NASA's Mission Specific

Launch Vehicle Secondary Payload Adapter

System Interface Specifications

For

Heliophysics Missions of Opportunity

Revision 3
Effective Date: September 3, 2019

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 Term "Aggregator" has been replaced by "Integrator" throughout the document 4.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 The stay-out zone is no longer applicable when considering the width of the RUAG PAS 610S Separation System c. Added notes for separation system mass allocation 13. Remove Figure 5.2 RPL Volume Stay-Out Zone, no longer applicable 14.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

3	1. Title Change (removed "Evolved Expendable")
	2. ESPA acronym replaced with SPA
	3. Addition of Table of Contents
	4. Additional Acronyms & Definitions
	5. Replaced AFSPCMAN 91-710 with NASA-STD-8719.24
	6. Section 4 updates GR&A:
	    a. Restructure, reorder, & renumbering of section
	    b. 4.1.1 Added 'primary mode frequency'
	    c. 4.1.2,.3,&.4 Update to reflect LVC will provide mass simulator, sep system, and IFDs
	    d. New 4.1.6, 4.1.8 & 4.1.10.1
	    e. Added clarification to 4.1.9 on timing of OPM
	    f. 4.1.10 Clarified Grade B vs 'dry'
	    g. 4.1.11 Updated LVC as the ESPA integrator & added PPF clarification
	    h. 4.1.12 Updated LVC as ESPA integrator & updated temperature levels
	7. New Section 6.1 for general Mission Integration requirements
	    a. 6.1.1 all data products required from RPLs
	    b. Data input timelines for RPLs
	8. 6.2.1 add clarification regarding LV end-of-mission disposal
	9. 6.3.3.1 Clarification of Sep systems to be provided by the LVC
	10. 6.3.4.1 Added GSFC Mass Acceleration Curve
	11. 6.4.3.1 & 6.4.3.3 Replaced AFSPCMAN 91-710 with NASA-STD-8719.24
	12. 6.5.1.1 Specified that RPL thermal requirements must not conflict with Primary SC
	13. 6.5.5.1 Added description of attenuation factors
	14. 6.6.2 clarification on the RPL GSE usage
	15. 6.7.2 Update section reference numbers
	16. Added 7.1.1 RPL compliance to PSWG
	17. 7.3.1 & 7.3.2 & 7.4.1 Replaced AFSPCMAN 91-710 with NASA-STD-8719.24
	18. Appendix A: Replaced table with new Table with timeline of RPL inputs to support the IMAP mission
	19. Appendix B: All environments updated
		September 3, 2019

Table of Contents

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 SPA and the SPA Integrator contractor are considered part of the Launch Vehicle (LV)/Launch Vehicle Contractor (LVC) and/or Government.

2 Definitions and Acronyms:

2.1 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 Payload
- RMA – Rideshare Mission Assurance
- RUG – Rideshare Users Guide
- SMD – Science Mission Directorate
- SPA – Secondary Payload Adapter
- TBD – To Be Determined
- TBR – To Be Resolved
- TBS – To Be Supplied
- VLC – Verification Loads Cycle

2.2 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. Rideshare Payloads are synonymous with Secondary Payloads.
- Secondary Payloads – Payloads that will be carried by a Secondary Payload Adapter. A secondary payload utilizes excess capability of a launch after the primary payload requirements are satisfied. A secondary payload can be an experiment, sensor, instrument or fully integrated spacecraft whose mission objective is different than that of the primary payload mission.
- Secondary Payload Adapter (SPA) is a generic term for a flight-proven qualified Launch Vehicle adapter carrier/ring enabling deployment of secondary payloads. (ex. Evolved Expendable Secondary Payload Adapter (ESPA), Cosmic Deployer Ring, ESPAStar, ESPA Grande, etc)

3 Documents

3.1 Applicable Documents

• NASA-STD-8719.24	NASA Expendable Launch Vehicle Payload Safety Requirements
• NPR 8715.6 NASA	Procedural Requirements for Limiting Orbital Debris
• NASA-STD-6016	Standard Materials and Processes Requirements for Spacecraft

3.2 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
• AFSPCMAN 91-70	Air Force Space Command Manual 91-710, Range Safety User Requirements Manual, 1 July 2004
• MIL-STD-461F	Requirements for the control of Electromagnetic Interference Characteristics of Subsystem and Equipment
• IEST-STD-CC1246	Product Cleanliness Levels and Contamination Control Program

4 Ground Rules and Assumption

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

4.1.1. In a case where a RPL is not able to meet the required mass properties, primary mode frequency, 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 SPA Port (non-separating).

