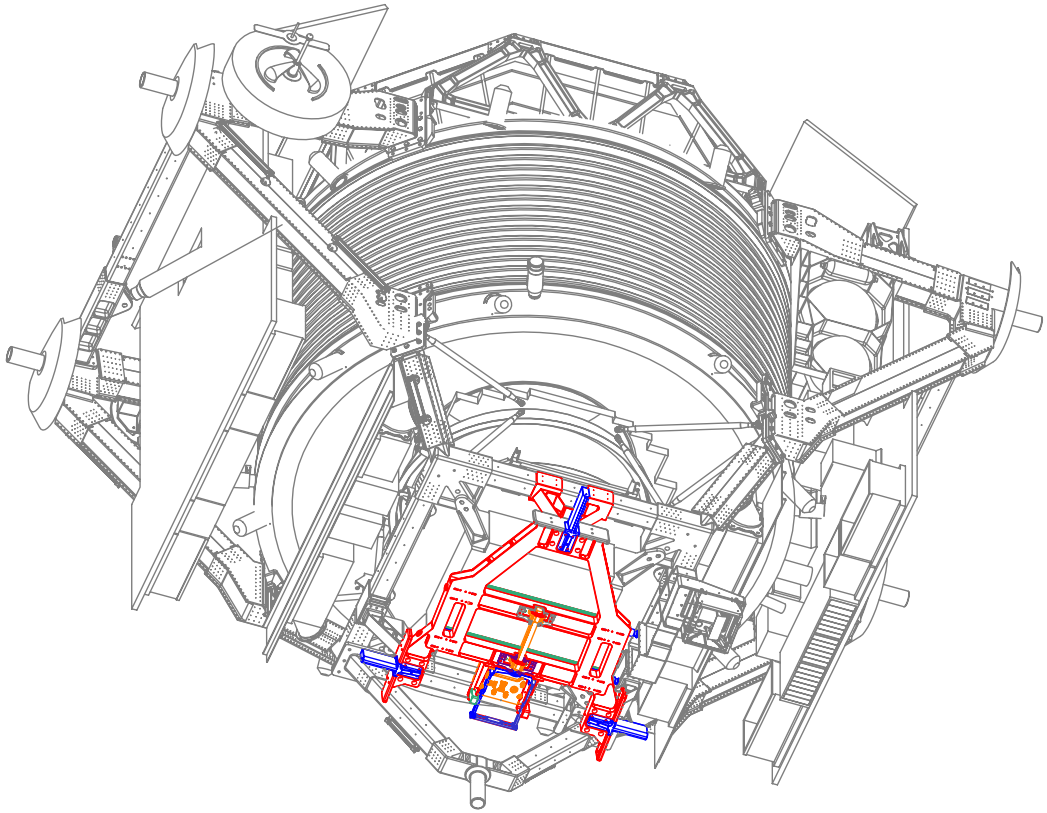
AMS-02 PASSIVE PAS MECHANICAL DESIGN



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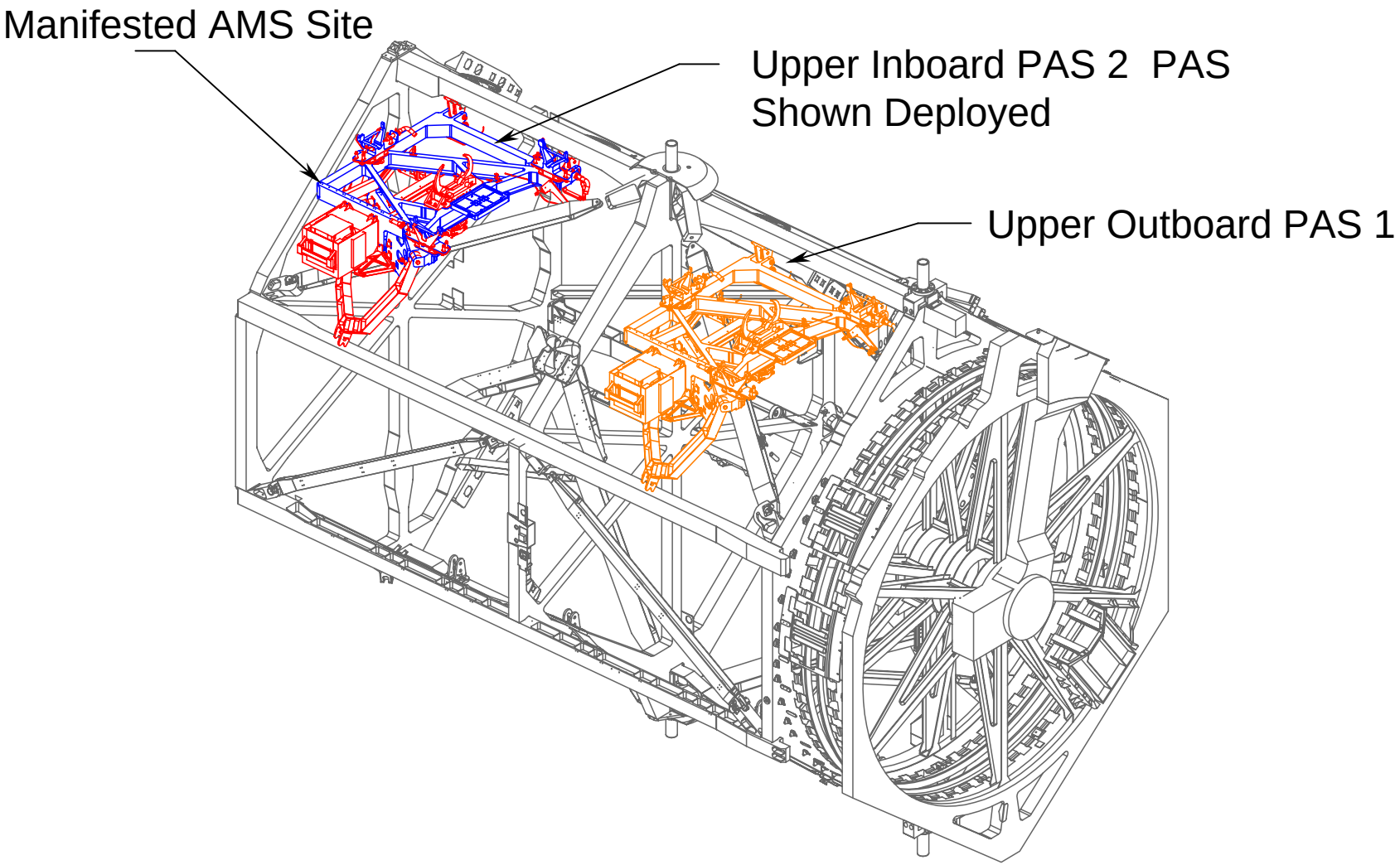
ISS INTERFACE REVIEW:
INTEGRATED TRUSS SEGMENT S3



S3 Truss Segment Iso View: Upper PAS Sites

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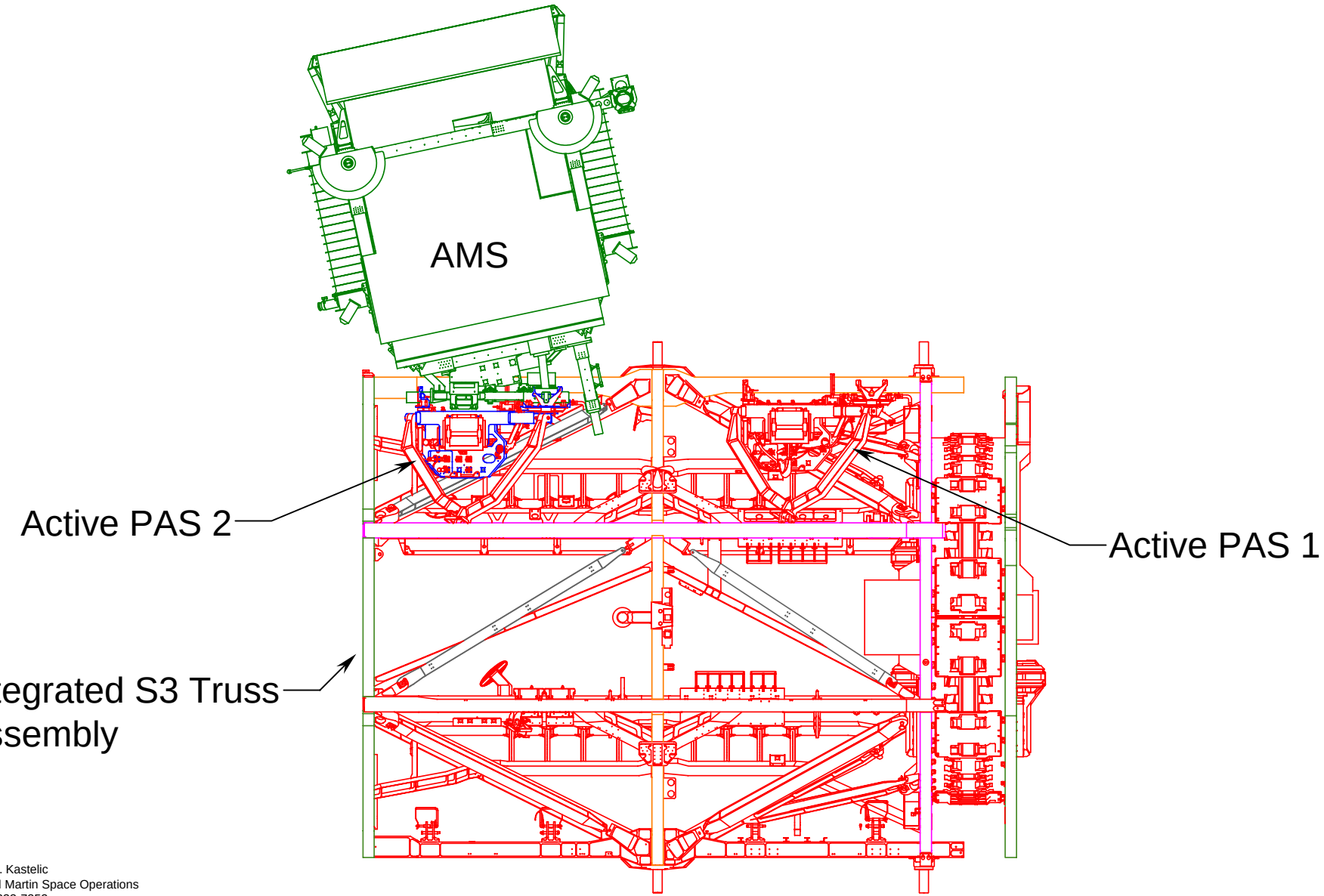
ISS INTERFACE REVIEW:
INTEGRATED TRUSS SEGMENT (ITS) S3



S3 Truss Segment Ortho View: Upper PAS Sites

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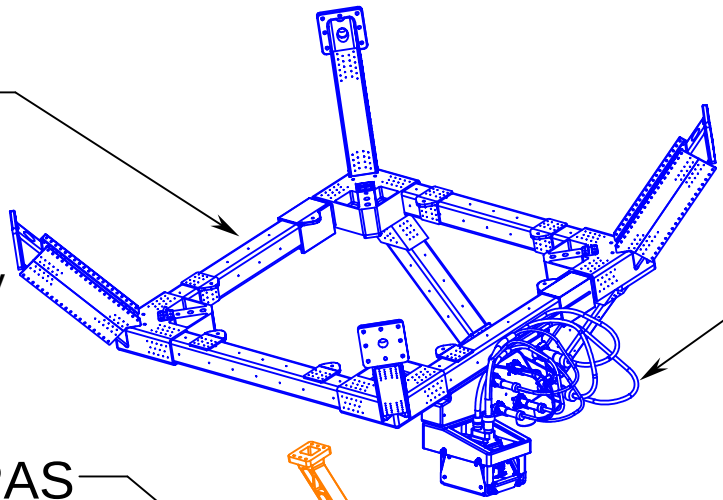
COMPONENTS OF THE COMMON ATTACH SYSTEM (CAS)

