TO:	Leonardo Cornejo/Ormitron (281) 226-4644
NASA Contact:	Cal Brogdon/OM7 (281) 244-7058
Analyst:	David Miller/MAGIK Team (281) 244-6331
DATE:	April 8, 2008
RE:	AMS Installation
CC:	Abigail De Los Reyes/OM, Alicia Mooty/OM, Paula Morris/ER, Larry Grissom/ER, Shakeel Razvi/OM, Stephanie Gill/Boeing, Trent Martin/EA, Mauro Najar/USA, Vic Sanders/Boeing, Mike Brown/Boeing, Susan Hatcliff/Boeing, MAGIK Library
PAGES:	10 **Action Item: 2279 Rev. A**

Abstract:

The MAGIK Robotic Analysis Team has completed an action to assess the kinematic feasibility of installing the Alpha Magnetic Spectrometer (AMS) to the S3 Truss. This analysis includes an assessment of removing the AMS from the Orbiter Payload Bay (PLB) with the Shuttle Remote Manipulator System (SRMS), the hand-off of the AMS from the SRMS to the Space Station Remote Manipulator System (SSRMS), and the installation of the AMS to the S3 truss using the SSRMS. All of the maneuvers were found to be kinematically feasible with all clearances and issues noted in this report.

Revision A adds information and graphics for the AMS grapple fixtures static approach and ExtraVehicular Activity (EVA) envelopes.

Assumptions:

- The AMS CAD model used in this analysis was created by the MAGIK Team from a high fidelity model received from Dennis Lyles/ISS CAD Team in March 2008. Pedigree information for other pertinent models may be obtained from the MAGIK Team upon request.
- The S1 Outboard Upper Camera Port 2 is shown empty for this analysis to allow the AMS to be installed to the S3 Truss.
- The OBSS is stored in the Orbiter Payload Bay (PLB) Starboard Sill and not in the Orbital Support Equipment (OSE) on the ISS starboard truss.
- The Special Purpose Dexterous Manipulator (SPDM) is located on the Lab Power and Data Grapple Fixture (PDGF).
- The Mobile Transporter (MT) is at Worksite 2 with the SSRMS based on Mobile Base System (MBS) PDGF #1.
- An Express Logistics Carrier (ELC) is on-orbit on the ISS S3 Outboard Upper Common Attach System (CAS) site. The ELC is populated with generic payloads that are the maximum payload size based on what will fit in the PLB.
- The AMS was placed in the aft portion of the PLB with the AMS keel forward at 1175.2 inches (with respect to the orbiter structural coordinate system +X direction). The ELC is placed in the forward section of the PLB with the keel aft at 954.93 inches. The Orbiter manifest is shown in Figure 2.
- This analysis addresses kinematic feasibility by analyzing manipulator configurations during robotic tasks. These manipulator configurations are driven by numerous constraints such as clearance with Orbiter or ISS structure, and manipulator joint limits and singularities. Areas not addressed in this document - lighting, EVA/EVR tasks, viewing, thermal and/or pressure effects on elements, and dynamics - could have a significant influence on manipulator configurations 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:

For this analysis the AMS was placed in the Orbiter PLB along with an ELC (shown in Figure 2). The AMS was placed in the aft PLB with the AMS keel forward at 1175.2 inches. The ELC is placed in the forward section of the PLB with the keel aft at 954.93 inches. Placing the ELC further aft in the PLB created a violation of the 24 inch robotic operational clearance envelope between the SRMS and the ELC during the AMS Unberth.

The static approach and EVA contingency envelopes for the AMS grapple fixtures each have violations. The AMS Flight Releasable Grapple Fixture (FRGF) SRMS static approach envelope has a violation by the Orbiter sidewall (when the AMS is in the orbiter manifest position) (Figure 3). The AMS FRGF SRMS EVA envelope has a number of violations by both the Orbiter sidewall and AMS structure (Figure 4). The AMS PVGF SSRMS static approach envelope has a single violation by the AMS trunnion structure (Figure 5). The AMS PVGF EVA envelope has multiple violations by general AMS structure and by EVA handrails (Figure 6).

The operations begin by removing the AMS from the PLB using the SRMS grappling the AMS FRGF (Figure 7). During unberth from the PLB, the AMS Orbiter forward trunnion pin passes through a 5 inch clearance with the OBSS (Figure 8). The SRMS hands off the AMS to the SSRMS (Figure 9). The SSRMS grapples the AMS Power and Video Grapple Fixture (PVGF) while based on the MBS PDGF #3 with the MT at Worksite 2. The SSRMS then manuevers the AMS toward the S3 truss (Figure 10). Finally, the SSRMS installs the AMS to the S3 Inboard Upper Payload Attach System (PAS) site (Figure 11). At the installation position, there is a 12 inch clearance between the SSRMS Wrist and the empty S1 Outboard Upper Camera Base as well as a 20 inch clearance between the AMS and the S1 Outboard Upper Camera Base (Figure 12). This camera base must be unoccupied in order for the maneuver to be feasible (The port is currently occupied by a Floating Potential Measurement Unit (FPMU) which must be removed before the AMS can be installed). During installation, there are also 16 inch clearances between the AMS and each of the ELC generic payloads (Figure 13). Upon SSRMS backoff from the AMS, the SSRMS enters a clearance of 18 inches between the SSRMS Lower Boom and the MBS Common Attach System (MCAS) (Figure 14). When the AMS is attached to the S3 truss, the AMS violates the Attached Payload Envelope (Figure 15).

All of the operations are kinematically feasible with the limitations and clearances described in this report.

