

Spaceflight, Inc. General Payload Users Guide



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Document Revision History

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1 Introduction

1.1 Document Overview

This Spaceflight Payload Users Guide (SPUG) is published by Spaceflight, Inc. to provide general information to payload developers whom will launch their payload or spacecraft using Spaceflight's integration services. It includes descriptions on the various flight support hardware, interfaces, capabilities, launch environments, policies and top level processes Spaceflight uses to manifest your payload and deliver you to your mission orbit. Further information may be obtained by contacting Spaceflight directly through spaceflightindustries.com

1.2 Spaceflight Overview

Spaceflight, Inc. (Spaceflight) provides launch services through various mission concepts that provide shared launch capability to multiple spacecraft. Spaceflight accomplishes this through several methods and provides varying levels of mission integration support to our customers. Spaceflight serves as the integrating entity across our platform of mission concepts where Spaceflight contracts directly with multiple payloads and the Launch Service Providers (LSP). Spaceflight has successfully opened an entirely new market to those payloads that cannot afford the cost of a dedicated launch. One of the biggest challenges of the past has been getting the LSPs to support the management of many disparate programs integrating on a single launch. Spaceflight has broken down this barrier by presenting a single point of contact to the LSPs representing an integrated payload stack that consists of 1 or more (at the date of this SPUG revision Spaceflight has developed an integrated payload stack that has free flying payloads) payload. This concept has proven so successful that Spaceflight now has agreements in place and/or weekly discussions with all the major launch providers, ensuring that there is a launch to match your mission requirements.

Spaceflight takes on the financial risk of the launch opportunities by procuring the excess capacity on dedicated launches of a primary payload or through procuring the entire launch capability ourselves and selling the launch opportunities to multiple customers. In either of these two scenarios we are able to provide access to space that is a true enabler for the emerging small satellite constellations, one-off demonstrations, Government science and operational objectives and the booming business sparked by the CubeSat community. To offer the best costs to our customers we have designed our support hardware to the common standards, yet our innovative staff of engineers and qualified vendors allow Spaceflight to accommodate the one-off designs as well as keep pace with the changing technologies.

Spaceflight is also unique in that our service costs are posted on line at spaceflightindustries.com. While committing to advertised firm fixed prices in the aerospace world has always been a challenge, Spaceflight's approach, laid out in this document, allows us to confidently and routinely provide our launch services to the what may be termed as the disadvantaged satellite community. When the business started we frequently labeled our customer base as secondary and small satellites. That has

changed and we are now supporting payloads that range from 1U CubeSats to Geo stationary satellites that mass upwards of 2,000kgs. This has allowed us to also expand our services from providing secondary services on an LSP's primary mission to Spaceflight procuring the entire launch capability. In fact, starting in 2017 and every year thereafter, Spaceflight will be procuring a Sun Synchronous launch dedicated to providing our customers consistent and reliable access to space.

A secondary payload provider can purchase payload launch services from Spaceflight, who then coordinates and arranges for integration and launch. Spaceflight, supported by the secondary payload providers, is responsible for analyses and physical integration of multiple payloads into a package that is treated as a discrete payload. This organizational structure is shown in Figure 1-1.

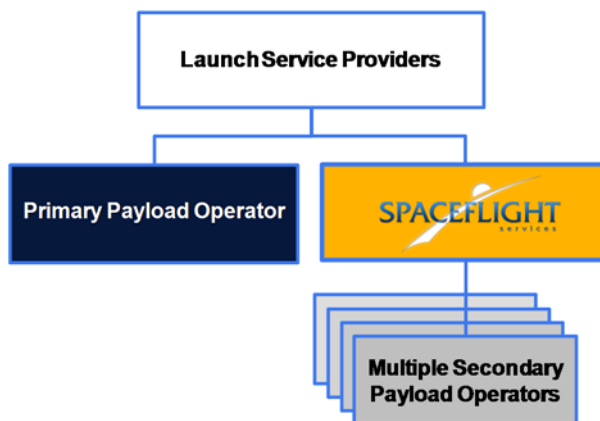


Figure 1-1 Spaceflight is responsible for the interface between all secondary payloads

Benefits for Satellite Developers

- Fully arranged launch, from contract to orbital insertion
- Experienced payload integrators with existing dispensers and interfaces
- Experienced licensing and export control assistance

Benefits for LSP

- Broad access to the small satellite market
- Experienced party as representative of ALL secondary payloads
- Standardized interface control, documentation and test reports

Spaceflight provides a single “one-stop shop” for integrating a wide range of suborbital and orbital payloads and providing them with responsive space access.

1.2.1 Procuring Spaceflight Services

Payload providers begin the mission integration process by completing a payload questionnaire (see Appendix B). The questionnaire includes payload information, requirements, and interface details allowing Spaceflight to match the payload with one or more of our launch opportunities. Adherence to this user’s guide and the referenced documents increases the payload’s opportunity to be quickly manifested. For those payloads that have unique requirements such as; volume exceedance, propulsion

or non-standard orbits will be accommodated, however the launch opportunities may be more limited and ultimately the acceptance of the payload is subject to approval by the Launch Services Provider and Spaceflight.

Based on the payload information and the identified launch opportunity Spaceflight provides preliminary pricing and mission information and begins the contract process. This begins with a Letter of Agreement (LOA) which is followed by a Launch Services Agreement (LSA) committing the payload to a launch opportunity. If the payload is a non-U.S. company or organization a Technical Assistance Agreement (TAA) is initiated that once signed by the U.S. State Department allows Spaceflight to exchange the technical data needed to successfully integrate the payload. This process is lengthy and Spaceflight starts drafting the documents as soon as the non-U.S. payload demonstrates commitment either through signing the LOA or through their interactions.

Once the LSA is signed, Spaceflight enters into the processes and timelines defined within this document.

1.3 Hardware Overview

Spaceflight offers all the hardware required to successfully integrate a payload into the specific integrated payload stack for a specific launch vehicle and/or mission. At a minimum Spaceflight provides the physical integration structure, a dispenser (for CubeSats) and a separation system as our standard service. In an effort to support the widest range of customer requirements, Spaceflight has developed a range of hardware that comes together in a modular manner. Spaceflight's hardware is currently qualified with flight heritage and in the event that new hardware is required, Spaceflight ensures that each item is fully qualified through industry recognized standards. Spaceflight's integration products are broken down into various categories and are explained in detail in the following sections:

Secondary Payload Integration or Hosting Products (Section 2)

These are Spaceflight's products that integrate directly with the launch vehicle to include non-propulsive and hosted options in a variety of sizes.

Secondary Payload Interface Adapters (Section 3)

These products connect the payload to the integration products explained above. There are four options available, depending on the mass and size of the payload.

Secondary Payload Dispensers (Section 4)

Spaceflight offers a variety of CubeSat dispensers that are compatible with the integration products described in Section 2.

Secondary Payload Separation Devices (Section 5)

For satellites larger than a CubeSat, Spaceflight provides separation systems of various sizes.

Spaceflight physically integrates the selected hardware into one discrete payload, the integrated payload stack, for launch. For more details on how the final integration and launch operations work, please see Section 8.

1.4 Mission Management Overview

Spaceflight provides full integration services for each payload. These services include engineering analysis, documentation support for the launch vehicle environments, interface control documentation, range safety, ITAR and Export Control support. The general mission management process for a 24 month timeline is summarized in Table 1-1.

Table 1-1 Standard Mission Integration Process

Milestone Date	Purpose	Spaceflight Deliverables	Secondary payload provider Deliverables
Contract Signing Typically L-24 Months	Provides Authority to Proceed with work	<ul style="list-style-type: none"> Secondary Payload User's Guide Procure deployment system Point of Contact Requirements for Payload CAD model, FEM ICD Template 	<ul style="list-style-type: none"> Signed LSA Point of Contact Completed Payload Questionnaire
Kickoff LSA signature + 2 months	Initiates technical mission development	<ul style="list-style-type: none"> Mission Schedule to a Level 2 Detail Summary of mission-unique requirements and implementation MSPSP Template Delivery File for Technical Assistance Agreement (Foreign Payload Providers Only) Requirements for Payload Thermal Model 	<ul style="list-style-type: none"> Payload CAD model Payload FEM Spacecraft Test Plan
MCDR Launch-9 months	Serves as the gate for fabrication and test of flight systems	<ul style="list-style-type: none"> Updated Mission Schedule to a Level 2 Detail Mission specific ICD Best-estimate launch campaign dates and launch date Preliminary Integration Schedule Preliminary Launch Operations Plan 	<ul style="list-style-type: none"> Updated Payload CAD model (if applicable) Updated Payload FEM (if applicable) Payload Thermal Model Updated Payload Mass Completed MSPSP Spacecraft launch site operations plan

Milestone Date	Purpose	Spaceflight Deliverables	Secondary payload provider Deliverables
System Readiness Review Launch-3 months	Verifies that all people, parts, and paper are ready for the shipment of the Payload to the Launch Site and ready to begin Launch Site activities	<ul style="list-style-type: none"> Updated mission analyses results (if applicable) Final integration schedule Final launch operations plan A list of facilities and services available for Payload checkout 	<ul style="list-style-type: none"> Verification of Payload compliance to ICD requirements (i.e. qualification report) Updates to CAD model, FEM, thermal model, and MSPSP (if applicable)
Integration Process Start Launch-8 weeks	SHERPA integration activity	<ul style="list-style-type: none"> Identify last access to the Payload Spaceflight will provide and operate a facility for the integration activity 	<ul style="list-style-type: none"> Final as-measured Payload mass and best estimated wet-mass Delivery of Payload and associated electrical and mechanical GSE to integration facility for system level integration Delivery of Payload mass model to integration facility for system level integration
Launch Readiness Review Launch-1 day	Final activities before launch	<ul style="list-style-type: none"> Approximate separation time 	<ul style="list-style-type: none"> Launch Readiness Review (LRR)
Launch Launch+0 hours	Ignition of Launch Vehicle	<ul style="list-style-type: none"> None 	<ul style="list-style-type: none"> None
Payload Separation Launch+4 hours	Support Secondary payload provider Acquisition of Payload on-orbit	<ul style="list-style-type: none"> Separation confirmation and state vector 	<ul style="list-style-type: none"> None
Acquisition Notification Payload Acquisition+12 hours	Support Spaceflight mission goal verification	<ul style="list-style-type: none"> None 	<ul style="list-style-type: none"> Indication of Payload Acquisition, command/telemetry status, and initial vehicle state-of-health assessment

2 Secondary Payload Integration and Hosting Products

Spaceflight uses a standard auxiliary payload accommodation system for medium and intermediate class launch vehicles (e.g. Falcon 9, Antares™, EELV), known as SHERPA. It has a Moog CSA Engineering adapter ring at its core, derived from an ESPA Grande ring, and features five 61 cm (24 inch) diameter ports, each capable of carrying payloads weighing up to 300 kg (660 lb). The SHERPA provides two common mechanical interfaces (top and bottom) and supports multiple integrated payload stack design concepts. The SHERPA system is qualified and the first flight in a configuration similar to Figure 2-1 is scheduled for December 2015 on a Falcon 9 launch vehicle.

