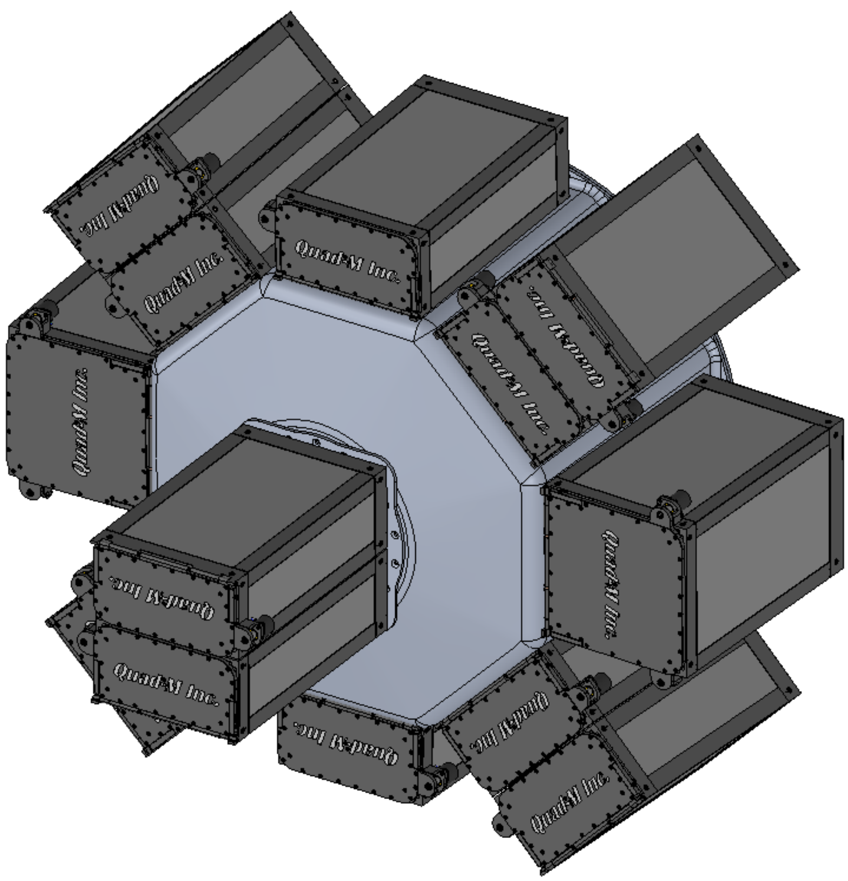
EQUALIZER INTERFACE CONTROL DOCUMENT



1. EQUALIZER Description

The EQUALIZER deployment system (patent pending) is designed to be compatible with 1U, 2U, 3U Rail, 6U Rail, 6U Tab, 12U Rail and 12U Tab CubeSats. EQUALIZER utilizes the SpaceX Rideshare Program to provide 96U per 24" launch adapter to orbit. These features are unique in the industry. The system is designed to mount on the SpaceX Falcon 9 Rideshare 24" adapter and deploy CubeSats from the mounted Deployers. See Figure 1-1.

This ICD is intended for payload designers.

Contents

1. Description……………………… 2
2. Satellite Parameters, Rail…….. 8
3. Satellite Parameters, Tab….. 11
4. Inhibit Switches…………........... 15
5. Satellite Access………………… 15
6. Mechanical Requirements….. 15
7. Materials………………………… 16
8. Electrical………………………… 16
9. Propulsion Systems…………….. 22
10. Environments…………………… 22
11. Revision History…………………. 28

Table 1-1: Applicable Documents

Doc No.	Rev	Title
SpaceX	July 2020	Rideshare Payload User's Guide

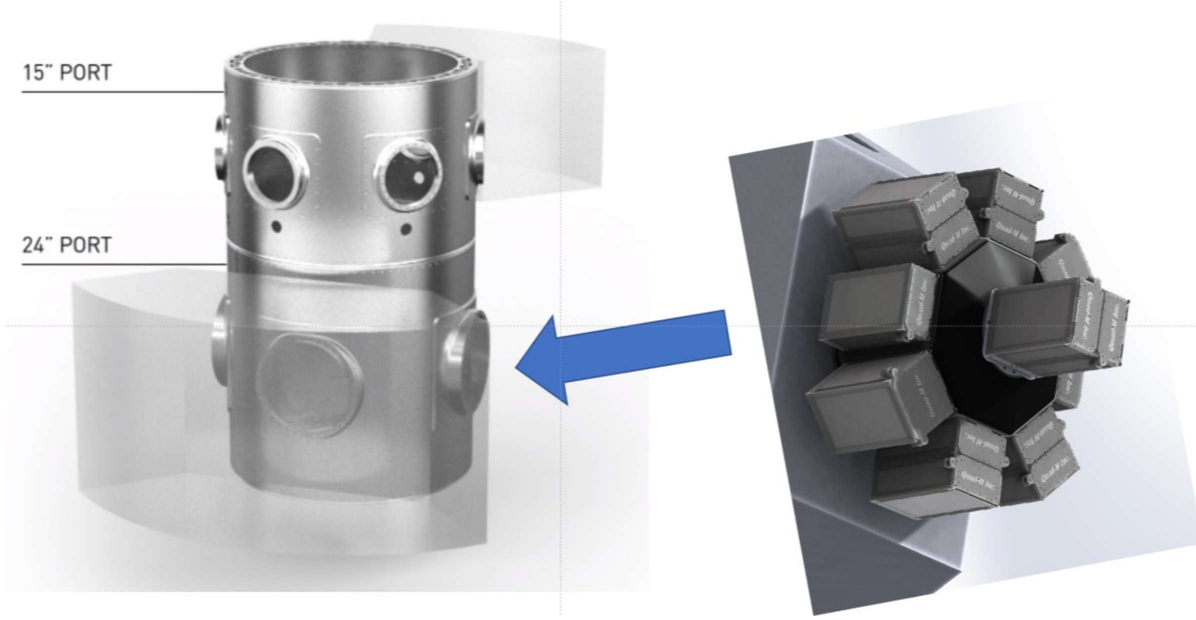


Figure 1-1: SEOPS EQUALIZER Deployer Configuration on SpaceX Falcon 9 Rideshare Adapter

1.1 EQUALIZER Launch System

The EQUALIZER launcher system is composed of the following major components:

1. Up to 7 preloaded 12U Deployers and 2 preloaded 6U Deployers (96U).
2. Preprogrammed control box for deployer selection and control.
3. SpaceX Rideshare Adapter structure.

Components are launched via the Falcon 9 and deployed on-orbit. Currently SpaceX Rideshare missions go to Sun Synchronous Orbit (SSO) and to Low Earth Orbit (~190 km/53°) missions as secondaries on the Starlink Constellation launches. See Figure 1-2 for Equalizer Deployer Details.

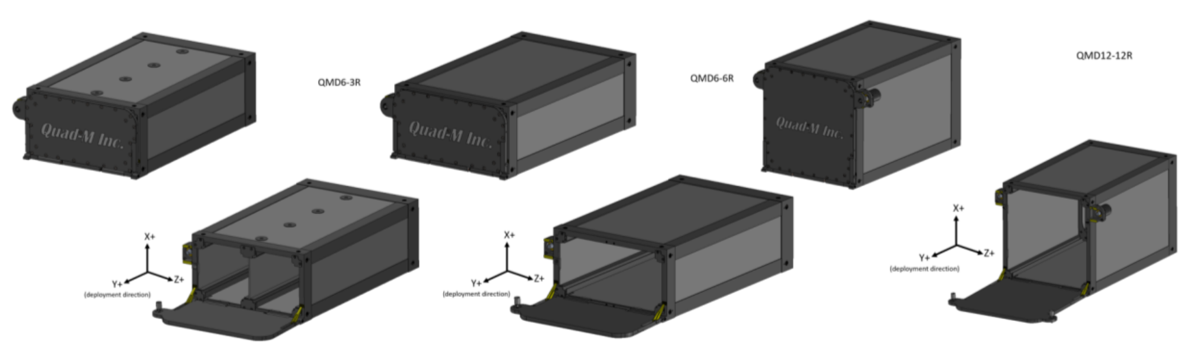


Figure 1-2: Equalizer Deployer Details

1.2 EQUALIZER Deployers

Each EQUALIZER Deployer accommodates 6U/12U satellites or combinations thereof. The EQUALIZER Deployers utilize a resettable shape memory alloy separation nut that can be tested and reset multiple times prior to launch. EQUALIZER has a separate controller that, when commanded by the SpaceX Falcon 9 launch vehicle, commences to open the deployers at a preprogrammed rate. The EQUALIZER Assembly is not powered or active until deployment and power is applied through a redundant self-contained battery pack.

1.3 EQUALIZER Integration Schedule

Table 1-2 is a standard EQUALIZER Integration Schedule. The detailed satellite schedule will be coordinated between SEOPS and the Satellite Developer.

Table 1-2: Standard EQUALIZER Integration Schedule

Milestone/Activity	Launch-minus Dates (months)
Regulatory Compliance Start (Spectrum Coordination License, Remote Sensing License) (Customer)	L – 14
Feasibility Study/Contract Signing (Both)	L – 8
SEOPS/Customer Data Call Phase I (Customer)	L-8.75
SEOPS Safety Initial Assessment Complete (SEOPS)	L-8.25
SEOPS/Customer Data Call Phase II (Customer)	L-7
Safety/Mass Properties Data Package Submittal to SpaceX (SEOPS)	L-6
Safety Review (SEOPS)	L-5
Satellite-Separation System Fit Check/Vibration Testing (Customer)	L-4
SEOPS/Customer Data Call Phase III (Customer)	L-3
Final SpaceX Regulatory Data Package Submittal (SEOPS)	L-2
Nominal Satellite Delivery to SEOPS (Customer)	L-1.5
SEOPS Delivery to SpaceX (SEOPS)	L-1

1.4 SEOPS Data Gathering for Operations

SEOPS will assess the combined satellite/deployer system to develop products and procedures in support of safety, integration, and final deployment. Data requirements are as follows.

