PAYLOAD FLIGHT HAZARD REPORT				a. NO:	AMS-02-F14
b. PAYLOAD	Alpha Magnetic Spectrometer-02 (AMS-02)			c. PHASE:	III
d. SUBSYSTEM:	Mechanical, Thermal, Electrical, Pressurized Systems	e. HAZARD GROUP:	Injury/Illness.	f. DATE:	August 4, 2010
g. HAZARD TITLE:	EVA/EVR Hazards			i. HAZARD CATEGORY:	CATASTROPHIC **X** CRITICAL
h. APPLICABLE SAFETY REQUIREMENTS:	NSTS 1700.7B, ISS Addendum, 200.1b, 200.3, 201.3, 217				
j. DESCRIPTION OF HAZARD:	The failure to design and construct the AMS-02 to be compatible with proximity to EVA translation paths and EVA activities can result in injury or death to the EVA crew. During EVR operations the AMS-02 has to be designed to avoid collision during SSRMS operations. Note: EVR compatibility with magnetic field covered in AMS-02-F07				

k. CAUSES

(list)

1. Inadequate Access for EVA Tasks
2. Excessive Radiation
3. Sharp Edges/Corners
4. Thermal Extremes
5. Release of residual loads/forces applied
6. Excessive Loads/Effort From EVA Crew
7. Electric Shock/Molten Metal
8. Entrapment of EVA Crew
9. Improper Installation of EBCS
10. Protrusion Outside of PAS Payload Envelope
11. Improper Placement/Installation of Grapple Fixtures

o. APPROVAL	PAYLOAD ORGANIZATION	SSP/ISS
PHASE I		
PHASE II		
PHASE III	[signature] TRENT MARTIN 8/4/10	[signature] 8/6/10

PAYLOAD FLIGHT HAZARD REPORT	a. NO: AMS-02-F14
b. PAYLOAD Alpha Magnetic Spectrometer-02 (AMS-02)	c. PHASE: III

l. HAZARD CONTROL (CONTROL), m. SAFETY VERIFICATION METHODS (SVM), n. STATUS OF VERIFICATIONS (STATUS)	OPS CONTROL
1. CAUSE: Inadequate Access for EVA Tasks	

1.1 CONTROL: The AMS-02 has provided handholds/handrails in appropriate locations to support potential contingency EVAs. This includes EVAs associated with AMS-02 contingency re-routing of connections for power and communications, release of the PAS capture bar and AMS-02 GFE EVAs to the ROEU, the UMA and both grapple fixtures. A WIF interface is available for all EVA operations where tools are required except the FRGF and PVGF have also been approved for free float operations in addition to WIF socket use. These have waivers to SSP 57003 for free float operations. EVA access complies with the guidelines of JSC 28918 and NSTS 07700, Vol XIV, Appendix 7 for EVA accessibility.

1.1.1 SVM: Review of design.

1.1.2 SVM: Inspection of as built hardware.

1.1.3 SVM: Approval of EVA aid locations/Site Analysis by JSC/XA.

1.1.4 SVM: <Deleted> Removal of folding ROEU mechanism removes need for Free Float Operations.

1.1.1 STATUS: Closed. ESCG Memorandum ESCG-4410-09-MSDE-MEMO-0002, "AMS-02 EVA Worksites," dated April 10, 2009 documents the review of the EVA worksites and tasks.

1.1.2 STATUS: Closed to SVTL.

1.1.3 STATUS: Closed. ESCG Memorandum ESCG-4410-09-MSDE-MEMO-0002, "AMS-02 EVA Worksites," dated April 10, 2009 documents the review of the EVA worksites and tasks and the review and acceptance of these sites and tasks.

1.1.4 STATUS: <Deleted>

1.2 CONTROL: All AMS-02 Operations involving the use of EVA tools, specifically the EVA release of the PAS, utilize standard EVA bolt interfaces to drive the ramp screws to release the PAS capture bar preload. These bolts are designed to interface with the EVA power tool.

1.2.1 SVM: Review of Design.

1.2.2 SVM: Tool Fit Check.

1.2.1 STATUS: Closed. ESCG Memorandum ESCG-4410-09-MSDE-MEMO-0001, "EVA Contingency Tool

Requirements," dated May 7, 2009 1.2.2 STATUS: Closed. Boeing document BCP-s3-T037, "S3 Zenith Inboard PAS 2/AMS Passive PAS Fit Check, Preload and Release Mechanism Evaluation," dated February 26, 2003	
1.3 CONTROL: AMS-02 EVA mechanisms that the crew is to operate by hand are design to facilitate operations with the gloved hand. All EVA interfaces meet the requirements/intent of NASA-STD-3000, SSP 50005 for crew operability and access. 1.3.1 SVM: Review of Design. 1.3.2 SVM: Inspection of as built hardware. 1.3.3 SVM: Crew Inspection 1.3.1 STATUS: Closed. ESCG Memorandum ESCG-4295-09-CPAS-MEMO-0006, "AMS-02 EVA Access," dated October 8, 2009 1.3.2 STATUS: Closed to SVTL. 1.3.3 STATUS: Closed. Astronaut Crew Consensus Report for November 12-15, 2002 Columbus and AMS Development Test, Report File dated 12./11/2002	
2. CAUSE: Excessive Radiation	
NOTE: This hazard/cause is addressed in AMS-02-F07 for EMI and magnetic fields.for ionizing radiation is no longer applicable, all radiation sources have been removed.	
3. CAUSE: Sharp Edges/Corners	
3.1 CONTROL: The AMS-02 is designed to eliminate sharp edges, corners, protrusions and any mechanism that could be a pinch or scissor location. The AMS-02 meets the requirements of NSTS 07700, Vol XIV, Appendix 7 for all accessible surfaces and structures, with the exception of the two Star Tracker optical baffles, which by the nature of the optical properties of the baffle, has thin metal edges that do not comply with the rounding of edges. The Star Tracker baffles will be noted as "no touch areas". There has been no identified need for the EVA crew to operate in the immediate vicinity of the Star Tracker baffles. To access these thin sheet edges, the EVA crewmember would have to reach to the interior of the Star Tracker baffle. (Reference Page A14-34 for figure showing Star Tracker Location, "STAR TRACKER BAFFLE – EVA No Touch Area.") Note: Silver Teflon Tape was used to cover edges that were not properly finished in accordance with NSTS 07700 Vol XIV,	I, S

PAYLOAD FLIGHT HAZARD REPORT	a. NO: AMS-02-F14
b. PAYLOAD Alpha Magnetic Spectrometer-02 (AMS-02)	c. PHASE: III

Appendix 7.

3.1.1 SVM: Review of Design

3.1.2 SVM: Inspection of flight hardware (including swatch testing) for sharp edges, corners, etc.

3.1.3 SVM: Acceptance of EVA no touch area for Star Tracker baffles by MOD through an OCAD. (OCAD 67862)

3.1.1 STATUS: Closed. ESCG Memorandum ESCG-4295-09-CPAS-MEMO-0005, "AMS-02 Sharp Edge Review," dated October 8, 2009

3.1.2 STATUS: Closed to SVTL.

3.1.3 STATUS: Closed to SVTL.

4. CAUSE: Thermal Extremes

4.1 CONTROL: The AMS-02 Design precludes contact between an EVA crewmember and surfaces that exceed the thermal limits of 235°F to -180°F (112°C to -118°C) for incidental contact not to exceed 30 seconds in length. The AMS-02 design will minimize the continuous contact potential for EVA worksite beyond the requirement temperatures of 145°F to -45°F (63°C to -41°C). This has considered the required EVA translation paths while in the Orbiter Payload Bay, mounted on the ISS and for potential EVA work sites for contingency actions of Grapple Fixture release, ROEU mate/demate, PAS EVA disconnect, AMS-02 Power/Communications Cable Swap, etc. If unable to meet the numerical values of temperature as documented in SSP 57003, paragraph 3.11.5.14.1 and 3.11.5.14.2 for the incidental/continuous contact, heat transfer limits will be shown to be equivalently compliant with the alternate analysis method provided for in those requirements. A non-compliance report has been generated to ask for equivalent compliance to NSTS 1700.7B ISS Addendum paragraphs 200.3 and 217, AMS-02-NCR-001.

4.1.1 SVM: Thermal Analysis of EVA Work Sites and Translation Paths

4.1.2 SVM: Approval of AMS-02-NCR-001

4.1.1 STATUS: Closed. ESCG Memorandum ESCG-4470-07-TEAN-DOC-0033-B, "Alpha Magnetic Spectrometer (AMS-02) EVA Touch Temperature Evaluation," dated July 28, 2008. ESCG Memorandum ESCG-4175-REENTES-MEMO-0025, "Cryomagnet Dump Diode Accessibility," dated June 8, 2009 establishes Cryomagnet Dump Diode Inaccessible to EVA. ESCG-4470-10-TEAN-DOC-0097, "Re-evaluation of AMS-02 EVA Touch Temperatures," July 19, 2010

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4.1.2 STATUS: Closed. AMS-02-NCR-001 "AMS-02 Payload EVA Touch Temperature," was approved as "Equivalent Safety" on January 6, 2009 by PSRP Chair.

4.2 CONTROL: Active thermal control devices will not be capable of heating AMS-02 components that are EVA accessible in exceedence of the EVA thermal limits for touch temperatures [235°F to -180°F (112°C to -118°C)]. Heaters have two thermal switches, one in the return leg and are monitored by the AMS-02 computer system and can be shut off if nominal working limits are exceeded. All of these limits are within the EVA thermal limits for touch temperature.

4.2.1 SVM: Review of Design

4.2.2 SVM: Inspection of as built hardware

4.2.3 SVM: Functional/workmanship testing of heater/thermal switch circuitry

4.2.4 SVM: Functional testing of thermal monitoring by avionics

4.2.5 SVM: Testing of software control of heaters.

4.2.1 STATUS: Closed. ESCG Memorandum ESCG-4470-09-TEAN-DOC-0181, "AMS-02 Active Thermal Devices and EVA Touch Temperature Limits," dated October 23, 2009. ESCG-4470-10-TEAN-DOC-0097, "Re-evaluation of AMS-02 EVA Touch Temperatures," July 19, 2010.

4.2.2 STATUS: Closed to SVTL.

4.2.3 STATUS: Closed. Thermal Vacuum Testing Report DEL037-UNIPC-20100603-is2.doc, "DEL037 TV TB Test Report," June 3, 2010, AMSTR-NLR-TR-080, "TTCS Condenser Heater Wire Test Report," February 2, 2010.

4.2.4 STATUS: Closed. Thermal Vacuum Testing Report DEL037-UNIPC-20100603-is2.doc, "DEL037 TV TB Test Report," June 3, 2010.

4.2.5 STATUS: Closed. Thermal Vacuum Testing Report DEL037-UNIPC-20100603-is2.doc, "DEL037 TV TB Test Report," June 3, 2010.

4.3 CONTROL: The AMS-02 is designed to position vent locations pressurized systems such that there will be no impingement of possible venting products, which could be extremely cold, upon EVA work sites and translation paths.

4.3.1 SVM: Review of Design of vents, vent locations and orientations.

4.3.2 SVM: Plume impingement assessment.

4.3.1 STATUS: Closed. ESCG Memorandum ESCG-4295-09-CPAS-MEMO-0014, "Review of AMS-02 Vent

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Locations," dated November 13, 2009

4.3.2 STATUS: Closed. ESCG Memorandum ESCG-4295-09-CPAS-MEMO-0014, "Review of AMS-02 Vent Locations," dated November 13, 2009

5. CAUSE: Release of Residual Loads/Forces Applied

5.1 CONTROL: The potential EVA operation to move AMS-02 EVA connectors to restore communications paths or redirect power does not involve systems that involve stored mechanical energy.

5.1.1 SVM: The design of the EVA connectors, cable restraints and EVA panel will be reviewed for any mechanically stored energy.

5.1.1 STATUS: Closed. ESCG Memorandum ESCG-4175-09-REENTES-MEMO-0028, "AMS-02 EVA Cable Stored Energy," dated June 3, 2009

5.2 CONTROL: The EVA release mechanism for the PAS passive mechanism releases stored energy (5650 lb preload) by the operation of the two EVA operated release mechanisms, each using a screw driven ramp that slowly releases the tension of latched capture bar. Two mechanisms must be released fully to allow for the capture bar to clear interference brackets that preclude the attempts to extract the bar prior to full release of the preload. The SSRMS will be put into a limp mode to preclude a buildup of loads that could be released with the removal of the bar.

5.2.1 SVM: Review of Design.

5.2.2 SVM: Inspection of as built hardware.

5.2.3 SVM: Functional testing of EVA PAS Release Mechanism.

5.2.4 SVM: Review of Procedures associated with the EVA release of the AMS-02 PAS capture bar.

5.2.5 SVM: Acceptance of OCAD for EVA PAS Release(OCAD 67863)

5.2.1 STATUS: Closed. Memo ESCG-4390-06-SP-MEMO-0001, "Mechanical Design of the Payload Attach System (PAS)", dated 8 January, 2006 from AMS-02 Chief Engineer.

5.2.2 STATUS: Closed. Memo ESCG-4390-06-SP-MEMO-0003, "Quality Inspection of the Payload Attach System" dated 03 March 2006, from AMS-02 Chief Engineer Chris Tutt.

5.2.3 STATUS: Closed. Memo ESCG-4390-05-SP-MEMO-0012, "Functional Testing of the Payload Attach System" dated 28 December 2005, from AMS-02 Chief Engineer Chris Tutt.

I

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5.2.4 STATUS: Closed. Procedure "AMS-02 Passive PAS Assembly Capture Bar Release and Reinstallation Procedure," reviewed October 6, 2009 by AMS-02 Jacobs Project Manager for appropriate steps and functionality.

5.2.5 STATUS: Closed. OCAD Closure reported to AMS-02 Project on 6/4/2010 by JSC-DA8/B. O'Keeffe.

5.3 CONTROL: <Deleted> ROEU Bracket no longer folds

5.3.1 SVM: <Deleted>

5.3.1 STATUS: <Deleted>

NOTE: The EVA tasks involving the release of grapple fixtures and other GFE hardware items are not covered under these assessments as the AMS-02 does not have any involvement in the design and operation of these EVA tasks.

6. CAUSE: Excessive Loads/Effort from EVA Crew

6.1 CONTROL: Mate/demating of EVA compatible connectors, operation of PAS passive mechanism for releasing stored energy and extraction of capture bar have all been assessed and established to be within EVA crew capabilities.

6.1.1 SVM: Ground testing of EVA interfaces.

6.1.1 STATUS: Closed. Functional Testing of PAS at thermal extremes documented in TPS 2A0720229 dated September 27, 2009 and TPS 2A0730116 dated January 18, 2008

6.2 CONTROL: <DELETED>

6.2.1 SVM: <DELETED> I

6.2.1 STATUS: <Deleted>

7. CAUSE: Electric Shock/Molten Metal

NOTE: Electric Shock/Molten Metal for EVA crew (only electric shock potential for AMS-02) is addressed in AMS-02-F08.

8. CAUSE: Entrapment of EVA Crew

8.1 CONTROL: The design of the AMS-02 is such that all cables length and position are such that they will not snare or entangle EVA crew during EVA access to the AMS-02 or translation past or adjacent to the AMS-02.

8.1.1 SVM: Review of design.

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8.1.2 SVM: Inspection of as built hardware. 8.1.1 STATUS: Closed. ESCG Memorandum ESCG-4175-09-REENTES-MEMO-0041-A, "EVA Entrapment by AMS-02 Cables," dated July 26, 2010 8.1.2 STATUS: Closed to SVTL.	
8.2 CONTROL: Magnetic field is insufficient to entrap an EVA crew member by attraction of ferromagnetic materials in the EMU or EVA tools. 8.2.1 SVM: Magnetic Field Analysis 8.2.1 STATUS: Closed. Scientific Magnetics Memorandum AMS-302, "Force Estimates for ISS Equipment (Phase II Safety), Dated April 28, 2008. Note Permanent Magnet field approximately one-sixth of Cryomagnet field strength.	I
9. CAUSE: Improper Installation of EBCS	
9.1 CONTROL: The EBCS is installed and aligned to allow for proper alignment of the AMS-02 to the ISS PAS location during berthing operations per SSP 57003. Proper alignment of an operating EBCS provides visual cues for proper installation into the PAS location without unplanned contact. 9.1.1 SVM: Review of Design 9.1.2 SVM: Inspection of EBCS Installation on Flight hardware 9.1.3 SVM: Alignment testing of EBCS to PAS passive hardware mounted to AMS-02 (operational check) 9.1.1 STATUS: Closed. ESCG Memorandum ESCG-4410-09-MSDE-MEMO-0003, "EBCS Alignment," dated 04/17/09 9.1.2 STATUS: Closed to SVTL. 9.1.3 STATUS: Closed to SVTL.	
10. CAUSE: Protrusion Outside of PAS Payload Envelope	
10.1 CONTROL: AMS-02 has been designed to minimize the protrusions outside of the nominal define PAS site payload envelope per SSP 57003. AMS-02 has identified all locations where exceedences of the AMS-02 PAS site payload occur and confirmed that none of these protrusions will violated the installation envelope for an adjacent PAS site payload including worst case alignment in translation and rotation of that payload during installation.	

