NASA

Science Mission Directorate (SMD)

Launch Vehicle Secondary Payload Adapter

Rideshare Users Guide

(2020 SMD ESPA RUG)

Color coding: **red/bold = requirement**, *blue/italic = guideline for maximum flight opportunity*

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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 Earth System Science Pathfinder (ESSP) Earth Venture Mission-3 Announcement of Opportunity which will utilize an Evolved Expendable Launch Vehicle (EELV) Secondary Payload Adapter (ESPA) or ESPA Grande.

This document was developed by the NASA Science Mission Directorate (SMD).

1.2 Scope

This document provides ground rules and assumptions for RPLs intended to launch on an ESPA or ESPA Grande. **These cannot be exhaustive.** Since the primary payload and the launch vehicle will not be known at the time of proposal submittal, and neither the type of ESPA ring nor the ESPA integrator will be known, specific interface requirements and generic environment definitions will not be formalized until the launch vehicle contractor and primary observatory have been selected and the primary mission integration cycle has begun. **It is critical that secondary payloads carry additional margins** to account for any associated applicable uncertainty.

"*Should*" statements and *Guidelines for Maximum Flight Opportunity* are provided to assist proposers looking to maximize their opportunity for rideshare. Violating these guidelines does not make a payload ineligible for inclusion as a rideshare, but may limit the number of missions that are compatible with the RPL's launch requirements, and may increase integration and launch costs. "**Shall**" statements refer to requirements.

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.

An Accommodation Study will be conducted as part of the selection process. To aid in this process, proposers are asked to document additional RPL requirements that must 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.

2 Definitions and Acronyms

2.1 Acronyms:

- CCAMs – Contamination Control Avoidance Maneuvers
- CLA – Couple Loads Analysis
- DNH – Do No Harm
- DOT – Department of Transportation
- EMI – Electromagnetic Interference
- ESPA – Evolved ~~Expendable~~ Launch Vehicle Secondary Payload Adapter
- FEM – Finite Element Model
- GSE – Ground Support Equipment
- ICD – Interface Control Document
- IFD – In Flight Disconnect
- I&T – Integration and Test
- IPS – Integrated Payload Stack – Fully integrated ESPA with mated RPL
- LSP – Launch Service Program
- LSTO – Launch Service Task Order
- LV – Launch Vehicle
- LVC – Launch Vehicle Contractor
- PGAA – Performance and Guidance Accuracy Analysis
- PSWG – Payload Safety Working Group
- RF – Radio Frequency
- RPL – Rideshare Payload(s)
- RMA – Rideshare Mission Assurance
- RUG – Rideshare Users Guide
- SC – Spacecraft
- 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 driving 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.)

- Spacecraft bus essential power: Ability for spacecraft to be powered on at launch in order to power survival heaters and enable detection of spacecraft separation as a mission unique service.

3 Documents

3.1 Applicable Documents:

• NASA-STD-8719.24	NASA Expendable Launch Vehicle Payload Safety Requirements
• NPR 8715.6B NASA	Procedural Requirements for Limiting Orbital Debris
• NPR 8715.7B NASA	NASA Payload Safety Program
• NASA-STD-6016	Standard Materials and Processes Requirements for Spacecraft
• IEST-STD-CC1246	Product Cleanliness Levels and Contamination Control Program
• ASTM E2900	Standard Practice for Spacecraft Hardware Thermal Vacuum Bakeout

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

4 Ground Rules and Assumption

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

4.1.1 In a case where a RPL is not able to meet the required mass properties or 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 6.3.3

4.1.4 LVC will provide In Flight Disconnect (IFD) to each ESPA-class RPL per section 6.4.2.

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 (if any).

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 as a mission unique service. Any requirement for RPL GN2 purge systems from RPL arrival at integration facility through launch must be noted on the Accommodations Worksheet. *Max flight opportunity: no purge requirement.*

4.1.10.1 Purge interruptions will be inherent for all LV's due to standard launch vehicle 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, fueling, 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. Any requirements to use this space for fueling or pressurization of a propulsion system must be specified on the Accommodation Worksheet.*

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

4.2 RPLs will/will not:

4.2.1 RPLs will not have the 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. Plan for removal of non-flight covers etc to occur prior to encapsulation. Any requirements for access to the RPL after delivery for integration must be noted on the Accommodation Worksheet*. Max flight opportunity: no requirement for late access to RPL.*

4.2.4 No down range telemetry support will be provided for RPL deployments. Any requirement for down range telemetry support for RPL deployments may be assessed as a RPL mission unique service by LSP and must be noted on the Accommodation Worksheet. *Max flight opportunity: no requirement for down range telemetry for RPL deployment.*

4.2.5 RPLs **must** 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.

4.2.7 Proposers should assume that the launch vehicle upper stage will act as a 3-axis-stabilized inertial platform. Any requirement for the launch vehicle to be pointed in a particular direction at the moment an RPL is released should be noted on the Accommodation Worksheet. *Max flight opportunity: no requirement for specific direction or upper stage maneuver requirement.*

4.2.8 RPLs should anticipate that they will be required to remain “dormant” (with no RF transmission and no appendages deployed) for some period following their release.

