



CAKE TOPPER PAYLOAD USER'S GUIDE

Version 2 - December 2024

COPYRIGHT

Subject to the existing rights of third parties, Space Exploration Technologies Corp. (SpaceX) is the owner of the copyright in this work, and no portion hereof is to be copied, reproduced, or disseminated without the prior written consent of SpaceX.

No U.S. Export Controlled Technical Data or Technology.



TABLE OF CONTENTS

1	INTRODUCTION	1
1.1	CAKE TOPPER PAYLOAD USER'S GUIDE PURPOSE.....	1
1.2	CAKE TOPPER PROGRAM OVERVIEW.....	2
1.3	FALCON 9 PROGRAM.....	2
1.4	PRICING.....	2
1.5	RIDESHARE PROGRAM.....	2
2	MECHANICAL INTERFACES	3
2.1	LAUNCH VEHICLE FAIRING.....	3
2.2	LAUNCH VEHICLE COORDINATE FRAME.....	3
2.3	PAYLOAD COORDINATE FRAME.....	3
2.4	CAKE TOPPER INTERFACE AND AVAILABLE PAYLOAD VOLUME.....	3
3	PERFORMANCE	6
3.1	MASS PROPERTIES.....	6
3.2	LAUNCH WINDOWS.....	7
3.3	PAYLOAD SEPARATION.....	7
4	ENVIRONMENTS	9
4.1	FLIGHT ENVIRONMENTS.....	9
4.2	TRANSPORTATION ENVIRONMENTS.....	18
4.3	CLEANROOM ENVIRONMENTS.....	18
5	PAYLOAD DESIGN REQUIREMENTS	19
5.1	DESIGN FACTORS.....	19
5.2	FASTENERS AND CABLE TIES.....	19
5.3	MATERIALS AND CONTAMINATION.....	21
5.4	ISOLATORS.....	22
5.5	PRESSURE VESSELS AND SYSTEMS.....	22
5.6	SOLID PROPULSION SYSTEMS.....	25
6	VERIFICATION	26
6.1	VERIFICATION TEST APPROACH.....	26
6.2	TEST-LIKE-YOU-FLY EXCEPTIONS.....	28



6.3	POST-INTEGRATED TEST MODIFICATIONS & PENALTY RE-TEST.....	28
6.4	DOCUMENTATION REQUIREMENTS.....	28
6.5	PAYLOAD UNIT TEST LEVELS.....	29
6.6	ACOUSTIC VS RANDOM VIBE TEST DOWNSELECTION.....	33
6.7	ENVIRONMENTAL VERIFICATION REQUIREMENTS.....	34
6.8	VERIFICATION FOR PRESSURE VESSELS AND SYSTEMS.....	40
6.9	VERIFICATION FOR SOLID PROPULSION SYSTEMS.....	43
7	AVIONICS AND ELECTRICAL INTERFACES.....	44
7.1	ELECTRICAL INTERFACES.....	44
7.2	DEPLOYMENT PROPERTIES.....	44
7.3	BREAKWIRE CHANNEL PROPERTIES.....	44
7.4	ELECTRICAL UMBILICAL CONNECTORS.....	45
7.5	FLIGHT HARNESS DESIGN.....	45
7.6	UMBILICAL CONNECTIVITY DURING PAYLOAD PROCESSING AND ON LAUNCH PAD.....	45
7.7	GROUND HARNESS DESIGN.....	46
7.8	TIMING SERVICES.....	47
7.9	INTERFACE COMPATIBILITY VERIFICATION REQUIREMENTS.....	47
8	LAUNCH SITE FACILITIES.....	48
8.1	FACILITY ACCESS AND WORKING HOURS.....	48
8.2	CUSTOMER OFFICES.....	48
8.3	SPACEX PAYLOAD PROCESSING FACILITY (PPF).....	48
8.4	HAZARDOUS PROCESSING FACILITY AND ASSOCIATED SUPPORT.....	49
8.5	LAUNCH COMPLEX.....	50
8.6	SECURITY.....	50
9	MISSION INTEGRATION AND SERVICES.....	51
9.1	CONTRACTING.....	51
9.2	US EXPORT AND IMPORT CONTROL LAWS.....	51
9.3	MISSION MANAGEMENT.....	51
9.4	PROGRAM DOCUMENTATION.....	52
9.5	CUSTOMER RESPONSIBILITIES.....	53
9.6	SPACEX RESPONSIBILITIES.....	55



10	OPERATIONS	59
10.1	OVERVIEW AND SCHEDULE	59
10.2	CAKE TOPPER PAYLOAD DELIVERY AND TRANSPORTATION	59
10.3	PAYLOAD PROCESSING	59
10.4	JOINT OPERATIONS AND INTEGRATION	60
10.5	LAUNCH OPERATIONS	60
10.6	FLIGHT OPERATIONS	61
11	SAFETY	62
11.1	SAFETY REQUIREMENTS	62
11.2	HAZARDOUS SYSTEMS AND OPERATIONS	62
11.3	WAIVERS.....	62
	APPENDIX A: MECHANICAL INTERFACES AND VOLUMES.....	63
	APPENDIX B: PAYLOAD DYNAMIC MODEL REQUIREMENTS	74
	APPENDIX C: PAYLOAD CAD MODEL REQUIREMENTS.....	78
	APPENDIX D: PAYLOAD ENCAPSULATION & LAUNCH READINESS CERTIFICATES.....	79
	APPENDIX E: DELIVERY FORMAT OF SEPARATION STATE VECTOR	81
	APPENDIX F: PAYLOAD LICENSING CERTIFICATION.....	81
	APPENDIX G: DELIVERABLE DESCRIPTIONS.....	83
	APPENDIX H: PAYLOAD CONSTITUENTS.....	90
	APPENDIX I: OPTIONAL SERVICES.....	91
	APPENDIX J: DEFINITIONS	92
	APPENDIX K: EMI/EMC DESCRIPTIONS.....	94



ACRONYMS

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



NASTRAN NASA Structural Analysis

OASPL overall sound pressure level

NTE not-to-exceed

OPM orbital parameter message

OTM output transformation matrix

P&ID piping and instrumentation diagram

PL Payload

PLA payload adapter

PPF payload processing facility

Q dynamic pressure

RE radiated emissions

QSL quasi-static loads

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

SC spacecraft

SCAPE self-contained atmospheric protective ensemble

sccs standard cubic centimeter per second

SLC space launch complex

SpaceX Space Exploration Technologies Corp.

SPCS Space Control Squadron

SPL sound pressure level

SRM solid rocket motor

SRS shock response spectrum

STEP standard for the exchange of product model data

TAA technical assistance agreement

TE transporter-erector

TML total mass loss

US DOT United States Department of Transportation

US United States

SSO sun-synchronous orbit

TBD to be defined

USSPACECOM United States Space Command

UTC coordinated universal time

VC-HS visibly clean – highly sensitive

VSFB Vandenberg Space Force Base

WVR water vapor regained



LIST OF FIGURES

Figure 1-1: Cake Topper Location (green)*.....	1
Figure 1-2: Cake Topper Typical Mission Integration Timeline	2
Figure 2-1: Launch Vehicle Coordinate Frame	3
Figure 2-2: Topper Plate configuration (left) and Clampband configuration (right) (1194 mm example clampband shown as a reference)	4
Figure 2-3: 4-point interface options (width and depth are interchangeable)	4
Figure 2-4: Cake Topper Payload Keep-In Volume (Clampband Configuration)	5
Figure 2-5: Cake Topper Payload Keep-In Volume (Topper Plate and 4-point Configuration)	5
Figure 3-1: Cake Topper Mass and Center of Gravity Restrictions (Clampband Configuration)	6
Figure 3-2: Cake Topper Mass and CG (Topper Plate Configuration)	6
Figure 3-3: Cake Topper Mass and CG (4-point Interface)	7
Figure 4-1: Cake Topper Axial and Lateral Load Factors (MPE).....	10
Figure 4-2: Axial and Lateral Sine Vibration MPE	11
Figure 4-3: Maximum Predicted Acoustic Environment	12
Figure 4-4: Payload Mechanical Interface Shock.....	13
Figure 4-5: Random Vibration MPE.....	14
Figure 4-6: In-Flight and Environmental Radiated Emissions / Payload Radiated Susceptibility Limit	15
Figure 4-7: Bounding Conductive Boundary Temperature	17
Figure 4-8: Maximum Fairing Spot Temperature Seen by Payload.....	17
Figure 6-1: Flight vs. Test Configuration for Cake Toppers using a Clampband Configuration	27
Figure 6-2: Flight vs. Test Configuration for Cake Toppers using a Topper Plate Configuration	27
Figure 6-3: Cake Topper Verification Decision Tree	29
Figure 6-4: Manual Notch Limit Definitions (Primary Mode ONLY)	37
Figure 6-5: Isolated System Additional Testing.....	39
Figure 6-6: The 15% Rule, Explained	41
Figure 7-1: Illustration of Breakwire Channel Categories	44
Figure 7-2: On-Pad Electrical Interfaces.....	46
Figure 9-1: Mission Management Organization	52
Figure A-1: 15" Diameter Mechanical Interface	63
Figure A-2: 24" Diameter Mechanical Interface	64
Figure A-3: 937 mm Clampband Interface	65
Figure A-4: 937 mm Clampband Configuration.....	66
Figure A-5: 1194 mm Clampband Interface	67
Figure A-6: 1194 mm Clampband Configuration	68
Figure A-7: 1666 mm Clampband Interface	69



Figure A-8: 1666 mm Clampband Configuration	70
Figure A-9: 4-point Cake Topper Interface.....	71
Figure A-10: Cake Topper Keep-in Volume (Clampband Configuration)	72
Figure A-11: Cake Topper Keep-in Volume (Topper Plate Configuration)	73

LIST OF TABLES

Table 3-1: Typical Orbital Dispersions	7
Table 3-2: Launch Vehicle Rates Before Payload Separation.....	8
Table 4-1: Cake Topper Minimum Frequency Requirements	9
Table 4-2: Cake Topper Payload Design Load Factors	10
Table 4-3: Cake Topper Axial and Lateral Accelerations	11
Table 4-4: Third Octave Acoustic MPE.....	12
Table 4-5: Full Octave Acoustic MPE.....	12
Table 4-6: Payload Mechanical Interface Shock	13
Table 4-7: Random Vibration MPE	14
Table 4-8: Launch Vehicle Radiated Emissions.....	15
Table 4-9: Launch Site Radiated Emissions.....	15
Table 4-10: Maximum Payload Emissions	15
Table 4-11: Payload Transmitter Delay Time (seconds).....	16
Table 4-12: Bounding Conductive Boundary Temperature and Conductance.....	17
Table 4-13: Temperature and Cleanliness Environments	18
Table 5-1: Factors of Safety	19
Table 5-2: Peaking Factors	19
Table 5-3: Acceptance Criteria for Reworked Fasteners After Environmental Testing	20
Table 5-4: Acceptance Criteria for Fasteners Attaching to SpaceX Hardware	20
Table 5-5: Payload Materials and Contamination Requirements	21
Table 5-6: Design and Test Factors for Pressure Vessels and Systems.....	22
Table 5-7: Pressure Vessel Classification and Use Restrictions.....	23
Table 6-1: Payload Unit Test Levels and Durations – Cake Topper Payloads under 500 kg	30
Table 6-2: Payload Unit Test Levels and Durations – Cake Topper Payloads 500 kg to 1,500 kg	31
Table 6-3: Payload Unit Test Levels and Durations – Cake Topper Payloads above 1,500 kg.....	32
Table 6-4: Low-Level Sine Sweep Acceptance Criteria	34
Table 6-5: Quasi Static Load Verification Test Requirements.....	34
Table 6-6: Manual Notch Limits (Primary Mode ONLY).....	36
Table 6-7: Non-Metallic Materials Classification.....	39
Table 6-8: Verification Requirements for Pressure Vessels.....	41



Table 6-9: Leak Test Requirements for Pressure Vessels..... 42

Table 6-10: Test Methods and Requirements for Integrated Payloads..... 43

Table 7-1: Electrical Interface Summary..... 44

Table 7-2: PL-Side Breakwire Resistance Requirements..... 44

Table 7-3: Example In-Flight Disconnect Connectors 45

Table 7-4: Payload Electrical Interface Connectivity 45

Table 7-5: Maximum Expected Cable Lengths between Payload Racks/EGSE and the Separation Plane 46

Table G-1: SpaceX Deliverables 83

Table G-2: Customer Deliverables 87

Table H-1: Payload Constituent Details 90

Table I-1: Optional Services 91



CHANGE LOG

Version	Date	Update
1	Jan 2023	Original Release
2	Dec 2024	<p>Updated Release</p> <ul style="list-style-type: none">• Overall: Formatting to be consistent with updates to Rideshare Payload User's Guide (RPUG)• Section 1: Added < 500 kg cake toppers as a programmatic option• Section 2: Updated standard interfaces<ul style="list-style-type: none">○ Added standard PLA and Topper Plate interfaces○ Added 4-point interfaces• Section 4: Updated Environments for:<ul style="list-style-type: none">○ <500 kg cake topper payloads (new)○ Acoustics (decreased)○ Random vibe (decreased)○ Thermal (increased)○ EMI/EMC (increased)• Section 6: Updated and improved verification<ul style="list-style-type: none">○ Updated to be consistent with updates to RPUG○ Separated verification into different Cake Topper mass classes○ Updated test verification levels○ Changed shock testing to Advised○ Added guidance on random vibe vs acoustics test selection• Section 7: Recommended electrical connectors• Appendix A: Added 937-, 1194-, and 1666-mm and 4-point standard interfaces• Appendix B: Updated dynamic model requirements• Appendix C: Updated CAD model requirements• Appendix E: Updated OPM to Rideshare format• Appendix I: Added Table of Optional Services



1 INTRODUCTION

1.1 CAKE TOPPER PAYLOAD USER'S GUIDE PURPOSE

Space Exploration Technologies Corp. (SpaceX) is pleased to offer a unique solution for small-to-medium-class spacecraft up to 2500 kg that wish to launch in a forward-mounted orientation. This offering combines the schedule assurances of the Rideshare Program with many of the capabilities of primary, dedicated missions. This User's Guide is an applicable document for Cake Topper contracts. Deviation requests are considered on a per-contract basis, are not guaranteed to be accepted, and are not applicable to other contracts.

The Cake Topper Payload User's Guide is a planning document provided for medium-sized satellite Customers of SpaceX. This document is intended to help Customers understand SpaceX's standard services for pre-contract mission planning and to delineate Customer requirements for contracted Cake Topper Launch Services. This User's Guide provides environmental, interface, and preliminary launch operations information for payloads utilizing the "Cake Topper" location, a top-mount interface on the forward end of a rideshare hardware "stack". This document outlines the standard 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 Cake Topper product offering.

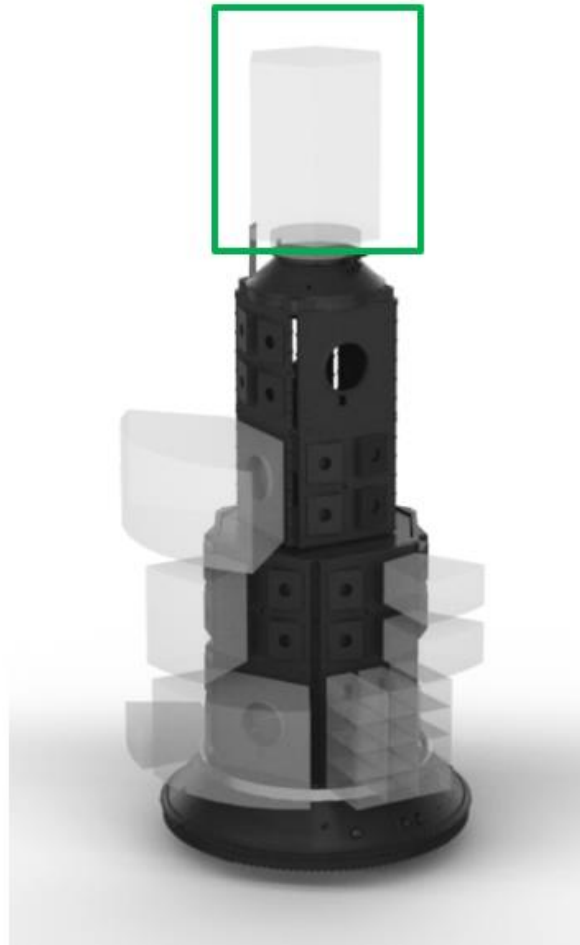


Figure 1-1: Cake Topper Location (green)*

*Example hardware configuration shown above for Payload mounted on Rideshare Plates; configuration is subject to change.



1.2 CAKE TOPPER PROGRAM OVERVIEW

The timeline of a typical Cake Topper contract is shown in Figure 1-2. Contract signature to launch is typically 1-2 years depending on spacecraft readiness and Launch Vehicle (LV) availability.

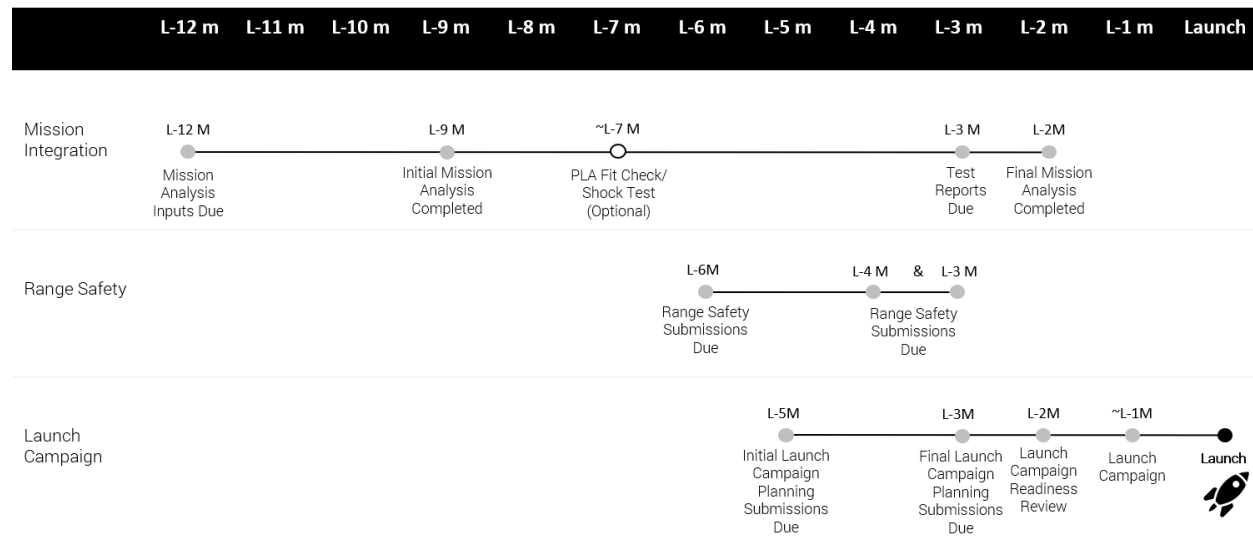


Figure 1-2: Cake Topper Typical Mission Integration Timeline

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

To ensure a smooth Launch Campaign and a successful mission for all Customers, SpaceX will maintain an Interface Control Document (ICD) for the Payload. Requirements in the ICD are designed to ensure the safety of all Co-Payloads and the Launch Vehicle. SpaceX and the Customer will periodically review and update the ICD throughout the mission integration process. Approximately six months before Launch, the Customer and SpaceX begin planning Range Safety and Launch Campaign operations.

Detailed mission analysis deliveries that rely on a known rideshare stack configuration are not available until approximately L-2 months. 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.

SpaceX will provide a best-estimate Payload separation state vector, or Orbital Parameter Message (OPM) to the Customer shortly after Payload separation, as described in Appendix E: Delivery Format of Separation State Vector.

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 Operations and Launch Vehicle safety and reliability.

1.4 PRICING

For Cake Topper pricing, please reach out to sales@spacex.com.

1.5 RIDESHARE PROGRAM

Please refer to the SpaceX Rideshare Payload User's Guide latest revision, available on <https://www.spacex.com/rideshare/>, for more information about flying small satellites on side-mounted ports.



2 MECHANICAL INTERFACES

2.1 LAUNCH VEHICLE FAIRING

Payload, Co-Payload(s), and all SpaceX hardware, including the Rideshare Plate system will be co-located in the Falcon-9 fairing volume. Please refer to the SpaceX Falcon User's Guide, latest revision, available on www.spacex.com/vehicles/falcon-9/ 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 separation plane. The Payload should use a right-hand X-Y-Z coordinate system (indicated with a subscript "PL") such that it is aligned with launch vehicle axes: Payload axial direction $+X_{PL}$ aligned with launch vehicle $+X_{LV}$ (in the direction of deployment), and $+Z_{PL}$ aligned with the launch vehicle $+Z_{LV}$ direction. Customers should provide **all** data and deliverables in this Payload Coordinate Frame.

2.4 CAKE TOPPER INTERFACE AND AVAILABLE PAYLOAD VOLUME

2.4.1 CIRCULAR MECHANICAL INTERFACE

SpaceX offers three standard circular clampband interfaces for Cake Topper Payloads (**Clampband Configuration**):

- 937 mm (36.89")
- 1194 mm (47.01")
- 1666 mm (65.59")

These spacecraft interfaces adapt to a standard 1575 mm interface at the base of the Payload Adapter (PLA) interface with the rideshare stack. SpaceX will either procure and integrate a PLA and clampband separation system or integrate a PLA chosen and provided by the Customer with these standard circular interfaces requirements as a standard service. See Appendix A for specifications.



In addition to standard clampband interfaces, SpaceX offers two standard circular interfaces for smaller Cake Topper Payloads that adapt to a Cake Topper Plate (**Topper Plate Configuration**).

- 381 mm (15") circular interface
- 610 mm (24") circular interface

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

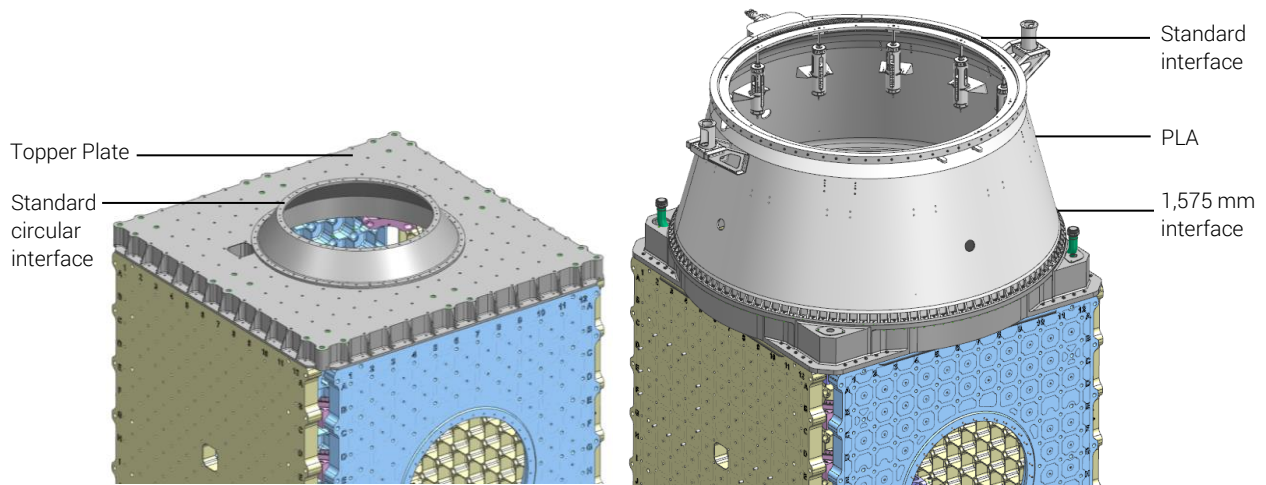


Figure 2-2: Topper Plate configuration (left) and Clampband configuration (right) (1194 mm example clampband shown as a reference)

2.4.2 4-POINT INTERFACES

In addition to circular interfaces, SpaceX can also accommodate 4-point standard interfaces, with the interface footprint options as shown in Figure 2-3. Width and depth are interchangeable.

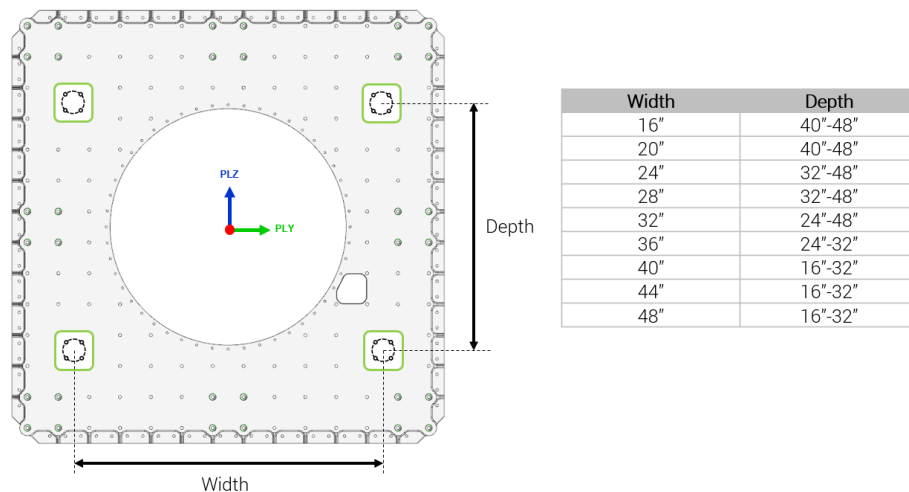


Figure 2-3: 4-point interface options (width and depth are interchangeable)

All payloads using a 4-point interface will mechanically attach to the Launch Vehicle hardware at each interface foot via four clearance holes, for 0.5" diameter fasteners on a 3.5" diameter circle. 4-point Cake Topper Payloads may assume a rigid mounting interface to the Topper Plate.



Payloads must conform to the customer-side interface specifications. Tolerances, as measured on the customer-side of the Launch Vehicle interface, must be within the maximum positional tolerances. See Appendix A for all detailed specifications. Customers must provide a metrology report of their 4-point interface to ensure it complies with these specifications.

2.4.3 AVAILABLE VOLUME

2.4.3.1 AVAILABLE VOLUME FOR CLAMPBAND CONFIGURATION

For Payloads using a Clampband Configuration, the Cake Topper Payload keep-in volume is shown in Figure 2-4 and Appendix A. A CAD model of the payload volume is available upon request. To verify that the Payload fits inside the keep-in volume, Customers should align their Payload such that the separation plane is aligned with the base of the volume.



Figure 2-4: Cake Topper Payload Keep-In Volume (Clampband Configuration)

2.4.3.2 AVAILABLE VOLUME FOR TOPPER PLATE AND 4-POINT CONFIGURATIONS

For Payloads using a Topper Plate or 4-point Configuration, the Cake Topper Payload keep-in volume is shown in Figure 2-5 and Appendix A.

