Interface Control Document Between NanoLab Modules and the NanoRacks Platforms 1&2

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0.0 Revision History

Issue	Date	Author	Details

1.0 Introduction

The NanoLab Standard exists to expand the research capabilities in microgravity in the US National Laboratory onboard the International Space Station (ISS) to a broader and more diverse collection of researchers. The NanoLab standard leverages several well known, well defined, and well supported standards to simplify access to space for those researchers and users. The standard include the CubeSat standard for the physical form- factor and the USB standard for power and data connection.

1.1 Document Purpose

This document was created to define the interface requirements between the NanoRacks Platforms 1 or 2 and individual NanoLab Modules. The primary responsibility of NanoLab Module users or their payload developers is to ensure they conform to the requirements of this document and to incorporate safe engineering practices throughout the design, fabrication, and testing processes. NanoRacks will ensure the NanoLab Module's compliance with the requirements of this document and all applicable testing procedures. Compliance with this document is required for flight and installation of a NanoLab Module to the NanoRacks Platform.

NanoLab Module developers shall adhere to the requirements of the latest revision of this document.

1.2 Scope

This document covers NanoLab Module compatibility with the NanoRacks Platforms 1& 2 currently in operation on the ISS. Users should reference the appropriate ICD's for NanoRacks Platform 3 (SuperLabs) and Platform 4 (External)

1.3 Abbreviations and Acronyms

ELC	EXPRESS Rack Laptop Computer
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
ExPRESS	Expedite the Processing of Experiments to the Space Station
ISS	International Space Station
JEM	Japanese Experiment Module
JSC	Johnson Space Center

KSC	Kennedy Space Center
MSFC	Marshall Space Flight Center
NASA	National Aeronautics and Space Administration
NRP	NanoRacks Payload Designator
TDRSS	Tracking and DATA Relay Satellite System network
USB	Universal Serial Bus

1.4 Referenced Documents

Many of the requirements spelled out in this document flow down from NASA standards regarding hardware on manned spacecraft. With that, all standards referenced in this document can be found at the following link:

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2.0 The NanoRacks Platform

2.1 Overview

The NanoRacks Platform serves as the interface between individual NanoLab Modules and the ISS, providing mechanical mounting points and electrical connections for power and data connectivity. Each of these platforms are installed in an EXPRESS rack locker within an EXPRESS rack located in the JEM of the ISS as shown in Figure 1 & Figure 2. As of December 2010 two NanoRack Platforms have been installed and are operational aboard the ISS.

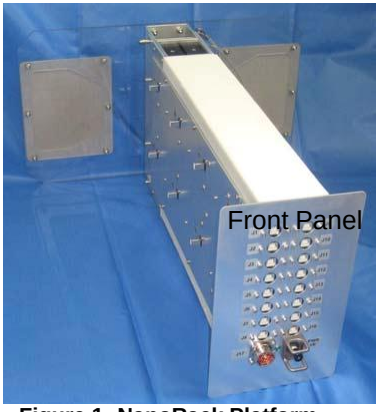

Figure 1: NanoRack Platform

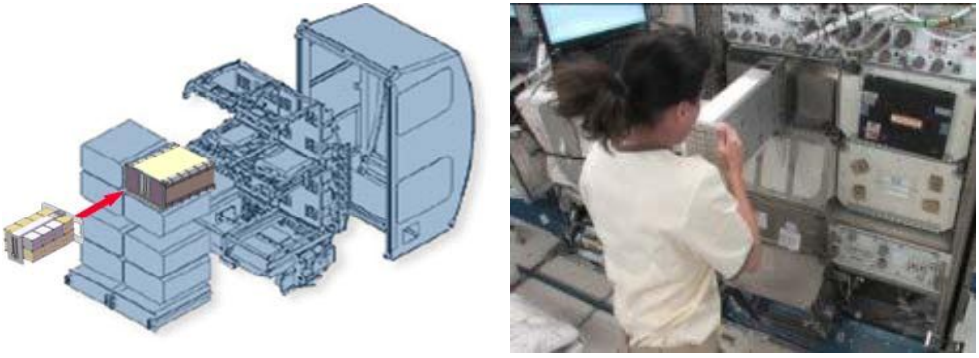

Figure 2: NanoRack Platform Installation in ISS

2.2 Coordinate System

The coordinate system used on the NanoRacks Platform concerning dimensioning and spacing for individual NanoLab Modules follows the convention shown in Figure 3. NanoLab Module requirements are specified using this convention and developers shall use the same convention in their designs.