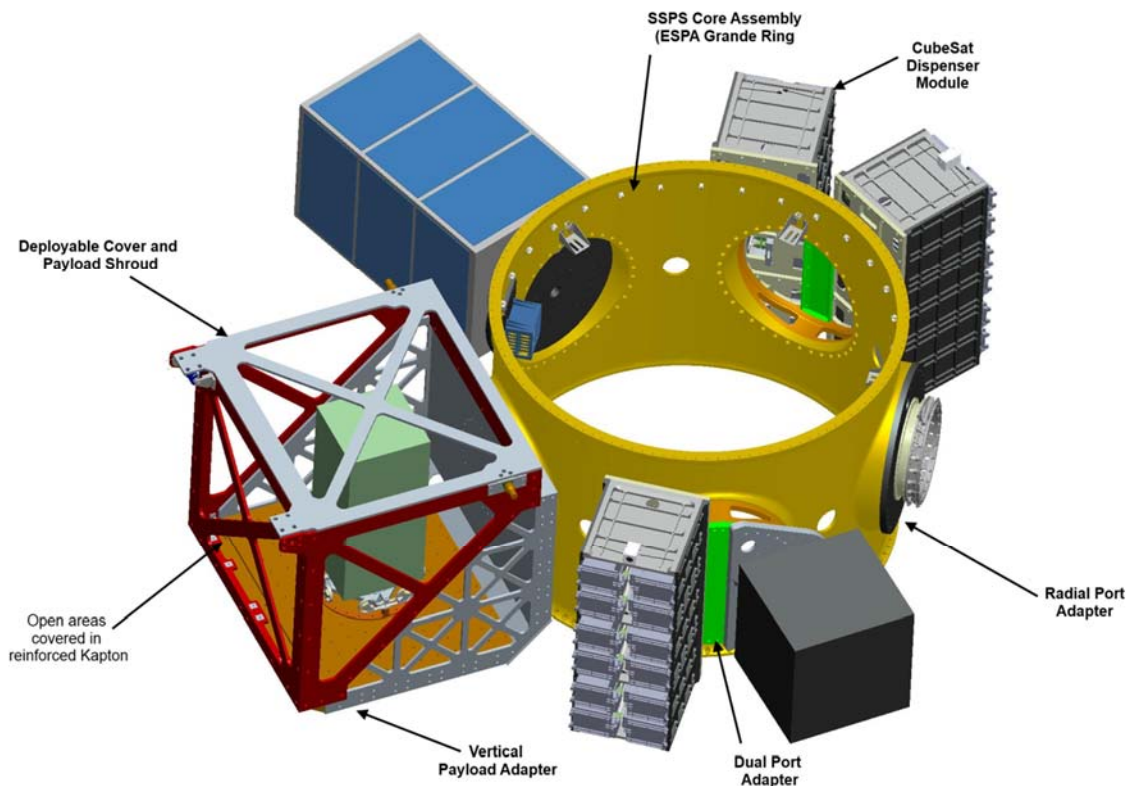


Figure 2-1 SHERPA with Adapters

Large minisatellites, with wet mass greater than 190 kg (419 lb), are cantilevered directly from the SHERPA 61 cm (24 in) Radial Port Interface (RPI) using a 24-inch-class separation system. Microsatellites, with wet mass less than 190 kg (419 lb), are cantilevered from a port by means of a Radial Port Adapter (RPA) and a 20.32 cm (8 in) or 38.10 cm (15 in) separation system. If required, secondary payloads can be mounted in a vertical orientation using a Vertical Payload Adapter (VPA), a shelf-like structure that mounts to the port interface. The VPA accommodates both 20.32 cm (8 in) and 38.10 cm (15 in) payload separation systems. More details about these systems is available in Section 3.

The simplest version, the SHERPA, has only an avionics suite, while a proposed SHERPA 2200 design is propulsive and can provide payload power to each ESPA port. For CubeSats and nanosatellites, a MiniSHERPA can provide propulsion. Details about the capabilities of each SHERPA are outlined below.

2.1 SHERPA

The SHERPA is a free-flier auxiliary payload deployment system capable of deploying up to 1500 kg. Unlike the SHERPA 400/1000/2200, it is not propulsive. Spaceflight uses the capabilities of the SHERPA to provide the following:

- Physical integration of the payloads
- Sequence payload deployments
- Transmit separation data
- Interface to the launch vehicle
- Electrical ground support (pre-launch charging and payload checkout)
- Record selected deployments via video camera (non-standard service)

Not every function is available for each launch. The capability of the SHERPA is dependent on the Spaceflight customer requirements and restrictions levied on Spaceflight by Launch Service Providers and their primary payload providers. If a specific function is required it should be coordinated with Spaceflight.

2.2 SHERPA 400/1000/2200

To provide unprecedented flexibility to the auxiliary payload provider, SHERPA 400/1000 /2200 incorporate a propulsion system, solar arrays, and an Attitude Determination and Control System (ADCS). The ADCS uses a combination of star trackers, GPS, and Inertial Measurement Units (IMUs) to update the flight computer on attitude and orbital velocity and position.

In addition to the capabilities of the SHERPA, SHERPA 400, 1000 and 2200 offer:

- Auxiliary payload pointing
- Auxiliary payload power
- Collision avoidance maneuvers
- Orbit changes (inclination and altitude)
- Deep space access from GTO
- Payload hosting

Features for hosted payloads are detailed in Table 2-1

Table 2-1 Propulsive SHERPA Technical Details

Feature	Specification
Mission Duration	1 year
Payload Power	50 W (average) to each port

Attitude Accuracy	< 50 arc-sec
Payload Data RAM Capacity	4 GB
Payload Downlink	Up to 100 Mbps

Delta-V Capabilities of each SHERPA level are shown in Figure 2-2

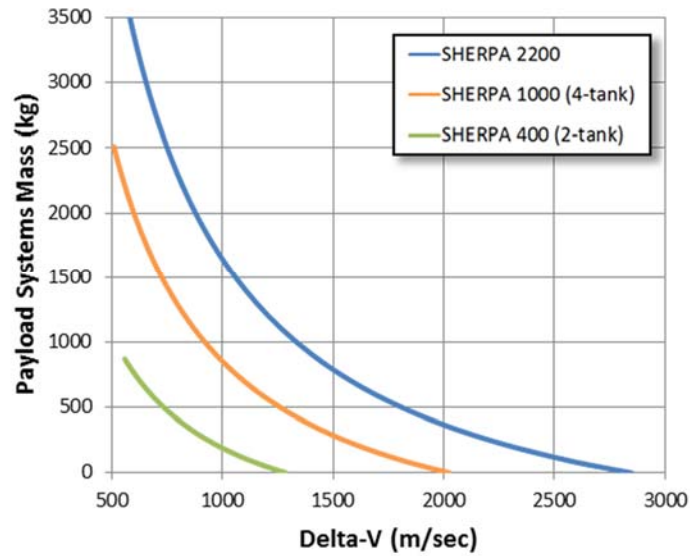


Figure 2-2 Delta-V Capabilities

The deep space capabilities of SHERPA from GTO are outlined in Figure 2-3

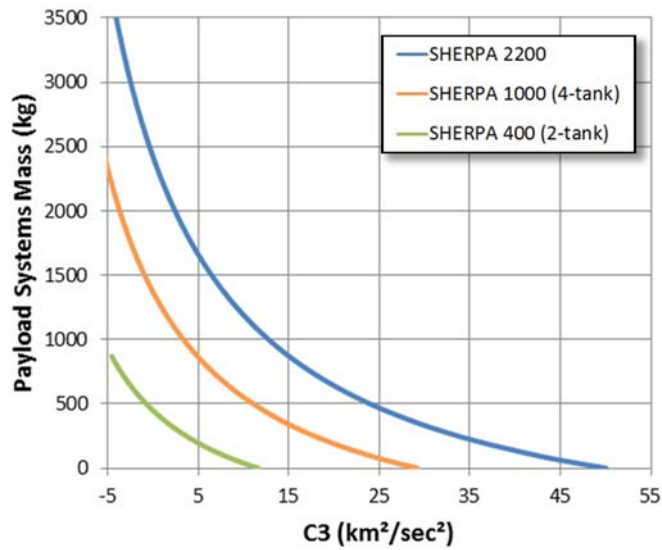


Figure 2-3 Propulsive SHERPA Capabilities

Not every function is available due to restrictions levied on Spaceflight by Launch Service Providers and primary payload providers. If a specific function is required it should be coordinated with Spaceflight.

2.3 MiniSHERPA

Spaceflight’s MiniSHERPA enables orbital changes and hosted payload charging for nanosatellites. It is an excellent option for deploying CubeSat constellations because it can host nine 3U CubeSats, which can be deployed in a predetermined orbit using MiniSHERPA’s propulsive and pointing capabilities.

Technical details regarding MiniSHERPA’s capabilities are outlined in Table 2-2 and Figure 2-4 .

Table 2-2 MiniSHERPA Capabilities

Feature	Specification
Available Payload Volume	40 x 40 x 60 cm
Payload Peak Power	40 W
Pointing Knowledge	< 15 arc-sec
Pointing Accuracy	< 50 arc-sec
Position Knowledge	10 m

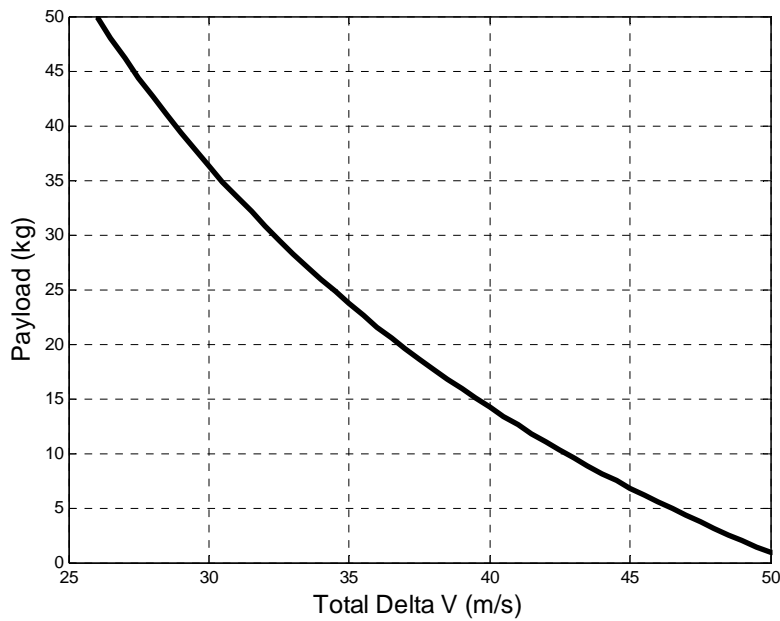


Figure 2-4 MiniSHERPA Delta-V Capabilities

MiniSHERPA offers flexibility to non-propulsive nanosatellites that want access to orbits other than that of the primary payloads and provides coordinated deployment for CubeSat constellations.

3 Secondary Payload Interface Adapters

Spaceflight has four interface options available at this time to maximize availability for individual missions. These various options can accommodate Cubesats and picosatellites, as well as microsatellites weighing up to 300 kilograms. Figure 3-1 displays different adapters with payload accommodations attached.