PAYLOAD FLIGHT HAZARD REPORT	a. NO: AMS-02-F14
b. PAYLOAD Alpha Magnetic Spectrometer-02 (AMS-02)	c. PHASE: III

10.1.1 SVM: Review of Design

10.1.2 SVM: MAGIK analysis of installation clearances for adjacent payload.

10.1.3 SVM: ISS acceptance of SSP 57003 envelope exceedences.

10.1.1 STATUS: Closed. Review documented in ISS PIRN 57213-NA-0008, "AMS (Alpha Magnetic Spectrometer) – On-orbit Operations Envelope Exceedance," dated June 11, 2007, Approved 2/26/2009.

10.1.2 STATUS: Closed. Published MAGIK Analysis Action Item #1705 Report dated May 12, 2003, Published MAGIK Analysis Action Item #2172 Revision A dated February 27, 2007. MAGIK Analysis Action Item #2483 dated July 16, 2010.

10.1.3 STATUS: Closed to SVTL. To be closed with ISS PIRN # 57213-NA-0008

10.2 CONTROL: The AMS-02 ROEU fixture does not intrude into the adjacent payload envelope.

10.2.1 SVM: Review of Design

10.2.2 SVM: MAGIK analysis of installation clearances for adjacent payload.

10.2.3 SVM: ISS acceptance of SSP 57003 envelope exceedences.

10.2.1 STATUS: Closed. Review documented in ISS PIRN 57213-NA-0008, "AMS (Alpha Magnetic Spectrometer) – On-orbit Operations Envelope Exceedance," dated June 11, 2007, Approved 2/26/2009.

10.2.2 STATUS: Closed. Published MAGIK Analysis Action Item #1705 Report dated May 12, 2003, Published MAGIK Analysis Action Item #2172 Revision A dated February 27, 2007

10.2.3 STATUS: Closed. ISS PIRN 57213-NA-0008, "AMS (Alpha Magnetic Spectrometer) – On-orbit Operations Envelope Exceedance," dated June 11, 2007, Approved 2/26/2009.

11. CAUSE: Improper Placement/Installation of Grapple Fixtures

11.1 CONTROL: AMS-02 has placed the Flight Releasable Grapple Fixture and the Power Video Grapple Fixture on opposites sides of the AMS-02 structure to facilitate the hand off between the SRMS and SSRMS during AMS-02 installation operations.

11.1.1 SVM: Review of Design

11.1.2 SVM: MAGIK Analysis of robotic operations of removal from Orbiter Payload Bay, handoff and installation into PAS location.

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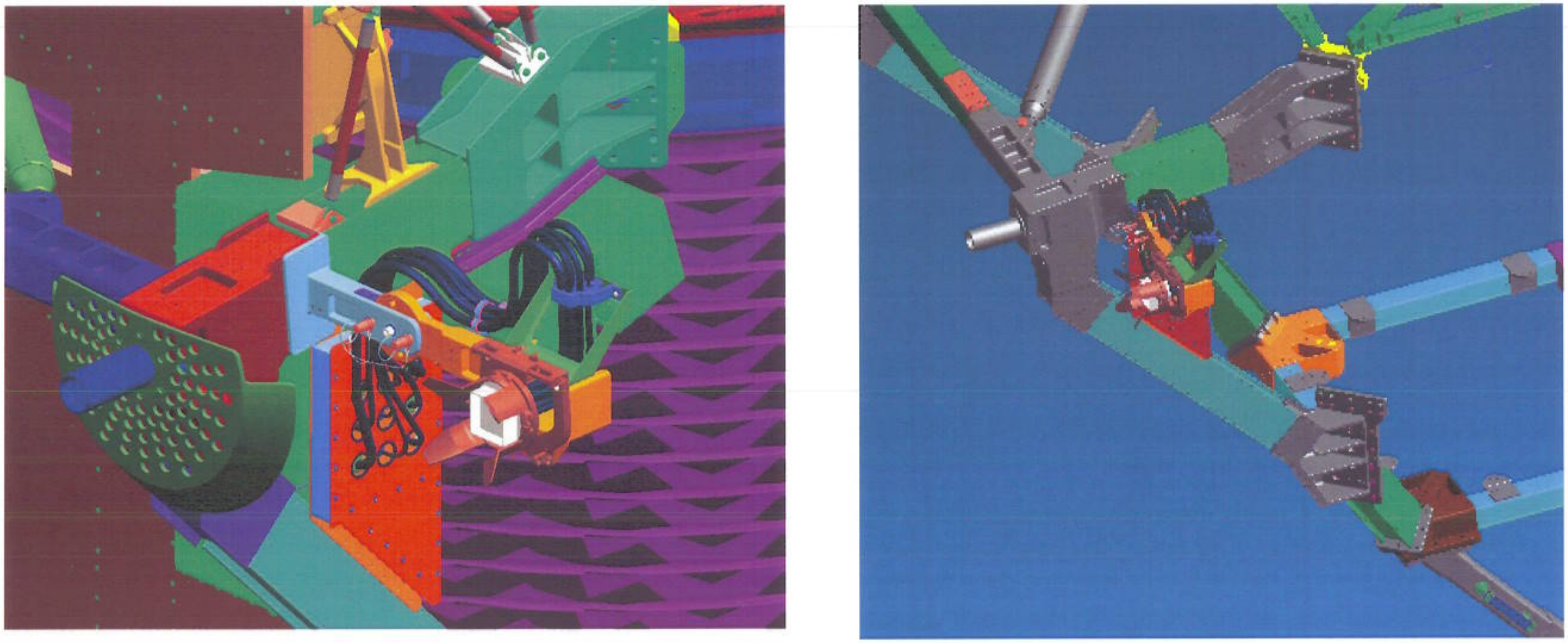
11.1.1 STATUS: Closed. ESCG Memorandum ESCG-4175-09-REENTES-MEMO-0056, "AMS-02 Grapple Fixtures," dated August 18, 2009

11.1.2 STATUS: Closed. Published MAGIK Analysis Action Item 2279 Revision A dated April 8, 2008. Published MAGIK Analysis Action Item 2483 dated July 15, 2010.

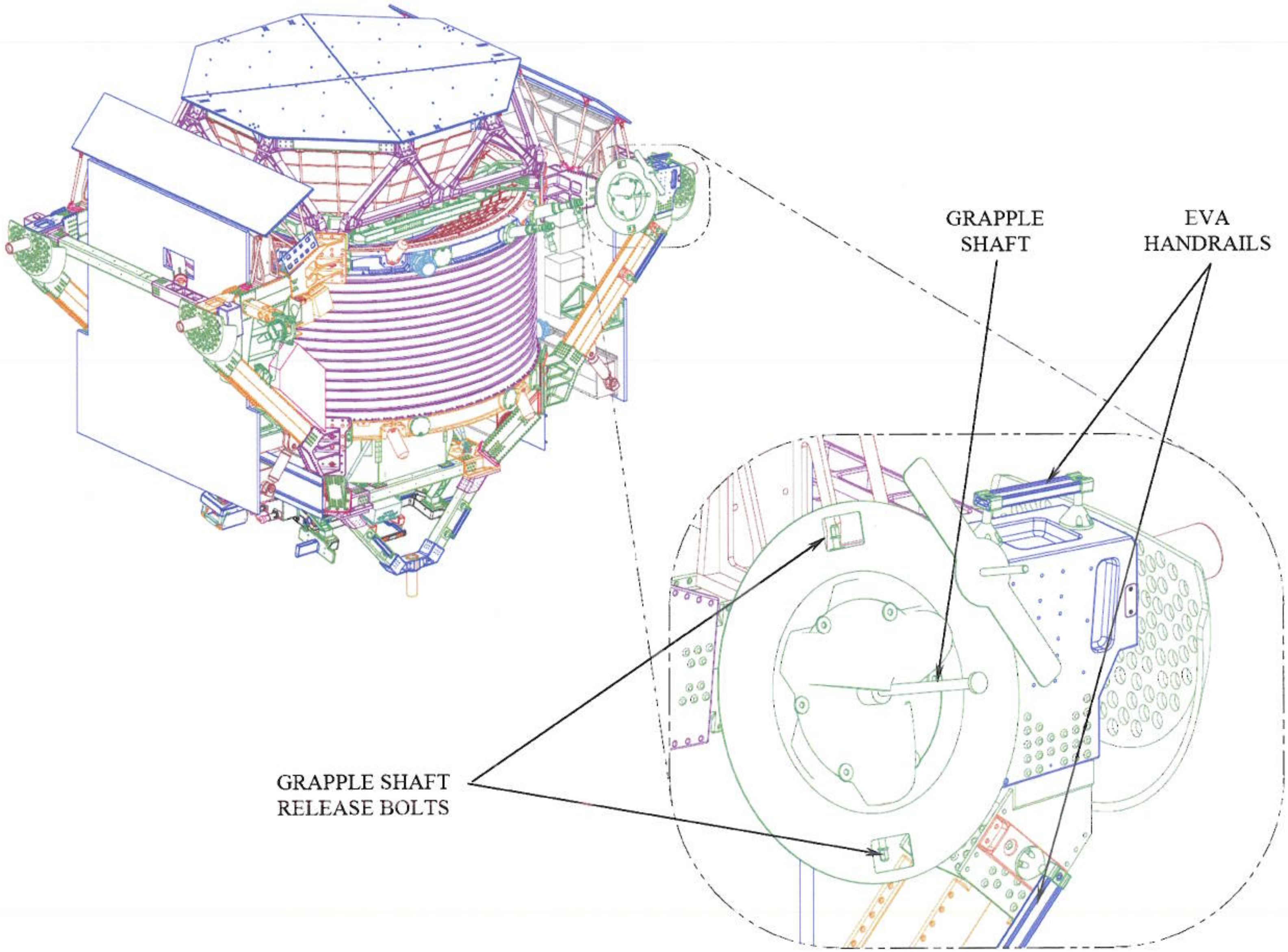
ACRONYMS	
°C – Degrees Centigrade (Celsius)	GFE – Government Furnished Equipment
°F – Degrees Fahrenheit	MAGIK – Manipulator Analysis Graphic and Interactive Kinematics (Team)
AMS-02 – Alpha Magnetic Spectrometer - 02	PAS – Payload Attach System, Payload Attach Site
ATA -	PVGF – Power Video Grapple Fixture
EVA – Extravehicular Activity	ROEU – Remotely Operated Electrical Umbilical
EVR – Extravehicular Robotic (activity)	SRMS – Shuttle Remote Manipulator System
EMU – Extravehicular Mobility Unit	SSRMS – Space Station Remote Manipulator System
EVA – Extravehicular Activity	SVM – Safety Verification Method
FRGF – Flight Releasable Grapple Fixture	WIF – Worksite Interface Fixture
EMI – Electromagnetic Interference	

SHUTTLE BASED EVAs

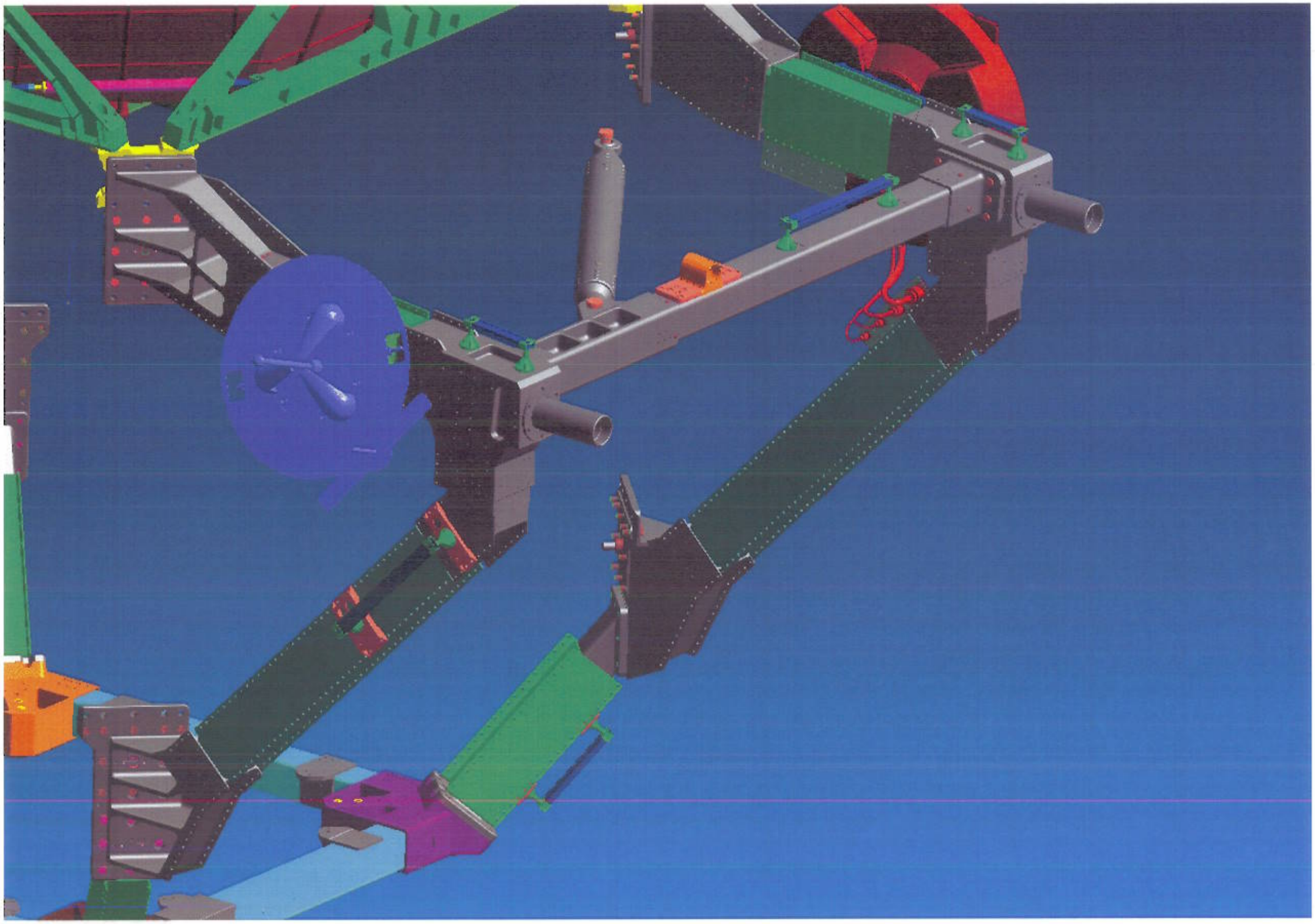
- ROEU Release/Mate
- FRGF Release
- PRLA Release/Closure



Potential EVA Work Site: Remotely Operated Electrical Umbilical (ROEU)



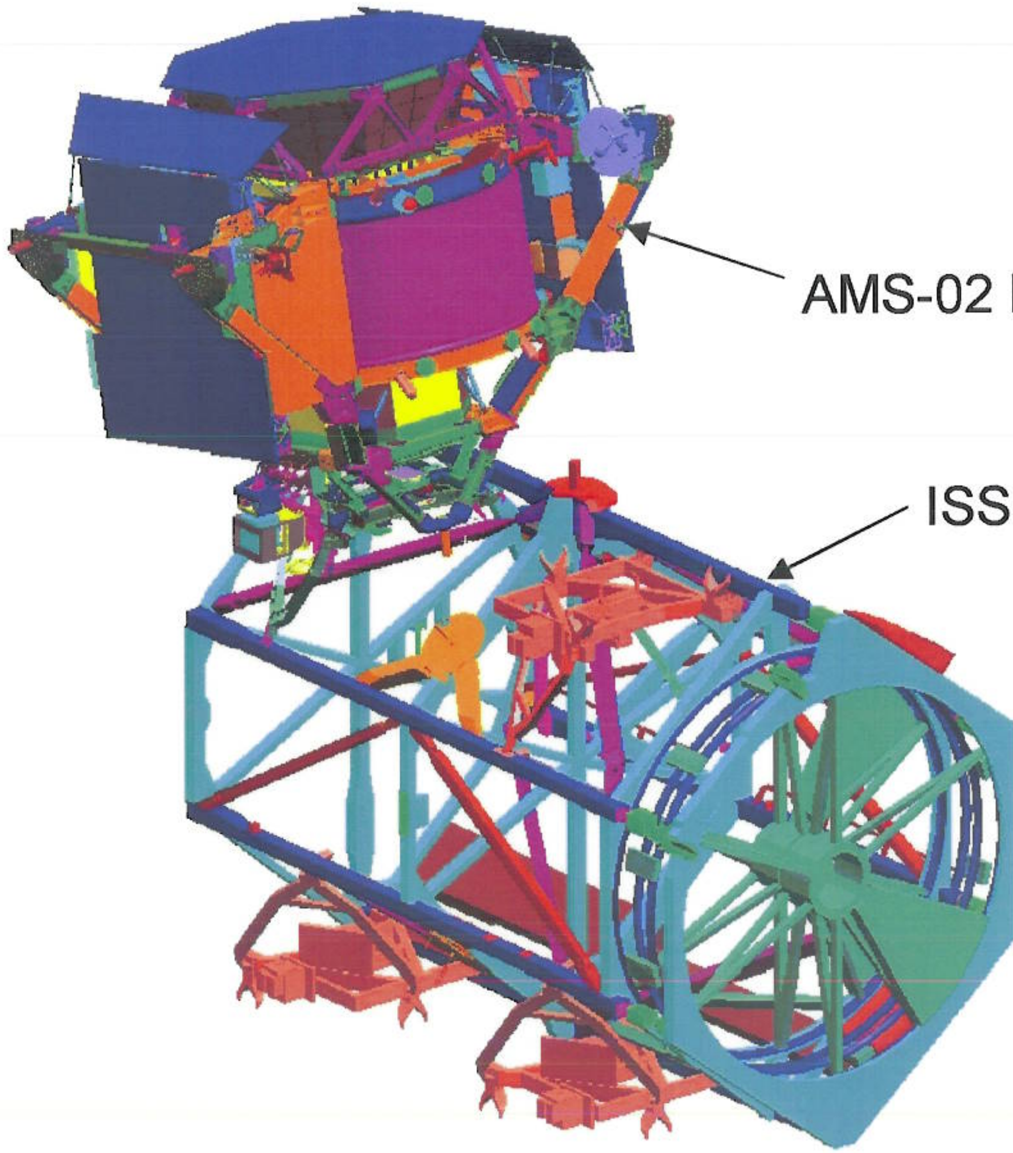
Potential EVA Work Site: Flight Releasable Grapple Fixture (FRGF)