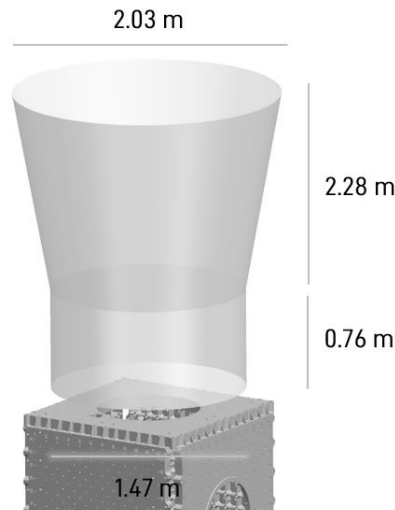


Figure 2-5: Cake Topper Payload Keep-In Volume (Topper Plate and 4-point Configuration)



3 PERFORMANCE

3.1 MASS PROPERTIES

Cake Topper Payloads must comply with the mass and center-of-gravity limitations given in Figure 3-1, Figure 3-2, and Figure 3-3, depending on the Cake Topper interface configuration that is chosen. Mass/CG may be further constrained by the separation system capabilities. The center of gravity is relative to the Cake Topper origin, with the origin defined at the separation plane. The Launch Vehicle may be able to accommodate Cake Topper Payloads with characteristics in excess of these limits: for example, with a reduced Rideshare capacity. Please contact SpaceX with your mission-unique requirements.

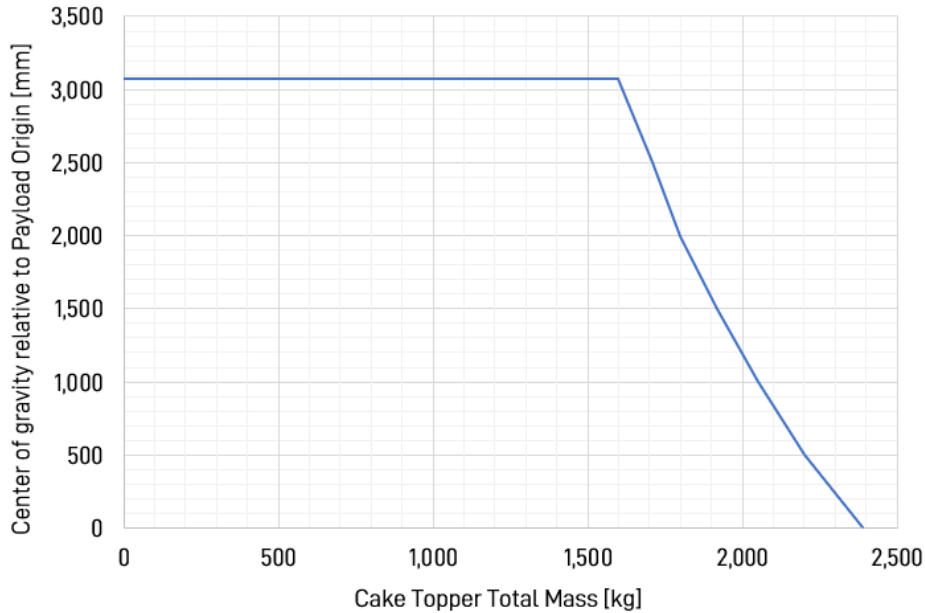


Figure 3-1: Cake Topper Mass and Center of Gravity Restrictions (Clampband Configuration)

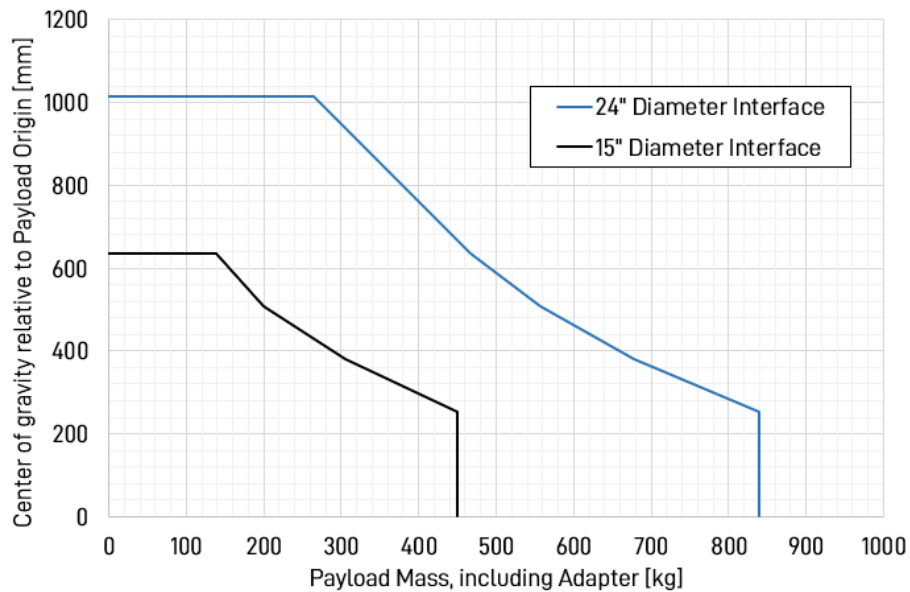


Figure 3-2: Cake Topper Mass and CG (Topper Plate Configuration)



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

Examples:

- For a 16" x 40" 4-point interface, mass and CG must be within the 'Short edge 16" or greater' capability curve.
- For a 28" x 32" 4-point interface, mass and CG must be within the 'Short edge 24" or greater' capability curve.

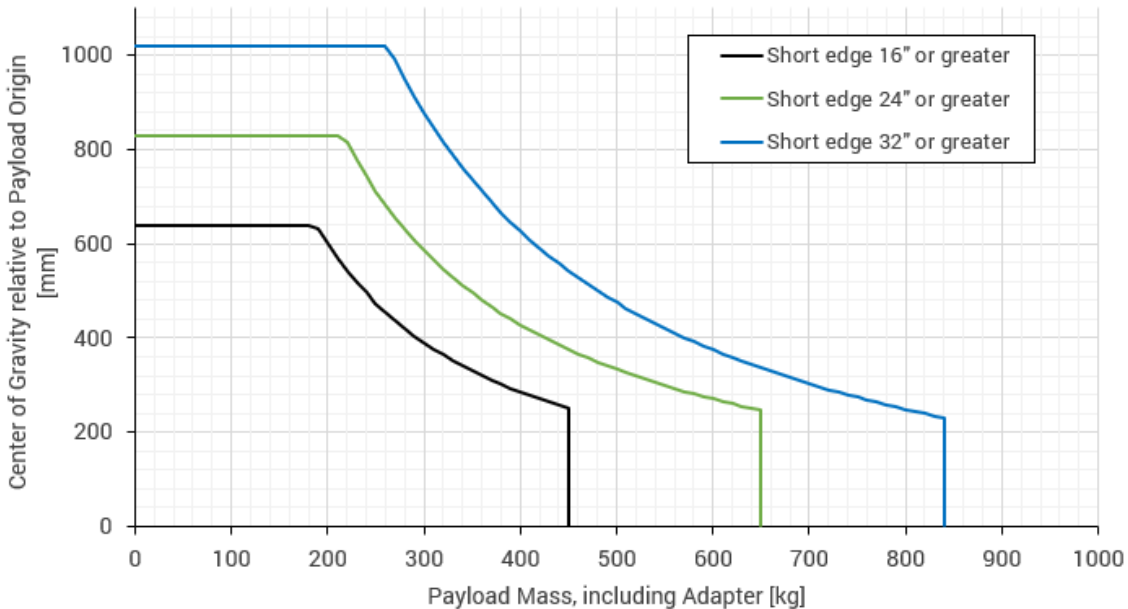


Figure 3-3: Cake Topper Mass and CG (4-point Interface)

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 the Cake Topper Customer (if applicable) or by SpaceX otherwise.

Cake Topper Payloads may be part of a two-orbit drop-off mission, to ensure Co-Payloads can be deployed within standard Rideshare Program mission altitudes. Orbit parameters are defined in terms of semi-major axis altitude and eccentricity (as opposed to apogee and perigee). Standard dispersions of orbital parameters are as follows:

Table 3-1: Typical Orbital Dispersions

Parameter	Example Transporter Values	Allowable Dispersion
Mean Semi-Major Axis Altitude	510 km or 590 km (<i>typical</i>)	+/- 20 km
Mean Inclination	SSO (<i>typical</i>) or 45 degrees	+/- 0.1 deg
Mean Eccentricity	Circular (<i>typical</i>)	<0.004
Mean LTAN or Mean LTDN	Customer-defined	Customer-defined



SpaceX may be able to provide reduced dispersions on a mission-specific basis. Please contact SpaceX for more details. Note that all missions fly south out of SpaceX launch sites that are north of the equator, so Local Time Ascending Node (LTAN) will be approximately 12 hours after launch time for sun-synchronous orbits (SSO). Osculating elements are available, upon request.

3.3.2 POST-SEPARATION RATES AND VELOCITY

Cake Topper Payloads should be designed to meet a separation velocity typically between 0.3 m/s and 1.5 m/s, which is determined by both the payload mass and the Payload separation system characteristics. Post-separation rates will also depend on spacecraft mass properties and the separation mechanism but typically target < 2.5 deg/s in all axes. Please contact SpaceX for any mission-specific requests. Note that post-separation rates are inclusive of the pre-separation rates, as defined below in Table 3-2. Post-separation rates are determined through mission-specific separation analysis.

Table 3-2: 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 SUN ANGLE EXPOSURE

Sun angle exclusion requirements during ascent may affect performance or launch availability. However, most sun-angle exclusion requirements are driven by component thermal limits. Therefore, Cake Topper Payloads are encouraged to evaluate sun angle exclusion requirements as a maximum amount of time in direct sunlight. Please contact SpaceX for details and pricing if sun angle exclusions are required, as these can be evaluated on a mission-specific basis.

3.3.4 PAYLOAD MANEUVERS AND DEPLOYMENTS

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

- Delay attitude maneuvers until at least **120 seconds** after Payload separation from the Launch Vehicle
- Delay mechanical appendage deployment (e.g., solar panel deployment) until at least **120 seconds** after Payload separation from the Launch Vehicle
 - For any mechanical appendage deployment within first 24 hours, Customer must communicate to SpaceX a bounding hard body radius for the Payload
- Delay secondary deployments, if applicable (e.g., a deployed object deploying a sub-Payload) until at least **7 days** after Payload separation from the Launch Vehicle
- Delay propulsive maneuvers until at least **one orbit** after Payload separation
- Any secondary deployments (if applicable) must be performed while under active attitude control. Deployments in uncontrolled directions or during Payload tumbling are not allowed

The 7-day period for secondary deployments and one-orbit period for propulsive maneuvers allows adequate time for external cataloging of all Co-Payloads deployed from the Launch Vehicle and sufficient orbital spreading before additional release of Payload Constituents or orbital maneuvers.

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



4 ENVIRONMENTS

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

4.1 FLIGHT ENVIRONMENTS

This section describes the MPE the Cake Topper Payload will experience from liftoff through separation. Environments are defined at the Payload interface.

Payloads must show compliance to all environments in Table 6-1, Table 6-2, or Table 6-3 (according to payload mass), as well as contamination requirements. Other environments are given for informational purposes only.

IMPORTANT: To ensure mission safety, all Payloads must be tested in a fully integrated, flight configuration (everything, including all Payload Constituents that comprise the Payload and attach to the SpaceX-provided mechanical interface, all firmware, software affecting deploy/power inhibits, 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

Cake Topper Payloads are subject to the minimum frequency requirements in Table 4-1 below. Payloads must have no elastic natural frequencies below the frequencies in Table 4-1.

Table 4-1: Cake Topper Minimum Frequency Requirements

Size	Minimum Lateral Frequency	Minimum Axial Frequency
< 500 kg	40 Hz	40 Hz
> 500 Kg	15 Hz	25 Hz

Payloads with fundamental frequencies at or below these values will require SpaceX approval and may be subject to increased load factors. Payloads must have a quality factor between $Q = 10$ and $Q = 50$ in order to ensure that the requirements defined in Section 4 are sufficient to cover the appropriate flight environments.

An 'elastic natural frequency' is defined in this document as 'any frequency response of the Payload with any modal participation, as computed by a fixed-base modal analysis.'

See Section 6.7.1 for detailed verification requirements.



4.1.2 PAYLOAD QUASI-STATIC FACTORS

Cake Topper Payload design load factors are listed in Table 4-2, and are valid for Payloads with fundamental frequencies and quality factors as described in Section 4.1.1.

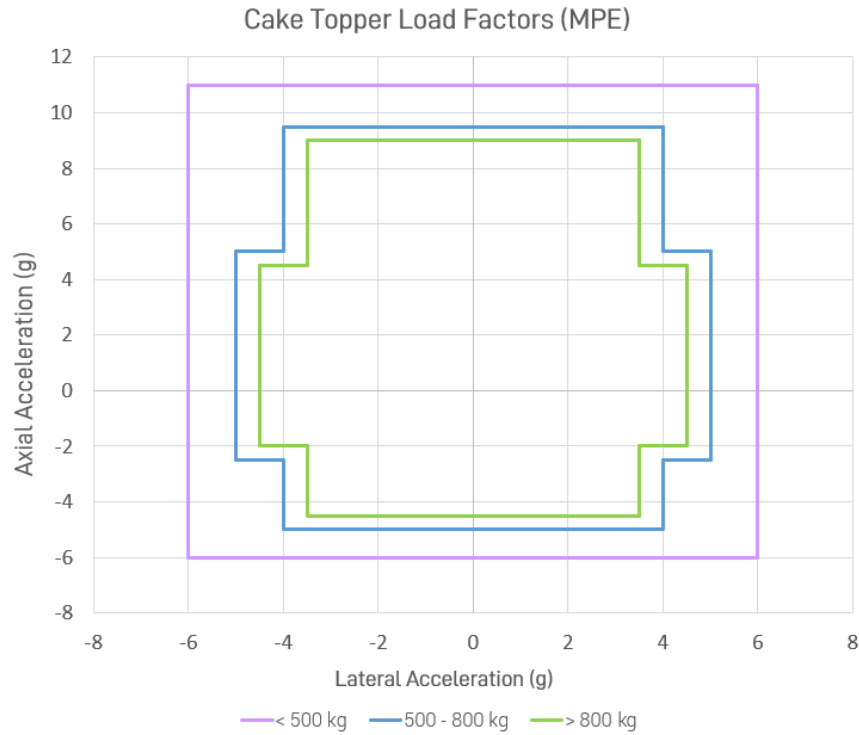


Figure 4-1: Cake Topper Axial and Lateral Load Factors (MPE)

Table 4-2: Cake Topper Payload Design Load Factors

< 500 kg		500 - 800 kg		> 800 kg	
Lateral (g)	Axial (g)	Lateral (g)	Axial (g)	Lateral (g)	Axial (g)
6	11	4	9.5	3.5	9
-6	11	4	5	3.5	4.5
-6	-6	5	5	4.5	4.5
6	-6	5	-2.5	4.5	-2
		4	-2.5	3.5	-2
		4	-5	3.5	-4.5
		-4	-5	-3.5	-4.5
		-4	-2.5	-3.5	-2
		-5	-2.5	-4.5	-2
		-5	5	-4.5	4.5
		-4	5	-3.5	4.5
		-4	9.5	-3.5	9
		4	9.5	3.5	9

4.1.3 SINE VIBRATION

The maximum predicted sine vibration environment is defined below in Figure 4-2 and Table 4-3. This environment is defined for Payloads with $Q \geq 10$ and may be notched at primary mode(s) to stay within the design load factors defined in Section 4.1.2. Notching profiles, along with calculations to show notch derivations, are due at least two weeks before spacecraft testing begins but should be delivered as soon as possible to ensure alignment on notching profiles.

Dynamic models are required to be submitted per Appendix B: Payload Dynamic Model Requirements.

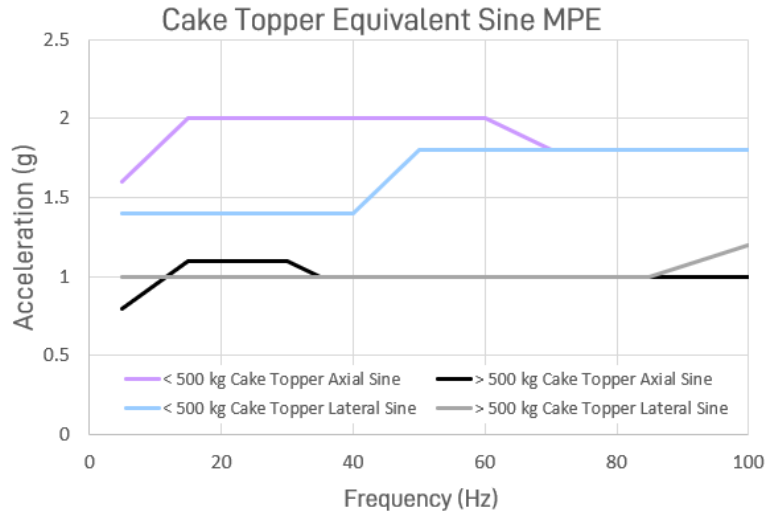


Figure 4-2: Axial and Lateral Sine Vibration MPE

Table 4-3: Cake Topper Axial and Lateral Accelerations

Frequency (Hz)	< 500 kg		> 500 kg	
	Axial Acceleration (g) (Q ≥10)	Lateral Acceleration (g) (Q ≥10)	Axial Acceleration (g) (Q ≥10)	Lateral Acceleration (g) (Q ≥10)
5	1.6	1.4	0.8	1.0
15	2	1.4	1.1	1.0
30	2	1.4	1.1	1.0
35	2	1.4	1.0	1.0
40	2	1.4	1.0	1.0
50	2	1.8	1.0	1.0
60	2	1.8	1.0	1.0
70	1.8	1.8	1.0	1.0
85	1.8	1.8	1.0	1.0
100	1.8	1.8	1.0	1.2

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 4-3. Table 4-4 and Table 4-5 define the environment in third octave and full octave, respectively. A Mission-specific analysis will not be provided by SpaceX.

Acoustic mitigations may be available as an optional service. Please contact SpaceX for assessment of mission-specific acoustic requirements and pricing.

See Sections 6.5, 6.6, and 6.7.5 for detailed verification requirements.

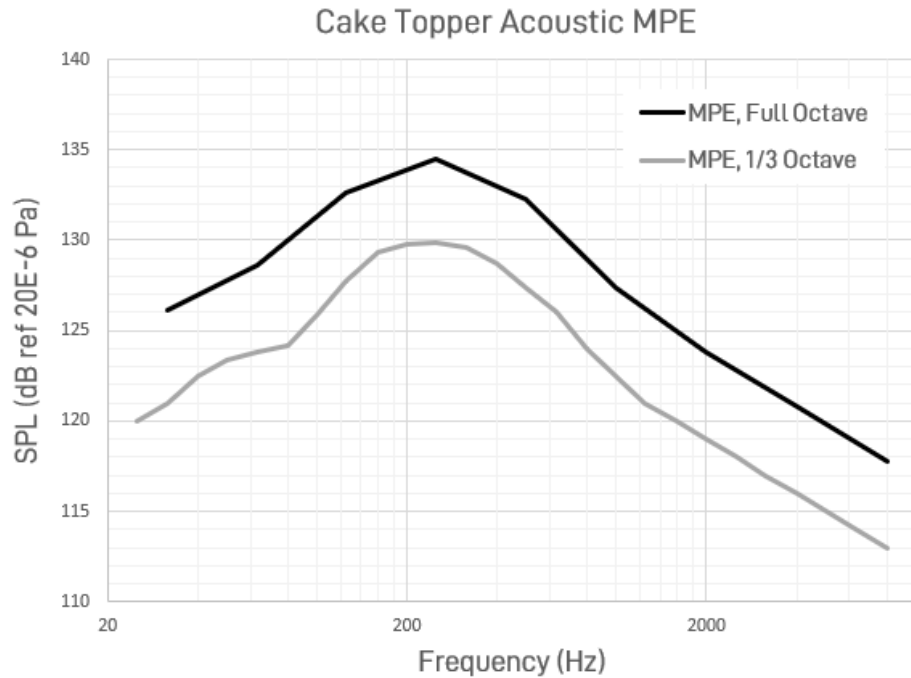


Figure 4-3: Maximum Predicted Acoustic Environment

Table 4-4: Third Octave Acoustic MPE

Frequency (Hz)	Acoustic MPE 1/3 Octave (dB)
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 4-5: Full Octave Acoustic MPE

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



4.1.5 SHOCK

The shock response spectrum MPE, for Q=10 at the Payload mechanical interface is defined in Table 4-6 and Figure 4-4 (solid black line). This MPE envelopes the following shock events:

- Fairing deployment shock
- Co-Payload separation(s) shock (assuming a minimum of three bolted joints between Co-Payloads)
- Average shock for the Payload separation system (SpaceX-provided)

SpaceX-provided separation systems provide an *average* shock within the MPE in Table 4-6. Some separation systems may have shock characteristics that vary and differ from the stated average. Contact SpaceX or the separation system manufacturer for more details.

Customers may opt for a spacecraft shock test with the flight Payload Adapter (PLA), which takes place at the Customer facility. For low-shock separation systems that provide shock levels lower than those defined below in this section, the shock levels stated in Table 4-6 must still be evaluated in order to account for co-payload and fairing shock. Customer-defined shock requirements lower than Table 4-6 are not permitted.

Note that "Maximum Allowable Induced by Payload Separation System" is for Customers that wish to bring their own separation system (dotted black line); SpaceX-provided separation systems provide an average shock within the MPE (solid black line).

Table 4-6: 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
1,000	1000	--
1,950	--	2850
10,000	1000	2850

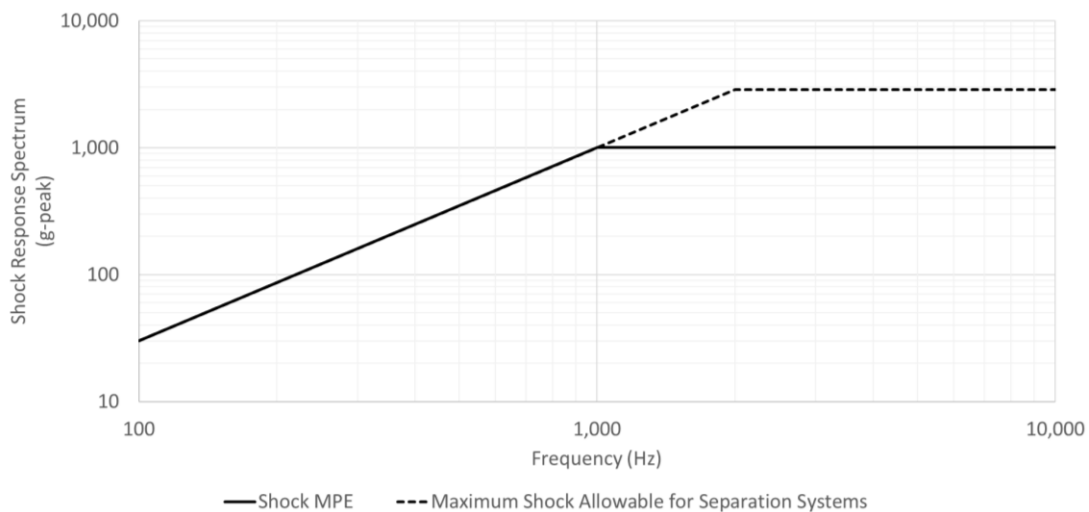


Figure 4-4: Payload Mechanical Interface Shock



4.1.6 RANDOM VIBRATION

The random vibration MPE for the Payload, derived at a P95/50 level, is defined in Table 4-7 and Figure 4-5. These Cake Topper levels are applicable only if flying with Rideshare Co-Payloads. A change in mission type to a Dedicated Launch must follow the standard dedicated Falcon 9 User Guide random vibration levels.

See Sections 6.5, 6.6, and 6.7.6 for detailed verification requirements.

Table 4-7: Random Vibration MPE

Frequency (Hz)	Random Vibration MPE (P95/50) (g^2/Hz), All Axes
20	0.0044
100	0.0044
300	0.01
700	0.01
800	0.015
925	0.015
2000	0.00322
GRMS	4.05

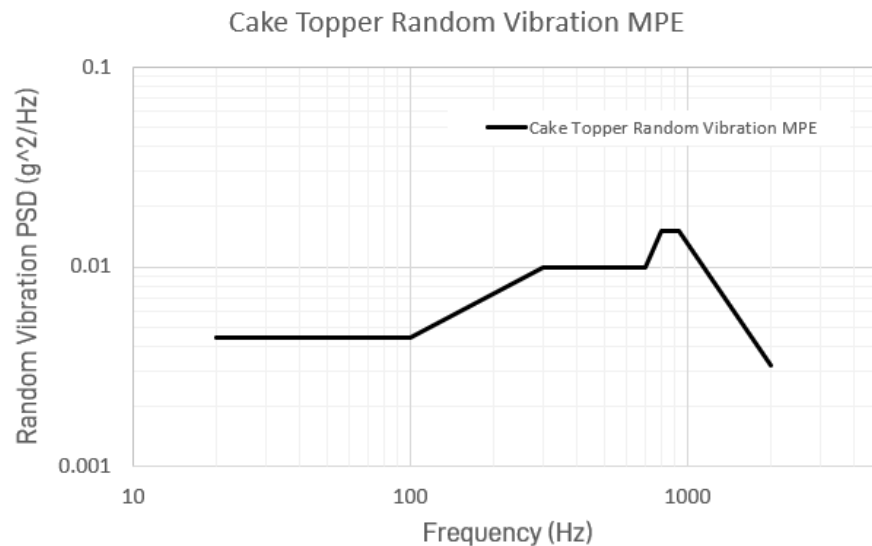


Figure 4-5: Random Vibration MPE

4.1.7 ELECTROMAGNETIC

Payloads are subject to the electromagnetic environments in the following sections. Payloads with launch pad connectivity should be powered off at T-1 hour before launch through deployment plus the time in Table 4-11, but may still experience the electromagnetic environment MPE during launch site processing. Payloads powered on during ascent must show compatibility to the environments in this section and may be subject to additional optional service pricing. Incompatibilities with environments in this section will be evaluated on a case-by-case basis.

4.1.7.1 IN-FLIGHT AND PRE-FLIGHT ENVIRONMENTAL EMISSIONS

Customers must ensure that Payload materials or components sensitive to RF environments are compatible with the worst-case radiated environment shown in Figure 4-6. LV, including Co-Payloads, and Launch Site radiated emissions, are shown in Table 4-8 and Table 4-9 respectively. EMI margin is not included.

