



# RIDESHARE PAYLOAD USER'S GUIDE

**Version 9 - December 2023**

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## ACRONYMS

AFSPCMAN	Air Force Space Command Manual
AIAA	American Institute of Aeronautics and Astronautics
ATM	acceleration transformation matrix
CAD	computer-aided design
CCSFS	Cape Canaveral Space Force Station
CG	center of gravity
CLA	coupled loads analysis
CSLA	Commercial Space Launch Act
CSpOC	Combined Space Operations Center
CVCM	collected volatile condensable material
DRM	data recovery matrix
DTM	displacement transformation matrix
EAR	export administration regulations
ECEF	earth-centered, earth-fixed
EGSE	electrical ground support equipment
EIRP	equivalent isotropically radiated power
EMI	electromagnetic interference
EMISM	EMI safety margin
ETFE	ethylene tetrafluoroethylene
FAA	Federal Aviation Administration
FCC	Federal Communications Commission
FEED	field-emission electric propulsion
FEM	finite element model
GN2	gaseous nitrogen
GOP	ground operations plan
GPS	global positioning system
GSE	ground support equipment
HDRM	hold down and release mechanism
HTP	high test peroxide
HVAC	heating, ventilation and air conditioning
ICD	interface control document
IRIG	inter-range instrumentation group
ITAR	international traffic in arms regulations
KSC	Kennedy Space Center
LOX	liquid oxygen
LTM	load transformation matrix
LV	Launch Vehicle
LVLH	local vertical/local horizontal
MDP	maximum design pressure
MEOP	maximum expected operating pressure
MPE	maximum predicted environment
MPT	maximum and minimum predicted temperatures



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MSPSP .....	missile system prelaunch safety package
NASA .....	National Aeronautics and Space Administration
NASTRAN .....	NASA Structural Analysis
OASPL .....	overall sound pressure level
OPM .....	orbital parameter message
OTM .....	output transformation matrix
P&ID .....	pipng and instrumentation diagram
PL .....	Payload
PPF .....	payload processing facility
Q .....	dynamic pressure
RE .....	radiated emissions
RF .....	radio frequency
RML .....	recovered mass loss
RMS .....	root-mean-square
RP-1 .....	rocket propellant-1 (rocket-grade kerosene)
RS .....	radiated susceptibility
RSS .....	root sum squared
RTV .....	room temperature vulcanizing
SCAPE .....	self-contained atmospheric protective ensemble
sccs .....	standard cubic centimeter per second
SLC .....	space launch complex
SpaceX .....	Space Exploration Technologies Corp.
SPCS .....	Space Control Squadron
SPL .....	sound pressure level
SRM .....	solid rocket motor
SRS .....	shock response spectrum
STEP .....	standard for the exchange of product model data
TAA .....	technical assistance agreement
TE .....	transporter-erector
TML .....	total mass loss
US DOT .....	United States Department of Transportation
US .....	United States
USSPACECOM .....	United States Space Command
UTC .....	coordinated universal time
VC-HS .....	visibly clean – highly sensitive
VSFB .....	Vandenberg Space Force Base
WVR .....	water vapor regained



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## CHANGE LOG

Version	Date	Update
1	December 2019	Original Release
2	January 2020	Updated Release
3	June 2020	Updated Release
4	November 2020	Updated Release
5	September 2021	Updated Release
6	March 2022	Updated Release
7	June 2022	Updated Release
8	October 2022	Updated Release
9	December 2023	<p>Updated Release. Major updates listed as follows:</p> <ul style="list-style-type: none"><li>• Added 4-point standard interfaces (Section 2, Appendix A)</li><li>• Added CubeSat dispenser standard interface (Section 2, Appendix A)</li><li>• Added Half XL Plate standard option (Section 2, Appendix A)</li><li>• Updated Starlink adapter offering (Section 2, Appendix A)</li><li>• Added 4-point mass-CG curves (Section 3)</li><li>• Added guidance on separation architecture (Section 3)</li><li>• Modified transmitter turn-on times and RF bands (Section 4)</li><li>• Updated boundary temperatures (Section 4)</li><li>• Added guidance on peaking factors (Section 5)</li><li>• Expanded guidance on reworked fasteners (Section 5)</li><li>• Modified guidance on materials &amp; contamination (Section 5)</li><li>• Added design requirements for isolators (Section 5)</li><li>• Modified and expanded guidance on pressure vessels &amp; systems (Section 5)</li><li>• Added guidance on solid propulsion systems (Section 5)</li><li>• Consolidated verification approach into Section 6; clarified protoflight test philosophy</li><li>• Clarified and modified requirements on test-like-you-fly exceptions and post-test modifications (Section 6)</li><li>• Added requirement on 3-axis testing; modified protoflight sine sweep rate (Section 6)</li><li>• Added low level sine requirement for verification of natural frequencies (Section 6)</li><li>• Modified and expanded guidance on verification of quasi-static loading (Section 6)</li><li>• Changed requirements on random vibration verification (Section 6)</li><li>• Added testing requirements for isolators (Section 6)</li><li>• Clarified and modified requirements on leak testing (Section 6)</li><li>• Added requirements on verification of HTP propellants (Section 6)</li><li>• Added requirements on verification of solid propulsion systems (Section 6)</li><li>• Modified customer storage requirements (Section 9)</li><li>• Added requirements for on-orbit tracking/coordination (Section 9.5.7)</li><li>• Updated dynamic model requirements (Appendix B)</li><li>• Updated CAD model and mass properties requirements (Appendix C)</li><li>• Updated template letter for licensing verification (Appendix F)</li><li>• Updated deliverables description (Appendix G)</li></ul>



# 1 INTRODUCTION

## 1.1 RIDESHARE PAYLOAD USER'S GUIDE PURPOSE

The Rideshare Payload User's Guide is a planning document provided for small satellite customers of SpaceX (Space Exploration Technologies Corp.). This document is intended to help Rideshare Launch Customers understand SpaceX's standard services for pre-contract Mission planning and to delineate Customer requirements for contracted Rideshare Launch Services.

SpaceX reserves the right to update this guide as required. Future revisions are likely as SpaceX continues to gather additional data and works to improve the Rideshare program.



**Figure 1-1: Example Mission Configuration using Rideshare Plates**



## 1.2 COMPANY DESCRIPTION

SpaceX offers a family of Launch Vehicles that improves launch reliability and increases access to space. The company was founded on the philosophy that simplicity, reliability and cost effectiveness are closely connected. We approach all elements of Launch Services with a focus on simplicity to both increase reliability and lower cost. The SpaceX corporate structure is flat and business processes are lean, resulting in fast decision-making and product delivery. SpaceX products are designed to require low-infrastructure facilities with little overhead, while vehicle design teams are co-located with production and quality assurance staff to tighten the critical feedback loop. The result is highly reliable and producible Launch Vehicles with quality embedded throughout the process.

Established in 2002 by Elon Musk, the founder of Tesla Motors, PayPal and the Zip2 Corporation, SpaceX has developed and flown the Falcon 1 light-lift Launch Vehicle, the Falcon 9 medium-lift Launch Vehicle, the Falcon Heavy heavy-lift Launch Vehicle, the most powerful operational rocket in the world by a factor of two, and Dragon, which is the first commercially produced spacecraft to visit the International Space Station.

SpaceX has built a launch manifest that includes a broad array of commercial, government and international customers. In 2008, NASA selected the SpaceX Falcon 9 Launch Vehicle and Dragon spacecraft for the International Space Station Cargo Resupply Services contract. NASA has also awarded SpaceX contracts to transport astronauts to space as well as to launch scientific satellites. In addition, SpaceX services the National Security community and is on contract with the Air Force for multiple missions on the Falcon family of Launch Vehicles.

SpaceX has state-of-the-art production, testing, launch and operations facilities. SpaceX design and manufacturing facilities are conveniently located near the Los Angeles International Airport. This location allows the company to leverage Southern California's rich aerospace talent pool. The company also operates cutting-edge propulsion and structural test facilities in Central Texas, along with Launch Sites in Florida and California, and the world's first commercial orbital Launch Site in development in South Texas.

## 1.3 RIDESHARE PROGRAM OVERVIEW

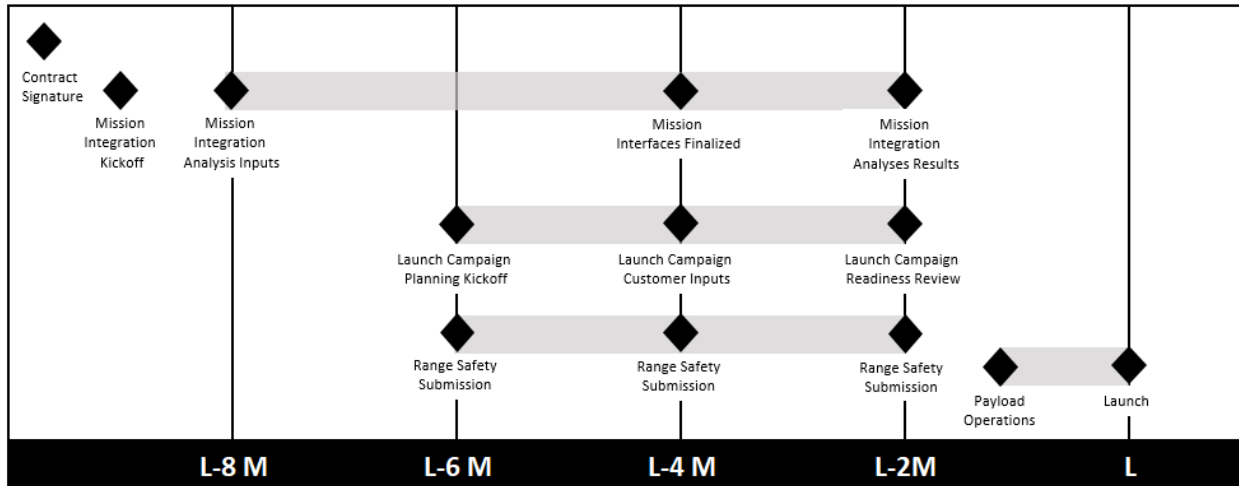
SpaceX offers Rideshare Missions for small spacecraft on the Falcon 9 Launch Vehicle. This document applies to CubeSat dispensers, small spacecraft with an 8", 15", or 24" diameter standard mechanical interface, and small spacecraft with a 4-point interface (compatible with the Rideshare Plate). In the case of small spacecraft, a single deployment from the Launch Vehicle is assumed. These spacecraft are referred to as "Payloads" throughout this document. Sub-components that comprise the Payload are referred to as "Payload Constituents".

As an optional service, which may incur an additional fee, SpaceX can provide alternative configuration information for Payloads that are not compatible with the 8", 15", or 24" diameter mechanical interface, for small spacecraft Payloads that require multiple deployments from the Launch Vehicle, or for Payloads that host multiple Payload Constituents that separate from an orbital transfer vehicle, or similar, after the Payload itself is deployed from the Launch Vehicle.

In an effort to reduce the orbital debris footprint of the Rideshare Program, Payloads are expected to adhere to the FCC's rule requiring the disposal of spacecraft as soon as practicable but no later than 5 years after the mission ends.

Customer is responsible for registering all deployed objects with the 18th Space Control Squadron (SPCS) to assist with the tracking and identification of all deployed Payload Constituents in a timely manner; see Section 9.5.7 for detailed information.

The timeline of a typical Rideshare contract is shown in Figure 1-2.



**Figure 1-2: Typical Rideshare Program Schedule**

SpaceX will provide kickoff materials shortly after the launch services contract is signed. To aid in communication, SpaceX will send document templates for Customer to complete. A description of the documents associated with each milestone can be found in Appendix G.

To ensure a smooth Launch Campaign and a successful mission for all Rideshare Customers, SpaceX will maintain an Interface Control Document (ICD) for the Payload. Requirements in the ICD and this document are designed to ensure the safety of all Co-Payloads and the Launch Vehicle. SpaceX and Customer will periodically review and update the ICD throughout the mission integration process.

Approximately six months before Launch, Customer and SpaceX begin planning Range Safety and Launch Campaign operations. Before the Payload is delivered to the Launch Site, the ICD is signed and a review is held to confirm Launch Campaign readiness as well as the Payload specific schedule. The Payload is then shipped to the Launch Site, where it is integrated to the Launch Vehicle for Launch.

SpaceX will provide a best-estimate Payload separation state vector to the Customer shortly after Payload separation, as described in Appendix E. Customer is responsible for tracking and contacting the Payload after separation from the Launch Vehicle.

## 1.4 FALCON 9 PROGRAM

Please refer to the SpaceX Falcon User's Guide, latest revision, available on [www.spacex.com/vehicles/falcon-9/](http://www.spacex.com/vehicles/falcon-9/) for detailed information regarding the Falcon program including Launch Vehicle safety and reliability.

## 1.5 PRICING

Pricing for rideshare Launch Services can be found at [www.spacex.com/rideshare](http://www.spacex.com/rideshare).

## 2 MECHANICAL INTERFACES

### 2.1 LAUNCH VEHICLE FAIRING

Payload, Co-Payload(s), and all SpaceX hardware, including the Rideshare Plate system will be co-located in the Falcon-9 fairing volume. Please refer to the SpaceX Falcon User's Guide, latest revision, available on [www.spacex.com/vehicles/falcon-9/](http://www.spacex.com/vehicles/falcon-9/) for details.

### 2.2 LAUNCH VEHICLE COORDINATE FRAME

The Launch Vehicle uses a right-hand X-Y-Z coordinate frame, indicated with the subscript "LV", centered 440.69 cm (173.5 in.) aft of the first-stage radial engine gimbal, with  $+X_{LV}$  aligned with the vehicle long axis and  $+Z_{LV}$  opposite the TE strongback as shown in Figure 2-1.  $X_{LV}$  is the roll axis,  $Y_{LV}$  is the pitch axis, and  $Z_{LV}$  is the yaw axis.



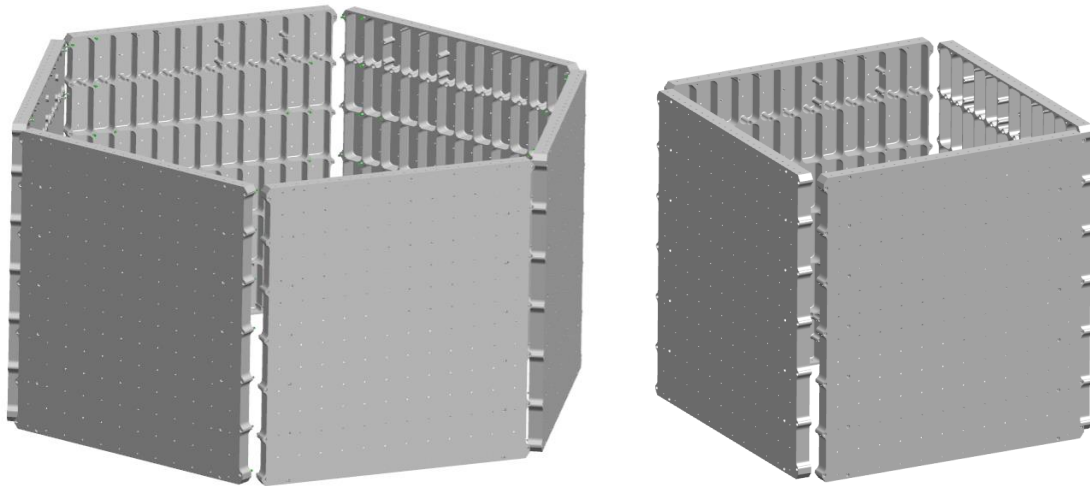
Figure 2-1: Launch Vehicle Coordinate Frame

### 2.3 PAYLOAD COORDINATE FRAME

The origin of the Payload coordinate system is fixed at the center of the mechanical interface between Customer-supplied hardware and SpaceX-supplied hardware. The Payload will use a right-hand X-Y-Z coordinate system, indicated with a subscript "PL", with  $+X_{PL}$  aligned with the Payload axial direction as described in Section 2.4 and  $+Z_{PL}$  aligned with the launch vehicle  $+X_{LV}$  direction. Customers must provide **all** data and deliverables in this Payload Coordinate Frame.

### 2.4 RIDESHARE PLATE CONFIGURATIONS AND AVAILABLE PAYLOAD VOLUME

Rideshare Plates can be either arranged in a **hexagon** shape, comprised of six (6) modular plates, or in a **cube** shape, comprised of four (4) modular plates, as shown in Figure 2-2. The cube configuration, due to its lower profile geometry, provides increased radial volume for Payloads. Payloads must be confined to the available volumes defined in the following sections, as well as in Appendix A.

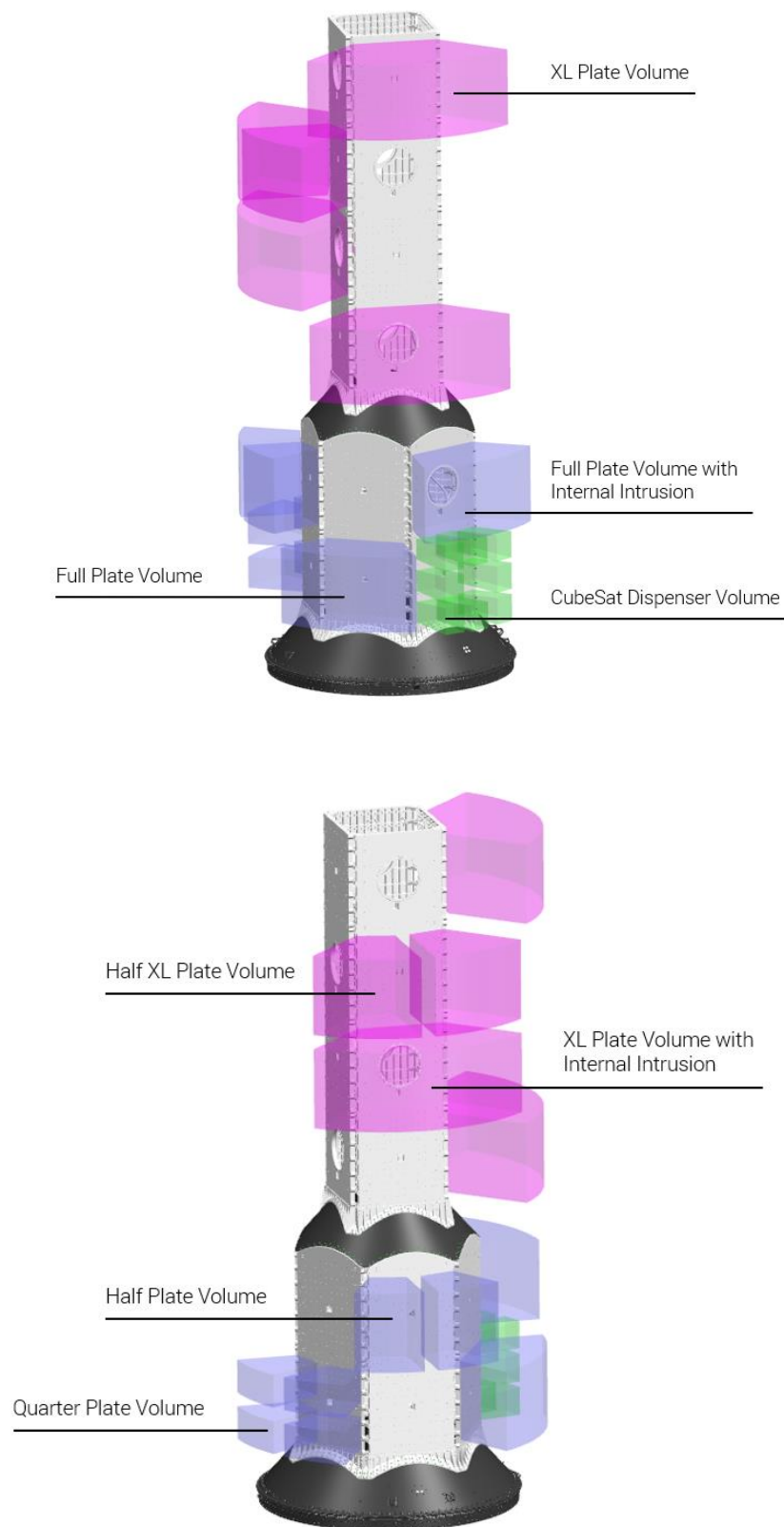


**Figure 2-2: Rideshare Plates - Hexagon Configuration (left) and Cube Configuration (right)**

Although each Rideshare Plate has the same footprint dimensions, Payload volumes vary depending on the Rideshare Plate configuration (hexagon vs. cube as stated above) and the portion of the plate used. Rideshare Plates can accommodate a variety of mechanical interfaces broken down into the following standard options:

- Hexagon Configuration
  - Quarter Plate
  - Half Plate
  - Full Plate
- Cube Configuration
  - Half XL Plate
  - XL Plate
- CubeSat Dispenser Plate

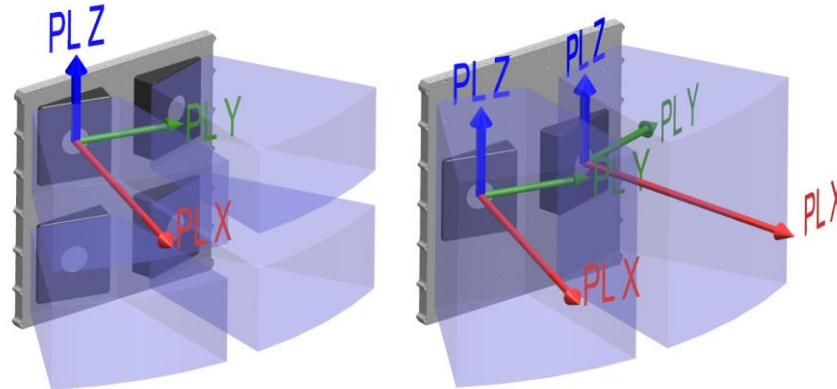
Figure 2-3 provides an overview of standard Payload volumes.



**Figure 2-3: Example Payload Volumes and Configuration**

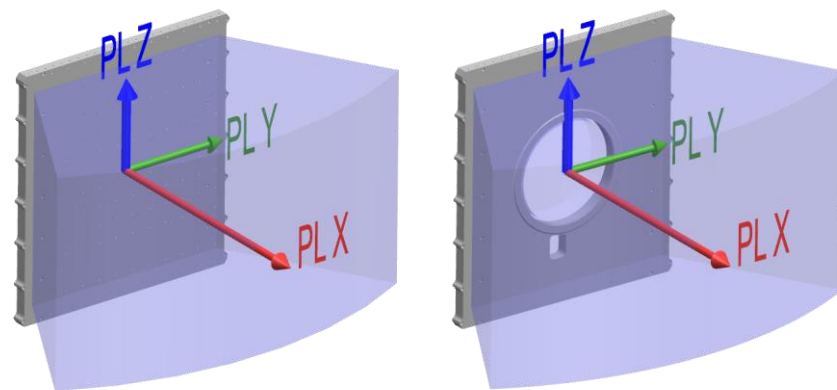


The **Quarter Plate** and **Half Plate** volumes can accommodate 8" and 15" diameter, or equivalent, sized interfaces, as well as 4-point interfaces, as specified in Section 2.5. Allowable volumes are shown in Figure 2-4 and are accommodated as part of the hexagon configuration. Payloads are placed on 15-degree wedges, with a standard fastener interface provided by SpaceX. Detailed volume dimensions and fastener interfaces can be found in Appendix A.



**Figure 2-4: Quarter Plate - 4 shown (left) and Half Plate - 2 shown (right) Volumes**

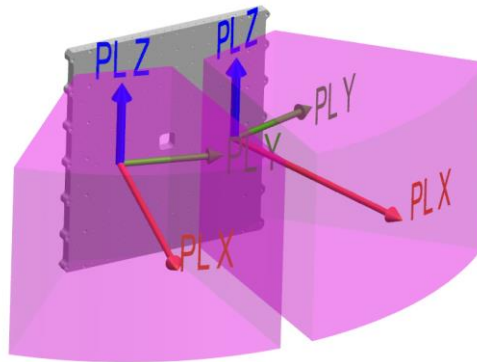
The **Full Plate** volume can accommodate 15" and 24" diameter, or equivalent, sized interfaces. Additionally, it can accommodate a range of 4-point interfaces, as specified in Section 2.5. For a single Payload with a 24" diameter interface there is an allowable 177.8 mm intrusion through the SpaceX-provided mechanical interface. Full Plate volumes are shown in Figure 2-5 and are accommodated as part of the hexagon configuration. Detailed volume dimensions and fastener interfaces can be found in Appendix A.



**Figure 2-5: Full Plate (left) and Full Plate with Intrusion (right) Volumes**

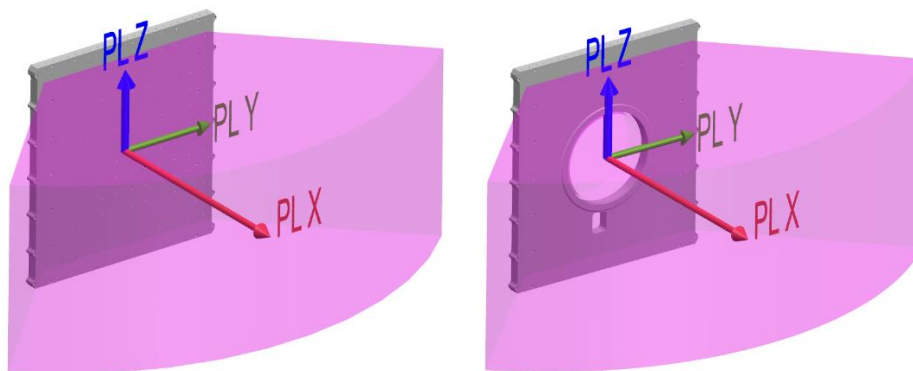
The **Half XL Plate** volume is designed to accommodate Payloads on a 15" diameter, or equivalent, sized interfaces, as well as a range of 4-point interfaces, as specified in Section 2.5. Half XL Plate volumes are shown in Figure 2-6 and are accommodated as part of the cube configuration. Detailed volume dimensions and fastener interfaces can be found in Appendix A.





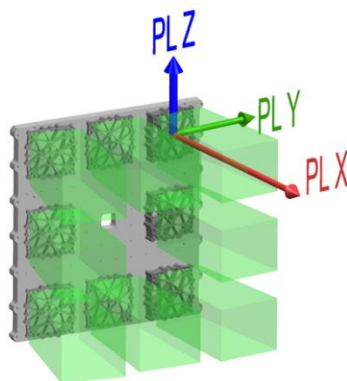
**Figure 2-6: Half XL Plate Volume - 2 shown**

The **XL Plate** volume can accommodate a 24" diameter, or equivalent, sized interface. Additionally, it can accommodate a range of 4-point interfaces, as specified in Section 2.5. For a single Payload with a 24" diameter interface there is an allowable 177.8 mm intrusion through the SpaceX-provided mechanical interface. XL Plate volumes are shown in Figure 2-7 and are accommodated as part of the cube configuration. Detailed volume dimensions and fastener interfaces can be found in Appendix A.



**Figure 2-7: XL Plate (left) and XL Plate with Intrusion (right) Volumes**

Finally, CubeSat dispensers can be accommodated on a unique Rideshare Plate with an allowable volume as shown in Figure 2-8. Up to eight CubeSat dispensers can be accommodated on a single plate. CubeSats dispensers are placed on 8-degree wedge or straight adapters via a standard fastener interface provided by SpaceX. Detailed volume dimensions and fastener interfaces can be found in Appendix A.



**Figure 2-8: CubeSat Dispenser Volume - 8 shown**



A guide for selecting the appropriate volume is shown in Table 2-1, summarizing the configurations available for each plate type.

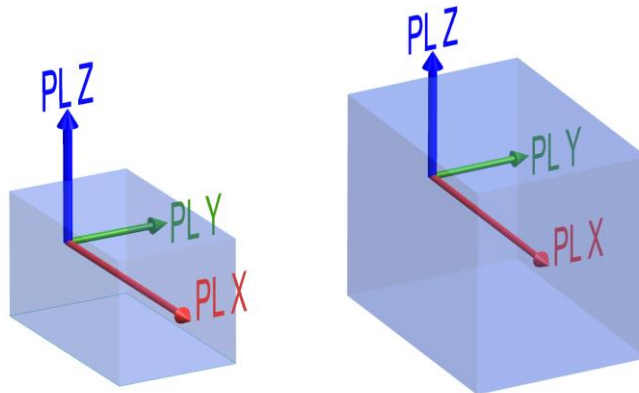
**Table 2-1: Plate Section Guide**

Mechanical Interface	Hexagonal Configuration				Cube Configuration		
	Quarter Plate Volume	Half Plate Volume	Full Plate Volume	Full Plate Volume with Intrusion	Half XL Plate Volume	XL Plate Volume	XL Plate Volume with Intrusion
8" diameter	X	X					
15" diameter	X	X	X	X	X		
24" diameter			X	X		X	X
4-point	X <sup>1</sup>	X <sup>1</sup>	X	X	X <sup>1</sup>	X	X

1. Contact SpaceX for further information regarding 4-point separation systems on quarter, half, and half XL plates. (Reference Section 2.6.2).
2. CubeSat dispensers are by default mounted to a dedicated Rideshare Plate as shown in Figure 2-8.

## 2.5 STARLINK ADAPTERS AND AVAILABLE PAYLOAD VOLUME

Payloads may be accommodated on SpaceX's Starlink missions as an alternative service to the standard Rideshare Plate configuration. Starlink adapters are offered for a 15" diameter and 24" diameter mechanical interface, the volumes for which are shown in Figure 2-9 and Appendix A. Contact SpaceX for further details.



**Figure 2-9: Starlink Adapter 15" Diameter (left) and 24" Diameter (right) Volumes**

## 2.6 STANDARD MECHANICAL INTERFACES

SpaceX provides standard mechanical interfaces between Launch Vehicle hardware and Customer-provided hardware, including circular, 4-point, and CubeSat Dispenser interfaces. Customer is responsible for providing the fasteners that directly mate to their interface, along with a corresponding fastener structural analysis that validates their fastener selection. Customer-provided fasteners must be compliant with the requirements defined in Section 5.2.2, including minimum acceptable thread protrusion/depth.

### 2.6.1 CIRCULAR INTERFACE

SpaceX will provide a single 8", 15" and 24" diameter standard interfaces per the specifications in Appendix A as part of the standard services. This interface will be provided, either directly to the Rideshare Plate or via a SpaceX-provided adapter, at SpaceX's discretion.



For standard bolt circle interfaces, the Payload must mechanically interface to the Launch Vehicle hardware via 0.25" diameter 28 threads-per-inch fasteners. The number of fasteners will be dependent on the diameter of the bolt circle and are defined in Appendix A.

### 2.6.2 4-POINT INTERFACE

SpaceX provides a standard 4-point interface for Payloads that require a Full or XL Plate. The mounting interface to the Rideshare Plate maximizes configurability for a wide range of 4-point footprints, ranging from a minimum of 16" x 16" to a maximum of 32" x 40" (width x height). The footprint can be selected, independently of width and height, in 4" increments, as shown in Figure 2-10 and Figure 2-11. Detailed 4-point specifications and interfaces are provided in Appendix A.

A 4-point interface is also available for Payloads that require a Full or XL Plate with intrusion. In this case, the mounting interface to the Rideshare Plate ranges from a minimum footprint of 32" x 32" to a maximum of 32" x 40" (width x height). Height can be varied from 32" to 40" in 4" increments, as shown in Figure 2-10 and Figure 2-12.

SpaceX can also accommodate 4-point interfaces for the following options (contact SpaceX for more information):

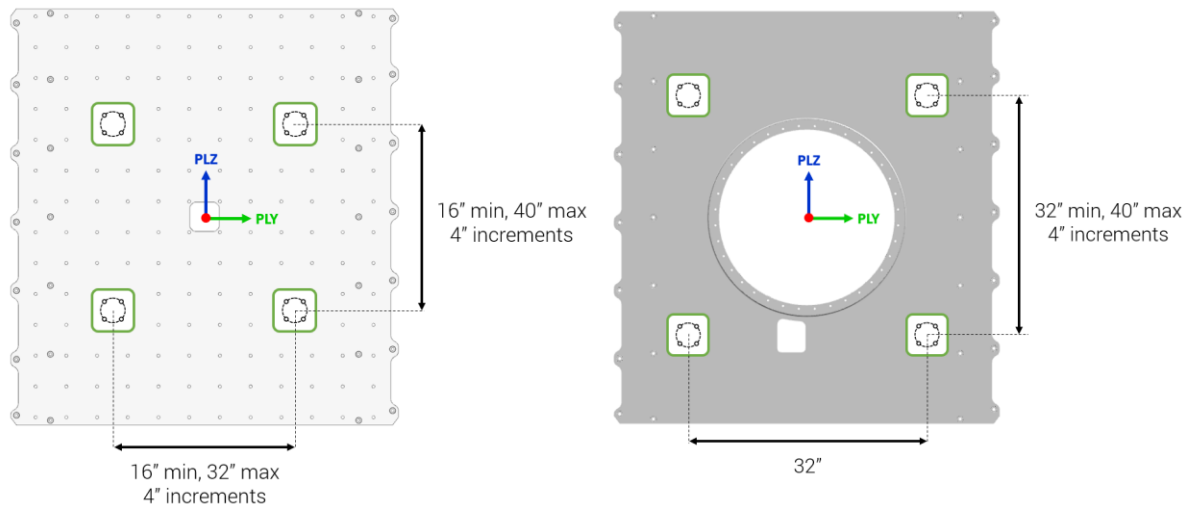
- Quarter Plate: must have a 16" x 16" footprint. Additional Payload placement restrictions may apply.
- Half and Half XL Plate: footprint width is set to 16". Height can be varied from 16" to 40" in 4" increments.

Payloads using a 4-point interface will mechanically attach to the Launch Vehicle hardware at each interface foot via four clearance holes, for 0.5" diameter fasteners on a 3.5" diameter circle. Payloads must conform to the customer-side interface specifications. Tolerances, as measured on the customer-side of the Launch Vehicle interface must be within the maximum positional tolerances. See Appendix A for all detailed specifications. Customers must provide a metrology report of their 4-point interface to ensure it complies with these specifications.

