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RE: Misalignment Clearances Between AMS and ELC During Berthing, Revision A

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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)

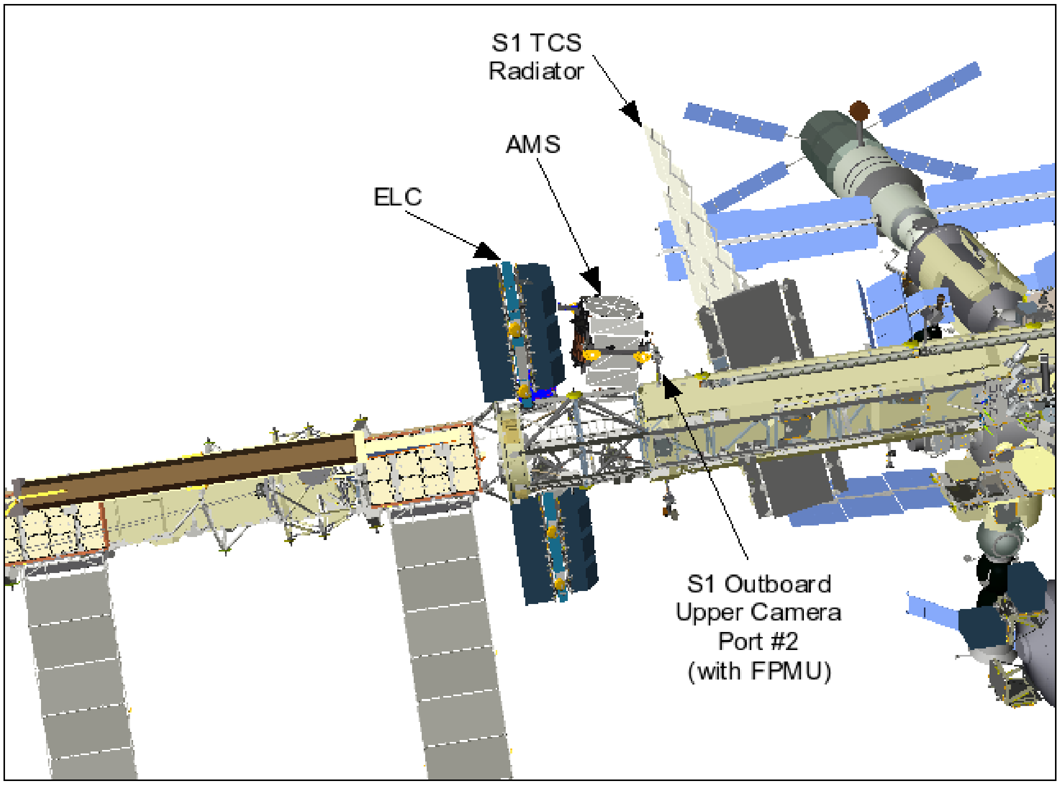

Figure 1: Overall View of AMS and the ELC Installed on S3
(Both Fully Berthed, No Misalignments)
View Looking ISS Aft, Port and Nadir