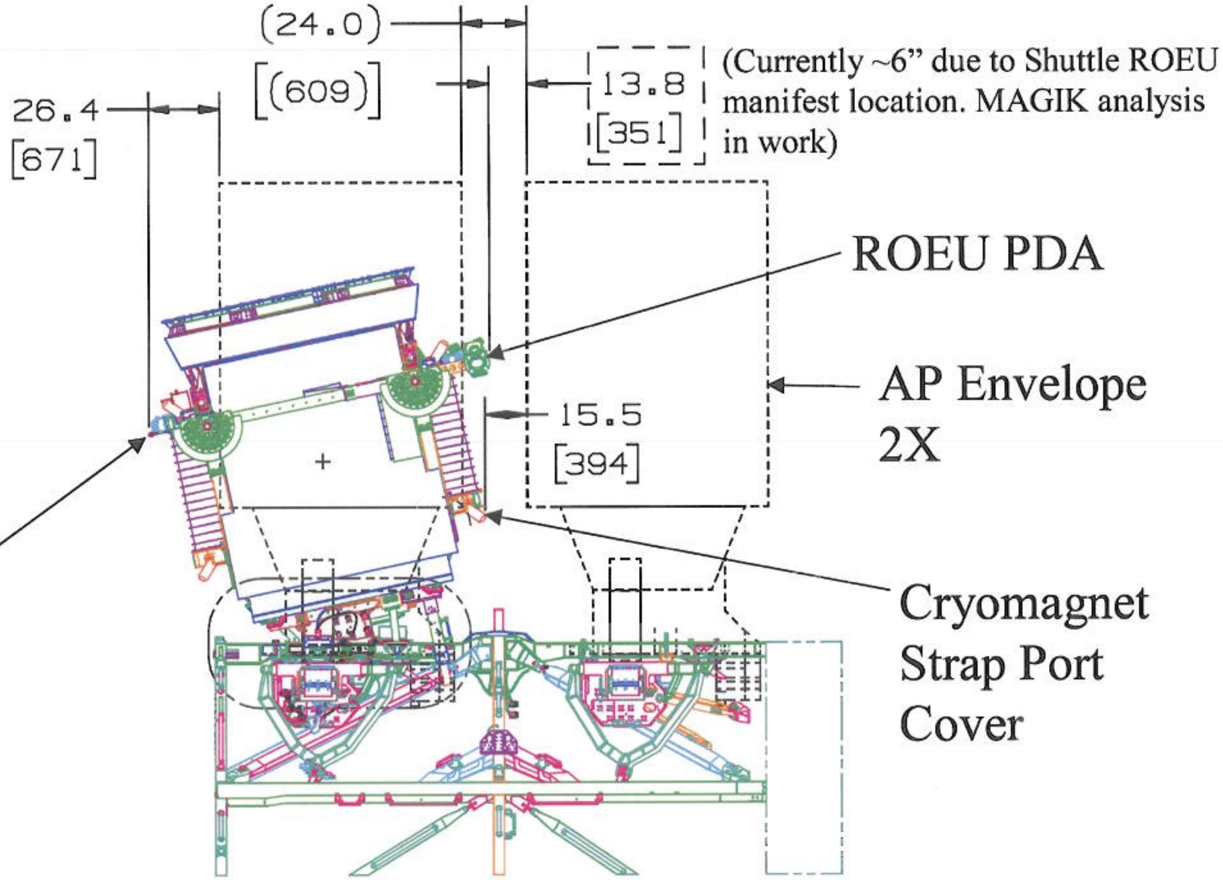
Handrails around FRGF

ISS BASED EVAs

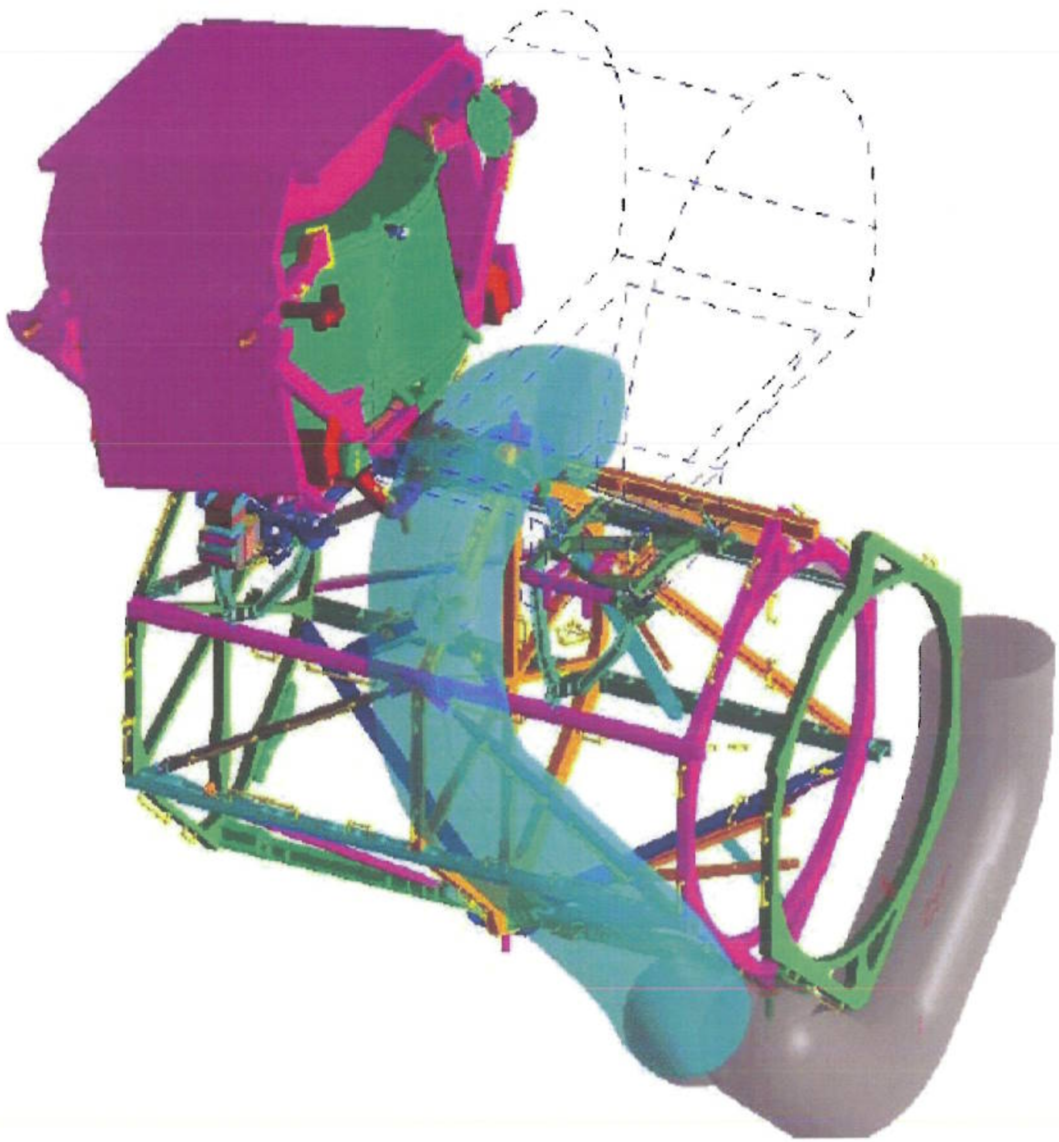
- General Translation Compatibility
- AMS-02 Passive PAS Release
- ISS UMA Release/Connect
- AMS-02 EVA Connector Swap
- ISS PVGF Release



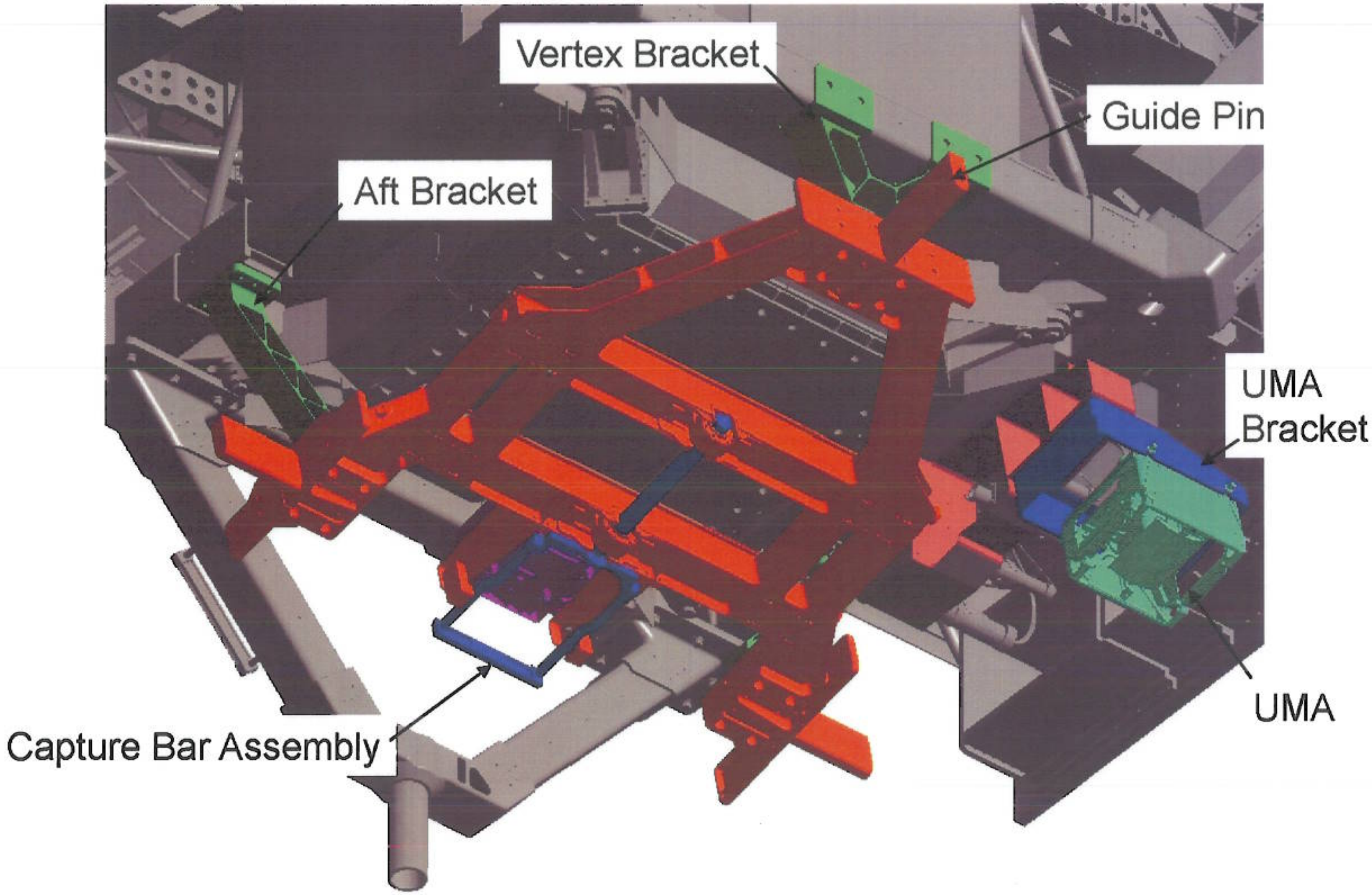
AMS-02 Location During Potential ISS Based EVAs