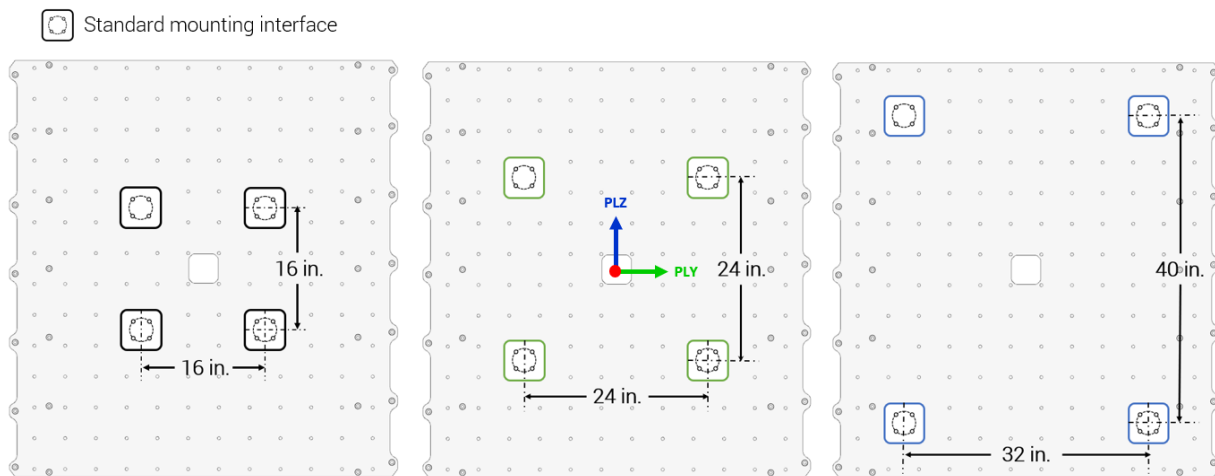
Customers using 4-point interfaces should assume the interface stiffness to the Launch Vehicle is as defined in Table 2-2. Interface stiffness applies to each interface foot, independently. Spacecraft must meet all other requirements of this user's guide with this interface stiffness, including the requirement on Payload minimum natural frequency content (see Section 4.1.1). Payloads with 4-point interfaces must test with a SpaceX-supplied GSE adapter which will simulate an equivalent stiffness.

**Table 2-2: 4-Point Interface Stiffness Specifications**

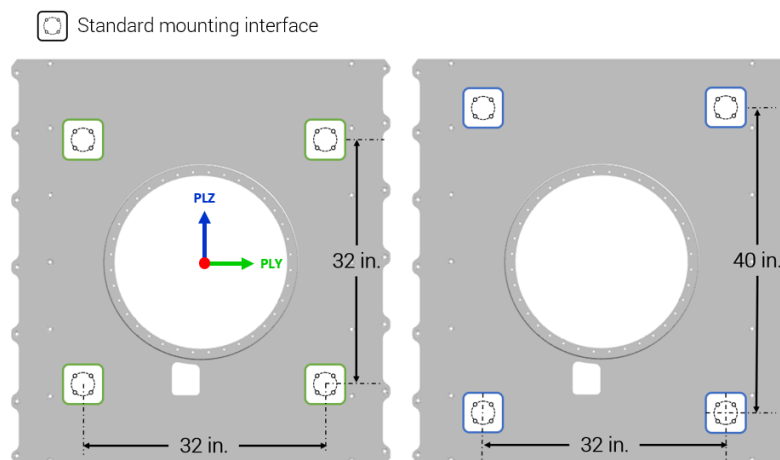
Direction	Translation stiffnesses ( $10^6$ N/m)			Rotational stiffnesses ( $10^6$ N.m/rad)		
	X <sub>PL</sub> axis	Y <sub>PL</sub> axis	Z <sub>PL</sub> axis	X <sub>PL</sub> axis	Y <sub>PL</sub> axis	Z <sub>PL</sub> axis
LV Stiffness	154	459	57	2.0	0.30	0.30



**Figure 2-10: 4-Point Interface Footprint Variation for Full / XL Plate and Full / XL Plate with Intrusion**



**Figure 2-11: 16 x 16 (smallest), 24 x 24 (mid-range), and 32 x 40 (largest) 4-Point Footprints for Full / XL Plate**



**Figure 2-12: 32 x 32 (smallest) and 32 x 40 (largest) 4-Point Footprints for Full / XL Plate with Intrusion**



### **2.6.3 CUBESAT DISPENSER INTERFACE**

SpaceX provides a standard CubeSat dispenser interface; see Appendix A for detailed specifications.

### **2.6.4 NON-STANDARD INTERFACES**

Non-standard mechanical interfaces may be accommodated by using an adapter provided by SpaceX as an optional service (see Appendix I). For non-standard interfaces, including CubeSat dispensers, please contact SpaceX.

### **2.6.5 INTERFACE MATING OPERATIONS**

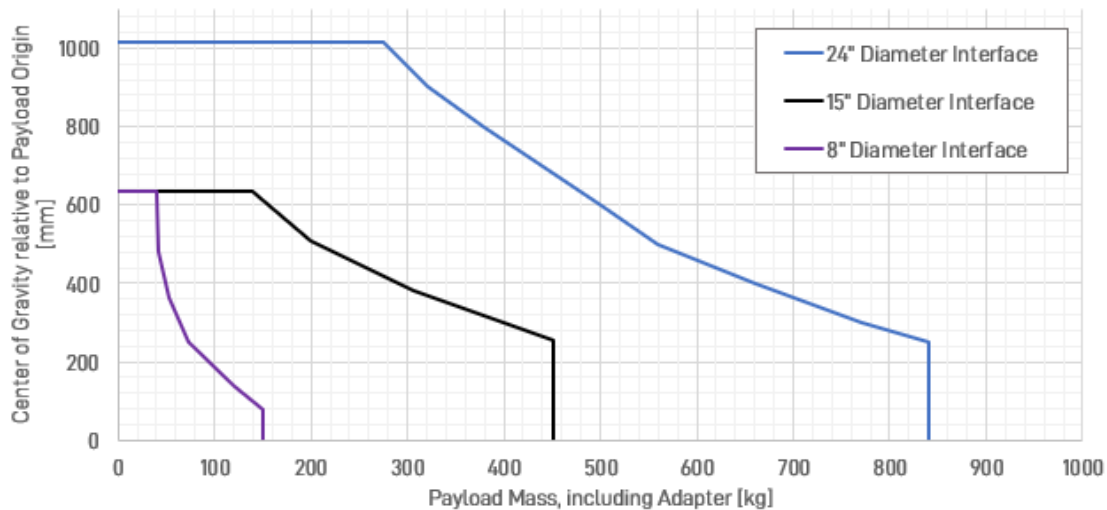
SpaceX is responsible for the final mate to the Launch Vehicle hardware. SpaceX, in its sole discretion, may provide access to the Launch Vehicle mechanical interface to support a Payload-to-Launch Vehicle mechanical fit check at the Launch Site before flight mating. The fit check will confirm the mechanical compatibility of the SpaceX-provided mechanical interface and the Payload interface and, optionally, the mechanical alignment of the umbilical connectors.



## 3 PERFORMANCE

### 3.1 MASS PROPERTIES

For Payloads with an 8", 15" or 24" diameter mechanical interface, the mass and  $X_{PL}$  center of gravity (CG) limitations are defined in Figure 3-1.

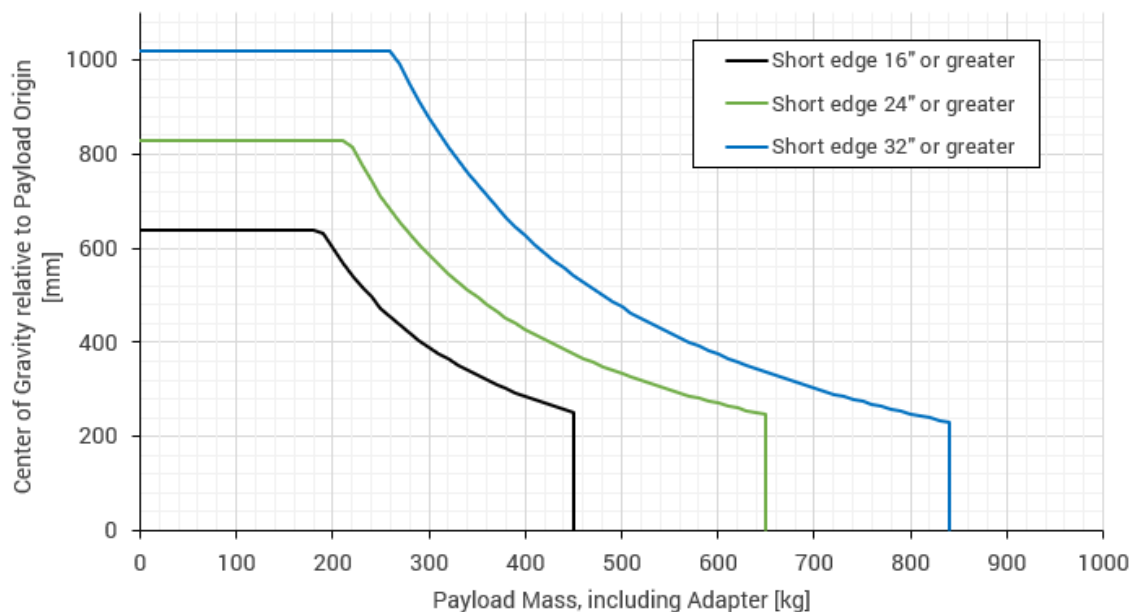


**Figure 3-1: Payload Mass and  $X_{PL}$  CG for Circular Mechanical Interfaces**

For Payloads with a 4-point interface, the mass and  $X_{PL}$  CG limitations are defined in Figure 3-2. Customers must select the mass and  $X_{PL}$  CG curve that matches the shorter edge of their 4-point interface, as measured from foot to foot.

Examples:

- For a 16" x 24" 4-point interface, mass and CG must be within the 'Short edge 16" or greater' capability curve.
- For a 28" x 28" 4-point interface, mass and CG must be within the 'Short edge 24" or greater' capability curve.



**Figure 3-2: Payload Mass and  $X_{PL}$  CG for 4-Point Interfaces**



$Y_{PL}$  and  $Z_{PL}$  CG dimensions must fall within the mechanical interface diameter/4-point footprint for the Payload, and it is preferred to centralize  $Y_{PL}$  and  $Z_{PL}$  CG positions to the extent possible. Mass property capabilities may be further constrained by mission-unique Payload adapters, dispensers, or separation systems. Customers must consult separation system User's Guides to determine any further mass-CG restrictions for their chosen separation system.

## 3.2 LAUNCH WINDOWS

The Launch Vehicle is capable of launching any day of the year, at any time of day, subject to environmental limitations and constraints as well as range availability and readiness within the SpaceX-determined Launch Period. Launch Window times and durations are developed specifically for each Mission. Customers may benefit from recycle operations (reference Section 10.5.5), maximizing launch opportunities within the Launch Window.

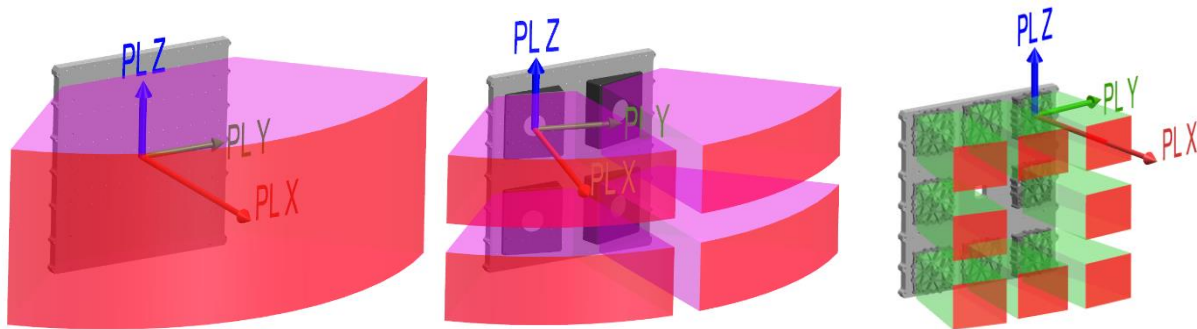
## 3.3 PAYLOAD SEPARATION

### 3.3.1 ATTITUDE AND ACCURACY

The Launch Vehicle offers 3-axis attitude control as standard practice. The Launch Vehicle will point the second stage and Payload to an attitude determined by SpaceX. More information about separation attitude and rate accuracy is available from SpaceX upon request.

### 3.3.2 RATES AND VELOCITY

All deployed Payloads must exit through the  $+X_{PL}$  surface of the allowable Payload volume. Customer must show by analysis that none of the deployed Payload Constituents contact other portions of the Payload before exiting the  $+X_{PL}$  surface of the allowable Payload volume. Examples of Payload volume exit criteria are shown in Figure 3-3.



**Figure 3-3: Payload  $+X_{PL}$  Surface Exit Requirement (red) for Example Rideshare Plate Configurations**

Payloads must target a minimum separation velocity of 0.3 m/s and a maximum separation velocity of 1.0 m/s. Containerized deployments such as CubeSats may be deployed at a velocity greater than 1.0 m/s. For Payloads that include more than one deployment, the separation velocities should be different between deployed Payload Constituents such that the fastest deployment is first.

The Launch Vehicle is subject to the rotational rates in Table 3-1 prior to Payload separation.

**Table 3-1: Launch Vehicle Rates Before Payload Separation**

Axis	Rate
Launch Vehicle Roll ( $W_x$ )	$\pm 2.0$ deg/s
Launch Vehicle Pitch ( $W_y$ )	$\pm 1.0$ deg/s
Launch Vehicle Yaw ( $W_z$ )	$\pm 1.0$ deg/s



### 3.3.3 SEPARATION ARCHITECTURE

Each separating Payload must be controlled by a unique signal that only deploys that single Payload. This allows an overall deployment scheme that minimizes risk of collision between deployed objects.

Payload separation architecture and placement **must not** impose deploy constraints on the Launch Vehicle, such as deployment sequence order. An exception can be made to Payloads that are stacked in the X<sub>PL</sub> direction, such that the outermost Payload is deployed first.

### 3.3.4 PAYLOAD MANEUVERS AND DEPLOYMENTS

Payloads must adhere to the following rules on payload maneuvers and deployments after Payload separation from the Launch vehicle:

- Delay attitude maneuvers until at least **120 seconds** after Payload separation from the Launch Vehicle
- Delay mechanical appendage deployment (e.g. solar panel deployment) until at least **120 seconds** after Payload separation from the Launch Vehicle
  - For any mechanical appendage deployment within first 24 hours, Customer must communicate to SpaceX a bounding hard body radius for the Payload.
- Delay secondary deployments (e.g. a deployed object deploying a sub-Payload) until at least **seven days** after Payload separation from the Launch Vehicle
- Delay propulsive maneuvers until at least **seven days** after Payload separation
- All secondary deployments must be performed while under active attitude control. Deployments in uncontrolled directions or during Payload tumbling are not allowed.

The seven-day period for secondary deployments and propulsive maneuvers allows adequate time for external cataloging of all Co-Payloads deployed from the Launch Vehicle and sufficient orbital spreading before additional release of Payload Constituents or orbital maneuvers.

It is the Customer's responsibility to pre-coordinate orbital maneuvers or the secondary deployment of Payload Constituents with the 18th Space Control Squadron (SPCS), submit estimated trajectories for screening to the 18th SPCS, and demonstrate to SpaceX that coordination with the 18th SPCS has been completed. See Section 9.5.7 for information on Coordination with Space Situational Awareness Agencies.





## 4 ENVIRONMENTS

The Launch Vehicle has been designed to provide a benign Payload environment. The environments presented below reflect typical Mission maximum predicted environments (MPE) for Payloads. Mission-specific analyses will be performed by SpaceX as indicated in Section 9.6.9.

### 4.1 FLIGHT ENVIRONMENTS

This section describes the MPE the Payload will experience from liftoff through separation from the Launch Vehicle for Payloads utilizing Rideshare Plate hardware.

**IMPORTANT:** To ensure mission safety, all Payloads must be tested in a fully integrated, flight configuration (everything, including all Payload Constituents that comprise the Payload and attach to the SpaceX provided mechanical interface, all firmware, software, and electrical systems). Integrated flight hardware testing provides workmanship screening as well as validation of design analyses for the entire Payload assembly. This testing is required to ensure safety of the primary Mission and of Co-Payloads. Verification testing is detailed in Section 6.

#### 4.1.1 PAYLOAD NATURAL FREQUENCIES AND DAMPING

Payloads must have no elastic natural frequencies below 40 Hz and must have a quality factor between  $Q=10$  and  $Q=50$  in order to ensure that the requirements defined in Section 4.1 are sufficient to cover the appropriate flight environments.

Payloads with elastic natural frequencies below 40 Hz will not be permitted. An elastic natural frequency is defined in this document as any frequency response of the Payload with any modal participation, as computed by a fixed-base modal analysis.

See Section 6.7.1 for detailed verification requirements.

#### 4.1.2 PAYLOAD QUASI-STATIC FACTORS

##### 4.1.2.1 QUASI-STATIC LOAD FACTORS FOR CUBESAT DISPENSERS WITH CUBESATS

Payload maximum predicted design load factors are shown in Table 4-1 for CubeSat dispensers loaded with CubeSats. These load factors are defined as “combined loads,” which include all contributions from static loads, low frequency loads ( $<100$  Hz), and high frequency loads ( $>100$  Hz). These load factors are applicable to CubeSat dispensers loaded with CubeSats that meet the requirements in Section 4.1.1 and have a combined mass of at least 20 kg.

See Table 6-1 and Section 6.7.2 for detailed verification requirements.

**Table 4-1: CubeSat Dispenser (including CubeSats) Quasi-Static Load Factors**

Axial ( $X_{PL}$ ) Load Factor (g)	Lateral (RSS $Y_{PL}$ , $Z_{PL}$ ) Load Factor (g)
10	17

##### 4.1.2.2 QUASI-STATIC LOAD FACTORS FOR MICROSATS AND SMALLSATS

Payload maximum predicted design load factors are shown in Figure 4-1 as a function of Payload mass. These load factors are defined as “combined loads,” which include all contributions from static loads, low frequency loads ( $<100$  Hz), and high frequency loads ( $>100$  Hz). Port lateral load factors are given as RSS of  $Y_{PL}$  and  $Z_{PL}$  lateral accelerations.

These load factors are applicable to payloads  $<60$  kg with a primary bending mode between 40-200 Hz and  $>60$  kg with a primary bending mode between 40-100 Hz. Contact SpaceX if your primary mode is above these values.

These loads represent the overall net CG response of a Payload (interface force divided by Payload mass) and should not be utilized for individual internal components, appendage, or Payload Constituent loads.

See Table 6-1 and Section 6.7.2 for detailed verification requirements.

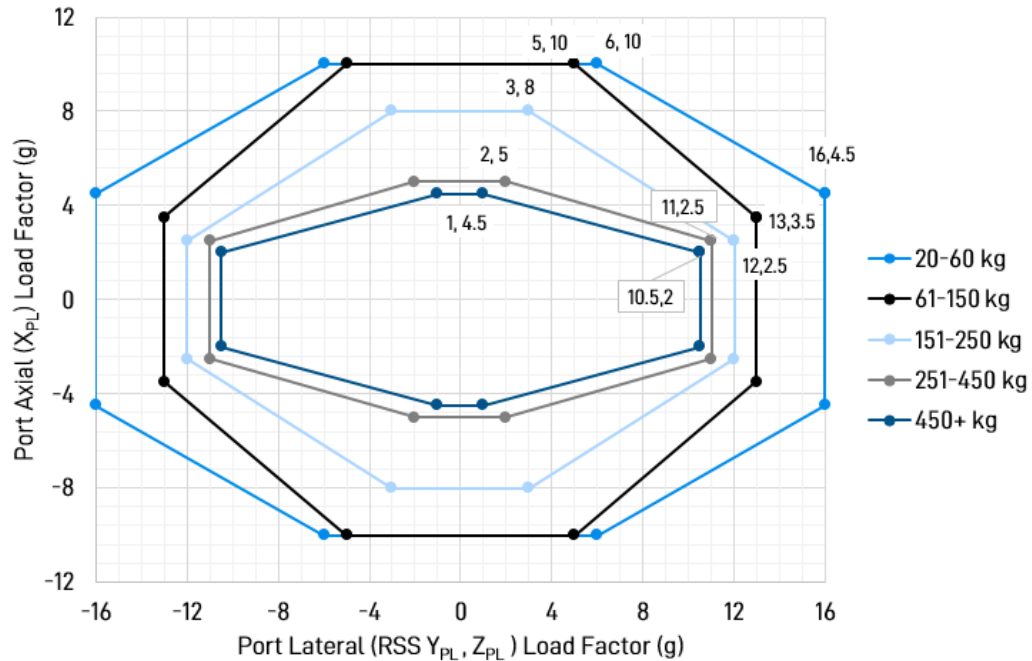


Figure 4-1: Rideshare Plate Payload Quasi-Static Load Factors

#### 4.1.3 SINE VIBRATION

The maximum predicted sine vibration environment is defined in Table 4-2. This environment is defined for Payloads with  $Q \geq 10$  in Rideshare Plate configuration, and may be notched at primary mode(s) to stay within the design load factors defined in Section 4.1.2.

See Table 6-1 and Section 6.7.3 for detailed verification requirements.

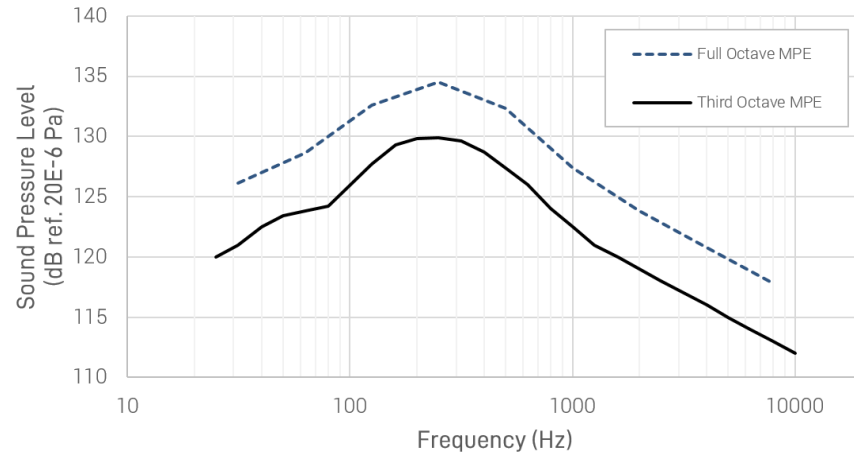
Table 4-2: Maximum Predicted Sinusoidal Vibration Environment

Frequency (Hz)	Sinusoidal Vibration MPE (g)	
	Axial $X_{PL}$	Lateral $Y_{PL}, Z_{PL}$
5	1.4	1.5
100	1.4	1.5

#### 4.1.4 ACOUSTIC

The maximum predicted acoustic environment, defined as the spatial average and derived at a P95/50 level, is shown in Figure 4-2. Table 4-3 and Table 4-4 defines the environment in third octave and full octave, respectively. A Mission-specific analysis will not be provided by SpaceX.

See Table 6-1 and Section 6.7.4 for detailed verification requirements.

**Figure 4-2: Maximum Predicted Acoustic Environment****Table 4-3: Third Octave Acoustic MPE**

Frequency (Hz)	Acoustic MPE
25	120.0
31.5	121.0
40	122.5
50	123.4
63	123.8
80	124.2
100	125.9
125	127.7
160	129.3
200	129.8
250	129.9
315	129.6
400	128.7
500	127.4
630	126.0
800	124.0
1000	122.5
1250	121.0
1600	120.0
2000	119.0
2500	118.0
3150	117.0
4000	116.0
5000	115.0
6300	114.0
8000	113.0
10000	112.0
OASPL (dB)	139.3

**Table 4-4: Full Octave Acoustic MPE**

Frequency (Hz)	Acoustic MPE
31.5	126.1
63	128.6
125	132.6
250	134.5
500	132.3
1000	127.4
2000	123.8
4000	120.8
8000	117.8
OASPL (dB)	139.3



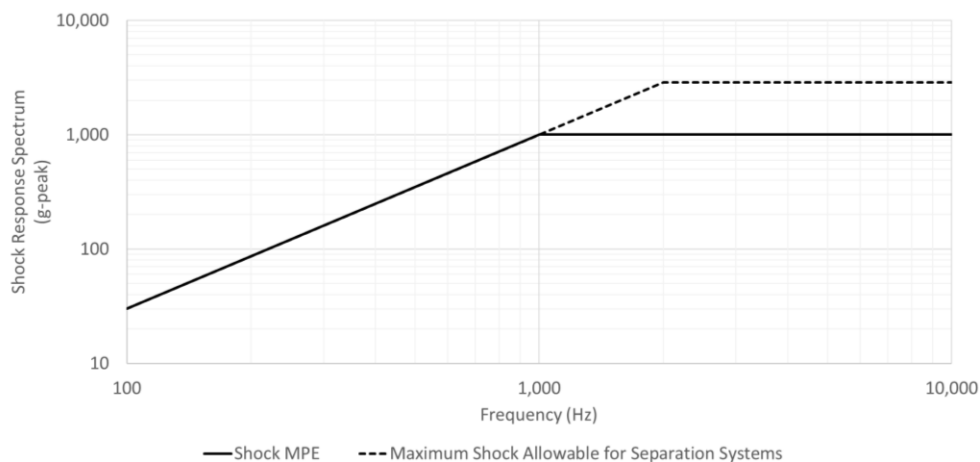
#### 4.1.5 SHOCK

The shock response spectrum MPE, for Q=10, at the Payload mechanical interface for fairing deployment and Co-Payload separation(s), as well as the maximum allowable shock for a single separation system are defined in Table 4-5 and Figure 4-3. These levels are defined assuming a minimum of 3 bolted joints between Co-Payloads. Customers flying mission-unique configurations are encouraged to independently evaluate the shock levels produced by their Payload's separation system. Additional constraints may be imposed if the separation system selected by the Customer exceeds these shock levels. A Mission-specific analysis will not be provided by SpaceX.

See Table 6-1 and Section 6.7.5 for detailed verification requirements.

**Table 4-5: Payload Mechanical Interface Shock**

Frequency (Hz)	MPE Induced by Launch Vehicle and Co-Payload(s) SRS (g)	Maximum Allowable Induced by Payload Separation System SRS (g)
100	30	30
1000	1000	--
1950	--	2850
10000	1000	2850



**Figure 4-3: Payload Mechanical Interface Shock**

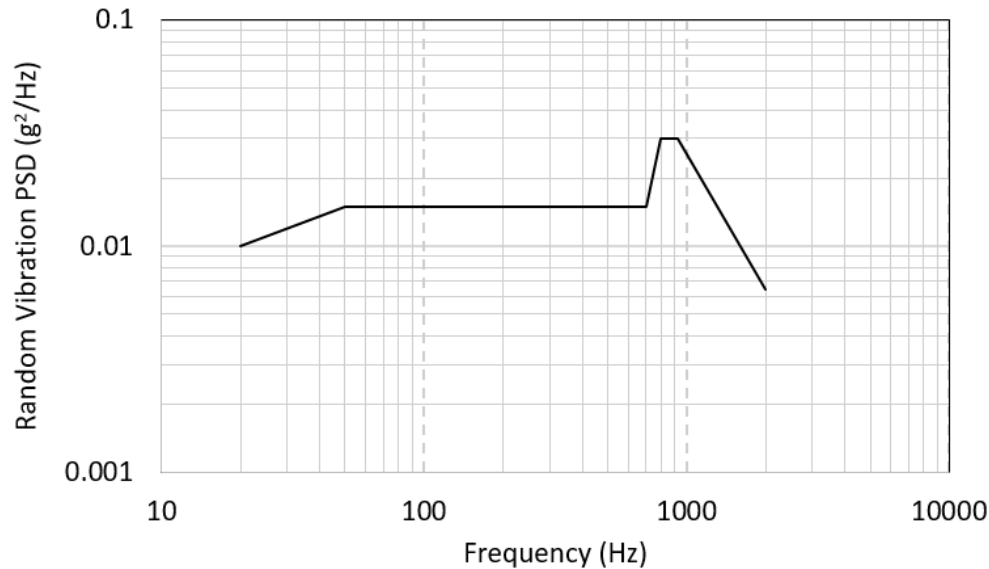
#### 4.1.6 RANDOM VIBRATION

The random vibration MPE for the Payload, derived at a P95/50 level, is defined in Table 4-6 and Figure 4-4.

See Table 6-1 and Section 6.7.6 for detailed verification requirements.

**Table 4-6: Random Vibration MPE**

Frequency (Hz)	Random Vibration MPE (P95/50), All Axes
20	0.01
50	0.015
700	0.015
800	0.03
925	0.03
2000	0.00644
GRMS	5.57



**Figure 4-4: Random Vibration Maximum Predicted Environment**

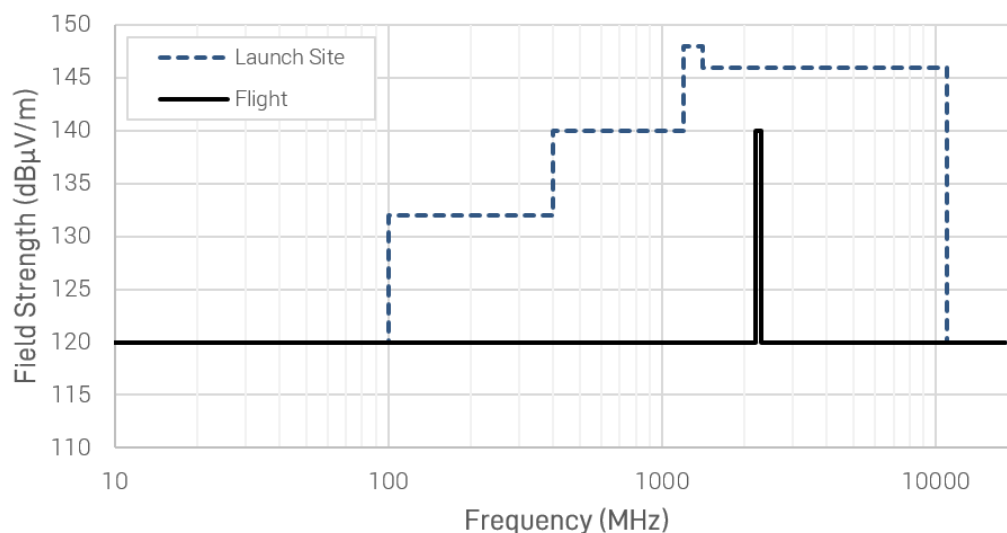
#### 4.1.7 ELECTROMAGNETIC

The Payload must show compliance with the electromagnetic environments in the following sections. See Table 6-1 and Section 6.7.7 for detailed verification requirements.

##### 4.1.7.1 IN-FLIGHT AND PRE-FLIGHT ENVIRONMENTAL EMISSIONS

Customer must ensure that Payload materials or components sensitive to RF environments are compatible with the worst-case radiated environment shown in Figure 4-5. Launch Vehicle, including Co-Payloads, and Launch Site radiated emissions, are shown in Table 4-7 and Table 4-8, respectively. EMI margin is not included.

These limits envelope the expected emissions from the Launch Vehicle, Co-Payloads, and Launch Site radar transmitters. Customer should assume 26 dB of shielding from Launch Site sources when testing and integrating the Payload in either the PPF or the Hangar Annex (CCSFS only).



**Figure 4-5: In-Flight & Environmental Radiated Emissions / Payload Radiated Susceptibility Limit**

**Table 4-7: Launch Vehicle Radiated Emissions**

Frequency Range (MHz)	E-Field Limit (dBμV/m)
1.00 – 2200.0	120
2200.0 – 2300.0	140
2300.0 – 18000.0	120

**Table 4-8: Launch Site Radiated Emissions**

Frequency Range (MHz)	E-Field Limit (dBμV/m)
1.00 – 100	120
100 – 400	132
400 – 1200	140
1200 – 1400	148
1400 – 11000	146
11000 – 18000	120

**4.1.7.2 MAXIMUM PAYLOAD EMISSIONS**

The emission envelope, including 6 dB of EMI safety margin by test, or 12 dB of EMI safety margin by analysis, is shown in Table 4-9. Payloads not flying on dedicated Rideshare missions (such as “Transporter”) may be subject to different maximum payload emission levels and should contact SpaceX for more information.

**Table 4-9: Maximum Payload Emissions**

Frequency Range (MHz)	Maximum Payload Emissions (dBμV/m)	
	by Test	by Analysis
30.00 – 1555.42	90	84
1555.42 – 1595.42	48	42
1595.42 – 18000	90	84

**4.1.7.3 PAYLOAD TRANSMITTER TURN-ON DELAY TIME**

Standard launch services do not permit use of Payload transmitters while integrated to the Launch Vehicle hardware. Payload transmitters may only be enabled after a minimum time after Payload separation, as defined in Table 4-10 (values may be interpolated). Turn-on times apply to Payloads flying on dedicated Rideshare missions (such as “Transporter”); Payloads not flying on dedicated Rideshare missions may be subject to different minimum turn-on delay times and should contact SpaceX for more information.

**Table 4-10: Payload Transmitter Minimum Turn-On Delay Time (seconds after Payload separation)**

EIRP (Watts)		≤0.001	0.01	0.1	1	10	20	100	1000
EIRP (dBm)		0	10	20	30	40	43	50	60
Separation Velocity (m/s)	0.3	1	2	6	19	58	82	183	578
	0.5	1	2	4	11	35	49	110	347
	1.0	1	1	2	6	18	25	55	174
	2.0	1	1	1	3	9	13	28	87
	5.0	1	1	1	2	4	5	11	35

Additionally, any transmitter centered in the following bands must wait to enable these transmitters until “End of Mission,” as defined by the Mission-specific second stage re-entry time (usually a maximum of 1 hour, or 3600 seconds, after the first Payload deploy).

- Band 1: 2206.0 – 2216.0 MHz
- Band 2: 2227.5 – 2237.5 MHz
- Band 3: 2242.5 – 2260.5 MHz
- Band 4: 2267.5 – 2277.5 MHz
- Band 5: 2365.5 – 2375.5 MHz
- Band 6: 2377.5 – 2387.5 MHz



#### 4.1.8 FAIRING INTERNAL PRESSURE

Fairing internal pressure will decay at a rate no larger than 0.40 psi/sec (2.8 kPa/sec) from liftoff through immediately prior to fairing separation, except for brief periods during flight, where the fairing internal pressure will decay at a rate no larger than 0.65 psi/sec (4.5 kPa/sec), for no more than 5 seconds. A Mission-specific analysis will not be provided by SpaceX. In order to meet the fairing internal pressure environments defined in Section 4.1.8, Payloads should be designed such that the enclosed volume to total vent cross-sectional area for all individual volumes does not exceed 400 m. See Section 6.7.8 for detailed verification requirements.