LOCKHEED MARTIN

Lower USS

Mounting Structure For Passive PAS and UMA Assembly

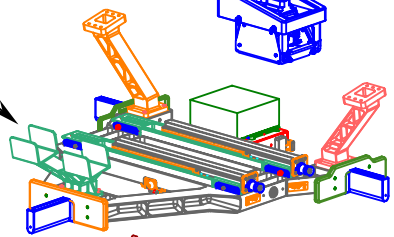


Passive UMA

Umbilical Mechanism Assembly: Payload Interface to Station Electrical Services

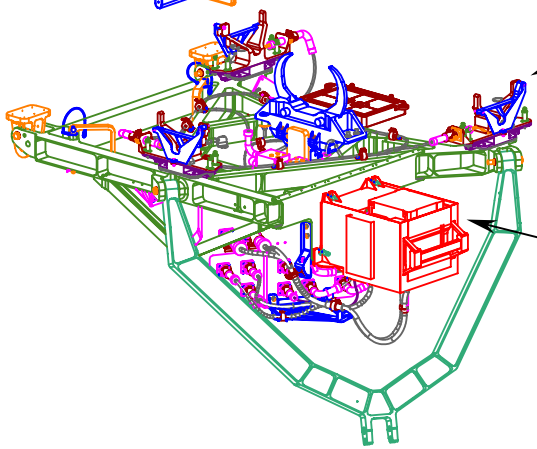
AMS Passive PAS

Payload Interface Platform



Active PAS

Interface Platform to ISS



Active UMA

ISS Power and Data Services Provider

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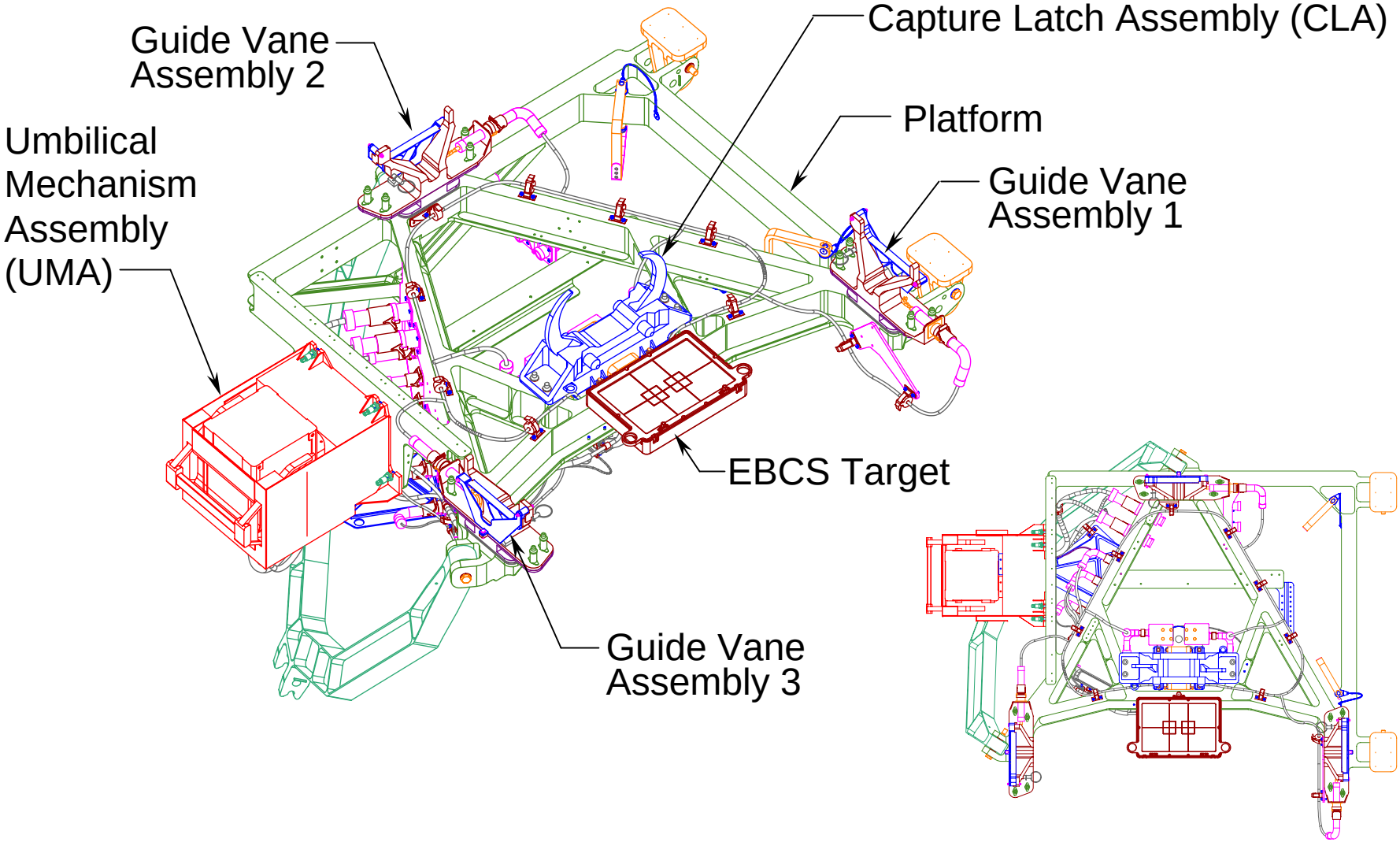
COMPONENTS OF THE CAS SYSTEM
ACTIVE PAS GEOMETRY



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PASSIVE PAS FUNCTION

- Payload half of the Common Attachment System (CAS)
- Apparatus to Berth and fix AMS payload to ISS S3 Active PAS site 2
- Provides Interface to station Power/Data Services via UMA
- Provides method of Payload Removal as a Contingency Operation.
- Provides Mounting Platform for the Berthing Cues Avionics Package.

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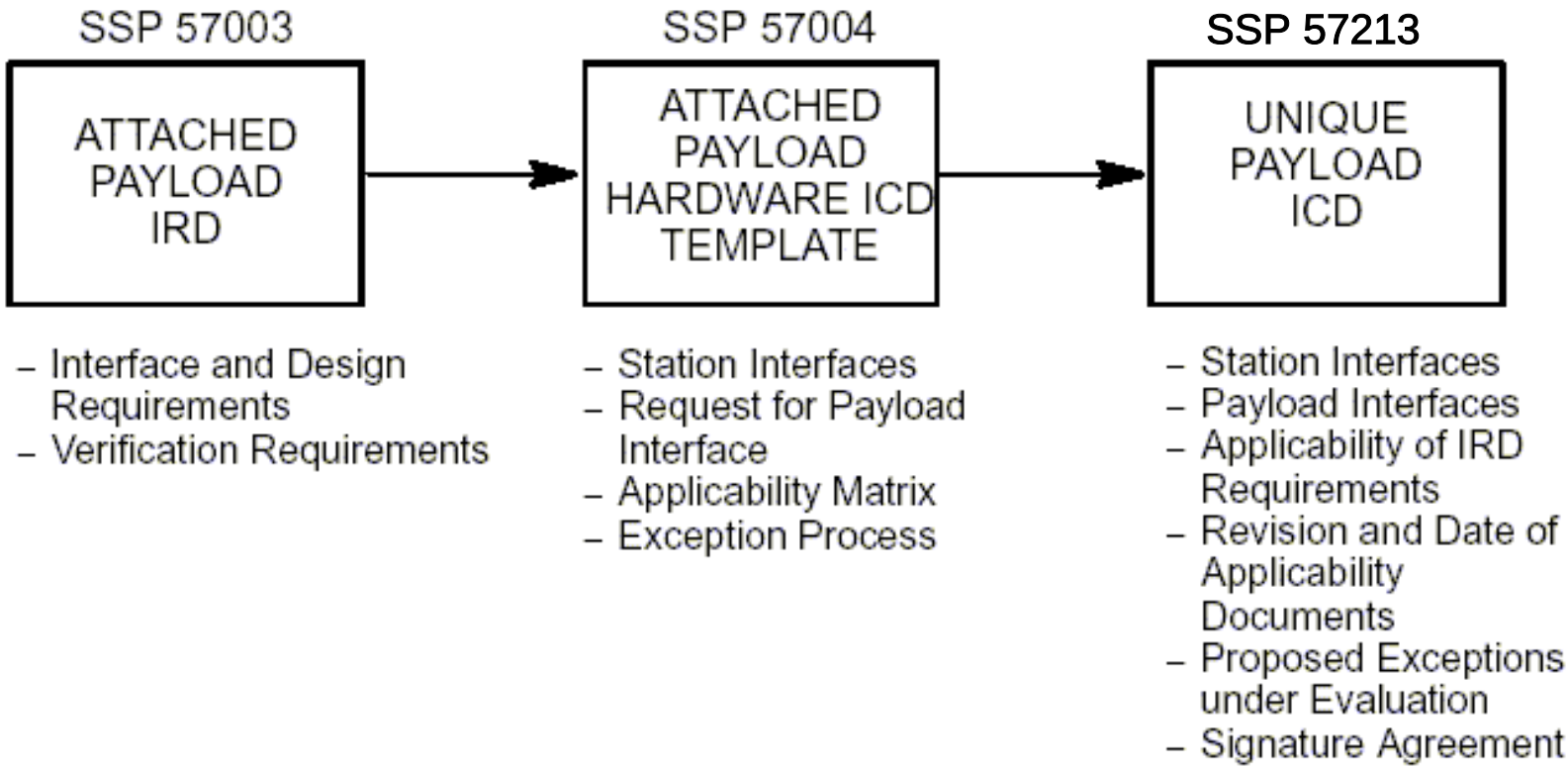
PRIMARY REQUIREMENTS DOCUMENTS



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SUMMARY OF INTERFACE REQUIREMENTS AND DESIGN CRITERIA

- Provide an Interface Platform that conforms to the physical envelope defined in SSP 57004 section 3.1.2.2 Figure 3.1.2.2-1.
  - Overall Geometric sizing and tolerances
  - Three Guide Pins to I/F Guide Vane Assemblies (GVA)
  - Three Scuff Plates to facilitate Payload Berthing
  - Provide a Capture Bar with adherence to size and position requirements
- Design shall produce a platform conforming to the Stiffness Criteria as defined in SSP 57003 Section 3.1.3.1.3.2
  - Stiffness shall be 13500 lb/in +/- 10%
- Design Shall provide for an Unloadable Releasable Capture Bar.
- Design shall use a Passive UMA part number 1F70162-1 to interface the active UMA. Positioned to SSP 57004
- Design shall utilize an EBCS Avionics Assembly part number 202918-1 to support SSRMS (Space Station Remote Manipulator System) Berthing Operations. SSP57003 section 3.7.6.1

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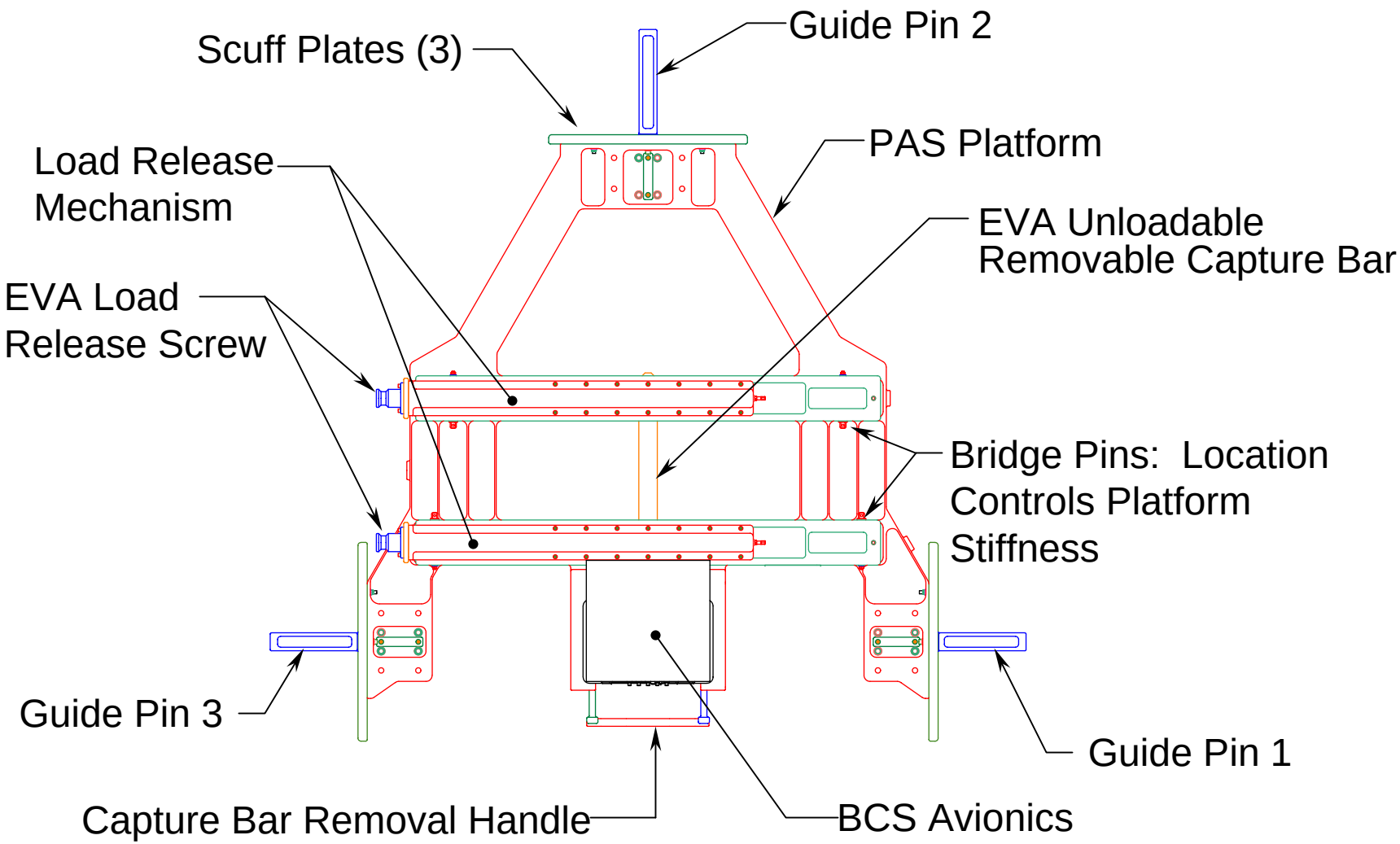
AMS PASSIVE PAS ASSEMBLY
HARDWARE DESCRIPTION: Key Features



