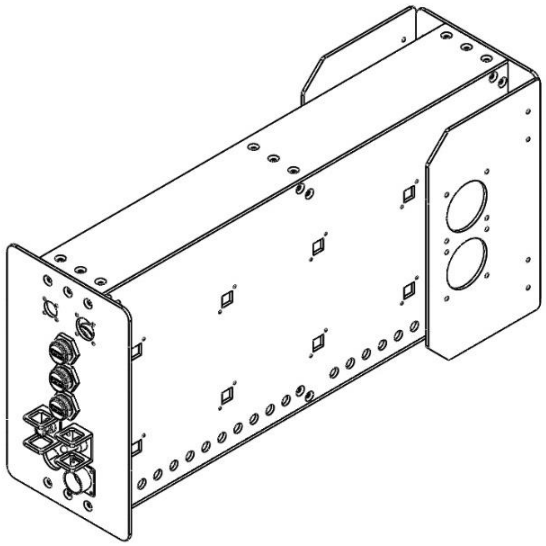

NanoRacks Internal Platforms 1A/2A and NanoLab Modules Interface Control Document

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NANORACKS

Issue	Date	Author	Approved	Details
.1	2010	Various		Baseline
.2	4/21/2013	ACP		
.21	6/18/2013	ACP		Further details added
.3	8/12/2013	ACP		
.31	6/05/2014	MLR		Further details added
.4	2/13/2015	MLR, MMM	MDJ	Major Revision

Acronyms

BOM	Bill of Materials
EMI	Electromagnetic Interference
EXPRESS	EXpedite the PRocessing of Experiments to Space Station
ICD	Interface Control Document
ISS	International Space Station
JEM	Japanese Experiment Module
NLT	No Later Than
NR	NanoRacks
PDR	Preliminary Design Review
PI	Principal Investigator
SDP	Safety Data Package
SDT	Safety Data Template
STELLA	Software Toolkit for Ethernet Lab-Like Architecture
USB	Universal Serial Bus

Table of Contents

1 Introduction

1.1 Document Purpose

This Interface Control Document (ICD) defines the interface requirements between the NanoRacks Platforms (Mark 1A and 2A) and NanoLabs for developers utilizing the NanoRacks Internal Platform services.

1.2 Scope

This ICD provides the minimum requirements for compatibility with NanoRacks Platforms 1A and 2A and the International Space Station flight safety program when using NanoRacks Internal Platform services. NanoRacks verifies compliance on behalf of Principal Investigators (PI) based on incremental data requests.

2 Timeline

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

Launch-minus dates	**Activity**
L-8 months to NLT L-6.5 months	Contract signing, experiment name and general payload information
NLT L-6 months	Submit initial manifest request
NLT L-6 months	Detailed information for Safety and Ops
L-5.5 months	Phase 0/I/II SDP
L-5.5 to L-4 months	Complete hardware testing
L-5.5 to NLT 3.5 months	Submit procedures inputs and payload requirements
NLT L-3.5 months	Phase III SDP submit/ Fit Check and Functional Test
L-2 months to L-2.5 weeks	Phase III Safety Review Close Out and Final Approval
L-45 days to NLT L-32 hours	Turn over to NR for final testing and prep
L-30 days to NLT L-24 hours	Turn over to NASA

3 The NanoRacks Platforms

3.1 Overview

The NanoRacks Platform interfaces between individual NanoLab Modules and the ISS, providing mechanical mounting points and electrical connections for power, data, and communication

capabilities. Each platform is installed in its own EXPRESS rack locker located in the Japanese Experiment Module (JEM) of the ISS as shown in Figure 1. As of August 2013, two identical NanoRacks Platforms have been installed and are operational on ISS.