#### 4.1.9 PAYLOAD TEMPERATURE EXPOSURE DURING FLIGHT

The Launch Vehicle fairing is designed such that the temperature seen by the Rideshare Payload never exceeds the temperature profile shown in Figure 4-6. The emissivity of the fairing is approximately 0.9.

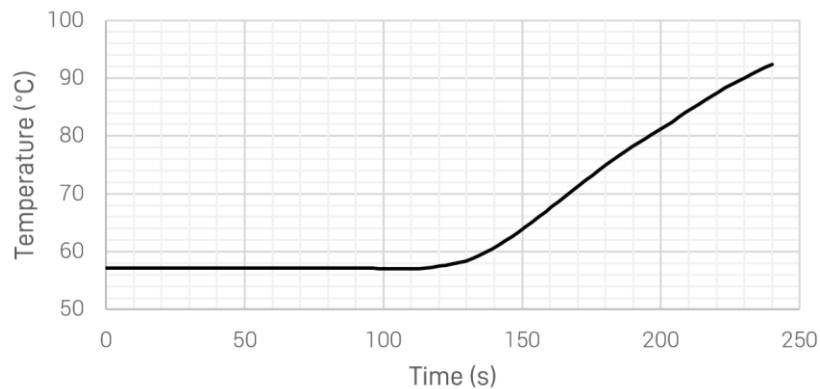


Figure 4-6: Maximum Fairing Spot Temperature Seen by Rideshare Payload

#### 4.1.10 FREE MOLECULAR HEATING

The maximum free molecular aero-thermal heating rate experienced by the Payload is less than 3,500 W/m<sup>2</sup> at fairing separation. This aero-thermal heating declines significantly and becomes negligible over the next couple of minutes.

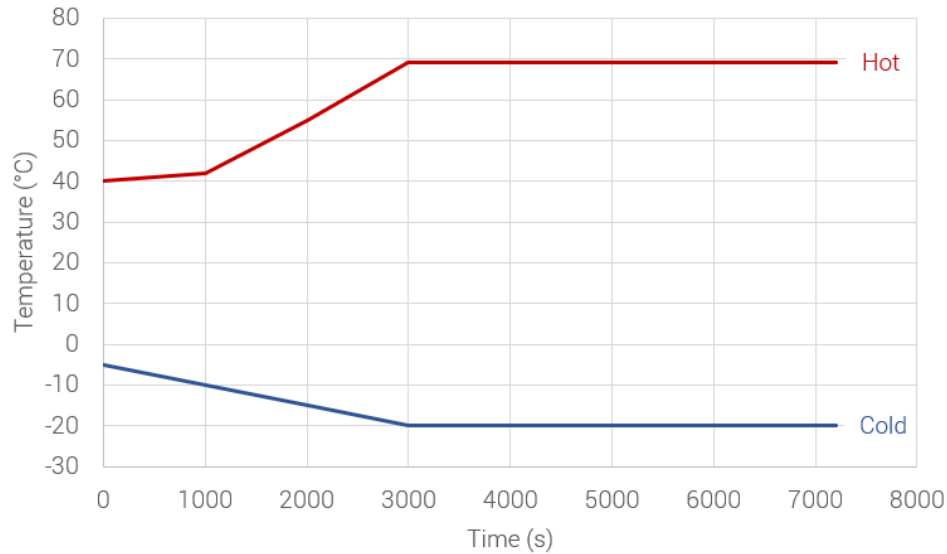
#### 4.1.11 PAYLOAD CONDUCTIVE BOUNDARY TEMPERATURES

Bounding hot and cold boundary temperatures and conductance values at the interface of the Payload and the SpaceX-provided Mechanical Interface are shown in Table 4-11 and Figure 4-7.

Customer may use these boundary conditions to run a Payload-specific thermal analysis. Note that these boundary conditions are only relevant after Liftoff at Time = 0 as they contain analysis uncertainty that is not appropriate on the ground. The convective environment in Table 4-12 fully defines the pre-launch environment. A Mission-specific analysis will not be provided by SpaceX. The values listed below are for the SpaceX side of the interface, no results are provided for the customer side of the interface and the below should not be assumed to be enveloping of Payload temperatures through flight. See Table 6-1 and Section 6.7.8 for detailed verification requirements.

Table 4-11: Bounding Conductive Boundary Temperature and Conductance

Time (s)	Hot Temperature (°C)	Cold Temperature (°C)	Min Conductance (W/°C)	Max Conductance (W/°C)
0	40	-5	0	7.7
1000	42	-10	0	7.7
2000	55	-15	0	7.7
3000	69	-20	0	7.7
7200	69	-20	0	7.7

**Figure 4-7: Bounding Conductive Boundary Temperature**

## 4.2 TRANSPORTATION ENVIRONMENTS

Transportation environments at launch facilities will be enveloped by the flight environments in Section 4.1.

## 4.3 CLEANROOM ENVIRONMENTS

The standard service temperature, humidity and cleanliness environments during various processing phases are provided in Table 4-12.

Conditioned air will only be disconnected for short durations (generally between 30 and 60 minutes) during pre-determined operations such as movements, lifts, and rollout to the pad. Payload environmental temperatures will be maintained above the dew point of the supply air at all times. The SpaceX supplied mechanical interface and fairing surface are cleaned to VC-HS.

**Table 4-12: Temperature and Cleanliness Environments**

Phase	Control System	Temp °C (°F)	Humidity	Cleanliness (class)
Payload Processing	PPF HVAC	21 ± 3 (70 ± 5)	CCSFS/KSC: 45% ± 15% VSFB: 50% ± 15%	100,000 (class 8) or better
Propellant Conditioning and Loading <sup>1</sup>	Facility HVAC			
Transport to Hangar (CCSFS/KSC only)	Transport trailer unit		25% to 60%	
Encapsulated in Hangar	Ducted supply from standalone HVAC unit or transport trailer unit (if required)		CCSFS/KSC: 45% ± 15% VSFB: 50% ± 15%	
Encapsulated Roll-Out to Pad	None (transport trailer unit if required)	No Control System	No Control System	
Encapsulated on Pad (Vertical or Horizontal)	Pad air conditioning	Bulk air temperature will remain between 10 and 32 (50 to 90), targeting 21 (70)	0% <sup>2</sup> to 65%	

1. Payload fueling is available as an optional service (see Appendix I) and is not part of the standard Rideshare services.

2. Supply air is switched to GN2 during the Launch Countdown sequence.





## 5 PAYLOAD DESIGN REQUIREMENTS

### 5.1 DESIGN FACTORS

**Purpose:** To ensure safety and reliability of the Payload, the Launch Vehicle, and personnel present during operations.

Payload systems and structural components, including separation mechanisms, should hold to the minimum design factors shown in Table 5-1 and Table 5-2. Customers should use the peaking factor table to account for additional load peaking when determining the compatibility of Payloads with their selected separation system. Peaking factors from the Launch Vehicle, the separation system, and the Payload are compounding.

**Table 5-1: Factors of Safety**

Factor of Safety	Min design factor
Yield (flight, ground)	1.10
Joint gap and slip (interfaces)	1.10
Ultimate (flight)	1.25
Ultimate (ground operations)	1.40

**Table 5-2: Peaking Factors**

Peaking factor	Min design factor
Launch vehicle interface	1.25
Separation system interface	Variable <sup>1</sup>
1. Consult separation system User's Guide for guidance on peaking factor	

### 5.2 FASTENERS AND CABLE TIES

#### 5.2.1 REWORKED PAYLOAD FASTENERS

**Purpose:** To ensure the structural integrity of the Payload and any parts replaced on a Payload after exposure to environments designed to qualify and/or screen structural load paths and secondary structures. Any fasteners removed and reworked after environmental testing must meet the acceptance criteria given in Table 5-3.

See Section 6.7.10 for detailed verification requirements.

**Table 5-3: Acceptance Criteria for Reworked Fasteners After Environmental Testing**

Criteria	#08 (0.164" diameter) or larger M4 (4 mm diameter) or larger	Between #03 (0.099" diameter) and #08 Between M3 (3 mm diameter) and M4	Smaller than #03 Smaller than M3
Locking features	<ul style="list-style-type: none"><li>Fastener must incorporate a minimum of <b>one locking feature</b> that does not depend upon preload to function. In order of preference:<ul style="list-style-type: none"><li>prevailing torque feature like a distorted thread locking nut or patched fastener</li><li>lock wire/lock cable</li><li>staked fastener head with process hardness check</li><li>thread locker with process joint strength check on a representative sample</li><li>cotter pin through each fastener</li></ul></li></ul>	<ul style="list-style-type: none"><li>Fastener must incorporate a minimum of <b>two locking features</b> that do not depend upon preload to function. In order of preference:<ul style="list-style-type: none"><li>prevailing torque feature like a distorted thread locking nut</li><li>tab washer with one mechanical stop on the fastener and one stop on the underlying part</li><li>lock wire/lock cable</li><li>staked fastener head with process hardness check</li><li>cotter pin through each fastener</li></ul></li></ul>	Not allowed
Thread engagement	<ul style="list-style-type: none"><li>Fasteners installed in <b>through-holes</b> shall have a minimum acceptable thread protrusion beyond the end of a nut or nut plate of <b>two</b> thread pitches. This ensures that all of the fully formed threads on the fastener can carry load.</li><li>Fasteners threaded into <b>blind holes</b> shall be selected to prevent contacting the bottom of the hole or interfering with incomplete internal threads</li></ul>		
Installation	<ul style="list-style-type: none"><li>Fasteners must be installed by means of an installation procedure that uses a calibrated torque tool, measures installation torque, and verifies retention is functional (e.g. measures prevailing torque and compares to limits, visual verification on lock wire/cable, test coupon for thread locker to test breakaway torque, etc.)</li></ul>		



- Fastener rework should be kept to a minimum, and Payload providers should ensure that the Payload is tested in its integrated state to the fullest extent. If more than **twenty fasteners** are reworked on a Payload (within guidelines set out above), a penalty vibe acceptance test will be required. The intent is to allow for one access panel to be removed and replaced for inspection/instrumentation access post vibe and/or multiple deployment devices to be reset.
- Fasteners reworked to reset deployable devices such as ejectors, microlatches, and other HDRMs must follow the guidance set out by the manufacturer of the device and the acceptance criteria in Table 5-3. For these devices, a minimum of one locking feature is required for reworked fasteners #03/M3 or larger. The locking feature must be selected to maintain the correct function of the deployment device.
- The following fasteners are exempt from the rework criteria set out above and do not count towards the number of fasteners reworked (best practices on secondary retention features and installation methods still apply):
  - Fasteners used to reattach access panels mounted on fully containerized CubeSats
  - Fasteners securing non-structural components that are fully containerized within the Payload or an enclosure

### 5.2.2 FASTENERS ATTACHING TO SPACEX HARDWARE

**Purpose:** To ensure the structural integrity of the Payload and of Launch Vehicle hardware, once mated.

Any fasteners used to mate the Payload to SpaceX hardware must meet the requirements shown in Table 5-4. Contact SpaceX for more information on recommended fastener types and/or part numbers.

**Table 5-4: Acceptance Criteria for Fasteners Attaching to SpaceX Hardware**

Fastener size	Per standard interface
Locking features	<ul style="list-style-type: none"><li>• Fastener must incorporate a minimum of <b>one locking feature</b> that do not depend upon preload to function. In order of preference:<ul style="list-style-type: none"><li>○ prevailing torque feature like a nut plate, distorted thread locking nut or patched fastener</li><li>○ lock wire/lock cable</li><li>○ staked fastener head with process hardness check</li><li>○ thread locker with proper application process hardness check</li></ul></li></ul>
Thread engagement	<ul style="list-style-type: none"><li>• Fasteners installed in <b>through-holes</b> shall have a minimum acceptable thread protrusion beyond the end of a nut or nut plate of <b>two</b> thread pitches. This ensures that all of the fully formed threads on the fastener can carry load.</li><li>• Fasteners threaded into <b>blind holes</b> shall be selected to prevent contacting the bottom of the hole or interfering with incomplete internal threads</li></ul>
Installation	<ul style="list-style-type: none"><li>• Fasteners must be installed by means of an installation procedure that uses a calibrated torque tool, measures installation torque, and verifies retention is functional (e.g. measures prevailing torque and compares to limits, visual verification on lock wire/cable, test coupon for thread locker to test breakaway torque, etc.)</li></ul>

### 5.2.3 CABLE TIES

All cable ties intended for flight must be non-removable preferably made from Nylon 6/6 or ETFE/Tefzel and must be included in vibration testing. Removable cable ties are only for temporary use during in-process harness routing and must be removed before flight. Contact SpaceX for recommended part numbers.

## 5.3 MATERIALS AND CONTAMINATION

**Purpose:** To limit the contamination of the Payload to Co-Payload(s) and the Launch Vehicle.

Payloads must meet the materials and contamination requirements defined in Table 5-5.



Fully containerized CubeSats are exempt from requirements on Visual Cleanliness, Non-Metallic Materials, Metallic Materials, and Silicone Sensitivity (all requirements still apply to the CubeSat dispensers).

See Section 6.7.11 for detailed verification requirements.

**Table 5-5: Payload Materials and Contamination Requirements**

Requirement	Description
Visual Cleanliness	Payloads must be cleaned to VC-HS standards per NASA-SN-C-005D prior to integration onto Launch Vehicle hardware.
Non-Metallic Materials	<p>Each individual non-metallic material used in the construction of the Payload that will be exposed to vacuum must satisfy the following quantities, when tested per ASTM E-595:</p> <ul style="list-style-type: none"><li>• <math>RML \leq 1.0\%</math> (<math>RML = TML - WVR</math>), <b>AND</b></li><li>• <math>CVCM \leq 0.1\%</math></li></ul> <p>If WVR is unknown, then assume <math>WVR = 0\%</math></p> <p>To comply with this requirement, Customers should avoid the use of markers, pens, and paint pens to mark Payload hardware. If markers are required for use, for instance for torque striping, SpaceX encourages the use of Mighty Marker MM07/MM08 black. Sharpie markers are prohibited.</p> <p>Exceptions to this requirement are allowed using the rationale codes as given in 6.7.11. Rationale codes will be evaluated by SpaceX.</p>
Metallic Materials	The selection of metallic materials by the Customer will include consideration of corrosion, wear products, shedding, and flaking in order to reduce particulate contamination. Dissimilar metals in contact will be avoided unless adequately protected against galvanic corrosion.
Payload Particulate Generation	The Payload will not create particulate during the vibroacoustic ascent environment. Actuation of any Payload mechanisms nearby any Co-Payload(s) or Launch Vehicle Hardware must not create particulate.
Payload Deployment	The Payload deployment system will not include the use of uncontained pyrotechnics (e.g. Frangible nuts).
Payload Propulsion	Payload propulsion systems will not be operated in close proximity (within 1 km) of Co-Payload(s).
Prohibited Materials	<p>The following materials are not to be used on Payload hardware:</p> <ul style="list-style-type: none"><li>• cadmium parts</li><li>• cadmium-plated parts</li><li>• zinc plating</li><li>• mercury, compounds containing mercury</li><li>• pure tin or tin electroplate (except when alloyed with lead, antimony, or bismuth)</li></ul>
Silicone Sensitivity	All silicone rubber or RTV silicones with probability of transfer to Co-Payload(s) or Launch Vehicle hardware will require SpaceX approval, coordination, and notification prior to use.

## 5.4 ISOLATORS

The use of isolated components or assemblies on a Payload is generally discouraged by SpaceX. However, SpaceX may allow, on a case-by-case basis, the use of isolators, provided they meet the following additional design requirements.

- Isolated components & assemblies must meet all requirements of this user's guide, including the requirement on minimum natural frequency
- Isolators must have all-metallic fail-safe features
- Isolated assemblies must be on a pattern of four or more isolators

See Section 6.7.12 for detailed verification requirements.







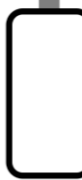
## 5.5 PRESSURE VESSELS AND SYSTEMS

See Section 6.8 for detailed verification requirements regarding pressure vessels and systems.

### 5.5.1 PRESSURE VESSEL SELECTION AND FABRICATION

A pressure vessel is any system containing more than 20,000 J of stored energy (pneumatic and chemical energy) **OR** a MEOP greater than 100 PsiD [6.9 barD]. Large sealed containers that are at atmospheric pressure on the ground are classified as a pressure vessel if they exceed this energy threshold, because of the pressure difference that develops on-orbit. Systems that contain pressure but do not meet the above are considered “pressure components”, “specialized pressurized equipment” or “pressure systems”. Pressure vessel classification and restrictions are shown in Table 5-6.

**Table 5-6: Pressure Vessel Classification and Use Restrictions**

	Type 1	Type 2	Type 3	Type 4	Type 5
					
	All metallic	Metallic liner with composite hoop overwrap	Metallic liner with full composite overwrap	Non-metallic liner with full composite overwrap	All composite pressure vessel (no metallic liner)
Design Standard & Release	AIAA-S-080 (Current approved release)	AIAA-S-081 (Current approved release)	AIAA-S-081 (Current approved release)	AIAA G-082 <sup>1</sup> (Current approved release)	N/A
Restrictions	Consult Section 5.5.4 for material compatibility			<ul style="list-style-type: none"><li>• <b>Use is discouraged</b></li><li>• <b>Some restrictions on fluid eligibility apply.</b> See Section 5.5.4</li></ul>	

1. SpaceX may apply additional requirements beyond those defined in AIAA-G-082. Contact SpaceX for more details.

#### 5.5.1.1 US DOT PRESSURE VESSELS

Pressure vessels that are United States Department of Transportation (US DOT) certified and are operated within their published limits and working fluids are strongly preferred over custom vessels.

#### 5.5.1.2 NON-US DOT PRESSURE VESSELS

Any pressure vessels that are not US DOT classified require a SpaceX review of qualification and acceptance testing and must meet the following requirements:

- No Type 2, 3, 4, or 5 pressurized-structure tanks where non-pressure loading makes up more than 15% of maximum combined flight stress (15% Rule).
- No pressure tanks that require pressure stabilization to hold external structural load.
- Pressurization state of the tank must not change between the time that the Payload is mated to Launch Vehicle hardware and deployment from the Launch Vehicle, as part of the overall Payload inhibit strategy.
- Qualification must include all testing per applicable AIAA document listed in Table 5-6 based on pressure vessel type, and AFSPC 91-710 (section 12).
- Pressure vessels must have a contingency pressure relief valve to vent pressure above personnel safe MEOP while in ground operations.
- Pressure vessels must hold burst factors of safety on pressure per applicable AIAA document listed in Table 5-6 based on pressure vessel type; not below factors defined in Section 6.5 or overall design factors of safety defined in Section 5.1 on all combined loading cases. Vessels that carry significant loads beyond pressure



(pressurized-structure tanks, secondary structure mounts) must include combined loading in qualification testing and demonstrate testing to the combined factors of safety defined in Section 5.1.

### 5.5.2 FULLY INTEGRATED PRESSURE SYSTEMS

A pressure system is any system that is intended to be pressurized beyond 0.5 atmospheres (differential pressure). This includes both pressure vessels and pressure components like valves, fittings, and tubes that have potential to see internal pressure between Customer delivery and on-orbit deployment. A sealed system that is at atmospheric pressure on the ground may be classified as a pressure system, because of the pressure difference that develops on-orbit.

### 5.5.3 SPECIAL PRESSURIZED EQUIPMENT

Specialized pressurized equipment are containers that do not meet the definitions of pressure vessel or pressure system but may be pressurized at any point between Customer delivery and on-orbit deployment. This may include, for example: batteries, heat pipes, cryostats and sealed containers. Special pressurized equipment is subject to the design and test requirements as specified in AIAA-S-080 (current approved release).

### 5.5.4 PROPELLANT AND MATERIAL COMPATIBILITY REQUIREMENTS

Accepted material compatibility and standards are per the following industry accepted design guides:

- Uney, P.E. & Fester, D.A. (1972). *Material Compatibility with Space Storable Propellants Design Guidebook*. Martin Marietta Corporation.
- Johnson, H.T. et al (2005). *Fire, Explosion, Compatibility, and Safety Hazards of Hydrogen Peroxide* (Report No. NASA TM-2005-213151). National Aeronautics and Space Administration.

SpaceX applies the following restrictions:

- **Hypergols usage:** All hypergolic propellants are **prohibited** for use in Type 4 and Type 5 pressure vessels. Contact SpaceX for more information.
- **NTO/Titanium usage:** Titanium usage in an NTO-wetted application is **prohibited**.
- **Cryogenic propellants:** The use of cryogenic fuels and consumables that require loading post encapsulation is **prohibited**.
- **Hydrogen Peroxide:** Hydrogen peroxide, otherwise known as High Test Peroxide (HTP) may be used as propellant but carries additional requirements on design and analysis:
  - A propellant tank relief must be provided to protect the propellant tank from excessive pressure due to HTP decomposition. This relief should be set for no more than 10% above MEOP.
  - The propellant tank must have a MEOP that envelopes the max expected pressure after self-pressurization due to HTP decomposition when the tank is at 32°C, over a 60-day period.
  - The relief outlet should be configured such that there is no danger to personnel in case of tank relief.
  - Tank, and if so equipped, tank positive expulsion diaphragm, must be compatible with HTP. This includes any material on the gas-side of the diaphragm, including tank weldment alloys, tank cleaning agents, etc.
  - To minimize the possibility of reactions, all materials that may come in contact with HTP must be cleaned and passivated, and designs must minimize excessive surface area contact with, and entrapment of, HTP.

Any material combinations outside of this specification require SpaceX approval and may require testing modifications.

## 5.6 SOLID PROPULSION SYSTEMS

**Solid propulsion ion thrusters** are generally acceptable for use and do not have the same restrictions as pressure vessels. Examples of ion thrusters that use solid propellants include gridded electrostatic ion thrusters and field-emission electric propulsion (FEEP). All solid propulsion systems require at least one ignition inhibit. **Solid Rocket Motors** require SpaceX review. SRMs require at least **TWO** ignition inhibits and should be hermetically sealed. Igniters require a Safe/Arm system to protect against accidental firing.



## 6 VERIFICATION

Customer must verify the compatibility of the Payload with the maximum predicted environments defined in Section 4.1. SpaceX will review the Customer's chosen verification approach as well as test results during Mission integration to ensure Mission safety. Where possible, verification methods have been adapted from publicly-available standards such as SMC-S-016, GSFC-STD-7000 (GEVS) and other NASA/AIAA standards.

### 6.1 VERIFICATION TEST APPROACH

SpaceX allows two approaches to environmental verification testing: **Flight Unit Protoflight Qualification Testing** and **Unit/Fleet Qualification and Acceptance Testing**. The protoflight approach is preferred by SpaceX.

1. **Flight Unit Protoflight Qualification (Preferred)**: Each individual Payload flight unit is subjected to protoflight qualification test levels. Testing must be performed at the fully integrated Payload assembly level, even if the Payload consists of multiple smaller Payload Constituents. With this approach the protoflight qualification test validates both structural design and workmanship, while allowing for reduced test factors and durations.
2. **Unit/Fleet Qualification and Acceptance**: A dedicated qualification unit (not flown) is subjected to testing at qualification levels and every flight unit is tested to acceptance test levels. The acceptance tests must be performed at the fully integrated Payload assembly level, even if the Payload consists of multiple smaller Payload Constituents. With this approach the qualification test validates the structural design and design margin while the acceptance test(s) validate workmanship. Payloads using a Unit/Fleet Qualification approach must submit evidence that the qualification unit is identical to the flight unit to the maximum extent practical.

Every Payload flying on a SpaceX Rideshare Mission must undergo either flight unit protoflight environmental verification testing (if following a protoflight qualification approach) or acceptance verification testing (if following a unit/fleet qualification and acceptance approach) at the fully integrated Payload assembly level. **SpaceX does not allow the use of qualification-by-analysis, similarity, or qualification testing on lower levels of assembly as a standalone method of verification.**

The environments verification approach in this section is designed to ensure the safety of Co-Payloads and the Launch Vehicle. Throughout this user's guide, tests that are "Advised" are designed to ensure on-orbit health and functionality of the Payload but are not required in order to fly on a SpaceX Rideshare Mission. Tests that are "Required" must be completed by the Customer to ensure mission safety through Payload separation.

#### 6.1.1 SEPARATION SYSTEM TESTING

Each Payload's flight separation system must be included as part of the fully integrated Payload protoflight qualification or acceptance test campaign.

#### 6.1.2 FUNCTIONAL TESTING

For all Payloads, separation detection circuits must be functionally verified before and after dynamic tests to ensure that a Payload does not inadvertently activate during ascent. Additionally, the Customer must verify that any RF emissions or deployable systems are successfully inhibited while attached to the Launch Vehicle. It is acceptable for these tests to be coupled with the required vibration tests referenced in Table 6-1.

### 6.2 TEST-LIKE-YOU-FLY EXCEPTIONS

For protoflight qualification and acceptance tests performed on the Payload flight unit, test-like-you-fly exceptions **MUST** be approved by SpaceX. Test-like-you-fly exceptions include **ALL** changes from the flight configuration to the test configuration that are not already accepted in this User's Guide. This includes flight firmware, software, and other electrical systems. Rationale for the deviation must be provided to SpaceX. Common examples include:



- Not testing propulsion systems at flight pressure
- Not filling propulsion tanks with reactive propellants during testing
- Deviations in mass, CG, and other physical and dynamic properties (see Section 4.1.2 for allowed deviations)

The following changes are not considered to be test-like-you-fly exceptions for environmental testing, unless they result in noncompliance to other sections of this User's Guide, such as Reworked Fasteners:

- Software changes, as long as these changes do not affect power, deployment timing and/or inhibit systems
- MLI not present

### **6.3 POST-INTEGRATED TEST MODIFICATIONS**

Limited disassembly of the Payload for functional checkouts after the integrated test is allowed, as long as disassembly/rework falls in one or more of the following categories:

- Fastened joints that meet the criteria in Section 5.2.1
- Deployment mechanisms that are deployed and reset using fastener-free resettable devices, such as pin pullers
- Deployment mechanisms that are re-assembled after testing and that demonstrate similar workmanship insensitivity to fasteners, have redundant workmanship controls, or undergo post-reassembly proof testing
- Installation of add-before-flight items, such as fill/drain line caps, connectors and plugs, as long as these items were present during environmental testing, and suitable secondary retention is demonstrated
- Installation of MLI
- Replacement of CubeSat mass dummies with CubeSat flight units in CubeSat dispensers

If a disassembly is performed that does not meet these requirements, a random vibration re-test to acceptance levels per Section 6.5 must be performed in all 3 axes for 1 minute. Workmanship sensitive joints (adhesive, epoxy, brazed, welded, etc.) require a retest if they are modified after testing. Re-assembly after test must follow the fastener installation requirements in Section 5.2.1.

### **6.4 DOCUMENTATION REQUIREMENTS**

Customer must deliver to SpaceX:

- An environmental test approach summary, including test-like-you-fly exceptions, for review by SpaceX prior to Payload testing, as defined in the Payload contract's Statement of Work (SOW). Test approaches that meet the guidance and requirements as specified in this User's Guide do not need to be submitted as deviation requests.
- Propulsion system details, for review by SpaceX prior to Payload testing, according to requirements as specified in Section 6.8 or Section 6.9, if applicable.
- A summary of the verification test results for the completed testing, for review by SpaceX prior to the Launch Campaign Readiness Review, as defined in the SOW and requirements as specified in Section 6.5 and Section 6.7. The summary report must include all test-like-you-fly exceptions for approval by SpaceX, including details on test versus flight boundary conditions, and any hardware not included in the test set up that will be in the flight configuration. If Customer chooses not to complete any "Advised" tests an acknowledgment of the inherent risks to the Payload incurred by not completing the "Advised" testing must be included within the summary report.



## 6.5 PAYLOAD UNIT TEST LEVELS

Payload unit testing must conform to the parameters shown in Table 6-1. Fully containerized CubeSat levels are provided in Table 6-2. The **protoflight qualification approach is preferred** by SpaceX.

**Table 6-1: Payload Unit Test Levels and Durations**

Test	Required/Advised	Unit/Fleet Qualification and Acceptance Approach		Flight Unit
		Qualification	Acceptance Must be performed on fully integrated Payload assembly	Protoflight Qualification Must be performed on each fully integrated Payload assembly
		Unit Not flown	Unit Flown	Unit Flown
Quasi Static Load <sup>1</sup>	REQUIRED	1.25 times the limit load in each of 3 axes	1.1 times the limit load in each of 3 axes	1.25 times the limit load in each of 3 axes
Sine Vibration	Advised	1.25 times limit levels, two octave/minute sweep rate in each of 3 axes	1.0 times limit levels, four octave/minute sweep rate in each of 3 axes	1.25 times limit levels, four octave/minute sweep rate in each of 3 axes
Acoustic	Advised	6 dB above acceptance for 2 minutes	MPE spectrum for 1 minute	3 dB above acceptance for 1 minute
Shock	Advised	6 dB above MPE, 3 times in each of 3 orthogonal axes	Not Required	3 dB above MPE, 2 times in each of 3 orthogonal axes
Random Vibration <sup>2</sup>	REQUIRED	6 dB above acceptance for 2 minutes in each of 3 axes	MPE spectrum for 1 minute in each of 3 axes	3 dB above acceptance for 1 minutes in each of 3 axes
Electromagnetic Compatibility <sup>3</sup>	REQUIRED	6 dB EMISM by Test or 12 dB EMISM by Analysis	Not Required	6 dB EMISM by Test or 12 dB EMISM by Analysis
Combined Thermal Vacuum and Thermal Cycle <sup>4</sup>	Advised	±10 °C beyond acceptance for 27 cycles total	Envelope of MPT and minimum range (-24 to 61 °C) for 14 cycles total	±5 °C beyond acceptance for 20 cycles total
Pressure System <sup>5,6</sup>	REQUIRED	Pressures as specified in Table 6.3.12-2 of SMC-S-016 following acceptance proof pressure test, duration sufficient to collect data. Minimum 2.0 times MEOP.	1.5 times ground MEOP for pressure vessels and pressure components. Other metallic pressurized hardware items per References 4 and 5 from SMC-S-016	See Note 6
System-Level Pressure Leak Test <sup>7</sup>	REQUIRED	Not Required	Full Pressure System MEOP Leak Test per Section 6.8.4	Full Pressure System MEOP Leak Test per Section 6.8.4
Pressure Vessel Leak Test <sup>7</sup>	REQUIRED	Not Required	Pressure Vessel Level MEOP Leak Test per Section 6.8.4	Pressure Vessel Level MEOP Leak Test per Section 6.8.4

1. Static load testing can be achieved through either a sine-burst test or sine sweep test. See Section 6.7.2 for further guidance on test load factors and axes.
2. Random vibration must be conducted as a standalone test. Power inhibits must be verified at an integrated level as part of random vibration testing.
3. EMISM (6 dB by test, 12 dB by analysis) is already included in Table 4-9. See Section 6.7.7 for further guidance on electromagnetic compatibility verification.
4. Thermal cycles can be accrued as a combination of thermal cycling in air and thermal vacuum. It is recommended to include at least four cycles of thermal vacuum unless strong rationale exists that the Payload is not sensitive to vacuum.
5. Pressure systems cannot be protoflight qualified at the Payload level. Pressure systems must therefore be qualified via the fleet qualification approach at the component level. Supplier qualification testing is acceptable in place of fleet level qualification testing if approved by SpaceX. Reference Section 6.8 for additional information.
6. For all Non-US Department of Transportation (US DOT) rated pressure vessels, please contact SpaceX for detailed qualification and testing requirements (reference Section 6.8.1).
7. Pressure Systems that do not meet material compatibility requirements specified in Section 5.5.4 must contact SpaceX for specific leak testing requirements.





## 6.6 FULLY CONTAINERIZED CUBESAT UNIT TEST LEVELS

Fully containerized CubeSats may be tested at the Payload Constituent level using the unit test levels and durations defined in Table 6-2. If these CubeSats are not included in the fully integrated Payload assembly level test (defined in Section 6.5) then mass models must be used in their place to represent the omitted CubeSats. The **protoflight qualification approach is preferred** by SpaceX.

CubeSats are considered fully containerized if there are no holes in the dispenser larger than 0.250" [6.35 mm] in diameter, and holes make up less than 10% of the total surface area of the dispenser. CubeSats utilizing deployment devices that are not fully containerized do not fall within this specification, nor does this section apply to the CubeSat dispenser itself. Both the CubeSat dispenser as well as CubeSats that are not fully-containerized as defined above must be tested at the Payload levels defined in Table 6-1.

**Table 6-2: Containerized CubeSat Unit Test Levels and Durations**

Test	Required/Advised	Unit/Fleet Qualification and Acceptance Approach		Flight Unit
		Qualification	Acceptance	Protoflight Qualification
		Unit Not Flown	Unit Flown	Unit Flown
Quasi Static Load	Not Required			
Sine Vibration				
Acoustic				
Shock	Advised	6 dB above MPE, 3 times in each of 3 orthogonal axes	Not Required	3 dB above MPE, 2 times in each of 3 orthogonal axes
Random Vibration <sup>1</sup>	REQUIRED	3 dB above acceptance for 2 minutes in each of 3 axes	MPE spectrum for 1 minute in each of 3 axes	MPE spectrum for 1 minute in each of 3 axes
Electromagnetic Compatibility <sup>2</sup>	REQUIRED	6 dB EMISM by Test or 12 dB EMISM by Analysis	Not Required	6 dB EMISM by Test or 12 dB EMISM by Analysis
Combined Thermal Vacuum and Thermal Cycle <sup>3</sup>	Advised	±10 °C beyond acceptance for 27 cycles total	Envelope of MPT and minimum range (–24 to 61 °C) for 14 cycles total	±5 °C beyond acceptance for 20 cycles total
Pressure Systems <sup>4,5</sup>	REQUIRED	Pressures as specified in Table 6.3.12-2 of SMC-S-016 following acceptance proof pressure test, duration sufficient to collect data. Minimum 2.0 times MEOP	1.5 times ground MEOP for pressure vessels and pressure components. Other metallic pressurized hardware items per References 4 and 5 from SMC-S-016	See Note 5
System-Level Pressure Leak Test <sup>6</sup>	REQUIRED	Not Required	Full Pressure System MEOP Leak Test per Section 6.8.4	Full Pressure System MEOP Leak Test per Section 6.8.4
Pressure Vessel Leak Test <sup>6</sup>	REQUIRED	Not Required	Pressure Vessel Level MEOP Leak Test per Section 6.8.4	Pressure Vessel Level MEOP Leak Test per Section 6.8.4

1. SpaceX requires random vibration testing on CubeSats to no less than the MPE levels defined in Section 4.1.6, however strongly advises that the MPE is derived from fully integrated Payload assembly level testing. Failure to use derived random vibration levels should be understood by Customer to be an under-test to the expected flight environments, and highlighted in the environmental summary report.
2. EMISM (6 dB by test, 12 dB by analysis) is already included in Table 4-9. See Section 6.7.7 for further guidance on Electromagnetic Compatibility verification
3. Thermal cycles can be accrued as a combination of thermal cycling in air and thermal vacuum. It is recommended to include at least four cycles of thermal vacuum unless strong rationale exists that the Payload is not sensitive to vacuum.
4. Pressure systems cannot be protoflight qualified at the Payload level. Pressure systems must therefore be qualified via the fleet qualification approach at the component level. Supplier qualification testing is acceptable in place of fleet level qualification testing if approved by SpaceX. Reference Section 6.8 for additional information.
5. For all Non-US Department of Transportation (US DOT) rated pressure vessels, please contact SpaceX for detailed qualification and testing requirements (reference Section 6.8.1).
6. Pressure Systems that do not meet material compatibility requirements specified in Section 5.5.4 must contact SpaceX for specific leak testing requirements.