4.1.2. LVC will build and provide mass simulators for each SPA port.

4.1.3. LVC will provide the separation system for each ESPA-class RPL per section 5.3.3.

4.1.4. LVC will provide In Flight Disconnect (IFD) to each ESPA-class RPL per section 5.4.2.

4.1.5. 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.

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

4.1.7. LVC will provide the RPL separation signal (primary and redundant) to each RPL or to an LVC-provided SPA sequencer.

4.1.8. LVC will provide confirmation of RPL separation/deployment.

4.1.9. LVC will provide Orbital Parameter Message within 30 minutes of RPL separation.

4.1.10. LVC may provide accommodations for RPL GN2 (Grade B) purge systems from RPL arrival at integration facility through launch.

4.1.10.1. Interruptions will be inherent for all LV's due to processing, therefore RPL missions shall ensure they can handle interruptions and have plans in place appropriately.

4.1.11. Facility space will be provided by the LVC for integration onto the SPA at the launch site. It can be used by RPLs for receiving, unpacking, functional checks, battery charging, and facility power. If standalone processing time is required by the RPL prior to delivery to the LVC, NASA will contract a Payload Processing Facility as a RPL mission unique service.

4.1.12. LVC integration facility's temperature and humidity will typically be controlled to the following levels:

Temperature: 55° – 85° Fahrenheit (12.8° - 29.4°Celsius)

Relative humidity: < 65%

4.1.13. Cleanroom environment will be provided for integrated operations thru fairing encapsulation to meet contamination requirement for primary mission.

4.2 RPLs will/will not:

4.2.1 RPLs will have no authority to make a GO, No-GO call on day of launch.

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

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

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

4.2.5 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.

4.2.6 All RPLs will be deployed after the Primary mission separation.

5 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 not to ensure mission success for individual RPLs. It is the responsibility of the RPLs to ensure their own mission success.

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.

6 Requirements:

6.1 Mission Integration:

6.1.1 RPLs shall provide all data products listed in Appendix A to meet the IMAP Mission Integration Cycle Schedule.

6.1.2 RPLs shall meet the data input timelines for the IMAP Mission Integration Analysis Cycles (e.g., PGAA-1, 2, 3, and Verification Load Cycle (VLC)). See Appendix A for a list of RPL inputs to support the Primary Mission Integration Cycle.

6.2 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:

$$C3 = -0.68 \text{ to } -0.48\ km^2/s^2$$

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.

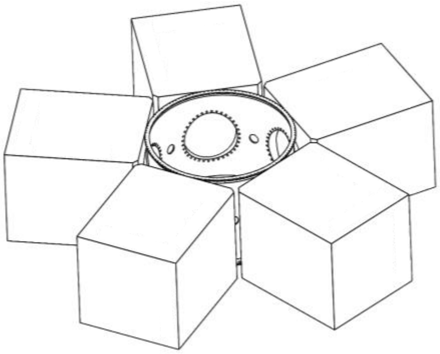
6.2.1 The RPL orbit insertion shall be designed not to make physical contact with the primary spacecraft, or LV performing end of mission operations. Its target, including C3, will be dependent on excess capability of the launch vehicle after inserting the primary spacecraft and considering additional resources needed by LV for end of mission disposal.

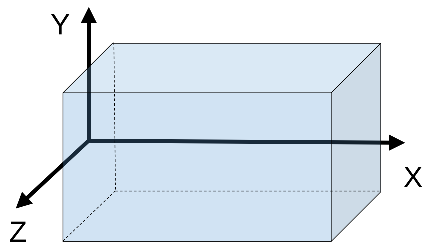
6.3 Mechanical:

6.3.1 Reference Coordinates and Origin

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

Figure 5.2 ESPA and RPL Coordinate System





6.3.2 ESPA Grande Class Payloads Interface Requirements

6.3.2.1 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.