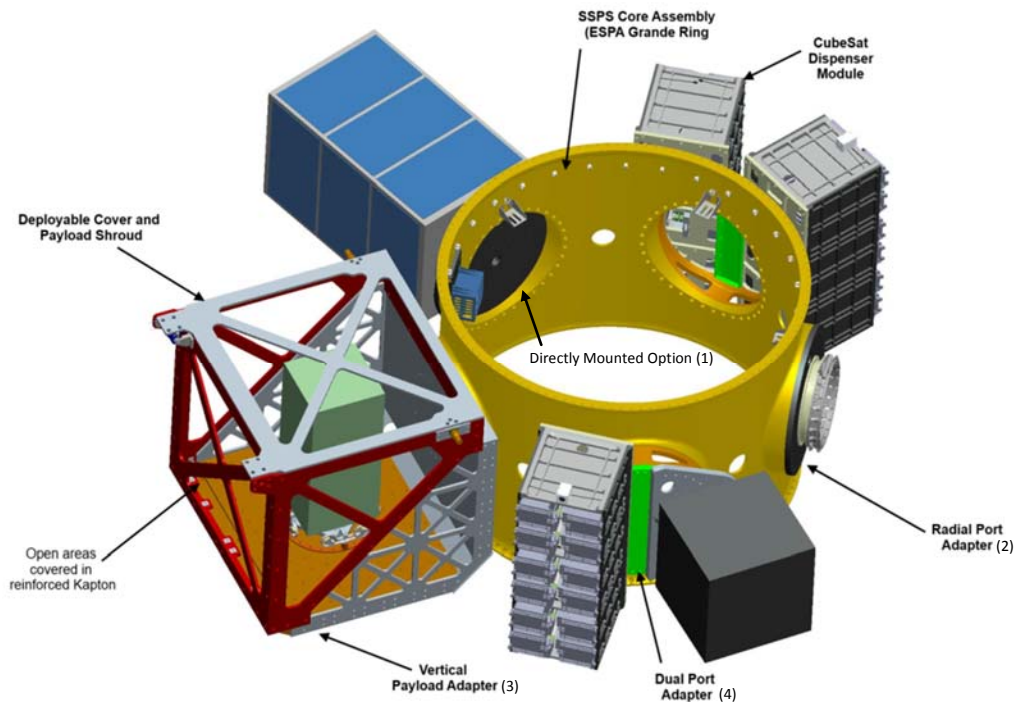


Figure 3-1 SHERPA with Interface Adapters

Adapter selection is limited by wet mass of the payload. Secondary payloads with a wet mass greater than 190 kg can only be integrated via the directly mounted interface option. Table 3-1 shows the wet mass limits for each interface option.

Table 3-1 Allowable Spacecraft Wet Mass per Interface Adapter

Wet Mass	Interface Option
Less than 300 kg	Directly Mounted to ESPA
Less than 190 kg	Radial Port Adapter
Less than 120 kg	Vertical Port Adapter
Less than 100 kg	Dual Port Adapter

3.1 Directly-Mounted Payload to ESPA Ring Port Interface Adapter

For larger payloads, Spaceflight offers direct-mounting to the ESPA port. This configuration consists of a 24" (61 cm) diameter circular separation system, such as the Planetary Sciences Corporation Motorized

Light Band (5.1) or the RUAG clamp band, which connects the spacecraft to the ESPA ring. Figure 3-2 shows an exploded view of a payload directly mounted to the SHERPA payload interface.

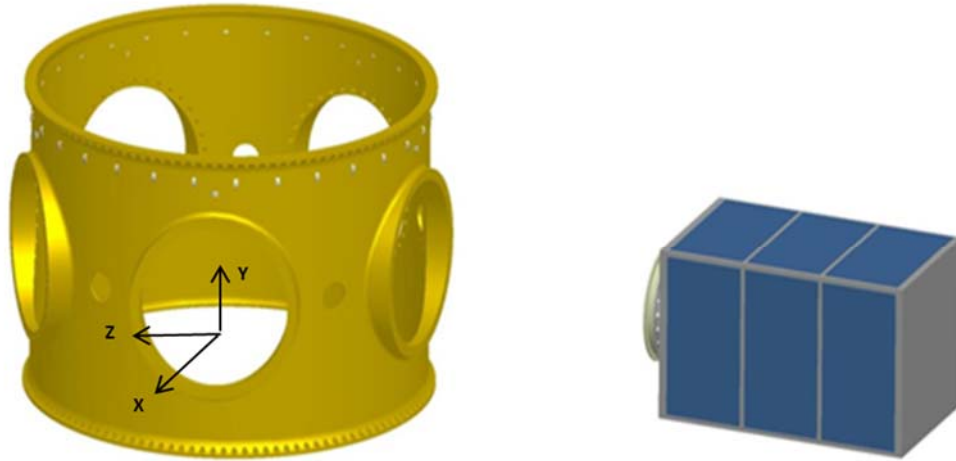


Figure 3-2 Directly-Mounted Payload - Exploded View

The payload port coordinate system is right-handed; the origin is centered on the bolt pattern at the radial port interface (RPI) on the SHERPA core as shown in Figure 3-5. The +X-axis direction is pointing outward from the external side of the RPI toward the LV payload fairing. The +Y-axis direction is pointing toward the forward end of the launch vehicle. The +Z-axis completes the right-handed coordinate system, and is perpendicular to the plane formed by the X- and Y-axes.

3.1.1 Payload Requirements

Auxiliary payloads utilizing direct mounting to the ESPA ring must comply with the following interfaces as well as the environments detailed in Section 7. A further refined interface control document will be provided by Spaceflight after contracting for services with Spaceflight Inc.

Table 3-2 Directly Mounted Payload Mass Properties

Feature	Requirement
Center of Mass	Less than 50.8 cm from ESPA/Payload Interface
Mass	Less than 300 kg

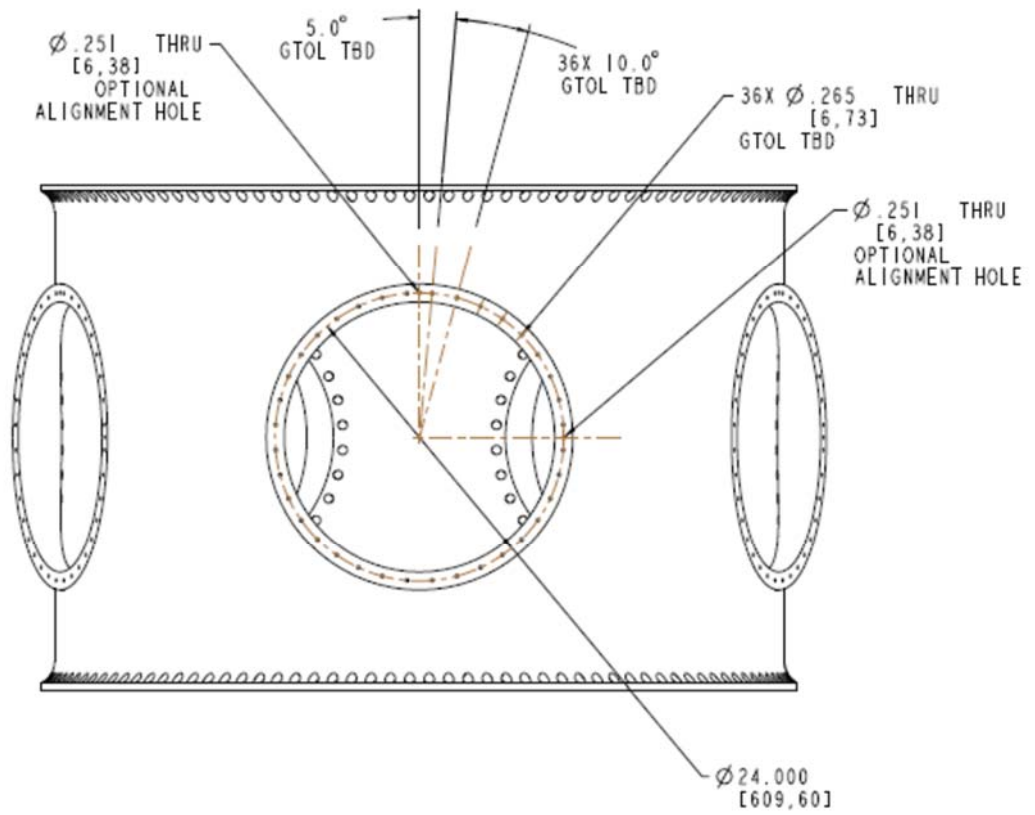


Figure 3-3 Bolt Hole Pattern for Directly Mounted Payload

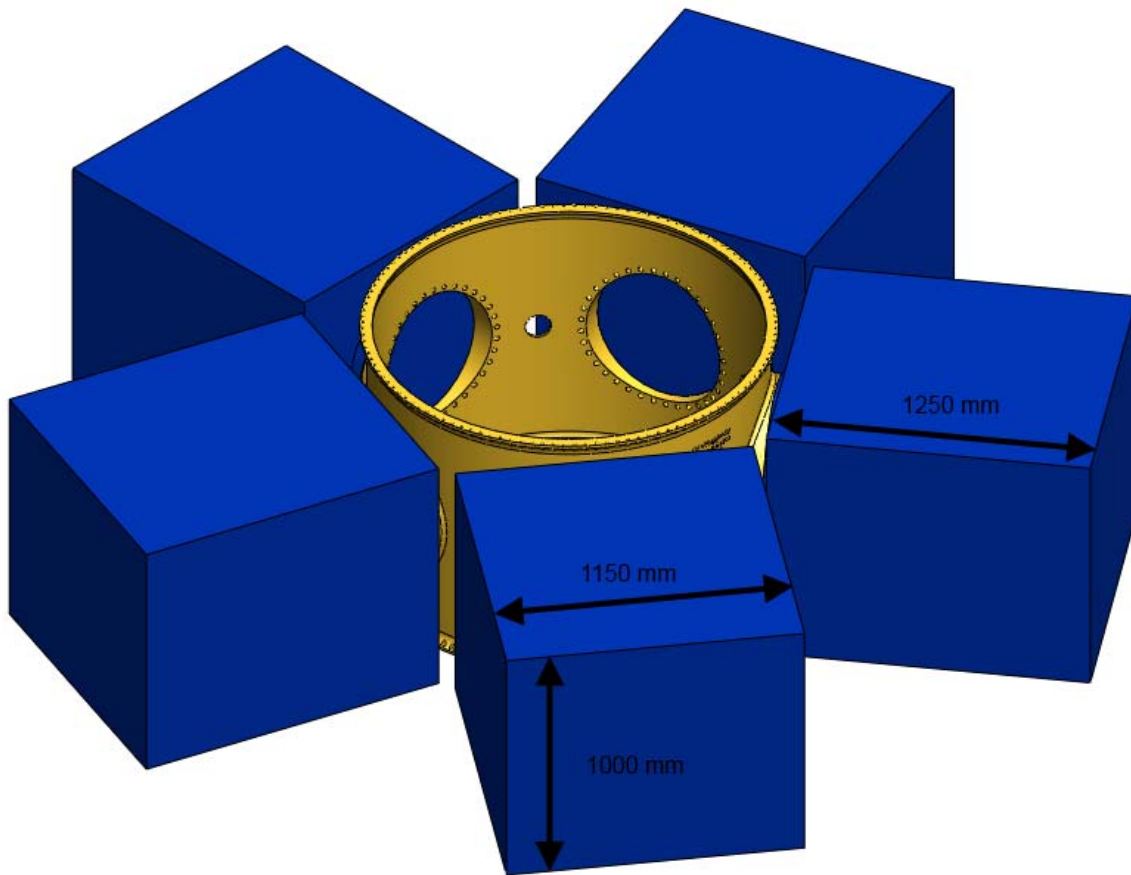


Figure 3-4 Volume Constraints (5.2m fairing baselined)

Available volume is defined from the ESPA Grande ring interface, therefore additional systems such as adapter plates and separation systems must be accounted for in the total volume of the payload.

3.2 RPA Mounting Interface Definition

Spaceflight also offers mounting to a radial port adapter plate. This configuration consists of a 15" (38.1 cm) diameter circular separation system, such as the Planetary Sciences Corporation Motorized Light Band (5.1), which connects the spacecraft to the ESPA ring.