## 6.7 ENVIRONMENTAL VERIFICATION REQUIREMENTS

### 6.7.1 NATURAL FREQUENCIES

**Purpose:** To ensure that the payload's elastic natural frequencies do not couple with the Launch Vehicle.

**Verification:** Testing is **REQUIRED** to verify that the Payload's elastic natural frequencies are all above **40 Hz**. This includes any isolated equipment. Payloads with 4-point interfaces must be tested with SpaceX-provided GSE adapters to represent the Launch Vehicle stiffness, as given in Section 2.6.2. Verification must be achieved through a low-level sine sweep before and after full level environmental testing to determine modal frequencies and assess any changes as a result of full level testing (Table 6-3).

**Table 6-3: Low-Level Sine Sweep Acceptance Criteria**

Low-Level Sine Sweep	
Level	0.1 g (minimum)
Sweep rate	3 oct/min or slower
Test axes <sup>1</sup>	X <sub>PL</sub> , Y <sub>PL</sub> , Z <sub>PL</sub>
Success criteria	<ul style="list-style-type: none"><li>• All modes above 40 Hz</li><li>• &lt; 10% shift in first mode frequency</li><li>• &lt; 30% shift in first mode response</li></ul>

1. For 4-point interfaces required to test in lateral directions other than Y<sub>PL</sub> and Z<sub>PL</sub> (see Table 6-5), it is acceptable to use those test axis directions for low-level sine sweep testing, as an alternative. Customers pursuing this strategy should also report their lowest natural frequency, determined analytically.

### 6.7.2 QUASI STATIC LOADING

**Purpose:** To verify that the Payload's structural load path and interfaces are qualified to the flight environments and to ensure structural integrity of the Payload to Launch Vehicle interface and safety of Co-Passengers.

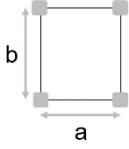
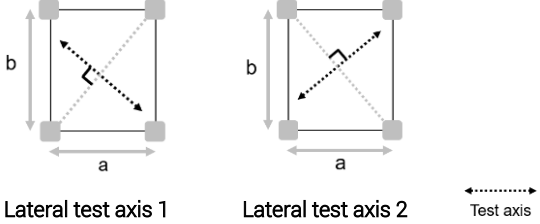
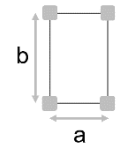
**Verification:** Testing is **REQUIRED** to the quasi-static load test levels and durations defined in Table 6-4 (Load factors) and Table 6-1 (test factors). Static load test requirements can be achieved through either a **sine burst test** (preferred) OR a **sine sweep test**. Test verification using random vibration or static load tests is not permitted. An individual test in three axes must be performed – see Table 6-5 for detailed guidance and acceptance criteria for each accepted method.

As the "port lateral" loads are an RSS of Y<sub>PL</sub> and Z<sub>PL</sub> loads in flight they could be applied in any direction onto the spacecraft in the Y<sub>PL</sub> - Z<sub>PL</sub> plane. If a Payload or separation system is more sensitive to one orientation of load in the Y<sub>PL</sub> - Z<sub>PL</sub> plane, that orientation must be tested or engineering rationale must be provided to SpaceX. If using a 4-point interface, the payload must be oriented such that two interface points see the full test loads. This is because a 4-point interface will see higher interface loads when the lateral load is aligned with two rather than four of the mounts, so testing of the separation system and Payload should reflect this worst-case scenario.

**Table 6-4: Rideshare Plate Payload Minimum Test Load Factors**

Payload Mass	Axial Load Factor (g) X <sub>PL</sub>	Lateral Load Factor (g) See Table 6-5 for required test axes	
		Circular interfaces, CubeSats and 4-points with footprint ratio a/b ≥ 0.6	4-point interfaces with footprint ratio a/b < 0.6
CubeSat Dispenser	10.0	17.0	N/A
20-60 kg	10.0	16.0	18.4
61-150 kg	10.0	13.0	15.0
151-250 kg	8.0	12.0	13.8
251-450 kg	5.0	11.0	12.7
451 kg +	4.5	10.5	12.1

**Table 6-5: Quasi Static Load Verification Test Requirements**

Criteria		Sine Burst Test	Sine Sweep Test
Test parameters		<ul style="list-style-type: none"> <li>Sine burst input frequency &lt; 2/3 of Payload first mode frequency</li> <li>5 cycles at full level minimum</li> </ul>	Sweep rates as specified in Table 6-1 for sine vibration
CG difference between flight and test		$X_{PL}$ direction: Max 10% <sup>1</sup> $Y_{PL}$ , $Z_{PL}$ directions: Max 20%	
Test axes	Circular interfaces & CubeSat Dispensers	Three orthogonal axes: <ul style="list-style-type: none"> <li>Axial payload direction: <math>X_{PL}</math></li> <li>Lateral payload directions: <math>Y_{PL}</math>, <math>Z_{PL}</math></li> </ul>	
	4-point interface with footprint ratio $a/b$ between 0.6 and 1.0 <sup>2</sup> 	Three axes: <ul style="list-style-type: none"> <li>Axial payload direction: <math>X_{PL}</math></li> <li>Lateral payload directions: axes orthogonal to diagonal axes as shown<sup>3</sup></li> </ul> 	
	4-point interface with footprint ratio $a/b$ less than 0.6 <sup>2</sup> 	Three orthogonal axes: <ul style="list-style-type: none"> <li>Axial payload direction: <math>X_{PL}</math></li> <li>Lateral payload directions: <math>Y_{PL}</math>, <math>Z_{PL}</math></li> </ul> <p><b>Note:</b> this interface aspect ratio requires higher test levels, as shown in Table 6-4</p>	
Accelerometer placement		<ul style="list-style-type: none"> <li>At CG (preferred), <b>OR</b></li> <li>Customer to determine accelerometer placement</li> </ul>	
Success criteria		Measured or calculated acceleration at CG achieves target acceleration	

- Significant deviation between as tested and flight CG locations may result in underqualified primary load paths and interfaces. A lower CG in test generally results in an undertest in lateral directions. Customers should aim in the test to replicate as close as possible the CG position of the flight article. If the CG is outside the limit specified, Customers must account for CG differences in test and adjust levels.
- Footprint ratio  $a/b$  is the ratio between the short edge to the long edge of the 4-point interface, as shown in the diagrams. A square interface corresponds to an  $a/b$  ratio of 1.0.
- For a square footprint, the test directions align with the diagonal axes of the Payload. For non-square footprints, the test directions need to be constructed such that they are orthogonal to each diagonal axis. This is designed to exercise each interface to the highest loads that could be seen in flight.

#### Examples:

- a 260 kg Payload mounted to circular interface pursuing a protoflight qualification strategy must show that CG acceleration reaches 6.25 g during test in the axial direction and 13.75 g in each of the  $Y_{PL}$ ,  $Z_{PL}$  lateral directions.
- a 180 kg Payload mounted to a square 4-point interface (aspect ratio of 1.0) must protoflight test to 10 g in the axial direction and 15 g with Payload oriented at 45 degrees to  $Y_{PL}$  and  $Z_{PL}$  lateral directions.
- a 140 kg Payload mounted to a 4-point interface with a footprint aspect ratio of 0.5 must protoflight test to 12.5 g in the axial direction and 18.8 g in the each of the  $Y_{PL}$  and  $Z_{PL}$  lateral directions.



### 6.7.3 SINE VIBRATION

**Purpose:** To ensure Payloads are compatible with loads on primary and secondary structures with modes < 100 Hz.

**Verification:** Testing is ADVISED to the sine vibration test levels and durations defined in Table 6-1 in accordance with the MPE defined in Section 4.1.3.

### 6.7.4 ACOUSTIC

**Purpose:** To ensure Payloads are compatible with acoustic environments inside the Launch Vehicle fairing. Note that most Rideshare sized Payloads are driven by structure-borne random vibration (Section 4.1.6) and not by direct acoustic impingement.

**Verification:** Testing is ADVISED to the acoustic test levels and durations defined in Table 6-1 in accordance with the MPE defined in Section 4.1.4.

### 6.7.5 SHOCK

**Purpose:** To ensure Payloads are compatible with shock environments experienced during flight.

**Verification:** Testing is ADVISED to the shock test levels and durations defined in Table 6-1 in accordance with the MPE defined in Section 4.1.5.

Customers are responsible for verifying compliance to both this requirement and the shock levels for the Payload separation system. To ensure Mission safety for Co-Payloads, separation systems provided by the Customer must be approved by SpaceX (reference Section 6.1.1).

### 6.7.6 RANDOM VIBRATION

**Purpose:** To ensure structural integrity of the Payload during flight dynamic events and to verify power inhibit systems. Exposure to the random vibration environment ensures that primary and secondary structures, Payload Constituents, and smaller components are exposed to flight loads plus margin. This ensures Mission and Co-Payload safety.

**Verification:** Testing is **REQUIRED** to the random vibration test levels and durations defined in Table 6-1 in accordance with the MPE defined in Section 4.1.6. This random vibration test is standalone and **cannot** be used to meet the quasi static loads factors requirement defined in Section 4.1.2. Payloads with 4-point interfaces must be tested with SpaceX-provided GSE adapters to represent the Launch Vehicle stiffness. For 4-point interfaces that conduct strength testing in lateral directions other than  $Y_{PL}$  and  $Z_{PL}$  directions (see Table 6-5), it is acceptable to use those test axis directions for random vibe testing.

In verifying compliance to this requirement, notching of the **primary mode** of the Payload to avoid an over-test is acceptable. Notching is only permitted to prevent the Payload from exceeding the quasi-static load levels defined in Section 4.1.2. SpaceX recommends the use of the following methods for notching, in descending order of preference:

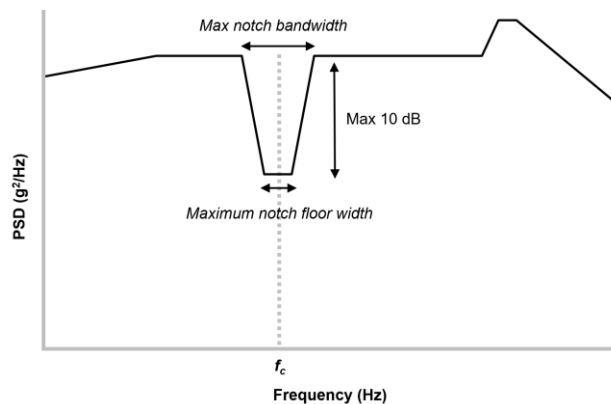
1. **Interface force limiting** (preferred) using triaxial force gages mounted at the spacecraft interface. If mounting force gages below the spacecraft interface, the additional mass above the force gage must be accounted for.
2. **Acceleration response limiting** using a flight correlated analytical model
3. **Manual notching** using limits on bandwidth as shown in Table 6-6 and Figure 6-1

The use of these methods will be reviewed by SpaceX along with final report documentation. Notching must derive force limits per NASA-HDBK-7004C. The following constraints must be followed when using the Semi-Empirical Method:

- $C^2 \geq 5$
- Primary mode maximum notch depth less than 10 dB
- Notching to protect secondary structure or constituent responses is **not permitted** because that would result in an under-test as related to flight environments. A Mission-specific analysis will not be provided by SpaceX.

**Table 6-6: Manual Notch Limits (Primary Mode ONLY)**

Primary Mode Frequency $f_c$ (Hz)	Maximum Notch Bandwidth (Hz)	Maximum Notch Floor Width (Hz)
20 – 40	10	5
41 – 80	20	10
81 – 160	40	20
161 – 320	80	40
321 – 700	100	50
700 – 2000	Notching not allowed	


**Figure 6-1: Manual Notch Limit Definitions (Primary Mode ONLY)**

Random vibration testing may be used to verify that power inhibit systems function as intended.

**IMPORTANT:** In order to verify that power inhibit systems function as expected, all necessary power components **MUST** be fully integrated and in a flight-like state. Batteries must be in their flight-like charge state and any RBF/GSE inhibits must be removed. Verification testing must show that power to the Payload and secondary devices was successfully inhibited from a mechanical separation signal, and not because of other factors such as software delays.

### 6.7.7 ELECTROMAGNETIC

**Purpose:** To ensure that Launch Vehicle and launch site radiated emissions do not compromise the electrical integrity of the Payload, and to ensure that Payload emissions do not compromise safety of the Launch Vehicle or of Co-Payloads.

**Verification:** Testing or verification by analysis is **REQUIRED** to the electromagnetic compatibility test levels and durations defined in Table 6-1 in accordance with the environments defined in Section 4.1.7.

Verification by test may be performed in-house per MIL-STD-461 with supporting test documentation or obtained from an IEC-17025 accredited (or equivalent) test facility. Verification by analysis must provide (1) a mechanical battery isolation inhibit strategy verified in vibrational testing or (2) electromagnetic circuit and wiring emissions analysis. For Payloads with GPS receivers, verification by analysis may be achieved through demonstration of self-compatibility with on-board GPS navigation systems.

### 6.7.8 VENTABLE VOLUMES

**Purpose:** To limit the differential pressure experienced by the Payload to ensure Mission and Co-Payload safety.

**Verification:** Customers are ADVISED to conduct a venting analysis to the environment detailed in Section 4.1.8.



### 6.7.9 THERMAL

**Purpose:** To ensure Payloads are compatible with the thermal environments experienced during flight.

**Verification:** Testing is ADVISED to the combined thermal vacuum and thermal cycle test levels and durations defined in Table 6-1 in accordance with the environments defined in Section 4.1.9.

### 6.7.10 REWORKED FASTENERS

**Purpose:** To ensure that any rework conducted post environmental test verification does not compromise the structural integrity of the Payload or the safety of other Co-Payloads.

**Verification:** Customers are **REQUIRED** to provide details on all reworked fasteners in the final verification test report. Reworked fasteners that comply with Section 5.2.1 do not require prior SpaceX approval for rework, but need to be reported in the test report. Customers should provide the following information:

- Overview of all post-test rework, clearly separating out and indicating which reworked fasteners are compliant to this User Guide and which are not (SpaceX approval required)
- For each, or group of, reworked fasteners installed in a blind hole, provide: fastener diameter, hole depth measurement, fastener length measurement during installation, a close-up photo of the reworked fastener(s), secondary retention method(s), and schematic or photo showing general location of reworked fastener(s)
- For each, or group of, reworked fasteners installed in a through hole, provide: fastener diameter, grip length and protrusion measurement, a close-up photo of the reworked fastener(s), and accompanying schematic or photo showing general location of reworked fastener on the Payload

### 6.7.11 MATERIALS AND CONTAMINATION

**Purpose:** To ensure that the Payload does not contaminate Co-Payloads, Launch Vehicle hardware, or cleanroom environments.

**Verification:** Customers are **REQUIRED** to provide a Payload contamination report. A complete vacuum-exposed non-metallic materials list including quantities (surface area or mass) will be delivered to SpaceX for review. Materials shall be classified according to Table 6-7.

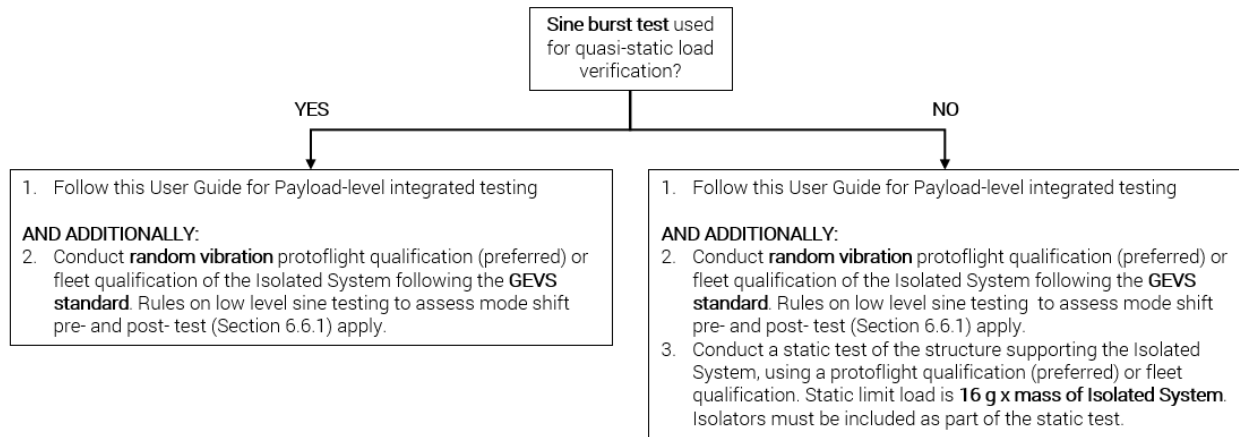
**Table 6-7: Non-Metallic Materials Classification**

Criteria	Additional criteria	Rationale Code
RML < 1.0% <b>and</b> CVCM < 0.1%	None, complies to requirement	-
RML < 3.0% <b>and</b> CVCM < 0.1%	Exposed area < 2 in <sup>2</sup>	A
RML > 3.0% <b>or</b> CVCM > 0.1%	Exposed area < 0.25 in <sup>2</sup>	B
Any	Meets thermal vacuum stability requirements in configuration	C
Any	Material in hermetically sealed container (leak rate $\leq 10^{-4}$ sccs)	D
Any	Other rationale, customer to add additional slide with rationale	E

### 6.7.12 ISOLATORS

**Purpose:** To ensure the structural integrity of isolated equipment on a Payload.

**Verification:** Customers using isolated assemblies are **REQUIRED** to conduct additional testing as shown in Figure 6-2. The "Isolated System" is defined as inclusive of the component or assembly being isolated and the isolators themselves. If the Isolated System is part of a CubeSat dispenser, it is acceptable to use CubeSat mass dummies for testing.

**Figure 6-2: Isolated System Additional Testing**

## 6.8 VERIFICATION FOR PRESSURE VESSELS AND SYSTEMS

### 6.8.1 PRESSURE VESSEL VERIFICATION REQUIREMENTS

**Purpose:** To verify that pressure vessels are qualified for flight and do not pose a hazard to ground personnel, Co-Passengers, and the Launch Vehicle.

**Verification:** Customers using pressure vessels are **REQUIRED** to provide a) the pressure vessel classification type as detailed in Section 5.5.1 and b) the evidence shown in Table 6-8.

**Table 6-8: Design Verification Requirements for Pressure Vessels**

	US DOT Pressure vessels	Non-US DOT Pressure vessels that meet the 15% Rule	Non-US DOT Pressure vessels that do not meet the 15% Rule
Documentation	<ul style="list-style-type: none"><li>A certificate of conformance from vendor stating vessel maximum design pressure (MDP), including any special permits on the bottle design from vendor.</li><li>A picture of the bottle including the mounting demonstrating a mounting scheme that does not induce significant loading into the bottle (i.e. bottle is not a primary load path for anything besides the bottle itself).</li></ul>	Combined structural loading analysis in SpaceX template for flight including all loading and material assumptions demonstrating that less than 15% of maximum flight stress is from mounting/external loads (to demonstrate that pressure-only testing is sufficient on the pressure vessel).	<b>Either:</b> Static and random vibration qualification of the pressure vessel while pressurized to 1.25 times flight MEOP in flight-like mounting (preferred approach)  <b>OR:</b> analysis report demonstrating complete flight stress coverage between unpressurized vibration/static testing and pressure-only (burst) testing.
Qualification	N/A	Qualification testing strategy including: <ul style="list-style-type: none"><li>vibration</li><li>pressure cycle testing</li><li>residual vessel strength after cycle testing</li><li>leak testing (Reference Section 6.8.4)</li><li>burst</li><li>inspections</li></ul>	
Acceptance	N/A	Acceptance testing strategy and per-vessel proof test.	



### 6.8.2 PRESSURE SYSTEMS

**Purpose:** To verify that pressure systems and components are qualified for flight and do not pose a hazard to ground personnel, Co-Passengers, and the Launch Vehicle.

**Verification:** For all pressurized systems, Customers are **REQUIRED** to provide the following evidence:

1. Document detailing system design criteria, MEOP derivation for flight and ground cases for all pressurized components, features and pressure vessels, including valve set points and relief device sizing.
2. System schematic using standard P&ID symbols and an (excel) tabulated parts list, including valves, reliefs, transducers, and reference designators for all parts.
3. List of all single point failures in the system.
4. Qualification and acceptance testing for each component of the pressure system and the overall system qualification strategy.
5. Document detailing combined system test-like-you-fly exceptions between test and flight including rationale.

### 6.8.3 PRESSURE SYSTEM MATERIAL COMPATIBILITY

**Purpose:** To verify that pressure system materials are compatible with stored fluids, including propellants.

**Verification:** All Customers are **REQUIRED** to a comprehensive list of pressure system materials for a compatibility assessment and comply with requirements as detailed in Section 5.5.4. The list must include:

- All pressure system materials within the pressure vessel, and all other pressurized components, **AND**
- All working fluids, processing fluids, and expected/potential by-product fluids
- For systems using HTP, the Customer shall additionally provide an analysis predicting the decay rate and subsequent propellant tank pressure increase over a 60-day period. The analysis shall be performed assuming a nominal storage temp of 24°C and a maximum allowable storage temp of 32°C. Customer must provide list of materials that may contact HTP (including gas-side of positive expulsion diaphragm, if used), and must provide evidence that these materials are compatible with HTP

### 6.8.4 LEAK TEST REQUIREMENTS FOR PRESSURE VESSELS AND PRESSURE SYSTEMS

**Purpose:** To verify that pressure vessels and fully integrated pressure systems, including propulsion systems, do not pose a hazard to ground personnel, Co-Passengers, and the Launch Vehicle.

**Verification:** Pressure vessel and fully integrated pressure system testing is **REQUIRED** according to the method and success criteria shown in Table 6-9. Leak testing must be verified, at a minimum, post environmental testing.

Pressure system tests must take proper precautions to ensure safety. Documentation must be submitted to SpaceX in order to evaluate conformance. All non-conforming material compatibility pressure vessels (see Section 6.8.3) must contact their SpaceX representative for special leak test requirements.



**Table 6-9: Test Methods and Requirements for Pressure Vessels and Systems**

	Pressure Vessel	Fully Integrated Pressure System
Pressure	MEOP	MEOP
Test fluid	<ul style="list-style-type: none"><li>If working fluid is gaseous helium: <b>100% Helium</b></li><li>If working fluid is not gaseous helium or is a liquid: <b>100% Nitrogen</b>, if working fluid has a higher molecular weight</li></ul>	<ul style="list-style-type: none"><li>If working fluid is gaseous helium: <b>100% Helium</b> <sup>1</sup></li><li>If working fluid is not gaseous helium: <b>Flight system working fluid or 100% Nitrogen</b></li><li>If working fluid is a liquid: <b>100% Nitrogen</b></li></ul>
Method	Fully <b>submerge</b> pressurized vessel in water  <b>Verification:</b>  Continuous video of full water surface and each fitting and connection individually (acceptable for video to show multiple areas within the minimum duration)  <b>Success criterion:</b>  No bubbles  (Max 10 <sup>-4</sup> sccs leak rate)	Coat all fittings and connections with <b>Snoop</b> <sup>2</sup>  <b>Verification:</b>  Close-up video of each fitting and connection individually (acceptable for video to show multiple areas of the system within the minimum duration)  <b>Success criterion:</b>  No bubbles  (Max 10 <sup>-4</sup> sccs leak rate)
Min Duration	1 hour	5 min

1. If 100% Helium cannot be used, a minimum helium mix of 10% Helium/90% Nitrogen or 100% Nitrogen is allowed.
2. Ask a SpaceX representative to verify acceptable equivalents.

## 6.9 VERIFICATION FOR SOLID PROPULSION SYSTEMS

**Purpose:** To verify that solid propulsion systems do not pose a hazard to ground personnel, Co-Passengers, and the Launch Vehicle

**Verification:** For all solid propulsion systems, Customers are **REQUIRED** to provide the following evidence:

1. Description/Schematic of the propulsion system and propellant used
2. Details and verification of the ignition system and inhibit(s). If ignition is controlled by Payload power, demonstration of the electrical ignition inhibit may be combined with the verification of Payload power inhibit (see Section 6.7.6)
3. If system is hermetically sealed, workmanship details of the sealing method

## 6.10 VERIFICATION FOR 4-POINT INTERFACES

**Purpose:** To verify that 4-point interfaces can mechanically mate with the Launch Vehicle without integration issues

**Verification:** For Payloads using 4-point separation systems, Customers are **REQUIRED** to provide a metrology report of their 4-point interface to ensure it complies with the specifications defined in Section 2.6.2.



## 7 AVIONICS AND ELECTRICAL INTERFACES

The Launch Vehicle provides electrical connectivity between the Payload and Customer-provided EGSE prior to Launch. During Launch, the Launch Vehicle provides in-flight separation device initiation and separation. Other Payload commands or interleaved telemetry access is not provided as a standard service.

### 7.1 STANDARD OFFERING INTERFACE

The Launch Vehicle provides an electrical bulkhead located next to each mechanical interface where a Payload is mounted. This bulkhead exposes all of the channels that will be used by the Payload for the Mission. The bulkhead consists of several MIL-STD-1560 connectors which will be specified as part of the Payload-specific ICD.

The number of channels available varies based on the type of channel and mechanical interface defined in the Customer's SOW. Table 7-1 summarizes the maximum available channels per offering.

**Table 7-1: Standard Offering Interface - Maximum Number of Available Channels**

Channel Type <sup>1,2</sup>	Per Quarter Plate	Per Half Plate	Per Full Plate	Per Half XL Plate	Per XL Plate	Per CubeSat Dispenser <sup>3</sup>
Primary Deployment	1	2	6	4	8	4
Secondary Deployment <sup>4</sup>	1	2	6	4	8	4
Breakwire (PL-side loopback)	2	4	12	8	16	8

1. The number of channels listed are the maximum available for a given configuration. Default channel allocations for one contract will be for a single Payload deployment.
2. Additional channels, beyond those needed for a single Payload deployment, (primary, secondary, and breakwire signals) are available as an optional service as described in Appendix I.
3. Number of channels available is per CubeSat dispenser assuming the CubeSat dispenser is mounted to the unique CubeSat plate. Up to 8 CubeSat dispensers can be installed on a CubeSat dispenser plate, for a total number of 32 deployment signals.
4. Secondary deployment channels are paired 1:1 with primary deployment channels.

### 7.2 DEPLOYMENT CHANNEL PROPERTIES

Deployment channels are offered in pairs of primary and secondary commands. One primary and one secondary command must be used for each actuation.

All deployment/separation devices directly interfacing with Launch Vehicle electrical systems must have sufficient reliability to ensure safe deployment. The preferred method of achieving reliability is two independent actuators on separate circuits. Either of these actuators must be capable of independently initiating Payload separation, effectively removing a single point of failure to Launch Vehicle separation. Exceptions to this method are discouraged but can be considered on a case-by-case basis at SpaceX's sole discretion.

All deployments from the Launch Vehicle will be commanded by SpaceX. The use of Customer-provided sequencers for commanding more than one deployment from the Launch Vehicle within the Payload is **prohibited**.

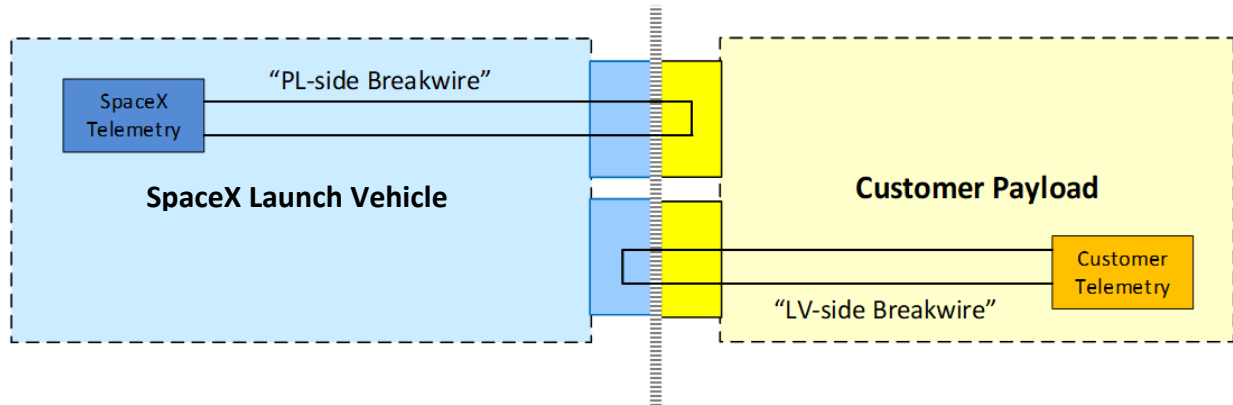
Each deployment command sent by the Launch Vehicle can be configured in one of two ways:

1. Constant-Current Pulse: Used for low-resistance loads, this mode of operation provides up to 6 A of constant current. Specifics of the pulse duration and current setting will be specified as part of the Payload-specific ICD.
2. Bus-Voltage Pulse: Used for high-resistance or motor-driven loads, this mode of operation will provide an unregulated voltage signal between 24-36 V with a maximum current draw of 6 A. Specifics of the pulse duration will be specified as part of the Payload-specific ICD.

The specific configuration of the deployment commands will be determined by SpaceX through analysis and testing of each separation device. The deployment device timing delay from receipt of the Launch Vehicle deployment signal to physical release of the Payload is required to be characterized as < 2 seconds ± 0.5 second uncertainty.

### 7.3 BREAKWIRE CHANNEL PROPERTIES

Breakwire channels are used to determine separation status of the Payload Constituents from the Launch Vehicle. Breakwires are organized into two categories, “PL-side breakwires” which are used by the Launch Vehicle to detect separation and “LV-side breakwires” which are used by the Payload to detect separation. This is illustrated in Figure 7-1.



**Figure 7-1: Illustration of Breakwire Channel Categories**

A minimum of one (1) PL-side breakwire is recommended to be used for each deployment from the Launch Vehicle, SpaceX will evaluate exceptions on a case by case basis. There are no restrictions from SpaceX on the number of LV-side breakwires requested by the Customer.

PL-side breakwire channels must transition from a low resistance state to a high resistance state, or vice-versa. Table 7-2 defines the required properties of each state.

**Table 7-2: PL-Side Breakwire Resistance Requirements**

PL-Side Breakwire State	Resistance Requirement
Low-resistance state	<200 $\Omega$
High-resistance state	>8 k $\Omega$

It is acceptable for either loopback circuits or separation switches to be used for PL-side and LV-side breakwires. The final properties of the PL-side breakwire circuit(s), including the expected transition during deployment, will be captured as part of the Payload-specific ICD.

### 7.4 UMBILICAL CHANNEL PROPERTIES

Umbilical channels offer connectivity between the Payload and Customer EGSE systems. Umbilical channels are offered in “umbilical groups” consisting of six (6) channels. The transmission properties of each of these channels is specified in Table 7-3. Up to two (2) umbilical groups per (Full Plate, XL Plate, or equivalent combination of partial plates), are available as an optional service as described in Appendix I. Contact SpaceX for availability.

**Table 7-3: Umbilical Channel Electrical Properties**

Umbilical Channel Name	Example Usage	Maximum One-Way Resistance ( $\Omega$ )	Maximum Allowable Steady-State Current (A)	Controlled Characteristic Impedance
BATT_CHG_1 BATT_CHG_2	Battery charging	5	3.5	--
BATT_SNS_1 BATT_SNS_2	Battery sensing	13.5	3.5	--
COMM_1 COMM_2	Communication	18	2.5	100 $\Omega$

The “example usage” column in Table 7-3 represents the expected usage of the channel, but is not a requirement. The Customer can use the umbilical signals as required for the Payload, with the following restrictions:

- The electrical properties of the signal must be de-rated to the advertised capabilities of the cable.
- No AC signals may be transmitted.

## 7.5 FLIGHT HARNESS DESIGN

The build responsibility for the harnesses between the Standard Offering Interface and Payload (hereafter referred to as “Customer-specific harnessing”) will be specified as part of the Payload-specific ICD. In general, any harness containing deploy signals will be built by SpaceX, while any harness that exclusively has breakwire and/or umbilical signals will be built by the Customer.

For Customer-specific harnessing built by SpaceX, SpaceX may require the Customer to send SpaceX the flight connectors at the Payload interface.

For Customer-specific harnessing built by the Customer, SpaceX will send the Customer the required flight connectors to interface at the Standard Offering Interface. Customer-specific harnessing built by the Customer must be designed and built in accordance with the Wire Harness Build Guide provided by SpaceX as part of the mission integration process.

In all instances, details of the harness design, including length and routing path, will be determined through routing review meetings between SpaceX and the Customer and documented as part of the Payload-specific ICD.

## 7.6 CONNECTIVITY DURING PAYLOAD PROCESSING

SpaceX accommodates electrical connectivity between Customer EGSE and the Payload during standalone processing. Electrical interfaces will not be available during SpaceX adapter mate, encapsulation, Launch Vehicle integration, and rollout operations. Between these steps, Customers may elect additional connectivity as an optional service as described in Table 7-4.

The Launch Vehicle does not provide power to Rideshare Payloads during Launch operations. All payload systems, including batteries, must be powered off during the Launch phase, except for portions of the circuit used to sense battery inhibits/isolation.