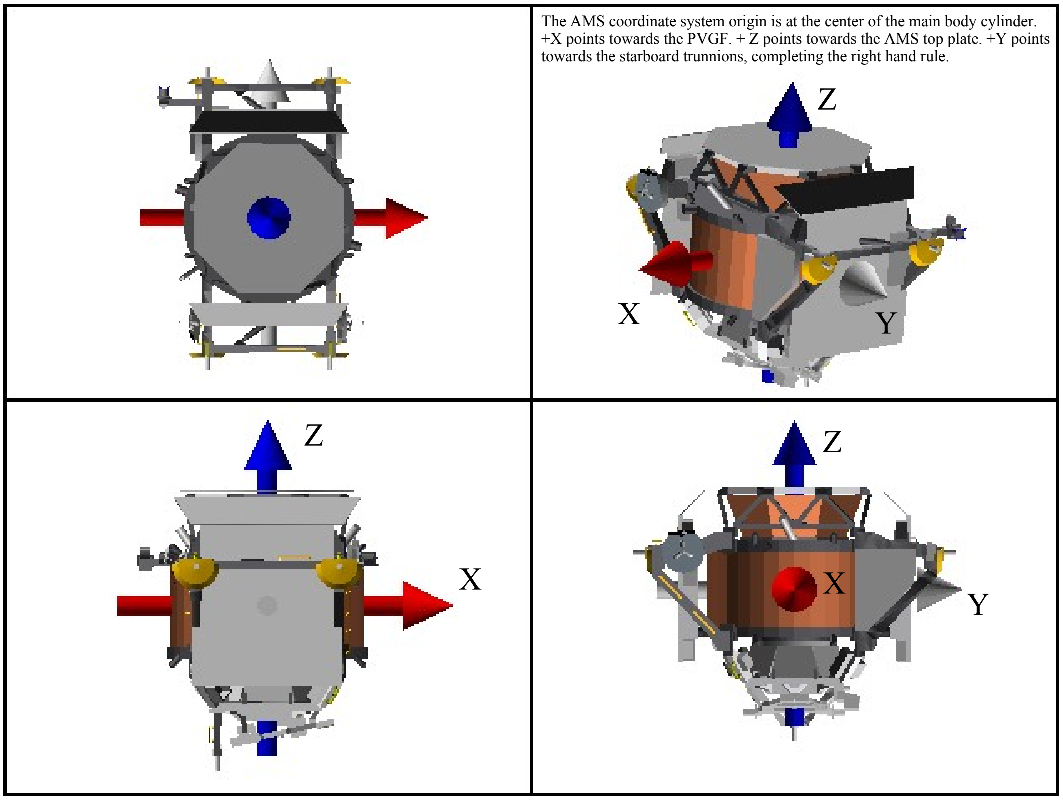

Figure 1: Coordinate System and Grapple Fixture Locations for AMS

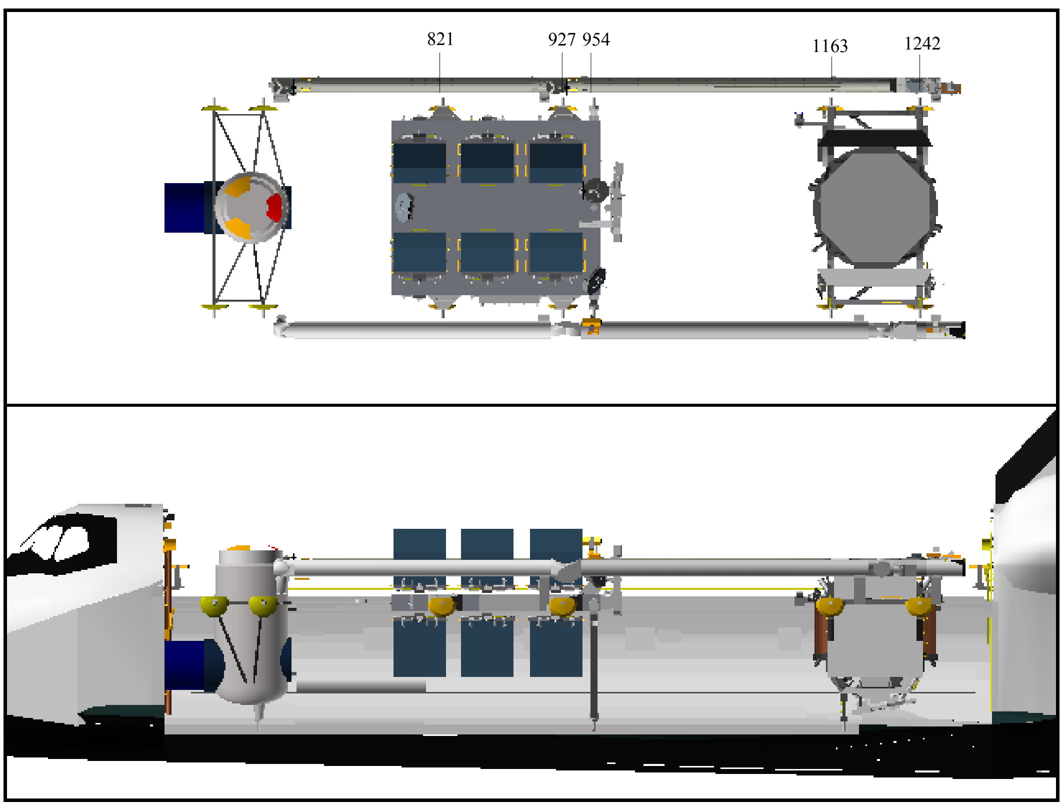

Figure 2: Orbiter Manifest (Inches)

