SPACEX

RIDESHARE PAYLOAD USER'S GUIDE

Version 11 - August 2026

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ACRONYMS

ABF ..... add before flight
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
COLA ..... collision avoidance
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
ECS ..... environmental control system
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
FEEP ..... field-emission electric propulsion
FEM ..... finite element model
GN2 ..... gaseous nitrogen
GNSS ..... global navigation satellite system
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
IPA ..... isopropyl alcohol
IRIG ..... inter-range instrumentation group
ISS ..... International Space Station
ITAR ..... international traffic in arms regulations
KSC ..... Kennedy Space Center
LOX ..... liquid oxygen
LSA ..... Launch Services Agreement
LTM ..... load transformation matrix
LV ..... Launch Vehicle
LVLH ..... local vertical/local horizontal
MDP ..... maximum design pressure

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MEOP ..... maximum expected operating pressure
MLI ..... multilayer insulation
MPE ..... maximum predicted environment
MPT ..... maximum and minimum predicted temperatures
MSPSP ..... missile system prelaunch safety package
NASA ..... National Aeronautics and Space Administration
NASTRAN ..... NASA Structural Analysis
NORAD ..... North American Aerospace Defense Command
NTO ..... nitrogen tetraoxide (or dinitrogen tetroxide)
OASPL ..... overall sound pressure level
OML ..... outer mold line
OPM ..... orbital parameter message
OTM ..... output transformation matrix
P&ID ..... piping and instrumentation diagram
PL ..... Payload
PPF ..... payload processing facility
Q ..... dynamic pressure
RBF ..... remove before flight
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
SDS ..... Space Defense Squadron
SLC ..... space launch complex
SOW ..... statement of work
SpaceX ..... Space Exploration Technologies Corp.
SPL ..... sound pressure level
SRM ..... solid rocket motor
SRS ..... shock response spectrum
SSCMAN ..... Space Systems Command Manual
STEP ..... standard for the exchange of product model data
TAA ..... technical assistance agreement
TAC ..... temperature and cleanliness
TE ..... transporter-erector
TLE ..... two-line element
TML ..... total mass loss
TPL ..... third party liability
US DOT ..... United States Department of Transportation
US ..... United States
USSPACECOM ..... United States Space Command
UTC ..... coordinated universal time

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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	Updated Release
10	September 2024	Updated Release
11	July 2026	Updated Release. Major updates listed as follows: • **Section 1.3, 2.4, and 2.6.3**: Updated requirements for CubeSat Dispensers (added new definition of Integrated CubeSat Dispenser Assembly; updated One Payload One Volume rule; expanded CubeSat keep-in volume • **Section 2.4**: Clarified plate selection guide, allowable configurations, and clearance verification rules; added new clearance assessment rules for Integrated CubeSat Dispenser Assemblies and 4-point spacecraft • **Section 2.6.2**: Updated 4-point standard configurations (new configuration with 2 flexures, 2 rigid adapters; new dual bolt pattern configuration option; updated flexure stiffness; other minor updates) • **Section 3.1**: Expanded mass properties for 4-point spacecraft • **Section 3.3.2**: Added requirement on tip-off body rates • **Section 3.3.3:** Clarified restriction on simultaneous parallel deployments • **Section 3.3.4**: Clarified that the Payload Deployment rules apply to all Payloads, inclusive of CubeSats • **Section 4.1.7**: Updated Electromagnetic environments • **Section 4.3:** Updated Temperature, Humidity & Cleanliness levels • **Section 5.3**: Revised and clarified silicone material requirements • **Section 5.5.2**: Updated pressure vessel and system design requirements (disallowed bimetallic welded joints, revised restriction on additively manufactured tanks, included thermal effects in MEOP analysis) • **Section 5.5.4**: Expanded definition of "Other Pressurized Equipment and Sealed Containers" • **Section 5.5.6 and 6.8.2**: Revised design, analysis, and verification requirements for Payloads containing HTP propellants • **Section 5.7**: New requirements on CubeSat Dispenser design • **Section 6.1.1**: Expanded options for testing of separation systems • **Section 6.3**: Expanded post-integrated test modifications allowed without retest • **Section 6.7.6**: Revised random vibration notching methods and criteria • **Section 6.8.3:** Expanded methods for pressure vessel leak testing • **Section 7.1**: Clarified standard deploy signal offering for each Integrated CubeSat Dispenser Assembly (limit 4 deploy signals per individual CubeSat Volume) • **Section 7.5**: Updated flight harness design requirements • **Section 9.5.1**: Revised required GSE departure timeline • **Section 9.5.7**: Clarified and expanded space situational awareness coordination requirements • **Appendix A**: Revised circular interfaces tolerances; revised 4-point interface and CubeSat volume drawings. Clarified the CubeSat Mechanical Interface drawing • **Appendix C**: Changed acceptable file type to STEP only (Parasolid no longer accepted) • **Appendix G**: Added Orbit Selection and Bridgewire Verification deliverable details; obsolete deliverables removed • **Throughout**: AFSPCMAN 91-710 updated to SSCMAN 91-710 in title only; existing requirements remain unchanged

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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 Space Exploration Technologies Corp. (SpaceX). 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.

This user's guide is an applicable document to the Rideshare Launch Services Agreement (LSA). Deviations to the requirements set within this document are strongly discouraged and will be reviewed on a case-by-case basis for individual LSA applicability. Any deviation acceptance is applicable only to the individual LSA unless otherwise specified. Future approvals for deviations are not guaranteed and will be granted solely at SpaceX's discretion.



Figure 1-1: Example Mission Configuration using Rideshare Plates

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1.2 RIDESHARE PROGRAM OVERVIEW

SpaceX offers Rideshare Missions for small spacecraft. 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). For all spacecraft other than CubeSats, a single deployment from the Launch Vehicle per LSA is assumed. CubeSat Plate deployment allocations may include multiple spacecraft, and requirements are specified in Section 2.4. These spacecraft are referred to as "Payloads" throughout this document. Sub-components that comprise the Payload are referred to as "Payload Constituents." A Payload can be either:

- a single *MicroSat* with Payload Constituents, OR
- a single *Integrated CubeSat Dispenser Assembly*, consisting of one or multiple CubeSat Dispensers, with a single mechanical interface to the Launch Vehicle. Each Dispenser contains Payload Constituents (CubeSats).

For MicroSats, a single deployment from the Launch Vehicle is assumed, whereas each Integrated CubeSat Dispenser Assembly may have multiple Launch Vehicle deployments to deploy CubeSats. Mechanical adapters for non-standard interfaces, additional deploy signals, and other specialized configurations are subject to additional fees (see Appendix I: Optional Services).

In an effort to reduce the orbital debris footprint of the Rideshare Program, all Payloads are expected to adhere to the Federal Communications Commission's (FCC) 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 Defense Squadron (SDS) and SpaceX Space Traffic Coordination to assist with the tracking and identification of all deployed Payload Constituents no later than L-2 months; see Section 9.5.7 for detailed information.

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

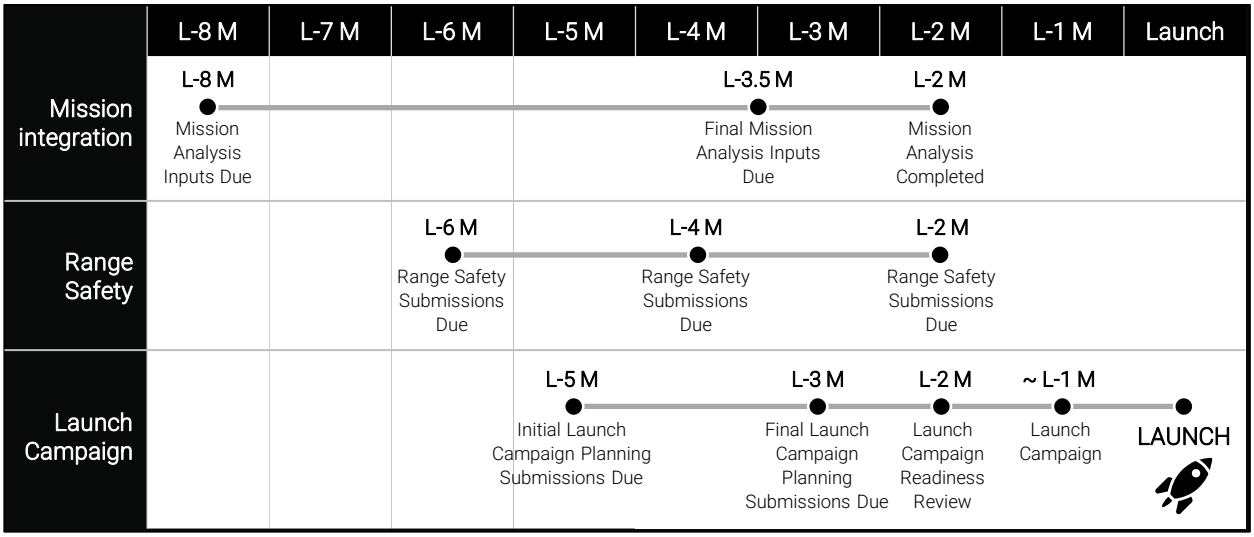


Figure 1-2: Typical Rideshare Program Schedule

SpaceX will provide kickoff materials shortly after the launch services contract is signed. SpaceX document templates and webforms are stored in the Customer Portal. A description of the documents associated with each milestone can be found in Appendix G.

The Rideshare Interface Control Document (ICD) is a standard document that references a list of applicable documents. Customers are required to review and sign the ICD, indicating that the documents and information contained within are correct.

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 hardware for Launch.

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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.

1.3 FALCON 9 PROGRAM

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

1.4 PRICING

Pricing for rideshare Launch Services can be found at www.spacex.com/rideshare.

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2 MECHANICAL INTERFACES

2.1 LAUNCH VEHICLE FAIRING

Payload, Co-Payload(s), and all SpaceX hardware, including the Rideshare Plate system (if applicable) will be co-located in the Launch Vehicle fairing volume. Please refer to the SpaceX Falcon User's Guide, latest revision, available on 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 shall 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.

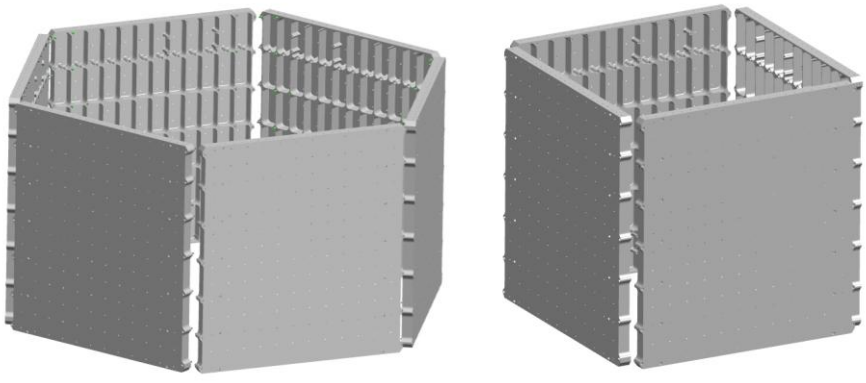


Figure 2-2: Rideshare Plates - Hexagon Configuration (left) and Cube Configuration (right)

Customers shall adhere to the One Payload One Volume rule, as described below:

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One Payload One Volume rule (Standard Offering)

MicroSats:

- Each Payload Volume containing a MicroSat shall contain one (1) Payload.
- Each Payload shall only have one (1) deployment channel, with exceptions allowed for 4-point spacecraft.

CubeSat Dispensers:

- Each CubeSat Payload volume shall contain one (1) Integrated CubeSat Dispenser Assembly. The Integrated CubeSat Dispenser Assembly may have one or multiple distinct dispensers.
- Each Integrated CubeSat Dispenser Assembly shall interface to a **single** CubeSat pattern on SpaceX hardware, following the specifications in Figure A-11. The Customer shall provide any additional CubeSat Dispenser adapter hardware, if needed to interface to the single CubeSat mechanical interface, as part of the Integrated CubeSat Dispenser Assembly.
- If the Integrated CubeSat Dispenser Assembly contains multiple distinct dispensers, the arrangement of CubeSat dispensers must not impose a deploy order constraint (doors may be commanded to open in any order, at SpaceX discretion, without obstruction to other doors or actuation mechanisms).
- Each Integrated CubeSat Dispenser Assembly may have up to four (4) deployment channels.

See Section 7.1 for more details on electrical interfaces.

Although each Plate in the Hexagon and Cube Configurations has the same footprint dimensions, Payload *volumes* vary depending on the Rideshare Plate configuration 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 (with or without Intrusion)
- Cube Configuration
  - Half XL Plate
  - XL Plate (with or without Intrusion)
- CubeSat Plate

Clearance Verification: To verify that the Payload fits inside the keep-in volume, Customers shall align their Payload, inclusive of their separation system, such that the LV side of the separation system is aligned with $X_{PL} = 0$, at the base of volumes defined in Appendix A. Payloads shall be confined to the available volumes defined in the following sections, as well as in Appendix A. SpaceX hardware is excluded from these volumes and shall not be included in this verification, unless otherwise indicated. By submitting the payload CAD, the Customer acknowledges they have verified compliance.

- CubeSat Dispensers: Each Integrated CubeSat Dispenser Assembly must fit inside of one (1) Integrated CubeSat Dispenser volume (see Appendix A) in both stowed and deployed states. Customers shall check ground support equipment (GSE) clearances between CubeSat volumes to ensure each Integrated CubeSat Dispenser Assembly can be installed without obstruction.
- MicroSats with Circular Separation Systems: The Payload must fit inside of the relevant Payload volume (see Appendix A) in a stowed state. A further restriction applies to Payloads with a 15" interface, see Table 2-1.
- MicroSats with 4-point Separation Systems: The Payload must fit inside of the relevant Payload volume (see Appendix A) in a stowed state. Additionally, any part of the Payload that is not physically mated to SpaceX hardware must maintain a 1" clearance to SpaceX hardware (including flexures, rigid, and/or ski adapters).

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

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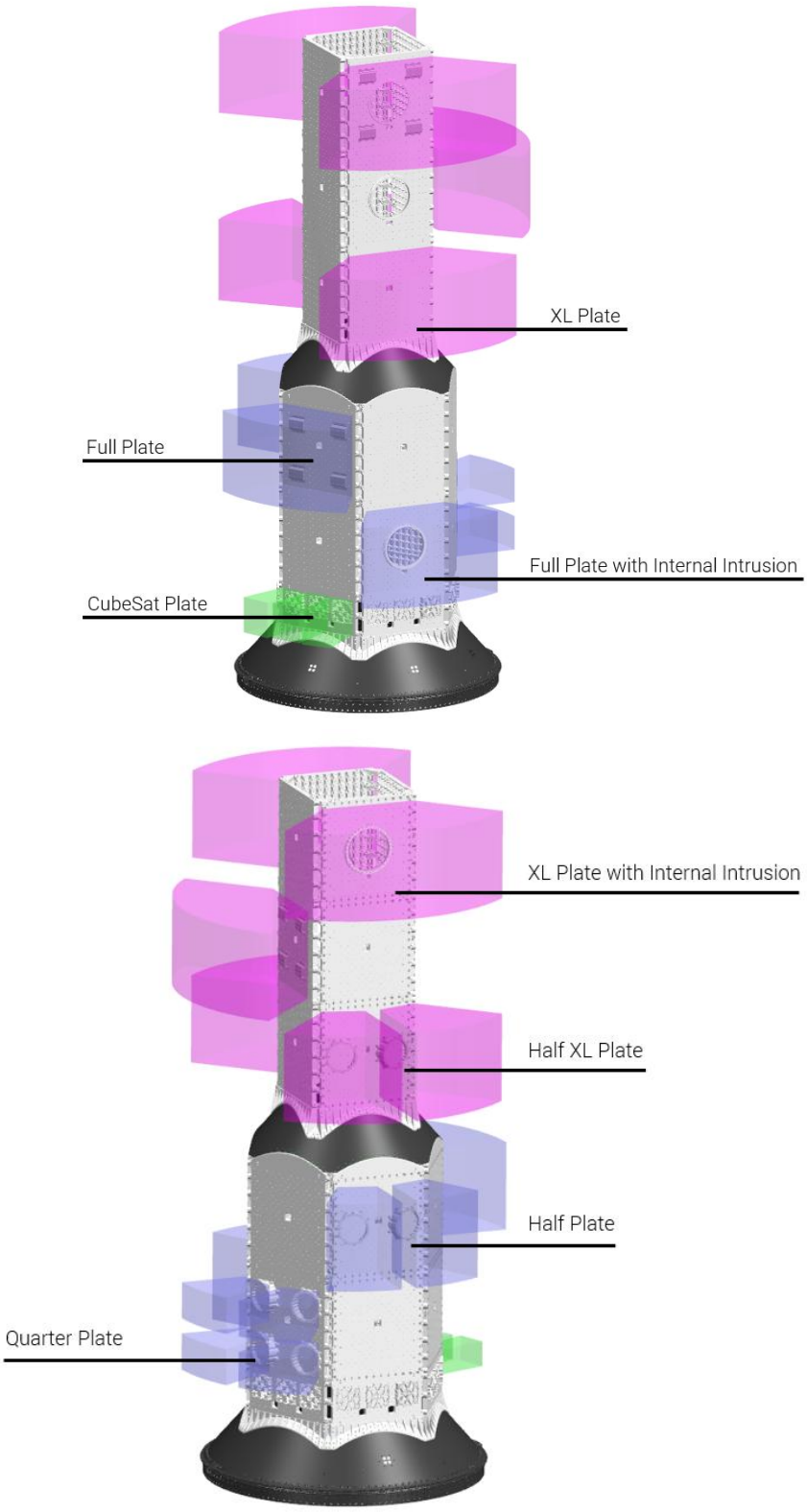


Figure 2-3: Payload Plate and Volume Configurations

Table 2-1 provides a plate selection guide, summarizing the configurations available for each plate type.

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Table 2-1: Plate Section Guide

Mechanical Interface	Hexagon Configuration				Cube Configuration			CubeSat Plate
	Quarter Plate	Half Plate	Full Plate	Full Plate with Intrusion	Half XL Plate	XL Plate	XL Plate with Intrusion	
8" diameter	X	X						
15" diameter	X	X		X[1]	X		X[1]	
24" diameter			X	X		X	X	
4-point – 16" wide		X			X			
4-point – all other			X	X		X	X	
CubeSat								X

[1] Payloads will be placed on a 15-24" cone adapter. Customers need to subtract 1.75" from the available radial volumes provided in Appendix A.

The CubeSat Plate can accommodate up to three (3) CubeSat volumes, each containing a single Integrated CubeSat Dispenser Assembly (Figure 2-4). Each Integrated CubeSat Dispenser Assembly is placed on an 8-degree wedge or a straight adapter (configured by SpaceX) via a single standard fastener interface provided by SpaceX. Detailed volume dimensions and fastener interfaces can be found in Appendix A. Each Integrated CubeSat Dispenser Assembly must fit inside of the Integrated CubeSat Dispenser volume in both stowed and deployed states. Customers shall check ground support equipment (GSE) clearances between CubeSat volumes to ensure each Integrated CubeSat Dispenser Assembly can be installed without obstruction.

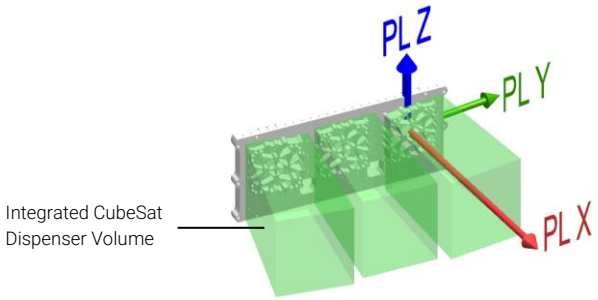


Figure 2-4: CubeSat Plate (Inclusive of 3 Integrated CubeSat Dispenser Volumes)

The Quarter Plate and Half Plate volumes can accommodate 8" and 15" diameter, or equivalent-sized interfaces (Figure 2-5). Additionally, the Half Plate volume can support 4-point interfaces that are 16" wide, as specified in Section 2.6. Quarter Plate and Half Plate volumes are accommodated as part of the hexagon configuration and may be moved to the Cube configuration at SpaceX's sole discretion. Payloads are placed on 15-degree wedges (circular interfaces) or "ski" adapters (4-point interfaces), with a standard fastener interface provided by SpaceX. Detailed keep-in volume dimensions and fastener interfaces are found in Appendix A.

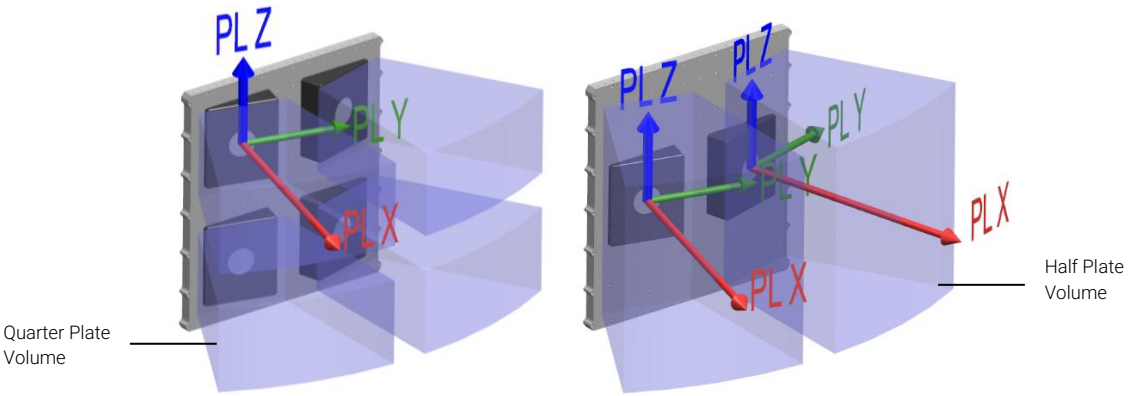


Figure 2-5: Quarter Plate Volumes - 4 shown (left) and Half Plate Volumes - 2 shown (right)

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The Full Plate volume can accommodate 24" diameter, or equivalent, sized interfaces. Additionally, it can accommodate a range of 4-point interfaces, as specified in Section 2.6.

The Full Plate with Intrusion volume has an allowable 177.8 mm intrusion through the SpaceX-provided mechanical interface and can accommodate:

- a single Payload with a 24" diameter interface requiring an intrusion into the Plate, OR
- a single Payload with a 4-point interface requiring an intrusion into the Plate, OR
- a single Payload with a 15" diameter. SpaceX will provide the 15"-to-24" adapter cone as a standard service.

Full Plate and Full Plate with Intrusion volumes are shown in Figure 2-6 and are accommodated as part of the Hexagon configuration and may be moved to the Cube configuration at SpaceX's sole discretion. Detailed volume dimensions and fastener interfaces can be found in Appendix A.

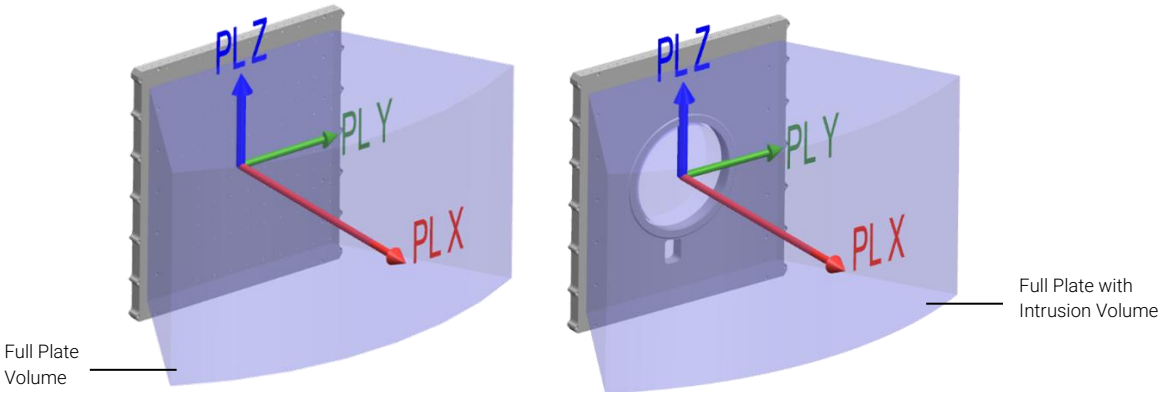


Figure 2-6: Full Plate Volume (left) and Full Plate with Intrusion Volume (right)

The Half XL Plate volume is designed to accommodate Payloads on a 15" diameter, or equivalent, sized interfaces, as well as 4-point interfaces that are 16" wide, as specified in Section 2.6. Half 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.

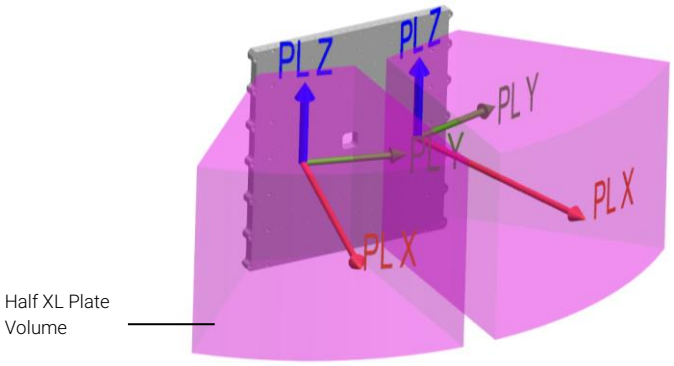


Figure 2-7: Half XL Plate Volume - 2 shown

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 2.6.

The XL Plate with Intrusion, which has a 24" bolt circle and an allowable 177.8 mm intrusion through the SpaceX-provided mechanical interface, can accommodate:

- a single Payload with a 24" diameter interface requiring an intrusion into the Plate, OR
- a single Payload with a 4-point interface requiring an intrusion into the Plate, OR
- a single Payload with a 15" diameter. SpaceX will provide the 15"-to-24" adapter cone as a standard service.

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XL Plate and XL Plate with Intrusion volumes are shown in Figure 2-8 and are accommodated as part of the Cube configuration. Detailed volume dimensions and fastener interfaces can be found in Appendix A.

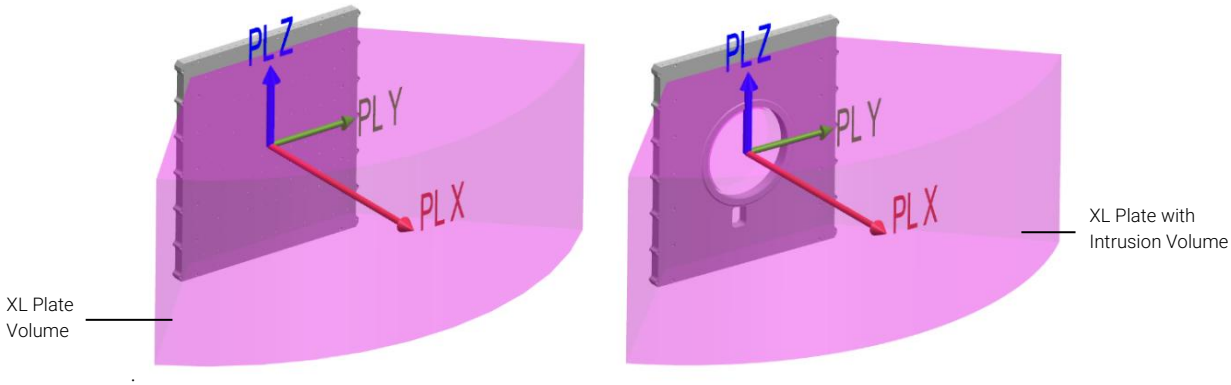


Figure 2-8: XL Plate (left) and XL Plate with Intrusion (right) Volumes

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. Environments for this mission configuration are different from those described in this guide. Please contact SpaceX for further details.