AMS-02 Location During Potential ISS Based EVAs

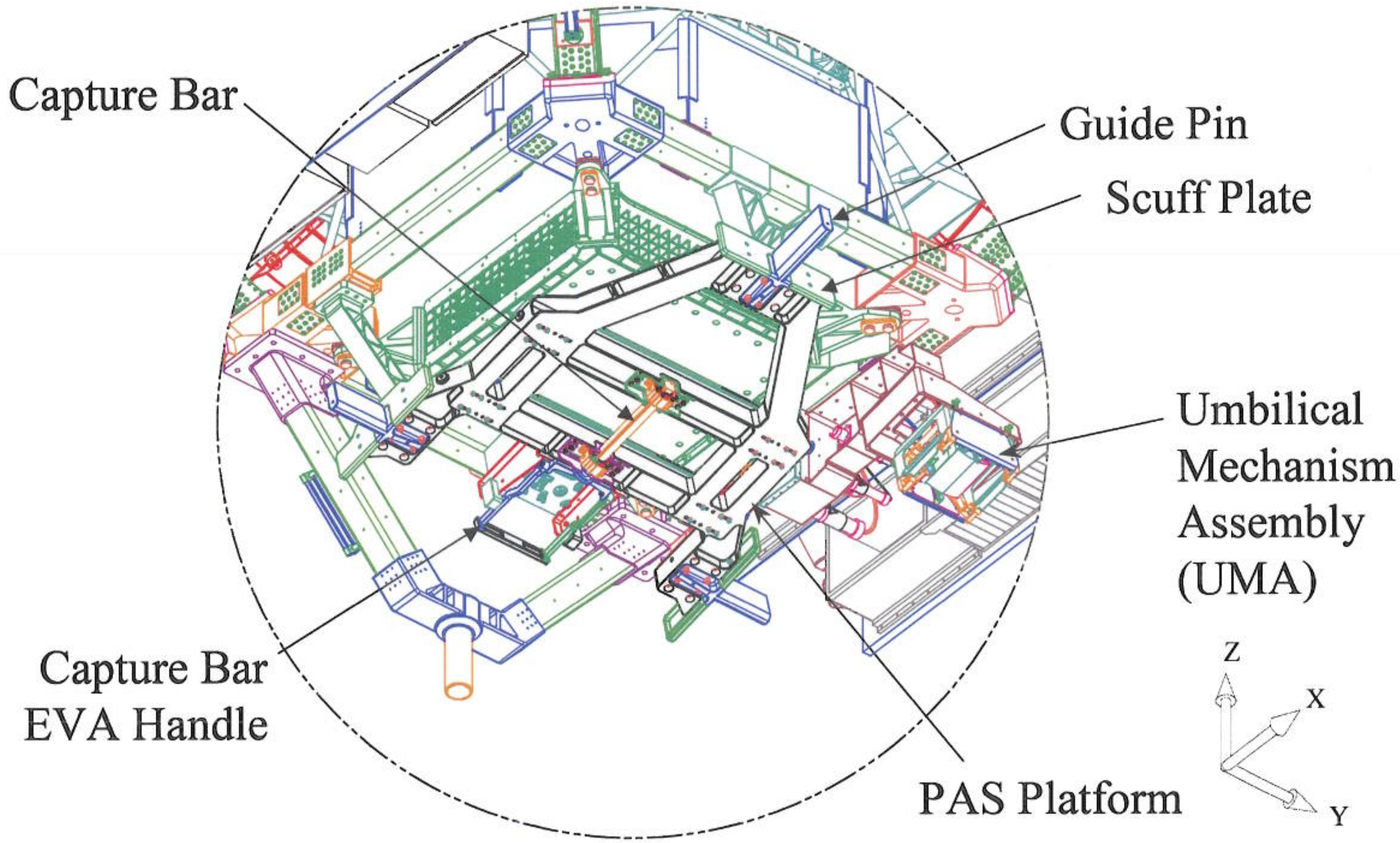


EVA Worksite Translation Analysis Results

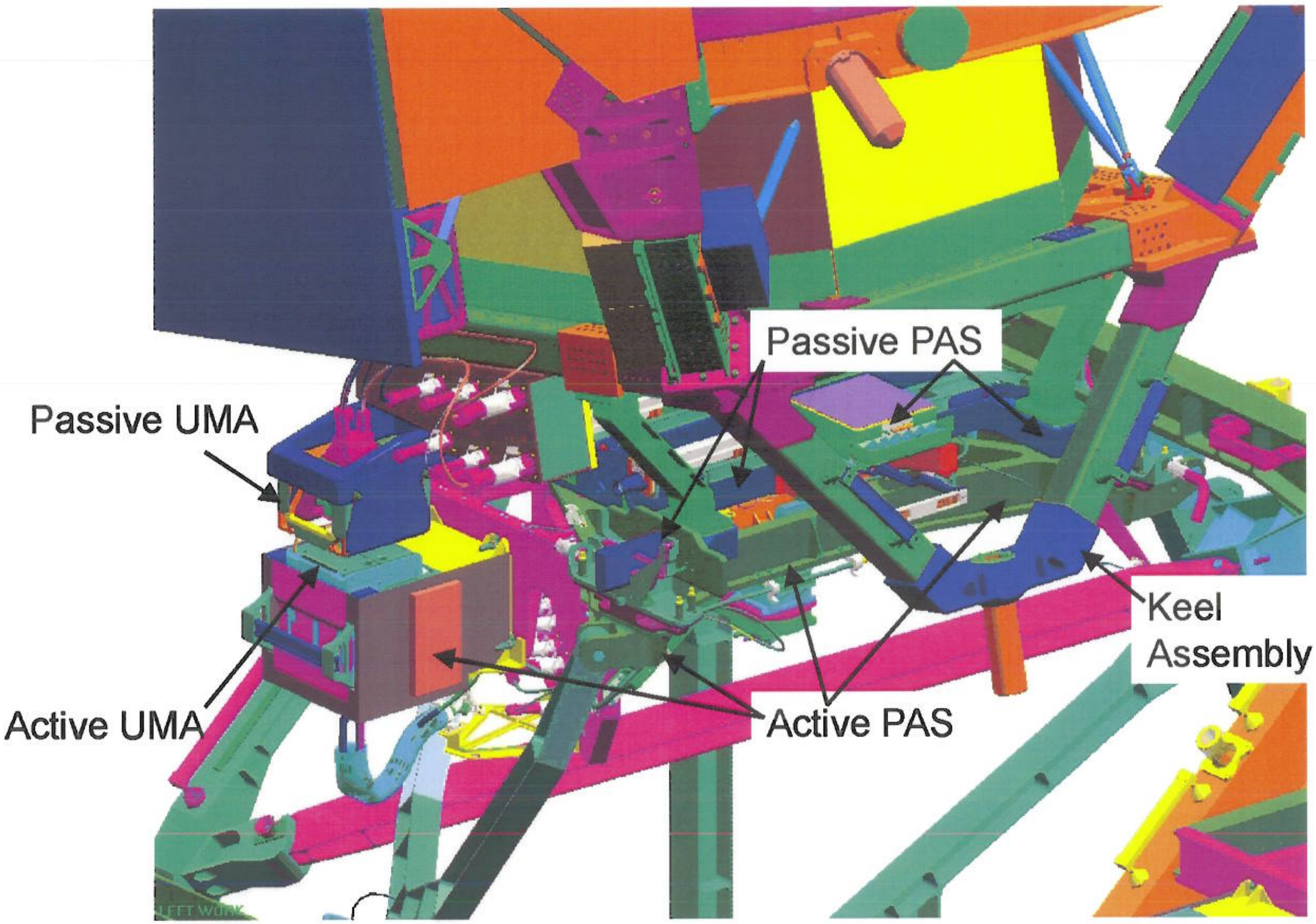


Potential EVA Work Site: Passive Payload Attach System (PAS)

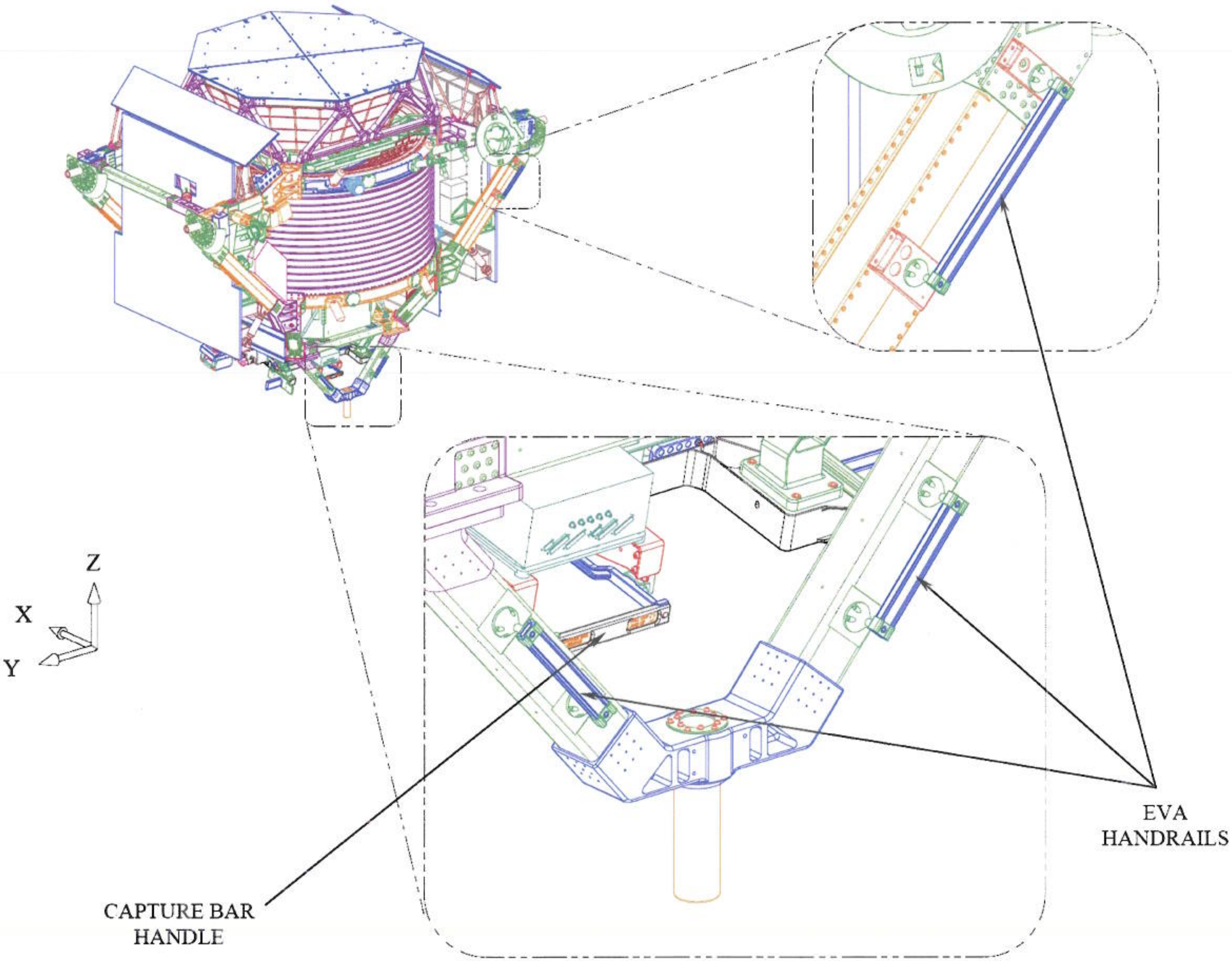
Passive PAS



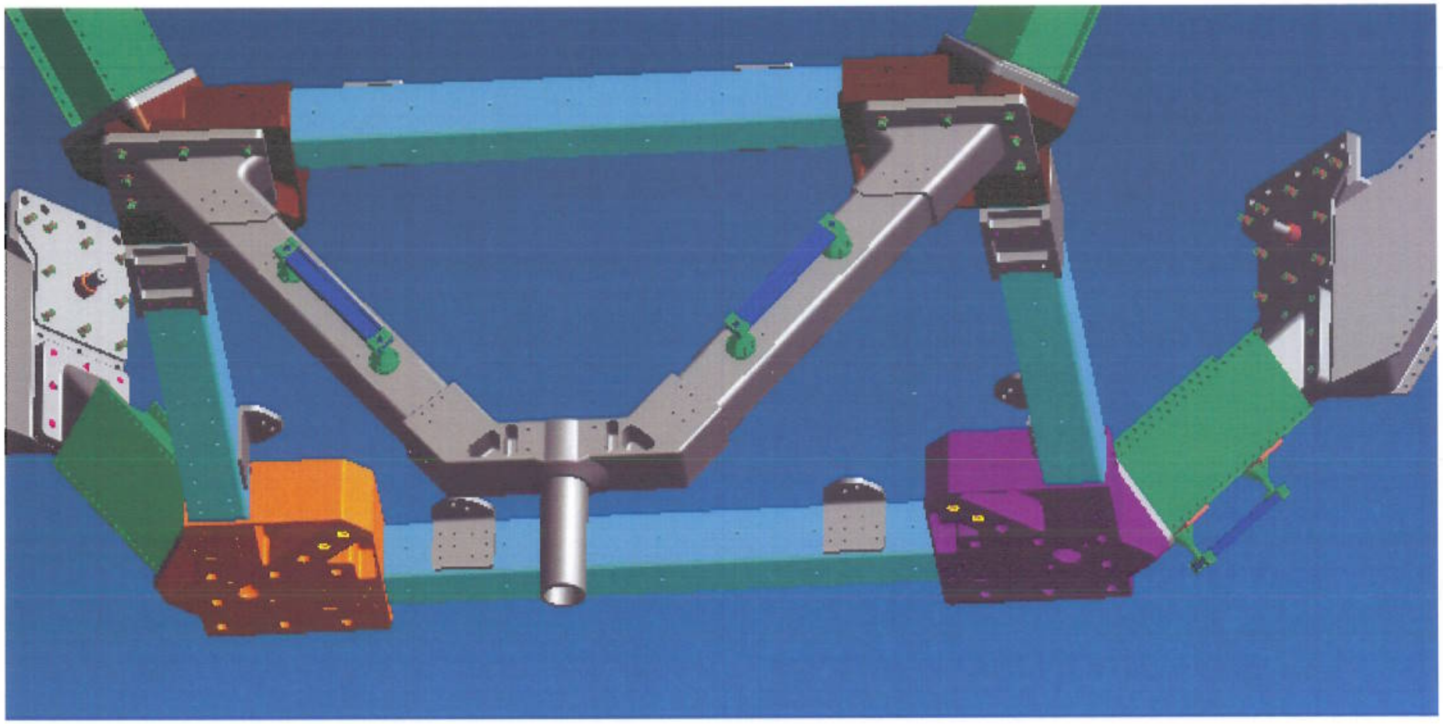
Potential EVA Work Site: AMS-02 Passive PAS



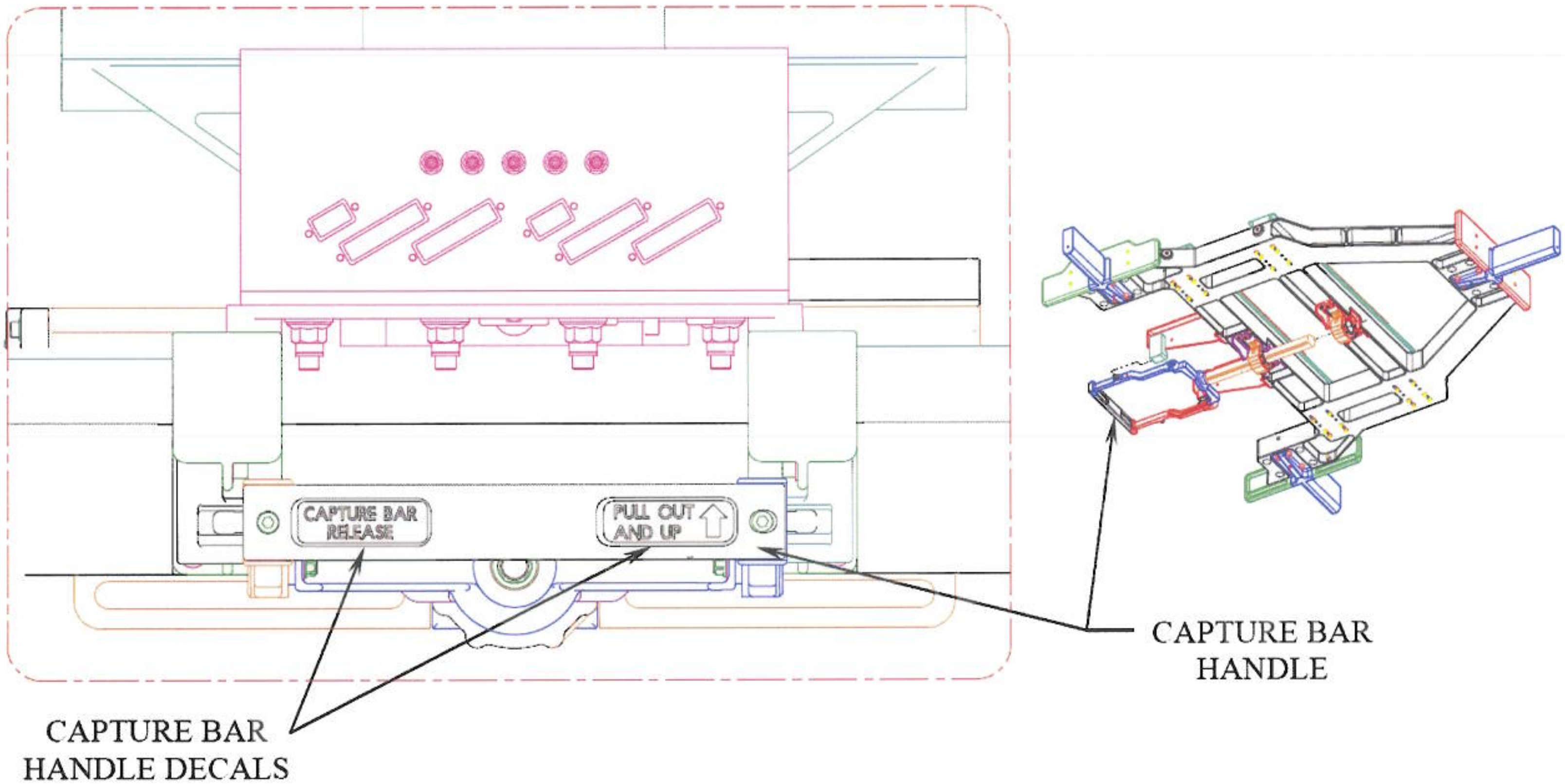
Potential EVA Work Site: AMS-02 Passive PAS, EVA Interface Panel and UMA



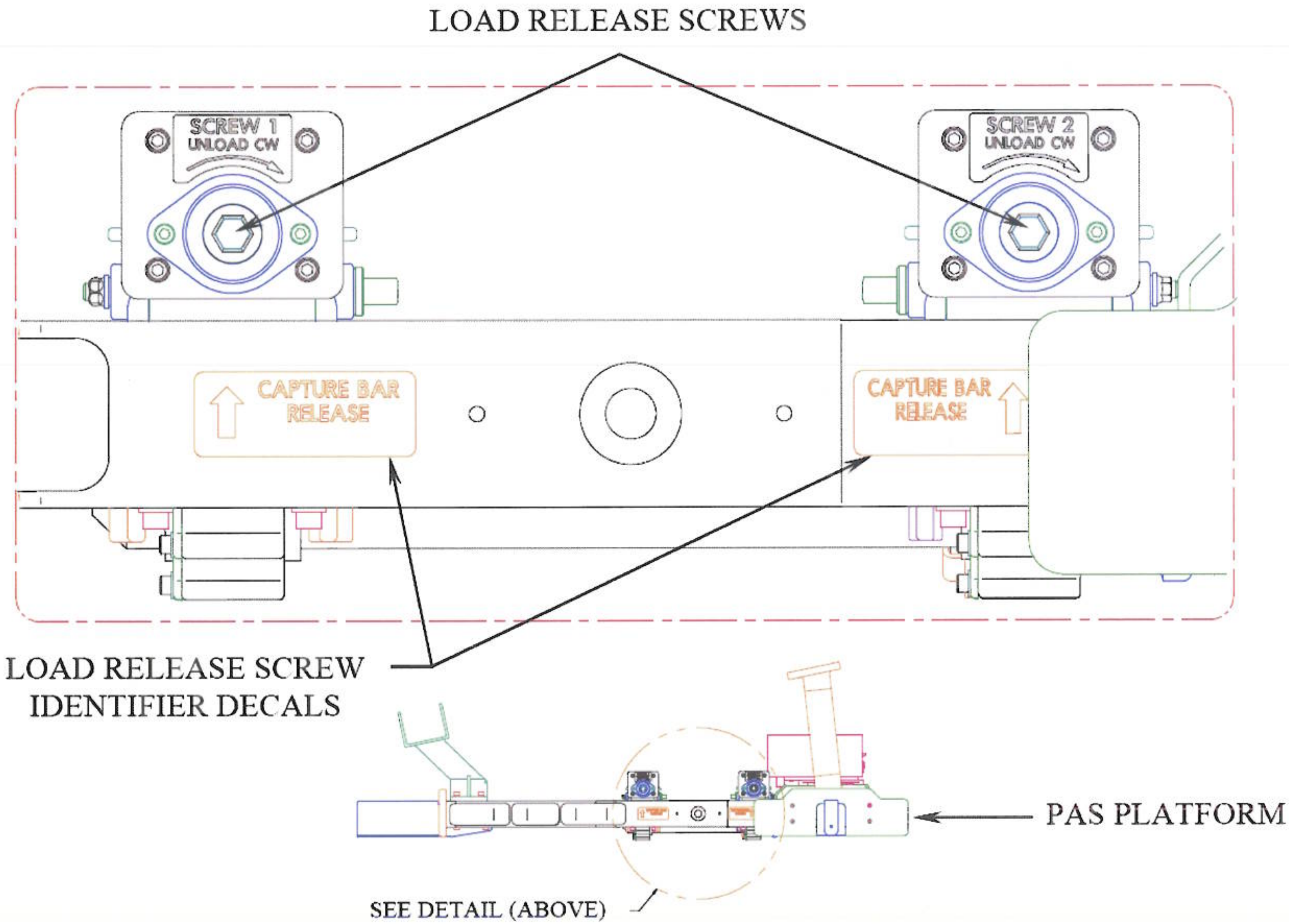
Potential EVA Work Site: AMS-02 Passive PAS