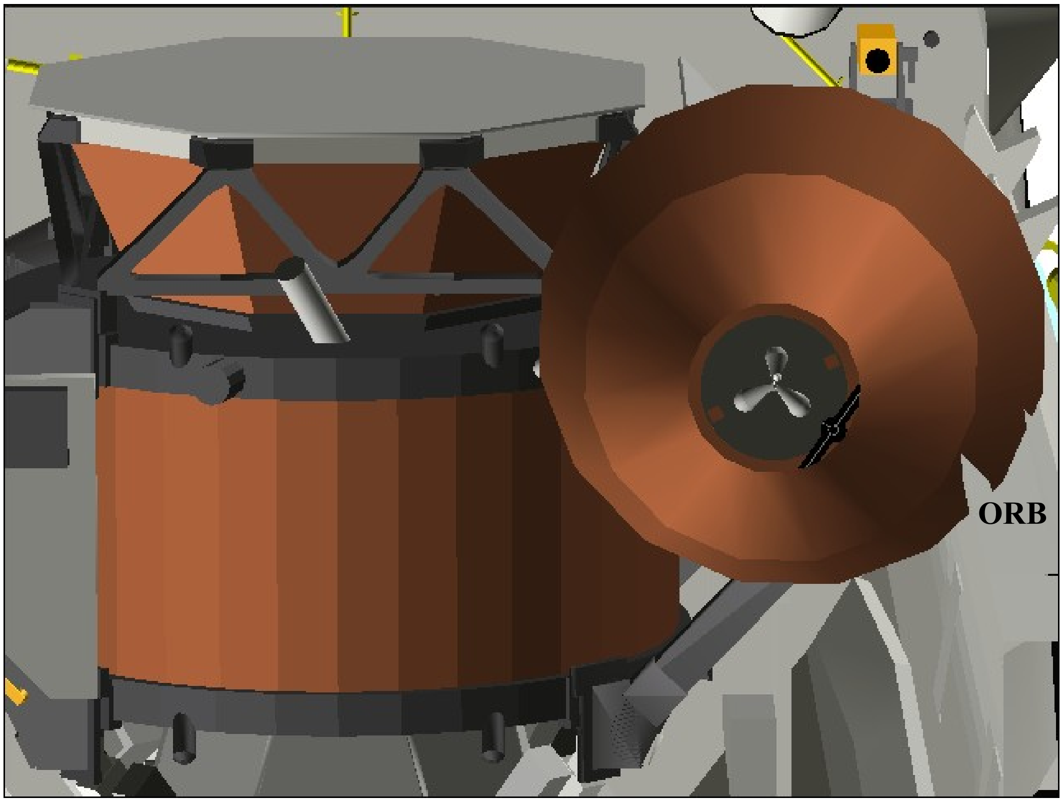

Figure 3: FRGF SRMS Static Approach Envelope with Violations by Orbiter Sidewall

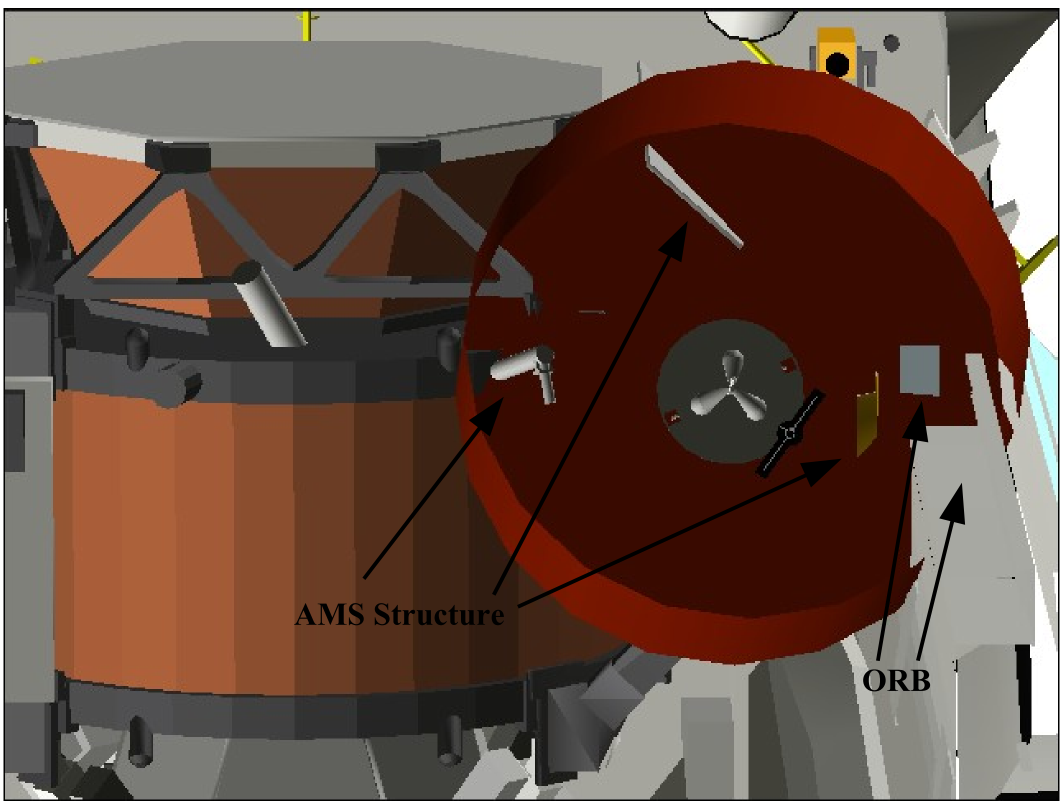

Figure 4: FRGF EVA Envelope with Violations by Orbiter Sidewall and AMS Structure