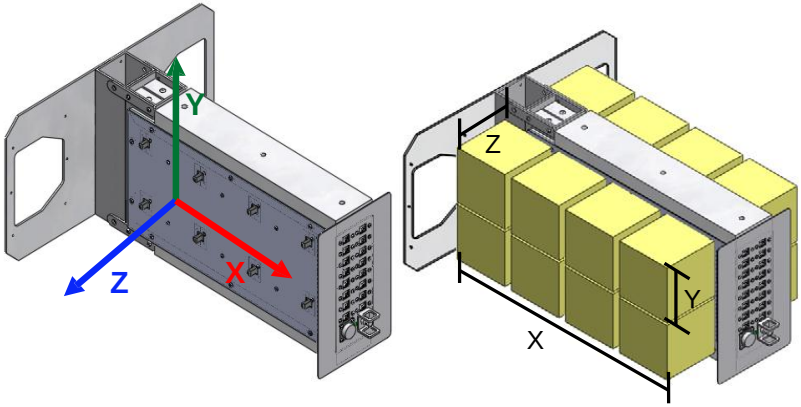

Figure 3: NanoRack Platform Coordinate System with and without NanoLab Modules

2.3 USB Spacing and Orientation

NanoRack Platforms 1 and 2 include 8 USB type B male connectors per side for a total of 16 attachments for NanoLab Modules. The connections are oriented as shown in Figure 4 with the flat edge of the USB facing towards the front panel of the NanoRack Platform. A Mechanical Drawing of the side panel of a NanoRacks Platform showing the spacing of the connectors is included in Appendix A.

Figure 4: NanoRack Platform USB Orientation

3.0 The NanoLab Standard

3.1 Dimensioning from USB Connections

A 1U NanoLab Module shall have external dimensions of no larger than 110 mm x 100mm x 100mm (4.33in x 3.94in x 3.94in). The NanoRacks Platform is designed to support NanoLab Modules ranging in size from a 1U (Figure 8) to as large as 4U x 2U; as shown in Figure 9. Dimensioning for NanoLab Modules is centered off of the center of their respective USB connector(s); Figures 5, 6, and Table 1 display this dimensioning convention. Figure 7 is a mechanical drawing of a USB type B female connector required for NanoLab compatibility. For NanoLab Modules of larger than 1U the envelope measurements of this section would be moved to farthest used USB.

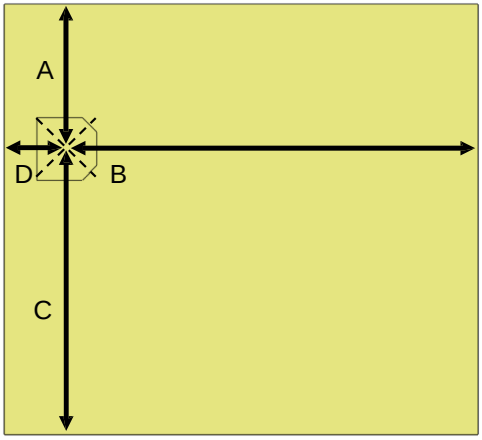

Figure 5: NanoLab Module Dimensions Measured from USB Connector after disconnected from NanoRack Platform and rotated 180° on Y axis