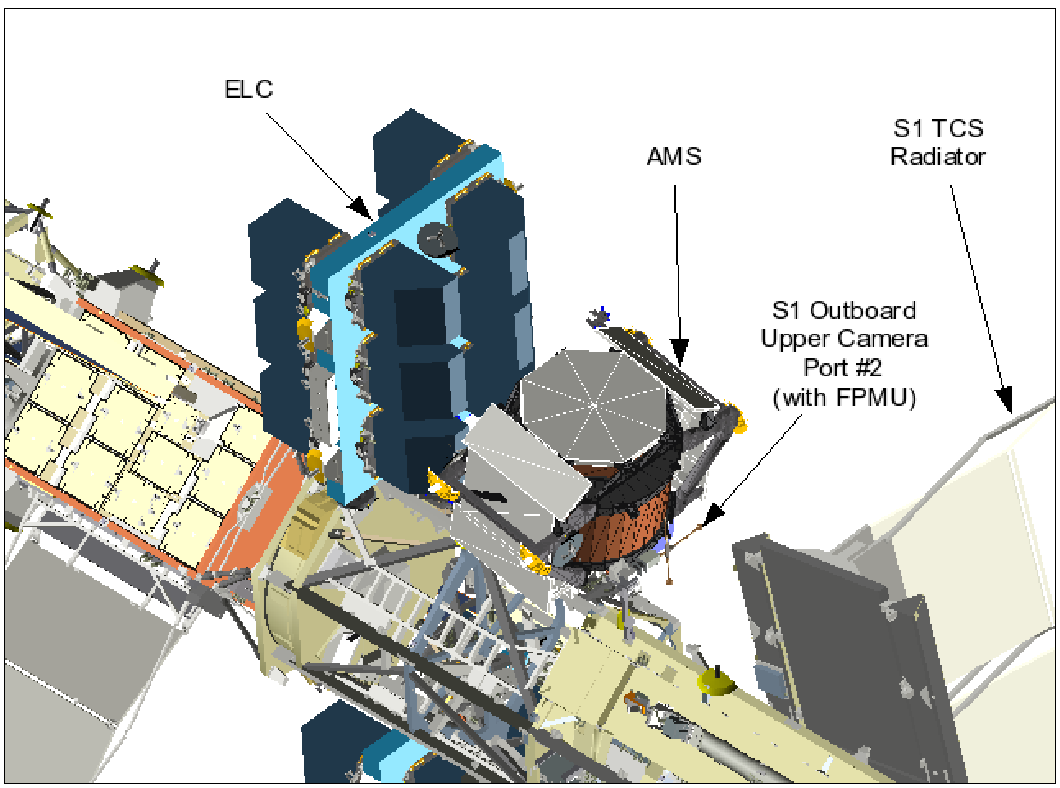

Figure 2: Overall View of AMS and the ELC Installed on S3
(Both Fully Berthed, No Misalignments)
View Looking ISS Aft, Starboard and Nadir

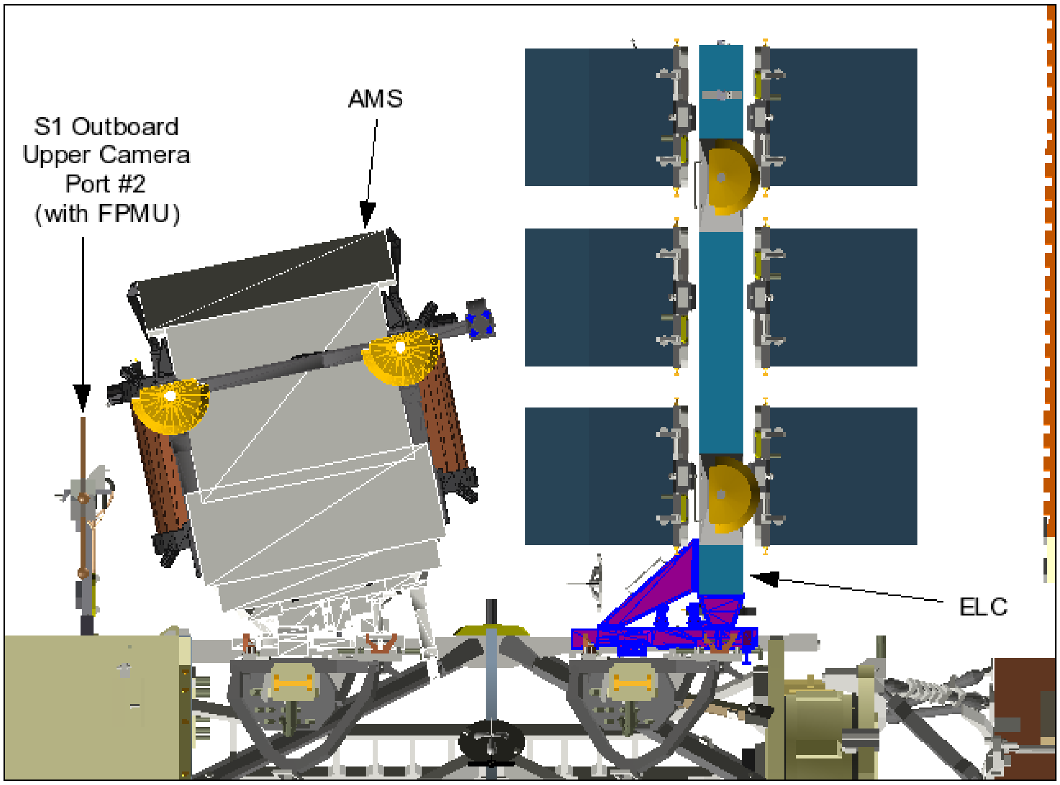

Figure 3: AMS and the ELC Installed on S3
(Both Fully Berthed, No Misalignments)
View Looking ISS Forward

