JSC 29788

Alpha Magnetic Spectrometer-02 (AMS-02) Master Verification Plan

Engineering Directorate

Verify this is the correct version before use
For correct version go to:
http://ams-02project.jsc.nasa.gov/html/Documents.htm

Basic
February 10, 2009

National Aeronautics and
Space Administration

Lyndon B. Johnson Space Center
Houston, Texas 77058

ALPHA MAGNETIC SPECTROMETER-02 (AMS-02) MASTER VERIFICATION PLAN

Prepared By:

Michael Fohey
AMS Deputy Project Manager, ESCG

Reviewed By:

Phil Mott
AMS Certification & Testing Lead, ESCG

Joe Kastelic
AMS Mechanical Design Lead Engineer, ESCG

Tim Urban
AMS Avionics Lead Engineer, ESCG

Approved By:

Chris Tutt
AMS Project Manager, ESCG

Trent Martin
NASA AMS Project Manager, NASA/JSC/EA

Wade Bostick
NASA AMS Quality Representative, NASA/JSC/NT

PAGE __1__ OF __1___

DOCUMENT CHANGE/REVISION LOG

CHANGE/ REVISION	DATE	DESCRIPTION OF CHANGE	PAGES AFFECTED
Basic	Feb. 2009	Initial release for baseline	All

FOREWARD

This volume of the Alpha Magnetic Spectrometer – 02 contains the AMS-02 Payload and subsystem verification requirements and plans. The requirements are derived directly from:

- JSC 29879, Project Technical Requirements Specification (PTRS) for the Alpha Magnetic Spectrometer-02 (AMS-02) Payload Integration Hardware (PIH);
- SSP 57213, AMS-02 Hardware Interface Control Document (ICD);
- JSC 49978, Phase II Flight Safety Data Package for the AMS-02;

with additional items from:

- JSC 29095, AMS-02 Experiment/PIH Interfaces, Part II (ICD);
- JSC 28792, Structural Verification Plan for the Space Transportation System and International Space Station (SVP).

The Office of Primary Responsibility (OPR) for this is the AMS Project Office (APO) of the Engineering Directorate Office.

TABLE OF CONTENTS

TABLE OF FIGURES

TABLE OF TABLES

1. Introduction

1.1 PURPOSE AND SCOPE

The purpose of this Alpha Magnetic Spectrometer – 02 (AMS-02) Master Verification Plan (MVP) is to establish the plan for, and document the results of the AMS-02 Payload's verification activities. The AMS-02 is a multi-agency/organization payload utilizing components designed and managed at multiple locations world-wide. The activities documented within the AMS-02 MVP confirm that the AMS-02 components and end items comply with their specifications, function properly as an integrated unit when interfaced with program/vehicle components, and are ready for use as a part of the flight system. Appendices C & D of this MVP include a "Results" column for documenting the objective evidence (results) of verification activities performed during the Flight Production and Certification Phase. The first baseline of the MVP when finalized is to establish the plan for verification, and all columns of the appendices are completed except the "Results" column (i.e., results are TBS). During the Flight Production and Certification Phase, the planned verification activities are performed and the "Results" column is documented (including TPS #, "use as is" DR # or waiver, memo or report, etc., as appropriate). The MVP, with the appendices "Results" column documented, is released with the appropriate revision number and change record information. This revised release of the MVP, with associated "Results" documentation attached, form a part of the Certification Data Package.

Safety verifications, taken directly from the AMS-02 Phase II Hazard Reports, are reported in the format compatible with NSTS/ISS 13830, "Payload Safety Review and Data Submittal Requirements for Payloads Using the Space Shuttle, International Space Station." Reporting of the Status of the Safety Verifications will be reported directly to the Payload Safety Review Panel as a post Phase III Safety Verification Tracking Log (SVTL). ~~as a primary means of reporting,~~The safety verifications contained in this ~~document~~ MVP are intended to provide a single-source location for all verifications, when fully compiled, lead to the Certificate of Flight Readiness (CoFR) for the AMS-02 Payload.
~~as a second documentation location lagging in publication after the SVTL.~~

This MVP will be used by the AMS-02 Project to plan for, and document the results of, the verification of AMS-02 components. This MVP includes the verification of AMS-02 functional capabilities and subsystem performance through analyses using non-real-time tools, tests using real-time test facilities, inspection as it applies to the manufacturing processes used in hardware fabrication and software generation, and demonstration as it applies to human factors, serviceability, accessibility, and transportability of the system features.

1.2 RESPONSIBILITY AND CHANGE AUTHORITY

This document is prepared and maintained in accordance with EA-WI-023, Project Management of GFE Flight Projects. The responsibility for the development of this document lies with the AMS-02 Project Office (APO) of the Engineering Directorate. Change authority will be the AMS-02 Configuration Control Board (CCB) with the concurrence of all signatories.

1.3 DEFINITIONS

The term "verification" refers to the formal process, using the method of test, analysis, inspection or demonstration, to confirm that a system and its hardware and software components satisfy all specific performance and operational requirements. That is, it is the proof that a system meets all its "shalls".

The following definitions differentiate between requirements and other non-binding statements.

Shall:	This is the only verb used for defining binding requirements.
Should/May:	These verbs are used for stating non-mandatory goals.
Will:	This verb is used for stating facts or declaration of purpose.

Wording of the Safety Verification Methods is reviewed and approved by the Payload Safety Review Panel and all such verifications are by default the equivalent of "Shall" requirements, as all must be closed prior to approval for launch by the launch manager.

There are no 'shall, should, may, or will' statements in this document. All of these requirements can be found in other documents as described in the Foreward or the Appendices.

2. 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
SSP 57003	Revision C 07/06	Attached Payload Interface Requirements Document
SSP 57213	Original 09/07	AMS-02 Hardware Interface Control Document
JSC 29789	Revision A 08/17/04	Project Technical Requirements Specification for the Alpha Magnetic Spectrometer-02 (AMS-02) Payload Integration Hardware (PIH)
JSC 28792	Revision E 06/06	AMS-02 Structural Verification Plan for the Space Transportation System and the International Space Station
JSC 29095 Part II	Revision A 12/04	AMS-02 Experiment/Payload Integration Hardware (PIH) Interfaces (ICD-C)
JSC 49978	Revision A 03/07	Phase II Flight Safety Data Package for the Alpha Magnetic Spectrometer – 02 (AMS-02)
JSC 63123	Original 02/06	AMS-02 Assembly and Testing Integration Plan

2.2 REFERENCE DOCUMENTS

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

Document Number	Revision/ Release Date	Document Title
SSP 57004	Revision B 06/13/03	Attached Payload Hardware Interface Control Document Template
NSTS 1700.7B	Latest Revision	Safety Policy and Requirements for Payloads Using the STS
NSTS 1700.7B ISS Addendum	Latest Revision	Safety Policy Requirements for Payloads Using the International Space Station (ISS Addendum)
NSTS/ISS 13830	Latest Revision	Payload Safety Review and Data Submittal Requirements for Payloads Using the Space Shuttle, International Space Station

2.3 ORDER OF PRECEDENCE

In the event of a conflict between this document and an applicable document cited herein, the text of this document takes precedence.

3. AMS-02 Description

3.1 AMS-02 REQUIREMENTS FLOWDOWN

The AMS-02 verification requirements are obtained from the following documents:

TABLE 3-1 AMS-02 VERIFICATION REQUIREMENT SOURCE

JSC 29789	AMS-02 Project Technical Requirements Specification
SSP 57003	Attached Payload Interface Requirements Document
SSP 57213	AMS-02 Hardware Interface Control Document
JSC 28792	AMS-02 Structural Verification Plan for the Space Transportation System and the International Space Station
JSC 29095 Part II	AMS-02 Experiment/Payload Integration Hardware (PIH) Interfaces (ICD-C)
JSC 49978	Phase II Flight Safety Data Package for the Alpha Magnetic Spectrometer – 02 (AMS-02)

3.2 AMS-02 PAYLOAD ARCHITECTURE

The AMS-02 experiment is a state-of-the-art particle physics detector being designed, constructed, tested and operated by an international team organized under United States Department of Energy (DOE) sponsorship. The AMS Experiment will use the unique environment of space to advance knowledge of the universe and potentially lead to a clearer understanding of the universe's origin. Specifically, the science objectives of the AMS are to search for antimatter (anti-helium and anti-carbon) in space, to search for dark matter (90% of the missing matter in the universe) and to study astrophysics (to understand Cosmic Ray propagation and confinement time in the Galaxy).

The AMS-02 Experiment utilizes a large cryogenic superfluid helium (SFHe @ 1.8K) superconducting magnet (Cryomagnet) to produce a strong, uniform magnetic field (~ 0.8 Tesla) within the interior of the magnet. The experiment has planes of detectors above, in the center of, and below the magnet (Figures ~~4.1~~3.2-~~1~~ 2 and ~~4.1~~3.2-~~2~~3). Electrically charged particles will curve when they pass through the magnetic field. Particles made of matter will curve one way, and those of antimatter will curve the opposite way. ~~The positions of electrons released as the charged particles pass through the detectors will be electronically recorded (Figure 4.1-3). Physicists will be able to study the trajectory of curvature and determine the charge of the particles from the direction of curvature. They will also be able to determine the mass of the particles from the amount of curvature. They will then be able to tell whether it was matter or antimatter.~~ As a particle passes through the different detectors it induces signals which are electronically recorded [no Figure reference needed]. By studying these signals and their locations, physicists will be able to reconstruct which type of particle left them (for example was it matter or antimatter) and its momentum.

An Implementing Arrangement (IA) between NASA and DOE signed in September 1995 established two flights for AMS: an Engineering Test on Shuttle (AMS-01 on STS-91 – June 1998) and a 3-year Science Mission on ISS~~ (Launch Ready December 2008 – Date under review)~~. The flight of AMS-01 was a precursor flight of the detectors proposed for AMS-02. AMS-01 utilized a permanent magnet in place of the cryomagnet. The purpose of the precursor flight was to verify operation of the AMS experiment, verify command and data communications, collect thermal data for the ISS flight, determine actual accelerations on some AMS internal instruments and establish experimental background data.

The AMS-02 is designed to be transported to the International Space Station (ISS) in the cargo bay of the Space Shuttle ~~(Figure 4.1-4)~~ for installation on the external truss of the ISS~~ (Figures 4.1-5 and 4.1-6)~~. The AMS-02 is scheduled to remain on the ISS for at least three operational years of data collection. ~~Do~~ Due to limited space shuttle flights, AMS-02 is not scheduled to return to Earth and will remain on the ISS.

The ~~major~~ subsystems of the AMS-02 are listed below:

- Cryogenic Superconducting Magnet (Cryomagnet)
- Unique Support Structure – 02 (USS-02) with integral Vacuum Case (VC)
- Transition Radiation Detector and associated Gas System (TRD)
- Time-of-Flight (TOF) Scintillator Assemblies
- Silicon Tracker
- Tracker Alignment System (TAS)
- Anti-Coincidence Counters (ACC)
- Ring Imaging Cerenkov Counter (RICH)
- Electromagnetic Calorimeter (ECAL)
- Star Tracker
- Global Positioning System (GPS)
- Data and Interface Electronics
- Thermal Control System (TCS)
- Micrometeoroid and Orbital Debris (MMOD) Shields

- Payload Attach System (PAS) (Passive Half)
- Digital Data Recording System – 02 (DDRS-02)
- Space Shuttle Program (SSP) and ISS Program (ISSP) Provided Hardware
    - Flight Releasable Grapple Fixture (FRGF) SSP
    - Remotely Operated Electrical Umbilical (ROEU)/Payload Disconnect Assembly (PDA) SSP
    - Power Video Grapple Fixture (PVGF) ISSP
    - Umbilical Mechanism Assembly (UMA) (passive half) ISSP
    - External Berthing Camera System (EBCS) ISSP

The AMS-02 Payload also requires the use of the Shuttle Remote Manipulator System (SRMS) and the Space Station Remote Manipulator System (SSRMS) for removing the payload from the Orbiter Cargo Bay and berthing it on the station. The payload requires an active ISS PAS and an active UMA, which are ISS hardware and part of the Integrated Truss Segment (ITS). ~~Figure 3.2-1 shows the AMS-02 interfaces. Figure 3.2-2 is a cut-away view of the Payload and shows the location of most of its major sub-elements. Figure 3.2-3 shows the experiment stack and the physical relationship of the detectors to one another.~~

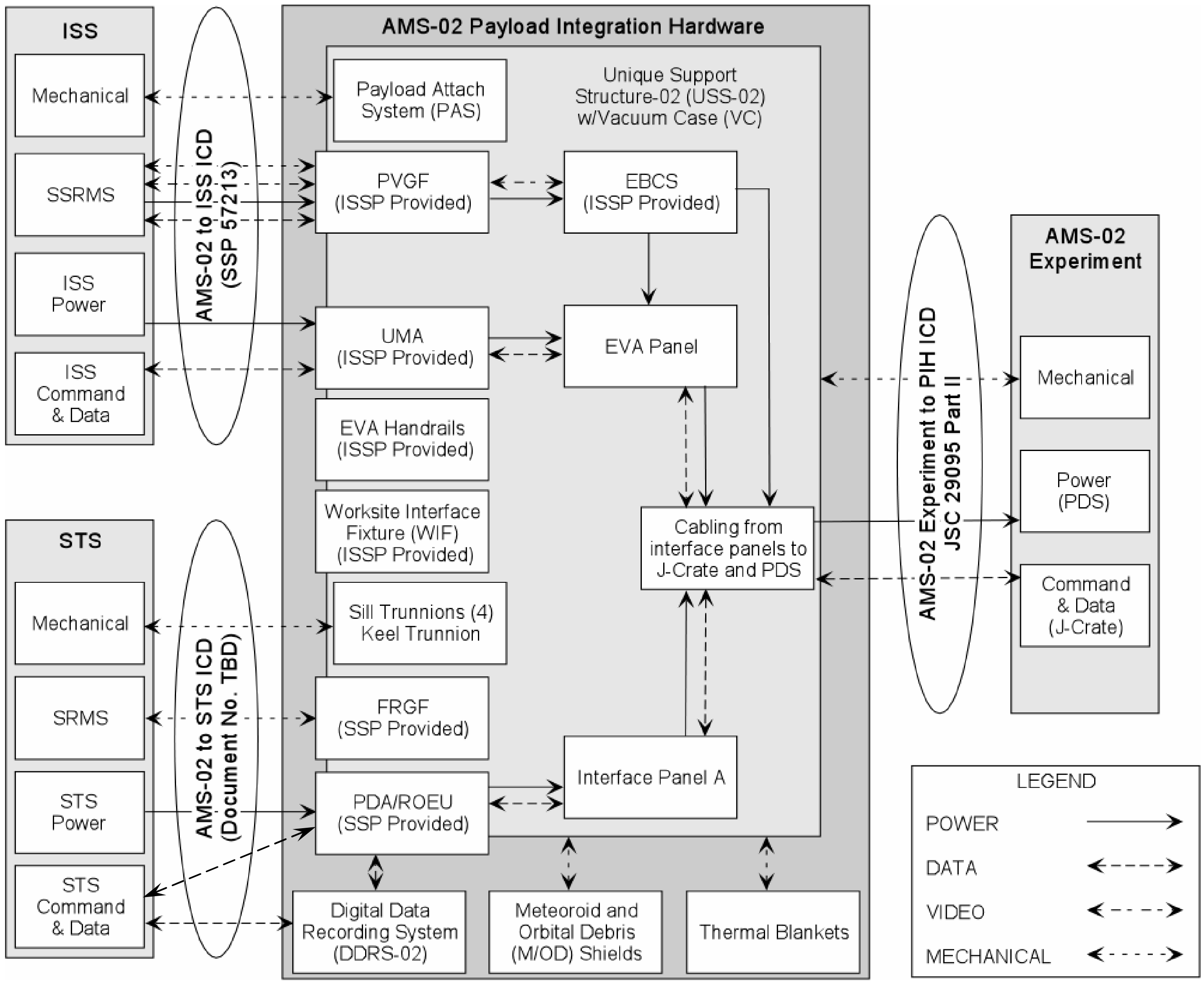


Figure 3.2-1 The AMS-02 System Interfaces

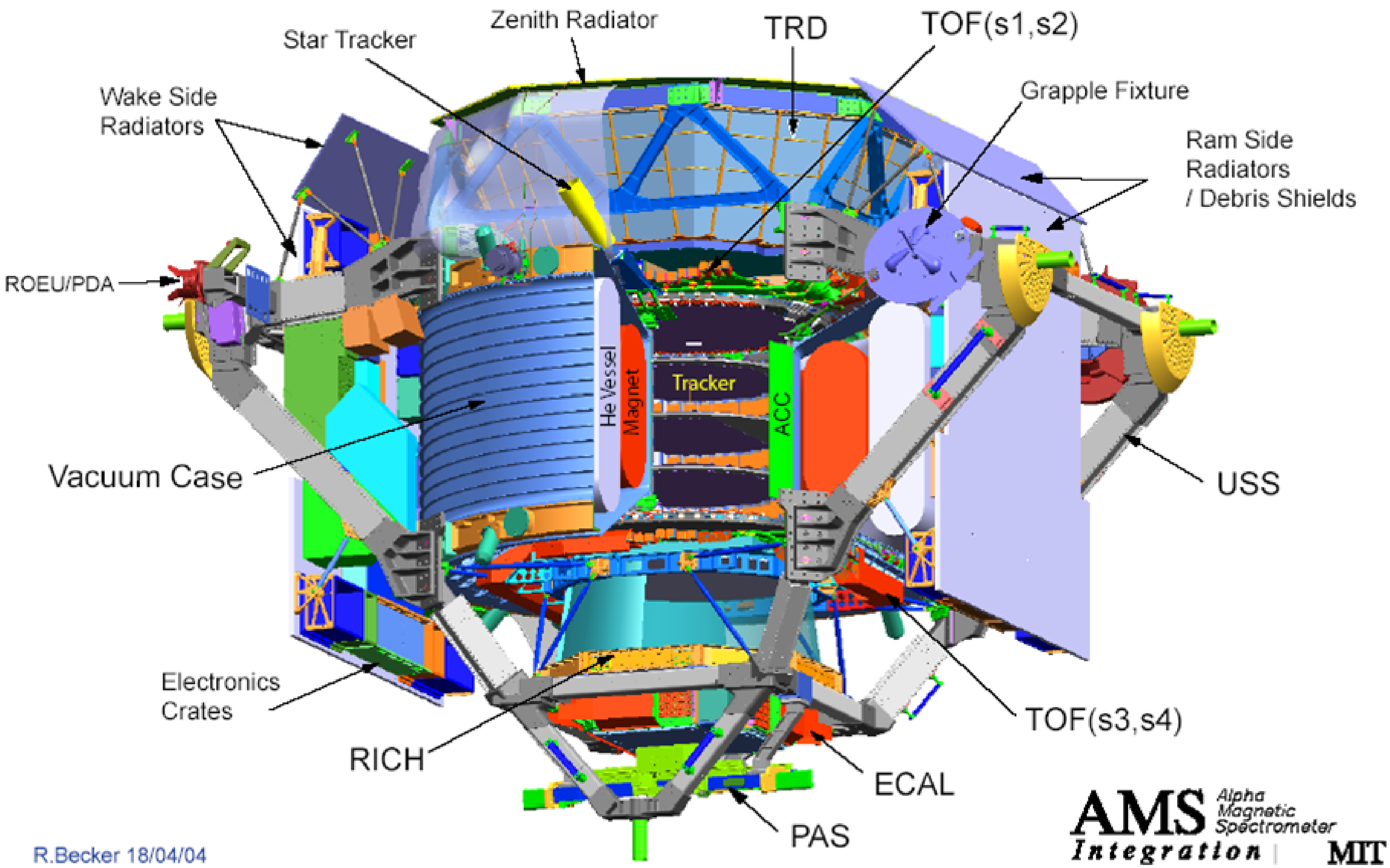


Figure 3.2-2 The AMS-02 Payload Components

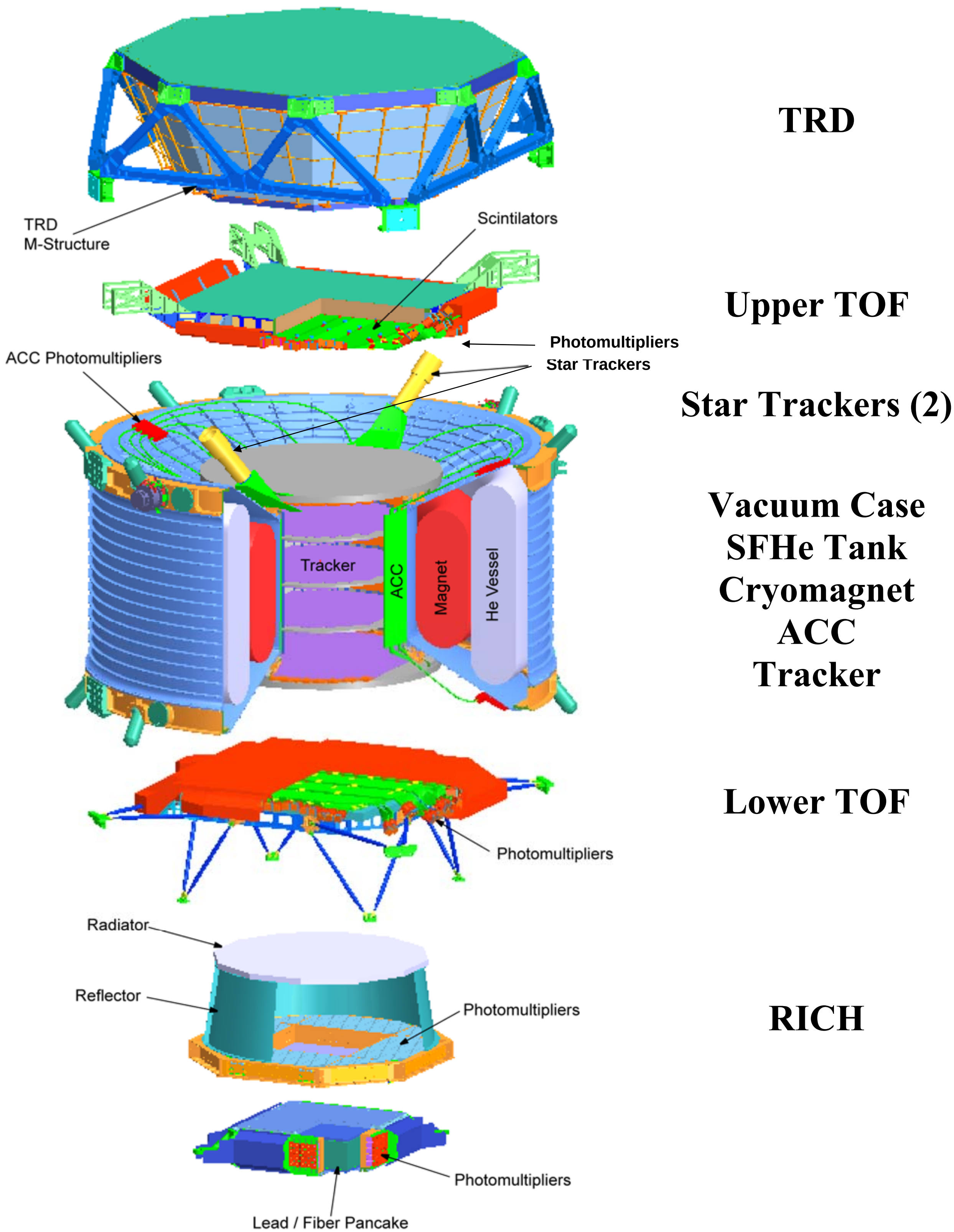


Figure 3.2-3 The AMS-02 Experiment Elements

3.3 END ITEM ARCHITECTURES

3.3.1 AMS-02 Payload

The fully integrated AMS-02 Payload is the primary end item of the AMS-02 Project. An overview of the Payload Experiment was provided in Section 3.2. The AMS-02 Payload is comprised of the *Payload Integration Hardware* (PIH), designed and built by NASA/JSC and the *Experiment Hardware*, designed and built by the AMS Collaboration under the sponsorship of the U.S. Department of Energy (DOE).

3.3.1.1 AMS-02 Payload Integration Hardware (PIH)

The PIH provides the structural, mechanical, electrical, and data interfaces between the experiment and the Shuttle for transportation to the ISS and between the experiment and the ISS for the remainder of its on-orbit life. The following paragraphs describe the structures and elements that comprise the PIH.

3.3.1.1.1 AMS-02 Unique Support Structure-02 (USS-02)

The Unique Support Structure – 02 (USS-02) is the primary structural element of the AMS-02 Payload (Figure 3.3.1.1.1-1). Its purpose is to structurally support the Cryomagnet Cold Mass and the AMS-02 Experiment during launch, (contingency) landing, and on-orbit loading and provides the mechanical and structural interfaces to the Shuttle and ISS.

The USS-02 (Figures 3.3.1.1.1-2 and 3.3.1.1.1-3) consists of five subassemblies: Upper USS-02, Vacuum Case (VC), Lower USS-02, Keel, and the AMS Payload Attach System (PAS). These subassemblies are bolted and shear pinned together to form the top-level USS-02.

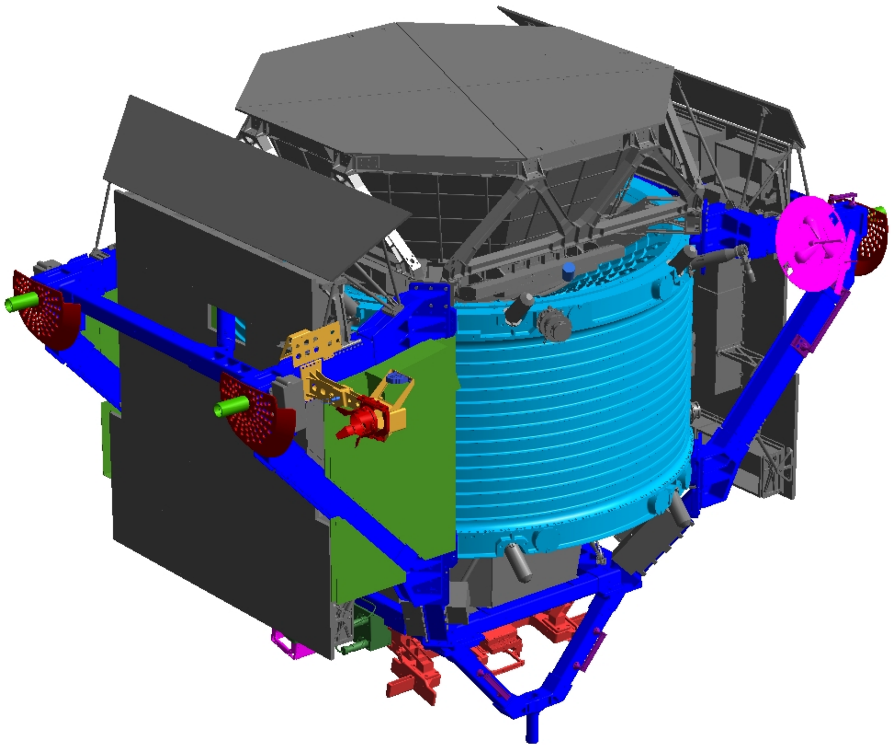


Figure 3.3.1.1.1-1 AMS-02 Payload with the USS-02 Highlighted

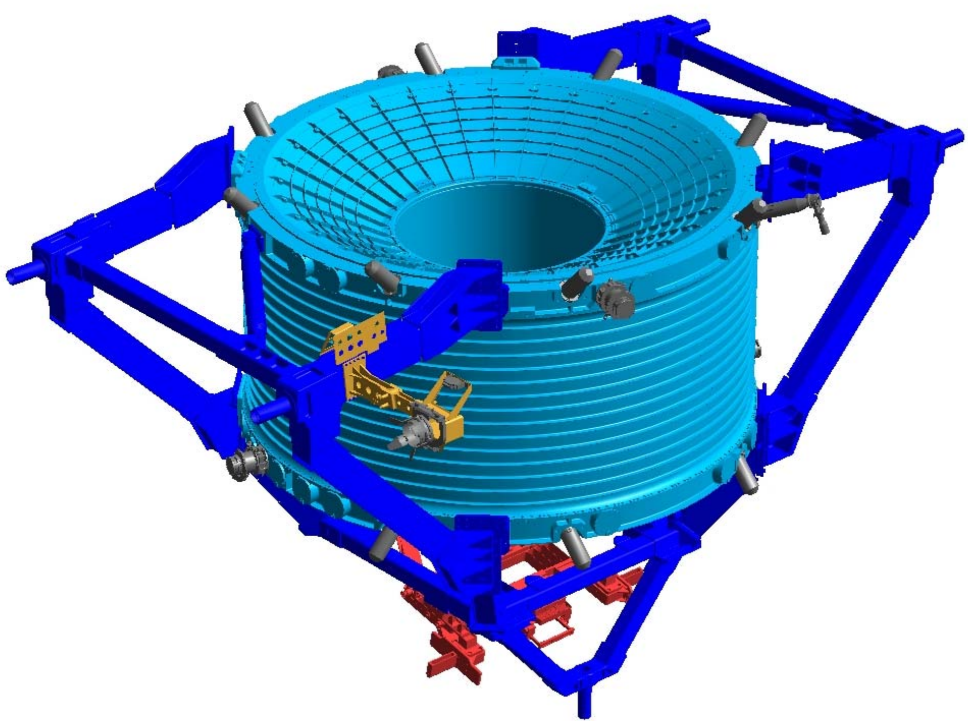


Figure 3.3.1.1.1-2 Unique Support Structure (USS) – 02

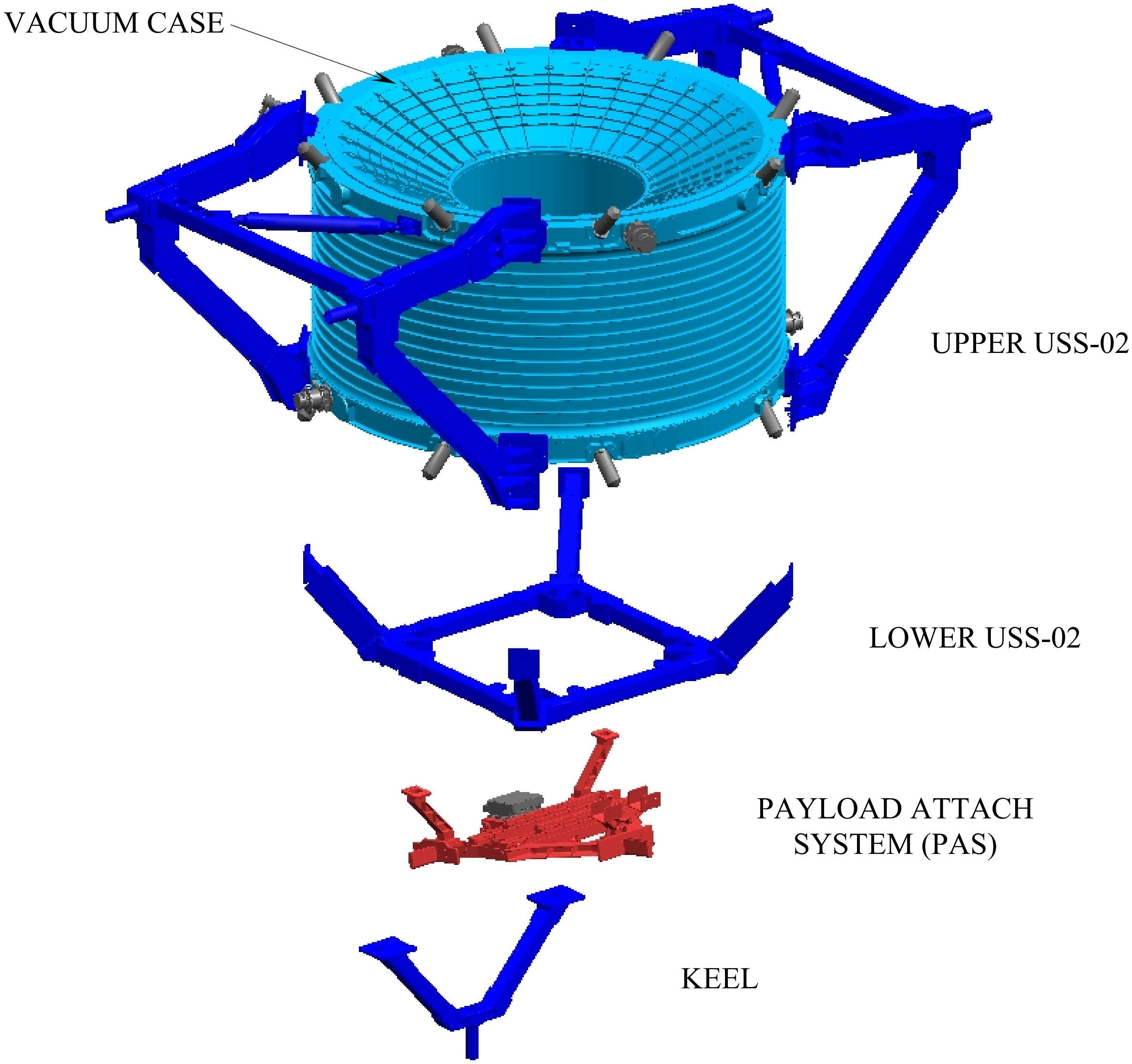


Figure 3.3.1.1.1-3 Subassemblies of the Unique Support Structure (USS) – 02

The Upper USS-02, Lower USS-02 and Keel are comprised of joints riveted to hollow tubes (Figure 3.3.1.1.1-4. The joints are made of machined aluminum alloy (7050-T7451) plate. The hollow tubes are extruded from an aluminum alloy (7075-T73511) and machined to their final configuration.

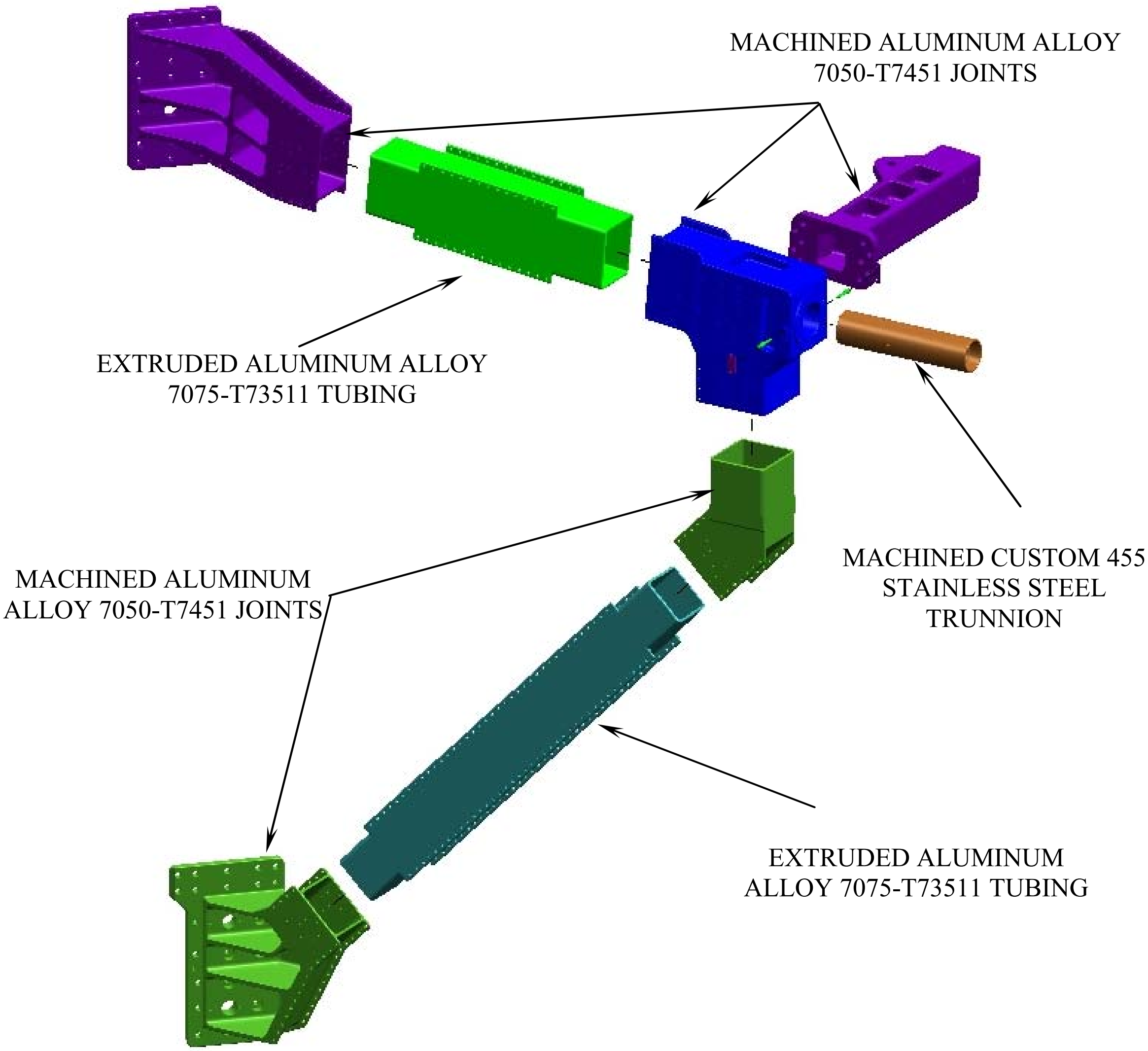


Figure 3.3.1.1.1-4 USS-02 Construction with Aluminum Tubes and Machined Joints

The Upper USS-02 includes two struts (Figure 3.3.1.1.1-5). The struts are fabricated from machined 6061-T6511 extruded aluminum tubing with machined end fittings that are riveted to the tube. Rod-end bearings are threaded into the end fittings. The struts are pinned to the Upper USS-02 at both ends using custom-made steel shear pins fabricated from 455 stainless steel.

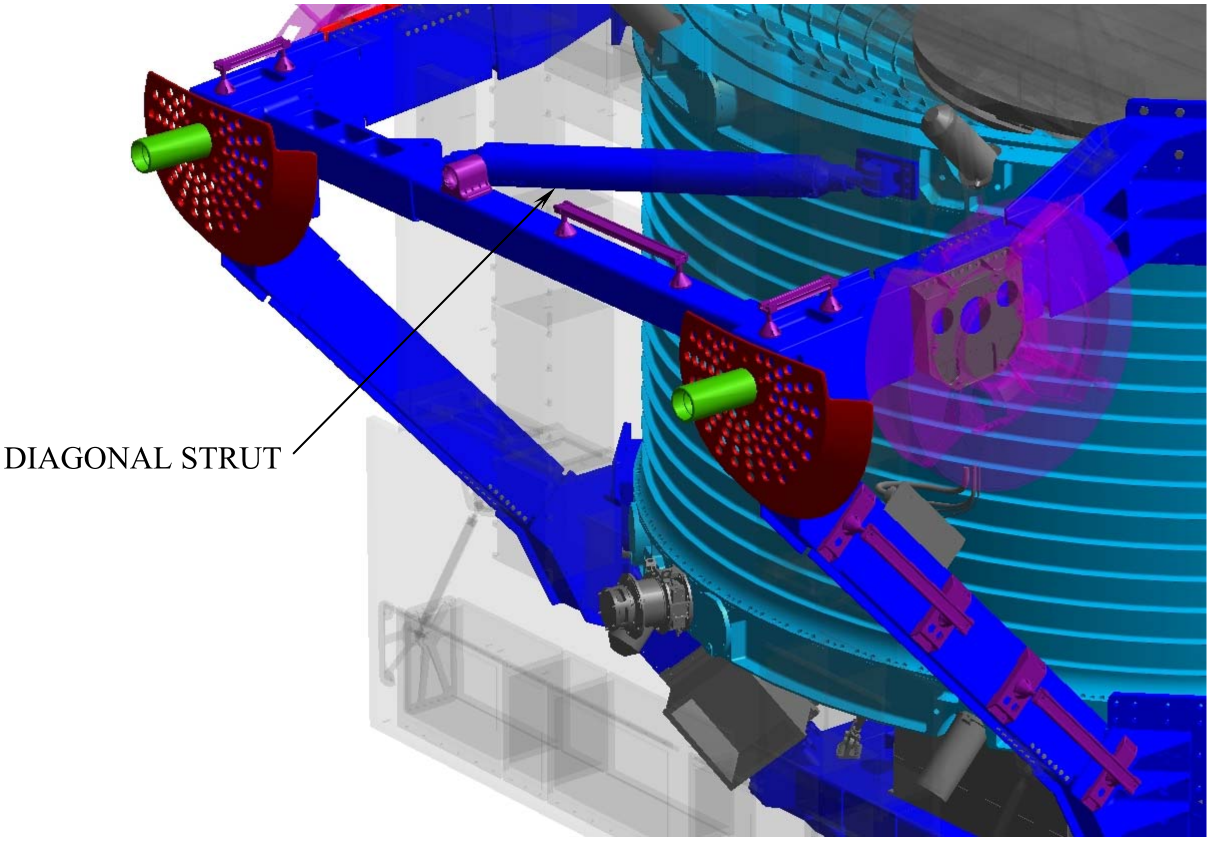


Figure 3.3.1.1.1-5 Location of the Diagonal Strut on the USS-02

3.3.1.1.2 AMS-02 Vacuum Case (VC)

The VC serves a dual purpose: It is a primary structural support that works in conjunction with the USS-02 to form the foundation structure of the AMS-02 and serves as a vacuum jacket for the superfluid helium tank and superconducting magnet which are suspended inside by 16 support straps. The Vacuum Case assembly and cross section is shown in Figure 3.3.1.1.2-1. The main structural components of the VC are described in the following paragraphs.

The weight of the VC is 1626 lbs (738 kg), which includes all of the Feed-thru and Strap Port blank cover plates. The VC attaches to the USS-02 at the eight Interface plates and the two Clevis Plates. Since the VC is an integral part of the primary structure with the USS-02, a Structural Test Article (STA) was developed and fabricated at the same time as the Flight VC. The STA VC will be used for much of the AMS-02 structural testing. The Flight unit and the STA unit are identical.

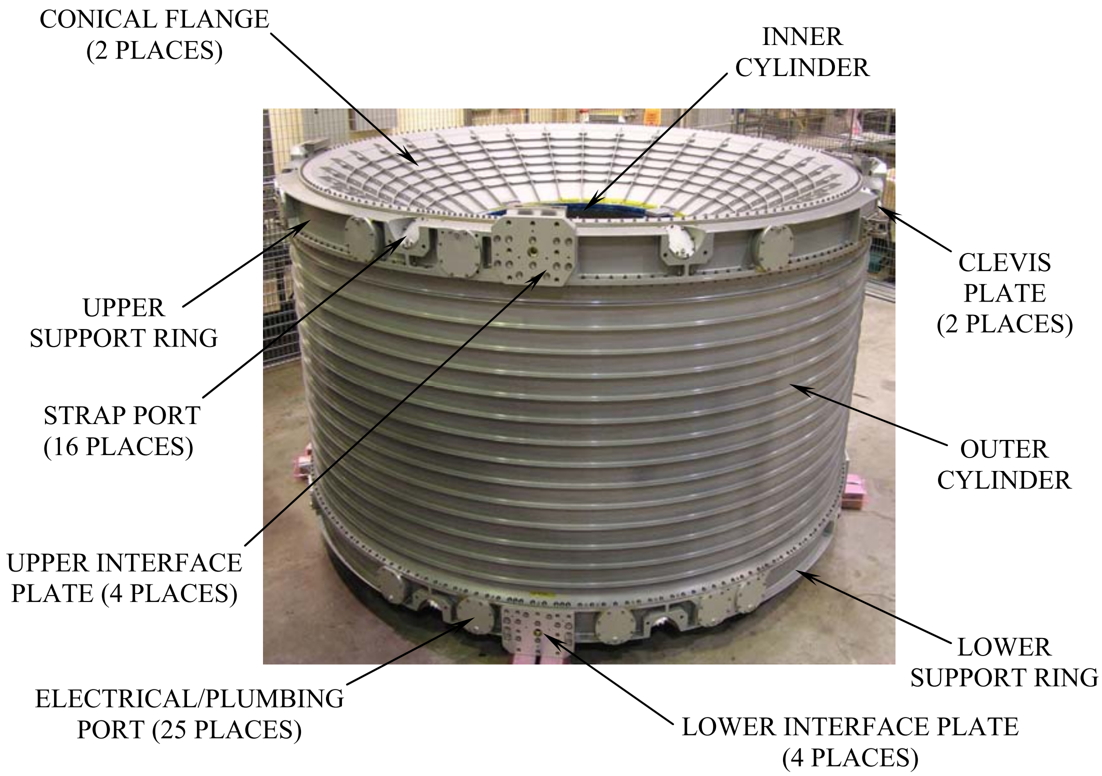


Figure 3.3.1.1.2-1 Vacuum Case

3.3.1.1.2.1 Conical Flanges

The Upper and Lower Conical Flanges are made of spin formed Al 2219-T62. The Conical Flanges start as an annealed plate (T0) and spin formed to rough shape using two dies. They are then solution heat treated and quenched (T42) followed by aging to final condition (T62) to complete a spin form blank. The blanks are then machined to final dimensions to form the Conical Flanges.

3.3.1.1.2.2 Support Rings

The Upper and Lower Support Rings are made of rolled ring forged Al 7050-T7451. The forging is then machined to final dimensions. The Support Rings contain all of the ports for the magnet support straps along with ports for electrical/plumbing feed-throughs and cyrocooler interfaces. The dove-tail O-ring grooves, which prevent the O-ring from falling out during VC assembly, are machined into the sealing faces of the feed thru ports.

3.3.1.1.2.3 Outer Cylinder

The Outer Cylinder is milled from a rolled ring forging of Al 7050-T7451. The forging is machined to provide reinforcing ribs along the height of the cylinder. The ribs are spaced approximately 3.0 inches apart and are 0.10 inch thick.

3.3.1.1.2.4 Inner Cylinder

The Inner Cylinder is made from an Al 2219-T852 rolled ring forging milled to the final dimensions. The inner cylinder provides the interior cavity for mounting the Anti-coincidence Counters and the Silicon Tracker.

3.3.1.1.2.5 Clevis Plates

The Clevis Plates are fabricated from CRES A286 and are used for attaching the diagonal struts from the USS-02 to the Upper Support Ring

3.3.1.1.2.6 Interface Plates

The Upper and Lower Interface Plates are fabricated from Al 7050-T7451 plate and are the main interface with the USS-02 at 8 locations.

3.3.1.1.2.7 Feed-thru Cover Plates

The Feed-thru Port Cover Plates are fabricated from Al 6061-T651 plate. The Feed-thru Cover Plates protect the access ports during ground processing and seal unused ports for flight. Plates can be removed to allow for the installation of plumbing components or electrical feed-thrus for the Cryomagnet System. Strap Port blank cover plates are used to protect the surfaces of the strap ports until the straps are installed

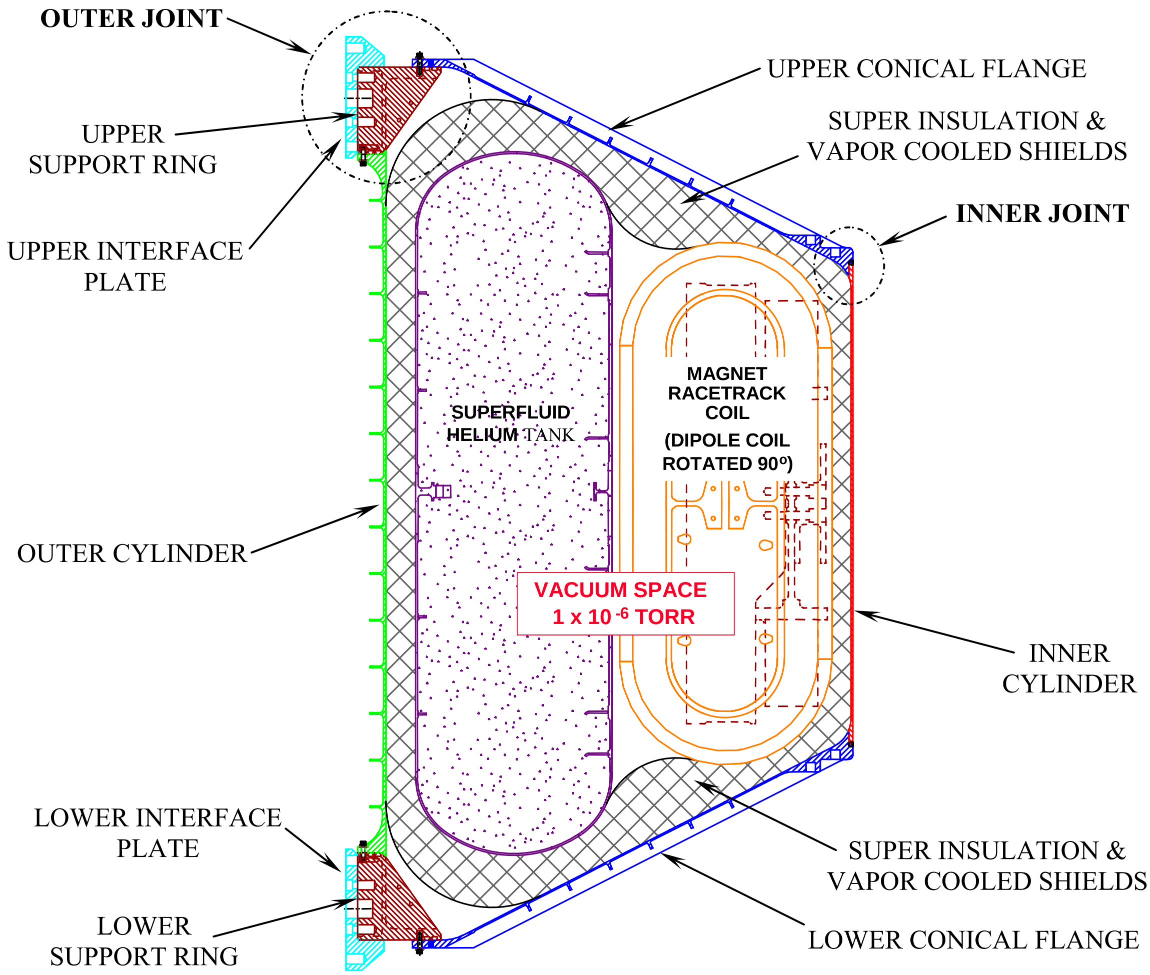


Figure 3.3.2.2.1-2 Vacuum Case Cross Section

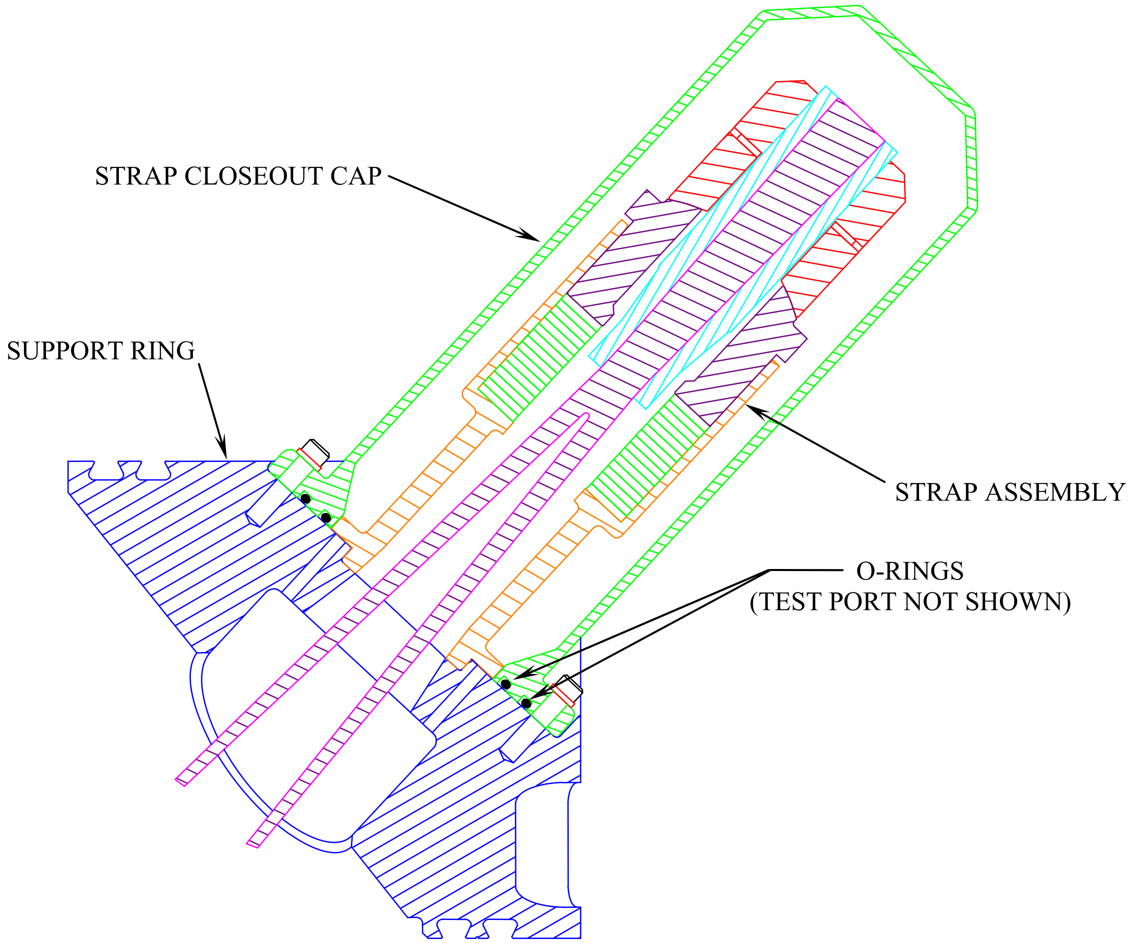


Figure 3.3.2.2.1-3 Strap Port Cross Section

3.3.1.1.3 <u>AMS-02 Sill and Keel Trunnions and Scuff Plates</u>

The AMS-02 sill and keel trunnions and scuff plates form the structural interface between the AMS-02 Payload and the Shuttle Orbiter in the Orbiter payload bay. The trunnion and keel pins are manufactured to comply with Payload Deployment and Retrieval System requirements for dimension and strength. Scuff plates are required due to the requirement of the AMS-02 to be handled by the Orbiter Remote Manipulator System. Figure 3.3.1.1.3-1 shows the locations of the trunnions, keel pin and scuff plates.

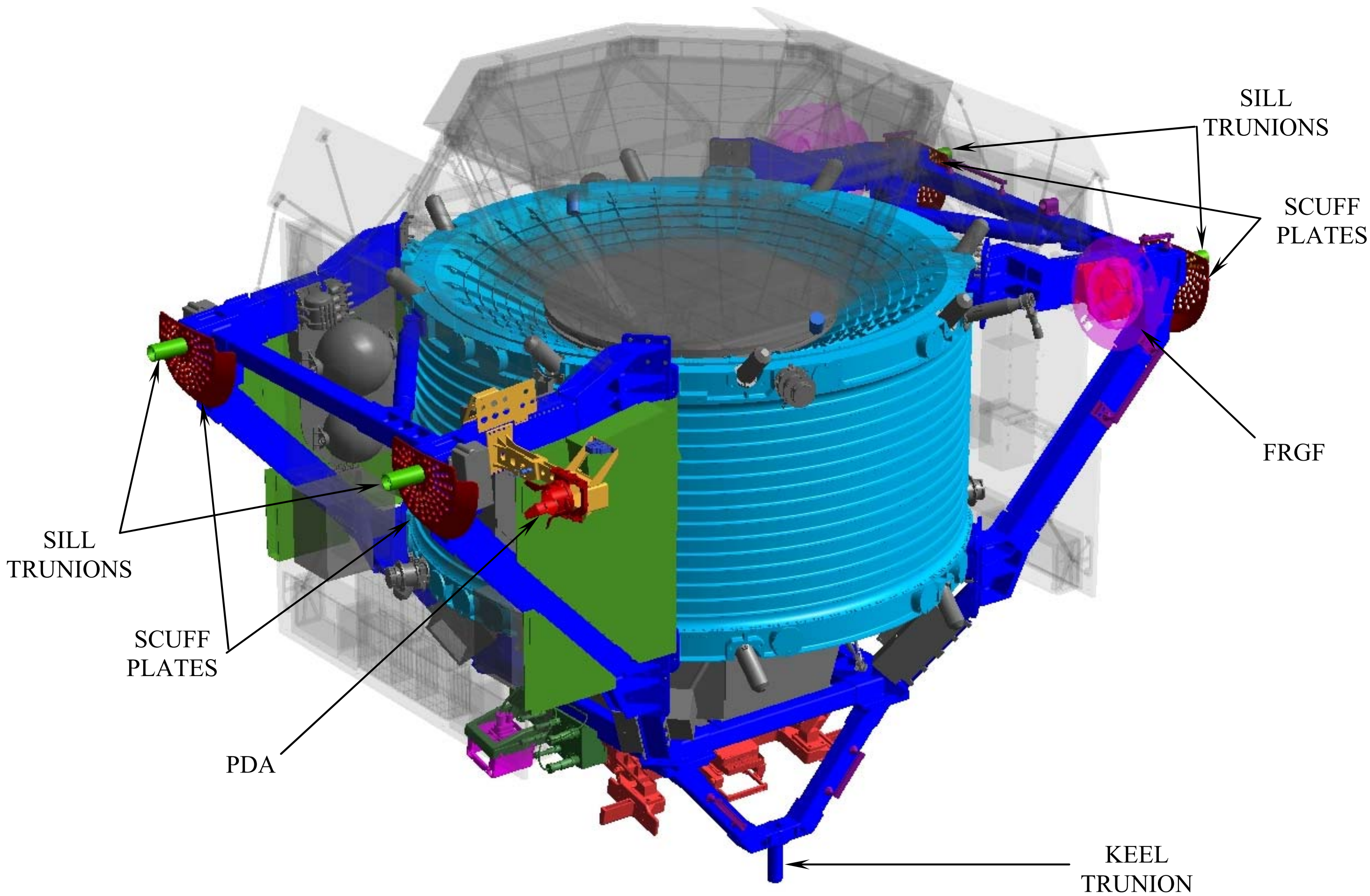


Figure 3.3.1.1.3-1 AMS-02 Shuttle Interfaces

Figures 3.3.1.1.3-2 and 3.3.1.1.3-3 provide more detailed views of the trunnion pins and scuff plates and of the keel pin.

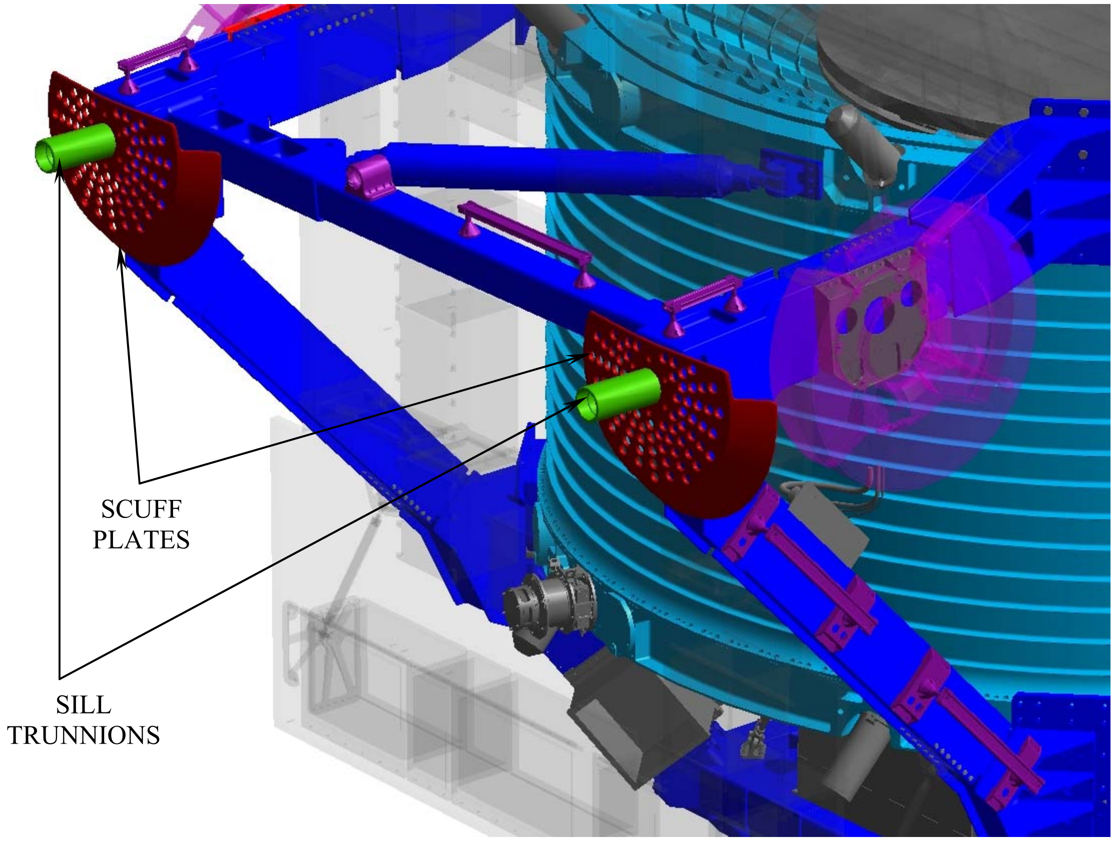


Figure 3.3.1.1.3-2 AMS-02 Shuttle Interfaces – Sill Trunnions and Scuff Plates

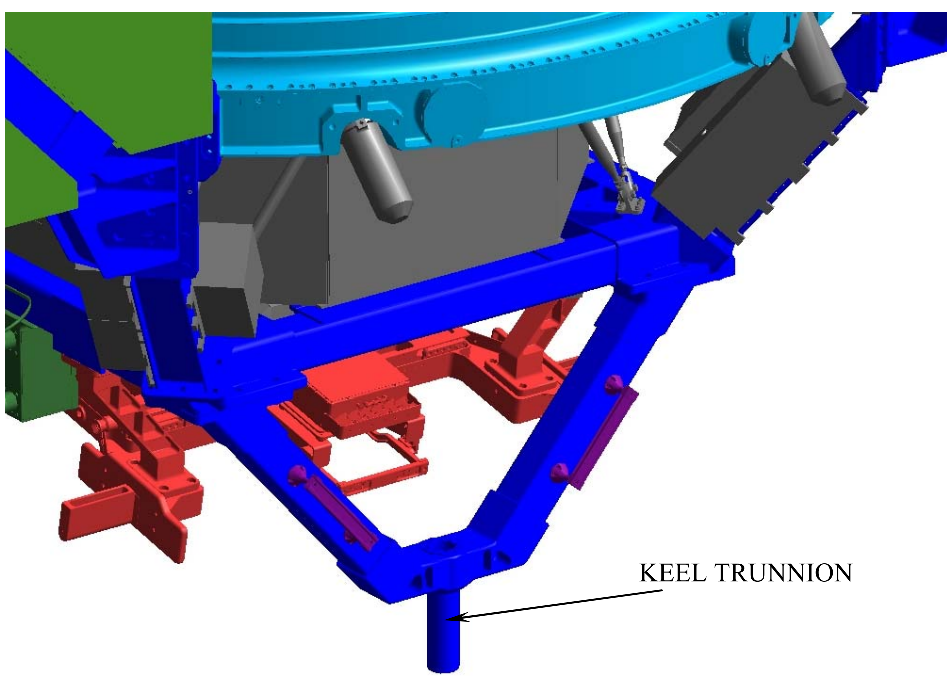


Figure 3.3.1.1.3-3 AMS-02 Shuttle Interfaces – Keel Trunnion

3.3.1.1.4 <u>AMS-02 EVA Aids</u>

The EVA aids that the AMS-02 requires consist of EVA compatible handrails and the installation of a WIF (worksite interface) socket on the USS-02. Handrails are designed to be compatible with the requirements of JSC 28918, "EVA Design Requirements and Considerations." The AMS-02 utilizes nine handrails and one WIF socket. The positioning of the handrails and WIF socket are dictated by the requirements of contingency EVA activities associated with GFE hardware (PVGF, FRGF, ROEU) and the AMS-02 (cable connection exchange, PAS EVA Mechanism Release.) Figures 3.3.2.4-1 through 3.3.2.4-4 show the locations of the handrails and EVA interfaces.

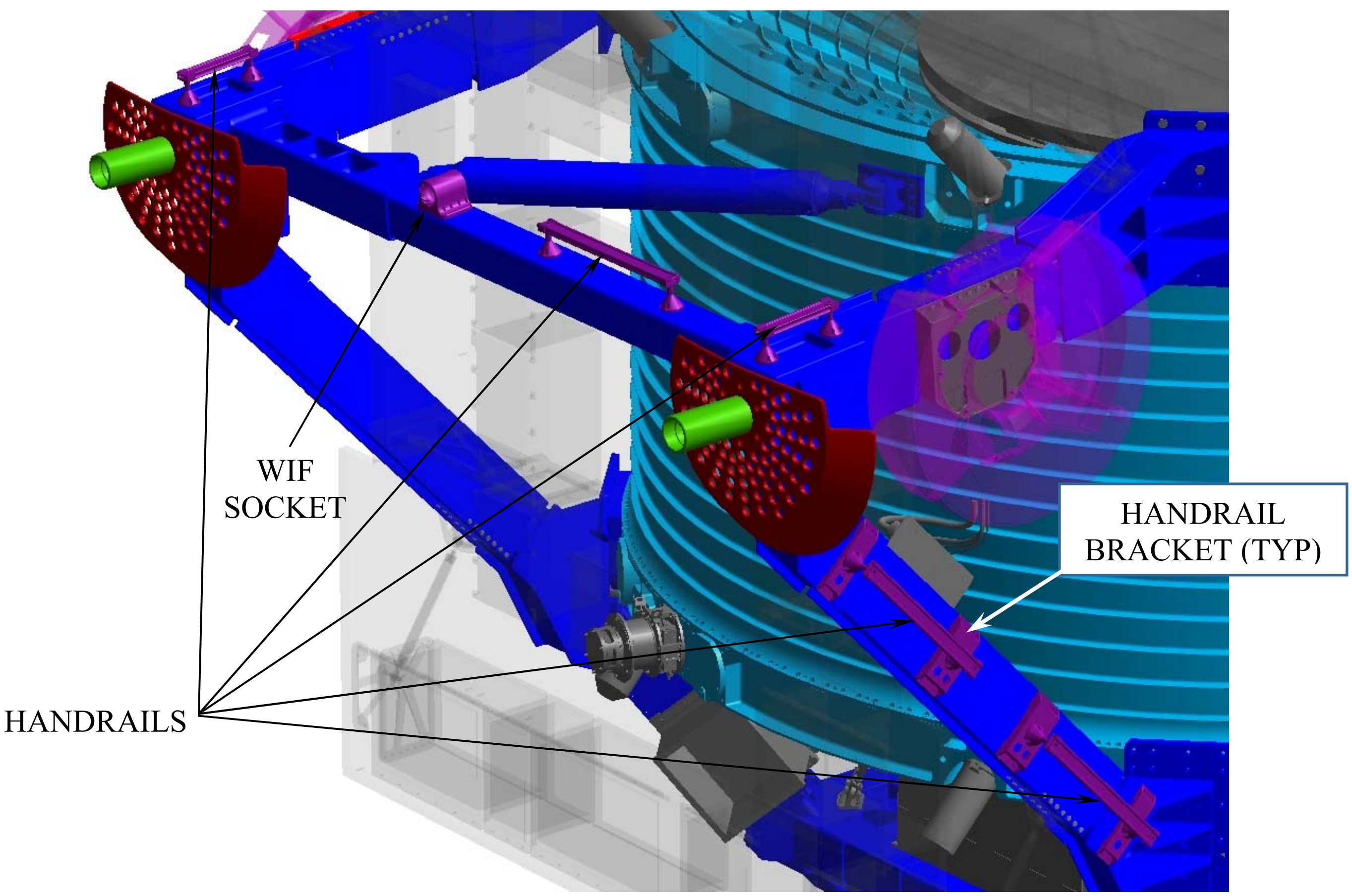


Figure 3.3.1.1.4-1 EVA Interfaces – WIF Socket and Handrails

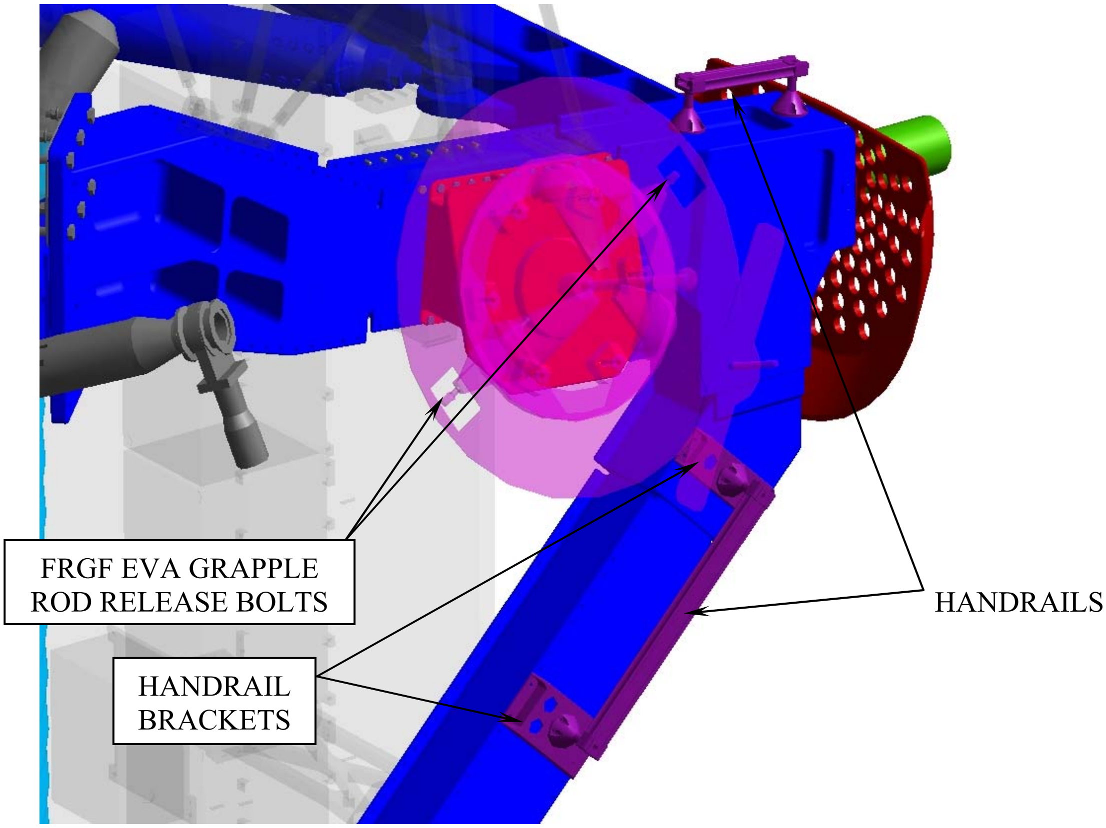


Figure 3.3.1.1.4-2 EVA Interfaces – Handrails and FRGF Release Bolts

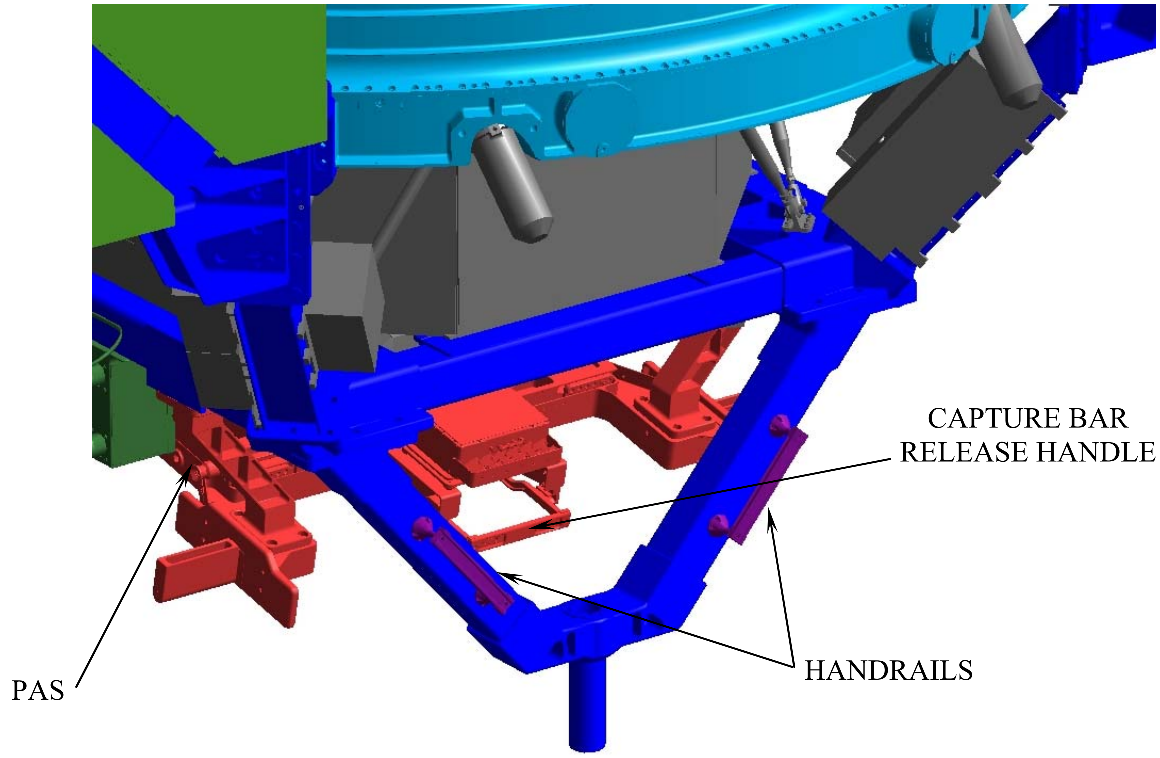


Figure 3.3.1.1.4-3 EVA Interfaces – Handrails and PAS Capture Bar Handle

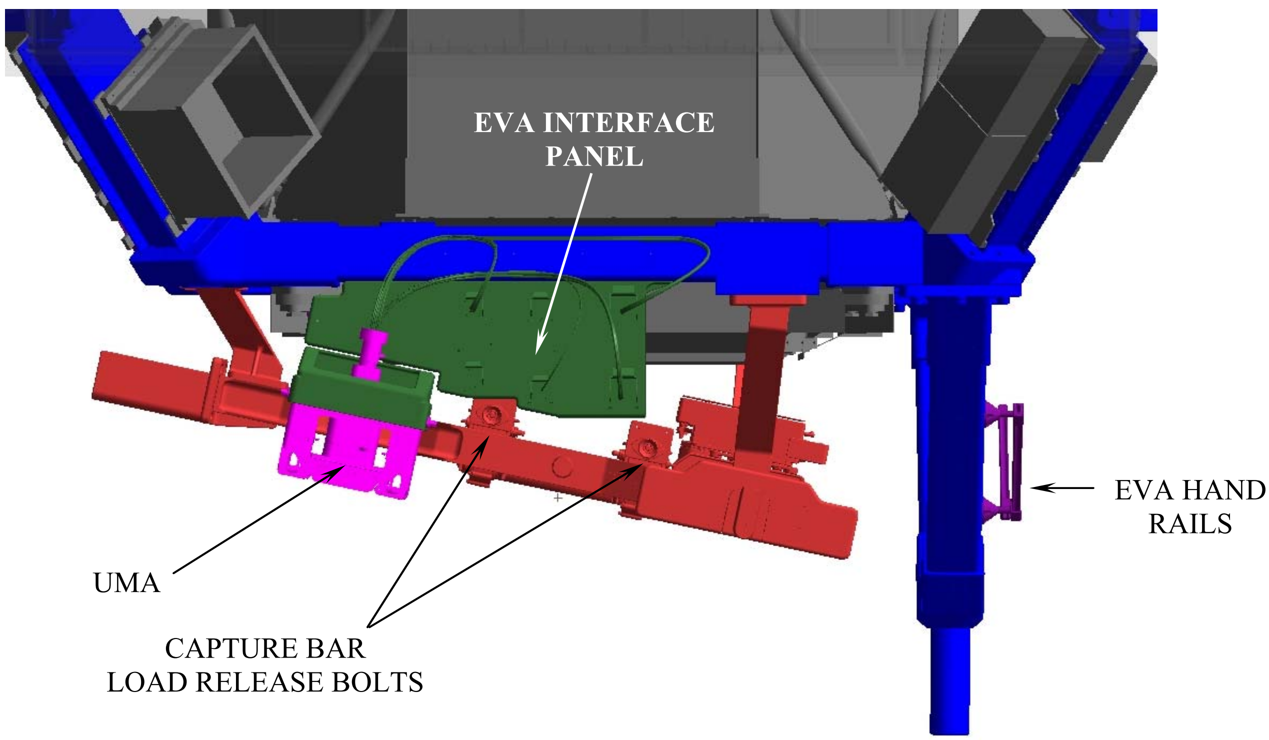


Figure 3.3.1.1.4-4 EVA Interfaces – PAS Capture Bar Handle

3.3.1.1.5 AMS-02 Passive Payload Attach System (PAS) with EVA Release Mechanism

The AMS-02 Passive PAS is the mechanical and structural interface between the AMS-02 and the ISS. The passive PAS provided by the AMS-02 interfaces with the active PAS that is an integral component of the ISS truss. The AMS-02 will interface with the ISS through the S3 upper inboard PAS location. Figures 3.3.1.1.5-1 and 3.3.1.1.5-2 show the PAS and its location on the AMS-02.

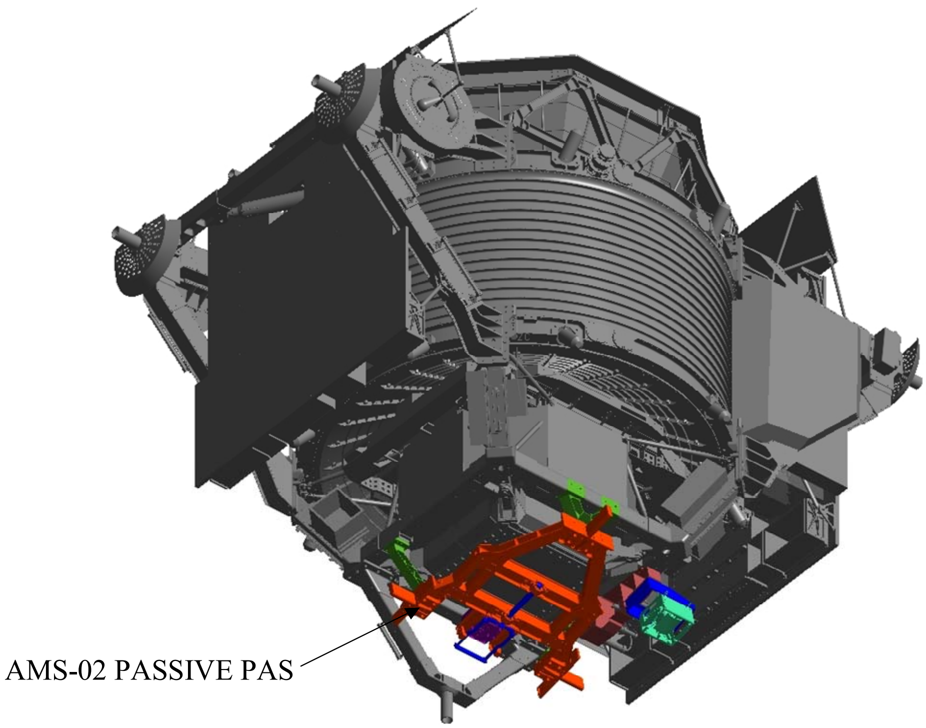


Figure 3.3.1.1.5-1 The Passive PAS on the bottom of the AMS-02 Payload (1 of 2)

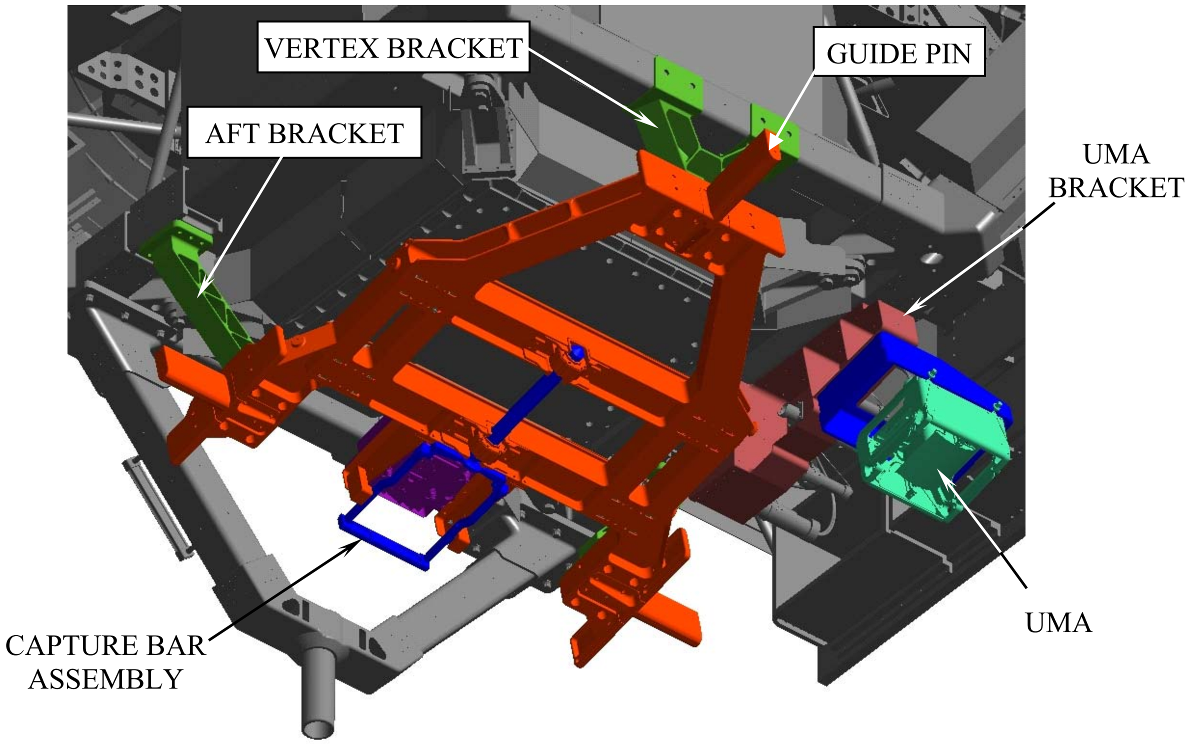


Figure 3.3.1.1.5-2 The Passive PAS on the bottom of the AMS-02 Payload (2 of 2)

The PAS (active and passive) consists of three basic pairs of components that interact to mate the payload to the ISS: the active half Capture Claw (ISS) and passive half Capture Bar (AMS-02); the three active half Guide Vanes (ISS) and the passive half Guide Pins (AMS-02); and the active Umbilical Mechanism Assembly (UMA) (ISS) and the passive UMA (ISS Provided mounted on the AMS-02 PAS). The Capture Claw, Capture Bar, Guide Vanes, and Guide Pins provide the structural attachment for the Payload to ISS and the active and passive UMA provide power and data connection from ISS to the Payload. Figures 3.3.1.1.5-3 through 3.3.1.1.5-5 show additional details of the interface and mechanisms of the active and passive PAS.

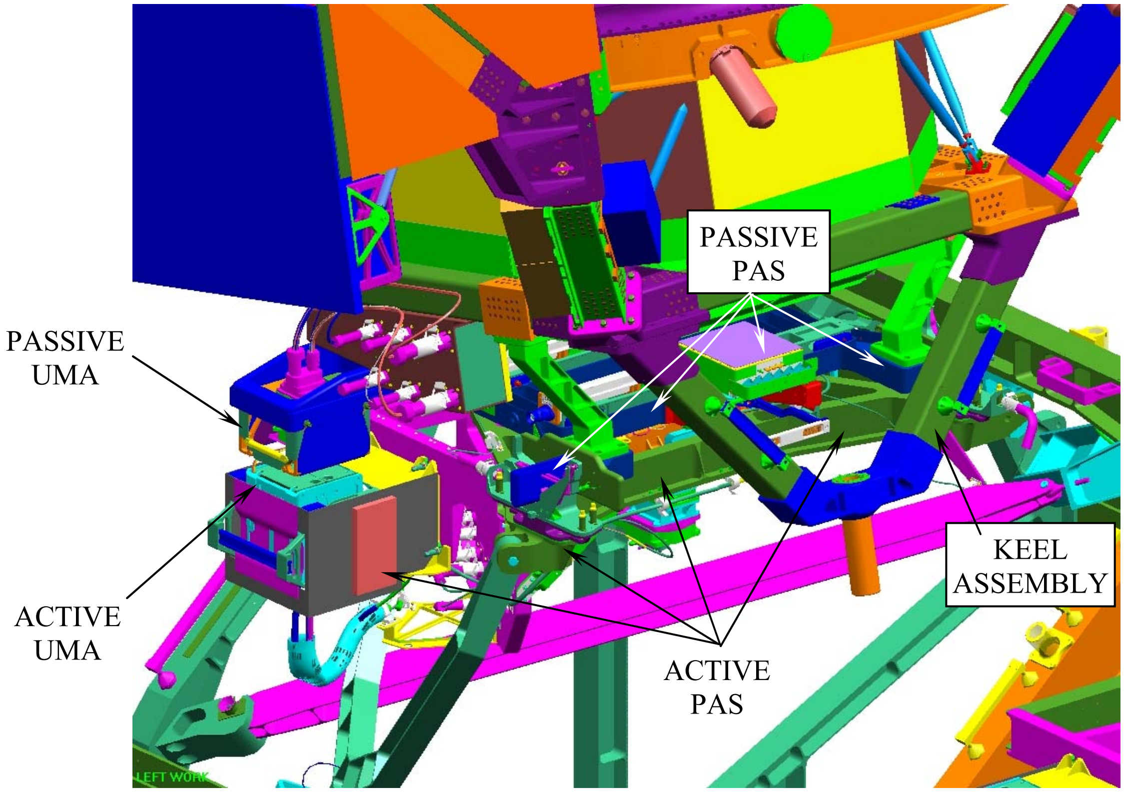


Figure 3.3.1.1.5-3 The AMS-02 Passive PAS attached to the ITS3 Active PAS (1 of 3)

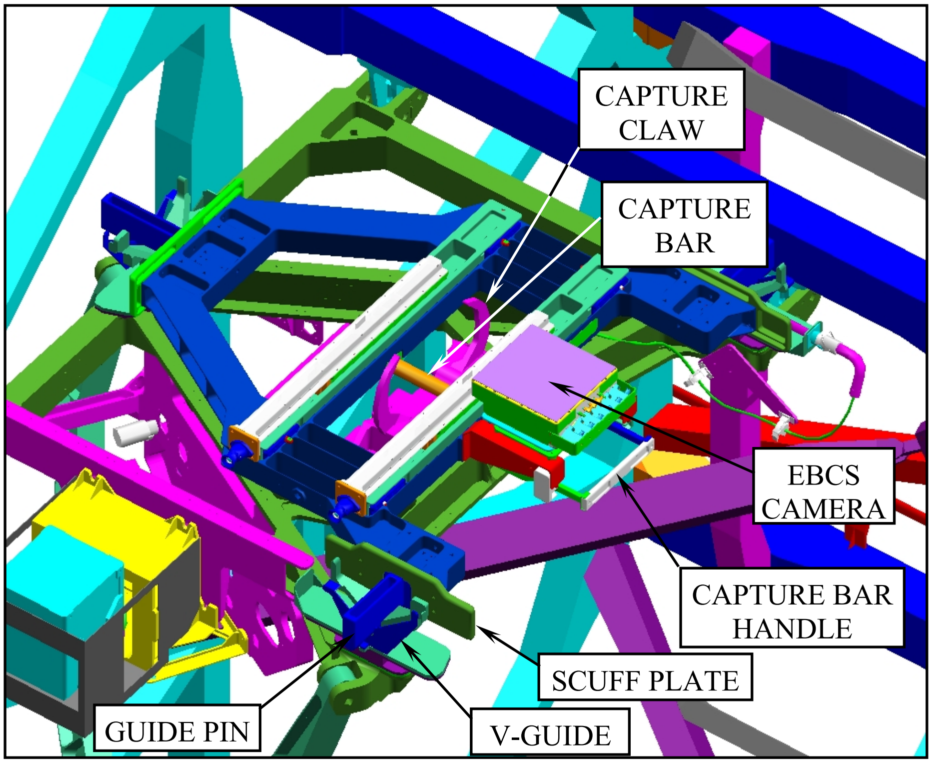


Figure 3.3.1.1.5-4 AMS-02 Passive PAS attached to the ITS3 Active PAS (2 of 3)

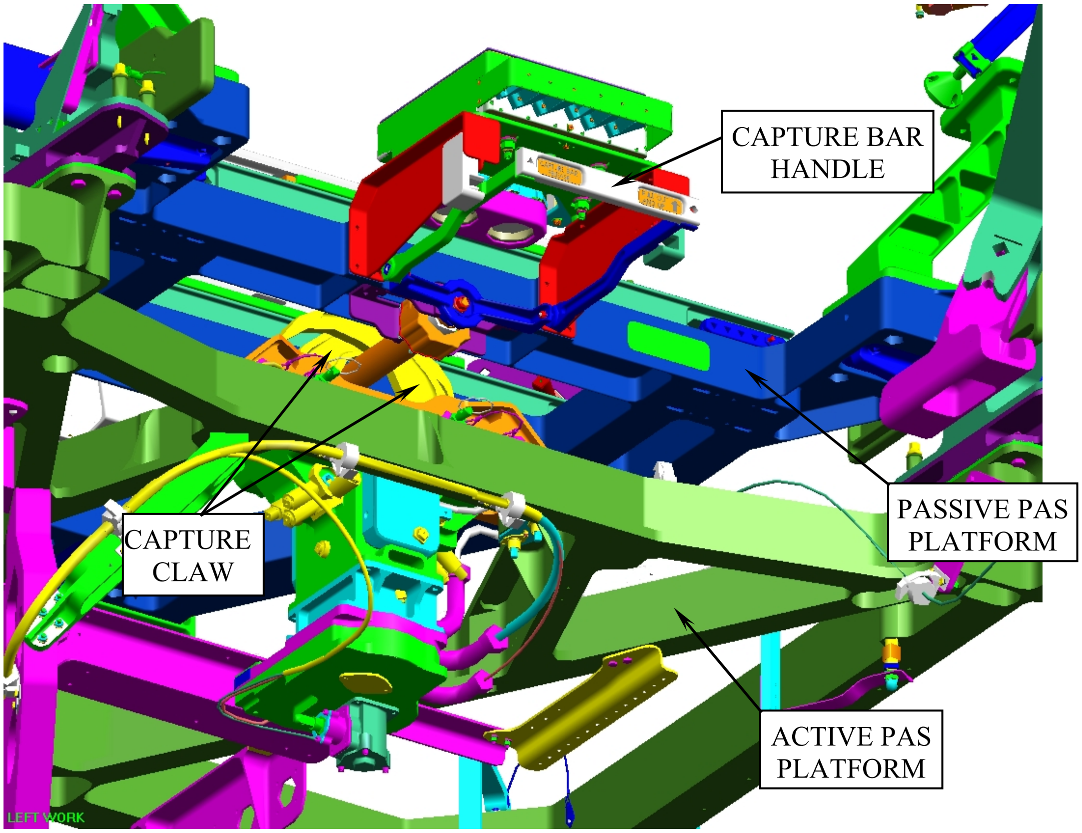


Figure 3.3.1.1.5-5 AMS-02 Passive PAS attached to the ITS3 Active PAS (3 of 3)

Per SSP 57003, the AMS-02 PAS incorporates a mechanism to unload the capture bar and release the Payload from the ISS. To unload and release the AMS-02 Payload from ISS, an EVA crewmember first unloads the capture bar, by driving two EVA bolts using the Pistol Grip Tool (PGT). Turning the bolts a defined number of turns and alternating between the two bolts lowers the Capture Bar and relieves any load in the system. The crewmember then retracts the capture bar by reaching thru the AMS-02 Keel structure, grasping the Capture Bar Assembly handle, and pulling the capture bar out towards the keel and up towards the Payload. Once the capture bar is retracted, the Payload is free from the PAS and the ISS. Figure 3.3.1.1.5-6 shows the PAS with the EVA interfaces for operating the EVA release mechanism indicated.

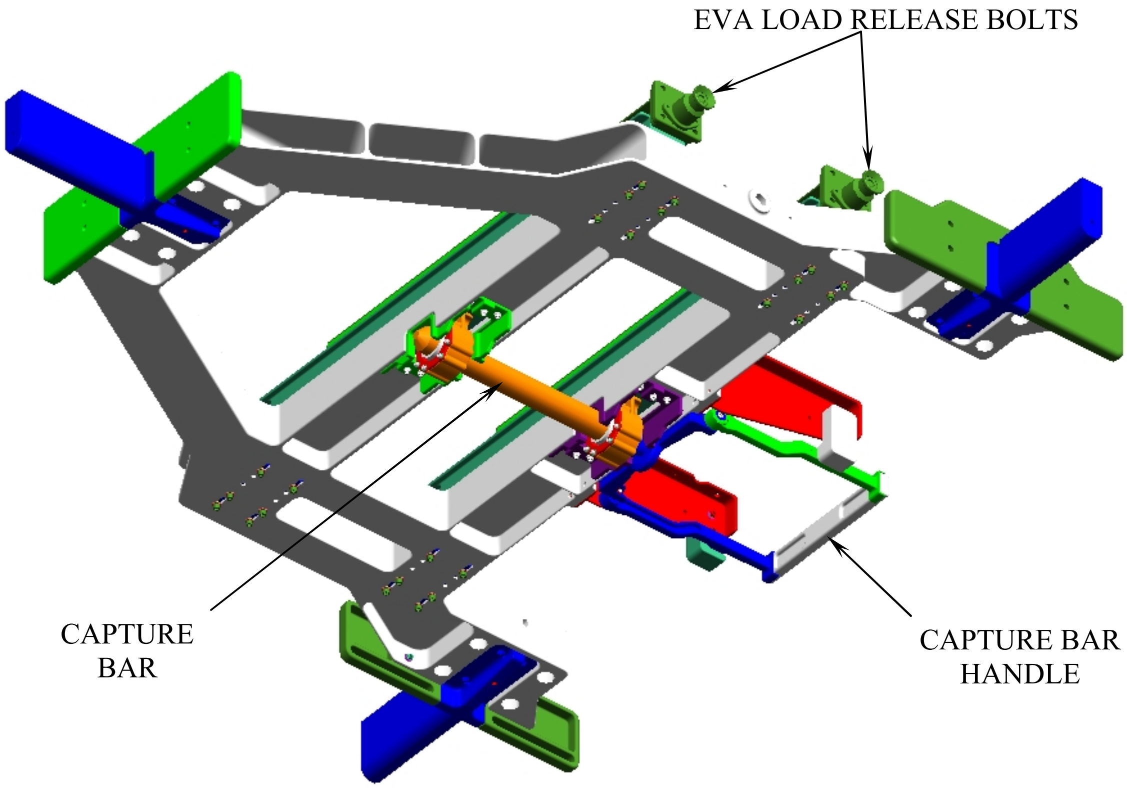


Figure 3.3.1.1.5-6 PAS EVA Releasable Capture Bar

The AMS-02 PAS Assembly is bolted to the Lower USS-02 via four brackets, the Vertex Bracket, two Aft Brackets and the UMA Bracket. The AMS-02 PAS Assembly (Figure 3.3.1.1.5-7) consists of five bolted subassemblies, the PAS Base Assembly, EVA Extension Assembly, PAS Bridge Assembly, Capture Bar Assembly, and EBCS Avionics Assembly.

