (LV)/Launch Vehicle Contractor (LVC) and/or Government.

1.3 Definitions and Acronyms:

1.3.1 Acronyms:

- CCAMs – Contamination Control Avoidance Maneuvers
- CLA – Couple Loads Analysis
- DNH – Do No Harm
- DOT – Department of Transportation
- ESPA – Evolved Expendable Launch Vehicle Secondary Payload Adapter
- FEM – Finite Element Model
- HPD – Heliophysics Division
- IFD – In Flight Disconnect
- IMAP – Interstellar Mapping and Acceleration Probe
- I&T – Integration and Test
- IPS – Integrated Payload Stack – Fully integrated ESPA with mated RPL
- LSP – Launch Service Provider
- LSTO – Launch Service Task Order
- LV – Launch Vehicle

- LVC – Launch Vehicle Contractor
- PGAA – Performance and Guidance Accuracy Analysis
- PSWG – Payload Safety Working Group
- RPL – Rideshare Payloads
- RMA – Rideshare Mission Assurance
- RUG – Rideshare Users Guide
- SMD – Science Mission Directorate
- TBD – To Be Determined
- TBR – To Be Resolved
- TBS – To Be Supplied
- VLC – Verification Loads Cycle

1.3.2 Definitions:

- Rideshare Payloads (RPL) are those payloads that will have no authority to impact mission integration cycle for the primary mission. This includes but is not limited to go-no-go call for launch and drive environmental conditions within the fairing.

2 Documents

2.1 Applicable Documents

- AFSPCMAN 91-710 — Range Safety User Requirements Manual Volume 3 – Launch Vehicle, Payloads, and Ground Support Systems Requirements
- NPR 8715.6 NASA — Procedural Requirements for Limiting Orbital Debris
- NASA-STD-6016 — Standard Materials and Processes Requirements for Spacecraft

2.2 Reference Documents

- EELV RUG — Evolved Expendable Launch Vehicle Rideshare User's Guide (SMC/LE)
- TOR-2016-02946 — Rideshare Mission Assurance and the Do No Harm Process – Aerospace Report
- GSFC-STD-7000 — General Environmental Verification Standard (GEVS) for GSFC Flight Program and Projects
- MMPDS — Metallic Materials Properties Development and Standardization
- MIL-HDBK-5 — Military Handbook 5, Metallic Materials and Elements for Aerospace Vehicle Structures
- EELV SIS — Evolved Expendable Launch Vehicle Standard Interface Specification
- LSP-REQ-317.01B — Launch Services Program (LSP) Program Level Dispenser and CubeSat Requirements Document

- MIL-STD-1540C Military Standard Test Requirements for Launch, Upper-Stage, and Space Vehicles
- NASA-STD-8719.24 NASA Expendable Launch Vehicle Payload Safety Requirements

3 Ground Rules and Assumption

3.1 The Government and/or LVC will provide the following:

3.1.1 In a case where a RPL is not able to meet the required mass properties, milestone schedule, or is determined by NASA to be unfit to launch, then NASA has the right to replace the RPL with an equivalent mass simulator or with a backup RPL if available. Note, mass simulators will be hard mounted to the ESPA Port (non-separating).

3.1.2 NASA will provide mass simulators as Government Furnished Equipment (GFE) for each ESPA port.

3.1.3 LVC will coordinate RPL deployment time and sequencing with all invested stakeholders.

3.1.4 LVC will perform a separation analysis to validate no contact between RPLs, upper stage and primary payload and demonstrate no impediment to the upper stage Contamination Control Avoidance Maneuvers (CCAMs) until RPLs activate propulsion systems.

3.1.5 LVC will provide Orbital Parameter Message when RPL deployment signal is sent from the LV.

3.1.6 LVC will provide the RPL separation signal (primary and redundant) to each RPL or to an ESPA sequencer.

3.1.7 LVC will provide confirmation of RPL separation/deployment over interleaved telemetry.

3.1.8 LVC may provide accommodations for RPL GN2 purge systems from RPL arrival at integration facility through launch.

3.1.9 NASA will provide the separation system as GFE for each ESPA class RPL per section 5.2.3.

3.1.10 NASA will provide In Flight Disconnect (IFD) as GFE to each ESPA class RPL per section 5.3.2.

3.1.11 Facility space will be provided at the ESPA Integrator. It can be used by RPLs for receiving, unpacking, functional checks, battery charging, and facility power.

