# NASA Docking System (NDS) Interface Definitions Document (IDD)

## Development Projects Office
## International Space Station Program

# JSC 65795

Date: November 16, 2013
Revision H

National Aeronautics and Space Administration
Houston, Texas 77058

# REVISION AND HISTORY PAGE

| REV. | DESCRIPTION | PUB DATE |
|---|---|---|
| Basic | Initial issue | 05/2010 |
| A | Revised to add definition to the interface by removing TBDs and providing updates based on matured design. Sections 4 and 5 were swapped, including Section 6 and Section 5, in order to improve readability by discussing the docking interface prior to the host interface. | 07/2010 |
| B | Changed Export Control designation from ITAR to EAR. Made non-technical editorial changes. Updated errata, documenting comments from NDS Baseline Review. | 08/2010 |
| C | Incorporated changes approved during the NDS Baseline Review. Added definition of -301, -302, -303, and -304 configurations. Added IDs to interface definition requiring verification. Added Section 7.0 describing Host Requirements for NDS Integration. Removed Export Control EAR designation. Document can be released in the public domain. | 11/2010 |
| D | Updated based on latest Project Technical Requirements Specification and design for Critical Design Review. Refer to Appendix J (Rev. D) for complete list of changes. | 03/2011 |
| E | Updated based on the closure of open TBDs/TBRs. Updated based on the Critical Design Review RIDs and comments closure. Refer to Appendix K (Rev. E) for changes not covered by RIDs. | 08/2011 |
| F | Updated based on the closure of open action items (AI). Updated on the closure of open TBDs/TBRs. Updated based on design maturity. Refer to Appendix L (Rev. F) for details. | 12/2011 |
| G | Updated based on the closure of open action items (AI), the closure of open TBDs/TBRs, the -305 configuration, and the 28 VDC design. Refer to Appendix J for details. | 08/2012 |
| H | Rev H per SSCN 013982<br>Revision H is the first release on the ISS Program | 12-06-13 |

ERU: /s/Beth Mason 12-6-13

# PREFACE

The contents of this document define the integrated performance and interface design for NASA Docking System (NDS) Block 1 and the International Docking Adapter. The intent of this IDD is to provide the interface design for using, installing, and interfacing to the NDS Block 1 that will enable successful docking to the IDA. This document is under the control of the ISS Development Projects Office (OG).

**NASA Docking System (NDS)**
**Interface Definitions Document (IDD)**

Approved By:

11-22-13

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Date

11/22/13

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Date

# NASA Docking System (NDS)
# Interface Definitions Document (IDD)

## Boeing Concurrence

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| Approved By: | James A. Davis<br>Systems Engineering | 11/21/13<br>Date |
| Approved By: | James Engle<br>NDSB1 Chief Architect | 11/21/13<br>Date |
| DQA: | Everett K Auzenne<br>Everett Auzenne<br>Systems Engineering | 11/21/13<br>Date |

# NASA Docking System (NDS)
# Interface Definitions Document (IDD)

## LIST OF CHANGES

All changes to paragraphs, tables and figures in this document are shown below:

| DATE | PARAGRAPH | CHANGE SUMMARY |
|---|---|---|
| 11/16/13 | ALL | Total re-write to accommodate NDSB1 design |

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## 1.0 Introduction

The National Aeronautics and Space Administration (NASA) Docking System Block 1 (NDSB1) and the International Docking Adapter (IDA) are a mating system that supports both crewed and un-crewed docking at USOS docking ports.

The NDSB1 is NASA's implementation of an International Docking System Standard (IDSS) compatible system. NDSB1 and IDA can mate based on the requirements of IDSS Interface Definition Document, Revision B, released April, 2013 with Soft Capture System parameters modified in accordance with DCB-DP-10R1.

## 1.1 Purpose and Scope

This NDSB1 IDD defines the interface characteristics and performance capability of the NDSB1, and supports both crewed and un-crewed space vehicles for Low Earth Orbit (LEO).

The responsibility for developing space vehicles and for making them technically and operationally compatible with the NDSB1\IDA rests with the vehicle providers. This document defines the NDSB1-to-IDA interfaces, the NDSB1-to-host vehicle interfaces, and the performance capabilities. It is up to implementers to examine the IDD to determine if there are any issues regarding the implementation of the NDS on their vehicle. Section 1 of this document is an introduction. Section 2 is the Applicable and Reference Document section. Section 3 provides a general system overview. Section 4 describes the NDSB1 to IDA interface implementation details. Section 5 describes the NDSB1 to Host Vehicle (HV) interface implementation details. Section 6 describes the NDSB1 to Test Equipment interfaces. Section 7 describes the Host Vehicle interface requirements for using the NDSB1. Refer to Figure 1.1-1: the NDS IDD structure and scope.

Revision H of this document is specific to the NDSB1 and IDA designs. Refer to revision G for the previous NDS Block 0 designs. Future NDS block upgrade design(s) will be documented in future revisions of this IDD.

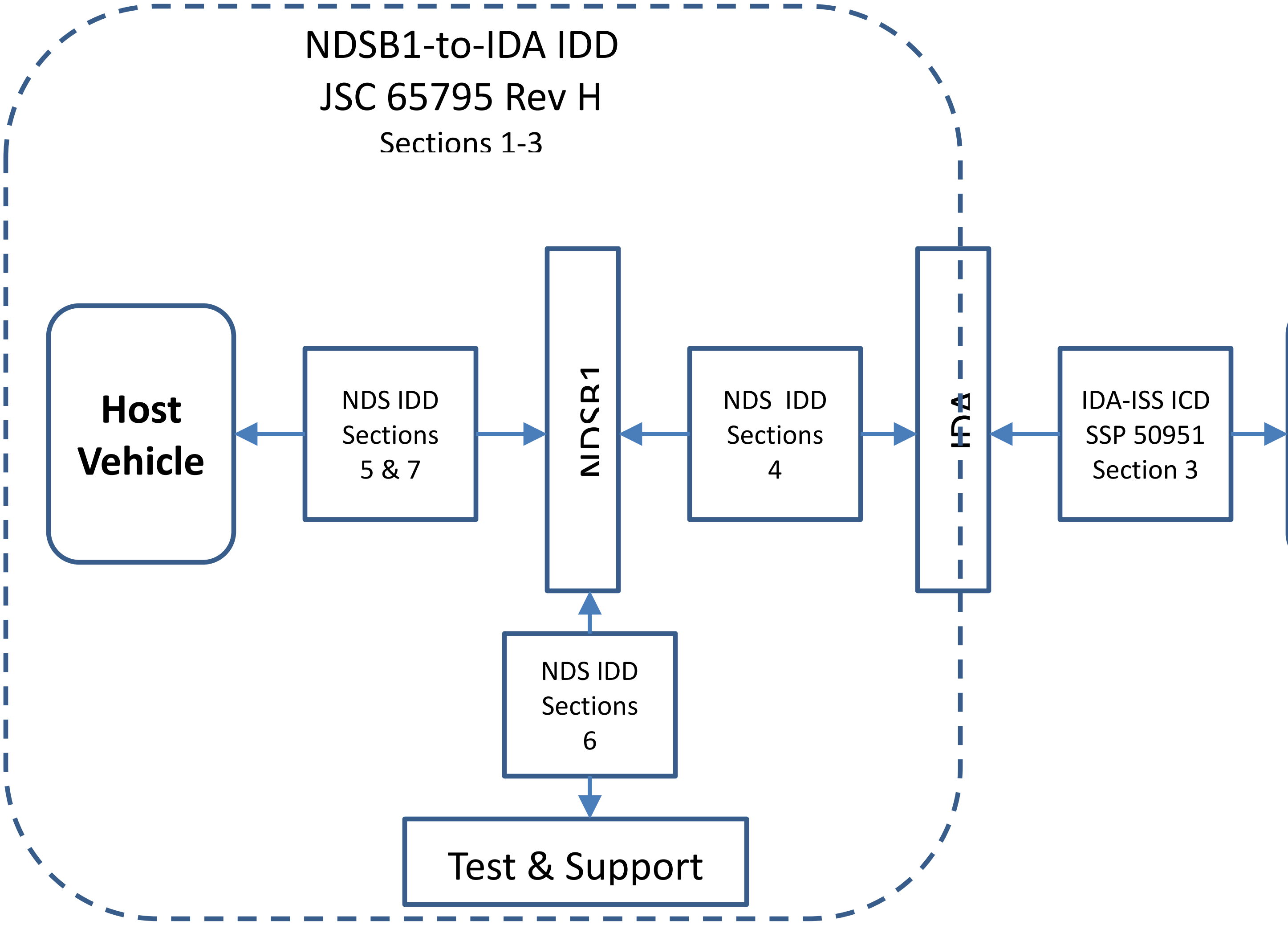



**FIGURE 1.1-1: IDD STRUCTURE**

## 1.2 Responsibility and Change Authority

The responsibility for this document, including change authority, rests with the International Space Station (ISS) Development Projects Office

# 2.0 Applicable and Reference Documents

## 2.1 Applicable Documents

The following documents, of the exact date and revision shown, form a part of this document to the extent specified herein.

| Document Number | Revision/ Release Date | Document Title |
|---|---|---|
| ANSI/TIA/EIA 568B.2 | Rev. B<br>April 2001 | Balanced Twisted-Pair Telecommunications Cabling and Components Standards |
| IEEE802.3 | 28 Dec, 2012 | Ethernet - IEEE Computer Society |
| JSC-62809 | Rev. D<br>April 22, 2010 | Human Rated Spacecraft Pyrotechnic Specification |
| JSC-63844 | Draft<br>August 2012 | NDS Capture Performance Data Book |
| JSC-64595 | Rev. C<br>October 3, 2012 | International Low Impact Docking System (iLIDS) Dynamic Seal End Item Specification |
| JSC-66161 | January 2013 | Low Impact Docking System (iLIDS) Dynamic Seal Verification Document |
| JSC 66380 | Revision B<br>March 22, 2013 | Project Technical Requirements Specification for the International Docking Adapter Docking Targets |
| MA2-00-057 | Draft<br>September 28, 2000 | Mechanical Systems Safety |
| MIL-STD-1553B | Rev. B, Notice 2<br>September 2, 1986 | Digital Time Division Command/Response Multiplex Data Bus |
| NASA-STD-4003 | Rev. Basic<br>September 8, 2003 | Electrical Bonding for NASA Launch Vehicles, Spacecraft, Payloads, and Flight Equipment |
| NASA-STD-5017 | Baseline<br>June 13, 2006 | Design and Development Requirements for Mechanisms |
| NDBC-TFE-22-285-75 | | |
| SKB26100066 | Rev. A<br>May 21, 2012 | Design and Performance Specification for NSI-1 (NASA Standard Initiator-1) |
| SN-C-0005 | Rev. D w/Change 13<br>February 13, 2008 | Contamination Control Requirements |

## 2.2 Reference Documents

The following documents are reference documents used in the development of this document. These documents do not form a part of this document, and are not controlled by their reference herein.

| Document Number | Revision/ Release Date | Document Title |
|---|---|---|
| 684-018763 | May 2013 | Electro-Mechanical Actuator Assembly, Umbilical |
| AMS4078 | Latest | 7075-T7351 Aluminum Alloy Plate 5.62n Specification |
| AMS 4144 | Latest | 2219 Aluminum Alloy Specification |
| AMS 4965 | Latest | Titanium Alloy Specification |
| AMS 5659 | Latest | Stainless Steel Consumable Electrode Melted Specification |
| AMS 6930 | Latest | Titanium Alloy Bars, Forgings and Forging Stock |
| AMS-QQ-A-250/12 | Latest | 7075-T7351 Aluminum Alloy Plate Specification |
| ARP 5412 | Rev. A<br>February 2005 | Aircraft Lightning Environment and Related Test Waveforms |
| AS9390 | | Pin, Straight, Headless, UNS66286 standard |
| D684-15386 | | NDSB1 Concept of Operations |
| DRPSDZ29101974-5003 | Draft pending | Drill Template, NDS – Host Interface |
| EID684-15524 | | NDSB1 Thermal Analysis Report |
| IDSS IDD | Rev. B<br>November 15 2012 | International Docking System Standard (IDSS) Interface Definition Document (IDD) |
| JSC-28596 | Rev. A<br>February 29, 2000 | NASA Standard Initiator User's Guide |
| JSC-63686 | Rev. H<br>August 2012 | International Low Impact Docking System (iLIDS) Project Technical Requirements Specification |
| JSC-63688 | Phase II Draft<br>November 17, 2011 | Risk Assessment Executive Summary Report (RAESR) for the International Low Impact Docking System (iLIDS) |
| JSC-65842 | Basic<br>November 16, 2011 | iLIDS Electromagnetic Environmental Effects (E3) Requirements Document |
| JSC-66188 | Draft pending | NASA Docking System (NDS) Operations Manual |
| JSC-66189 | Draft pending | NASA Docking System (NDS) to Host Vehicle Integration and Checkout |

| Document Number | Revision/ Release Date | Document Title |
|---|---|---|
| MIL-DTL-5541 | Rev. F<br>July 11, 2006 | Chemical Conversion Coatings on Aluminum and Aluminum Alloys |
| NCR-ISS-iLIDS-002 | | Non-conformance Compliance Report |
| PRC-2001 | Rev. G<br>August 10, 2009 | Heat Treatment of Steel Alloys |
| PRC-5002 | Rev. E<br>September 2006 | Process Specification for Passivation and Pickling of Metallic Materials |
| PRC-5006 | Rev. C<br>May 2003 | Process Specification for the Anodizing of Aluminum Alloy |
| 683-100100-0001 | | NDSB1 Top Assembly |
| SDZ29101861 | Rev. 7<br>August 28, 2011 | Guide Petal Drawing – SCS, iLIDS |
| SLZ29101649 | Rev. 4<br>September 9, 2011 | Umbilical EMA Specification Control Drawing |
| SSP 30309 | Rev. F<br>November 2005 | Safety Analysis and Risk Assessment Requirements Document |
| SSP 30559 | Rev. D<br>July 27, 2007 | Structural Design and Verification Requirements |
| SSP 50021 | Baseline, DCN 004<br>July 8, 2009 | Safety Requirements Document |
| SSP 50038 | Rev. B<br>November 17, 1995 | Computer-Based Control System Safety Requirements |
| SSP 50920 | Rev. A<br>November 2010 | NASA Docking System (NDS) Users Guide |
| SSQ 22680 | Rev J<br>May 2011 | Connectors, Rectangular, (ORU), Space Quality, General Specification For |
| TIA-422-B | Rev. B<br>May 1994 | Electrical Characteristics of Balanced Voltage Digital Interface Circuits |

### 2.3 Order of Precedence

This document provides a set of interface definitions to support integrating the NDS with existing and future space vehicles. In the event of a conflict between the text of this document and any other document, this NDS IDD takes precedence over other documents.

## 3.0 General System Overview

The NDSB1 system will establish the initial connection of a visiting vehicle to ISS USOS docking port through the soft capture mechanisms for NDSB1 and IDA. The soft capture subsystems will consist of guide petals on both systems, Soft Capture System (SCS) latch striker interfaces on IDA and mechanical latches on NDSB1 for SCS mate, and 6 electromechanical actuators independently controlling six legs of the SCS platform using a feed forward control law on NDSB1. During docking soft capture, the guide petals are the first element to make contact providing course alignment and a transmitted first contact signal that will indicate to the NDSB1 host vehicle to go in to free drift. Upon initial contact the SCS actuators will lunge to perform initial capture with SCS latches to IDA passive latch strikers. The SCS will then perform attenuation, align SCS parallel to Hard Capture System (HCS) mating plane and then retract to the ready to hook position using pins on the HCS for fine alignment.

The NDSB1 HCS will utilize powered hooks to engage with the IDA passive hooks, providing a structural connection ready for pressurization between the mated vehicles that allows for cargo and crew transfer. The HCS consists of a tunnel, electro-mechanical mating mechanism with 12 active/passive hook pairs, seals, fine alignment features, mechanized umbilicals, contingency pyro release, and undocking separation system and multiple sensors elements.

The docking will be completed when 12 active hooks are closed, separators are energized and resource transfer umbilicals are engaged. The umbilical system will provide pass through for power and data communications between the two vehicles. The control of both the HCS and SCS is performed by a remotely located Docking System Controller that receives 28 V power from the Commercial Crew Program (CCP) HV and communicates with the HV via either RS-422 or 1553 data bus.

The following subsections describe the system interfaces for the NDSB1. Interface responsibilities are defined with respect to the interface boundaries presented in Figure 3-1: NDSB1 System Functional Interface Diagram.

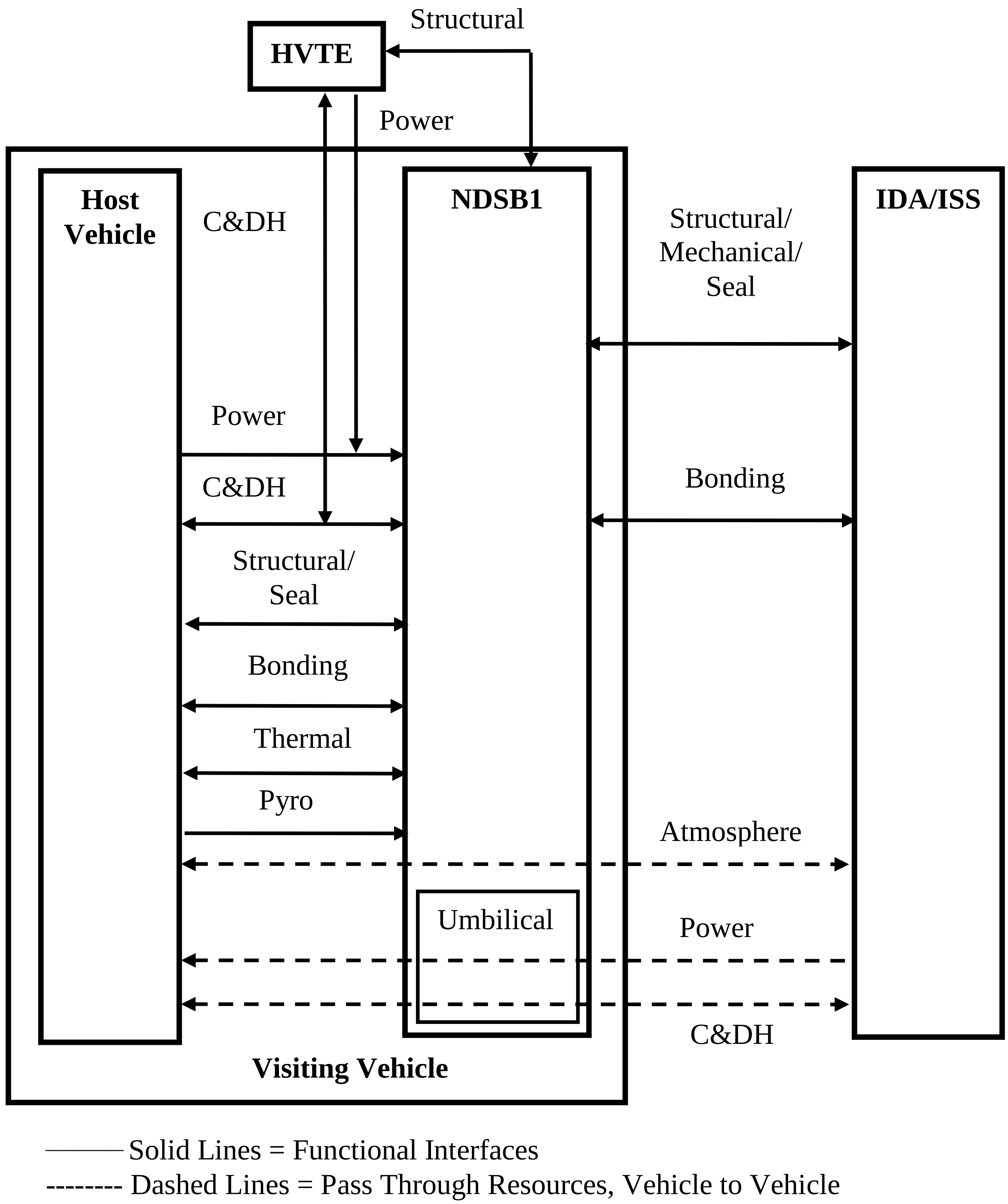



**FIGURE 3-1: NDSB1 SYSTEM FUNCTIONAL INTERFACE DIAGRAM**

### 3.1 System Description

#### 3.1.1 NDS Block 1

The NDS Block 1, as shown in Figure 3.1.1-1, consists of three major subsystems: the SCS, the Hard Capture System, and Docking System Controller (DSC)

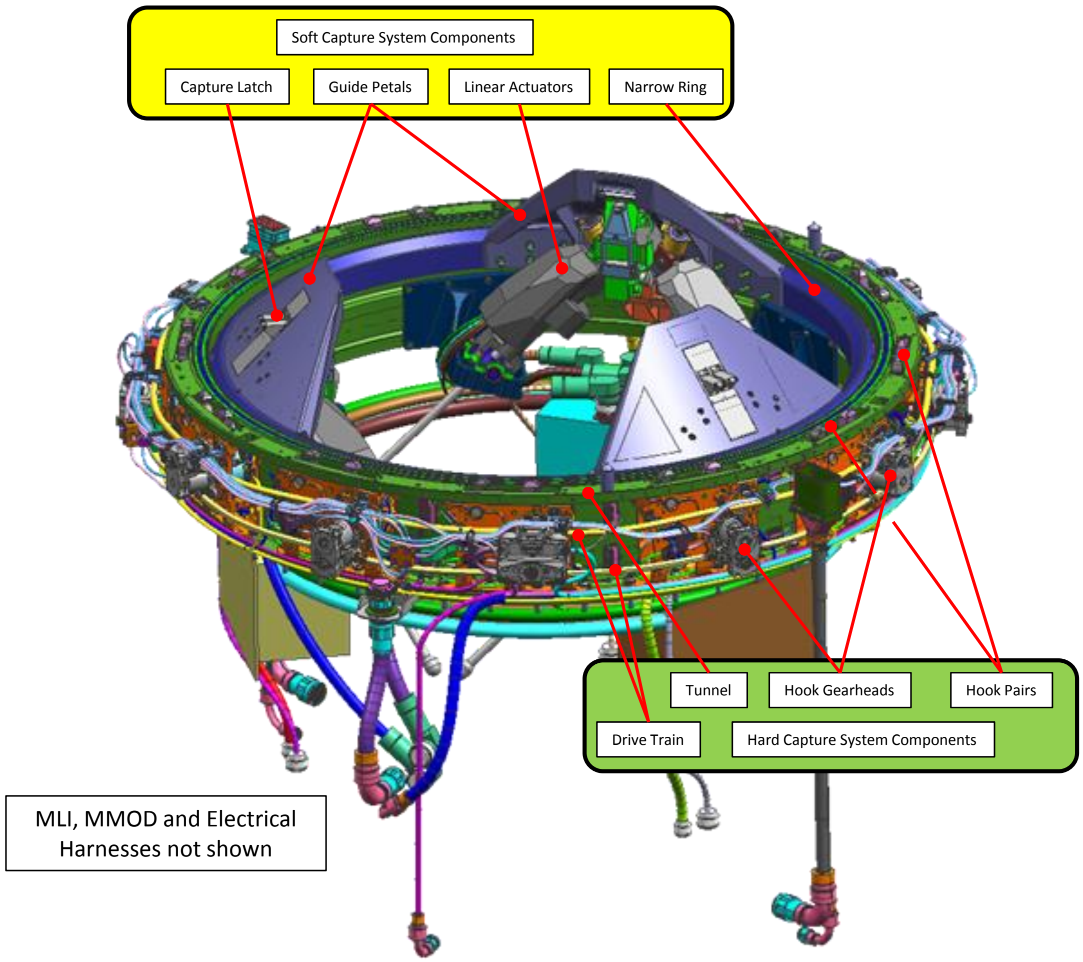



**FIGURE 3.1.1-1: NDSB1**

The SCS is an integrated mechanical soft capture on the NDSB1 that uses a narrow soft capture ring compatible with the International Docking System Standard (IDSS) Interface Definition Document (IDD) and the Development Control Board Decision Package DSCB-DP-10R1.

The SCS uses the host vehicle inertia in conjunction with electrical actuators to align and connect the host vehicle to IDA for capture. Soft capture is not a structural mating, but the first level of attachment in the docking sequence where mechanical connection, attenuation, and alignment between the HV and ISS occur. The SCS actuators are controlled by the Linear Actuator Controller (LAC) to provide attenuation and alignment during the initial docking phase. The guide petals mounted to the soft capture ring face inward and will not be removable on orbit. The petals are equally spaced around the circumference of the soft capture docking ring. The SCS guide petals mounts an active latch for soft capture and are extended from its stowed position by electrically driven linear actuators.

The NDSB1 provides an electrical interface to allow the HV to re-mode the soft capture system latches for contingency/emergency situations. The functionality provided is independent of the normal (redundant) NDSB1 avionics. Operation of the contingency release is intended only for situations when standard NDSB1 electronics interfaces are non-functioning or unavailable. Activation of the contingency release configures all 3 soft capture system latches to an Open/Releasing mode. Contingency release is a one-time operation meaning the latches cannot be reset to Closed/Capturing mode after activation. Soft Capture after contingency release operation will not be possible.

The LAC controls the SCS linear actuators to provide sensing of initial contact between the HV and IDA, soft capture of the IDA, attenuation of initial contact forces, and alignment for hard capture. The LAC receives operational commands from, and returns status data to the DSC.

The HCS uses powered hooks to engage with the passive system, providing a structural connection ready for pressurization between the mated vehicles that allows for cargo and crew transfer. The HCS consists of a tunnel, 12 active/passive hook pairs, seals, fine alignment guide pins, mechanized separation springs, and mechanized umbilicals.

Docking is complete when mechanized resource transfer umbilicals are engaged and the spring-loaded separation system is energized for undocking. The NDSB1 commanded via an NDS electronics interface from the HV.

The DSC provides control of the NDSB1. The DSC is the interface between the system operation and status of the NDSB1 and the resultant docking system operation. The DSC receives commands from a HV Flight Computer (FC) on a 1553B bus or a RS-422 interface to perform active docking/undocking, HSC or SCS checkout, manual control operations or monitoring system performance. The DSC is packaged in two flight boxes with redundant A and B systems. Along with the LAC the DSC boxes are remotely mounted and powered by 28 volt DC power supply from the host vehicle.

### 3.1.2 International Docking Adapter

The ISS IDA provides a docking port on the ISS for Visiting Vehicles (VV). The IDA's purpose is to convert the ISS APAS docking ports into IDSS-compatible docking ports. The CCP vehicle will have an active docking mechanism to dock with the IDA. The IDA has a fixed capture ring with guide petals, capture sensors, and mechanical SCS body latches (mechanical latch strikers). The IDA HCS consists of a tunnel with a metallic sealing surface, electro-mechanical mating mechanism with 12 active/passive hook pairs, and mechanized separation system and fixed umbilicals. The IDA will provide power and data utility connections to the VV after docking. It will allow cargo and crew to be exchanged between the VV and ISS through a pressurized tunnel. The IDA will also provide passive navigation aids to assist the VV during proximity operations. IDA provides contingency active hooks that can be driven by the IDA Control Panel (ICP) on ISS if there is a hook gang failure on NDSB1. At the end of VV attached operations, in case of NDS Block1 separators contingency, the IDA may provide a nominal separation impulse to undock the HV. Note – The need for the use of the IDA separator would be identified in docking operations when the NDSB1 separators are energized.

Figure 3.1.2-1, IDA Major Components, shows the IDA major components which include the Energia IDA Primary Structure (EIPS) (consisting of a Modified Androgynous Peripheral Attachment System (MAPAS), the EIPS Adapter Ring (EAR), and the Passive Hard Mate Assembly (PHMA)), and the Passive Soft Capture System.

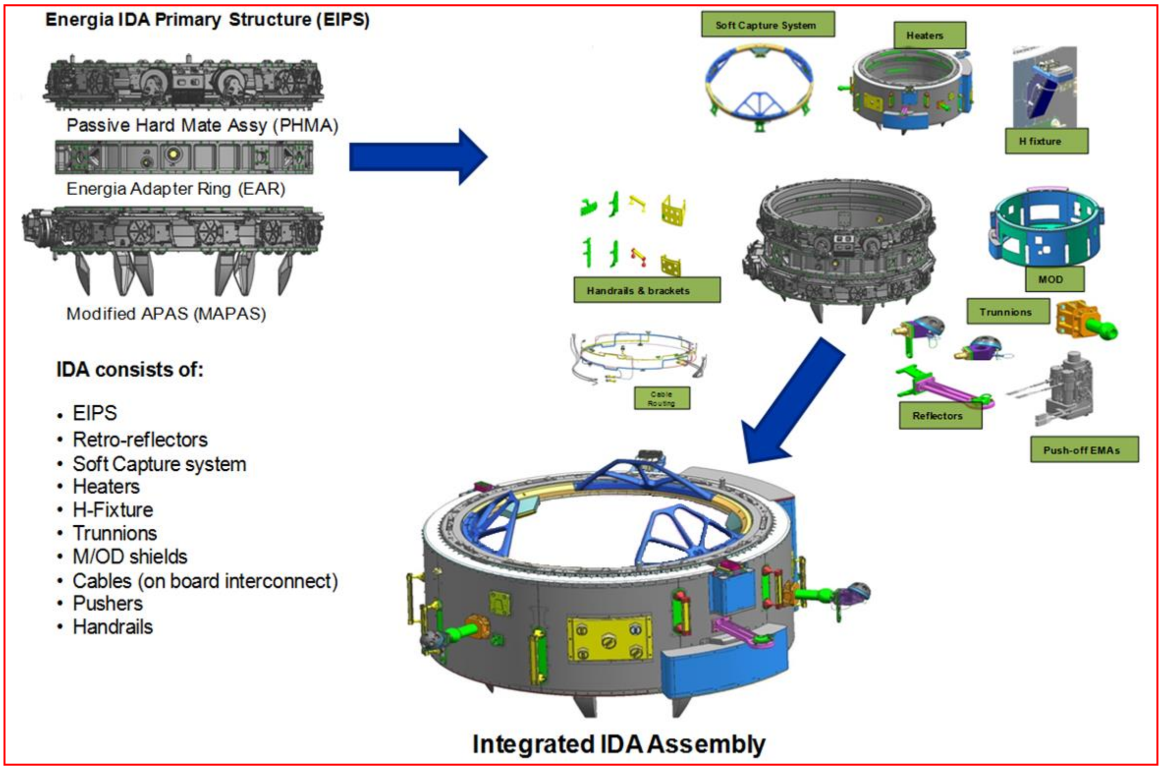



**FIGURE 3.1.2-1: IDA MAJOR COMPONENTS**

The current operational concept specifies that two IDAs will be installed on the ISS to support docking of VVs. One IDA will be installed on Pressurized Mating Adapter 2 (PMA2) at Node 2 Forward. The second IDA will be installed on Pressurized Mating Adapter 3 (PMA3) at Node 2 Zenith. Figure 3.1.2-2 shows the IDA installed on PMA2 at the Node 2 Forward location. Figure 3.1.2-2 also shows the ISS outfitted with IDA forward and zenith docking ports on Node 2.

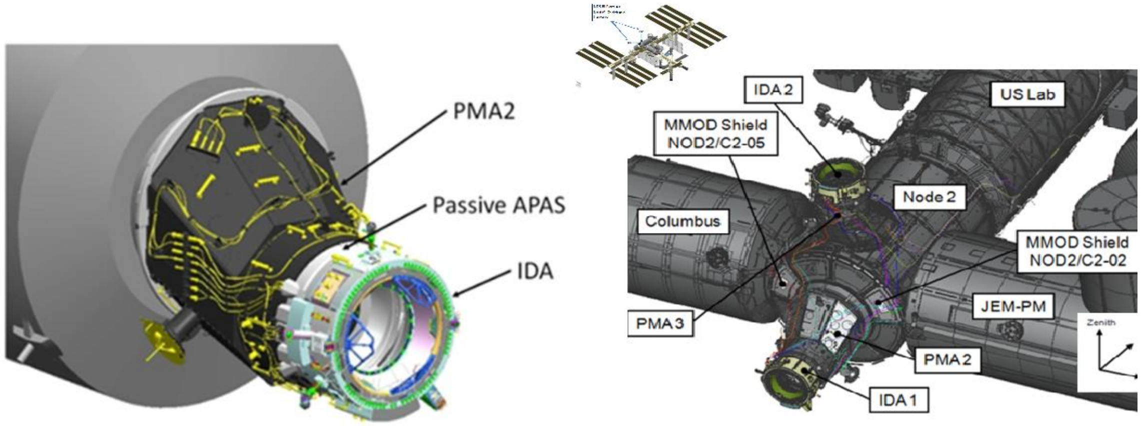



**FIGURE 3.1.2-2: IDA DOCKING PORTS INSTALLED ON ISS NODE 2**

## 3.2 Mass Properties

The mass properties for NDSB1 are described in Table 3.2-1: Mass Properties. Mass properties reference the NDSB1 center of gravity relative to the coordinate system defined in Figure 3.6-1: NDSB1 STRUCTURAL COORDINATE SYSTEM . These mass properties are for the integrated mechanism, including the electrical boxes. See Table 5.2.1.5-1: Electrical Box Mass Properties for electrical boxes that are integrated by the host separately from the mechanism.

**TABLE 3.2-1: NDSB1 MASS PROPERTIES**

| Mass lb (kg) **[Not to exceed]** | Center of Mass (1) In (mm) **[Not to exceed]** | | | Moments of Inertia (2) lb-in² (kg-mm²) **[Not to exceed]** | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | X | Y | Z | Ixx | Iyy | Izz | Pxy | Pxz | Pyz |
| 715 (324) | 0.014 (-0.356) | 0.178 (4.5) | -6.505 (-165.0) | 1.706E+06 (4.992E+08 | 1.722E+06 (5.039E+08) | 2.28E+06 (6.67E+08) | 7.006E+02 (2.05E+05) | -1.095E+02 (-3.206E+04) | -1.92E=02 (-5.643E04) |

Notes:
(1) Center of gravity tolerances : ± 0.5 in ( 12.7mm)
(2) Moments of inertia are based on the nominal center of gravity location.

## 3.3 Volume Properties

For host Environmental Control and Life Support System (ECLSS) analysis, the following worst-case volumes may be used. The NDSB1 internal vestibule volume is not to exceed 10.3 ft$^3$ (0.286 m$^3$). This volume is defined from the NDSB1 mounting plane to the NDSB1 HCS mating plane. The calculated volume assumes no hardware inside the pressure wall of the NDSB1 tunnel. Therefore, the actual volume will be slightly less. The IDA internal volume is not to exceed 27.26 ft$^3$ (0.772 m$^3$).

### 3.4 Mating Plane Definition

The HCS mating plane is defined as the seal plane between HCS tunnels when structurally mated. The SCS mating plane is defined as the outboard surface of the SCS ring where ring to ring contact would occur after soft capture. In the launch configuration the NDSB1 SCS mating plan is parallel to the HCS mating plane. Reference Figure 4.1.1-1.

### 3.5 Units of Measure, Dimensions, and Tolerances

Unless otherwise noted herein, all dimensions in this document are shown in the English system of inch-pound units followed by the System International (SI) equivalents in parentheses or square brackets. All dimensions shown in this document assume ambient conditions [i.e., 70 °F (21 °C) and 14.7 psi (101.35 kPa)]. Linear tolerances on metric dimensions are derived from English measurements and tolerances. Implied tolerances on linear dimensions are defined in Table 3.5-1: Linear Tolerances. Angular tolerances are shown in Table 3.5-2: Angular Tolerances. Dimensions enclosed within parentheses are for reference only and provide no tolerance. Orthographic projections are constructed using the third angle projection system.

**TABLE 3.5-12: LINEAR TOLERANCES**

| English Dimensions | Implied Tolerances | |
|---|---|---|
| | (in) | (mm) |
| x.x | ± 0.1 | ± 2.5 |
| x.xx | ± 0.02 | ± 0.5 |
| x.xxx | ± 0.005 | ± 0.13 |

**TABLE 3.5-23: ANGULAR TOLERANCES**

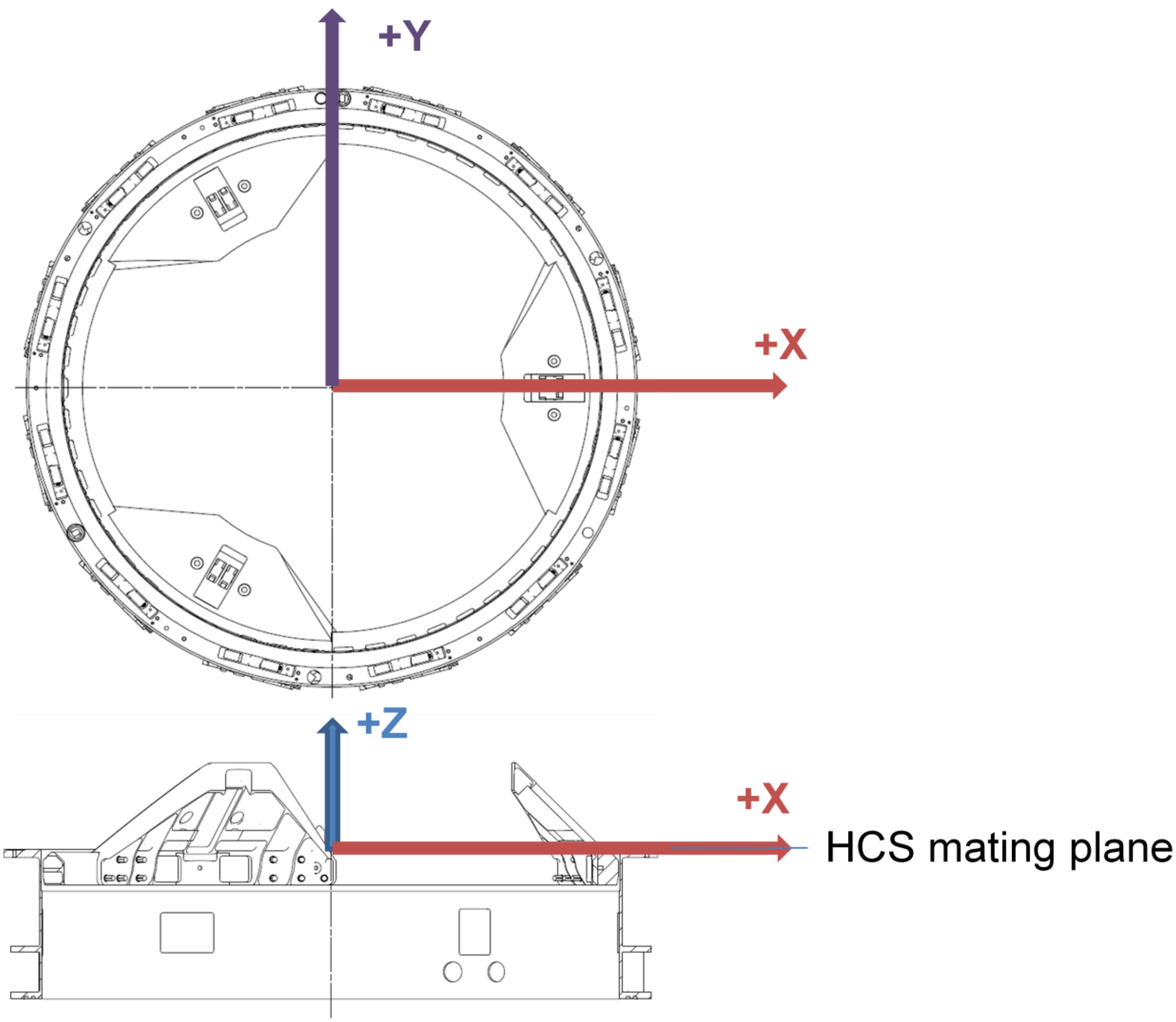
| Dimensions | Tolerances |
|---|---|
| Angular dimension (degrees) | ± 0.5 degrees |

### 3.6 NDSB1 Coordinate System

NDSB1 defines two sets of coordinate systems—the Structural coordinate system set and the Docking coordinate system set. The Docking coordinate system set is for docking operations and includes two different subsets—one for the active unit and the other for the passive unit. All of the coordinate frames described in this section are standard, right-handed coordinate frames with orthogonal axes at the origin.

### 3.6.1 NDSB1 Structural Coordinate System

The NDSB1 structural coordinate system shown in Figure 3.6.1-1: NDSB1 Structural Coordinate System is used for internal NDSB1 design, reference for mechanism geometry, mechanical configuration, and mass properties information.

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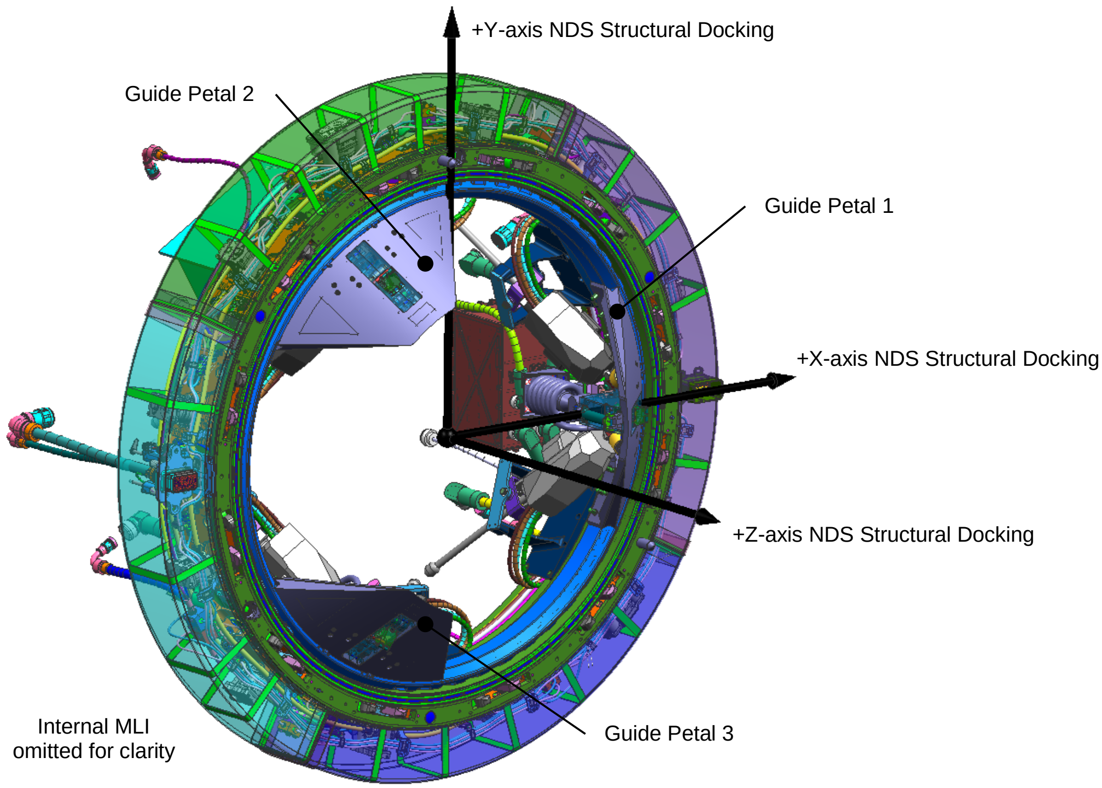



Origin: The origin of the NDSB1 Structural Docking Coordinate System is defined as the intersection of the NDSB1 cylindrical axis and the hard capture mating plane and is coincident with the NDSB1 Active Docking Coordinate System Origin.

X-axis: The X-axis lies in the hard capture mating plane and is positive from the origin toward the NDSB1 Guide Petal 1. The X-axis coincides with the NDSB1 line of symmetry.

Y-axis: The Y-axis lies in the hard capture mating plane and is positive from the origin toward the HCS guide pin-receptacle combo. The Y-axis coincides with the NDSB1 line of androgyny.

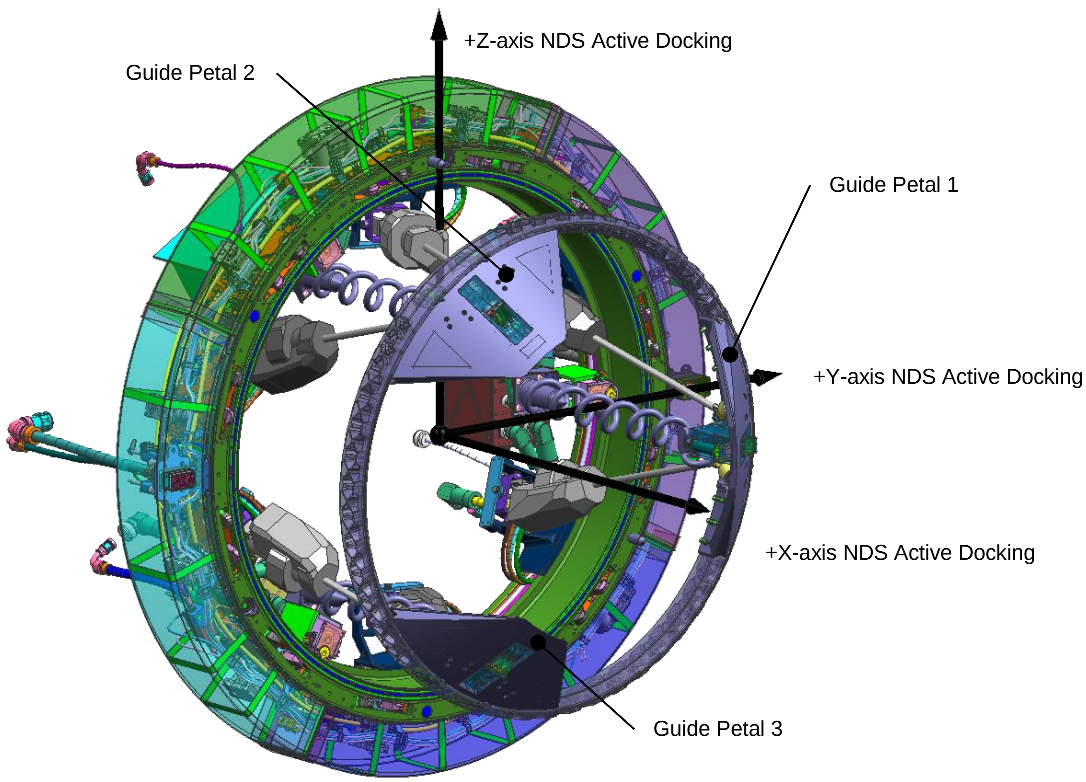
Z-axis: The Z-axis coincides with the NDSB1 cylindrical axis and is positive in the direction pointing away from the hard capture mating plane (forward flight direction) and completes the right-handed system.

(Page 2 of 2)
**FIGURE 3.6.1-1: NDSB1 STRUCTURAL COORDINATE SYSTEM**

### 3.6.2 NDSB1 Docking Coordinate Systems

The NDSB1B1 Docking coordinate system set is used for docking operations and analysis. It uses the same coordinate center or origin as does the NDSB1 Structural Coordinate System. Its orientation follows an approach common in flight dynamics, where the X-axis is positive in the forward flight direction. The NDSB1 Docking coordinate system set contains the NDSB1 Docking coordinate system and the IDA Docking coordinate system (see Figure 3.6.2-1: NDSB1 AND IDA

DOCKING COORDINATE SYSTEMS ). The origins of the NDSB1 and IDA coordinate systems coincide, once the docking units are fully mated.

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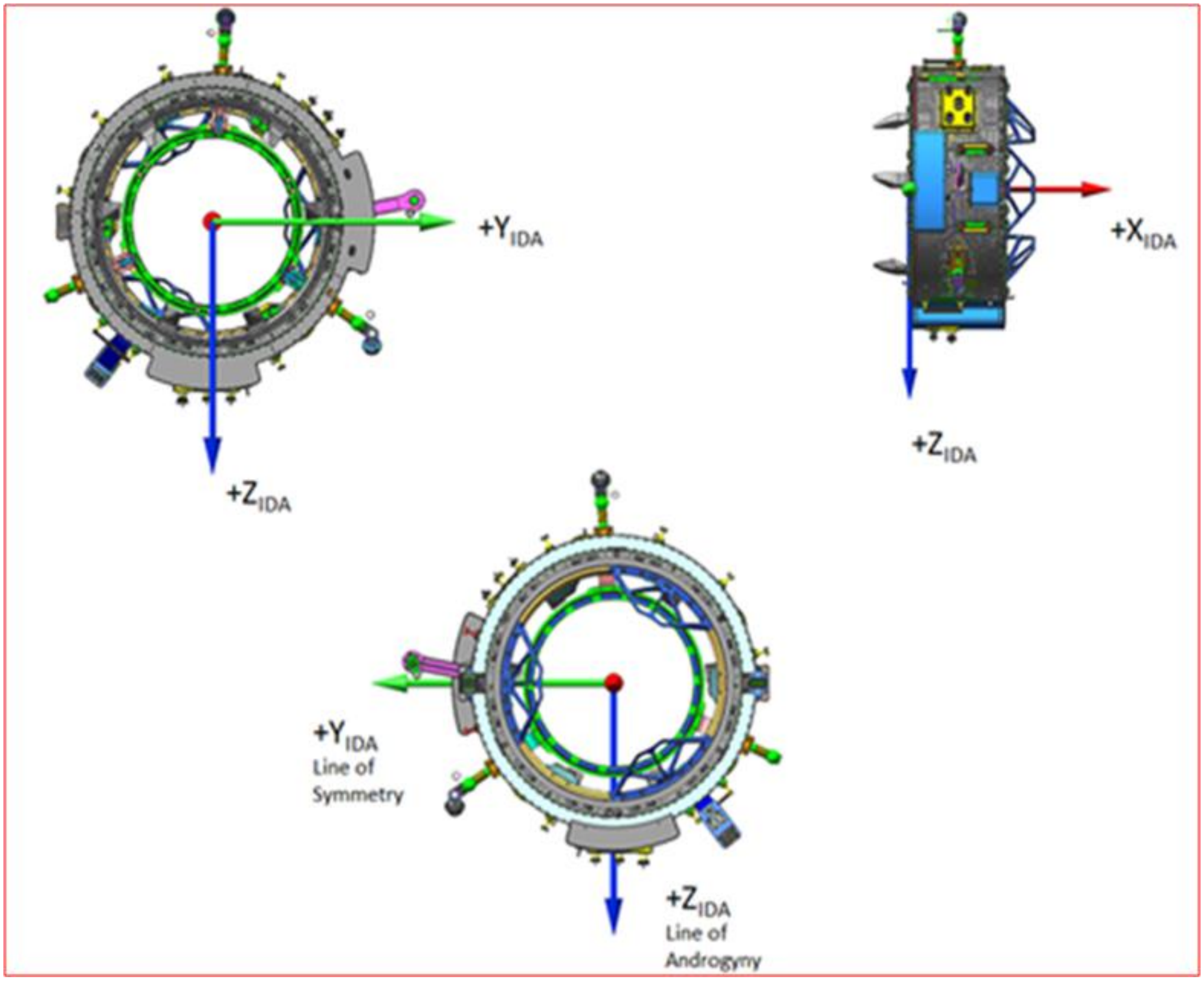
Origin: The origin of the NDSB1 Active Docking Coordinate System is defined as the intersection of the NDSB1 cylindrical axis and the hard capture mating plane and is coincident with the NDSB1 Structural Docking Coordinate System Origin.

X-axis: The X-axis coincides with the NDSB1 cylindrical axis and is positive in the direction pointing away from the hard capture mating plane (forward flight direction).

Y-axis: The Y-axis lies in the hard capture mating plane and is positive from the origin toward the NDSB1 Guide Petal 1. The Y-axis coincides with the NDSB1 line of symmetry.

Z-axis: The Z-axis lies in the hard capture mating plane and is positive from the origin toward the HCS guide pin-receptacle combo. The Z-axis coincides with the NDSB1 line of androgyny and completes the right-handed system.




(Page 2 of 2)

**FIGURE 3.6.2-1: NDSB1 AND IDA DOCKING COORDINATE SYSTEMS**

### 3.6.2.1 NDSB1 Active Docking Coordinate System

The NDSB1 active docking coordinate system shown in Figure 3.6.2-1 is used for docking performance analysis and is associated with the NDSB1 unit in the active mode.

Origin: The origin of the NDSB1 Active Docking Coordinate System is defined as the intersection of the NDSB1 cylindrical axis and the HCS mating plane (see Figure 3.6.1-1), coincident with the NDSB1 Docking Coordinate System origin.

X-axis: The X-axis coincides with the NDSB1 cylindrical axis and is positive in the direction pointing away from the vehicle mounting plane.

Z-axis: The Z-axis lies in the HCS mating plane and is positive from the origin toward the HCS guide pin-receptacle combo. The Z-axis coincides with the NDSB1 line of androgyny.

Y-axis: The Y-axis lies in the HCS mating plane and is positive from the origin toward the NDSB1 guide petal 1. The Y-axis coincides with the NDSB1 line of symmetry.

#### 3.6.2.2 IDA Coordinate System

The IDA docking coordinate system shown in Figure 3.6.2-1 is used for docking performance analysis and is associated with the IDA as the passive mode.

Origin: The origin of the IDA Coordinate System is defined as the intersection of the IDA cylindrical axis and the HCS mating plane (see Figure 3.6.1-1), coincident with the NDSB1 Docking Coordinate System origin.

X-axis: The X-axis coincides with the IDA cylindrical axis and is positive in the direction pointing toward the vehicle mounting plane.

Z-axis: The Z-axis lies in the HCS mating plane and is positive from the origin toward the HCS guide pin-receptacle combo. The Z-axis coincides with the IDA line of symmetry.

Y-axis: The Y-axis lies in the HCS mating plane and is positive from the origin pointing away from the NDSB1 guide petal 1. The Y-axis coincides with the IDA line of symmetry.

## 3.7 NDSB1 Component Numbering and Labeling

### 3.7.1 NDSB1 Component Numbering

The docking system components are numbered. The numbering method is based on the following convention. Starting from the positive X-axis (structural coordinate system), the first component of a subsystem is labeled “1” with the next component being “2” in a counterclockwise fashion. Reference Figure 3.6.1-1.

### 3.7.2 NDSB1 Component Labeling

To aid operations, NDSB1 includes some visible labels. For subsystems with the same quantity of components, a single zone label (e.g., “2”) represents all components in that zone, as shown in Figure 4.3-1: NDSB1 Resource Transfer.

## 3.8 System Performance Parameters

The NDSB1 is designed to support docking without hardware reconfiguration.

### 3.8.1 NDSB1 Docking

#### 3.8.1.1 NDSB1 Docking Capture Performance

The baseline capture envelope is defined in Table 3.8.1.1-1, NDSB1 Initial Contact Conditions.

### TABLE 3.8.1.1-1: NDSB1 INITIAL CONTACT CONDITIONS "DESIGN TO" LIMITS

| Initial Conditions | Limiting Value |
|---|---|
| Closing (axial) rate | 0.1 to 0.2 ft/sec (0.03 to 0.06 m/s) |
| Lateral (radial) rate | 0.13 ft/sec (0.04 m/s) |
| Angular rate | 0.40 deg/sec about NDSB1 X axis;<br>0.15 deg/sec about any axis within the NDSB1 Y-Z plane |
| Lateral (radial) misalignment | 4.33 in. (110 mm) |
| Angular misalignment | 5.0 degrees about NDSB1 X axis;<br>5.0 degrees about any axis within the NDSB1 Y-Z plane |

**Notes:**

1. Initial conditions are 3σ maxima and are to be applied simultaneously in a statistically appropriate manner.
2. Mean closing rate may be adjusted depending on vehicle mass combinations. Refer to Table 3.8.1.1-2 Vehicle Mass Properties.
3. Lateral (radial) rate limit includes combined lateral and rotational rates of both vehicles.
4. Lateral misalignment is defined as the minimum distance between the center of the active soft capture ring and the longitudinal axis of the passive soft capture ring at the moment of first contact between the guide petals.
5. The NDSB1 will use a right-hand orthogonal body coordinate system, the origin of which lies in the intersection of the NDSB1 cylindrical center line X-axis and HCS mating plane (refer to Figure 3.6.2-1, NDSB1 Active Docking Coordinate System).
6. The NDSB1 will control the accuracy of the position of the SCS ring at the Ready-To-Capture height within 0.14 inch per lateral axis and 0.28 degrees per axis with respect to the NDSB1 docking coordinate frame

### TABLE 3.8.1.1-2 VEHICLE MASS PROPERTIES

| Vehicle | Mass (lb) | Moment of Inertia (ft*lbf*sec2) | | | | | | Coordinates of the Hard Capture System Mating Plane Center (ft) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Ixx | Iyy | Izz | Ixy | Ixz | Iyz | X | Y | Z |
| ISS – N2F docking | 9.71E05 | 9.82E07 | 6.25E07 | 1.39E08 | -2.42E06 | -3.56E06 | -1.21E06 | 52.65 | 0.0 | 18.25 |
| ISS – N2Z docking | 9.71E05 | 9.82E07 | 6.25E07 | 1.39E08 | -2.42E06 | -3.56E06 | -1.21E06 | 33.52 | 0.0 | -0.55 |
| | | | | | | | | | | |
| IDSS-10T HV | 22000 | 12500 | 31000 | 31000 | 0 | 0 | 0 | 11.5 | 0 | 0 |
| 18T HV | 40000 | 37100 | 81700 | 81700 | 0 | 0 | 0 | 13.9 | 0 | 0 |
| ISS C.G. (ft) X = -13.95 , Y = -1.34, Z = 13.74 | | | | | | | | | | |
| Notes:<br>1. Moments of inertia (MOI) are about C.G. and products of inertia (POI) are positive integral.<br>2. HV mass properties and mating plane coordinates defined in coordinate system located at C.G. with X-axis along vehicle longitudinal axis and positive toward the docking interface.<br>3. ISS mass properties and mating plane coordinates defined in ISS coordinate system. (ISS L&D Model xd94ih, EID684-15328, dated 12-14-2012). | | | | | | | | | | |

### 3.8.1.2 Vehicle Relative Dynamic Motion Limits During Docking

The maximum relative motion between two docking vehicles occurs during the soft capture and attenuation phases of docking. During soft capture, the SCS is contending with vehicle misalignment and trying to achieve capture. During attenuation, the SCS is contending with limiting the relative motion between the two docking vehicles. After soft capture and attenuation, the SCS aligns then retracts the two docking interfaces. For NDSB1, the maximum relative motion between two docking vehicles has been defined at select SCS extension heights in Table 3.8.1.2-1: Vehicle Relative Dynamic Motion Limits During Docking. This data provides host vehicles with the necessary information to assess vehicle-to-vehicle clearances during docking. It is the responsibility of the applicable mission or program to determine the vehicle clearance pass-fail requirements and approve any exceptions.

**TABLE 3.8.1.2-1: VEHICLE RELATIVE DYNAMIC MOTION LIMITS DURING DOCKING**

| Condition(1)(2) | Stand-Off Distance(3) in (mm) | Misalignments(4) | | |
|---|---|---|---|---|
| | | Wobble Angle(5) (deg) | Radial Miss in (mm) | Roll Angle(6) (deg) |
| 1 | 13.0 (330) | 15.0 | 8.5 (216) | 15.0 |
| 2 | 12.5 (317) | 13.5 | 8.5 (216) | 13.5 |
| 3 | 7.0 (178) | 3.0 | 2.9 (74) | 3.0 |
| 4 | 5.7 (145) | 1.5 | 2.3 (59) | 1.5 |
| 5 | 2.0 (50) | 1.0 | 0.12 (3) | 1.0 |

Notes:

To utilize this data for clearance analysis, begin by creating a swept-out volume for Condition 1 for the two docking vehicles. If the vehicles clear satisfactorily, then translate the swept-out volume forward by the Stand-Off distance all the way until zero. If this passes, then assessment of the remaining conditions is not necessary. Otherwise, verify clearance when the swept volume is translated forward to the Stand-Off distance of Condition 2. If this passes, apply the Condition 2 misalignments, and repeat the process of translating the swept-out volume forward to a standoff distance of zero. Again, if this passes, the assessment is complete. If not, increment forward to the next Condition and repeat process, thus creating smaller and smaller swept volumes.

For each condition, 1) begin with HCS mating planes coincident and aligned for docking , 2) back away to the stand-off distance, 3) move the passive SCS radially by the specified distance, 4) rotate the passive SCS mating plane by the specified wobble angle (either positive or negative, whichever minimizes clearances) in the plane defined by the active docking mechanism cylindrical axis and the radial misalignment, and 5) apply the roll misalignment up to the specified limit in the direction that minimizes clearance.

The stand-off distance is measured from the center of the active HCS mating plane to the center of the passive SCS mating plane along the active HCS cylindrical axis. Note that the passive SCS mating plane is 0.236 in (6 mm) below the passive HCS mating plane. Refer to. 4.1.1.2.2-1 SCS Feature Definition

Misalignments are to be applied to passive SCS mating plane with respect to the active HCS mating plane.

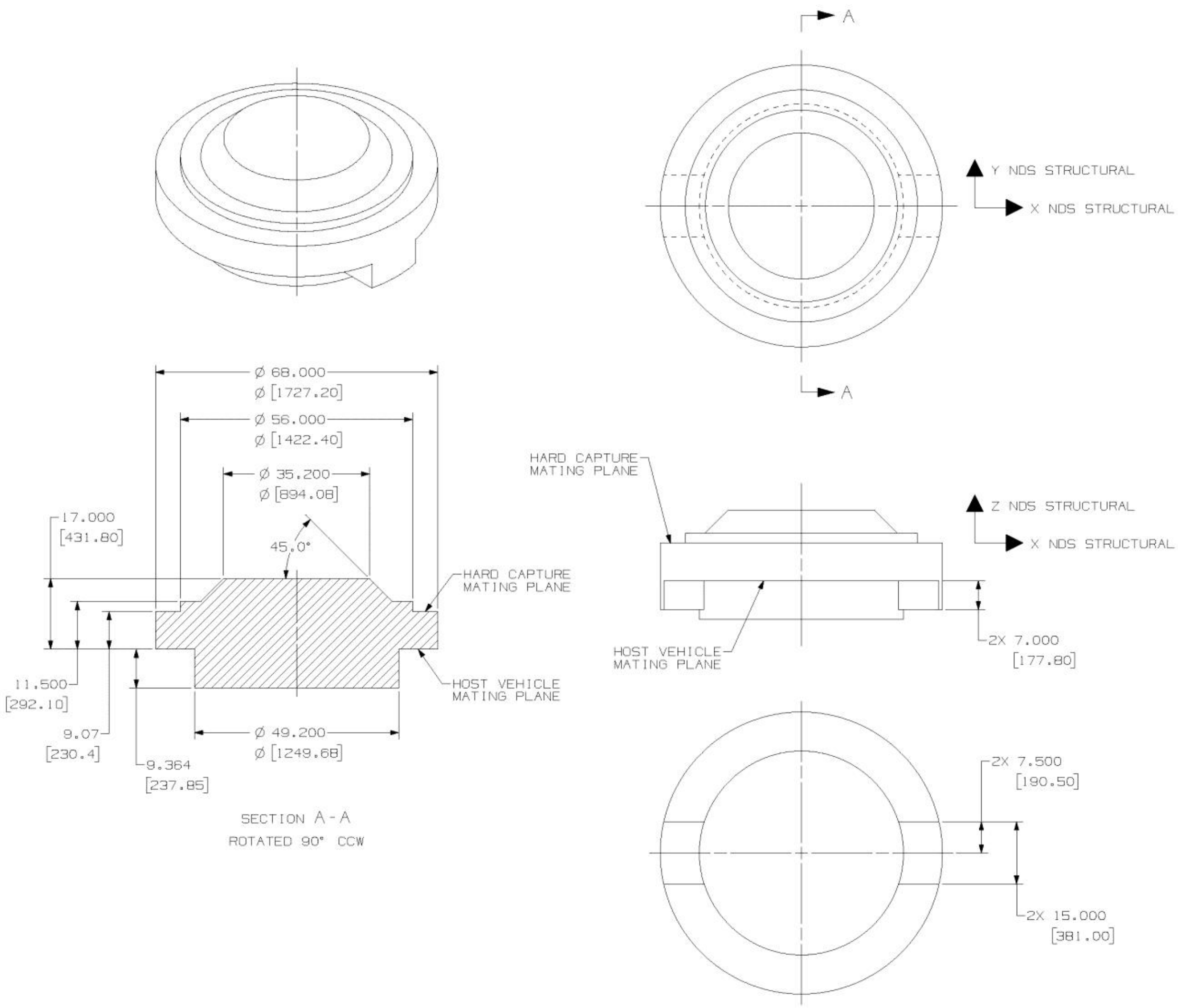
Wobble Angle is the angle between the active HCS cylindrical axis and the passive HCS cylindrical axis.

Roll angle is the angle about the rotated (wobbled) passive HCS cylindrical axis.

### 3.8.1.3 NDSB1 envelopes

#### 3.8.1.3.1 Static Envelope

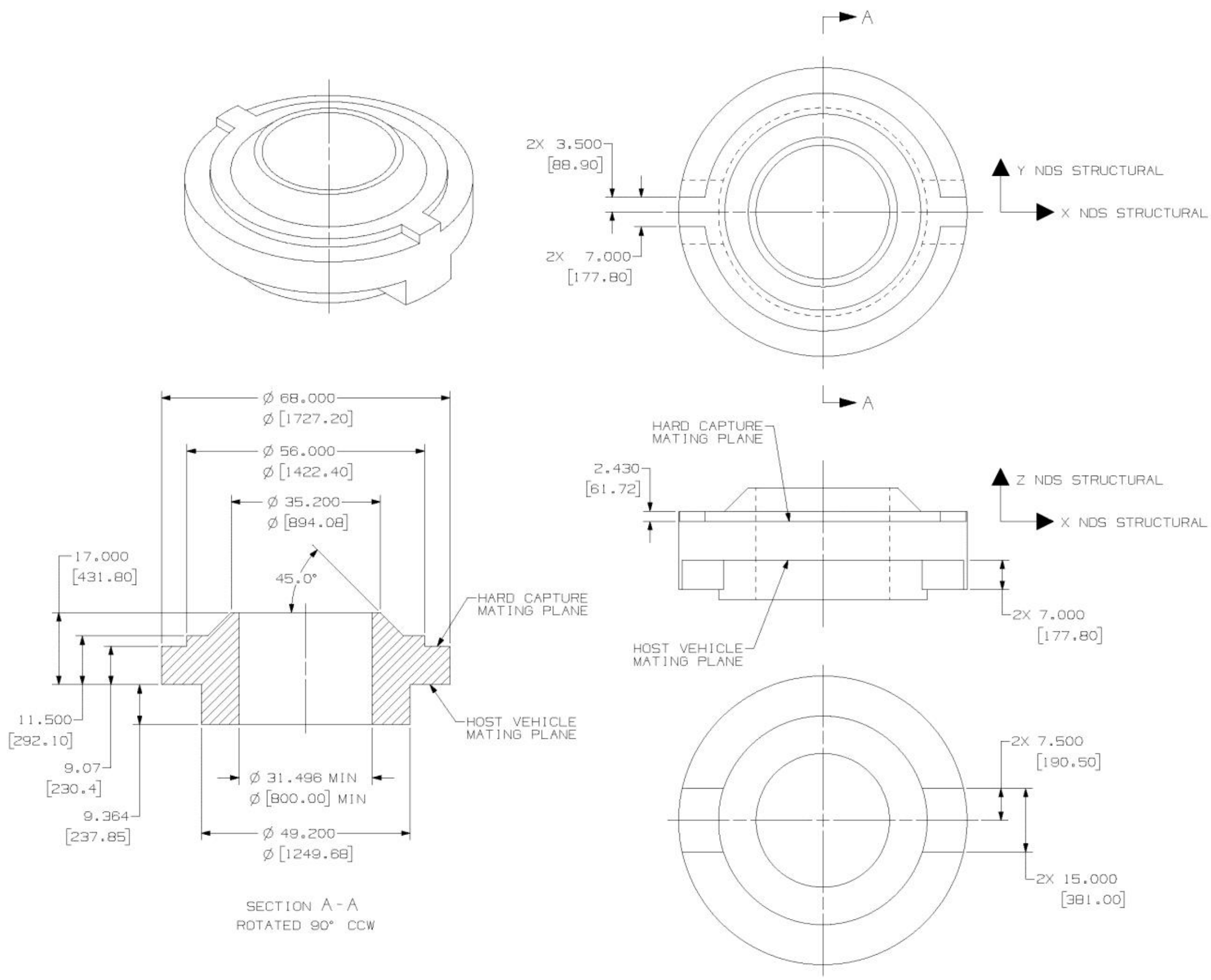
The NDSB1 static envelope in the stowed configuration is shown in Figure 3.8.1.3.1-1. This Figure does not include HV interface cabling and the NDSB1 avionics boxes placement on Host Vehicle tunnel inside this envelope.




Note: Envelope excludes the interfacing Host Vehicle cables and avionics boxes.

**FIGURE 3.8.1.3.1-1: NDSB1 STATIC ENVELOPE, STOWED CONFIGURATION**

The NDSB1 static envelope in the docked configuration is shown in Figure 3.8.1.3.1-2. This Figure does not include HV interface cabling and the NDSB1 avionics boxes placement on Host Vehicle tunnel inside this envelope.

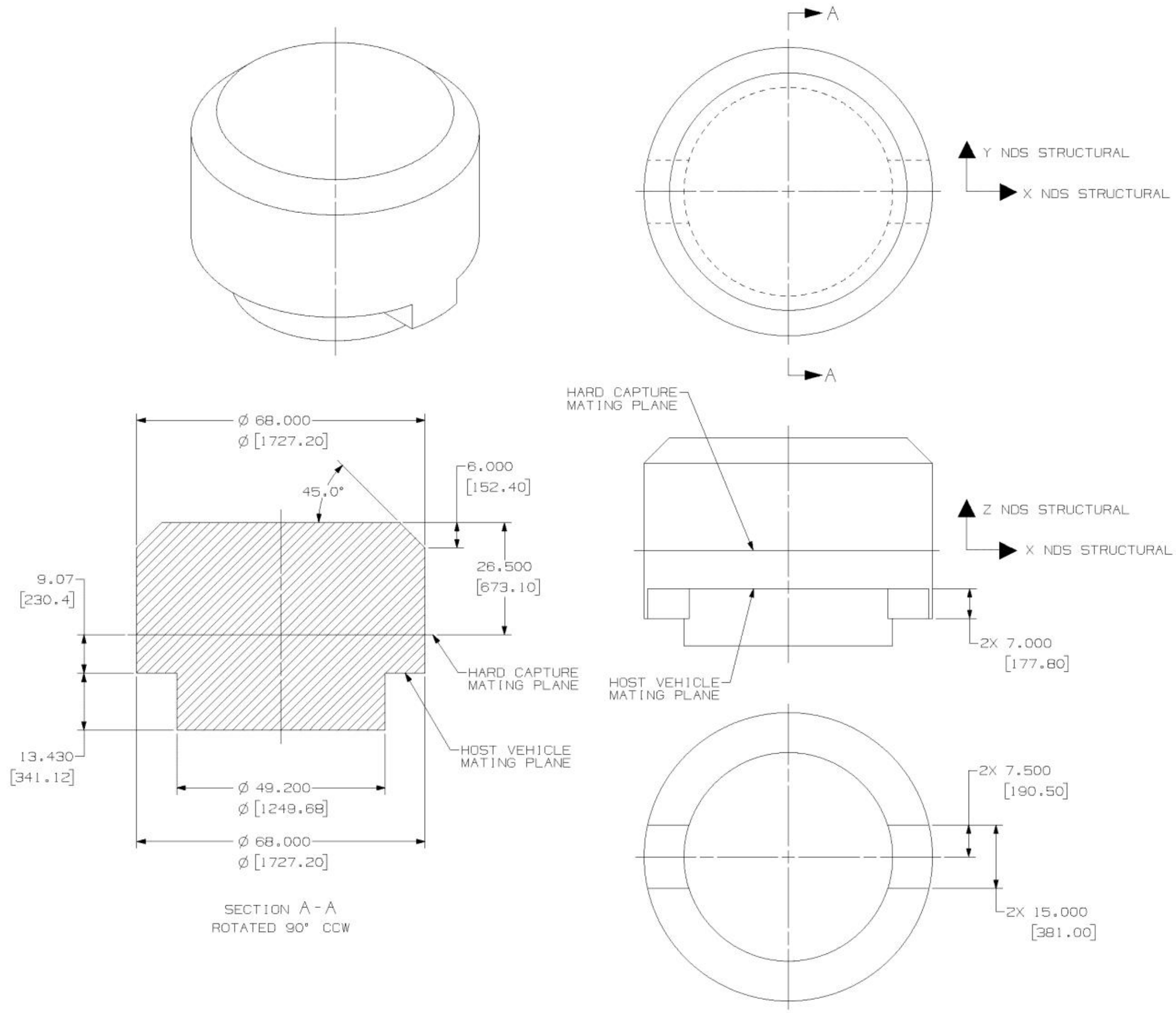



Note: Envelope excludes the interfacing Host Vehicle cables and avionics boxes.

**FIGURE 3.8.1.3.1-2: NDSB1 STATIC ENVELOPE, DOCKED CONFIGURATION**

### 3.8.1.3.2 Kinematic Envelope

The NDSB1 kinematic envelope is shown in Figure 3.8.1.3.2-1. This Figure includes the NDSB1 avionics boxes placement on Host Vehicle tunnel inside this envelope.




Note: Envelope excludes the interfacing Host Vehicle cables and avionics boxes.

**FIGURE 3.8.1.3.2-1: KINEMATIC ENVELOPE**

### 3.8.1.4 IDA Envelope

The IDA envelope is defined in Figure 3.8.1.4-1, IDA Envelope.

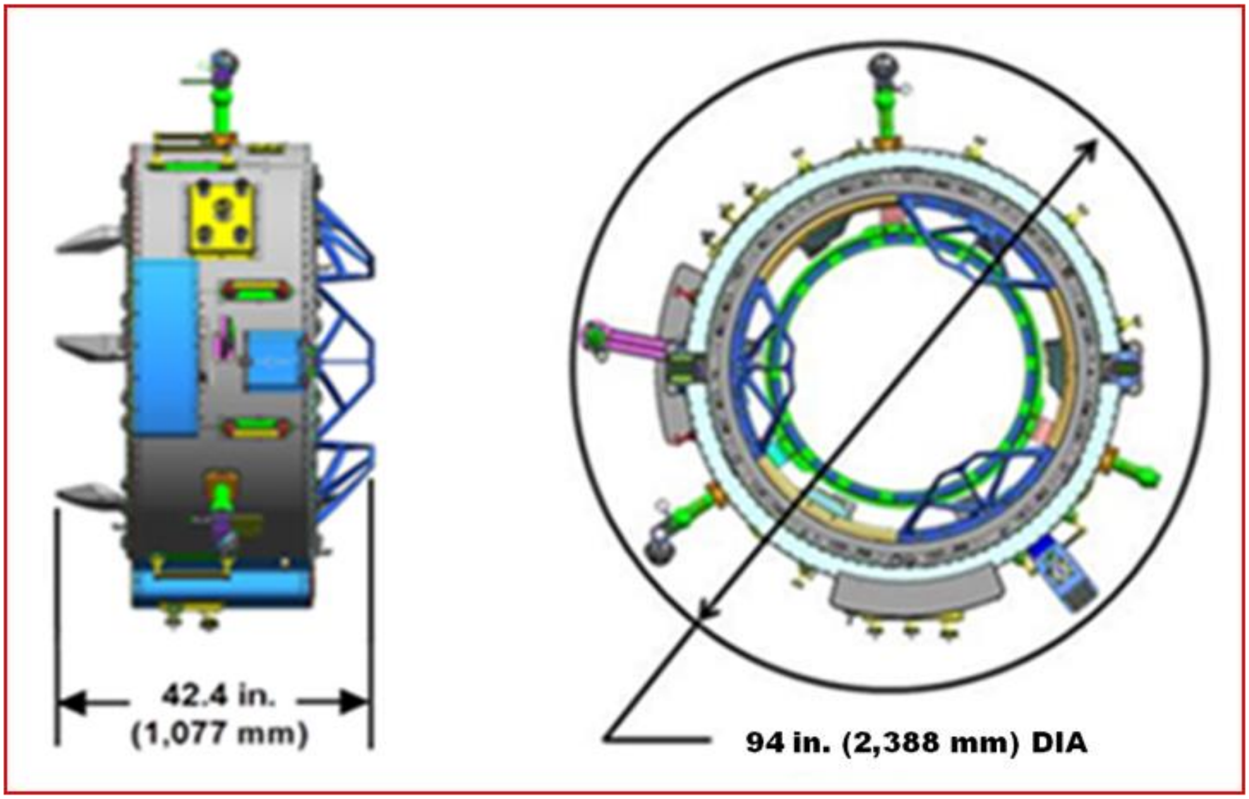



**FIGURE 3.8.1.4-1: IDA ENVELOPE**

### 3.8.2 NDSB1 Berthing

Reserved

### 3.8.3 NDSB1 Separation Limitations

The system was mass optimized such that separation greater than 6 in/sec (0.15 m/sec) could result in internal damage.

# 4.0 NDSB1 DOCKING INTERFACE

This section describes the interfaces for mating with the active NDSB1 and a passive IDA. The figures and text show/describe interfaces between the active NDSB1 and passive IDA assemblies.

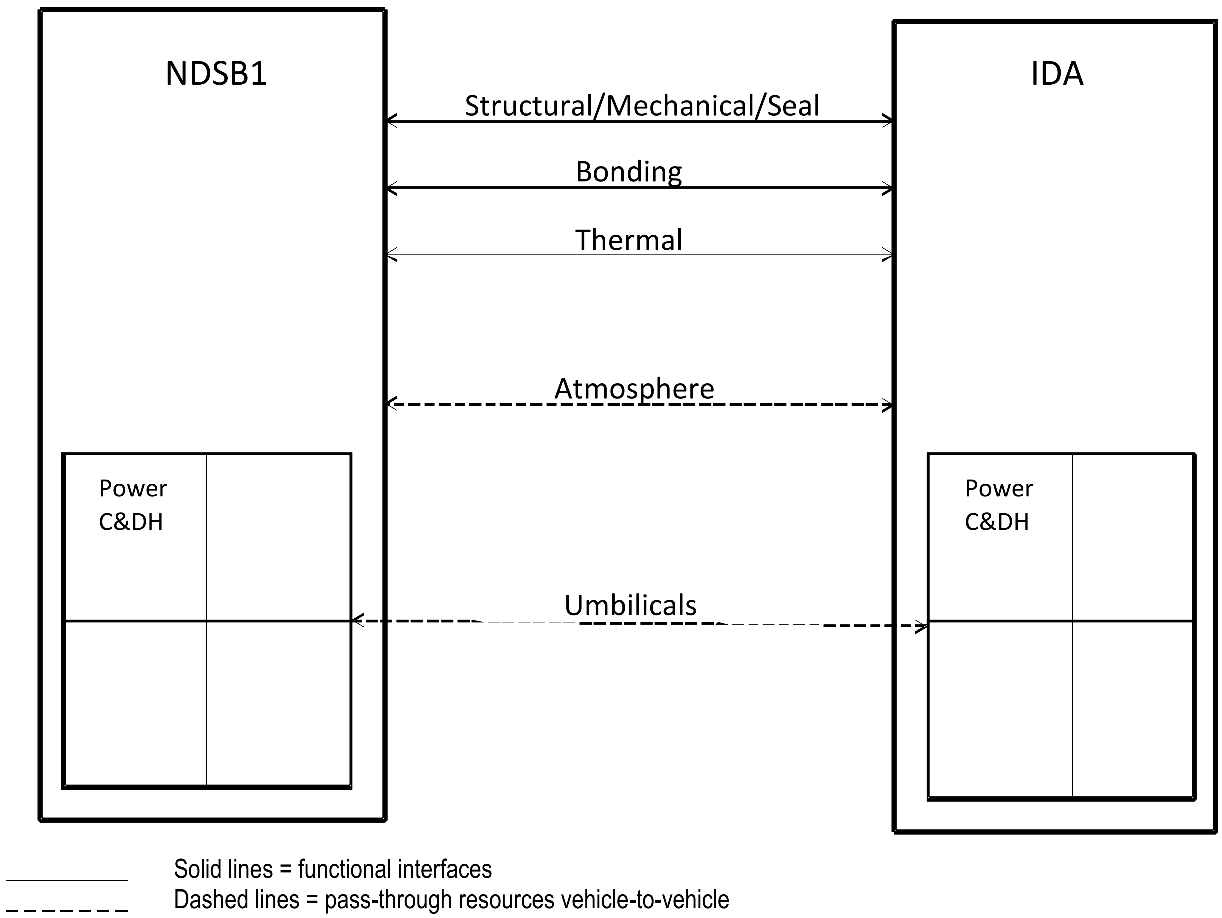


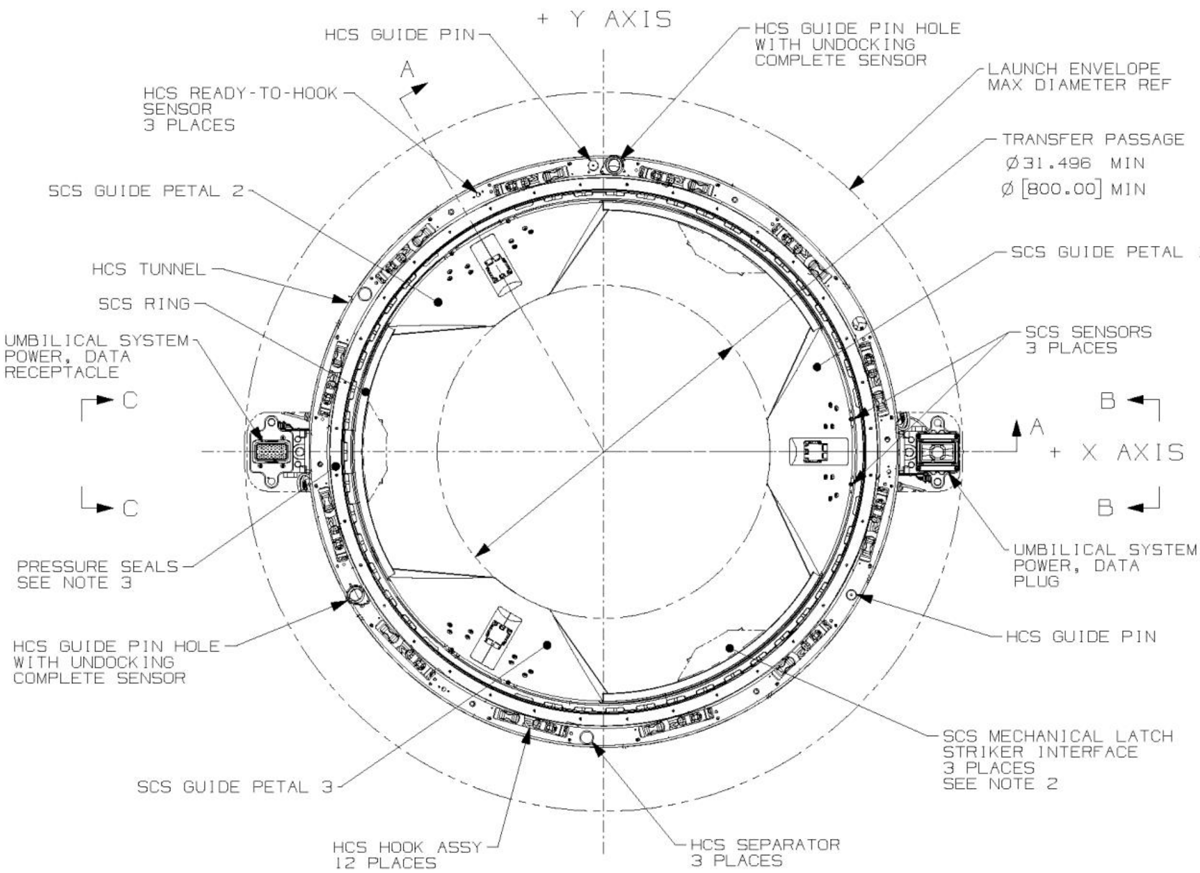

**FIGURE 4-1: NDSB1 DOCKING INTERFACE DIAGRAM**

## 4.1 NDSB1 Interfaces

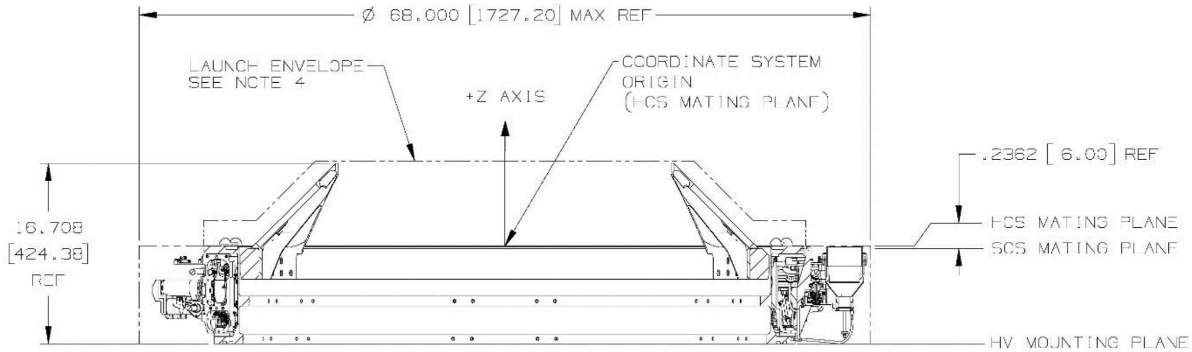
### 4.1.1 Structural/Mechanical

When the NDSB1 unit docks to an IDA, the initial connection occurs in the SCS between the capture latch on the NDSB1 and the striker plates on the IDA. Once the soft capture phase is finished, the HCS on the NDSB1 completes the docking structural connection via the hook assembly system. The NDSB1 unit can only mate with an IDA with a unique relative clocking orientation, which is determined by the pair of adjacent guide pins and guide pin receptacles on the HCS, as shown in Figure 4.1.1-1: NDSB1 Docking Interface. The volume for the NDSB1 is defined in Figure 3.8.1.3.1-2: NDSB1 Static Envelope, Docked Configuration.

The NDSB1 will satisfy the VV Keep Out Zones (KOZs) as defined in Figure 4.2.1-2: IDA Envelopes.


+ Y AXIS
HCS GUIDE PIN
HCS GUIDE PIN HOLE
WITH UNDOCKING
COMPLETE SENSOR
LAUNCH ENVELOPE
MAX DIAMETER REF
A
HCS READY-TO-HOOK
SENSOR
3 PLACES
TRANSFER PASSAGE
Ø31.496 MIN
Ø [800.00] MIN
SCS GUIDE PETAL 2
SCS GUIDE PETAL 1
HCS TUNNEL
SCS RING
SCS SENSORS
3 PLACES
UMBILICAL SYSTEM
POWER, DATA
RECEPTACLE
C
B
A
+ X AXIS
C
B
PRESSURE SEALS
SEE NOTE 3
UMBILICAL SYSTEM
POWER, DATA
PLUG
HCS GUIDE PIN HOLE
WITH UNDOCKING
COMPLETE SENSOR
HCS GUIDE PIN
SCS MECHANICAL LATCH
STRIKER INTERFACE
3 PLACES
SEE NOTE 2
SCS GUIDE PETAL 3
HCS HOOK ASSY
12 PLACES
HCS SEPARATOR
3 PLACES

(page 1 of 4)

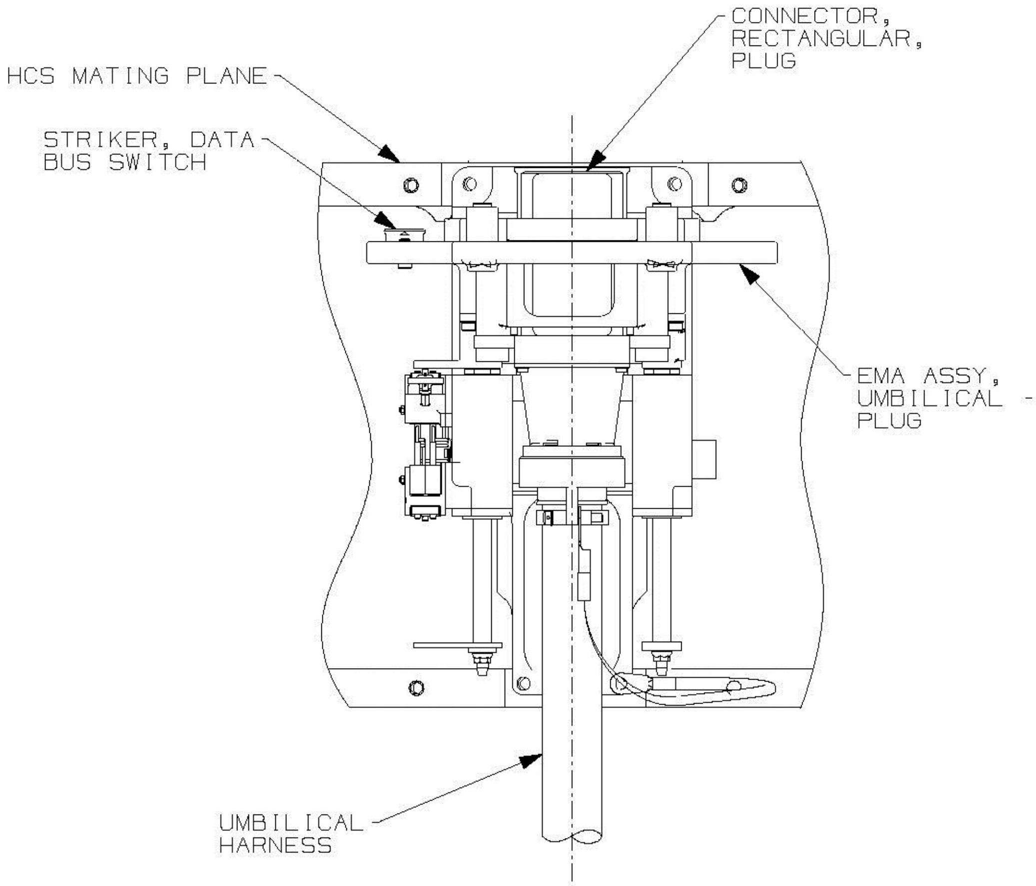



SECTION A-A
NDSB1 LAUNCH CONFIGURATION

Notes

1. General: For clarity, many of the SCS internal components are not shown.
2. Indicates general location allocated for a SCS mechanical latch design (Volume reserved in NDSB1 for Block 2 implementation)
3. Seals on NDSB1, mating flange on IDA.
4. The NDSB1 Launch Envelope is the same as the NDSB1 Static Envelope, Stowed Configuration – See Figure 3.8.1.3.1-1.

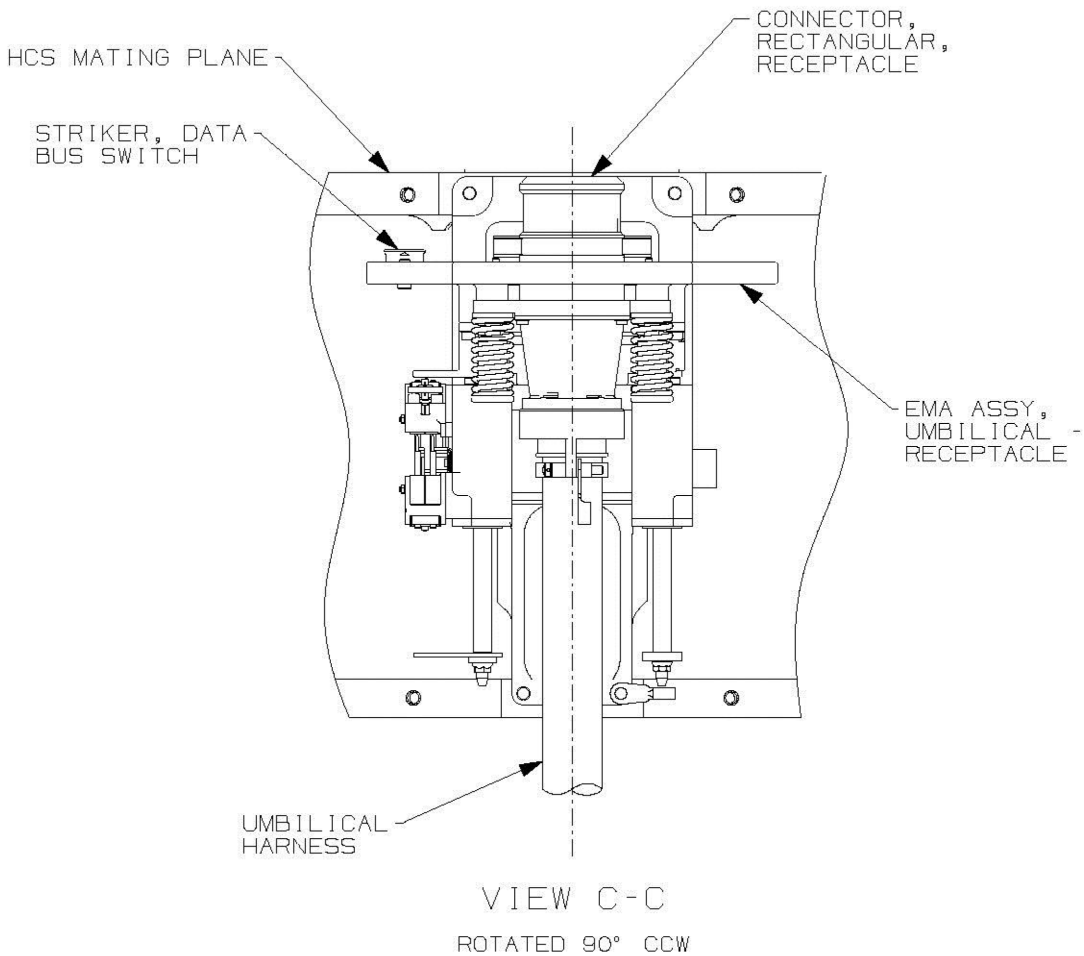
(page 2 of 4)




VIEW B-B

ROTATED 90° CW

(page 3 of 4)




(page 4 of 4)

**FIGURE 4.1.1-1: NDSB1 DOCKING INTERFACE**

#### 4.1.1.1 Thermal Interface

The thermal interfaces and hardware performance are analyzed using the following approach:

Thermal Model Development

Thermal models of NDSB1 are developed based on drawings, Computer Aided Design (CAD) models of the design, and interfaces defined in specifications. The NDSB1 system level thermal models will be capable of simulating solo flight or docking scenarios with the ISS and IDA.

Host Vehicle Conduction

The NDSB1 utilizes heaters and heat transfer with the host vehicle to condition/maintain temperatures within limits for each operating model. The NDSB1 thermal model assumes heat transfer by conduction across the structural interface with the host vehicle. The NDSB1 will limit heat transfer across the interface. The host vehicle will provide the required boundary temperatures based on the heat transfer.

Host Vehicle Radiation

A disc representing the NDSB1 view to host vehicle is included in the NDSB1 system level thermal model to represent radiation to the host vehicle. The disc representing the host vehicle will have a radius 1.43 times larger than the NDSB1. The disc is modeled with arithmetic nodes and optical properties of $\alpha = 0.3$ and $\varepsilon = 0.9$. This disc will be flush with the NDSB1 base/vehicle interface point.

Host Vehicle Micro Meteoroid/ Orbital Debris (MMOD)/External Hardware Thermal Interface

NDSB1 system level thermal analysis will be performed with the NDSB1 external Multi-Layer Insulation (MLI) exposed and no additional heat leak applied at the external flange interfaces.

Environment and Attitudes

The NDSB1 system level thermal model simulates the LEO environments and attitudes to predict temperature ranges for comparison to hardware limits. Table 4.1.1.1-1 shows the LEO environmental parameters for thermal: Solar flux, albedo, and Earth Outgoing Long-wave Radiation (OLR) environments. Table 4.1.1.1-2 gives the flight attitudes used for design. Figure 4.1.1.1-1 shows the NDSB1 coordinate system and the Local Vertical, Local Horizontal (LVLH) coordinate system for docking to the ISS.