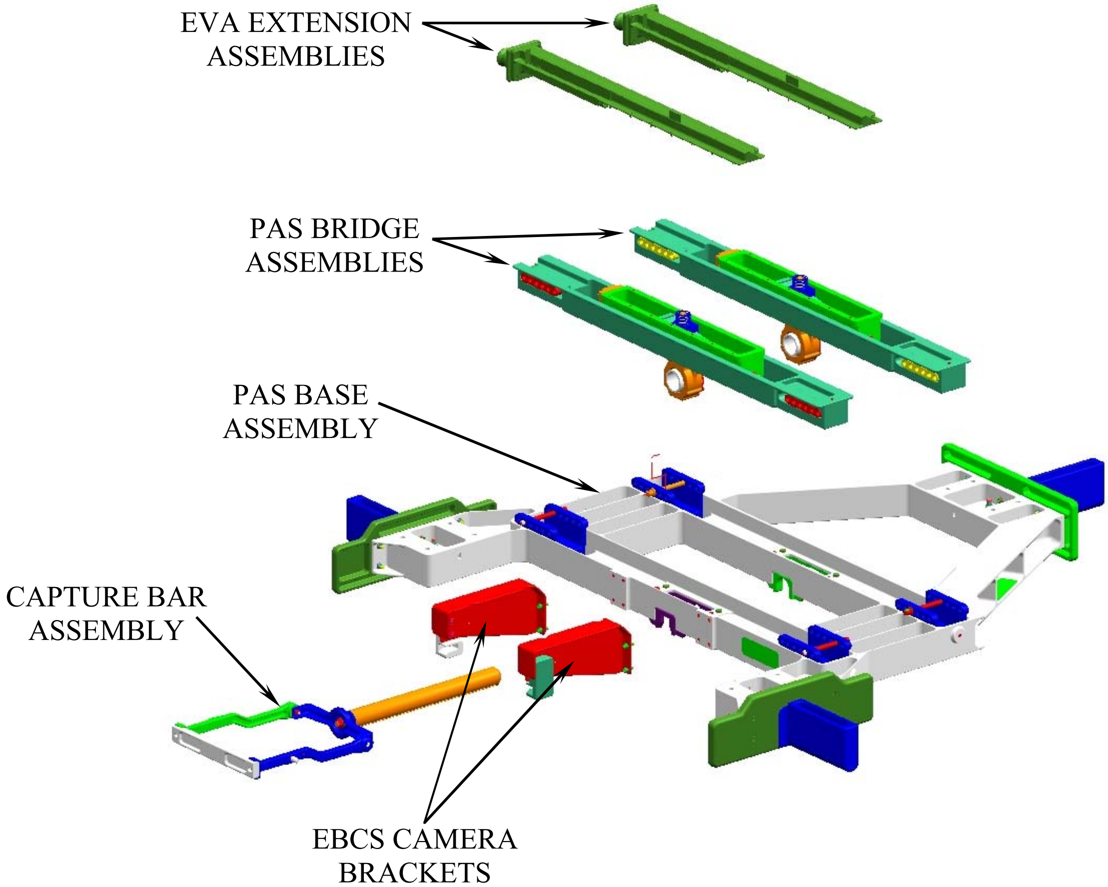


Figure 3.3.1.1.5-7 AMS-02 PAS Component Detailed Description

3.3.1.1.6 <u>AMS-02 ROEU Support Bracket</u>

The AMS-02 utilizes a Remotely Operated Electrical Umbilical (ROEU) to provide electrical and communications links to the Orbiter while the AMS-02 is secure in the payload bay. In order to position the passive half of the ROEU, the Payload Disconnect Assembly (PDA) that is attached to the AMS-02 in the correct position to mate with the Orbiter active half of the ROEU the AMS-02 ROEU support bracket is required. Figures 3.3.1.1.6-1 (1 and 2) show the ROEU Bracket with the PDA and its Cabling attached to the USS-02 and Interface Panel A.

PIVOT PIN

ARM

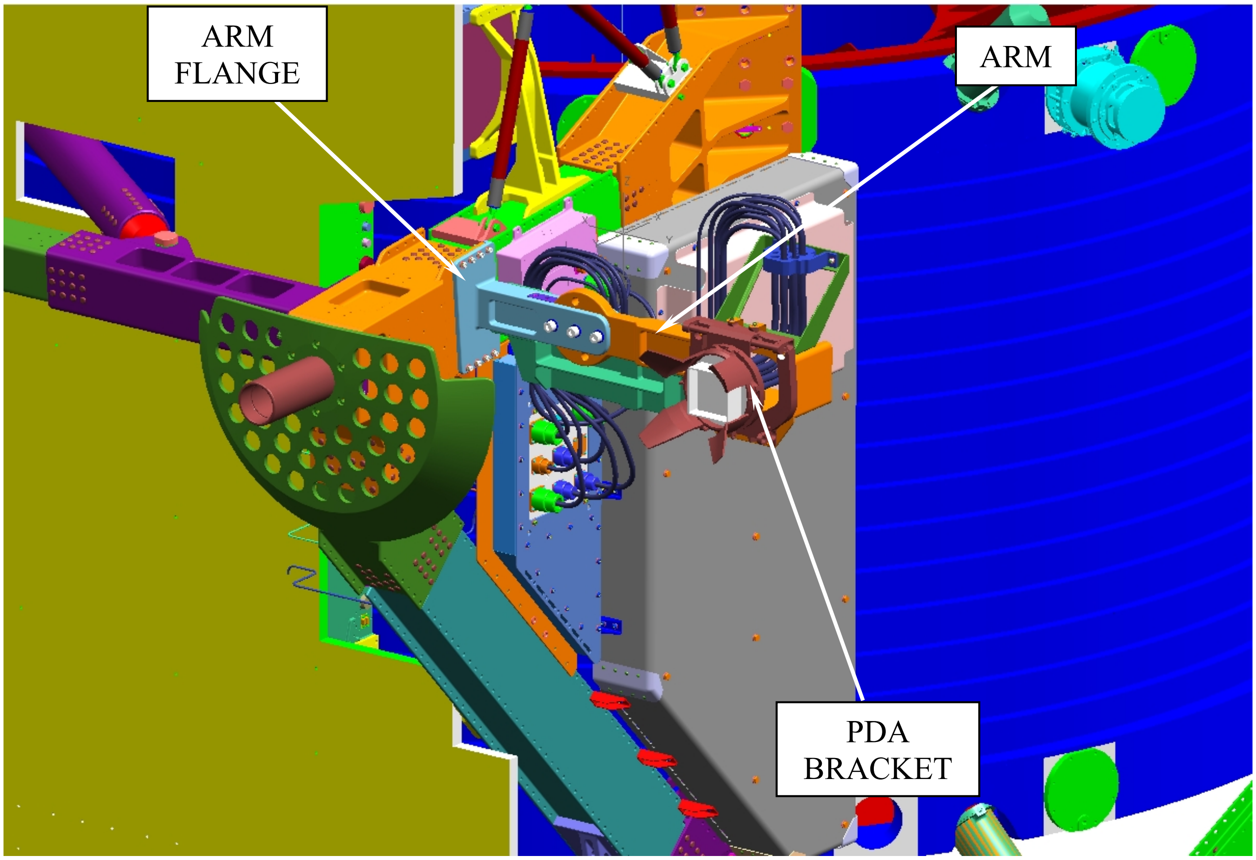


Figure 3.3.1.1.6-1 ROEU Bracket **with PDA and Cabling to Interface Panel A (1 of 2)**

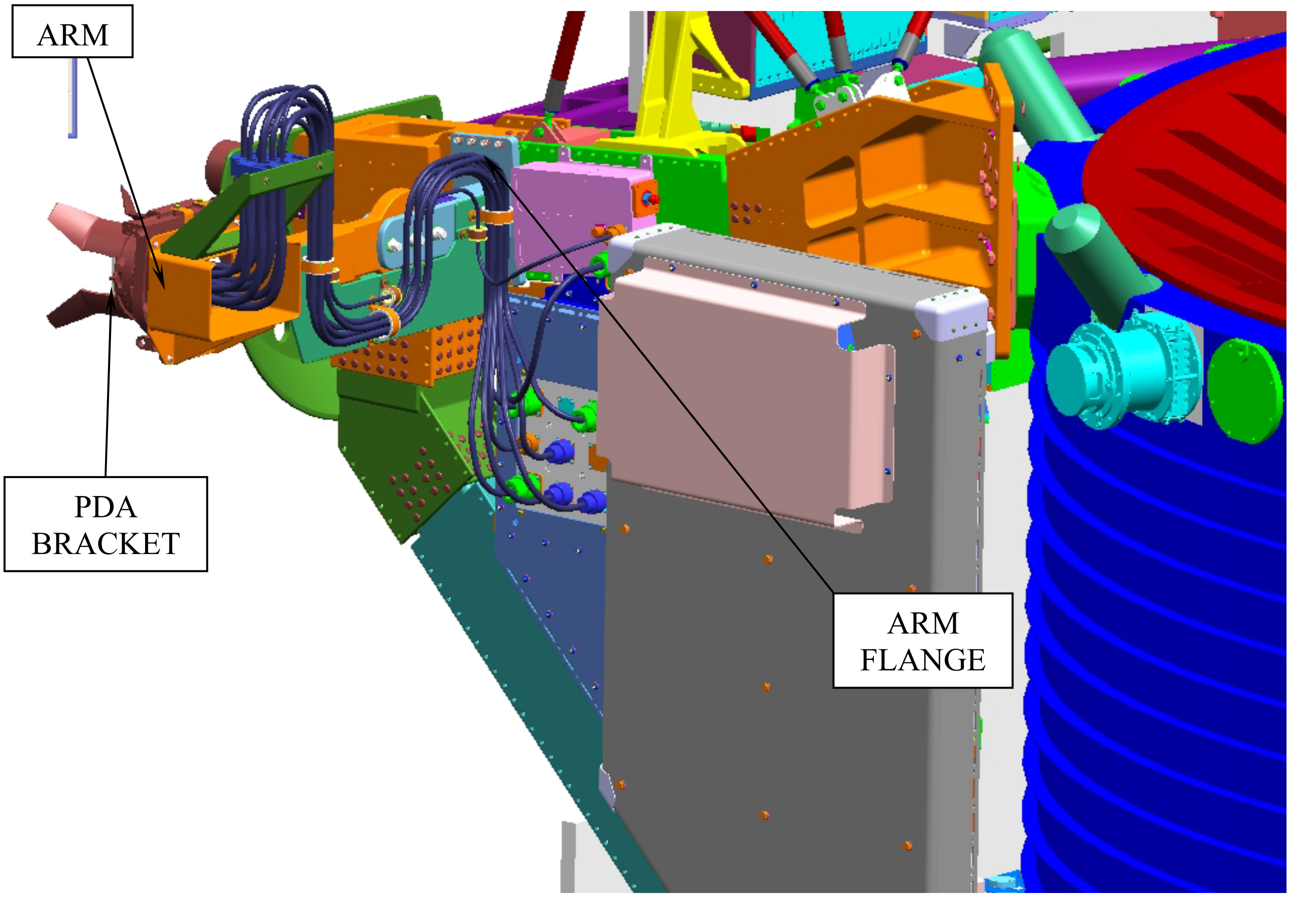


Figure 3.3.1.1.6-1 ROEU Bracket with PDA and Cabling to Interface Panel A (2 of 2)

3.3.1.1.7 AMS-02 Power and Data Interfaces

The AMS-02 will interface with three sources of power, the shuttle Orbiter, the ISS at the S3 Truss upper inboard PAS position and with the Space Station Remote Manipulator System (SSRMS). On board the Orbiter all power is routed through the ROEU. The PIH associated with the Shuttle Program provided ROEU PDA includes the wiring into the AMS-02 Power Distribution System (PDS) and the structural interface (See 3.3.1.1.6). The power supplied by the ISS through the truss connection at the PAS is provided through the ISS provided Passive UMA connector. The Passive UMA connector is wired into the AMS-02 PDS as part of the PIH and the structural interface is provided as part of the PAS (See 3.3.1.1.5). The electrical power provided to the AMS-02 during SSRMS handling goes through the ISS provided Power Video Grapple Fixture (See 3.3.1.1.9) and wired into the AMS-02 power distribution system utilizing a fuse to limit the maximum current the AMS-02 can draw through the SSRMS.

3.3.1.1.8 AMS-02 Power Video Grapple Fixture (PVGF)

A PVGF, mounted on the aft port side of the Upper Trunnion Bridge Beam of the AMS-02 payload, provides an additional structural/mechanical interface with the Mobile Servicing System allowing the SSRMS or the Payload/Orbiter Replaceable Unit (ORU) Accommodation to grapple the payload. The PVGF mounts to the PVGF Bracket using six high strength (200 ksi ultimate) ⅜" diameter bolts. The PVGF Bracket is mounted to the Upper Trunnion Bridge Beam with 24 high strength (180 ksi ultimate) ¼" diameter bolts. The PVGF attachment location on AMS-02 is shown in figure 3.3.1.1.8-1. An exploded view of the attachment hardware is shown in Figure 3.3.1.1.8-2. Electrically the PVGF will provide pass-through power from the SSRMS to AMS-02, but not data communication. Power supplied to AMS-02 during this operation is for heater operations and the EBCS only.

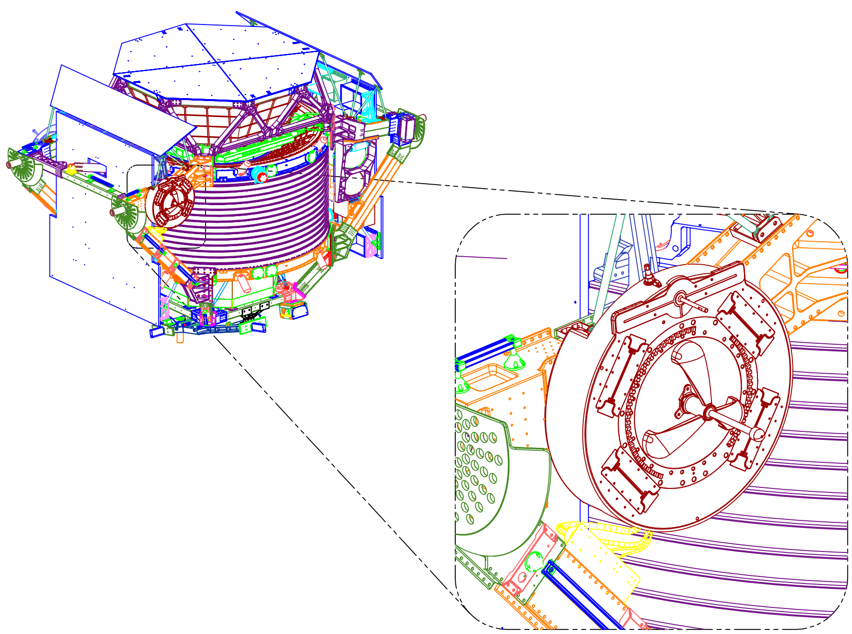


Figure 3.3.1.1.8-1 PVGF Mounted to the Upper Trunnion Bridge Beam USS-02

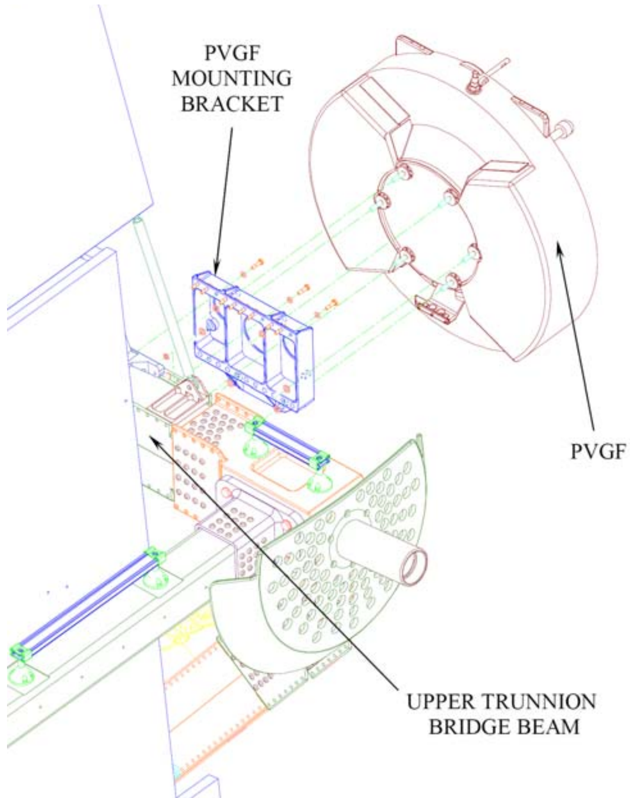


Figure 3.3.1.1.8-2 The PVGF to USS-02 Mounting Hardware

3.3.1.1.9 AMS-02 External Berthing Camera System (EBCS)

The EBCS is a camera and avionics package provided by the ISS Program that is structurally mounted to the passive PAS assembly on the AMS-02 (Figure 3.3.1.1.9-1). The EBCS provides visual cues to the SSRMS operator through robotic workstation monitors to assist in the berthing of the payload to the active PAS on the ISS truss. The system is comprised of an avionics package which contains both primary and secondary video cameras and an EBCS Target which his mounted on the active PAS site. Electrical and video connections are made through the SSRMS and PVGF when the PVGF is grappled by the SSRMS. The electrical services of EBCS include video, power, heater power and AMS-02 heater power. The EBCS Avionics mounting is the responsibility of AMS-02. The mounting requirements are defined in SSP 57003 Section 3.7.6.1, SSP 57004 Figures 3.1.2.2-1 and SSP 57004 Figures 3.7.1-1. Additional mounting data is contained in MDR-BTM-7498, EBCS Avionics Package Detailed Installation Instructions produced by MD Robotics per NASA contract NAS9-00089.

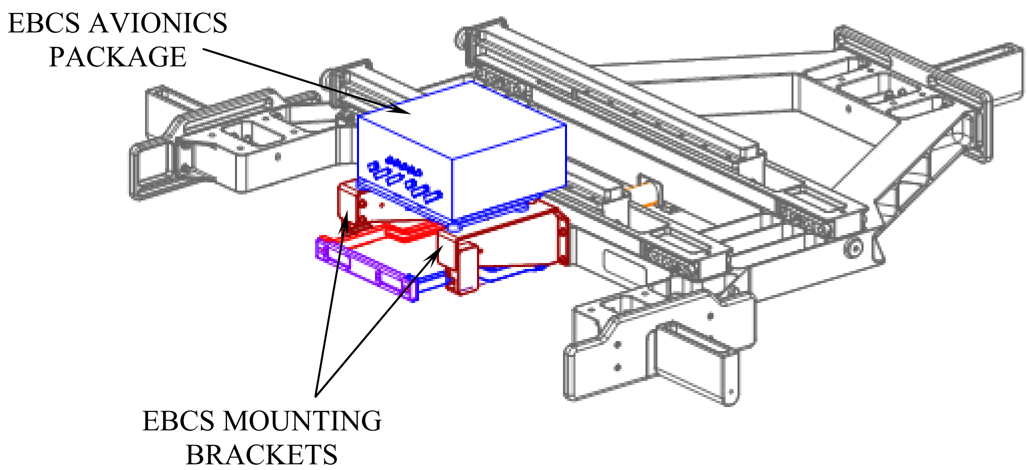


Figure 3.3.1.1.8-1 The EBCS Mounted on the AMS-02 Passive PAS

3.3.1.1.10 AMS-02 Flight Releasable Grapple Fixture (FRGF)

An FRGF, mounted to the AMS-02 payload, will be used by the Shuttle Remote Manipulator (SRMS) to lift the AMS-02 out of the Orbiter payload bay. The FRGF is mounted to the FRGF Bracket using six high strength (200 ksi ultimate) ⅜" diameter bolts. The FRGF Bracket is bolted to the forward face of the port Upper Trunnion Bridge Beam using 24 high strength (180 ksi ultimate) ¼" diameter bolts. The FRGF placement on the USS-02 is shown in Figure 3.3.1.1.10-1. An exploded view of the attachment hardware is shown in Figure 3.3.1.1.10-2.

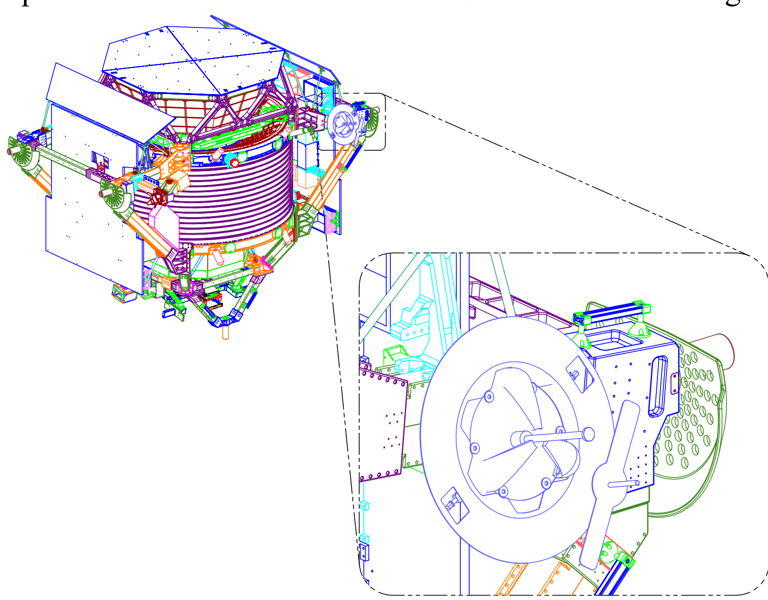


Figure 3.3.1.1.10-1 The FRGF Mounted to the Upper Trunnion Bridge Beam USS-02

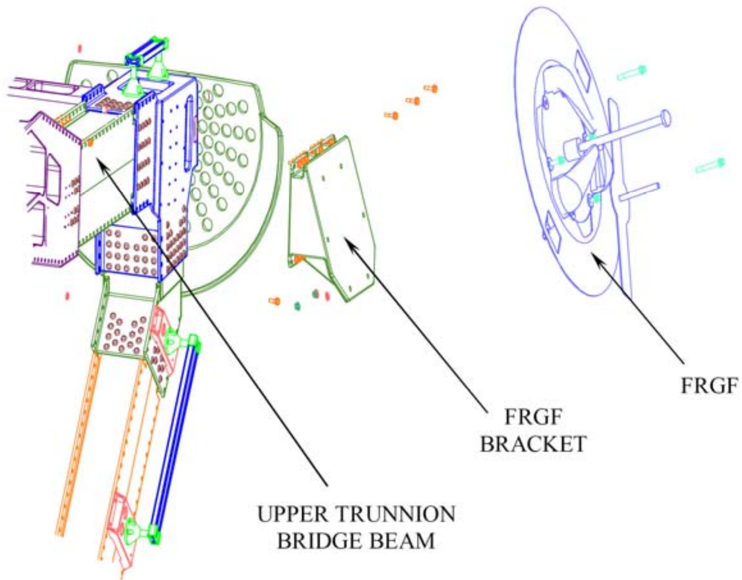


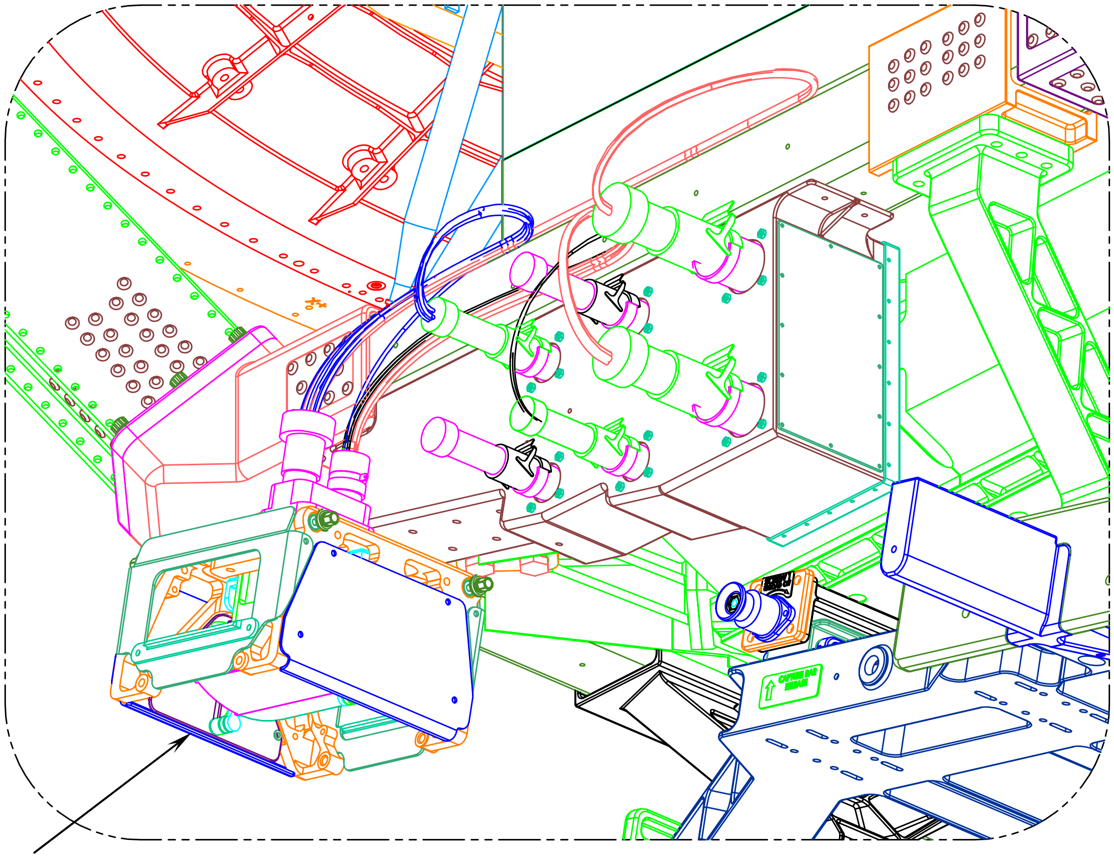
Figure 3.3.1.1.10-1 The FRGF to USS-02 Mounting Hardware

3.3.1.1.11 AMS-02 Payload Disconnect Assembly/Remotely Operated Electrical Umbilical (PDA/ROEU)

The PDA for the ROEU is the AMS-02 half of the ROEU system. The PDA is used to make the electrical interface between the Shuttle and the AMS-02 payload. The PDA is mounted to the ROEU bracket which is attached to both the Primary Sill Joint and the Upper Trunnion Bridge Beam with 12 high strength (180 ksi Ultimate Strength) ¼" diameter bolts. The PDA mounted to the ROEU Bracket Assembly is shown in Figures 3.3.1.1.6-1 through 3.3.1.1.6-3.

3.3.1.1.12 AMS-02 Umbilical Mechanism Assembly (UMA)

The passive UMA is used to electrically connect the AMS-02 payload to the ISS truss attach site. The UMA attaches to the lower USS-02, as shown in figure 3.3.1.1.12-1, and interfaces with the active UMA mounted to the ISS PAS site as per SSP-57003.



UMA

Figure 3.3.1.1.12-1 The UMA Mounted to the EVA Connector Panel

3.3.1.2 AMS-02 Experiment Hardware

The AMS-02 Experiment utilizes a large cryogenic superfluid helium (SFHe @ 2° K) superconducting magnet (Cryomag) to produce a strong, uniform magnetic field (~ 0.8 Tesla) within the core of the magnet. The experiment has planes of detectors above (TRD, Upper TOF), in the center of (Silicon Tracker, ACC), and below (Lower TOF, RICH, ECAL) the magnet (reference Figure 3.2-1). In addition to the detectors, the experiment has a number of subsystems that interface with the detectors to provide power, collect experiment data, provide precise time and positioning data, and keep the instruments within thermal limits. The following paragraphs provide descriptions of the detectors and subsystems that comprise the experiment hardware.

3.3.1.2.1 <u>AMS-02 Cryogenic Superconducting Magnet (Cryomag)</u>

The Cryogenic Superconducting Magnet, or Cryomagnet, is at the heart of the AMS-02 experiment. Trajectories of incoming particles are bent by the magnetic field. The Silicon tracker detects this trajectory, which allows AMS-02 to identify the magnitude and sign of the particles' electrical charge. The magnet has a bending power of 0.86 Tm^2, which combined with the spatial resolution of the tracker, allows measurements of particles extending into the multi-TeV energy range. The high field strength of the Cryomagnet is possible through the use of superconductors that are chilled by a superfluid helium (SFHe) Cryosystem serving as a heat sink operating at 4 K or below.

Most of the Cryomagnet (Figure 3.3.1.2.1-1) and related special test equipment has been developed and manufactured by Eidgenossische Technische Hochschule (ETH) in Zurich through a sub-contract with Scientific Magnetics (SM) in Culham, England and Hans Bieri Engineering (HBE) in Winterthur, Switzerland. The magnet and its cryosystem are controlled through the Cryomagnet Avionics Box (CAB), which is being developed by Computadoras, Redes e Ingeniería SA (CRISA) in Madrid, Spain. The Vacuum Case (VC) was designed by Lockheed Martin and was built at the Standard Tool and Die Company (STADCO) in Los Angeles. The entire cryomagnet system is currently estimated to weigh 7050 lbs (3,198 Kg).

The magnet consists of 14 coils. The primary component of the field is created by the two large dipole coils. The twelve racetrack coils further shape the field, raising the strength within the bore of the magnet to 8600 G while minimizing the stray field external to the VC. The external field has a maximum value of 2000 G at the outer surface of the vacuum case and drops rapidly as distance increases away from the center of the AMS-02. To generate the required field of 8600 G, the AMS-02 magnet will run with a nominal current of 459.5 A. The field in the primary measurement volume and the fringe field will be completely mapped as part of the magnet functional testing.

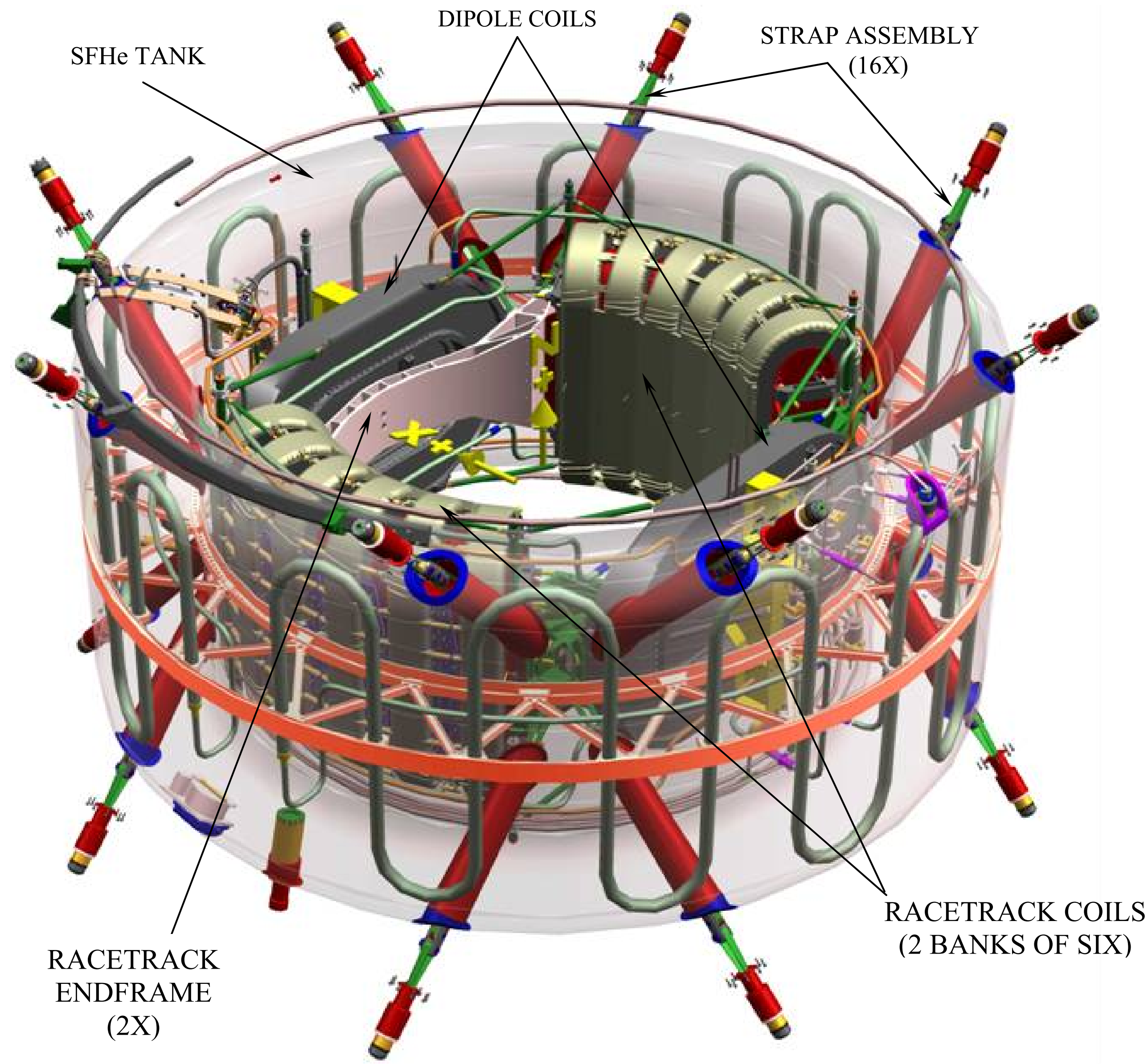


Figure 3.3.1.2.1-1 Cryomagnet, Helium Tank, and Support Straps

Each magnet coil is comprised of superconducting wire wrapped around a structural support made of Al 6061, which keeps the coil in its elliptical shape. The large racetrack end frames are also made of Al 6061, hold the coils in their proper relative positions and resists the magnetic forces generated when the magnet is active. These magnetic forces are on the order of 250 tons and are much larger than any other loads the magnet will see during either flight or ground operations.

The magnet is attached to the Vacuum Case (VC) by sixteen support straps (also shown in Figure 3.3.1.2.1-1). Each strap attaches to one of the VC support rings and a clevis at the corner of the racetrack end frames. The design prevents the high magnetic operational loads from being transmitted back to the rest of the structure and the thermal loads of the rest of the structure from being transmitted to the coils. Figure 3.3.1.2.1-2 shows the basic construction of the strap.

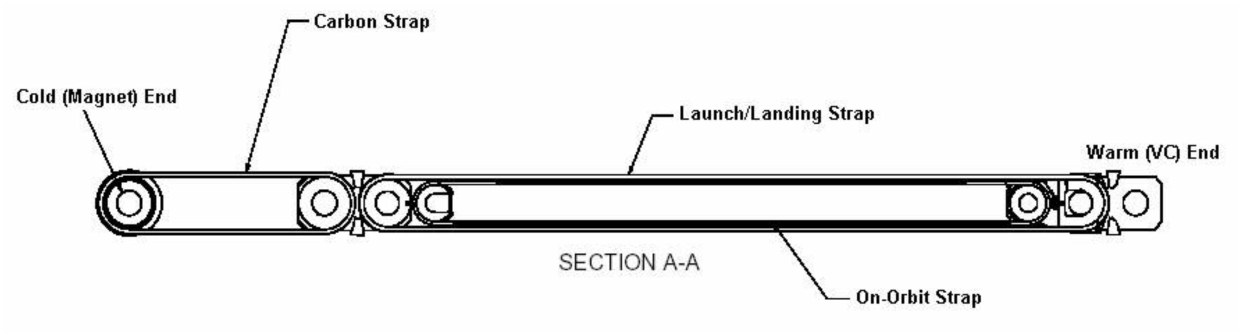


Figure 3.3.1.2.1-2 Support Strap Construction

The warm end of each strap assembly rests on a stack of Belleville washers inside a cylindrical fitting known as the "wineglass." The wineglass is in turn bolted to one of the support rings of the VC. An overall schematic of the fitting is shown in Figure 3.3.1.2.1-3. The Belleville washers are present in order to reduce the stiffness of the overall system and avoid causing long-term assembly stresses in the VC. This low-stiffness response will continue until the washer stack fully flattens and becomes for all practical purposes infinitely rigid.

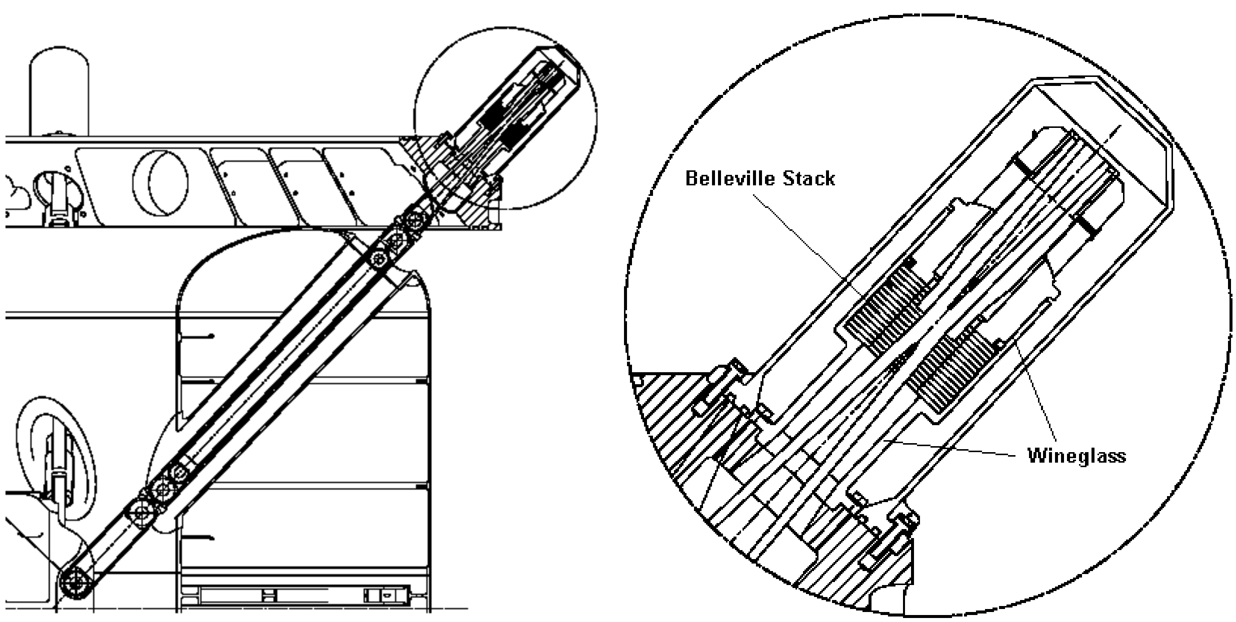


Figure 3.3.1.2.1-3 Wineglass Fitting

The magnet coils must be kept at a temperature of 4 K or less in order to remain super-conductive. Not only must the temperature be maintained for the life of the mission, but the magnet must also be able to be recharged after an on-orbit quench without EVA support. Helium becomes a superfluid when normal liquid helium is cooled below 2.17 K and serves as the cooling medium for the Cryomag.

The AMS-02 cryogenic system schematic is shown in Figure 3.3.1.2.1-4. Heat is removed from the magnet coils through the Superfluid Cooling Loop, which then conducts the heat into the main Helium tank. This tank is at 1.8 K and is the ultimate heat sink for the entire system. As the Helium slowly boils away, vapor is removed from the system and flows through a series of four vapor cooled shields operating between 1.8 K and 60 K which surround the magnet assembly. Small thermal connections run between these shields and the metallic fittings on the support straps to further reduce the heat leak into the main tank from the structural supports. The outermost vapor-cooled shield is thermally attached to four cryocoolers, which further reduce the overall temperature and slow the rate of helium loss.

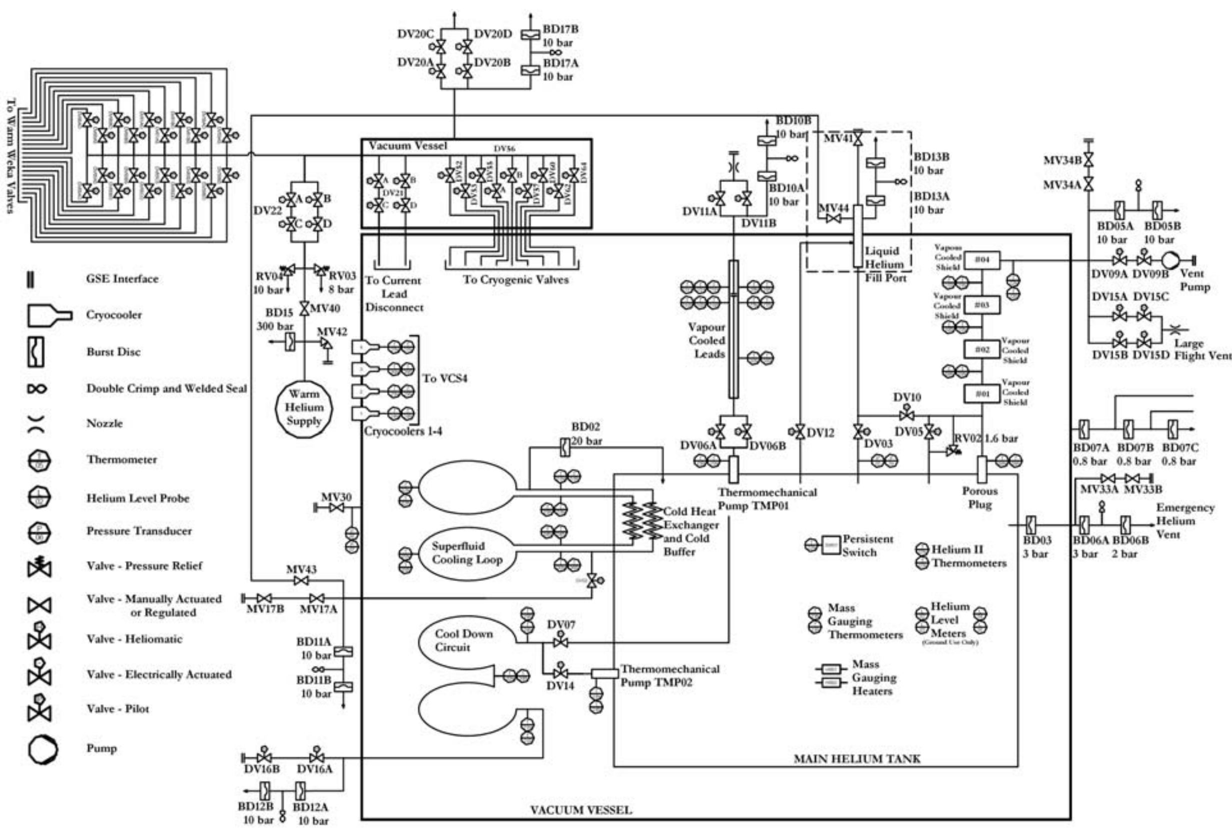


Figure 3.3.1.2.1-4 Cryogenic Cooling System

Each magnet coil has two thermal shunts attached to the Superfluid Cooling Loop, which runs along the top and bottom of the magnet. The loop is a copper pipe filled with superfluid helium at 1 bar pressure. Heat in the coils is conducted through the shunt into the liquid inside the loop. The cooling loop in turn extends into the main Helium Tank where a serpentine heat exchanger dissipates the heat into the superfluid helium. Cooling the magnet by means of a thermal bus and external tank provides AMS-02 the ability to recover from a quench.

The SFHe Tank is a 2500 liter toroidal vessel which contains the cryogen used by AMS-02. The tank consists of a central support ring attached to two rib-stiffened cylinders. The inner cylinder has a radius of 0.96 meters (3.15 ft) and the outer cylinder has a radius of 1.29 meters (4.23 ft). The tank is made up of Al 5083 forgings and all interfaces are welded. The construction technique used to fabricate the tank optimizes the ability of the tank to withstand helium permeation of the aluminum by careful control of the material "grain" orientation.

Sixteen through-tubes are included in the tank to allow the strap assemblies to pass through tank. Structural analysis has shown that these tubes are wide enough to prevent the strap from contacting the side of the tank. The remainder of the ports seen in the figure are thermal and electrical interfaces with components inside the tank or ports designed to support filling and venting operations.

As heat is dissipated into the SFHe Tank, the vapor generated is separated from the liquid by means of a porous plug. This vapor then flows into small tubes inside a series of four Vapor Cooled Shields (VCS). These shields surround the magnet and helium tank assembly and are connected via small thermal shunts to the metallic portions of the support strap assemblies.

The final stage of the magnet thermal control system is four Stirling-cycle cryocoolers which attach to the outermost VCS. Together they remove approximately 12W of heat from the system. This additional temperature drop has been calculated to reduce Helium consumption by a factor of four. After this final cooling stage, the helium gas is allowed to vent to space from a zero-thrust vent aligned with the ISS Y-axis.

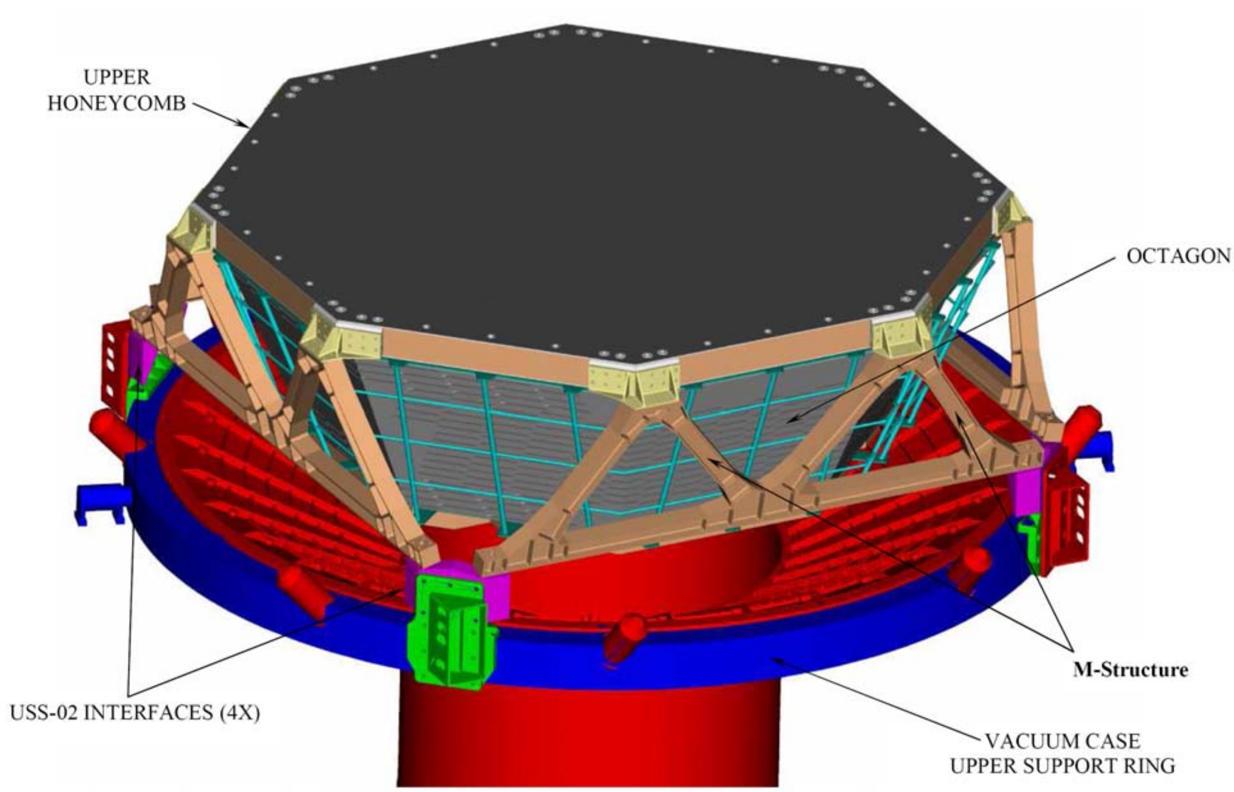
3.3.1.2.2 Transition Radiation Detector and associated Gas System (TRD)

The role of the TRD (Figure 3.3.1.2.2-1) is to discriminate between electrons/anti-protons (e^-/p^-) and positrons/protons (e^+/p^+) over the Energy (E) range E = 3 – 300 GeV. This is accomplished by detecting X-ray photons emitted by electrons and positrons when they pass through a radiator. For heavier particles the emission of this radiation is strongly suppressed. The radiation is detected in tubes filled with Xe and CO_2 gas in an 80:20 ratio. Xenon gas ionizes very easily and is thus very sensitive to the passage of photons.

The TRD detector is composed of 5248 proportional tubes which are made from a multi-layer wound composite structure. The composite includes layers of polyurethane, carbon-polyimide, aluminum, and Kapton. The straw tubes are grouped into 10 distinct segments which are connected through gas manifolds. The straws have an inner diameter of 0.24 inch (6.02 mm), a wall thickness of 0.003 inches (72 microns), and vary in length from 31.5 inches (0.8m) to 78.7 inches (2.0m).

A straw module consists of 16 straws glued together with 6 stiffeners running alongside the straws. Every 3.94 inches (10 cm), additional stiffeners are glued across the module for extra rigidity. The straw ends are glued into polycarbonate endpieces. The endpieces contain the wire fixation pieces (wire: gold plated tungsten, 0.001 inch (30 microns) diameter; wire fixation pieces (Cu/Te alloy), the gas distributor, and the gas seal.

The TRD is constructed with 20 layers of the straw modules where a gap of 0.91 inch (23 mm) between the layers is filled with a radiator material (polypropylene fleece). The upper 4 layers (72 modules) and the lower 4 layers (56 modules) are oriented in the X-direction and the 12 middle layers (200 modules) in the Y-direction



.

Figure 3.3.1.2.2-1 Transition Radiation Detector Structure

The 20 layers of straw modules and radiators are mounted in an octagon structure which consists of 8 honeycomb side panels [1.18 inches (30 mm) thickness], a lower honeycomb support plate, and an upper honeycomb plate. The size of the octagon structure is 91 inches x 24.5 inches (height) (2.3 m x 0.6 m). The combined weight of the TRD is 742.3 lbs (336.7 Kg). Inside the octagon structure, the straw modules are further supported by 4 bulkheads (0.1 inch (3 mm) thick), 2 in the Y-direction and 2 times 2 smaller ones in the X-direction.

The TRD is located at the top of the experiment stack above the Upper TOF. The Octagon Structure is supported by the M-Structure, which is mounted to the USS-02 at four locations, just above the Vacuum Case interface. The TRD corner joints are hard-mounted to the corner joints on the upper USS-02 (Figure 3.3.4-1).

The front-end readout electronics and the High Voltage (HV) distribution boards are mounted on special boards close to the module end pieces. The gas distribution system is also mounted close to the ends of the modules on the opposite side of the electronics.

The TRD Gas Supply System (Figure 3.3.1.2.2-2) supplies a mixture of 80% Xenon (Xe) and 20% Carbon Dioxide (CO_2) to the straw tube modules. The density and purity of the gas mixture is monitored and adjusted to ensure efficient photon detection. The gas supply system (Box S) includes three tanks, one for the Xe, one for the CO_2, and one mixing tank. These tanks are mounted to a support bracket and covered by shields to protect them from orbital debris.

The Xe tank is a composite over-wrapped stainless steel tank that is designed and built by Arde, Inc. It has a maximum design pressure (MDP) of 3000 psid with a minimum temperature rating of –60°F and a maximum temperature rating of 150°F. The tank was designed with a proof test factor of 1.5 x MDP and a minimum burst factor of 3.1 x MDP. It has an outside diameter of 15.4 inches (390 mm) and a volume of 1680 cubic inches (27.5 liters). It carries 109 lbs (49 Kg) of Xe at launch and has been tested to 8.9 G_{rms} at 0.08 g^2/Hz.

The CO_2 tank is also a composite over-wrapped stainless steel tank designed and built by Arde, Inc. This tank has a maximum design pressure of 3000 psid with a minimum operating temperature of –100°F and a maximum operating temperature of 300°F. The tank is designed with a proof test factor of 1.6 x MDP and a minimum burst factor of 2.1 x MDP. The outside diameter is 12.4 inches (315 mm) and it has a volume of 813 cubic inches (13.3 liters). The tank weighs 9.5 lbs (20.9 kg) and it can hold a maximum of 11 lbs (5.0 kg) of CO_2. A vibration test has been performed to 8.9 G_{rms} at 0.07 g^2/Hz axially and 4.5 G_{rms} at 0.02 g^2/Hz laterally.

The small mixing tank is also manufactured by Arde, Inc. It has a nominal operating pressure of 200 psia, a normal operating temperature of 77°F and an MDP of 300 psid established by dual pressure relief devices and the source gas supply control. A proof test factor of 2.0 x MDP and a minimum burst factor of 4.0 x MDP will be used. The volume will be 61 cubic inches (1 liter).

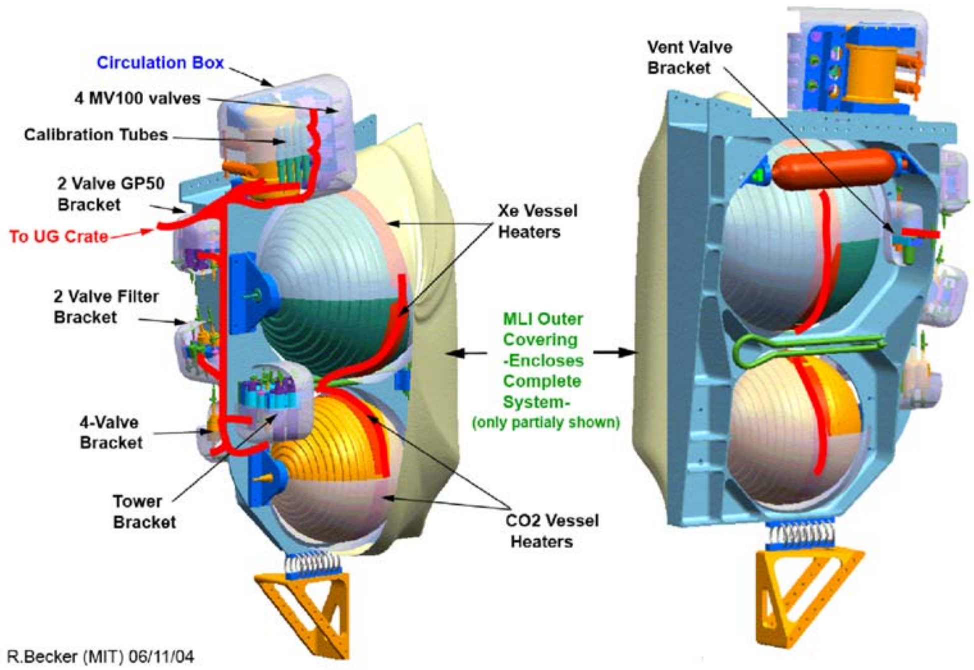


Figure 3.3.1.2.2-2 TRD Gas Box S (Calibration Tubes represent older design)

The fittings and connections in the gas system include stainless steel tubing, welded joints, and numerous gas manifolds. The stainless steel tubing ranges from 0.06 - 0.25 inch (1.6 - 6 mm) outer diameter. Connections are made with welded joints (as an alternate, metal sealed fittings could be used). The connections between the gas manifolds and the TRD segments are made with 0.04 inch (1 mm) inner diameter stainless steel tubing and metal connectors.

The TRD straw tubes have a maximum design pressure of 29.4 psid. The minimum design temperature is –4°F and maximum design temperature is 95°F. The relief valves will be set to 30 psia. Each of the ten separate segments contains 796 – 1708 in^3 (16 – 28 liters) of gas, for a total gas volume of 8.1 ft^3 (0.23 m^3). The nonflammable gas mixture is circulated through these tubes in a continuous loop. The density and purity of the gas mixture is monitored and corrected.

The ten TRD segments are connected through manifolds to Box C, containing controls, monitors, and recirculation pumps. Box S provides Box C with pre-mixed gas from the gas supplies in a limited transfer volume (approximately 1 liter). A feed control between Boxes S and C is activated by computer approximately once a week.

Box C, shown in Figure 3.3.1.2.2-4, contains the two KNF Neuberger UNMP830 pumps for the primary TRD gas circuit. By causing the gas to flow continuously throughout each of the TRD's 10 segments, the gas is not able to separate into pockets and uniform properties are ensured. Box C is mounted on the USS-02 just above the main TRD Gas Supply.

From Box C, 3 mm stainless steel gas lines run to the top rim of the TRD, where input and output manifolds are located. The 5248 tubes of the TRD are grouped into ten separate segments, each separately attached to input and output manifolds (Figure 3.3.4-5). Each manifold is connected to the ten TRD segments via pressure controlled isolation valves. 0.06 inch (1.6 mm) steel tubing runs from the isolation valves to the segment inputs and outputs, where it is joined to the straws via RWTH Aachen designed special connectors. Where other connections need to be made, Cajon VCR fittings are used.

The isolation system is designed to protect the TRD against gas loss in order to maximize efficiency. Leakage of the Xe/CO_2 gas cannot produce a safety hazard, but can cause the gas supply to be used at a faster rate than anticipated and reduce the operational life of the TRD.

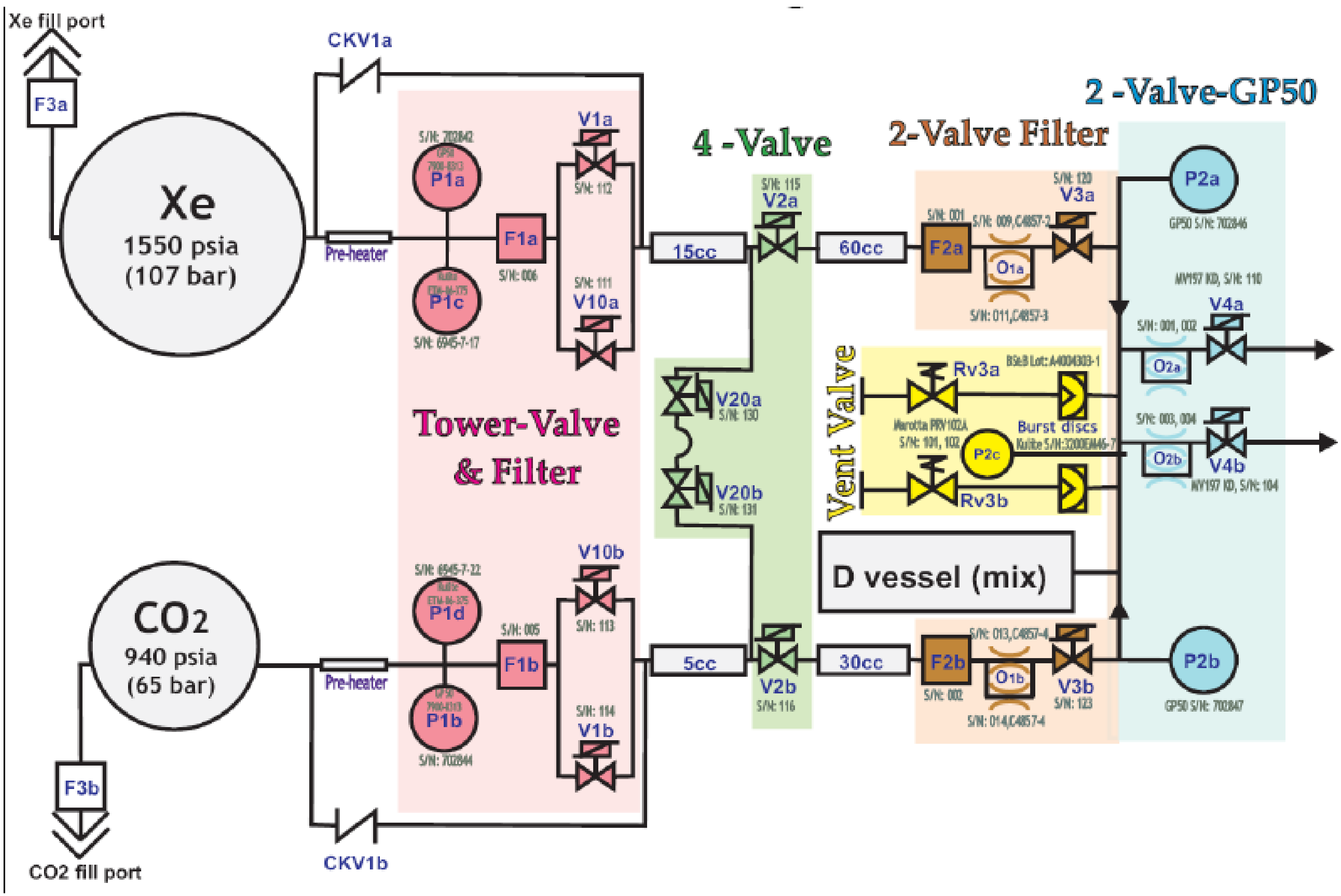


Figure 3.3.1.2.2-3 Box S Schematic

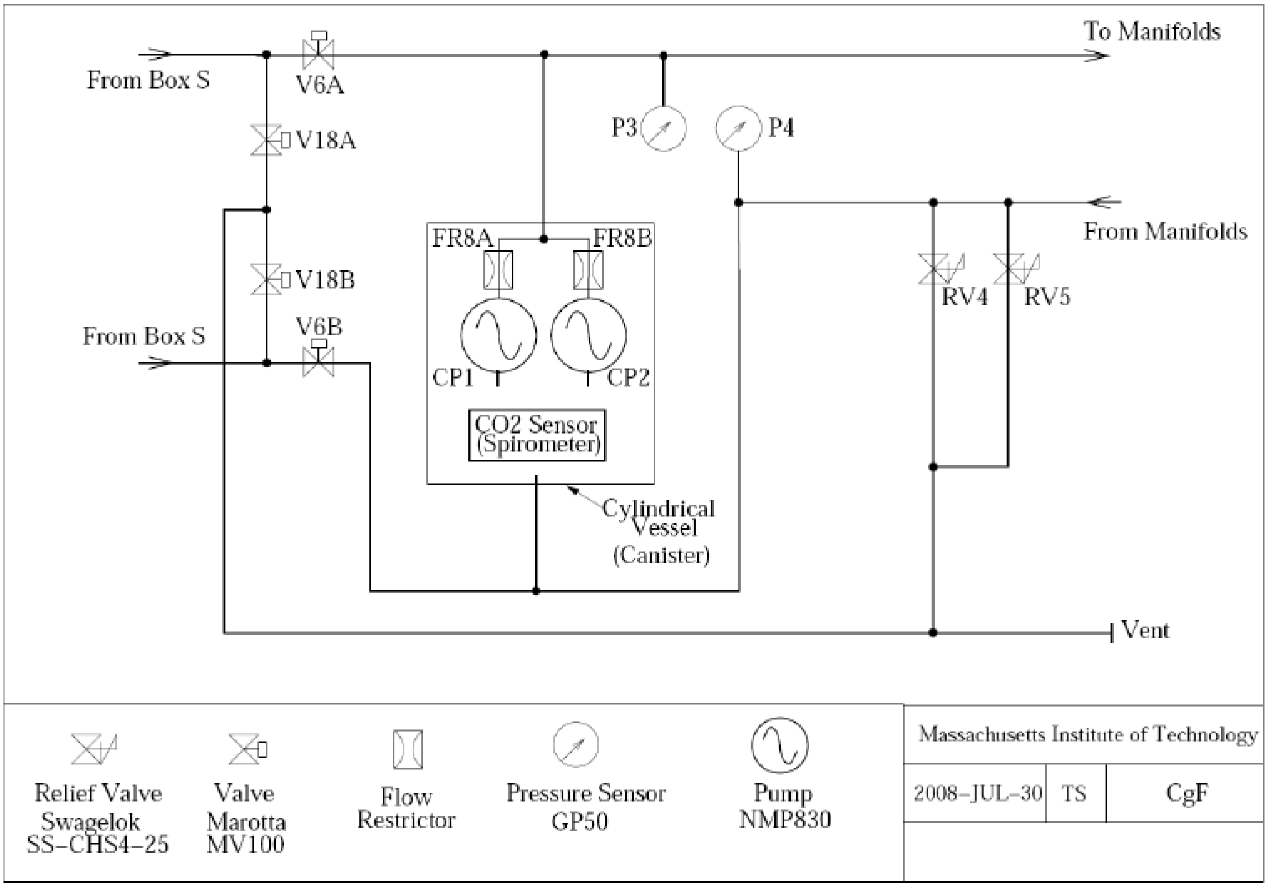


Figure 3.3.1.2.2-4 Box C Schematic

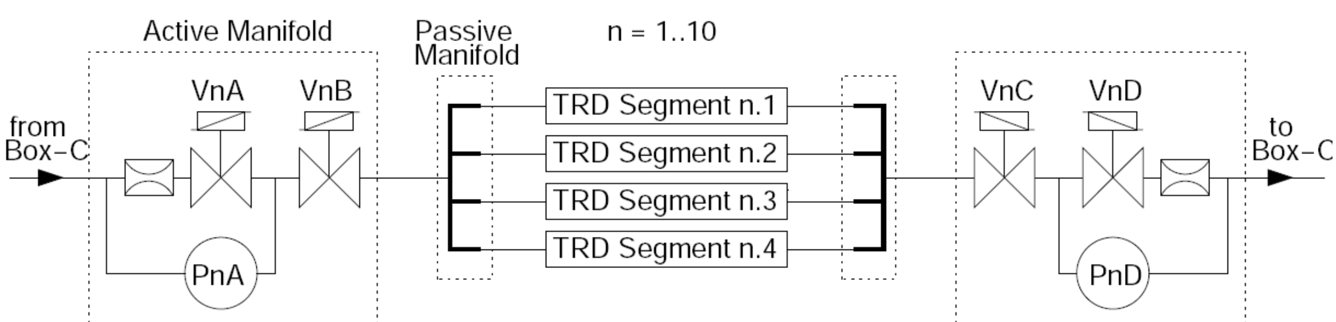


Figure 3.3.1.2.2-5 TRD Straw Manifold Schematic (Example)

The electronics that control the gas system will be located in the UG-crate. This crate will contain a Universal Slow Control Module (USCM) computer that will manage the monitoring and control tasks, as well as maintain communication with the AMS-02 Main DAQ Computer (JMDC). The USCM will be provided with interface electronics to the various gas transducers and actuators scattered throughout the gas system. The USCM and interface electronics will perform the following tasks:

1. Close or open emergency isolation valves in the manifolds.
2. Provide housekeeping data (temperature of valves, pressure vessels, etc.)
3. Store calibration constants.
4. Condition and perform analog to digital conversion for 29 pressure sensors and approximately 500 temperature sensors distributed around the TRD and gas system.
5. Control two recirculation pumps.
6. Provide logic control for 56 gas valves.
7. Interface electronics to provide the power electronics to drive valves, etc.
8. Read out digital signals from the gas analyzer (spirometer)
9. Have control logic to switch the gas system to “Safe Mode” (for mission success) in case of communication failure.

The USCM and interface electronics are doubled to provide single fault tolerance for mission success.

The TRD HV system consists of HV generation cards (UHVG) with six each located in the two U-crates controlled by the crate interface cards (JINF). Each UHVG card drives seven HV lines with twofold internal redundancy to provide single fault tolerance for mission success. Each line is connected via shielded HV cabling to a HV distribution board (UHVD) mounted on the octagon in the vicinity of the readout cards to distribute the HV to four modules (64 tubes). Each unit provides +1600V (control range: 700-1750V) with current limited to <100 microamps.

3.3.1.2.3 Time-of-Flight (TOF) Scintillator Assemblies

The TOF serves to a) be a fast trigger to the experiment for traversal of a particle across the bore of Cryomagnet and Silicon Tracker, b) measure the particles traversing the detector to a resolution sufficient to distinguish between upward and downward traveling particles and c) measure the absolute charge of the particle. Particles that pass through the scintillators generate photons as they pass through the counter paddles, these events detected by groups of two or three sensitive photomultiplier tubes (PMT) on either end of the detector element, the counter paddles. The TOF is composed of four planes of detectors, two atop the AMS tracker, two below as shown in Figure 3.3.1.2.3-1. Numbered from the top down, detector assemblies 1, 2 and 4 have eight detector paddles per plane and detector assembly 3 has ten. The pairs of detector assemblies are oriented 90° to each other, shown in Figure 3.3.1.2.3-2. This configuration gives a 12 x 12 cm^2 resolution for triggering particle events over the 1.2 m^2 area the TOF covers.

Each individual detector paddle is made of polyvinyl toluene (a Plexiglas-like material) that is 12 cm wide and 10 mm thick. End paddles of each layer are trapezoidal with a width of 18.5 to 26.9 cm. Each detector paddle is wrapped in aluminized Mylar and enclosed in a cover made of carbon fiber and includes a depressurization pipe to allow for pressure equalization. In the center of each detector is an LED that is used for calibration and testing. At the ends of each panel are light guides which direct the light of scintillation to photo multipliers. These light guides are curved to orient the photomultiplier tubes within the AMS-02 magnetic field for minimum impact to photomultiplier operations.

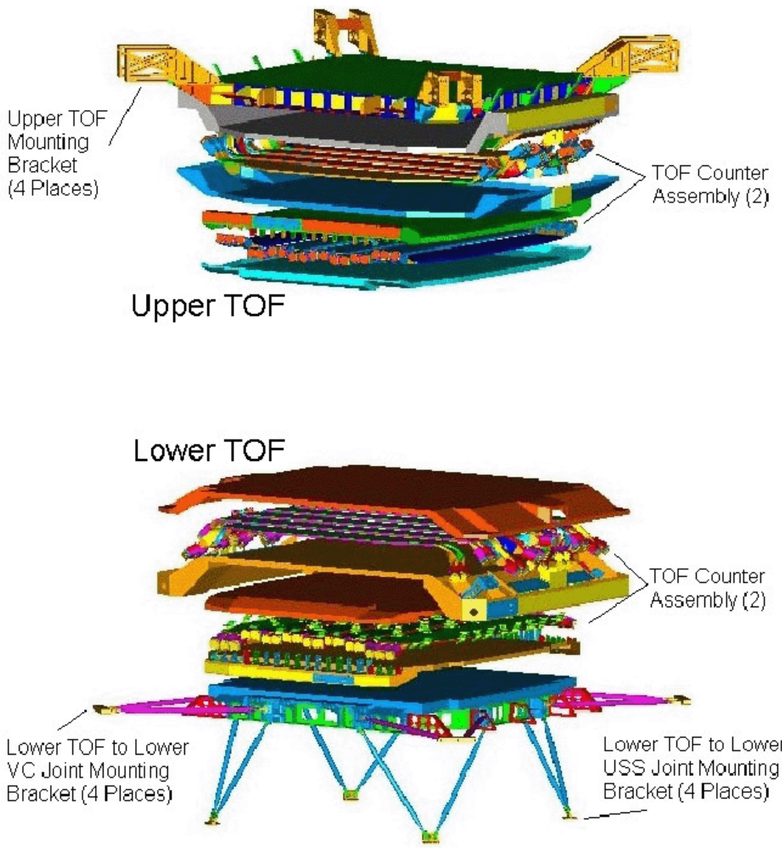


Figure 3.3.1.2.3-1 Time of Flight Counter Construction

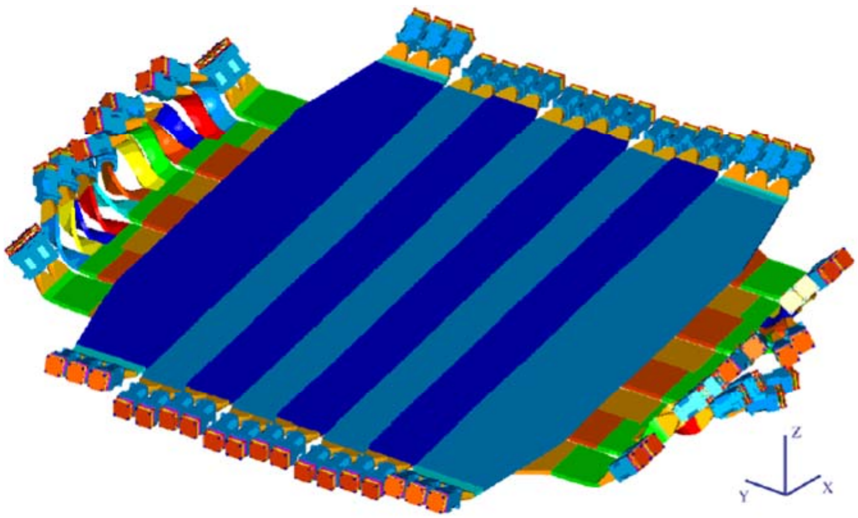


Figure 3.3.1.2.3-2 TOF Detector Paddles Orientation

The TOF is instrumented with 144 Hamamatsu R5946 photomultipliers, used to detect the scintillating light. The PMT operated with a 700-750 Vdc voltage that is supplied by the SHV Crates. The output from the PMTs on each end of the TOF detectors are summed to provide the necessary triggering signal that is provided to the four S Crates for data processing.

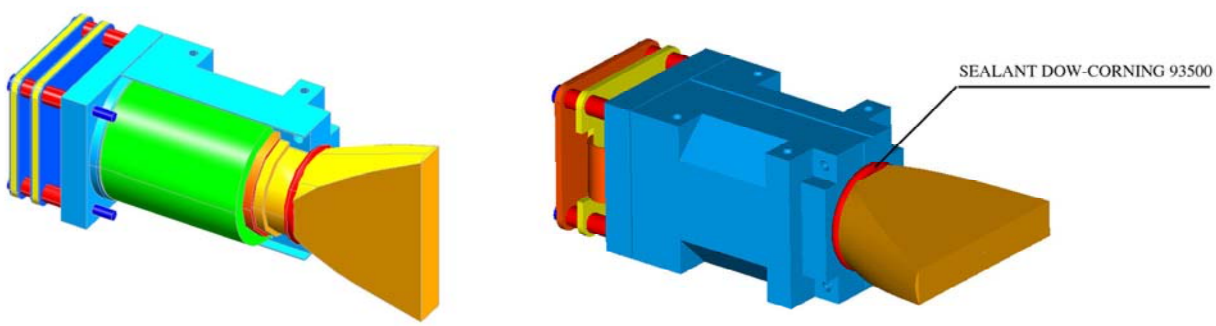


Figure 3.3.1.2.3-3 TOF PMT Construction

The Hamamatsu R5946 PMT is within a PMT housing, shown in Figure 3.3.1.2.3-3.

The PMTs are mounted to the TOF structure at orientations that minimize the impact of the magnetic fields on the PMT operations. Light guides have complex curves to orient the light from the paddles into the carefully oriented PMTs.

Two large flat aluminum honeycomb panels are used to support the scintillator counters. The upper TOF attaches via brackets to the TRD corner joints which hard-mount to the USS-02 upper corner joints. The lower TOF honeycomb is supported to the lower USS-02. The honeycomb panels are roughly circular with a 60.6 inches (1540 mm) equivalent outside diameter. The thickness of the honeycomb aluminum core is 1.97 inches (50 mm) and the aluminum skin is 0.04 inch (1 mm) thick. Figure 3.3.1.2.3-4 shows the mounting of the TOF Upper and Lower units.

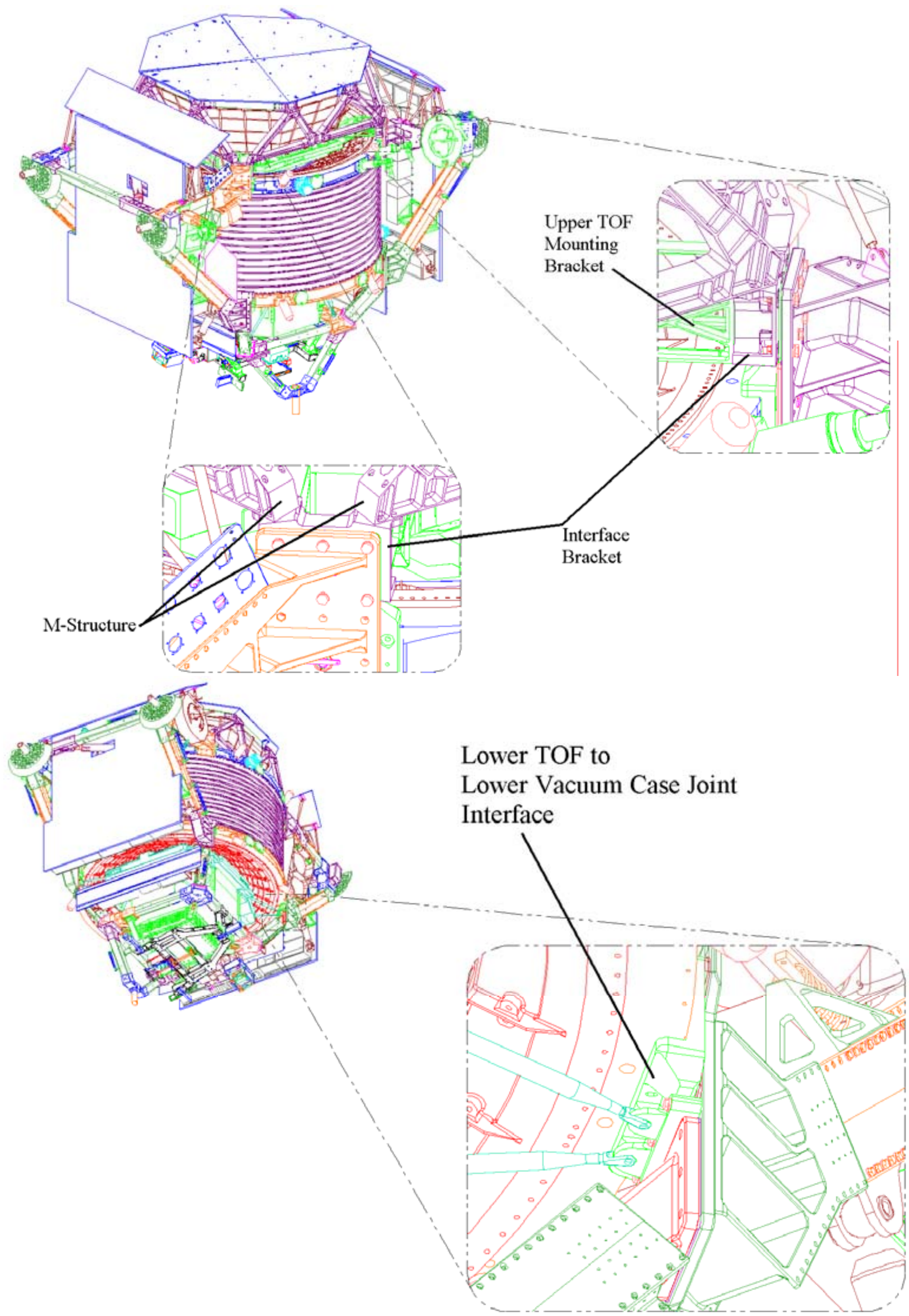


Figure 3.3.1.2.3-4 Structural Interfaces for the Upper & Lower TOF

3.3.1.2.4 Silicon Tracker

In combination with the Superconducting Cryomagnet, the Silicon Tracker represents the centerpiece of the AMS-02 suite of detectors. The Tracker (Figure 3.3.1.2.4-1) consists of eight layers of double-sided silicon micro-strip detectors (ladders) on five support planes. The spatial resolution will be better than 10 µm in the magnet's bending plane and 30 µm perpendicular to that. The planes are placed inside the bore of the magnet, with the six innermost combined to build pairs. The two outermost layers serve as the entrance and outlet windows. All eight tracker planes together comprise 192 silicon ladders corresponding to an active area of about 6 m^2 of silicon and 200,000 readout channels. The entire tracker electronics consume 800 W of power.

The Tracker mounts at eight attach locations (4 at the top, 4 at the bottom) to the Vacuum Case conical flanges.

The three inner planes are ≈ 3.6 ft (1.1 m) in diameter and the top and bottom planes are a ≈ 4.9 ft (1.5 m) in diameter. The Tracker is ≈ 3.9 ft (1.2 m) high and weighs ≈ 438 lbs (198.5 kg).

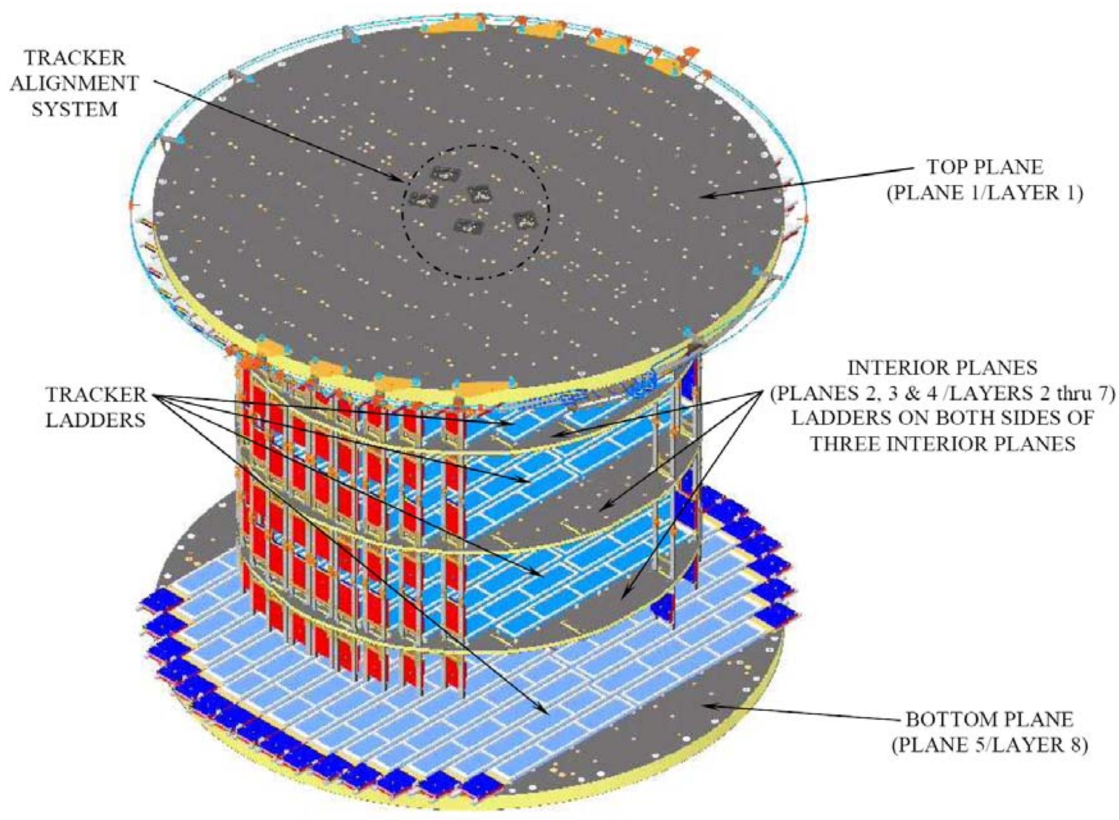


Figure 3.3.1.2.4-1 Layout of the AMS-02 Silicon Tracker

The AMS experiment silicon detector assemblies (Figure 3.3.1.2.4-2) contain silicon ladders made up of a series of 2.836 inches (72.045 mm) x 1.628 inches (41.360 mm) x 0.012 inches (0.300 mm) double-sided silicon micro-strip sensors, electrically connected by microbonds. The silicon sensors are reinforced by sandwich structures made of a 0.2 inch (5 mm) thick Airex foam with light-weight 100 µm thick layer of carbon fiber composite backing. Hybrid boards at the ends of the ladders enable the sensors to be electrically connected to the tracker electronics. The ladder assemblies vary in length from ≈ 11.47 inches (290 mm) to ≈ 40.75 inches (1035 mm), and are 2.836 inches (72.045 mm) wide and ≈ .394 inches (10 mm) thick. Thin-film, 50 µm Upilex (an ultra-high heat-resistant polyimide film) is used extensively in the ladder. A metalized Upilex film, glued directly to the silicon sensors, serves as a routing cable to bring the n-side signals to the n-side front end hybrid, which is located at the ladder end closest to the magnet wall. The flexible Upilex film and a second short Upilex film joining the p-side strips to their hybrid allow the hybrids to be placed back-to-back, perpendicular to the detection plane, thus minimizing the material in the sensitive region of the tracker. Finally, an electromagnetic shield in the form of a doubly-metalized Upilex film surrounds each ladder.

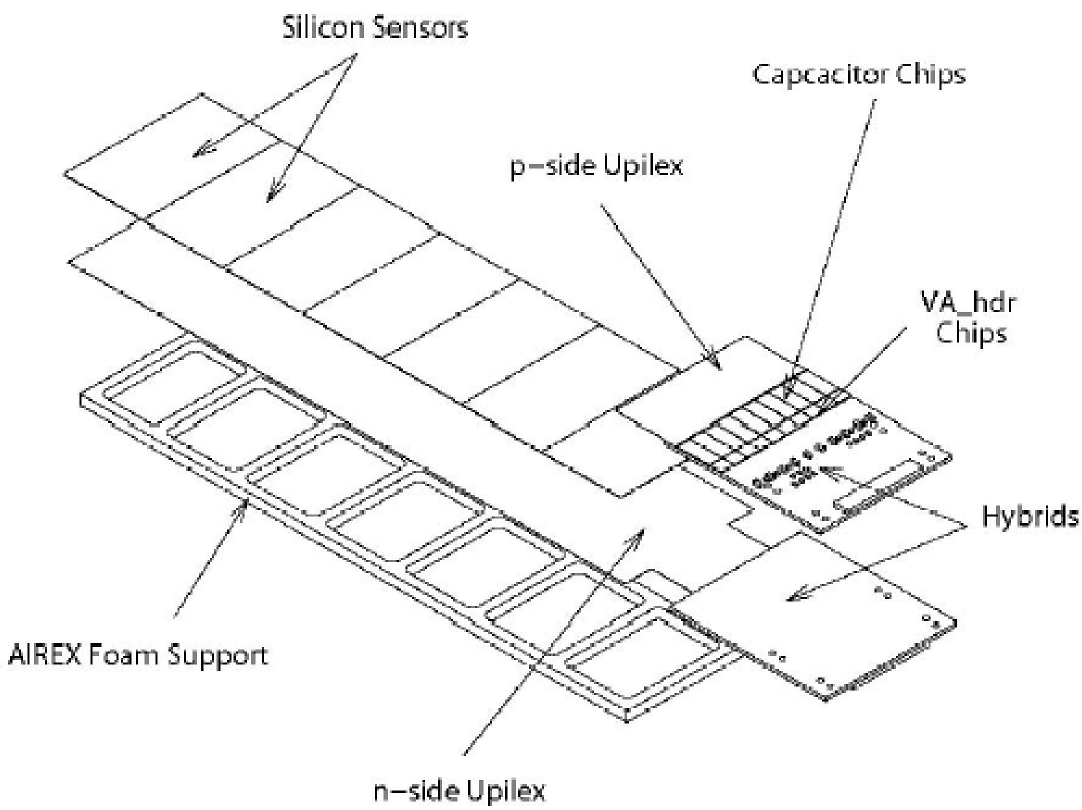


Figure 3.3.1.2.4-2 The principle components of the Silicon Ladder

Small (5 mm^3) 7075 aluminum support feet are glued to the carbon fiber surface; the exact number depends on the ladder length. The feet contain screw fixation holes which are used to attach the ladder to its tracker plane.

The tracker support structure is divided into three sections: a carbon fiber cylindrical shell which supports the planes 2 to 4 located inside the magnet, and two carbon fiber flanges which support the exterior planes 1 and 5. They have a composite structure with two 220 (700) µm thick layers of carbon fiber surrounding a 12 (40) mm thick, low density aluminum honeycomb interior, ρ = 16.02 (32.0) kg/m^3. The diameter of the interior (exterior) planes is 1.0 (1.4) m. In view of the marginal increase of the plane hermeticity, and the very significant complication of the mechanical design, there is no overlap between the ladders in the planes of the tracker. To equalize the pressure inside the Tracker with the pressure in the payload bay during launch and landing, the Upper and Lower Conical Flanges each contain two light tight, filtered vents that permit air to exit or enter the enclosed Tracker volume of 40.26 ft^3 (1.14 m^3).

The Tracker Support Planes, Cylindrical Shell, and Conical Flanges are fabricated from M55J Fiber/Cyanate Ester Composite face sheet with a Hexcell Composite Honeycomb Core. The Tracker Support Feet are made from Titanium Ti6AlV4.

3.3.1.2.5 Anti-Coincidence Counters (ACC)

The ACC is a single layer of scintillating panels that surround the AMS-02 Silicon Tracker inside the inner bore of the superconducting magnet (Figure 3.3.1.2.5-1). The ACC identifies particles that enter or exit the Tracker through the side, detecting particles that have not cleanly traversed the Tracker. The ACC provides a means of rejecting particles that may confuse the charge determination if they leave "hits" in the Tracker close to the tracks of interest.

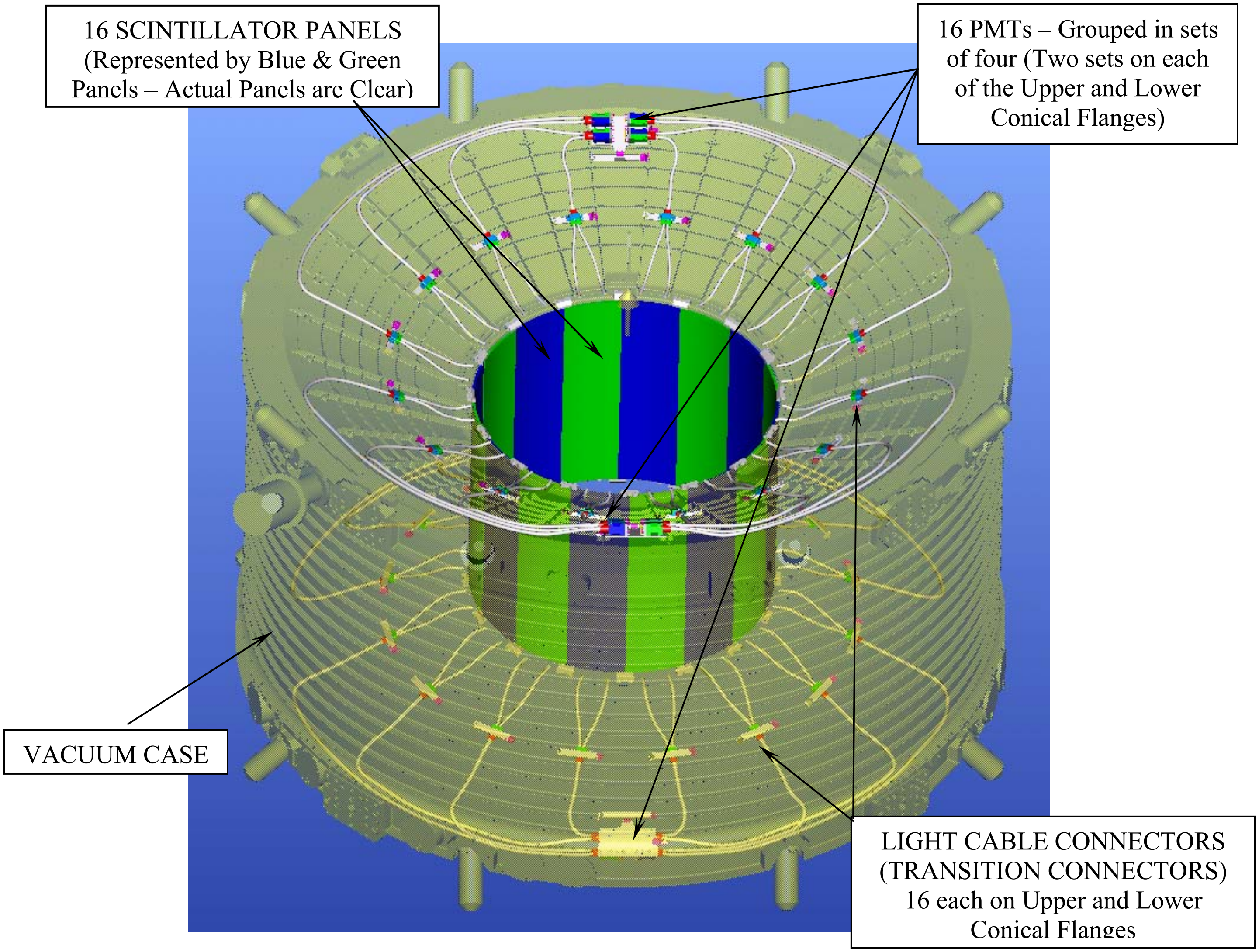


Figure 3.3.1.2.5-1 ACC Location Within the Inner Cylinder of the Vacuum Case

The ACC scintillating panels are fitted between the Tracker shell and the inner cylinder of the Vacuum Case, which contains the Cryomagnet system. The ACC is composed of sixteen interlocking panels fabricated from BICRON BC414. The panels are 8 mm thick and are milled with tongue and groove interfaces along their vertical edges to connect adjacent panels. This provides hermetic coverage for the ACC detection function around the Silicon Tracker. The panels are supported by a 33.46 in (850 mm) tall x .78 in (1086.7) diameter x 0.047 in (1.2 mm) thick M40J/CE Carbon Fiber Composite (CFC) Support Cylinder.

The light of scintillation from particles passing through the panels are collected by 1 mm wavelength shifter fibers (Kuraray Y-11(200)M) that are embedded in groves milled into the panel surface. A panel has two collection arrays, each consisting of 37 fibers. The embedded fibers are collected into 2 output ports of 37 fibers each at both ends of the panel. For each panel there are two transition connectors, one each located on the upper and lower conical flanges of the Vacuum Case. From these transition connectors the light is routed through clear fibers up to PMTs mounted on the rim of the Vacuum Case (Figure 3.3.1.2.5-2).

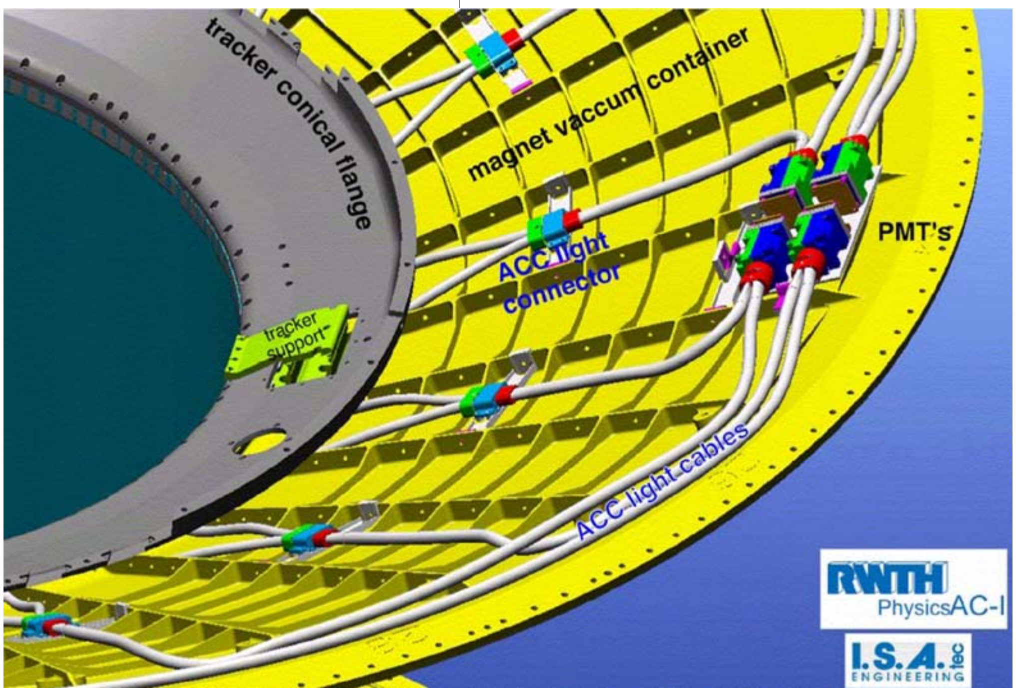


Figure 3.3.1.2.5-2 Routing of the Fiber Optic Cables from the ACC Scintillating Panels through the Transition Connectors to the PMTs

The PMTs that record the light signals from the ACC panels are identical to the PMTs used in the TOF system (Hamamatsu R5946). To minimize the impact of the magnetic field on the function of the PMTs, the PMTs are oriented with their axes parallel to the stray magnetic field.

The ACC also utilizes the same avionics architecture as the TOF to detect and interpret the passage of particles through the scintillating panels. Cables from the ACC PMTs are routed out from under the MLI covering the conical flanges to high voltage sources the S-Crate.

3.3.1.2.6 Tracker Alignment System (TAS)

The Tracker Alignment System (TAS) provides optically generated signals in the 8 layers of the silicon tracker that mimic straight (infinite rigidity) tracks of particles. These artificial straight tracks allow the tracing of changes of the tracker geometry with a position (angular) accuracy of better than 5 µm (2 µrad). The system (Figure 3.3.1.2.6-1) uses the same silicon sensors for both particle detection and control of the alignment. It serves to generate position control data within seconds at regular time intervals (4 to 6 times per orbit), for example, while the ISS flies into the shadow of the Earth or comes back into the sunlight.