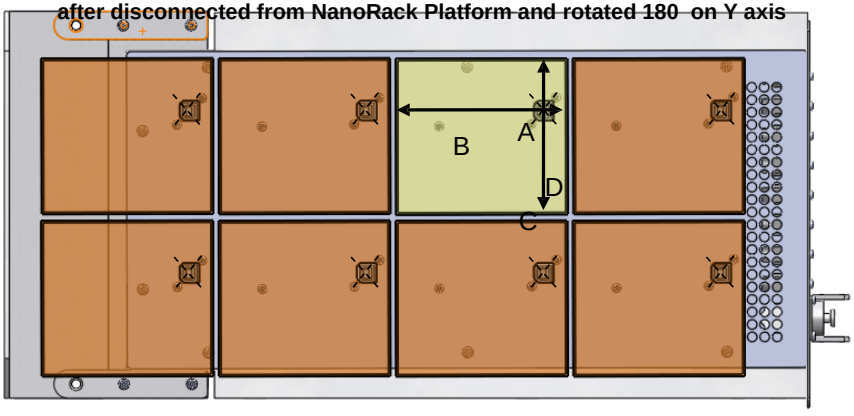

Figure 6: NanoLab Module Dimensions off USB Connectors with Other Modules Attached

Table 1: Dimensions from Figure 5

-	Maximum Dimensions
A	33.55 mm (1.321 in)
B	95.37 mm (3.755 in)
C	66.45 mm (2.616 in)
D	14.63 mm (0.576 in)

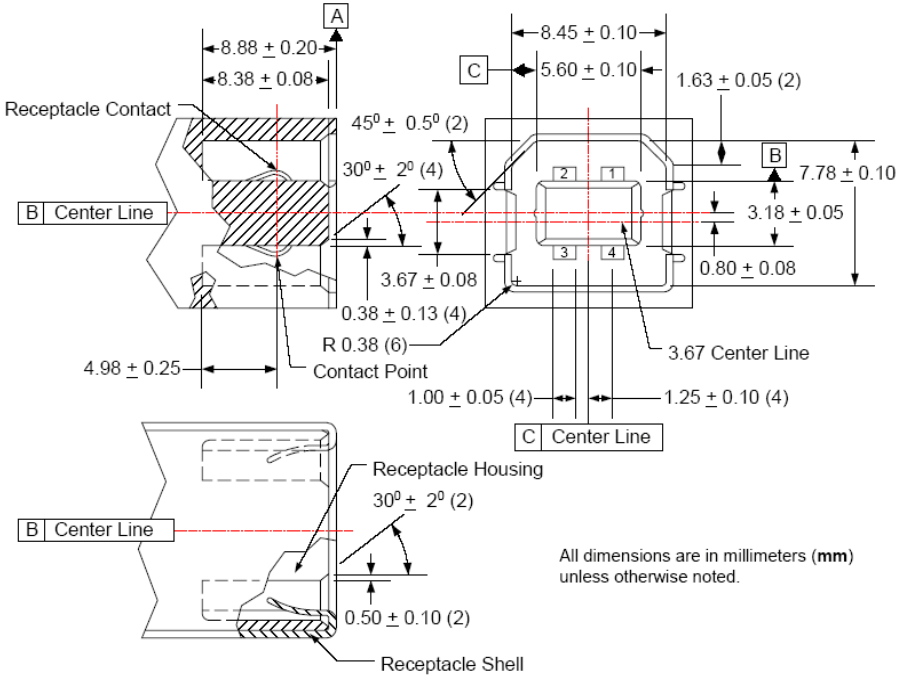

Figure 7: USB Series B Receptacle Interface[1]

[1] Taken from USB 2.0 Standard

3.2 Maximum Volume

NanoLab Modules shall adhere to the maximum dimensions displayed in Table 2. Refer to Figure 3 for relevant coordinate system. Maximum volumetric envelopes are specified from the USB connectors on the NanoRack Platforms. Each individual unit shall contain at least one USB type B female connector for power, data, and mechanical attachment to the NanoRack Platforms. If mission success requires dimensions outside of those outlined in Table 2 designs shall be evaluated on a case by case basis.