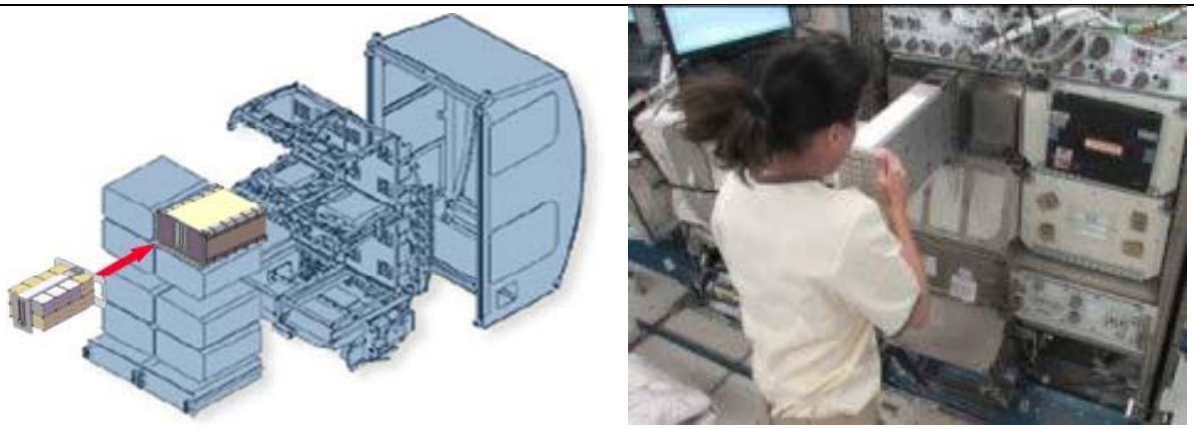


Figure 1: NanoRacks Platform Installation to the ExPRESS Rack Locker on ISS

3.2 Electrical Properties

Power is provided to each NanoLab through at least one USB port. The maximum power the Platform provides per a USB port is 2 Watts at 5 VDC. Additional power is available through the usage of multiple USB ports. Please discuss the usage of multiple USB ports with NanoRacks personnel.

For more information regarding USB ports, please refer to Sections 3.3 and 4.4.

3.3 USB Spacing and Orientation

Each NanoRacks Platform includes a total of 16 USB type B male connectors (8 on each side). The connections are oriented as shown in Figure 2 and Figure 3, with the flat edge of the USB connector facing towards the front panel of the NanoRacks Platform. USB spacing dimensions are included in Figure 2. For more information about USB orientation and dimensions, refer to Section 4.4.