The AMS-02 tracker is equipped with 2 x 10 pairs of alignment control beams. The beams are narrow (diameter < 0.5 mm) and of small divergence (< 1 mrad). The TAS generates laser energy from ten independent laser diodes, pairs of the diodes contained within five Laser Fiber Coupler (LFCR) boxes. This energy is generated by Eagleyard EYP-RWL-1083 infrared (1083 nm) laser diodes with a maximum power output of 80 mW. Each laser will emit at a 1 Hz interval with a 4 μs pulse duration when operating. Each laser diode's emissions are split into four output mono-mode optical fibers, each with approximately one quarter of the total power output. The LFCR boxes are light tight and cannot release any laser emissions with the exception of the fiber ports where laser emissions are nominal design features.

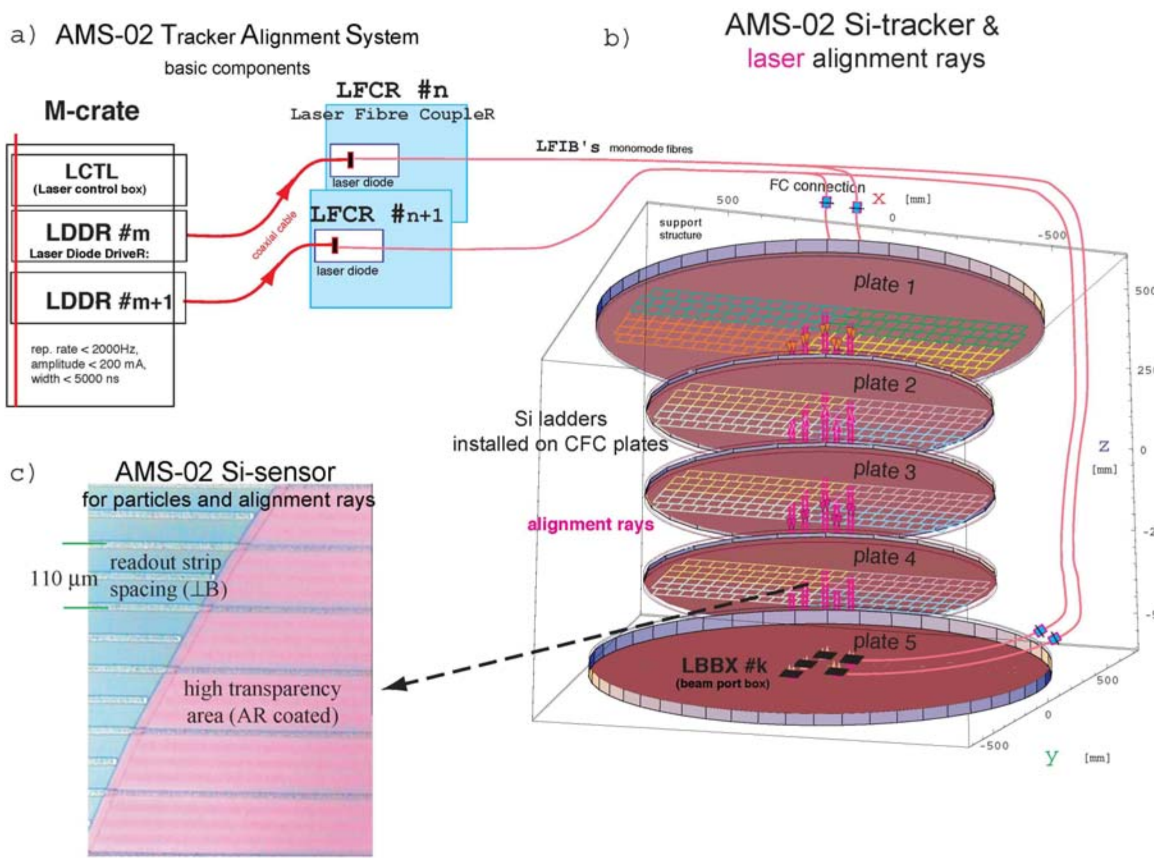


Figure 3.3.1.2.6-1 Tracker Alignment System Functional Diagram

The beams enter the tracker volume through 2 x 5 beamport boxes (LBBX) mounted on the outer face of the two outer tracker support plates. The tracker sensors on the alignment beams are equipped with antireflective coatings (SiO_2 and Si_3N_4) optimized for the wavelength chosen (residual reflectivity ~ 1%). In addition, the readout strip metallization width was reduced to 10 μm width in the coated areas and the other implants not metallized. Together these measures have resulted in a transparency of the alignment sensors of 50% and the 8th layer of the tracker receives about 0.8% of the intensity coming out of the LBBX. Alignment beams are arranged in pairs in order to distinguish between changes in beam geometry and sensor displacements. Laser alignment will be performed coincident with data taking. The operation of the TAS consists of less than 1% of the AMS-02 operational time.

3.3.1.2.7 Ring Imaging Cerenkov Counter (RICH)

The RICH is located near the bottom of the experiment stack, below the Lower TOF and above the ECAL. The RICH is used in conjunction with the Silicon Tracker to establish the mass of particles that traverse the AMS-02. The function of the Silicon Tracker is capable of establishing the momentum of the particle with a relative accuracy of approximately 1%. The RICH is able to determine the velocity of charged particles based on the Cerenkov Effect as the particle passes through the mass of the silica aerogel or sodium fluoride blocks. Cerenkov radiation is emitted as a charged particle passes through a transparent non-conducting material at a speed greater than the speed of light in that material. The use of a high efficiency reflector ring allows for greater data acquisition than direct incident of the photons on the PMTs alone.

Functionally the RICH (Figure 3.3.1.2.7-1) is composed of three basic elements, the top layer, the Cerenkov radiator, is composed of silica aerogel and sodium fluoride (NaF) blocks that serve as sources for the Cerenkov radiation generated by the passage of the high energy particles. The intermediate layer is the conical mirror and the lower the PMT and structural interfaces.

In the top layer the aerogel and NaF blocks are mounted between a PORON spacer and carpet and a PMMA cover, all supported by a carbon fiber reinforced composite (CFRC) structure (Figure 3.3.1.2.7-2). The entire structure is sealed with a viton gasket between the PMMA cover and the composite structure. The PMMA cover allows the photons generated by the passage of the high-energy particles to be observed by the photomultipliers. Polymethylmethacrylate (PMMA, Acrylic, Plexiglas™) is used to contain the aerogel and crystalline NaF blocks and allow the photons to enter the zone of the conical mirror and the PMTs.

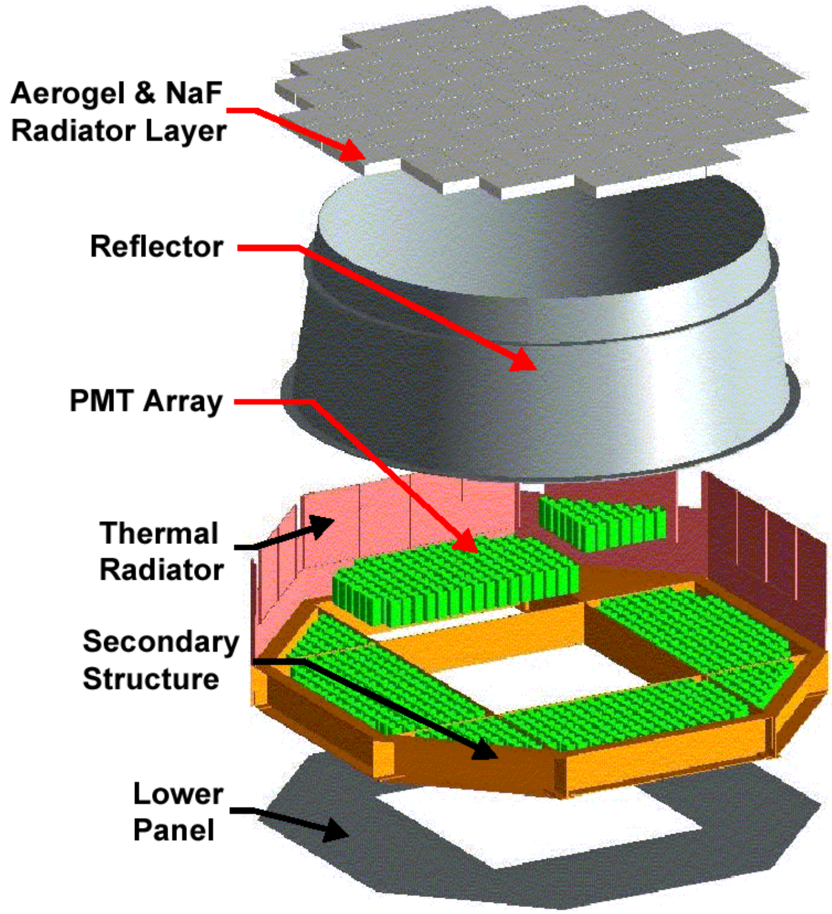


Figure 3.3.1.2.7-1 RICH Basic Elements

The RICH upper assembly of aerogel and NaF blocks is vented during ascent by four vent valves and during descent repressurization is controlled by three vent valves. In order to protect this volume once constructed it will be purged through a dedicated valve port with dry nitrogen to provide a clean controlled environment within the Cerenkov Radiator. 50 µm filter screens on the valves will prevent large aerogel or NaF particles that could possibly evolve from being released or exterior contaminants becoming ingested. These valves will be Halkey Roberts C770RP 1.0 one way valves that have a cracking pressure with a 1 psi differential. The valves will be interfaced to the 50 µm filter screens through a polyetheretherketone (PEEK) interface block as shown in Figure 3.3.1.2.7-2. During ground handling/transportation and processing this interior volume is protected from thermal and atmospheric pressure variation introducing humidity into the interior of the Cerenkov Radiator by having a buffer volume contained within an expandable reservoir (0.5 l) made of Teflon®/Tedlar® supported within a vented enclosure (Figure 3.3.1.2.7-3). Design of this assembly assures that there will not be more than a 1 psi differential between the interior and exterior pressure. Reentry loads of pressure loading on the aerogel during repressurization have been conservatively established to be approximately 1/15th of aerogel compression allowable. The aerogel is considered the most sensitive element of the sandwich of materials.

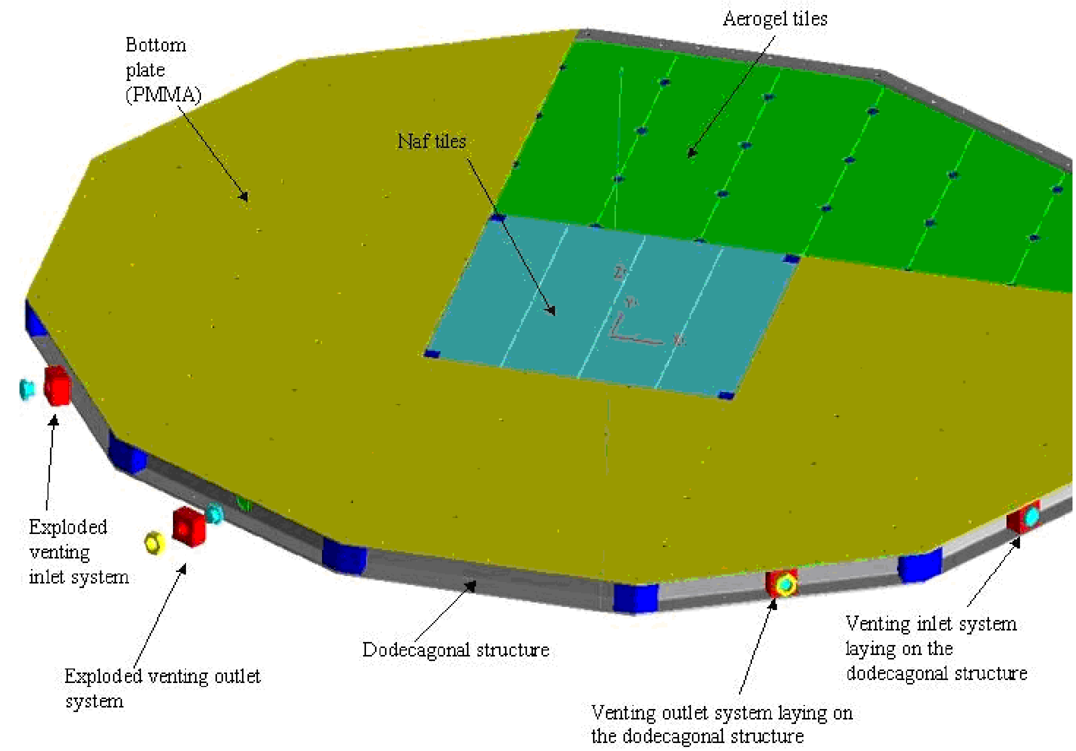


Figure 3.3.1.2.7-2 RICH Aerogel and NaF Assembly

(Vent interface updated below)

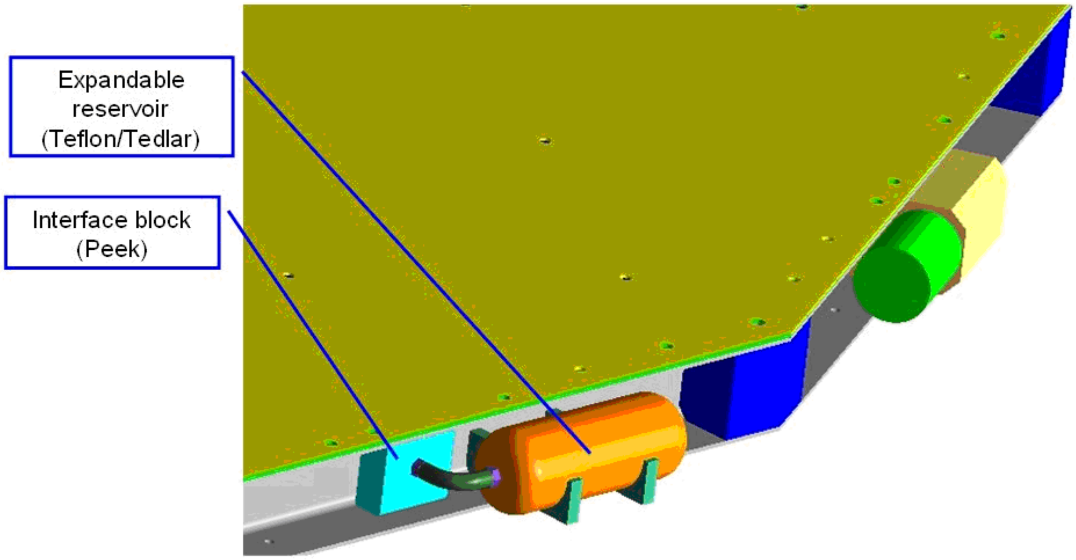


Figure 3.3.1.2.7-3 RICH Expandable Reservoir

The second layer of the RICH is a reflector that is shaped as a truncated cone, described by a trapezoid rotated about its centroid. The interior surface of this element is a highly polished composite/metal mirror. The mirror is manufactured in three pieces (Figure 3.3.1.2.7-4) to be very light and have a precise, highly reflective, surface. The reflector is made of composite material with layers of deposited gold, alumina, chromium, and quartz. A debris shield consisting of eight aluminum panels surround the reflector to protect it from penetrations that would damage the mirrored surface and allow light to enter the RICH and disturb detection.

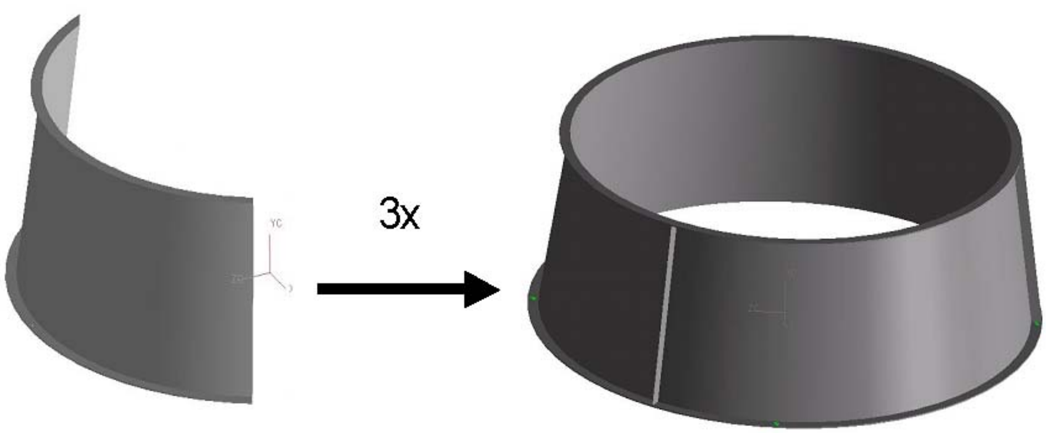


Figure 3.3.1.2.7-4 RICH Reflector Construction

The lower layer of the RICH construction contains the primary structure that supports the RICH and interfaces to the Lower USS-02. Within the secondary structure of the lower assembly are the rectangular and triangular arrays of photomultiplier tubes that will detect the photons from the Cerenkov radiation. Construction of the Lower RICH support structure and PMT support grids are shown in Figure 3.3.1.2.7-5.

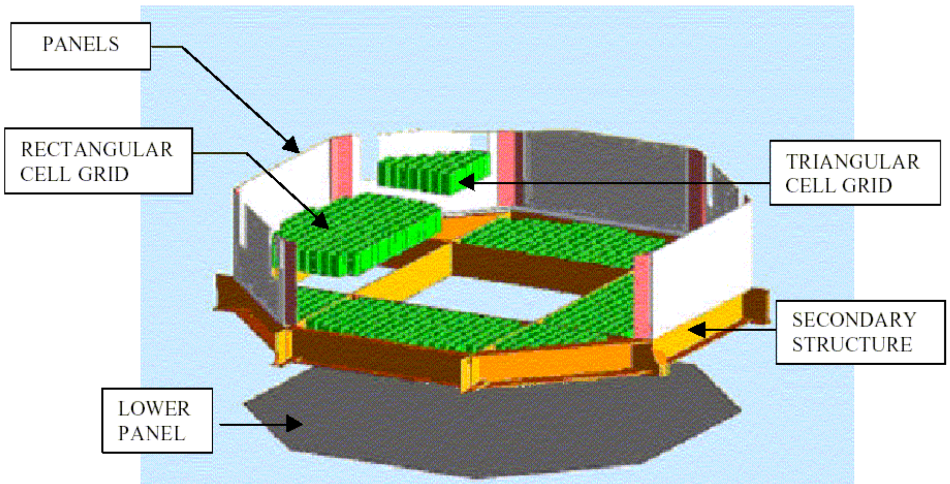


Figure 3.3.1.2.7-5 Lower RICH Construction

The PMTs for the RICH are constructed using Hamamatsu R7600 M16 photomultiplier tubes and a 4x4 matrix of light guides to correlate with the 4x4 photocathode grid of the photomultiplier tube. An optical pad assures the proper transmission of light into the photomultiplier tube and also seals off the glass front of the vacuum tube. The light guides are compressed into this optical pad using Nylon cords to assure good light transmissivity. The assembly of an individual PMT is shown in Figure 3.3.1.2.7-6.

The base of the photomultiplier tube is potted and the boards of the PMT are conformally coated to protect the electronics and to limit the coronal breakdown potential for the high voltage system. The welded soft iron outer body provides attenuation of the magnetic fields and support interfaces for integrating into the triangular and rectangular grids that form the arrays that cover the octagonal configuration.

The RICH PMTs are powered by four RICH high voltage bricks attached to the Lower USS-02 structure. Each of these bricks generates voltages at 1000 VDC and supplies this voltage to the PMTs. The RICH high voltage bricks are fully potted as are the high voltage electronics on the PMTs. The cabling used to route this power is rated in excess of the voltages present and use high voltage connection techniques to eliminate possible sources for discharge, corona and electrical shock. The signals from the PMTs are sent to the R Crate for data processing to establish the high energy particle or radiation incident characteristics.

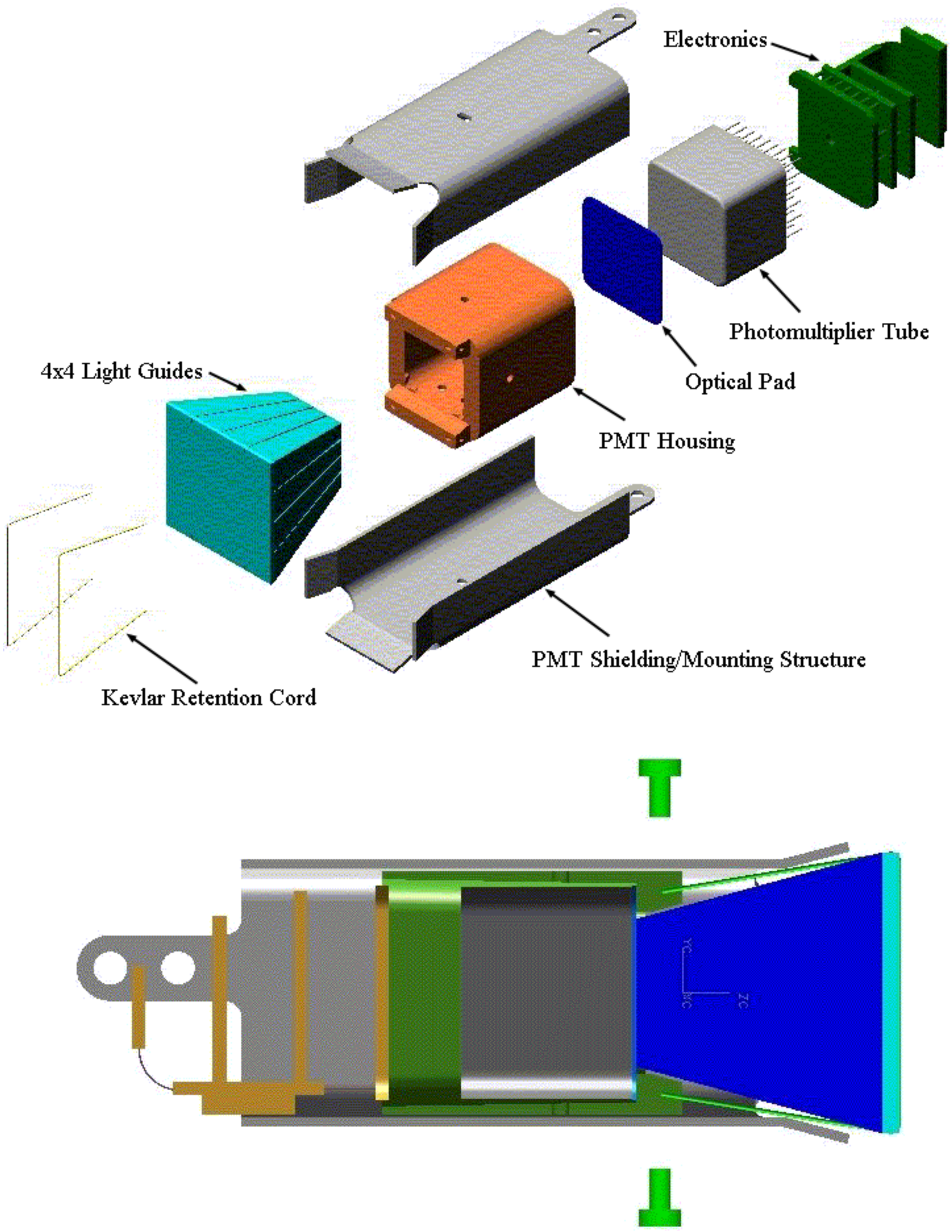


Figure 3.3.1.2.7-6 RICH PMT Construction (Kevlar cord replaced with Nylon wire)

The 406 lb (184 kg) RICH interfaces with 8 flanges on the Lower USS-02 as shown in Figure 3.3.1.2.7-7. Each interfaces uses 2 bolts per flange (16 total) secure the RICH to the Lower USS-02. Each of these flanges is riveted to the Lower USS-02 box beams with 24 structural rivets.

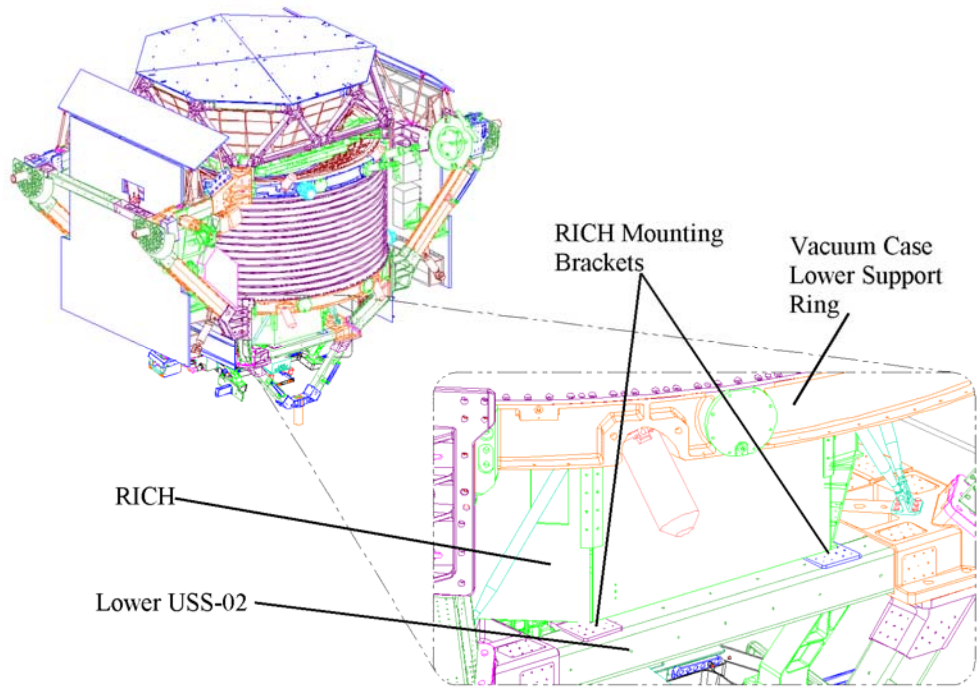


Figure 3.3.1.2.7-7 RICH Structural Interface

3.3.1.2.8 Electromagnetic Calorimeter (ECAL)

The Electromagnetic Calorimeter (ECAL) of the AMS-02 experiment is a fine grained lead-scintillating fiber sampling calorimeter that allows precise, 3-dimensional imaging of the longitudinal and lateral shower development, providing high ($\geq 10^6$) electron/hadron discrimination (identify particle type) in combination with the other AMS-02 detectors and good energy resolution (energy measurement). The calorimeter also provides a stand-alone photon trigger capability to AMS. The ECAL measures the energy of electrons, positrons and gamma rays up to 1 TeV.

The active sensing element of the ECAL consists of layers of lead foils and polymer scintillating fibers (Figure 3.3.1.2.8-1). Each lead foil a lead-antimony alloy with a density of 11.2 ± 0.5 gr/cm^{3}with an effective thickness of 0.04 inch (1 mm). Each lead layer is grooved (rolled) on both sides (Figure 3.3.1.2.8-2) to accommodate the PolyHiTech Polifi 0244-100 scintillating fibers. Each fiber is 1.0 mm in diameter and is secured in the aligned groves with BICRON BC-600 Optical glue that is applied as lead layers are assembled and pressed together. Each layer consists of 490 fibers across the 25.9 inch (658 mm) width of the layers Lead layers are grouped together in “superlayers” that are comprised of eleven layers of lead foil and ten layers of scintillating fibers. Each superlayer has all scintillating fibers oriented in the same direction, alternating the direction orthogonally of the fibers with each of the superlayers (Figure 3.3.1.2.8-1), 9 in total. Once assembled and pressed, each cured superlayer is milled to a uniform thickness of 0.7 inch (18.5 mm) thick. The superlayers are assembled as larger elements and sized (milled) for flight into squares with 25.9-inch (658 mm) long sides. The last (bottom) lead layer of the bottom superlayer has been replaced with a milled aluminum plate to reduce weight of the overall ECAL. Estimated savings by replacing the last plate with aluminum is approximately 2 kg.

Figure 3.3.1.2.8-1 Three Superlayers Showing Alternating Layers Of Lead Foil And Scintillating Fibers And Alternating Superlayer Orientation

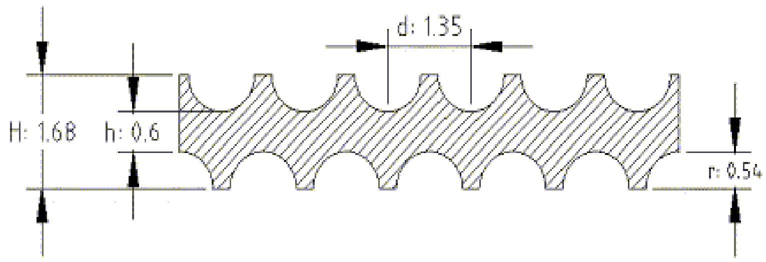


Figure 3.3.1.2.8-2 Individual Lead Foil Profile (Dimensions in mm)

The "pancake" of lead layers with scintillating fibers is the foundation of the ECAL sensor. Sensitive photomultiplier tubes (PMTs) are positioned around the periphery of the brick to sense photons generated by the passage of particles, secured against the edges of the brick where the Super-layer fibers terminate.

The ECAL is approximately 31.5 inches (800 mm) square x 9.8 inches (250 mm) high and weighs approximately 1402 lbs (636 Kg). Approximately 75% of this weight is due to the lead foils.

The ECAL "pancake" is supported by the ECAL "box". The box is made of 6 elements (Figure 3.3.1.2.8-3). The top and bottom pieces are aluminum honeycomb plates framed with aluminum. The plates are bolted to four lateral panels along the edges. The four lateral panels are made of Aluminum plates, 4 inch (10.16 cm) thick, carved with squared holes of 1.26-inch (32 mm) sides to house the light collection system. Four corner brackets, made of Aluminum plate, link the four plates together and connect the detector to the USS-02 at the bottom of the AMS-02 instrument (Figure 3.3.1.2.8-4). The four mounting locations include a pair of radially slotted holes so that the loads of the ECAL are transferred to the USS-02, but the loads from the USS-02 that are transferred into the ECAL are limited.

The light collection system is mounted about the periphery of the ECAL pancake in the four lateral panels. Two sides, serving four super-layers, have 72 holes while the two other faces, serving 5 super-layers, have 90 holes each.

The ECAL Intermediate Boards (EIBs) are electronic boards coated and fixed in aluminum frames directly mounted on the ECAL back panels. The EIBs provide the interface for the PMTs to get commands from the data acquisition system and to send data from driver electronics to it.

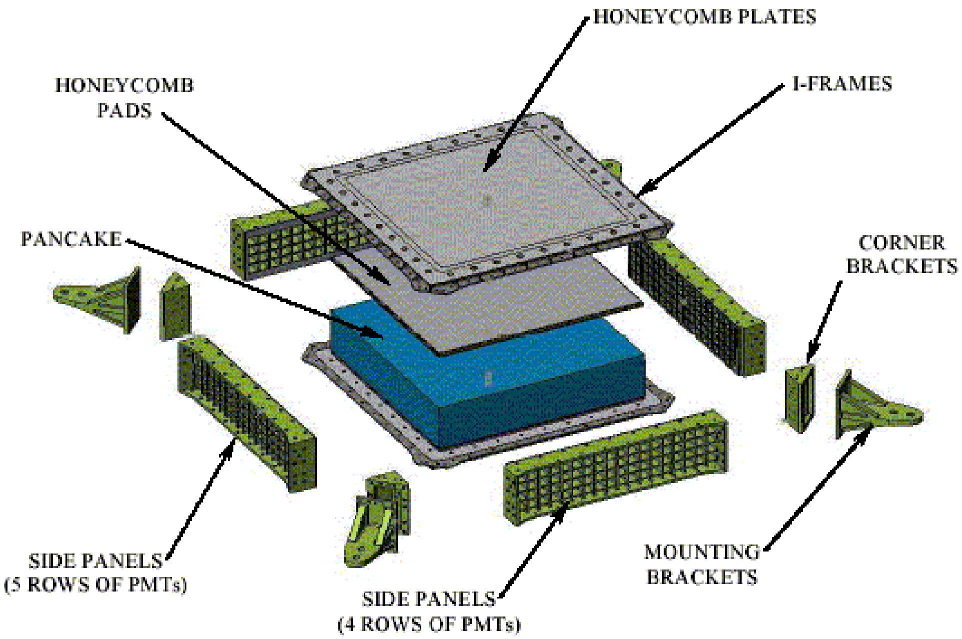


Figure 3.3.1.2.8-3 ECAL Construction

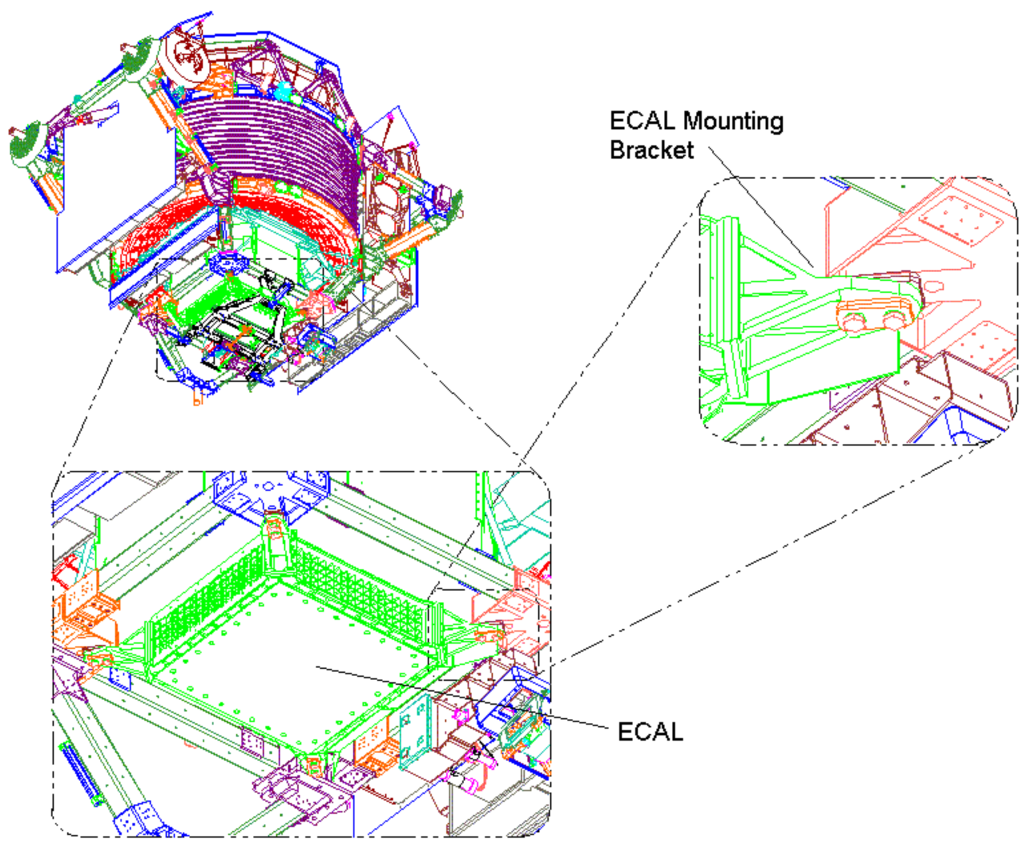


Figure 3.3.1.2.8-4 Location of the ECAL on the AMS-02

The ECAL utilizes two types of electronics boxes, the E-Crate and ECAL High Voltage (EHV) boxes, which are mounted to the lower USS-02 structure (Figure 3.3.1.2.8-5). The two E-Crates provide data acquisition and triggering functions and the four EHV boxes contain high voltage (HV) bricks – each with 55 HV channels per brick – supply the high voltages for PMT operations. The HV bricks are fully potted. Two EHV boxes mounted on diagonally opposite legs of the lower USS-02 accommodate two HV bricks each, while the EHV boxes mounted on the two other legs accommodate one brick each. Three bricks are packaged per each of the four EHV boxes. The ECAL utilizes high voltages up to 800 VDC to operate the PMTs.

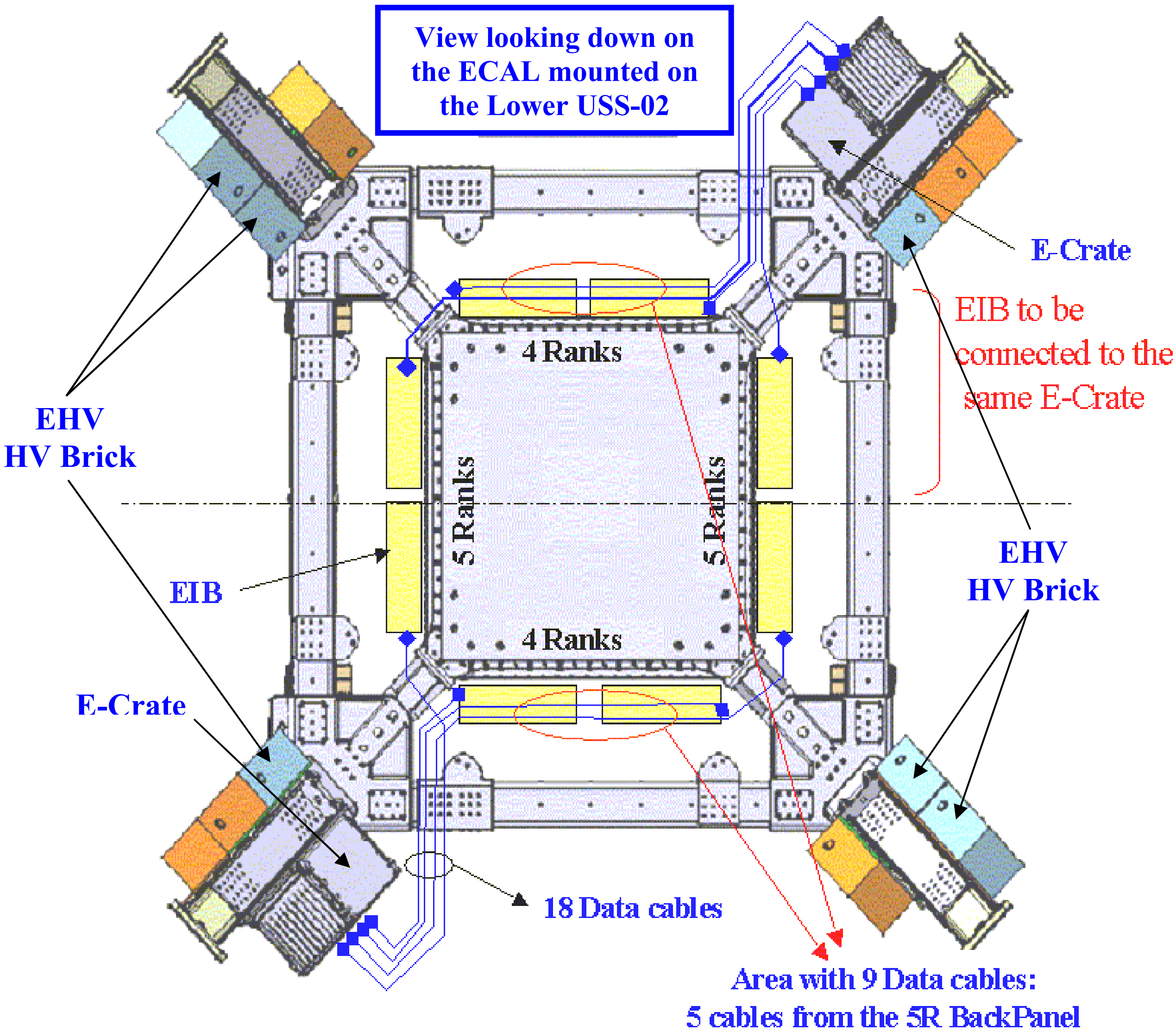


Figure 3.3.1.2.8-5 Location of E-Crates and EHV High Voltage Bricks

3.3.1.2.9 Star Tracker

The Space Station, which is large and fairly flexible, cannot measure its own position with a high degree of accuracy and thus cannot directly tell the AMS-02 where it is exactly and where it is pointing. To optimize science from the Tracker detector carried by AMS it is important to have the capability to determine accurately the position of the AMS payload at the exact time that an event occurs. To accurately determine its position, AMS carries a Star Tracker called AMICA (for Astro Mapper for Instrument Check of Attitude). AMICA is equipped with a pair of small optical telescopes (AMICA Star Tracker Cameras or ASTCs). The ASTCs are mounted to the upper Vacuum Case Conical Flange on opposite sides of AMS to increase the probability that one has a clear view of the stars (Figure 3.3.1.2.9-1).

Each camera acquires an image of the stars with a Charged Coupling Device (CCD) detector (Figure 3.3.1.2.9-2) and compares the resultant image to an on-board sky map. With this information, the attitude of AMS can be determined within a few arc-seconds (arc-sec) accuracy.

The hardware consists of an optics system (Figure 3.3.1.2.9-4) [f/1.25 lens with 75 mm focal length and a 6.3° X 6.3° field of view (FoV)]; a lens cover containing a 3 mm thick blue filter and a 2 mm thick red filter; a low noise frame-transfer CCD (512 X 512 pixels); and a baffle to limit the stray light intrusion to the optics. The baffle is made of black anodized aluminum Al 6061 that is 1 mm thick. The baffle is not mechanically connected to the lens assembly and is supported independently by a bracket mounting the baffle to the M-Structure (Figure 3.3.1.2.9-3), the configuration allowing for relative motion between the baffle and the lenses without leaking light into the optical path. The interface between the baffle and the lens assembly is made light tight by a fabric MLI cover.

The AMICA operates on 28 Vdc. The ASTCs are interfaced to the M-crate located on the ram side by three cables, two 8 conductor 24 AWG shielded conductors to provide the SpaceWire Link for data and one three conductor 22 AWG cable for power. The thermal load from the Star Tracker CCD and electronics board inside the sensors is carried by a copper "bus" to the thermal blocks connecting to the Tracker Thermal Control System. The CCD and power switching boards for each ASTC are contained in the AMICA Star Tracker Supports (ASTSs) that attach the instrument to the Tracker.

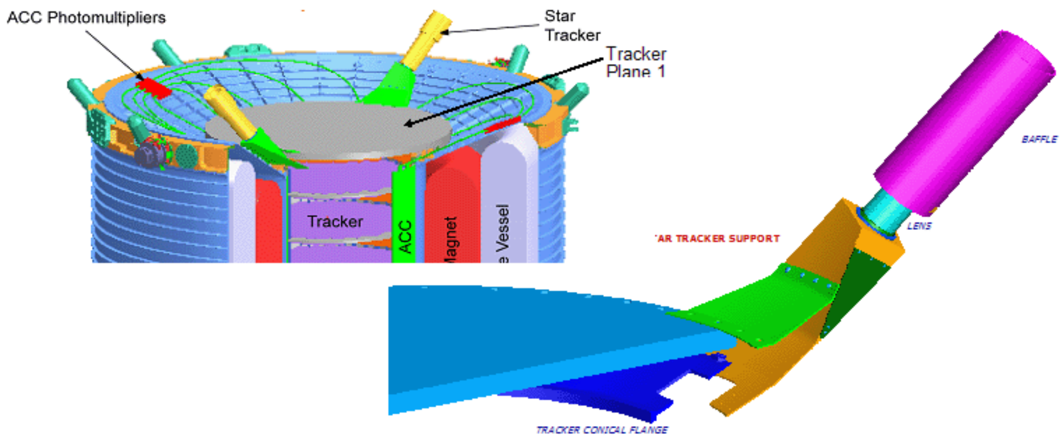


Figure 3.3.1.2.9-1 Star Tracker Mounting Location

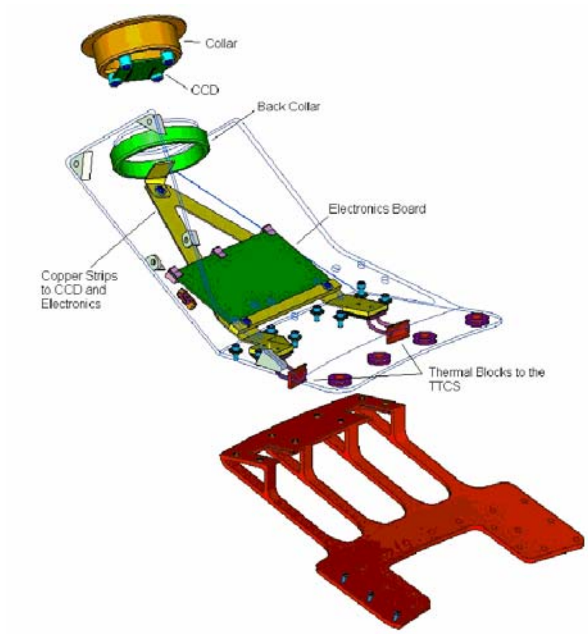


Figure 3.3.1.2.9-2 Star Tracker CCD and Electronics

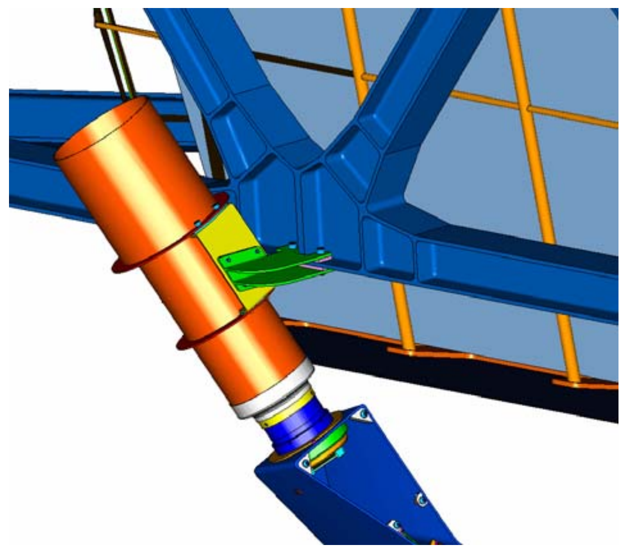


Figure 3.3.1.2.9-3 Star Tracker Baffle Mounting

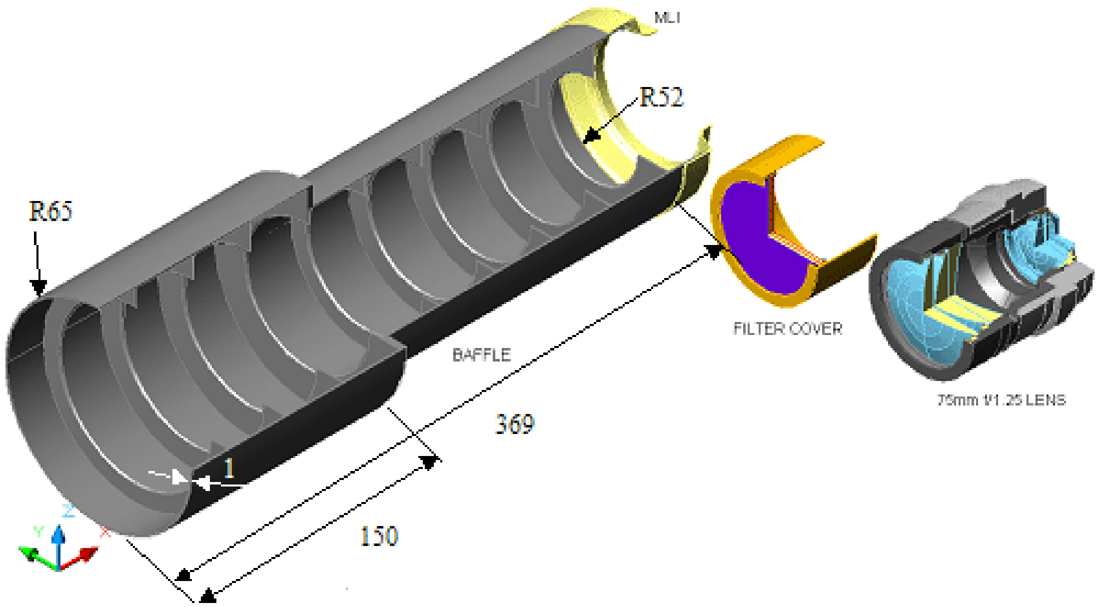


Figure 3.3.1.2.9-4 Baffle and Optics Design

3.3.1.2.10 Global Positioning System (GPS)

The AMS-02 utilizes an ALCATEL TOPSTAR 3000D which will be integrated into AMS by IN2P3-Montpellier. A single patch type antenna (Sextant Avionique model 3407-79) will be mounted on an upper USS-02 structural member. A signal from the GPS unit will be used for precision time correlation that exceeds the capabilities of the ISS to provide. The need for the GPS is to correct time drift over time within the precision timing systems that trigger the particle events.

Interface electronics within the M-Crate receive the precise time at which the timing pulse from the GPS unit was emitted and this is included, along with the value of the local timer, in the event data. To reach the required accuracy, software has been developed to include all the corrections required for low earth orbit GPS applications. The GPS operates off of the AMS-02 internal 28 VDC power bus.

3.3.1.2.11 Data and Interface Electronics

The AMS avionics primary functions are front end data collection for the scientific instruments, data and command communication interface between the various portions of the payload, as well as between the payload and the STS and ISS; and power distribution throughout the payload.

AMS-02 contains numerous electronics boxes, some termed “Crates,” that supply the necessary readout/monitor/control electronics and power distribution for each detector (Figures 3.3.1.2.11-

1 and 3.3.1.2.11-2). The box nomenclature is generically x-Crate or xPD, where “x” is a letter designating the detector function, and “Crate” refers to the readout/monitor/control electronics box and “PD” refers to the Power Distribution box for that specific detector. Similarly xHV bricks provide high voltage for some detectors. Values of “x” are designated as follows:

- E ECAL
- J Main Data Computers (MDC) and Command & Data Handling interfaces
- JT Trigger and central data acquisition
- M Monitoring
- R RICH
- S Time of Flight (TOF) Counters and Anti-Coincidence Counters (ACC)
- T Tracker
- TT Tracker Thermal
- U Transition Radiation Detector (TRD)
- UG TRD Gas

Additionally, electronics are mounted in the Power Distribution System (PDS), the Cryomagnetic Avionics Box (CAB), the Cryocooler Electronics Box (CCEB), and the Uninterruptible Power Supply (UPS).

The interface boxes PDS and J-Crate provide the isolation and protection functions necessary to protect the STS and ISS vehicles from damage. In most cases the PDS provides the isolation and circuit protection required to prevent feedback to the ISS; however, the Cryomagnet Avionics Box (CAB); the Cryocooler Electronics Box (CCEB); and some Heater Circuits receive 120Vdc pass-through power from the PDS.

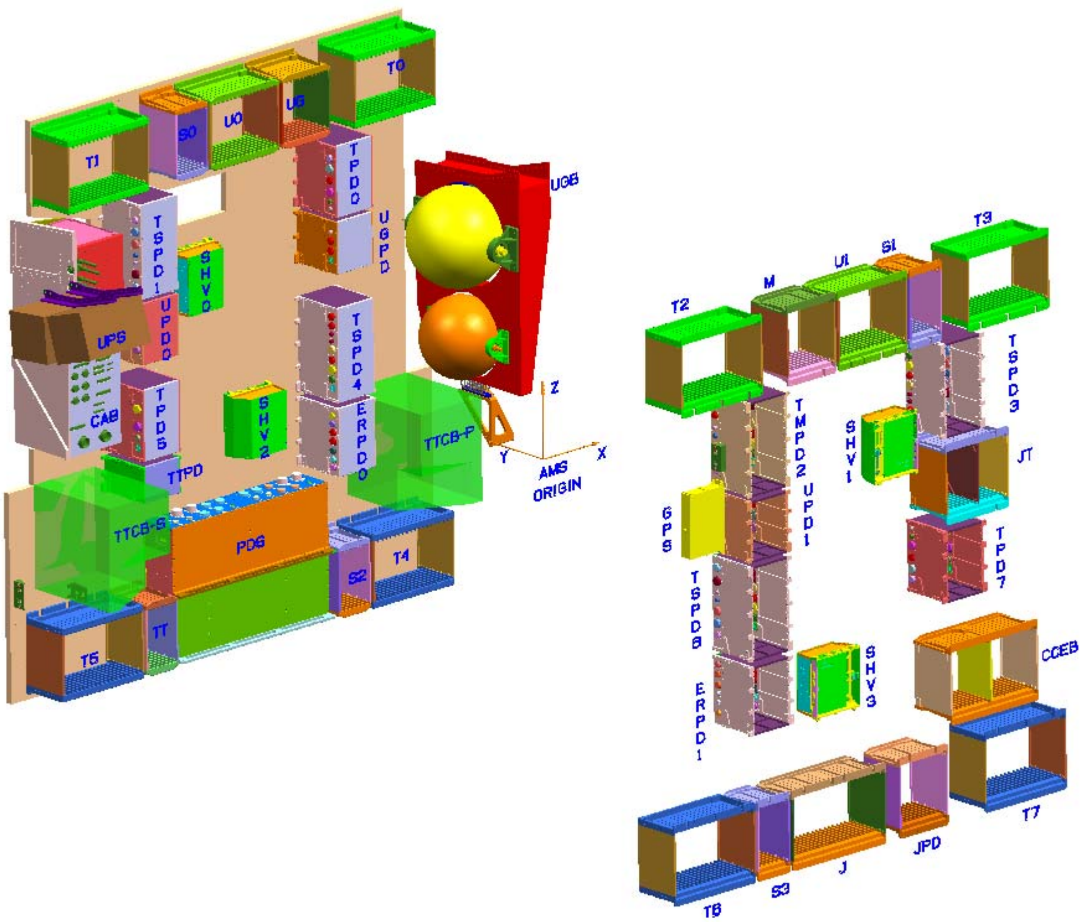


Figure 3.3.1.2.11-1 Electronics Crate Locations

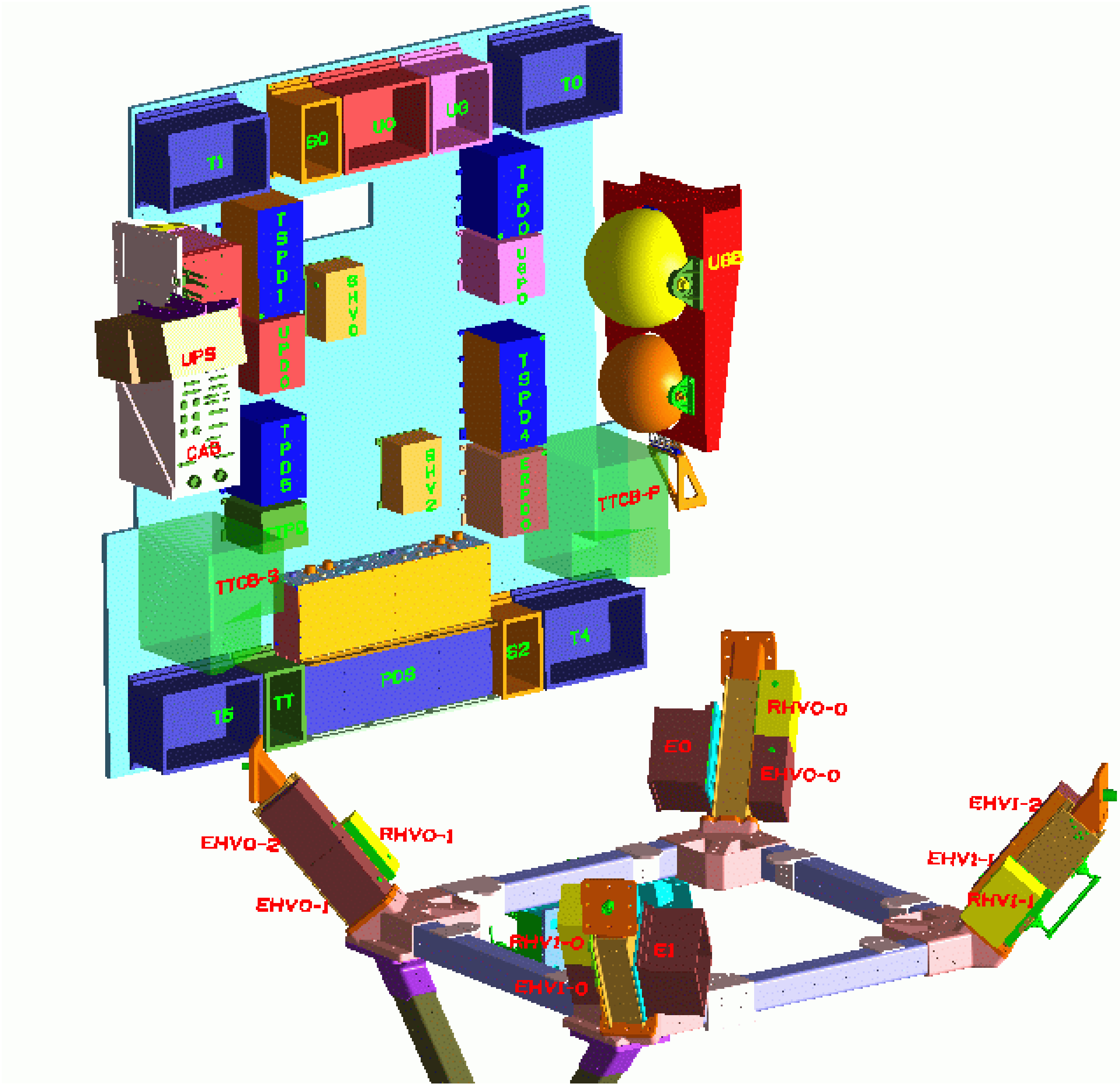


Figure 3.3.1.2.11-2 Electronics Crate Locations

3.3.1.2.11.1 Power Distribution System (PDS)

The AMS-02 Power Distribution System (PDS) serves as the primary front-end for the power distribution to the subsystems and experiment detector electronics. It performs power conversion and distribution functions for the payload. The power isolation within the PDS is designed to meet the 1 mega ohm isolation requirement defined in SSP-57003.

Wire sizing has been selected in compliance with the requirements defined in NSTS 1700.7b, “Safety Policy and Requirements for Payloads Using the Space Transportation System”, NSTS 1700.7b ISS Addendum, “Safety Policy and Requirements for Payloads Using the International Space Station”, and NASA Technical Memorandum TM 102179, “Selection of Wires and Circuit Protection Devices for NSTS Orbiter Vehicle Payload Electrical Circuits”.

Power for the AMS-02 Payload is supplied from several sources dependent upon mission phase. During pre-launch operations the power is supplied through the Orbiter T-0 connection through the Orbiter ROEU to the AMS-02 and the AMS-02 PDS. During Orbiter Operations APCU 120 VDC and Orbiter 28VDC are supplied through the ROEU to the AMS-02 through the AMS-02 PDS. During Space Station RMS operations power (120VDC) is supplied to the AMS-02 through the PVGF to the PDS to power heaters on the AMS-02. Once attached to the ISS truss the ISS Supplied 120 VDC is routed through the UMA through the AMS-02 PDS to the AMS-02 Systems. See Table 3.3.1.2.11.1-1 for details on PDS interface details.

The PDS, the yellow shaded box in Figure 3.3.1.2.11.1-3a & -3b, consists of four distinct sections: 120 Vdc Input; 120 Vdc Output; 28 Vdc Output; and Low Voltage Control and Monitor. The bus to bus isolation of the 120Vdc outputs is provided by the end-subsystem, by either DC-to-DC or AC converters, or relays. The isolation for all other outputs is provided internally to the PDS by DC-to-DC converters. The PDS has two independent “channels” side A and side B which have four identical subsections. The only difference between the two channels is that side A is the only side that provides power to the CAB for magnet charging.

The PDS is located on the Main Wake Crate Rack very close to the Passive Umbilical Mechanism Assembly.

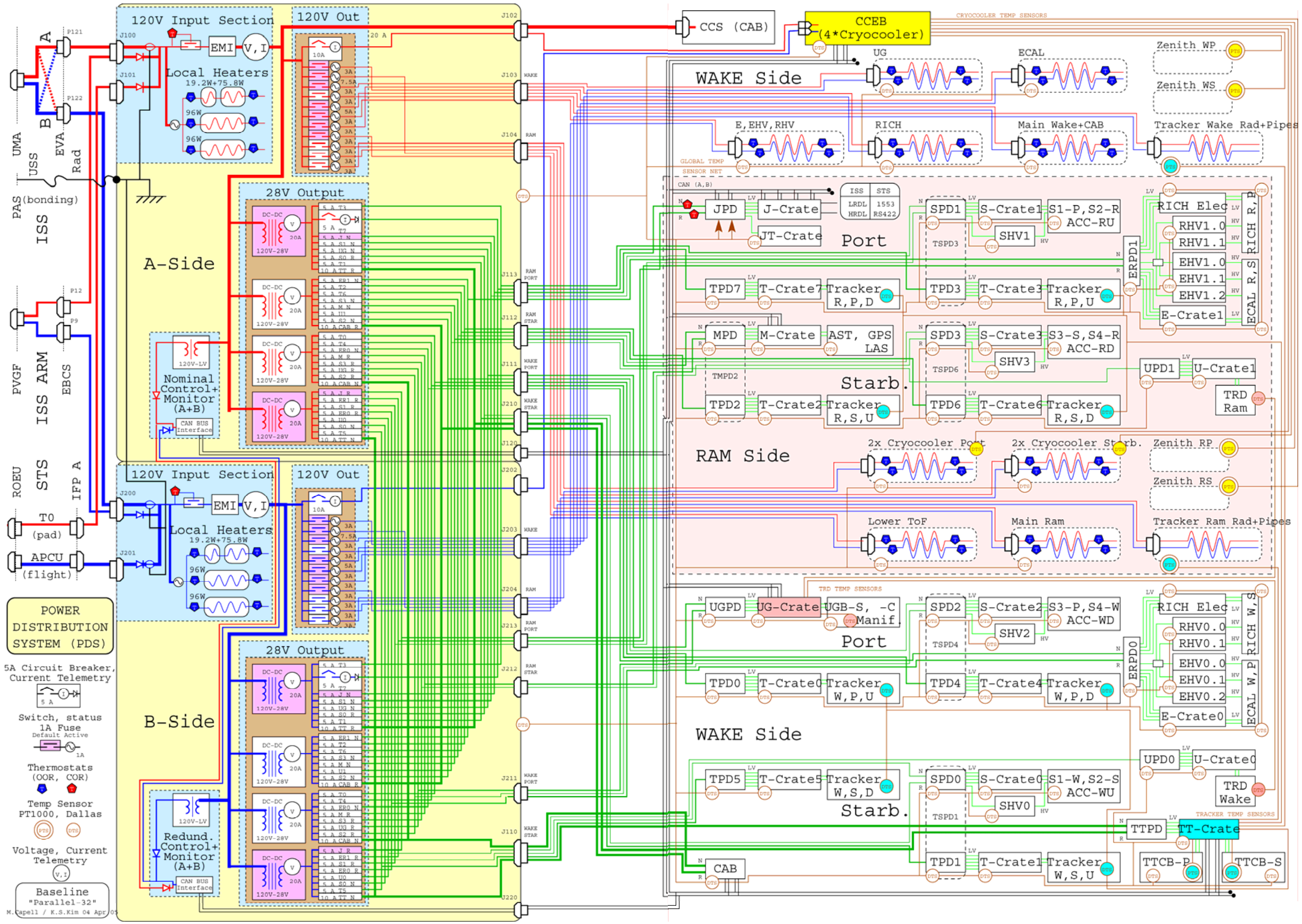


Figure 3.3.1.2.11.1-1 Payload Power Interfaces

TABLE 3.3.1.2.11.1-1 PDS SECTION INTERFACE DETAILS

PDS SIGNAL & POWER INTERFACES		
INPUT SECTION		
ISS	Power I/F input	• 120V Feeder A • 120V Feeder B
STS	Power I/F input	• 120V Feeder APCU • 120V Feeder T0
BCS (PVGF)	Power I/F input	• 120V Feeder PVGF 1 • 120V Feeder PVGF 2
EMI FILTER		• EMI I/F
INPUT TELEMETRY		
INPUT TELEMETRY	Signal I/F	(Via internal serial I/F to the CAN BUS module) • INPUT CURRENT • INPUT VOLTAGE
INTERNAL POWER SUPPLY SECTION		
ESEM 1-A	Power I/F	15V Internal Power Supply

	Signal I/F	(Via internal serial I/F to the CAN BUS module)
		• ON/OFF DC/DC CONVERTER
		• DIGITAL Board Status Monitoring
		  • OK/NOK
		  • OVERTEMP
		  • DC/DC 1 OVERCURRENT
		  • DC/DC 2 OVERCURRENT
		  • DC/DC 1 MAIN ON/OFF
		  • DC/DC 2 MAIN ON/OFF
		  • MAIN POWER ON
		  • DIGITAL TEST OUT
		• ANALOGUE Board Monitoring
		  • TEMPERATURE
		  • ANALOG REFERENCE VOLTAGE
		  • MAIN POWER VOLTAGE

120V OUTPUT SECTION		
DIRECT OUTPUT	Power I/F	• 120V Feeder to CCS in CAB
ESEM 3-B	Power I/F	• OUT 1 for AMS heaters • OUT 2 for AMS heaters • OUT 3 for AMS heaters • OUT 4 for AMS heaters • OUT 5 for AMS heaters • OUT 6 for AMS heaters • OUT 7 for AMS heaters • OUT 8 for AMS heaters • OUT 9 for AMS heaters • OUT 10 for AMS heaters • OUT 11 for AMS heaters • OUT 12 CCEB (Cryocoolers)

TABLE 3.3.1.2.11.1-1 PDS SECTION INTERFACE DETAILS (CONTINUED)

PDS SIGNAL & POWER INTERFACES		

	Signal I/F	(Via internal serial I/F to the CAN BUS module)
		• ON/OFF OUTLET Command
		• DIGITAL Board Status Monitoring
		  • OK/NOK
		  • OVERTEMP
		  • OUTLET STATUS (ON/OFF)
		  • OUTLET TRIP STATUS (only for CCEB line)
		• ANALOGUE Board Monitoring
		  • TEMPERATURE
		  • OUTLET CURRENT (only for the CCEB line)
		  • ANALOG REFERENCE VOLTAGE

120V TO 28V CONVERSION SECTION		
PB2	Power I/F	• 28V OUTPUT to the ESEM 3-A distribution board

PB2	Signal I/F	(Via internal serial I/F to the CAN BUS module)
		• ON/OFF DC/DC CONVERTER Command
		• DIGITAL Board Status Monitoring
		  • OK/NOK
		  • OVERTEMP
		  • DC/DC CONVERTER STATUS (ON/OFF)
		  • INPUT OVERCURRENT
		  • OUTPUT OVERVOLTAGE
		• ANALOGUE Board Monitoring
		  • TEMPERATURE
		  • 28V OUTPUT VOLTAGE
		  • ANALOG REFERENCE VOLTAGE

ESEM 3-A	Power I/F	• 8 x 28V output lines
		  • out 1 to 7 @ 5A each
		  • out 8 @ 10A

ESEM 3-A	Signal I/F	(Via internal serial I/F to the CAN BUS module)
		• ON/OFF OUTLET Command
		• DIGITAL Board Status Monitoring
		  • OK/NOK
		  • OVERTEMP
		  • OUTLET STATUS (ON/OFF)
		  • OUTLET TRIP STATUS
		• ANALOGUE Board Monitoring
		  • TEMPERATURE
		  • OUTLETS CURRENT
		  • ANALOG REFERENCE VOLTAGE

DIGITAL I/F SECTION		
CAN BUS I/F	Signal I/F	• CAN BUS I/F • PDS INTERNAL BUS I/F • DIGITAL Command to the boards • ANALOGUE ACQUISITIONS of the boards telemetry • DIGITAL ACQUISITIONS of the boards status

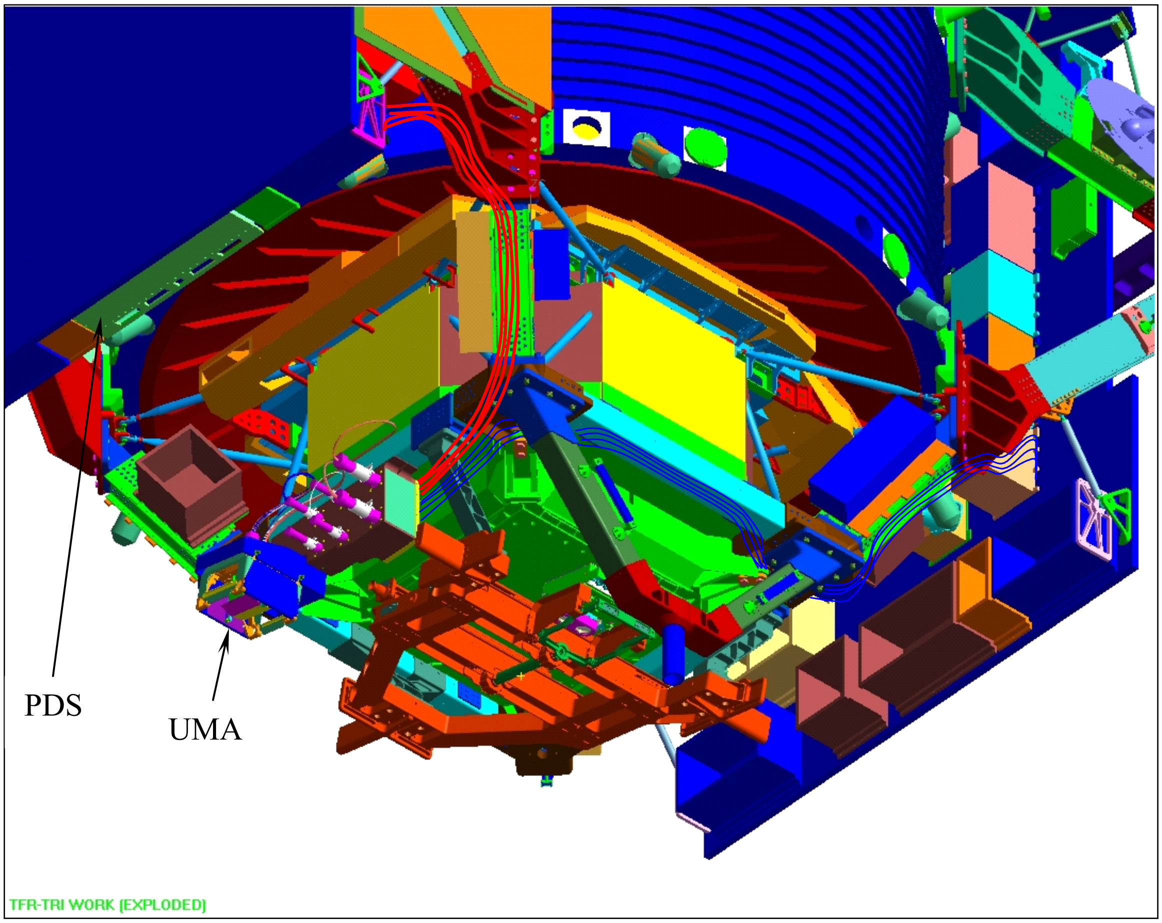


Figure 3.3.1.2.11.1-2 Location of the PDS and UMA on AMS-02

3.3.1.2.11.2 Cryomagnet Avionics Box (CAB)

The CAB is designed to perform all control and monitoring functions for the Cryomagnet Subsystem (including SFHe Tank and Vacuum Case). The CAB consists of four sections: the Cryomagnet Current Source (CCS); the Cryomagnet Controller and Signal Conditioner (CCSC); the Cryomagnet Self Protection (CSP); and the Power Switches (PS) (Figure 3.3.1.2.11.2-1).

The CAB is located on the Unique Support Structure (USS) very close to the current input port of the Vacuum Case to minimize the length of the Cryomagnet Current Leads.

High Voltage Isolation is provided at all inputs to the CAB from the ISS side to prevent passing any high-voltage that could be developed during a multiple fault "unassisted" quench back to the ISS power or data systems. Isolation for the 120Vdc line (feed thru from PDS) is performed via

DC-to-DC Converters in the CCS. Analysis has shown that the maximum voltage that could be achieved during an "unassisted" quench is 5.5kV. 8kV isolation is provided at all these points to ensure margin. The unassisted quench is an off-nominal scenario, and would result in damage to the CAB and the magnet that would render them unusable, but not create a safety hazard. The one fault "assisted" quench would prevent these voltage levels from arising and protect the CAB and the magnet for mission success.

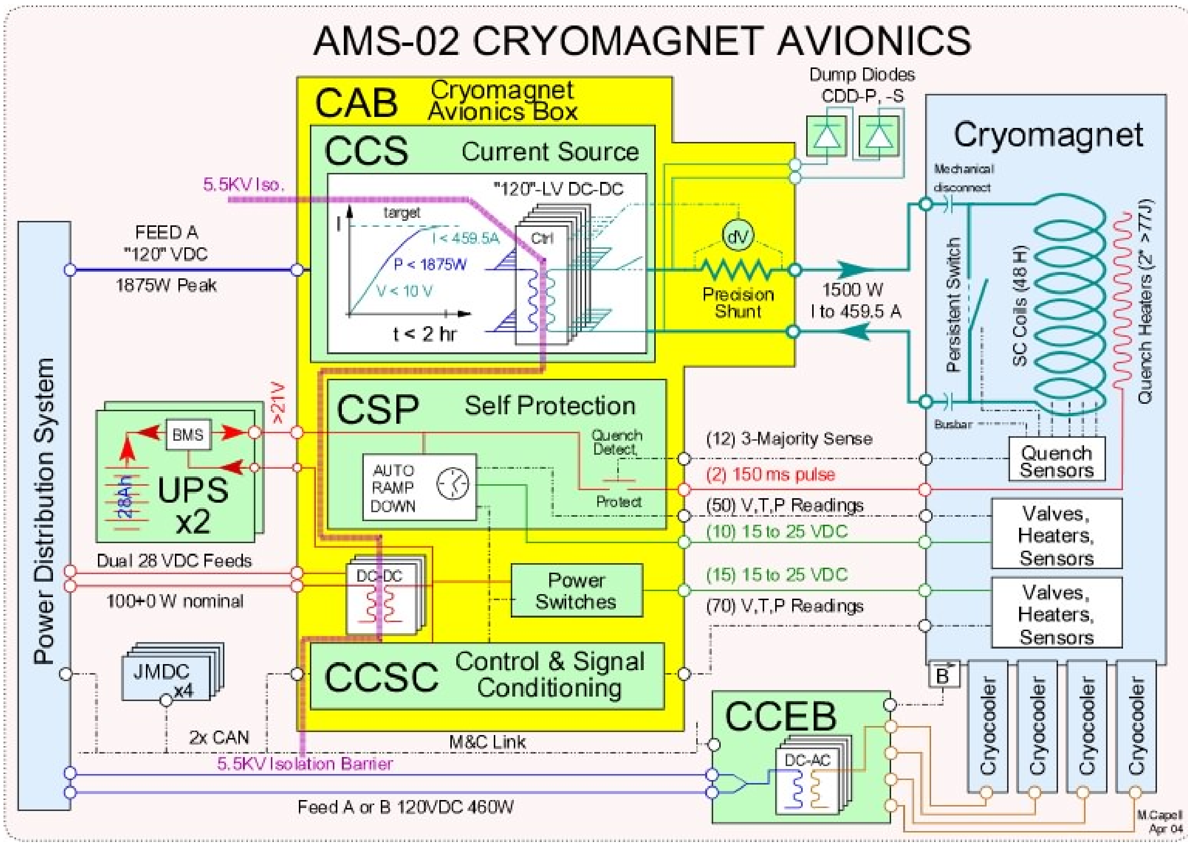


Figure 3.3.1.2.11.2-1 Schematic of the AMS-02 Cryomagnet Avionics Box (CAB) and Cryomagnet

3.3.1.2.11.3 Cryomagnet Current Source (CCS)

The 120 Vdc Power input (feed through from the PDS) is routed solely to the CCS. A DC-to-DC converter at the input to the CCS provides isolation for this Power Bus. The 120 Vdc power is required only for magnet charging. All other sections of the CAB are operated with 28 Vdc from the PDS.

The 120 Vdc input is limited to a maximum of 1875 W for power management. Power supplied to the DC-to-DC converter is controlled by Opto-Isolating feedback from the DC-to-DC converter output with a power switch and pulse width modulation of the input.

To charge the magnet, the Semiconductor switch on the charging circuit is closed, and power is supplied to the transformer input. The current is slowly ramped up over a period of approximately 1.5 hours to 459 Amps. Current during charge and discharge operations is monitored using a 500A shunt. The connection from the CCS to the magnet is made via three pairs of AWG 2/0 wires. Once full operating current is reached, the Persistent Switch is closed (the switch consists of a pair of super-conducting wires – “closed” by cooling them down to superconducting temperatures). With the persistent switch closed, 459 A is running through both sides of the circuit (the magnet side and the charger side). To avoid ripple currents through the persistent switch, the current on the charger side is slowly reduced to zero. Once the current on the charger side is depleted, the Semiconductor Switch is opened, and the Charging System is disconnected from the Magnet Circuit.

If an event occurs that necessitates a power down of the magnet, the system is designed to perform a nominal “ramp down” function. The nominal ramp down is the most acceptable method for powering down the magnet without the potential for substantially decreasing the endurance of the magnet. To perform a ramp down, the mechanical leads are connected and the persistent switch is opened (by allowing it to warm to a non-superconducting state), diverting the current from the magnet through the Cryomagnet Dump Diodes (CDDs). The connection from the magnet is to the CAB with three pairs of AWG 2/0 wires, and then on to the CDD, with a loop of one AWG 2/0 wire. The energy from the magnet is dissipated in the form of heat through the CDD chain. The CDD consists of three sets in series of three diodes in parallel that are used solely for the purpose of dissipating the stored energy of the magnet. These dump diodes are located on the wake/starboard-side sill trunnion joint, directly above the CAB, which was selected for its large thermal mass. The CDDs are protected by a metal cover to prevent incidental contact by ground personnel or crew. The total time required to dissipate the magnet energy is estimated to be 134 minutes.

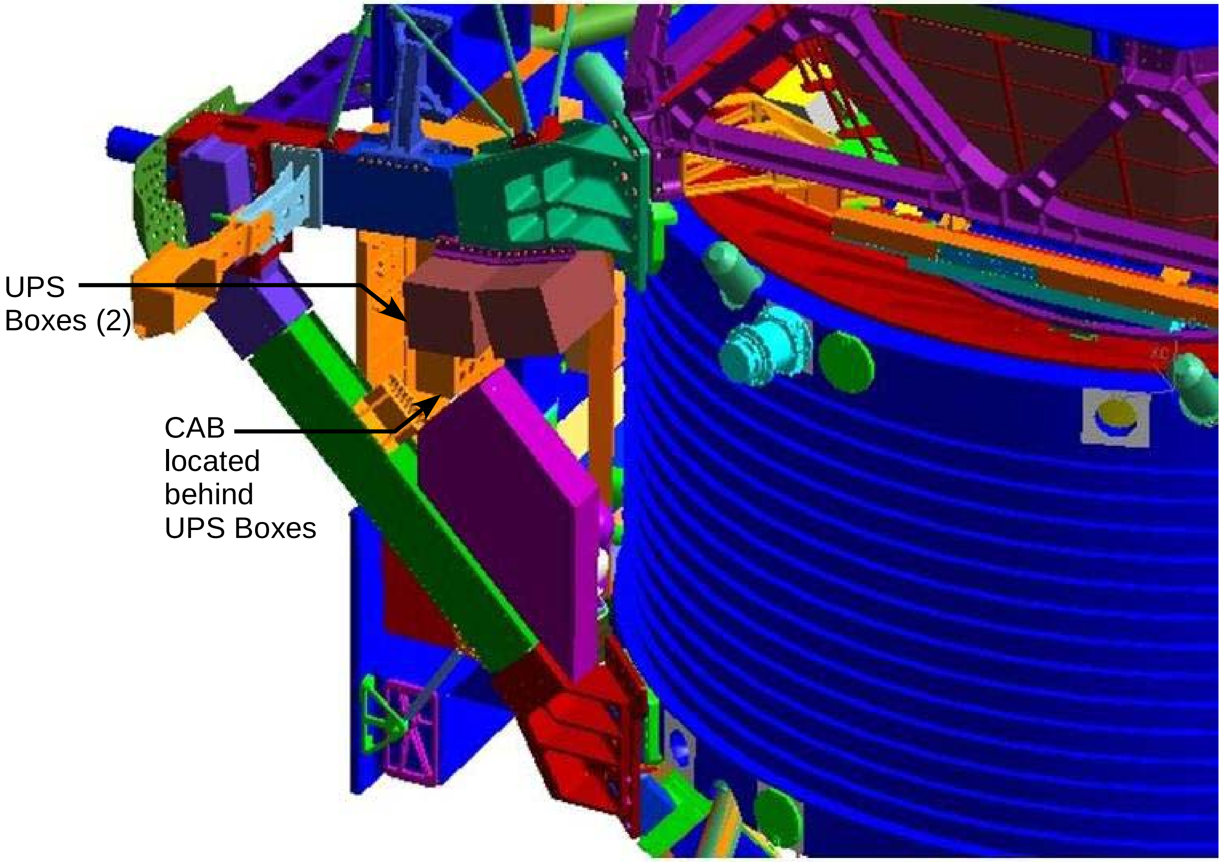


Figure 3.3.1.2.11.3-2 Cryomagnet Avionics Box (CAB) on the USS-02

3.3.1.2.11.4 Cryomagnet Control and Signal Conditioning (CCSC)

The CCSC provides the interface between the AMS-02 Main Data Computers (MDCs) and the Cryomagnet. The CCSC is responsible for:

- reception of commands from the MDCs
- transmission of telemetry to the MDCs
- commanding of the CCS
- control of the Cryomagnet auxiliary functions (i.e. heaters, valves, etc.)
- monitoring of the CCS, Cryomagnet, and CAB operating parameters and status

The CCSC also performs system fault detection and management functions, formatting of telemetry, and data storage for system status. The CCSC is required to interface with the Uninterruptible Power Source (UPS).

3.3.1.2.11.5 Power Switches

The power switches control the 28 VDC power supply to valves and cryogenic heaters. With the exception of the power switches controlled directly by the CSP, the power switches are galvanically isolated from the 28 VDC power bus.

3.3.1.2.11.6 Cryomagnet Self Protection (CSP)

Super-conducting magnets, such as the one utilized by AMS-02, may develop a condition where a portion of the coil begins to rise above super-conducting temperatures. When this condition occurs, the section of wire affected begins to develop resistance, and the current running through this resistance begins to heat the wire rapidly. This eventually leads to dissipation of the magnet energy (in the form of heat) within the magnet, and is referred to as a magnet quench. This condition is highly undesirable from a mission success standpoint because resulting unbalanced magnetic forces in the different sections of the magnet may cause it to deform, making it unable to be recharged to the maximum field or even to return to a superconducting state, thus preventing the recharging of the magnet. This is a possible mission success critical failure, not a safety issue. Alterations in the magnetic field have already been accounted for in the safety assessment for nominal field strengths.

To protect the magnet from this condition, referred to as an unassisted quench, electronics have been designed that will detect the initiating condition and apply heat quench evenly throughout the magnet coils, causing the magnetic field to dissipate uniformly. This will prevent the heating from being isolated to a small section of the magnet, which could become damaged if the quench was uncontrolled. By performing an assisted quench, mission success criteria can be maintained. The Cryomagnet Self Protection (CSP) section of the CAB was developed to detect a change in voltage across a coil and perform this assisted quench.

The CSP contains quench detection electronics that monitor the status of the magnet coils to determine if a quench condition is starting to occur. To perform this function, redundant voltage measurements are taken across each coil. If a quench condition is imminent, a voltage will develop across the affected coil. When the CSP detects a change in voltage, the quench protection electronics issues a command to the Uninterruptible Power Source (UPS) to provide a pulse of at least 45A to quench heaters located throughout the magnet. The pulse, for a duration of 150 ms, is required to raise the entire magnet up to a non-superconducting state. This spreads the quench throughout the magnet and prevents isolated heating that could result in degraded performance.

The quench heater chains are redundant and supplied by two separate UPS systems. The chains are routed to alternate coils throughout the magnet. Both heater chains are nominally used by the CSP to control a quench, however either chain independently is sufficient to protect the magnet coils from deformation.

The CSP provides additional functions to protect the magnet during off-nominal conditions. A "watchdog" timer, powered by the UPS, is continuously counting down. Periodically the timeout is reset via external command to about 8 hours. In the event of a power loss, or the loss of communication to the AMS-02 payload, the timeout is not reset and if power or communications are not restored to the AMS within the eight-hour period, the timer will trigger the CSP Control Electronics to initiate the nominal ramp down function, discharging the magnet. During the eight hour period and the ramp down, the UPS will continue to power the Quench Detection Electronics, and maintain the capability to perform an assisted quench (if necessary) until the magnet is completely discharged.

3.3.1.2.11.7 CSP Uninterruptible Power Source (UPS)

The UPS consists of dual redundant 28 Amp-hour (A-h) Lithium Ion Batteries and a Battery Management System (BMS) for each, developed by Yardney/Lithion Corporation, Pawcatuck, CT. Each battery consists of eight cells in series to generate the required nominal 28 Vdc for the system. To ensure mission success during loss of ISS power or communication, the UPS is required to supply power for the watchdog timer function, quench monitoring functions, nominal ramp-down at watchdog timer rundown, and initiation of a quench pulse of at least 45 A for 150ms anytime during the sequence.

Figure 3.3.1.2.11.7-1 shows the protection circuitry for the CAB Battery Charger Electronics (BCE), providing isolation between the UPS and PDS. The CAB BCE design includes the following protection electronics:

- Two double diodes in a cross-strapping configuration of the nominal and redundant 28Vdc primary power busses coming from PDS unit.
- SSPC (Solid State Power Conditioner), implemented by means of a Latching Current Limiter (LCL), which opens in case of failure.
- The HV power transformer barrier, which provides galvanic isolation between the electronics on primary side and the electronics on secondary side.
- The control electronics to provide the fit current to the battery, and also includes a power transformer with galvanic isolation.
- The blocking diode included in the BMS Battery Management System Electronics, which only permits the current way in only one direction.

All the above-mentioned protections included in the CAB BCE guarantee no propagation of failure to the ISS or any other unit, such as the PDS, which provides the 28Vdc primary power busses.

The CSP electronics design includes the following protection electronics between UPS and the loads (quench heaters, magnet valves):

- Two switches in series to power the quench heaters. These switches are only closed during 150ms of time required for the quenching sequence.

- SSPC (Solid State Power Conditioner), implemented by means of an LCL Latching Current Limiter, which opens in case of failure.
- The power transformer barrier, which provides galvanic isolation between the electronics on secondary side and the electronics on the load side.
- Two switches in series to open or close the valves.

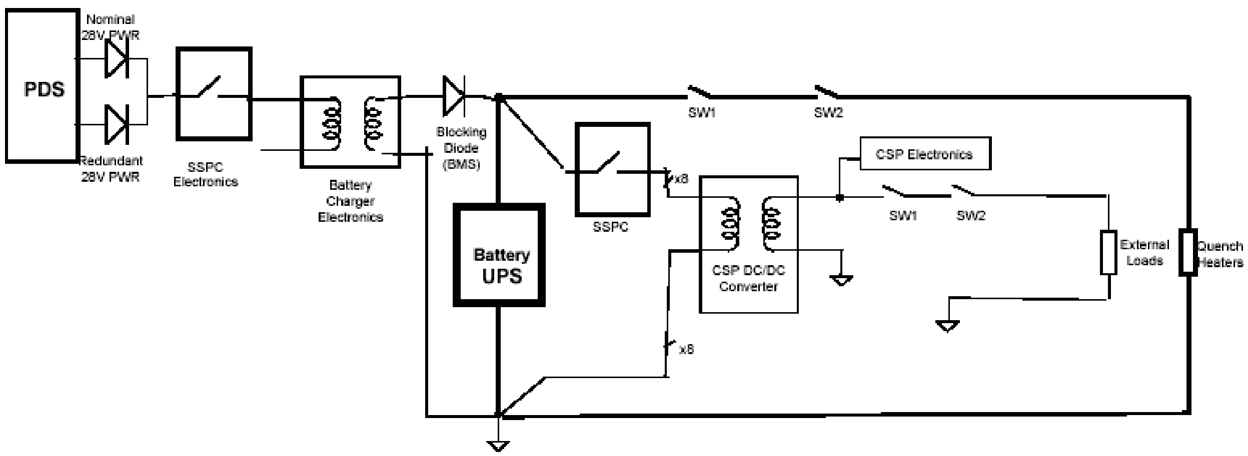


Figure 3.3.1.2.11.7-1 PDS to UPS Interface Diagram

3.3.1.2.11.8 Battery Management System

The Battery Management System (BMS) consists of four independent circuit boards and is designed to have the primary responsibility for battery condition (along with good design). The four boards consist of: a master controller board, two monitor/equalizer boards, and a protection/regulator board.

The BMS master controller board communicates with the two monitor/equalizer boards to obtain cell voltage and temperature. The master controller board uses this information to calculate the battery state of charge (SOC) for use in the charge algorithm and to control the battery pack cell equalization. In case of a critical hardware failure, such as loss of communication to the monitor equalizer boards, the master controller board determines this condition and activates the protection board or charger switch.

The two monitor/equalizer boards monitor cell voltage and pack temperature. They perform cell equalization on each charge cycle by resistively bypassing any cell with a voltage in excess of a predetermined maximum. The bypass current is dissipated through a resistor array on the board. The master control board determines when the voltage condition is reached and activates the bypass. The master control board also determines when a cell voltage is exceeding allowable safety limits and activates the Protection and/or Charger switch as well.

The protection/regulator board is used to disconnect the pack from the load during fault conditions that include high cell temperature, low cell voltage and high current.

Additionally, a charger switch will disconnect the battery from the charger in cases of high cell temperature, high cell voltage or if the charger becomes uncontrollable. The switch will open in the case of a critical hardware failure, such as loss of communication to the monitor equalizer boards. The master controller board determines these conditions and sends the signal to the protection board or charger switch. The protection board employs multiple parallel metal-oxide-silicon field effect transistors (MOSFET) to carry the battery load current. Upon the occurrence of a short circuit the protection switch will open within 100msec (TBR) to isolate the battery from the short circuit condition.

Two sets of bricks and BMSs are mounted into a UPS box (Figure 3.3.1.2.11.8-1), apiece, which provide further containment and protection from MM/OD. Both UPS boxes are mounted to the USS in proximity to the CAB and the input port on the Vacuum Case to decrease line resistance (Figure 3.3.1.2.11.3-2).

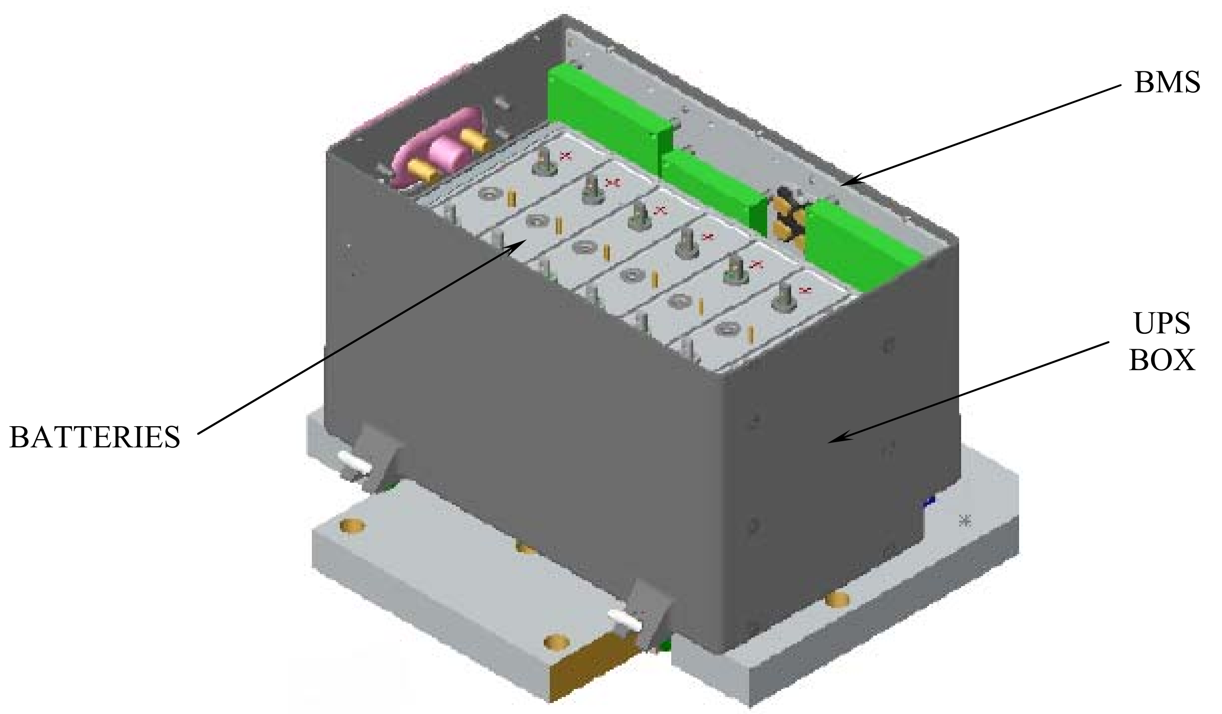


Figure 3.3.1.2.11.8-1 Battery and BMS mounted in UPS Box

3.3.1.2.11.9 Cryocooler Electronics Box (CCEB)

The CCEB receives 120 Vdc from either or both buses to power the Cryocoolers and their Monitor & Control Electronics. Bus-to-Bus isolation for the 120 Vdc is provided by relays. Over-current protection is provided by dedicated circuitry in eight power amplifiers. An SSPC in the PDS and fuses (TBR) in the CCEB provide additional circuit protection.

Monitor and Control Power for the CCEB is supplied by DC-to-DC converters operating from both buses (Figure 3.3.1.2.11.9-1). The DC-to-DC converters provide the necessary isolation bus-to-bus for the low voltage power.

Cryocooler power is routed from each bus through a set of four power amplifiers and passed through a power switch to each Cryocooler. The power amplifier consists of a 60-hertz pulse width modulated H-bridge with clamp logic, to improve efficiency and reduce electromagnetic interference (EMI). This provides the required drive signal for the Cryocoolers. The output of the power amplifier is then routed to the power switch. Each power amplifier has a current limiting circuit with a shutdown option.

The power switch contains inputs for the power amplifier signals from both buses. Four-pole, double throw relays select which bus each Cryocooler will be powered from. One pair of the poles are used to select the Hi and Lo signals from the selected power amplifier to power the Cryocoolers, and the other two poles are used for feedback of the relay position. Control of the power switch is provided by a Universal Slow Control Module (USCM), an AMS standard board with firmware used for control of low rate equipment. The USCM uses both ground command and automated configuration setting capabilities to control the Cryocoolers.

