|  |
| --- |
|  |
| NanoRacks  Safety Data Template (SDT)  Project Name: Ukpik-1 |
|  |
| NanoRacks, LLC  555 Forge River Rd, Suite 120  Webster, TX 77598  (281) 984-4040  [www.NanoRacks.com](http://www.NanoRacks.com/) |
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**Acronyms**

|  |  |
| --- | --- |
| ADCS | Attitude Determination and Control System |
| BOM | Bill of Materials |
| COTS | Commercial Off the Shelf |
| CTB | Cargo Transfer Bag |
| EMI/EMC | Electromagnetic Interference / Electromagnetic Compatibility |
| EPS | Electrical Power System |
| ICD | Interface Control Document |
| KOZ | Keep Out Zone |
| MSDS | Material Safety Data Sheet |
| NR | NanoRacks |
| NRCSD | NanoRacks CubeSat Deployer |
| RBF | Remove Before Flight |
| RFA | Radio Frequency Authorization |
| SDT | Safety Data Template |
| SOW | Statement of Work |

# Introduction

General NanoRacks Safety Data Template (SDT) for CubeSats.

This template is intended to be used with the NanoRacks Customer Portal at portal.nanoracks.com (no www or http prefix). Customers are issued a portal account by the NanoRacks Customer Service representative. Customers should insert requested data directly into the template as much as possible (either within the tables or immediately below applicable sections). Large schematics, native CAD files, or other content not easily inserted into the template may be uploaded into the Customer Portal Repository. In such case, insert the filename uploaded to the Repository into the appropriate template field.

# Project Description

Provide the following information.

|  |  |
| --- | --- |
| Project Name | Ukpik-1 |
| Project Sponsor | Canadian Space Agency |
| Project Manager | Dr. Matthew Cross |
| Point of Contact | Dr. Jayshri Sabarinathan |
| Mission Overview | * The primary objective of Ukpik-1 is to provide experiential learning and training opportunities for students in spacecraft development and operations, and in STEM outreach program development and delivery. * The secondary objective is to integrate and operate an immersive VR camera in orbit for science and education. |

## Nominal Safety Schedule

Based on the delivery date of the SDT provided by NanoRacks, please provide a nominal safety schedule for completing the data call as well as for completing all required testing. Note, delivery dates of the phased safety review deliverables to be provided by NanoRacks.

|  |  |
| --- | --- |
| Date | SDT Section to be Completed / Testing to be Performed |
| Pending | Vibration Testing |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

## Concept of Operations and Timeline

Provide a brief timeline describing major events from time of NRCSD deployment to initial mission operations.

|  |  |
| --- | --- |
| Deploy + time (minutes) | Event |
| 0 | Camera turns on to begin imaging (pending) |
| 30 | CubeSat systems switch on |
| 30 + n | OBC boots up |
| 30 + n + | Detumble maneuver begins |
| 30 + n + | Tranceiver switches on |
| 30 + n + | Antenna deployment |
| 30 + n + | Detumble concludes |
|  |  |

# Physical Characteristics

## System Description

Provide the following

|  |
| --- |
| **Major Systems Block Diagrams** |
| Structural Diagram (exploded view of CAD w/ subsystems identified): |
| A screenshot of text  Description automatically generated |
| Power System Block Diagram: |
|  |
| Communications System Block Diagram: |
| Ground Station:    CubeSat Communication System |
| ADCS Block Diagram: |
| Top Level ADCS diagram: |
| Payload Block Diagram: |
| Pending |
| Propulsion System Block Diagram: |
| N/A |
| Thermal System Block Diagram: |
| Pending |

## Dimensions and Mass Properties

Provide the following.

|  |  |
| --- | --- |
| **CAD File(s)** | |
| CubeSat CAD file uploaded to NanoRacks customer portal. Preferred file formats: Solidworks 2017, Parasolid, STEP | |
|  | |
| **Exterior View Engineering Drawings** | |
| +/- X face drawing with dimensions annotated: | |
| A close up of a device  Description automatically generated | |
| +/- Y face drawing with dimensions annotated: | |
| A picture containing table  Description automatically generated | |
| +/- Z face drawing with dimensions annotated: | |
| A close up of text on a white background  Description automatically generated | |
| **Mass Properties** | |
| Total Mass (g), Design | 1986.4g |
| Total Mass (g), As-built | 3.6kg |