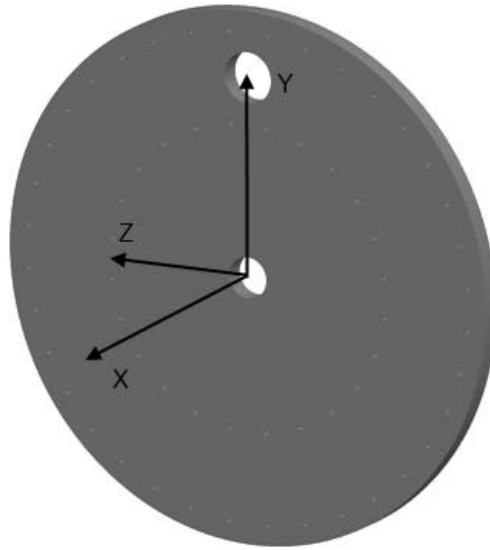


Figure 3-5 Radial Payload Adapter Secondary Payload Coordinate System

The RPA coordinate system is right-handed; the origin is centered on the bolt pattern at the radial port adapter as shown in Figure 3-5. The secondary payload axial +X-axis begins at the external side of the RPA plate and points outward to the LV fairing as shown. The Y-axis is parallel to the launch vehicle longitudinal axis, and points toward the forward end of the launch vehicle. The Z-axis completes the right-handed coordinate system, and is perpendicular to X and Y plane.

3.2.1 Payload Requirements

Auxiliary payloads utilizing mounting to the ESPA radial port adapter plate must comply with the following interfaces as well as the environments detailed in Section 7. A further refined interface control document will be provided by Spaceflight after contracting for services with Spaceflight Inc.

Table 3-3 Radially Mounted Payload Mass Properties

Feature	Requirement
Center of Mass	Less than 40 cm from ESPA/Payload Interface
Mass	Less than 190 kg

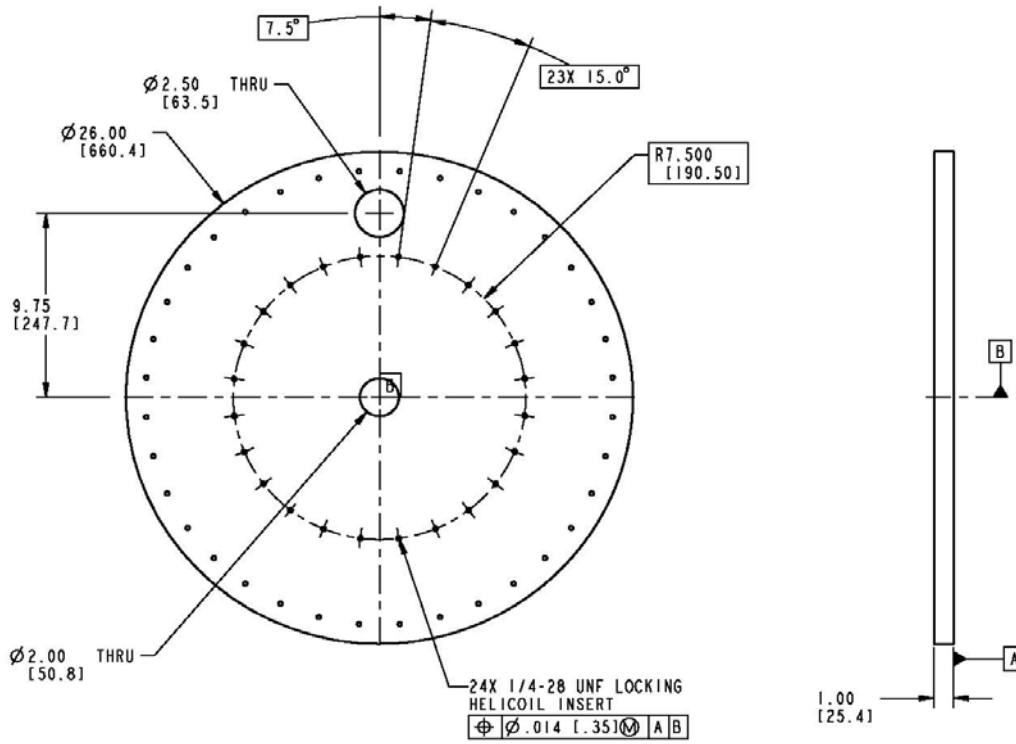


Figure 3-6 Bolt hole pattern for radial port adapter

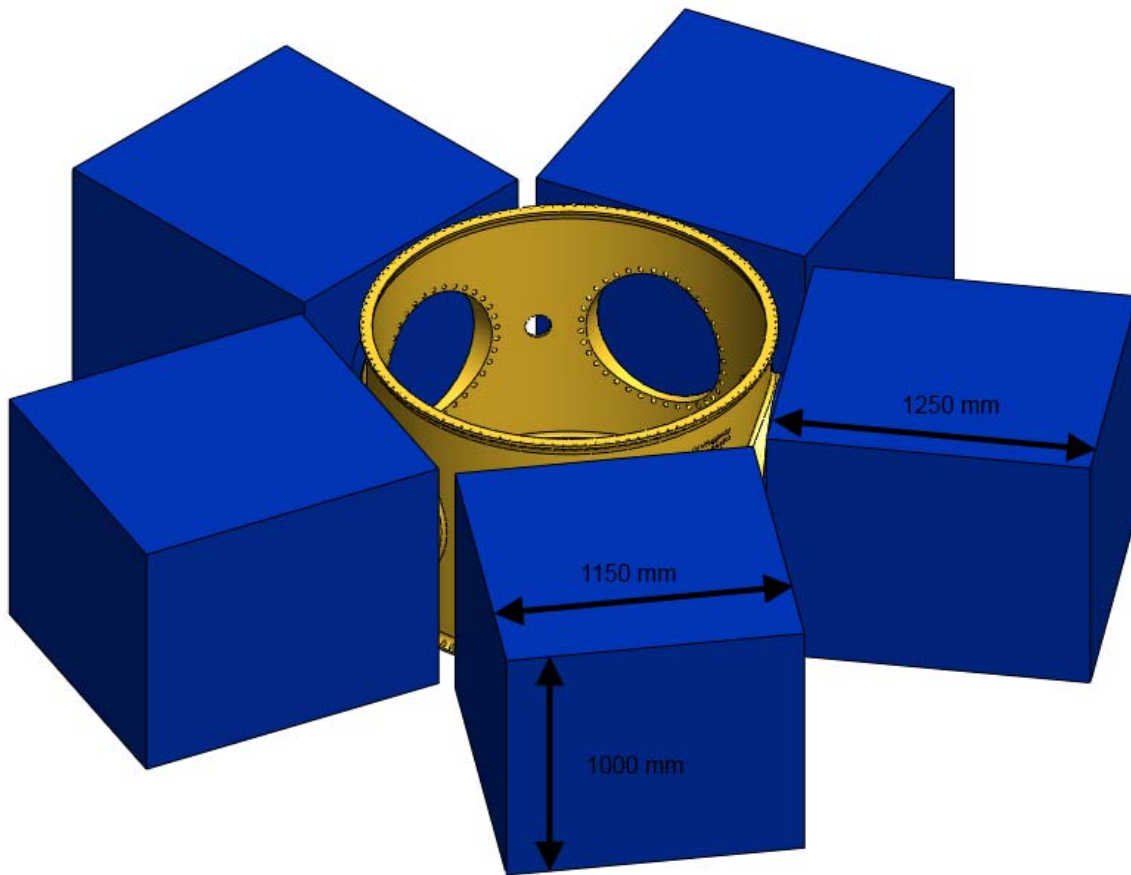


Figure 3-7 Volume Constraints (5.2m fairing baselined)

Please contact Spaceflight for details regarding the use of this system.

3.2.2 Payload Requirements

Auxiliary payloads utilizing the vertical port adapter must comply with the following interfaces as well as the environments detailed in Section 7. A further refined interface control document will be provided by Spaceflight after contracting for services with Spaceflight Inc.

Table 3-4 Vertically Mounted Payload Mass Properties

Feature	Requirement
Center of Mass	Less than 48 cm from VPA/Payload Interface
Mass	Less than 120 kg

The bolt hole pattern and volumetric constraints are shown on the following page.

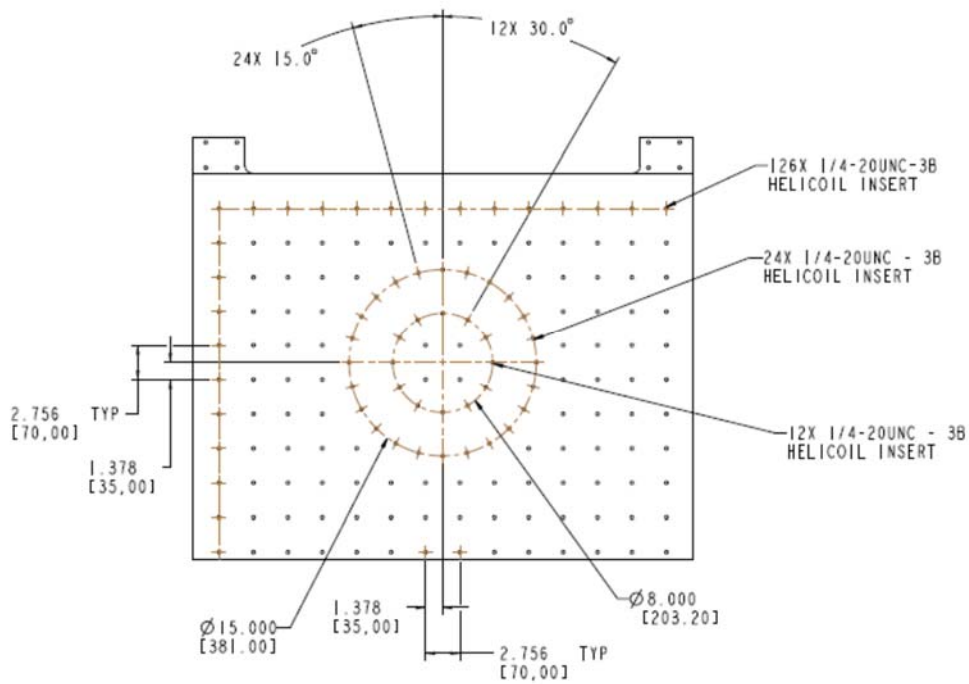


Figure 3-8 VPA mechanical interface with dimensions in inches [mm]

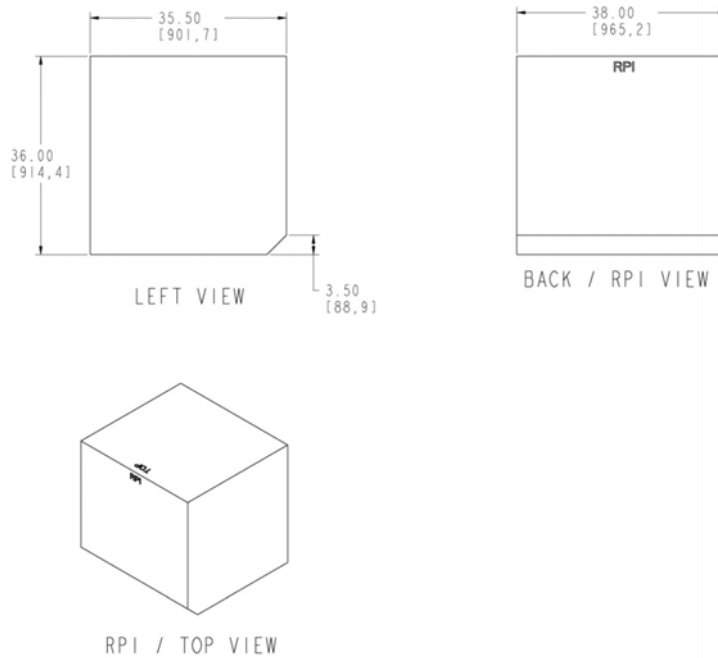


Figure 3-9 Allowable Static Payload Envelope within the Deployable Shroud with dimensions in inches [mm]

3.3 DPA Mounting Interface

The Dual Port Adapter has the capability to mount up to two small microsatellites, <100kg (220 lbs) to a single radial port of the SHERPA. Microsatellites having a mass less than 100 kg (220 lbs) can also be mounted to a DPA.