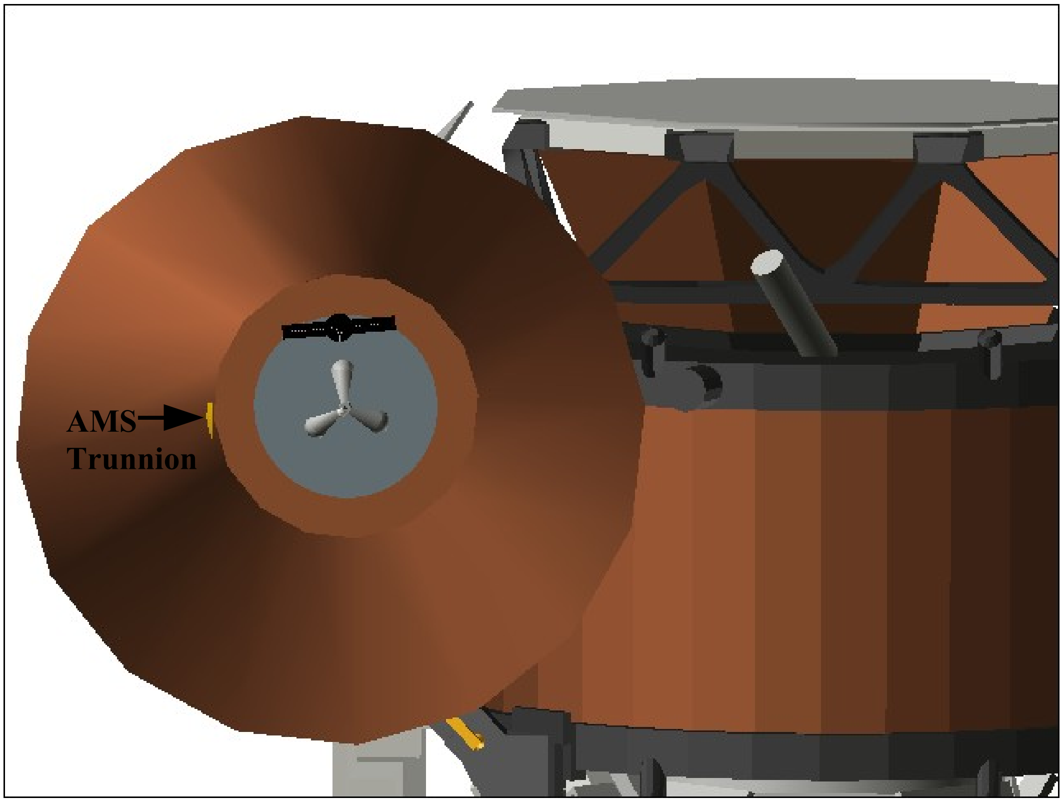

Figure 5: PVGF SSRMS Static Approach Envelope with Small Violation by AMS Trunnion Structure