1.5 Data Call Phase I (Required at Contract Signing + 1 Week)

1.5.1 Satellite Description and Concept of Operations

Please supply a one to two paragraph description of what your satellite(s) will do. SEOPS will coordinate this with your team.

1.5.2 Mechanical Fundamentals

Provide the format (1U, 2U, 3U, 6U rail, 6U tab, 12U rail or 12U tab), length of satellite, mass, Center of Gravity (C.G.) location and any deployable appendage dimensions (either constrained by the satellite or constrained by the deployer.

Table 1-3: Satellite Mass Limits

Format	1U	2U	3U	6U	12U
Mass Max (kg)	2.0	4.0	6.0	12.0	24.0

1.5.3 Radio Details

For each radio transmitter and receiver specify the upper and lower transmission frequencies, the power output (in Watts) of each transmitter, the type of transmitter antenna used and the gain of each transmitter antenna.

1.5.4 Electrical Schematic of Inhibits

SEOPS will need an Electrical Inhibit Schematic and Plan showing how the satellite power (battery) is isolated while in the deployer. See Figure 1-4.

Electrical Subsystem Block Diagram (note: RBF pins switches not shown)

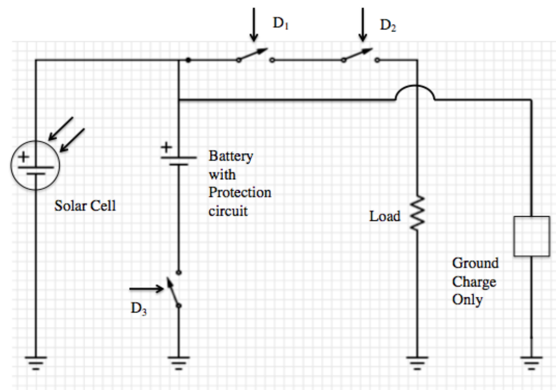


Figure 1-4: Electric Inhibit Example

1.5.5 Battery Information

SEOPS will need cell part numbers (may be in BOM), cell manufacturer, quantity of cells, and how the cells are connected (e.g. 3 cells in series/2 strings in parallel). Cell charging while on the launch vehicle is not allowed.

1.5.6 Propulsion System Details (if required)

If the satellite has propulsion, please provide a schematic diagram of the propulsion system as well as the location of the thruster(s) on the satellite. Other details such as propellant type (may be in BOM), inhibit scheme, commanding scheme, Operations Concept (detailed enough to gather propulsion plan), magnitude of thrust per thrust event, total delta V, etc. will be required. SEOPS is highly motivated to prevent satellite/launch vehicle collisions and your propulsion system information will provide us with this knowledge.

1.5.7 Pressurized System Details (if required)

Schematic diagram of the system and details of the proof testing of the system (Maximum Operating Pressure, Factors of Safety, Rated Burst Pressure, Materials of Construction/Compatibility). This may be part of BOM.

1.6 Data Call Phase II (Required at Contract Signing + 1 Month)

1.6.1 Bill of Materials

From this information we determine flammability hazards, identify fluids and gasses with associated ground handling Material Safety Data Sheets (MSDS).

1.6.2 CAD model of satellite

SEOPS uses this for a CAD virtual "fit check" of your satellite in the EQUALIZER Deployer. This can be a stripped-down model mainly showing the main body and any deployable appendages (e.g. antennas, solar panels). We will also need to know inhibit switch throw details (e.g. location of switches, amount of travel needed for activation) for the EQUALIZER Deployer tolerance stack up analysis.

1.6.3 Radio Frequency License Application

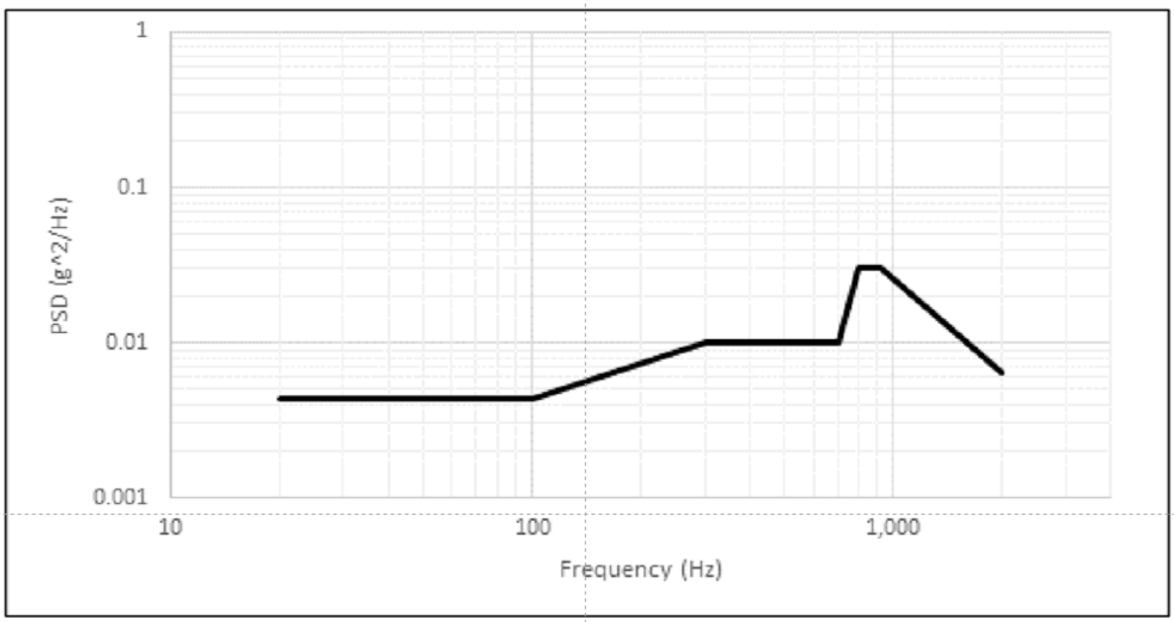
Please supply the country of origin radio license application (FCC if in US), or NTIA application and the ITU notification for each on-board radio and ground station you plan to use. Preliminary submittal license application will be acceptable, followed by the final approval prior to satellite turnover. **No satellites will be loaded on the launch vehicle without appropriate licensing.**

1.7 Data Call Phase III (Required 1.5 Months Before Hardware Turnover)

1.7.1 Vibration Test Report

A vibration test of your satellite may be required if the satellite has frangible materials (e.g. solar cells). The following spectra are the minimum required for this test (60 seconds in each axis). See Table 1-4 (courtesy SpaceX).

Table 1-4: Random Vibration Environments



Random Vibration MPE

Random Vibration MPE

Frequency (Hz)	Random Vibration MPE (P95/50), All Axes
20	0.0044
100	0.0044
300	0.01
700	0.01
800	0.03
925	0.03
2000	0.00644
GRMS	**5.13**

SEOPS can supply an EQUALIZER Test Deployer (per your request) or you may use any other deployer to perform this test. SEOPS will also accept GEVS level vibration test spectra for this test.

SEOPS can also perform a vibration test at the above 5.13 grms spectra for the customer. This configuration consists of the satellite inside of an EQUALIZER Deployer which is strapped to the vibration table. Testing arrangements will be documented in the finalized contract.

1.7.2 Mass and C.G. Test Report

Provide final as measured satellite mass properties (mass and C.G.).

1.7.3 Propulsion System Test Report (if required)

Inhibit test reports showing the propulsion system inhibits are properly functioning.

1.7.4 Pressurized System Test Report (if required)

Pressurized system test report showing the system survived proof testing and has no leaks for flight.

1.8 EQUALIZER Fit Check (L-4 Months nominal)

SEOPS will coordinate to complete mechanical interface checks between the satellite and the Deployer. Fit checks are conducted with the satellite flight hardware and a SEOPS mockup Deployer. Use of flight-like engineering qualification hardware in lieu of flight models must be coordinated with SEOPS. SEOPS provided vibration testing can be performed at this time.

1.9 Satellite Delivery to SEOPS (L-1.5 months)

The satellite customer will deliver the integrated satellite to the SEOPS Cape Canaveral facility, or another facility as identified in the finalized contract, by approximately L-1.5 months. Any special requirements, such as lifting equipment, ground handling hardware, special handling instructions, ESD sensitivity, etc., will be documented in the finalized contract.

1.10 SEOPS Testing

SEOPS will perform any agreed to testing of the completed assembly based on the finalized contract. This may include, but is not limited to, grounding checks, bonding checks, fit checks, and vibration testing. Any special requirements will be documented in the finalized contract.

1.11 Customer Ground Servicing

The customer can perform last minute checkout activities at the SEOPS facilities prior to final loading if these activities are part of the documented and verified satellite design. No material or design changes are allowed at this phase of the processing. Once the satellite has been delivered to SEOPS, no further satellite servicing will be allowed. Any special requirements will be documented in the finalized contract.

1.12 SEOPS Packaging and Delivery

SEOPS will deliver the loaded Equalizer assembly to SpaceX for incorporation into its launch vehicle.

1.13 Launch

After turnover and integration of the Equalizer Assembly to SpaceX, SpaceX will be responsible for launch of the Equalizer Assembly.

2. Rail Satellite Parameters

2.1 Rail Type Satellites

1U, 2U, 3U, 6U, and 12U rail satellites are compatible with EQUALIZER. Optional "tuna can" is also compatible. See Figures 2-1a and 2-1b. Note: Non-standard payloads may be considered.