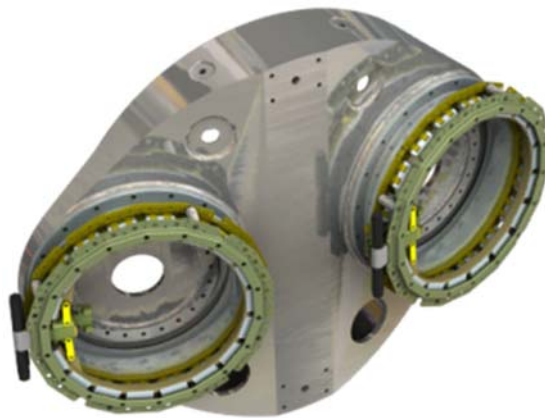


Figure 3-10 DPA System

The primary coordinate system used for microsatellites attached to a DPA is a right-handed coordinate system as shown in Figure 3-10. The +X-axis begins at the external side of the DPA back-plate and points toward the LV fairing. The +Y-axis is parallel to the launch vehicle longitudinal axis, and points toward

the forward end of the launch vehicle. The +Z-axis completes the right-handed coordinate system, and is perpendicular to the plane formed by the X- and Y-axes.

3.3.1 Payload Requirements

Auxiliary payloads utilizing the dual port adapter must comply with the following interfaces as well as the environments detailed in Section 7. A further refined interface control document will be provided by Spaceflight after contracting for services with Spaceflight Inc.

Table 3-5 Vertically Mounted Payload Mass Properties

Feature	Requirement
Center of Mass	20.32 cm (8") interface: < 28 cm 38.1 cm (15") interface: < 50 cm
Mass	Less than 100 kg

Volume constraints are defined on an individual basis; volume limitations are dependent upon the size of the spacecraft sharing the port.

Please contact Spaceflight for details regarding the use of this system.

4 CubeSat Requirements and Dispensers

Spaceflight has a great deal of heritage in providing launch opportunities for CubeSats on a variety of launch vehicles and deployment systems. A payload provider looking for a launch opportunity is encouraged to follow the specifications and guidelines in this document to maximize their options as well as being approved/accepted for launch as a secondary payload by Spaceflight, the launch service providers and most importantly the primary spacecraft. The number one thing a payload provider can do to optimize their opportunities is to comply with the industry standards and develop a simple system both in operation and ground handling. Section 4.1 of this document defines the general requirements CubeSat developers should consider when designing their spacecraft for Spaceflight launch opportunities. Spaceflight realizes that not all mission requirements can be met within the requirements listed and will work with payload providers to ensure there is a solution to meet their unique requirements. Specific requirements agreed to between Spaceflight and their customers are documented in the mission interface control document.

4.1 General CubeSat Requirements

- Satellite shall be in compliance with AFSPCMAN 91-710
 - Propulsion systems, if accepted, shall be designed, integrated and tested in accordance with Volume 3. Additionally, activation of propulsion shall have 3 inhibits.
 - Hazardous material shall be in compliance with Volume 3
- CubeSats shall not create any additional space debris
- CubeSats should consider using an identification device for use in ground tracking
- CubeSats shall use materials that have a Total Mass Loss of $\leq 1.0\%$ and a Collected Volatile Condensable Material of $\leq 0.1\%$.
 - These are standards generally set by payloads that are sensitive to out-gassing and Spaceflight will verify that the CubeSat has met this through payload provider testing.
- CubeSat dimensions and dispenser interfaces are dependent on the dispenser used on the mission.
- The general requirements for the electrical system are centered on the concept of making the system safe.
 - CubeSat shall be launched in a power off state
 - Power off state shall be maintained throughout any short term storage, integration operations (other than those required for system check out if required), and once in the dispenser. This is generally accomplished through the use of a rail mounted deployment switch which while activated all powered functions are disconnected from the power supply system.
 - If the deployment switch is toggled, it shall reset to $t=0$.
- Spaceflight discourages CubeSat payloads from requiring any check outs, battery charging or RF testing once the satellite is delivered to the integration site. Should there be a requirement to do so, Spaceflight will consider the request on a mission-by-mission basis as a non-standard service.

- The satellite shall inhibit inadvertent radio frequency (RF) transmission through the use of three inhibits. Should the payload provider decide not to use three inhibits other schemes will be considered, however the use of a timer is not considered an inhibit.
- Satellite deployable systems (solar panels, antennas and other non-separating items) shall not deploy for 15 minutes after they have been deployed.
- Satellite shall not transmit signals any earlier than 30 minutes post separation. This can, and most likely, will be modified on a mission-by-mission basis depending on the mission constraints. Payload providers should not consider transmitting any sooner than the 30 minutes without prior discussions with Spaceflight.
- Spaceflight will not launch any satellite that has not or cannot provide evidence of having met the proper regulatory requirements.
 - Payload providers shall provide evidence of the following:
 - Licensing in accordance with their country's authority for the use of radio frequency(ies). Amateur frequency is acceptable.
 - Orbital debris is compliant with NPR 8715.6
 - Approvals necessary for any earth imaging via proper authority.
- The payload provider is responsible to complete all necessary testing and shall provide a test plan to Spaceflight per delivery schedule documented in this document or per the SOW/ICD.
 - Required testing:
 - Random vibration
 - Thermal vacuum bake-out
 - Shock testing

There are multiple resources available to payload providers in regards to the regulatory and testing that should be referenced. Below is a list of web sites. Spaceflight provides support to payload providers in all areas as needed.

- Amateur Radio Information – www.iaru.org
- FCC Amateur Radio Information – www.arrl.org/part-97-amateur-radio
- NASA Debris Analysis Tool – <http://orbitaldebris.jsc.nasa.gov/mitigate/das.html>
- Remote Sensing Licensing – www.nesdis.noaa.gov/CRSRA/licenseHome.html
- For common U.S. Government documents such as AFSPCMAN, Military Standards and other such documents visit – <http://everyspec.com>

4.2 ISIS ISIPOD Dispensers

ISIS Launch Services provides a variety of CubeSat dispensers for small spacecraft. The ISIPOD (pronounced “easy-pod”) is a launch adapter for pico- and nanosatellites that adheres to the CubeSat interface standard defined by the CubeSat Design Specification. Spaceflight utilizes the 3U ISIPOD to deploy dedicated 3U CubeSats as well as 1U and 2U CubeSats which share the ISIPOD volume. The ISIPOD 3U dispenser is shown in Figure 4-1.

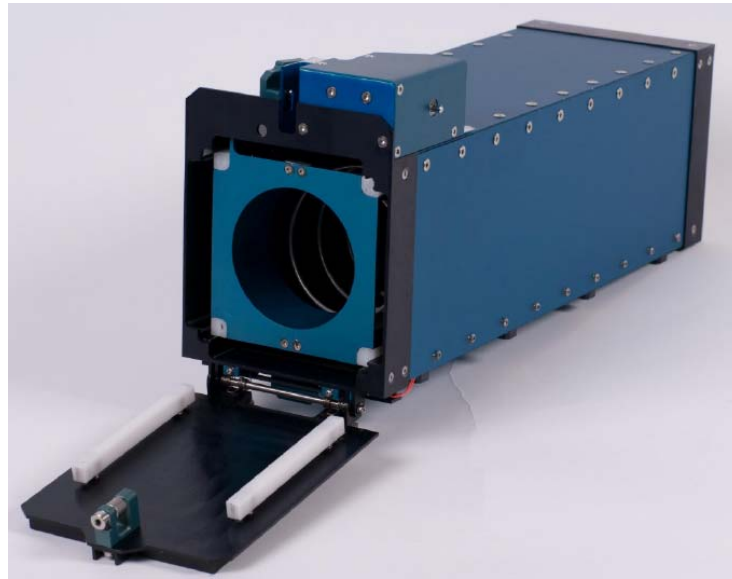


Figure 4-1 ISIPOD 3U CubeSat Dispenser

The CubeSat is inserted into the 3U ISIPOD along the POD long axis. It is constrained by four hardened anodized aluminum guide rails, four polyoxymethylene (POM) feet on the spring-loaded pusher plate, and two spring-loaded POM rails located on the door. With the door closed, the springs in the POM rails located on the door suppress chattering or rattling of the CubeSat during launch. The guiderails ensure that minimum tipoff rates are imparted to the CubeSat payload upon deployment. The Cubesat(s) are completely enclosed by the ISIPOD to ensure the safety of other payloads. With the grounding bolt, the ISIPOD is designed to be a Faraday cage to satisfy EMI/EMC standards. Upon receipt of the deployment command, the ISIPOD door release mechanism activates releasing the door, and the spring-loaded pusher plate pushes the CubeSat(s) out of the ISIPOD. The ISIPOD main spring imparts 1-2 m/s separation velocity in most configurations.

Spaceflight Systems has signed an agreement with Innovative Solution in Space (ISIS) of the Netherlands to manufacture the ISIPOD, branded the EZPOD, in the United States.

- ISIPOD CubeSat Deployer Brochure (PDF)
http://www.isispace.nl/brochures/ISIS_ISIPOD_Brochure_v.7.11.pdf

To accommodate larger CubeSat configurations, Spaceflight offers both 6U and 12U containerized nanosatellite dispensers. Contact Spaceflight for more information.

4.3 Planetary Systems Corp. Canisterized Satellite Dispenser

The Planetary Systems Corporation Canisterized Satellite Dispenser (CSD) is a reliable, testable, and cost-effective deployment mechanism for small secondary or tertiary payloads. It fully encapsulates the payload during launch and thus provides mission assurance for both the primary payload and launch vehicle. All external surfaces are electrically conductive chem-film aluminum alloy.

The CSD is easy to use and operate. The act of closing the CSD door automatically preloads the payload tabs, and there are no pyrotechnics. The door initiator is a DC brush motor with substantial flight heritage. The CSD can be cycled in a matter of seconds without consumables.

- Planetary Systems Corporation Payload for Containerized Satellite Dispenser (CSD) Specification Sheet for 3U, 6U, and 12U (PDF)
http://www.planetarysystemscorp.com/#!_downloads

4.4 CubeSat deployment from the International Space Station

Spaceflight works with our mission partners to provide deployment from the International Space Station (ISS). The requirements to deploy from the ISS include section 4.1 of this document as well as sections 4.4.1 and 4.4.2. This deployment configuration has minimal launch loads (Figure 4-5). Deployment speeds range from 0.5 m/s to 1.5 m/s.



Figure 4-2 NanoRacks CubeSat Deployer

CubeSats deployed through the NanoRacks CubeSat Deployer (NRCSD) must meet certain requirements, in order to meet the safety standards of the ISS. These requirements include:

4.4.1 Electrical Inhibits

CubeSat design shall include three (3) inhibit switches with three (3) corresponding deployment switches. Ground charge shall not energize the satellite systems (load). An example circuit diagram is shown in Figure 4-3.