## Deployable Systems

Please provide the following.

|  |  |
| --- | --- |
| **Antenna System** | |
| Antenna stowed engineering drawing: | |
|  | |
| Antenna deployed engineering drawing: | |
|  | |
| Deployable force which could be exerted on the inside of the NRCSD (N) |  |
| Description of controls, commands and/or mechanisms for release |  |
| Intended timing for release |  |
| Drawing/render of release system: | |
|  | |
| **Solar Array System** | |
| Solar array stowed engineering drawing: | |
| N/A | |
| Solar array deployed engineering drawing: | |
| N/A | |
| Deployable force which could be exerted on the inside of the NRCSD | N/A |
| Description of controls, commands and/or mechanisms for release | N/A |
| Intended timing for release | N/A |
| Drawing/render of release system: | |
| N/A | |
| **Payload instruments, etc.** | |
| Payload stowed engineering drawing: | |
| N/A | |
| Payload deployed engineering drawing: | |
| N/A | |
| Deployable force which could be exerted on the inside of the NRCSD | N/A |
| Description of controls, commands and/or mechanisms for release | N/A |
| Intended timing for release | N/A |
| Drawing/render of release system: | |
| N/A | |

Note: If using a melt-line, please provide details of the line used (line strength, force on the line, heater temp, etc.). The line should be redundant so that if one breaks, the other will hold.

## Separation Springs

If applicable, also provide a figure denoting the location of the separation springs on the CubeSat structure.

|  |  |  |
| --- | --- | --- |
| Separation Springs | | |
|  | Location | Spring force (N) |
| Separation spring [1] |  |  |
| Separation spring [2] |  |  |

## Deployment Switches

As outlined in the NRCSD IDD Section 4.1.4, a minimum of three (3) deployment switches corresponding to electrical inhibits are required. Note, an RBF pin (or equivalent) does not count as a deployment switch. Please also provide a figure denoting the location of each deployment switch with nomenclature that can be referenced with the inhibit diagram (so that physical switches can be easily translated to corresponding electrical inhibits upon review).

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Deployment Switches** | | | | |
|  | Manufacturer | Part no. | Location | Type |
| Deployment switch [1] |  |  |  |  |
| Deployment switch [2] |  |  |  |  |
| Deployment switch [3] |  |  |  |  |

For each roller/slider i.e. “Ali” switches please complete the following. All units in millimeters (mm).

|  |  |
| --- | --- |
| Switch Manufacturer and Part No. |  |
| [A] CubeSat linear outside rail-to-rail dimension, measured at switch location |  |
| [E] Free position measured from switch mount points |  |
| [F] Operating position measured from switch mount points |  |
| [I] Switch depth, measured from switch mount points to top of CubeSat rail |  |

|  |  |
| --- | --- |
|  |  |
| Figure 1 CubeSat rail roller/slider measurement [A], [E], [F], [I] | |

## Vent Area Assessment

A notional example of an unobstructed vent area is shown in Figure 2. The red shading represents a cut-out in the CubeSat Z-face structure for a typical sensor such as a CMOS imager.

|  |
| --- |
|  |
| Figure 2 CubeSat notional unobstructed vent area example |

|  |  |
| --- | --- |
| **Vent Area Assessment** | |
| Effective volume of air within CubeSat structure (if exact value unknown, provide conservative estimate) [cm3] |  |
| Total Unobstructed vent area (i.e. estimated gap area of components that permit venting) [cm2] |  |

# Electrical Power System (EPS)

## EPS Schematics

Please provide the following.