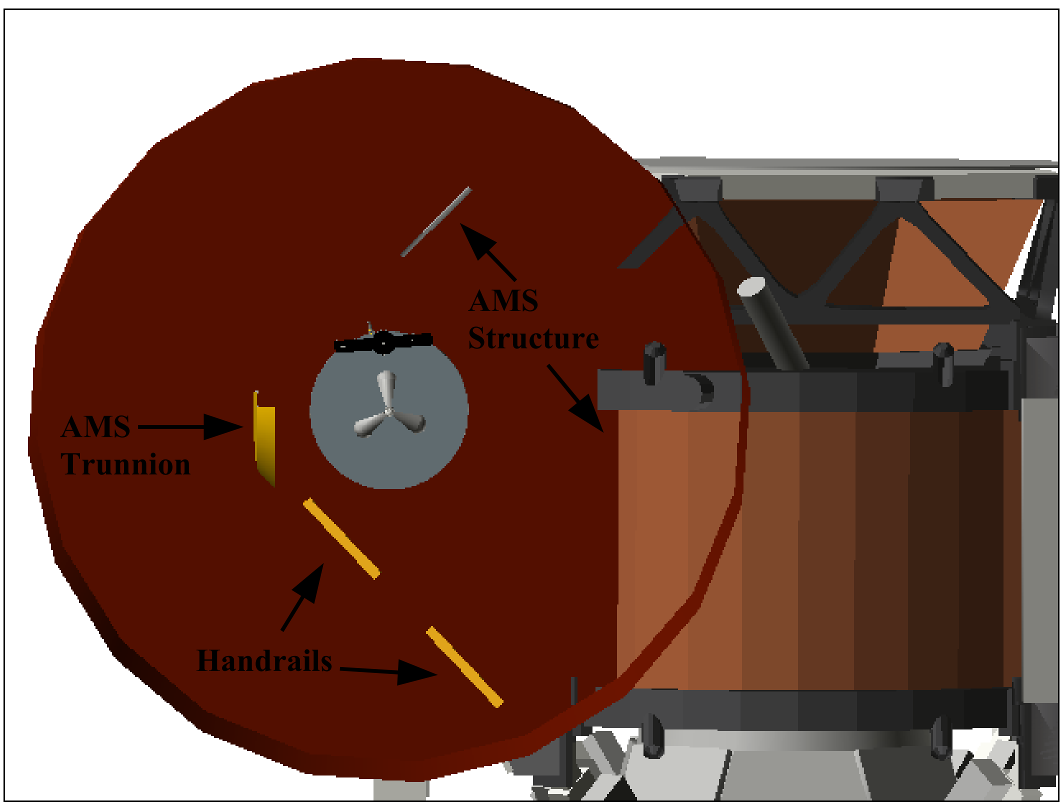

Figure 6: PVGF EVA Envelope with Violations by AMS Structure and EVA Handrails

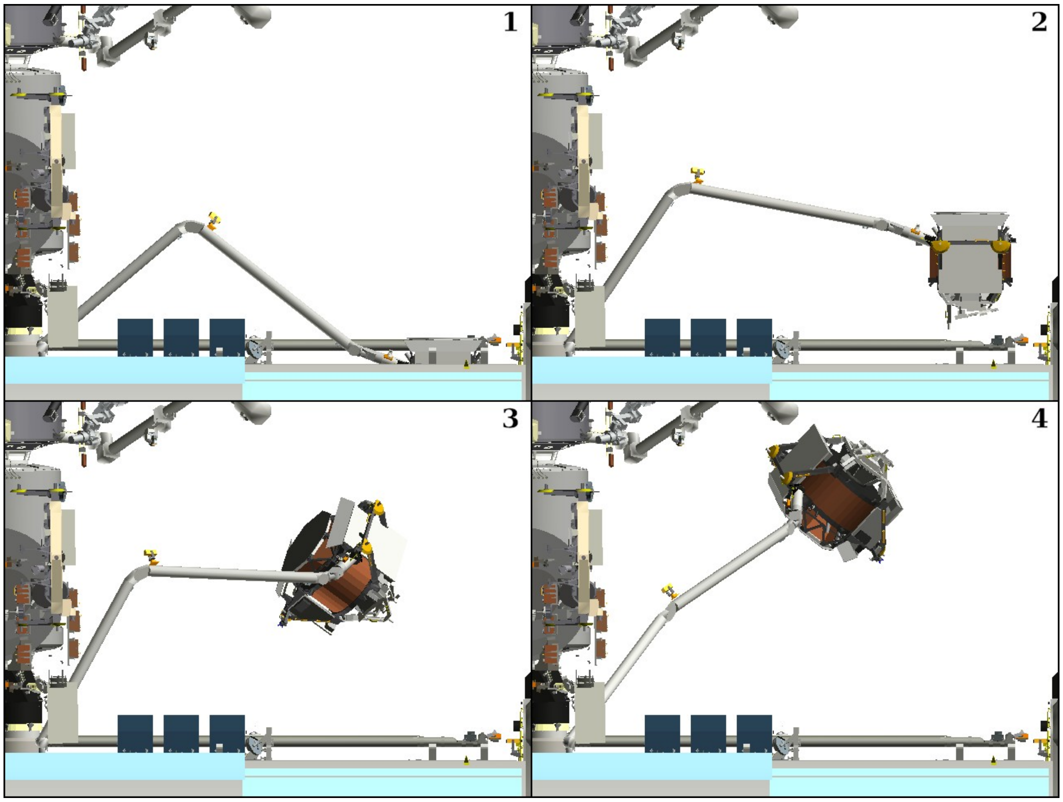

Figure 7: AMS Unberth from Orbiter PLB using SRMS
View Looking Orbiter Starboard

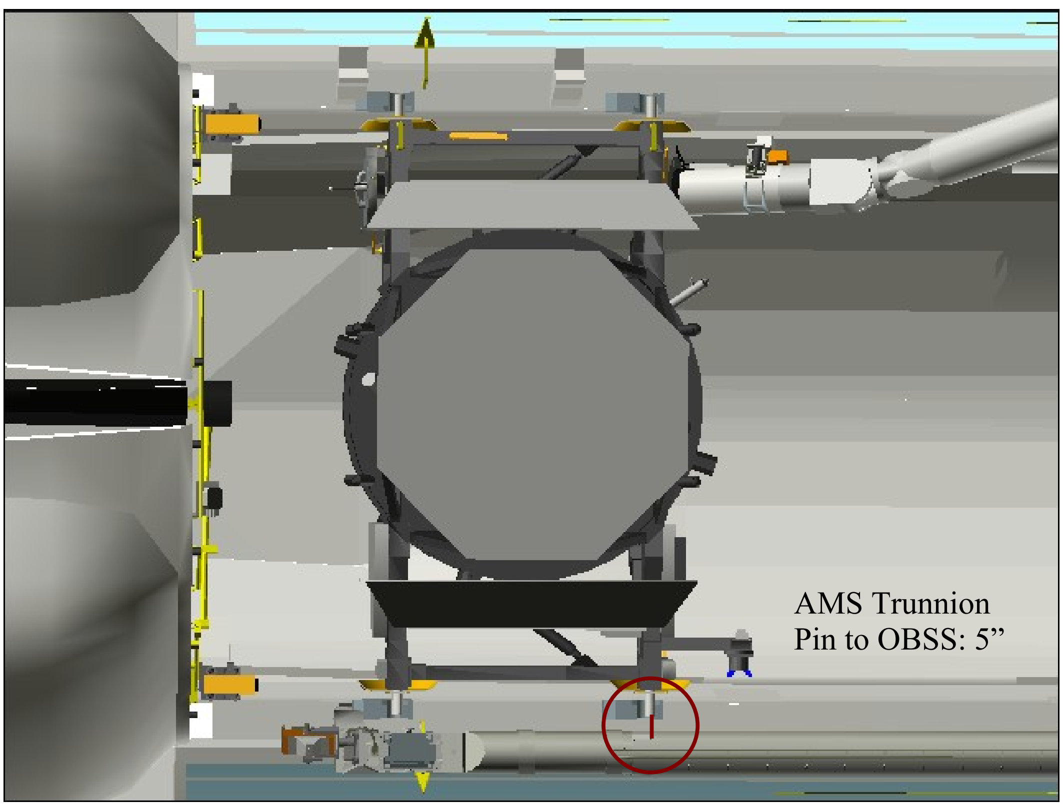

Figure 8: Clearance Between AMS and OBSS During AMS Unberth
View Looking Orbiter Nadir