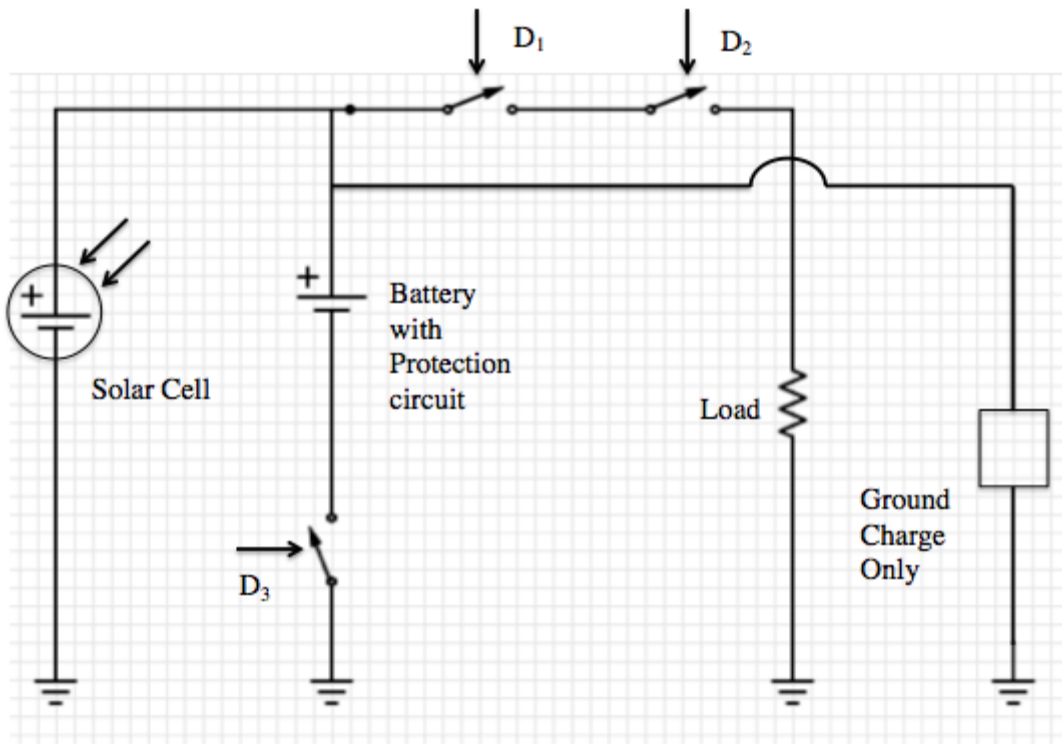


Figure 4-3 NanoRacks Electrical Inhibit Diagram

4.4.2 Batteries

Batteries must maintain charge for a minimum of 6 months. Batteries require additional testing for NASA safety certification.

Testing procedures and requirements are detailed in JSC-20793 Rev.B Crewed Space Vehicle Battery Safety Requirements.

Contact Spaceflight for additional information.

5 Secondary Payload Separation Devices

5.1 Mark II Motorized Lightband

Planetary Systems provides a range of containerized and circular ring satellite dispensers. The Mark II Motorized Lightband is a space-vehicle separation system, shown in Figure 5-1. It generates a relatively low shock at separation, and it is non-pyrotechnic and therefore generates no debris. It is motor driven, which eliminates the need for refurbishment or consumable initiators. The system is delivered with separation springs, switches, and connectors within the assembly that does not require additional brackets. Finally, it has been flight proven over 30 times.

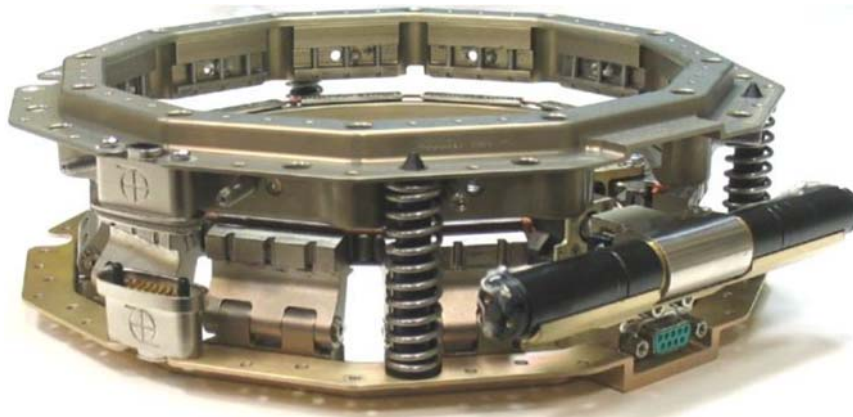


Figure 5-1 Mark II Motorized Lightband Manufactured by Planetary Systems Corporation (8-inch)

To accommodate a variety of payloads, the Mark II Lightband is produced in multiple diameters, ranging from 8 inch to 38 inch. Table 5-1 shows the Lightband diametrical options with associated mass. The mass of the separation system is not charged to customer, for example a 150kg with a 381mm separation system that has a mass of 2.63kg is charged at the price of 150kg.

Table 5-1 Mark II Lightband Options

Diameter (in)	Diameter (mm)	Mass (lb)	Mass (kg)
8.000	203	3.28	1.49
11.732	298	4.62	2.10
13.000	330	5.03	2.28
15.000	381	5.79	2.63
18.250	464	6.88	3.12
19.848	504	7.24	3.28
23.250	591	8.44	3.83
24.000	610	8.95	4.06
31.600	803	12.38	5.62
38.810	986	15.08	6.84

- Planetary Systems Corporation User Manual for Mark II Motorized Lightband (PDF)
<http://www.planetarysystemscorp.com/#!/downloads>

6 Analyses Coordinated with LSP

6.1 Trajectory Analysis

Trajectory analysis is performed early in the mission planning process. Early analysis will use the requirements submitted with the Payload Questionnaire, and is primarily used to discover potential issues and understand secondary payload manifesting opportunities. Later analyses will provide information on payload sequencing and orbit dispersions, as well as any range-imposed restrictions for environmental or safety concerns. In the case where Spaceflight has manifested the integrated payload stack with a primary payload, the primary payload mission requirements will always take precedence, and will not be affected by secondary payload requirements. For those missions where Spaceflight has procured the entire launch capacity, the trajectory will be in accordance with a pre-determined orbit or with Co-lead customers.

6.2 Coupled Loads Analysis

Spaceflight develops a finite element model of the integrated payload stack to provide input to the launch vehicle combined coupled loads analysis (CLA). Two CLAs are conducted, the initial analysis followed by a final verification. These analyses are used to determine potential dynamic envelope exceedances and inform the payload provider about design concerns related to the launch dynamic environment. To facilitate these analyses, each manifested secondary payload (with the exception of CubeSats) provider is expected to provide a NASTRAN finite element model. The schedule includes sufficient time to update models and update the coupled loads analysis if there are significant changes in the models or environments.

Typical launch vehicle events simulated in the CLA include liftoff, air-loads, engine restarts, and engine cut-off. Not all events may be analyzed if flight experience or class analyses show them to be benign events. CLA output will include maximum accelerations and interface loads at selected nodes of the spacecraft.

6.3 RF Compatibility Analysis

The launch vehicle provider will perform a Radio Frequency (RF) compatibility analysis to verify that all RF sources identified at the launch site or used to support the mission are compatible with the launch vehicle and ground telemetry and tracking systems. Systems to be analyzed include any telemetry, tracking, and flight termination systems. A report will detail all findings, including system link requirements, and will include any interference issues with secondary payload RF systems. All secondary payloads are to be off prior to deployment; however, the secondary payload provider is expected to ensure that RF sensitive components and materials are not affected by launch vehicle RF sources. The ICD contains a table with all known emitters for the payload provider to assess. Spaceflight uses

procedural constraints (coordinated RF transmitting if required and the fact that all payloads are powered off) as well as verification of harness design to ensure EMI/EMC requirements are met.

6.4 Thermal Analysis

A thermal analysis will be conducted, taking into account environments imposed on the primary and secondary payloads during ground operations following encapsulation up until the secondary payload is separated from the launch vehicle. Accordingly, each secondary payload provider (with the exception of CubeSats) is expected to provide a thermal math model and geometric math model. Complexity of the thermal model required may vary, depending on the size of the spacecraft and the fidelity of the thermal interfaces required.

6.5 Separation Timing and Re-contact Analysis

Spaceflight develops a mission timeline based on multiple factors and characteristics of each of the payloads. Spaceflight uses a combination of mission requirements, separation system specifications, payload mass, and other variables that contribute to the re-contact possibility. The Separation Timing and Re-contact analysis will determine minimum relative velocities required for payload deployment. It will also ensure that the payloads do not re-contact the launch vehicle upper stage or each other after deployment.

6.6 Range Safety Analysis

Each payload is responsible for ensuring that they are in compliance with the applicable AFSPCMAN 91-710 requirements. Spaceflight has the ultimate responsibility for the integrated payload stack and relies on the inputs from each payload. This is primarily accomplished through each payload provider's Missile System pre-Launch Safety Package (MSPSP) as well as AFSPCMAN 91-710 tailoring inputs as applicable. Spaceflight provides an MSPSP template and support throughout the range safety analysis process.

6.7 Post-flight Data Analysis

Following launch completion, the launch vehicle provider will perform a post-flight analysis to verify launch vehicle performance from flight data. The post-flight analysis will include an assessment of injection accuracy and spacecraft separation attitudes. The analysis may also include payload environmental data, including temperature, pressure, shock, acoustic, or other data depending on sensor use and extent of instrumentation. This data will be available to secondary payload Secondary payload providers for verification activities.

6.8 Documentation

Documentation will be required from secondary payload providers in a timely fashion, as listed in Table 1-1. These documents represent the general types of necessary communication between the secondary payload, the secondary payload integrator, the primary payload provider, the launch vehicle provider,

and various support agencies associated with the launch. Spaceflight will interface with a single point-of-contact (POC) assigned by the secondary payload, through whom all data will be routed. Specific documentation needs will be provided once a secondary payload is manifested on particular mission.

Table 6-1 Required Mission-Specific Deliverables

Item #	Description
1	<p>Payload Questionnaire (See Appendix B) The spacecraft questionnaire is the first step in the secondary payload manifest process. It should include the initial secondary payload requirements, orbit requirements, interface details, mass properties, preliminary drawings, etc. Any special fairing requirements should be specified in the questionnaire and updated through the mission integration process.</p>
2	<p>Spacecraft Finite Element Model A spacecraft FEM is required for each secondary payload to be used in coupled loads analysis.</p>
3	<p>Spacecraft Thermal Model A spacecraft thermal model is required for each secondary payload to be used in an integrated thermal analysis</p>
4	<p>Verification of ICD Compliance Each secondary payload is required to document the test plan and provide test results (e.g., static loads, vibration, acoustics, shock) for the spacecraft.</p>
5	<p>Spacecraft CAD Model All secondary payloads are required to submit drawings showing the configuration, shape, and dimensions of their satellite. Internal details are generally not required in the drawings / CAD models. Each secondary payload is required to report their respective spacecraft mass properties. The values should include the nominal values and 3σ uncertainties.</p>
6	<p>Missile System Pre-launch Safety Package (MSPSP) The MSPSP is a data package that provides detailed technical data on all hazardous items including drawings, schematics, RF Radiation, and assembly and handling procedures. More specifics on the MSPSP can be found in the AFSPCMAN 91-710.</p>
7	<p>Spacecraft Launch Operations Plan Each secondary payload must specify any handling constraints, environmental constraints, personnel requirements, equipment requirements, etc. for their satellite.</p>

7 Analysis of Adherence to Other Requirements

7.1 Common Environments

The following sections contain baseline environments based upon common launch vehicles. These environments represent a conservative approach to the satellite design and should not be used to determine the absolute compatibility with launch opportunities that Spaceflight has available. Spaceflight understands that designing to overly conservative environments imposes the possibility of greater mass and overall cost to the payload provider, and we encourage early engagement with Spaceflight for any of the environments within this document that pose a significant issue or concern. Also, the General Environmental Verification Standard (GEBS, GSFC-STD-7000) as well as MIL-STD-1540 are a great resource for designing when the specific launch opportunity has not yet been defined.