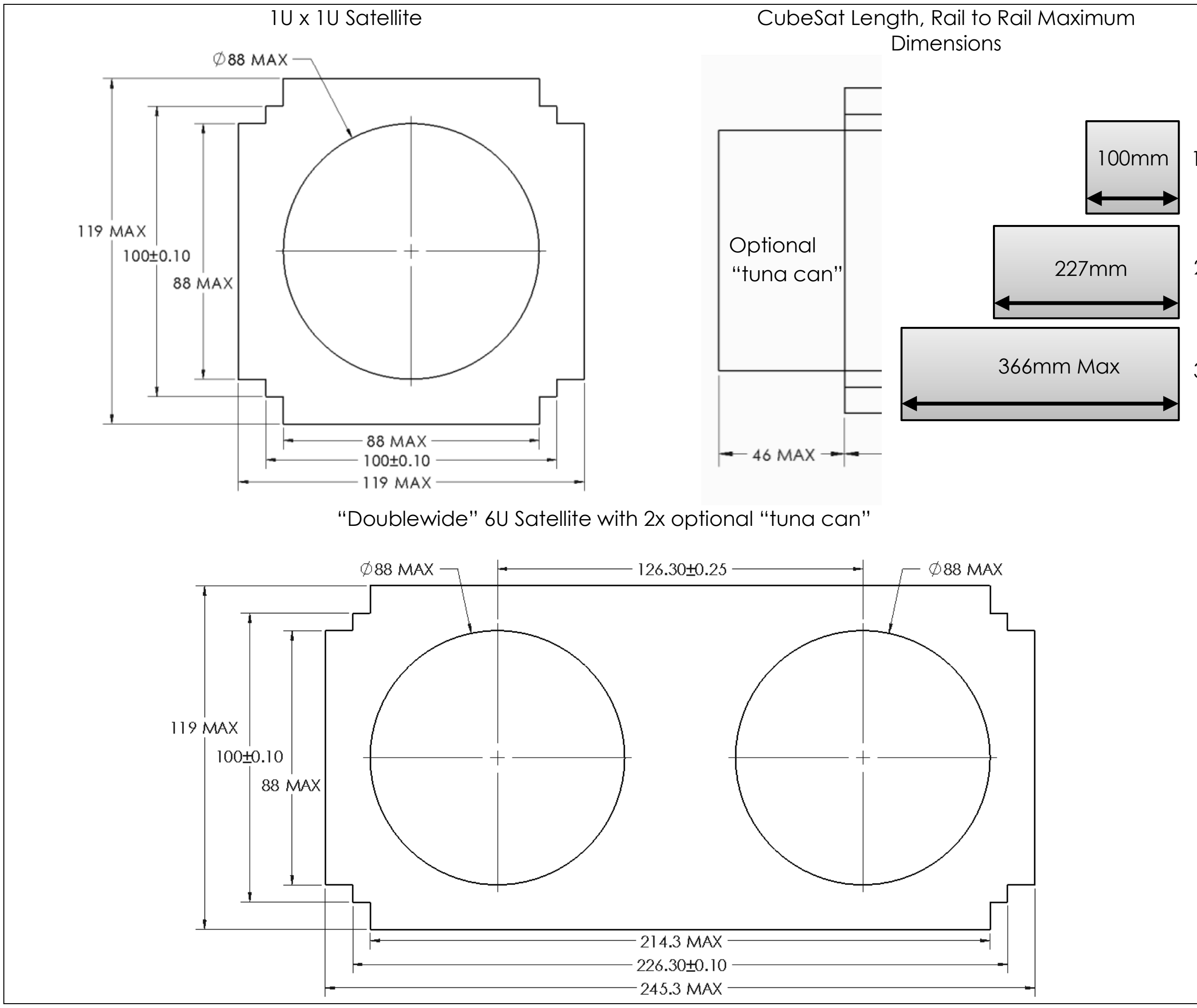
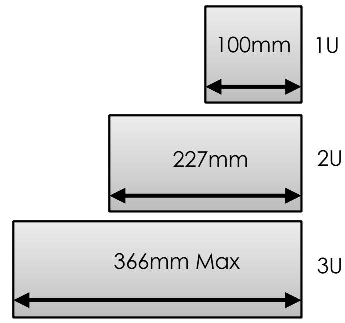


Figure 2-1a: Rail Type Satellite Parameters

12U Satellite with 4x optional “tuna can”

CubeSat Length, Rail to Rail Maximum Dimensions



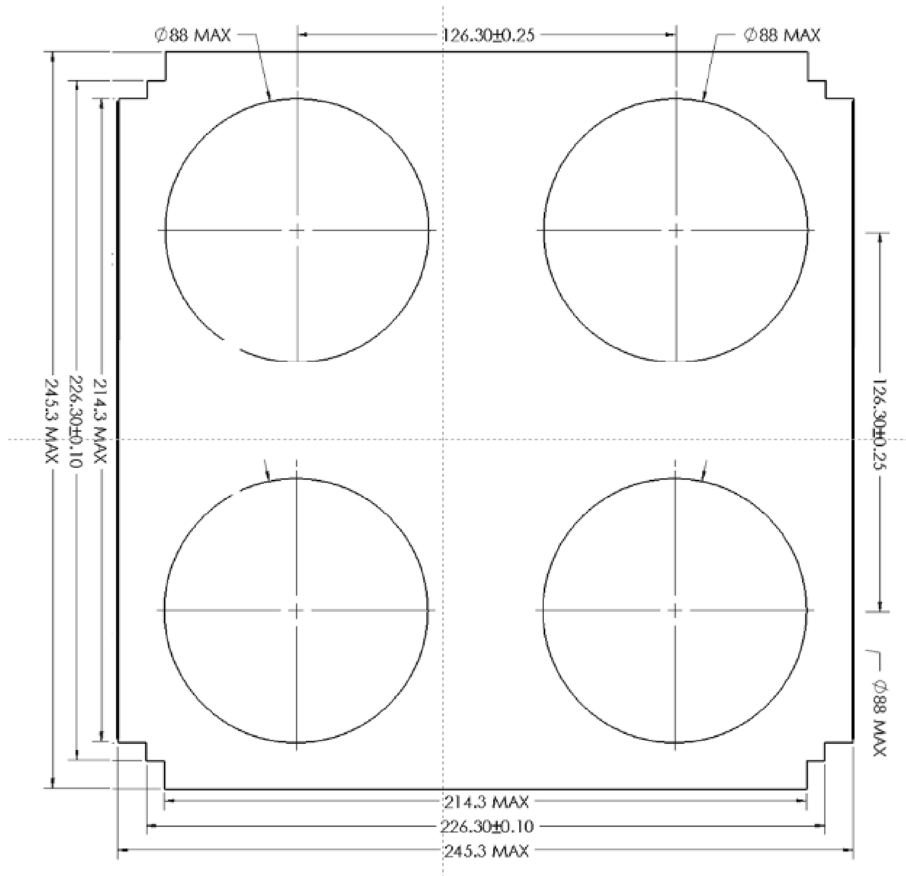
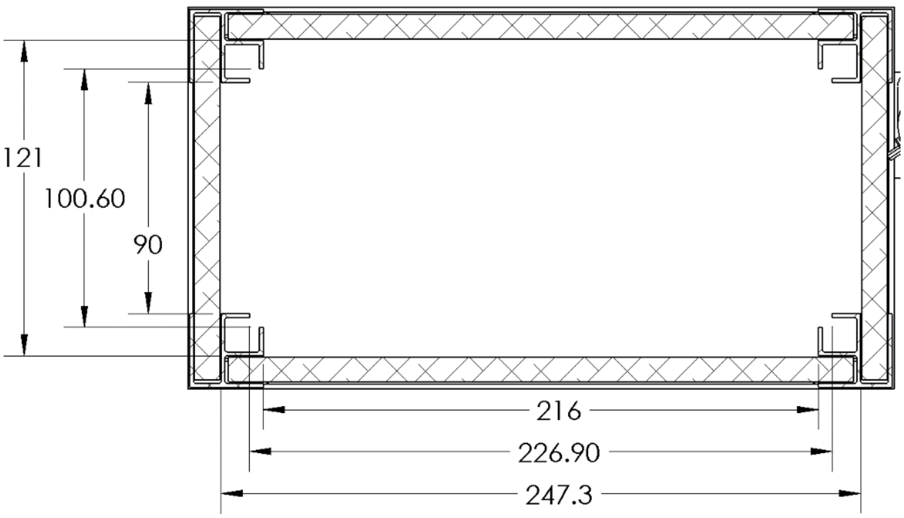


Figure 2-1b: 12U Rail Type Satellite Parameters

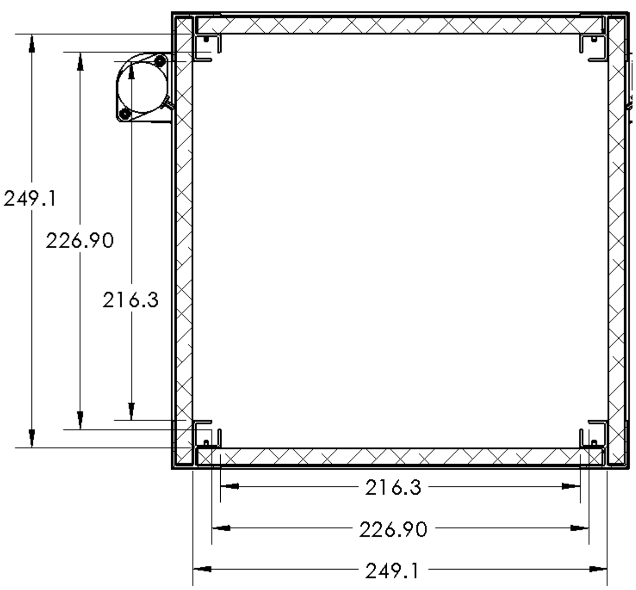
2.2 Deployer Interface, Rail Type

After your satellite is integrated there will be no gap at the Y+ end of the satellite as the deployer pusher plate will push the satellite up to the door and the pusher plate will be secured with a locking jamb nut. The satellite will be contacted via rails in the deployer. See Figure 2-2.