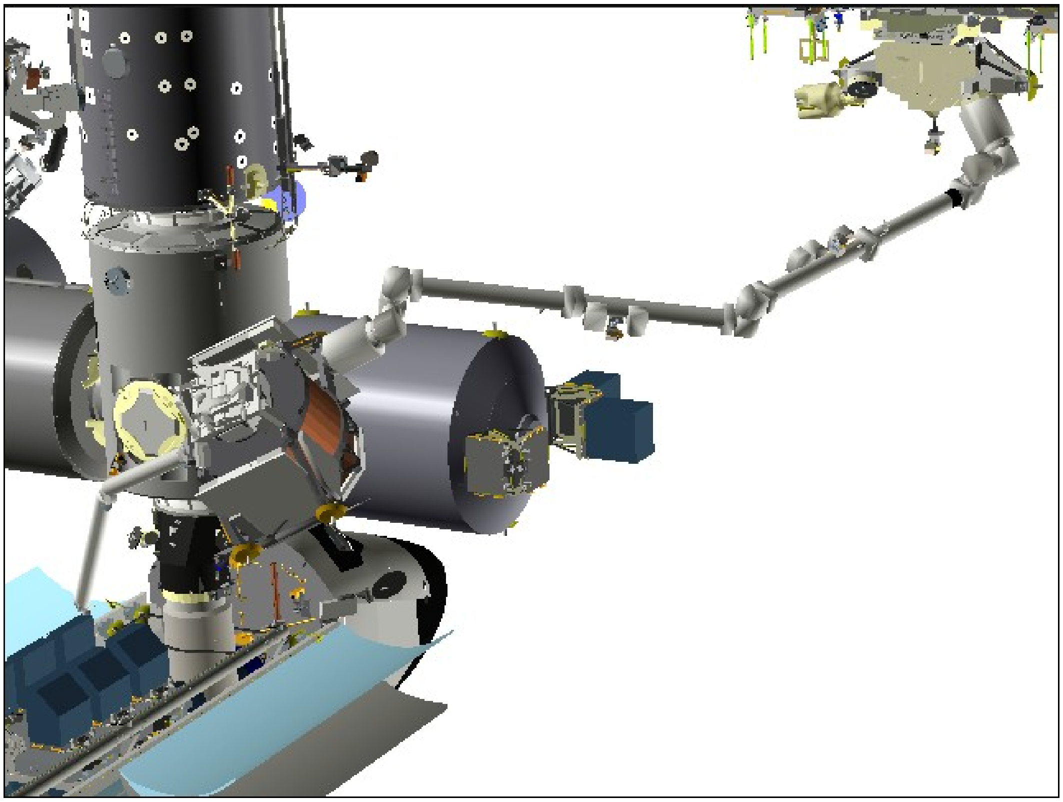

Figure 9: AMS Handoff from SRMS to SSRMS
View Looking ISS Forward-Port-Zenith

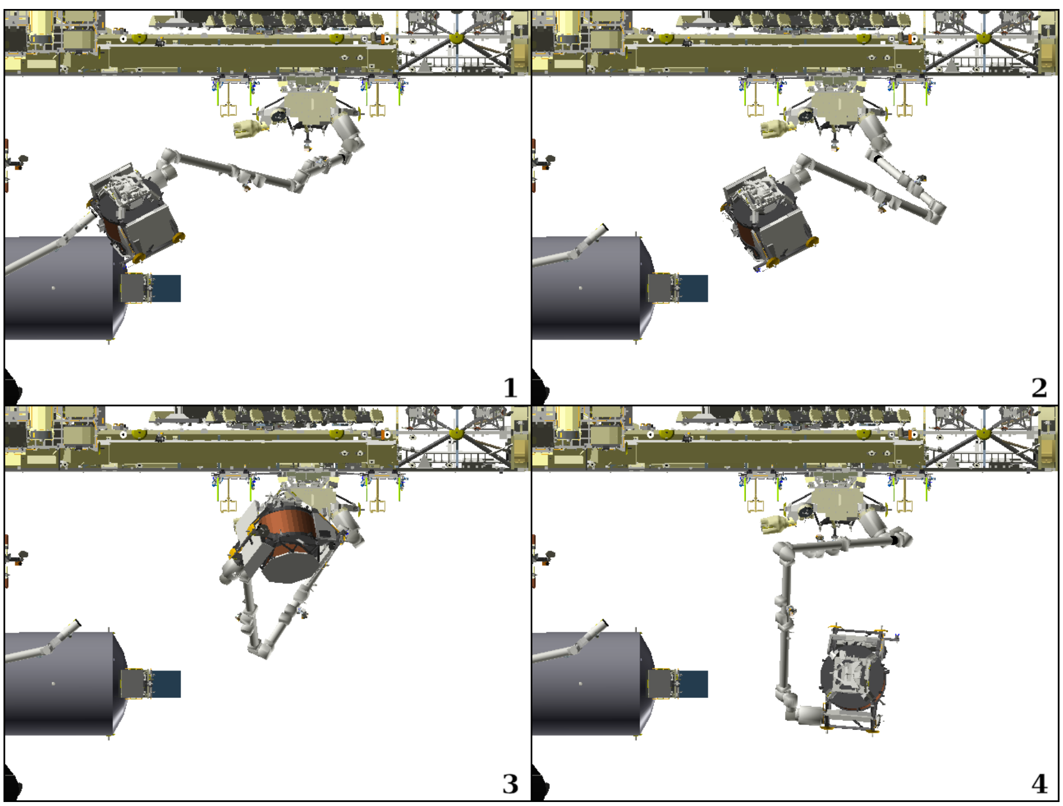

Figure 10: AMS Grapple by SSRMS and Move Toward AMS Install
View Looking ISS Zenith

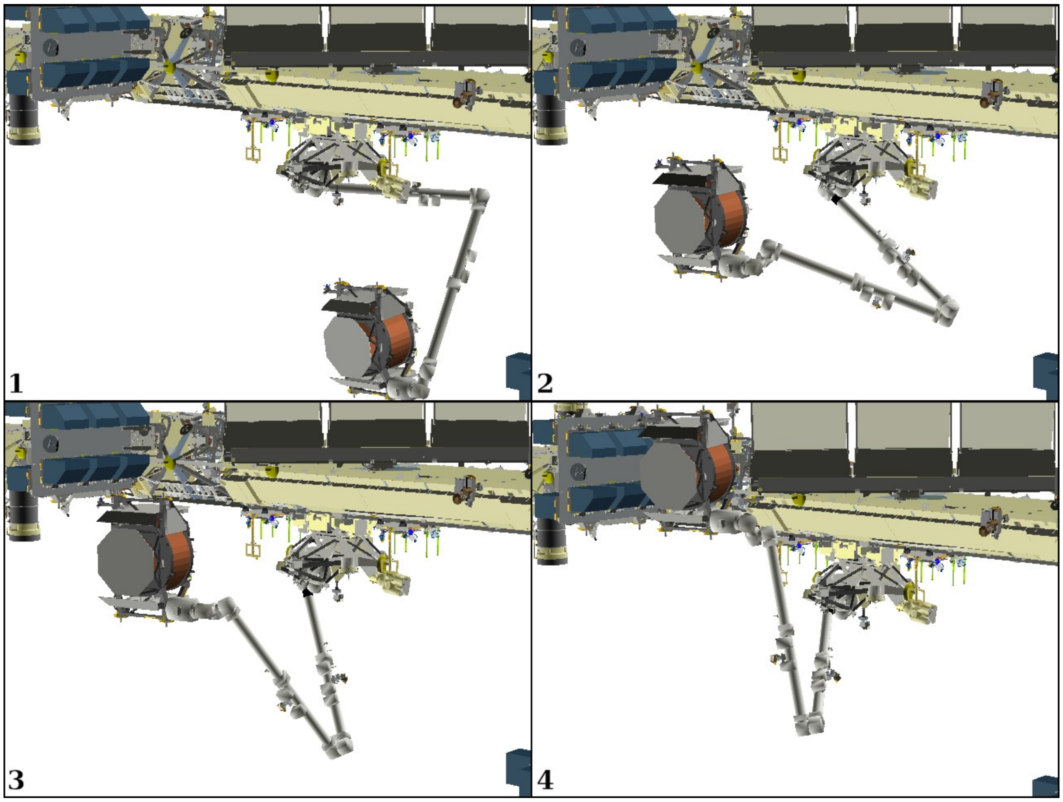

Figure 11: AMS install to S3 Inboard Upper PAS Site
View Looking ISS Starboard-Forward-Nadir (Clipped for Clarity)