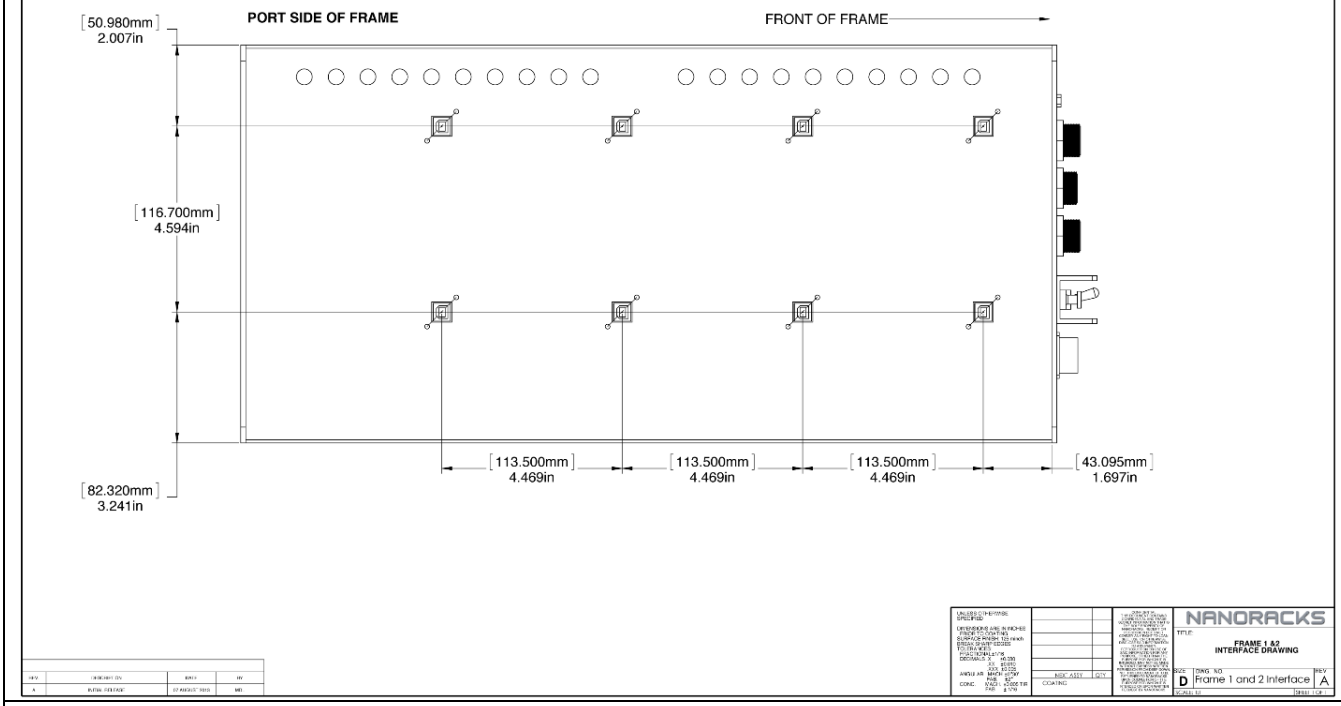


Figure 2: Platform 1A and 2A side-view with the front panel to the right. The rear fans are not shown.

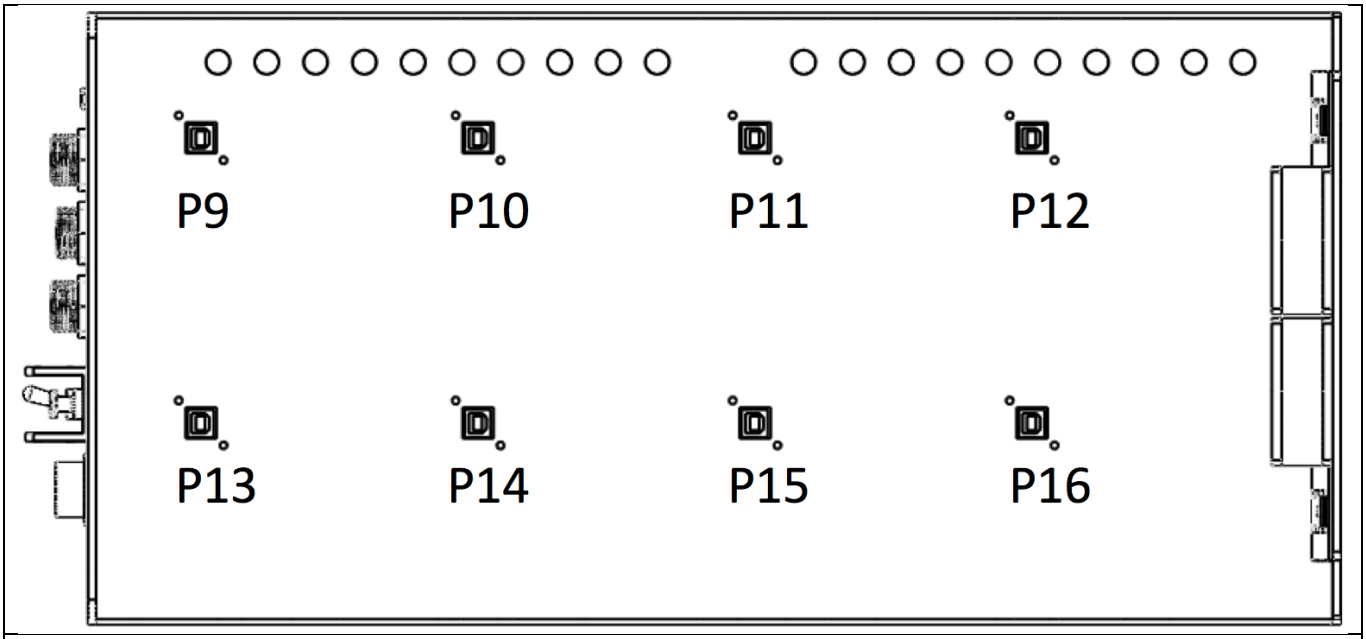


Figure 3: Platform 1A and 2A side-view with the front panel to the left and the rear fans to the right.