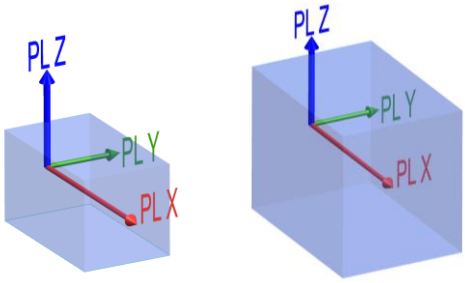


Figure 2-9: Starlink Adapter 15" Diameter (left) and 24" Diameter (right) Volumes

2.6 STANDARD MECHANICAL INTERFACES

SpaceX provides standard mechanical interfaces between Launch Vehicle hardware and Customer-provided hardware, including circular, 4-point, and integrated CubeSat Dispenser Assembly 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 shall be compliant with the requirements defined in Section 5.2.2, including minimum acceptable thread protrusion/depth. Customer is also responsible for providing fastener lubricants following the requirements defined in Section 5.3 for interfaces with SpaceX hardware.

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 shall 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 is defined in Appendix A. The fastener clocking pattern as indicated in Appendix A (holes on either side of Z_{PL} axis) is the standard interface for all sized interfaces. Customers shall design their spacecraft and separation system clocking to meet the standard interface as stated above.

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2.6.2 4-POINT INTERFACES

SpaceX provides a range of standardized 4-point mounting interfaces for Payloads. This hardware does not include additional supports for separation connectors, such as for umbilical towers. Height is defined along Z_{PL} axis, width along Y_{PL} axis. Tolerances, as measured on the customer-side of the Launch Vehicle interface, shall be within the maximum positional tolerances. See Appendix A for all detailed specifications.

2.6.2.1 FULL AND XL PLATE (WITH AND WITHOUT INTRUSION)

Standard Fastener Pattern

All payloads will mechanically attach to the Launch Vehicle hardware at each interface foot via a **single** bolt pattern (see Figure 2-11 (left)): four clearance holes for 0.5" diameter fasteners on a 3.5" diameter circle. SpaceX can also accommodate attachment to the Launch Vehicle at each foot via a **dual** bolt pattern (see Figure 2-11 (right)): eight clearance holes for two sets of 0.5" diameter fasteners on a 3.5" diameter circle. Launch Vehicle hardware is identical for both single and dual bolt patterns—the dual bolt pattern will interface with all eight available fastener holes, whereas the single bolt pattern will interface with either the inner or outer pattern of four fastener holes.

Full or XL Plate Allowable Footprints

The Full/XL Plate 4-point interfaces use two flexure adapters and two rigid adapters, positioned as shown in Figure 2-10. Adapters must be positioned as shown and cannot be rotated by 90 degrees. Allowable 4-point footprints range from a minimum of 20" x 20" to a maximum of 40" x 40" (width x height), or if using a dual bolt pattern, from a minimum of 20" x 20" to a maximum of 32 x 40" (width x height) for the inner bolt pattern, as shown in Figure 2-11 and Figure A-5.

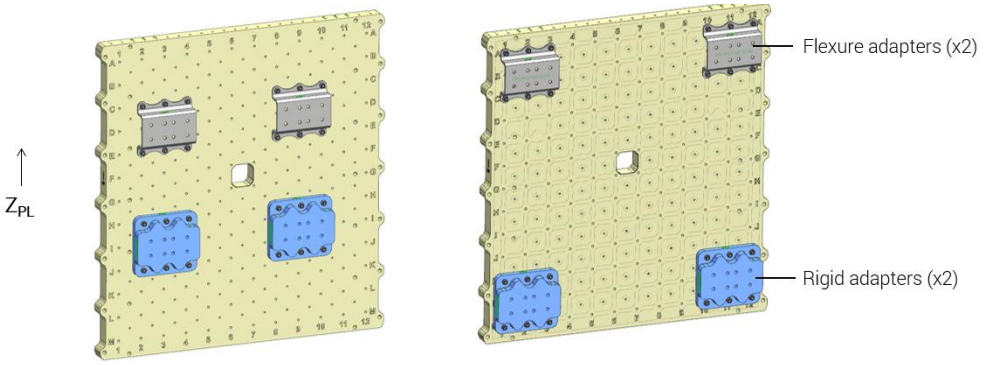


Figure 2-10: 4-point configuration for Full/XL Plates, showing extreme small (left) and large (right) footprints

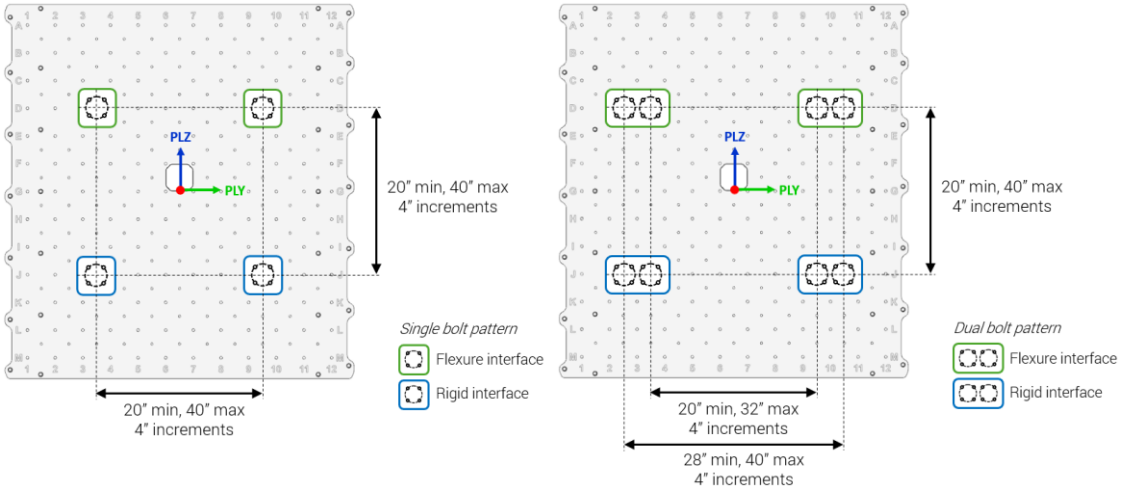


Figure 2-11: 4-Point Interface for Full / XL Plate for a single bolt pattern (left) and a dual bolt pattern (right)

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The footprint can be selected in 4" increments, as shown in Figure 2-11. Height and width do not need to be equal (a square footprint is recommended but not required). Footprints divisible by 8" will be centered on the plate (preferred). As such, SpaceX recommends the following footprints with a single bolt pattern at each foot (Footprint is square and Payload is centered on plate.):

- 24" x 24"
- 32" x 32"
- 40" x 40"

If the desired footprint is compatible with a Full or XL Plate with Intrusion, SpaceX may place the Payload on a Full or XL Plate with Intrusion, at no additional cost to the Customer. The final 4-point Payload configuration, within parameters required by each Payload, will be communicated by SpaceX to the Customer.

Full or XL Plate with Intrusion Allowable Footprints

A 4-point interface is also available for Payloads that require a Full or XL Plate with Intrusion. Similar to Full/XL Plate, the 4-point interfaces for Full/XL Plates with Intrusion utilize two flexure adapters and two rigid adapters, positioned as shown in Figure 2-12. Adapters must be positioned as shown and cannot be rotated by 90 degrees. Allowable 4-point footprints range from a minimum of 32" x 20" to a maximum of 40" x 40" (width x height), or if using a dual bolt pattern, from a minimum of 32" x 20" to a maximum of 32 x 40" (width x height) for the inner bolt pattern, as shown in Figure 2-13 and Figure A-7.

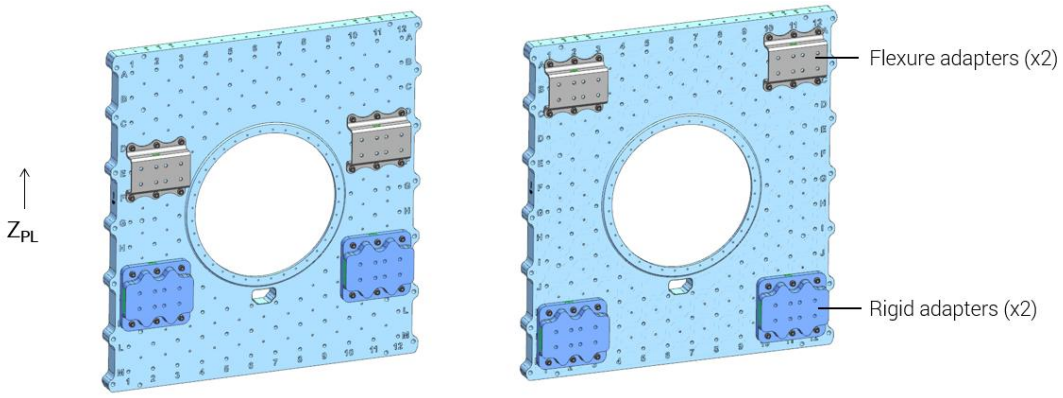


Figure 2-12: 4-point configuration for Full/XL Plates with Intrusion, showing extreme small (left) and large (right) footprints

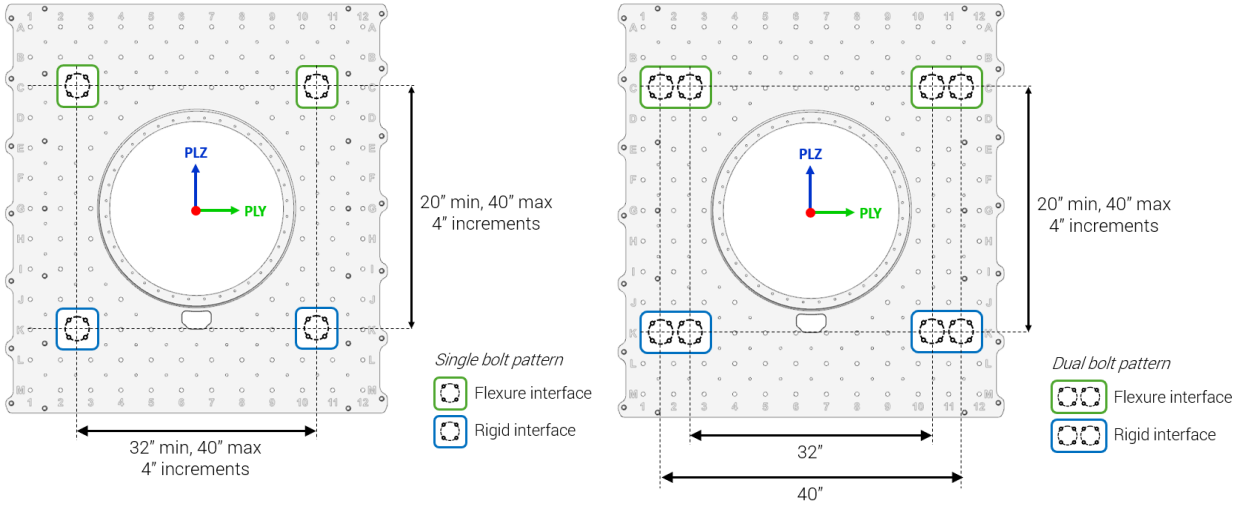


Figure 2-13: 4-Point Interface for Full/XL Plate with Intrusion for a single bolt pattern (left) and a dual bolt pattern (right)

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The footprint can be selected in 4" increments, as shown in Figure 2-13. Height and width do not need to be equal (a square footprint is recommended but not required). Footprints divisible by 8" will be centered on the plate (preferred). Please coordinate with SpaceX on other footprints, as this could result in off-centered intrusions into the plate. SpaceX recommends the following footprints with a single bolt pattern at each foot (Footprint is square and Payload is centered on plate.):

- 32" x 32"
- 40" x 40"

The final 4-point Payload configuration, within parameters required by each Payload, will be communicated by SpaceX to the Customer.

Flexure Interface Stiffness

Customers using the above 4-point interfaces shall assume the interface stiffness to the Launch Vehicle defined in Table 2-2 (single bolt pattern) and Table 2-3 (dual bolt pattern) for the flexure adapters and a rigid mounting interface for the rigid adapters. Interface stiffness applies to each interface foot independently. Spacecraft shall 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). Please contact SpaceX for a CAD file of the flexure for detailed structural analysis.

Table 2-2: 4-Point Interface Stiffness Specifications - Single Bolt Pattern

	Translation stiffnesses (10^6 N/m)			Rotational stiffnesses (10^6 N.m/rad)		
	X_{PL} axis	Y_{PL} axis	Z_{PL} axis	X_{PL} axis	Y_{PL} axis	Z_{PL} axis
LV Stiffness - Each **Flexure** Interface (2 locations) – **single bolt** pattern	162	727	124	2.8	0.43	0.38
LV Stiffness - Each **Rigid** Interface (2 locations)	Infinite stiffness (rigid)					

Table 2-3: 4-Point Interface Stiffness Specifications - Dual Bolt Pattern

	Translation stiffnesses (10^6 N/m)			Rotational stiffnesses (10^6 N.m/rad)		
	X_{PL} axis	Y_{PL} axis	Z_{PL} axis	X_{PL} axis	Y_{PL} axis	Z_{PL} axis
LV Stiffness - Each **Flexure** Interface (2 locations) – **dual bolt** pattern	251	884	154	5.1	0.68	2.3
LV Stiffness - Each **Rigid** Interface (2 locations)	Infinite stiffness (rigid)					

Testing & Metrology

Payloads with 4-point interfaces on Full/XL Plate or Full/XL Plate with Intrusion shall test with the 2x flexure, 2x rigid adapter configuration outlined above.

- SpaceX will provide flight-like GSE flexures (identical interfaces and stiffness). Customer shall provide the rigid adapters and fasteners to the shaker table. Contact SpaceX for Launch Vehicle-side flexure adapter details.
- GSE flexures are qualified for **four (4)** test campaigns. A test campaign is:
  - A protoflight OR qualification OR acceptance test in all 3 axes, AND
  - A penalty vibe test in all 3 axes (if one of those tests requires a penalty vibe)
- Customer may reuse flexures for different spacecraft, and a penalty vibe test cannot be traded for an extra test life.
- Customer is wholly responsible for tracking GSE flexure life usage and handling of hardware.
- Customer may retain the GSE flexures after testing.
- Identical hardware adapters will be provided by SpaceX at launch site for flight.

Customers shall provide a metrology report of their 4-point interface to ensure it complies with the tolerance specifications outlined in Figure A-10. Please note these are allowable tolerances for *the customer side* of the Payload interface (SpaceX positional tolerances are built-in and do not need to be factored in.).

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2.6.2.2 HALF AND HALF XL PLATE

Standard Fastener Pattern

All Payloads will mechanically attach to the Launch Vehicle hardware at each interface foot via a **single** bolt pattern: four clearance holes for 0.5" diameter fasteners on a 3.5" diameter circle. SpaceX does not accommodate a dual bolt pattern for Half or Half XL Plate.

Half or Half XL Plate Allowable Footprints

4-point footprint width for Half or Half XL Plate is fixed at 16", while height can be varied from 16" to 40" in **4" increments**, as shown in Figure 2-14.

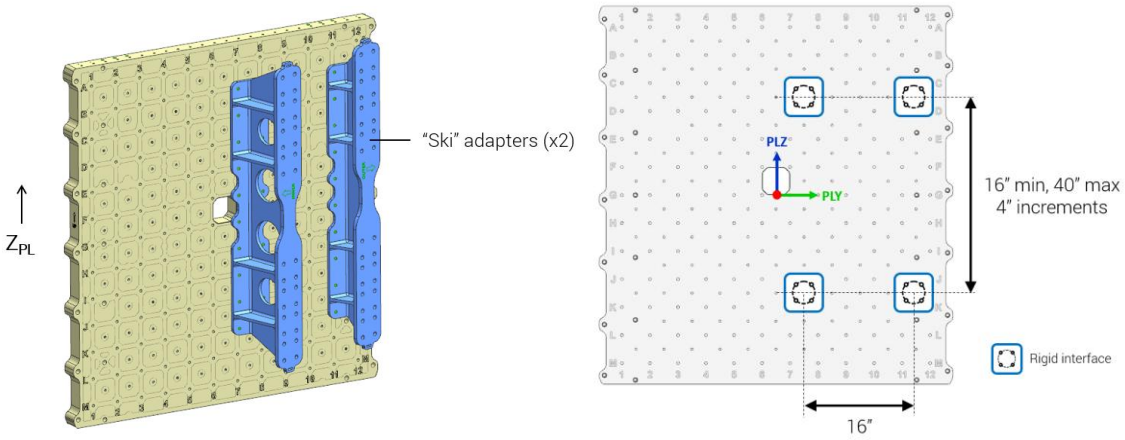


Figure 2-14: 4-Point Interface Footprint Options for Half / Half XL Plate

Flexure Interface Stiffness

4-point Payloads on a Half and Half XL Plate may assume a rigid mounting interface.

Testing & Metrology

Payloads with 4-point interfaces on Half/Half XL Plate may follow this User Guide per normal test practices (rigid interface to shaker table, all interfaces to shaker table provided by Customer).

Similar to requirements for 4-points on Full/XL Plate, Customers on Half/Half XL Plate shall provide a metrology report of their 4-point interface to ensure it complies with the tolerance specifications outlined in Figure A-9 (Appendix A).

2.6.3 INTEGRATED CUBESAT DISPENSER ASSEMBLY INTERFACE

SpaceX provides a standard Integrated CubeSat Dispenser Assembly interface; see Appendix A for detailed specifications. Customers shall design or adapt to this standard Integrated CubeSat Dispenser Assembly interface. Each Integrated CubeSat Dispenser Assembly shall interface to a **single** CubeSat pattern on SpaceX hardware, following the specifications in Figure A-11. The Customer shall provide any additional CubeSat Dispenser adapter hardware, if needed, to interface to the single CubeSat mechanical interface as part of the Integrated CubeSat Dispenser Assembly.

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, 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

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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.

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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.

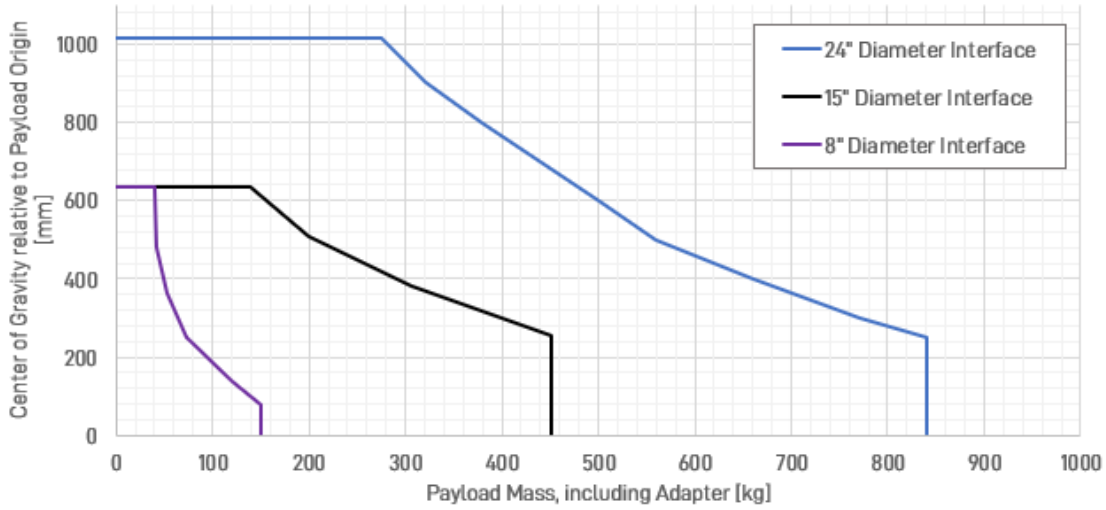


Figure 3-1: Payload Mass and X_{PL} CG for Circular Mechanical Interfaces

For Payloads with a 4-point interface, the mass and X_{PL} CG limitations are defined in Figure 3-2. Customers shall 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 shall be within the 'Short edge 16" or greater' capability curve.*
- *For a 28" x 28" 4-point interface, mass and CG shall be within the 'Short edge 24" or greater' capability curve.*

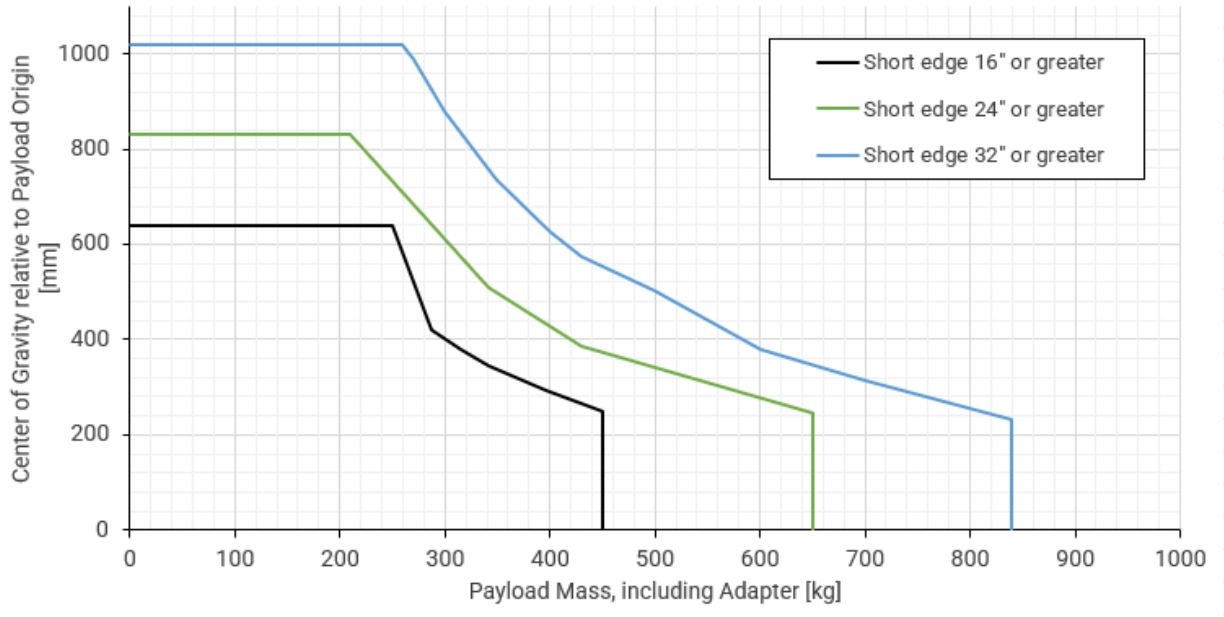


Figure 3-2: Payload Mass and X_{PL} CG for 4-Point Interfaces

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Integrated CubeSat Dispenser Assemblies on the Rideshare CubeSat Plate shall fall within the mass and X_{PL} CG limitations as defined in Figure 3-3.

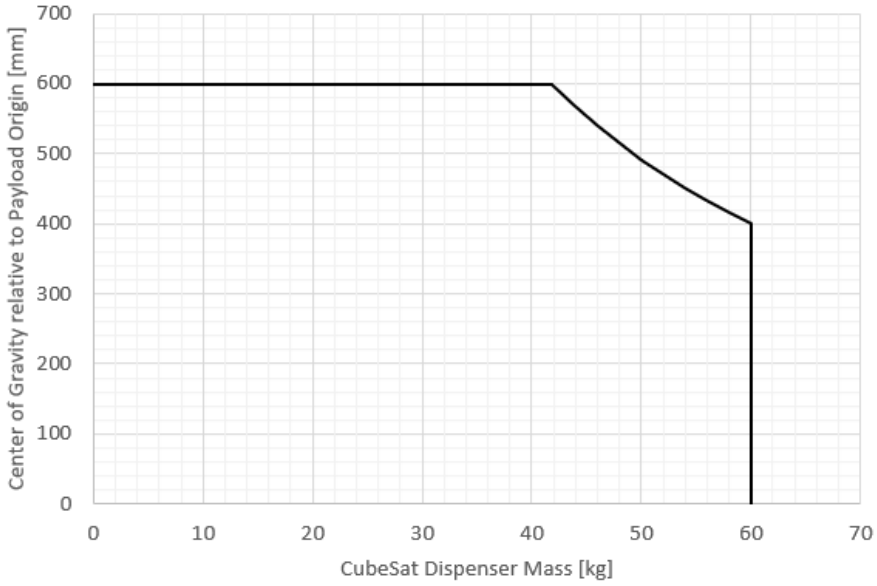


Figure 3-3: Payload Mass and X_{PL} CG for CubeSat Plate Payloads

Y_{PL} and Z_{PL} CG dimensions shall fall within the mechanical interface diameter/4-point/fastener 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 shall 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.

3.3.2 RATES AND VELOCITY

All deployed Payloads shall exit through the $+X_{PL}$ surface of the allowable Payload volume. Customer shall 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 3-4.

Payloads shall 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.

Payloads and payload separation mechanisms shall be designed to minimize the tip-off rate during separation. MicroSats shall target a maximum tip-off body rate of 5 deg/s in any direction upon separation.

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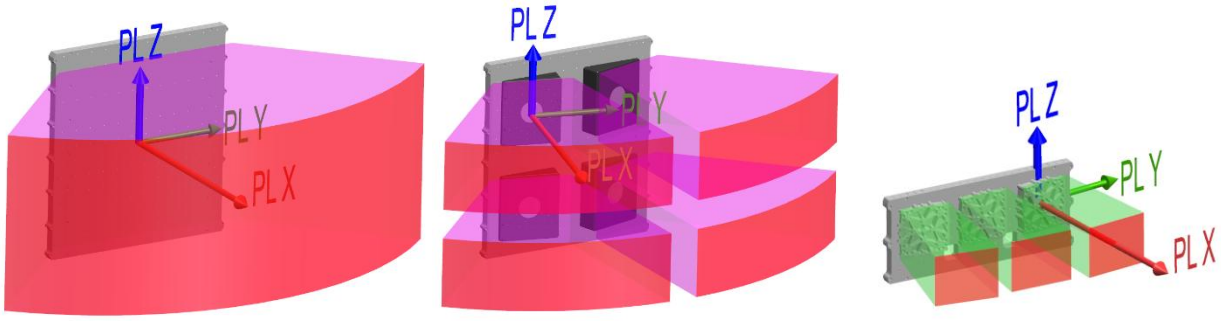


Figure 3-4: Payload $+X_{PL}$ Surface Exit Requirement (red) for Example Rideshare Plate Configurations

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)	± 2.0 deg/s
Launch Vehicle Pitch (W_Y)	± 1.0 deg/s
Launch Vehicle Yaw (W_Z)	± 1.0 deg/s

3.3.3 SEPARATION ARCHITECTURE

Each separating Payload or in series-separating Payload constituent shall be controlled by a unique signal that only deploys that single Payload. This allows an overall deployment scheme that minimizes the risk of collision between deployed objects. Parallel deployments under the same unique signal are not allowed.

Payload separation architecture and placement shall 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_{PL} direction, such that the outermost Payload is deployed first.