6.3.2.2 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)

6.3.3 ESPA Class Separation Systems:

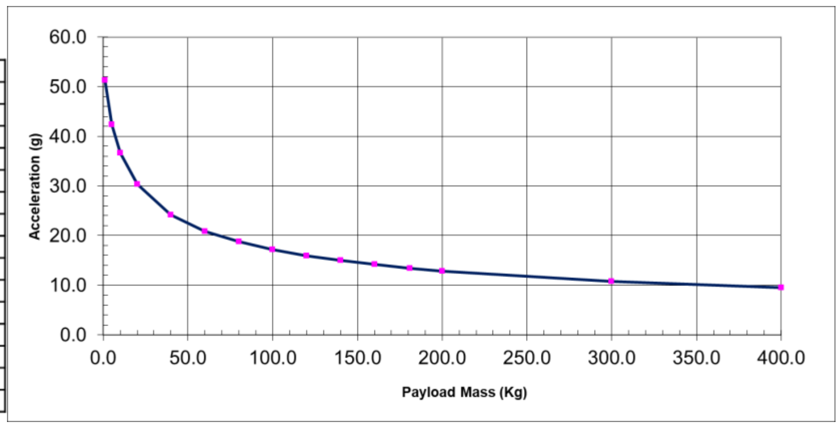
6.3.3.1 LVC will provide the appropriate Separation System for each RPL. A typical separation system used for a 24” port is the RUAG PAS 610S. Specification for this separation system can be found at the following link:
https://www.ruag.com/sites/default/files/2017-01/PAS_610S_Separation_System.indd_.pdf

6.3.4 Static Loads

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

Break Points*

Mass (kg)	Accel (g)
1.0	51.3
5.0	42.4
10.0	36.6
20.0	30.3
40.0	24.2
60.0	20.9
80.0	18.7
100.0	17.2
120.0	15.9
140.0	15.0
160.0	14.2
181.0	13.5
200.0	12.9
300.0	10.8
400.0	9.5



Mass acceleration Curve for RPLs provided by GSFC

6.3.5 RPL Stiffness

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

6.4 Electrical:

6.4.1 Electrical Power

6.4.1.1 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.

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

6.4.1.3 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.

6.4.2 Connectors:

6.4.2.1 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.

6.4.3 Battery:

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

6.4.3.1 RPLs shall utilize Underwriter Laboratory (or-equivalent) approved batteries with no modifications and be compliant with Range Safety requirements (NASA-STD-8719.24)

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

6.4.3.3 RPLs shall meet battery charge monitoring requirements per NASA-STD-8719.24. RPL monitoring of the charge activity will be required to avoid generation of Radio Frequency (RF) emissions that may affect nearby hardware.

6.5 Environments:

This section contains general requirements for early development/design because mission-specific environments have not been defined. 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. 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.

6.5.1 Thermal

6.5.1.1 RPLs shall not specify any temperature and humidity requirements that are in conflict with the primary spacecraft requirements.

6.5.2 Random Vibration

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

6.5.3 Sine Vibration

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

6.5.4 Acoustics

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

6.5.5 Shock

6.5.5.1 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 for separation of Primary Spacecraft. Proper attenuation factor must be considered for shock environment at the RPL separation plane. There are at least 2 joints of attenuation: (1) bolted interface between the SPA and RPL sep system, and (2) bolted interface between sep system and RPL structure.

6.5.6 Pressure

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

6.5.7 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.