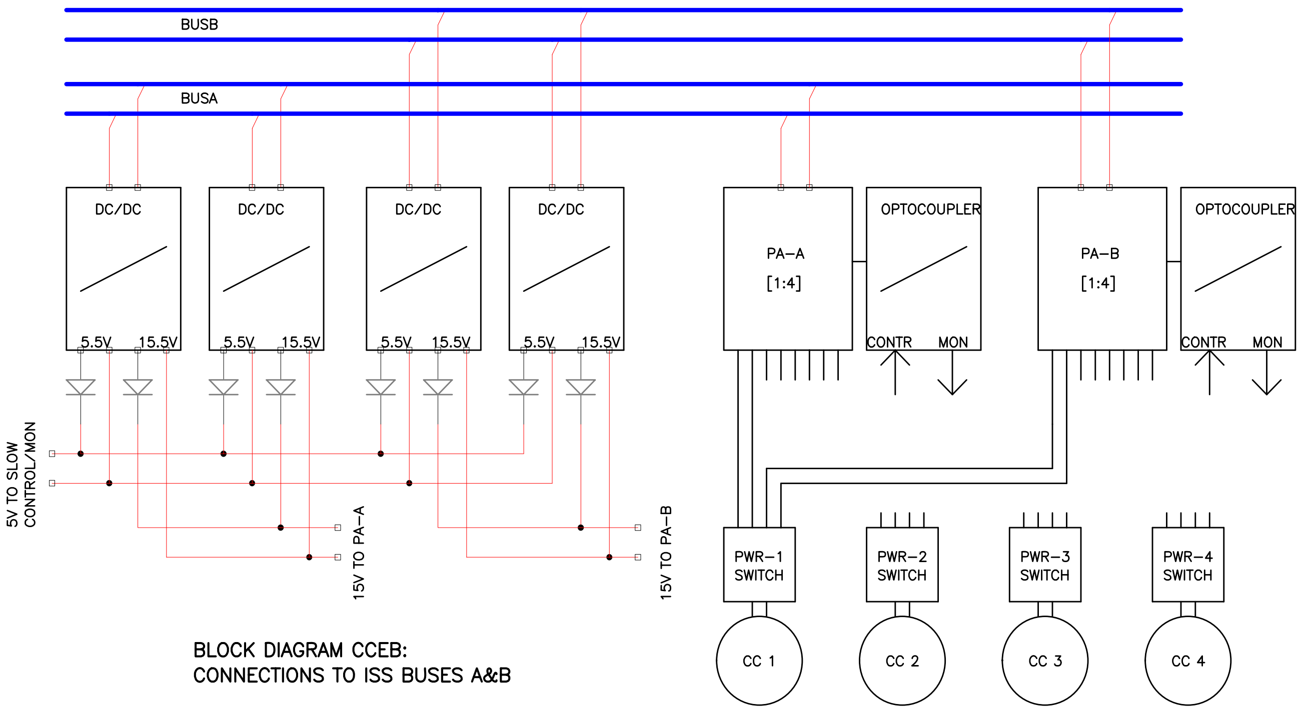


Figure 3.3.1.2.11.9-1 Block Diagram of Cryocooler Electronics Box (CCEB)

3.3.1.2.11.10 High Voltage Sources

The Cryomagnet is a potential high-voltage source in the event of a quench and the protection scheme is described in the CAB description. Other than the path to the CAB, the Cryomagnet generated high voltage would be contained within the Vacuum Case, which is grounded to the Unique Support Structure (USS). Table 3.3.1.2.11.10 lists the remaining high voltage and current sources on the AMS-02.

TABLE 3.3.1.2.11.10 AMS-02 HIGH VOLTAGE OR CURRENT SOURCES

High Voltages (and Currents) in AMS-02.						
Item	**Subsystem**	**Source**	**Load**	**Voltage**	**Current**	**AWG**
1	Cryocooler	CCEB	Cryocooler	<120Vpwm	<5A	3x22
2	Cryomagnet	CCS in CAB	Cryomagnet	<10VDC	<460A	3x00
3	Cryomagnet	Cryomagnet	CDD-P, CDD-S	<10VDC	<460A	00
4	Cryomagnet	UPS	CSP in CAB	<32VDC	<90A	3x12
5	Cryomagnet	CSP in CAB	Quench Heaters	<32VDC	<90A	3x12

High Voltages (and Currents) in AMS-02.						
6	Cryomagnet	Cryomagnet	Quench Detectors	<1000VDC	<1A	HV 24
7	ECAL	EHV	55 ECAL PMTs	<1000VDC	<250uA	HV 36
8	Interface	ISS	AMS	120VDC	<25A	8
9	Interface	ISS/PVGF	AMS	120VDC	<15A	12
10	Interface	STS/T0, APCU	AMS	120VDC	<25A	8
11	Power	PDS	CCS in CAB	120VDC	<17A	2x16
12	Power	PDS	CCEB	120VDC	<7.5A	2x16
13	RICH	RHV	40 RICH PMTs	<1000VDC	<80uA	HV 36
14	S:TOF+ACC	SHV	20 TOF+4 ACC PMTs	<1000VDC	<25uA	HV 36
15	Thermal	PDS	ECAL Heaters	120VDC	<3A	20
16	Thermal	PDS	Ram Heaters	120VDC	<7.5A	3x20
17	Thermal	PDS	TRD Heaters	120VDC	<3A	20
18	Thermal	PDS	Tracker Wake Heaters	120VDC	<3A	20
19	Thermal	PDS	Wake Heaters	120VDC	<5A	2x20
20	Thermal	PDS	LUSS Boxes	120VDC	<3A	20
21	Thermal	PDS	RICH Heaters	120VDC	<3A	20
22	Thermal	PDS	LTOF Heaters	120VDC	<3A	20
23	Thermal	PDS	CC1&2 Heaters	120VDC	<3A	20
24	Thermal	PDS	Tracker Ram Heaters	120VDC	<3A	20
25	Thermal	PDS	CC3&4 Heaters	120VDC	<3A	20
26	Tracker	TPD	2 TBS in T-Crate	<120VDC	<10mA	2x22
27	Tracker	2 TBS in T-Crate	24 Tracker Ladders	<80VDC	<10mA	26
28	TRD	UPD	6 UHVG in U-Crate	<120VDC	<35mA	22
29	TRD	6 UHVG in U-Crate	2624 TRD Straw Tubes	<1800VDC	<100uA	HV 36

Wire: AWG 00=M22759/41-02-5D, AWG 12 – 24=M22759/44-*, HV 24= Reynolds 178-8066, Coax 36=Reynolds 167-2896

Table 5.10.6-1 AMS-02 High Voltage or Current Sources (Continued)

High Voltages (and Currents) in AMS-02.						
Item	**Subsystem**	**Source**	**Load**	**Voltage**	**Current**	**AWG**
1	Cryocooler	CCEB	Cryocooler	<120Vpwm	<5A	3x22
2	Cryomagnet	CCS in CAB	Cryomagnet	<10VDC	<460A	3x00
3	Cryomagnet	Cryomagnet	CDD-P, CDD-S	<10VDC	<460A	00
4	Cryomagnet	UPS	CSP in CAB	<32VDC	<90A	3x12
5	Cryomagnet	CSP in CAB	Quench Heaters	<32VDC	<90A	3x12
6	Cryomagnet	Cryomagnet	Quench Detectors	<1000VDC	<1A	HV 24
7	ECAL	EHV	55 ECAL PMTs	<1000VDC	<250uA	HV 36
8	Interface	ISS	AMS	120VDC	<25A	8
9	Interface	ISS/PVGF	AMS	120VDC	<15A	12
10	Interface	STS/T0, APCU	AMS	120VDC	<25A	8
11	Power	PDS	CCS in CAB	120VDC	<17A	2x16
12	Power	PDS	CCEB	120VDC	<7.5A	2x16
13	RICH	RHV	40 RICH PMTs	<1000VDC	<80uA	HV 36

High Voltages (and Currents) in AMS-02.						
14	S:TOF+ACC	SHV	20 TOF+4 ACC PMTs	<1000VDC	<25uA	HV 36
15	Thermal	PDS	ECAL Heaters	120VDC	<3A	20
16	Thermal	PDS	Ram Heaters	120VDC	<7.5A	3x20
17	Thermal	PDS	TRD Heaters	120VDC	<3A	20
18	Thermal	PDS	Tracker Wake Heaters	120VDC	<3A	20
19	Thermal	PDS	Wake Heaters	120VDC	<5A	2x20
20	Thermal	PDS	LUSS Boxes	120VDC	<3A	20
21	Thermal	PDS	RICH Heaters	120VDC	<3A	20
22	Thermal	PDS	LTOF Heaters	120VDC	<3A	20
23	Thermal	PDS	CC1&2 Heaters	120VDC	<3A	20
24	Thermal	PDS	Tracker Ram Heaters	120VDC	<3A	20
25	Thermal	PDS	CC3&4 Heaters	120VDC	<3A	20
26	Tracker	TPD	2 TBS in T-Crate	<120VDC	<10mA	2x22
27	Tracker	2 TBS in T-Crate	24 Tracker Ladders	<80VDC	<10mA	26
28	TRD	UPD	6 UHVG in U-Crate	<120VDC	<35mA	22
29	TRD	6 UHVG in U-Crate	2624 TRD Straw Tubes	<1800VDC	<100uA	HV 36

Wire: AWG 00=M22759/41-02-5D, AWG 12 – 24=M22759/44-*, HV 24= Reynolds 178-8066, Coax 36=Reynolds 167-2896

3.3.1.2.12 Thermal Control System (TCS)

The AMS-02 Thermal Control System (TCS) is being developed and designed by the AMS experiment team. During nominal operations on ISS, AMS-02 draws up to 2600 watts of power. This power must be dissipated as heat, while maintaining all components within their temperature limits and maintaining the Vacuum Case as cold as possible. The payload also must be able to survive STS environments, handoff between STS and ISS, periods with no power (both during transfer and while berthed on ISS) and peak power excursions (e.g. magnet charging). Passive thermal design options are utilized as much as possible, but more complex thermal control hardware is required for some sub-detector components to assure mission success. TCS specific hardware includes radiators, heaters, thermal blankets, heat pipes, loop heat pipes, optical coatings and a dedicated CO2 pumped loop system for Tracker cooling. AMS-02 is designed such that passive thermal control is all that is required to sustain the payload safely through extended periods of power loss without hazard.

3.3.1.2.12.1 Ram and Wake Radiators

The Ram and Wake Main Radiators are designed to both dissipate heat from the electronics crates and provide their structural support. The crates, which are optimized to transfer heat to the radiator, are bolted directly to the honeycomb panel using threaded inserts. A silicone based thermal interface filler, Chotherm 1671, is used to minimize the thermal resistance across this interface. During nominal operations the Ram radiator dissipates 525 watts over its 4.24 m^2 surface area, while the Wake dissipates up to 812 watts over its 3.99 m^2 area. Heaters mounted on these radiators are used to bring electronics above their minimum turn-on temperature after periods without power. The outer surfaces of the radiator face sheets are painted with SG121FD white paint to optimize heat rejection. Portions of the crates and inner radiator surfaces are covered with MLI blankets to minimize heat rejection back to the vacuum case and to adjacent ISS payloads.

These radiators consist of a 25mm thick ROHACELL® core with 0.5mm thick 2024 T81 aluminum face sheets and imbedded heat pipes. A cross section is shown in Figure 3.3.1.2.12.1 -1. Heat pipe layouts are shown in Figures 3.3.1.2.12.1-2a & -2b. The heat pipes are standard axial groove, made of aluminum 6063 and filled with high purity ammonia. Each Main Radiator mounts to the USS-02 at six locations. Two brackets at the top fix the radiator to the Upper Trunnion Bridge Beams; two mid-brackets fix the middle portion of the radiator to the Lower Trunnion Bridge Beams and two pin-ended struts span the distance from the lower row of crates on the radiator to the Lower Vacuum Case Joint.

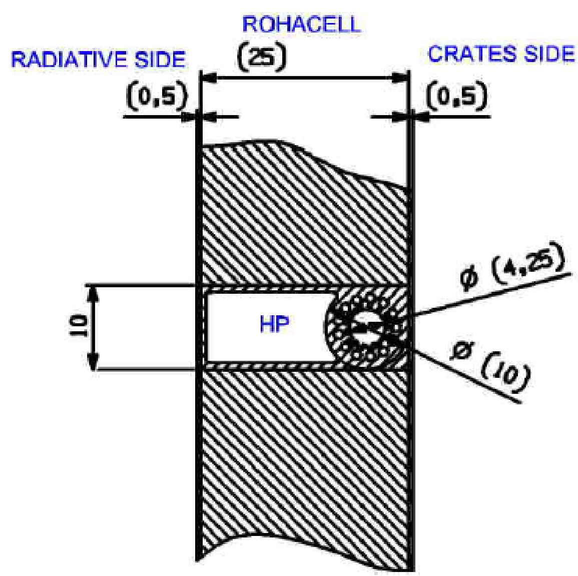
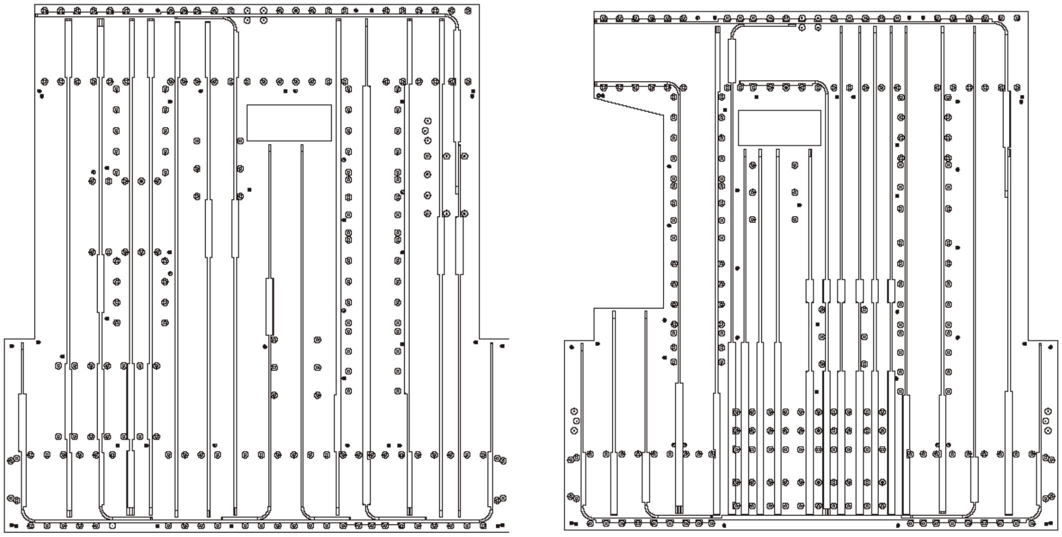


Figure 3.3.1.2.12.1-1 Main Radiator Cross Section



a) Ram Main Radiator Heat Pipes b) Wake Main Radiator Heat Pipes

Figure 3.3.1.2.12.1-2 Ram and Wake Main radiator Heat Pipe Layout

3.3.1.2.12.2 Tracker Radiators

The Ram and Wake Tracker radiators are designed to reject the heat transported by the Tracker Thermal Control System (TTCS), a two-phase CO_2 loop running from inside the Tracker (~144 watts) to condensers mounted on the Radiators. Tracker radiators use Aluminum 2024 T81 face sheets with a ROHACELL® 52 core and imbedded aluminum/ammonia heat-pipes. The tracker radiators are trapezoidal, with a lower width of 2250 mm, an upper width of 2500 mm, and a height of 530 mm. 7 heat pipes are embedded in each Tracker Radiator. CO_2 loop condensers mount directly to the heat pipes by bolting through the radiator. Each radiator is mounted using 8 pin-ended struts; 1 attached to each of the Upper Trunnion Bridge Beams and 3 attached to each of the Upper Vacuum Case joint. There is also a bracket attaching each Tracker Radiator to the adjoining Main Radiator. The outer surfaces of the Tracker Radiators are painted with SG121FD white paint. The back sides will be covered with MLI blankets.

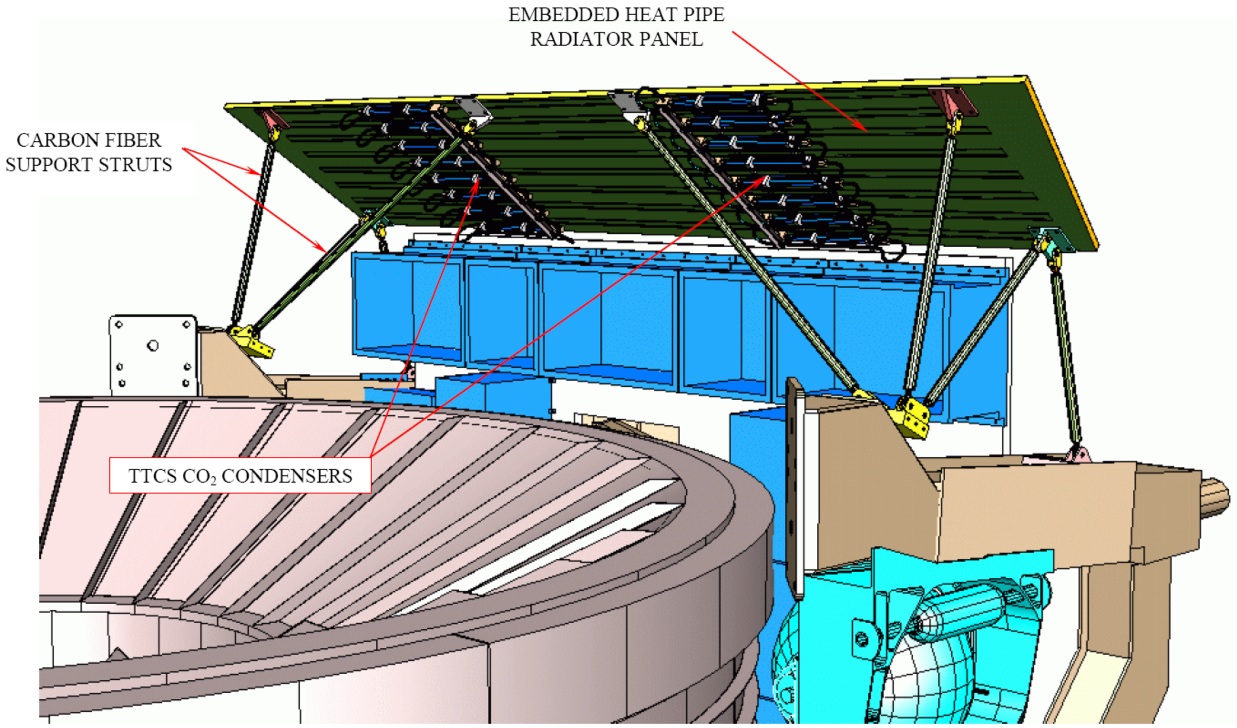


Figure 3.3.1.2.12.2-1 Tracker Radiators

3.3.1.2.12.3 Zenith Radiator

The Zenith Radiator actually consists of four separate panels, each design to reject heat (up to 150 watts) transported via two Loop Heat Pipes (LHPs) from a single Cryocooler (Figure 3.3.1.2.12.3-1). The radiator panels are constructed with aluminum 2024 T81 face sheets (1.6 mm for the upper face sheet and 0.3 for the lower), with a 10 mm ROHACELL® core. The condenser portion of each Loop Heat Pipe is a 4mm OD (3mm ID) aluminum 6063 tube, which is brazed to the upper face sheet of the radiator along a path designed to optimally reject heat. At the outer edge of each panel, the aluminum condenser tubes transition to stainless steel tubes via bimetallic joints. Each radiator panel is mounted to the top of the Upper TRD honeycomb panel via 14, 3mm OD x 35 mm long glass fiber-composite pins, designed to minimize heat leak, and two brackets; a Glass Fiber Reinforced Polymer (GFRP) bracket in the center and an aluminum one on the outer edge. The outer face of the Zenith Radiator is covered with Silver-Teflon film to maximize heat rejection capability. An MLI blanket is used on the under side to thermally isolate the Zenith Radiator from the TRD.

Cryocooler cooling is achieved using two redundant Loop Heat Pipes (LHPs) to collect and transport heat from each of the four cryocoolers to a zenith-mounted, direct-flow radiator. The Loop Heat Pipes (along with the Zenith Radiators) were built by IberEspacio, Madrid. The evaporator portion of each LHP is attached to a heat rejection collar on the cryocooler body. This bolted interface includes an Indium interface filler to minimize the thermal resistance. The LHP does not interface directly with the Cryomagnet pressurized systems.

Heaters are used for Cryocooler startup and to keep them above minimum storage limits. A control valve is used to redirect flow into a bypass loop if cryocooler temperatures start getting too cold. This valve uses a bellows system, filled with Argon at a predetermined pressure to control the direction of propylene flow. Each LHP is made primarily of stainless steel, with nickel wicks and high purity propylene as a working fluid. 3 mm stainless steel tubing runs to the edge of the radiator, where it is transitioned to aluminum tubing via a bi-metallic joint. As mentioned in the previous section, this aluminum tubing is brazed to the upper aluminum skin of the zenith radiators.

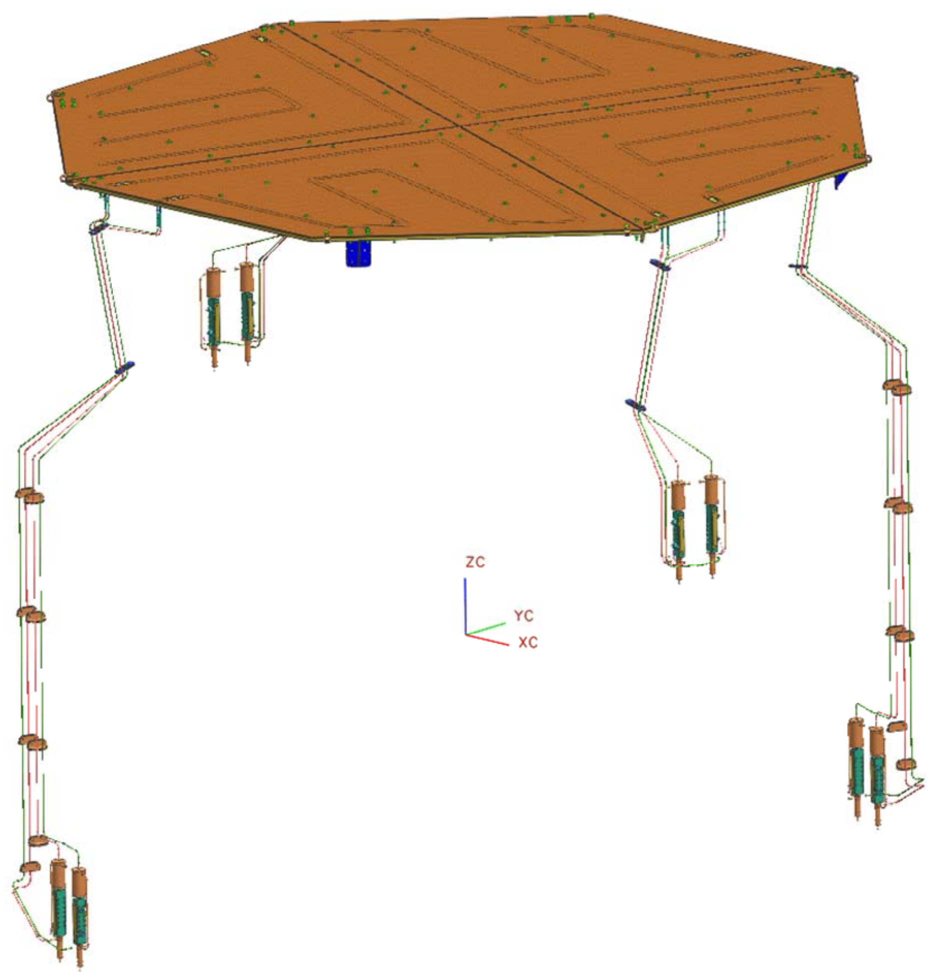


Figure 3.3.1.2.12.3-1 Zenith Radiator Panels

3.3.1.2.12.4 Multi-Layer Insulation (MLI) Blankets

AMS-02 will have numerous MLI blankets on various components and detectors. Typical construction will include Beta cloth as the outermost surface, 5 to 20 layers of aluminized Mylar separated by Dacron scrim, and reinforced aluminized Kapton as an inner surface. All MLI blankets used on AMS-02 will meet or exceed the NASA requirements for grounding and venting. These specifications are called out in CTSD-SH-1782, Multi-Layer Insulation for the Alpha Magnetic Spectrometer Guidelines.

3.3.1.2.12.5 Tracker Thermal Control System (TTCS)

The TTCS is the most complex thermal control system on the AMS-02, to reject heat from the Silicon Tracker system and provide a uniform temperature distribution across the Tracker Silicon sensor arrays. The Silicon Tracker, completely encased inside the inner bore of the Vacuum Case, generates 144 watts that needs to be rejected while minimizing heat flow to the Vacuum Case Inner Cylinder. The TTCS thermal design includes thermal bars, a pumped CO_2 cooling loop, radiators, manifolds, accumulators and numerous other components to accomplish this controlled heat rejection.

3.3.1.2.12.5.1 TTCS Evaporator

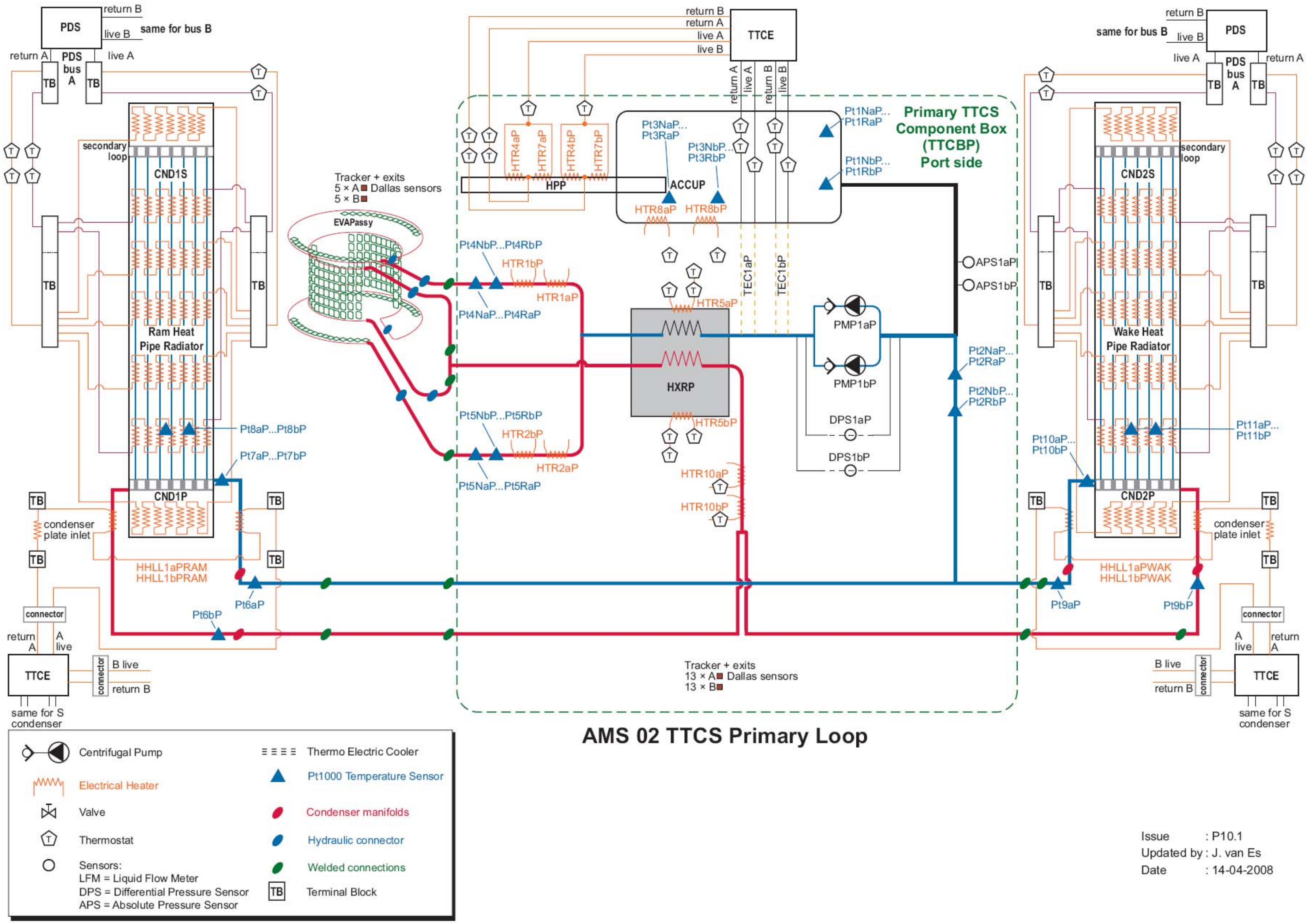
Each of the 192 hybrid electronic boards or Hybrids, located on the periphery of eight Tracker planes, generates 0.75 watts. There are six inner rings of Hybrids inside the Vacuum Case Inner Cylinder, one above and one below. The Hybrids are attached to thermal bars, frames made of Thermal Pyrolytic Graphite (TPG) encased in aluminum 6061. Between inner planes, the Thermal Bars are thermally connected to each other via flexible connecters made of copper. Thermal Bridges, also made of copper, connect the end thermal bars to the inner evaporator ring tube. Hybrids on the two Outer Planes connect to the outer ring evaporator tubes via copper braids. There is an Inner and Outer ring evaporator on both the upper and lower Tracker flange. For redundancy, all evaporators include two separate tubes connected to independent cooling loops.

3.3.1.2.12.5.2 TTCS CO_2 Cooling Loop

The TTCS cooling loop uses carbon dioxide to pick up heat from the evaporator rings inside the Silicone Tracker. The CO_2 transports heat to condensers connected to radiators on both ram and wake sides of AMS. Fluid is transported back to the evaporator by means of a mechanical pump. Condensers and radiators are designed to assure that the CO_2 is sufficiently cooled so that only liquid will enter the pump.

To maintain the Tracker as isothermal as possible, two-phase cooling is desired throughout the evaporator. This is achieved by using an electric heater to pre-heat the fluid to the saturation temperature before it enters the evaporator. To minimize required heater power, a heat exchanger connects the evaporator inlet and outlet near the electric

pre-heater. Figures 3.3.1.2.12.5.2-1 and 3.3.1.2.12.5.2-2 show schematics of the Primary and Secondary TTCS Cooling Loops. The two loops are identical.
For each loop, the pump, accumulator, heat exchanger, pre-heater and valves are located in the Tracker Thermal Control Box (TTCB) shown in Figure 3.3.1.2.12.5.2-3. The Primary TTCB is mounted on the +X +Y Lower Trunnion Bridge Beam while the Secondary is mounted to the –X +Y Lower Trunnion Bridge Beam. The boxes are thermally isolated from the beams and covered with an MLI blanket, except for the wake facing surface which is used as a radiator.



AMS 02 TTCS Primary Loop

Issue : P10.1
Updated by : J. van Es
Date : 14-04-2008

Figure 3.3.1.2.12.5.2-1 AMS-02 Tracker Thermal Control System Primary Loop

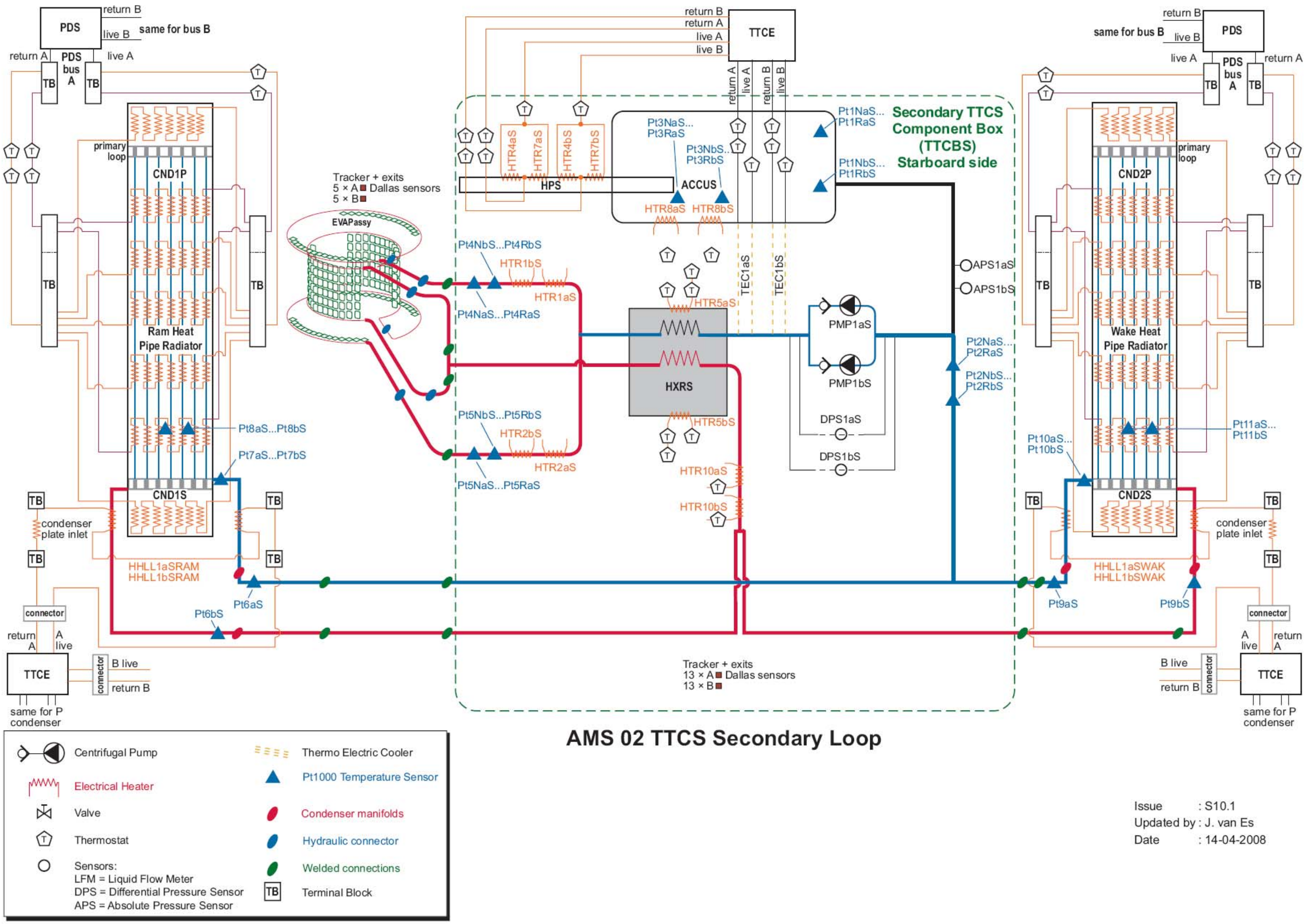


Figure 3.3.1.2.12.5.2-2 AMS-02 Tracker Thermal Control System Secondary Loop

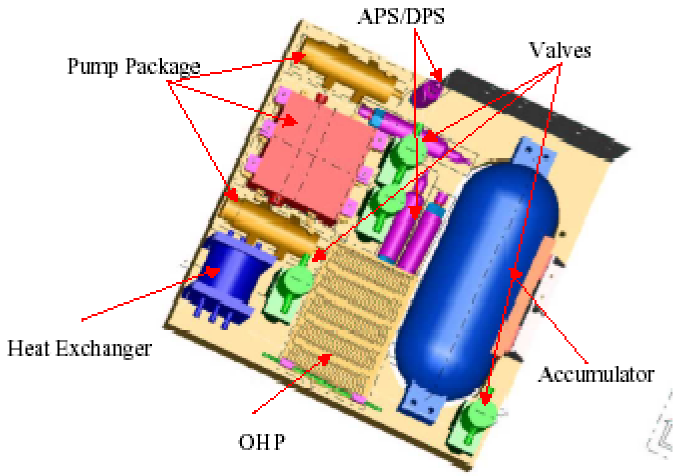


Figure 3.3.1.2.12.5.2-3 TTCB

3.3.1.2.12.5.3 Condensers

There are 14 TTCS condensers mounted on both the Ram and Wake Tracker Radiators. Pairs of condensers are thermally connected to each of the seven heat pipes embedded in each radiator. Mounting is achieved by bolting through the radiator with Chotherm 1671 used as a thermal interface filler.

The condenser is constructed with seven parallel lines of capillary tubing made of Inconel 718, soldered to an aluminum plate (Figure 3.3.1.2.12.5.3-1). Inconel tubing (1mm ID) also runs from the condensers to manifolds mounted on the Vacuum Case conical flange. The manifold combines the parallel flow from the capillary tube and transitions it to 2.6 mm ID stainless steel tubing. The condensers (including all capillary tubes) are designed to withstand freezing and thaw of CO_2. Heater wires are mounted on the capillary tubes to thaw the lines in case of freezing after loss of power.

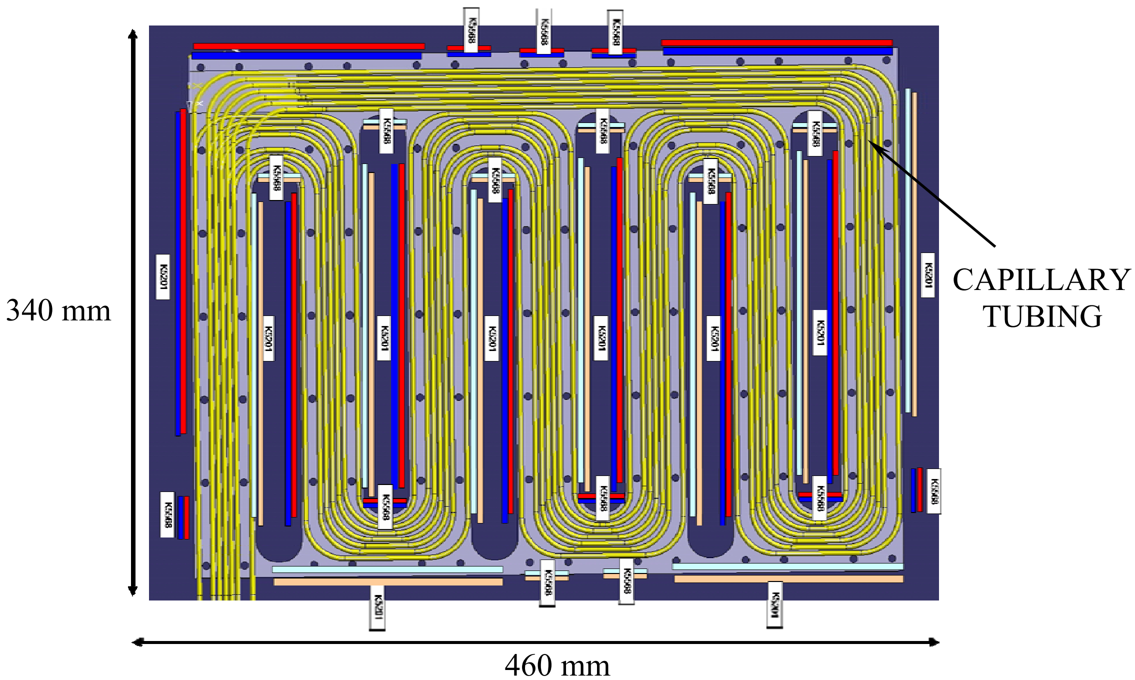


Figure 3.3.1.2.12.5.3-1 TTCS Condenser

3.3.1.2.13 <u>Micrometeoroid and Orbital Debris (MMOD) Shields</u>

The MMOD will be designed, analyzed, built and integrated by NASA/ESCG. The shielding is designed to protect the pressure systems on the AMS-02 experiment according to the environments specified in SSP 30425, paragraph 8.0. These systems include the Vacuum Case, Warm Helium Supply, and the TRD Gas System which contains both the Xe tank and CO_2 tank.

The shielding will be made from various components in different locations depending on the required shield thickness, shape and size. The MMOD shielding for AMS-02 consists of a 0.1 inch outer and inner aluminum sheet with a layer of 0.1 inch Kevlar/Nextel. Standoffs will be used to separate the outer aluminum sheet from the inner aluminum sheet. The shield design is shown in figure 3.3.1.2.13-1. Both sets of MMOD shields will have the same general design.

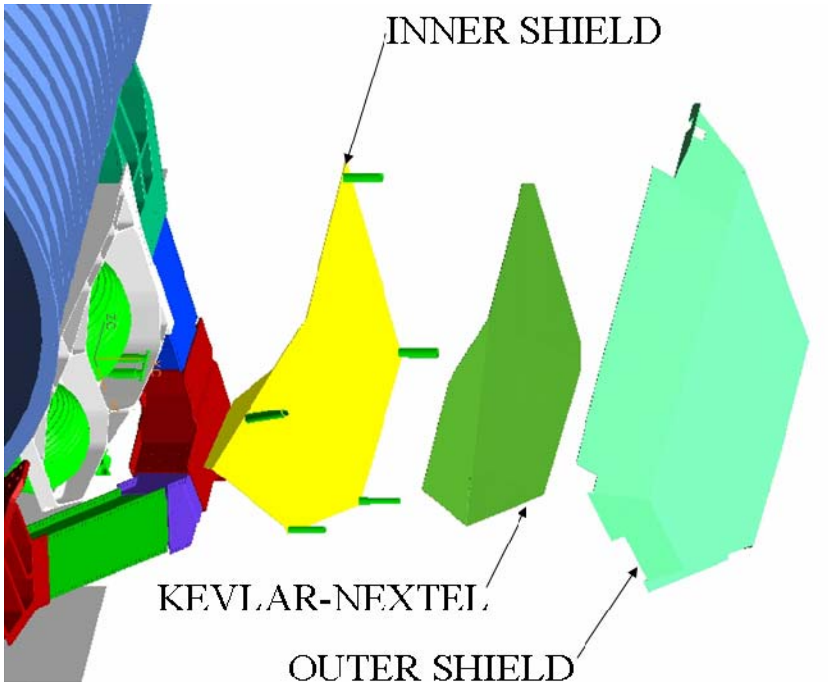


Figure 3.3.1.2.13-1 MMOD Shield Design

The shield assemblies will be bolted to the Upper and Lower Trunnion Bridge Beams of the USS-02.

3.3.1.2.14 Digital Data Recording System – 02 (DDRS-02)

The DDRS-02 utilizes a standard Space Shuttle Program Provided Next Generation Laptop (NGL) and a dedicated Digi International DataFire Sync 570I PCI, two port, Universal Interface Bus Card and DataFire Sync 570I to PDIP Cables (2 data cables) to interface with the Orbiter provided data port.

4. Verification Process

The following subparagraphs detail the verification process in terms of management responsibilities and methodology.

4.1 VERIFICATION MANAGEMENT RESPONSIBILITIES

AMS-02 management responsibilities are defined in JSC 27296, Project Plan for the Alpha Magnetic Spectrometer (AMS).

4.2 VERIFICATION METHODS

Each performance and design requirement of the AMS-02 hardware and software specifications is assigned a method for verification in the requirement verification matrix of this MVP. Four distinct methods are used to satisfy verification requirements: analysis, inspection, demonstration, and test, or a combination of these. As the specification is developed, each requirement is analyzed and assigned a method that is documented in the verification matrix. This matrix thus provides the foundation for all further verification planning for that item. The assigned method may prove invalid as the design matures. In this case, the verification method will be updated in the verification matrix through normal document control channels, with the appropriate approvals.

4.2.1 Analysis

Analysis is a verification method utilizing techniques and tools such as math models, prior test data, simulations, analytical assessments, etc. Verification by similarity is acceptable if the subject article is similar or identical in design, manufacturing process, and quality control to another article that has been previously verified to an equivalent or more stringent criteria.

Examples of verification by analysis include thermal analysis and stress analysis to show that the the AMS-02 Payload does not exceed specification limits during the mission operation.

4.2.2 Inspection

Inspection is a method of verification of software code or hardware physical characteristics that determine compliance without the use of special laboratory equipment, procedures, test support items, or services. Inspection often uses visual methods to verify compliance with design requirements. A record of the inspection (TPS, weld inspection record, etc.) is required.

Examples of verification by inspection include verification of surface finish, elimination of sharp edges, software code evaluations and drawing evaluations.

4.2.3 Demonstration

Demonstration is a qualitative method of verification that evaluates the properties of the subject end item. Demonstration is used with or without special test equipment or instrumentation to verify required characteristics such as operational performance, human engineering features, service and access features, transportability, and displayed data. A formal record of demonstration (TPS) is required.

One example of verification by demonstration is verifying the weight and center of gravity of the AMS-02 Payload.

4.2.4 Test

Test is a method of verification wherein formal project hardware, software and firmware requirements (performance, environment, etc.) are verified by measurement or functional test during or after the controlled application of functional and/or environmental stimuli. These measurements may require the use of laboratory equipment, recorded data, procedures, test support items, or services. Examples include vibration testing and thermal/vacuum testing. Different types of testing that may be included in this section are qualification, acceptance, system integration, program integration, major ground testing, orbital flight demonstrations, pre-launch checkout, and on-orbit checkout.

Of note, when the results of any testing are intended for use in the formal verification of the project's products (i.e., verification of requirements listed in Appendix C), the test must be performed on controlled hardware/software, using only controlled and approved GSE, and must be documented (Task Performance Sheets, Discrepancy Reports, Test Reports or equivalent).

4.2.4.1 Qualification Testing

Qualification testing is performed on units that are identical to the flight articles but are not intended for flight, i.e. a qualification unit. The purpose of qualification tests is to ensure the design of the project's deliverables meet the environment (thermal, pressure, radiation, vibration, etc.) requirements imposed on the deliverable. These tests may exceed the expected induced environment levels. Qualification testing proves that an end item's design is adequate to meet the environment specification requirements. This testing will include functional tests before and after exposure to the test environment to determine the success or failure of the test. Depending on the project requirements, this may also include functional and performance tests being conducted during the environment tests.

4.3 VALIDATION METHODS

Validation is performed to ensure that, regardless of any specific set of requirements, the customer/sponsor will be satisfied with the product provided. Validation ensures the purpose of a system is not lost in the specification of the detailed requirements. Validation provides a means to confirm with the customer/sponsor to determine whether the product will meet their expectations. When performed early in the project, validation prevents wasted time and effort resulting from misunderstandings and wrong assumptions.

The same four methods can be used to perform validation: analysis, inspection, demonstration, and test, or a combination of these. The validation activities are documented in Appendix D, Validation Matrix for AMS-02 Experiment Hardware.

4.4 CERTIFICATION PROCESS

The Project Manager provides evidence to JSC S&MA that the AMS-02 satisfies all performance and design requirements. The verification products provide the basis for this certification and may be supplemented with any validation products. Based on this evidence, JSC S&MA approves the request for certification. This process is an audit of how the project has verified each requirement in Appendix C.

4.5 ACCEPTANCE TESTING

Acceptance testing is used to prove that the flight unit(s) has (have) replicated the certified design. These flight units are tracked by serial number (or software identifier). Acceptance testing is performed on each deliverable end item. In addition to proving the functionality of each unit at a selected subset of specification values, this testing also is intended to screen out manufacturing defects, workmanship errors, incipient failures and other performance anomalies not readily detectable by inspection. The acceptance testing process also ensures the verified firmware and/or software resident within the flight item has been properly installed.

Examples of functional acceptance tests include measurement of an output voltage level, proper software response, or a proper response to control stimuli. Examples of environment acceptance tests include vibration and thermal vacuum.

5. Verification Implementation

5.1 AMS-02 VERIFICATION FLOW

The AMS-02 verification process is broken down into three distinct categories: Requirements verification of the Payload Integration Hardware (PIH); Requirements verification of the Experiment Hardware; and Verification of the Phase II Safety Requirements. Verifications for the PIH and Experiment Hardware are included in Appendix C. Verifications for the Safety Requirements are included in Appendix E. Validations for the Experiment Hardware are included in Appendix D. AMS Project Office (APO) at JSC is responsible for the verifications contained in Appendices C and E. The AMS Collaboration is responsible for the validations contained in Appendix D.

5.2 TEST ARTICLES

The AMS Project has built a structural test article (STA) Vacuum Case for verifying welding parameters and the structural integrity of the cryomagnet system including the support straps for the cold mass (cryomagnet, SFHe tank, etc.). The STA and the flight article were fabricated in parallel paths and as such are identical in every way. Mass simulators were used to simulate the mass of the magnet and tank during the static, modal and acoustic testing of the integrated system. STAs or mass simulators were used for the TRD, ECAL, Ram & Wake Radiators (with electronics crates), and TTCS Radiators during the static and modal tests. For all other testing of the integrated payload, the actual flight hardware was (will be) used. As an example, an Interface Verification Test (IVT) was performed at KSC where the AMS-02 Passive PAS flight article was mated to the actual flight Active PAS on the S3 Truss to verify the interface and perform verifications of the EVA-releasable Capture Bar on the Passive PAS.

In most cases the Collaboration has taken the approach, when designing the experiment hardware, of building an engineering model (EM) and qualification model (QM) for evaluation, testing and certification before building the flight model (FM). In rare instances when schedules and/or budgets were tight, the Collaboration, with concurrence from NASA, has shortened the design effort by building a "proto-flight" unit to be used for qualification testing and for flight.

5.3 SUPPORT EQUIPMENT

In conjunction with the flight hardware, the AMS Project designed and built a vacuum case test fixture (VCTF) as an interface between the STA Vacuum Case and the sine sweep test device. A test fixture that was used for AMS-01 was modified to accommodate the wider trunnion spacing on the AMS-02 Payload. This test fixture was used for the modal and static testing of the full-up payload. The Collaboration is responsible for designing and building a test stand for use at ESTEC for the full-up TVT and EMI testing of the payload and a test stand for use at CERN for beam testing of the payload. The test stands will be capable of rotating the payload 90 degrees to the horizontal position for performing the TVT and beam tests.

5.4 FACILITIES

The major testing of the AMS-02 Payload was (or is being) conducted at various sites throughout Europe. Sine Sweep Testing of the STA was conducted in January 2007 at an INFN facility in Terni, Italy. Acoustic Testing of the STA was conducted in March 2007 at ESTEC in Noordwijk, The Netherlands. Static and Modal Testing of the full-up payload was conducted at IABG in Munich, Germany. Static testing was completed in June 2007 and modal testing was completed in July 2007. Thermal Vacuum Testing and EMI Testing of the integrated AMS-02 Payload will be conducted at ESTEC. Beam testing of the payload will be conducted (schedule permitting) at CERN in Geneva, Switzerland.

5.4.1 National Aeronautics and Space Administration (NASA)

In addition to providing the Payload Integration Hardware defined in JSC-29095, NASA serves as the overall payload integration authority. Additionally, NASA/Johnson Space Center (JSC) will serve as the overall flight and ground safety certification authority at all NASA facilities. NASA will provide flight safety certification and specify/inspect for all requirements that impact flight safety at all Collaborator facilities. Although not covered by this document, the NASA/Kennedy Space Center (KSC) will provide specialized test facilities, support equipment, and personnel to integrate the payload into the Shuttle Orbiter payload bay at KSC.

NASA JSC will also provide some of the specialized ground support or test equipment to CERN and test sites as defined in JSC-29095.

5.4.2 European Organization of Nuclear Research (CERN)

CERN, together with the other collaborators listed in Section 6.7, will provide the specialized facilities, support equipment, and personnel to support final payload assembly and integration testing. This will include local facility safety, security, configuration management, quality control and assurance, and test planning and conducting.

5.4.3 European Space Agency (ESA)

ESA will provide specialized test facilities, support equipment, and personnel to support the structural test article magnet acoustic test, assembled payload thermal vacuum testing, and assembled payload Electromagnetic Interference/Electromagnetic Compatibility (EMI/EMC) testing. Testing will be conducted in the European Research and Technology Center (ESTEC) in Noordwijk, the Netherlands.

5.4.4 Industrieanlagen-Betriebsgesellschaft (IABG)

IABG will provide specialized test facilities, support equipment, and personnel to support the integrated modal and static testing of the Structural Test Article. Testing will be conducted in Munich, Germany.

5.4.5 Scientific Magnetics (SM)

SCL will provide specialized facilities, support equipment, and personnel to support the integration of the magnet system into the payload assembly. Integration will be conducted in Culham, England.

5.4.6 Istituto Nazionale di Fisica Nucleare (INFN) Perugia

INFN provided specialized facilities, support equipment, and personnel to support the sine-sweep test of the Structural Test Article magnet. Testing was conducted in Terni, Italy.

5.4.7 Other Collaborators

The following collaborators support the project by providing payload hardware and/or funding, per established agreements:

- I. Physikalisches Institut B., RWTH Aachen – Germany
- III. Physikalisches Institu, RWTH Aachen - Germany
- University of Aarhus - Denmark
- National Institute for Nuclear Physics and High Energy Physics – The Netherlands
- Laboratoire d'Annecy-le-Vieux de Physique des Particules - France
- Johns Hopkins University - USA
- Beijing Institute of Spacecraft Environment Engineering - China
- Institute of Electrical Engineering - China
- Institute of High Energy Physics - China
- Universita di Bologna & INFN-Sezione di Bologna - Italy
- Institute of Microtechnology, Institute for Space Science and University of Bucharest - Romania
- Massachusetts Institute of Technology - USA
- National Central University - Taiwan
- University of Maryland - USA
- Kyungpook National University – South Korea
- National Aerospace Laboratory – The Netherlands
- Instituto di Ricerca sulle Onde Elettromagnetiche – Italy
- Max-Planck Institut fur Extraterrestrische Physik – Germany
- Universite de Geneve – Switzerland
- NASA Goddard Space Flight Center – USA
- Laboratoire de Physique Subatomique et de Cosmologie & Universite J. Fourier – France

- Sun Yet-sen University – China
- National Space Program Office – Taiwan
- Shandong University – China
- Universitat Karlsruhe – Germany
- Helsinki University of Technology – Finland
- Laboratorio de Instrumentacao e Fisica Experimental de Particulas – Portugal
- Chung-Shan Institute of Science and Technology – Taiwan
- Centro de Investigaciones Energeticas, Medioambientales y Tecnologicas – Spain
- Universidad Nacional Autonoma de Mexico – Mexico
- Universita di Milano-Bicocca & INFN-Sezione di Milano – Italy
- Universite Montpellier – France
- Institute of Theoretical and Experimental Physics – Russia
- Institute for Space Research – Russia
- Kurchatov Institute – Russia
- Lomonosov Moscow State University – Russia
- Southeast University – China
- Yale University – USA
- INFN-Sezione di Perugia & Universita degli Studi di Perugia – Italy
- INFN-Sezione di Pisa and Universita di Pisa – Italy
- Aganzia Spaziale Italiana – Italy
- INFN-Sezione di Roma and Universita di Roma – Italy
- Ewha Womens University – South Korea
- Shanghai Jiaotong University – China
- INFN-Sezione di Siena and Universita di Siena – Italy
- National Cheng Kung Univeristy – Taiwan
- Academia Sinica – Taiwan
- Florida A&M University – USA
- Instiuto de Astrofisica de Canarias – Spain
- Center for Advanced Research in Space Optics – Italy
- University of Turku – Finland
- Eidenossische Technische Hochschule – Switzerland
- Texas A&M University – USA

- Florida State University – USA
- Aerospace Industrial Development Corporation - Taiwan

6. AMS-02 End Item Verification

6.1 PAYLOAD INTEGRATION HARDWARE (PIH)

6.1.1 Developmental/Engineering Unit Evaluations

6.1.2 Verification Activities

All tests, inspections, and demonstrations performed on the PIH were (will be) performed using either a JSC TPS or a KSC WAD. All analyses will be documented on a formal memo or analysis report. The "Results" column in the MVP Matrix in Appendix C will contain the necessary information (TPS/WAD number, memo number, report number, etc.) to identify where the requirement has been verified. When the verification is performed at vendor facilities, Certificates of Compliance and/or Test Reports of tests performed by the vendor will be used as proof of compliance of the requirements.

6.1.2.1 Verification Testing

6.1.2.1.1 Qualification Testing

Verification of the full payload is described in Section 7.0. Separate component testing will be performed on some low margin elements of the primary structure which cannot be easily tested at the integrated system level. These tests will include component tests of highly loaded joints, fittings, tubes, etc. Some of these tests will be to 1.4 x limit load, while others could be tests to failure. These tests have been identified in the AMS-02 Structural Verification Plan (JSC 28792) and are summarized here:

Lower Vacuum Case Joint Test – The lower USS-02 joint will be tested first to 140% of limit load and then to failure. The complex geometry is not easy to model using standard finite element techniques. This test will give additional confidence that the model used is providing accurate results.

Lower Vacuum Case Interface Plate Test – This test will be used to characterize the load distribution in the interface plate, bolts and shear pin connecting the USS-02 to the VC. The test will be performed to 110% of limit load followed by a check for detrimental deformations. Once it passes this portion of the test, the same configuration will be taken to failure.

PAS Vertex Bracket Test – This test will demonstrate that the PAS Vertex Bracket can withstand a 140% limit load and will determine the actual load at which the Vertex Bracket will fail. Data will be collected to correlate the analysis of the PAS to LUSS structural interface.

6.1.2.1.2 Other Testing

PAS Thermal Acceptance Test – The PAS Thermal Acceptance Test will demonstrate the function of the AMS-02 Passive PAS EVA Releasable Capture Bar under both extreme cold and extreme hot conditions with an environment temperature range from -130 F to + 200 F per SSP

57003, 3.4.1.1.1. The mechanism will also be operated before and after the test to demonstrate that no detrimental deformation occurred during testing.

PAS Vibration Test – The PAS vibration Test is a three-axis qualification and acceptance vibration test of the PAS assembly. As with the thermal acceptance test, the mechanism will be operated before and after the test to demonstrate that no detrimental deformation has occurred during testing. The test will be considered successful once this mechanism functional test is successfully completed.

PAS Stiffness Test – The PAS Stiffness Test will be performed to verify that the system stiffness meets the ISS requirements. A USS simulator will be included in the test to account for the AMS-02 payload stiffness. The Capture bar load will be taken to the maximum ICD level of 6430 lbf. Deflections and stresses on the platform, along with the capture bar deflection, will be recovered to assist in correlation of the PAS model.

STA Vacuum Case Sine Sweep Test – A high-level sine sweep test of the Vacuum Case with a mass simulator of the magnet and helium tank assembly will be performed to study the nonlinear modal response of the magnet support strap assemblies. This response will assist in the correlation of the VC model.

6.1.2.2 Verification Analysis

Analysis will be used extensively in verifying the requirements levied on AMS-02 by the PTRS (JSC 29789), the Attached Payload Interface Requirements Document (SSP 57003), and the AMS-02 Hardware Interface Control Document (SSP 57213). Appendix D, Requirement Verification Matrix identifies those requirements that will be certified by analysis. All analysis will be documented as analysis reports or engineering memoranda. Each analysis will be approved by the appropriate the requirement owner (Working Group, Control Board, Safety Panel, etc.) prior to formal closure of the requirement verification.

6.1.2.2.1 Thermal Analysis

The majority of the thermal analysis used to verify the PIH will be done at the payload level, as described in Section 7.0, and documented in the Launch-to-Activation (LTA) thermal analysis report. Certain component level analyses will be performed to support EVA touch-temperature analyses, localized insulation design, and detector performance studies and will be documented in individual engineering memoranda.

6.1.2.2.2 Stress Analysis

Stress analysis will be performed to verify the PIH has positive margins of safety for all design load cases, including launch and landing loads, on-orbit operational loads, EVA kick loads, etc.

Because the AMS-02 Vacuum Case is both a pressure vessel and primary structure and contains a nonlinear structural support system, several unique analyses will be performed on it. These analyses will include non-linear NASTRAN buckling analysis with worst-case imperfections in

VC, point-to-point BOSOR and PANDA buckling analysis, and NASTRAN non-linear transient analysis.

All of these analyses will be coordinated with the NASA SWG and will be documented in the AMS-02 stress report.

For strength, the PAS will be verified by analysis, using the correlated model from the stiffness verification test, using factors of safety of 2.0 for ultimate and 1.25 for yield. PAS load cases analyzed will include:

- Liftoff/landing load factors from Table 4.1 of the Structural Verification Plan (SVP)
- Maximum capture bar load combined with the loads given in Table 4.2 of the SVP
- On-orbit accelerations from SSP-57003, paragraph 3.5.1.12, as referred to in Section 4.2 of the SVP

6.1.2.2.3 Analysis of Fracture Control

The fracture control requirements applicable to the AMS-02 Payload are contained in NASA-STD-5003, Fracture Control Requirements for Payloads Using the Space Shuttle and SSP 30558B, Fracture Control Requirements for Space Station. AMS-02 uses the guidelines of Fracture Control Plan for JSC Flight Hardware (JSC-25863A) to satisfy the requirements of the fracture control documents. Fracture Control Analysis will be performed to verify positive margins of safety including four full design lifetimes for each part, considering both launch/landing and all planned transportation events. Bolt patterns will be shown to be fail-safe by an analysis using a FS of 1.0 against failure. This fail-safe analysis will be contained in the formal stress report. All integration drawings will identify the fracture criticality of the part and the non-destructive evaluation method to be used will be included on both the drawings of fracture critical parts and in the Fracture Control Report.

6.1.2.2.4 Materials Analysis

All materials used will be certified for use in the intended environment. A Materials Certification Memorandum will be included as part of the Certification Data Package. Materials Usage Agreements will be provided only as needed.

6.1.2.2.5 EEE Parts Analysis

A EEE parts analysis and a derating analysis will be performed for all integration cables used as a part of the AMS-02 Payload. Parts will be derated in accordance with SSP 30312, Electrical, Electronic, and Electromechanical (EEE) and Mechanical Parts Management and Implementation Plan for Space Station Program, Appendix B.

6.1.2.3 Verification Inspection

Inspection will be used extensively in verifying the requirements levied on AMS-02 by the PTRS (JSC 29789), the Attached Payload Interface Requirements Document (SSP 57003), and the AMS-02 Hardware Interface Control Document (SSP 57213). Appendix D, Requirement Verification Matrix identifies those requirements that will be verified by inspection. All inspections used as proof of requirement compliance will be documented via JSC TPS, KSC WAD, or engineering memoranda.

6.1.2.3.1 Vacuum Case Weld Inspections

Inspections for the closeout weld will include visual, dye penetrant (Type I, Level 3) and ultrasonic – all per MSFC-SPEC-504C. The requirements for the Flight Vacuum Case closeout weld are identical to those for the STA Vacuum Case closeout weld and are documented in the AMS-02 Weld Control Plan.

6.1.2.4 Verification Demonstration

PAS Interface Verification Test (IVT)

A fit check of as-built flight AMS-02 Passive Payload Attach System (PAS) with the as-built S3 Zenith Inboard Payload Attach System (PAS) Assembly was performed at KSC. The PAS was mated to the truss and the CAS capture claw was operated multiple times to demonstrate proper function of the hardware. In addition, the capture bar release mechanism was operated to demonstrate its proper function with the capture claw fully closed.

6.1.3 Acceptance Testing

Vacuum Case Proof Pressure Test – The STA Vacuum Case will be proof tested twice; once at the VC subcontractor's facility with the original weld and once the CMR is installed at CERN and the closeout weld is completed. The requirements for this test can be found in the latest revision of JSC-28792, AMS-02 Structural Verification Plan for the STS and the ISS. The subcontractor must use calibrated gages and a pneumatic pressure supply with dry nitrogen.

Vacuum Case Leak Test –The STA Vacuum Case was leak checked at the subcontractor's facility before the first closeout weld was made (using temporary seals), after the closeout weld was made at the subcontractor's facility and after the final closeout weld is made. Both the inner and outer O-rings at each joint will be tested by injecting helium both around the perimeter and between the O-ring grooves utilizing the test ports. A helium detector at the vacuum pump will determine any helium leakage into the Vacuum Case or the area between the O-ring grooves. The requirements for this test can be found in JSC-28792, AMS-02 Structural Verification Plan for the STS and the ISS.

Integration Cable Acceptance Testing – All integration cables will be designed, fabricated and tested per SSP 30242; Space Station Cable/Wire Design and Control Requirements for Electromagnetic Compatibility; PRC-7003, Process Specification for the Manufacture of

Electrical Cables, Wiring, and Harnesses; NASA-STD-8739.4, Crimping, Interconnecting Cables, Harnesses and Wiring; and NASA-STD-8739.5, Fiber Optic Terminations, Cable Assemblies, and Installation. Acceptance testing will be performed during fabrication, post assembly and post installation. All cable testing to be used for requirement verification will be documented in the applicable cable fabrication and integration TPSs. Required testing includes:

- Contact Crimp Pull Test (not applicable to fiber-optic components)
- Contact Retention Test (not applicable to fiber-optic components)
- Continuity Test
- Dielectric Withstanding Test (not applicable to fiber-optic components)
- Insulation Resistance Test (not applicable to fiber-optic components)
- Fiber-optic Insertion Loss Test (fiber-optic components only)
- Sharp Edge Inspection Test

6.2 COLLABORATION HARDWARE

The AMS Collaboration is responsible for providing the detectors that make up the AMS Experiment. The payload is comprised of six major detectors:

1) Transition Radiation Detector and associated Gas System
2) Time of Flight Counters
3) Tracker
4) Ring Imaging Cerenkov Counter
5) Electromagnetic Calorimeter
6) Anti-Coincidence Counter

The payload also includes several small subsystems that will be integrated during the installation of the major detectors. They include the Star Trackers and the Global Positioning System. The payload includes several large subsystems that support the major detectors. They include:

1) Experiment Avionics
2) Thermal Control System
3) Superconducting Cryogenic Magnet

ESCG is responsible for the overall structural analysis of the AMS-02 payload, its detectors, and integration hardware. The detector providers are responsible for submitting the appropriate analysis reports to ESCG for review. ESCG will review the analysis, and if necessary, provide comments or prepare an independent analysis of each safety critical component and submit a final report to the Payload Safety Review Panel.

Per the AMS-02 Structural Verification Plan, it is the responsibility of each detector or subsystem group to provide the following information to support all design and safety reviews. This information, once formalized, will also provide the basis for the verifications in this MVP.

- Predicted and actual measured weights
- Design Drawings
- Component Materials List
- Structural Fastener List
- Stress analysis report with the appropriate factors of safety and load factors (must include a summary table of the minimum margins of safety)
- Details and results of any structural testing that is performed

6.2.1 Developmental/Engineering Unit Evaluations

Avionics Functional Interface Test (FIT)

A functional interface test (FIT) will be conducted to characterize the operation of the AMS-02 avionics in the ISS and STS environments. The goal of FIT is to enhance the development of the AMS-02 avionics and to mitigate risks of the development process. FIT will exercise the avionics systems and ground segments of AMS-02 within the ISS and STS test environments of the Payload Test and Checkout System (PTCS). The integrated flight and ground segments will be used to test most communications paths and command and data formats in the AMS-02 system from end to end (albeit local to KSC). Similar tests will be performed on the full payload during normal payload processing to qualify AMS-02 for flight. These tests are performed too late to allow recovery in the case of test failure.

6.2.2 Verification Activities

6.2.2.1 Verification Testing

6.2.2.1.1 Qualification Testing

Magnet Testing and Field Mapping

The AMS cryogenic superfluid helium superconducting magnet (the Cryomagnet) and its associated cryosystem is one of the most critical elements of the AMS-02 Payload. The 2500 liter Superfluid Helium Tank is the largest ever flown in Shuttle. In order to ensure mission success and safety the Cryomagnet and cryosystem will undergo a rigorous test regimen.

Numerous materials tests were performed to certify the aluminum used in magnet development. Test coils were quench tested to 5kV by the magnet developer, Scientific Magnetics (SM). Each individual flight coil was tested to 3kV and the full coil system was tested to 1kV. Static testing will be conducted on the assembled flight magnet to 1.1 x limit load due to magnetic forces. When completely assembled, magnetic field checks and field mapping will be performed.

Emergency venting of Helium into the payload bay was a major concern for NASA Safety. Vent testing of a similar dewar with flight like thermal characteristics provided the mass flow of the vented helium. These measurements were then used in a full scale venting analysis of the flight unit. These results were provided to the SSP for assessment and found to be acceptable with certain flight controls in place. These controls have been developed into payload Launch Commit Criteria. Proof pressure tests will be conducted on all plumbing systems and all welded joints have been thoroughly inspected to prevent the possibility of leak rate beyond what has already been analyzed

SFHE Tank Qualification Program

The SFHe Tank is a complex aluminum design with numerous welded joints both on the exterior of the vessel shell and on the internal helium loop tubing. All welding for this vessel was made by machine and robotic welding with manual welding practices being utilized only for tack welding and for any repair and/or rework. All procedures were developed and qualified by test by the tank fabricator using production welding equipment. Minimum requirements for the weld qualification protocol were per MSFC-SPEC-504C, Class I with the exception that standardized bend tests were required to evaluate cross sectional weld soundness, and tensile testing at 4 degrees K was required.

SFHE Tank Leak Test

The SFHe Tank was leak tested at 1.8K in a specially-constructed leak test facility.

SFHE Tank Proof Pressure Test

A proof pressure test to 1.1 X Maximum Design Pressure (MDP) was performed on the Helium Tank. To ensure that the vessel is leak tight, measurements were taken during the proof pressure test to ensure the integrity of the system. This is a mission success issue only and is not required for safety. This testing meets the requirements specified in SSP-30559B.

SFHE Tank Weld Inspection

For this vessel, all production welds are classified as Class I therefore were required to be subjected to the highest level of inspection and NDE requirements as specified by MSFC-SPEC-504C. In addition, numerous base material tests from the production material lots were performed by the fabricator at room temperature and 4 degrees K. Because the SFHe vessel meets the requirements as a pressure vessel in NSTS 1700.7B ISS Addendum, all welds have had NDE performed after the proof pressure testing. All welded interfaces meet the requirements defined in Section 12.4 and 12.5 of the SVP. The pressure vessel has a two-fault tolerant relief device to prevent the pressure from exceeding the maximum design pressure (MDP) of the system.

No static loads testing will be performed on the helium tank since a high factor of safety was used for the design. (Reference Appendix A of the AMS SVP, JSC 28792)

Non-Linear Support Strap Static Testing

Factors of safety (FS) of 1.4 (ultimate) and 1.2 (yield) were used to design the strap support system for the cryomagnet system. Because the static stiffness characteristics of the AMS-02 magnet support straps are distinctly nonlinear, static testing was conducted to determine the nonlinear stiffness characteristics of a strap assembly; Verify that there is no permanent deformation at 1.2 x Maximum Flight Load (MFL) and there is no failure at 1.4 x MFL of the strap assembly; and to determine the failure load of the strap assembly.

All Non-linear Straps for both the STA and flight system were static tested to 1.2 X limit load with no detrimental deformation prior to installation. Tests included maximum preload and loads were factored to account for cryogenic temperature at the magnet end (cold end) and maximum expected temperature at the vacuum vessel end (warm end).

Nonlinear Support Strap Dynamic Testing

Two complete strap assemblies were dynamically tested to determine dynamic and damping characteristics. The tests included enough instrumentation to dynamically correlate the individual strap math models. A Structural Test Article (STA) magnet assembly with 16 fight-identical straps was installed into a flight-identical STA vacuum case and underwent a sine-sweep at force levels sufficient to induce a nonlinear response. Correlation data from the individual strap tests combined with the results of this high-level test were combined to create a correlated nonlinear model of the entire magnet assembly. This data was then be used to validate basic assumptions in the stress analysis, in particular that the strap assemblies only see tensile loading.

Non-Linear Support Strap Fatigue Testing

A static test to 1.0 x limit load was used to characterize the strap. Fatigue testing was then conducted with the cold end at 77K (includes transportation, launch, on-orbit and landing loads). A second static test to 1.0 x limit load was then conducted for comparison with the pre-fatigue test. Fatigue testing was conducted on the Belleville washers by SM: Three were tested to 1.5 million cycles and three more were tested to a more limited test protocol. At the conclusion of fatigue testing, two strap system were static tested to failure: one at ambient temperature and one at cryogenic temperature.

All strap components have been tested to failure by the manufacturer, Compton Technologies (CT). Approximately 19 fatigue tests have been performed on strap components by CT and the magnet developer, Scientific Magnetics (SM). Two complete strap assemblies have been tested for fatigue and failure.

Other Nonlinear Support Strap Testing and Analysis

SM completed an analysis for creep of the strap system. The calculations were based on test data from other composite strap systems in a similar thermal environment. The system is designed with a fairly small strap preload (~2000 lbs). There is additional load if the magnet is on the ground under a 1 G load. With this preload, the expected creep is only 16.8 microns for 1 year of ground operations and 3 years of on-orbit operations. This is a negligible amount, and only reduces the on-orbit preload by 1.6 lbs.

Cryomagnet System Acoustic Test

An acoustic test was performed on the Cryomagnet System Structural Test Article (STA) at ESTEC in The Netherlands. For the test, the Cryomagnet System STA will be comprised of the STA Vacuum Case with a cold mass replica of the Cryomagnet and SFHe Tank suspended inside with 16 flight-like Support Straps. The Cryomagnet System STA will be tested to launch acoustic levels both to determine if there is any leakage around the o-ring seals and to measure the induced random vibration environment at the attachment points of certain sensitive components. Test levels will be the payload bay acoustic environment as defined in NSTS-21000-IDD-ISS. The test will be performed with the Cryosystem at room temperature and vacuum in order to facilitate the measurement of potential leaks past the o-ring seals. The preload of the straps will be increased to simulate thermal load of Cold Mass Replica.

Cryocooler Engineering Model Testing

Engineering models (EM) of the Stirling-cycle cryocoolers have undergone extensive thermal characterizations and magnetic compatibility testing. Two EM cryocoolers have undergone electrical characterizations and vibration qualification. The two EM cryocoolers have been subjected to life testing, each accumulating over 2,000 hours of run time with no change in thermal performance.

The EMs have been subjected to pressure vessel leak testing, vacuum flange leak testing and vibration testing to 6.8 Grms. Functional testing was conducted to verify that the cryocoolers would operate in any orientation. All cryocooler flight units will be vibration tested to 6.8 Grms.

Magnetic compatibility testing was conducted to ensure that the cryocoolers will perform nominally in the magnetic field of the AMS-02 Cryomagnet. Tests were performed over a range of field levels that were lower than, higher than, and comparable to the field levels that the cryocoolers are expected to experience in the AMS-02 operating environment with no performance impacts.

Cryocooler Flight Model Testing

The flight cryocoolers integrated with their flight mounting brackets have been subjected to a qualification program consisting of the following tests:

- Vacuum leak test
- Acceptance vibration test of cooler in a compliant mount
- Functional tests
    - Characterizing base reaction forces

  - o Measure temperature delta at the heat reject collar
  - o Measure the temperature distribution around the cooler
- Measure thermal conductance of the bracket
- Thermal cycling test

A helium leak check was performed on all of the flight cryocoolers. This test measured the rate of helium loss from the cryocooler and assessed the impact of this rate on the likely performance of the cooler.

All six flight cryocoolers and EM #2 were put through low temperature testing to identify any problems the coolers might have with low temperature operation caused by thermal contraction of internal components. The coolers were tested through a wide temperature range (-60ºC to +20ºC) while capturing the motor current during startup to look for changes due to binding.

Qualification and Performance Verification: After an initial leak check and the low temperature binding test, the flight cryocoolers were subjected to thermal performance characterization. A series of baseline performance curves were generated while testing the flight cryocoolers under various heat reject temperatures, power levels and thermal loads. Periodically, a subset of this characterization will be repeated to check for thermal performance degradation. All the flight coolers tested exceed the AMS-02 thermal performance requirement with an 80% margin.

Thermal cycling tests were performed on all of the flight cryocoolers to put them through the extreme temperature ranges that could be experienced on orbit. Operational cryocooler thermal cycling took place under vacuum with the cryocooler powered to the nominal on-orbit power level of 100 W. The cryocooler was cycled through a temperature range of -20ºC to +40ºC eight times with a minimum dwell time at the extreme temperatures of four hours. Non-operational thermal cycling took place at ambient pressure in an environmental chamber where the cryocooler was cycled through a temperature range of –55ºC to +55ºC eleven times with a minimum dwell time at the extreme temperatures of four hours. A load line was performed after thermal cycling to verify there was no performance degradation.

<u>Detector/Subsystem Thermal Vacuum Tests (TVT)</u>

Thermal vacuum testing was used extensively in the development and qualification phases of the AMS detectors and subsystems to verify the thermal design and ensure mission success. TVTs were not used to verify that individual components and subsystems meet requirements. A full-payload TVT will be conducted at the European Space Research and Technology Centre (ESTEC) in Noordwijk, The Netherlands prior to shipment to KSC for final launch processing. The full payload TVT will be used for requirements verification as described in Section 7 of this MVP.

<u>Detector Vibration Tests</u>

- A full-scale prototype unit of the ECAL will be manufactured for testing purposes.

- Perform sine sweep test (0.25 G from 10-300 Hz, scan rate = 2 oct/min) on the entire prototype assembly.
- Perform random vibration testing on the entire prototype assembly to the levels defined in Table 15.1 (MEFL).
- Perform sine sweep test on the entire prototype assembly and verify that there is no change when compared to the first sine sweep test.
- Perform sine burst test. Test will be performed to 1.2 x design limit load.
- Perform final sine sweep test on the entire prototype assembly and verify that there is no change when compared to the first and second sine sweep tests.

The tests to be performed and stress to be applied are of different types:

- Thermal and vibration stress: performed in order to identify possible weak point in the assembly workmanship. To be performed on both QM and FM/FS hardware. The detailed procedure should be:
    - o 10 thermal cycles, with profile as defined in Fig. 1, with functional tests performed at the hot and cold operating temperature of the first two and last two cycles. The system must be kept at each temperature for one hour.
    - o Random vibration test, on 3 axis, with vibration spectra as shown in Fig. 2, with functional tests performed during the vibration. Accelerometer should be mounted on the external walls of the box being vibrated, in order to verify the absence of eigenfriquency below 50 Hz. Vibration duration is 10 minutes total (about 3 minutes per axis) for QM and 3 minutes total (about 1 minute per axis) for FM/FS hardware.
    - o 5 thermal cycles, with profiles as defined in Fig. 1, with functional tests performed at the hot and cold operating temperature of the first cycle and last two cycles.

<u>Detector and Subsystem EMI/EMC Testing</u>

All detectors and subsystems with a potential for radiating electromagnetic interference or susceptible to it are required to perform EMI/EMC testing per SSP 30238, Space Station Electromagnetic Techniques to verify design and conformance of the as-built hardware to the flight requirements per SSP 30237, Space Station Electromagnetic Emission and Susceptibility Requirements. EMI testing of the detectors and subsystems was performed to identify potential problem areas, but final verification will be through a full payload-level EMI test at ESTEC in Noordwijk, The Netherlands. EMI/EMC testing of the full payload is described in Section 7.2.2.1 of this MVP.

<u>Pressure Systems Qualification Testing</u>

All pressure systems used on the AMS-02 Payload will be proof pressure tested to at least 1.5 x MDP with the exception of the SFHe tank and the Weka heliomatic valves (1.1 x MDP). Reference Flight Hazard Reports AMS-02-F03, AMS-02-F04 and AMS-02-F05 of JSC 49978, Phase II Flight Safety Data Package for the AMS-02 for specific test requirements for each pressure system and component. In addition, the composite over-wrapped pressure vessels (COPVs) for Xe and CO_2 used on AMS-02 are subjected to a random vibration test to 8.9 Grms, which exceeds AMS-02 requirements.

Acoustic testing of individual AMS-02 experiment components is not planned, but specific components referenced in Section 17 of the SVP will be assessed for acoustic susceptibility. If it is determined that a component is susceptible to acoustic excitation an acceptable test plan will be negotiated with the Structures Working Group.

6.2.2.1.2 Other Testing

A Power Quality Test (PQT) will be performed on an engineering model (EM) of the AMS-02 Power Distribution System (PDS). The PQT will be used to identify any potential compatibility issues with the STS and ISS power systems. The test will demonstrate that the PDS, as the AMS-02 experiment power front-end, is compliant with the Electrical Power System (EPS) interface requirements of SSP 57003.

6.2.2.2 Verification Analysis

Each of the AMS-02 detector and subsystem groups is responsible for conducting the analyses necessary to verify that their hardware meets the requirements for space flight. NASA and ESCG share responsibility for mentoring the experiment provider, conducting independent review, and, if necessary, ESCG will perform the verification analyses of all safety-critical items that are a part of the payload.

ESCG shall be responsible for all fail-safe and fracture analysis of the AMS-02 primary structure and experiment hardware.

6.2.2.2.1 Thermal Analysis

Detector/Subsystem Level Thermal Analysis

AMS02 detector and subsystems groups are responsible for their own thermal design, modeling and hardware. Detector and subsystems analysis is performed in conjunction with an integrated thermal analysis performed by CGS.

Certain component level analyses will be performed to support EVA touch-temperature analyses, localized insulation design, and detector performance studies and will be documented in individual engineering memoranda.

6.2.2.2.2 Stress Analysis

Each detector and subsystem group is responsible for performing a stress analysis on their flight hardware and providing the stress analysis report to the ESCG AMS Structural Analysis Group for review and approval.

6.2.2.2.3 Analysis of Fracture Control

The AMS-02 payload will use the guidelines of JSC-25863A, Fracture Control Plan for JSC Flight Hardware to satisfy the requirements of NASA-STD-5003 Fracture Control Requirements for Payloads Using the Space Shuttle and SSP 30558, Fracture Control Requirements for Space Station. The fail-safe analysis will be contained in the formal stress report. A fracture classification of all parts and fracture analysis of parts, which are fracture critical, is required. All integration drawings will identify the fracture criticality of the part and the non-destructive evaluation method to be used will be included on the drawings of fracture critical parts.

The AMS-02 hardware shall be certified to the fatigue life spectra defined in the Structural Verification Plan. This includes the effect of two launches and one abort landing, all planned testing events, and all planned transportation events. ESCG will be responsible for all fail-safe and fracture analysis of the AMS-02 primary structure and experiment hardware.

6.2.2.2.4 Materials Analysis

Each detector and subsystem group is responsible for submitting a Declared Materials List for their flight hardware to the ESCG materials engineer for certification. Material Certification will be documented with a Materials Memorandum for inclusion in the Certification Data Package for the entire payload. Materials Usage Agreements will be prepared and submitted only as needed.

6.2.2.2.5 EEE Parts Analysis

Parts will be derated in accordance with SSP 30312, Electrical, Electronic, and Electromechanical (EEE) and Mechanical Parts Management and Implementation Plan for Space Station Program, Appendix B. A Component Level Derating Analysis will be conducted on the primary power supply boxes [Power Distribution System (PDS) and Cryomagnet Avionics Box (CAB)] and the high voltage systems for the detectors.

6.2.2.3 Verification Inspection

Inspections will be used extensively in verifying the requirements levied on AMS-02 by the Attached Payload Interface Requirements Document (SSP 57003) and the AMS-02 Hardware Interface Control Document (SSP 57213). Appendix D, Validation Matrix for AMS-02 Experiment Hardware, identifies those requirements that will be verified by inspection. All inspections used as proof of requirement compliance will be documented via AMS Task Sheet (ATS), KSC WAD, or formal test/inspection report.

6.2.3 Validation Activities

Avionics Preliminary Integration Test (PIT) and Final Integration Test

This test was the remote terminal validation on 1553 bus to ensure we meet the 1553 specifications called out in SSP 57003. This test will be done twice, once with early engineering hardware and once with final flight hardware.

6.2.4 Acceptance Testing

7. AMS-02 Payload Verification and Validation

7.1 END ITEM TO END ITEM INTEGRATION

7.1.1 Developmental/Engineering Unit Evaluations

No development activities are planned at this level of assembly.

7.1.2 Verification Activities

All tests, inspections, and demonstrations to be performed will be performed using a formal TPS (for NASA-provided hardware) or an ATS (for Collaboration-provided hardware). Additionally, analyses, memos, reports etc., will be used for the certification process. The "Results" column in the MVP Matrices in Appendix D and E will contain the necessary information (TPS #, Analysis #, Memo #, Report #) required to meet one or more specified requirements. Furthermore, certificates of compliance and/or reports of tests performed by the vendor will be used as proof of compliance of one or more requirements. Verification activities and the results of those activities will be approved by the appropriate stakeholder. SF/Flight Crew Integration will provide approval for all Human Factors related verifications.

7.1.2.1 Verification Testing

Appendices C and D of this MVP identify the full payload requirements that will be certified by test. All tests will be documented using a formal TPS and/or a test report. Requirements verified using test results will be approved by the appropriate stakeholder(s) and/or the requirement owner(s).

<u>Cryomagnet System Sine Sweep Test</u>

The Cryomagnet STA (STA VC utilizing a cold mass replica for the magnet and SFHe tank) was tested in a sine sweep test to excite the non-linear support straps to load levels higher than the stiffness region expected with the launch strap engagement. The input environment was developed using non-linear DCLA results. The Cryomagnet system response was analytically determined and reproduced during testing. The STA was instrumented to dynamically correlate the nonlinear response of the FEM. The results of the sine sweep testing were compiled in a test report.

<u>Full Payload Static and Modal Tests</u>

Static and modal tests were conducted on the full AMS-02 Payload in the orbiter configuration in the Shuttle Payload Simulator at IABG in Munich Germany. STAs were used to represent the Ram, Wake and Tracker Radiators. Mass replicas were used for the other experiment components. For the static test, the payload was fully instrumented with 153 strain gauges, 8 deflection gages, and 10 load cells. Ten hydraulic actuators [11,915-23380 lbf (53-104 kN)] were used to statically load the test article. The test measurements will be used to statistically correlate the FEM to 1.4 x limit load. For the modal test, the payload was fully instrumented with 146 accelerometers and seven 0.25g actuators to provide sufficient results to dynamically correlate linear response of the FEM.

Main and Tracker Radiator Performance Test

The Main and Tracker Radiators design-, manufacturing and assembly shall be verified during full AMS-02 payload thermal vacuum testing. Heat rejection capability, heat pipe performance, workmanship adequacy, heaters performance and radiator operations in a vacuum are the key parameters to be experimentally verified.

Support of the Main and Tracker radiator designer is ~~recommended~~ requested to cope with this verification activity.

7.1.2.2 Verification Analysis

Appendices C and D of this MVP identify those full payload requirements that will be certified by analysis. All analyses will be documented as analysis reports or AMS-02 Project Engineering Memorandums. The analyses will be approved by the appropriate stakeholder(s) and/or the requirement owner(s).

Thermal Analysis

A thermal analysis survey will be performed for 259 ISS attitudes [37 combinations of YPR (yaw pitch roll) for 7 different beta angles] to cover the ISS attitude envelope both with and without the orbiter docked. ~~The ISS thermal mathematical and geometrical model shall be version VnRm~~[MM1]~~xx (IDENTIFICATION TO BE PROVIDED BY NASA) AC (Assembly Complete), as per document XXXX~~ [A2]~~in the Project Plan for the Alpha Magnetic Spectrometer.~~ Version 5, Revision 4 of the ISS Simplified Thermal Model shall be used for all thermal analysis of the AMS-02 Payload per NASA/JSC Memorandum EA3-09-004. Additional detailed analyses will be performed for worst case attitudes. An AMS-02 thermal model will be prepared and provided to the ISS and STS Programs for integration with the ISS Assembly Complete ~~m~~Model~~.~~ An analysis of AMS-02 to PAS interface temperature extremes will be conducted. An integrated analysis will be performed to verify that active radiation surfaces with VF>0.1 to attached payload envelope (APE) do not adversely affect the operation of other attached payloads and that specular surfaces do not adversely affect the operation of other attached payloads. A drawing will be created showing AMS-02 external surface optical nodes and a table will be provided indicating external optical surface properties (absorptivity and emissivity) for all significant surfaces.

7.1.2.3 Verification Inspection

Appendices C and D of this MVP identify those full payload requirements that will be verified by inspection. Inspections used to verify full payload requirements will be documented with a

TPS or ATS. Quality assurance (QA) buy-off that confirms that hardware is assembled per drawing/procedure may also be used to verify requirements.

7.1.2.4 Verification Demonstration

Appendices C and D of this MVP identify those full payload requirements that will be verified by demonstration. Demonstrations used to verify full payload requirements will be documented with a TPS or ATS.

Pre-integration of the AMS-02 Payload

Prior to delivery of the flight cryostat (Cryomagnet/SFHe Tank/Vacuum Case Assembly), the entire payload was integrated to verify interfaces and identify potential interferences between elements. In this pre-integration exercise the STA VC was used in place of the flight cryostat and hi-fidelity mock-ups, engineering units, or qualification units substituted for detectors and subsystems where the flight units were unavailable. Pre-integration was also used to determine power and data cable lengths and cable run locations and attachment points. This pre-integration activity was documented with AMS-02 Task Sheets (ATS), the AMS Collaboration's equivalent of the JSC Task Performance Sheet (TPS).

7.1.3 Validation Activities

No validation activities are planned at this level of assembly.

7.2 COMPLETE SYSTEM INTEGRATION

7.2.1 Developmental/Engineering Unit Evaluations

No development activities are planned at this level of assembly.

7.2.2 Verification Activities

7.2.2.1 Verification Testing

Appendices C and D of this MVP identify the full payload requirements that will be certified by test. All tests will be documented using a formal TPS and/or a test report. Requirements verified using test results will be approved by the appropriate stakeholder(s) and/or the requirement owner(s).

Static and Modal Testing

The Cryomagnet Vacuum Case STA will be used during the static and modal testing of the AMS-02 payload. The static test of the entire payload is to be to 1.1 x limit load with a FEM correlation to 1.4 x limit load. AMS-02 will assess the feasibility of performing one of the full payload static test cases so that the STA VC reaches 1.4 x limit load. This will only be done if the USS-02 does not exceed 1.1 x limit load during this sub-case. Strain and displacement measurements will be used to correlate the FEM. Vacuum will be applied to the Vacuum Case during all static and modal testing of the all-up payload. The modal test of the all-up configuration and the sine sweep test will include sufficient instrumentation to dynamically correlate the FEM.

Pad Operations Preliminary Integration Test (POPIT)

The POPIT was conducted on the Mobile Launch Platform (MLP) at KSC to verify the data interfaces between the AMS-02 Payload and dedicated GSE computers in the MLP via the T0 umbilical. In the test, flight-like data systems hardware emulating the payload 1553 and RS-422 communication streams were interfaced to the MLP GSE computer through the T0 Umbilical and MLP wiring, thereby verifying the correct connector pin-out. The test successfully showed that the payload flight / GSE transmit and receive capabilities meet their requirements.

Full Payload EMI Test

EMI testing of the AMS-02 Payload will be conducted to ensure electromagnetic compatibility with the Shuttle Transportation System (STS) Orbiter and the International Space Station (ISS). The test will be performed at the Maxwell EMI test facility at the European Space Research Technology Center (ESTEC) located in Noordwijk, The Netherlands. The test program will be performed in calendar year 2009.

The specific test objectives of the AMS-02 EMI test are:

- To verify that the AMS-02 payload does not generate EMI that will adversely affect the surrounding STS and ISS systems (emissions)
- To verify that the AMS-02 payload's performance is not adversely affected by the expected EMI environment of STS and ISS (susceptibility)

Full Payload Thermal Vacuum Test (TVT)

An integrated Thermal Vacuum Test will be performed on the full-up AMS-02 Payload to verify that the detectors and subsystems operate as expected in the temperature extremes and vacuum of the space environment. Of particular interest in the test is how well the key elements of the Thermal Control System (TCS) perform under vacuum conditions. During the test the payload will be operated at various thermal environments and power levels. Functional checks of the detectors and subsystems will be performed before, during and after the test. Test results will be used to validate the thermal model and provide data to verify thermal requirements identified in Appendices C and D of this MVP.

7.2.2.2 Verification Analysis

Appendices C and D of this MVP identify those full payload requirements that will be certified by analysis. All analyses will be documented as analysis reports or AMS-02 Project Engineering Memorandums. The analyses will be approved by the appropriate stakeholder(s) and/or the requirement owner(s).

Fracture/Fatigue Analysis

Fracture Control Analysis will be performed to verify design margins, margins of safety, kick loads, launch and landing loads. A report will be generated which will include:

- Identification of fracture critical and low risk fracture parts showing the material and heat treatment used and the basis for acceptability (test, acceptable durability, insignificant fatigue loading, etc). Fracture critical parts that are limited life will be specifically noted where applicable.
- Identification of the Nondestructive Evaluation (NDE) and/or tests applied for fracture control purposes to each fracture critical part and to each low risk part requiring specific inspection where applicable.

Refer to the AMS-02 Structural Verification Plan (JSC 28792), Section 8 for details.

Worksite Analysis (WSA)

A Worksite Analysis was conducted to assess EVA accessibility for AMS-02 contingency operations. The analysis included:

- Removal and replacement of the passive Umbilical Mechanism Assembly (UMA)
- Actuation of the passive Payload Attachment System (PAS) release mechanism
- Remove of the PAS capture bar
- Release of the AMS from the passive PAS
- Access to the AMS EVA connector panel
- Translation Paths around the AMS Payload

This analysis, in conjunction with the Neutral Buoyancy Laboratory (NBL) Evaluations discussed in Section 7.2.2.4, will be used to verify EVA requirements identified in Appendices C and D of this MVP.

Thermal Analysis

Carlo Gavazzi Space (CGS), , through ~~contract with the~~dedicated contracts,~~,~~ shall support the AMS collaboration~~, is responsible~~ for the integrated payload thermal design, analysis, and testing. Thermal analyses will include:

- Launch-to-activation (LTA) analysis of AMS-02 in payload bay
- Analysis of transfer from STS to ISS
- EVA touch temperature analyses (as required)
- “Failed On” heater analyses
- Auto-ignition assessment
- Stuck open vent door

Materials Analysis

All materials used will be certified for use in the intended environment. A Materials Certification Memorandum will be included as part of the Certification Data Package. Materials Usage Agreements will be provided only as needed.

7.2.2.3 Verification Inspection

Appendices C and D of this MVP identify those full payload requirements that will be verified by inspection. Inspections used to verify full payload requirements will be documented with a TPS or ATS. Quality assurance (QA) buy-off that confirms that hardware is assembled per drawing/procedure may also be used to verify requirements.

7.2.2.4 Verification Demonstration

Neutral Buoyancy Laboratory (NBL) Evaluations

A low-fidelity mock-up of the AMS-02 was used to evaluate contingency EVA interfaces and generic crew translation on and around the payload. Testing was performed by suited crewmembers in the NBL at JSC to determine accessibility to the worksites and the ability to perform the following contingency activities:

- FRGF Contingency Release
- PVGF Contingency Release
- PAS Capture Bar Unloading and Release
- EVA Connector Panel (contingency demate/mate of power and data cables)
- Passive Umbilical Mechanism Assembly (UMA) Contingency Release

Magnetic Susceptibility of EVA Systems and Tools and Neighboring ORUs

Testing was performed to evaluate the Extravehicular Mobility Unit (EMU) system level, flight accessories, Simplified Aid for EVA Rescue (SAFER) and Pistol Grip Tool (PGT) equipment operation for magnetic field exposure during EVA. The equipment was suspended in various orientations and moved through magnetic fields to determine susceptibility up to a maximum field of 600 gauss. As a result of the testing, 300 gauss was set as the new limit (factor of safety = 2) with the exception of the Russian Orlan Suit (175 gauss set as new limit)

In addition, neighboring ORUs on the S3 Truss were analyzed and tested to ensure that there will be no susceptibility issues based on the magnetic fields predicted at their mounting locations. The ISS Electromagnetic Effects Panel has reviewed the results and determined that all of the following items are acceptable with various caveats:

- Umbilical Mechanism Assembly (UMA)
- Capture Latch Assembly (CLA)
- External TV Camera
- Video Luminaire Assembly
- Space Station Remote Manipulator System (SSRMS)
- Special Purpose Dexterous Manipulator (SPDM)
- Remote Power Control Module (RPCM)

- Multiplexer/Demultiplexer (MDM)

Bonding/Grounding Checks

During final integration of the payload, bonding and grounding checks will be performed as each detector, subsystem, and component is installed to verify that all payload elements have a ground path back to the Passive PAS guide vanes that serve as the bonding/grounding point for the payload to the ISS Truss. All Bonding/Grounding check will be documented via TPS or ATS.

8. AMS-02 Program Verification and Validation

8.1 VEHICLE INTEGRATION

STS Mated Interface Verification Test/Functional Test

An interface verification test and functional test will be conducted with the integrated AMS Payload in the Shuttle payload bay at the pad prior to launch. During these tests, operation of the 1553 and RS422 communications to command and monitor the payload will be verified. A full functional check-out of the payload (excluding magnet charging and thermal control systems operation) will be conducted, including operation of the Digital Data Recording System – 02 (DDRS-02) on the orbiter aft flight deck (AFD).

8.2 END-TO-END INTEGRATION

ISS Interface Verification Test

An ISS interface verification test will be conducted in the SSPF at KSC utilizing the Express Logistics Carrier (ELC) Rotation Stand and the Payload Rack Checkout Unit (PRCU). The integrated AMS Payload will be mated to the ELC Rotation Stand and the procedure to align the EBCS Camera will be performed. While in the Stand, the PAS and UMA interfaces will be verified with the Active CAS Simulator System (ACASS). A functional interface test will be conducted to verify ISS power and data interfaces utilizing the PRCU and the Programmable Electrical Power System Emulator (PEPSE). The power and data connections will be via the UMA. The test will verify the 1553 and High Rate Data Link (HRDL) communications via the PRCU to the Huntsville Operations Support Center (HOSC) and the JSC Payload Operations Control Center (POCC).