Table 2: Possible Form Factors for NanoLab Modules

Form Factor	Maximum Dimensions (X x Y x Z)<
1U	110mm x 100mm x 100mm (4.33in x 3.94in x 3.94in)
2U	223.5mm x 100mm x 100mm (8.80in x 3.94in x 3.94in)
3U	337mm x 100mm x 100mm (13.27 in x 3.94in x 3.94in)
4U	450.5mm x 100mm x 100mm (17.74in x 3.94in x 3.94in)
2U x 2U	223.5mm x 204mm x 100mm (8.80in x 8.03in x 3.94in)
3U x 2U	337mm x 204mm x 100mm (13.27 in x 8.03in x 3.94in)
4U x 2U	450.5mm x 204mm x 100mm (17.74in x 8.03in x 3.94in)
2 x 4U x 2U‡	2 x (450.5mm x 204mm x 100mm) 2 x (17.74in x 8.03in x 3.94in)

< Represents maximum possible dimensions for each form factor. Smaller dimensions are permissible.
‡ Represents two 4U x 2U NanoLab Modules with a dedicated harness across the center column; this configuration will take up every available space in the NanoRacks Platform

Figure 8: 1U NanoLab Module

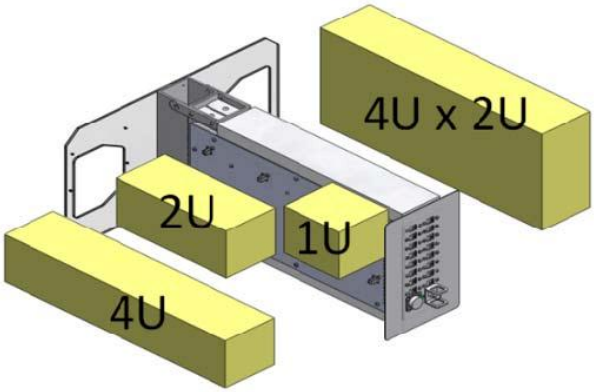

Figure 9: Possible NanoLab Module Configurations

3.3 Mass

The mass properties of NanoLab Modules shall fall within the specification outlined in Table 3:

Table 3: NanoLab Module Mass Properties Specification

Form Factor	Maximum Mass (grams)	Maximum Mass (lbs)
1U	1000	2.20
2U	2000	4.41
3U	3000	6.62
4U	4000	8.82
2U x 2U	4000	8.82
3U x 2U	6000	13.23
4U x 2U	8000	17.64
2 x 4U x 2U	16000	35.27

3.4 Operations

3.4.1 Data Downloads

Data downloads from NanoLab Modules installed on a NanoRacks Platform involve an astronaut connecting a USB data cable from the front panel of a NanoRacks Platform (Figure 10) to the ELC. Once connected, the NanoLab Module shall come up as an external drive on the ELC and files will be manually transferred from the NanoLab Module to a dedicated partition on the ELC. A ground controller transfers data from the partition on the ELC to NanoRacks control facilities viathrough the TDRSS network. From there, data can be disseminated to researchers via a secure internet connection.