**Table 7-4: Payload Electrical Interface Connectivity**

Phase	Interface Connection	Note
Payload processing (in PPF)	Customer cables directly to Payload	Standard Service
Mate (in PPF)	None	--
Encapsulated (in PPF)	Customer cables to PPF junction box or equivalent interface	Optional Service
Transport to hangar	None	--
Pre-integration (in Hangar)	None	--
LV integration (in Hangar)	None	--
on TE (in Hangar)	Customer cables to hangar junction box or equivalent interface	Optional Service
Rollout	None	--
On pad	Customer cables to pad junction box or equivalent interface	Optional Service
Flight	Separation initiation and indication only	Standard Service



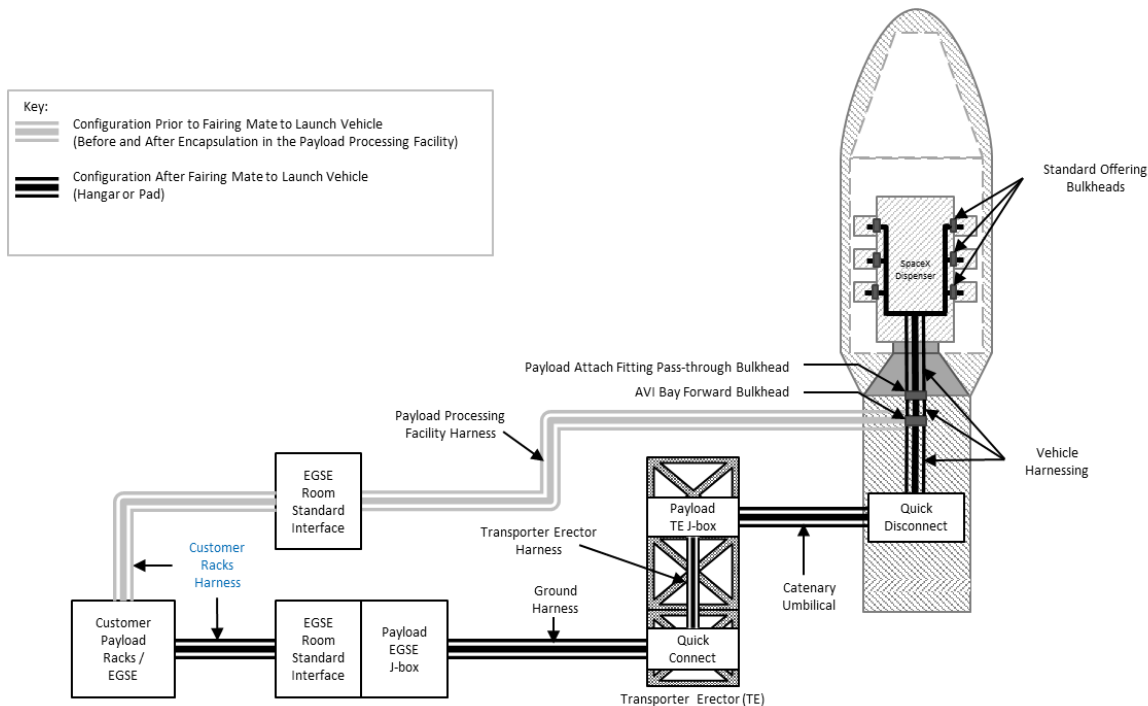
## 7.7 GROUND HARNESS DESIGN

If the Payload is charging in the Launch Vehicle hangar, Customer is expected to provide a 6.1-m (20-ft) harness to connect the Payload EGSE to SpaceX ground systems. SpaceX will supply the Payload EGSE-side electrical connector(s) and any required accessories.

The maximum total cable lengths between the Payload EGSE and the SpaceX payload attach fitting pass through bulkhead are listed in Table 7-5. The total cable length between Payload EGSE and the Standard Offering Interface will be determined during Mission design. The general path is shown in Figure 7-2.

**Table 7-5: Maximum Expected Cable Lengths Between Payload EGSE and Payload Electrical Bulkhead**

Launch Site	PPF	Hangar
VSFB (SLC-4)	37 m (120 ft.)	207 m (679 ft.)
CCSFS (SLC-40)	24.5 m (80 ft.)	196.5 m (644 ft.)
KSC (LC-39A)	24.5 m (80 ft.)	180 m (589 ft.)



**Figure 7-2: Ground Side Electrical Interfaces**

## 7.8 TIMING SERVICES

SpaceX can supply inter-range instrumentation group IRIG-B000 or IRIG-B120 time from its GPS clocks to Customer EGSE at the PPF.

## 7.9 ELECTRICAL INTERFACE COMPATIBILITY

SpaceX may in its sole discretion require an electrical compatibility test between Launch Vehicle avionics and separation devices. This test will confirm the ability of the Launch Vehicle to initiate and detect separation and will use flight-like systems for both the upstream firing circuit and downstream separation system.



## 8 LAUNCH SITE FACILITIES

SpaceX operates Launch Sites at:

1. Space Launch Complex 40 (SLC-40) at Cape Canaveral Space Force Station (CCSFS), Florida
2. Launch Complex 39A (LC-39A) at John F. Kennedy Space Center (KSC), Florida and
3. Space Launch Complex 4 East (SLC-4E) at Vandenberg Space Force Base (VSFB), California.

Details about these Launch Sites can be found in the SpaceX Falcon User's Guide, latest revision, available at [www.spacex.com/vehicles/falcon-9/](http://www.spacex.com/vehicles/falcon-9/).

SpaceX will provide the Launch Site facilities, equipment, documentation, and procedures to receive Customer's hardware, validate interfaces to Customer's hardware, integrate the Payload with the Launch Vehicle, and perform a Launch of the Payload.

### 8.1 FACILITY ACCESS AND WORKING HOURS

SpaceX supports Customer personnel access to Launch Site facilities for two eight-hour working shifts per day, during those portions of the Launch Campaign when Customer's activities require use of a given facility.

SpaceX additionally supports 24/7 access to Launch Site facilities on an as-needed basis for Customer's scheduled activities throughout the campaign, provided such access is coordinated in advance and mutually agreed with SpaceX. SpaceX supports 24/7 access (24 hours per day, 7 days per week) to Launch Site facilities for responding to emergency or off-nominal situations related to flight hardware.

During the Launch Campaign, SpaceX may provide short-term, controlled facility access to SpaceX personnel, SpaceX's contractors, or other third parties (e.g., other customers, potential customers, VIPs, SpaceX-hosted tours). SpaceX is not required to provide Customer advance notice for short-term, controlled access to areas free of Payload or Customer's hardware. SpaceX will provide prior notice and request approval for physical or visual access to areas with Payload or Customer's hardware. At all times, SpaceX will follow Customer proprietary information and security requirements.

### 8.2 CUSTOMER OFFICES

SpaceX provides an office area at the Launch Site during Payload processing. The office area could be shared with Co-Payload Customer(s) and could be located at the PPF or a nearby SpaceX facility. Office accommodations include 100-Mbps-class Internet connection, which may be common with other Customer Internet connections, air conditioning, and standard office equipment such as desks chairs and phones.

### 8.3 SPACEX PAYLOAD PROCESSING FACILITY (PPF)

SpaceX provides a PPF at the Launch Site for the Customer to perform Payload pre-Launch processing activities. Payload and Co-Payload(s) may be co-located in the processing area. The processing area will be defined in a Mission-specific Launch Campaign Plan based on Payload and Co-Payload(s) space requirements. The Payload processing area will:

- a. Operate at ISO 14644-1 Class 8 (Class 100,000) cleanliness.
- b. Operate at 70 °F ± 5 °F air temperature (21 °C ± 3 °C).
- c. Operate at 45% ± 15% relative humidity.
- d. Include 30-ton and 10-ton capacity cranes with 100 ft. (30 m) hook height.
- e. Provide a designated floor space for Payload processing activities defined in the Payload-specific ICD.

The PPF includes an area for Payload EGSE adjacent to the Payload processing area. A 100-Mbps-class Internet connection is provided, which may be common with other Customer Internet connections.



#### **8.4 LAUNCH COMPLEX**

SpaceX provides a Launch Complex including the Launch pad, and related Launch Vehicle GSE. SpaceX provides conditioned air into the fairing including environmental monitoring of the encapsulated Payload when at the Launch pad. In the event of a Launch Site power outage, conditioned air will be resumed on backup power systems within 10 minutes.

#### **8.5 LAUNCH COUNTDOWN MONITORING**

SpaceX may provide Customer personnel (determined on an as-needed basis) a space at the Launch Site for Launch countdown monitoring. Space will be shared between Payload and Co-Payload Customer(s), as documented in the Mission-specific Launch Campaign Plan.



## 9 MISSION INTEGRATION AND SERVICES

### 9.1 CONTRACTING

Rideshare Launch Services are available via direct contract with SpaceX and through certain managed procurement services. To begin your direct contract relationship with SpaceX, please visit [www.spacex.com/rideshare](http://www.spacex.com/rideshare).

### 9.2 US EXPORT AND IMPORT CONTROL LAWS

Provision of all items, information, and services identified in the Agreement by SpaceX to any foreign person (including Customer and/or Customer's Related Third Parties, if applicable) is subject to US export control laws, including the ITAR, administered by the US Department of State, and EAR, administered by the US Department of Commerce. Customer must comply with US export and import control laws, including clearance from US Customs and Border Protection, with respect to the Payload and any Customer provided hardware, including GSE and propellant (if any).

If SpaceX reasonably determines that obtaining a License by either Party is not possible or highly unlikely within a reasonable amount of time, despite commercially reasonable efforts by both parties to do so, SpaceX reserves the right to re-book Customer, with applicable rebooking fees, or terminate the Agreement and return all amounts paid to Customer, without interest, with no further liability.

### 9.3 MISSION MANAGEMENT

To streamline communication and ensure customer satisfaction, SpaceX provides each Launch Services Customer with a single technical point of contact from contract award through Launch (Figure 9-1). Your mission manager will be responsible for coordinating Mission integration analysis and documentation deliverables, planning integration meetings and reports, conducting mission-unique analyses and coordinating all integration and test activities associated with the Mission. The mission manager also coordinates all aspects of Launch Vehicle production, range and range safety integration, and all Mission-required licensing leading up to the Launch Campaign. The mission manager works closely with the Customer, SpaceX technical execution staff and all associated licensing agencies in order to achieve a successful Mission.

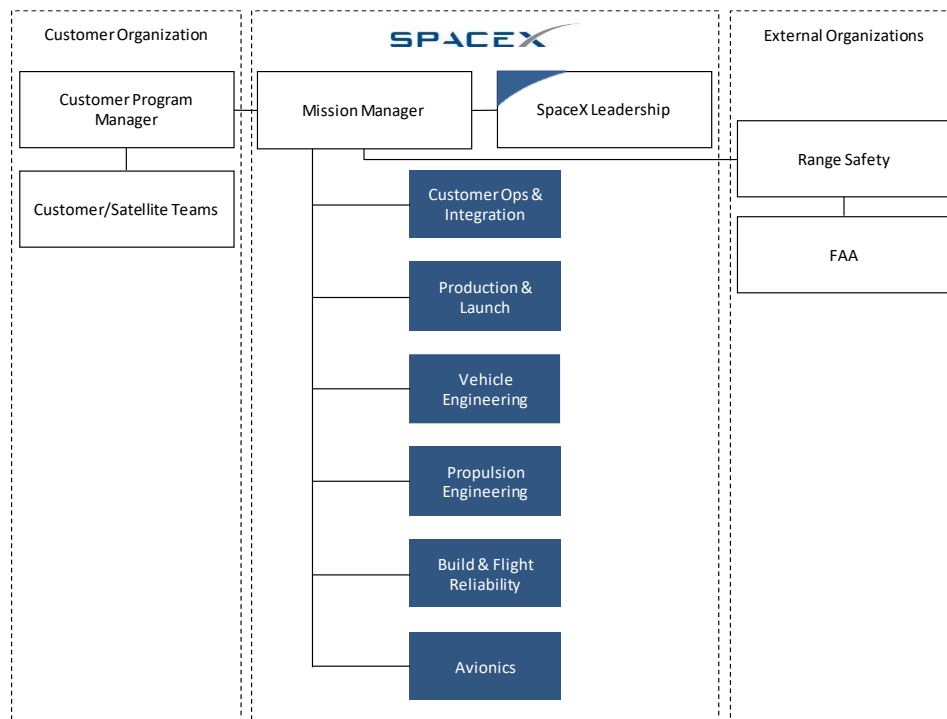


Figure 9-1: Mission Management Organization





## **9.4 PROGRAM DOCUMENTATION**

### **9.4.1 INTERFACE CONTROL DOCUMENT (ICD)**

SpaceX creates and maintains the Payload ICD in conjunction with Customer inputs. The Payload ICD will be negotiated in good faith between the Parties and at a minimum define physical interfaces (mechanical and electrical), functional requirements (orbit, attitude, etc.), Payload MPEs, and Launch operations requirements. Following signature by SpaceX and Customer, the Payload ICD will take precedence (in the event of a conflict) over the Statement of Work. Prior to signature, the Payload ICD is maintained in draft. SpaceX will deliver the Payload ICD for signature following the completion of Mission integration analyses. Once delivered for signature, the Parties will work in good faith to promptly sign the Payload ICD.

### **9.4.2 LAUNCH CAMPAIGN PLAN**

SpaceX provides a Launch Campaign Plan and schedule of Launch Site operations, including required delivery dates for Launch Range-related documentation. SpaceX will coordinate with the Customer to integrate Launch Vehicle and Payload timelines into this plan.

### **9.4.3 PROGRAM STATUS, MEETINGS, WORKING GROUPS AND REVIEWS**

SpaceX will provide program status and conduct meetings, working groups and reviews as described in the following subsections. SpaceX will provide advance copies of deliverables, as noted; otherwise, deliverables will be provided at the time of the corresponding event.

#### **9.4.3.1 INTEGRATION WORKING GROUPS**

SpaceX will organize integration working group meetings on an as-needed basis to address specific issues or operations related to integration of the Payload with the Launch Vehicle. The meeting schedules and locations will be mutually agreed between the Parties.

#### **9.4.3.2 PROGRAM REVIEWS AND MILESTONES**

SpaceX will hold a program review to discuss Launch Campaign readiness at the completion of the Mission integration analysis cycle. Program milestones and timeline are defined in the Payload contract's Statement of Work.

## **9.5 CUSTOMER RESPONSIBILITIES**

Customer responsibilities include the following items. Timely completion is necessary to ensure that SpaceX can fulfill its responsibilities and obligations described in Section 9.6. The Parties understand that any material failure by Customer to meet its responsibilities, including any non-compliance with the Payload ICD, may result in a Customer delay requiring rebooking with applicable fees.

### **9.5.1 TRANSPORTATION & STORAGE**

- Customer is responsible for delivering the Payload and associated GSE to the PPF or other Launch Site facility designated by SpaceX. Customer remains responsible for environmental control of the Payload during Payload delivery, until the Payload is removed from its shipping container, including generators and fuel to maintain environmental control.
- Customer delivers the Payload and GSE to the Launch Site no more than six weeks prior to the Launch Date unless requested by SpaceX. Timing of delivery will be coordinated by SpaceX based on Payload and Co-Payload(s) processing schedule.
- Customer arranges and executes the shipment of the Payload shipping container and all Customer-furnished GSE from the Launch Site no later than three days after Launch.



- Customers are permitted to store no more than one standard shipping container or truck trailer at the Launch site for the duration of their integration activities.
- Customer is responsible for all shipping and logistics of hazardous items from the port of entry to the Launch Site, including the required labeling for storage at the Launch Site.
- Customer is responsible for obtaining any required permits, Licenses, or clearances, including from U.S. Customs and Border Protection for Customer's and Customer's Related Third Parties' hardware and consumables.

### 9.5.2 HARDWARE, PROCESSING AND INTEGRATION

- Customer provides the Payload and all Payload-unique GSE required for Customer's Launch readiness activities at the Launch Site, interfacing to SpaceX hardware at the Launch Site (as defined in the Payload-specific ICD), and ensure that all Payload and Payload-unique GSE meet the appropriate safety requirements, reference Section 11.1.
- Customer will coordinate activities with SpaceX to create an integrated schedule and procedures where necessary.
- Beginning upon Payload arrival at the Launch Site and throughout the Launch Campaign, Customer provides to SpaceX once per working day, an updated Payload processing schedule. The schedule should include a three-day look-ahead summarizing all items requiring SpaceX support, such as: opening processing area doors, SpaceX GSE usage (cranes, forklifts, man lifts, etc.), and any other items requiring SpaceX support. Note also, Payload hazardous operations require 72 hours' advance notice, with precise activity timing, from SpaceX to the Launch Range safety authorities.
- Upon request, Customer will provide SpaceX with access to the flight-mating interface for a mating interface to SpaceX-provided Mechanical Interface fit check after Payload arrival at the Launch Site but before flight mating.
- Customer is responsible for providing all personal protective equipment, such as fall protection harnesses, for Customer and Customer's Related Third Parties at the Launch Site. Customer and Customer's Related Third Parties may not borrow personal protective equipment from SpaceX personnel.
- Customer is responsible for cleaning all Customer-provided equipment and hardware to the appropriate SpaceX-designated contamination-control levels prior to entering SpaceX's cleanliness-controlled facilities at the Launch Site (e.g. the PPF). Standard cleaning products (e.g. isopropyl alcohol and cleanroom wipes) are provided by SpaceX; however, SpaceX personnel will not clean Customer hardware.
- Open air Payload RF checkouts during integration are **prohibited** for safety reasons. RF transmissions are prohibited throughout mating to Launch Vehicle hardware and are only allowed until after Payload separation as defined Section 4.1.7.2.
- The Payload will have access to the electrical harnesses referenced in Section 7 for Payload health checks and battery charging up until Launch Vehicle rollout from the integration hangar to the Launch pad. Additional access to Payload telemetry and battery charging can be procured as an optional service (see Appendix I).

### 9.5.3 HAZARDOUS PROCEDURES

Fueling of Rideshare Payloads at the Launch Site is available as an optional service (see Appendix I), but not part of the standard offering.

- Customer will provide any pressurant and other consumables required by the Payload, including transportation of such consumables to and from the Launch Site. Delivery of all Payload consumables must be coordinated in advance with SpaceX.
- Customer will provide advance copies of all hazardous operation procedures, in addition to a Payload GOP (Ground Operations Plan) which references each hazardous procedure (reference Appendix G). Hazardous



procedures and the GOP are reviewed and approved by the Launch Range safety authority. Customer will also provide copies of any non-hazardous procedures requested by the Launch Range safety authority.

- Customer will arrange for and implement the disposal of hazardous waste generated during Payload processing activities in accordance with Launch Range and facility regulations.
- Customer will provide the necessary decontamination equipment and perform all required decontamination activities for Payload GSE that is contaminated by hazardous substances during Payload processing activities in accordance with Launch Range and facility regulations.
- Fueling of cryogenic propellants or other consumables post encapsulation is not allowed.

#### **9.5.4 ENTRY AND EXIT VISAS**

Customer is responsible for obtaining any visas required for Customer's personnel; including Customer's Related Third Parties and guests. SpaceX can provide letters of invitation for Customer's Launch Campaign personnel to support the issuance of U.S. entry visas by the U.S. Department of State.

#### **9.5.5 ANOMALY, MISHAP, ACCIDENT OR OTHER EVENT**

In the event of an anomaly, mishap, accident or other event resulting in property damage, bodily injury or other loss, Customer will cooperate with SpaceX, any insurers, and federal, state and local government agencies, in their respective investigations of the event, including the completion of witness statements, if applicable. Such cooperation will include providing all data arising out of or related to the Payload, any ground support, and any activities relating to the performance of the Agreement, reasonably requested by SpaceX, the insurers, or federal, state and local agencies. Notwithstanding Customer's obligation to cooperate, SpaceX may use reasonable means to independently access such information. Customer and Customer's customers may not make any public comment, announcement, or other disclosure regarding such event without SpaceX's review and approval.

#### **9.5.6 PAYLOAD LICENSING AND REGISTRATION**

Customer will flow down its responsibilities relating to Payload licensing and registration under the Agreement (including registration pursuant to the Convention on Registration of Objects Launched into Outer Space) to each of its customers, in writing. Evidence of proper flow-down will be provided to SpaceX upon request. Customer will provide a letter in the form of Appendix F, certifying that Customer has obtained all required Licenses and that all Payload information provided to SpaceX and/or any licensing agencies is complete and accurate.

#### **9.5.7 COORDINATION WITH SPACE SITUATIONAL AWARENESS AGENCIES**

Customer is responsible for registering all deployed objects with the 18<sup>th</sup> SPCS to assist with the tracking and identification of all deployed Payload Constituents. More information can be found at <https://www.space-track.org> on how to register a Payload and the process for communicating and coordinating with the 18<sup>th</sup> SPCS. If required, SpaceX can provide direct contact information with personnel from the 18<sup>th</sup> SPCS.

To further aid in U.S. Space Force satellite tracking, identification, cataloging and collision avoidance screening, Customers must publish forward predicted satellite ephemerides and covariance to <https://www.space-track.org> as quickly as possible post Launch. If Customer is unable to generate propagated ephemeris and covariance SpaceX strongly recommends they work with a commercial provider (SpaceX can provide recommendations) to contract for this work. Publishing predicted ephemerides and covariance drastically improves and accelerates the cataloging process by USSPACECOM, as well as enhancing collision avoidance screening.

SpaceX may offer alternative mission insertion altitudes to Payloads that agree to either share GPS/GNSS estimated position and velocity data with SpaceX or a vetted third party, at a pre-determined frequency, no later than 24 hours after deployment or plan to upload propagated ephemerides and covariance to <https://www.space-track.org> no later than 24 hours after deployment. Payloads that either don't have access to on-board GPS/GNSS position and velocity data, or



choose not to share, will be required to deploy to a default mission insertion orbit specified by SpaceX within the contractual range.

Furthermore, SpaceX recommends Customers consider adopting and following the best practices outlined in the NASA Spacecraft Conjunction Assessment and Collision Avoidance Best Practices Handbook, which can be found at [https://nodis3.gsfc.nasa.gov/OCE\\_docs/OCE\\_50.pdf](https://nodis3.gsfc.nasa.gov/OCE_docs/OCE_50.pdf).

## **9.6 SPACEX RESPONSIBILITIES**

SpaceX responsibilities include the following items. The Parties understand that any material failure by SpaceX to meet its responsibilities may result in changes in the scheduling of the Launch Period or Launch Date; such changes are not subject to any Customer rebooking fees.

### **9.6.1 LAUNCH SCHEDULING**

SpaceX will advise the Customer approximately sixty days prior to the start of the Launch Period, of the Launch Date. The above-referenced dates will be determined by SpaceX in its sole discretion.

### **9.6.2 TRANSPORTATION SERVICES**

- SpaceX will provide transportation of the Payload and associated GSE between facilities at the Launch Site. This includes transportation of the Payload from the PPF to the Launch Complex and transportation of hazardous fluids and gasses between facilities at the Launch Site.
- SpaceX will provide Launch Range coordination for Payload and associated GSE transportation activities when at the Launch Site.
- To the extent required by the Launch Range, SpaceX will arrange safety and security escorts for Payload and GSE transportation events at the Launch Site.
- SpaceX will provide transportation for Customer's non-U.S. personnel between a designated off-site parking area and SpaceX Launch Site facilities, and between SpaceX facilities, on a reasonable schedule. U.S. government regulations require that non-U.S. personnel and U.S. personnel representing non-U.S. entities must be escorted while on a U.S. government Launch Site.

### **9.6.3 PAYLOAD INTEGRATION AND ASSOCIATED HARDWARE**

- SpaceX will lead the operations required to physically integrate the Payload with the Launch Vehicle, including any operations involving integrated Payload and Launch Vehicle hardware.
- SpaceX will provide all non-Payload-unique encapsulation equipment, the GSE required to handle the encapsulated Payload, and the GSE required to transport the encapsulated Payload to the Launch Complex.
- SpaceX will provide the equipment to integrate the encapsulated Payload with the Launch Vehicle at the Launch Complex.

### **9.6.4 PHOTOGRAPHIC SERVICES**

At SpaceX's sole discretion, SpaceX may provide still photography and/or videography services during selected Payload processing, testing and integration operations. This service does not include delivery or broadcast of photography or videography in real-time or near real-time.

All media intended for release is subject to Launch Range security procedures, U.S. export control laws, and where applicable, the prior written approval of the U.S. Government. Media that includes images of SpaceX hardware or facilities is also subject to SpaceX's prior written approval for release.

### **9.6.5 SECURITY**

SpaceX provides security via a combination of locked facilities (security card access or cipher locks), closed circuit video monitoring and/or personnel present 24 hours/day at the relevant Launch Site facilities when Customer flight hardware



is present. During any hazardous operations for which the Launch Range safety authority requires non-essential personnel to evacuate, video monitoring will be the sole method of surveillance available. Customer will not be granted access to SpaceX's video footage.

#### **9.6.6 LAUNCH CAMPAIGN**

SpaceX will prepare for and perform a Launch of the Payload. Starting upon Payload arrival at the Launch Site and throughout the Launch Campaign, the SpaceX mission manager will provide to the Customer, at least once per working day, an updated Launch Campaign schedule (including key milestones and joint operations), relevant Launch Range safety status and information, and Launch Vehicle integration status.

SpaceX may conduct one or more Launch Vehicle wet dress rehearsals (inclusive of loading the Launch Vehicle with propellant) and static fire tests (inclusive of first-stage engine ignition) at the Launch pad prior to Launch. SpaceX may perform these operations with encapsulated Rideshare Payloads mated to the Launch Vehicle.

#### **9.6.7 FACILITY SUPPORT AND OPERATIONS**

SpaceX will integrate the scheduling of Payload processing activities with Launch Vehicle processing activities. SpaceX will maintain and communicate the integrated schedules and procedures. In addition, SpaceX will act as the primary point of contact between the Launch Range and the Customer and coordinate all Launch Range support, including the following:

1. Launch Range security and badge control
2. Launch Range scheduling
3. Launch Range system safety
4. Meteorology
5. Communications and timing
6. Fire protection
7. Non-hazardous fluids and gases:
  - a. Gaseous helium per MIL-PRF-27407, Grade A (5700 psi max)
  - b. Gaseous nitrogen per MIL-PRF-27401, Grade A (4150 psi max)
  - c. Compressed Air (120 psi max)
  - d. Isopropyl Alcohol (IPA)

SpaceX will maintain PPF management and scheduling responsibilities throughout the Payload processing and encapsulation phase. As facility manager, SpaceX will require some oversight of Payload activities.

SpaceX will provide training for Customer personnel regarding the PPF (cranes, warning lights, etc.) and applicable Launch Range/facility safety and security procedures. Training will be provided in advance of Payload arrival and offloading at the Launch Site.

#### **9.6.8 LICENSING AND REGISTRATION**

SpaceX will provide to Customer commercially reasonable support and information to enable Customer to satisfy the requirements of all applicable regulatory/licensing agencies and associated statutes, including Launch Range safety, the US Departments of State and Commerce, the US FAA, the US FCC and the CSLA.

Each Party will be responsible for obtaining all Licenses to carry out its obligations under the Agreement. For example, SpaceX is responsible for licensing RF emissions entering free-space from SpaceX-provided hardware and the Customer is responsible for licensing RF emissions entering free-space from Customer-provided hardware.



If Customer or any of Customer's Related Third Parties takes any action or fails to take an action that SpaceX reasonably determines requires delaying any application for or amending any License for which SpaceX is responsible to obtain, SpaceX reserves the right to re-book Customer, with applicable rebooking fees.

#### **9.6.9 MISSION INTEGRATION ANALYSES**

SpaceX will conduct the following analyses in support of the Payload as required. All other environments are verified by Customer using requirements found in Section 4 and verification found in Section 6.

##### **9.6.9.1 TRAJECTORY**

SpaceX performs a trajectory and performance analysis in order to analyze the following Mission parameters:

1. The nominal flight timeline, profile (plots of altitude and acceleration. vs. time), and ground track
2. The free molecular heating environment at fairing jettison
3. The Earth-Centered-Earth-Fixed (ECEF) Payload separation state vector
4. Payload and Co-Payload(s) deploy timeline
5. Orbit injection accuracy

SpaceX analyzes and implements a single Earth-referenced Launch trajectory, a single Earth-referenced ascent attitude profile, and a single Earth-referenced Payload separation attitude, which will be used for all dates and times throughout the Launch Period. SpaceX does not implement multiple trajectories for various dates/times within the Launch Period, and does not provide sun-referenced or inertially-referenced attitudes during ascent or for Payload separation. Results will be provided by SpaceX.

##### **9.6.9.2 COLLISION AVOIDANCE**

SpaceX performs an analysis to determine the need for a collision avoidance maneuver following separation of Payload and Co-Payload(s). This analysis will characterize the relative separation distance between the second stage and the Payload for one orbit after separation. This analysis will assume that no propulsive activities are executed by the Payload during the period analyzed. SpaceX does not perform additional analyses with respect to collision avoidance of potential debris or other space objects. These results will be provided by SpaceX as part of the trajectory and performance results described in Section 9.6.9.1.

SpaceX coordinates with applicable US regulatory authorities, such as the FAA and the Combined Space Operations Center (CSpOC), to select a Launch Window that results in a sufficiently low risk of collision with another space object during the Mission. In order to facilitate this coordination with the regulatory authorities, SpaceX will utilize the separation velocity imposed on the Payload by the separation system as documented in the Payload ICD and position predicted by the Trajectory analysis. Any Payload propulsive maneuvers or secondary Payload deployments within three (3) hours of Launch must be coordinated with SpaceX for inclusion in CSpOC analysis and will be documented in the Payload ICD.

##### **9.6.9.3 COUPLED LOADS**

SpaceX performs a CLA to verify the predicted dynamic flight loads and responses of the Payload are within the MPE described in Sections 4.1.2 and 4.1.3. If any results are found to exceed the MPE described in Sections 4.1.2 and 4.1.3, SpaceX will provide the CLA results to the Customer for further evaluation.

##### **9.6.9.4 PAYLOAD SEPARATION**

SpaceX may perform a separation analysis for MicroSat-class Payload Constituents deploying from the Launch Vehicle to verify the Customer provided analysis as described in Section 3.3. CubeSat deployments from Containerized dispensers are not specifically analyzed; SpaceX instead relies on the separation properties provided by the Customer. These results are used as an input for the collision avoidance analysis. Since Payload mass properties and slosh are



outside of SpaceX's control, SpaceX will evaluate requirements compliance via the ideal analysis case. If required, SpaceX will provide a presentation summarizing the results of the analysis and highlighting any issues or concerns for the Payload.

#### **9.6.9.5 PAYLOAD CLEARANCE**

SpaceX performs a clearance analysis to validate the dynamic envelope compatibility between the Launch Vehicle and the Payload, and the Co-Payload(s) to the Payload, during all phases of the Mission. Clearance analysis results will be provided to the Customer for any Payload in excess of the allowable Payload allowable volume defined in Appendix A.



## 10 OPERATIONS

Launch Vehicle operations are described in this section for launches from CCSFS, KSC, and VSFB. SpaceX launch operations are designed for rapid response (targeting less than one hour from vehicle rollout from the hangar to launch). Customers are strongly encouraged to develop launch readiness capabilities and timelines consistent with a rapid prelaunch concept of operations.

### 10.1 OVERVIEW AND SCHEDULE

The Launch Vehicle system and associated operations have been designed for minimal complexity and minimal time at the pad. Customer Payload processing is performed in the PPF. After completion of standalone Payload operations (over a 7-day period), SpaceX performs the Payload mate to Launch Vehicle hardware followed by fairing encapsulation at the PPF. Payload and Co-Payload arrivals will be scheduled by SpaceX and may be staggered. The encapsulated assembly is then transported to the integration hangar. The Launch Vehicle is processed in the integration hangar at the Launch Complex and then loaded on the TE. The encapsulated assembly is mated to the Launch Vehicle at approximately L-5 days, followed by end-to-end system checkouts. Launch Vehicle systems are designed for rollout and Launch on the same day.

### 10.2 RIDESHARE PAYLOAD DELIVERY AND TRANSPORTATION

Payload and associated GSE must be delivered to the Launch Site by Customer. SpaceX will assist in arranging for Air Force Base access.

### 10.3 RIDESHARE PAYLOAD PROCESSING

SpaceX provides an ISO Class 8 (Class 100,000) PPF for processing Customer Payload, including equipment unloading, unpacking/packing, final assembly, nonhazardous flight preparations, and checkouts. The PPF is available to Customer for two eight-hour working shifts per day. Layouts as well as standard services and equipment available in the PPF for VSFB and CCSFS can be found in the SpaceX Falcon User's Guide, latest revision, available on [www.spacex.com/vehicles/falcon-9/](http://www.spacex.com/vehicles/falcon-9/).

The PPF is also designed to accommodate hazardous operations such as hypergolic propellant loading and ordnance installation. Fueling operations are allowed as an optional service (see Appendix I).

### 10.4 JOINT OPERATIONS AND INTEGRATION

Joint operations begin once Customer has completed the Payload mate to the SpaceX-provided Mechanical Interface, if applicable. Payload to Launch Vehicle hardware mate and fairing encapsulation are performed by SpaceX within the PPF. Fairing encapsulation is performed in the vertical orientation. Transportation is performed in the vertical orientation, and environmental control is provided throughout the transportation activity. Once at the Launch Vehicle integration hangar, the encapsulated assembly is rotated to horizontal and mated with the Launch Vehicle already positioned on the TE.

Once the encapsulated assembly is mated to the Launch Vehicle, the hangar facility HVAC system is connected via a fairing air conditioning duct to maintain environmental control inside the fairing. The Payload and Co-Payload(s) are then reconnected to EGSE (if required) and Customer has a final chance to perform electrical checkouts prior to Launch Vehicle rollout and launch.

### 10.5 LAUNCH OPERATIONS

#### 10.5.1 ORGANIZATION

A breakdown of decision-making roles between SpaceX and the Launch range can be found in SpaceX Falcon User's Guide, latest revision, available on [www.spacex.com/vehicles/falcon-9/](http://www.spacex.com/vehicles/falcon-9/).





### **10.5.2 LAUNCH CONTROL**

Launch countdown monitoring and access to Payload telemetry throughout the Launch countdown is available as an optional service (see Appendix I). Space within the Launch Control Center would be shared between Payload and Co-Payload Customer(s), as documented in a Launch Campaign Plan.

### **10.5.3 ROLLOUT AND PAD OPERATIONS**

After all Payload and Co-Payload(s) EGSE is disconnected and readiness is verified the integrated Launch Vehicle may be rolled out from the hangar to the pad on the TE. Once the Launch Vehicle is at the pad, the fairing air conditioning system is reconnected, which helps maintain environmental control through liftoff. Electrical connectivity is provided via ground cables (reference Section 7.6). The Launch Vehicle will typically be erected only once, although the capability exists to easily return it to a horizontal orientation if necessary.