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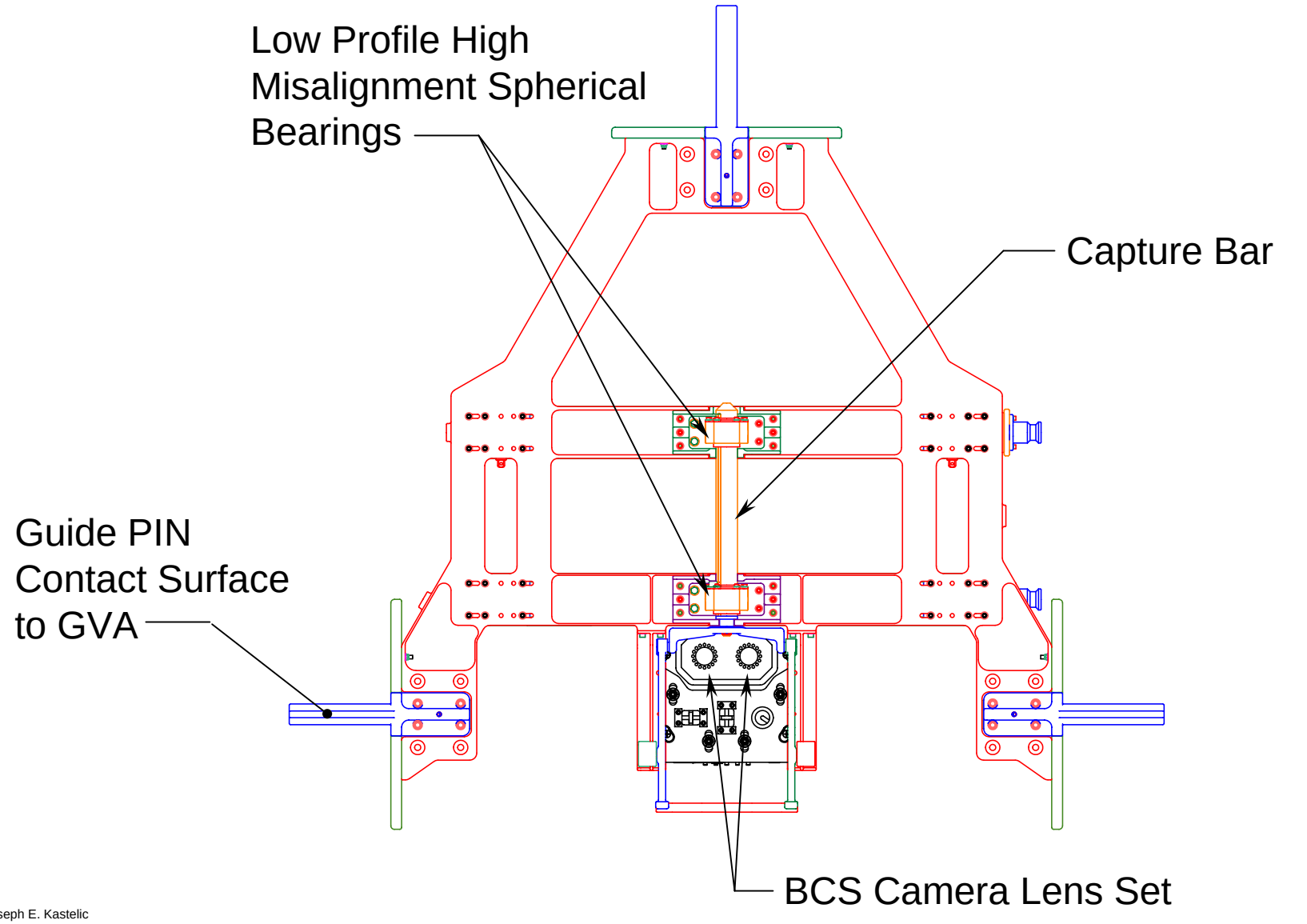
AMS PASSIVE PAS ASSEMBLY
HARDWARE DESCRIPTION



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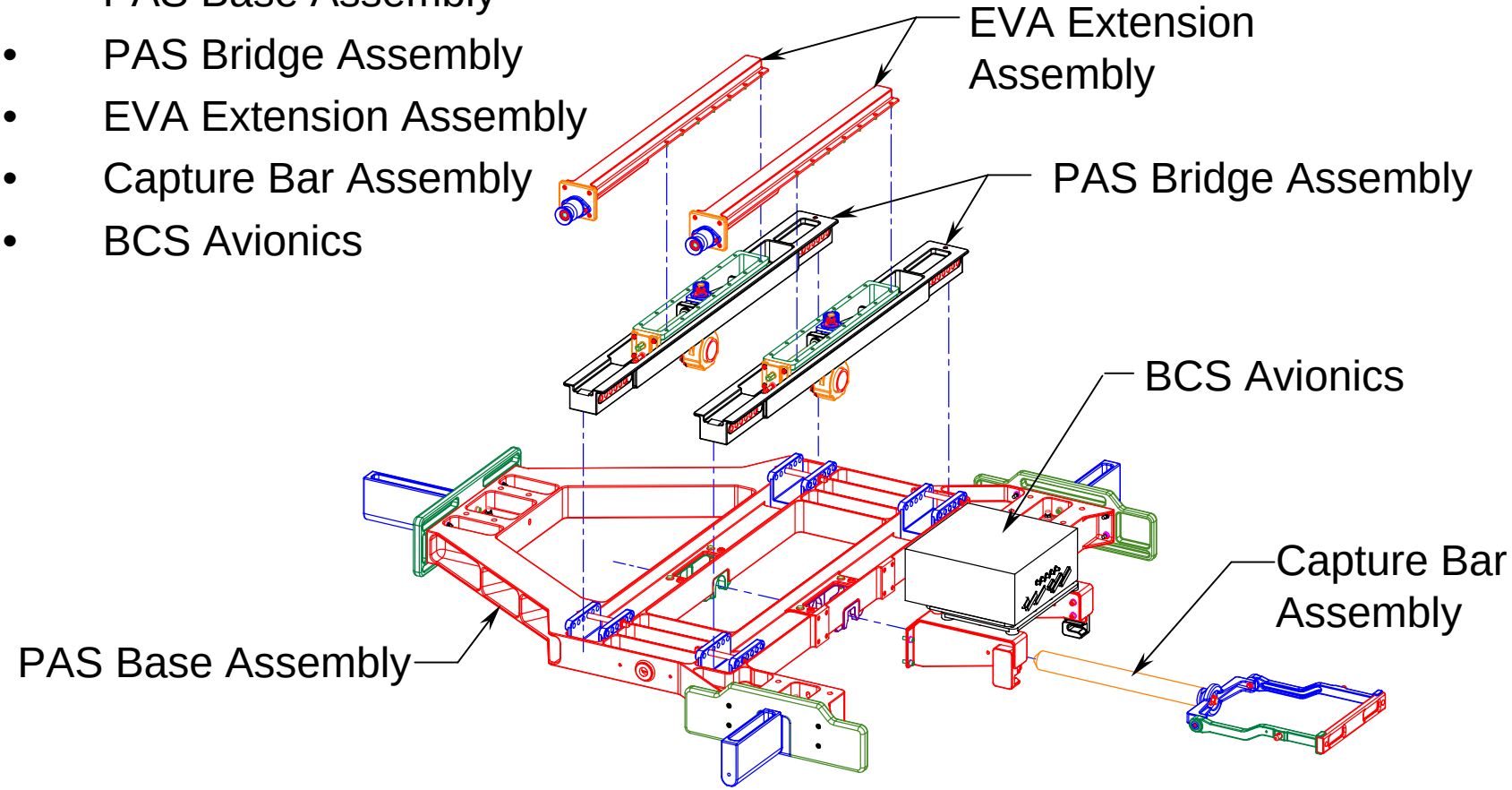
AMS PASSIVE PAS ASSEMBLY
HARDWARE DESCRIPTION

AMS Passive PAS is composed of 5 primary sub-assemblies

- PAS Base Assembly
- PAS Bridge Assembly
- EVA Extension Assembly
- Capture Bar Assembly
- BCS Avionics



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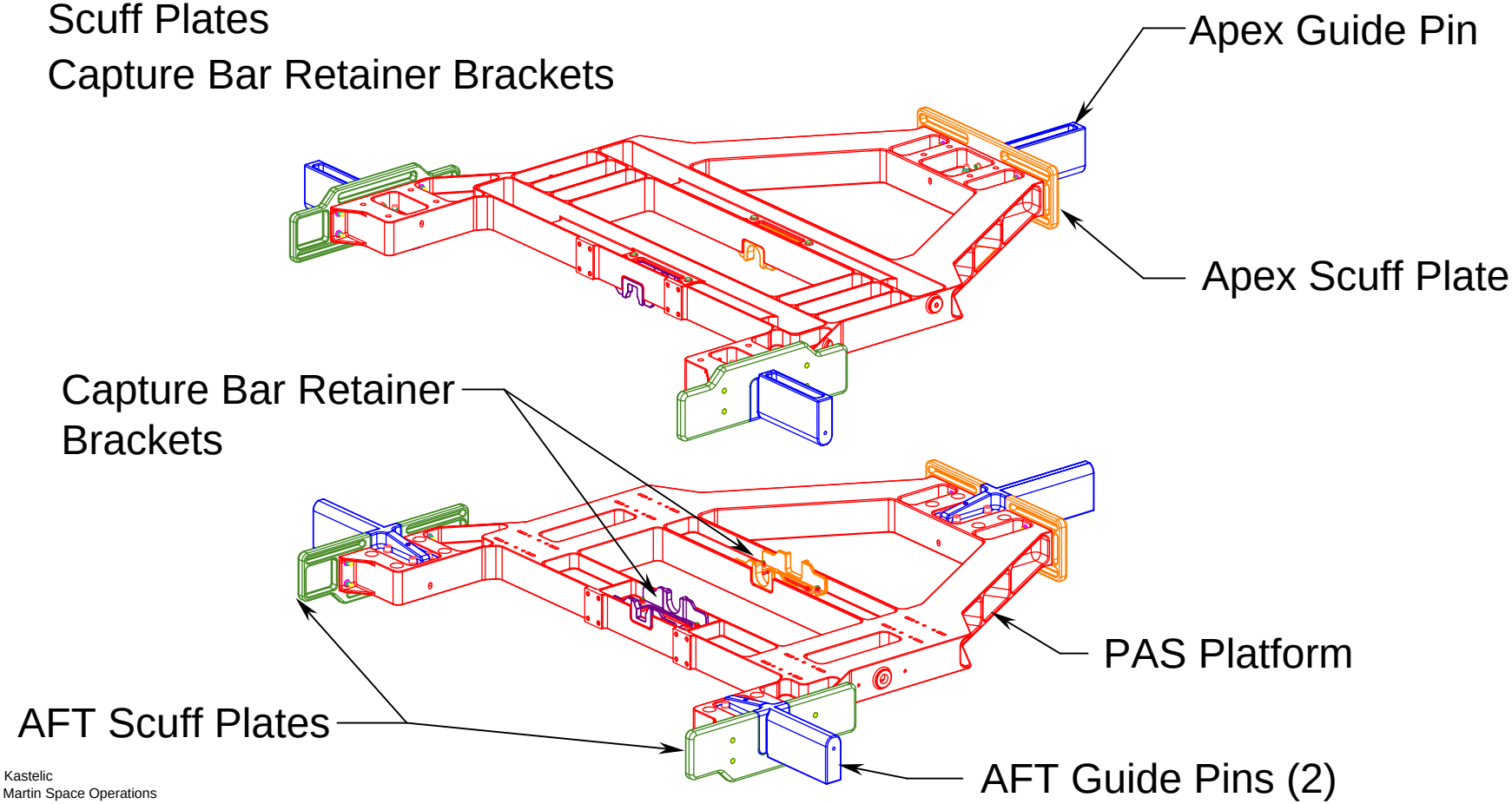
AMS PASSIVE PAS ASSEMBLY
HARDWARE DESCRIPTION
PAS BASE ASSEMBLY