4 The NanoLab Standard

The NanoRacks Platform is designed to support NanoLab modules. NanoLab module sizes can range from a 1U (shown in Figure 4) to a 4 by 2 by 1.5U. This portion of the ICD defines the interface requirements to ensure NanoLab compatibility with the Platforms.

4.1 General Requirements

1) NanoLab modules shall not have any objects protruding from the external module walls. USB connections will be on the inside of the NanoLab and flush with the outer surface of the module. Modules which require a different setup require prior approval from NanoRacks.
2) Threadlocker gels shall not be used on threaded joints on the outer walls of the NanoLab.
3) NanoLabs shall not contain pyrotechnics.
4) Flight verification is based on several data requests from NanoRacks to the PI. PIs must submit the NanoRacks Safety Data Template (SDT), receive Safety Data Package (SDP) approval, and pass a fit check and functional test. Additional data and requirements may apply. Payload handling constraints and requirements may apply depending on PI needs. Schedules for these data requests are based on launch delivery deadlines.
5) Delivery times to NanoRacks are dependent on the payload requirements and can range from L-9 weeks to L-36 hours. Please discuss delivery times with NanoRacks personnel.
6) NanoLab modules may experience an unexpected power loss or multiple power cycles as a result of normal operations aboard the ISS. PIs may consider a recovery mode for their NanoLabs to recover and return the payload to normal operations.

4.2 NanoLab Module Dimensions

Dimensional property guidelines for the NanoLabs using the NanoRacks Platforms are summarized in Table 1. An example of a 1U NanoLab is shown in Figure 4. Payloads that require different dimensions require approval by NanoRacks.

Form Factor	**Outer Dimensions of NanoLab**
1U	100mm x 100mm x 100mm
1.5U	100mm x 100mm x 152.4mm
2U	100mm x 100mm x 203.2mm
3U	100mm x 100mm x 304.8mm
4U	100mm x 100mm x 406.4mm
Table 1: Form Factors for NanoLab Modules	

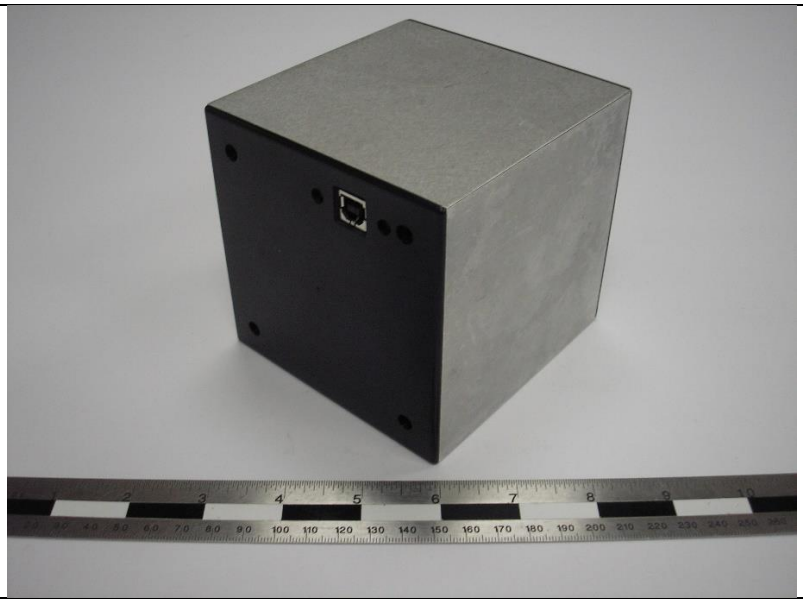


Figure 4: 1U NanoLab Module

4.3 NanoLab Mass Properties

The mass properties of a NanoLab module shall follow the specifications outlined in Table 2.