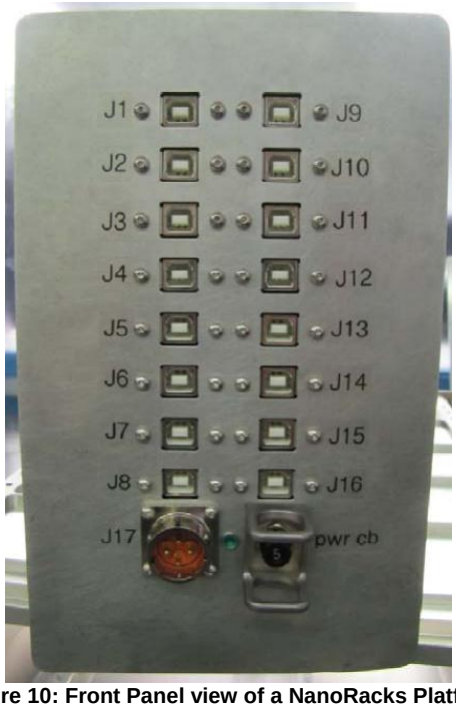

Figure 10: Front Panel view of a NanoRacks Platform

3.5 General Requirements

3.5.1 NanoLab Modules shall adhere to all applicable ISS standards listed in the International Space Station

3.5.2 NanoLab Modules shall be self-contained during transport to the ISS.

3.5.3 NanoLab Modules shall not contain pyrotechnics.

3.5.4 For flight verification, NanoLab Module designs shall pass a Preliminary Design Review (PDR) and a Critical Design Review (CDR) conducted by NanoRacks LLC members on a schedule based upon the launch delivery deadline.

3.5.5 Depending on the nature of the experiment, delivery time shall be between: L-6 (Launch Date minus 6 months) to L-3 (Launch Date minus 3 month).

3.5.6 If a standard or process is in question, NanoRacks will work with NASA and the NanoLab Module developers to clarify or accommodate mission requirements.

3.5.7 Crew time shall be negotiated as needed, however developers shall design their NanoLabs to minimize required astronaut interaction

3.6 NanoRack Platform Interface

3.6.1 Each NanoLab Module shall be connected to the NanoRack Platform by a type B female USB connector shown in Figure 7.

3.6.2 USB port location shall be designed to minimize the impact to other NanoLab Modules. Placement shall be approved during the PDR.

3.6.3 If multiple 1U units are combined (See Table 1), inactive USB ports shall be "dummy" units, with excess dimensional tolerance to facilitate easy alignment of the NanoLab Module to the NanoRacks Platform.

3.7 Materials

3.7.1 NanoLab Module housing and internals shall be made of materials approved by NASA for use aboard the ISS. Refer to NASA STD-6016 for detailed requirements.
https://standards.nasa.gov/documents/detail/3315591

3.7.2 NanoLab Modules shall not contain hazardous materials. If unsure of the classification of a material contact NanoRacks.

3.7.3 Low offgassing materials shall be used. For a list of offgassing requirements, refer to NASA-STD-(I)-6001A.
https://standards.nasa.gov/documents/detail/3314908

3.7.4 NanoLab Modules shall not contain sharp edges that could potentially harm an astronaut on orbit. For testing requirements refer to section 4.4.

3.8 Electrical

3.8.1 Maximum power shall be 2 Watts per USB port at 5VDC**.**

3.8.2 Data transfer shall be completed through scheduled USB connectivity to ELC. See 3.10 for more detail.

3.8.3 NanoLab Modules shall operate nominally during periods of intermittent power as a result of normal operations aboard the ISS. Should power be cut unexpectedly to the NanoLab Module, a recovery mode shall exist allowing the NanoLab Module to recover and return to normal operations.

3.8.4 USB interface on the NanoLab Module shall be USB type B female receptacle. Refer to Figure 7 for dimensional requirements of the USB type B Female connector. Additional information can be found at the NanoRacks developers website referenced above.

3.9 Operations

3.9.1 Upon being plugged into the NanoRacks Platform, NanoLab Modules will receive 5V through the USB port. Communication shall only occur when initiated by an astronaut using the data cable to connect the ELC to the corresponding port on the NanoRacks Platform.

3.9.2 NanoLab Modules should be standalone units. Astronaut interaction with a NanoLab Modules should be limited to installation and data collection. More involved crew interaction must be discussed as early as possible with NanoRacks personnel.

3.10 Data Handling

3.10.1 Communication between the NanoLab Module and the ELC shall follow the USB standard.

3.10.2 NanoLab Modules shall adhere to the Mass Storage Bulk Only subclass of the Universal Serial Bus Mass Storage Class Specification found here:
http://www.usb.org/developers/devclass_docs/usbmassbulk_10.pdf

3.10.3 To verify USB mass storage requirement, tests shall be performed by using the latest *Command Verifier* utility found here:
http://www.usb.org/developers/tools/

3.10.4 Each NanoLab Module shall pass the 'MSC Test' suite, part of the *Command Verifier* utility.

3.10.5 The NanoLab Module/ELC interface shall not require any drivers to be loaded onto the ELC to operate nominally.

3.10.6 The NanoLab Module shall use the USB storage port driver (*usbstor.sys*) which is included in Microsoft Windows 2000 and later.