3.1.12 ESPA Integrator and LV integration facility's temperature and humidity will typically be controlled to the following levels:

Temperature: 60° – 80° Fahrenheit (15.6° - 26.7°Celsius)

Relative humidity: < 65%

3.1.13 Clean room environment will be provided for integrated contamination control environments to meet contamination requirement for primary mission.

3.2 RPLs will not have the authority to make a GO, No-GO call on day of launch.

3.3 RPLs will have no authority to change launch readiness date of Primary mission.

3.4 At a minimum, the RPL will be required to provide the following data products to meet the Primary Mission Integration Cycle. See Appendix A for a general guideline of Primary Mission Integration Cycle for rideshare.

- Computer-Aided Design (CAD) Model
- Finite Element Model (FEM)
- Thermal Math Model (TMM)
- Venting Model
- Official Mass Properties Data
- Safety Data Package
- Test Procedures
- Separation Systems Characteristics
- Slosh Model (if applicable)

3.5 RPLs will need to meet Primary Mission Integration Cycle (e.g., PGAA-1, 2, 3, and Verification Load Cycle (VLC)). See Appendix A for a general ESPA rideshare integration schedule

3.6 RPLs will need to support and comply with the primary mission Payload Safety Working Group (PSWG).

3.7 RPL will have no physical access post fairing encapsulation; this includes launch delays/scrubs.

3.8 No down range telemetry support will be provided for RPL deployments.

3.9 RPLs have the responsibility to meet Department of Transportation requirements and acquire applicable certification for the transportation of hazardous commodities and/or pressurized system when not at the launch site.

3.10 <u>All RPLs will be deployed after the Primary mission deployment</u>.

4 Rideshare Mission Assurance and Do-No-Harm

As Rideshare missions become more feasible and accepted in today's space and science industry, there is a growing need to mitigate risks from the RPLs to the primary mission and all payloads on the mission. The Department of Defense (DoD) Space Test Program (STP) has implemented a hybrid system of risk mitigation called Rideshare Mission Assurance (RMA). The objective of the RMA process is 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 DoD STP developed a Rideshare Mission Assurance Do-No-Harm (TOR-2016-02946) guideline document. This document is only releasable to Government and Government contractors and will not be in the program library. NASA will be establishing a similar process and a tailored set of Do-No-Harm criteria in support of NASA SMD missions.

The RMA process mitigates risks by assessing each payload flying on a mission against a tailored set of criteria, known as "Do No Harm" criteria. The primary concern of the RMA process is to ensure that the payloads are robust enough to survive the environments experienced during launch and/or will not inadvertently power on, and perform functions that could be harmful. Other areas also assessed includes any co-use of facilities during the launch campaign and the critical function inhibit scheme utilized by the payload. The focus of this process is to ensure safety of flight for all mission partners and is <u>not to ensure mission success for individual RPLs</u>. <u>It is the responsibility of the RPLs to ensure their own mission success.</u>

This document incorporates key elements of the RMA process for this early procurement and concept development phase. Once the LVC is on contract, this process will be formalized and a detailed mission specific set of Do-No-Harm criteria will be developed and validated as part of the overall mission integration cycle.

5 Requirements:

5.1 Mission Trajectory:

At this stage in the IMAP mission development, the trajectory and RPL orbit insertion are still to be determined, therefore RPL should consider a range of orbit insertions from:

C3= -0.68 to -0.48 km2/s2

The declination and right ascension directions will be determined by the primary spacecraft, which is targeting a transfer orbit to a Sun-Earth L1 Lissajous Orbit.

The LV will perform a disposal burn following primary spacecraft separation, so this final burn could be utilized to achieve an escape trajectory (C3 = 0 or C3 > 0) for the RPL.