8.3 ON-ORBIT V&V ACTIVITIES

On-Orbit Check-out of AMS-02 Avionics in the Orbiter PLB

An initial check-out and thermal conditioning of the AMS Payload will be initiated approximately 2 hours and 30 minutes into the flight with AMS-02 still in the Orbiter PLB. Commanding of the payload will be through the DDRS-02 connected to the Payload Data Interface Panel (PDIP) located on the AFD. After activating two ISS-provided Auxiliary Power Control Units (APCUs) the front-end data interface electronics are activated to initiate the downlink of housekeeping data and the Cryocoolers on the AMS-02 are activated. The AMS-02 avionics subsystems are activated and checked out. During avionics checkout, RS-422 data is recorded on the hard-drive of the PGSC continuously, and RS-422 from another feed-thru from the PDIP will be downlinked via the Ku-Band as coverage and scheduling permit. No magnet charging is performed while AMS-02 is located in the Orbiter PLB.

On-Orbit Check-out of AMS-02 on the ISS

Following successful berthing of the AMS-02 on the S3 Truss, an abbreviated avionics checkout will be conducted. Once the avionics have been checked out, all unnecessary equipment (including all detector subsystems) will be powered down and magnet charging operations will be initiated. Magnet charging requires 1850 W, and with the required monitoring electronics, all unnecessary equipment must be deactivated to keep power consumption within the maximum power allocation of 2.3 kW. Approximately one and a half hours are required to fully charge the magnet. Once fully charged, the magnet is disconnected from the charger and the detectors are once again powered. At this point the recording of science data begins. Due to the complexity of the experiment, and the numerous critical subsystems that must operate nominally to achieve mission success, AMS-02 must operate for a period of time to verify that all critical systems are functioning correctly.

9. AMS-02 Certification Products

Acceptance Data Packages (ADPs) will be delivered to the APO with each of the detectors and subsystems. At a minimum the Collaboration-provided ADPs shall contain:

1. Description of product defining all functions and current approved design specification
2. List of all waivers and deviations from design specifications for qualification and flight hardware
3. List of unexplained anomalies for qualification and flight hardware status
4. Product historical log/notes/comments
5. As-built drawings
6. Age sensitive or limited life items (if applicable)
7. Pressure Vessel Data, including pressure cycle data
8. Non-flight hardware temporary installation (e.g. caps for shipping which are removed before flight, etc.)
9. Material Safety Data Sheets
10. Engineering Model Files (e.g. assembly level drawings and assembly level computer models)
11. Software Model Files/Firmware Version Description files for all systems that communicate directly with NASA supplied equipment
12. Special instructions to maintain safety and functionality of the equipment during storage, ground handling, ground operations, maintenance and disposal
13. Certification and references to supporting records including:
    a. Qualification test procedures
    b. Certification Analysis
    c. Vendor-supplied data sheets
    d. Justifications for variances from vendor specifications and any records of approval
    e. Certification inspection procedures for all design requirements and acceptance requirements
    f. Log of all hardware with corresponding references to certification records for devices with stored energy (i.e. pressure vessels, capacitors, batteries)
    g. Log of hazardous chemical and materials with corresponding references to certification records

ADPs for the PIH and the fully integrated payload are the responsibility of ESCG. The ADPs will be assembled by the ESCG Configuration Management Team of the ESCG Safety and Mission Assurance (S&MA) Department with inputs from the AMS Project.

1. Safety Data Package (see Sections 7.1.4.2, 7.1.5.2 and 7.1.6.2)
2. The revision of the MVP, with the "Results" column of the appendices completed and associated "Results" documentation attached.
3. Materials Certification
4. Fracture Control Report
5. Materials Usage Agreement
6. Stress Analysis

7. Thermal Analysis
8. EEE Parts Stress Analysis/De-rating Analysis
9. Qualification Test Reports
10. Waivers
11. Limited Life Items List
12. Engineering Drawings (electronic or hardcopy as required by NT-GFE-007, “Certification Approval of JSC GFE”)

APPENDIX A: ACRONYMS AND ABBREVIATIONS

A	Ampere
AC	Alternating Current
ACASS	Active CAS Simulator System
ACC	Anti-Coincidence Counter
AFD	Aft Flight Deck
Al	Aluminum
AMICA	Astro Mapper for Instrument Check of Attitude
AMS	Alpha Magnetic Spectrometer
APCU	Assembly Power Converter Unit
APE	Attached Payload Envelope
APO	AMS Project Office
ASTC	AMICA Star Tracker Camera
ATS	AMS Task Sheet
AWG	American Wire Gauge
BCE	Battery Charger Electronics
BMS	Battery Management System
BOSOR	Buckling of Shell of Revolution
CAB	Cryomagnet Avionics Box
CCB	Configuration Control Board
CCD	Charged Coupling Device
CCEB	Cryocooler Electronics Box
CCS	Cryomagnet Current Source
CDD	Cryomagnet Dump Diode
CCSC	Cryomagnet Controller and Signal Conditioner
C&DH	Command and Data Handling
CDR	Critical Design Review
CFC	Carbon Fiber Composite
CFRC	Carbon Fiber Reinforced Composite
CG	Center of Gravity
CGS	Carlo Gavazzi Space
CLA	Capture Latch Assembly
cm	centimeter

APPENDIX A: ACRONYMS AND ABBREVIATIONS (CONTINUED)

CMR	Cold Mass Replica
CO_2	Carbon Dioxide
COTS	Commercial Off-the-Shelf
CR/DIR	Change Request/Directive
CRES	Corrosion Resting Steel
CRISA	Computadoras, Redes e Ingeniería SA
CSP	Cryomagnet Self Protection
CT	Compton Technologies
Cu/Te	Copper/Tellurium
DAQ	Data Acquisition
DC	Direct Current
DDRS-02	Digital Data Recording System-02
DOE	Department Of Energy
DR	Discrepancy Report
e^-	Electron
e^+	Positron
EA	JSC Engineering Directorate
EBCS	External Berthing Camera System
ECAL	Electromagnetic Calorimeter
EIB	ECAL Intermediate Boards
ELC	Express Logistics Carrier
EM	Engineering Model
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EPS	Electrical Power System
ESCG	Engineering and Science Contract Group
ESTEC	European Space Research Technology Center
ETH	Eidgenossische Technische Hochschule
EVA	Extravehicular Activity
EXPRESS	EXpedite the PRocessing of Experiments to Space Station
F	Fahrenheit

APPENDIX A: ACRONYMS AND ABBREVIATIONS (CONTINUED)

FEM	Finite Element Model
FOR	Flight Operations Review
FM	Flight Model
FPSR	Flight Planning and Stowage Review
FRGF	Flight Releasable Grapple Fixture
FRR	Flight Readiness Review
FS	Flight Spare
g	gram (also gravity)
G	Gravity (also g)
G	Gauss
GeV	Giga Electron Volt
GFE	Government Furnished Equipment
GFRP	Glass Fiber Reinforced Polymer
GHE	Ground Handling Equipment
GPS	Global Positioning System
GSE	Ground Support Equipment
HBE	Hans Bieri Engineering
He	Helium
HOSC	Huntsville Operations Support Center
HP	Heat Pipe
HRDL	High Rate Data Link
HV	High Voltage
Hz	Hertz
IA	Implementing Agreement
IABG	Industrieanlagen-Betriebsgesellschaft (German aerospace company)
ICD	Interface Control Document
IDD	Interface Design Document
I/F	Interface
in	inch
IPT	Integrated Product Team
ISS	International Space Station

APPENDIX A: ACRONYMS AND ABBREVIATIONS (CONTINUED)

ISSP	International Space Station Program
ITS	Integrated Truss Segment
IVT	Interface Verification Test
JSC	Lyndon B. Johnson Space Center
K	Kelvin
kg	kilogram
KHB	KSC Handbook
kN	kiloNewton
KSC	John F. Kennedy Space Center
kV	kilovolt
L	Liter (also l)
LBBX	Laser Beamport Box
lbf	pounds force
lbs	pounds
LCL	Latching Current Limiter
LED	Light Emitting Diode
LFCR	Laser Fiber Coupler
LHP	Loop Heat Pipe
LTA	Launch-to-activation
MAGIK	Manipulator Analysis, Graphics, and Integrated Kinematics
MDC	Main Data Computer
MDM	Multiplexer/Demultiplexer
MDP	Maximum Design Pressure
MIL	Military
MIT	Massachusetts Institute of Technology
MLI	Multi-layer Insulation
MLP	Mobile Launch Platform
MM/OD	Micrometeoroid and Orbital Debris
MOSFET	Metal-Oxide-Silicon Field Effect Transistor
MVP	Master Verification Plan

APPENDIX A: ACRONYMS AND ABBREVIATIONS (CONTINUED)

NaF	Sodium Flouride
N/A	Not Applicable
NASA	National Aeronautics and Space Administration
NBL	Neutral Buoyancy Laboratory
NDE	Non-Destructive Evaluation
NGL	Next Generation Laptop
NHB	National Aeronautics and Space Administration Handbook
NSTS	National Space Transportation System
OPR	Office of Primary Responsibility
ORU	Orbiter Replaceable Unit
p^-	Anti-proton
p^+	Proton
PANDA	Passive Nondestructive Assay
PAS	Payload Attach System
PCS	Portable Computer System
PDA	Payload Disconnect Assembly
PDIP	Payload Data Interface Panel
PDR	Preliminary Design Review
PDS	Power Distribution System
PEEK	Polyetheretherketone
PEPSE	Programmable Electrical Power System Emulator
PFR	Portable Foot Restraint
PGSC	Payload General Support Computer
PGT	Pistol Grip Tool
PIH	Payload Integration Hardware
PMMA	Polymethylmethacrylate (Acrylic, Plexiglas™)
PMT	Photomultiplier Tube
POCC	Payload Operations Control Center
POPIT	Pad Operations Preliminary Integration Test
PQT	Power Quality Test
PRCU	Payload Rack Checkout Unit

APPENDIX A: ACRONYMS AND ABBREVIATIONS (CONTINUED)

psia	Pounds per Square Inch Absolute
psid	Pounds per Square Inch Differential
PSS	Primary Support Stand
PTRS	Project Technical Requirements Specification
PVGF	Power Video Grapple Fixture
QA	Quality Assurance
QM	Qualification Model
RICH	Ring Imaging Cerenkov Counter
ROEU	Remotely Operated Electrical Umbilical
RPCM	Remote Power Control Module
S&MA	Safety and Mission Assurance
SAFER	Simplified Aid for EVA Rescue
SCSI	Small Computer Systems Interface
SFHe	Superfluid Helium
SM	Scientific Magnetics
SOC	State of Charge
SPDM	Special Purpose Dextrous Manipulator
SPEC	Specification
SRMS	Shuttle Remote Manipulator System
SSP	Space Station Program
SSPC	Solid State Power Conditioner
SSPF	Space Station Processing Facility
SSRMS	Space Station Remote Manipulator System
STA	Structural Test Article
STADCO	Standard Tool and Die Company
STD	Standard
STE	Special Test Equipment
STS	Space Transportation System
SVP	Structural Verification Plan
SVTL	Safety Verification Tracking Log
SWG	Structures Working Group

APPENDIX A: ACRONYMS AND ABBREVIATIONS (CONTINUED)

T	Tesla
TAS	Tracker Alignment System
TBD	To be Determined
TCS	Thermal Control System
TOF	Time of Flight (Scintillator Counters)
TPG	Thermal Pyrolytic Graphite
TPS	Task Performance Sheet
TRD	Transition Radiation Detector
TRDGS	Transition Radiation Detector Gas Supply
TTCS	Tracker Thermal Control System
TVT	Thermal Vacuum Test
UMA	Umbilical Mechanism Assembly
UPS	Uninterruptible Power Supply
USCM	Universal Slow Control Module
USS-02	Unique Support Structure-02
VAR	Verification Acceptance Review
VC	Vacuum Case
VCS	Vapor Cooled Shields
Vdc or VDC	Volts Direct Current
VF	View Factor
W	Watt
WAD	Work Authorization Document
WI	Work Instruction
WIF	Worksite Interface Fixture
WSA	Worksite Analysis
Xe	Xenon
YPR	Yaw, Pitch, Roll

APPENDIX B: DEFINITION OF TERMS

Verification Terms

Certification: the audit process by which the body of evidence that results from the verification activities presented are provided to the appropriate certifying authority to indicate all requirements are met.

Deviation: Written authorization issued "before the fact" to develop a product that departs from established requirements.

HSI1: Hardware/software integration (HSI) that is performed prior to PDR. This testing establishes confidence that the hardware and software design concepts are adequate to meet functional interfaces.

HSI2: Hardware/software integration that is performed prior to CDR on engineering unit or DVTU hardware. This testing establishes confidence that the hardware and software detailed designs meets requirements.

Validation: the process that ensures a system meets the customer/sponsor's expectations for intended use. Unique validation activities may not be required if validation is satisfied through verification or acceptance testing activities.

Verification: a formal process, using the method of test, analysis, inspection or demonstration, to confirm that a system and its hardware and software components satisfy all specified performance and operational requirements.

Waiver: Written authorization to temporarily accept an item that departs from a particular performance or design requirement of a specification, drawing, or other contract document. The authorization is granted for a specific number of items and/or a specific period of time. The item(s) is/are considered suitable for use "as is" for a specified period of time or quantity of items, until reworked by approved method.

Types of Verification Methods

Test: a method of verification wherein formal project requirements (performance, environment, etc.) are verified by measurement or functional test during or after the controlled application of functional and/or environmental stimuli. These measurements may require the use of laboratory equipment, recorded data, procedures, test support items, or specialized software.

Analysis: a verification method utilizing techniques and tools such as math models, prior test data, simulations, analytical assessments, etc. Verification by similarity is acceptable if the subject article is similar or identical in design, manufacturer, manufacturing process, and quality control to another article that has been previously verified to equivalent or more stringent criteria.

Inspection: a method of verification of physical characteristics that determines compliance without the use of special laboratory equipment, procedures, test support items, or services.

Inspection uses standard methods such as visual gauges, etc. to verify compliance with design requirements.

Demonstration: a qualitative method of verification that evaluates the properties of the subject end item. Demonstration is used with or without special test equipment or instrumentation to verify required characteristics such as operational performance, human engineering features, service and access features, transportability, and displayed data.

Testing Levels

Development testing: subsystem or component level testing (including firmware/software testing) that is performed on end items in order to show that a specific design approach is acceptable for both functional and performance requirements. The tests may be performed on controlled or uncontrolled hardware components, software, or major configuration end items.

Qualification testing: performed on end items that are identical to the flight units. The purpose of qualification tests is to ensure the design of the project's deliverables meets the environment (thermal, pressure, vibration, etc.) requirements imposed on the deliverable.

Acceptance testing: used to show a specific end item, tracked by serial number, or unique firmware and/or software identifier, has successfully replicated the end item design. Acceptance testing is performed on each deliverable end item. In addition to proving the functionality of each unit at defined specification values, this testing also is intended to screen out manufacturing defects, workmanship errors, incipient failures, and other functional anomalies not readily detectable by inspection. The acceptance testing process also ensures the verified firmware and/or software resident within the system has been properly loaded into the appropriate end item.

System level testing: performed with all end items assembled and integrated together. Ensures that all items being provided by the project are compatible. May also include interface testing between the system and its immediate interfaces with other systems.

End-to-End testing: performed with not only the provided system but also all its other internal (vehicle) and external (ground, satellite, etc) interfaces. Basically, a test from initial bit generation on-board to the end user whether that occurs on-board or on the ground (MCC, customer/sponsor center, etc).

Types of Test Articles

Prototype Unit: The breadboard, generic component or developmental assembly of hardware and software that roughly performs the basic functions of the engineering unit, but is not fully functional equivalent. This unit is used for proof of concept testing of the preliminary design.

Engineering Unit: The hardware, firmware, and software unit that is functionally equivalent to the qualification unit, but not necessarily form and fit equivalent. This unit is used for proof of concept testing of the detailed design. It may be used for software verification credit after CDR with quality controls as defined in the Software Development Plan.

Design Verification Test Unit: (DVTU) The hardware, firmware, and software unit which is form, fit and functional equivalent to the flight unit, but may not be manufactured using the exact flight parts. This unit is used for design proof of concept.

Qualification Unit: A hardware, firmware and software unit which is identical to the flight unit in form, fit and function, as well as in manufacturing processes, parts, and quality control. This unit is used for verification and certification credit for all environmental requirements and performance requirements as needed.

Flight Unit: The hardware, firmware and software unit that is used operationally in the flight environment. This unit is designed and manufactured under strict quality control, with complete records of unit manufacturing, testing, shipping and handling.

Protoflight Unit: A flight unit used for qualification testing in lieu of a dedicated test article. This use of the flight unit for qualification testing often requires reduced test levels and/or duration and post-test hardware refurbishment where required.

Ground support equipment: All equipment (implements, tools, test equipment devices, simulations, etc.) required on the ground to support ground testing or training.

APPENDIX C: REQUIREMENT APPLICABILITY MATRIX

Rqmt No.	Document	Paragraph	Requirement Title	Shall Statement	Payload	PIH	Cryomagnet System	TRD	TRDGS	TOF	ACC	Tracker	RICH	ECAL	Avionics	TCS	TTCS	Star Trackers	GPS
P-1	JSC 29789	3.2.1.1.1	Transition Radiation Detector (TRD) and Upper Time of Flight (TOF) Structural Interfaces – Location	The PIH shall provide structural interfaces to locate the TRD and Upper TOF at the top of the AMS-02 experiment stack so that the TRD/Upper TOF is centered above the Cryomagnet and the top surface of the TRD is 57.48 inches above the AMS-02 origin X-Y plane. [NOTE: Upper TOF is attached to the TRD at the TRD Corner Brackets. (Reference JSC 29095, paragraph 4.1.6.1-D-1)]		A													
P-2	JSC 29789	3.2.1.1.2-A	Cryomagnet System (Includes Cryomagnet, SFHe Tank, and Support System) Structural Interfaces – Location	The PIH/Vacuum Case shall provide structural interfaces to locate the AMS-02 Cryomagnet System within the Vacuum Case.		A													
P-3	JSC 29789	3.2.1.1.2-B	Cryomagnet System Structural Interfaces – Cabling	The PIH/Vacuum Case shall provide feed-thru ports for cabling to the Cryomagnet system.		A													
P-4	JSC 29789	3.2.1.1.2-C	Cryomagnet System – Air Exclusion	The PIH/Vacuum Case shall prevent air from contacting the surfaces of the SFHe Tank and the Cryomagnet system by maintaining a vacuum of at least 1 X 10^{-6} torr.		A													
P-5	JSC 29789	3.2.1.1.2-D	Cryomagnet System – Cryocooler Interfaces	The PIH/Vacuum Case shall provide interfaces for five cryocoolers used to help maintain the cryogenic temperature of the SFHe in the tank.		A													
P-6	JSC 29789	3.2.1.1.2-E	Cryomagnet System – Cryocooler Access	The PIH/Vacuum Case shall provide access ports at the five cryocooler locations.		A													
P-7	JSC 29789	3.2.1.1.2-F	Cryomagnet System – Fill Port	The PIH/Vacuum Case shall provide an interface for the SFHe Tank fill port.		A													
P-8	JSC 29789	3.2.1.1.2-G	Cryomagnet System – Emergency Vent	The PIH/Vacuum Case shall provide an interface for an emergency vent for the SFHe Tank.		A													
P-9	JSC 29789	3.2.1.1.2-H	Cryomagnet System – Pressure Relief System	The PIH/Vacuum Case shall provide interfaces for an emergency pressure relief system for the Vacuum Case.		A													
P-10	JSC 29789	3.2.1.1.2-I	Cryomagnet System – Plumbing	The PIH/Vacuum Case shall provide feed-thru ports for the plumbing of gas lines to the gas-operated valves for the SFHe.		A													
P-11	JSC 29789	3.2.1.1.3	Anti-Coincidence Counter (ACC)	The PIH shall provide structural interfaces for mounting the ACC within the inner cylinder of the Vacuum Case.		A													
P-12	JSC 29789	3.2.1.1.4	Tracker	The PIH shall provide structural interfaces for mounting the Tracker within the inner cylinder of the Vacuum Case.		A													
P-13	JSC 29789	3.2.1.1.5	Lower Time of Flight (TOF)	The PIH shall provide structural interfaces to locate the Lower TOF within the Lower Conical Flange of the AMS-02 Vacuum Case directly below the Tracker and centered below the Cryomagnet.		A													
P-14	JSC 29789	3.2.1.1.6	Ring Imaging Cherenkov Counter (RICH)	The PIH shall provide structural interfaces to locate the RICH directly below the Lower TOF and centered below the Cryomagnet.		A													
P-15	JSC 29789	3.2.1.1.7	Electronic Calorimeter (ECAL)	The PIH shall provide structural interfaces to locate the ECAL directly below the RICH and centered below the Cryomagnet.		A													
P-16	JSC 29789	3.2.1.1.8	TRD Gas Supply System	The PIH shall provide structural interfaces for the TRD Gas Supply System.		A													
P-17	JSC 29789	3.2.1.1.9	Integrated Radiators, Debris Shield and Electronic Box Assemblies	The PIH shall provide structural interfaces for the RAM and Wake Integrated Radiator, Debris Shield and Electronic Box Assemblies.		A													
P-18	JSC 29789	3.2.1.1.10	AMS Experiment Plumbing, Cabling, and Other Miscellaneous Hardware	The PIH/Vacuum Case shall provide generic interfaces for securing gas and fluid lines, electrical cables, and other miscellaneous experiment hardware.		A													

Rqmt No.	Document	Paragraph	Requirement Title	Shall Statement	Payload	PIH	Cryomagnet System	TRD	TRDGS	TOF	ACC	Tracker	RICH	ECAL	Avionics	TCS	TTCS	Star Trackers	GPS
P-19	JSC 29789	3.2.1.2.1-A	STS Structural Interfaces	The PIH shall provide structural interfaces with the Shuttle Orbiter (in the Cargo Bay) via four sill trunnions and one keel trunnion.		A													
P-20	JSC 29789	3.2.1.2.1-B	STS Structural Interfaces	The sill and keel trunnions shall meet the requirements of NSTS-21000-IDD-ISS, Section 3.3.1.		A													
P-21	JSC 29789	3.2.1.2.2-A	STS Power and Data Interfaces	The PIH power and data interfaces shall be through the Remotely Operated Electrical Umbilical/Payload Disconnect Assembly (ROEU/PDA) on the Orbiter side.		A													
P-22	JSC 29789	3.2.1.2.2-B	STS Power and Data Interfaces	The PIH shall provide pass-through 124 Vdc power up to 2 kilowatts (kW) from the APCUs on the Orbiter to the PDS via the ROEU/PDA and Interface Panel A.		A													
P-23	JSC 29789	3.2.1.2.2-C	STS Power and Data Interfaces	The PIH shall provide pass-through GSE 120 Vdc power up to 2 kW from the T-0 umbilical to the PDS via the ROEU/PDA and Interface Panel A.		A													
P-24	JSC 29789	3.2.1.2.2-D	STS Power and Data Interfaces	The PIH shall provide pass-through GSE TBD Vdc power at 200 watts (W) from the T-0 umbilical to the Vent Pump via the ROEU/PDA and Interface Panel A.		A													
P-25	JSC 29789	3.2.1.2.2-E	STS Power and Data Interfaces	The PIH shall provide pass-through momentary 28 Vdc ascent power at up to 4 amps (A) from a Standard Switch Panel (SSP) in the Orbiter Aft Flight Deck (AFD) to the AMS-02 Vent Valve Electronics via the ROEU/PDA and Interface Panel A.		A													
P-26	JSC 29789	3.2.1.2.2-F	STS Power and Data Interfaces	The PIH shall provide pass-through command and data handling cables from the Orbiter to the AMS-02 front-end data acquisition box (J-Crate) via the ROEU/PDA and Interface Panel A. Two sets of cables (including bus couplers) shall be used for 1553 communications at 20 kilobytes per second (kbps) to two separate Remote-Terminals (RTs) on AMS-02, and one set of cables shall be used for a redundant set of high rate data at 2 Megabytes per second (Mbps) via RS-422 connection.		A													
P-27	JSC 29789	3.2.1.2.2-G	STS Power and Data Interfaces	The PIH shall provide pass-through command and data handling cabling from the Orbiter Backup Flight System (BFS) General Purpose Computer (GPC) to the AMS-02 Vent Valve Electronics via the ROEU/PDA and Interface Panel A (Discreet Output, Low 5 Vdc).		A													
P-28	JSC 29789	3.2.1.2.2-H	STS Power and Data Interfaces	The PIH shall provide a digital data recording system-02 (DDRS-02) for recording high rate data (2 Mbps avg) from the AMS-02 payload on-orbit operations. The DDRS-02 shall consist of an Orbiter Payload General Support Computer (PGSC) and Payload provided interface boards, cabling, and software.		A													
P-29	JSC 29789	3.2.1.2.2-I	*STS Power and Data Interfaces*	The PIH shall provide cables to route one channel of the RS-422 data (2 Mbps) to the T-0 during ground operations and another cable to route the same data to the DDRS-02 via the Payload Data Interface Panel (PDIP) on the Orbiter mid-deck		A													
P-30	JSC 29789	3.2.1.2.2-J	STS Power and Data Interfaces	The PIH shall provide cabling to route another channel of the RS-422 data (2 Mbps) to the Ku-Band at the PDIP.		A													
P-31	JSC 29789	3.2.1.3.1-A	ISS Structural Interfaces	The PIH shall provide structural interfaces with the ISS upper inboard Payload Attach Site on the Starboard 3 (S3) Integrated Truss Segment (ITS) via the active Payload Attach System (PAS) on the truss and the passive PAS on AMS-02.		A													
P-32	JSC 29789	3.2.1.3.1-B	ISS Structural Interfaces	The PIH/PAS shall permit/facilitate the robotic berthing of the AMS-02 Payload.		A													
P-33	JSC 29789	3.2.1.3.1-C	ISS Structural Interfaces	The PIH/PAS shall provide an EVA flight releasable capture bar to facilitate payload unberthing in a contingency situation.		A													
P-34	JSC 29789	3.2.1.3.2-A	ISS Power and Data Interfaces	The PIH power and data interfaces shall be through the Umbilical Mechanism Assembly (UMA) active half on the ISS side and the UMA passive half on the AMS-02 side.		A													
P-35	JSC 29789	3.2.1.3.2-B	ISS Power and Data Interfaces	The PIH shall provide two (Power A, Power B) pass-through 120 Vdc power feeds (2.4 kW continuous, 2.8 kW max) from the ISS to the PDS via the UMA and the EVA Interface Panel.		A													

Rqmt No.	Document	Paragraph	Requirement Title	Shall Statement	Payload	PIH	Cryomagnet System	TRD	TRDGS	TOF	ACC	Tracker	RICH	ECAL	Avionics	TCS	TTCS	Star Trackers	GPS
P-36	JSC 29789	3.2.1.3.2-C	ISS Power and Data Interfaces	The PIH shall provide two (Bus A, Bus B) pass-through MIL-STD-1553 command and data handling buses (20 kbps) from the ISS to the AMS-02 front-end data acquisition box (J-Crate) via the UMA and the EVA Interface Panel.		A													
P-37	JSC 29789	3.2.1.3.2-D	ISS Power and Data Interfaces	The PIH shall provide a pass-through fiber optic High Rate Data Link (HRDL) interface (125 Mbaud, 40 Mbps peak, 2 Mbps) from the ISS to the AMS-02 front-end data acquisition box (J-Crate) via the UMA and the EVA Interface Panel.		A													
P-38	JSC 29789	3.2.1.3.2-E	ISS Power and Data Interfaces	The PIH shall provide a secondary fiber optic HRDL interface (125 Mbaud, 40 Mbps peak, 2 Mbps orbit avg) from the EVA Interface Panel to the AMS-02 front-end data acquisition box (J-Crate). This will only be used for contingency purposes.		A													
P-39	JSC 29789	3.2.1.4.1	Shuttle Remote Manipulator System (SRMS) Interfaces Functional Requirements	A Space Shuttle Program (SSP) provided FRGF serves as the interface between the AMS-02 Payload and the SRMS. The FRGF shall be mounted to the PIH to facilitate grappling of the payload in the Orbiter payload bay with the SRMS, removing it from its berthed position, and extending it to the robotic hand-off position.		A													
P-40	JSC 29789	3.2.1.4.2-A	Space Station Remote Manipulator System (SSRMS) Interfaces Functional Requirements	The PVGF shall be mounted on the PIH to facilitate robotic hand-off of the payload from the SRMS and subsequent berthing on the S3 Truss by the SSRMS.		A													
P-41	JSC 29789	3.2.1.4.2-B	Space Station Remote Manipulator System (SSRMS) Interfaces Functional Requirements	The PIH shall provide cabling for redundant (Bus 1 & Bus 2) pass-through 120 Vdc power (<1800 W) from the SSRMS via the PVGF to the EBCS.		A													
P-42	JSC 29789	3.2.1.4.2-C	Space Station Remote Manipulator System (SSRMS) Interfaces Functional Requirements	The PIH shall provide pass-through 120 Vdc power (<1800 W) for both Bus 1 and Bus 2 from the EBCS to the AMS-02 payload, to supply contingency heater power during transfer operations.		A													
P-43	JSC 29789	3.2.1.4.2-D	*Space Station Remote Manipulator System (SSRMS) Interfaces Functional Requirements*	The PIH shall provide routing for redundant video cabling from the EBCS to the SSRMS via the PVGF for the transmission of video signals to the ISS.		A													
P-44	JSC 29789	3.2.1.4.2-E	Space Station Remote Manipulator System (SSRMS) Interfaces Functional Requirements	The PIH shall provide a method to secure and terminate cables from the PVGF that provide services that are not used by AMS.		A													
P-45	JSC 29789	3.2.1.5-A	EVA Interfaces Functional Requirements	Attached Payloads shall be designed such that all operations are performed via EVR with contingency EVA capability.		A													
P-46	JSC 29789	3.2.1.5-B	EVA Interfaces Functional Requirements	Attached Payloads shall be designed to the sharp edge, protrusion, and glove temperature requirements of NSTS 07700, Volume XIV, Appendix 7, even if EVA is not planned or anticipated.		A													
P-47	JSC 29789	3.2.1.5-C	EVA Interfaces Functional Requirements	EVA contingency operations shall be performed by a crewmember restrained at the end of the SSRMS. (TBR)		A													
P-48	JSC 29789	3.2.1.5-D	EVA Interfaces Functional Requirements	EVA aids shall be provided in all locations necessary to support SSRMS based EVA contingency operations as specified in SSP 50005, paragraph 12.3.		A													
P-49	JSC 29789	3.2.1.5-E	EVA Interfaces Functional Requirements	All loose equipment and cargo operated on or by an EVA crewmember shall have attachment points or restraints so it can be secured or tethered at all times during transfer and at the worksite during EVA contingency operations as specified in SSP 50005, paragraph 12.3.		A													
P-50	JSC 29789	3.2.1.5-F	EVA Interfaces Functional Requirements	EVA worksites shall provide a force reaction mechanism independent of the robotic stabilization platform for forces greater than 10 lbf within 24 inches of the task site.		A													

Rqmt No.	Document	Paragraph	Requirement Title	Shall Statement	Payload	PIH	Cryomagnet System	TRD	TRDGS	TOF	ACC	Tracker	RICH	ECAL	Avionics	TCS	TTCS	Star Trackers	GPS
P-51	JSC 29789	3.2.1.5.1	Extravehicular Activity Translation	The ISS truss provides a translation path to each of the six PAS/UCCAS sites for contingency support of the ORUs at the interface and contingency operations involving the PAS/UCCAS. These translation paths allow for EVA contingency operations involving the PAS/UCCAS active half UMA, the three PAS/UCCAS guide vanes at each site, the PAS/UCCAS capture latch, the Attached Payload passive half UMA, and the Attached Payload EVA releasable capture bar. Attached Payloads shall provide for EVA translation for contingency operations.		A													
P-52	JSC 29789	3.2.1.5.2	Payload Attach System/ Unpressurized Cargo Carrier Attach System Clearances	Attached Payloads shall be designed not to violate the PAS/UCCAS EVA access envelopes as defined by SSP 57003, paragraph 3.1.3.1.1.3A to allow for attach site ORU removal and replacement.		A													
P-53	JSC 29789	3.2.1.5.3	Extravehicular Activity Translation Corridor Protrusion	Attached Payloads impinging on EVA translation corridors and worksites shall provide EVA fixtures serving the same functions as those obscured by the payload as specified in SSP 50005, paragraph 14.5.3.		A													
P-54	JSC 29789	3.2.1.6	Micro-meteoroid and Orbital Debris (M/OD) Shields Functional Requirements	The AMS-02 PIH shall provide protection from micrometeoroids and orbital debris for all safety critical elements of the AMS-02 Payload per paragraph 3.2.3.9 of this PTRS.		A													
P-55	JSC 29789	3.2.1.7	Thermal Insulation Functional Requirements	The AMS-02 PIH shall provide thermal insulation for safety critical elements of the AMS-02 Payload that require protection from thermal extremes to ensure safe operations.		A													
P-56	JSC 29789	3.2.2.1-A	Weight/Center of Gravity (CG) – Weight	Total weight of the PIH shall not exceed 3,828 lbs (1736 kg).		A													
P-57	JSC 29789	3.2.2.1-B	Weight/Center of Gravity (CG) – CG	Design of the PIH shall not cause the center of gravity (CG) of the AMS-02 Payload to exceed the maximum allowable CG offsets on the ISS. The maximum allowable offsets are: X +/– 32 inches, Y +/– 32 inches, Z between 0 and +75 inches		A													
P-58	JSC 29789	3.2.2.2	Dimensions/ Volume	The PIH shall not cause the AMS-02 Payload to exceed the operational envelope as defined in SSP 57003, Figure 3.1.3.1.1.1-1.		A													
P-59	JSC 29789	3.2.3.1	Thermal	The AMS-02 PIH shall meet the thermal requirements as specified in SSP 57003, Paragraph 3.5.1.2		A													
P-60	JSC 29789	3.2.3.2	Pressure	The AMS-02 PIH shall meet the pressure requirements as specified in SSP 57003, paragraph 3.5.1.1		A													
P-61	JSC 29789	3.2.3.3	Vibration	The AMS-02 PIH shall meet the vibration requirements as specified in NSTS-21000-IDD-ISS, International Space Station Interface Definition Document, section 4.1.1.6, Vibration (paragraphs 4.1.1.6.1 & 4.1.1.6.2).		A													
P-62	JSC 29789	3.2.3.4-A	Acceleration – Flight & Ground Handling	The AMS-02 PIH shall be designed to show positive structural margins of safety during all flight and ground handling phases. Initial design load factors are listed in Table 3.2.4-1. These load factors may be superceded by the load factors from the official Verification Loads Analysis when the analysis is complete.		A													
P-63	JSC 29789	3.2.3.4-B	Acceleration – On-orbit	The AMS-02 PIH shall be designed to withstand an on-orbit acceleration environment including reboost having peak transient accelerations of up to 0.085 g's, a vector quantity acting in any direction.		A													
P-64	JSC 29789	3.2.3.4-C	Acceleration – Berthing	The AMS-02 PIH shall be designed to withstand berthing the Attached Payload in its berthing configuration having peak transient accelerations of up to 0.185 g's, a vector quantity acting in any direction. This criteria is to be used as a component load factor applied to the subsystem's center of gravity.		A													
P-65	JSC 29789	3.2.3.6	EMI/EMC	The AMS-02 PIH does not include any powered equipment, thus radiated electromagnetic interference (EMI) is not an issue. Cables that are part of the PIH shall be shielded if testing of the full AMS-02 Payload indicates that EMI shielding is necessary.		A													

Rqmt No.	Document	Paragraph	Requirement Title	Shall Statement	Payload	PIH	Cryomagnet System	TRD	TRDGS	TOF	ACC	Tracker	RICH	ECAL	Avionics	TCS	TTCS	Star Trackers	GPS
P-66	JSC 29789	3.2.3.7.1	Transportation Humidity Environment	All components of the AMS-02 PIH shall operate satisfactorily after being exposed to non-condensing relative humidity ranges up to 95% and condensing relative humidity up to 100% during transportation.		A													
P-67	JSC 29789	3.2.3.7.2	Storage Humidity Environment	All components of the AMS-02 PIH shall operate satisfactorily after being exposed to an external environment of up to 75% relative humidity during storage.		A													
P-68	JSC 29789	3.2.3.7.3	Pre-Launch Humidity Environment	All components of the AMS-02 PIH shall operate satisfactorily after being exposed to an external environment of up to 55% relative humidity during pre-launch processing.		A													
P-69	JSC 29789	3.2.3.7.4	On-Orbit Humidity Environment	The AMS USS-02 will be exposed to an external environment of 0% relative humidity during on–orbit operations. This is to be used for design and analysis purposes.		A													
P-70	JSC 29789	3.2.3.7.5	Orbiter Cabin Humidity Environment	The AMS DDRS-02 shall meet the humidity environments as defined in NSTS 2100-IDD-MDK specification.		A													
P-71	JSC 29789	3.2.3.8	Acoustic Emissions	The AMS-02 PIH does not have any components that produce acoustic emissions.		A													
P-72	JSC 29789	3.2.3.9	Micrometeoroids and Orbital Debris	The Attached Payload will be exposed to the MM/OD environments as specified in SSP 30425, paragraph 8.0. Parameters of ISS MM/OD environments definition are given in Table 3.2.3.9-1 and NASA TM 104825. This is to be used for design and analysis purposes. For the safety critical structures of AMS, this environment translates into a Probability of No Penetration (PNP) of 0.997. For non-safety critical AMS structures, a goal of 0.95 PNP has been established.		A													
P-73	JSC 29789	3.2.3.10	Atomic Oxygen	The AMS-02 PIH will be exposed to a flux of 5.0×10^{21} atoms per cm^2 per year for the on-orbit exposure duration. This is to be used for design and analysis purposes. Silver plated hardware shall not be used per SSP 57003, paragraph 3.6.4.		A													
P-74	JSC 29789	3.2.3.11	External Contamination	The AMS-02 PIH will be exposed to on-orbit external contamination environments as defined in SSP 30426, External Contamination Control Requirements, paragraphs 3.4 and 3.5. This will be used for design and analysis purposes.		A													
P-75	JSC 29789	3.2.3.12.1	Ionizing Radiation Dose	The AMS-02 PIH shall be designed to not produce an unsafe condition or one that could cause damage to external equipment as a result of exposure to a total dose specified in SSP 30512, Space Station Ionizing Radiation Design Environment, paragraph 3.1.2.		A													
P-76	JSC 29789	3.2.3.12.2	Nominal Single Event Effects Ionizing Radiation	The AMS-02 PIH shall be designed to operate in and to not produce an unsafe condition or one that could cause damage to other equipment as a result of exposure to the radiation dose environment specified in SSP 30512, paragraph 3.2.1.		A													
P-77	JSC 29789	3.2.3.12.3	Extreme Single Event Effects	The AMS-02 PIH shall be designed to not produce an unsafe condition or one that could cause damage to external equipment as a result of exposure to extreme Single Event Effect (SEE) ionizing radiation assuming exposure levels specified in SSP 30512, paragraph 3.2.2.		A													
P-78	JSC 29789	3.2.4.1.2	Failure Tolerance Power and Data Interfaces	The AMS-02 PIH cabling for power and data interfaces shall be single fault tolerant.		A													
P-79	JSC 29789	3.2.4.1.3	Failure Tolerance O-ring Seals	AMS-02 PIH Vacuum Case interfaces containing O-rings shall be two fault tolerant. (NOTE: The Payload Safety Review Panel has approved an equivalent fault tolerant approach for the two O-ring seal on the Vacuum case. The approach establishes a verification regimen for the two O-ring seal that would be equivalent to design, test and verification of a two fault tolerant system.)		A													
P-80	JSC 29789	3.2.4.2	Failure Propagation	A single failure of the AMS-02 PIH end item in a functional path shall not induce any other failures external to the failed end item.		A													
P-81	JSC 29789	3.2.6.1	Ground Transportability	The AMS-02 Payload and associated ground handling equipment (GHE) is being designed primarily for air transport. The Primary Support Stand (PSS) and Lower USS-02 Support Fixture are being designed specifically to be compatible with Boeing 747 cargo aircraft. Unassembled components of the AMS-02 PIH shall be designed to be compatible with transportation by truck.		A													

Rqmt No.	Document	Paragraph	Requirement Title	Shall Statement	Payload	PIH	Cryomagnet System	TRD	TRDGS	TOF	ACC	Tracker	RICH	ECAL	Avionics	TCS	TTCS	Star Trackers	GPS
P-82	JSC 29789	3.2.6.2	Transport to Orbit	The AMS-02 payload shall be capable of being transported to orbit by the Orbiter in accordance with NSTS 21000-IDD-ISS. The AMS-02 payload will be transported in the Orbiter cargo bay. Design loads are defined in JSC 28792, AMS-02 Structural Verification Plan for the STS and the ISS.		A													
P-83	JSC 29789	3.3.1.1-A	Materials and Processes	Materials and processes for flight hardware shall meet the requirements of SSP 30233, "Space Station Requirements for Materials and Processes," as implemented by JSC 27301, "Material Control Plan for JSC Space Station GFE".		A													
P-84	JSC 29789	3.3.1.1-B	Materials and Processes	Materials and process for payloads shall meet the requirements of SE-M-0096, "General Specification for Materials and Processes for JSC Controlled Payloads".		A													
P-85	JSC 29789	3.3.1.1-F	Materials and Processes	Materials and processes shall meet the materials requirements of NSTS 1700.7B, section 209 and NSTS 1700.7B ISS Addendum 209.		A													
P-86	JSC 29789	3.3.1.1-G	Materials and Processes	Nonmetallic materials shall be selected to the maximum extent possible from JSC 09604, "JSC GFE Materials Selection List and Materials Documentation Procedures."		A													
P-87	JSC 29789	3.3.1.1-H	Materials and Processes	Selection of materials shall be approved by the Structural Mechanical Design and Analysis Branch (ES5) of the JSC Structures and Mechanics Division.		A													
P-88	JSC 29789	3.3.1.2-A	Electrical, Electronic and Electromechanical (EEE) Parts	EEE parts for all Payload Integration Flight Hardware shall be selected in accordance with JSC 61360, "Engineering Directorate Certified Parts Approval Process (EDCPAP) and SSP 30312, Electrical, Electronic, and Electromechanical (EEE) and Mechanical Parts Management and Implementation Plan for Space Station Program.		A													
P-89	JSC 29789	3.3.1.2-B	Electrical, Electronic and Electromechanical (EEE) Parts	ESCG shall provide an as-built parts list and perform component stress analysis for all Payload Integration Hardware (PIH). EEE parts traceability to the serial and lot number will be provided for PIH. Parts shall be derated in accordance with SSP 30312, Electrical, Electronic, and Electromechanical (EEE) and Mechanical Parts Management and Implementation Plan for Space Station Program, Appendix B.		A													
P-90	JSC 29789	3.3.2	Structural Design	The AMS-02 PIH shall be designed to meet the structural design requirements of SSP 57003, paragraphs 3.1.1.7 and 3.1.1.8		A													
P-91	JSC 29789	3.3.3-A	Nameplates and Product Marking	Nameplates shall conform to the requirements of JSC-SPEC-M1B.		A													
P-92	JSC 29789	3.3.3-B	Nameplates and Product Marking	All other labels, decals, placards and product marking shall conform to the requirements of SSP 57003, paragraph 3.10.		A													
P-93	JSC 29789	3.3.4-A	Workmanship	Workmanship standards shall comply with NASA-STD-8739.3, "Soldered Electrical Connections"		A													
P-94	JSC 29789	3.3.4-B	Workmanship	Workmanship standards shall comply with NASA-STD-8739.4, "Crimping, Interconnecting Cables, Harnesses and Wiring"		A													
P-95	JSC 29789	3.3.4-C	Workmanship	Workmanship standards shall comply with IPC-6011, "Generic Performance Specification for Printed Boards"		A													
P-96	JSC 29789	3.3.4-D	Workmanship	Workmanship standards shall comply with IPC-6012A, "Qualification and Performance Specification for Rigid Printed Boards"		A													
P-97	JSC 29789	3.3.4-E	Workmanship	Workmanship standards shall comply with NASA-STD-8739.1, "Workmanship Standard for Staking and Conformal Coating of Printed Wiring Boards and Electronic Assemblies"		A													
P-98	JSC 29789	3.3.4-F	Workmanship	Workmanship standards shall comply with IPC-2221, "Generic Standard on Printed Board Design" and IPC-2222, "Sectional Design Standard for Rigid Organic Printed Boards"		A													
P-99	JSC 29789	3.3.4-G	Workmanship	Workmanship standards shall comply with ANSI/ESD S20.20-1999, Development of an Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)		A													
P-100	JSC 29789	3.3.4-H	Workmanship	Workmanship standards shall comply with NASA-STD-8739.2, "Workmanship Standard for Surface Mount Technology"		A													

Rqmt No.	Document	Paragraph	Requirement Title	Shall Statement	Payload	PIH	Cryomagnet System	TRD	TRDGS	TOF	ACC	Tracker	RICH	ECAL	Avionics	TCS	TTCS	Star Trackers	GPS
P-101	JSC 29789	3.3.4-I	Workmanship	Workmanship standards shall comply with NASA-STD-8739.5, "Fiber Optic Terminations, Cable Assemblies, and Installation"		A													
P-102	JSC 29789	3.3.4-J	Workmanship	The external surfaces of the AMS-02 Payload shall conform to Visibly Clean–Standard (VC–S) as specified in SN–C–0005, NSTS Contamination Control Requirements Manual.		A													
P-103	JSC 29789	3.3.5-A	Human Engineering	The AMS-02 Payload shall be designed to meet the requirements of SSP 57003, section 3.8.3, Human Engineering Design.		A													
P-104	JSC 29789	3.3.5-B	Human Engineering	The AMS-02 Payload shall be designed to meet the requirements of SSP 57003, section 3.8.4, Human Engineering Safety.		A													
P-105	JSC 29789	4.1	Packaging Levels and Methods	Packaging and packing shall be in general accordance with MIL-STD-2073-1D, "Standard Practice for Military Packaging."		A													
P-106	JSC 29789	4.3	Military Transportation Procedures Documentation and Reports	Shipments entered into the military airlift system shall be documented and reported in accordance with DODR-4500.32R, "Military Standard Transportation and Movement Procedures."		A													
I-1	SSP 57003	3.1.1	General Design Requirements	Attached Payload hardware design drawings, exceedances, deviations, waivers, and engineering change requests shall reflect the as-built hardware.	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
I-2	SSP 57003	3.1.1.1.1	Fail safe, Safe-life, or Low risk Fracture parts	AP structure shall be designed to be fail safe, safe life, or be low risk fracture critical parts in accordance with SSP 52005.	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
I-3	SSP 57003	3.1.1.1.2	Fracture Control	APs shall meet the fracture control requirements for on-orbit interfaces with a PAS/UCCAS site in accordance with SSP 52005, Sect. 5.3.	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
I-4	SSP 57003	3.1.1.1.3	MOD Protection for External payloads	An AP that is a stored energy device or contains hardware that can create a catastrophic hazard if impacted by MMOD shall be designed to SSP 52005, para.5.1.5 and NASA/TP-2002-210780.	A	A													
I-5	SSP 57003	3.1.1.2.1	Margins of Safety	APs shall provide margins of safety when exposed to crew induced and on-orbit loads in accordance with SSP 52005, section 5.2.	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
I-6	SSP 57003	3.1.1.2.2	Factors of Safety	Safety factors for attached payload structural design shall be in accordance with SSP 52005, section 5.1.	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
I-7	SSP 57003	3.1.1.2.3 A	Design Loads - External to Payload	A) AP structures and systems shall be designed in accordance with SSP 30559 para 3.2 and the loads referenced in Table 3.1.1.2.3-1. The PAS//UCCAS interface shall be designed to withstand the interfaces loads in Table 3.1.1.2.3-2 combined with the preload defined in 3.5.1.2. The AP shall also be designed to accommodate the associated On-Orbit transient load spectra that are defined in Tables 3.1.1.2.3-3 and 3.1.1.2.3-4.	A	A													
I-8	SSP 57003	3.1.1.2.3 B	Design Loads - Internal to Payload	B) When the payload is coupled to the ISS attachment structure, the AP/UCC interface loads shall not exceed those specified in Table 3.1.1.2.3-2.	A	A													
I-9	SSP 57003	3.1.1.2.4.1	Guide Pin Contact Forces	APs shall withstand berthing contact forces at guide pins based on a robotic installation approach speed of 0.1 ft/second and berthing contact conditions as specified in Table 3.1.1.2.4.1-1.	A	A													
I-10	SSP 57003	3.1.1.2.4.2	Capture Bar Contact Forces	AP capture bar shall withstand the maximum berthing contact forces as defined in table 3.1.1.2.4.2-1.	A	A													
I-11	SSP 57003	3.1.1.2.5	Thermal Effects	AP structure shall meet the interface requirements when subjected to structural interface temperatures ranging from -120 F to 200 F when combined with static and dynamic loads.	A	A													
I-12	SSP 57003	3.1.1.2.6	EVA On-orbit Induced loads	External components of AP hardware exposed to EVA shall withstand the loads defined in Table 3.1.1.2.6-1.	A	A													
I-13	SSP 57003	3.1.1.3	Design Service Life	The design service life of the PAS/UCCAS shall have a maximum expected on-orbit life plus 2 years.	A	A													
I-14	SSP 57003	3.1.1.5	Interchangeability	APs shall be compatible with contingency installation and safety related operations on any one of the six PAS/UCCAS site locations.	A	A													

Rqmt No.	Document	Paragraph	Requirement Title	Shall Statement	Payload	PIH	Cryomagnet System	TRD	TRDGS	TOF	ACC	Tracker	RICH	ECAL	Avionics	TCS	TTCS	Star Trackers	GPS
I-15	SSP 57003	3.1.1.6	Attached Payload Interface Durability	APs shall withstand a minimum of 6 combined mate and demate cycles per year combined with the MCAS, PAS, and UCCAS attached sites.	A	A													
I-16	SSP 57003	3.1.1.7A	Structural Materials Criteria and Selection	A. Mechanical properties of attached payload structural materials shall be in accordance with MIL-HDBK-5, MIL-HDBK-17-1, and NSTS 1700.7, ISS Addendum , para 208.3.	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
I-17	SSP 57003	3.1.1.8	Structural Degradation from Material Erosion	Potential structural erosion, e.g. plasma environmental effects compatibility-induced, atomic oxygen (AO) during the design life and exposure to the environment as defined in SSP 30425 "Space Station Program Natural Environment definition for Design", shall be included in the design and analysis of the attached payload structure.	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
I-18	SSP 57003	3.1.2.1	Structural Design Interface	APs shall structurally interface with the MCAS as specified in SSP 42004, para. B3.2.2.3	A	A													
I-19	SSP 57003	3.1.2.2	Mechanical Design Interface	The AP shall mechanically interface with the MCAS as specified in SSP 42004, para. B3.2.2.2	A	A													
I-20	SSP 57003	3.1.2.3 A	Mass and Envelope Dimensions – Total Mass	A. The total mass of the AP (facility carrier and payload experiments) to be attached at the MCAS by the mobile transporter along the ISS truss shall not exceed 19000 lbs. (Note: The capability of the MCAS is reduced to 10000 lbs. during Russian dockings.	A														
I-21	SSP 57003	3.1.2.3 B	Mass and Envelope Dimensions – Envelope	B. The AP (facility carrier and payload experiments) shall not exceed the MCAS user envelope dimensions of SSP 42004, para. B3.2.2.1.	A														
I-22	SSP 57003	3.1.3.1.1.1	PAS/UCCAS On-Orbit Operational Envelope	APs and equipment shall be designed such that the payload does not exceed the allowable -on-orbit operational envelope in accordance with Figure 3.1.3.1.1.1-1.	E														
I-23	SSP 57003	3.1.3.1.1.2	Interface Plane Protrusion	APs shall be designed to ensure that no structural, mechanical, utility, or ORU component protrudes past the PAS/UCCAS interface plane as defined by the X/Y plane in figure 3.1.3.1.2.1-1, except for the capture bars and envelope for the attached payload trunnion.	A	A													
I-24	SSP 57003	3.1.3.1.1.3 A	EVA/Robotics Envelope - EVA	A. EVA translation corridor and accessibility shall be maintained between the AP and other ISS equipment, including attached payloads or other installations on adjacent PAS/UCCAS sites in accordance with SSP 50005, ISS Flight Crew Integration Standard (NASA STD 3000/T) document, para. 14.5.	A														
I-25	SSP 57003	3.1.3.1.1.3 B	EVA/Robotics Envelope - Robotics	B. Robotic translation corridor and accessibility shall be maintained around the operational/deployed AP for ISS operations and the installation/removal of attached payloads or other installations on adjacent PAS/UCCAS sites in accordance with SSP 41162, para 3.2.2.7..	A														
I-26	SSP 57003	3.1.3.1.2.1	PAS Coordinate System Origin Location	For analysis or measurements involving unberthed APs, the AP shall use the passive PAS local coordinate system as defined in SSP 57004, Figure 3.1.2.2-1. For analysis involving APs berthed to a PAS or UCCAS site, the AP shall use the Active PAS local coordinate system as defined in Figure 3.1.3.1.2.1-1.	A	A													
I-27	SSP 57003	3.1.3.1.2.2	Mass and Center of Gravity	For APs between masses of 3000 lbs. And 19000 lbs., the allowable center of gravity offsets shall be as follows: A. 3000 lbs: X+/- 32 inches, Y +/- 32 inches, Z between 0 and +100 inches B. 19000 lbs: X+/- 32 inches, Y +/- 32 inches, Z between 0 and +66 inches	A														
I-28	SSP 57003	3.1.3.1.3	Attached Payload Fundamental Frequency	The AP shall exhibit a minimum fundamental frequency of 1.5 Hz or greater when rigidly fixed in all 6 degrees of freedom at the PAS/UCCAS interface points as defined in 3.1.3.1.3.2 (Interface stiffness).	A	A													
I-29	SSP 57003	3.1.3.1.3.1	Interface Preload	The AP shall be designed and constructed to allow the active CLA to achieve and maintain a minimum and maximum loading in the –Z direction of 4900 lbf and 6430 lbf, respectively. Loads will be applied by the CLA to the Capture Bar as the AP is pulled toward the active half as shown in Figure3.1.2.3-1 of SSP 57004. For analysis purposes, this load is to be applied at the midpoint of the capture bar at PAS coordinate X=0, Y=0, Z=1.142.	A	A													
I-30	SSP 57003	3.1.3.1.3.2	Interface Stiffness	The stiffness of the attached payload interface in the z direction shall be 13500+/- 10% lbf/in the Z direction of the AP/UCC coordinate system. The stiffness is measured with the AP/UCC Guide Pins simply supported on the Guide Vane Assemblies while a preload is applied per 3.1.3.1.3.1.	A	A													

Rqmt No.	Document	Paragraph	Requirement Title	Shall Statement	Payload	PIH	Cryomagnet System	TRD	TRDGS	TOF	ACC	Tracker	RICH	ECAL	Avionics	TCS	TTCS	Star Trackers	GPS
I-31	SSP 57003	3.1.3.2.1A	EVA Releasable and Removable Capture Bar	The AP design shall include an EVA releasable and removable capture bar to interface with the PAS/UCCAS CLA per SSP 30256:001.	A	A													
I-32	SSP 57003	3.1.3.2.1B	EVA Releasable and Removable Capture Bar - Design	EVA releasable and removable capture bar design, location, and tolerances shall be in accordance with SSP 57004, Figure 3.1.2.2-1.	A	A													
I-33	SSP 57003	3.1.3.2.1C	EVA Releasable and Removable Capture Bar	The design of the EVA releasable and removable capture bar shall allow removal of the preload and subsequent removal and reinstallation of the capture bar.	A	A													
I-34	SSP 57003	3.1.3.2.2A	Guide Pins	The attached payload shall have 3 guide pins for interface to the PAS/UCCAS guide vanes.	A	A													
I-35	SSP 57003	3.1.3.2.2B	Guide Pins	The guide pins design, location, and tolerances shall be in accordance with SSP 57004, Figure 3.1.2.2-1.	A	A													
I-36	SSP 57003	3.1.3.2.3A	Passive Umbilical Mechanism – Parts Selection	The AP shall use the passive UMA part # 1F70162-1 to interface to the PAS/UCCAS UMA active half.	A	A													
I-37	SSP 57003	3.1.3.2.3B	Passive Umbilical Mechanism –EVA Access	The passive UMA shall be accessible for manual EVA backup operations and EVA removal in accordance with SSP 50005, para. 12.3.	A	A													
I-38	SSP 57003	3.1.3.2.3.1A	Passive UMA Mounting	The AP shall locate the passive UMA on the payload structure as defined in SSP 57004, Figure 3.1.2.2-1.	A	A													
I-39	SSP 57003	3.1.3.2.3.1B	Passive UMA Mounting – Loads	When components are positioned as specified in SSP 57004, Figure 3.1.2.2-1 and nominal preload of 5650 lbs is applied per 3.1.3.1.3.1 and 3.1.3.1.3.2, each of the 4 AP/UCC Passive Half UMA mounting interface locations shall not displace by more than X = +/-0.012", Y = +/-0.021", and Z=+/-0.064" when subjected to the interface loads as defined in Table 3.1.1.2.3-2.	A	A													
I-40	SSP 57003	3.1.3.2.3.1C	Passive UMA Mounting – Temperature Range	The AP shall be designed to maintain the UMA passive half within its on-orbit operating temperature of -90 to 190F.	A	A													
I-41	SSP 57003	3.1.3.2.6.1	Limit Quasi-Steady Accelerations	For frequencies below 0.01 Hz, attached payloads shall limit unbalanced transitional average impulse to generate less than 10lb-s (44N-s) within any 10 to 500 second period, along any ISS coordinate system vector.	A	A	A												
I-42	SSP 57003	3.1.3.2.6.2.1	Vibratory Requirements	Between 0.01 and 300 Hz, payloads shall limit vibration so that acceleration limits of Figure/Table 3.1.3.2.6.2.1-1 are not exceeded using simultaneously the force transfer functions of figures/tables 3.1.3.2.6.2-2/4 and moment transfer functions of figures/tables 3.1.3.2.6.2-3/5	A	A	A												
I-43	SSP 57003	3.1.3.2.6.2.2A	Transient Requirements	APs shall limit force applied to the ISS over any 10 second period to an impulse of no greater that 10 lbs.	A	A	A												
I-44	SSP 57003	3.1.3.2.6.2.2B	Transient Requirements	APs shall limit their peak force applied to the ISS to less than 1000 lb. (4448 N) for any duration.	A	A	A												
I-45	SSP 57003	3.1.3.2.6.3.1	Limit Induced ISS Attitude Rate	Payload shall have an angular momentum impulse of less than the per axis values shown on Table 3.1.3.2.6.3.1-1 during any continuous 9 minute period. Over no interval time of 10 seconds or less shall a payload angular momentum impulse to exceed 250 ft-lbs-(340 N-m-s) and over no interval of time of 2 minutes or less shall a payload angular momentum impulse exceed 2900 ft-lb-s (3930 N-m-s).	A	A	A												
I-46	SSP 57003	3.1.3.2.6.3.2	Limit Disturbance Induced CMG Moment Usage	When the on–orbit Space Station is in the microgravity mode, any disturbance induced on the on–orbit Space Station by an individual disturbance source of a payload shall have an angular momentum impulse that produces an estimated Control Moment Gyroscope (CMG) momentum magnitude less than 10,000 ft–lb–sec (13,558 N–m–sec) during any continuous 110 minute period when evaluated per the expression in Table 3.1.3.2.6.3.2–1.	A	A	A												
I-47	SSP 57003	3.1.3.2.7	Contact Surfaces	The AP capture bar, guide pins, and associate passive half platform structure subject to contact shall be coated with a dry film lubricant and provide a .25" minimum edge radius as depicted in SSP 57004, Figure 3.1.2.2-1.	A	A													
I-48	SSP 57003	3.2.2.1.1	Steady-State Voltage Characteristics	The AP connected to Interface C shall operate and be compatible with the steady state voltage limits of 112.5 to 126 VDC	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A

Rqmt No.	Document	Paragraph	Requirement Title	Shall Statement	Payload	PIH	Cryomagnet System	TRD	TRDGS	TOF	ACC	Tracker	RICH	ECAL	Avionics	TCS	TTCS	Star Trackers	GPS
I-49	SSP 57003	3.2.2.1.2.1	Ripple Voltage and Noise	The AP connected to the Interface C shall operate and be compatible with the EPS time domain ripple voltage and noise level of 2.5 volts root-mean-square maximum from 30 Hz to 10 kHz.	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
I-50	SSP 57003	3.2.2.1.2.2	Ripple Voltage Spectrum	The AP connected to Interface C shall be compatible with the EPS spectrum shown in Figure 3.2.2.1.2.2-1.	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
I-51	SSP 57003	3.2.2.1.3.1	Normal Transient Voltages	The AP connected to Interface C shall operate and be compatible with the limits and magnitude and duration of the voltage transients as shown in Figure 3.2.2.1.3.1-1.	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
I-52	SSP 57003	3.2.2.1.3.2	Fault Clearing and Protection	The AP connected to Interface C shall be safe and not suffer damage with the transient voltage conditions that are within the limits shown in Figure 3.2.2.1.3.2-1.	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
I-53	SSP 57003	3.2.2.1.3.3A	Interface C Non-Normal Voltage Range - Overvoltage	The AP connected to Interface C shall not produce an unsafe condition or one that could result in damage to ISS equipment with a maximum overvoltage to 165 VDC for up to 10 seconds.	A														
I-54	SSP 57003	3.2.2.1.3.3B	Interface C Non-Normal Voltage Range - Undervoltage	The AP connected to Interface C shall not produce an unsafe condition or one that could result in damage to ISS equipment with a minimum undervoltage of 102 VDC.	A														
I-55	SSP 57003	3.2.2.2.1A	Attached Payload Connectors and Pin Assignments - Connector	APs shall utilize the passive UMA connector P/N NUR1-005 and shall meet the requirements of this connector as defined in SSQ 21637 or equivalent.	A	A													
I-56	SSP 57003	3.2.2.2.1B	Attached payload Connectors and Pin Assignments - Pin Assignments	APs shall meet pin assignments and avionics interface terminations as specified in the unique payload ICD per SSP 57004. para. 3.2.1 in order to mate with the UMA connector.	A	A													
I-57	SSP 57003	3.2.2.2.2A	Power Bus Isolation – Independent Feeds	APs requiring power from 2 independent ISS power feeds shall provide a minimum of 1MΩ isolation in parallel with not more than 0.03 microfarads of mutual capacitance between the two independent power feeds including supply and return lines within the AP at all times such that no single failure shall cause the independent power feeds to be electrically tied.	A	A	A								A				
I-58	SSP 57003	3.2.2.2.2B	Power Bus Isolation – Diodes	The AP shall not use diodes to electrically tie together independent ISS power bus high side or return lines.	A		A								A				
I-59	SSP 57003	3.3.2.2.3	Compatibility with Soft Start/Stop Remote Power Controller	The AP connected to Interface C shall initialize with a soft start/stop performance characteristics when power is applied, sustained, and removed by control of remote power control switches.	A										A				
I-60	SSP 57003	3.2.2.2.4A	Surge Current – Amplitude	The amplitude shall not exceed the values defined in Figure 3.2.2.2.4-1.	A										A				
I-61	SSP 57003	3.2.2.2.4B	Surge Current – Rate of Change	The rate of current change shall not exceed the values defined in figure 3.2.2.2.4-2.	A										A				
I-62	SSP 57003	3.2.2.2.5.1	Reverse Current Limits	The AP shall limit reverse current transients that can occur when a hard fault occurs across the power source within the transient envelope defined for 25A curves shown in Figures 3.2.2.2.5.1-1, -2, and -3.	A										A				
I-63	SSP 57003	3.2.2.2.5.2	Transients Partially Contained within the Envelope	If the reverse current exceeds the envelope limits defined in paragraph 3.2.2.5.1 for one of more short time intervals, the transient peak current and the ratio of the times of intersection with the envelope shall satisfy the following inequality $(\frac{i_{pk}}{i_e})^2 \bullet \ln(\frac{t_2}{t_1}) \leq 1$ Where l_n represents the natural logarithm, t_1 and t_2 correspond to the beginning and end times, respectively, of each interval when the transient is outside the envelop, i_{pk} is the peak of the transient occurring between t_2 and t_1, and i_e is the point on the envelope at the time of the peak i_{pk}. For multiple intervals in which the envelope is exceeded, the left-hand side of this expression will be evaluated for each interval and the sum of all such results will total less than unity.	A										A				
I-64	SSP 57003	3.2.2.2.6.1A	ISS EPS Circuit Protection Characteristics – RPC	AP connected to the Interface C electrical interface shall operate and be compatible with the characteristics of the RPCs in Figure 3.2.5-1 as specified in SSP 57004 para. 3.2.5.	A										A				
I-65	SSP 57003	3.2.2.2.6.1B	ISS EPS Circuit Protection Characteristics – Overcurrent Protection	Overcurrent protection shall be provided at all points in the system where power is distributed to the lower level (wire size not protected by upstream protection devices) feeder and branch lines	A										A				
I-66	SSP 57003	3.2.2.2.6.2	Attached Payload Trip Ratings	The AP connected to interface C circuit protection device shall be designed to provide trip coordination as defined in par. 3.2.2.2.6.1.A	A										A				

Rqmt No.	Document	Paragraph	Requirement Title	Shall Statement	Payload	PIH	Cryomagnet System	TRD	TRDGS	TOF	ACC	Tracker	RICH	ECAL	Avionics	TCS	TTCS	Star Trackers	GPS
I-67	SSP 57003	3.2.2.2.7	Interface C Attached Payload Complex Load Impedances	The load impedance presented by the attached payload to Interface C shall not exceed the bounds defined by Figures 3.2.2.2.7-1 and 3.2.2.2.7-2 for input over the frequency range of 50Hz to 100 kHz.	A										A				
I-68	SSP 57003	3.2.2.2.8	Large Signal Stability	The AP connected to Interface C shall maintain the stability with the EPS interface by damping a transient response to 10% of the maximum response within 1.0 milliseconds and remaining 10% thereafter when the rise time/fall time (between 10 and 90% amplitude) of the input voltage is less than 10 microseconds and the voltage pulse is varied from 100 to 150 microseconds in duration.	A										A				
I-69	SSP 57003	3.2.2.3.1	Wire Derating	Derating criteria for loads and downstream of AP PI shall be per TM 102179 as interpreted by TA-92-038.	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
I-70	SSP 57003	3.2.2.3.2	Exclusive Power Feeds	AP shall utilize feeds dedicated to a specific S3/P3 attach site location only.	A														
I-71	SSP 57003	3.2.2.3.3	Loss of Power	Payloads shall fail safe in the event of a total or partial loss of power in accordance with NSTS 1700.7B ISS Addendum.	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
I-72	SSP 57003	3.2.2.4	EMC	The AP connected to Interface C shall meet the EMC requirements of SSP 30243, paragraphs 3.1 and 3.6.2.	A														
I-73	SSP 57003	3.2.2.4.1	Electrical Grounding	The AP connected to Interface C shall meet all requirements specified in SSP 30240.															
I-74	SSP 57003	3.2.2.4.2	Electrical Bonding	Electrical bonding of the AP connected to Interface e C shall be in accordance with SSP 30245 and NSTS 1700.7B, ISS Addendum paras. 213 and 220. Electrical bonding of the AP shall include providing a Class R bond at the attached payload guide pin interface with the guide vane assembly at the final berthed position, for the fully mated, preloaded and deflected system.															
I-75	SSP 57003	3.2.2.4.3	Cable/Wire Design and Control Requirements	Cabling between payload electrical power consuming equipment and Interface C shall meet all cable and wire design requirements of SSP 30242.															
I-76	SSP 57003	3.2.2.4.4	EMI	APs shall meet all EMI requirements of SSP 30237.															
I-77	SSP 57003	3.2.2.4.5B	ESD – Labeling	AP EPCE that may be damaged by ESD between 4 and 15 kV shall have a label affixed to the case in the location clearly visible in the installed position. Labeling of AP EPCE to ESD up to 15k volts shall be in accordance with MIL-STD-1686.															
I-78	SSP 57003	3.2.2.4.6	AC Magnetic Fields	Payloads containing devices that intentionally generate magnetic fields (electromagnets) shall not generate AC magnetic fields that exceed the levels in the table below. The requirement applies at a distance of 7cm from a point on the enclosure of the AP or equipment case nearest the source of the field.															
I-79	SSP 57003	3.2.2.4.7	DC Magnetic Fields	Payloads containing devices that intentionally generate magnetic fields shall not generate DC magnetic fields that exceed 170 dB above a picotesla (dBpT). The requirement applies at a distance of 7cm from a point on the enclosure of the AP or equipment case nearest to source of the field.	E														
I-80	SSP 57003	3.2.2.4.8	Corona	AP electrical and electronic subsystems, equipment, and systems shall be designed to preclude damaging or destructive corona in its operating environment.															
I-81	SSP 57003	3.2.2.5.1	Payload Electrical Safety	The AP shall meet the electrical safety requirements defined in NSTS 1700.7B ISS addendum.	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
I-82	SSP 57003	3.2.2.5.1.1	Mating/Demating of powered connectors	Prior to mating/demating to/from PAS/UCCAS active half, the AP shall comply with requirements of letter MA2-99-170.	A	A													
I-83	SSP 57003	3.3.1	C&DH Interface with Mobile Servicing System	The AP requiring C&DH services while positioned on the MCAS shall be designed to interface with the MCAS active UMA to transmit and receive data from the ISS during MBS operations in accordance with SSP 42004, para B3.2.2.6.	A														

Rqmt No.	Document	Paragraph	Requirement Title	Shall Statement	Payload	PIH	Cryomagnet System	TRD	TRDGS	TOF	ACC	Tracker	RICH	ECAL	Avionics	TCS	TTCS	Star Trackers	GPS
I-84	SSP 57003	3.3.2.1.1	Word/Byte Notations	The AP connected to the S3 or P3 LRDL or HRDL shall use the word/byte notations as specified in SSP 52050, part 1, para. 3.1.1.	A										A				
I-85	SSP 57003	3.3.2.1.2	Data Types	The AP connected to the S3 or the P3 LRDL or HRDL shall use the data types as specified in SSP 52050, para. 3.2.1, or D684-10056-01, Appendix J.	A										A				
I-86	SSP 57003	3.3.2.1.3A	Data Transmissions – LRDL	The AP data transmitting data on the LRDL, MIL-STD-1553 bus shall use the data transmission order in accordance with D684-10056-01, paragraph 3.4.	A										A				
I-87	SSP 57003	3.3.2.1.3B	Data Transmissions – HRDL	The AP data transmitting data on the HRDL shall use the data transmission order in accordance with CCSDS 701.0-B-2, para. 1.6.	A										A				
I-88	SSP 57003	3.3.2.2.1A	Consultative Committee for Space Data Systems Data Ku-Band	AP data that is to be sent to the ground via the Ku-band shall be CCSDS data packets.	A										A				
I-89	SSP 57003	3.3.2.2.1B	Consultative Committee for Space Data Systems – Data	The AP who have data that is transmitted ground to space or from the S3/P3 attach sites to the payload MDM shall utilize CCSDS data packets.	A										A				
I-90	SSP 57003	3.3.2.2.1.1	Consultative Committee for Space Data Systems Data Packets	The AP shall develop data packets in accordance with SSP 52050, para. 3.1.3.	A										A				
I-91	SSP 57003	3.3.2.2.1.1.1	Consultative Committee for Space Data Packet Data Systems Primary Header	The attached payload shall develop a CCSDS primary header in accordance with SSP 52050 , para 3.1.3.1.	A										A				
I-92	SSP 57003	3.3.2.2.1.1.2A	Consultative Committee for Space data Systems Data Secondary Header	The AP shall develop a CCSDS secondary header immediately following the CCSDS primary header.	A										A				
I-93	SSP 57003	3.3.2.2.1.1.2B	Consultative Committee for Space data Systems Data Secondary Header	The AP secondary header shall develop in accordance with SSP 52050, para 3.1.3.2 as tailored in Appendix D of SSP 52050.	A										A				
I-94	SSP 57003	3.3.2.2.1.2	Consultative Committee for Space Data Systems Data Field	The AP CCSDS data field shall contain the AP data from the transmitting data application to the receiving application and the CCSDS checksum in accordance with SSP 52050, para 3.1.	A										A				
I-95	SSP 57003	3.3.2.2.2.1	Consultative Committee for Space Data Systems Unsegmented Time	The AP shall use the CCSDS Unsegmented time code (CUC) in the secondary header as specified in CCSDS 301.0-B-2, para. 2.2.	A										A				
I-96	SSP 57003	3.3.2.3A	MIL-STD-1553 Low Data Rate Link – Single RT	The AP shall implement a single MIL-STD-1553 RT to the payload unique MIL-STD-1553 bus.	A										A				
I-97	SSP 57003	3.3.2.3B	MIL-STD-1553 Low Data Rate Link – Address	AP MIL-STD-1553 RT bus addresses shall be in accordance with SSP 50193, Book 1.	A										A				
I-98	SSP 57003	3.3.2.3.1	MIL-STD-1553 Protocol	AP bus interface shall use MIL-STD-1553B for electrical characteristics and protocol.	A										A				
I-99	SSP 57003	3.3.2.3.1.1A	Standard Messages	The AP shall develop standard messages for the Payload MIL-STD-1553 in accordance with SSP 52050, para. 3.2.3.3.	A										A				
I-100	SSP 57003	3.3.2.3.1.1B	Standard Messages – Subaddresses	MIL-STD-1553 subaddress assignment for standard messages shall be per SSP 52050, Table 3.2.3.2.1.4-1.	A										A				
I-101	SSP 57003	3.3.2.3.1.2A	Commanding	The AP shall receive and process commands from the payload MDM that originate from the ground, timeline, payload MDM and PCS inn accordance with SSP 52050, para 3.2.3.4.	A										A				
I-102	SSP 57003	3.3.2.3.1.2B	Commanding – Subaddresses	MIL-STD-1553 subaddress assignments for commands shall be per SSP 52050, Table 3.2.3.21.4-1.	A										A				
I-103	SSP 57003	3.3.2.3.1.3A	Heath and Status Data	The AP shall develop heath and status data in accordance with SSP 52050, para. 3.2.3.5.	A										A				
I-104	SSP 57003	3.3.2.3.1.3B	Heath and Status Data – Format	The heath and status data field format shall be developed in accordance with the data field format defined in SSP 57002, Table A-5.	A										A				
I-105	SSP 57003	3.3.2.3.1.3C	Heath and Status Data – Response	The AP shall respond to the payload MDM polls to health status with updated data at a predefined rate of 1Hz or 0.1Hz.	A										A				

Rqmt No.	Document	Paragraph	Requirement Title	Shall Statement	Payload	PIH	Cryomagnet System	TRD	TRDGS	TOF	ACC	Tracker	RICH	ECAL	Avionics	TCS	TTCS	Star Trackers	GPS
I-106	SSP 57003	3.3.2.3.1.5	Service Requests	The AP shall develop service requests in accordance with SSP 52050, para 3.2.3.7. The service request data format shall be developed in accordance with SSP 52050, table 3.2.3.7-1.	A										A				
I-107	SSP 57003	3.3.2.3.1.7	File Transfer	The AP requiring file transfers shall perform file transfers in accordance with SSP 52050, para 3.2.3.9.	A										A				
I-108	SSP 57003	3.3.2.3.1.8	Low Rate Telemetry	The AP requiring low rate telemetry shall develop low rate telemetry in accordance with SSP 52050, para. 3.2.3.10.	A										A				
I-109	SSP 57003	3.3.2.3.1.10	Implemented Mode Codes	The attached payload shall implement MIL-STD-1553 mode codes in accordance with SSP 52050, para 3.2.3.2.1.5 and Table 3.2.3.2.1.5-1.	A										A				
I-110	SSP 57003	3.3.2.3.1.11	Illegal Commands	If an illegal command occurs from MIL-STD-1553, the AP shall be respond to such illegal commands by setting a message error bit in the RT status word.	A										A				
I-111	SSP 57003	3.3.2.3.2.1	LRDL Connector Pin Assignments	The AP that interfaces with MIL-STD-1553 bus to transmit data and/or receive commands shall utilize the connector and pins assignments for the UMA in accordance with SSP 57004, para 3.2.1.	A														
I-112	SSP 57003	3.3.2.3.2.2A	LRDL Signal Characteristics	The AP which requires connectivity to the payload MIL-STD-1553 bus shall meet the electrical characteristics in accordance with MIL-STD-1553.	A										A				
I-113	SSP 57003	3.3.2.3.2.2B	LRDL Signal Characteristics – Terminal	The AP MIL-STD-1553 bus shall meet the terminal characteristics in accordance with MIL STD-1553, para. 4.5.2.	A										A				
I-114	SSP 57003	3.3.2.3.2.3A	LRDL Cabling – Characteristics	The AP MIL-STD-1553 bus internal wiring characteristics of 75Ω or equivalent shall be in accordance with SSQ 21655 or equivalent.	A										A				
I-115	SSP 57003	3.3.2.3.2.3B	LRDL Cabling – Stub Length	The AP MIL-STD-1553 bus internal wiring stub length shall not exceed 10 feet when measured from the UMA active half connector to the AP/UCC MIL-STD-1553 RT.	A	A													
I-116	SSP 57003	3.3.2.4.1	Payload to High Rate Frame Multiplexer Protocols	HRDL stations that require the use of the HRFM through the USOS Ku-Band system shall operate under the downlink protocols.	A										A				
I-117	SSP 57003	3.3.2.4.1.1.1	CCSDS Packet Data Frames	The AP shall implement data frames in accordance with SSP 50184, Section 3.3.3.1.1.	A										A				
I-118	SSP 57003	3.3.2.4.1.1.2	CCSDS Packet Data Rates	The AP shall modulate the HRDL data rate by insertion of Sync symbols in the data stream. The number and distribution of Sync symbols shall be in accordance with SSP 50184, Section 3.3.3.1.2.	A										A				
I-119	SSP 57003	3.3.2.4.1.1.3	CCSDS Packet Format	The AP shall implement data packets in accordance with SSP 50184, Section 3.3.3.1.3.	A										A				
I-120	SSP 57003	3.3.2.4.1.2.1	Bitstream Data Frames	The AP shall transmit data on the HRDL network as bitstream data in accordance with SSP 50184, Section 3.3.3.2.1.	A										A				
I-121	SSP 57003	3.3.2.4.1.2.2	Bitstream Data Rates	The AP shall modulate the HRDL data rate by the insertion of Sync symbols in the data stream. The number and distribution of Sync symbols shall be in accordance with SSP 50184, Section 3.3.3.2.2.	A										A				
I-122	SSP 57003	3.3.2.4.2.1	HRDL Physical Signaling	Physical signaling of the HRDL shall be in accordance with SSP 50184, Section 3.1.	A										A				
I-123	SSP 57003	3.3.2.4.2.1.1A	Physical Signaling Data Rates	The AP shall assign its selectable data rate values between zero and 95 Mbps.	A										A				
I-124	SSP 57003	3.3.2.4.2.2	Encoding	The attached payload using the HRDL shall encode data in accordance with SSP 50184, Section 3.1.3.	A										A				
I-125	SSP 57003	3.3.2.4.3.1	HRDL Transmitted Optical Power	The AP that transmits data on the HRDL shall be designed to transmit a HRDL signal in accordance with SSP 50184, Section 3.1.1, at an average optical power greater than -15.6 dBm.	A										A				
I-126	SSP 57003	3.3.2.4.3.2	HRDL Received Optical Power	The AP that receives data on the HRDL shall be designed to receive a HRDL signal in accordance with SSP 50184, Section 3.1.2, at an average optical power greater than or equal to -31.6 dBm.	A										A				
I-127	SSP 57003	3.3.2.4.4	HRDL Fiber Optic Cable	The AP shall use fiber optic cable in accordance with SSQ 21654.	A	A									A				

Rqmt No.	Document	Paragraph	Requirement Title	Shall Statement	Payload	PIH	Cryomagnet System	TRD	TRDGS	TOF	ACC	Tracker	RICH	ECAL	Avionics	TCS	TTCS	Star Trackers	GPS
I-128	SSP 57003	3.3.2.4.5	HRDL Fiber Optic Cable Bend Radius	The AP shall develop the routing, installation, and handling procedures to assure the minimum bend radius of 2 inches or greater is maintained at all times for the fiber optic cable except where protected by a connector backshell.	A	A									A				
I-129	SSP 57003	3.3.2.4.6A	HRDL Connectors and Fiber	The AP interfacing to the HRDL shall utilize the UMA passive half connectors as defined in SSQ 21637.	A	A													
I-130	SSP 57003	3.3.2.4.6B	HRDL Connectors and Fiber	The AP HRDL Fiber shall meet the requirements of SSQ 21654 or equivalent.	A										A				
I-131	SSP 57003	3.3.2.4.7	HRDL Connector/Pin Assignments	The AP that interfaces with the HRDL shall utilize the connector and pins assignments for the UMA in accordance with SSP 57004, para 3.2.1.	A	A									A				
I-132	SSP 57003	3.3.2.5	Portable Computer System	AP who desire to utilize the PCS shall interface remotely through the MIL-STD-1553 in accordance with the requirements of SSP 57000, paras. 3.3.8.2/3.3.8.2.1.	A										A				
I-133	SSP 57003	3.4.1.1.1	Temperature Requirement	The AP to the S3 PAS and P3 UCCAS shall meet all requirements specified when the structural interface temperature is within -120 F and 200F.	A	A													
I-134	SSP 57003	3.4.2	Thermal Model Requirements	Simplified thermal models of the attached payloads shall be provided to the ISS program by the payload developer	A														
I-135	SSP 57003	3.4.3A	Thermal Exchange Between Payloads	Attached payload radiation surfaces (designed to reject heat) shall be oriented so that they have a cumulative view no greater than 0.1 to any surface of the generic attached payload operational envelop as defined in figure 3.1.3.1.1.1-1 placed on any other S3 or P3 attached site.	A											A	A		
I-136	SSP 57003	3.4.3B	Thermal Exchange Between Payloads	AP surfaces with a view of other attached payloads shall have a specularity of 10% or less	E	E										E	E		
I-137	SSP 57003	3.5.1.5.1	Molecular Column Density from Venting, Leakage, and Out-gassing	Contributions to the molecular column density created by an AP along any unobstructed line of sight shall not exceed 1*10^14 molecules/cm2 for any individual species, when viewed from any other attached payload location.	A		A	A	A							A	A		
I-138	SSP 57003	3.5.1.5.2A	Molecular Deposition from Materials Out-gassing and Venting – Other Attached Payloads	APs and their compliment materials exposed to space vacuum and vents shall not produce a cumulative contaminate deposit in excess of 1*10^-14 gm/cm2/sec on other APs using the nominal operating temperature of the contamination source materials and nominal operating temperatures of other APs.	A		A	A	A							A	A		
I-139	SSP 57003	3.5.1.5.2B	Molecular Deposition from Materials Out-gassing and Venting – ISS	APs and their compliment materials exposed to space vacuum and vents shall not produce contaminate deposit of $1X10^{-15}$ gm/cm2/sec on ISS elements using normal operating temperatures of the contamination source materials(emmitters) and normal operating temperatures of ISS external contamination sensitive surfaces (receivers). .	A		A	A	A							A	A		
I-140	SSP 57003	3.5.1.5.3	Particulates	APs shall limit any active venting release of particulates to less than 100 microns in size.	A		A	A	A										
I-141	SSP 57003	3.5.1.8.1	AP Contained or Generated Ionizing Radiation	AP containing or using radioactive materials or that generate ionizing radiation shall comply with NSTS 1700.7 ISS Addendum, para. 212.1.	A				A										
I-142	SSP 57003	3.5.1.8.2	Ionizing Radiation Dose	APs shall be designed to not produce an unsafe condition or one that could cause damage to external equipment as a result of exposure to a total dose specified in SSP 30512, para. 3.1.2.	A														
I-143	SSP 57003	3.5.1.8.3	Nominal Single Event Effects Ionizing Radiation	APs shall be designed to operate in and to not produce an unsafe condition or one that would cause damage to other equipment as a result of exposure to the radiation dose specified in SSP 30512. para. 3.2.1.	A														
I-144	SSP 57003	3.5.1.8.4	Extreme SEE	APs shall be designed to not produce an unsafe condition or one that would cause damage to external equipment as a result of extreme single event effect ionizing radiation assuming exposure levels specified in SSP 30512, para. 3.2.2.	A														
I-145	SSP 57003	3.5.1.12A	Acceleration Environment – CG Induced	AP/UCC shall meet structural integrity requirements in an on-orbit acceleration environment having peak transient accelerations of up to 0.2 g's, a vector acting in any direction.	A	A													
I-146	SSP 57003	3.5.1.12B	Acceleration Environment – Berthing	During payload installation, the AP/UCC shall meet the structural integrity requirements having peak transient accelerations of up to 0.4 g's, a vector quantity in any direction.	A	A													

Rqmt No.	Document	Paragraph	Requirement Title	Shall Statement	Payload	PIH	Cryomagnet System	TRD	TRDGS	TOF	ACC	Tracker	RICH	ECAL	Avionics	TCS	TTCS	Star Trackers	GPS
I-147	SSP 57003	3.5.1.13	Vibration Environment – Linear Peak Loads	AP components weighing less than 300 lbm shall be designed to withstand the on-orbit linear peak vibration levels specified in Figure 3.5.1.13-1.	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
I-148	SSP 57003	3.6.1	Materials Parts and Selection	Materials and processes used in the design and fabrication of the attached payload facility and associated support hardware shall comply with NSTS 1700.7, ISS Addendum	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
I-149	SSP 57003	3.6.1.1	Thermal Vacuum Stability	Non-metallic materials exposed to space vacuum shall have low out-gassing characteristics as defined by the total mass loss of less than 1.0% and a volatile condensable material of less that 0.1% when tested per ASTM -E595.	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
I-150	SSP 57003	3.6.3	Cleanliness	AP hardware external surfaces shall conform to Visibly Clean Standard specified in SN-C-0005.	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
I-151	SSP 57003	3.6.4	Atomic Oxygen Interaction	APs shall not utilize silver plated hardware.	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
I-152	SSP 57003	3.7.1A	Attached Payload Requiring Robotic Support – Impulse	An AP requiring SRMS support shall meet its performance requirements after an impulse as specified in NSTS 21000-IDD-ISS, para 14.4.1.6, for imparted impulse at the GF to payload interface.	A	A													
I-153	SSP 57003	3.7.1B	Attached Payload Requiring Robotic Support – Clearance Zone	An AP requiring SRMS support shall provide a clearance zone from the GF centerline in accordance with NSTS 21000-IDD-ISS, Figure 14.4.2.1-1.	A	A													
I-154	SSP 57003	3.7.1C	Attached Payload Requiring Robotic Support – Grapple Fixture	An AP requiring SRMS support shall accommodate the GF centerline in accordance with NSTS 21000-IDD-ISS, Figures 14.4.1.1.1-2 and 14.4.3.1-1.	A	A													
I-155	SSP 57003	3.7.1D	Attached Payload Requiring Robotic Support – GF Location	An AP requiring SRMS support shall locate the GF in the unique attached payload ICD.	A	A													
I-156	SSP 57003	3.7.1E	Attached Payload Requiring Robotic Support – Mass	An AP requiring SRMS support shall be within the certified mass handling capacity of the SRMS in accordance with the payload mass noted in NSTS 21000-IDD-ISS, para 14.1.5 and have the GF located in accordance with NSTS 21000-IDD-ISS, para 14.4.3, 2nd paragraph, where the GF centerline is in accordance with NSTS 21000-IDD-ISS, Figure 14.4.2.1-1.	A	A													
I-157	SSP 57003	3.7.1F	Attached Payload Requiring Robotic Support – Loads	An AP requiring SRMS support shall meet its performance requirements after being subjected to the load cases shown in NSTS 21000-IDD-ISS, paragraph 14.4.5.1, when torsion moments and bending moments are applied simultaneously.	A	A													
I-158	SSP 57003	3.7.1G	Attached Payload Requiring Robotic Support – Vibration Frequency	The vibration frequency of an AP requiring SRMS support shall be in accordance with NSTS-IDD-ISS, para 14.4.5.2.	A	A													
I-159	SSP 57003	3.7.1H	Attached Payload Requiring Robotic Support – Grounding	An AP requiring SRMS support shall electrical interface with the GFs ground strap whose length, gauge, and general outline are in accordance with NSTS 21000-IDD-ISS, para 14.4.6, Figue 14.4.6.1-1, and SSP 30245, sections 3.2.1.3, 3.3, and 4.0.	A	A													
I-160	SSP 57003	3.7.1I	Attached Payload Requiring Robotic Support – Thermal Isolation	An AP requiring SRMS support shall thermally interface with the GF in accordance with NSTS 21000-IDD-ISS, para 14.4.7, and shall maintain the GF temperature within the survival and operating temperature limits identified in NSTS 21000-IDD-ISS, para 14.4.7.	A	A										A			
I-161	SSP 57003	3.7.1J	Attached Payload Requiring Robotic Support – Scuff Plates	An AP requiring SRMS support shall provide scuff plates in accordance with NSTS 21000-IDD-ISS, figure 3.3.1.1.2.2.2-1.	A	A													
I-162	SSP 57003	3.7.1K	Attached Payload Requiring Robotic Support – Shielding	An AP requiring SRMS support shall shield critical and hazardous components from contact with other objects during robotic operations.	A	A													
I-163	SSP 57003	3.7.1L	Attached Payload Requiring Robotic Support – Contact Velocity	An AP requiring SRMS support and that is being robotically manipulated shall meet all its performance requirements after being subjected to 0.11 ft/s contact between it and another object.	A	A													
I-164	SSP 57003	3.7.1M	Attached Payload Requiring Robotic Support – Capture Envelope	An AP (requiring SRMS support) berthing mechanisms shall have a capture envelope larger than the SRMS placement accuracy specified in Table 3.7.1-1 when using just the SRMS.	A	A													
I-165	SSP 57003	3.7.1N	Attached Payload Requiring Robotic Support – Ready to Latch Indication	An AP requiring SRMS support shall provide ready to latch indication to positively indicate when the two pieces of equipment are place within the berthing mechanism's capture envelope.	A	A													
I-166	SSP 57003	3.7.2	Attached Payload Requiring Robotic Hand-off	An AP requiring robotic handoff shall be equipped with a minimum of one GF for each robot; the GF must meet the requirements of the robot using it.	A	A													

Rqmt No.	Document	Paragraph	Requirement Title	Shall Statement	Payload	PIH	Cryomagnet System	TRD	TRDGS	TOF	ACC	Tracker	RICH	ECAL	Avionics	TCS	TTCS	Star Trackers	GPS
I-167	SSP 57003	3.7.3A	Attached Payload Requiring SSRMS Support – LEE	An AP requiring SSRMS support shall Interface with the SSRMS LEE using a PDGF, PVGF, or a Shuttle GF that is compatible with SSRMS LEE as specified in SSP 42004, Table 1.4.1.2-1.	A	A													
I-168	SSP 57003	3.7.3B	Attached Payload Requiring SSRMS Support – Properties	An AP requiring SSRMS support shall be within the robotic properties of Table 3.7.3-1.	A	A													
I-169	SSP 57003	3.7.3C	Attached Payload Requiring SSRMS Support – Contact Conditions	An AP requiring SSRMS support shall meet its performance requirements after being subjected to the contact conditions specified in table 3.7.3-2, but is not required to capture during impact.	A	A													
I-170	SSP 57003	3.7.3D	Attached Payload Requiring SSRMS Support – Backdrive	An AP requiring SSRMS support and not using the SSRMS programmable force/moment accommodation capability, shall provide capture, berthing, and closure drive capability to overcome the back-drive thresholds (static friction) defined in Table 3.7.3-3 and complete the closure of the capture/berthing operation when the SSRMS is limp per Note 1 of the table.	A	A													
I-171	SSP 57003	3.7.3E	Attached Payload Requiring SSRMS Support – Ready to Latch	An AP requiring SSRMS support shall provide ready to latch indication to positively indicate when the 2 pieces of equipment are placed within the berthing mechanism's capture envelope.	A	A													
I-172	SSP 57003	3.7.3F	Attached Payload Requiring SSRMS Support – Scuff Plates	An AP requiring SSRMS support in the Shuttle cargo bay shall provide scuff plates in accordance with NSTS 21000-IDD-ISS, para 3.3.1.1.2.2.2 and Figure 3.3.1.1.2.2.2-1 to limit motion in the Orbiter port and starboard directions during berthing/unberthing from the Orbiter.	A	A													
I-173	SSP 57003	3.7.3G	Attached Payload Requiring SSRMS Support – Shielding	An AP requiring SSRMS support shall shield critical and hazardous components from contact with other objects during robotic operations.	A	A													
I-174	SSP 57003	3.7.3H	Attached Payload Requiring SSRMS Support – Contact with Equipment	An AP located within 2 feet of equipment that will be robotically manipulated shall meet all its performance requirements after being subjected to contact conditions specified in Table 3.7.3-2, where the contact is between it and equipment being robotically manipulated.	A														
I-175	SSP 57003	3.7.3I	Attached Payload Requiring SSRMS Support – SSRMS Limits	An AP requiring SSRMS support shall be designed such that its needs for the programmable back-drive after the initial contact are within the SSRMS programmable force/moment accommodation capability of Table 3.7.3-4, when the SSRMS elbow joint angle is not less that 60 degrees from the straight arm configuration and the maximum distance between the GF and berthing contact point is 14.76 ft(4.5m).	A	A													
I-176	SSP 57003	3.7.3J	Attached Payload Requiring SSRMS Support – Capture Envelope	An AP (requiring SSRMS support) berthing mechanisms shall have a capture envelope larger than the SSRMS placement accuracy specified in Table 3.7.1-1 when using just the SSRMS.	A	A													
I-177	SSP 57003	3.7.3K	Attached Payload Requiring SSRMS Support – Grapple Fixture	An AP requiring SSRMS support shall define the location of the GF in the unique attached payload hardware ICD.	A	A													
I-178	SSP 57003	3.7.3.1A	AP Requiring SSRMS Support using NSTS System Grapple Fixture	An Attached Payload requiring SSRMS support shall provide a clearance envelope around the GF as specified in SSP 42004, paragraph I3.2.2.1.	A	A													
I-179	SSP 57003	3.7.3.1B	AP Requiring SSRMS Support using NSTS System Grapple Fixture	An Attached Payload requiring SSRMS support shall provide a mechanical interface in accordance with SSP 42004, Section I3.2.2.2; and NSTS 21000−IDD−ISS, Figures 14.4.1.1.1−1 and 14.4.1.1.1−2.	A	A													
I-180	SSP 57003	3.7.3.1C	AP Requiring SSRMS Support using NSTS System Grapple Fixture	An Attached Payload requiring SSRMS support will be subject to the MBS POA and SSRMS tip loads as defined in NSTS 21000−IDD−ISS, Section 14.4.5.1.4.1.	A	A													
I-181	SSP 57003	3.7.3.1D	AP Requiring SSRMS Support using NSTS System Grapple Fixture	An Attached Payload requiring SSRMS support shall be subjected to an impulse as specified in SSP 42004, Section I3.2.2.3.1.	A	A													
I-182	SSP 57003	3.7.3.1E	AP Requiring SSRMS Support using NSTS System Grapple Fixture	The vibration frequency of an Attached Payload requiring SSRMS support shall be in accordance with SSP 42004, Section I3.2.2.3.2.	A														
I-183	SSP 57003	3.7.3.1F	AP Requiring SSRMS Support using NSTS System Grapple Fixture	An Attached Payload requiring SSRMS support shall provide thermal isolation between the payload and the GF by installing the thermal isolation washers and bushings provided with the GF in accordance with NSTS 21000−IDD−ISS, Figure 14.4.7.4−1.	A	A													
I-184	SSP 57003	3.7.3.1G	AP Requiring SSRMS Support using NSTS System Grapple Fixture	An Attached Payload requiring SSRMS support shall electrically interface with the GFs in accordance with SSP 42004, Section I3.2.2.5.1.	A	A													