Unmated solar inertial attitudes with the NDSB1 facing the sun are known to cause violations of operational and survival limits. These attitudes will be assessed for capability only. Time constraints to protect the NDSB1 will be documented in EID684-15524, NDSB1 Thermal Analysis Report.

**TABLE 4.1.1.1-1: EXTREME HOT AND COLD NATURAL THERMAL ENVIRONMENTS**

| Condition (1,2) | | ALBEDO* | OLR** (Btu/hr-ft$^2$) |
|---|---|---|---|
| Cold | A | 0.27 | 65.3 |
| | B | 0.20 | 76.4 |
| Hot | A | 0.30 | 90.6 |
| | B | 0.40 | 76.4 |

Solar Constants (Btu/hr-ft$^2$)
Cold 418.8
Hot 451.2

**Notes:**

(1) Values in this table represent a 3 sigma probability. Albedo and OLR are adjusted to the top of the atmosphere (18.6 nm altitude).

(2) Both Set A and Set B are design requirements. Set A represents worst case OLR values with corresponding albedo values. Set B represents worst case albedo values with corresponding OLR values.

*Albedo is the fraction of solar energy (shortwave radiation) reflected from the Earth back into space. It is a measure of the reflectivity of the earth's surface.

**Outgoing Longwave Radiation (OLR) is the energy leaving the earth as infrared radiation. The OLR is dependent on the temperature of the radiating body.

Source: NASA Technical Memorandum 4527 “Natural Orbital Environment Guidelines for use in Aerospace Vehicle Development”, dated June 1994 by Jeffrey Anderson.

**TABLE 4.1.1.1-2: NDSB1 DESIGN ATTITUDES**

| Attitude | Configuration | Reference frame | Solar Beta range | Yaw* | Pitch* | Roll* | Description |
|---|---|---|---|---|---|---|---|
| +X on -VV | NDSB1/ISS | LVLH | -75° ≤ β ≤ +75° | -15° to +15° | -20° to +15° | -15° to +15° | NDSB1 solo or approaching attitude toward ISS Node2 PMA2 forward docking port. The NDSB1 +X axis on the opposite of the velocity vector. |
| +X on Nadir | NDSB1/ISS | LVLH | -75° ≤ β ≤ +75° | -15° to +15° | -20° to +15° | -15° to +15° | NDSB1 solo or approaching attitude toward ISS node2 PMA3 Zenith docking port. The NDSB1 +X points toward earth. |
| +X on Zenith | NDSB1 solo | LVLH | -75° ≤ β ≤ +75° | -15° to +15° | -15° to +15° | -15° to +15° | NDSB1 solo flight and not a docking attitude. The NDSB1 +X points away from earth. |
| +X to Sun To -X to Sun | NDSB1 solo | SI | -75° ≤ β ≤ +75° | N/A | N/A | N/A | Two fixed orientations per orbit. At solar noon the NDSB1 +X axis pointing at the sun. At solar midnight the -X axis pointing at the sun. Attitude switches at true anomaly 90 and 270 degrees. |
| +/- Y/Z to Sun | NDSB1 solo | SI | -75° ≤ β ≤ +75° | N/A | N/A | N/A | Two fixed orientations per orbit. At solar noon the NDSB1 +X axis on velocity vector. At solar midnight the +X axis on velocity vector. |
| -X to Sun | NDSB1 solo | SI | -75° ≤ β ≤ +75° | N/A | N/A | N/A | NDSB1 -X axis pointing at the sun all around orbit. |

* Allowable ISS reference attitude deviations

****General Notes**

1. Basic vehicle orientations are described by indicating the direction that Space Station body axes are pointing. VV is the Velocity Vector, Zenith is up and Nadir is down.
2. The Space Station average orbital inclination is 51.6 degrees.
3. The Space Station altitude varies between 180 and 270 nautical miles.
4. All attitudes are yaw, pitch and roll Euler angle rotation sequences with 0, 0, 0 YPR aligned with the LVLH reference frame.
5. When Torque Equilibrium Attitude (TEA) is also specified, it means that the attitude will be the nearest TEA to the designated orientation such as +XVV TEA. The TEA is normally also the minimum propellant attitude (MPA).
6. Solar beta angle is the angle between the ISS orbit plan and the Sun vector. Solar beta angle takes the sign of the orbit angular momentum vector - Sun on the north side of the orbit is positive, south side is negative.
7. NDSB1 +X axis to Sun, solar inertial (SI) attitude, will be assessed for capability only and not as a design attitude requirement. This attitude results in the NDSB1 +X axis facing the sun throughout the orbit. Transient analyses will determine allowable exposure times in this attitude. See section D684-15386 NDSB1 Concept of Operations, section 1.5.2 HV DRM for additional information.

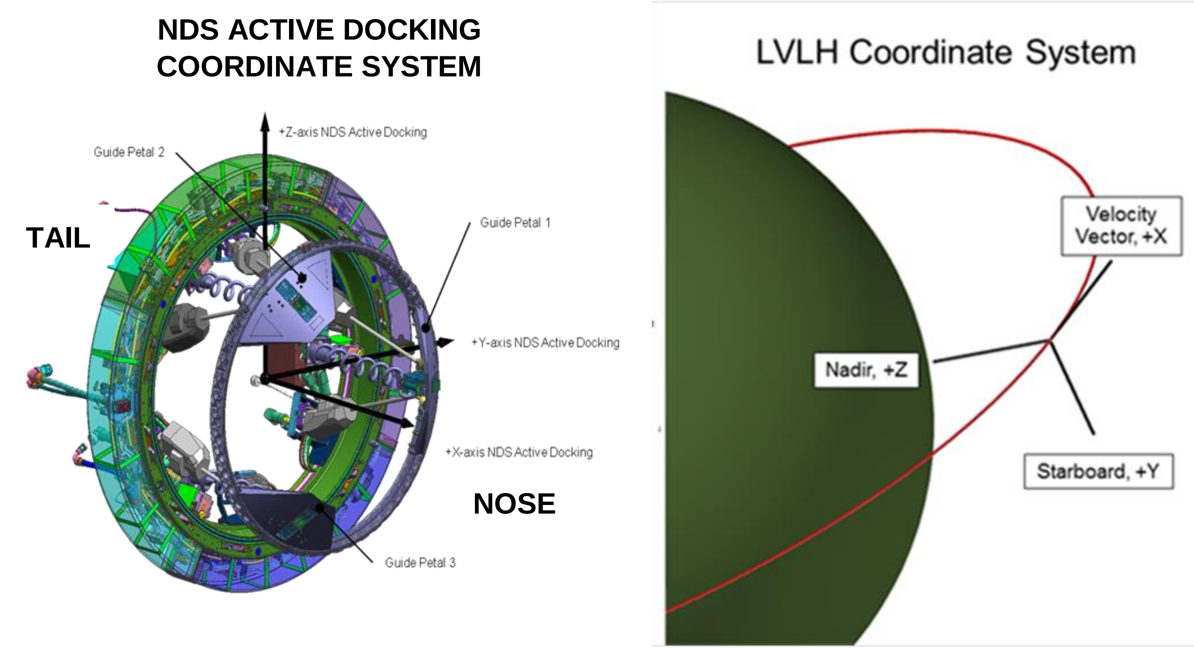



**FIGURE 4.1.1.1-1: NDSB1 AND LVLH COORDINATE SYSTEMS**

<u>NDSB1 Analysis Results</u>

The results of the thermal model are used to select proper materials, optics, and insulation to maintain components within limits for both hot and cold environments. Hardware and interface temperature predictions will be documented in EID684-15524, NDSB1 Thermal Analysis Report.

<u>Thermal Gradients</u>

Predicted temperatures from the NDSB1 thermal models will be mapped to structural models to assess thermal gradients within the NDSB1.

<u>Integrated NDSB1/Host Vehicle Analysis</u>

Integrated NDSB1/host vehicle analysis, with host provided MMOD shielding, must show that NDSB1 design is capable of meeting the minimum requirements for solo flight, checkout, docking and mated/pressurized conditions expected for that vehicle's mission.

<u>NDSB1-to-IDA Thermal Conductance</u>

For steady state mated configurations, the NDSB1-to-IDA docking interface is assumed to be adiabatic. For evaluation of transient response in mated configurations, the integrated models should use the appropriate conductance to be conservative from that thermal evaluation's perspective. The thermal conductance across the NDSB1-to-IDA HCS docking interface is defined as ranging from 75 Btu/hr-°F (40 W/°K) to 187 Btu/hr-°F (98 W/°K).

Dynamic Seal Temperature Range

The dynamic seal is the limiting component of the HCS-to-IDA thermal interface. The dynamic seal operational and non-operational temperature limits are documented in JSC-64595C, International Low Impact Docking System (iLIDS) Dynamic Seal End Item Specification and JSC-66161, International Low Impact Docking System (iLIDS) Dynamic Seal Verification Document. The temperature ranges were derived from analyses of NDSB0 thermal performance and seal material properties.

The operational range is -38 °F to 122 °F.

The non-operational (survival) range is -65 °F to 192 °F.

The allowable NDSB1-to-IDA interface temperature ranges for each mission phase are defined in the following subsections.

##### 4.1.1.1.1 Non-Operational Survival

Non-operational survival conditions apply to solo flight prior to check-out and docking operations.

The following NDSB1 temperature range applies to HCS and SCS interface hardware prior to docking of NDSB1 and IDA (Only heaters and electrical boxes will be active at this point):

-65 °F to +192 °F (-54 °C to +89 °C)

Minimum – The minimum temperature of -65 °F (-54 °C) is defined by the minimum dynamic seal survival temperature limit.

Maximum – The maximum temperature of +192 °F (+89 °C) is the limiting maximum temperature survival limit for the NDSB1 hardware.

##### 4.1.1.1.2 Operational

This subsection defines operational temperature limits for the NDSB1-to-IDA interface during check-out and docking operations. Individual components have capabilities outside these ranges. Specific component allowable limits will be described and evaluated in EID684-15524, NDSB1 Thermal Analysis Report.

###### 4.1.1.1.2.1 Tunnel and Seal Mating Interface

The following applies to the HCS tunnel and seal mating interfaces when the system is preparing to dock, up through hard mate, but prior to pressurization:

-38 °F to +122 °F (-39 °C to +50 °C)

Minimum – The minimum interface temperature of -38 °F (-39 °C) is defined by the minimum seal operational temperature limit. The predicted temperature is expected to be significantly warmer due to conduction from the HV.

Maximum – The maximum interface temperature of +122 °F (+50 °C) is defined by the maximum seal operational temperature limit.

The allowable temperature differential between the sealing interfaces during docking hard capture is also restricted. The maximum allowable difference between the average temperatures of the hard capture mating interface from initial contact through hard mate complete is 100 °F (56 °C).

The hard mate differential was determined by analyses of the maximum differential temperature allowed for soft capture guide petal engagement and seal mating interface temperatures. This differential can be evaluated via mission profile analysis prior to docking.

#### 4.1.1.1.2.2 Soft Capture Mating Interfaces

The following applies to soft capture components when the system is preparing to dock, up through hard mate, but prior to pressurization:

-65 °F to +165 °F (-54 °C to +74 °C)

Minimum – The minimum interface temperature of -65 °F (-54 °C) is defined by the minimum hardware operational temperature limit.

Maximum – The maximum interface temperature of +165 °F (+74 °C) is defined by the maximum hardware operational temperature limit.

The allowable temperature difference between the top rings is also restricted. The maximum allowable difference between the average temperatures of the soft capture mating surfaces is 100 °F (56 °C) from initial contact through hard mate complete. This restriction is based on thermal expansion limits for the engagement of the mating guide petals in the mating NDSB1. This differential can be evaluated via mission profile analysis prior to docking.

#### 4.1.1.1.3 Mated and Pressurized

This subsection defines mated and pressurized limits for the NDSB1 after hard mate and pressurization.

#### 4.1.1.1.3.1 Mated and Pressurized Steady-State Temperature Range

The following is the steady-state temperature range after hard mate and pressurization:

+60 °F to +113 °F (+15.6 °C to +45 °C)

Minimum –The NDSB1 internal volume temperatures will be above +60 F to preclude condensation. The typical dew point temperature range for crewed vehicles is +40 °F to +60 °F (+4.4 °C to +15.6 °C). The host vehicle will provide thermal conditioning for steady state mated operations.

Maximum – The temperature of +113 °F (+45 °C) is the maximum bare-handed touch temperature for continuous contact.

These temperatures apply to all mated and pressurized conditions, except for the transient temperature response period of 10 hours after docking and pressurization.

#### 4.1.1.1.3.2 Mated and Pressurized Transient Temperatures

Hardware temperatures at the time of docking may be below the dew point and minimum IVA touch temperature for cold cases environments and attitudes, or above the maximum IVA touch temperature for hot case environments and attitudes. The NDSB1 temperature conditions will approach the steady state temperatures described in Paragraph 4.1.1.1.3.1 as a function of time. The time-to-limit for worst case hot and cold case conditions will be assessed and documented in EID684-15524, Thermal Analysis Report.

Pressurization or hatch opening is not restricted by the transient temperature profile. However, if hatch opening is required prior to the system achieving safe touch temperatures, the crew may be required to use Personal Protective Equipment (PPE). If the temperature of the vestibule is not above the dew point, condensation would result within the vestibule during this transition period.

#### 4.1.1.1.4 Mated and Unpressurized

For scenarios in which the NDSB1 is hard mated and the vestibule is unpressurized, the following temperature ranges apply:

-38 °F to +122 °F (-39 °C to +50 °C) at docking

Minimum – The minimum interface temperature of -38 °F (-39 °C) is defined by the minimum seal operational temperature limit at docking.

Maximum – The maximum interface temperature of +122 °F (+50 °C) is defined by the maximum seal operational temperature limit at docking.

+60 °F to +120 °F (+15.6 °C to +49 °C) at undocking

Minimum – The minimum interface temperature is limited to +60 °F (+15.6 °C) to prevent excessive heat transfer with the IDA. Temperatures colder than +60 °F (+15.6 °C) will affect the IDA’s ability to maintain interface requirements with the PMA. Maximum – The maximum interface temperature is limited to +120°F (+49 °C) to prevent excessive heat transfer with the IDA. Temperatures warmer than +120°F (+49 °C) will affect the IDA’s ability to maintain interface requirements with the PMA.

#### 4.1.1.2 Soft Capture System

The soft capture is not final structural mating but the first level of attachment in the docking sequence where attenuation and alignment between the HV and ISS occurs following initial impact. The NDSB1 SCS utilizes an open loop control feed-forward control system for the attenuation and alignment sequences during the initial docking phase. The guide petals are mounted to the soft capture ring, face inward and they will not be removed on orbit. The petals are equally spaced around the circumference of the soft capture docking ring. The SCS guide petals mounts an active latch for soft capture. An overview is shown in Figure 4.1.1.2-1.

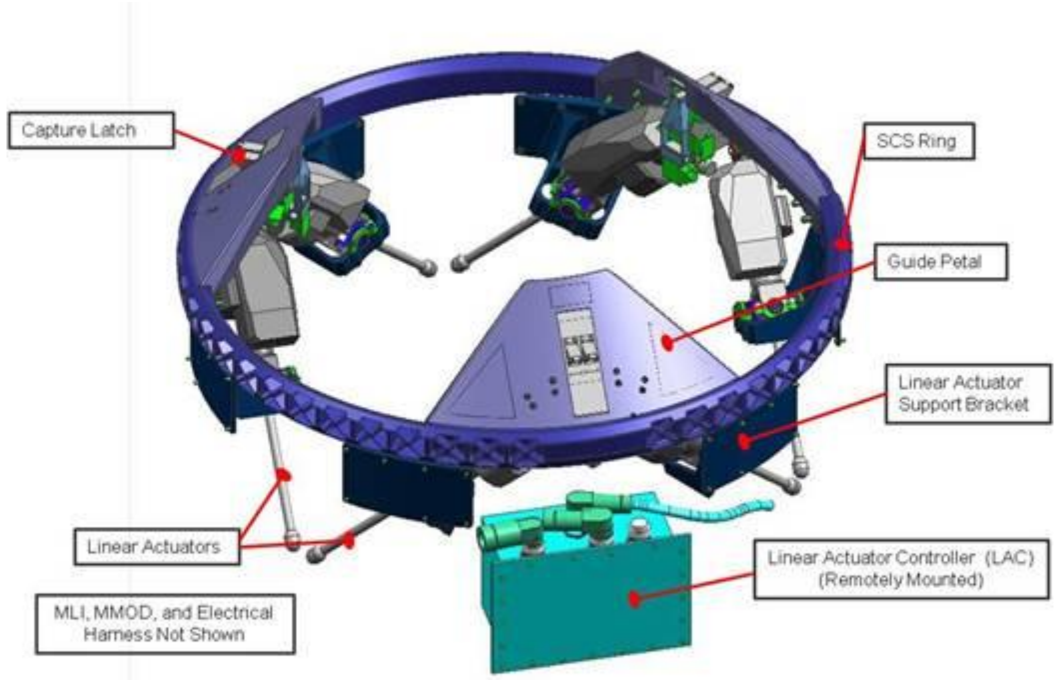



**FIGURE 4.1.1.2-1: SOFT CAPTURE SYSTEM**

##### 4.1.1.2.1 Guide Petal System

Three guide petals mount to the soft capture ring and face inward. The petals are equally spaced around the circumference of the soft capture docking ring. A representative depiction of the guide petal layout can be seen in Figure 4.1.1.2.1-1: SCS GUIDE PETAL SYSTEM, Figure 4.1.1.2.1-2: SCS Guide Petal System Detail, and Figure 4.1.1.2.2-1: SCS Feature Definition. The stiffness and hardness characteristics of the guide petals also impact capture performance. Hosts with other docking systems must either match the NDSB1 petal design or prove that their design has equivalent hardness and stiffness characteristics.

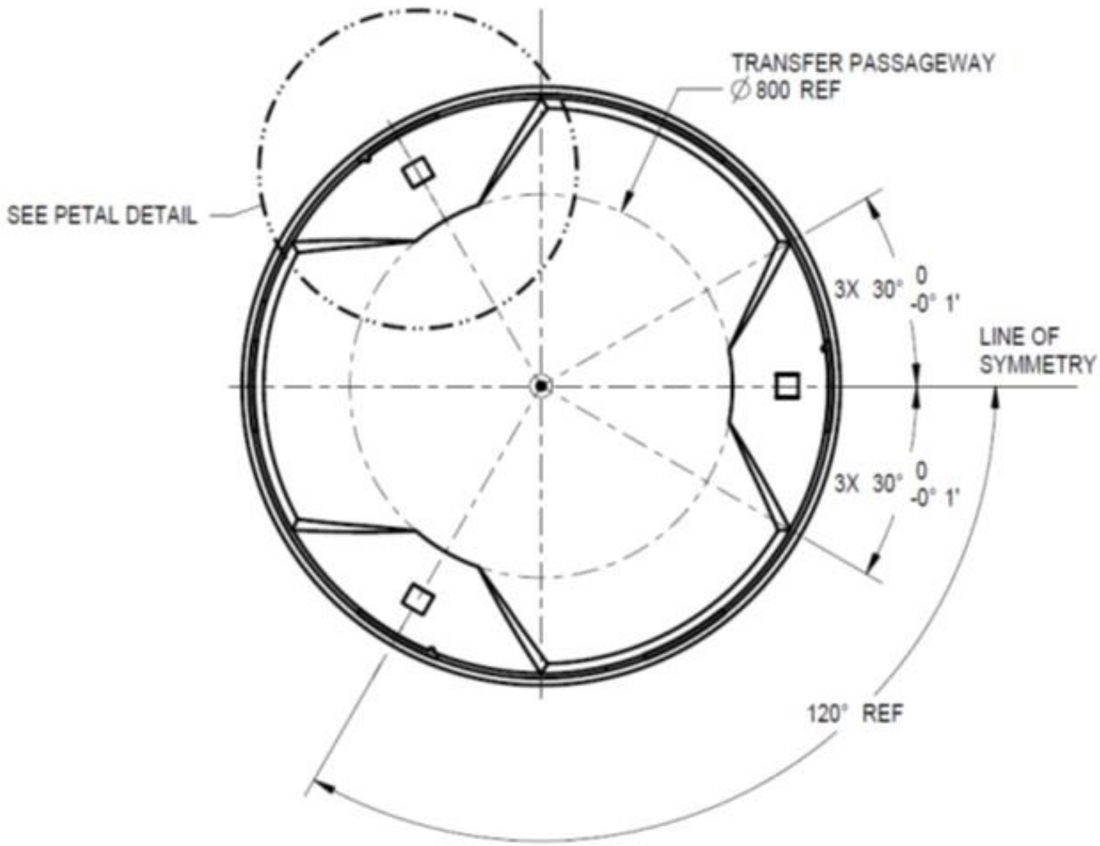



**FIGURE 4.1.1.2.1-1: SCS GUIDE PETAL SYSTEM**

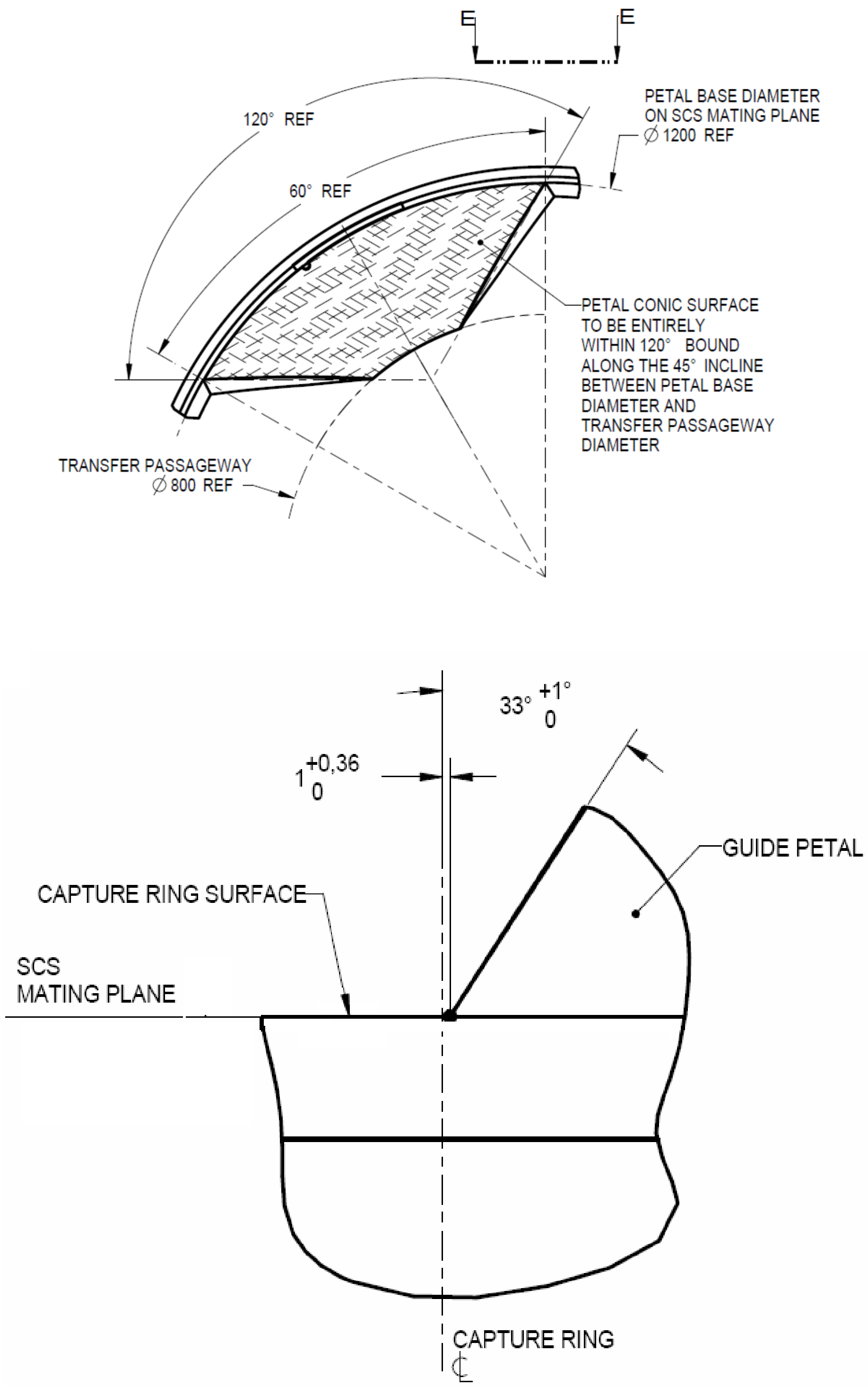
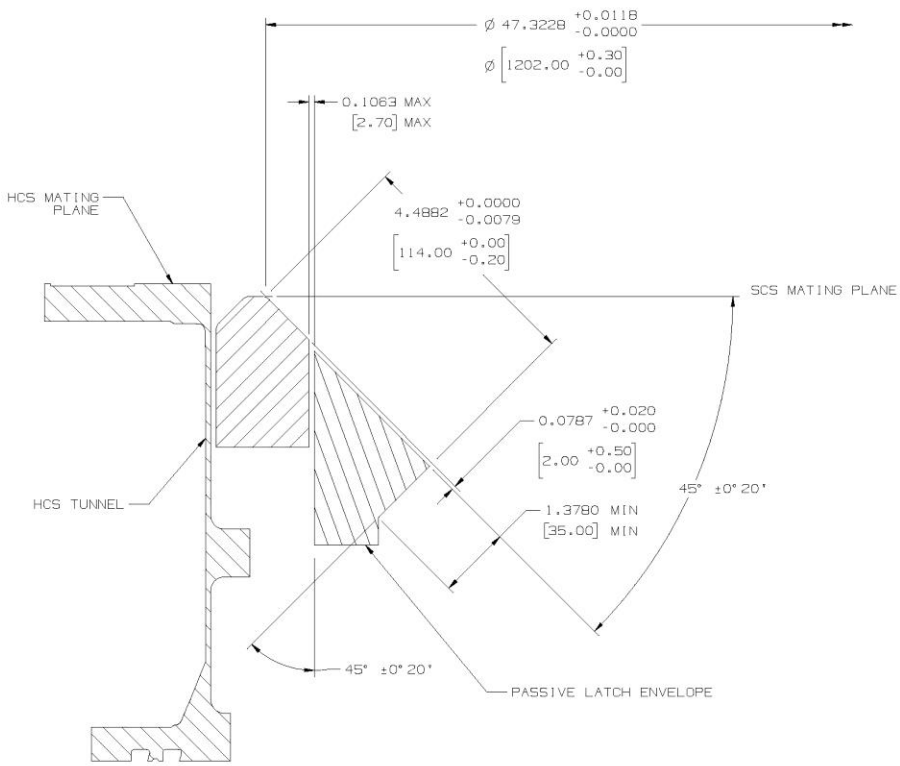



**FIGURE 4.1.1.2.1-2: SCS GUIDE PETAL SYSTEM DETAIL**

### 4.1.1.2.2 Soft Capture Ring

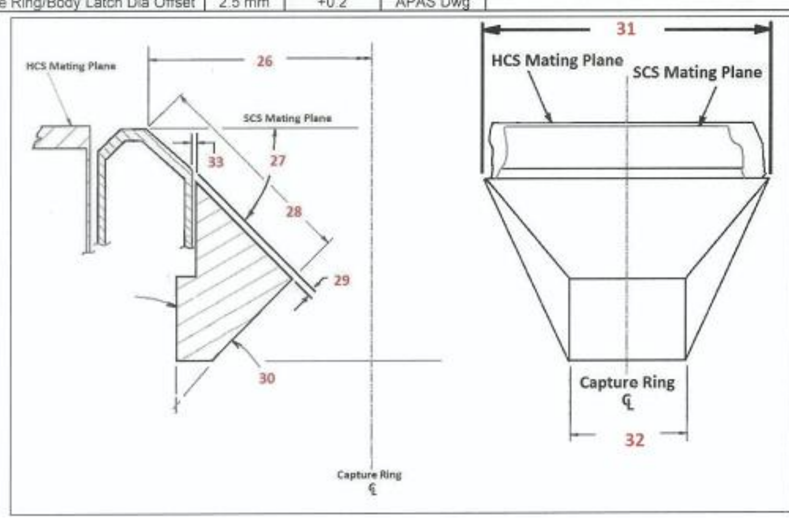
The dimensions of SCS ring features are defined in Figure 4.1.1.2.2-1. The SCS ring, in active mode, is actuated above the mating plane for soft capture as depicted in Figure 4.1.1-2.



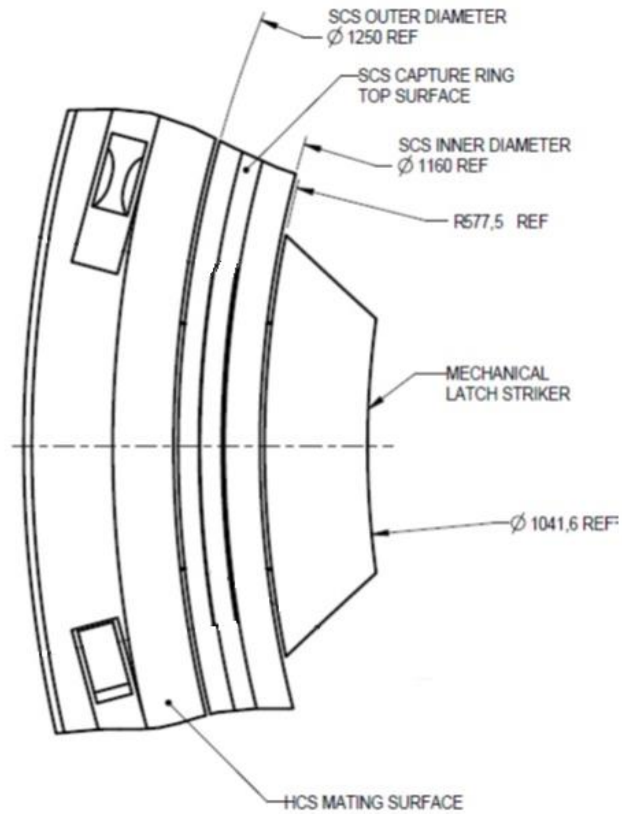

Definition of SCS Mating Plane

Cross Section

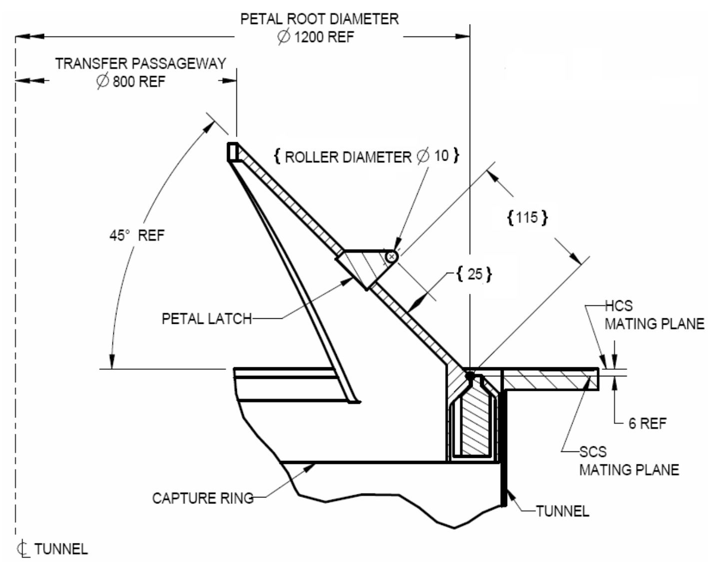
| Dim # | Dimension Name | Energia | Tolerance | Source | Notes |
|---|---|---|---|---|---|
| 26 | Inner Dia Ring/Body Latch Location | 1202 mm | + 0,4 | 33Y.6322.020 | |
| 27 | Capture Latch/Guide Ring Angle | 45 ° | +/- 20 ' | 33Y.6322.020 | |
| 28 | Capture Surface Length | 114 mm | + 0.2 | 33Y.6322.020 | |
| 29 | Capture Surface Offset | 2 mm | + 0.5 | 33Y.6322.020 | |
| 30 | Base Capture Latch Angle | 45 ° | +/- 20 ' | | |
| 31 | Body Latch Entry Width | 232 mm | Max Ref | 33Y.8221.151 | Dim. 31 greater than Dim. 32 as determined by IC's at capture |
| 32 | Body Latch Base Width | 70 mm | -0.4/-0.130 | 33Y.8347.050 | Width determined based on configuration of latch and final IC's |
| 33 | Guide Ring/Body Latch Dia Offset | 2.5 mm | +0.2 | APAS Dwg | |




Radial View (Page 1 of 2)




Top View, Mechanical Latch




Active Mechanical Soft Capture Latch Interface

(Page 2 of 2)

**FIGURE 4.1.1.2.2-1: SCS FEATURE DEFINITION**

#### 4.1.1.2.3 Magnet and Striker

Reserved.

#### 4.1.1.2.4 Soft Capture Sensors and Strikers

The SCS of the docking system provides an indication when the two SCS mating planes become coplanar through the use of position sensors. The NDSB1 has three soft capture indication positions, located at an offset from the centerline as defined in Figure 4.1.1.1-1.

#### 4.1.1.2.5 Pre-Capture SCS Compressive Force Resistance

The NDSB1 SCS will not exceed a maximum compressive resistance force of 22.48 lbf (100 N). This resistance includes the soft capture latch resistance, guide petals, SCS capture sensors, and actuators.

#### 4.1.1.2.6 SCS Mechanical Latch Striker

The NDSB1 configuration has reserved volume for potential implementation of SCS mechanical latch strikers, which would allow other IDSS-compatible docking systems that use SCS mechanical latches to dock to an NDSB1. This is not structural mating, but the first level of attachment. The NDSB1 configuration has reserved volume, as defined in Figure 4.1.1.2.2-1 located as depicted in Figure 4.1.1-1.

### 4.1.1.3 Hard Capture System

The NDSB1 HCS conceptual design includes the following components: active/passive hook assemblies, a motor to drive the hook assemblies, a hook assembly release mechanism, a hook assembly drive mechanism, a hook assembly power resource, a hook assembly electrical interface, a tunnel with a HV mounting interface, an IDA interface, seals, retractable pushers, contingency pyro hook release, and mechanized separation umbilicals.  The HCS Subsystem uses powered hooks to engage with the IDA, providing a structural connection ready for pressurization between the mated vehicles that allows for cargo and crew transfer.  The HCS completes the docking sequence when resource transfer umbilicals are engaged. See Figure 4.1.1.3-1.

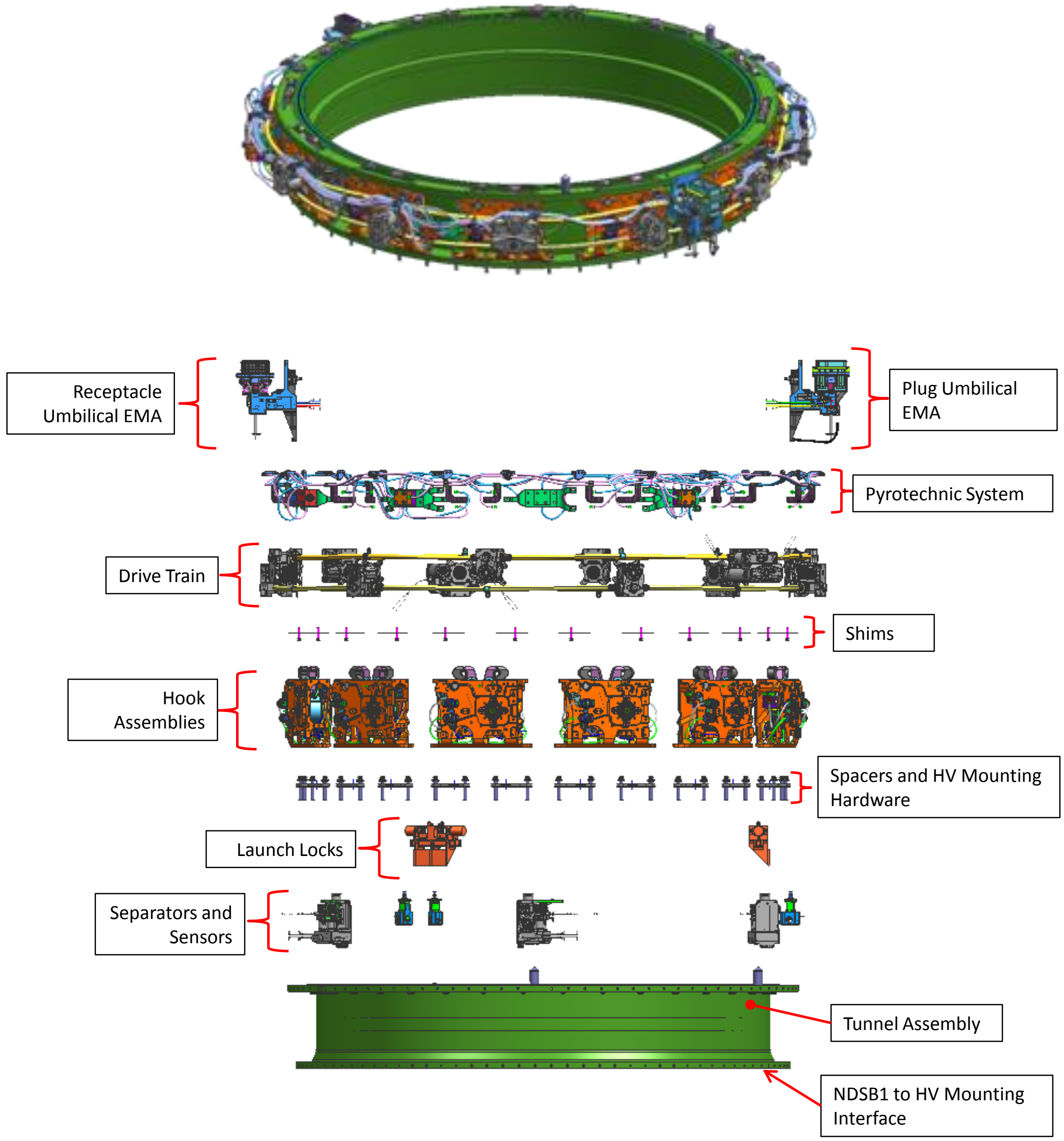
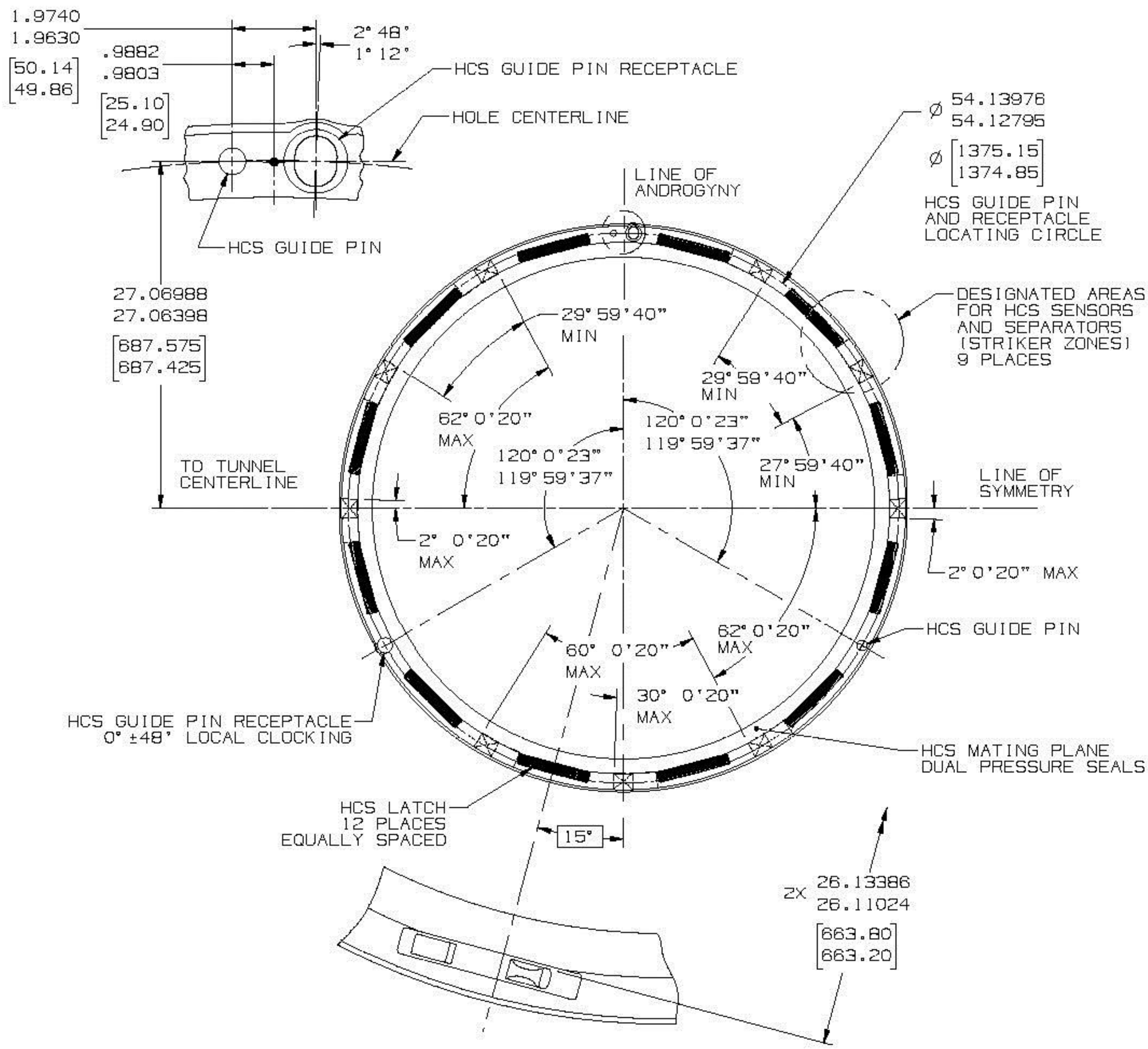



**FIGURE 4.1.1.3-1: NDSB1 HARD CAPTURE SYSTEM**

#### 4.1.1.3.1 Tunnel

For tunnel interfaces refer to Figure 4.1.1.3.1-1: HCS Docking Interface.



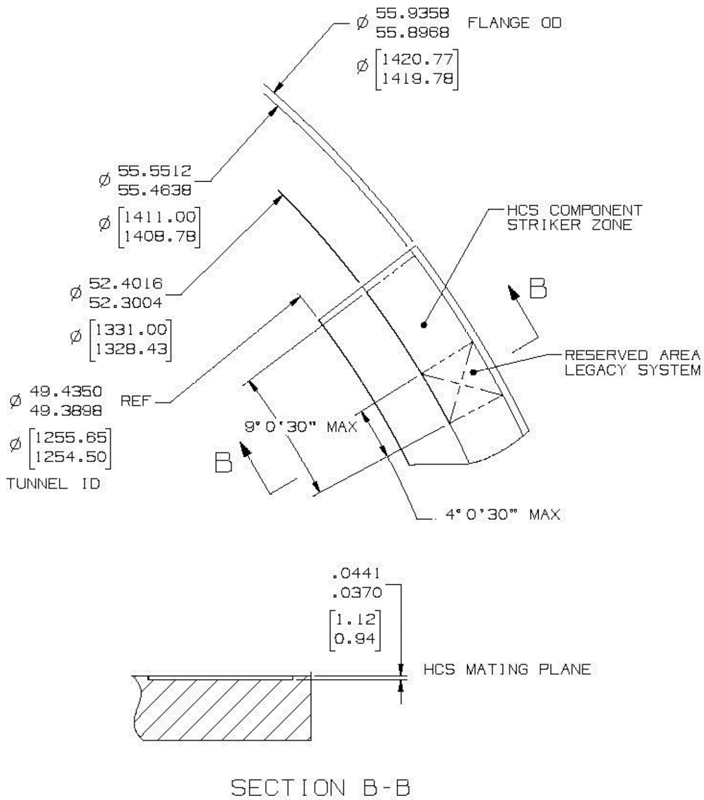

HCS Component Interface Definition

Notes:

1. Boxed angular dimensions are shown as basic dimensions that illustrate the theoretical construction lines. No dimensional tolerances are to be applied to the basic dimensions.

2. Separate systems are retracted below the HCS mating plane prior to closure of HCS interface.

(Page 1 of 3)




Sensor Striker Zone Detail View

Notes for Sensor Striker Zone detail view:

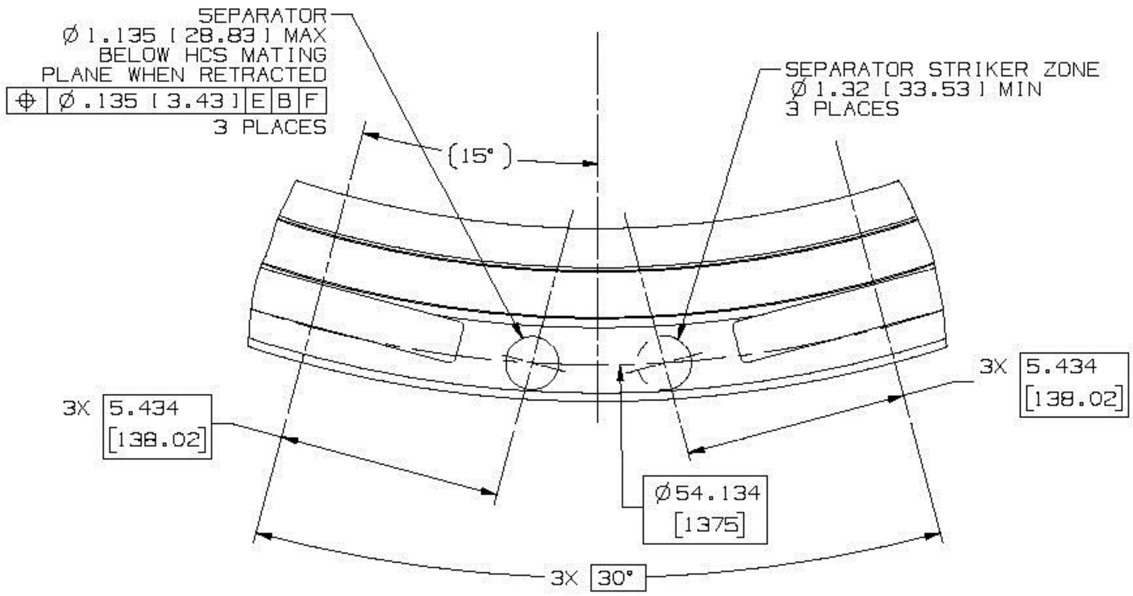
1. “HCS Component Striker Zone” is to depict the area for any international partner’s components to strike. This zone provides the area for the HCS sensors and separation mechanisms to contact.

2. “Reserved Area” is the area inside the “HCS Component Striker Zone” for legacy HCS components and strikers.

3. “HCS Component Striker Zone” and “Reserved Area” are recessed from HCS mating plane as shown in Section B-B.

4. “HCS Component Striker Zone” may contain features that require accommodation.

(page 2 of 3)



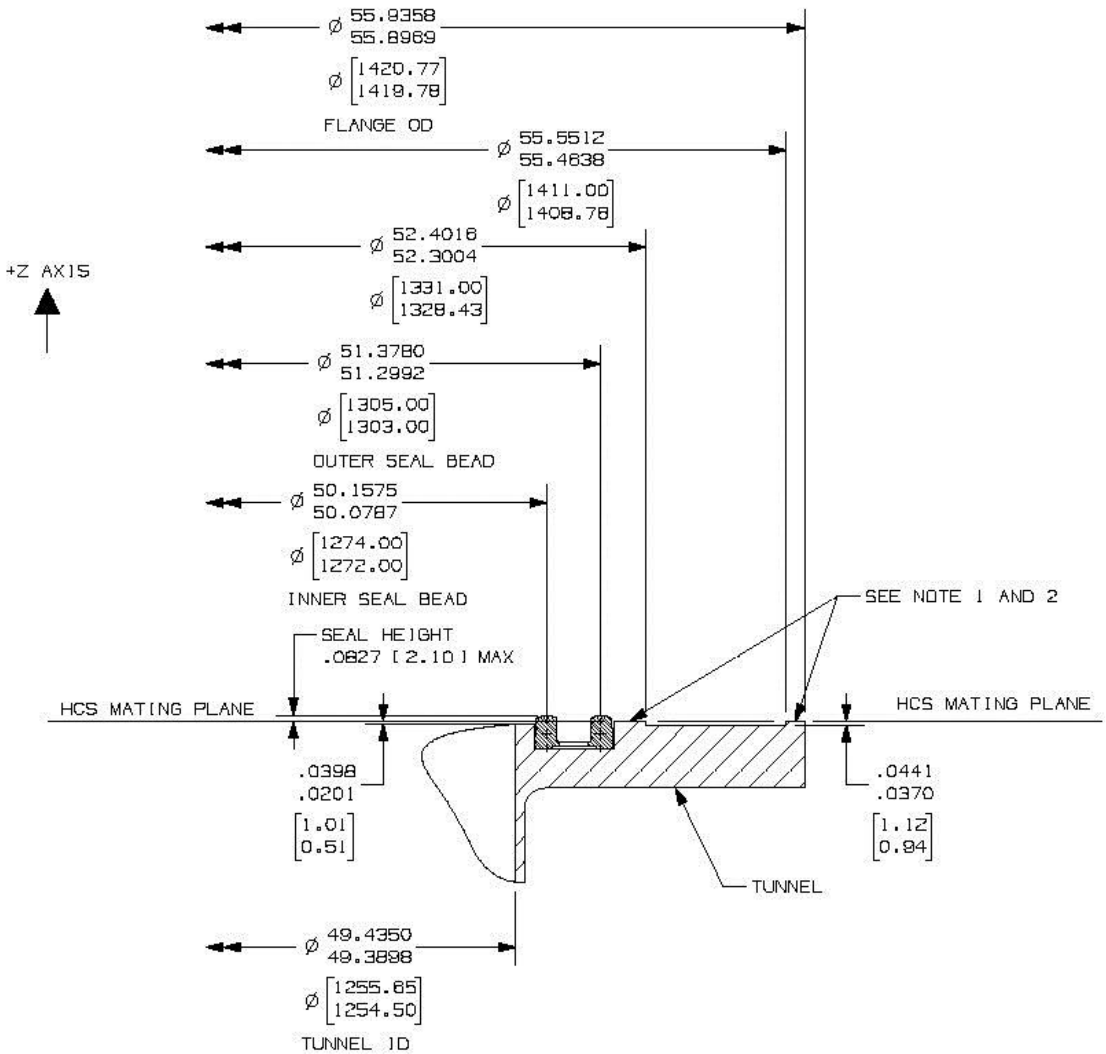

Separator Detail View

(Page 3 of 3)

**FIGURE 4.1.1.3.1-1: HCS DOCKING INTERFACE**

#### 4.1.1.3.2 Seal

The HCS of the NDSB1 accommodates a seal-on-metal interface with two concentric seals at specified diameters. The NDSB1 has the pressure seal interfaces located internally with respect to the tangential hook location. For seal-on-metal interfaces, refer to Figure 4.1.1.3.2-1, NDSB1 Mating Plane Seal.




Notes:

1. Chemical conversion coat per MIL-DTL-5541, Type 1, Class 3. Surface finish applicable prior to chemical conversion coating.
2. Global surface flatness not to exceed 0.010 [0.25] on indicated surfaces. Local surface flatness not to exceed 0.003 [0.08] across any area on indicated annular surfaces for an arbitrary 30° arc

**FIGURE 4.1.1.3.2-1: NDSB1 HCS MATING PLANE SEAL**

### 4.1.1.3.3 Guide Pins and Receptacles

The NDSB1 has two guide pins and two guide pin receptacles, as illustrated in Figure 4.1.1.3.1-1, for final alignment of the hard-mate interface. Refer to Figure 4.1.1.3.3-1: HCS Guide Pin Detail and Figure 4.1.1.3.3-2: HCS Guide Pin Receptacle Detail.

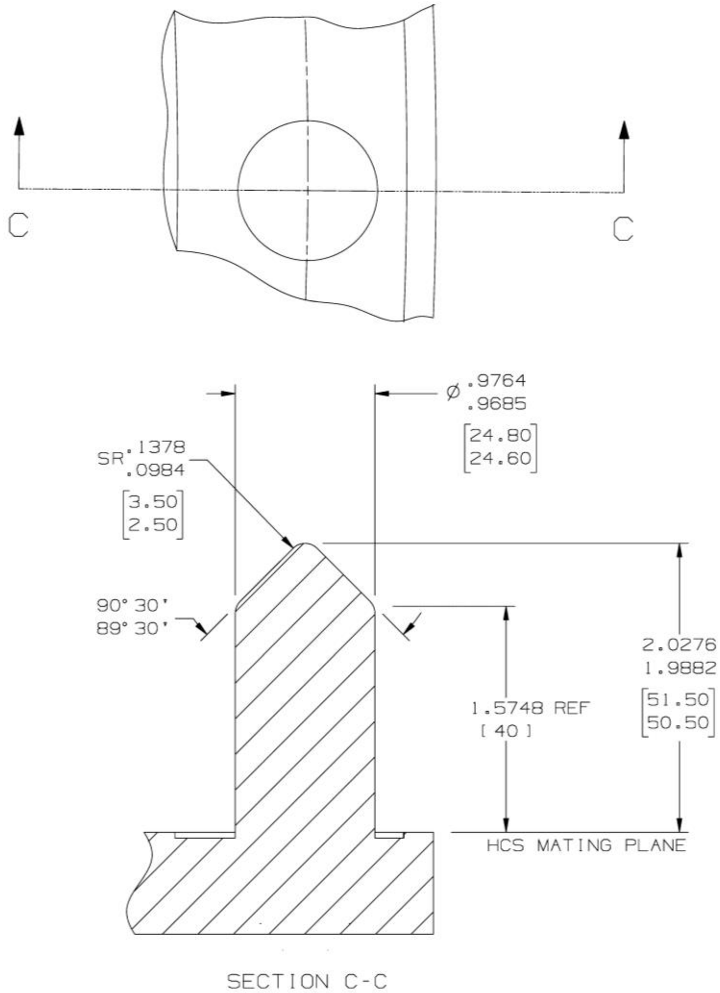
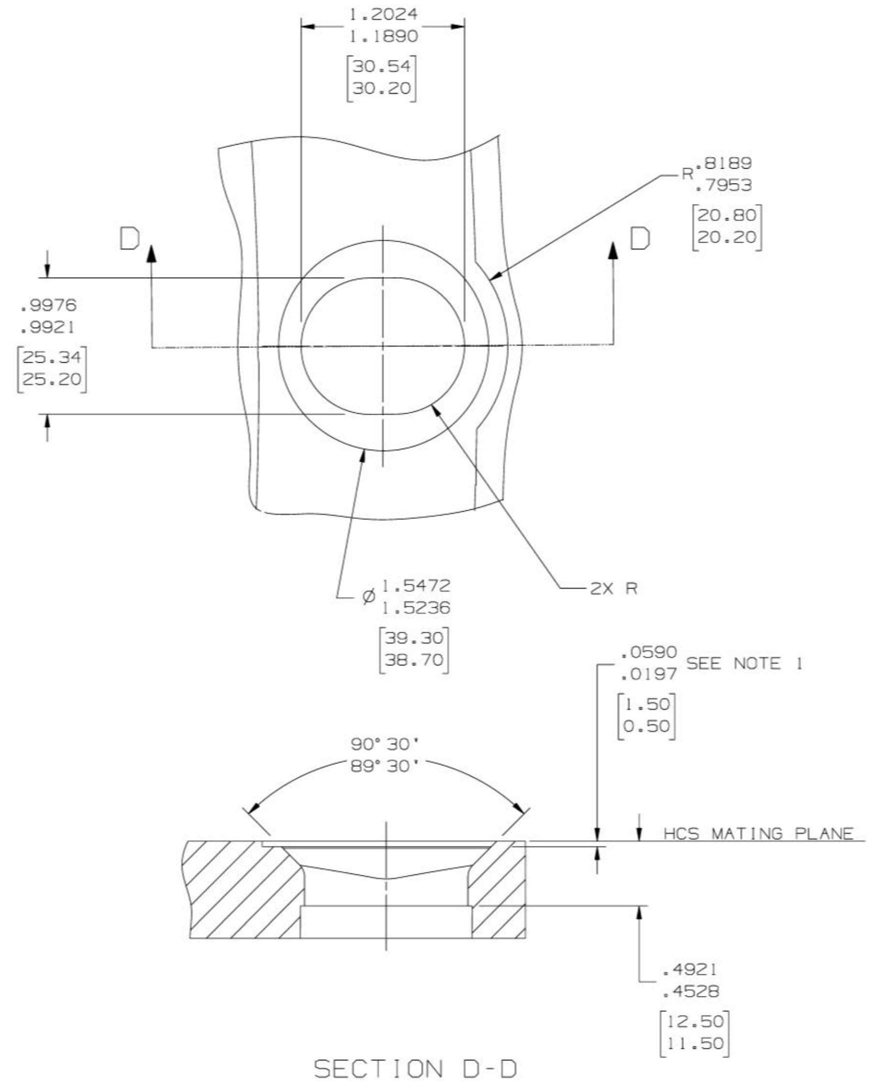



**FIGURE 4.1.1.3.3-1: HCS GUIDE PIN DETAIL**



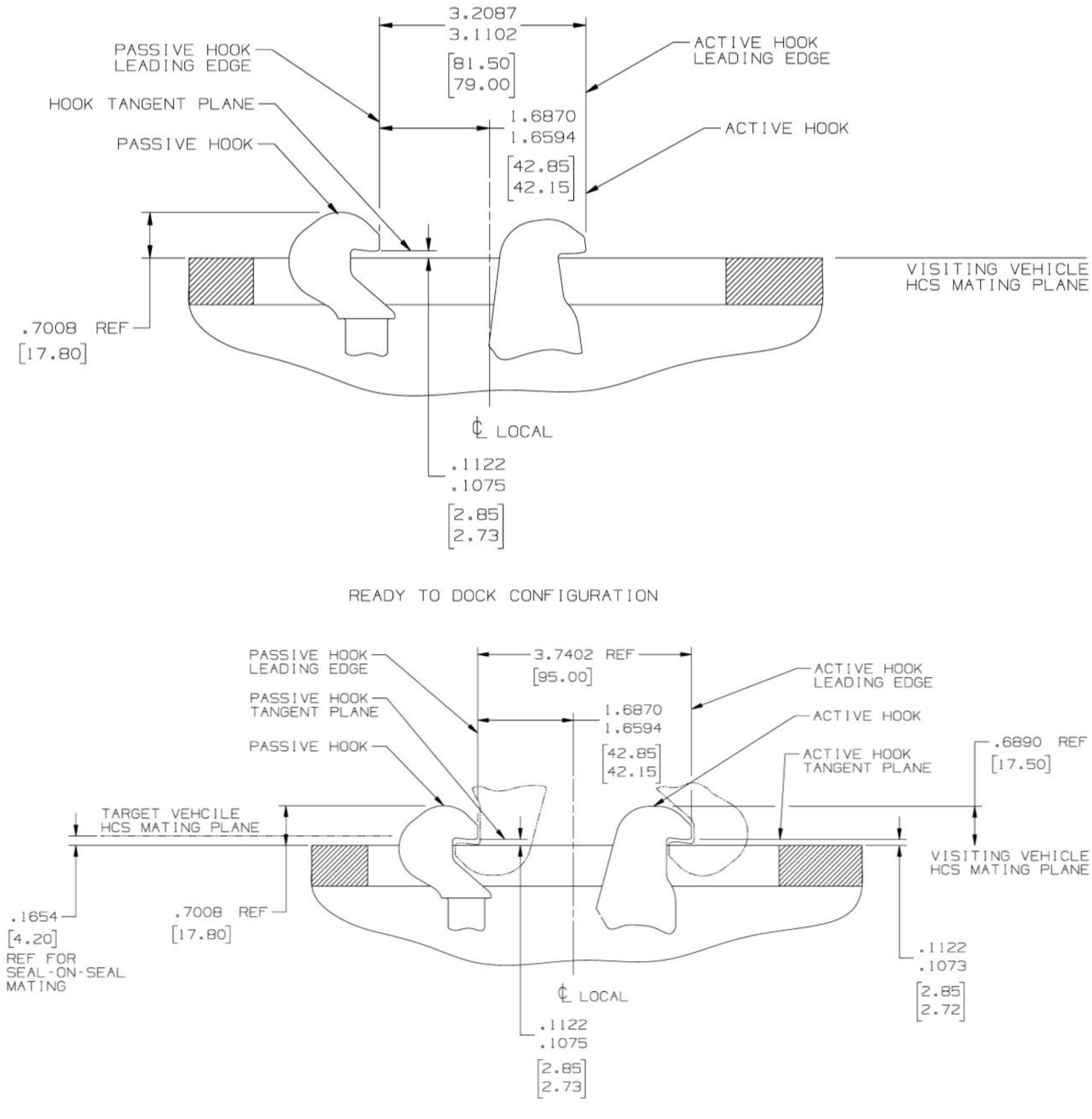

NOTE 1: As the Guide Pin Hole is located in a recessed area, this dimension depicts the distance from the HCS Mating plane to the start of the hole chamfer.

**FIGURE 4.1.1.3.3-2: HCS GUIDE PIN RECEPTACLE DETAIL**

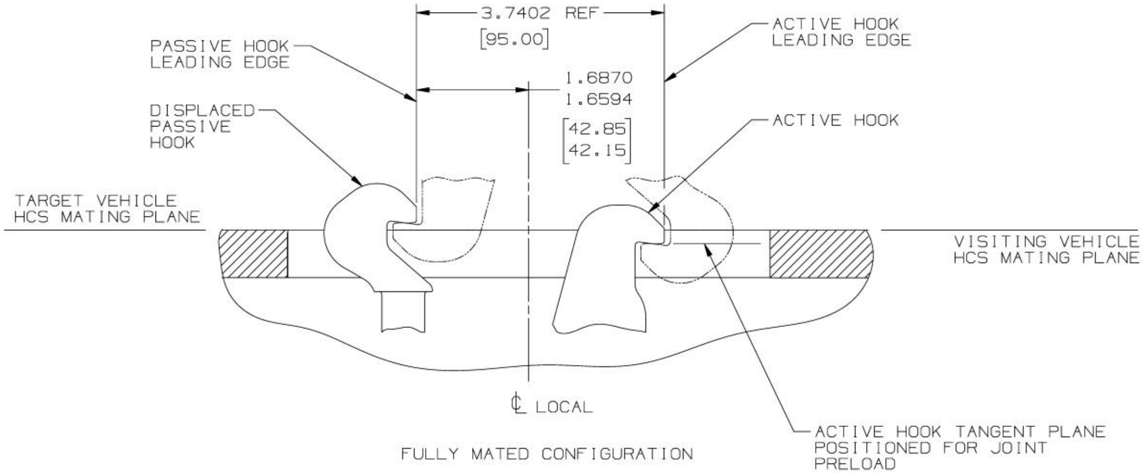
#### 4.1.1.3.4 Hard Capture Hooks

The NDSB1 is configured with tangential hooks on the HCS. The NDSB1 when mated has 24 attachment points where 12 active hooks on one system engage 12 passive hooks on the mating system to carry nominal loads. Refer to Figure 4.1.1.3.4-1: HCS Hook Configurations and Figure 4.1.1.3.1-1. The 12 active hooks can be driven in 2 gangs of 6 that form an alternating pattern (i.e., every other hook). Each of the 12-hook pair locations on the HCS has 1 passive and 1 active hook assembly. The NDSB1 implements a spring-biased self-compliance passive hook between the mating active-passive hook pair. Refer to Figure 4.1.1.3.1-1, Figure 4.1.1.3.4-2: HCS Active Hook

Detail, and Figure 4.1.1.3.4-3: HCS Passive Hook Detail. The hook motion envelope is defined in Figure 4.1.1.3.4-4: HCS Active Hook Motion Envelope.

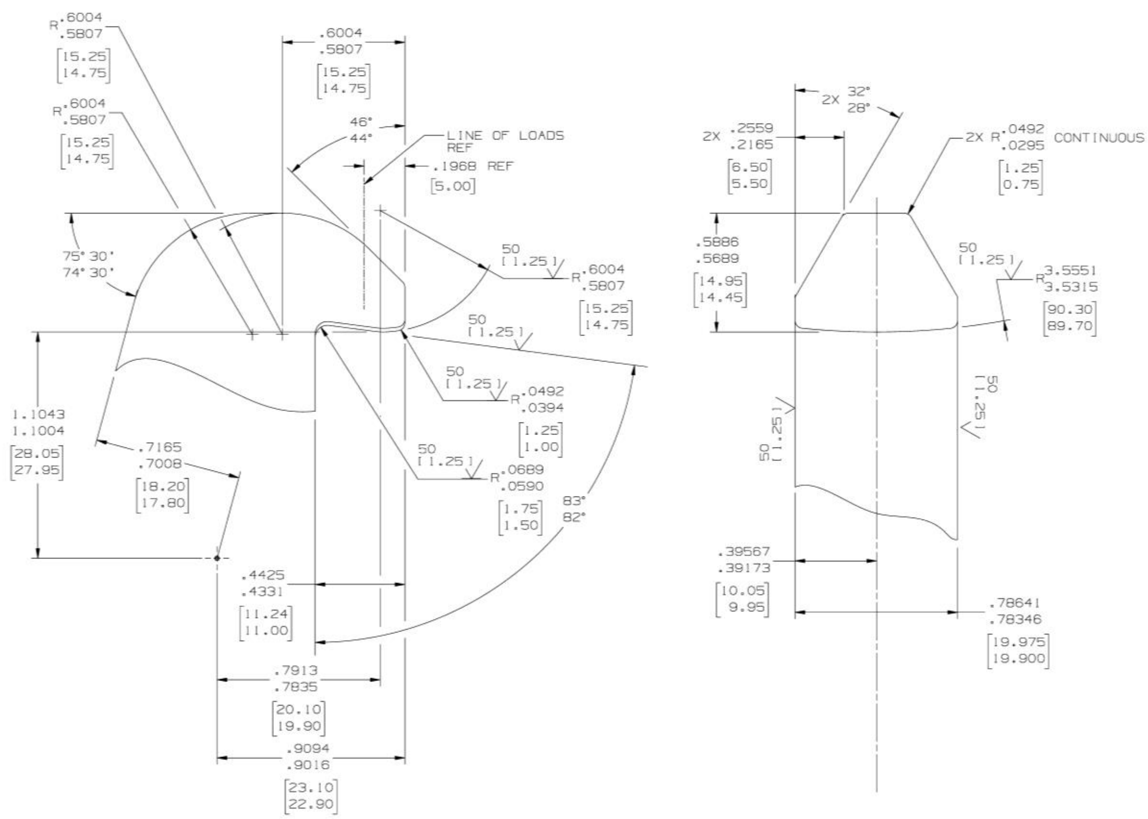



(page 1 of 2)




(page 2 of 2)

**FIGURE 4.1.1.3.4-1: HCS HOOK CONFIGURATIONS**




Note: See previous page for ready-to-dock, ready-to-hook, and fully mated configurations.

**FIGURE 4.1.1.3.4-2: HCS ACTIVE HOOK DETAIL**

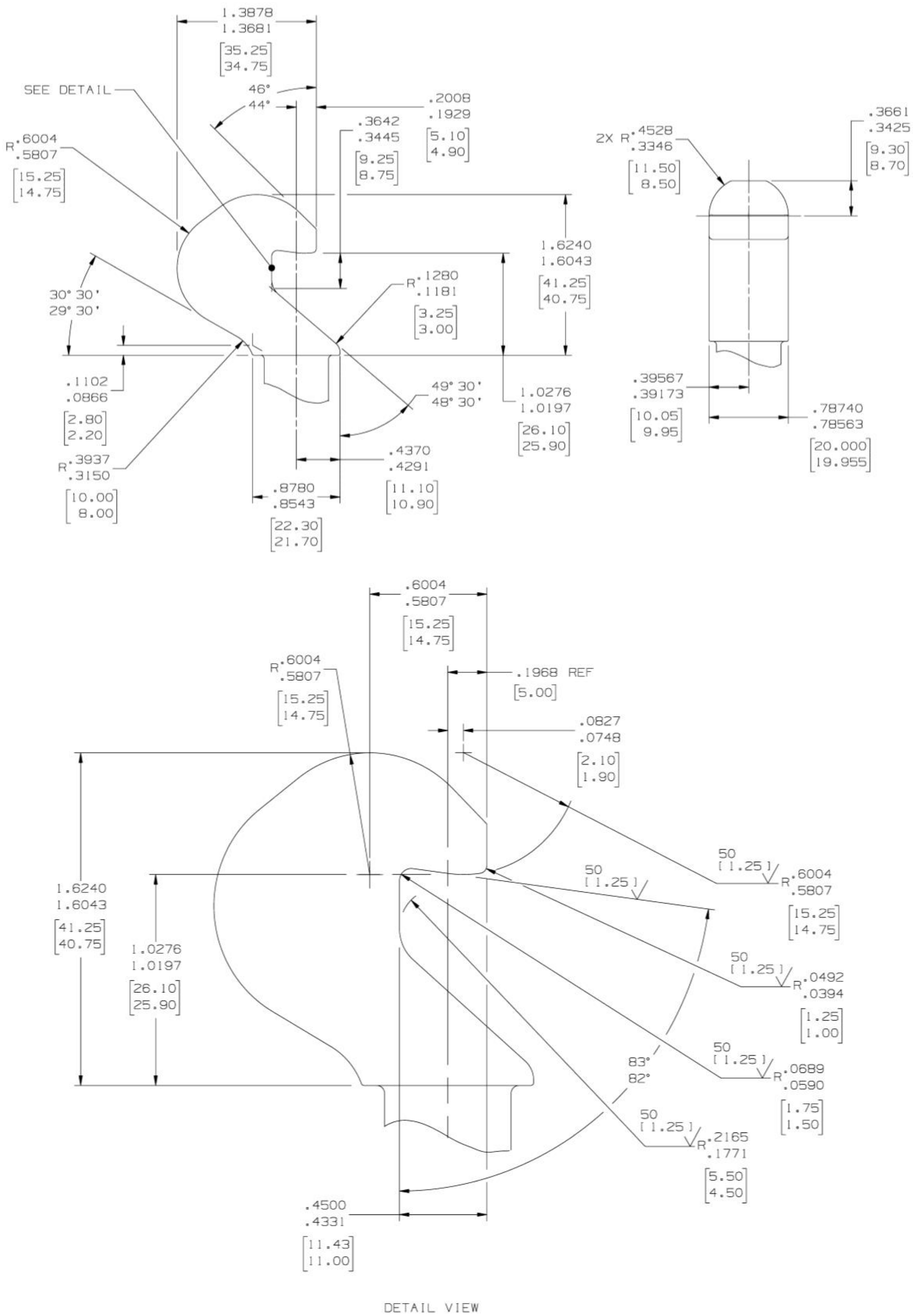



**FIGURE 4.1.1.3.4-3: HCS PASSIVE HOOK DETAIL**

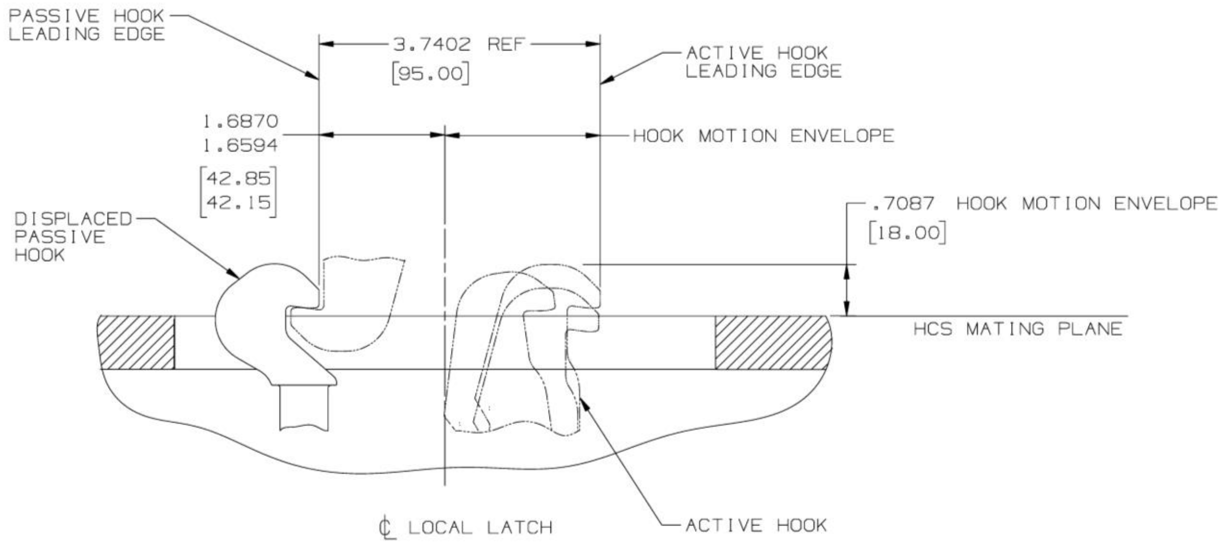



**FIGURE 4.1.1.3.4-4: HCS ACTIVE HOOK MOTION ENVELOPE**

The Hook System is defined as the serial combination of the Active Hook Mechanism, the Passive Hook Mechanism, and the structural elements that are in compression.

The Preload of the Hook System after locking is between the following values:

Minimum Preload of Hook System after locking = 7037 lbf (31300 N)
Maximum Preload of Hook System after locking = 9968 lbf (44340 N)

The Design Limit Capability of the Active and Passive Hook element is = 11240 lbf (50000 N).

The load response (stiffness) of the Active Hard Capture Hook Mechanism is between the upper and lower curves, as defined in Figure 4.1.1.3.4-5: Load Response of Active Hook Mechanism.

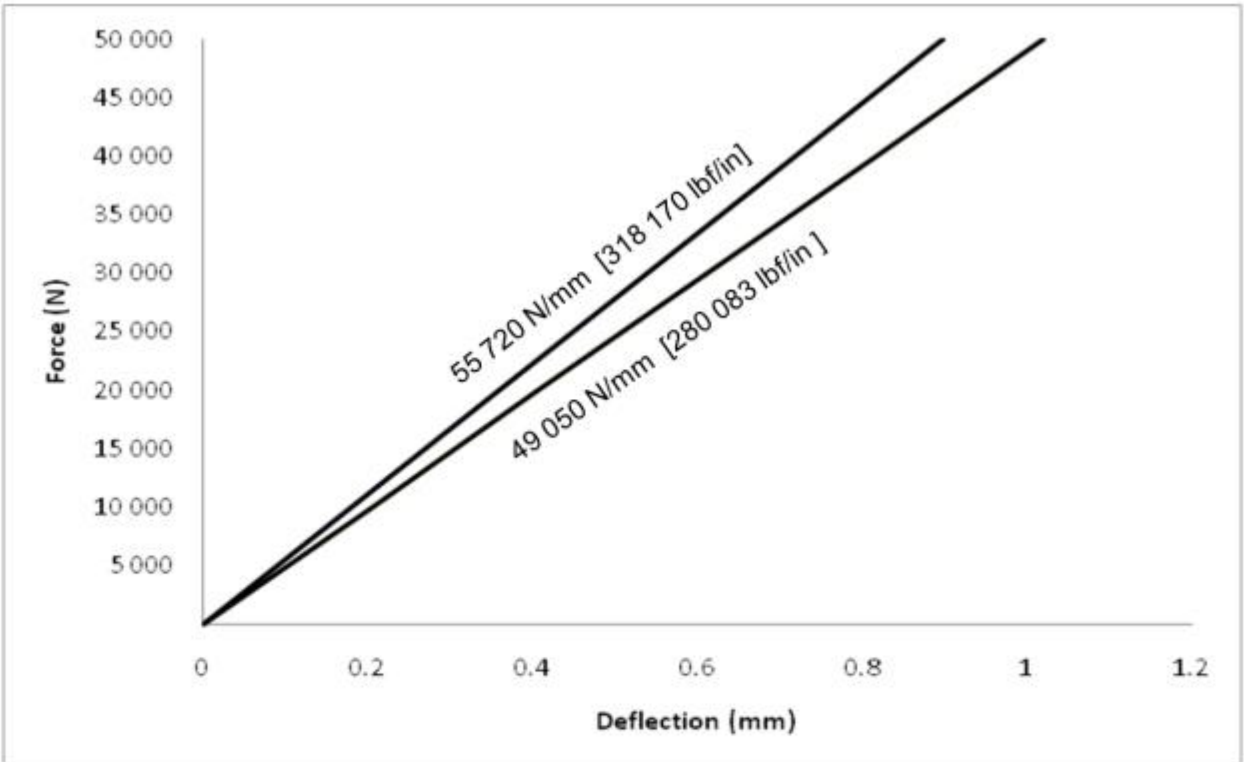



**FIGURE 4.1.1.3.4-5: LOAD RESPONSE OF ACTIVE HOOK MECHANISM**

The load response (stiffness) of the Passive Hard Capture Hook Mechanism is between the upper and lower curves, as defined in Figure 4.1.1.3.4-6: Load Response of Passive Hook Mechanism (Including Spring Washer Stack) Hard Capture Sensors and Strikers.

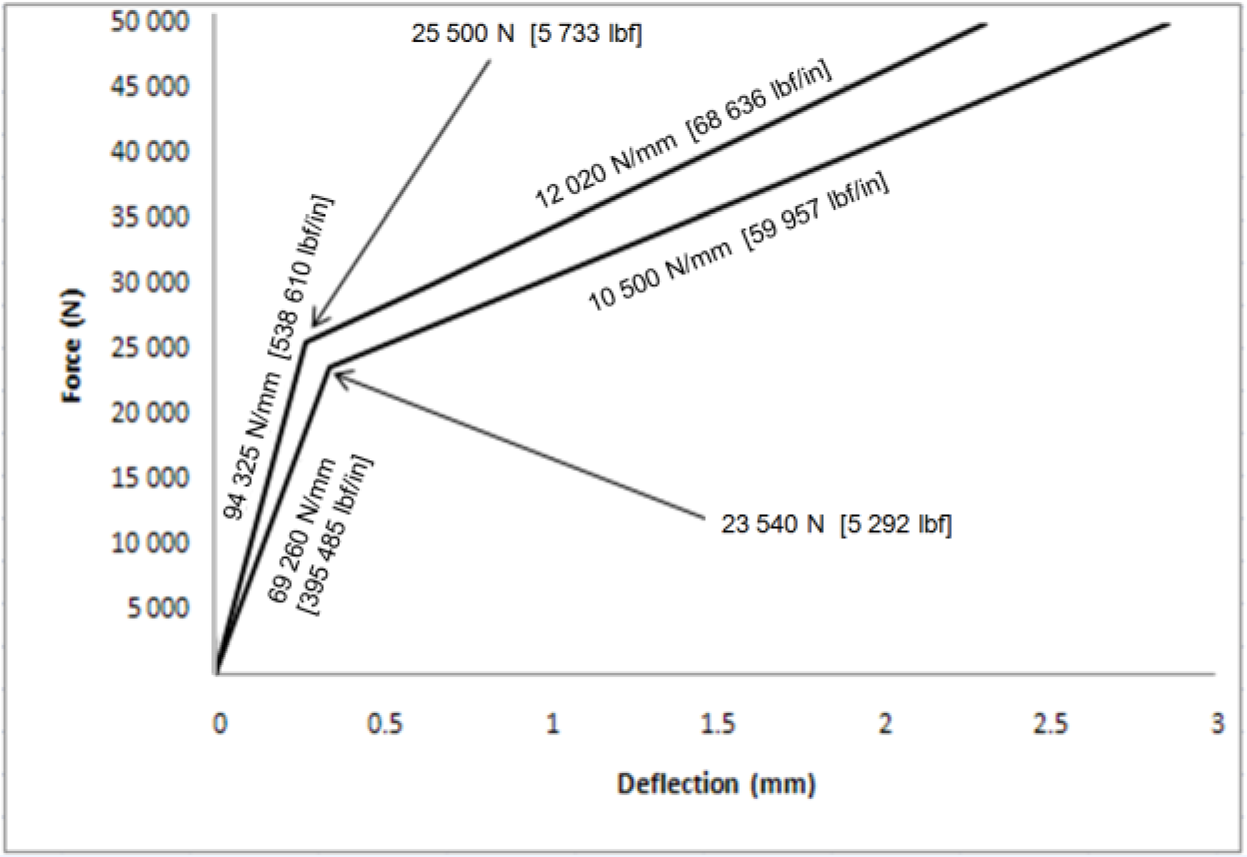



**FIGURE 4.1.1.3.4-6: LOAD RESPONSE OF PASSIVE HOOK MECHANISM (INCLUDING SPRING WASHER STACK) HARD CAPTURE SENSORS AND STRIKERS**

The NDSB1 has a Ready-to-Hook (RTH) indication capability achieved by having RTH sensors and strikers. There are three RTH sensors and three striker locations, which reside 120 degrees from one another on the hard capture tunnel. The NDSB1 also has hook position sensors, which indicate the active hook is fully open, fully closed, and the hook is locked in the over-center position. Refer to Figure 4.1.1.3.4-1

The striker zones for RTH sensors are recessed below the HCS mating plane, as illustrated in Figure 4.1.1.3.1-1, HCS DOCKING INTERFACE. Refer to Figure 4.1.1.3.4-1 for the RTH activation point above the HCS mating plane.

#### 4.1.1.3.5 Undocking Complete Sensors and Strikers

The NDSB1 has an undocking complete indication capability achieved by having an undocking-complete sensor. There are two sensor locations that correspond to the guide pin receptacle locations. The two NDSB1 undocking complete sensors indicate when the guide pin has cleared the receptacles. The guide pins on the mating docking system are used as striker areas for undocking-complete sensors. Refer to Figure 4.1.1.3.1-1 for the location of the separation system. The sensors indicate that undocking is complete at a separation distance of ~1.18 in. (~30 mm).

#### 4.1.1.3.6 HCS Compressive Force Resistance During SCS Retraction

The SCS requires minimal compressive force resistance. As the SCS retracts, it encounters the RTH and undocking complete sensors while in a kinematic configuration that has limited axial pulling force capability. To ensure the ability to engage the hooks, a maximum of 37.8 lbf (168 N) compressive force resistance is allowed across the interface. This means each side is allowed to have a maximum of 18.9 lbf (84 N) resistance.

#### 4.1.1.3.7 Separation System Springs and Strikers

The NDSB1 includes three separation springs recessed below the docking sealing surface, which can be remotely engaged for separation and reset to a recessed position for docking. This system provides force to overcome the seal stiction and energy to accelerate the vehicle away when the structural mate mechanism is released.

The umbilical resource connectors are nominally retracted prior to undocking. However, in the event of failure to retract the umbilicals, the separation system is capable of providing enough force to de-mate the umbilical resource connectors during separation.

The separation system and associated striker zones are shown in Figure 4.1.1.3.1-1. The striker zones are recessed below the HCS mating plane, as illustrated in Figure 4.1.1.3.1-1, HCS DOCKING INTERFACE.

Once charged against the striker on the mating docking interface, the separator has a minimum total extension stroke of 1.295 in. (32.9 mm) to be used for separation. The first part of the stroke is used for loosening the pressure seals and disengaging umbilical connectors, if any. The second part is used for vehicle separation dynamics. The three NDSB1 separators together provide a total initial stored energy between 28.9 ft-lb (4.0 kgf-m) and 35 ft-lb (4.8 kgf-m) at zero interface separation. The nominal force applied by a single charged separator to the striker surface is 155 to 160 lbf (689 to 712 N). However, during contingency cases, such as a limit switch failure, the maximum force can reach 200 lbf (890 N).

Figure 4.1.1.3.7-1: Single Separator Force Separation Curve shows the linear force separation curves of a single separator where the undocking separation distance indicates the separation between the two HCS mating planes. Multiply the force values by three to get the total system force acting on the vehicles at a given separation point. At a separation of 0.165 in. (4.2 mm), the separation system provides a minimum of 133.3 lbf (593 N) for each separator.

Nominally, it can be assumed that the vehicles have zero relative axial velocity as the hooks disengage. This occurs at a separation of approximately 0.22 in. (5.6 mm). Hence, a total energy between 21.2 ft-lb (2.9 kgf-m) and 26.1 ft-lb (3.6 kgf-m) is applied to vehicle separation under nominal conditions.

**Note:** In a contingency situation where the NDS*B1* umbilicals are not retracted first, the umbilical connectors resist separation until a separation of approximately 0.512 in. (*13* mm) is achieved. Therefore, the energy available for vehicle separation is reduced in this scenario.

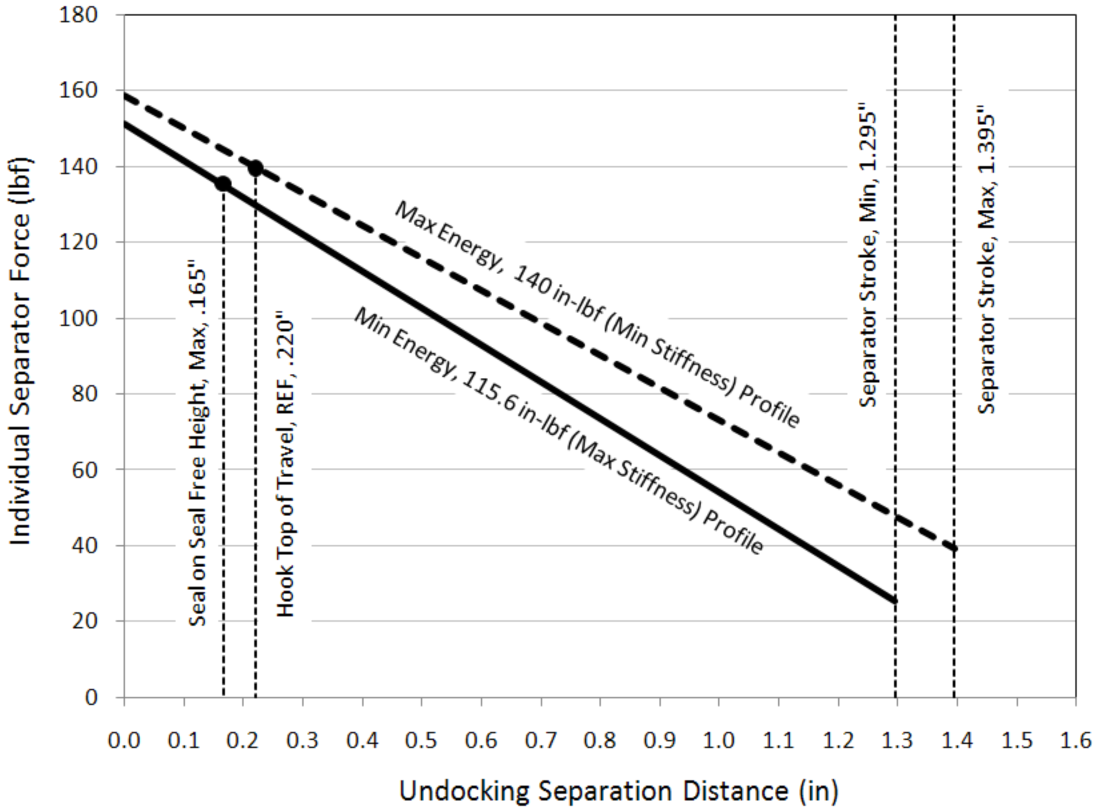



**FIGURE 4.1.1.3.7-1: SINGLE SEPARATOR FORCE SEPARATION CURVE TBR34**

### 4.1.1.4 NDSB1 Interface Component Materials

At the docking interface, during docking operations and the post-docking phase, various types of events may occur, such as relative motion between mating components, contacts or impacts between mating parts, and/or preloading of mating structures. It is necessary to include the description of material characteristics so that the behavior of the components of interest can be predicted. Refer to Table 4.1.1.4-1: NDSB1 I/F Component Materials for materials, surface coatings, and surface finishes of the interface components.

**TABLE 4.1.1.4-1: NDSB1 I/F COMPONENT MATERIALS**

| Component | Material | Material Specification | Coating | Coating Specification | Finish (µ-in) |
|---|---|---|---|---|---|
| Guide Petal | 7075-T7351 Al | AMS-QQ-A-250/12 | Teflon Hard Anodized | AMS 2482 | 32 |
| SCS Ring | 7075-T7351 Al | AMS 4078 | Hard Anodized | MIL-A-8625 Type III | 32 |
| Tunnel (HCS Mating Plane) | 2219 Al | AMS 4144 | Chemical conversion coat | MIL-DTL-5541, TYPE 1, Class 3 | 16 |
| Guide Pin | Inconel 718 | AMS 5662 | NPI 425 | AS 5528 | 16 |
| Guide Pin Receptacle | Inconel 718 | AMS 5662 | PI425 | AS 5228 | 16 |
| Hard Capture Hook | TITANIUM 6AL-4V | AMS 6930 COND STA or AMS 4965 COND STA | Lubricant, dry film | VITRO-LUBE NPI-1220C, cage code: 1P492 | 63 |

### 4.1.1.5 Loads

The NDSB1 is capable of performing docking operations under the following load conditions, as outlined in Table 4.1.1.5.1-1: SCS Maximum Docking Loads, Table 4.1.1.5.1-2: SCS Maximum Component Loads, Table 4.1.1.5.2-1: HCS Maximum Mated Loads.

#### 4.1.1.5.1 Soft Capture Docking Loads

**TABLE 4.1.1.5.1-1: SCS MAXIMUM DOCKING LOADS**

| | | |
|---|---|---|
| Tension | 877 lbf | (3900 N) |
| Compression (Static) | 787 lbf | (3500 N) |
| Compression (Dynamic, < 0.1 sec) | 1461 lbf | (6500 N) |
| Shear | 719 lbf | (3200 N) |
| Torsion | 1106 lbf*ft | (1500 Nm) |
| Bending | 2065 lbf*ft | (2800 Nm) |

Notes:
1. Values are design limit loads.
2. Values are defined at the center of the SCS mating plane.
3. Values are to be applied simultaneously not to exceed the component values in Table 4.1.1.5.1-2.
4. Shear and bending loads are vector sums in the plane of the SCS mating plane.

**TABLE 4.1.1.5.1-2: SCS MAXIMUM COMPONENT LOADS**

| **Mechanical Latch Striker Tension (4)** | **674 lbf (3000 N)** | | | |
|---|---|---|---|---|
| **Petal Edge Length** | **0%** | **10%** | **60%** | **80%** |
| **Petal Contact Loads** | **787 lbf (3500 N)** | **517 lbf (2300 N)** | **517 lbf (2300 N)** | **225 lbf (1000 N)** |

Notes:

1. Values are design limit loads.
2. The petal contact load is to be applied to the petal edge from the root of the petal to 80% of the petal length.
3. The petal contact load is to be applied to the outer face of the petal from the root of the petal to 60% of the petal length.
4. Load vector oriented along docking axis. For striker surface canted 45 degrees to the docking axis, the load corresponds to 953 lbf applied perpendicular to the striker surface and 674 lbf load vector in the tunnel radial direction.

#### 4.1.1.5.2 Hard Capture Mated Loads

The NDSB1 is capable of withstanding mated loads at the NDSB1 to IDA Interface Plane as defined in Table 4.1.1.5.2-1: On-Orbit NDSB1-to-IDA Mated Load Cases.

**TABLE 4.1.1.5.2-1: ON-ORBIT NDSB1-TO-IDA MATED LOAD CASES**

| Load Set | Case 1 | Case 2 | Case 3 | Case 4 |
|---|---|---|---|---|
| Compressive Axial | 1,124 lbf (5,000 N) | 3,979 lbf (17,700 N) | 3,080 lbf (13,700 N) | 67,443 lbf (300,000 N) |
| Tensile Axial | 1,124 lbf (5,000 N) | 3,979 lbf (17,700 N) | 3,080 lbf (13,700 N) | 22,481 lbf (100,000 N) |
| Shear [2] | 1,124 lbf (5,000 N) | 3,327 lbf (14,800 N) | 3,754 lbf (16,700 N) | 2,248 lbf (10,000 N) |
| Torsion | 11,063 ft-lbf (15,000 N-m) | 11,063 ft -lbf (15,000 N-m) | 11,063 ft-lbf (15,000 N-m) | 11,063 ft-lbf (15,000 N-m) |
| Bending [2] | 48,163 ft-lbf (65,300 N-m) | 28,912 ft-lbf (39,200 N-m) | 50,671 ft-lbf (68,700 N-m) | 29,502 ft-lbf (40,000 N-m) |

Notes:
1. Loads are defined at the HCS mating plane in the NDSB1 structural coordinate system.
2. Shear and bending loads may act in any direction in the HCS mating plane.
3. The load components are to be applied concurrently in all possible combinations of positive and negative values.
4. These values are design limit loads.
5. Does not include internal pressure, seal force or pusher/separator loads.
6. Cases 1 through 3 are pressurized mated cases. Case 4 is an unpressurized mated case.
7. Case descriptions:
   Case 1 – Attitude control by Orbiter-like, combined with crew activity.
   Case 2 – Berthing of ISS segment while mated.
   Case 3 – Orbiter-like translation with payload attached to Orbiter Docking System (ODS).
   Case 4 – Trans-Lunar Insertion (TLI)-like, modified from Constellation analysis.
8. These loads are for the nominal 12-hook case.

#### 4.1.1.6 Leak Rate

The leak rates defined in this subsection assume a pressure internal to the NDSB1 vestibule of 14.7 psia and an external pressure of 7.5E-14 Torr (1.0E-11 Pascal). The total leak rate for the mated NDSB1 is less than 0.015 lbm dry air/day. This includes the host vehicle interface leakage rate.

When calculating the mated leak rate for a combined mated NDSB1 stack, the NDSB1-to-IDA leak rate should only be accounted for once.

### 4.1.2 Electrical Interfaces

#### 4.1.2.1 Electrical Bonding

The NDSB1 establishes bond paths to mitigate electrical hazards on the integrated subsystem interfaces. The electrical bond meets the requirements established in NASA-STD-4003, Electrical Bonding for NASA Launch Vehicles, Spacecraft, Payloads, and Flight Equipment.

##### 4.1.2.1.1 Electrical Bonding at Hard Capture (Class-R – Protection Against Radio Frequency Emission)

The NDSB1 is protected against Radio Frequency (RF) emissions by maintaining a NASA-STD-4003 Class R bond at the hard capture NDSB1-to-IDA interface. There are three Class R bond paths between the mated systems. The first bond path is through the metal-to-metal contact on the seal interface between the two NDSB1 mated systems. Refer to Figure 4.1.1.3.1-1, HCS DOCKING INTERFACE. The second bond path is through the electrical umbilical connector backshell for the plug connector. The third bond path is through the electrical umbilical connector backshell for the receptacle connector. Refer to Figure 4.1.2.1.1.1-1 Electrical Bonding for the 2$^{nd}$ and 3$^{rd}$ bond paths.

###### 4.1.2.1.1.1 Electrical Bonding at Hard Capture (Class-H Protection Against Electrical Faults)

The NDSB1 will provide a class-H bond at the cable and Umbilical NDSB1 to HV interfaces in accordance with NASA-STD-4003, Electrical Bonding for NASA Launch Vehicles, Spacecraft, Payloads, and Flight Equipment, paragraph 4.2. Refer to Figure 4.1.2.1.1.1-1 for an example of bonding between host vehicles.

The NDSB1 will provide a class-H bond through the metal-to-metal contact on the seal interface between the two NDS mated systems interfaces in accordance with NASA-STD-4003, Electrical Bonding for NASA Launch Vehicles, Spacecraft, Payloads, and Flight Equipment, paragraph 4. 2.