3.3.4 PAYLOAD MANEUVERS AND DEPLOYMENTS

All Payloads (including CubeSats) shall 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 the first 24 hours, Customer shall 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 shall 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 SDS, submit estimated trajectories for screening to the 18th SDS, and demonstrate to SpaceX that coordination with the 18th SDS and SpaceX Space Traffic Coordination, if applicable, has been completed. See Section 9.5.7 for information on Coordination with Space Situational Awareness Agencies.

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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. MPEs are defined at the Payload Interface to the Launch Vehicle. Mission-specific analyses to determine different MPEs will not be provided by SpaceX. Other 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 shall 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 shall have no elastic natural frequencies below 40 Hz and shall have a quality factor (Q) 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 is 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 Integrated CubeSat Dispenser Assemblies 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 Integrated CubeSat Dispenser Assemblies 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: Integrated CubeSat Dispenser Assembly (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 shall not be utilized for individual internal components, appendage, or Payload Constituent loads.

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See Table 6-1 and Section 6.7.2 for detailed verification requirements. These contain some combination of lateral and axial load factors; additional load factor combinations are not required if compliant to Section 6.7.2.

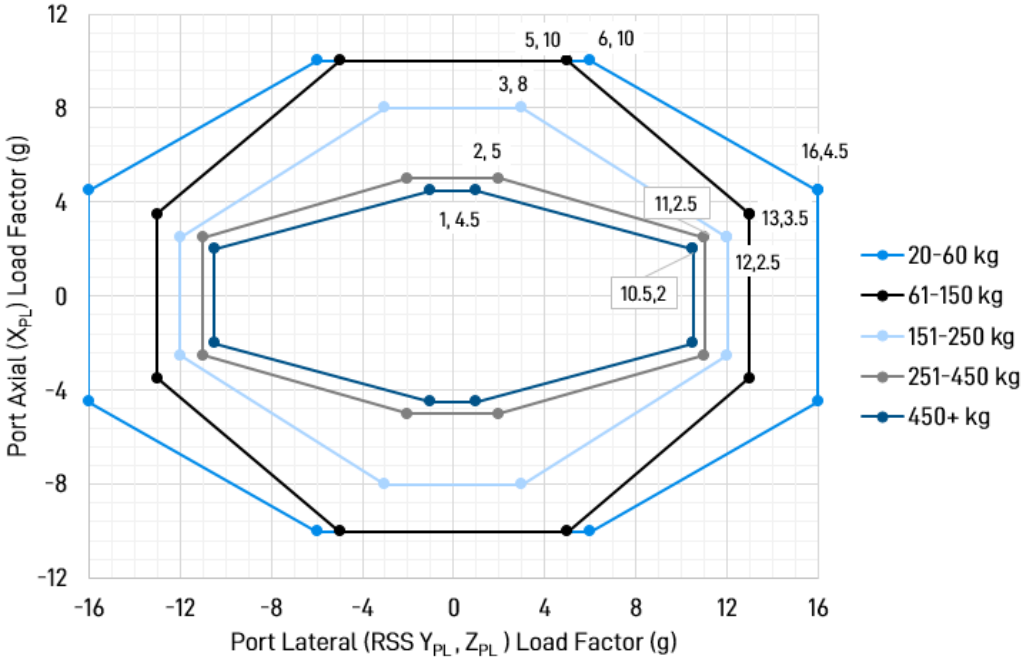


Figure 4-1: Rideshare Plate Payload Quasi-Static Load Factors

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 ≥ 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 define the environment in third octave and full octave, respectively.

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

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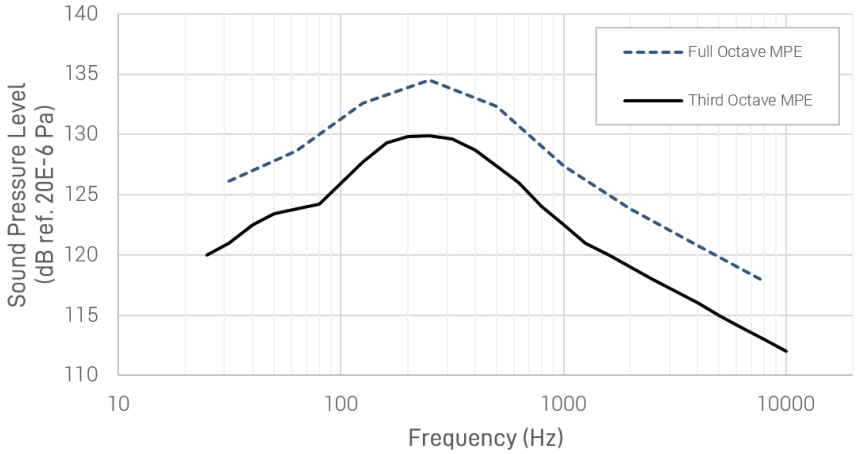


Figure 4-2: Maximum Predicted Acoustic Environment

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

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4.1.5 SHOCK

The shock response spectrum MPE, for Q=10, at the Payload mechanical interface during 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.

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

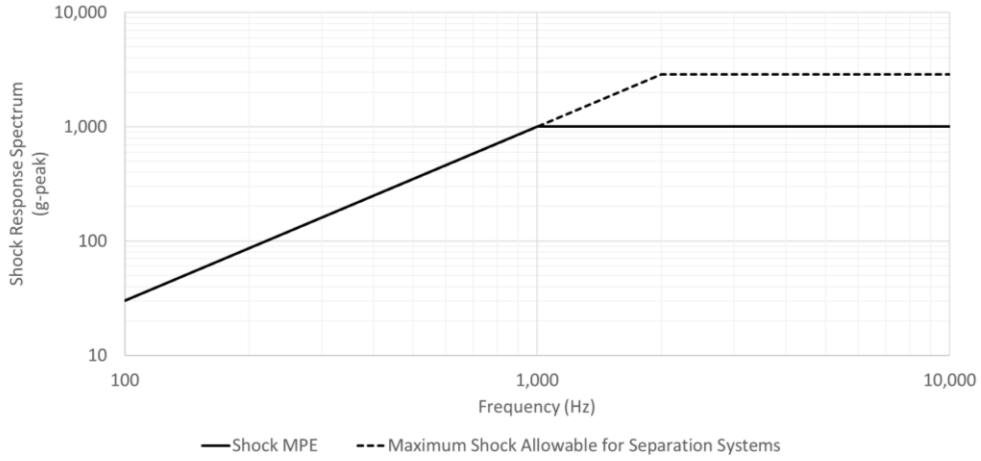


Figure 4-3: Payload Mechanical Interface Shock

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

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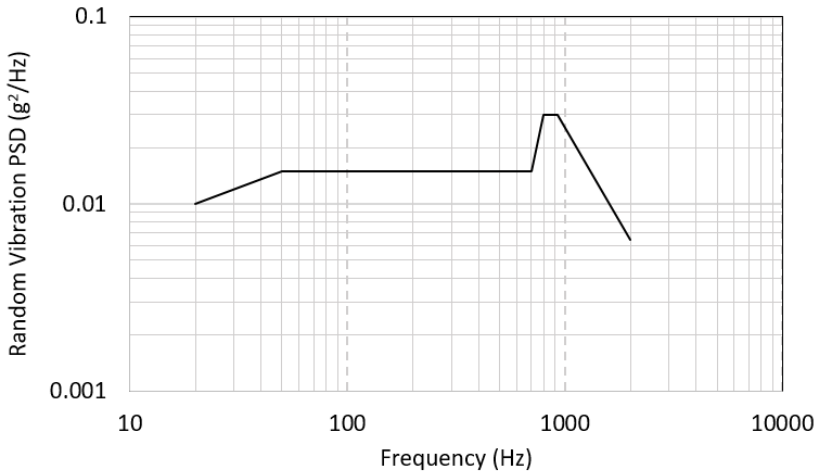


Figure 4-4: Random Vibration Maximum Predicted Environment

4.1.7 ELECTROMAGNETIC

The maximum predicted electromagnetic environments during launch campaign and flight are shown in the following sections. See Table 6-1 and Section 6.7.8 for detailed verification requirements.

4.1.7.1 IN-FLIGHT AND PRE-FLIGHT ENVIRONMENTAL EMISSIONS

The worst-case radiated environment is 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).

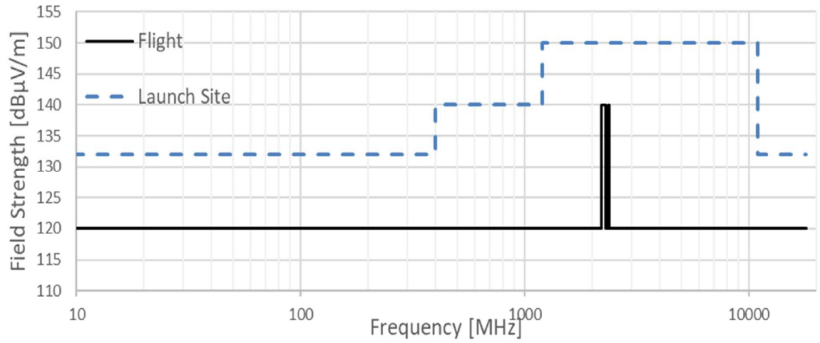


Figure 4-5: In-Flight & Environmental Radiated Emissions / Payload Radiated Susceptibility Limit

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 – 2360.0	120
2360.0 – 2395.0	140
2395.0 –18000.0	120

Table 4-8: Launch Site Radiated Emissions

Frequency Range (MHz)	E-Field Limit (dBµV/m)
1.00 – 400.0	132
400.0 – 1200.0	140
1200.0 – 11000.0	150
1100.0 – 18000.0	132

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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 that are flying on Rideshare dedicated missions such as "Transporters" are subject to these EMI requirements. Customers on non-dedicated Rideshare missions 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 – 1000.0	108	102
1000.0 – 1127.0	154	148
1127.0 – 1327.0	33	27
1327.0 – 1475.0	154	148
1475.0 – 1675.0	33	27
1675.0 – 18000.0	154	148

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 shall wait to enable these transmitters until "End of Mission," as defined by the Mission-specific second stage re-entry time (usually a minimum of 1 hour, or 3600 seconds, after the first Payload deploy for missions with a single stop).

- 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. In order to meet the fairing internal pressure environments defined in Section 4.1.8, Payloads should be designed such that the ratio of enclosed volume to total vent

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cross-sectional area for all individual volumes does not exceed 400 m. See Section 6.7.9 for detailed verification requirements.

4.1.9 PAYLOAD TEMPERATURE EXPOSURE DURING FLIGHT

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

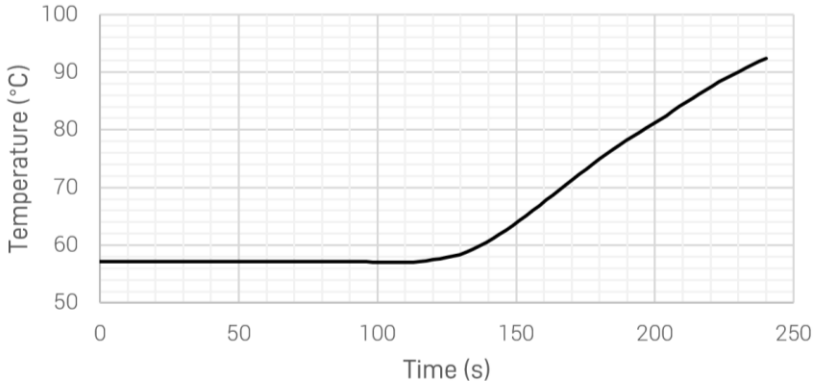


Figure 4-6: Maximum Fairing Spot Temperature Seen by Rideshare Payload

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^2 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.

Customers 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 until Payload deployment, 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. The environment below should not be assumed to be enveloping of Payload temperatures through flight or on orbit. See Table 6-1 and Section 6.7.9 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

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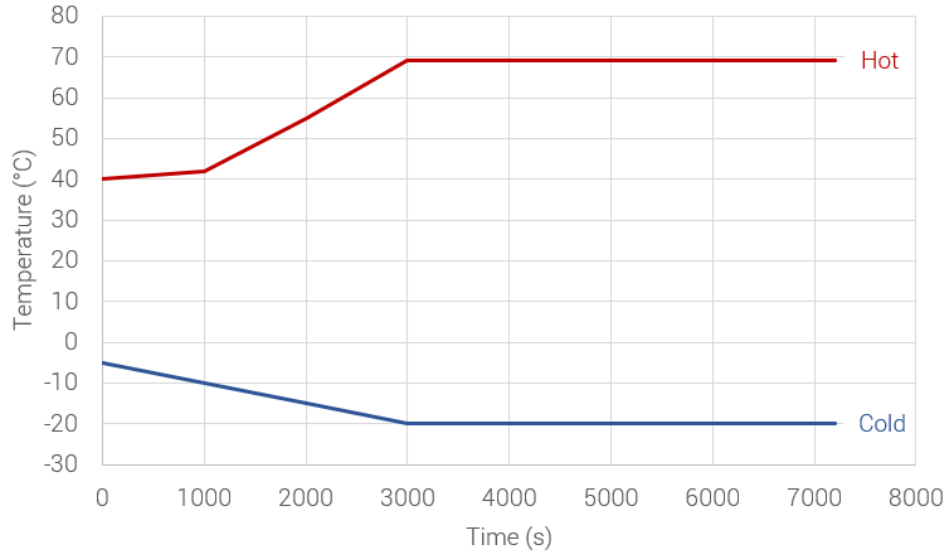


Figure 4-7: Bounding Conductive Boundary Temperature

4.2 TRANSPORTATION ENVIRONMENTS

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

4.3 TEMPERATURE, HUMIDITY, AND CLEANLINESS

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 Visibly Clean-Highly Sensitive (VC-HS).

Table 4-12: Temperature and Cleanliness Environments

Phase	Control System	Max. Duration	Temperature	Humidity	Cleanliness (class)
Spacecraft processing, Propellant conditioning & loading[1]	Facility HVAC	45 days	15°C – 25°C [59°F – 77°F]	30% – 65%	100,000 (Class 8) or better
Transport from PPF to Hangar	Trailer TAC	12 hours	15°C – 30°C [59°F – 86°F]	0% – 65%	
Encapsulated in hangar	Ducted supply from hangar environmental control system (ECS)	40 days	15°C – 25°C [59°F – 77°F]	30% – 65%	
Encapsulated rollout to pad without ECS	None	1 hour	No Control System	No Control System	
Encapsulated on pad (vertical or horizontal)[2]	Pad ECS	5 days	15°C – 30°C [59°F – 86°F]	0% – 65%	
Total		*90 days (approx.)*			

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 Gaseous Nitrogen (GN2) during the Launch Countdown sequence.

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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, shall hold to the minimum design factors shown in Table 5-1 and Table 5-2. Customers shall 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]	1.05
Separation system interface	Variable[2]

1. Only applicable to circular interfaces other than 24" interface
2. 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 shall meet the acceptance criteria given in Table 5-3. See Section 6.7.11 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 M2.5 (2.5 mm diameter) and M4	Smaller than #03 Smaller than M2.5
Locking features	• Fastener shall incorporate a minimum of **one locking feature** that does not depend upon preload to function. In order of preference: o prevailing torque feature like a distorted thread locking nut or patched fastener o lock wire/lock cable o staked fastener head with process hardness check o thread locker with process joint strength check on a representative sample o cotter pin through each fastener	• Fastener shall incorporate a minimum of **two locking features** that do not depend upon preload to function. In order of preference: o prevailing torque feature like a distorted thread locking nut o tab washer with one mechanical stop on the fastener and one stop on the underlying part o lock wire/lock cable o staked fastener head with process hardness check o cotter pin through each fastener	Not allowed
Thread engagement	• Fasteners installed in **through-holes** shall have a minimum acceptable thread protrusion beyond the end of a nut or nut plate of **two** thread pitches. This ensures that all of the fully formed threads on the fastener can carry load • Fasteners threaded into **blind holes** shall be selected to prevent contacting the bottom of the hole or interfering with incomplete internal threads		
Installation	• Fasteners shall 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.)		

- 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

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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 deployment devices to be reset.

- Fasteners reworked to reset deployable devices such as ejectors, microlatches, and other HDRMs shall 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/M2.5 or larger. The locking feature shall 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
- Fasteners used to attach the separation system to the Payload do not count towards the number of fasteners reworked, but all other acceptance criteria apply.

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 shall 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	• Fastener shall incorporate a minimum of **one locking feature** that does not depend upon preload to function. In order of preference: o prevailing torque feature like a nut plate, distorted thread locking nut or patched fastener o lock wire/lock cable o staked fastener head with process hardness check o thread locker with proper application process hardness check
Thread engagement	• Fasteners installed in **through-holes** shall have a minimum acceptable thread protrusion beyond the end of a nut or nut plate of **two** thread pitches. This ensures that all of the fully formed threads on the fastener can carry load. • Fasteners threaded into **blind holes** shall be selected to prevent contacting the bottom of the hole or interfering with incomplete internal threads
Installation	• Fasteners shall 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.)

5.2.3 CABLE TIES

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

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5.3 MATERIALS AND CONTAMINATION

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

Payloads shall 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 Integrated CubeSat Dispenser Assemblies). See Section 6.7.12 for detailed verification requirements.

Table 5-5: Payload Materials and Contamination Requirements

Requirement	Description
Visual Cleanliness	Payloads shall be cleaned to VC-HS standards per NASA-SN-C-005D prior to integration onto Launch Vehicle hardware.
Non-Metallic Materials	Each individual non-metallic material used in the construction of the Payload that will be exposed to vacuum shall satisfy the following quantities, when tested per ASTM E-595: • RML ≤ 1.0% (RML = TML - WVR), AND • CVCM ≤ 0.1% If WVR is unknown, then assume WVR = 0%. To comply with this requirement, Customers shall 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. Exceptions to this requirement are allowed using the rationale codes as given in 6.7.12. Rationale codes will be evaluated by SpaceX.
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 shall not create particulate during the vibroacoustic ascent environment. Actuation of any Payload mechanisms nearby any Co-Payload(s) or Launch Vehicle Hardware shall not create particulate.
Payload Deployment	The Payload deployment system shall not include the use of uncontained pyrotechnics (e.g., Frangible nuts).
Payload Propulsion	Payload propulsion systems shall not be operated in close proximity (within 1 km) of Co-Payload(s).
Prohibited Materials	The following materials shall not to be used on Payload hardware: • cadmium parts • cadmium-plated parts • zinc plating • mercury, compounds containing mercury • pure tin or tin electroplate (except when alloyed with lead, antimony, or bismuth)
Silicone Sensitivity	All silicone rubber or RTV silicones with probability of transfer (e.g., line of sight or other contamination pathways) to Co-Payload(s) or Launch Vehicle hardware shall require SpaceX approval, coordination, and notification prior to use. If silicones meet the requirements for non-metallic materials as set out above, OR if the silicone meets one of the exceptions to this requirement using the rationale codes A through D as given in 6.7.12, then Customers may use silicones without seeking SpaceX approval and coordination. The exception must be documented by Customer in the Payload environmental report submitted to SpaceX.

5.4 ISOLATORS

The use of isolators, defined as any component or assembly that results in the isolated assembly having a Q less than 10, is generally discouraged by SpaceX. However, SpaceX may allow the use of isolators, provided they meet the following additional design requirements (see Section 6.7.13 for detailed verification requirements):

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

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5.5 PRESSURE VESSELS AND SYSTEMS

5.5.1 DESIGN AND TEST FACTORS

The design and test factors in Table 5-6 shall be used for the design and testing of pressure vessels, lines, and other pressurized components. See Section 6.8 for further detailed verification requirements on pressure vessels and systems.

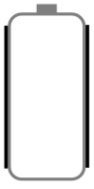
Table 5-6: Design and test factors for pressure vessels and systems

Pressure Component	Design safety factors	Qualification test factors **Shall be performed on a dedicated Qualification** Component	Acceptance test factors Shall be performed on Component prior to Integration on Flight Unit
US DOT Pressure Vessels	*Accepted as is per US DOT certification*		
Non-US DOT Pressure Vessels	**Yield:** 1.5 x MEOP **Ultimate:** 2.0 x MEOP	**Proof Pressure**: 1.5 x MEOP **Burst Pressure**: 2.0 x MEOP	**Proof Pressure**: 1.5 x MEOP
Lines and Fittings (Dia. ≥ 1.5 in)	**Yield:** 1.5 x MEOP **Ultimate:** 2.5 x MEOP	*Not required*	
Lines and Fittings (Dia. < 1.5 in)	**Yield:** 1.5 x MEOP **Ultimate:** 4.0 x MEOP	*Not required*	
Valves, Regulators, Cryostats & Other Pressurized Components	**Yield:** 1.5 x MEOP **Ultimate:** 2.5 x MEOP	**Proof Pressure**: 1.5 x MEOP **Burst Pressure**: 2.5 x MEOP	
Sealed Containers (MEOP ≤ 1 atm on orbit)	**Yield:** 1.5 x MEOP **Ultimate:** 2.0 x MEOP	*Not required*	

5.5.2 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. If the pressurized system does not meet this criterion, it can still be classified as another type of pressure component tabulated in Table 5-6, Pressure vessel classification and restrictions are shown in Table 5-7.

Table 5-7: Pressure Vessel Classification and Use Restrictions

	Type 1	Type 2	Type 3	Type 4	Type 5
	Preferred	Preferred	Preferred	Discouraged	Discouraged
					
	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 [1] (Current approved release)	N/A
Restrictions	Consult Section 5.5.5 for material compatibility			• **Use is solely at SpaceX's discretion** • **Some restrictions on fluid eligibility apply.** See Section 5.5.5	

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

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5.5.2.1 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.

5.5.2.2 NON-US DOT PRESSURE VESSELS

Any pressure vessels that are not US DOT classified require a SpaceX review of qualification and acceptance testing and shall 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.
- No bimetallic welded joints in the pressure vessel lines or payload pressure systems.
- Additively manufactured tanks are prohibited. Specific exceptions may be granted at SpaceX's sole discretion, but SpaceX strongly discourages the use of such tanks. SpaceX reserves the right to de-manifest spacecraft with additively manufactured tanks that have not been approved for flight.
- Pressurization state of the tank shall not change between the time that the Payload is mated to Launch Vehicle hardware and deployment from the Launch Vehicle. Pressure change from as-loaded condition due to thermal environment shall be accounted for in MEOP analysis. Use of High Test Peroxide (HTP) is treated separately (see Section 5.5.6).
- Pressure vessels with means of exceeding MEOP shall have a contingency pressure relief valve set to 10% above MEOP for ground operations through Payload deployment.
- Qualification shall include all testing per applicable AIAA document listed in Table 5-7 based on pressure vessel type, Section 6.8.3, and SSCMAN 91-710 (Section 12). Pressure vessels shall hold burst factors of safety on pressure per applicable AIAA document listed in Table 5-7 based on pressure vessel type and shall not be below factors defined in Table 5-6 or overall design factors of safety defined in Section 5.1 on all combined loading cases. Vessels that carry significant loads beyond pressure (do not meet the 15% Rule) shall include combined loading in qualification testing per Section 6.8.3.

5.5.3 FULLY INTEGRATED PRESSURE SYSTEMS

A pressure system is any system that is intended to be pressurized and that doesn't meet the previous definition of a pressure vessel. This includes pressure components like valves, fittings, and lines that have potential to see internal pressure between Customer delivery and on-orbit deployment. Refer to Table 5-6 for design and test factors.

5.5.4 OTHER PRESSURIZED EQUIPMENT AND SEALED CONTAINERS

Other pressurized equipment are components that do not meet the definitions of pressure vessel or pressure systems but may be pressurized at any point between Customer delivery and on-orbit deployment. This may include, for example, batteries, cryostats, and small pressurized containers that do not meet the energy thresholds defined in 5.5.2. Sealed containers that are at atmospheric pressure on the ground may also become pressurized on orbit because of the pressure difference that develops on orbit (up to 1 atm). Refer to Table 5-6 for design and test factors. If the container cannot be pressurized in test, a vacuum test is required.

5.5.5 GENERAL 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.

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- Oxidizers: All oxidizers are prohibited for use in Type 4 and Type 5 pressure vessels.
- NTO/Titanium usage: Titanium usage in an NTO-wetted application is prohibited.
- Bimetallic welded joints are prohibited.
- Cryogenic propellants: Cryogenic fuels and consumables that require loading post encapsulation are prohibited.

5.5.6 HYDROGEN PEROXIDE PROPELLANT SYSTEM REQUIREMENTS

Hydrogen peroxide, otherwise known as HTP, may be used as propellant but carries additional requirements on design and analysis.

1. The propellant tank shall have a MEOP that envelopes the max expected pressure after self-pressurization due to HTP decomposition, from propellant load to payload separation. The analysis shall follow the maximum temperature and duration profile in Section 4.3 (approx. 90 days of HTP in storage conditions, with temperature profile as defined in Table 4-12) and account for any changes in propellant temperature during ascent.
2. A propellant tank relief shall be provided to protect the propellant tank from excessive pressure due to HTP decomposition. The relief outlet shall be on the liquid side (capable of relieving HTP or HTP-decomposed byproducts) and configured such that there is no danger to personnel in case of tank relief. This relief shall be set for no more than 10% above MEOP.
3. The tank, and if so equipped, tank positive expulsion diaphragm, shall be compatible with HTP. This includes any material on the gas-side of the diaphragm, including tank weldment alloys, tank cleaning agents, etc. Customers should analyze for and account for possible leakage of HTP into the gas side of the tank (leakage across the membrane) and how this impacts the design of the overall pressure system relief architecture.
4. To minimize the possibility of reactions, all materials that may be exposed to HTP shall be cleaned and passivated and designs shall minimize excessive surface area contact with, and entrapment of, HTP.
5. The tank pressure system shall be designed to be remotely monitored during launch site processing.

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

5.5.7 FAULT TOLERANCE FOR PRESSURANT/PROPELLANT RELEASE

The pressure and propellant system shall be designed to tolerant a minimum number of credible failures and prevent an overall system failure or mishap due to inadvertent pressurant and/or propellant release.

- For systems using hypergols, or if a system failure may lead to a catastrophic hazard, the system shall have dual fault tolerance (three inhibits to propellant release). *This can be accomplished, e.g., through three independently-controlled valves in series.*
- For all other pressure/propellant systems, the system shall be at least single fault tolerant (two inhibits to propellant release). *This can be accomplished, e.g., through two independently-controlled valves in series.*

Inhibits shall be independent and cannot be combined. *For example, a single electrical command of two valves in series is not a dual fault tolerant system.* A burst disk *can* be used in series with a relief valve to demonstrate two inhibits to pressurant/propellant release. For further details, please refer to Chapter 3 of SSCMAN 91-710.

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 (SRMs) require SpaceX review. SRMs require at least TWO ignition inhibits and shall be hermetically sealed. Igniters require a Safe/Arm system to protect against accidental firing.

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5.7 CUBESAT DISPENSER SEPARATION SYSTEMS

Integrated CubeSat Dispenser Assemblies and deployment systems shall be designed such that:

- Deployment of CubeSat doors shall not impose deployment order constraints. In other words, SpaceX must be able to command deployment of any door in any order, without interference with other doors of the Integrated CubeSat Dispenser Assembly.
- The Integrated CubeSat Dispenser Assembly must remain fully within the Integrated CubeSat Dispenser volume in both stowed and fully deployed states (refer to Appendix A for the Integrated CubeSat Dispenser Volume).
- Each door must be designed to provide free, unobstructed travel for each CubeSat(s) in a deployed state.
- Each door must have a lock-out, ratchet, or other latching mechanism that locks the door into an open configuration to prevent bounce-back and ensure free deployment of the CubeSat(s).
- Passive deployment of secondary appendages during CubeSat deployment is not allowed. See Section 3.3 for further details on Separation architecture requirements.
- The Integrated CubeSat Dispenser Assembly must be designed to withstand Flight Environments in both the stowed and deployed states. Customer shall especially assess that the Integrated CubeSat Dispenser Assembly can withstand Flight Environments described in Sections 4.1.2.1 (Load Factors) and 4.1.6 (Random Vibration) in a deployed state.