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; the relevant requirements are included in this document. 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 meet the data input timelines for the Primary Mission Integration Cycle (e.g., PGAA-1, 2, 3, and Verification Load Cycle (VLC)). See Appendix A of for an example of expected timelines for RPL data product deliverables for ESPA rideshare integration.

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

6.2 Mission Trajectory

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 trajectory insertion, 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.

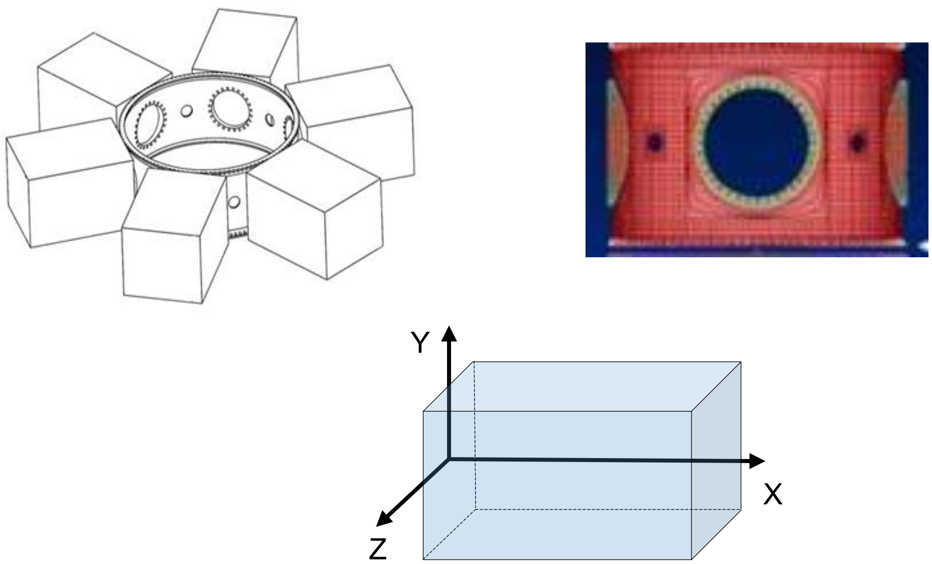
6.2.2 RPLs consisting of CubeSat constellations (or that otherwise separate into multiple free-flying components) shall provide analysis showing no re-contact.

6.3 Mechanical

6.3.1 Reference Coordinates and Origin:

6.3.1.1 RPL will use the coordinate system specified in Figure 6.1. The coordinate origin is that the center of the -X face of the spacecraft (the center of the ESPA port). The X-dimension is measured from the ESPA port interface plane, and the dimension in the table includes the width of the separation system.

Figure 6.1 ESPA, ESPA Grande and RPL Coordinate System



6.3.2 ESPA Class Payloads Interface Requirements

6.3.2.1 RPLs **shall not** exceed the mass and volume requirements as specified in Table 6.1; *RPL with lower mass* will be easier to accommodate. *If your design requires protrusion outside the cube volume, please provide rationale for consideration in the Accommodation Worksheet.* *Max flight opportunity: x-dimension < 38" would be compatible with 4-m and 5-m fairing launch vehicles.*

Table 6.1 ESPA RPL Mass, Volume Interface Requirements for 4-meter Fairing

ESPA	Port Mass Capacity(5)	Allowable RPL Volume(1, 2, 3,4,6)	RPL Interface
ESPA Grande 4 Port	465 kg	42"x46"x38" Y, Z, X	24" circular
ESPA 6 Port	220 kg	24"x28"x38" Y,Z,X	15" circular

(1) X-dimension assumes a 4-meter fairing; ESPA Grande on 5-meter fairing allows 56".
(2) The Atlas V 4-meter fairing has additional fairing sweep stay-out zones at the base of the fairing that may be applicable. These are defined in the LV users guide. See following link: 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-axis 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) Separation system tip-off must be accounted for to ensure any RPL structure that extends into the internal volume of the ring will exit the volume upon RPL deployment without contacting the port inner diameter.