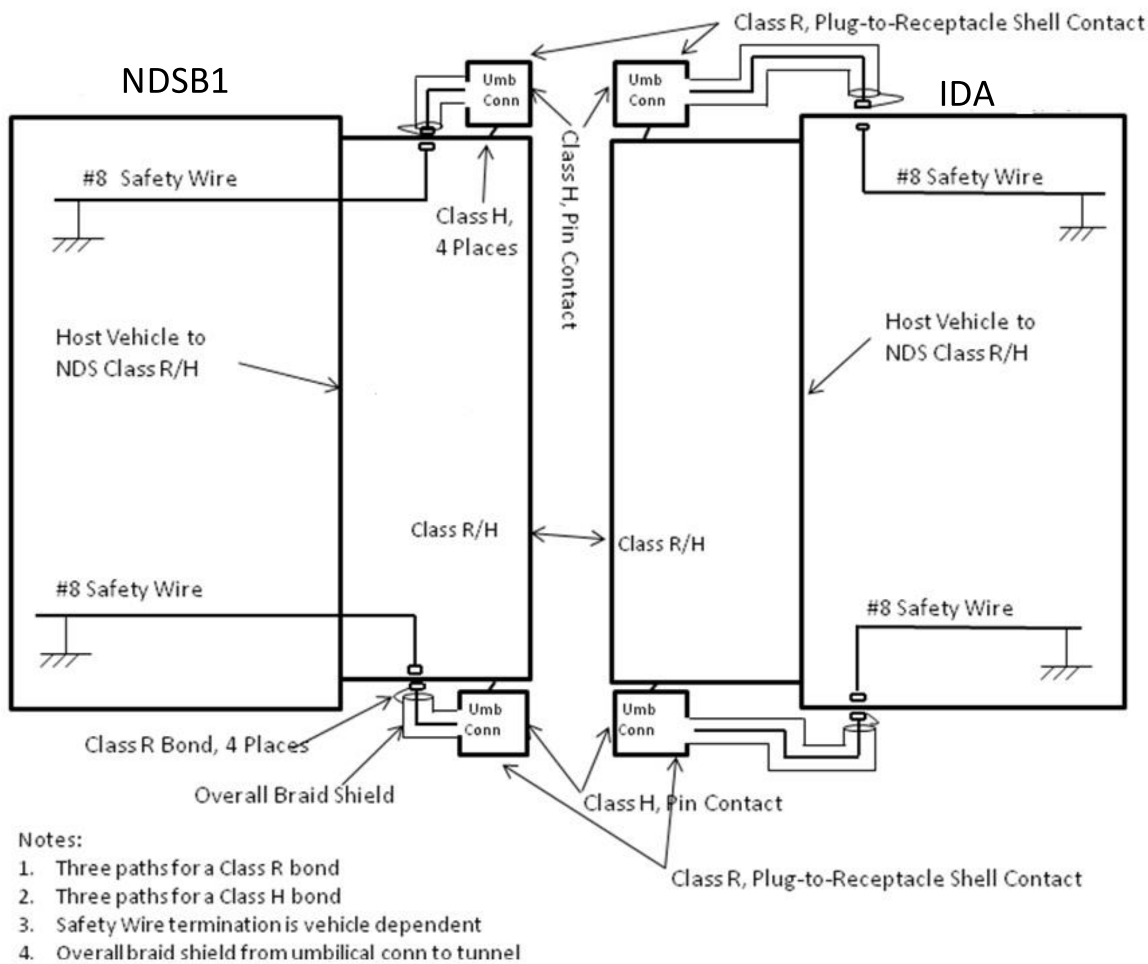



**FIGURE 4.1.2.1.1.1-1: NDSB1 ELECTRICAL BONDING**

#### 4.1.2.1.2 Electrical Bonding at Soft Capture (Class-S – Protection Against Electrostatic Discharge)

Reserved

### 4.1.3 Resource Transfer

The NDSB1 umbilical connector interfaces transfer resources between the docked vehicles. These resources are power, data, and ground safety wire for the NDSB1 configurations defined in this IDD. All umbilical connections are recessed below the docking mating plane during docking. The umbilical connectors are mechanized such that they can be driven to mate after docking hard capture occurs. Upon undocking, these connectors are nominally driven to the unmated state prior to unlatching the hooks. However, they can be separated passively by the energized separation system in the event of a failure to retract the umbilicals. For the NDSB1-to-IDA umbilical interface location, refer to Figure 4.1.3-1. For a detailed description of NDSB1 umbilical implementation, refer to 684-018763, Umbilical EMA Specification Control Drawing.

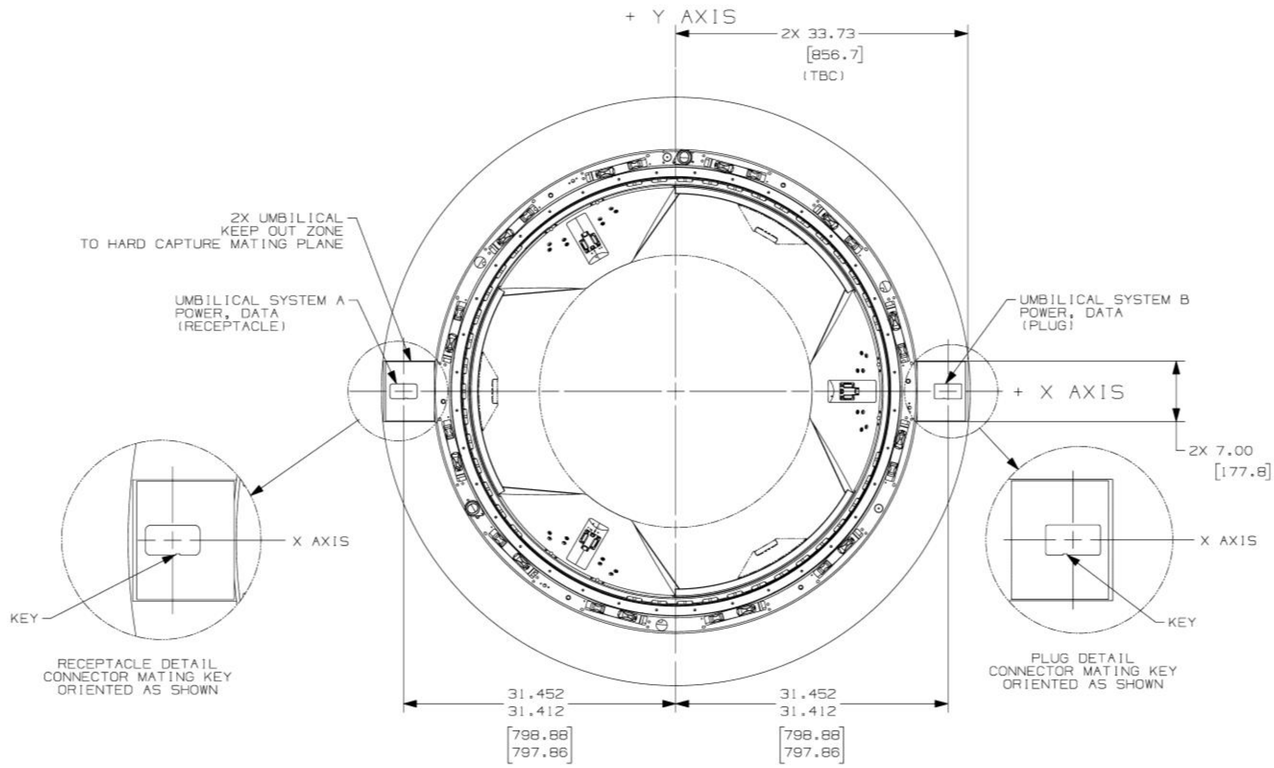



**FIGURE 4.1.3-1: NDSB1 RESOURCE TRANSFER**

### 4.1.3.1 Power Transfer and Command and Data Handling Transfer Umbilical

As shown in Figure 4.1.3-1, there are two umbilical connectors for power/data transfer. Each connector is a SSQ22680 Flight Releasable Attachment Mechanism (FRAM)-type connector that contains both power and data in the same connector shell. Separate power and data cable bundles are routed to the connector, and then combined in the connector backshell. The connector body is the only shared volume where these two different Electromagnetic Compatibility (EMC) classes are combined. Refer to JSC-65842, Electromagnetic Environmental Effects (EEE) Requirements Document, for the exception allowing two different EMC classes to reside in the same connector. Table 4.2.3.1-1: FRAM-Type Connector Pinouts shows the pinouts of the FRAM-type umbilical connector.

#### 4.1.3.1.1 Power Transfer

The NDSB1, after hard-mate is complete, transfers redundant 25 amps at a maximum of 126 VDC power from the IDA to the Host Vehicle in accordance with SSP 50933. The Pin Assignments are shown in Table 4.2.3.1-1, IDA to HV Interface (SYS A) –J35 and Table 4.2.3.1-2, IDA to HV Interface (SYS B) – P35.

#### 4.1.3.1.2 Data Transfer

The NDSB1 to Host Vehicle umbilical interfaces will provide the utilities to transfer two hard-line MIL-STD-1553 and two IEEE 802.3 Ethernet data and communication between the mated vehicles when the Host Vehicle is hard mated to the ISS.

##### 4.1.3.1.2.1 Ethernet Cable Specification

The Ethernet Cables utilize American National Standards Institute (ANSI)/Telecommunications Industry Association (TIA)/Electronic Industry Alliance (EIA) 568B.2, 100 Ohm Twisted Pair Cabling Standards, Category 5e 100 ohm two-pair twisted cable for each Ethernet link.

##### 4.1.3.1.2.2 MIL-STD-1553 Cable Specification

The NDSB1 umbilical cabling for MIL-STD-1553 communication is constructed in accordance with SSQ 21655, Cable, Electrical, MIL-STD-1553 Databus, Space Quality, General Specification.

##### 4.1.3.1.2.3 Performance Data

Performance test data (e.g., voltage drop, frequency response) for power and data transfer is described in D684-14211-01, iLIDS FRAM Connector Test Evaluation.

### 4.1.3.2 Water Transfer

Reserved

### 4.1.3.3 Fuel Transfer

Reserved

### 4.1.3.4 Pressurant Transfer

Reserved

### 4.1.3.5 Oxidizer Transfer

Reserved

### 4.1.4 Surface Cleanliness

Exterior surfaces shall be Visibly Clean Level Sensitive in accordance with SN-C-0005. Sealing surfaces shall be Visibly Clean Level Highly Sensitive in accordance with SN-C-0005.

## 4.2 IDA Interfaces

### 4.2.1 Structural/Mechanical

When the NDSB1 unit docks to an IDA, the initial connection occurs in the SCS between the capture latch on the NDSB1 and the striker plates on the IDA. Once the soft capture phase is finished, the HCS on the NDSB1 completes the docking structural connection via the hook assembly system. The NDSB1 unit can only mate with an IDA with a unique relative clocking orientation, which is determined by the pair of adjacent guide pins and guide pin receptacles on the HCS, as shown in Figure 4.2-1: IDA Docking Interface. The volume for the IDA is defined in Figure 4.2.1-2: IDA Envelopes.

The NDSB1 KOZs for the IDA are defined in Figure 3.8.1.3.1-1: NDSB1 Static Envelope, Stowed Configuration, Figure 3.8.1.3.1-2: NDSB1 Static Envelope, Docked configuration, and Figure 3.8.1.3.2-1: Kinematic Envelope.

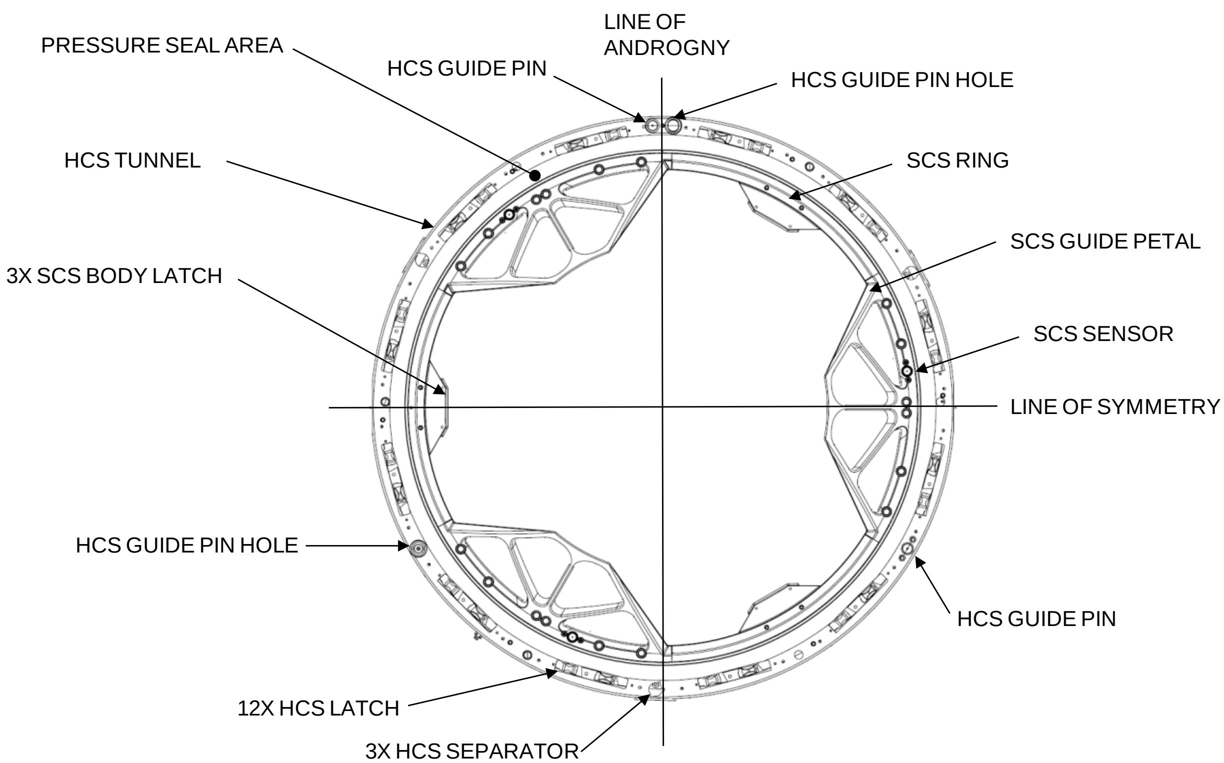
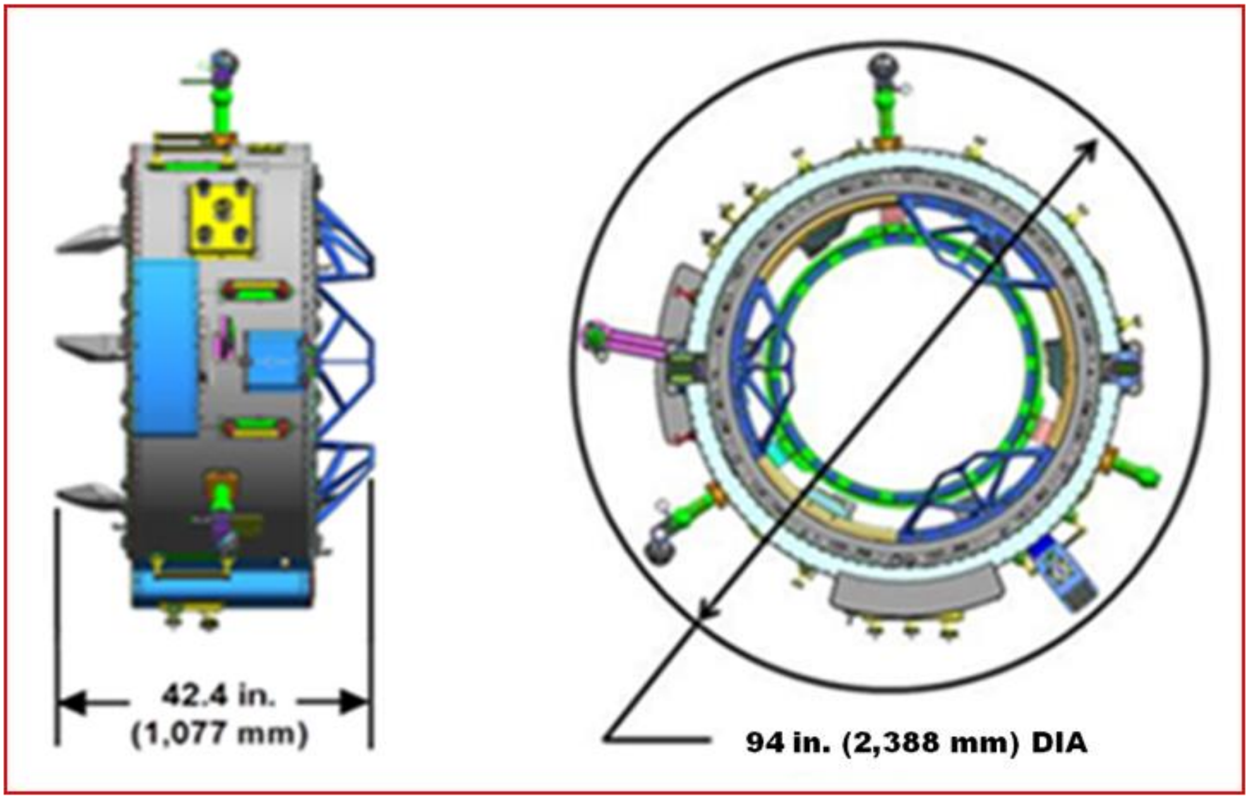



**FIGURE 4.2.1-1: IDA DOCKING INTERFACE**



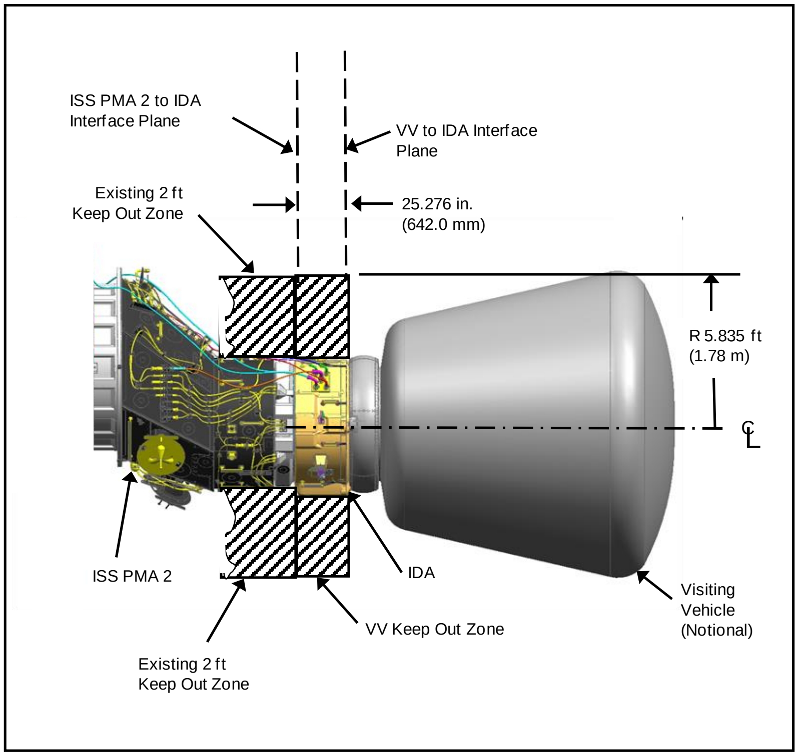




**FIGURE 4.2.1-2: IDA ENVELOPES**

#### 4.2.1.1 Thermal Interface

For steady state mated configurations, the NDSB1-to-IDA docking interface is assumed to be adiabatic. For evaluation of transient response in mated configurations, the integrated models should use the appropriate conductance to be conservative from that thermal evaluation's perspective. The thermal conductance across the NDSB1-to-IDA HCS docking interface is defined as ranging from 75 Btu/hr-°F (40 W/°K) to 187 Btu/hr-°F (98 W/°K).

##### 4.2.1.1.1 Non-Operational Survival

Not required

##### 4.2.1.1.2 Operational

###### 4.2.1.1.2.1 Tunnel and Seal Mating Interface

Before capture the temperature of the IDA docking ring at the docked VV to IDA interface is maintained in the temperature range of -38°F (-38.9°C) to +122 °F (50°C).

Note: The minimum temperature of -38°F (-38.9°C) is based on the minimum capability of the NDSB1 dynamic seals. However, the expected nominal minimum temperature is approximately +60°F (+15.56°C) provided that required PMA and IDA electrical power for heaters to maintain this temperature level is provided. After VV docking, the IDA ensures that the docking mechanism and vestibule surfaces between the PMA Hatch and the docking interface plane are between +60°F (+15.5°C) and +113°F (+45°C), except for a period of 10 hours after docking is complete, without relying on heat transfer with the ISS or visiting vehicle via conduction or radiation.

###### 4.2.1.1.2.2 Soft Capture Mating Interfaces

The following applies to soft capture assembly when the system is preparing to dock, up through hard mate, but prior to pressurization:

-65 °F to +165 °F (-54 °C to +74 °C)

##### 4.2.1.1.3 Mated and Pressurized

###### 4.2.1.1.3.1 Mated and Pressurized Steady-State Temperature Range

When the IDA is pressurized, the IDA maintains the temperatures of vestibule surfaces between the PMA Hatch and the docking interface plane between +60°F (+15.5°C) and +113°F (+45°C). These conditions are accomplished without relying on conduction or radiation heat transfer between IDA and VV.

During depressurization, the IDA maintains the temperatures of the vestibule surfaces between the PMA Hatch and the docking interface plane between +60°F (+15.6°C) and +113°F (+45°C), without relying on heat transfer with the ISS or VV via conduction or radiation.

During depressurization, when a VV is present, the exterior of the hatch facing the VV are also maintained between +60°F (+15.6°C) and +113°F (+45°C), without relying on heat transfer with the ISS or VV via conduction or radiation.

##### 4.2.1.1.3.2 Mated and Pressurized Transient Temperatures

Reserved

#### 4.2.1.1.4 Mated and Unpressurized

For scenarios in which the IDA is hard mated and the vestibule is unpressurized, the following temperature ranges apply:

-38 °F to +122 °F (-39 °C to +50 °C) at docking

Minimum – The minimum interface temperature of -38 °F (-39 °C) is defined by the NDSB1 minimum seal operational temperature limit at docking.

Maximum – The maximum interface temperature of +122 °F (+50 °C) is defined by the maximum NDSB1 seal operational temperature limit.

+60 °F to +120 °F (15.6 °C to +49 °C) at undocking

Minimum – The minimum interface temperature is limited to 60 °F (15.6 °C) to maintain IDA/PMA interface requirements.

Maximum – The maximum interface temperature is limited to +120°F (+49 °C) to maintain IDA/PMA interface requirements.

### 4.2.1.2 Soft Capture System

The IDA soft capture system is a passive ring with an androgynous petal arrangement as shown in Figure 4.2.1.2-1, IDA Soft Capture System. It has mechanical latch strikers for the NDSB1 capture latches.

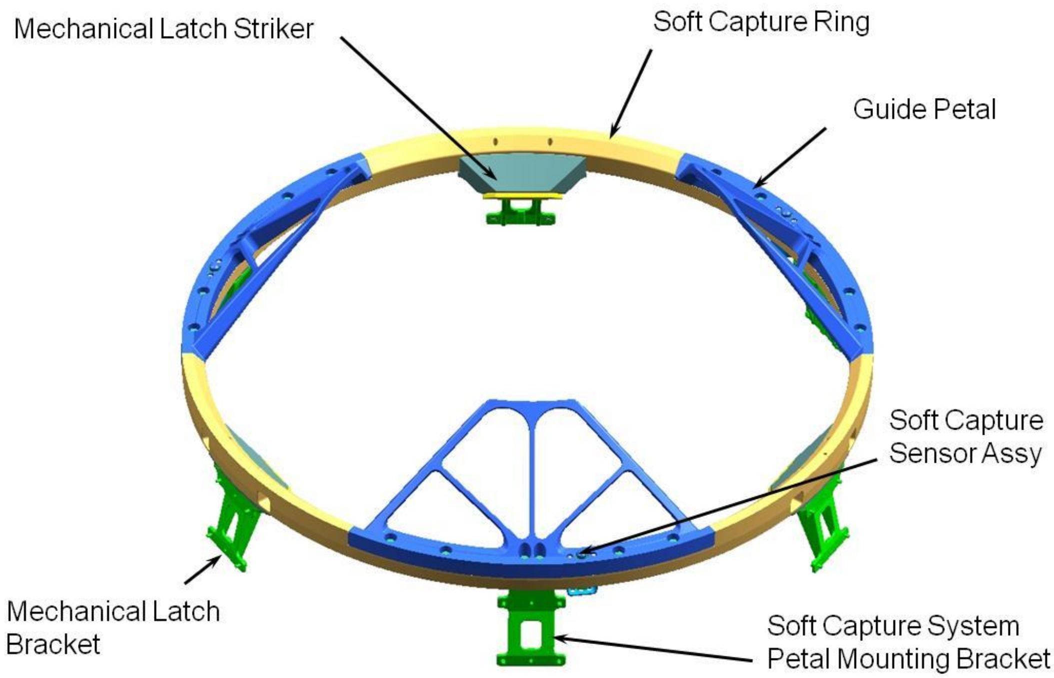



**FIGURE 4.2.1.2-1: IDA SOFT CAPTURE SYSTEM**

#### 4.2.1.2.1 Guide Petal System

The IDA has three guide petals, mounted to the soft capture ring, equally spaced around the circumference that faces inward.

The guide petal layout is shown in Figure 4.2.1.2.1-1 SCS Guide Petal System. Details of the design are shown in the following figures:

Figure 4.2.1.2.1-2 SCS Guide Petal System Detail,

Figure 4.2.1.2.1-3 SCS Guide Petal System Detail – View B,

Figure 4.2.1.2.1-4 SCS Guide Petal System Detail – Section C-C,

Figure 4.2.1.2.1-5 SCS Guide Petal System Detail – Section D-D.

The offset between the Soft Capture System (SCS) mating plane and the HCS mating plane is shown in Figure 4.2.1.2.1-6 Definition of SCS Mating Plane.

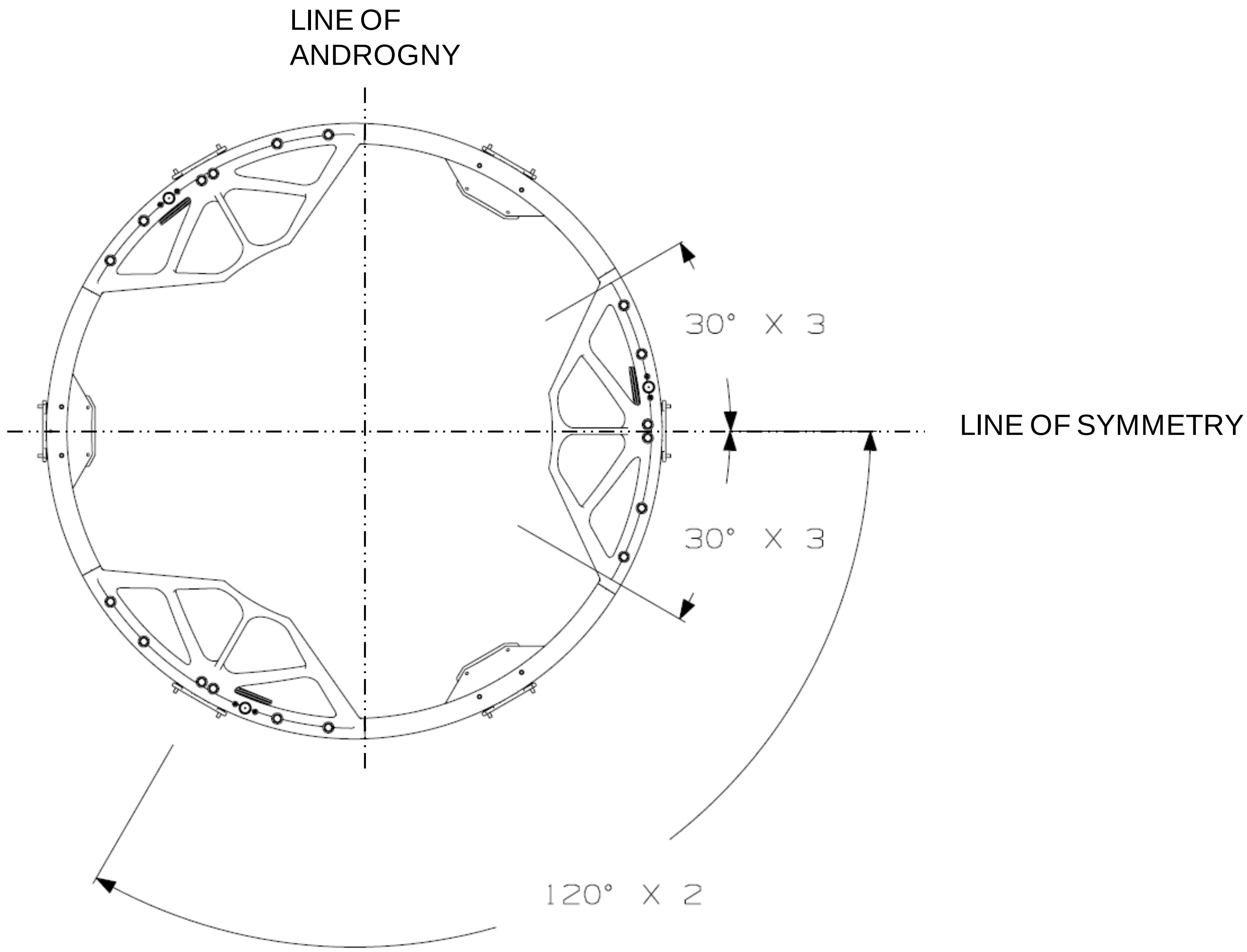



**FIGURE 4.2.1.2.1-1 SCS GUIDE PETAL SYSTEM**

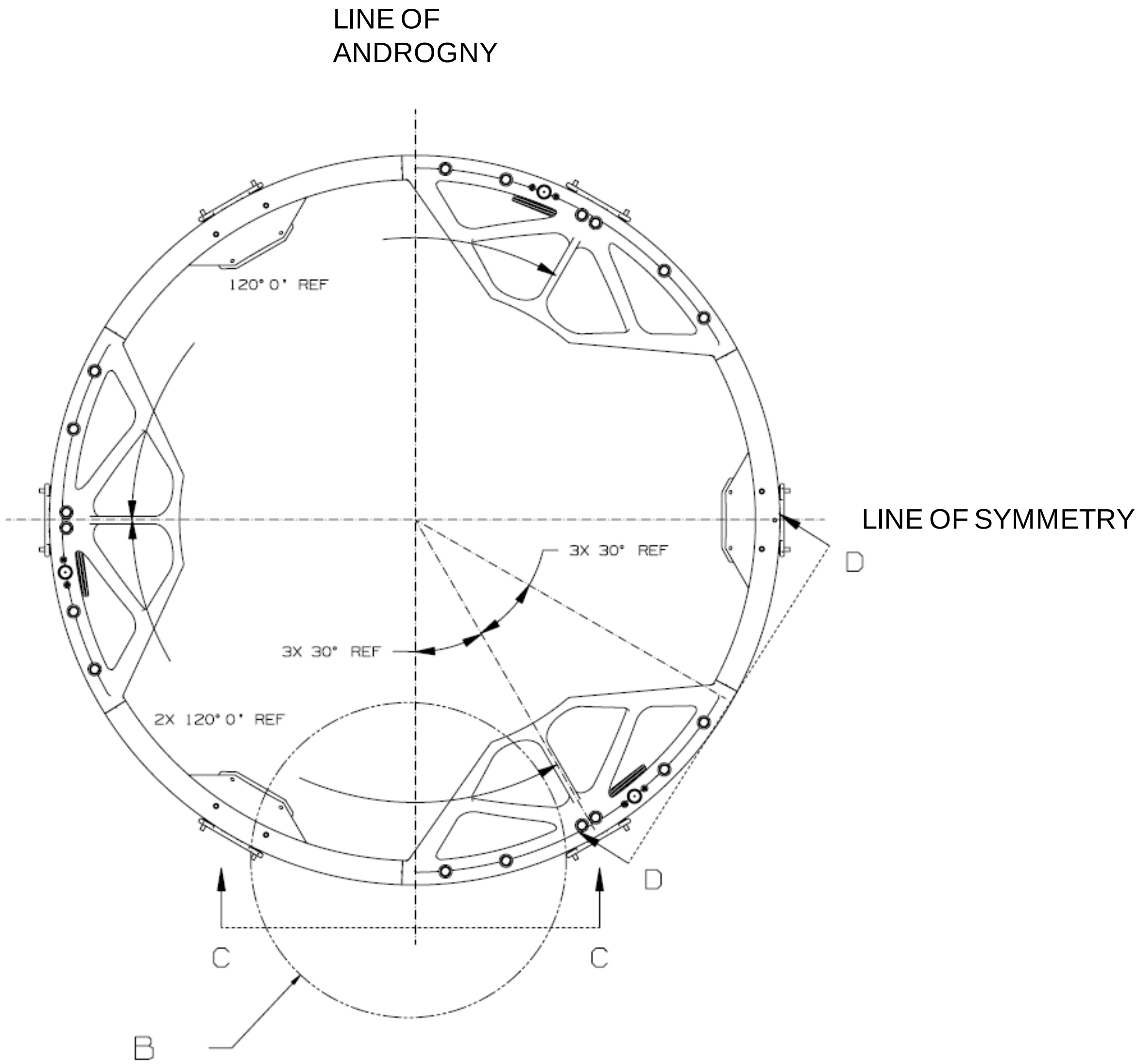



**FIGURE 4.2.1.2.1-2: SCS GUIDE PETAL SYSTEM DETAIL**

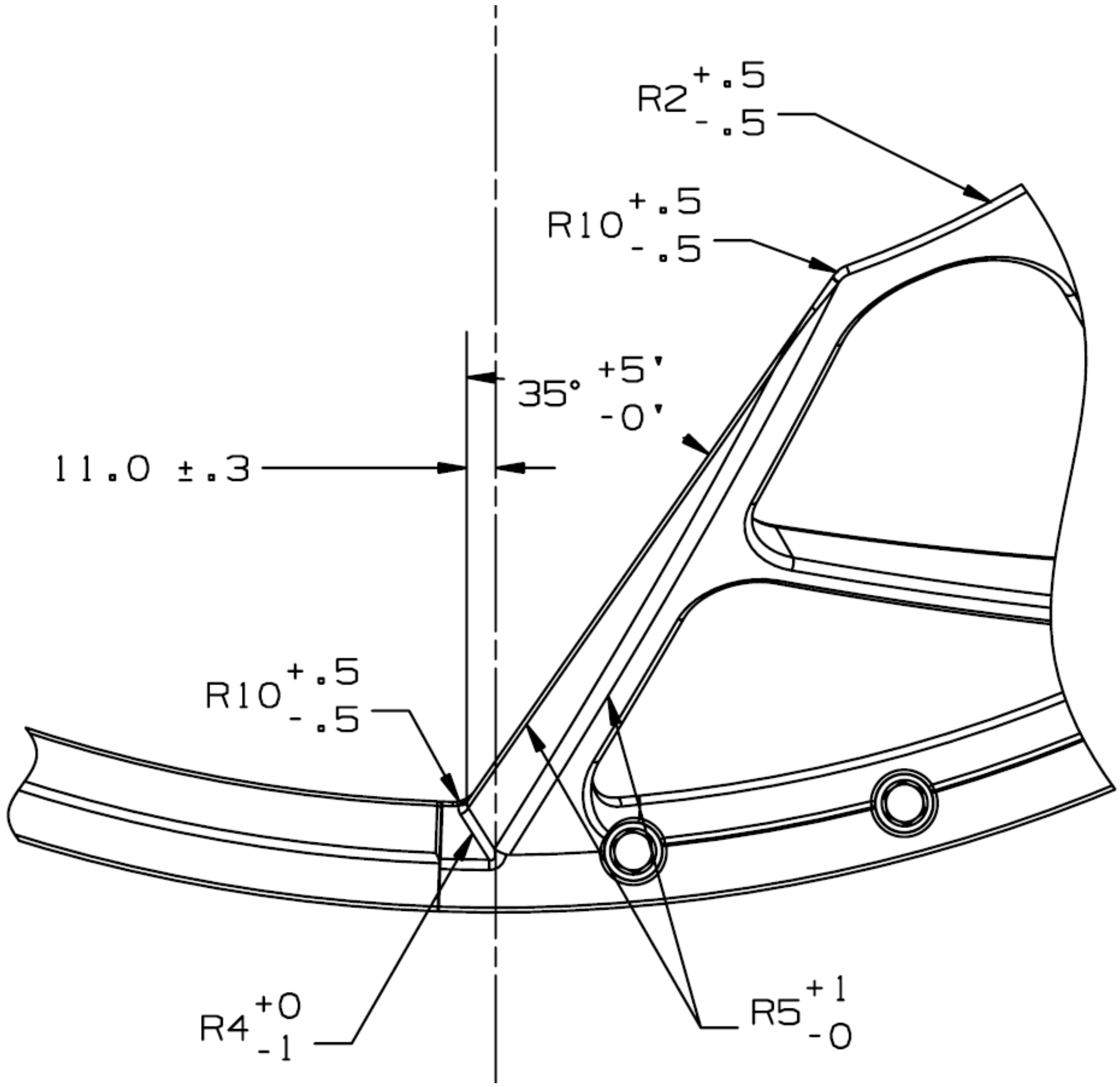



**FIGURE 4.2.1.2.1-3: SCS GUIDE PETAL SYSTEM DETAIL- VIEW B**

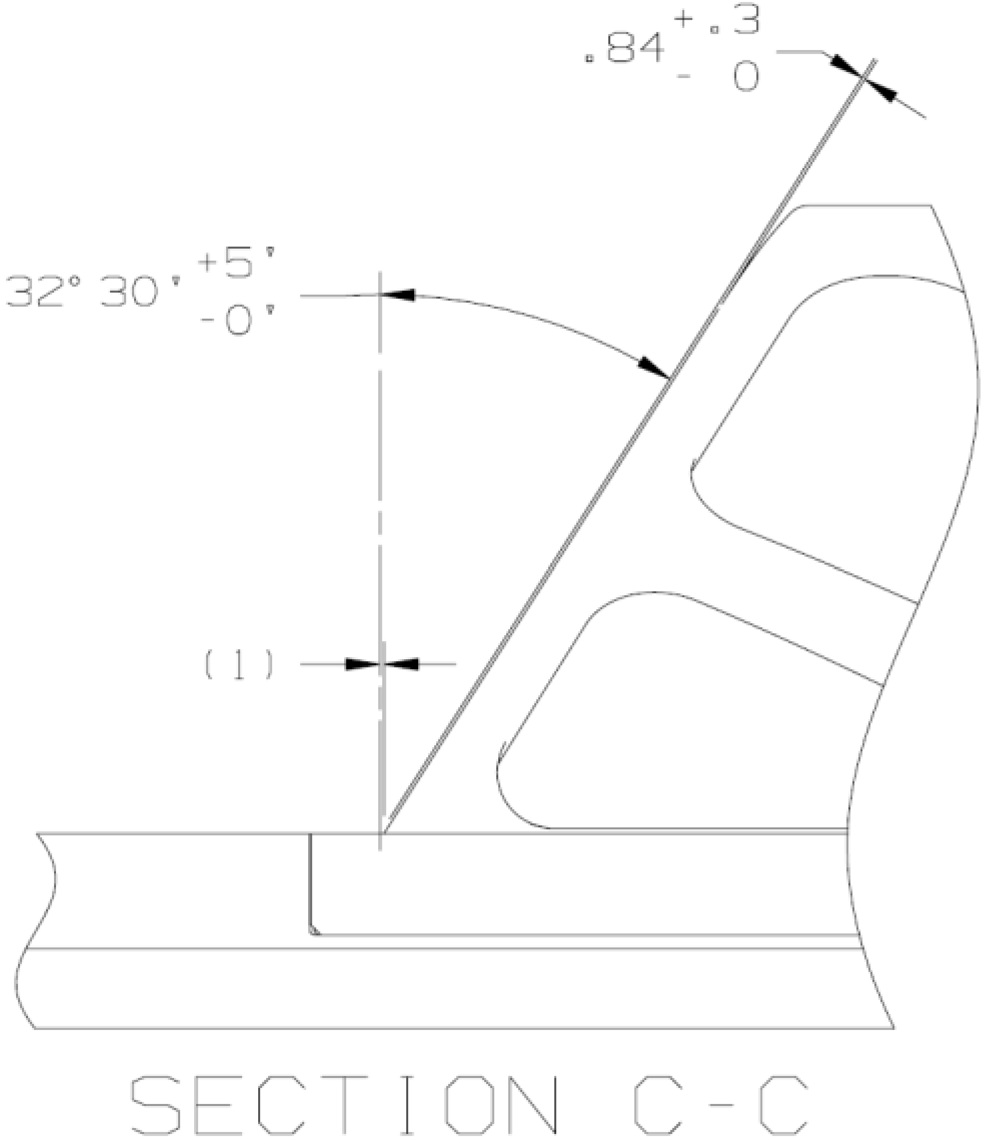



**FIGURE 4.2.1.2.1-4: SCS GUIDE PETAL SYSTEM DETAIL- SECTION C-C**

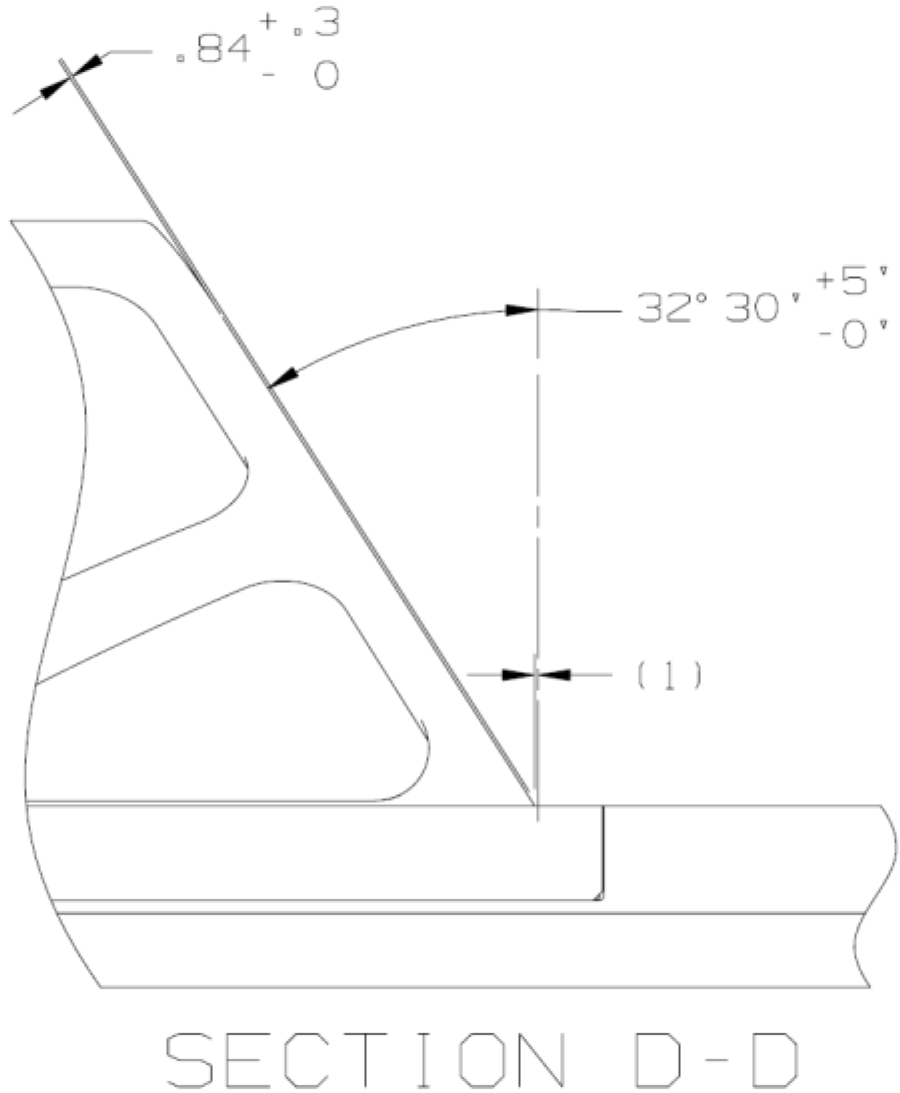



**FIGURE 4.2.1.2.1-5: SCS GUIDE PETAL SYSTEM DETAIL- SECTION D-D**

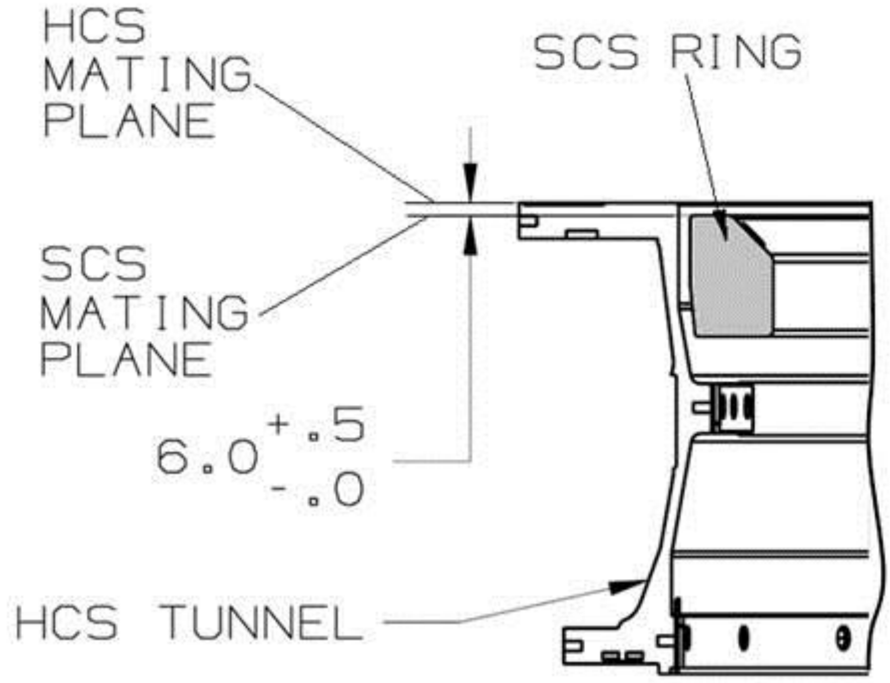



**FIGURE 4.2.1.2.1-6: DEFINITION OF SCS MATING PLANE**

### 4.2.1.2.2 Soft Capture Ring

The IDA SCS ring dimensions are defined in Figure 4.2.1.2.2-1 Soft Capture Ring Dimensions.

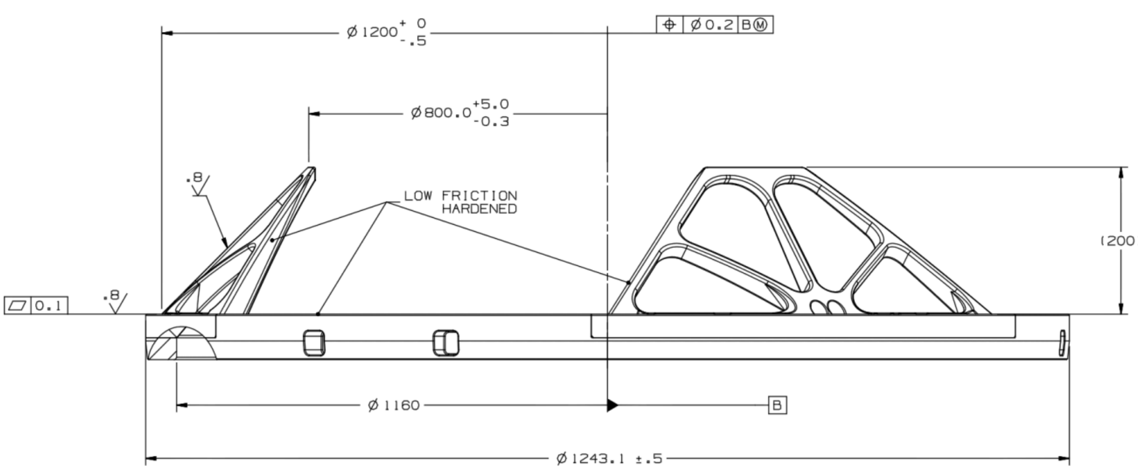
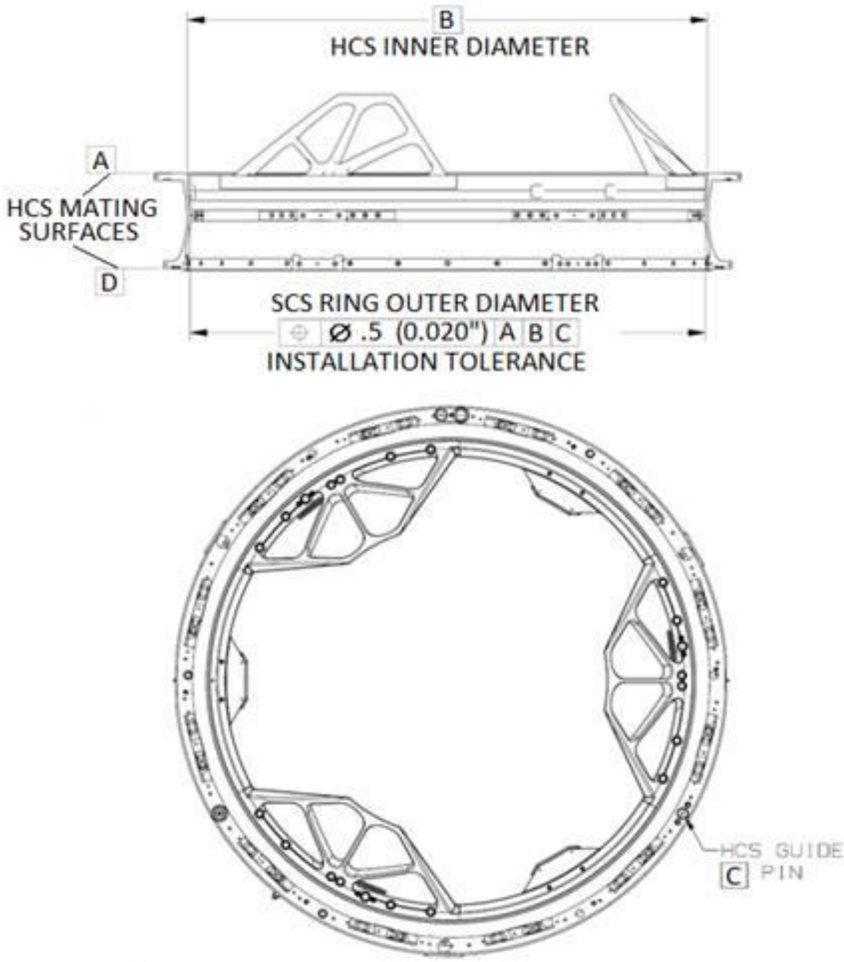



**FIGURE 4.2.1.2.2-1: SOFT CAPTURE RING DIMENSIONS**

The IDA SCS ring location is shown in Figure 4.2.1.2.2-2 SCS Capture Ring. The sensor locations are shown in Figure 4.2.1.3.7-5, IDA Soft Capture Sensor Locations.

Note: The IDA performs soft capture using an SCS mechanical latch striker interface, which allows an active Commercial Docking System-compatible docking system. Soft capture is not structural mating, but the first level of attachment in the docking sequence.

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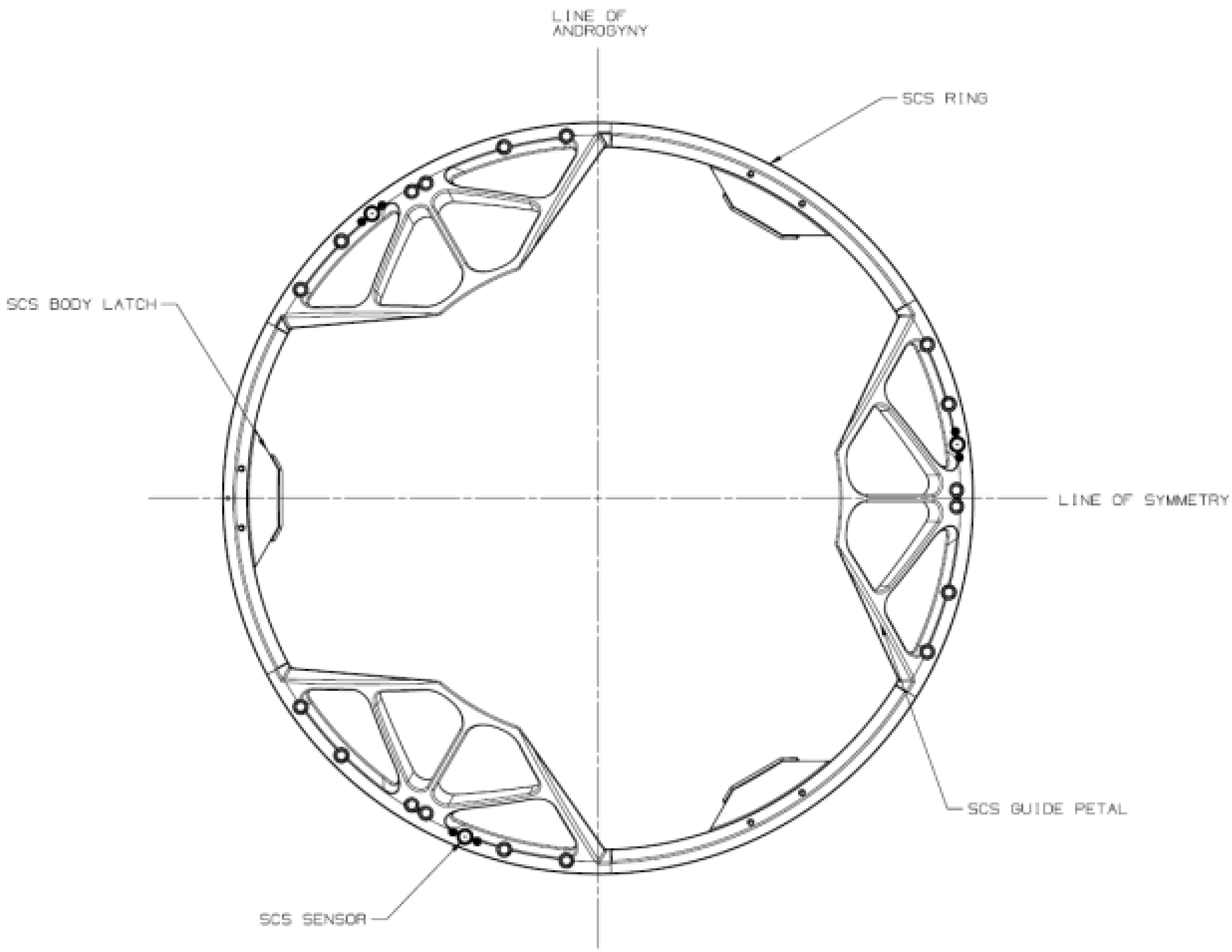


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**FIGURE 4.2.1.2.2-2: SCS CAPTURE RING**

#### 4.2.1.2.3 Magnet and Striker

Not applicable

#### 4.2.1.2.4 Pre-Capture SCS Compressive Force Resistance

The IDA can withstand a total compressive resistance force of 22.48 lbf (100 N), plus margin, during capture for the IDA soft capture interface.

Note: This resistance includes the SCS capture sensors and any other sources of compressive force resistance prior to soft capture latch engagement.

#### 4.2.1.2.5 SCS Mechanical Latch Striker

The IDA SCS interface includes three mechanical latch strikers that are sized as defined in Figure 4.2.1.2.5-1 SCS Mechanical Latch Striker Interface and Figure 4.2.1.2.5-2 SCS Mechanical Latch

Striker – Radial View. The SCS mechanical latch striker locations are shown in Figure 4.2.1.2.5-1.

Rationale: The SCS mechanical latch strikers allow other IDSS-compatible docking systems to use SCS mechanical latches to dock to the IDA.

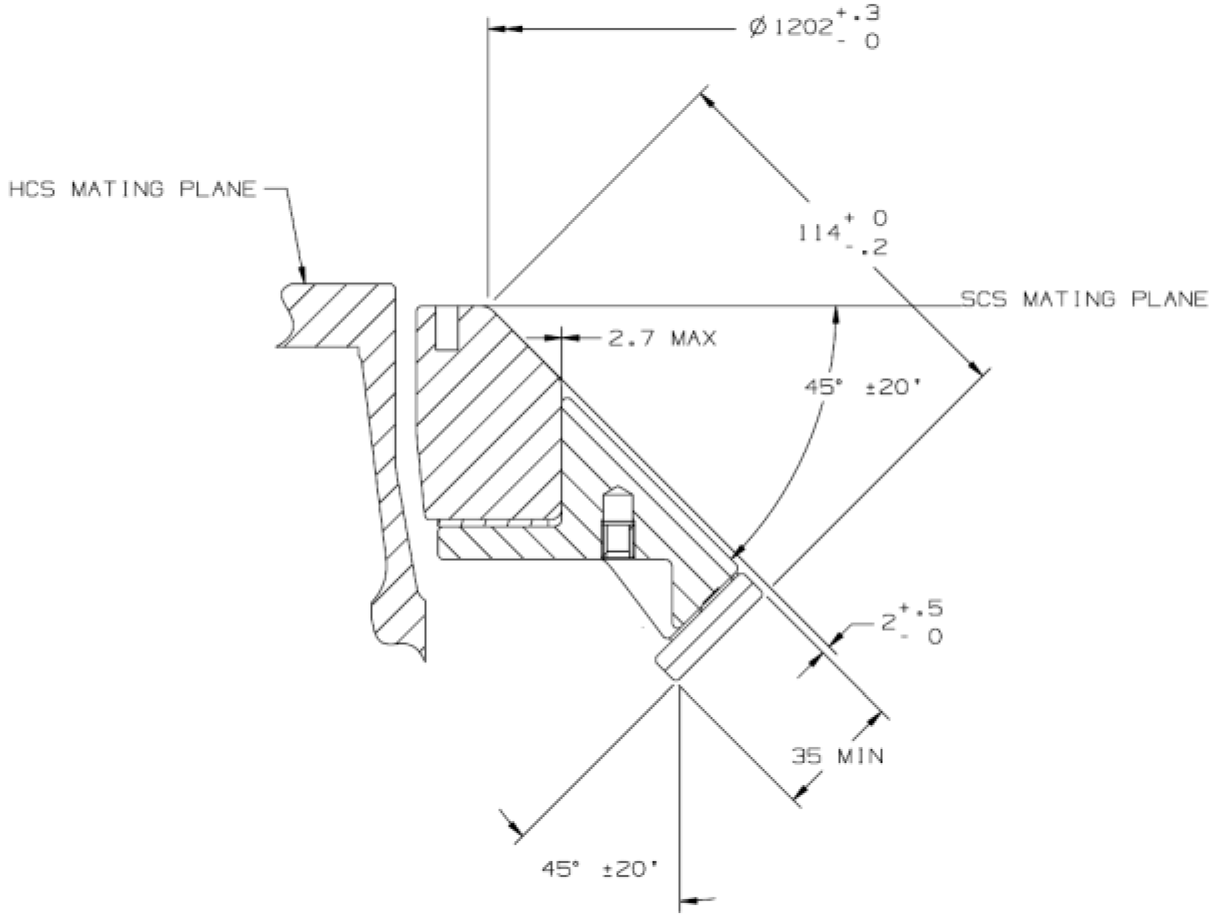



**FIGURE 4.2.1.2.5-1: SCS MECHANICAL LATCH STRIKER INTERFACE**

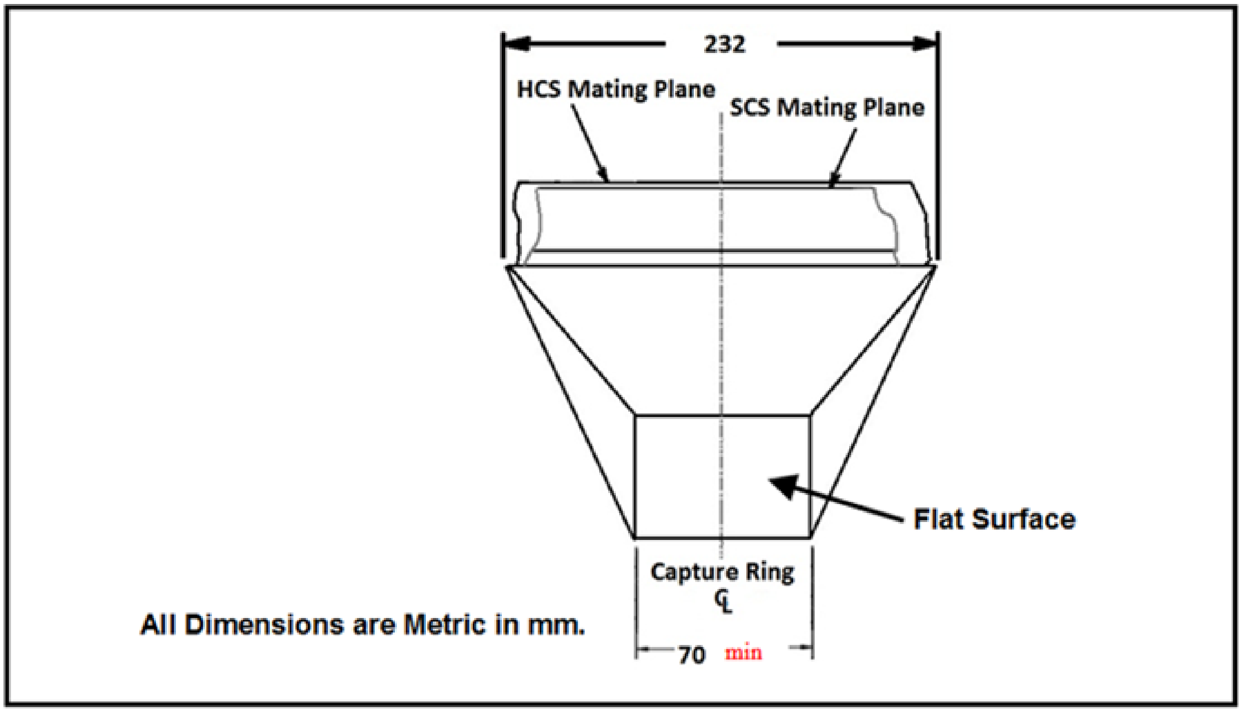



**FIGURE 4.2.1.2.6-2: SCS MECHANICAL LATCH STRIKER – RADIAL VIEW**

### 4.2.1.3 Hard Capture System

The IDA Hard Capture system is a mating half to the NDSB1 and is able to perform the same functions of hook engagement and push-off as shown in Figure 4.2.1.3-1, IDA HCS Exploded View. It utilizes a motor driven pulley system to close each gang of 6 hooks on the IDA HSC interface. It provides only a passive interface for resource umbilicals and requires the NDSB1 to provide the active function for engagement.

The IDA has three interface sealed sensors that provide indication when a structural seal has been achieved between the IDA and a mating hard capture system. The interface sealed sensors are located on the hard capture tunnel as shown in Figure 4.2.1.3-1. The IDA is also equipped with individual “Hooks Closed” position sensors. The sensors are located inside the hook assembly and are read by the IDA control panel.

The IDA has an undocking complete indication capability achieved by having an undocking-complete sensor. There are two sensor locations that correspond to the guide pin receptacle locations. The two IDA undocking complete sensors indicate when the guide pin has cleared the receptacles. The guide pins on the mating docking system push against the undocking-complete sensors as they enter the receptacle. The sensors indicate that undocking is complete at a separation distance of ~1.18 in. (~30 mm).

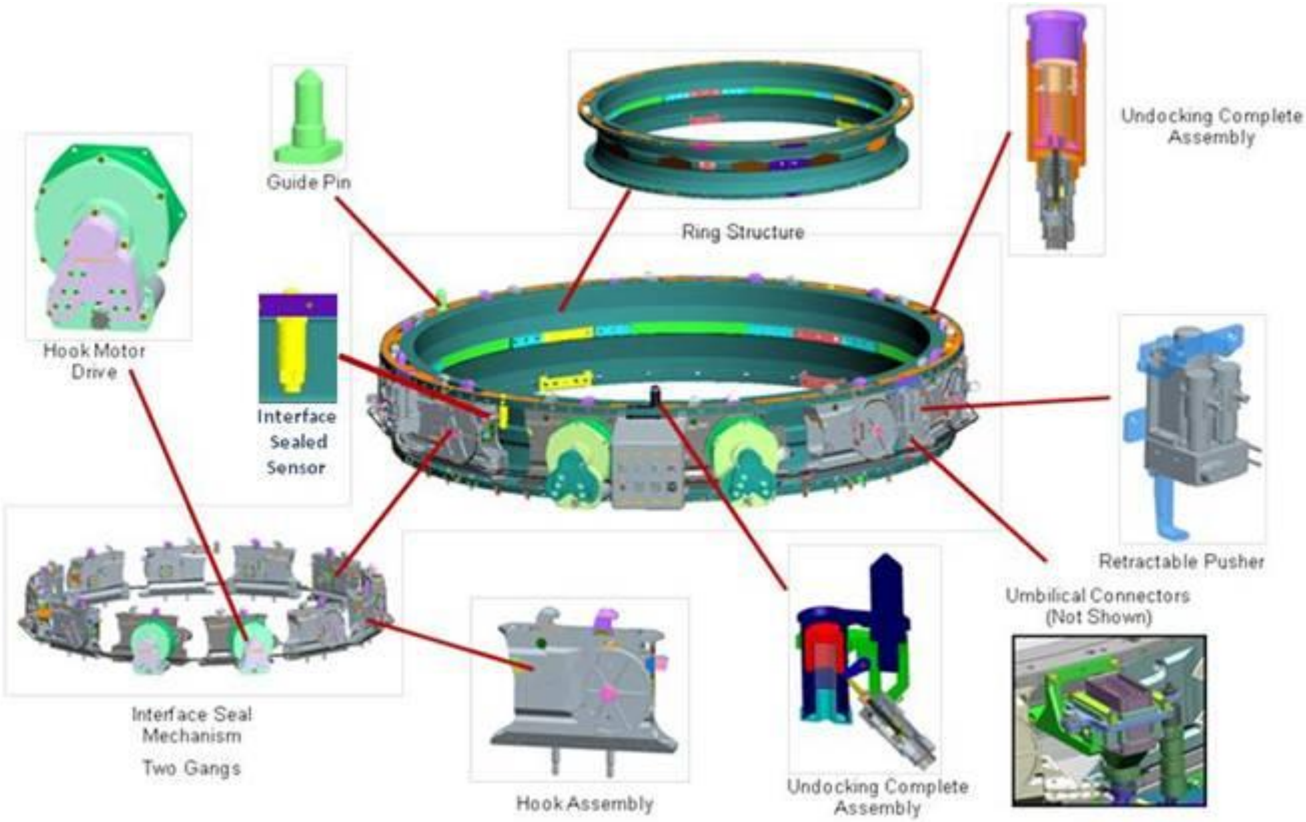



**FIGURE 4.2.1.3-1: IDA HCS EXPLODED VIEW**

The IDA HCS interface is defined in Figure 4.2.1.3-2 HCS Component Interface Definition, Figure 4.2.1.3-3 HCS Guide Pin and Guide Pin Hole Detail, Figure 4.2.1.3-4 HCS Hook Location Detail and Figure 4.2.1.3-5 HCS Separator Detail.

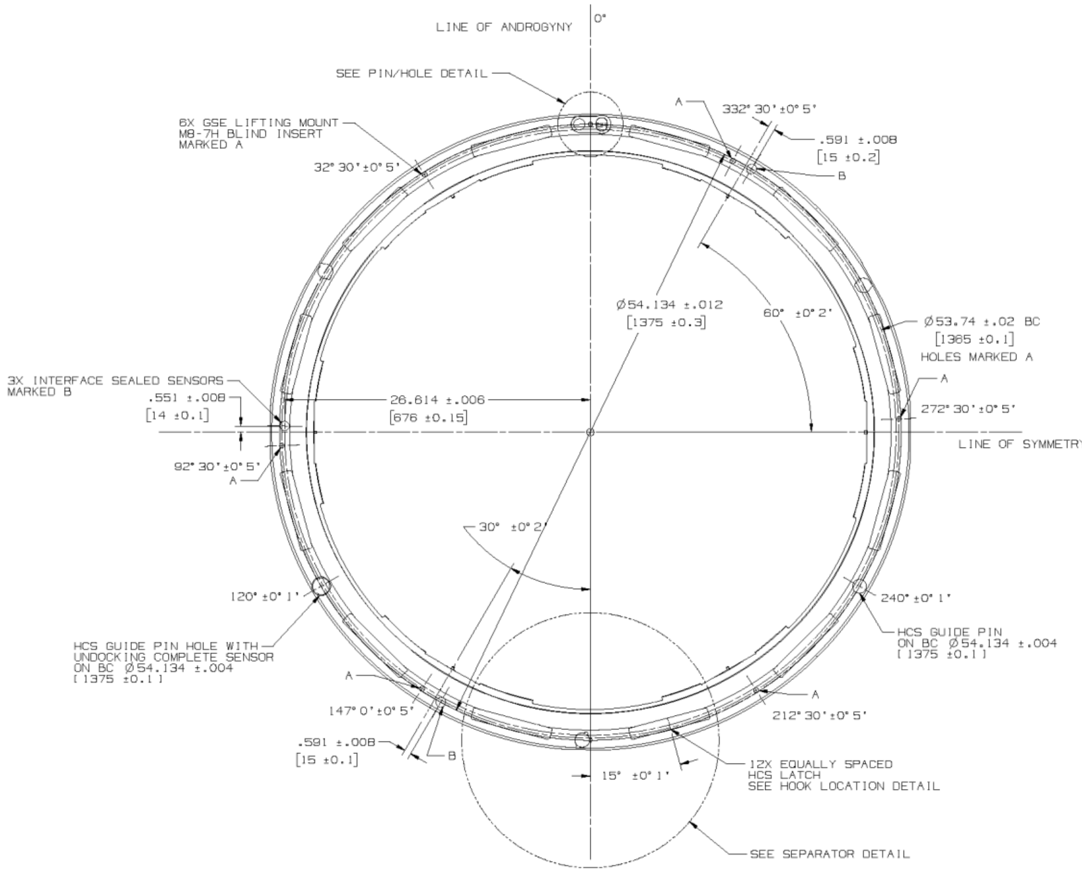



**FIGURE 4.2.1.3-2: HCS COMPONENT INTERFACE DEFINITION**

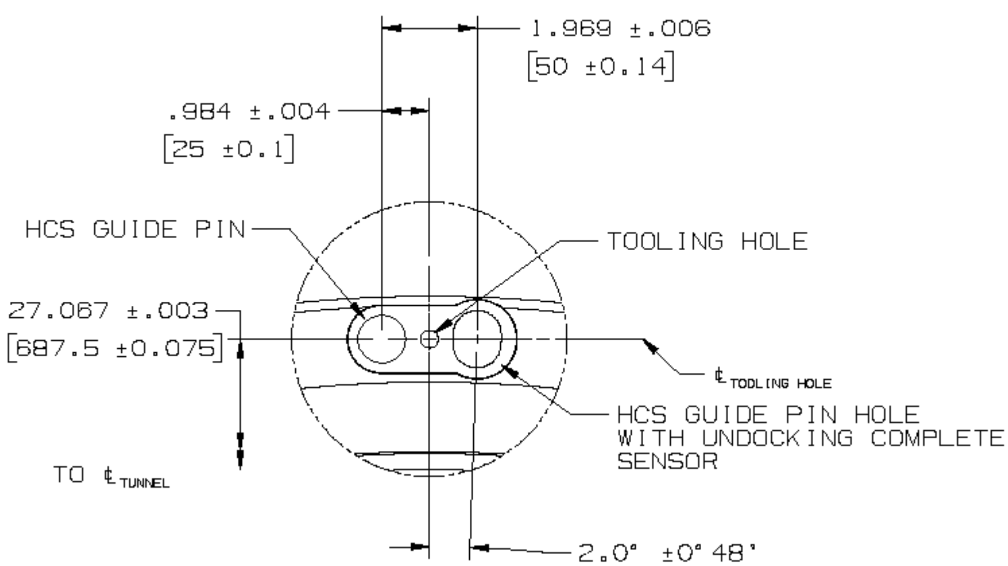



**FIGURE 4.2.1.3-3: HCS GUIDE PIN AND GUIDE PIN HOLE DETAIL**

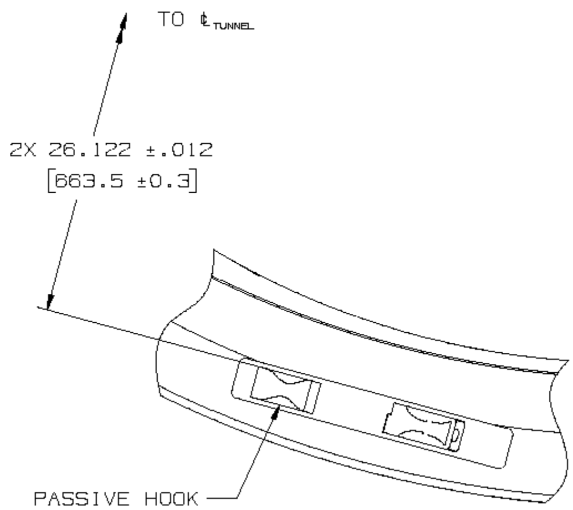



**FIGURE 4.2.1.3-4: HCS HOOK LOCATION DETAIL**

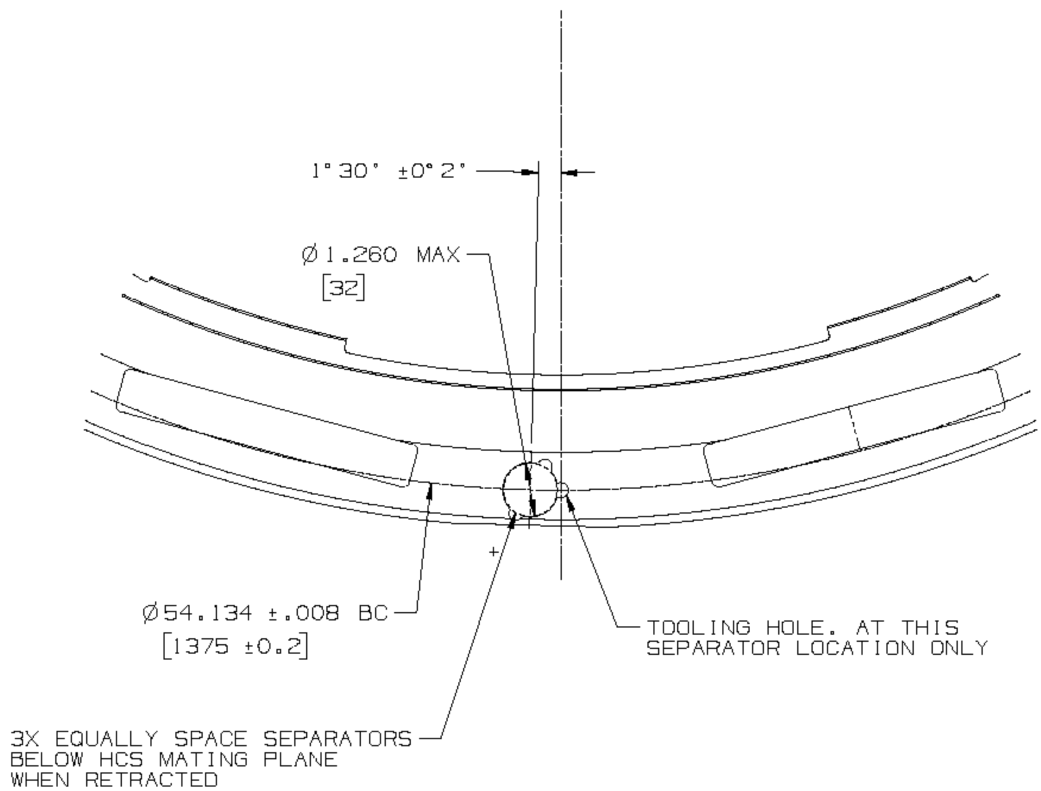



**FIGURE 4.2.1.3-5: HCS SEPARATOR DETAIL**

#### 4.2.1.3.1 Tunnel

See Figure 4.2.1.3.1-1, Tunnel Interfaces.

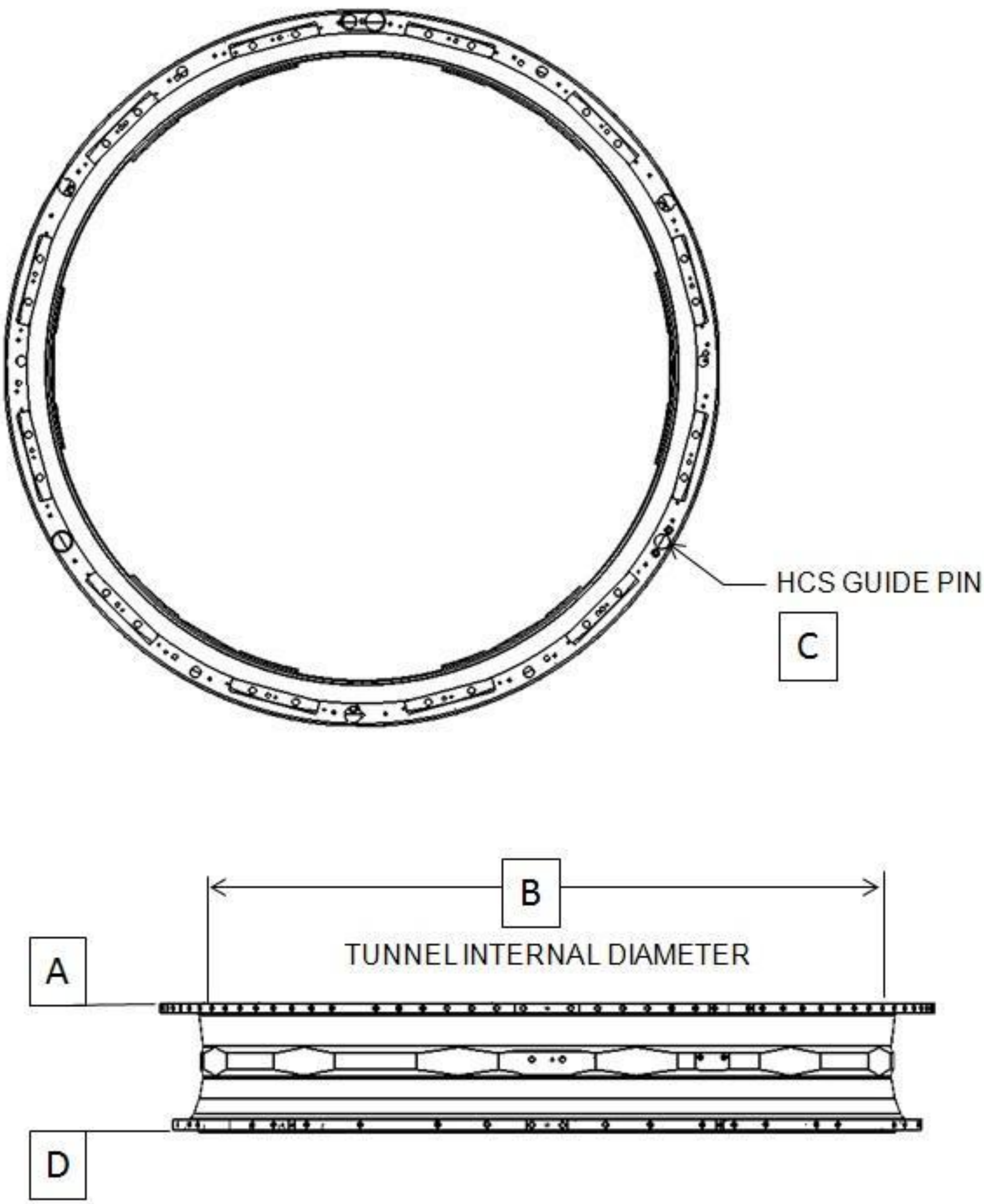
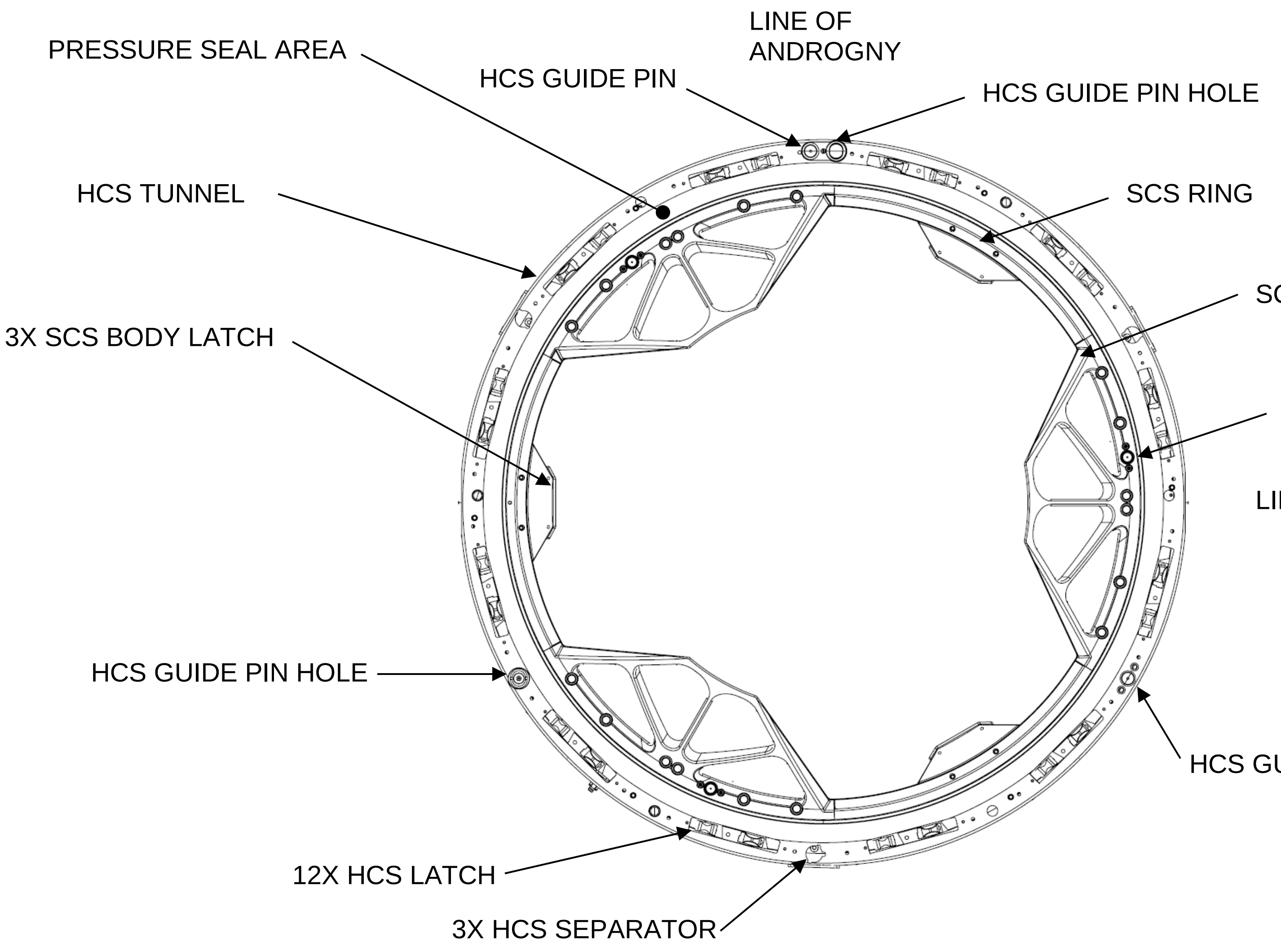



**FIGURE 4.2.1.3.1-1: TUNNEL INTERFACES**

### 4.2.1.3.2 Reserved

### 4.2.1.3.3 Guide Pins and Receptacles

The IDA has two guide pins and two guide pin holes as depicted in Figure 4.2.1.3.3-1, HCS Docking Interface, with details of the HCS guide pins as depicted in Figure 4.2.1.3.3-2, HCS Guide Pin Detail, and with details of the HCS guide pin holes as depicted in Figure 4.2.1.3.3-3, HCS Guide Pin Receptacle Detail.




HCS Component Interface

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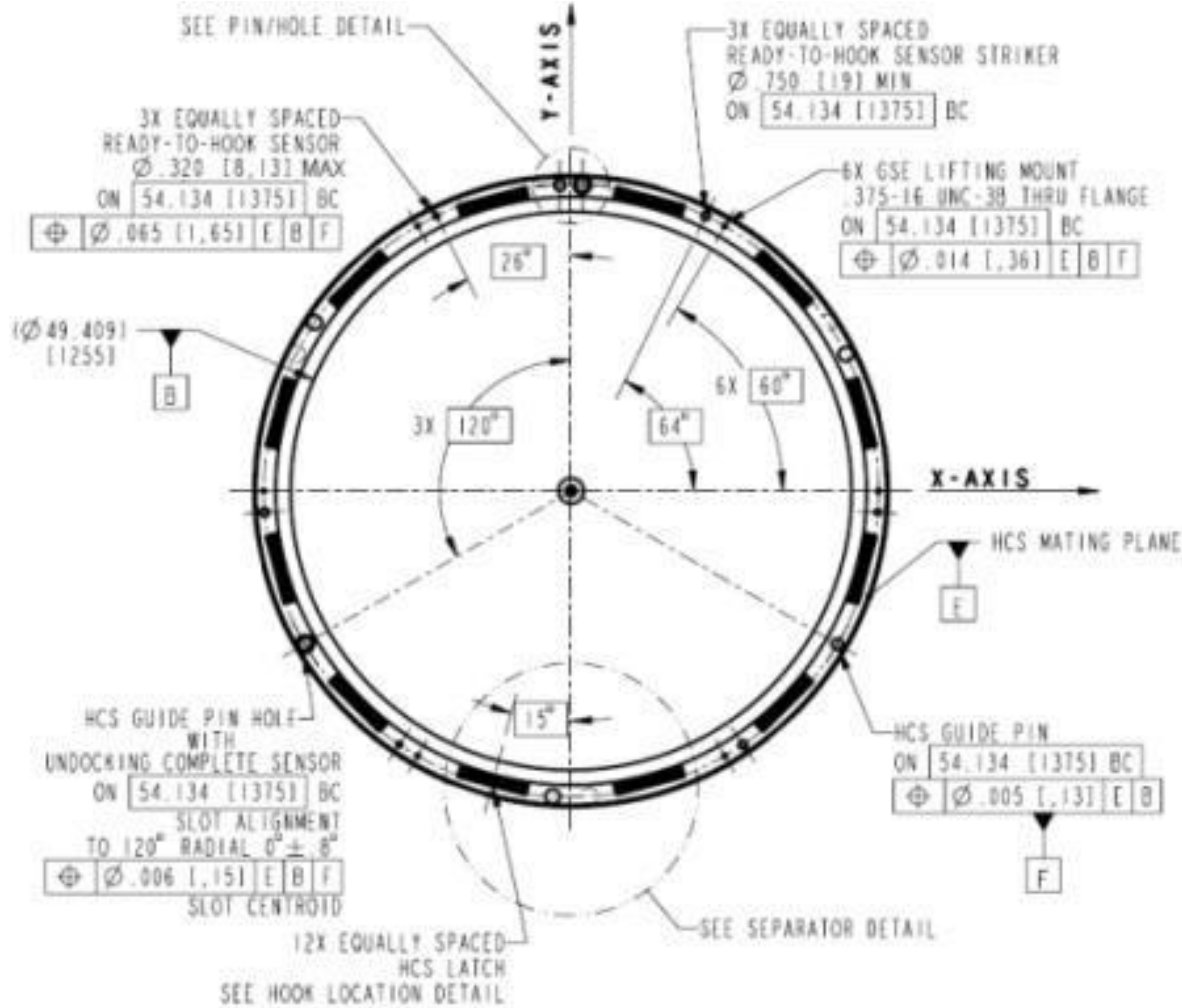


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**FIGURE 4.2.1.3.3-1: HCS DOCKING INTERFACE**

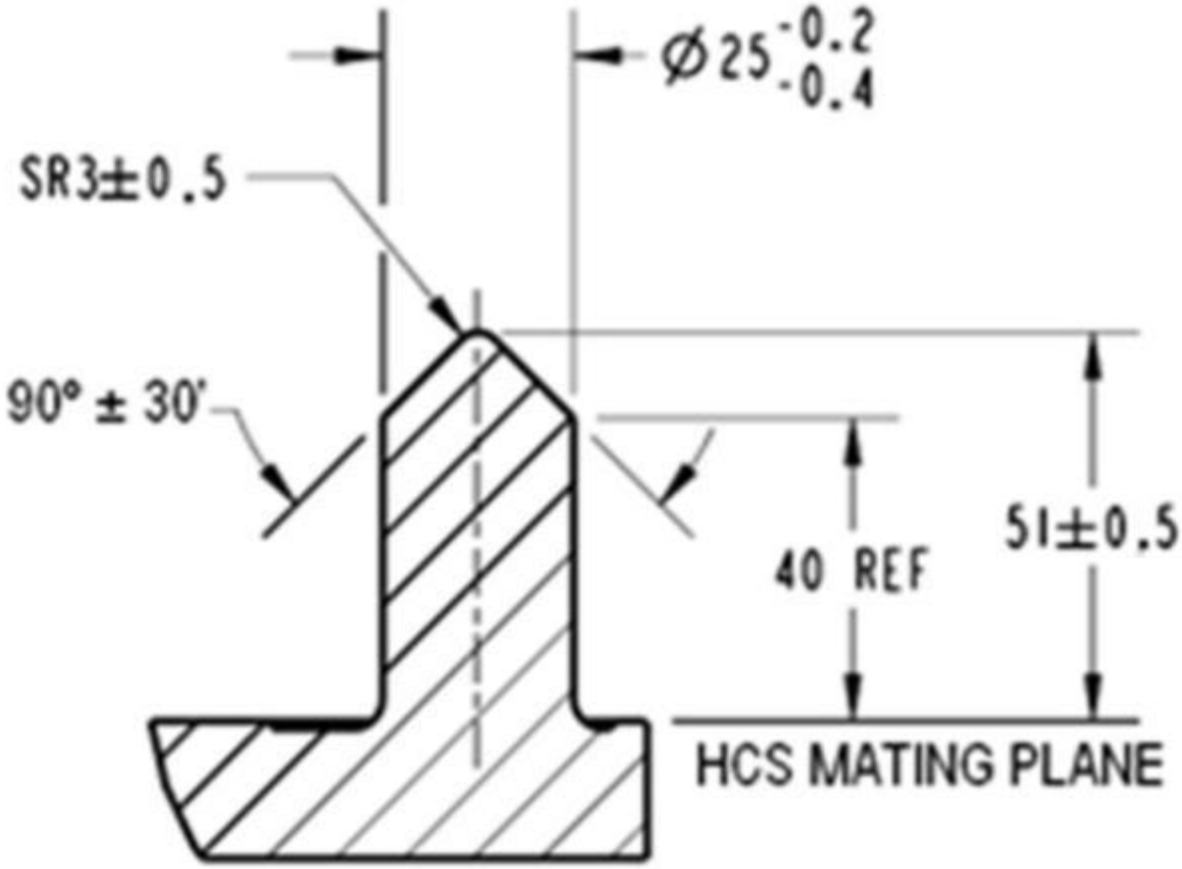



**FIGURE 4.2.1.3.3-2: HCS GUIDE PIN DETAIL**

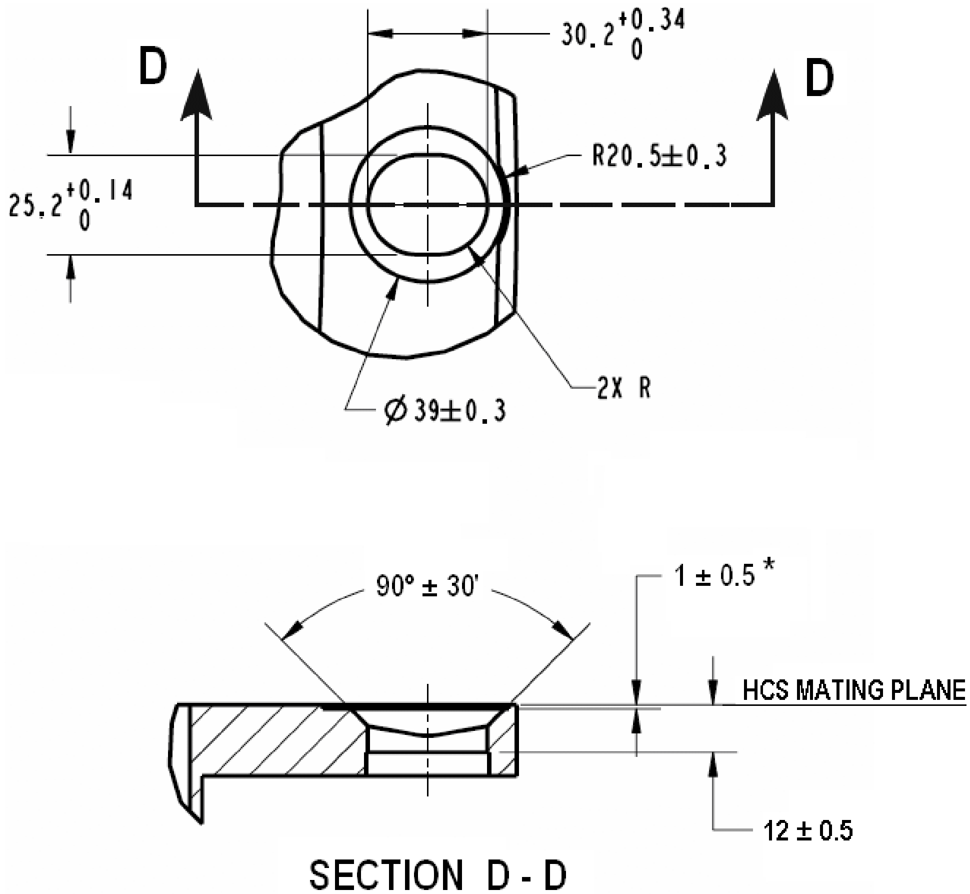
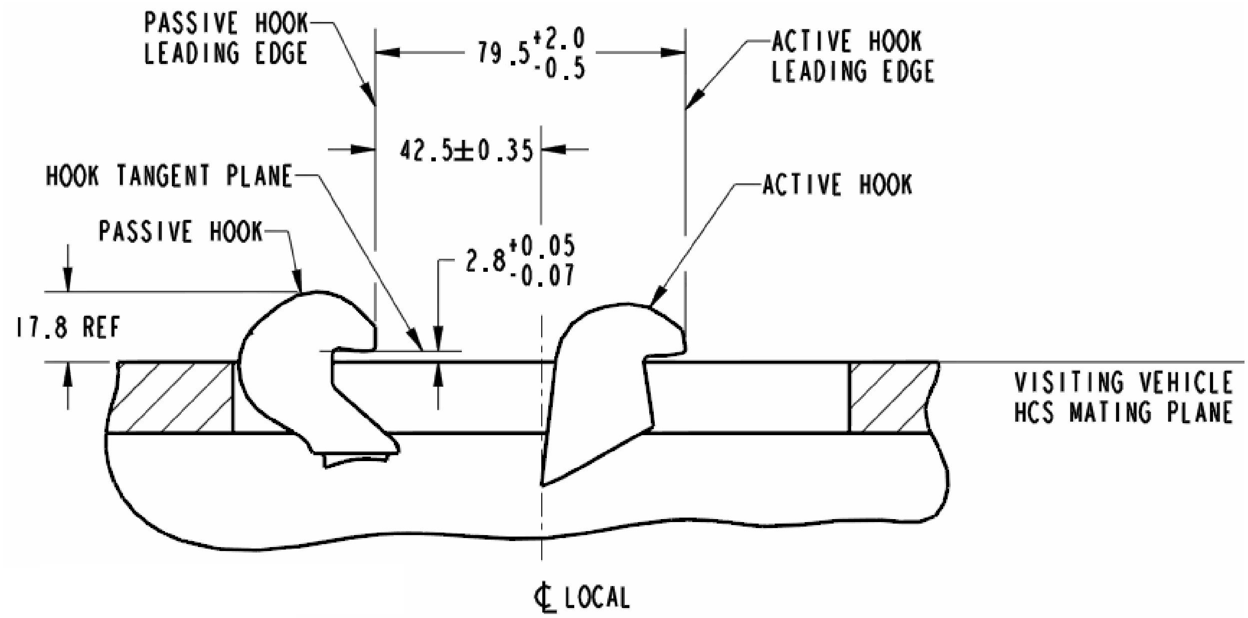



**FIGURE 4.2.1.3.3-3: HCS GUIDE PIN RECEPTACLE DETAIL**

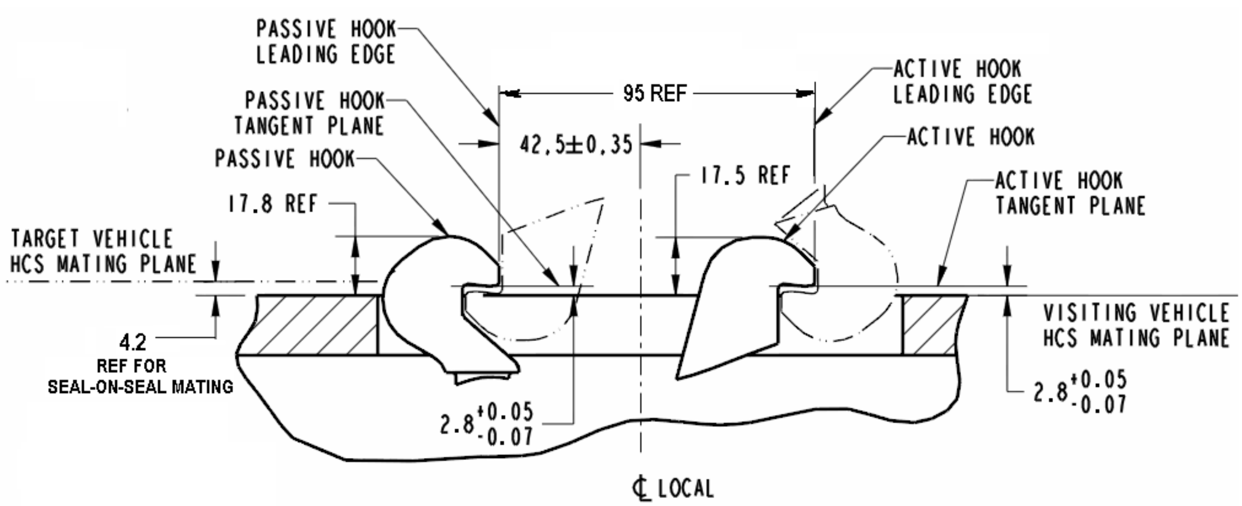
### 4.2.1.3.4 Hard Capture Hooks

The IDA hard mates with the passive hook assemblies of the VV as defined below.