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6 VERIFICATION

Customer shall 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. If SpaceX determines that Payload design introduces unacceptable risk to the mission, SpaceX may determine, in its sole discretion, to impose further verification requirements.

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 shall 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 shall 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) validates workmanship. Payloads using a Unit/Fleet Qualification approach shall 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 shall 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" shall be completed by the Customer to ensure mission safety through Payload separation.

6.1.1 SEPARATION SYSTEM TESTING

Purpose: To ensure a successful separation of the Payload from the Launch Vehicle.

Verification: Each Payload's flight separation system is REQUIRED to be included as part of the fully integrated Payload protoflight qualification or acceptance test campaign and be functionally tested (actuated) after the Payload's environmental campaign.

If the separation system is fully qualified to SpaceX standards, Customer may conduct an integrated environmental test of the Payload *without* the flight separation system installed. In this case, Customer is REQUIRED to:

1. Conduct integrated Payload tests with a separation system engineering unit (preferred) or a stiffness simulator (not allowed for 4-point separation systems). If a stiffness simulator is used:
   a. The stiffness simulator shall not shift the first natural frequency of the system by more than 10% as compared to the actual separation system.
   b. The flight representative harnesses, connectors, and switches shall be installed such that power inhibit verification is flight-like.
2. Provide evidence of the flight separation system's acceptance and functional testing per SpaceX requirements.

Reach out to SpaceX for separation system qualification and acceptance specifications as they differ from Payload qualification requirements as detailed in this document.

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6.1.2 POWER INHIBIT TESTING

For all Payloads, separation detection circuits shall be functionally verified before and after dynamic tests to ensure that a Payload does not inadvertently activate during ascent. Additionally, the Customer shall verify that any RF emissions or deployable systems are successfully inhibited while attached to the Launch Vehicle during random vibe testing, see Section 6.7.7.

6.2 TEST-LIKE-YOU-FLY EXCEPTIONS

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 shall be provided to SpaceX.

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

- Minor deviations in mass, CG, and other physical and dynamic properties that are within allowed deviations as detailed in Section 4.1.2.
- Not filling propulsion tanks with reactive propellants during ground vibration testing, if the mass and dynamic properties of the integrated system are achieved through other means (e.g., using propellant mass simulants).
- Software changes, if these changes do not affect power, deployment timing, and/or inhibit systems.
- MLI not present, if the MLI does not interfere with the function of the separation system.

6.3 POST-INTEGRATED TEST MODIFICATIONS & PENALTY RE-TEST

Limited disassembly of the Payload for functional checkouts after the integrated test is allowed without retest, if disassembly/rework falls in one or more of the following categories:

1. Fastened joints that meet the criteria in Section 5.2.1.
2. Deployment mechanisms that are deployed and reset using fastener-free resettable devices, such as pin pullers.
3. 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.
4. 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.
5. Installation of MLI, if the MLI does not interfere with the function of the separation system.
6. Replacement of CubeSat mass dummies with CubeSat flight units in CubeSat dispensers.
7. Fully containerized CubeSats only: all of the above, plus the replacement and resetting of burn wires. Burn wires shall be identical and installed in the same way, and integrated testing shall show that the original burn wire did not fail because of environmental testing.
8. CubeSat(s) demanifesting after dispenser testing: SpaceX prefers that the Customer leave the CubeSat slot(s) empty if the Dispenser is qualified for the missing mass/offset loading, rather than filling the slot(s) with an equivalent mass simulator for flight. The Customer shall assess any other effects on the Integrated CubeSat Dispenser Assembly and that it still meets the requirements specified in this document. The following are methods to show the empty slot is qualified:
    a. Analysis to show that the revised Integrated CubeSat Dispenser Assembly interface (fastener) loads (interface to Launch Vehicle) are bounded by previous testing or analysis, OR
    b. Evidence of testing of the dispenser with an empty CubeSat slot or bounding CG offset on a separate qualification unit or a random vibration re-test on the flight unit.

    If the above criteria cannot be met, Customer is responsible for providing a CubeSat mass simulator in the empty slot and ensuring the door is secured.

If a disassembly is performed that does not meet the above requirements, a random vibration re-test to acceptance levels per Section 6.5 shall be performed in all 3 axes for 30 seconds. Workmanship sensitive joints (adhesive, epoxy, brazed, welded, etc.) require a retest if they are modified after testing. Re-assembly after test shall follow the fastener installation requirements in Section 5.2.1.

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6.4 DOCUMENTATION REQUIREMENTS

Customer shall 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, as defined in the SOW and requirements as specified in Section 6. The summary report shall 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 shall be included within the summary report.

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6.5 INTEGRATED PAYLOAD UNIT TEST LEVELS

Integrated Payload unit testing shall 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: Test Levels and Durations

Test	REQUIRED OR Advised	Unit/Fleet Qualification and Acceptance Approach		Flight Unit
		Qualification	Acceptance Shall be performed on fully integrated Payload assembly	Protoflight Qualification *(SpaceX Preferred)* Shall be performed on each fully integrated Payload assembly
		Unit Not Flown	*Unit Flown*	*Unit Flown*
Quasi Static Load [1]	**REQUIRED**	**Level:** Min 1.25 times the limit load in each of 3 axes per Table 6-4 and Table 6-5	**Level:** Min 1.1 times the limit load in each of 3 axes per Table 6-4 and Table 6-5	**Level:** Min 1.25 times the limit load in each of 3 axes per Table 6-4 and Table 6-5
Sine Vibration	Advised	**Level:** Limit Levels x 1.25 **Duration:** 2 oct./minute sweep rate in each of 3 axes	**Level:** Limit Levels x 1.0 **Duration:** 4 oct./minute sweep rate in each of 3 axes	**Level:** Limit Levels x 1.25 **Duration:** 4 oct./minute sweep rate in each of 3 axes
Acoustic	Advised	**Level:** MPE + 6 dB **Duration**: 2 minutes	**Level**: MPE **Duration**: 1 minute	**Level:** MPE + 3 dB **Duration:** 1 minute
Shock	Advised	**Level**: MPE + 6 dB **Actuations**: 3 times in each of 3 orthogonal axes	Not Required	**Level**: MPE + 3 dB **Actuations**: 2 times in each of 3 orthogonal axes
Random Vibration [2]	**REQUIRED**	**Level**: MPE + 6 dB **Duration**: 2 minutes in each of 3 axes	**Level**: MPE **Duration**: 1 minute in each of 3 axes	**Level:** MPE + 3 dB **Duration:** 1 minute in each of 3 axes
Power Inhibit [3]	**REQUIRED**	Verification that the power inhibit system functions as intended during random vibe	Verification that the power inhibit system functions as intended during random vibe	Verification that the power inhibit system functions as intended during random vibe
Electromagnetic Compatibility [4]	Advised	**By test**: 6 dB EMISM OR **By analysis**: 12 dB EMISM	Not Required	**By test**: 6 dB EMISM OR **By analysis**: 12 dB EMISM
Thermal Vacuum & Thermal Cycle [5]	Advised	**Level**: Acceptance ±10 °C **Duration**: 27 cycles total	**Level**: Envelope of MPT and min. range (-24 to 61°C) **Duration**: 14 cycles total	**Level**: Acceptance ±5 °C **Duration**: 20 cycles total
Integrated Leak Test[6]	**REQUIRED**	**Level**: MEOP per Table 6-10 **Duration:** 5 min	**Level**: MEOP per Table 6-10 **Duration:** 5 min	**Level**: MEOP per Table 6-10 **Duration:** 5 min

1. Static load testing can be achieved through either a sine-burst test or sine vibration (sweep) test. See Section 6.7.2 for further guidance on test load factors and axes. These verification levels already contain some lateral and axial load combination of the values in section 4.1.2.
2. Random vibration shall be conducted as a standalone test. Static load verification through Random Vibration is not allowed.
3. Power inhibits shall be verified at an integrated level as part of random vibe testing, see Section 6.7.7.
4. EMISM (6 dB by test, 12 dB by analysis) is already included in Table 4-9.
5. 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.
6. Additional requirements apply to individual pressure vessels and systems, see Section 5.5 and 6.8. Pressure Systems that do not meet material compatibility requirements specified in Section 5.5.5 shall contact SpaceX for specific leak testing requirements.

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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 shall 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. This section does not apply to the CubeSat dispenser itself. Both the CubeSat dispenser as well as CubeSats that are not fully containerized as defined above shall be tested at the Payload levels defined in Table 6-1. If the Integrated CubeSat Assembly contains multiple CubeSat dispensers, Customer shall provide all adapter plate hardware and test as a single, integrated assembly.

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

Test	REQUIRED OR Advised	Unit/Fleet Qualification and Acceptance Approach		Flight Unit
		Qualification	Acceptance Shall be performed on fully integrated Payload assembly	Protoflight Qualification *(SpaceX Preferred)* Shall be performed on each fully integrated Payload assembly
		Unit Not Flown	*Unit Flown*	*Unit Flown*
Quasi Static Load	Not Required			
Sine Vibration				
Acoustic				
Shock	Advised	**Level**: MPE + 6 dB **Actuations**: 3 times in each of 3 orthogonal axes	Not Required	**Level**: MPE + 3 dB **Actuations**: 2 times in each of 3 orthogonal axes
Random Vibration [1]	**REQUIRED**	**Level**: MPE + 3 dB **Duration**: 2 minutes in each of 3 axes	**Level**: MPE **Duration**: 1 minute in each of 3 axes	**Level:** MPE **Duration:** 1 minute in each of 3 axes
Power Inhibit [2]	**REQUIRED**	Verification that the power inhibit system functions as intended during random vibe	Verification that the power inhibit system functions as intended during random vibe	Verification that the power inhibit system functions as intended during random vibe
Electromagnetic Compatibility [3]	Advised	**By test**: 6 dB EMISM OR **By analysis**: 12 dB EMISM	Not Required	**By test**: 6 dB EMISM OR **By analysis**: 12 dB EMISM
Thermal Vacuum & Thermal Cycle [4]	Advised	**Level**: Acceptance ±10 °C **Duration**: 27 cycles total	**Level**: Envelope of MPT and min. range (-24 to 61°C) **Duration**: 14 cycles total	**Level**: Acceptance ±5 °C **Duration**: 20 cycles total
Integrated Leak Test [5]	**REQUIRED**	**Level**: MEOP per Table 6-10 **Duration:** 5 min	**Level**: MEOP per Table 6-10 **Duration:** 5 min	**Level**: MEOP per Table 6-10 **Duration:** 5 min

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 shall be understood by Customer to be an under-test to the expected flight environments and highlighted in the environmental summary report.
2. Power inhibits shall be verified at an integrated level as part of random vibe testing, see Section 6.7.7.
3. EMISM (6 dB by test, 12 dB by analysis) is already included in Table 4-9.
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. Additional requirements apply to individual pressure vessels and systems, see Sections 5.5 and 6.8. Pressure Systems that do not meet material compatibility requirements specified in Section 5.5.5 shall contact SpaceX for specific leak testing requirements.

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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 and Payloads on 4-point interfaces. Payloads with 4-point interfaces shall be tested with SpaceX-provided GSE adapters to represent Launch Vehicle stiffness, as given in Section 2.6.2. Verification shall 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 [1]	X_{PL}, Y_{PL}, Z_{PL}
Success criteria	• All modes above 40 Hz • < 10% shift in first mode frequency[2] • < 30% shift in first mode response amplitude

1. For 4-point interfaces required to test in lateral directions other than Y_{PL} and Z_{PL} (see Table 6-5), Customers should determine whether these axes may also be used for low-level sine sweep testing to determine first mode frequency.
2. Customers shall investigate any shifts in first mode frequency greater than 5% and establish root cause.

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).

The lateral test levels below include some combination of lateral and axial loading using environments defined in Section 4.1.2. Actual combinations may differ spacecraft to spacecraft, but these levels are the minimum accepted levels.

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 shall 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_{PL} and Z_{PL} loads, in flight they could be applied in any direction onto the spacecraft in the Y_{PL} - Z_{PL} plane.

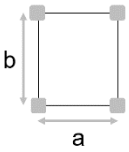
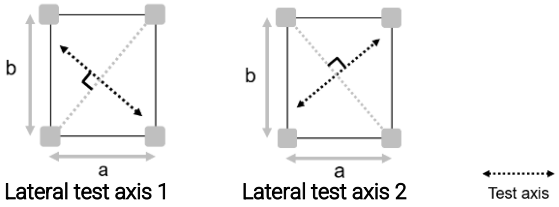
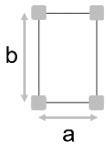
If using a 4-point interface, the payload shall be oriented such that two interface points see the full test loads. This is because a 4-point interface will see higher interface loads when the lateral load is aligned with two rather than four of the mounts, so testing of the separation system and Payload shall reflect this worst-case scenario.

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

Payload Mass	Axial Load Factor (g) X_{PL}	Lateral Load Factor (g) (See Table 6-5 for required test axes)	
Applicability	All Interfaces	Circular interfaces, CubeSats and 4-points with footprint ratio a/b ≥ 0.6	4-point interfaces with footprint ratio a/b < 0.6
Integrated CubeSat Dispenser Assembly	10.0	17.0	N/A
20-60 kg	10.0	16.6	18.8
61-150 kg	10.0	13.5	15.3
151-250 kg	8.0	12.5	14.1
251-450 kg	5.0	11.4	12.9
451 kg +	4.5	10.9	12.3

Table 6-5: Quasi Static Load Verification Test Requirements

Criteria		Sine Burst Test	Sine Sweep Test
Test parameters		• Sine burst input frequency < 2/3 of Payload first mode frequency • 5 cycles at full level minimum	Sweep rates as specified in Table 6-1 for sine vibration
Mass difference between flight and test[1]		Max 2%	
CG difference between flight and test[1]		X_{PL} direction: Max 5% Y_{PL}, Z_{PL} directions: Max 20% OR Max 10 mm	
Test axes	Circular interfaces & Integrated CubeSat Dispenser Assemblies	Three orthogonal axes: • Axial payload direction: X_{PL} • Lateral payload directions: Y_{PL}, Z_{PL}	
	4-point interface with footprint ratio *a/b* between 0.6 and 1.0[2] 	Three axes: • Axial payload direction: X_{PL} • Lateral payload directions: axes orthogonal to diagonal axes as shown[3] 	
	4-point interface with footprint ratio *a/b* less than 0.6[2] 	Three orthogonal axes: • Axial payload direction: X_{PL} • Lateral payload directions: Y_{PL}, Z_{PL} Note: this interface aspect ratio requires higher test levels, as shown in Table 6-4	
Success criteria		Measured or calculated acceleration at CG achieves target acceleration	

1. Significant deviation between as tested and flight CG locations and Payload mass may result in underqualified primary load paths and interfaces. A lower CG and/or mass in test generally results in an undertest in lateral directions. Customers shall replicate as close as possible the CG position and mass of the flight article. If the CG or mass is outside the limit specified in Table 6-5, Customers shall account for CG and mass differences in test and adjust levels and/or use fluid simulants to represent propellant.
2. 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.
3. 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:

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- a 260 kg Payload mounted to circular interface pursuing a protoflight qualification strategy shall show that net CG acceleration reaches 6.3 g during test in the axial direction and 14.3 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) shall protoflight test to 10.0 g in the axial direction and 15.6 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 shall protoflight test to 12.5 g in the axial direction and 19.1 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.

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 qualified for flight. 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 shall be tested with SpaceX-provided 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.

Notching is only permitted to prevent the Payload from exceeding the quasi-static load levels defined in Section 4.1.2 (notch to quasi-static load (QSL) x 1.0, for any test, inclusive of protoflight/qualification tests). SpaceX recommends the use of the following methods for notching, in descending order of preference:

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1. Interface force/moment limiting (*preferred*) using triaxial force gages or other direct force measurement device mounted at the spacecraft interface. If mounting force gages below the spacecraft interface, the additional mass above the force gage shall be accounted for. Interface force limiting may cover a frequency range up to 200 Hz and may include secondary notching of components to the force limiting curve. Notching past 200 Hz is not permitted. Customers shall report to SpaceX the force limiting curve and notched input, as well as the notching parameters.
2. Acceleration response limiting using a flight-correlated analytical model. If using this method, notching is allowed only for the primary mode of the Payload. Secondary mode notching is not permitted.
3. Manual notching using limits on bandwidth as shown in Table 6-6 and Figure 6-1. If using this method, notching is allowed only for the primary mode of the Payload. Secondary mode notching is not permitted.

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

- $C^2 \geq 5$
- Maximum notch depth less than 10 dB
- Notching to protect secondary structure or constituent responses (unless using interface force limiting) is not permitted because that would result in an under-test as related to flight environments. As with all 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)
40 – 80	20	10
81 – 160	40	20
161 – 200	80	40
200 – 2000	Notching not allowed	

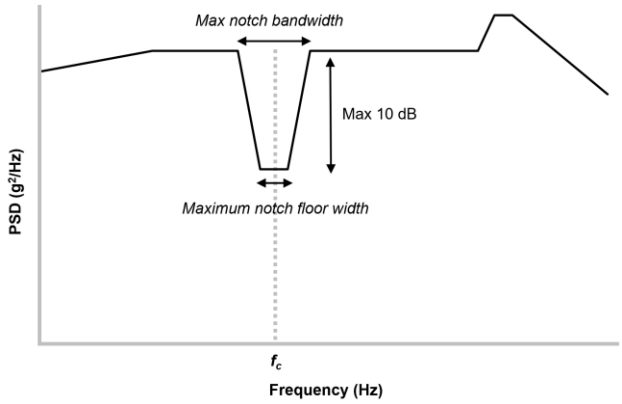


Figure 6-1: Manual Notch Limit Definitions (Primary Mode ONLY)

6.7.7 POWER INHIBITS

Purpose: To ensure that the Payload remains powered off up until Payload separation and any deployable/transmission systems are isolated from sources of power.

Verification: Testing is REQUIRED as part of the random vibration test to verify that power inhibit systems function as intended. Evidence shall be provided that shows no inadvertent power-ups and that isolated systems remain isolated during random vibe. This evidence could include, for example, boot logs or oscilloscope data.

IMPORTANT: In order to verify that power inhibit systems function as expected, all necessary power components SHALL be fully integrated and in a flight-like state. Batteries shall be in their flight-like charge state and any RBF/GSE inhibits

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shall be removed. Verification testing shall 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.

6.7.8 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 the safety of the Launch Vehicle or of Co-Payloads.

Verification: Testing or verification by analysis is ADVISED 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 shall provide electromagnetic circuit and wiring emissions analysis.

6.7.9 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.

6.7.10 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 and 4.1.11. Customers should determine the Payload's maximum and minimum predicted temperatures (MPT) using the environments from this user's guide as well as the Customer's own analysis for their spacecraft and on-orbit conditions.

6.7.11 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 shall 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

6.7.12 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.

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Table 6-7: Non-Metallic Materials Classification

Criteria		Rationale Code
RML < 1.0% **and** CVCM < 0.1%	*(Complies to requirement)*	-
RML < 3.0% **and** CVCM < 0.1%	Exposed area < 12.9 cm² (2 in²)	A
RML > 3.0% **or** CVCM > 0.1%	Exposed area < 1.6 cm² (0.25 in²)	B
Any	Meets thermal vacuum stability requirements in configuration	C
Any	Material in hermetically sealed container (leak rate ≤ 10^{-4} sccs)	D
Any	Other rationale, customer to add additional slide with rationale	E

6.7.13 ISOLATORS

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

Verification: Customers using secondary isolated subassemblies (e.g., optical head, star tracker, etc.), as defined as having a Q below 10, 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.

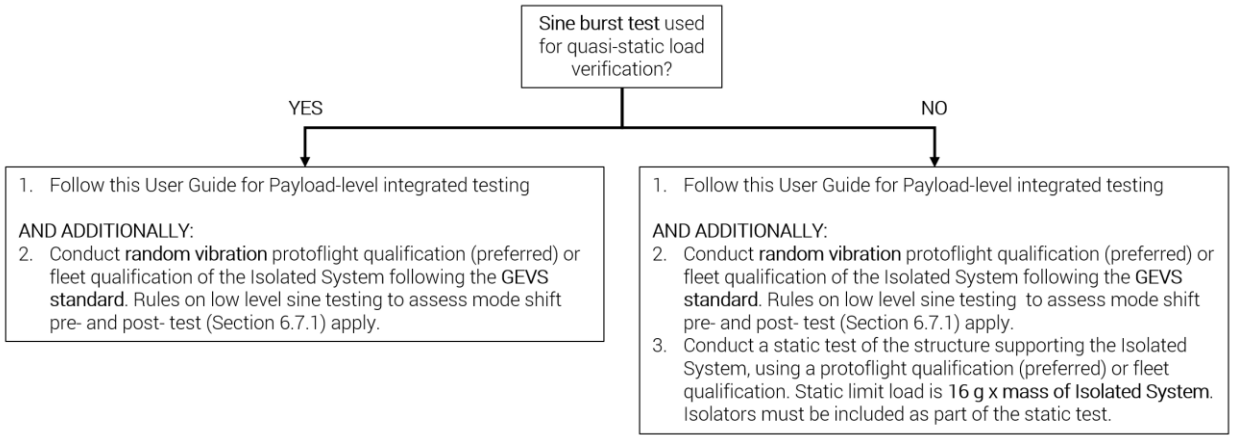


Figure 6-2: Isolated System Additional Testing

6.8 VERIFICATION FOR PRESSURE VESSELS AND SYSTEMS

6.8.1 PRESSURE SYSTEMS GENERAL REQUIREMENTS

Purpose: To verify that pressure systems and components are qualified for flight, compatible with stored propellants, 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. All pressure system materials within the pressure vessel, and all other pressurized components,
4. All working fluids, processing fluids, and expected/potential by-product fluids
5. Qualification and acceptance testing for each component of the pressure system and the overall system qualification strategy (see Sections 5.5 and 6.8 for further details and requirements).
6. Document detailing combined system test-like-you-fly exceptions between test and flight including rationale,

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6.8.2 HYDROGEN PEROXIDE ADDITIONAL REQUIREMENTS

Purpose: To verify that pressure system materials are compatible with stored hydrogen peroxide for long durations and do not pose a hazard to ground personnel, Co-Passengers, and the Launch Vehicle.

Verification: All Customers using HTP systems are additionally REQUIRED to:

1. Provide a list of materials that are either normally wetted by or may contact HTP (including gas-side of positive expulsion diaphragm, if used) and evidence that these materials are compatible with HTP.
2. Using test-correlated data, provide an analysis predicting the HTP decay rate and subsequent propellant tank pressure increase. The analysis shall be performed assuming the maximum temperature/time profile as detailed in Section 4.3 (approx. 90 days) and account for any changes in propellant temperature during ascent.
3. Conduct pressure monitoring after fill during payload processing at SpaceX facilities and before integration to the Launch Vehicle, to verify the rate of HTP decomposition and pressure increase as compared to analysis. Pressure shall be monitored over 72 hours immediately after fueling and within the Customer contractual processing timeline. Measurement frequency shall be at least every 12 hours. All propulsion components (such as tanks, lines, and valves) that will normally be wetted with HTP at any time during payload processing (including payload breakover) and launch must be exposed to HTP prior to pressure monitoring. Therefore, the Payload may need to be temporarily broken over using Customer GSE prior to integration to the Launch Vehicle to expose the propulsion components to HTP in all possible Payload orientations (vertical and horizontal).

6.8.3 PRESSURE VESSEL TEST 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 5.5.2 and b) the evidence shown in Table 6-8. To decide on the correct verification strategy for pressure vessels:

- *Step 1*: Identify whether the vessel is US DOT or non-US DOT
- *Step 2*: If non-US DOT, determine whether the vessel meets the 15% rule. The 15% rule seeks to address whether most of the combined flight stresses in the vessel arise from flight pressure (MEOP), rather than mechanical, external, and/or environmental limit level loads (See Figure 6-3). If most of the stress on the pressure vessel is from the flight pressure (at least 85%), this means it meets the 15% rule.
- *Step 3*: Build the corresponding qualification and acceptance testing strategy from Table 6-8, Table 6-9, and Section 5.5.

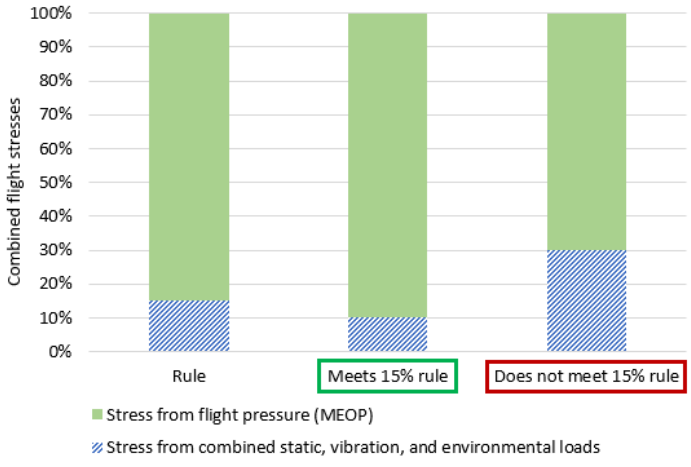


Figure 6-3: The 15% Rule, explained

Pressure system tests shall take proper precautions to ensure safety. Documentation shall be submitted to SpaceX to evaluate conformance.

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All Customers with non-conforming material compatibility pressure vessels shall contact SpaceX for special leak test requirements. Note: the helium sniffer method is **not** allowed for pressure *vessel* leak testing (it is only available for leak testing of fully integrated payloads that use inert, non-hazardous propellants or pressurants—see following section). The intent for pressure vessel leak testing is to verify that the pressure vessel is bubble-tight.

Table 6-8: Verification Requirements for Pressure Vessels

	US DOT Pressure vessels *(SpaceX Preferred)*	Non-US DOT Pressure vessels that meet the 15% Rule	Non-US DOT Pressure vessels that do not meet the 15% Rule
Documentation	• A certificate of conformance from vendor stating vessel maximum design pressure (MDP), including any special permits on the bottle design from vendor • A picture of the bottle including the mounting demonstrating a mounting scheme that does not induce significant loading into the bottle	Combined structural loading analysis for flight loads including all loading and material assumptions demonstrating that the pressure vessel meets the 15% rule	**Either:** Quasi-static and random vibration qualification of the pressure vessel while pressurized to 1.25 x MEOP in flight-like mounting (**preferred approach**) **OR:** analysis report demonstrating that the 15% rule is met if MEOP is substituted with qualified burst capability
Qualification	N/A	• proof test • vibration test • pressure cycle test • leak test per Table 6-9 • burst test • inspections	
Acceptance	N/A	• proof test • leak test per Table 6-9 • inspections	

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Table 6-9: Leak test requirements for pressure vessels

	Submersion method	Vacuum chamber method
Method	Fully **submerge** pressurized vessel in water **Verification**: Continuous video of full water surface and each fitting and connection individually (acceptable for video to show multiple areas within the minimum duration)	1. Draw a hard vacuum around the payload (10^{-3} Torr or less) 2. Charge article with 100% Helium at required pressure 3. Maintain pressure for at least 30 min 4. Collect readings. Readings shall not vary by more than 10% of max range over 5 min (max variation 1 x 10^{-5} sccs) **Verification:** Reading that meets success criteria
Test gas	• If flight fluid is gaseous helium: **100% Helium** • If flight fluid is not gaseous helium or is a liquid: **100% Nitrogen**, if working fluid has a higher molecular weight	**100% Helium**
Pressure	MEOP (+5%/-0%)	
Success criteria	No bubbles (Max 10^{-4} sccs leak rate)	Max leak rate 1 x 10^{-4} sccs of helium
Min Duration	1 hour	Readings over 5 min

6.8.4 LEAK TEST REQUIREMENTS FOR FULLY INTEGRATED PAYLOADS

Purpose: To verify that 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 **one** or more methods shown in Table 6-10. Leak testing shall be verified, at a minimum post environmental testing of the integrated Payload. Note, the helium sniffer method is only available for integrated payloads that use inert, non-hazardous propellants or pressurants, such as Helium, Argon, etc. The intent is to verify that the propulsion system is bubble-tight.