Rqmt No.	Document	Paragraph	Requirement Title	Shall Statement	Payload	PIH	Cryomagnet System	TRD	TRDGS	TOF	ACC	Tracker	RICH	ECAL	Avionics	TCS	TTCS	Star Trackers	GPS
I-185	SSP 57003	3.7.3.3.1	AP Envelopes	An attached payload requiring SSRMS support shall provide a clearance envelope as specified in SSP 42004, para.N3.2.2.1.	E	E													
I-186	SSP 57003	3.7.3.3.2	AP Mechanical Interface	An AP requiring SSRMS support shall provide a mechanical interface in accordance with SSP 42004, section N3.2.2.2, and NSTS 21000 IDD-ISS Figures 14.4.1.1.4-1 and 14.4.3.1-3.	A	A													
I-187	SSP 57003	3.7.3.3.3	AP Structural Interface	The PVGF to AP interface shall meet all performance requirements while being subjected to the MBS POA and SSRMS Tip Loads as defined in SSP 42004, section N3.2.2.3.	A	A													
I-188	SSP 57003	3.7.3.3.3.1	Impact Loads	During capture of an AP by the SSRMS/SPDM or mating an AP on the POA, the impact load to the AP shall be as defined in SSP 42004, Figure N3.2.1.3.1-1.	A	A													
I-189	SSP 57003	3.7.3.3.3.2	AP Stiffness Requirements	The AP shall provide a stiffness at the interface that maintains a fundamental structural frequency as defined in SSP 42004, section N3.2.2.3.2, while constrained only at the interface.	A	A													
I-190	SSP 57003	3.7.3.3.4A	AP Electrical Interface Hardware	Users may terminate the pigtail wire end of the PVGF cable harness with a connector of their choice. The user shall not shorten the PVGF cable harness.	A	A													
I-191	SSP 57003	3.7.3.3.4B	AP Electrical Interface Hardware	The PVGF cable harness shall be secured to the payload within 6.0 inches of the cable harness exit bracket. The user shall be responsible for routing and securing the harness to ensure it is outside of the SSRMS and EVA clearance zone specified in NSTS 21000-IDD-ISS.	E	E													
I-192	SSP 57003	3.7.3.3.4.1	Electrical Connectors	Electrical connectors shall be provided by the AP as specified in SSP 42004, para N3.2.2.4.1.	A	A													
I-193	SSP 57003	3.7.3.3.5	AP Power Interface	The user shall provide the capability to receive power through the PVGF1 and PVGF2 power circuits.	A	A													
I-194	SSP 57003	3.7.3.3.5.1	Power Quality	The interface power quality shall be in accordance with SSP 30482, Volumes 1 and 2, with the exception of the steady state voltage range as defined in Table N3.2.1.5.1-1.	A	A									A				
I-195	SSP 57003	3.7.3.3.5.2	Fault Protection	The AP shall be fault protected in accordance with SSP 42004, Table N3.2.1.5.1-1 as specified in SSP 42004, para N3.2.2.5.2.	A										A				
I-196	SSP 57003	3.7.3.3.5.3	Electrical Connector Dead-facing	The AP shall comply with the electrical connector deadfacing requirements as defined in SSP 42004, Figure N3.2.1.5.4-1 as specified in SSP 42004, para N3.2.2.5.4.	A										A				
I-197	SSP 57003	3.7.3.3.6	C&DH Interfaces	The AP shall provide a 1553 data bus interface from the PVGF harness as defined in SSP 42004, Figure N3.2.1.5-1 as specified in SSP 42004, section N3.2.2.6.	A	A									A				
I-198	SSP 57003	3.7.3.3.6.1A	MIL-STD-1553 Interfaces	The AP shall communicate over the MSS LB with the interface characteristics as specified in MIL-STD-1553.	A	A									A				
I-199	SSP 57003	3.7.3.3.6.1B	MIL-STD-1553 Interfaces	The AP harness shall receive the A and B channels of the MSS local bus stub through separate connectors.	A	A									A				
I-200	SSP 57003	3.7.3.3.6.1C	MIL-STD-1553 Interfaces	The AP shall de designed so as not to require data services during MT translation.	A										A				
I-201	SSP 57003	3.7.3.3.6.1D	MIL-STD-1553 Interfaces	The AP to RWS CEU data interfaces shall be defined in accordance with SSP 42004, Appendix A.	A										A				
I-202	SSP 57003	3.7.3.3.6.1.1B	Bus Termination	The AP shall provide terminations at both ends of the AP bus interface as defined in SSP 42004, Figures N3.2.2.6.1.1-1	A	A									A				
I-203	SSP 57003	3.7.3.3.6.1.2	MIL-STD-1553 Data Bus Addresses	The MIL-STD-1553 bus addresses for the AP RTs on both the MSS LB and PVGF LB shall be 2, 4, 7, and 21.	A										A				
I-204	SSP 57003	3.7.3.3.6.1.3	Provide Output Amplitude	The AP shall provide a signal amplitude of at least 3.6V, peak-to-peak, line-to-line at the PVGF interface.	A										A				
I-205	SSP 57003	3.7.3.3.7A	Sync, Control, and Video Interfaces	The AP shall receive Pulse Frequency Modulation (PFM) sync, control, and video interfaces from the PVGF harness as shown in SSP 42004, Figure N3.2.1.5-1.	A	A													
I-206	SSP 57003	3.7.3.3.7B	Sync, Control, and Video Interfaces	The AP shall receive copper lines from the PVGF harness.	A	A													

Rqmt No.	Document	Paragraph	Requirement Title	Shall Statement	Payload	PIH	Cryomagnet System	TRD	TRDGS	TOF	ACC	Tracker	RICH	ECAL	Avionics	TCS	TTCS	Star Trackers	GPS
I-207	SSP 57003	3.7.3.3.7.1	Video, Sync, and Control Transmission and Signal Characteristics	The video, sync, and control signals shall be transmitted between the PVGF and the AP in accordance with SSP 50002, section 4.2.1.5.4.	A	A													
I-208	SSP 57003	3.7.3.3.7.2A	Sync and Video Power Levels	The AP shall be capable of receiving from the SSRMS Tip LEE a minimum of -4 dBm and a maximum of +9 dBm PFM sync signal via the AP PVGF.	A	A													
I-209	SSP 57003	3.7.3.3.7.2B	Sync and Video Power Levels	The AP shall be capable of transmitting to the SSRMS Tip LEE a minimum of -4 dBm and maximum of +9 dBm PFM video signal via the AP PVGF.	A	A													
I-210	SSP 57003	3.7.3.3.7.2C	Sync and Video Power Levels	The payload camera commands carried by the PFM sync and control signals and the telemetry carried by the video signal shall meet the requirements as defined in SSP 50002, Section 4.2.1.3.2.	A	A													
I-211	SSP 57003	3.7.3.3.7.2D	Sync and Video Power Levels	The PFM sync and control signals received by the AP shall meet the video quality requirements defined in SSP 50002 section 4.2.1.5.4.	A	A													
I-212	SSP 57003	3.7.3.3.8A	Passive Thermal Interface	During non-operating periods for the PVGF, the AP shall be capable of maintaining the PVGF within its non-operational limits of -157 deg C to +121 deg C.	A	A									A	A			
I-213	SSP 57003	3.7.3.3.8B	Passive Thermal Interface	During PVGF operations, the AP shall be capable of maintaining the PVGF within its operational limits of -70 deg C to +90 deg C,	A	A									A	A			
I-214	SSP 57003	3.7.3.3.8C	Passive Thermal Interface	The thermal conductance from the AP to the PVGF will be 2.0W/K maximum.	A	A													
I-215	SSP 57003	3.7.3.3.9.1	Electromagnetic Compatibility	The PVGF to AP interface shall meet the requirements of SSP 30243, para 3.1 and 3.6.2.	A	A									A				
I-216	SSP 57003	3.7.3.3.9.2	Grounding	The PVGF to AP interface shall meet the requirements of SSP 30240.	A	A													
I-217	SSP 57003	3.7.3.3.9.3A	Bonding	The PVGF to AP structural/mechanical interface shall meet the requirements of SSP 30245.	A	A													
I-218	SSP 57003	3.7.3.3.9.3B	Bonding	Bonding provisions at the interface between the PVGF pedestal and the AP structure, via the ground strap installation, shall satisfy a Class R bond in accordance with SSP 30245.	A	A													
I-219	SSP 57003	3.7.3.3.9.4	Cable and Wire Design	The PVGF to AP cable and wire interface shall meet the requirements of SSP 30242.	A	A									A				
I-220	SSP 57003	3.7.3.3.9.4A	Cable and Wire Design	The ground wire on both power channels shall be terminated to the AP structure and tested for a Class H electrical bond.	A	A													
I-221	SSP 57003	3.7.3.3.9.4B	Cable and Wire Design	The video and data bus shields shall be terminated to the AP supplied connectors via the connector backshell and shall satisfy a Class R bond. The electrical connector backshells shall be electrically bonded to the structure by a Class S bond.	A	A													
I-122	SSP 57003	3.7.3.3.9.4C	Cable and Wire Design	The prime and redundant SSRMS ground wires shall be terminated to the AP structure and shall satisfy a Class H electrical bond.	A	A													
I-223	SSP 57003	3.7.3.3.9.5	Electrostatic Discharge	The PVGF to AP interface shall meet the requirements of SSP 30243.	A	A													
I-224	SSP 57003	3.7.3.3.9.6	Corona	The PVGF to AP interface shall meet the requirements of SSP 30243.	A	A													
I-225	SSP 57003	3.7.6.1A	EBCS Avionics Package Envelope and Mounting – Operation Envelope and Optical Keep-out Zone	The payload developer shall accommodate the operational envelope, roll adjustments, and optical keep-out zone for the EBCS Avionics Package as defined in Figures 3.7.6.1-1/2.	E	E													
I-226	SSP 57003	3.7.6.1B	EBCS Avionics Package Envelope and Mounting - Location	The payload shall locate the EBCS Avionics package as defined in SSP 57004, figure 3.7.1-1 with an error of -+ 0.125", -+ 0.25", and 0.2" about the X/YZ axis and lateral offset (X-y plane about the Z axis (alpha-a) of L/0.182+a/0.4"=1.	E	E													
I-227	SSP 57003	3.7.6.1C	EBCS Avionics Package Envelope and Mounting - Maintain Location	The payload shall maintain the location of the EBCS avionics package mounting surface as specified in B above after exposure to vibration and impact loads and during exposure to the on-orbit thermal environment conditions specific herein.	E	E													
I-228	SSP 57003	3.7.6.2A	EBCS Avionics Package Power – Cable Routing and Connections	The payload shall route the PVGF cable to the EBCS Avionics Package and provide connections as indicated in SSP 57004, Figure 3.7.2-1.	A	A													

Rqmt No.	Document	Paragraph	Requirement Title	Shall Statement	Payload	PIH	Cryomagnet System	TRD	TRDGS	TOF	ACC	Tracker	RICH	ECAL	Avionics	TCS	TTCS	Star Trackers	GPS
I-229	SSP 57003	3.7.6.2B	EBCS Avionics Package Power – Heater Power	The payload shall provide 2 heater buses, each capable of delivering 25W to the Avionics Package for keep-alive heater power.	A	A									A	A			
I-230	SSP 57003	3.7.6.3A	EBCS Thermal Requirement - Non-Operational On-Orbit	Attached Payloads shall be designed to ensure that the EBCS avionics package operational and non-operational thermal limits, as defined in Table 3.7.6.3-1, are not violated during any phase of nominal ground, transport or on-orbit operations.	A	A										A			
I-231	SSP 57003	3.7.6.4	EBCS Vibration Environment	The payload shall not exceed the vibration limits in Table 3.7.6.4-1.	A	A													
I-232	SSP 57003	3.7.6.5	EBCS Avionics Package Video	The payload shall route the PVGF cable to the EBCS Avionics package and provide connections as indicated in SSP 57004, Figure 3.7.2-1.	A	A													
I-233	SSP 57003	3.9.1.3B	Access – ORU Removal	Access to inspect or replace an item (i.e. a payload remove/replace item) shall not require removal of another ORU or more than one access cover.	A	A													
I-234	SSP 57003	3.9.1.3C	Access – SSP 50005	Attached payload shall provide EVA access for attached payload remove and replace items in accordance with SSP 50005, para 14.3.2.3.1 and 14.4.3.	A	A													
I-235	SSP 57003	3.9.1.6.7.1	ORU CLA and Umbilical Mechanism Assembly EVA Overrides	The attached payload shall provide EVA access for the CLA and UMA override.	A	A													
I-236	SSP 57003	3.9.1.6.7.2	PAS & UCCAS ORU EVA Maintenance	The payload shall provide EVA access for PAS and UCCAS ORU (CLA, UMA, and guide vane) maintenance per SSP 50005, paras. 14.3.2.3.1 and 14.4.3.	A	A													
I-237	SSP 57003	3.10A	Nameplates and Product Marking	AP elements, loose equipment, consumables, payload remove/replace items, crew accessible connectors and cables, switches, indicators, and controls shall be labeled.	A	A													
I-238	SSP 57003	3.10B	Nameplates and Product Marking – Structural Integrity	Marking techniques shall not degrade the structural integrity of the equipment.	A	A													
I-239	SSP 57003	3.11.1.1	EVA Translation Path Interference	Payloads shall not interfere with the established primary and secondary translation paths in SSP 30256:001, Section 3.9.	A	A													
I-240	SSP 57003	3.11.1.2	EVA Operations Access Corridor	APs shall not interfere with the EVA operations access corridor for the mobility and translation part (CETA cart) per SSP 41162, para 3.3.6.12.10.	A														
I-241	SSP 57003	3.11.1.3	Payload Translation Paths	The payload shall supply EVA translation paths on the payload from the ISS established EVA translation path to the payload EVA worksites, with gaps in the path not to exceed 24 inches measured in accordance with Figure 3.11.1.3-1.	A	A													
I-242	SSP 57003	3.11.1.3.1	Translation Path Diameter	External translation paths shall be a minimum of 43 inches in diameter with no protrusions.	A	A													
I-243	SSP 57003	3.11.1.3.2	Translation Path Direction Change Angles	Translation paths with direction change angles greater than 30 degrees shall have a minimum diameter at the change point of 74 inches.	A	A													
I-244	SSP 57003	3.11.1.3.3	Tethered Two-Handed Translation	All EVA translation paths shall support a tethered, two-handed EVA translation of crew and equipment.	A	A													
I-245	SSP 57003	3.11.1.3.4	Tethered Attachment Points	The AP shall provide crew safety tether points along translation routes established on the payload per para 3.11.3.8.	A	A													
I-246	SSP 57003	3.11.2	EVA Worksites	The payload shall establish external EVA worksites on the payload as required to support external operations tasks for the control, tethering, and restraint of the crew and hardware.	A	A													
I-247	SSP 57003	3.11.2.1	External Task Location Requirements	All tasks to be performed by a crewmember wearing a pressurized suit at a dedicated worksite or a robotic assisted worksite shall be located per Figure 3.11-1.	A	A													
I-248	SSP 57003	3.11.2.2	EVA Crewmember Field of View	Payload equipment, controls, displays, and markings required to be seen to perform EVA tasks shall be located within the field of view of the EMU as shown in Figure 3.11.2.2-1.	A	A													
I-249	SSP 57003	3.11.2.3	Working Volume	Payload equipment to be EVA manipulated shall be located to provide the crewmember with the working volume as shown in Figure 3.11.2.3-1.	A	A													
I-250	SSP 57003	3.11.2.3.1	Working Volume Height	The working volume envelope height shall be 82 inches or 2.1 meters.	A	A													

Rqmt No.	Document	Paragraph	Requirement Title	Shall Statement	Payload	PIH	Cryomagnet System	TRD	TRDGS	TOF	ACC	Tracker	RICH	ECAL	Avionics	TCS	TTCS	Star Trackers	GPS
I-251	SSP 57003	3.11.2.4	Gloved Operation	For payload operations requiring EVA crewmember hand actuation, clearance shall be provided for an EVA gloved hand work envelope in accordance with Figure 3.11.2.4-1.	A	A													
I-252	SSP 57003	3.11.2.5.1	Criteria for Dedicated EVA Worksites	APs shall establish dedicated EVA worksites at locations where any of the conditions listed in the paragraph apply and robotic crew transport and restraint capability cannot be used due to kinematic or reach limitations.	A	A													
I-253	SSP 57003	3.11.2.5.2.1	Translation Paths to the Worksite	APs shall provide translation paths to the dedicated EVA worksites.	A	A													
I-254	SSP 57003	3.11.2.5.2.2	Foot Restraint Interfaces at the Worksite	APs shall mount WIF sockets per section 3.11.3.3 for utilization of the APFR at the dedicated EVA worksites.	A	A													
I-255	SSP 57003	3.11.2.5.2.3	Translation Aids	APs shall provide the translation aids necessary to install, ingress, egress, and remove the APFR.	A	A													
I-256	SSP 57003	3.11.2.5.2.4	Dedicated EVA Worksite Tether Points	APs shall provide local crew and equipment tether points as specified in para 3.11.3.8.	A	A													
I-257	SSP 57003	3.11.2.5.2.5	Dedicated EVA Worksite Restraints and Handling Aids	APs shall provide local restraints and handling aids as specified in paragraph 3.11.3.	A	A													
I-258	SSP 57003	3.11.2.6	Robotic Assisted EVA Worksites	Robotic assisted EVA worksites may be utilized when the crew transport and restraint capability is within the kinematic and reach envelope of the manipulator. If a robotic assisted worksite is utilized, the attached payload worksite location shall be within the kinematic and reach envelope of the manipulator utilized.	A	A													
I-259	SSP 57003	3.11.2.6.1.1	Robotic Assisted EVA Worksite Force Reaction Mechanism	EVA Worksites requiring crew positioning when the SSRMS or SRMS is stationary shall provide a force reaction mechanism independent of the robotic stabilization platform for EVA worksite operations requiring crew generated forces greater than 10 lbf.	A	A													
I-260	SSP 57003	3.11.2.6.1.2	Robotic Assisted Worksite Force Reaction Location	The force reaction mechanism shall be within 24 inches of the task site.	A	A													
I-261	SSP 57003	3.11.2.6.1.3	Robotic Assisted Worksite Tether Points	APs shall provide local crew and equipment tether points as specified in paragraph 3.11.3.8.	A	A													
I-262	SSP 57003	3.11.2.7.1.1	Translation Paths to the Free-Float Worksite	APs shall provide translation paths to the free-floating EVA worksite.	A	A													
I-263	SSP 57003	3.11.2.7.1.2	Free-Float EVA Worksite Tether Points	APs shall provide local crew and equipment tether points as specified in paragraph 3.11.3.8.	A	A													
I-264	SSP 57003	3.11.2.7.1.3	Free-Float EVA Worksite Restraints and Handling Aids	APs shall provide local restraints and handling aids as specified in para 3.11.3.	A	A													
I-265	SSP 57003	3.11.2.8	EVA Actuation Loads	External components of AP hardware which will have a crew or crew attached tool interface shall be operable by the loads defined in Table 3.11.2.8-1.	A	A													
I-266	SSP 57003	3.11.3.1.1	Translation Handhold/Handrail Locations	Handholds/handrails shall be located at terminal points and direction change points on established crew translation paths.	A	A													
I-267	SSP 57003	3.11.3.1.2	Translation Handhold/Handrail Orientation	Handholds/handrails to be used for translation paths shall be oriented such that the plane formed by the handhold longitudinal axis and the cross-section major axis is parallel with the body torso frontal plane.	A	A													
I-268	SSP 57003	3.11.3.1.3	Equipment Accessibility	Translation and mobility handholds/handrails shall be positioned such that crew-operated equipment and consoles are accessible and are not obstructed visually or physically by the handholds.	A	A													
I-269	SSP 57003	3.11.3.1.4	EVA Handhold/Handrail Dimensions	EVA handhold and handrail dimensions shall conform to Figure 3.11.3.1.4-1.	A	A													
I-270	SSP 57003	3.11.3.1.4.1	EVA Handhold/Handrail Clearance	The minimum clearance distance between the low surface of the handrail/handhold and the mounting surface shall be 5.7 cm.	A	A													
I-271	SSP 57003	3.11.3.1.4.2	Handhold/Handrail Grip Length	The minimum grip length for handholds/handrails shall be 15.24 cm.	A	A													

Rqmt No.	Document	Paragraph	Requirement Title	Shall Statement	Payload	PIH	Cryomagnet System	TRD	TRDGS	TOF	ACC	Tracker	RICH	ECAL	Avionics	TCS	TTCS	Star Trackers	GPS
I-272	SSP 57003	3.11.3.1.4.3	EVA Handhold/Handrail Clearance Envelope	A 4-inch radial clearance envelope shall exist around each of the handhold/handrails as shown in Figure 3.11.3.1.4.3-1.	A	A													
I-273	SSP 57003	3.11.3.1.5A	Handhold/Handrail Color and Structural Loading	EVA handhold/handrails for translation, mobility, and safety tethering shall be yellow and meet the structural requirements defined in SSP 30256:001 paras 3.6.1.3.1 and 3.6.5.3.1.	A	A													
I-274	SSP 57003	3.11.3.1.5B	Handhold/Handrail Color and Structural Loading	EVA Handles that do not meet the loads of 3.11.3.1.5A shall be clear anodized and meet the loads defined in SSP 30256:001 para 3.6.2.	A	A													
I-275	SSP 57003	3.11.3.1.6	Handrail/Handhold Electrical Bonding	The handrail/handhold to AP interface shall satisfy a class S band per SSP 30245.	A	A													
I-276	SSP 57003	3.11.3.1.7.1	Spacing for Worksites – Above or Below	Crew mobility aids or grasp points shall be placed within 18 inches above or below the center of the crewmember's optimum two-handed work envelope as shown in Figure 3.11-1.	A	A													
I-277	SSP 57003	3.11.3.1.7.2	Spacing for Worksites – Left or Right	Crew mobility aids shall be placed within 24 inches to the left or right of the body centerline s shown in Figure 3.11-1.	A	A													
I-278	SSP 57003	3.11.3.1.7.3	APFR Installation Aids	Crew mobility aids shall be placed within 24 inches of the APFR interface for installation of the foot restraint.	A	A													
I-279	SSP 57003	3.11.3.1.7.4	APFR Ingress Aids	Crew mobility aids or grasp points shall be placed within 48 inches above the APFR interface.	A	A													
I-280	SSP 57003	3.11.3.2.1	EVA Handhold/Handrail Safety Tether Hooks	EVA handrails/handholds shall accommodate safety tether hooks.	A	A													
I-281	SSP 57003	3.11.3.2.2A	EVA Handhold/Handrail Safety Tether Point Color and Structural Loading	EVA handhold/handrail safety tether points shall be yellow and meet the structural requirements for safety tethering defined in SSP 30256:001 paras 3.6.1.3.1 and 3.6.5.3.1.	A	A													
I-282	SSP 57003	3.11.3.2.2B	EVA Handhold/Handrail Safety Tether Point Color and Structural Loading	EVA handle tether points that do not meet the loads of 3.11.3.2.2A shall be clear anodized and meet the loads defined in SSP 30256:001 para 3.6.2.	A	A													
I-283	SSP 57003	3.11.3.2.3	EVA Handrail/hold Tether Point Dimensions	The EVA handrail/handhold tether point shall be designed as shown in Figure 3.11.3.2.3-1.	A	A													
I-284	SSP 57003	3.11.3.2.4	EVA Equipment Tether Attachment Points	All equipment items shall provide a standardized tether hook receptacle as shown in Figure 3.11.3.2.4-1.	A	A													
I-285	SSP 57003	3.11.3.2.5	EVA Standardized Tether Receptacle	The standardized receptacle shown in Figure 3.11.3.2.4-1 shall also be provided on the interfacing surface to which the item is to be secured.	A	A													
I-286	SSP 57003	3.11.3.3.1	Worksite Interface EVA Clearance	EVA clearance envelopes per Figures 3.11.3.3.1-1, 3.11.3.3.1-2, and 3.11.3.3.1-3 shall be free from obstruction to allow for installation and removal of EVA hardware outfitted with an active WIF.	A	A													
I-287	SSP 57003	3.11.3.3.2	Worksite Interface Structural Loading	Payloads hardware shall meet the loading requirements at the WIF to structure interface as described in SSP 30256:001 para 3.6.4.3.2.	A	A													
I-288	SSP 57003	3.11.4.1.1	One-Handed Operation	All connectors, whether operated by hand or tool, shall be designed so they can be mated/demated using one hand, either right or left hand.	A	A													
I-289	SSP 57003	3.11.4.1.2	Accessibility	It shall be possible to mate/demate or replace individual connectors without having to remove or replace other connectors.	A	A													
I-290	SSP 57003	3.11.4.1.4.1	Ease of Disconnect	Electrical connector plugs shall require no more than one turn to disconnect.	A	A													
I-291	SSP 57003	3.11.4.1.4.2	Self-Locking	Electrical connector plugs shall provide a self-locking safety catch.	A	A													
I-292	SSP 57003	3.11.4.1.4.3	Access	Electrical connectors and cable installations shall permit disconnection and reconnection without damage to wiring or connectors.	A	A													
I-293	SSP 57003	3.11.4.1.4.4	Arc Containment	Electrical connector plugs shall be designed to confine/isolate the mate/demate electrical arcs or sparks.	A	A													
I-294	SSP 57003	3.11.4.1.4.5	Scoop Proof	All connectors shall be scoop proof.	A	A													

Rqmt No.	Document	Paragraph	Requirement Title	Shall Statement	Payload	PIH	Cryomagnet System	TRD	TRDGS	TOF	ACC	Tracker	RICH	ECAL	Avionics	TCS	TTCS	Star Trackers	GPS
I-295	SSP 57003	3.11.4.1.4.6	Electrical Hazards	All electrical connectors shall have provisions for alignment and mating of connector shells prior to electrical path completion.	A	A													
I-296	SSP 57003	3.11.4.1.5.1	Alignment Provisions	All structural connectors shall incorporate alignment features.	A	A													
I-297	SSP 57003	3.11.4.1.5.2	Soft Latching	All structural connectors shall provide the capability to “soft latch” prior to full firm connection or full release.	A	A													
I-298	SSP 57003	3.11.4.1.5.3	Lock Indication	All structural connectors shall provide an indication of positive locking.	A	A													
I-299	SSP 57003	3.11.4.1.6	Optical Connectors Design Requirements	EVA fiber optic connectors shall incorporate alignment features.	A	A													
I-300	SSP 57003	3.11.4.1.7.1	Connector Mismate Prevention	EVA connectors shall be selected, designed, and installed so they cannot be mismated or cross-connected.	A	A													
I-301	SSP 57003	3.11.4.1.7.2	Connector Shape	Connectors that are of different shapes and physically incompatible shall be used when lines differ in content.	A	A													
I-302	SSP 57003	3.11.4.1.7.3	Alignment Provisions	All connectors shall have provisions to ensure proper alignment during mating and demating and visible alignment markings.	A	A													
I-303	SSP 57003	3.11.4.1.7.3.1	Alignment Aids	Mating connectors shall be provided with aligning pins or equivalent devices to aid in alignment and to preclude inserting in other than the desired orientation.	A	A													
I-304	SSP 57003	3.11.4.1.7.3.2	Electrical Connector Alignment Pin Length	If aligning pins are used on electrical connectors, they shall extend beyond the plug’s electrical pins to ensure that alignment is obtained before the electrical pins engage.	A	A													
I-305	SSP 57003	3.11.4.1.7.4.1	Use of Alignment Marks	Alignment marks shall be applied to mating parts.	A	A													
I-306	SSP 57003	3.11.4.1.7.4.2	Alignment Mark Design	Alignment marks shall consist of a straight or curved line of a width and length sufficient to allow accurate alignment.	A	A													
I-307	SSP 57003	3.11.4.1.7.5	Orientation	Grouped plugs and receptacles shall be oriented so that the aligning pins or equivalent devices are in the same relative position.	A	A													
I-308	SSP 57003	3.11.4.1.8.1	Cable/Hose End Identification	If the connectors on the ends of a loose cable/hose are not identical, each end shall be identified per Appendix C.	A	A													
I-309	SSP 57003	3.11.4.1.8.2	Cable/Hose Restraints	The loose ends of electrical cables or fluid lines shall be restrained.	A	A													
I-310	SSP 57003	3.11.4.1.9	Status	Methods shall be provided to indicate connector mating status.	A	A													
I-311	SSP 57003	3.11.4.1.11	Protective Caps	All connector protective caps shall be tethered.	A	A													
I-312	SSP 57003	3.11.4.1.12	Connector Protection	All demated connectors shall be protected against physical damage and contamination.	A	A													
I-313	SSP 57003	3.11.4.1.13.1	Connectors and Adjacent Obstructions	Space between connectors and adjacent obstructions shall be a minimum of 40.6mm.	A	A													
I-314	SSP 57003	3.11.4.1.13.2	Connectors in Rows Which are Removed Sequentially	For single rows or staggered rows of EVA connectors, 40.6 mm of clearance for 270 degrees sweep shall be provided.	A	A													
I-315	SSP 57003	3.11.4.1.13.3	Wing Connector Spacing	Where wing connectors are used, the minimum clearance between adjacent wing tabs shall be 63.5mm.	A	A													
I-316	SSP 57003	3.11.4.3	EVA Equipment Handling Capabilities	External equipment or hardware to be handled or transported by the EVA crew shall be handled in accordance with the requirements as specified in Table 3.11.4.3-1.	A	A													
I-317	SSP 57003	3.11.4.4	EVA Equipment Attachment Points/Restraints	All EVA manipulated APs and EVA manipulated hardware shall have attachment points or restraints so it can be secured or tethered at all times during transfer and at the worksite.	A	A													
I-318	SSP 57003	3.11.4.5	Access	AP equipment item design shall provide physical and visual access around the equipment item.	A	A													
I-319	SSP 57003	3.11.4.7.1.1	Hand-actuated Fasteners	Hand actuated fasteners shall be used where size, location, structural, and 50^{th} percentile female strength requirements are met.	A	A													

Rqmt No.	Document	Paragraph	Requirement Title	Shall Statement	Payload	PIH	Cryomagnet System	TRD	TRDGS	TOF	ACC	Tracker	RICH	ECAL	Avionics	TCS	TTCS	Star Trackers	GPS
I-320	SSP 57003	3.11.4.7.1.2.1	Captive Fastener Provisions	External fasteners and their components shall be captive or have special provisions to restrain the fasteners.	A	A													
I-321	SSP 57003	3.11.4.7.1.2.2	Temporary Fasteners	External hardware shall preclude the use of temporary fasteners.	A	A													
I-322	SSP 57003	3.11.4.7.1.3.1	Direct Access	Fasteners shall be located so that they can be actuated without removing other parts or units first.	A	A													
I-323	SSP 57003	3.11.4.7.1.3.2	Access Holes	Covers or shields through which mounting fasteners must pass for attachment to the basic chassis of the unit shall have holes for passage of the fastener without precise alignment.	A	A													
I-324	SSP 57003	3.11.4.7.1.4	One-Handed Actuation	All fasteners shall allow actuation by one hand, and by either right or left hand.	A	A													
I-325	SSP 57003	3.11.4.7.1.5	Engagement Status Indication	An indication of incorrect engagement of fasteners shall be provided.	A	A													
I-326	SSP 57003	3.11.4.7.1.6	Indication of Status	EVA actuated fasteners/devices shall be visually accessible to ensure proper seating or restraint in stowed or installed locations.	A	A													
I-327	SSP 57003	3.11.4.7.1.7.1	Number of Fasteners	When several fasteners are required, they shall be of identical type.	A	A													
I-328	SSP 57003	3.11.4.7.1.7.2	Arrangement	When several fasteners are used on one item, they shall be arranged so that the unit can be assembled in only the correct manner.	A	A													
I-329	SSP 57003	3.11.4.7.1.8	Safety	Fasteners shall be designed so as to preclude injury to the crewmember when the fastener is released.	A	A													
I-330	SSP 57003	3.11.4.7.1.9	Actuation Force/Torque	Fastener actuation/torque shall be less than that specified in Figure 3.11.4.7.1.9-1 using the tools on the standard on-orbit tool list in SSP 30256:001, table 3.2-1 and 3.2-2.	A	A													
I-331	SSP 57003	3.11.4.7.1.10	Cotter Keys	Cotter keys shall not be used for EVA.	A	A													
I-332	SSP 57003	3.11.4.7.1.11	Ratchet Type Tool Engage/Disengage Force	On-orbit maintainable fasteners shall require no greater than 20 lbf for engagement or disengagement with ratchet type tools.	A	A													
I-333	SSP 57003	3.11.4.7.1.12	Driver Type Tool Engage/Disengage Torque	On-orbit maintainable fasteners shall require no greater than 11 ft-lb torque for engagement or disengagement with driver type tools.	A	A													
I-334	SSP 57003	3.11.4.7.1.13	EVA Access to Fasteners	When EVA fasteners are recessed in a robotic interface, the clearance between the fastener and the robotic interface shall allow for insertion, actuation, and removal of the drive end of a standard EVA tool as specified in SSP 30256:001, para 3.2.	A	A													
I-335	SSP 57003	3.11.4.7.2.1	Fastener Knobs	Fastener knobs shall be textured.	A	A													
I-336	SSP 57003	3.11.4.7.2.2	Fastener and Knob Head Diameter	Fasteners and knobs for suited gloved hand operation shall have minimum head diameter of 1.5in and maximum diameter of 2.0 in.	A	A													
I-337	SSP 57003	3.11.4.7.2.3	Fastener and Knob Head Height	Fastener and knobs for suited gloved hand operation shall have a minimum head height of 0.75in.	A	A													
I-338	SSP 57003	3.11.4.7.2.4	Override Feature	All EVA hand actuated rotational fasteners shall be provided with a standard-sized internal or external hexagonal feature for override with a hand tool.	A	A													
I-339	SSP 57003	3.11.4.7.2.5.1	Fastener Turns	Quick-release captive fasteners shall require a maximum of one complete turn to operate.	A	A													
I-340	SSP 57003	3.11.4.7.2.5.2	One-Handed Actuation	Quick-release captive fasteners shall require only one hand to operate.	A	A													
I-341	SSP 57003	3.11.4.7.2.5.3	Positive Locking	Quick-release captive fasteners shall be positive locking in open and closed positions.	A	A													
I-342	SSP 57003	3.11.4.7.2.6.1	Locking Feature	Hand-actuated threaded fasteners shall have a locking feature that provides a visual feedback to the crewmember.	A	A													
I-343	SSP 57003	3.11.4.7.2.6.2	Fastener Back-out	Locking features shall assure that threaded fasteners will not unthread themselves without crew activation.	A	A													
I-334	SSP 57003	3.11.4.7.2.8	Safety Wire	Safety wire shall not be used on fasteners.	A	A													
I-345	SSP 57003	3.11.4.7.3.1	Nonstandard Tools	Fasteners requiring nonstandard tools shall not be used.	A	A													

Rqmt No.	Document	Paragraph	Requirement Title	Shall Statement	Payload	PIH	Cryomagnet System	TRD	TRDGS	TOF	ACC	Tracker	RICH	ECAL	Avionics	TCS	TTCS	Star Trackers	GPS
I-346	SSP 57003	3.11.4.7.3.2.1	EVA Actuated Bolts	All EVA actuated bolts shall conform to one of the standard five configurations in order to interface with the standard EVA hand and power tools.	A	A													
I-347	SSP 57003	3.11.4.7.3.3	Precision Torquing	Where precise torque or preload is required, the payload shall use fasteners that incorporate torque-indicating features or that are compatible with onboard EVA torque indicating tools per SSP 30256:001, Tables 3.2-1 and 3.2-2.	A	A													
I-348	SSP 57003	3.11.4.7.3.4	Torque Instructions	When fastener torquing to specifications is required, instructions shall be provided.	A	A													
I-349	SSP 57003	3.11.4.7.3.5.1	Use of Left-Hand Threads	Left-hand threads shall not be used unless system requirements demand them.	A	A													
I-350	SSP 57003	3.11.4.7.3.5.2	Marking of Left-Hand Threads	Left-hand threaded fasteners shall be identified by marking.	A	A													
I-351	SSP 57003	3.11.4.7.3.6	Locking	Threaded fasteners shall incorporate features that allow them to be locked so they will not unthread without using a tool.	A	A													
I-352	SSP 57003	3.11.4.7.3.7	Hand Tool Operable	All fasteners installed with power tools shall be removable by a hand-operated tool.	A	A													
I-353	SSP 57003	3.11.4.8	Equipment Item Interconnecting Devices	The AP shall provide utility line attachment/mounting length to allow removal/replacement of the equipment item.	A	A													
I-354	SSP 57003	3.11.4.9	Incorrect Equipment Installation	The AP shall contain physical provisions to preclude incorrect installation of equipment.	A	A													
I-355	SSP 57003	3.11.4.10	Restraining and Handling Devices for Temporary Storage	AP external equipment shall allow for restraining and handling by EVA crew to provide temporary storage.	A	A													
I-356	SSP 57003	3.11.4.11	Installation Removal Force	Hardware mounted into a capture-type receptacle that requires an EVA push/pull action shall require a force less that 35 lbf to install or remove.	A	A													
I-357	SSP 57003	3.11.4.12	Direction of Removal	EVA replaceable items (remove/replace or maintenance items) shall be removeable along a straight path until they have cleared the surrounding structure.	A	A													
I-358	SSP 57003	3.11.4.13	Visibility	All forward edges of the equipment item shall be visible to the restrained crewmember during alignment and attachment.	A	A													
I-359	SSP 57003	3.11.4.14.1	Visual Alignment Method	A method of visual alignment shall be provided.	A	A													
I-360	SSP 57003	3.11.4.14.2	Alignment Marks on Both Sides of Interface	The hardware design shall incorporate alignment marks and/or orientation arrows at both sides of the interface.	A	A													
I-361	SSP 57003	3.11.4.14.3	Alignment for Operational Position	If alignment marks are used, alignment marks shall be applied to both mating parts and the marks shall align when the parts are in the operational position.	A	A													
I-362	SSP 57003	3.11.4.14.4	Alignment Mark Description	An alignment mark shall consiste of a straight or curved line of a width and length to allow accurate alignment.	A	A													
I-363	SSP 57003	3.11.4.14.5	Alignment Devices	Guide pins or their equivalent shall be provided to assist in alignment of hardware during mounting.	A	A													
I-364	SSP 57003	3.11.4.15	EVA Tool Access	AP Attached Payload Requiring EVA shall utilize the tools specified in SSP 30256:001 Tables 3.2-1 and 3.2-2.	A	A													
I-365	SSP 57003	3.11.4.15.1	Tool Head Clearance	Clearance shall be provided around the fastener or drive stud for insertion, actuation, and removal of the drive end of the tool, as shown in Figure 3.11.4.15.1-1.	A	A													
I-366	SSP 57003	3.11.4.15.2	Tool Handle Clearance	A minimum of three inches of clearance between the tool handle engaged on a fastener or drive stud and surrounding structure shall be maintained for EVA gloved-hand access around the tool handle for the sweep of the handle.	A	A													
I-367	SSP 57003	3.11.4.15.3	Driver-Type Tool Clearance	For a driver-type tool, clearance shall be maintained through 360 degrees.	A	A													
I-368	SSP 57003	3.11.4.15.4	Ratchet-Type Tool Throw Angles	Equipment and structures surrounding bolts requiring EVA ratcheting shall protect a 90 degree throw angle and allow right or left handed operations.	A	A													
I-369	SSP 57003	3.11.4.17.1	Controls	There shall be no EVA actuated controls on APs	A														

Rqmt No.	Document	Paragraph	Requirement Title	Shall Statement	Payload	PIH	Cryomagnet System	TRD	TRDGS	TOF	ACC	Tracker	RICH	ECAL	Avionics	TCS	TTCS	Star Trackers	GPS
I-370	SSP 57003	3.11.4.17.2	Displays	There shall be no EVA displays on APs.	A														
I-371	SSP 57003	3.11.5.1	Latches	Latches or similar devices shall be designed to prevent entrapment of crewmember appendages.	A	A													
I-372	SSP 57003	3.11.5.2	Equipment Clearance for Entrapment Hazard	Clearance shall be provided for equipment removal and replacement to prevent the creation of a crew entrapment hazard.	A	A													
I-373	SSP 57003	3.11.5.3	Holes in EVA Handrails/holds	Holes in EVA translation handrails/holds shall be 1 inch or greater in diameter.	A	A													
I-374	SSP 57003	3.11.5.4	Covered Holes	Holes that are round or slotted in the range of 0.4 inch to 1.0 inch shall be covered.	A	A													
I-375	SSP 57003	3.11.5.5	Pinch Points	Equipment located outside the habitable volume which pivots, retracts, or flexes such that a gap of greater than 0.5 inches but less than 1,4 inches exists between the equipment in its deployed configuration and adjacent structure shall be designed to prevent entrapment of EVA crewmember appendages.	A	A													
I-376	SSP 57003	3.11.5.6	Screws and Bolts	Screws and bolts with exposed threads protruding greater than 0.12 inches in length shall have protective features that do not prevent installation or removal of the fastener.	A	A													
I-377	SSP 57003	3.11.5.7	Levers, Cranks, Hooks, and Controls	Levers, cranks, hooks, and controls shall be located such that they cannot pinch, snag, cut, or abrade the crewmembers or their clothing.	A	A													
I-378	SSP 57003	3.11.5.8	Burrs	Exposed surfaces shall be free of burrs.	A	A													
I-379	SSP 57003	3.11.5.10	Danger Warnings	Translation and mobility handholds located within three feet of flight equipment which poses a critical or catastrophic hazard to the crewmember or to the equipment shall be identified and color coded per Appendix C.	A	A													
I-380	SSP 57003	3.11.5.11	Control for Exposed Risks	External hardware posing a risk to EVA crew in the primary or secondary EVA translation paths and established EVA worksites shall be placarded and controlled as listed in Table 3.11.5.11-1.	A	A													
I-381	SSP 57003	3.11.5.12	Moving or Rotating Equipment	The EVA crewmember shall be protected from moving or rotating equipment.	A	A													
I-382	SSP 57003	3.11.5.13	Sharp Edges	AP hardware requiring EVA manipulation, along a translation route, or at an EVA worksite shall protect the crew from injury due to sharp edges by the use of corner and edge guards or by rounding the corners and edges.	A	A													
I-383	SSP 57003	3.11.5.13.1	Sharp Edges and Protrusion Criteria	Sharp edges and protrusions shall meet the criteria provided in Tables 3.11.5.13.1-1.	A	A													
I-384	SSP 57003	3.11.5.13.2	Thin Materials	Materials less than 0.08 inches thick, with exposed edges that are uniformly spaced, not to exceed 0.5 inch gaps, flush at the exposed surface plane and shielded from direct EVA interaction shall have edge radii greater than 0.003 inches.	A	A													
I-385	SSP 57003	3.11.5.14.1	Incidental Contact	For incidental contact, temperatures shall be maintained within -180 to +235 degrees F or limit heat transfer rates as listed in Table 3.11.5.14.1-1.	A	A													
I-386	SSP 57003	3.11.5.14.2	Unlimited Contact	For unlimited contact, temperatures shall be maintained within -45 to +145 degrees F, or for designated EVA crew interfaces listed in Table 3.11.5.14.2-1, limit heat transfer rates as listed in Table 3.11.5.14.1-1.	E	E													
I-387	SSP 57003	3.11.5.15	Component Hazardous Energy Provision	Components which retain hazardous energy potential shall either be designed to prevent a crewmember from releasing the stored energy potential or be designed with provisions to allow safing of the potential energy, including provisions to confirm that the safing was successful.	A	A													
I-388	SSP 57003	3.11.5.18	Locking Wires	No AP hardware shall be lockwired or staked.	A	A													
I-389	SSP 57003	3.11.5.19	Safety Critical Fasteners	Safety critical fasteners shall be designed to prevent inadvertent back-out.	A	A													

Appendix D: Requirement Verification Matrix

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
P-1	JSC 29789	3.2.1.1.1	Transition Radiation Detector (TRD) and Upper Time of Flight (TOF) Structural Interfaces – Location	Inclusion of appropriate interfaces in as-built flight hardware.	JSC	(I) Drawing review and QA inspection		Structural interface provided by Upper Vacuum Case Joint. Review of drawing SDG39135727 confirms design requirement met. QA inspection confirms that hardware built per drawing.
P-2	JSC 29789	3.2.1.1.2-A	Cryomagnet System (Includes Cryomagnet, SFHe Tank, and Support System) Structural Interfaces – Location	Inclusion of appropriate interfaces in as-built flight hardware.	JSC	(I) Drawing review and QA inspection		Structural interface provided by VC Upper and Lower Support Rings. Review of drawings SDG39135784, SDG39135785, SEG39135796, and SEG39135797 confirms design requirements met. QA inspection confirms hardware built per drawing except for inclusion of strap port inserts. Inserts added per DR#????.
P-3	JSC 29789	3.2.1.1.2-B	Cryomagnet System Structural Interfaces – Cabling	Inclusion of appropriate interfaces in as-built flight hardware.	JSC	(I) Drawing review and QA inspection		Feed-thrus suitable for cabling provided by VC Upper and Lower Support Rings. Review of drawings SDG39135784 and SDG39135785 confirms design requirement met. QA inspection confirms hardware built per drawing.
P-4	JSC 29789	3.2.1.1.2-C	Cryomagnet System – Air Exclusion	VC holds vacuum of at least $1x10^{-6}$ torr indefinitely..	SM	(T) Leak Test		
P-5	JSC 29789	3.2.1.1.2-D	Cryomagnet System – Cryocooler Interfaces	Inclusion of appropriate interfaces in as-built flight hardware.	JSC	(I) Drawing review and QA inspection		Cryocooler ports provided by VC Upper and Lower Support Rings. Review of drawings SDG39135784 and SDG 39135785 confirms design requirement met. QA inspection confirms hardware built per drawing.
P-6	JSC 29789	3.2.1.1.2-E	Cryomagnet System – Cryocooler Access	Inclusion of appropriate interfaces in as-built flight hardware.	JSC	(I) Drawing review and QA inspection		Cryocooler access ports provided by VC Upper and Lower Support Rings. Review of drawings SDG39135784 and SDG 39135785 confirms design requirement met. QA inspection confirms hardware built per drawing.
P-7	JSC 29789	3.2.1.1.2-F	Cryomagnet System – Fill Port	Inclusion of appropriate interfaces in as-built flight hardware.	JSC	(I) Drawing review and QA inspection		Fill port provided by VC Upper Support Ring. Review of drawing SDG39135784 confirms design requirement met. QA inspection confirms hardware built per drawing.
P-8	JSC 29789	3.2.1.1.2-G	Cryomagnet System – Emergency Vent	Inclusion of appropriate interfaces in as-built flight hardware.	JSC	(I) Drawing review and QA inspection		VC ICD has reserved one feed-through port in the Lower Support Ring for use as a helium tank emergency vent. Review of drawing SDG39135785 confirms design requirement met. QA inspection confirms hardware built per drawing.
P-9	JSC 29789	3.2.1.1.2-H	Cryomagnet System – Pressure Relief System	Inclusion of appropriate interfaces in as-built flight hardware.	JSC	(I) Drawing review and QA inspection		VC ICD has reserved one feed-through port in the Lower Support Ring for use as a Vacuum Case Emergency Vent. Review of drawing SDG39135785 confirms design requirement met. QA inspection confirms hardware built per drawing.
P-10	JSC 29789	3.2.1.1.2-I	Cryomagnet System – Plumbing	Inclusion of appropriate interfaces in as-built flight hardware.	JSC	(I) Drawing review and QA inspection		Feed-thrus suitable for plumbing provided by VC Upper and Lower Support Rings. Review of drawings SDG39135784 and SDG39135785 confirms design requirement met. QA inspection confirms hardware built per drawing.
P-11	JSC 29789	3.2.1.1.3	Anti-Coincidence Counter (ACC)	Inclusion of appropriate interfaces in as-built flight hardware.	JSC	(I) Drawing review and QA inspection		Structural interfaces provided by VC Upper and Lower Conical Flanges. Review of drawings SDG39135788 and SDG39135800 confirms design requirement met. QA inspection confirms hardware built per drawing.
P-12	JSC 29789	3.2.1.1.4	Tracker	Inclusion of appropriate interfaces in as-built flight hardware.	JSC	(I) Drawing review and QA inspection		

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
P-13	JSC 29789	3.2.1.1.5	Lower Time of Flight (TOF)	Inclusion of appropriate interfaces in as-built flight hardware.	JSC	(I) Drawing review and QA inspection		Structural interfaces provided by Lower VC Joint and Lower Centerbody Joint. Review of drawings SDG39135737, SDG39135759, and SDG39135760 confirms design requirement met. QA inspection confirms hardware built per drawing.
P-14	JSC 29789	3.2.1.1.6	Ring Imaging Cherenkov Counter (RICH)	Inclusion of appropriate interfaces in as-built flight hardware.	JSC	(I) Drawing review and QA inspection		Structural interfaces provided by RICH mounting bracket. Review of drawings SDG39135763 confirms design requirement met. QA inspection confirms hardware built per drawing.
P-15	JSC 29789	3.2.1.1.7	Electronic Calorimeter (ECAL)	Inclusion of appropriate interfaces in as-built flight hardware.	JSC	(I) Drawing review and QA inspection		Structural interfaces provided by Lower Centerbody Joint. Review of drawings SDG39135759 and SDG39135760 confirms design requirement met. QA inspection confirms hardware built per drawing.
P-16	JSC 29789	3.2.1.1.8	TRD Gas Supply System	Inclusion of appropriate interfaces in as-built flight hardware.	JSC	(I) Drawing review and QA inspection		
P-17	JSC 29789	3.2.1.1.9	Integrated Radiators, Debris Shield and Electronic Box Assemblies	Inclusion of appropriate interfaces in as-built flight hardware.	JSC	(I) Drawing review and QA inspection		
P-18	JSC 29789	3.2.1.1.10	AMS Experiment Plumbing, Cabling, and Other Miscellaneous Hardware	Inclusion of appropriate interfaces in as-built flight hardware.	JSC	(I) Drawing review and QA inspection		
P-19	JSC 29789	3.2.1.2.1-A	STS Structural Interfaces	Inclusion of trunnions in as-built flight hardware.	JSC	(I) Drawing review and QA inspection		Trunnions included in USS-02 Assembly. Review of drawing SEG39135724 confirms design requirement met. QA inspection confirms hardware built per drawing.
P-20	JSC 29789	3.2.1.2.1-B	STS Structural Interfaces	Review of design to confirm trunnions meet requirements.	JSC	(I) Drawing review and QA inspection		Review of drawings SDG39135732 and SDG39135772 confirms trunnions meet all design requirements. QA inspection confirms hardware built per drawing.
P-21	JSC 29789	3.2.1.2.2-A	STS Power and Data Interfaces	Review of design to confirm avionics hardware meets requirements.	JSC	(I) Drawing review and QA inspection		
P-22	JSC 29789	3.2.1.2.2-B	STS Power and Data Interfaces	Review of design to confirm avionics hardware meets requirements.	JSC	(I) Drawing review and QA inspection		
P-23	JSC 29789	3.2.1.2.2-C	STS Power and Data Interfaces	Review of design to confirm avionics hardware meets requirements.	JSC	(I) Drawing review and QA inspection		
P-24	JSC 29789	3.2.1.2.2-D	STS Power and Data Interfaces	Review of design to confirm avionics hardware meets requirements.	JSC	(I) Drawing review and QA inspection		

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
P-25	JSC 29789	3.2.1.2.2-E	STS Power and Data Interfaces	Review of design to confirm avionics hardware meets requirements.	JSC	(I) Drawing review and QA inspection		
P-26	JSC 29789	3.2.1.2.2-F	STS Power and Data Interfaces	Review of design to confirm avionics hardware meets requirements.	JSC	(I) Drawing review and QA inspection		
P-27	JSC 29789	3.2.1.2.2-G	STS Power and Data Interfaces	Review of design to confirm avionics hardware meets requirements.	JSC	(I) Drawing review and QA inspection		
P-28	JSC 29789	3.2.1.2.2-H	STS Power and Data Interfaces	Review of design to confirm DDRS-02 included.	JSC	(I) Drawing review		
P-29	JSC 29789	3.2.1.2.2-I	STS Power and Data Interfaces	Review of design to confirm avionics hardware meets requirements.	JSC	(I) Drawing review and QA inspection		
P-30	JSC 29789	3.2.1.2.2-J	STS Power and Data Interfaces	Review of design to confirm avionics hardware meets requirements.	JSC	(I) Drawing review and QA inspection		
P-31	JSC 29789	3.2.1.3.1-A	ISS Structural Interfaces	Review of design to confirm appropriate interface hardware included.	JSC	(I) Drawing review		
P-32	JSC 29789	3.2.1.3.1-B	ISS Structural Interfaces	Review of design to confirm payload hardware meets berthing requirements.	JSC	(I) Drawing review and QA inspection		
P-33	JSC 29789	3.2.1.3.1-C	ISS Structural Interfaces	Review of design to confirm flight releasable capture bar included.	JSC	(I) Drawing review		Review of drawing SEG39135815 confirms flight-releasable capture bar included in design.
P-34	JSC 29789	3.2.1.3.2-A	ISS Power and Data Interfaces	Review of design to confirm avionics hardware meets requirements.	JSC	(I) Drawing review and QA inspection		
P-35	JSC 29789	3.2.1.3.2-B	ISS Power and Data Interfaces	Review of design to confirm avionics hardware meets requirements.	JSC	(I) Drawing review and QA inspection		
P-36	JSC 29789	3.2.1.3.2-C	ISS Power and Data Interfaces	Review of design to confirm avionics hardware meets requirements.	JSC	(I) Drawing review and QA inspection		
P-37	JSC 29789	3.2.1.3.2-D	ISS Power and Data Interfaces	Review of design to confirm avionics hardware meets requirements.	JSC	(I) Drawing review and QA inspection		

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
P-38	JSC 29789	3.2.1.3.2-E	ISS Power and Data Interfaces	Review of design to confirm avionics hardware meets requirements.	JSC	(I) Drawing review and QA inspection		
P-39	JSC 29789	3.2.1.4.1	Shuttle Remote Manipulator System (SRMS) Interfaces Functional Requirements	Inclusion of FRGF on as-built flight hardware.	KSC	(I) Drawing review and QA inspection		
P-40	JSC 29789	3.2.1.4.2-A	Space Station Remote Manipulator System (SSRMS) Interfaces Functional Requirements	Inclusion of PVGF on as-built flight hardware.	KSC	(I) Drawing review and QA inspection		
P-41	JSC 29789	3.2.1.4.2-B	Space Station Remote Manipulator System (SSRMS) Interfaces Functional Requirements	Review of design to confirm avionics hardware meets requirements.	JSC	(I) Drawing review and QA inspection		
P-42	JSC 29789	3.2.1.4.2-C	Space Station Remote Manipulator System (SSRMS) Interfaces Functional Requirements	Review of design to confirm avionics hardware meets requirements.	JSC	(I) Drawing review and QA inspection		
P-43	JSC 29789	3.2.1.4.2-D	Space Station Remote Manipulator System (SSRMS) Interfaces Functional Requirements	Review of design to confirm avionics hardware meets requirements.	JSC	(I) Drawing review and QA inspection		
P-44	JSC 29789	3.2.1.4.2-E	Space Station Remote Manipulator System (SSRMS) Interfaces Functional Requirements	Review of design to confirm appropriate tie-down points included.	JSC	(I) Drawing review and QA inspection		
P-45	JSC 29789	3.2.1.5-A	EVA Interfaces Functional Requirements	Program office review of design to confirm all nominal operations will be performed by EVR but allow EVA access for contingency operations.	JSC	(A) APO Review		Program office confirms that AMS-02 that al nominal transfer operations done as EVR. All EVR operations will have contingency EVA support capability. Compliance with SSP57003 Section 3.11 requirements for each worksite and translation path tracked in that section of this matrix.
P-46	JSC 29789	3.2.1.5-B	EVA Interfaces Functional Requirements	Review of design to confirm all hardware in EVA translation paths meets sharp edge requirements.	JSC	(I) Drawing review and QA inspection		
P-47	JSC 29789	3.2.1.5-C	EVA Interfaces Functional Requirements	Program office review to confirm that all AMS-02 contingency EVA operations shall be performed using an astronaut on the SSRMS	JSC	(A) APO Review		
P-48	JSC 29789	3.2.1.5-D	EVA Interfaces Functional Requirements	Review of design to confirm EVA aids included in design at all EVA locations.	JSC	(I) Drawing review and QA inspection		
P-49	JSC 29789	3.2.1.5-E	EVA Interfaces Functional Requirements	Review of design to confirm that all loose equipment includes appropriate tether points.	JSC	(I) Drawing review and QA inspection		
P-50	JSC 29789	3.2.1.5-F	EVA Interfaces Functional Requirements	Review of design to confirm appropriate force reaction point included.	JSC	(I) Drawing review and QA inspection		

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
P-51	JSC 29789	3.2.1.5.1	Extravehicular Activity Translation	Review of design to confirm no interferences with EVA translation path.	JSC	(I) Drawing review and QA inspection		
P-52	JSC 29789	3.2.1.5.2	Payload Attach System/ Unpressurized Cargo Carrier Attach System Clearances	Review of design to confirm no interferences between AP hardware and EVA translation corridors.	JSC	(I) Drawing review and QA inspection		Exceptions E4 and E5 of SSP 57213
P-53	JSC 29789	3.2.1.5.3	Extravehicular Activity Translation Corridor Protrusion	Review of design to confirm no interferences between AP hardware and EVA worksites and translation aids.	JSC	(I) Drawing review and QA inspection		
P-54	JSC 29789	3.2.1.6	Micro-meteoroid and Orbital Debris (M/OD) Shields Functional Requirements	1) Safety analysis to identify all safety-critical elements. 2) MMOD analysis to confirm shielding provides adequate protection.	JSC	(I&A) Flight Safety Data Package and MMOD Analysis Report		
P-55	JSC 29789	3.2.1.7	Thermal Insulation Functional Requirements	Safety analysis to confirm all hardware remains within thermal limits required for safe operation.	JSC	(I&A) Flight Safety Data Package		Safety hazards related to thermal extremes discussed explicitly in Cause 5 of Hazard Report 13, Cause 4 of Hazard Report 14, and Hazard Report 15. Thermal analysis referenced implicitly in most other hazard reports.
P-56	JSC 29789	3.2.2.1-A	Weight/Center of Gravity (CG) – Weight	Measurement of as-built PIH hardware	KSC	(D) Weighing of PIH		
P-57	JSC 29789	3.2.2.1-B	Weight/Center of Gravity (CG) – CG	1) Review of CAD model to confirm PIH weight estimate does not cause the entire payload to exceed CG offset. 2) Measurement of as-built PIH hardware.	KSC	(D&I) Mass properties analysis and weighing of full payload.		
P-58	JSC 29789	3.2.2.2	Dimensions/ Volume	Review of design to confirm no violations of on-orbit operational envelope.	JSC	(I) Drawing review and QA inspection		Exception E2 of SSP 57213
P-59	JSC 29789	3.2.3.1	Thermal	Full documentation of thermal analysis in Thermal Analysis Report	JSC	(A) Thermal Analysis Report		
P-60	JSC 29789	3.2.3.2	Pressure	Review of design to confirm that hardware meets pressure requirements.	JSC	(A) Stress Report		Requirement deleted in Revision C of SSP 57003. so verification is moot.
P-61	JSC 29789	3.2.3.3	Vibration	Stress analysis demonstrating positive margins of safety to required loading conditions.	JSC	(A) Stress Report		
P-62	JSC 29789	3.2.3.4-A	Acceleration – Flight & Ground Handling	Stress analysis demonstrating positive margins of safety to required loading conditions.	JSC	(A) Stress Report		
P-63	JSC 29789	3.2.3.4-B	Acceleration – On-orbit	Stress analysis demonstrating positive margins of safety to required loading conditions.	JSC	(A) Stress Report		
P-64	JSC 29789	3.2.3.4-C	Acceleration – Berthing	Stress analysis demonstrating positive margins of safety to required loading conditions.	JSC	(A) Stress Report		

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
P-65	JSC 29789	3.2.3.6	EMI/EMC	1) Program office review of design to confirm no powered elements within PIH. 2) Review of design to confirm all cables have appropriate shielding.	JSC	(A) APO Review, Drawing review, and QA inspection		1) Program Office confirms that AMS-02 PIH contains no powered elements.
P-66	JSC 29789	3.2.3.7.1	Transportation Humidity Environment			(A)		
P-67	JSC 29789	3.2.3.7.2	Storage Humidity Environment			(A)		
P-68	JSC 29789	3.2.3.7.3	Pre-Launch Humidity Environment			(A)		
P-69	JSC 29789	3.2.3.7.4	On-Orbit Humidity Environment			(A)		
P-70	JSC 29789	3.2.3.7.5	Orbiter Cabin Humidity Environment			(A)		
P-71	JSC 29789	3.2.3.8	Acoustic Emissions	Program Office review to confirm no hardware capable of producing acoustic emissions	JSC	(A) APO Review		Program Office confirms that AMS-02 contains no elements capable of producing acoustic emissions.
P-72	JSC 29789	3.2.3.9	Micrometeoroids and Orbital Debris	MMOD analysis to verify that AMS-02 meets PNP requirements.	JSC	(A) MMOD Analysis Report		
P-73	JSC 29789	3.2.3.10	Atomic Oxygen	1) Review of design to confirm all nonmetallic elements vulnerable to AO will not be exposed to on-orbit environment. 2) Review of design to confirm no silver plated hardware used.	JSC	(I) Review of design and QA inspection		
P-74	JSC 29789	3.2.3.11	External Contamination	Review of design to confirm external contamination environment does not pose a problem.	JSC	(I) APO Review		
P-75	JSC 29789	3.2.3.12.1	Ionizing Radiation Dose	Safety analysis to confirm no hazard can be created by exposure to required ionizing radiation design environment.	JSC	(A) Flight Safety Data Package		
P-76	JSC 29789	3.2.3.12.2	Nominal Single Event Effects Ionizing Radiation	Safety analysis to confirm no hazard can be created by exposure to required ionizing radiation design environment.	JSC	(A) Flight Safety Data Package		
P-77	JSC 29789	3.2.3.12.3	Extreme Single Event Effects	Safety analysis to confirm no hazard can be created by exposure to required ionizing radiation design environment.	JSC	(A) Flight Safety Data Package		
P-78	JSC 29789	3.2.4.1.2	Failure Tolerance Power and Data Interfaces	Safety analysis to confirm fault tolerance of PIH cabling.	JSC	(A) Flight Safety Data Package		
P-79	JSC 29789	3.2.4.1.3	Failure Tolerance O-ring Seals	Safety analysis to confirm fault tolerance of VC O-Ring interfaces.	JSC	(A) Flight Safety Data Package		
P-80	JSC 29789	3.2.4.2	Failure Propagation	Safety analysis to confirm fault tolerance of PIH hardware	JSC	(A) Flight Safety Data Package		
P-81	JSC 29789	3.2.6.1	Ground Transportability	Stress analysis demonstrating positive margins of safety to required loading conditions.	JSC	(A) Stress Report		

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
P-82	JSC 29789	3.2.6.2	Transport to Orbit	Stress analysis demonstrating positive margins of safety to required loading conditions.	JSC	(A) Stress Report		
P-83	JSC 29789	3.3.1.1-A	Materials and Processes	Review of design to confirm all materials meet the requirements of SSP 30233.	JSC	(I) Materials Usage Agreement		
P-84	JSC 29789	3.3.1.1-B	Materials and Processes	Review of design to confirm all materials meet the requirements of SE-M-0096.	JSC	(I) Materials Usage Agreement		
P-85	JSC 29789	3.3.1.1-F	Materials and Processes	Review of design to confirm all materials meet the requirements of NSTS 1700.7B and NSTS 1700.7B ISS Addendum.	JSC	(I) Materials Usage Agreement		
P-86	JSC 29789	3.3.1.1-G	Materials and Processes	Review of design to confirm all nonmetallic materials come from JSC 09604.	JSC	(I) Materials Usage Agreement		
P-87	JSC 29789	3.3.1.1-H	Materials and Processes	Review of design to confirm all materials meet previous requirements.	JSC	(I) Materials Usage Agreement		
P-88	JSC 29789	3.3.1.2-A	Electrical, Electronic and Electromechanical (EEE) Parts					
P-89	JSC 29789	3.3.1.2-B	Electrical, Electronic and Electromechanical (EEE) Parts					
P-90	JSC 29789	3.3.2	Structural Design	Stress analysis demonstrating positive margins of safety to required loading conditions.	JSC	(A) Stress Report		
P-91	JSC 29789	3.3.3-A	Nameplates and Product Marking	Review of design to confirm nameplates meet requirements.	JSC	(I) Drawing review and QA inspection		
P-92	JSC 29789	3.3.3-B	Nameplates and Product Marking	Review of design to confirm that appropriate labeling included.	JSC	(I) Drawing review and QA inspection		
P-93	JSC 29789	3.3.4-A	Workmanship					
P-94	JSC 29789	3.3.4-B	Workmanship					
P-95	JSC 29789	3.3.4-C	Workmanship					
P-96	JSC 29789	3.3.4-D	Workmanship					
P-97	JSC 29789	3.3.4-E	Workmanship					
P-98	JSC 29789	3.3.4-F	Workmanship					
P-99	JSC 29789	3.3.4-G	Workmanship					
P-100	JSC 29789	3.3.4-H	Workmanship					
P-101	JSC 29789	3.3.4-I	Workmanship					
P-102	JSC 29789	3.3.4-J	Workmanship					
P-103	JSC 29789	3.3.5-A	Human Engineering	Review of design to confirm that hardware meets all human engineering requirements.	JSC	(I) Drawing review and QA inspection		

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
P-104	JSC 29789	3.3.5-B	Human Engineering	Review of design to confirm that hardware meets all human engineering safety requirements.	JSC	(I) Drawing review and QA inspection		
P-105	JSC 29789	4.1	Packaging Levels and Methods					
P-106	JSC 29789	4.3	Military Transportation Procedures Documentation and Reports	Confirmation that AMS-02 will not use military airlift system.	JSC	APO Review		APO confirms no military airlifts shall be used during payload lifetime.

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
I-1	SSP 57003	3.1.1	General Design Requirements	Accepted and approved AMS-02 Acceptance Data Package (ADP) and DD 250 Verification shall be considered successful when the inspection results in certification of the design drawings, exceedances, deviations, waivers, and engineering change requests as reflecting the as-built hardware.	JSC	(I) ADP	Certificate of Compliance	
I-2	SSP 57003	3.1.1.1.1	Fail safe, Safe-life, or Low risk Fracture parts	Stress analysis demonstrating appropriate fracture classification for all parts. When it is shown that Attached Payload structural components and materials can be classified as fail–safe, safe–life, or low–risk and that the primary structure has +0.00 or positive safety margins with respect to the loads used in the component/ material analyses during ascent, on–orbit, and descent, then the verification shall be satisfied.	JSC	(A) Fracture Control Report	Data Cert. providing a fracture control summary	
I-3	SSP 57003	3.1.1.1.2	Fracture Control	1) Fracture analysis for all parts showing maximum allowable flaw size for each part. 2) NDE inspection of all parts for flaws greater than maximum allowable. The verification will be considered successful when the applicable Attached Payload level demonstration, analysis or inspection is shown to satisfy SSP 52005 requirements. Fracture control planning, analysis, inspection requirement, and inspection results shall be performed per a user–developed Fracture Control Plan approved by the PSRP.	JSC	(I) Fracture Control Report and QA Inspection	Data Cert. providing a fracture control summary	
I-4	SSP 57003	3.1.1.1.3	MOD Protection for External payloads	1) Hazard analysis identifying all stored energy devices or potential catastrophic hazards. 2) MMOD Analysis demonstrating compliance with PNP requirements for all stored energy devices and other hardware that could create catastrophic hazards. Verification shall be considered successful when the analysis shows the requirements of SSP 52005 are satisfied.	JSC	(A&I) Flight Safety Data Package and MMOD Analysis and Test Report	Certificate of Compliance	1) Stored energy devices potentially vulnerable to MMOD impact addressed as Cause 8 in Hazard Report 3 and Cause 9 of Hazard Report 5.
I-5	SSP 57003	3.1.1.2.1	Margins of Safety	Stress analysis demonstrating positive margins of safety to required loading conditions. An inspection of the structural analysis reports shall be performed to verify that positive margins of safety exist for all Attached Payload structural components. When it is shown that Attached Payload structural components have positive margins of safety for the specified combined loads conditions, then the verification shall be satisfied.	JSC	(A) Stress Report	Data Cert providing a summary listing of all operational modes analyzed and showing positive margins of safety	
I-6	SSP 57003	3.1.1.2.2	Factors of Safety	Use of appropriate factors of safety in structural analyses. An inspection of the structural analysis reports shall be performed to verify that the specified factors of safety have been used in the analysis of the structure. When it is shown that Attached Payload structural components have +0.00 or positive margins of safety for the specified combined loads conditions, then the verification shall be satisfied.	JSC	(I) Stress Report	1. Data Cert. that provides a summary of the margins of safety for all SCS identified in accordance with SSP 52005 using design loads if the Design Loads Analysis (DLA) results are not available. 2. Data cert. that provides a summary of the margins of safety for all SCS identified in accordance with SSP 52005 using loads validated by the verification loads analysis (VLA) results.	

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
I-7	SSP 57003	3.1.1.2.3 A	Design Loads - External to Payload	Stress analysis demonstrating positive margins of safety to required loading conditions. The requirement shall be considered successfully verified when the structural components have been shown by test or analysis to have positive margins of safety for the design loads specified in paragraph 3.1.1.2.3 in accordance with SSP 30559, paragraph 3.2.	JSC	(A or T) Stress Report	1. Data Cert. that provides a summary of the margins of safety for all SCS identified in accordance with SSP 52005 using design loads if the Design Loads Analysis (DLA) results are not available. 2. Data cert. that provides a summary of the margins of safety for all SCS identified in accordance with SSP 52005 using loads validated by the verification loads analysis (VLA) results.	
I-8	SSP 57003	3.1.1.2.3 B	Design Loads - Internal to Payload	Coupled loads analysis demonstrating interface loads within requirements. Verification shall be considered successful when the analysis or test assessment shows that the payload does not induce loads greater than those allowed in Table 3.1.1.2.3−2.	JSC	(A or T) DAC Analysis Report	1. Data Cert. that provides a summary of the margins of safety for all SCS identified in accordance with SSP 52005 using design loads if the Design Loads Analysis (DLA) results are not available. 2. Data cert. that provides a summary of the margins of safety for all SCS identified in accordance with SSP 52005 using loads validated by the verification loads analysis (VLA) results.	AP/UCC interface loads from DAC-8 accepted by ISS program.

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
I-9	SSP 57003	3.1.1.2.4.1	Guide Pin Contact Forces	Stress analysis demonstrating positive margins of safety to required loading conditions. Verification shall be successful when the analysis shows the requirements in paragraph 3.1.1.2.4.1 have been met.	JSC	(A) Stress Report	1. Data Cert. that provides a summary of the margins of safety for all SCS identified in accordance with SSP 52005 using design loads if the Design Loads Analysis (DLA) results are not available. 2. Data cert. that provides a summary of the margins of safety for all SCS identified in accordance with SSP 52005 using loads validated by the verification loads analysis (VLA) results.	
I-10	SSP 57003	3.1.1.2.4.2	Capture Bar Contact Forces	Stress analysis demonstrating positive margins of safety to required loading conditions. Verification shall be successful when the analysis shows the requirements in paragraph 3.1.1.2.4.2 have been met.	JSC	(A) Stress Report	1. Data Cert. that provides a summary of the margins of safety for all SCS identified in accordance with SSP 52005 using design loads if the Design Loads Analysis (DLA) results are not available. 2. Data cert. that provides a summary of the margins of safety for all SCS identified in accordance with SSP 52005 using loads validated by the verification loads analysis (VLA) results.	

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
I-11	SSP 57003	3.1.1.2.5	Thermal Effects	1) Integrated Thermal analysis of worst case cold and hot thermal environments 2) Inclusion of appropriate thermal knockdowns and thermally-induced deflections in structural margin of safety calculations for on-orbit loading events. The Attached Payload structure shall be considered successfully verified for thermal effects combined with static and dynamic loading when the structure and structural components have a +0.00 or positive margins of safety.	JSC	(A) Thermal Analysis Report and Stress Report	1. Data Cert. that provides a summary of the margins of safety for all SCS identified in accordance with SSP 52005 using design loads if the Design Loads Analysis (DLA) results are not available. 2. Data cert. that provides a summary of the margins of safety for all SCS identified in accordance with SSP 52005 using loads validated by the verification loads analysis (VLA) results.	
I-12	SSP 57003	3.1.1.2.6	EVA On-orbit Induced loads	Stress analysis demonstrating positive margins of safety to required loading conditions. Verification shall be considered successful when the analysis shows that the Attached Payload is capable of withstanding the specified loads.	JSC	(A) Stress Report	Data cert. providing a summary listing of all operational modes analyzed and showing positive margins of safety.	
I-13	SSP 57003	3.1.1.3	Design Service Life	Fracture analysis demonstrating required service life. When it is shown that Attached Payload structural components satisfy the maximum expected design life in paragraph 3.1.1.3 and have been analyzed in conformance with the requirements as specified in SSP 30559, paragraph 3.5, then the verification shall be satisfied.	JSC	(I) Fracture Control Report	Certificate of Compliance	
I-14	SSP 57003	3.1.1.5	Interchangeability	Review of design to demonstrate no safety issue associated with contingency berthing on any CAS site. The verification shall be considered successful when analysis including maximum and minimum tolerance stack-up shows that the Attached Payload is installable and capable of safe operations at any of the truss attach sites.	JSC	(A) Review of Design	Certificate of Compliance	
I-15	SSP 57003	3.1.1.6	Attached Payload Interface Durability	Fracture analysis demonstrating required service life. The verification shall be considered successful when the analysis shows that the on orbit Attached Payload interface to ISS will perform its intended function following the number of mate and de-mate cycles specified in paragraph 3.1.1.6.	JSC	(A) Fracture Control Report	Certificate of Compliance	
I-16	SSP 57003	3.1.1.7A	Structural Materials Criteria and Selection	Stress report documenting use of appropriate material properties. Verification will be considered successful when the inspection shows that the structural material selection is in accordance with the requirements.	JSC	(I) Stress Report	Certificate of Compliance	
I-17	SSP 57003	3.1.1.8	Structural Degradation from Material Erosion	Review of design to confirm that all composite materials are protected from exposure to the on-orbit plasma and AO environment. When it is shown that Attached Payload structural components have a positive margin of safety for the required combined loads conditions, as specified in SSP 30425, then the verification shall be satisfied.	CERN	(I) Drawing review and QA Inspection	Certificate of Compliance	

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
I-18	SSP 57003	3.1.2.1	Structural Design Interface	Review of design to confirm compatibility with MCAS interface. Verification shall be considered successful when the analysis shows that the requirements of SSP 42004 are met.	JSC	(A) Drawing review and QA inspection	1. Preliminary Data Cert. based on static analysis using approved Finite Element Model (FEM) (or Design Coupled Loads (DCL) analysis results), providing the interface attach point forces and margins of safety calculations based on the allowable limits as specified. 2. Final Data Cert. providing the interface attach point forces and margins of safety calculations based on the allowable limits as specified. (Attachment force can be obtained from the result of the Verification Coupled Loads (VCL)).	
I-19	SSP 57003	3.1.2.2	Mechanical Design Interface	1) Review of design to confirm mechanical compatibility with MCAS interface. 2) Fit check of flight hardware to ACASS. Verification shall be considered successful when the inspection and test confirm compatibility.	KSC	(I&T) Drawing Review and ACASS fit check	Certificate of Compliance	
I-20	SSP 57003	3.1.2.3 A	Mass and Envelope Dimensions – Total Mass	a1) Payload weight measurement a2) Operational control to address mass during Russian docking. Verification shall be considered successful when the tests show the actual mass to be no greater than the control mass specified in paragraph 3.1.2.3.	KSC	(T) Weight Measurement	Data Cert. that provides weight and CG summary for on-orbit configuration of the Attached Payload	
I-21	SSP 57003	3.1.2.3 B	Mass and Envelope Dimensions – Envelope	Review of CAD models to confirm AMS-02 fits within MCAS user envelope. Verification shall be considered successful when the inspection shows that the Attached Payload On–Orbit configuration translation envelope does not exceed the dimensions specified in SSP 42004, paragraph B3.2.2.1.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	
I-22	SSP 57003	3.1.3.1.1.1	PAS/UCCAS On-Orbit Operational Envelope	Review of design to confirm no violations of on-orbit operational envelope. Verification shall be considered successful when the inspection and analysis shows that the Attached Payload installation configuration fits within the envelope specified in paragraph 3.1.3.1.1.1.	JSC	(I) Drawing review and QA inspection	Data Cert. providing all exceedances identified to date for the on-orbit operational envelope	Exception 57213-NA-0003
I-23	SSP 57003	3.1.3.1.1.2	Interface Plane Protrusion	Review of design to confirm no violations of PAS/UCCAS interface plane. Verification shall be considered successful when the inspection shows that the Attached Payload installation does not include protrusions into the PAS/UCCAS side of the datum plane as specified in paragraph 3.1.3.1.1.2.	JSC	(I) Drawing review and QA inspection	Data Cert. providing drawings identifying all protrusions	Exception 57213-NA-0002

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
I-24	SSP 57003	3.1.3.1.1.3 A	EVA/Robotics Envelope - EVA	Review of design to confirm no interferences between AP hardware and EVA translation corridors. Verification shall be considered successful when the analysis shows that the Attached Payload meets the specified envelope in the unique ICD.	JSC	(A) Drawing review and QA inspection	Analysis Report	Exceptions E4 and E5 of SSP 57213
I-25	SSP 57003	3.1.3.1.1.3 B	EVA/Robotics Envelope - Robotics	Review of design to confirm no interferences between AP hardware and EVR envelopes. Verification shall be considered successful when the analysis shows that the Attached Payload meets the specified envelope in paragraph 3.1.3.1.1.3B.	JSC	(A) Drawing review and QA inspection	Certificate of Compliance	
I-26	SSP 57003	3.1.3.1.2.1	PAS Coordinate System Origin Location	Stress report demonstrating compliance with coordinate system convention. Verification shall be considered successful when the inspection shows that all analysis for the Attached Payload uses the proper convention.	JSC	(I) Stress Report	Certificate of Compliance	
I-27	SSP 57003	3.1.3.1.2.2	Mass and Center of Gravity	Measurement of payload weight to minimum accuracy of 0.3% and measurement CG location to minimum accuracy of ±0.25 in. in all three axes. Verification shall be considered to be successful when the analysis shows the requirements have been met.	KSC	(A) Weight Measurement	Data Cert. that provides weight and CG summary for on-orbit configuration of the Attached Payload	
I-28	SSP 57003	3.1.3.1.3	Attached Payload Fundamental Frequency	Calculation of fundamental frequency using on-orbit boundary conditions. Verification shall be considered successful when the analysis or test shows the Attached Payload meets the requirements of paragraph 3.1.3.1.3.	JSC	(A or T) Dynamic Analysis Memo	Verified Finite Element Model or Data Cert.	
I-29	SSP 57003	3.1.3.1.3.1	Interface Preload	1) Stress analysis demonstrating positive margins of safety to required loading conditions. 2) Functional testing of capture claw mechanism to demonstrate proper preload applied. Verification shall be by analysis and test. The analysis and strength test shall show that the Attached Payload hardware will withstand a maximum preload of 6430 lbs from the PAS/UCCAS capture latch. A functional test shall show that the Attached Payload hardware when mounted on a simulated CAS active half, allows the active CLA to achieve and maintain a nominal preload of 5650 lbs ±5% applied to the payload passive PAS.	KSC	(I&T) Stress Report and Functional Test Report	Certificate of Compliance	2) Functional test of AMS-02 PAS performed at LMSO. Measured preload was ???? lbf. Results documented in test report.
I-30	SSP 57003	3.1.3.1.3.2	Interface Stiffness	Static testing of PAS to verify stiffness requirement. Verification shall be by test. Verification shall be considered successful when the test shows the Attached Payload interface stiffness meets the requirements of paragraphs 3.1.3.1.3.2.	JSC	(T) Test Report	Certificate of Compliance	Stiffness test of PAS unit measured capture bar stiffness of 13,602 lbf/in. Results documented in test report.
I-31	SSP 57003	3.1.3.2.1A	EVA Releasable and Removable Capture Bar	Review of design to confirm inclusion of capture bar release mechanism meeting requirements of SSP 30256:001. Verification shall be by inspection of the production drawings. Verification shall be considered successful when the inspection shows that an EVA releasable and removable capture bar is provided by the Attached Payload design and that all crew EVA interfaces associated with the operation, removal and reinstallation of the EVA releasable and removable capture bar are in accordance with SSP 30256:001.	JSC	(I) Drawing Review and QA Inspection	Certificate of Compliance	Review of drawing SEG39135815 confirms flight-releasable capture bar included in design.
I-32	SSP 57003	3.1.3.2.1B	EVA Releasable and Removable Capture Bar - Design	Review of design to confirm capture bar release mechanism meets requirements. Verification shall be by analysis. Verification shall be considered successful when the analysis shows that the design, location and tolerances are in accordance with SSP 57004.	JSC	(I) Drawing Review and QA Inspection	Certificate of Compliance	
I-33	SSP 57003	3.1.3.2.1C	EVA Releasable and Removable Capture Bar	1) Functional test using ACASS or flight hardware demonstrating removal and reinstallation of capture bar. 2) Thermal/vac testing to demonstrate removal and reinstallation of capture bar at thermal operational extremes. Verification shall be by test. Verification shall be considered successful when the Attached Payload shows by test using the Active Common Attach System Simulator (ACASS) that the maximum release dimension shown in Section 3.1.3.2.1 can be attained and that the bar may be subsequently removed and reinstalled.	JSC	(T) Functional Test Report	Certificate of Compliance	1) Functional test performed at KSC using actual PAS site on S3 truss segment. Capture bar was removed and reinstalled successfully.

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
I-34	SSP 57003	3.1.3.2.2A	Guide Pins	Review of design to confirm inclusion of guide pins. Verification shall be by test to verify that three guide pins for interfacing with the PAS/UCCAS guide vanes are provided by the Attached Payload design. Verification shall be considered successful when the test shows that the requirement of interfacing with the PAS/UCCAS guide vanes has been satisfied.	JSC	(T) Drawing Review	Certificate of Compliance	Three guide pins included in PAS Base Assembly. Review of drawing SEG39135816 confirms design requirement met.
I-35	SSP 57003	3.1.3.2.2B	Guide Pins	Review of design to confirm guide pins meet requirements of SSP 57004, Figure 3.1.2.2-1. Verification shall be by inspection of as-built hardware, fit check test, and by analysis. The inspection shall show that the Attached Payload guide pin design, location and dimensions are in accordance with SSP 57004 Figure 3.1.2.2−1. Analysis shall be performed to show that the positional tolerances between Guide Pins 1, 3, as noted in Figure 3.1.2.2−1 of SSP 57004, are maintained over the interface temperature range of –140°F to +166°F. Verification shall be considered successful when the inspection, test, and analysis shows that the design, location and tolerances are in accordance with SSP 57004.	JSC	(A&I&T) Drawing Review and QA Inspection	Certificate of Compliance	
I-36	SSP 57003	3.1.3.2.3A	Passive Umbilical Mechanism – Parts Selection	Review of design to confirm inclusion of passive UMA part# 1F70162-1. Verification shall be by analysis. Verification shall be considered successful when the analysis shows that the Attached Payload UMA configuration has provided the structural/mechanical interface to the PAS/UCCAS UMA part number 1F70162−1, or equivalent, to allow physical integration of the Attached Payload to a truss site.	JSC	(I) Drawing Review	Certificate of Compliance	
I-37	SSP 57003	3.1.3.2.3B	Passive Umbilical Mechanism –EVA Access	Review of design and stress analysis to confirm passive UMA meets requirements for EVA removal in SSP 50005, para 1.2.3. Verification shall be by analysis. Verification shall be considered successful when the analysis shows that the Attached Payload UMA configuration is accessible for manual EVA backup operations and EVA removal in accordance with SSP 50005, paragraph 12.3.	JSC	(A) Drawing Review and Stress Analysis	Certificate of Compliance	
I-38	SSP 57003	3.1.3.2.3.1A	Passive UMA Mounting	Review of design to confirm that passive UMA located per SSP 57004, Figure 3.1.2.2-1. Verification shall be by analysis and test. Verification shall be considered successful when the analysis shows that the passive UMA is located on the payload structure as defined in SSP 57004, Figure 3.1.2.2−1 and when the test shows that the Attached Payload structurally and mechanically interfaces with the passive UMA and allows physical integration of the PAS/UCCAS UMA passive and active halves.	JSC	(A&T) Drawing review and QA inspection	1. Preliminary Data Cert. based on static analysis using approved Finite Element Model (FEM) (or Design Coupled Loads (DCL) analysis results), providing the interface attach point forces and margins of safety calculations based on the allowable limits as specified 2. Final Data Cert. providing the interface attach point forces and margins of safety calculations based on the allowable limits as specified. (Attachment force can be obtained from the result of the Verification Coupled Loads (VCL)).	