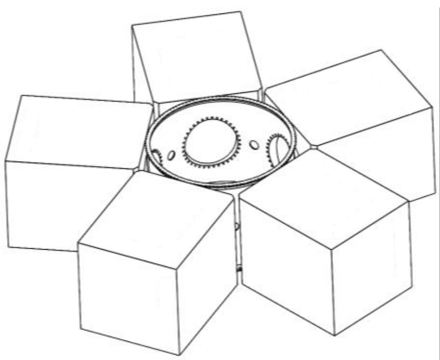
5.1.1 The RPL orbit insertion shall be designed not to make physical contact with the primary spacecraft, or LV performing end of mission operations. Its target, including C3, will be dependent on excess capability of the launch vehicle after inserting the primary spacecraft.

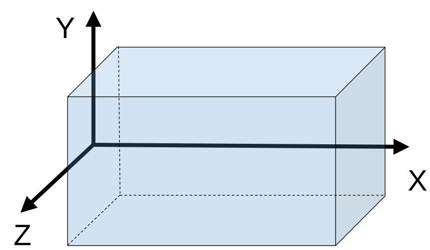
5.2 Mechanical

5.2.1 Reference Coordinates and Origin

5.2.1.1 RPL will use the coordinate system specified in Figure 5.2.

Figure 5.2 ESPA and RPL Coordinate System





5.2.2 ESPA Grande Class Payloads Interface Requirements

5.2.2.1 RPLs shall not exceed the mass and volume requirements as specified in Table 5.2.

Table 5.2 ESPA RPL Mass, Volume Interface Requirements

ESPA	Max RPL Mass	Allowable RPL Volume	RPL Interface
ESPA 5 Port (PN: 5-24-42)	320 kg[5]	42"x46"x38" [1, 2, 3, 4] Y, Z, X	24" circular

(1) This assumes a 4-meter fairing.
(2) The Atlas V 4-meter fairing has additional fairing sweep stay-out zones at the base of the fairing that may be applicable to the IMAP mission. These are defined in the LV users guide see link below: https://www.ulalaunch.com/docs/default-source/rockets/atlasvusersguide2010.pdf
(3) The RPL X-axes starts at the ESPA port interface plane.
(4) The RPL X-axes dimension includes the separation system width. This means separation system width will be subtracted from the 38" allowable dimension.

(5) The flyaway portion of the separation system shall be considered as part of the RPL total mass.

5.2.2.2 RPLs shall maintain a center of gravity as follows:

- CG along the RPL X-axis shall be less than 20" from the ESPA interface port
- Lateral CG (Y, and Z axis) shall be within 1" of the RPL X-axis centerline (TBR)

5.2.2.3 Deleted

5.2.3 ESPA Class Separation Systems:

5.2.3.1 NASA will provide the RUAG PAS 610S (24") Separation System as GFE. Specification for this separation system can be found at the following link.
https://www.ruag.com/sites/default/files/2017-01/PAS_610S_Separation_System.indd_.pdf

5.2.4 Static Loads

5.2.4.1 The peak line load across the ESPA/RPL interface shall not exceed 400 lbs. /in.

5.2.5 RPL Stiffness

5.2.5.1 RPLs shall have first fixed-free fundamental frequencies above 75 Hz constrained at the separation system interface plane.

5.3 Electrical Requirements

5.3.1 Electrical Power

5.3.1.1 RPLs shall be powered off during all integrated and hazardous operations and from T-5 minutes through deployment. Once the RPL has been integrated to the ESPA, the RPL can only be powered on for battery charging and hazardous system monitoring.

5.3.1.2 The RPL T-0 electrical interface shall be deadfaced (electrically isolated) at T-5 minutes prior to launch.

5.3.1.3 RPLs shall incorporate a Remove Before Flight pin that cuts power to the spacecraft bus. This will be used during transportation and ground processing/integration activities.

5.3.2 Connectors:

5.3.2.1 LVC will provide one in flight disconnect (IFD) connector and one spare to each of the RPL developers for incorporation into spacecraft build. IFD commonly used in the RUAG PAS 610S Sep System is the DBAS 79 -12 pin connector.

5.3.3 Battery:

Battery charging can be provided through an ESPA T-0 connector. Battery charging will not be provided during integrated operation or hazardous operations. LVC will provide RPL telemetry for battery monitoring data up until T-5 minutes before launch.

5.3.3.1 RPLs shall utilize Underwriter Laboratory (or-equivalent) approved batteries with no modifications and be compliant with Range Safety requirements (AFSPCMAN-91-710).