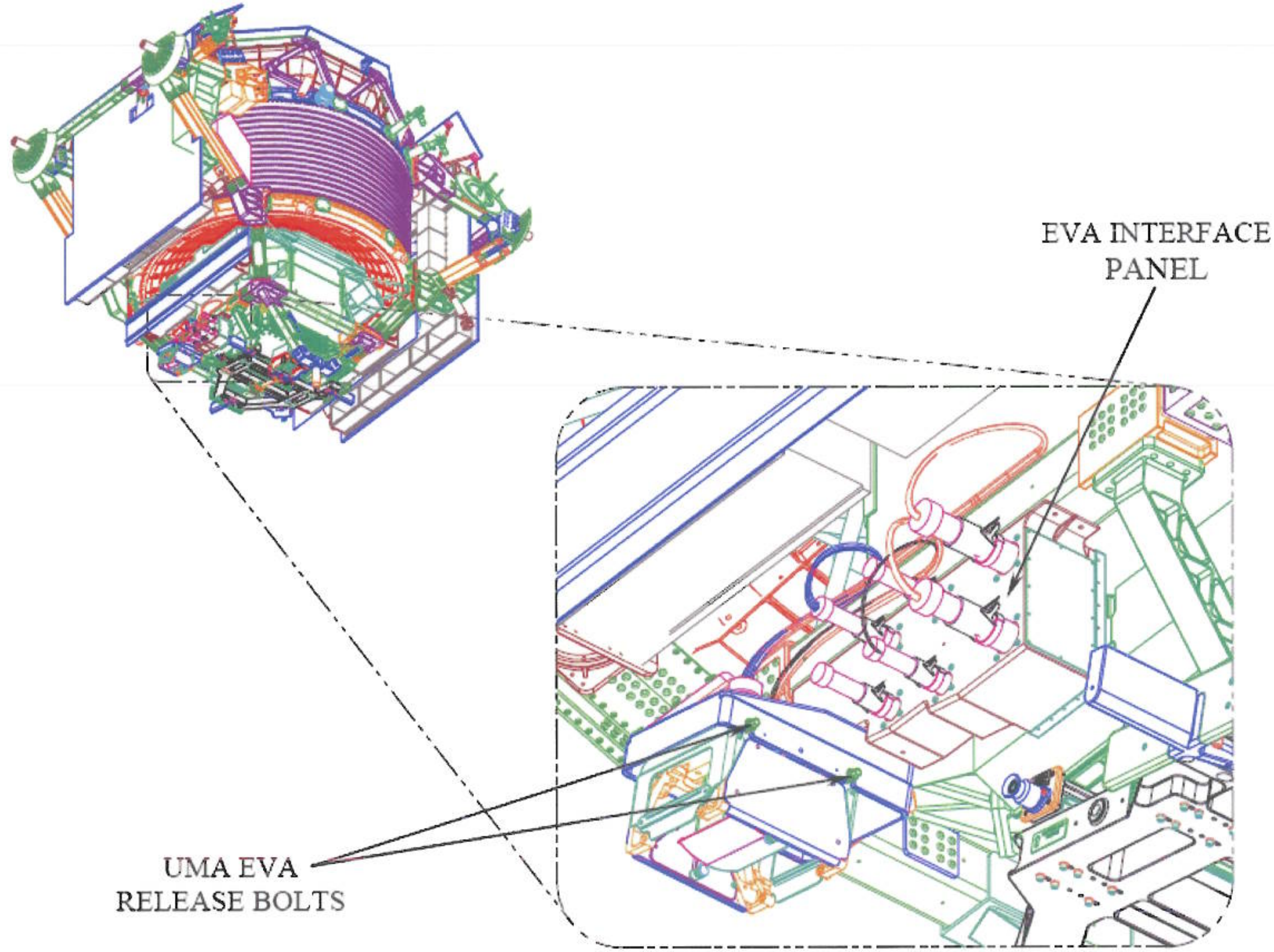
Keel Area Handrails



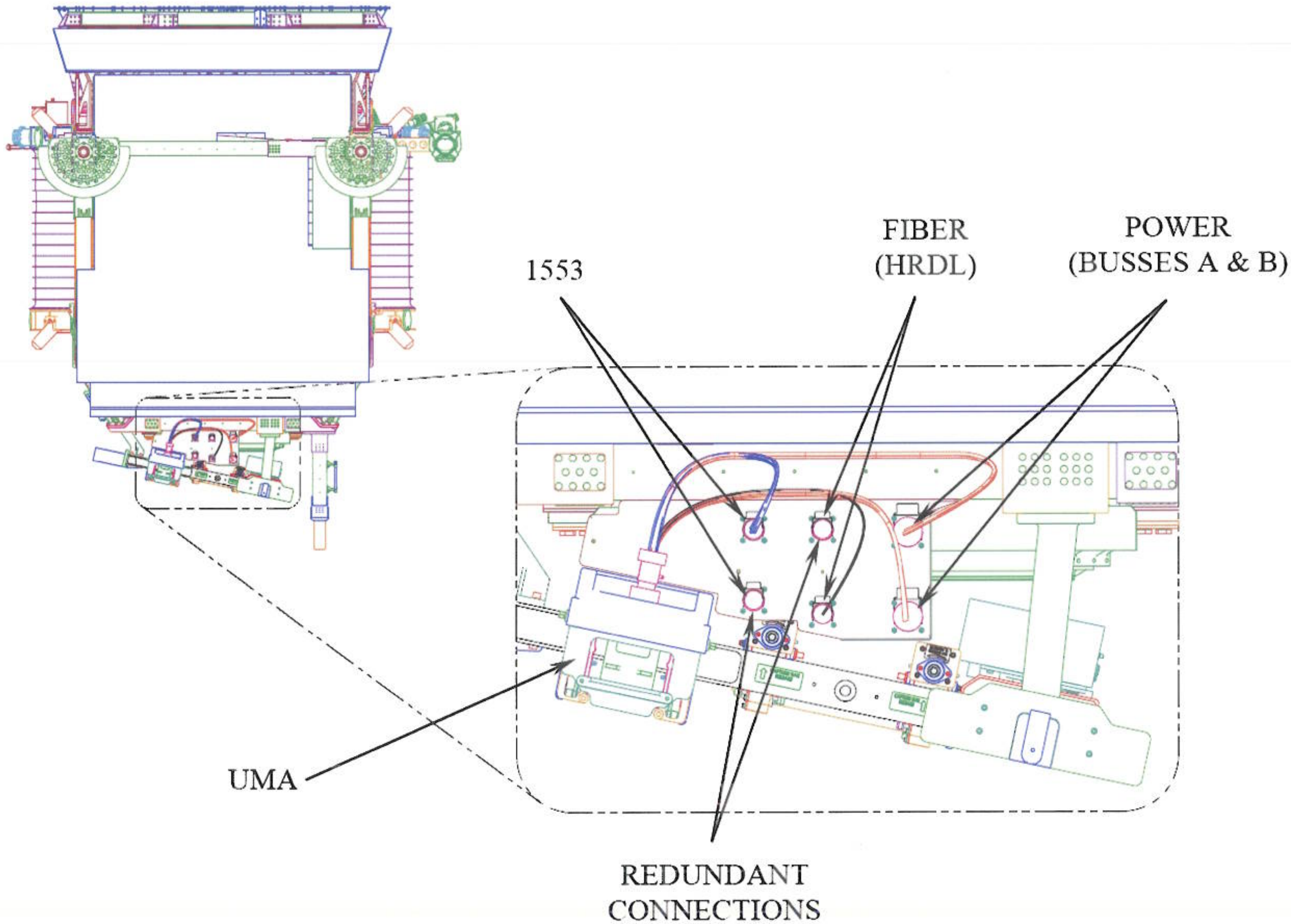
PAS Capture Bar Location



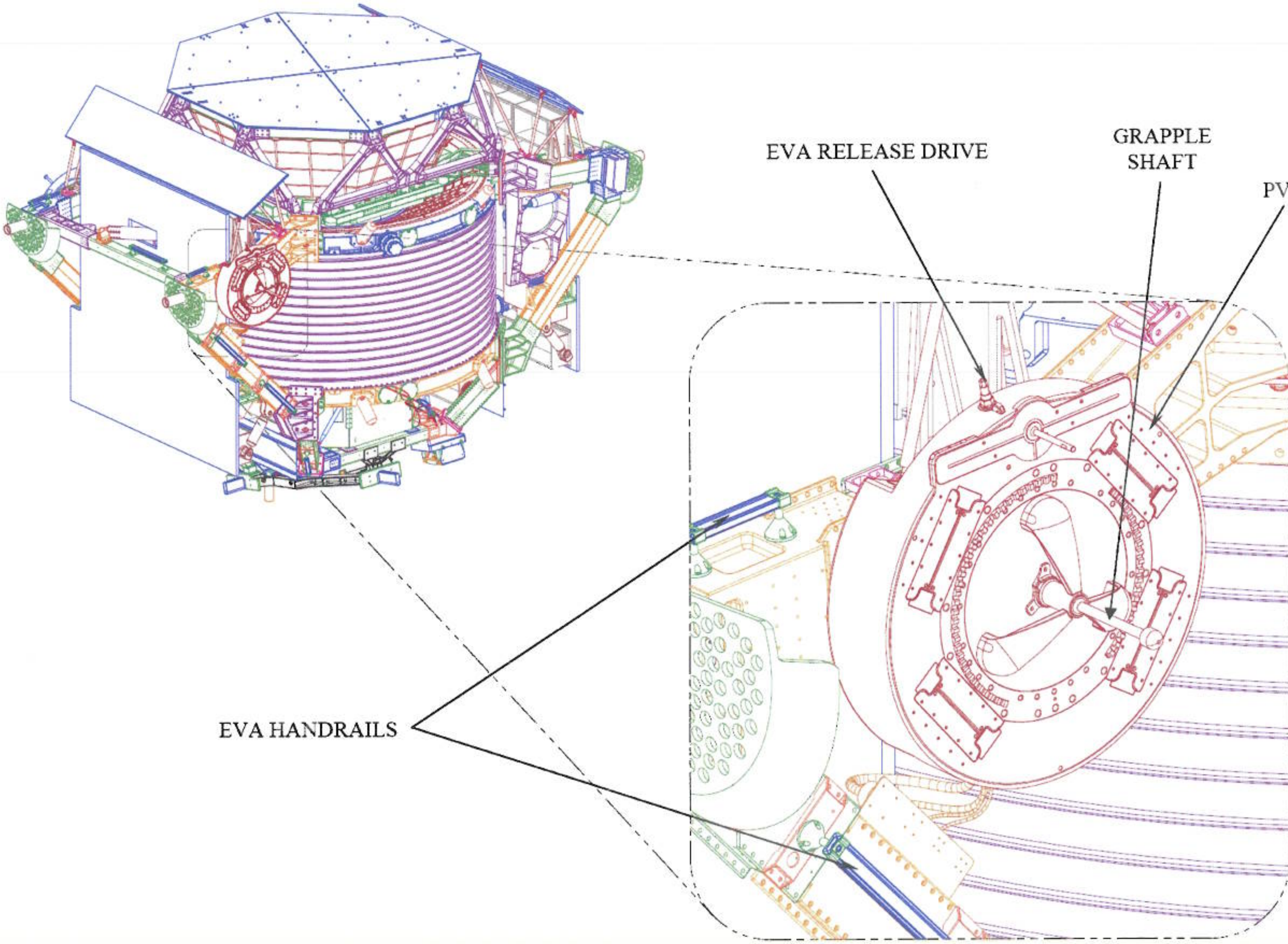
PAS EVA Interface Locations



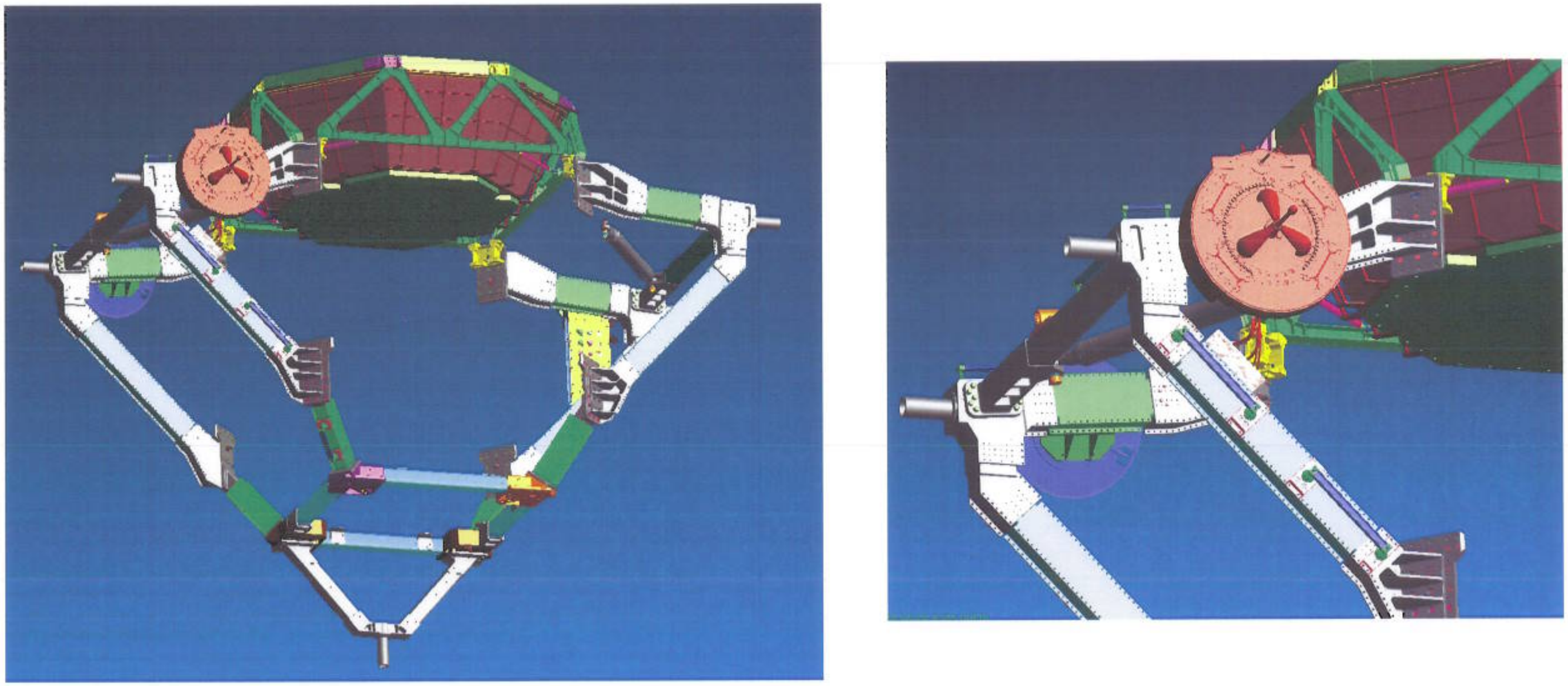
Potential EVA Worksite: AMS-02 EVA Panel, PAS EVA Release Location and UMA Release