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

6.3.3 ESPA Class Separation Systems:

6.3.3.1 LVC will provide the appropriate separation system for each RPL, based on the payload design characteristics: this will be either a 15" system for an ESPA, or a 24" system for an ESPA Grande. Specification for commonly-used separation systems are listed below:

RUAG PAS 381S (15"): https://www.ruag.com/sites/default/files/media_document/2018-06/PAS%20381S%20Separation%20System_rev4.pdf

RUAG PAS 610S (24"): https://www.ruag.com/sites/default/files/media_document/2019-03/PAS%20610S%20Separation%20System.pdf

PSC MkII MLB (15" or 24"): https://www.planetarysystemscorp.com/wp-content/uploads/2018/07/2000785G-MkII-MLB-User-Manual.pdf

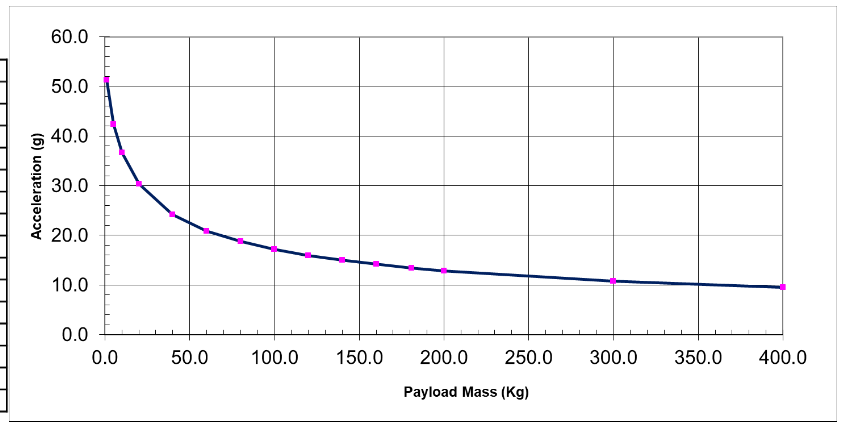
6.3.4 Static Loads

6.3.4.1 The peak line load across the ESPA/RPL interface **shall** not exceed 400 lbs. /in. This is defined at the separation plane between the active and passive parts of the separation system. This limit is based on a maximum LV acceleration of 8.5g; if the LV acceleration is greater, this load may be restricted to lower values. Also, see Figure 6.2 for the Mass Acceleration Curve for RPLs.

Figure 6.2 Mass Acceleration Curve for RPLs provided by GSFC

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



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. *RPL's with frequencies below 75Hz would require a Coupled Loads Analysis to be performed with the selected LV to determine any adverse CLA response impacts to the Primary mission. Unfavorable results could result in the* ***demanifesting*** *of the RPL.*

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. *Requirements for powering on after integration to the ESPA must be detailed in the Accommodation Worksheet.*

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 The connector interface varies with the separation system selection and will be coordinated with the RPL after LV selection. LVC will provide one in flight disconnect (IFD) connector and one spare to each of the RPL developers for incorporation into spacecraft build. Pinout assignments and electrical characteristics of the harness will be defined during the interface control document development.

6.4.3 Battery:

Battery charging can be provided through an ESPA T-0 connector. *Requirements for battery charging and monitoring must be detailed in the Accommodation Worksheet.* 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.

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 which would be adequate for the launch vehicles currently on NASA LSP contracts, but may change when new launch vehicles become available. Mission specific environments will be defined once the launch vehicle contractor and primary observatory have been selected and the mission integration cycle has begun. These Mission Specific environments will be flowed down to the RPLs from the Launch Vehicle to Primary Payload Interface Control Document (ICD). The environments defined in the LV to Primary Payload ICD will take precedence over the requirement defined in this section.

6.5.1 Thermal

6.5.1.1 RPLs **shall not** impose specific requirements that constrain the environment of the launch vehicle, or specify temperature and humidity requirements that would be in conflict with the Primary Payload requirements.

6.5.2 Random Vibration

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

6.5.3 Sine Vibration

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

6.5.4 Acoustics

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

6.5.5 Shock

6.5.5.1 RPLs **shall** be designed to the representative composite acoustic environments defined in Appendix B defined at the LV standard interface plane (i.e. top of payload adapter/attach fitting). Separation plane shock environment provided is based on LV candidate 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 primary mission will drive these requirements, and they may be more restrictive than what is listed below. Often NASA spacecrafts have high sensitivity (ISO Level 7 (Class 10,000) contamination control) requirements for both molecular and particulate contamination on all surfaces within the fairing volume. As a result, strict cleanliness requirements may be placed on secondary payloads.