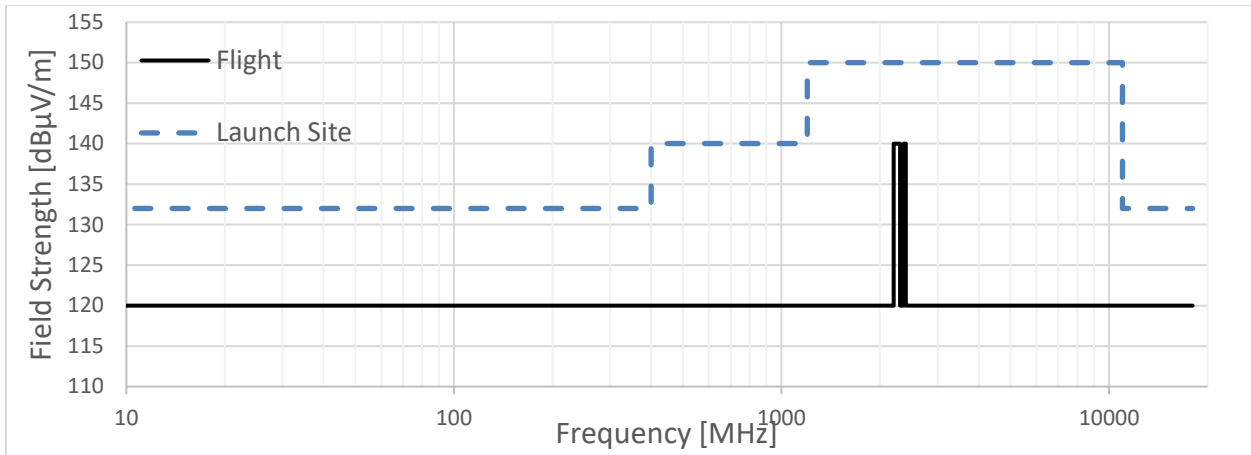


Figure 4-6: In-Flight and Environmental Radiated Emissions / Payload Radiated Susceptibility Limit

Table 4-8: 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 4-9: Launch Site Radiated Emissions

Frequency Range (MHz)	E-Field Limit (dBµV/m)
1.00–400	132
400–1200	140
1200–11000	150
11000–18000	132

These limits envelope the expected emissions from the LV, Co-Payloads, and Launch Site emitters. The 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).

4.1.7.2 MAXIMUM SPACECRAFT EMISSIONS

The emission envelope for Cake Topper missions, including 6 dB of EMI safety margin by test, or 12 dB of EMI safety margin by analysis, is shown in Table 4-10. Levels shown are as measured at the spacecraft separation plane.

Table 4-10: Maximum Payload Emissions

Frequency Range (MHz)	by Test (dBµV/m)	by Analysis (dBµV/m)
30.0–1000.0	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

Standard Launch Services do not permit use of Payload transmitters while integrated to the LV hardware. Payload transmitters may be enabled after the time interpolated using the information found in Table 4-11.

4.1.7.3 PAYLOAD TRANSMITTER TURN-ON DELAY TIME

Standard launch services do not permit use of Payload transmitters during ascent and must be powered off at T-1 hour. Payloads that require power during ascent must inform SpaceX prior to launch services agreement (LSA) finalization. See Section 6.7.7 for Verification requirements for Payloads that must be powered ON.



Payload transmitters may only be enabled after a minimum time after Payload separation, as defined in Table 4-11 (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 4-11: Payload Transmitter Delay Time (seconds)

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 may need to 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 3,600 seconds, after the first Payload deploy).

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

Cake Topper Payloads must inform SpaceX prior to launch services agreement (LSA) finalization if transmitting inside one of these bands.

4.1.8 FAIRING INTERNAL PRESSURE

Fairing internal pressure will decay at a rate no larger than 0.40 psi/sec (2.8 kPa/sec) from liftoff through immediately prior to fairing separation, except for brief periods during flight, where the fairing internal pressure will decay at a rate no larger than 0.65 psi/sec (4.5 kPa/sec), for no more than 5 seconds. A mission-specific analysis will not be provided by SpaceX.

4.1.9 THERMAL

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 4-12 and Figure 4-7.

Customer may use these boundary conditions to run a Payload-specific thermal analysis. Upon request, SpaceX will provide a representative description of thermal attitude parameters to the Customer once a target orbit has been identified in the Statement of Work (SOW).

Note that these boundary conditions are only relevant after Liftoff at Time = 0 as they contain analysis uncertainty that is not appropriate on the ground. The convective environment in Table 4-12 fully defines the Pre-Launch environment. A Mission-specific thermal analysis will not be provided by SpaceX. The values listed below are for the SpaceX side of the interface; no results are provided for the customer side of the interface and the below should not be assumed to be enveloping of Payload temperatures through flight. See Table 6-1 and Section 6.7.10 for detailed verification requirements.



Table 4-12: Bounding Conductive Boundary Temperature and Conductance

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

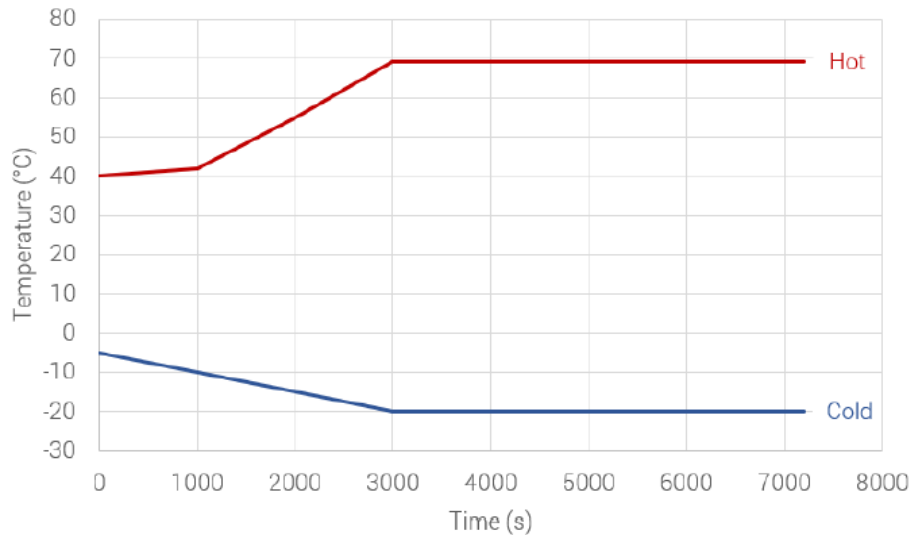


Figure 4-7: Bounding Conductive Boundary Temperature

4.1.10 PAYLOAD TEMPERATURE EXPOSURE DURING FLIGHT

The LV fairing is designed such that the temperature seen by the Payload never exceeds the temperature profile shown in Figure 4-8. The emissivity of the fairing is approximately 0.9.

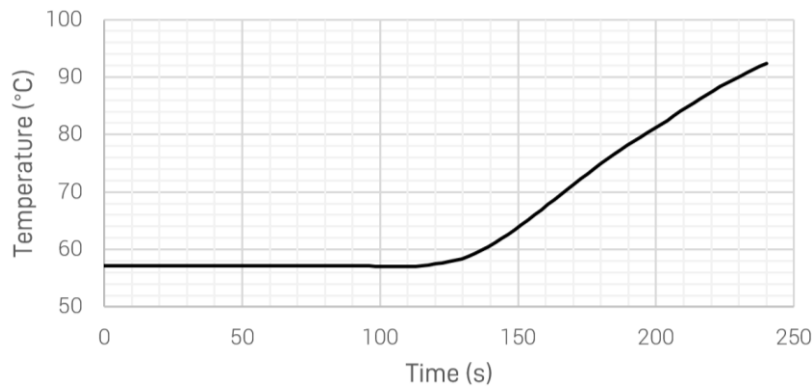


Figure 4-8: Maximum Fairing Spot Temperature Seen by Payload

4.1.11 FREE MOLECULAR HEATING

The maximum free molecular aero-thermal heating rate experienced by the Payload is less than 3,500 W/m² at fairing separation. Free molecular aero-thermal heating declines significantly and becomes negligible over the next couple of minutes. The free molecular heating environment can be assessed on a mission-specific basis, if required. Please contact SpaceX for additional details.



4.2 TRANSPORTATION ENVIRONMENTS

Transportation environments at launch site facilities will be enveloped by the flight environments in Section 4.

4.3 CLEANROOM ENVIRONMENTS

The standard service temperature, humidity, and cleanliness environments during various processing phases are provided in Table 4-13. 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) level.

Table 4-13: Temperature and Cleanliness Environments

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

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



5 PAYLOAD DESIGN REQUIREMENTS

5.1 DESIGN FACTORS

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

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

Table 5-1: Factors of Safety

Factor of Safety	Min design factor
Yield (flight, ground)	1.10
Joint gap and slip (interfaces)	1.10
Ultimate (flight)	1.25
Ultimate (ground operations)	1.40
Yield (GSE lifting hardware) ¹	3.0
Ultimate (GSE lifting hardware) ¹	4.0

1. AFSPCMAN 91-710 Vol 3 for detailed requirements

Table 5-2: Peaking Factors

Peaking factor	Min design factor
Separation system interface	Variable ¹

1. Consult separation system User's Guide for guidance on peaking factor

5.2 FASTENERS AND CABLE TIES

5.2.1 REWORKED PAYLOAD FASTENERS

Purpose: To ensure the structural integrity of the Payload and any parts replaced on a Payload after exposure to environments designed to qualify and/or screen structural load paths and secondary structures. Any fasteners removed and reworked after environmental testing must meet the acceptance criteria given in Table 5-3. Customers are strongly encouraged to design Payloads to fully meet fastener rework design requirements, as deviations are not permitted and will result in a mandatory delta-vibration workmanship test.

See Section 6.7.11 for detailed verification requirements.

- 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 **20 fasteners** are reworked on a Payload (within guidelines set out above), a penalty vibrate acceptance test will be required. The intent is to allow for one access panel to be removed and replaced for inspection/instrumentation access post vibrate and/or multiple deployment devices to be reset.
- Fasteners reworked to reset deployable devices such as ejectors, microlatches, and other HDRMs must follow the guidance set out by the manufacturer of the device and the acceptance criteria in Table 5-3. For these devices, a minimum of one locking feature is required for reworked fasteners #03/M2.5 or larger. The locking feature must be selected to maintain the correct function of the deployment device.
- The following fasteners are exempt from the rework criteria set out above and do not count towards the number of fasteners reworked (best practices on secondary retention features and installation methods still apply):
 - Fasteners used to reattach access panels mounted on fully containerized CubeSats
 - Fasteners securing non-structural components that are fully containerized within the Payload or an enclosure



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	<ul style="list-style-type: none"> Fastener must incorporate a minimum of one locking feature that does not depend upon preload to function. In order of preference: <ul style="list-style-type: none"> prevailing torque feature like a distorted thread locking nut or patched fastener lock wire/lock cable staked fastener head with process hardness check thread locker with process joint strength check on a representative sample cotter pin through each fastener 	<ul style="list-style-type: none"> Fastener must incorporate a minimum of two locking features that do not depend upon preload to function. In order of preference: <ul style="list-style-type: none"> prevailing torque feature like a distorted thread locking nut tab washer with one mechanical stop on the fastener and one stop on the underlying part lock wire/lock cable staked fastener head with process hardness check cotter pin through each fastener 	Not allowed
Thread engagement	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> Fasteners must be installed by means of an installation procedure that uses a calibrated torque tool, measures installation torque, and verifies retention is functional (e.g., measures prevailing torque and compares to limits, visual verification on lock wire/cable, test coupon for thread locker to test breakaway torque, etc.) 		

5.2.2 FASTENERS ATTACHING TO SPACEX HARDWARE (IF APPLICABLE)

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

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

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

Fastener size	Per standard interface
Locking features	<ul style="list-style-type: none"> Fastener must incorporate a minimum of one locking feature that do not depend upon preload to function. In order of preference: <ul style="list-style-type: none"> prevailing torque feature like a nut plate, distorted thread locking nut or patched fastener lock wire/lock cable staked fastener head with process hardness check thread locker with proper application process hardness check
Thread engagement	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> Fasteners must be installed by means of an installation procedure that uses a calibrated torque tool, measures installation torque, and verifies retention is functional (e.g., measures prevailing torque and compares to limits, visual verification on lock wire/cable, test coupon for thread locker to test breakaway torque, etc.)



5.2.3 CABLE TIES

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

5.3 MATERIALS AND CONTAMINATION

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

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

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

See Section 6.7.12 for detailed verification requirements.

Table 5-5: Payload Materials and Contamination Requirements

Requirement	Description
Visual Cleanliness	Payloads must be cleaned to VC-HS standards per NASA-SN-C-005D prior to integration onto Launch Vehicle hardware
Non-Metallic Materials	<p>Each individual non-metallic material used in the construction of the Payload that will be exposed to vacuum must satisfy the following quantities, when tested per ASTM E-595:</p> <ul style="list-style-type: none"> RML \leq 1.0% (RML = TML - WVR), AND CVCM \leq 0.1% <p>If WVR is unknown, then assume WVR = 0%</p> <p>To comply with this requirement, Customers should avoid the use of markers, pens, and paint pens to mark Payload hardware. If markers are required for use, for instance for torque striping, SpaceX encourages the use of Mighty Marker MM07/MM08 black. Sharpie markers are prohibited</p> <p>Exceptions to this requirement are allowed using the rationale codes as given in 6.7.12. Rationale codes will be evaluated by SpaceX</p>
Metallic Materials	The selection of metallic materials by the Customer will include consideration of corrosion, wear products, shedding, and flaking in order to reduce particulate contamination. Dissimilar metals in contact will be avoided unless adequately protected against galvanic corrosion
Payload Particulate Generation	The Payload will not create particulate during the vibroacoustic ascent environment. Actuation of any Payload mechanisms nearby any Co-Payload(s) or Launch Vehicle Hardware must not create particulate
Payload Deployment	The Payload deployment system will not include the use of uncontained pyrotechnics (e.g., Frangible nuts).
Payload Propulsion	Payload propulsion systems will not be operated in close proximity (within 1 km) of Co-Payload(s)
Prohibited Materials	<p>The following materials are not to be used on Payload hardware:</p> <ul style="list-style-type: none"> 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 to Co-Payload(s) or Launch Vehicle hardware will require SpaceX approval, coordination, and notification prior to use



5.4 ISOLATORS

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

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

See Section 6.7.13 for detailed verification requirements.

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





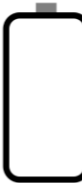
Pressure Component	Design Safety Factors	Qualification Test Factors Must be performed on a dedicated Qualification Component	Acceptance Test Factors Must be performed on Component prior to Integration on Flight Unit
US DOT Pressure Vessels	<i>Accepted as is per US DOT certification</i>		
Non-US DOT Pressure 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. \geq 1.5 in)	Yield: 1.5 x MEOP Ultimate: 2.5 x MEOP	<i>Not required</i>	
Lines and Fittings (Dia. $<$ 1.5 in)	Yield: 1.5 x MEOP Ultimate: 4.0 x MEOP	<i>Not required</i>	
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 \leq 1 atm on orbit)	Yield: 1.5 x MEOP Ultimate: 2.0 x MEOP	<i>Not required</i>	



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. 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
					
	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			<ul style="list-style-type: none"> • Use is discouraged • 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.

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 must meet the following requirements:

- **No** Type 2, 3, 4, or 5 pressurized-structure tanks where non-pressure loading makes up more than 15% of maximum combined flight stress (15% Rule)
- **No** pressure tanks that require pressure stabilization to hold external structural load
- **No** additively manufactured tanks. Contact SpaceX for further information
- Pressurization state of the tank must not change between the time that the Payload is mated to Launch Vehicle hardware and deployment from the Launch Vehicle. Use of HTP is treated separately, see Section 5.5.5
- Pressure vessels must have a contingency pressure relief valve to vent pressure above personnel safe MEOP while in ground operations
- Qualification must include all testing per applicable AIAA document listed in Table 5-7 based on pressure vessel type, Section 6.8.3, and AFSPC 91-710 (Section 12). Pressure vessels must hold burst factors of safety on pressure per applicable AIAA document listed in Table 5-7 based on pressure vessel type, not 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) must 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 does not meet the previous definition of a pressure vessel. This includes both 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 and cryostats. 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.

5.5.5 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.
- **Oxidizers:** All oxidizers are **prohibited** for use in Type 4 and Type 5 pressure vessels. Contact SpaceX for further information.
- **NTO/Titanium usage:** Titanium usage in an NTO-wetted application is **prohibited**.
- **Cryogenic propellants:** Cryogenic fuels and consumables that require loading post encapsulation is **prohibited**.
- **Hydrogen Peroxide:** Hydrogen peroxide, otherwise known as High Test Peroxide (HTP) may be used as propellant but carries additional requirements on design and analysis:
 - A propellant tank relief must be provided to protect the propellant tank from excessive pressure due to HTP decomposition. This relief should be set for no more than 10% above MEOP.
 - The propellant tank must have a MEOP that envelopes the max expected pressure after self-pressurization due to HTP decomposition when the tank is at 32°C, over a 60-day period.
 - The relief outlet should be configured such that there is no danger to personnel in case of tank relief.
 - The tank, and if so equipped, tank positive expulsion diaphragm, must be compatible with HTP. This includes any material on the gas-side of the diaphragm, including tank weldment alloys, tank cleaning agents, etc.
 - To minimize the possibility of reactions, all materials that may come in contact with HTP must be cleaned and passivated, and designs must minimize excessive surface area contact with, and entrapment of, HTP.

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



5.5.6 FAULT TOLERANCE FOR PRESSURANT/PROPELLANT RELEASE

The pressure and propellant system must 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 must have dual fault tolerance (three inhibits to propellant release). *This can be accomplished, for example, through the use of three valves in series.*
- **For all other pressure/propellant systems**, the system must be at least single fault tolerant (two inhibits to propellant release). *This can be accomplished, for example, through the use of two 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 AFSPC 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 should be hermetically sealed. Igniters require a Safe/Arm system to protect against accidental firing.



6 VERIFICATION

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

6.1 VERIFICATION TEST APPROACH

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

1. **Flight Unit Protoqualification and Acceptance (Preferred)**: The flight unit is subjected to protoqualification test levels (or the first flight unit if flying a series of identical spacecraft). Follow-on identical units are tested at acceptance levels (applicable for Cake Topper payloads only). Testing must be performed at the fully integrated Payload assembly level, even if the Payload consists of multiple smaller Payload Constituents. With this approach the protoqualification 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), that is identical to the flight unit (mass simulators, for example, are not allowed) is subjected to testing at qualification levels and every flight unit is tested to acceptance test levels. The acceptance tests must be performed at the fully integrated Payload assembly level. With this approach, qualification testing validates the structural design and design margin while the acceptance test(s) validate workmanship.

Note that for Customers pursuing a static load test for qualification of their primary structure (allowed for Cake Toppers > 500 kg), a Structural Test Model may be used to qualify the primary load path and verify the quasi-static environment (the flight model must still be verified to acceptance levels through a sine sweep or other test).

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

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



6.1.1 SEPARATION SYSTEMS AND ENVIRONMENTAL TESTING SETUP

For Cake Topper Payloads utilizing a qualified separation system, testing with the separation system installed is not required. However, Customer-provided GSE is required for testing, to adapt the spacecraft interface to the shaker table. A diagram of the flight configuration vs. test configuration is shown in Figure 6-1 for customers utilizing a clamp-band style separation system and Figure 6-2 for customers utilizing a Topper Plate (lightband) configuration. 4-point configurations may also test with an adapter to the shaker table. Other configurations may be acceptable, upon review.

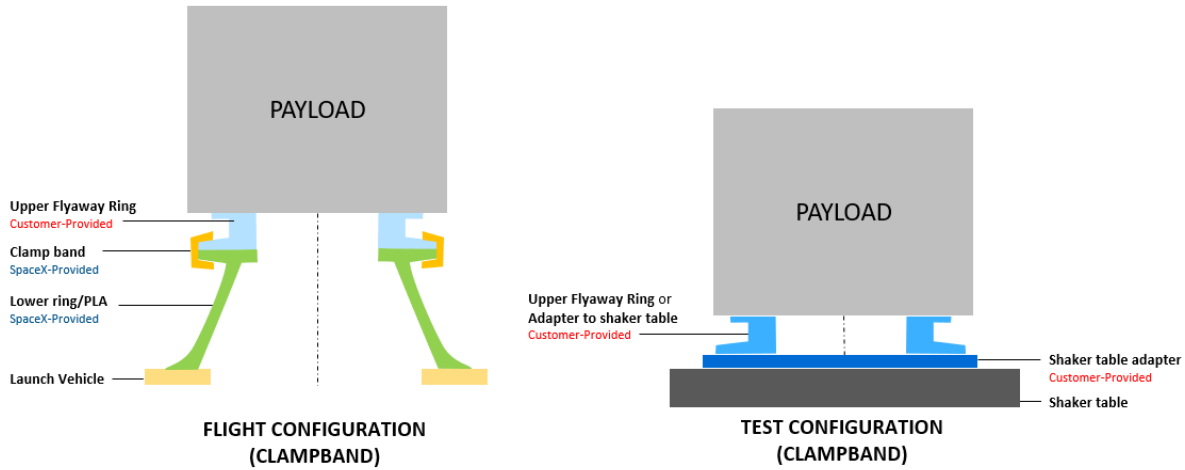


Figure 6-1: Flight vs. Test Configuration for Cake Toppers using a Clampband Configuration

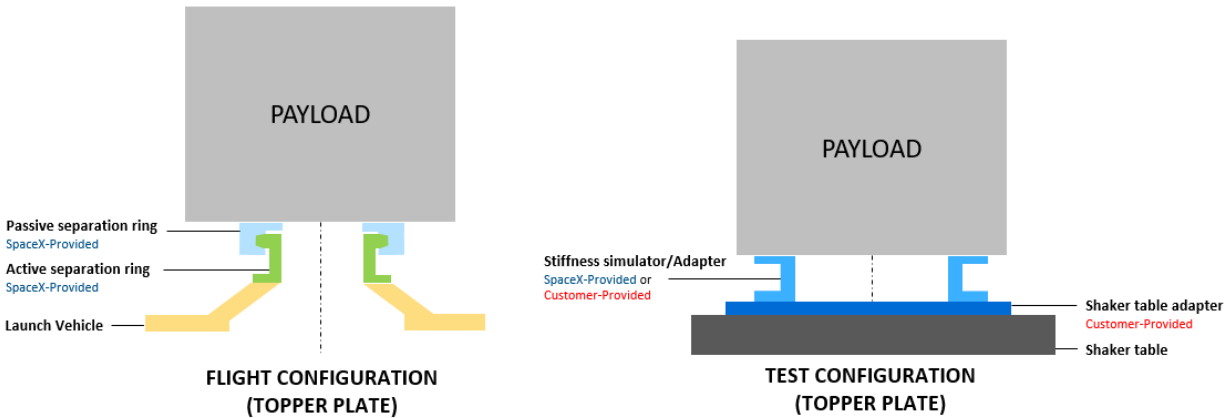


Figure 6-2: Flight vs. Test Configuration for Cake Toppers using a Topper Plate Configuration

The qualification and suitability of separation systems supplied by SpaceX will be reviewed for the specific Cake Topper application. For new or unqualified separation systems, please reach out to SpaceX for more information. The separation system provider must demonstrate complete qualification of their product to SMC-S-016 standards. A qualification and acceptance plan template can be supplied by SpaceX. All flight separation systems must undergo acceptance and functional testing, as agreed with SpaceX.

For Payloads designed to be powered OFF during ascent, separation detection circuits must be functionally verified before and after dynamic tests to ensure that a Payload does not inadvertently activate during ascent. Flight representative harnesses, connectors, and switches must be installed such that power inhibit verification is flight-like.



Additionally, all Customers must verify that deployable systems, propulsion systems, and unwanted RF emissions are successfully inhibited while attached to the Launch Vehicle. It is expected for these tests to be coupled with the required vibration tests referenced in Section 6.5.

6.2 TEST-LIKE-YOU-FLY EXCEPTIONS

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

- Not testing propulsion systems at flight pressure
- Not filling propulsion tanks with reactive propellants during testing
- Deviations in mass, CG, and other physical and dynamic properties (see Section 6.7 for allowed deviations)

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

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

6.3 POST-INTEGRATED TEST MODIFICATIONS & PENALTY RE-TEST

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

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

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

6.4 DOCUMENTATION REQUIREMENTS

Customers must deliver to SpaceX:

- A test approach summary, using the SpaceX test template, including any and all test-like-you-fly exceptions and deviations from this guide, for review by SpaceX prior to Payload testing, and in accordance with the SOW
- Propulsion system details using the SpaceX test template, for review by SpaceX prior to Payload testing, according to requirements as specified in Section 6.8 or Section 6.9 if applicable
- Verification results, using the SpaceX test template, including test results and other artifacts per requirements defined in Section 6, for review by SpaceX in accordance with the SOW. The results must include all *new* test-like-you-fly exceptions for approval by SpaceX, including details on test versus flight boundary conditions, and any hardware not included in the test set up that will be in the flight configuration. If Customer chooses not to complete any "Advised" tests an acknowledgment of the inherent risks to the Payload incurred by not completing the "Advised" testing must be included



6.5 PAYLOAD UNIT TEST LEVELS

6.5.1 OVERVIEW

Figure 6-3 provides a decision tree for the verification strategy to pursue, depending on Cake Topper mass class. The strategy is broadly identical for all mass classes and only differs for verification of medium to high frequency launch environments (acoustics, random vibe) and methods for verification of the quasi-static environment.

For the verification of these environments, low mass Cake Toppers (under 500 kg) should pursue a random vibration test verification strategy, while high mass Cake Toppers (over 1,500 kg) should pursue an acoustic test verification strategy. Cake Toppers in the intermediate mass class (500 to 1,500 kg) should evaluate which environment envelopes the highest response on components susceptible to medium-to-high frequency vibration or, alternatively, test to both environments. Environment susceptibility is highly dependent and is a function of the Payload's architecture, mass, exposed surface area, components, and component mounting.

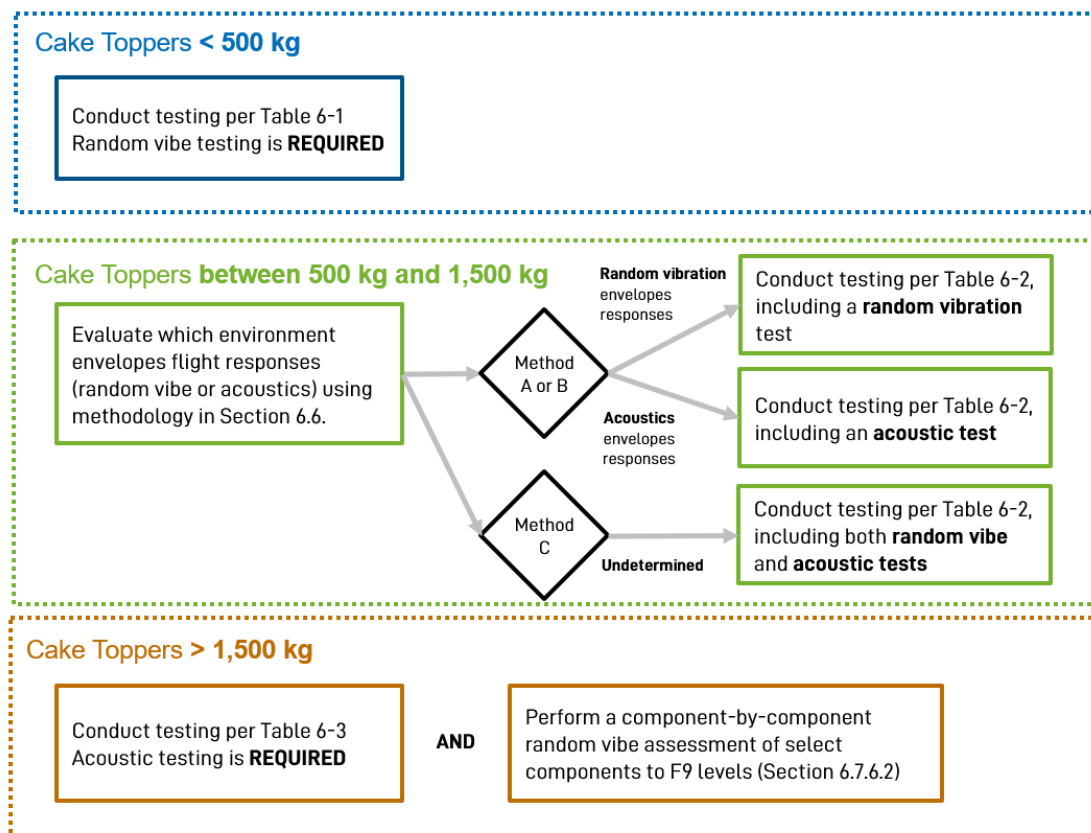


Figure 6-3: Cake Topper Verification Decision Tree



6.5.2 TEST REQUIREMENTS FOR CAKE TOPPER PAYLOADS UNDER 500 KG

Payload unit testing for Cake Topper Payloads under 500 kg must conform to Table 6-1.