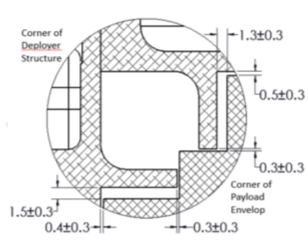
Satellite Rail Contact and fit (max volume shown)



6U Rail Deployer



12U Rail Deployer



"Doublewide" 6U Rail Contact and fit (max volume shown)

Figure 2-2: Deployer Interface, 6U and 12U Rail Type Satellites

3. Tab Satellite Parameters

3.1 Tab Type Satellites

6U/12U tab satellites are compatible with EQUALIZER. Optional "tuna can" is also compatible. This deployer is mechanically compatible with satellites that follow the 2002367 PSC specification, contact SEOPS with regards to this compatibility. See Figures 3-1a1, 3-1a2, 3-1b1 and 3-1b2. Note: Non-standard payloads may be considered.

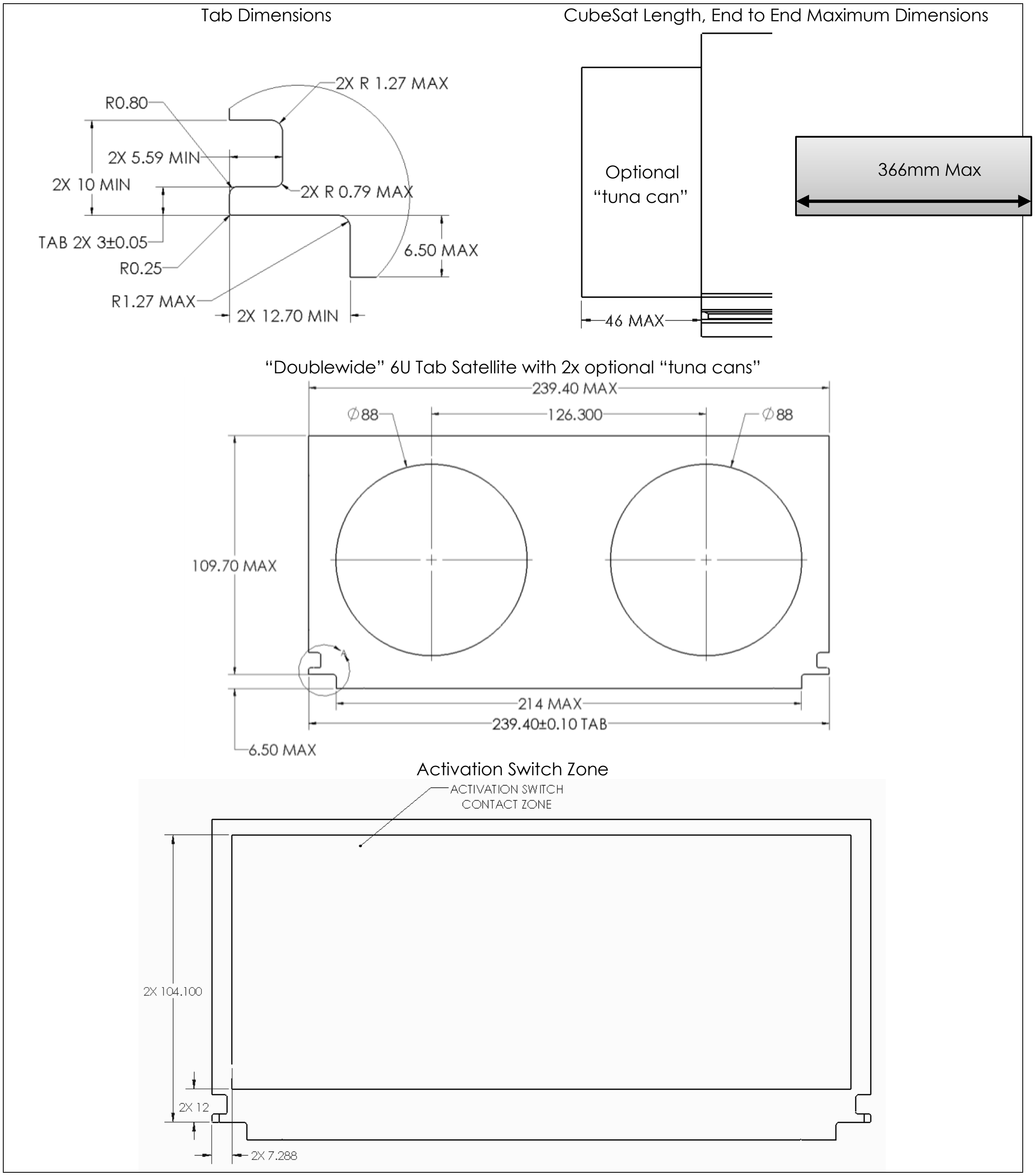


Figure 3-1a1: 6U Tab Type Satellite Parameters

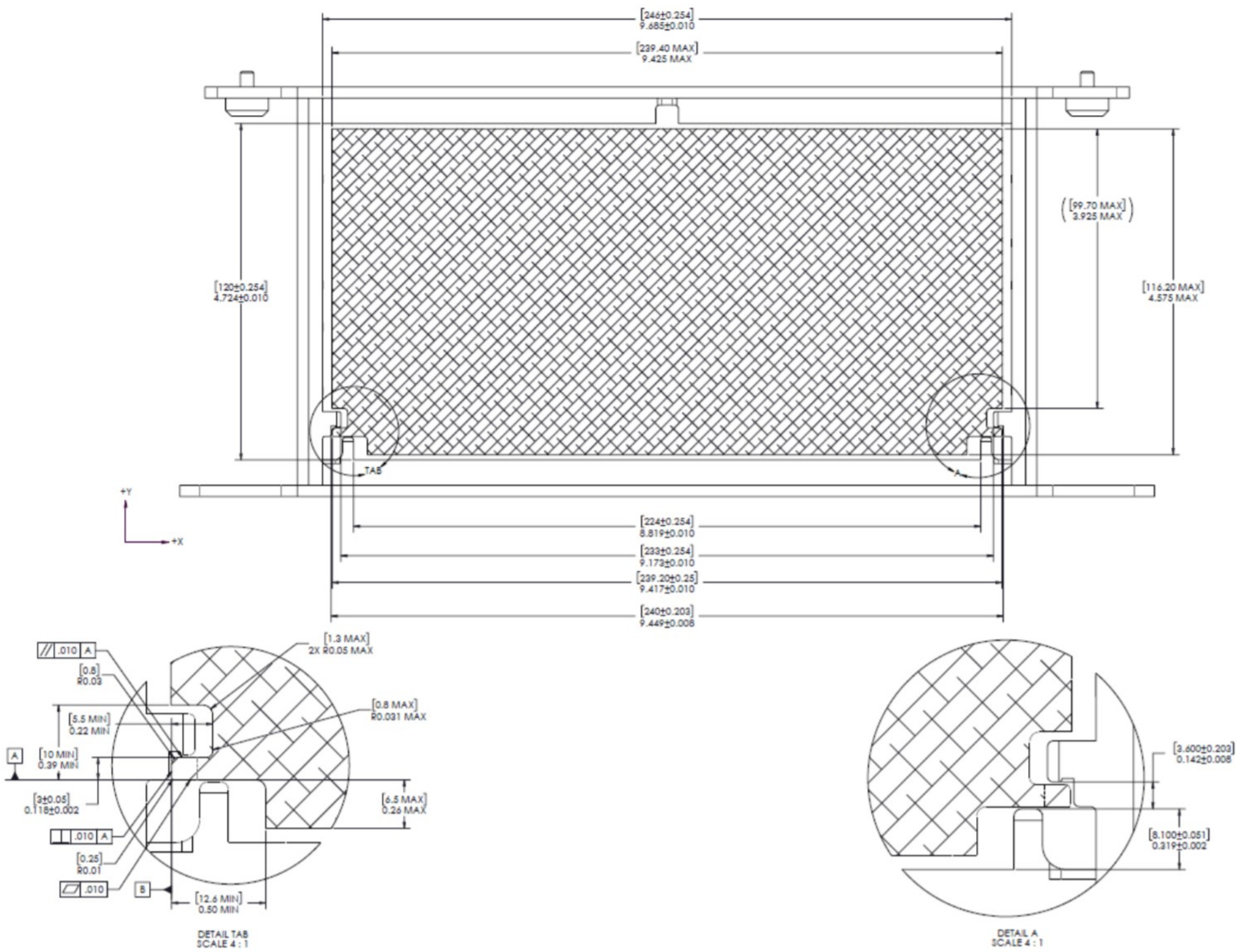


Figure 3-1a2: 6U Deployer Parameters

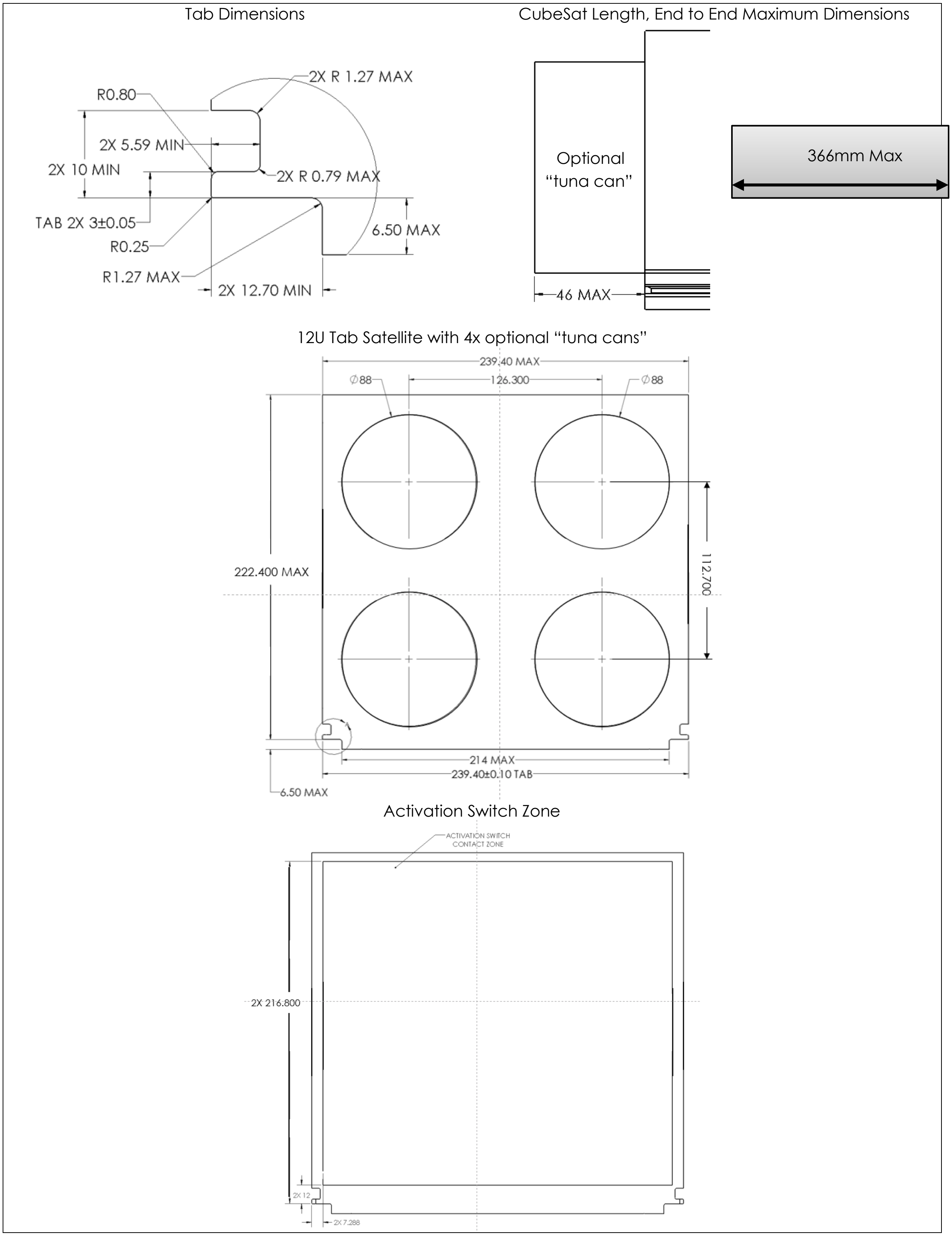


Figure 3-1b1: 12U Tab Type Satellite Parameters

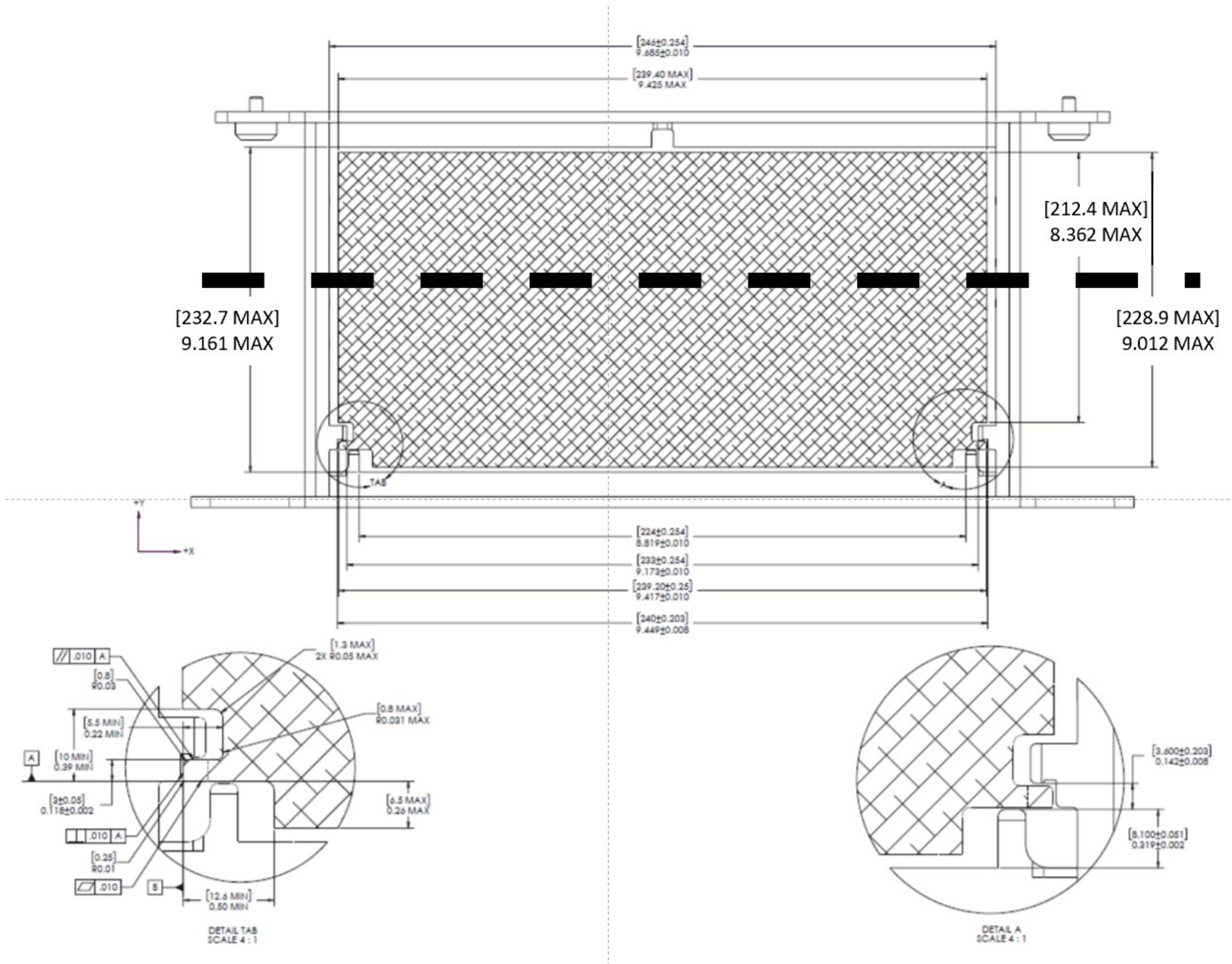


Figure 3-1b2: 12U Deployer Parameters

4. Inhibit/Activation Switches

4.1 Activation Switches

1) The CubeSat shall have a minimum of one (1) deployment switch that correspond to independent electrical inhibits on the main power system (see section on electrical interfaces).
2) Tab Format CubeSats deployment switches shall all be located on the same face of the payload at the front or the back of the CubeSat (+/-Y face) as defined in Figure 1-2. Rail Format CubeSat deployment switches can be of the pusher variety, located on the +/–Y rail ends/load regions, or roller/lever switches embedded in a CubeSat rail and riding along the guide rails in the +/-X and Z axes.
3) The CubeSat deployment switches in the +/-Y axes shall engage / actuate with sufficient travel beyond that of the plane of the tab and load points in either the +/- Y end of the payload. Note: The travel of each deployment switch relative to the applicable plane shall be characterized prior to integration with the Deployer and approved by SEOPS.