The IDA is configured with tangential hooks on the HCS. The IDA, when mated, has 24 attachment points where 12 active hooks on one system engage 12 passive hooks on the mating system to carry nominal loads. Refer to Figure 4.2.1.3.4-1, HCS Hook Configurations and Figure 4.2.1.3.4-2, HCS Active Hook Detail. The 12 active hooks can be driven in 2 gangs of 6 that form an alternating pattern (i.e., every other hook). Each of the 12-hook pair locations on the HCS has 1 passive and 1 active hook assembly. The IDA implements a spring-biased self-compliance passive hook between the mating active-passive hook pair. Refer to Figure 4.2.1.3.4-1, and Figure 4.2.1.3.4-3, HCS Passive Hook Detail. The active hook motion envelope is defined in Figure 4.2.1.3.4-4, HCS Active Hook Motion Envelope.




Ready-To-Dock Configuration




Ready-To-Hook Configuration

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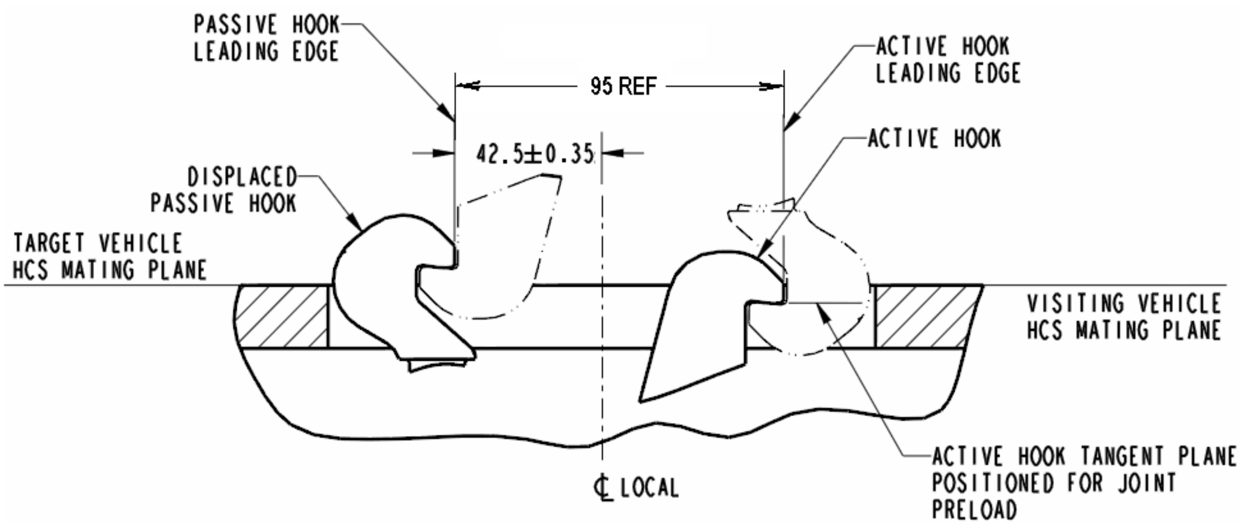
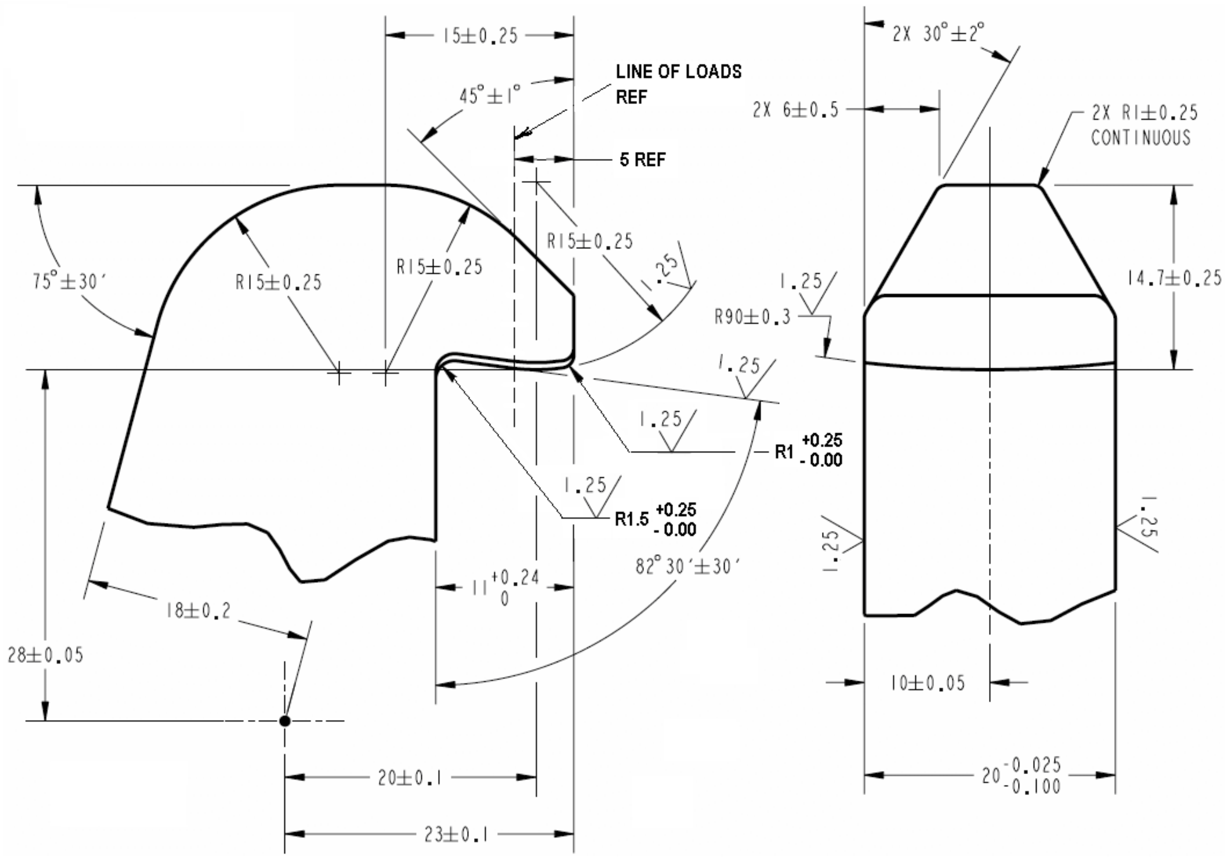



Fully Mated Configuration

(page 2 of 2)

**FIGURE 4.2.1.3.4-1: HCS HOOK CONFIGURATIONS**




Detail View

**FIGURE 4.2.1.3.4-2: HCS ACTIVE HOOK DETAIL**

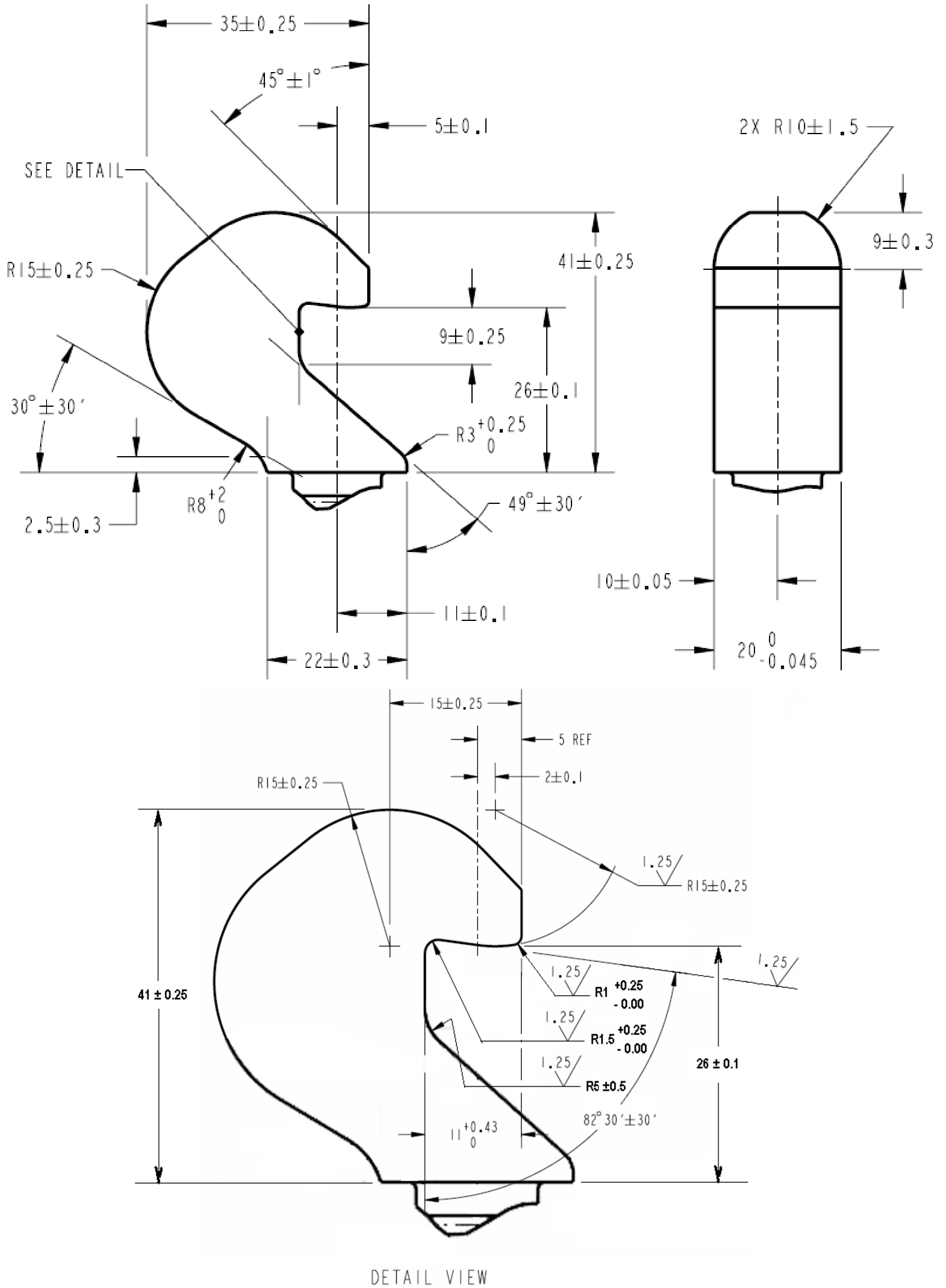



**FIGURE 4.2.1.3.4-3: HCS PASSIVE HOOK DETAIL**

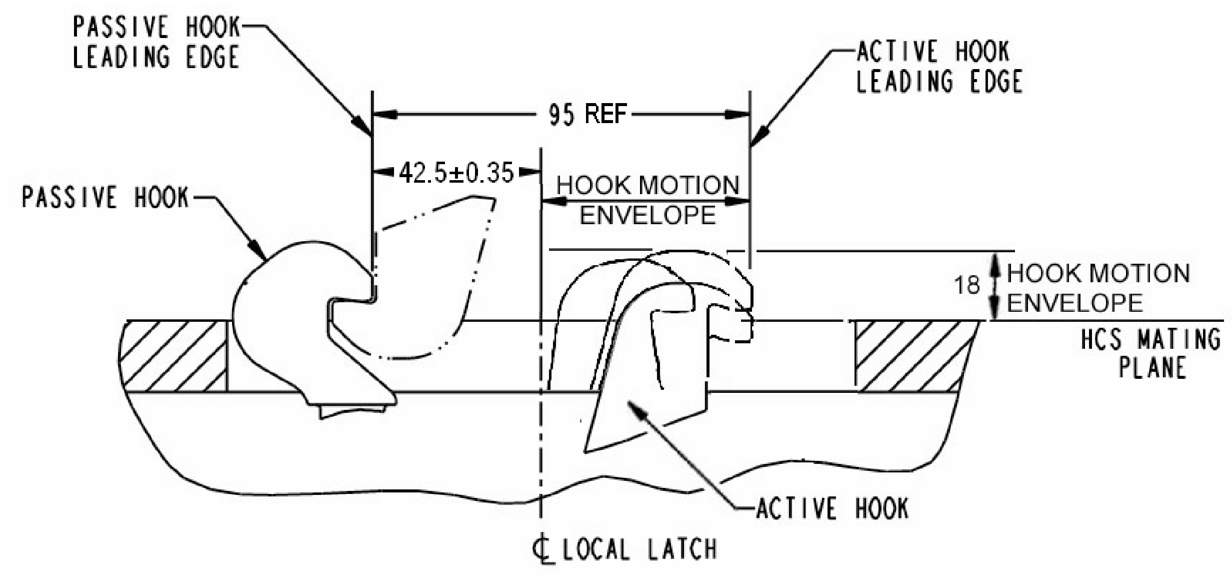



**FIGURE 4.2.1.3.4-4: HCS ACTIVE HOOK MOTION ENVELOPE**

The Hook System is defined as the serial combination of the Active Hook Mechanism, the Passive Hook Mechanism, and the structural elements that are in compression.

The Preload of the Hook System after locking is between the following values:

Minimum Preload of Hook System after locking = 7037 lbf (31300 N)

Maximum Preload of Hook System after locking = 9968 lbf (44340 N)

The Design Limit Capability of the Active and Passive Hook element is =

11240 lbf (50000 N).

The load response (stiffness) of the Active Hard Capture Hook Mechanism is between the upper and lower curves, as defined in Figure 4.2.1.3.4-5, Load Response of Active Hook Mechanism.

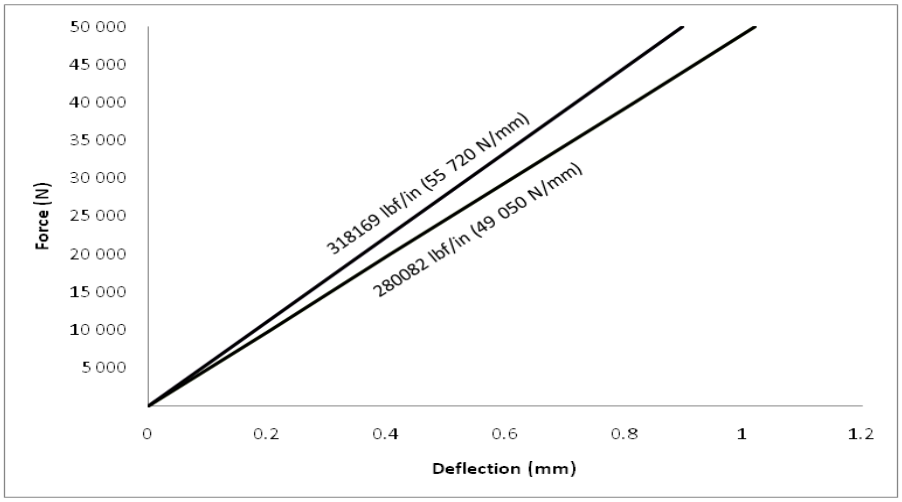



**FIGURE 4.2.1.3.4-5: LOAD RESPONSE OF ACTIVE HOOK MECHANISM**

The load response (stiffness) of the Passive Hard Capture Hook Mechanism is between the upper and lower curves, as defined in Figure 4.2.1.3.4-6, Load Response of Passive Hook Mechanism (Including Spring Washer Stack) Hard Capture Sensors and Strikers.

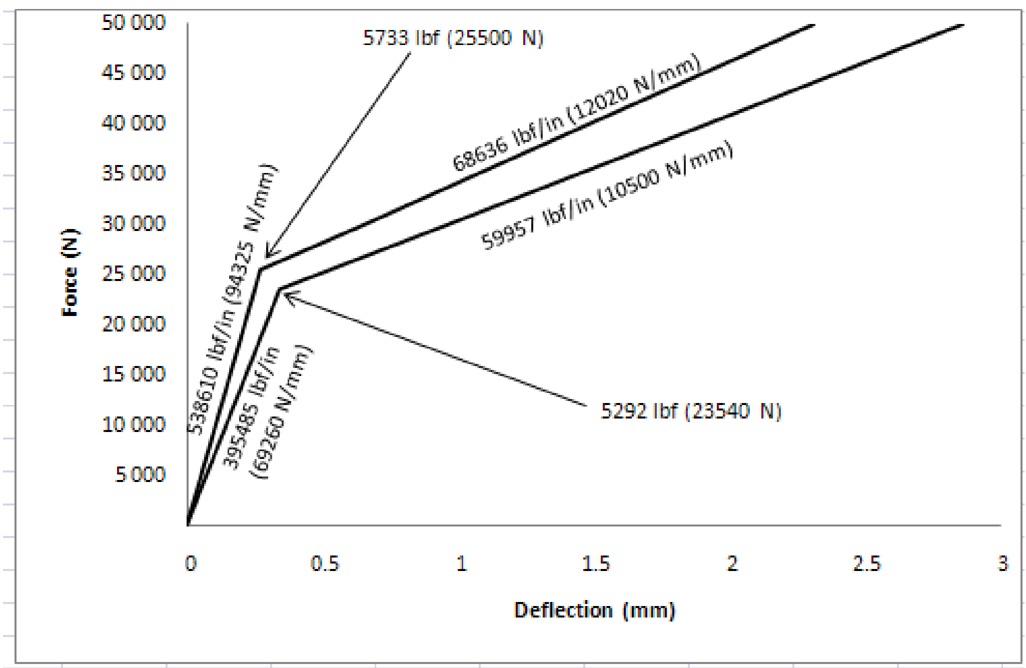



**FIGURE 4.2.1.3.4-6: LOAD RESPONSE OF PASSIVE HOOK MECHANISM (INCLUDING SPRING WASHER STACK) HARD CAPTURE SENSORS AND STRIKERS**

The NDSB1 has a RTH indication capability achieved by having RTH sensors and strikers. There are three RTH sensors and three striker locations, which reside 120 degrees from one another on the hard capture tunnel. The NDSB1 also has hook position sensors, which indicate the active hook is fully open, fully closed, and the hook is locked in the over-center position. Refer to Figure 4.2.1.3.4-1.

The striker zones for RTH sensors are recessed below the HCS mating plane, as illustrated in Figure 4.2.1.3.7-3, HCS Interface – Axial View. Refer to Figure 4.2.1.3.4-1 for the RTH activation point above the HCS mating plane.

#### 4.2.1.3.5 Undocking Complete Sensors and Strikers

The IDA has two undocking complete sensors at the VV to IDA interface at the guide pin receptacle locations as defined in Figure 4.2.1.3.3-1 and Figure 4.2.1.3.3-2. Note: The sensors indicate that undocking is complete at a separation distance of ~1.18 in. (~30 mm).

#### 4.2.1.3.6 HCS Compressive Force Resistance During SCS Retraction

The IDA hard capture interface is 18.9 lbf (84 N) compressive force resistance during SCS retraction.

Note: As the SCS retracts, it encounters the RTH and undocking complete sensors while in a kinematic configuration that has limited axial pulling force capability. To ensure the ability to engage the hooks, a maximum of 37.8 lbf (168 N) compressive force resistance is allowed across the interface. This means each side is allowed to have a maximum of 18.9 lbf (84 N) resistance.

#### 4.2.1.3.7 Separation System Springs and Strikers

The IDA provides three retractable separation mechanisms capable of providing a force sufficient to push the VV away from the ISS in accordance with the IDA as defined below.

The IDA includes three separation springs recessed below the docking sealing surface, which can be remotely engaged for separation and reset to a recessed position for docking. This system provides force to overcome the seal stiction and energy to accelerate the vehicle away when the structural mate mechanism is released.

The umbilical resource connectors are nominally retracted prior to undocking. However, in the event of failure to retract the umbilicals, the separation system is capable of providing enough force to de-mate the umbilical resource connectors during separation.

The separation system and associated striker zones are shown in Figure 4.2.1.3.3-1. The striker zones are recessed below the HCS mating plane, as illustrated in Figure 4.2.1.3.7-3, HCS Interface – Axial View.

Once charged against the striker on the mating docking interface, the separator has a minimum total extension stroke of 1.295 in. (32.9 mm) to be used for separation. The first part of the stroke is used for loosening the pressure seals and disengaging umbilical connectors, if any. The second part is used for vehicle separation dynamics. The three IDA separators together provide a total initial stored energy between 28.9 ft-lb (4.0 kgf-m) and 35 ft-lb (4.8 kgf-m) at zero interface separation. The nominal force applied by a single charged separator to the striker surface is 155 to 160 lbf (689 to 712 N). However, during contingency cases, such as a limit switch failure, the maximum force can reach 200 lbf ( 890 N).

Figure 4.2.1.3.7-1, Single Separator Force Separation Curve shows the linear force separation curves of a single separator where the undocking separation distance indicates the separation between the two HCS mating planes. Multiply the force values by three to get the total system force acting on the vehicles at a given separation point. At a separation of 0.165 in. (4.2 mm), the separation system provides a minimum of 133.3 lbf (593 N) for each separator.

Nominally, it can be assumed that the vehicles have zero relative axial velocity as the hooks disengage. This occurs at a separation of approximately 0.22 in. (5.6 mm). Hence, a total energy between 21.2 ft-lb (2.9 kgf-m) and 26.1 ft-lb (3.6 kgf-m) is applied to vehicle separation under nominal conditions.

**Note:** In a contingency situation where the NDSB1 umbilicals are not retracted first, the umbilical connectors resist separation until a separation of approximately 0.512 in. (13 mm) is achieved. Therefore, the energy available for vehicle separation is reduced in this scenario.

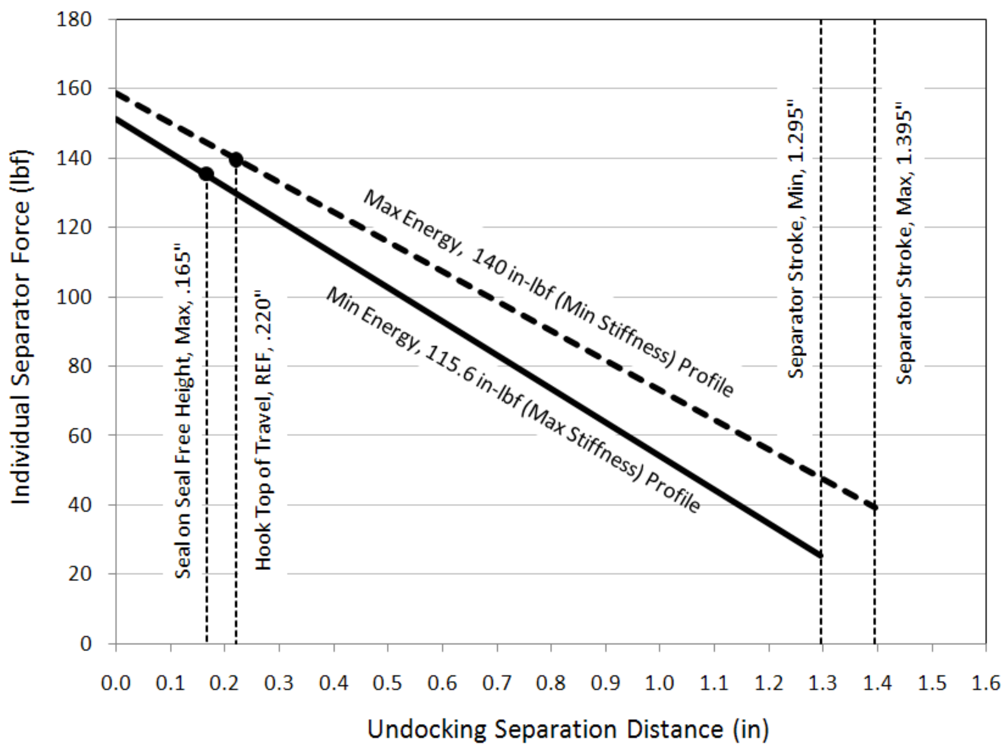
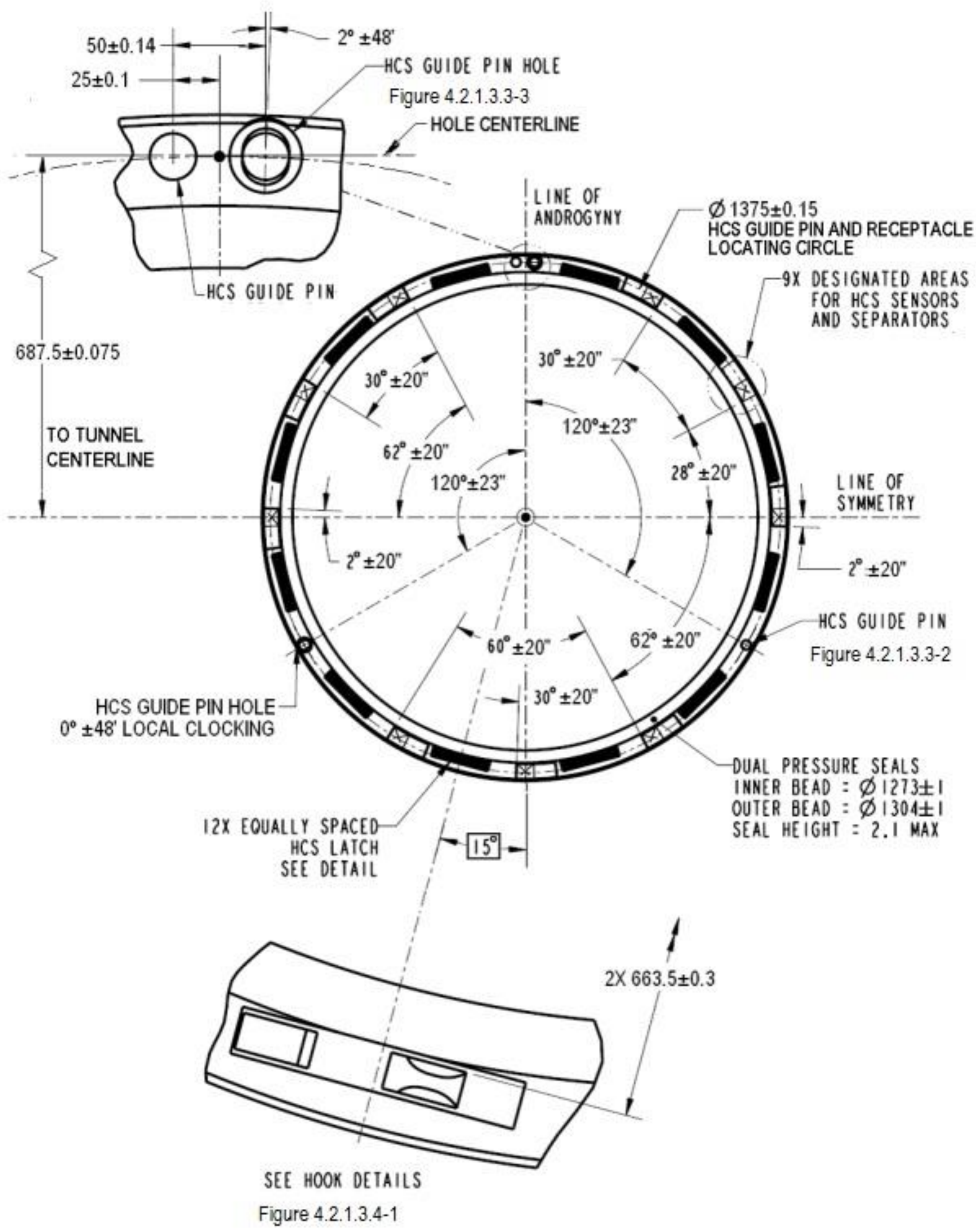



**FIGURE 4.2.1.3.7-1: SINGLE SEPARATOR FORCE SEPARATION CURVE TBR35**

The IDA accommodates a visiting vehicle equipped with an undocking separation system, which utilizes separation pushers located in accordance with any of the 9 potential striker locations as defined below.

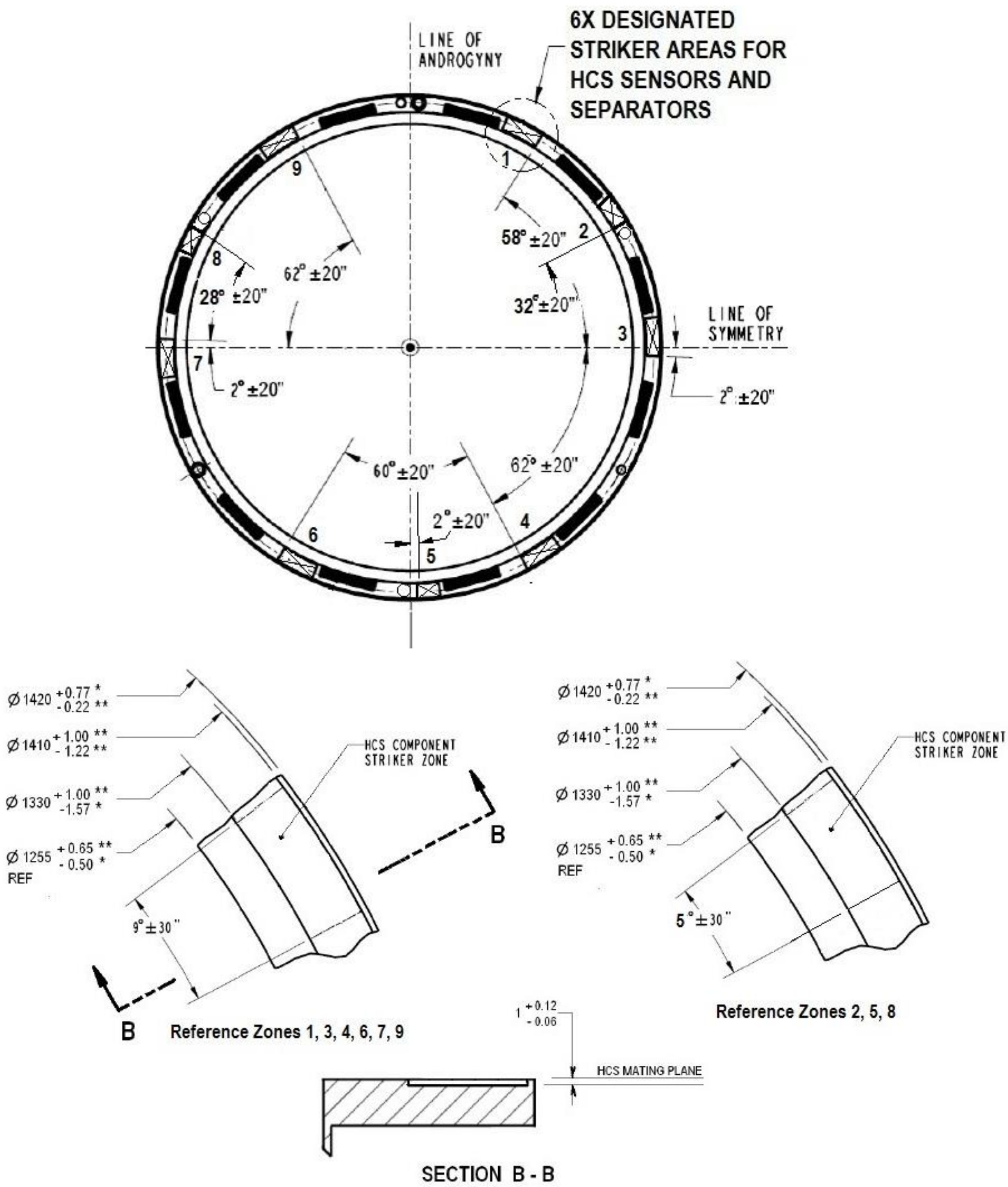
The HCS has designated areas for striker zones used by the opposing docking system. These striker areas can be used for various HCS sensory components or other subsystems such as separation system push-off devices. IDSS compliant systems abide by the designated striker zones defined in Figure 4.2.1.3.7-2: HCS Interface – Axial View and Figure 4.2.1.3.7-3: HCS Interface – Axial View.



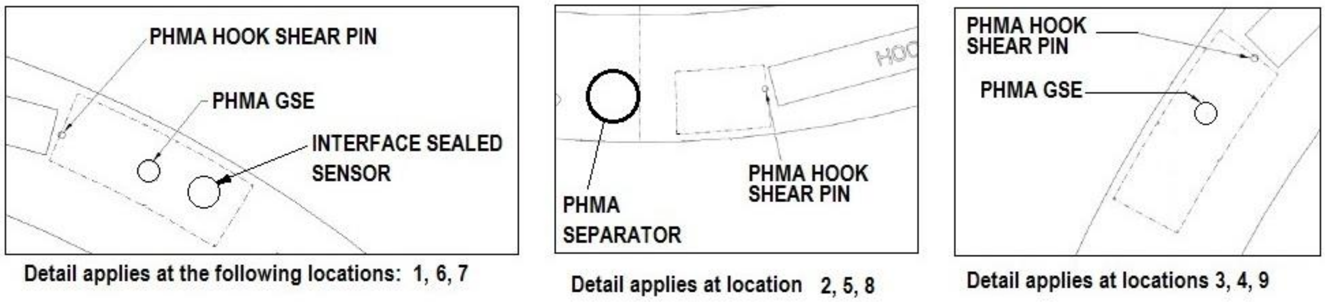

**NOTES:**

- Boxed angular dimensions are shown as Basic Dimensions that illustrate the theoretical construction lines. No dimensional tolerances are to be applied to the Basic Dimensions.
- Separation systems are retracted below the HCS mating plane prior to closure of HCS interface.

**FIGURE 4.2.1.3.7-2: HCS INTERFACE – AXIAL VIEW**


6X DESIGNATED STRIKER AREAS FOR HCS SENSORS AND SEPARATORS
LINE OF ANDROGYNY
LINE OF SYMMETRY
58° ±20"
62° ±20"
28° ±20"
32° ±20"
2° ±20"
2° ±20"
60° ±20"
62° ±20"
2° ±20"
1
2
3
4
5
6
7
8
9
Ø 1420 +0.77 * -0.22 **
Ø 1410 +1.00 ** -1.22 **
Ø 1330 +1.00 ** -1.57 *
Ø 1255 +0.65 ** -0.50 *
REF
HCS COMPONENT STRIKER ZONE
9° ± 30"
5° ± 30"
B
B
Reference Zones 1, 3, 4, 6, 7, 9
Reference Zones 2, 5, 8
1 +0.12 -0.06
HCS MATING PLANE
SECTION B - B

(Page 1 of 2)

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NOTES:
1. Hard capture System features in striker zones as noted in detail view shown above
2. Reference Figure 4.2.1.3-2 HCS Component Interface Definition for PHMA/IDA GSE lifting points and Interface Sealed locations.
3. PHMA Hook shear Pin feature only in 2 locations 2 and 8 (view not shown for simplicity)

**FIGURE 4.2.1.3.7-3: HCS INTERFACE – AXIAL VIEW**

The IDA has a 1553 bus termination switch and striker on the Flight Releasable Attachment Mechanism (FRAM) Plug connector that corresponds to a matching bus termination striker and switch on the VV FRAM Receptacle connector, as specified in SLZ29101649, Specification Control Drawing, Umbilical EMA, Figure 3-9 and Figure 3-12 and as shown in Figure 4.2.1.3.7-4 IDA Bus Termination Switch and Striker.

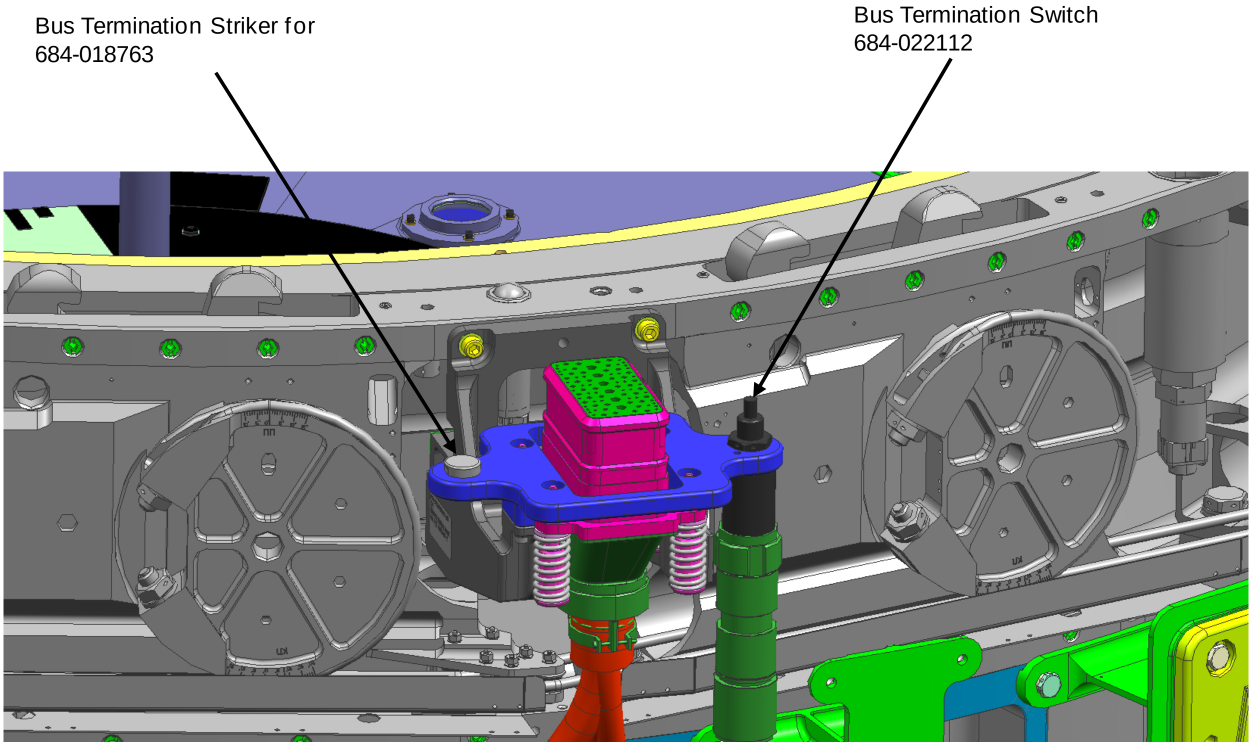



**FIGURE 4.2.1.3.7-4: IDA BUS TERMINATION SWITCH AND STRIKER**

The IDA has a 1553 bus termination switch and striker on the FRAM Receptacle connector that corresponds to a matching bus termination striker and switch on the VV FRAM Plug connector, as specified in SLZ29101649, Figure 3-17 and Figure 3-18.

The IDA has three soft capture sensors and three reserved soft capture sensor striker areas at the VV to IDA interface, to provide sensing of the VV SCS contact with IDA with the locations defined in Figure 4.2.1.3.7-5 IDA Soft Capture Sensor Locations.

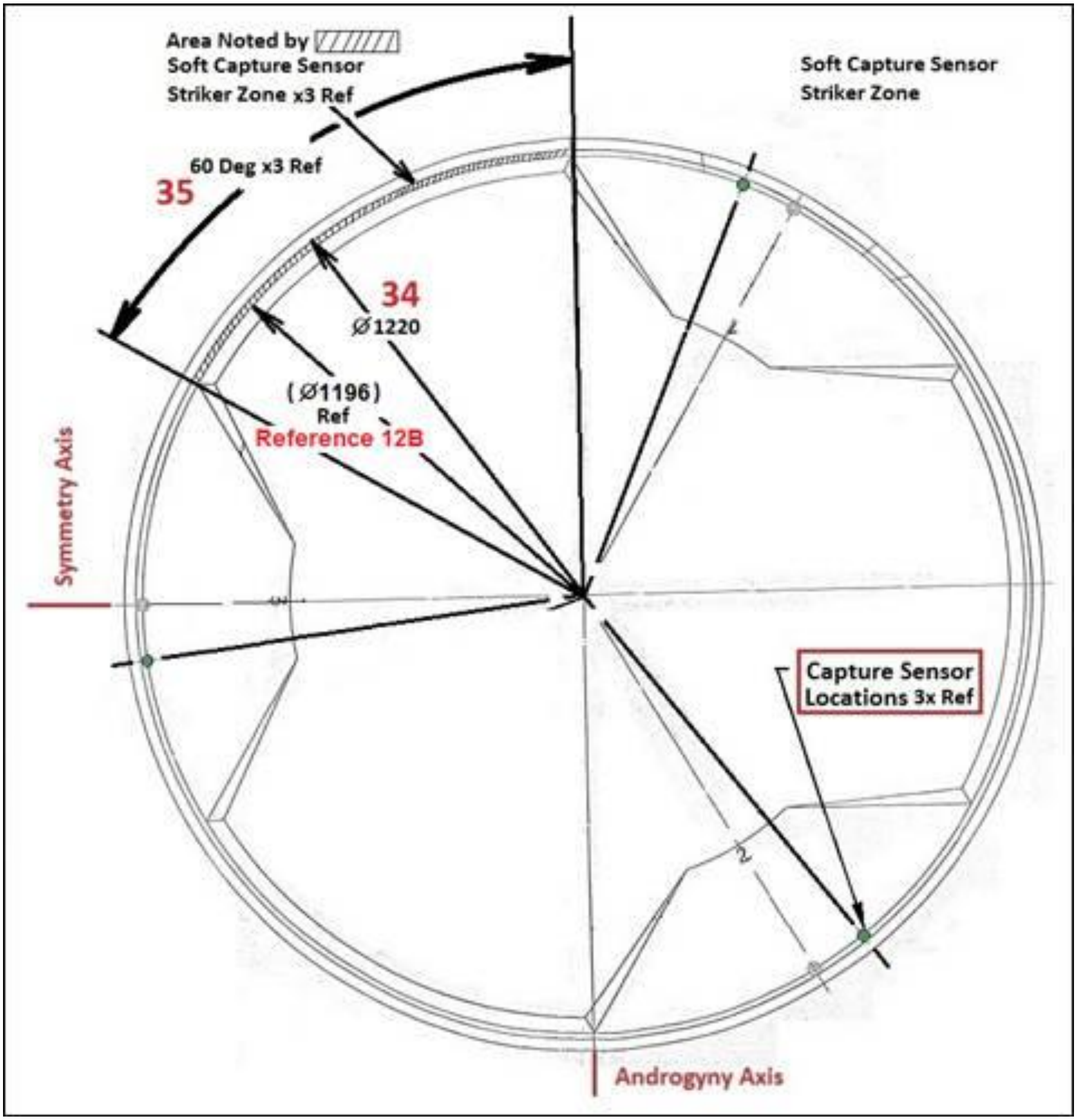



**FIGURE 4.2.1.3.7-5: IDA SOFT CAPTURE SENSOR LOCATIONS**

### 4.2.1.4 IDA Interface Component Materials

At the docking interface, during docking operations and the post-docking phase, various types of events may occur, such as relative motion between mating components, contacts or impacts between mating parts, and/or preloading of mating structures. It is necessary to include the description of material characteristics so that the behavior of the components of interest can be predicted. Refer to Table 4.2.1.4-1: IDA I/F Component Materials.

**TABLE 4.2.1.4-1: IDA I/F COMPONENT MATERIALS**

| Component | Material | Material Specification | Coating | Coating Specification | Finish (µ-in) |
|---|---|---|---|---|---|
| Guide Petal | 6061-T651 Aluminum | AMS 4027 | Hard Anodize | MIL-A-8625, Type III | 32 |
| SCS Narrow Ring | 7075-T7351 Aluminum | AMS 4078 | Hard Anodize | MIL-A-8625, Type III | 32 |
| Mechanical Latch Striker Plate | A286 CRES | AMS 5525, Cond. H1025 | Passivation | AMS 2700, Method 1, Class 1 | 125 |
| Plunger, Soft Capture Sensor | 6061-T651 Aluminum | AMS 4117 | Hard Anodize with PTFE | AMS 2482, Type I | 125 |
| Tunnel (HCS Mating Plane) | Сплав алюминия АМГ6 (Aluminum) | | Ан.Окс.нв | | 16 |
| Hard Capture Hook | Сплав титановый ВТ-14 (Titanium VT-14) | | ВНИИ НП-213, 8-15 мкм (micrometers) | | 50(1) |
| Guide Pin | Сталь (Steel) 03Х11Н10М2Т | | ВНИИ НП-230, 8-15 мкм (micrometers) | | 16 |
| Guide Pin Receptacle | Сталь (Steel) 03Х11Н10М2Т | | ВНИИ НП-230, 8-15 мкм (micrometers) | | 32 |
| Umbillical Connector | 6061-T6511 Aluminum | QQ-A-200/8 or QQ-A-250/11 | Electroless Nickel Plate (plug and receptacle) and Dry Film Lubricant (receptacle only) | MIL-C-26074, Class 4, .0015-.0018in thick and MIL-L-46010, .0002-.0005in thick | |
| EMA Separator, Pusher | Stainless Steel | AMS5659 | Passivate<br>Heat Treat | GPS3000-1 CLASS 1<br>AMS 2759/3, Condition H1075 | 125 |

Note:

(1) Surface finish 1.25 micron (equivalent to 50 µ-in) for structural hooks as defined in IDSS IDD.

### 4.2.1.5 Loads

#### 4.2.1.5.1 Soft Capture Docking Loads

During soft capture, the IDA is capable of performing docking operations under the soft capture docking loads as specified in Table 4.2.1.5.1-1 SCS Maximum Docking Loads, and Table 4.2.1.5.1-2 SCS Maximum Component Loads.

### TABLE 4.2.1.5.1-1: SCS MAXIMUM DOCKING LOADS

| | |
|---|---|
| **Tension** | **877 lbf (3900 N)** |
| **Compression (Static)** | **787 lbf (3500 N)** |
| **Compression (Dynamic, < 0.1 sec)** | **1461 lbf (6500 N)** |
| **Shear** | **719 lbf (3200 N)** |
| **Torsion** | **1106 lbf-ft (1500 N-m)** |
| **Bending** | **2065 lbf-ft (2800 N-m)** |

### TABLE 4.2.1.5.1-2: SCS MAXIMUM COMPONENT LOADS

| | | | | |
|---|---|---|---|---|
| **Mechanical Latch Striker Tension (7)** | **674 lbf (3000 N)** | | | |
| **Petal Edge Length** | **0%** | **10%** | **60%** | **80%** |
| **Petal Contact Loads** | **787 lbf (3500 N)** | **517 lbf (2300 N)** | **517 lbf (2300 N)** | **225 lbf (1000 N)** |

Notes for Table 4.2.1.5.1-1 and Table 4.2.1.5.1-2:

- Values are design limit loads.
- Values in Table.4.2.1.5.1-1 and Table 4.2.1.5.1-2 are defined at the center of the SCS mating plane. Refer to Figure 4.2.1.2.2-1 SCS Capture Ring Dimensions.
- Values are 3σ maxima and are to be applied simultaneously, as provided in Table 4.2.1.5.1-1 and such that the component values in Table 4.2.1.5.1-2 are not exceeded.
- Shear and bending loads are vector sums in the plane of the SCS mating plane. Refer to Figure 4.2.1.2.2-1 SCS Capture Ring Dimensions.
- The passive soft capture interface meets all of its functional and performance requirements during and after exposure to loads defined in Table 4.2.1.5.1-1 and Table 4.2.1.5.1-2.
- The petal contact load is applied to the edge of the petal or the outer face of the petal. The load can only be applied to the petal edge from the root of the petal to 80% of the petal length. The load can only be applied to the outer face from the root of the petal to 60% of the petal length from the base.
- Load vector oriented along docking axis. For striker surface canted 45 degrees to the docking axis, the load corresponds to 953 lbf applied perpendicular to the striker surface and 674 lbf load vector in the tunnel radial direction.

#### 4.2.1.5.2 Hard Capture Mated Loads

The IDA is capable of withstanding mated loads at the VV to IDA Interface Plane as defined in Table 4.2.1.5.2-1: HCS Maximum Mated Loads and Table 4.2.1.5.2-2: HCS Mated Load Sets.

**TABLE 4.2.1.5.2-1: HCS MAXIMUM MATED LOADS**

| | Mated ISS |
|---|---|
| Maximum Design Pressure | 1 100 hPa |
| Seal Closure Force | 97 150 N |
| Compressive Axial Load | 17 700 N |
| Tensile Axial Load | 17 700 N |
| Shear Load | 16 700 N |
| Torsion Moment | 15 000 Nm |
| Bending Moment | 68 700 Nm |

**TABLE 4.2.1.5.2-2: HCS MATED LOAD SETS**

| Load Set | Case 1 | Case 2 | Case 3 |
|---|---|---|---|
| Design Pressure | 1 100 hPa | 1 100 hPa | 1 100 hPa |
| Seal Closure Force | 97 150 N | 97 150 N | 97 150 N |
| Compressive Axial | 5 000 N | 17 700 N | 13 700 N |
| Tensile Axial Load | 5 000 N | 17 700 N | 13 700 N |
| Shear Load | 5 000 N | 14 800 N | 16 700 N |
| Torsion Moment | 15 000 Nm | 15 000 Nm | 15 000 Nm |
| Bending Moment | 65 300 Nm | 39 200 Nm | 68 700 Nm |

*Notes for Table 4.2.1.5.2-2:*

a) Values are design limit loads.
b) Hard capture hook preload and tunnel stiffness are such that, when under external loading within limits, there remains metal-to-metal contact in the local vicinity of the hooks.
c) Shear loads may be applied in any direction in the HCS mating plane.
d) Bending moment may be applied about any axis in the HCS mating plane.
e) The outer seal bead is to be used for all pressure calculations.
f) Load cases are defined in *Table 4.2.1.5.2-2: HCS Mated Load Sets and Table* 4.2.1.5.2-1: HCS Maximum Mated Loads is a summary of the maximum loads.
g) Case descriptions:
   i) Case 1 – Attitude control by Orbiter-sized vehicle, combined with crew activity.
   ii) Case 2 – Interface loads due to ISS segment berthing.
   iii) Case 3 – Orbiter-sized vehicle translation with payload attached to ODS.

#### 4.2.1.6 Leak Rate

At the VV to IDA interface, the IDA has an atmospheric seal leakage rate as specified below.

The leak rates assume a pressure internal to the NDSB1 vestibule of 14.7 psia and an external pressure of 7.5E-14 Torr (1.0E-11 Pascal). The leak rate at the host interface is less than 0.0008 lbm dry air/day. The leak rate at the NDS-to-IDA interface is less than 0.0025 lbm dry air/day.

When calculating the mated leak rate for a combined mated NDS stack, the NDSB1-to-IDA leak rate should only be accounted for once.

The following assumption is made:

The leak rate at the NDSB1-to-IDA interface assumes 12 hooks fully closed.

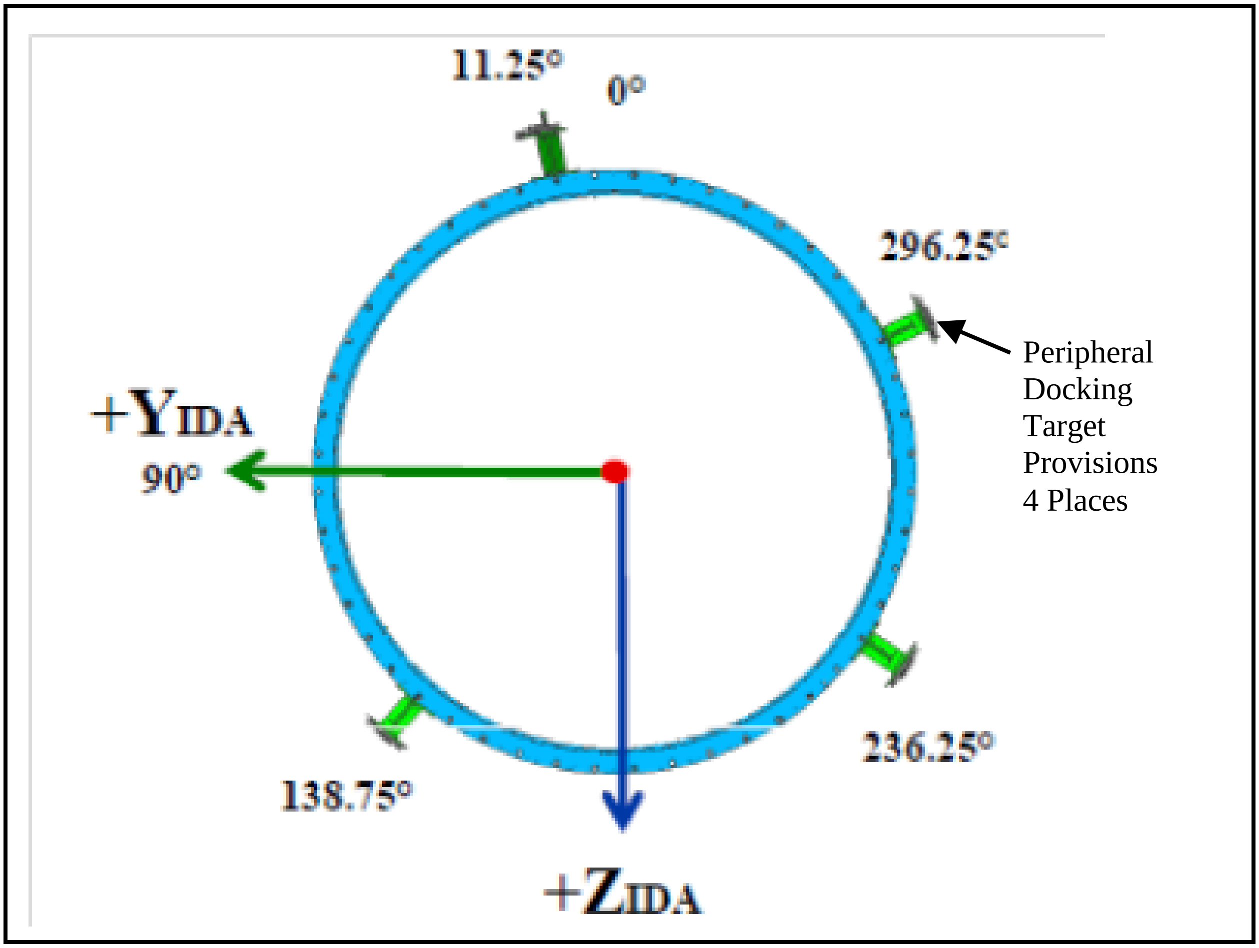
#### 4.2.1.7 GN&C Aids

The IDA has Perimeter Reflector Target (PRT) interfaces, consisting of one Planar Retro Reflector and two Hemispherical Retro Reflectors, for laser ranging from equipment on an approaching VV as shown in Figure 4.2.1.7-2 Configuration of Perimeter Reflector Targets on IDA.

The IDA has Perimeter Reflector Targets with the coverage angles as defined in JSC 66380, section 3.2.3.1.5.

The IDA has no structural obstructions within +90 degrees to -90 degrees of the bore sight of the reflective elements of the PRTs as shown in Figure 4.2.1.7-2.

The IDA provides four provisional locations for ground-installed Peripheral Docking Targets that are visible to a VV as it approaches for final guidance and navigation within 30 m of the docking interface to ISS at Node 2 Forward port, as shown in Figure 4.2.1.7-1 Peripheral Docking Target Provisions on IDA.




Note: The origin (0°) of the angular position of the Peripheral Docking Target Provisions is on the –$Z_{IDA}$-axis.

**FIGURE 4.2.1.7-1: PERIPHERAL DOCKING TARGET PROVISIONS ON IDA**

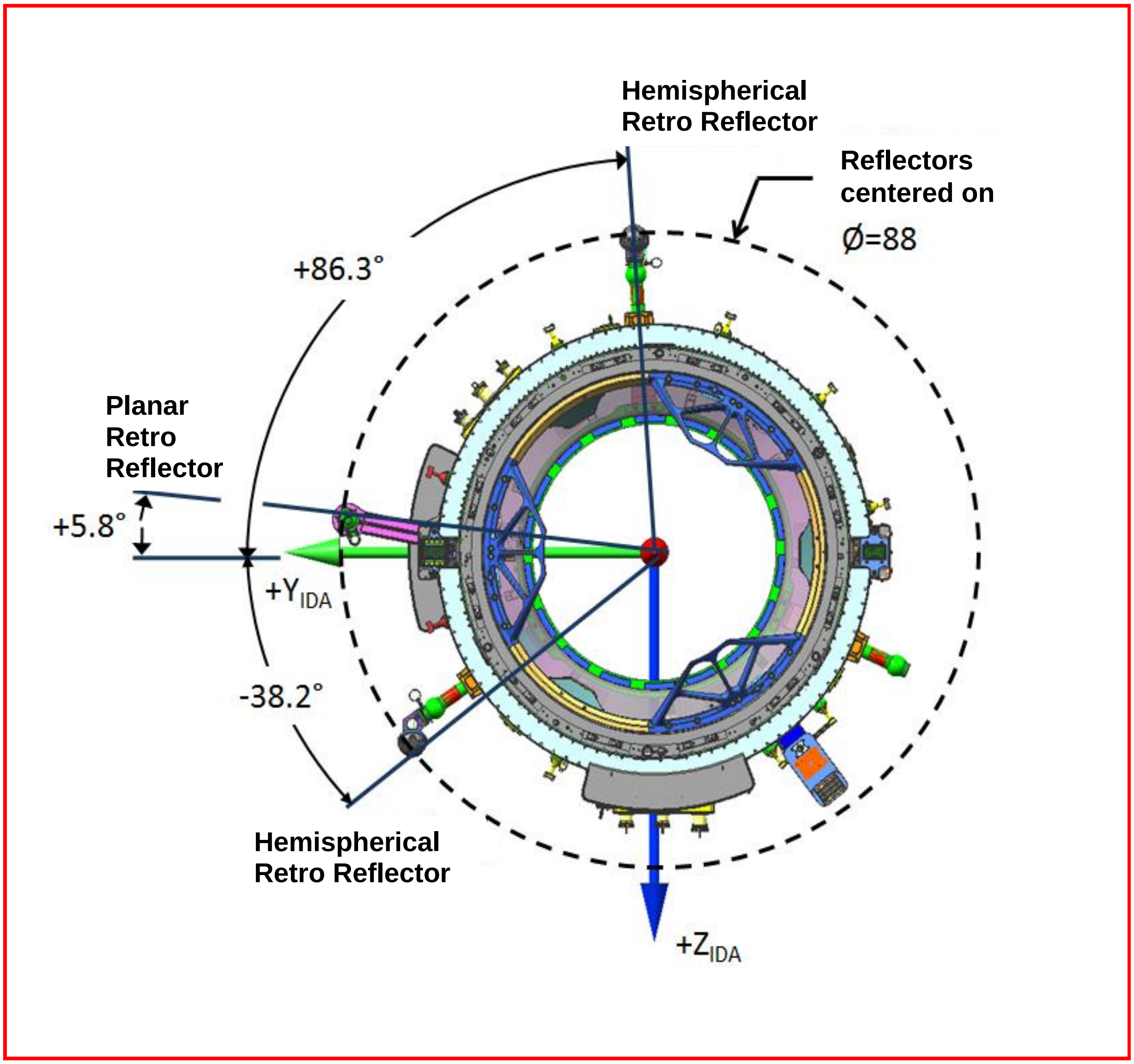



**FIGURE 4.2.1.7−2: CONFIGURATION OF PERIMETER REFLECTOR TARGETS ON IDA**

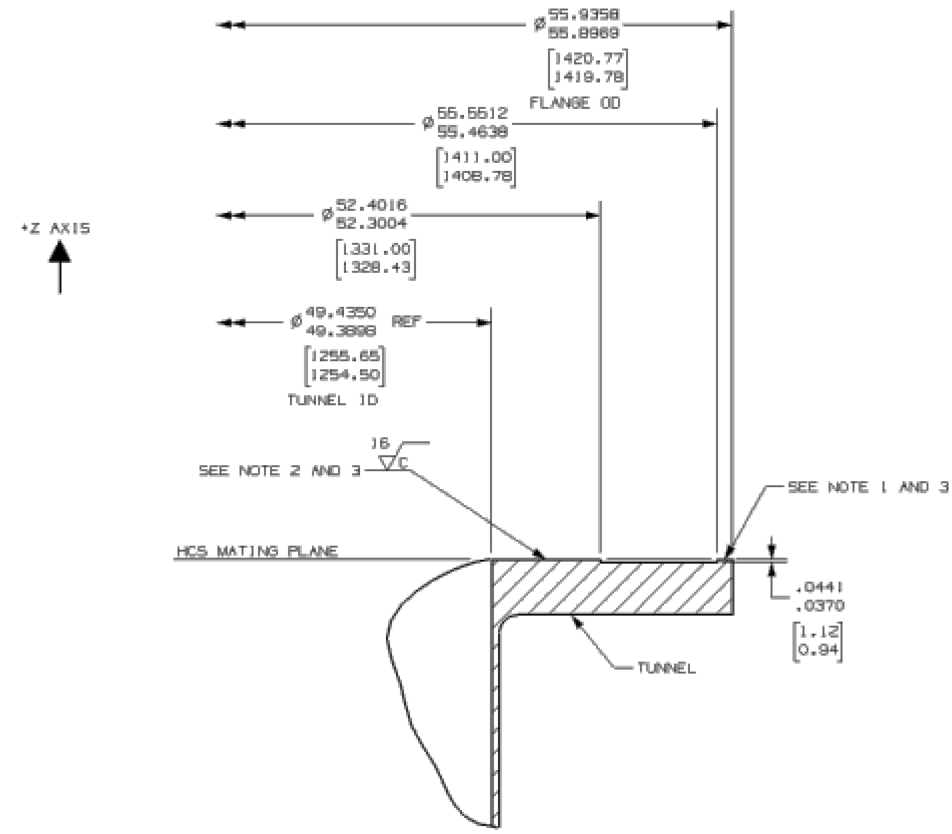
## 4.2.2 Electrical Interfaces

### 4.2.2.1 Electrical Bonding

#### 4.2.2.1.1 Electrical Bonding at Hard Capture (Class-R – Protection Against Radio Frequency Emission)

At the VV to IDA hard capture interface, the IDA has a Class R electrical bond to protect against radio frequency emissions, as specified below.

The IDA is protected against RF emissions by maintaining a NASA-STD-4003 Class R bond at the hard capture IDA-to-NDSB1 interface. There are three Class R bond paths between the two mated systems. The first bond path is through the metal-to-metal contact on the seal interface between the two mated systems. Refer to Figure 4.2.2.1.1-1 Bonding Details. The second bond path is through the electrical umbilical connector backshell for the plug connector. The third path is through the electrical umbilical connector backshell for the receptacle connector. Refer to 4.1.2.1.1.1-1: NDSB1 Electrical Bonding.




Notes:

1. Chemical conversion coat per MIL-DTL-5541, Type 1, Class 3. Surface finish applicable prior to chemical conversion coating.
2. Anodize per MIL-A-8625, Type II, Class 1, and using hot water seal. Surface finish applicable prior to anodize.
3. Global surface flatness not to exceed 0.010 [0.25] on indicated surfaces. Local surface flatness not to exceed 0.003 [0.08] across any area on indicated annular surfaces for an arbitrary 30° arc.

**FIGURE 4.2.2.1.1-1: BONDING DETAILS**

#### 4.2.2.1.1.1 Electrical Bonding at Hard Capture (Class-H Protection against Electrical Faults)

At the VV to IDA hard capture interface, the IDA has a Class H electrical bond to protect against electrical faults.

#### 4.2.2.1.2 Electrical Bonding at Soft Capture (Class-S – Protection against Electrostatic Discharge)

At the VV to IDA soft capture interface, the IDA has a Class S electrical bond to protect against static charge buildup.

### 4.2.3 Resource Transfer

The IDA provides automated blind electrical mating to the electrical connectors (power, commands and data) at the VV to IDA interface during the Hard Mate phase of the HV docking operation.

#### 4.2.3.1 Power Transfer and Command and Data Handling Transfer Umbilical

The IDA has an Umbilical Mated Loopback feature in each FRAM connector at the VV to IDA interface to provide a return electrical path for a mated VV to ensure electrical connections are engaged.

The IDA has SSQ 22680 FRAM-type electrical connectors (power and data) that are external to the pressure seals at the VV to IDA interface as defined below.

As shown in Figure 4.2.1.3-1, there are two umbilical connectors for power/data transfer. Each connector is a SSQ22680 FRAM-type connector that contains both power and data in the same connector shell. Separate power and data cable bundles are routed to the connector, and then combined in the connector backshell. Maximum possible separation is maintained inside the connector. The connector body is the only shared volume where these two different EMC classes are combined. Refer to JSC-65842, EEE Requirements Document, for the exception allowing two different EMC classes to reside in the same connector. Table 4.2.3.1-1, IDA TO HV INTERFACE (SYS A) – J35 and Table 4.2.3.1-2, IDA TO VV INTERFACE (SYS B) – P35 shows the pinouts of the FRAM-type umbilical connector.

# TABLE 4.2.3.1-1: IDA TO VV INTERFACE (SYS A) – J35

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| IDA CONN ID: | | | J35 | | | | |
| IDA CONN PART NO: | | | SSQ22680-022 | | | | |
| NDSB1 CONN ID: | | | P35 | | | | |
| NDSB1 CONN PART NO: | | | SSQ22680-021 | | | | |
| EMC CLASS | PIN FUNCT | PIN NO. | WIRE GA | IDA FUNCTION (J35) | NDS FUNCTION (P35) | NOTES | MISC |
| EO | PWR | 42 | 8 | ISS TO VV 120VDC SYSA PWR | 120VDC PWR1 SYSA | | |
| EO | RTN | 43 | 8 | ISS TO VV 120VDC SYSA RTN | 120VDC PWR1 RTN SYSA | | |
| HO | PWR | 44 | 8 | ISS TO VV 28VDC SYSA SPARE PWR | 28VDC PWR2 SYSA | 1 | |
| HO | RTN | 45 | 8 | ISS TO VV 28VDC SYSA SPARE RTN | 28VDC PWR2 RTN SYSA | 1 | |
| EO | GND | 46 | 8 | IDA GROUND SAFETY WIRE SYSA | GROUND SAFETY WIRE SYSA | | |
| RF | SIG | 13 | 22 | ISS TO VV 100BASETX-1 TX SIG | 100BASETX-1 RX P | | |
| RF | RTN | 27 | 22 | ISS TO VV 100BASETX-1 TX RTN | 100BASETX-1 RX N | | |
| RF | SIG | 86 | 22 | ISS FROM VV 100BASETX-1 RX SIG | 100BASETX-1 TX P | | |
| RF | RTN | 72 | 22 | ISS FROM VV 100BASETX-1 RX RTN | 100BASETX-1 TX N | | |
| RF | SIG | 25 | 22 | IDA TO VV 1553 ORB-X-1 (A) SIG | SYSA 1553 LB ORB-X-1 P | 3 | |
| RF | RTN | 38 | 22 | IDA TO VV 1553 ORB-X-1 (A) RTN | SYSA 1553 LB ORB-X-1 N | 3 | |
| RF | SIG | 70 | 22 | IDA TO VV 1553 ORB-X-2 (A) SIG | SYSA 1553 LB ORB-X-2 P | 3 | |
| RF | RTN | 57 | 22 | IDA TO VV 1553 ORB-X-2 (A) RTN | SYSA 1553 LB ORB-X-2 N | 3 | |
| HO | SIG | 21 | 22 | IDA VV I/F RECEPTACLE SHORT TO PIN 34 SIG | SYSA UMB PLUG LOOPBACK P | | |
| HO | RTN | 34 | 22 | IDA VV I/F RECEPTACLE SHORT TO PIN 21 RTN | SYSA UMB PLUG LOOPBACK N | | |
| HO | SIG | 53 | 22 | IDA SPARE SYSA VV I/F RECEPTACLE LOOPBACK SIG | SHORT TO PIN 66 | 2 | |
| HO | RTN | 66 | 22 | IDA SPARE SYSA VV I/F RECEPTACLE LOOPBACK RTN | SHORT TO PIN 53 | 2 | |
| RF | SIG | 87 | 22 | ISS TO VV 100BASETX-2 TX SIG | 100BASETX-2 RX P | | |
| RF | RTN | 88 | 22 | ISS TO VV 100BASETX-2 TX RTN | 100BASETX-2 RX N | | |
| HO | SIG | 1 | 22 | ISS-ICP HOOK GANG1 OP VV CMD SIG | HOOK GANG1 OP VV CMD P | | |
| HO | RTN | 6 | 22 | ISS-ICP HOOK GANG1 OP VV CMD RTN | HOOK GANG1 OP VV CMD N | | |
| HO | SIG | 74 | 22 | ISS-ICP HOOK GANG1 CL VV CMD SIG | HOOK GANG1 CL VV CMD P | | |
| HO | RTN | 75 | 22 | ISS-ICP HOOK GANG1 CL VV CMD RTN | HOOK GANG1 CL VV CMD N | | |
| HO | SIG | 3 | 22 | ISS-ICP TO VV MON HOOK GANG1A/B OP MTR POS SIG | HOOK GANG1A/B OP MTR POS P | | |
| HO | RTN | 4 | 22 | ISS-ICP TO VV MON HOOK GANG1A/B OP MTR POS RTN | HOOK GANG1A/B OP MTR POS N | | |
| HO | SIG | 76 | 22 | ISS-ICP TO VV MON HOOK GANG1A/B CL MTR POS SIG | HOOK GANG1A/B CL MTR POS P | | |
| HO | RTN | 77 | 22 | ISS-ICP TO VV MON HOOK GANG1A/B CL MTR POS RTN | HOOK GANG1A/B CL MTR POS N | | |
| RF | SIG | 14 | 22 | ISS FROM VV 100BASETX-2 RX SIG | 100BASETX-2 TX P | | |
| RF | RTN | 15 | 22 | ISS FROM VV 100BASETX-2 RX RTN | 100BASETX-2 TX N | | |
| N/A | N/A | 2 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 5 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 7 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 8 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 9 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 10 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 11 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 12 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 16 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 17 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 18 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 19 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 20 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 22 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 23 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 24 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 26 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 28 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 29 | N/A | NOT WIRED | NOT WIRED | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| IDA CONN ID: | | J35 | | | | | |
| IDA CONN PART NO: | | SSQ22680-022 | | | | | |
| NDSB1 CONN ID: | | P35 | | | | | |
| NDSB1 CONN PART NO: | | SSQ22680-021 | | | | | |

| EMC CLASS | PIN FUNCT | PIN NO. | WIRE GA | IDA FUNCTION (J35) | NDS FUNCTION (P35) | NOTES | MISC |
|---|---|---|---|---|---|---|---|
| N/A | N/A | 30 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 31 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 32 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 33 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 35 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 36 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 37 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 39 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 40 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 41 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 47 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 48 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 49 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 50 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 51 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 52 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 54 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 55 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 56 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 58 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 59 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 60 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 61 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 62 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 63 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 64 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 65 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 67 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 68 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 69 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 71 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 73 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 78 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 79 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 80 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 81 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 82 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 83 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 84 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 85 | N/A | NOT WIRED | NOT WIRED | | |

Note: (1) SPARE WIRING TO STOWED IDA EVA CABLE CONNECTOR.
(2) SPARE WIRING TO IDA EVA CONNECTOR PANEL (J2).
(3) FOR IDA1 (on PMA2), X = N2.
FOR IDA2 (on PMA3), X = HAB

# TABLE 4.2.3.1-2: IDA TO VV INTERFACE (SYS B) – P35

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| IDA CONN ID: | P35 | | | | | | |
| IDA CONN PART NO: | SSQ22680-021 | | | | | | |
| NDSB1 CONN ID: | J35 | | | | | | |
| NDSB1 CONN PART NO: | SSQ22680-022 | | | | | | |
| EMC CLASS | PIN FUNCT | PIN NO. | WIRE GA | IDA FUNCTION (P35) | NDS FUNCTION (J35) | NOTES | MISC |
| EO | PWR | 42 | 8 | ISS TO VV 120VDC SYSB PWR | 120VDC PWR1 SYSB | | |
| EO | RTN | 43 | 8 | ISS TO VV 120VDC SYSB RTN | 120VDC PWR1 RTN SYSB | | |
| HO | PWR | 44 | 8 | ISS TO VV 28VDC SYSB SPARE PWR | 28VDC PWR2 SYSB | 1 | |
| HO | RTN | 45 | 8 | ISS TO VV 28VDC SYSB SPARE RTN | 28VDC PWR2 RTN SYSB | 1 | |
| EO | GND | 46 | 8 | IDA GROUND SAFETY WIRE SYSB | GROUND SAFETY WIRE SYSB | | |
| RF | SIG | 13 | 22 | ISS FROM VV 100BASETX-3 RX SIG | 100BASETX-3 TX P | | |
| RF | RTN | 27 | 22 | ISS FROM HVVV 100BASETX-3 RX RTN | 100BASETX-3 TX N | | |
| RF | SIG | 86 | 22 | ISS TO VV 100BASETX-3 TX SIG | 100BASETX-3 RX P | | |
| RF | RTN | 72 | 22 | ISS TO VV 100BASETX-3 TX RTN | 100BASETX-3 RX N | | |
| RF | SIG | 25 | 22 | IDA TO VV 1553 ORB-X-1 (B) SIG | SYSB 1553 LB ORB-X-1 P | 3 | |
| RF | RTN | 38 | 22 | IDA TO VV 1553 ORB-X-1 (B) RTN | SYSB 1553 LB ORB-X-1 N | 3 | |
| RF | SIG | 70 | 22 | IDA TO VV 1553 ORB-X-2 (B) SIG | SYSB 1553 LB ORB-X-2 P | 3 | |
| RF | RTN | 57 | 22 | IDA TO VV 1553 ORB-X-2 (B) RTN | SYSB 1553 LB ORB-X-2 N | 3 | |
| HO | SIG | 21 | 22 | IDA SPARE SYSB VV I/F PLUG LOOPBACK SIG | SHORT TO PIN 34 | 2 | |
| HO | RTN | 34 | 22 | IDA SPARE SYSB VV I/F PLUG LOOPBACK RTN | SHORT TO PIN 21 | 2 | |
| HO | SIG | 53 | 22 | IDA VV I/F PLUG SHORT TO PIN 66 SIG | SYSB UMB PLUG LOOPBACK P | | |
| HO | RTN | 66 | 22 | IDA VV I/F PLUG SHORT TO PIN 53 RTN | SYSB UMB PLUG LOOPBACK N | | |
| RF | SIG | 87 | 22 | ISS FROM VV 100BASETX-4 RX SIG | 100BASETX-4 TX P | | |
| RF | RTN | 88 | 22 | ISS FROM VV 100BASETX-4 RX RTN | 100BASETX-4 TX N | | |
| HO | SIG | 1 | 22 | ISS-ICP HOOK GANG2 OP VV CMD SIG | HOOK GANG2 OP VV CMD P | | |
| HO | RTN | 6 | 22 | ISS-ICP HOOK GANG2 OP HVVV CMD RTN | HOOK GANG2 OP VV CMD N | | |
| HO | SIG | 74 | 22 | ISS-ICP HOOK GANG2 CL VV CMD SIG | HOOK GANG2 CL VV CMD P | | |
| HO | RTN | 75 | 22 | ISS-ICP HOOK GANG2 CL VV CMD RTN | HOOK GANG2 CL VV CMD N | | |
| HO | SIG | 3 | 22 | ISS-ICP TO VV MON HOOK GANG2A/B OP MTR POS SIG | HOOK GANG2A/B OP MTR POS P | | |
| HO | RTN | 4 | 22 | ISS-ICP TO VV MON HOOK GANG2A/B OP MTR POS RTN | HOOK GANG2A/B OP MTR POS N | | |
| HO | SIG | 76 | 22 | ISS-ICP TO VV MON HOOK GANG2A/B CL MTR POS SIG | HOOK GANG2A/B CL MTR POS P | | |
| HO | RTN | 77 | 22 | ISS-ICP TO VV MON HOOK GANG2A/B CL MTR POS RTN | HOOK GANG2A/B CL MTR POS N | | |
| RF | SIG | 14 | 22 | ISS TO VV 100BASETX-4 TX SIG | 100BASETX-4 RX P | | |
| RF | RTN | 15 | 22 | ISS TO VV 100BASETX-4 TX RTN | 100BASETX-4 RX N | | |
| N/A | N/A | 2 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 5 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 7 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 8 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 9 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 10 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 11 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 12 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 16 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 17 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 18 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 19 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 20 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 22 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 23 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 24 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 26 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 28 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 29 | N/A | NOT WIRED | NOT WIRED | | |

| IDA CONN ID: | P35 | | | | | | |
|---|---|---|---|---|---|---|---|
| IDA CONN PART NO: | SSQ22680-021 | | | | | | |
| NDSB1 CONN ID: | J35 | | | | | | |
| NDSB1 CONN PART NO: | SSQ22680-022 | | | | | | |
| EMC CLASS | PIN FUNCT | PIN NO. | WIRE GA | IDA FUNCTION (P35) | NDS FUNCTION (J35) | NOTES | MISC |
| N/A | N/A | 30 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 31 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 32 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 33 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 35 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 36 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 37 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 39 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 40 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 41 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 47 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 48 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 49 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 50 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 51 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 52 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 54 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 55 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 56 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 58 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 59 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 60 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 61 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 62 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 63 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 64 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 65 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 67 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 68 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 69 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 71 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 73 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 78 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 79 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 80 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 81 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 82 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 83 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 84 | N/A | NOT WIRED | NOT WIRED | | |
| N/A | N/A | 85 | N/A | NOT WIRED | NOT WIRED | | |

Note: (1) SPARE WIRING TO STOWED IDA EVA CABLE CONNECTOR.
(2) SPARE WIRING TO IDA EVA CONNECTOR PANEL (J8).
(3) FOR IDA1 (on PMA2), X = N2.
FOR IDA2 (on PMA3), X = HAB

The IDA has SSQ 22680 FRAM-type electrical connectors (power and data) at the VV to IDA interface as defined below and Figure 4.2.1.3-1.

The NDSB1 electrical power transfer between the two docked vehicles is not used by the NDSB1, but only transferred between the docked vehicles. Each connector has six #8 American Wire Gauge (AWG) pins, but utilizes only five wires, a maximum of four feet long, for power transfer. The pins on either side of the interface must be assigned to match the mating vehicle for the desired power transfer; this would allow transfer of two independent power circuits in a single connector.

The IDA has electrical connector pin assignments as specified in Tables 4.2.3.1-1 and 4.2.3.1-2.

The VV electrical connectors (power and data) are external to the pressure seals at the VV to IDA interface.

The VV to IDA interface design incorporates provisions for the mechanical connection of power and C&DH utilities during on-orbit installation. Location of IDA to VV electrical interface connectors are depicted in Figure 4.2.3.1-1, HV to IDA Electrical Interface Connectors. Associated interconnect utilities are shown in Figures 4.2.3.1.1-1 VV to IDA Electrical Interfaces on PMA 2 on NODE 2 Forward Port and 4.2.3.1.1-2, VV to IDA Electrical Interfaces on PMA 3 on NODE 2 Zenith Port

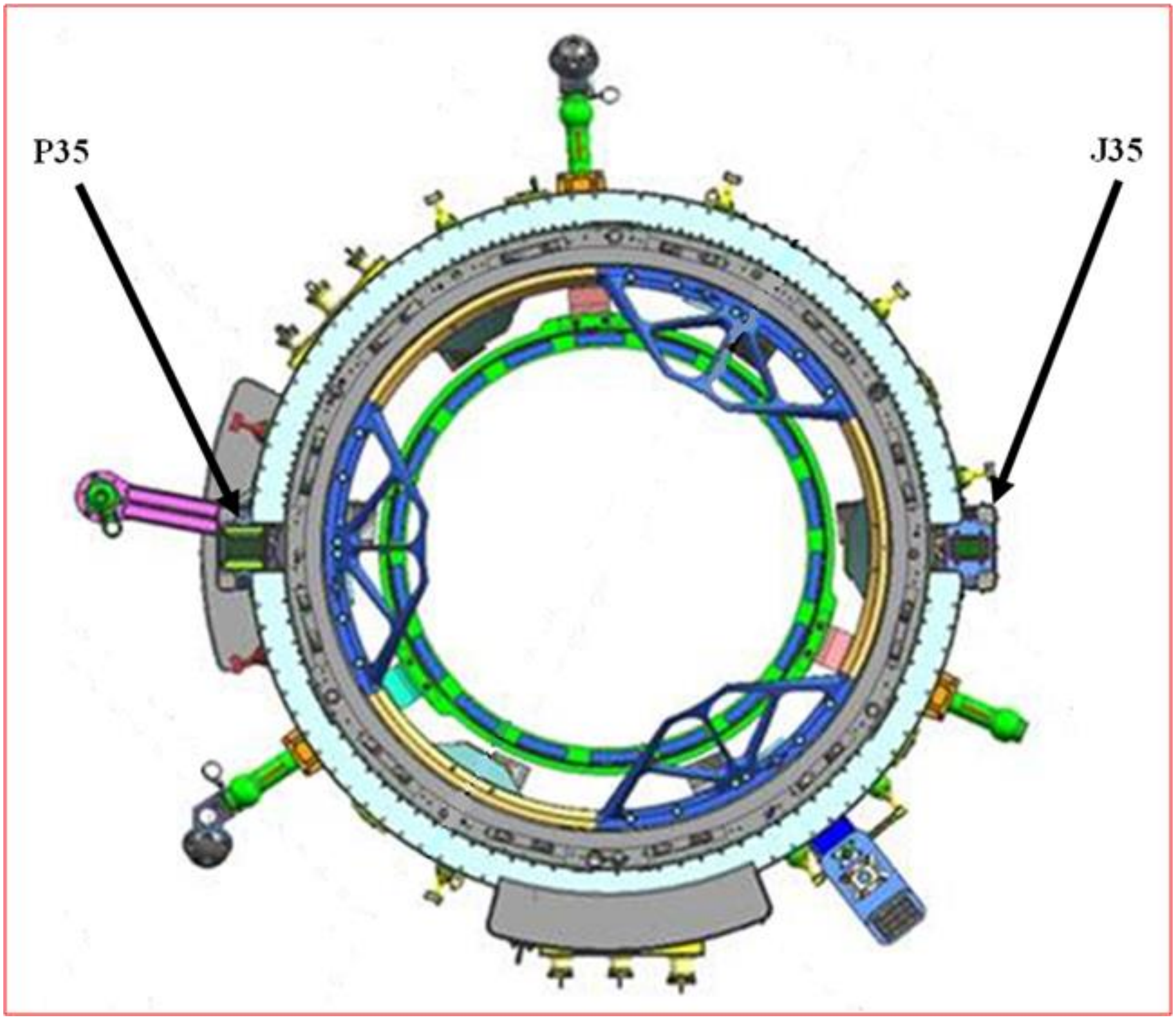



**FIGURE 4.2.3.1-1: IDA TO VV ELECTRICAL INTERFACE CONNECTORS**

#### 4.2.3.1.1 Power Transfer

The IDA transfers power as follows:

The NDSB1 electrical power transfer between the two docked vehicles is not used by the NDSB1, but only transferred between the docked vehicles. Each connector has six #8 AWG pins, but utilizes only five wires, a maximum of four feet long, for power transfer. The pins on either side of the interface must be assigned to match the mating vehicle for the desired power transfer; this would allow transfer of two independent power circuits in a single connector.

The IDA provides one (1) secondary 120 VDC primary power feed (receptacle for A-String) and one (1) secondary 120 VDC redundant power feed (plug for B-String) to the VV at the VV to IDA interface. The IDA power feeds for PMA 2 on Node 2 Forward Port are shown at VV to IDA electrical interface in Figure 4.2.3.1.1−1, VV to IDA Electrical Interfaces on PMA 2 on Node 2 Forward Port. The IDA power feeds for PMA 3 on Node 2 Zenith Port are shown at VV to IDA electrical interface in Figure 4.2.3.1.1−2, VV to IDA Electrical Interfaces on PMA 3 on Node 2 Zenith Port.

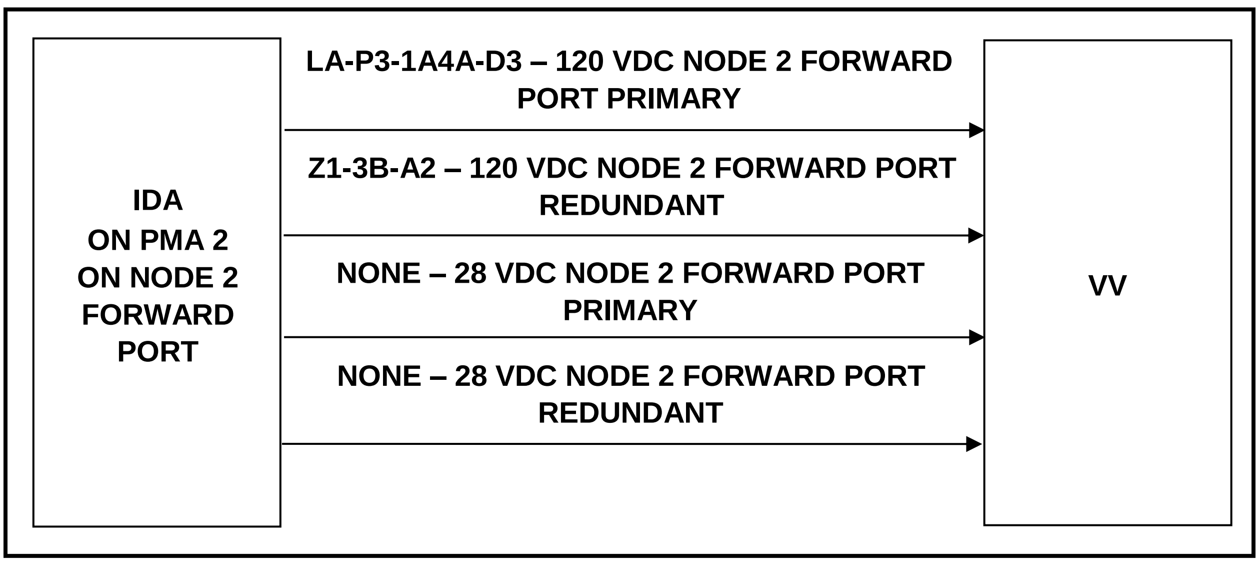



**FIGURE 4.2.3.1.1−1: VV TO IDA ELECTRICAL INTERFACES ON PMA 2 ON NODE 2 FORWARD PORT**

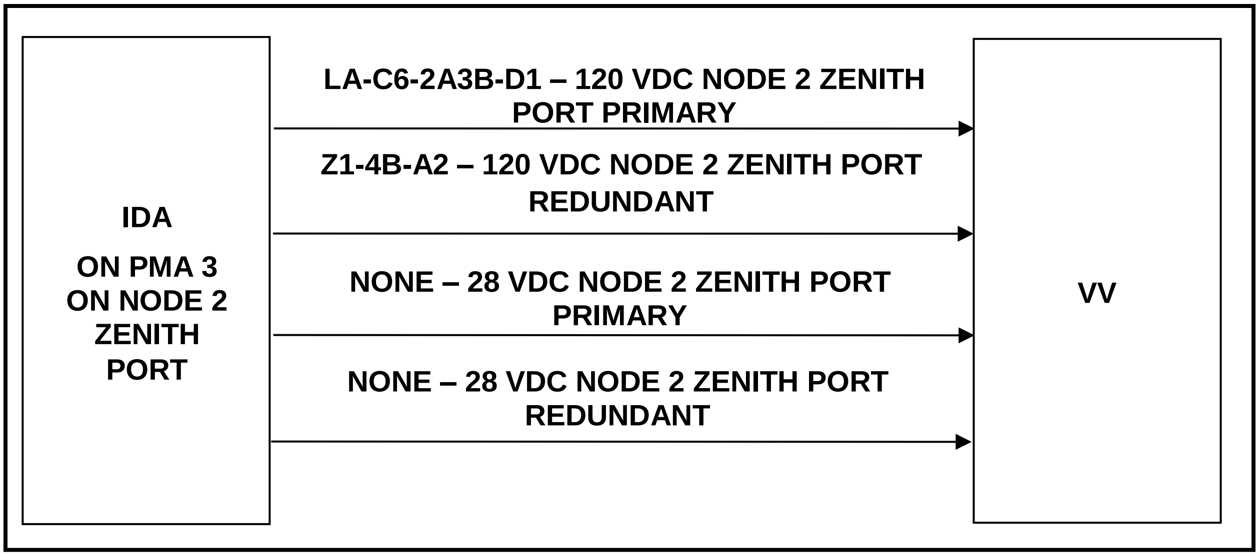



**FIGURE 4.2.3.1.1−2: VV TO IDA ELECTRICAL INTERFACES ON PMA 3 ON NODE 2 ZENITH PORT**

The IDA provides cabling for future use for one (1) 28 VDC primary power feed (receptacle for A-String) and one (1) 28 VDC redundant power feed (plug for B-String) to the VV at the VV interface. The IDA power feeds for PMA 2 on Node 2 Forward Port are shown at VV to IDA electrical interface in Figure 4.2.3.1.1−1. The IDA power feeds for PMA 3 on Node 2 Zenith Port are shown at VV to IDA electrical interface in Figure 4.2.3.1.1−3.

Note: There is no 28 VDC electrical power source for Visiting Vehicles on ISS. This was written for the future addition of a 28 VDC power source on ISS. Therefore, the electrical connectors to ISS must be capped and meets EVA requirements for engagement and disengagement.

#### 4.2.3.1.2 Power Quality

The IDA supplies secondary 120 VDC power quality to the VV at the VV to IDA interface in accordance with SSP 30482, Electric Power Specifications and Standards, Volume 1: EPS Electrical Performance Specifications, Interface B, with a Type VI Remote Power Controller Module (RPCM) with the following exceptions:

1. The minimum steady state voltage is 115 VDC
2. The minimum normal transient voltage is 97 VDC
3. The source impedance is defined in Figure 4.2.3.1.2-1, Modified Source Impedance Phase Limits, and Figure 4.2.3.1.2-2, Modified Source Impedance Magnitude Limit.

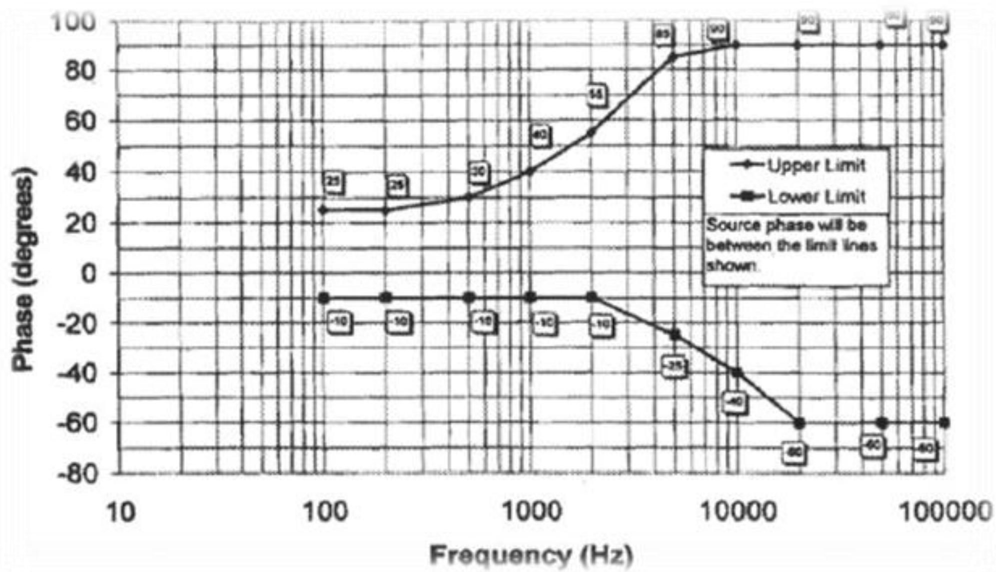



**FIGURE 4.2.3.1.2-1: MODIFIED SOURCE IMPEDANCE PHASE LIMITS**

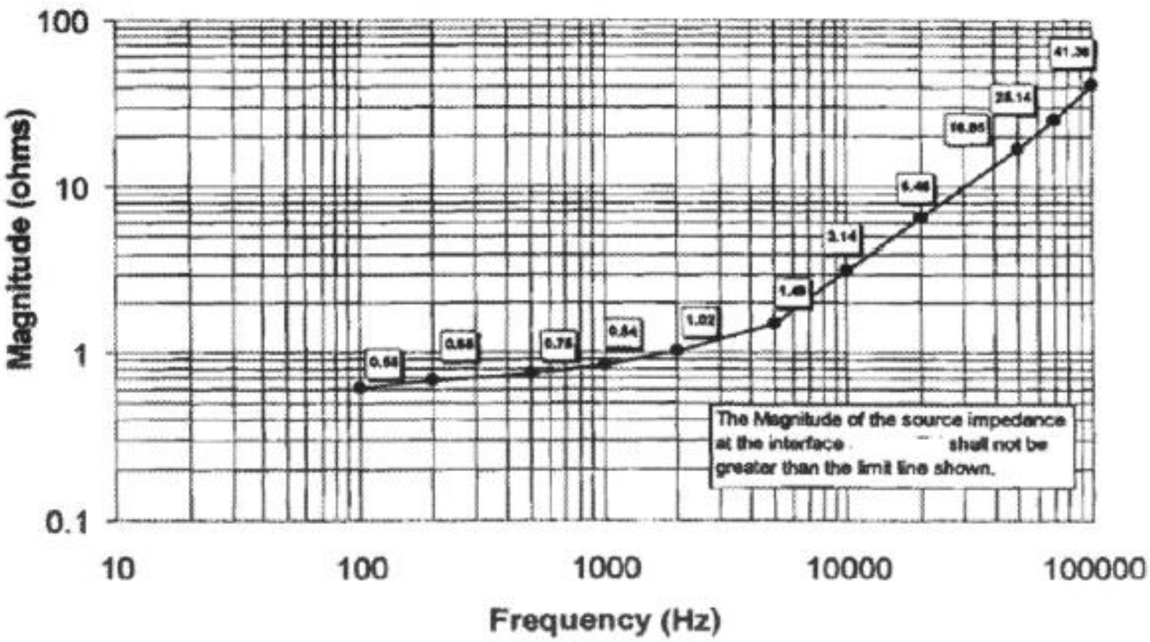



**FIGURE 4.2.3.1.2-2: MODIFIED SOURCE IMPEDANCE MAGNITUDE LIMIT**

At the VV to IDA interface, the IDA passes through steady state voltage over the operating current range within the envelope shown in Table 4.2.3.1.2-1, Electrical Interface Parameters – PMA 2 on Node 2 Forward Port and Table 4.2.3.1.2.-2, Electrical Interface Parameters – PMA 3 on Node 2 Zenith Port.