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
I-39	SSP 57003	3.1.3.2.3.1B	Passive UMA Mounting – Loads	Stress analysis demonstrating passive UMA attachment points meet deflection requirements. Verification shall be by analysis. Verification shall be considered successful when the analysis shows that the AP/UCC Passive Half UMA mounting interface locations do not exceed the allocated displacements when subjected to the stated interface loads in Section 3.1.3.2.3.1.	JSC	(A) Deflection Analysis Memo	1. Data Cert. that provides a summary of the margins of safety for all SCS identified in accordance with SSP 52005 using design loads if the Design Loads Analysis (DLA) results are not available. 2. Data Cert. that provides a summary of the margins of safety for all SCS identified in accordance with SSP 52005 using loads validated by the verification loads analysis (VLA) results.	
I-40	SSP 57003	3.1.3.2.3.1C	Passive UMA Mounting – Temperature Range	Thermal analysis demonstrating hardware remains within design limits. Verification shall be by analysis. Verification shall be considered successful when the analysis shows that UMA passive half as mounted is maintained within its on-orbit operating temperature range. A passive UMA model, including thermal properties at the interface, shall be supplied by NASA.	JSC	(A) Thermal Analysis Report	Certificate of Compliance	
I-41	SSP 57003	3.1.3.2.6.1	Limit Quasi- Steady Accelerations	Structural analysis demonstrating no impulse is exerted by the payload to the ISS greater than 10 lbs–s (44.5 N–s) over any 10 to 500 second interval. as specified in paragraph 3.1.3.2.6.1. Forces produced by a payload below 0.01 Hz shall be verified by analysis against paragraph 3.1.3.2.6.1. This analysis shall be considered successful when it is shown that no impulse is exerted by the payload to the ISS greater than 10 lbs−s (44.5 N−s) over any 10 to 500 second interval.	JSC	(A) Microgravity Analysis Memo	Analysis Report	
I-42	SSP 57003	3.1.3.2.6.2.1	Vibratory Requirements	Structural analysis demonstrating AP interface forces less than the limits specified in para. 3.1.3.2.6.2.1 (used to limit force and moment transfers between frequencies of 0.01 to 300 Hz.)	JSC	(A or T) Microgravity Analysis Memo	Analysis or Test Report	
I-43	SSP 57003	3.1.3.2.6.2.2A	Transient Requirements	Structural analysis demonstrating AP impulse over any 10 second period is less than 10 lb s (44.5 N s) and the sum of the impulse and vibration resulting from the impulse do not exceed the vibratory limits of 3.1.5.2 over any 100 second period. Verification of maximum transient impulse shall be by analysis or test. Acceptable test methods are defined in SSP <TBD 4−1>, Appendix E. Verification shall be considered successful when the impulse delivered by an attached payload over any 10 second period is shown to be less than 10 lb s (44.5 N s) and when the sum of the impulse and vibration resulting from the impulse do not exceed the vibratory limits of paragraph 3.1.5.2 over any 100 second period. FEM time domain analysis is an acceptable verification method for this requirement as defined in paragraph 4.3.1.5.2. Acceleration or force response test data is acceptable if interface impedance considerations are included, including adjustment for possible modal frequency shift and interface structural amplification or attenuation.	JSC	(A or T) Microgravity Analysis Memo	Analysis or Test Report	

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
I-44	SSP 57003	3.1.3.2.6.2.2B	Transient Requirements	Structural analysis demonstrating AP maximum force at the AP/ISS interface is less than 1000 lb (4448 N) in any direction. The maximum force at the attached payload interface, as determined by either analysis or test, shall be less than 1000 lb (4448 N) in any direction. Rigid body analysis may be used if it can be shown that the rigid payload force to a rigid interface will not exceed 500 lb (2224 N). Otherwise, FEM payload analysis using a Payload Project Office supplied ISS model must be used to show that the flexible interface force will not exceed 1000 lb (4448 N).	JSC	(A or T) Microgravity Analysis Memo	Analysis or Test Report	
I-45	SSP 57003	3.1.3.2.6.3.1	Limit Induced ISS Attitude Rate	Structural analysis demonstrating AP angular momentum impulses do not exceed requirements. This requirement shall be verified by analysis. The analysis shall consist of a comparison of the calculated angular momentum impulse due to individual payload on-board disturbances to the per axis angular momentum allocations to verify that the allocations are not exceeded. The disturbance angular momentum impulse will normally be calculated as the integral of the disturbance torque relative to the ISS Assembly Complete center of mass over the specified period of time. For constant, continuously increasing, or continuously decreasing disturbance torques over two or more adjacent time periods, the difference in angular momentum impulse of the adjacent time periods should be used. Each attached payload source may be verified independently against the nine minute limit. Each attached payload shall be verified under worst-case combined source conditions against the two minute and ten second limits. ISS assembly complete mass properties and worst case element location/design parameters should be used when assessing compliance with this requirement. The verification shall be considered successful when analysis shows that the per axis disturbance angular momentum impulses are specified for each axis.	JSC	(A) Microgravity Analysis Memo	Analysis Report	
I-46	SSP 57003	3.1.3.2.6.3.2	Limit Disturbance Induced CMG Moment Usage	Structural analysis demonstrating AP angular momentum impulses do not exceed requirements. This requirement shall be verified by analysis utilizing analytical models of the disturbance. This analysis shall consist of calculating the angular momentum impulse for each axis due to individual payload on-board disturbances and applying them in the specified equation for estimating worst case CMG momentum usage. The disturbance angular momentum impulse will normally be calculated as the integral of the disturbance torque relative to the ISS Assembly Complete center of mass over the specified period of time. For constant, continuously increasing, or continuously decreasing disturbance torques over two or more adjacent 110 minute periods, the difference in angular momentum impulse of the adjacent 110 minute periods should be used. ISS assembly complete mass properties and worst case element location/design parameters (location and orientation producing the greatest H impulse vector with respect to the requirement of Table 3.1.3.2.6.3.2−1) should be used when assessing compliance with this requirement. The verification shall be considered successful when analysis shows that the estimated worst case CMG momentum usage is less than the specified amount.	JSC	(A) Microgravity Analysis Memo	Analysis Report	
I-47	SSP 57003	3.1.3.2.7	Contact Surfaces	Review of drawings to confirm inclusion of dry film lubricant and appropriate edge radii. Verification shall be by inspection of the production drawings to verify that the Attached Payload Capture Bar, Guide Pins and passive half platform subject to contact are coated with a dry film lubricant and provide a .25" minimum edge radius in accordance with SSP 57004.	JSC	(I) Review of drawings and QA inspection	Certificate of Compliance	
I-48	SSP 57003	3.2.2.1.1	Steady-State Voltage Characteristics	Functional test demonstrating compatibility with voltage limits. Verification of compatibility with steady-state voltage limits shall be performed by test at low and high input voltage values of 112.5 to 126 Vdc. The Attached Payload shall be operated under selected loading conditions that envelope operational loading. The verification shall be considered successful when the test shows under low and high voltage conditions the Attached Payload is compatible with the steady-state voltage limits of 112.5 to 126 Vdc. Verification may be performed by the Payload Rack Checkout Unit (PRCU) or NASA approved equivalent.		(T) Test Report	Certificate of Compliance	

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
I-49	SSP 57003	3.2.2.1.2.1	Ripple Voltage and Noise	01 test demonstrating AP is compatible with ripple voltage/noise requirements. Ripple voltage and noise requirements shall be verified by analysis. The verification shall be considered successful when the CS−01 test per SSP 30238, Space Station Electromagnetic Techniques, shows the Attached Payload operates and is compatible with the EPS time domain ripple voltage and noise level of at least 2.5 Vrms within the frequency range of 30 Hz to 10 kHz. Verification may be performed by the PRCU or equivalent.		(A or T)	Data Cert. Providing plot of input voltage vs. frequency	
I-50	SSP 57003	3.2.2.1.2.2	Ripple Voltage Spectrum	CS–01 and CS–02 tests demonstrating AP is compatible with the ripple voltage spectrum in Figure 3.2.2.1.2.2–1. Ripple voltage spectrum requirements shall be verified by Analysis. Verification shall be considered successful when analysis of the CS−01 and CS−02 test data per SSP 30238, generated as a result of paragraph 4.3.2.2.4 of this document, shows the Attached Payload at interface C is compatible with the ripple voltage spectrum in Figure 3.2.2.1.2.2−1 of this document.		(A or T)	Data Cert. Providing plot of input voltage vs. frequency	
I-51	SSP 57003	3.2.2.1.3.1	Normal Transient Voltages	Electrical analysis demonstrating AP compatibility with specified transient voltages across the transient envelope as specified in Figure 3.2.2.1.3.1–1. Transient voltages shall be verified by test or analysis. Input voltage shall be 112.5 Vdc and 126 Vdc with the Interface C source impedance, as specified in SSP 30482 Volume 1, Electric Power Specifications and Standards, Volume 1: EPS Electrical Performance Specifications. Verification of compatibility with the specified transient voltages shall be performed by test or analysis of the Attached Payload operation across the transient envelope as specified in Figure 3.2.2.1.3.1−1 of this document. The verification shall be considered successful when the test or analysis shows the Attached Payload is compatible with the EPS transient voltage characteristics as specified in Figure 3.2.2.1.3.1−1.		(A or T)	Certificate of Compliance	
I-52	SSP 57003	3.2.2.1.3.2	Fault Clearing and Protection	Safety analysis demonstrating AP does not produce an unsafe condition or one that could result in damage due to EPS transient voltages as specified in Figure 3.2.2.1.3.2–1. Fault clearing and protection shall be verified by analysis. The verification shall be considered successful when analysis shows the Attached Payload at Interface C does not produce an unsafe condition or one that could result in damage to ISS equipment or Attached Payload hardware from the EPS transient voltages as specified in Figure 3.2.2.1.3.2−1 of this document.	JSC	(A) Flight Safety Data Package	Certificate of Compliance	
I-53	SSP 57003	3.2.2.1.3.3A	Interface C Non-Normal Voltage Range - Overvoltage	Safety analysis demonstrating AP does not produce unsafe conditions to overvoltage of 165 VDC for up to 10 seconds. Verification of compatibility with maximum overvoltage conditions shall be performed by analysis. The analysis shall ensure the Attached Payload will not produce an unsafe condition or one that could result in damage to ISS equipment external to the Attached Payload when parameters are as specified in paragraph 3.2.2.1.3.3. The analysis should be performed with all converters directly downstream of Interface C. The verification shall be considered successful when analysis shows that Attached Payload is safe within ISS interface conditions as defined in paragraph 3.2.2.1.3.3.	JSC	(A) Flight Safety Data Package	Certificate of Compliance	
I-54	SSP 57003	3.2.2.1.3.3B	Interface C Non-Normal Voltage Range - Undervoltage	Safety analysis demonstrating AP does not produce unsafe conditions to undervoltage of 102 VDC. Verification of compatibility with undervoltage conditions shall be performed by analysis. The analysis shall ensure the Attached Payload will not produce an unsafe condition or one that could result in damage to ISS equipment external to the Attached Payload when parameters are as specified in paragraph 3.2.2.1.3.3. The analysis should be performed with all converters directly downstream of Interface C. The verification shall be considered successful when analysis shows the Attached Payload is safe within ISS interface conditions as defined in paragraph 3.2.2.1.3.3.	JSC	(A) Flight Safety Data Package	Certificate of Compliance	
I-55	SSP 57003	3.2.2.2.1A	Attached payload Connectors and Pin Assignments - Connector	Review of drawings to confirm proper connector used. Attached Payload to ISS Connectors shall be verified by inspection and demonstration. The verification shall be considered successful when an inspection of the Attached Payload specifications and drawings shows the Attached Payload connector plug is the Passive UMA connector NUR1−005 or NASA approved equivalent meets the requirements for this connector as specified in SSQ 21637.	JSC	(I&D) Drawing review and QA inspection	Certificate of Compliance	

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
I-56	SSP 57003	3.2.2.2.1B	Attached payload Connectors and Pin Assignments - Pin Assignments	Review of avionics design to demonstrate appropriate pin assignments and avionics terminations present. Pin Assignments shall be verified by inspection and demonstration. The verification shall be considered successful when an inspection of the Attached Payload specifications and drawings shows the Attached Payload connector plug is the Passive UMA connector NUR1−005 or NASA approved equivalent meet the pin assignments and avionics interface terminations as specified in the unique payload hardware ICD per SSP 57004 and demonstrates successful mating with the active UMA connector on the common attach system interface verification test article.	JSC	(I&D) Drawing review and QA inspection	Certificate of Compliance	
I-57	SSP 57003	3.2.2.2.2A	Power Bus Isolation – Independent Feeds	1) Electrical analysis demonstrating minimum isolation between power feeds. 2) Safety analysis demonstrating minimum isolation after any single failure Verification of Power Bus Isolation between two independent ISS Power feeds as specified, shall be performed by analysis. The verification shall be considered successful when the analysis shows the Attached Payload, with a source voltage of +126 Vdc, and its internal and external Attached Payload EPCE provides a minimum of 1−megohm isolation in parallel with not more than 0.03 microfarads of mutual capacitance between the two independent power feeds including both the supply and return lines and that no single failure shall cause the independent power feeds to be electrically tied.	JSC	(A) Flight Safety Data Package	Certificate of Compliance	
I-58	SSP 57003	3.2.2.2.2B	Power Bus Isolation – Diodes	Review of design to confirm no diodes used. Verification of power bus isolation without the use of diodes shall be verified by analysis. The analysis shall show the exclusion of diodes used to isolate the two independent ISS power bus high side or return lines. The verification shall be considered successful when analysis shows there are no diodes used to electrically tie together independent ISS power bus high side or return lines within the Attached Payload and its internal and external EPCE.	JSC	(A) Drawing review and QA inspection	Certificate of Compliance	
I-59	SSP 57003	3.3.2.2.2.3	Compatibility with soft Start/Stop Remote Power Controller	Functional test demonstrating AP compatibility with soft start/stop performance characteristics. Compatibility with soft start/stop RPCs shall be verified by test. Verification of initialization with soft start/stop performance characteristics shall be performed by test when the initial supply of power is provided to the equipment connected to the RPCs. Input power to the Attached Payload shall be delivered through a PRCU or equivalent. The Attached Payload connected to interface C shall be operated with multiple load combinations at levels ranging from 0% to 100% of the RPC rated conductivity. Verification may be performed by the PRCU or NASA approved equivalent.		(T)	Certificate of Compliance	
I-60	SSP 57003	3.2.2.2.4A	Surge Current – Amplitude	Electrical analysis demonstrating AP compatibility with surge current limits at high, nominal, and low input voltage values with range of power between 0 kilowatt (kW) to 3 kW at 112.5–126. Surge Current amplitude shall be verified by test and analysis. Input power to the Attached Payload should be representative of the ISS power environment. Verification of compatibility with Surge Current limits shall be performed by test at high and low input voltage values as specified. The power source used to perform the test shall be capable of providing a range of power between 0 kiloWatt (kW) to 3 kW at 112.5−126. The Attached Payload EPCE shall be operated under selected loading conditions that envelope operational loading. The analysis shall be performed using test data from the above test. The analysis shall indicate operability and compatibility exist based on test data and the requirements specified in paragraph 3.2.2.2.4. The verification shall be considered successful when test and analysis shows under high and low voltage conditions the Attached Payload can perform all functional capabilities and prove compatibility by operating within the specified limits of paragraph 3.2.2.2.4. Verification may be performed by the PRCU or NASA approved equivalent.		(A&T)	1. Analysis report including surge current profiles for Attached Payload configurations. 2. Test report	

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
I-61	SSP 57003	3.2.2.2.4B	Surge Current – Rate of Change	Electrical analysis demonstrating AP compatibility with surge current limits at high, nominal, and low input voltage values with range of power between 0 kilowatt (kW) to 3 kW at 112.5–126. Surge Current rate of current change shall be verified by test and analysis. Input power to the Attached Payload should be representative of the ISS power environment. Verification of compatibility with Surge Current limits shall be performed by test at high and low input voltage values as specified. The power source used to perform the test shall be capable of providing a range of power between 0 kW to 3 kW at 112.5−126. The Attached Payload EPCE shall be operated under selected loading conditions that envelope operational loading. The analysis shall be performed using test data from the above test. The analysis shall indicate that operability and compatibility exist based on test data and the requirements specified in paragraph 3.2.2.2.4. The verification shall be considered successful when test and analysis shows under high and low voltage conditions the Attached Payload can perform all functional capabilities and prove compatibility by operating within the specified limits of paragraph 3.2.2.2.4. Verification may be performed by the PRCU or NASA approved equivalent.		(A&T)	1. Analysis report including surge current profiles for Attached Payload configurations. 2. Test report	
I-62	SSP 57003	3.2.2.2.5.1	Reverse Current Limits	Electrical analysis demonstrating compliance with reverse current requirements. Reverse current limits requirements shall be verified by analysis. If the Attached Payload has aggregated input connected capacitance less than 25 micro−farads, no verification is required. Input power to the Attached Payload should be representative of the ISS power environment. Verification of compatibility with reverse current limits shall be performed by analysis. The input voltages prior to the occurrence of fault shall be 112.5 V and 126 V for Attached Payload connected to Interface C. The Attached Payload shall be analyzed under selected loading conditions that envelope operational loading. The verification will be considered successful when analysis shows that the Attached Payload complies with requirements defined in paragraphs 3.2.2.2.5.1 for the reverse current into the upstream power source.		(A)	Data Cert. comparing worst case reverse current and potential reverse current case conditions to allowables in SSP 57003, Figures 3.2.2.2.5.1-1, 2 & 3.	
I-63	SSP 57003	3.2.2.2.5.2	Transients Partially Contained within the Envelope	If the Attached Payload meets the requirements in paragraph 3.2.2.2.5.1, no verification is required. If the reverse current exceeds the envelope limits defined in paragraph 3.2.2.2.5.1 for one or more short time intervals, the requirement for reverse current transients partially contained within the envelope shall be verified by analysis. The verification will be considered successful when analysis shows that the Attached Payload complies with requirement defined in paragraphs 3.2.2.2.5.2 for the reverse current exceeding the envelope limits defined in paragraph 3.2.2.2.5.1 for one or more short time intervals.		(A)	Data Cert. comparing worst case reverse current and potential reverse current case conditions to allowables in SSP 57003, Figures 3.2.2.2.5.1-1, 2 & 3.	
I-64	SSP 57003	3.2.2.2.6.1A	ISS EPS Circuit Protection Characteristics – RPC	Electrical analysis demonstrating initial AP current flow does not exceed the current magnitude/and duration defined in Figure 3.2.5–1 of SSP 57004. Analysis of the test data required by paragraph 4.3.2.2.2.4 shall be performed to show the Attached Payload connected to an Interface C electrical interface operates and is compatible with the characteristics shown and described in Figure 3.2.5−1 of SSP 57004, with the exception that the Auxiliary USL current-limiting and trip curve in Figure 3.2.5−1 applies to both the power feeds at S3/P3 Attach site locations. The analysis shall be performed at initiation of power to the Attached Payload and with multiple internal load combinations. The verification shall be considered successful if the analysis results show the initial current flow, when powered on, to the Attached Payload and current flow during the Attached Payload operations with multiple internal load does not exceed the current magnitude and duration as defined and described in Figure 3.2.5−1 of SSP 57004, with the exception that the Auxiliary USL current-limiting and trip curve in Figure 3.2.5−1 applies to both the power feeds at S3/P3 Attach site location.		(A)	Certificate of Compliance	

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
I-65	SSP 57003	3.2.2.2.6.1B	ISS EPS Circuit Protection Characteristics – Overcurrent Protection	Review of design to confirm overcurrent protection exists at all points in electrical architecture system where power is distributed to lower level feeder and branch lines. Analysis of electrical circuit schematics shall be performed to show overcurrent protection exists at all points in the Attached Payload electrical architecture system where power is distributed to lower level (wire size not protected by upstream circuit protection device) feeder and branch lines. The analysis shall be considered successful when results show overcurrent protection exists at each point in the Attached Payload electrical architecture system where power is distributed to lower level (wire size) feeder and branch lines.	JSC	(A) Drawing review and QA inspection	Certificate of Compliance	
I-66	SSP 57003	3.2.2.2.6.2	Attached Payload Trip Ratings	Electrical analysis demonstrating overcurrent which trips circuit protection in a downstream device will not also trip the protection device upstream. The Attached Payload Trip Ratings shall be verified by analysis. Input power to the Attached Payload shall be representative of the ISS power environment. The analysis shall be performed as specified in Figure 3.2.5−1 of SSP 57004, with the exception that the Auxiliary USL current-limiting and trip curve in Figure 3.2.5−1 applies to both the power feeds at S3/P3 Attach site location. The verification shall be considered successful when analysis of the Attached Payload shows that the overcurrent which trips the circuit protection in a downstream device will not also trip the protection device upstream.		(A)	Certificate of Compliance	
I-67	SSP 57003	3.2.2.2.7	Interface C Attached Payload Complex Load Impedances	Functional test demonstrating all load impedances measured for high and low voltage conditions remain within limits defined in Figures 3.2.2.2.7-1 and 3.2.2.2.7-2. Attached Payload load impedance shall meet the amplitude and phase requirements as specified in Figure 3.2.2.2.7−1 and 3.2.2.2.7−2. If downstream devices can be shown to have negligible effect on load impedance magnitude and phase, or be realistically simulated by passive devices, then simulated loads may be used as downstream devices for test. Load impedance shall be tested under conditions of high and low voltage to the integrated Attached Payload system. The active converters directly downstream shall also be exercised through the complete range of their loading. Selected combinations of converters that can influence the measured load impedance at Interface C shall be tested. The verification shall be considered successful when the test shows that all load impedances measured for high and low voltage conditions remain within specified limits identified by Note 1 in Figures 3.2.2.2.7−1 and 3.2.2.2.7−2.		(T)	Test Report	
I-68	SSP 57003	3.2.2.2.8	Large Signal Stability	Functional testing demonstrating large input signals damped per the requirement. Large signal stability shall be verified by test and analysis. A large signal stability test shall be conducted for the Attached Payload connected to Interface C. An integrated analysis shall be provided for representative maximum and minimum power loading to demonstrate that impedance variations will not impact system stability. The input and transient response waveform for the Attached Payload shall be recorded from the start of the pulse through the time when the transient diminishes to and remains below 10 percent of the maximum amplitude of the response. The required test conditions may be produced using a programmable power source or the test configuration shown in Figure 4.3.2.2.2.8−1, Stability Test Setup, Transient Responses. The 25 amp ISS Line Impedance Simulation Network (LISN) or equivalent shown in Figure 4.3.2.2.2.8−2, International Space Station Line Impedance Simulation Network, will be used. The pulse generator/amplifier must provide a source impedance of less than 0.2 ohms from 100 Hz to 10 kHz to the 2 ohm load of the primary side of the pulse transformer. Pulses of 100, 125 and 150 microsecond (□□10 microsecond) duration shall be applied. The pulse amplitude at the secondary side of the injection transformer should be between 10 and 15 Volts. Pulse rise and fall times must not exceed 10 microseconds between 10 and 90 percent of the pulse amplitude. The resulting transient responses must remain within the EPS normal transient limits. The test and analysis shall be considered successful when results show transient responses, measured at the input to the Attached Payload, diminish to 10 percent of the maximum amplitude within 1.0 milliseconds and remain below 10 percent thereafter.		(T&A)	Test report showing compliance with the Unique Payload Hardware ICD Analysis Data	

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
I-69	SSP 57003	3.2.2.3.1	Wire Derating	Review of electrical analysis demonstrating appropriate wire derating factors used. Wire Derating shall be verified by analysis. Analysis of the Attached Payload electrical power schematics shall be performed in accordance with derating criteria for loads downstream of the APPI per NASA TM 102179, as interpreted by NSTS 18798, and TA−92−038. The verification shall be considered successful when the analysis shows the Attached Payload to ISS power interface or Attached Payload EPCE meets Wire Derating requirement as specified in paragraph 3.2.2.3.1.		(A)	Certificate of Compliance	
I-70	SSP 57003	3.2.2.3.2	Exclusive Power Feeds	Review of design to confirm payload has no capability of drawing power from other attach sites. The Attached Payload design with exclusive power feeds shall be verified by demonstration and inspection. The demonstration shall be considered successful when the result shows each individual Attached Payload will be provided power from its dedicated Attached Payload to ISS power interface location and no intra−site cabling exists. The inspection shall be considered successful when the result shows each individual S3/P3 attach site input power cabling will interface to a dedicated Attached Payload to ISS power interface and no cabling from external source(s) exists.	JSC	(D&I) Drawing review	Certificate of Compliance	
I-71	SSP 57003	3.2.2.3.3	Loss of Power	Safety analysis demonstrating AP meets the loss of power safety requirements specified in NSTS 1700.7 ISS Addendum. Verification that the Attached Payload equipment connected to Interface C meets the loss of power safety requirements specified in NSTS 1700.7B, Safety Policy and Requirements for Payloads using the International Space Station, ISS Addendum shall be performed and submitted to the PSRP in accordance with NSTS/ISS 13830, Payload Safety Review and Data Submittal Requirements for Payloads using the Space Shuttle and International Space Station. Verification shall be considered successful when hazard reports and safety data presented to the PSRP during the phased safety reviews are approved.	JSC	(Safety) Flight Safety Data Package	Certificate of Compliance	
I-72	SSP 57003	3.2.2.4	EMC	EMC testing demonstrating compliance with SSP 30243, paras 3.1 and 3.6.2. The requirements of SSP 30243, paragraphs 3.1 and 3.6.2 shall be verified by test and analysis. The test shall be considered successful when results show the Attached Payload connected to Interface C meet the requirements specified in SSP 30243 paragraph 3.6.2. The results of the EMC test shall be documented in the EMC test plan/report. The analysis shall be documented in an EMC Control Plan and Design Analysis Report. The analysis shall include determining the necessary requirements for equipment not connected directly to Interface C such that the entire payload meets the EMC requirements of this IRD. The analysis shall be considered successful when results show that requirements defined in paragraph 3.1 of SSP 30243 have been met. Note: A. The Control Plan and the Design Analysis Report can be combined into one document per payload provider format. B. Clarifications to SSP 30243, paragraph 3.6.2: • Only the impedance characteristics of the power source need to simulated • Only representative simulated signals and loads for the interface tests are required • Verification of the On-Orbit configuration of the integrated rack may be performed analytically if and only if the On-Orbit configuration differs from the Qualification Test configuration C. If analysis shows requirements of paragraph 3.6.2 of SSP 30243 are met during Attached Payload EMI testing, as specified in paragraph 3.2.2.4 of this document, a separate EMC test plan/report is not needed.	ESTEC	(T&A) EMI/EMC Test Report	Test Report (Results must be provided for each configuration in the worst-case operational modes. The report should include the test configuration/layout (including cables), photographs of the test configuration, and a description of testing equipment.)	

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
I-73	SSP 57003	3.2.2.4.1	Electrical Grounding	1) Review of design to confirm AP grounding meets requirements in SSP 30240. 2) QA inspection to verify grounding characteristics of as-built hardware. The Electrical Grounding of the Attached Payload EPCE shall be verified by test and analysis. The test shall be considered successful when the results show that Attached Payload grounding is in compliance with the requirements in Section 3 of SSP 30240. The analysis shall be based on end item qualification data and Attached Payload EPCE design and analysis data. The analysis shall be considered successful when the data shows the Attached Payload EPCE is electrically grounded within the requirements of Section 3 of SSP 30240.	CERN	(T&A) Design review and QA inspection	Analysis report showing (A.) compliance of actual grounding (based on end item qualification test data) versus grounding design philosophy (in Design Analysis Report), and (B.) the compliance with SSP 30242.	
I-74	SSP 57003	3.2.2.4.2	Electrical Bonding	1) Review of design to confirm AP bonding meets requirements in SSP 30245 and NSTS 170.7B, ISS Addendum, paras 213 and 220. 2) QA inspection to verify bonding characteristics of as-built hardware. The Electrical Bonding of the Attached Payload EPCE shall be verified by Test, Analysis and Inspection. The test shall be considered successful when the results show the requirements of SSP 30245 and the requirements of NSTS 1700.7B ISS Addendum in sections 213 and 220 are met. The analysis shall be based on end item qualification data and Attached Payload EPCE design and analysis data. The analysis shall be considered successful when the data shows the Attached Payload EPCE is electrically bonded within the requirements of SSP 30245 and the requirements of NSTS 1700.7B ISS Addendum in sections 213 and 220 are met. The inspection shall be based on the Attached Payload EPCE design drawings and any applicable analysis and test reports. The inspection shall be considered successful when the requirements of SSP 30245 and the requirements of NSTS 1700.7B ISS Addendum in sections 213 and 220 are met. The class R bond at the Guide Pin to Guide Vane interface shall be verified by Analysis. The analysis shall include a review of Attached Payload design drawings, design and analysis data and any applicable test data. The analysis shall be considered successful when the data shows that the Attached Payload Guide Pins meet the material and surface preparation/finish requirements of SSP 30245, paragraphs 3.2.1.2, 3.3.4, 3.3.5 and 3.3.6, the Guide Pin dimensions meet the requirements of SSP 57004, Figure 3.1.2.2−1 and the Attached Payload PAS interface stiffness meets the requirement specified in paragraph 3.1.3.1.3.2 of this document. Note: An Attached Payload interface meeting these requirements is considered capable of achieving a class R bond at the Guide Pin to Guide Vane interface based on the results of the CAS Interface Class R Bonding Test documented in test report MDC 02H1044, Common Attach System (CAS) Interface Class R Bonding Test Report.	CERN	(T&A&I) Design review and QA inspection	1. Test report showing compliance with SSP 30245 and NSTS 1700.7B/ISS, 213 and 220. 2. Analysis report showing compliance with SSP 30245, NSTS 1700.7B/ISS, 213 and 220, and the Unique Payload Hardware ICD. 3. Certificate of Compliance for inspection	
I-75	SSP 57003	3.2.2.4.3	Cable/Wire Design and Control Requirements	Review of design to demonstrate compliance with cable and wire design requirements. The Cable and Wire Design of the Attached Payload EPCE external cables shall be verified by Test, Analysis, or Inspection. The test shall be considered successful when the results show all requirements of SSP 30242 are met. The analysis shall be based on Attached Payload design and analysis data. The analysis shall be considered successful when the results show all requirements of SSP 30242 are met. The inspection shall be based on physical/visual indications of the Attached Payload EPCE. The inspection shall be considered successful when physical/visual indications show that external cable and wire design is in compliance with the requirements can normally be met by inspection of drawings and hardware. Analysis is required to determine impedance and sensitivity characteristics of the circuit when classification cannot be determined by examination of the circuit known characteristics. Note: SSP 30242 harness requirements can normally be met by inspection of drawings and hardware. Analysis is required to classify signals and determine the necessary isolation between signals. Test may be required to determine impedance and sensitivity characteristics of the circuit when classification cannot be determined by examination of the circuit known characteristics.	JSC	(A&T or A&I) Drawing review and QA inspection	Analysis report showing (A.) compliance of actual grounding (based on end item qualification test data) versus grounding design philosophy (in Design Analysis Report), and (B.) the compliance with SSP 30242.	

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
I-76	SSP 57003	3.2.2.4.4	EMI	EMI testing demonstrating compliance with requirements The Electromagnetic Interference of the Attached Payload EPCE shall be verified by test and analysis. Tests shall be performed and data submitted for conducted susceptibility and radiated susceptibility, in addition to that for conducted emissions and radiated emissions. This data shall be evaluated against the limits of SSP 30237. The test shall be considered successful when the tests are performed using SSP 30238 and the results show requirements of SSP 30237 are met by the Attached Payload. The test results shall be documented in the EMI test plan/report. The analysis of each Attached Payload to ISS power interface shall be performed using equipment test data as mentioned in the above paragraph. The analysis shall be considered successful when the results show requirements of SSP 30237 are met by the Attached Payload. This analysis includes evaluating the degree of isolation from 30 Hz to 400 MHz provided by the Attached Payload EPCE for power ripple and transients to the equipment using isolated power. An analysis of the isolation in conjunction with the equipment conducted requirements should be submitted in the EMC analysis report to verify the requirements of this IRD are met.	ESTEC	(T&A) EMI/EMC Test Report	Test Report (Results must be provided for each configuration in the worst-case operational modes. The report should include the test configuration/layout (including cables), photographs of the test configuration, and a description of testing equipment.)	
I-77	SSP 57003	3.2.2.4.5B	ESD	Electrical analysis demonstrating no hardware vulnerable to ESD. The labeling of unpowered Attached Payload EPCE shall be verified by inspection. The inspection shall be considered successful when physical/visual indications show the labeling of Attached Payload EPCE susceptible to ESD up to 15000 V is in accordance with MIL−STD−1686.		(I)	Certificate of Compliance	
I-78	SSP 57003	3.2.2.4.6	AC Magnetic Fields	Review of design to demonstrate no AC magnetic fields generated. The AC magnetic fields requirement for payload equipment as defined in paragraph 3.2.4.6 shall be verified by test. Tests shall be performed using the MIL−STD−462D RE101 method with the following modifications: A. Test setup guidelines shall be per SSP 30238, Figure 3.2.3.1.4−1 or 3.2.3.1.4−2, not the setup identified by MIL−STD−462D. B. Guidelines of SSP 30238, Figure 3.2.3.1.4−1 and 3.2.3.1.4−2, requirement of 1 meter separation does not apply to RE101. C. Measurements are required from 30 Hz to 50 kHz rather than 100 kHz required by MIL−STD−461D. D. Measurements are performed at 7 cm from the enclosure of the generating equipment nearest the source of the field. In the event emissions are out-of-specification, measurements shall be performed at 10 cm from a point on the enclosure of the generating equipment nearest the source of the field and at 10 cm increments away from a point on the enclosure of the generating equipment nearest the source of the field until data proves the AC magnetic fields are 6dB less than the requirement in paragraph 3.2.2.4.6. E. Emissions greater than 20 dB below the specified limits shall be recorded in the EMI test report. In cases where the noise floor and ambient are not 20 dB below specified level, only those emissions above the noise floor/ambient are required to be recorded. The verification shall be considered successful when test results show the generated AC magnetic fields do not exceed the magnetic fields emission limits of paragraph 3.2.2.4.6. Note: Requirements are not applicable to solenoid valves, solenoid relays, and electric motors with current of less than 1 Amp.	JSC	(T) Drawing review	Test Report (emissions greater than 20 dB below specified limits will be recorded in the EMI test report. In cases where the noise floor and ambient are not 20 dB below specified level, only those emissions above the noise floor/ambient are required to be recorded.)	

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
I-79	SSP 57003	3.2.2.4.7	DC Magnetic Fields	Magnetic field analysis demonstrating AP DC magnet field within required limits The DC Magnetic fields requirement for payload equipment as defined in 3.2.2.4.7 shall be verified by test. The measurement of DC magnetic fields shall be performed at 7 cm from a point on the enclosure of the generating equipment nearest the source of the field. For Attached Payloads and equipment that exceed the design requirement of paragraph 3.2.2.4.7, measurements shall be performed at 10 cm from a point on the enclosure of the generating equipment nearest the source of the field and at 10 cm increments away from a point on the enclosure of the generating equipment nearest the source of the field until data proves the DC magnetic fields are less than 164 dBpT. The verification shall be considered successful when test results show the generated DC magnetic fields do not exceed the design requirement of paragraph 3.2.2.4.7. A certificate of compliance stating the DC magnetic field does not exceed the design requirement will be sufficient for equipment that meets the requirement. Note: Requirements are not applicable to solenoid valves, solenoid relays, and electric motors with power consumption of less than 120 Watts.	JSC	(T) Magnetic Field Analysis Memo	Test Report (a tabular listing of each magnetic field measurement, distance from the Experiment Under Test (EUT), and mode of EUT operation.)	Exception E6 of SSP 57213
I-80	SSP 57003	3.2.2.4.8	Corona	Safety analysis to demonstrate proper controls for all high-voltage hardware susceptible to damaging corona effects. Attached Payload equipment with voltages (steady−state, transient, internal, or external) greater than 190 volts shall be verified by test to the degree necessary to ensure no permanent damaging effects and no hazardous conditions due to destructive corona will exist in the partial pressure environment above 1.93E−05 pounds per square inch absolute (psia) (1.0E−03 Torr). The fault clearing and protection transient voltage limits defined in paragraph 3.2.2.1.3.2−1 is not considered the equipment voltage.	JSC	(T) Flight Safety Data Package	1. A report on test results and an analysis showing compliance during functional testing. 2. Test Report and detailed analysis for items requiring more detailed corona test (if any).	Coronal discharges addressed as Cause 3 of Hazard Report 8.
I-81	SSP 57003	3.2.5.1	Payload Electrical Safety	Safety analysis demonstrating compliance with electrical safety requirements. Verification of this requirement shall be by inspection of the JSC Radio Frequency Authorization approval form from the NASA JSC Frequency Spectrum Manager, which provides approval for the payload's frequency range and power levels for radiating and/or receiving signals. Verification shall be considered successful when the inspection of the JSC Radio Frequency Authorization approval form shows frequency approval for the use of the specified frequency band. Note: Attached Payload still must meet the EMI Radiation Emissions requirement per SSP 30237 outside the intentional radiating frequency band.	JSC	(A) Flight Safety Data Package	Certificate of Compliance	
I-82	SSP 57003	3.2.2.5.1.1	Mating/Demating of powered connectors	Safety analysis demonstrating compliance with powered connector safety requirements. Verification shall be by analysis. The analysis showing that the Attached Payload meets the requirements of NSTS 1700.7B ISS Addendum shall be submitted to the PSRP in accordance with NSTS 13830. Verification shall be considered successful when hazard reports and safety data presented to the PSRP during the phased reviews are approved.	JSC	(Safety) Flight Safety Data Package	Certificate of Compliance	Causes and controls of hazards associated with mating and demating of connectors addressed as Hazard Report 12.
I-83	SSP 57003	3.3.1	C&DH Interface with Mobile Servicing System	Program office review to confirm that AMS-02 does not require C&DH services while on the MCAS. Verification of the Attached Payload interface to the UMA shall be by test. Verification shall be considered successful when the test shows that the Attached Payload can transmit and receive data from the ISS in accordance with SSP 42004, paragraph B3.2.2.6.	JSC	(T) APO Review	Certificate of Compliance	Program office confirms that AMS-02 nominal operational profile does not include transfer on the MCAS. Program office would not ask for C&DH services while on MCAS during a hypothetical contingency operation.
I-84	SSP 57003	3.3.2.1.1	Word/Byte Notations	1) Review of AP software IC D to confirm proper use of word/byte notation. 2) Functional test of AP telemetry confirming proper use of word/byte notations. Verification of the Attached Payload word/byte notations shall be by inspection and test. The inspection shall consist of a review of the word/byte notations in the unique payload software ICD and should be considered successful when it is shown that the word/byte notations used in that ICD conform with paragraph 3.1.1 of this IRD, Notations of SSP 52050. Verification shall be considered successful when the AP communicates on the required telemetry links with the PRCU, Suitcase Test Environment for Payloads (STEP), or equivalent.		(I&T)	Certificate of Compliance	

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
I-85	SSP 57003	3.3.2.1.2	Data Types	Review of AP software ICD to confirm appropriate data types used. Verification of the Attached Payload data types shall be by inspection. The inspection shall consist of a review of the data types against paragraph 3.2.1 of this IRD and subparagraphs, Data Formats, of SSP 52050. Verification shall be considered successful when it is shown that the data types in the unique Attached Payload software ICD conforms with paragraph 3.2.1 of this IRD and subparagraphs, Data Formats, of SSP 52050.		(I)	Certificate of Compliance	
I-86	SSP 57003	3.3.2.1.3A	Data Transmissions – LRDL	Review of AP software ICD to confirm appropriate data transmission order. Verification of the LRDL transmissions shall be by inspection. The inspection shall consist of a review of the LRDL data transmissions against paragraph 3.4, Non-Signal Data Coding Standards, of D684−10056−01. Verification shall be considered successful when it is shown that the word/byte notations in the unique payload software ICD conforms with SSP 52050, paragraph 3.1.2 and paragraph 3.4 and the Non-Signal Data Coding Standards, of D684−10056−01.		(I)	Certificate of Compliance	
I-87	SSP 57003	3.3.2.1.3B	Data Transmissions – HRDL	Review of AP software ICD to confirm appropriate data transmission order. Verification of the HRDL transmissions shall be by inspection. The inspection shall consist of a review of the HRDL data transmissions against paragraph 1.6, Bit Numbering Convention and Nomenclature, of CCSDS 701.0−B−2. Verification shall be considered successful when it is shown that the word/byte notations in the unique payload software ICD conforms with SSP 52050, paragraph 3.4.1 and paragraph 1.6, Bit Numbering Convention and Nomenclature, of CCSDS 701.0−B−2.		(I)	Certificate of Compliance	
I-88	SSP 57003	3.3.2.2.1A	Consultative Committee for Space Data Systems Data Ku-Band	Review of AP software ICD to confirm use of CCSDS data packets. Verification of the Attached Payload CCSDS data that is transmitted from space to ground shall be by analysis or test. The analysis shall consist of a review of the CCSDS data in the software design documentation. The test shall consist of a data transmission with the PRCU, STEP, or equivalent and inspection of the transmitted data against the SSP 52050 formats. Analysis shall be considered successful when it is shown that in the software design documentation the Attached Payload data which is transmitted space to ground is CCSDS data packet format. Test shall be considered successful when the PRCU, STEP or equivalent correctly receives the Attached Payload CCSDS data.		(A or T)	Certificate of Compliance	
I-89	SSP 57003	3.3.2.2.1B	Consultative Committee for Space Data Systems – Data	Review of AP software ICD to confirm use of CCSDS data packets. Verification of the Attached Payload CCSDS data that is transmitted ground to space or from the S3/P3 Attach Sites to the Payload MDM shall be by analysis or test. The analysis shall consist of a review of the CCSDS data in the software design documentation. The test shall consist of a data transmission with the PRCU, STEP, or equivalent and inspection of the transmitted data against the SSP 52050 format. Analysis shall be considered successful when it is shown that in the software design documentation the Attached Payload data which is transmitted ground to space or from the S3/P3 attach sites to the payload MDM are CCSDS data packets. Test shall be considered successful when the PRCU, STEP, or equivalent correctly receives the Attached Payload CCSDS data.		(A or T)	Certificate of Compliance	
I-90	SSP 57003	3.3.2.2.1.1	Consultative Committee for Space Data Systems Data Packets	1) Review of AP software ICD to confirm use of CCSDS data packets. 2) Functional test of data transmission demonstrating correct receipt of data packet. Verification of the Attached Payload CCSDS data packet shall be by inspection and test. Inspection shall be considered successful when it is shown that the CCSDS data packets in the unique Attached Payload software ICD conform with SSP 52050 and SSP 57002. Test shall be considered successful when the PRCU, STEP, or equivalent correctly receives the Attached Payload CCSDS data packets.		(I&T)	Certificate of Compliance	
I-91	SSP 57003	3.3.2.2.1.1.1	Consultative Committee for Space Data Packet Data Systems Primary Header	Functional test of data transmission demonstrating correct receipt of data packet. Verification of the Attached Payload CCSDS primary header shall be by inspection and test. The test shall consist of a data transmission with the PRCU, STEP, or equivalent and inspection of the transmitted data against the SSP 52050 formats. Test shall be considered successful when the PRCU, STEP, equivalent correctly receives the Attached Payload CCSDS primary header.		(I&T)	Certificate of Compliance	

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
I-92	SSP 57003	3.3.2.2.1.1.2A	Consultative Committee for Space data Systems Data Secondary Header	Functional test of data transmission demonstrating correct receipt of data packet. Verification of the Attached Payload CCSDS secondary header shall be test. The test shall consist of a data transmission with the PRCU, STEP, or equivalent and inspection of the transmitted secondary header immediately following the CCSDS primary header. Test shall be considered successful when the PRCU, STEP, or equivalent correctly receives the Attached Payload CCSDS secondary header.		(I&T)	Certificate of Compliance	
I-93	SSP 57003	3.3.2.2.1.1.2B	Consultative Committee for Space data Systems Data Secondary Header	Functional test of data transmission demonstrating correct receipt of data packet. Verification of the Attached Payload CCSDS secondary header shall be by test. The test shall consist of a data transmission with the PRCU, STEP, or equivalent and inspection of the transmitted data against the SSP 52050 formats. Test shall be considered successful when the PRCU, STEP, or equivalent correctly receives the Attached Payload CCSDS secondary header.		(I&T)	Certificate of Compliance	
I-94	SSP 57003	3.3.2.2.1.2	Consultative Committee for Space Data Systems Data Field	Functional test of data transmission demonstrating correct receipt of data packet. Verification of the Attached Payload CCSDS data field shall be by test. The test shall consist of a data transmission with the PRCU, STEP, or equivalent and inspection of the transmitted data against the SSP 52050 formats. Test shall be considered successful when the PRCU, STEP, or equivalent correctly receives the Attached Payload CCSDS data field.		(T)	Certificate of Compliance	
I-95	SSP 57003	3.3.2.2.2.1	Consultative Committee for Space Data Systems Unsegmented Time	Functional test of data transmission demonstrating correct receipt of data packet. Verification of the Attached Payload CCSDS unsegmented time shall be by test. The test shall consist of a data transmission with the PRCU, STEP, or equivalent and inspection of the transmitted data against the SSP 52050 formats. Verification shall be to test with the PRCU, STEP or equivalent, for correct test CCSDS unsegmented time at the UMA.		(T)	Certificate of Compliance	
I-96	SSP 57003	3.3.2.3A	MIL-STD-1553 Low Data Rate Link – Single RT	Review of design demonstrating single RT used in design Verification of the Attached Payload MIL−STD−1553 LRDL shall be by inspection. Inspection shall be considered successful when it is shown that there is a single MIL−STD−1553 Remote Terminal to the payload unique MIL−STD−1553 bus.	JSC	(T) Drawing Review	Certificate of Compliance	
I-97	SSP 57003	3.3.2.3B	MIL-STD-1553 Low Data Rate Link – Address	1) Review of software ICD to confirm appropriate format used for RT bus addresses. 2) Functional test demonstrating correct data transmission through LRDL. Verification of the Attached Payload MIL−STD−1553 LRDL bus address shall be by inspection and test. Inspection shall be considered successful when it is shown that the MIL−STD−1553 LRDL in the unique Attached Payload software ICD conforms with SSP 50193. Test shall be considered successful when the PRCU, STEP, or equivalent correctly receives the Attached Payload data over the MIL−STD−1553 LRDL.		(I&T)	Certificate of Compliance	
I-98	SSP 57003	3.3.2.3.1	MIL-STD-1553 Protocol	1) Review of software ICD to confirm transmission meets MIL-STD-1553B requirements. 2) Functional test demonstrating correct data transmission through LRDL. Verification shall be by inspection and test. Inspection shall be considered successful when it is shown that the MIL−STD−1553 protocol conforms with SSP 52050. Test shall be considered successful when the PRCU, STEP, or equivalent correctly receives the Attached Payload data over the MIL−STD−1553.		(I&T)	Certificate of Compliance	
I-99	SSP 57003	3.3.2.3.1.1A	Standard Messages	1) Review of software ICD to confirm appropriate format used for standard messages. 2) Functional test demonstrating correct data transmission through LRDL. Verification of the Attached Payload standard messages shall be by inspection and test. The inspection shall consist of a review of the CCSDS data packets against paragraph 3.1.3, CCSDS Formats, of SSP 52050. The test shall consist of a data transmission with the PRCU, STEP, or equivalent and inspection of the transmitted data against the SSP 52050 format. Inspection shall be considered successful when it is shown that the CCSDS data packets in the unique Attached Payload software ICD conform with paragraph 3.1.3, CCSDS Formats, of SSP 52050. Test shall be considered successful when the PRCU, STEP, or equivalent correctly receives the Attached Payload CCSDS data packets.		(I&T)	Certificate of Compliance	

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
I-100	SSP 57003	3.3.2.3.1.1B	Standard Messages – Subaddresses	1) Review of software ICD to confirm appropriate format used for standard messages. 2) Functional test demonstrating correct data transmission through LRDL. Verification of the Attached Payload subaddress assignments for standard messages shall be by inspection and test. Inspection shall be considered successful when it is shown that the CCSDS data packets in the unique Attached Payload software ICD conform with Table 3.2.3.2.1.4−1 of SSP 52050. Tests shall be considered successful when the PRCU, STEP or equivalent correctly receives the Attached Payload CCSDS data packets.		(I&T)	Certificate of Compliance	
I-101	SSP 57003	3.3.2.3.1.2A	Commanding	1) Review of software ICD to confirm appropriate format used for AP commands. 2) Functional test demonstrating correct data transmission through LRDL. Verification of Attached Payload commanding shall be by inspection and test. Inspection shall be considered successful when it is shown that the command in the unique Attached Payload software ICD conforms with SSP 52050 and SSP 57002. Test shall be considered successful when the PRCU, STEP, or equivalent correctly receives the Attached Payload commanding.		(I&T)	Data Cert providing transmitted commands and received messages.	
I-102		3.3.2.3.1.2B	Commanding – Subaddresses	1) Review of software ICD to confirm appropriate subaddress assignments used for AP commands. 2) Functional test demonstrating correct data transmission through LRDL. Verification of the Attached Payload subaddress assignments for commands shall be by inspection and test. Inspection shall be considered successful when it is shown that the CCSDS data packets in the unique Attached Payload software ICD conform with Table 3.2.3.2.1.4−1 of SSP 52050. Tests shall be considered successful when the PRCU, STEP, or equivalent correctly receives the Attached Payload CCSDS data packets.		(I&T)	Certificate of Compliance	
I-103	SSP 57003	3.3.2.3.1.3A	Heath and Status Data	Review of software IC D to confirm AP health and status data included per requirements of SSP 52050, para. 3.2.3.5. Verification of the Attached Payload health and status data shall be by analysis. The analysis shall be considered successful when it shows that the requirements of SSP 52050 have been met.		(A)	Certificate of Compliance	
I-104	SSP 57003	3.3.2.3.1.3B	Heath and Status Data – Format	Review of software IC D to confirm AP health and status data uses data field format defined in SSP 57002, Table A-5. Verification of the Attached Payload health and status data field format shall be by inspection. The inspection shall be considered successful when it shows the format is developed in accordance with SSP 57002.		(I)	Certificate of Compliance	
I-105	SSP 57003	3.3.2.3.1.3C	Heath and Status Data – Response	Functional test demonstrating AP responds to health status poll from payload MDM. Verification of the Attached Payload health and status data response to the payload MDM shall be by test. The test shall be considered successful when the PRCU, STEP, or equivalent correctly receives the health and status data from the Attached Payload.		(T)	Certificate of Compliance	
I-106	SSP 57003	3.3.2.3.1.5	Service Requests	1) Review of software ICD to confirm that service requests meet the requirements of SSP 52050, para 3.2.3.7. 2) Functional test demonstrating service requests transmitted correctly. Verification of the Attached Payload service requests shall be by inspection and test. Inspection shall be considered successful when it is shown that the service requests in the unique Attached Payload software ICD conforms with SSP 52050 and SSP 57002. Verification shall be to test with the PRCU, for correct test service requests at the UMA.		(I&T)	Certificate of Compliance	
I-107	SSP 57003	3.3.2.3.1.7	File Transfer	1) Review of software ICD to confirm that file transfers meet the requirements of SSP 52050, para 3.2.3.9. 2) Functional test demonstrating file transfers transmitted correctly. Verification of the Attached Payload file transfer shall be by inspection and test. Inspection shall be considered successful when it is shown that the file transfer in the unique Attached Payload software ICD conforms with SSP 52050 and SSP 57002. Verification shall be to test with the PRCU, for correct test file transfer at the UMA.		(I&T)	Certificate of Compliance	

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
I-108	SSP 57003	3.3.2.3.1.8	Low Rate Telemetry	1) Review of software ICD to confirm that low rate telemetry meets the requirements of SSP 52050, para 3.2.3.10. 2) Functional test demonstrating low rate telemetry transmitted correctly. Verification of the Attached Payload low rate telemetry shall be by inspection and test. Inspection shall be considered successful when it is shown that the low rate telemetry in the unique Attached Payload software ICD conforms with SSP 52050 and SSP 57002. Verification shall be to test with the PRCU, for correct low rate telemetry at the UMA.		(I&T)	Certificate of Compliance	
I-109	SSP 57003	3.3.2.3.1.10	Implemented Mode Codes	1) Review of software ICD to confirm that mode codes meet the requirements of SSP 52050, para 3.2.3.2.1.5. 2) Functional test demonstrating mode codes transmitted correctly. Verification of the Attached Payload implemented mode codes shall be by inspection and test. Inspection shall be considered successful when it is shown that the implemented mode codes in the unique Attached Payload software ICD conforms with SSP 52050 and SSP 57002. Inspection shall be considered successful when it is shown that the implemented mode codes in the unique Attached Payload software ICD conforms with SSP 52050 and SSP 57002. Test shall be considered successful when the PRCU correctly receives the implemented mode codes from the Attached Payload.		(I&T)	Certificate of Compliance	
I-110	SSP 57003	3.3.2.3.1.11	Illegal Commands	Functional test demonstrating message error bit set correctly in response to illegal command. Verification of the Attached Payload illegal commands shall be by test. Verification shall be to test with the PRCU, for correct test of the MIL−STD−1553 illegal commands produced by setting the message error bit in the status word response at the UMA.		(T)	Certificate of Compliance	
I-111	SSP 57003	3.3.2.3.2.1	LRDL Connector Pin Assignments	1) Review of design to confirm that pin assignments meet requirements of SSP 57004, para 3.2.1. 2) Functional test to demonstrate correct data transmission through LRDL. Verification of the Attached Payload MIL−STD−1553 bus A connector and pin assignment shall be by inspection and test. Verification shall be by inspection of the UMA MIL−STD−1553 to the unique Attached Payload hardware ICD against SSP 57004. Verification shall be to test with the PRCU, for correct test of the MIL−STD−1553 to receive and execute commands at the UMA with various address assignments. Verification shall be by inspection of the UMA HRDL connector to mate with a test connector SSQ 21635, NATC07T15N4SN.		(I&T)	Certificate of Compliance	
I-112	SSP 57003	3.3.2.3.2.2A	LRDL Signal Characteristics	Functional test using MIL-STD-1553 bus analyzer demonstrating all requirements met. Verification of the Attached Payload as it connects to MIL−STD−1553 bus A and bus B shall be by test. Verification shall be to test with the PRCU, for correct test of the MIL−STD−1553 signal characteristics at the UMA with a MIL−STD−1553 bus analyzer as specified in MIL−HDBK−1553, Multiplex Application Handbook.		(T)	Certificate of Compliance	
I-113	SSP 57003	3.3.2.3.2.2B	LRDL Signal Characteristics – Terminal	Function test demonstrating correct signal characteristics. Verification of the Attached Payload MIL−STD−1553 bus A and bus B shall be by test. Verification shall be to test with the PRCU, for correct test of the MIL−STD−1553 signal characteristics at the UMA with a MIL−STD−1553 bus analyzer as specified in MIL−HDBK−1553 Handbook.		(T)	Certificate of Compliance	
I-114	SSP 57003	3.3.2.3.2.3A	LRDL Cabling – Characteristics	Review of design to confirm LRDL wiring has appropriate resistance. Verification shall be by inspection of the UMA LRDL cable. Verification shall be considered successful when the UMA LRDL cable meets the requirements of SSQ 21655 for 75 Ohm or equivalent.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	
I-115	SSP 57003	3.3.2.3.2.3B	LRDL Cabling – Stub Length	Review of drawings to confirm internal wiring stub length meets requirements Verification shall be by inspection of the UMA LRDL cable. Verification shall be considered successful when the cable drawings are shown to require that the LRDL cable(s) does not exceed 10 feet (3.05 meters).	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
I-116	SSP 57003	3.3.2.4.1	Payload to High Rate Frame Multiplexer Protocols	Functional test to demonstrate correct data transmission through HRDL. Verification of the HRDL shall be by test and inspection. The test shall consist of a transmission of the payload HRDL data to the PRCU or equivalent and confirmation that the correct numbers of words were received as documented in the Attached Payload unique software ICD. Verification by inspection shall consist of a comparison of the received data against the format defined in the Attached Payload unique software ICD. Verification shall be considered successful when the correct number of words and correct format are received by the PRCU or equivalent per the Attached Payload unique software ICD.		(I&T)	Certificate of Compliance	
I-117	SSP 57003	3.3.2.4.1.1.1	CCSDS Packet Data Frames	1) Review of software ICD to confirm data frames match SSP 50184. 2) Functional test to demonstrate correct data transmission through HRDL. Verification of packet data frames shall be by test and inspection. Verification shall be to test the Attached Payload with the PRCU. Verification shall be by inspection of the Attached Payload HRDL protocol against Section 3.3.3.1.1, 3.3.3.1.1.1, and 3.3.3.1.1.2 of SSP 50184. Verification shall be considered successful when it is shown that the packet data frames comply with the requirements of SSP 50184.		(I&T)	Certificate of Compliance	
I-118	SSP 57003	3.3.2.4.1.1.2	CCSDS Packet Data Rates	Functional test to demonstrate correct data transmission through HRDL. Verification of packet data rates shall be by test and inspection. Verification shall be to test the Attached Payload with a Transparent Asynchronous Transmitter Receiver Interface (TAXI) Analyzer. A flight equivalent HRFM may be substituted as hardware availability permits. (Note: A TAXI Analyzer is a “Boeing Test Tool.”) Verification shall be by inspection of the Attached Payload HRDL protocol against Sections 3.3.3.1.2, 3.3.3.1.2.1, 3.3.3.1.2.2, 3.3.3.1.2.2.1, and 3.3.3.1.2.2.2 of SSP 50184. Verification shall be considered successful when it is shown that the data rates comply with the requirements of SSP 50184. NOTE: There is a risk when using the HRFM test that all data configurations have not been tested and packet loss may occur when those configurations are used on orbit. The packet data rate should follow the structure provided in SSP 50184. If this structure is not followed, there is a possibility that data could be lost. PDs will have to accept the risk if this verification method is used.		(I&T)	Certificate of Compliance	
I-119	SSP 57003	3.3.2.4.1.1.3	CCSDS Packet Format	Functional test to demonstrate correct data transmission through HRDL. Verification of packet format shall be by test and inspection. Verification shall be to test the Attached Payload with the PRCU. Verification shall be by inspection of the Attached Payload HRDL protocol against Sections 3.3.3.1.3.1 and 3.3.3.1.3.2 of SSP 50184. Verification shall be considered successful when it is shown that the packet format complies with the requirements of SSP 50184.		(I&T)	Certificate of Compliance	
I-120	SSP 57003	3.3.2.4.1.2.1	Bitstream Data Frames	Functional test to demonstrate correct data transmission through HRDL. Verification of data frames shall be by test and inspection. Verification shall be to test the Attached Payload with a TAXI Analyzer. A flight equivalent HRFM may be substituted as hardware availability permits. (Note: A TAXI Analyzer is a “Boeing Test Tool.”) Verification shall be by inspection of the Attached Payload HRDL protocol against Sections 3.3.3.2.1.1 and 3.3.3.2.1.2 of SSP 50184. Verification shall be considered successful when it is shown that the data frames comply with the requirements of SSP 50184. NOTE: There is a risk when using the HRFM test that all data configurations have not been tested and packet loss may occur when those configurations are used on orbit. The packet data rate should follow the structure provided in SSP 50184. If this structure is not followed, there is a possibility that data could be lost. PDs will have to accept the risk if this verification method is used.		(I&T)	Certificate of Compliance	

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
I-121	SSP 57003	3.3.2.4.1.2.2	Bitstream Data Rates	Functional test to demonstrate correct data transmission through HRDL. Verification of data rates shall be by test and inspection. Verification shall be to test the Attached Payload with a TAXI Analyzer. A flight equivalent HRFM may be substituted as hardware availability permits. (Note: A TAXI Analyzer is a "Boeing Test Tool.") Verification shall be by inspection of the Attached Payload HRDL protocol against Sections 3.3.3.2.2, 3.3.3.2.2.1, 3.3.3.2.2.2, and 3.3.3.2.2.2.1 of SSP 50184. Verification shall be considered successful when it is shown that the data rates comply with the requirements of SSP 50184. NOTE: There is a risk when using the HRFM test that all data configurations have not been tested and packet loss may occur when those configurations are used on orbit. The packet data rate should follow the structure provided in SSP 50184. If this structure is not followed, there is a possibility that data could be lost. PDs will have to accept the risk if this verification method is used.		(I&T)	Certificate of Compliance	
I-122	SSP 57003	3.3.2.4.2.1A	HRDL Physical Signaling	Functional test to demonstrate transmitted waveform and BER meet requirement of SSP 50184, section 3.1. Verification of the Attached Payload HRDL physical signaling shall be by test and analysis. Verification of the fiber optic transmitted waveform at the fiber optic transmitter component shall be by test. This test may be conducted at the fiber optic component subassembly. Verification of the Attached Payload fiber optic transmitted waveform shall be by analysis. Verification of the fiber optic receiver fiber optic sensitivity and bit error rate (BER) shall be by test of the fiber optic receiver component. Verification of the BER (per ANSI X3.255 test) and the Attached Payload fiber optic receiver sensitivity shall be by test. Verification shall be considered successful when the results of the test and analysis meet the applicable requirements in Sections 3.1.1, 3.1.2, and 3.1.3 of SSP 50184 and the BER test Section in ANSI X3.255, Fibre Distributed Data Interface (FDDI) − Abstract Test Suite for FDDI Physical Medium Dependent Conformance Testing (PMD ATS).		(T&A)	Data Cert. providing rates, signal coding, and control signals.	
I-123	SSP 57003	3.3.2.4.2.1.1A	Physical Signaling Data Rates	Functional test to demonstrate data rate meets limits. Verification of HRDL physical signaling shall be by test and is considered successful when the HRDL data rate is less than or equal to the Attached Payload assigned data rate. All selectable data rates are to be recorded.		(T)	Data Cert. providing rates, signal coding, and control signals.	
I-124	SSP 57003	3.3.2.4.2.2	Encoding	Functional test demonstrating correct data transmission through HRDL. Verification of the Attached Payload UMA HRDL encoding shall be by test. Verification shall be to test the Attached Payload UMA with the PRCU. Verification shall be considered successful when it is shown that encoding complies with Section 3.1.3 of SSP 50184.		(T)	Data Cert. providing rates, signal coding, and control signals.	
I-125	SSP 57003	3.3. 2. 4.3.1	HRDL Transmitted Optical Power	Functional test demonstrating optical power levels meet requirements. Verification shall be to test the Attached Payload UMA with fiber optic power meter per ANSI X3.255, for correct optical power using the Halt symbol. The optical power perturbations from the test setup are not included in the stated power requirement. The perturbations from the test are to be documented. This test shall be considered successful when the requirement is met or exceeded after the test setup variations are removed from the result.		(T)	Certificate of Compliance	
I-126	SSP 57003	3.3.2.4.3.2	HRDL Received Optical Power	Functional test demonstrating optical power levels meet requirements. Verification shall be to test the Attached Payload UMA with a calibrated fiber optic source using the Halt symbol at the minimum power. The optical power perturbations from the test setup are not included in the stated power requirement. The perturbations from the test are to be documented. This test shall be considered successful when the requirement is met or exceeded after the test setup variations are removed from the result.		(T)	Certificate of Compliance	

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
I-127	SSP 57003	3.3.2.4.4	HRDL Fiber Optic Cable	Review of design to confirm HRDL cable meets requirements. Verification shall be by inspection of the Attached Payload to UMA HRDL cable. Verification shall be considered successful when it is shown that the Attached Payload to UMA HRDL cable meets SSQ 21637 or NASA Attached Payload approved equivalent.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	
I-128	SSP 57003	3.3.2.4.5	HRDL Fiber Optic Cable Bend Radius	Review of design to confirm HRDL cable meets minimum bend radius requirements. Verification shall be by inspection of the Attached Payload to UMA HRDL Cable routing, installation and handling procedures. Verification shall be considered successful when the inspection shows that the routing, installation and handling procedures do not cause the cable to be bent in a tighter radius, as specified in Section 3.3.2.4.5 of SSP 57003.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	
I-129	SSP 57003	3.3.2.4.6A	HRDL Connectors and Fiber	Review of design to confirm appropriate passive half connectors used. Verification that the UMA HRDL connector meets the requirements of SSQ 21635 shall be by inspection. The inspection shall consist of an inspection of the drawings to identify that the SSQ 21635 requirement is identified on the drawing for the UMA HRDL connector.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	
I-130	SSP 57003	3.3.2.4.6B	HRDL Connectors and Fiber	Review of design to confirm appropriate fiber used. Verification that the HRDL fiber meets the requirements of SSQ 21654 shall be by inspection. The inspection shall consist of an inspection of the drawings to identify that the SSQ 21654 requirement is identified on the drawing for the HRDL fiber.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	
I-131	SSP 57003	3.3.2.4.7	HRDL Connector/Pin Assignments	Review of design to confirm pin assignments meet SSP 57004 para 3.2.1. Verification of the Attached Payload UMA HRDL connector/pin assignments shall be by inspection. Verification shall be considered successful when the inspection shows that the connector and pin assignments are in accordance with Section 3.2.1 of SSP 57004, Attached Payload Hardware ICD Template.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	
I-132	SSP 57003	3.3.2.5	Portable Computer System	Review of software ICD to confirm that requirements have been met. Verification shall be by analysis. The verification shall be considered successful when the analysis shows that the requirements defined in SSP 57000, paragraph 3.3.8.2 and 3.3.8.2.1 are met.		(A)	Certificate of Compliance	
I-133	SSP 57003	3.4.1.1.1	Temperature Requirement	1) Thermal analysis showing no thermal exceedences for AMS-02 equipment. 2) Review of stress analysis to confirm appropriate thermal knockdown factors used. Verification shall be by analysis. The analysis shall show that the Attached Payload meets all requirements when the S3 PAS and P3 UCCAS interface temperature is between −120 degrees Fahrenheit (F) and +200 degrees F. Verification shall be considered successful when the analysis shows the requirements have been met.	JSC	(A) Thermal Analysis Report and Stress Report	Analysis Report	
I-134	SSP 57003	3.4.2	Thermal Model Requirements	Delivery of AP thermal math model to ISS program.	JSC	Thermal Math Model	Certificate of Compliance	
I-135	SSP 57003	3.4.3A	Thermal Exchange Between Payloads	Thermal analysis demonstrating compliance with requirements.	JSC	(A) Thermal Analysis Report	Certificate of Compliance	
I-136	SSP 57003	3.4.3B	Thermal Exchange Between Payloads	Thermal analysis demonstrating compliance with requirements.	JSC	(A) Thermal Analysis Report	Certificate of Compliance	

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
I-137	SSP 57003	3.5.1.5.1	Molecular Column Density from Venting, Leakage, and Outgassing	Outgassing analysis demonstrating compliance with requirements. An analysis shall be performed using Attached Payload design data and operational conditions to determine molecular column densities for individual species. Verification shall be considered successful when the analysis shows that the molecular column densities produced by the Attached Payload do no exceed 1 x 10+14 molecules/cm2 for any individual species, when viewed from any other Attached Payload location. The vent axis will be oriented to preclude direct plume impingement on other Attached Payloads.	JSC	(A) Materials Usage Agreement	1. Data Cert. providing the required outgassing characteristics including materials, locations, surface area, outgassing rate, and temperature. 2. Data Cert. providing the required venting characteristics including mass flow rate, composition (effluents), blowdown curves, temperature, plume model and pressure.	
I-138	SSP 57003	3.5.1.5.2A	Molecular Deposition from Materials Outgassing and Venting – Other Attached Payloads	Vacuum testing to confirm outgassed products do not exceed requirements. Outgassing testing shall be performed of the Attached Payload component materials exposed to space vacuum and one used in quantities greater than 0.1 m2 surface area per guidelines established in ASTM E1559, Standard Test Method for Contamination Outgassing Characteristics of Spacecraft Materials. The test shall be of long duration (144 hours minimum). The materials samples (emitters) shall be tested at their nominal operating temperature. During the ASTM E1559 testing, one Quartz Crystal Microbalance (QCM) will be maintained at −40°C; one QCM will be maintained at +25°C; and one QCM will be maintained at a temperature between −40°C and +25°C. Verification shall be considered successful when the Attached Payload demonstrates by analysis that cumulative contaminant deposits do not exceed 1x10−14 gm/cm2/sec on other Attached Payloads.		T&A	1. Data Cert. providing the required outgassing characteristics including materials, locations, surface area, outgassing rate, and temperature. 2. Data Cert. providing the required venting characteristics including mass flow rate, composition (effluents), blowdown curves, temperature, plume model and pressure.	
I-139	SSP 57003	3.5.1.5.2B	Molecular Deposition from Materials Outgassing and Venting – ISS	Vacuum testing to confirm outgassed products do not exceed requirements. Outgassing testing shall be performed of the Attached Payload component materials exposed to space vacuum and are used in quantities greater than 0.1 m2 surface area per guidelines established in ASTM E1559. The test shall be of long duration (144 hours minimum). The materials samples (emitters) shall be tested at their nominal operating temperature. During the ASTM E1559 testing, one QCM will be maintained at −40°C; one QCM will be maintained at +25°C; and one QCM will be maintained at a temperature between −40°C and +25°C. Verification shall be considered successful when the Attached Payload demonstrates by analysis that cumulative contaminant deposits do not exceed 1x10−15 gm/cm2/sec on ISS element external contamination sensitive surfaces.	JSC	(T&A) Materials Usage Agreement	1. Data Cert. providing the required outgassing characteristics including materials, locations, surface area, outgassing rate, and temperature. 2. Data Cert. providing the required venting characteristics including mass flow rate, composition (effluents), blowdown curves, temperature, plume model and pressure.	

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
I-140	SSP 57003	3.5.1.5.3	Particulates	Review of design to confirm no venting of particles above requirement limit. Verification of limitation of particulate dispersal by active venting shall be by analysis and/or inspection. The analysis and/or inspection of drawings shall verify that gases containing particulates greater than 100 microns are not actively vented from the attached payload. The verification shall be considered successful when the analysis and/or inspection of drawings show that the attached payload design does not release particulates greater than 100 microns in size.	JSC	A and/or I) Drawing review	Certificate of Compliance	
I-141	SSP 57003	3.5.1.8.1	AP Contained or Generated Ionizing Radiation	Safety analysis demonstrating that AP equipment complies with requirements. Verification that Attached Payloads containing or using radioactive materials or generating ionizing radiation meet the requirements of NSTS 1700.7B ISS Addendum shall be performed and submitted to the PSRP in accordance with NSTS 13830. Verification shall be considered successful when hazard reports and safety data presented to the PSRP during the phased safety reviews are approved.	JSC	(Safety) Flight Safety Data Package	Certificate of Compliance	
I-142	SSP 57003	3.5.1.8.2	Ionizing Radiation Dose	Safety analysis demonstrating that AP equipment can survive on-orbit radiation environment. Verification that equipment and subsystems are designed to not produce an unsafe condition or one that could cause damage to equipment external to the payload as a result of exposure to ionizing radiation shall be by analysis. An analysis of equipment and subsystems shall be performed using the operational lifetime and parts characterization data to assure that the design meets the requirement when exposed to ionizing radiation. The verification shall be considered successful when the analysis shows that the Attached Payload equipment and subsystems will not produce an unsafe condition or one that could cause damage to equipment external to the payload when exposed as specified in SSP 30512, Table 3.1.2.	JSC	(A) Flight Safety Data Package	Data Cert providing the analysis results	
I-143	SSP 57003	3.5.1.8.3	Nominal Single Event Effects Ionizing Radiation	Safety analysis demonstrating that AP equipment can survive on-orbit radiation environment. Verification that equipment and subsystems are designed to not produce an unsafe condition or one that could cause damage to equipment external to the payload as a result of exposure to SEE ionizing radiation shall be by analysis. An analysis of equipment and subsystems shall be performed using the operational lifetime and parts characterization data to assure that the design meets the requirement when exposed to SEE ionizing radiation. The verification shall be considered successful when the analysis shows that the Attached Payload equipment and subsystems will not produce an unsafe condition or one that could cause damage to Attached Payload equipment external to the payload when exposed to the specified environment.	JSC	(A) Flight Safety Data Package	Data Cert providing the analysis results	
I-144	SSP 57003	3.5.1.8.4	Extreme SEE	Safety analysis demonstrating that AP equipment can survive on-orbit radiation environment. Verification that equipment and subsystems are designed to not produce an unsafe condition or one that could cause damage to equipment external to the payload as a result of exposure to extreme SEE ionizing radiation shall be by analysis. An analysis of equipment and subsystems shall be performed using the operational lifetime and parts characterization data to assure that the design meets the requirement when exposed to extreme SEE ionizing radiation. The verification shall be considered successful when the analysis shows that the Attached Payload equipment and subsystems will not produce an unsafe condition or one that could cause damage to equipment external to the payload when exposed to the specified environment.	JSC	(A) Flight Safety Data Package	Data Cert providing the analysis results	

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
I-145	SSP 57003	3.5.1.12A	Acceleration Environment – CG Induced	Stress analysis demonstrating positive margins of safety to required loading conditions. An analysis shall be performed to verify that the Attached Payload will withstand On-Orbit accelerations as specified in paragraph 3.5.1.12.A. This analysis shall be based on lower level component qualification data as well as test verification of Attached Payload primary structure to equivalent static loads equal to or greater than the specified On-Orbit environment. The verification shall be considered successful when the analysis shows that the Attached Payload design will withstand specified On-Orbit accelerations and loads.	JSC	(A) Stress Analysis Report	1. Data Cert. that provides a summary of the margins of safety for all SCS identified in accordance with SSP 52005 using design loads if the Design Loads Analysis (DLA) results are not available. 2. Data cert. that provides a summary of the margins of safety for all SCS identified in accordance with SSP 52005 using loads validated by the verification loads analysis (VLA) results.	
I-146	SSP 57003	3.5.1.12B	Acceleration Environment – Berthing	Stress analysis demonstrating positive margins of safety to required loading conditions. An analysis shall be performed to verify that the Attached Payload will withstand On-Orbit accelerations during berthing of the Attached Payload as specified in paragraph 3.5.1.12.B. This analysis shall be based on lower level component qualification data as well as test verification of Attached Payload primary structure to equivalent static loads equal to or greater than the specified On-Orbit environment. The verification shall be considered successful when the analysis shows that the Attached Payload design will withstand specified On-Orbit accelerations and loads.	JSC	(A) Stress Analysis Report	1. Data Cert. that provides a summary of the margins of safety for all SCS identified in accordance with SSP 52005 using design loads if the Design Loads Analysis (DLA) results are not available. 2. Data cert. that provides a summary of the margins of safety for all SCS identified in accordance with SSP 52005 using loads validated by the verification loads analysis (VLA) results.	

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
I-147	SSP 57003	3.5.1.13	Vibration Environment – Linear Peak Loads	Stress analysis demonstrating positive margins of safety to required loading conditions. An analysis shall be performed to show that Attached Payload operating equipment shall withstand the specified On-Orbit linear peak vibration environment. The analysis shall be based on component tests. The verification shall be considered successful when the analysis shows that the operating equipment can withstand the requirement as specified.	JSC	(A) Stress Analysis Report	1. Data Cert. that provides a summary of the margins of safety for all SCS identified in accordance with SSP 52005 using design loads if the Design Loads Analysis (DLA) results are not available. 2. Data cert. that provides a summary of the margins of safety for all SCS identified in accordance with SSP 52005 using loads validated by the verification loads analysis (VLA) results.	
I-148	SSP 57003	3.6.1	Materials Parts and Selection	Analysis demonstrating that all materials used meet requirements of NSTS 1700.7B, ISS Addendum. Verification that parts and materials meet the requirements of NSTS 1700.7B ISS addendum shall be performed and submitted to the PSRP in accordance with NSTS 13830. Verification shall be considered successful when hazard reports and safety data presented to the PSRP during the phased safety reviews are approved.	JSC	(Safety) Materials Usage Agreement	Certificate of Compliance	
I-149	SSP 57003	3.6.1.1	Thermal Vacuum Stability	Analysis demonstrating that all materials used meet outgassing requirements. Verification that Attached Payload non-metallic materials are tested per ASTM E595 shall be by inspection. The verification shall be considered successful when the payload developer certifies that all non-metallic materials have a Total Mass Loss of <1.0 percent and a volatile condensable material of <0.1 percent when tested per ASTM E595 or have obtained approval from the cognizant NASA materials organization for usage of materials not meeting the specified criteria in the intended use application.	JSC	(I) Materials Usage Agreement	Data Cert. providing all of the surface materials and thermal vacuum stability data to the Materials Working Group for approval, (additional updates as required).	
I-150	SSP 57003	3.6.3	Cleanliness	QA inspection of AP hardware external surfaces to confirm hardware meets visibly clean requirements. Verification that Attached Payload hardware external surfaces conform to visibly clean–sensitive cleanliness requirements as specified in SN–C–0005, NSTS Contamination Control Requirements Manual shall be by inspection. An inspection of the hardware as specified in SN–C–0005 shall be performed to show that the Attached Payload hardware meets the visibly clean–sensitive requirement. Verification shall be considered successful when the inspection shows the Attached Payload hardware external surfaces meets the requirements for visibly clean–sensitive specified in SN–C–0005.	KSC	(I) QA Inspection	Certificate of Compliance	
I-151	SSP 57003	3.6.4	Atomic Oxygen Interaction	Review of design to confirm no silver-plated hardware used. Verification shall be by inspection. Verification shall be considered successful when a drawing inspection shows that no silver plated hardware is used.	JSC	(I) Drawing review	Certificate of Compliance	

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
I-152	SSP 57003	3.7.1A	Attached Payload Requiring Robotic Support – Impulse	Stress analysis demonstrating positive margins of safety to required loading conditions. This requirement shall be verified by analysis of lower–level verification data. The verification shall be considered successful when the analysis shows compliance with the requirement as specified.	JSC	(A) Stress Analysis Report	Analysis Report showing structure can withstand an impact load (Note: This requirement can be satisfied using data to verify 3.7.1F).	
I-153	SSP 57003	3.7.1B	Attached Payload Requiring Robotic Support – Clearance Zone	Review of design to confirm appropriate clearance zone exists. This requirement shall be verified by inspection of flight drawings. The verification shall be considered successful when the inspection shows compliance with the requirement as specified.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	
I-154	SSP 57003	3.7.1C	Attached Payload Requiring Robotic Support – Grapple Fixture	Review of design to confirm GF centerline meets requirements. This requirement shall be verified by inspection of flight drawings. The verification shall be considered successful when the inspection shows compliance with the requirement as specified.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	
I-155	SSP 57003	3.7.1D	Attached Payload Requiring Robotic Support – GF Location	Review of ICD to confirm GF location specified. This requirement shall be verified by inspection of flight drawings in the unique Attached Payload hardware ICD. The verification shall be considered successful when the inspection shows compliance with the requirement as specified.	JSC	(I) ICD Review	Certificate of Compliance	
I-156	SSP 57003	3.7.1E	Attached Payload Requiring Robotic Support – Mass	1) Structural analysis to determine mass properties about GF interface meet requirements. 2) Weighing of flight hardware to confirm as-built hardware meets predictions. This requirement shall be verified by analysis of lower–level verification data. The verification shall be considered successful when the analysis shows compliance with the requirement as specified.	KSC	(A) Weighing of flight hardware	Data Cert. that provides weight and CG summary for on-orbit configuration of the Attached Payload	
I-157	SSP 57003	3.7.1F	Attached Payload Requiring Robotic Support – Loads	Stress analysis demonstrating positive margins of safety to required loading conditions. This requirement shall be verified by analysis of lower–level verification data. The verification shall be considered successful when the analysis shows compliance with the requirement as specified.	JSC	(A) Stress Analysis Report	Analysis Report showing that the structure meets the tip loads induced by the SRMS	
I-158	SSP 57003	3.7.1G	Attached Payload Requiring Robotic Support – Vibration Frequency	Dynamics analysis demonstrating natural frequencies of payload in grappled boundary conditions meets requirements. This requirement shall be verified by analysis of lower–level verification data. The verification shall be considered successful when the analysis shows compliance with the requirement as specified.	JSC	(A) Dynamics Analysis	Verified Finite Element Model or Data Cert., and Analysis Report showing frequency with respect to the GF	
I-159	SSP 57003	3.7.1H	Attached Payload Requiring Robotic Support – Grounding	Review of drawings to confirm ground strap interface present. This requirement shall be verified by inspection of flight drawings. The verification shall be considered successful when the inspection shows compliance with the requirement as specified.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	
I-160	SSP 57003	3.7.1I	Attached Payload Requiring Robotic Support – Thermal Isolation	1) Review of drawings to confirm required thermal isolation hardware included. 2) Thermal analysis to confirm that GF remains within temperature limits. This requirement shall be verified by analysis of lower–level verification data. The verification shall be considered successful when the analysis shows compliance with the requirement as specified.	JSC	(A) Drawing review and QA inspection an d Thermal Analysis Report	Analysis Report showing thermal conductance with respect to the GF	

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
I-161	SSP 57003	3.7.1J	Attached Payload Requiring Robotic Support – Scuff Plates	Review of drawings to confirm scuff plate present. This requirement shall be verified by inspection of flight drawings. The verification shall be considered successful when the inspection shows compliance with the requirement as specified.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	
I-162	SSP 57003	3.7.1K	Attached Payload Requiring Robotic Support – Shielding	Kinematics analysis demonstrating that no critical/hazardous components come into contact with other items during robotic operations. This requirement shall be verified by analysis of lower–level verification data. The verification shall be considered successful when the analysis shows compliance with the requirements as specified.	JSC	(A) MAGIK Analysis	Strength analysis report showing that any peripheral hardware that makes contact when the AP Passive CAS is within the allowable misalignments (about 3 inches translational, 1.5 degrees rotational) of the Active CAS either operates fully after the contact or is shielded so that the hardware is not damaged.	
I-163	SSP 57003	3.7.1L	Attached Payload Requiring Robotic Support – Contact Velocity	Stress analysis demonstrating positive margins of safety to required loading conditions. This requirement shall be verified by analysis of lower–level verification data. The verification shall be considered successful when the analysis shows compliance with the requirement as specified.	JSC	(A) Stress Analysis Report	Analysis Report	
I-164	SSP 57003	3.7.1M	Attached Payload Requiring Robotic Support – Capture Envelope	Review of deign to confirm capture envelope meets requirements. This requirement shall be verified by analysis of lower–level verification data. The verification shall be considered successful when the analysis shows compliance with the requirement as specified.	JSC	(A) Drawing review and QA inspection	Data Cert. providing the interface attach point forces and margins of safety calculations based on the allowable limits as specified. (Attachment force can be obtained from the result of the Verification Coupled Loads (VCL)).	
I-165	SSP 57003	3.7.1N	Attached Payload Requiring Robotic Support – Ready to Latch Indication	Review of design to confirm RTL indication meets requirements. This requirement shall be verified by analysis of lower–level verification data. The verification shall be considered successful when the analysis shows compliance with the requirements as specified.	JSC	(A) Drawing review and QA inspection	Analysis Report showing that the payload interface does not impair RTL (Compliance with ICD stay-out zones, envelopes)	
I-166	SSP 57003	3.7.2	External Attached Payload Requiring Robotic Hand-off	Review of design to confirm multiple grapple fixtures installed. This requirement shall be verified by analysis of lower–level verification data. The verification shall be considered successful when the analysis shows compliance with the requirement as specified.	JSC	(A) Drawing review	Certificate of Compliance (Inspect drawings and review analysis for SRMS GF and SSRMS GF to determine compliance)	

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
I-167	SSP 57003	3.7.3A	External Attached Payload Requiring SSRMS Support – LEE	Review of design to confirm PVGF included. This requirement shall be verified by inspection of flight drawings. The verification shall be considered successful when the inspection shows compliance with the requirement as specified.	JSC	(I) Drawing review	Certificate of Compliance	
I-168	SSP 57003	3.7.3B	External Attached Payload Requiring SSRMS Support – Properties	1) Structural analysis to confirm mass properties about GF location are within limits given in Table 3.7.3-1. 2) Dynamics analysis to confirm fundamental frequency using grappled BCs is less than requirement. 3) Final weighing of flight hardware to confirm mass properties of as-built hardware This requirement shall be verified by analysis of lower–level verification data. The verification shall be considered successful when the analysis shows compliance with the requirement as specified.	KSC	(A) Mass properties analysis, dynamics analysis, and final weighing of flight hardware	Verified Finite Element Model or Data Cert., and Analysis Report showing mass, moments of inertia, center of mass, frequency with respect to the GF	
I-169	SSP 57003	3.7.3C	External Attached Payload Requiring SSRMS Support – Contact Conditions	Stress analysis demonstrating positive margins of safety to required loading conditions. This requirement shall be verified by analysis of lower–level verification data. The verification shall be considered successful when the analysis shows compliance with the requirement as specified.	JSC	(A) Stress Analysis Report	Analysis Report	
I-170	SSP 57003	3.7.3D	External Attached Payload Requiring SSRMS Support – Backdrive	Stress analysis demonstrating ability to berth when SSRMS is limp. This requirement shall be verified by analysis of lower–level verification data. The verification shall be considered successful when the analysis shows compliance with the requirement as specified.	JSC	(A) Stress Analysis Memo	Certificate of Compliance	
I-171	SSP 57003	3.7.3E	External Attached Payload Requiring SSRMS Support – Ready to Latch	Review of design to confirm RTL indication meets requirements. This requirement shall be verified by analysis of lower–level verification data. The verification shall be considered successful when the analysis shows compliance with the requirements as specified.	JSC	(A) Drawing review and QA inspection	Analysis Report showing that the payload interface does not impair RTL (Compliance with ICD stay-out zones, envelopes)	
I-172	SSP 57003	3.7.3F	External Attached Payload Requiring SSRMS Support – Scuff Plates	Review of drawings to confirm scuff plate present. This requirement shall be verified by inspection of flight drawings. The verification shall be considered successful when the inspection shows compliance with the requirement as specified.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	
I-173	SSP 57003	3.7.3G	External Attached Payload Requiring SSRMS Support – Shielding	Kinematics analysis demonstrating that no critical/hazardous components come into contact with other items during robotic operations. This requirement shall be verified by analysis of lower–level verification data. The verification shall be considered successful when the analysis shows compliance with the requirement as specified.	JSC	(A) MAGIK Analysis	Strength analysis report showing that any peripheral hardware that makes contact when the AP Passive CAS is within the allowable misalignments (about 3 inches translational, 1.5 degrees rotational) of the Active CAS either operates fully after the contact or is shielded so that the hardware is not damaged.	

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
I-174	SSP 57003	3.7.3H	External Attached Payload Requiring SSRMS Support – Contact with Equipment	Stress analysis demonstrating positive margins of safety to required loading conditions. This requirement shall be verified by analysis of lower–level verification data. The verification shall be considered successful when the analysis shows compliance with the requirement as specified.	JSC	(A) Stress Analysis Report	Strength analysis report showing that any peripheral hardware that makes contact when the AP Passive CAS is within the allowable misalignments (about 3 inches translational, 1.5 degrees rotational) of the Active CAS either operates fully after the contact or is shielded so that the hardware is not damaged.	
I-175	SSP 57003	3.7.3I	External Attached Payload Requiring SSRMS Support – SSRMS Limits	Stress analysis demonstrating ability to berth without exceeding SSRMS backdrive limits. This requirement shall be verified by analysis of lower–level verification data. The verification shall be considered successful when the analysis shows compliance with the requirement as specified.	JSC	(A) Stress Analysis Memo	Certificate of Compliance	
I-176	SSP 57003	3.7.3J	External Attached Payload Requiring SSRMS Support – Capture Envelope	Review of design to confirm capture envelope meets requirements. This requirement shall be verified by analysis of lower–level verification data. The verification shall be considered successful when the analysis shows compliance with the requirement as specified.	JSC	(A) Drawing review and QA inspection	Report that verifies that no AP hardware interferes with or restricts the nominal CAS capture envelope (inspection of drawings).	
I-177	SSP 57003	3.7.3K	External Attached Payload Requiring SSRMS Support – Grapple Fixture	Review of ICD to confirm GF location specified. This requirement shall be verified by inspection of flight drawings in the unique Attached Payload hardware ICD. The verification shall be considered successful when the inspection shows compliance with the requirements as specified.	JSC	(I) ICD Review	Certificate of Compliance	
I-178	SSP 57003	3.7.3.1A	AP Requiring SSRMS Support using NSTS System Grapple Fixture	Project Office confirmation that AMS-02 does not require SSRMS support using a standard NSTS Grapple Fixture. This requirement shall be verified by inspection of flight drawings. The verification shall be considered successful when the inspection shows compliance with the requirement as specified.	JSC	(I) APO Review	Certificate of Compliance	Project Office confirms that AMS-02 will only be grappled by SSRMS using PVGF.
I-179	SSP 57003	3.7.3.1B	AP Requiring SSRMS Support using NSTS System Grapple Fixture	Project Office confirmation that AMS-02 does not require SSRMS support using a standard NSTS Grapple Fixture. This requirement shall be verified by inspection of flight drawings. The verification shall be considered successful when the inspection shows compliance with the requirement as specified.	JSC	(I) APO Review	Certificate of Compliance	Project Office confirms that AMS-02 will only be grappled by SSRMS using PVGF.
I-180	SSP 57003	3.7.3.1C	AP Requiring SSRMS Support using NSTS System Grapple Fixture	Project Office confirmation that AMS-02 does not require SSRMS support using a standard NSTS Grapple Fixture. This requirement shall be verified by analysis. The verification shall be considered successful when the analysis shows compliance with the requirements as specified.	JSC	(A) APO Review	Verified Finite Element Model or Data Cert., and Analysis Report showing structure can withstand SSRMS tip loads.	Project Office confirms that AMS-02 will only be grappled by SSRMS using PVGF.

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
I-181	SSP 57003	3.7.3.1D	AP Requiring SSRMS Support using NSTS System Grapple Fixture	Project Office confirmation that AMS-02 does not require SSRMS support using a standard NSTS Grapple Fixture. This requirement shall be verified by analysis. The verification shall be considered successful when the analysis shows compliance with the requirements as specified.	JSC	(A) APO Review	Verified Finite Element Model or Data Cert., and Analysis Report showing structure can withstand SSRMS impact load.	Project Office confirms that AMS-02 will only be grappled by SSRMS using PVGF.
I-182	SSP 57003	3.7.3.1E	AP Requiring SSRMS Support using NSTS System Grapple Fixture	Project Office confirmation that AMS-02 does not require SSRMS support using a standard NSTS Grapple Fixture. This requirement shall be verified by analysis. The verification shall be considered successful when the analysis shows compliance with the requirements as specified.	JSC	(A) APO Review	Model or Data Cert. and Analysis Report showing structure can withstand SSRMS vibration frequency.	Project Office confirms that AMS-02 will only be grappled by SSRMS using PVGF.
I-183	SSP 57003	3.7.3.1F	AP Requiring SSRMS Support using NSTS System Grapple Fixture	Project Office confirmation that AMS-02 does not require SSRMS support using a standard NSTS Grapple Fixture. This requirement shall be verified by analysis. The verification shall be considered successful when the analysis shows compliance with the requirements as specified.	JSC	(A) APO Review	Analysis Report showing thermal conductance with respect to the GF	Project Office confirms that AMS-02 will only be grappled by SSRMS using PVGF.
I-184	SSP 57003	3.7.3.1G	AP Requiring SSRMS Support using NSTS System Grapple Fixture	Project Office confirmation that AMS-02 does not require SSRMS support using a standard NSTS Grapple Fixture. This requirement shall be verified by inspection of flight drawings. The verification shall be considered successful when the inspection shows compliance with the requirements as specified.	JSC	(I) APO Review	Certificate of Compliance	Project Office confirms that AMS-02 will only be grappled by SSRMS using PVGF.
I-185	SSP 57003	3.7.3.3.1	AP Envelopes	Review of design to confirm that clearance envelope provided. This requirement shall be verified by inspection of flight drawings. The verification shall be considered successful when the inspection shows compliance with the requirement as specified.	JSC	(I) Drawing Review and QA inspection	Certificate of Compliance	Exception Tracking number 57213-0005
I-186	SSP 57003	3.7.3.3.2	AP Mechanical Interface	Review of design to confirm that mechanical interface meets requirements. This requirement shall be verified by inspection of flight drawings. The verification shall be considered successful when the inspection shows compliance with the requirement as specified.	JSC	(I) Drawing Review and QA inspection	Certificate of Compliance	
I-187	SSP 57003	3.7.3.3.3	AP Structural Interface	Stress analysis demonstrating positive margins of safety to required loading conditions. This requirement shall be verified by analysis of lower–level verification data. The verification shall be considered successful when the analysis shows compliance with the requirement as specified.	JSC	(A) Stress Analysis Report	Analysis Report showing structure can withstand SSRMS tip loads.	
I-188	SSP 57003	3.7.3.3.3.1	Impact Loads	Stress analysis demonstrating positive margins of safety to required loading conditions. This requirement shall be verified by analysis of lower–level verification data. The verification shall be considered successful when the analysis shows compliance with the requirement as specified.	JSC	(A) Stress Analysis Report	Analysis Report showing structure can withstand SSRMS impact loads.	
I-189	SSP 57003	3.7.3.3.3.2	AP Stiffness Requirements	Dynamics analysis demonstrating natural frequencies of payload in grappled boundary conditions meets requirements. This requirement shall be verified by analysis of lower–level verification data. The verification shall be considered successful when the analysis shows compliance with the requirement as specified.	JSC	(A) Dynamics Analysis	Analysis Report showing structure can withstand SSRMS vibration frequency.	
I-190	SSP 57003	3.7.3.3.4A	AP Electrical Interface Hardware	Review of design to confirm PVGF pigtail not shortened	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
I-191	SSP 57003	3.7.3.3.4B	AP Electrical Interface Hardware	Review of design to confirm harness secured properly and not interfering with GF clearance zone.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	Exception Tracking number 57213-0007
I-192	SSP 57003	3.7.3.3.4.1	Electrical Connectors	Review of design to confirm appropriate connectors chosen.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	
I-193	SSP 57003	3.7.3.3.5	AP Power Interface	Review of design to confirm power can be received through both circuits.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	
I-194	SSP 57003	3.7.3.3.5.1	Power Quality	Electrical analysis to confirm design meets requirements.		(A)	Analysis report showing the AP to be fault protected in accordance with SSP 42004 Table A3.2.1.5.1-1. Data Cert providing plot of input voltage vs. frequency	
I-195	SSP 57003	3.7.3.3.5.2	Fault Protection	Review of design to confirm proper fault protection in place.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	
I-196	SSP 57003	3.7.3.3.5.3	Electrical Connector Deadfacing	1) Review of design to confirm connector will deadface in power-off condition 2) Functional test to demonstrate connector will deadface.		(A&T)	Analysis Report	
I-197	SSP 57003	3.7.3.3.6	C&DH Interfaces	Review of design to confirm data bus included.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	
I-198	SSP 57003	3.7.3.3.6.1A	MIL-STD-1553 Interfaces	Functional test using MIL-STD-1553 bus analyzer demonstrating correct signal characteristics.		(T)	Certificate of Compliance	
I-199	SSP 57003	3.7.3.3.6.1B	MIL-STD-1553 Interfaces	Review of design to confirm two connectors included.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	
I-200	SSP 57003	3.7.3.3.6.1C	MIL-STD-1553 Interfaces	Program office review confirming no data services required during MT translation.	JSC	(A) APO Review	Certificate of Compliance	
I-201	SSP 57003	3.7.3.3.6.1D	MIL-STD-1553 Interfaces	Review of design to confirm data interfaces meet requirements		(I)	Certificate of Compliance	
I-202	SSP 57003	3.7.3.3.6.1.1B	Bus Termination	Review of design to confirm terminations at both ends of AP bus interface.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	
I-203	SSP 57003	3.7.3.3.6.1.2	MIL-STD-1553 Data Bus Addresses	1) Review of assigned bus addresses for AP to confirm appropriate choices made. 2) Functional test to demonstrate correct data transmission through PVGF interface.		(I&T)	Certificate of Compliance	
I-204	SSP 57003	3.7.3.3.6.1.3	Provide Output Amplitude	Functional test using MIL-STD-1553 bus analyzer demonstrating correct signal characteristics.		(T)	Certificate of Compliance	

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
I-205	SSP 57003	3.7.3.3.7A	Sync, Control, and Video Interfaces	1) Review of design to confirm appropriate interfaces included. 2) Functional testing demonstrating correct EBCS video transmission through PVGF.		(I&D)	Certificate of Compliance	
I-206	SSP 57003	3.7.3.3.7B	Sync, Control, and Video Interfaces	Review of design to confirm AP can accept PVGF harness.	JSC	(I&D) Drawing review and QA inspection	Certificate of Compliance	
I-207	SSP 57003	3.7.3.3.7.1	Video, Sync, and Control Transmission and Signal Characteristics	Functional testing demonstrating correct EBCS video transmission through PVGF interface.		(I&D)	Certificate of Compliance	
I-208	SSP 57003	3.7.3.3.7.2A	Sync and Video Power Levels	Functional testing confirming correct transmission of EBCS video through PVGF interface.		(I&D)	Certificate of Compliance	
I-209	SSP 57003	3.7.3.3.7.2B	Sync and Video Power Levels	Functional testing confirming correct transmission of EBCS video through PVGF interface.		(I&D)	Certificate of Compliance	
I-210	SSP 57003	3.7.3.3.7.2C	Sync and Video Power Levels	Functional testing confirming correct transmission of EBCS video through PVGF interface.		(I&D)	Certificate of Compliance	
I-211	SSP 57003	3.7.3.3.7.2A	Sync and Video Power Levels	Functional testing confirming correct transmission of EBCS video through PVGF interface.		(I&D)	Certificate of Compliance	
I-212	SSP 57003	3.7.3.3.8A	Passive Thermal Interface	Thermal analysis demonstrating PVGF remains within thermal limits.	JSC	(A) Thermal Analysis Report	Analysis Report	
I-213	SSP 57003	3.7.3.3.8B	Passive Thermal Interface	Thermal analysis demonstrating PVGF remains within operational thermal limits during transfer and berthing operations.	JSC	(A) Thermal Analysis Report	Analysis Report	
I-214	SSP 57003	3.7.3.3.8C	Passive Thermal Interface	Thermal analysis demonstrating interface conductance is less than requirement.	JSC	(A) Thermal Analysis Report	Analysis Report	
I-215	SSP 57003	3.7.3.3.9.1	Electromagnetic Compatibility	EMC testing demonstrating compliance with requirements.	ESTEC	(A&T) EMI/EMC Test Report	Test Report (Results must be provided for each configuration in the worst–case operational modes. The report should include the test configuration/layout (including cables), photographs of the test configuration, and a description of testing equipment.)	

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
I-216	SSP 57003	3.7.3.3.9.2	Grounding	1) Analysis demonstrating AP meets grounding requirements. 2) QA inspection of interface to determine actual grounding levels.	KSC	(A&T) Grounding analysis and QA inspection	Analysis report showing (A.) compliance of actual grounding (based on end item qualification test data) versus grounding design philosophy (in Design Analysis Report), and (B.) the compliance with SSP 30242.	
I-217	SSP 57003	3.7.3.3.9.3A	Bonding	1) Analysis demonstrating AP meets bonding requirements. 2) QA inspection of interface to determine actual bonding levels.	KSC	(A&I&T) Bonding analysis and QA inspection	1. Test report showing compliance with SSP 30245 and NSTS 1700.7B/ISS, 213 and 220. 2. Analysis report showing compliance with SSP 30245, NSTS 1700.7B/ISS, 213 and 220, and the Unique Payload Hardware ICD. 3. Certificate of Compliance for inspection	
I-218	SSP 57003	3.7.3.3.9.3B	Bonding	1) Analysis demonstrating AP meets bonding requirements. 2) QA inspection of interface to determine actual bonding levels.		(A&I&T)	1. Test report showing compliance with SSP 30245 and NSTS 1700.7B/ISS, 213 and 220. 2. Analysis report showing compliance with SSP 30245, NSTS 1700.7B/ISS, 213 and 220, and the Unique Payload Hardware ICD. 3. Certificate of Compliance for Inspection	
I-219	SSP 57003	3.7.3.3.9.4	Cable and Wire Design	Review of design to confirm all requirements of SSP 30242 met.	JSC	(A&T or A&I) Drawing review and QA inspection	Analysis report showing: (A.) compliance of actual grounding (based on end item qualification test data) versus grounding design philosophy (in Design Analysis Report), and (B.) the compliance with SSP 30242.	

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
I-220	SSP 57003	3.7.3.3.9.4A	Cable and Wire Design	Review of design to confirm all requirements of SSP 30242 met.	JSC	(A&T or A&I) Drawing review and QA inspection	Analysis report showing: (A.) compliance of actual grounding (based on end item qualification test data) versus grounding design philosophy (in Design Analysis Report), and (B.) the compliance with SSP 30242.	
I-221	SSP 57003	3.7.3.3.9.4B	Cable and Wire Design	Review of design to confirm all requirements of SSP 30242 met.	JSC	(A&T or A&I) Drawing review and QA inspection	Analysis report showing: (A.) compliance of actual grounding (based on end item qualification test data) versus grounding design philosophy (in Design Analysis Report), and (B.) the compliance with SSP 30242.	
I-222	SSP 57003	3.7.3.3.9.4C	Cable and Wire Design	Review of design to confirm all requirements of SSP 30242 met.	JSC	(A&T or A&I) Drawing review and QA inspection	Analysis report showing: (A.) compliance of actual grounding (based on end item qualification test data) versus grounding design philosophy (in Design Analysis Report), and (B.) the compliance with SSP 30242.	
I-223	SSP 57003	3.7.3.3.9.5	Electrostatic Discharge	Electrical analysis demonstrating no hardware vulnerable to ESD.		(I)	Certificate of Compliance	
I-224	SSP 57003	3.7.3.3.9.6	Corona	Safety analysis to demonstrate proper controls for all high-voltage hardware susceptible to damaging corona effects.	JSC	(T) Flight Safety Data Package	1. A report on test results and an analysis showing compliance during functional testing. 2. Test Report and detailed analysis for items requiring more detailed corona test (if any).	

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
I-225	SSP 57003	3.7.6.1A	EBCS Avionics Package Envelope and Mounting – Operation Envelope and Optical Keep-out Zone	Review of design to confirm optical keep-out zone is clear.	JSC	(I) Review of design and QA inspection	Certificate of Compliance	Exception
I-226	SSP 57003	3.7.6.1B	EBCS Avionics Package Envelope and Mounting - Location	Review of design to confirm EBCS located in correct location relative to PAS.	JSC	(I&A) Review of design and QA inspection	Certificate of Compliance	Exception
I-227	SSP 57003	3.7.6.1C	EBCS Avionics Package Envelope and Mounting - Maintain Location	1) Thermal analysis demonstrating deflection of EBCS meets requirements at thermal extremes. 2) Stress analysis demonstrating positive margins of safety to required load conditions.	JSC	(A) Thermal Analysis Report and Stress Report	Certificate of Compliance	Exception
I-228	SSP 57003	3.7.6.2A	EBCS Avionics Package Power – Cable Routing and Connections	1) Review of design to confirm power cable routed to EBCS location. 2) Functional test demonstrating power available to EBCS.		(I&D)	Certificate of Compliance	
I-229	SSP 57003	3.7.6.2B	EBCS Avionics Package Power – Heater Power	Review of design to confirm presence of two heater buses.	JSC	(I&D) Drawing review and QA inspection	Certificate of Compliance	
I-230	SSP 57003	3.7.6.3A	EBCS Thermal Requirement - Non-Operational On-Orbit	Verification shall be by analysis. Verification shall be considered successful when the analysis shows that EBCS avionics package is maintained within its operational and non-operational temperature limits. An EBCS avionics package thermal model shall be supplied by NASA.		(A)	Analysis Report	
I-231	SSP 57003	3.7.6.4	EBCS Vibration Environment	Structural analysis demonstrating that vibration levels remain within limits.	JSC	(A) Random vibration analysis	Certificate of Compliance	
I-232	SSP 57003	3.7.6.5	EBCS Avionics Package Video	1) Review of design to confirm data cable routed to EBCS location. 2) Functional test demonstrating correct video transmission from EBCS.		(I&D)	Certificate of Compliance	
I-233	SSP 57003	3.9.1.3B	Access – ORU Removal	Review of design to confirm compliance with EVA removal requirement.	JSC	(I&A) Drawing review and QA inspection	Certificate of Compliance	
I-234	SSP 57003	3.9.1.3B	Access – SSP 50005	Review of design to confirm EVA access requirements met for all contingency operations.	JSC	(I&A) Drawing review and QA inspection	Certificate of Compliance	
I-235	SSP 57003	3.9.1.6.7.1	ORU CLA and Umbilical Mechanism Assembly EVA Overrides	Review of design to confirm adequate EVA access to CLA and UMA overrides.	JSC	(A) Drawing review and QA inspection	Certificate of Compliance	
I-236	SSP 57003	3.9.1.6.7.2	PAS & UCCAS ORU EVA Maintenance	Review of design to confirm adequate EVA access to PAS/UCCAS ORUs.	JSC	(A) Drawing review and QA inspection	Certificate of Compliance	
I-237	SSP 57003	3.10A	Nameplates and Product Marking	Review of design to confirm that appropriate labeling included.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance showing Form 732 approval.	