5.3.3.2 RPLs shall incorporate battery circuit protection for charging/discharging to avoid unbalanced cell condition.

5.3.3.3 RPLs shall meet battery charge monitoring requirements per AFPSCMAN 91-710. RPL monitoring of the charge activity will be required to avoid generation of Radio Frequency (RF) emissions that may affect nearby hardware.

5.4 Environments:

This section contains general requirements for early development/design because mission-specific environments have not been defined. <u>Mission specific environments will be defined once the launch vehicle contractor and primary observatory have been selected and the IMAP mission integration cycle has begun</u>. These Mission specific environments will be flowed down to the RPLs from the Launch Vehicle to IMAP Interface Control Document (ICD). The environments defined in the LV to IMAP ICD will take precedence over the requirement defined in this section.

5.4.1 Thermal

5.4.1.1 RPLs shall not specify any specific temperature and humidity requirement.

5.4.2 Random Vibration

5.4.2.1 RPLs shall be designed to the random vibration environments defined in Appendix B.

5.4.3 Sine Vibration

5.4.3.1 RPLs shall be designed to the sine vibration environments defined in Appendix B.

5.4.4 Acoustics

5.4.4.1 RPLs shall be designed to the acoustic environments defined in Appendix B.

5.4.5 Shock

5.4.5.1 RPLs shall be designed to the acoustic environments defined in Appendix B. ESPA separation plane shock environment is based on LV users guides interface levels attenuated 2 joints to the ESPA rideshare interface.

5.4.6 Pressure

5.4.6.1 RPLs shall demonstrate compliance with pressure decay rate during LV ascent.

5.4.7 Contamination

The IMAP spacecraft is highly sensitive (ISO Level 7 (Class 10,000) contamination control) to both molecular and particulate contamination. As a result, strict cleanliness requirements must be placed on secondary payloads and will be documented in the LV to IMAP ICD. Surfaces within the fairing volume shall meet the IMAP requirements unless proven through contamination transport analysis to not pose a contamination threat to the IMAP observatory.

5.4.7.1 RPLs shall be cleaned, certified and maintained to level 500A per IEST-STD-CC1246.

5.4.7.2 RPLs shall undergo thermal vacuum bakeout per ASTM E2900.

5.4.7.3 RPLs material selection shall be in accordance with NASA-STD-6016 Standard Materials and Processes Requirements for Spacecraft.

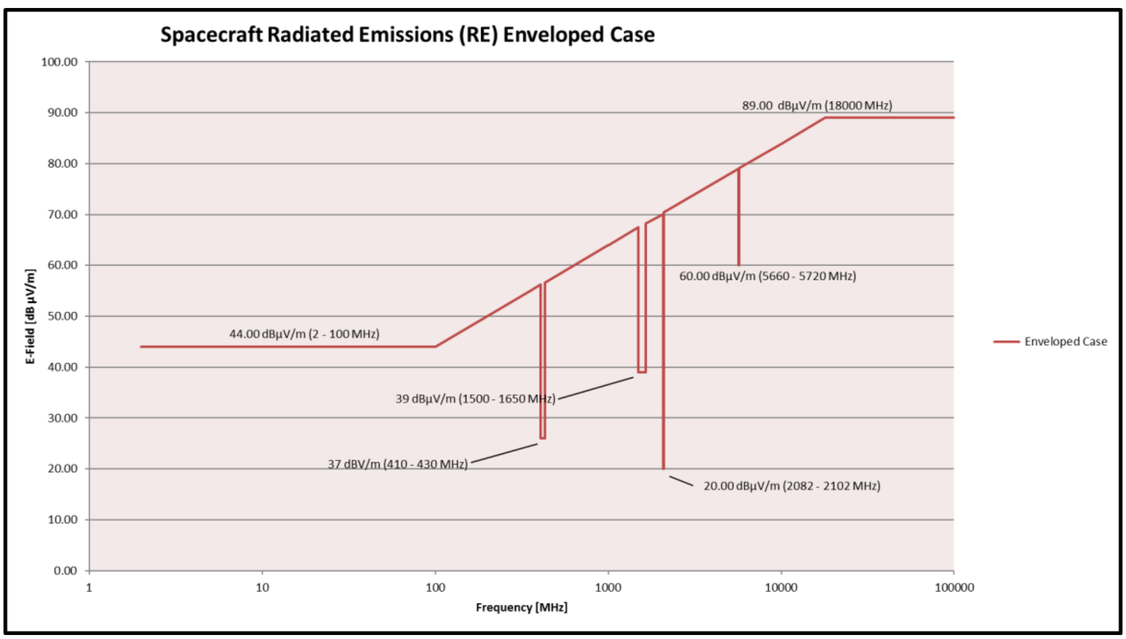
5.4.8 Electromagnetic Interference/Electromagnetic Compatibility (EMI/EMC)