PAS Base Assembly Components

- PAS Platform
- Guide Pins
- Scuff Plates
- Capture Bar Retainer Brackets



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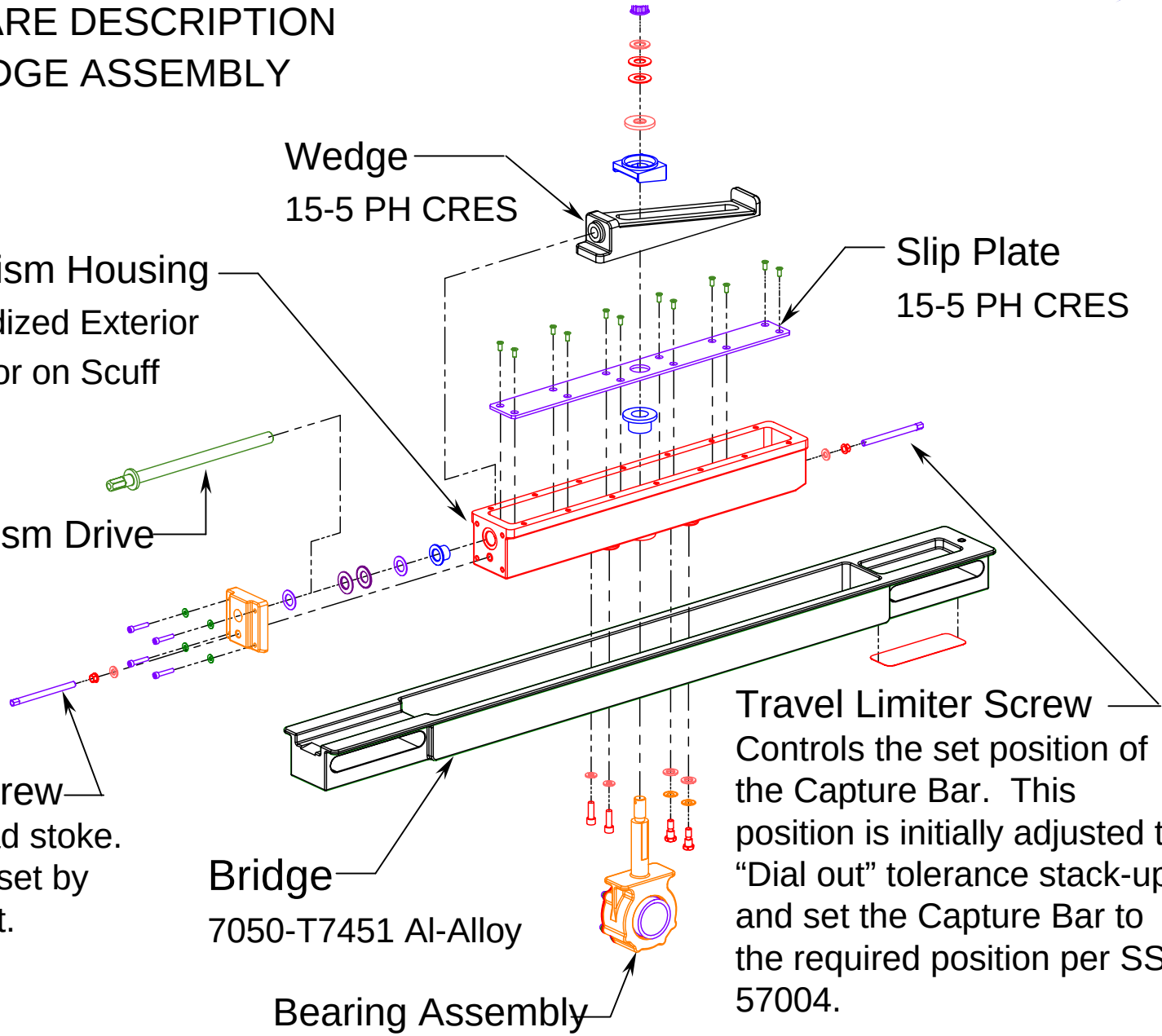
AMS PASSIVE PAS ASSEMBLY
HARDWARE DESCRIPTION
PAS BRIDGE ASSEMBLY



Wedge
15-5 PH CRES

Release Mechanism Housing
7075 Al-Alloy, Anodized Exterior
Nickel Plated Interior on Scuff Surfaces

Slip Plate
15-5 PH CRES

Release Mechanism Drive Screw
½-20UNF-3A
A286 Alloy Steel

Travel Limiter Screw
Controls the off-load stoke. This position is preset by unload requirement.

Bridge
7050-T7451 Al-Alloy

Bearing Assembly

Travel Limiter Screw
Controls the set position of the Capture Bar. This position is initially adjusted to "Dial out" tolerance stack-ups and set the Capture Bar to the required position per SSP 57004.

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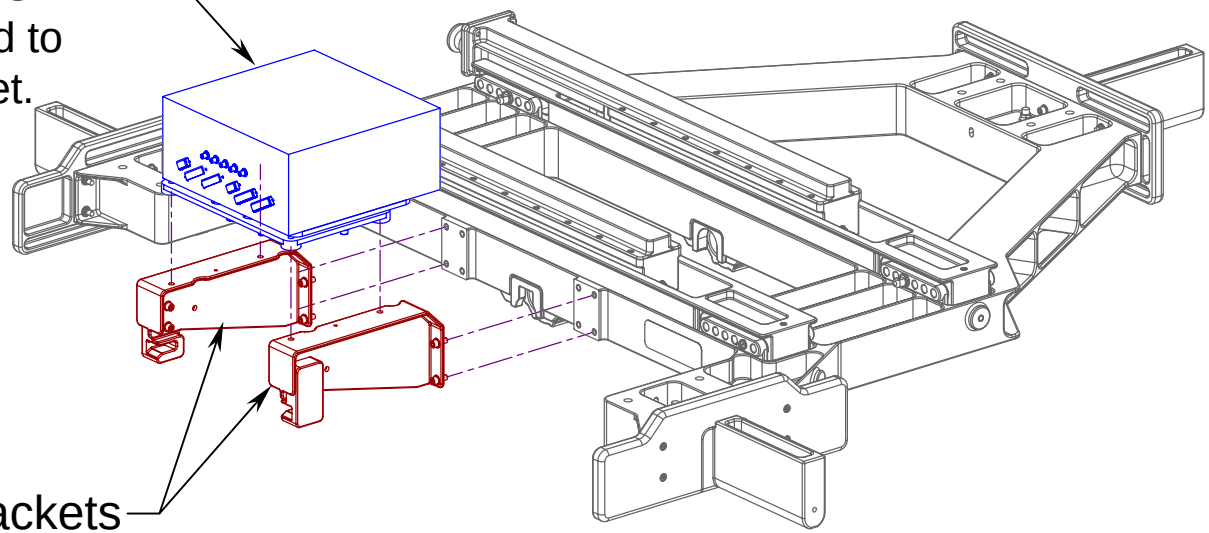
EXTERNAL BERTHING CUES SYSTEM (EBCS) AVIONICS PACKAGE

BCS Avionics Package

Mounted to AMS Passive PAS assembly. Camera is aligned to comply with BCS error budget.



BCS Camera Mounting Brackets

Designed and toleranced to comply with SSP 57004 hole mounting pattern.

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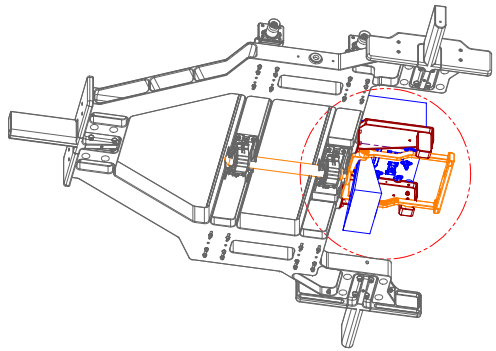
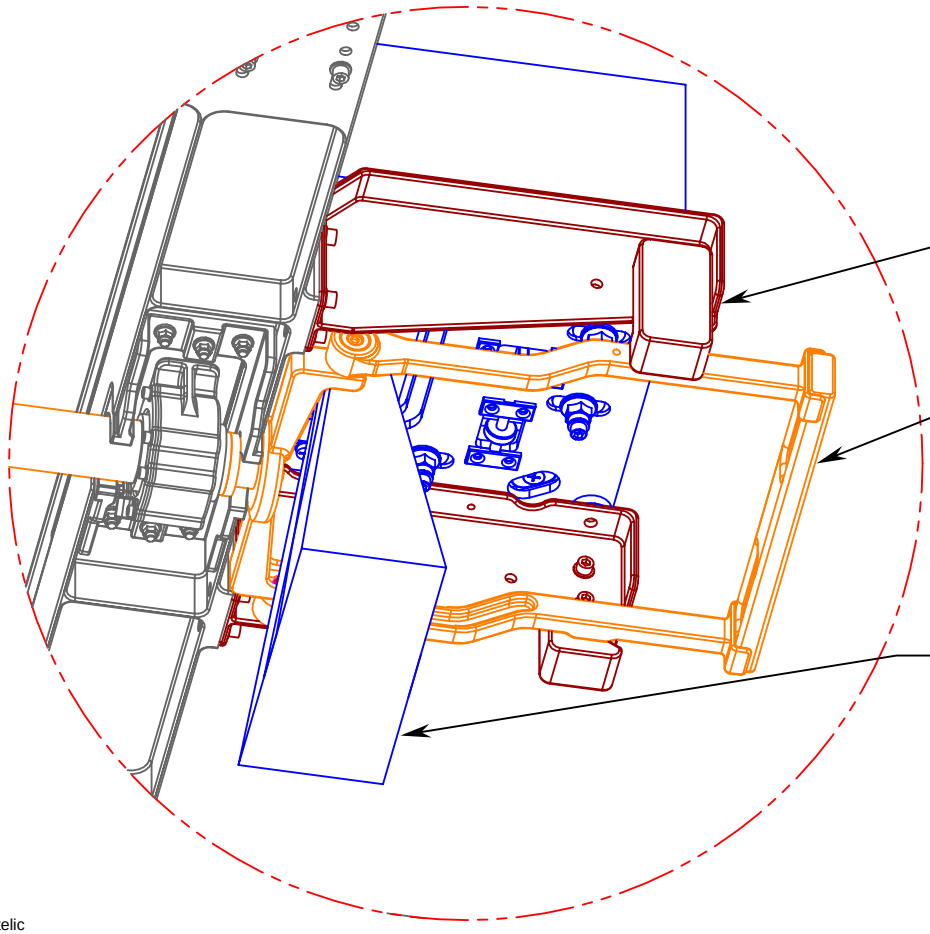
EXTERNAL BERTHING CUES SYSTEM (EBCS) AVIONICS PACKAGE





- SSP 57003 defines keep out zone for FOV
- Capture Bar Handle bypasses camera FOV