|  |  |
| --- | --- |
| **EPS Schematics** | |
| Overall electrical system functional schematic: | |
| Note with goal of turning on early camera operation the camera and OBC will directly turn on from EPS source for the time being. | |
| Battery configuration schematic: | |
|  | |
| Battery protection circuit schematic: | |
|  | |
| Solar array configuration schematic: | |
|  | |
| RTC or memory keep-alive battery schematic: | |
|  | |
| System inhibits preventing premature operation | |
| Ground leg inhibit: | |
| Note that this is preventing only the ADCS + COMMS subsystems from activating. This is through a 555 timer. (OBC and camera will start before 30 minute timer) | |
| Remove before flight feature (RBF): | |
|  | |
| Location of each inhibit (deploy switch and RBF) on the vehicle structure: | |
| A picture containing electronics  Description automatically generated  A screenshot of a computer  Description automatically generated  A close up of a device  Description automatically generated | |
| Length of wire between batteries & 1st *electrical* inhibit (FET or equivalent) [in] | 3.8 in |

|  |  |
| --- | --- |
| **EPS Board** | |
| Manufacturer | Endurosat |
| Model or part no. | Power Module I Plus |
| Main Power Batteries | |
| Manufacturer | Endurosat |
| Model or part no. | EPS I PLUS |
| Date of manufacture |  |
| Number of Packs | 1 |
| Number of Cells | 2 |
| Configuration (i.e. 4s2p) | 1s2p |
| Total Energy [W-h] | 10.2 |
| Battery cell type/chemistry | Li-Po |
| Cell dimension and mass | 96 x 90.2 mm (entire EPS board) |
| Previous flight history of battery/cells if applicable. |  |
| Operational power requirement | 74V |
| Operational current requirement | 20mA |
| Specify cell casing type (i.e. “hard” or “pouch”) | Hard |
| Containment method (if pouch casing is used on cells) |  |
| Maximum battery temperature before failure [°C)] | 155 |
| Material Safety Data Sheet (MSDS) uploaded to the NanoRacks customer portal (dated within the last 5 years) (provide link) |  |
| Battery Specification Sheet uploaded to the NanoRacks customer portal (provide link) | https://www.endurosat.com/modules-datasheets/EPS\_Datasheet\_Rev1.pdf |
| Battery Heaters | |
| Maximum heater temperature [°C] |  |
| Minimum heater temperature [°C] |  |
| Physical location relative to batteries [°C] |  |
| Maximum failed on temperature of cells [°C] |  |
| Coin or Button Cells | |
| Manufacturer |  |
| Model or part no. |  |
| Number of cells |  |
| Schematic: | |
|  | |
| Solar Arrays | |
| Solar array manufacturer |  |
| Schematic showing mounting and location |  |
| Materials identification/configuration |  |
| Encapsulation/protective covering. Specify spray vs. manual application, and thickness of application layer |  |
| Schematic showing mounting and location: | |
| A picture containing text  Description automatically generated  Dimensions in millimeters, this is used on all four sides | |
| Solar array lay-up diagram, including thicknesses of each layer: | |
|  | |
| Battery charging system | |
| Battery charging system schematic: | |
|  | |
| Battery protection system | |
| Battery protection circuit schematic: | |
|  | |
| Other power systems | |
| Energy storage devices, e.g. large capacitors, etc. |  |
| Is it an alternative energy source? |  |
| If capacitor, ceramic or electrolyte? |  |
| If electrolyte, wet tantalum or aluminum electrolyte? |  |
| If yes to any of the above, please provide the following for each component: | |
| Manufacturer |  |
| Part Number |  |
| Physical dimensions |  |
| Description of application in system |  |
| Electrical schematic: | |
|  | |

## Battery Flight Acceptance Tests

1. Battery testing to be conducted according to NanoRacks provided statement of work (SOW). Please provide reference to test reports once completed.

|  |  |
| --- | --- |
| **Flight Battery Testing** | |
| Main flight batteries |  |
| Coin or button cells (if required) |  |

# Secondary Locking Feature

A secondary locking feature is required for fasteners external to the CubeSat chassis, that will not be held captive by the spacecraft structure and enclosure should it come loose. LocTite is an approved thread locker. Note: Other locking compounds may be approved by NASA via NanoRacks. Self-priming liquid-locking compounds are not approved. Please refer to the NanoRacks Customer Portal for approved procedure for the application of LocTite primer/ thread locker.

|  |  |
| --- | --- |
| **Secondary Locking Compound Data** | |
| LocTite primer # (or alternative) |  |
| LocTite liquid-locking compound # (or alternative) |  |