5.4.8.1 RPLs shall not conduct free radiation during launch processing. “Plugs out” testing may be conducted with antenna hats.

5.4.8.2 RPLs shall ensure Underwriter Laboratory (UL) or equivalent certification on all electrical ground support equipment (EGSE).

5.4.8.3 The RPLs radiated emissions at the payload interface plane shall not exceed the levels shown in Figure 5.3.

Figure 5.3, Spacecraft Radiated Emissions



5.4.8.4 The RPLs shall be compatible with the launch vehicle and Range radiated emissions as shown below:

20 V/m	2 MHz to 18 GHz
TBD V/m	TBD ±TBD MHz (launch site and launch vehicle telemetry transmitters)

5.4.8.5 The RPLs shall meet the following EMI margin requirements:

5.4.8.5.1 Electroexplosive Devices (EED) - The RPLs shall demonstrate a 20 dB Electro- Magnetic Interference Safety Margin (EMISM) to the RF environment (vs. dc no-fire threshold) for all EED firing circuits.

5.4.8.5.2 Safety Critical Circuits - The RPLs shall demonstrate a 6 dB EMISM to the RF environment for all safety critical circuits and circuits that could propagate a failure to the launch vehicle.

5.4.8.6 RPLs shall be magnetically clean from encapsulation through separation on orbit, with magnetic fields less than or equal to 1 Gauss at 1 meter from the RPL and all ground support equipment (GSE).

5.4.9 Radiation

5.4.9.1 No hazardous radiation is permitted.

5.5 Ground Operations

5.5.1 RPLs shall provide GSE lifting fixtures to support mate operations onto the ESPA.

5.5.2 RPLs shall provide their own GSE.

5.6 U-Class Containerized (CubeSat) RPLs Requirements

5.6.1 RPLs proposing U-Class payloads shall provide their own flight qualified dispenser system that meets the requirement of this specification. The dispenser system will be mounted to the ESPA Port.

5.6.2 U-Class Containerized (CubeSats) RPLs shall meet the requirement of this specification, except for sections 5.2.1, 5.2.2, 5.2.3, 5.2.4, 5.2.5, 5.3.2.

6 Safety

6.1 Fault Tolerance

6.1.1 All hazardous operations (such as deployments of deployables, RF transmission and propulsion activation) shall be dual fault tolerant.

6.2 Hazard System activation

6.2.1 RPLs shall have the ability to activate hazardous systems based on time limit identified in the LV to IMAP mission ICD. These hazardous systems may consist of, but are not limited to:

- Deployments of solar arrays, booms, and antennas etc.
- RF transmission
- Propulsion system
- Any other systems

6.3 Propulsion and Pressure vessels

6.3.1 RPLs with pressure vessels shall comply with Range Safety (AFSPCMAN-91-710) standards at the launch site.

6.3.2 RPLs shall comply with Range Safety (AFSPCMAN-91-710) standards for Loading and offloading of propellants and hazardous commodities.

6.4 Hazardous Materials

6.4.1 RPLs hazardous material shall conform to AFSPCMAN 91-710, Range Safety User Requirements Manual Volume 3 – Launch Vehicles, Payloads, and Ground Support Systems Requirements.