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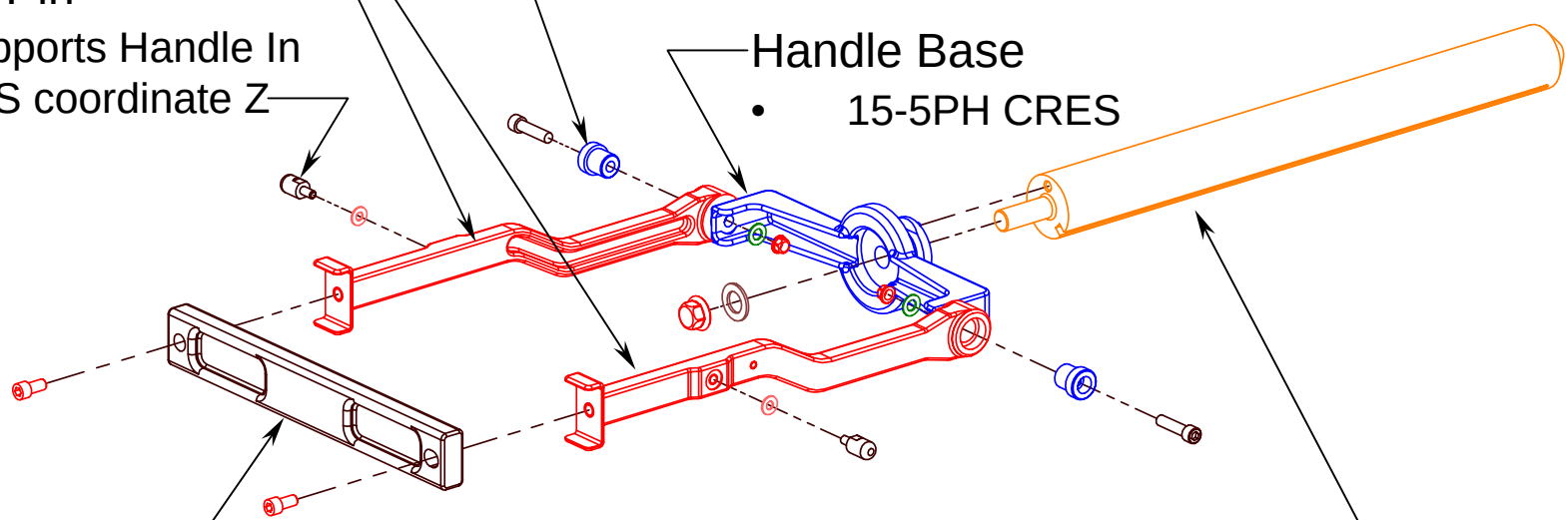
AMS PASSIVE PAS ASSEMBLY
HARDWARE DESCRIPTION
CAPTURE BAR ASSEMBLY



Handle Extension
- 6061-T6 Aluminum Alloy

Handle Bushing
- Aluminum Bronze Per AMS 9640

Handle Pin
- Supports Handle In PAS coordinate Z

Handle Base
- 15-5PH CRES

Capture Bar
- A286 Alloy Steel Per AMS 5737
- Fracture Critical Part: NDE Dye Penetrant Inspected to PRC-6506, Type I, Level 3.

Capture Bar Removal Handle (EVA)
- 6061-T6 Aluminum Alloy

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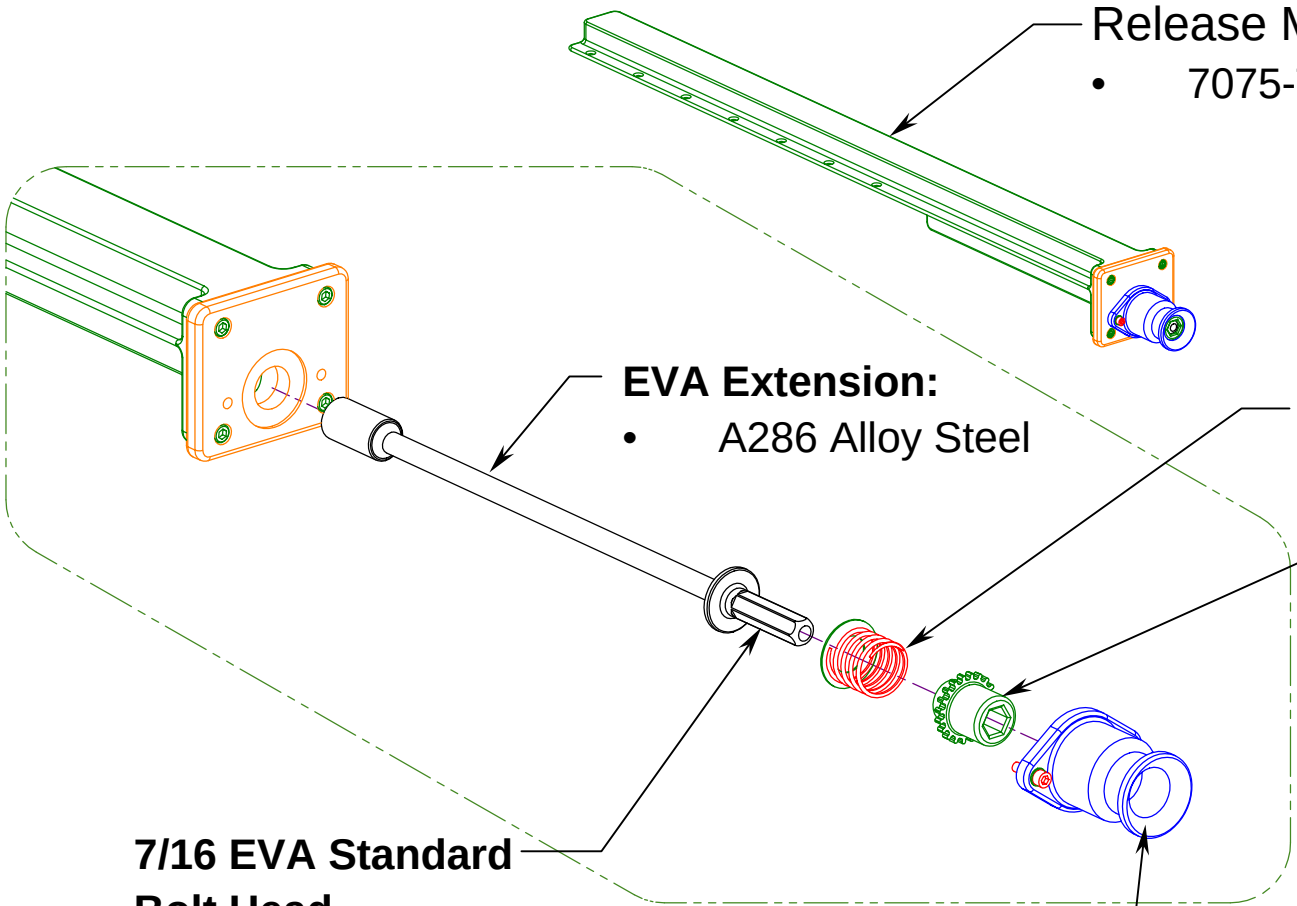
AMS PASSIVE PAS ASSEMBLY
HARDWARE DESCRIPTION
EVA EXTENSION ASSEMBLY



Release Mechanism Cover:
- 7075-T7351 Aluminum Alloy

EVA Extension:
- A286 Alloy Steel

Compression Spring
- Spring Rate: 6.2 Lb/in

Locking Retractor
- A286 CRES

7/16 EVA Standard Bolt Head

Locking Mechanism Base
- A286 Alloy Steel

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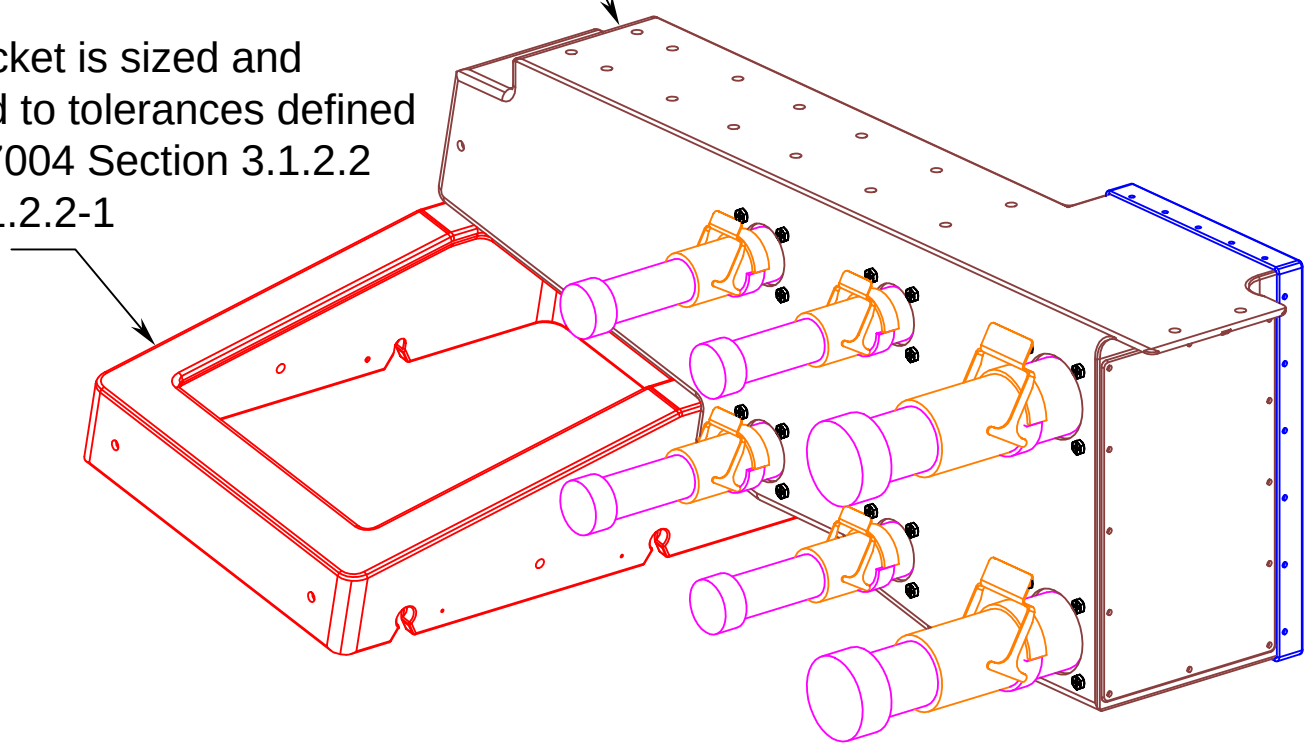
UMBILICAL MECHANISM ASSEMBLY
MOUNTING HARDWARE

EVA Connector Panel Assembly

UMA Bracket

UMA Bracket is sized and positioned to tolerances defined in SSP 57004 Section 3.1.2.2 Figure 3.1.2.2-1



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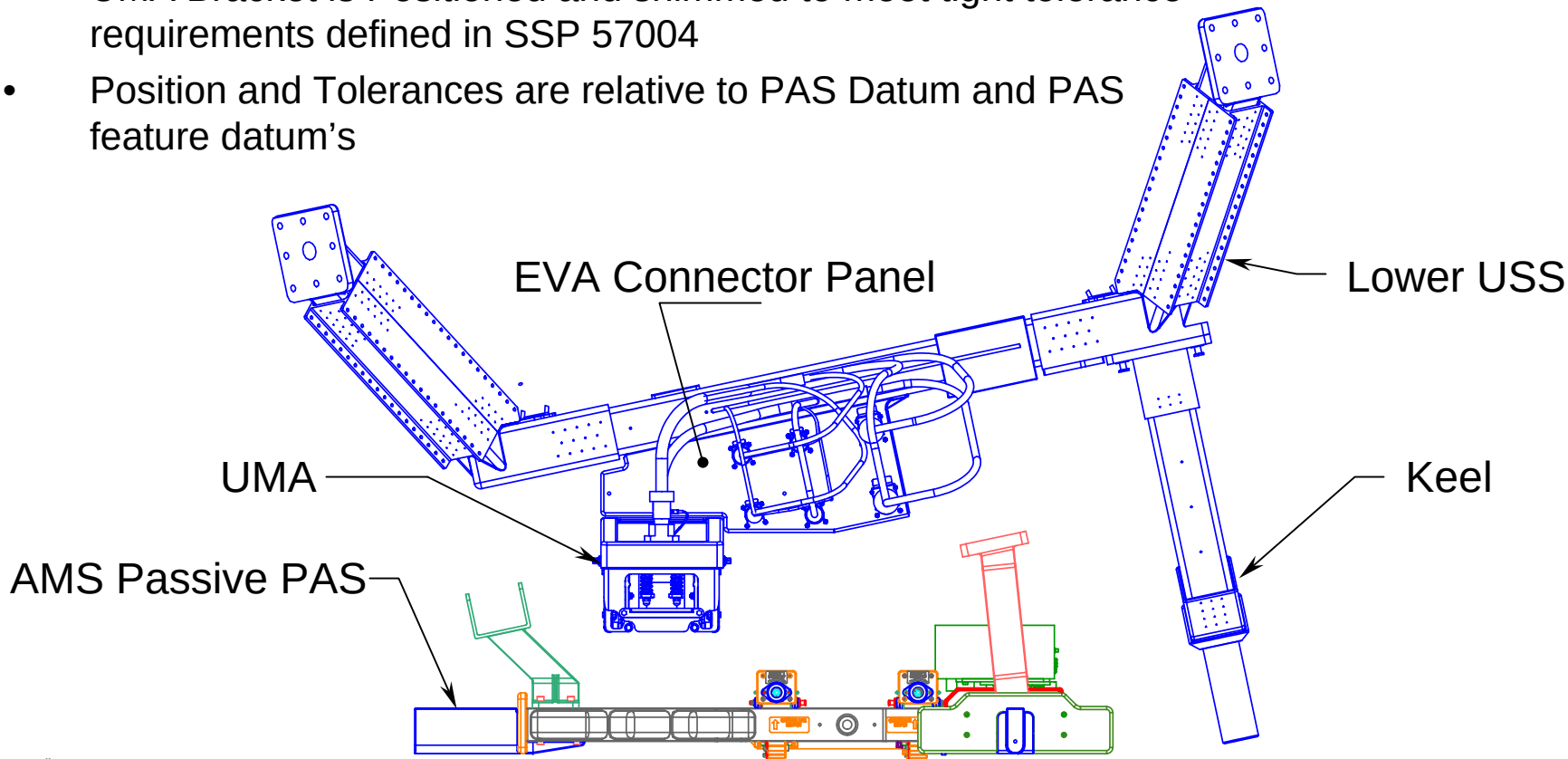
UMBILICAL MECHANISM ASSEMBLY CONFIGURATION

LOCKHEED MARTIN

Features

- Design shall use a Passive UMA part number 1F70162-1 to interface the active UMA. Positioned to SSP 57004 Figure 3.1.2.2-1
- UMA is attached to Lower USS Via EVA Connector Panel Assembly
- UMA Bracket is Positioned and shimmed to meet tight tolerance requirements defined in SSP 57004
- Position and Tolerances are relative to PAS Datum and PAS feature datum's



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AMS Passive PAS EVA Decals

EVA Interfaces and Descriptive Hardware Labels have been developed in accordance with SSP 50005 and JSC 27260C.