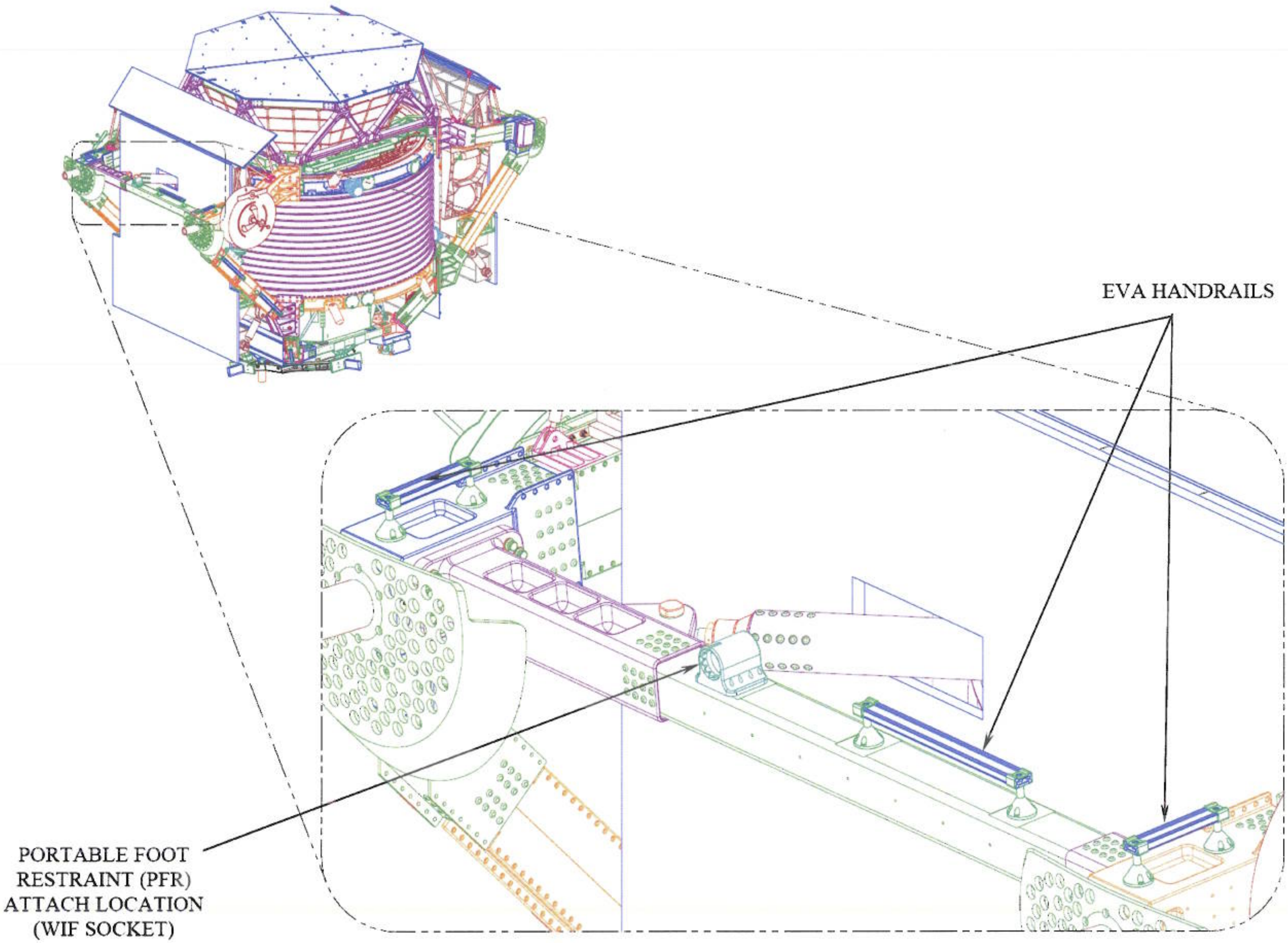
Potential EVA Work Site: AMS-02 Connector Panel and Passive UMA



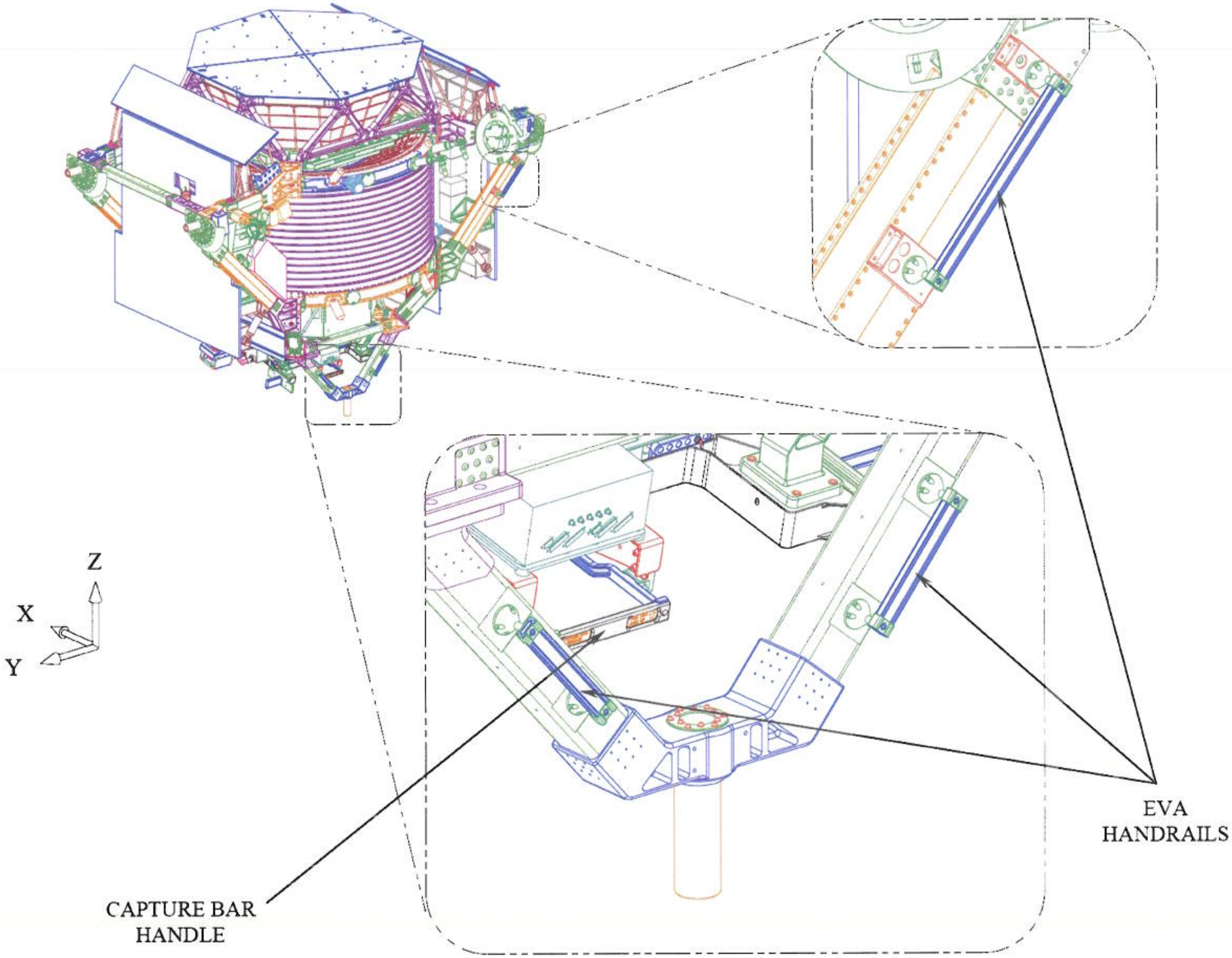
Potential EVA Work Site: Power Video Grapple Fixture (PVGF)



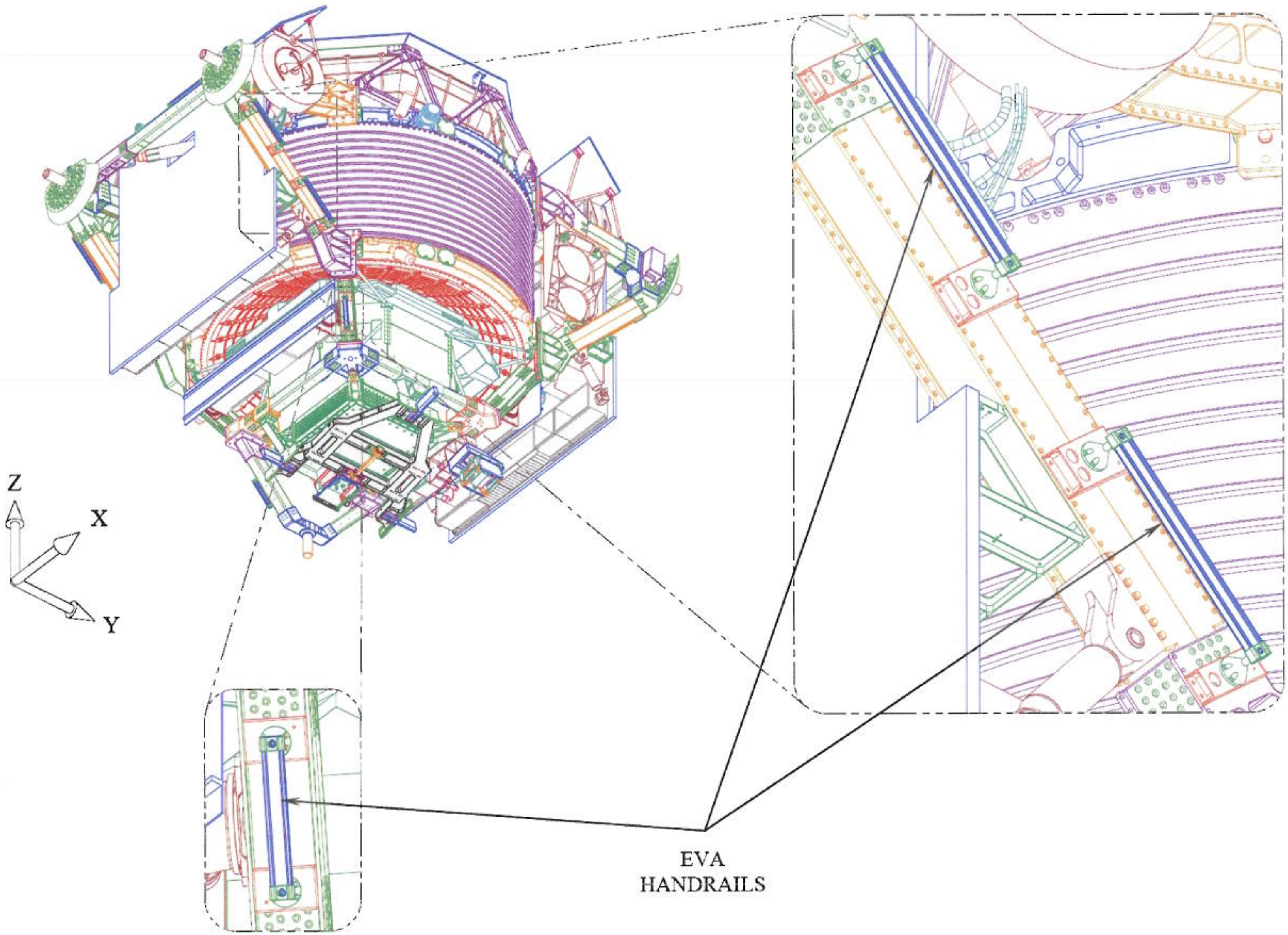
PVGF Area Handrails



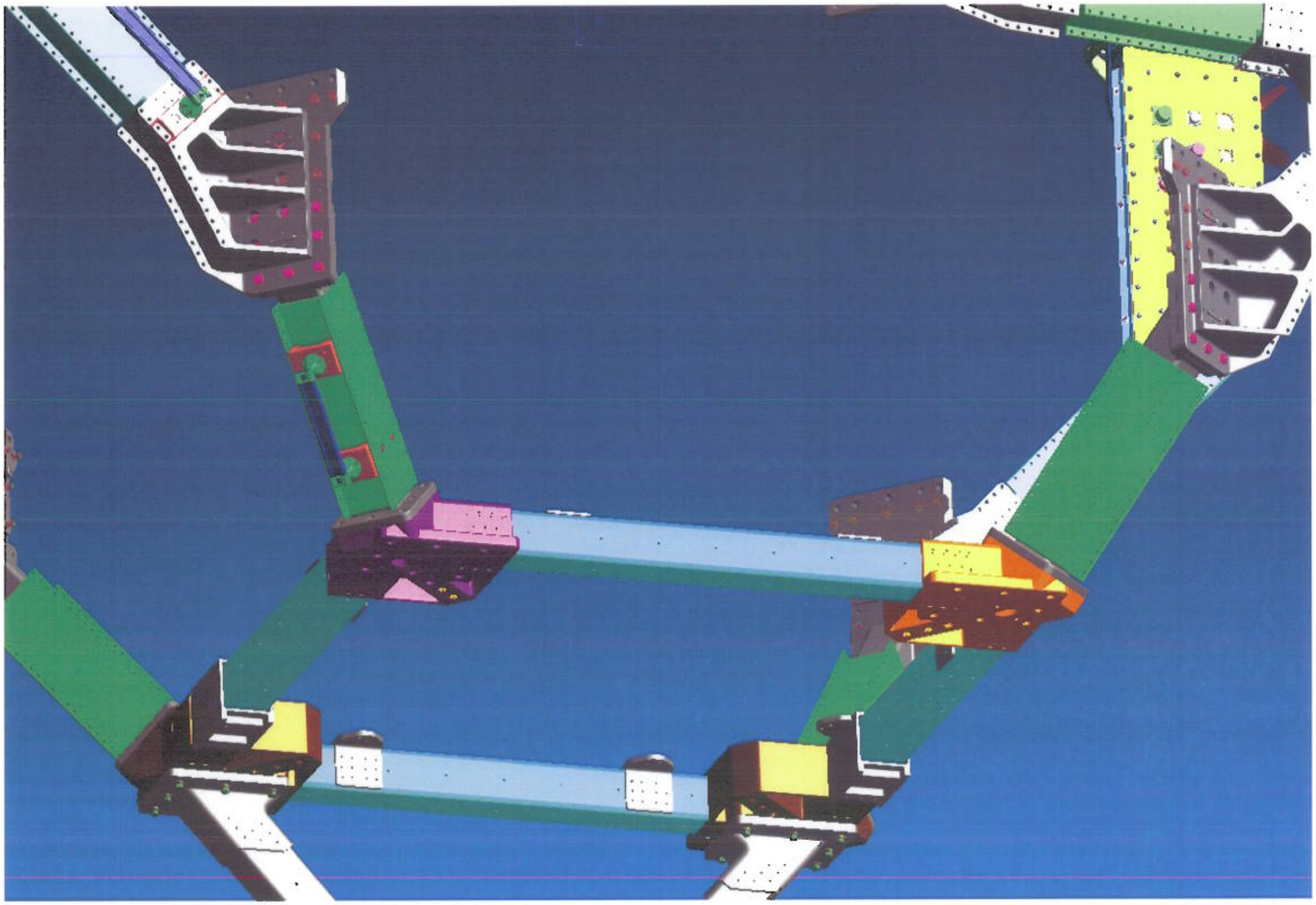
AMS-02 EVA TRANSLATION AID LOCATION



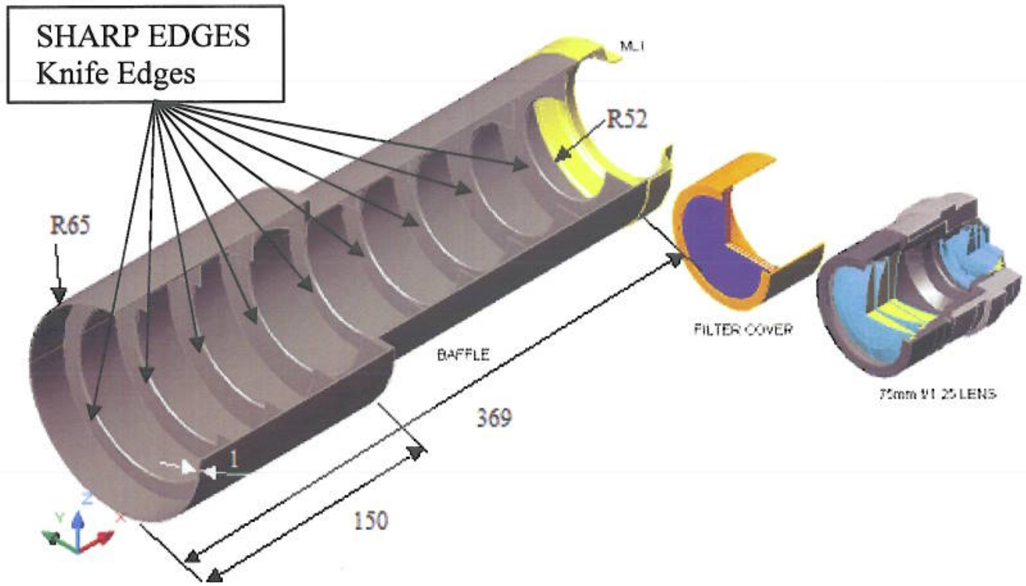
AMS-02 EVA TRANSLATION AID LOCATION



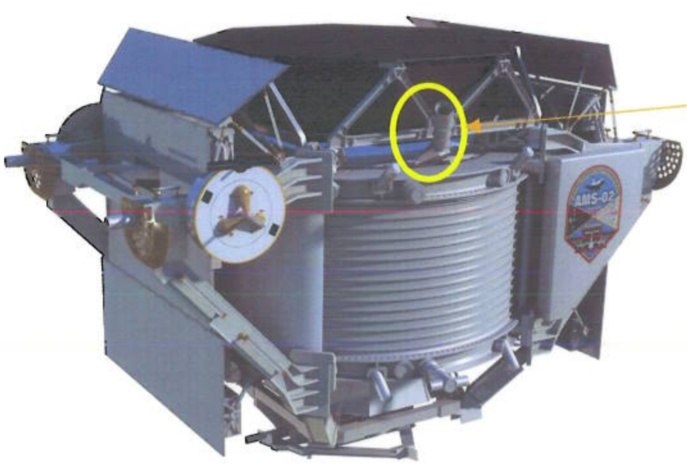
AMS-02 EVA TRANSLATION AID LOCATION



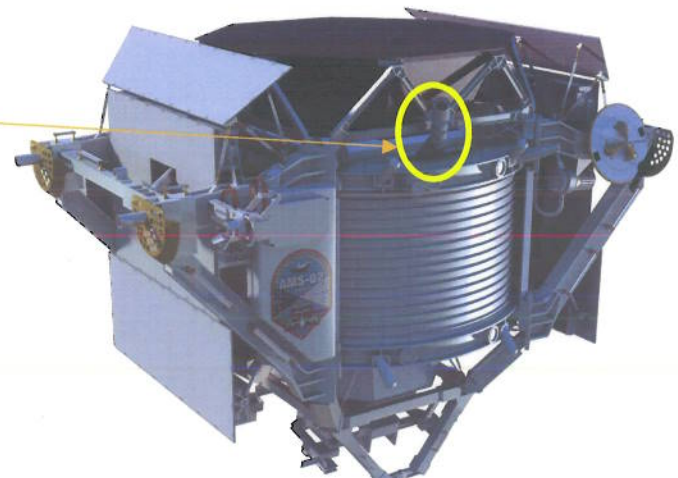
Lower USS-02 Handrail



STAR TRACKER BAFFLE – EVA No Touch Area



STAR Tracker Location,
EVA No Touch Area



TO:	Bob Miley (281) 244-4968
NASA Contact:	Cal Brogdon/OM7 (281) 244-7058
Analyst:	Alicia Mooty/MAGIK Team (281) 483-8491
DATE:	February 27, 2007
RE:	Misalignment Clearances Between AMS and ELC During Berthing, Revision A
CC:	Michael Brown/Boeing, John Cook/Boeing, Trent Martin/EA, Chris Tutt/Jacobs, Paul Nemeth/Jacobs, Gene Cook/OZ, Vic Sanders/Boeing, Stacey Dries/Boeing, AJ Alfonzo/Boeing, Rodney Nabizadeh/OM, Paula Morris/ER, Larry Grissom/ER, Shakeel Razvi/OM, RS Library
PAGES:	10 **Action Item: 2172, Revision A**

Abstract:

The MAGIK Robotic Analysis Team has completed an action to determine the clearances between the Alpha Magnetic Spectrometer – 02 (AMS) payload and the ExPRESS Logistics Carrier (ELC) during the berthing of AMS to the S3 Upper Inboard Payload Attach Site (PAS) and during the berthing of the ELC to the S3 Upper Outboard PAS.