Form Factor	**Maximum Mass (g)**
1U	1000
2U	2000
3U	3000
4U	4000

Table 2: NanoLab Maximum Mass Properties

4.4 Dimensions for the USB Connectors

NanoLabs that require power and data will interface with the NanoRacks Platforms through at least one Type B female USB connector. Proper positioning of the USB port is identified in Figure 6 and Table 3. A mechanical drawing of the USB type B female connector that is required for Platform compatibility is included in Appendix A. USB ports shall be designed to minimize impact on other NanoLab modules. All USB placements shall be approved during the Preliminary Design Review (PDR).

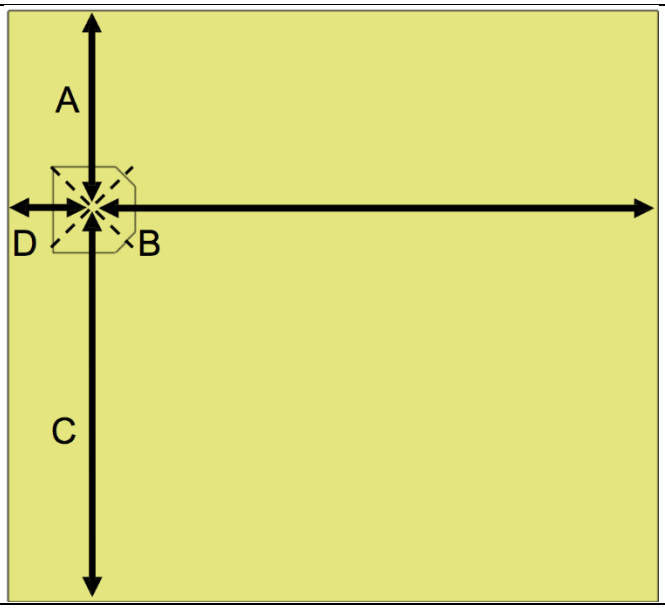


Figure 6: NanoLab USB connector dimensions

Side	Dimension
A	33.55 mm
B	95.37 mm
C	66.45 mm
D	14.63 mm

Table 3: Dimensions for Figure 5

4.5 Material Requirements

The NanoLab housing and internal components shall comply with NASA guidelines for hazardous materials. PIs who choose to manufacture their own NanoLab housing are required to seek material and color approval from NanoRacks personnel.

NanoLab developers shall submit a Bill of Materials (BOM) to NanoRacks for assessment.

4.6 Liquid Containment Requirements

Multiple levels of containment and additional testing may be required depending on the toxicity and the biohazard level of any liquid. Please speak to NanoRacks personnel for more information concerning research involving fluids of any kind.

4.7 Grounding and Bonding Requirements

Grounding and bonding is required for all powered modules. PIs using aluminum NanoLabs shall strip all faying surfaces to ensure that all panels and screws make contact. A single point ground shall be implemented from the NanoLab to the USB connector shell. The resistance of the grounding/ bounding shall measure less than 0.1 Ohms. For more information, please contact NanoRacks personnel.

4.8 Vent Requirements

The usage of vents on a NanoLab is permitted. Please speak to NanoRacks personnel for more information and approval.

4.9 Motor Requirements

The usage of motors within a NanoLab is permitted, but may require additional testing. Please speak to NanoRacks personnel for more information.

5 Operations

Operations for a NanoLab are defined by the payload's timespan on-board the ISS. Crew interaction with a NanoLab module is limited to installation and removal from the Platforms. Additional crew time needs to be discussed and negotiated with NanoRacks personnel as early as possible.

5.1 Data Handling

STELLA allows NanoRacks ground control to remotely operate the DOS command terminal on an on-orbit Windows XP embedded computer. STELLA also allows for the transfer of files between the NanoLab, the NanoRacks platform, and a NanoRacks ground computer. The file rates for download and upload between ground control and the on-orbit computer are:

i. A download rate of 3 Megabits per second.
ii. An uplink rate of 50 bytes per second. A 60 KB file is considered practical for uplink.

While uploading files is possible, uplink capability and bandwidth are limited.