Additional requirements were levied per the EVA AIT Crew Consensus Reports, post Low Fidelity NBL Run

AMS PAS Labeling

- EVA Capture Bar Handle
- EVA Load Release Screws 1 and 2

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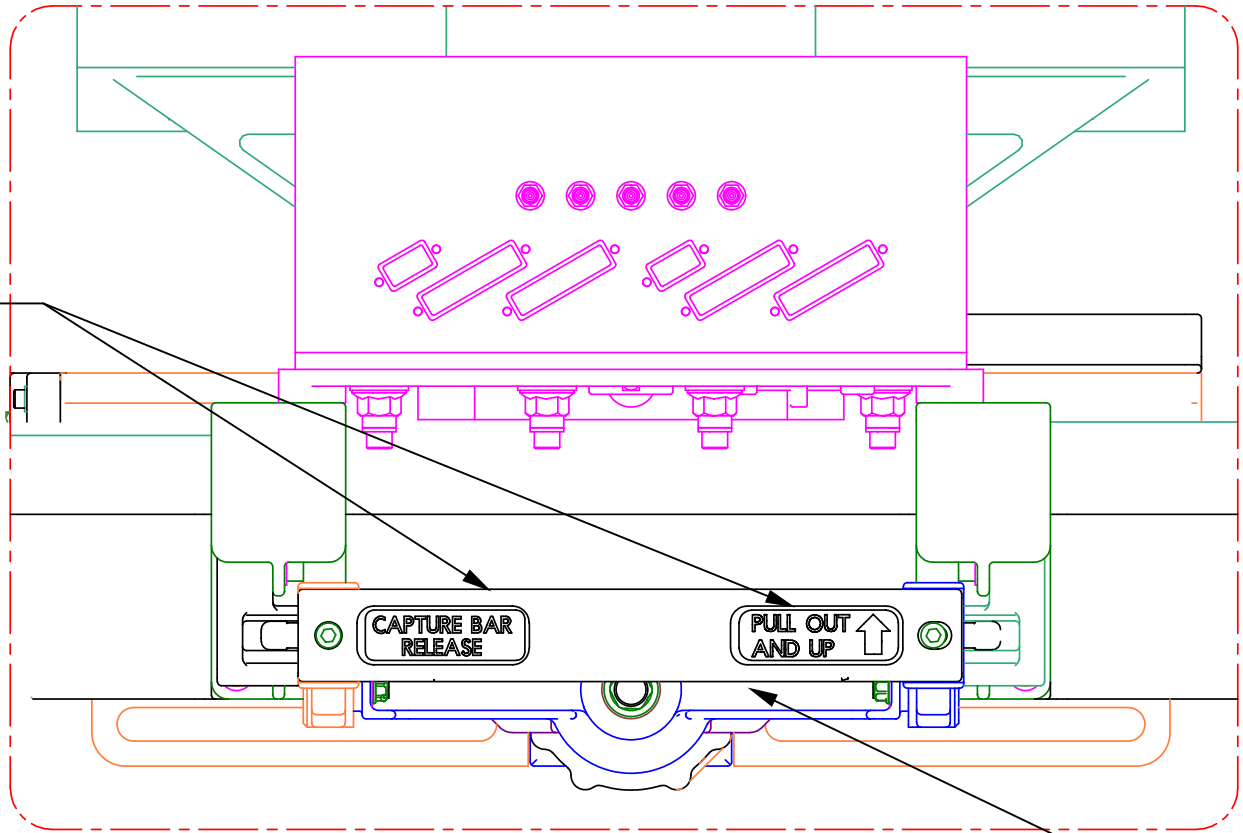
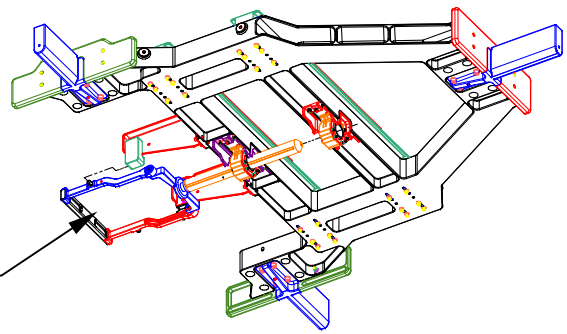
AMS PASSIVE PAS EVA DECALS
CAPTURE BAR HANDLE





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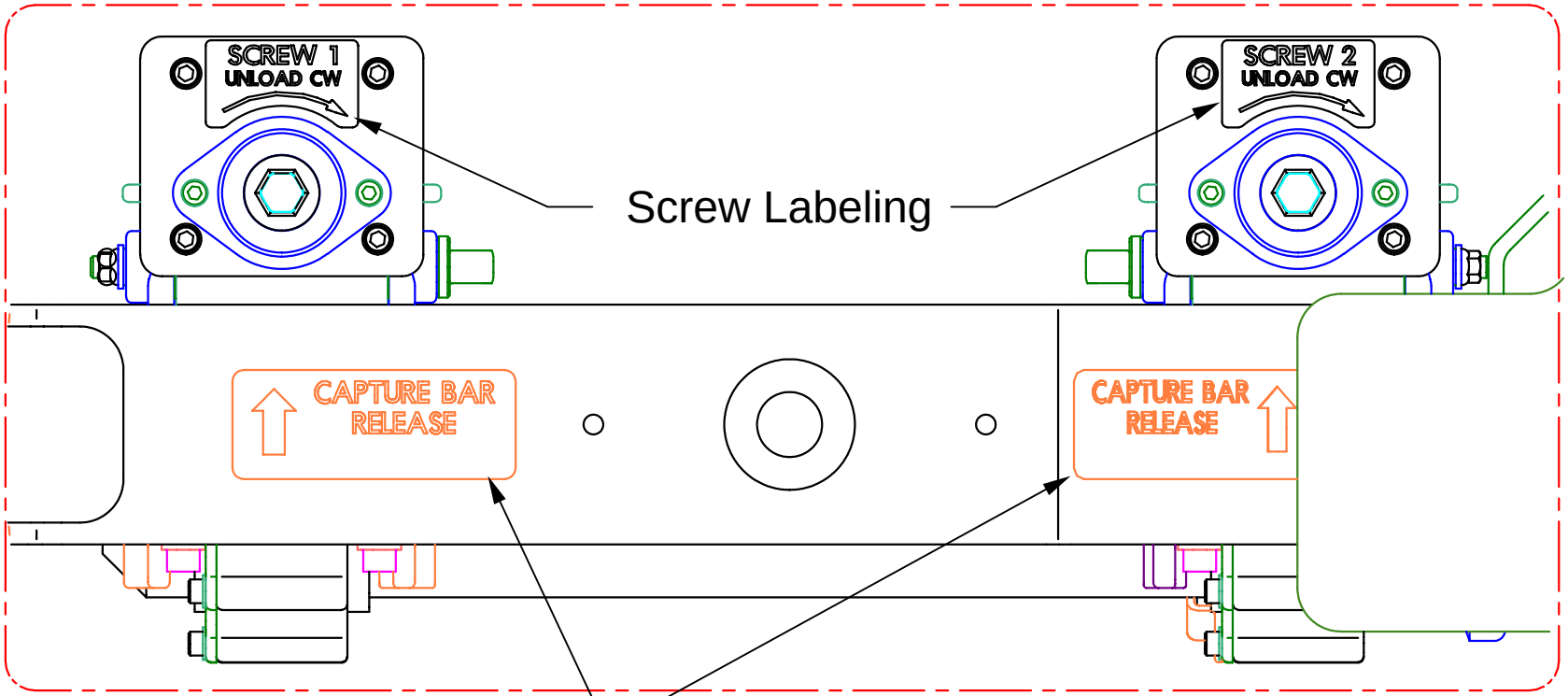
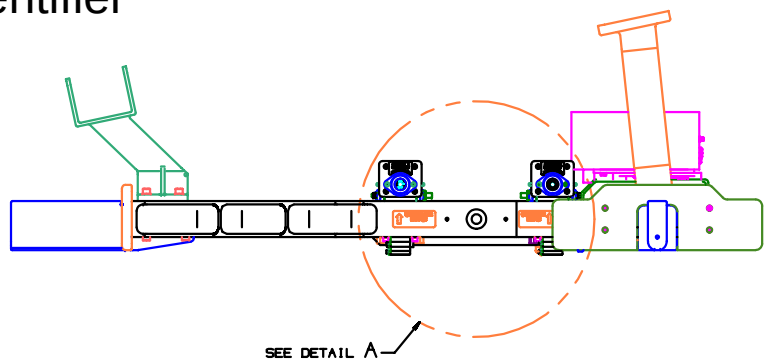
AMS PASSIVE PAS EVA DECALS
LOAD RELEASE SCREWS





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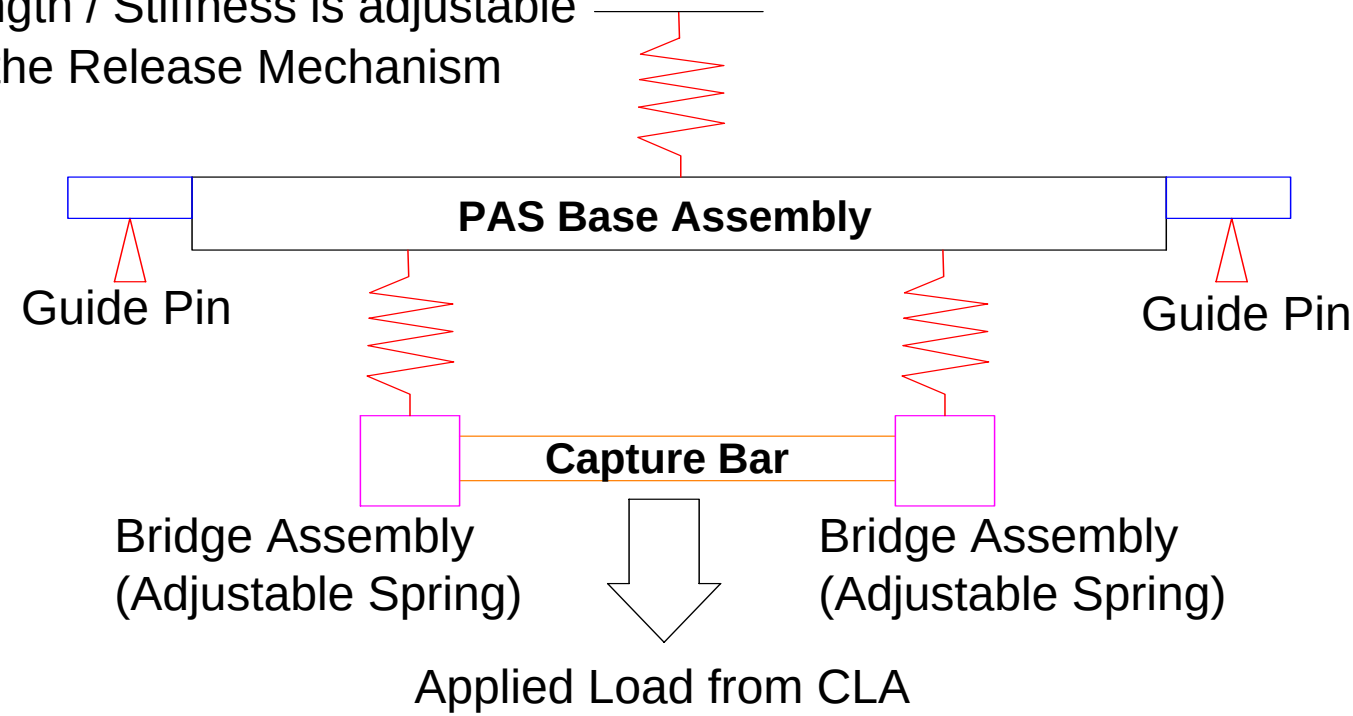
PAS SPRING RATE MODEL
SPRING RATE SCHEMATIC