### **10.5.4 COUNTDOWN**

The Launch Vehicle is designed to support a countdown duration as short as one hour. Early in the countdown, the vehicle performs LOX, RP-1 and pressurant loading, and it executes a series of vehicle and range checkouts. The TE strongback is retracted just prior to launch. Automated software sequencers control all critical Launch Vehicle functions during terminal countdown. Final Launch activities include verifying flight termination system status, transferring to internal power, and activating the transmitters. Engine ignition occurs shortly before liftoff, while the Launch Vehicle is held down at the base via hydraulic clamps. The flight computer evaluates engine ignition and full -power performance during the prelaunch hold-down, and if nominal criteria are satisfied, the hydraulic release system is activated at T-0. A safe shutdown is executed should any off-nominal condition be detected.

### **10.5.5 RECYCLE AND SCRUB**

Launch Vehicle systems and operations have been designed to enable recycle operations when appropriate. Although every recycle event and launch window requirement is unique, the Launch Vehicle offers the general capability to perform multiple recycles within a given launch window, eliminating unnecessary launch delays.

In the event of a launch scrub, the TE and Launch Vehicle will stay vertical. However, for any long-duration Launch postponements, SpaceX will return the Launch Vehicle on the TE to the hangar.

## **10.6 FLIGHT OPERATIONS**

A summary of Launch Vehicle flight operations including Liftoff, Ascent, and Payload Separation can be found in SpaceX Falcon User's Guide, latest revision, available on [www.spacex.com/vehicles/falcon-9/](http://www.spacex.com/vehicles/falcon-9/). SpaceX will provide a quick-look orbit injection report to the Customer shortly after Payload separation, including a best-estimate Payload separation state vector as described in Appendix E. Customer is responsible for tracking and contacting the Payload after separation from the Launch Vehicle.



## **11 SAFETY**

### **11.1 SAFETY REQUIREMENTS**

Customers are required to meet AFSPCMAN 91-710 Range User's Manual in the design and operation of their flight and ground systems. These requirements encompass mechanical design, electrical design, fluid and pressurant systems, lifting and handling systems, ordnance and RF systems, GSE, and other design and operational features. SpaceX will serve as the safety liaison between the Customer and the range and will provide templates for document compliance.

### **11.2 HAZARDOUS SYSTEMS AND OPERATIONS**

Most ranges consider hazardous systems and operations to include ordnance operations, pressurized systems that operate below a 4-to-1 safety factor, lifting operations, operations or systems that include toxic or hazardous materials, high-power RF systems and laser systems, batteries, and a variety of other systems and operations. The details of the system design and its operation will determine whether the system or related operations are considered hazardous. Typically, additional precautions are required for operating systems that are considered hazardous, such as redundant valving between pressurant and propellant. Additional precautions will be determined during the safety approval process with SpaceX and the Launch Range. All hazardous operations require procedures that are approved by both SpaceX and the Launch Range prior to execution. Ordnance operations, in particular, require coordination to provide reduced RF environments, cleared areas, safety support and other requirements.

### **11.3 WAIVERS**

For systems or operations that do not meet safety requirements but are believed to be acceptable for ground operations and launch, a waiver is typically produced for approval by the Launch Range safety authority. Waivers require considerable coordination and are considered a last resort; they should not be considered a standard practice.



## APPENDIX A: MECHANICAL INTERFACES AND VOLUMES

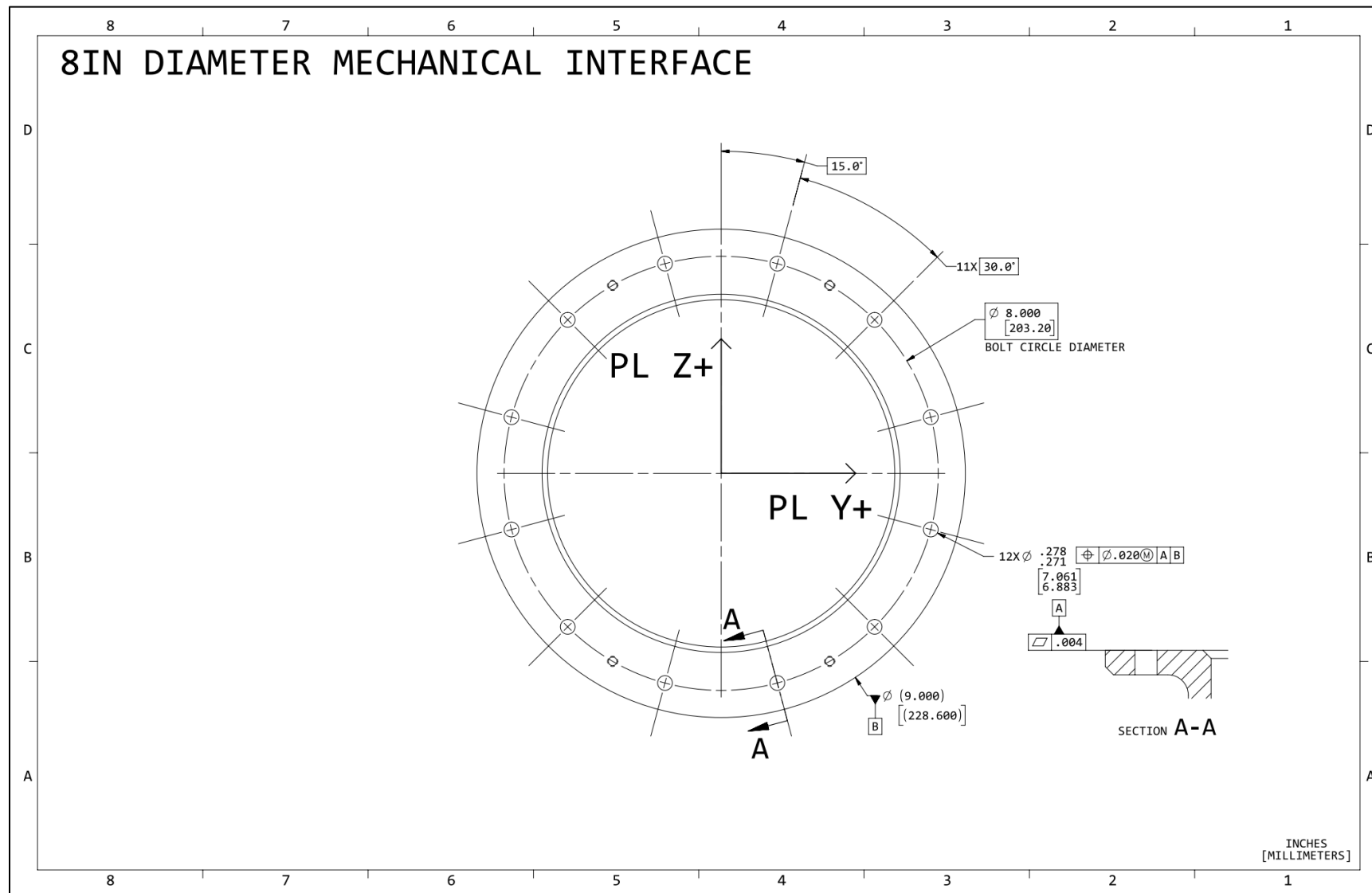


Figure A-1: 8" Diameter Mechanical Interface

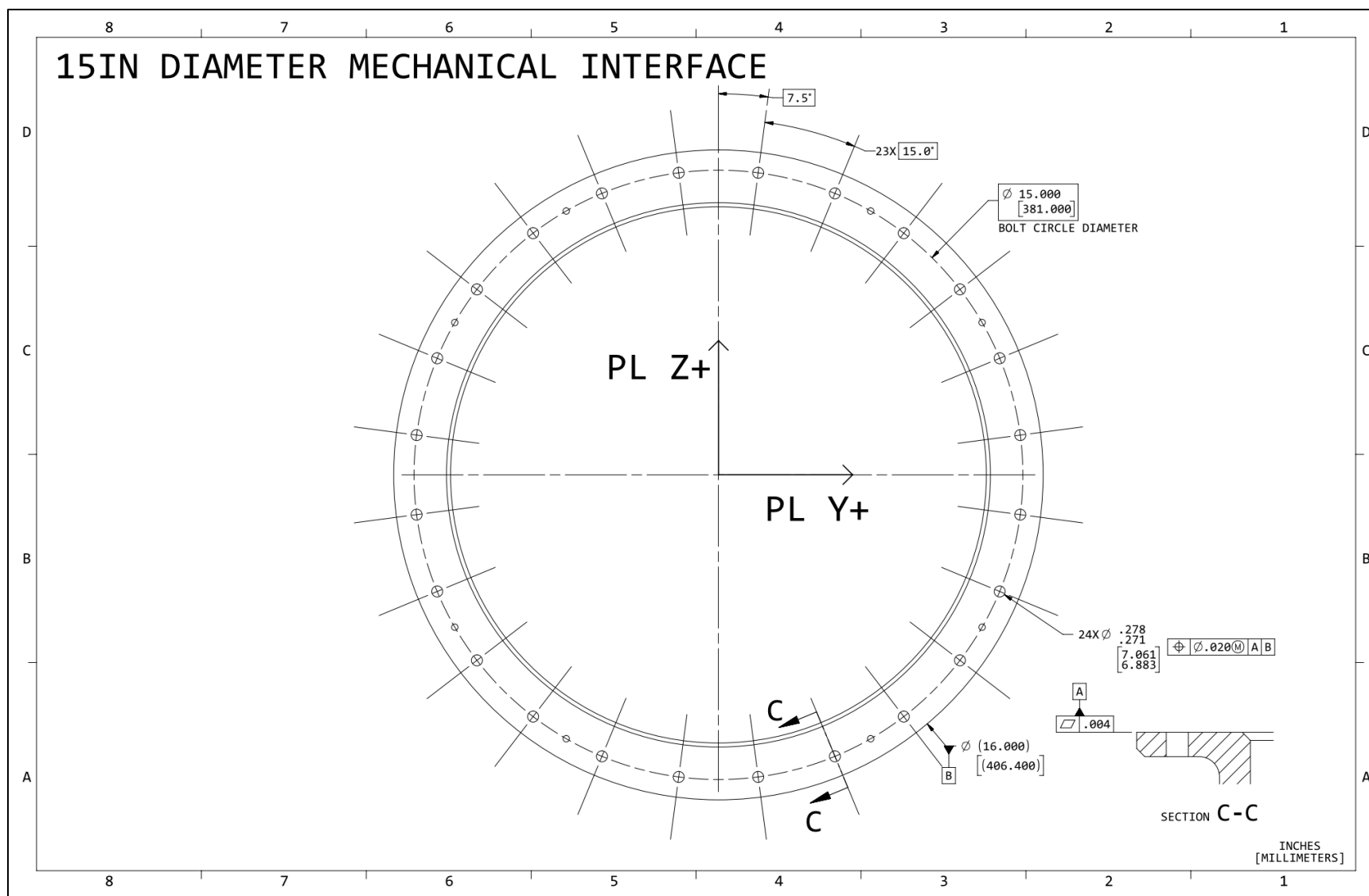


Figure A-2: 15" Diameter Mechanical Interface

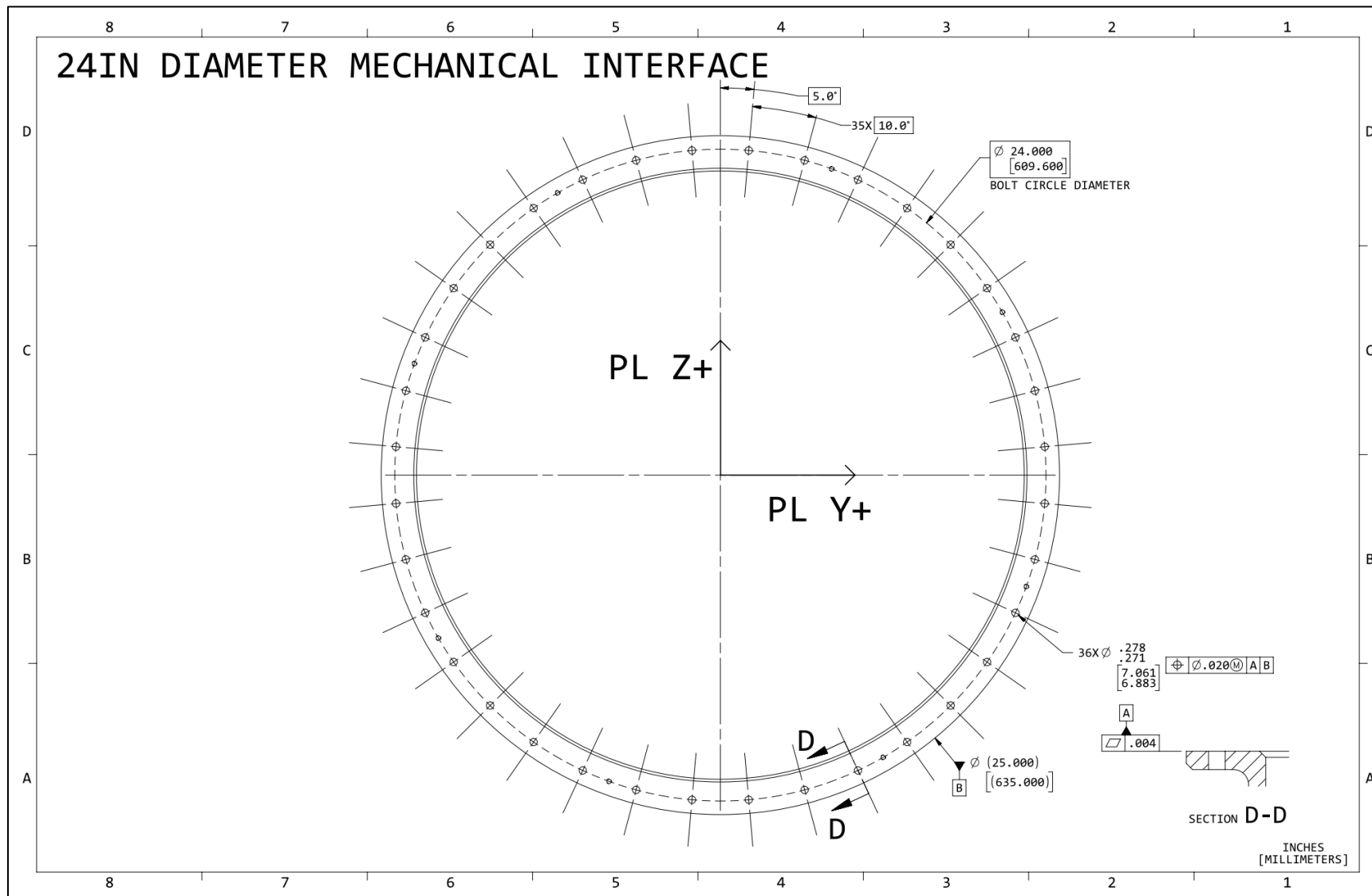


Figure A-3: 24" Diameter Mechanical Interface



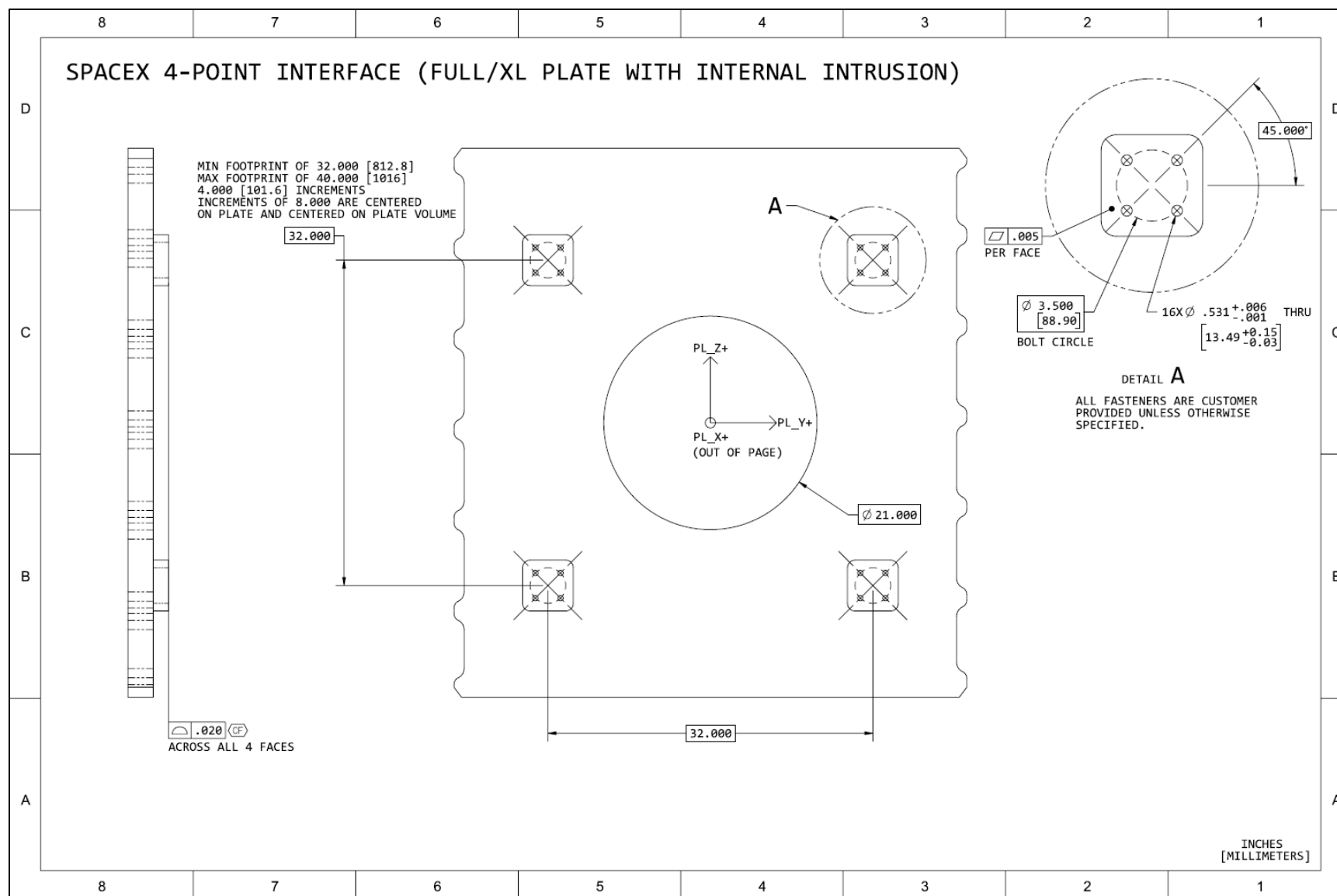
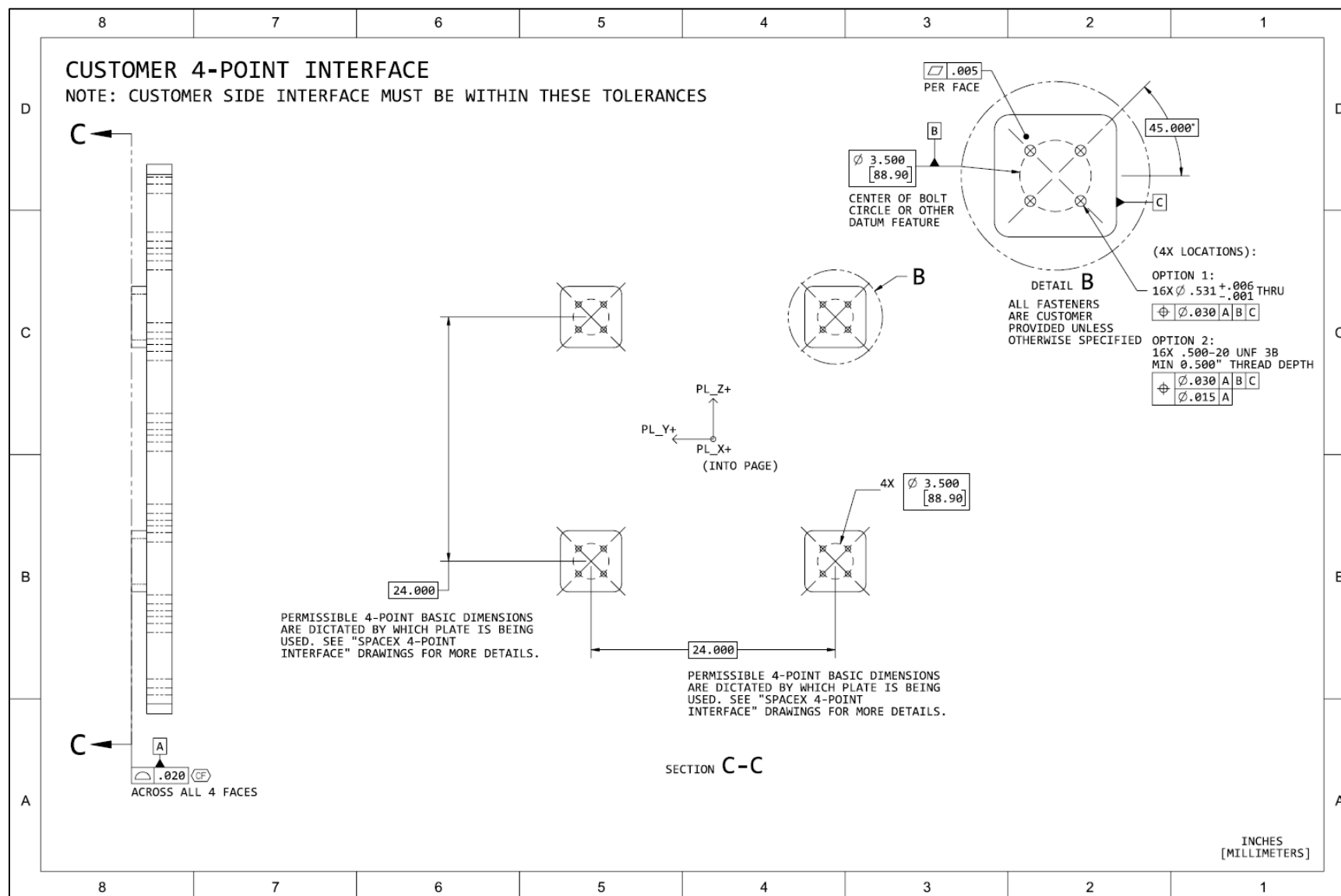


Figure A-5: 4-Point Mechanical Interface (Full / XL Plate with Internal Intrusion)

**Figure A-6: 4-Point Customer-Side Mechanical Interface (All 4-point Interfaces)**



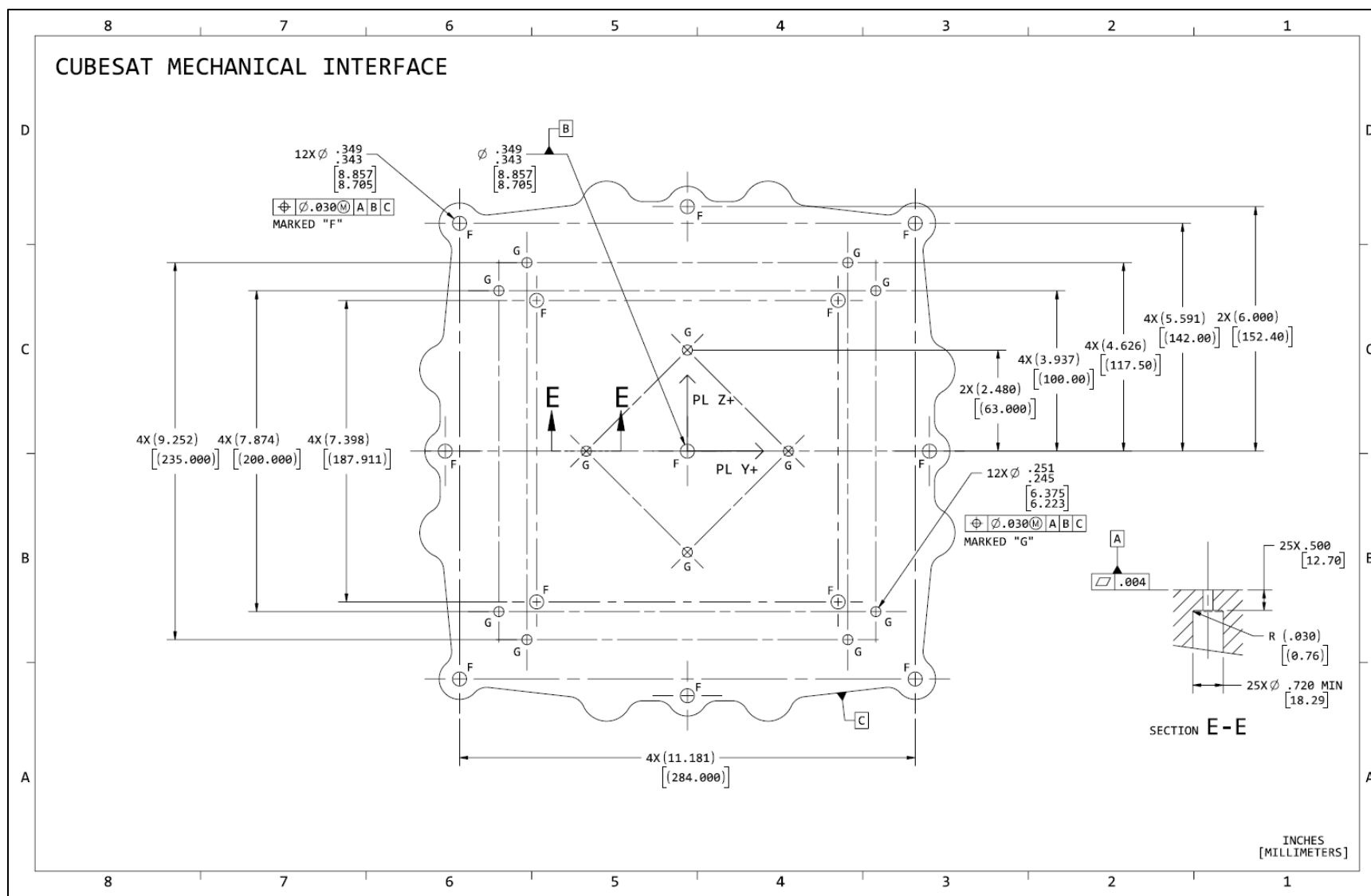


Figure A-7: CubeSat Dispenser Standard Mechanical Interface

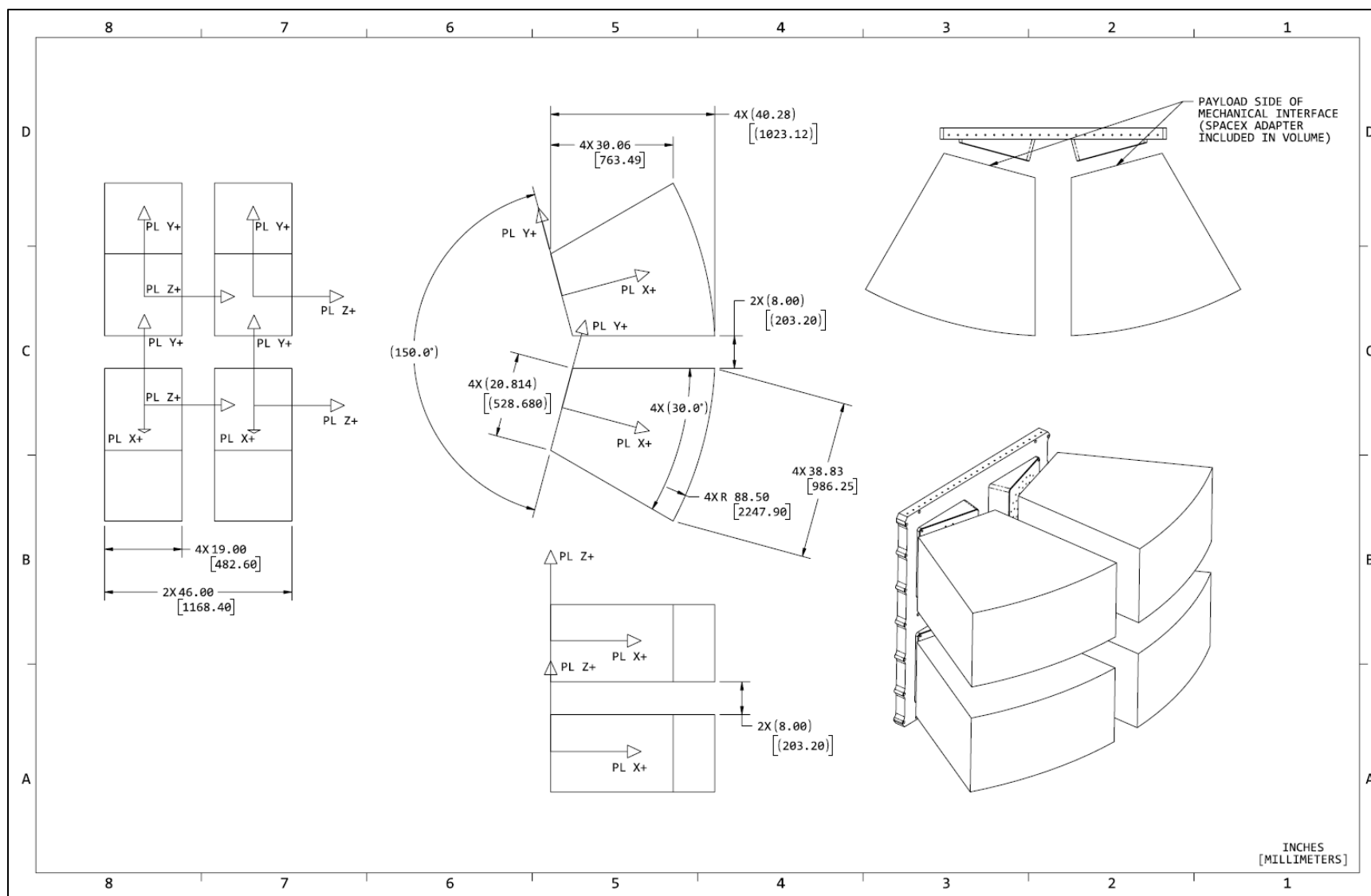


Figure A-8: Quarter Plate Volume (4 shown)