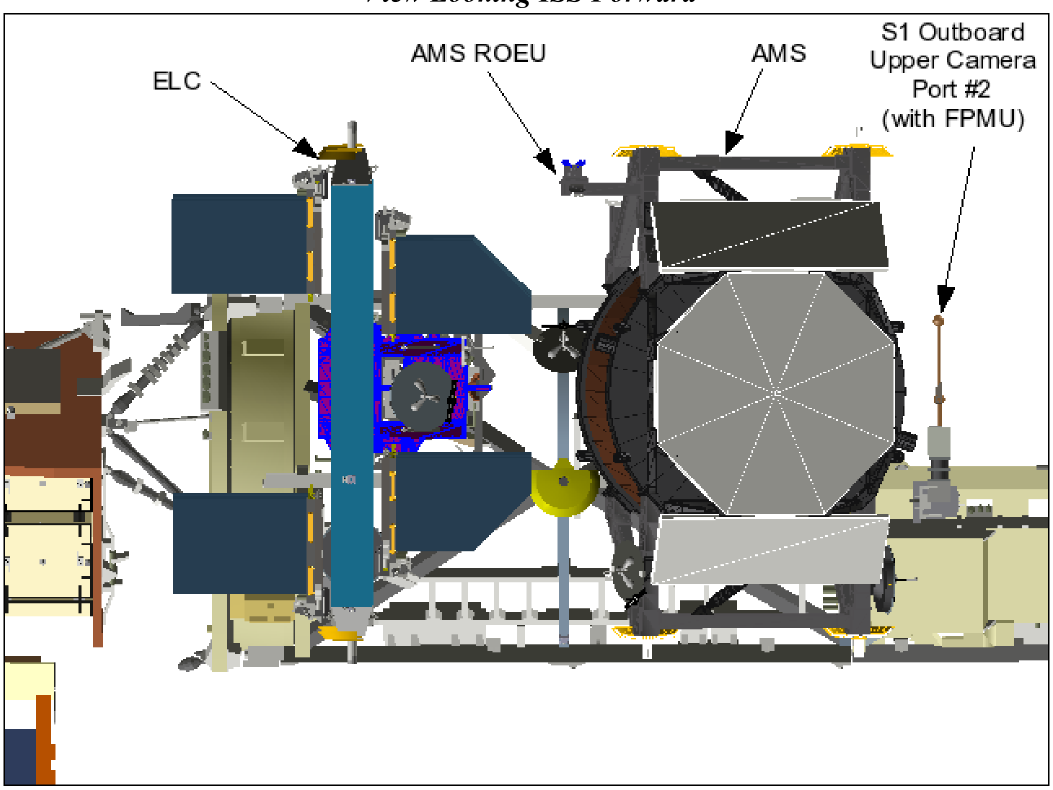

Figure 4: AMS and the ELC Installed on S3
(Both Fully Berthed, No Misalignments)
View Looking ISS Nadir
View Clipped for Clarity