6.5 Orbital Debris

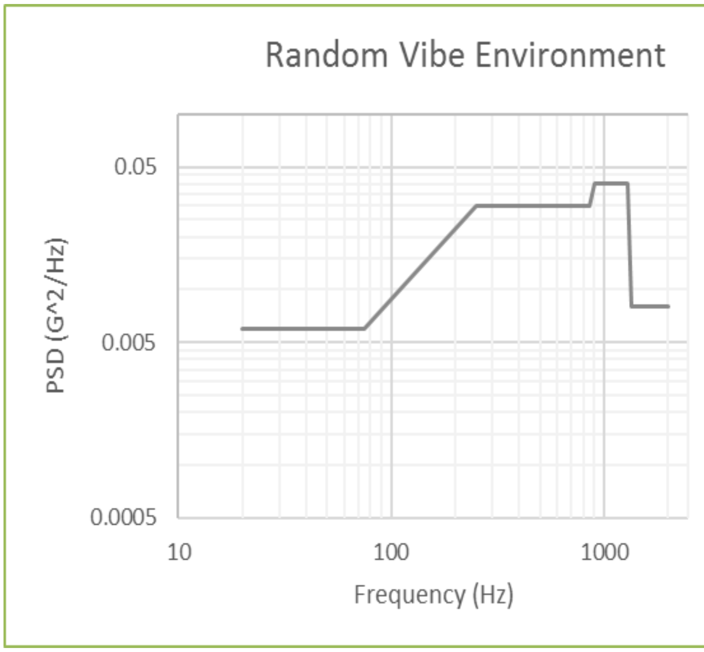
6.5.1 RPLs mission design and hardware shall be in accordance with NPR 8715.6B NASA Procedural Requirements for Limiting Orbital Debris and Evaluating the Meteoroid and Orbital Debris Environments.

Appendix A - General Guideline of Primary Mission Integration Cycle

General Timeline			
Rideshare Activity	**General Timeline**	**Responsible Organization**	**Comment**
Release Final LSTO	L-44	Launch Services Program	LSTO includes RPL and ESPA mission unique requirements
Early CLA for Spacecraft CDR (pre selection CLA)	L-40	Launch Services Program	Include models of ESPA and RPL mass simulators
LSTO Proposals Due	L-42	LV Contractor	
Launch Vehicle Selection	L-36	NASA Headquarters	
Perform Preliminary Loads Cycle (CLA #1)	L-33	LV Contractor	Analysis to envelope potential configuration range of ESPA payloads
Initial ESPA Finite Element Model (FEM)	L-28	Integrator	Initial ESPA FEM
Mass Simulators delivered to the Integrator	L-24	Integrator	Support ESPA test verified FEM with mass simulators
Perform Final Loads Cycle (CLA #2)	L-24	LV Contractor	This analysis must envelope all potential configurations for the ESPA Integrated Flight System to establish bounding CLA levels in support of primary spacecraft environmental test
Approval of RPL Inclusion	L-18	NASA Program Office	Final RPL manifest approved
Finalize the mass of the RPLs	L-14	Integrator	Changes to RPL mass could result in de-manifesting
RPLs provide test verified FEM	L-12	Integrator	Last update to ESPA Integrated Flight System for FEM
Verification CLA (VLC) (CLA #3)	L-12	LV Contractor	
Updated Trajectory Study (3 of 4)	L-12	LV Contractor	
RPLs delivered for RPL-to-ESPA I&T	L-4	Integrator	
ESPA w/ RPLs delivered for ESPA-to-LV I&T	L-2	Integrator	
Final Trajectory Study (4 of 4)	L-1	LV Contractor	
Launch	ILC	NASA Program Office	

