PAYLOAD FLIGHT HAZARD REPORT

a. NO:	AMS-02-F11
b. PAYLOAD	Alpha Magnetic Spectrometer-02 (AMS-02)
c. PHASE:	III
d. SUBSYSTEM:	Structural, Mechanical
e. HAZARD GROUP:	Impact, Collision
f. DATE:	August 4, 2010
g. HAZARD TITLE:	Mechanism Failure
i. HAZARD CATEGORY:	CATASTROPHIC X CRITICAL X
h. APPLICABLE SAFETY REQUIREMENTS:	NSTS 1700.7B and ISS Addendum, 200.1b, 200.2, 200.3
j. DESCRIPTION OF HAZARD:	Failure of these mechanisms could place the AMS-02 in conditions that pose a risk of inadequate structural load conditions or damage to vehicle systems. The AMS-02 is complying with ICD requirements for Shuttle and ISS interfaces and is subject to integrated hazard analyses performed by the applicable Programs.

k. CAUSES

(list)

1. Inability to Open/Close Orbiter Payload Retention Latch Assembly (PRLA)/ Keel Latch.
2. Inability to Operate the ROEU. (Critical Only)
3. Improper Installation of Grapple Fixtures.
4. Inability to fully capture/release the Payload Attach System, including the UMA.
5. Inadvertent release of Payload Attach System EVA Release Mechanism.
6. Inability to Secure ROEU Support Structure.

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

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l. HAZARD CONTROL (CONTROL), m. SAFETY VERIFICATION METHODS (SVM), n. STATUS OF VERIFICATIONS (STATUS)	OPS CONTROL
1. CAUSE: Inability to Open/Close Orbiter Payload Retention Latch Assembly (PRLA).	
1.1 CONTROL: The AMS-02 interface to the PRLAs, the Trunnions, Scuff Plates and keel pin are constructed and installed in accordance with NSTS 21000-IDD-ISS. Trunnions and keel pin are constructed of custom 455 stainless steel and the scuff plates are constructed of aluminum 7050. Integrated hazard analysis to be performed by Shuttle Program to establish fault tolerance of integrated cargo to establish secured PRLA conditions for a contingency return or assure that a complete release of the AMS-02. 1.1.1 SVM: Review of design 1.1.2 SVM: Inspection of as built hardware 1.1.3 SVM: AMS-02 Installation into Orbiter 1.1.1 STATUS: Closed. Memorandum ESCG-4390-06-SP-MEMO-0008, "USS-02 Trunnion Interfaces," dated 13 March 2006, AMS-02 Chief Engineer Chris Tutt. 1.1.2 STATUS: Closed to SVTL. 1.1.3 STATUS: Closed to SVTL.	
1.2 CONTROL: In the event that one or more Orbiter PRLA is unable to open during the AMS-02 deploy sequence, the AMS-02 is designed to be compatible with an unscheduled EVA to open/close the PRLAs. AMS-02 hazard report AMS-02-F14 indicates the constraints to EVA activities; none of these no touch areas/keep out zones will impact the ability of the crew to access the PRLAs for EVA operations. The unscheduled EVA to open/close PRLA is a standardized EVA operation for the Shuttle, no unique operations are required for the AMS-02. 1.2.1 SVM: Review of design. 1.2.2 SVM: Inspection of as built hardware. 1.2.1 STATUS: Closed. ESCG Memorandum 4295-09-CPAS-MEMO-0006, "AMS-02 EVA Access," dated October 8, 2009. 1.2.2 STATUS: Closed to SVTL.	
1.3 CONTROL: The AMS-02 is safe to return only with all PRLAs and the Active Keel (latch) Assembly closed. 1.3.1 SVM: Structural Analysis to confirm safe return configuration of PRLA and KEEL latches.	S

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1.3.2 SVM: Formal acceptance of safety criteria for safety return configuration by MOD by way of OCAD acceptance. (OCAD 67866) 1.3.1 STATUS: Closed. ESCG-4005-05-AMS-0039, "Strength and Stability Assessment of the Alpha Magnetic Spectrometer-02 (AMS-02) Unique Support Structure (USS-02), Vacuum Case, Payload Attach System (PAS), and STS and ISS Integration Hardware," August 12, 2009 1.3.2 STATUS: Closed. OCAD Closure reported to AMS-02 Project on 6/4/2010 by JSC-DA8/B. O'Keeffe.	
NOTE: Nominal generic flight rules for PRLA/AKA operations (A10-281) are all applicable for the AMS-02.	
2. CAUSE: Inability to Operate the ROEU. (Critical Only)	
2.1 CONTROL: In the event that the ROEU fails to separate, the AMS-02 can provide access and all required EVA interfaces to support an unscheduled EVA to access the ROEU EVA interfaces to either disengage or reengage the ROEU. 2.1.1 SVM: Review of Design. 2.1.2 SVM: Inspection of as built hardware. 2.1.1 STATUS: Closed. ESCG Memorandum 4295-09-CPAS-MEMO-0006, "AMS-02 EVA Access," dated October 8, 2009. 2.1.2 STATUS: Closed to SVTL.	
2.2 CONTROL: The inability to reattach the ROEU will not create a scenario where a hazardous condition will exist for the AMS-02 or the Orbiter, however there is a damage potential for AMS-02 scientific hardware that will preclude its reuse (Mission Success Only). If possible the use of an unscheduled EVA to reattach the ROEU is encouraged, but not required. 2.2.1 SVM: Review of design to confirm no safety impact to loss of power and communication for return configuration. 2.2.1 STATUS: Closed. ESCG Memorandum ESCG-4175-09-REENTES-MEMO-0022, "AMS-02 Potential Abort Landing Configurations," dated April 28, 2009	
2.3 CONTROL: The design and installation of the AMS-02 passive half of the ROEU is compatible with the requirements of NSTS 21000-IDD-ISS for interface, alignment, strength and deflection. 2.3.1 SVM: Review of design. 2.3.2 SVM: Inspection of as built hardware.	

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2.3.3 SVM: Structural Analysis.

2.3.1 STATUS: Closed. ESCG Memorandum ESCG-4175-09-REENTES-MEMO-0019, "Review of the AMS-02 ROEU Bracket Design," Dated April 24, 2009

2.3.2 STATUS: Closed to SVTL.

2.3.3 STATUS: Closed. ESCG-4005-05-AMS-0039, "Strength and Stability Assessment of the Alpha Magnetic Spectrometer-02 (AMS-02) Unique Support Structure (USS-02), Vacuum Case, Payload Attach System (PAS), and STS and ISS Integration Hardware," August 12, 2009

3. CAUSE: Improper Installation of Grapple Fixtures.

3.1 CONTROL: Grapple fixtures are located and mounted in accordance with NSTS 21000-IDD-ISS and SSP 57003 for clearances, mass, CG offset and visibility. Grapple fixture locations have been selected to facilitate the exchange of the AMS-02 between SRMS and SSRMS and SSRMS berthing activities.

3.1.1 SVM: Review of design.

3.1.2 SVM: Inspection of as-built hardware.

3.1.1 STATUS: Closed. ESCG Memorandum ESCG-4175-REENTES-09-MEMO-0023, "Review of AMS-02 FRGF and PVGF Bracket Design," dated April 28, 2009

3.1.2 STATUS: Closed to SVTL.

4. CAUSE: Inability to fully capture/release the Payload Attach System, including the UMA.

4.1 CONTROL: The AMS-02 passive half of the Payload Attach System (PAS), including the UMA interface has been built to comply with the requirement of SSP57213 (AMS-02 to ISS ICD) and through the ICD, SSP 57003 and SSP 57004. NOTE: The AMS-02 is unable to control operations or design of the ISS side of the interface and this must be covered in an integrated ISS hazard report. It is understood that the active PAS with regards to inadvertent release of the ISS mechanism is established by the ISS to be equivalent to a two fault tolerant event.

4.1.1 SVM: Review of design.

4.1.2 SVM: Inspection of as-built hardware.

4.1.3 SVM: AMS-02 PAS interface testing between flight Passive (AMS-02) and flight Active (ISS) components.

4.1.4 SVM: UMA electrical connectors verified to be mechanically and electrically compatible across the UMA interface.

4.1.5 SVM: AMS-02 will be tested prior to installation into the Orbiter on the Active Common Attach System Simulator (ACASS) to confirm proper mating and interface.

4.1.1 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.

4.1.2 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.