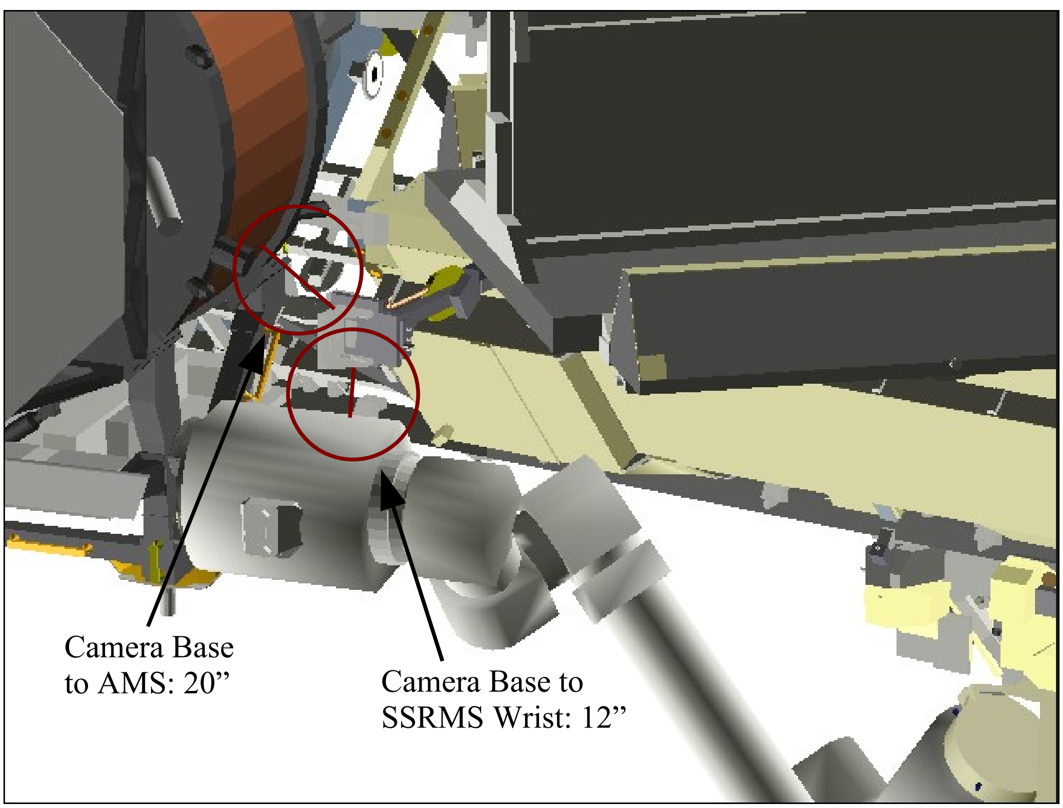

Figure 12: Close Clearance Between SSRMS Wrist and Camera Port
View Looking ISS Starboard-Forward-Nadir (Clipped for Clarity)

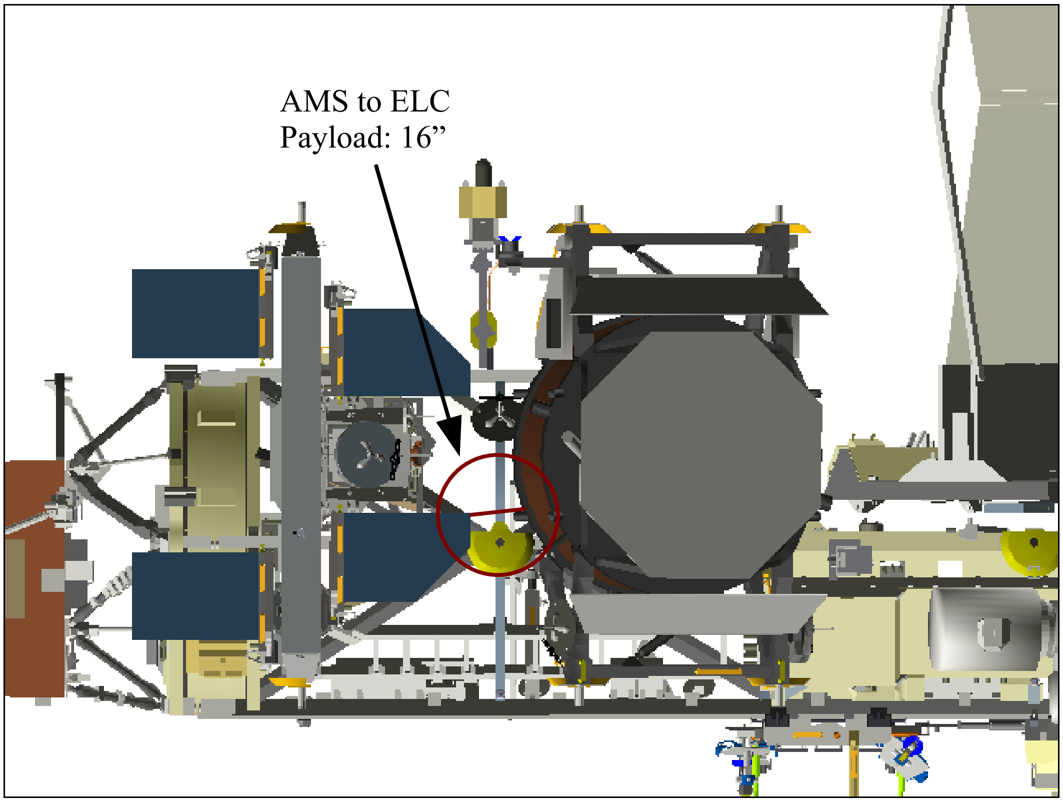

Figure 13: Close Clearance Between AMS and ELC Generic Payload
View Looking ISS Nadir