Table 6-1: Payload Unit Test Levels and Durations – Cake Topper Payloads under 500 kg

Test	REQUIRED OR Advised	Unit/Fleet Qualification and Acceptance Approach		Flight Unit
		Qualification	Acceptance Must be performed on fully integrated Payload assembly	Protoqualification Must be performed on the 1 st fully integrated Payload
		<i>Unit Not Flown</i>	<i>Unit Flown</i>	<i>Unit Flown</i>
Quasi Static Load ¹	REQUIRED	Level: Min 1.25 times the limit load in each of 3 axes	Level: Min 1.0 times the limit load in each of 3 axes	Level: Min 1.25 times the limit load in each of 3 axes
Sine Vibration	REQUIRED	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
Shock	Advised	Level: MPE + 3 dB Events: 2 times in each of 3 axes OR 2 actuations of device	Not Required	Level: MPE + 3 dB Actuations: 2 times in each of 3 axes OR 2 actuations of device
Acoustic	Advised	Level: MPE + 3 dB Duration: 2 minutes	Level: MPE Duration: 1 minute	Level: MPE + 3 dB Duration: 1 minute
Random Vibration ²	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 + 3 dB Duration: 1 minute in each of 3 axes
Power Inhibit ³	REQUIRED	Verification that power inhibits function as intended	Verification that power inhibits function as intended	Verification that power inhibits function as intended
Electromagnetic Compatibility ⁴	REQUIRED for Payloads Powered ON	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 and 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. Quasi-static load testing can be achieved through either a **sine-burst** test or **sine vibration (sweep)** test.
2. Random vibration must be conducted as a standalone test.
3. Power inhibits must be verified at an integrated level as part of random vibrate testing. See Section 6.7.7.
4. EMISM (6 dB by test, 12 dB by analysis) is already included in Table 4-9. See Section 6.7.7 for further guidance on electromagnetic compatibility verification.
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 6.8. Pressure Systems that do not meet material compatibility requirements specified in Section 5.5.5 must contact SpaceX for specific leak testing requirements.



6.5.3 TEST REQUIREMENTS FOR CAKE TOPPER PAYLOADS BETWEEN 500 KG AND 1,500 KG

Payload unit testing for Cake Topper Payloads between 500 kg and 1,500 kg must conform to Table 6-2.

Table 6-2: Payload Unit Test Levels and Durations – Cake Topper Payloads 500 kg to 1,500 kg

Test	REQUIRED OR Advised	Unit/Fleet Qualification and Acceptance Approach		Flight Unit
		Qualification	Acceptance Must be performed on fully integrated Payload assembly	Protoflight Qualification Must be performed on the 1 st fully integrated Payload
		<i>Unit Not Flown</i>	<i>Unit Flown</i>	<i>Unit Flown</i>
Static Load ¹	REQUIRED	Level: Min 1.25 times the limit load in each of 3 axes	Level: Min 1.0 times the limit load in each of 3 axes	Level: Min 1.25 times the limit load in each of 3 axes
Sine Vibration	REQUIRED	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
Shock	Advised	Level: MPE + 3 dB Events: 2 times in each of 3 axes OR 2 actuations of device	Not Required	Level: MPE + 3 dB Actuations: 2 times in each of 3 axes OR 2 actuations of device
Acoustic	See Section 6.6 and Figure 6-3 ² to determine REQUIRED tests ²	Level: MPE + 3 dB Duration: 2 minutes	Level: MPE Duration: 1 minute	Level: MPE + 3 dB Duration: 1 minute
Random Vibration		Level: MPE + 3 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 power inhibits function as intended	Verification that power inhibits function as intended	Verification that power inhibits function as intended
Electromagnetic Compatibility ⁴	REQUIRED for Payloads Powered ON	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 and 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 Pressure 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. Quasi-static load testing can be achieved through either a **sine vibration (sweep), static load, sine burst**, or a combination of one or more tests. Static load testing may be conducted on a separate qualification model, even if the main testing approach is protoflight qualification.
2. Random vibration shaker testing is often aggressive when it comes to larger spacecraft. Therefore, the Customer must determine whether the acoustic or random vibration flight environment is enveloping of the spacecraft responses that are not screened by other tests. See Section 6.6 on methodology for evaluation and selection of the correct test. If the outcome of this evaluation shows that the random vibration is enveloping of spacecraft responses, then a standalone random vibration test is REQUIRED and an acoustic test is Advised. Vice-versa, if the outcome of this evaluation shows that acoustic test is sufficiently enveloping of random vibration levels for main spacecraft responses, then the Customer may pursue an acoustic test as an alternative.
3. Power inhibits must be verified at an integrated level as part of random vibrate or acoustic testing, see Section 6.7.7.
4. EMISM (6 dB by test, 12 dB by analysis) is already included in Table 4-9. See Section 6.7.7 for further guidance on electromagnetic compatibility verification.
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 6.8. Pressure Systems that do not meet material compatibility requirements specified in Section 5.5.5 must contact SpaceX for specific leak testing requirements.



6.5.4 TEST REQUIREMENTS FOR CAKE TOPPER PAYLOADS ABOVE 1,500 KG

Payload unit testing for Cake Topper Payloads above 1,500 kg must conform to Table 6-3.

Table 6-3: Payload Unit Test Levels and Durations – Cake Topper Payloads above 1,500 kg

Test	REQUIRED OR Advised	Unit/Fleet Qualification and Acceptance Approach		Flight Unit
		Qualification	Acceptance Must be performed on fully integrated Payload assembly	Protoflight Qualification Must be performed on the 1 st fully integrated Payload
		<i>Unit Not Flown</i>	<i>Unit Flown</i>	<i>Unit Flown</i>
Static Load ¹	REQUIRED	Level: Min 1.25 times the limit load in each of 3 axes	Level: Min 1.0 times the limit load in each of 3 axes	Level: Min 1.25 times the limit load in each of 3 axes
Sine Vibration	REQUIRED	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
Shock	Advised	Level: MPE + 3 dB Events: 2 times in each of 3 axes OR 2 actuations of device	Not Required	Level: MPE + 3 dB Actuations: 2 times in each of 3 axes OR 2 actuations of device
Acoustic	REQUIRED	Level: MPE + 3 dB Duration: 2 minutes	Level: MPE Duration: 1 minute	Level: MPE + 3 dB Duration: 1 minute
Random Vibration	ANALYSIS REQUIRED ²	Level: MPE + 3 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 power inhibits function as intended	Verification that power inhibits function as intended	Verification that power inhibits function as intended
Electromagnetic Compatibility ⁴	REQUIRED for Payloads Powered ON	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 and 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 Pressure 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 vibration (sweep)** or **static load** or a combination of these tests. Static load testing may be conducted on a separate qualification model, even if the main testing approach is protoflight qualification.
2. Customer to evaluate the random vibrate analysis environment by analysis, using the component-by-component analysis methodology described in Section 6.7.6.2.
3. Power inhibits must be verified at an integrated level as part of acoustic testing. See Section 6.7.7.
4. EMISM (6 dB by test, 12 dB by analysis) is already included in Table 4-9. See Section 6.7.7 for further guidance on electromagnetic compatibility verification.
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 6.8. Pressure Systems that do not meet material compatibility requirements specified in Section 5.5.5 must contact SpaceX for specific leak testing requirements.



6.6 ACOUSTIC VS RANDOM VIBE TEST DOWNSELECTION

Purpose: This section details the methodology for determining whether Cake Toppers in the 500 kg – 1,500 kg mass class are driven by the acoustic or random vibe environment (see Table 6-2); in other words, to determine whether an acoustic or random vibe test is sufficient to qualify and screen the Cake Topper's secondary interfaces and components for flight.

Verification: Customers must list the method selected, provide details on the methodology pursued, and provide the final results. Note the levels may be modified (increased) to envelope one or the other environment. In other words, Customers may notch up, but may not go below flight level, with test margin.

Method	Method A: Response Comparison by Test	Method B: Response Comparison by Analysis or Hybrid Analysis/Test	Method C: Test to Both Environments
Method overview	Compare component responses from an acoustic and low-level random vibe test	Compare component responses from acoustic and random vibe high-fidelity analysis or an acoustic test and random vibe high-fidelity analysis	Test to both random vibe and acoustic environments

Method A

- Select relevant interfaces and/or secondary components of interest; *for example*:
 - Net CG acceleration of an avionics box*
 - Force at mounting interface between Cake Topper structure and a deployable appendage*
 - Acceleration at the center of a large solar array panel*
- Exclude components with a cumulative acceleration/force response > 95% at 100 Hz (screened by sine vibration testing)
- Conduct a **base-driven vibration low level test** to determine transfer function from base input to selected component locations
- Compute predicted random vibe responses from flight random vibe environment at the locations established from Steps 1 and 2
- Conduct an acoustic test**; measure and/or correlate responses at same locations
- Calculate equivalent rms force/acceleration at each location, excluding contribution from 0-100 Hz band
- Compare equivalent rms force/acceleration at each location and determine overall which environment envelopes responses

Method B

- Select relevant interfaces and/or secondary components of interest, for example:
 - Net CG acceleration of an avionics box*
 - Force at mounting interface between Cake Topper structure and a deployable appendage*
 - Acceleration at the center of a large solar array panel*
- Exclude components with a cumulative acceleration/force response > 95% at 100 Hz (screened by sine vibration testing)
- Compute predicted random vibe responses from flight random vibe environments, using a **high-fidelity, correlated random vibe model**
- Conduct an acoustic test**; measure and/or correlate responses at same locations, OR use a **high-fidelity acoustics analysis** to predict the responses at same locations
- Calculate equivalent rms force/acceleration at each location, excluding contribution from 0-100 Hz band
- Compare equivalent rms force/acceleration at each location and determine overall which environment envelopes responses

Method C

- Both acoustic and random vibe tests are conducted.



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 above **15 Hz** in the **lateral directions** and **25 Hz** in the **axial direction (or over 40 Hz in all directions for Payloads < 500 kg)**. This includes any isolated equipment. Verification must be achieved through a low-level sine sweep before and after full level environmental testing to determine modal frequencies and assess any changes as a result of full level testing (Table 6-4).

Table 6-4: 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	<ul style="list-style-type: none"> Lateral modes above 15 Hz; Axial mode above 25 Hz (Payloads > 500 kg) All modes above 40 Hz (Payloads < 500 kg) < 5% shift in first mode frequency¹ < 30% shift in first mode amplitude of response¹

¹ These are general requirements. Customer to determine if more stringent criteria are required for particular payload.

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 Section 4.1.2 (flight environments) and Section 6.5 (test factors). Quasi-static load test requirements can be achieved through either a static load test, sine burst test, OR a sine sweep test. See Section 6.5 for which are permitted per Cake Topper mass class. The test levels should be derived from combined axial and lateral loading to meet the required interface forces/line loading.

Verification of quasi static loading using random vibration is not permitted. An individual test in three axes must be performed. See Table 6-5 for detailed guidance and acceptance criteria for each accepted method.

Table 6-5: Quasi Static Load Verification Test Requirements

Criteria	Sine Burst Test	Sine Sweep Test	Static Test
Test parameters	<ul style="list-style-type: none"> 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	Hold at maximum load for 30 s or sufficient time to collect data
Test configuration	Fully integrated payload	Fully integrated payload	Main structural load path present and identical to maximum extent possible to flight configuration
Mass difference between flight and test	Max 2%		N/A
CG difference between flight and test	Axial direction: Max 5% ¹ ; Lateral directions: Max 20% OR Max 10 mm		
Success criteria	Measured or calculated acceleration at CG achieves target acceleration		Measured loads achieve target loads

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 should aim in the test to replicate as close as possible



the CG position and mass of the flight article. If the CG or mass is outside the limit specified, Customers must account for CG and mass differences in test and adjust levels and/or use fluid simulants to represent propellant.

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 **REQUIRED** to the sine vibration test levels and durations defined in Table 6-1, Table 6-2, or Table 6-3 in accordance with the MPE defined in Section 4.1.3. Any notching must be pre-coordinated with SpaceX for approval at least 2 weeks in advance of testing.

IMPORTANT: Mission-specific sine vibration levels, including Output Transfer Matrices (OTMs) from Coupled Loads Analysis (CLA) are not available until L-2 months due to the Rideshare Program configuration timeline. Therefore, Cake Topper Payloads are expected to test, with appropriate test factors, to the enveloping values as described in this section. No secondary notching is allowed. Final CLA results will only validate test levels of all hardware and spacecraft on the mission and will not be available prior to SC testing.

6.7.4 SHOCK

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

Verification: Testing or Analysis is **ADVISED** to the shock test levels and durations defined in Table 6-1, Table 6-2, or Table 6-3 in accordance with the MPE defined in Section 4.1.5. Alternatively, Customers may show compliance via analysis of all shock-critical components to the shock levels defined in this section.

Verification by Analysis must show that all shock-sensitive components are qualified to a higher level than the MPE below. Attenuation propagated to the component's location on the spacecraft is accepted, and it is the Customer's responsibility to show the attenuation analysis.

Customers are ultimately responsible for verifying compliance to the MPE defined in Section 4.1.5. To ensure Mission safety for Co-Payloads, separation systems provided by the Customer must be approved by SpaceX (reference Section 6.1.1).

6.7.5 ACOUSTIC

Purpose: To ensure Payloads are compatible with acoustic environments inside the Launch Vehicle fairing. To ensure structural integrity of the Payload during ascent and to verify power inhibit systems. Exposure to the acoustic vibration environment ensures that secondary structures, Payload Constituents, large surfaces, and other components are exposed to flight loads plus margin

Verification:

Payloads > 1,500 kg: Testing is **REQUIRED** to the acoustic test levels and durations defined in Table 6-1 in accordance with the MPE defined in Section 4.1.4.

Payloads < 500 kg: Testing is **ADVISED** to the acoustic test levels and durations defined in Table 6-3 in accordance with the MPE defined in Section 4.1.4.

Payloads between 500 and 1,500 kg: Per Table 6-2, Customer to **determine** whether testing is **REQUIRED** or **Advised** per methodology outlined in Section 6.6. Testing will be in accordance with the MPE defined in Section 4.1.4.

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

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



If a Payload is designed to be Powered OFF during ascent, the test must additionally show that power to the Payload and any transmitting devices was successfully inhibited.

6.7.6 RANDOM VIBRATION

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

Verification:

Payloads < 500 kg: Testing is **REQUIRED** to the random vibration test levels and durations defined Table 6-1 in accordance with the MPE defined in Section 4.1.6.

Payloads > 1,500 kg: **Integrated testing is discouraged.** Component evaluation/analysis is **REQUIRED** per Section 6.7.6.2.

Payloads between 500 and 1,500 kg: Per Table 6-2, Customer to **determine** whether testing is **REQUIRED** or **Advised** per methodology outlined in Section 6.6. Testing will be in accordance with the MPE defined in Section 4.1.6.

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

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

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

- Minimum interface forces as derived from the Quasi-Static Levels defined in 4.1.2
- $C^2 \geq 5$
- Primary mode maximum notch depth less than 10 dB
- Notching to protect secondary structure or constituent responses is **not permitted** because that would result in an under-test as related to flight environments. A Mission-specific analysis will not be provided by SpaceX

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

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

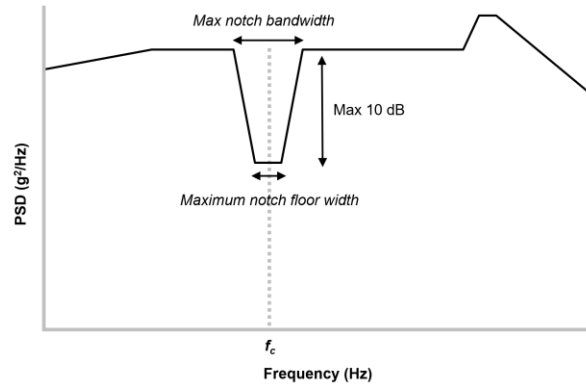


Figure 6-4: Manual Notch Limit Definitions (Primary Mode ONLY)

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

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

6.7.6.1 BAND SPLITTING

Applicability: Band splitting may be used as part of the integrated random vibration test on a case-by-case basis. This is only permitted if the test facility requires a reduction in interface loads to meet the vibration shaker table force limitations. Band splitting must follow the following rules:

- Maximum 3 bands
- Minimum 1/3 Octave overlap between bands
- No band splitting at or near a Payload primary mode
- The unit must be exposed to minimum workmanship levels (0.004 g²/Hz) in every test. Hence every test needs to have a frequency range of 20 – 2,000Hz, with one side of the band being reduced to minimum workmanship while the other is being tested to the full levels
- All tests must be performed with the same unit
- Qualification or protoqualification tests should target reaching the random vibration MPE grms as defined in Section 4.1.6

6.7.6.2 COMPONENT BY COMPONENT RANDOM VIBE EVALUATION

Applicability: Component-by-component evaluation of the random vibration environment is only required for Payloads that do not have an integrated random vibe test or are not qualified through an integrated acoustic test.

Method:

1. Identify components susceptible to random vibration and/or near the interface plane and their in-plane and out-of-plane qualification levels. Components that are effectively screened by integrated tests such as sine vibe or acoustics should not be included in this assessment. Use the SpaceX-supplied environmental test template to perform the assessment.
2. Compare each component's qualification level with the Random vibe qualification levels (MPE + 3dB), as constructed from the limit levels in Section 4.1.6, OR the Component's qualification level with the predicted component response from the input Random vibe qualification levels (MPE + 3dB). Identify deviations in the SpaceX-supplied environmental test template.



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 must be provided that shows no inadvertent power-ups and that isolated systems remain isolated during random vibrate. 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 **MUST** be fully integrated and in a flight-like state. Batteries must be in their flight-like charge state and any RBF/GSE inhibits must be removed. Verification testing must show that power to the deployable and secondary devices was successfully inhibited from a mechanical separation signal, and not because of other factors such as software delays. If a Payload is designed to be Powered OFF during ascent, the test must additionally show that power to the Payload and any transmitting devices was successfully inhibited.

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 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 must provide electromagnetic circuit and wiring emissions analysis. Payloads that require power during ascent must inform SpaceX prior to launch services agreement (LSA) finalization.

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.

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 should provide the following information:

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



- For each, or group of, reworked fasteners installed in a through hole, provide fastener diameter, grip length and protrusion measurement, a close-up photo of the reworked fastener(s), and accompanying schematic or photo showing general location of reworked fastener on the Payload

6.7.12 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.

Table 6-7: Non-Metallic Materials Classification

Criteria	Additional criteria	Rationale Code
RML < 1.0% and CVCM < 0.1%	None, complies to requirement	-
RML < 3.0% and CVCM < 0.1%	Exposed area < 2 in ²	A
RML > 3.0% or CVCM > 0.1%	Exposed area < 0.25 in ²	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 isolated equipment on a Payload.

Verification: Customers using isolated assemblies are **REQUIRED** to conduct additional testing. Sine burst and sine vibrate are the only two tests allowed for quasi-static load verification.

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 (if applicable).

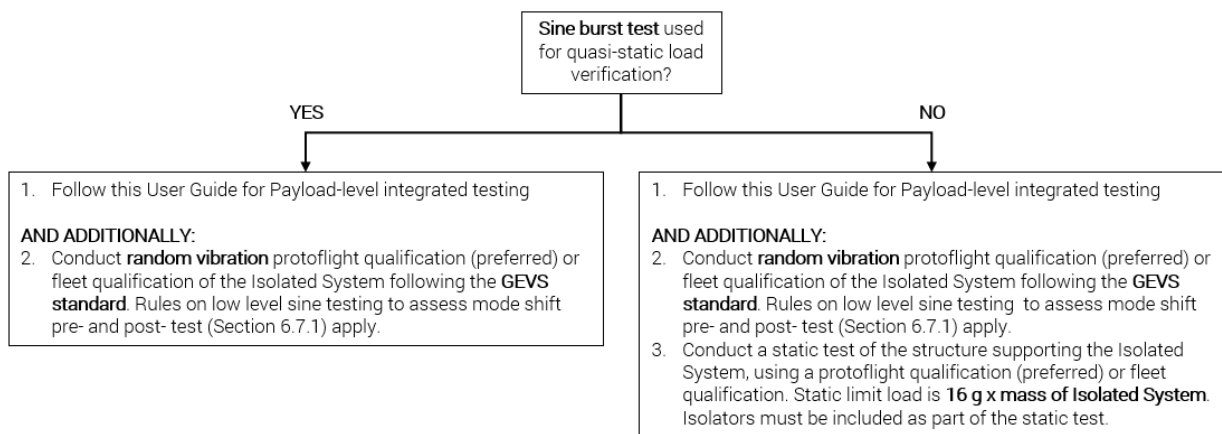


Figure 6-5: Isolated System Additional Testing



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 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. 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)
4. Document detailing combined system test-like-you-fly exceptions between test and flight including rationale

6.8.2 PRESSURE SYSTEM MATERIAL COMPATIBILITY

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

Verification: All Customers are **REQUIRED** to a comprehensive list of pressure system materials for a compatibility assessment and comply with requirements as detailed in Section 5.5.5. The list must include:

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

6.8.3 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 5.5.1 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 6-6).
- **Step 3.** Build the corresponding qualification and acceptance testing strategy from Table 6-8, Table 6-9, and Section 5.5.

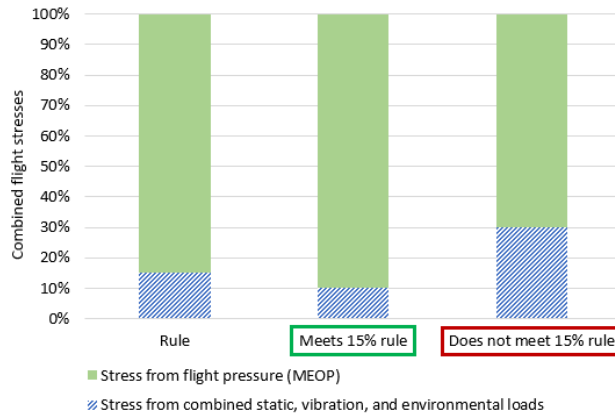


Figure 6-6: The 15% Rule, Explained

Table 6-8: Verification Requirements for Pressure Vessels

	US DOT Pressure vessels	Non-US DOT Pressure Vessels that Meet the 15% Rule	Non-US DOT Pressure Vessels that do not Meet the 15% Rule
Documentation	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> proof test vibration test pressure cycle test leak test per Table 6-9 burst test inspections 	
Acceptance	N/A	<ul style="list-style-type: none"> proof test leak test per Table 6-9 inspections 	

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



Table 6-9: Leak Test Requirements for Pressure Vessels

Pressure Vessel Leak Test Requirements	
Pressure	MEOP
Test fluid	<ul style="list-style-type: none"> 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
Method	<p>Fully submerge pressurized vessel in water</p> <p>Verification: Continuous video of full water surface and each fitting and connection individually (acceptable for video to show multiple areas within the minimum duration)</p>
Success criteria	No bubbles (Max 10^{-4} sccs leak rate)
Min Duration	1 hour

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 must 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.

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



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
Pressure	MEOP		
Test gas	<ul style="list-style-type: none"> 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 	<ul style="list-style-type: none"> If flight fluid is gaseous helium: 100% Helium If flight fluid is a gas that isn't gaseous helium or if flight fluid is a liquid: 100% Helium 	<ul style="list-style-type: none"> If flight fluid is gaseous helium: 100% Helium If flight fluid is a gas that isn't gaseous helium or if flight fluid is a liquid: 100% Helium
Method	<ol style="list-style-type: none"> Charge article with test gas at known concentration and at required pressure Coat all fittings and connections with Snoop Inspect for bubbles <p>Verification: Close-up video of each fitting and connection individually (acceptable for video to show multiple areas of the system within the minimum duration)</p>	<ol style="list-style-type: none"> Draw a hard vacuum around the payload (10^{-3} Torr or less) Charge article with 100% Helium at required pressure Maintain pressure for at least 30 min Collect readings. Readings should not vary by more than 10% of max range over 5 min (max variation 1×10^{-5} sccs) <p>Verification: Reading that meets success criteria</p>	<ol style="list-style-type: none"> Seal article from surrounding environment Charge article with 100% Helium at required pressure Do not zero/tare the detector (maintain tracer gas background reading) Collect measurements <p>Verification: Reading that meets success criteria</p>
Success criteria	No bubbles	Max leak rate 1×10^{-4} sccs of helium	Max leak rate 1×10^{-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



7 AVIONICS AND ELECTRICAL INTERFACES

7.1 ELECTRICAL INTERFACES

Falcon vehicles provide electrical connectivity between the Payload and Customer-provided Electrical Ground Support Equipment (EGSE) prior to launch, as well as in-flight separation device command and separation monitoring. Table 7-1 summarizes the standard electrical offering for Cake Topper Payloads.

Table 7-1: Electrical Interface Summary

Signal Type	937mm, 1194mm, or 1666 mm Clampband Offering	15" or 24" Circular Interface (Topper Plate) Offering	4-point Interface Offering
Ground-side Umbilical	Up to 2x 61-pin connectors See Appendix A	Up to 4x 15-pin connectors	Contact SpaceX
Separation Command	1x primary and redundant deploy signal	1x primary and redundant deploy signal	Up to 4x primary and redundant deploy signals

7.2 DEPLOYMENT PROPERTIES

For SpaceX-provided separation systems, one primary and one secondary command are used for each actuation. Please contact SpaceX for more details.