PAS Base Assembly:

- Fixed Stiffness
- Satisfy Geometric I/F Requirements

Bridge Assemblies:

- Simply Supported C-Channels
- Act in Series with PAS Base Assembly
- Act in Parallel with each other
- Beam Length / Stiffness is adjustable
- Contains the Release Mechanism



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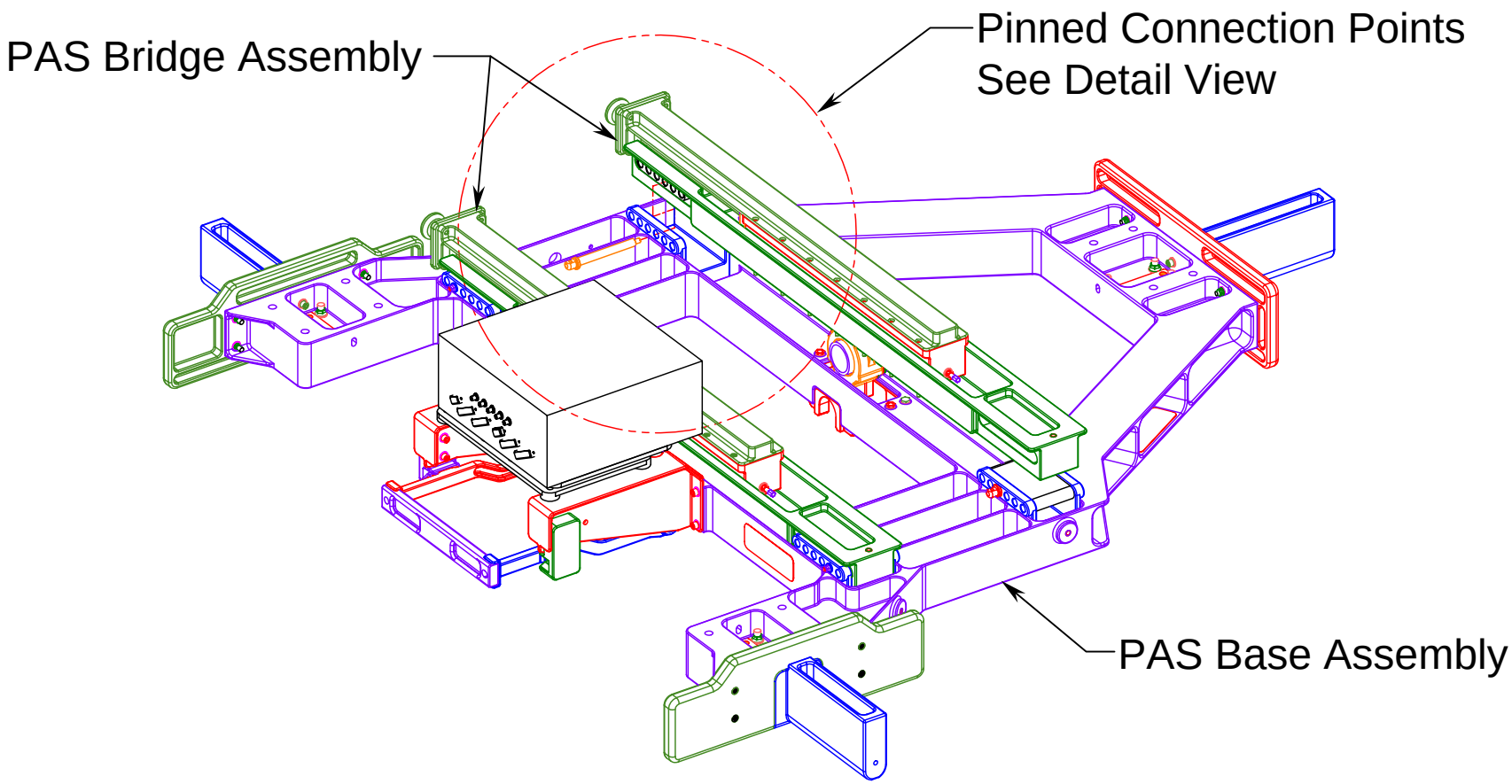
PAS SPRING RATE MODEL

SPRING RATE: Pin Connection Points



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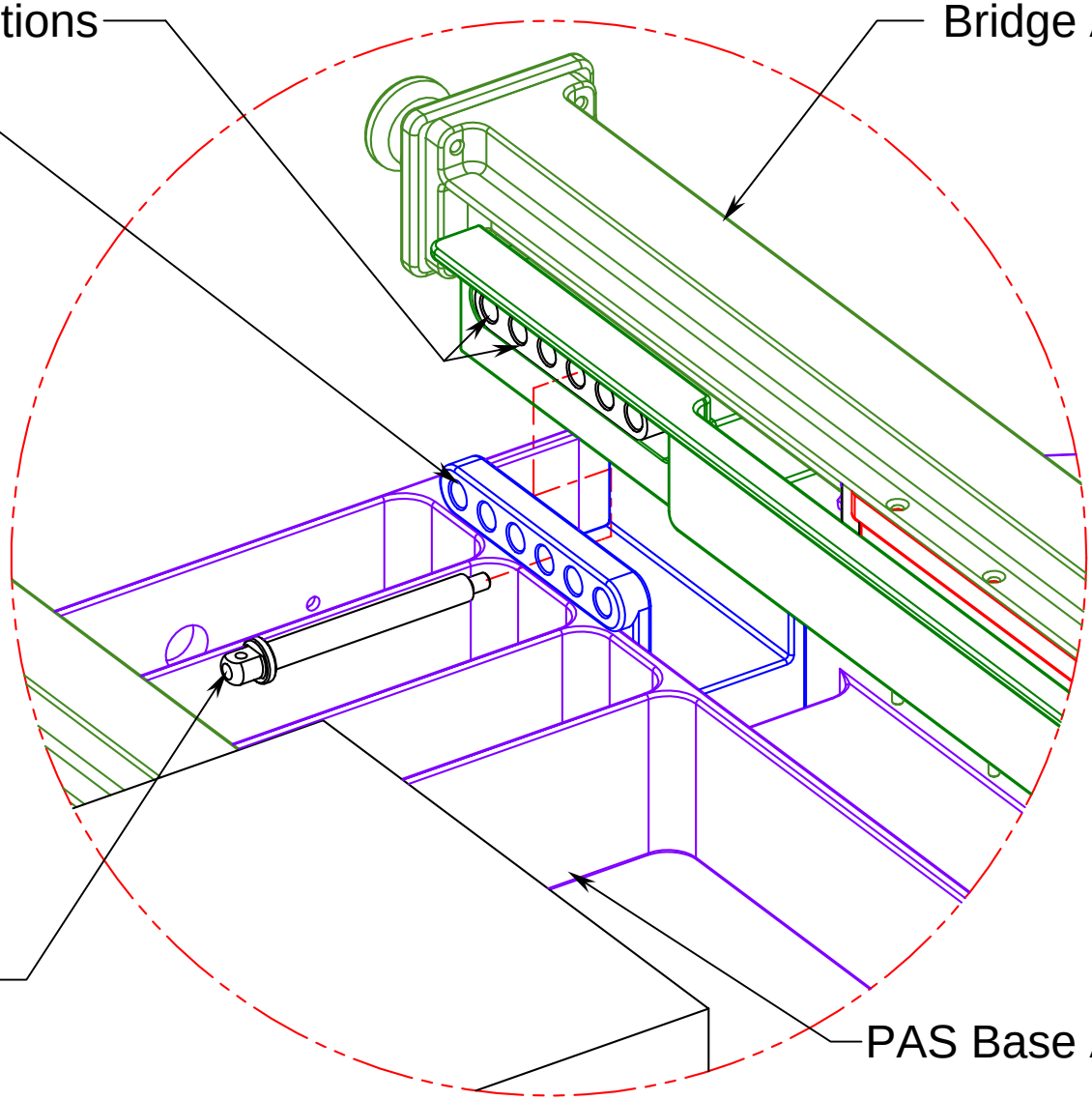
PAS SPRING RATE MODEL
ADJUSTABLE SPRING RATE



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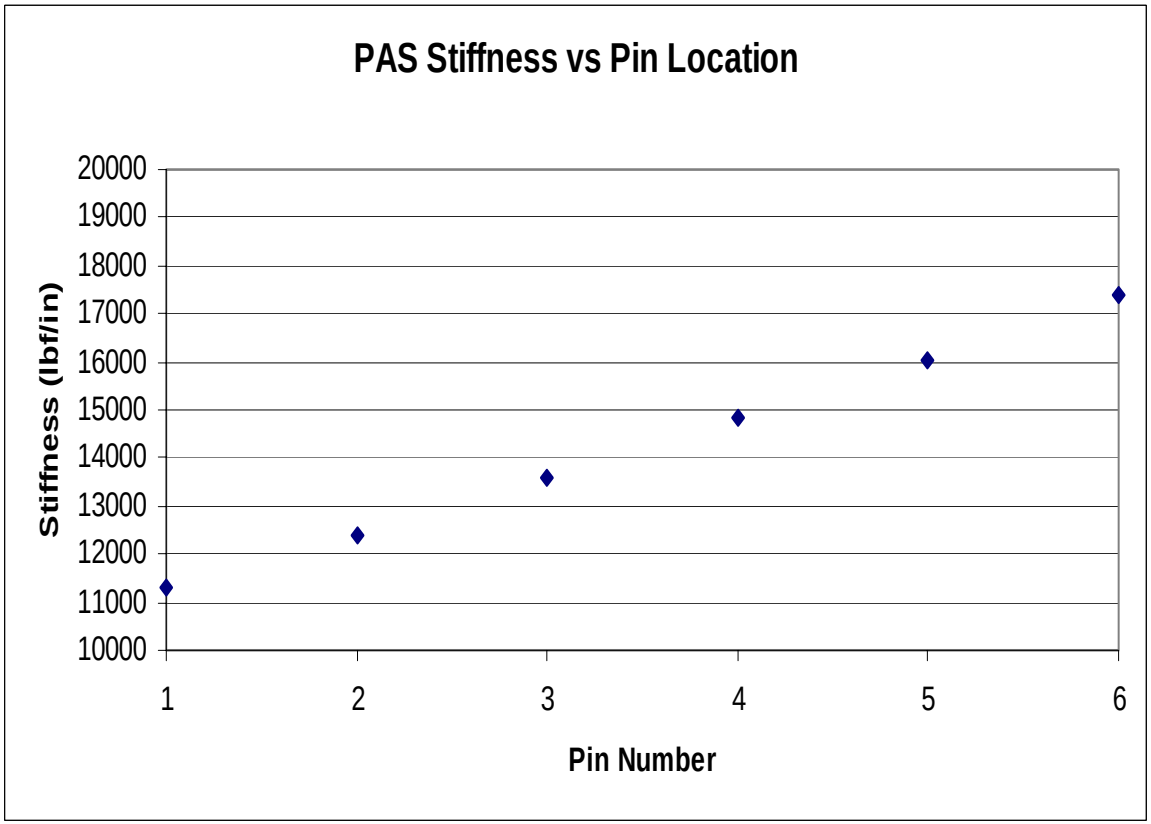
PAS SPRING RATE MODEL
PREDICTED PAS STIFFNESS VS PIN LOCATION



System Stiffness			
Pin Number	Bushing	Bridge Length	Stiffness NASTRAN
6	C	27.5	18618
6	B	28.0	17955
6	A	28.5	17398
5	C	29.0	16913
5	B	29.5	16472
5	A	30.0	16056
4	C	30.5	15650
4	B	31.0	15246
4	A	31.5	14839
3	C	32.0	14428
3	B	32.5	14016
3	**A**	**33.0**	**13604**
2	C	33.5	13197
2	B	34.0	12797
2	A	34.5	12408
1	C	35.0	12029
1	B	35.5	11656
1	A	36.0	11283