Pressure system tests shall take proper precautions to ensure safety. Documentation shall be submitted to SpaceX in order to evaluate conformance. All Customers with non-conforming material compatibility pressure vessels (see Section 5.5.5) shall contact their SpaceX representative for special leak test requirements.

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Table 6-10: Test Methods and Requirements for Integrated Payloads

Method	Snoop test method	Vacuum chamber method	Helium sniffer test method
Applies to	Integrated Payloads with any permissible propellant	Integrated Payloads with any permissible propellant	Only Integrated Payloads with non-hazardous propellants/pressurants
Method	1. Charge article with test gas at known concentration and at required pressure 2. Coat all fittings and connections with Snoop 3. Inspect for bubbles Verification: Close-up video of each fitting and connection individually (acceptable for video to show multiple areas of the system within the minimum duration)	1. Draw a hard vacuum around the payload (10^{-3} Torr or less) 2. Charge article with 100% Helium at required pressure 3. Maintain pressure for at least 30 min 4. Collect readings. Readings shall not vary by more than 10% of max range over 5 min (max variation 1 x 10^{-5} sccs) Verification: Reading that meets success criteria	1. Seal article from surrounding environment 2. Charge article with 100% Helium at required pressure 3. Do not zero/tare the detector (maintain tracer gas background reading) 4. Collect measurements Verification: Reading that meets success criteria
Test gas	• If flight fluid is gaseous helium: 100% Helium • If flight fluid is a gas that isn't gaseous helium: Flight gas, 100% Nitrogen, or 100% Helium • If flight fluid is a liquid: 100% Nitrogen or 100% Helium	100% Helium	100% Helium
Pressure	MEOP (+5%/-0%)		
Success criteria	No bubbles	Max leak rate 1 x 10^{-4} sccs of helium	Max leak rate 1 x 10^{-4} sccs of helium
Min Duration	5 min (total over all fittings)	Readings over 5 min	Readings over 5 min

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.

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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 detection telemetry.

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	Per Quarter Plate	Per Half Plate	Per Full Plate	Per Half XL Plate	Per XL Plate	Per CubeSat Plate[2]	Per Integrated CubeSat Dispenser Assembly
Deployment	1[1]					12	4
Breakwire (PL-side loopback)	2[1]					24	8

1. Default channel allocations for one contract will be for a single Payload deployment. Additional channels are available for 4-point separation mechanisms at additional cost. Secondary deployment channels are paired 1:1 with primary deployment channels.
2. No more than 4 primary deployment channels per Integrated CubeSat Assembly, with a maximum of 3 Integrated CubeSat Assemblies per CubeSat Plate.

7.2 DEPLOYMENT CHANNEL PROPERTIES

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

All deployment/separation devices directly interfacing with Launch Vehicle electrical systems shall have sufficient reliability to ensure safe deployment. The preferred method of achieving reliability is two independent actuators on separate circuits. Either of these actuators shall 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 are 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 with a bus voltage of 24-36 V with a maximum current draw of 6 A. Specifics of the voltage provided to the separation device and 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.

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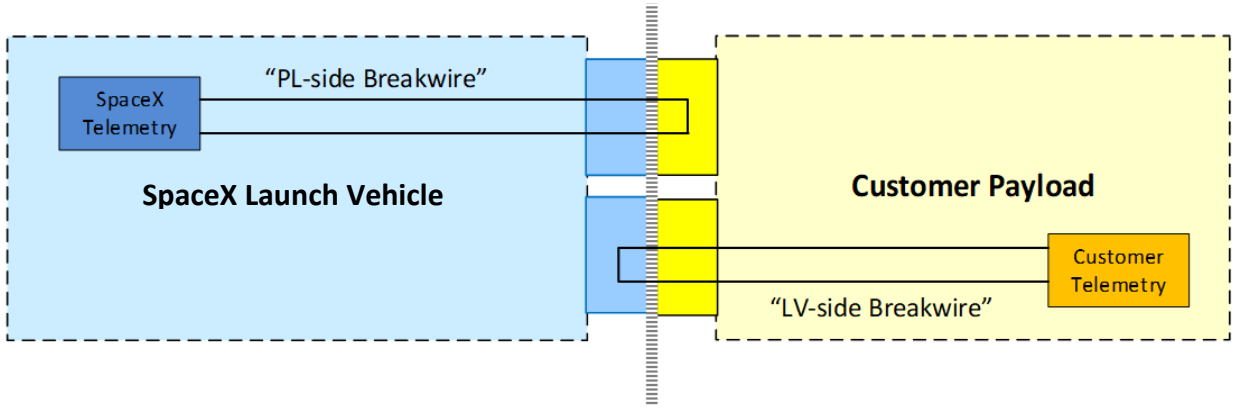


Figure 7-1: Illustration of Breakwire Channel Categories

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. Additional breakwires may be provided to the Customer subject to availability. Contingent on availability, there are no restrictions from SpaceX on the number of Launch Vehicle-side breakwires requested by the Customer.

PL-side breakwire channels shall 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 Ω
High-resistance state	>8 kΩ

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 are specified in Table 7-3. Up to four (4) 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. The availability of umbilical groups on a particular mission may be restricted by the total number of umbilical groups that SpaceX can support across all customers.

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Table 7-3: Umbilical Channel Electrical Properties

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

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 shall 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. Any harness containing deploy signals is built by SpaceX, while any harness that exclusively has breakwire and/or umbilical signals are built by the Customer. Deviations to this allocation are at SpaceX's sole discretion and will be specified in the ICD.

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 shall be designed and built in accordance with the Wire Harness Build Guide provided by SpaceX as part of the mission integration process.

Customer shall design harnesses to a length of 108" (2.743 m) to be compatible with all possible positions on the plate. Details of the harness design, including routing path, are determined at SpaceX discretion.

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, shall 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.

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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	Launch Pad
VSFB (SLC-4)	37 m (120 ft.)	208.5 m (684 ft.)	171.9 m (565 ft)
CCSFS (SLC-40)	24.5 m (80 ft.)	197.8 m (649 ft.)	171.9 m (565 ft)
KSC (LC-39A)	24.5 m (80 ft.)	181.1 m (594 ft.)	196.3 m (664 ft)

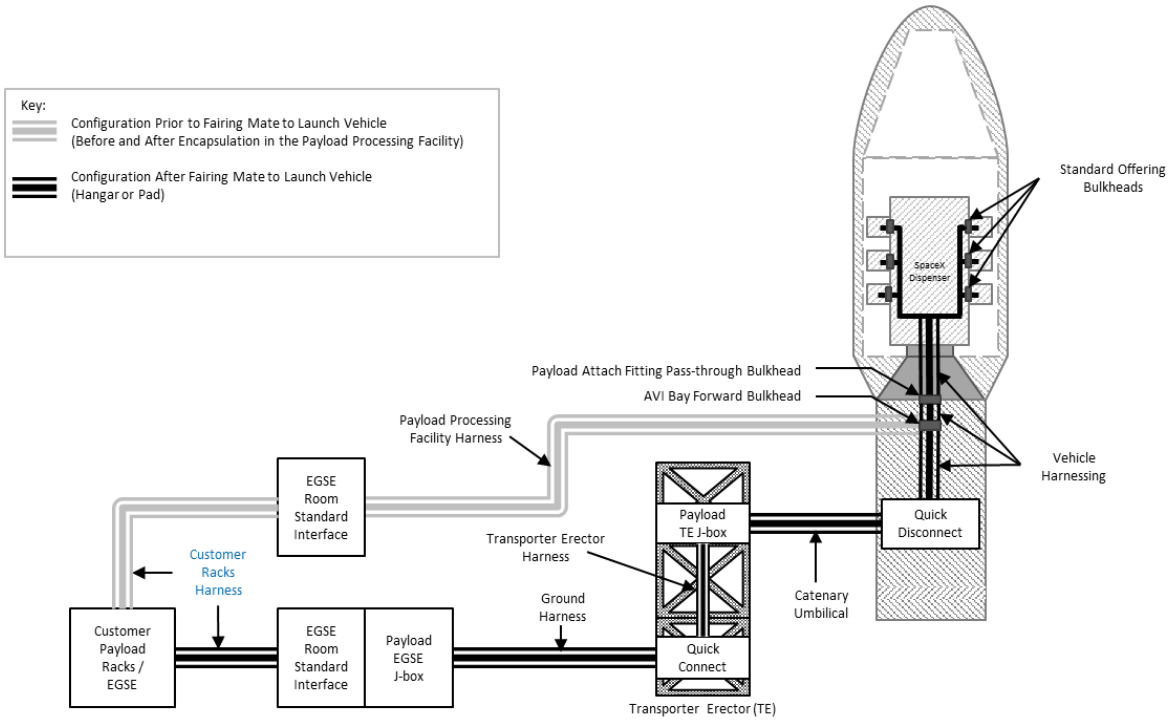


Figure 7-2: Ground Side Electrical Interfaces

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.

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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/.

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. Third parties will not be allowed physical contact or close inspection of Customer cleanroom hardware at any time.

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 35 ft. (10.5 m) hook height.
e. Provide a designated floor space for Payload processing activities defined in the Payload-specific Statement of Work.

The PPF includes an area for Payload EGSE adjacent to the Payload processing area, if needed and as elected per associated optional services. A 100-Mbps-class Internet connection is provided, which may be common with other Customer Internet connections.

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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.

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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.

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 shall 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.

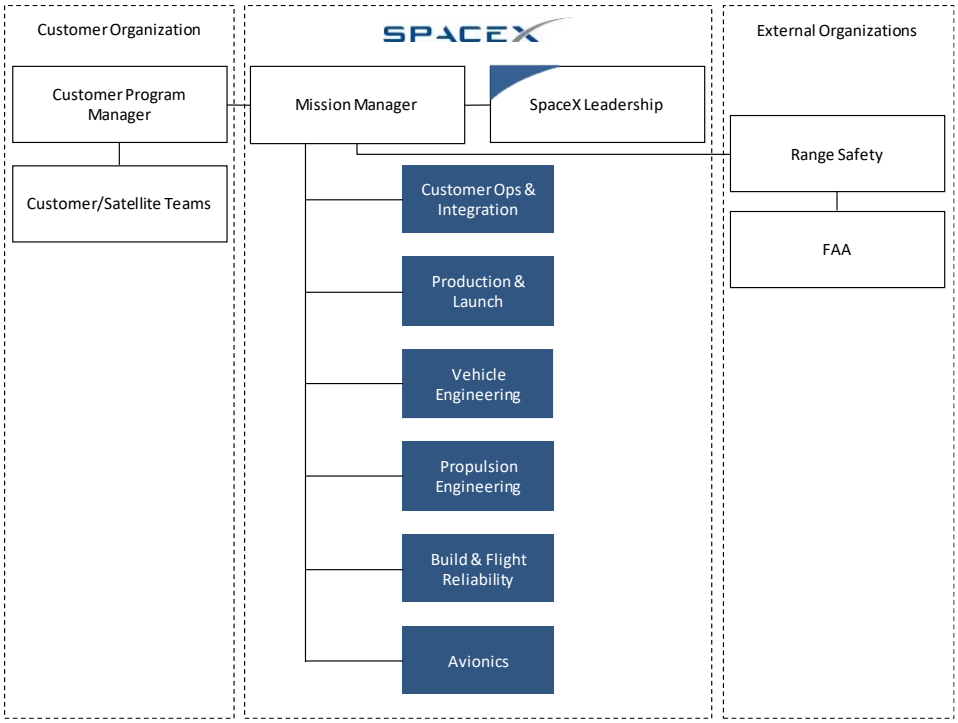


Figure 9-1: Mission Management Organization

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9.4 PROGRAM DOCUMENTATION

9.4.1 INTERFACE CONTROL DOCUMENT (ICD)

The Rideshare Interface Control Document (ICD) is a standard document that references a list of applicable documents. Customers are required to review and sign the ICD, indicating that the documents and information contained within are correct.

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 and receiving 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 eight 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 the final day of on-site integration days as scheduled in the Daily Launch Campaign Schedule.
- 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.

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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 shall 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 SpaceX an updated Payload processing schedule once per working day. The schedule shall 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 Customer flight-mating interface. This interface may be used for a fit check with SpaceX-provided Mechanical Interface 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 providing qualified forklift and crane operators, if required to complete Customer's nominal processing activities.
- 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 with a time delay as defined Section 4.1.7.2.
- Customers may access their spacecraft for final battery charging while in the PPF with coordination with SpaceX. If electrical connectivity has been purchased as an optional service (see Appendix I), the payload will have access to the electrical harnesses referenced in Section 7.

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 shall 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 shall be coordinated in advance with SpaceX.
- Customer shall provide advanced copies of all hazardous operation procedures, in addition to a Payload Ground Operations Plan (GOP) which references each hazardous procedure (reference Appendix G). Hazardous procedures and the GOP are reviewed and approved by the Launch Range safety authority. Customer shall also provide copies of any non-hazardous procedures requested by the Launch Range safety authority.
- Customer shall arrange for and implement the disposal of hazardous waste generated during Payload processing activities in accordance with Launch Range and facility regulations.
- Customer shall 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.

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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 shall 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 shall 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 shall 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 shall be provided to SpaceX upon request. Customer shall 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

9.5.7.1 PRE-LAUNCH PAYLOAD REGISTRATION

Customer is required to register all deployed objects with the 18th SDS to assist with tracking and identification. 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 18th SDS (SPOC.SPACE.CustomerService@spaceforce.mil). If required, SpaceX can provide direct contact information with personnel from the 18th SDS. Contact information for Customer's operating team must be provided as part of this registration, and SpaceX additionally requires that Customer opt into public listing of that contact information within the space-track.org system for the lifetime of their mission.

Additionally, if any of the payload's operational, transfer, or disposal orbits cross the International Space Station (ISS) altitude, NASA requests direct coordination at jsc-dl-topo-iwg@mail.nasa.gov for ISS conjunction deconfliction.

SpaceX also 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.

9.5.7.2 POST-LAUNCH EPHEMERIS UPLOADS

Customer is required to publish forward predicted GPS/GNSS-based satellite ephemerides with covariance to:

- Space-Track: https://www.space-track.org
- SpaceX Space Traffic Coordination: Details at https://docs.space-safety.starlink.com/, contact space-safety-onboarding@spacex.com for pre-launch setup and testing.

Ephemerides should be published within 24 hours of first contact with the spacecraft. Publication is required at regular intervals (e.g., after every ground station pass) and at least every 24 hours, starting from initial signal acquisition after Payload separation and ending no earlier than completion of Payload cataloging by the 18th SDS. Cataloging is considered complete when:

- The 18th SDS has assigned Customer's spacecraft its permanent North American Aerospace Defense Command (NORAD) identification number,

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- Satellite positional data is available via space-track.org, and
- Customer's operational contact information is public.

Customers not capable of publishing ephemerides due to lack of GPS or predictive capability must coordinate with a third party to meet these requirements prior to integration to the Launch Vehicle. SpaceX can provide third party support recommendations.

Integrators are responsible for enforcing these requirements with their constituents. Failure to demonstrate the ability to meet these requirements may result in mandatory re-booking to a later launch. Repeated failures to enforce these requirements will be treated as a demonstrated inability to meet these requirements and may impact future launch contracts.

All customers must claim their object with the 18th SDS no later than 30 days after deployment and must include public contact information within the space-track.org system for the lifetime of their mission.

9.5.7.3 MANEUVERING PAYLOADS EPHEMERIS PUBLICATION TIMELINES

Ephemerides must be published to the SpaceX Space Traffic Coordination System and to space-track.org no less than 24 hours prior to any planned maneuver and as quickly as possible after first contact following maneuver completion. Maneuvers for collision avoidance shall be communicated with all impacted parties as soon as conjunction risks are identified. Operators are responsible for performing collision risk reduction maneuvers. Failures to publish maneuver information with sufficient advanced notice will be treated as a demonstrated inability to meet these requirements and may impact future launch contracts.

9.5.7.4 SECONDARY DEPLOYMENTS

The operator of a dispenser or any spacecraft conducting secondary deployments is responsible for publishing a predicted ephemeris for the deployed object at least 6 hours prior to the deployment of the object. Secondary deployment payloads must comply with all requirements stated in Sections 9.5.7.1, 9.5.7.2, and 9.5.7.3. Secondary deployment spacecraft should begin publishing ephemerides as soon as possible following separation from their host vehicle.

Customers are responsible for enforcing the above requirements with all secondary deployments. Failure to demonstrate the ability to meet these requirements may result in mandatory re-booking to a later launch. Repeated failures to enforce these requirements will be treated as a demonstrated inability to meet these requirements and may impact future launch contracts.

9.5.7.5 BEST PRACTICES

The ephemeris upload requirement exists to mitigate the risk of collisions with other satellites operating in the targeted injection orbit and to expedite cataloging by the 18th SDS. Customers should follow best practices above and beyond these requirements whenever possible, including but not limited to:

- Uploading ephemerides within 3 hours of deployment from either the Launch Vehicle or when the Launch COLA analysis expires, and
- Publishing ephemerides a minimum of three times per day.

The SpaceX Space Traffic Coordination team publishes ephemeris quality and covariance realism metrics on Starlink's Space Safety website. As an additional safety measure, SpaceX submits post-launch ephemeris for each deployed payload based on Stage 2's state and estimated separation system impulse, but customer-provided orbit determination from satellite telemetry (e.g., from GPS or GNSS) is more accurate. Publishing post-deployment ephemerides with covariance reduces collision risk and drastically reduces uncertainty and accelerates the cataloging process by USSPACECOM. By accelerating cataloging efforts, two-line element (TLE) ambiguity is reduced for all deployed payloads, thereby helping all rideshare operators establish contact with their respective payload(s).

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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 gases 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.
- If required due to Launch Site restrictions, 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 shall be escorted while on certain U.S. government Launch Sites.

9.6.3 PAYLOAD INTEGRATION AND ASSOCIATED HARDWARE

- If required and determined at SpaceX's sole discretion, SpaceX will lead the operations 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. The SpaceX mission manager will provide to the Customer any relevant programmatic updates related to Launch of the Payload during the Launch Campaign on an as-needed basis.

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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 familiarization for Customer personnel regarding the PPF (cranes, warning lights, etc.) and applicable Launch Range/facility safety and security procedures. Familiarization 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 shall 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, or terminate the Agreement and return all amounts paid to Customer, without interest, with no further liability.

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.

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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 in the format of the Orbital Parameter Message as defined in Appendix E.

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 seven (7) days of Launch shall be coordinated with SpaceX for inclusion in CSpOC analysis.

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.

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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, 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 shall be delivered to the Launch Site by Customer. SpaceX will assist in arranging for Space 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/.

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 purchased as an optional service), 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/.

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 monitoring area may be shared with Co-Payload Customer(s) at a designated SpaceX facility.

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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/. 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.

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11 SAFETY

11.1 SAFETY REQUIREMENTS

Customers are required to meet SSCMAN 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 standard practice.

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APPENDIX A: MECHANICAL INTERFACES AND VOLUMES

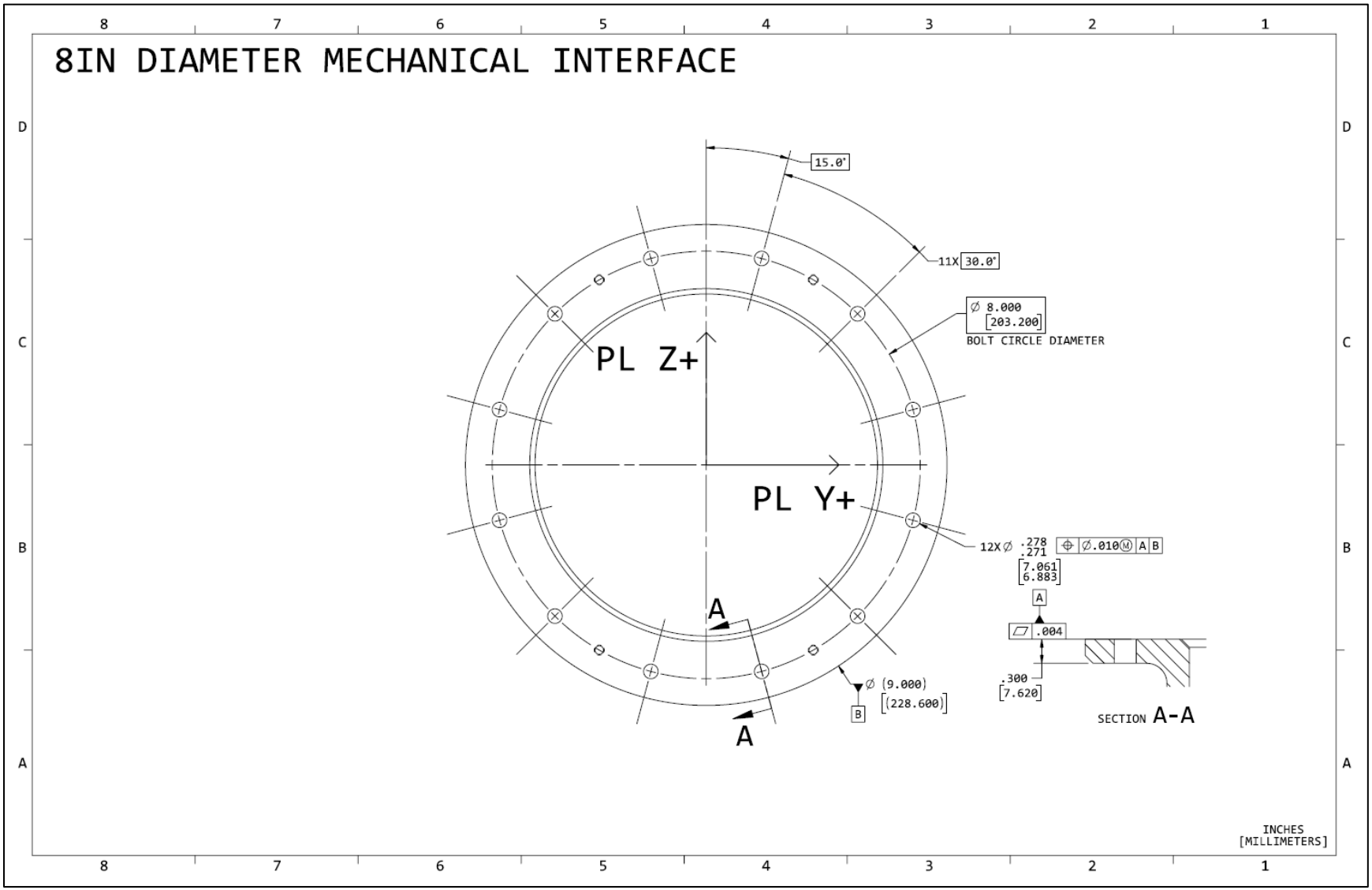


Figure A-1: 8" Diameter Mechanical Interface

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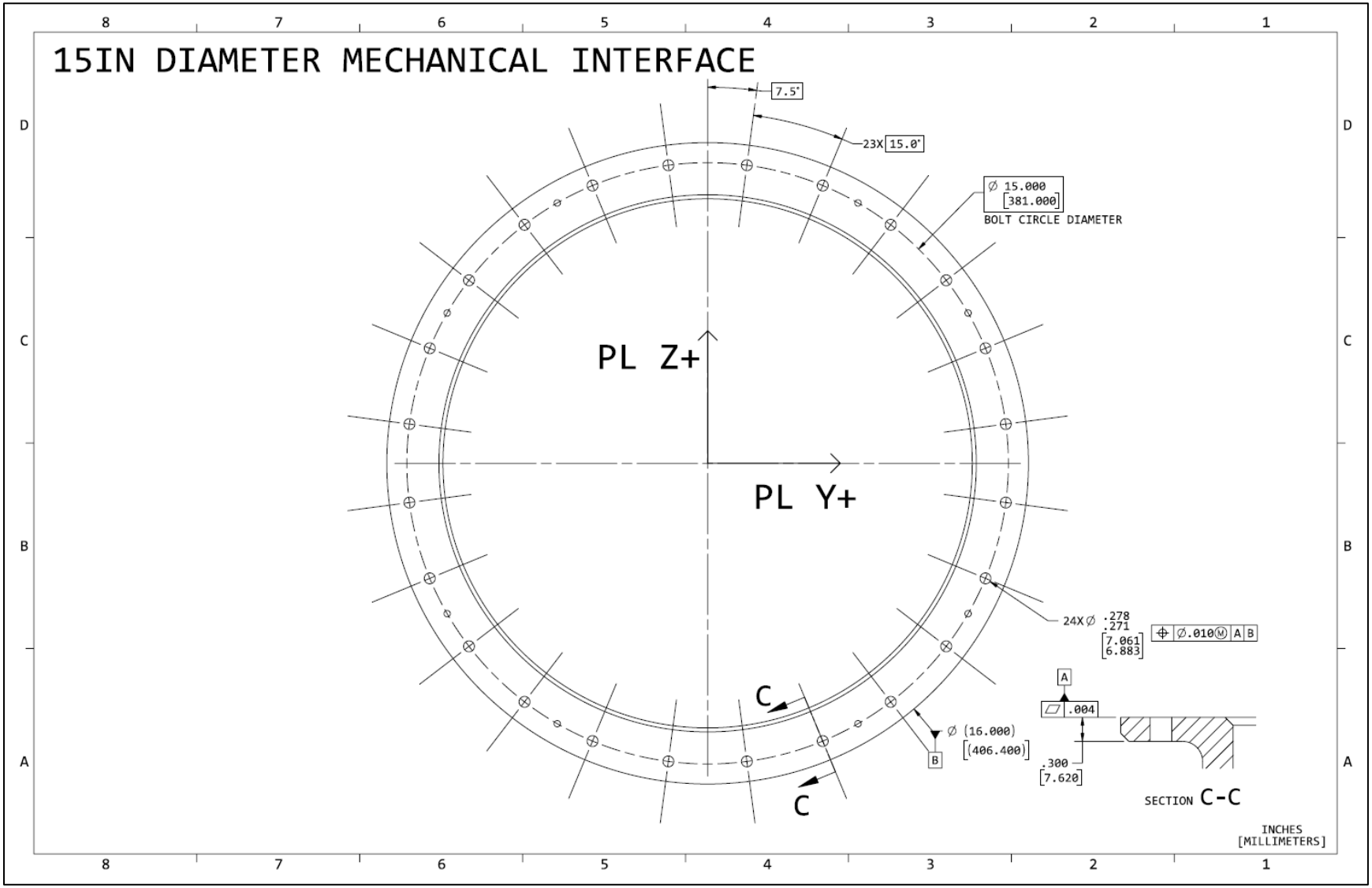