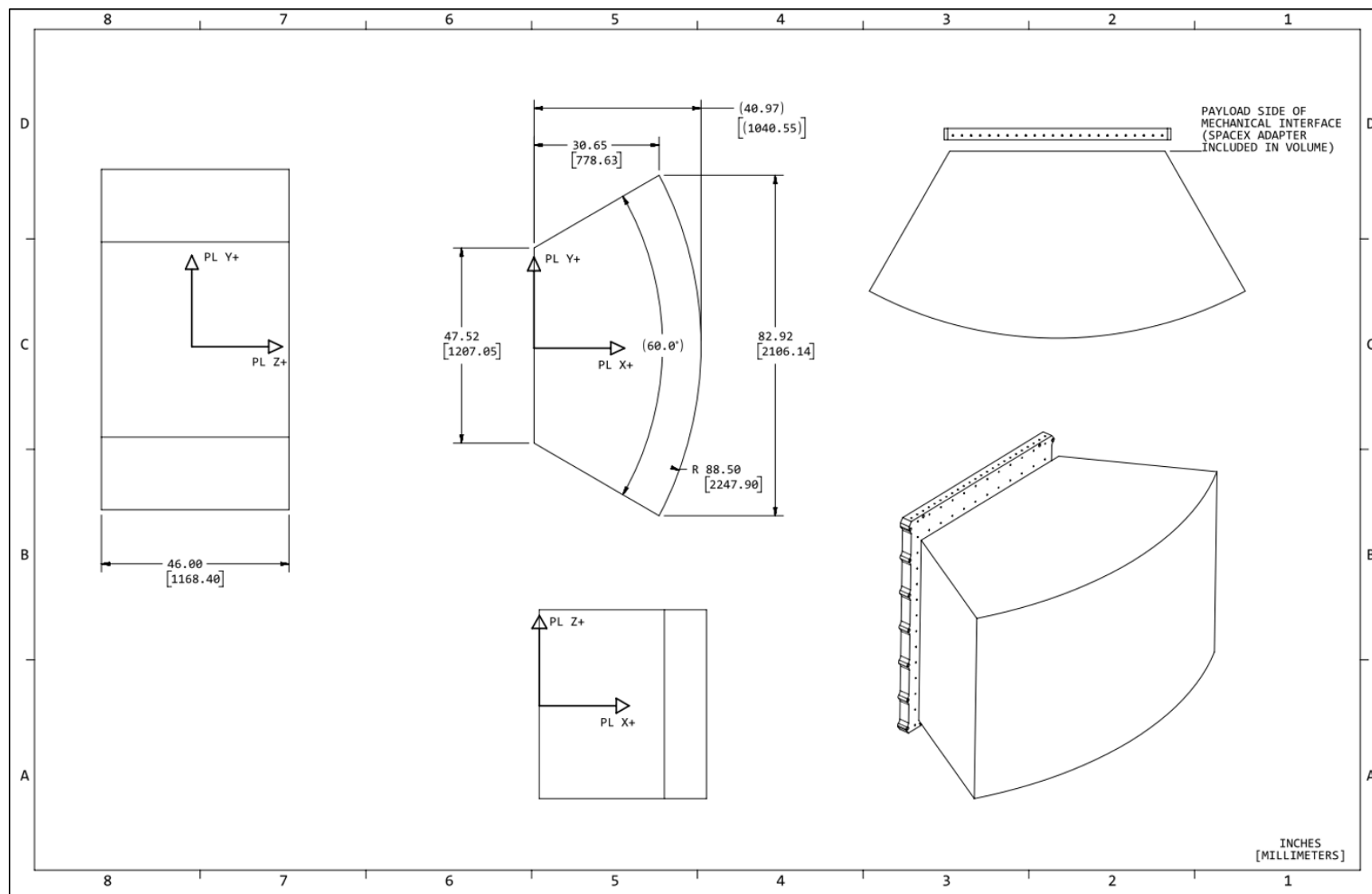


Figure A-10: Full Plate Volume

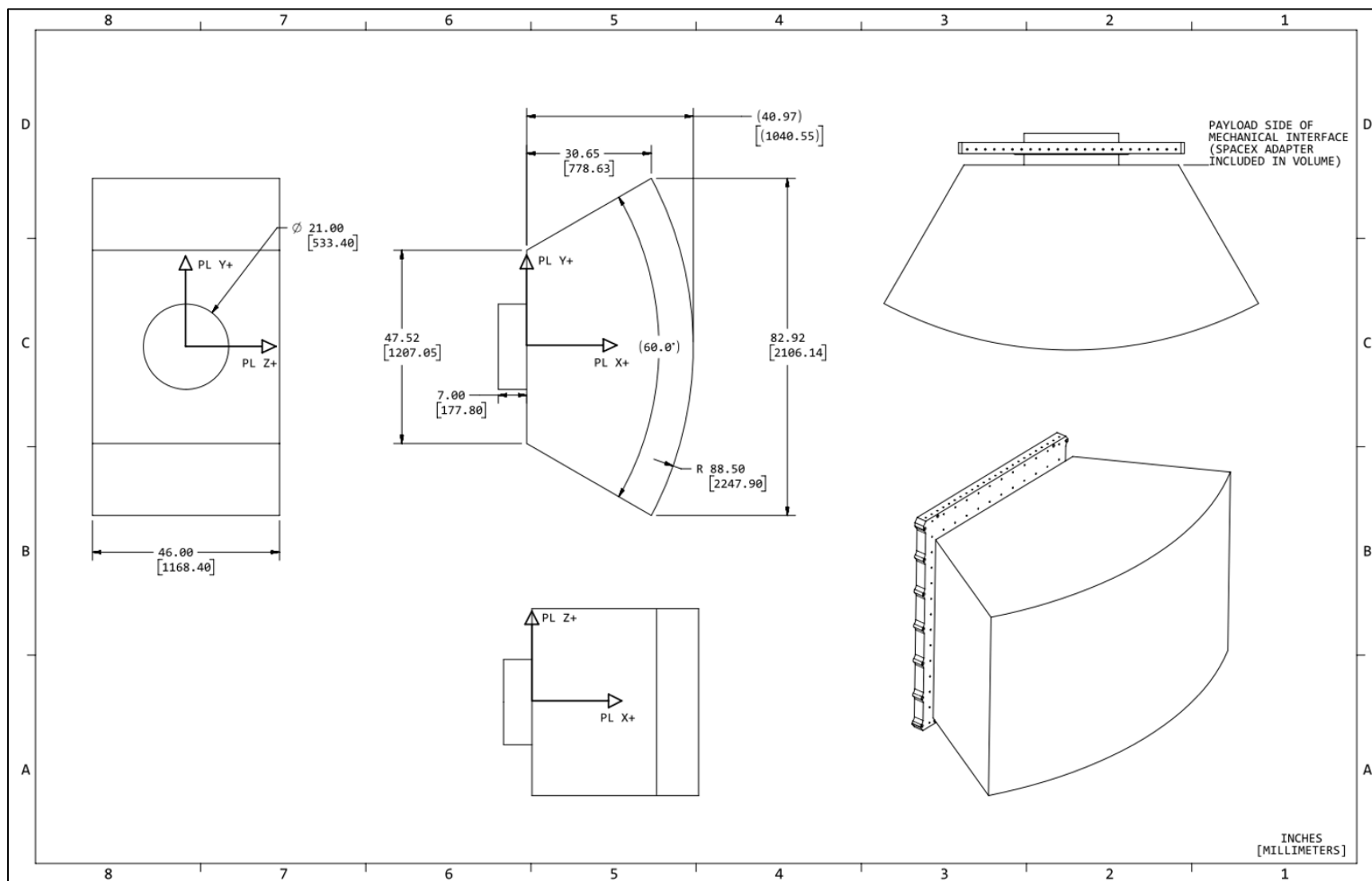


Figure A-11: Full Plate with Intrusion Volume

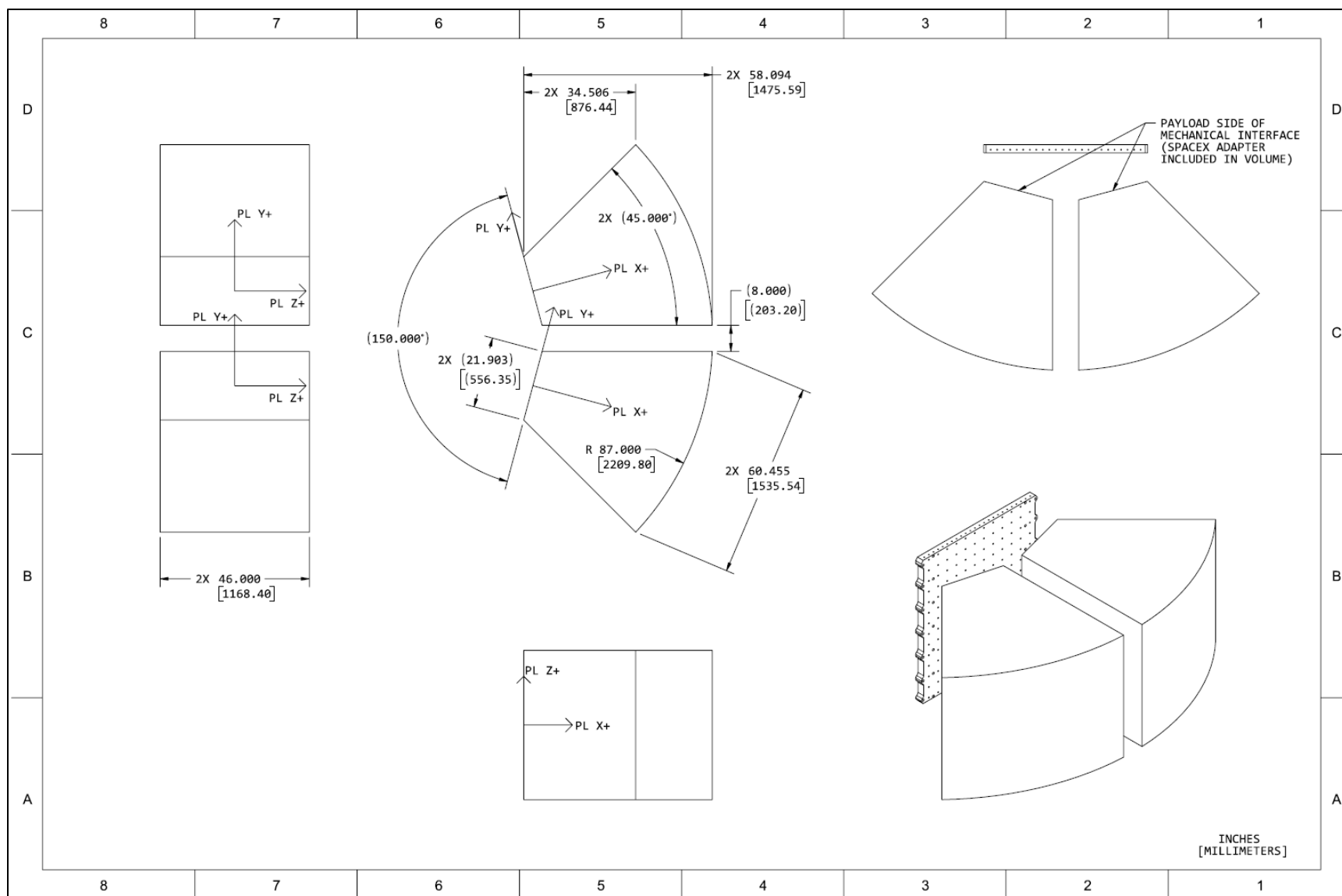


Figure A-12: Half XL Plate Volume (2 shown)

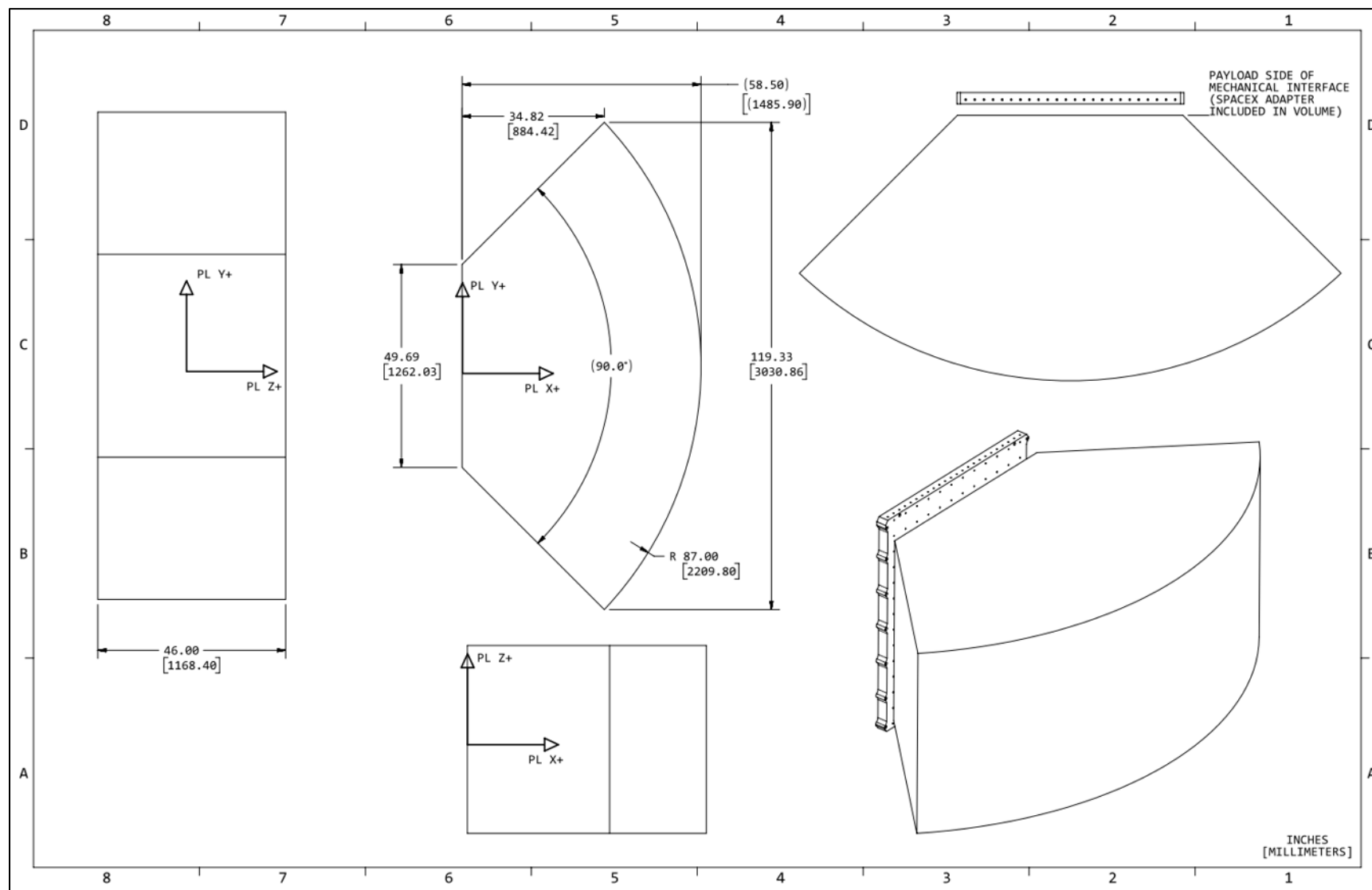


Figure A-13: XL Plate Volume

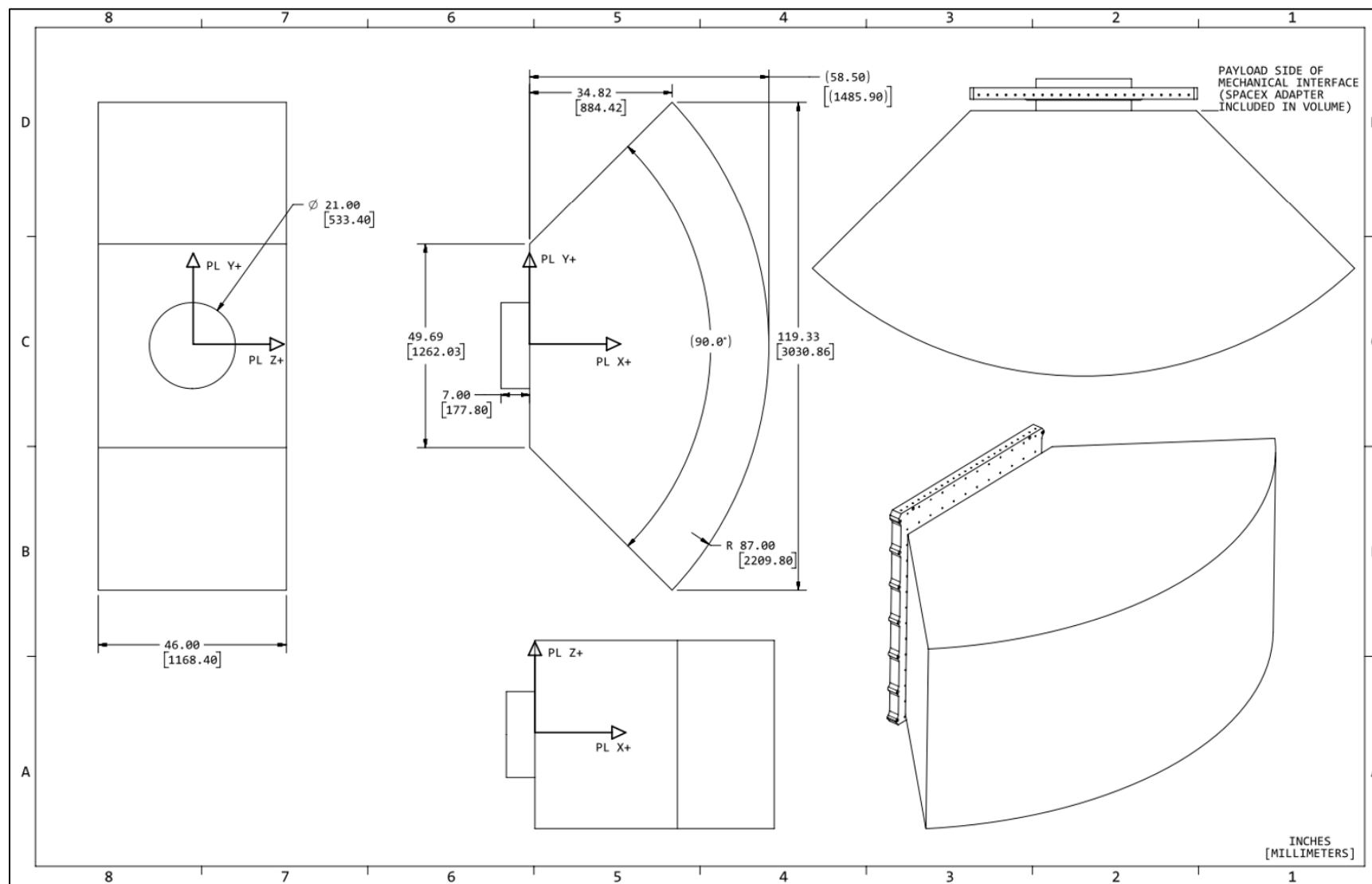


Figure A-14: XL Plate with Intrusion Volume





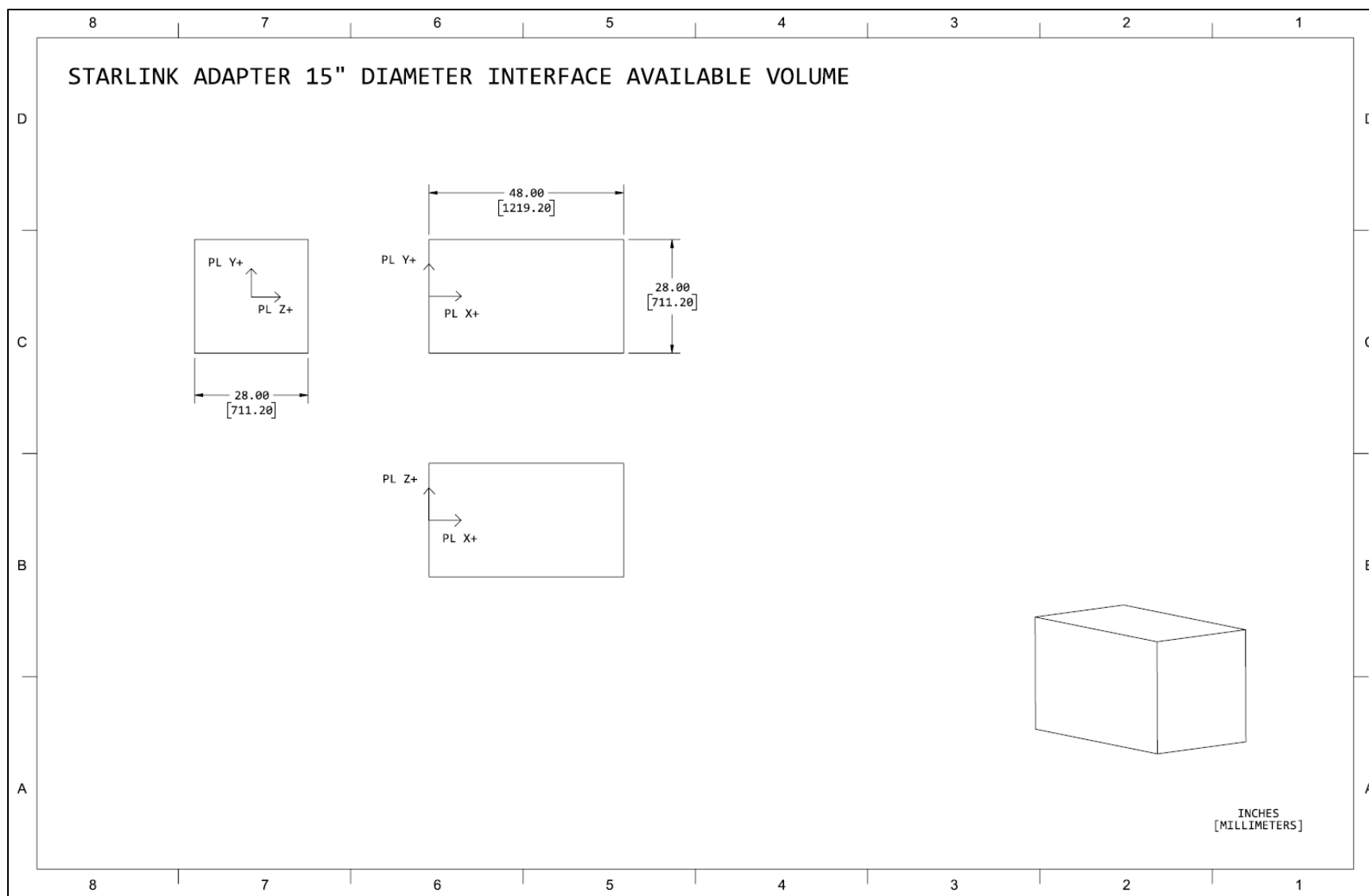


Figure A-16: 15" Diameter - Starlink Adapter Volume

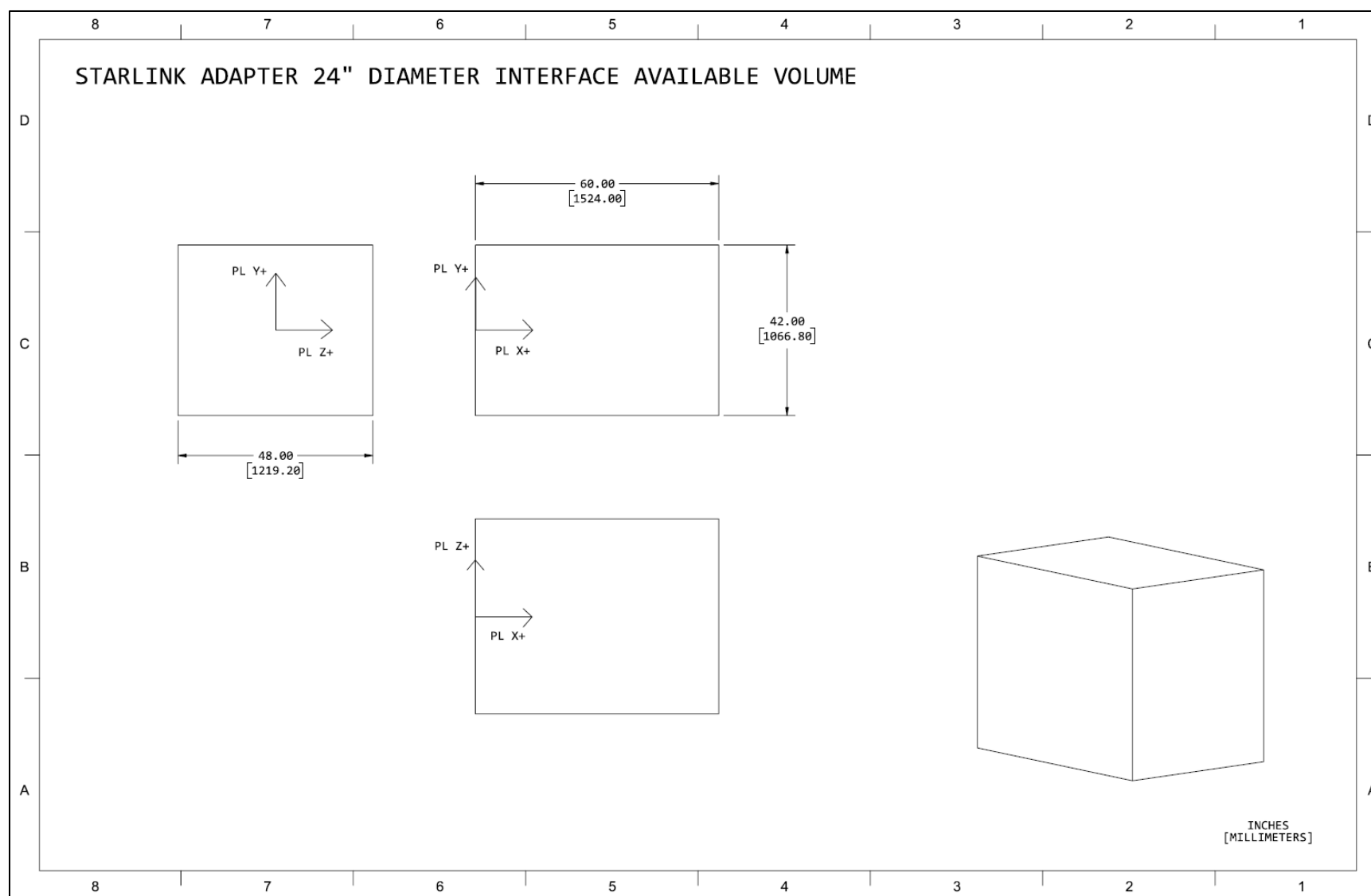


Figure A-17: 24" Diameter - Starlink Adapter Volume



## APPENDIX B: PAYLOAD DYNAMIC MODEL REQUIREMENTS

An analysis may be run to generate predictions of loads. The environments discussed in Sections 4.1.2 and 4.1.3 are intended to be enveloping for Payloads, thus no delivery of Payload results is guaranteed, but may be provided in the interest of Mission assurance.

### Payload Craig-Bampton Model Definition

#### Model Requirements:

- The units of the model must be clearly defined (English or SI)
- The Payload coordinate system must follow the coordinate system described in Section 2.3.
- The model must be Craig-Bampton formatted
- Modal damping must be specified (see Damping Definition section)
- Any uncertainty factor applied to the modal responses must be defined (see Uncertainty Factor section)
- The model must have frequency content up to 150 Hz
- All output requests must be clearly defined (see Analysis Outputs section)
- The model must be an accurate, in good faith, representation of the Payload including primary and secondary structures

#### Interface Requirements:

- The interface between the Payload and the Launch Vehicle must remain physical
- The Payload coordinate system described in Section 2.3 must be used for the boundary interface node output degrees of freedom
- Separation systems, including for example Lightband-style interfaces (circular interfaces) or HDRMs (4-point interfaces), must be included in the Payload model Craig-Bampton reduction
- If using circular separation systems, the model should be delivered with a single-interface node to the Launch Vehicle remaining physical with six degrees of freedom
- If using 4-point separation systems, the model should be delivered with four boundary nodes representing the four interface points to the Launch Vehicle. Each of these four nodes must remain physical with six degrees of freedom (total of 24 degrees of freedom)

#### Matrix Requirements:

- The model must be delivered in a NASTRAN, Formatted .op4 file and must include the stiffness and mass matrices as the first two matrices (example NASTRAN deck assign statement below)

```
ASSIGN OUTPUT4='Payload.op4',  
UNIT=501,FORMATTED,DELETE
```

#### **Example NASTRAN statement for providing matrices**

- To aid in coupling to the Launch Vehicle, the corresponding Nastran .asm and .pch files should also be delivered, since these files define the boundary grids.
- If the Payload has structures sensitive below 100Hz, the model may include Output Transformation Matrices (OTMs) to recover response of these items
- The mass and stiffness matrices (M and K, respectively) must be provided as complete matrices
- The M and K matrices must be defined as shown below.
  - $i$  are the modal degrees of freedom
  - $b$  are the boundary degrees of freedom
  - $\omega_i^2$  is a diagonal matrix of the eigenvalues
  - $K_{bb}$  is the stiffness from the boundary degrees of freedom



$$M = \begin{bmatrix} M_{bb} & M_{bi} \\ M_{ib} & I \end{bmatrix}, K = \begin{bmatrix} K_{bb} & 0 \\ 0 & \omega_i^2 \end{bmatrix}$$

- OTM a.k.a. Data recovery matrices (**DRM**) used to recover Payload responses (**R**) must be in one of the three forms shown below, where  $\ddot{x}$  are accelerations and  $x$  are displacements.

$$\{R\} = [DRM1] \begin{Bmatrix} \ddot{x}_b \\ \ddot{x}_i \end{Bmatrix}$$

$$\{R\} = [DRM2] \begin{Bmatrix} x_b \\ x_i \end{Bmatrix}$$

$$\{R\} = [DRM1] \begin{Bmatrix} \ddot{x}_b \\ \ddot{x}_i \end{Bmatrix} + [DRM2] \begin{Bmatrix} x_b \\ x_i \end{Bmatrix}$$

- Responses may be recovered using a **DRM1** (acceleration transformation matrix), a **DRM2** (displacement transformation matrix), or using both a **DRM1** and a **DRM2**.
  - DRM1 and DRM2 must each be provided as separate matrices.
  - Load transformation matrices for element forces, pressures, stresses, etc. must be recovered with either a **DRM1** (single or multiple point interface models), or using both a **DRM1** and a **DRM2** (multiple point interface models only).
- Total number of recoveries will be limited to 100 rows.
- Definition of the Craig-Bampton model rows and columns must be provided to facilitate coupling of the Payload to Launch Vehicle model.
- Labels for the rows of the (**DRM**) must be provided for inclusion in results tables.
- All LTM matrices must be defined such that they produce loads when multiplied by accelerations (not in g's) and displacements: e.g. inch/sec<sup>2</sup> and rad/sec<sup>2</sup> and inch and radian or other consistent units.

### Analysis Outputs

No delivery of Payload results is guaranteed, but may be provided in the interest of Mission assurance. If provided, the following CLA outputs are delivered in Microsoft Excel and are reported by load case unless otherwise specified:

- Payload Net-CG response max/min table
- OTM response max/min tables\*
- Interface sine vibe curves with Q specified by Customer

\* OTM = Output Transformation Matrix. May also be referred to as a DRM (Data Recovery Matrix). OTMs can include DTM (Displacement Transformation Matrix), ATM (Acceleration Transformation Matrix), LTM (Load Transformation Matrix) and others.

The output coordinate system of the net-CG max/min tables and the interface sine-vibe curves will be defined in the coordinate system of the Payload, as described in Section 2.3.

If outputs in any other coordinate system are desired, then the Customer must generate and provide such outputs in the ATM and/or LTM response recovery matrices.

### Damping Definition

Diagonal modal damping must be defined as a percent of critical (and may vary from mode to mode). Damping values should be test-correlated where possible.



## Uncertainty Factor

SpaceX, as a standard practice, will apply a model uncertainty factor to all responses that reflects launch configuration maturity. However, if Customer desires the application of a larger model uncertainty factor, this must be specifically requested. Under no circumstance will the model uncertainty factor be less than that used in SpaceX standard practice.

## Documentation

Models must be delivered alongside a filled-out excel file, based on a template provided by SpaceX. This standardized template eases coupling of the spacecraft to the Launch Vehicle and ensures that required information is provided in a clear format. SpaceX also requests that the dynamic model and populated worksheet be accompanied by any other supporting documentation that will aid in interpreting and processing the dynamic model. In total, the following information must be provided:

1. Definition of units used (SI or English)
2. Location of all interface grids in Payload coordinate system
3. An image of the boundary grid locations relative to the spacecraft FEM
4. Comparison of unreduced (FEM) and condensed (Craig-Bampton) models
  - a. Mass
  - b. Center of gravity relative to interface
  - c. Strain energy
  - d. First seven modes of free-free analysis
  - e. Modal analysis, including modal effective mass
5. A list of all frequencies
6. Pictures and/or descriptions and frequencies of the first few mode shapes (including the three fundamental modes in X, Y, and Z)
7. Definition of damping
8. Definition of the model response (dynamic) uncertainty factor
9. (Optional) If internal Payload responses are requested, provide appropriate DRMs (ATMs, DTMs, and LTMs) as well as tables defining the rows of these matrices.
10. (Optional) Definition of any Payload limit loads, including primary structure and component level, in order for SpaceX to evaluate the CLA results (net CG, interface loads, and ATM/DTM/LTM) and determine if the CLA indicates an exceedance of Payload structural capability.



## APPENDIX C: PAYLOAD CAD MODEL REQUIREMENTS

Customer must provide SpaceX a CAD model of the Payload in NX Parasolid (preferred) or STEP 214 or lower file format. SpaceX will integrate the Payload CAD model with the models of the Launch Vehicle second stage, SpaceX-provided Mechanical Interface, and fairing for visualization, integration, clearance check, and operations development purposes.

The Payload CAD model must be simplified by the Customer and focus primarily on outer mold line and interface fidelity (to facilitate efficient model manipulation and processing). Customer must limit their CAD model complexity, as requested by SpaceX, to only the details and interfaces necessary for integration with the Launch Vehicle, while retaining the basic structure of the Payload. Spurious information must be removed from the model by Customer before transmission to SpaceX (an example of unnecessary detail is thousands of bodies within a CAD model representing individual cells on a solar array).

Mass properties are provided in concert with CAD. This mass data must match exactly with the delivered CAD coordinate system configuration and units. The Payload coordinate system must follow the coordinate system described in Section 2.3.

The Payload CAD model must include the following information in order for SpaceX to analyze clearances, prepare compatibility drawings, and produce Payload ICD images:

- Payload interface to Launch Vehicle:
  - Payload mechanical interface to Launch Vehicle
  - Electrical connectors and associated brackets, as defined in AV2052 (Electrical ICD)
  - Pusher pads
- Components subject to review for clearance analysis:
  - External components to review for clearance to fairing volume (e.g. solar array panels, aft and forward antenna components, reflectors)
  - Any components in the immediate vicinity (<20 cm) of the interface components above
  - Any components which protrude below the separation plane
- Any points which may require access after encapsulation
- Simple Payload bus structure.

The Payload CAD model must NOT include:

- Internal Payload or bus components
- Spurious details, including individual solar array cells, fasteners, antenna, reflectors, etc., that do not add to the understanding of external volumes.

Prior to delivering CAD to SpaceX, please verify:

- ☐ All SpaceX hardware has been removed
- ☐ Entire payload is fully contained within the desired flight configuration keep-in volume
- ☐ Unnecessary detail that does not add to the understanding of external volumes has been removed
- ☐ Simplified bodies fully envelope OML of actual payload
- ☐ All direct LV interface bodies are included
- ☐ Payload is properly configured: origin is at SpaceX standard interface, clocked correctly and using the SpaceX Payload coordinate system (Section 2.3), and agrees with the corresponding mass properties
- ☐ File size is 50 MB or less
- ☐ The file type is Parasolid (.x\_t), preferred by SpaceX. Alternatively, the file format is STEP 214 or lower file format



## APPENDIX D: PAYLOAD ENCAPSULATION & LAUNCH READINESS CERTIFICATES

The Payload Customer must provide Payload readiness certification letters prior to Payload encapsulation and prior to Launch Vehicle roll out to the Launch Pad. The letter templates below are broken out into three possible scenarios:

- Scenario A: No battery charging after stand-alone operations
- Scenario B: Battery charging prior to Launch Vehicle rollout to Launch Pad (Optional Service)
- Scenario C: Battery charging at Launch Pad (Optional Service)

### Encapsulation Readiness Letter Template

[Insert Company Logo]

[Insert Company Name]  
[Insert Company Address]

To: Space Exploration Technologies Corp. (SpaceX)  
From: [Insert Company Name]  
Date: [Insert Date]  
Subject: Encapsulation Readiness Certification Letter

[Insert Company] certifies that the [Insert Name] Rideshare Payload is ready for fairing encapsulation. [Insert Company] confirms the following:

1. All Remove Before Flight (RBF) items have been removed from the Rideshare Payload
2. All Add Before Flight (ABF) items have been installed on the Rideshare Payload
3. All closeout pictures have been taken and reviewed
4. All mechanical and electrical connections between the [Insert Name] Rideshare Payload and the SpaceX Rideshare dispenser hardware is complete
5. No entry into the fairing is required once the Rideshare Payload is encapsulated

#### [CHOOSE ONE OF THE FOLLOWING]

- A. [Insert Company] certifies that the [Insert Name] Rideshare Payload batteries were last charged to full capacity on [Insert Date] at [Insert Time] [Insert Local Time Zone] and will remain flight ready for up to 45 days after Payload encapsulation [Insert encapsulation + 45 days Date].
- B. [Insert Company] certifies that the [Insert Name] Rideshare Payload batteries will be fully charged prior to Launch Vehicle roll out to the Launch Pad and remain flight ready for up to 5 days since last charge.
- C. [Insert Company] certifies that the [Insert Name] Rideshare Payload batteries will be fully charged while connected to the Launch Pad and that charging will be terminated prior to T-1 hour.

Sincerely,

[Insert Signature]

[Insert Company]





## Launch Readiness Letter Template

[Insert Company Logo]

[Insert Company Name]  
[Insert Company Address]

**To:** Space Exploration Technologies Corp. (SpaceX)  
**From:** [Insert Company Name]  
**Date:** [Insert Date]  
**Subject:** Launch Readiness Certification Letter

[Insert Company] certifies that the [Insert Name] Rideshare Payload is GO for launch on the Falcon 9 rocket, including conforming to all applicable Payload safety requirements of the Air Force Space Command Range Safety User Requirement Manual (AFSPCMAN 91-710), as tailored for the Mission.

[Insert Company] has reviewed all open issues and risks and certifies that there are no current constraints to Launch. If there are any new issues that arise prior to Launch, [Insert Company] will inform SpaceX.