4.1.3 STATUS: Closed. On March 10-11, 2003, PAS was placed in position on S3 truss (flight) and capture claw was fully closed and reopened three times. All mechanical interfaces operated successfully. Closure Reference Memorandum ESCG-4390-05-SP-MEMO-0012, "Functional Testing of the Payload Attach System (PAS)", dated 28 December 2005 from AMS-02 Chief Engineer Chris Tutt.

4.1.4 STATUS: Closed to SVTL.

4.1.5 STATUS: Closed to SVTL.

4.2 CONTROL: The AMS-02 passive interface to the Payload Attach System includes an EVA release mechanism capable of releasing the stored energy of the maximum preload of 6430 lbs and removing the capture bar to release the AMS-02 from the ISS. EVA operated, screw driven ramps release the preload created by the capture of the Passive PAS capture bar. Once the loads are released, an EVA release bar allows for the extraction of the capture bar from the Active PAS.

4.2.1 SVM: Review of Design.

4.2.2 SVM: Inspection of as-built hardware.

4.2.3 SVM: Functional testing of the EVA Release mechanism.

4.2.1 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.

4.2.2 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.

4.2.3 STATUS: Closed. On February 12-14, 2003, the PAS capture bar release mechanism was successfully used to release the loaded PAS as part of the general PAS qualification testing. On March 10-11, 2003, the PAS was placed in position on S3 truss (flight) with the capture claw fully closed and the capture bar mechanism was also

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successfully used to release the loaded PAS. Closure Reference Memorandum ESCG-4390-05-SP-MEMO-0012, "Functional Testing of the Payload Attach System (PAS)", dated 28 December 2005 from AMS-02 Chief Engineer Chris Tutt.

4.3 CONTROL: To assure that the appropriate preload is present when the AMS-02 is interfaced with the active PAS, a travel limiting screw is adjusted prior to flight to provide the appropriate placement of the capture bar, utilizing the 10° ramp to raise and lower the capture bar. When positioned correctly the capture position of the latch and the required displacement of the bar generated the preload. This travel limiter (with two forms of backout prevention (locking nut and locking insert with preload torque) allows for the EVA crew to readily replace the capture bar once it is removed and make the passive PAS of the AMS-02 capable of being installed in a functioning active PAS. Reinstallation of the mechanism is the reversal of the removal process with the restoration/reinsertion of the capture bar and handle then reversing the EVA bolt rotation using the release bolt turn counts to establish the appropriate number of rotations to drive to hardstops (driving to hardstops, if past the original counts is preferred cessation point). I

4.3.1 SVM: Review of Design

4.3.2 SVM: Inspection of as built hardware. (MIP)

4.3.3 SVM: Functional testing of preload set travel limiter.

4.3.4 SVM: Final setting/check of preload position of latching bar.

4.3.5 SVM: Acceptance of OCAD by MOD (OCAD 67868)

4.3.6 SVM: EVA IPT acceptance of SSCN 1819 EVA Fastener and Threaded Insert Data

4.3.1 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.

4.3.2 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.

4.3.3 STATUS: Closed. During integration testing with S3 Truss February 12-14, 2003 and March 10-11, 2003 travel limiters were confirmed. Closure Reference Memorandum ESCG-4390-05-SP-MEMO-0012, "Functional Testing of the Payload Attach System (PAS)", dated 28 December 2005.

4.3.4 STATUS: Closed. JSC DR 2A0830036, Closed August 21, 2008

4.3.5 STATUS: Closed to SVTL

4.3.6 STATUS: Closed. Email confirmation of acceptance of submitted bolt data by MOD and EVA IPT provided by XO/M. Tullar, July 16 2010.

5. CAUSE: Inadvertent release of Payload Attach System EVA Release Mechanism.

5.1 CONTROL: To release the AMS-02 from the ISS PAS the EVA Releasable Capture Bar must be withdrawn from the latched PAS mechanism, the AMS-02 is two fault tolerant to inadvertent release of the AMS-02 by way of the AMS-02 PAS mechanism. Once latched, the preload generated by the capture event and the design of the AMS-02 is 5650 lbs nominal/6430 lbs maximum to prevent gapping of the AMS-02. To relieve this load, two independent load relief devices must be operated to drive apart two wedges. The sliding of these wedges apart releases the energy of the interface and lowers the guides through which the capture bar runs. The capture bar cannot be extracted due to interference with the alignment brackets that lock the capture bar in place until the bar is lowered by each of the load relief devices. Each EVA Load Release Screws have a separate spring operated lock to preclude the 7/16th inch EVA bolt head from turning until depressed by the EVA tool. NOTE: The AMS-02 is unable to control operations or design of the ISS side of the interface and this must be covered in an integrated ISS hazard report. It is understood that the active PAS with regards to inadvertent release of the ISS mechanism is established by the ISS to be equivalent to a single fault tolerant event.

Thus to release the AMS-02 from the PAS by AMS-02 fault, the following must occur:

- Failure of first EVA Load Release Screw locking mechanism
- Fault operation of first EVA Load Release Screw and wedges to release the 5650 lb (nominal) preload and lower the guides
- Failure of second EVA Load Release Screw locking mechanism
- Fault operation of second EVA Load Release Screw and wedges to release the 5650 lb (nominal) preload and lower the guides
- Fault extraction of the EVA Releasable Capture Bar from PAS latch.

5.1.1 SVM: Review of Design.

5.1.2 SVM: Inspection of as built hardware.

5.1.3 SVM: Functional testing of EVA Release Mechanism,

5.1.4 SVM: Final setting/check of Load Release Screw Locking Mechanism.

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5.1.1 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.

5.1.2 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.

5.1.3 STATUS: Closed. On February 12-14, 2003, the PAS capture bar release mechanism was successfully used to release the loaded PAS as part of the general PAS qualification testing. On March 10-11, 2003, the PAS was placed in position on S3 truss (flight) with the capture claw fully closed and the capture bar mechanism was also successfully used to release the loaded PAS. Closure Reference Memorandum ESCG-4390-05-SP-MEMO-0012, "Functional Testing of the Payload Attach System (PAS)", dated 28 December 2005 from AMS-02 Chief Engineer Chris Tutt.

5.1.4 STATUS: Closed to SVTL.

5.2 CONTROL: <DELETED> I

5.3 CONTROL: `The Capture Bar is design to preclude a complete release of the bar by a physical interference to complete extraction from the support structure.

5.3.1 SVM: Review of design.

5.3.2 SVM: Inspection of as built hardware.

5.3.1 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.

5.3.2 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.

5.4 CONTROL: The AMS-02 will maintain the SSP 57003 required stiffness of the AMS-02 to ISS interface by accurately positioning the AMS-02 PAS Capture Bar during ground processing prior to flight. Preflight testing has established the proper spring constant required to exceed the required stiffness and the AMS-02 PAS is configured specifically to provide this stiffness capability. When the capture bar is lowered, this stiffness is reduced. The AMS-02 is equipped with anti-rotation devices to preclude the wedge drive screws from backing out. Although structurally isolated from significant vibrational and acoustic loading, the design of the anti-rotation device was analyzed to establish its sensitivity to directly applied random vibrational loads. The natural frequency of the anti-rotation device, based on the spring constant of the design, is 36.6 Hz. The design of the anti-rotation device requires a compressive force of 4.88 lbs. A maximum acceleration of the induced random vibrations at 36.6 Hz generates a acceleration of 4.79g, resulting in an applied force of 0.63 lbs to the anti-rotation device. Using the maximum Power Spectral Density level anywhere (well outside what is possible for this equipment), the maximum applied force of 1.58 lb is calculated (again assuming direct application of the loads). This is a factor of three less than that required to depress the anti-rotation device even if the structure of the AMS-02 did not attenuate the transmission of these random loads to the mechanisms. A broken spring analysis has shown that the spring (with coil lost) is capable of providing sufficient force to retain the anti-rotation function making it equivalent of single fault tolerant)

NOTE: Given that the design of the anti-rotation device did not preclude the rotation, the drive screws have a measured minimum running torque of 3 in-lbs that would resist rotation and a minimum "break" torque of 5 in-lbs. Assuming that the anti-rotation devices can be overcome or experience failure, and the rotation of the drive shafts were to occur, to lose the preload of the AMS-02 passive PAS to the ISS active PAS, the shafts driving the wedges that support the capture bar must rotate through a minimum of 12.7 rotations. Given that the exposure to a vibration load (again ignoring the attenuation of the AMS-02 structure that essentially makes the forces at the anti-rotation mechanism insignificant) lasts for approximately 20 seconds, the statistical probability to rotate the shafts sufficiently during launch to reposition the capture bar to reduce the stiffness/preload to below the SSP 57003 allowable is 10^{38} to 1 against or 5.877×10^{-39} chance.