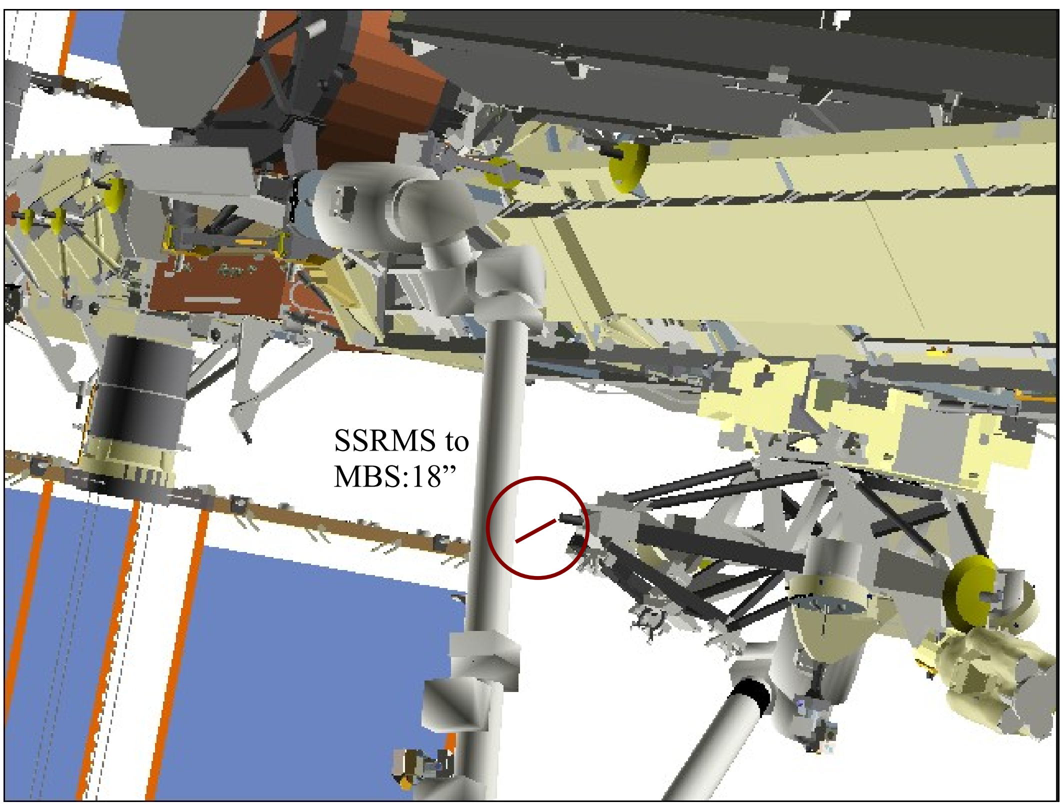

Figure 14: Close Clearance Between SSRMS and MBS
View Looking ISS Starboard-Aft-Nadir

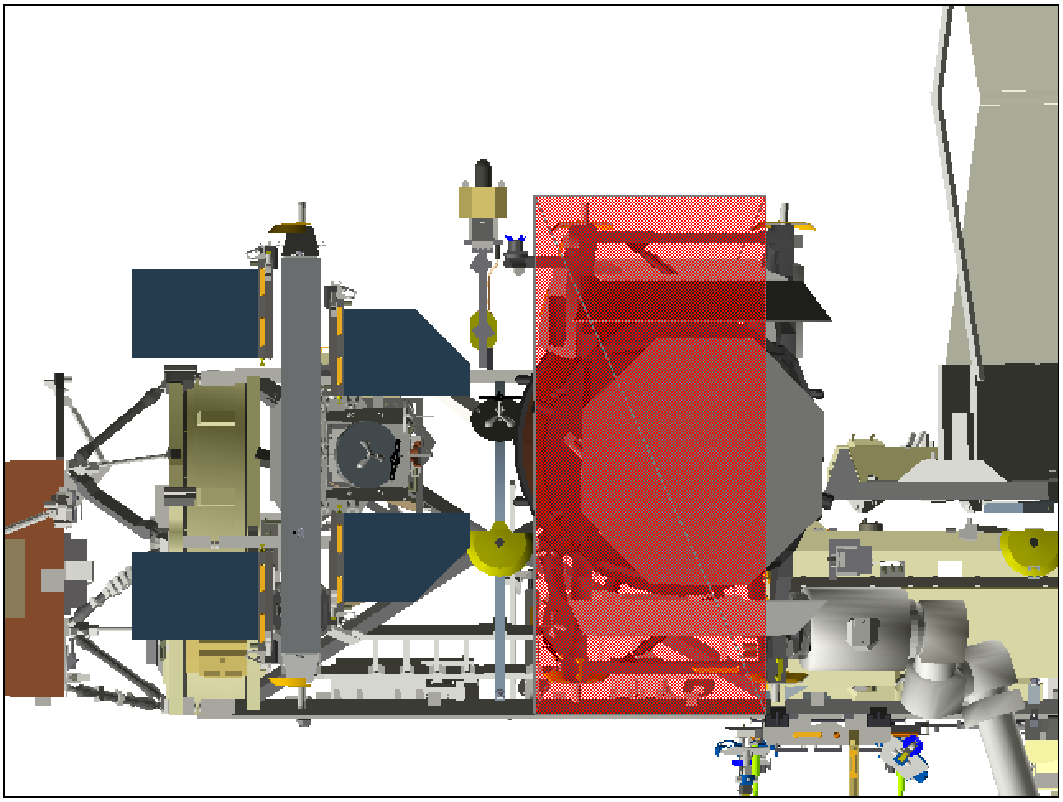

Figure 15: AMS Violation of S3 Attached Payload Envelope
View Looking ISS Nadir