Figure A-2: 15" Diameter Mechanical Interface

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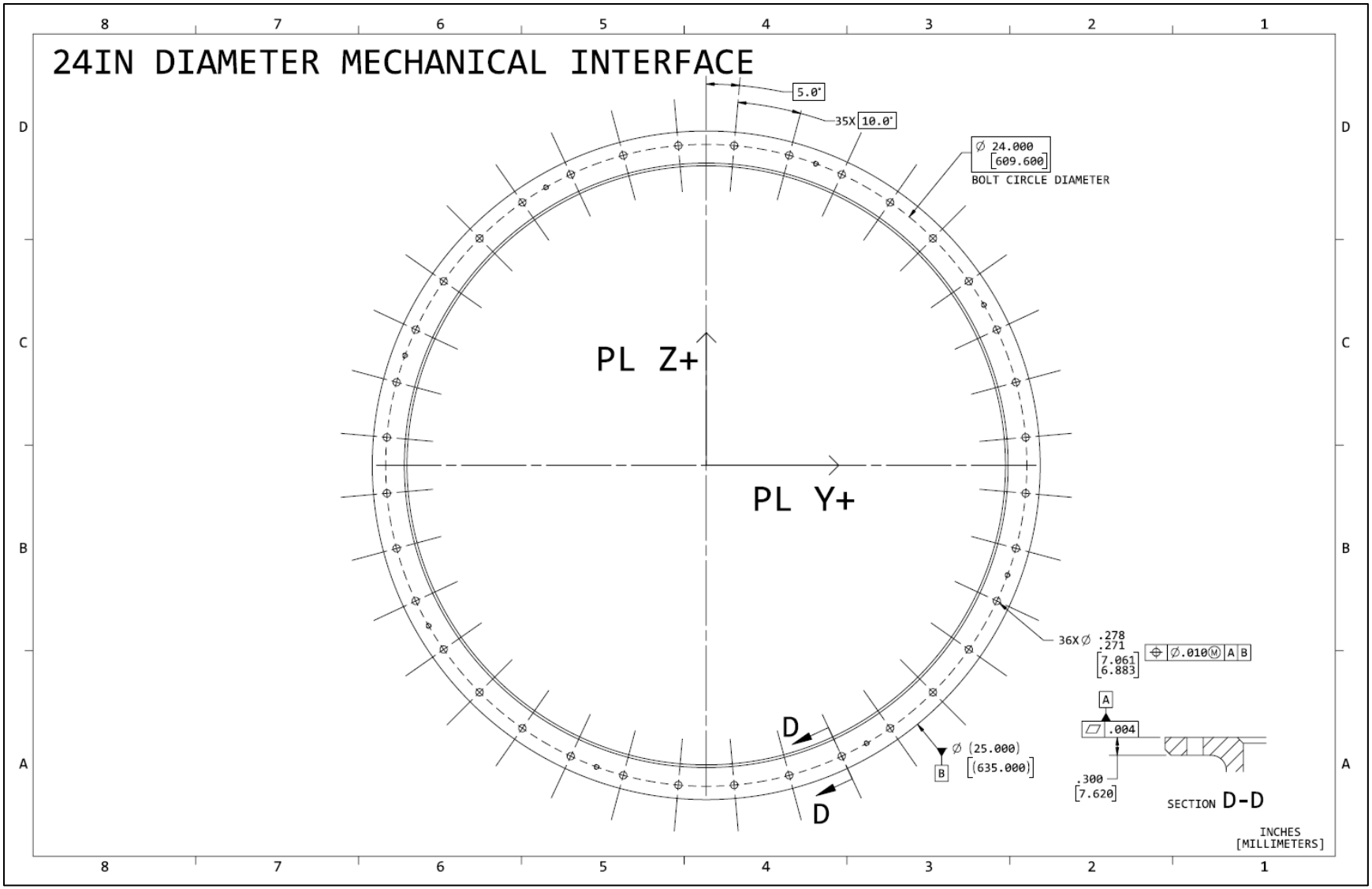


Figure A-3: 24" Diameter Mechanical Interface

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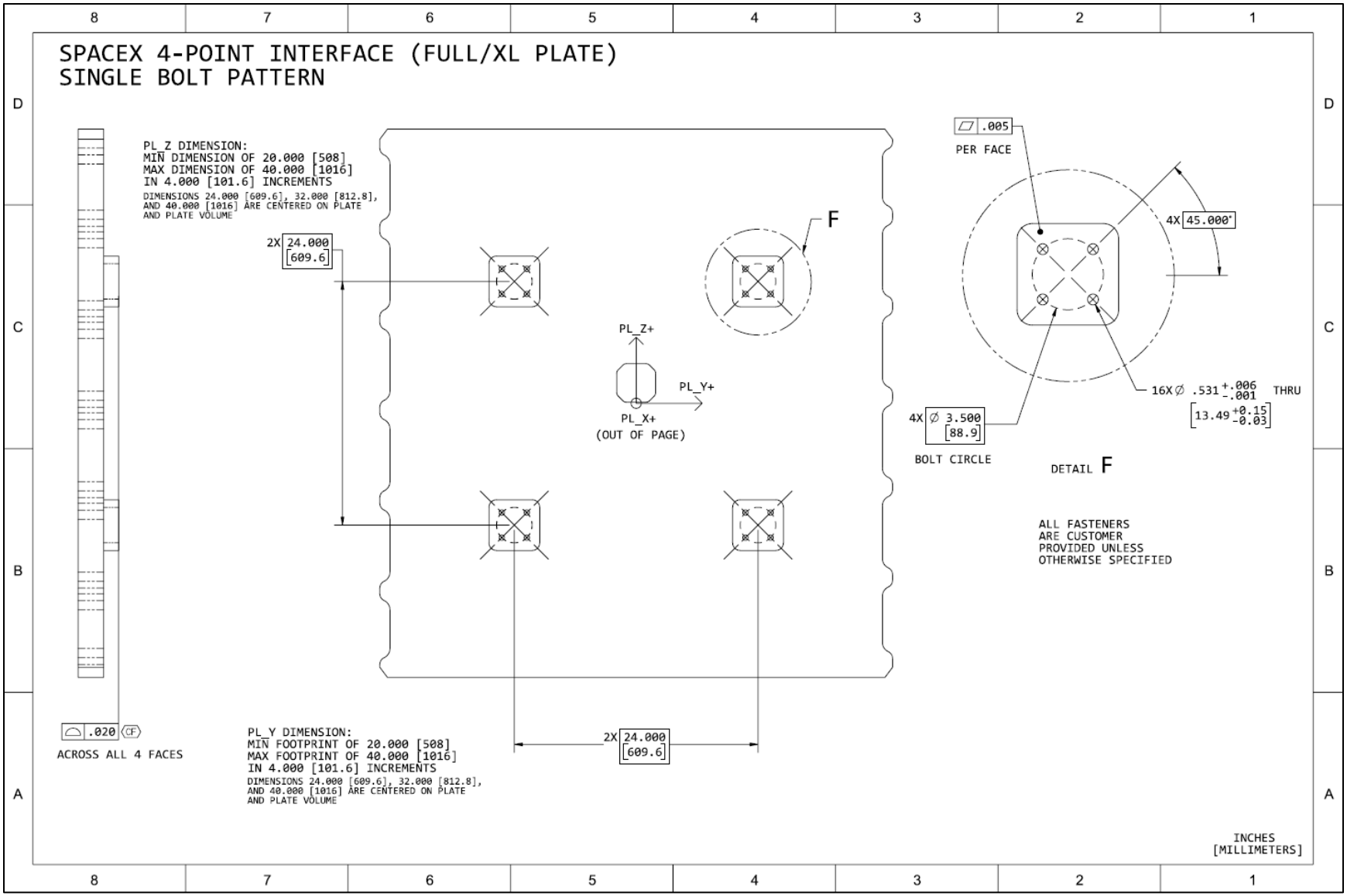


Figure A-4: 4-Point Mechanical Interface (Full / XL Plate) - Single Bolt Pattern

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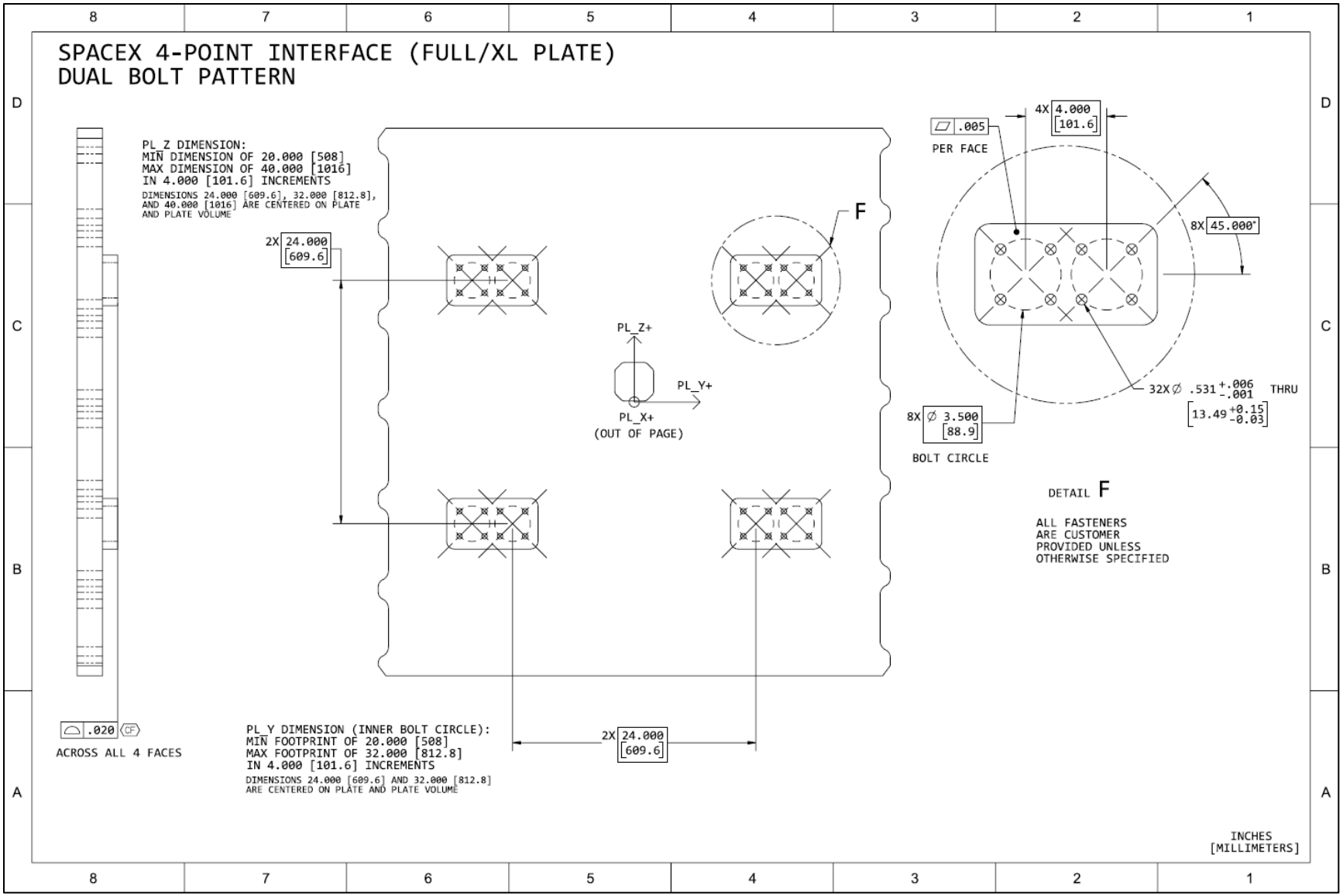


Figure A-5: 4-Point Mechanical Interface (Full / XL Plate) - Dual Bolt Pattern

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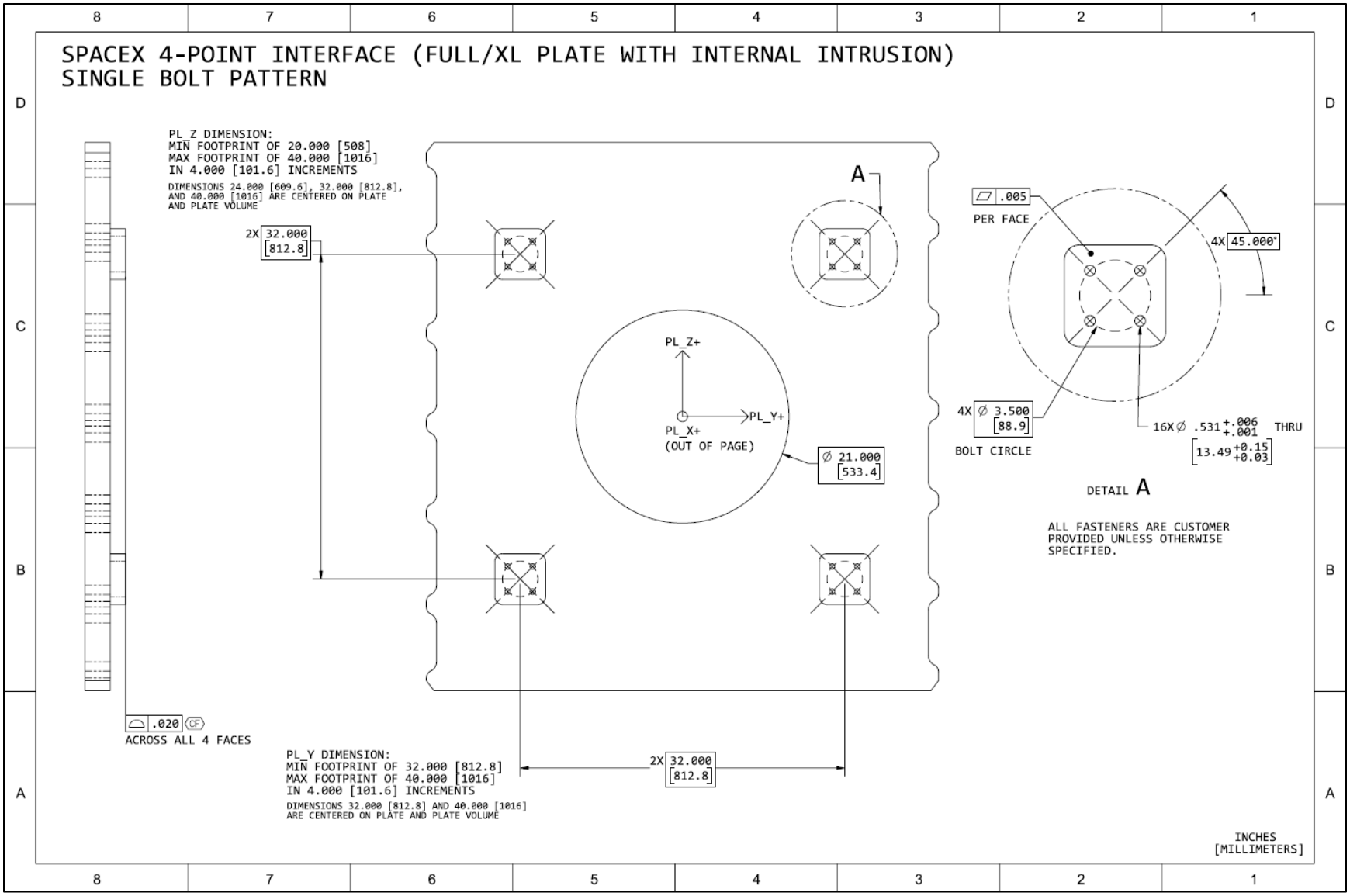


Figure A-6: 4-Point Mechanical Interface (Full / XL Plate with Internal Intrusion) - Single Bolt Pattern

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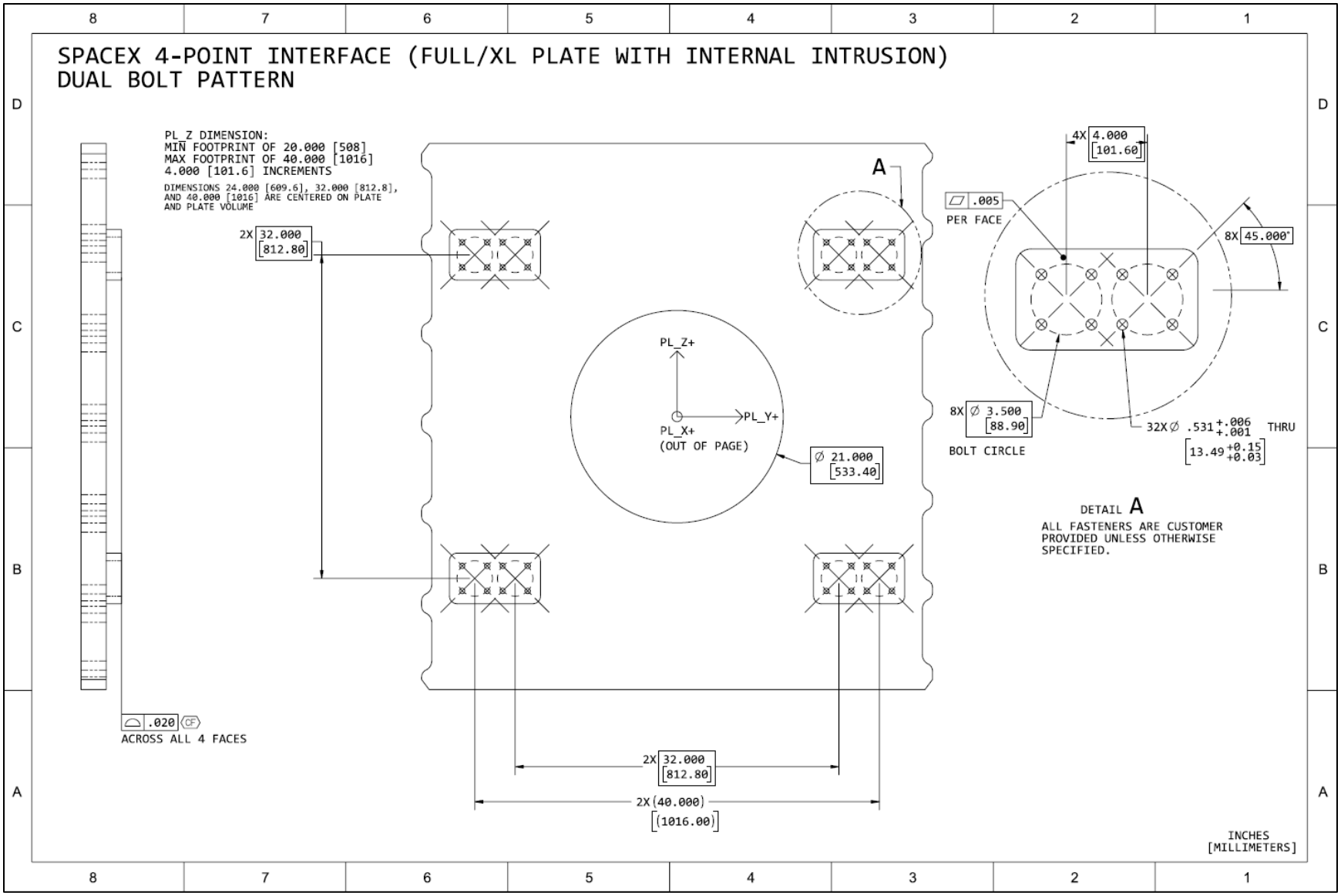


Figure A-7: 4-Point Mechanical Interface (Full / XL Plate with Internal Intrusion) - Dual Bolt Pattern

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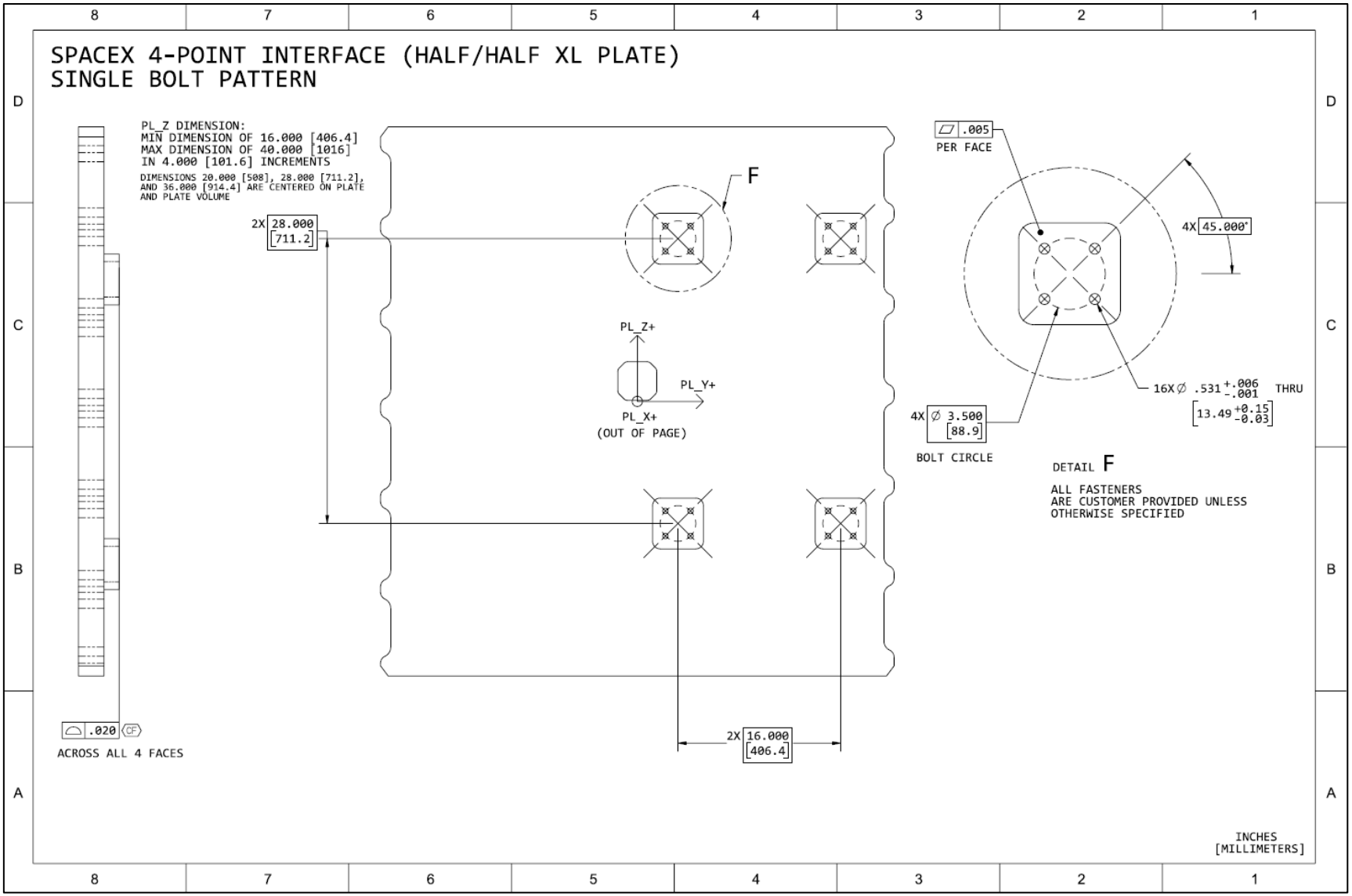


Figure A-8: 4-Point Mechanical Interface (Half / Half XL Plate) - Single Bolt Pattern

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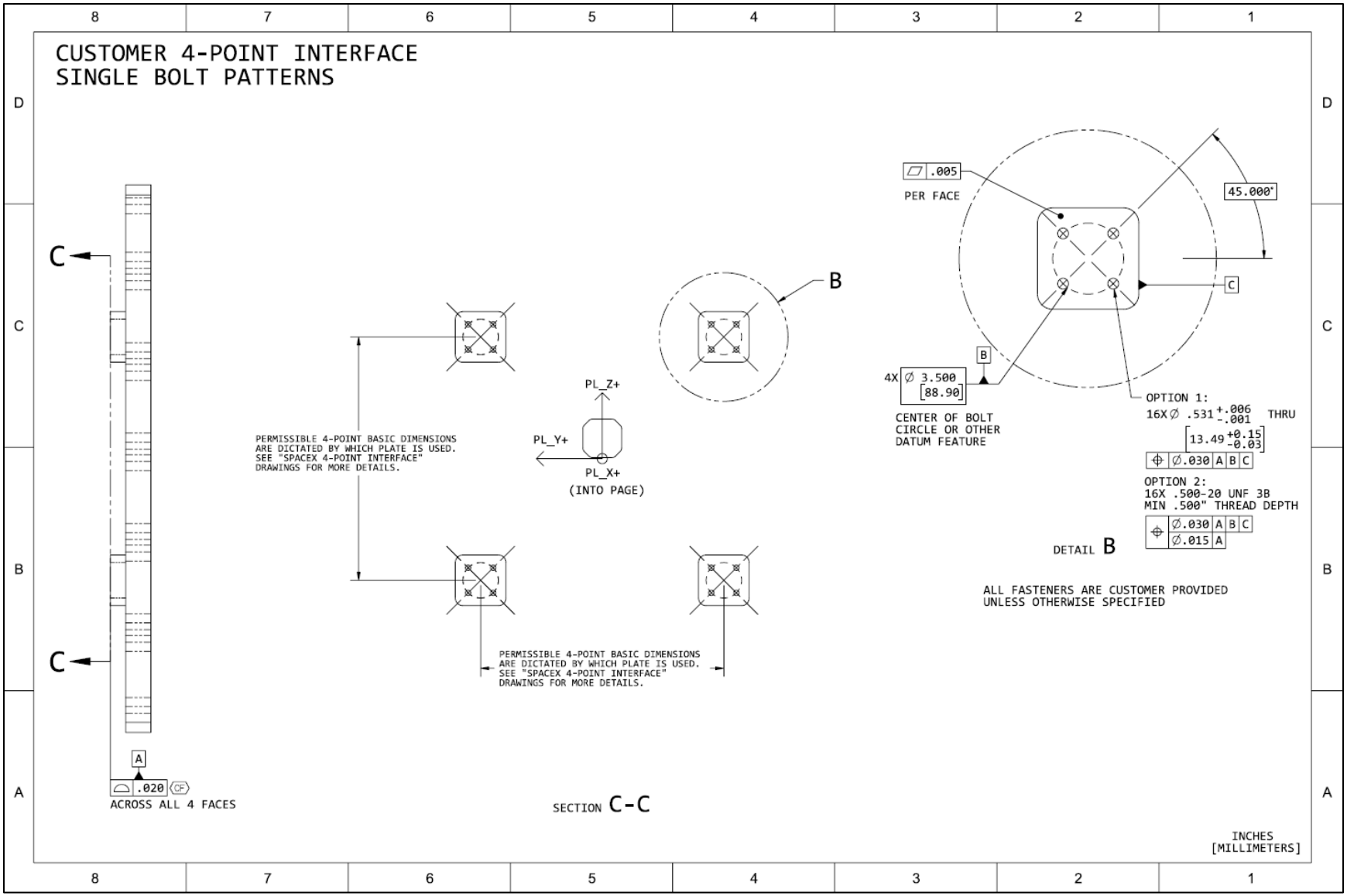


Figure A-9: 4-Point Customer-Side Mechanical Interface (All Single Bolt Pattern 4-point Interfaces)