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

6.5.7.2 RPLs shall undergo thermal vacuum bakeout per ASTM E2900.

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

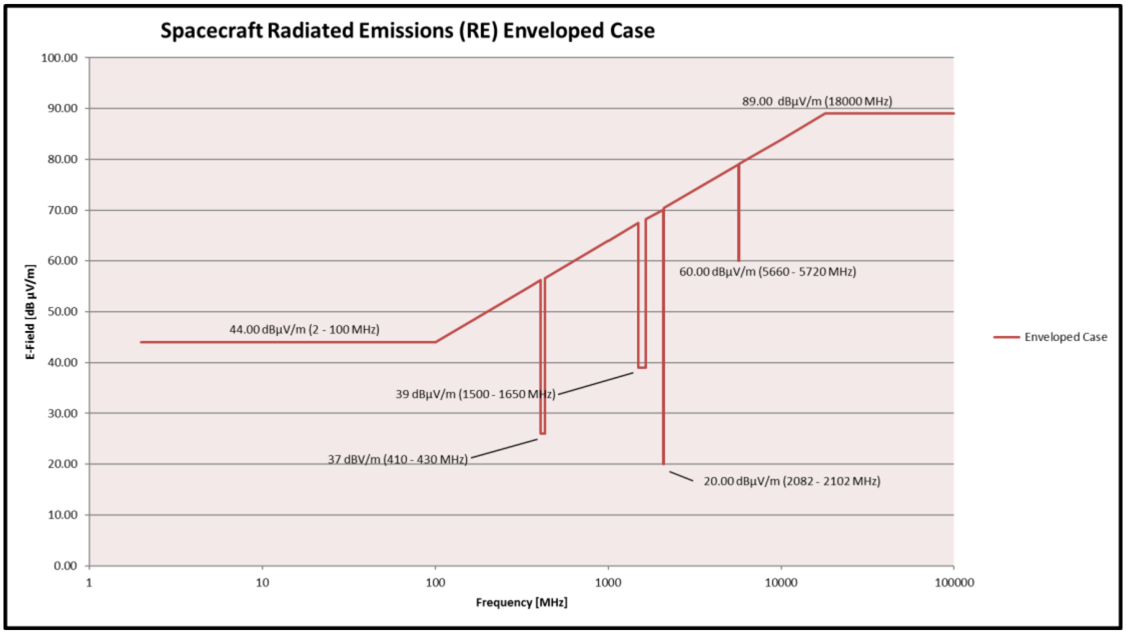
6.5.8 Electromagnetic Interference/Electromagnetic Compatibility (EMI/EMC)

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

6.5.8.2 RPLs shall ensure Underwriter Laboratory (UL) or equivalent certification on all electrical ground support equipment (EGSE). All EGSE shall meet NASA-STD-8719.24, NASA Expendable Launch Vehicle Payload Safety Requirements.

6.5.8.3 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



6.5.8.4 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)

6.5.8.5 The RPLs shall meet the following EMI margin requirements:

6.5.8.5.1 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.

6.5.8.5.2 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.

6.5.8.6 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).

6.5.9 Radiation

6.5.9.1 No hazardous radiation is permitted.

6.6 Ground Operations

6.6.1 RPLs shall provide GSE lifting fixtures to support mate operations onto the SPA.

6.6.2 RPLs shall provide their own GSE for payload operations such as battery charging, monitoring, testing, etc.

6.7 U-Class Containerized (CubeSat) RPLs Requirements

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

6.7.2 U-Class Containerized (CubeSats) RPLs shall meet the requirement of this specification, except for sections 6.3.1, 5.2.2, 6.3.3, 6.3.4, 5.2.5, 6.4.2.

7 Safety

7.1 Fault Tolerance

7.1.1 RPLs shall support and comply with the primary mission Payload Safety Working Group (PSWG).

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

7.2 Hazard System activation

7.2.1 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

7.3 Propulsion and Pressure vessels

7.3.1 RPLs with pressure vessels shall comply with NASA-STD-8719.24, NASA Expendable Launch Vehicle Payload Safety Requirements, at the launch site.

7.3.2 RPLs shall comply with NASA-STD-8719.24, NASA Expendable Launch Vehicle Payload Safety Requirements, for Loading and offloading of propellants and hazardous commodities.

7.4 Hazardous Materials

7.4.1 RPLs hazardous material shall conform NASA-STD-8719.24, NASA Expendable Launch Vehicle Payload Safety Requirements.

7.5 Orbital Debris

7.5.1 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 – Nominal Timeline of Inputs to support IMAP Mission Integration Cycle

Timelines may be adjusted after the IMAP Launch Vehicle has been selected (~8/1/2020).