4) Rail Format CubeSat deployment switches that utilize the Deployer rails in the +/-X and Z axes as the mechanical interface shall have a minimum actuation travel of 1 mm to accommodate for design tolerance extremes of the CubeSats and Deployer rails. Note: Experience with roller / lever switches along the rails has shown them to be less reliable and subject to more rigging issues and damage during satellite handling.
5) The CubeSat deployment switches shall reset the payload to the pre-launch state if cycled at any time within the first 30 minutes of the switches closing (including but not limited to radio frequency transmission and deployable system timers).
6) The CubeSat deployment switches shall be captive.
7) For plunger switches used in the +/-Y axis or roller switches used in the +/-X and Z axes, the total force of the switches shall not exceed 18N.
8) Rail Format CubeSat deployment switches that utilize the Deployer rails in the +/-X and Z axes as the mechanical interface shall maintain a minimum of 75% (ratio of roller/slider-width to guiderail width) contact.

5. Satellite Access

Satellite access is not provided with the Equalizer Deployer after loading of the satellite.

6. Mechanical Requirements

6.1 Safe/Arm plug

If necessary, shall reside in specified access zones.

6.2 Deployables

All deployables must be constrained during deployment via burn wires or other mechanisms. This requirement may be waved after review from SEOPS.

6.3 Debris

No debris shall be generated that will inhibit separation.

6.4 Satellite Dimensions

The maximum dimensions stated in this document are the satellite's dynamic envelope and shall include all load cases (vibration, thermal, acoustic, etc.).

6.5 Plating Clearance

Maximum dimensions stated in this document apply after plating on all surfaces.

6.6 Appendages Constraint

No appendages or any part of the satellite shall contact the walls of the Deployer, pending SEOPS review.

6.7 Rail Specific Requirements

6.7.1 Plungers

Rail end separation plungers (example 3.2.17 Cal Poly CubeSat Design Specification Rev 13) must be removed before integration with the Deployer.