# Communications System

Provide the following. Note, all fields must be populated in order for the Radio Frequency Authorization (RFA) to be processed by JSC. If multiple transmitters/receivers on CubeSat, please duplicate the tables below as needed.

|  |  |
| --- | --- |
| **Communications Overview** | |
| Radio Frequency License (NTIA, FCC, ITU) |  |
| **CubeSat owner or operator** | **Dr. Jayshri Sabarinathan** |
| **Time interval from deployment to radio activation** | **>30 minutes** |
| **Description of operations (how & when satellite is commanded, how transmission is terminated, etc.)** |  |
| **Expected mission duration/lifetime** | **6 – 12 months** |
| **Transmitter Specification** | |
| TX Manufacturer | EnduroSat |
| TX Model No. | UHF Transceiver Type II |
| TX Antenna Manufacturer: | GOMspace |
| Antenna Type: Other, dipole, helix, horn, loop, monopole, patch, phased array, reflector, slot, spiral | Canted turnstile |
| Antenna location (with respect to CubeSat body) | 96.5mm in +Y direction |
| Frequency Range Upper [MHz] | 440 MHz |
| Center Frequency (after frequency coordination is obtained) [MHz] | 435 MHz |
| Frequency Range Lower [MHz] | 430 MHz |
| Maximum power output to antenna [W] | 1 |
| Maximum transmitter field strength (volts/meter); assume 1 meter from the source and transmitter radiating with deployed antenna |  |
| Peak Antenna Gain: [dBi] | 1.6 |
| Circuit Loss: [dB] | 0.42 |
| Antenna Polarization: [Other, Horizontal, Left Handed Elliptical, Right Handed Elliptical, Vertical | Left Handed Circular When viewed from top (Away from CubeSat)  Right Handed Circular When viewed from bottom (Towards CubeSat) |
| Antenna Axial Ratio: [dB] |  |

|  |  |  |
| --- | --- | --- |
| Emission Bandwidth (2-sided): | -3 dB [MHz] |  |
| -20 db [MHz] |  |
| -40 db [MHz] |  |
| -60 db [MHz] |  |
| Data Rate (Referenced at modulator input. If forward error correction (FEC) is used, this field is the coded symbol rate. If FEC is not used, this field is the information rate + overhead) [Mbps] | 0.0096 | |
| Modulation Scheme: Other, AM, ASK, BPSK, FM, FSK, GMSK, MSK, QAM, QPSK | GMSK | |
| **Receiver Specification** | | |
| RX Manufacturer | EnduroSat | |
| RX Model No. | UHF Transceiver Type II | |
| RX Antenna Manufacturer | GOMspace | |
| Antenna Type: Other, dipole, helix, horn, loop, monopole, patch, phased array, reflector, slot, spiral | Canted turnstile | |
| Antenna location (with respect to CubeSat body) |  | |
| Frequency Range Upper [MHz] | 440 | |
| Center Frequency (after frequency coordination is obtained) [MHz] | 435 | |
| Frequency Range Lower [MHz] | 430 | |
| Circuit Loss: [dB] |  | |
| Antenna Gain: [dBi] | 1.6 | |
| Antenna Polarization: [Other, Horizontal, Left Handed Elliptical, Right Handed Elliptical, Vertical] | Left Handed Circular When viewed from top (Away from CubeSat)  Right Handed Circular When viewed from bottom (Towards CubeSat) | |
| Antenna Axial Ratio: [dB] |  | |
| **Ground Station Transmitter Specification** | | |
| Ground station name (if multiple, duplicate this table below) | Western Ground Station | |
| Location (longitude & latitude in degrees) | lat: 43.192 lon: -81.316 | |
| Maximum RF transmit power output to antenna [W] | 1 | |
| Peak Antenna Gain [dBi] | 13.3 | |
| Frequency Range Upper [MHz] | 440 MHz | |
| Frequency Range Lower [MHz] | 432 MHz | |
| Circuit Loss [dB] | 0.78 | |
| Antenna Type: Other, dipole, helix, horn, loop, monopole, patch, phased array, reflector, slot, spiral | Yagi-Uda | |
| Antenna Polarization: [Other, Horizontal, Left Handed Elliptical, Right Handed Elliptical, Vertical | Circular Polarized, polarization switch will be purchased for either RHCP or LHCP | |
| Antenna Axial Ratio: [dB] |  | |
| Emission Bandwidth (2-sided): | -3 dB [MHz] |  |
| -20 db [MHz] |  |
| -40 db [MHz] |  |
| -60 db [MHz] |  |
| Data Rate (Referenced at modulator input. If forward error correction (FEC) is used, this field is the coded symbol rate. If FEC is not used, this field is the information rate + overhead) [Mbps] | 0.0012 | |
| Modulation Scheme: Other, AM, ASK, BPSK, FM, FSK, GMSK, MSK, QAM, QPSK | GMSK | |