6.5.7.1 RPL shall adhere to a minimum of ISO Level 8 (Class 100,000) cleanliness requirements.

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

6.5.7.3 RPLs shall undergo thermal vacuum bakeout per ASTM E2900.

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

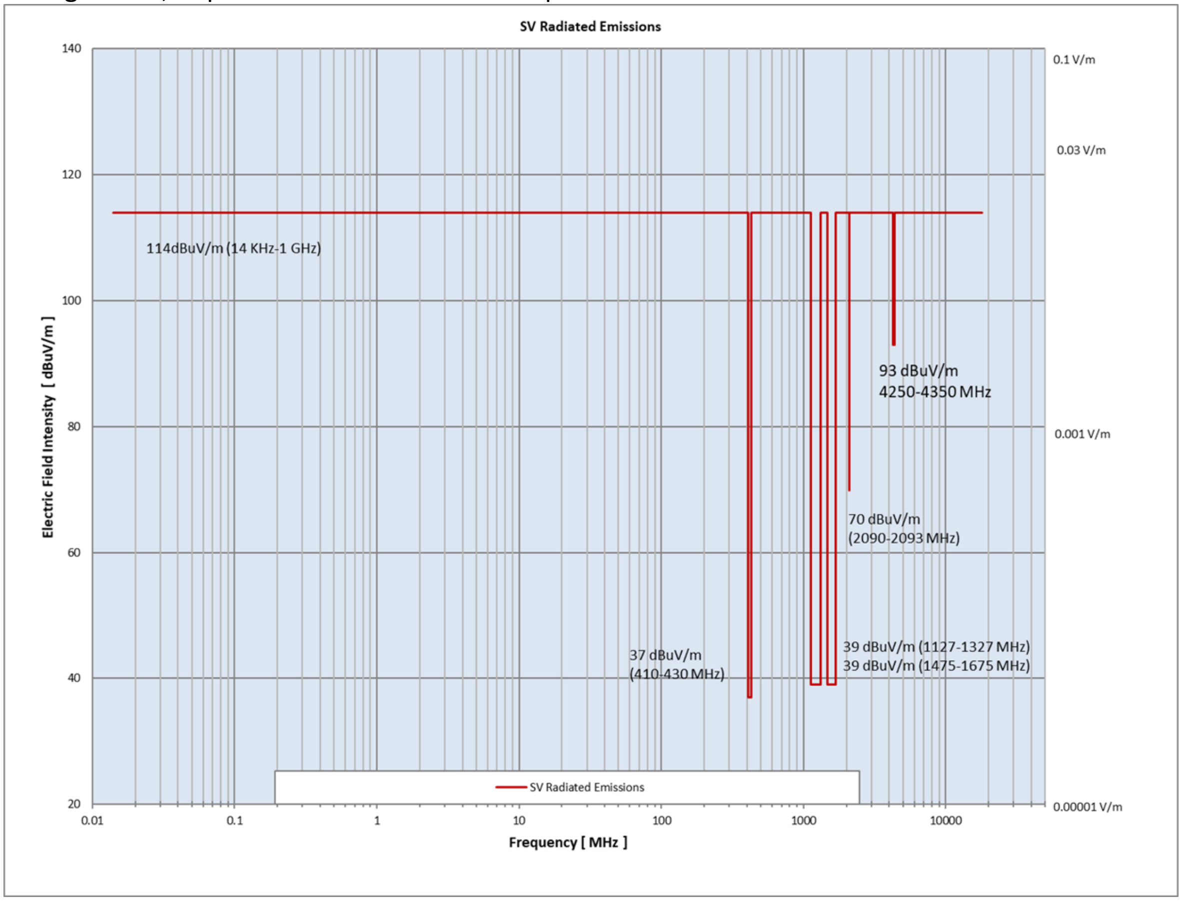
6.5.8 Electromagnetic Interference/Electromagnetic Compatibility (EMI/EMC)

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 RPLs radiated emissions at the payload interface plane shall not exceed the levels shown in Figure 6.3.

Figure 6.3, Representative Constraint on Spacecraft Radiated Emissions



6.5.8.4 The RPLs shall be compatible with the launch vehicle and Range radiated 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.

6.5.8.5.3 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 ionizing radiation is permitted.

6.6 Ground Operations

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

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

6.7 Requirements for U-Class Containerized (CubeSat) RPLs and CubeSat Constellations

6.7.1 RPLs proposing CubeSat 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. Only the CubeSats will be deployed.

6.7.2 CubeSat RPLs shall meet the requirement of this specification, except for sections 6.3.1, 6.3.2, 6.3.3, 6.3.4, 6.3.5, and 6.4.2.