MoO Timeline	S/C Input needed	IMAP LV Timeline To LSP	LV Deliverable
(1) CSR Phase A 11/1/19 (2)CSR 5/15/20	S/C Questionnaire/IRD Mission Support Requirements draft. LSIRD Final at LSTO start. Assume LSTO start to be ATP need date minus 6-9 M.	Prelim Compl by 2/1/21; Final by L-15M	Mission Interface Control Document (ICD) Draft
(1) CSR Phase A 11/1/19 (2) CSR 5/15/20 (3) L-46M 12/1/20	S/C drawings and fairing Requirements, CAD models (ie. Details of mechanical interface, CAD showing outer skin line, location of SC access needs so door locations can be determined)	Prelim Compl by L-44M 5/1/21; Final by L-15M	Payload Compatibility/Critical Static Clearance Drawing/MICD. Updates as required thru the mission as the SC changes.
L-42M 4/1/2021	S/C dynamic model (Craig Bampton (CB) format) (first delivery) and accompanying memo to describe use of model. First CLA date is not set in stone in contract. Most SC desire for it to be done ASAP after ATP.	Compl by L-34.5M 11/15/21	Preliminary Design Loads Cycle and dynamic clearance assessment to LV hardware (i.e. separation system, fairing) **Feeds IMAP S/C CDR (1/14/22 L-33M)*
L-39M 7/1/21	S/C Target spec and Mass Properties (first delivery) Most SC desire to kick this effort off ASAP after ATP. Per contract, several contractors allow this but SX has first one at ATP + 6 M.	L-34M 12/1/21	Initial Performance and Guidance Accuracy Analysis (PGAA) **Feeds IMAP S/C CDR (1/14/22 L-33M)*
L-34M 12/1/21	S/C flight harnesses requirements	L-27M 7/1/22 Final by L-15M	Electrical Interface Control Drawings (or as soon as available; flight hardware is needed sooner than GSE info) Many connectors require long lead times. For connectors, Flight **and GSE**, the LV is providing, need dates for the SC drive procurement. Preferred to understand these need dates ASAP after ATP.
L-19M 3/1/23	S/C dynamic model, CB format and accompanying memo to describe use of model (second delivery)	L-11M 9/1/23	Intermediate Design Loads Cycle (AKA FDLC) and dynamic clearance assessment to LV hardware (i.e. separation system, fairing) **Feeds IMAP S/C PER (11/15/23 L-10.5M)*
L-24M 10/1/22	Mass Simulator Specifications (updated S/C CAD model, Mass, CG, freq)	L-18M 4/1/23	Mass Simulator

L-24M 10/1/22 & In conjunction with final trajectory analysis	The S/C nutation time constant (if applicable), otherwise, ICD details and trajectory analysis results are input to SC separation analysis.	L-21M 1/1/23; Final ~L-6M	Spacecraft Separation Analysis: Initial is As required. Final is required but contracts between contractors varies this deliverable from L-6M to L-1M
L-18M 1/1/23	S/C Target spec and Mass Properties (second delivery)	L-10.5M 8/15/23	Performance and Guidance Accuracy S/C PMA requirements and Analysis (PGAA) **Feeds IMAP S/C PER (11/15/23 L-10.5M)*
L-13M 9/1/23	S/C radio frequency application	L-9M 1/1/24	RF Link Analysis (initial data in IRD/ICD, confirmed as input to RF link at this time) Cannot be done until PMA complete
L-20M 2/1/23	S/C ventable and non-ventable volumes. Timing of this is not set in stone in contract. Timing tends to be after L-18 M but can be as late as L-6M	L-15M 7/1/23	Payload Fairing Venting Analysis (initial data in IRD, confirmed as input to venting analysis at this time)
L-12M 10/1/23	Simplified S/C geometrical and thermal mathematical models. Format and maximum sizes are negotiated with contractor after award. Potential SC will be required to simplify their existing models used for their on orbit thermal analysis due to size limitations to run the full SC/LV integrated models. Preferred around L-12M	L-8M 2/1/24	Integrated Thermal Analysis. Cannot be done until PMA but preferred to be done after FMA.
L-16M 6/1/23	S/C RF Systems summary	L-12M 10/1/23 L-3M 7/1/24	EMI/EMC and RF Compatibility Study (initial data in IRD, confirmed as input to RF Compat at this time)
60 days prior to SC CDR	S/C MSPSP inputs	>= 30 days prior to SC ship to launch site	Final Spacecraft Mission System Prelaunch Safety Package (MSPSP) (this is time of final release of MSPSP, inputs would be much earlier)
L-11M 11/1/23	S/C **verified** dynamic model, CB plus memo (third delivery). This delivery drives final availability of LV input to final flight software validation and timing is critical	L-6M 4/1/24	Verification Loads Cycle (VLC) and dynamic clearance assessment to LV hardware (i.e. separation system, fairing)