# Attitude Determination and Control System (ADCS)

## ADCS Description

Provide the following:

|  |  |
| --- | --- |
| **ADCS Description** | |
| Passive | |
| Gravity-gradient (if deployable mass or appendage used, list in Section 3.3) |  |
| Spin stabilization (describe means of rotation imparted to CubeSat) |  |
| Active | |
| Impulse type (if thrusters used, list in Section 10) | N/A |
| Momentum or Control Moment Gyros (if magnetic bearings used, list in Section 7.2) | Magnetorquers |

## Magnetic Devices

If permanent/electro-magnets used:

|  |  |
| --- | --- |
| Magneto Torquers Description | |
| Number of permanent/electro-magnets | 3 electro-magnets |
| Schematic depicting physical layout within CubeSat: | |
|  | |
| Manufacturer |  |
| Model or part no. |  |
| If permanent magnets, list magnetic field strength at 10cm [Gauss] |  |
| If electro-magnets, list field strength per each [amps-turns-m2] |  |

# Integration

Customers must provide a letter describing their integration requirements. The letter, at a minimum, must contain:

|  |  |
| --- | --- |
| Customer Integration Letter | |
| Description of Remove Before Flight (RBF) pin (or functional equivalent) and physical location of deployment switches. |  |
| Procedure to reset delay timer clock |  |
| General handling procedures and keep out zones (KOZs), with applicable figures/pictures |  |

## CubeSat Flight Model Data

Please provide.

|  |  |
| --- | --- |
| As-built Dimensions [mm](see Figure 3 ) | |
| +Z end, +X face, Length rail-to-rail, measured from outside of rail |  |
| +Z end, +Y face, Length rail-to-rail, measured from outside of rail |  |
|  | |
| -Z end, +X face, Length rail-to-rail, measured from outside of rail |  |
| -Z end, +Y face, Length rail-to-rail, measured from outside of rail |  |

|  |
| --- |
|  |
| Figure 3 CubeSat Flight Rail-to-Rail Dimensions |

# General Requirements

## Regulatory Compliance

US Customers must submit evidence of FCC space debris mitigation compliance. Non-US Customers are certified compliant during NASA flight safety review. Note, if CubeSat is greater than 5kg, special considerations must be taken. Please coordinate with NanoRacks Payload Coordinator.

|  |  |
| --- | --- |
| Regulatory Compliance | |
| Customers are required to forward RF spectrum license from home country RF spectrum licensing authority. In advance of license grant, please provide filing number, call sign, or equivalent. |  |
| If using the Amateur Radio frequencies, IARU approval documents must be forwarded. |  |
| US Customers must submit evidence of FCC space debris mitigation compliance. Non-US Customers are certified compliant during NASA flight safety review. |  |
| US Customers with any remote sensing capability are required to forward a NOAA Remote Sensing license. |  |

# Propulsion System

If CubeSat has a propulsion system, please populate the table below as an initial data call. NanoRacks has developed specific templates and procedures for processing propulsive systems through the ISS flight safety process. Please consult with NR Payload Coordinator further if applicable.

|  |  |
| --- | --- |
| Propulsion System | |
| Technology description, including nominal operational plan | N/A |
| Performance (Thrust, specific impulse and ΔV capability) | N/A |
| Propellant type | N/A |
| Propellant storage description (pressure levels, valves including relief valves, fill and drain/servicing, isolation, thruster control, levels of containment, etc.) | N/A |
| Propulsion system detailed schematic, with reference to electrical inhibits: | |
| N/A | |