1) Communication with NanoLabs is done through a DOS command terminal that is controlled through an on-orbit Windows XP embedded computer within the NanoRacks Platform.
2) NanoLabs that require data handling must be recognized as a USB mass storage device by the Platform computer.

6 Testing

6.1 Sharp Edge Test

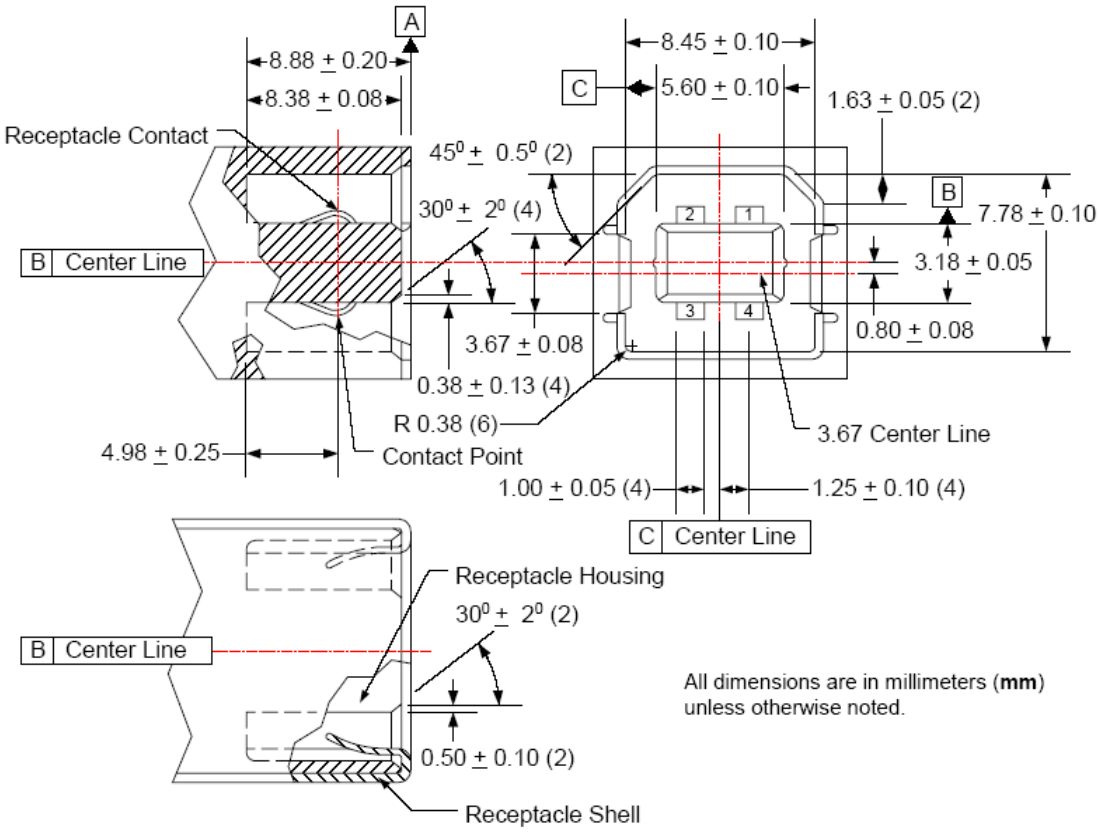
NanoLab modules shall undergo a cotton glove test to ensure that no protruding or sharp edges exist that could potentially snag the glove as it passes over all of the NanoLab surfaces, including the USB connector and its fasteners.

6.2 Additional Testing Requirements

Additional testing may be required by NASA depending on the nature of the payload. Examples of additional testing requirements may be found in Appendix B.

Appendices

Appendix A



USB Series B Female Receptacle Interface for NanoLab

Appendix B

The following is a list of potential testing requirements that may be required depending on the design of the NanoLab. Additional requirements may include, but are not limited to:

a) Electromagnetic Interference (EMI)
b) Offgassing
c) Vibration Testing
d) Express Payload Frequency Compatibility
e) Payload-Generated Acoustic Noise
f) Usage of Batteries
g) External Surface Touch Temperature