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
I-238	SSP 57003	3.10B	Nameplates and Product Marking – Structural Integrity	Review of design to confirm that marking techniques do not degrade equipment.	JSC	(A) Drawing review and QA inspection	Certificate of Compliance	
I-239	SSP 57003	3.11.1.1	EVA Translation Path Interference	Review of design to confirm that AP hardware does not interfere with EVA translation paths.	JSC	(A) Drawing review and QA inspection	Analysis Report	
I-240	SSP 57003	3.11.1.2	EVA Operations Access Corridor	Review of design to confirm that AP hardware does not interfere with MT translation paths.	JSC	(A) Drawing review and QA inspection	Analysis Report	
I-241	SSP 57003	3.11.1.3	Payload Translation Paths	Review of design to confirm that EVA paths meeting all requirements included in design.	JSC	(I) Drawing review and QA inspection	Data Cert documenting all translation paths have gaps less than or equal to 24 inches.	
I-242	SSP 57003	3.11.1.3.1	Translation Path Diameter	Review of design to confirm EVA translation paths have adequate diameter.	JSC	(I) Drawing review and QA inspection	Data Cert showing all translation paths provide an unobstructed translation corridor that is a minimum of 43 inches in diameter.	
I-243	SSP 57003	3.11.1.3.2	Translation Path Direction Change Angles	Review of design to confirm EVA translation paths have adequate radii at sharp angle change points.	JSC	(I) Drawing review and QA inspection	Data Cert showing all translation paths provide a translation corridor that is a minimum of 74 inches at locations with direction change angles of greater than 30 degrees.	
I-244	SSP 57003	3.11.1.3.3	Tethered Two-Handed Translation	Review of design to confirm EVA translation paths have adequate movement aids.	JSC	(A) Drawing review and QA inspection	Analysis Report	
I-245	SSP 57003	3.11.1.3.4	Tethered Attachment Points	Review of design to confirm EVA translation paths have safety tether points.	JSC	(A) Drawing review and QA inspection	Analysis Report	
I-246	SSP 57003	3.11.2	EVA Worksites	Review of design to confirm inclusion of EVA worksites at all relevant locations.	JSC	(A) Drawing review and QA inspection	Analysis Report	
I-247	SSP 57003	3.11.2.1	External Task Location Requirements	Review of design to confirm worksite located appropriately to EVA task.	JSC	(A) Drawing review and QA inspection	Analysis Report	

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
I-248	SSP 57003	3.11.2.2	EVA Crewmember Field of View	Review of design to confirm markings located within the astronaut's field of view.	JSC	(A) Drawing review and QA inspection	Analysis Report	
I-249	SSP 57003	3.11.2.3	Working Volume	Review of design to confirm EVA manipulated hardware located within working volume.	JSC	(A) Drawing review and QA inspection	Analysis Report	
I-250	SSP 57003	3.11.2.3.1	Working Volume Height	Review of design to confirm working volume of appropriate height available.	JSC	(A) Drawing review and QA inspection	Analysis Report	
I-251	SSP 57003	3.11.2.4	Gloved Operation	Review of design to confirm adequate clearance for EVA glove to all relevant hardware.	JSC	(A) Drawing review and QA inspection	Analysis Report	
I-252	SSP 57003	3.11.2.5.1	Criteria for Dedicated EVA Worksites	Stress analysis demonstrating positive margins of safety to required load conditions.	JSC	(A) Stress Report	Analysis Report	
I-253	SSP 57003	3.11.2.5.2.1	Translation Paths to the Worksite	Worksite Analysis confirming that translation paths have been provided to EVA worksites on the payload	JSC	(A) Worksite Analysis	Analysis Report	
I-254	SSP 57003	3.11.2.5.2.2	Foot Restraint Interfaces at the Worksite	Worksite Analysis confirming that the worksite(s) provides a WIF socket (WIF Sockets) located to provide worksite access.	JSC	(A) Worksite Analysis	Analysis Report	
I-255	SSP 57003	3.11.2.5.2.3	Translation Aids	Worksite Analysis confirming that translation aids have been provided to install, ingress, egress, and remove the APFR.	JSC	(A) Worksite Analysis	Analysis Report	
I-256	SSP 57003	3.11.2.5.2.4	Dedicated EVA Worksite Tether Points	Worksite Analysis confirming that the attached payload provides tether points at the dedicated worksite as required.	JSC	(A) Worksite Analysis	Analysis Report	
I-257	SSP 57003	3.11.2.5.2.5	Dedicated EVA Worksite Restraints and Handling Aids	Worksite Analysis confirming that mobility aids are provided at the worksite as required.	JSC	(A) Worksite Analysis	Analysis Report	
I-258	SSP 57003	3.11.2.6	Robotic Assisted EVA Worksites	Worksite Analysis confirming that for an identified Robotic assisted EVA worksite the crew transport and restraint capability is within the kinematic and reach envelope of the manipulator.		(A) Worksite Analysis	Analysis Report	
I-259	SSP 57003	3.11.2.6.1.1	Robotic Assisted EVA Worksite Force Reaction Mechanism	Worksite Analysis confirming that the identified Robotic assisted EVA worksite(s) on the payload provide(s) the force reaction mechanism for the conditions as specified.	JSC	(A) Worksite Analysis	Analysis Report	
I-260	SSP 57003	3.11.2.6.1.2	Robotic Assisted Worksite Force Reaction Location	Worksite Analysis confirming that the identified Robotic assisted EVA worksite(s) on the payload provide(s) the force reaction mechanism is located as specified.	JSC	(A) Worksite Analysis	Analysis Report	
I-261	SSP 57003	3.11.2.6.1.3	Robotic Assisted Worksite Tether Points	Worksite Analysis confirming that the attached payload provides tether points at the robotic assisted worksite as required.	JSC	(A) Worksite Analysis	Analysis Report	
I-262	SSP 57003	3.11.2.7.1.1	Translation Paths to the Free-Float Worksite	Worksite Analysis confirming that a translation path has been provided to the worksite.	JSC	(A) Worksite Analysis	Analysis Report	
I-263	SSP 57003	3.11.2.7.1.2	Free-Float EVA Worksite Tether Points	Worksite Analysis confirming that the attached payload provides tether points at the free−float worksite as required.	JSC	(A) Worksite Analysis	Analysis Report	
I-264	SSP 57003	3.11.2.7.1.3	Free-Float EVA Worksite Restraints and Handling Aids	Worksite Analysis confirming that mobility aids are provided at the worksite as required.	JSC	(A) Worksite Analysis	Analysis Report	
I-265	SSP 57003	3.11.2.8	EVA Actuation Loads	Structural analysis to determine required actuation force for each EVA mechanism.	JSC	(A) Stress Analysis	Analysis Report	

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
I-266	SSP 57003	3.11.3.1.1	Translation Handhold/Handrail Locations	Review of design to confirm handrails included at all direction change points.	JSC	(I) Drawing review and QA inspection	Data Cert showing that all terminal points and direction change points on translation paths provide mobility aids.	
I-267	SSP 57003	3.11.3.1.2	Translation Handhold/Handrail Orientation	Review of design to confirm handrails oriented appropriately.	JSC	(I) Drawing review and QA inspection	Report	
I-268	SSP 57003	3.11.3.1.3	Equipment Accessibility	Review of design to confirm handrails placed appropriately.	JSC	(A) Worksite Analysis	Analysis Report	
I-269	SSP 57003	3.11.3.1.4	EVA Handhold/Handrail Dimensions	Review of design to confirm handrails of appropriate size.	JSC	(I) Drawing review and QA inspection	Report	
I-270	SSP 57003	3.11.3.1.4.1	EVA Handhold/Handrail Clearance	Review of design to confirm handrails mounted in appropriate position.	JSC	(I) Drawing review and QA inspection	Report	
I-271	SSP 57003	3.11.3.1.4.2	Handhold/Handrail Grip Length	Review of design to confirm handrails of appropriate size.	JSC	(I) Drawing review and QA inspection	Report	
I-272	SSP 57003	3.11.3.1.4.3	EVA Handhold/Handrail Clearance Envelope	Review of design to confirm appropriate clearances maintained.	JSC	(I) Drawing review and QA inspection	Report	
I-273	SSP 57003	3.11.3.1.5A	Handhold/Handrail Color and Structural Loading	Review of design to confirm appropriate surface treatment used.	JSC	(A&I) Drawing review and QA inspection	1. Analysis Report 2. Report	
I-274	SSP 57003	3.11.3.1.5B	Handhold/Handrail Color and Structural Loading	Review of design to confirm appropriate surface treatment used.	JSC	(A&I) Drawing review and QA inspection	1. Analysis Report 2. Report	
I-275	SSP 57003	3.11.3.1.6	Handrail/Handhold Electrical Bonding	Review of design to confirm bonding requirements met.	JSC	(I) Drawing review and QA inspection	Report	
I-276	SSP 57003	3.11.3.1.7.1	Spacing for Worksites – Above or Below	Review of design to confirm handrails mounted in appropriate position.	JSC	(A) Worksite Analysis	Analysis Report	
I-277	SSP 57003	3.11.3.1.7.2	Spacing for Worksites – Left or Right	Review of design to confirm handrails mounted in appropriate position.	JSC	(A) Worksite Analysis	Analysis Report	
I-278	SSP 57003	3.11.3.1.7.3	APFR Installation Aids	Review of design to confirm handrails mounted in appropriate position.	JSC	(A) Worksite Analysis	Analysis Report	

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
I-279	SSP 57003	3.11.3.1.7.4	APFR Ingress Aids	Review of design to confirm handrails mounted in appropriate position.	JSC	(A) Worksite Analysis	Analysis Report	
I-280	SSP 57003	3.11.3.2.1	EVA Handhold/Handrail Safety Tether Hooks	Review of design to confirm handrails can support safety tether hooks.	JSC	(I) Drawing review and QA inspection	Report	
I-281	SSP 57003	3.11.3.2.2A	EVA Handhold/Handrail Safety Tether Point Color and Structural Loading	Review of design to confirm appropriate surface treatment used.	JSC	(I) Drawing review and QA inspection	Report	
I-282	SSP 57003	3.11.3.2.2B	EVA Handhold/Handrail Safety Tether Point Color and Structural Loading	Review of design to confirm appropriate surface treatment used.	JSC	(I) Drawing review and QA inspection	Report	
I-283	SSP 57003	3.11.3.2.3	EVA Handrail/hold Tether Point Dimensions	Review of design to confirm handrails of appropriate size.	JSC	(I) Drawing review and QA inspection	Report	
I-284	SSP 57003	3.11.3.2.4	EVA Equipment Tether Attachment Points	Review of design to confirm handrails can support equipment tether hooks.	JSC	(I) Drawing review and QA inspection	Report	
I-285	SSP 57003	3.11.3.2.5	EVA Standardized Tether Receptacle	Program Office review to confirm that no EVA equipment will be stored on AMS-02	JSC	(I) APO Review	Report	
I-286	SSP 57003	3.11.3.3.1	Worksite Interface EVA Clearance	Review of design to confirm EVA clearance envelope exists.	JSC	(I) Drawing review and QA inspection	Report	
I-287	SSP 57003	3.11.3.3.2	Worksite Interface Structural Loading	Review of design to confirm that EVA paths meeting all requirements included in design.	JSC	(A) Drawing review and QA inspection	Analysis Report	
I-288	SSP 57003	3.11.4.1.1	One-Handed Operation	Review of design to confirm connectors meet requirement.	JSC	(A) Drawing review and QA inspection	Certificate of Compliance	
I-289	SSP 57003	3.11.4.1.2	Accessibility	Review of design to confirm connectors meet requirement.	JSC	(A) Drawing review and QA inspection	Certificate of Compliance	
I-290	SSP 57003	3.11.4.1.4.1	Ease of Disconnect	Review of design to confirm connectors meet requirement.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	
I-291	SSP 57003	3.11.4.1.4.2	Self-Locking	Review of design to confirm connectors meet requirement.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
I-292	SSP 57003	3.11.4.1.4.3	Access	Review of design to confirm connectors meet requirement.	JSC	(A) Drawing review and QA inspection	Certificate of Compliance	
I-293	SSP 57003	3.11.4.1.4.4	Arc Containment	Review of design to confirm connectors meet requirement.	JSC	(A) Drawing review and QA inspection	Certificate of Compliance	
I-294	SSP 57003	3.11.4.1.4.5	Scoop Proof	Review of design to confirm connectors meet requirement.	JSC	(A) Drawing review and QA inspection	Certificate of Compliance	
I-295	SSP 57003	3.11.4.1.4.6	Electrical Hazards	Review of design to confirm connectors meet requirement.	JSC	(A) Drawing review and QA inspection	Certificate of Compliance	
I-296	SSP 57003	3.11.4.1.5.1	Alignment Provisions	Review of design to confirm structural connectors meet requirement.	JSC	(A) Drawing review and QA inspection.	Certificate of Compliance	
I-297	SSP 57003	3.11.4.1.5.2	Soft Latching	Review of design to confirm structural connectors meet requirement.	JSC	(A) Drawing review and QA inspection.	Certificate of Compliance	
I-298	SSP 57003	3.11.4.1.5.3	Lock Indication	Review of design to confirm structural connectors meet requirement.	JSC	(A) Drawing review and QA inspection.	Certificate of Compliance	
I-299	SSP 57003	3.11.4.1.6	Optical Connectors Design Requirements	Review of design to confirm connectors meet requirement.	JSC	(A) Drawing review and QA inspection	Certificate of Compliance	
I-300	SSP 57003	3.11.4.1.7.1	Connector Mismate Prevention	Review of design to confirm connectors meet requirement.	JSC	(A) Drawing review and QA inspection	Certificate of Compliance	
I-301	SSP 57003	3.11.4.1.7.2	Connector Shape	Review of design to confirm connectors meet requirement.	JSC	(A) Drawing review and QA inspection	Certificate of Compliance	
I-302	SSP 57003	3.11.4.1.7.3	Alignment Provisions	Review of design to confirm connectors meet requirement.	JSC	(A) Drawing review and QA inspection	Certificate of Compliance	
I-303	SSP 57003	3.11.4.1.7.3.1	Alignment Aids	Review of design to confirm connectors meet requirement.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
I-304	SSP 57003	3.11.4.1.7.3.2	Electrical Connector Alignment Pin Length	Review of design to confirm connectors meet requirement.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	
I-305	SSP 57003	3.11.4.1.7.4.1	Use of Alignment Marks	Review of design to confirm connectors meet requirement.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	
I-306	SSP 57003	3.11.4.1.7.4.2	Alignment Mark Design	Review of design to confirm connectors meet requirement.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	
I-307	SSP 57003	3.11.4.1.7.5	Orientation	Review of design to confirm plugs grouped according to requirement	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	
I-308	SSP 57003	3.11.4.1.8.1	Cable/Hose End Identification	Review of design to confirm connectors meet requirement.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	
I-309	SSP 57003	3.11.4.1.8.2	Cable/Hose Restraints	Review of design to confirm cable restraint method exists.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	
I-310	SSP 57003	3.11.4.1.9	Status	Review of design to confirm connectors meet requirement.	JSC	(A) Drawing review and QA inspection	Certificate of Compliance	
I-311	SSP 57003	3.11.4.1.11	Protective Caps	Review of design to confirm connectors meet requirement.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	
I-312	SSP 57003	3.11.4.1.12	Connector Protection	Review of design to confirm connectors meet requirement.	JSC	(A) Drawing review and QA inspection	Certificate of Compliance	
I-313	SSP 57003	3.11.4.1.13.1	Connectors and Adjacent Obstructions	Review of design to confirm appropriate clearance exists.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	
I-314	SSP 57003	3.11.4.1.13.2	Connectors in Rows Which are Removed Sequentially	Review of design to confirm appropriate clearance exists.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	
I-315	SSP 57003	3.11.4.1.13.3	Wing Connector Spacing	Review of design to confirm appropriate clearance exists.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
I-316	SSP 57003	3.11.4.3	EVA Equipment Handling Capabilities	Review of design to confirm requirements in table met.	JSC	(A) Drawing review and QA inspection	Analysis Report	
I-317	SSP 57003	3.11.4.4	EVA Equipment Attachment Points/Restraints	Review of design to confirm requirements met.	JSC	(I) Drawing review and QA inspection	Report	
I-318	SSP 57003	3.11.4.5	Access	Review of design to confirm requirements met.	JSC	(A) Drawing review and QA inspection	Analysis Report	
I-319	SSP 57003	3.11.4.7.1.1	Hand-actuated Fasteners	Review of design to confirm fasteners meet requirement.	JSC	(A) Drawing review and QA inspection	Certificate of Compliance	
I-320	SSP 57003	3.11.4.7.1.2.1	Captive Fastener Provisions	Review of design to confirm fasteners meet requirement.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	
I-321	SSP 57003	3.11.4.7.1.2.2	Temporary Fasteners	Review of design to confirm no temporary fasteners used.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	
I-322	SSP 57003	3.11.4.7.1.3.1	Direct Access	Review of design to confirm fasteners located appropriately.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	
I-323	SSP 57003	3.11.4.7.1.3.2	Access Holes	Review of design to confirm holes are sized appropriately.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	
I-324	SSP 57003	3.11.4.7.1.4	One-Handed Actuation	Review of design to confirm fasteners meet requirement.	JSC	(A) Drawing review and QA inspection	Certificate of Compliance	
I-325	SSP 57003	3.11.4.7.1.5	Engagement Status Indication	Review of design to confirm fasteners meet requirement.	JSC	(A) Drawing review and QA inspection	Certificate of Compliance	
I-326	SSP 57003	3.11.4.7.1.6	Indication of Status	Review of design to confirm fasteners located appropriately.	JSC	(A) Drawing review and QA inspection	Certificate of Compliance	
I-327	SSP 57003	3.11.4.7.1.7.1	Number of Fasteners	Review of design to confirm fasteners meet requirement.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
I-328	SSP 57003	3.11.4.7.1.7.2	Arrangement	Review of design to confirm fastener pattern meets requirement.	JSC	(A) Drawing review and QA inspection	Certificate of Compliance	
I-329	SSP 57003	3.11.4.7.1.8	Safety	Review of design to confirm fasteners meet requirement.	JSC	(A) Drawing review and QA inspection	Certificate of Compliance	
I-330	SSP 57003	3.11.4.7.1.9	Actuation Force/Torque	Review of design to confirm fasteners meet requirement.	JSC	(A) Drawing review and QA inspection	Certificate of Compliance	
I-331	SSP 57003	3.11.4.7.1.10	Cotter Keys	Review of design to confirm no cotter keys used.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	
I-332	SSP 57003	3.11.4.7.1.11	Ratchet Type Tool Engage/Disengage Force	Program Office review to confirm no ratchet-type tools required for AMS-02 contingency EVA operations.	JSC	(A) APO Review	Certificate of Compliance	
I-333	SSP 57003	3.11.4.7.1.12	Driver Type Tool Engage/Disengage Torque	Review of design to confirm fasteners meet requirement.	JSC	(A) Drawing review and QA inspection	Certificate of Compliance	
I-334	SSP 57003	3.11.4.7.1.13	EVA Access to Fasteners	Review of design to confirm appropriate clearance exists.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	
I-335	SSP 57003	3.11.4.7.2.1	Fastener Knobs	Review of design to confirm fasteners meet requirement.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	
I-336	SSP 57003	3.11.4.7.2.2	Fastener and Knob Head Diameter	Review of design to confirm fasteners meet requirement.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	
I-337	SSP 57003	3.11.4.7.2.3	Fastener and Knob Head Height	Review of design to confirm fasteners meet requirement.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	
I-338	SSP 57003	3.11.4.7.2.4	Override Feature	Review of design to confirm fasteners meet requirement.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	
I-339	SSP 57003	3.11.4.7.2.5.1	Fastener Turns	Review of design to confirm fasteners meet requirement.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	
I-340	SSP 57003	3.11.4.7.2.5.2	One-Handed Actuation	Review of design to confirm fasteners meet requirement.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
I-341	SSP 57003	3.11.4.7.2.5.3	Positive Locking	Review of design to confirm fasteners meet requirement.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	
I-342	SSP 57003	3.11.4.7.2.6.1	Locking Feature	Review of design to confirm fasteners meet requirement.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	
I-343	SSP 57003	3.11.4.7.2.6.2	Fastener Back-out	Review of design to confirm fasteners meet requirement.	JSC	(A) Drawing review and QA inspection	Certificate of Compliance	
I-344	SSP 57003	3.11.4.7.2.8	Safety Wire	Review of design to confirm no safety wire used.	JSC	(I) Drawing review	Certificate of Compliance	
I-345	SSP 57003	3.11.4.7.3.1	Nonstandard Tools	Review of design to confirm fasteners meet requirement.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	
I-346	SSP 57003	3.11.4.7.3.2.1	EVA Actuated Bolts	Review of design to confirm fasteners meet requirement.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	
I-347	SSP 57003	3.11.4.7.3.3	Precision Torquing	Review of design to confirm fasteners meet requirement.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	
I-348	SSP 57003	3.11.4.7.3.4	Torque Instructions	Procedures for achieving precision torquing during EVA.	JSC	(I) EVA Procedure	Certificate of Compliance	
I-349	SSP 57003	3.11.4.7.3.5.1	Use of Left-Hand Threads	Review of design to confirm fasteners meet requirement.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	
I-350	SSP 57003	3.11.4.7.3.5.2	Marking of Left-Hand Threads	Review of design to confirm fasteners meet requirement.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	
I-351	SSP 57003	3.11.4.7.3.6	Locking	Review of design to confirm fasteners meet requirement.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	
I-352	SSP 57003	3.11.4.7.3.7	Hand Tool Operable	Review of design to confirm fasteners meet requirement.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	
I-353	SSP 57003	3.11.4.8	Equipment Item Interconnecting Devices	Review of design to confirm utility lines of appropriate length included.	JSC	(A) Drawing review and QA inspection	Certificate of Compliance	

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
I-354	SSP 57003	3.11.4.9	Incorrect Equipment Installation	Review of design to confirm EVA replaceable equipment cannot be installed incorrectly.	JSC	(A) Drawing review and QA inspection	Analysis Report	
I-355	SSP 57003	3.11.4.10	Restraining and Handling Devices for Temporary Storage	Review of design to confirm EVA replaceable equipment can be stored temporarily.	JSC	(A) Drawing review and QA inspection	Analysis Report	
I-356	SSP 57003	3.11.4.11	Installation Removal Force	Review of design to confirm EVA operation can be accomplished within load level requirement.	JSC	(A) Drawing review and QA inspection	Analysis Report	
I-357	SSP 57003	3.11.4.12	Direction of Removal	Review of design to confirm adequate clearance exists for EVA operations.	JSC	(A) Drawing review and QA inspection	Analysis Report	
I-358	SSP 57003	3.11.4.13	Visibility	Review of design to confirm adequate visibility exists for EVA operations.	JSC	(A) Drawing review and QA inspection	Analysis Report	
I-359	SSP 57003	3.11.4.14.1	Visual Alignment Method	Review of design to confirm EVA replaceable equipment has appropriate alignment markings.	JSC	(I) Drawing review and QA inspection	Data Cert listing equipment items and showing that they incorporate a visual alignment method.	
I-360	SSP 57003	3.11.4.14.2	Alignment Marks on Both Sides of Interface	Review of design to confirm EVA replaceable equipment has appropriate alignment markings.	JSC	(I) Drawing review and QA inspection	Data Cert showing alignment marks or orientation arrows are on both sides of the interface.	
I-361	SSP 57003	3.11.4.14.3	Alignment for Operational Position	Review of design to confirm EVA replaceable equipment has appropriate alignment markings.	JSC	(I) Drawing review and QA inspection	Data cert showing alignment marks are applied to both mating parts and the marks are aligned in the operational position.	
I-362	SSP 57003	3.11.4.14.4	Alignment Mark Description	Review of design to confirm EVA replaceable equipment has appropriate alignment markings.	JSC	(I) Drawing review and QA inspection	Data Cert showing the alignment marks consist of a straight or curved line of a width and length to allow accurate alignment.	
I-363	SSP 57003	3.11.4.14.5	Alignment Devices	Review of design to confirm EVA replaceable equipment has appropriate guide pins.	JSC	(I) Drawing review and QA inspection	Data Cert listing the equipment items and showing they have guide pins or equivalent alignment devices.	

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
I-364	SSP 57003	3.11.4.15	EVA Tool Access	Review of design to confirm no nonstandard tools used.	JSC	(I) Drawing review and QA inspection	Data Cert listing the Attached Payload operations and showing they can be performed with the specified tools of SSP 30256:001, Table 3.2-1 and Table 3.2-2.	
I-365	SSP 57003	3.11.4.15.1	Tool Head Clearance	Review of design to confirm appropriate clearance exists.	JSC	(I) Drawing review and QA inspection	Data Cert listing the Attached Payload operations and showing they provides tool head clearance as defined in Figure 3.11.4.15.1-1.	
I-366	SSP 57003	3.11.4.15.2	Tool Handle Clearance	Review of design to confirm appropriate clearance exists.	JSC	(I) Drawing review and QA inspection	Date Cert listing the Attached Payload operations and showing structure surrounding tool-actuated fasteners provide the proper clearance as shown in Figure 3.11.4.15.1-1.	
I-367	SSP 57003	3.11.4.15.3	Driver-Type Tool Clearance	Review of design to confirm appropriate clearance exists.	JSC	(I) Drawing review and QA inspection	Data Cert listing the Attached Payload operations and showing equipment and structures surrounding bolts requiring EVA driver-type tools provide 360 degrees of clearance.	
I-368	SSP 57003	3.11.4.15.4	Ratchet-Type Tool Throw Angles	Review of design to confirm appropriate clearance exists.	JSC	(I) Drawing review and QA inspection	Data Cert listing the Attached Payload operations and showing equipment and structures surrounding bolts requiring EVA ratcheting shall protect a 90 degree throw angle and shall allow right or left handed operation.	
I-369	SSP 57003	3.11.4.17.1	Controls	Program office review to confirm no EVA actuated controls on AMS-02.	JSC	APO Review	Certificate of Compliance	(I) Program office confirms AMS-02 has no EVA actuated controls.
I-370	SSP 57003	3.11.4.17.2	Displays	Review of design to confirm no EVA displays on AMS-02	JSC	Drawing review	Certificate of Compliance	(I) Review of design confirms AMS-02 includes no EVA displays.

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
I-371	SSP 57003	3.11.5.1	Latches	Review of design to confirm no over-center latches used on AMS-02	JSC	(A) Drawing review	Certificate of Compliance	
I-372	SSP 57003	3.11.5.2	Equipment Clearance for Entrapment Hazard	Review of design to confirm appropriate clearances provided.	JSC	(A) Drawing review and QA inspection	Certificate of Compliance	
I-373	SSP 57003	3.11.5.3	Holes in EVA Handrails/holds	Review of design to confirm holes sized appropriately.	JSC	(A) Drawing review and QA inspection	Certificate of Compliance	
I-374	SSP 57003	3.11.5.4	Covered Holes	Review of design to confirm holes covered appropriately.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	
I-375	SSP 57003	3.11.5.5	Pinch Points	Review of design to confirm appropriate clearances provided.	JSC	(A) Drawing review and QA inspection	Certificate of Compliance	
I-376	SSP 57003	3.11.5.6	Screws and Bolts	Review of design to confirm fasteners meet requirement.	JSC	(A) Drawing review and QA inspection	Certificate of Compliance	
I-377	SSP 57003	3.11.5.7	Levers, Cranks, Hooks, and Controls	Review of design to confirm appropriate clearances provided.	JSC	(A) Drawing review and QA inspection	Certificate of Compliance	
I-378	SSP 57003	3.11.5.8	Burrs	Full QA inspection of hardware to confirm no burrs on exposed surfaces	JSC	(A) QA inspection	Certificate of Compliance	
I-379	SSP 57003	3.11.5.10	Danger Warnings	1) Safety analysis to identify hardware within three feet of handholds that could pose critical or catastrophic hazard to crewmember. 2) Review of design to confirm that handholds colored appropriately.	JSC	(I) Flight Safety Data Package, Drawing review, and QA inspection	Certificate of Compliance	
I-380	SSP 57003	3.11.5.11	Control for Exposed Risks	1) Safety analysis to identify hardware in translation path that could pose critical or catastrophic hazard to crewmember. 2) Review of design to confirm that hardware placarded appropriately	JSC	(A) Flight Safety Data Package, Drawing review, and QA inspection	Certificate of Compliance	
I-381	SSP 57003	3.11.5.12	Moving or Rotating Equipment	Safety analysis to confirm astronaut protected from moving/rotating equipment.	JSC	(A) Flight Safety Data Package	Certificate of Compliance	
I-382	SSP 57003	3.11.5.13	Sharp Edges	Review of design to confirm that EVA removable hardware meets sharp edge requirements.	JSC	(A) Drawing review and QA inspection	Certificate of Compliance	

Rqmt No.	Document	Paragraph	Requirement Title	Verification Success Criteria	Facility	Verification Method	Required Submittal Data	Results
I-383	SSP 57003	3.11.5.13.1	Sharp Edges and Protrusion Criteria	Review of design to confirm that EVA removable hardware meets sharp edge requirements.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	
I-384	SSP 57003	3.11.5.13.2	Thin Materials	Review of design to confirm that EVA removable hardware meets sharp edge requirements.	JSC	(A) Drawing review and QA inspection	Certificate of Compliance	
I-385	SSP 57003	3.11.5.14.1	Incidental Contact	Thermal analysis to confirm all hardware in EVA translation path meets thermal requirements.	JSC	(A) Thermal Analysis Report	Certificate of Compliance	
I-386	SSP 57003	3.11.5.14.2	Unlimited Contact	Thermal analysis to confirm all hardware intended for unlimited EVA contact meets thermal requirements.	JSC	(A) Thermal Analysis Report	Certificate of Compliance	Exception
I-387	SSP 57003	3.11.5.15	Component Hazardous Energy Provision	Safety analysis of all hardware retaining hazardous energy potential	JSC	(A) Flight Safety Data Package	Certificate of Compliance	
I-388	SSP 57003	3.11.5.18	Locking Wires	Review of design to confirm no lockwire or staking used for EVA-accessible hardware.	JSC	(I) Drawing review and QA inspection	Certificate of Compliance	
I-389	SSP 57003	3.11.5.19	Safety Critical Fasteners	Review of design to confirm appropriate backout prevention measures taken for all hardware	JSC	(A) Drawing review and QA inspection	Certificate of Compliance	

APPENDIX E: VALIDATION MATRIX FOR AMS-02 EXPERIMENT HARDWARE

Validation Product #	Activity	Objective	Valid. Method	Facility or Lab	Phase	Perform. Org	Results
Superconducting Magnet							
CS-1	RT-1B Racetrack Coil Test	Cool to 1.8 K in vacuum, charge to maximum load condition, quench, re-cool and re-charge. Per Work Instructions WI073, ETH Single Coil Test Cool Down Procedure and WI074, AMS Racetrack Coil Testing.	T	SM		SM	AMS: First Test of RT-1B (07/26/2002)
CS-2	RT-1B & RT-1D Racetrack Coil Tests	Cool to 1.8 K in vacuum, charge to maximum load condition, quench, re-cool and re-charge. Per Work Instructions WI073, ETH Single Coil Test Cool Down Procedure and WI074, AMS Racetrack Coil Testing.	T	SM		SM	AMS SCTR Test #3: RT-1B & RT-1D (09/20/2002)
CS-3	RT-3B & RT-3CR (1st Test) Racetrack Coil Tests	Cool to 1.8 K in vacuum, charge to maximum load condition, quench, re-cool and re-charge. Per Work Instructions WI073, ETH Single Coil Test Cool Down Procedure and WI074, AMS Racetrack Coil Testing.	T	SM		SM	AMS RT-3B & RT-3CR First Test (12/10/2002)
CS-4	RT-3B & RT-3CR Racetrack Coil Tests	Cool to 1.8 K in vacuum, charge to maximum load condition, quench, re-cool and re-charge. Per Work Instructions WI073, ETH Single Coil Test Cool Down Procedure and WI074, AMS Racetrack Coil Testing.	T	SM		SM	Coil Test #5 RT-3B & RT-3CR (12/12/2002)
CS-5	RT-3B & RT-3CR Racetrack Coil Tests	Cool to 1.8 K in vacuum, charge to maximum load condition, quench, re-cool and re-charge. Per Work Instructions WI073, ETH Single Coil Test Cool Down Procedure and WI074, AMS Racetrack Coil Testing.	T	SM		SM	AMS Racetrack Test #06 RT-3B & RT-3CR (01/22/2003)
CS-6	RT-1C & RT-5A Racetrack Coil Tests	Cool to 1.8 K in vacuum, charge to maximum load condition, quench, re-cool and re-charge. Per Work Instructions WI073, ETH Single Coil Test Cool Down Procedure and WI074, AMS Racetrack Coil Testing.	T	SM		SM	AMS Racetrack Test #07 RT-1C & RT-5A (02/11/2003)
CS-7	RT-1A & RT-5B Racetrack Coil Tests	Cool to 1.8 K in vacuum, charge to maximum load condition, quench, re-cool and re-charge. Per Work Instructions WI073, ETH Single Coil Test Cool Down Procedure and WI074, AMS Racetrack Coil Testing.	T	SM		SM	AMS Racetrack Test #08 RT-1A & RT-5B (03/10/2003)

Validation Product #	Activity	Objective	Valid. Method	Facility or Lab	Phase	Perform. Org	Results
CS-8	RT-1A & RT-5B Racetrack Coil Tests	Cool to 1.8 K in vacuum, charge to maximum load condition, quench, re-cool and re-charge. Per Work Instructions WI073, ETH Single Coil Test Cool Down Procedure and WI074, AMS Racetrack Coil Testing.	T	SM		SM	AMS Racetrack Test #09 RT-1A & RT-5B (06/03/2003)
CS-9	RT-1B & RT-5C Racetrack Coil Tests	Cool to 1.8 K in vacuum, charge to maximum load condition, quench, re-cool and re-charge. Per Work Instructions WI073, ETH Single Coil Test Cool Down Procedure and WI074, AMS Racetrack Coil Testing.	T	SM		SM	AMS Racetrack Test #10 RT-1B & RT-5C (07/29/2003)
CS-10	RT-3D & RT-5D Racetrack Coil Tests	Cool to 1.8 K in vacuum, charge to maximum load condition, quench, re-cool and re-charge. Per Work Instructions WI073, ETH Single Coil Test Cool Down Procedure and WI074, AMS Racetrack Coil Testing.	T	SM		SM	AMS Racetrack Test #11 RT-3D & RT-5D (18/12/2003)
CS-11	Dipole #2 Coil Test	Cool to 1.8 K in vacuum, charge to maximum load condition, quench, re-cool and re-charge. Per Work Instructions WI073, ETH Single Coil Test Cool Down Procedure and WI114, AMS Dipole single coil test.	T	SM		SM	AMS Coil Test #12 Dipole #2 (06/24/2004)
CS-12	Dipole #1 Coil Test	Cool to 1.8 K in vacuum, charge to maximum load condition, quench, re-cool and re-charge. Per Work Instructions WI073, ETH Single Coil Test Cool Down Procedure and WI114, AMS Dipole single coil test.	T	SM		SM	AMS Coil test #13 Dipole #1 (07/16/2004)
CS-13	RT-1A Racetrack Coil Test	Test 3 kV insulation between coils and ground, coils and quench heaters, quench heaters and ground per WI061, ETH Coil Tests – Final Stage.	T	SM		SM	RT-1A completed WI061 (09/12/2003)
CS-14	RT-1B Racetrack Coil Test	Test 3 kV insulation between coils and ground, coils and quench heaters, quench heaters and ground per WI061, ETH Coil Tests – Final Stage.	T	SM		SM	RT-1B completed WI061 (12/08/2003)
CS-15	RT-1C Racetrack Coil Test	Test 3 kV insulation between coils and ground, coils and quench heaters, quench heaters and ground per WI061, ETH Coil Tests – Final Stage.	T	SM		SM	RT-1C completed WI061 (09/15/2003)
CS-16	RT-1D Racetrack Coil Test	Test 3 kV insulation between coils and ground, coils and quench heaters, quench heaters and ground per WI061, ETH Coil Tests – Final Stage.	T	SM		SM	RT-1D completed WI061 (07/07/2003)

Validation Product #	Activity	Objective	Valid. Method	Facility or Lab	Phase	Perform. Org	Results
CS-17	RT-3A Racetrack Coil Test	Test 3 kV insulation between coils and ground, coils and quench heaters, quench heaters and ground per WI061, ETH Coil Tests – Final Stage.	T	SM		SM	RT-3A completed WI061 (05/12/2003)
CS-18	RT-3B Racetrack Coil Test	Test 3 kV insulation between coils and ground, coils and quench heaters, quench heaters and ground per WI061, ETH Coil Tests – Final Stage.	T	SM		SM	RT-3B completed WI061 (07/04/2003)
CS-19	RT-3CR Racetrack Coil Test	Test 3 kV insulation between coils and ground, coils and quench heaters, quench heaters and ground per WI061, ETH Coil Tests – Final Stage.	T	SM		SM	RT-3CR completed WI061 (07/07/2003)
CS-20	RT-3D Racetrack Coil Test	Test 3 kV insulation between coils and ground, coils and quench heaters, quench heaters and ground per WI061, ETH Coil Tests – Final Stage.	T	SM		SM	RT-3D completed WI061 (12/11/2003)
CS-21	RT-5A Racetrack Coil Test	Test 3 kV insulation between coils and ground, coils and quench heaters, quench heaters and ground per WI061, ETH Coil Tests – Final Stage.	T	SM		SM	RT-5A completed WI061 (09/16/2003)
CS-22	RT-5B Racetrack Coil Test	Test 3 kV insulation between coils and ground, coils and quench heaters, quench heaters and ground per WI061, ETH Coil Tests – Final Stage.	T	SM		SM	RT-5B completed WI061 (12/05/2003)
CS-23	RT-5C Racetrack Coil Test	Test 3 kV insulation between coils and ground, coils and quench heaters, quench heaters and ground per WI061, ETH Coil Tests – Final Stage.	T	SM		SM	RT-5C completed WI061 (12/10/2003)
CS-24	RT-5D Racetrack Coil Test	Test 3 kV insulation between coils and ground, coils and quench heaters, quench heaters and ground per WI061, ETH Coil Tests – Final Stage.	T	SM		SM	RT-5D completed WI061 (12/18/2003)
CS-25	D-01 Dipole Coil Test	Test 3 kV insulation between coils and ground, coils and quench heaters, quench heaters and ground per WI061, ETH Coil Tests – Final Stage.	T	SM		SM	D-01 completed WI061 (02/27/2004)
CS-26	D-02 Dipole Coil Test	Test 3 kV insulation between coils and ground, coils and quench heaters, quench heaters and ground per WI061, ETH Coil Tests – Final Stage.	T	SM		SM	D-02 completed WI061 (07/21/2004)

Validation Product #	Activity	Objective	Valid. Method	Facility or Lab	Phase	Perform. Org	Results
CS-27	RT-1A Racetrack Coil Inspections	Dimensional and insulation tests on quench heaters – AMS-02 Quench Heater QA Inspection	T & A	SM		SM	RT-1A Inspection Record (01/29/2002)
CS-28	RT-1B Racetrack Coil Inspections	Dimensional and insulation tests on quench heaters – AMS-02 Quench Heater QA Inspection	T & A	SM		SM	RT-1B Inspection Record (12/18/2002)
CS-29	RT-1C Racetrack Coil Inspections	Dimensional and insulation tests on quench heaters – AMS-02 Quench Heater QA Inspection	T & A	SM		SM	RT-1C Inspection Record (01/24/2002)
CS-30	RT-1D Racetrack Coil Inspections	Dimensional and insulation tests on quench heaters – AMS-02 Quench Heater QA Inspection	T & A	SM		SM	RT-1D Inspection Record (05/09/2003)
CS-31	RT-3A Racetrack Coil Inspections	Dimensional and insulation tests on quench heaters – AMS-02 Quench Heater QA Inspection	T & A	SM		SM	RT-3A Inspection Record (01/24/2002)
CS-32	RT-3B Racetrack Coil Inspections	Dimensional and insulation tests on quench heaters – AMS-02 Quench Heater QA Inspection	T & A	SM		SM	RT-3B Inspection Record
CS-33	RT-3CR Racetrack Coil Inspections	Dimensional and insulation tests on quench heaters – AMS-02 Quench Heater QA Inspection	T & A	SM		SM	RT-3CR Inspection Record (07/29/2002)
CS-34	RT-3D Racetrack Coil Inspections	Dimensional and insulation tests on quench heaters – AMS-02 Quench Heater QA Inspection	T & A	SM		SM	RT-3D Inspection Record (01/24/2002)
CS-35	RT-5A Racetrack Coil Inspections	Dimensional and insulation tests on quench heaters – AMS-02 Quench Heater QA Inspection	T & A	SM		SM	RT-5A Inspection Record (10/03/2002)
CS-36	RT-5B Racetrack Coil Inspections	Dimensional and insulation tests on quench heaters – AMS-02 Quench Heater QA Inspection	T & A	SM		SM	RT-5B Inspection Record (09/04/2002)
CS-37	RT-5C Racetrack Coil Inspections	Dimensional and insulation tests on quench heaters – AMS-02 Quench Heater QA Inspection	T & A	SM		SM	RT-5C Inspection Record (02/26/2003)
CS-38	RT-5D Racetrack Coil Inspections	Dimensional and insulation tests on quench heaters – AMS-02 Quench Heater QA Inspection	T & A	SM		SM	RT-5D Inspection Record (03/19/2003)
CS-39	D-01 Dipole Coil Inspections	Dimensional and insulation tests on quench heaters – AMS-02 Quench Heater QA Inspection	T & A	SM		SM	D-01 Inspection Record (09/04/2003)

Validation Product #	Activity	Objective	Valid. Method	Facility or Lab	Phase	Perform. Org	Results
CS-40	D-02 Dipole Coil Inspections	Dimensional and insulation tests on quench heaters – AMS-02 Quench Heater QA Inspection	T & A	SM		SM	D-02 Inspection Record (10/14/2003)
CS-41	Validation of the Magnetic & Mechanical Analysis of the Racetrack coils (1 only)	Validate the magnetic and mechanical analysis of one racetrack coil by using strain gauges to measure deflections in the coil structure under magnetic load per Work Instruction WI084, ETH Test Procedure for SG Coil 1B.	T	SM		SM	Strain Gauge Testing of Racetrack 1B Completed WI098 (07/17/2003)
CS-42	Validation of the Magnetic & Mechanical Analysis of the Dipole coils (1 only)	Validate the magnetic and mechanical analysis of one dipole coil by using strain gauges to measure deflections in the coil structure under magnetic load per Work Instruction WI098, ETH Test Procedure for Dipole Strain Gauging	T	SM		SM	Strain gauge testing of Racetrack 1B Completed WI098 (06/11/2004)
CS-43	Mechanical Survey of Assembled Coils	Carry out a mechanical survey to determine the relative positions of the coils precisely.	T	SM		SM	Coil Parameter Definitions and Values from Magnet Survey – Jan 2006 (01/26/2006)
CS-44	Quench Heater Voltage Withstand Evaluation	Check the voltage withstand of a quench heater per Work Instruction WI113, Quench Heater 6 kV Test Rig Build and Test Instructions	T	SM		SM	Completed WI113 (05/20/2004)
CS-45	Cryogenic System Catastrophic Loss of Vacuum Tests	Perform catastrophic loss of vacuum tests on a model vessel containing superfluid helium to measure heat loads under various scenarios, to verify the thermodynamic models used for helium venting, and to test a reverse buckling burst disc at 2 K. Perform testing per Work Instruction WI067, ETH small scale loss of vacuum demonstration test procedure	T	SM		SM	Loss of Vacuum Demonstration Test #01 (04/18/2001) Loss of Vacuum Demonstration Test #03 (05/10/2001) Loss of Vacuum Test #05 (07/03/2001) Loss of Vacuum Test #06 (09/10/2001)
CS-46	Cryogenic System Superfluid Cooling Loop Proof of Concept	Prove operation of the superfluid cooling loop principle in a full-scale demonstration cryostat.	T	SM		SM	Superfluid Cooling Loop Test #01 (08/10/2001) Cooling loop test #03 (11/29/2001)
CS-47	Cryogenic Valve Pre-qualification Testing	Perform pre-qualification tests on prototype valves to assess the design per Work Instruction WI075, Cryogenic Valve Test Set-up	T	SM		SM	Cryo-valve Testing (09/13/2002) Cryo-valve #3 Testing (09/08/2003) Cryo-valve #4 Testing (09/18/2003) Cryo-valve #4 Retest (03/23/2004) Cryo-valve #3 Retest (03/29/2004)

Validation Product #	Activity	Objective	Valid. Method	Facility or Lab	Phase	Perform. Org	Results
CS-48	Persistent Switch Operability Test	Test the operability of persistent switches at 1.8 K in helium vapor in background magnetic field per Work Instruction WI090, AMS Persistent Switch Test Procedure – Test in Gas at 1.8 K	T	SM		SM	AMS Persistent Switch Test in Gas Persistent Switch Test in Gas – 2 Flight/STA Switch Test in Gas at 1.8 K Flight/STA Switch Test in Gas at 1.8 K Flight/STA Switch Test in Gas at 1.8 K Switch SY11495 Retest Switch SY11495 Second Retest (Note that as a result of these tests the MRI switches were rejected for use in AMS.)
CS-49	Persistent Switch Operability Test – New Design	Test the functionality of a new design of switch at 4.2 K in background field per Work Instruction WI121, Persistent Switch Test Procedure – Test at 4.2 K in 0.8 T and 0 T Background Fields	T	SM		SM	Mk 2 Switch Test (02/14/2005)
CS-50	Persistent Switch Operability Test – New Design	Test the functionality of the new AMS switch design in 1.8 K helium vapor and background field per Work Instruction WI150, AMS Persistent Switch Test Procedure at 4.2 K and 1.8 K, with and without Background Field	T	SM		SM	Mk 3 Switch Test (05/09/2005)
CS-51	Persistent Switch Test	Measure the persistence of the switch per Work Instruction WI175, AMS 500 A Switch Persistence Testing	T	SM		SM	AMS 500 A Switch Persistence Test (07/26/2005)
CS-52	Persistent Switch Vibration Test	Vibrate flight switches are at ambient temperature before functional testing as an acceptance test before installation in the system. Perform testing per Work Instruction WI207, AMS-02 Switches Warm Vibration Testing	T	SM		SM	TUV Test House Certificate SJ200023-001 Issue 1 (11/24/2005)
CS-53	Persistent Joints Optimization Evaluation	Measure various configurations of persistent joints to determine the optimum parameters for AMS per Work Instruction WI151, Joint Test at 4.2 K (Inductive Method)	T	SM		SM	Development and Testing of Superconducting Joints after 8th November 2004 (12/08/2004)
CS-54	Non-persistent Joints Optimization	Find optimum arrangement for making lap joints between AMS conductor and cold bus bars per Work Instruction WI177, ETH Soldering Twin Lead in Procedure	T	SM		SM	Completed WI177 (06/21/2005)
CS-55	Pipe Crimp Testing for Burst Discs	Establish a technique for reliably sealing the interspace between series burst discs per Work Instruction WI157, Pipe Crimp Testing for Burst Discs	T	SM		SM	Pipe Crimping Trials 11/25/2005 – Issue 2 (01/03/2006)

Validation Product #	Activity	Objective	Valid. Method	Facility or Lab	Phase	Perform. Org	Results
CS-56	Pipe Crimp Testing for Burst Discs	Establish a technique for reliably sealing the interspace between series burst discs in stainless steel per Work Instruction WI208, Burst Disc Stub Pipe Crimping Development	T	SM		SM	Completed WI208 Pipe Crimping Trials – 01/05/2006 (01/05/2006, 01/10/2006)
CS-57	Cryogenic Pipework Bi-metallic Joint Qualification	Test the pressure worthiness and leak tightness of explosively bonded bi-metallic joints used to connect pipework to the helium vessel per Work Instruction WI097, ETH Bi-metal Testing	T	SM		SM	Completed WI097 (09/30/2004)
CS-58	Cryogenic Pipework Cutting Tests	Test techniques for cutting pipes to minimize debris which might otherwise contaminate the cryogenic system per Work Instruction WI189, AMS Tube Cleaning Procedure	T	SM		SM	Initial Report for Cutting Debris (22/08/2005) Report III for Cutting Debris (07/09/2005) Practical Pipe Cleaning for Flight System (01/11/2005)
CS-59	Assessment of Current Leads Heat Transfer	Assess the heat transfer from one lead to another when (a) clamped or (b) bonded together per Work Instruction WI111, Short Current Lead Test Assembly	T	SM		SM	Current Lead Sample Completed WI111 (06/30/2004)
CS-60	Current Leads Functional Testing	Functional test of prototype current leads per Work Instruction WI185, AMS VCLTR Testing	T	SM		SM	Completed WI185 (08/03/2005) AMS Current Leads Test Report (08/23/2005)
CS-61	Helium Vessel Leak Test and Instrumentation Feed Through Electrical Tests	Leak test and electrically test the helium vessel instrumentation feed-throughs at 1.8 K per Work Instruction WI159, Instrumentation Interface Connector Cold Test	T	SM		SM	Instrumentation Interface Cold Test (01/10/2006)
CS-62	Warm Valve Magnetic Field Compatibility Evaluation	Test valves from MRC to check if they can be used in the magnetic field outside the vacuum vessel per Work Instruction WI205, MRC Valve Test in Field	T	SM		SM	Completed WI205 MRC Valve Test – Issue 2 (12/20/2005)
CS-63	Instrumentation Fixation Evaluation	Test the pull-out force for tape used to hold down cryogenic instrumentation wiring, subject to solvents (to replicate cleaning) and cryogenic temperatures per Work Instruction WI214, Cold Adhesion of Al Tape and WI215, Kapton Ribbon Fixing Tests	T	SM		SM	Tests of Novec with Aluminum Tape (02/20/2006)
CS-64	Cryogenic System LAD Evaluations	Perform tests in a glass Dewar on a liquid acquisition device (LAD) which will maintain helium flow to the thermo-mechanical pumps per Work Instruction WI197, LAD Test	T	SM		SM	

Validation Product #	Activity	Objective	Valid. Method	Facility or Lab	Phase	Perform. Org	Results
CS-65	Cryogenic Valve Acceptance Testing	Perform acceptance testing of cryogenic valves, including leak rate measurements and cycling tests per Work Instruction WI190, Clean Valve Test Rig Build and Test	T	SM		SM	
CS-66	Cryogenic Pipework Pressure & Leak Testing of Brazed Joints	Check the pressure worthiness and leak tightness of brazed joints between copper and stainless steel pipework per Work Instruction WI087, ETH Qualification Testing of Brazed Joints	T	SM		SM	
CS-67	Pipe Crimp Testing for Burst Discs	Perform qualification procedure to ensure reliable seals can be made for the burst discs per Work Instruction WI217, Qualification Procedure for Burst Disc Crimping.	T	SM		SM	
CS-68	Helium Vessel Leak Testing at 1.8 K	Perform leak test the completed helium vessel at 1.8 K in a specially-constructed leak test facility per Work Instruction WI128, HVLT Testing	T	SM		SM	
CS-69	Evaluation of Passive Phase Separator Characteristics at 1.8 K	Test to measure the passive phase separator (PPS) flow/pressure characteristic with 1.8 K gas, and to see if the PPS can recover if the helium tank temperature exceeds T□ per Work Instruction WI180, PPS Functional Test	T	SM		SM	
CS-70	Tracker Thermal Control System	Test on the electrical conductivity of the TPG material used to transfer heat out of the tracker. This will allow analysis of eddy currents and forces induced in a magnet quench. Perform testing per Work Instruction WI226, TPG Resistivity Measurement	T	SM		SM	
CS-71	Assembled Coils – Demonstration of Stability at Full Field	The completed assembly of 14 coils and support structure will be mounted in a specially-designed test rig and cooled to 1.8 K in vacuum. The magnet will be charged – either using an existing SM power supply or the Elegant Breadboard Cryomagnet Avionics Box (EBB CAB) supplied by CRISA. The test will demonstrate the ability of the magnet to operate stably at full field, the integrity of the joints, the effectiveness of the quench protection system, and the operation of the conduction cooling scheme for the coils. Some field plotting may be carried out external to the cryostat to verify the magnetic models and estimate the dipole moment.	D	SM		SM	

Validation Product #	Activity	Objective	Valid. Method	Facility or Lab	Phase	Perform. Org	Results
CS-72	Thermo-mechanical Pump Validation	A flight standard thermo-mechanical pump (TMP) will be operated in a test cryostat with the prototype current lead. This will establish operating parameters and confirm the performance of the pump.	D	SM		SM	
CS-73	Warm Latching Valves Qualification & Acceptance Testing	A series of qualification and acceptance tests for the warm valves has yet to be established.	T	SM		SM	
CS-74	Magnet System Characterization Testing	The magnet system in the flight cryostat will be connected to the cryogenic ground support equipment (CGSE) at the SM facility at Culham. The system will be cooled down and operated. A comprehensive set of TBD tests will be carried out to measure and characterize all relevant operating parameters.	T	SM		SM	
CS-75	Persistent Switch – Qualification Vibration Testing	Cryogenic vibration test of the qualification model before functional testing.	T	Centre Spatiale de Liege		SM	Cryo-vibration Test Report SCL AMS Switch RP-CSL-SHK-05013 (10/19/2005)
CS-76	Magnet Support Strap Load Test	Load test to failure	T	Lockheed Martin			Magnet Support Strap Assembly Warm Static Failure Test (11/20/2003)
CS-77	Magnet Support Straps Load Test at Cryogenic Temperature	Load testing at cryogenic temperature.	T	Forschungzentrum Karlsruhe (FZK)			Cold Tensile Tests on Magnet C1W1 Support Strap (11/27/2003)
CS-78	Magnet Support Strap – Load/ Deflection Testing and Fatigue Testing	Load/deflection testing and fatigue testing.	T	Crompton Technology Group (CTG)			Measurement & Test of Suspension Strap Assemblies 4 & 5 (18/03/2003) Measurements on System Test 4 & 5 Suspension Strap Assemblies (24/03/2003) Test on Inverted Wineglass Assembly (22/01/2003) Space Magnet Fatigue of System Test 2 Suspension Strap Assembly (13/08/2002) Space Magnet Fatigue of System Test 3 Suspension Strap Assembly (29/08/2002)
CS-79	Passive Phase Separator – Acceptance Testing	Proof pressure, warm leak test, functional test, vibration test (4.2 K for STA model, 295 K for flight model).	T	Linde		SM	Acceptance Data Package (ADP) for the STA (10/08/2003) Acceptance Data Package (ADP) for the Flight Model (FM) (10/09/2003)

Validation Product #	Activity	Objective	Valid. Method	Facility or Lab	Phase	Perform. Org	Results
CS-80	Cryogenic Pressure Relief Valve – Acceptance Testing	Proof pressure, warm leak test, set pressure test, vibration test (4.2 K for STA model, 295 K for flight model).	T	Linde		SM	Acceptance Data Package (ADP) for the STA (06/28/2004) Acceptance Data Package (ADP) for the Flight Model (FM) (11/04/2004)
CS-81	Mass Gauges (DLCM) – Acceptance Testing	Proof pressure, warm leak test, functional test, electrical test, vibration test (4.2 K for STA model, 295 K for flight model).	T	Linde		SM	Acceptance Data Package (ADP) for the STA (11/11/2003) Acceptance Data Package (ADP) for the Flight Model (FM) (10/11/2003)
CS-82	Cryogenic Valves – Acceptance Testing	Cryogenic vibration testing with leak tests	T	ILK		SM	ILK-B-2/06-480 (09/01/2006)
CS-83	Thermo-Mechanical Pump (TMP) Functional Testing	Functional test of the TMP with Vitrapor separator.	T	ILK		SM	ILK-B-2/04-364-1 (02/09/2004)
Transition Radiation Detector (TRD)							
TRD-1	Straw Module System (QM) [Straw Module, UTE, UHVD, UFE]	Mechanical Stiffness and Eigenfrequencies Operative Temperature Ranges (see table1 of TRDTN 1) Gas Tightness, Long Term Test Gas Gain, Performance EMI Test	T & A T & A T T T	RWTH+MPE, ISAtec, RWTH+MPE, OHB RWTH RWTH RWTH, Krauss-Maffai		RWTH RWTH RWTH RWTH RWTH	TRDTN 1+2 TRDTN 1 TRDTN 1+ 3 TRDTN 1+ 3 TRDTN 3
TRD-2	Straw Module (328 FM)	Gas Tightness Gas Gain, Performance	T T	RWTH RWTH		RWTH RWTH	TRDTN 4 TRDTN 4
TRD-3	Front End Electronics (82 FM + 20 FS)	Vibration Test (grms = 6,8 g) Operative Temperature Ranges (TVT) Performance	T T T	RWTH RWTH RWTH		RWTH RWTH RWTH	TRDTN 5 TRDTN 5 TRDTN 5
TRD-4	TRD gas segments (QM)	Vibration Test (grms = 6,8 g) Operative Temperature Ranges (TVT)	T T	RWTH RWTH		RWTH RWTH	TRDTN 1 TRDTN 1+3

Validation Product #	Activity	Objective	Valid. Method	Facility or Lab	Phase	Perform. Org	Results
		Gas Tightness	T	RWTH		RWTH	TRDTN 1+3
TRD-5	TRD 41 gas segments (FM)	Gas Tightness	T	RWTH		RWTH	TRDTN 6
TRD-6	Manifolds (QM)	Vibration Test (grms = 6,8 g) Operative Temperature Ranges (TVT) Gas Tightness	T T T	RWTH RWTH RWTH		RWTH RWTH RWTH	TRDTN 7 TRDTN 7 TRDTN 7
TRD -7	Manifolds (16 FM + 2 FS)	Vibration Test (grms = 6,8 g) Operative Temperature Ranges (TVT) Gas Tightness	T T T	RWTH RWTH RWTH		RWTH RWTH RWTH	TRDTN 8 TRDTN 8 TRDTN 8
TRD-8	CB Patch Panel	TBD					TRDTN 9
TRD-9	Octagon Structure (8 Side Panels, Lower Cover, Upper Cover, 6 Bulkheads)	Vibration Test Operative Temperature Range Side Panel Bending Test Octagon Panel Pull Test Panel Static Load Test Octagon Deformation Test under 1g	T T T T T & A T & A	RWTH+MPE RWTH+MPE RWTH RWTH RWTH, ISAtec RWTH, ISAtec		RWTH RWTH RWTH RWTH RWTH RWTH	TRDTN 10
TRD-10	M-Structure	Modal Test 3D Survey	T & A I & T	RWTH, ISAtec RWTH, ISAtec		RWTH RWTH	TRDTN 11
TRD-11	TRD Structure (Octagon, M-Structure, Corner + Upper Bracket	Deformation Eigen Modes Material Stresses Dye Penetration Test	A A A T	RWTH, ISAtec RWTH, ISAtec RWTH, ISAtec Britte		RWTH RWTH RWTH RWTH	
TRD-l	TRD Heating					RWTH	
TRD-m	Box S/C +Control					MIT,INFN Rome	

Validation Product #	Activity	Objective	Valid. Method	Facility or Lab	Phase	Perform. Org	Results
TRD-n	DAQ - U-Crate + UHVG + UPD					IEKP	
TRD-o	TRD System Test	Gas Tightness Calibration with Cosmic Muons		RWTH,CERN		RWTH, IEKP, MIT, INFN Rome	
Time of Flight (TOF) Detectors							
TOF-1	Upper TOF acceptance vibration test	Vibration Test (grms=6.8g)	T	INFN Terni		INFN Terni	Successfully completed
TOF-2	Lower TOF acceptance vibration test	Vibration Test (grms=6.8g)	T	INFN Terni		INFN Terni	Successfully completed
TOF-3	Upper TOF EMI test	EMI test	T	INFN Terni		INFN Terni	Successfully completed
TOF-4	Lower TOF EMI test	EMI test	T	INFN Terni		INFN Terni	Successfully completed
TOF-5	Upper TOF TVT	Thermal Vacuum Test	T	INFN Terni		INFN Terni	Successfully completed
TOF-6	Lower TOF TVT	Thermal Vacuum Test	T	INFN Terni		INFN Terni	Successfully completed
Anti-Coincidence Counter (ACC)							
ACC-1	Scintillating Panel (QM)	Vibration Test (grms=6,8g) Temperature Range Light Yield & Efficiency (LED, Cosmics & Beam Test)	T(S) T(S) T	RWTH + MPE, ISAtec, RWTH + MPE RWTH		RWTH RWTH RWTH	ACCTN 1 ACCTN 2 ACCTN 3
ACC-2	Scintillating Panel (FM)	Light Yield & Efficiency (LED, Cosmics)	T	RWTH		RWTH	ACCTN 4
ACC-3	WLS-Clear Fibre Connector + Support(QM)	Vibration Test (grms=6,8g) Temperature Range Light Yield & Efficiency (LED, Beam Test)	T & A T T	RWTH, ISAtec RWTH RWTH		RWTH RWTH RWTH	ACCTN 5

Validation Product #	Activity	Objective	Valid. Method	Facility or Lab	Phase	Perform. Org	Results
ACC-4	WLS-Clear Fibre Connector (FM)	Light Yield & Efficiency (LED, Beam Test)	T	RWTH		RWTH	ACCTN 6
ACC-5	PMT-System (QM) [Clear Fibre Coupler, PMT, PMT Housing]	Vibration Test (grms=6,8g) Temperature Range, HV Test Light Yield & Efficiency (LED)	T & A T T	RWTH, ISAtec RWTH RWTH		RWTH RWTH RWTH	ACCTN 7
ACC-6	PMT-System (FM) [Clear Fibre Coupler, PMT, PMT Housing]	Vibration Test (grms=3,4g) Temperature Range, HV Test Light Yield & Efficiency (LED)	T T T	RWTH RWTH RWTH		RWTH RWTH RWTH	ACCTN 8
ACC-7	Scintillating Panel Support(FM)	Eigenfrequency	A(S)	RWTH, ISAtec		RWTH	ACCTN 9
ACC-8	DAQ + S-Crate						ACCTN 10
ACC-9	HV Supply						ACCTN 11
ACC-10	ACC System Test	Light Yield (LED)		CERN		RWTH	ACCTN 12
Silicon Tracker							
T-1	Hardware Design	Layout Modification between AMS01 and AMS02	D	University of Geneva – Physics Dept.	Prior to CDR	University of Geneva – Physics Dept.	AMS01 modification.gif
T-2	Bolt Analysis		A	INFN Perugia / ISATech Aachen		INFN Perugia / University of Geneva – Physics Dept. / ISATech Aachen	AMS-02 Tracker Bolt Analysis (File name: NSTS 08307 Tracker Bolt Assessment.pdf)
T-3	Declared Material List	Material Identification and Usage List; The document has been submitted to Jacobs for Safety assessment	D	University of Geneva – Physics Dept.		University of Geneva – Physics Dept.	AMS_Tracker_DMLv2.xls (rev2 august 3, 200)

Validation Product #	Activity	Objective	Valid. Method	Facility or Lab	Phase	Perform. Org	Results
T-4	AMS-02 Tracker Fracture Control for Composite		D	University of Geneva – Physics Dept.		University of Geneva – Physics Dept.	Memo_Fracture_control_composite1.doc (July 7, 2005)
T-5	Inspection of as-built hardware	Check and verify the correct positioning and installation of the venting holes on the conical flanges	I	University of Geneva – Physics Dept.		University of Geneva – Physics Dept.	
T-6	Raw Material Incoming Inspection and test	Check of the Incoming Material and Acceptance Test;	I & T	INFN/Ge	Incoming	INFN/Ge	DB
T-7	QA control on production (three assembly facility)	Control the production process; check and test all the production process assembly sub-steps; Ladder electrical properties; Phase 2 verification; (E) Hybrid box installation; (A) Hybrid pair electrical test; (B) ladder first electrical test; (F) Leg gluing; (M) metrology; (I) Plane pre-installation; (D) Reception at Geneva; (C) Reception at Perugia; (H) Shield wrapping; (W) Source test - After shielding; (V) Source test - Reception @ GVA; (G) Spacer gluing; (L) total current;	I & T	Assembly Facility	During produc-tion	Assembly Company	AMS-02 Silicon Tracker DB (scpc65.unige.ch)
T-8*	Inspection of as-built hardware See also the ladder QA forms during installation	Check and verify that the Tracker Silicon Wafers has been glued to a flexible metalized film that will retain any fractured pieces. The film is Upilex which is supported (adhered to) on 5 mm Airex Foam. The foam is glued to a carbon fiber layer which is glued to the aluminum ladders that support the sensors as a whole. In addition, the light tight air vents have been fitted with a mesh screen to preclude the release of any particles.	I	Assembly facility	During produc-tion	Assembly facility	
T-9	Plane Gluing Procedure	QA control of the plane installation	I	University of Geneva – Physics Dept.	During produc-tion	University of Geneva – Physics Dept.	University of Geneva – Physics Dept. peek gluing.gif
T-10	Inspection on the Ladders Integration	Check and verify the Ladders correct installation	I	University of Geneva – Physics Dept.	During produc-tion	University of Geneva – Physics Dept.	University of Geneva – Physics Dept. AMS02 Tracker Ladders inspection form Ladder_visual.pdf

Validation Product #	Activity	Objective	Valid. Method	Facility or Lab	Phase	Perform. Org	Results
T-11	(P) Plane installation	Ladder tested once installed on plane.	T	University of Geneva – Physics Dept.	During product selection process	University of Geneva – Physics Dept.	AMS-02 Silicon Tracker DB (scpc65.unige.ch)
T-12	VIBRATION TEST on cables	Test and validation of the cables fixation inside the tracker volume.	T	University of Bern	During plane integra-tion	University of Geneva – Physics Dept.	AMS02 internal note: 02Perrin_TrackerAssy.ppt (TIM april 06)
T-13	TEST BEAM 2002	Verify the performance of the EM readout and power electronics	T	CERN		INFN Pg, UniGe, UniPG	PhD Thesys P. Azzarello, University of Geneva
T-14	TEST BEAM 2003, June	Verify the performance on the QM readout electronics and optimize the behavior of the Front-End electronics	T	CERN		INFN Pg, UniGe, UniPG	The AMS Silicon Tracker: performance results for protons and helium nucleai, submitted to NIM
T-15	TEST BEAM 2003, October	Verify the performance of the full system (detector, front-end electronics, readout electronics) with both protons and ions	T	CERN		INFN Pg, UniGe	The AMS Silicon Tracker: performance results for protons and helium nucleai, submitted to NIM
T-16	TEST BEAM 2003, November	Verify the performance of the full system (detector, front-end electronics, readout electronics) with ions	T	GSI (Germany)		INFN Pg, UniGe	Charge determination of nucleai with the AMS-02 Silicon Tracker, published on NIM A540 (2005)
T-17	TEST BEAM 2004, August	Verify the performance of the full system (detector, front-end electronics, readout electronics) in almost final configuration. Use of QM full crate for electronics and 17 ladders in the final mechanical configuration	T	CERN		INFN Pg, UniGe	PhD Thesis I. Sevilla, CIEMAT (Madrid)
Tracker Alignment System (TAS)							
TAS 1	Laser Roads in Si-Tracker in plane 2 to7 Laser Roads in Si-Tracker in plane 1, 8	1 mm radial margin on 2 sigma beam width at all diaphragms	T T	DPNC Geneva DPNC Geneva		RWTH RWTH	TASTN 07/1a TASTN 07/1b

Validation Product #	Activity	Objective	Valid. Method	Facility or Lab	Phase	Perform. Org	Results
TAS 2	Laser Beam Box (LBBX)	Mechanical Alignment of LBBX	T	DPNC Geneva		RWTH	TASTN 07/2
		Optical Laser Beam Emittance	T	RWTH		RWTH	
		Vibration Test (g_{rms} = 6.8g for QM, MEFL for FM (JSC 28792,Rev.B,Table15.1))	T	RWTH		RWTH	TASTN 07/3
		TVT	T	RWTH		RWTH	TASTN 07/4
TAS 3	Optical Fibers (LFIB)	Feeding connectors from LFCR via LFIB to LBBX	T	RWTH		RWTH	TASTN 07/4
TAS 4	Laser-Fiber Coupler (LFCR)	Laser Power Efficiency	T	RWTH		RWTH	TASTN 07/5
		Optical Laser Beam Emittance	T	RWTH		RWTH	TASTN 07/6
		Vibration Test (g_{rms} =6.8g for QM, MEFL for FM (JSC 28792,Rev.B,Table15.1))	T	RWTH		RWTH	TASTN 07/7
		TVT	T	RWTH		RWTH	TASTN 07/8
TAS 5	Laser Diode Driver (LDDR)	Pulse Shape Verification (QM)	T	RWTH		RWTH	TASTN 07/9
	in M-Crate	Vibration Test (g_{rms} =6.8g for QM	T	RWTH		RWTH	
		TVT	T	RWTH		RWTH	
		Latch up Verification	T	MIT, RWTH		RWTH	TASTN 0710
		Pulse Shape Verification (FM)	T	RWTH		RWTH	TASTN 07/11
		Vibration Test (g_{rms} MEFL for FM (JSC 28792,Rev.B,Table15.1))	T	RWTH		RWTH	
		TVT	T	RWTH		RWTH	
TAS 6	Laser Control (LCTL) in M-Crate	Rep Rate & Gating Verification (QM)	T	RWTH		RWTH	TASTN 07/12
		Vibration Test (g_{rms} =6.8g for QM	T	RWTH		RWTH	
		TVT	T	RWTH		RWTH	
		Latch up Verification	T	MIT, RWTH		RWTH	TASTN 07/13
		Rep Rate & Gating Verification (FM)	T	RWTH		RWTH	TASTN 07/14
		Vibration Test (g_{rms} MEFL for FM (JSC 28792,Rev.B,Table15.1))	T	RWTH		RWTH	
		TVT	T	RWTH		RWTH	

Validation Product #	Activity	Objective	Valid. Method	Facility or Lab	Phase	Perform. Org	Results
TAS 7	M-Crate	Vibration & TV Test in common with LDDR & LCTL Power Test Board Compatibility Test EMI Test	 T T T	 RWTH MIT,RWTH Terni		 RWTH RWTH RWTH	 TASTN 07/15 TASTN 07/16 TASTN 07/17
Ring Imaging Cerenkov Counter (RICH)							
RICH-1							
ECAL							
ECAL-1	ECAL Final Assembly → Validation thru Test Beam in 2006.	Gives the Physics performances of ECAL by the mean of a Test Beam performed at CERN.	T & A	CERN		ECAL Group	Test beam performed in July 2007 at CERN showed that the ECAL performances fulfill the requirements, and are even beyond nominal. Technical notes to be published soon.
ECAL-2	Pancake Assembly in 2004	Assembly of the 9 "superlayers" (lead + fibers) to built the Flight Pancake (658mm x 658mm x 166.5mm; approx. 490Kg).	I & T	INFN Pisa		ECAL Group	OK
ECAL-3	Mechanical Assembly in 2004	Mechanical fixation of the parts that hold the Pancake + Spring foams around the 6 faces. Refer to the note written by IHEP. The concept has been validated by Space Qualification Tests (SQT) on QM unit at BISEE (including mechanics of Light Collection System: Back panels + PMT tube simulators).	I & T – Tested in sine sweep, torque wrench controlled	BISEE Beijing (China)		ECAL Group, Overseen by NASA	OK
ECAL-4	Light Collection System (LCS) Assembly on ECAL	Mechanical Assembly of the Light Collection System (LCS) made of PMT Tubes, EIB, cables and Radiators (ECAL instrumentation). The mechanical concept has been validated	I & T	LAPP, INFN Pisa, CERN		ECAL group	

Validation Product #	Activity	Objective	Valid. Method	Facility or Lab	Phase	Perform. Org	Results
		by a SQT at BISEE.					
ECAL-5	4 Back Panels fixation (2 types: 5 ranks, and 4 ranks).	Mechanical support holding and centering the 324 PMT Tubes attached to the ECAL side Panel thru 14 ISO M4 bolts, with tightening torque and self locking helicoils. Overseen and approved by the LAPP Quality Assurance Engineer (refer to LAPP Tech. Note).	I – Torque wrench controlled				
ECAL-6	PMT Tube Assembly (x 324)	Assembly of the mechanics that holds: PMT, Electronic boards, Light guides, and magnetic shielding (TV Tested Ë TVT). One PMT Tube "QM" has been tested in vibration at workmanship level (electronically OK up to 8 Grms, no mechanic failure up to 12 Grms). Refer to LAPP Tech. Note.	Thermal Vacuum tested during 12 hours at 650 Volts and thermal range from -30°C, to +40°C, I, A.	LAPP		LAPP	OK
ECAL-7	PMT Calibration (x approx. 380)	A "one-by-one" checking on Hamamatsu R7600-00-M4 PMT to give its "physics" performance (to get the optimization of the distribution on ECAL sides, best PMT close to the Pancake central part). Overseen and approved by the LAPP Quality Assurance Engineer (refer to LAPP Tech. Note). .	T & A	LAPP, IHEP, INFN PISA		ECAL Group	OK
ECAL-8	Front End Electronic (FEE) assembly (x 324)	Assembly of "FEE+2HVdividers" (pre assembled by a subcontractor) on PMT, then "coated" and "potted" to prevent any Corona effect on HV pins. Overseen and approved by the LAPP Quality Assurance Engineer (refer to LAPP Tech. Note).	I & T	LAPP		ECAL group	OK – Each FEE and EIB was fully tested in thermal vacuum.
ECAL-9	PMT Tubes fixed thru ECAL Back Panels (x324)	Fixation via end caps on Back Panels using "large head" ISO M4 bolts (tightening torques + self locking helicoils). Overseen and approved by the LAPP Quality Assurance Engineer (refer to LAPP Tech. Note).	I – Torque wrench controlled	LAPP		ECAL group	
ECAL-10	DTS (Desy chain) integration on PMT Tube end caps (6 per Back panel)	Gluing of DTS sensors (2 per PCB) on End caps side using "3M" 2216 epoxy glue. Pre tested at LAPP and tested after integration by A. Koulemzine (CERN). These 4 ECAL chains will control the temperature of 6 PMT Tubes / side (incl.	I	LAPP		ECAL Group, AMS electronics expert (A.	OK

Validation Product #	Activity	Objective	Valid. Method	Facility or Lab	Phase	Perform. Org	Results
		double redundancy). Mechanically fixed on both ends by 9 pins microD connectors plus some points of glue along the chain.				Koulemzine)	
ECAL-11	EIB assembly (x36)	36 EIB Boards that collect data (9 PMT per EIB) from each PMT, are fixed on 4 Back Panels (via 20 Frames).					
ECAL-12	EIB pre-assembly on mechanics (x20)	EIB Board bolted on EIB aluminum (7075T7351) frame via 8 ISO M2 bolts (tightening torque and gluing with 2216). Each EIB board is treated with coating and 2216 glue for wires potting on the board. Each EIB is TV tested [-30°C; +40°C], and functional tests (electronics) before and after TVT. The EIB QM unit has been tested in vibrations at workmanship level (6.8 Grms).	I – Torque Wrench controlled	LAPP		ECAL Group	OK
ECAL-13	EIB integration on ECAL	Fixation of each EIB frame on Back Panel thru 4 ISO M4 bolts, with tightening torque and self locking helicoil. Refer to the LAPP Tech. note. Pre cabling of HV, DAQ and Trigger cables with space qualified tie wraps.	I – Torque Wrench controlled	LAPP		ECAL Group	
ECAL-14	ECAL Radiators fixation (x 4)	These 4 radiators will provide to ECAL both a thermal and a mechanical protection. Made of 2 mm thick aluminum plate (5086), covered with silver Teflon straps (Carlo Gavazzi Space) and equipped with 4 heaters per radiator. They are fixed with 36 ISO M4 bolts (Top and bottom) plus some ISO M3 bolts (connection thru EIB frames), with tightening torques and self locking helicoils. Note that a global Mission Success Test has been performed on ECAL QM including the whole mechanics (Back Panels, PMT Tubes, EIB and Radiators), at 3.2 Grms in TERNI. It showed no failure.	I – Torque Wrench controlled	LAPP~~, CGS in Tortona~~		ECAL group	
Avionics							

Validation Product #	Activity	Objective	Valid. Method	Facility or Lab	Phase	Perform. Org	Results
Cryomagnet Avionics Box (CAB)							
CAB-1	HW Design Description	The Cryomagnet Avionics Box (CAB) is designed to perform all control and monitoring functions for Organization responsible of system tests the Cryomagnet Subsystem (including SFHe Tank and Vacuum Case). The CAB consists of four sections: the Cryomagnet Current Source (CCS); the Cryo Controller and Signal Conditioner (CCSC); the Cryomagnet Self Protection (CSP); and the Power Switches (PS)	N/A	N/A	N/A	N/A	N/A
CAB-2	AMS-02 Integration	The CAB is located on the Unique Support Structure (USS) very close to the current input port of the Vacuum Case to minimize the length of the Cryomagnet Current Leads.	I	System integration lab.	System-level	Organization responsible of system tests	System Inspection sheet
CAB-3	HW Design	High Voltage Isolation is provided at all inputs to the CAB from the ISS side to prevent passing any high-voltage that could be developed during a multiple fault “unassisted” quench back to the ISS power or data systems. Isolation for the 120Vdc line (feed thru from PDS) is performed via DC-to-DC Converters in the CCS. Analysis has shown that the maximum voltage that could be achieved during an “unassisted” quench is 5.5kV. 8kV isolation is provided at all these points to ensure margin. The unassisted quench is an off-nominal scenario, and would result in damage to the CAB and the magnet that would render them unusable, but not create a safety hazard. The one fault “assisted” quench would prevent these voltage levels from arising and protect the CAB and the magnet for mission success.	A	CRISA	Prior to PDR	CRISA	CAB Design Description
CAB-4	HW Design	The 120 Vdc Power input (feed through from the PDS) is routed solely to the Cryomagnet Current Source (CCS). A DC-to-DC converter at the input to the CCS provides isolation for this Power Bus. The 120 Vdc power is required only for magnet charging. All other sections of the CAB are operated with 28 Vdc from the PDS.	A	CRISA	Prior to PDR	CRISA	CAB Design Description
CAB-5	HW Design and Test	The 120 Vdc input is limited to a maximum of 1875 W for power management.	A & T	CRISA and CERN	Box and System	CRISA and Organization	CAB Test Report Magnet Test Report

Validation Product #	Activity	Objective	Valid. Method	Facility or Lab	Phase	Perform. Org	Results
		NOTE.- Regarding the 500W magnet power limitation to guarantee a magnet current ramp rate lower than 2 Amps per minute, the maximum power consumption from 120 Vdc bus is 1200W (Magnet, Electronics, Current Shunt and cabling power dissipation) when charging the magnet with either 6 or 5 CCS CVs.~~The maximum power consumption from 120 Vdc bus is 2150W when charging the magnet with 6 CCS CVs and 2250W for 5 CCS CVs~~			Tests	responsible of system tests	
CAB-6	HW Design	Power supplied to the DC-to-DC converter is controlled by Opto-Isolating feedback from the DC-to-DC converter output with a power switch and pulse width modulation of the input.	A	CRISA	Prior to PDR	CRISA	CAB Design Description
CAB-7	HW Design and Test	To charge the magnet, the Semiconductor switch on the charging circuit is closed, and power is supplied to the transformer input. The current is slowly ramped up over a period of approximately ~~1~~2.5 hours to ~~459~~ 424 Amps. Current during charge and discharge operations is monitored using a 500A shunt NOTE.- The magnet can be charged at any value of current between 50 Amps and the maximum full current of 424A.~~The magnet will be charged at the maximum full current of 455.33A ± 3.5A~~	A & T	CRISA and CERN	Box and System Tests	CRISA and Organization responsible of system tests	CAB Test Report Magnet Test Report
CAB-8	AMS02 Integration	The connection from the CCS to the magnet is made via three pairs of AWG 2/0 wires. Once full operating current is reached, the Persistent Switch is closed (the switch consists of a pair of super-conducting wires – “closed” by cooling them down to superconducting temperatures)	System Test	CERN	System-level	Organization responsible of system tests	System test report
CAB-9	HW Design and Test	With the persistent switch closed, ~~459 A~~the magnet full current is running through both sides of the circuit (the magnet side and the charger side).To avoid ripple currents through the persistent switch, the current on the charger side is slowly reduced to zero. Once the current on the charger side is depleted, the Semiconductor Switch is opened, and the Charging System is disconnected from the Magnet Circuit.	A & T	CRISA and CERN	Box and System Tests	CRISA and Organization responsible of system tests	CAB Test Report Magnet Test Report
CAB-10	HW Design and Test	If an event occurs that necessitates a power down of the magnet, the system is designed to perform a nominal “ramp down” function. The nominal ramp down is the most acceptable method for powering down the magnet without the potential for substantially decreasing the endurance of the	A & T	CRISA and CERN	Box and System Tests	CRISA and Organization responsible of system	CAB Test Report Magnet Test Report

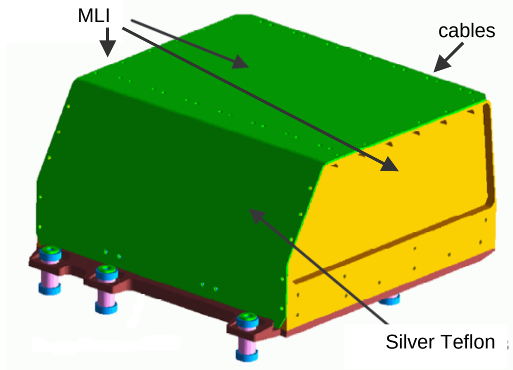
Validation Product #	Activity	Objective	Valid. Method	Facility or Lab	Phase	Perform. Org	Results
		magnet.				tests	
CAB-11	AMS-02 Integration	To perform a ramp down, the mechanical leads are connected and the persistent switch is opened (by allowing it to warm to a non-superconducting state), The connection from the magnet is to the CAB with three pairs of AWG 2/0 wires, and then on to the CDD, with a loop of one AWG 2/0 wire. The energy from the magnet is dissipated in the form of heat through the CDD chain. The CDD consists of six three sets in series of three diodes in parallel that are used solely for the purpose of dissipating the stored energy of the magnet. These dump diodes are located on the wake / startboard-side sill trunnion joint, directly above the CAB, which was selected for its large thermal mass. These dump diodes are located on the two wake-side sill trunnion joints (three sets on each joint), which were selected for their large thermal mass. The CDDs are protected by a metal cover to prevent incidental contact by ground personnel or crew. The total time required to dissipate the magnet energy is estimated to be 80 134 minutes.	System Test	CERN	System-level	Organization responsible of system tests	System test report
CAB-12	HW Design and Test	The Cryomagnet Control and Signal Conditioning (CCSC) provides the interface between the AMS-02 Main Data Computers (MDCs) and the Cryomagnet. The CCSC is responsible for: • reception of commands from the MDCs • transmission of telemetry to the MDCs • commanding of the CCS • control of the Cryomagnet auxiliary functions (i.e. heaters, valves, etc.) • monitoring of the CCS, Cryomagnet, and CAB operating parameters and status The CCSC also performs system fault detection and management functions, formatting of telemetry, and data storage for system status. The CCSC is required to interface with the Uninterruptible Power Source (UPS).	A & T	CRISA and CERN	Box and System Tests	CRISA and Organization responsible of system tests	CAB Test Report Magnet Test Report
CAB-13	HW Design and Test	The power switches control the 28 VDC power supply to valves and cryogenic heaters. With the exception of the power	A & T	CRISA and	Box and System	CRISA and	CAB Test Report

Validation Product #	Activity	Objective	Valid. Method	Facility or Lab	Phase	Perform. Org	Results
		switches controlled directly by the CSP, the power switches are galvanically isolated from the 28 VDC power bus.		CERN	Tests	Organization responsible of system tests	Magnet Test Report
CAB-14	Magnet Description	Cryomagnet Self Protection (CSP): Super-conducting magnets, such as the one utilized by AMS-02, may develop a condition where a portion of the coil begins to rise above super-conducting temperatures. When this condition occurs, the section of wire affected begins to develop resistance, and the current running through this resistance begins to heat the wire rapidly. This eventually leads to dissipation of the magnet energy (in the form of heat) within the magnet, and is referred to as a magnet quench. This condition is highly undesirable from a mission success standpoint because resulting unbalanced magnetic forces in the different sections of the magnet may cause it to deform, making it unable to be recharged to the maximum field or even to return to a superconducting state, thus preventing the recharging of the magnet. This is a possible mission success critical failure, not a safety issue. Alterations in the magnetic field have already been accounted for in the safety assessment for nominal field strengths.	A	CERN	Magnet System	SCL	Magnet Report
CAB-15	HW Design and Test	To protect the magnet from this condition, referred to as an unassisted quench, electronics have been designed that will detect the initiating condition and apply heat quench evenly throughout the magnet coils, causing the magnetic field to dissipate uniformly. This will prevent the heating from being isolated to a small section of the magnet, which could become damaged if the quench was uncontrolled. By performing an assisted quench, mission success criteria can be maintained. The Cryomagnet Self Protection (CSP) section of the CAB was developed to detect a change in voltage across a coil and perform this assisted quench.	A & T	CRISA and CERN	Box and System Tests	CRISA and Organization responsible of system tests	CAB Test Report Magnet Test Report
CAB-16	HW Design and Test	The CSP contains quench detection electronics that monitor the status of the magnet coils to determine if a quench condition is starting to occur. To perform this function, redundant voltage measurements are taken across each coil. If a quench condition is imminent, a voltage will develop across the affected coil. When the CSP detects a change in voltage, the quench protection electronics issues a command to the Uninterruptible Power Source (UPS) to provide a pulse of at least 45A to quench heaters located throughout the magnet.	A & T	CRISA and CERN	Box and System Tests	CRISA and Organization responsible of system tests	CAB Test Report Magnet Test Report

Validation Product #	Activity	Objective	Valid. Method	Facility or Lab	Phase	Perform. Org	Results
		The pulse, for a duration of 150 ms, is required to raise the entire magnet up to a non-superconducting state. This spreads the quench throughout the magnet and prevents isolated heating that could result in degraded performance.					
CAB-17	HW Design and Test	The quench heater chains are redundant and supplied by two separate UPS systems. The chains are routed to alternate coils throughout the magnet. Both heater chains are nominally used by the CSP to control a quench, however either chain independently is sufficient to protect the magnet coils from deformation.	A & T	CRISA and CERN	Box and System Tests	CRISA and Organization responsible of system tests	CAB Test Report Magnet Test Report
CAB-18	HW Design and Test	The CSP provides additional functions to protect the magnet during off-nominal conditions. A “watchdog” timer, powered by the UPS, is continuously counting down. Periodically the timeout is reset via external command to about 8 hours. In the event of a power loss, or the loss of communication to the AMS-02 payload, the timeout is not reset and if power or communications are not restored to the AMS within the eight-hour period, the timer will trigger the CSP Control Electronics to initiate the nominal ramp down function, discharging the magnet. During the eight hour period and the ramp down, the UPS will continue to power the Quench Detection Electronics, and maintain the capability to perform an assisted quench (if necessary) until the magnet is completely discharged. ~~The CSP, showing the cross-strapping configuration between the power busses coming from the PDS and the two batteries of UPS.~~	A & T	CRISA and CERN	Box and System Tests	CRISA and Organization responsible of system tests	CAB Test Report Magnet Test Report
Thermal Control System (TCS)							
TCS-1	TRD dissipation	The TRD dissipation is 18.5 W (82 PCB, 0.226 W each)	T	RWTH		RWTH	
TCS-2	TRD MLI	TRD shall be completely wrapped, together with Upper TOF, by MLI in order to minimize heat transfer with the surroundings and reduce internal gradients. The TRD outer layer shall be composed by Beta Cloth	I	CERN		NASA	
TCS-3	TRDGB dissipation, 1	TRD Gas Box Heat Dissipation (Supply) 0.6W on the Tower Valve group 0.3W on the upper 2-valve group	T	CERN		MIT	

Validation Product #	Activity	Objective	Valid. Method	Facility or Lab	Phase	Perform. Org	Results
TCS-4	TRDGB dissipation, 2	TRD Gas Box Heat Dissipation (Circulation) = 3.6W	T	CERN		MIT	
TCS-5	TOF temperature ranges	The operative temperature range for the TOF shall be: from -30 °C to +45 °C on the PMT, which corresponds to -32°C to +43°C on the accessible location for the Dallas sensors.	T	SERMS			
TCS-6	TOF dissipation	Upper TOF power dissipation 3.68W are dissipated on the 68PMTs, 0.130 W are dissipated on the 4 SFEC boards, for a total of 0.52 W.	T	SERMS		CGS	
TCS-7	Tracker dissipation	The total amount of power generated by Tracker hybrids is 144 W (± 10%).	T	UNI GENEVA		Tracker group	
TCS-8	TTCS pump dissipation	The maximum power dissipated by the TTCS pump is 10 W	T	NLR		NLR	
TCS-9	TTCS pump electronic dissipation	The maximum power dissipated by the TTCS pump electronics (mounted on the TTCB baseplate) is 5 W	T	NLR		NLR	
TCS-10	Tracker shell emissivity	Towards the ACC stabilizing cylinder the emissivity of the Tracker shell shall be less than 0.1	I	CERN		TWG	
TCS-11	Tracker emissivity	The lower plane of the Tracker shall be protected from the external environment by means of 7 layers of MLI blanket, 1 layer of Beta Cloth	I	CERN		TWG	
TCS-12	Tracker radiator MLI	Backward radiation from the tracker radiators is minimized by means of 7 MLI blankets, 1 Beta Cloth layer. Its external t/o properties shall be Beta Cloth	I	CERN		TWG	
TCS-13	TTCS condenser interface	The mechanical interface between the Tracker CO_2 loop condensers and the radiator shall be showed in a dedicated ICD	ROD	N/A		CGS	
TCS-14	TTCS pipes MLI	Pipes and supporting tubes of the TTCS piping shall be wrapped in MLI	I	CERN	System AI	TWG	
TCS-15	Star tracker temp range	The operative temperature range of the electronic board of the star tracker shall be: from -20°C to +55°C.	T	SERMS		INFN-RM / CARSO	

Validation Product #	Activity	Objective	Valid. Method	Facility or Lab	Phase	Perform. Org	Results
TCS-16	Star tracker lens temp range	The operative temperature range of the lens shall be: from –20°C to +55°C.	T	SERMS		INFN-RM / CARSO	
TCS-17	ACC cylinder emissivity	The CFC stabilizing cylinder of the ACC inner surface (pointing to the tracker) will be coated with low emissivity (ε < 0.1) material	I	CERN	System AI	TWG	
TCS-18	Electronic crates temp. range, OP	Standard crates: Operational range -20°C │ +50°C	T A	NSPO/ SERMS/ INTA		Subdetectors electronics responsibles / TWG	
TCS-19	Electronic crates temp. range, NON-OP	Standard crates: Non operational range -40°C │+80°C	T A	NSPO/ SERMS/ INTA		Subdetectors electronics responsibles / TWG	
TCS-20	Main and Tracker radiators emissivity	The thermo optical properties of the Main and Tracker radiators shall be white paint	I	CERN	System AI	CGS/AIDC	
TCS-21	ECAL crates coating	ECAL crates need to be white painted on their main walls and side walls	I	CERN	System AI	TWG	
TCS-22	ECAL and RICH HV bricks coatings	ECAL and RICH HV bricks thermo optical properties are shown in	I	CERN	System AI	TWG	

Validation Product #	Activity	Objective	Valid. Method	Facility or Lab	Phase	Perform. Org	Results
							
TCS-23	CAB ramp up	The CAB dissipation is: In Cold Redundancy: Minimum: 51.5W Typical: 99.7W Maximum: 114.0W In Hot Redundancy: Typical: 120.7W Maximum: 138.5W	T	CRISA		CRISA	
TCS-24	CAB heaters	CAB heaters shall consume maximum 100W at 113V.	T	CERN	System AI	CGS	
TCS-25	CAB LHP	CAB is sunk to two LHPs that in turn are sunk to wake radiator.	I	CERN	System AI	CGS	
TCS-26	CAB external coating	CAB walls thermo-optical properties is silver Teflon 5mils	I	CERN	System AI	CGS	
TCS-27	CAB LHP MLI	MLI is used CAB LHP tubes	I	CERN	System AI	CGS	
TCS-28	CAB heat pipes	Two axial grooved heat pipes are mounted along the CAB height, on the wake side and on the top cover, to homogenize the temperature across the modules.	I	CERN	System AI	CGS	

Validation Product #	Activity	Objective	Valid. Method	Facility or Lab	Phase	Perform. Org	Results
TCS-29	USS heat pipes for CAB	Three axial grooved heat pipes are interconnecting the USS upper Trunnion bridge and the VC I/F Joint	I	CERN	System AI	CGS	
TCS-30	VC MLI	The Outer Vacuum Case (VC) shell on ± Y quadrants (towards crates) will be covered with MLI.	I	CERN	System AI	NASA	
TCS-31	VC rings MLI	MLI is foreseen on the upper and lower support rings. Its external t/o properties are Beta Cloth	I	CERN	System AI	TWG	
TCS-32	MLI Skirt	MLI is foreseen between upper support ring and TRD (also called the 'skirt MLI'). Its external t/o properties are Beta Cloth	I	CERN	System AI	TWG	
TCS-33	MLI on VC conical	VACUUM CASE CONICAL FLANGES MLI: MLI blanket is foreseen ONLY on the outermost band of the lower conical flange of the vacuum case. Its external t/o properties are Beta Cloth	I	CERN	System AI	TWG	
TCS-34	VC silver Teflon	The Outer Vacuum Case shell on ± X quadrants will be covered with Silver Teflon including the Ribs as far as practical.	I	CERN	System AI	NASA	
TCS-35	Cryocoolers minimum storage temp	The minimum storage temperature of the cryocoolers shall be: -40°C.	T	NASA / GSFC		NASA	
TCS-36	Cryocoolers minimum turn on temp	The minimum turn on mode of the cryocoolers shall be: -20 °C.	T	NASA / GSFC		NASA	
TCS-37	Cryocoolers temp range (OP)	The steady-state operating mode temperature range of the cryocoolers shall be: from -20 °C to +40 °C (TBC by GSFC).	T	NASA / GSFC		NASA	
TCS-38	Cryocoolers LHP	Each cryocoolers operational nominal power is sunk to direct condensing radiators by means of LHP.	I	CERN	System AI	CGS	
TCS-39	Cryocoolers LHP bypass valve	Each LHP is equipped with a bypass valve with set point -30°C	ROD		Design	CGS	
TCS-40	Zenith radiator coating	Outer (+ Z pointing) surfaces thermo optical properties shall be silvered Teflon 5 mils	I	CERN	System AI	CGS	

Validation Product #	Activity	Objective	Valid. Method	Facility or Lab	Phase	Perform. Org	Results
TCS-41	RICH temp ranges	The RICH PMTs operative temperature range shall be: from -30 °C to +50°C.	T	INFN BO		INFN/CGS	
TCS-42	RICH dissipation, 1	The RICH PMTs dissipation is 20.4W (dissipated on 680 PMT, 30 mW each).	T	CIEMAT		INFN BO/ CIEMAT	
TCS-43	RICH dissipation, 2	Additional 29.5 W shall be dissipated on the PCB around the octagonal structure.	T	CIEMAT		INFN BO/ CIEMAT	
TCS-44	RICH/TOF MLI	RICH and TOF are completely surrounded by the same MLI.	I	CERN	System AI	CGS	
TCS-45	ECAL temp range	The operative temperature range of the ECAL shall be: from -20 °C to +40°C.	T	SERMS		CGS	
TCS-46	ECAL dissipation	49.6 W are dissipated on the 324 PMTs, 17.8W are dissipated on the EIBs for a total dissipation of 67.33W.	T	INFN PI		INFN PI	
TCS-47	ECAL MLI	MLI is assumed covering the ECAL bottom panel and brackets. Its external t/o properties are Beta Cloth	I	CERN	System AI	CGS/NASA	
TCS-48	ECAL radiators	Four radiators are fixed on the Back Panels of the ECAL. Thermo/optical properties are Silvered Teflon 10 mils	I	CERN	System AI	CGS	
TCS-49	AMS02 power, STS unmated phases	The AMS-02 power profile during the STS unmated phases shall not exceed 1800W at 120V	A			TWG	
TCS-50	AMS02 power, SSRMS phases	The AMS-02 power profile in the transfer phase from the Hand-Off position to the ISS truss site (via SSRMS) shall be such as to draw no more than 16.7 amps over the minimum to maximum voltage range	A			TWG	
TCS-51	Main radiator RAM, operations in vacuum	The RAM radiator shall be tested in vacuum at AMS-02 level and inspected after the test	I			CGS	
TCS-52	Main radiator RAM, heat rejection capability	The RAM radiator heat rejection capability shall be determined in the test data analysis	A			CGS	
TCS-53	Main radiator RAM, coupling to the electronic crates	The temperature drop between electronic crates and the RAM radiator shall be measured in vacuum	T			CGS	

Validation Product #	Activity	Objective	Valid. Method	Facility or Lab	Phase	Perform. Org	Results
TCS-54	Main radiator WAKE, operations in vacuum	The WAKE radiator shall be tested in vacuum at AMS-02 level and inspected after the test	I			CGS	
TCS-55	Main radiator WAKE, heat rejection capability	The WAKE radiator heat rejection capability shall be determined in the test data analysis	A			CGS	
TCS-56	Main radiator WAKE, coupling to the electronic crates	The temperature drop between electronic crates and the WAKE radiator shall be measured in vacuum	T			CGS	
TCS-57	Tracker radiator RAM, operations in vacuum	The Tracker RAM radiator shall be tested in vacuum at AMS-02 level and inspected after the test	I			CGS	
TCS-58	Tracker radiator RAM, coupling to the electronic crates	The temperature drop between TTCS condenser and the RAM tracker radiator shall be measured in vacuum	T			CGS	
TCS-59	Tracker radiator WAKE, operations in vacuum	The Tracker WAKE radiator shall be tested in vacuum at AMS-02 level and inspected after the test	I			CGS	
TCS-60	Tracker radiator WAKE, coupling to the electronic crates	The temperature drop between TTCS condenser and the WAKE tracker radiator shall be measured in vacuum	T			CGS	
AMICA Star Trackers							
AST-1	ASTC EMI test	EMI performances of the star tracker camera	T	Eng dep. Of University Perugia, TERNI	4	CARSO	Test report AMIA/CEMT/1/A
AST-2	ASTC vibration test	Start tracker camera vibration test	T	SERMS Terni	4	CARSO	Test report AMST/ACQFV/1/A
AST-3	ASTC functional thermal cycling	To verify the thermal vacuum performances of the camera electronics	T	SERMS Terni	4	CARSO	Test report AMIA/CTVC/1/A
AST-4	ASTC lens thermal vacuum	To verify the lens venting and performances at hot temperatures	T	CARSO	4	CARSO	Test report AMIF/LETV/1/
AST-5	ASTC lens thermal cold	To verify the lens at low temperatures	T	SERMS Terni	4	CARSO	Test report AMST/CTVL/1/A
AST-6	ASTC thermal balance	To verify the start tracker camera (with mechanical structure)	T	SERMS Terni	4	CARSO	Test report AMIA/CTVB/1/A

Validation Product #	Activity	Objective	Valid. Method	Facility or Lab	Phase	Perform. Org	Results
		Performances at hot and cold temperatures					
AST-7	ASTE functional test	To verify the ASTE electronics functional performances	T	CARSO	4	CARSO	Test report AMST/ASTT/1/A
Global Positioning System (GPS)							
GPS-1							

APPENDIX F: VERIFICATION OF AMS-02 SAFETY REQUIREMENTS

Leland's Matrix goes here