7.3 BREAKWIRE CHANNEL PROPERTIES

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

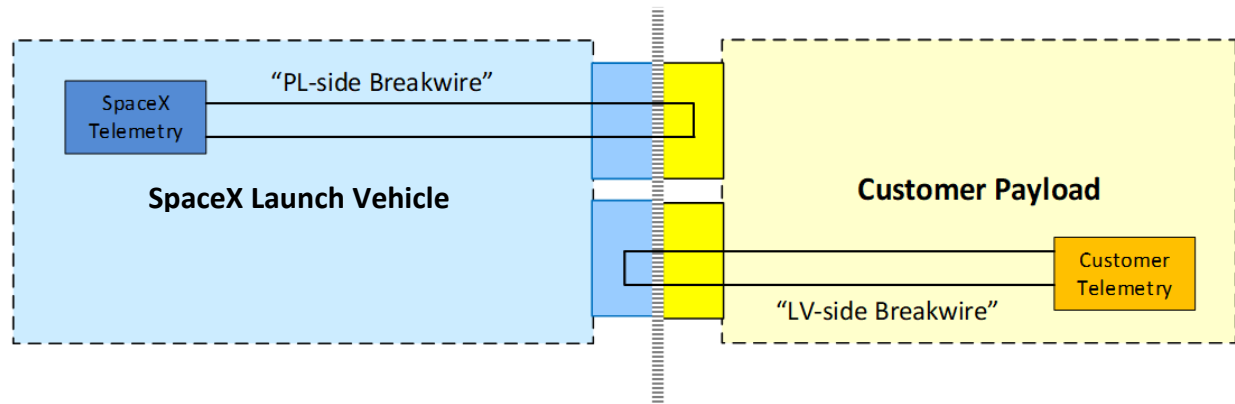


Figure 7-1: Illustration of Breakwire Channel Categories

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

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

Table 7-2: PL-Side Breakwire Resistance Requirements

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



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.

The Falcon vehicle provides up to 8 PL-side breakwire channels for the Cake Topper region. Additional breakwire channels can be accommodated as a nonstandard service; please contact SpaceX for details. Customer may request any number of LV-side breakwire loops at a separation connector.

7.4 ELECTRICAL UMBILICAL CONNECTORS

As a standard service, Falcon launch vehicles provide up to two in-flight disconnect electrical interface points located at the payload separation plane. See Appendix A for umbilical locations. MIL-C-81703 connectors are strongly recommended to encourage schedule compatibility. A list of example in-flight disconnect connectors is shown below in Table 7-3. Falcon is compatible with many connectors outside of this list. Please contact SpaceX if you have questions regarding use of a specific connector.

Table 7-3: Example In-Flight Disconnect Connectors

Part Number (Payload-side)	Part Number (LV-side)	Number of Electrical Contacts
DBAS-70-61-OSN	DBAS-79-61G-OPN	61
DBAS-70-61-OSY	DBAS-79-61G-OPY	61

All customer electrical interfaces, including EGSE interfaces, will be defined as part of the Payload-specific ICD.

7.5 FLIGHT HARNESS DESIGN

The build responsibility for the harnesses between the Standard Offering Interface and Payload will be specified as part of the Payload-specific ICD.

7.6 UMBILICAL CONNECTIVITY DURING PAYLOAD PROCESSING AND ON LAUNCH PAD

The Falcon systems accommodate electrical connectivity between Customer EGSE and the payload during most processing and integration activities. Table 7-4 summarizes the availability of interfaces during standard processing and integration activities. Customers may connect directly between their EGSE and their payload during payload processing operations. Electrical interfaces will not be available during SpaceX adapter mate, encapsulation, LV integration, and rollout operations. However, between these steps the Customer will be able to interface with the Payload. Customers may supply separate EGSE for the PPF and pad operations or may relocate EGSE from the PPF to the pad.

Table 7-4: Payload Electrical Interface Connectivity

Phase	Interface Connection
In PPF (payload processing)	Customer cables directly to payload
In PPF (adapter mate and encapsulation)	None – SpaceX is connecting the payload to the flight adapter harness; SpaceX will provide payload to PAF connection cables
In PPF (encapsulated)	Customer cables to PPF junction box adapter cable
Transport to hangar	None – mobile
In hangar (pre-integration)	Customer cables to hangar junction box
In hangar (LV integration)	None – SpaceX is connecting the flight adapter harness to the second-stage flight harness
In hangar (on transporter-erector)	Customer cables to hangar junction box (J-box) adapter cable
Rollout	None – mobile
On pad (horizontal and vertical)	Customer cables to pad junction box (J-box) adapter cable
Flight	None – separation indication only

Pad EGSE provided by the Customer will be housed in an instrument bay beneath the launch pad deck. Payload EGSE is connected to a SpaceX-provided junction box. If utilizing hangar and pad EGSE connections, Customers must provide 6.1 m (20 ft) cables to connect the payload EGSE to the junction box.



The junction box ("J-box") is connected to the LV transporter-erector via a ground harness. A harness then runs along the length of the transporter-erector and connects to the second-stage T+0 quick-disconnect. The flight side of the second-stage quick-disconnect mates to up to four dedicated payload electrical harnesses that are provided by SpaceX as part of the second stage. The payload harnesses are routed along the exterior of the second-stage propellant tanks, underneath raceway covers that provide protection during ground and flight operations. At the top of the second stage, the harnesses are routed through the Rideshare hardware stack region and to the spacecraft separation plane.

7.7 GROUND HARNESS DESIGN

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

The total cable lengths between the Payload EGSE and the spacecraft separation plane are listed in Table 7-5 and shown in Figure 7-2.

Table 7-5: Maximum Expected Cable Lengths between Payload Racks/EGSE and the Separation Plane

Launch Site	PPF	Hangar	Launch Pad
VSFB (SLC-4)	37 m (120 ft)	208.5 m (684 ft)	171.9 m (564 ft)
CCSFS (SLC-40)	24.5 m (80 ft)	197.8 m (649 ft)	171.9 m (564 ft)
KSC (LC-39A)	24.5 m (80 ft)	181.1 m (594 ft)	196.3 m (644 ft)

The minimum one-way resistance from EGSE to separation plane is 5 ohms. SpaceX ground systems maintain a minimum of 1MΩ of isolation resistance.

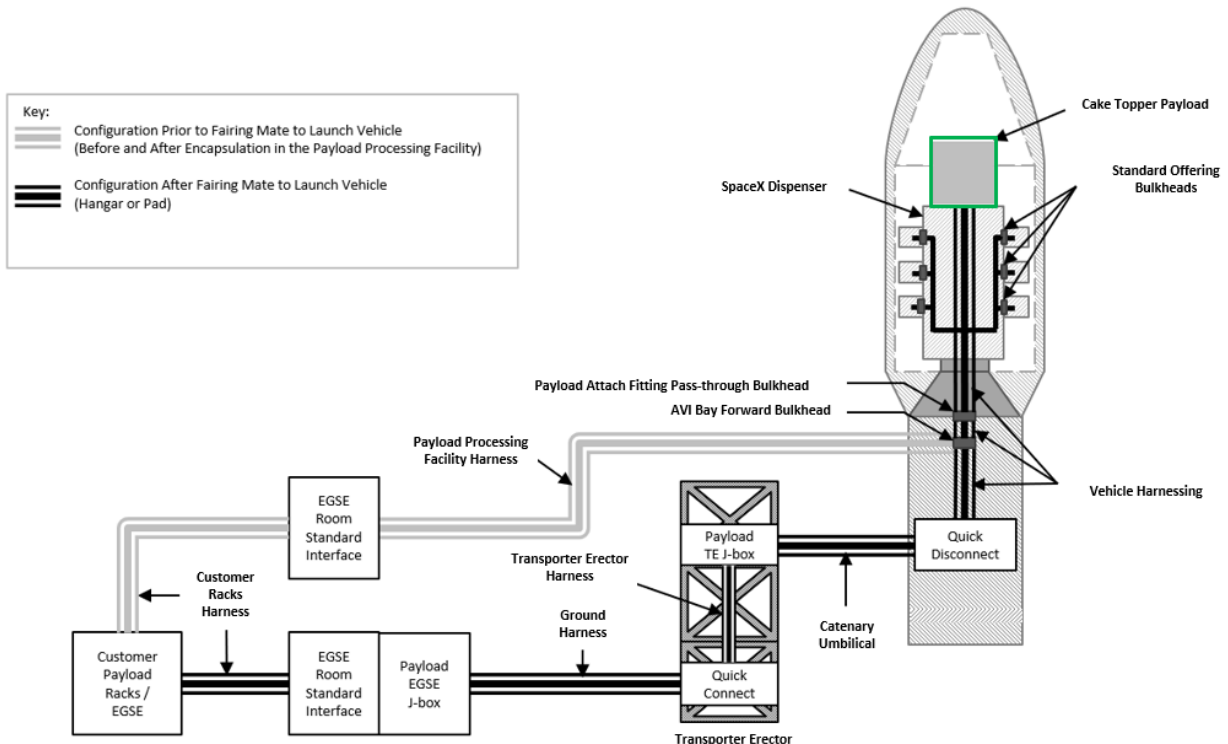


Figure 7-2: On-Pad Electrical Interfaces



7.7.1 FALCON-TO-PAYLOAD COMMAND INTERFACE

Separation device commands are used to initiate spacecraft separation from the second stage. Falcon LVs can provide up to four redundant separation device commands. Additional separation device command requests can be accommodated as a nonstandard service; please contact SpaceX for details.

Separation devices are typically procured by SpaceX for the Cake-Topper interface. For Customer-supplied separation devices, reference the Rideshare Payload User's Guide Section 7.2: Deployment Channel Properties.

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 and/or the launch pad. A launch countdown clock can also be supplied in the IRIG CS-5246 format. These timing services are provided as a standard service; other options are available as nonstandard services.

7.9 INTERFACE COMPATIBILITY VERIFICATION REQUIREMENTS

SpaceX requires that Customers verify the compatibility of their systems with the Falcon mechanical and electrical interfaces before shipment to the launch site. As a standard service, SpaceX will support a payload adapter mechanical fit check, including electrical connector location compatibility, at a facility of the Customer's choosing. Second-unit and later flights of similar systems may be subject to reduced pre-ship verification requirements. Nonstandard verification approaches can be developed on a mission-unique basis.



8 LAUNCH SITE FACILITIES

SpaceX operates Launch Sites at:

- Space Launch Complex 40 (SLC-40) at Cape Canaveral Space Force Station (CCSFS), Florida
- Launch Complex 39A (LC-39A) at John F. Kennedy Space Center (KSC), Florida
- 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 hardware, validate interfaces to Customer hardware, integrate the Payload with the LV, and perform a Launch of the Payload.

Customers should prepare to launch from both the Florida and California locations, as a Launch Site is not typically confirmed until approximately L-5 months and may be subject to change.

8.1 FACILITY ACCESS AND WORKING HOURS

SpaceX supports Customer personnel access to Launch Site facilities for two 8-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 hours per day, 7 days per week (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 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 hardware. SpaceX will provide prior notice and request approval for physical or visual access to areas with Payload or Customer hardware. At all times, SpaceX will follow Customer proprietary information and security requirements; however, visual access to Co-Payloads is expected after mating to LV hardware.

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:

- Operate at ISO 14644-1 Class 8 (Class 100,000) cleanliness
- Operate at 70 °F ± 5 °F air temperature (21 °C ± 3 °C)
- Operate at 45% ± 15% relative humidity
- Include 30-ton capacity crane with 59 ft (18 m) hook height
- Provide minimum floor dimensions of 30 ft x 20 ft (9 m x 6 m) for Payload processing activities

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



8.3.1 CLEANROOM

PPF Office spaces and EGSE rooms, and garment changing rooms are shared with Co-Payload Customers. Specific network/ethernet, power, and space requirements are detailed in the ICD. SpaceX provides a spacecraft processing area inside of the cleanroom of 9 m x 6 m. This area is sectioned off with standard-height welding screens in the PPF. Note that larger spacecraft may be visible above the screen height.

Customers are required to stay within their zones or the shared spaces of the PPF; however, physical locks in these areas are not standard. Customers may provide security teams but must coordinate and obtain approval by SpaceX and cannot interfere with other Customer or SpaceX operations.

An Uninterrupted Power Supply (UPS) is available as an electrical power backup in all cleanrooms, as a standard facility service.

Hazardous operations must declare a clear-zone in the Range Safety documentation, and Customers must coordinate these operations with SpaceX mission management.

8.3.2 STORAGE

Unconditioned (outdoor) equipment storage is available outside the PPF.

Conditioned storage within the PPF is limited and must be coordinated by the Launch Campaign Readiness Review at L-2 months.

Propellant conditioned storage inside of the PPF or PPF airlock is available starting up to 5 days before fueling activities, through completion of fueling activities. Hazardous fueling zones are defined in the facility user guides.

Equipment must be picked up within the time frame described in the Statement of Work. Equipment left behind after this time without coordinated plans for pickup may be placed outside in uncovered/unconditioned storage and may be subject to removal at the sole discretion of SpaceX.

8.3.3 EQUIPMENT

PPF facility cranes, forklifts, and boom lifts are shared with Co-Payload Customers. Cake Topper Customers will get initial schedule priority, as declared in the hourly processing schedule; however, if delays occur, Co-Payload Customers on schedule will receive subsequent priority, and mission management will deconflict any further scheduling overlaps.

The Customer is responsible for providing all personal protective equipment, such as hard hats, goggles, gloves, fall protection harnesses, and grounding straps, for Customer personnel and Customer's Related Third Parties at the Launch Site, with the exception of the SCAPE materials identified in Section 8.4.1.

8.4 HAZARDOUS PROCESSING FACILITY AND ASSOCIATED SUPPORT

SpaceX provides unconditioned storage of Payload propellants at the Launch Site from arrival of Payload propellant (up to 30 days ahead of the start of Launch Campaign) through the start of Payload fueling, which may be at a non-SpaceX location. The unconditioned storage temperature is not regulated, and propellants may be stored outside with partial sun exposure. Customers must arrange for pickup of unused propellants no later than 90 days after the Launch.

SpaceX provides for temporary conditioned storage of Payload propellants beginning several days prior to the start of Payload fueling through completion of fueling activities, as allowable by Range Safety and SpaceX safety regulations. When in use, the conditioned storage temperature is maintained within $\pm 5^{\circ}\text{F}$ ($\pm 3^{\circ}\text{C}$) of the average Payload fueling area temperature.

SpaceX transports the Payload propellants from unconditioned storage to a conditioned storage area prior to Payload fueling operations.



SpaceX provides access to a hazardous processing facility (HPF) for Payload fueling operations. The HPF is a sub-section of the PPF:

- Provides minimum floor dimensions of 30 ft x 20 ft
- Operates at ISO 14644-1 Class 8 (Class 100,000) cleanliness
- Operates at 70°F ± 5°F air temperature (21°C ± 3°C)
- Operates at 45% ± 15% relative humidity
- Includes an exterior vent to accommodate propellant vapor in accordance with safety and environmental regulations
- Includes a drain system to accommodate waste propellant and water in accordance with safety and environmental regulations

8.4.1 SELF-CONTAINED ATMOPHERIC PROTECTIVE ENSEMBLE (SCAPE) OPERATIONS

Standard facility consumables are noted in the facility user guides. For hazardous fueling operations, SpaceX provides up to 600 gallons (2273 liters) of decontamination water, and up to 3 days (with two 4-hour shifts per day) of radio-equipped SCAPE suits and breathing air upon request. Customers must comply with NASA requirements for SCAPE training, and this training for personnel is coordinated by SpaceX.

Customer must arrange for and implement the disposal of hazardous waste generated during Payload processing activities, including during propellant loading and related activities, in accordance with Range Safety and facility regulations, with the exception of the decontamination water mentioned above.

8.5 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.

8.5.1 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.

8.5.2 CUSTOMER CONTROL ROOM

SpaceX provides a control room at the Launch Site for use by Customer and Customer's Related Third-Party personnel, determined on an as-needed basis. The control room may be shared between Payload Customer and other Co-Payload Customers. The control room includes the mission-specific electrical interfaces as defined in the ICD, for Customer-provided EGSE for Payload monitoring and control activities on the day of Launch. Customer EGSE is limited in size to 1 m x 0.5 m x 1.5 m, unless otherwise mutually agreed and documented in the ICD. SpaceX provides 2 Payload-specific voice nets and 1 console for the Customer to view a limited subset of Launch Vehicle parameters during rehearsal and launch operations, consistent with US export control laws.

8.6 SECURITY

SpaceX provides security via a combination of locked facilities (security card access or cipher locks), closed-circuit video monitoring, and/or personnel presence 24 hours/day at the relevant Launch Site facilities when Customer flight hardware is present. During any hazardous operations for which the Range Safety authority requires non-essential personnel to evacuate, video monitoring will be the sole method of surveillance available. Customers will not be granted access to SpaceX's video footage due to proprietary and restrictions under US export control laws.



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 must comply with US export and import control laws, including clearance from US Customs and Border Protection, with respect to the Payload and any Customer provided hardware, including GSE and propellant (if any).

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

9.3 MISSION MANAGEMENT

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

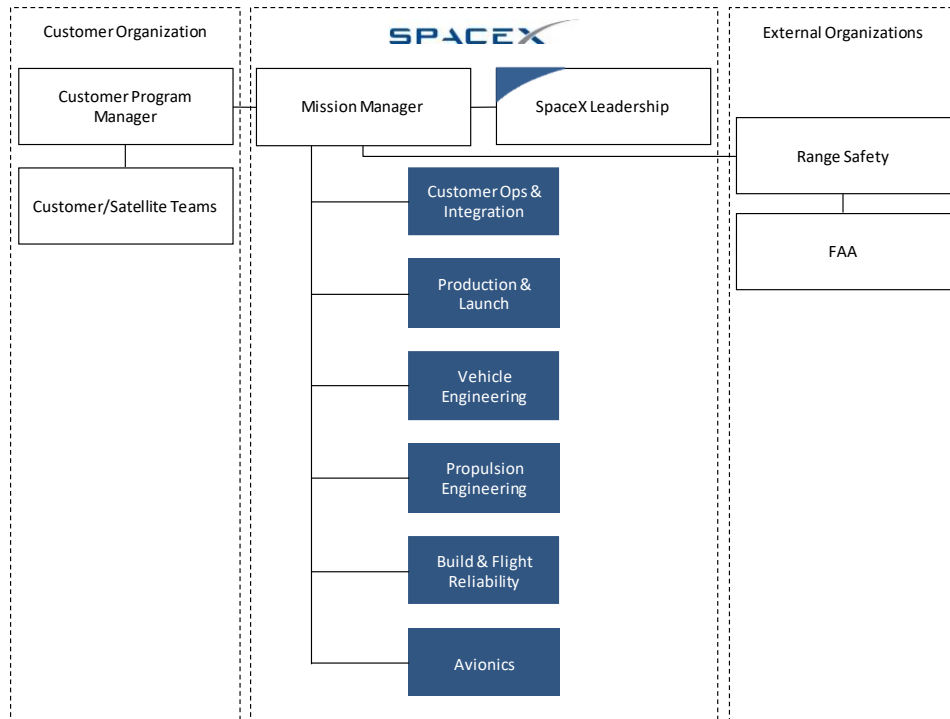


Figure 9-1: Mission Management Organization

9.4 PROGRAM DOCUMENTATION

9.4.1 INTERFACE CONTROL DOCUMENT (ICD)

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

9.4.2 LAUNCH CAMPAIGN PLAN

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

9.4.3 PROGRAM STATUS, MEETINGS, WORKING GROUPS AND REVIEWS

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

9.4.3.1 INTEGRATION WORKING GROUPS

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



9.4.3.2 PROGRAM REVIEWS AND MILESTONES

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

9.5 CUSTOMER RESPONSIBILITIES

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

9.5.1 TRANSPORTATION AND STORAGE

- If Customer ships by aircraft, SpaceX shall provide physical transportation of the SC (in its shipping container) and associated GSE from the launch site airport to the PPF and shall return the empty SC container and associated GSE to the airport after offloading the SC at the PPF.
- If Customer ships by ground, Customer is responsible for delivering the Payload and associated GSE to the PPF or other Launch Site facility designated by SpaceX. Customer remains responsible for environmental control of the Payload during Payload delivery, until the Payload is removed from its shipping container, including generators and fuel to maintain environmental control.
- Customer delivers the Payload and GSE to the Launch Site no more than six weeks prior to the Launch Date unless requested by SpaceX. Timing of delivery will be coordinated by SpaceX based on Payload and Co-Payload(s) processing schedule.
- Customer arranges and executes the shipment of the Payload shipping container and all Customer-furnished GSE from the Launch Site no later than 3 days after Launch.
- Customers are permitted to store no more than one standard shipping container or truck trailer at the Launch site for the duration of their integration activities.
- Customer is responsible for all shipping and logistics of hazardous items from the port of entry to the Launch Site, including the required labeling for storage at the Launch Site.
- Customer is responsible for obtaining any required permits, Licenses, or clearances, including from US Customs and Border Protection for Customer's and Customer's Related Third Parties' hardware and consumables.

9.5.2 HARDWARE, PROCESSING AND INTEGRATION

- Customer provides the Payload and all Payload-unique GSE required for Customer's Launch readiness activities at the Launch Site, interfacing to SpaceX hardware at the Launch Site (as defined in the Payload-specific ICD), and ensures that all Payload and Payload-unique GSE meet the appropriate safety requirements (reference Section 11.1).
- Customer will coordinate activities with SpaceX to create an integrated schedule and procedures where necessary.
- Beginning upon Payload arrival at the Launch Site and throughout the Launch Campaign, Customer provides to SpaceX once per working day, an updated Payload processing schedule. The schedule should include a 3-day look-ahead summarizing all items requiring SpaceX support, such as: opening processing area doors, SpaceX GSE usage (cranes, forklifts, man lifts, etc.), and any other items requiring SpaceX support. Note also, Payload hazardous operations require 72 hours' advance notice, with precise activity timing, from SpaceX to the Launch Range safety authorities.
- Upon request, Customer will provide SpaceX with access to the flight-mating interface for a mating interface to SpaceX-provided Mechanical Interface fit check after Payload arrival at the Launch Site but before flight mating.



- Customer is responsible for providing all personal protective equipment, such as fall protection harnesses, for Customer and Customer's Related Third Parties at the Launch Site. Customer and Customer's Related Third Parties may not borrow personal protective equipment from SpaceX personnel.
- Customer is responsible for cleaning all Customer-provided equipment and hardware to the appropriate SpaceX-designated contamination-control levels prior to entering SpaceX's cleanliness-controlled facilities at the Launch Site (e.g., the PPF). Standard cleaning products (e.g., isopropyl alcohol and cleanroom wipes) are provided by SpaceX; however, SpaceX personnel will not clean Customer hardware.
- Open air Payload RF checkouts during integration are **prohibited** for safety reasons. RF transmissions are prohibited throughout mating to Launch Vehicle hardware and are only allowed until after Payload separation as defined Section 4.1.7.3.
- The Payload will have access to the electrical harnesses referenced in Section 7 for Payload health checks and battery charging up until Launch Vehicle rollout from the integration hangar to the Launch pad. Additional access to Payload telemetry and battery charging can be procured as an optional service (see Appendix I).

9.5.3 HAZARDOUS PROCEDURES

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

- Customer will provide any pressurant and other consumables required by the Payload, including transportation of such consumables to and from the Launch Site. Delivery of all Payload consumables must be coordinated in advance with SpaceX.
- Customer will provide advance copies of all hazardous operation procedures, in addition to a Payload 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 will also provide copies of any non-hazardous procedures requested by the Launch Range safety authority.
- Customer will arrange for and implement the disposal of hazardous waste generated during Payload processing activities in accordance with Launch Range and facility regulations.
- Customer will provide the necessary decontamination equipment and perform all required decontamination activities for Payload GSE that is contaminated by hazardous substances during Payload processing activities in accordance with Launch Range and facility regulations.
- Fueling of cryogenic propellants or other consumables post encapsulation is not allowed.

9.5.4 ENTRY AND EXIT VISAS

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

9.5.5 ANOMALY, MISHAP, ACCIDENT OR OTHER EVENT

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



9.5.6 PAYLOAD LICENSING AND REGISTRATION

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

9.5.7 COORDINATION WITH SPACE SITUATIONAL AWARENESS AGENCIES

Pre-Launch Payload Registration

Customer is responsible for registering all deployed objects with the 18th SPCS 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 SPCS (18SPCS.doo.customerservice@us.af.mil).

Additionally, if any of the payload's operational, transfer, or disposal orbits cross the 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.

Post-Launch Ephemeris Uploads

Customer is responsible for publishing forward predicted 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

An important benchmark is uploading ephemerides within Launch + 3 hours when the Launch COLA analysis expires. SpaceX additionally submits post-launch ephemeris for each deployment event based on Stage 2's state and estimated deployment impulse, but customer-provided orbit determination from satellite telemetry (e.g., from GPS) is more accurate.

If Customer is unable to generate propagated ephemeris and covariance, SpaceX strongly recommends they work with a commercial provider to contract for this work (SpaceX can provide recommendations). Publishing predictions drastically improves and accelerates the cataloging process by USSPACECOM, as well as enhancing collision avoidance screening.

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

9.6.2 TRANSPORTATION SERVICES

- SpaceX will provide transportation of the Payload and associated GSE between facilities at the Launch Site. This includes transportation of the Payload from the PPF to the Launch Complex and transportation of hazardous fluids and gasses between facilities at the Launch Site.



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

9.6.3 PAYLOAD INTEGRATION AND ASSOCIATED HARDWARE

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

9.6.4 PHOTOGRAPHIC SERVICES

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

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

9.6.5 SECURITY

SpaceX provides security via a combination of locked facilities (security card access or cipher locks), closed-circuit video monitoring and/or personnel present 24 hours/day at the relevant Launch Site facilities when Customer flight hardware is present. During any hazardous operations for which the Launch Range safety authority requires non-essential personnel to evacuate, video monitoring will be the sole method of surveillance available. Customer will not be granted access to SpaceX's video footage.

9.6.6 LAUNCH CAMPAIGN

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

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

9.6.7 FACILITY SUPPORT AND OPERATIONS

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



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

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

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

9.6.8 LICENSING AND REGISTRATION

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

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

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

9.6.9 MISSION INTEGRATION ANALYSES

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

9.6.9.1 TRAJECTORY

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

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

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



9.6.9.2 COLLISION AVOIDANCE

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

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

9.6.9.3 COUPLED LOADS

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

9.6.9.4 PAYLOAD SEPARATION

SpaceX may perform a separation analysis for MicroSat-class Payload Constituents deploying from the Launch Vehicle to verify the Customer provided analysis as described in Section 3.3. CubeSat deployments from Containerized dispensers are not specifically analyzed; SpaceX instead relies on the separation properties provided by the Customer. These results are used as an input for the collision avoidance analysis. Since Payload mass properties and slosh are outside of SpaceX's control, SpaceX will evaluate requirements compliance via the ideal analysis case. If required, SpaceX will provide a presentation summarizing the results of the analysis and highlighting any issues or concerns for the Payload.

9.6.9.5 PAYLOAD CLEARANCE

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

9.6.10 WEBCAST LOGO

Cake Topper Payloads may submit a logo and brief summary (typically around one-half of a page, summarized in bullet points) of the spacecraft mission for the SpaceX Launch webcast. A short video from the Customer is also acceptable, subject to SpaceX approval; please contact SpaceX for video requirements.



10 OPERATIONS

Launch Vehicle operations are described in this section for launches from CCSFS, KSC, and VSF. 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 pre-Launch concept of operations.

10.1 OVERVIEW AND SCHEDULE

The Launch Vehicle system and associated operations have been designed for minimal complexity and minimal time at the pad. Customer Payload processing is performed in the PPF. After completion of standalone Payload operations (over a 15-day period), SpaceX performs the Payload mate to Launch Vehicle hardware followed by fairing encapsulation at the PPF. Payload and Co-Payload arrivals will be scheduled by SpaceX and may be staggered. The encapsulated assembly is then transported to the integration hangar. The Launch Vehicle is processed in the integration hangar at the Launch Complex and then loaded on the TE. The encapsulated assembly is mated to the Launch Vehicle at approximately L-5 days, followed by end-to-end system checkouts. Launch Vehicle systems are designed for rollout and Launch on the same day.