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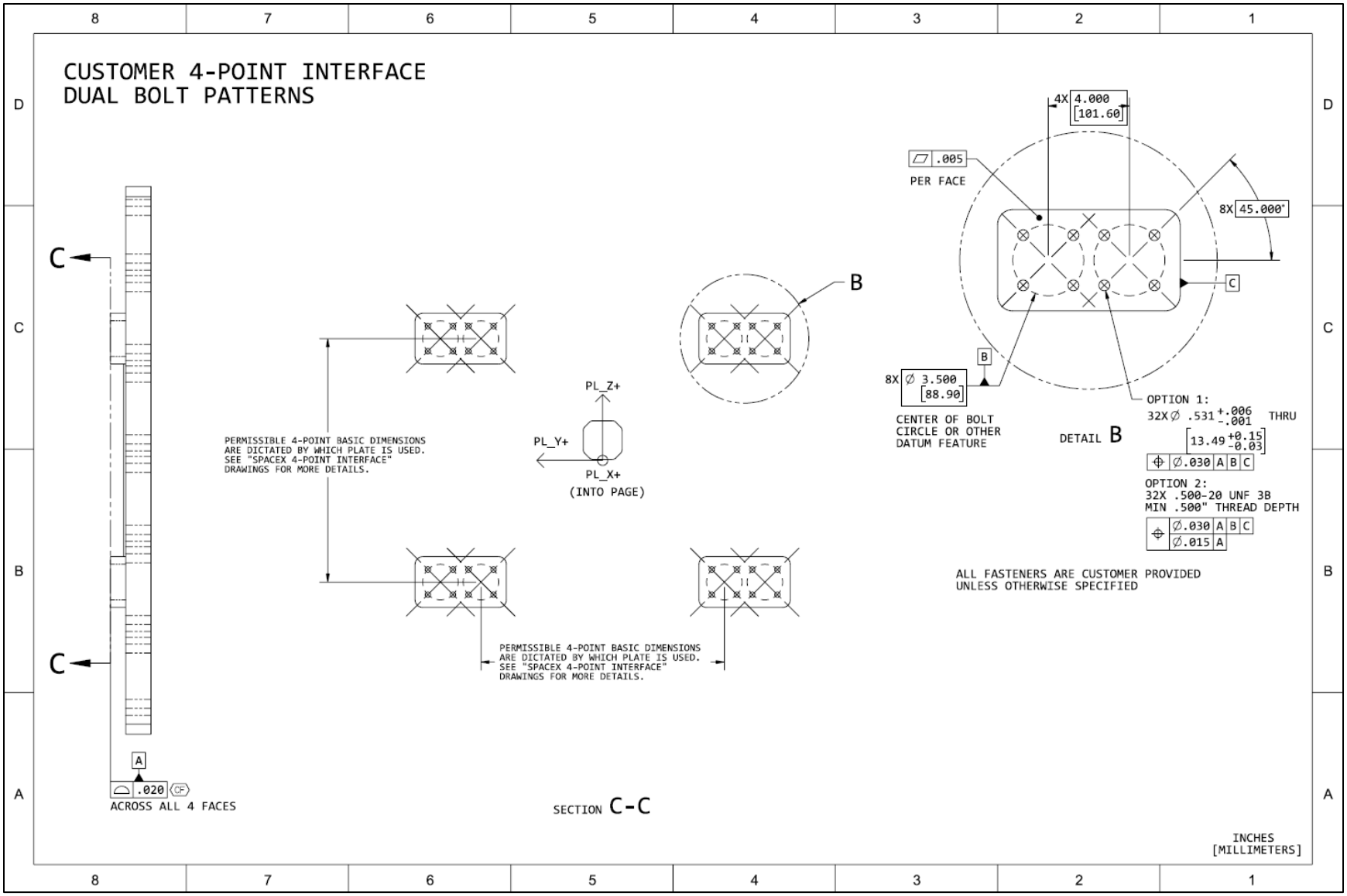


Figure A-10: 4-Point Customer-Side Mechanical Interface (All Dual Bolt Pattern 4-point Interfaces)

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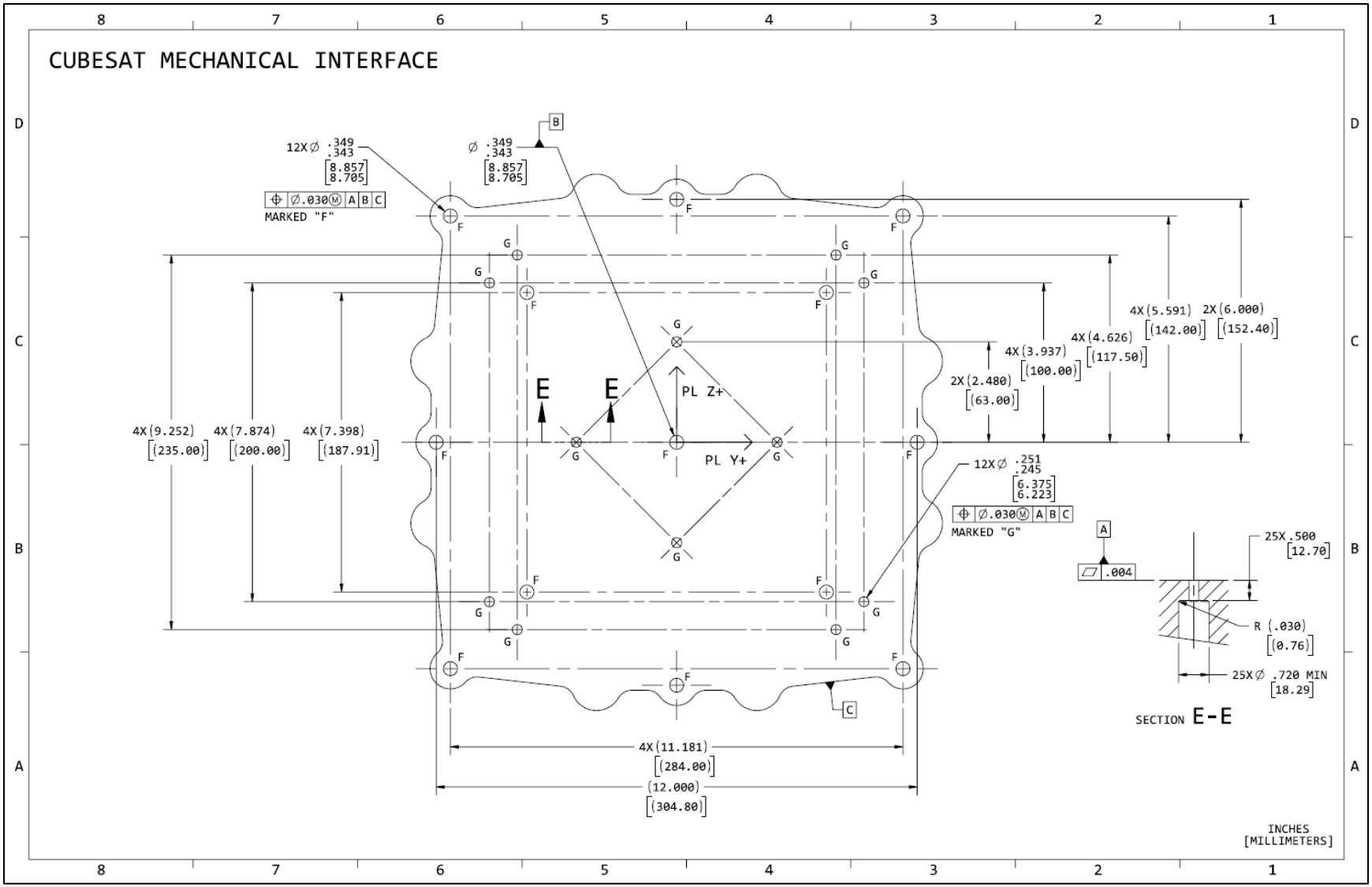


Figure A-11: Integrated CubeSat Dispenser Assembly Standard Mechanical Interface

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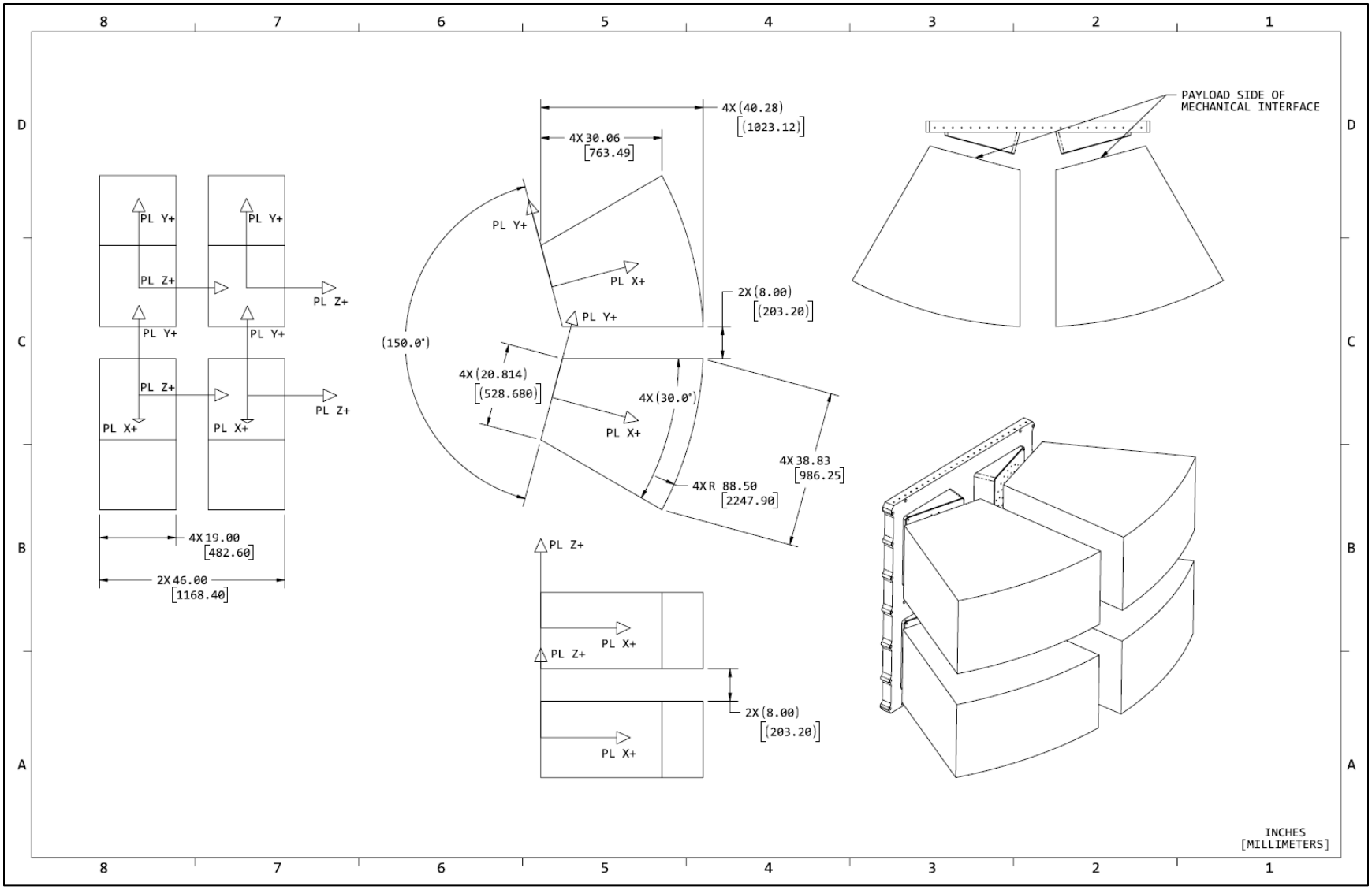


Figure A-12: Quarter Plate Volume (4 shown)

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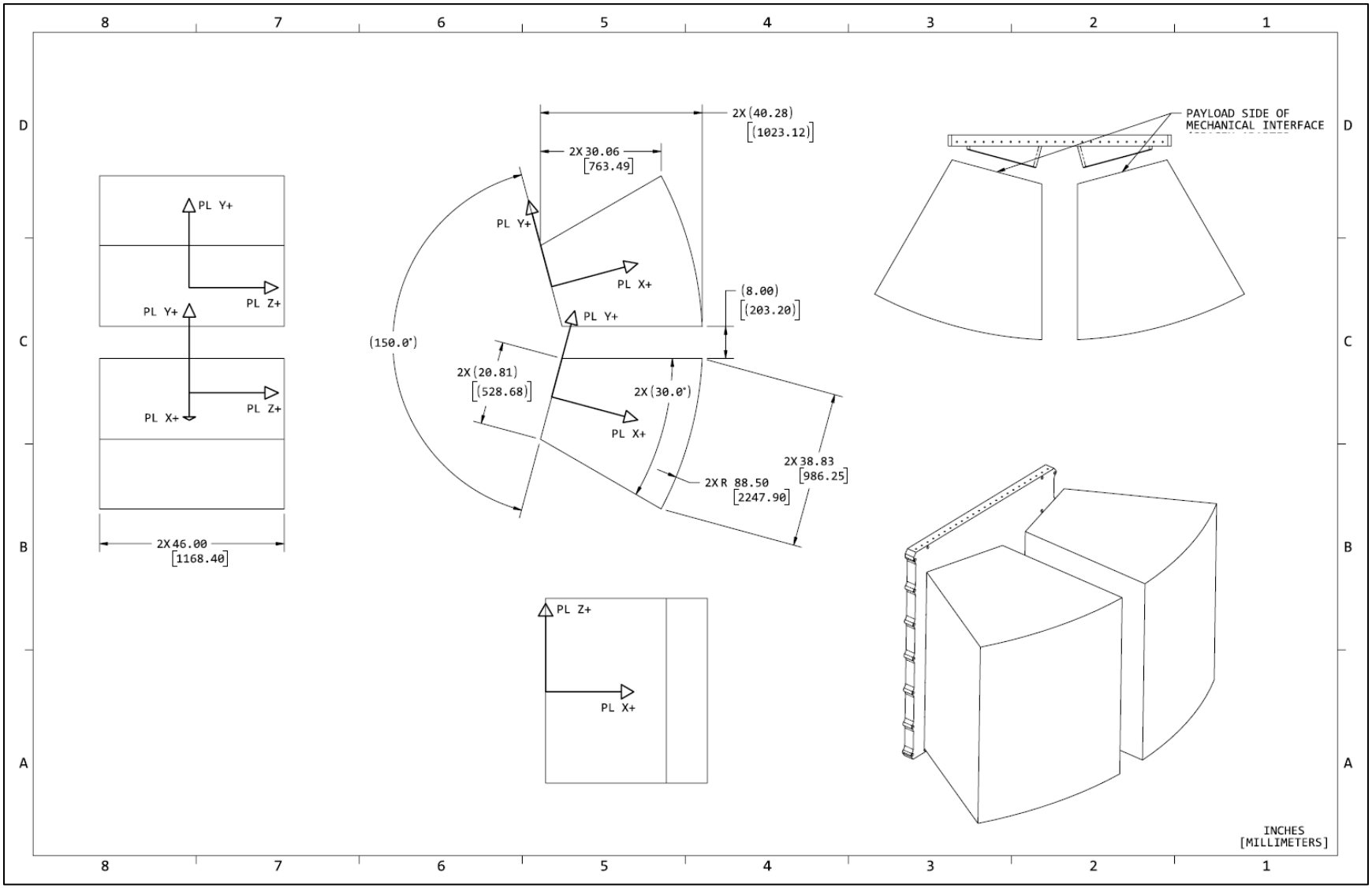


Figure A-13: Half Plate Volume (2 shown)

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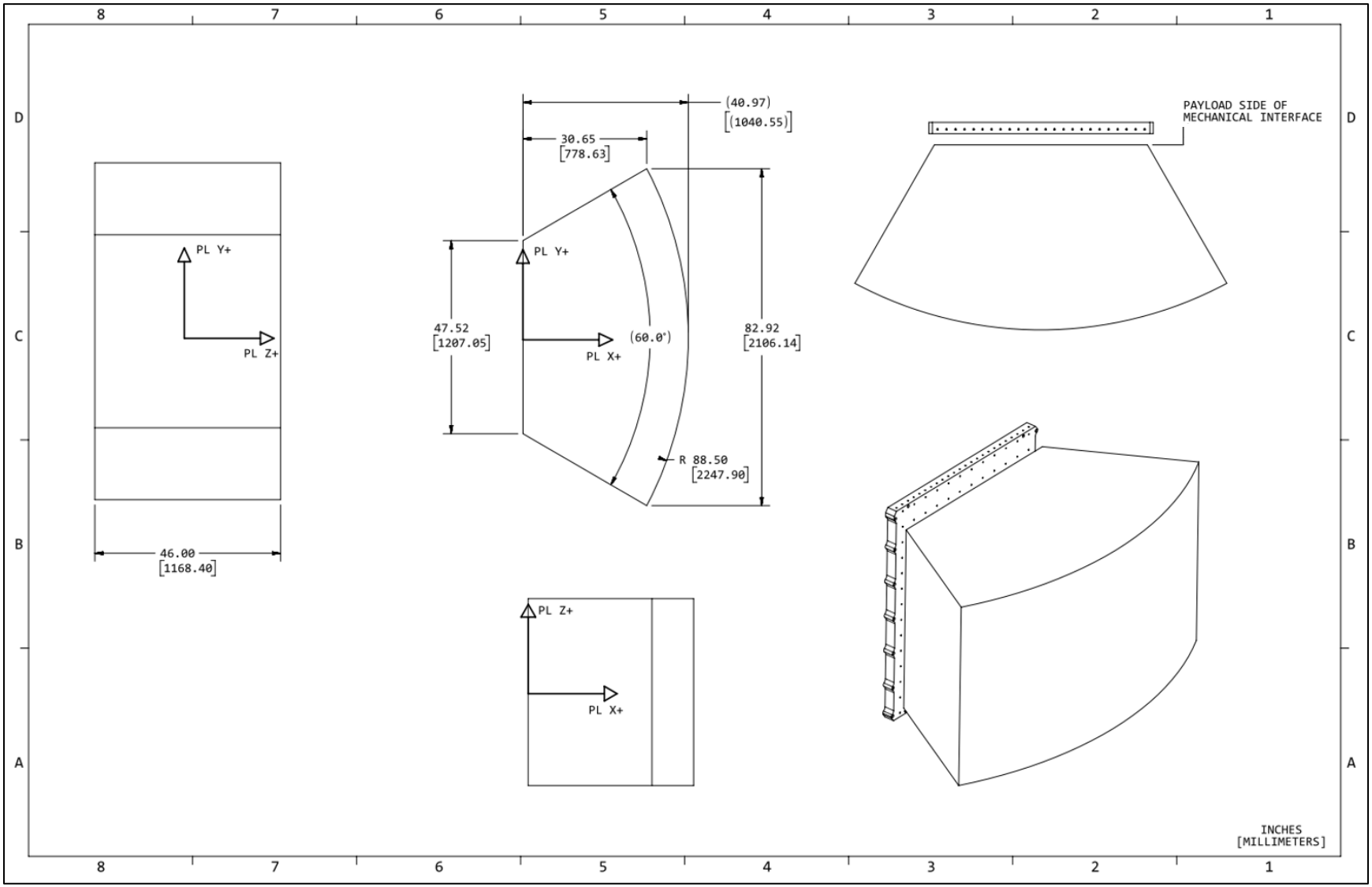


Figure A-14: Full Plate Volume

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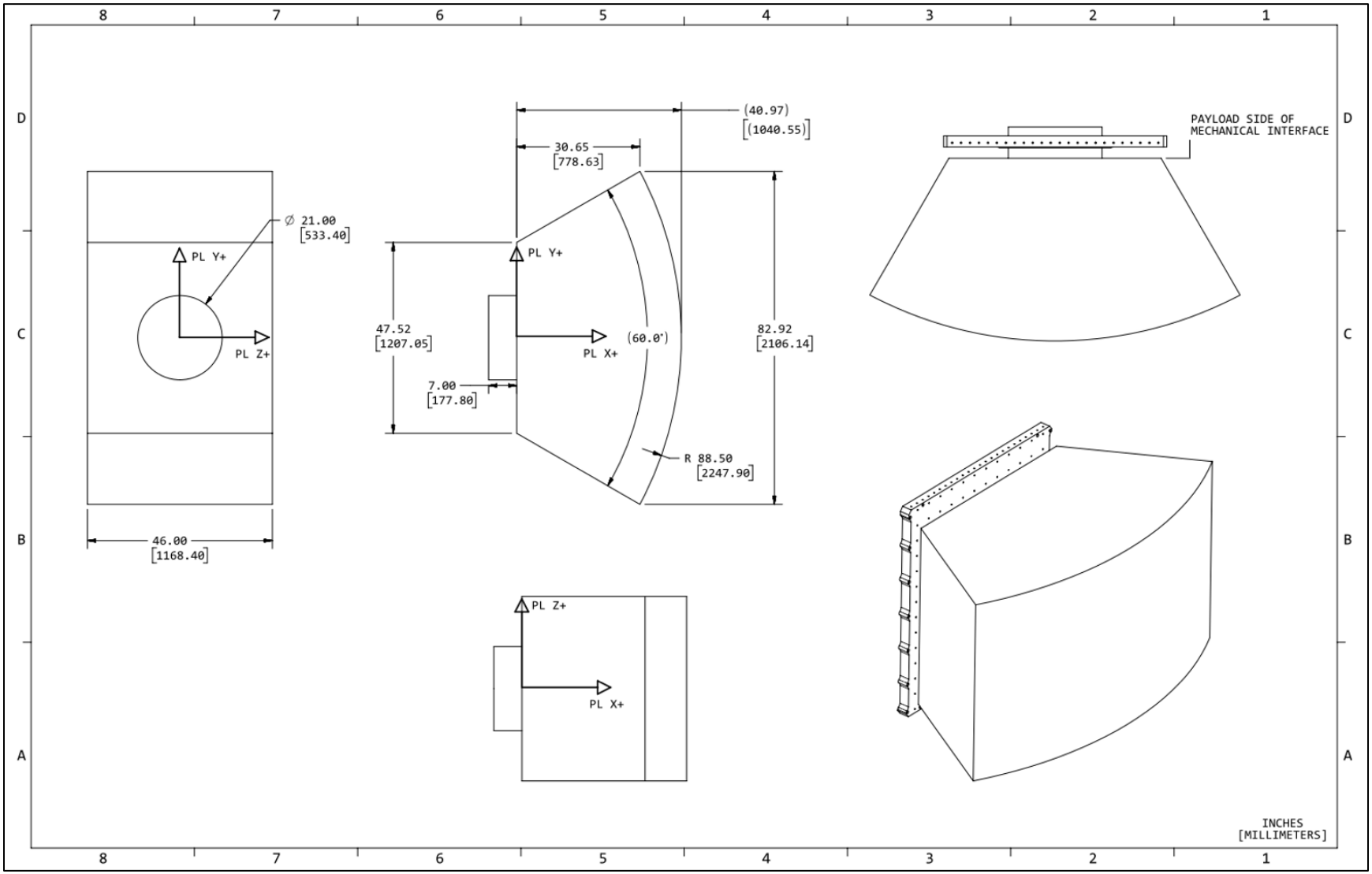


Figure A-15: Full Plate with Intrusion Volume

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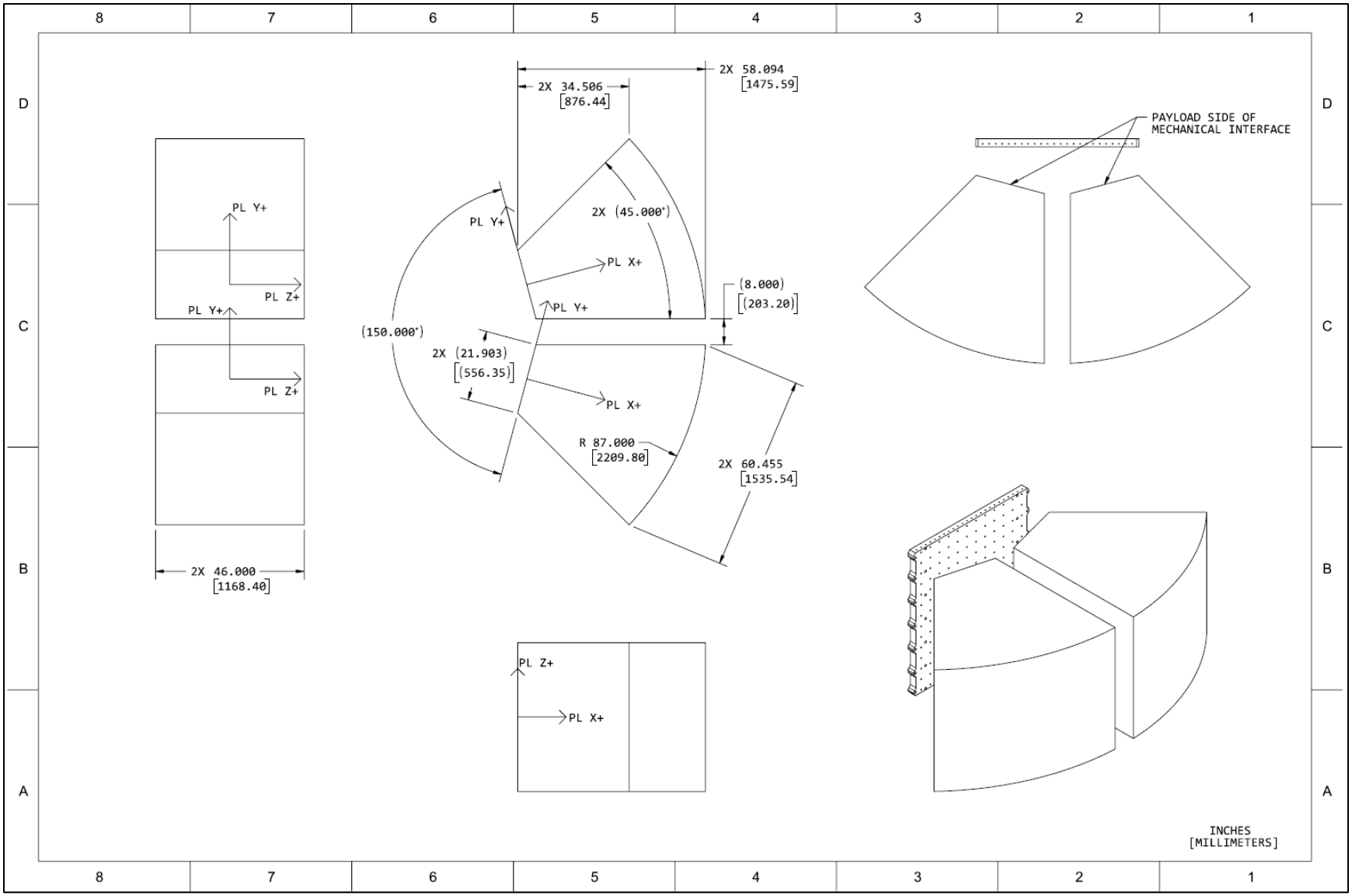


Figure A-16: Half XL Plate Volume (2 shown)