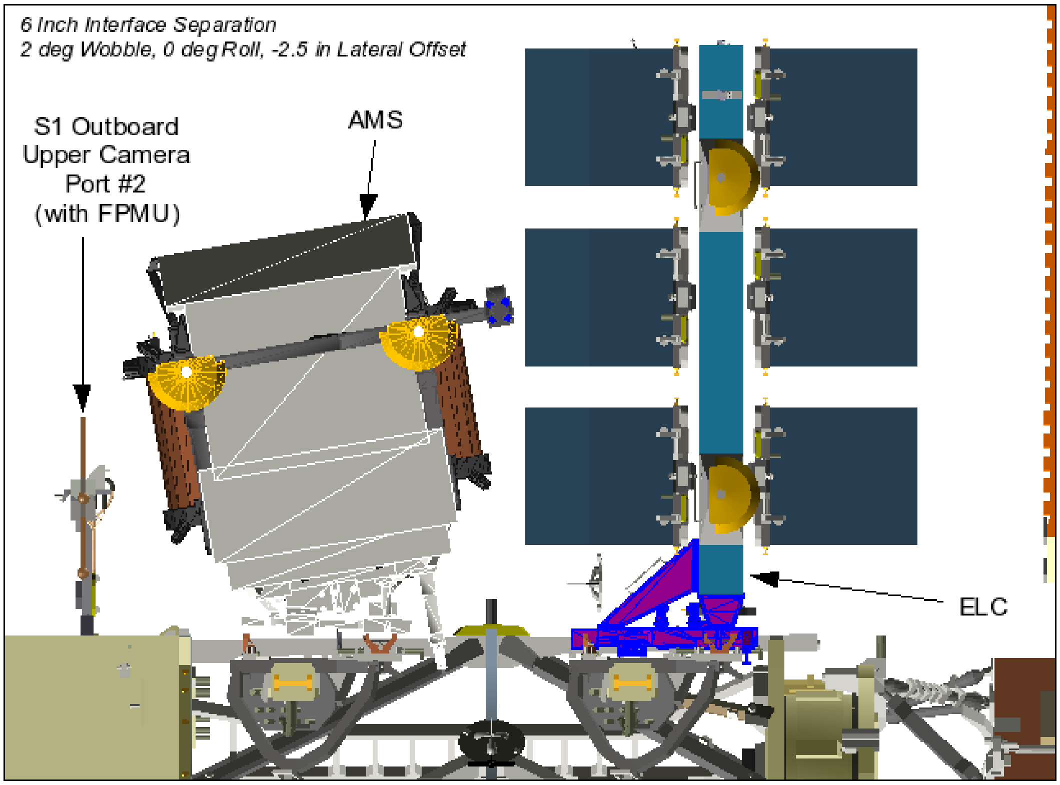

Figure 5: AMS and the ELC Installed on S3
(AMS Misaligned, ELC Fully Berthed with No Misalignments)
View Looking ISS Forward