10.2 CAKE TOPPER PAYLOAD DELIVERY AND TRANSPORTATION

If the Customer ships via aircraft transport, the Customer delivers the Payload and GSE to the Launch Site airport designated by SpaceX, and SpaceX will transport the container from the launch site airport to the PPF. If Customer ships via road or sea transport, the Customer delivers the Payload and associated GSE to the PPF or other Launch Site facility designated by SpaceX. The Customer is 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.

The Customer may also choose to ship the payload and GSE by ground directly to the PPF, or to the Launch Site airport designated by SpaceX, where SpaceX will then transport the Payload and GSE to the PPF. The Customer is responsible for all transportation to/from the Launch Site when shipping by sea or arriving at an airport not located at the Launch Site. Transport within SpaceX facilities, including safety and security coordination with the Launch Range, is arranged by SpaceX. The Customer must arrange and execute the shipment of the Payload shipping container and all Customer-furnished GSE from the Launch Site no later than 3 days after Launch.

The Customer can deliver propellants to the Launch Site no more than 30 days before Launch and must remove any unused propellant from the Launch Site no more than 90 days after Launch.

10.2.1 CUSTOMS, VISAS, AND LICENSING

The Customer is responsible for obtaining any required permits, Licenses, or clearances for hardware import or export, as well as visas for non-US personnel, including Customer's Related Third Parties and guests. SpaceX can provide letters of invitation for Customer Launch Campaign personnel to support the issuance of US entry visas by the US Department of State.

The Customer is responsible for obtaining customs clearance of Customer's hardware and consumables, including the Payload.

10.3 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 8-hour working shifts per day. Layouts as well as standard services and equipment available in the PPF for VSF 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).

IMPORTANT NOTE: All Cake Topper remove before flight (RBF) items must be removed before the final stacking operation to the top of the rideshare stack.

10.3.1 PHOTOGRAPHY

Upon Customer request, SpaceX can provide still photography services during selected Payload processing, testing, and integration operations. This service does not include delivery or broadcast of photography in real-time or near-real-time. The Customer may use still photography that does not include video or sound. No phones or tablets are permitted in the cleanroom, and laptop cameras and microphones must be covered/off. Live meetings, including audio streaming, are not permitted in the cleanroom. All photos are subject to SpaceX review prior to leaving the facility and may not include other Customer or SpaceX hardware or personnel.

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

10.4 JOINT OPERATIONS AND INTEGRATION

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

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

10.5 LAUNCH OPERATIONS

10.5.1 ORGANIZATION

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

10.5.2 LAUNCH CONTROL

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

10.5.3 ROLLOUT AND PAD OPERATIONS

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



10.5.4 COUNTDOWN

The Launch Vehicle is designed to support a countdown duration as short as 1 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 pre-Launch 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.