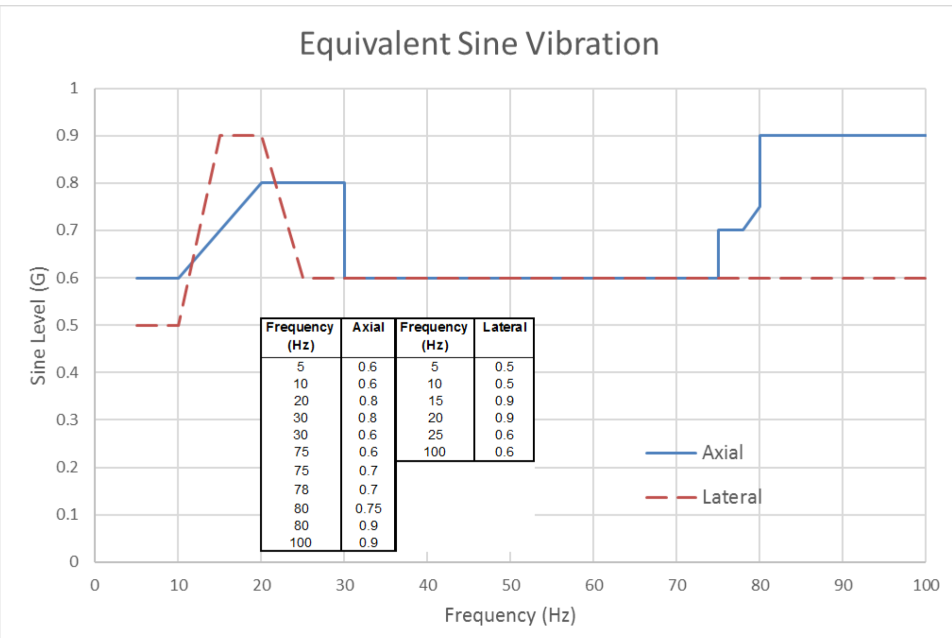
Appendix B – Environments

Random Vibration Environment



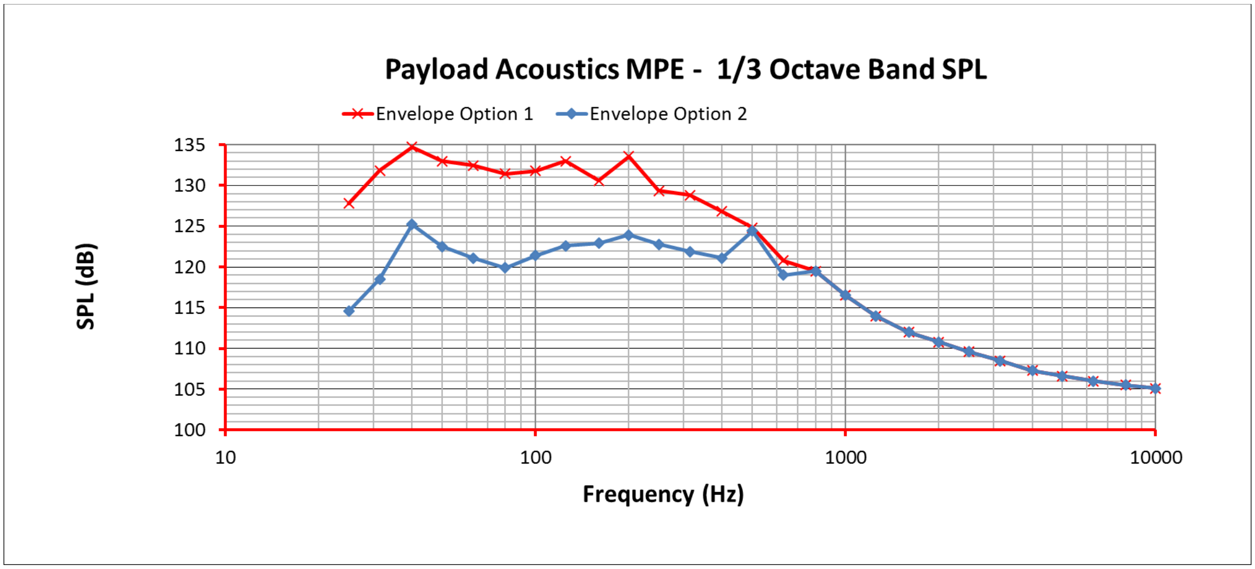
Frequency (Hz)	PSD (g^2/Hz)
20	0.006
75	0.006
250	0.03
850	0.03
900	0.04
1300	0.04
1350	0.008
2000	0.008

Sine Vibration Environment:



Frequency (Hz)	Axial	Frequency (Hz)	Lateral
5	0.6	5	0.5
10	0.6	10	0.5
20	0.8	15	0.9
30	0.8	20	0.9
30	0.6	25	0.6
75	0.6	100	0.6
75	0.7		
78	0.7		
80	0.75		
80	0.9		
100	0.9		

Acoustic Environment:



Shock Environment: