NanoRacks DoubleWide Deployer (NRDD) System

Interface Definition Document (IDD)

09/20/2017

Nanoracks

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List of Revisions

Revision	Revision Date	Revised By	Revision Description
-	3/30/2017	Conor Brown	Initial Release
A	09/19/2017	Robert Adams	Added details for NRDD with Rails

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1 Introduction

1.1 Purpose

This Interface Definition Document (IDD) provides the minimum requirement set to verify compatibility of a small satellite with the NanoRacks DoubleWide Deployer system (NRDD). This IDD includes all applicable International Space Station (ISS) flight safety and interface requirements for payload use of the NRDD. NanoRacks verifies compliance to all applicable requirements directly to the ISS Program on behalf of the Payload Developer (PD) based on incremental data requests.

1.2 Scope

This IDD is the sole requirements document for end users of the NRDD (the PD or the Customer). The physical, functional, and environmental design requirements associated with payload safety and interface compatibility for flight with the NRDD are included herein. The requirements defined in this document apply to all phases of the mission leading up to the deployment of the payload from the ISS, including both the pressurized and unpressurized operations on ISS. In some circumstances, the design requirements outlined in this document may also govern the operational, post-deployment mission phase of the payload. The interface requirements defined herein primarily address the Payload to NRDD interface, but also include requirements derived from ISS Program safety documentation and interface control agreements with the Japan Aerospace Exploration Agency (JAXA).

This IDD covers 2 configurations of the NRDD design. The first configuration has 4 rails in the deployer only at the bottom of the satellite which interfaces with only 2 tabs (or rails) at the bottom of the satellite. The second configuration uses 8 rails, two at each of the four corners, supporting the traditional CubeSat standard with 4 rails on the Satellite. Details of each of these rail configurations are defined in section 4.1.

1.3 Usage

This document levies design interface and verification requirements on payload developers (i.e. NRDD satellite customers). These requirements are allocated to a payload through the unique payload Interface Control Agreement (ICA). The unique payload ICA documents the payload compliance with the requirements defined in this IDD. The ICA is utilized as the documentation tool to capture requirements verification approaches, data submittals, schedule updates, and any required exceptions.

1.4 Exceptions

The general term used to identify any payload-proposed departure from specified requirements or interfaces. Any exception to requirements, capabilities, or services defined in this IDD shall be documented in the ICA and evaluated to ensure that the stated condition is controlled and acceptable. The ICA will be revised throughout the payload design verification process and will document the specific requirement excepted, the exception number, the exception title, and the approval status.

2 Acronyms, Definitions and Applicable Documents

Table 2-1: Acronyms

Acronym	Definition
BN	Ballistic Number
BoM	Bill of Materials
CD&H	Command Data & Handling
CMC	Cargo Mission Contract
CM	Center of Mass
CoC	Certificate of Compliance
COTS	Commercial Off-the-Shelf
CVCM	Collected Volatile Condensable Material
CTB	Cargo Transfer Bag
DFMR	Designed for Minimum Risk
DOT	Department of Transportation
EF	Exposed Facility
EPS	Electrical Power System
ESD	Electrostatic Discharge
ETFE	Ethylene tetrafluoroethylene
EVR	Extravehicular Robotics
FCC	Federal Communications Commission
FOD	Foreign Object Debris
GSE	Ground Support Equipment
HFIT	Human Factors Implementation Team
ICA	Interface Control Agreement
IDD	Interface Definition Document
I/F	Interface
ISS	International Space Station
ITU	International Telecommunication Union
JEM	Japanese Experiment Module
JEMRMS	Japanese Experiment Module Remote Manipulator System
JSC	Johnson Space Center
LCM	Launch Command Multiplexer
MLI	Multi-Layer Insulation
MEFL	Maximum Expected Flight Level

Acronym	Definition
MPEP	Multi-Purpose Experiment Platform
MSWG	Mechanical Systems Working Group
MWL	Minimum Workmanship Level
NASA	National Aeronautics and Space Administration
NLT	No Later Than
NOAA	National Oceanic and Atmospheric Administration
NRCSD	NanoRacks CubeSat Deployer
NRDD	NanoRacks DoubleWide Deployer
NTIA	National Telecommunications and Information Administration
ODAR	Orbital Debris Assessment Report
OLR	Outgoing Longwave Radiation
PCM	Pressurized Cargo Module
PD	Payload Developer
POIF	Payload Operations Integration Function
PTFE	Polytetrafluoroethylene
PSRP	Payload Safety Review Panel
RBF	Remove Before Flight
RH	Relative Humidity
RSS	Root Sum Square
RTC	Real-Time Clock
SDP	Safety Data Package
SE&I	Systems Engineering & Integration
SMA	Shape Memory Alloy
TIM	Technical Interchange Meeting
TML	Total Mass Loss
US	United States

Table 2-2: Applicable Documents

Doc No.	Rev	Title
JSC TA-92-038		Protection of Payload Electrical Power Circuits
JSC 20793	C	Crewed Space Vehicle Battery Safety Requirements
JX-ESPC-101193D	D	JEM System / NanoRacks CubeSat Deployer (NRCSD) Interface Control Document
MSFC-SPEC-522	B	DESIGN CRITERIA FOR CONTROLLING STRESS CORROSION CRACKING
NASA-STD-8719.14A		NASA Technical Standard Process for Limiting Orbital Debris
NASDA-ESPC-2903-B	B	JEM Payload Accommodation Handbook Vol. 6 Airlock/Payload Standard Interface Control Document
SSP 30233	H	Space Station Requirements for Materials and Processes
SSP 30245	P	Space Station Electrical Bonding Requirements
SSP 42004	K	Mobile Servicing System (MSS) to User (Generic) Interface Control Document Part 1
SSP 50835	D	ISS Pressurized Volume Hardware Common Interface Requirements Document
SSP 51700		Payload Safety Policy and Requirements for the International Space Station
SSP 52005	F	Payload Flight Equipment Requirements and Guidelines for Safety-Critical Structures
SSP 57000	R	Pressurized Payloads Interface Requirements Document
SSP 57003	L	External Payload Interface Requirements Document

3 NanoRacks DoubleWide Deployer System Overview

This section is an overview of the NanoRacks DoubleWide Deployer (NRDD) system and describes the various system interfaces and the operational elements of the payload lifecycle. The payload interface requirements are captured in Section 4.

3.1 NRDD Overview and Payload Capacity

The NRDD (see Figure 3.1-1 and Figure 3.1-2) is a self-contained CubeSat deployer system for small satellites staged from the International Space Station (ISS). The NRDD launches inside the Pressurized Cargo Module (PCM) of ISS cargo resupply vehicles and utilizes the ISS Japanese Experiment Module (JEM) as a staging facility for operation. The NRDD is integrated with payloads on the ground at a NanoRacks facility prior to flight and mechanically and electrically isolates CubeSats from the cargo resupply vehicles, ISS, and ISS crew.

Figure 3.1-1: NanoRacks DoubleWide Deployer (NRDD)

Figure 3.1-2: NRDD Payload Jettison (configuration with Tabs shown)

The NRDD has a maximum payload capacity of 12U and is designed to accommodate 6U CubeSats in the 2x3x1U form factor, 12U CubeSats in 2x6x1U form factor, or potentially other non-standard form factors (see Figures 3.1-3 and 3.1-4). The standard payload form factors and dimensional requirements are detailed in Section 4.

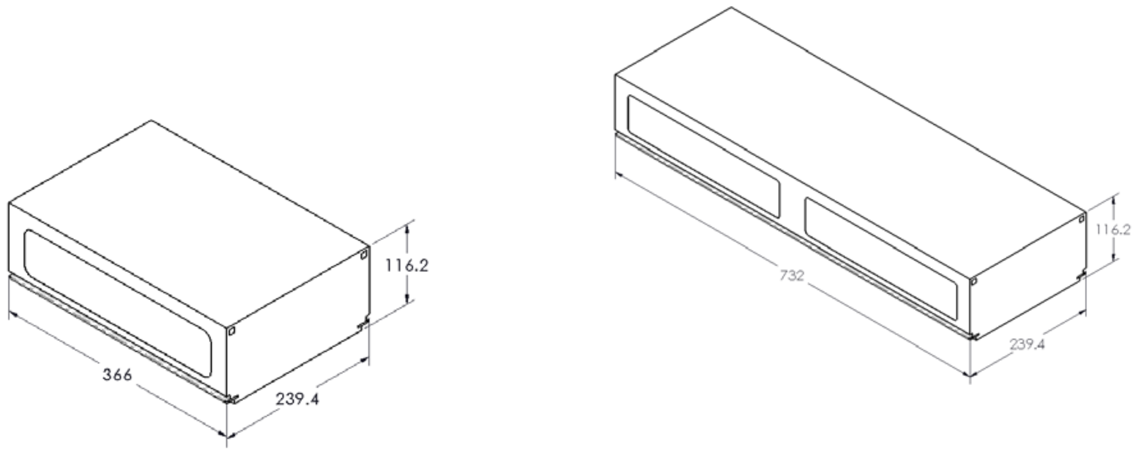


Figure 3.1-3: NRDD 6U and 12U CubeSat Form Factors

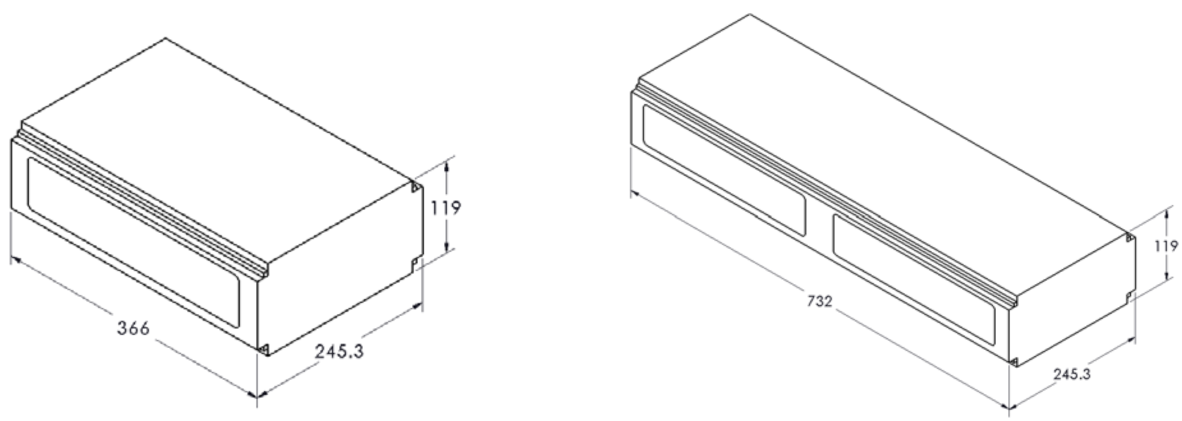


Figure 3.1-4: NRDD with Rails 6U and 12U CubeSat Form Factors

3.2 NRDD Coordinate System

The NRDD coordinate system is defined in Figure 3.2-1 (location of origin not considered).

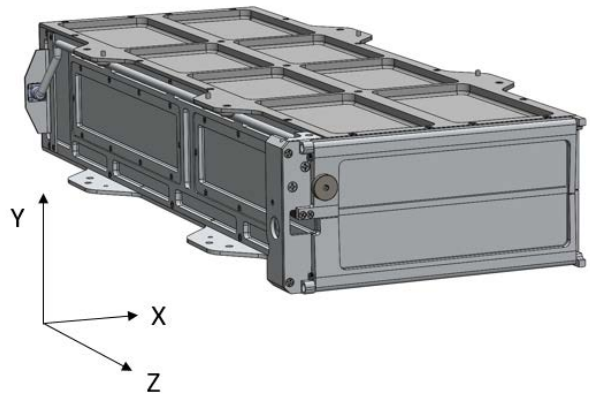


Figure 3.2-1: NRDD Coordinate System

3.3 NRDD Design Features

The NRDD is a rectangular 'silo' that consists of four (4) sidewalls, a base plate, a pusher plate assembly with ejection spring, four (4) access panels, two (2) doors, and a primary release mechanism (see Figure 3.3-1). The deployer doors are located on the forward end (+Z face), the base plate assembly is located on the aft end (-Z face), and the access panels are on the sides of the dispenser (+/- X faces). The inside walls of the NRDD are smooth bore design to minimize and / or preclude hang-up or jamming of CubeSat appendages during deployment should these become released prematurely.

The release mechanism is a TiNi Aerospace P10 Pinpuller; the Pinpuller is a commercial off-the-shelf (COTS) mechanism that uses Shape Memory Alloy (SMA) material for activation, has redundant channels, and has an extensive space heritage. The integrated door design was completed by NanoRacks and has been designated 'DFMR', or Designed For Minimum Risk, by the Mechanical Systems Working Group (MSWG) at the Johnson Space Center (JSC). The design is identical in function to the NanoRacks CubeSat Deployer (NRCSD).

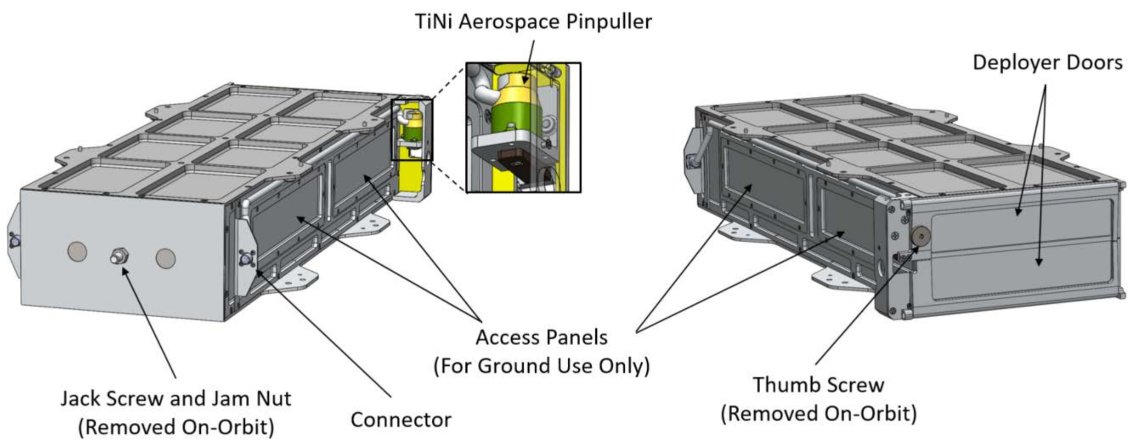


Figure 3.3-1: NanoRacks DoubleWide Deployer Design Features

The NRDD has a thumb screw that secures the NRDD doors for flight. The thumb screw ensures that the primary release mechanism does not experience excess loading during the ground handling and ascent / launch portion of the mission. The NRDD also has a jack screw and jam nut assembly that allows the integrated payload subsystem to be preloaded / secured in the Z axis for flight. The jack screw and jam nut assembly are installed on the deployer base plate. The thumb screw, jack screw, and jam nut are removed by the ISS crew prior to deployment operations. The NRDD access panels are removed on the ground so that additional access is available during the payload fit-check and integration process. The access ports provide the only access for remove before flight (RBF) and / or apply before flight (ABF) features while the payloads are inside the NRDD. The access panels are installed prior to handover for flight and are never opened on-orbit by the ISS crew.

3.4 NRDD Operations Overview

3.4.1 Schedule

Table 3.4.1-1 is a template schedule outlining the major safety and hardware milestones for payload developers (PDs). The majority of the schedule milestones are related to the phased ISS safety review process with the Payload Safety Review Panel (PSRP) and the associated data milestones. The detailed payload schedule will be coordinated between NanoRacks and the payload developer and documented in the unique payload ICA.

Table 3.4.1-1: Template Milestone Schedule

Milestone/Activity	Launch-minus Dates (Months)
Feasibility Study / Contract Signing	L – 12
Regulatory Compliance Initiation by PD (Spectrum Coordination, Remote Sensing)	L – 12
NanoRacks / PD Kickoff Meeting	L-12
Interface Control Agreement (ICA) Initiation	L-12
NanoRacks / PD Safety Data Call Initiation	L-12
Baseline ICA	L-11
Phase 0/I Support Data from PD Complete	L-11
Phase 0/I Safety Data Package (SDP) Submittal to PSRP	L-10
NanoRacks / ISS Program Kickoff Meeting	L – 9.5
Phase 0/I Safety Review	L – 9
Phase 2 Support Data from PD Complete	L-8
Phase 2 SDP Submittal to PSRP	L-7
Phase 2 Safety Review	L-6

Milestone/Activity	Launch-minus Dates (Months)
ICA Signed by PD and NanoRacks	L-6
NRDD and CubeSat Fit-Check	L-5
Payload Environmental Testing	L-5
ISS Program Required Flight Acceptance Testing	L-5
Phase 3 Support Data from PD Complete	L-4.5
Phase 3 SDP Submittal to PSRP	L-4
Phase 3 Safety Review	L-3.5
Regulatory Licensing in Place	L-3.5
Payload Delivery to NanoRacks	L-1.5 to L-3.5
NanoRacks Cargo Handover to NASA	L-1 to L-3

3.4.2 Ground Operations

3.4.2.1 Mechanical Fit-Check

NanoRacks will coordinate complete mechanical interface checks between the satellite and the NRDD prior to final integration of the payload. Fit-checks are conducted with the hardware intended for flight. Use of flight-like engineering qualification hardware in lieu of flight models must be coordinated with NanoRacks and documented in the ICA.

3.4.2.2 Delivery to NanoRacks

The PD will deliver the complete payload to the NanoRacks Houston facility, or another facility as documented in the ICA, by the dates listed in the schedule for installation into the deployer. Any special requirements, such as ground support equipment (GSE), special handling instructions, cleanliness requirements, humidity requirements, ESD sensitivity, etc., shall be documented in the payload specific ICA.

3.4.2.3 NanoRacks Inspection

NanoRacks performs inspections of the payload to verify it meets the required safety and mechanical design requirements outlined in this IDD and the ICA. Typically, this includes, but is not limited to, mass properties and critical mechanical dimensions. This inspection takes place at the point of the fit-check and is repeated at the point that the payload is handed over to NanoRacks prior to final integration with the NRDD. Note that any requirements that cannot be verified through inspection, measurements, and fit-check with the NRDD must be verified via documentation and data submittals in advance of final payload delivery to NanoRacks.

3.4.2.4 Payload Developer Ground Servicing

The PD may perform payload activities at the NanoRacks facilities prior to final installation into the deployer, based on the agreements in the ICA, as long as these activities are within the scope of the documented and verified payload design. These payload activities may include post-shipment functional tests, battery charging, etc. Typically, these activities are completed prior to installation of the payload into the NRDD. Note that the only access to the payload after the installation is complete is via the NRDD access ports on the +/-X faces of the dispenser. No material or design changes shall be implemented at this phase of the processing. Once the payload has been delivered for flight to the ISS Cargo Mission Contract (CMC) team, no further payload servicing is permitted. The time between payload handover to NanoRacks and transfer to CMC is nominally about 1 week. Any post-delivery payload activities besides standard post-shipment receive and inspect procedures must be coordinated in advance and documented in the payload specific ICA.

3.4.2.5 NanoRacks Data Gathering for On-Orbit Operations

NanoRacks will assess the payload to develop products and procedures in support of on-orbit operations and crew interaction. Typically, no crew-interaction with the CubeSats are permitted. Any request for crew interaction with the payload, including most-commonly imagery requests during the deployment, must be coordinated with NanoRacks and documented via the unique payload ICA.

3.4.2.6 NanoRacks Testing

Although not normally required for CubeSats, NanoRacks may perform testing of the CubeSat based on the agreements made in the unique payload ICA. This may include, but is not limited to support of vibration tests utilizing NanoRacks GSE, final charging of the payloads, visual and mechanical inspections, etc.

3.4.2.7 NanoRacks Packaging and Delivery

NanoRacks delivers the completed payload assembly to the ISS Cargo Mission Contract (CMC) team for incorporation into its final stowage configuration. This typically occurs approximately 1 week or less after NanoRacks receives the payload from the Customer. The payloads are delivered integrated with the NRDD in flight configuration secured in ground packaging. The CMC team removes the integrated flight assembly from ground packaging and places into flight approved packing materials. The NRDD is wrapped in bubble-wrap for flight and packed inside a foam-lined cargo transfer bag (CTB) prior to shipment of the hardware to the launch site and remains in this configuration for launch. Any specific packing requirements or orientation constraints of payloads shall be captured in the unique payload ICA.

Figure 3.4.2.7-1: Sample NRDD Stowage Configuration for Launch (NRCSD Quad-Pack in M2 CTB)

3.4.2.8 Delivery to Launch Site

The CMC team is responsible for delivering the final stowed configuration to the appropriate launch site facility and for integration of the cargo into the ISS visiting vehicle.

3.4.3 On-Orbit Environments, Interfaces, and Operations

3.4.3.1 NRDD Destow

Once the launch vehicle is on orbit and berthed, the ISS crew is responsible for transferring the integrated hardware assembly from the visiting vehicle to the on-orbit stowage location until it is time to deploy the CubeSats.

3.4.3.2 NRDD On-Orbit Environments

The NRDD is stowed inside the ISS prior to deployment operations. The on-orbit environmental information provided below is for design and analysis purposes.

Table 3.4.3.2-1: ISS Environmental Conditions (Ref SSP 57000)

Environmental Condition	Value
Atmospheric Conditions on ISS	
Pressure Extremes	0 to 104.8 kPa (0 to 15.2 psia)
Normal operating pressure	See Figure 3.4.3.2-1
Oxygen partial pressure	See Figure 3.4.3.2-1
Nitrogen partial pressure	See Figure 3.4.3.2-1
Dew point	4.4 to 15.6 °C (40 to 60 °F)
Percent relative humidity	25 to 75%
Carbon dioxide partial pressure during normal operations with 6 crewmembers plus animals	24–hr average exposure 5.3 mm Hg Peak exposure 7.6 mm Hg
Carbon dioxide partial pressure during crew change out with 11 crewmembers plus animals	24–hr average exposure 7.6 mm Hg Peak exposure 10 mm Hg
Cabin air temperature in USL [1], JEM, and COL	18.3 to 26.7 °C (65 to 80 °F)
Cabin air temperature in Node 1	18.3 to 29.4 °C (65 to 85 °F)
Air velocity (Nominal)	0.051 to 0.203 m/s (10 to 40 ft/min)
Airborne microbes	Less than 1000 CFU/m3
Atmosphere particulate level	Average less than 100,000 particles/ft3 for particles less than 0.5 microns in size
General Illumination	108 Lux (10 fc) measured 30 inches from the floor in the center of the aisle
Ionizing Radiation Dose	Up to 30 Rads(Si) / year

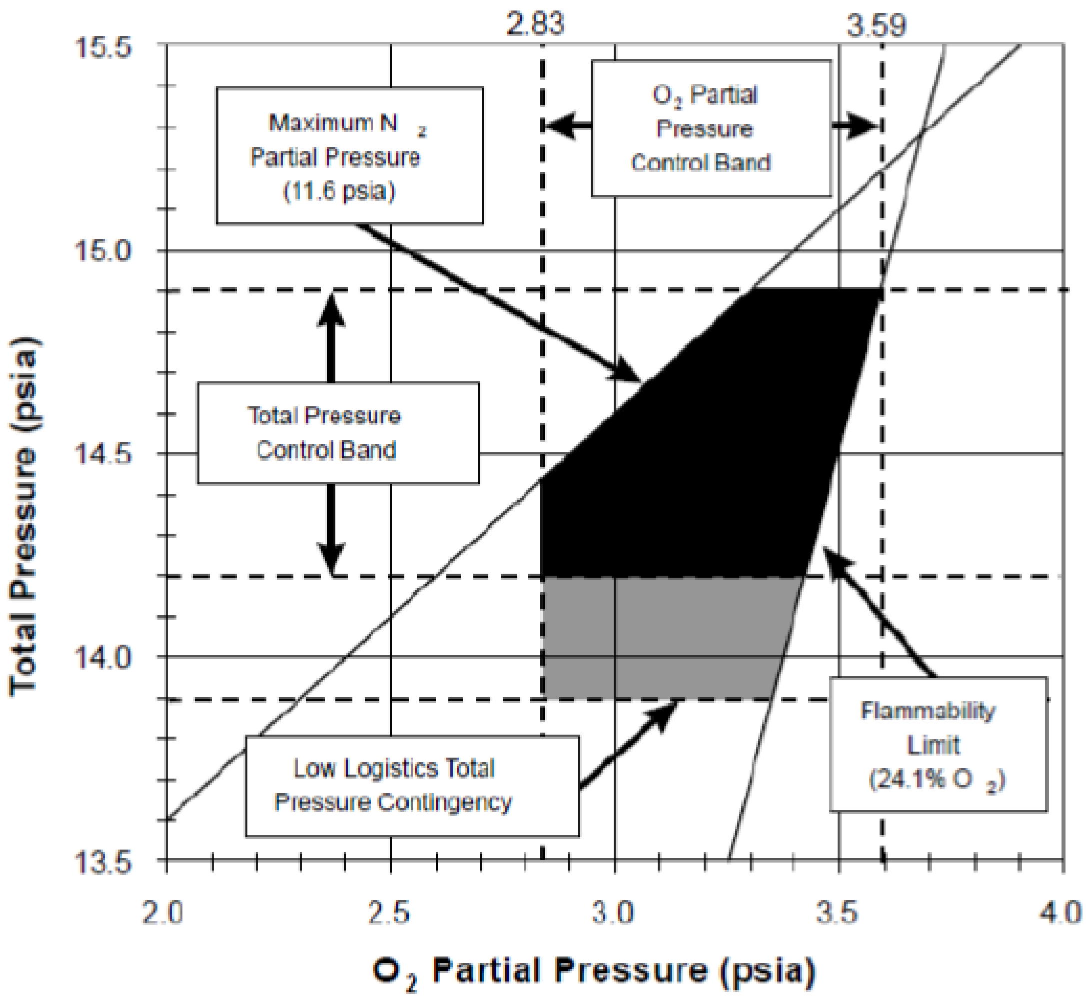


Figure 3.4.3.2-1: Operating Limits of the ISS Atmospheric Total Pressure, and Nitrogen and Oxygen Partial Pressures (Ref SSP 57000)

3.4.3.3 NRDD On-Orbit Interfaces

The JEM Airlock is the facility on the ISS utilized to transport the NRDD from the pressurized volume to the extra-vehicular environment of ISS. The NRDD mounts to the Multi-Purpose Experiment Platform (MPEP), which in turn mounts to the JEM Airlock Slide Table. The NRDD is a modular system that interfaces to the MPEP in the same way as the standard 6U NanoRacks CubeSat Deployer (NRCSD). Depending on the mission compliment, NanoRacks may deploy CubeSats using the DoubleWide Deployer and Standard NRCSD on the same airlock cycle / mission. An example of an integrated NRCSD mission configuration on the MPEP is displayed in Figure 3.4.3.3-1.

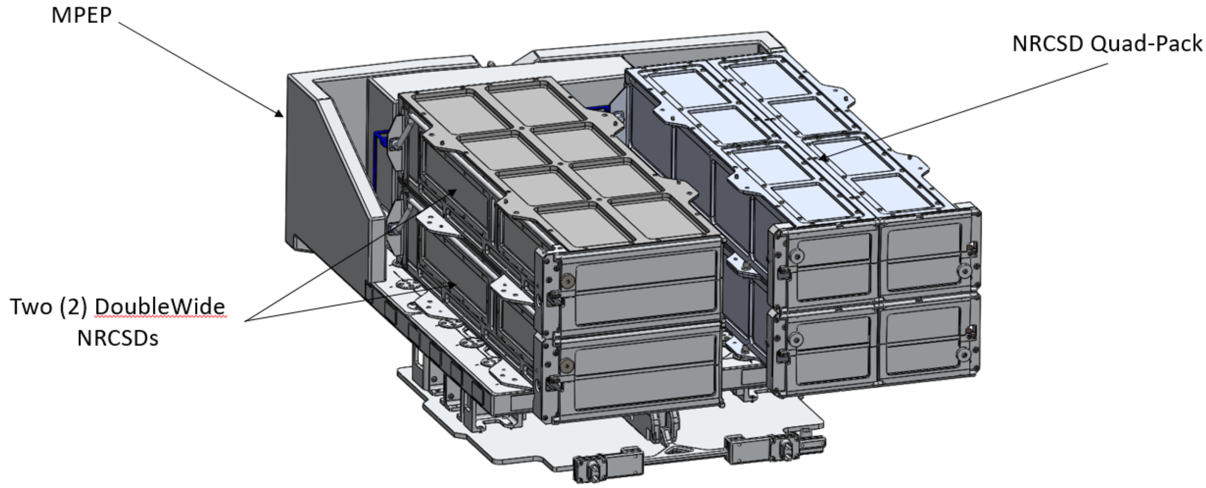


Figure 3.4.3.3-1: NRCSD Standard and DoubleWide on MPEP

A Multi-Layer Insulation (MLI) thermal blanket is secured around the NRCSD top-level mission assembly prior to JEM Airlock depress.

The JEM Remote Manipulator System (JEMRMS) is the Extravehicular Robotics (EVR) system that grapples the MPEP, removes the integrated assembly from the JEM airlock slide table, and positions the NRCSDs for deployment. The NRDD release mechanism receives power from the NanoRacks Launch Command Multiplexer (LCM), which in turn receives power/data from the MPEP via the JEMRMS.

3.4.3.4 JEM Operation / Deployment from ISS

The JEM operations are managed by JAXA ground controllers. Once the ISS Program schedules the CubeSat deployment window (subject to various constraints such as visiting vehicle traffic, crew time, etc.) the on-orbit crew is responsible for unpacking the loaded NRCSDs and assembling the deployers onto the MPEP and JEM slide table (along with the LCM and associated cables). The NanoRacks perations team provides support to the crew in all aspects of the assembly in coordination with ISS Payload Operations Integration Function (POIF). The standard concept of operations for the NRCSD hardware is outlined below (see Figure 3.4.3.4-1, Figure 3.4.3.4-2, and Figure 3.4.3.4-3):

- MPEP is installed onto the JEM Airlock Slide Table
- NRCSDs are mechanically installed on the MPEP along with the LCM
- NRCSD jack screws, jam nuts, and thumb screws are removed
- NRCSDs are electrically connected to the LCM, which is in turn is connected to the MPEP using NanoRacks on-orbit cables
- The NRCSD/MPEP assembly is covered with an MLI thermal blanket
- The JEM Airlock Slide Table maneuvers the assembly into the airlock
- The JEM Airlock inner hatch is closed
- The JEM Airlock is depressurized
- The JEM Airlock outer hatch is opened
- The JEM Airlock Slide Table maneuvers outside the ISS
- The JEMRMS grapples the MPEP/NRCSD assembly by the grapple fixture located on the MPEP and translates it to the pre-approved deployment position (pointed retrograde to the ISS).
- JAXA ground controllers send the deployment command to the NRDD via ISS CD&H backbone and then a single the NRCSD (DoubleWide or Standard) deploys one silo of CubeSats. There may be more than one CubeSat in a single silo depending on the form factor. Deployment of the satellite(s) is captured by ISS external cameras to verify good deployment.
- The NRCSD/MPEP assembly is returned to the JEM Airlock and reverse steps taken to remove NRCSDs from JEM Airlock Slide Table
- NRCSDs are packed for return to Earth or on-orbit disposal on appropriate ISS cargo resupply vehicle

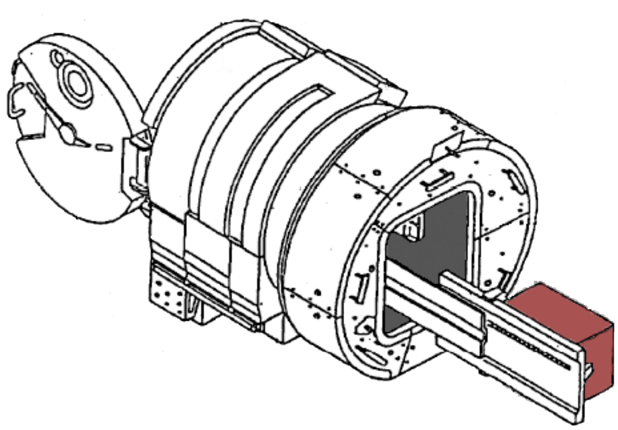


Figure 3.4.3.4-1: JEM Airlock Slide Table

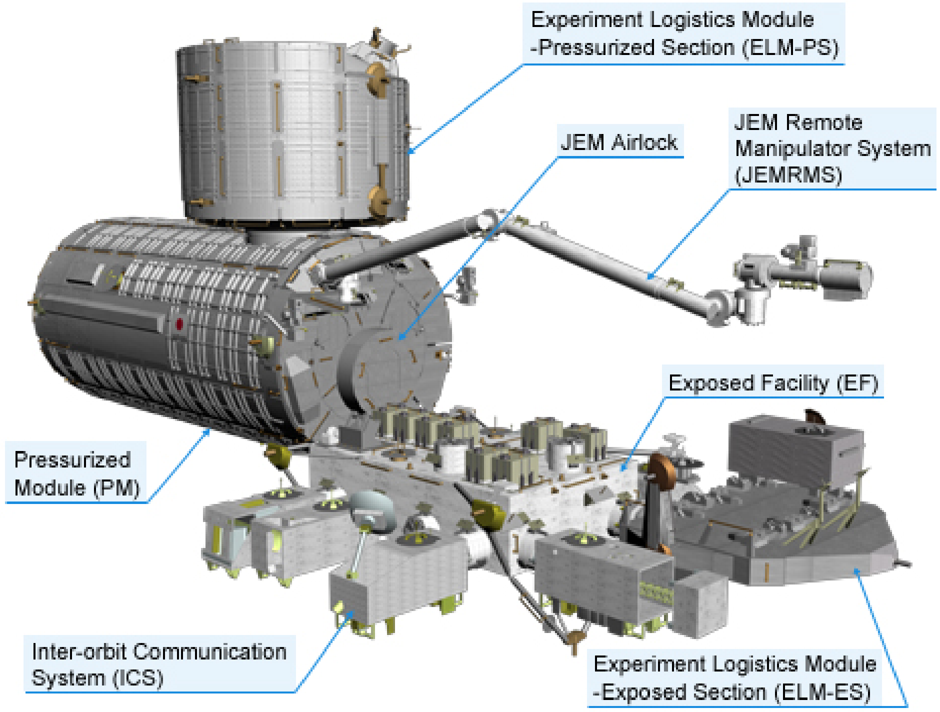


Figure 3.4.3.4-2: JEM Overview

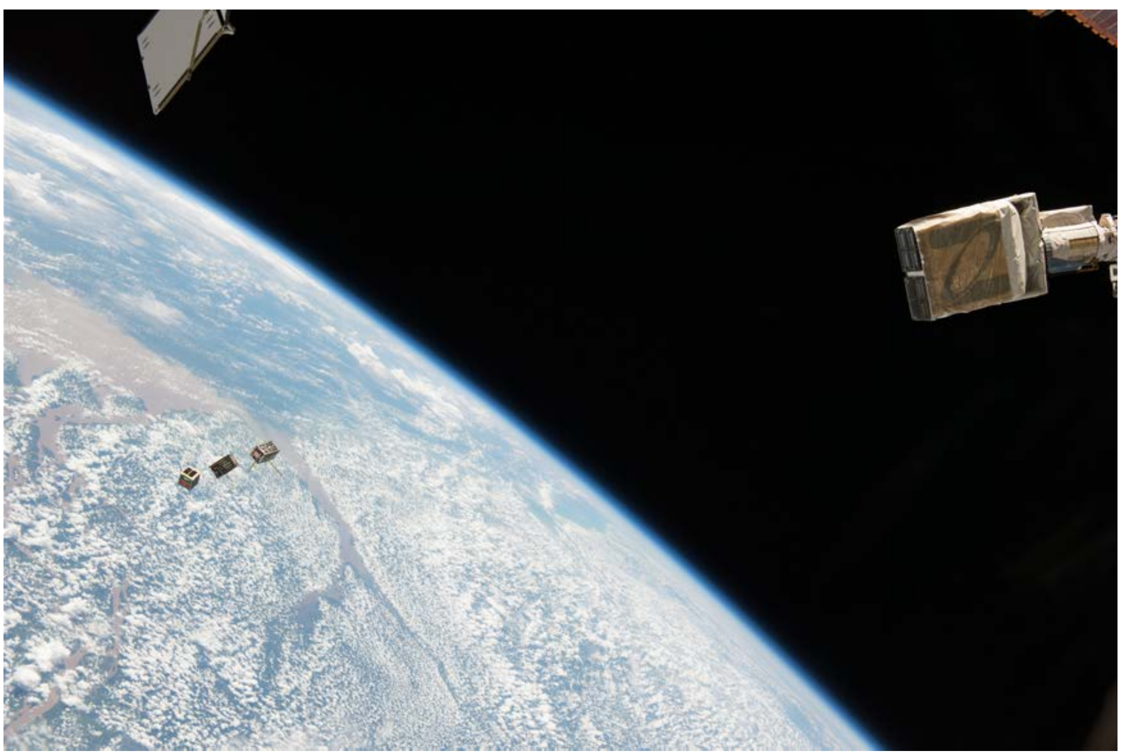


Figure 3.4.3.4-3: NRCSD Deployment of Three (3) CubeSats from ISS (Photo Credit: NASA)

4 Payload Interface Requirements

The requirements contained in this section shall be complied with in order to certify the payload for integration into the NRDD, launch and stowage inside an ISS Cargo resupply vehicle, and operation with the JEM module via the NRDD and associated support hardware. The requirements are presented in the following categories: Structural and Mechanical Systems, Electrical, Environmental, Safety, Jettison, and Documentation. In the event a requirement cannot be adhered to, exceptions are often possible depending on the nature of the noncompliance. All required exceptions and associated acceptance rationale shall be captured in the unique payload ICA.

4.1 Structural and Mechanical Systems Interface Requirements

The NRDD is designed to house two (2) 6Us CubeSats in the 2x3x1U form factor or a single 12U CubeSat in the 2x6x1U form factor. The only dimensional requirement that vary between the two form factors is the total length (Z-axis dimension), which is specifically noted in the requirements herein. This section captures all mechanical and dimensional requirements to ensure the payloads interface correctly with the NRDD and adjacent CubeSats (for 6Us).

4.1.1 CubeSat Mechanical Specification – NRDD Tab Configuration

1. The CubeSat shall have two (2) tabs that protrude from the main payload envelope and allow the payload to slide into the rail-capture interface of the NRDD as outlined in Figure 4.1.1-1.
2. The CubeSat tabs and envelope shall adhere to the dimensional specification outlined in Figure 4.1.1-2.

   Note: Any dimension followed by 'MIN' shall be considered a minimum dimensional requirement for that feature and any dimension followed by 'MAX' shall be considered a maximum dimensional requirement for that feature. There are other dimensions in Figures 4.1.1-1 and 4.1.1-2 that specify a range with +/- 0.XXX.
3. The maximum outer radius of the tab at the ends of the payload (+/- Z axis) shall be 3.5mm as outlined in Figure 4.1.1-3.
4. The CubeSat shall have load points on the +/- Z faces of the payload that are coplanar with the end of the tabs within +/- 0.25mm (0.010") and envelope the designated load path regions / contact zones outlined in Figure 4.1.1-4.

   Note: The contact zones are specified to ensure the load path is spread out across the pusher plate and NRDD doors and to ensure compatibility between 6U CubeSats integrated inside the same deployer. If the CubeSat does not have contact points in the specified load path regions, exceptions may be granted on a case-by-case basis with NanoRacks Engineering review. As with any exception, this shall be captured in the unique payload ICA.
5. The CubeSat tab length shall be the following for the respective 6U and 12U payload form factors.
   a. 6U Payload Tab Length: 366mm (+0.0 / -65.0)
   b. 12U Payload Tab Length: 732mm ((+0.0 / -130.0)

   Note: Non-standard payload lengths may be considered. Anything system tab length outside the above must be approved by NanoRacks and recorded in the unique payload ICA.

6. The CubeSat tabs shall be contiguous. No gaps, holes, fasteners, or any other features may be present along the length of the tabs (Z-axis) in regions that contact the NRDD rails (see Figure 4.1.1-1).

   Note: The NRDD is capable of supporting systems that do not have contiguous tabs along the entire length of the payload. This sort of non-standard tab payload accommodation shall be approved by NanoRacks and documented in the unique payload ICA.
7. The CubeSat tabs shall be the only mechanical interface to the NRDD in the lateral axes (X and Y axes; does not account for longitudinal, Z-axis contact points).

   Note: For clarification, this means that if the satellite is moved left/right or up/down while inside the NRDD, the only contact points of the payload shall be on the tabs.
8. The CubeSat tabs shall extend beyond the +/-Z faces of the entire payload, including all external features (with the exception of load points on the +/-Z face of the payload).
9. The CubeSat tabs and all load points shall have a hardness equal to or greater than hard-anodized aluminum (Rockwell C 65-70).

   Note: NanoRacks recommends a hard-anodized aluminum surface.
10. The CubeSat tabs and all load points shall have a surface roughness of less than or equal to 1.6 µm.

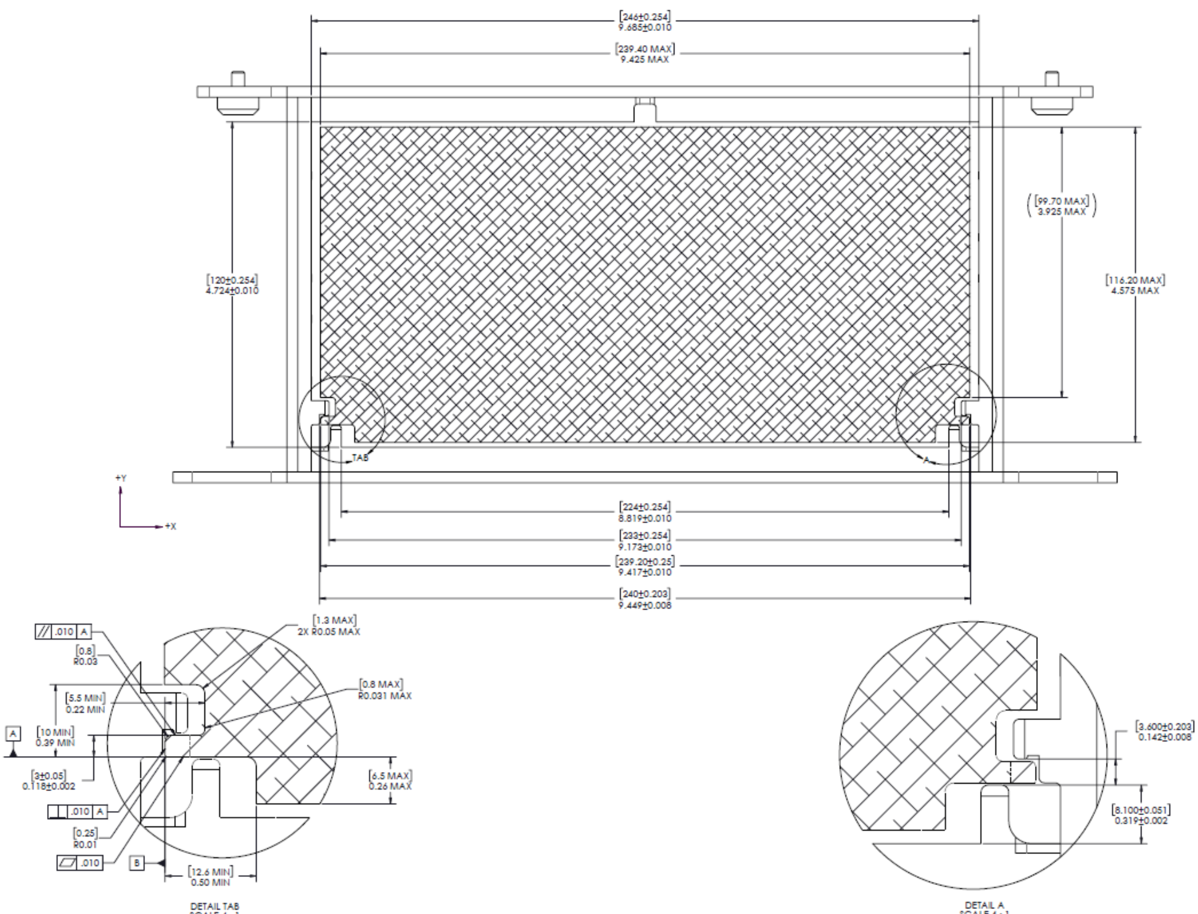
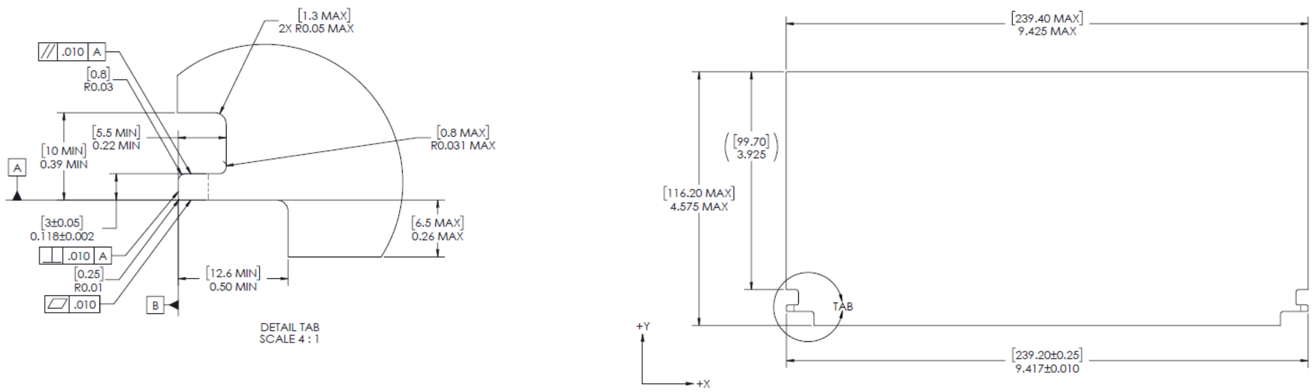
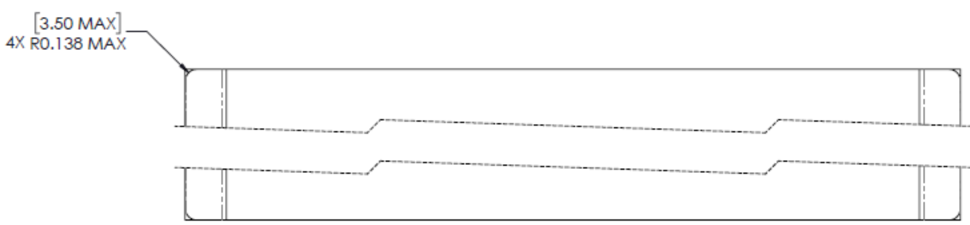


Figure 4.1.1-1: NRDD Payload Mechanical Interface (Dimensions in [mm] and inches)



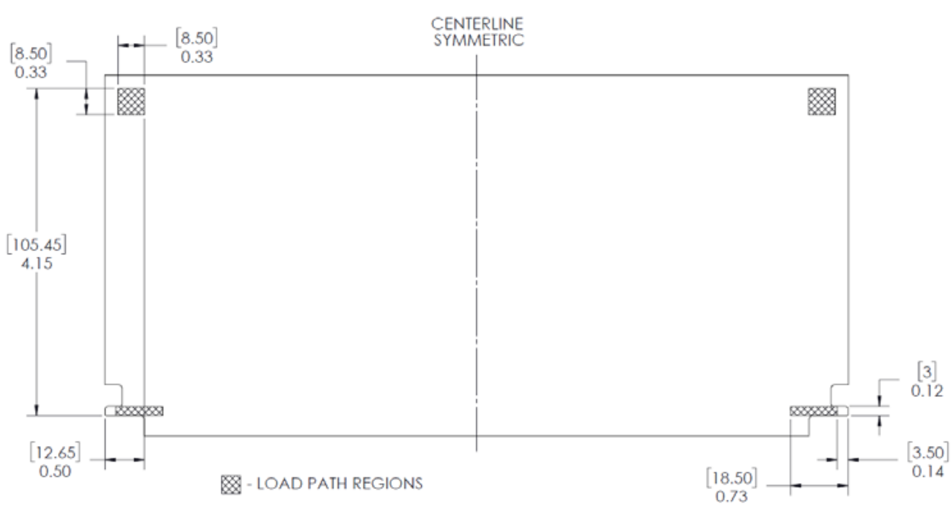
Dimensions in [mm] and inches.

Figure 4.1.1-2: NRDD Payload Envelope and Tab Specification



Dimensions in [mm] and inches.

Figure 4.1.1-3: NRDD Payload Tab Outer Radius



Dimensions in [mm] and inches.

Figure 4.1.1-4: NRDD Payload +/-Z Load Points

4.1.2 CubeSat Mechanical Specification – NRDD With Rails Configuration

1. The CubeSat shall have four (4) rails that are integral with the main structure and allow the payload to slide on the rail interface of the NRDD as defined in Figure 4.1.2-1.
2. The CubeSat rails and envelope shall adhere to the dimensional specification outlined in Figure 4.1.2-1.

   Note: The envelope dimensions are maximum dimensions that the payload must not exceed to fit in the deployer. The rail dimensions are critical dimensions that must be met in order to ensure proper fit (+/-0.1mm).
3. The edges of the rails shall be rounded to a radius of 0.5mm (+/-0.1mm).
4. The CubeSat shall have load points on the +/- Z faces of the payload that are coplanar with the end of the rails within +/- 0.25mm (0.010”) and envelope the designated load path regions / contact zones outlined in Figure 4.1.2-1.

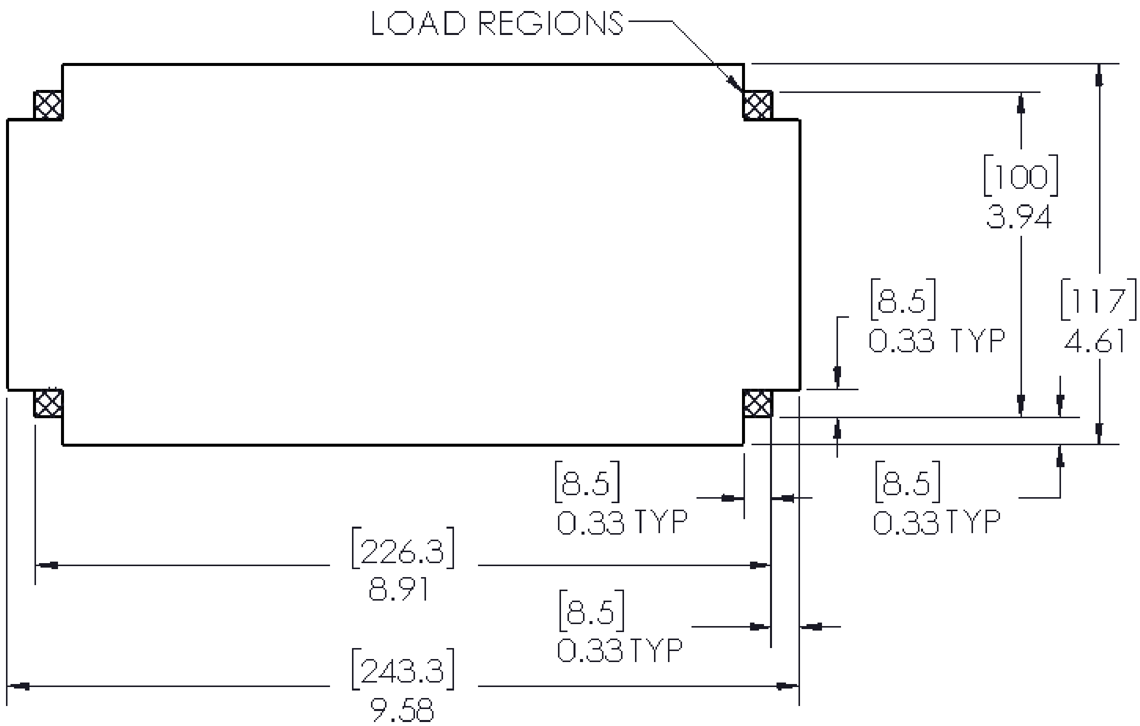
   Note: The contact zones are specified to ensure the load path is spread out across the pusher plate and NRDD doors and to ensure compatibility between 6U CubeSats integrated inside the same deployer. If the CubeSat does not have contact points in the specified load path regions, exceptions may be granted on a case-by-case basis with NanoRacks Engineering review. As with any exception, this shall be captured in the unique payload ICA.
5. The CubeSat rail length shall be the following for the respective 6U and 12U payload form factors.
   a. 6U Payload rail Length: 366mm (+0.0 / -65.0)
   b. 12U Payload rail Length: 732mm ((+0.0 / -130.0)

   Note: Non-standard payload lengths may be considered. Anything with system rail length outside the above must be approved by NanoRacks and recorded in the unique payload ICA.
6. The CubeSat rails shall be contiguous. No gaps, holes, fasteners, or any other features may be present along the length of the rails (Z-axis) in regions that contact the NRDD rails. The exception to this are the deployment switches if rail mounted switches are used.

   Note: The NRDD is capable of supporting systems that do not have contiguous rails along the entire length of the payload. This sort of non-standard rail payload accommodation shall be approved by NanoRacks and documented in the unique payload ICA.
7. The CubeSat rails shall be the only mechanical interface to the NRDD in the lateral axes (X and Y axes; does not account for longitudinal, Z-axis contact points). The exception to this are separation springs or the deployment switches if these items are used.

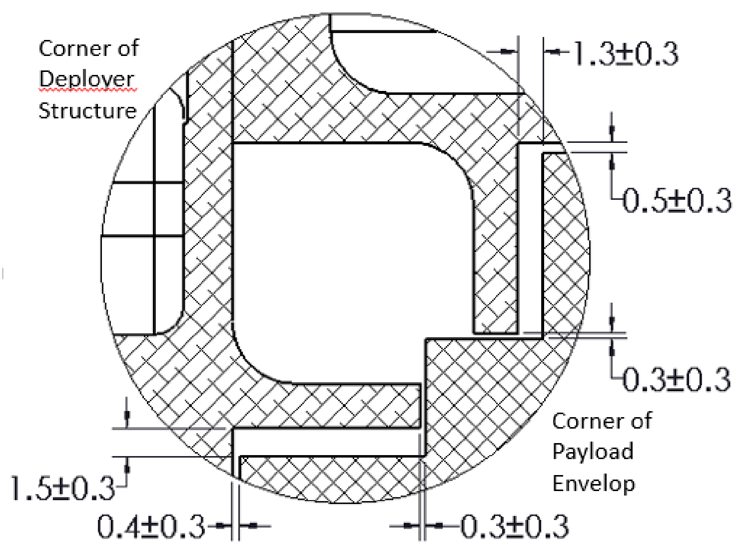
   Note: For clarification, this means that if the satellite is moved left/right or up/down while inside the NRDD, the only contact points of the payload shall be on the rails.
8. The CubeSat rails/load points shall extend beyond the +/-Z faces of the entire payload, including all external features, by no less than 2mm (with the exception of load points on the +/-Z face of the payload).
9. The CubeSat rails and all load points shall have a hardness equal to or greater than hard-anodized aluminum (Rockwell C 65-70).

   Note: NanoRacks recommends a hard-anodized aluminum surface.
10. The CubeSat rails and all load points shall have a surface roughness of less than or equal to 1.6 µm.



Dimensions in [mm] and inches.

Figure 4.1.2-1: NRDD with Rails Payload Envelop and +/-Z Load Points



Dimensions in [mm] and inches.

Figure 4.1.2-2: NRDD with Rails Payload Envelope and Rails Interface (Corner Detail clearances with payload envelop centered in deployer)

4.1.3 CubeSat Mass Properties

1) The CubeSat mass shall be less than the maximum allowable mass for each respective payload form factor per Table 4.1.3-1.

   Note: The requirement driver for the CubeSat mass is the ballistic number (BN), which is dependent on the projected surface area of the payload on-orbit. The mass values in Table 4.1.3-1 assume no active or passive attitude control of the payload once deployed. If the CubeSat has attitude control capabilities or design features, then the operational ballistic number (BN) will drive the mass requirement. If applicable, this shall be captured in the unique payload ICA.

Table 4.1.3-1: CubeSat Mass Limits

Form Factor	Maximum Mass (kg)
6U	12.0
12U	18.0

2) The CubeSat center of mass (CM) shall be located within the following range relative to the geometric center of the payload.

   a. X-axis: (+/- 5cm)
   b. Y-axis: (+/- 3cm)
   c. Z-axis:
      i. 6U: (+/- 8cm)
      ii. 12U: (+/- 16cm)

   Note: The '6U' and '12U' payload designators assume the payload is built to the maximum payload envelope in all three axes. If a CubeSat is designed to be significantly smaller than the payload envelope dimensions, these requirements may need to be re-evaluated at the discretion of NanoRacks.

4.1.4 RBF / ABF Access

1) The CubeSat shall have a remove before flight (RBF) feature or an apply before flight (ABF) feature that is physically accessible via the NRDD access ports on the +/-X face of the dispenser / payload. The access port regions on the payload are defined in Figure 4.1.4-1 and 4.1.4-2.

   Note: There is no physical access to the payload after integration into the NRDD besides what can be accessed from the below access ports.

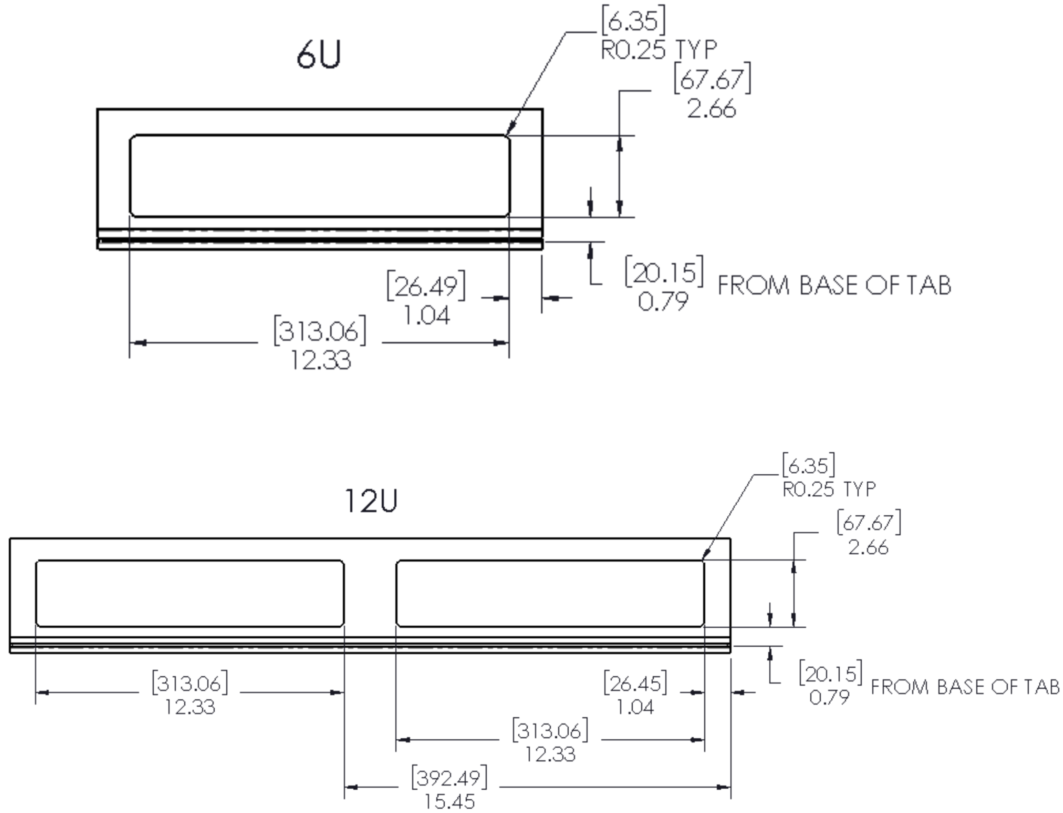


Figure 4.1.4-1: Payload Access Port Locations NRDD with Tabs

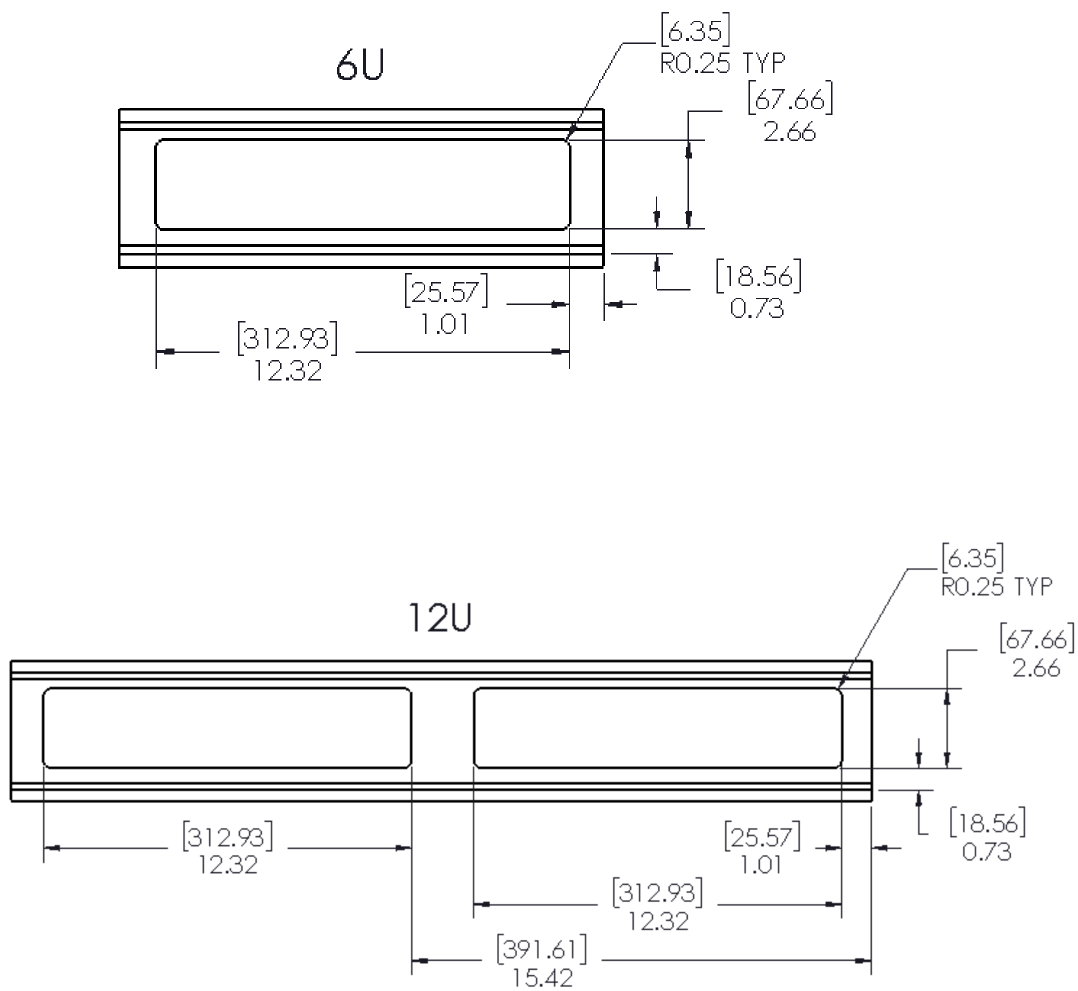


Figure 4.1.4-2: Payload Access Port Locations NRDD with Rails

4.1.5 Deployment Switches

1) The CubeSat shall have a minimum of three (3) deployment switches that correspond to independent electrical inhibits on the main power system (see section on electrical interfaces).
2) NRDD with Tabs CubeSat deployment switches shall all be located on the same face of the payload at the front or the back of the CubeSat (+/-Z face). NRDD with Rails CubeSat deployment switches can be of the pusher variety, located on the +/–Z rail ends/load regions as defined in Figure 4.1.2-1, or roller/lever switches embedded in a CubeSat rail and riding along the NRDD guide rails in the +/-X and Y axes.
   Note: The deployment switches for CubeSats designed to interface with the NRDD with Tabs must interface with the NRDD door or the NRDD pusher-plate (both of which make up a completely flat interface across the payload envelope). Deployment switches cannot be located on both the +/-Z faces of the CubeSat because switches cannot interface with an adjacent payload in the NRDD.
3) The CubeSat deployment switches in the +/-Z axes shall engage / actuate with sufficient travel beyond that of the plane of the tab and load points in either the +/- Z end of the payload.
   Note: The travel of each deployment switch relative to the applicable plane shall be characterized prior to integration with the NRDD and approved by NanoRacks.
4) NRDD with Rails CubeSat deployment switches that utilize the NRDD rails in the +/-X and Y axes as the mechanical interface shall have a minimum actuation travel of 1 mm to accommodate for design slop and tolerance extremes of the CubeSats and NRDD 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 +/-Z axis or roller switches used in the +/-X and Y axes, the total force of the switches shall not exceed 18N.
8) NRDD with Rails CubeSat deployment switches that utilize the NRDD rails in the +/-X and Y axes as the mechanical interface shall maintain a minimum of 75% (ratio of roller/slider-width to guide-rail width) contact along the entire Z-axis.

4.1.6 Deployable Systems and Integration Constraints

1) CubeSat deployable systems (such as solar arrays, antennas, payload booms, etc.) shall have independent restraint mechanisms that do not rely on the NRDD dispenser.
2) The CubeSat shall be capable of being integrated forwards and backwards inside of the NRDD (such that the +/-Z face could be deployed first without issue).
   Note: This requirement is only essential for 6U CubeSats and not 12U CubeSats, as this ensures that a 6U CubeSat can be integrated in either the front or the back position and still have a flat interface for the deployment switches (inside of deployer doors or pusher plate).

4.1.7 Deployment Velocity and Tip-Off Rate Compatibility

1) The CubeSat shall be capable of withstanding a deployment velocity of 0.5 to 1.5 m/s at ejection from the NRDD.
2) The CubeSat shall be capable of withstanding up to 5 deg/sec/axis tipoff rate.
Note: The target tip-off rate of the NRDD is less than two (2) deg/sec/axis. Additional testing / analysis being completed by NanoRacks in order to refine / verify this value. If a payload has specific tip off rate requirements, these should be captured in the unique payload ICA.

4.2 Electrical System Interface Requirements

CubeSat electronic system designs shall adhere to the following requirements.

4.2.1 Electrical System Design and Inhibits

1) All electrical power storage devices shall be internal to the CubeSat.
2) CubeSat shall not operate any system (including RF transmitters, deployment mechanisms or otherwise energize the main power system) for a minimum of 30 minutes where hazard potential exists. Satellites shall have a timer (set to a minimum of 30 minutes and require appropriate fault tolerance) before satellite operation or deployment of appendages where hazard potential exists.
3) The CubeSat electrical system design shall incorporate a minimum of three (3) independent inhibit switches actuated by physical deployment switches as shown in Figure 4.2.1-1. The satellite inhibit scheme shall include a ground leg inhibit (switch D3 on Figure 4.2.1-1) that disconnects the batteries along the power line from the negative terminal to ground.
Note: This requirement considers an inhibit as a power interrupt device, and a control for an inhibit (electrical or software) cannot be counted as an inhibit or power interrupt device. The requirement for three (3) inhibits is based on the worst-case assumption that the CubeSat contains a potential catastrophic hazard that exists in the event of an inadvertent power-up while inside the NRDD. In actuality, the electrical system design shall incorporate an appropriate number of inhibits dictated by the hazard potential of the payload. If this requirement cannot be met, a hazard assessment can be conducted by NanoRacks to determine if an exception can be granted and documented in the unique payload ICA.
4) The CubeSat electrical system design shall not permit the ground charge circuit to energize the satellite systems (load), including flight computer (see Figure 4.2.1-1). This restriction applies to all charging methods.
5) The CubeSat shall have a remove before flight (RBF) feature or an apply before flight (ABF) feature that keeps the satellite in an unpowered state throughout the ground handling and integration process into the NRDD.
Note: The RBF pin is required in addition to the three (3) inhibit switches. See Section 4.1.2 for details on mechanical access while the payload is inside the NRDD.
6) The RBF /ABF feature shall preclude any power from any source operating any satellite functions with the exception of pre-integration battery charging.
7) The CubeSat Electronics Power System (EPS) shall have no more than six (6) inches of wire 26AWG or larger between the power source (i.e. battery pack) and the first electrical inhibit.

Note: If more than six (6) inches of wire is required between the batteries and the first electrical inhibit, then SAE AS22759 or equivalent wiring shall be utilized. Wiring shall be insulated with Polytetrafluoroethylene (PTFE) or Ethylene tetrafluoroethylene (ETFE) and adhere to the 200°C wire rating outlined on Page 2-8 of TA-92-038 (can be provided by NanoRacks).

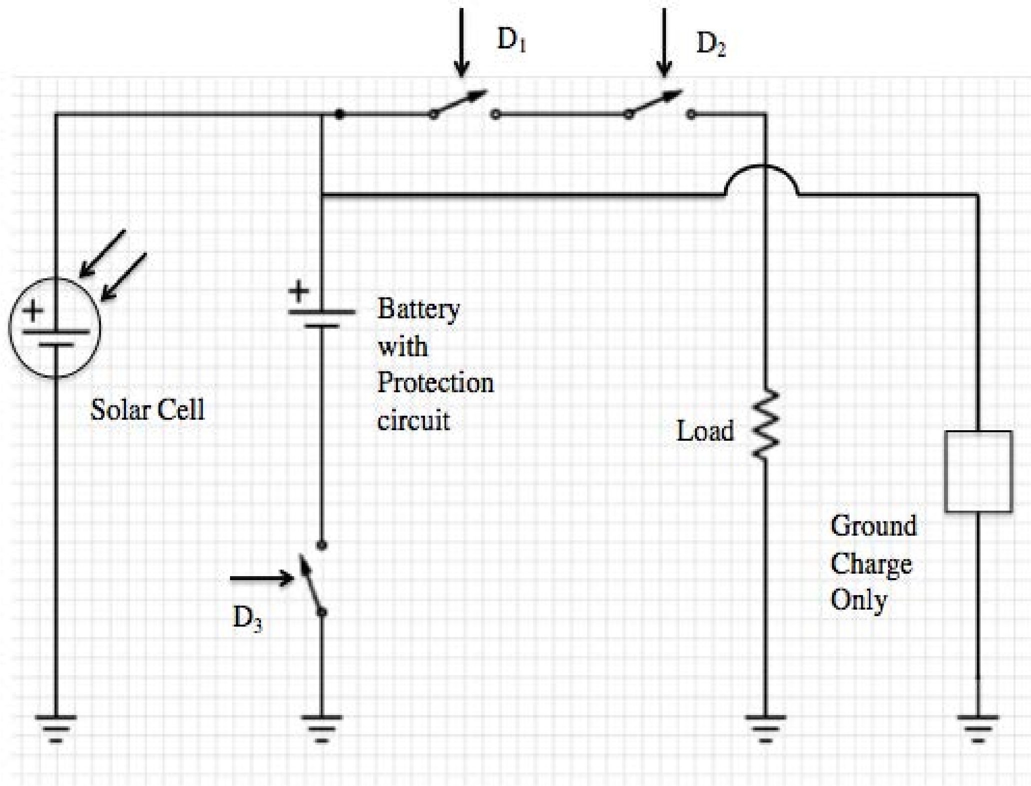


Figure 4.2.1-1: CubeSat Electrical Subsystem Block Diagram (Note: RBF pins not shown)

4.2.2 Electrical System Interfaces

1) There shall be no electrical or data interfaces between the CubeSat and the NRDD. As outlined in Section 4.2, the CubeSat shall be completely inhibited while inside the NRDD.

4.3 Environmental Interface Requirements

4.3.1 Acceleration Loads

1) Payload safety critical structures shall (and other payload structures *should*) provide positive margins of safety when exposed to the accelerations documented in Table 4.3.1-1 at the CG of the item, with all six degrees of freedom acting simultaneously.
   Note: The acceleration values are applicable to both soft-stowed and hard-mounted hardware (Per SSP 57000, Section D.3.1.1). NanoRacks and the PD shall identify any safety critical structures in the unique payload ICA in order to determine what is required to verify this requirement. In general, all CubeSats structures are considered safety critical because failure of the CubeSat structure could produce untrackable space debris that could impact an ISS visiting vehicle (which is considered a catastrophic hazard by ISS Program).

Table 4.3.1-1: Launch / Landing Load Factors Envelope

	Nx (g)	Ny (g)	Nz (g)	Rx (rad/sec^2)	Ry (rad/sec^2)	Rz (rad/sec^2)
Launch	+/- 7.0	+/- 4.0	+/- 4.0	+/- 13.5	+/- 13.5	+/- 13.5

Note: The RSS of Ny and Nz is +/-1.8 g, which can be applied one axis at a time in combination with the Nx load.

4.3.2 Random Vibration Environment

1) The CubeSat shall be capable of withstanding the random vibration environment for flight with appropriate safety margin as outlined in Section 4.3.2.1.
   Note: The vibration test profiles vary depending on the configuration of the hardware during test (soft-stow or hard-mount). The different test options outlined below in Section 4.3.2.1 are based on guidance from the JSC Structural and Mechanical engineering branch (per JSC memo 'CubeSat Random Vibration (RV) Technical Requirements' dated October 24th, 2017). Specific post-vibration test inspection records are required to verify all external components are properly installed and do not pose a hazard of coming loose. Additional post-test inspection records may be required depending on the hazard classification of the CubeSat. The verification plan and all required inspection records are to be documented in the unique payload ICA.

4.3.2.1 Random Vibration Test Options

Since the NRDD launches in the soft-stow configuration (wrapped in bubble wrap and secured in a foam-lined CTB, as outlined in Section 3.4.2.7), the satellites contained within the NRDD are exposed to a soft-stow random vibration launch environment. This allows the payload developer to test in a flight equivalent configuration if desired. The acceptable random vibration test options for CubeSat payload developers are outlined below.

1) Random vibration test the flight article in the soft-stow flight configuration to the Maximum Expected Flight Level (MEFL) +3dB ('Soft-Stow Test Profile' in Figure 4.3.2.1-1 / Table 4.3.2.1-1).

   Note: Test configuration is the CubeSat integrated with the NRDD or mechanically equivalent test fixture wrapped in flight approved bubble wrap and foam. NanoRacks must provide flight approved packing material for test.

2) Random vibration test the flight article in the hard-mount configuration to a combined test profile that envelopes the MEFL+3dB and a minimum workmanship level (MWL) vibe ('Hard-Mount Test Profile' in Figure 4.3.2.1-1 / Table 4.3.2.1-1).

   Note: Test configuration is the CubeSat integrated with the NRDD or mechanically equivalent test fixture bolted directly to a vibration table. This test profile also includes additional margin to the MEFL profile beyond that of the +3dB to account for potential amplification of the acceleration loads caused by the foam during flight.

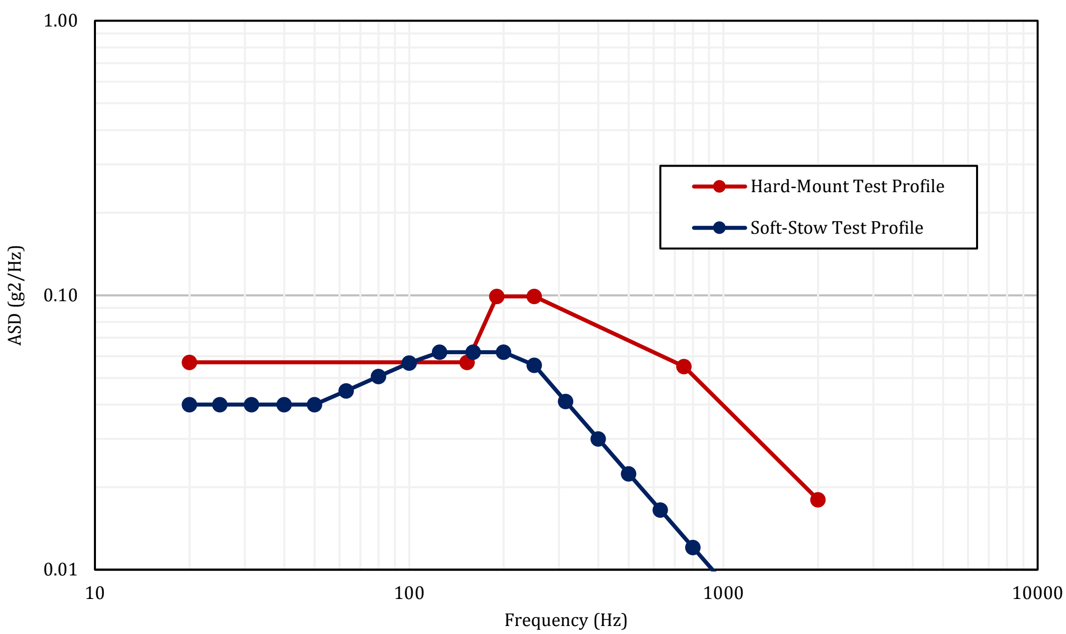


Figure 4.3.2.1-1: Random Vibration Test Profiles

Table 4.3.2.1-1: Random Vibration Test Profiles

Soft-Stow Test Profile	
Frequency (Hz)	**ASD (g^2/Hz)**
20	4.000E-02
25	4.000E-02
31.5	4.000E-02
40	4.000E-02
50	4.000E-02
63	4.490E-02
80	5.062E-02
100	5.660E-02
125	6.200E-02
160	6.200E-02
200	6.200E-02
250	5.558E-02
315	4.102E-02
400	2.998E-02
500	2.236E-02
630	1.651E-02
800	1.206E-02
1000	9.000E-03
1250	6.034E-03
1600	3.878E-03
2000	2.600E-03
grms	**5.76**
Duration (sec)	**60**

Hard-Mount Test Profile	
Frequency (Hz)	**ASD (g^2/Hz)**
20	5.700E-02
153	5.700E-02
190	9.900E-02
250	9.900E-02
750	5.500E-02
2000	1.800E-02
grms	**9.47**
Duration (sec)	**60**

4.3.3 Launch Shock Environment

Integrated end items packed in the soft-stow configuration do not experience significant mechanical shock. As a result, there is no shock test requirement for CubeSats launching inside the NRDD. Any mechanical or electrical components on the spacecraft hat are highly sensitive to shock should still be identified and assessed on a case-by-case basis as defined in the unique payload ICA.

4.3.4 On-Orbit Acceleration

The CubeSat shall be capable of withstanding the loads inside of the NRDD when exposed to the acceleration environment defined in Table 4.3.4-1.

Table 4.3.4-1: On-Orbit Acceleration Environment

EVR Mission Phase	Acceleration	Reference Doc, Paragraph
On-Orbit Acceleration	0.2G	JCX-2003157, 4.1.2 (3)
Acceleration During Airlock Carry Out	1.5 m/sec^2	NASDA-ESPC-2903, 4.1.3.3
JEMRMS Acceleration during E-STOP Maneuver	400mm/sec^2, 12 deg/sec^2	NASDA-ESPC-2901, 3.4.2.5

Note: These loads are enveloped by the launch, ground handling, and quasi-static analysis loads. No verification data shall be required.

4.3.5 Integrated Loads Environment

The CubeSat shall be capable of withstanding a force 1200N across all load points equally in the Z direction.

Note: This number is conservative and will be refined based on qualification testing and further analyses by NanoRacks.

4.3.6 Thermal Environment

The CubeSat shall be capable of withstanding the expected thermal environments for all mission phases, which are enveloped by the on-orbit, EVR phase prior to deployment. The expected thermal environments for all phases of the mission leading up to deployment are below in Table 4.3.6-1.

Note: The on-orbit temperature extremes for the EVR phase prior to deployment are to be considered worst-case extremes based on the results of the thermal analysis conducted for the NRDD. The thermal analysis was conducted based on worst-case atmospheric conditions that are expected to be exceeded no more than 0.5 percent of the time, with albedo and outgoing longwave radiation (OLR) adjusted to the top of the atmosphere (30 kilometer altitude) per SSP 41000 Table XXV. The solar loading conditions for these also took into account extreme beta angle conditions as dictated by JAXA of 73 degrees and -60 degrees. At the time of initial release, the thermal analysis is being refined to better predict worst-case extreme temperatures of the payloads inside the NRDD. Contact NanoRacks for the latest status on the thermal analysis.

Table 4.3.6-1: Expected Thermal Environments

Mission Phase	Temperature Extremes
Ground Transport (Customer facility to NanoRacks)	Determined for each payload
Ground Processing NanoRacks	Determined for each payload
Ground Processing NASA / JAXA Envelope	10°C to 35°C
Dragon Pressurized Cargo	18.3°C to 29.4°C
Cygnus Pressurized Cargo	10°C to 46°C
HTV Pressurized Cargo	0°C to 50°C
On-orbit, Pre-deployment, U.S. and JEM Modules	16.7°C to 28.3°C
On-orbit, EVR Prior to Deployment	-7°C to 57°C

Ref SSP 50835, Table E.2.10-1

4.3.7 Humidity

The CubeSat shall be capable of withstanding the relative humidity environment for all mission phases leading up to deployment, which is between 25% to 75% relative humidity (RH) for ascent and on-orbit phases of flight.

Note: Special consideration may be possible for payload with more stringent RH requirements. These requirements shall be captured in the unique payload ICA and special handling requirements negotiated directly with NanoRacks.

4.3.8 Airlock Depressurization

The CubeSat shall be capable of withstanding the pressure extremes and depressurization / pressurization rate of the airlock as defined below.

Airlock Pressure: 0 to 104.8 kPa

Airlock pressure depressurization/re-pressurization rate: 1.0 kPa/sec

Note: Verification of this requirement completed by ensuring the payload adheres to the venting requirements outlined in Section 4.4.2.

4.4 Safety Requirements

CubeSats shall be designed to preclude or control all hazards present according to the requirements and guidelines outlined in this section. The following sections contain the specific safety requirements common to standard CubeSat designs. In many cases though, the specific design requirements are dependent on the hazard classification of the CubeSat (particularly for CubeSats with non-standard design features). While NanoRacks is responsible for performing the hazard classification for all payloads (with ultimate concurrence from the ISS PSRP), the general guidelines of the process have been outlined below and should be considered background info for the PD.

In general, hazards are classified according to the following definitions:

1) **Catastrophic** Hazard Definition – Any condition that may result in the potential for:
   - A disabling or fatal personnel injury,
   - Loss of the ISS,
   - Loss of a crew-carrying vehicle
   - Loss of a major ground facility

SSP 50700 paragraph 3.1.1.2 Catastrophic HAZARDS - The payload shall be designed such that no combination of two failures, two operator errors (or one of each), can cause a disabling or fatal personnel injury or loss of one of the following: loss of ISS, loss of a crew-carrying vehicle, or loss of major ground facility.

2) **Critical** Hazard Definition - Any condition that may result in either:
   - A non-disabling personnel injury or illness
   - Loss of a major ISS element
   - Loss of redundancy (i.e. with only a single hazard control remaining) for on-orbit life sustaining function

SSP 51700 paragraph 3.1.1.1 CRITICAL HAZARDS - The payload shall be designed such that no single failure or single operator error can cause a non-disabling personnel injury or illness, loss of a major ISS element, loss of redundancy (i.e. with only a single hazard control remaining) for on-orbit life sustaining function, or loss of use of the Space Station Remote Manipulator System (SSRMS).

3) **Marginal** Hazard Definition - Any condition which may cause damage to:
    - An ISS element in a non-critical path
    - A personal injury causing minor crew discomfort that does not require medical intervention from a second crewmember, and/or consultation with a Flight Surgeon

Some examples of CubeSat features/failures that are assessed for hazard potential are:

- Structure Failure
    - Inability to sustain applied loads
    - Fracture
    - Stress corrosion
    - Mechanisms
    - Fastener integrity and secondary locking features
- Pressure System Failure
    - Explosion
    - Rupture
- Leakage of, or exposure to hazardous or toxic substances
- Propulsion System Hazards
    - Including inadvertent operation
- Deployment of appendages
- RF system operation hazard to ISS hardware and Crew
- Battery Failure
- Flammable or toxic material usage
- Frangible material usage
- Electrical system failures causing shock or burn
    - Includes wiring, fusing, grounding
- Electromagnetic Interference (EMI)
- Magnetic field
- Collision with ISS or Visiting Vehicles post deploy on subsequent orbits
- Operational procedures

Control of hazards shall be appropriate for the hazard type and occurrence. Many CubeSat Hazards are controlled by the deployer itself since the CubeSat is contained in the deployer while at ISS until deployment. Some examples of other controls are:

- Structural hazards
    - Application of factor of safety with positive margin
        - Supports design for minimum risk
    - Fault tolerance where applicable
        - Controlled by remaining elements not failing under resulting load
        - Redundant mechanisms
- Electrically operated systems
    - Inhibits to control inadvertent operations appropriate to the hazard level
    - Redundancy as necessary to perform required functions
    - Design controls

- Leakage of toxic substances
  - Fault tolerance in seals
  - Structural strength of containers
  - Multiple levels of containment
- Flammable materials
  - Elimination of flammable materials
  - Containment
  - Wire sizing and fusing
- Pressure systems
  - Factor of safety
  - Venting
- RF systems
  - Design to have power below hazard level and frequency in approved range
  - Inhibits to control inadvertent operations appropriate to the hazard level
- Battery hazards
  - Containment
  - Protection circuits
  - Separation to prevent thermal runaway propagation
  - Screening and testing

4.4.1 Containment of Frangible Materials

The CubeSat design shall preclude the release or generation of any foreign object debris (FOD) for all mission phases.

Note: The primary concern is exposed frangible materials on the satellite exterior (solar cell cover glass, optical lenses, etc). For most frangible materials on CubeSats, a containment or protection method is not required (however all frangible materials shall be identified in the payload unique ICA for NanoRacks review).

4.4.2 Venting

The Maximum Effective Vent Ratio (MEVR) of the CubeSat structure and any enclosed containers internal to the CubeSat shall not exceed 5080cm.

The MEVR is calculated as follows:

$$MEVR = \left(\frac{Internal\ Volume\ (cm)^3}{Effective\ Vent\ Area\ (cm)^2}\right) \leq 5080\ cm$$

Effective vent area shall be considered as the summation of the unobstructed surface area of any vent hole locations or cross-sectional regions that air could escape the CubeSat or subsystems.

4.4.3 Secondary Locking Feature

The CubeSat shall have an approved secondary locking feature for any and all fasteners or subcomponents external to the CubeSat chassis that would not be held captive by the spacecraft structure should it come loose.

Note: The measured and recorded fastener torque is considered the primary locking feature for fasteners. Mechanical or liquid locking compounds are approved. Mechanical secondary locking features are preferred and may be either a locking receptacle such as a locking helical insert or locknut. Approved thread locking compounds include Loctite® Threadlocker Red 271™ and Blue 242™. Contact NanoRacks to determine what other commonly used locking compounds have been approved for use and for appropriate application instructions. The secondary locking feature for all external fasteners and the application procedure of all liquid locking compounds shall be approved by NanoRacks and documented in the unique payload ICA.

4.4.4 Passivity

The CubeSat shall be passive and self-contained from the time of integration up to the time of deployment.
Note: No charging of batteries, support services, and or support from ISS crew is provided after final integration.

4.4.5 Pyrotechnics

The CubeSat shall not contain any pyrotechnics unless the design approach is approved by NanoRacks.
Note: Electrically operated melt-wire systems for deployables that are necessary controls for hazard potentials are permitted.

4.4.6 Space Debris Compliance

1) CubeSats shall not have detachable parts during launch or normal mission operations. Any exceptions will be coordinated with NanoRacks and documented in the unique payload ICA.
2) CubeSats shall comply with NASA space debris mitigation guidelines as documented in NASA Technical Standard NASA-STD-8719.14A.

4.4.7 Batteries

All cells / batteries on the CubeSat shall adhere to the design and testing requirements for spacecraft flight onboard or near the ISS as derived from the NASA requirement document JSC 20793 Crewed Space Vehicle Battery Safety Requirements. Specific provisions for battery use are designed to assure that a battery is safe for ground personnel and ISS crew members to handle and/or operate during all applicable mission phases and particularly in an enclosed environment of a crewed space vehicle. These NASA provisions also assure that the battery is safe for use in launch vehicles, as well as in unpressurized spaces adjacent to the habitable portion of a space vehicle. 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. Certain battery cell chemistries and battery configurations may trigger higher scrutiny to protect against thermal runaway propagation.

It is imperative that NanoRacks 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 and to identify all necessary verifications and testing required (as documented in the unique payload ICA). Redesign efforts greatly impact the payload developer both in cost and schedule. Consult with NanoRacks before hardware is manufactured. Cell/Battery testing associated with the verification of the safety compliance shall be completed as part of the safety certification of the spacecraft. To comply with the requirements herein, every battery design, along with its safety verification program, its ground and/or on-orbit usage plans, and its post-flight processing shall be evaluated and approved by the appropriate technical review panel in the given program or project and captured in the unique payload ICA.

4.4.7.1 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:

- Fire/Explosion/Flammability
- Venting/Burst of Battery Enclosure
- Overcharge Failure/Over-discharge Failure
- External Short Circuit
- Internal Short Circuit Failure
- Thermal Runaway Propagation/Extreme Temperature Hazards
- Chemical Exposure Hazards

4.4.7.2 Battery Types

Although any battery may be made safe to fly in the crewed space vehicle environment there are some batteries that are not practical to make safe. For example, lithium-sulfur dioxide cells have built-in overpressure vents that will release SO2 (sulfur dioxide) gas and other electrolyte components that are highly toxic; thus, these are unacceptable in the habitable area of a space vehicle. However, these chemistries have been used safely in the non-pressurized areas of crewed spacecraft. Often the cells used in batteries for crewed space vehicle are commercially available.

Battery types typically used in spacecraft include:

- Alkaline-manganese primary
- LeClanche (carbon-zinc) primary
- Lead-acid secondary cells having immobilized electrolyte
- Lithium/lithium-ion polymer secondary (including lithium-polymer variation)
- Lithium metal anode primary cells having the following cathodic (positive) active materials
- Poly-carbon monofluoride
- Iodine
- Manganese dioxide
- Silver chromate
- Sulfur dioxide (external to habitable spaces only)
- Thionyl chloride
- Thionyl chloride with bromine chloride complex additive (Li-BCX)
- Iron disulfide
- Lithium sulfur
- Mercuric oxide-zinc primary
- Nickel-cadmium secondary
- Nickel-metal hydride secondary
- Silver-zinc primary and secondary
- Zinc-air primary
- Sodium-sulfur secondary (external to habitable space)
- Thermal batteries

Note: Pressurized battery chemistries required coordination with NanoRacks.

4.4.7.3 Required Battery Flight Acceptance Testing

All flight cells and battery packs shall be subjected to an approved set of acceptance screening tests to ensure the cells will perform in the required load and environment without leakage or failure. While the specific test procedures vary depending on the type of battery, the majority of Lithium ion or Lithium polymer cells / batteries used in CubeSats can be tested to a standard statement of work issued by NanoRacks (NR-SRD-139). Some generic battery design requirements are outlined below.

Note: The battery test plan and verification approach shall be captured in the payload unique ICA. No testing shall be performed without the approval of NanoRacks.

4.4.7.4 Internal Short

Protection circuity and safety features shall be implemented at the cell level to prevent an internal short circuit.

- Application of all cells shall be reviewed by NanoRacks.
- Charger circuit and protection circuit schematics shall be reviewed and evaluated for required fault tolerance.

4.4.7.5 External Short

Protection circuity and safety features shall be implemented at the cell level to prevent an external short circuit.

- Circuit interrupters that are rated well below the battery's peak current source capability shall 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 shall 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.
- 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.
- All inner surfaces of metal battery enclosures should be anodized and/or coated with a non-electrically conductive electrolyte-resistant paint to prevent a subsequent short circuit hazard (if applicable).
- The surfaces of battery terminals on the outside of the battery case should be protected from accidental bridging.
- Battery terminals that pass through metal battery enclosures should be insulated from the case by an insulating collar or other effective means.
- Wires inside the battery case should be insulated, restrained from contact with cell terminals, protected against chafing, and physically constrained from movement due to vibration or shock.
- In battery designs greater than 50 Vdc, corona-induced short circuits (high-voltage induced gas breakdown) shall be prevented.

4.4.7.6 Overvoltage and Undervoltage Protection

Protection circuitry and safety features shall be implemented at the cell level to prevent overvoltage or undervoltage conditions of the cell.

4.4.7.7 Battery Charging

It should be verified that the battery charging equipment (if not the dedicated charger) has at least two levels of control that will prevent it from causing a hazardous condition on the battery being charged.

Note: This does not apply if the CubeSat will not be charged at NanoRacks.

4.4.7.8 Battery Energy Density

For battery designs greater than 80 Wh energy employing high specific energy cells (greater than 80 watt-hours/kg, for example, lithium-ion chemistries) require additional assessment by NanoRacks due to potential hazard in the event of single-cell, or cell-to-cell thermal runaway.

Note: Any system over 80 Wh will require additional design scrutiny and testing (likely including destructive thermal runaway testing). It is possible that this additional testing may be avoided by implementing design features in the system, such as splitting up the cells into distinct battery packs less than 80 Wh and physically isolating them at opposite ends of the CubeSat (so that where thermal runaway cannot propagate between packs). Other methods such as reducing the state of charge of the batteries at the time of delivery can be explored with the JSC Battery Safety team to reduce the risk of a thermal runaway event.

4.4.7.9 Lithium Polymer Cells

Lithium Polymer Cells i.e. “pouch cells” shall be restrained at all times to prevent inadvertent swelling during storage, cycling, and low pressure or vacuum environments with pressure restraints on the wide faces of the cells to prevent damage due to pouch expansion. Coordinate with NanoRacks for guidance on specific implementation.

4.4.7.10 Button Cells

Button cell or coin cell batteries are often used in COTS components to power real-time clocks (RTCs), watch-dog circuits, or secondary systems for navigation, communication, or attitude control. These batteries shall be clearly identified by part number and UL listed or equivalent.

Note: Flight acceptance screening testing of these cells is typically not required, only a functional test of the system needs to be reported. NanoRacks will confirm requirements upon documentation of all coin cell part numbers in the unique payload ICA.

4.4.7.11 Capacitors Used as Energy Storage Devices

Capacitors are used throughout today’s modern electronics. Capacitors used as energy storage devices are treated and reviewed like batteries. Hazards associated with leaking electrolyte can be avoided by using solid state capacitors. Any wet capacitors that utilize liquid electrolyte must be reported to NASA. The capacitor part number and electrolyte must be identified along with details of how the capacitor is used and any associated schematics.

Note: NanoRacks to advise on any required flight acceptance screening testing once the information has been captured in the payload unique ICA.

4.4.7.12 Pressure Vessels

A pressure vessel is defined by SSP 52005 as any sealed container with an internal pressure greater than 100 psia. A pressure vessel may be made acceptable for Flight Safety with proper controls for any hazard potential both for inside ISS and outside ISS. If a satellite has a pressure vessel, the PD shall provide documentation with respect to the materials used, tank history (including cycles and life time assessment) and control measures taken 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 certified by the Department of Transportation (DOT) or have a DOT issued waiver for transportation across the US. Use of non-DOT certified pressure vessels generally would not be permitted. Exceptions must be coordinated with NanoRacks during the pre-contract signing phase. Systems will have to demonstrate via test that required factors of safety are present for tanks, lines and fittings that can be exposed to pressure with 1 or 2 failures depending on hazard potential. Pressure vessels and components procured from third party vendors must have proper certification records or the PD must develop the appropriate records to assure that the systems are safe by meeting NASA requirements. NanoRacks will assist in negotiating with NASA to define the work and analysis necessary to meet the NASA requirements.

4.4.8 Propulsion System

The propulsion system will need to be assessed for hazard potential. NanoRacks 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 in or around ISS could be catastrophic or critical. Depending on hazard potential, both mechanical and electrical fault tolerance may be required.
Systems with toxic propellant may not be allowed onboard ISS but might be approvable if outside ISS. Propellants with explosive potential may not be approvable. Acceptable propellant type must be coordinated with NanoRacks and documented in the ICA.

4.4.9 Materials

4.4.9.1 Stress Corrosion Materials

Stress corrosion resistant materials from Table I of MSFC-SPEC-522 are preferred. Any use of stress corrosion susceptible materials (Table II) shall be pre-coordinated with NanoRacks and documented in the ICA. Any use of Table III materials shall be avoided.

4.4.9.2 Hazardous Materials

Satellites shall comply with NASA guidelines for hazardous materials. Beryllium, cadmium, mercury, silver or other materials prohibited by SSP-30233 shall not be used.

4.4.9.3 Outgassing / External Contamination

Satellites shall comply with NASA guidelines for selecting all non-metallic materials based on available outgassing data. Satellites shall not utilize any non-metallic materials with a Total Mass Loss (TML) greater than 1.0 percent or a Collected Volatile Condensable Material (CVCM) value of greater than 0.1 percent.

Note: A Bill of Materials (BoM) must be provided to NanoRacks to verify all materials requirements are met. The BoM shall be provided in the template specified by NanoRacks, and must include the vacuum-exposed surface areas of all non-metals. The ISS Space Environments Team screens the BoMs to ensure there are no external contamination concerns due to high-outgassing components. A bake out is not required. The NASA website linked below is a useful source for obtaining outgassing data for materials. https://outgassing.nasa.gov/

4.4.9.4 Electrical Bonding

All spacecraft components shall be electrically bonded per SSP 30245 to ensure the spacecraft is free from electrical shock and static discharge hazards. Typically, spacecraft components may be bonded by either nickel plating or chemical film treated faying surfaces or dedicated bonding straps.

4.5 Jettison Requirements

The insertion parameters of the CubeSat are dictated by the NRDD and therefore the jettison approval process is coordinated by NanoRacks based on inputs provide by the PD. However, payloads should be aware of the following criteria as a minimum. Special cases where post deploy collision controls necessitate other criteria are possible.

4.5.1 Delta Velocity (Delta V)

Satellites with propulsion capability (including use for attitude control) require further assessment by NanoRacks. The full Delta V capability of the payload shall not raise the payload's apogee to less than 5 km DH relative to the ISS perigee. The payload developer shall submit an analytical analysis accounting for maximum theoretical Delta V capability using the equation below.

$\Delta v = -ISP*g*\ln(1 - m_p/m_0)$

Where ISP is the system highest specific impulse, m_p is the total propellant mass, m_o is satellite initial mass, and g = 9.8 m/sec.

Note: The information above is just so that NanoRacks can characterize the capabilities of any propulsion system. All propulsion systems will be subject to a compatibility assessment with the ISS Program prior to manifesting for flight.

4.5.2 Re-entry Survivability

1) CubeSats over 5kg shall provide an Orbital Debris Assessment Report (ODAR) that verifies compliance with NASA-STD-8719.14.

2) CubeSats that are designed to survive re-entry or have components that are designed to survive re-entry shall provide an ODAR that verifies compliance with NASA-STD-8719.14.

   Note: Any payload that is designed to survive re-entry may require additional data submittals or justification that will be handled on a case-by-case basis and documented in the payload unique ICA.

4.6 Documentation Requirements

4.6.1 Regulatory Compliance

The CubeSat developer shall submit evidence of all regulatory compliance for spectrum utilization and remote sensing platforms prior to handover of the payload. This evidence shall come in the form of the authorization or license grant issued directly from the governing body / agency (which is dependent on the country the CubeSat originates).

Note: NanoRacks is not responsible for facilitating the licensure effort for spectrum and remote sensing authorization but is required to provide ISS Program with proof of compliance prior to delivering the payload for launch.

For United States (US) CubeSats, the governing body for spectrum authorization is the Federal Communications Commission (FCC) unless the payload is government owned / operated, in which case the regulatory body is the National Telecommunications and Information Administration (NTIA). The governing body for US CubeSats with remote sensing platforms is the National Oceanic and Atmospheric Administration (NOAA), which is not required if the payload is government owned / operated.

For non-US CubeSats, proof of regulatory compliance with appropriate domestic agencies and the International Telecommunication Union (ITU) coordination details shall be provided.

NanoRacks is not responsible for facilitating the licensure effort but is required to provide ISS Program with proof of compliance prior to delivering the payload for launch.

4.6.2 Documentation

In addition to the payload unique ICA, payload providers will be required to provide various documents and reports to progress through the flight safety and verification process. Table 4.6.2-1 captures the major documents that are required. Note that the deliverables outlined below may not apply to all payloads and in turn additional documentation required at the discretion of NanoRacks. The required documentation for verification shall be captured in the unique payload ICA.

Table 4.6.2-1: Data Deliverables

Item	Deliverable	Description
1	Safety Data Template	Summary of Satellite Design, requires filling in NanoRacks template with basic satellite design information appropriate for processing the satellite through the Safety Review Process.
2	Structural Analysis	NR to provide specific guidance on what is required depending on the hazard classification of the payload.
3	Bill of Materials	To be utilized for external outgassing contamination assessment and formation of Materials Identification Usage List (MIUL).
4	Vibration Test Report	Integrated test report outlining test set-up, as-run accelerometer response plots, and post-vibration functional and inspection results.
5	Inspection Reports for fracture critical parts (if any fracture critical parts)	
6	Inspection Reports for stress corrosion parts (if any stress corrosion sensitive parts)	
7	Power System Functional Test Report for EPS inhibits verification	For safety inhibits part of the spacecraft EPS system.
8	Pressure System Qualification Test Report (if Qual Test is performed)	If Pressure Systems are onboard the payload
9	Provide Pressure System Acceptance Test Report	If Pressure Systems are onboard the payload
10	Materials Compatibility Report for Pressure System	If Pressure Systems are onboard the payload
11	Battery Test Report	Test report shows compliance with work instruction provide by NanoRacks.
12	Final Satellite As-Measured Mass Properties	Mass and CM (Mass Measured, CM Calculated)
13	Investigation Summary Form	Template provided by NanoRacks documenting the science objectives of the payload for use on public NASA webpage.

5 Requirements Matrix

Table 5-1: NR-NRCSD-S0002 NanoRacks DoubleWide Deployer IDD Requirements Matrix

Paragraph	IDD Title	Requirement Text	Payload Applicability	Verification Method	Submittal Data
4.1	**Structural and Mechanical Systems**				
4.1.1	**CubeSat Mechanical Specification- NRDD Tab Configuration**				
4.1.1-1	Tab Specification	The CubeSat shall have two (2) tabs that protrude from the main payload envelope and allow the payload to slide into the rail-capture interface of the NRDD as outlined in Figure 4.1.1-1.	A	I, T	Engineering Drawing and Fit-Check
4.1.1-2	Tab Dimensions and CubeSat Envelope	The CubeSat tabs and envelope shall adhere to the dimensional specification outlined in Figure 4.1.1-2.	A	I, T	Engineering Drawing and Fit-Check
4.1.1-3	CubeSat Load Points	The maximum outer radius of the tab at the ends of the payload (+/- Z axis) shall be 3.5mm as outlined in Figure 4.1.1-3.	A	I	Engineering Drawing
4.1.1-4	Tab Outer Radius	The CubeSat shall have load points on the +/- Z faces of the payload that are coplanar with the end of the tabs within +/- 0.25mm (0.010”) and envelope the designated load path regions / contact zones outlined in Figure 4.1.1-4.	A	I	Engineering Drawing and Measurement
4.1.1-5	Tab Length	The CubeSat tab length shall be the following for the respective 6U and 12U payload form factors. a. 6U Payload Tab Length: 366mm (+0.0 / -65.0) b. 12U Payload Tab Length: 732mm ((+0.0 / -130.0)	A	I	Engineering Drawing and Measurement

Paragraph	IDD Title	Requirement Text	Payload Applicability	Verification Method	Submittal Data
4.1.1-6	Tab Continuity	The CubeSat tabs shall be contiguous. No gaps, holes, fasteners, or any other features may be present along the length of the tabs (Z-axis) in regions that contact the NRDD rails (see Figure 4.1.1-1).	A	I	Engineering Drawing
4.1.1-7	NRDD Mechanical Interface	The CubeSat tabs shall be the only mechanical interface to the NRDD in the lateral axes (X and Y axes; does not account for longitudinal, Z-axis contact points).	A	I, T	Engineering Drawing and Fit-Check
4.1.1-8	Tab Envelope	The CubeSat tabs shall extend beyond the +/-Z faces of the entire payload, including all external features (with the exception of load points on the +/-Z face of the payload).	A	I	Engineering Drawing
4.1.1-9	Tab Hardness	The CubeSat tabs and all load points shall have a hardness equal to or greater than hard-anodized aluminum (Rockwell C 65-70).	A	I	Material Certification
4.1.1-10	Tab Surface Roughness	The CubeSat tabs and all load points shall have a surface roughness of less than or equal to 1.6 µm.	A	I	Material Certification
4.1.2	**CubeSat Mechanical Specification-NRDD With Rails Configuration**				
4.1.2-1	Rail Specification	The CubeSat shall have four (4) rails that are integral with the main payload envelope and allow the payload to slide on the rail interface of the NRDD as outlined in Figure 4.1.2-1.	A	I, T	Engineering Drawing and Fit-Check
4.1.2-2	Rail Dimensions and CubeSat Envelope	The CubeSat rails and envelope shall adhere to the dimensional specification outlined in Figure 4.1.2-1.	A	I, T	Engineering Drawing and Fit-Check
4.1.2-3	CubeSat Load Points	The edges of the rails shall be rounded to a radius of at least 0.5mm +/-0.1mm.	A	I	Engineering Drawing
4.1.2-4	Rail Outer Radius	The CubeSat shall have load points on the +/- Z faces of the payload that are coplanar with the end of the rails within +/- 0.25mm	A	I	Engineering Drawing and Measurement

Paragraph	IDD Title	Requirement Text	Payload Applicability	Verification Method	Submittal Data
		(0.010”) and envelope the designated load path regions / contact zones outlined in Figure 4.1.2-1			
4.1.2-5	Rail Length	The CubeSat rail length shall be the following for the respective 6U and 12U payload form factors. a. 6U Payload rail Length: 366mm (+0.0 / -65.0) b. 12U Payload rail Length: 732mm ((+0.0 / -130.0)	A	I	Engineering Drawing and Measurement
4.1.2-6	Rail Continuity	The CubeSat rails shall be contiguous. No gaps, holes, fasteners, or any other features may be present along the length of the rails (Z-axis) in regions that contact the NRDD rails. The exception to this are the deployment switches if rail mounted switches are used.	A	I	Engineering Drawing
4.1.2-7	NRDD Mechanical Interface	The CubeSat rails shall be the only mechanical interface to the NRDD in the lateral axes (X and Y axes; does not account for longitudinal, Z-axis contact points). The exception to this are separation springs or deployment switches if rail mounted switches are used.	A	I, T	Engineering Drawing and Fit-Check
4.1.2-8	Rail Envelope	The CubeSat rails/load points shall extend beyond the +/-Z faces of the entire payload, including all external features, by no less than 2 mm (with the exception of load points on the +/-Z face of the payload).	A	I	Engineering Drawing
4.1.2-9	Rail Hardness	The CubeSat rails and all load points shall have a hardness equal to or greater than hard-anodized aluminum (Rockwell C 65-70).	A	I	Material Certification
4.1.2-10	Rail Surface Roughness	The CubeSat rails and all load points shall have a surface roughness of less than or equal to 1.6 µm.	A	I	Material Certification
4.1.3	**CubeSat Mass Properties**				
4.1.3-1	Mass Limits	The CubeSat mass shall be less than the maximum allowable mass for each respective payload form factor per Table 4.1.3-1.	A	T	Mass Props Report (Measured)

Paragraph	IDD Title	Requirement Text	Payload Applicability	Verification Method	Submittal Data
4.1.3-2	Center of Mass	The CubeSat center of mass (CM) shall be located within the following range relative to the geometric center of the payload. a. X-axis: (+/- 5cm) b. Y-axis: (+/- 3cm) c. Z-axis: i. 6U: (+/- 8cm) ii. 12U: (+/- 16cm)	A	I	Mass Props Report (Calculated not Measured)
4.1.4	**RBF / ABF Access**				
4.1.4-1	RBF / ABF Access	The CubeSat shall have a remove before flight (RBF) feature or an apply before flight (ABF) feature that is physically accessible via the NRDD access ports on the +/-X face of the dispenser / payload. The access port regions on the payload are defined in Figure 4.1.4-1 and 4.1.4-2.	A	I, T	Engineering Drawing and Fit-Check
4.1.5	**Deployment Switches**				
4.1.5-1	Deployment Switch	The CubeSat shall have a minimum of three (3) deployment switches that correspond to independent electrical inhibits on the main power system (see section on electrical interfaces).	A	I, T	Engineering Drawing and Electrical Schematic
4.1.5-2	Deployment Switch Location	NRDD with Tabs CubeSat deployment switches shall all be located on the same face of the payload at the front or the back of the CubeSat (+/-Z face). NRDD with Rails CubeSat deployment switches can be of the pusher variety, located on the +/–Z face on one or more of the rail ends/load regions as defined in Figure 4.1.2-1, or roller/lever switches embedded in a CubeSat rail and riding along the NRCSD guide rails in the +/-X and Y axes.	A	I	Engineering Drawing

Paragraph	IDD Title	Requirement Text	Payload Applicability	Verification Method	Submittal Data
4.1.5-3	Deployment Switch Travel	The CubeSat deployment switches in the +/-Z axes shall engage / actuate with sufficient travel beyond that of the plane of the tab and load points in either the +/- Z end of the payload.	A	I, T	Measurement and Fit-Check
4.1.5-4	Deployment Switch Travel	NRDD with Rails CubeSat deployment switches that utilize the NRDD rails in the +/-X and Y axes as the mechanical interface shall have a minimum actuation travel of 1 mm to accommodate for design slop and tolerance extremes of the CubeSats and NRDD rails.	A	I,T	Measurement and Fit-Check
4.1.5-5	Deployment Switch Reset	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).	A	T	Test Report
4.1.5-6	Deployment Switch Captivation	The CubeSat deployment switches shall be captive.	A	I	Engineering Drawing
4.1.5-7	Deployment Switch Force	For plunger switches used in the +/- Z axis or roller switches used in the +/- X and Y axes, the total force of all the switches shall not exceed 18N.	A	I, T	Switch Spec and Measurement
4.1.5-8	Switch Location	NRDD with Rails CubeSat deployment switches that utilize the NRDD rails in the +/- X and Y axes as the mechanical interface shall maintain a minimum of 75% (ratio of roller/slider-width to guide-rail width) contact along the entire Z-axis.	A	I	Fit-Check
4.1.6	**Deployable Systems and Integration Constraints**				
4.1.6-1	Deployable Restraint Mechanisms	CubeSat deployable systems (such as solar arrays, antennas, payload booms, etc.) shall have independent restraint mechanisms that do not rely on the NRDD dispenser.	A	I	Design Information
4.1.7	**Deployment Velocity and Tip Off Rate**				

Paragraph	IDD Title	Requirement Text	Payload Applicability	Verification Method	Submittal Data
4.1.7-1	Deployment Velocity	The CubeSat shall be capable of withstanding a deployment velocity of 0.5 to 1.5 m/s at ejection from the NRDD.	A	NVR	
4.1.7-2	Tip-Off Rate	The CubeSat shall be capable of withstanding up to 5 deg/sec/axis tipoff rate.	A	NVR	
4.2	**Electrical Systems**				
4.2.1	**Electrical System Design and Inhibits**				
4.2.1-1	Power Storage Device Location	All electrical power storage devices shall be internal to the CubeSat.	A	I	Design Information
4.2.1-2	Post-Deployment Timer	CubeSat shall not operate any system (including RF transmitters, deployment mechanisms or otherwise energize the main power system) for a minimum of 30 minutes where hazard potential exists. Satellites shall have a timer (set to a minimum of 30 minutes and require appropriate fault tolerance) before satellite operation or deployment of appendages where hazard potential exists.	A	I, T	Design Information and Test Report
4.2.1-3	Electrical Inhibits	The CubeSat electrical system design shall incorporate a minimum of three (3) independent inhibit switches actuated by physical deployment switches as shown in Figure 4.2.1-1. The satellite inhibit scheme shall include a ground leg inhibit (switch D3 on Figure 4.2.1-1) that disconnects the batteries along the power line from the negative terminal to ground.	A	I	Electrical Schematics
4.2.1-4	Ground Circuit	The CubeSat electrical system design shall not permit the ground charge circuit to energize the satellite systems (load), including flight computer (see Figure 4.2.1-1). This restriction applies to all charging methods.	A	I	Electrical Schematic

Paragraph	IDD Title	Requirement Text	Payload Applicability	Verification Method	Submittal Data
4.2.1-5	RBF / ABF Location	The CubeSat shall have a remove before flight (RBF) feature or an apply before flight (ABF) feature that keeps the satellite in an unpowered state throughout the ground handling and integration process into the NRDD.	A	I	Engineering Drawing
4.2.1-6	RBF / ABF Functionality	The RBF /ABF feature shall preclude any power from any source operating any satellite functions with the exception of pre-integration battery charging.	A	I	Electrical Schematic
4.2.1-7	Wire Requirement	The CubeSat Electronics Power System (EPS) shall have no more than six (6) inches of wire 26AWG or larger between the power source (i.e. battery pack) and the first electrical inhibit.	A	I	Design Information
4.2.2	**Electrical Systems Interfaces**	There shall be no electrical or data interfaces between the CubeSat and the NRDD. As outlined in Section 4.2.1, the CubeSat shall be completely inhibited while inside the NRDD.	A	NVR	
4.3	**Environmental Interface**				
4.3.1-1	Acceleration Loads	Payload safety critical structures shall (and other payload structures *should*) provide positive margins of safety when exposed to the accelerations documented in Table 4.3.1- at the CG of the item, with all six degrees of freedom acting simultaneously.	A	A	Structural Analysis Report
4.3.2-1	Random Vibration Environment	The CubeSat shall be capable of withstanding the random vibration environment for flight with appropriate safety margin as outlined in Section 4.3.2.1.	A	T	Test Report
4.3.3	Launch Shock Environment	Integrated end items packed in the soft-stow configuration do not experience significant mechanical shock. As a result, there is no shock test requirement for CubeSats launching inside the NRDD. Any mechanical or electrical components on the spacecraft hat are highly sensitive to shock should still be identified and assessed on a case-by-case basis as defined in the unique payload ICA.	N/A	NVR	

Paragraph	IDD Title	Requirement Text	Payload Applicability	Verification Method	Submittal Data
4.3.4	On-Orbit Acceleration	The CubeSat shall be capable of withstanding the loads inside of the NRDD when exposed to the acceleration environment defined in Table 4.3.4-.	A	NVR	
4.3.5	Integrated Loads Environment	The CubeSat shall be capable of withstanding a force 1200N across all load points equally in the Z direction.	A	A	Structural Analysis Report
4.3.6	Thermal Environment	The CubeSat shall be capable of withstanding the expected thermal environments for all mission phases, which are enveloped by the on-orbit, EVR phase prior to deployment. The expected thermal environments for all phases of the mission leading up to deployment are below in Table 4.3.6-.	A	NVR	
4.3.7	Humidity	The CubeSat shall be capable of withstanding the relative humidity environment for all mission phases leading up to deployment, which is between 25% to 75% relative humidity (RH) for ascent and on-orbit phases of flight.	A	NVR	
4.3.8	Airlock Depressurization	The CubeSat shall be capable of withstanding the pressure extremes and depressurization / pressurization rate of the airlock as defined below. Airlock Pressure: 0 to 104.8 kPa Airlock pressure depressurization/re-pressurization rate: 1.0 kPa/sec	A	I	Effective Vent Area
4.4	**Safety Requirements**				
4.4.1	Containment of Frangible Materials	The CubeSat design shall preclude the release or generation of any foreign object debris (FOD) for all mission phases.	A	T	Vibration Test Report

Paragraph	IDD Title	Requirement Text	Payload Applicability	Verification Method	Submittal Data
4.4.2	Venting	The Maximum Effective Vent Ratio (MEVR) of the CubeSat structure and any enclosed containers internal to the CubeSat shall not exceed 5080cm.	A	A	Effective Vent Area
4.4.3	Secondary Locking Feature	The CubeSat shall have an approved secondary locking feature for any and all fasteners or subcomponents external to the CubeSat chassis that would not be held captive by the spacecraft structure should it come loose.	A	I, T	Design Information and Vibration Test Report
4.4.4	Passivity	The CubeSat shall be passive and self-contained from the time of integration up to the time of deployment.	A	NVR	
4.4.5	Pyrotechnics	The CubeSat shall not contain any pyrotechnics unless the design approach is approved by NanoRacks.	A	NVR	
4.4.6	**Space Debris Compliance**				
4.4.6-1	CubeSat Sub-Deployables	CubeSats shall not have detachable parts during launch or normal mission operations. Any exceptions will be coordinated with NanoRacks and documented in the unique payload ICA.	A	I	Design Information
4.4.6-2	Space Debris Compliance	CubeSats shall comply with NASA space debris mitigation guidelines as documented in NASA Technical Standard NASA-STD-8719.14A.	A	A	ODAR
4.4.7	**Batteries**				
4.4.7.3	Battery Testing	All flight cells and battery packs shall be subjected to an approved set of acceptance screening tests to ensure the cells will perform in the required load and environment without leakage or failure. While the specific test procedures vary depending on the type of battery, the majority of Lithium ion or Lithium polymer cells / batteries used in CubeSats can be tested to a standard statement of work issued by NanoRacks (NR-SRD-139). Some generic battery design requirements are outlined below.	A	I, T	Electrical Schematics and Battery Test Report

Paragraph	IDD Title	Requirement Text	Payload Applicability	Verification Method	Submittal Data
4.4.7.4	Internal Short Circuit	Protection circuity and safety features shall be implemented at the cell level to prevent an internal short circuit.	A	I	Electrical Schematic
4.4.7.5	External Short Circuit	Protection circuity and safety features shall be implemented at the cell level to prevent an external short circuit.	A	I, T	Electrical Schematic and Battery Test Report
4.4.7.6	Overvoltage and Undervoltage Protection	Protection circuitry and safety features shall be implemented at the cell level to prevent overvoltage or undervoltage conditions of the cell.	A	I, T	Electrical Schematic and Battery Test Report
4.4.7.7	Battery Charging	It should be verified that the battery charging equipment (if not the dedicated charger) has at least two levels of control that will prevent it from causing a hazardous condition on the battery being charged.	Only if Charging	I	Electrical Schematic
4.4.7.8	Battery Energy Density	For battery designs greater than 80 Wh energy employing high specific energy cells (greater than 80 watt-hours/kg, for example, lithium-ion chemistries) require additional assessment by NanoRacks due to potential hazard in the event of single-cell, or cell-to-cell thermal runaway.	Only if Power System > 80Wh	I, T	Electrical Schematic, Design Info, and Battery Testing
4.4.7.9	Lithium Polymer Cells	Lithium Polymer Cells i.e. “pouch cells” shall be restrained at all times to prevent inadvertent swelling during storage, cycling, and low pressure or vacuum environments with pressure restraints on the wide faces of the cells to prevent damage due to pouch expansion. Coordinate with NanoRacks for guidance on specific implementation.	Only if Power System Uses Li-Poly Cell(s)	I	Design Information
4.4.7.10	Button Cells	Button cell or coin cell batteries are often used in COTS components to power real-time clocks (RTCs), watch-dog circuits, or secondary systems for navigation, communication, or attitude control. These batteries shall be clearly identified by part number and UL listed or equivalent.	Only if Power System Uses Button Cell(s)	I, T	Design Information and Test Report

Paragraph	IDD Title	Requirement Text	Payload Applicability	Verification Method	Submittal Data
4.4.7.11	Capacitors	Capacitors are used throughout today's modern electronics. Capacitors used as energy storage devices are treated and reviewed like batteries. Hazards associated with leaking electrolyte can be avoided by using solid state capacitors. Any wet capacitors that utilize liquid electrolyte must be reported to NASA. The capacitor part number and electrolyte must be identified along with details of how the capacitor is used and any associated schematics.	Only if Power System Uses Capacitor as Storage Device	I, T	Design Information and Test Report
4.4.8	Pressure Vessels	A pressure vessel is defined by SSP 52005 as any sealed container with an internal pressure greater than 100 psia. A pressure vessel may be made acceptable for Flight Safety with proper controls for any hazard potential both for inside ISS and outside ISS. If a satellite has a pressure vessel, the PD shall provide documentation with respect to the materials used, tank history (including cycles and life time assessment) and control measures taken 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 certified by the Department of Transportation (DOT) or have a DOT issued waiver for transportation across the US. Use of non-DOT certified pressure vessels generally would not be permitted. Exceptions must be coordinated with NanoRacks during the pre-contract signing phase. Systems will have to demonstrate via test that required factors of safety are present for tanks, lines and fittings that can be exposed to pressure with 1 or 2 failures depending on hazard potential. Pressure vessels and components procured from third party vendors must have proper certification records or the PD must develop the appropriate records to assure that the systems are safe by meeting NASA requirements. NanoRacks will assist in negotiating with NASA to define the work and analysis necessary to meet the NASA requirements.	Only if CubeSat Has a Pressure Vessel	I, A, T	Design Information, Analysis, and Test Report

Paragraph	IDD Title	Requirement Text	Payload Applicability	Verification Method	Submittal Data
4.4.9	Propulsion System	The propulsion system will need to be assessed for hazard potential. NanoRacks 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 in or around ISS could be catastrophic or critical. Depending on hazard potential, both mechanical and electrical fault tolerance may be required. Systems with toxic propellant may not be allowed onboard ISS but might be approvable if outside ISS. Propellants with explosive potential may not be approvable. Acceptable propellant type must be coordinated with NanoRacks and documented in the ICA.	Only if CubeSat Has a Propulsion System	I, A, T	Design Information, Analysis, and Test Report
4.4.10	**Materials**				
4.4.10.1	Stress Corrosion Materials	Stress corrosion resistant materials from Table I of MSFC-SPEC-522 are preferred. Any use of stress corrosion susceptible materials (Table II) shall be pre-coordinated with NanoRacks and documented in the ICA. Any use of Table III materials shall be avoided.	A	I	BoM
4.4.10.2	Hazardous Materials	Satellites shall comply with NASA guidelines for hazardous materials. Beryllium, cadmium, mercury, silver or other materials prohibited by SSP-30233 shall not be used.	A	I	BoM
4.4.10.3	Outgassing / External Contamination	Satellites shall comply with NASA guidelines for selecting all non-metallic materials based on available outgassing data. Satellites shall not utilize any non-metallic materials with a Total Mass Loss (TML) greater than 1.0 percent or a Collected Volatile Condensable Material (CVCM) value of greater than 0.1 percent.	A	I	BoM
4.5	**Jettison Requirements**				

Paragraph	IDD Title	Requirement Text	Payload Applicability	Verification Method	Submittal Data
4.5.1	Delta V	Satellites with propulsion capability (including use for attitude control) require further assessment by NanoRacks. The full Delta V capability of the payload shall not raise the payload's apogee to less than 5 km DH relative to the ISS perigee. The payload developer shall submit an analytical analysis accounting for maximum theoretical Delta V capability using the equation below. $\Delta v = -ISP*g*\ln(1 - m_p/m_0)$ Where ISP is the system highest specific impulse, m_p is the total propellant mass, m_o is satellite initial mass, and g = 9.8 m/sec.	Only if CubeSat Has a Propulsion System	I, A	Design Information and Analysis
4.5.2	**Re-entry Survivability**				
4.5.2-1	CubeSats Over 5kg	CubeSats over 5kg shall provide an Orbital Debris Assessment Report (ODAR) that verifies compliance with NASA-STD-8719.14.	A	A	ODAR & DAS Input File
4.5.2-2	Reentry	CubeSats that are designed to survive re-entry or have components that are designed to survive re-entry shall provide an ODAR that verifies compliance with NASA-STD-8719.14.	Only if CubeSat is Designed to Survive Reentry	I, A	Design Information and Analysis
4.6	**Documentation**				
4.6.1	Regulatory Compliance	The CubeSat developer shall submit evidence of all regulatory compliance for spectrum utilization and remote sensing platforms prior to handover of the payload. This evidence shall come in the form of the authorization or license grant issued directly from the governing body / agency (which is dependent on the country the CubeSat originates).	A	I	Regulatory Licenses