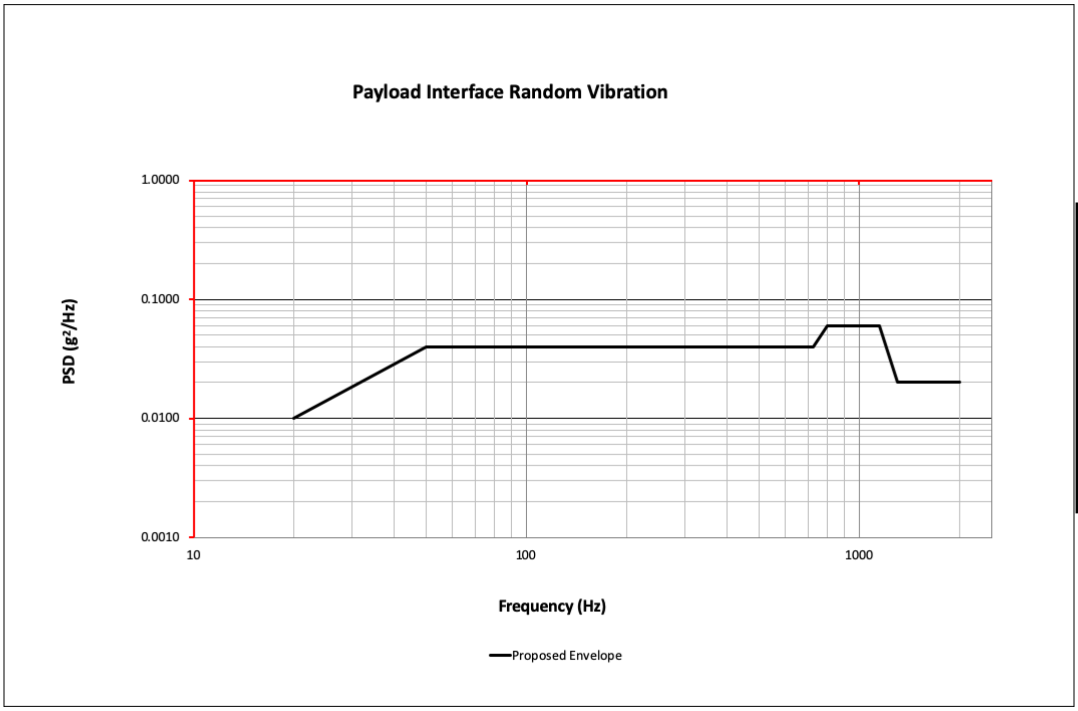
L-10M 12/1/23	S/C Target spec, S/C mass properties statement, launch window (third delivery)	L-6M 4/1/24	Performance and Guidance Accuracy Analysis (PGAA) (some need as early as L-36 weeks)
NLT 30 days prior to use	S/C launch site test plan, S/C launch site standalone test procedures, and S/C integrated test procedure inputs	Final: NLT use – 4 weeks	Integrated and standalone Test Procedures at PPF and pad
30 days prior to need/use date	Misc S/C data as needed (eg: Environmental Test Plans, Procedures and Results)	Delivered with each update of the ICD revision	Mission ICD Verification Matrix
L-3M 7/1/24	S/C Final Target spec and final s/c mass properties statement. Note this is listed as A/R for all contractors. Timing of this final delivery will be set after award	L-2M 8/1/24	Final Mission Analysis (FMA)