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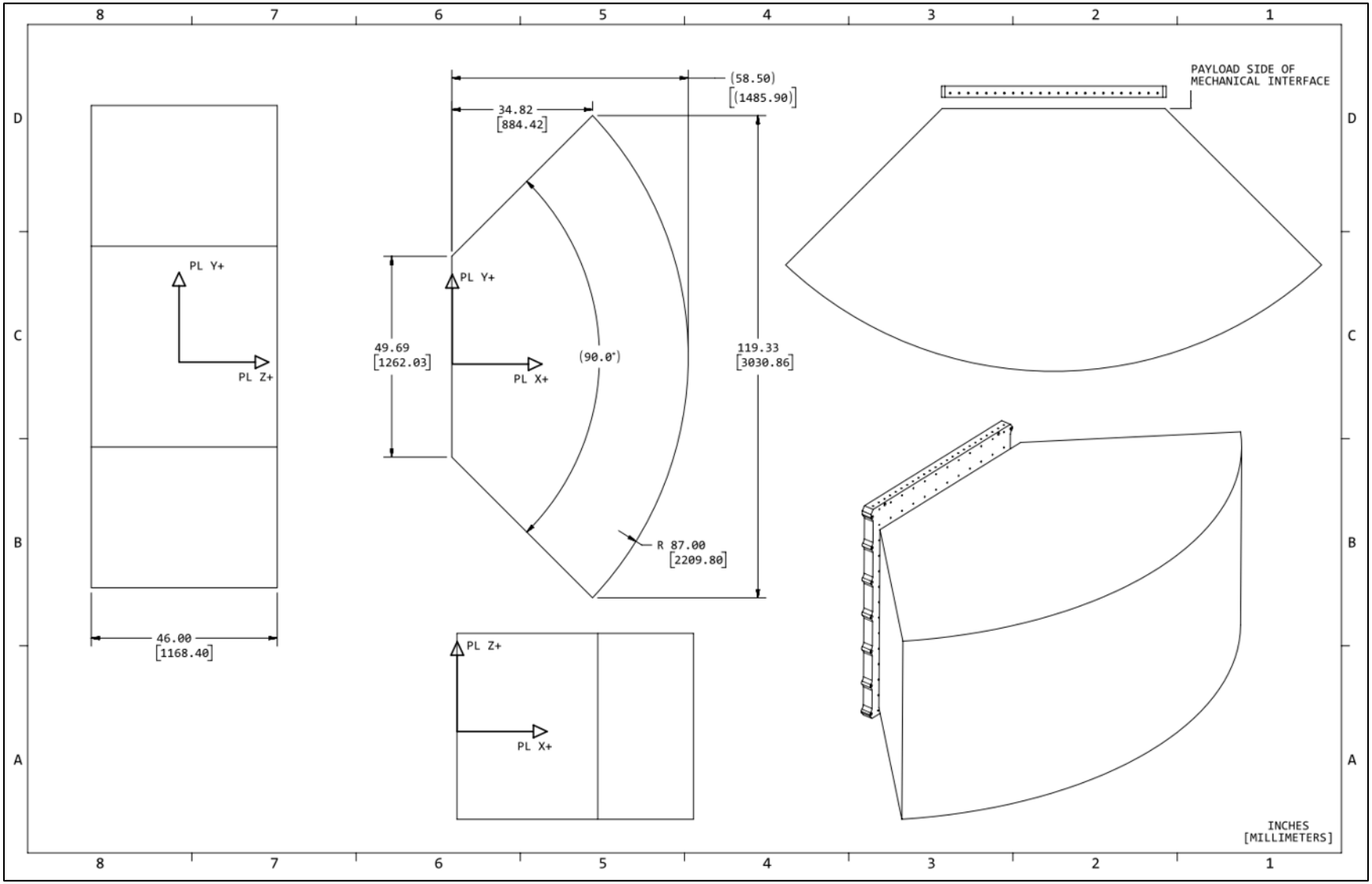


Figure A-17: XL Plate Volume

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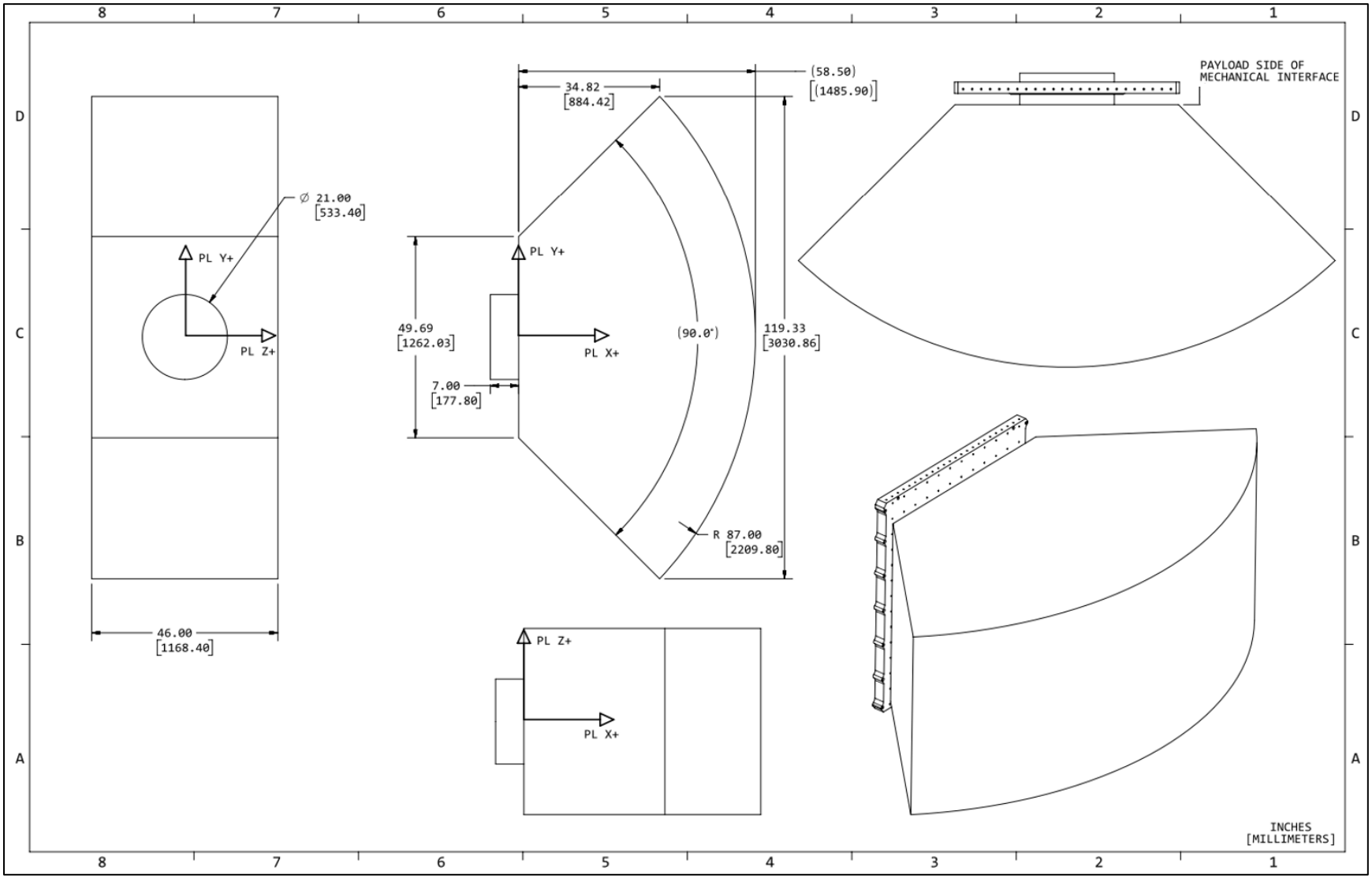


Figure A-18: XL Plate with Intrusion Volume

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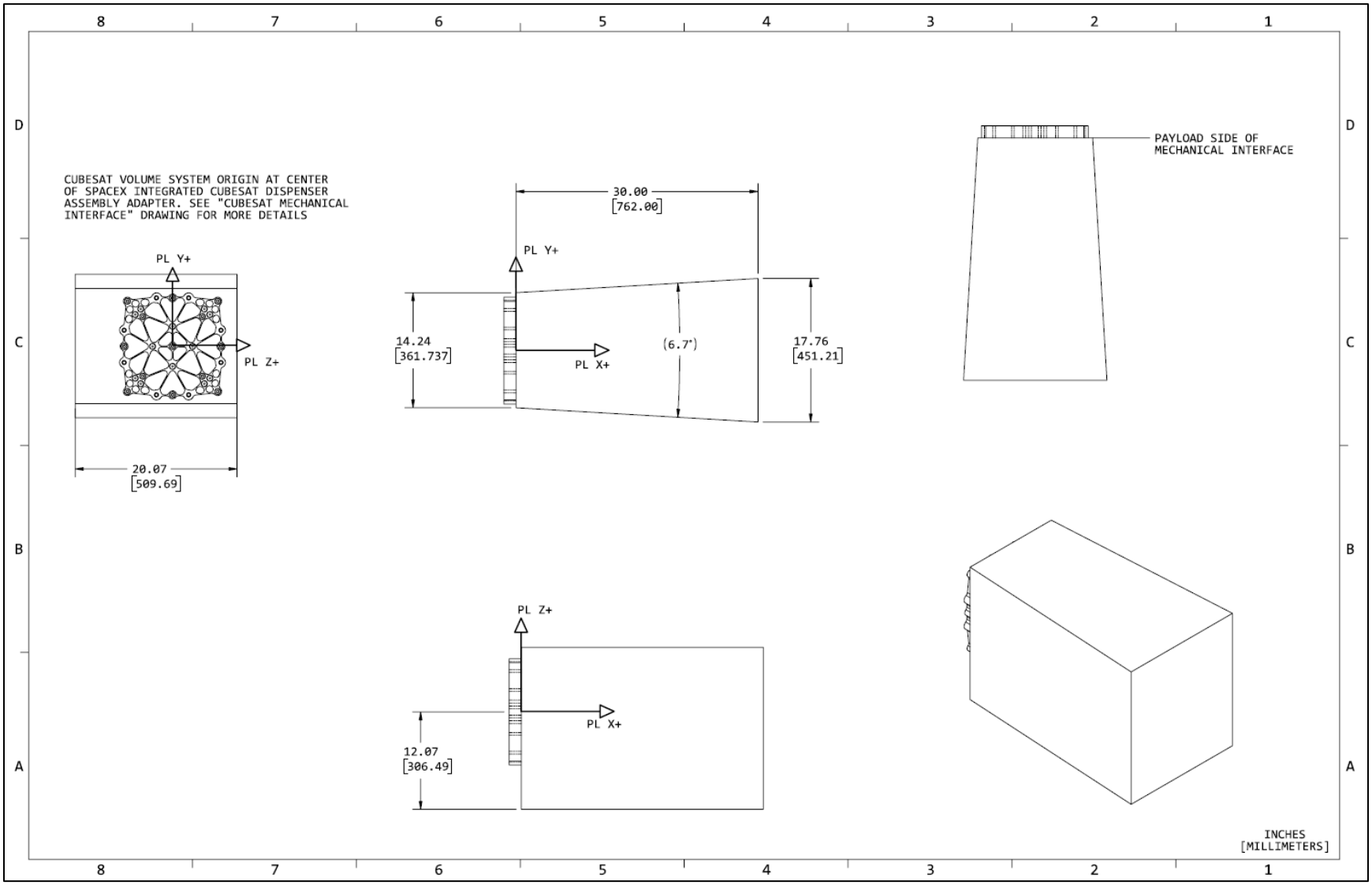


Figure A-19: Integrated CubeSat Dispenser Assembly Volume (1 of 3 shown)

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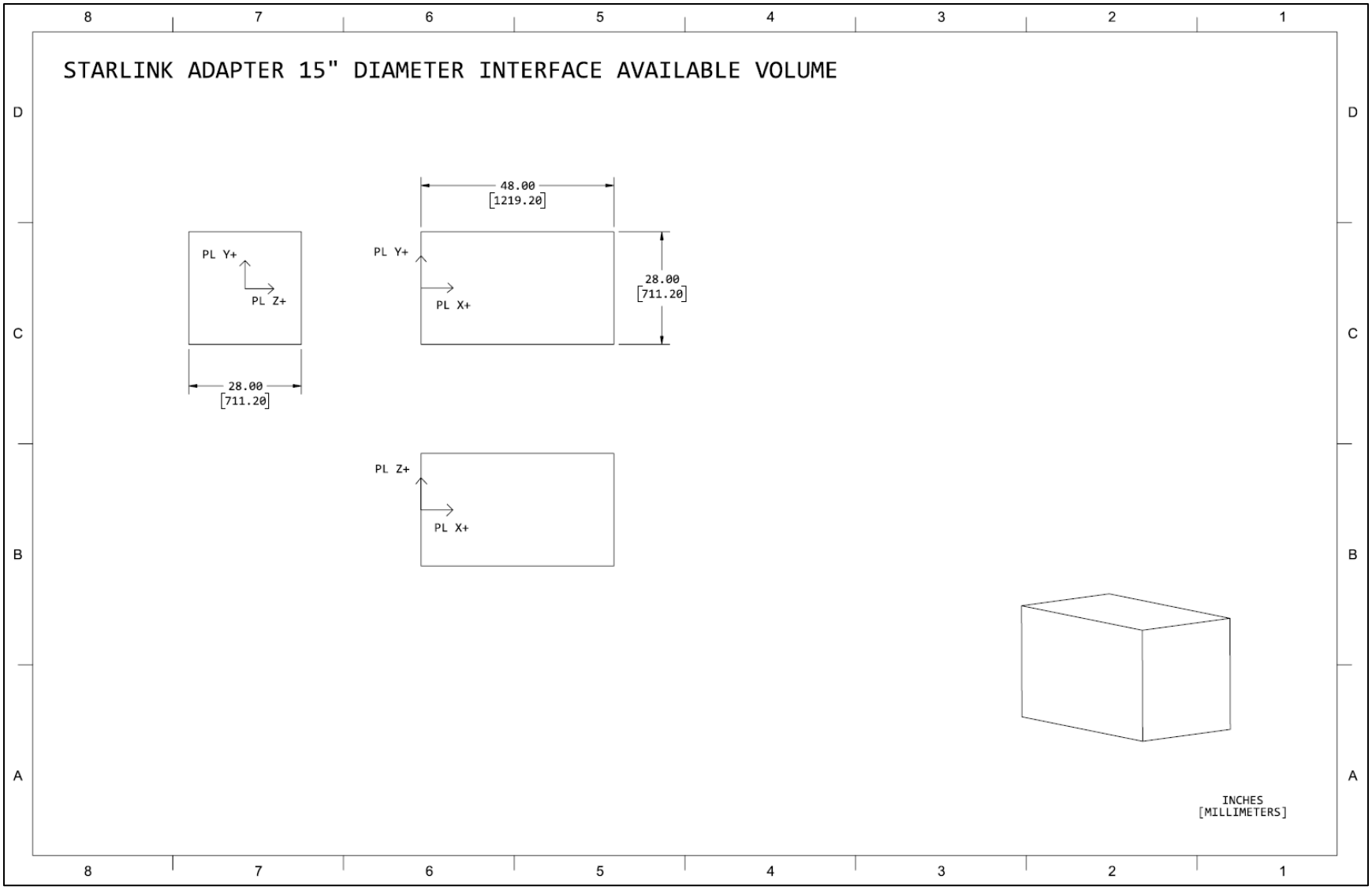


Figure A-20: 15" Diameter - Starlink Adapter Volume

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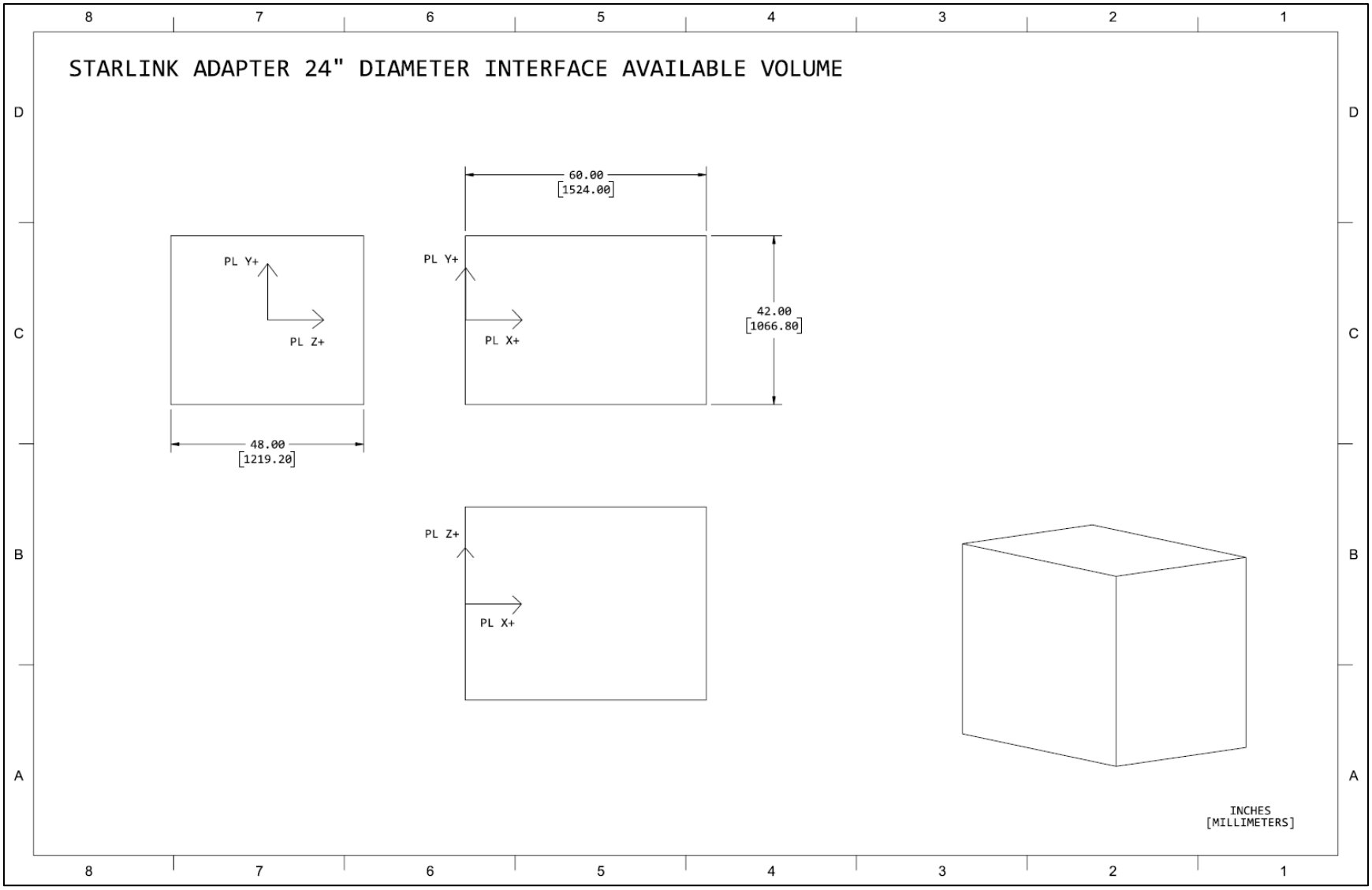


Figure A-21: 24" Diameter - Starlink Adapter Volume

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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 shall be clearly defined (English or SI).
- The Payload coordinate system shall follow the coordinate system described in Section 2.3.
- The model shall be Craig-Bampton formatted.
- Modal damping shall be specified (see Damping Definition section).
- Any uncertainty factor applied to the modal responses shall be defined (see Uncertainty Factor section).
- The model shall have frequency content up to 150 Hz.
- All output requests shall be clearly defined (see Analysis Outputs section).
- The model shall 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 shall remain physical.
- The Payload coordinate system described in Section 2.3 shall 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), shall be included in the Payload model Craig-Bampton reduction.
- If using circular separation systems, the model shall 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 shall be delivered with four boundary nodes representing the four interface points to the Launch Vehicle. Each of these four nodes shall remain physical with six degrees of freedom (total of 24 degrees of freedom).

Matrix Requirements:

- The model shall be delivered in a NASTRAN, Formatted .op4 file and shall 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 shall 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) shall be provided as complete matrices
- The M and K matrices shall be defined as shown below.
    - i are the modal degrees of freedom
    - b are the boundary degrees of freedom
    - ω_i^2 is a diagonal matrix of the eigenvalues
    - K_{bb} is the stiffness from the boundary degrees of freedom

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

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- OTM a.k.a. Data recovery matrices (DRM) used to recover Payload responses (R) shall 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 shall each be provided as separate matrices.
  - Load transformation matrices for element forces, pressures, stresses, etc. shall 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 shall be limited to 100 rows.
- Definition of the Craig-Bampton model rows and columns shall be provided to facilitate coupling of the Payload to Launch Vehicle model.
- Labels for the rows of the (DRM) shall be provided for inclusion in results tables.
- All LTM matrices shall be defined such that they produce loads when multiplied by accelerations (not in g's) and displacements: e.g. inch/sec^2 and rad/sec^2 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 shall 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 shall generate and provide such outputs in the ATM and/or LTM response recovery matrices.

Damping Definition

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

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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 shall be specifically requested. Under no circumstance shall the model uncertainty factor be less than that used in SpaceX standard practice.

Documentation

Models shall 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. The model and accompanying documentation cannot be provided in a .zip format. In total, the following information shall 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.

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APPENDIX C: PAYLOAD CAD MODEL REQUIREMENTS

Customer shall provide SpaceX a CAD model of the Payload in NX STEP 214 or lower file format. Parasolid file types are not accepted. 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 shall be simplified by the Customer and focus primarily on outer mold line and interface fidelity (to facilitate efficient model manipulation and processing). Customer shall 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 shall 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 shall match exactly with the delivered CAD coordinate system configuration and units. The Payload coordinate system shall follow the coordinate system described in Section 2.3.

The Payload CAD model shall 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 shall 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. Representative RPUG keep-in volumes have been removed.
- ☐ Entire payload is fully contained within the desired flight configuration keep-in volume. Payload clearances are acceptable per Section 2.4. Minimum clearance to all SpaceX hardware is verified to be at least 1".
- ☐ Unnecessary detail that does not add to the understanding of external volumes has been removed
- ☐ Simplified bodies fully envelope outer mold line (OML) of actual payload
- ☐ All direct Launch Vehicle 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 STEP 214 or lower file format
- ☐ The file is not compressed into a .zip file

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APPENDIX D: PAYLOAD ENCAPSULATION & LAUNCH READINESS CERTIFICATES

The Payload Customer shall 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 are 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 until [Insert Date] at [Insert Time] [Insert Local Time Zone], which meets the 45 days after Payload encapsulation requirements based on the original encapsulation date of [Insert 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]

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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 (SSCMAN 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 until [Insert Date] at [Insert Time] [Insert Local Time Zone], which meets the 45 days after Payload encapsulation requirements based on the original encapsulation date of [Insert 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]

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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, +XXXXXXXX.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


…
```

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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]

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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 webform	Online webform 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 webform	Online webform 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 webform	Online webform for Customer to verify compatibility of Payload transmitter turn on times in accordance with Section 4.1.7.2.
	Electrical interface pinout webform	Online webform for Customer to populate the Payload electrical harness properties and pin-outs. SpaceX will populate the Launch Vehicle side after initial Customer submittal.
	Orbit Selection webform	Online webform for Customer to choose the orbital parameters of their deployment from the Launch Vehicle from a list of available orbit parameters for the mission. The different orbital parameters (drop-off altitude or other orbital parameter) are pre-populated from a list of available orbit parameters for the mission selected by SpaceX.
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. The worksheet also records any deviations from the Rideshare Payload User's Guide requested by the Customer. Test approach and User's Guide deviations 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. 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.

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Table G-2: SpaceX Statement of Work Deliverables

Milestone	SpaceX Deliverables	Description
Launch Campaign Planning	Launch integration schedule (preliminary)	Schedule of Launch Site operations identifying Payload stand-alone activities and combined Payload/Launch Vehicle operations for the Mission.
Mission Integration	Predicted orbit injection report	Predicted state vector information, based on a nominal trajectory. This state vector will be provided in SpaceX-defined format (reference Appendix E) and may be based on representative historical trajectories.
	Released Payload electrical interface pinout webform	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.
	Electrical connector shipment to Customer (if applicable)	If applicable, electrical connectors supplied by SpaceX, required for Customer-built harnessing, are shipped to Customer, and electrical connectors supplied by Customer, required for SpaceX-built harnessing, are 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 and includes collision avoidance. Analysis will be delivered in the form of the OPM as defined in Appendix E.
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 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 shall 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.

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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.
Mission Integration Analysis Inputs	Completed Payload configuration webform	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).
	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 webform	Current best estimate of the Payload mass properties within ± 15% (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 webform provided by SpaceX.
	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 webform.
	Payload electrical interface pinout webform	Customer inputs provided in the SpaceX provided webform 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	Spacecraft Declaration of Hazardous Systems (SDHS)	The SDHS provides an overview of hazardous, and safety critical ground support and flight hardware equipment, systems, subsystems, and materials and their interfaces used in the launch of the Customer payload. Customer, through this document and, as required, additional safety documentation, will provide descriptions of the payload design and ground support equipment in accordance with the mission-specific tailored version of SSCMAN 91-710 and other safety requirements, as necessary.
	SSCMAN 91-710 Compliance Letter	Signed confirmation from Customer that the Payload complies with all safety requirements.
L-5 M Orbit Selection	Orbit Selection	Customer selects their deployment orbit using the SpaceX online webform, from a list of available orbit parameters for the mission pre-populated by SpaceX.
Launch Campaign Planning	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.
	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. File size is limited to 50 MB. Spacecraft is not required in GSE hardware CAD model if clear instructions or visuals are provided.
	List of emails for launch site badging Org Leads	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 or verification that harness length meets the requirement specified in Section 7.5.
Final Mission Integration Analysis Inputs	Payload mass properties webform (update, final predicted)	Customer to provide SpaceX refined Payload mass properties inputs within ± 1% for Payloads with flyaway mass ≥ 10 kg and ± 5% for payloads with flyaway mass < 10 kg (mass, center of mass, moments of inertia) for the Monte Carlo analysis of the nominal trajectory using the Payload mass properties webform provided by SpaceX. Updates shall 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 shall 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.

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Milestone	Customer Deliverables	Description
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.
L-2 M Range Safety Submissions	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 shall 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 shall 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 shall use the Payload environmental verification report template provided by SpaceX to summarize data into a single report.
L-2 M Launch Campaign Readiness	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 shall 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.
	Coordination with space situational agency	Customer coordination for space object identification as described in Section 9.5.7.
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.
	Bridgewire Verification	Customer submits electrical measurements taken at the launch site that verify the health and pinout of the customer-provided separation device
	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.

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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.

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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.

Table I-1: Optional Services

Service	Description
Mechanical Interface Adapter	SpaceX can provide an adapter for MicroSat Payloads with circular 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.
Separation System	SpaceX can procure a 3rd party separation system for MicroSat 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.
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 one additional day of processing at the Launch Site. 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 as part of our standard service. As an optional service, SpaceX can provide electrical connectivity (via umbilical access) between Customer EGSE and the Payload in the Hangar, after transport from the PPF, as well as on the Pad after rollout. For electrical connectivity at the Pad, charging shall be completed and Payload switched off by T-1 hour. A customer console will be provided for remote monitoring if necessary. The Spacecraft must be capable of being disconnected from electrical charging for at least 72 hours.
Additional Deployment Channels	The standard electrical interface offering is for a single deployment event. Additional deployment channels, beyond those needed for a single Payload deployment, as well as additional deployment channels required for 4-pt separation systems, are available as an optional service.
Insurance	SpaceX can provide, at Customer's request, optional Launch-only insurance for the Payload and the cost of Launch.

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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.

"Integrated CubeSat Dispenser Assembly" means all Customer components within a CubeSat volume, inclusive of CubeSat dispenser(s) and Customer CubeSat adapter plate, if used.

"**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 shall 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 Space Force Station, Vandenberg Space Force Base, 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.

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"**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. 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.

"**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.

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