It was determined that the clearances between AMS and the ELC are less than the required 24 inches of clearance, with a minimum clearance during AMS berthing operations of approximately 11 inches and 12 inches during ELC berthing. Note that certain misalignment cases produce contact between the S3 longeron and both the AMS and ELC guide pins.

Revision A updated the minimum clearances between the AMS and the ELC payloads for the ELC berthing to S3 (Part 2), resulting from additional analysis evaluating a 2 degree wobble of the ELC towards the AMS payload during berthing.

Assumptions:

- ISS Flight 19A configuration (based on SSCB Approved Assembly Sequence dated February 22, 2006) was used for the analysis.
- The AMS CAD model used in this analysis was created by the MAGIK Team from a high fidelity model received from the ISS CAD Modeling Team in May, 2003.
- The ELC CAD model used in this analysis was created by the MAGIK Team from a high fidelity model received from Rodney Nabizadeh in October, 2006.
- Pedigree information for pertinent models may be obtained from the MAGIK Team upon request.
- This analysis addresses clearance issues by measuring distances between 3D graphic models. Areas not addressed in this document - lighting, viewing, EVA/EVR tasks, thermal and/or pressure effects on elements, and dynamics - could have a significant influence on the measurements and overall feasibility.

- 3D graphical models used in this analysis are a result of the MAGIK Team's "best efforts" to obtain accurate models reflecting actual volumetric dimensions of the various ISS elements and/or create in the best possible manner an encompassing low fidelity model representative of the hardware and kinematically applicable to MAGIK analyses. Applicability is defined by the probability of interaction with the robotic arm(s), EVA on the arm, or a robotically moved hardware."Best efforts" include obtaining/creating models directly from the ISS CAD Modeling Team, the hardware designers, a 3rd party (a source other than the hardware designers), drawings/information from hardware designer or customer, or the ISS External Cargo Handbook (D684-11233-01). The MAGIK created models are lower fidelity, comparative to the source model, consisting of less detail. For applicable areas, the encompassing shape has a tolerance of +0.5/ -0.1 inch with respect to the source model; meaning the nearest source surface should be no greater than 0.5 inch from the surface on the encompassing shape. Non-applicable areas are modeled to tolerances of +1.5/ -0.1 inch.

Discussion and Results:

A berthing misalignment analysis was performed for two scenarios. Part 1 of this analysis looked at misalignments and resulting clearances for berthing the AMS payload to the S3 Upper Inboard PAS with an ELC on the adjacent S3 Upper Outboard PAS location. Part 2 analyzed the misalignments and clearances for berthing the ELC to the S3 Upper Outboard PAS with the AMS payload on the adjacent S3 Upper Inboard PAS. The misalignment cases evaluated are based on information provided by Michael Brown/Boeing - End to End Berthing Integration Team (EBIT) in MAGIK Action Item 2044.

Figure 1 - Figure 4 show the AMS payload and the ELC both installed on S3 (fully berthed with no misalignments). Table 1 summarizes the clearances between the AMS payload and the ELC payloads with both the AMS and ELC fully berthed with no misalignments and also at 2, 4 and 6 inch interface separation distances with no misalignments.

Table 1: Minimum Clearances Between AMS and ELC Payloads - No Misalignments

Interface Separation Distance (in)	Misalignment Case Wobble, Roll, Lateral Offset (deg, deg, in)	ELC Payload 1	ELC Payload 2	ELC Payload 3	ELC Payload 4	ELC Payload 5	ELC Payload 6
0	0, 0, 0	45	23	16	16	29	45
2	0, 0, 0	45	23	16	16	28	45
4	0, 0, 0	45	23	16	16	28	44
6	0, 0, 0,	43	23	16	16	28	43

The maximum misalignments used in the analysis (2 degrees wobble, 2.5 inches lateral offset, and 5.5 degrees roll) were provided by EBIT/Boeing. This analysis evaluated misalignment cases for separation distances of 2 inches, 4 inches and 6 inches.

Part 1

For Part 1, the AMS payload was misaligned to a set of cases and the clearances between the AMS payload and adjacent hardware, including ISS envelopes, was evaluated. Misalignments were applied about a point located at the center of the bottom of the AMS capture bar.

The minimum distances between the ELC payloads and AMS were found at an interface separation distance of 6 inches and a misalignment case of 2 degrees wobble, 0 degrees roll and -2.5 inches lateral offset, as illustrated in Figure 5. Figure 6 shows the orientation of the ELC payloads on the side adjacent to AMS when installed on S3. This produced the minimum clearance for all payloads simultaneously. The minimum clearances for this case, as well as additional cases producing the same minimum clearances, are noted in Table 2.

Table 2: Minimum Clearances Between AMS and ELC Payloads During AMS Berthing

Interface Separation Distance (in)	Misalignment Case Wobble, Roll, Lateral Offset (deg, deg, in)	ELC Payload 1	ELC Payload 2	ELC Payload 3	ELC Payload 4	ELC Payload 5	ELC Payload 6
6	2, 0, -2.5	36	17	11	11	22	36
6	2, 2, -1.5	37	17	12	13	24	38
4	2, 0. -2.5	37	17	11	11	23	37
4	2, 2. -1.5	37	17	12	13	24	38

Note that several of the cases analyzed produced contact (or clearances of less than an inch) between the AMS guide pin and the S3 longeron.

Clearances between AMS and the following ISS hardware (or envelopes) were also found to be less than the required 24 inches:

- -S1 Outboard Upper Camera Sweep Envelope (Camera Port (CP) 2)*
  - Minimum clearance = Contact
  - (Fully berthed with no misalignments and several other cases)
- -Floating Potential Measurement Unit (FPMU) installed at CP2*
  - Minimum clearance – 14 inches
  - (No misalignments – fully berthed and at 2 inch interface separation distance)
- -AMS to S1 Thermal Control System Radiator Sweep Envelope
  - Minimum clearance – 20 inches
  - (Fully berthed with no misalignments)
- -AMS to S1 Bulkhead
  - Minimum clearance = 16 inches
  - (Fully berthed with no misalignments and several other cases)
- -AMS to S3 Grapple Fixture
  - Minimum clearance = 18 inches
  - (Fully berthed with no misalignments and several other cases)

** CP2 should remain vacant if AMS is installed on the S3 Upper Inboard PAS according to the ISS Configuration Document, SSP 50504, Revision C.*

A.14-36

Part 2

For Part 2, the ELC was misaligned to a set of cases and the clearances between the ELC and adjacent hardware, including AMS and ISS envelopes, was evaluated. Misalignments were applied about a point located at the center of the bottom of the ELC capture bar. **Revision A added cases to evaluate a wobble of 2 degrees in the direction of the AMS payload.**

The minimum clearances between the ELC payloads and AMS, and their corresponding misalignment cases, are noted in Table 3. Figure 7 illustrates a misalignment case of 6 inch interface separation distance, 2 degrees wobble (away from AMS), 0 degrees roll and 2.5 inches lateral offset. Figure 8 and Figure 9 **illustrate a misalignment case of 4 inch interface separation distance, -2 degrees wobble (towards AMS), 0 degrees roll and 2.5 inches lateral offset.**

Table 3: Minimum Clearances Between AMS and ELC Payloads During AMS Berthing

Interface Separation Distance (in)	Misalignment Case Wobble, Roll, Lateral Offset (deg, deg, in)	ELC Payload 1	ELC Payload 2	ELC Payload 3	ELC Payload 4	ELC Payload 5	ELC Payload 6
0	0, 0, 0	45	23	16	16	28	45
2	0, 0, 0	46	23	16	16	29	46
2	2, 1, -0.5	53	27	18	17	17	52
4	0, 0, 0	47	23	16	16	29	47
4	2, 0, 2.5	50	24	15	15	30	50
4	2, 5.5, 0	55	29	20	15	30	51
4	2, -5.5, 0	51	24	15	20	35	55
4	2, 2, 1.5	52	26	17	15	30	51
4	2, -2, 1.5	51	24	15	17	32	52
6	0, 0, 0.	48	23	16	16	29	48
6	2, 0, 2.5	51	24	15	15	30	51
6	2, 5.5, 0	56	39	20	15	30	51
6	2, -5.5, 0	51	24	15	20	35	56
6	2, 2, 1.5	53	26	17	15	30	51
6	2, -2, 1.5	51	24	15	17	32	53
4	-2, 0, 2.5	39	17	11	11	23	39
4	-2, 5.5, 0	44	23	17	11	23	39
4	-2, -5.5, 0	39	16	11	17	28	44
4	-2, 2, 1.5	41	19	13	12	23	39
4	-2, -2, 1.5	39	17	12	13	24	41
6	-2, 0, 2.5	40	17	12	12	23	40
6	-2, 5.5, 0	45	23	17	11	23	40
6	-2, -5.5, 0	40	17	11	17	28	45
6	-2, 2, 1.5	42	19	13	12	23	40

Note that several of the cases analyzed produced contact (or clearances of less than an inch) between the ELC guide pin and the S3 longeron.

Clearances between the ELC hardware and the following ISS hardware were also found to be less than the required 24 inches:

-ELC Power and Video Grapple Fixture (PVGF) #2 to S3
  Minimum clearance = 10 inches
  (Fully berthed with no misalignments)

-ELC Deck to S3
  Minimum clearance = 13 inches
  (Fully berthed with no misalignments)

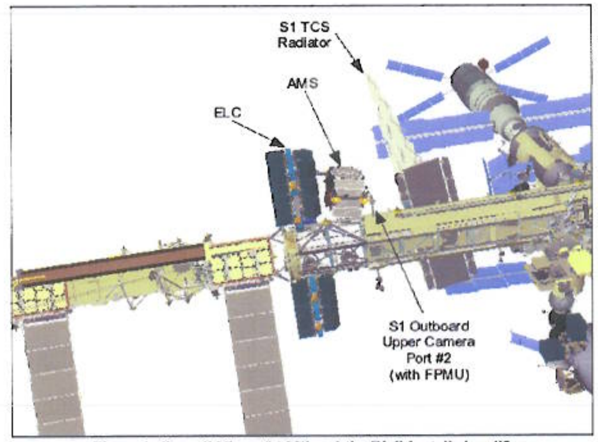


Figure 1: Overall View of AMS and the ELC Installed on S3
(Both Fully Berthed, No Misalignments)
View Looking ISS Aft, Port and Nadir

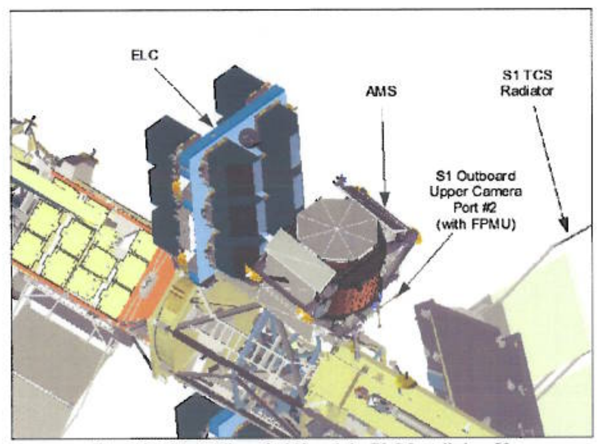


Figure 2: Overall View of AMS and the ELC Installed on S3
(Both Fully Berthed, No Misalignments)
View Looking ISS Aft, Starboard and Nadir

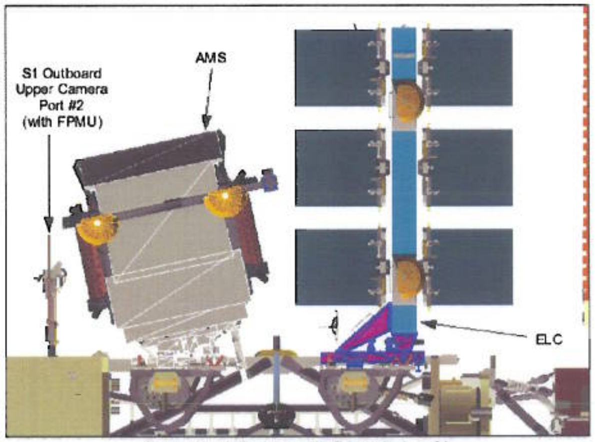


Figure 3: AMS and the ELC Installed on S3
(Both Fully Berthed, No Misalignments)
View Looking ISS Forward

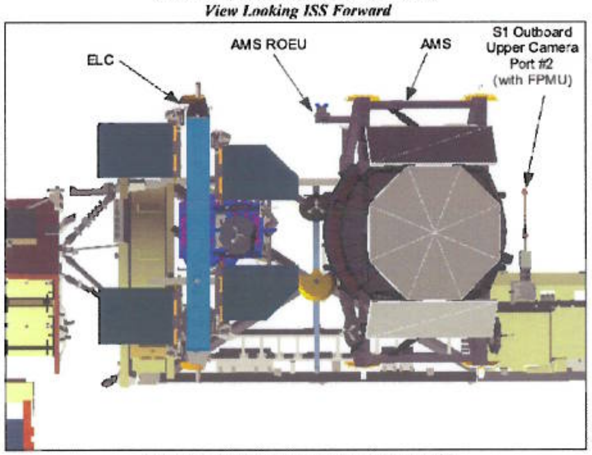


Figure 4: AMS and the ELC Installed on S3
(Both Fully Berthed, No Misalignments)
View Looking ISS Nadir
View Clipped for Clarity

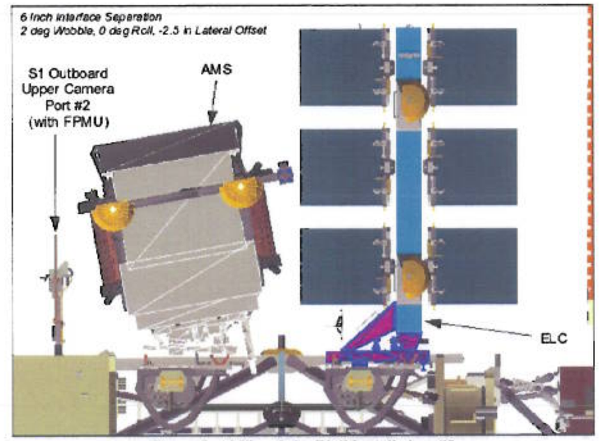


Figure 5: AMS and the ELC Installed on S3
(AMS Misaligned, ELC Fully Berthed with No Misalignments)
View Looking ISS Forward