7 Safety

7.1 Fault Tolerance

7.1.1 NASA RPL missions require the implementation of a Payload Safety Working Group (PSWG) per NPR 8715.7B. RPLs must also 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 Primary Payload mission ICD. These hazardous systems must be noted in the Accommodation Worksheet. They may consist of, but are not limited to:

- Deployments of solar arrays, booms, and antennas etc. The proposal must show that these will not be deployed inadvertently such as to impact the primary spacecraft, other secondaries, or the launch vehicle.
- RF transmission. The proposal must show RF inhibit architecture such that the spacecraft cannot transmit until after it has separated and achieved a safe distance from the other spacecraft and from the upper stage.
- 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 to 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 Primary Mission Integration Cycle*

Timelines will be adjusted after the Primary Launch Vehicle has been selected.

RPL Timeline	S/C Input needed	LVC Timeline To LSP	LVC Deliverable
LSTO start plus 6 M	S/C Questionnaire/LSIRD Mission Support Requirements draft. Final at LSTO start. Assume LSTO start to be ATP need date plus 6-9 M.	LV ATP + 6M for Preliminary; final by contract L-15M	Mission Interface Control Document (ICD) Draft
NLT LV ATP + 4 weeks	S/C drawings and fairing Requirements, CAD models (i.e. Details of mechanical interface, CAD showing outer skin line, location of SC access needs so door locations can be determined)	ATP + 6M for Preliminary; final by contract L-15 M for MICD	Payload Compatibility/Critical Static Clearance Drawing/MICD. Updates as required thru the mission as the SC changes.
LV ATP + 4 weeks	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.	Receipt of SC CB model plus 3-4 M with dynamic clearance plus another 1 M	Preliminary Design Loads Cycle and dynamic clearance assessment to LV hardware (i.e. separation system, fairing) ***Feeds Primary S/C CDR (~ L-33M)**
ATP + 1M-6M	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.	SC input +2-3M	Initial Performance and Guidance Accuracy Analysis (PGAA) ***Feeds Primary S/C CDR (~ L-33M)**
LV ATP +4 weeks	S/C flight harnesses requirements	ATP + 6M for Preliminary; final by L-15M	Electrical Interface Control Drawings (or as soon as available; flight hardware is needed sooner than GSE info) Many connector 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.
NLT L-24M	Mass Simulator Specifications (updated S/C CAD model, Mass, CG, freq)	L-18 M	Mass Simulator
L-24 M & 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.	Initial L-21M 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-20M	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	Payload Fairing Venting Analysis (initial data in IRD, confirmed as input to venting analysis at this time)
NLT L-19M	S/C dynamic model, CB format and accompanying memo to describe use of model (second delivery)	~L-12 M	Intermediate Design Loads Cycle (AKA FDLC) and dynamic clearance assessment to LV hardware (i.e. separation system, fairing) ***Feeds Primary S/C PER***
L-16M	S/C Target spec and Mass Properties (second delivery)	~L-12M	Performance and Guidance Accuracy S/C PMA requirements and Analysis (PGAA) ***Feeds Primary S/C PER***
L-16M	S/C RF Systems summary	L-12 M and L-3M As required	EMI/EMC and RF Compatibility Study (initial data in IRD, confirmed as input to RF Compat at this time)
L-13M	S/C radio frequency application	L-9M	RF Link Analysis (initial data in IRD/ICD, confirmed as input to RF link at this time) Cannot be performed until PMA complete
L-12M	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	Integrated Thermal Analysis. Cannot be performed until PMA but preferred to be done after FMA.
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	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	Verification Loads Cycle (VLC) and dynamic clearance assessment to LV hardware (i.e. separation system, fairing)

L-10M	S/C Target spec, S/C mass properties statement, launch window (third delivery)	~L-6	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 stand-alone Test Procedures at PPF and pad
L-3M	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	Final Mission Analysis (FMA)
30 days prior to need/use date	Misc S/C data as needed (e.g. Environmental Test Plans, Procedures and Results)	Delivered with each update of the ICD revision	Mission ICD Verification Matrix