No mechanism for removal of the preload has been identified as credible for any other mission phase.

5.4.1 SVM: Preflight Inspection for proper configuration of preload mechanism.

5.4.2 SVM: Analysis of anti-rotation devices on EVA Release Mechanism of AMS-02 PAS.

5.4.3 SVM: Testing of EVA Release Mechanism for Breaking Torque and Running Torque.

5.4.4 SVM: Analysis of AMS-02 Preload to rotation of EVA Release Mechanism drives.

5.4.5 SVM: Approval of ISS Mechanism Working Group/Mechanical Systems Working Group.

5.4.6 SVM: Preflight Inspection of Anti-Rotation Devices to assure Anti-Rotation Device is properly engaged for launch.

5.4.7 SVM: Post testing inspection to assure anti-rotation device has not worn during any testing/operational uses.

5.4.8 SVM: Broken Spring Analysis.

5.4.1 STATUS: Closed to SVTL.

5.4.2 STATUS: Closed. Memo ESCG-4390-06-SP-MEMO-0017, superseded by ESCG Memorandum ESCG-4390-07-SP-MEMO-0006, "Safety Analysis of the PAS Anti-Rotation Device," dated August 8, 2007.

5.4.3 STATUS: Closed. TPS 2A0720243, Completed October 26, 2007 confirms breaking torque and running torque of the EVA release mechanism.

5.4.4 STATUS: Closed. ESCG Memo ESCG-4390-07-SP-MEMO-0006, "Safety Analysis of the PAS Anti-Rotation Device", August 8, 2007

5.4.5 STATUS: Closed. Email Acceptance of AMS-02 AMS-02-F11 approach from JSC/ES5/S. Ross to JSC/EA3/T. Martin, et al, titled "AMS-02 Hazard Report 11" dated January 25, 2010.

5.4.6 STATUS: Closed to SVTL.

5.4.7 STATUS: Closed. JSC DR 2A0830036, Closed August 21, 2008

5.4.8 STATUS: Closed. ESCG Memo ESCG-4390-07-SP-MEMO-0006, "Safety Analysis of the PAS Anti-Rotation Device", August 8, 2007

Note: ISS requirements imposed on the AMS-02 and other external payloads to attach to the PAS only require that a means of EVA release from the PAS be provided, not that the release be multiply fault tolerant. The AMS-02 PAS EVA Release mechanism is designed to be zero-fault tolerant in its operation and not represent a multiple fault tolerant approach.

6. CAUSE: Inability to Secure ROEU Support Structure.

Note: The AMS-02 EVA operation to rotate the ROEU Support Structure to maximize the distance between the AMS-02 and the adjacent PAS payload envelope is a contingency operation that will only be performed if required by the specific installation of an adjacent payload or ISS External Logistics Carrier (ELC). With the redesigned ELC information, the ROEU on the AMS-02 is no longer a driving factor for clearances.

6.1 CONTROL: The AMS-02 ROEU Support Structure had been designed to reduce the protrusion of the ROEU from the SSP 57003, 3.1.3.1.1.1 defined payload envelope. MAGIK Analysis of the extended (worst case protrusion) of the ROEU from the AMS-02 indicates that there is no longer an identified contact issue from the ROEU and the worst case displaced (translation and rotation) SSRMS installation of a full size payload next to the AMS-02. NOTE: As there is no residual issue with the proximity of the extended ROEU, the folding mechanism has been fixed with fasteners and is no longer EVA

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reconfigurable.

6.1.1 SVM: <deleted>

6.1.2 SVM: Installation testing of AMS-02 PAS interface on flight hardware confirming AMS-02 berthing accuracy and by extension, positional accuracy of the ROEU.

6.1.3 SVM: Geometric Analysis of Installation Process (MAGIK).

6.1.4 SVM: Inspection of as built hardware for AMS-02 Geometry compliance.

6.1.1 STATUS: <Deleted>

6.1.2 STATUS: Closed. Tests conducted February 12-14, 2003 and March 10-11, 2003. Test results are discussed in detail in ATA Reports 53013 and 53013A respectively.

6.1.3 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

6.1.4 STATUS: Closed to SVTL.

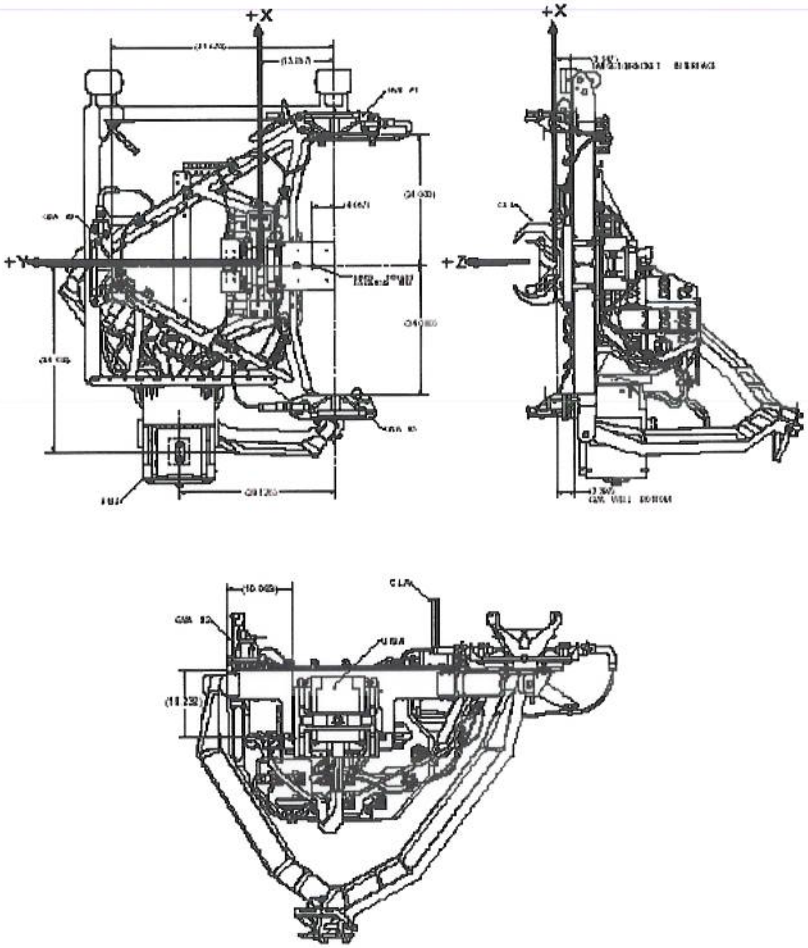
6.2 CONTROL: <Deleted>

Notes:

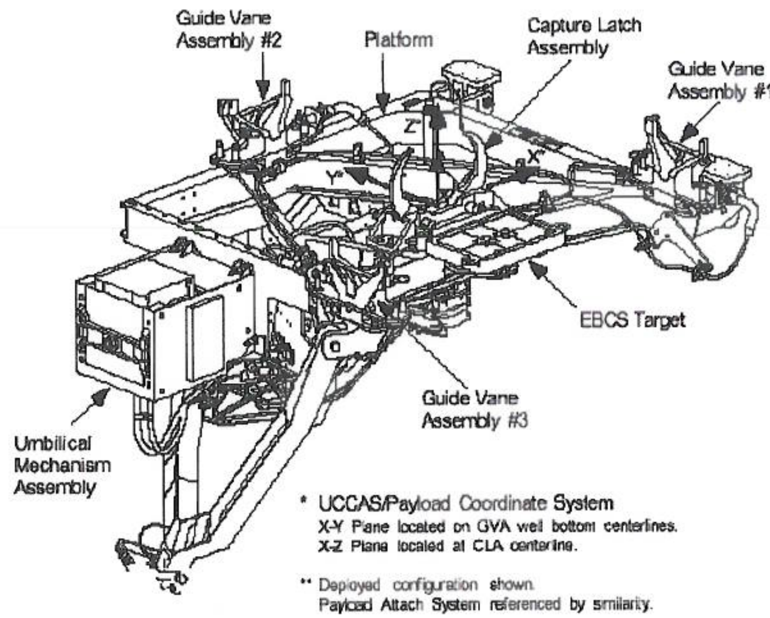
ACRONYMS	
ACASS – Active Common Attach Site Simulator	PAS – Payload Attach System, Payload Attach Site
AKA – Active Keel Assembly	PRLA – Payload Retention Latch Assembly
AMS-02 – Alpha Magnetic Spectrometer - 02	ROEU – Remotely Operated Electrical Umbilical
BCS – Berthing Camera System	SRMS – Shuttle Remote Manipulator System
DFMR – Design for Minimum Risk	SSRMS – Space Station Remote Manipulator System
ELC – External Logistics Carrier	SVM – Safety Verification Method
EVA – Extravehicular Activity	UMA – Umbilical Mating Assembly
MSWG – Mechanical Systems Working Group	

Mechanisms Associated With the AMS-02

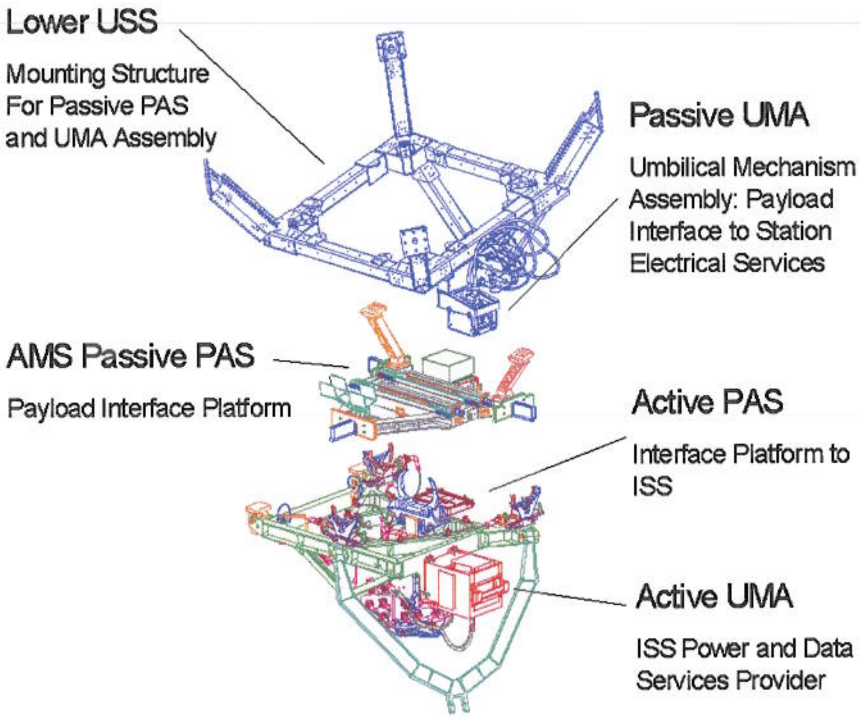
Mechanisms	Type	Operated by
Orbiter PRLA	GFE	Electrical/EVA
Orbiter Keel Latch	GFE	Electrical
Orbiter ROEU	GFE	Electrical/EVA
SRMS Grapple Fixture (FRGF)	GFE	Physical Interface to SRMS, EVA Release Capable
SSRMS Grapple Fixture (PVGF)	GFE	Physical Interface to SSRMS, EVA Release Capable
Active Payload Attach System	ISS System/GFE	Electrical
EVA Releasable Passive Payload Attach System	Payload Hardware	Passive interface to ISS. EVA interfaces (two preload relief interfaces and Capture Bar retraction)
UMA Interface	GFE	Electrical, EVA



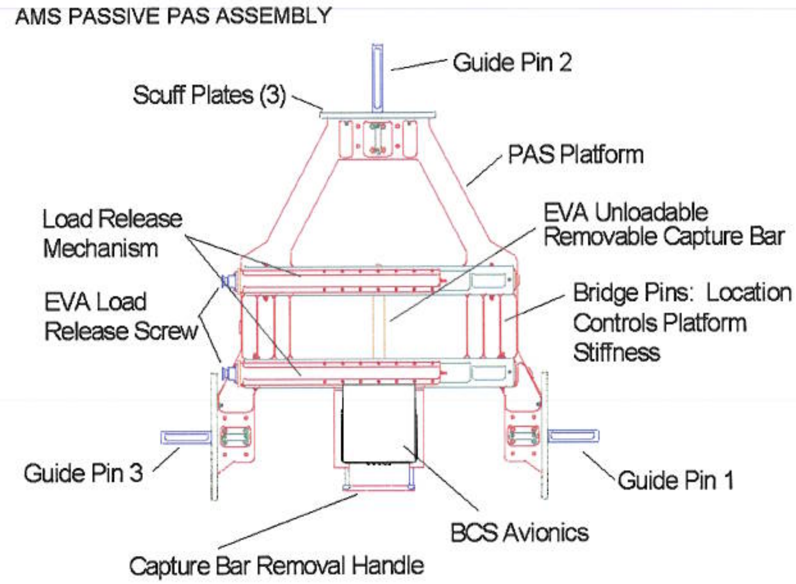
ISS Payload Attach Site



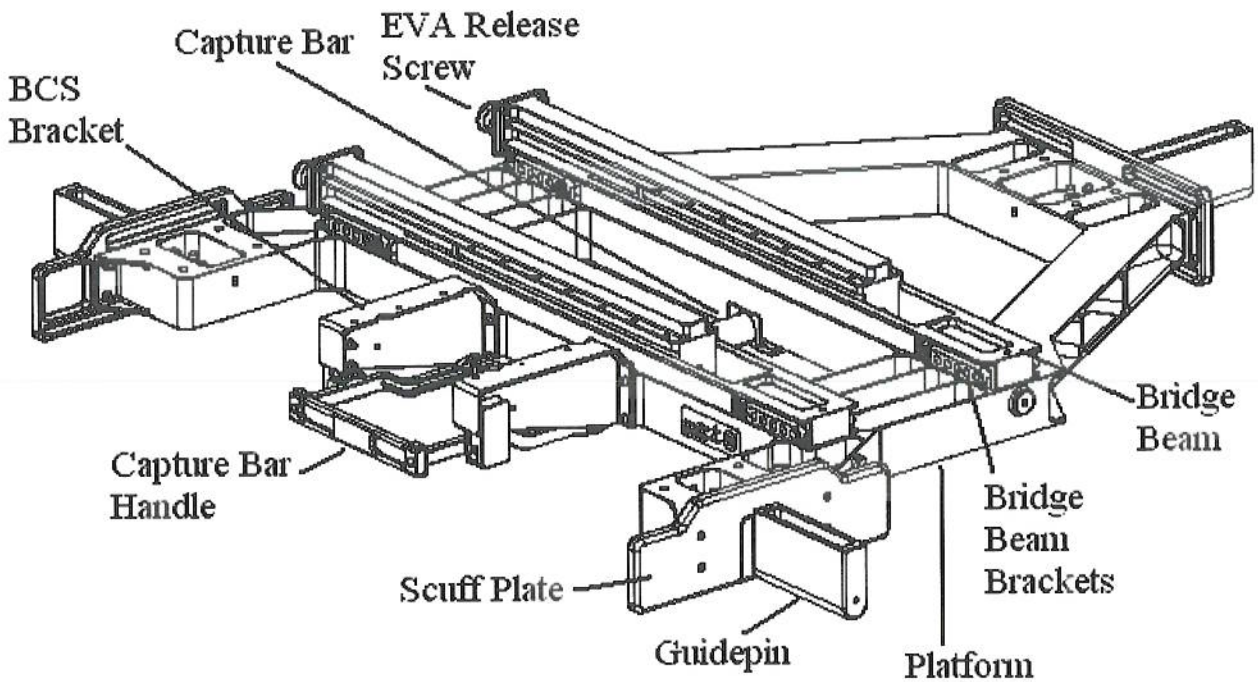
ISS Payload Attach Site



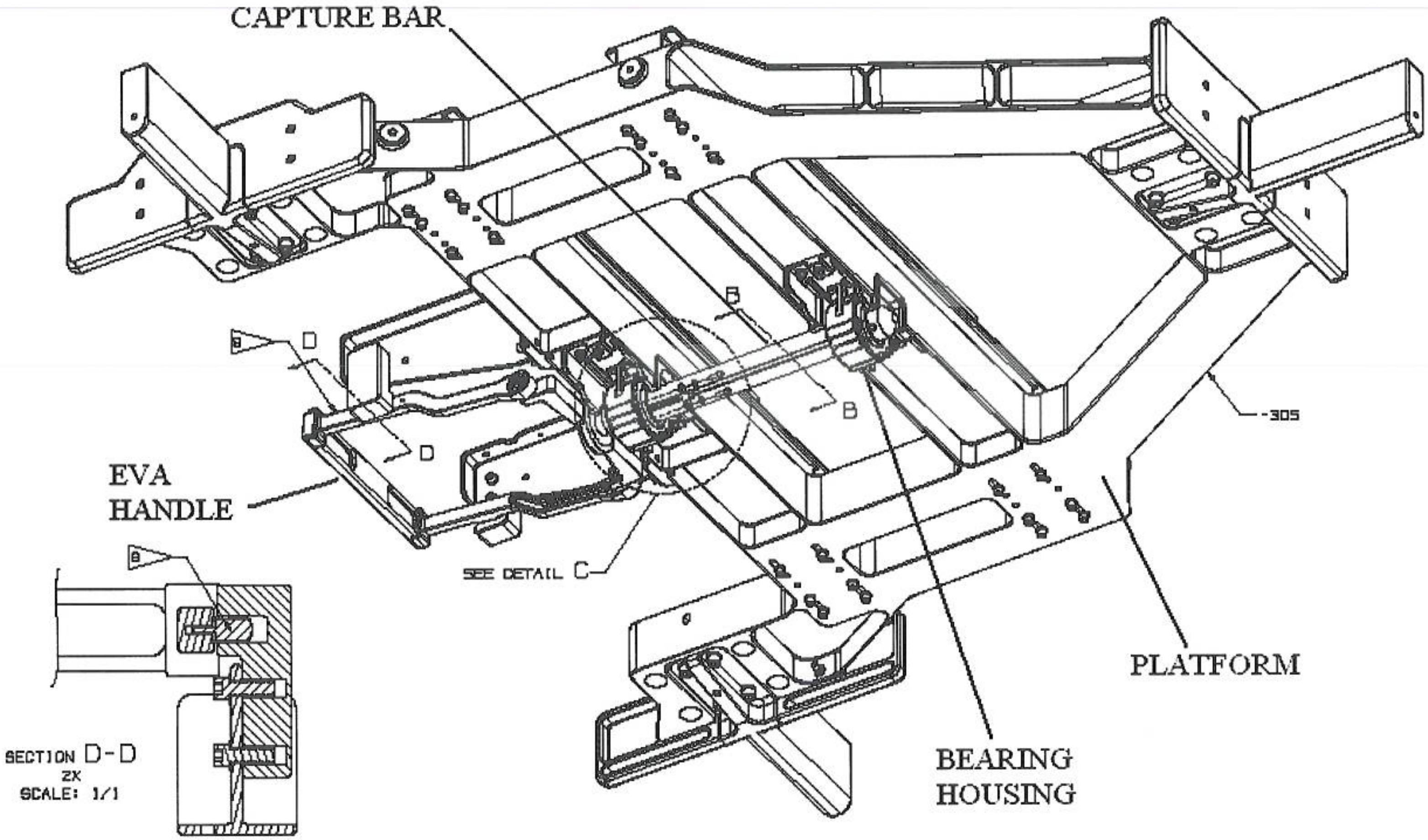
AMS-02 Interface to ISS Payload Attach Site



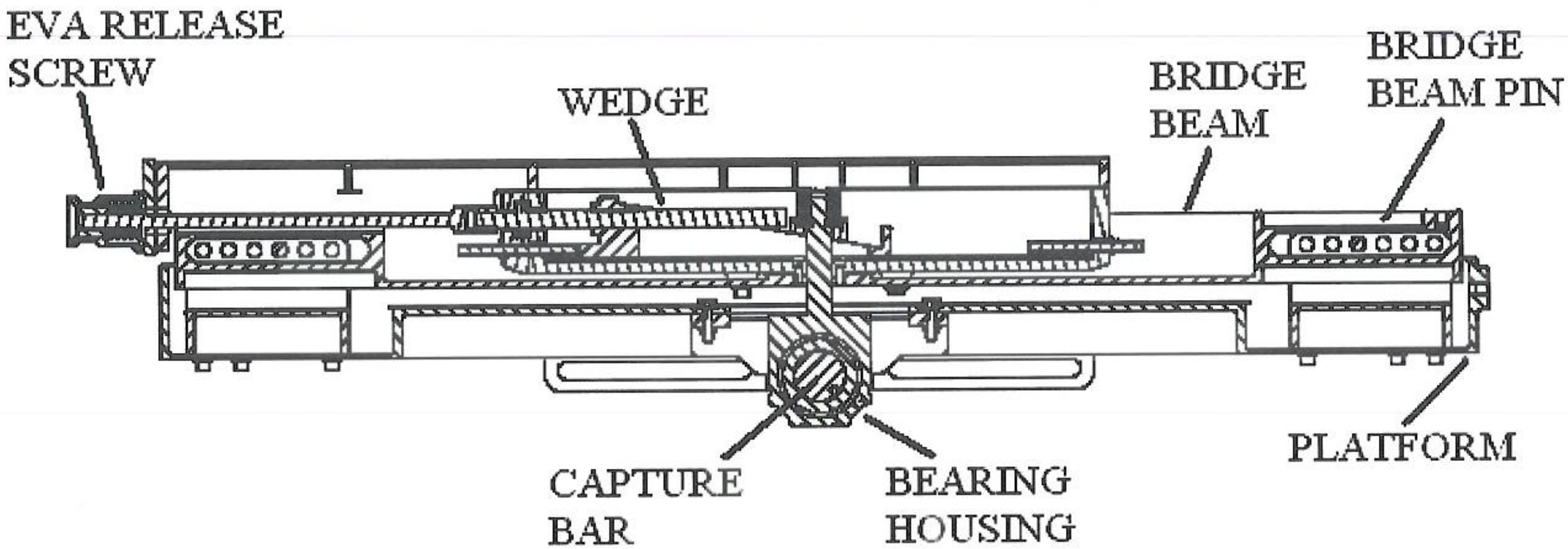
AMS-02 Passive PAS Assembly with EVA Release Mechanism



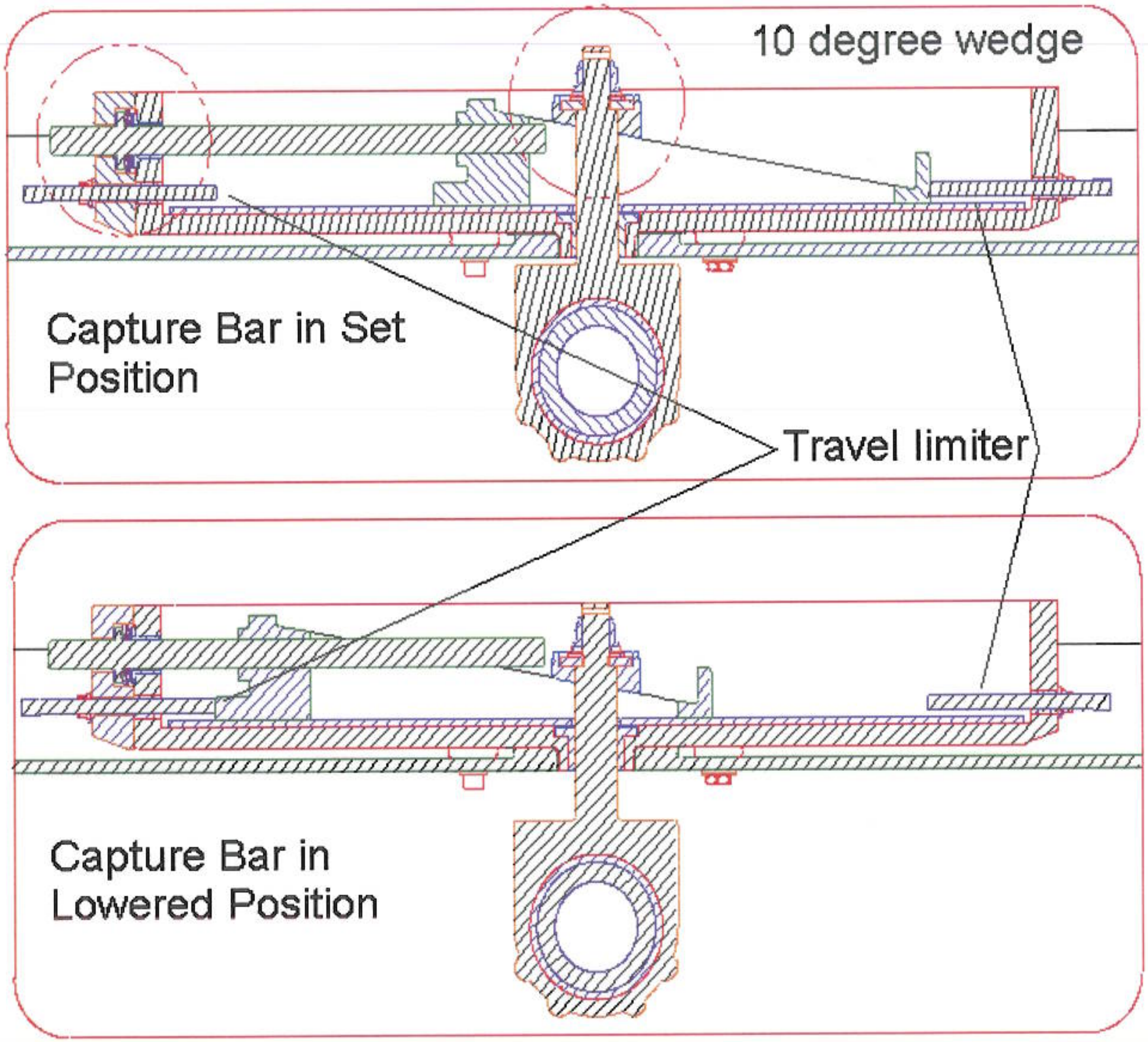
AMS-02 Passive Attach System with EVA Release Mechanism



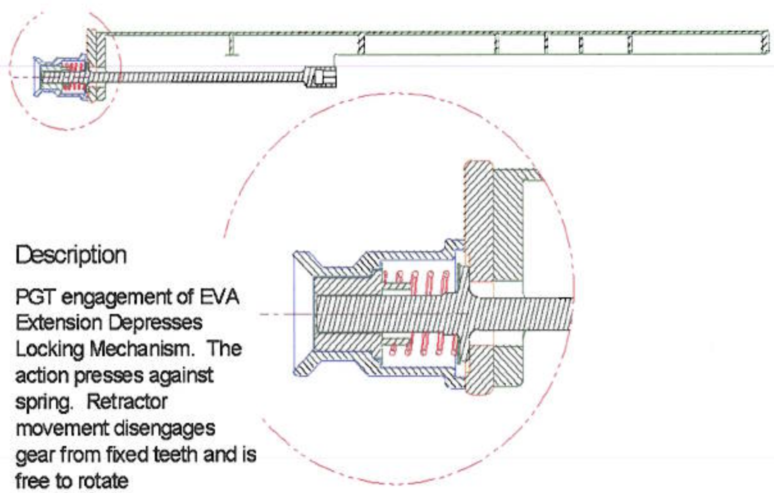
AMS-02 Passive Attach Mechanism with EVA Release Mechanism (View from ISS PAS)



AMS-02 PAS Preload Release Mechanism with EVA Release Screw



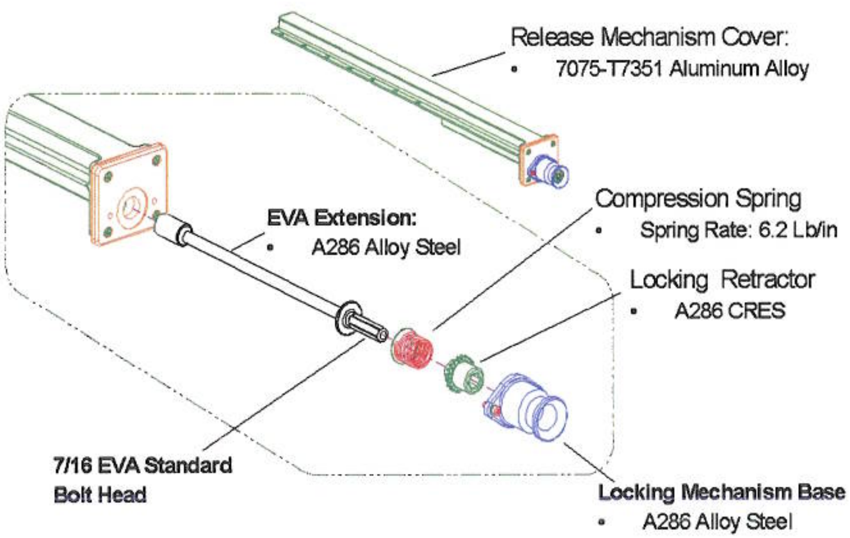
AMS-02 PAS Load Relief Wedge Operation



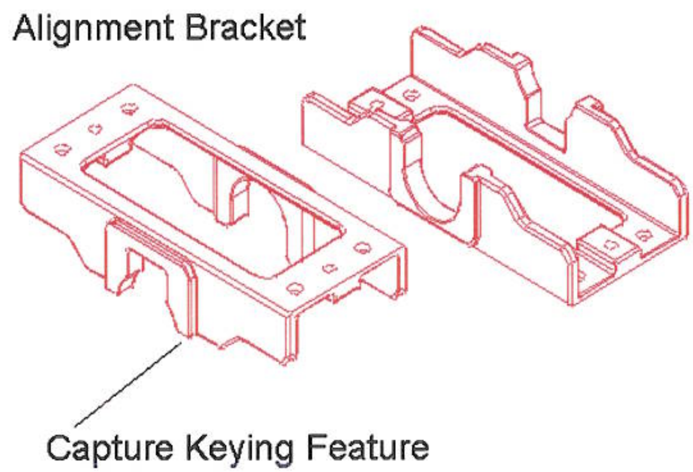
Description

PGT engagement of EVA Extension Depresses Locking Mechanism. The action presses against spring. Retractor movement disengages gear from fixed teeth and is free to rotate

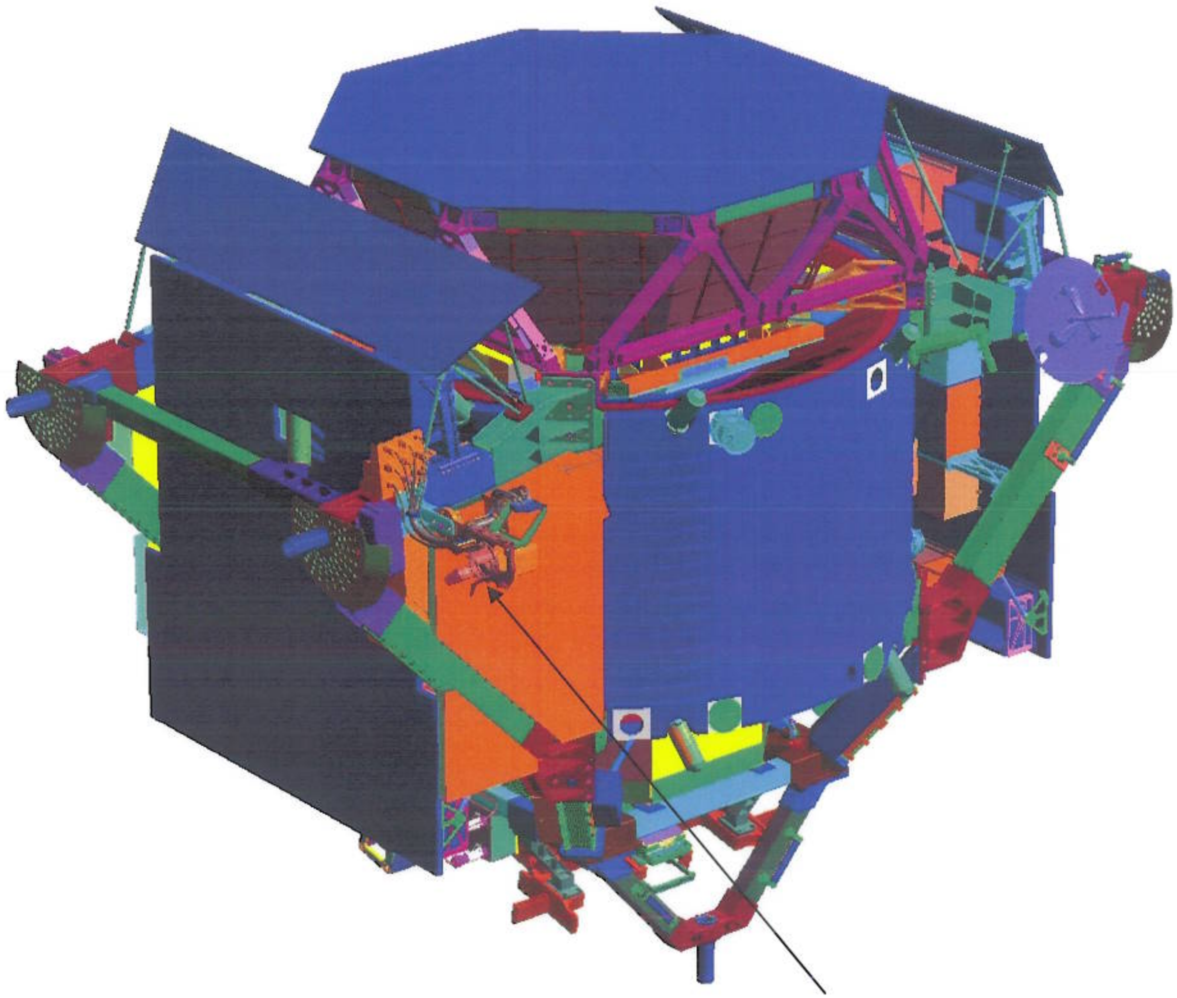
AMS-02 PAS EVA Release Screw Locking Mechanism



AMS-02 PAS EVA Screw Interface Design

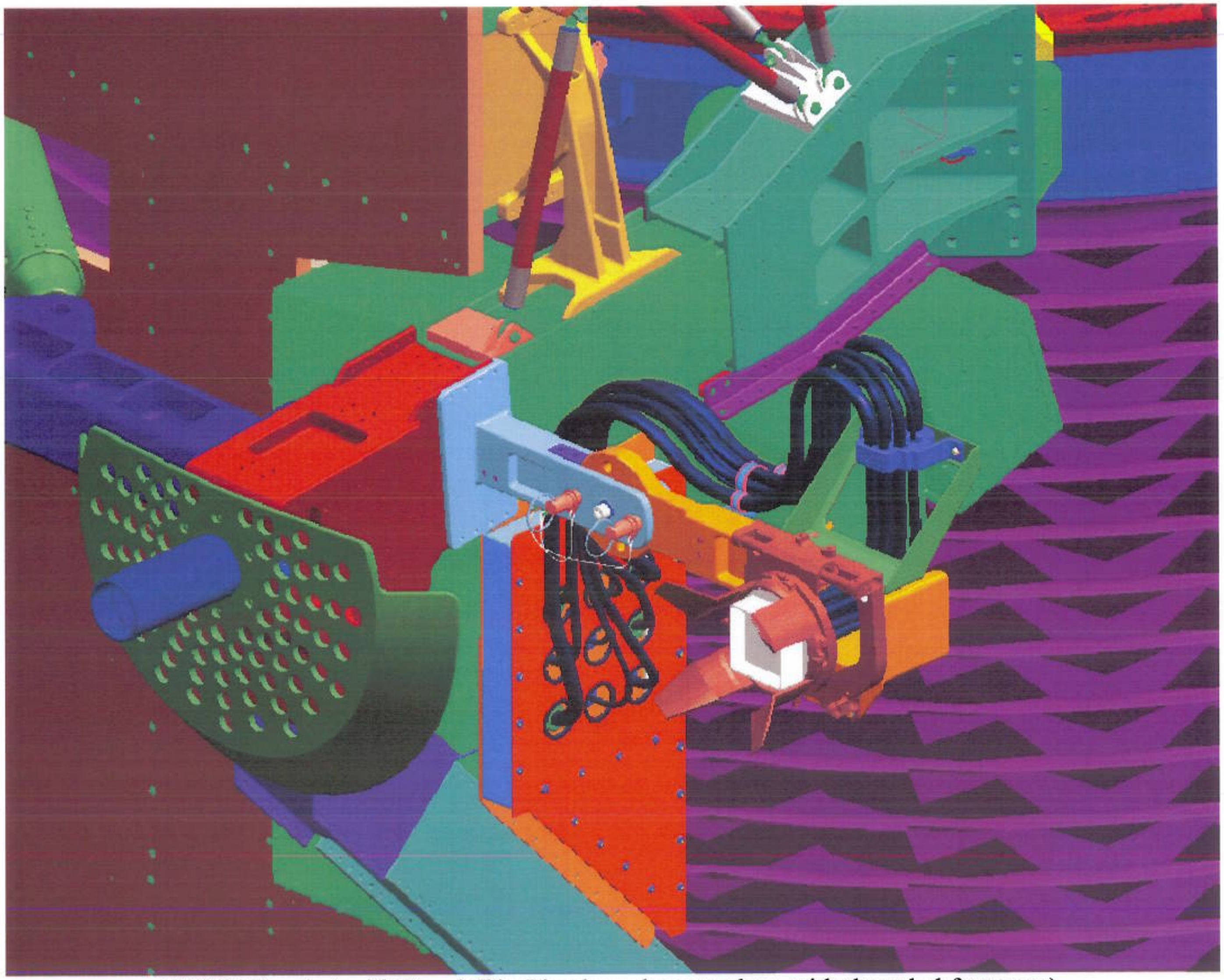


Capture Bar Capture Feature

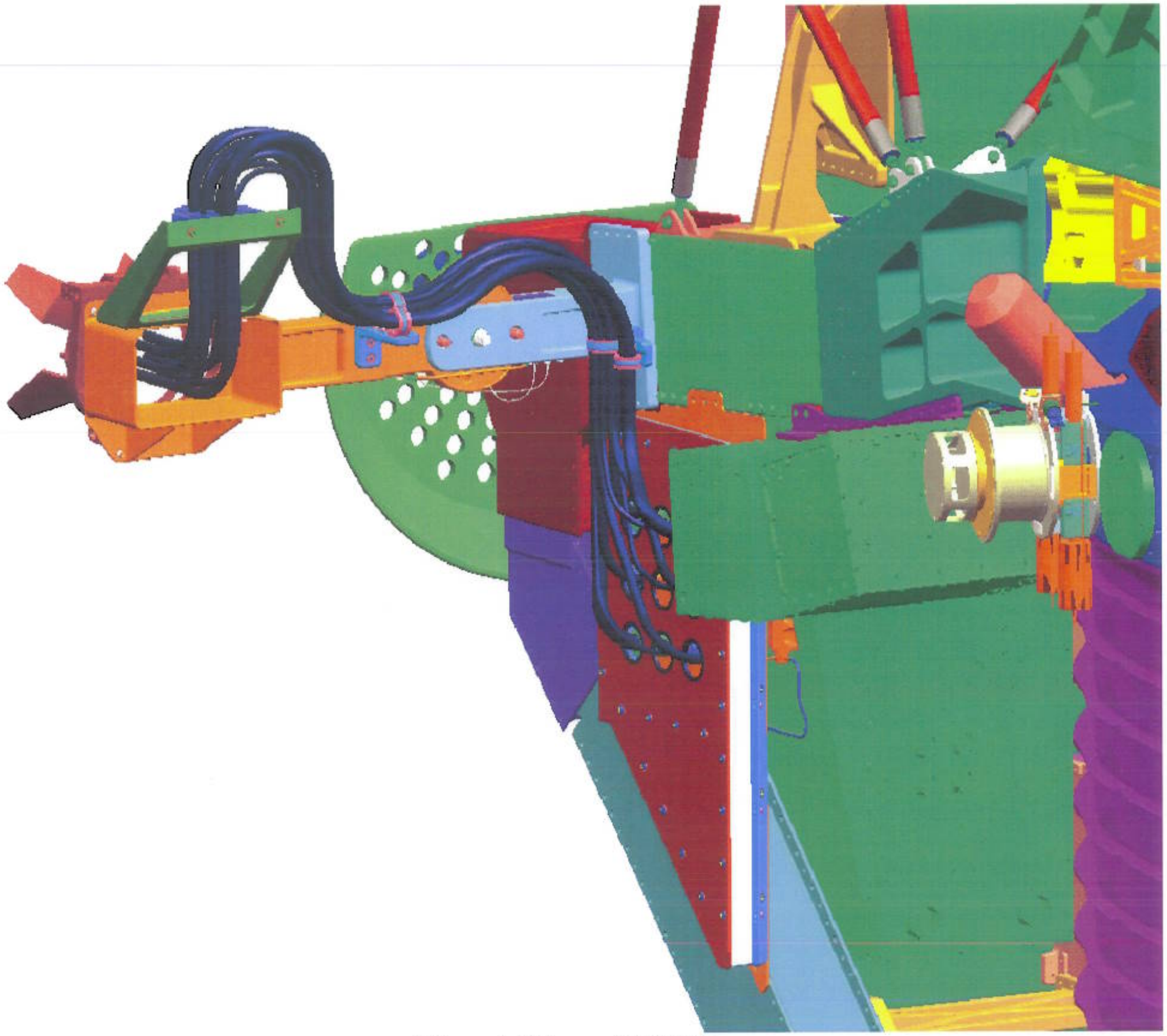


AMS-02 ROEU Folding Bracket

(Electrical Panel in Old position above the ROEU Bracket, following pictures reflect updated position of electrical panel.)