Spaceflight uses a philosophy of gradually reducing the margin applied to environments as the mission progresses. During the initial planning, Spaceflight recommends using this document or the two previously mentioned. This represents the highest amount of margin or uncertainty applied to the values. With the release of the initial interface control document a more refined maximum predicted environment is provided, however there is still a level of uncertainty applied and depends on the maturity of the launch system and/or the integrated payload stack. The final maximum predicted environments are provided after the launch vehicle mission critical design review.

7.1.1 Quasi-Static Loading

Maximum predicted quasi-static loads for minisatellites are expected to be ≤ 10 g applied non-simultaneously in each orthogonal axis.

Maximum predicted quasi-static loads for CubeSats are expected to be < 20 g applied non-simultaneously in each orthogonal axis.

Actual loads, accelerations, and deflections are a function of the launch vehicle, primary payload, and other secondary payload dynamic structural properties. These are accurately determined via coupled loads analysis (CLA).

7.1.2 Sine Vibration

The sine vibration environment is based on a CLA performed by the launch vehicle provider when the full manifest is locked down. The results from CLA are used to derive a response spectrum of the vibration levels at the secondary payload interface. For a given modal damping value, a smoothed envelope of peak responses is created, which is then used to produce a sine vibration input curve.

7.1.3 Acoustic Environment

The maximum predicted acoustic environment is shown in Figure 7-1. Spacecraft with large flat surfaces are susceptible to acoustic environments. Acoustic testing is recommended for any spacecraft with structural components susceptible to excitation by acoustic environments.

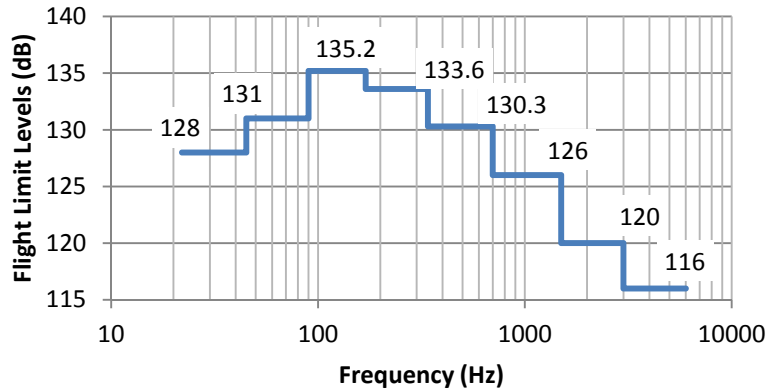


Figure 7-1 Maximum Predicted Acoustic Environment

Table 7-1 shows the maximum predicted acoustic environment inside a payload fairing.

Table 7-1 Maximum Predicted Acoustic Environment

Octave Center Frequency (Hz)	Maximum Predicted Acoustic Environment (OASP = 139.6 dB)
31.5	128.0
63	131.0
125	135.2
250	133.6
500	130.3
1000	126.0
2000	120.0
4000	116.0

This is the maximum predicted environment and does not include margin for qualification or acceptance testing. For test factors and durations, consult GSFC-STD-7000 Table 2.2-2.

7.1.4 Random Vibration

Generalized random vibration qualification and acceptance level environments are shown in Figure 7-2 for a payload having a mass less than 22.7 kg (50 lb).

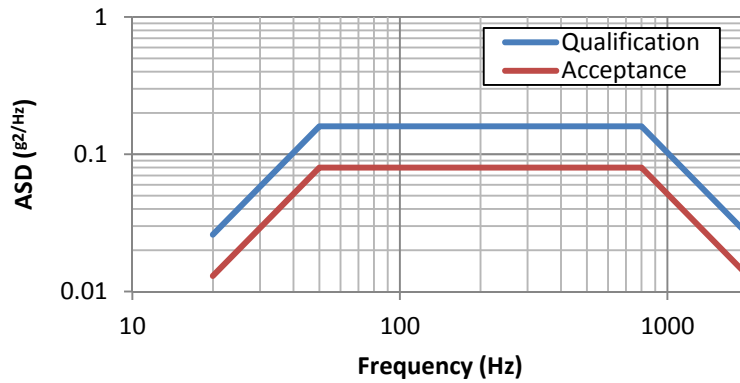


Figure 7-2 Secondary Payload Generalized Random Vibration Environment

Table 7-2 shows the generalized random vibration environment for a payload with mass less than 22.7 kg (50 lb).

Table 7-2 Secondary Payload Generalized Random Vibration Environment

Frequency (Hz)	Generalized Random Vibration Environment	
	22.7 kg (50 lb) or less (g ² /Hz)	
	Qualification	Acceptance
20	0.026	0.013
50	0.16	0.08
800	0.16	0.08
2000	0.026	0.013
G _{RMS}	14.1	10.0

7.1.5 Electromagnetic Interference / Compatibility Environment

The maximum predicted electromagnetic environment is shown in Figure 7-3. The secondary payload provider is expected to ensure that spacecraft materials and components are not susceptible to RF environment given in Figure 7-3.

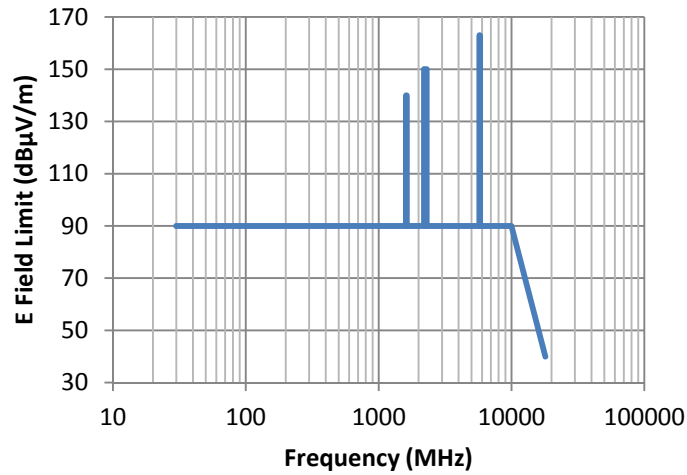


Figure 7-3 Maximum Predicted Electromagnetic Environment during Pad Operations and Launch

Table 7-3 shows the maximum predicted electromagnetic environment during pad operations and launch.

Table 7-3 Maximum Predicted Electromagnetic Environment during Pad Operations and Launch

Freq (MHz)	E Field Limit (dBµV/m)
30	90
1609.9	90
1610	140
1626	140
1626.1	90
2199.5	90
2200	150
2300	150
2300.5	90
5754.9	90
5755	163
5775	163
5775.1	90
10000	90
18000	40

7.1.6 Pressure and Venting

The pressure decay rate inside the payload fairing is less than 6.2 kPa/s (0.899 psi/sec).

Selected CubeSat dispensers are expected to be designed to maintain interior pressure within 6.9 kPa (1 psi) of the internal payload fairing pressure.

7.1.7 Temperature, Cleanliness, and Handling

The temperature, humidity, and air cleanliness during ground operations are given in Table 7-4.

Table 7-4 Payload environments during ground processing

	SHERPA Payload Processing Facility (PPF) during Integration Processes	LSP PPF during Integration Processes	Encapsulated in Payload Fairing	During transport from PPF	On-pad Encapsulated
Temperature	21°C ± 5.0°C (70°F ± 8.8°F)	21°C ± 2.9°C (70°F ± 5°F)	21°C ± 2.9°C (70°F ± 5°F)	21°C ± 2.9°C (70°F ± 5°F)	between 10°–29.4°C ± 2.9°C (50°F – 85°F ± 5°F)
Humidity	50% ± 15%	50% ± 5%	50% ± 5%	50% ± 5%	any setting between 20% and 50% ± 5%
Cleanliness	Class 100,000	Class 10,000	Class 10,000	Class 10,000	Class 5,000

A maximum inner payload fairing wall temperature seen by the payload, with emissivity 0.9, is given in Figure 7-4 and Table 7-5.

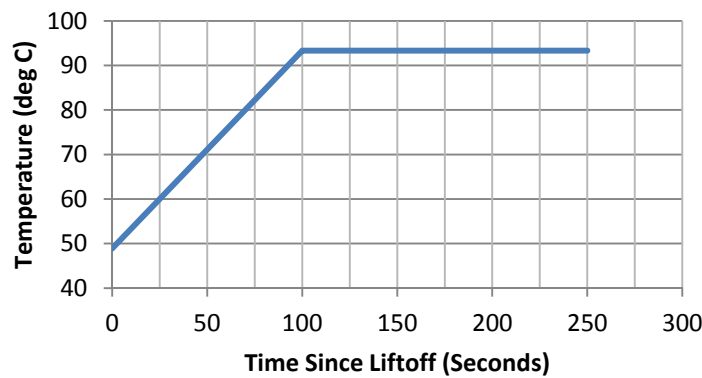


Figure 7-4 Maximum Payload Fairing (PLF) Temperature Seen by the Payload

Table 7-5 Maximum PLF Temperature seen by the Payload

Time Since Launch (sec)	Temperature (°C)
0	48.9
100	93.3
250	93.3

7.2 Payload Design and Construction Constraints

7.2.1 Parts Selection

The Secondary Payload is expected to use materials that comply with NASA-STD-6016, Standard Materials and Processes Requirements for Spacecraft.

The Secondary Payload is expected to use materials that when exposed to a vacuum environment will not exceed a total mass loss of 1.0% and volatile condensable matter of 0.1% when tested per ASTM E-595 or an equivalent method.

7.2.2 Processes

The Secondary Payload is expected to be maintained in clean assembly areas meeting a class 100,000 cleanliness specification as a minimum during ground processing and payload integration IAW US-FED-STD 209E.

The Secondary Payload is expected to be handled only with clean gloves after testing in preparation for and during ground processing and payload integration.

The Secondary Payload surfaces are expected to be maintained visibly clean under black light inspection, per the IEST-STD-CC1246D level 300A as a minimum during ground processing and payload integration.

7.2.3 Venting

All enclosed volumes of the Secondary Payload are expected to have the capability to maintain interior pressure within 6.9 kPa (1 psi) of the external pressure when in an enclosed configuration and when subjected to the launch venting environment.

7.2.4 Electromagnetic Interference / Compatibility

The Secondary Payload is expected to inhibit wireless transmission until deployed from the SHERPA or launch vehicle.

Launch Service Providers expect the secondary payload to maintain narrowband radiation emissions within the levels shown in Figure 7-5 while in an active state in close proximity to the launch vehicle upper stage.