**TABLE 4.2.3.1.2-1: ELECTRICAL INTERFACE PARAMETERS – PMA 2 ON NODE 2 FORWARD PORT**

| Function | Circuit Name | Interface $V_{range}$ (Volts) | Operating Current (Amps) | Overcurrent Protection (Amps) | Minimum Steady State Wire Rating (Amps) |
|---|---|---|---|---|---|
| Node 2 Forward Port 120 VDC Primary Power | LA-1A4A-D3 | 115 to 126 | 25 | 27.5 to 30.0 | 30 |
| Node 2 Forward Port 120 VDC Redundant Power | Z1-3B-A2 | 115 to 126 | 25 | 27.5 to 30.0 | 30 |
| Node 2 Forward Port 28 VDC Primary Power | N/A | N/A | N/A | N/A | N/A |
| Node 2 Forward Port 28 VDC Redundant Power | N/A | N/A | N/A | N/A | N/A |

**TABLE 4.2.3.1.2-2: ELECTRICAL INTERFACE PARAMETERS – PMA 3 ON NODE 2 ZENITH PORT**

| Function | Circuit Name | Interface $V_{range}$ (Volts) | Operating Current (Amps) | Overcurrent Protection (Amps) | Minimum Steady State Wire Rating (Amps) |
|---|---|---|---|---|---|
| Node 2 Zenith Port 120 VDC Primary Power | LA-2A3B-D1 | 115 to 126 | 25 | 27.5 to 30.0 | 30 |
| Node 2 Zenith Port 120 VDC Redundant Power | Z1-4B-A2 | 115 to 126 | 25 | 27.5 to 30.0 | 30 |
| Node 2 Zenith Port 28 VDC Primary Power | N/A | N/A | N/A | N/A | N/A |
| Node 2 Zenith Port 28 VDC Redundant Power | N/A | N/A | N/A | N/A | N/A |

#### 4.2.3.1.3 Data Transfer

##### 4.2.3.1.3.1 Ethernet Cable Specification

The Ethernet Cables utilize American National Standards Institute (ANSI)/Telecommunications Industry Association (TIA)/Electronic Industry Alliance (EIA) 568B.2, 100 Ohm Twisted Pair Cabling Standards, Category 5e 100 ohm two-pair twisted cable for each Ethernet link.

##### 4.2.3.1.3.2 MIL-STD-1553 Cable Specification

The ISS provides from the ISS to the VV interface two dual redundant MIL-STD-1553B, Digital Time Division Command/Response Multiplex Data Bus.

#### 4.2.3.1.4 EME Effects

At the NDSB1 to IDA interface, the IDA meets the electromagnetic compatibility requirements in SSP 30243, Space Station Requirements for Electromagnetic Compatibility, paragraphs 3.2 through 3.6.

At the NDSB1 to IDA interface, the IDA meets the electromagnetic interference requirements in SSP 30237, paragraphs 3.2 and 3.3.

At the NDSB1 to IDA interface, the IDA meets the grounding requirements in SSP 30240, Space Station Grounding Requirements, section 3.0.

#### 4.2.3.2 Water Transfer

Reserved

#### 4.2.3.3 Fuel Transfer

Reserved

#### 4.2.3.4 Pressurant Transfer

Reserved

#### 4.2.3.5 Oxidizer Transfer

Reserved

#### 4.2.3.6 Intermodule Ventilation

Internal volume in the IDA is reserved at the ISS to IDA interface for the IDA Intermodule Ventilation (IMV) Duct. A representation of the duct is shown in Figures 4.2.3.6-1, IMV Duct, 4.2.3.6-2, Duct Coupling, and 4.2.3.6-3, Duct Details.

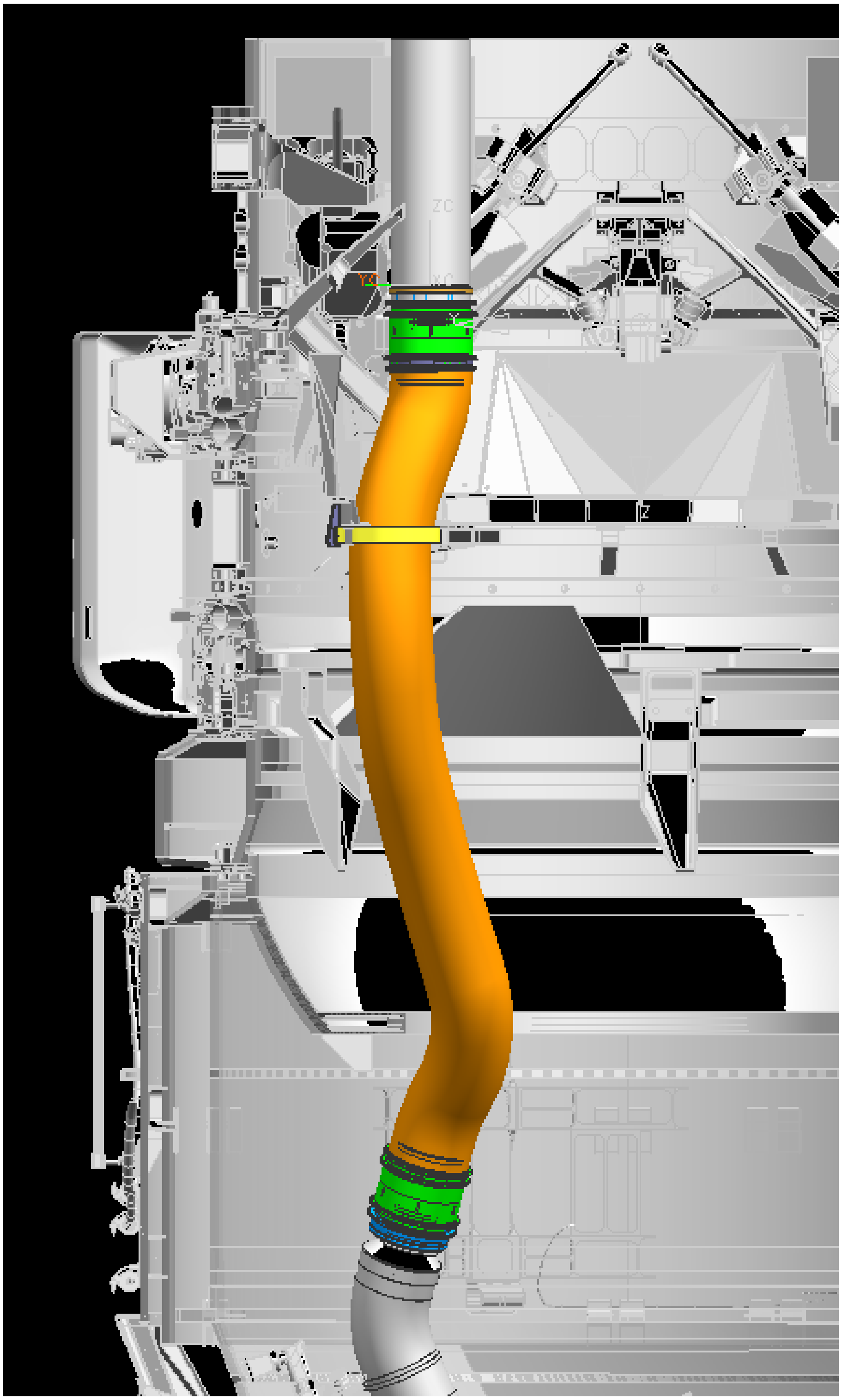


**FIGURE 4.2.3.6-1, IMV DUCT**

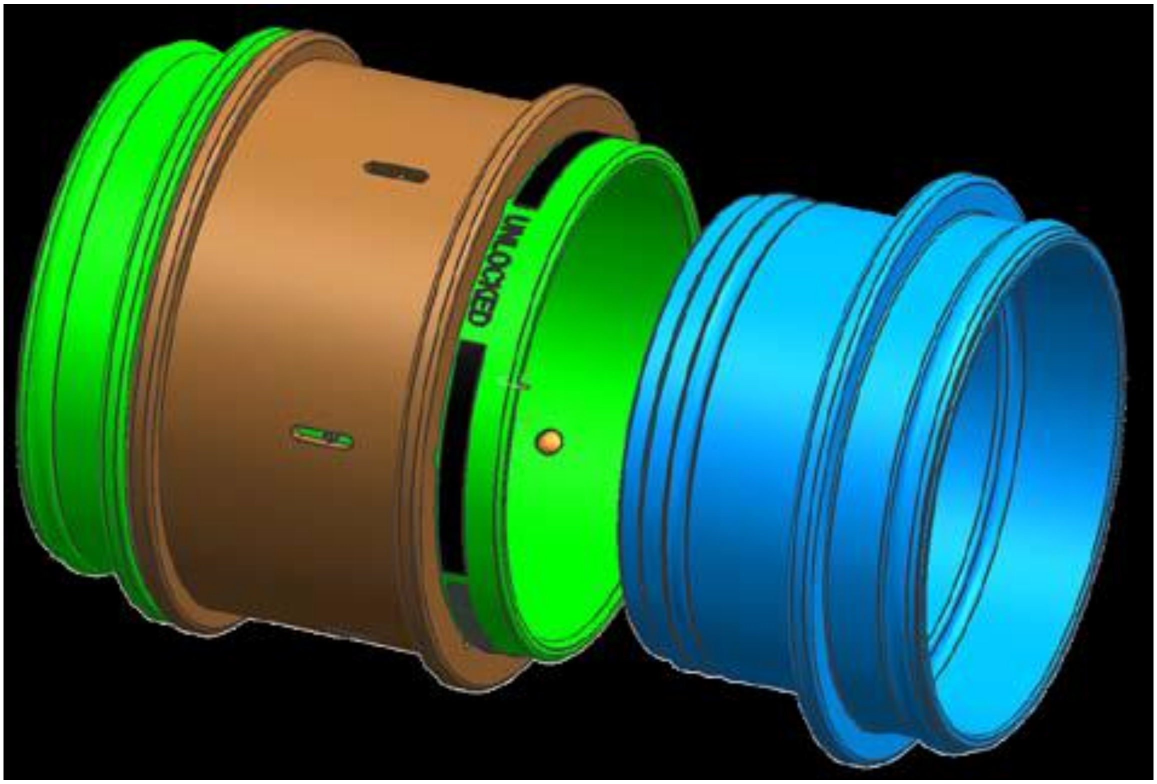



**FIGURE 4.2.3.6-2, DUCT COUPLING**

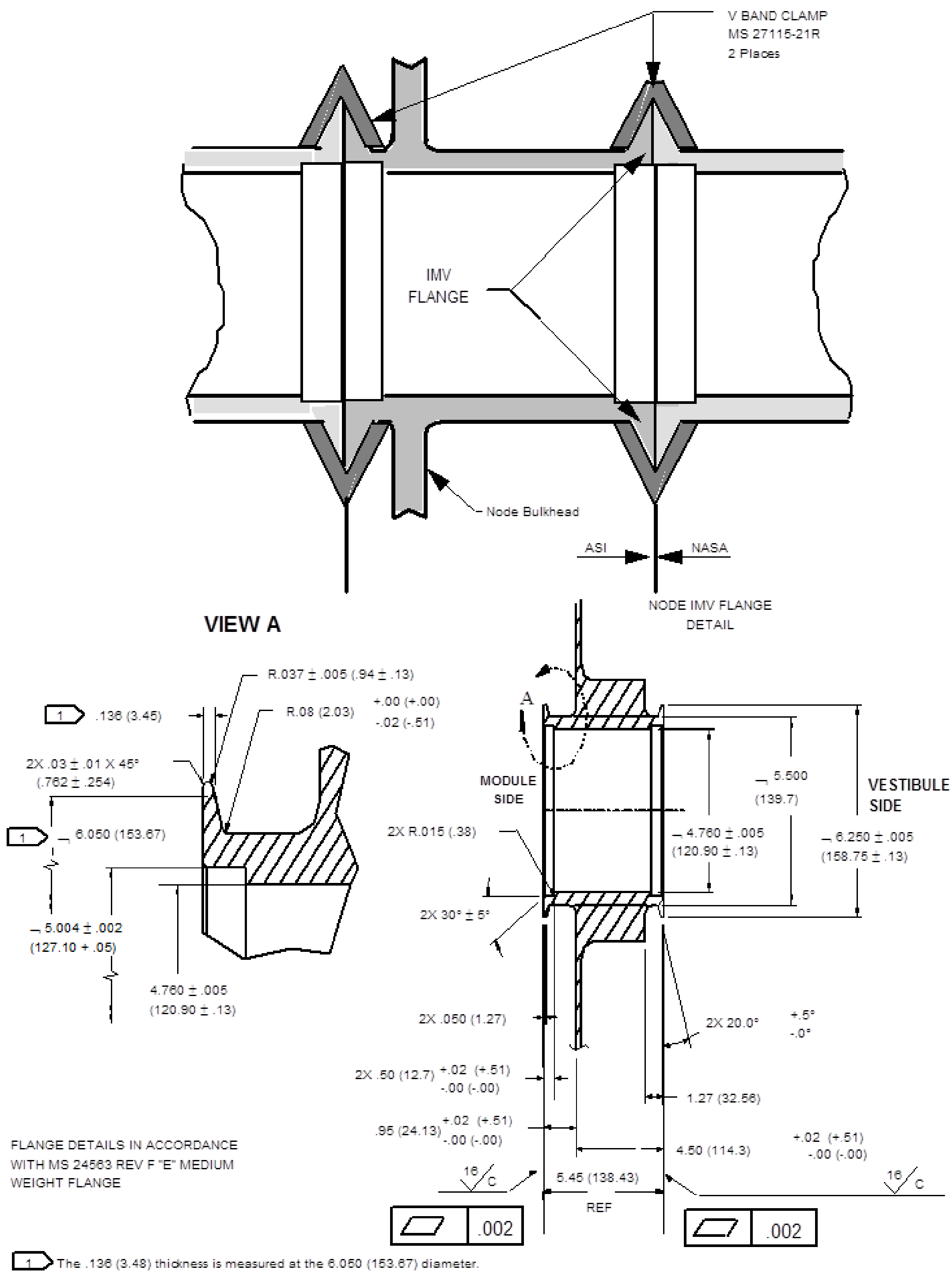



**FIGURE 4.2.3.6-3, DUCT DETAILS**

#### 4.2.3.6.1 Temperature

The IDA transfers inter-module ventilation from the ISS to the VV at the VV to IDA interface through the IDA IMV Duct at a temperature range of +65°F (+18.3°C) to +80°F (+26.7°C).

#### 4.2.3.6.2 Dew Point

The IDA transfers inter-module ventilation from the ISS to the VV at the VV to IDA interface at dew point range of +40°F (+4.4°C) to +60°F (+15.6°C) except during the first 10 hours after pressurization. During this period, the dew point will range from 40 °F (4.4 °C) and 45 °F (7.2 °C).

#### 4.2.3.6.3 Flowrate

When the IDA is in its Operational Configuration (See Appendix B), the IDA transfers inter-module ventilation from the ISS to the VV at the VV to IDA interface through the IMV duct with a volumetric flow rate in the range of 125 cfm (3.5 m3/min) to 210 cfm (5.95 m3/min).

#### 4.2.3.6.4 Pressure Loss in IMV Ducting

When the IDA is in its Operational Configuration (See Appendix B), the maximum pressure loss of the ISS inter-module ventilation supply in the IMV duct will have a pressure loss no greater than 1.5 inches of water (373 Pa) at a minimum flow rate of 125 cfm (3.5 m3/min) between the IMV fan and the end of the IDA IMV duct at the VV to IDA interface plane.

### 4.2.4 Surface Cleanliness

Exterior surfaces will be Visibly Clean Level Sensitive in accordance with SN-C-0005. Sealing surfaces will be Visibly Clean Level Highly Sensitive in accordance with SN-C-0005.

### 4.2.5 Environments

#### 4.2.5.1 Loads

#### 4.2.5.1.1 Transient Limit Loads

The IDA performs as designed after withstanding the loads specified in Table 4.2.5.1.1-1, HCS Maximum Mated Loads, Table 4.2.5.1.1-2: HCS Mated Load Sets, and using the load spectra defined in Table 4.2.5.1.1-3, IDA Loads Spectra for VV to IDA Interface.

### TABLE 4.2.5.1.1-1: HCS MAXIMUM MATED LOADS

| | Mated ISS |
|---|---|
| Maximum Design Pressure | 1 100 hPa |
| Seal Closure Force | 97 150 N |
| Compressive Axial Load | 17 700 N |
| Tensile Axial Load | 17 700 N |
| Shear Load | 16 700 N |
| Torsion Moment | 15 000 Nm |
| Bending Moment | 68 700 Nm |

### TABLE 4.2.5.1.1-2: HCS MATED LOAD SETS

| Load Set | Case 1 | Case 2 | Case 3 |
|---|---|---|---|
| Design Pressure | 1 100 hPa | 1 100 hPa | 1 100 hPa |
| Seal Closure Force | 97 150 N | 97 150 N | 97 150 N |
| Compressive Axial | 5 000 N | 17 700 N | 13 700 N |
| Tensile Axial Load | 5 000 N | 17 700 N | 13 700 N |
| Shear Load | 5 000 N | 14 800 N | 16 700 N |
| Torsion Moment | 15 000 Nm | 15 000 Nm | 15 000 Nm |
| Bending Moment | 65 300 Nm | 39 200 Nm | 68 700 Nm |

*Notes for Table Table 4.2.5.1.1-2:*

h) Values are design limit loads.
i) Hard capture hook preload and tunnel stiffness are such that, when under external loading within limits, there remains metal-to-metal contact in the local vicinity of the hooks.
j) Shear loads may be applied in any direction in the HCS mating plane.
k) Bending moment may be applied about any axis in the HCS mating plane.
l) The outer seal bead is to be used for all pressure calculations.
m) Load cases are defined in *Table 4.2.1.5.2-2: HCS Mated Load Sets and* Table 4.2.1.5.2-1: HCS Maximum Mated Loads is a summary of the maximum loads.
n) Case descriptions:
   iv) Case 1 – Attitude control by Orbiter-sized vehicle, combined with crew activity.
   v) Case 2 – Interface loads due to ISS segment berthing.
   vi) Case 3 – Orbiter-sized vehicle translation with payload attached to ODS.

**TABLE 4.2.5.1.1−3: IDA LOADS SPECTRA FOR VV TO IDA INTERFACE**

| Amplitude Tier (%) | Cycle Count |
|---|---|
| 90-100 | 3 |
| 80-90 | 3 |
| 70-80 | 3 |
| 60-70 | 3 |
| 50-60 | 81 |
| 40-50 | 287 |
| 30-40 | 866 |
| 20-30 | 3,731 |
| 15-20 | 296,308 |
| 10-15 | 1,004,866 |
| 5-10 | 2,854,371 |
| 2.5-5 | 5,757,292 |
| Note: Cycle count corresponds to 365 days at port per year for fifteen years (IDA design life). | |

### 4.2.5.1.2 Thermal Structural Loads

The IDA supports the induced loads associated with a maximum VV to IDA temperature differential at the time of VV docking, combined with the induced loads associated with a maximum VV to IDA transient (steady state) temperature differential or the loads specified in Table 4.2.5.1.2-1 Peak On-orbit Thermal Loads Induced by ISS at VV-to-IDA Interface.

**TABLE 4.2.5.1.2-1: PEAK ON-ORBIT THERMAL LOADS INDUCED BY ISS AT VV-TO-IDA INTERFACE**

| VV/ISS Coupled Interface Thermal Loads | | $F_R$ (radial, positive outboard) (lbf/in (N/m)) | $M_T$ (Tangential) (in.-lbf/in (N-m/m)) |
|---|---|---|---|
| Case 1 | Mean Load | 600 (105,076.1) | 962 (4,279.2) |
| | Transient Load | 106 (18,563.4) | 172 (765.1) |
| Case 2 | Mean Load | -600 (-105,076.1) | -962 (-4,279.2) |
| | Transient Load | -106 (-18,563.4) | -172 (-765.1) |

The IDA withstands the thermally induced structural loads, during Rendezvous, Proximity Operations, Docking, and Undocking (RPODU) and mated operations, due to the maximum on-orbit temperature difference across the VV to IDA interface as specified in 4.1.1.1.2.1 when cycled fully reversible according to the loads spectra as specified in Table 4.2.5.1.2-2 On-orbit Thermally Induced Loads Spectra Induced by ISS at VV-to-ISS Interface During RPODU and Mated Operations.

**TABLE 4.2.5.1.2-2: ON-ORBIT THERMALLY INDUCED LOADS SPECTRA INDUCED BY ISS AT VV-TO-ISS INTERFACE DURING RPODU AND MATED OPERATIONS**

| Amplitude Tier (%) | Cycle Count |
|---|---|
| 90-100 | 0 |
| 80-90 | 0 |
| 70-80 | 0 |
| 60-70 | 0 |
| 50-60 | 12 |
| 40-50 | 16 |
| 30-40 | 40 |
| 20-30 | 80 |
| 15-20 | 380 |
| 10-15 | 3,670 |
| 5-10 | 6,016 |
| 2.5-5 | 22,033 |

## 5.0 NDSB1-TO-HOST VEHICLE INTERFACE

This section describes the interfaces between the NDSB1 to a host vehicle.

### 5.1 Interface Description

See Figure 5.1-1: NDSB1-to-Host Vehicle Interface Diagram.

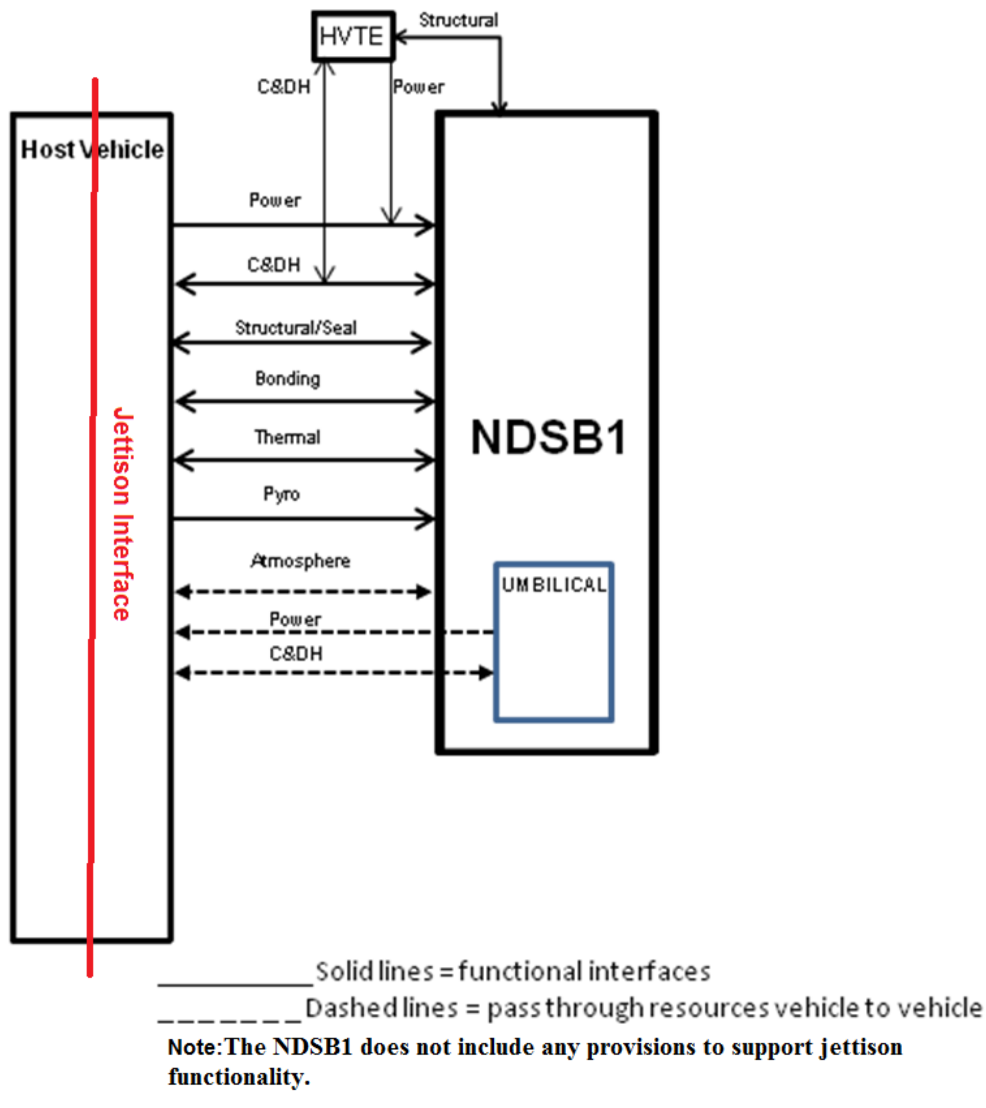


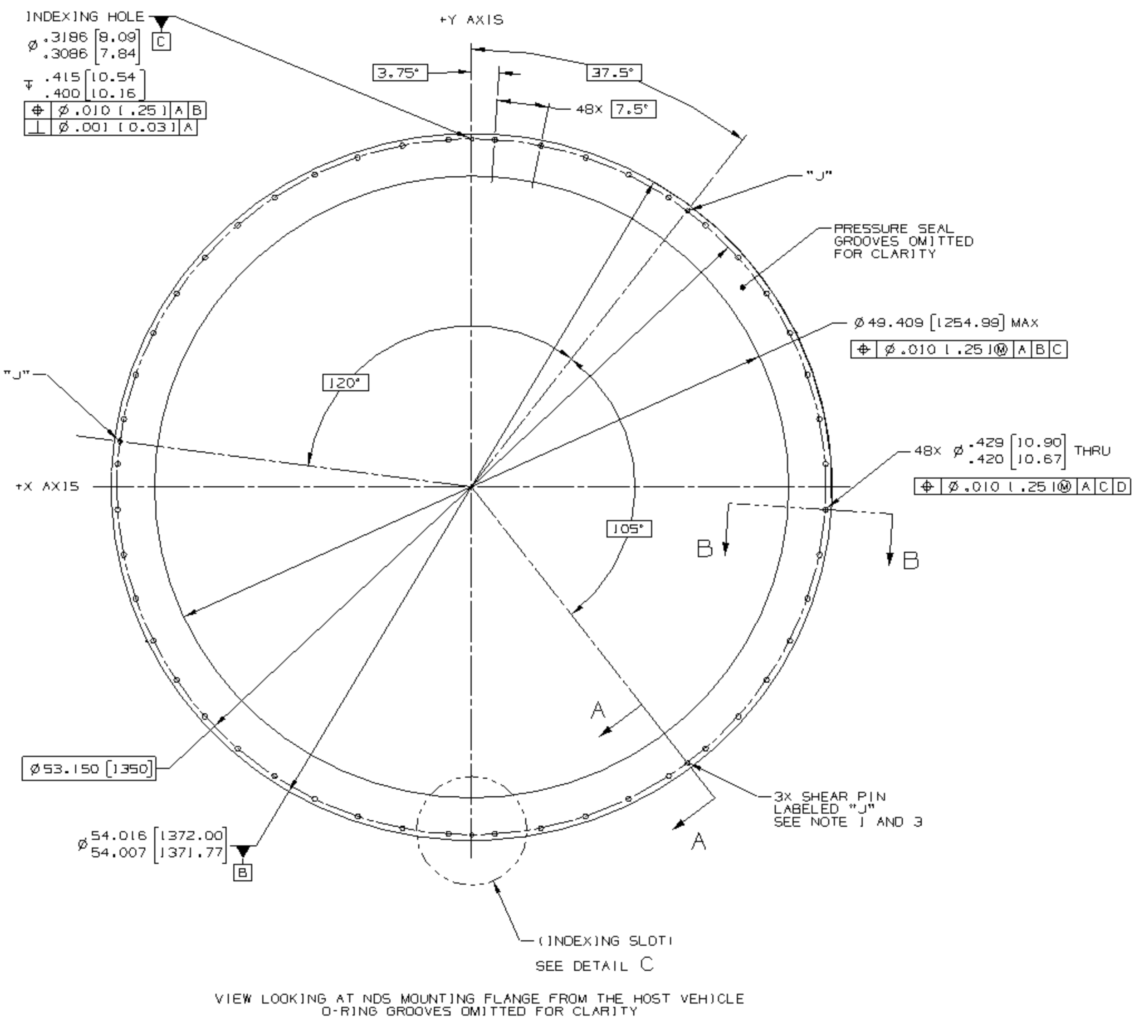

FIGURE 5.1-1: NDSB1-TO-HOST VEHICLE INTERFACE DIAGRAM

### 5.2 Structural/Mechanical/Seal/Thermal Interfaces

The structural/mechanical/seal interface for the NDSB1 resides at the plane of attachment between the host vehicle and the NDSB1. The NDSB1 attaches directly to a bolt and seal interface flange on the host vehicle. The NDSB1 attaches to the host vehicle with a circular arrangement of fasteners.

### 5.2.1 Structural/Mechanical Interfaces

Refer to Figure 5.2.1-1: NDSB1-to-Host Vehicle Mounting Interface for an overview of the NDSB1-to-host vehicle mounting interface.

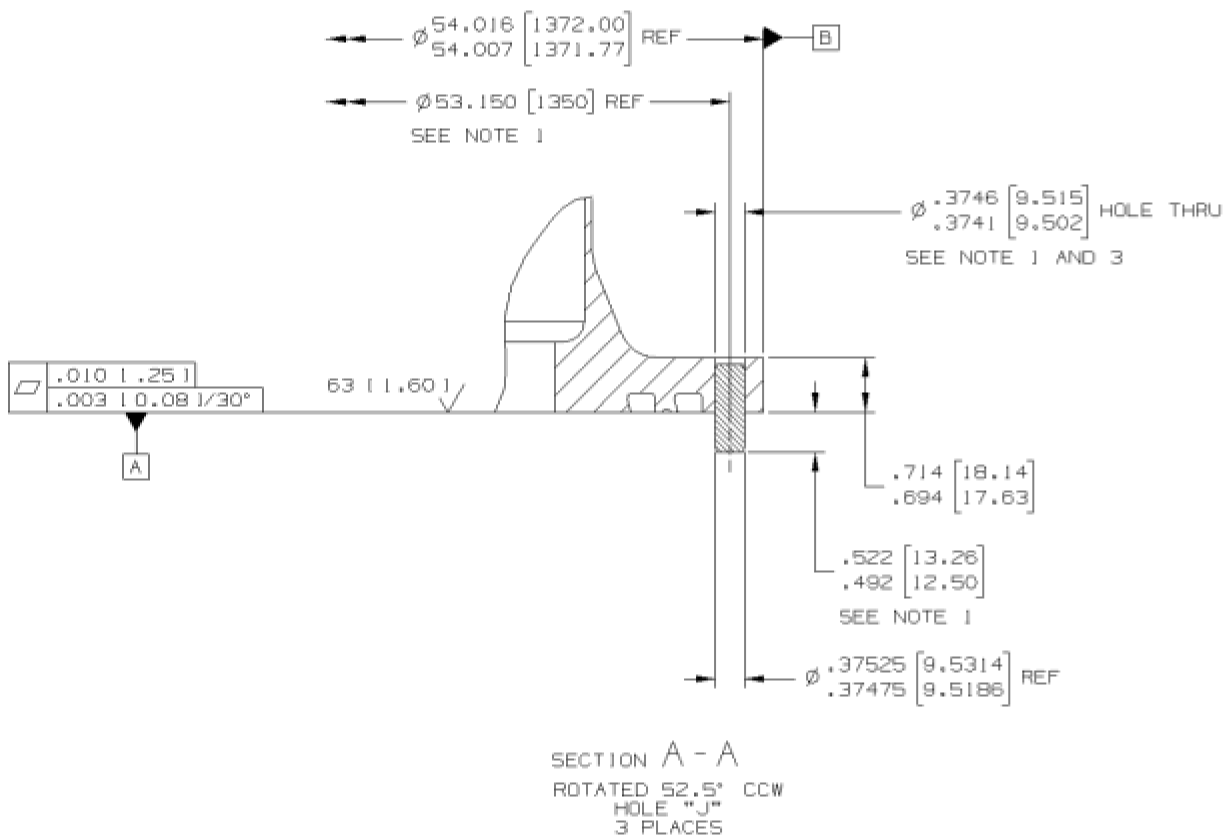



View Looking at NDSB1 Mounting Flange from the Host Vehicle.

O-Ring Grooves Omitted for Clarity

(Page 1 of 8)




Section A-A

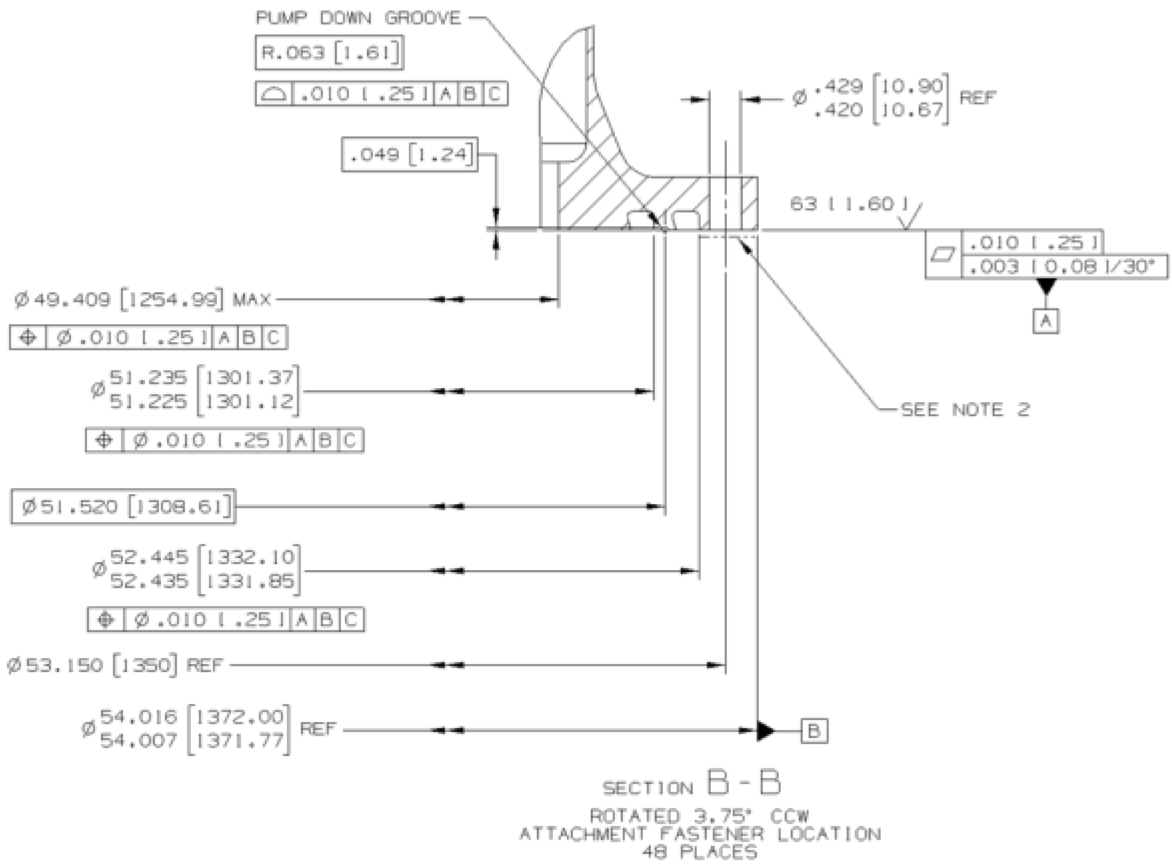
View Rotated to Horizontal

NDSP Provided Standard Pin Per

AS9390 – Pin, Straight, Headless, Uns S66286, Standard

P/N: MS9390-680

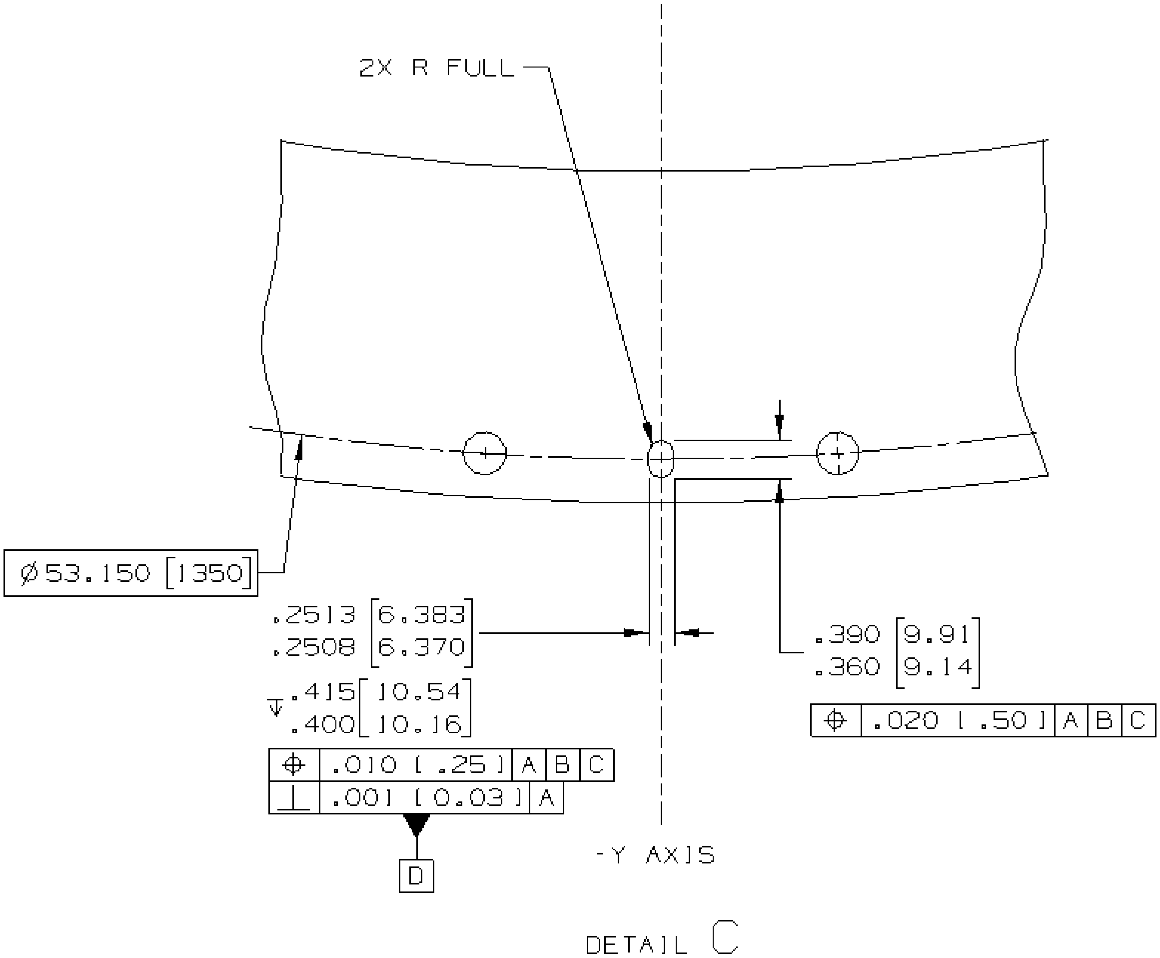
(Page 2 of 8)




Section B-B

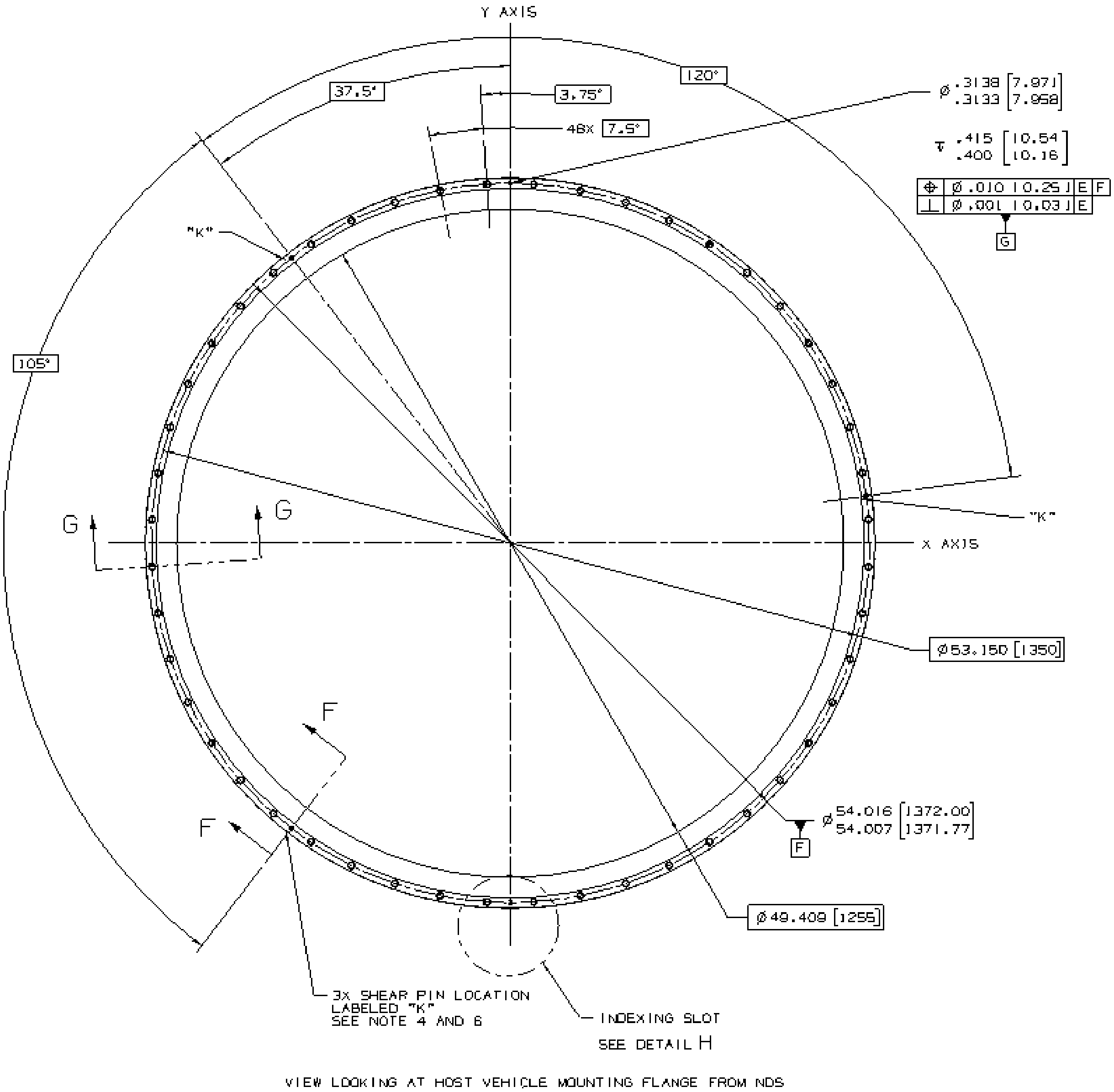
Rotated 3.75º CCW

(Page 3 of 8)



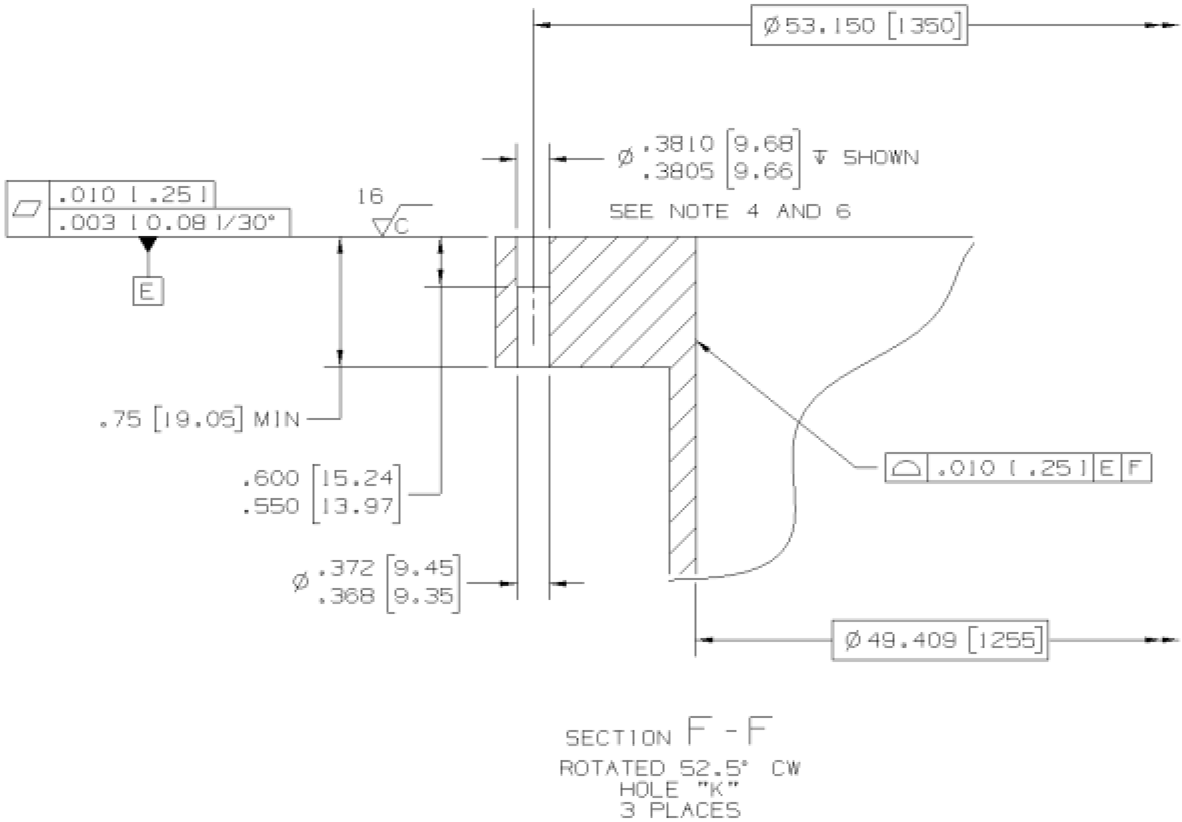

Detail C

(Page 4 of 8)



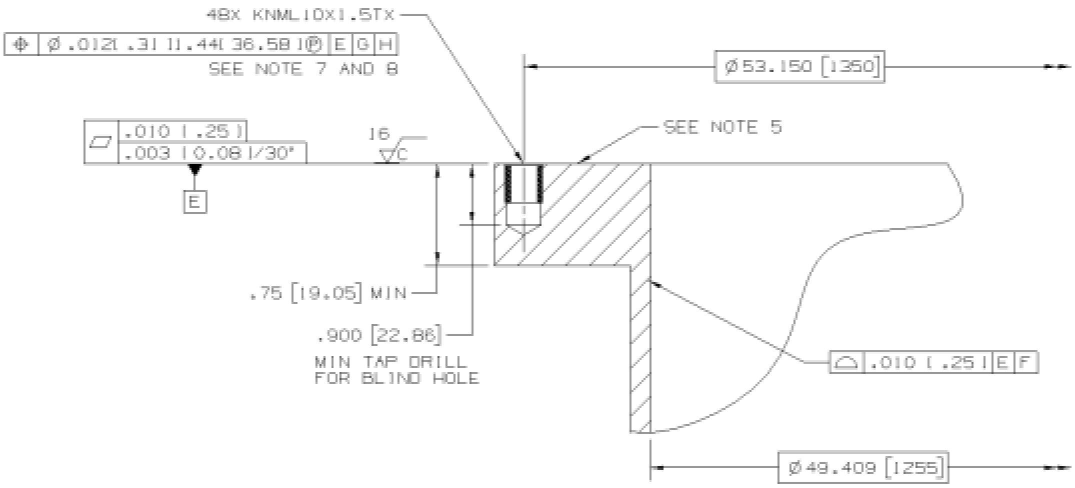

Host Vehicle Mating Flange view looking from NDSB1

(Page 5 of 8)



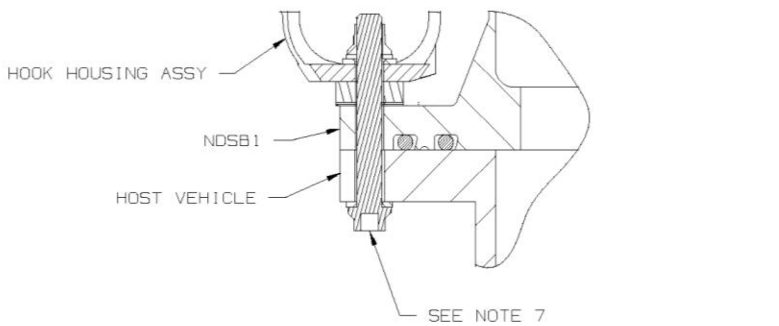

Host Vehicle Mounting Flange Detail (Shear Pin Hole)

(Page 6 of 8)




SECTION G-G
ROTATED 3.75° CW
ATTACHMENT FASTENER LOCATION
48 PLACES

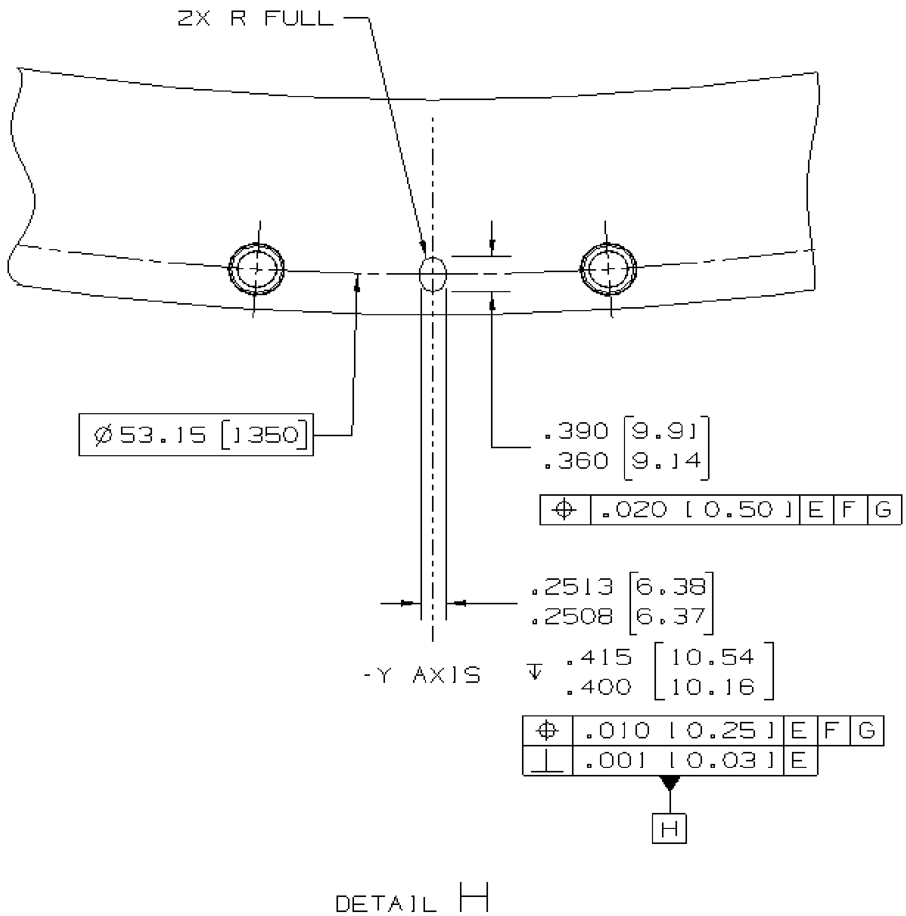
Host Vehicle Mounting Flange Insert Detail (Insert)




SECTION G-G (ALTERNATE HARDWARE)
ROTATED 3.75° CW
ATTACHMENT FASTENER LOCATION
48 PLACES

Example Host-Through Hole Detail.

(page 7 of 8)




Host Vehicle Mating Flange Attachment Tooling Slot Definition Detail H

(page 8 of 8)

Notes:

1. Shear pin holes located using DRPSDZ29101974-5003 Drill Template. Hole specified in Section A-A IS for NDS flange only. Install MS9390-710 Pin in flange to dimensions shown. Wet install shear pin using approved zinc-chromate primer.
2. Chemical conversion coat datum surface in area indicated per MIL-DTL-5541, Type 1, Class 3.
3. Tooling design must control positional location within true position diameter of 0.020 [0.508] with respect to Datums A, C and D.
4. Shear pin holes located using DRPSDZ29101974-5003 Drill Template. Hole specified in Section D-D is for host vehicle flange only. Chemical conversion coat tool drilled hole per MIL-DTL-5541, Type 1, Class 3.
5. Chemical conversion coat entire datum surface per MIL-DTL-5541, Type 1, Class 3.
6. Tooling design must control positional location within true position diameter of 0.020 [0.508] with respect to Datums E, G and H.
7. The NDS provides through holes and associated fasteners for host vehicle mounting. Host Vehicle provides mating insert P/N KNML10 X 1.5TX KEENSERT (CAGE CODE: 29372). Blind installation shown; however, host vehicle may implement either through hole or bottom tap for KEENSERT installation as desired. Additionally, a through-bolt and nut mounting installation option is feasible, but requires additional certification prior to implementation. See Section G-G (alternate hardware).
8. Install insert per NA0145, except tap drill depth as indicated. Wet install insert using approved zinc-chromate primer.

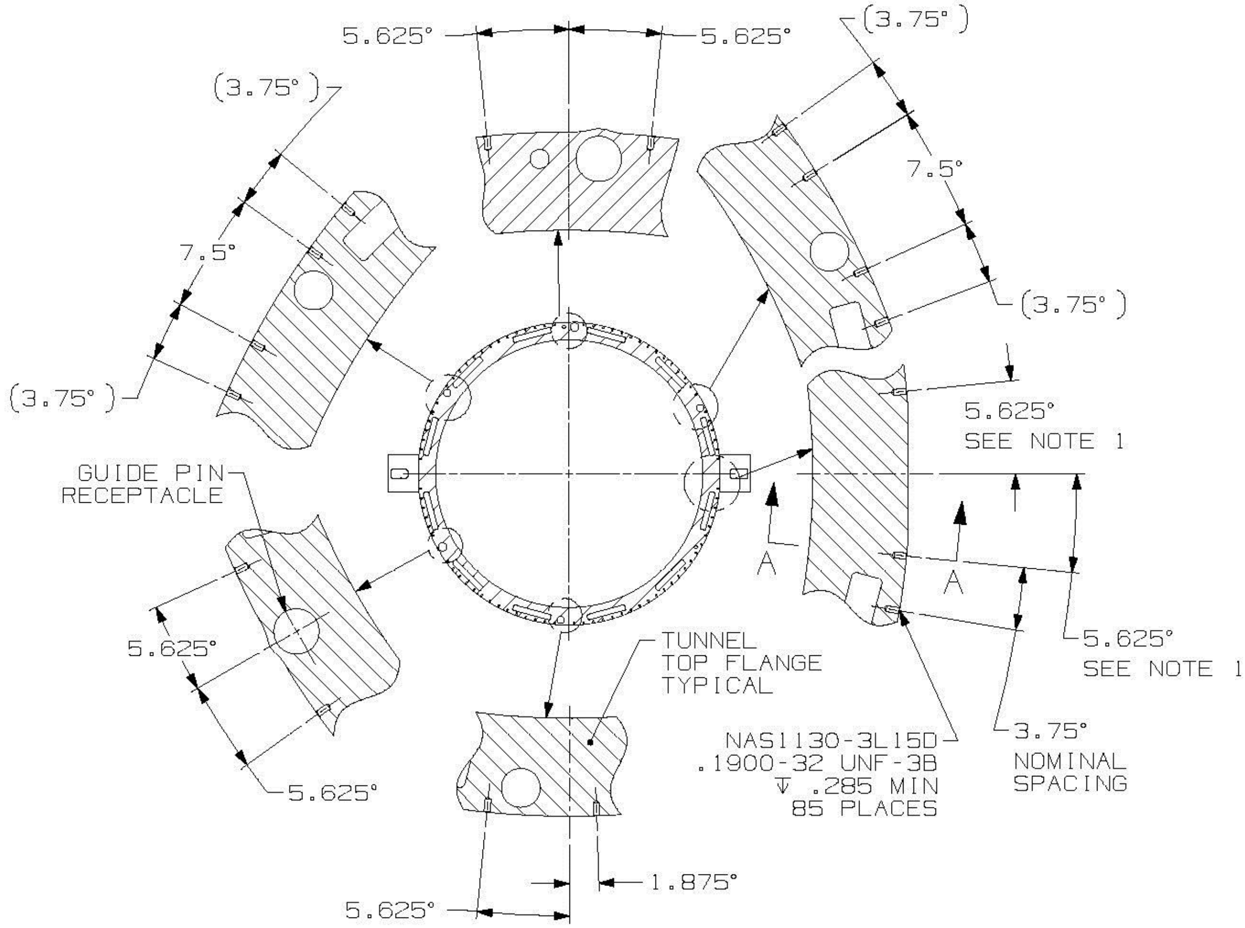
**FIGURE 5.2.1-1: NDSB1-TO-HOST VEHICLE MOUNTING INTERFACE**

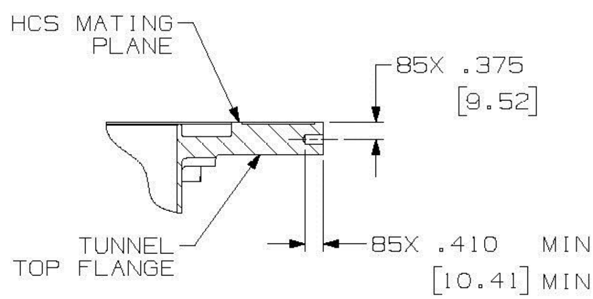
#### 5.2.1.1 Mechanical Mounting and Seal Interface

The NDSB1 will limit seal leakage at the NDSB1 to HV mounting interface to less than 0.0008 lbm dry air/day when the internal pressure is 14.7 psia and external pressure is a 7.5E-14 Torr (1.0E-11 Pascal).

#### 5.2.1.2 NDSB1 Installation and MMOD Shield Mounting Interfaces

The NDSB1 provides an exterior MMOD shield mounting interface defined in Figure 5.2.1.2-1: NDSB1 Host-Provided MMOD Interface. The NDSB1 is installed on the host vehicle by metric fasteners provided by NDSP. In order to maintain NDSB1 certification, the host must follow 683-100000-0001, Docking Adapter Kit. The NDSB1 provides MMOD protection inside the HCS tunnel, if required. Refer to Figure 5.2.1.2-2, HCS MMOD Protection.



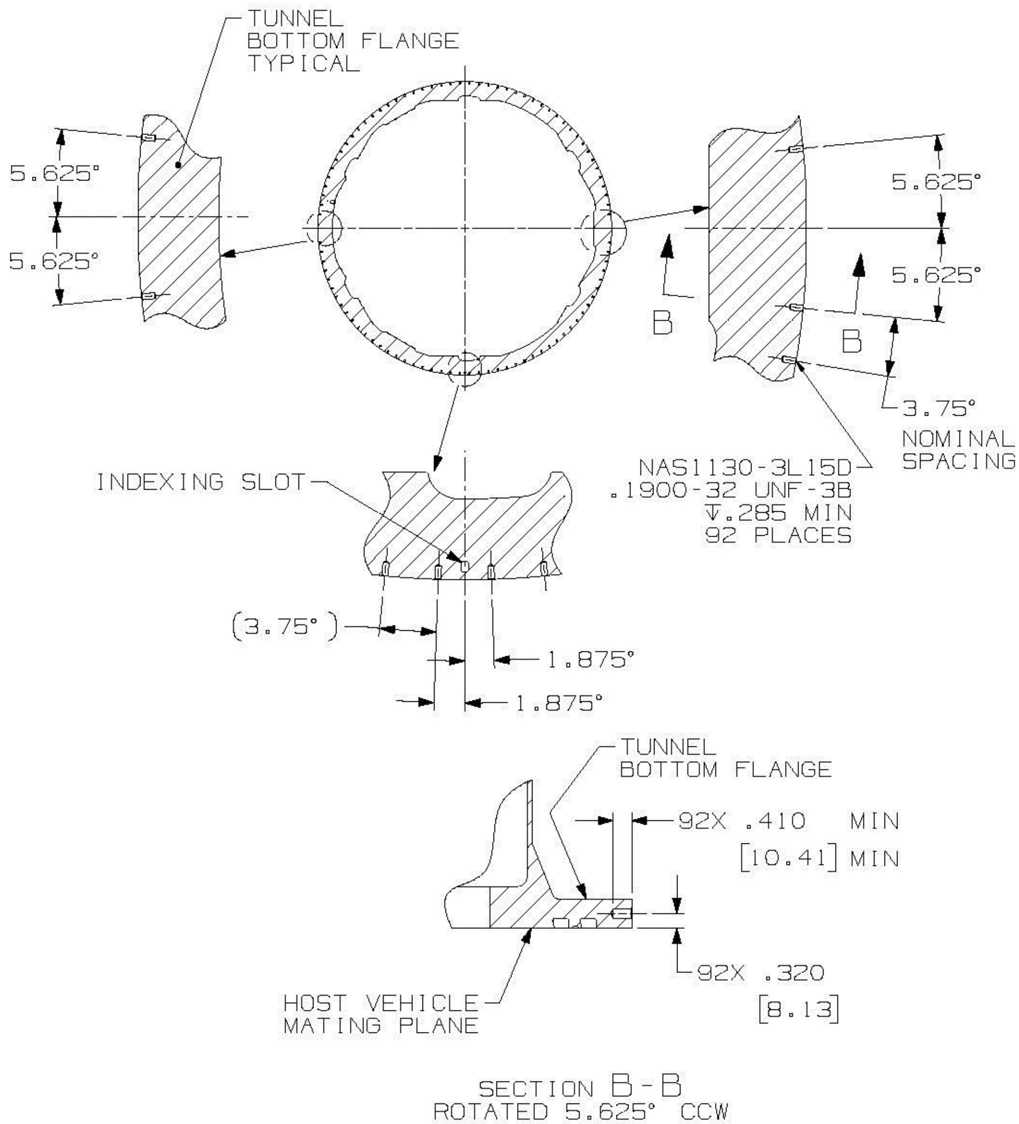

SECTION A - A
ROTATED 5.625° CCW

NOTE: Applicable for both Umbilical locations

Section Through Mounting Hole

MMOD Shield Interface on Tunnel HSC Mating Plane

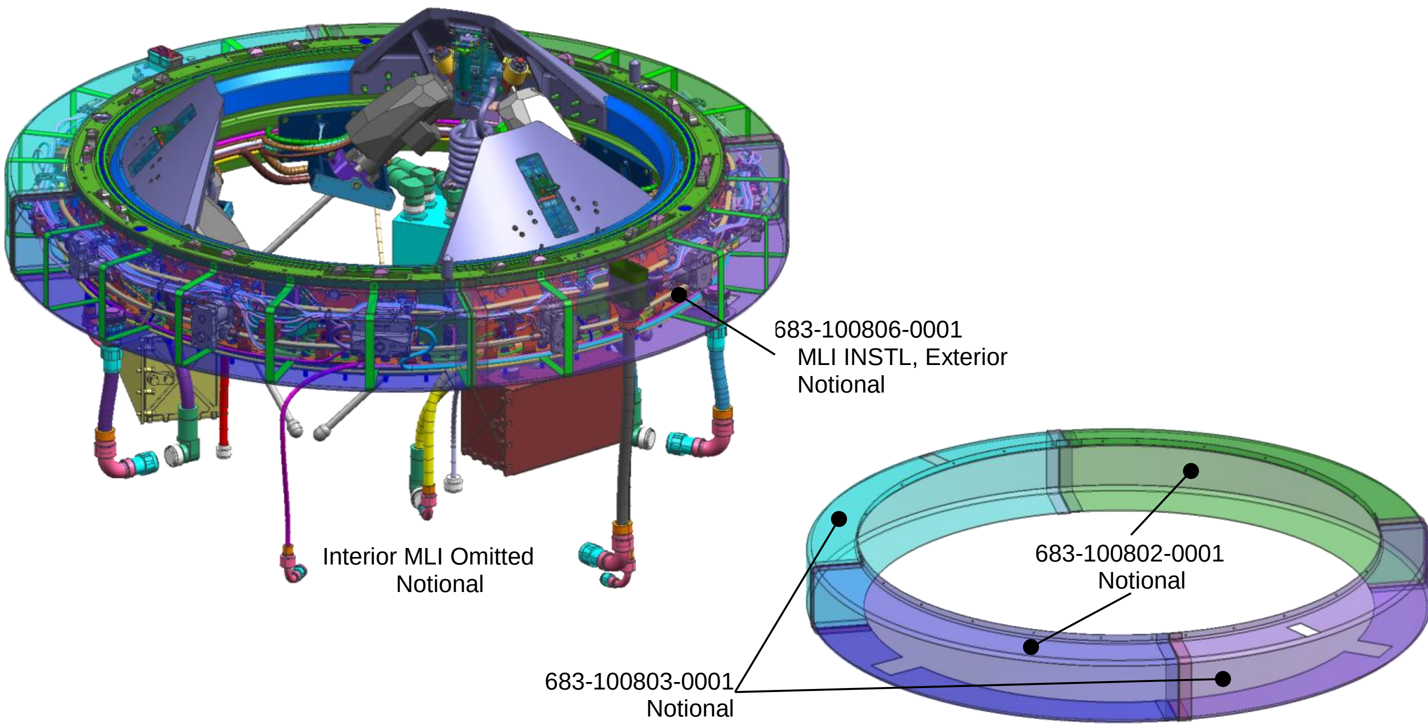
(Page 1 of 2)



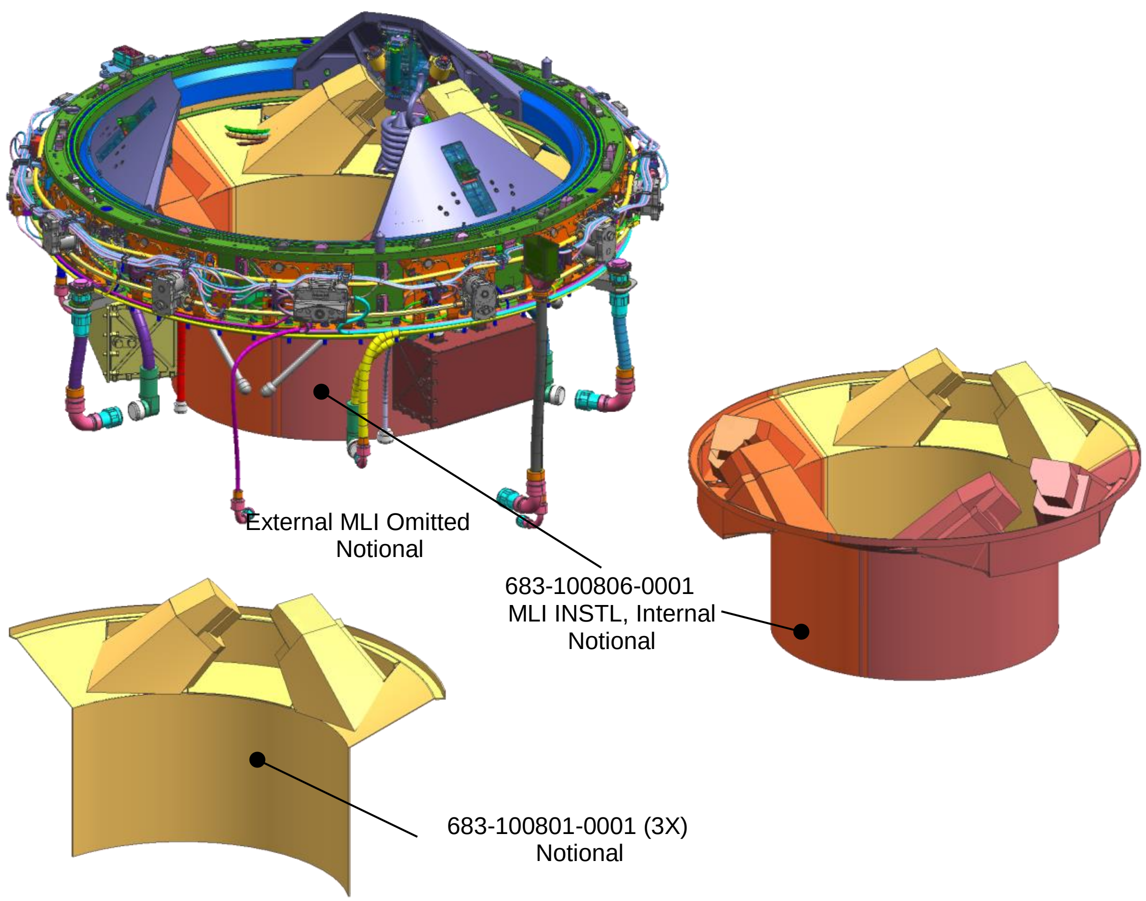

MMOD Shield Interface on Tunnel Host Mating Flange

(page 2 of 2)

**FIGURE 5.2.1.2-1: NDSB1 HOST-PROVIDED MMOD INTERFACE**




**Exterior MLI Protection**



**Interior MLI/MMOD Protection**
**FIGURE 5.2.1.2-2: HCS MMOD PROTECTION**

### 5.2.1.3 SCS Mechanism Keep Out Zone (KOZ)

During soft capture, attenuation, and retraction, the SCS mechanism requires a clear operational motion envelope. The SCS Mechanism KOZ is defined in Figure 3.8.1.3.2-1, Kinematic Envelope.

### 5.2.1.4 NDSB1 Vestibule Closeout Cover

The NDSB1 provides a closeout cover designed to close out the NDSB1 vestibule crew passageway during docked operations. The cover protects the crew from exposure to sharp edges in the SCS mechanism, as well as to protect the mechanism from Foreign Object Debris (FOD) which could be floating in the passageway. The cover for NDSB1 is shown in Figure 5.1.4-1: NDSB1 Vestibule Closeout Cover.

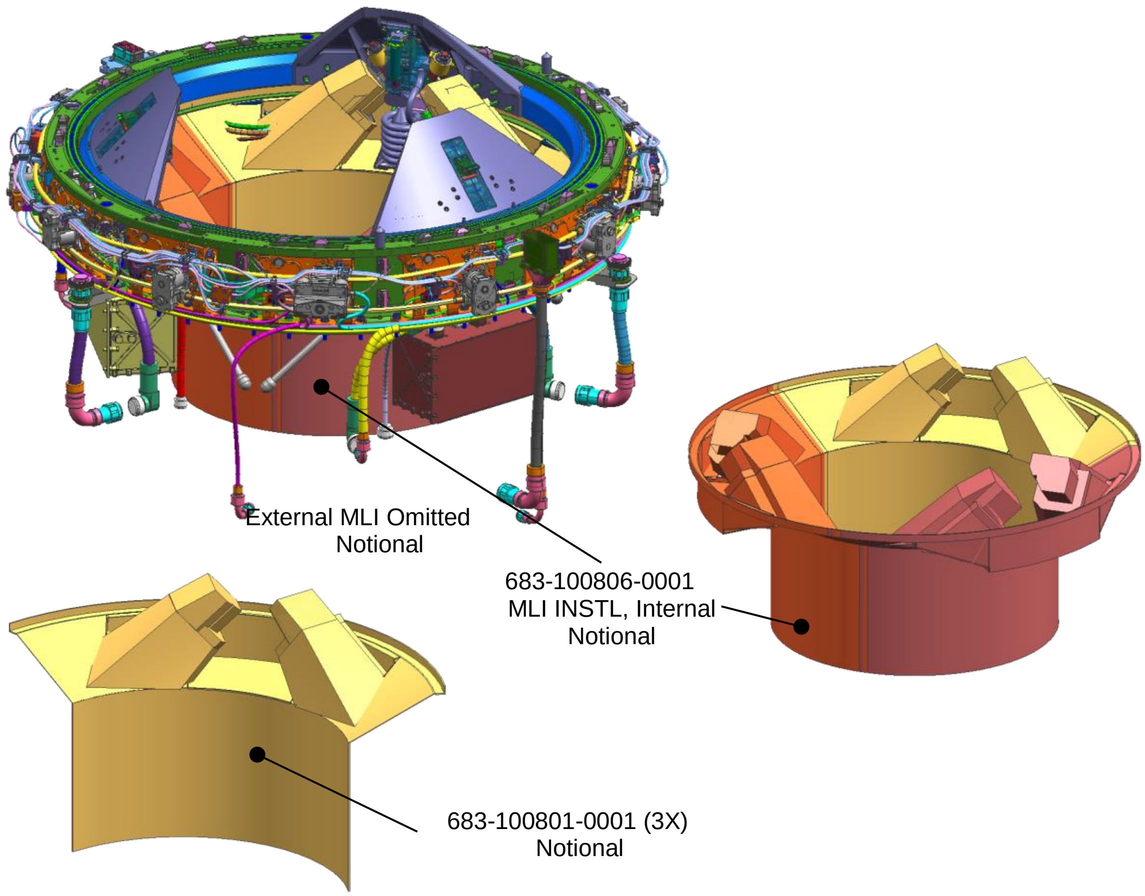



**FIGURE 5.2.1.4-1: NDSB1 VESTIBULE CLOSEOUT COVER**

### 5.2.1.5 NDSB1 Electrical Boxes

The NDSB1 Avionics subsystem conceptual design (See Figure 5.2.1.5-1, Avionics Architecture) includes the following components: DSC and LAC.

The DSC will be powered by the HV. The DSC controls the NDSB1 System. The DSC can receive commands from a HV interface to perform active docking/undocking, HCS or SCS Checkout, Manual Control operations or Monitoring of system performance. The DSCs provide Health and Status data from the NDSB1 System to the HV. Communications between DSC and HV will uses a 1553B or RS-422 data interface. Details of the DSC box interface are shown in Figure 5.2.1.5-2 DSC Box Interfaces.

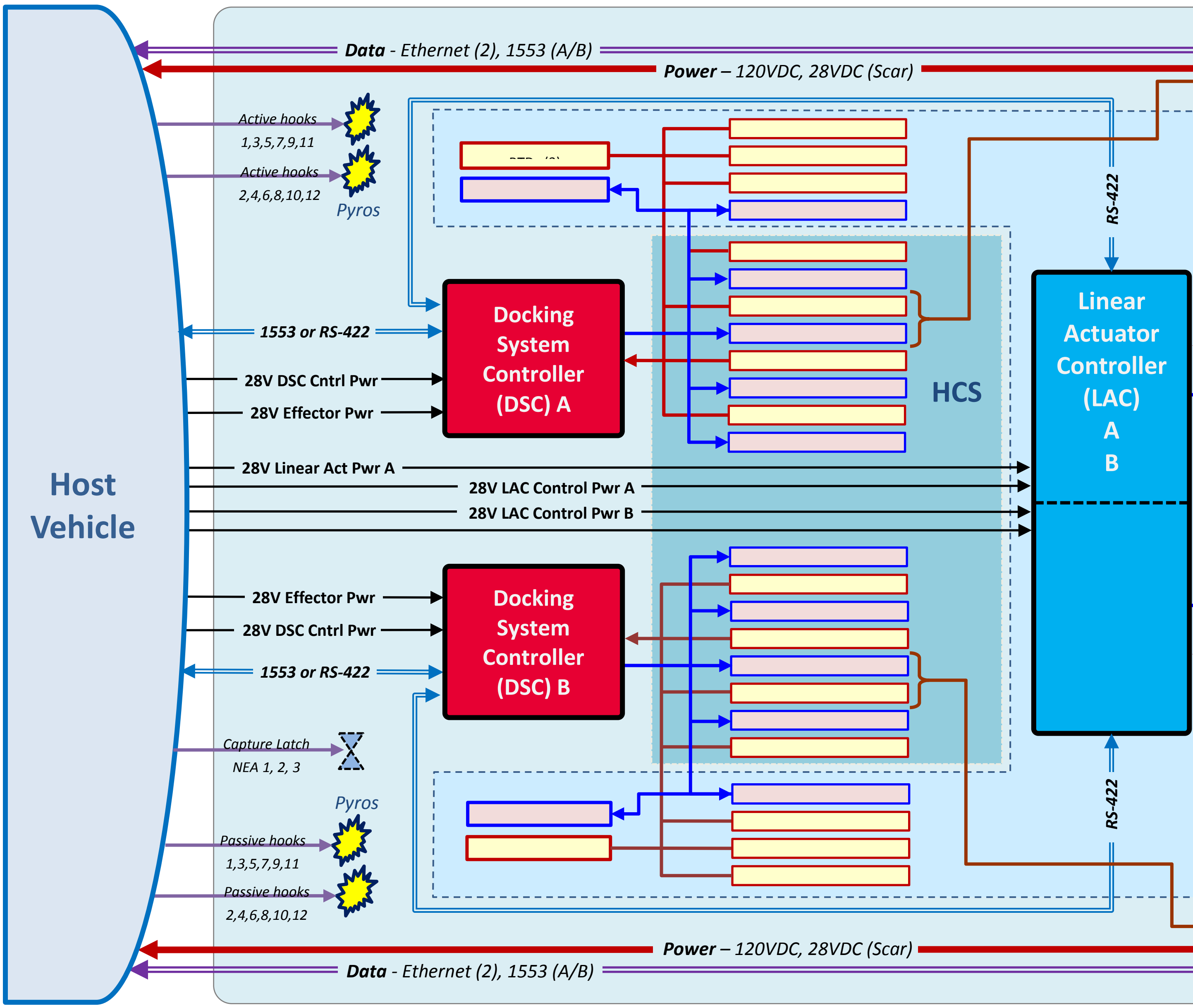
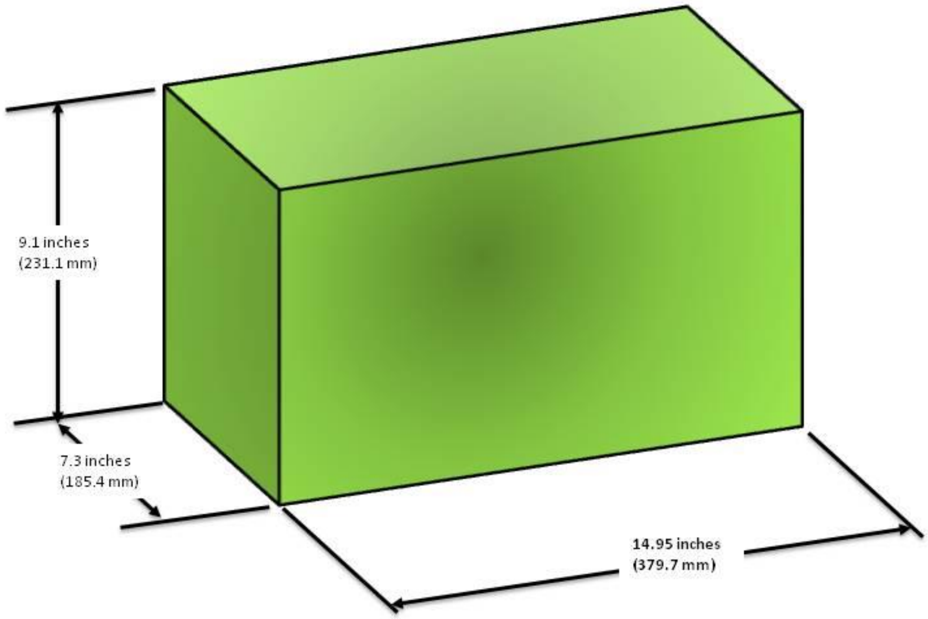
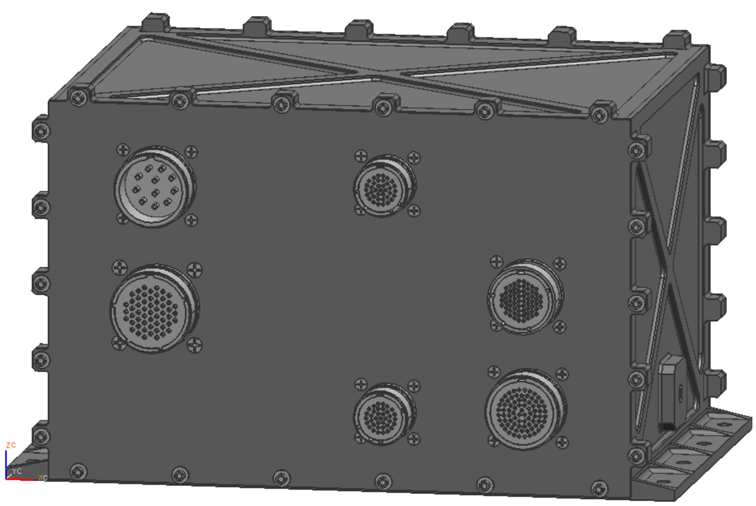



FIGURE 5.2.1.5-1: NDSB1 AVIONICS ARCHITECTURE

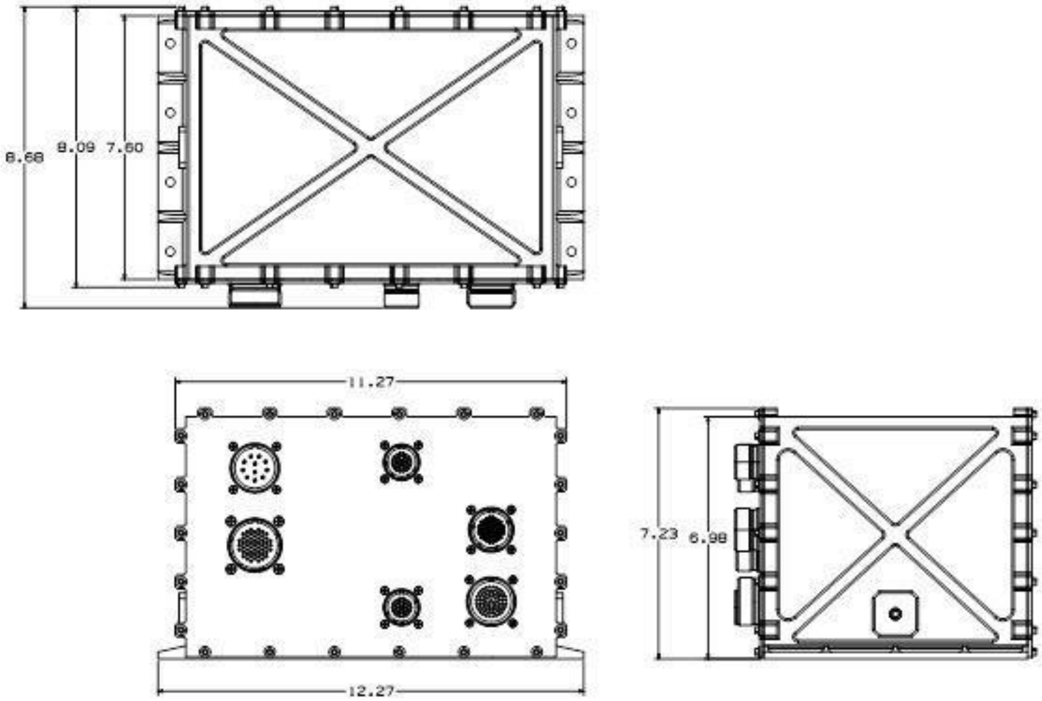



DSC Envelope

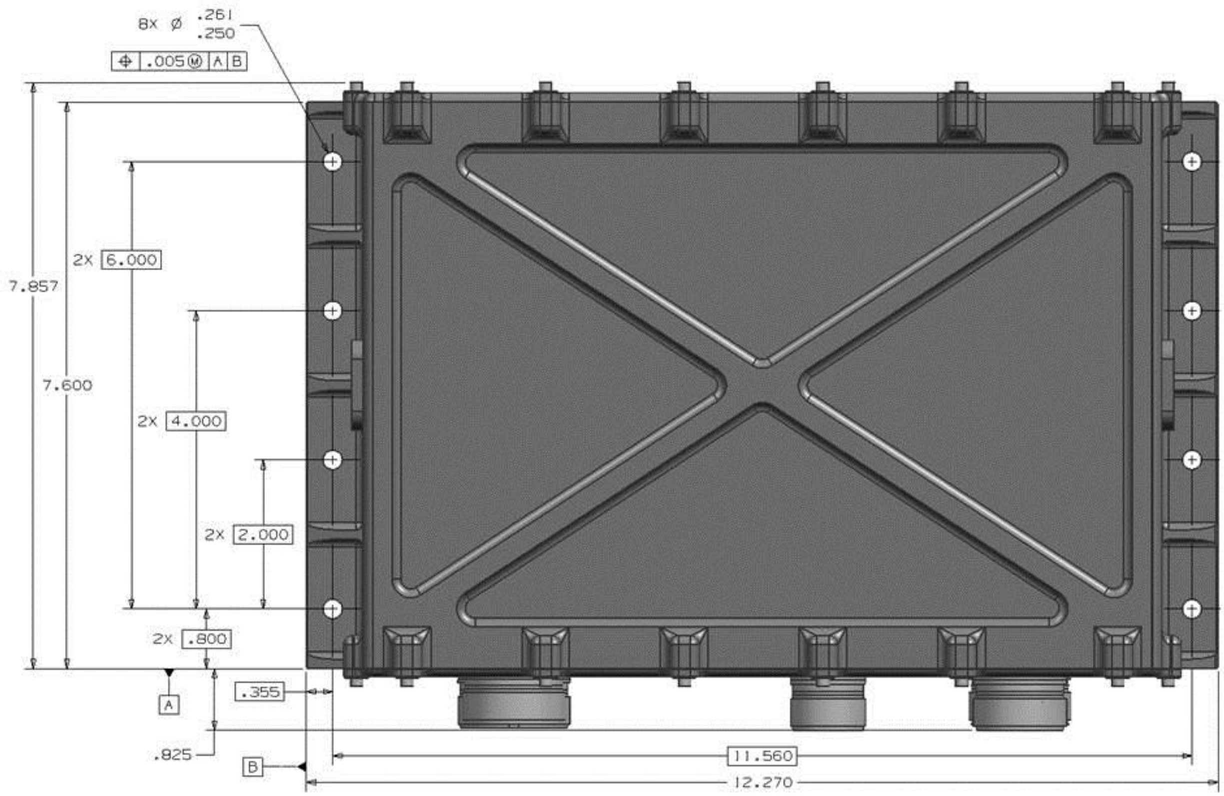


DCS Design

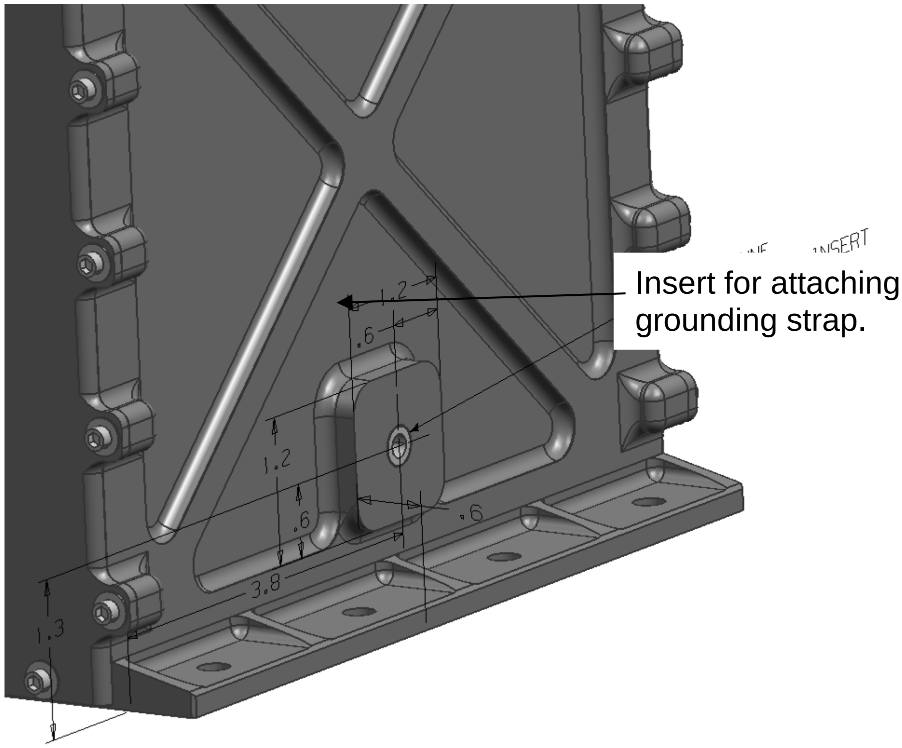
Page (1 of 3)




Page (2 of 3)




DSC Mounting Hole Locations



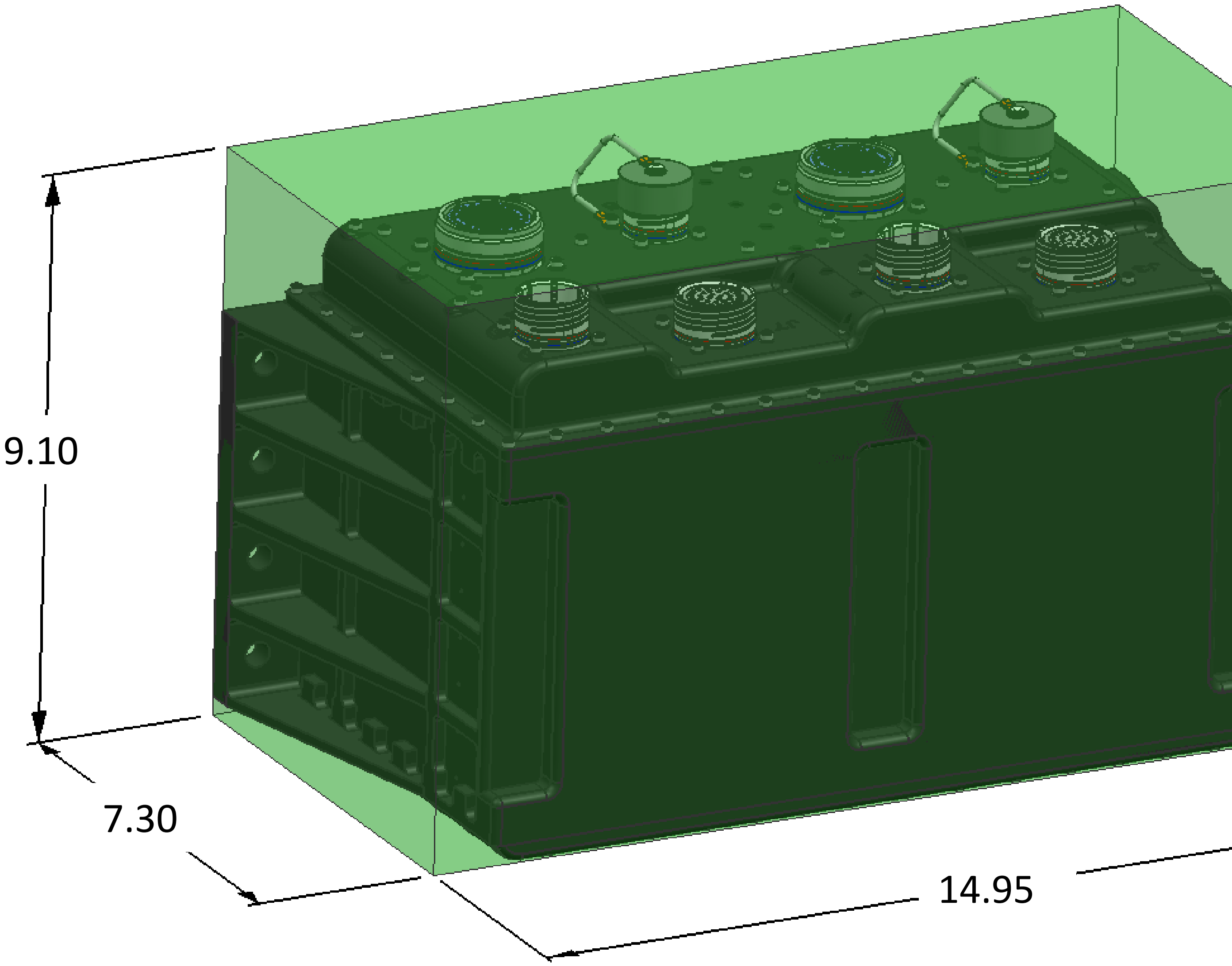

Typical Dimension for Both Left and Right Side of DSC

DSC Grounding Strap Location

Page (3 of 3)

**FIGURE 5.2.1.5-2: DSC BOX INTERFACES (TBR32)**

Mass properties of the boxes are shown in Table 5.2.1.5-1, Electrical Box Mass Properties. The cabling is shown in Figure 5.5-1, NDSB1 to Host Vehicle Electrical Interface.




LAC Envelope and Design

Page (1 of 2)

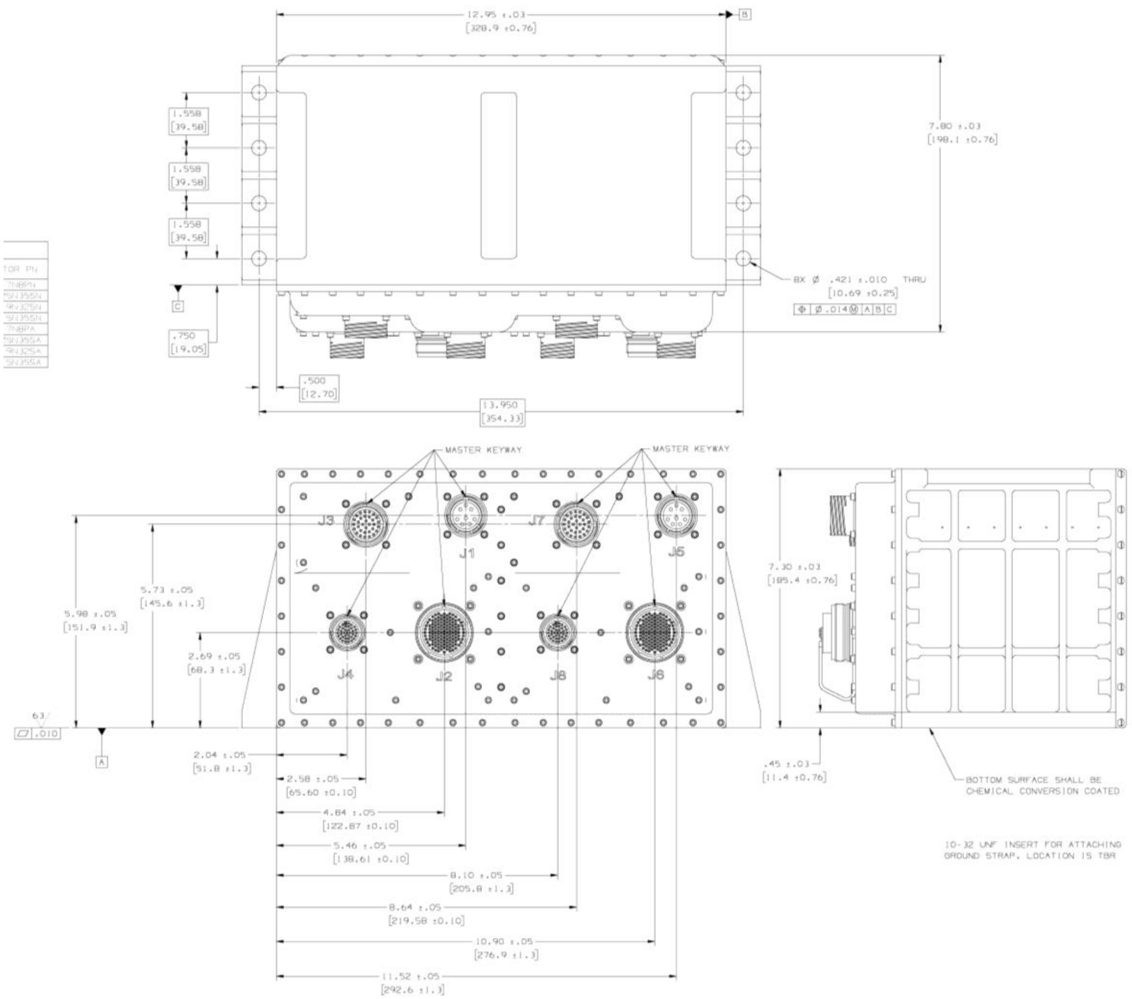



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**FIGURE 5.2.1.5-3: LAC INTERFACES TBR33**

The LAC is a component of the NASA Docking System Block 1(NDSB1) system. The LAC is a flight-critical Line Replaceable Unit (LRU) that controls linear actuators to provide sensing of initial contact between the two vehicles, capture of the target vehicle, attenuation of initial contact forces, alignment, and retraction for hard capture. The LAC receives operational commands from, and returns status data to the DSC. The LAC receives power directly from the Host Vehicle. The LAC interfaces are shown in Figure 5.2.1.5-2. The mounting location of the DSC and LAC boxes is shown in Figure 5.2.1.5-4.