ROEU Bracket with Panel (Pip Pins have been replace with threaded fasteners)



Alternate View of ROEU

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.*

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)

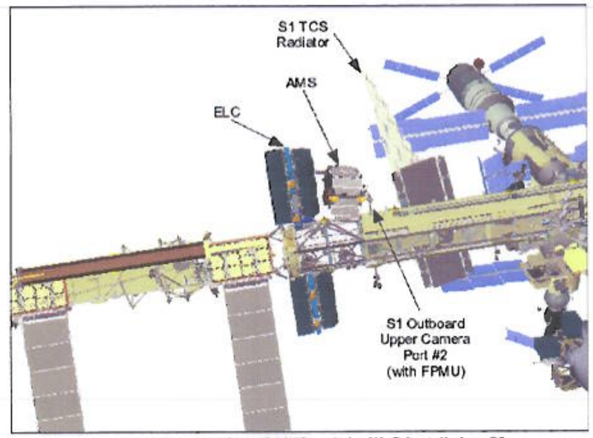


Figure 1: Overall View of AMS and the ELC Installed on S3
(Both Fully Berthed, No Misalignments)
View Looking ISS Aft, Port and Nadir

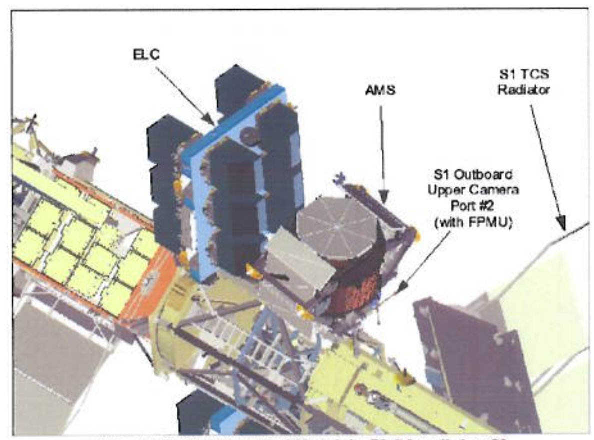


Figure 2: Overall View of AMS and the ELC Installed on S3
(Both Fully Berthed, No Misalignments)
View Looking ISS Aft, Starboard and Nadir

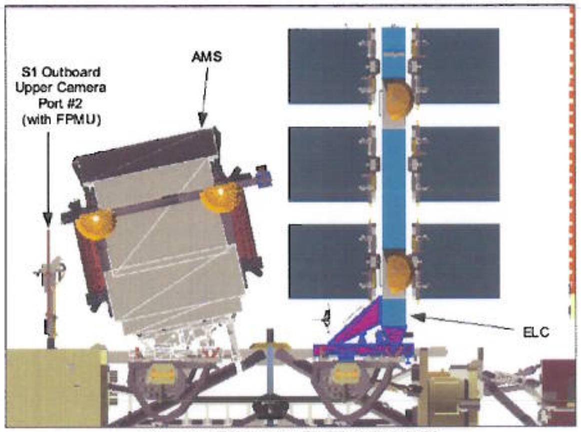


Figure 3: AMS and the ELC Installed on S3
(Both Fully Berthed, No Misalignments)
View Looking ISS Forward

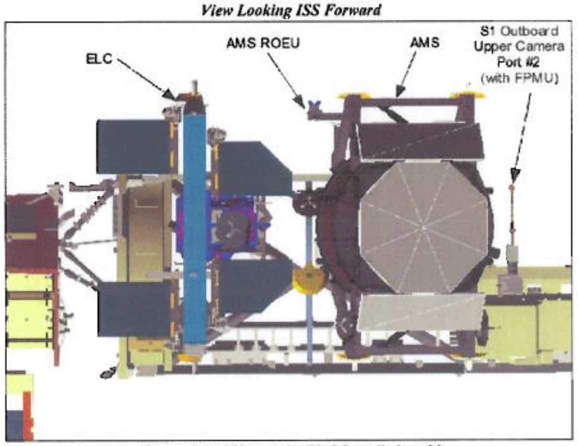


Figure 4: AMS and the ELC Installed on S3
(Both Fully Berthed, No Misalignments)
View Looking ISS Nadir
View Clipped for Clarity

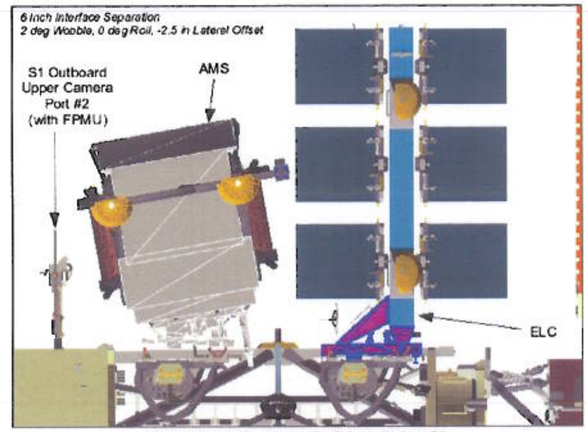


Figure 5: AMS and the ELC Installed on S3
(AMS Misaligned, ELC Fully Berthed with No Misalignments)
View Looking ISS Forward

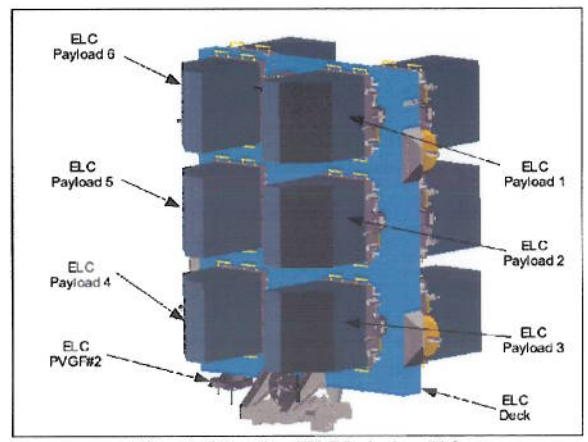


Figure 6: Orientation of ELC Payloads on ELC

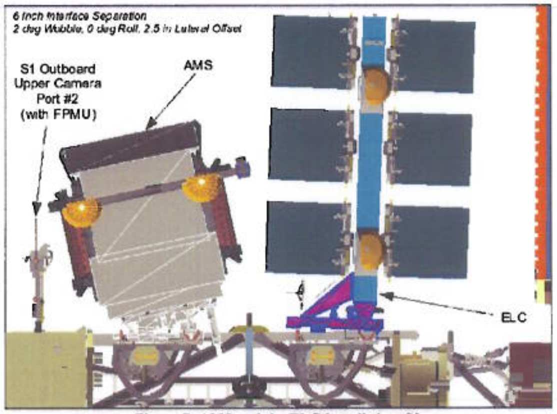


Figure 7: AMS and the ELC Installed on S3
(AMS Fully Berthed with No Misalignments, ELC Misaligned)
View Looking ISS Forward

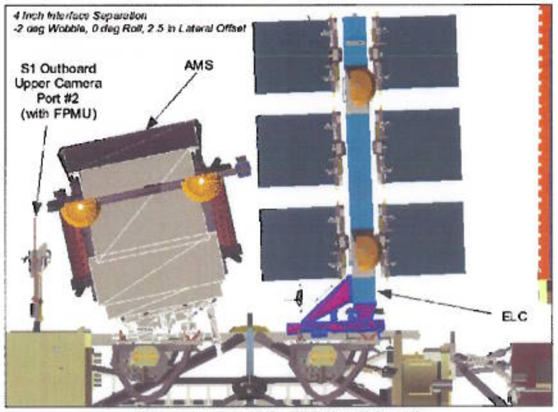


Figure 8: AMS and the ELC Installed on S3
(AMS Fully Berthed with No Misalignments, ELC Misaligned)
View Looking ISS Forward

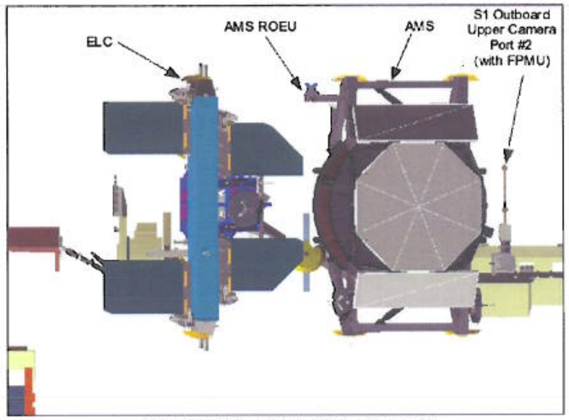


Figure 9: AMS and the ELC Installed on S3
(AMS Fully Berthed with No Misalignments, ELC Misaligned)
View Looking ISS Nadir
View Clipped for Clarity