11 SAFETY

11.1 SAFETY REQUIREMENTS

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

11.2 HAZARDOUS SYSTEMS AND OPERATIONS

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

11.3 WAIVERS

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



APPENDIX A: MECHANICAL INTERFACES AND VOLUMES

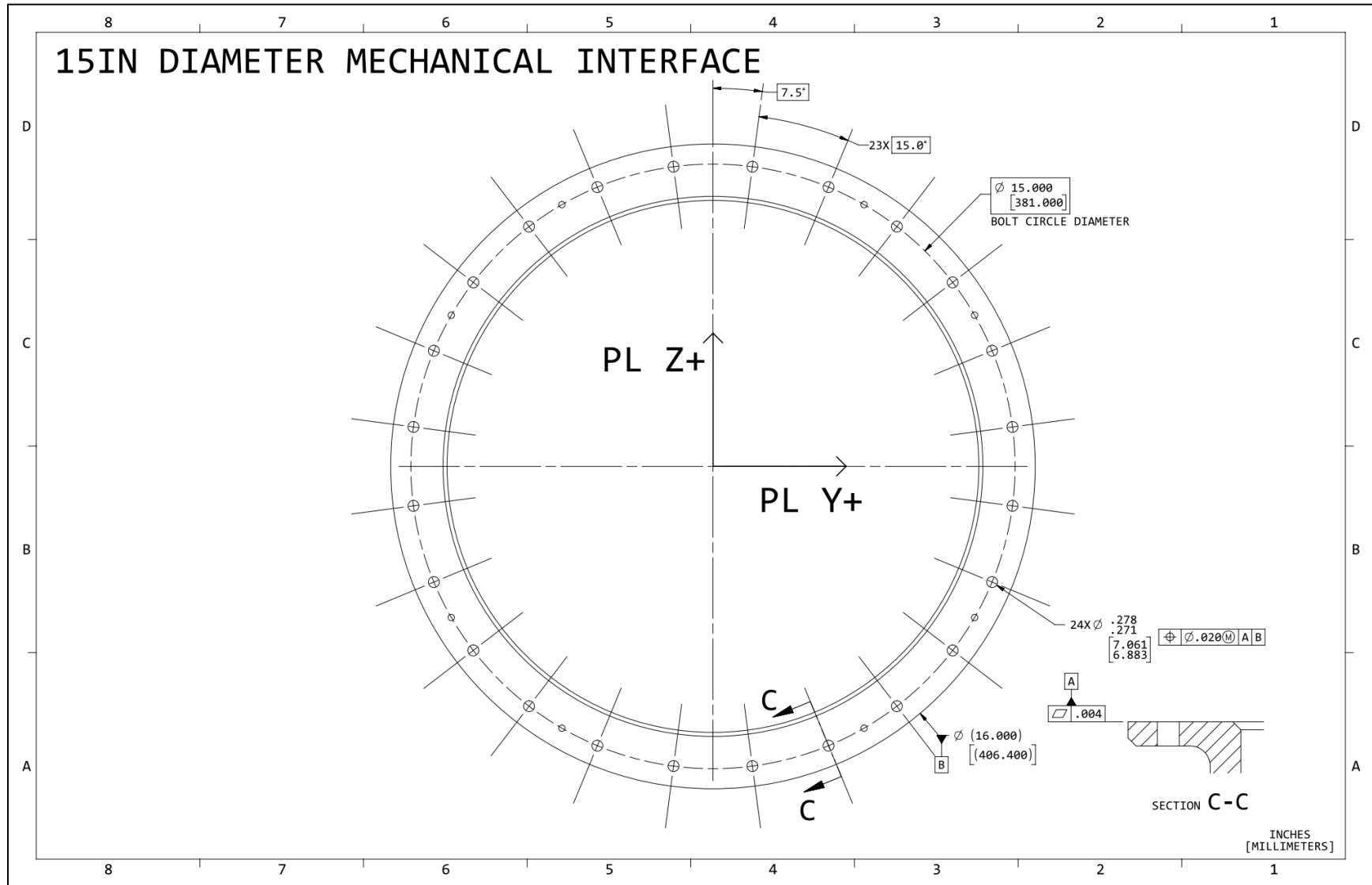


Figure A-1: 15" Diameter Mechanical Interface

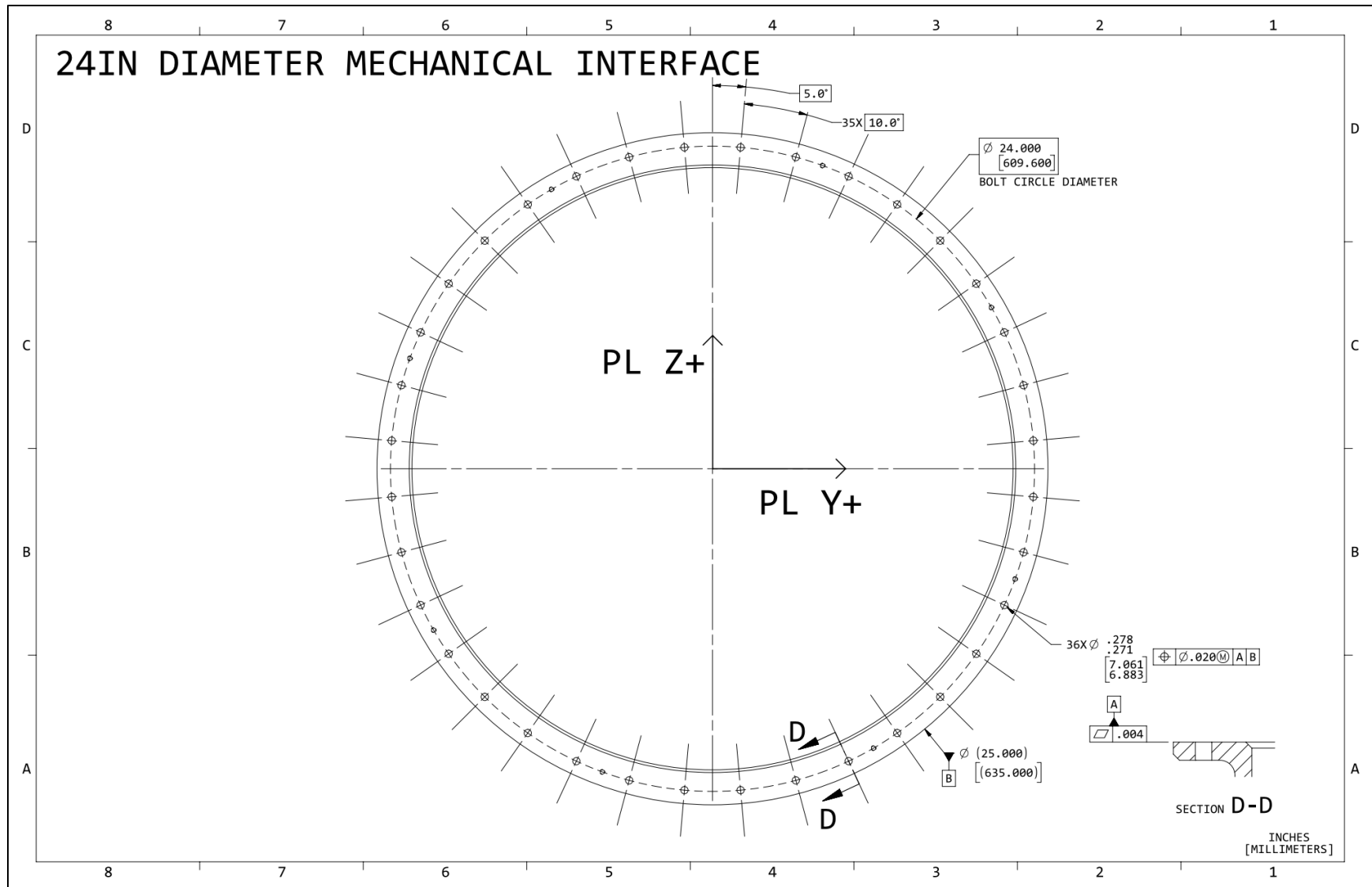


Figure A-2: 24" Diameter Mechanical Interface

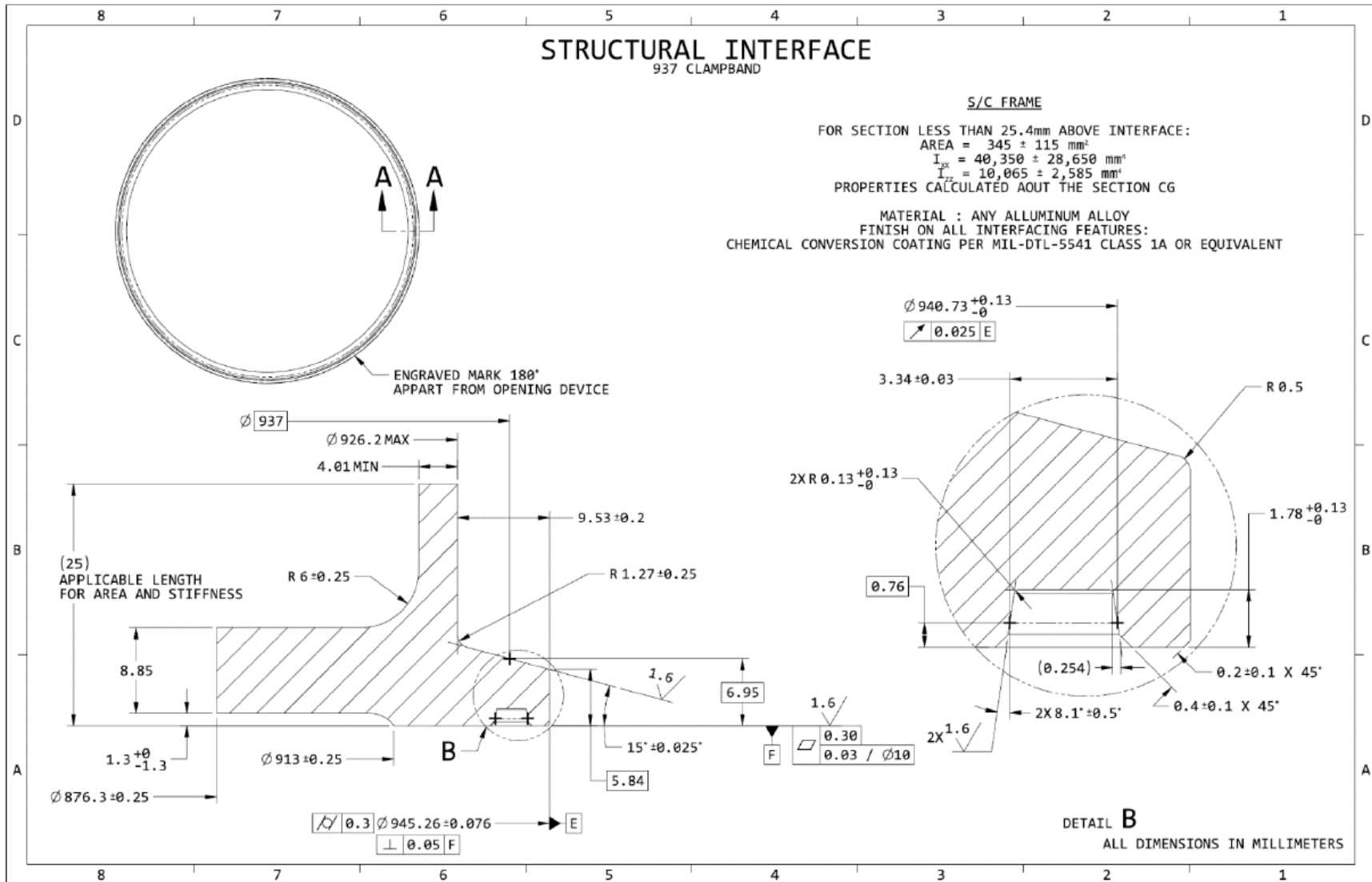


Figure A-3: 937 mm Clampband Interface

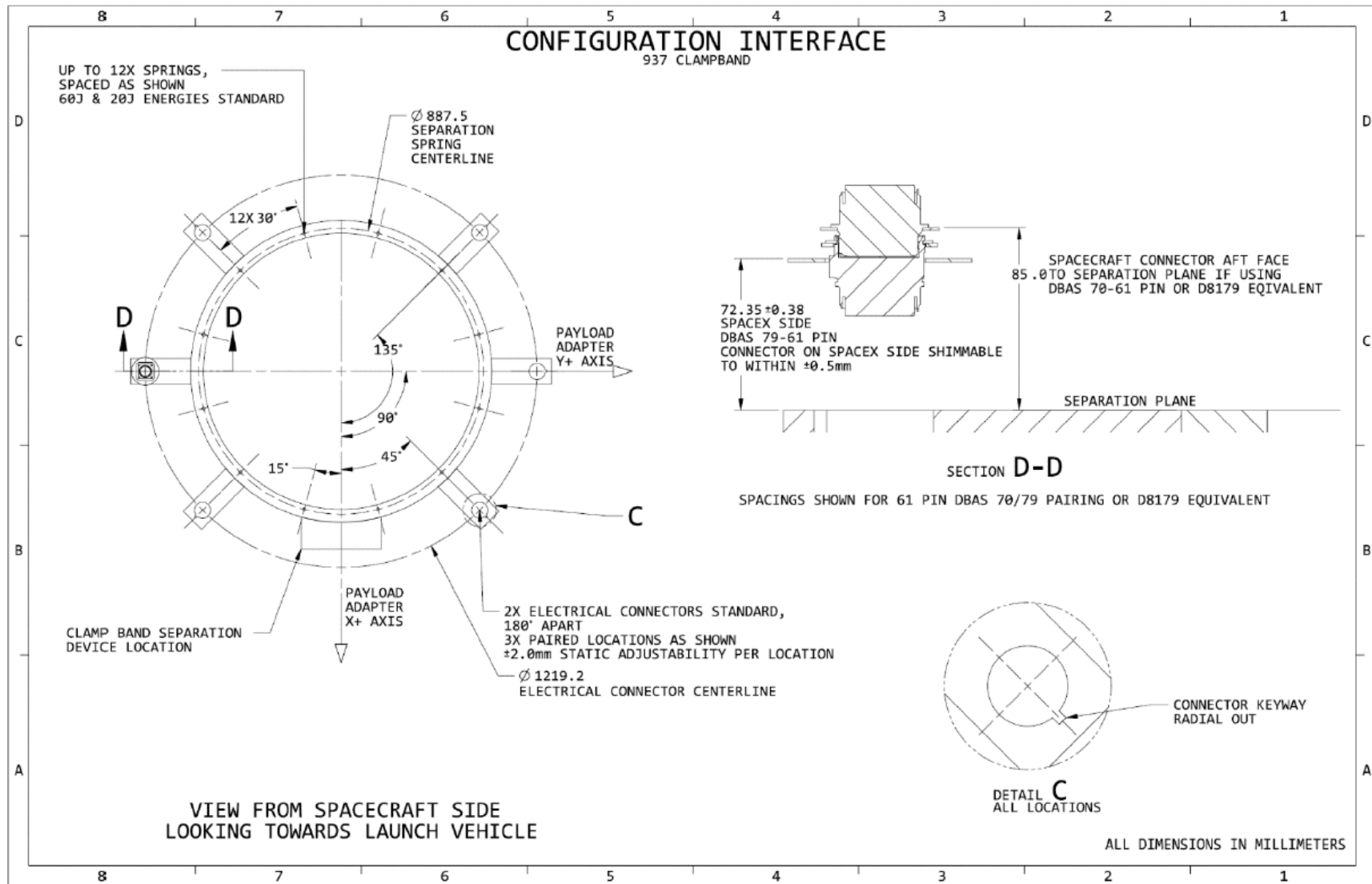


Figure A-4: 937 mm Clampband Configuration

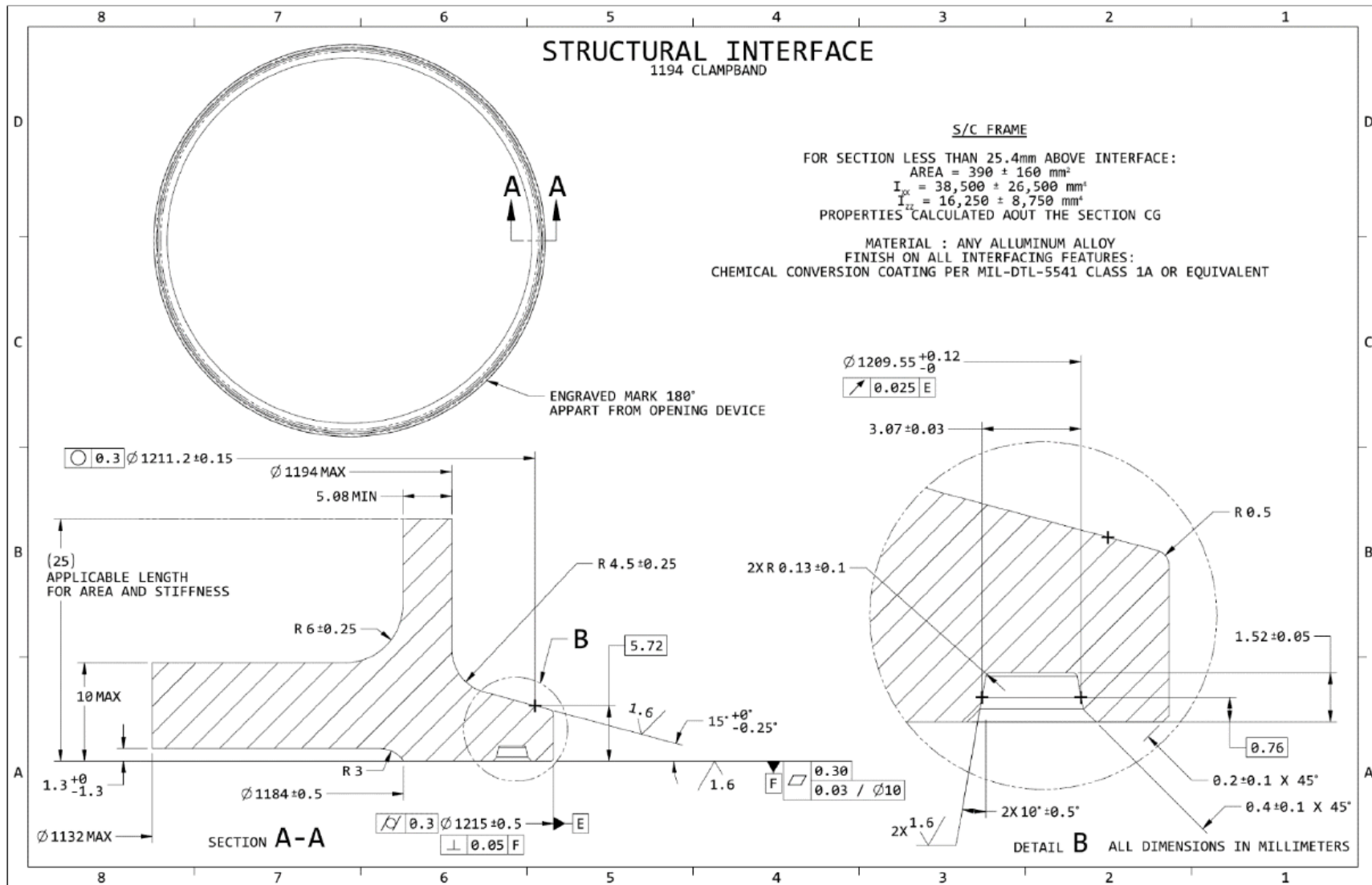


Figure A-5: 1194 mm Clampband Interface

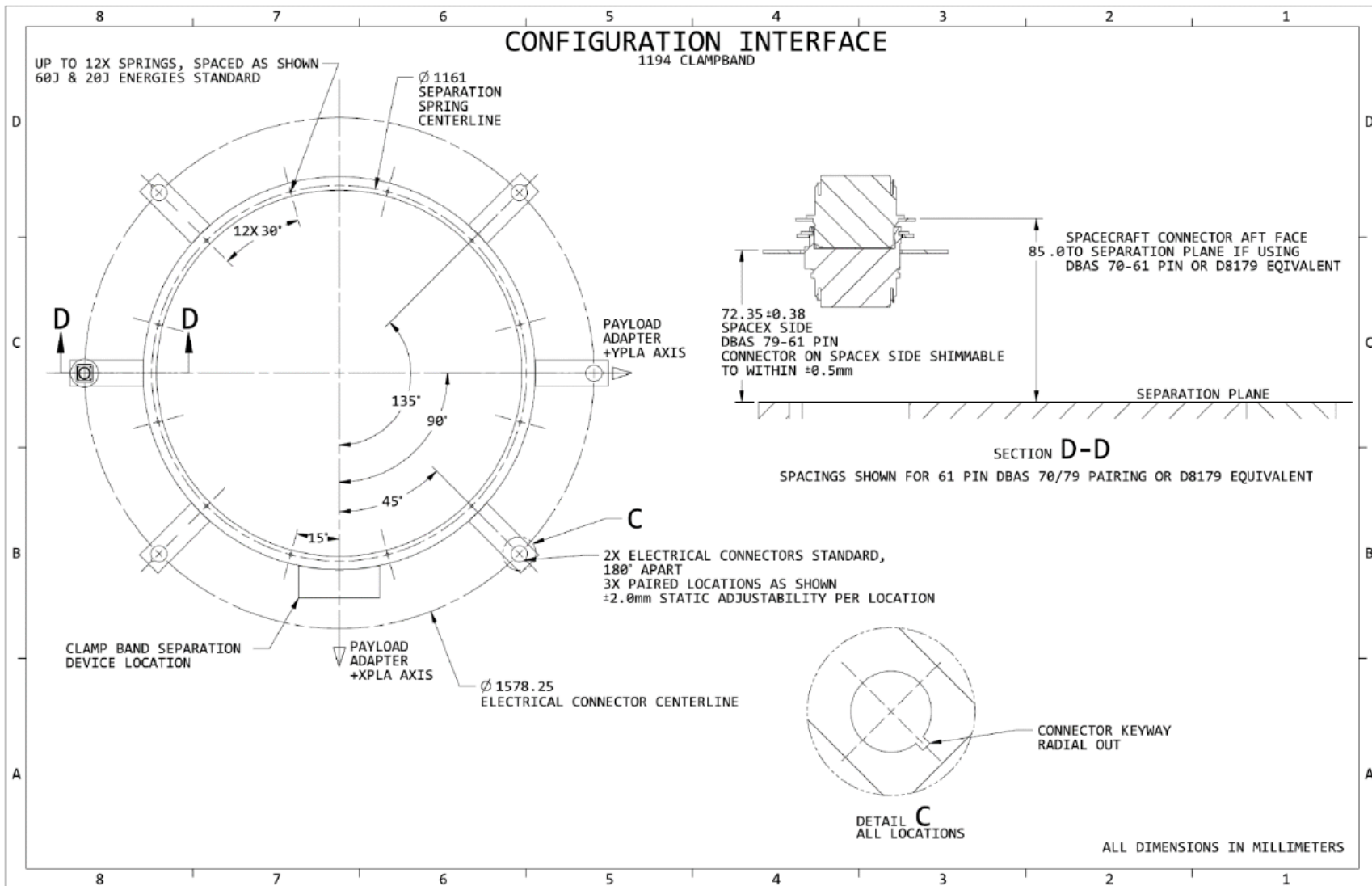


Figure A-6: 1194 mm Clampband Configuration

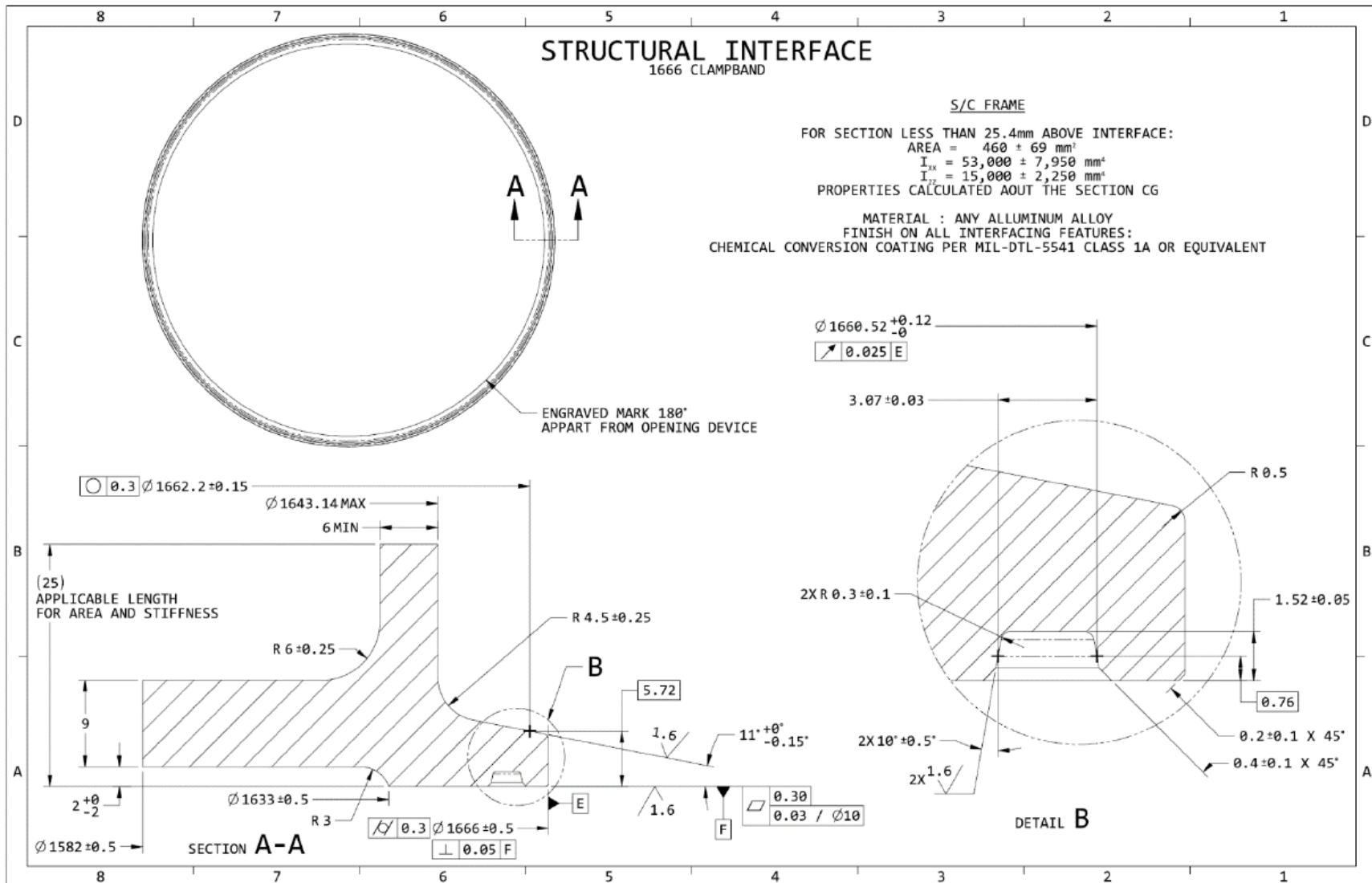


Figure A-7: 1666 mm Clampband Interface

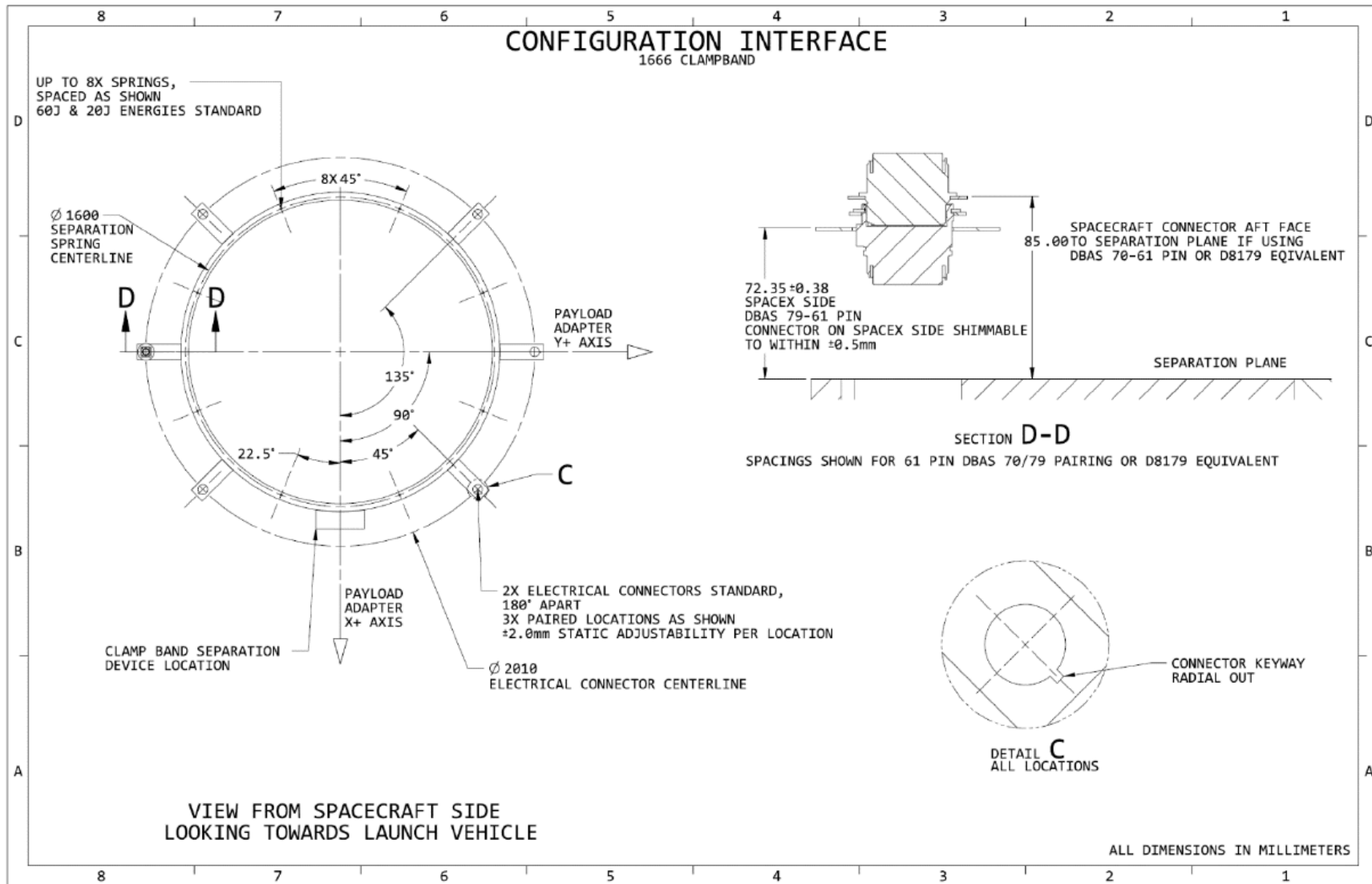


Figure A-8: 1666 mm Clampband Configuration

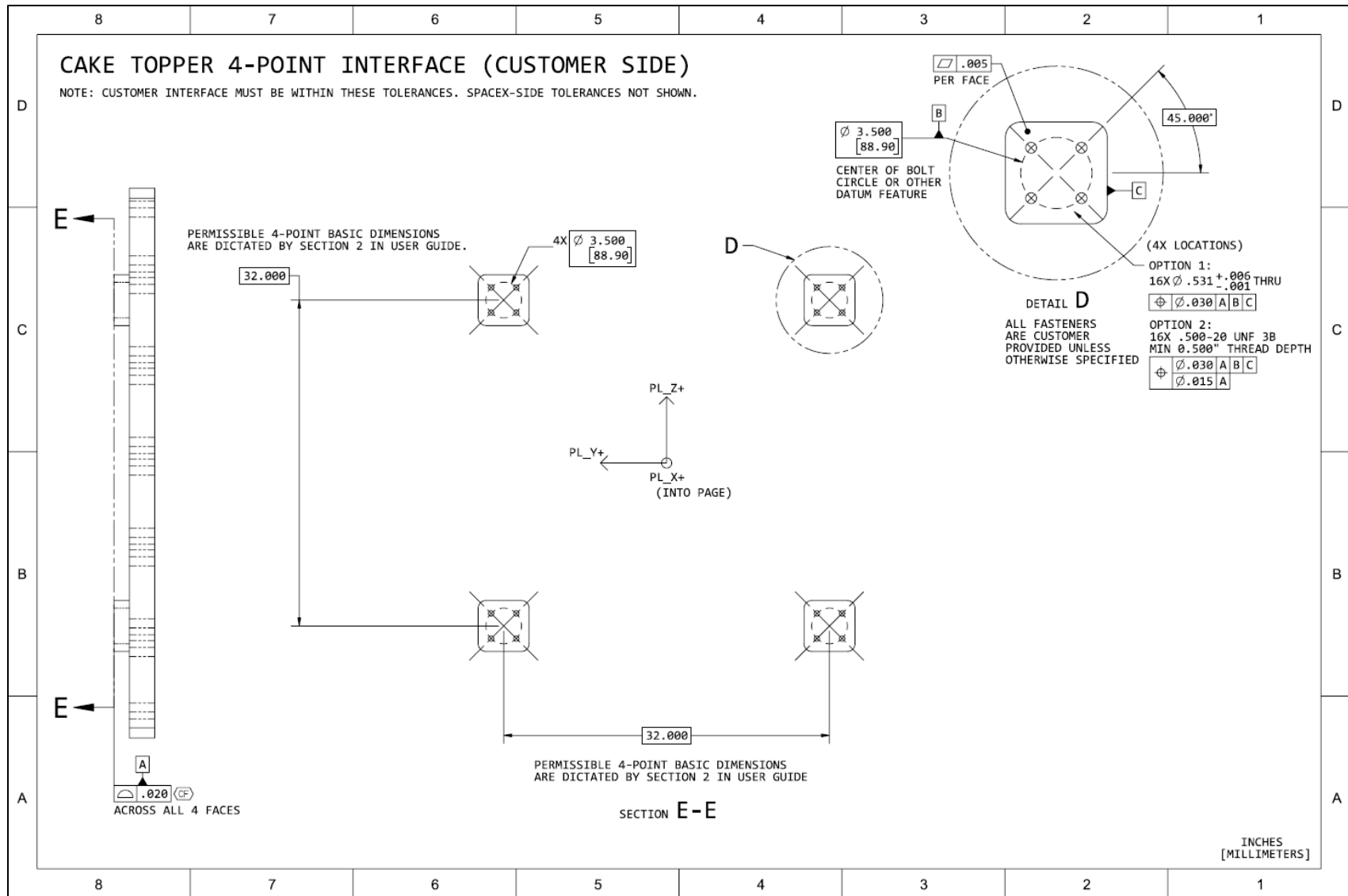


Figure A-9: 4-point Cake Topper Interface

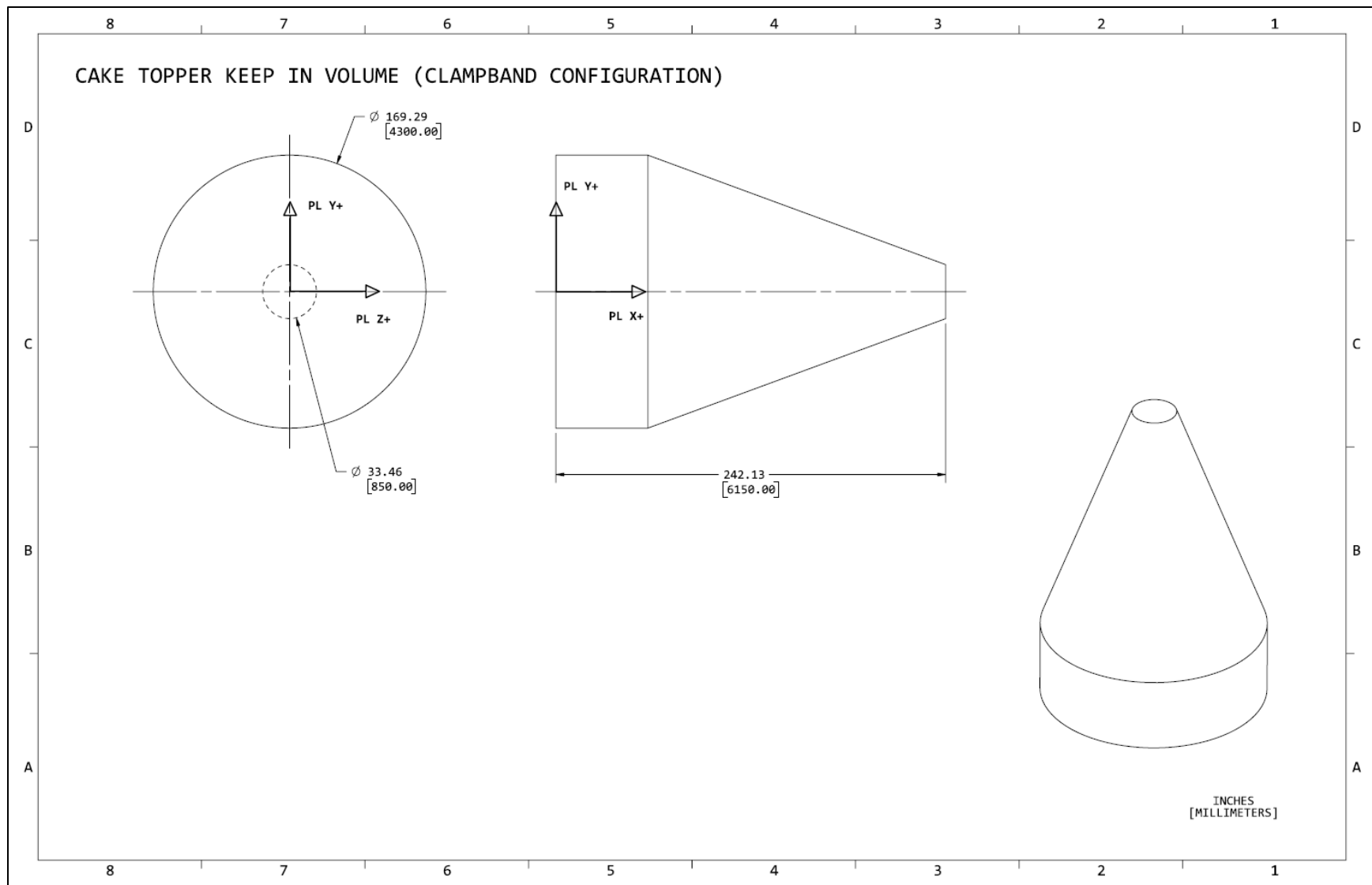


Figure A-10: Cake Topper Keep-in Volume (Clampband Configuration)

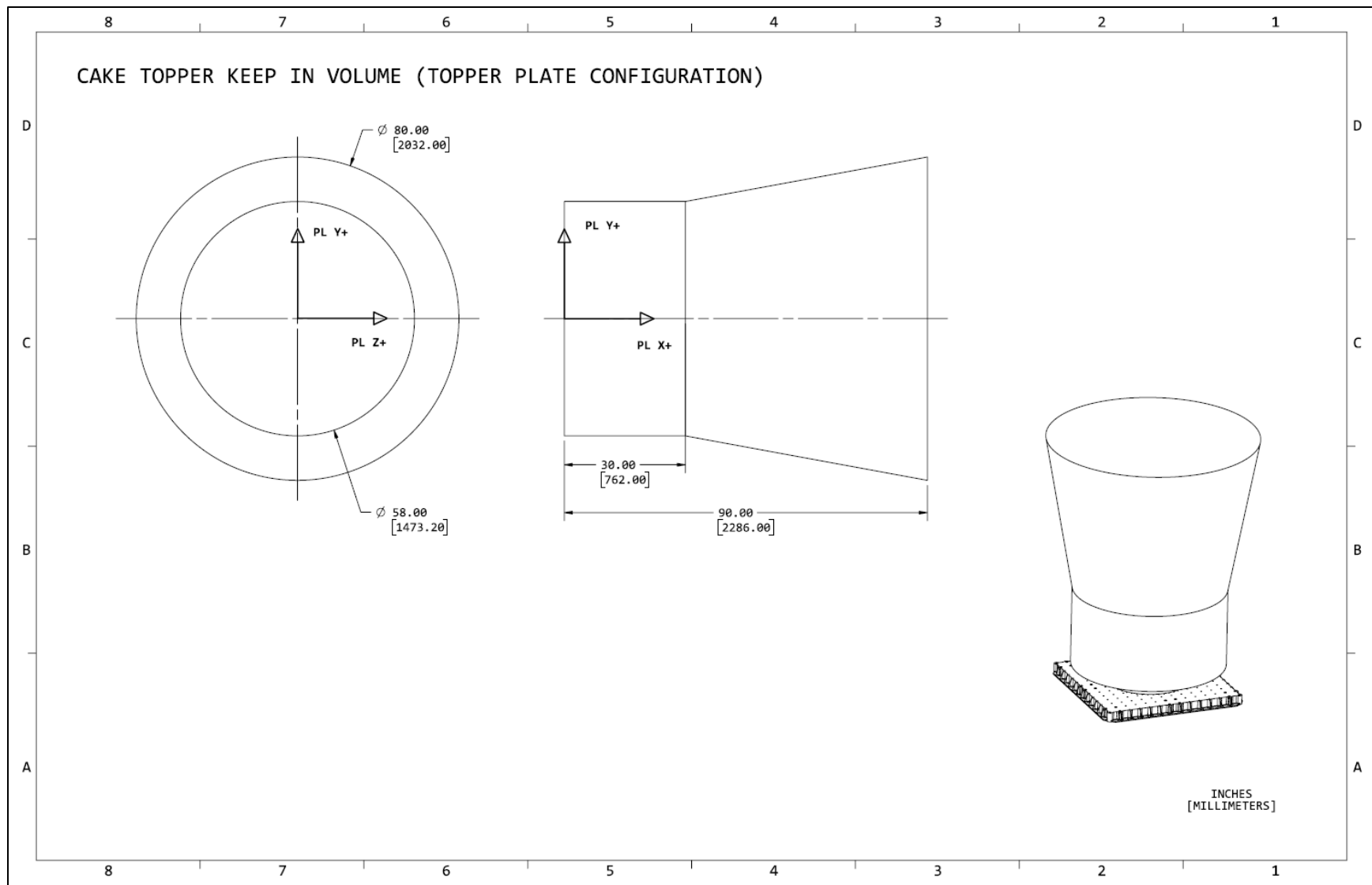


Figure A-11: Cake Topper Keep-in Volume (Topper Plate Configuration)



APPENDIX B: PAYLOAD DYNAMIC MODEL REQUIREMENTS

The Payload dynamic model shall be provided to SpaceX as a Craig-Bampton reduced model. SpaceX provides a dynamic model summary template for Customer to ensure the following requirements are met.

Payload Craig-Bampton Model Definition

Model Requirements:

- The model file should be no larger than 500 MB
- The units of the model shall be clearly defined (English or SI)
- The model will be delivered as a multipoint interface model (see Interface Requirements section)
- 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
- Slosh effects shall be included, slosh modes identified, and method of scaling for acceleration shall be clearly defined

Interface Requirements:

- The interface to the Launch Vehicle shall remain physical with six degrees of freedom at each interface node
- The location of the interface shall match the Payload to Launch Vehicle mechanical interface definition (e.g., if Customer is providing the separation system, it must be included in the model)
- Boundary node locations shall be clearly defined in accordance with the following table for all Payload interfaces matching the provided diameters. This ensures correspondence with Payload Adapter models

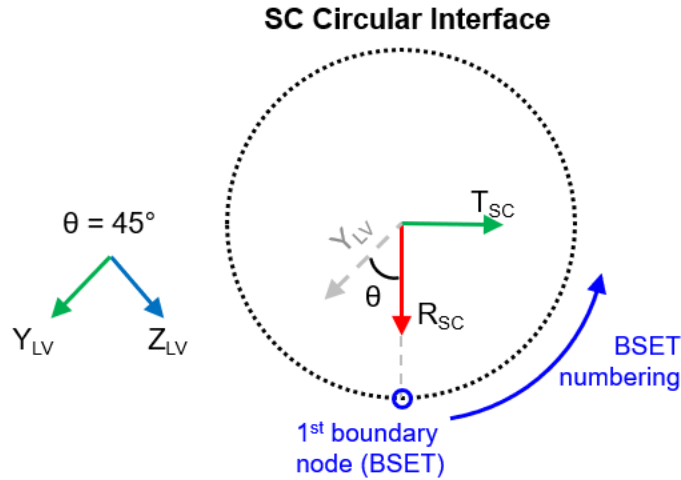
Boundary Grid Numbering

Interface Diameter (mm)	Number of Boundary Grids
937	120
1194	240
1575	120
1666	360
2624	244
2795	180
3117	180

- Interface points not defined at the Payload to Launch Vehicle interface plane will not be allowed
 - Exception: the Customer can prove their necessity, and the interface point is sufficiently stiff; e.g., no electrical connections or ducting
- The coordinate system used for the boundary degrees of freedom relative to the Launch Vehicle (Payload clocking) shall be a cylindrical output coordinate system with the origin at the center of the interface. This coordinate system will be defined only once and in a clear manner. Boundary nodes will be numbered sequentially and ordered counterclockwise (i.e., about LV +X in a right-hand coordinate system). Example is shown in the figure below



- All grid points (in the DTM) for which fairing relative deflections are desired shall include all three translations sequentially. If an acceleration-based DTM is provided for Launch Vehicle to Payload relative deflection calculations, then the displacement-based portion shall also be provided



Boundary coordinate system definition example

Matrix Requirements:

- The model shall Include mass, stiffness and Output Transformation Matrices
- 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

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

- Output Transformation Matrices (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, or using both a DRM1 and a DRM2
- Total number of recoveries shall be limited to 5,000 rows



- Time histories are not a standard output and will not be provided unless determined necessary by SpaceX
- 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/sec² and rad/sec² and inch and radian or other consistent units.

Analysis Outputs

The following standard 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 force max/min tables
- Interface sine vibe curves with Q specified by Customer
- Relative displacements (between Payload and fairing)

* 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 interface force max/min tables and the interface sine vibe curves is dependent on the coordinate system in which the grid points are defined. The available coordinate systems are:

For a multi-point interface with a single coordinate system

- LV coordinate system
- SC coordinate system (as defined by the coordinate system of the spacecraft interface DOF in the stiffness/mass matrices)

For a multi-point interface with multiple coordinate systems

- LV coordinate system
- SV coordinate system (as defined by the coordinate system of the first boundary point in the stiffness/mass matrices)

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) unless there is firm rationale why full matrix damping should be exercised, such as the existence of an internal highly damped isolation system with known physical characteristics.

Expected slosh mode damping shall be included in the damping definition.

Uncertainty Factor

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



Documentation

SpaceX requests that the Customer fill out the “spacecraft_customer_template” excel file when providing their dynamic model. This standardized template eases coupling of the spacecraft to the LV and ensures that required information is provided in a clear format.

SpaceX also requests that the Payload dynamic model and populated customer template be accompanied by any Customer generated supporting documentation (in the Customer desired format) as needed. Provided documentation should include:

1. Definition of units used (SI or English)
2. Definition of the Payload coordinate system relative to the Launch Vehicle
3. Location of all interface grids in Payload coordinate system
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. Definition of output format and requests, e.g., interface loads, interface accelerations, net CG loads, internal Payload loads, shock response spectra (SRSs), etc. If SRSs are requested, the number of rows shall be limited to 500.
10. If internal Payload responses are requested, provide appropriate DRMs (ATMs, DTMs, and LTMs) as well as tables defining the rows of these matrices
11. 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
12. Definition of slosh mode frequencies and mode numbers, along with expected damping and method for scaling relative to acceleration

The above list is not all-inclusive, and Customer is encouraged to provide additional information that will assist SpaceX in processing the Payload dynamic model for the coupled loads analysis.



APPENDIX C: PAYLOAD CAD MODEL REQUIREMENTS

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

SpaceX uses Siemens NX for CAD processing and, upon mutual agreement of the Parties, can accept Customer CAD models in a Parasolid file, the native format of NX.

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

Mass properties are provided in concert with CAD. This mass data must match exactly with the delivered CAD coordinate system configuration and units.

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

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

The Payload CAD model must not include:

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

Prior to delivering CAD to SpaceX, please verify:

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



APPENDIX D: PAYLOAD ENCAPSULATION & LAUNCH READINESS CERTIFICATES

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

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

Encapsulation Readiness Letter Template

[Insert Company Logo]

[Insert Company Name]
[Insert Company Address]

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

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

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

[CHOOSE ONE OF THE FOLLOWING]

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

Sincerely,

[Insert Signature]

[Insert Company]



Launch Readiness Letter Template

[Insert Company Logo]

[Insert Company Name]
[Insert Company Address]

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

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

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

[CHOOSE ONE OF THE FOLLOWING]

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

Sincerely,

[Insert Signature]

[Insert Company]



APPENDIX E: DELIVERY FORMAT OF SEPARATION STATE VECTOR

Pre-Launch Example

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

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

```
UTC time at liftoff:           DOY:HH:MM:SS.SS
UTC time of current state:    DOY:HH:MM:SS.SS
Mission elapsed time (s):     +XX.XX
ECEF (X,Y,Z) Position (m):    +XXXXXX.XXX, +XXXXXXXXX.XXX, +XXXXXXXXX.XXX
ECEF (X,Y,Z) Velocity* (m/s): +XXXX.XXX, +XXXX.XXX, +XXXX.XXX
LVLH to BODY quaternion (S,X,Y,Z): +X.XXXXXXXXXX, +X.XXXXXXXXXX, +X.XXXXXXXXXX, +X.XXXXXXXXXX
Inertial body rates (X,Y,Z) (deg/s): +X.XXXXXXXXXX, +X.XXXXXXXXXX, +X.XXXXXXXXXX
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: [+XXXXXXXX.XXX, +XXXXXXXX.XXX, +XXXXXXXX.XXX]
  v_ecef_m_per_s: [+XXXXX.XXX, +XXXXX.XXX, +XXXXX.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: [+XXXXXXXX.XXX, +XXXXXXXX.XXX, +XXXXXXXX.XXX]
  v_ecef_m_per_s: [+XXXXX.XXX, +XXXXX.XXX, +XXXXX.XXX]
  mean_perigee_altitude_km: +XXX.XXX
  mean_apogee_altitude_km: +XXX.XXX
  mean_inclination_deg: +XX.XXX
  mean_argument_of_perigee_deg: +XXX.XXX
  mean_longitude_ascending_node_deg: +XXX.XXX
  mean_mean_anomaly_deg: +XX.XXX
  ballistic_coef_kg_per_m2: +XX.XX
```



APPENDIX F: PAYLOAD LICENSING CERTIFICATION

[Insert Company Logo]

[Insert Company Name]
[Insert Company Address]

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

[Insert description of Payload]

[Insert Company] certifies that:

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

Sincerely,

[Insert Signature]

[Insert Company]



APPENDIX G: DELIVERABLE DESCRIPTIONS

The deliverables described in this appendix correspond to SpaceX and Customer deliverables and corresponding due dates defined in Table 1 of the Payload contract's statement of work.