Other SC Inputs needed:

- SC documents/drawings to show compliance with following concerns:
  - SC separation detection methods across the LV-SC interface which initiate mission critical functions should be electrically and mechanically single fault tolerant.
  - SC separation detection circuits should provide protection to tolerate open circuit durations of up to 100 µsec on all contacts of all connectors at the same time.
  - The SC transmitter(s) should be electrically and mechanically single fault tolerant (2 inhibits) against inadvertent radiation.
  - The SC should have the capability to prevent erroneous RF signals from inadvertently initiating SC transmitter radiation.
  - The SC timer should accommodate timing dispersions that encompass the entire launch window and LV 3-sigma / contingency flight time dispersions.
  - During launch operations, the SC should provide the capability to remotely reset the timer. A timer reset may be required for circumstances including but not limited to a launch recycle or launch abort. Note: timers are not recommended implementation
    - The SC timer reset capability should be single fault tolerant (2 different methods are required to reset the timer)
  - The SC detection mechanism should be tested to a flight like LV simulation to mitigate incorrect determination of LV phase of flight.
  - The SC ground command up-link should be single fault tolerant against inadvertent commands from being initiated until after SC Separation

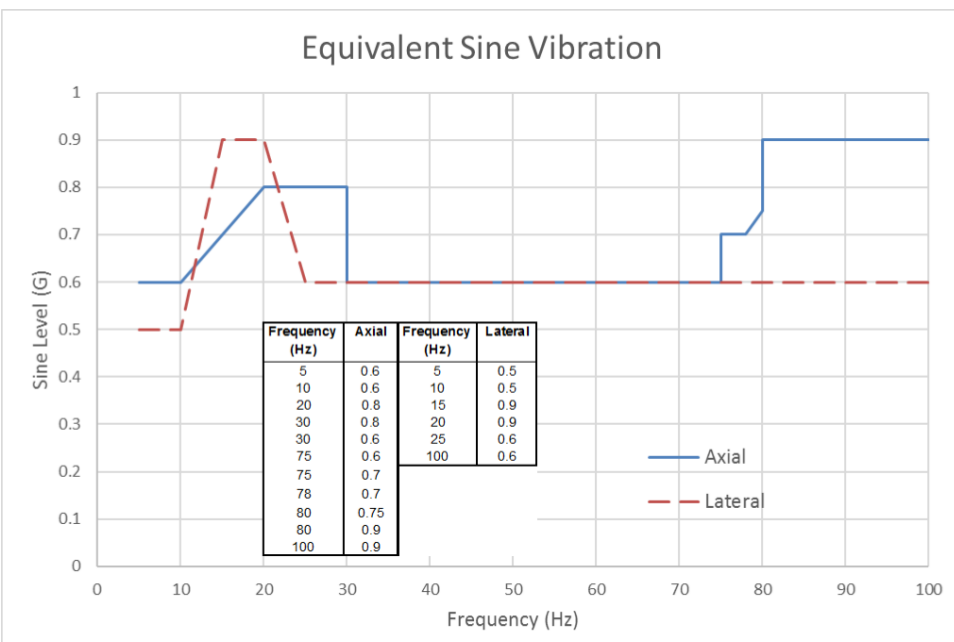
Appendix B – Environments

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

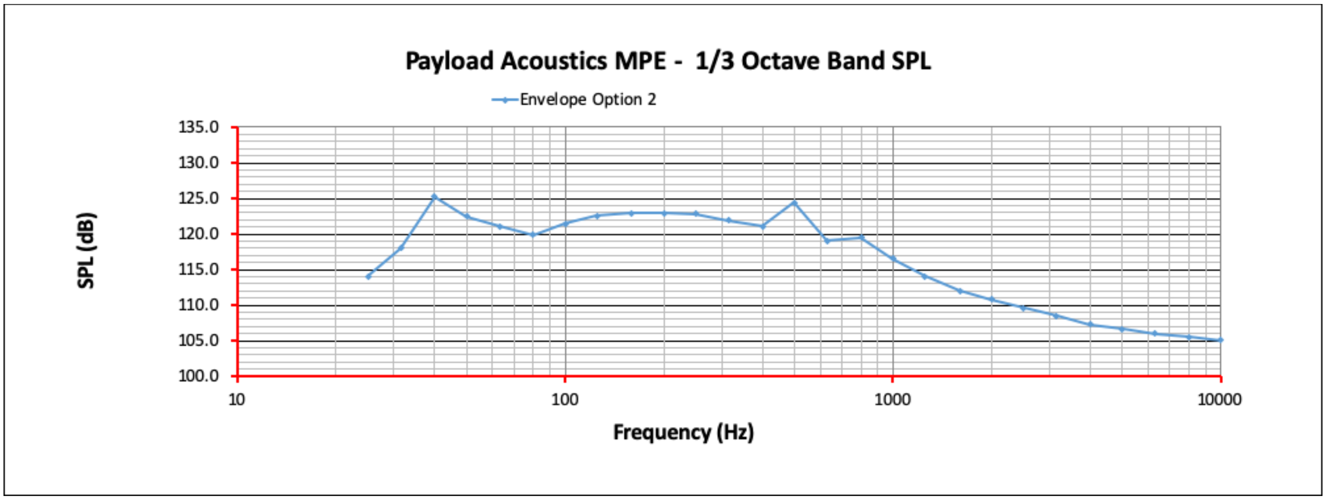
Sine Vibration Environment:



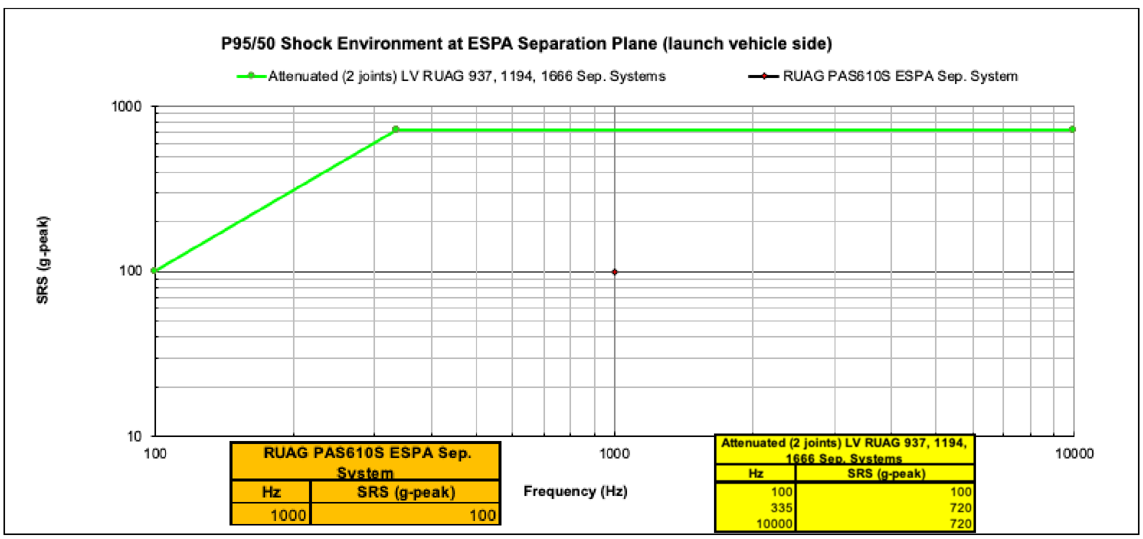
Frequency (Hz)	Axial
5	0.6
10	0.6
20	0.8
30	0.8
30	0.6
75	0.6
75	0.7
78	0.7
80	0.75
80	0.9
100	0.9

Frequency (Hz)	Lateral
5	0.5
10	0.5
15	0.9
20	0.9
25	0.6
100	0.6

Acoustic Environment:



Shock Environment:



RUAG PAS610S ESPA Sep. System	
Hz	SRS (g-peak)
1000	100

Attenuated (2 joints) LV RUAG 937, 1194, 1666 Sep. Systems	
Hz	SRS (g-peak)
100	100
335	720
10000	720

The provided shock curve is based on LSP experience with separation shock test data of past missions and appropriate joint attenuation to the ESPA rideshare interface.