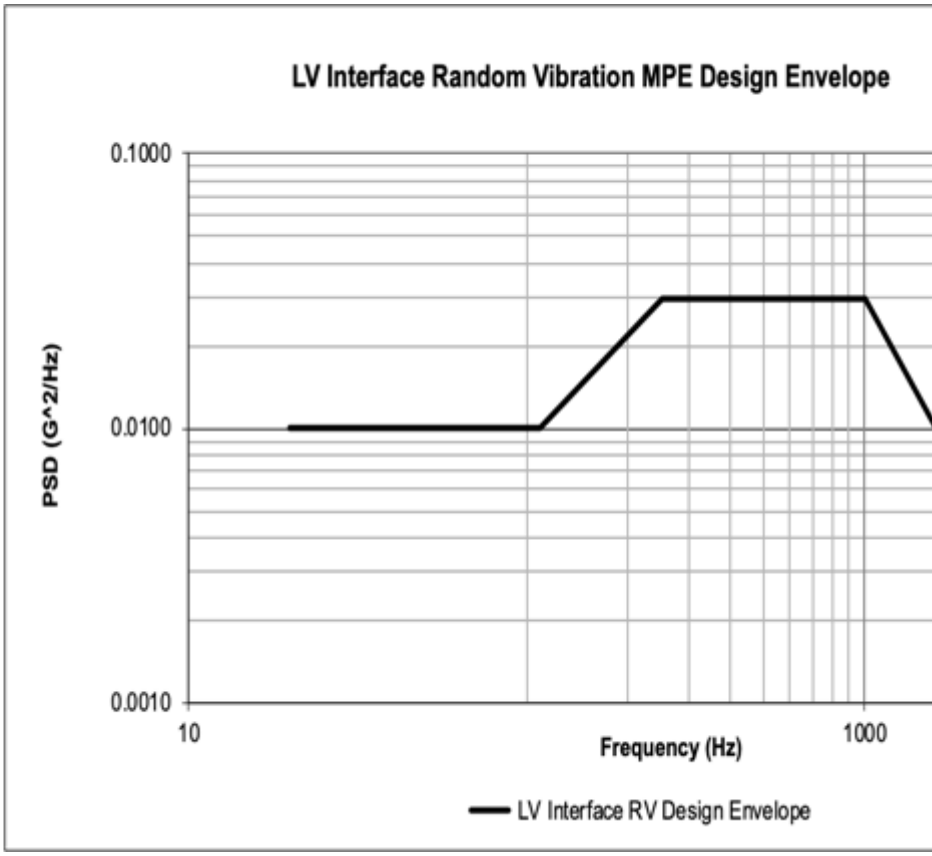
Other SC Inputs needed:

- SC documents/drawings to show compliance with following concerns:
    - SC separation detection methods across the LV-SC interface which initiate mission critical functions shall be electrically and mechanically single fault tolerant.
    - SC separation detection circuits shall 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) shall be electrically and mechanically dual fault tolerant (3 inhibits) against inadvertent radiation.
    - The SC shall have the capability to prevent erroneous RF signals from inadvertently initiating SC transmitter radiation.
    - The SC timer shall accommodate timing dispersions that encompass the entire launch window and LV 3-sigma / contingency flight time dispersions.
    - During launch operations, the SC shall 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 shall be single fault tolerant (2 different methods are required to reset the timer)
    - The SC flight phase detection mechanism shall be tested to a flight like LV simulation to mitigate incorrect determination of LV phase of flight.
    - The SC ground command up-link shall be single fault tolerant against inadvertent commands from being initiated until after SC Separation

Appendix B – Encompassing Launch Vehicle Environments (updated 7/1/2020)

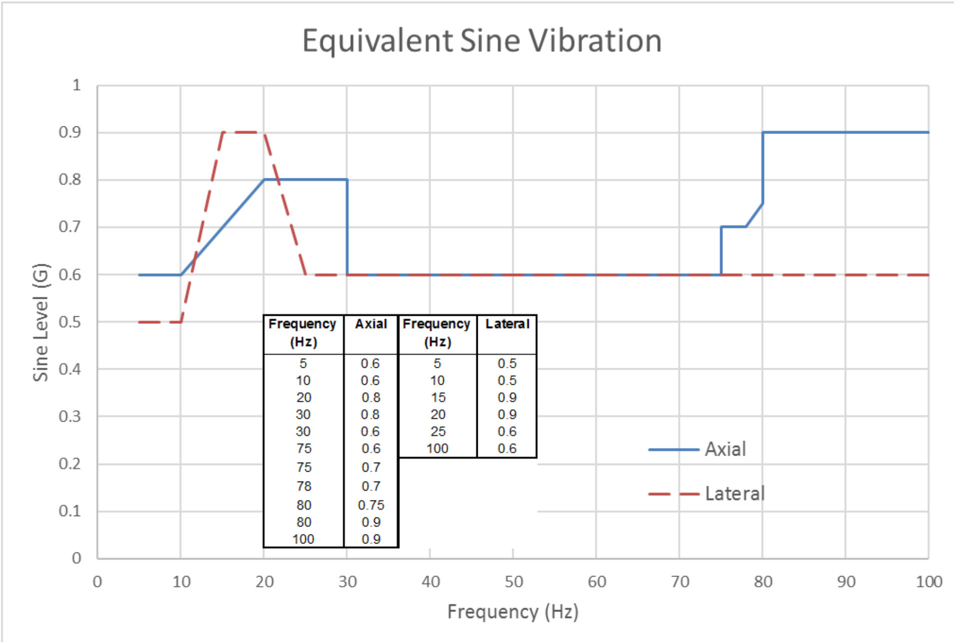
*All environments are defined at the LV standard interface plane (i.e. top of payload adapter/attach fitting).