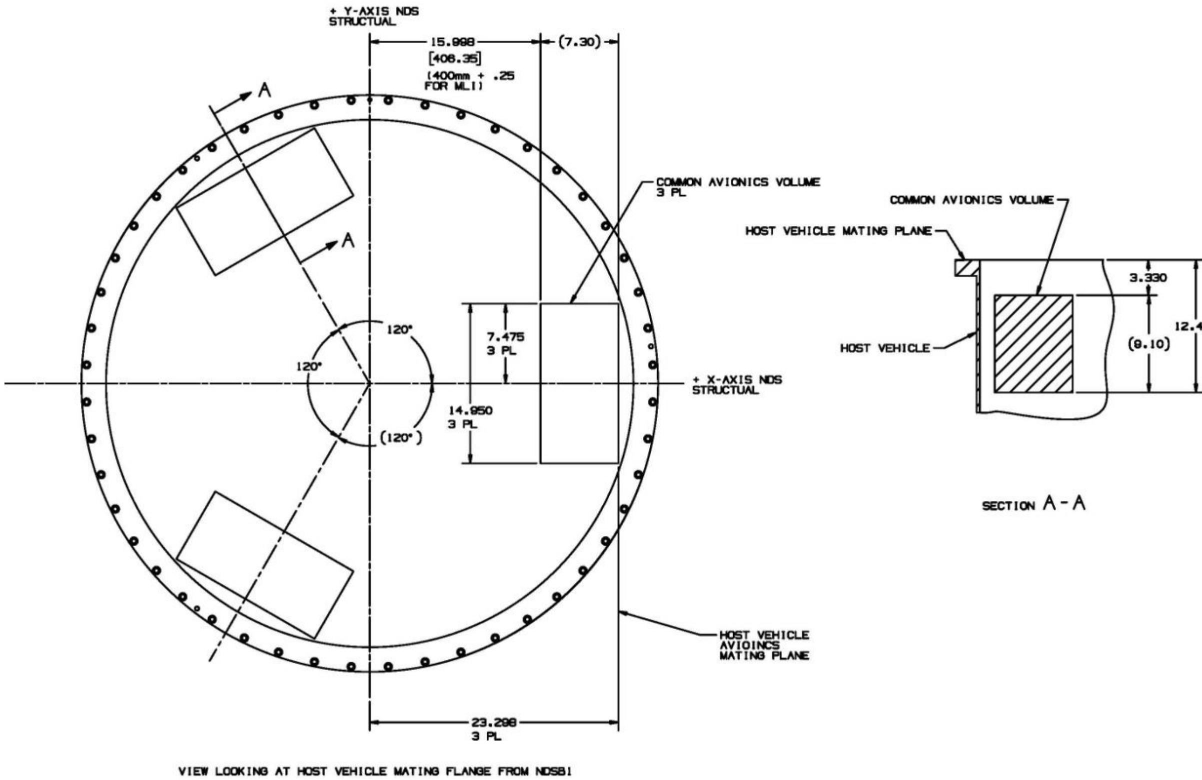



**FIGURE 5.2.1.5-4: NDSB1 AVIONICS BOX MOUNTING LOCATIONS**

**TABLE 5.2.1.5-1: ELECTRICAL BOX MASS PROPERTIES (TBD13)**

| | Mass lb (kg) | Center of Mass (1) In (mm) | | | Moments of Inertia (2) lb-in² (kg-mm²) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | X | Y | Z | Ixx | Iyy | Izz | Pxy | Pxz | Pyz |
| DSC | 26.0 (11.8) | | | | | | | | | |
| LAC | 27.0 (12.2) | | | | | | | | | |

Notes:
(1) Center of gravity tolerances : ± 0.5 in ( 12.7mm)
**(2)** Moments of inertia are based on the nominal center of gravity location.

### 5.2.1.5.1 DSC Random Vibration Environment

The DSC continues to perform after exposure to the Maximum Performance Environment (MPE) for random vibration represented in Figure 5.2.1.5.1-1 and Table 5.2.1.5.1-1 when configured for launch.

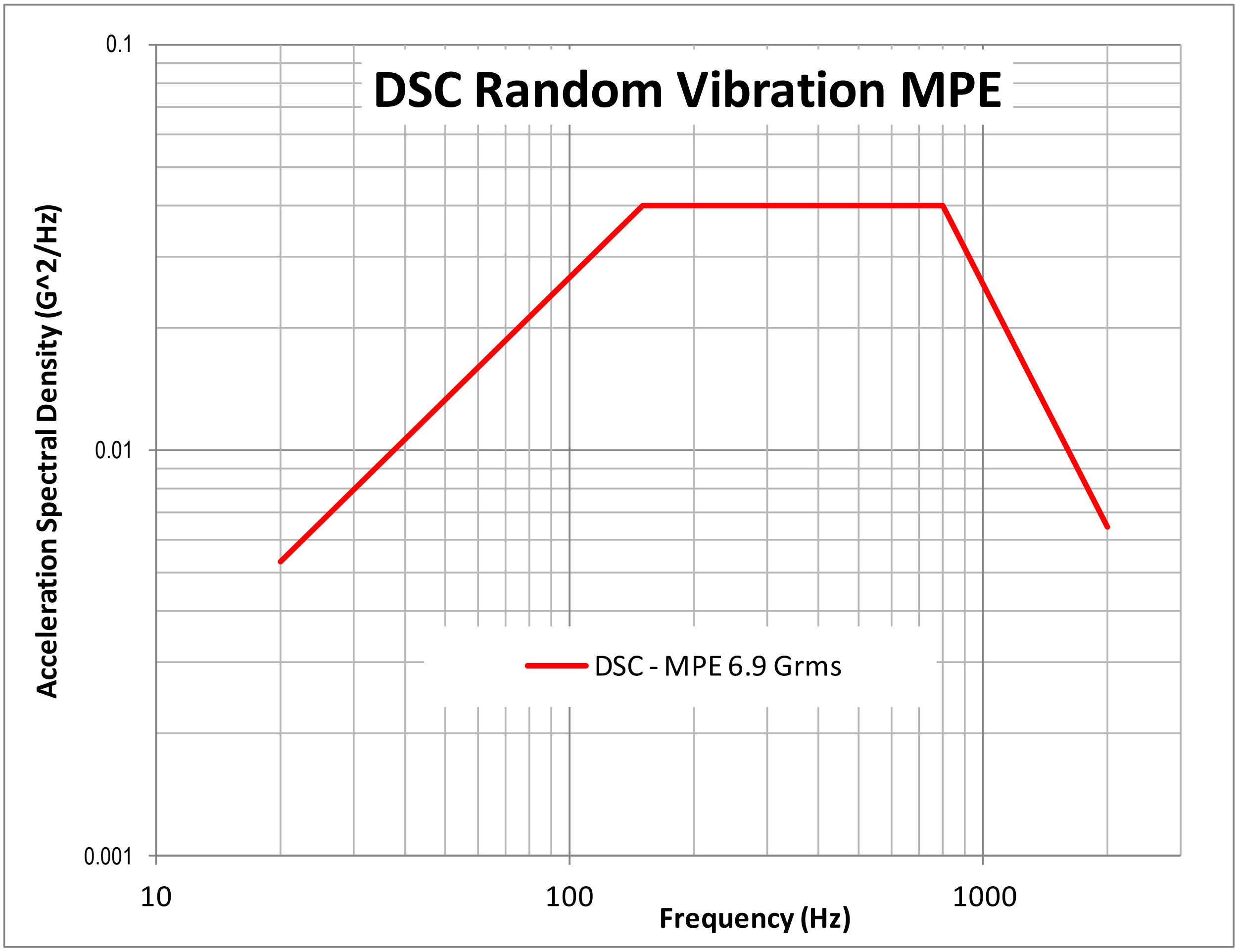



**FIGURE 5.2.1.5.1-1 DSC RANDOM VIBRATION MPE**

**TABLE 5.2.1.5.1-1 DSC RANDOM VIBRATION MPE**

| DSC Random Vibration MPE (OA 6.9 Grms) | |
|---|---|
| Frequency (Hz) | ASD (G^2/Hz) |
| 20 | 0.0053 |
| 150 | 0.04 |
| 800 | 0.04 |
| 2000 | 0.00644 |

#### 5.2.1.5.2 DSC Shock Environment

The DSC continues to perform after exposure to the MPE for shock levels represented in Figure 5.2.1.5.2-1 and Table 5.2.1.5.2-1.

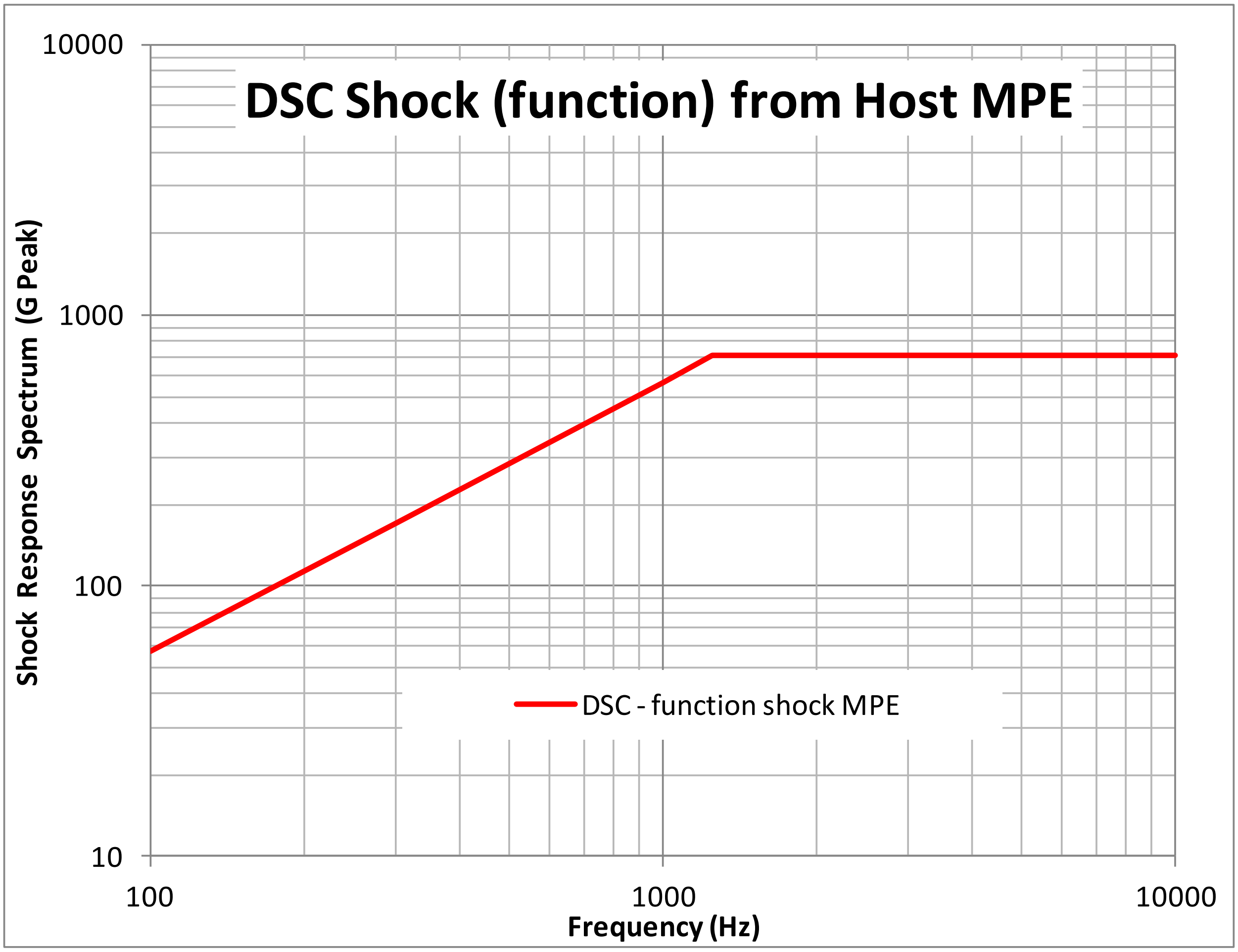



**FIGURE 5.2.1.5.2-1 DSC SHOCK RESPONSE MPE**

**TABLE 5.2.1.5.1-1 DSC SHOCK RESPONSE MPE**

| DSC Shock (function) from Host | |
|---|---|
| Frequency (Hz) | SRS (G Peak) |
| 100 | 57 |
| 300 | 170 |
| 1000 | 567 |
| 1250 | 710 |
| 6000 | 710 |
| 10000 | 710 |

### 5.2.1.5.3 DSC Jettison Shock Environment

The DSC (non-functioning only) stays contained after exposure to the MPE for jettison shock levels represented in Figure 5.2.1.5.3-1 and Table 5.2.1.5.3-1.

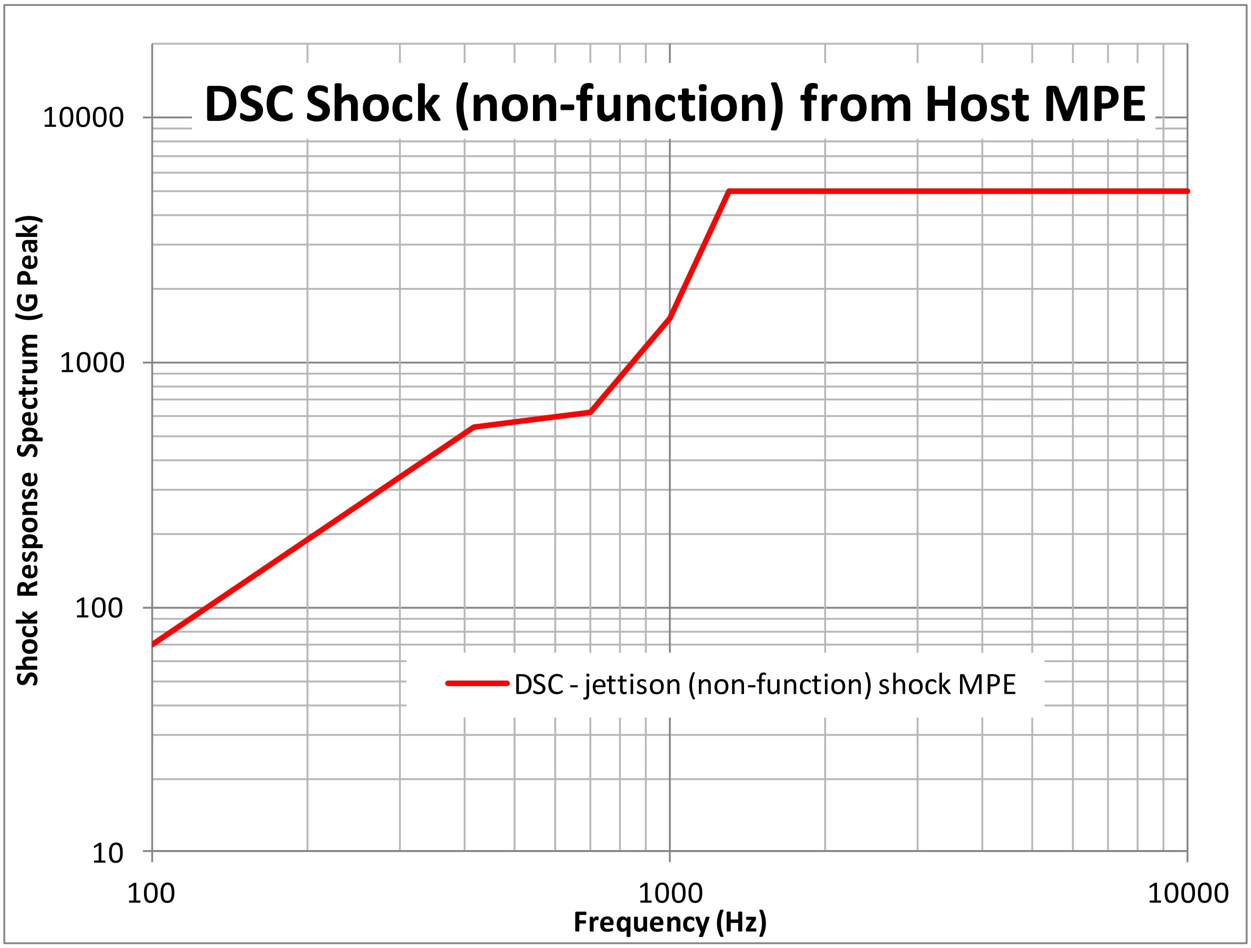



**FIGURE 5.2.1.5.3-1 DSC JETTISON SHOCK RESPONSE MPE**

**TABLE 5.2.1.5.3-1 DSC JETTISON SHOCK RESONSE MPE**

| DSC Jettison Shock Response (Non-Function) | |
|---|---|
| Frequency (Hz) | SRS (G Peak) |
| 100 | 70 |
| 420 | 540 |
| 700 | 625 |
| 1000 | 1500 |
| 1300 | 5000 |
| 10000 | 5000 |

### 5.2.1.5.4 LAC Random Vibration Environment

The LAC continues to perform after exposure to the MPE for random vibration represented in Figure 5.2.1.5.4-1 and Table 5.2.1.5.4-1 when configured for launch.

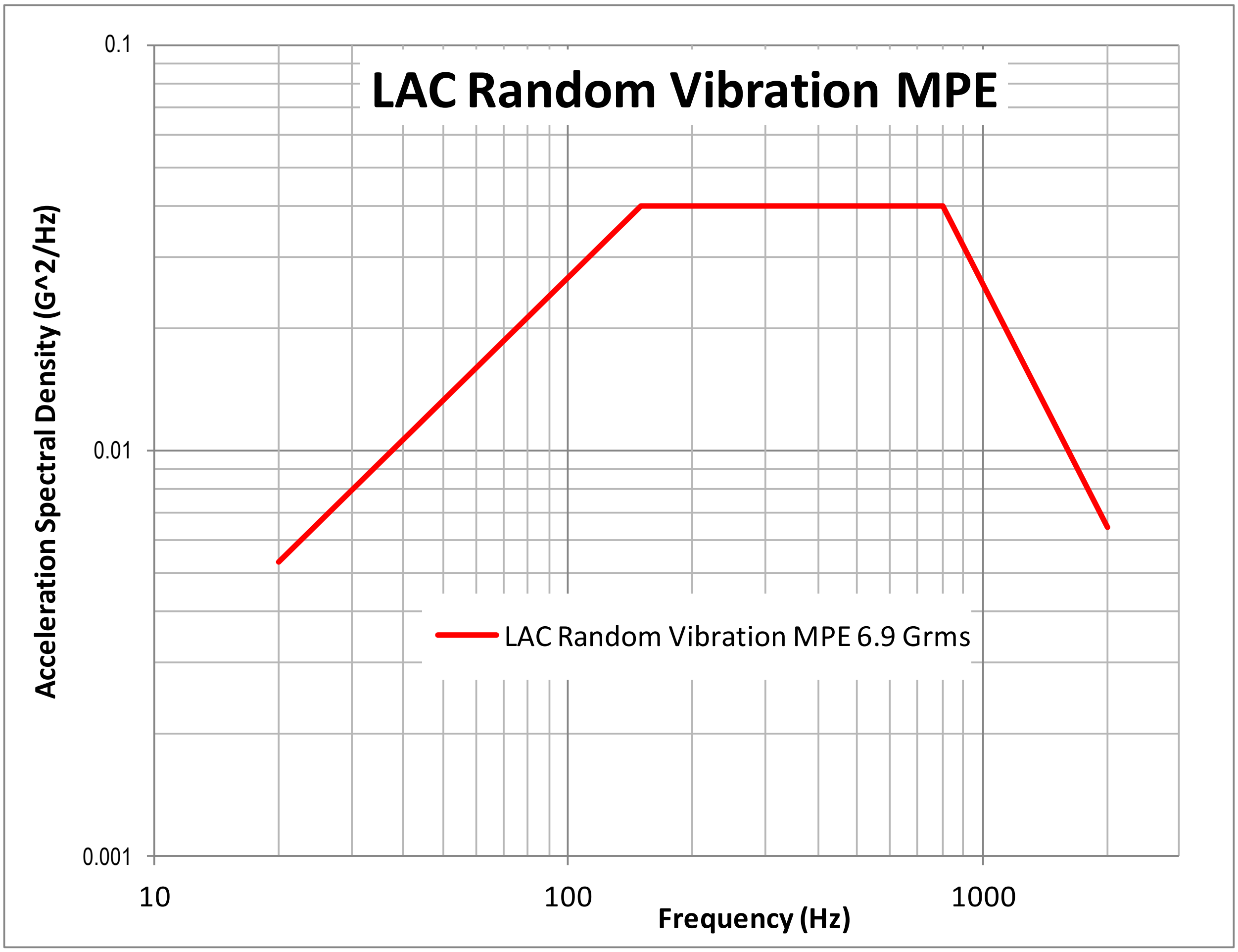



**FIGURE 5.2.1.5.4-1 LAC RANDOM VIBRATION MPE**

**TABLE 5.2.1.5.4-1 LAC RANDOM VIBRATION MPE**

| LAC Random Vibration MPE (OA 6.9 Grms) | |
|---|---|
| Frequency (Hz) | ASD (G^2/Hz) |
| 20 | 0.0053 |
| 150 | 0.04 |
| 800 | 0.04 |
| 2000 | 0.00644 |
| OA | 6.9 Grms |

#### 5.2.1.5.5 LAC Shock Environment

The LAC continues to perform after exposure to the MPE for shock levels represented in Figure 5.2.1.5.5-1 and Table 5.2.1.5.5-1.

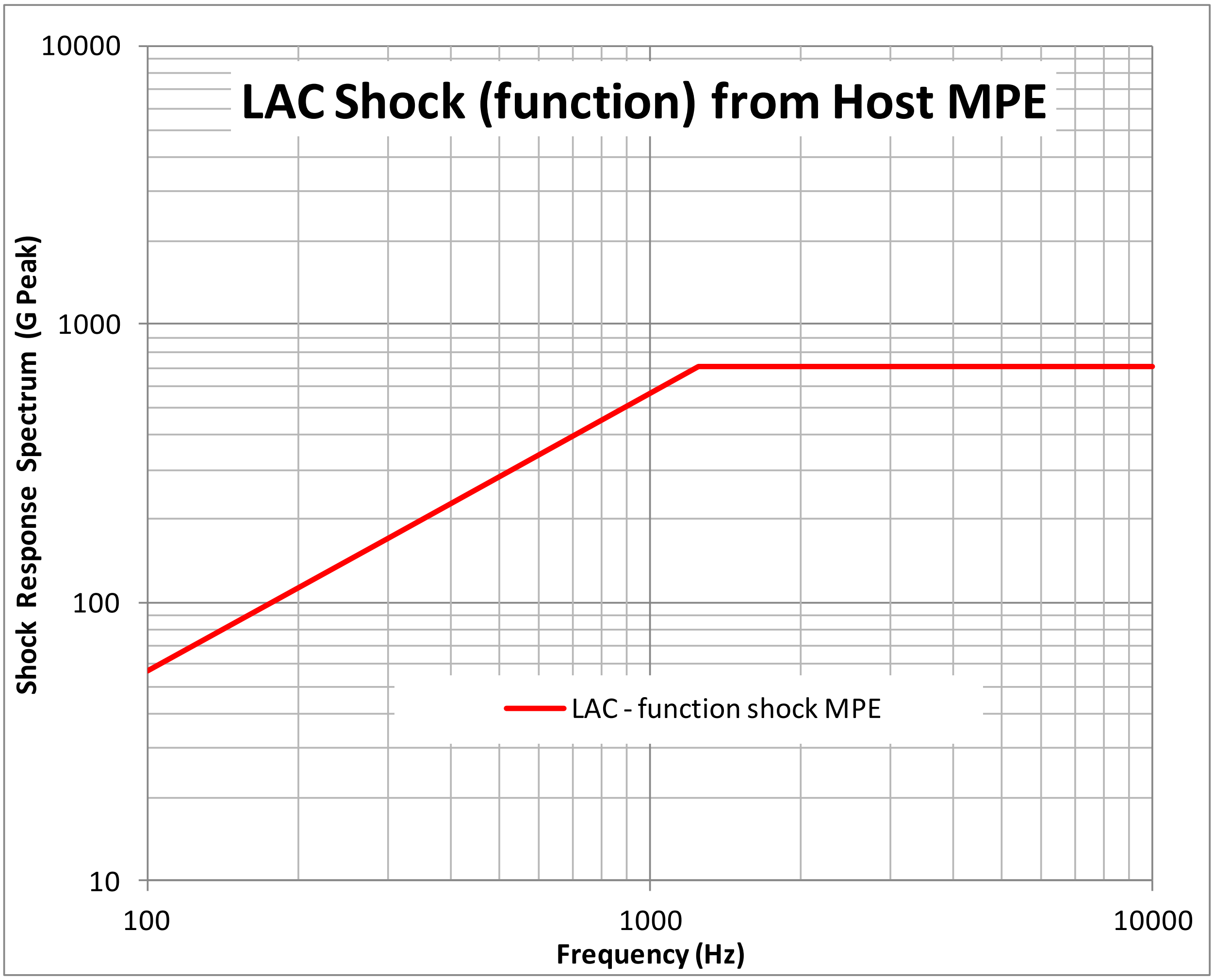



**FIGURE 5.2.1.5.5-1 LAC SHOCK REPONSE MPE**

**TABLE 5.2.1.5.5-1 LAC SHOCK RESPONSE MPE**

| LAC Shock (function) from Host | |
|---|---|
| Frequency (Hz) | SRS (G Peak) |
| 100 | 57 |
| 300 | 170 |
| 1000 | 567 |
| 1250 | 710 |
| 6000 | 710 |
| 10000 | 710 |

### 5.2.1.5.6 LAC Jettison Shock Environment

The LAC (non-functioning only) stays contained after exposure to the MPE for jettison shock levels represented in Figure 5.2.1.5.6-1 and Table 5.2.1.5.6-1.

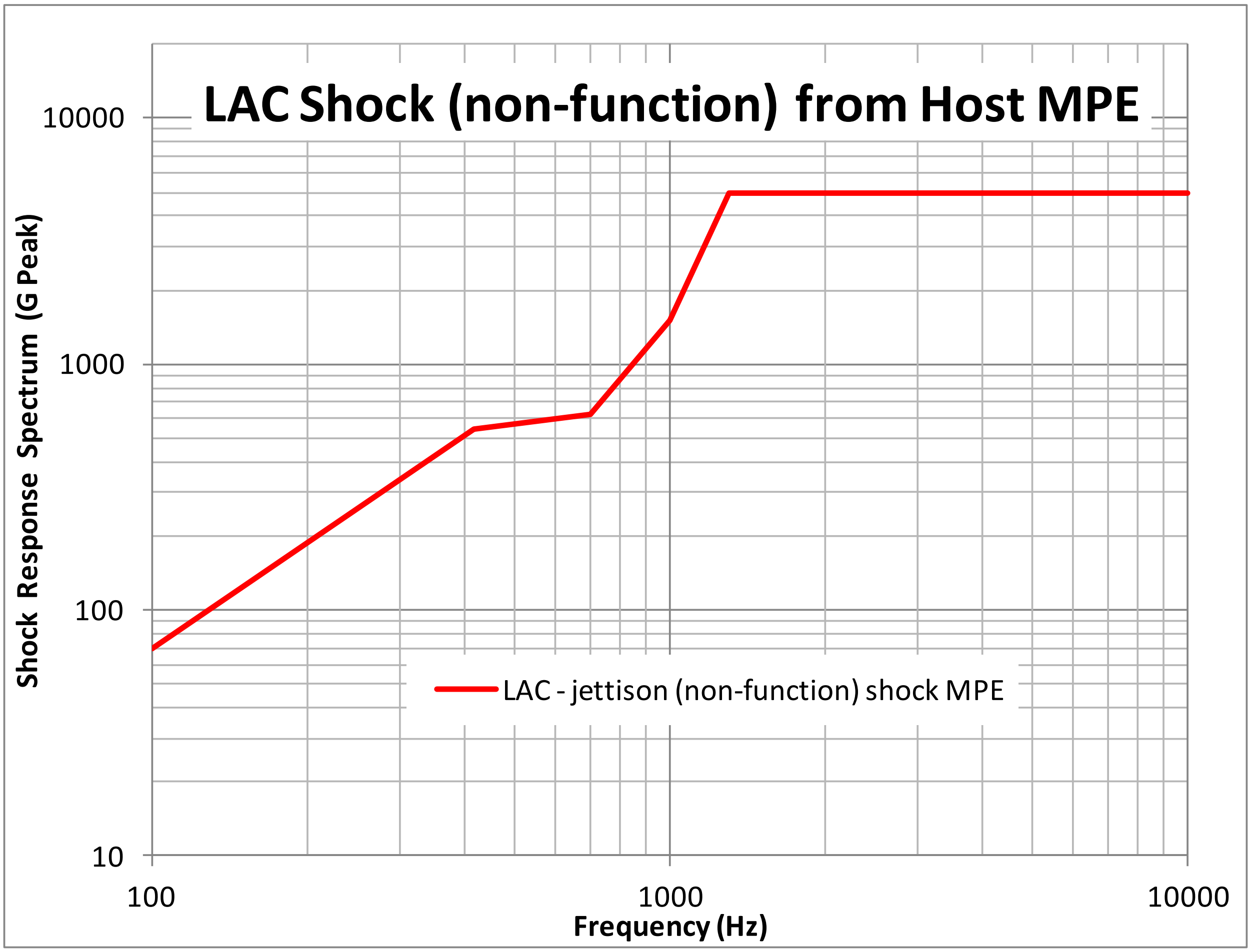



**FIGURE 5.2.1.5.6-1 LAC JETTISON SHOCK RESPONSE MPE**

**TABLE 5.2.1.5.6-1 LAC JETTISON SHOCK RESPONSE MPE**

| LAC Jettison Shock Response (Non-Function) | |
|---|---|
| Frequency (Hz) | SRS (G Peak) |
| 100 | 70 |
| 420 | 540 |
| 700 | 625 |
| 1000 | 1500 |
| 1300 | 5000 |
| 10000 | 5000 |

#### 5.2.1.6 Surface Cleanliness

The HV will maintain NDSB1 surfaces Visibly Clean (VC) “Level Sensitive” following receipt for integration through launch as defined in SN-C-0005, paragraph 2.4, Contamination Control Requirements.

#### 5.2.1.7 Seal Surface Cleanliness

The HV will maintain NDSB1 seal surfaces at least VC Level “Highly Sensitive” following receipt for integration through launch as defined in SN-C-0005, paragraph 2.4, Contamination Control Requirements.

#### 5.2.1.8 Leak Check Port

The NDSB1 will provide leak check ports to permit independent verification of the seals at the NDSB1 to HV interface during ground operations.

### 5.2.2 Thermal Interface

The thermal interfaces and hardware performance are analyzed using the following approach:

Thermal Model Development

Thermal models of NDSB1 are developed based on drawings, CAD models of the design, and interfaces defined in specifications. The NDSB1 system level thermal models will be capable of simulating solo flight or docking scenarios with the ISS and IDA.

Host Vehicle Conduction

The NDSB1 utilizes heaters and heat transfer with the host vehicle to condition/maintain temperatures within limits for each operating model. The NDSB1 thermal model assumes heat transfer by conduction across the structural interface with the host vehicle. The NDSB1 will limit heat transfer across the interface. The host vehicle will provide the required boundary temperatures based on the heat transfer.

Host Vehicle Radiation

A disc representing the NDSB1 view to host vehicle is included in the NDSB1 system level thermal model to represent radiation to the host vehicle. The disc representing the host vehicle will have a radius 1.43 times larger than the NDSB1. The disc is modeled with arithmetic nodes and optical properties of $\alpha = 0.3$ and $e = 0.9$. This disc will be flush with the NDSB1 base/vehicle interface point.

Host Vehicle MMOD/External Hardware Thermal Interface

NDSB1 system level thermal analysis will be performed with the NDSB1 external MLI exposed and no additional heat leak applied at the external flange interfaces.

Environment and Attitudes

The NDSB1 system level thermal model simulates the LEO environments and attitudes to predict temperature ranges for comparison to hardware limits. Table 5.2.2-1 shows the LEO environmental parameters for thermal: Solar flux, albedo, and Earth Outgoing Long-wave Radiation (OLR) environments. Table 5.2.2-2 gives the flight attitudes used for design. Figure 5.2.2-1 shows the NDSB1 coordinate system and the LVLH coordinate system for docking to the ISS.

Unmated solar inertial attitudes with the NDSB1 facing the sun are known to cause violations of operational and survival limits. These attitudes will be assessed for capability only. Time constraints to protect the NDSB1 will be documented in EID684-15524, NDSB1 Thermal Analysis Report.

**TABLE 5.2.2-1: EXTREME HOT AND COLD NATURAL THERMAL ENVIRONMENTS**

| Condition (1,2) | | ALBEDO* | OLR** (Btu/hr-ft$^2$) |
|---|---|---|---|
| Cold | A | 0.27 | 65.3 |
| | B | 0.20 | 76.4 |
| Hot | A | 0.30 | 90.6 |
| | B | 0.40 | 76.4 |

Solar Constants (Btu/hr-ft$^2$)
Cold 418.8
Hot 451.2

**Notes:**

(1) Values in this table represent a 3 sigma probability. Albedo and OLR are adjusted to the top of the atmosphere (18.6 nm altitude).

(2) Both Set A and Set B are design requirements. Set A represents worst case OLR values with corresponding albedo values. Set B represents worst case albedo values with corresponding OLR values.

*Albedo is the fraction of solar energy (shortwave radiation) reflected from the Earth back into space. It is a measure of the reflectivity of the earth's surface.

**Outgoing Longwave Radiation (OLR) is the energy leaving the earth as infrared radiation. The OLR is dependent on the temperature of the radiating body.

Source: NASA Technical Memorandum 4527 "Natural Orbital Environment Guidelines for use in Aerospace Vehicle Development", dated June 1994 by Jeffrey Anderson.

## TABLE 5.2.2-2: NDSB1 DESIGN ATTITUDES

| Attitude | Configuration | Reference frame | Solar Beta range | Yaw* | Pitch* | Roll* | Description |
|---|---|---|---|---|---|---|---|
| +X on -VV | NDSB1/ISS | LVLH | -75° ≤ β ≤ +75° | -15° to +15° | -20° to +15° | -15° to +15° | NDSB1 solo or approaching attitude toward ISS Node2 PMA2 forward docking port. The NDSB1 +X axis on the opposite of the velocity vector. |
| +X on Nadir | NDSB1/ISS | LVLH | -75° ≤ β ≤ +75° | -15° to +15° | -20° to +15° | -15° to +15° | NDSB1 solo or approaching attitude toward ISS node2 PMA3 Zenith docking port. The NDSB1 +X points toward earth. |
| +X on Zenith | NDSB1 solo | LVLH | -75° ≤ β ≤ +75° | -15° to +15° | -15° to +15° | -15° to +15° | NDSB1 solo flight and not a docking attitude. The NDSB1 +X points away from earth. |
| +X to Sun To -X to Sun | NDSB1 solo | SI | -75° ≤ β ≤ +75° | N/A | N/A | N/A | Two fixed orientations per orbit. At solar noon the NDSB1 +X axis pointing at the sun. At solar midnight the -X axis pointing at the sun. Attitude switches at true anomaly 90 and 270 degrees. |
| +/- Y/Z to Sun | NDSB1 solo | SI | -75° ≤ β ≤ +75° | N/A | N/A | N/A | Two fixed orientations per orbit. At solar noon the NDSB1 +X axis on velocity vector. At solar midnight the +X axis on velocity vector. |
| -X to Sun | NDSB1 solo | SI | -75° ≤ β ≤ +75° | N/A | N/A | N/A | NDSB1 -X axis pointing at the sun all around orbit. |

* Allowable ISS reference attitude deviations

****General Notes**

1. Basic vehicle orientations are described by indicating the direction that Space Station body axes are pointing. HV is the Velocity Vector, Zenith is up and Nadir is down.
2. The Space Station average orbital inclination is 51.6 degrees.
3. The Space Station altitude varies between 180 and 270 nautical miles.
4. All attitudes are yaw, pitch and roll Euler angle rotation sequences with 0, 0, 0 YPR aligned with the LVLH reference frame.
5. When Torque Equilibrium Attitude (TEA) is also specified, it means that the attitude will be the nearest TEA to the designated orientation such as +XHV TEA. The TEA is normally also the minimum propellant attitude (MPA).
6. Solar beta angle is the angle between the ISS orbit plan and the Sun vector. Solar beta angle takes the sign of the orbit angular momentum vector – Sun on the north side of the orbit is positive, south side is negative.
7. NDSB1 +X axis to Sun, solar inertial (SI) attitude, will be assessed for capability only and not as a design attitude requirement. This attitude results in the NDSB1 +X axis facing the sun throughout the orbit. Transient analyses will determine allowable exposure times in this attitude. See section D684-15386 NDSB1 Concept of Operations, section 1.5.2 HV DRM for additional information

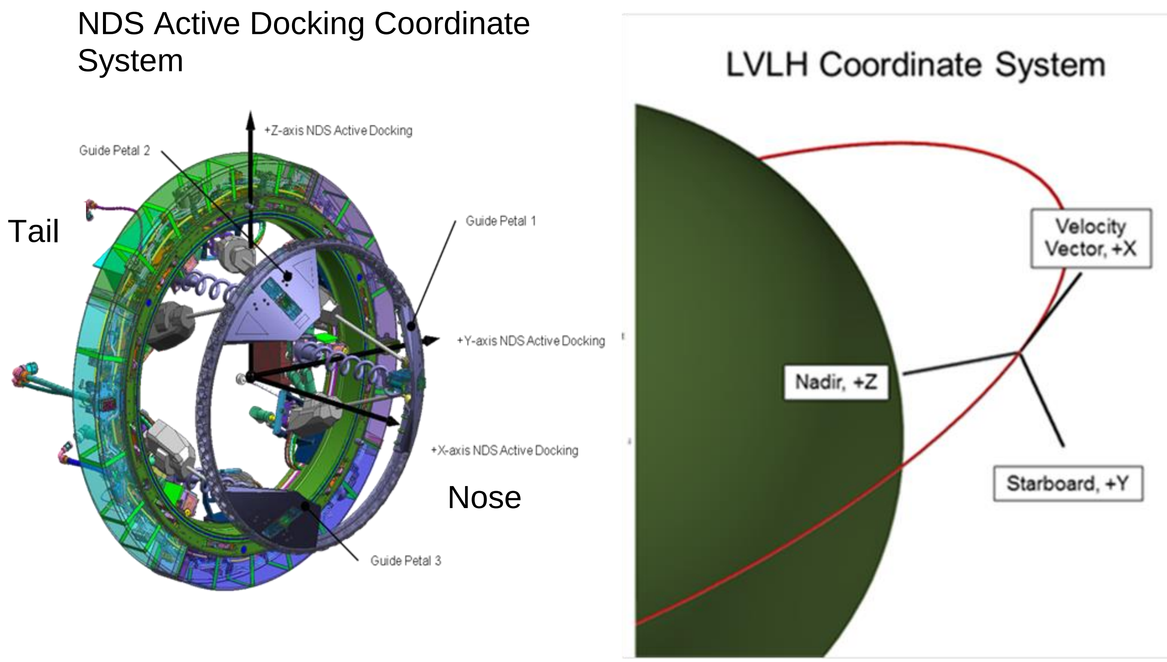



**FIGURE 5.2.2-1, NDSB1 AND LVLH COORDINATE SYSTEMS**

NDSB1 Analysis Results

The results of the thermal model are used to select proper materials, optics, and insulation to maintain components within limits for both hot and cold environments. Hardware and interface temperature predictions will be documented in EID684-15524, NDSB1 Thermal Analysis Report.

Thermal Gradients

Predicted temperatures from the NDSB1 thermal models will be mapped to structural models to assess thermal gradients within the NDSB1.

Integrated NDSB1/Host Vehicle Analysis

Integrated NDSB1/host vehicle analysis, with host provided MMOD shielding, must show that NDSB1 design is capable of meeting the minimum requirements for solo flight, checkout, docking and mated/pressurized conditions expected for that vehicle's mission.

NDSB1-to-IDA Thermal Conductance

For steady state mated configurations, the NDSB1-to-IDA docking interface is assumed to be adiabatic. For evaluation of transient response in mated configurations, the integrated models should use the appropriate conductance to be conservative from that thermal evaluation's perspective. The thermal conductance across the NDSB1-to-IDA HCS docking interface is defined as ranging from 75 Btu/hr-°F (40 W/°K) to 187 Btu/hr-°F (98 W/°K).

#### 5.2.2.1 NDSB1-to-Host Vehicle

The NDSB1 utilizes heaters and conduction to the HV to maintain temperatures within the temperature limits for each operating mode. .

The allowable NDSB1-to-host vehicle interface temperature ranges, the heat transfer rate for each operating condition, the thermal conductance across the interface flange, the electrical box heat dissipation, and the HV MMOD thermal interface are defined in the following subsections.

##### 5.2.2.1.1 Non-Operational Survival

Non-operational survival conditions apply to NDSB1 to host vehicle structural interfaces during solo flight.

###### 5.2.2.1.1.1 Structural

The following applies when the docking system is unmated and the system is not in checkout or docking mode. Heaters may be required depending on mission profile.

NDSB1 to HV Heat Transfer

Maximum heat loss from HV-to-NDSB1: 360 W

Maximum heat gain to HV from NDSB1: 370 W

The NDSB1 will be designed to limit the orbital average heat transfer across the NDSB1-to-HV structural interface.

HV-to-NDSB1 Interface temperatures

60°F (-15.6°C) to 103°F (+39.4°C)

The HV controls the temperature of the structural interface between the HV and the NDSB1 to this range during Host Vehicle Solo Flight.

###### 5.2.2.1.1.2 NDSB1 Electrical boxes

The following applies when the docking system is unmated and the system is not in checkout or docking mode.

Unpowered

The non-operational temperature range for the NDSB1 electrical boxes is:

-11 °F to +142 °F (-24 °C to +61 °C)

The HV thermal design should maintain the temperature of the electrical boxes (Docking System Controller and Linear Actuator Controller) within this range prior to activation of the system.

Powered

The operational temperature range for the NDSB1 electrical boxes is:

-11 °F to +142 °F (-24 °C to +61 °C)

Figure 5.2.1.5-1 shows the mounting interface for the DSC. Figure 5.2.1.5-2 shows the mounting interface for the LAC.

The HV is responsible for the design of the mounting provisions for the electrical boxes. The thermal design of the host vehicle mounting must provide the combination of conduction and mounting interface temperatures necessary to maintain DSC and LAC baseplate temperatures within limits during powered operations. Integrated host vehicle analysis must be performed to assess this interface. The mounting interface temperature during operation will vary depending on box power dissipation and environment parameters. To minimize the temperature difference between the box and the mounting surface, the HV design should provide a thermal contact conductance greater than 25 Btu/hr-ft$^2$-°F (142 W/m$^2$-°K) across the full area of the box baseplate. A higher contact conductance may be required depending on the vehicle design and temperature conditions. A thermal conductive elastomer or gap filler will be needed between the mounting surface and the box baseplate if the components are mounted in the unpressurized environment.

The thermal optical properties of the electrical boxes analysis are required for HV thermal analysis. The LAC and DSC have an emissivity greater than 0.75 and a solar absorptivity-to-emissivity ratio less than 1.2 on non-baseplate surfaces.

Section 5.2.2.1.6 provides the component heat dissipation for different phases of operation. The LAC contains a set of redundant cards and will dissipate heat on one half of the baseplate contact area during operation. Note: If electrical boxes are remotely mounted inside the host vehicle, they may reach temperatures during operation that exceed the bare handed touch temperature limit of +113 °F (45 °C). If integrated host vehicle analysis indicates this condition can occur, the host may need to apply warning labels or guards.

#### 5.2.2.1.1.3 Deleted

#### 5.2.2.1.1.4 NDSB1 Component Level Non-Operating Temperature Limits

Non-operating temperature limits for individual NDSB1 components are shown in Table 5.2.2.1.1.4-1.

**TABLE 5.2.2.1.1.4-1 NON-OPERATING TEMPERATURE LIMITS FOR NDSB1 COMPONENTS**

| Assembly | Component | SCD/ED doc. | Non-Operating Temperature Limits (°F) | |
|---|---|---|---|---|
| | | | Lower | Upper |
| Tunnel | Tunnel | D683-93052-85 | -65 | 192 |
| Pyro | Pyrobolt | ED684-016650-C | -100 | 225 |
| | ETL | ED684-016643-D | -100 | 225 |
| Seals | Dynamic Seals | JSC-64595C | -65 | 192 |
| | Static Seals | JSC-65978 | -65 | 192 |
| Hook Assembly | Structure | S684-14475 | -65 | 192 |
| | Hooks | S684-14475 | -100 | 225 |
| Hook Drive System | Flex Shafts | SSW FABOE25AZ | -85 | 212 |
| | Gear heads | SLZ29101646 | -65 | 192 |
| | EMA | SLZ29101646 | -65 | 192 |
| Separation System | Structure | ED684-018764 | -65 | 192 |
| | Plunger | ED684-018764 | -65 | 192 |
| | EMA | ED684-018764 | -65 | 192 |
| | Limit Switches | ED684-016231 | -85 | 500 |
| Umbilical Assembly | Connector | SSQ 22680-J | -135 | 372 |
| | Structure | ED684-018763 | -65 | 192 |
| | EMA | ED684-018763 | -65 | 192 |
| | Limit Switches | ED684-016231 | -85 | 500 |
| Ready to Hook Sensor | Structure | D683-93052-85 | -65 | 192 |
| | Limit Switches | ED684-016231 | -85 | 500 |
| Lockdown Assembly | Structure | D683-93052-85 | -65 | 192 |
| | Motor/Solenoid | TBD | TBD | TBD |
| | Limit Switches | ED684-016231 | -85 | 500 |
| Guide Ring | Ring | D683-93052-85 | -65 | 192 |
| Guide Petals | Petals | D683-93052-85 | -65 | 192 |
| Capture Latch Assembly | Structure | D683-93052-85 | -65 | 192 |
| | Motor/Solenoid | TBD | TBD | TBD |
| | Limit Switches | ED684-016231 | -85 | 500 |
| Soft Capture Sensor | Structure | IDA CDR | -65 | 204 |
| | Limit Switches | ED684-016231 | -85 | 500 |
| Linear Actuators | Housing | ED683-101103-A | -65 | 160 |
| | Motor | ED683-101103-A | -65 | 160 |

| | | | | |
|---|---|---|---|---|
| | Shaft | ED683-101103-A | -65 | 170 |
| Linear EMA Joints | Upper Yoke | D683-93052-85 | -65 | 192 |
| | Lower Yoke | D683-93052-85 | -65 | 192 |
| MLI | MLI | Material Data | -240 | 300 |
| SCS Heaters | Heaters | ED684-022454 | -85 | 187 |

Note: Structural hardware will be analyzed to non-operating temperature limits given in D683-93052-85 NDSB1 Assembly Structural Verification Plan.

#### 5.2.2.1.2 Operational

Operational conditions apply to NDSB1 to host vehicle structural interfaces during check-out and docking.

##### 5.2.2.1.2.1 Structural

The following NDSB1-to-HV Structural Interface conditions apply during Checkout, soft capture, and prior to Hard Capture State.

NDSB1-to-HV Heat Transfer

Maximum heat loss from HV-to-NDSB1: 360 W

Maximum heat gain to HV from NDSB1: 370 W

The NDSB1 will be designed to limit the orbital average heat transfer across the NDSB1-to-HV structural interface.

HV-to-NDSB1 Interface temperatures

60°F (-15.6°C) to 103°F (+39.4°C)

The HV controls the temperature of the structural interface between the HV and the NDSB1 to this range during Checkout, soft capture, and prior to Hard Capture State.

##### 5.2.2.1.2.2 NDSB1 Electrical Boxes

The operational temperature range for the NDSB1 electrical boxes is:

-11 °F to +142 °F (-24 °C to +61 °C)

Figure 5.2.1.5-1 shows the mounting interface for the DSC. Figure 5.2.1.5-2 shows the mounting interface for the LAC.

The HV is responsible for the design of the mounting provisions for the electrical boxes. The thermal design of the host vehicle mounting must provide the combination of conduction and mounting interface temperatures necessary to maintain DSC and LAC baseplate temperatures within limits during powered operations. Integrated host vehicle analysis must be performed to assess this interface. The mounting interface temperature during operation will vary depending on box power dissipation and environment parameters. To minimize the temperature difference between the box and the mounting surface, the HV design should provide a thermal contact conductance greater than 25 Btu/hr-ft$^2$-°F (142 W/m$^2$-°K) across the full area of the box baseplate. A higher contact conductance may be required depending on the vehicle design and temperature conditions. A thermal conductive elastomer or gap filler may be needed between the mounting surface and the box baseplate if the components are mounted in the unpressurized environment.

The thermal optical properties of the electrical boxes analysis are required for HV thermal analysis. The LAC and DSC have an emissivity greater than 0.75 and a solar absorptivity-to-emissivity ratio less than 1.2 on non-baseplate surfaces.

Section 5.2.2.1.6 provides the component heat dissipation for different phases of operation. The LAC contains a set of redundant cards and will dissipate heat on one half of the baseplate contact area during operation. Note: If electrical boxes are remotely mounted inside the host vehicle, they may reach temperatures during operation that exceed the bare handed touch temperature limit of +113 °F (45 °C). If integrated host vehicle analysis indicates this condition can occur, the host may need to apply warning labels or guards.

#### 5.2.2.1.3 Mated and Pressurized

This subsection defines steady-state mated and pressurized limits for the NDSB1 after hard mate and pressurization.

##### 5.2.2.1.3.1 Mated and Pressurized Steady-State Temperature Range

The following applies during mated pressurized operation:

NDSB1-to-HV Heat Transfer

Maximum heat loss from HV to NDSB1: 100 W when the HV side of the structural interface is at +65°F (+18.3°C)

Maximum heat gain to HV from NDSB1: No heat gain at maximum temperature

The NDSB1 is unheated during mated pressurized operations. The design will limit heat loss from the HV when exposed to cold case conditions

HV-to-NDSB1 Interface temperatures

+65°F (+18.3°C) to +113°F (+45°C)

The HV control the temperature at the structural interface between the HV and the NDSB1 during mated operations.

NDSB1 Internal Volume

60°F (15.6°C) and 113°F (+45°C)

Temperatures within this range are above the maximum dew point requirement and below the maximum IVA touch temperature.

#### 5.2.2.1.3.2 Mated and Pressurized Steady-State Time Period

Hardware temperatures at the time of docking may be below the dew point and minimum IVA touch temperature for cold cases environments and attitudes, or above the maximum IVA touch temperature for hot case environments and attitudes. The NDSB1 temperature conditions will approach the steady state temperatures described in Paragraph 5.2.2.1.3.1 as a function of time. The time-to-limit for worst case hot and cold case conditions will be assessed and documented in EID684-15524, NDSB1 Thermal Analysis Report.

Pressurization or hatch opening is not restricted by the transient temperature profile. (Refer to Nonconformance Compliance Report NCR-ISS-iLIDS-002 allowing early hatch opening.) However, if hatch opening is required prior to the system achieving safe touch temperatures, the crew may be required to use PPE. If the temperature of the vestibule is not above the dew point, condensation will occur within the vestibule during this transition period.

#### 5.2.2.1.4 Mated and Unpressurized

For scenarios in which the NDSB1 is hard mated and the vestibule remains unpressurized, the steady state temperatures and heat transfer will be similar to mated pressurized conditions. However, the touch temperature and condensation limits are not in effect, so the transient temperature response is not an issue.

The following applies during mated unpressurized operation:

NDSB1-to-HV Heat Transfer

Maximum heat loss from HV to NDSB1: 100 W when the HV side of the structural interface is at +65°F (+18.3°C)

Maximum heat gain to HV from NDSB1: No heat gain at maximum temperature

The NDSB1 is unheated during mated pressurized operations. The design will limit heat loss from the HV for the mated configuration.

HV-to-NDSB1 Interface temperatures

+65°F (+18.3°C) to +113°F (+45°C)

The HV provides control of the temperature of the structural interface between the HV and the NDSB1 during mated operations.

NDSB1 Internal Volume

60°F (15.6°C) and 113°F (+45°C)

The NDSB1 design does not rely on convection to maintain thermal conditioning for steady-state mated conditions. The NDSB1 design will be able to maintain the temperatures within the same range for both pressurized and unpressurized conditions.

#### 5.2.2.1.5 Thermal Conductance

The HV design is responsible for the providing the thermal conductance across the NDSB1-to-HV interface. The thermal contact conductance across the structural interface is defined as being greater than or equal to 50 Btu/hr-ft$^2$-°F (284 W/m$^2$-°K). Integrated models should use the appropriate contact conductance to be conservative from that thermal evaluation's perspective.

##### 5.2.2.1.5.1 Umbilical Power Transfer Interface-to-Host Vehicle

The NDSB1, after hard-mate is complete, will transfer redundant 25 amps at a maximum of 126 VDC power from the IDA to the Host Vehicle in accordance with SSP 50933. The pinouts are shown in Table 4.2.2.3.1-1, IDA to HV Interface (SYS A) –J35 and Table 4.2.2.3.1-2, IDA to HV Interface (SYS B) – P35.

#### 5.2.2.1.6 NDSB1 Remote-Mounted Electrical Boxes and Heater Power Dissipation

The NDSB1 design consists of three remotely mounted boxes, a LAC and two DSC. The heat dissipation of these components depends on the mode of operation. The power dissipation for the Linear Actuator Controller is provided in Table 5.2.2.1.6-1. The power dissipation for the Docking System Controller is provided in Table 5.2.2.1.6-2. The DSC controls the NDSB1heater system. Table 5.2.2.1.6-3, NDSB1 HEATER POWER DISSIPATION, documents the heaters and DSC power dissipation due to driving the heaters. The heater power dissipation is calculated as follows:

Energy = ((Total Heater Power x 24 hrs) + (DSC dissipation x 1hr$^{(1)}$)) x Duty Cycle

(1) Docking = 1hr, Undocking=0.5hr

The power dissipation on each box is provided to allow host vehicles to size environmental systems for remote mounted boxes.

**TABLE 5.2.2.1.6-1: NDSB1 REMOTE-MOUNTED ELECTRICAL BOXES POWER DISSIPATION**

| LAC A & B Docking | | |
|---|---|---|
| Condition | Power (W) | |
| | Average | Peak |
| Monitor Mode | 10 | 12 |
| SCS Checkout | 55 | 66 |
| Active Docking | 25 | 30 |
| Standby Docking | 10 | 12 |

**TABLE 5.2.2.1.6-2: POWER CHARACTERISTICS**

| DSC A or B - Docking/Undocking | | |
|---|---|---|
| Condition | Power (W) | |
| | Average | Peak |
| Monitor Mode | 15 | 25 |
| Monitor + Heater | 25 | 32 |
| Active Docking | 60 | 75 |
| Standby Docking | 60 | 75 |
| Active Undocking | 60 | 75 |

**TABLE 5.2.2.1.6-3, NDSB1 HEATER POWER DISSIPATION**

| NDSB1 Heaters Energy Consumption (Watt-Hrs) Docking | | | | | | | |
|---|---|---|---|---|---|---|---|
| Heater Setpoint | Beta Angle | Attitude | | | | | |
| | | 1) +X on –VV | 2) +X on Nadir | 3) +X on Zenith | 4) +X to Sun to -X to Sun | 5) +/-Y/Z to Sun | 6) -X to Sun |
| -45 F to -40 F Setpoint | ±0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | ±15 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | ±30 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | ±45 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | ±60 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 924.9 |
| | ±75 | 598.5 | 0.0 | 3046.8 | 0.0 | 0.0 | 1523.4 |
| -40 F to -35 F Setpoint | ±0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | ±15 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | ±30 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 380.9 |
| | ±45 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 924.9 |
| | ±60 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1741.1 |
| | ±75 | 1197.0 | 0.0 | 3645.3 | 0.0 | 0.0 | 2230.7 |
| 0 F to 5 F Setpoint | ±0 | 0.0 | 0.0 | 0.0 | 0.0 | 2557.2 | 5440.8 |
| | ±15 | 0.0 | 0.0 | 0.0 | 0.0 | 2666.0 | 5440.8 |
| | ±30 | 326.4 | 217.6 | 0.0 | 0.0 | 2502.8 | 5440.8 |
| | ±45 | 0.0 | 0.0 | 1741.1 | 0.0 | 2285.1 | 5440.8 |
| | ±60 | 2394.0 | 0.0 | 2176.3 | 0.0 | 1958.7 | 5440.8 |
| | ±75 | 4679.1 | 816.1 | 5440.8 | 0.0 | 0.0 | 5440.8 |

Note: The tables above represent NDSB1 heater power consumption in solo flight. Power consumption is dependent on attitude and heater setpoint. The HV can reset heater setpoints during operation based on mission attitude profile and power availability.

- -45°F to -40°F Setpoint: Minimum setpoint to protect hardware limits.
- -40°F to -35°F Setpoint: Minimum setpoint with additional 5°F margin.
- 0°F to 5°F Setpoint: Maximum recommended setpoint for solo flight and docking at worst case attitude.
- Heater power is assumed worst case at 73.5W and 36VDC
- DSC power dissipation due to driving heaters is incorporated in the Watt-Hr calculations
- Watt-Hrs are calculated for a 24 hour cycle

#### 5.2.2.2 Host Vehicle provided MMOD

The MMOD protection for the NDSB1 is provided by the HV. Figure 5.2.1.2-1: NDSB1 Host-Provided MMOD Interface shows the mounting points on the tunnel flange for MMOD shielding or other external hardware.

Integrated NDSB1/host vehicle analysis, with host vehicle hardware mounted at this interface, must show that the NDSB1 is capable of meeting requirements for non-operational, operational and mated/pressurized conditions expected for that vehicle's mission (see paragraph 7.1.1.2.3.2).

General design guidelines for HV MMOD to meet thermal requirements are listed below.

- HV MMOD shields or other tunnel flange mounted hardware can only contact the NDSB1 at the upper and lower tunnel flanges.

- HV external hardware should incorporate isolators, optical properties, or other design features to prevent excessive heat transfer at the flange mounts.

- The temperature of external HV MMOD and hardware should be limited to avoid excessive thermal radiation to umbilicals and hooks not covered by the NDSB1 provided MLI.

- An MLI Thermal cover over the external tunnel hardware is provided by the NDSB1. The NDSB1 MLI thermal blankets are located internal to the HV provided MMOD shields.

- The HV will prevent the components external to the NDSB1 tunnel from receiving any incident solar rays except for the docking flange hook assembly openings.

## 5.3 NDSB1-to-Host Vehicle Electrical and Signal Interface Umbilical

This subsection describes the electrical and signal interfaces between the NDS and the host vehicle. As indicated in Figure 5.2.1.5-3 NDSB1 Cabling there are two NDSB1-to-IDA electrical umbilical connectors allowing redundant electrical signals. Both power and Command and Data Handling (C&DH) are routed through a single connector. However, after exiting the backshell of the NDSB1-to-IDA umbilical connector, the power and C&DH are separated and run to individual connectors at the host side. The NDSB1 electrical connections are located as shown in Figure 5.5-

1: NDSB1 -to-Host Vehicle Electrical Interface. The electrical interface between the NDSB1 and the host vehicle has the functions indicated in Figure 5.2.1.5-3, NDSB1 Cabling .

### 5.3.1 Umbilical Data Transfer Interface-to-the-Host Vehicle

The NDSB1 to Host Vehicle umbilical interfaces will provide the utilities to transfer two MIL-STD-1553 and two IEEE 802.3u Ethernet connections between the mated vehicles when the Host Vehicle is hard mated to the ISS. The pinouts are shown in Table 4.2.3.1-1: IDA to HV Interface (SYS A) – J35 and Table 4.2.3.1-2: IDA to HV Interface (SYS B) – P35.

#### 5.3.1.1 Umbilical Connector Mated Indication

The data connector interface to the host provides indication that pins have engaged between the NDSB1-to-IDA umbilical connectors. Each connector has pins that are electrically shorted together; when the connectors mate, this short can be sensed by the docking vehicles. This is an indication that the connectors are seated and the pins have engaged, which signifies that power and data can be exchanged. For the umbilical connector to host vehicle interface locations, see Figure 4.1.1-1.

### 5.3.2 Umbilical Connector Data Bus Termination Wires Interface-to-the-Host Vehicle

The MIL-STD-1553 data bus passing through the umbilical resource is not terminated by the NDSB1. The NDSB1 implements a striker plate that switches the MIL-STD-1553 data bus from the IDA bus terminator to the Host Vehicle MIL-STD-1553 interface when the mating umbilicals are in contact. The MIL-STD-1553 wires are routed to a connector at the interface to the host vehicle as shown in Table 4.2.3.1-1: IDA to HV Interface (SYS A) – J35 and Table 4.2.3.1-2: IDA to HV Interface (SYS B) – P35. It is the host vehicle's responsibility to terminate the MIL STD-1553 data bus as required by the integrated MIL-STD-1553 design when the umbilical is connected. See Figure 4.1.1-1 for the mechanical implementation of the striker plate and the bus termination switch on the NDSB1 umbilical.

### 5.3.3 Pyrotechnic Interface NDSB1

The NDSB1 contains pyrotechnics in both the active and passive hooks at the hard mate interface. Therefore, if the NDSB1 active hooks fail to unlatch, the host may fire the pyrotechnics releasing either or both active and passive gangs of hooks. The 24 hooks will be fired in gangs, six at a time. A single gang of six is every other hook. The total time required for hook release within one gang of six hooks is less than 150 ms. The control and inhibits for this firing are provided by the host vehicle. The host provides three inhibits to inadvertent firing. There are four NASA Standard Initiators (NSIs) in the NDSB1 (one per gang of six hooks, active and passive). For each NSI, the HV provides an all-fire bridgewire control signal compliant to JSC-28596A from the HV and NDSB1 introduces a resistance of no more than 1.5 ohms, which provides the necessary firing energy and duration for each NSI.

Pyrotechnics would be used as contingency measures in the event of two failures to undock. Therefore, no redundancy is required in the NSIs or pyrotechnic controller channel. All pyrotechnics used in this system follow the requirements of JSC-62809, Human Rated Spacecraft

Pyrotechnic Specification (Sections 3.2, 3.6.2, 3.6.3, 3.6.8, 3.6.20, 7.3 – 7.3.4, 8.1 – 8.3.6, 8.4.2 – 8.4.5, 8.4.7 – 8.4.10, and 8.5), e.g., requirements for pyrotechnic system fault tolerance, EMI susceptibility, processing and handling.

The NDSB1 induces pyroshock at the NDSB1-to-IDA and at the host vehicle per Figure 5.3.3-1: Maximum Pyroshock Levels at NDSB1/IDA and NDSB1/Host I/F for Contingency Pyrotechnic NDSB1 Separation, and Table 5.3.3-1 Maximum Pyroshock Levels at NDSB1/IDA and NDSB1/Host I/F for Contingency Pyrotechnic NDSB1 Separation. The NDSB1 provides connectors for host initiation of the pyrotechnics. The pinouts are shown in Figure 5.3.3-2, Pin Assignments. The HV will decide whether to fire two gangs of hooks (all active or all passive) or a single gang of 6 hooks at one time. The shock value generated during on-orbit contingency separation is shown in Figure 5.3.3-1.

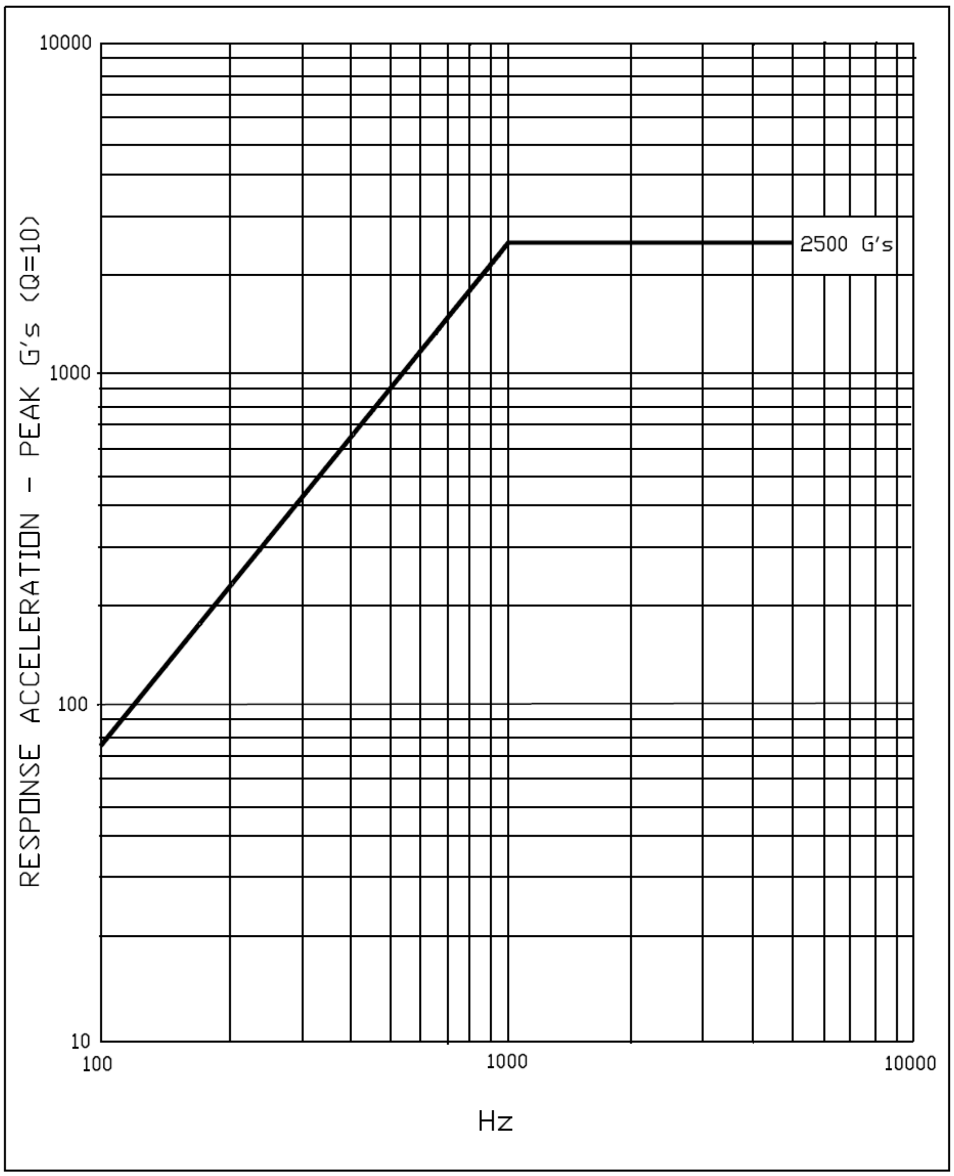


**FIGURE 5.3.3-1: MAXIMUM PYROSHOCK LEVELS AT NDSB1/IDA AND NDSB1/HOST I/F FOR CONTINGENCY PYROTECHNIC NDSB1 SEPARATION**

**TABLE 5.3.3-1, MAXIMUM PYROSHOCK LEVELS AT NDSB1/IDA AND NDSB1/HOST I/F FOR CONTINGENCY PYROTECHNIC NDSB1 SEPARATION**

| NDSB1 Contingency Separation Shock | |
|---|---|
| Frequency (Hz) | SRS (G Peak) |
| 100 | 75 |
| 1000 | 2500 |
| 5000 | 2500 |

**TABLE 5.3.3-2: PIN ASSIGNMENTS**

| **Connector** | **P300A** | |
|---|---|---|
| Function | Pyro Active Connector | |
| Chassis Type | NATC06G13N98SN | |
| Cable Type | | |
| | | |
| **Pin Number** | **Pin Name** | **Pin Function** |
| A | | |
| B | NSI Active hooks 1 (+) | NSI Active Hooks1 P |
| C | | |
| D | NSI Active hooks 1 (-) | NSI Active Hooks1 N |
| E | | |
| F | NSI Active hooks 2 (+) | NSI Active Hooks2 P |
| G | | |
| H | NSI Active hooks 2 (-) | NSI Active Hooks2 N |
| J | | |
| K | | |

| **Connector** | **P300B** | |
|---|---|---|
| Function | Pyro Passive Connector | |
| Chassis Type | NATC06G13N98SA | |
| Cable Type | | |
| | | |
| **Pin Number** | **Pin Name** | **Pin Function** |

| | | |
|---|---|---|
| A | | |
| B | NSI Passive hooks 1 (+) | NSI Passive Hooks1 P |
| C | | |
| D | NSI Passive hooks 1 (-) | NSI Passive Hooks1 N |
| E | | |
| F | NSI Passive hooks 2 (+) | NSI Passive Hooks2 P |
| G | | |
| H | NSI Passive hooks 2 (-) | NSI Passive Hooks2 N |
| J | | |
| K | | |

### 5.3.4 Electrical Power from Host Vehicle-to-NDSB1

The NDSB1 operates with power from the host vehicle that meets Appendix K Power Quality Description Document. The NDSB1 operates on 28 VDC power from the host vehicle. There are two redundant power system feeds required: one for System A and one for System B. Both System A and System B will draw power during the docking/undocking event per Appendix K. The pin assignments are shown in Table 5.3.4-1. The HV will provide power for the contingency operation of the capture latch release independently from the utility strings used to operate the NSB1 System A and System B.

**TABLE 5.3.4-1: HV TO NDSB1 POWER PIN ASSIGNMENTS**

| | | |
|---|---|---|
| Connector | J1 for DSCs | |
| Function | BUS Power from Host Vehicle | |
| Connector P/N | NATC00T21N11PN | Size 12 contacts, 23 amps current rating |
| Cable Type | | Size 12 contacts, 23 amps current rating |
| | | |
| Pin Number | Pin Name | Pin Function |
| A | CNTRLBUS28V | 28V input - DSC Control |
| B | CNTRLBUS28VRTN | 28V input DSC Control Return |
| C | MHSBUS28V | 28V input - Motors_Heaters |
| D | MHSBUS28VRTN | 28V input - Motors_Heaters Return |
| E | | |
| F | | |
| G | | |
| H | | |
| J | | |
| K | CHASSIS1 | DC Chassis |
| L | CHASSIS2 | DC Chassis |
| | | |
| Connector | J1 for LAC | |

| | | |
|---|---|---|
| Function | BUS Power from Host Vehicle | |
| Connector P/N | NATC00T21N11PN | Size 12 contacts, 23 amps current rating |
| Cable Type | | Size 12 contacts, 23 amps current rating |
| | | |
| Pin Number | Pin Name | Pin Function |
| A | CNTRLBUS28V | 28V input - DSC Control |
| B | CNTRLBUS28VRTN | 28V input DSC Control Return |
| C | MHSBUS28V | 28V input - Motors_Heaters |
| D | MHSBUS28VRTN | 28V input - Motors_Heaters Return |
| E | | |
| F | | |
| G | | |
| H | | |
| J | | |
| K | CHASSIS1 | DC Chassis |
| L | CHASSIS2 | DC Chassis |
| | | |
| Connector | J5 for LAC | |
| Function | BUS Power from Host Vehicle | |
| Connector P/N | NATC00T21N11PN | Size 12 contacts, 23 amps current rating |
| Cable Type | | Size 12 contacts, 23 amps current rating |
| | | |
| Pin Number | Pin Name | Pin Function |
| A | CNTRLBUS28V | 28V input - DSC Control |
| B | CNTRLBUS28VRTN | 28V input DSC Control Return |
| C | MHSBUS28V | 28V input - Motors_Heaters |
| D | MHSBUS28VRTN | 28V input - Motors_Heaters Return |
| E | | |
| F | | |
| G | | |
| H | | |
| J | | |
| K | CHASSIS1 | DC Chassis |
| L | CHASSIS2 | DC Chassis |
| | | |

### 5.3.5 Communications between the Host Vehicle and the NDSB1

Each NDSB1 system communicates with its host vehicle via a serial interface. The NDSB1 supports two types of serial interfaces: TIA-422-B and MIL-STD-1553B. The host vehicle selects which interface type to use by way of configuring a jumper in the NDSB1 host communications connector. Refer to Table 7.1.2.1.1-1 NDSB1-to-Host vehicle Electrical interface for the pinout and installation of the jumper for this connector.

The NDSB1 requires two redundant communication interfaces: one for System A and one for System B. Both System A and System B will communicate with the host vehicle simultaneously. All communication (e.g., commands, data, status) for operating the NDSB1 are sent through the selected serial interfaces.

#### 5.3.5.1 C&DH TIA-422-B Interface

As described in Table 5.3.5.1-1 the TIA-422-B interface is selected by shorting the COMMID1+ and COMMID1- pins on both systems and not shorting the COMMID2+ and COMMID2- pins.

The TIA-422-B interface is a point-to-point, full duplex, serial interface utilizing 8 data bits with no parity. The systems are connected so that each transmitter connects to a dedicated receiver.

## TABLE 5.3.5.1-1: TIA-422B PIN ASSIGNMENTS

| Connector ID | J3 | |
|---|---|---|
| Function | DSC to HV Communication | |
| Connector P/N | NATC00T15N35SN | Size 22D contacts, 5 amps current rating |
| **Pin Number** | **Pin Name** | **Pin Function** |
| 1 | | |
| 2 | | |
| 3 | RTJMPRJ0+ | R T Address Jumper 0 + |
| 4 | RTJMPRJ0- | R T Address Jumper 0 - |
| 5 | RTJMPRJ1+ | R T Address Jumper 1 + |
| 6 | RTJMPRJ1- | R T Address Jumper 1 - |
| 7 | RTJMPRJ2+ | R T Address Jumper 2 + |
| 8 | RTJMPRJ2- | R T Address Jumper 2 - |
| 9 | RTJMPRJ3+ | R T Address Jumper 3 + |
| 10 | RTJMPRJ3- | R T Address Jumper 3 - |
| 11 | RTJMPRJ4+ | R T Address Jumper 4 + |
| 12 | RTJMPRJ4- | R T Address Jumper 4 - |
| 13 | RTJMPRJP+ | R T Address Jumper P + |
| 14 | RTJMPRJP- | R T Address Jumper P - |
| 15 | | |
| 16 | | |
| 17 | UNITID1+ | Unit A Select + |
| 18 | UNITID1- | Unit A Select - |
| 19 | UNITID2+ | Unit B Select + |
| 20 | UNITID2- | Unit B Select - |
| 21 | RS422TXHI | DSC to HV RS422 Transmit Hi |
| 22 | RS422TXLO | DSC to HV RS422 Transmit Lo |
| 23 | RS422RXHI | DSC to HV RS422 Receive Hi |
| 24 | RS422RXLO | DSC to HV RS422 Receive Lo |
| 25 | | |
| 26 | | |
| 27 | COMMID1+ | Select RS422 Comm + |
| 28 | COMMID1- | Select RS422 Comm - |
| 29 | COMMID2+ | Select 1553 Comm + |
| 30 | COMMID2- | Select 1553 Comm - |
| 31 | | |
| 32 | MIL1553HIA | 1553 Stub A Hi |
| 33 | MIL1553LOA | 1553 Stub A Lo |
| 34 | MIL1553HIB | 1553 Stub B Hi |
| 35 | MIL1553LOB | 1553 Stub B Lo |
| 36 | | |
| 37 | | |

### 5.3.5.2 C&DH MIL-STD-1553B Interface

Each NDSB1 DSC is a (separate) Remote Terminal (RT). The host vehicle is the Bus Controller (BC).

As described in Table 5.3.5.1-1 the MIL-STD-1553 interface is selected by not shorting the COMMID1+ and COMMID1- pins on both systems and shorting the COMMID2+ and COMMID2- pins. If both pairs of Communications ID pins are shorted jumpers together or neither pair is shorted together, this indicates a failure, and the controller will transition to a non-operational state with no communication provided to the HV. The MIL-STD-1553B RT address for the NDSB1 System is set in the host communications connector by shorting the appropriate RT address pins. Refer to Appendix C for the pin locations for signals RT_ADDR0, RT_ADDR1, RT_ADDR2, RT_ADDR3, RT_ADDR4, and RT_ADDR_PARITY. Odd Parity must be used when setting the RT address parity bit. Shorting each signal to its associated signal return will set it to a zero. Leaving the signal open will set it to a one.

The NDSB1 provides the ability to receive a subset of the Mode Codes defined in MIL-STD-1553. The Mode Codes supported by NDSB1 are listed in Table 5.3.5.2-1: NDSB1 Implementation of MIL-STD-1553B Mode Codes. The message formats and behavior associated with Mode Code transactions are defined in MIL-STD-1553B Notice 2.

When the host vehicle Bus Controller (BC) requests data from the NDSB1, it will receive NDSB1 Health and Status (H&S) telemetry as described in Appendix C. Described in detail in Appendix C, these packets comprise multiple sub-addresses. For example, the H&S packet is divided across multiple sub-addresses.

**TABLE 5.3.5.2-1: NDSB1 IMPLEMENTATION OF MIL-STD-1553B MODE CODES**

| T/R | Mode Code | Function | Data Words | Implemented |
|---|---|---|---|---|
| 1 | 00000 | Dynamic Bus Control | No | No |
| 1 | 00001 | Synchronize w/o data word | No | No |
| 1 | 00010 | Transmit Status Word | No | Yes* |
| 1 | 00011 | Initiate Self Test | No | No |
| 1 | 00100 | Transmitter Shutdown | No | Yes* |
| 1 | 00101 | Override Transmitter Shutdown | No | Yes* |
| 1 | 00110 | Inhibit Terminal Flag | No | No |
| 1 | 00111 | Override Inhibit Terminal Flag | No | No |
| 1 | 01000 | Reset Remote Terminal | No | Yes* |
| 1 | 01001 to 01111 | Reserved | No | N/A |
| 1 | 10000 | Transmit Vector Word | Yes | No |
| 0 | 10001 | Synchronize w/Data word | Yes | No |
| 1 | 10010 | Transmit Last Command | Yes | No |
| 1 | 10011 | Transmit Built-In-Test Word | Yes | No |
| 0 | 10100 | Selected Transmitter Shutdown | Yes | No |
| 0 | 10101 | Override Selected Transmitter Shutdown | Yes | No |
| 1/0 | 10110 to 11111 | Reserved | Yes | N/A |

* - Required RT mode codes per MIL-STD-1553B Notice 2.

Appendix C also shows the sub-addresses that the host vehicle BC will use to send commands to the NDSB1. When multiple 1553 messages are grouped into a BC-to-RT transaction, and one or more of the 1553 messages in the transaction fails, the NDSB1 system will disregard the entire transaction.

#### 5.3.5.2.1 MIL-STD-1553 Remote Terminals

The NDSB1 will function as a remote terminal in accordance with MIL-STD-1553B at the MIL-STD-1553 interface with the Host Vehicle.

#### 5.3.5.2.2 MIL-STD-1553 RT Addressing

The NDSB1 will read the 1553 Jumper and define the RT for the controller as defined in Table 5.3.5.2.2-1 for valid RT’s, other combinations not in the table will result in no MIL-STD-1553 traffic.

Note: IN means the Jumper is present; OUT means no interconnection across the two pins.

**TABLE 5.3.5.2.2-1: 1553 RT JUMPER SELECTION DEFINITION**

| Acceptable RT Selections | J0 | J1 | J2 | J3 | J4 | JP |
|---|---|---|---|---|---|---|
| RT=1, Odd Parity | OUT | IN | IN | IN | IN | IN |
| RT=2, Odd Parity | IN | OUT | IN | IN | IN | IN |
| RT=3, Odd Parity | OUT | OUT | IN | IN | IN | OUT |
| RT=4, Odd Parity | IN | IN | OUT | IN | IN | IN |
| RT=5, Odd Parity | OUT | IN | OUT | IN | IN | OUT |
| RT=6, Odd Parity | IN | OUT | OUT | IN | IN | OUT |
| RT=7, Odd Parity | OUT | OUT | OUT | IN | IN | IN |
| RT=8, Odd Parity | IN | IN | IN | OUT | IN | IN |
| RT=9, Odd Parity | OUT | IN | IN | OUT | IN | OUT |
| RT=10, Odd Parity | IN | OUT | IN | OUT | IN | OUT |
| RT=11, Odd Parity | OUT | OUT | IN | OUT | IN | IN |
| RT=12, Odd Parity | IN | IN | OUT | OUT | IN | OUT |
| RT=13, Odd Parity | OUT | IN | OUT | OUT | IN | IN |
| RT=14, Odd Parity | IN | OUT | OUT | OUT | IN | IN |
| RT=15, Odd Parity | OUT | OUT | OUT | OUT | IN | OUT |
| RT=16, Odd Parity | IN | IN | IN | IN | OUT | IN |
| RT=17, Odd Parity | OUT | IN | IN | IN | OUT | OUT |
| RT=18, Odd Parity | IN | OUT | IN | IN | OUT | OUT |
| RT=19, Odd Parity | OUT | OUT | IN | IN | OUT | IN |
| RT=20, Odd Parity | IN | IN | OUT | IN | OUT | OUT |
| RT=21, Odd Parity | OUT | IN | OUT | IN | OUT | IN |
| RT=22, Odd Parity | IN | OUT | OUT | IN | OUT | IN |
| RT=23, Odd Parity | OUT | OUT | IN | IN | OUT | IN |
| RT=24, Odd Parity | IN | IN | IN | OUT | OUT | OUT |
| RT=25, Odd Parity | OUT | IN | IN | OUT | OUT | IN |
| RT=26, Odd Parity | IN | OUT | IN | OUT | OUT | IN |
| RT=27, Odd Parity | OUT | OUT | IN | OUT | OUT | OUT |
| RT=28, Odd Parity | IN | IN | OUT | OUT | OUT | IN |
| RT=29, Odd Parity | OUT | IN | OUT | OUT | OUT | OUT |
| RT=30, Odd Parity | IN | OUT | OUT | OUT | OUT | OUT |
| RT=31, Odd Parity | OUT | OUT | OUT | OUT | OUT | IN |

### 5.3.5.2.3 Host Vehicle MIL-STD-1553B Bus Controller

The HV will perform BC functions in accordance with MIL-STD-1553B at the MIL-STD-1553 interface with the NDSB1 interface.

#### 5.3.5.2.4 Host Vehicle MIL-STD-1553B Parity

The HV will use odd parity when setting the RT address parity bit in accordance with MIL_STD-1553.

#### 5.3.5.2.5 Host Vehicle MIL-STD-1553 Mode Commands

The HV will transmit the mode code commands as defined in MIL-STD-1553B Notice 2.

#### 5.3.5.2.6 Host Vehicle Response to NDSB1 H&S Data

##### 5.3.5.2.6.1 Host Vehicle Isolation of NDSB1 Faults

The HV will isolate NDSB1 faults to the recovery level.

##### 5.3.5.2.6.2 Host Vehicle Response to NDSB1 Faults

Refer to Appendix G

#### 5.3.5.3 Jumpers

The DSC will read the two AB SEL Jumpers, designated A and B. If jumper A is present and B is not present, then the DSC is System A, if jumper A is absent and jumper B is present, then the DSC is System B. If both jumpers are present or absent, this indicates a failure, and the DSC will transition the system into the monitor mode and disable further mode transitions.

### 5.3.6 Heater Power and Control

NDSB1 heaters receive power from the Host Vehicle. Default heater set points and Resistive Temperature Device (RTD) error set points will be defined for each heater zone. The DSC will energize enabled zone heaters when the corresponding zone RTD temperature sensor values are less than the minimum set point value for the zone. The DSC will de-energize enabled zone heaters when the corresponding zone RTD temperature sensor values are greater than the maximum set point for the zone. If RTD temperature sensor values are outside of the RTD Error Guard Range, the DSC will disable the corresponding zone heaters and report an RTD Range Error. The zone heaters will remain disabled until the system is reset or until the error is explicitly reset by a command.

Heater control is allowed in the following modes: Monitor Mode, Active Docking Mode, SCS Checkout Mode, Standby Docking Mode, and Manual Mode. Heater set point values and RTD error set point values can be changed via commands from the Host Vehicle.

Heaters are temporarily disabled any time the DSC is driving an effector.

### 5.3.7 Ground Support Equipment Software Interface-to-NDSB1

Reserved (Not Provided)

### 5.3.8 Electrical Bonding Between the Host Vehicle and the NDSB1

The NDSB1 establishes bond paths to mitigate electrical hazards on the ground test article and integrated subsystem interfaces. The electrical bond meets the requirements established in NASA-STD-4003, Electrical Bonding for NASA Launch Vehicles, Spacecraft, Payloads, and Flight Equipment. The NDSB1 will be protected against RF emissions by maintaining a class-R/H bond at the NDSB1-to-host vehicle interface. The DC bond resistance across the interface will be 2.5 milliohms or less.

The bond path will be through the chemical conversion coated metal-to-metal contact on the seal interface between the host vehicle and the NDSB1. Refer to Figure 4.1.2.1.1.1-1.

### 5.3.9 Electromagnetic Environmental Effects

The NDSB1 is capable of operating in electromagnetic environments defined in JSC-65842 Electromagnetic Environmental Effects Requirements Document, Sections 5.0 – 5.3 and a tailored set of environments from Section 5.4. Specifically, JSC-65842 Figures 5-1 and 5-4 are not applicable and Table 5.3.9-1, Conducted & Radiated EMI and Indirect Lightning Requirements is tailored from JSC-65842, Table 5-1.

**TABLE 5.3.9-1, CONDUCTED & RADIATED EMI AND INDIRECT LIGHTNING REQUIREMENTS TBR**

| Requirement | Location | Frequency | Amplitude | Notes/Modulation |
|---|---|---|---|---|
| ~~CE101~~ | ~~Power~~ | ~~30 Hz – 10 kHz~~ | ~~Figure 5-1~~ | ~~relax 20 log (I) for I > 5A~~ |
| CE102 | Power | 10 kHz – 10 MHz | Figure 5-2, Basic Curve | ~~Use 115 V curve for 120 VDC circuits~~ Use Basic Curve for 28 Volt System |
| CS101 | Power | 30 Hz – 150 kHz | Figure 5-3, curve #2 | ~~LISN per MIL-STD-461F~~ LISN per MIL-STD-461F, Use Curve 2 for 28V and Curve 1 for above 28V |
| ~~CS06 Spike~~ | ~~Power~~ | ~~10 µs 0.15 µs~~ | ~~Figure 5-4~~ | ~~waveform per SSP30237~~ |
| CS114 | Cables | 10 kHz – 200 MHz | Figure 5-5, curve #3 | curve #3 |
| ~~CS115~~ | ~~Cable bundles~~ | ~~impulse~~ | ~~5A~~ | ~~waveform per MIL-STD-461F~~ |
| ~~CS 116~~ | ~~Cable Bundles~~ | ~~10 kHz – 100 MHz~~ | ~~10 amps~~ | ~~Waveform per MIL-STD-461F~~ |

| Requirement | Location | Frequency | Amplitude | Notes/Modulation |
|---|---|---|---|---|
| RE102 | Boxes and cables | 30 MHz – 18 GHz, Ka Band 24 – 27 GHz | Figure 5-6 | ~~“ “~~ Horizontal and vertical polarization required. Testing above 1 GHz only required to 10 times the highest operating frequency. |
| RS103 | Boxes and cables | 100 MHz – 18 GHz, Ka Band 24 – 27 GHz | Figure 5-7 | ~~clock frequencies~~ Horizontal and Vertical Polarizations |
| SAE ARP5412A | SCS pins | Waveforms 3,4,5A | 4 V, 12 A | Indirect Lightning 6 dB margin |
| SAE ARP5412A | SCS cables | Waveforms 2,3,5A | 300 V, 234 A | Indirect Lightning 6 dB margin |
| SAE ARP5412A | HCS pins | Waveforms 3,4,5A | 2 V, 10 A | Indirect Lightning 6 dB margin |
| SAE ARP5412A | HCS cables | Waveforms 2,3,5A | 54 V, 166 A | Indirect Lightning 6 dB margin |
| SAE ARP5412A | Power/Comm pins | Waveforms 3,4,5A | 72V/140A | Indirect Lightning 6 dB margin |
| SAE ARP5412A | Power/Comm cables | Waveforms 2,3,5A | 200V/2750A | Indirect Lightning 6 dB margin |
| ANSI/ESD S20.20 | Boxes | Broadband pulse | 4,000 V | man model static |

Note: Figure numbers referenced are in JSC 65842.

## 5.4 NDSB1-to-Host Vehicle Command and Health & Status Interface

The NDSB1 will receive commands from the host vehicle reference Appendix C for the command set.

### 5.4.1 NDSB1-to-Host Vehicle Application Command and Health & Status Interface

#### 5.4.1.1 NDSB1-to-Host Command Handling

The NDSB1 avionics provides a standard asynchronous RS-422 communications interface between the HV and the DSC and a standard synchronous RS-422 interface between the DSC and the LAC. A standard dual redundant MIL-STD-1553B communications interface is also provided between the HV and the DSC. Either RS-422 or MIL-STD-1553B interfaces can be used for receiving commands from the HV and sending status information to the HV. Each of the two systems (A and B) has its own communications interfaces. The Host Vehicle will utilize either the RS-422 interface or the MIL-STD-1553B interface, but not both, for communication between the HV and the DSC.  Selection of which interface is active in the avionics is determined by the two Communications Jumpers. See Appendix C for Host Vehicle to NDSB1 commands.

##### 5.4.1.1.1 Host Vehicle Commands to NDSB1

The HV will control the NDSB1 using the commands listed in Appendix C Command Definitions Tab.

##### 5.4.1.1.2 Host Vehicle Command Rates

The maximum HV to NDSB1 command rate is specified in paragraph 7.1.2.4.3.3.2, Host Vehicle Command Rates.

#### 5.4.1.2 NDSB1-to-Host Vehicle H&S Data Handling

The NDSB1 will make health and status data available for collection on the MIL-STD-1553B data bus as defined in Appendix C.

#### 5.4.1.3 NDSB1 FDIR

The NDSB1 has two controllers: System A and System B. Systems A and B do not communicate directly with each other in any way, but both receive commands from, and provide health and status data to, the host vehicle. During NDSB1 docking operation, systems A and B are both turned on, one in an active mode and the other in a standby mode. In general, during soft capture operations, if there is a fault in a system that results in loss of that system's functionality, the host vehicle can command the healthy system to continue performing the desired function. In several cases (hook motors, for example), both systems drive the effector and thus the desired function will continue with no intervention, but the operation will take twice as much time.

The tables in Appendix G, Failure Response Table, define the host vehicle's automated response to detected faults that occur during docking. The first table identifies the action to take on the first detected fault. The second table defines the action to take on a subsequent fault. Note that the tables identify different actions depending on the current operational state of the docking (which is determined from the telemetry returned from the NDS).

If a fault requiring a switch to the redundant string is identified, a minimum amount of time is needed to switch between controllers in order to maintain safe control of the linear actuators, depending on the phase of operation. This switch time is most critical during docking capture and attenuation phases.

The maximum total time required for a switch to take place from A to B is 580 ms. This time is from fault detection, output of the fault indicator in the NDSB1 H&S data to the host vehicle, passage of the H&S message through the host vehicle's subsystem interfaces and buses/networks into the flight computer/software that monitors the fault indicator to the time it takes for the host vehicle's switching commands to traverse back to the NDSB1 and for NDSB1 to effect the switch. The total time has to be allocated between the NDSB1 and the host vehicle. The host vehicle will be required to send the commands to switch primary control from System A to System B within

140 ms from when it receives an indication from the NDSB1 that a fault has been occurred and the standby mode system and needs to be switched to become active. The measure of this performance is from the time the NDSB1 provides the failure indication to the time the host vehicle's response commands cross the host vehicle-to-NDSB1 interface.

For a complete description of how the host vehicle will respond to various NDSB1 fault indications, reference Appendix G, NDSB1 Control System Failure Response Table.

#### 5.4.1.4 NDSB1 i-LOADS Parameters for Docking or Berthing Operations

Reserved

### 5.4.2 NDSB1 Packet Structures

The structure of MIL-STD-1553B and RS-422 Command Packets, coming from the HV to NDSB1, is defined in Table 5.4.2-1. Definitions of the different fields used in the Primary Header and Packet Data Field of the Host Vehicle to NDSB1 command packets are further defined in Table 5.4.2-2.

The structure of MIL-STD-1553B and RS-422 Health and Status Telemetry Packets, being sent from NDSB1 to the HV, is defined in Table 5.4.2-3. Definitions of different fields used in the Primary Header and Packet Data Field of these H&S packets are further defined in Table 5.4.2-4.

A CRC is included as the last word in both Command and H&S Telemetry Packets. The CRC-CCITT parameters used to calculate these CRCs are listed in Table 5.4.2-5.

**TABLE 5.4.2-1: HOST VEHICLE-TO-NDSB1 COMMAND PACKET**

| **Primary Header** | | | | | | | **Packet Data Field** | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Packet Identification** | | | | **Packet Seq. Control** | | | **Secondary Header** | | **Payload** | **Checkword** |
| CCSDS Version (3 bits) | Type (1 bit) | Sec. Hdr. Flag (1 bit) | Application ID (11 bits) | Seq. Flags (2 bits) | Source Seq. Count (14 bits) | Packet Data Length (16 bits) | Time-Stamp (64 bits) | Command ID (16 bit) | User Data (Six 16-bit Command Parameters = 96 bits) | CRC (16 bit) |

### TABLE 5.4.2-2: HOST VEHICLE-TO-NDSB1 COMMAND PACKET PARAMETERS

| Field Name | Size | Values | Description |
|---|---|---|---|
| Version | 3 bit | 000 (binary) | Consultative Committee for Space Data Systems (CCSDS) packet version ‘000.’ |
| Type | 1 bit | 1 (binary) | 1 identifies command packets. |
| Sec Hdr Flag | 1 bit | 1 (binary) | 1 indicates a secondary header. |
| Application ID | 11 bits | 0-2047 | Currently zero; may be used later to determine command source. |
| Sequence Flags* | 2 bits | 11 (binary) | Will be 0x11 to indicate an un-segmented packet. |
| Source Seq Count | 14 bits | 0-16383 | Packet sequence counter. |
| Packet Data Length | 16 bits | 23 | This 16-bit field contains a length count ‘C’ that equals one fewer than the length (in octets) of the Packet Data Field. The length count ‘C’ is expressed as: C = (total number of octets in the Packet Data field) – 1. |
| Time-stamp | 64 bits | 32-bit sec field and 32-bit micro-seconds field | Currently, a relative time-stamp from when the DSC is powered on. Used for data logging and debugging. |
| Command ID | 16 bits | Defined in Appendix C | |
| Payload | 12 Bytes | Defined in Appendix C | The payload will consist of up to 6 command arguments (16-bit) data fields. |
| CRC | 2 Bytes | Algorithm parameters defined in Table 5.4.2-5 | 16-bit CRC will immediately follow the sixth command parameter |
| *- only for 1553, For RS422 these 2 bits are set to 0x11. | | | |

### TABLE 5.4.2-3: NDSB1-TO-HOST VEHICLE H&S PACKET

| **Primary Header** | | | | | | | **Packet Data Field** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Packet Identification** | | | | **Packet Seq. Control** | | | **Secondary Header** | | | | **Payload** |
| Version (3 bits) | Type (1 bit) | Sec. Hdr. Flag (1 bit) | Application ID (11 bits) | Seq. Flags (2 bits) | Source Seq. Count (14 bits) | Packet Data Length (16 bits) | Time-Stamp (64 bits) | Command Response ID (16 bit) | Command Response Type (8 bits) | Reserved (8 bits) | 0 – 65448 |

### TABLE 5.4.2-4: NDSB1-TO-HOST VEHICLE H&S PACKET PARAMETERS

| Field Name | Size | Values | Description |
|---|---|---|---|
| Version | 3 bit | 0 | CCSDS packet version '000.' |
| Type | 1 bit | 0 | 0 identifies telemetry packets. |
| Sec Hdr Flag | 1 bit | 1 | 1 Indicates a secondary header. |
| Application ID | 11 bits | 0 | Always zero |
| Sequence Flags* | 2 bits | 0x11 | Will be 0x11 to indicate an unsegmented packet. |
| Source Seq Count | 14 bits | 0-16383 | Packet sequence counter. |
| Packet Length | 16 bits | 0 – 65535 | This 16-bit field contains a length count 'C' that equals one fewer than the length (in octets) of the Packet Data Field. The length count 'C' is expressed as: C = (total number of octets in the Packet Data field) – 1. |
| Time-stamp | 64 bits | 32-bit sec field and 32-bit micro-seconds field | Currently, a relative time-stamp from when the DSC is powered on. Used for data logging and debugging. |
| Command Response ID | 16 bits | Defined in Appendix C | Command ID of the command being reported on. |
| Command Response Type | 8 bits | Defined in Appendix C | Command response such as Valid, Invalid, Received, and Executed. |
| Reserved | 8 bits | 0 | Reserved field (currently used to keep 32-bit alignment between secondary header and payload). |
| Payload | Defined in Appendix C | Defined in Appendix C | H&S payload packet defined in Appendix C. |
| *- only for 1553, For RS422 these 2 bits are set to 0x11. | | | |

The DSC will implement a CRC for the H&S Transmit Packet and Verify on the Command Interface. The CRC is calculated for the entire length of the transfer frame payload data field, excluding the CRC.