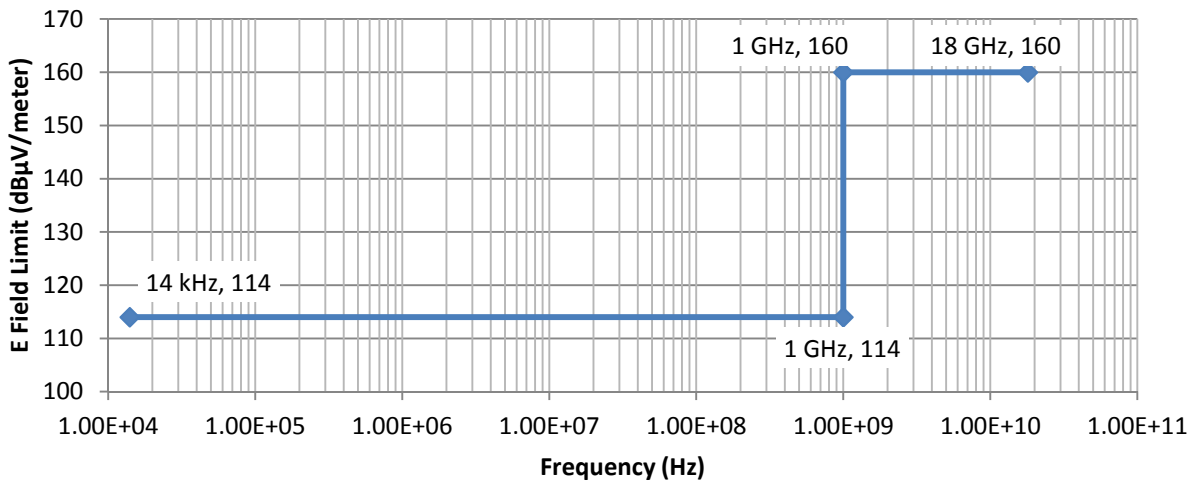


Figure 7-5 Narrowband Radiated E-field Limits

The Secondary Payload is expected to maintain broadband radiation emissions within the levels shown in Figure 7-6 while in an active state within close proximity to the launch vehicle upper stage.

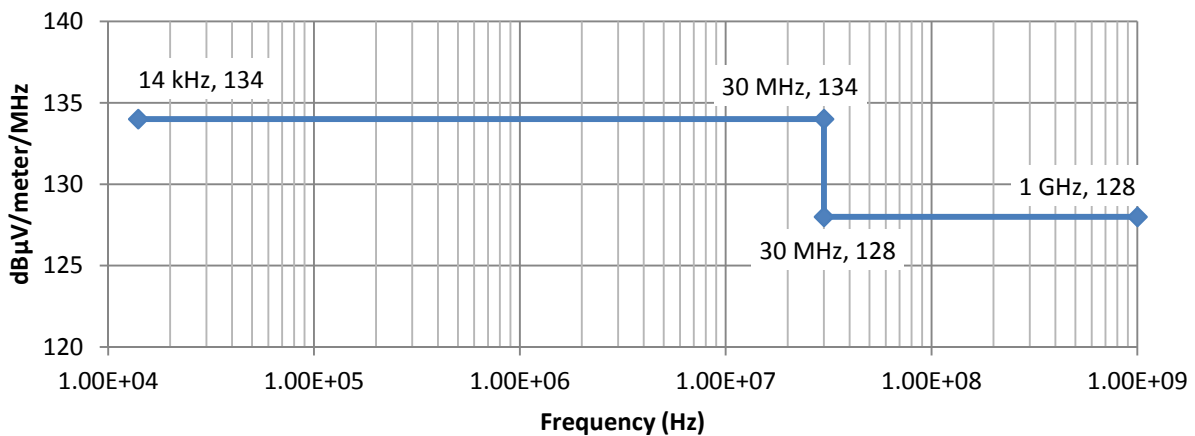


Figure 7-6 Broadband Radiation Limits

7.2.5 Space Debris

Secondary payload are expected to comply with the National Space Policy requirement for space debris, which states that small satellites in LEO should re-enter the atmosphere within 25 years from launch.

7.3 Payload Safety and Hazards

Secondary payload providers are expected to provide a Payload Questionnaire (PQ) prior to contract signing that describes any potential hazards associated with their spacecraft. A PQ template is provided in Appendix B.

Secondary payload providers are expected to provide a Missile System Pre-launch Safety Package (MSPSP) at L-9 months that includes detailed technical data on all hazardous items including drawings, schematics, and assembly and handling procedures. An MSPSP template will be provided by Spaceflight after contract signing and identification of the launch vehicle.

This documentation is required by the launch service provider as part of obtaining launch approvals by the range. Hazards are subject to approval by Spaceflight.

7.3.1 Handling Safety

Secondary payload design is expected to be compatible with operations that place the payload in horizontal as well as vertical attitudes during ground handling and integration. Access to the secondary payload may be limited following integration into the launch vehicle fairing, depending on the level of access that has been contracted.

7.3.2 Pressurized Systems

Design and verification of secondary payload pressurized systems and components are expected to be in accordance with aerospace industry guidelines and must preclude inadvertent operation. The design is expected to protect personnel and hardware from damage due to pressure system failure before launch, and protect the launch system and primary payload from pressure system failure during flight. Documentation of any pressurized systems design and safety verification will be required of the secondary payload contractor to support regulatory agency approvals.

7.3.3 Actuated / Energetic Systems

Secondary payload actuation and other energetic systems for spacecraft propulsion, separation, and mechanical systems are expected to be designed in accordance with aerospace industry guidelines, and must preclude inadvertent operation when subjected to the environments mentioned in this guide during pre-launch and launch operations. Documentation of any actuation and other energetic systems design and safety verification will be required of the secondary payload contractor to support regulatory agency approvals.

7.4 Electrical and Data Interfaces

Secondary payloads are expected to be powered off during launch. No electrical signals are sent from the SHERPA to the payloads, except the deployment command to the separation device.

For minisatellite and nanosatellite payloads, the SHERPA provides redundant payload separation signals per the separation device user's manual.

Separation status is not supplied directly to the payload.

8 Final Integration and Launch Operations

This section defines the four standard payload interfaces offered by the SHERPA: direct integration to the SHERPA Radial Port Interface (RPI), Radial Port Adapter (RPA) mounting, Vertical Payload Adapter (VPA) mounting, and Dual Port Adapter (DPA) mounting.

8.1 Payload Transportation

The secondary payload provider is expected to arrange for transport of the spacecraft from the secondary payload provider facility to the Spaceflight Payload Processing Facility. Upon payload arrival at the Payload Processing Facility, the secondary payload provider is expected to have a representative perform a post transportation inspection prior to handoff to Spaceflight for payload integration activities. Following integration activities, Spaceflight will arrange for transport of the fully integrated Spaceflight payload adapter to the LSP payload processing facility for integration to the launch vehicle.

8.2 Secondary payload provider involvement during integration

Secondary payload provider involvement in the integration activity is generally a function of the secondary payload complexity. Levels of access during payload integration can be negotiated. For picosatellites and nanosatellites having minimal complexity, no secondary payload provider involvement is expected after delivery. Spaceflight will conduct the integration activity, and test the separation circuit continuity.

For microsatellites and minisatellites having greater complexity, secondary payload personnel are expected to be present to observe integration to the Spaceflight payload adapter. Generally for these types of payloads, Spaceflight performs the integration activity under secondary payload provider observation. Using secondary payload provider provided GSE, the secondary payload provider may run health status checks and conduct battery charging until last access.

For hosted payloads, the secondary payload provider is expected to be heavily involved in payload integration and Spaceflight payload adapter testing, to include end-to-end functional testing and mission simulation.

8.3 Integration and Handoff

Spaceflight must receive secondary payloads at the Spaceflight payload processing facility approximately 6 weeks prior to launch to allow enough time for payload adapter integration, test, and delivery to the launch vehicle provider facility.

The integration process takes place in a controlled facility near the launch site. The payload integration activity and system level tests take between two and four weeks to complete. Prior to handoff to the LSP, Spaceflight will conduct a series of continuity checks ensuring the proper functioning of Spaceflight

systems. A mission simulation will also be conducted at that time to test Spaceflight hardware and secondary payload separation systems, and to verify the mission deployment timeline.

Once the Spaceflight secondary payload adapter is fully integrated and tested, the system is handed off to the LSP for the remainder of the integration process. Nominally, this is the last access to secondary payloads. However, in some cases battery charging can be accommodated until payload fairing encapsulation.

The fully-populated Spaceflight secondary payload adapter is then mated with the prime satellite, and then the payload stack is mated with the launch vehicle upper stage. Finally the payload is encapsulated within a payload fairing. Upon completion of the integration process, the launch vehicle is moved to the pad and erected for launch. Launch readiness approval is received via a Launch Readiness Review (LRR) held 24 hours before launch. From Spaceflight secondary payload adapter handoff to launch takes approximately ten (10) days.

Appendix A: Acronyms and Abbreviations

ATP	Authority to Proceed
CCAM	Contamination and Collision Avoidance Maneuver
CLA	Coupled Loads Analysis
EELV	Evolved Expendable Launch Vehicle
EGSE	Electrical Ground Support Equipment
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
ESPA	EELV Secondary Payload Adapter
FRR	Flight Readiness Review
GEVS	General Environmental Verification Specification
ICD	Interface Control Document
ISS	International Space Station
ITAR	International Traffic in Arms Regulations
LRR	Launch Readiness Review
LSP	Launch Services Provider
MPE	Maximum Predicted Environment
PLF	Payload Fairing
POC	Point of Contact
PPF	Payload Processing Facility
RF	Radio Frequency
SIP	Standard Interface Plane
SHERPA	Spaceflight Secondary Payload System
SSIP	Secondary Payload Interface Plane
SPUG	Secondary Payload Users Guide
TAA	Technical Assistance Agreement

Appendix B Secondary Payload Questionnaire Template

The Payload Questionnaire is typically provided to the secondary payload provider prior to Contract Signing. Inputs to this document flow into the draft payload-specific Interface Control Document as requirements. Therefore leave margin where necessary, and clearly mark fields where data still needs to be determined or reviewed. Explanation and rationale are extremely helpful in drafting the ICD. The following information should be contained within the completed Payload Questionnaire.

1. Payload Name/Title/Acronym
2. Payload class (e.g. ESPA, 1U cubesat, etc.)
3. Payload owner and operator
4. Payload points-of-contact and contact information
5. Spacecraft (maximum) mass and first fundamental frequency
6. Dimensioned three-view drawing of spacecraft showing the outer mold line of the satellite in stowed configuration (include coordinate system)
7. Center of gravity (CG) location
8. Moment of inertia (MOI) tensor of the spacecraft in its **stowed** configuration
9. Maximum spacecraft volume envelope
10. Image of spacecraft on-orbit (operational) surface configuration
11. Desired orbital parameters for parking, transfer, and final orbits, including acceptable bounds
12. Desired separation L+ time and attitude and acceptable bounds
13. Description of any planned or required processing at the launch site prior to encapsulation
14. Desired cleanliness level during payload integration operations
15. Description of level of spacecraft access required during spacecraft integration
16. Description of integration handling requirements (including ground handling load limitations)
17. Description of launch load limitations along payload axes
18. Description of power requirements during spacecraft integration
19. Description of any safety issues associated with the spacecraft (including materials or handling operations that might be considered hazardous)
20. Description of any propulsion systems to be used on the spacecraft.
21. Description of any pressure vessels to be used on the spacecraft.
22. Description of the spacecraft power system (e.g. types of batteries, solar cells, etc.)
23. Description of any RF systems to be used on the spacecraft. Detail each RF transmitter or receiver, its function, frequency, sensitivity, power output, and bandwidth
24. Planned timing of RF initialization following payload separation
25. Type of separation mechanism (including configuration of inhibit switches and separation connectors)
26. Description of any security requirements
27. High-level description of intended payload operations during payload lifetime
28. Other comments