### [CHOOSE ONE OF THE FOLLOWING]

- A. As certified in the Encapsulation Readiness Certification Letter dated [Insert Date], the [Insert Name] Rideshare Payload batteries were last charged to full capacity on [Insert Date] at [Insert Time] [Insert Local Time Zone] and will remain flight ready for up to 45 days after Payload encapsulation [Insert encapsulation + 45 days Date].
- B. [Insert Company] certifies that the [Insert Name] Rideshare Payload batteries were last charged on [Insert Date] at [Insert Time] [Insert Local Time Zone] to full capacity and will remain flight ready for up to 5 days since last charge, [Insert last charge + 5 days Date].
- C. [Insert Company] certifies that the [Insert Name] Rideshare Payload batteries will be fully charged while connected to the Pad and that charging will be terminated prior to T-1 hour.

Sincerely,

[Insert Signature]

[Insert Company]



## APPENDIX E: DELIVERY FORMAT OF SEPARATION STATE VECTOR

### Pre-Launch Example

SpaceX OPM output (generated YYYY-MM-DD-Day-HH-MM-SS):

All orbital elements are defined as osculating at the instant of the printed state. Orbital elements are computed in an inertial frame realized by inertially freezing the WGS84 ECEF frame at time of current state. This OPM is provided based on flight telemetry from the second-stage, and therefore represents the state of the second-stage and not the state of any other body. Any position, velocity, attitude, or attitude-rate differences between the second-stage and any other body need to be accounted for by the recipient of this OPM.

```
UTC time at liftoff:          DOY:HH:MM:SS.SS
UTC time of current state:    DOY:HH:MM:SS.SS
Mission elapsed time (s):     +XX.XX
ECEF (X,Y,Z) Position (m):    +XXXXXX.XXX, +XXXXXXX.XXX, +XXXXXXX.XXX
ECEF (X,Y,Z) Velocity* (m/s): +XXXX.XXX, +XXXX.XXX, +XXXX.XXX
LVLH to BODY quaternion (S,X,Y,Z): +X.XXXXXXX, +X.XXXXXXX, +X.XXXXXXX, +X.XXXXXXX
Inertial body rates (X,Y,Z) (deg/s): +X.XXXXXXX, +X.XXXXXXX, +X.XXXXXXX
Apogee Altitude** (km):       +XXXXX.XXX
Perigee Altitude** (km):      +XXX.XXX
Inclination (deg):            +XX.XXX
Argument of Perigee (deg):     +XXX.XXX
Longitude of the Asc. Node*** (deg): +XXX.XXX
True Anomaly (deg):           +XX.XXX
```

#### Notes:

- \* ECEF velocity is Earth relative
- \*\* Apogee/Perigee altitude assumes a spherical Earth, 6378.137 km radius
- \*\*\* LAN is defined as the angle between Greenwich Meridian (Earth longitude 0) and the ascending node

### Post-Launch Example

# SpaceX OPM output for XXX Mission

#### # Notes:

- # - ECEF velocity is Earth relative
- # - Apogee/Perigee altitude assumes a spherical Earth, 6378.137 km radius
- # - Orbital elements are computed in an inertial frame realized by inertially freezing the WGS84 ECEF frame at time of current state
- # - State is post-deployment, so includes separation delta-velocity

#### header:

```
generation_date: YYYY-MM-DD-Day-HH-MM-SS
launch_date: YYYY-MM-DD-Day-HH-MM-SS
```

#### deployments:

```
- name: payload-xxx
  sequence_number: 1
  mission_time_s: +XX.XX
  date: YYYY-MM-DD-Day-HH-MM-SS
  r_ecef_m: [+XXXXXX.XXX, +XXXXXX.XXX, +XXXXXX.XXX]
  v_ecef_m_per_s: [+XXXX.XXX, +XXXX.XXX, +XXXX.XXX]
  mean_perigee_altitude_km: +XXX.XXX
  mean_apogee_altitude_km: +XXX.XXX
  mean_inclination_deg: +XX.XXX
  mean_argument_of_perigee_deg: +XXX.XXX
  mean_longitude_ascending_node_deg: +XXX.XXX
  mean_mean_anomaly_deg: +XX.XXX
  ballistic_coef_kg_per_m2: +XX.XX

- name: payload-xxx
  sequence_number: 2
  mission_time_s: +XX.XX
  date: YYYY-MM-DD-Day-HH-MM-SS
  r_ecef_m: [+XXXXXX.XXX, +XXXXXX.XXX, +XXXXXX.XXX]
  v_ecef_m_per_s: [+XXXX.XXX, +XXXX.XXX, +XXXX.XXX]
  mean_perigee_altitude_km: +XXX.XXX
  mean_apogee_altitude_km: +XXX.XXX
  mean_inclination_deg: +XX.XXX
  mean_argument_of_perigee_deg: +XXX.XXX
  mean_longitude_ascending_node_deg: +XXX.XXX
  mean_mean_anomaly_deg: +XX.XXX
  ballistic_coef_kg_per_m2: +XX.XX
```

...



## APPENDIX F: PAYLOAD LICENSING CERTIFICATION

[Insert Company Logo]

[Insert Company Name]  
[Insert Company Address]

**To:** Space Exploration Technologies Corp. (SpaceX)  
**From:** [Insert Company Name]  
**Date:** [Insert Date]  
**Subject:** [Payload Name] Payload Licensing Certification Letter

[Insert description of Payload]

[Insert Company] certifies that:

- (1) it has obtained all required Payload Licenses, and
- (2) it has reviewed and understood the Hazardous Materials Table found at <https://www.law.cornell.edu/cfr/text/49/172.101> and accurately provided to SpaceX the list of Hazardous materials and quantities found within the Payload (via the FAA Payload review information template provided by SpaceX), and
- (3) it has adhered to all applicable registration requirements pursuant to the Convention on Registration of Objects Launched into Outer Space, and
- (4) all information submitted to SpaceX and/or to licensing agencies regarding its Payload is complete and accurate.

Sincerely,

[Insert Signature]

[Insert Company]



## APPENDIX G: DELIVERABLES DESCRIPTION

The deliverables described in this appendix correspond to SpaceX and Customer deliverables and corresponding due dates defined in Table 1 of the Customer's Statement of Work.

**Table G-1: SpaceX Templates and Reference Material**

Subject	SpaceX Template / Reference Material	Description
Contractual / Legal	TAA questionnaire OR Export Compliance Agreement template	Representations and certifications for Customer to complete for TAA application (if not already provided prior to Agreement signature) OR Export Compliance Agreement between US parties and SpaceX.
	Payload configuration worksheet	Template for Payload details including top-level Payload information and Payload Constituents (reference Appendix H).
	Rideshare Payload User's Guide	This document.
Regulatory / Licensing	FAA Payload review information template	Template for Customer to capture Payload inputs required for an interagency Payload review initiated by the FAA, including, but not limited to, owner/operator information, mission description, physical description, hazardous materials, operational licensing, operational orbits, etc.
	FAA cross-waiver template	Template for Customer to fill out and sign acknowledging all requirements and flow-down terms.
	Third Party Liability (TPL) additional insured template	Template for Customer to identify additional parties to be included on SpaceX's TPL insurance policy.
	Payload insurer information template	Template for Customer to capture Payload insurer details and account for Launch and in-orbit subrogation waiver status. Copies of subrogation waivers are required separately.
Range Safety	Payload Range Safety requirements	Summary of Range Safety submissions required for Rideshare Payloads, including general descriptions and due dates.
	Range Safety submission document templates	Templates for all Range Safety submission deliverables.
Mission Integration	Dynamic model worksheet	Template for Customer to complete which serves as a companion document to accompany the Customer Payload dynamics model (reference Appendix B) delivery.
	Mass properties worksheet	Template for Customer to complete which describes the Payload mass properties, including its center of gravity, moments of inertia and products of inertia for the Payload, broken up into fly-away and stay-behind portions. This template includes space for Customer to define the Payload separation system mechanical properties including spring, switch, and connector locations and separation energy.
	Customer separation analysis template	Template for Customer to verify compliant Payload separation as defined in Section 3.3.2.
	Payload transmitter verification worksheet	Template for Customer to verify compatibility of Payload transmitter turn on times in accordance with Section 4.1.7.2.
	Electrical interface pinout worksheet	Template for Customer to populate the Payload electrical harness properties and pin-outs. SpaceX will populate the Launch Vehicle side after initial Customer submittal.
Payload Verification	Customer-built harness build guide & verification worksheet	Detailed documentation that describes the requirements for Customer-built harnesses as well as a Template for Customer to verify build requirements.
	Payload environmental test approach worksheet	Template for Customer to complete which defines the test approach for the Payload per Section 6, including test schedule. Test approach must be approved by SpaceX.
	Payload environmental verification report template	Template for Customer to report results of fully integrated Payload testing in order to show compliance to Section 6 and in accordance with the previously SpaceX-approved Payload environmental test approach.
Launch Campaign	Launch Site Facility User's Guide	User's Guides covering SpaceX Launch Site facilities for Vandenberg Space Force Base (VSFB) and Cape Canaveral Space Force Station (CCSFS).
	Launch Campaign planning checklist template	Launch Campaign planning checklist template to track miscellaneous aspects of the Launch Campaign, including GSE shipment list, personnel attendance, an OPM email distribution list, and Launch Campaign action items.
	Launch Campaign daily schedule template	Template for Customer to provide a daily break-down of stand-alone operations, including SpaceX resource requirements, and hazardous operations.
	Generic Rideshare Launch Campaign plan	Introduction to the Launch Range and SpaceX Launch Site facilities, including security information, badging and access control, Launch Site delivery information, and example Rideshare Mission operational overview.

**Table G-2: SpaceX Statement of Work Deliverables**

Milestone	SpaceX Deliverables	Description
Mission Integration	Launch Vehicle-side mechanical interface	SpaceX provides Customer with information regarding the Launch Vehicle-side mechanical interface for Customer to use when planning Customer-built harness routing and confirming clearances for Payload hardware installation.
Launch Campaign Planning	Launch Campaign planning checklist (preliminary)	Preliminary draft of Launch Campaign planning checklist including preliminary customer inputs.
	Launch integration schedule (preliminary)	Schedule of Launch Site operations identifying Payload stand-alone activities and combined Payload/Launch Vehicle operations for the Mission.
	Launch Campaign plan (preliminary)	Plan for Payload integration and Launch, including the facilities to be used, Payload space allocation in those facilities, and the top-level operations to be performed for both Launch Vehicle and Payload processing.
Mission Integration	Predicted orbit injection report	Predicted state vector information, based on a nominal trajectory optimized for the Mission. This state vector will be provided in SpaceX-defined format (reference Appendix E).
	Draft ICD	Preliminary draft of the ICD utilizing inputs from Customer for Mission-specific requirements and other interface information to be developed and populated during the course of Mission integration. The ICD defines the Mission requirements and interfaces between Customer and SpaceX systems.
	Released Payload electrical interface pinout worksheet	Documentation capturing the electrical interfaces of the Payload to the Launch Vehicle and documenting the end-to-end pin-out of the SpaceX and Customer built harnessing, including electrical characteristics of each pin.
	SpaceX-built harness routing CAD model	SpaceX provides the Customer with a CAD model of the SpaceX-built harnessing.
	Electrical connector shipment to Customer (if applicable)	If applicable, electrical connectors supplied by SpaceX, required for Customer-built harnessing, is shipped to Customer and electrical connectors supplied by Customer, required for SpaceX-built harnessing is shipped to SpaceX. Connectors and shipping details are defined in the released Payload electrical interface pinout worksheet.
Mission Integration Analyses	Trajectory analysis results, including collision avoidance and Monte Carlos	SpaceX will develop a nominal trajectory optimized for the Mission. This nominal trajectory will be used to determine the nominal injection state vector, develop the Launch Window, and define the Mission level deploy order and timeline. SpaceX will conduct a Monte Carlo analysis to formally quantify dispersions on the injection orbit and Launch Vehicle performance. These Monte Carlo results will serve as the verification for orbit injection accuracy requirements. This analysis includes collision avoidance.
Launch Campaign Readiness Review	ICD revision for signature including compliance status	Revision of the ICD to be signed by the Parties, having mutually reviewed and agreed to the content, including a compliance matrix and status for all open deliverables.
	Launch Campaign planning checklist (update)	Updated Launch campaign planning checklist to track Launch campaign documentation, GSE shipment list, Customer personnel attendance, Payload details related to Launch Site operations, an OPM email distribution list, and Launch campaign action items.
	Launch integration schedule (update)	Updated and refined schedule of Launch Site operations identifying Payload stand-alone activities and combined Payload/Launch Vehicle operations.
	Launch Campaign plan (update)	Updated plan for Payload arrival, integration and Launch, including the facilities to be used and the operations to be performed for both Launch Vehicle and Payload processing.
Mission Integration Analyses	Verification of Launch Vehicle Loads compliance	SpaceX confirms to Customer that the Launch Vehicle is compliance to the Loads MPE defined in Section 4.1.
	Verification of Payload clearance	SpaceX confirms clearance of the Payload using the Customer provided CAD model defined in Appendix C to the allowable Payload allowable volume defined in Appendix A.
	Payload separation analysis results (if required)	Results of the separation analysis predicting the maximum linear and angular separation rates of the Payload upon separation from the Launch Vehicle. CubeSat deployments from Containerized dispensers are not analyzed by SpaceX.
Launch Campaign	Launch Campaign arrival briefing	Briefing to the Customer providing information about working at the Launch Site, including contact information, security, SpaceX policies, transportation, medical, facility overview, hazardous operations and natural hazards (e.g. lightning), and personnel safety, reinforcing the training material Customer personnel completed prior to arrival at the Launch Site.
	Hazardous operations planning meetings (if required)	If required, a meeting to plan and coordinate any hazardous operations that the Payload must undergo at the Launch Site.
	Electrical checkout results (if required)	If Customer is accessing the payload after encapsulation through the umbilical harness, SpaceX provides documentation detailing the results of the SpaceX electrical checkouts performed on the harnessing which interfaces with the Payload.
	Daily Launch Campaign schedule updates	Daily updates to the Launch Campaign schedule as coordinated in real time with the Customer.
	Facility environmental reports	Reports of facility temperature, relative humidity and particle count are provided to the Customer point of contact.
	Launch Vehicle readiness certificate	Signed confirmation from SpaceX to the Customer that the Launch Vehicle is ready for countdown and Launch, obtained after a Launch Readiness Review between SpaceX and the Range.
Post Launch	Orbit injection report	Provides operational state vector information, based on best available telemetry during the flight. This state vector will be provided in the SpaceX-defined format (reference Appendix E). Customer is solely responsible for conversion, if necessary, of the data into a Customer-preferred format.

**Table G-3: Customer Statement of Work Deliverables**

Milestone	Customer Deliverables	Description
Agreement Signature	Technical point(s) of contact	Identification for the Customer point(s) of contact that will interface with the SpaceX appointed mission manager(s).
Mission Integration Kickoff	Completed TAA questionnaire or Export Compliance Agreement	Representations and certifications from Customer for Technical Assistance Agreement (TAA) application (if not already completed prior to the Kickoff) or signed Export Compliance Agreement.
	Completed Payload configuration worksheet	Preliminary information regarding the Payload provided by the Customer for SpaceX use in support of program deliverables including the list of Payload Constituents (in accordance with the details in Appendix H).
Mission Integration Analysis Inputs	Payload CAD model	Payload CAD model, in accordance with Appendix C.
	Payload dynamic model and worksheet	Payload dynamic model, in accordance with Appendix B and accompanying dynamics model worksheet.
	Payload mass properties	Current best estimate of the Payload mass properties (mass, center of mass, moments of inertia) as well as Payload separation system mechanical and electrical properties including spring, switch, and connector locations and separation energy, using the worksheet provided by SpaceX. Reasonable uncertainty bounds are highly encouraged.
	Payload separation verification analysis	Customer provides an analysis verifying that Payload Constituents deployed from the Launch Vehicle are packaged in such a way to meet the separation requirements outlined in Section 3.3.2.
	Payload transmitter verification	Customer verification that Payload transmitter turn on times are compatible with Launch Vehicle frequency restrictions using the SpaceX provided worksheet.
	Payload electrical interface pinout worksheet	Customer inputs provided in the SpaceX provided template that defines the Launch Vehicle to Payload electrical harness properties and pin-outs.
	Payload environmental test approach and schedule	Provide the test approach compared to Section 6 for each Payload Constituent using the SpaceX provided worksheet, including additional rationale for any requests for deviation to the requirements found in Section 6.
	Propulsion system details (if applicable)	Customer provides SpaceX with propulsion system details for SpaceX evaluation in accordance with Section 6.8 if applicable to the Payload.
L-6 M Range Safety Submissions	Rideshare Range Safety checklist	A checklist defining the Payload design and hazardous subsystems. For subsystems, depending on complexity and hazard level, additional documentation may be required by the Range, such as 91-710 Tailoring, Missile System Prelaunch Safety Packages (MSPSP), and certification data for hazardous systems.
	Program Introduction	A simplified and high-level overview of the Payload and its associated hazardous systems in a condensed format for Launch Range safety authorities (template provided by SpaceX). The Program Introduction provides quick reference on Payload appearance, size, mass, propellants, batteries, pressure vessels, heat pipes, and radiating sources.
Launch Campaign Planning	Initial inputs to launch campaign checklist	Customer inputs to the launch campaign checklist including status for launch campaign documentation, GSE shipment list, Customer personnel attendance, Payload details related to Launch Site operations, and OPM email distribution list.
	Initial inputs to Launch Campaign daily schedule	Description of Customer Launch Site activities required in the launch campaign daily schedule for Payload stand-alone processing.
	CAD for lifting GSE for joint mating operations	CAD model of the Customer-provided lifting GSE that will be used for the final mate of the Payload to the Launch Vehicle, after Customer has mated the Payload to the SpaceX-provided Mechanical Interface (if applicable) described in Section 2.
	List of emails for launch site badging access	Customer provided list of emails for potential launch site personnel in order to fill out badge access paperwork online.
	Completed FAA Payload review information template.	Completed template capturing Payload inputs required for an interagency Payload review initiated by the FAA.
	Completed and signed FAA cross-waivers.	Completed and signed Falcon Cross-Waivers using SpaceX-provided template. Required by U.S. federal law in order to launch (late submissions may require rebooking).
Mission Integration	Customer-built harness routing CAD model	Customer provides SpaceX with a CAD model of the Customer-built harnessing.



Milestone	Customer Deliverables	Description
L-4 M Range Safety Submissions	Group Operating Plan (GOP)	The Payload Ground Operations Plan (GOP) provides a detailed description of the hazardous and safety critical operations associated with the Payload and its GSE. The Payload GOP contains a description of planned operations and the hazard analysis of those operations. The Customer's GOP must be prepared in accordance with 91-710 Vol 6, attachment 1 for SpaceX to submit to the Launch Range safety authority for review and approval.
	AFSPCMAN 91-710 Tailoring (only if Customer determines the Payload is not compliant to 91-710)	Tailoring provides a means for formulating a Payload-specific edition of AFSPCMAN 91-710 (Volumes 1, 3, and 6) and documents whether or not the Customer will meet applicable safety requirements as written or achieve an equivalent level of safety through a requested and approved alternative approach. The Customer's tailoring requests must be prepared in accordance with 91-710 Vol 1, attachment 1 for SpaceX to submit to the Launch Range safety authority for review and approval.
	Mission System Prelaunch Safety Package (only if requested by the Range)	Payload safety information providing the Launch Range safety authority with a description of hazardous and safety-critical support equipment and flight hardware associated with the Payload. The Customer's MSPSP must be prepared in accordance with 91-710 Vol 3, attachment 1 for SpaceX to submit to the Launch Range safety authority for review and approval.
	Certification Data for Hazardous Systems (only if requested by the Range)	Certification data for Payload hazardous systems. A system is deemed hazardous if it includes any of the following: pressure vessels (over 100 psid), batteries, hazardous materials, non-ionizing and ionizing radiation systems, hazardous propulsion systems, or ordnance. Data must also be provided for GSE (for example, lift slings).
Final Mission Integration Analysis Inputs	Payload mass properties (final update)	Customer to provide SpaceX refined Payload mass properties inputs for the Monte Carlo analysis of the nominal trajectory using the Payload mass properties template provided by SpaceX. Updates must fall within previously provided uncertainty bounds.
	Payload environmental verification report	Customer to provide to SpaceX final environmental verification test and/or analysis results in order to show compliance to Section 6 and in accordance with the SpaceX approved Payload environmental test approach. Customer must use the Payload environmental verification report template provided by SpaceX to summarize data into a single report.
	Customer-built harness verification report	Completed report verifying that Customer-built harnesses meet build requirements.
Launch Campaign Planning	Third Party Liability (TPL) additional insureds	List of additional parties to be included on SpaceX's TPL insurance policy.
	Badging inputs complete	Customer details including personal information, and passport/visa scans and photos necessary for access to the Launch Site badging completed online.
	Payload insurance details and waiver(s) of subrogation	Payload insurer details and copies of subrogation waivers submitted to SpaceX.
	Updated inputs to Launch Campaign checklist	Customer updated inputs to the launch campaign checklist including status for launch campaign documentation, GSE shipment list, Customer personnel attendance, Payload details related to Launch Site operations, and OPM email distribution list.
	Updated inputs to Launch Campaign daily schedule	Customer updated inputs describing Launch Site activities required in the launch campaign daily schedule for Payload stand-alone processing.
L-2 M Range Safety Submissions	AFSPCMAN 91-710 Compliance Letter	Signed confirmation from Customer that the Payload complies with all safety requirements.
	Ground Operating Plan defined Hazardous procedures	Payload procedures provide detailed, systematic descriptions of the manner in which Customer's hazardous and safety critical operations will be accomplished at the Launch Site. These procedures are the basis from which approval to start hazardous or safety critical operations are obtained from the Launch Range safety authority. The Customer's hazardous procedures must be prepared in accordance with 91-710 Vol 6, attachment 2 for SpaceX to submit to the Launch Range safety authority for review and approval. Customer is strongly encouraged to deliver procedures earlier than 45 days before hardware arrival at the Launch Site. Procedures must be in English.
Mission Integration Analyses	CubeSat(s) environmental verification report (if applicable)	Customer to provide to SpaceX final environmental verification test and/or analysis results for independently tested CubeSats (if applicable) in order to show compliance to Section 6 and in accordance with the SpaceX approved Payload environmental test approach. Customer must use the Payload environmental verification report template provided by SpaceX to summarize data into a single report.



Milestone	Customer Deliverables	Description
Payload Shipment and Arrival	Payload licensing certification letter	Signed confirmation from Customer to SpaceX, in the form of the letter shown in Appendix F that required Payload licensing is in place and that the information provided to licensing agencies and SpaceX is accurate. The letter must be provided to SpaceX prior to Payload shipment to the Launch Site.
	Copies of all required Payload licenses	Customer to provide proof of all required on-orbit licensing required for Payload Constituents to legally operate on orbit.
	Launch Site awareness training complete	All Customer personnel participating in the Launch Campaign complete online Launch Site awareness training prior to arrival at the Launch Site.
Launch Campaign	Payload as-measured mass	Payload as-measured mass including adjustments for any non-flight items (e.g. remove-before-flight covers) which remained on the Payload during measurement, updated from the most recent mass properties worksheet provided to and approved by SpaceX.
	Payload encapsulation readiness certificate	Signed confirmation from Customer to SpaceX that the Payload is ready for fairing encapsulation, in the form of the letter shown in Appendix D.
	Coordination with space situational agency	Customer coordination for space object identification as described in Section 9.5.7.
	Payload launch readiness certificate	Signed confirmation from Customer to SpaceX that the Payload is ready for countdown and Launch, in the form of the letter shown in Appendix D.
Post Launch	Payload operations status	Brief summary of the current Payload status, as well as an early operations summary, if available.





## APPENDIX H: PAYLOAD CONSTITUENTS

SpaceX will provide a document template requesting the information defined in Table H-1.

**Table H-1: Payload Constituent Details**

Payload Constituent (satellite, separation system, etc.)	Constituent #1	Constituent #2	Constituent # XX
Owner			
Address (including Country) of Owner			
Manufacturer			
Address (including country) of Manufacturer			
Operator			
Address (including country) of Operator			
End User			
Address (including country) of End User(s)			
Delivery on Orbit User			
Delivery on Orbit User Address			
End Use			
General Description			
Propulsion System & Type			
CubeSat Size (i.e. #U) if applicable			
Quantity of Constituents within Payload			

SpaceX may approve or deny one or more of the requested Payload Constituents, including if SpaceX determines it is unable to obtain regulatory approvals. Customer is allowed to propose an alternate Payload Constituent in place of any rejected Payload Constituent. After Mission integration analyses have begun SpaceX may reject a proposed alternate Payload Constituent if the proposed Payload Constituent invalidates the Mission integration analyses (as determined by SpaceX) or invalidates any licensing or regulatory approvals. SpaceX's approval is at the sole discretion of SpaceX while timely approval for all items within the Payload be the sole responsibility of the Customer. Customer's failure to receive approval for any item within the Payload may result in rebooking and associated fees.



## APPENDIX I: OPTIONAL SERVICES

SpaceX offers the optional services described in this section for an additional cost above the baseline pricing found at [www.spacex.com/rideshare](http://www.spacex.com/rideshare).

**Table I-1: Optional Services**

Service	Description
Payload Adapter Plate	SpaceX can provide an adapter plate for Payloads with mechanical interfaces other than 8", 15" or 24" at the Customer request. The Payload adapter plate can accommodate mechanical interface diameters including 11.732", 13", and 18.25". Other Payload mechanical interfaces may be considered, please contact SpaceX for further details. See <a href="http://www.spacex.com/rideshare">www.spacex.com/rideshare</a> for adapter plate pricing details.
4-Point Custom Adapter	SpaceX can provide a tailored interface to the 4-point separation system if different from the SpaceX-designed interface. Contact SpaceX for details.
Separation System	SpaceX can provide a separation system for Payloads at the Customer request. Separation systems vary in price depending on the size of the system and require at least a 6-month lead-time for procurement. See <a href="http://www.spacex.com/rideshare">www.spacex.com/rideshare</a> for separation system pricing details.
Launch Site Fueling	Standard Rideshare Launch services do not include provisions for Payload fueling at the Launch Site. Customer may perform fueling operations at the Launch Site that do not require SCAPE, for an additional cost, which includes an additional day of processing at the Launch Site. See <a href="http://www.spacex.com/rideshare">www.spacex.com/rideshare</a> for pricing details. For any fueling operations that do require SCAPE, please contact SpaceX for further information.
Payload Electrical Connectivity	SpaceX accommodates electrical connectivity between Customer EGSE and the Payload prior to mating the Payload to Launch Vehicle hardware. SpaceX can provide electrical connectivity between Customer EGSE and the Payload in the Hangar after transport from the PPF and on the Pad after rollout until T-1 hour including allocation of a customer console for remote monitoring after as an optional service. Contact SpaceX for pricing details.
Additional Electrical Channels	The standard electrical interface offering per contract is for a single deployment event. Additional channels, beyond those needed for a single Payload deployment, (primary, secondary, and breakwire signals) are available as an optional service up to the maximum allowable per Table 7-1. See <a href="http://www.spacex.com/rideshare">www.spacex.com/rideshare</a> for pricing details.
Insurance	Up to two umbilical groups (see Section 7.4) per Rideshare modular plate (Full Plate, XL Plate, or equivalent combination of partial plates), are available as an optional service. Contact SpaceX for availability. SpaceX can provide, at Customer's request, optional Launch-only insurance for the Payload and the cost of Launch. Contact SpaceX for details.



## APPENDIX J: DEFINITIONS

**"Agreement"** refers to the Launch Services Agreement between SpaceX and Customer.

**"Acceptance of Request"** means the email sent to Customer by SpaceX upon acceptance of the Request for Launch Services submitted by Customer. The Acceptance of Request documents and becomes a part of SpaceX's acceptance of the Agreement between SpaceX and Customer.

**"Co-Payload"** means a payload of a customer of SpaceX, other than Customer, that is manifested on the same Mission as Customer.

**"Co-Payload Customer"** means any customer of SpaceX other than Customer that has a payload manifested on the same Mission as Customer.

**"CSLA"** means the Commercial Space Launch Act of 1988, as amended, 51 U.S.C. §§ 50901-50923 and the regulations issued pursuant thereto, including the Commercial Space Transportation Regulations, 14 C.F.R. Parts 400-460.

**"Customer"** has the meaning set forth in the Acceptance of Request signature page of the Agreement.

**"Dedicated Rideshare"** means a Mission with only Rideshare Payloads as defined in this document.

**"EAR"** means the Export Administration Regulations administered by the Bureau of Industry and Security, U.S. Department of Commerce, 15 C.F.R. Parts 730-744, pursuant to the Export Control Reform Act of 2018.

**"Excusable Delays"** shall mean a delay arising from causes beyond the control of the affected party, including acts of god or government (except to the extent such acts are undertaken by the government that owns or controls a party or of which a party is a part), terrorism, riot, revolution, hijacking, fire, embargo, sabotage, Launch Range 'no go' determinations or unavailability, or priority determinations by the US Government under the Defense Priorities and Allocations System (15 CFR Part 700).

**"Form of FAA Cross-Waiver"** means as found in Appendix B to 14 CFR Part 440 at the following hyperlink: <http://www.ecfr.gov/cgi-bin/text-idx?rgn=div5&node=14.4.0.2.9.22#14.4.0.2.9.22.1.30.12.33>. In the event this link is ever deactivated, the Form of Cross Waiver will be the most recent Form of Cross-Waiver published in the US Code of Federal Regulations.

**"Intentional Ignition"** means when the ignition command is given for purposes of Payload carriage causing ignition of the first-stage engines of the Launch Vehicle.

**"Interface Control Document (ICD)"** means that document which will be prepared by SpaceX with data to be supplied by Customer, negotiated in good faith and mutually agreed upon in writing by both Parties prior to the beginning of the Launch Period. The Interface Control Document will supersede any interface requirements document.

**"ITAR"** means the International Traffic in Arms Regulations administered by the Directorate of Defense Trade Controls, U.S. Department of State, 22 C.F.R. Parts 120-130, pursuant to the Arms Export Control Act of 1976, as amended, 22 U.S.C. § 2778.

**"Launch"** means Intentional Ignition followed by either: (a) Lift-Off or (b) the loss or destruction of the Payload or the Launch Vehicle (or both).

**"Launch Campaign"** means the activities and discussions leading up to and including Payload to Launch Vehicle integration at the Launch Site through Launch.

**"Launch Complex"** means the SpaceX-operated facility where the Launch Vehicle is integrated and from which the Launch Vehicle is launched.

**"Launch Date"** has the meaning set forth in Section 9.6.1. If the Launch Date has not yet been established in accordance with Section 9.6.1, the Launch Date will be deemed the first day of the Launch Period.

**"Launch Period"** has the meaning set forth in the Agreement.

**"Launch Range"** means the U.S. Governmental authorities and office with jurisdiction over the Launch Site.

**"Launch Services"** means those services described in this document to be performed by SpaceX.

**"Launch Site"** means the SpaceX launch facility at Cape Canaveral Air Force Station or another SpaceX launch facility capable of supporting the Launch Services, as determined by SpaceX.



**"Launch Vehicle"** means a launch vehicle capable of achieving Customer's orbital parameter requirements as set forth in the Agreement, and refers to the Falcon 9 Launch Vehicle in this document.

**"Launch Window"** means the time period established by SpaceX during which the Launch is scheduled to occur on the Launch Date.

**"Licenses"** means all licenses, authorizations, clearances, approvals and permits necessary for each Party to carry out its respective obligations under the Agreement. Each Party agrees to provide reasonable assistance to the other Party as necessary to obtain such Licenses.

**"Lift-Off"** means release of the hold-down restraints and physical separation of the Launch Vehicle from the launch pad.

**"Material Breach"** means a breach in which the non-breaching party did not receive the "substantial benefit" of the bargain under the Agreement. To exercise its right to terminate for Material Breach, Customer shall notify SpaceX of this election to terminate in writing and within thirty (30) days following the conclusion of the ninety (90) day cure period. For the sake of clarity, neither (i) a delay nor ii) a Launch or Launch Activities resulting in the loss or destruction of the Payload, shall be deemed a Material Breach by SpaceX hereunder, and except as expressly stated in the Termination section of the Terms and Conditions, nothing in this Agreement shall be construed in any way as obligating SpaceX to refund any payment made in connection with any Launch Services performed hereunder.

**"Mechanical Interface"** means the SpaceX provided structural interface utilized to mechanically mate the Payload to the Launch Vehicle hardware.

**"Mission"** means the services and deliverables to be provided by both SpaceX and Customer to perform a Launch of the Payload, with an initial Launch-ready mass and orbit parameters defined in the Agreement.

**"Parties"** means Customer and SpaceX.

**"Party"** means Customer or SpaceX.

**"Payload"** means the Customer provided integrated spacecraft, adapters, separation systems, harnessing, and avionics to be launched in accordance with the parameters set forth in the Acceptance of Request. The Payload may not contain any Payload Constituents provided by the Customer without the written mutual agreement of SpaceX.

**"Payload Constituent"** means (a) spacecraft, payload, instrument, experiment, or similar equipment that is integrated onto or into the Payload, but is not an integral part of the Payload, including but not limited to CubeSats, small satellites, and hosted payloads; and (b) any integrated dispenser, separation system, or other significant hardware that are contained within the Payload.

**"Primary Payload"** means a satellite independently contracted with SpaceX that does not meet the definition of a Rideshare Payload as defined in this document.

**"Registration Convention"** shall mean the Convention on Registration of Objects Launched into Outer Space, done Nov. 12, 1974 (opened for signatures Jan. 14, 1975), 28 U.S.T. 695, T.I.A.S. No. 8480, 1023 U.N.T.S. 15.

**"Related Third Parties"** means (a) the Parties' and Co-Payload Customer(s)' respective contractors and subcontractors involved in the performance of this Agreement and their respective directors, officers, employees, and agents; (b) the Parties' and Co-Payload Customer(s)' respective directors, officers, employees, and agents; and (c) any entity or person with any financial, property or other material interest in the Payload, Co-Payload(s), the Launch Vehicle or the GSE.

**"Secondary Rideshare"** means Rideshare Payloads that are paired on the same Mission as a Primary Payload.

**"SpaceX Account"** means the account to which Customer shall make payments to SpaceX, as notified by SpaceX from time to time, within a reasonable time to make such payments.

**"Standard Offering Bulkhead"** means the Launch Vehicle side electrical interface Customer built Payload harnessing will connect to consisting of two separation signal connectors and one umbilical connector.

**"Starlink"** means the satellite constellation operated by SpaceX and launched onboard SpaceX Launch Vehicles.

**"Terminated Ignition"** means Intentional Ignition not followed by Launch.