6.8 Tab Specific Requirements

6.8.1 Materials

Tabs shall be aluminum alloy with yield strength ≥56ksi. 7075-T7351 is common but numerous other alloys also meet this strength requirement.

6.8.2 Tab Envelope

The two tabs and the structure that contacts the Deployer doors on the Y+ face (see Figures 3-1a1, 3-1a2, 3-1b1 and 3-1b2) are the only required features of the satellite. The rest of the satellite may be any shape that fits within the maximum dynamic envelope. The minimum contact shown can be reviewed by SEOPS to verify the satellites compatibility with the Deployer as it is possible to have contact anywhere along the indicated area so long as it gives contact to properly constrain the satellite during launch and does not interfere with deployment.

7. Materials

7.1 Stress Corrosion Materials

Stress corrosion resistant materials used from MSFC-SPEC-522 are preferred. Table II materials will be reviewed by SEOPS and Table III materials shall be avoided.

7.2 Hazardous Materials

Any hazardous materials must be coordinated with SEOPS. The Hazardous Materials Table can be found at https://www.law.cornell.edu/cfr/text/49/172.101.

7.3 Bill of Materials

A bill of materials (BOM) must be provided to SEOPS to verify the type of materials used and material masses.

8. Electrical

8.1 Electrical System Design and Inhibits

All Electrical power shall be internal to Satellites. Satellite systems must be safe without Electrical services. Satellite electronics systems design shall adhere to the following requirements.

1) The Satellite operations shall not begin until a minimum of 30 minutes after deployment. Only an onboard timer system may be operable during this 30-minute post deploy time frame. Any timer operation initiated by satellite inhibits must automatically reset should inadvertent separation switch operation occur.
2) If activation of the satellite creates a hazard (e.g. activation of a powerful radio transmitter, activation of propulsion system, activation of a non-eye safe laser, etc.) the Satellite Electrical system design shall incorporate a minimum of three (3) inhibit switches actuated by physical deployment switches as shown in Figure 1-4. If activation of the Satellite does not present a hazard to ground crew or hardware one or two inhibit switches are satisfactory. Contact SEOPS for further clarification.
3) The Satellite Electrical system design shall not permit the battery charging circuit to energize the satellite systems (load), including flight computer. See Figure 1-4. This restriction applies to all charging methods.
4) Remove Before Flight (RBF) pins are required. Arming switch or captive jumpers may be an acceptable alternative; contact SEOPS.

5) The RBF pin shall prevent any power from any source operating any satellite functions except for pre-integration battery charging.
6) RBF pins must be capable of remaining in place during integration with the Deployer.
7) All RBF pins, switches, or jumpers utilized as primary Electrical system and RBF inhibits must be accessible for removal just prior to closure of the Deployer.

8.2 Batteries

Battery requirements for the Equalizer system are derived from the 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. The required provisions encompass hazard controls, design evaluation, and verification. Evaluation of the battery system must be complete prior to certification for flight and ground operations. To support this objective information on the battery system must be provided to SEOPS as soon as possible. For example, certain battery cell chemistries and battery configurations may trigger higher scrutiny to protect against thermal runaway propagation. It is imperative that SEOPS receive all requested technical data as early as possible to assure the necessary safety features are present to control the hazards associated with a particular battery design. True in nearly every case, redesign efforts greatly impact the satellite developer both in cost and schedule. This can often be avoided by consulting with SEOPS before hardware is actually manufactured (if possible). Cell/Battery testing associated with the verification of the safety compliance must be completed prior to safety certification of the spacecraft. To be compliant to the requirements herein, every battery design, along with its safety verification program, its ground and/or on-orbit usage plans should be evaluated and approved by the customer and SEOPS.

8.2.1 Battery Hazards

The possible sources of battery hazards are listed below and shall be identified for each battery system. Applicable hazards will be evaluated to determine and to identify design, workmanship, and other features to be used for hazard control (Electrical, mechanical, and/or thermal).

Potential Battery Hazards:

1. Fire/Explosion Hazard
2. Flammability
3. Venting of Battery Enclosure
4. Burst of Pressurized Battery Chemistries
5. Overcharge Failure/Over-discharge Failure
6. External Short Circuit
7. Internal Short Circuit Failure
8. Thermal Runaway Propagation
9. Chemical Exposure Hazards
10. Mechanical Failure
11. Seals and Vents
12. Electrical Hazards
13. Extreme Environment Temperature Hazards

8.2.2 Battery Types

Battery types typically used in spacecraft include:

1. Alkaline-manganese primary
2. LeClanche (carbon-zinc) primary
3. Lead-acid secondary cells having immobilized electrolyte
4. Lithium/lithium-ion polymer secondary (including lithium-polymer variation)
5. Lithium metal anode primary cells having the following cathodic (positive) active materials:
6. Poly-carbon monofluoride
7. Iodine
8. Manganese dioxide
9. Silver chromate
10. Sulfur dioxide (external to habitable spaces only)
11. Thionyl chloride
12. Thionyl chloride with bromine chloride complex additive (Li-BCX)
13. Iron disulfide
14. Lithium sulfur
15. Mercuric oxide-zinc primary

16. Nickel-cadmium secondary
17. Nickel-metal hydride secondary
18. Silver-zinc primary and secondary
19. Zinc-air primary
20. Sodium-sulfur secondary (external to habitable space)
21. Thermal batteries

Note: Pressurized battery chemistries require coordination with SEOPS.

8.2.3 Required Battery Flight Acceptance Testing

Acceptance screening tests are required for all cells intended for flight to ensure the cells will perform in the required load and environment without leakage or failure.

8.2.4 Internal Short

Protection circuity and safety features shall be implemented at the cell level.

1. Application of all cells shall be reviewed by SEOPS.
2. Charger circuit and protection circuit schematics shall be reviewed and evaluated for required failure tolerance.

8.2.5 External Short Circuit

1. Circuit interrupters that are rated well below the battery's peak current source capability should be installed in the battery power circuit. Interrupters may be fuses, circuit breakers, thermal switches, PTCs, or other effective devices. Circuit interrupters other than fuses should be rated at a value that is equal to or lower than the maximum current that the cell is capable of handling without causing venting, smoke, explosion, fire, or thermal runaway.
2. The battery case is usually grounded/bonded to the structure; the interrupters should be in the ground (negative) leg of a battery where the negative terminal is connected to ground. Where the circuit is "floating," as in plastic battery cases used in those for portable electronic devices, the circuit interrupters can be placed in either leg. In either case, the circuit interrupters should be placed as close to the cell or battery terminals as the design will allow maximizing the zone of protection.
3. All inner surfaces of metal battery enclosures shall be anodized and/or coated with a non-Electrically conductive electrolyte-resistant paint to prevent a subsequent short circuit hazard.
4. The surfaces of battery terminals on the outside of the battery case shall be protected from accidental bridging.
5. Battery terminals that pass-through metal battery enclosures shall be insulated from the case by an insulating collar or other effective means.
6. Wires inside the battery case shall be insulated, restrained from contact with cell terminals, protected against chafing, and physically constrained from movement due to vibration or shock.
7. In battery designs greater than 50 Vdc, corona-induced short circuits (high-voltage induced gas breakdown) shall be prevented.

8.2.6 Battery Charging

Battery charging is not permitted on the launch vehicle and must be performed on the ground prior to hardware turnover, including in the Deployer.

8.3 Radio Transmitter System

Satellite providers shall fill in the following table of RF transmitter parameters to evaluate any potential hazards.

Table 8-1: RF Transmitter Details

Transmitter Specification	
Manufacturer	
Model	Model #: S/N:
Maximum power output to antenna [W]	
Maximum transmitter field strength (volts/meter); assume 1 meter from the source and transmitter radiating with deployed antenna	
TX Manufacturer	
TX Model No	
TX Antenna Manufacturer	
Antenna Gain: [dBi]	
Frequency Upper [MHz]	
Frequency lower [MHz]	
Circuit Loss: [dB]	
Antenna Type: Other, dipole, helix, horn, loop, monopole, patch, phased array, reflector, slot, spiral	
Antenna Polarization: Other, Horizontal, Left Handed Elliptical, Right Handed Elliptical, Vertical	
Antenna Axial Ratio: [dB]	
Antenna location with respect to CubeSat body	

8.4 Electromagnetic Interference for On-Orbit

Satellites may be exposed to the following EMI environment on the SpaceX Falcon 9.

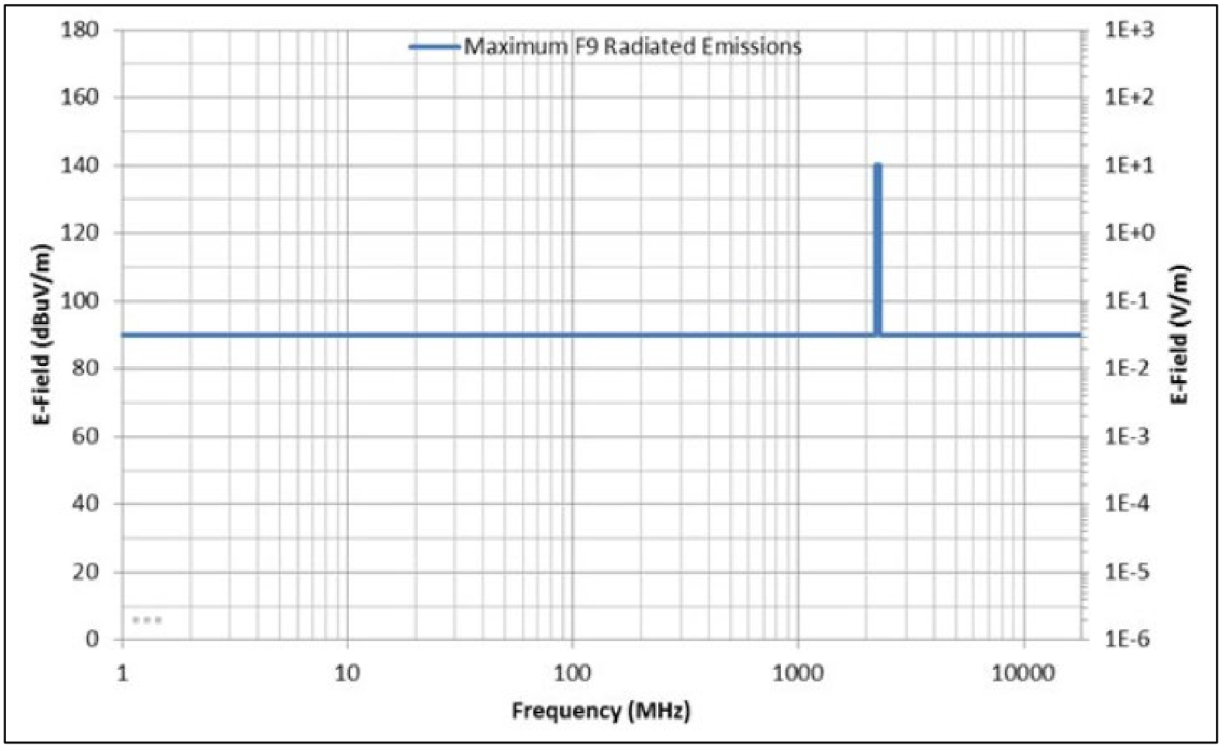


Figure 3-5: Launch Vehicle Radiated Emissions

Table 3-8: Launch Vehicle Radiated Emissions

Frequency Range (MHz)	E Field Limit (dBµV/m)	Launch Vehicle Transmit System
1.00 – 2200.0	90	
2200.0 – 2300.0	140	S-band telemetry and video
2300.0 – 18000.0	90	

Figure 8-1 Launch Vehicle RF Emissions (courtesy SpaceX)

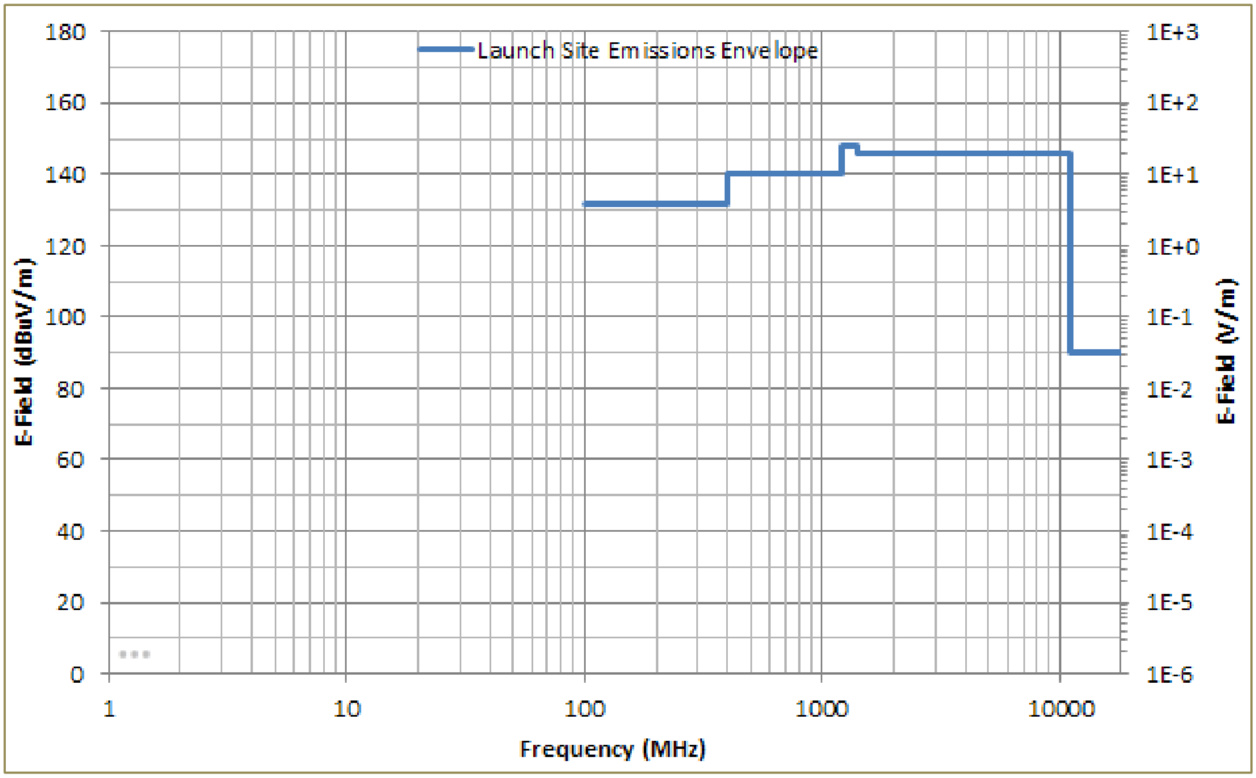


Figure 3-6: Launch Site Emissions

Table 3-9: Launch Site Emissions

Frequency Range (MHz)	E Field Limit (dBμV/m)
100 – 400	132
400 – 1200	140
1200 – 1400	148
1400 – 11000	146
11000 – 18000	90

Figure 8-2 Launch Site RF Emissions (courtesy SpaceX)

9. Propulsion Systems

9.1 Propulsion System

The propulsion system will need to be assessed for hazard potential. SEOPS will assist in the identification of hazards. Mechanical hazards may be related to pressure containment, flow containment, leakage, etc. Systems may also have hazard potential if inadvertent operation of the propulsion system could cause a collision hazard. Depending on hazard potential, both mechanical and electrical fault tolerance may be required.

Systems with toxic or explosive propellants must be coordinated with SEOPS.

9.2 Pressure Vessels

Pressure vessels (i.e. any vessel able to hold more than 2 atm of pressure at any time in its operation) must be coordinated with SEOPS. Providers should expect to provide documentation with respect to the materials used, tank history (including cycles and life time assessment) and control measure to assure tank integrity (damage control plan), testing performed, fracture control measures planned, inspection process and methods, etc. wherever hazard potential is present. All pressure vessels shall be DOT certified or have a DOT issued waiver for transportation across the U.S. Use of non-DOT certified pressure vessels generally is not be permitted. Exceptions must be coordinated with SEOPS. Systems will have to demonstrate via test that required factors of safety are present for tanks, lines and fittings that can be exposed to maximum design pressure. Pressure vessels and components procured from third party vendors must have proper certification records or the customer must develop the appropriate records to assure that the systems are safe for satellite use.

10. Environments

10.1 Ground Handling and Transportation Loads

Satellite safety-critical structures shall (and other satellite structures *should*) provide positive margins of safety when exposed to these accelerations.

Table 10-2: Ground Handling and Transportation Load Factors

	Nx (g)	Ny (g)	Nz (g)	Rx (rad/sec^2)	Ry (rad/sec^2)	Rz (rad/sec^2)
I (1,2)	+/- 5.0	+/- 3.5	+2.0/ -3.5	N/A	N/A	N/A
S (1,2)	+/-2.0	+/- 2.0	+2.0/ -3.5	N/A	N/A	N/A

Notes:

1) The reference frame for the ground handling and transportation load factors with respect to the directions of motion is as follows:

   X: Longitudinal direction along axis of motion.

   Y: Y axis is perpendicular to the x and z axes and completes the right-handed coordinate system.

   Z Z axis is perpendicular to the x and y axis. Positive direction is vertically upward. Gravity (g) is acting in the z axis in the negative direction.

2) (I) indicates that the loads occur independently in the three directions (except for gravity). (S) indicates that the loads occur simultaneously.

3) These levels envelope the maximum ground handling and transportation loads.

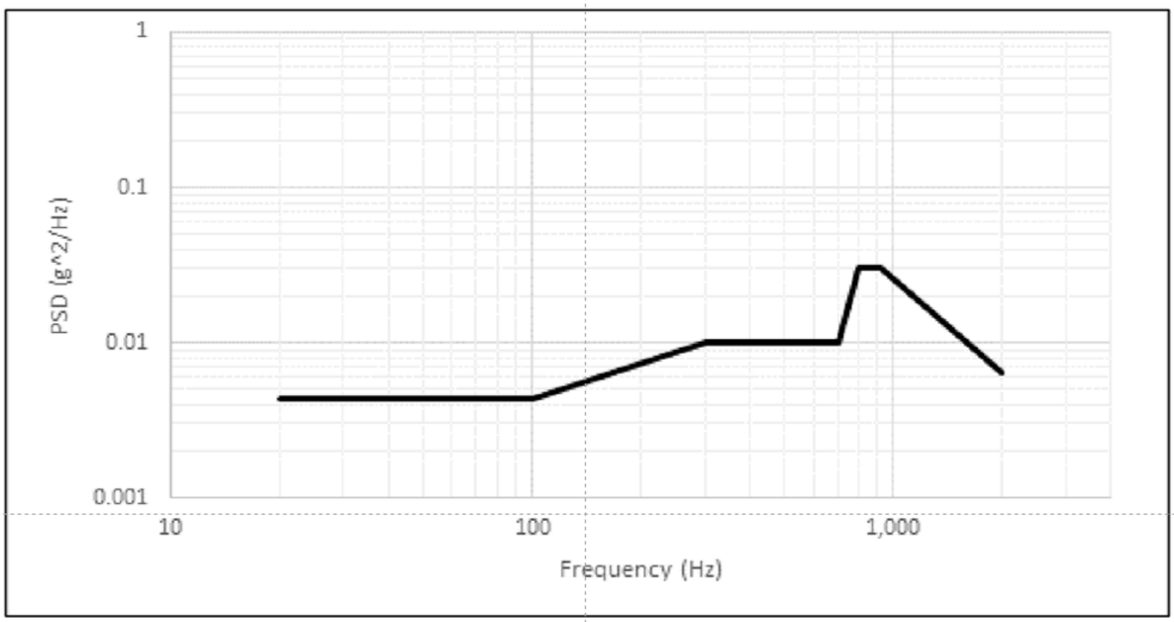
10.2 Acceleration Loads

Satellite safety-critical structures shall (and other satellite structures *should*) provide positive margins of safety when exposed to 9G's in all axes.