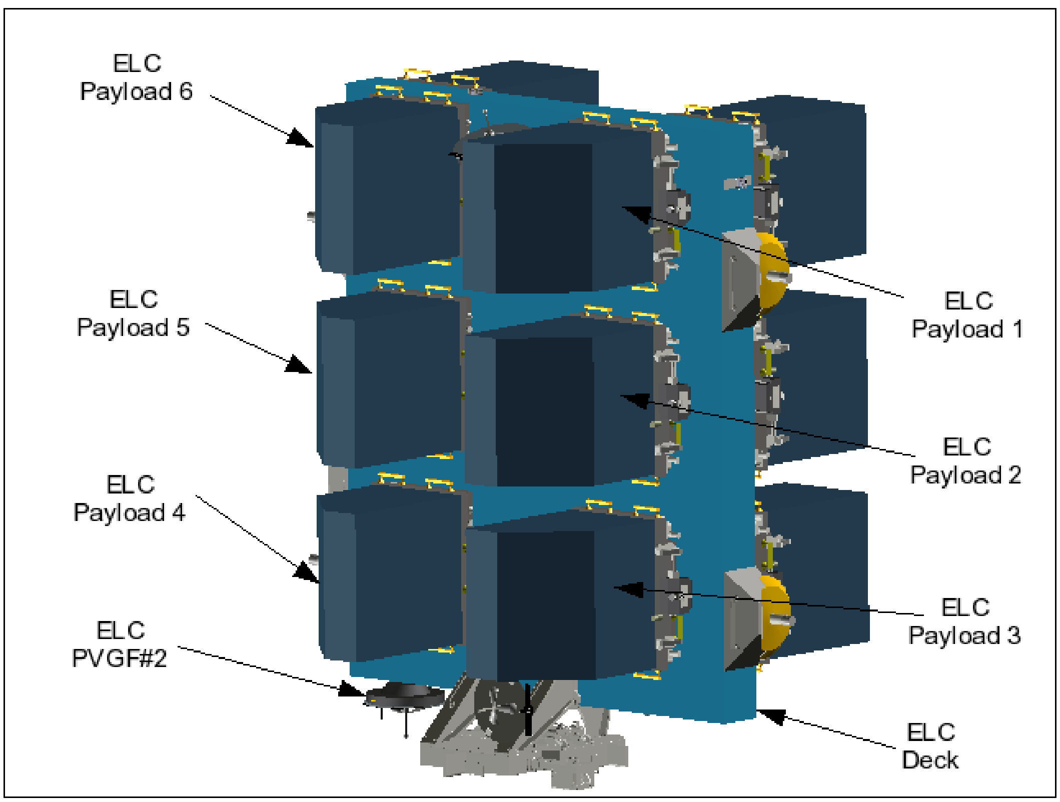

Figure 6: Orientation of ELC Payloads on ELC

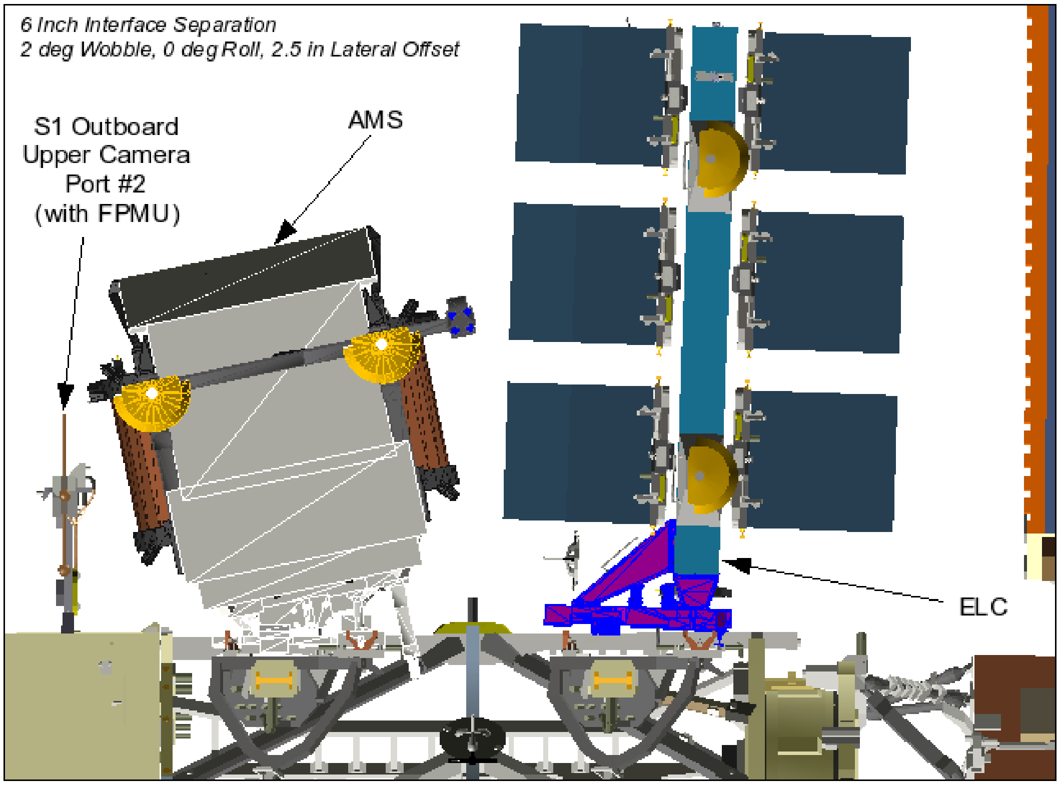

Figure 7: AMS and the ELC Installed on S3
(AMS Fully Berthed with No Misalignments, ELC Misaligned)
View Looking ISS Forward