# Pressure Systems

If CubeSat has a pressure vessel (other than propulsion system, if applicable) please populate the table below as an initial data call. NanoRacks has developed specific templates and procedures for processing pressure systems through the ISS flight safety process. Please consult with NR Payload Coordinator further if applicable.

|  |  |
| --- | --- |
| Pressure Systems | |
| Overall description | N/A |
| Containment description (pressure vessel) | N/A |
| Pressure levels | N/A |
| Pressurant | N/A |
| Detailed schematic: | |
| N/A | |

# Thermal Control System

Provide the following information on any thermal control systems other than battery heaters (previously addressed). Depending on the nature of the system, additional data call may be required.

|  |  |
| --- | --- |
| Thermal Control Systems | |
| Overall description of operational and control method |  |
| Type of heater (i.e. thermal strip heater) |  |
| Heater manufacturer and P/N (if COTS) |  |
| Maximum failed-on temperatures |  |
| Detailed system schematic, including reference to electrical inhibits: | |
|  | |

# Environmental Testing

## Random Vibration Testing

Random Vibration Testing of the CubeSat is required per NRCSD ICD NR-SRD-029. Prior to completing any testing, contact NanoRacks for the approved vibration test procedure and post-vibration test requirements. A spectrum or test set up other than the profile from the NRCSD ICD requires prior approval by NanoRacks.

|  |  |
| --- | --- |
| Random Vibration Testing | |
| Vibration Test Report | Pending |
| Spectrum and profile (specify NanoRacks or Custom) | Pending |

NanoRacks requires a post vibration test report. Customers may conduct a more in-depth inspection if needed but the following is the minimum required by NanoRacks.

|  |  |
| --- | --- |
| Random Vibration Post-test Inspection | |
| Include a memo in this safety data template addressing: | |
| Inspect for signs of debris or particles, etc. | Pending |
| Verify that appendages or deployables remain in stowed configuration. | Pending |
| Inspect external fasteners and secondary locking for integrity | Pending |
| Post-inspection photos of each axis of CubeSat for flight safety verification closeout. | Pending |
| Mechanical check of all deployment switches corresponding to electrical inhibits | Pending |
| Functional check of all deployment switches corresponding to electrical inhibits | Pending |

## Pre-delivery Mechanical Compatibility Check

Customers are encouraged to check CubeSat mechanical compatibility with the NRCSD prior to delivery to NanoRacks. The NRCSD ICD provides dimensions for a fit gauge, for the smallest NRCSD internal envelope accounting for tolerances. In some circumstances, NanoRacks will request that the Customer perform a deployment test of the CubeSat with a qualification model of the NRCSD. Contact NanoRacks to schedule fit-checks and to determine whether or not a deployment test will be required.

|  |  |
| --- | --- |
| Pre-delivery Mechanical Compatibility Check | |
| Include a memo in this safety data template addressing: | Pending |
| Test with fit gauge (pass/fail) | Pending |
| Test comments (e.g. if test fails reasons and mitigation actions) | Pending |
| Deployment Test - with all appendages released while inside NRCSD | |
| Video of CubeSat deployment | Pending |
| Deployment test (pass/fail) | Pending |
| Test comments (e.g. if test fails, reasons and mitigation actions) | Pending |

# Materials Assessment

## Frangible Materials

|  |  |
| --- | --- |
| Frangible Materials | |
| Identify material type and location (solar array cover glass, camera lens, etc) |  |
| Identify materials containment method  (enclosed area or encapsulation) |  |
| Detailed physical schematics | |
|  | |

## Toxic Materials

NanoRacks guidance on toxic materials available for download, (http://nanoracks.com/resources/documents)

|  |  |
| --- | --- |
| Toxic Materials | |
| Identify material type and location |  |
| Identify toxic materials containment method |  |
| Material Safety Data Sheet (MSDS) uploaded to the NanoRacks customer portal (provide link) |  |
| Detailed schematic | |
|  | |

## Radioactive Materials

|  |  |
| --- | --- |
| Radioactive Materials | |
| Identify material type and location | N/A |
| Identify radioactive materials containment method | N/A |
| Material Safety Data Sheet (MSDS) uploaded to the NanoRacks customer portal (provide link) | N/A |
| Detailed physical schematic | |
| N/A | |