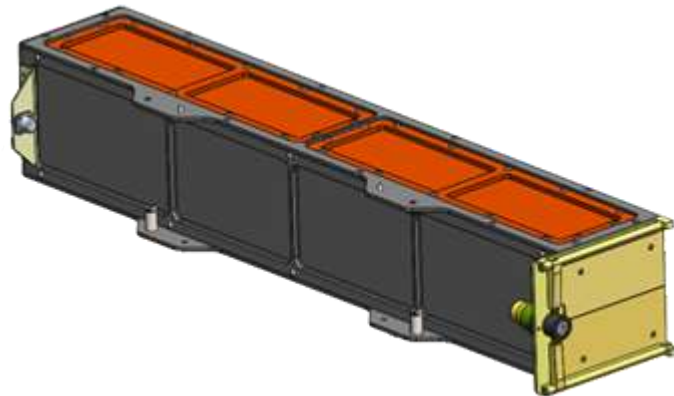


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NanoRacks CubeSat Deployer (NRCSD) Interface Control Document

NanoRacks, LLC
18100 Upper Bay Road, Suite 150
Houston, TX 77058
(815) 425-8553
www.NanoRacks.com



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Acronyms

CTB	Crew Transfer Bag
kgf	kilogram-force
NRCSD	NanoRacks CubeSat Deployer
RBF	Remove Before Flight

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1 Introduction

1.1 Document Purpose

This Interface Control Document (ICD) defines the interface requirements between the NanoRacks CubeSat Deployer (NRCSD) and CubeSats for developers utilizing NanoRacks CubeSat deployment services.

1.2 Scope

The ICD provides the minimum requirements for compatibility with the NRCSD and International Space Station (ISS) flight safety program when using NanoRacks CubeSat deployment services. NanoRacks verifies compliance on behalf of CubeSat developers based on incremental data requests.

2 Timeline

The following timeline of launch-minus dates are provided as template example when using the NanoRacks CubeSat deployment services. Tailored agreements can be discussed as part of contract negotiations.

Launch-minus dates	Activity
L – 12 to 14 months	Contract Signing
L – 10 months	<ul style="list-style-type: none"> • Functional Description • Interface Drawings • Material Identification and Usage List
L – 8 months	First data call to CubeSat developer for ISS safety process
L – 4 months	Environmental testing
L – 1 to 3 months	Delivery to NanoRacks

3 General Requirements

- 1) CubeSats shall be passive and self-contained from the time they are loaded into the NRCSD for transport to the ISS and until after deployment from the NRCSD. No charging of batteries, support services, and or support from ISS crew is provided after final integration.
- 2) CubeSats shall not contain pyrotechnics unless the design approach is pre-approved by NanoRacks. Electrically operated melt-wire systems for deployables that are necessary controls for hazard potentials are permitted.
- 3) CubeSats must have a timer (set to a minimum of 30 minutes) before satellite operation or deployment of appendages. If deploy switches should be released causing the timer to run, the timer must automatically re-set whenever the Remove Before Flight (RBF) feature is replaced and/or the deploy switches are returned to the open state.
- 4) CubeSats should not have detachable parts or create any space debris during launch or normal mission operations.
- 5) CubeSats shall use a secondary locking feature for fasteners external to the CubeSat chassis. An acceptable secondary locking compound is LocTite. Contact NanoRacks for the proper locking compound application procedure. Other secondary locking methods must be approved by NanoRacks.

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- 6) A description of frangible materials (e.g. solar cells) must be provided to NanoRacks for approval.

4 Physical Interfaces

4.1 NanoRacks CubeSat Deployer (NRCSD) Description

The NRCSD is a self-contained CubeSat deployer system that mechanically and electrically isolates CubeSats from the ISS, cargo resupply vehicles, and ISS crew. The NRCSD design is compliant with NASA ISS flight safety requirements and is space qualified.

The NRCSD is a rectangular tube that consists of anodized aluminum plates, base plate assembly, access panels and deployer doors. The NRCSD deployer doors are located on the forward end, the base plate assembly is located on the aft end, and access panels are provided on the top. The inside walls of the NRCSD are smooth bore design to minimize and/or preclude hang-up or jamming of CubeSat appendages during deployment should these become released prematurely. However, deployable systems shall be designed such that there is no intentional contact with the inside walls of the NRCSD.

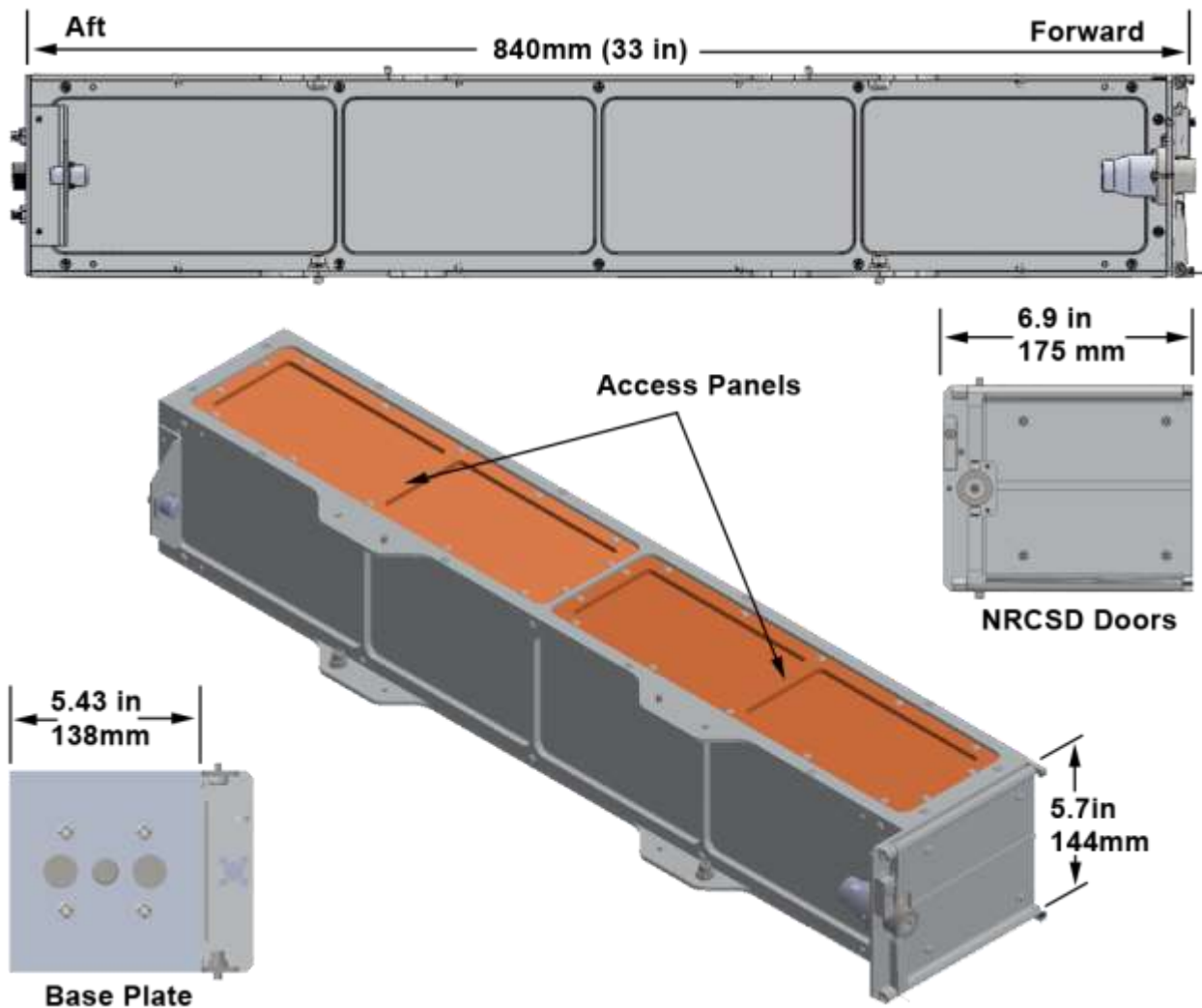


Figure 1 NRCSD

4.2 NRCSD Coordinate System

The coordinate system of the NRCSD is a right-handed system shown in Figure 2. The +X-axis is orientated as shown in the figure, the +Y axis points out of the top of the NRCSD normal to the access panels and the +Z-axis points forward to the NRCSD the deployer doors.

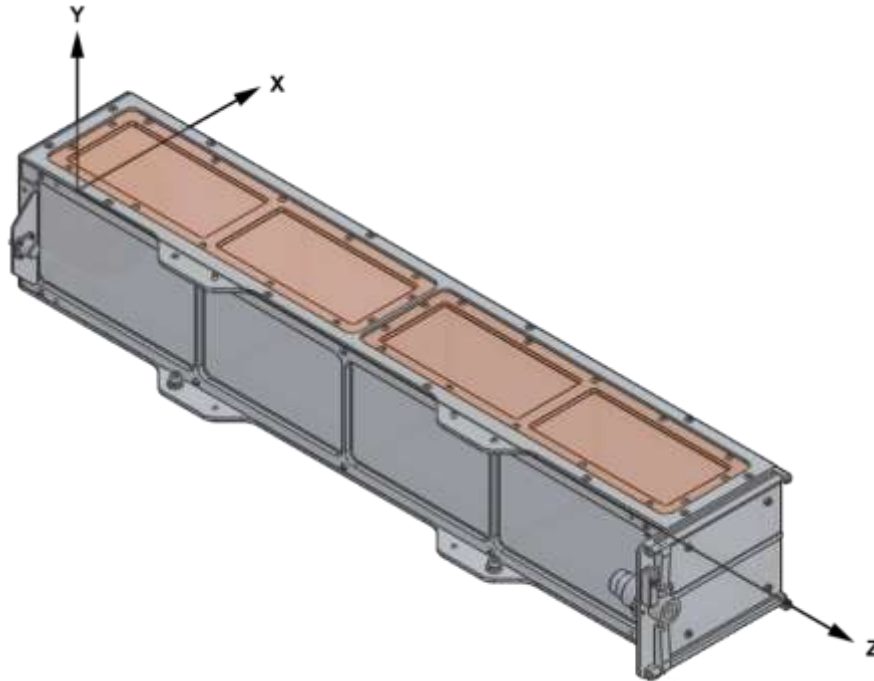


Figure 2 NRCSD Coordinate System

4.3 Access to CubeSat Inhibit Switches and Service Ports

Access for RBF pins and charging systems during the integration process is provided through access panels located on the topside (+Y axis) of the NRCSD as shown in Figure 3. CubeSats are accessible only through the access panels when integrated with the NRCSD.

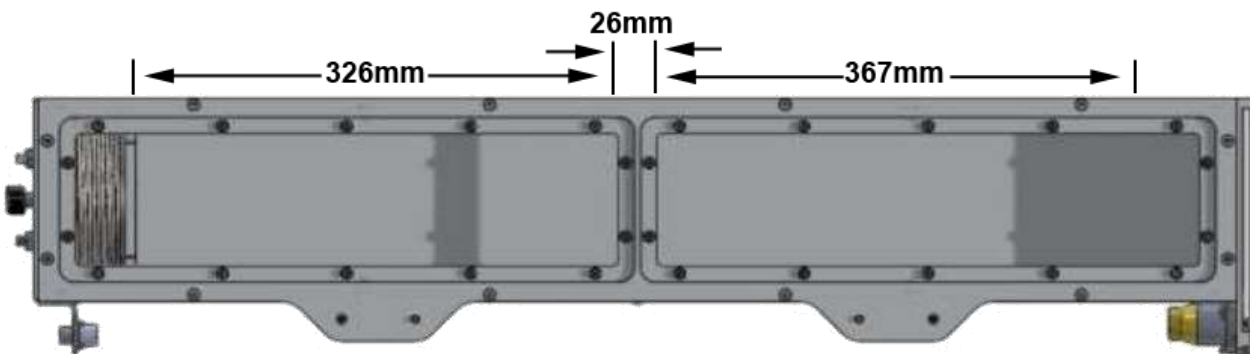


Figure 3: Lateral view of NRCSD and access panel dimensions

4.4 Mass Properties

Mass properties guidelines for CubeSats deployed by NanoRacks are summarized in Table 1. Mass limits are derived from the maximum ballistic number (BN) allowed for ISS deployed payloads. Exceeding

these values requires approval by NanoRacks. The CubeSat center of gravity shall be within 2cm of its geometric center.

Table 1 CubeSat Mass Properties	
Form Factor	Maximum Mass (Kg)
1U	2.82
2U	5.657
3U	8.485
4U	11.314
5U	14.142
6U	16.971

4.5 CubeSat Dimensional Requirements

CubeSats nominal envelope maximum dimensions are shown in Figure 5. No external components other than CubeSat rails or rail roller/slider switch, if used, shall contact the NRCSD interior. Additional envelope provided by a cylindrical recess within the NRCSD pusher plate is available subject to approval.

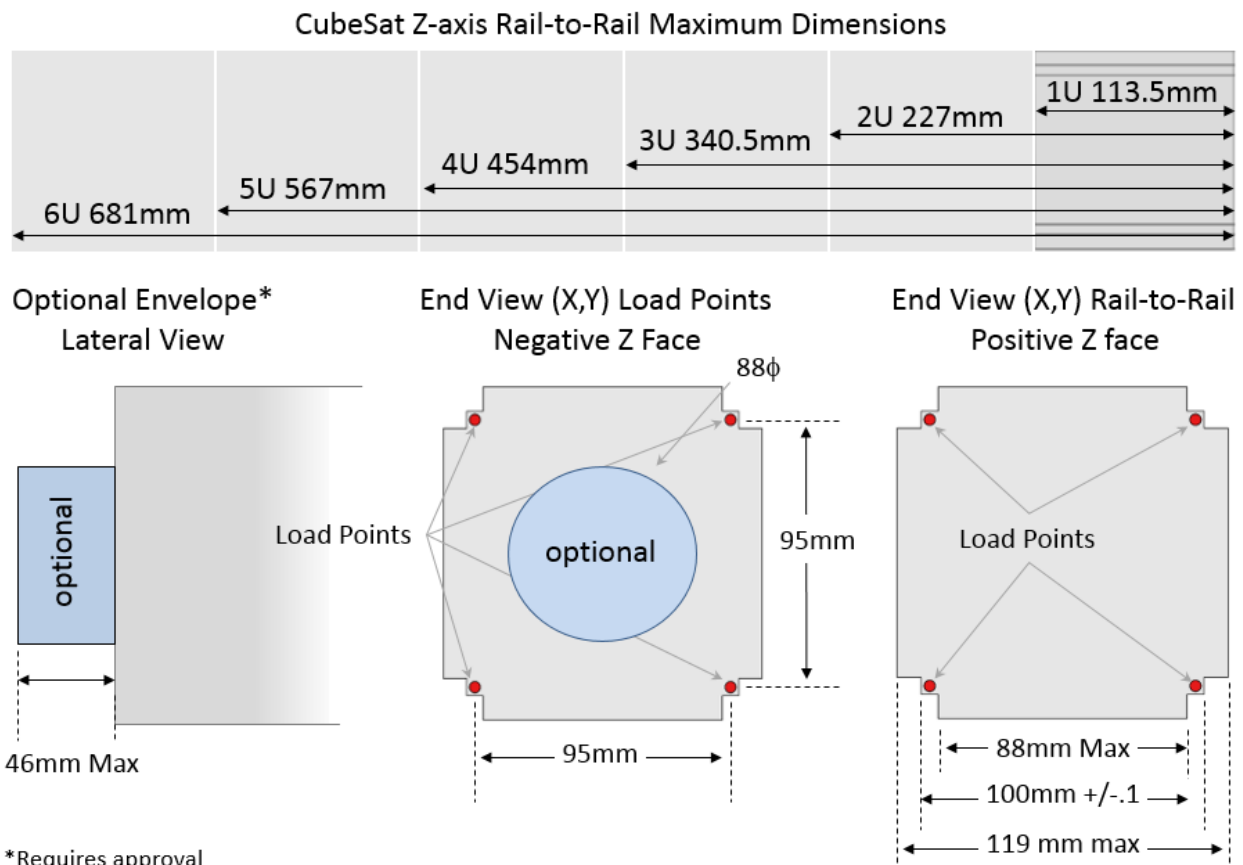


Figure 4 CubeSat Envelope Dimensions

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The clearances between NRCSD guide rails and CubeSat rails is shown in Figure 6.

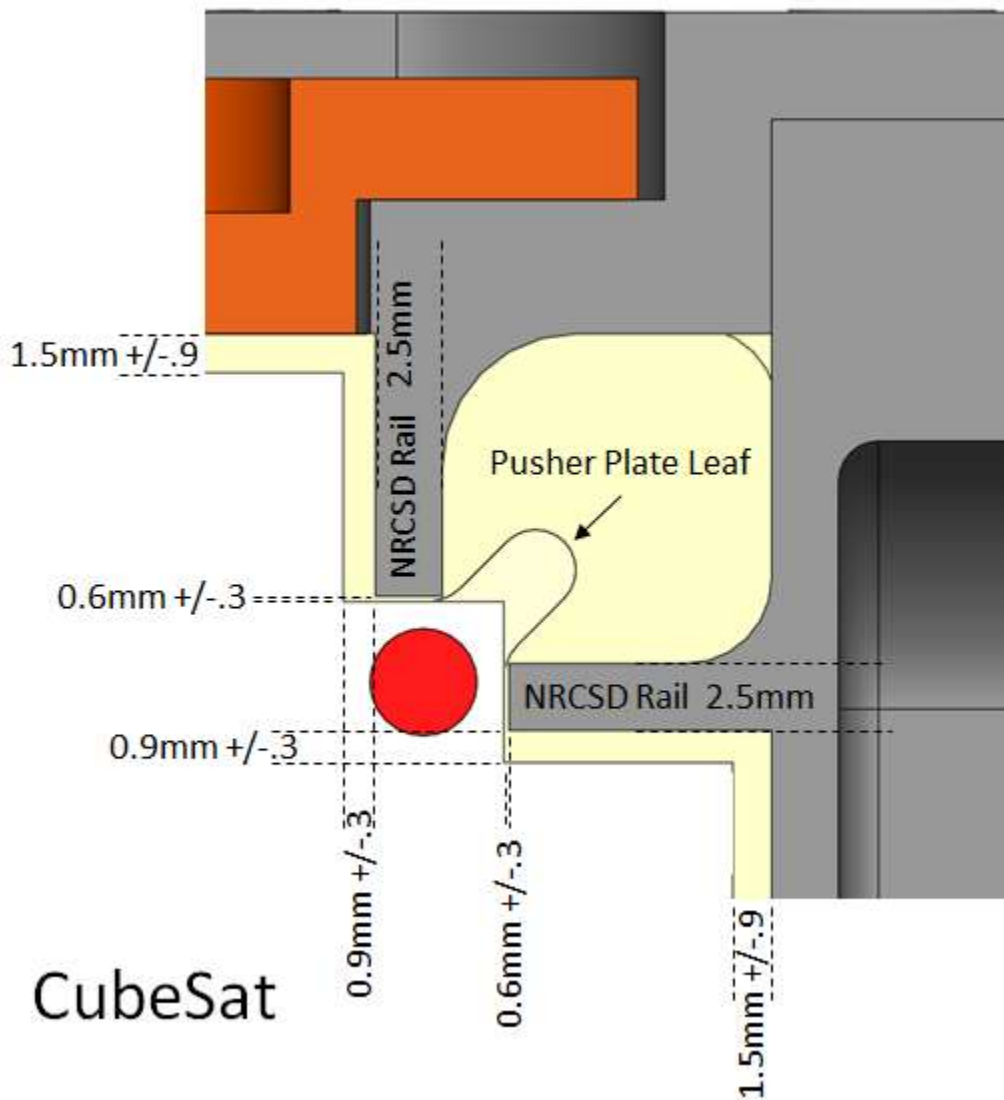


Figure 6 CubeSat Rail and NRCSD Rails Clearances (+Z view, +Y top).

4.6 CubeSat Rails

- 1) A CubeSat shall have four (4) rails, one per corner, along the Z axis.
- 2) Each rail shall have a minimum width of 6mm +0.1mm/ -0.0mm tolerance.
- 3) The edges of the rails shall be rounded to a radius of at least 0.5mm +/- .1mm.
- 4) Each rail end face shall have a minimum surface area of 4mm x 4mm for contact with the adjacent CubeSats.
- 5) The minimum extension of the CubeSat rail standoffs beyond the CubeSat +/-Z face shall be 6.5mm (see Figure 7).

- 6) Rail length variance in the Z axis between rails shall not exceed ± 0.1 mm
- 7) CubeSat rail surfaces that contact the NRCSD guide rails shall have a hardness equal to or greater than hard anodized aluminum (Rockwell C 65-70).

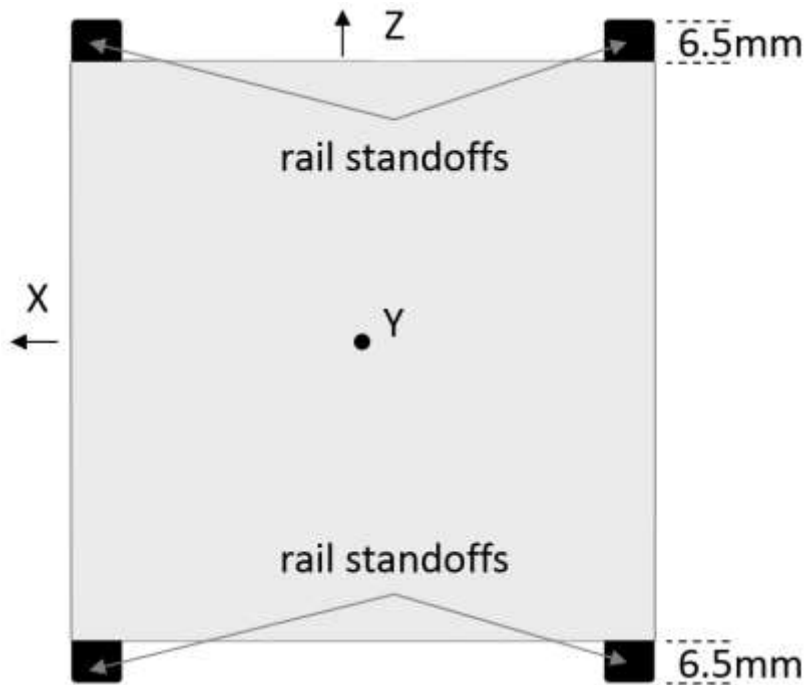


Figure 7 CubeSat Rail Standoff Clearance

- 8) CubeSat developers can verify mechanical compatibility by a fit check with a gauge built to the requirements in Figure 8.

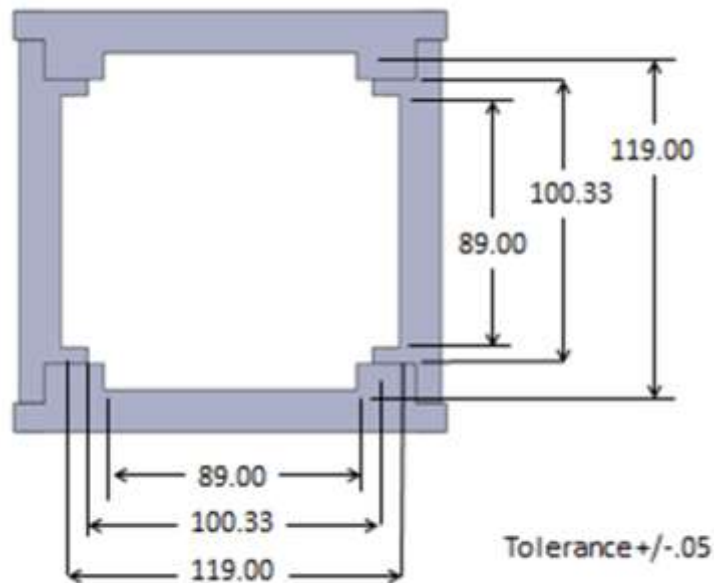


Figure 8 Dimensional fit check gauge cross section view

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4.7 Deployment Switches

- 1) CubeSats shall have a minimum of three (3) mechanical deployment switches corresponding to inhibits in the main electrical system (see section on electrical interfaces).
- 2) Deployment switches can be of the pusher variety, located on the $-Z$ face on one or more of the rail end faces, or roller/lever switches embedded in a CubeSat rail and riding along the NRCSD guide rail.
- 3) A roller or slider shall be centered on the deployer guide rail, allowing for placement accuracy, the roller or slider shall maintain a minimum of 75% (ratio of roller/slider width-to-guide rail width) contact along the entire Z-axis (see Figure 9)
- 4) Deployment switches force exerted shall not exceed 3N.

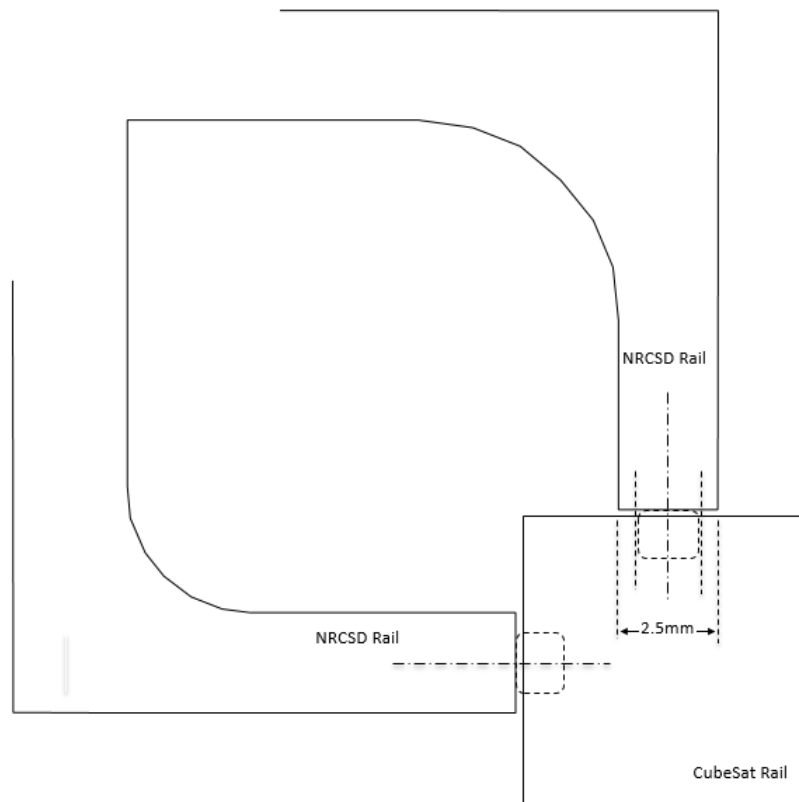


Figure 9 Roller/Slider Switch NRCSD Geometry

4.8 Separation Springs

- 1) CubeSats, except 6U, shall have separation springs. Separation springs shall be located at the $-Z$ end face of a diagonal pair of CubeSat rails as shown in Figure 10.
- 2) Each spring shall be captive. When compressed the spring shall be contained within the maximum rail length. Separation spring and the rail end face alignment are shown in Figure 11.
- 3) Individual separation spring force shall not exceed 3.34 N (0.75 lbs) with the total force for both springs not to exceed 6.67 N (1.5 lbs).

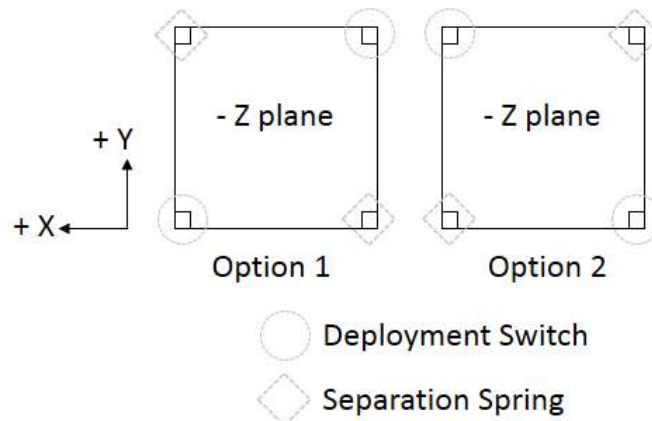


Figure 10 Separation spring placement options

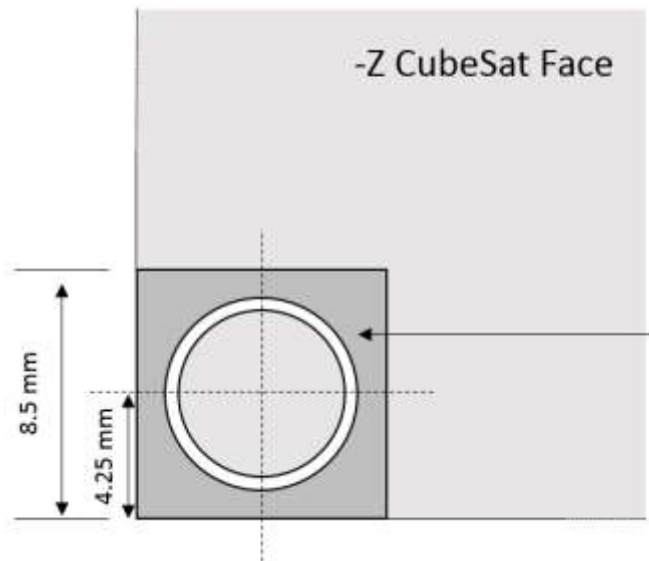


Figure 11 Separation spring rail standoff geometry

4.9 Deployment Compatibility

During deployment, the CubeSats must be compatible with deployment velocities between 0.5 m/s to 1.5 m/s and accelerations no greater than 2g's in the +Z direction.

5 Electrical Interfaces

5.1 Electrical System Design

The NRCSD does not accommodate an electrical interface to CubeSats. All electrical power shall be internal to CubeSats. CubeSat electronics systems design shall adhere to the following requirements.

- 1) The CubeSat operations shall not begin until a minimum of 30 minutes after deployment from the ISS. Only an onboard timer system may be operable during this 30-minute post deploy time frame.
- 2) The CubeSat electrical system design shall incorporate a minimum of three (3) inhibit switches actuated by physical deployment switches (see Deployment Switches section 4.7) as shown in Figure 12.
- 3) The CubeSat electrical system design shall not permit the ground charge circuit to energize the satellite systems (load), including flight computer (see Figure 12). This restriction applies to all charging methods.
- 4) RBF pins are required. Arming switch or captive jumpers may be an acceptable alternative; contact NanoRacks.
- 5) The RBF pin shall preclude any power from any source operating any satellite functions with the exception of pre-integration battery charging.
- 6) RBF pins must be capable of remaining in place during integration with NRCSD. It shall not be necessary to remove the RBF to facilitate loading into the NRCSD.
- 7) All RBF pins, switches, or jumpers utilized as primary electrical system and RBF inhibits must be accessible from the access panels (see Figure 1) for removal at the completion of loading into the NRCSD.

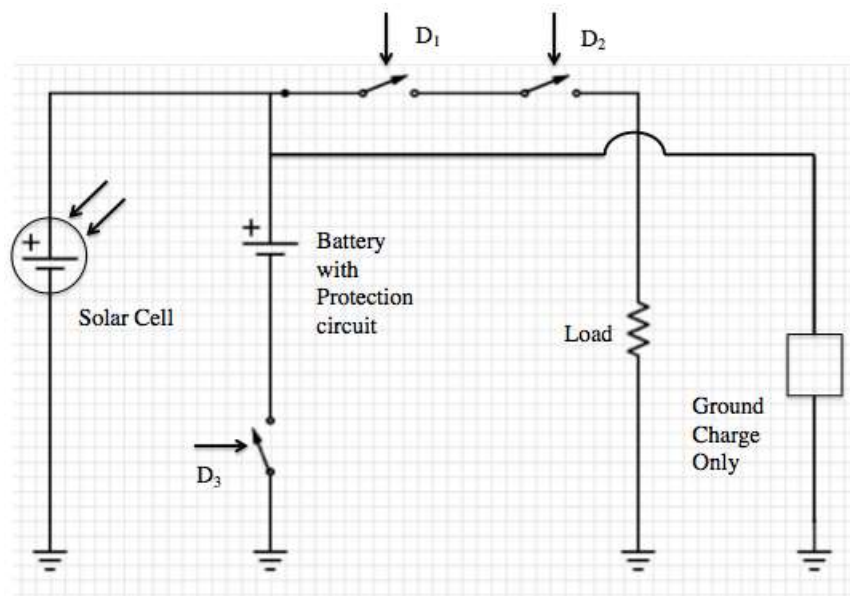


Figure 12 CubeSat Electrical Subsystem Block Diagram (note: RBF switch not shown)

5.2 Batteries

CubeSats that utilize on-board batteries shall comply with NASA requirements for battery safety. This requirement applies for main power batteries and for batteries associated with real-time clocks or watch-dog circuits i.e. “coin cell” batteries. Contact NanoRacks for the appropriate battery test procedure. Batteries should maintain charge for a minimum of 6 months from time of integration into the NRCSD by NanoRacks.

6 Launch Loads

CubeSats shall be tested for random vibration to comply with NASA guidelines per the random vibration profile shown in Table 2 .

Frequency (Hz)	Hard Mount Configuration (g ² /Hz)
20	0.057 (g ² /Hz)
20-153	0 (dB/oct)
153	0.057 (g ² /Hz)
153-90	+7.67 (dB/oct)
190	0.099 (g ² /Hz)
190-250	0 (dB/oct)
250	0.099 (g ² /Hz)
250-270	-1.61 (dB/oct)
750	0.055 (g ² /Hz)
750-2000	-3.43 (dB/oct)
2000	0.018 (g ² /Hz)
OA (grms)	9.47

Table 2 Random Vibration Test Profile

7 Thermal Interfaces

CubeSats shall be designed to withstand overall temperature range of -40C to +65C.

8 Hazardous Materials

CubeSats shall comply with NASA guidelines for hazardous materials. CubeSat developers shall submit a Bill of Materials (BOM) to NanoRacks for assessment.

9 CubeSat Integration

NanoRacks conducts final integration on behalf of the Customer. CubeSat developers shall include their integration requirements in memo format along with the CubeSat.