3.10.7 The following NanoLab Module activation options can be employed: EXPRESS Rack power application, NanoLab Module manual switch.

3.10.8 Experiment data can be retrieved by: USB file transfer to ELC followed by downlink transmission or downmass return if downmass is part of the mission profile.

3.10.9 Files to be downlinked shall be no larger than 10 Megabytes.

3.10.10 Possible deactivation options: NanoLab Module manual switch accessible from exterior of NanoLab Module, or removal of NanoLab Module from the USB docking port.

3.10.11 If permitted by mechanical design, it is highly recommended that the internal memory of the NanoLab Module be easily removable through an external interface so the memory can be returned from the ISS.

4.0 Testing Requirements

NanoLab Modules shall meet all requirements listed in this document and shall be verified by the interface designers. Additional testing may be required by NASA on a module by module basis, depending on the nature of the design.

4.1 Acoustics

NanoLab Modules shall adhere to the NASA ISS "HRF Acoustic Noise Control and Analysis Plan".

4.2 Electromagnetic Interference (EMI)

NanoLab Modules shall adhere to the NASA ISS "HRF Electromagnetic Compatibility Control Plan".
http://snebulos.mit.edu/projects/reference/International-Space-Station/SSP30243RG.pdf

4.3 Offgassing

An offgassing test shall be performed to ensure low offgassing requirements are met, refer to NASA-STD-(I)-6001A.
https://standards.nasa.gov/documents/detail/3314908

4.4 Sharp Edge Test

NanoLab Modules shall undergo a cotton glove test to ensure that no protruding or sharp edges exist that could potentially snag the glove as it is passed over all surfaces of the NanoLab Module.

4.5 Depressurization Test

For NanoLab Modules containing volumes of liquid, a pressure vessel, or a biological payload a depressurization/repressurization must be completed. This test stimulates a loss of pressure inside the ISS and demonstrates that the Module maintains fluid containment in this event.

4.6 Additional Requirements

NanoLab Modules shall adhere to all applicable requirements in the Expedite the Processing of Experiments to Space Station (EXPRESS) Rack Payloads Interface Definition Document - SSP 52000-IDD-ERP Revision H. Safety Data Package submissions to NASA will determine which sections are applicable to a module. The follow list is provided for reference to assist developers in the design of a module.

4.6.1 The aforementioned requirements include (but are not limited to) the following sections:

4.1.1.1/Express Payload Frequency Compatibility
4.7.2/Payload-Generated Acoustic Noise
4.8/DEPRESSURIZATION/REPRESSURIZATION REQUIREMENTS
4.9/GROUND HANDLING ENVIRONMENTS
4.10/MICROGRAVITY DISTURBANCES
5.1.1/EXTERNAL SURFACE TOUCH TEMPERATURE
5.1.2.1/CONDENSATION PREVENTION
5.1.3/LOSS OF COOLING
5.1.4/PRESSURE RELIEF/VENT VALVE SIZING
5.2/ENVIRONMENTAL CONDITIONS
5.3.1/PAYLOAD HEAT DISSIPATION
5.4.9/VACUUM OUTGASSING REQUIREMENTS
7.1/CIRCUIT EMC CLASSIFICATIONS
7.5.1/Electrical Bonding
10.1/PAYLOAD EQUIPMENT SURFACE CLEANLINESS
10.2.1/SPECULARITY
10.3.1/LASERS
10.3.2/NON IONIZING RADIATION
10.3.4/ACCIDENTAL EXPOSURES

Appendix A – NanoRack Platform Side Panel Drawing