Random Vibration Environment:

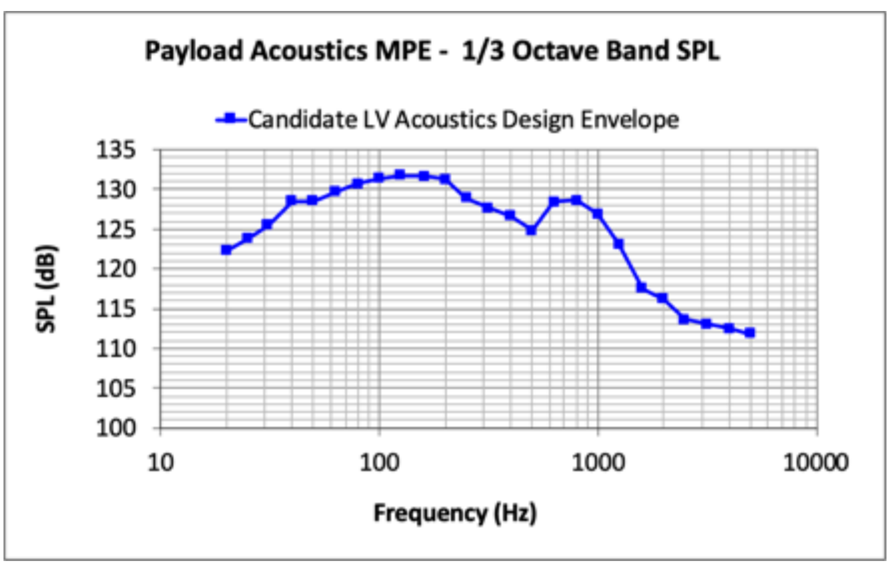


Candidate LV Interface RV Design Envelope	
Frequency (Hz)	PSD (G^2/Hz)
20	0.0100
110	0.01
250	0.03
1000	0.03
2000	0.0064

Sine Vibration Environment:

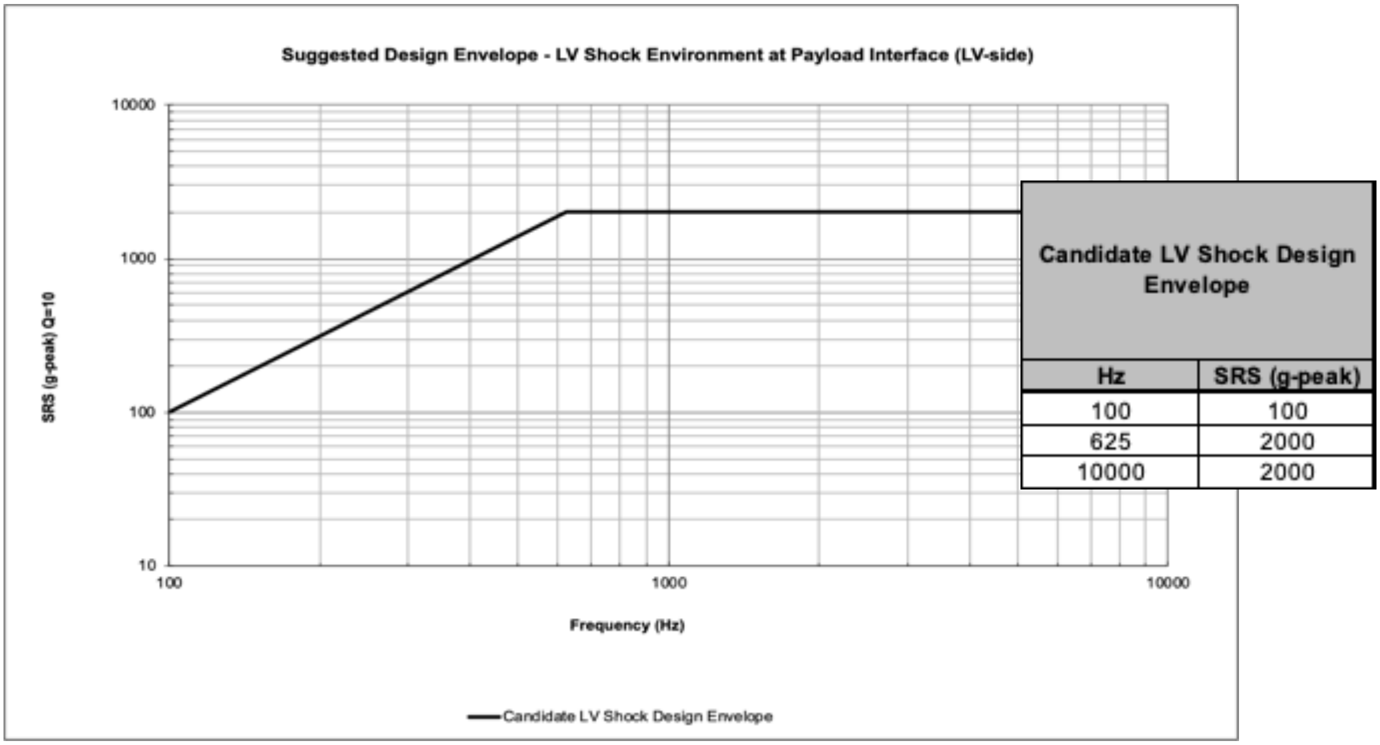


Acoustic Environment:

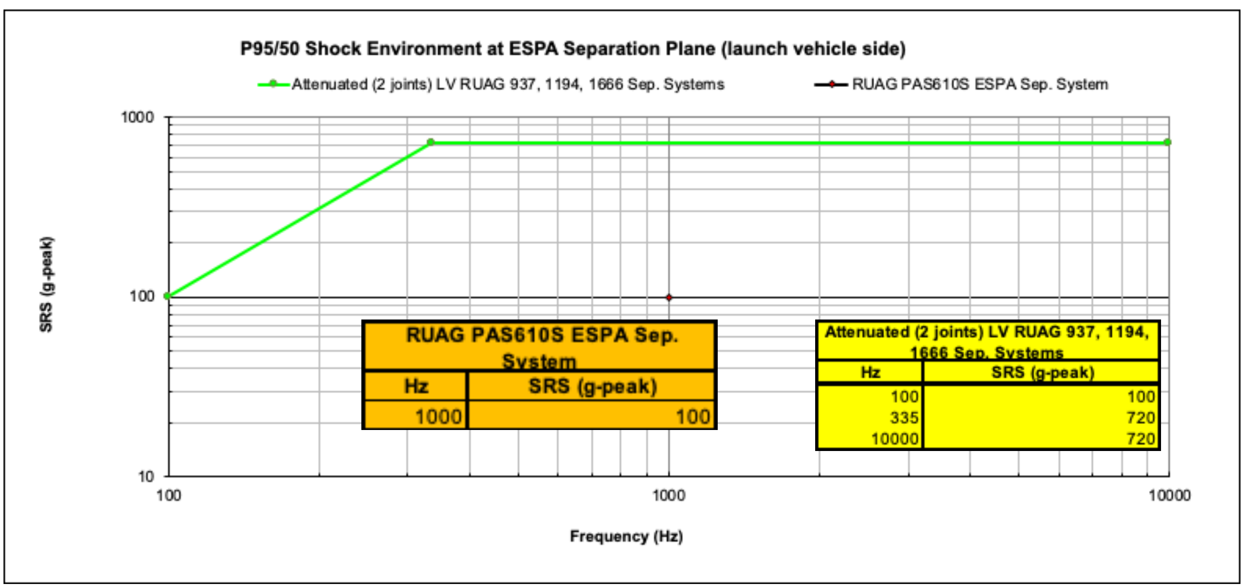


Candidate LV Acoustics Design Envelope	
Frequency (Hz)	SPL (dB)
20	122.3
25	123.8
31	125.5
40	128.5
50	128.5
63	129.7
80	130.7
100	131.4
125	131.7
160	131.6
200	131.3
250	128.9
315	127.7
400	126.6
500	124.8
630	128.4
800	128.6
1000	126.9
1250	123.1
1600	117.5
2000	116.2
2500	113.6
3150	113.1
4000	112.5
5000	111.8
6300	111
8000	110
10000	109.1
Overall SPL (dB)	141.6

Shock Environment:



Example for specific RUAG Sep Systems.



The provided ESPA shock curve is an example based on LSP experience with separation shock test data of past missions and appropriate joint attenuation to the ESPA rideshare interface. Please refer to specific provider user guides for other separation systems.