10.3 Random Vibration Environment

See Table 10-2 (courtesy SpaceX).

Table 10-2: Random Vibration Environments



Random Vibration MPE

Random Vibration MPE

Frequency (Hz)	Random Vibration MPE (P95/50), All Axes
20	0.0044
100	0.0044
300	0.01
700	0.01
800	0.03
925	0.03
2000	0.00644
GRMS	5.13

Table 2.4-3
Generalized Random Vibration Test Levels
Components (ELV)
22.7-kg (50-lb) or less

Frequency (Hz)	ASD Level (g^2/Hz)	
	Qualification	Acceptance
20	0.026	0.013
20-50	+6 dB/oct	+6 dB/oct
50-800	0.16	0.08
800-2000	-6 dB/oct	-6 dB/oct
2000	0.026	0.013
Overall	14.1 G_{rms}	10.0 G_{rms}

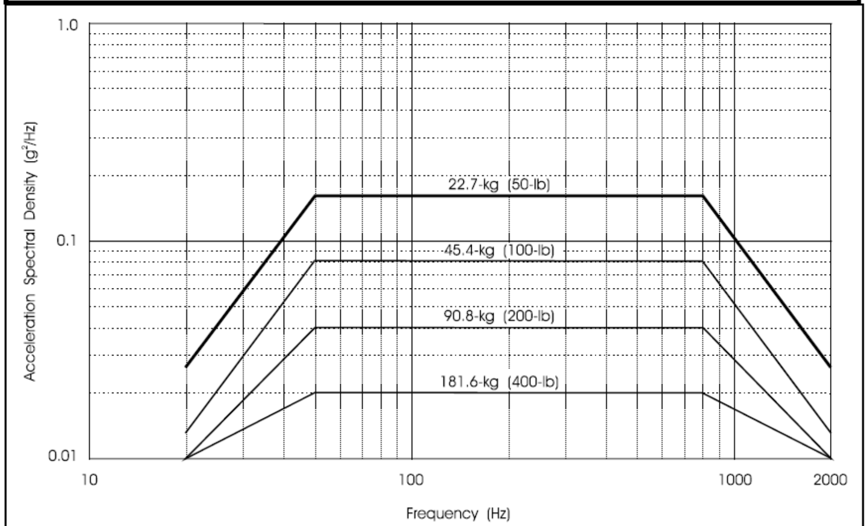
The acceleration spectral density level may be reduced for components weighing more than 22.7-kg (50 lb) according to:

	Weight in kg	Weight in lb	
dB reduction	= 10 log(W/22.7)	10 log(W/50)	
$ASD_{(50\text{-}800\ Hz)}$	= 0.16•(22.7/W)	0.16•(50/W)	for protoflight
$ASD_{(50\text{-}800\ Hz)}$	= 0.08•(22.7/W)	0.08•(50/W)	for acceptance

Where W = component weight.

The slopes shall be maintained at + and - 6dB/oct for components weighing up to 59-kg (130-lb). Above that weight, the slopes shall be adjusted to maintain an ASD level of 0.01 g^2/Hz at 20 and 2000 Hz.

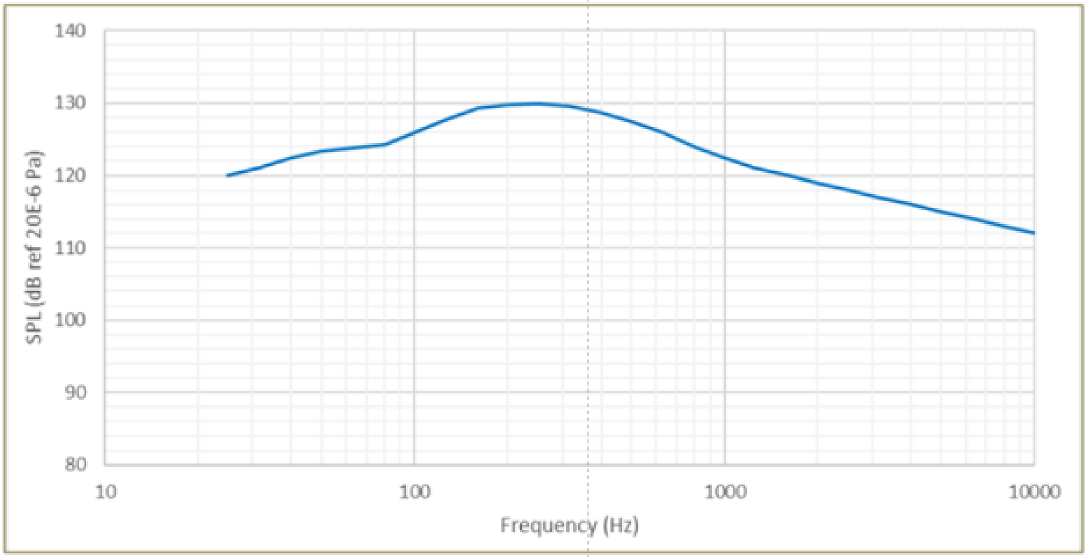
For components weighing over 182-kg (400-lb), the test specification will be maintained at the level for 182-kg (400 pounds).



10.4 Acoustic Environment

See Table 10-3 (courtesy SpaceX) .

Table 10-3: Acoustic Environments



Rideshare Payload Maximum Predicted Acoustic Environment (Third Octave)

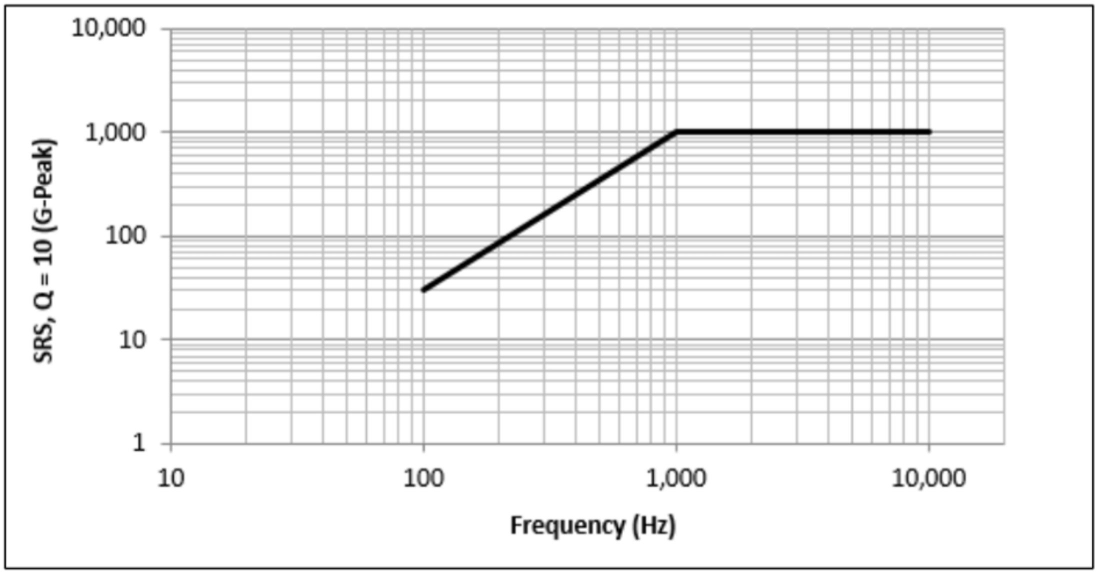
Rideshare Payload Maximum Predicted Acoustic Environment (Third Octave)

Frequency (Hz)	Acoustic MPE (P95/50, Space Average, 60% Fill, 4.1 in. Min Clearance)
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

10.5 Shock Environment

See Table 10-4 (courtesy SpaceX) .

Table 10-4: Shock Environments



Payload Mechanical Interface Shock Induced by Launch Vehicle and Co-Payload(s)

Payload Mechanical Interface Shock Induced by Launch Vehicle and Co-Payload(s)

Frequency (Hz)	SRS (g)
100	30
1000	1000
10000	1000

10.6 Pressure Loading

Integrated end items must maintain positive margins of safety when pressure effects (operational and pressurization/depressurization environments).

Integrated end items shall maintain positive margins of safety and not induce a hazard during or after exposure to a maximum pressure environment of 129.3 kilopascals (kPa) (18.8 pounds per square inch absolute (psia)) and a minimum pressure environment of 0.0 psia. These values are an envelope of the launch vehicle pressure design environments.''

Integrated end items shall maintain positive margins of safety when exposed to a depressurization rate of 13.3 kPa/second (116 pounds per square inch (psi)/minute).

10.7 Temperature

Integrated end items shall meet all performance and safety requirements after being exposed to temperatures ranging from 0 to +50°C (32 to 122°F). This includes the EQUALIZER external environment when mounted on the Falcon 9 Launch Vehicle

10.8 Humidity

Integrated end items shall operate properly after being exposed to a ground processing and launch atmosphere ranging from -34°C (-29.2°F) dewpoint to 90% relative humidity (at 20°C (68°F)).

11. Revision History:

Revision	Release Date	Created By	Approved By
-	7-22-20	MJ	

Revision Matrix

Revision	Section	Change
-	-	INITIAL RELEASE