### TABLE 5.4.2-5: CRC-CCITT PARAMETERS

| **Algorithm** | **CRC-CCITT** |
|---|---|
| Width: | 16 bits |
| (Truncated) Polynomial: | 0x1021 |
| Initial Remainder: | 0xFFFF |
| Final XOR Value: | 0x0000 |
| Reflect Data: | No |
| Reflect Remainder: | No |

### 5.4.3 NDSB1 Data Transfer

#### 5.4.3.1 TIA-422-B Serial

The NDSB1 will transmit packets using two independent serial data (TIA-422-B) command/control paths from the host vehicle as System A and System B. See Table 5.4.3.1-1: NDSB1-to-Host Vehicle C&DH Interface Layers for details. The data will be transferred in network byte order (big-endian).

**TABLE 5.4.3.1-1: HV TO DSC RS-422 INTERFACE PROTOCOL**

| C&DH Interface Layers | Implementation |
|---|---|
| Data Layer – C&DH Packets | |
| Network/Transport Layer – Transfer Frame Packet | |
| Data Link Layer – Frame UART definition | 1M baud, 8 bits data, no parity, 1 start bit, 1 stop bit, no flow control. |
| Physical Layer – TIA/EIA-422-B | 4-wire + return + shield. |

The NDSB1 will transmit and receive data to/from the host vehicle at 1 M bits/sec. The bit rate will be fixed.

#### 5.4.3.2 MIL-STD-1553B

The NDSB1 will transmit packets using two independent MIL-STD-1553B command/control paths from the host vehicle—System A and System B. See Table 5.4.3.2-1: NDSB1-to-Host Vehicle C&DH Interface Layers.

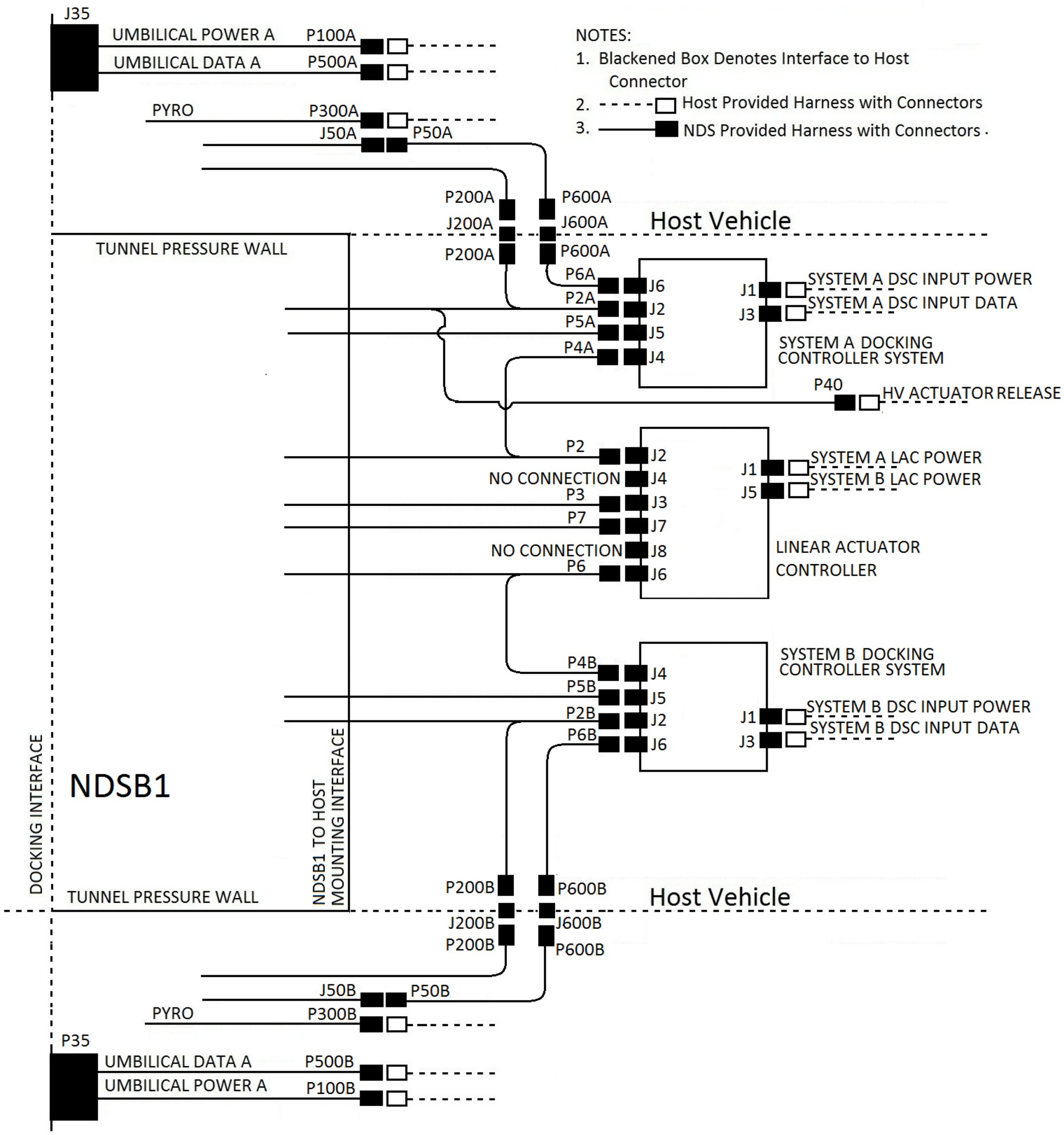
**TABLE 5.4.3.2-1: NDSB1-TO-HOST VEHICLE C&DH INTERFACE LAYERS**

| Layer # | C&DH Interface Layers | Implementation |
|---|---|---|
| 5, 6, 7 | Data Layer – C&DH Packets | See Table 5.4.2-1 and Table 5.4.2-3. |
| 3, 4 | Network/Transport Layer – Transfer Frame Packet | See Table 5.4.2-2 and Table 5.4.2-4. |
| 2 | Data Link Layer – 1 MHz Manchester II Bi-phase | 1 Mb/s baud, 3 sync bits + 16 data bits + 1 parity bit per word, 32 words per message, sync/async half-duplex with command/response protocol. |
| 1 | Physical Layer – MIL-STD-1553B Differential Serial | Twisted shielded pair (twinaxial). |

The NDSB1 will transmit and receive data to/from the host vehicle at a maximum rate of 1 Mbits/sec across a maximum of 31 remote terminals with each remote terminal accessing the data across a maximum of 30 sub-addresses.

### 5.5 NDSB1-to-Host Vehicle Connectors Locations and Pin Assignments

This section defines the NDSB1-to-host connector location. Refer to Section 5.3 for electrical interface details. Refer to Figure 5.5-1: NDSB1 to-Host Vehicle Electrical Interface and Table 5.5-1:NDSB1 Connections-to-Host Vehicle, for connector locations. Pin Assignments are shown in Table 5.5-2, NDSB1 to Host Vehicle Pin Assignments.




Note: NDSB1 interface is schematic representation only; not physical location.

**FIGURE 5.5-1: NDSB1 TO-HOST VEHICLE ELECTRICAL INTERFACE**

**TABLE 5.5-1: NDSB1 CONNECTIONS-TO-HOST VEHICLE**

| | CONNECTOR (AT HV) | FUNCTION | LOCATION | CABLE LENGTH (FT) |
|---|---|---|---|---|
| **EXTERNAL SYSTEM A** | P300A (W1734) | PYRO A | SEE FIGURE 5.5-1 | 2.1 |
| | P100A (W1735) | EXT UMB POWER A | | 1.9 |
| | P500A (W1735) | EXT UMB DATA A | | 1.8 |
| | P200A (W1733) | EMA POWER A | | 1.3 |
| | P600A (W1737) | INTMD HOOK LIMIT SWITCH A | | 1.0 |
| **EXTERNAL SYSTEM B** | P300B (W1754) | PYRO B | SEE FIGURE 5.5-1 | 2.1 |
| | P100B (W1755) | EXT UMB POWER B | | 1.9 |
| | P500B (W1755) | EXT UMB DATA B | | 1.8 |
| | P200B (W1753) | EMA POWER B | | 1.3 |
| | P600B (W1757) | INTMD HOOK LIMIT SWITCH B | | 1.0 |
| **INTERNAL SYSTEM A** | P200A P40 (W0609) | DSC TO EXT HCS POWER A | SEE FIGURE 5.5-1 | 1.6 |
| | P600A (W0604) | DSC TO EXT HSC SENSE A | | 1.7 |
| | P10A (W1721) | DSC INPUT POWER A | | 1.5 |
| | P30A (W1722) | DSC INPUT DATA A | | 1.7 |
| | P20A (W1723) | LAC INPUT POWER A | | 1.8 |
| **INTERNAL SYSTEM B** | P200B (W0612) | DSC TO EXT HCS POWER B | SEE FIGURE 5.5-1 | 1.6 |
| | P600B (W0607) | DSC TO EXT HSC SENSE B | | 1.7 |
| | P10B (W1741) | DSC INPUT POWER B | | 1.8 |
| | P30B (W1742) | DSC INPUT DATA B | | 1.7 |
| | P20B (W1743) | LAC INPUT POWER B | | 1.7 |

### TABLE 5.5-2, NDSB1 TO HOST VEHICLE PIN ASSIGNMENTS

| P100A Umbilical Power, Connector P/N NATC06G25LN7SN | | |
|---|---|---|
| Pin # | AWG | Signal |
| F | 8 | +120VDC POWER |
| A | 8 | +120VDC POWER RTN |
| C | 8 | +28VDC POWER |
| B | 8 | +28VDC POWER RTN |
| D | 8 | GROUND SAFETY WIRE |
| | | |
| P100B Umbilical Power, Connector P/N NATC06G25LN7SN | | |
| Pin # | AWG | Signal |
| F | 8 | +120VDC POWER |
| A | 8 | +120VDC POWER RTN |
| C | 8 | +28VDC POWER |
| B | 8 | +28VDC POWER RTN |
| D | 8 | GROUND SAFETY WIRE |
| | | |
| P500A Umbilical Data, Connector P/N NATC06G25N35SN | | |
| Pin # | AWG | Signal |
| 53 | 22 | ISS-ICP HOOK GANG1 OP HV CMD |
| 65 | 22 | ISS-ICP HOOK GANG1 OP HV CMD RTN |
| 76 | 22 | ISS-ICP HOOK GANG1 CL HV CMD |
| 64 | 22 | ISS-ICP HOOK GANG1 CL HV CMD RTN |
| 63 | 22 | ISS-ICP TO HV MON HOOK GANG1A/B OP MTR POS |
| 52 | 22 | ISS-ICP TO HV MON HOOK GANG1A/B OP MTR POS RTN |
| 41 | 22 | ISS-ICP TO HV MON HOOK GANG1A/B CL MTR POS |
| 30 | 22 | ISS-ICP TO HV MON HOOK GANG1A/B CL MTR POS RTN |
| 95 | 22 | ISS FROM HV 100BASETX-3 RX |
| 106 | 22 | ISS FROM HV 100BASETX-3 RX RTN |
| 96 | 22 | ISS TO HV 100BASETX-3 TX |
| 107 | 22 | ISS TO HV 100BASETX-3 TX RTN |
| 103 | 22 | ISS FROM HV 100BASETX-4 RX |
| 113 | 22 | ISS FROM HV 100BASETX-4 RX RTN |
| 104 | 22 | ISS TO HV 100BASETX-4 TX |
| 114 | 22 | ISS TO HV 100BASETX-4 TX RTN |
| 42 | 22 | IDA TO HV 1553 ORB-X-1 |
| 54 | 22 | IDA TO HV 1553 ORB-X-1 RTN |
| 66 | 22 | IDA TO HV 1553 ORB-X-2 |
| 77 | 22 | IDA TO HV 1553 ORB-X-2 RTN |
| 88 | 22 | IDA SPARE LOOPBACK HV I/F SIG |
| 99 | 22 | IDA SPARE LOOPBACK HV I/F RTN |
| 75 | 22 | IDA LOOPBACK HV I/F SIG |
| 87 | 22 | IDA LOOPBACK HV I/F RTN |
| | | |
| P500B Umbilical Data, Connector P/N NATC06G25N35SN | | |
| Pin # | AWG | Signal |

| | | |
|---|---|---|
| 53 | 22 | ISS-ICP HOOK GANG2 OP HV CMD |
| 65 | 22 | ISS-ICP HOOK GANG2 OP HV CMD RTN |
| 76 | 22 | ISS-ICP HOOK GANG2 CL HV CMD |
| 64 | 22 | ISS-ICP HOOK GANG2 CL HV CMD RTN |
| 63 | 22 | ISS-ICP TO HV MON HOOK GANG2A/B OP MTR POS |
| 52 | 22 | ISS-ICP TO HV MON HOOK GANG2A/B OP MTR POS RTN |
| 41 | 22 | ISS-ICP TO HV MON HOOK GANG2A/B CL MTR POS |
| 30 | 22 | ISS-ICP TO HV MON HOOK GANG2A/B CL MTR POS RTN |
| 95 | 22 | ISS FROM HV 100BASETX RX |
| 106 | 22 | ISS FROM HV 100BASETX RX RTN |
| 96 | 22 | ISS TO HV 100BASETX TX |
| 107 | 22 | ISS TO HV 100BASETX TX RTN |
| 103 | 22 | ISS FROM HV 100BASETX RX |
| 113 | 22 | ISS FROM HV 100BASETX RX RTN |
| 104 | 22 | ISS TO HV 100BASETX TX |
| 114 | 22 | ISS TO HV 100BASETX TX RTN |
| 42 | 22 | IDA TO HV 1553 -1 |
| 54 | 22 | IDA TO HV 1553 -1 RTN |
| 66 | 22 | IDA TO HV 1553 -2 |
| 77 | 22 | IDA TO HV 1553 -2 RTN |
| 88 | 22 | IDA SPARE LOOPBACK HV I/F SIG |
| 99 | 22 | IDA SPARE LOOPBACK HV I/F RTN |
| 75 | 22 | IDA LOOPBACK HV I/F SIG |
| 87 | 22 | IDA LOOPBACK HV I/F RTN |
| | | |
| P300A Active Pyro, Connector P/N NATC06G13N98SN | | |
| Pin # | AWG | Signal |
| B | 20 | NSI ACTIVE HOOKS1 (+) |
| D | 20 | NSI ACTIVE HOOKS1 (-) |
| F | 20 | NSI ACTIVE HOOKS2 (+) |
| H | 20 | NSI ACTIVE HOOKS2 (-) |
| | | |
| P300B Passive Pyro, Connector P/N NATC06G13N98SN | | |
| Pin # | AWG | Signal |
| B | 20 | NSI PASSIVE HOOKS1 (+) |
| D | 20 | NSI PASSIVE HOOKS1 (-) |
| F | 20 | NSI PASSIVE HOOKS2 (+) |
| H | 20 | NSI PASSIVE HOOKS2 (-) |
| | | |
| J200A EXTERNAL EMA POWER, Connector P/N NATC77H25N29PPN | | |
| Pin # | AWG | Signal |
| TBD65 | | |
| | | |
| J200B EXTERNAL EMA POWER, Connector P/N NATC77H25N29PPN | | |
| Pin # | Pin # | Pin # |
| TBD65 | | |
| | | |

| | | |
|---|---|---|
| | | |
| J600A EXTERNAL LIMIT SWITCHES, Connector P/N NATC77H25N35PPN | | |
| Pin # | AWG | Signal |
| TBD 66 | | |
| | | |
| J600B EXTERNAL LIMIT SWITCHES, Connector P/N NATC77H25N35PPN | | |
| Pin # | AWG | Signal |
| TBD66 | | |
| | | |
| | | |
| P40 HOST VEHICLE ACTUATOR RELEASE, Connector P/N NATC06G13N35SN | | |
| Pin # | AWG | Signal |
| 21 | 22 | HV ACTUATION PETAL1 + |
| 15 | 22 | HV ACTUATION PETAL1 - |
| 20 | 22 | HV ACTUATION PETAL2 + |
| 19 | 22 | HV ACTUATION PETAL2 - |
| 22 | 22 | HV ACTUATION PETAL3 + |
| 18 | 22 | HV ACTUATION PETAL3 - |
| | | |

### 5.5.1 NDSB1 Power Transfer Interface to Host Vehicle Connector Location

Deleted

#### 5.5.1.1 NDSB1 Power Transfer Interface to Host

Deleted

### 5.5.2 NDSB1 Data Transfer Interface to Host

Deleted

#### 5.5.2.1 NDSB1 Data Transfer Interface to Host

Deleted

### 5.5.3 Water Transfer

Reserved

### 5.5.4 Fuel Transfer

Reserved

### 5.5.5 Pressurant Transfer

Reserved

### 5.5.6 Oxidizer Transfer

Reserved

# 6.0 NDSB1-TO- SUPPORT EQUIPMENT INTERFACE TBR13

The NDSB1 contains features built in to accommodate Test Support Equipment interfaces for attaching lifting hardware, seal protective covers, bell jars, and electrical connectors.

## 6.1 Structural/Mechanical

### 6.1.1 Lifting Interface TBR13

Refer to Figure 4.1.2.3-1 for details showing lift points. The lift points are designed for a vertical lift only and require the use of an NASA Docking System Project (NDSP) provided spreader bar. For alternate installation orientations, contact the NDSP Office.

### 6.1.2 Seal Cover Interface TBR13

NDSP-provided upper and lower seal covers will provide protection for the seals during handling and shipping of the NDSB1 hardware (TBR).

The lower seal cover attaches to the NDSB1 lower surface through the NDSB1-Host Vehicle mounting interface holes (TBR) per Figure 5.2.1.2-2.

### 6.1.3 Pressure Dome Interfaces TBR13

NDSP-provided upper and lower pressure domes will be used for seal leak tests during ground testing. In addition to ground testing of seal leaks, the upper pressure dome will be used for leak testing of the upper seal while mounted to a vehicle.

The upper dome will attach to the NDSB1 by engaging the NDSB1 passive hook with a manually activated hook on the pressure dome side. The upper pressure dome includes pins and sockets to align with the NDSB1 alignment pins. Figure 4.1.3.1-1 shows the specific alignment pin and hook locations.

The lower pressure dome that will be used in ground testing of the NDSB1 will attach to the NDSB1 through the 48 NDSB1-to-vehicle bolt pattern. Refer to Figure 5.2.1.2-2.

### 6.1.4 Pressure Seal Interface, Pass-Through Connectors TBR13

TBR13

### 6.1.5 Pressure Seal Interface, Test Ports TBR13

Two pressure test ports are located on the NDSB1 host seal interface to provide the capability to perform individual seal leak tests of the host seal interface on the ground prior to host integration and while integrated to the host vehicle.

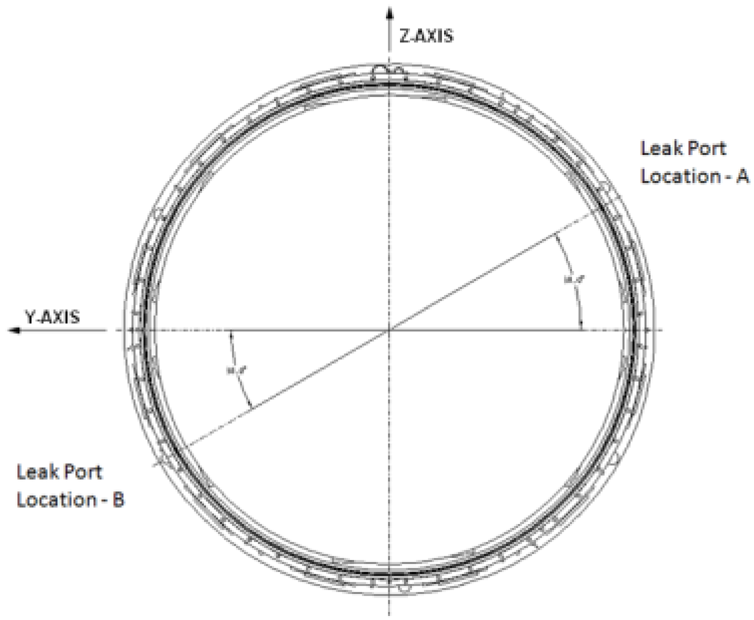



**FIGURE 6.5.1-1: LEAK TEST PORT LOCATIONS**

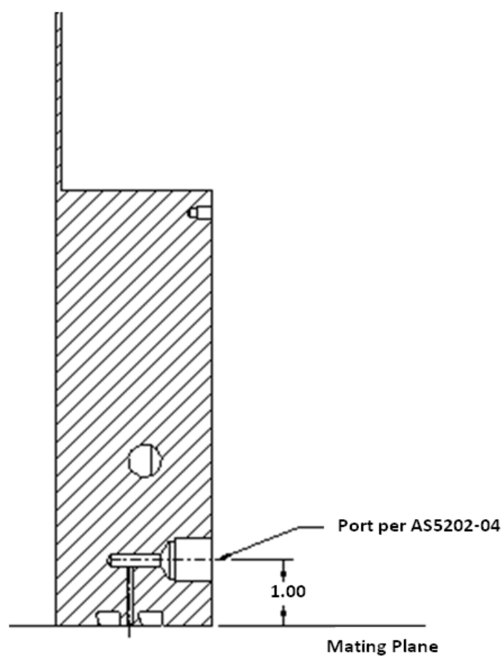
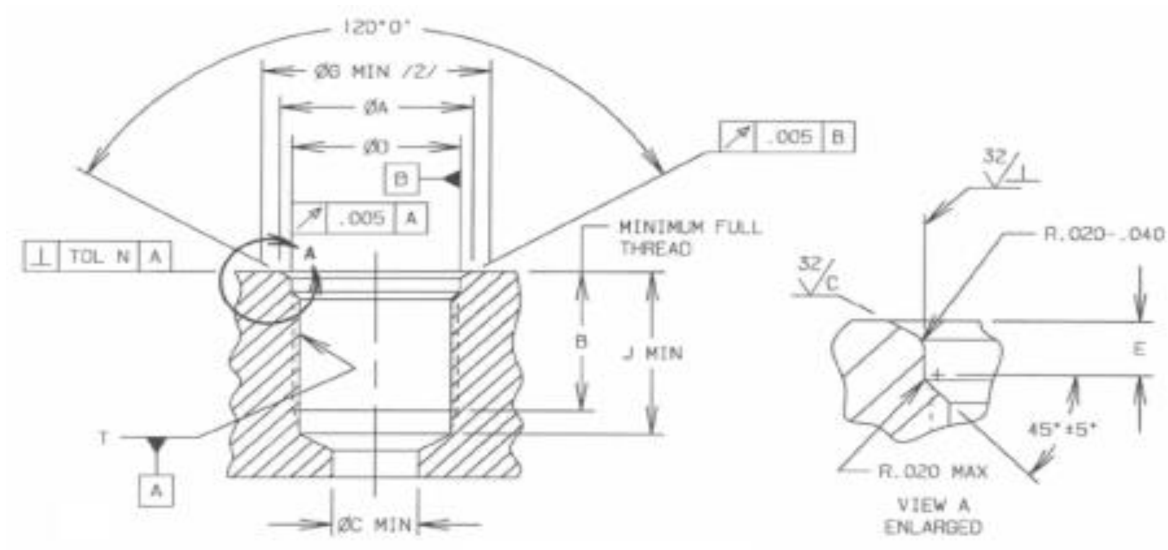



**FIGURE 6.5.1-2: LEAK TEST PORT CROSS SECTION**




| BASIC NO. AS5202 /9/ SIZE CODE | (NOMINAL TUBE SIZE) | T THREAD PER AS8879 CLASS 3B | A -.000/+.015 | B | C | D -.000/+.005 | E -.000/+.015 | G | J | N |
|---|---|---|---|---|---|---|---|---|---|---|
| 04 | .250 | .4375-20-UNJF | .562 | .568 | .172 | .454 | .075 | .728 | .656 | .003 |

**FIGURE 6.5.1-3: LEAK TEST PORT DETAIL**

### 6.1.6 Handling Fixture Interface TBR13

NDSP-provided handling fixtures interface to the NDSB1 through the 48 NDSB1-to-vehicle bolt pattern as shown in Figure 6.1.6-1: Handling Fixture Interface to NDSB1 Bolt Pattern. The lower seal cover will remain on the NDSB1 while using the handling fixture, providing protection to the seals.

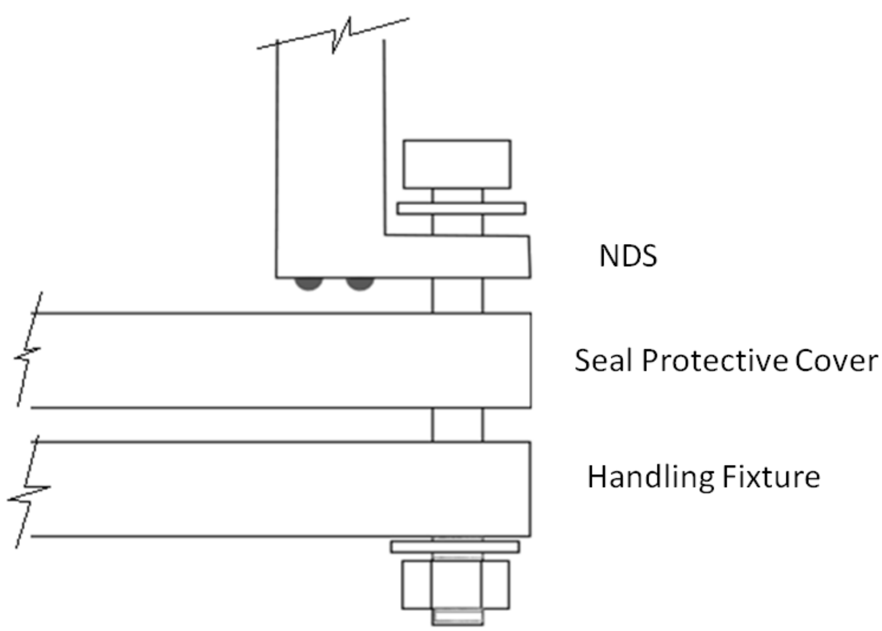



**FIGURE 6.1.6-1: HANDLING FIXTURE INTERFACE TO NDSB1 BOLT PATTERN**

### 6.1.7 Test Support Equipment – Docking System Emulator

The purpose of the Docking System Emulator (DSE) is to perform early 1553B/RS-422 interface integration checkout between the HV computer(s) and the NDSB1. The DSE provides a simulation that responds to commands issued from the Host Vehicle and provides telemetry to the HV per this IDD. The early integration tests will allow the HV teams to perform those scenarios defined in the NDSB1 ConOps document.

Figure 6.1.7-1 DSE Overview shows the major components of the DSE. The Chassis and circuits board comprise the DSE DIM Emulator, simulations (HCS/DSC and SCS/LAC) execute on the laptop. Wireshark is also available on the laptop to record/monitor 1553B/RS-422 traffic. The DSE will not connect to Flight Hardware.

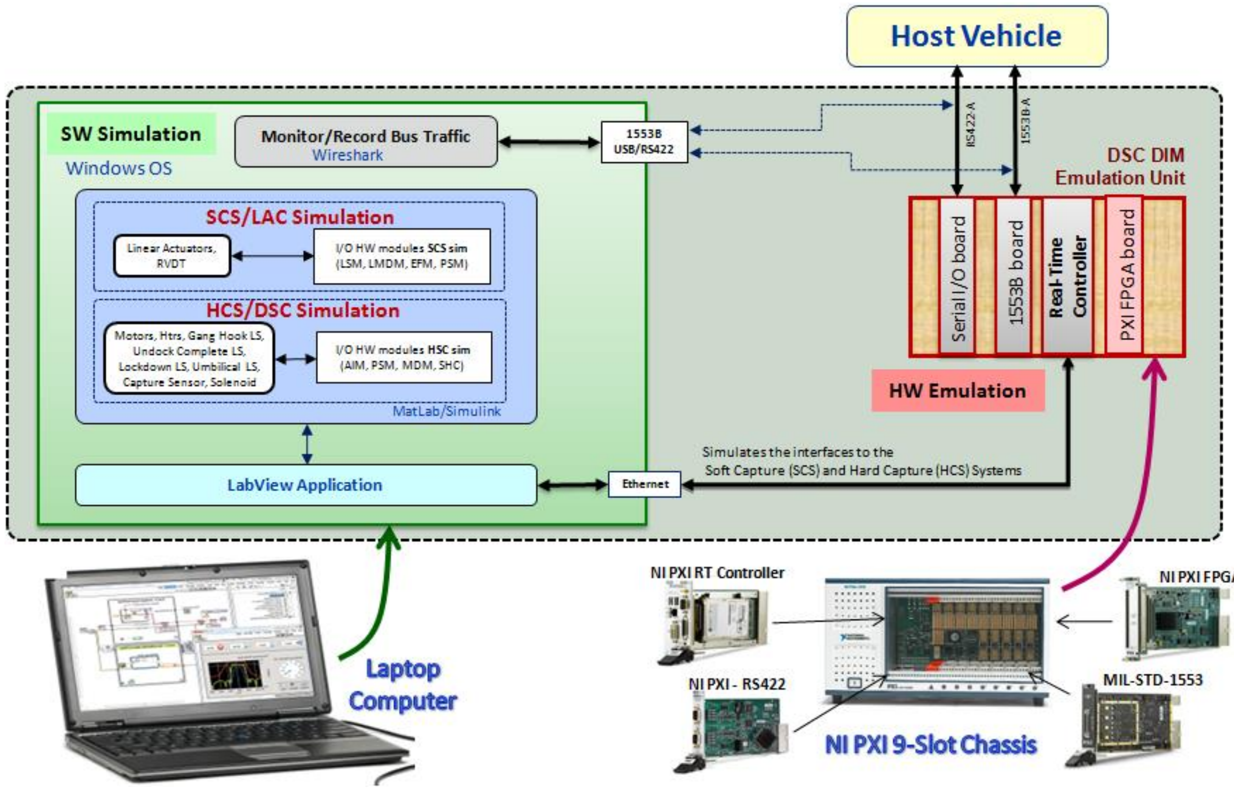



**FIGURE 6.1.7–4: DSE OVERVIEW**

## 7.0 Host Requirements for NASA Docking System Integration

This section defines the requirements that the host Vehicle must meet in order to control integrated host/NDSB1 hazards and/or specific host requirements to integrate the NDSB1. It is incumbent on the host to perform any analysis or test necessary to meet these requirements. The host vehicle is responsible for both developing the verification methods and verifying these requirements.

### 7.1 Interface Characteristics (Host Vehicle)

#### 7.1.1 Physical Interface

##### 7.1.1.1 Mechanical

###### 7.1.1.1.1 NDSB1 Keep Out Zones

The HV shall remain outside the KOZs as defined in Figure 3.8.1.3.1-2, NDSB1 Static Envelope, Docked Configuration.

Note: The entire envelope is a keep out zone for the Host Vehicle prior to start of docking and after dock

##### 7.1.1.2 Structural Attachment

The Host Vehicle shall be physically attached to the NDSB1 as shown in Figure 5.2.1.2-2.

###### 7.1.1.2.1 Seals

###### 7.1.1.2.1.1 Host Vehicle Seal Interface

The HV shall provide a chemical conversion coated aluminum seal land which corresponds to the NDSB1 seal locations defined in Figure 5.2.1.2- NDSB1-to-Host Vehicle Mounting Interface.

###### 7.1.1.2.2 Mounting

###### 7.1.1.2.2.1 Host Vehicle Mounting Inserts

The HV shall use the locking insert KNML10 x 1.5TX, as shown in Figure 5.2.1-1, NSB1-To-Host Vehicle Mounting Interface (Host Vehicle Mounting Flange Insert Detail (Insert)) for the structural interface to NDSB1 to prevent fastener back-out if Host Vehicle Through Bolt Mounting in accordance with 7.1.1.2.2.2 is not used.

###### 7.1.1.2.2.2 Host Vehicle Through Bolt Mounting

The HV shall use the use bolt with nut fastener as shown in Figure 5.2.1-1, NSB1-To-Host Vehicle Mounting Interface (Example Host-Through Hole Detail) if Host Vehicle Mounting Inserts in accordance with 7.1.1.2.2.1 are not used.

#### 7.1.1.2.2.3 Host Vehicle Mounting Flange

##### 7.1.1.2.2.3.1 Flange Thickness

The HV shall provide a mounting flange no less than 0.75 in. (19.05 mm) thick.

##### 7.1.1.2.2.3.2 Flange Stiffness at maximum gap

The HV flange stiffness shall be such that the maximum gap at the HV to NDSB1 seal interface is less than .002 inches under worse case loading.

Note: Gap values are the amount of flange separation at the inner seal midline. Stiffness is measured as a force applied at the bolt circle.

##### 7.1.1.2.2.3.3 Uniform Flange Stiffness

The HV shall provide a uniform interface flange stiffness ≥ 1,000 kip/in (TBR30). Flange stiffness is defined as the ratio of load to deflection when an axial force is applied at the interface bolt hole centerline and the maximum displacement is measured along the radius of the inner seal midline (R=25.46”). Reference configuration is shown in Figure 7.1.1.2.2.3.3-1 Definition of Load Deflection at Flange.

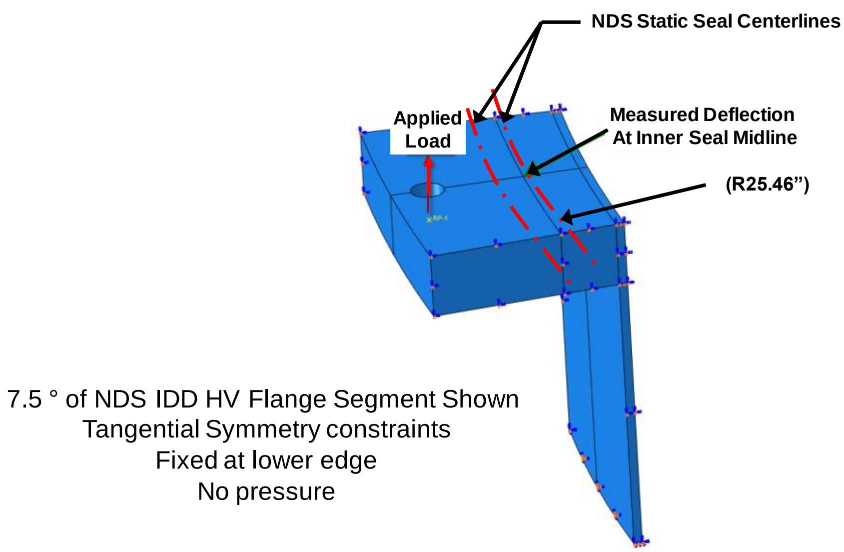



**FIGURE 7.1.1.2.2.3.3-1 DEFINITION OF LOAD DEFLECTION AT FLANGE**

#### 7.1.1.2.3 Host Vehicle Provided MMOD Shield

#### 7.1.1.2.3.1 Host Vehicle MMOD

The HV shall be responsible for MMOD protection for external components of theNDSB1 for the area defined in Figure 5.2.1.2-1: NDSB1 Host-Provided MMOD Interface.

#### 7.1.1.2.3.2 Minimum Probability of No Penetration

The HV integrating NDSB1 shall provide MMOD shielding for NDSB1 to meet HV Probability of No Penetration (PNP) requirements for 214 days.

#### 7.1.1.2.3.3 Host Vehicle External Thermal Interface

The HV hardware shall limit heat transfer at the external mounting interface defined in Figure 5.2.1.2-1: NDSB1 Host-Provided MMOD Interface to comply with thermal interface requirements in Sections 5.2.2 and 7.1.4.2.

#### 7.1.1.2.3.4 Host Vehicle MMOD Temperature

Deleted

### 7.1.2 Electronic Interface

### 7.1.2.1 Functional Electrical and Signal Interfaces

#### 7.1.2.1.1 Host Vehicle Electrical and Signal Interfaces

The Host Vehicle shall provide the functional electrical and signal interfaces as shown in Table 7.1.2.1.1-1 NDSB1-to-Host Vehicle Electrical Interface at the interface between NDSB1 and the Host Vehicle.

**TABLE 7.1.2.1.1-1: NDSB1-TO-HOST VEHICLE ELECTRICAL INTERFACE**

| Item | Int/Ext | ISS | NDSB1 | HV | Type | Description | Notes |
|---|---|---|---|---|---|---|---|
| Sys A 120VDC | Ext | From | Pass through | To | Power | | |
| Sys B 120VDC | Ext | From | Pass through | To | Power | | |
| Sys A 28VDC | Ext | From | Pass through | To | Power | For future use; 28VDC not supplied by ISS for Block 1 | |
| Sys B 28VDC | Ext | From | Pass through | To | Power | For future use; 28VDC not supplied by ISS for Block 1 | |
| Sys A MIL-STD-1553B | Ext | Connect | Pass through | Connect | MIL-STD-1553B | | |
| Sys B MIL-STD-1553B | Ext | Connect | Pass through | Connect | MIL-STD-1553B | | |
| Sys A Ethernet | Ext | Connect | Pass through | Connect | 100 Base T (IEEE 802.3u) | | |
| Sys B Ethernet | Ext | Connect | Pass through | Connect | 100 Base T (IEEE 802.3u) | | |
| Pyro | Ext | | To | From | NSI | | |
| Pyro | Ext | | To | From | NSI | | |
| Input Power 28VDC A | Int | | To | From | Power | Multiple 28V inputs (see Figure 3.2.3.2.1-1). | |
| Input Power 28VDC B | Int | | To | From | Power | Multiple 28V inputs (see Figure 3.2.3.2.1-1). | |
| RS422 A | Int | | Connect | Connect | TIA-422-B | 1 Mbit/second, asynchronous with RTS/CTS handshaking, 8 bits, no parity | |

| Item | Int/Ext | ISS | NDSB1 | HV | Type | Description | Notes |
|---|---|---|---|---|---|---|---|
| RS422 B | Int | | Connect | Connect | TIA-422-B | 1 Mbit/second, asynchronous with RTS/CTS handshaking, 8 bits, no parity | |
| 1553 Sys A (A&B) | Int | | Connect | Connect | MIL-STD-1553B | | |
| 1553 Sys B (A&B) | Int | | Connect | Connect | MIL-STD-1553B | | |
| RTJMPRJ0-RTJMPRJ4 and RTJMPRJP | Int | | To | From | Jumpers* | Select RT address and parity for MIL-STD-1553B communications | SEE NOTE 1 |
| | | | | | | | |
| UNITID1 | Int | | To | From | Jumpers* | Selects system A or B for system A | SEE NOTE 1 |
| UNITID2 | Int | | To | From | Jumpers* | Selects system A or B for system B | SEE NOTE 1 |
| COMMID1 | Int | | To | From | Jumpers* | Selects MIL-STD-1553B or TIA-422-B interface for system A | SEE NOTE 2 |
| COMMID2 | Int | | To | From | Jumpers* | Selects MIL-STD-1553B or TIA-422-B interface for system B | SEE NOTE 2 |
| Feed through<br><br>Power Contacts | Ext | Connect | Pass Through | Connect | Continuity | Available for future detection of docking; unused by IDA | |
| Hook Gang1 OP CMD | Int | ICP | Pass Through | From | Discrete<br><br>(Hi/Lo Impedance) | Discrete pair for alternate operation of hooks (optional) | |
| Hook Gang1 CL CMD Sig | Int | ICP | Pass Through | From | Discrete<br><br>(Hi/Lo Impedance) | Discrete pair for alternate operation of hooks (optional) | |

| Item | Int/Ext | ISS | NDSB1 | HV | Type | Description | Notes |
|---|---|---|---|---|---|---|---|
| Hook Gang1 OP POS Sig | Int | From | Pass Through | To | Discrete (Hi/Lo Impedance) | Discrete pair for alternate operation of hooks (optional) | |
| Hook Gang1 CL POS Sig | Int | From | Pass through | To | Discrete (Hi/Lo Impedance) | Discrete pair for alternate operation of hooks (optional) | |
| Hook Gang2 OP CMD | Int | ICP | Pass Through | From | Discrete (Hi/Lo Impedance) | Discrete pair for alternate operation of hooks (optional) | |
| Hook Gang2 CL CMD Sig | Int | ICP | Pass Through | From | Discrete (Hi/Lo Impedance) | Discrete pair for alternate operation of hooks (optional) | |
| Hook Gang2 OP POS Sig | Int | From | Pass Through | To | Discrete (Hi/Lo Impedance) | Discrete pair for alternate operation of hooks (optional) | |
| Hook Gang2 CL POS Sig | Int | From | Pass through | To | Discrete (Hi/Lo Impedance) | Discrete pair for alternate operation of hooks (optional) | |

Int – Internal to tunnel

Ext – External to tunnel

* Jumpers are used for three types of identifying, configuring or mapping/addressing of hardware.

- Communication ID
- Unit ID
- 1553 RT Selection

The DSC provides ten (10) jumper interfaces;

- six (6) 1553 RT
- two (2) Unit ID
- two (2) Communication ID

Jumpers are only read on system startup. The DSC uses pull-up resistors connected to at least 3 VDC and supplying at least 490 μA of current for each of the three types of Jumpers. This type of hardware design determines whether or not any particular pin within a connector has an electrical characteristic of being “high” or “low”. It is the electrical state of these individual pins or combination of pins that allows the FPGA to read, map, or assign hardware configurations within the NDSB1 assembly.

NOTE 1: There are two DSC avionics boxes per each NDSB1 assembly. Both of these DSCs are identified with the same part number; however a Unit Identification (ID) jumper will be installed on each of the DSCs that will address or specifically map which individual DSC belongs to System A and which DSC belongs to System B.

NOTE 2: A standard dual redundant MIL-STD-1553B communications interface is provided between the HV and the DSC. Either RS-422 or MIL-STD-1553B interfaces can be used for receiving commands from the HV and sending status information to the HV. Each of the two systems (A and B) has its own communications interfaces. The Host Vehicle will utilize either the RS-422 interface or the MIL-STD-1553B interface, but not both for communication between the HV and the DSC. Selection of which interface is active in the avionics is determined by the two Communication ID Jumpers, one jumper for each DSC. The Communication ID Jumper is installed between either the COMMID1+ and COMMID1- pins or the COMMID2+ and COMMID2- pins. Each of the two DSCs within the NDSB1 assembly shall check the Communication ID pins. If the COMMID1+ and COMMID- pins are shorted, and the COMMID2+ and COMMID2- pins are not shorted, the data shall be communicated over the RS-422 interface. If the COMMID1+ and COMMID- pins are not shorted, and the COMMID2+ and COMMID2- pins are shorted, data shall be communicated over the MIL-STD-1553 interface. If both sets of Communication ID pins are shorted together or neither pair is shorted together, this indicates a failure, and the controller will transition to a non-operational state with no communication provided to the HV.

#### 7.1.2.1.2 Host Vehicle Separation of Power and Command

The HV shall physically separate redundant avionics power and command functions.

### 7.1.2.2 Redundant Wiring

#### 7.1.2.2.1 Host Vehicle Wiring

The HV shall physically separate or protect redundant interconnecting wiring.

Note: To ensure that an event which damages one wire is not likely to prevent the other redundant wire from performing its function.

### 7.1.2.3 Umbilical Interface

The NDSB1 provides the utilities necessary for pass-through transfer of power and data from/to the ISS and the Host Vehicle.

#### 7.1.2.3.1 Host Vehicle Umbilical Data Transfer ISS to Host Vehicle

The NDSB1 to HV umbilical interfaces shall provide the utilities to transfer two hard-line MIL-STD-1553 and two IEEE 802.3u Ethernet data and communication between the mated vehicles when the Host Vehicle is hard mated to the ISS.

##### 7.1.2.3.1.1 Host Vehicle Receive IEEE 802.3u Ethernet Data

The HV shall receive data via two redundant IEEE 802.3u Ethernet data buses from the ISS via the NDSB1 to HV interface.

##### 7.1.2.3.1.2 Host Vehicle Receive MIL-STD-1553 Data Bus

After umbilical mate to ISS, the HV shall receive data via two redundant MIL-STD-1553B data buses from the ISS via the NDSB1 to HV interface.

##### 7.1.2.3.1.3 Host Vehicle Terminate MIL-STD-1553 Data Bus

The HV shall terminate MIL-STD-1553 buses on the HV side of the NDSB1 to HV interface in accordance with MIL-STD-1553B Notice 2.

#### 7.1.2.3.2 Host Vehicle Umbilical Power Transfer from ISS

The Host Vehicle shall receive redundant 120 VDC power from the ISS via the NDSB1 to HV interface as shown in Table 7.1.2.1.1-1 NDSB1-to-Host Vehicle Electrical Interface to the NDSB1.

### 7.1.2.4 Data Interface

Each NDSB1 system communicates with its HV via either a TIA-422B serial interface or MIL-STD-1553 interface.

#### 7.1.2.4.1 Two's Complement Notation

The HV shall employ two's complement notation to represent all signed integers.

#### 7.1.2.4.2 Zero Fill Unused Bits and Words

The HV shall zero fill all unused (or spare) bits and words in HV to DSC messages.

#### 7.1.2.4.3 Serial Data Communications

##### 7.1.2.4.3.1 Host Vehicle MIL-STD-1553/TIA-422 Communication Jumper

The HV shall provide one Communication ID Jumper for each DSC to define whether a MIL-STD-1553 or a TIA-422 communication interface will be used between the HV and the DSCs.

Note: If the Communication ID Jumper is installed between the COMMID1+ and COMMID1- pins then data will be communicated over the RS-422 interface. If the Communication ID Jumper is installed between the COMMID2+ and COMMID2- pins then data will be communicated over the MIL-STD-1553 interface. If both sets of Communication ID pins are shorted together or neither pair is shorted together, this indicates a failure, and the controller will transition to a non-operational state.

#### 7.1.2.4.3.2 Host Vehicle Transformer-coupled Remote Terminal

The HV shall provide transformer-coupled stubs to connect the NDSB1 to the MIL-STD-1553B buses.

#### 7.1.2.4.3.3 Host Vehicle Commanding

##### 7.1.2.4.3.3.1 Host Vehicle Commands to NDSB1

The HV shall control the NSDB1 using the commands listed in Appendix C.

##### 7.1.2.4.3.3.2 Host Vehicle Command Rates

The HV shall provide commands to the NDSB1 at a maximum rate of 50 Hz.

##### 7.1.2.4.3.3.3 Host Vehicle TIA-422 Commanding

When RS-422 communications is selected, the HV shall send commands to the Primary DSC at a minimum rate of one command per second.

Note: The Primary DSC will monitor the serial input to detect the Host Vehicle. If the HV has no commands to send, an "RS_422_Keep_Alive" command is available for the sole purpose of meeting this requirement. If the DSC does not detect a command within 3 seconds, it will assume the HV is not present or has failed and will revert to Monitor Mode.

#### 7.1.2.4.3.4 Host Vehicle Reception of NDSB1 Data

The HV shall receive serial data from the NDSB1 as defined in Appendix C

#### 7.1.2.4.3.5 Host vehicle Response to NDSB1 Data

##### 7.1.2.4.3.5.1 Response to Initial Docking Contact

The HV Guidance, Navigation, and Control (GN&C) shall transition into free drift within 500 ms of receipt of the Initial Contact indication in the NDSB1 H&S message from the NDSB1.

#### 7.1.2.4.4 C&DH TIA-422-B Network Topology

The HV shall implement a point-to-point network topology.

#### 7.1.2.4.5 C&DH MIL-STD-1553B Interface

##### 7.1.2.4.5.1 Host Vehicle MIL-STD-1553B Bus Controller

The HV shall perform Bus Controller (BC) functions in accordance with MIL-STD-1553B.

##### 7.1.2.4.5.2 Host Vehicle MIL-STD-1553B Parity

The HV shall use odd parity when setting the RT address parity bit in accordance with MIL_STD-1553.

##### 7.1.2.4.5.3 Host Vehicle MIL-STD-1553 Mode Commands

The HV shall transmit the mode code commands as defined in MIL-STD-1553B Notice 2.

##### 7.1.2.4.5.4 Host Vehicle Response to NDSB1 H&S Data

###### 7.1.2.4.5.4.1 Host Vehicle Isolation of NDSB1 Faults

The HV shall isolate NDSB1 faults to the recovery level.

#### 7.1.2.5 Pyrotechnic Interface

The HV shall provide the pyrotechnical interfaces shown in Figure 7.1.2.5-1, NDSB1 Pyrotechnic System Architecture.

Note: The Pyrotechnic System is used in a contingency scenario in the event demating a HV is prevented because of a malfunction of the Hook Assembly.

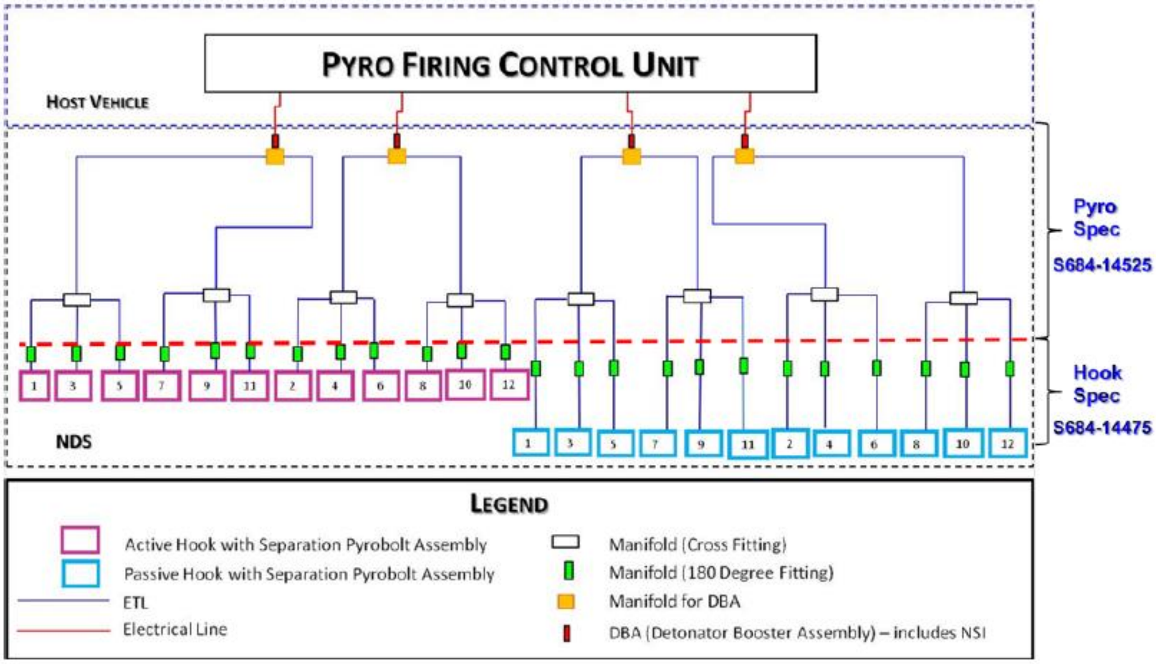


**FIGURE 7.1.2.5-1: NDSB1 PYROTECHNIC SYSTEM ARCHITECTURE**

### 7.1.2.5.1 Host Vehicle Pyrotechnic Firing

#### 7.1.2.5.1.1 Sources

The HV shall provide four pyrotechnic firing energy sources to the NDSB1 to affect the hooks as shown in Table 7.1.2.5.1.1-1, Gang/Hook Relationship.

**TABLE 7.1.2.5.1.1-1: GANG/HOOK RELATIONSHIP**

| | |
|---|---|
| **Gang 1** | **Active Hooks 1, 3, 5, 7, 9 ,11** |
| **Gang 2** | **Active Hooks 2, 4, 6, 8, 10, 12** |
| **Gang 3** | **Passive Hooks 1, 3, 5, 7, 9 ,11** |
| **Gang 4** | **Passive Hooks 2, 4, 6, 8, 10, 12** |

#### 7.1.2.5.1.2 Energy Level

The HV shall provide an all-fire bridgewire control signal compliant to JSC-28596A with a resistance of no more than 1.5 ohms introduced by the NDSB1.

Note: The HV may use any NSI firing mode desired, but must account for the total resistance of the HV wiring and the NDSB1 wiring.

#### 7.1.2.5.1.3 Simultaneous Firing

##### 7.1.2.5.1.3.1 HV Hook Firing Limit

The Host shall fire no more than 12 hooks (2 NSIs) simultaneously.

##### 7.1.2.5.1.3.2 HV Passive or Active Hook Firing

If the host vehicle fires 12 hooks (2 NSIs) simultaneously, the 12 hooks shall either be all passive or all active.

## 7.1.3 Electrical Interface

### 7.1.3.1 Electrical Bonding

#### 7.1.3.1.1 Host Vehicle Metal to Metal Bonding

The HV shall provide a class-H/R bond at the chemical conversion coated metal to metal NDSB1 to HV interfaces in accordance with NASA-STD-4003, Electrical Bonding for NASA Launch Vehicles, Spacecraft, Payloads, and Flight Equipment, paragraphs 4.2 and 4.3.

#### 7.1.3.1.2 Host Vehicle Cable/Umbilical Bonding

The HV shall provide a class-H/R bond at the cable and Umbilical NDSB1 to HV interfaces in accordance with NASA-STD-4003, Electrical Bonding for NASA Launch Vehicles, Spacecraft, Payloads, and Flight Equipment, paragraphs 4.2 and 4.3.

#### 7.1.3.1.3 DSC Grounding

The HV shall provide grounding for the DSC at the 10-32 UNF insert, ground strap interface shown in Figure 5.2.1.5-2.

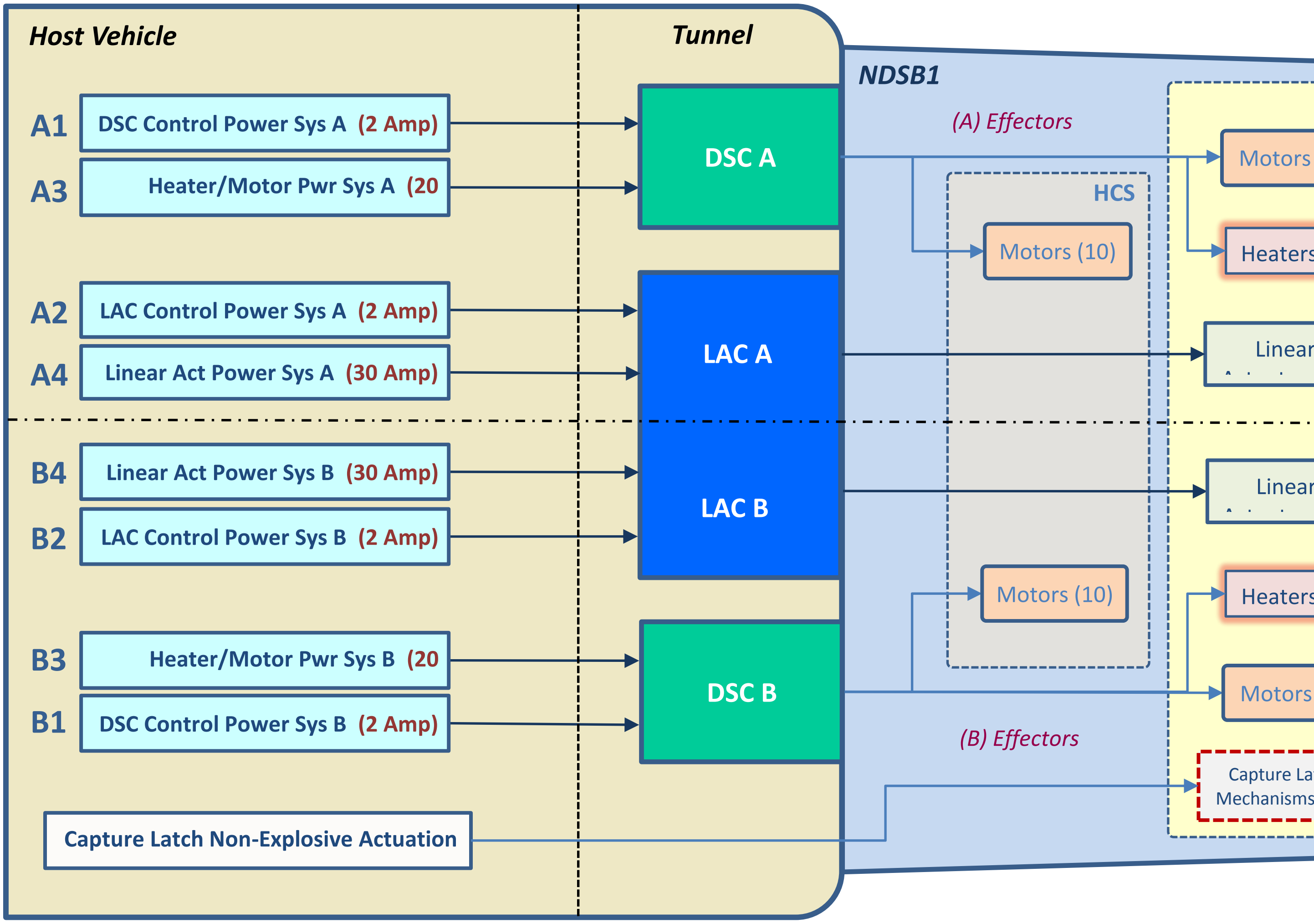
#### 7.1.3.1.4 LAC Grounding

The HV shall provide grounding for the LAC at the 10-32 UNF insert, ground strap interface in Figure 5.2.1.5-3.

### 7.1.3.2 Host Vehicle to NDSB1 Power

#### 7.1.3.2.1 Host Vehicle Power Supply

The HV shall provide independent/redundant power sources to the NDSB1 with the number of power input channels and rating of each as defined in Figure 7.1.3.2.1-1 NDSB1 Power System.




*- This is three 5 amp power feeds

**FIGURE 7.1.3.2.1-1: NDSB1 POWER SYSTEM**

### 7.1.3.2.2 Host Vehicle Power Application

It is expected that the HV will apply power to the NDSB1 DSC A1 and A3 power feeds, or the DSC B1 and B3 power feeds, immediately after exposing the NDSB1 structure to space. Note: Power is needed to enable monitoring and SCS heaters.

#### 7.1.3.2.2.1 LAC System A Power Application

The HV shall only apply power to the System A LAC power feeds (A2 and A4) after the successful power up of the System A DSC, indicated by nominal H&S packets from the DSC.

#### 7.1.3.2.2.2 LAC System B Power Application

The HV shall only apply power to the System B LAC power feeds (B2 and B4) after the successful power up of the System B DSC, indicated by nominal H&S packets from the DSC.

Note: The DSC must be powered on prior to the applying power to the corresponding LAC to prevent loss of communications detection and safing by the LAC. Power is only applied to the LAC in the Monitor, Manual, Active Docking, Standby Docking, and SCS Checkout modes. Power is not applied to the LAC in the Undocking or HCS Checkout modes.

#### 7.1.3.2.3 Host Vehicle Power to NDSB1 Consumption

##### 7.1.3.2.3.1 Primary System Docking Power

The HV shall provide power to the primary NDSB1 system as shown in Table 7.1.3.2.3.1-1 during docking.

**TABLE 7.1.3.2.3.1-1: PRIMARY POWER UTILIZATION FOR DOCKING**

| Checkout & Active Docking Mode | |
|---|---|
| Power Feed | Max Peak Power (W) |
| 2A DSC Control Power | 25 |
| 20A HCM Power | 490 |
| 2A LAC Control Power | 15 |
| 30A Linear Actuator | 460 |

##### 7.1.3.2.3.2 Standby System Docking Power

The HV shall provide power to the standby NDSB1 system during docking as shown in Table 7.1.3.2.3.2-1.

**TABLE 7.1.3.2.3.2-1: STANDBY UTILIZATION FOR DOCKING**

| Standby Docking Mode | |
|---|---|
| Power Feed | Max Peak Power (W) |
| 2A DSC Control Power | 25 |
| 20A HCMPower | 490 |
| 2A LAC Control Power | 15 |
| 30A Linear Actuator | 5 |

#### 7.1.3.2.3.3 Primary System Undocking Power

The HV shall provide power to the primary NDSB1 System as shown in Table 7.1.3.2.3.3-1, during undocking.

**TABLE 7.1.3.2.3.3-1: ACTIVE UTILIZATION FOR UNDOCKING**

| Active Undocking Mode[1] | |
|---|---|
| Power Feed | Max Peak Power (W) |
| 2A DSC Control Power | 25 |
| 20A HCM Power | 650[2][3] |
| 2A LAC Control Power | 0 |
| 30A Linear Actuator | 0 |

Notes:

(1) Power is specified per string
(2) Duration of Max Peak power is 20 ms.
(3) Peak power calculated at 36 VDC.

#### 7.1.3.2.3.4 Reserved

#### 7.1.3.2.3.5 Monitor Mode Power

The HV shall provide the NDSB1 with power of 15W average and 25W peak (exclusive of heaters) while in Monitor Mode.

#### 7.1.3.2.4 Host Vehicle Power Characteristics

The HV power system characteristics, looking from the NDSB1 inputs to the HV power system shall be as defined in Appendix K.

### 7.1.4 Induced Environmental Interfaces

#### 7.1.4.1 Structural Loads

The HV shall ensure that vehicle/mission-specific loads are enveloped by the NDSB1 designed-to loads.

#### 7.1.4.1.1 Host Vehicle Induced Operational Load

#### 7.1.4.1.1.1 On-Orbit Mated Loads

The HV shall limit the on-orbit mated loads at the NDSB1 interface to a level that is less than the load cases shown in Table 7.1.4.1.1.1-1, On-Orbit NDSB1-to-HV Maximum Mated Load Cases

**TABLE 7.1.4.1.1.1-1: ON-ORBIT NDSB1-TO-HV MAXIMUM MATED LOAD CASES**

| Load Set | Case 1 | Case 2 | Case 3 | Case 4 |
|---|---|---|---|---|
| Compressive Axial | 1,124 lbf (5,000 N) | 3,979 lbf (17,700 N) | 3,080 lbf (13,700 N) | 67,443 lbf (300,000 N) |
| Tensile Axial | 1,124 lbf (5,000 N) | 3,979 lbf (17,700 N) | 3,080 lbf (13,700 N) | 22,481 lbf (100,000 N) |
| Shear [2] | 1,124 lbf (5,000 N) | 3,327 lbf (14,800 N) | 3,754 lbf (16,700 N) | 2,248 lbf (10,000 N) |
| Torsion | 11,063 ft-lbf (15,000 N-m) | 11,063 ft-lbf (15,000 N-m) | 11,063 ft-lbf (15,000 N-m) | 11,063 ft-lbf (15,000 N-m) |
| Bending [2,8] | 47,313 ft-lbf (64,148 N-m) | 26,397 ft-lbf (35,789 N-m) | 47,833 ft-lbf (64,853 N-m) | 27,802 ft-lbf (37,695 N-m) |

Notes:

1. Loads are defined in a coordinate system with the same vector orientation as the NDSB1 structural coordinate system, but with its origin at the intersection of the axial vector with the NDSB1-to-HV mating plane.
2. Shear and bending loads may act in any direction in the NDSB1-to-HV mating plane.
3. The load components are to be applied concurrently in all possible combinations of positive and negative values.
4. These values are design limit loads.
5. Does not include internal pressure, seal force or pusher/separator loads.
6. Cases 1 through 3 are pressurized mated cases. Case 4 is an unpressurized mated case.
7. Case descriptions:
   Case 1 – Attitude control by Orbiter-like, combined with crew activity.
   Case 2 – Berthing of ISS segment while mated.
   Case 3 – Orbiter-like translation with payload attached to Orbiter Docking System (ODS).
   Case 4 – Trans-Lunar Insertion (TLI)-like, modified from Constellation analysis.
8. Bending Moment at HV interface is calculated as moment at IDA interface less shear times Tunnel length (9.07 in.).

#### 7.1.4.1.1.2 Acoustic Vibration

The HV shall limit the acoustic vibration environment received by NDSB1, to a level less than the maximum predicted environment for acoustic vibration represented in Figure 7.1.4.1.1.2-1, Acoustic Envelope Maximum Predicted Environment, and Table 7.1.4.1.1.2-1, Acoustic Envelope Maximum Predicted Environment, when configured for launch.

Note: NDSB1 remains functional after exposure to this environment.

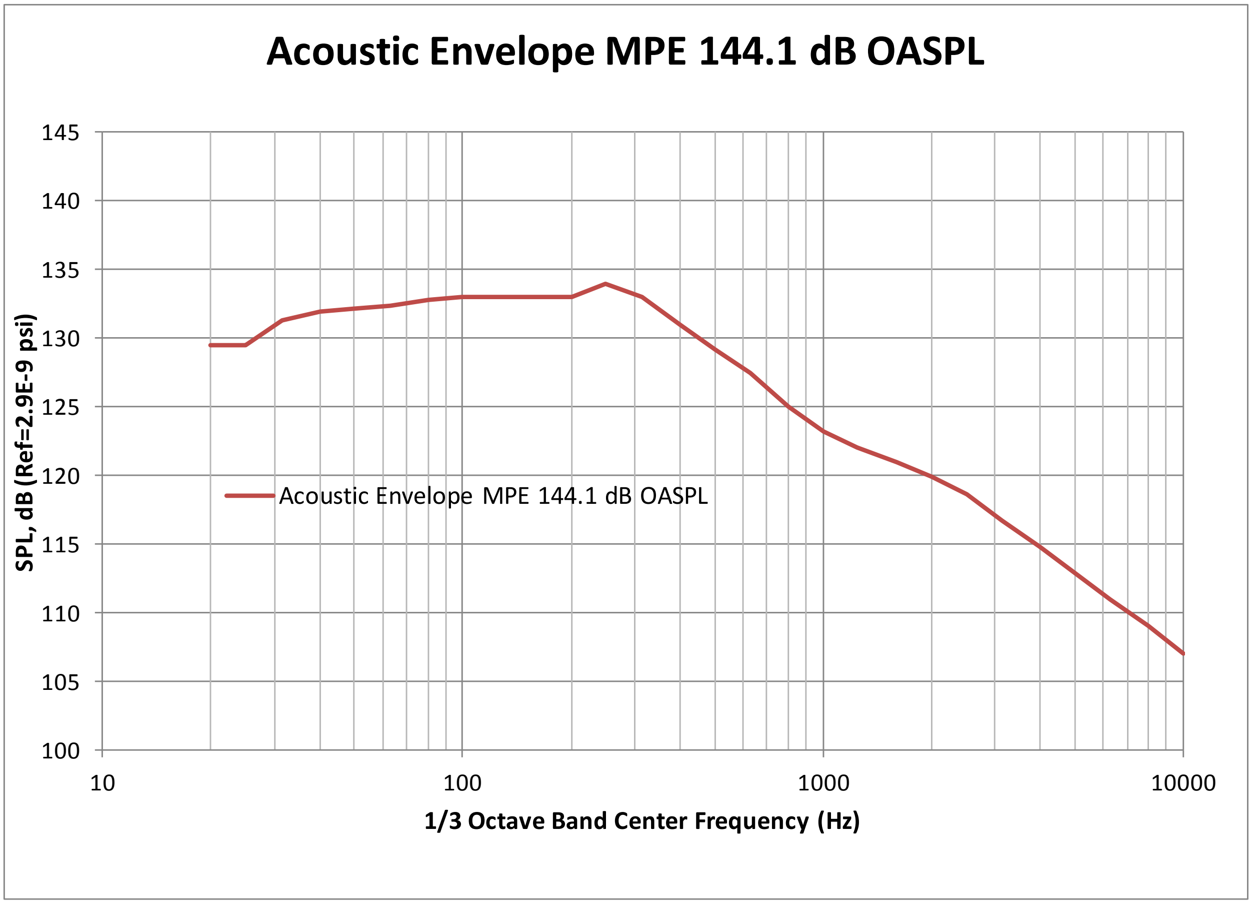



**FIGURE 7.1.4.1.1.2-1: ACOUSTIC ENVELOPE MAXIMUM PREDICTED ENVIRONMENT**

**TABLE 7.1.4.1.1.2-1: ACOUSTIC ENVELOPE MAXIMUM PREDICTED ENVIRONMENT**

| Third-Octave Band | Acoustic Envelope MPE 144.1 dB OASPL |
|---|---|
| **Hz** | **dB** |
| 20 | 129.5 |
| 25 | 129.5 |
| 31.5 | 131.3 |
| 40 | 132 |
| 50 | 132.2 |
| 63 | 132.4 |
| 80 | 132.8 |
| 100 | 133 |
| 125 | 133 |
| 160 | 133 |
| 200 | 133 |

| Third-Octave Band | Acoustic Envelope MPE 144.1 dB OASPL |
|---|---|
| 250 | 134 |
| 315 | 133 |
| 400 | 131 |
| 500 | 129.2 |
| 630 | 127.5 |
| 800 | 125 |
| 1000 | 123.2 |
| 1250 | 122.1 |
| 1600 | 121 |
| 2000 | 119.9 |
| 2500 | 118.6 |
| 3150 | 116.7 |
| 4000 | 114.8 |
| 5000 | 112.9 |
| 6300 | 111 |
| 8000 | 109.1 |
| 10000 | 107 |

#### 7.1.4.1.1.3 Ascent Random Vibration

The HV shall limit the ascent random vibration environment at the NDSB1 interface to a level less than the maximum predicted environment for random vibration represented shown in Figure 7.1.4.1.1.3-1, Random Vibration Envelope MPE for the Host-NDSB1 Interface, and Table 7.1.4.1.1.3-1, Random Vibration Envelope MPE for the Host-NDSB1 Interface, when configured for launch.

Note: NDSB1 remains functional after exposure to this environment.

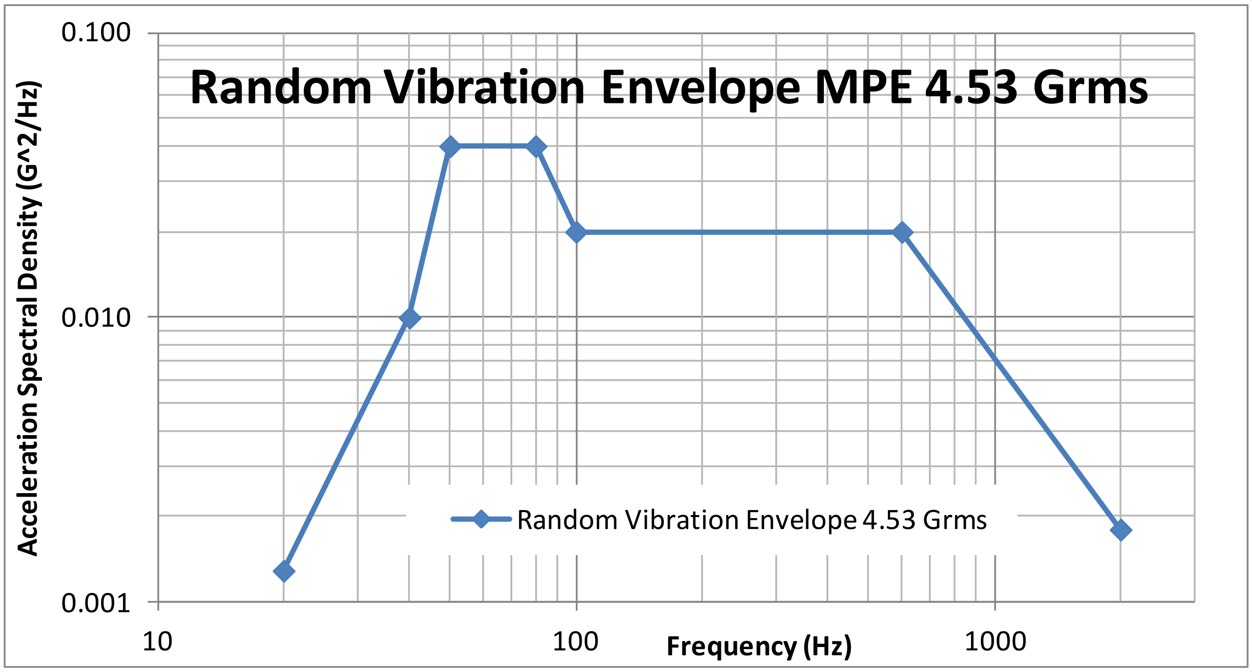



**FIGURE 7.1.4.1.1.3-1: RANDOM VIBRATION ENVELOPE MPE FOR THE HOST-NDSB1 INTERFACE**

**TABLE 7.1.4.1.1.3.3-1: RANDOM VIBRATION ENVELOPE MPE FOR THE HOST-NDSB1 INTERFACE**

| Random Vibration Envelope 4.53 Grms | |
|---|---|
| **FREQ (Hz)** | **ASD (G^2/Hz)** |
| 20 | 0.001 |
| 40 | 0.01 |
| 50 | 0.04 |
| 80 | 0.04 |
| 100 | 0.02 |
| 600 | 0.02 |
| 2000 | 0.002 |

### 7.1.4.1.1.4 Shock (Functional)

The HV shall limit the shock environment at the interface with NDSB1 to a level that is less than the shock shown in Figure 7.1.4.1.1.4-1, Shock Response Spectrum from Host, with spectrum as represented in Table 7.1.4.1.1.4-1 Shock Response Spectrum from Host.

Note: NDSB1 remains functional after exposure to this shock level.

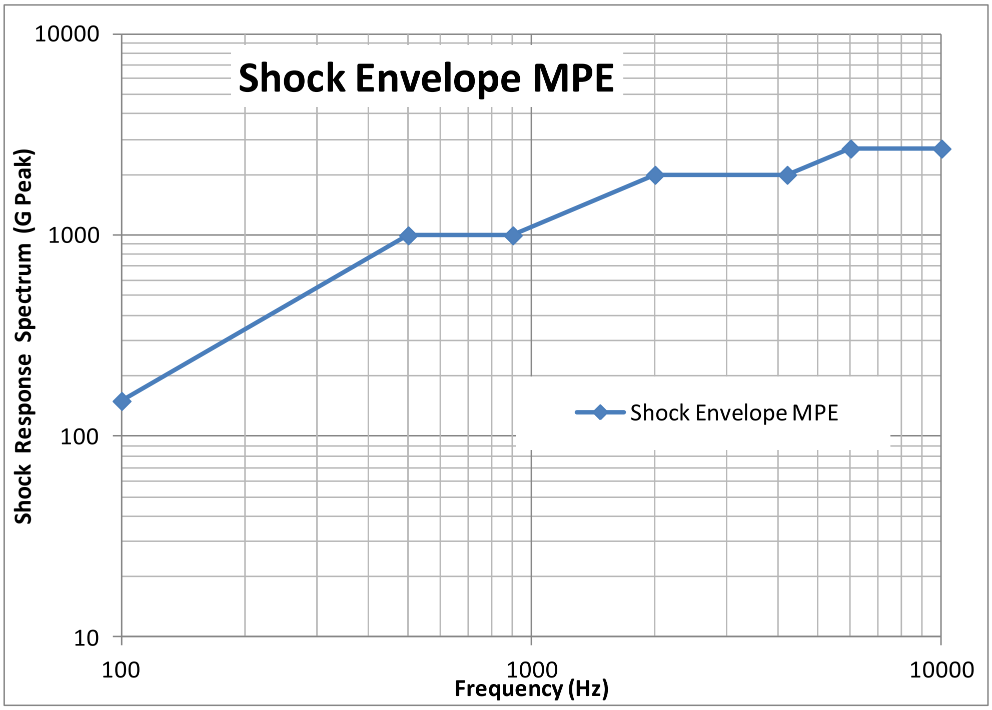



**FIGURE 7.1.4.1.1.4-1: SHOCK RESPONSE SPECTRUM FROM HOST**

**TABLE 7.1.4.1.1.4-1: SHOCK RESPONSE SPECTRUM FROM HOST**

| Envelope Shock MPE | |
|---|---|
| **Frequency (Hz)** | **Shock Response (G-Peak)** |
| 100 | 150 |
| 500 | 1000 |
| 900 | 1000 |
| 2000 | 2000 |
| 4200 | 2000 |
| 6000 | 2700 |
| 10000 | 2700 |

### 7.1.4.1.1.5 Ascent Load Factors

The HV shall limit the ascent load factor environment at the NDSB1 interface to a level that is less than the load factors shown in Table 7.1.4.1.1.5-1, Ascent Load Factors.

Note: NDSB1 remains functional after exposure to this event.

**TABLE 7.1.4.1.1.5-1: ASCENT LOAD FACTORS**

| AXIAL (g) | LATERAL (g) |
|---|---|
| ± 6.3 | ± 2.5 |
| Notes:<br>1. Axial + direction points in direction of Soft Capture System extension.<br>2. These load factors are applied simultaneously.<br>3. Values include static and transient acceleration. | |

#### 7.1.4.1.1.6 On-Orbit Load Factors

The HV shall limit the on-orbit load factor environment at the NDSB1 interface to less than 0.2g, acting in any direction when the NDSB1 is active with the SCS docking ring in the extended Ready-to-Capture position.

#### 7.1.4.1.1.7 Initial Contact Conditions

The HV shall control the vehicle approach to the ISS such that the initial contact between the NDSB1 and the IDA are within NDSB1's capability to capture and attenuate as defined by the limits defined in Table 3.8.1.1-1.

#### 7.1.4.1.2 Host Vehicle Induced Non-Operational Load

#### 7.1.4.1.2.1 Abort Acoustic Vibration

The HV shall limit the launch abort acoustic vibration environment received by NDSB1, to a level that is less than the environment shown in Figure 7.1.4.1.2-1, Abort Acoustic Maximum Predicted Environment and Table 7.1.4.1.2-1, Abort Acoustic Maximum Predicted Environment.

Note: NDSB1 does not function during or after this event.

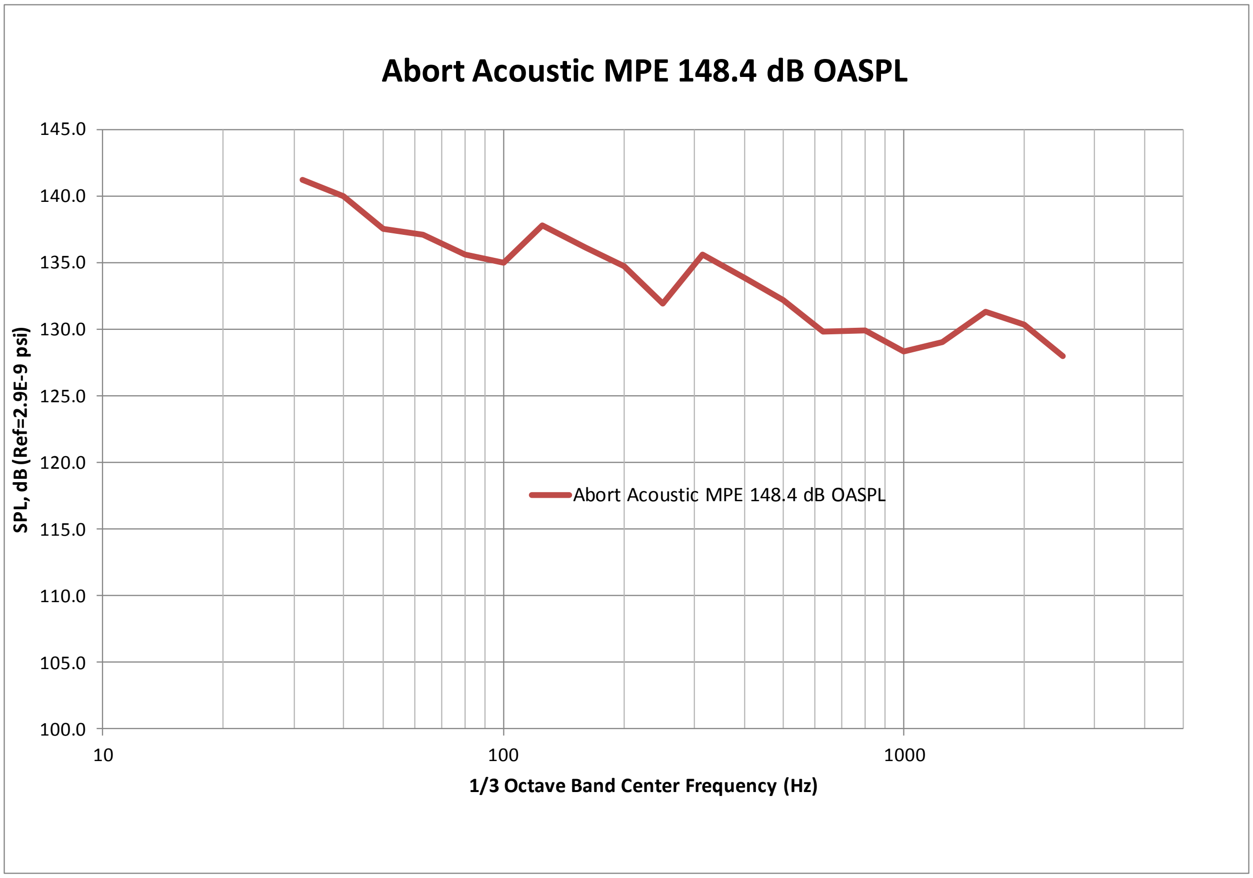



**FIGURE 7.1.4.1.2.1-1: ABORT ACOUSTIC MAXIMUM PREDICTED ENVIRONMENT**

**TABLE 7.1.4.1.2.1-1: ABORT ACOUSTIC MAXIMUM PREDICTED ENVIRONMENT**

| Third-Octave Band | Abort Acoustic MPE 148.4 dB OASPL |
|---|---|
| Hz | dB |
| 31.5 | 141.2 |
| 40 | 140.0 |
| 50 | 137.5 |
| 63 | 137.1 |
| 80 | 135.6 |
| 100 | 135.0 |
| 125 | 137.8 |
| 160 | 136.1 |
| 200 | 134.7 |
| 250 | 131.9 |
| 315 | 135.6 |
| 400 | 133.8 |
| 500 | 132.2 |
| 630 | 129.8 |
| 800 | 129.9 |
| 1000 | 128.3 |
| 1250 | 129.0 |
| 1600 | 131.3 |
| 2000 | 130.3 |
| 2500 | 128.0 |

### 7.1.4.1.2.2 Abort Random Vibration

The HV shall limit the random vibration environment at the interface with NDSB1 to a level that is less than the environment shown in Figure 7.1.4.1.2.2-1, Abort Random Vibration MPE for the Host-NDSB1 Interface, and Table 7.1.4.1.2.2-1, Abort Random Vibration MPE for the Host-NDSB1 Interface.

Note: NDSB1 does not function during or after this event.

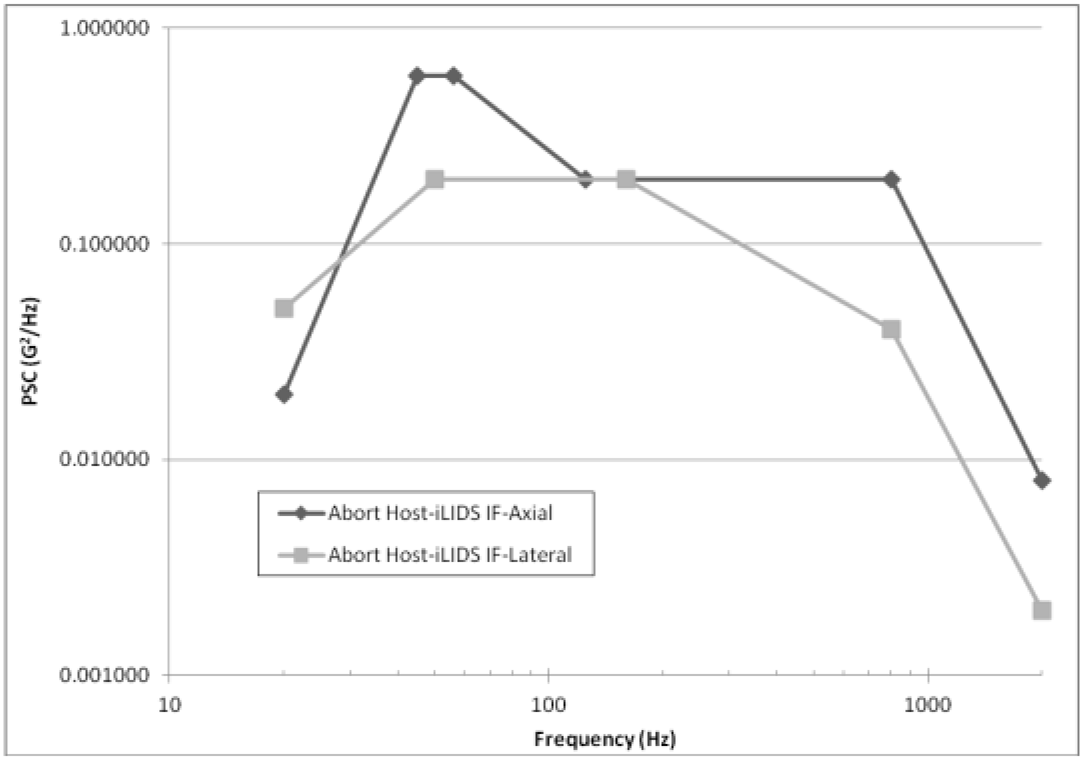



**FIGURE 7.1.4.1.2.2-1: ABORT RANDOM VIBRATION MPE FOR THE HOST-NDSB1 INTERFACE**

**TABLE 7.1.4.1.2.2-1: ABORT RANDOM VIBRATION MPE FOR THE HOST-NDSB1 INTERFACE**

| NOM HOST-NDSB1 AXIAL | | NOM HOST-NDSB1 LATERAL | |
|---|---|---|---|
| GRMS=15.1 | | GRMS=9.5 | |
| FREQ(HZ) | ASD(G2/HZ) | FREQ(HZ) | ASD(G2/HZ) |
| 20 | 0.02 | 20 | 0.05 |
| 45 | 0.6 | 50 | 0.2 |
| 56 | 0.6 | 160 | 0.2 |
| 125 | 0.2 | 800 | 0.04 |
| 800 | 0.2 | 2000 | 0.002 |
| 2000 | 0.008 | | |

### 7.1.4.1.2.3 Jettison Shock (Non-Functional)

The HV shall limit the jettison shock environment at the NDSB1 interface to a level that is less than the shock shown in FIGURE 7.1.4.1.2.3-1 NDSB1 Shock Response at The HV to NDSB1 Interface, with spectrum as represented in Table 7.1.4.1.2.3-1 NDSB1 Shock Response at the HV to NDSB1 Interface,

Note: NDSB1 does not function during or after this shock.

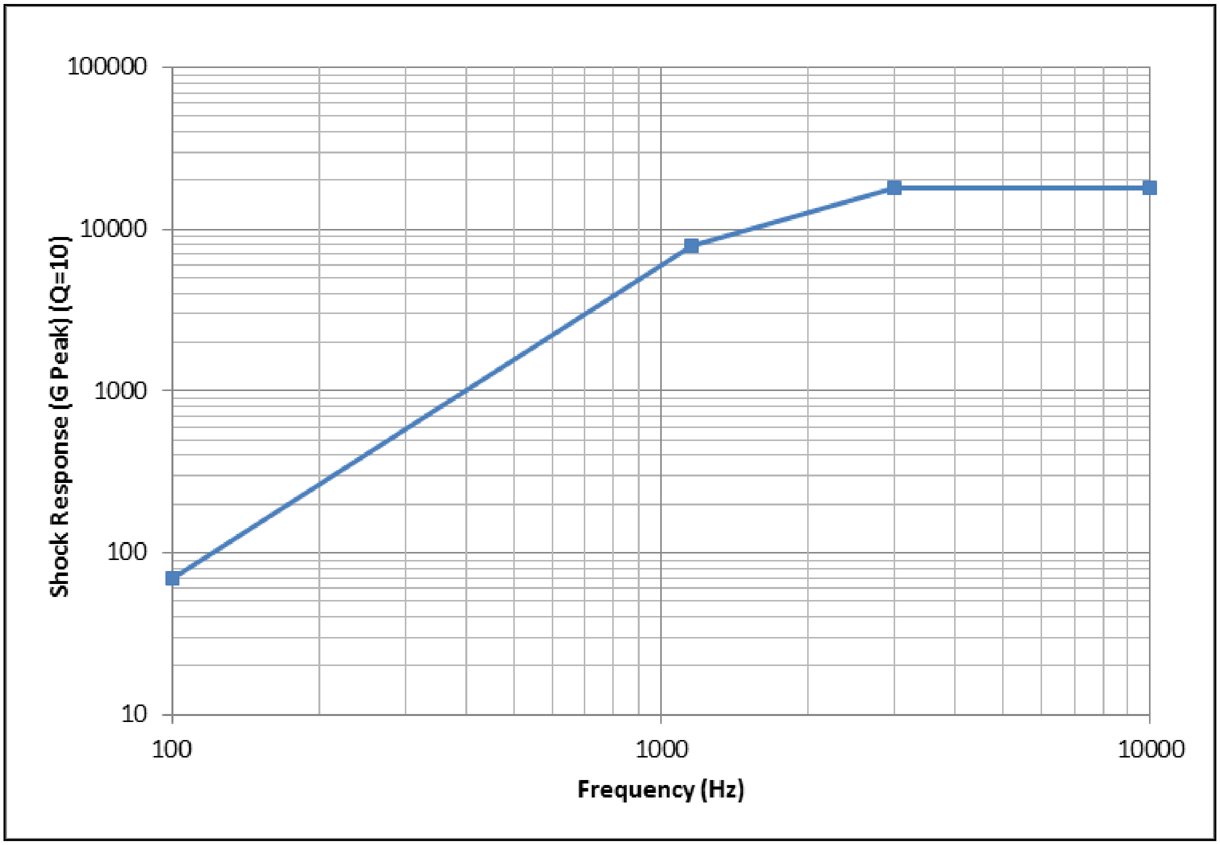



**FIGURE 7.1.4.1.2.3-1: NDSB1 SHOCK RESPONSE AT THE HV TO NDSB1 INTERFACE**

**TABLE 7.1.4.1.2.3-1: NDSB1 SHOCK RESPONSE AT THE HV TO NDSB1 INTERFACE**

| Jettison Shock Response | |
|---|---|
| Frequency (Hz) | MPE (G) |
| 100 | 70 |
| 1150 | 7800 |
| 3000 | 18000 |
| 10000 | 18000 |

### 7.1.4.1.2.4 Load Factors (Non-Functional)

The HV shall limit the non-operational load factor environment at the NDSB1 interface to a level less than the load factors in Table 7.1.4.1.2.4-1, Load Factors (Non-Function).

**TABLE 7.1.4.1.2.4-1: LOAD FACTORS (NON-FUNCTION)**

| AXIAL (g) | LATERAL1 (g) | LATERAL2 (g) |
|---|---|---|
| ± 20.6 | ± 4.5 | ± 5.3 |
| Notes:<br>1. Axial + direction points in direction of Soft Capture System extension.<br>2. These load factors are applied simultaneously.<br>3. Values envelope ascent abort, NDSB1 does not function during or after this flight event<br>4. Lateral 1 and Lateral 2 directions are perpendicular to each other in the lateral plane, and act in any direction. | | |

### 7.1.4.2 Thermal

#### 7.1.4.2.1 Host Vehicle Thermal Conductance

The HV design shall provide a thermal contact conductance across the NDSB1-to-HV structural interface greater than or equal to 50 Btu/hr-ft2-°F (284 W/m2-°K).

Note: The area assumed for contact conductance is the NDSB1’s total flange area including the voids due to the seals, air groove, and other mechanical features.

#### 7.1.4.2.2 Host Vehicle to NDSB1 Interface Temperature

##### 7.1.4.2.2.1 Solo Flight

The HV shall control the temperature of the structural interface between the HV and the NDSB1 to a range of 60°F 15.6°C) to 103°F (+39.4°C) during Host Vehicle Solo Flight.

##### 7.1.4.2.2.2 Checkout and Docking Operations

The HV shall control the temperature of the structural interface between the HV and the NDSB1 to a range of 60°F (15.6°C) to 103°F (+39.4°C) during Checkout, soft capture, and prior to Hard Capture State.

##### 7.1.4.2.2.3 Mated Operations

The HV shall control the temperature of the structural interface between the HV and the NDSB1 within +65°F (+18.3°C) to +113°F (+45°C) during mated operations.

Note: Docking is from initial contact until hard mate.

#### 7.1.4.2.3 Solar Ray Protection

The HV shall prevent the components external to the NDSB1 tunnel, excluding open mating flange components, from receiving any incident solar rays during on-orbit operations.

#### 7.1.4.2.4 Host Vehicle Heat Transfer Across The Interface

##### 7.1.4.2.4.1 Solo Flight, Checkout, and Docking Operations

The HV shall accommodate orbital average heat transfer across the NDSB1-to-HV structural interface ranging from a maximum heat leak of 360W to a maximum heat gain of 370W during Host Vehicle Solo Flight, Checkout, soft capture, and prior to Hard Capture State.

##### 7.1.4.2.4.2 Mated Operations

The HV shall accommodate a maximum heat loss across the NDSB1-to-HV structural interface of 100 W when the HV side of the structural interface is at +65°F (+18.3°C) during mated operations.

### 7.1.4.3 Salt Fog

The HV shall protect the NDSB1 from exposure to salt particles (i.e., salt fog) by maintaining at least a Class 100,000 conditioned air cleanliness level (as defined in FED-STD-209D) around the NDSB1 during ground integration and launch pad operations.

Note: The NDSB1 will provide non-flight covers. However, when these covers are removed, the HV must provide protection. For example, on the pad, the host might provide a purged environment around the docking system. The NDSB1 will tolerate an incidental short term exposure to salt particles (for example, potential exposure between purge termination and liftoff) by using corrosion resistant materials and parts and by design that protects parts and assemblies from potential impacts.

### 7.1.4.4 Lightning

The HV shall protect the NDSB1 from primary lightning effects (i.e., lightning direct current path) and limit the indirect lightning effects to 6 dB below the indirect lightning effect levels specified in JSC-65842 Table 5-1 and Section 7.0 for power, communications, control and pyrotechnic interfaces.

### 7.1.4.5 Debris Protection

The HV shall prevent debris generated or released during vehicle launch and/or ascent from contaminating NDSB1 mechanisms, seal surfaces, mating surfaces and umbilicals.

### 7.1.4.6 Ultraviolet Radiation Protection

The HV shall limit the NDSB1 dynamic seals' cumulative exposure to ultraviolet radiation to below 58 equivalent sun hours (ESH) during solo flight operations.

### 7.1.4.7 Surface Cleanliness

#### 7.1.4.7.1 NDSB1 Surface Cleanliness

The HV shall maintain NDSB1 surfaces VC Level "Sensitive" following receipt for integration through launch as defined in SN-C-0005, paragraph 2.4, Contamination Control Requirements.