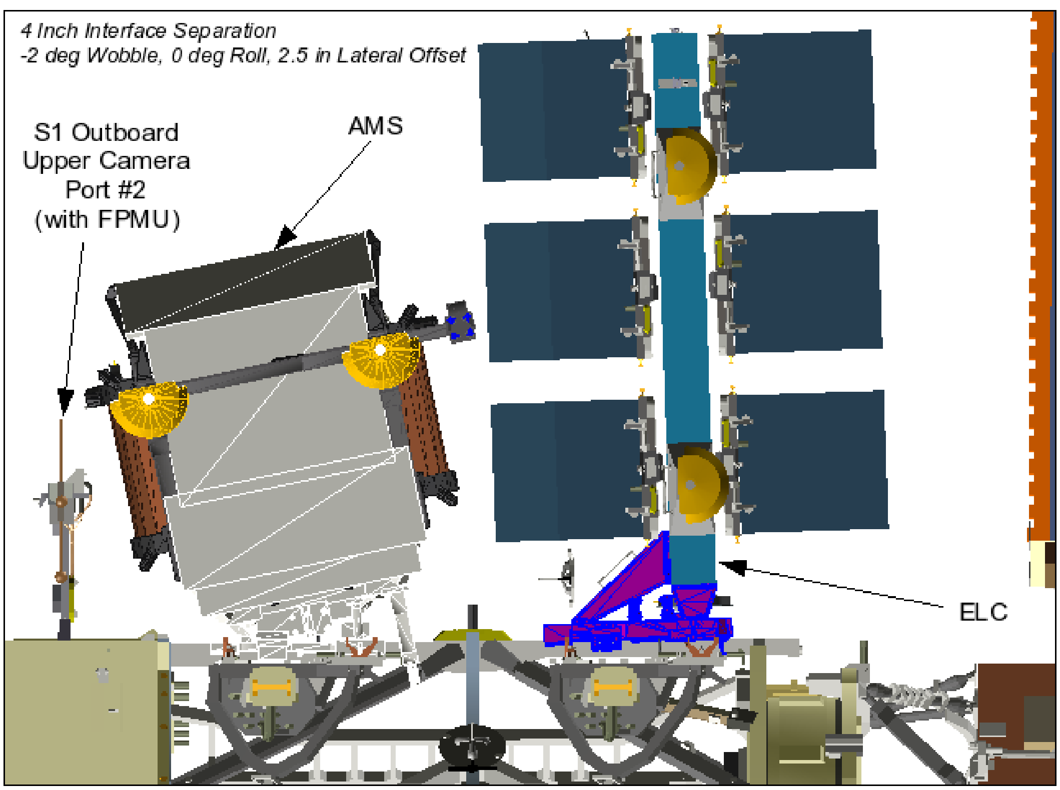

Figure 8: AMS and the ELC Installed on S3
(AMS Fully Berthed with No Misalignments, ELC Misaligned)
View Looking ISS Forward

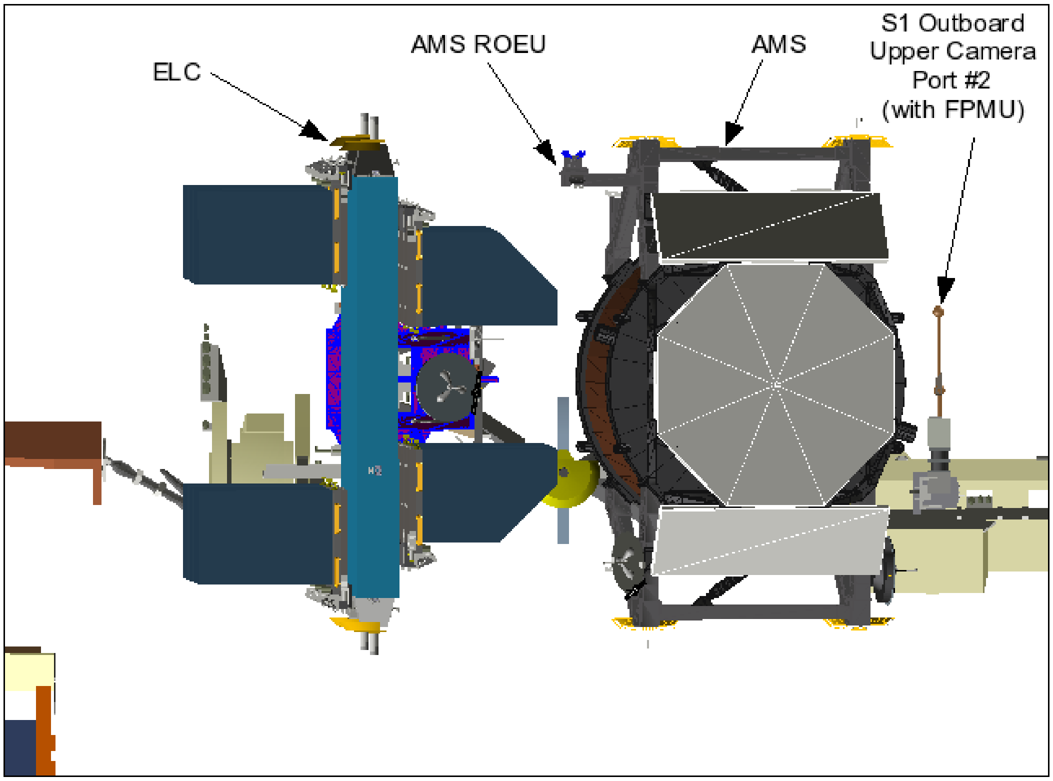

Figure 9: AMS and the ELC Installed on S3
(AMS Fully Berthed with No Misalignments, ELC Misaligned)
View Looking ISS Nadir
View Clipped for Clarity