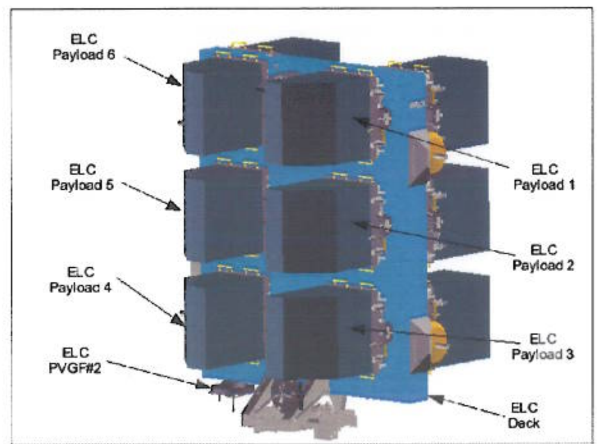


Figure 6: Orientation of ELC Payloads on ELC

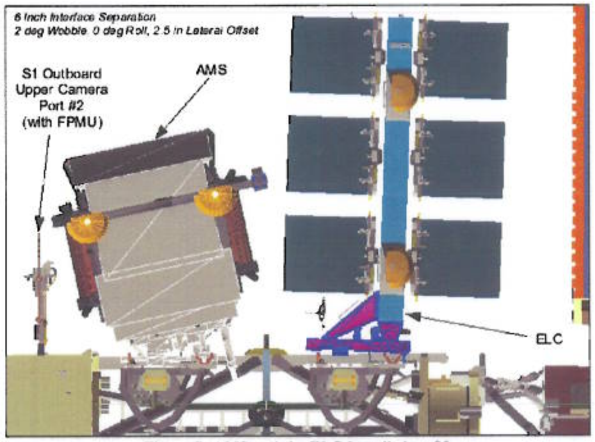


Figure 7: AMS and the ELC Installed on S3
(AMS Fully Berthed with No Misalignments, ELC Misaligned)
View Looking ISS Forward

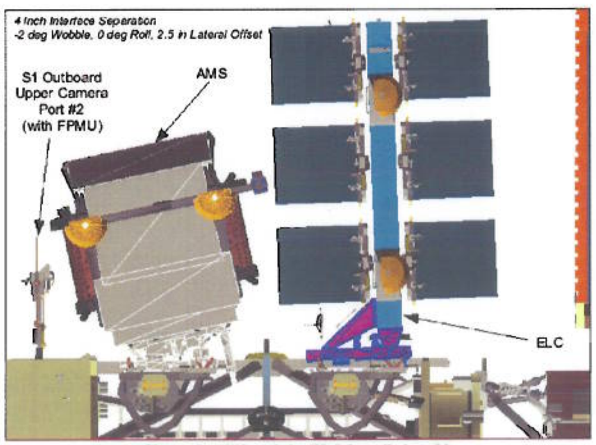


Figure 8: AMS and the ELC Installed on S3
(AMS Fully Berthed with No Misalignments, ELC Misaligned)
View Looking ISS Forward

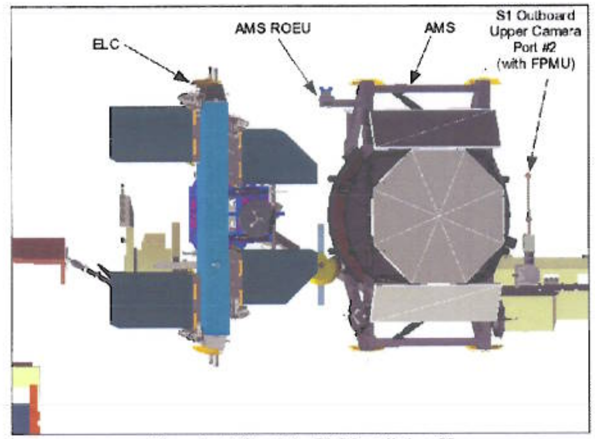


Figure 9: AMS and the ELC Installed on S3
(AMS Fully Berthed with No Misalignments, ELC Misaligned)
View Looking ISS Nadir
View Clipped for Clarity

Safety Noncompliance Report

Date: 12/10/08

NCR NUMBER: AMS-02-NCR-001

FLIGHT EFECTIVITY: non-flight specific EXPIRATION DATE: n/a

ORIGINATOR: *(Organization/Company)* JSC-EA3/AMS-02 Project Manager/Trent Martin

TITLE: AMS-02 Payload EVA Touch Temperature

END ITEM IDENTIFICATION: *(Include reference to applicable end item, subsystem, and/or component)*
Alpha Magnetic Spectrometer-02 (AMS-02) Payload

APPLICABLE REQUIREMENT:
NSTS 1700.7B ISS Addendum

217 Extravehicular Activity (EVA)

200.3 Environmental Compatibility. (See Note Below)

NOTE: Reference below for specific EVA contact temperature values consistent with NSTS 07700 Volume XIV, Appendix 7 and SSP 57003

SSP 57003, 3.11.5.14.1 INCIDENTAL CONTACT

For incidental contact, temperature shall be mintained within -180 to +235 degrees Fahrenheit or limited heat transfer rates as listed in Table 3.11.5.14.1-1 [per SSP 41162, paragraph 3.3.6.12.2.1]

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. [per SSP 41162, paragraph 3.3.6.12.2.2]

DESCRIPTION OF NONCOMPLIANCE: (Specify how the design or operation does not meet the safety requirements.)
A worst case thermal analysis of AMS payload shows a Debris Shield reaching -183 degrees F (violating Incidental contact temperatures and heat rates), a Flight Releasable Grapple Fixture (FRGF) reaching 258 degrees F (violating Unlimited contact temperature and heat rates) and an EVA Connector Panel reaching 174 degrees F (violating Unlimited contact temperature and heat rates). See attached memo.

REASON REQUIREMENT CANNOT BE FULFILLED:
Because of the induced thermal environment and hardware material, the hardware cannot remain within temperature limits or allowable heat rates for all ISS attitudes.

RATIONALE FOR ACCEPTANCE: (Define the design feature or procedure used to conclude that the noncompliance condition is safe. Attach applicable *support data, i.e. drawings, test reports, analyses, etc.)*
The hardware does meet the requirements of JSC 28918, "EVA Design Requirements and Consideration" for incidental contact and poses no risks to EVA suit or crewmember. Analysis of the EVA connector panel shows a high pressure grasp time of 4 minutes

JSC Form 542C (Rev September 13, 2007) (MS Word May 97) *and a 1-psi grasp time of 9.55 minutes. This should be ample time to perform the contigency EVA of swapping connectors. The connector panel does not need to be touched or held continuosly during this operation. Similarly, the FRGF shows high pressure grasp time of 2 minutes and 1-psi grasp time of 3.25 minutes. This should also be sufficient for the FRGF contigency EVA. All temperatures are enveloped by NCR-EVA-XA002.*

SIGNATURES			
SUBMITTED BY:			
AUTHOR TRENT MARTIN			DATE 12/10/08
PROGRAM MANAGER OF SUBMITTING ORGANIZATION OR GFE PROJECT MANAGER			DATE
CONCURRENCE			
AFFECTED AIT-SPRT-FIT	DATE	FLIGHT EQUIPMENT SAFETY AND RELIABILTY REVIEW PANEL (FESRRP)	DATE
AFFECTED AIT SPRT-FIT	DATE	Michael R. Suh SAFETY REVIEW PANEL (SRP/PSRP)	DATE 1/6/2009
ISS S&MA PANEL	DATE	SHUTTLE S&MA PANEL	DATE
APPROVAL			
ISS CHIEF S&MA OFFICER	DATE	SHUTTLE CHIEF S&MA OFFICER	DATE
ISS INDEPENDENT TECHNICAL AUTHORITY	DATE	SHUTTLE INDEPENDENT TECHNICAL AUTHORITY	DATE
ISS PROGRAM MANAGER	DATE	SHUTTLE PROGRAM MANAGER	DATE

* Approved as Equivalent Safety.

JSC Form 542C (Rev September 13, 2007) (MS Word May 97)

Engineering and Science Contract Group
2224 Bay Area Boulevard
Houston, Texas 77058

ESCG-4470-07-TEAN-DOC-0033-B
July 28, 2008

To:	J. C. Tutt	ESCG
Via:	J. L. Cox	ESCG
Reviewed by:	A. H. Milliken	ESCG
From:	E. L. Yagoda	ESCG
Revised by:	C. S. Clark	ESCG

Subject: **Alpha Magnetic Spectrometer (AMS-02) EVA Touch Temperature Evaluation**

Note: This document was revised to correct typos in a referenced document and transposed results in the Conclusions section.

1.0 Summary

This report presents an Extra Vehicular Activity (EVA) touch temperature evaluation of the Alpha Magnetic Spectrometer (AMS-02). EVA interfaces that were designed to be touched by the EVA Mobility Unit (EMU) include the handrails, the Flight Releasable Grapple Fixture (FRGF), the Power and Video Grapple Fixture (PVGF), the EVA connector panel, and the Remotely Operated Electrical Umbilical (ROEU). In addition to the EVA interfaces, an addition investigation was done in order to determine if any of the external portions of the payload that can be touched or bumped during EVA operations exceeds the incidental contact limits.

Craig S. Clark
Thermal and Environmental Analysis Section
Engineering and Science Contract Group

2.0 Introduction

The AMS-02 is a large external attached payload that will be mounted to the International Space Station (ISS) S3 truss payload attach site. There are no planned EVAs associated with the AMS-02 but there are several contingency EVAs while attached to the ISS that must be considered. Requirements for the AMS-02 are defined in SSP 57003 [1].

3.0 Environmental Survey

Extensive analysis has been performed to determine extreme temperatures for the AMS-02 while it is mounted to the ISS. Results were calculated considering the entire range of solar beta angles (-75 to +75°) as well as the range of possible ISS attitudes. These cases were further analyzed assuming extreme hot or cold natural environments.

This data was used to find temperature extremes for all EVA interfaces. For cold temperatures it was also assumed that the payload would be powered off with heaters disabled for 20 hours. The results of this survey are shown in Table 1. Note that only the hottest and coldest handrails are included.

Table 1: Environmental Survey Results

Component Description	Attitude	Beta Angle	Submodel	Node Number	Max/Min Temp °F	Results
Handrails	-15+25-15	b-75c	HANDRL	1033	-78.4	Cold
	+00-20-15	b+75h	HANDRL	1013	182.6	Hot
Grapple Fixture	+00+00+15	b+00c	FRGF3	8	-75.4	Cold
	+15+00+00	b-75h	FRGF3	3	258.3	Hot
Grapple Fixture	-15+00-15	b-75c	PVGF	7	-72.5	Cold
	+00-20-15	b+75h	PVGF	8	221.5	Hot
Connector Panel	-15-20-15	b+00c	USS02	53100	-6.7	Cold
	-15+00-15	b-75h	USS02	53100	173.6	Hot
ROEU Clevis	-15-20+15	b+75c	ROEU	10	-61.0	Cold
	-15+25+15	b-75h	ROEU	10	154.2	Hot
ROEU Mount Brkt	-15-20+15	b+75c	ROEU	20	-68.3	Cold
	-15+25+15	b-75h	ROEU	20	134.0	Hot
ROEU PDA	-15-20+15	b+75c	ROEU	50	-59.1	Cold
	-15+25+15	b-75h	ROEU	50	111.8	Hot
ROEU Pin	-15-20+15	b+75c	ROEU	102	-62.5	Cold
	-15+25+15	b-75h	ROEU	102	120.7	Hot

4.0 EVA Touch Temperature Evaluation

An EVA touch temperature evaluation was performed using the methods outlined in SSP 57003 [1]. This document dictates that for unlimited contact with designated crew interfaces, temperatures shall be maintained within -45 to +145°F or heat transfer rates be limited as specified in Table 2. For incidental contact, temperatures shall be maintained within -180 to +235°F or heat transfer rates be limited as specified in Table 2.

Table 2: Heat Transfer Rates [1]

Object Temperatures	Contact Duration (minutes)	Boundary Node Temperatures (°F)	Linear Conductor (BTU/hr.°F)	Maximum Avg Heat Rate (BTU/hr)
Hot Object	Unlimited Incidental (0.5 max)	113 113	1.149 1.444	45.52 (2) 176.2 (3)
Cold Object	Unlimited Incidental (0.5 max)	-40 -40	1.062 1.478	±132.7 (2) ±325.2 (3)

Notes:
(1) Positive denotes heat out of object, negative denotes heat into object.
(2) Averaged over 30 minutes of simulated contact.
(3) Averaged over 2 minutes of simulated contact.

If the touch temperature analysis fails to satisfy the above requirements, it is recommended that the EMU grasp limits outlined in JSC 28918 [2] be used to justify a waiver. This document dictates that for unlimited contact, EVA hardware temperatures shall be maintained between -80 to +150°F. If a particular component falls outside of these grasp limits, a heat rate analysis must be performed to ensure that the heat rate of any object does not exceed the maximum allowable average heat rates in Table 3. If any component fails to meet this criteria, grasp time limits are determined by the phase VI EMU glove palm limits which allow for a short duration grasp time for both "high pressure" and 1 PSI grasps [3]. Hardware that could be inadvertently touched by brushing or bumping during EVA shall be maintained within -244 to +320°F [2].

Table 3: 30 Minute Touch Temperature Heat Transfer Compliance [2]

Object Temperature (°F) Before Contact	Contact Duration (minutes)	Boundary Node Temperatures (°F)	Linear Conductance (BTU/hr.in^2.°F)	Maximum Avg Heat Rate (BTU/hr.in^2)
Greater Than 150	30	101	0.0033	0.205
Less Than -80	30	75	0.0033	-0.583

5.0 EVA Touch Temperature Results

Table 4 shows the results of the heat rate analysis for the method described in SSP 57003 [1]. All items passed this analysis with the exception of the FRGF and the EVA connector panel in the hot case. Table 5 shows that these two objects also fail the heat rate analysis of JSC 28918 [2]. The two right hand columns in Table 5 show the grasp times for these two items, per the phase VI EMU glove palm limits [3].

Table 4: Touch Temperature Results - Reference 1 Method

Component Description	Submodel	Node Number	Max/Min Temp °F	Unlimited Contact Analysis Required	Avg Heat Rate (BTU/hr)	Pass/Fail	Incidental Contact Analysis Required	Avg Heat Rate (BTU/hr)	Pass/Fail
Handrails	HANDRL	1033	-78.4	Yes	-53.5	P	No	NA	NA
	HANDRL	1013	182.6	Yes	41.6	P	No	NA	NA
Grapple Fixture	FRGF3	8	-75.4	Yes	-40.5	P	No	NA	NA
	FRGF3	3	258.3	Yes	46.9	F	Yes	163.6	P
Grapple Fixture	PVGF	7	-72.5	Yes	-40.5	P	No	NA	NA
	PVGF	8	221.5	Yes	34.3	P	No	NA	NA
Connector Panel	USS02	53100	-6.7	No	NA	NA	No	NA	NA
	USS02	53100	173.6	Yes	63.7	F	No	NA	NA
ROEU Clevis	ROEU	10	-61.0	Yes	-91.3	P	No	NA	NA
	ROEU	10	154.2	Yes	42.0	P	No	NA	NA
ROEU Mount Brkt	ROEU	20	-68.3	Yes	-101.2	P	No	NA	NA
	ROEU	20	134.0	No	NA	NA	No	NA	NA
ROEU PDA	ROEU	50	-59.1	Yes	-88.0	P	No	NA	NA
	ROEU	50	111.8	No	NA	NA	No	NA	NA
ROEU Pin	ROEU	102	-62.5	Yes	31.0	P	No	NA	NA
	ROEU	102	120.7	No	NA	NA	No	NA	NA

Table 5: Touch Temperature Results - Reference 2 & 3 Method

Component Description	Submodel	Node Number	Max/Min Temp °F	Contact Analysis Required	Avg Heat Rate (BTU/hr-in^2)	Pass/Fail	High PSI Grasp Time Limit (minutes)	1 PSI Grasp Time Limit (minutes)
Grapple Fixture	FRGF3	3	258.3	Yes	0.41	F	2.00	3.25
Connector Panel	USS02	53100	173.6	Yes	0.24	F	4.00	9.50

6.0 Incidental Touch Temperature Survey

A survey was done of all external surfaces (excluding soft goods) that can be inadvertently touched by brushing or bumping during an EVA operation. This survey was conducted for all surfaces at all attitudes and beta angles. The results of this survey indicated that a debris shield, node 60211, in the USS02 submodel reached a minimum temperature of -183°F. This temperature is outside the minimum incidental contact temperature stated in SSP 57003 [1] but is within the acceptable limits of those stated in JSC 28918 [2].

7.0 Conclusions

A touch temperature thermal evaluation of the AMS-02 was performed. EVA interfaces that were evaluated include the handrails, grapple fixtures, the EVA connector panel, and the ROEU. The results of this analysis showed that all the components passed touch temperature requirements as stated in SSP 57003 [1] with the exception of the EVA connector panel and the FRGF. Further analysis as described in References [2] and [3] result in an allowable high pressure and 1 PSI grasp times of 4.00 and 9.50 minutes respectively for the EVA connector panel. Similarly, the allowable high pressure and 1 PSI grasp times are 2.00 and 3.25 minutes respectively for the FRGF. The investigation to determine if any of the external portions of the hardware that can be touched or bumped during EVA operations exceeds the incidental contact limits revealed that the debris shield, reached a minimum temperature of -183°F. This temperature is outside the minimum incidental contact temperature stated in SSP 57003 [1] but is within the acceptable limits of those stated in JSC 28918 [2]. It is recommended that based on these results, a waiver be processed for these items.

References

1) "Attached Payload Interface Requirements Document", SSP 57003, Rev.C, NASA- Johnson Space Center, July 2006.
2) "EVA Design Requirements and Considerations", JSC 28918, NASA – Johnson Space Center, February 2005.
3) Bue, G., "EMU ISS EVA Thermal Environment Requirements for Certification", JSC 39117, NASA-JSC, May 2004.

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