#### 7.1.4.7.2 Seal Surface Cleanliness

The HV shall maintain NDSB1 seal surfaces at least VC Level "Highly Sensitive" following receipt for integration through launch as defined in SN-C-0005, paragraph 2.4, Contamination Control Requirements.

### 7.1.4.8 Radiant Energy Interaction

The HV shall limit radiant energy interaction upon other Space Station elements in accordance with D684-10058-03-04 Integrated ISS Math Models, Volume 3, Book 4.

### 7.1.4.9 On-Orbit External Contamination

The HV shall comply with ISS system level external contamination release control requirements as defined in SSP 30426, Sections 3.4 through 3.6.

### 7.1.4.10 Floating Potential Environment

The HV shall limit the NDSB1 exposure to the ISS floating potential environment to between +20V to -80 V.

### 7.1.4.11 Plasma Environment

The HV shall limit NDSB1 exposure to the natural plasma environment to below those defined in SSP 30425, Space Station Program Natural Environment Definition for Design, section 5.

### 7.1.4.12 Reentry Loads Environmental Protection

If the NDSB1 is returned from orbit, the Host Vehicle shall protect the NDSB1 against reentry, descent, and landing load environments as defined in paragraphs 5.2.1.5.3, 5.2.1.5.6, 7.1.4.1.2.2, 7.1.4.1.2.3, and 7.1.4.1.2.4.

#### 7.1.4.12.1 Thermal Re-entry Environmental Protection

If the NDSB1 is returned from orbit, the HV shall maintain the NDSB1 within -65 °F and 160 °F during re-entry, descent, and landing.

Note: The thermal capability of individual components is documented in paragraph 5.2.2.1.1.3.

#### 7.1.4.12.2 Descent Wind Pressure TBD

### 7.1.4.13 Interface Undocking Separation Conditions

The HV shall withstand the total potential undocking separation load of up to 600 lbf (2,669 N), per contingency case defined in 4.1.1.3.7. Note: This load is applied when the docking interfaces are fully mated (i.e. at zero separation distance).

### 7.1.4.14 HV Fundamental Frequency

The HV shall have a fundamental frequency of 1.5 Hz or greater when rigidly fixed at the IDA hard dock interface degrees of freedom. This frequency applies to overall-structure vibration modes and not to local appendage or antenna modes.

### 7.1.4.15 Electrical Power Consuming Equipment

When the HV is equipped with secondary 120 VDC electrical interfaces, the HV Electrical Power Consuming Equipment (EPCE) shall comply with SSP 52051, User Electric Power Specifications and Standards, Volume 1: 120 Volt DC Loads, Interface B, with the following exceptions:

1. The minimum steady voltage is 115 VDC
2. The minimum normal transient voltage is 97 VDC
3. The source impedance is defined in Figure 7.1.4.15-1, Modified Load Impedance Magnitude Limit, and Figure 7.1.4.15-2, Modified Load Impedance Phase Limit.

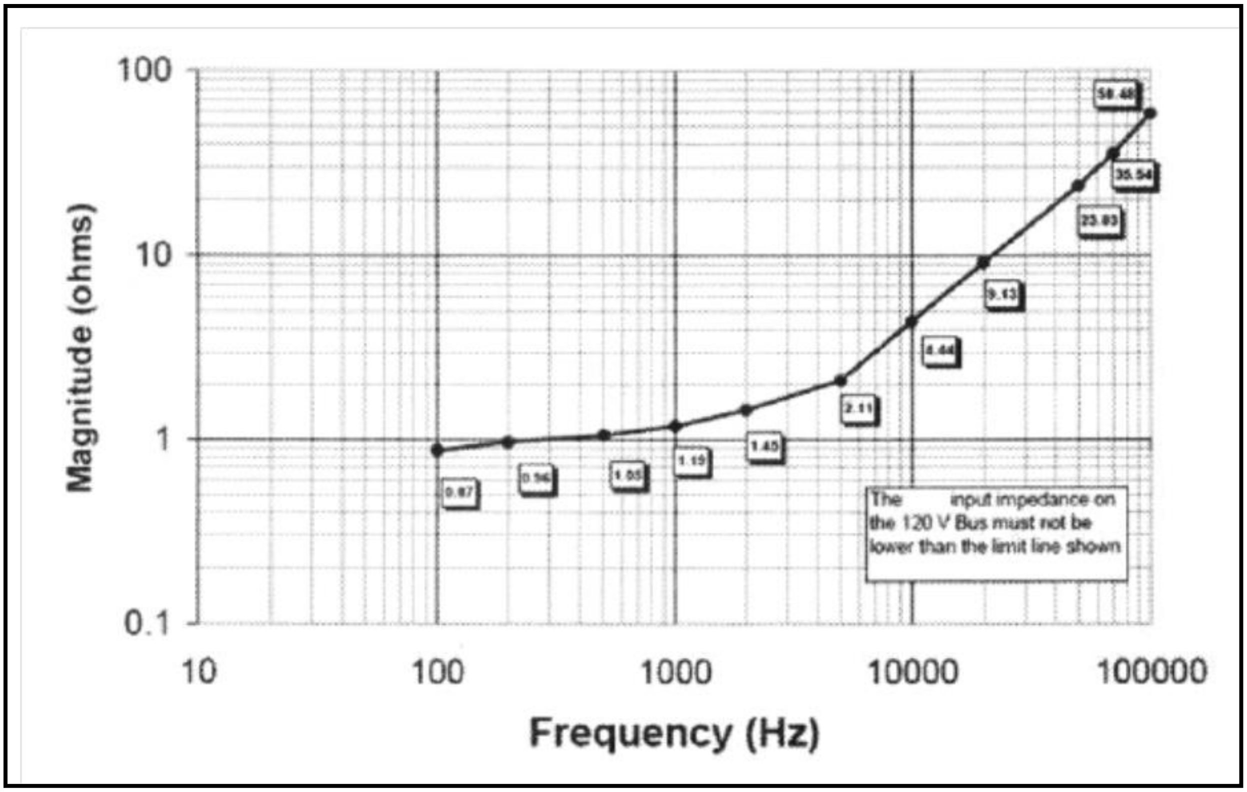



FIGURE 7.1.4.15-1: MODIFIED LOAD IMPEDANCE MAGNITUDE LIMIT

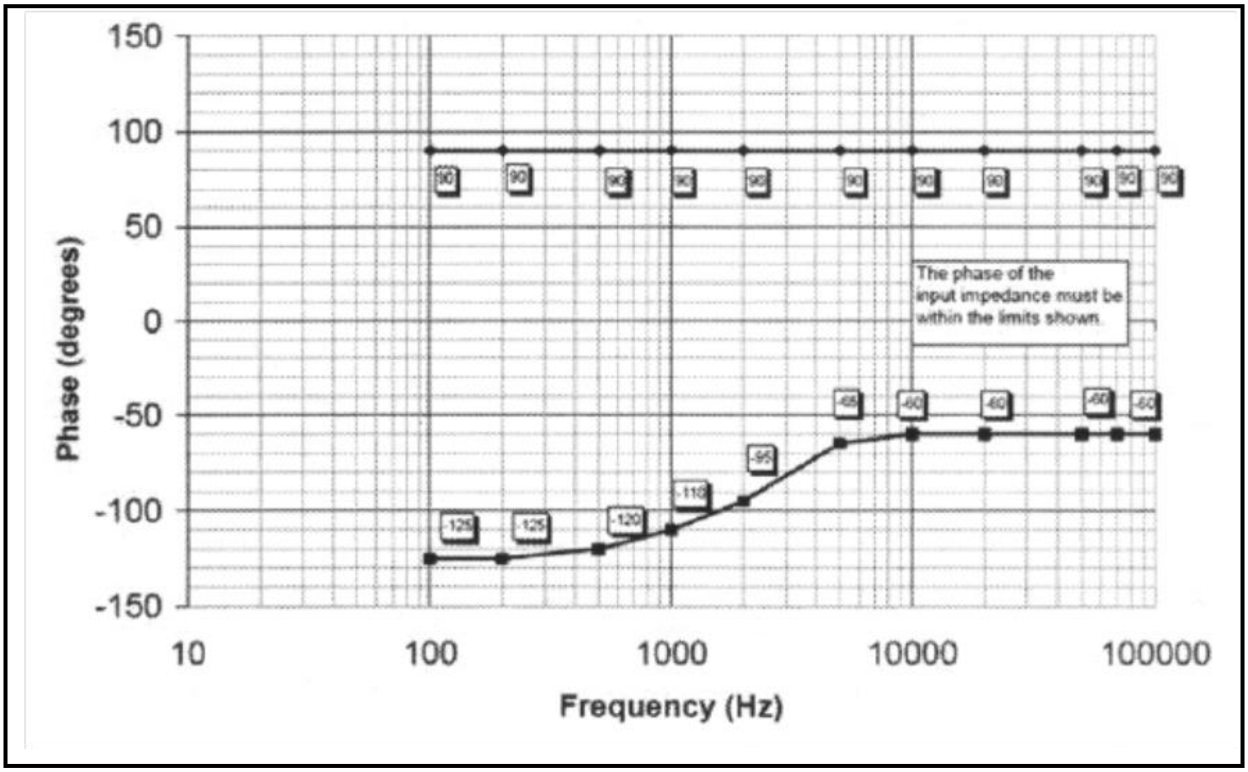



FIGURE 7.1.4.15-2: MODIFIED LOAD IMPEDANCE PHASE LIMIT

#### 7.1.4.16 BUS Coupler Type

##### 7.1.4.16.1 HV BUS Coupler Specification

The MIL-STD-1553 bus crossing the ISS interface shall have bus couplers that are in accordance with SSQ 21676, Coupler, Data Bus, MIL-STD-1553B, Space Quality, General Specification For.

##### 7.1.4.16.2 HV BUS Coupler Stubs

The MIL-STD-1553 bus crossing the ISS interface shall have bus couplers that contain a maximum of two stubs per coupler.

##### 7.1.4.16.3 BUS Stub Length

The MIL-STD-1553 bus crossing the ISS interface shall have a maximum bus stub length of 20 feet (6.1 m) as measured from the Coupling Transformer to the Isolation Transformer as defined in Figure 7.1.4.16.3-1, Bus Stub Length, Measurement A.

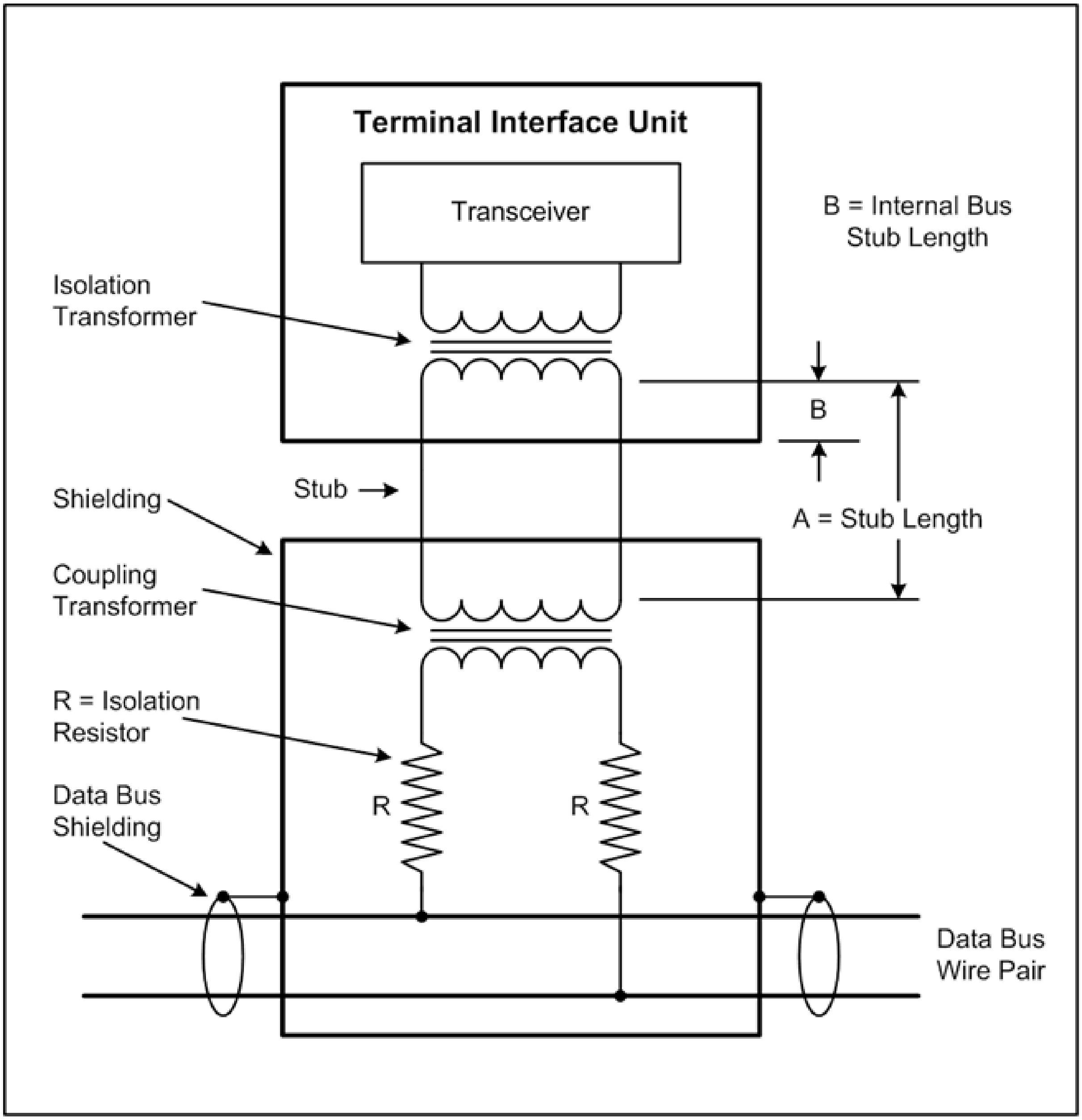



**FIGURE 7.1.4.16.3-1: BUS STUB LENGTH**

### 7.1.4.17 Receive Intermodule Ventilation

The VV shall receive Intermodule ventilation from the ISS.

#### 7.1.4.17.1 IMV Duct

Use of an IMV duct is optional. The IDA IMV duct will provide air flow up to the IDA/VV plane. If a VV chooses to connect a duct to the IDA IMV duct, the connection shall be made via a NASA provided coupling.

Rationale: ISS program office is not requiring the VV to provide a duct if they can meet their airflow requirements without one.

#### 7.1.4.18 Return Intermodule Ventilation

##### 7.1.4.18.1 Receive Intermodule Ventilation from VV

When the VV is Hard Mated and the hatches of the VV and ISS are open, the IDA receives return intermodule ventilation from the VV at the VV to IDA interface through the VV to IDA passageway.

##### 7.1.4.18.2 Return Intermodule Ventilation FROM VV

When the VV is Hard Mated and the hatches of the VV and ISS are open, the VV shall return intermodule ventilation to the IDA at the HVVV to IDA interface through the VV to IDA passageway.

#### 7.1.4.19 Deleted

#### 7.1.4.20 Deleted

#### 7.1.4.21 Plume Impingement Heating

During approach/separation from ISS, the VV thruster plume impingement heating on the IDA hardware does not exceed a maximum heat flux rate of 133 kW/m2 over a continuous period of .07 seconds and maximum heat flux integral of 119.6 kJ/m2 imposed as a heat flux of 0.2235 kW/m2 over a period of 535 seconds.

### 7.1.5 Safety

#### 7.1.5.1 Docking Operations Safety

##### 7.1.5.1.1 Automated Response to NDSB1 Failure Indications

Deleted

##### 7.1.5.1.2 Automated Response to NDSB1 System A and System B Failures

Deleted

##### 7.1.5.1.3 Host Vehicle Response to Ready to Capture Indication

The HV shall only proceed for final docking approach after receiving positive confirmation from the NDSB1 health and status message that the NDSB1 has reached the ready to capture configuration.

#### 7.1.5.1.4 Automated Host Vehicle Response to NDSB1 Faults

The HV shall execute a failure response to an NDSB1 failure as specified in Appendix G Failure Response Tables within 140 ms of a failure indication. Note: A failure indication may include both a distinct failure notification in the NDSB1 H&S message or any other abnormal H&S message as described in Appendix G.

#### 7.1.5.1.5 HV response to Failure to Ensure Initial Contact Conditions

The HV shall either ensure after any two faults that the initial contact between the NDSB1 and the IDA is within NDSB1's capability to capture and attenuate as defined by Table 3.8.1.1-1, or terminate the docking attempt and avoid a potential collision.

#### 7.1.5.1.6 Host Vehicle Provisions to Preclude Inadvertent Jet Firing

The HV shall enter free drift per paragraph 7.1.2.4.1.5.1 after any two faults or terminate the docking attempt and avoid a potential collision.

#### 7.1.5.1.7 Host Vehicle Response to Failure to Capture

Deleted

#### 7.1.5.1.8 Contingency Capture Latch Release – Independent Operation

The HV shall provide for the contingency operation of the capture latch release independently from the utility strings used to operate the NSB1 System A and System B.

Note: This requirement ensures that the contingency capture latch release function is operable following either two power bus failures within the HV or following two avionics failures within NDSB1.

#### 7.1.5.1.9 Inadvertent Capture Latch Release Prevention – Inhibits

The HV shall provide at least one inhibit against an inadvertent release of the contingency capture latch when NDS is not in a docking mode of operation.

Note 1: This inhibit will protect for a loss of mission due to inadvertent capture latch release.

Note 2: It is assumed that the status of the contingency capture latch release is checked either electrically or visually on the ground following NDS installation on the vehicle.

Note 3: It is recommended that the vehicle implement two-step commanding for manual activation (by the crew or ground) of the contingency capture latch release after the inhibit has been removed. However, the automated abort sequence may script these two commands together to ensure a safe abort.

#### 7.1.5.1.10 Reserved

#### 7.1.5.1.11 HV Docking Abort Performance

The HV shall have the capability to null vehicle motion within 600 milliseconds TBR31 with no assistance from NDS from docking initial contact through soft capture retraction complete. Note: The NDS soft capture system active control is only single fault tolerant. After two faults (e.g. avionics, power, commanding, electromechanical), NDS is no longer capable of preventing an uncontrolled collision between the HV and the ISS. The HV GN&C must, therefore, be capable of preventing collision by using thrusters in order to achieve two fault tolerance to that catastrophic hazard. NDS dynamics and avionics timing analyses indicate that the allowable time for the vehicle to prevent the collision may be as short as 600 milliseconds TBR31, presuming the HV operates within allowable initial contact condition limits.

### 7.1.5.2 Mated Operations Safety

#### 7.1.5.2.1 Inhibit power to NDSB1 for mated operations

The HV shall remove power from both NDSB1 Systems A and B prior to unlocking the docking hatch for mated operations until the hatch is closed and locked for undocking operations.

#### 7.1.5.2.2 Preparedness for Undocking

The HV shall be configured for undocking at times when the power is supplied to either System A or System B.

#### 7.1.5.2.3 Individual Crew Actions for Undocking

The HV shall separate crew actions required for NDSB1 to undock such that Motor Power Enable, Control Power Enable, and Enable Undock command, and Execute Undock commands each require a separate crew action.

#### 7.1.5.2.4 Monitoring of Inhibit to NDSB1 Motor Power

While power is removed from NDSB1 for mated operations, the HV shall monitor, in near real time or more frequently, the inhibit that prevents supplying NDSB1 with motor power.

#### 7.1.5.2.5 Separation of NDSB1 Controller and Motor Commands

Deleted

#### 7.1.5.2.6 Host Vehicle Pyrotechnic Inadvertent Firing

The HV shall provide three inhibits (safe, arm, fire) to preclude inadvertent firing of the NDSB1 pyrotechnics in accordance with JSC 62809 Section 8.2 and 8.3.

#### 7.1.5.2.7 Host Vehicle Pyrotechnic Inhibits Monitoring

The HV shall monitor in near real time at least two of the three inhibits used to prevent inadvertent firing of each NDSB1 NSI.

Note: Monitoring of inhibits is required per ISS program safety requirements to prevent the inadvertent operation of a function that could result in a catastrophic hazard (ref. SSP 50021 sections 3.3.6.1.5.1c and 3.3.6.2.3). This requirement is in addition to the fault tolerance requirements levied as part of JSC 62809 sections 8.2 and 8.3.

#### 7.1.5.2.8 Host Vehicle Pyrotechnic Firing Circuit Electrical Harness Design

The HV shall design electrical harnesses connected to the NDSB1 pyrotechnic system in accordance with JSC 62809 sections 8.4.7 through 8.4.10.

#### 7.1.5.2.9 Pyrotechnic Firing Circuit Wiring Checkout

The HV shall install and checkout pyrotechnic wiring harnesses connected to NDSB1 in accordance with JSC 62809 sections 7.3 through 7.3.4 and section 8.5.

#### 7.1.5.2.10 Pyrotechnic Firing Circuit EMC

The HV shall ensure the electromagnetic compatibility of the NDSB1 pyrotechnic system when integrated with the HV's firing circuitry in accordance with JSC 62809 sections 8.4.2 through 8.4.5.

#### 7.1.5.2.11 Host Vehicle IVA Interface Safety

The HV shall ensure that NDSB1 IVA-accessible surfaces are within the safe temperature range (+113°F to +39°F) for crew translation through the docking tunnel or provide the crew with appropriate personal protective equipment to protect them from hot or cold surfaces.

#### 7.1.5.3 Undocking Operations Safety

#### 7.1.5.3.1 HV Response to Undocking Complete Indication

The HV shall not initiate vehicle thrusters until at least two "Undocking Complete" indications are provided.

Note: The two means may include either indications from NDSB1 or one indication from NDSB1 and another from a separate means (e.g. crew visual, GN&C sensor etc.).

#### 7.1.5.3.2 Independent Pyrotechnic Controller Operation

The HV shall provide command / power to the NDSB1 pyrotechnic system that are independent from those used to command / power NDSB1 System A and System B avionics.

Note: This requirement ensures that the pyrotechnic hook release function is operable following two power bus or avionics failures within the HV

#### 7.1.5.3.3 Vestibule Depressurization and Repressurization Redundancy or Independence

The HV shall provide redundant vestibule depressurization capability or provide independent vestibule depressurization and repressurization capability.

### 7.1.5.4 Return Operations Safety

#### 7.1.5.4.1 Host Vehicle Response to Failure to Secure SCS

The HV shall provide a safe reentry configuration if the NDSB1 fails to stow and secure the NDSB1 soft capture system.

#### 7.1.5.4.2 NDSB1 Jettison Responsibilities

The HV shall provide for a partial or complete jettisoning of the NDSB1 from the HV.

Note: Complete (HCS, SCS and avionics) or partial (HCS and SCS) jettisoning may be implemented at the HV discretion.

# APPENDIX A – ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| # | Number |
| % | Percent |
| AI | Action Item |
| AMP | Ampere(s) |
| ANSI | American National Standards Institute |
| ASI | Agenzia Spaziale Italiana |
| AWG | American Wire Gauge |
| BC | Bus Controller |
| Btu | British Thermal Units |
| °C | Degrees Centigrade |
| CAD | Computer Aided Design |
| C&DH | Command and Data Handling |
| CCP | Commercial Crew Program |
| CCW | Counterclockwise |
| CDR | Critical Design Review |
| CFM | Cubic Feet per Minute |
| C.G. | Center of Gravity |
| CRC | Cyclic Redundancy Check |
| CW | Clockwise |
| dB | decibel(s) |
| Deg | Degrees |
| deg/sec | Degrees per Second |
| DIA | Diameter |
| DSC | Docking System Controller |
| DSE | Docking System Emulator |

| | |
|---|---|
| EAR | Export Administration Regulations or EIPS Adapter Ring |
| ECLSS | Environmental Control and Life Support System |
| ED | Engineering Drawing |
| EEE | Electromagnetic Environmental Effects |
| e.g. | for example |
| EIA | Electronic Industry Association |
| EIPS | Energia IDA Primary Structure |
| EMA | Electromechanical Actuator |
| EMC | Electromagnetic Compatibility |
| EPCE | Electrical Power Consuming Equipment |
| ESH | Equivalent Sun Hours |
| | |
| °F | Degrees Fahrenheit |
| FC | Flight Computer |
| FDIR | Fault Detection, Isolation, and Recovery |
| FOD | Foreign Object Debris |
| FRAM | Flight Releasable Attachment Mechanism |
| ft/sec | Feet per Second |
| $ft^2$ | Square Feet |
| $ft^3$ | Cubic Feet |
| | |
| G | Acceleration due to Gravity |
| GHz | Gigahertz |
| GN&C | Guidance, Navigation, and Control |
| Grms | Gravity, Root Mean Square |
| | |
| H&S | Health and Status |
| HCS | Hard Capture System |
| hPa | hectoPascal(s) |
| hr | hour(s) |
| HV | Host Vehicle |
| HVTE | Host Vehicle Test Equipment |
| Hz | Hertz |

| | |
|---|---|
| I/F | Interface |
| ICD | Interface Control Document |
| ICP | IDA Control Panel |
| ID | Internal Diameter or Identification |
| IDA | International Docking Adapter |
| IDD | Interface Definition Document |
| IDSS | International Docking System Standard |
| I/F | Interface |
| iLIDS | International Low Impact Docking System |
| in. | Inch(es) |
| ISS | International Space Station |
| ITAR | International Traffic in Arms Regulations |
| IVA | Intravehicular Activity |
| | |
| JSC | Johnson Space Center |
| | |
| °K | Degrees Kelvin |
| kg | Kilogram(s) |
| kg-mm$^2$ | Kilograms per square millimeter |
| kgf | Kilograms Force |
| kHz | Kilohertz |
| kJ | Kilojoules |
| KOZ | Keep Out Zone |
| kPa | Kilo Pascal(s) |
| kW | Kilowatts |
| | |
| L&D | Loads and dynamics |
| lb | Pound(s) |
| lb-in$^2$ | pounds per square inch |
| lbf | Pound Force |
| lbm | Pound Mass |
| LAC | Linear Actuator Controller |

| | |
|---|---|
| LEO | Low Earth Orbit |
| LRU | Line Replaceable Unit |
| LVLH | Local Vertical/Local Horizontal |
| | |
| M | Meter(s) |
| $M^2$ | square meters |
| m3 | cubic millimeters |
| MAPAS | Modified Androgynous Peripheral Attachment System |
| Max | Maximum |
| Mbits | Megabits |
| MHz | MegaHertz |
| Min | minimum or minute |
| m/s | Meters per Second |
| MLI | Multi-Layer Insulation |
| mm | Millimeter(s) |
| MMOD | Micro Meteoroid Orbital Debris |
| MOI | Moments of Inertia |
| MPA | Minimum Propellant Altitude |
| MPE | Maximum Performance Environment |
| ms | Millisecond(s) |
| | |
| N | Newton(s) |
| N/A | Not Applicable |
| NASA | National Aeronautics and Space Administration |
| NCR | Non-compliance Conformance Report |
| NDS | NASA Docking System |
| NDSB1 | NASA Docking System Block One |
| NDSP | NASA Docking System Project |
| nm | Nautical Miles |
| NSI | NASA Standard Initiator |
| | |
| OD | Outer Diameter |
| ODS | Orbiter Docking System |

| | |
|---|---|
| OLR | Outgoing Longwave Radiation |
| | |
| Pa | Pascal(s) |
| P/N | Part Number |
| PDR | Preliminary Design Review |
| PHMA | Passive Hard Mate Assembly |
| PMA | Pressurized Mating Adapter |
| PNP | Probability of No Penetration |
| POI | Products of Inertia |
| PPE | Personal Protective Equipment |
| PRT | Perimeter Reflector Target |
| psi | Pounds per Square Inch |
| psia | Pounds per Square Inch, Absolute |
| | |
| RAESR | Risk Assessment Executive Summary Report |
| REF | Reference |
| Rev. | Revision |
| RF | Radio Frequency |
| RID | Review Item Discrepancy |
| RPODU | Rendezvous, Proximity Operations, Docking, and Undocking |
| RT | Remote Terminal |
| RTD | Resistive Temperature Device |
| RTH | Ready to Hook |
| RX | Receive |
| | |
| SCD | Specification Control Drawing |
| SCS | Soft Capture System |
| sec | Second |
| SI | System International or Solar Inertial |
| SRR | System Requirements Review |
| SRS | Shock Response Spectrum |
| | |
| TBC | To Be Confirmed |

| | |
|---|---|
| TBD | To Be Determined |
| TBR | To Be Resolved |
| TEA | Torque Equilibrium Attitude |
| TIA | Telecommunication Industry Association |
| TLI | Trans-Lunar Insertion |
| TX | Transmit |
| | |
| UART | Universal Asynchronous Receiver/Transmitter |
| U.S. | United States |
| USOS | United States On-orbit Segment |
| | |
| VC | Visibly Clean |
| VDC | Volts Direct Current |
| VRT | Vestibule Reflector Target |
| VV | Visiting Vehicle |
| VVT | Vestibule Visual Target |
| | |
| W | Watt(s) |
| | |
| YPR | Yaw, Pitch, Roll |

# APPENDIX B – DEFINITION OF TERMS

Reserved

# APPENDIX C – NASA DOCKING SYSTEM (NDSB1) COMMAND AND H&S DEFINITIONS

NDSB1_Command_a
nd_H&S_Definitions_:

# APPENDIX D – NASA DOCKING SYSTEM (NDSB1) HEATER MASTER MEASUREMENT LIST (MML)

Reserved

# APPENDIX E – NASA DOCKING SYSTEM (NDSB1) CONFIGURATION DIFFERENCES

Reserved

# APPENDIX F – HOST INTERFACE CONNECTOR PINOUTS

Reserved

# APPENDIX G – FAILURE RESPONSE TABLES

## Automated Vehicle Responses to NDS Failures

The host vehicle is required to perform failure recovery actions in response to various NDS failures. The failure response actions differ depending on the following:

a. The NDS mode/function (i.e. phase of NDS operation)

   For failures that the NDS detects, the appropriate failure indication status is posted in the periodic Health and Status (H&S) message provided to the host vehicle through the selected Host Vehicle interface. For failures that the NDS cannot detect (e.g., loss of H&S message), the vehicle will detect the failures and respond based on the requirements in the Failure Response Tables using the NDS mode and function indicated in the most recently received NDS H&S message.

b. Whether the failure indication was received from the system commanded to Active Docking Mode or Standby Docking Mode.

   The System (A or B) in Active Docking mode controls the soft capture system, capture latches and launch restraints, but the System in Standby Docking mode only participates in hard capture system operations (hooks, separators, and umbilicals), driving the output simultaneously with the active system.

c. Whether a fault “Flag” has been set in the HV software because of a previous NDS failure that occurred and resulted in either of the following:

   1. a switch of the “Standby Docking” System to become the “Active Docking” system
   2. a failure in the “Standby Docking” System that would prevent it from serving as the “Active Docking” System in the event the current “Active Docking” System were to subsequently fail

The recommended vehicle responses to NDS failures are shown in the tables below. The responses are required to be automated and must comply with the FDIR timing requirements described in paragraph 7.1.5.1.4 of this document.

The failure responses shown are used in the NDS safety analyses; there are, however, multiple alternative ways the vehicle could choose to respond to the various failure scenarios. It is, ultimately, up to the HV to decide how to operate the NDS safely while maximizing the likelihood of mission success.

How to use these tables:

The tables below specify the actions to be taken in response to failure conditions. The types of failure conditions are listed in the row headings on the left (e.g., Switch, Sys Fail, Cap F Pos). The phases/functions in which those conditions could occur are listed in the column headings across the top (REL, EXT, RTC, LNG etc.). At the intersection of a column and a row are the actions the vehicle should take in that particular phase and for that particular reported failure condition. The meanings of the row headings, column headings, and letters/symbols in the tables are decoded in the “Keys” that follow.

## Failure Response Tables:

### First Failure (i.e., no fault "Flags" set yet):

| | Functions: | REL | EXT | RTC | LNG | HOL[7] | ATT | ALI | RET | G1 | STO | LCK | G2 | CHA | MAT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Active | Switch | F | HXF | HXF | HXF | HF | $A_T$F | $A_L$F | RF | RF | - | - | - | - | - |
| Active | Sys Fail | ↓F | ↓HXF | ↓HXF | ↓HXF | ↓HF | ↓$A_T$F | ↓$A_L$F | ↓RF | ↓RF | ↓ | ↓ | ↓ | ↓ | ↓ |
| Active | Cap Miss [6] | - | - | - | X | - | - | - | - | - | - | - | - | - | - |
| Standby | Functions: | WG1 | | | | | | | | G1 | WG2 | | G2 | CHA | MAT |
| Standby | Switch | F | | | | | | | | F | - | | - | - | - |
| Standby | Sys Fail | ↓F | | | | | | | | ↓F | ↓ | | ↓ | ↓ | ↓ |
| Combo | Cap F Pos | - | - | TX | TX | - | - | - | - | - | - | - | - | - | - |
| Combo | Cap Loss | - | - | - | - | - | TX | TX | TX | - | - | - | - | - | - |
| Combo | Cap F Neg | - | - | - | G | - | - | - | - | - | - | - | - | - | - |

### Subsequent Failures (i.e., a fault "Flag" was set from a previous failure):

| | Functions: | REL | EXT | RTC | LNG | HOL[7] | ATT | ALI | RET | G1 | STO | LCK | G2 | CHA | MAT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Active | Switch | - | X | OX | OX | O | OX | OX | OX | - | - | - | - | - | - |
| Active | Sys Fail | ↓ | ↓X | ↓OX | ↓OX | ↓O | ↓OX | ↓OX | ↓OX | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ |
| Active | Cap Miss [6] | - | - | - | X | - | - | - | - | - | - | - | - | - | - |
| Standby | Functions: | WG1 | | | | | | | | G1 | WG2 | | G2 | CHA | MAT |
| Standby | Switch | - | | | | | | | | - | - | | - | - | - |
| Standby | Sys Fail | ↓ | | | | | | | | ↓ | ↓ | | ↓ | ↓ | ↓ |
| Combo | Cap F Pos | - | - | TX | TX | - | - | - | - | - | - | - | - | - | - |
| Combo | Cap Loss | - | - | - | - | - | TX | TX | TX | - | - | - | - | - | - |
| Combo | Cap F Neg | - | - | - | G | - | - | - | - | - | - | - | - | - | - |

## Key 1:

| Modes: | Name | PUI | Value if Failed |
|---|---|---|---|
| Active | Active Docking Mode Status | NDS1DSYS_001 | 4 |
| Standby | Standby Docking Mode Status | NDS1DSYS_003 | 4 |
| Combo | Capture 1 Detected<br>Capture 2 Detected<br>Capture 3 Detected | NDS1DSCS_045<br>NDS1DSCS_046<br>NDS1DSCS_047 | N/A |

## Key 2[9]:

| Functions: | Name | PUI | Value if Failed |
|---|---|---|---|
| REL | Launch Restraint 1 Released Status | NDS1DHCS_067 | 3 |
| | Launch Restraint 2 Released Status | NDS1DHCS_068 | 3 |
| | Launch Restraint 3 Released Status | NDS1DHCS_069 | 3 |
| EXT | LAC Extend for Rdy for Capture Status | NDS1LSCS_027 | 3 |
| RTC | LAC Ready for Capture Status | NDS1LSCS_028 | 3 |
| LNG | LAC Lunge Status | NDS1LSCS_029 | 3 |
| HOL[7] | Hold and Release Status | NDS1DSCS_042 | 3 |
| ATT | LAC Attenuate Status | NDS1LSCS_030 | 3 |
| ALI | LAC Align Status | NDS1LSCS_031 | 3 |
| RET | LAC Retract Status | NDS1LSCS_032 | 3 |
| G1 | Hook Gang 1 Closed Status | NDS1DHCS_013 | 3 |
| ST0 | Capture Latch 1 RTR Status | NDS1DSCS_005 | 3 |
| | Capture Latch 2 RTR Status | NDS1DSCS_006 | 3 |
| | Capture Latch 3 RTR Status | NDS1DSCS_007 | 3 |
| | LAC Stow Status | NDS1LSCS_033 | 3 |
| LCK | Launch Restraint 1 Restrained Status | NDS1DHCS_064 | 3 |
| | Launch Restraint 2 Restrained Status | NDS1DHCS_065 | 3 |
| | Launch Restraint 3 Restrained Status | NDS1DHCS_066 | 3 |
| G2 | Hook Gang 2 Closed Status | NDS1DHCS_014 | 3 |
| CHA | Separator 1 Charge Status | NDS1DHCS_053 | 3 |
| | Separator 2 Charge Status | NDS1DHCS_054 | 3 |
| | Separator 3 Charge Status | NDS1DHCS_055 | 3 |
| MAT | Umbilical 1 Extend Status | NDS1DHCS_017 | 3 |
| | Umbilical 2 Extend Status | NDS1DHCS_018 | 3 |
| WG1 | Wait Gang 1 Status | NDS1DHCS_107 | 3 |
| WG2 | Wait Gang 2 Status | NDS1DHCS_108 | 3 |

**Key 3:**

| | Vehicle Command Response to NDS <u>Active</u> System (*if powered on*) | Vehicle Command Response to NDS <u>Standby</u> System | Additional Required Vehicle Response |
|---|---|---|---|
| **F** | none | none | Set “Flag” in vehicle software indicating which NDS System (A or B) experienced the failure such that the appropriate failure response will be taken on a subsequent relevant failure.[4] |
| ↓ | none | none | Remove all power (all control system power and all motor power) from BOTH the DSC & LAC on the failed NDS System (either A or B). |
| **$A_T$** | 1. DSC_MONITOR_MODE (NDS1DCMD_0014)<br>3. DSC_STANDBY_DOCKING_MODE (NDS1DCMD_0038) Parameter 1 = 1 (Enable)<br>4. DSC_STANDBY_DOCKING_MODE (NDS1DCMD_0038) Parameter 1 = 2 (Execute) | 2. DSC_ACTIVE_DOCKING_MODE (NDS1DCMD_0002) Parameter 1 = 4 (Execute_at_Attenuate) | none |
| **$A_L$** | 1. DSC_MONITOR_MODE (NDS1DCMD_0014)<br>3. DSC_STANDBY_DOCKING_MODE (NDS1DCMD_0038) Parameter 1 = 1 (Enable)<br>4. DSC_STANDBY_DOCKING_MODE (NDS1DCMD_0038) Parameter 1 = 2 (Execute) | 2. DSC_ACTIVE_DOCKING_MODE (NDS1DCMD_0002) Parameter 1 = 5 (Execute_at_Align) | none |
| **R** | 1. DSC_MONITOR_MODE (NDS1DCMD_0014)<br>3. DSC_STANDBY_DOCKING_MODE (NDS1DCMD_0038) Parameter 1 = 1 (Enable)<br>4. DSC_STANDBY_DOCKING_MODE (NDS1DCMD_0038) Parameter 1 = 2 (Execute) | 2. DSC_ACTIVE_DOCKING_MODE (NDS1DCMD_0002) Parameter 1 = 6 (Execute_at_Retract) | none |
| **H** | 1. DSC_MONITOR_MODE (NDS1DCMD_0014) | 2. DSC_ACTIVE_DOCKING_MODE (NDS1DCMD_0002) Parameter 1 = 8 (Hold_and_Release) [7] | none |
| **O** | 1. DSC_MONITOR_MODE (NDS1DCMD_0014) | 1. DSC_MONITOR_MODE (NDS1DCMD_0014) | Command contingency capture latch release power to operate all three of the NDS contingency capture latch release mechanisms. |
| **T** | 1. DSC_TERMINATE_DOCKING (NDS1DCMD_0040) [10] | none | none |
| **G** | 1. DSC_ACTIVE_DOCKING_MODE (NDS1DCMD_0002) Parameter 1 = 4 (Execute_at_Attenuate) | none | none |
| **X** | none | none | HV GN&C to perform hold, retreat, or abort maneuvers as appropriate to avoid vehicle-to-vehicle collision |
| **-** | none | none | none |

**Key 4:**

| | NDS Indication in H&S Message | Additional Detection Methods Required to be Implemented by the Vehicle to Detect Condition [8] |
|---|---|---|
| **Switch** | Function Failed[9] (see Key 2) | 1. NDS H&S Message indicates NDS is in the incorrect mode[2] |
| **Sys Fail** | none | 1. Lost/corrupt/repeating NDS H&S Message[1]<br>2. NDS H&S Message fails to indicate receipt, validity, or execution of commands<br>3. Both systems in Active Docking Mode[3]<br>4. Vehicle computer/communication failure to NDS[5] |
| **Cap Miss** | Missed Capture (NDS1DSCS_036) | none |
| **Cap F Pos** | none | *False positive capture sensor indication:*<br>There is a disagreement in two or more of the three capture sensor assemblies between the System A indication and the System B indication. In the absence of one string of data, this detection method is not used.<br>Relevant NDS H&S Message PUIs: Capture 1 Detected (NDS1DSCS_045), Capture 2 Detected (NDS1DSCS_046), Capture 3 Detected (NDS1DSCS_047) |
| **Cap Loss** | none | *Loss of capture:*<br>The capture sensor indications for two or more of the three capture sensor assemblies are FALSE in both the System A and System B NDS H&S messages. In the absence of one string of data, this detection method is based on the remaining string of data only.<br>Relevant NDS H&S Message PUIs: Capture 1 Detected (NDS1DSCS_045), Capture 2 Detected (NDS1DSCS_046), Capture 3 Detected (NDS1DSCS_047) |
| **Cap F Neg** | none | *False negative capture sensor indication:*<br>Five of six NDS capture indications are TRUE between the three from System A and three from System B. In the absence of one string of data, this detection method is not used.<br>Relevant NDS H&S Message PUIs: Capture 1 Detected (NDS1DSCS_045), Capture 2 Detected (NDS1DSCS_046), Capture 3 Detected (NDS1DSCS_047) |

**Notes:**

[1] MIL-STD-1553B Note: The MIL-STD-1553B interface between a host vehicle and an NDS System consists of two separate serial buses or channels (A and B). Each NDS System (A and B) is connected to both serial buses (channels A and B). The host vehicle communicates with an NDS System on either channel A or B (but not both at a time). The loss of communication over a single MIL-STD-1553B channel is not considered a communication failure (because it may be possible for the host vehicle to communicate via the other channel); the loss of communication over both channels is considered a communication failure and the host vehicle responds in accordance with the System Failure responses outlined in these tables.

[2] In the event of a brief power dropout, NDS may recover from the power loss in Monitor Mode instead of the previous operating mode. Because this could occur in less than the time for three communication cycles to pass, it is possible that the failure could go undetected except that NDS would then be in the incorrect operation Mode (e.g., Monitor Mode instead of Active Docking mode). Additionally, some NDS failures result in NDS failing over to Monitor Mode by design, or the vehicle crew could inadvertently send the Execute Monitor Mode command.

[3] NDS will not operate properly with both System A and System B in Active Docking mode simultaneously and this could potentially have hazardous consequences.

[4] The HV is responsible for resetting fault "Flags" between docking attempts. Also, if docking is to be performed on a single string (i.e., with either System B or System A turned off), the

vehicle failure responses should modified to exclude string switching (i.e. the fault flag should be pre-set before the docking attempt). These tables do not specifically address docking with one string failed.

[5] In the event that NDS senses a loss of communication from the HV (e.g., the HV computer responsible for controlling NDS fails off), NDS transitions to Monitor Mode in which all NDS effectors are disabled. In this scenario, the HV's redundant computer must sense the failure of the primary computer and send the appropriate commands to continue NDS operations on the redundant NDS string (A or B).

[6] If NDS experiences a missed capture during Lunge (i.e., time from initial contact until capture expires or an actuator exceeds a maximum length threshold), NDS automatically enters the "Hold and Release" function described in note [7] below, allowing the vehicle to safely retreat from the failed docking attempt.

[7] The "Hold and Release" function is an off-nominal function that NDS enters when safing the system after a fault has been experienced and a docking termination is required. In this function, the NDS soft capture system holds position (with a pre-determined linear actuator slip force limit) and NDS releases the soft capture latches to allow a HV to safely retreat from a terminated docking attempt.

[8] For failure detection methods that occur in the vehicle's computers, the vehicle should consider the appropriate inclusion of persistence counters in the fault detection algorithms employed. For example, for a "Cap F Pos" fault detection algorithm, a persistence count of at least two should be used to protect for a case where the NDS System A and System B Health & Status messages are slightly out of synch with one another. Additionally, it is expected that for a "Sys Fail" detection algorithm (e.g. detecting a lost/corrupt/repeating NDS H&S message), the vehicle will implement a persistence count of three to allow for intermittent communication errors. Conversely, for distinct failures reported by NDS in the H&S message (e.g. "Switch"), the vehicle is expected to perform the failure response actions after the first instance.

[9] Each NDS function has a unique status in the NDS H&S message. The possible status for a function may be one of the following: "NOT_ACTIVE", "ACTIVE", "COMPLETED", or "FAILED". Through this status, the HV can determine the NDS phase of operation as well as whether a failure has occurred in that function. Key 2, above, lists the applicable NDS functions for both Active Docking and Standby Docking modes. Key 2 also includes the unique identifier for each function's status in the NDS H&S message as well as what the value of that status will be if the function has failed. Note that for a function that has more than one associated Program Unique Identifier (PUI) (e.g. the "REL" function), the vehicle response action is to be taken when <u>any one</u> of the listed PUI's status is "FAILED".

[10] The "Terminate Docking" command is used by the HV to stop the docking process. During the soft capture phases of docking, the HV can send this command to the system in Active Docking Mode to cause NDS to transition to the "Hold and Release" function described in note [7] above. During the hard capture phases of docking (any time after gang 1 hooks begin to close), if the HV sends the command to an NDS system, NDS will transition to Monitor Mode where effectors are disabled.

# APPENDIX H – NDSB1 REMOTE ELECTRICAL BOX MOUNTING IMPEDANCE LIMITS

Reserved

## APPENDIX I – ERRATA AND TO BE DETERMINED/TO BE REVIEWED LIST

This document is intended to define all functional interfaces and their locations. However, the document is being released in parallel with the maturing interface definition. As such, there are several To Be Determined (TBD) and To Be Reviewed (TBR) values. These have been uniquely identified in Table I-1: TBD Identification and Table I-2, TBR Identification for closure tracking and update in future releases. Several NDSB1 SRR Review Item Discrepancies (RID)'s from NDSB1 System Requirements Review (SRR) are still open that could affect the NDSB1 host requirements in Section 7.0 and the design of the NDSB1 host vehicle (Section 5) and IDA docking interface (Section 4). The IDA design interface will be fully documented and presented at the IDA Critical Design Review (CDR) on August 28$^{th}$. The NDSB1 design interfaces will be documented and presented at the NDSB1 Preliminary Design Review (PDR) on Sept 19$^{th}$. Following IDA CDR/NDSB1 PDR and on-going work for TBX closeout, this document will be finalized and released by 10/31/2013.

## TABLE I-1: TBD IDENTIFICATION

| TBD # | Section, Figure, or Table # | Section, Figure, or Table Title | Issue | Status |
|---|---|---|---|---|
| 1 | P1.1 | Purpose and Scope | Need PTRS JSC doc # | Closed |
| 2 | F4.1.1-1 | NDSB1 Envelope | Note 4 is unknown | Closed |
| 3 | T4.1.3.1.1-1 | NDSB1 to IDA Power Pin Assignments | Need assignments | Closed |
| 4 | T4.1.3.1.1-1 | NDSB1 to IDA Power Pin Assignments | Need Connector P/N for J23A | Closed |
| 5 | T4.1.3.1.1-1 | NDSB1 to IDA Power Pin Assignments | Need Connector P/N J23B | Closed |
| 6 | F4.2.1.3-5 | HCS SEPARATOR DETAIL | Need update per Tomas | Closed |
| 7 | P4.2.1.7 | GN&C Aids | Need Appendix for approach/targets | Closed |
| 8 | P4.2.1.7 | GN&C Aids | Need Appendix for approach/targets | Closed |
| 9 | P4.2.3.6 | Duct Details | Need interface details | Closed |
| 10 | P5.2.1.2 | NDS Installation and MMOD Shield Mounting Interfaces | Need installation drawing # | Closed |
| 11 | F5.2.1.5-1 | DSC Box Interfaces | Need hole info, bonding, fastener, etc | Closed |
| 12 | F5.2.1.5-2 | LAC Interfaces | Need hole info, bonding, fastener, etc | Closed |
| 13 | T5.2.1.5-1 | Electrical Box Mass Properties | Need Mass Properties | Open |
| 14 | T5.2.1.5-2 | Impedance Requirements | Need values | Closed |
| 15 | T5.3.1-1 | NDSB1 to Host Vehicle Electrical Power Pin Assignments | Need values | Closed |
| 16 | T5.3.1-1 | NDSB1 to Host Vehicle Electrical Power Pin Assignments | Need connector P/N | Closed |
| 17 | T5.3.1-1 | NDSB1 to Host Vehicle Electrical Power Pin Assignments | Need connector P/N | Closed |
| 18 | T5.2.2.1.6-2 | Power Characteristics | Need values | Closed |
| 19 | T5.3.2-1 | Umbilical Data Pin Assignments | Need values | Closed |
| 20 | T5.3.2-1 | Umbilical Data Pin Assignments | Need Connector P/N | Closed |

| | | | | |
|---|---|---|---|---|
| 21 | T5.3.2-1 | Umbilical Data Pin Assignments | Need Connector P/N | Closed |
| 22 | T5.3.2-1 | Umbilical Data Pin Assignments | Need Connector P/N | Closed |
| 23 | T5.3.2-1 | Umbilical Data Pin Assignments | Need Connector P/N | Closed |
| 24 | P5.3.3 | Yet named | Need Pyro Pin Assignments | Closed |
| 25 | T5.3.4-1 | HV to NDSB1 Power Pin Assignments | Need values | Closed |
| 26 | T5.3.5.1-1 | TIA-422B Pin Assignments | Need values | Closed |
| 27 | P5.3.6 | Heater Power and Control | need write up | Closed |
| 28 | T5.4.2-2 | Host Vehicle-to-NDSB1 Command Packet Parameters | Need command ID Table # | Closed |
| 29 | T5.4.2-2 | Host Vehicle-to-NDSB1 Command Packet Parameters | Need Payload Table # | Closed |
| 30 | T5.4.2-4 | NDSB1-to-Host Vehicle H&S Packet Parameters | Need Table # | Closed |
| 31 | T5.4.2-4 | NDSB1-to-Host Vehicle H&S Packet Parameters | Need Table # | Closed |
| 32 | T5.4.2-4 | NDSB1-to-Host Vehicle H&S Packet Parameters | Need Table # | Closed |
| 33 | F5.5-1 | NDSB1 to-Host Vehicle Electrical Interface | Need figure | Closed |
| 34 | F5.5-2 | NDSB1 Box Connections-to-Host Vehicle Electrical Interface | Need figure | Closed |
| 35 | F5.5-3 | NDS Tunnel Connections-to-Host VB1ehicle Electrical Interface | Need figure | Closed |
| 36 | F5.5-4 | NDSB1 to-Host Vehicle Electrical Interfaces | Need figure | Closed |
| 37 | F5.5-5 | NDSB1-to-Host Vehicle Electrical Interfaces | Need figure | Closed |
| 38 | T5.5-1 | NDSB1 Connections-to-Host Vehicle | Need lengths | Closed |
| 39 | P6.1.5 | Pressure Seal Interface, Test Ports | confirm pressure test ports | Closed |
| 40 | P6.1.7 | Instrument checkout | provide information on Docking System Emulator (DSE) | Closed |

| | | | | |
|---|---|---|---|---|
| 41 | P6.2 | Electrical Interfaces for Command and Data Handling | This paragraph was deleted | Closed |
| 42 | P7.1.1.2.2.2 | Host Vehicle Thru Bolt Mounting | Need bolt defined | Closed |
| 43 | P7.1.1.2.2.2 | Host Vehicle Thru Bolt Mounting | Need nut defined | Closed |
| 44 | P7.1.1.2.2.2 | Host Vehicle Thru Bolt Mounting | Need figure | Closed |
| 45 | P7.1.1.2.2.3.2 | Flange Stiffness | Need gap defined | Closed |
| 46 | P7.1.1.2.3.4 | Host Vehicle MMOD Temperature | Need temperature defined | Closed |
| 47 | P7.1.1.2.3.4 | Host Vehicle MMOD Temperature | Need temperature defined | Closed |
| 48 | P7.1.2.5.1.3 | Simultaneous Firing | Need time defined<br>Deleted the need for timing information | Closed |
| 49 | Appendix G | Failure Response Tables | Need variable defined | Closed |
| 50 | Appendix G | Failure Response Tables | Mode States | Closed |
| 51 | Appendix G | Failure Response Tables | Vehicle response | Closed |
| 52 | Appendix G | Failure Response Tables | Vehicle response | Closed |
| 53 | Appendix G | Failure Response Tables | switch | Closed |
| 54 | Appendix G | Failure Response Tables | Sys fail | Closed |
| 55 | Appendix G | Failure Response Tables | Cap fail | Closed |
| 56 | Appendix K 3.8 | Power Quality | Reverse current Amp-sec | Closed |
| 57 | Appendix K 3.8 | Power Quality | Reverse current | Closed |
| 58 | F4.2.1-1 | IDA Docking Interface | Need figure | Closed |
| 59 | F5.2.1.4-1 | NDS Vestibule Closeout Cover | Need figure | Closed |
| 60 | F4.1.1.3.4-1 | HCS Hook Configurations | Need figure | Closed |
| 61 | F5.2.1.5-4 | Avionics Box Mounting locations | Need figure | Closed |
| 62 | F5.2.1.2-2 | HCS MMOD Protection | Need figure | Closed |
| 63 | F5.2.1.5.6-1 | LAC Jettison Shock response MPE | need Figure for LAC Jettison Shock graph | Closed |
| 64 | T5.2.1.5.6-1 | LAC Jettison Shock response MPE | need table for LAC Jettison Shock values | Closed |
| 65 | T5.5-2 | J200 A/B Pin Assignments | | Open |

| | | | | |
|---|---|---|---|---|
| 66 | T5.5-2 | J600 A/B Pin Assignments | | Open |
| | | | | |

**TABLE I-2: TBR IDENTIFICATION**

| TBR # | Section, Figure, or Table # | Section, Figure, or Table Title | Issue | Status |
|---|---|---|---|---|
| 1 | T3.2-1 | Mass Properties | Need values confirmed | Closed |
| 2 | T3.2-2 | Mass Properties for IDA | Need values confirmed | Closed |
| 3 | P3.3 | Volume Properties | NDSB1 vestibule volume | Closed |
| 4 | P3.4 | Mating Plane Definition | diameter | Closed |
| 5 | T3.8.1.1-1 | NDSB1 Initial Contact Conditions "Design To" Limits | Need values confirmed | Closed |
| 6 | T4.1.1.4-1 | NDSB1 I/F Component Materials | Need values confirmed | Closed |
| 7 | T4.1.1.5.2-1 | HCS Maximum Mated Loads | Need values confirmed | Closed |
| 8 | P5.2.2.1 | NDSB1-to-Host Vehicle | electrical box heat Heat dissipation | Closed |
| 9 | F5.2.1.5-3 | NDSB1-Cabling | need confirm figure | Closed |
| 10 | P5.4.1.1.2 | Host Vehicle Command Rates | Need values confirmed | Closed |
| 11 | P5.4.1.3 | NDSB1 FDIR | writeup | Closed |
| 12 | P5.4.1.3 | NDSB1 FDIR | time | Closed |
| 13 | P6.0 | NDSB1-TO- SUPPORT EQUIPMENT INTERFACE | confirm the support equipment that is provided to HV providers | Open |
| 14 | P7.1.2.4.1.3.2 | Host Vehicle Command Rates | speed | Closed |
| 15 | T7.1.4.1.1.1-1 | ON-ORBIT MATED LOAD SETS | Need values confirmed | Closed |
| 16 | P7.1.4.6 | Ultraviolet Radiation Protection | Time | Closed |
| 17 | Appendix C | NASA Docking System (NDSB1) Command Data Dictionary | Need values confirmed | Closed |
| 18 | Appendix D | NASA Docking System (NDSB1) Heater Master Measurement List (MML) | is this still needed | Closed |
| 19 | P4.1.1.1.2.2 | Soft capture mating interfaces | verify soft capture assembly temps | Closed |
| 20 | T4.2.1.4-1 | IDA I/F component Materials | confirm correct table | Closed |

| TBR # | Section, Figure, or Table # | Section, Figure, or Table Title | Issue | Status |
|---|---|---|---|---|
| 21 | F5.2.1.2-1 | MMOD i/f | | Closed |
| 22 | T5.3.5.3.2-1 | 1553 RT Jumper Selection Definition | | Closed |
| 23 | F7.1.3.2.1-1 | NDSB1 Power System | | Closed |
| 24 | T7.1.3.2.3.1-1 | SYSTEM A PRIMARY POWER UTILIZATION FOR DOCKING | | Closed |
| 25 | P7.1.3.2.3.5 | Monitor Mode Power | | Closed |
| 26 | T4.2.1.5.1-1<br><br>T4.2.1.5.1-2 | SCS MAXIMUM DOCKING LOADS<br>SCS MAXIMUM COMPONENT LOADS | | Closed |
| 27 | Table 5.4.2-1: | Host Vehicle-To-NDSB1 Command Packet | to be confirmed | Closed |
| 28 | 3.8.3 | NDSB1 Separation limitations | Wes' comments | Closed |
| 29 | T3.8.1.1-1 | SCS ring positioning accuracy | | Closed |
| 30 | 7.1.1.2.2.3.3 | Uniform flange stiffness | | Open |
| 31 | 7.1.5.1.11 | 600 milliseconds | | Open |
| 32 | F5.2.1-5 | DSC Box Interfaces | Bolt holes, connector locations | Open |
| 33 | F5.2.2.5-3 | LAC Interfaces | Bolt holes, connector locations, and ground strap location | Open |
| 34 | F4.1.1.3.7-1 | Single Separator Force Separation Curve | RCR 29 for force separation | Open |
| 35 | F4.2.1.3.7-1 | Single Separator Force Separation Curve | Force Separation change | Open |

**TABLE I-3: TBC IDENTIFICATION**

| Item TBC # | Section, Figure, or Table # | Section, Figure, or Table Title | Issue | Status |
|---|---|---|---|---|
| | | | | |
| 1 | T5.2.2.1.6-1 | NDSB1 Remote-Mounted Electrical Boxes Power Dissipation | | Closed |

# APPENDIX J - INTERFACE DEFINITION DOCUMENT (IDD) CHANGE RECORD FOR REVISION G

Reserved.

# APPENDIX K - ELECTRICAL POWER QUALITY REQUIREMENTS

## K.1.0 Electrical Power

The following sections are the power quality and compatibility requirements for the host vehicle/NDSB1 interfaces, which is defined at the input of the DSC and LAC hardware. The requirements are based on the NDSB1 architecture as defined in Figure K.1.0-1

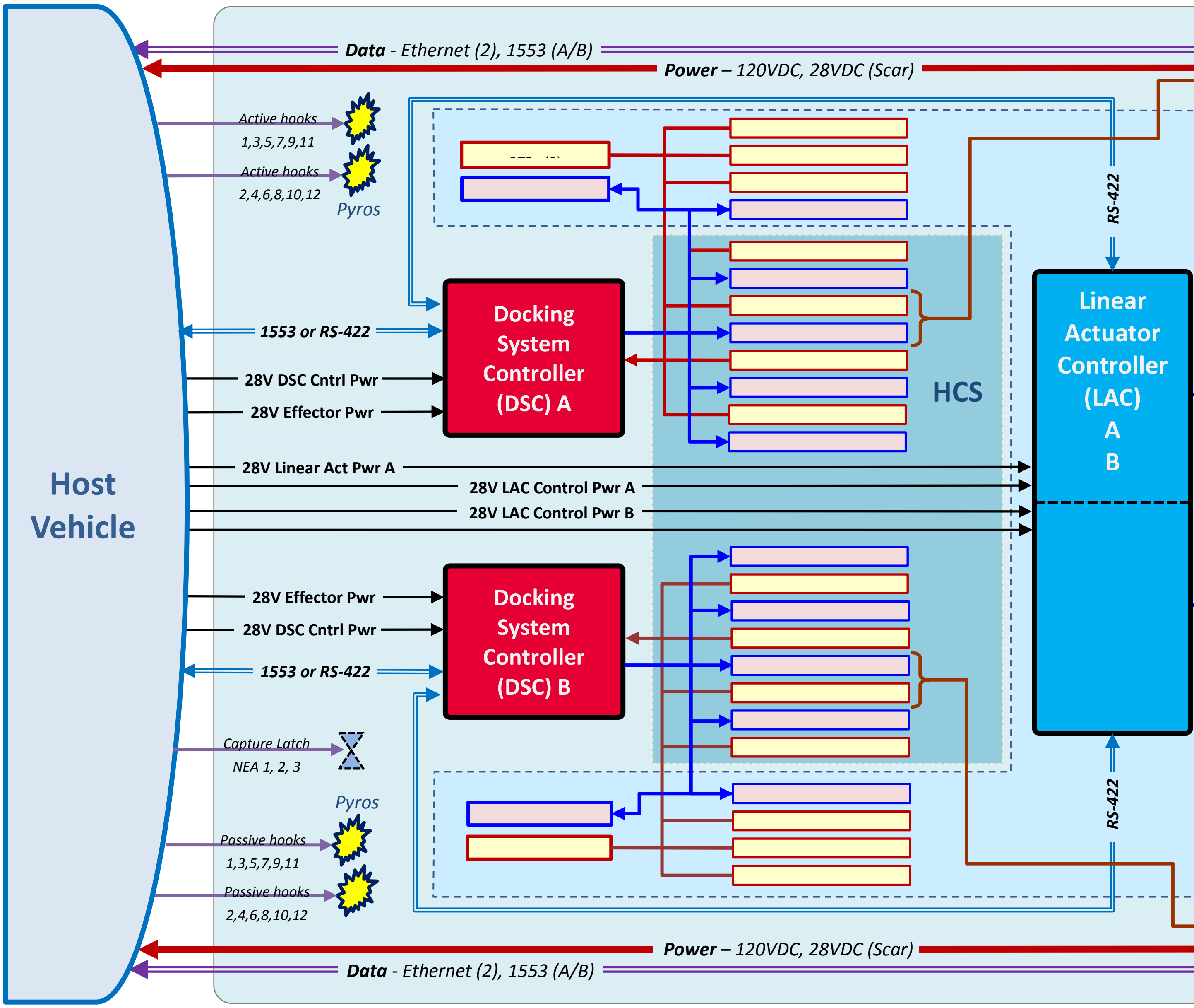



FIGURE K1.0-1:NDS-TO-HOST VEHICLE ELECTRICAL INTERFACE

The host vehicles shall provide eleven power feeds to the NDSB1 avionics, four per system A and B, and three for NEAs, as defined in Table K1.0-1 NDSB1 POWER INPUT FEEDS. System A and B power feeds are redundant and will meet the same requirements therefore only one set of feeds will be defined in the following sections.

Note: System A and B should be fed by different power feeds originating from different/ redundant power sources.

**TABLE K1.0-1 NDSB1 POWER INPUT FEEDS**

| Power Feed | System A Output Rating (Amps) | System B Output Rating (Amps) | NEA Output Rating (Amps) |
|---|---|---|---|
| DSC Input Power | 2 | 2 | NA |
| DSC HCM Input Power | 20 | 20 | NA |
| LAC Input Power | 2 | 2 | NA |
| Linear Actuator Input Power | 30 | 30 | NA |
| NEA (Qty 3) | NA | NA | 5 |

### K.2.0 Source Requirements

The host vehicle shall provide power to the NDSB1 avionics with the following characteristics.

### K.2.1 Source Impedance

The magnitude of the Host Vehicle (HV) source impedance shall be below the source magnitude limits and within the phase limits, from 200Hz to 20 KHz, as defined in Figures K2.1-1, K2.1-2, K2.1-3 and K2.1-4.

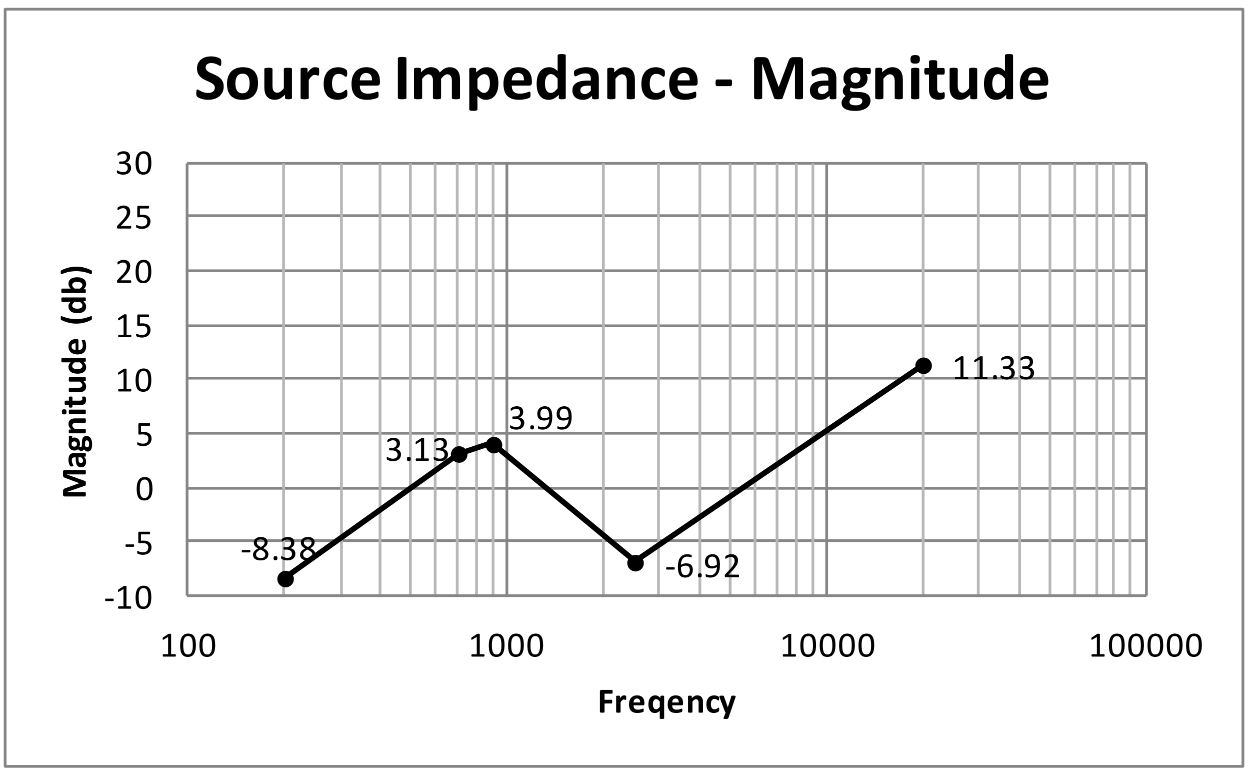



**FIGURE K2.1-1 SOURCE IMPEDANCE MAGNITUDE LIMITS – 2 AMPS**

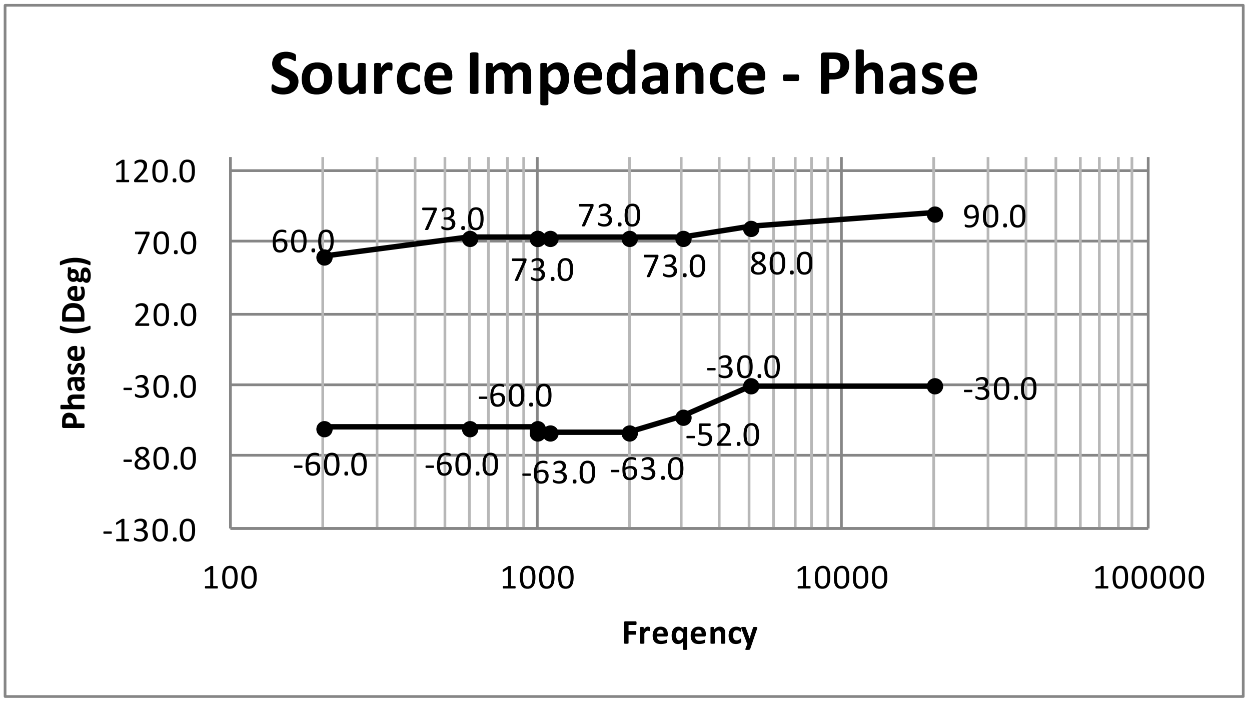



FIGURE K2.1-2 SOURCE IMPEDANCE PHASE LIMITS – 2 AMPS

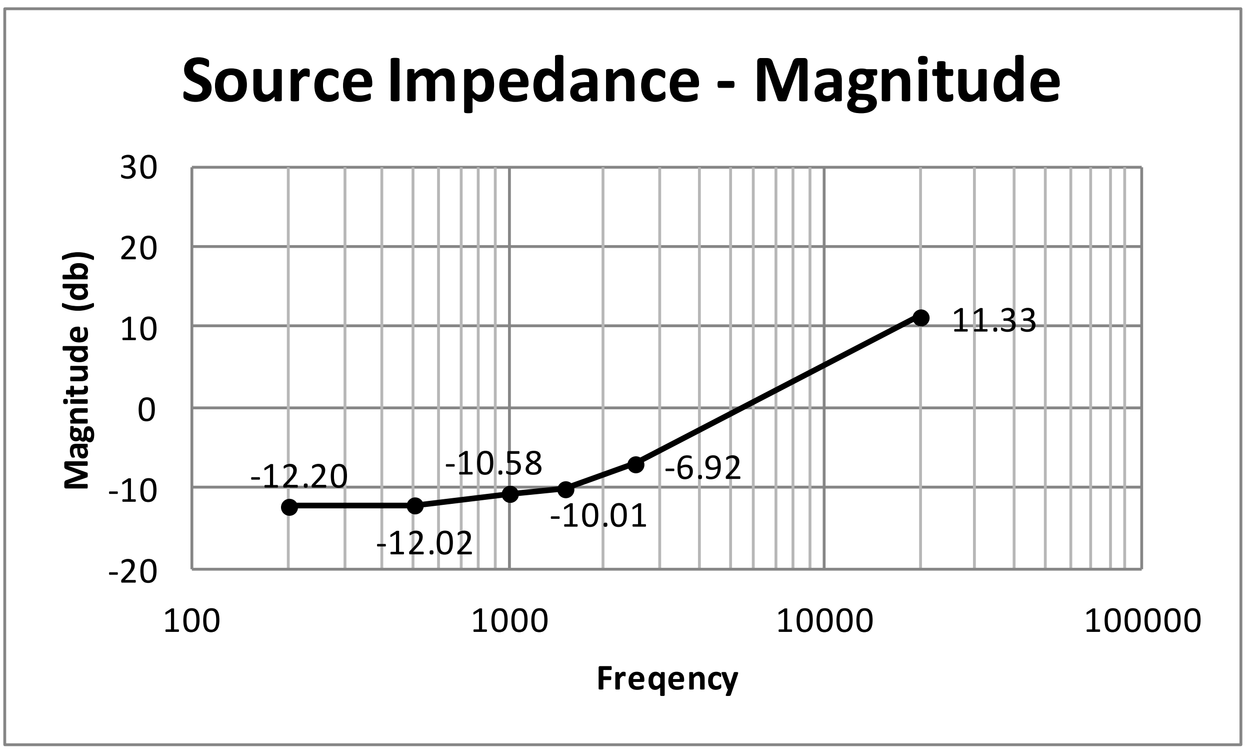



FIGURE K2.1-3 SOURCE IMPEDANCE MAGNITUDE LIMITS – 20 & 30 AMPS

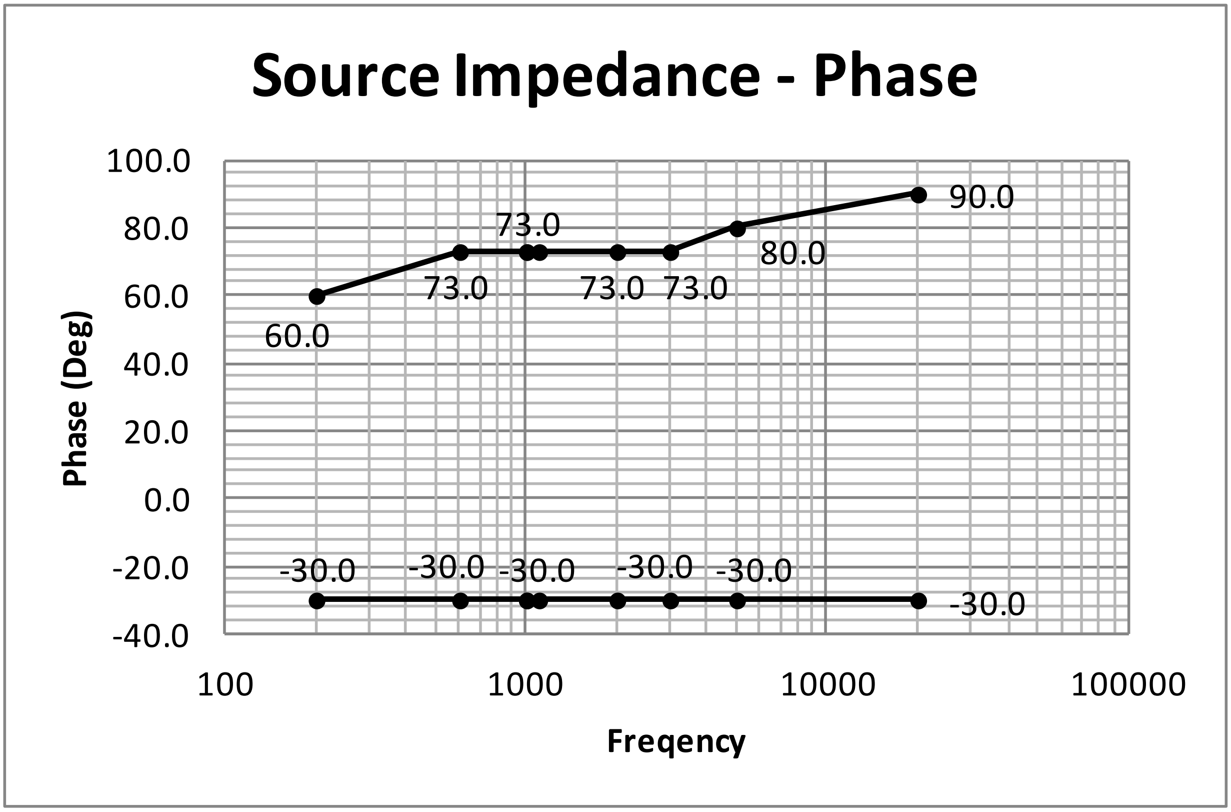



**FIGURE K2.1-4 SOURCE IMPEDANCE PHASE LIMITS – 20 & 30 AMPS**

### K.2.2 Steady State Voltage Range

The HV shall provide power to the HV/NDSB1 interface within the normal operating voltage range of 24 VDC and 36 VDC.

### K.2.3 Ripple Voltage and Noise

#### K2.3.1 Peak Ripple Voltage

The HV 28VDC electrical power feeds shall have a peak ripple voltage no greater than 1.5 volts Peak-to-Peak with a measurement bandwidth of 20MHz.

**K2.3.2 Ripple Voltage Spectrum**

The frequency distribution of the HV ripple voltage shall remain within the limits shown in the Figure K2.3.2-1

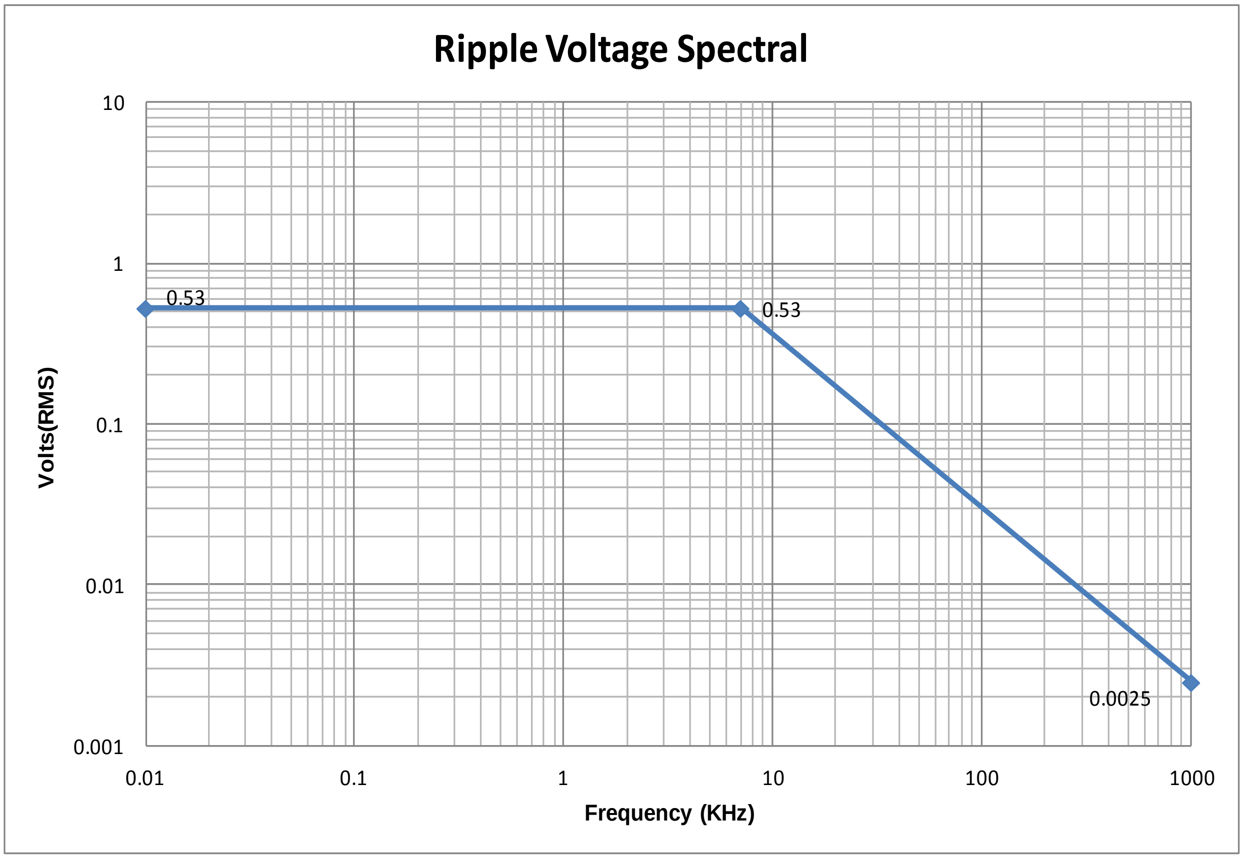



**FIGURE K2.3.2-1-1 RIPPLE VOLTAGE SPECTRUM**

### K.2.4 Normal Transient Voltage Range

The host vehicle transient voltage range shall be within the voltage envelope shown in Figure K2.4-1 Normal Transient Voltage.

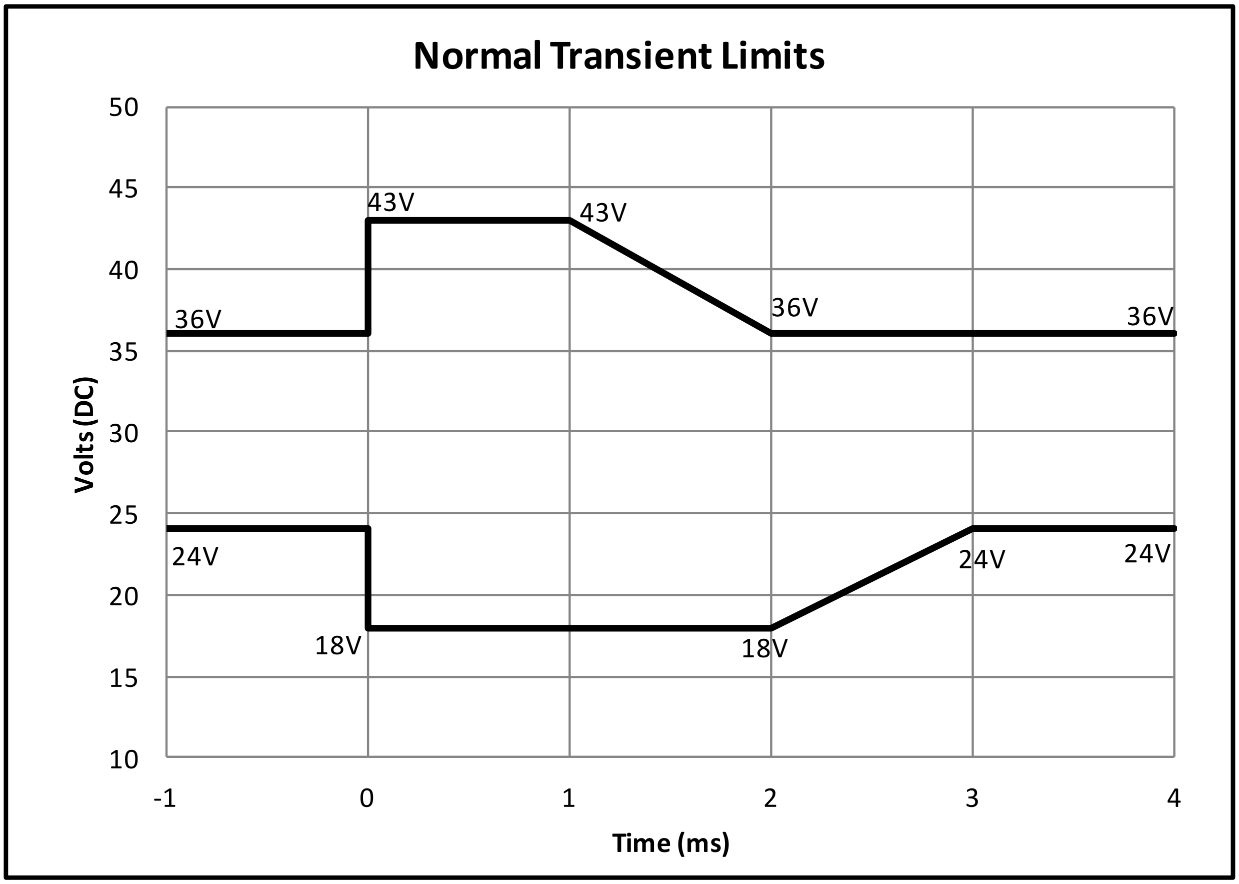



**FIGURE K2.4-1 NORMAL TRANSIENT VOLTAGE**

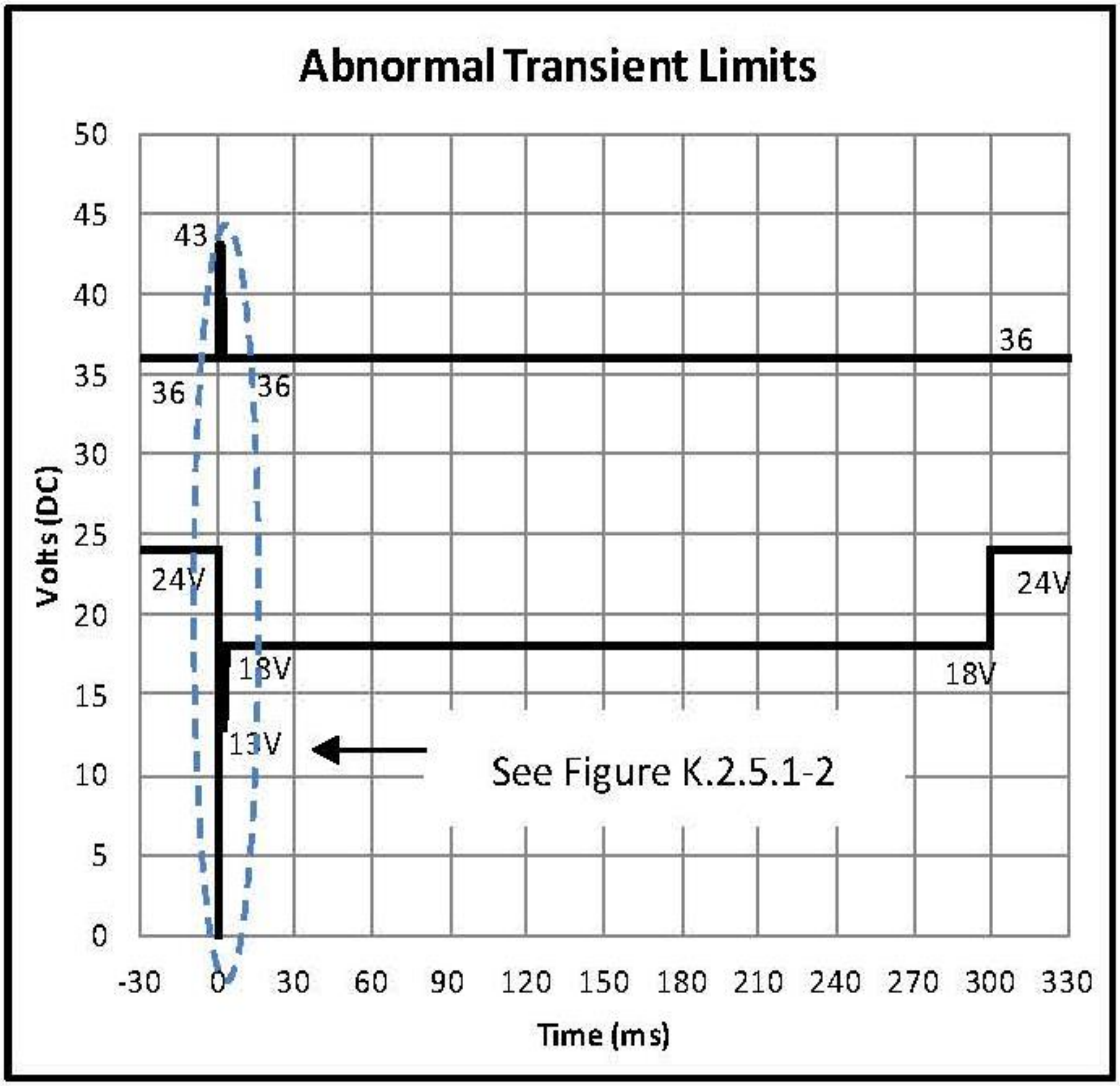
Note: The NDSB1 hardware will provide nominal performance with input voltage excursions as defined in Figure K.2.4-1.

### K.2.5 Abnormal Transient Voltage Range

The abnormal transient voltages are generated during faults in bus lines or loads or due to system overload conditions.

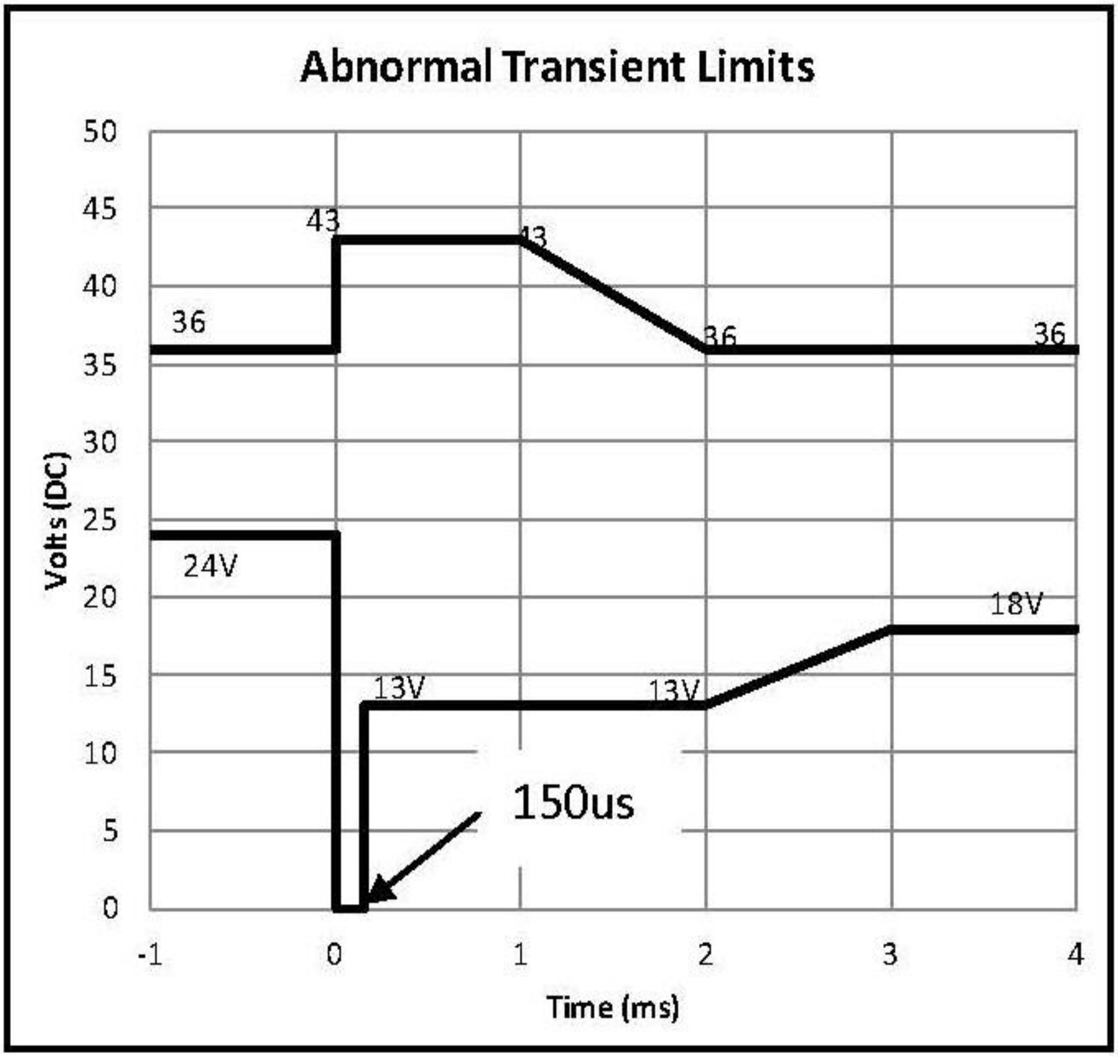
### K.2.5.1 NDSB1 Voltage Dropout

The HV shall generate voltage transients that will not exceed the limits of the envelopes shown in Figure K.2.5.1-1 ABNORMAL TRANSIENT LIMITS and K.2.5.1-2 ABNORMAL TRANSIENT LIMITS DETAILS.




Note: The NDSB1 hardware will provide normal performance, after nominal power is restored, with input voltage excursions as defined.

**FIGURE K.2.5.1-1 ABNORMAL TRANSIENT LIMITS**




Note: The NDSB1 hardware will provide normal performance, after nominal power is restored, with input voltage excursions as defined.

**FIGURE K.2.5.1-2 ABNORMAL TRANSIENT LIMITS DETAILS**

### K.2.5.2 Voltage Dropout Range

Deleted

### K2.6 Electrical Power Switching Characteristics

The HV switch gear shall not trip or current limit at initial power-up, of the NDSB1 avionics, under transient current demands of 7 times the current rating, as specified in Table K.1.0-1, for no greater than 4 milliseconds.

### K.2.7 Reserved

### K.2.8 Regeneration Current

The Host Vehicle shall operate nominally when supplied with regeneration currents, at the NDSB1 interfaces, no greater than 5.1A for 10ms or 0.7A for 1.4s, Figure K.2.8-1, Regeneration Current Limit.

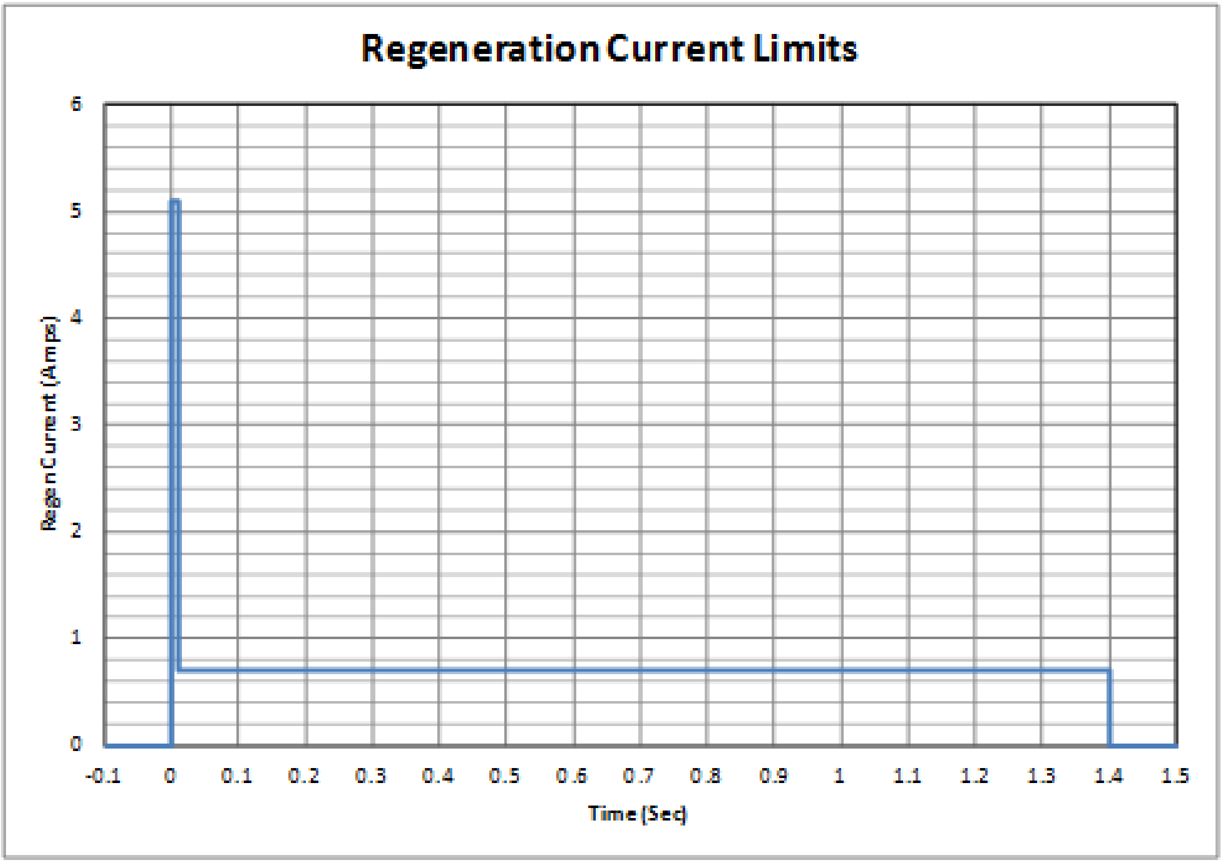



**FIGURE K.2.8-1, REGENERATION CURRENT LIMIT**