Table G-1: SpaceX Deliverables

Milestone	SpaceX Deliverables	Description
Agreement Signature	Signed Agreement	Copy of the Agreement signed by SpaceX.
	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 questionnaire	Request for preliminary information on the Payload that SpaceX will use in support of early internal analyses and program deliverables.
	FAA cross-waiver template	Agreement for waiver of claims and assumption of responsibility for licensed launch, to be filled out by Customer, SpaceX and Federal Aviation Administration (FAA).
Mission Integration Kickoff	Launch Range introduction	Introduction to the Launch Range, Launch Range processes, and how SpaceX/Customer/Launch Range will interface with each other during the campaign. Customer is also provided a copy of the safety regulations at the Launch Site.
	Payload Range Safety requirements	Summary of Range Safety submissions required for Rideshare Payloads.
	Range Safety submission document templates	Document templates for the Range Safety submission deliverables.
	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).
	ICD template	Preliminary draft of the ICD containing placeholders for mission-specific requirements and other interface information to be developed and populated during the course of the launch campaign. The ICD defines the Mission requirements and interfaces between Customer and SpaceX systems.
	Dynamic model worksheet	A worksheet for the Customer to complete which serves as a companion document to accompany the Customer Payload dynamics model (reference Appendix B) delivery.
	Mass properties worksheet	A worksheet for the 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.
	Payload transmitter verification worksheet	A worksheet for Customer to use to verify Payload transmitter turn on times.
	Electrical interface pinout worksheet (AV2052)	A spreadsheet that describes the Launch Vehicle to Payload electrical harness properties and pin-outs.
	Payload EMI/EMC worksheet template (AV2054)	A spreadsheet template for the Customer to complete which describes the spacecraft radio frequency electromagnetic emissions and susceptibility.
	Payload environmental test approach worksheet	A worksheet for the Customer to complete which defines the test approach for the Payload including requested deviations to Section 6 and test schedule, which must be approved by SpaceX.
FAA Payload review information template	A spreadsheet template for the customer to complete which provides information to support the Federal Aviation Administration's (FAA) Payload review process.	
Completion of Initial Mission Integration Analyses	Initial trajectory analysis results	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 (or assess the Customer provided Launch Window), and assess free molecular heating. This analysis also serves as an input to other SpaceX analyses such as Coupled Loads Analysis.
	Representative thermal attitude parameters	SpaceX will provide a file detailing the attitude information of a representative trajectory, as needed, for the Customer to perform a Payload thermal analysis.
	Contamination analysis results	SpaceX shall provide the Customer with a contamination analysis that shows compliance to a maximum particulate contamination level of 1% obscuration and maximum predicted organic contamination level of 4 mg/m ² onto any Payload surface, from the time period of encapsulation through collision avoidance maneuver. The presentation describes the inputs to these maximum levels and historical capabilities demonstrating compliance.



Milestone	SpaceX Deliverables	Description
	Fairing air impingement analysis results	SpaceX provides a generic analysis that characterizes the maximum predicted air or GN2 impingement velocity on the exterior of the allowable fairing volume surfaces from the fairing air conditioning system.
	Payload separation analysis results	Results of the separation analysis predicting the maximum linear and angular separation rates of the Payload upon separation from the Launch Vehicle.
	Spacecraft-to-LV Electrical interface details	Spreadsheet documenting the end-to-end pin-out of the Launch Vehicle umbilical, including electrical characteristics of each pin.
	Spacecraft-to-LV Mechanical interface details	Drawings (included in the ICD) capturing the mechanical interfaces of the Payload to the Launch Vehicle, including keep-out envelopes, relative clocking, electrical connectors, and fairing access door location(s).
	ICD - initial	Initial draft of the ICD to be reviewed by the Parties. Contains Mission requirements, interface information and mutually agreed TBDs for information to be populated prior to launch campaign.
Spacecraft to Payload Adapter Fit Check (if applicable)	Fit check plan jointly agreed with Customer	A document detailing the fit check operations, equipment, procedures and roles and responsibilities.
	Equipment packing list	A list of equipment which SpaceX will bring to the spacecraft facility in support of the fit check.
Launch Campaign Planning Kickoff	Launch campaign planning checklist (template)	Launch planning checklist template to track Launch campaign documentation, GSE shipment list, Customer personnel attendance, Payload details related to Launch Site operations, an OPM email distribution list, and Launch campaign action items.
	Launch campaign daily schedule (template)	Template for daily Launch Site activity planning for Customer to provide details such as stand-alone operations duration, SpaceX resource requirements, and hazardous operations.
	Licensing and insurance information template	A template for Customer to capture SpaceX licensing inputs such as hazardous materials and Customer crosswaiver inputs, as well as Payload insurer details, launch and in-orbit subrogation waiver accounting, and requests for additional parties to be included on SpaceX's third-party liability insurance policy.
	Payload and equipment delivery information	General information regarding the process and requirements for delivering the Payload and Customer GSE/EGSE to the Launch Site.
Launch Campaign Planning	Launch campaign planning checklist (preliminary)	Preliminary draft of Launch campaign planning checklist including preliminary Customer inputs.
	Launch integration schedule (preliminary)	Schedule of Launch Site operations identifying Payload stand-alone activities and combined Payload/Launch Vehicle operations for the Mission.
	Launch campaign plan (preliminary)	Plan for Payload integration and Launch, including the facilities to be used, Payload space allocation in those facilities, and the top-level operations to be performed for both Launch Vehicle and Payload processing.
Completion of Final Mission Integration Analyses	Predicted orbit injection report	Predicted state vector information, based on a nominal trajectory optimized for the Mission. This state vector will be provided in SpaceX-defined format (reference Appendix E).
	Coupled Loads Analysis (CLA) update (if applicable)	Updated coupled loads analysis results based on L-4 month mission configuration. Alternatively, SpaceX may provide confirmation that previously analyzed results are enveloping of final mission configuration.
	Payload clearance assessment results	Confirmation of positive clearance between Payload and Launch Vehicle hardware (or Co-Payloads) with worst case dynamic deflections. If necessary, identification of locations with minimal Payload to Launch Vehicle hardware (or Co-Payload) clearance, based on CAD modeling, will be provided.
	EMI/EMC analysis results	RF compatibility presented as described in Appendix E. Assesses whether the emissions and susceptibilities of the Payload, Launch Vehicle, and ground systems (including Co-Payloads during ground processing) are compatible with each other.
	ICD - update	Updated release of the ICD to be reviewed by the Parties and finalized for signature at Launch Campaign Readiness Review.
Trajectory Monte-Carlo Results	Trajectory analysis results, including monte carlo collision avoidance analysis and ascent telemetry coverage	SpaceX analyzes the Mission trajectory and delivers a chart-based presentation describing the analysis results. The presentation will include: <ul style="list-style-type: none"> a. A description of the tools used in the analysis b. The nominal flight timeline, profile, and ground track c. The free molecular heating environment at fairing jettison



Milestone	SpaceX Deliverables	Description
		<p>d. The predicted Launch Window, or assessment of the Launch Window (if Customer-provided)</p> <p>e. The Earth-Centered-Earth-Fixed (ECEF) Payload separation state vector</p> <p>f. Payload and Co-Payload(s) deploy timeline (provided at L-4 months)</p> <p>g. Ascent telemetry coverage (provided at L-4 months)</p> <p>h. Orbit injection accuracy (Mission-unique Monte Carlo analysis results at L-2 months)</p> <p>i. A discussion of requirements compliance in all these areas 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. The trajectory will be analyzed using the maximum Payload mass, including worst-case Payload mass properties tolerances. SpaceX does not implement multiple trajectories for multiple masses and does not utilize nominal Payload mass in the analyses.</p> <p>SpaceX also performs an analysis to determine the need for a collision avoidance maneuver (CAM) following separation of all payloads. This analysis will characterize the relative separation distance between the second stage and the Payload and all Co-Payloads for one orbit after separation. The analysis will show that all combinations of any two bodies (Payload and all Co-Payloads and launch vehicle) result in long term growth in relative distance. 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. SpaceX coordinates with applicable US regulatory authorities, such as the FAA and the North American Aerospace Defense Command (NORAD), to select a Launch Window that results in a sufficiently low risk of collision with another space object during the Mission.</p>
Launch Campaign Readiness Review	Mission analysis updates, if applicable	Updated analyses performed by mutual agreement of the Parties (for example, revised trajectory results following a significant deviation of measured Payload mass properties from the predicted Payload mass properties, or revised CLA results following an exceedance of predicted Payload load limits after Payload testing). SpaceX does not provide analysis updates for minor changes to Customer models or inputs (for example, nominal reduction of Payload mass properties uncertainty due to Payload maturity).
	ICD revision for signature	Revision of the ICD signed by the Parties.
	ICD compliance matrix and status	Lists the ICD requirements and verification status/evidence in accordance with the approved verification matrix within the ICD.
	Launch integration schedule (update)	Approved schedule of Launch Site operations identifying Payload stand-alone activities and combined Payload/Launch Vehicle operations.
	Launch Campaign Plan (update)	Finalized 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. The plan also defines SpaceX and Customer roles, communications, voice nets, mission constraints, and countdown steps.
Launch Campaign Kickoff	Launch Campaign Kickoff 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.
	Facility readiness letter	A letter to the Customer confirming that the payload processing facility is ready to receive the spacecraft.
Launch Campaign	Pre-arrival meeting (if arriving by air)	Briefing to the Customer providing information about spacecraft arrival timeline and operations ahead of the Payload aircraft offload.
	Electrical checkout results	Documents detailing the results of the SpaceX electrical checkouts performed on the harnessing which interfaces with the spacecraft.
	Facility environmental report	Reports of facility temperature, relative humidity and particle count are provided to the Customer point of contact.



Milestone	SpaceX Deliverables	Description
	Daily launch campaign schedule	Daily updates to the Launch Campaign schedule as coordinated in real time with the Customer.
	Launch Vehicle readiness certificate	Signed confirmation from SpaceX to the Customer that the Launch Vehicle is ready for countdown and Launch.
Insurance Mission Package	Insurance Mission Package	Slides provided to the Customer and their insurers including Mission Overview; Mission Timeline; Launch Vehicle Configuration; Significant Issues during Production, Test, and Launch Vehicle Integration; Significant Remove and Replace during Launch Campaign; Significant First Flight Items and Operations; Re-Flight Items; Other Items of Note; Responses to Written Questions from Underwriters; for Reused Boosters Only: "Life of the Booster".
Launch Readiness	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.
Launch	Orbit injection report	Provides operational state vector information, based on best available telemetry during the flight. This state vector will be provided in SpaceX-defined format (reference Appendix I); Customer is solely responsible for conversion, if necessary, of the data into a Customer-preferred format.



Table G-2: Customer Deliverables

Milestone	Customer Deliverables	Description
Agreement signature	Signed Agreement	Copy of the Agreement signed by Customer.
	Technical point(s) of contact	Identification for the Customer point of contact that will interface with the SpaceX mission manager.
Mission Integration Kickoff	Completed TAA questionnaire or Export Compliance Agreement (ECA)	Representations and certifications from Customer for Technical Assistance Agreement (TAA) application (if not already completed prior to the Kickoff) or signed Export Compliance Agreement.
	Completed Payload questionnaire	Preliminary information on the Payload provided by the Customer for SpaceX use in support of early internal analyses and program deliverables.
	Payload drawings and CAD models	Preliminary Payload CAD model, in accordance with Appendix C, and preliminary Payload interface drawings.
	Payload environmental test approach and schedule	Provide the test approach compared to Section 6 using the SpaceX provided worksheet, including additional rationale for any requests for deviation to the requirements found in Section 6, including notching.
	Propulsion system details	Customer provides SpaceX with propulsion system details for SpaceX evaluation in accordance Section 4.1.5 if applicable to the Payload.
	Signed FAA cross-waiver	Customer completed FAA cross-waiver form, including company name and address, Payload name(s), and customer signature. Required by U.S. federal law in order to launch. Late submissions may delay launch.
	Mission Integration Analysis Inputs	Payload inputs to ICD
Payload CAD model update (if applicable)		Updated Payload CAD model, in accordance with Appendix C.
Payload dynamic model and completed checkout worksheet		Payload dynamic model, in accordance with Appendix B.
Payload mass properties		Current best estimate of the Payload mass properties (mass, CoG, Mol, Pol, all with tolerances).
Payload transmitter verification		Customer verification that Payload transmitter turn on times are compatible with Launch Vehicle frequency restrictions using the SpaceX-provided worksheet.
Completed Payload ICD pinout worksheet (AV2052)		A spreadsheet which describes the launch vehicle to spacecraft electrical harness properties and pin-outs.
Completed Payload EMI/EMC worksheet template (AV2054)		A spreadsheet which describes the spacecraft radio frequency electromagnetic emissions and susceptibility.
Completion of Initial Mission Integration Analyses	Range Safety Program Introduction	A simplified and high-level overview of the Payload and its associated hazardous systems in a condensed format for Launch Range safety authorities (template provided by SpaceX). The PI provides quick reference on Payload appearance, size, mass, propellants, batteries, Pressure Vessels, heat pipes, and radiating sources. Detailed information about the Payload is provided in the MSPSP.
	Payload 91-710 tailoring, initial	Tailoring provides a means for formulating a Payload-specific edition of AFSPCMAN 91-710 (Volumes 1, 3, and 6) and documents whether or not the Customer will meet applicable safety requirements as written or achieve an equivalent level of safety through a requested and approved alternative approach. The Customer's tailoring requests must be prepared in accordance with 91-710 Vol 1, Attachment 1 for SpaceX to submit to the Launch Range safety authority for review and approval.
	Payload MSPSP, draft	Payload safety information providing the Launch Range safety authority with a description of hazardous and safety-critical support equipment and flight hardware associated with the Payload. The Customer's MSPSP must be prepared in accordance with 91-710 Vol 3, Attachment 1 for SpaceX to submit to the Launch Range safety authority for review and approval.
	Inputs to Launch Site activity planning / joint operations	Description of Customer Launch Site activities including Payload stand-alone processing, combined operations, Launch constraints, requested Launch Site services, and Launch Site interfaces.
Spacecraft to Payload	Fit check plan jointly agreed with Customer	A document detailing the fit check operations, equipment, procedures and roles and responsibilities.



Milestone	Customer Deliverables	Description
Adapter Fit Check (if applicable)		
Range Safety Submission	Payload 91-710 tailoring, final	Tailoring provides a means for formulating a Payload-specific edition of AFSPCMAN 91-710 (Volumes 1, 3, and 6) and documents whether or not the Customer will meet applicable safety requirements as written or achieve an equivalent level of safety through a requested and approved alternative approach. The Customer's tailoring requests must be prepared in accordance with 91-710 Vol 1, Attachment 1 for SpaceX to submit to the Launch Range safety authority for review and approval.
FAA Licensing Inputs	Completed FAA Payload review information form	Completed Payload review information spreadsheet, including Payload name, quantity, type, intended operations, life span, disposal plan, physical characteristics, Payload owner, Payload operator, Payload registration, operational orbit(s), and hazardous materials. Required by U.S. federal law in order to launch. Late submissions may delay launch.
Launch Campaign Planning	List of emails for launch site badging access	Customer-provided list of emails for potential launch site personnel in order to fill out badge access paperwork online.
Range Safety Submission	Payload Ground Operations Plan, draft	The Payload Ground Operations Plan (GOP) provides a detailed description of the hazardous and safety critical operations associated with the Payload and its ground support equipment. The Payload GOP contains a description of planned operations and the hazard analysis of those operations. The Customer's GOP must be prepared in accordance with 91-710 Vol 6, Attachment 1 for SpaceX to submit to the Launch Range safety authority for review and approval.
	Certification Data for Payload Hazardous Systems	Certification data for Payload hazardous systems. A system is deemed hazardous if it includes any of the following: Pressure Vessels (over 250 psi), batteries, hazardous materials, non-ionizing and ionizing radiation systems, hazardous propulsion systems, or ordnance. Data must also be provided for ground support equipment (for example, lift slings).
Trajectory Monte Carlo Inputs	Updated mass properties	Customer to provide SpaceX refined Payload mass properties inputs for the Monte Carlo analysis of the nominal trajectory using the Payload mass properties template provided by SpaceX. Updates must fall within previously provided uncertainty bounds.
Payload Environmental Verification	Payload environmental verification reports	Customer to provide to SpaceX final environmental verification test and/or analysis results in order to show compliance to Section 3.3 and in accordance with the SpaceX approved Payload environmental test approach.
Final Range Safety Submission	Payload 91-710 Compliance Letter	Signed confirmation from Customer to SpaceX, in the form of the letter as specified in the SpaceX Range document templates that the Payload complies with all Range Safety requirements.
	Payload MSPSP, final	Payload safety information providing the Launch Range safety authority with a description of hazardous and safety-critical support equipment and flight hardware associated with the Payload. The Customer's MSPSP must be prepared in accordance with 91-710 Vol 3, Attachment 1 for SpaceX to submit to the Launch Range safety authority for review and approval. The final Payload MSPSP must include Customer's qualification data for hazardous systems and certification data for hazardous systems.
	Payload Ground Operations Plan, final	The Payload Ground Operations Plan (GOP) provides a detailed description of the hazardous and safety critical operations associated with the Payload and its ground support equipment. The Payload GOP contains a description of planned operations and the hazard analysis of those operations. The Customer's GOP must be prepared in accordance with 91-710 Vol 6, Attachment 1 for SpaceX to submit to the Launch Range safety authority for review and approval.
	GOP-defined Hazardous Procedures	Payload procedures provide detailed, step-by-step descriptions of the manner in which Customer's hazardous and safety critical operations will be accomplished at the Launch Site. These procedures are the basis from which approval to start hazardous or safety critical operations are obtained from the Launch Range safety authority. The Customer's hazardous procedures must be prepared in accordance with 91-710 Vol 6, Attachment 2 for SpaceX to submit to the Launch Range safety authority for review and approval. Customer is strongly encouraged to deliver procedures earlier than 45 days before hardware arrival at the Launch Site. Procedures must be in English.
	Medical Certificates for SCAPE/SCBA Personnel	Medical certificates of good health for personnel using SCAPE or SCBA (self-contained breathing apparatus) at the Launch Site. Medical certificates for SCAPE/SCBA must be



Milestone	Customer Deliverables	Description
		valid throughout the expected duration of the campaign and contain all information required by NASA medical. Customer must provide Medical Exam information per KSC OCH-I-0106 and KSC Respirator Medical Evaluation questionnaire per KSC16-540V2.
	Propellant arrival information	The Payload propellant arrival plan describes the methods and logistics of Customer's propellant shipment to the Launch Site.
Launch Campaign Readiness Review	Final inputs to launch campaign checklist	Customer final 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.
	Final inputs to launch campaign daily schedule	Customer final inputs describing Launch Site activities required in the launch campaign daily schedule for Payload stand-alone processing.
	Badging details filled out via Customer Portal	Customer details including personal information, and passport/visa scans and photos necessary for access to the Launch Site badging completed online.
	Completed licensing and insurance information template	Customer provides the Hazardous Materials list in support of SpaceX's application of an FAA license for the mission as well as crosswaiver inputs. If applicable, evidence of insurance for the Payload, including identification of insurer point of contact and if Customer has procured Payload insurance, Customer to provide evidence of express waivers of subrogation as to SpaceX and its Related Third Parties. If applicable, Customer identifies any parties that would like to be listed as additional insured on the SpaceX procured third-party liability insurance.
	Hourly Schedule for Hazardous Operations	Launch Range safety scheduling information of hourly hazardous Payload operations. Required by the Launch Range safety authorities for awareness and oversight of hazardous Payload operations.
	Draft Dates and Times for EGSE Transfers	Schedule of Customer's expected EGSE transfers and movements between facilities at the Launch Site. SpaceX requires awareness of Customer's hardware transfer plans, to support the equipment movements and confirm personnel availability to assist with the transfer.
	Plan for Payload and GSE arrival at the Launch Site	The Payload and GSE arrival plan describes the methods and logistics of Customer's hardware arrival at the Launch Site.
	Payload insurance and cross-waivers	Evidence of insurance for the Payload, Customer property, equipment and personnel (with express waivers of subrogation as to SpaceX and its Related Third Parties). Evidence that the cross-waivers have been extended to (i) its Payload manufacturer(s); (ii) Related Third Parties with any ownership interest in the Payload; (iii) Customer's direct Customers for the Payload; and (iv) any other Related Third Parties, respective contractors, subcontractors and insurers, as requested by SpaceX. Each must waive (in writing) the right to sue or otherwise bring a claim against SpaceX or SpaceX's Related Third Parties, Co-Payload Customers or their Related Third Parties, or the US Government or its contractors or subcontractors for any injury, death, property loss or damage (including loss of or damage to the Payload, the Co- Payload(s), the Launch Vehicle, or other financial loss) sustained by them or any of their employees, officers, directors or agents, arising out of or related to activities relating to the performance of the Agreement.
Launch and In-Orbit Insurer Subrogation Waiver	Customer to provide evidence that the insurer has waived subrogation rights.	
Launch Campaign Kickoff	Launch site awareness training complete	All Customer personnel participating in the Launch Campaign complete online Launch Site awareness training prior to arrival at the Launch Site.
Launch Campaign	Payload mass properties - measured wet mass	Measured Payload mass, including adjustments for any non-flight items (e.g. remove-before-flight covers) which remained on the Payload during the final lift to Launch Vehicle hardware during join mating operations with SpaceX.
Launch Readiness	Payload Launch Readiness Certificate	Signed confirmation from Customer to SpaceX, in the form of the letter as determined by SpaceX, that the Payload is ready for countdown and Launch.
Flight Report	Coordination with the space situational agency	Customer coordination for space object identification as described in Section 9.5.7.
	Payload operations status	Brief summary of the current Payload status, as well as a launch and early operations informational summary.



APPENDIX H: PAYLOAD CONSTITUENTS

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

Table H-1: Payload Constituent Details

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

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



APPENDIX I: OPTIONAL SERVICES

SpaceX offers the optional services described in this section for an additional cost. Please contact SpaceX for details.

Table I-1: Optional Services

Service	Description	Select By
Non-Standard/Custom Payload Adapter	SpaceX offers a Payload Adapter (PLA) for spacecraft with 937mm, 1194mm, and 1666 mm interfaces as a standard service. Customers with spacecraft that have different sizes should reach out to SpaceX for details.	L-15 months
Spacecraft Shock Test at Customer facility	SpaceX provides access to a flight Launch Vehicle payload adapter to support a Payload to Launch Vehicle shock test. The shock test shall be performed per a mutually agreed schedule at a mutually agreed facility. This optional service includes two firings and travel to a single test event. It is anticipated the shock test will take no more than two days.	L-12 months
Fairing Acoustic Blankets	Acoustic blankets can be provided inside the fairing to mitigate acoustic levels	L-12 months
Payload powered ON during ascent	Customers may elect to have the spacecraft powered ON during ascent. Payload subject to electromagnetic MPE in Section 4.1.7 and must demonstrate verification per Section 6.7.7.	L-12 months
Additional Processing Days in the payload processing facility (PPF)	SpaceX can provide additional processing days, not to exceed 5 additional days, pending availability at the time of request.	L-6 months
FCC License for RF testing in the PPF	Spacecraft may transmit openly in the PPF with prior notice and coordination with SpaceX, who will procure the FCC license required for the testing.	L-6 months
Day-of-launch Go/No Go Launch Criteria	Customers may have Go/No Go input on day of Launch. Customers may select "No Go" on the launch attempt on day of launch, for a fee. Customers must provide launch criteria for Go/No Go on the day of launch for this option.	L-3 months



APPENDIX J: DEFINITIONS

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

"Cake Topper Payload" refers to a medium-sized (500-2500 kg) Payload, forward mounted on a stack of rideshare hardware.

"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.

"Co-Payload" means any 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.

"Customer" shall have the meaning set forth in the signature page of the Terms and Conditions.

"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).

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

"End of Mission," is defined by the mission-specific second stage re-entry time (usually a maximum of 1 hour, or 3600 seconds, after the last deploy).

"Interface Control Document" means that document which shall 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, US 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.

"L" means Launch Date and **"L-xx"** means the date xx months prior to the Launch Date (for example, if the Launch Date is currently July 1, 2018, L-6 means January 1, 2018).

"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 Activities" means the activities related to the performance of this Agreement following the arrival of the Payload or Launch Vehicle at the Launch Site, whichever comes first, including those prescribed by the CSLA and the terms of the launch license issued to SpaceX pursuant thereto for the Launch.

"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" shall have the meaning set forth in the LSA. If the Launch Date has not yet been established (as determined solely by SpaceX), the Launch Date shall be deemed to be the first day of the Launch Period. Any delay shall not change the payment due dates in the Terms and Conditions.



"Launch Range" means the US Governmental authorities and office with jurisdiction over the Launch Site.

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

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

"Launch Vehicle" shall mean a launch vehicle capable of achieving Customer's orbital parameter requirements as set forth in Section 1 of the SOW.

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

"Licenses" shall mean 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.

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

"Parties" shall mean Customer and SpaceX.

"Party" shall mean Customer or SpaceX.

"Payload" shall mean the Customer spacecraft. The Payload shall not contain any hosted or auxiliary spacecraft provided by the Customer without the written mutual agreement of SpaceX.

"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).

"Pressure System" is any system that is intended to be pressurized beyond 0.5 atmospheres. This includes both Pressure Vessels and pressure components like valves, fittings, and tubes that have potential to see internal pressure in the time between Customer delivery and on-orbit deployment.

"Range Safety" refers to the specific safety branch of the Launch Range, the US Governmental authorities and office with jurisdiction over the Launch Site.

"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 ground support equipment.

"Rideshare" means in reference to the SpaceX Rideshare Program offering for small satellite launch services.

"Rideshare Program" is the SpaceX offering for small satellite launch services.

"Terms and Conditions" means the Terms and Conditions to which the SOW is attached.



APPENDIX K: EMI/EMC DESCRIPTIONS

SpaceX will perform analysis demonstrating radio frequency (RF) and electromagnetic interference (EMI) compatibility between the Payload and Launch Vehicle. This analysis will couple the emissions and susceptibility of the Launch Vehicle systems with the Payload emission and susceptibility provided by the Customer. The Customer shall provide SpaceX the Payload RF information described below in the form of the AV2054 worksheet.

Outputs to the Customer are predicted compatibility and/or interference areas across the megahertz (MHz) to gigahertz (GHz) frequency spectrum.

Inputs Required from Customer:

- Payload intentional radiated emissions in the range from 10MHz to 18GHz (Payload transmitters) including:
 - Frequency in MHz
 - Bandwidth in MHz
 - Electric field in dB μ V/m at the separation plane
 - Effective isotropically radiated power (EIRP)¹
- Payload spurious radiated emissions in the range from 10MHz to 18GHz (all emission other than Payload transmitters)
 - Frequency in MHz
 - Electric field in dB μ V/m at the separation plane
- Payload susceptibility to E-field emissions in the range from 10MHz to 18GHz (Payload receivers/notches)
 - Frequency in MHz
 - Electric field in dB μ V/m at the Payload receiver
 - Threshold sensitivity receive power (of Payload receivers)
- Payload susceptibility to spurious E-field emissions in the range from 10MHz to 18GHz (other than receive notches)
 - Frequency in MHz
 - Electric field in dB μ V/m at the separation plane

Notes:

- ¹ SpaceX can accept transmitter power and antenna gain in place of EIRP.