Note: Spring Rate Requirement is 13500 +/- 10% (SSP 57003)

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PASSIVE PAS STATIC TEST

LOCKHEED MARTIN

Static Test Description: The AMS Passive PAS Static Test was conducted to achieve the following objectives:

- To Correlate the NASTRAN model with the flight hardware in terms of stiffness and stress
- To demonstrate the Maximum Preload Capability
- To “set” the PAS stiffness as close as possible to the required stiffness per SSP 57003
- To demonstrate the ability to off-load the Capture Bar Preload using the Capture Bar Release Mechanism
- To use the adjustability of the spring system to level the Capture Bar
- To Determine the Final Configuration

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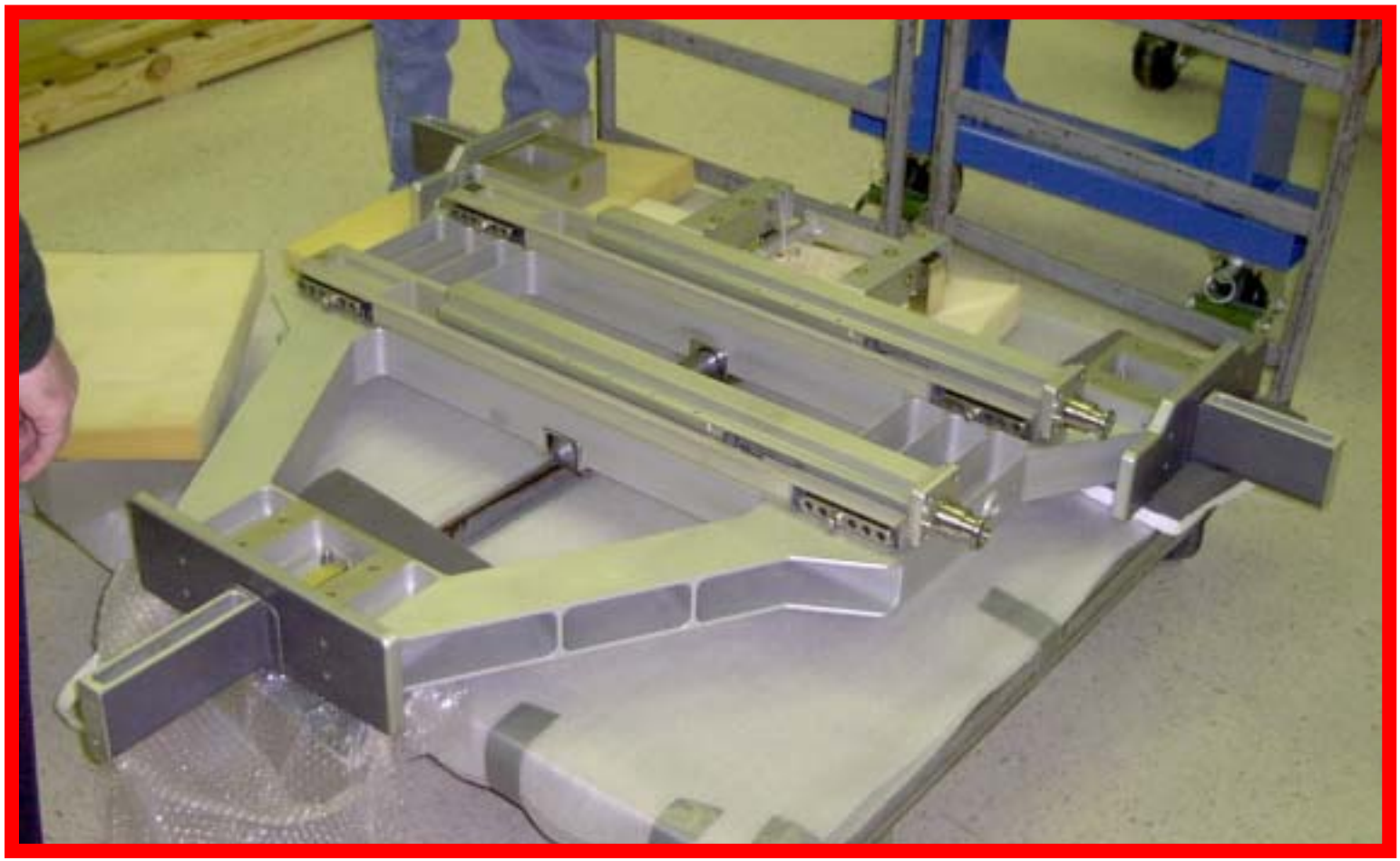
AMS Passive PAS
Static Test



AMS Passive PAS Assembly: SEG39135815-301

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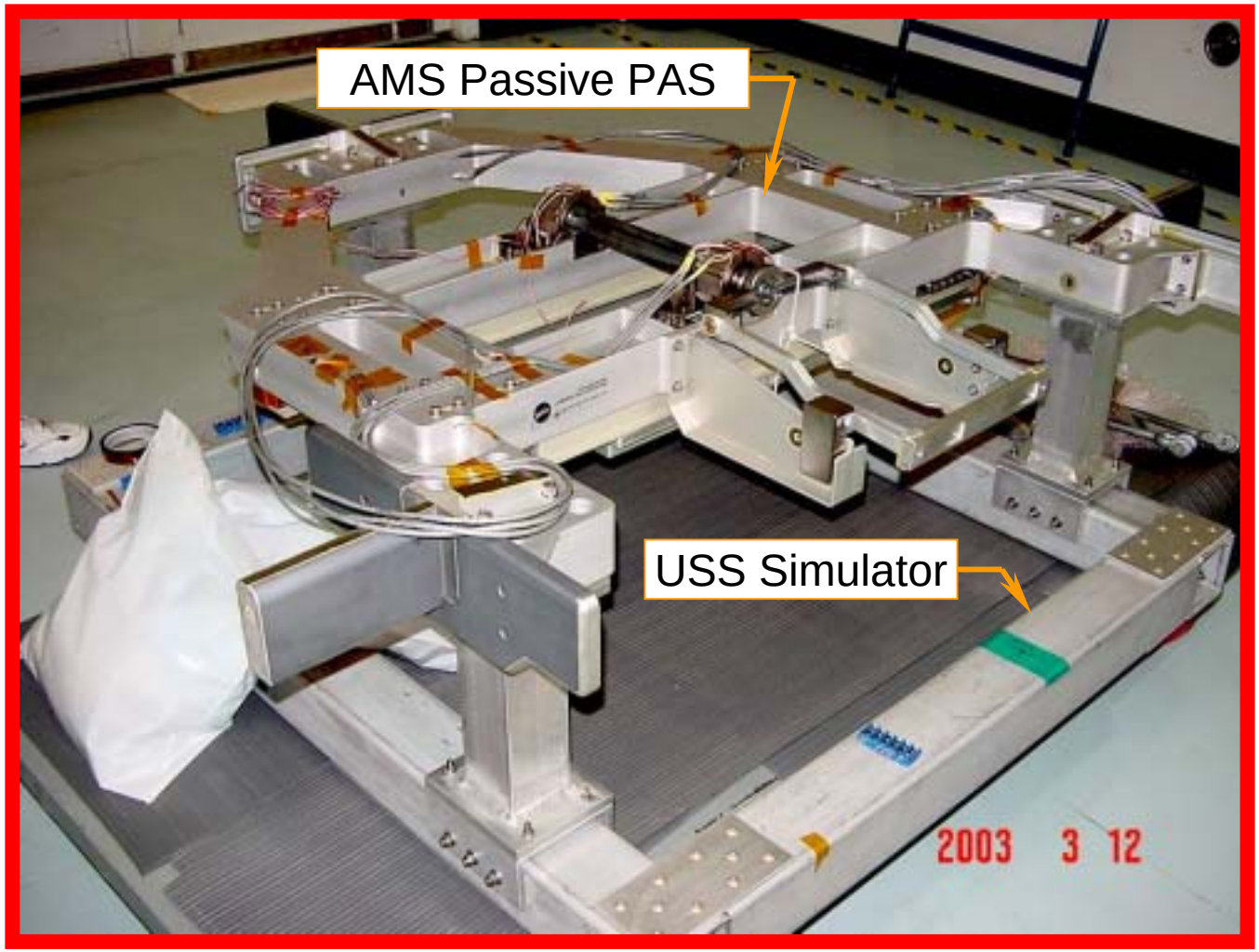
AMS PASSIVE PAS STATIC TEST



AMS Passive PAS with USS Simulator: Test Configuration

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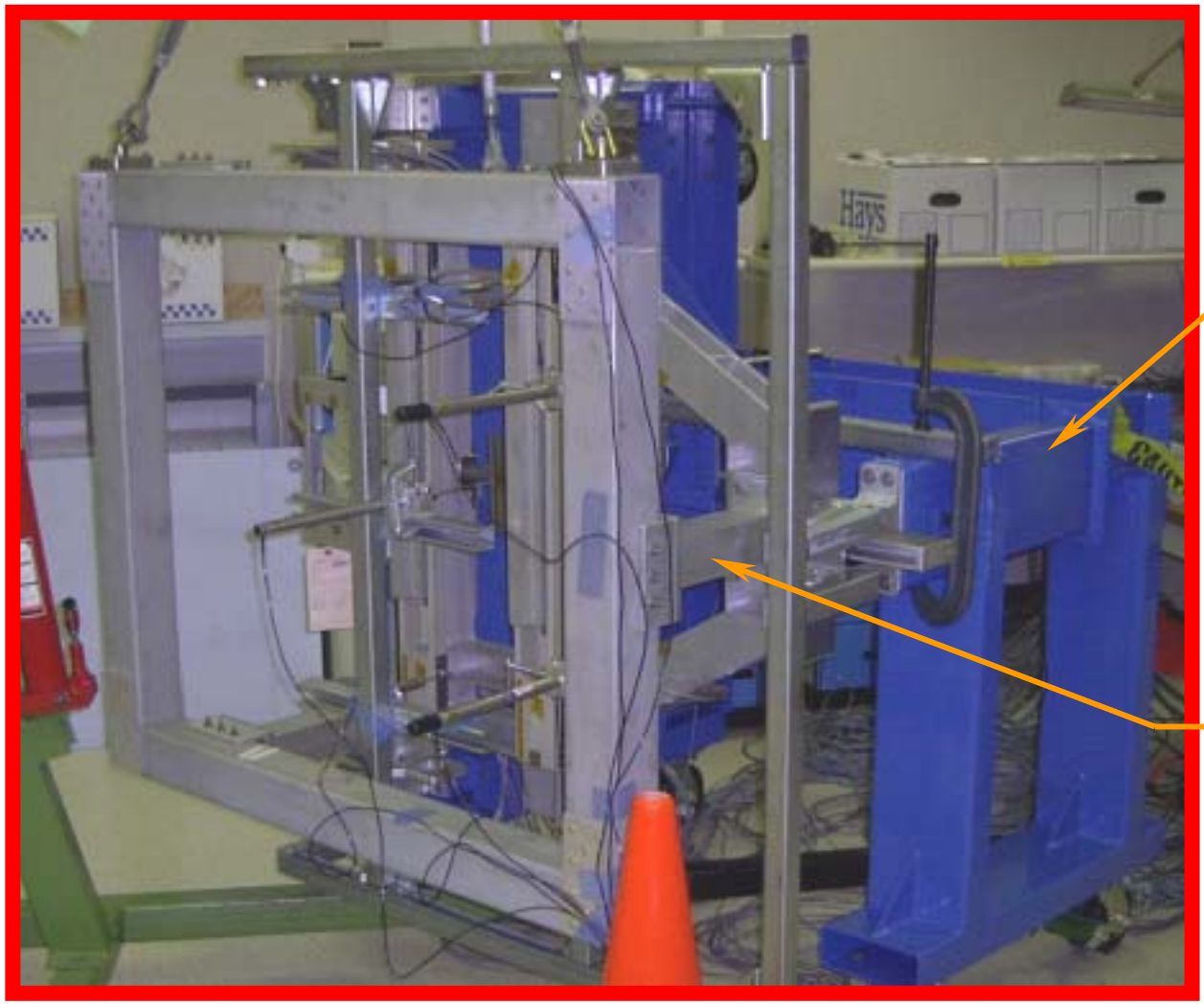
AMS PASSIVE PAS STATIC TEST



AMS Passive PAS with USS Simulator: Assembly On Test Stand

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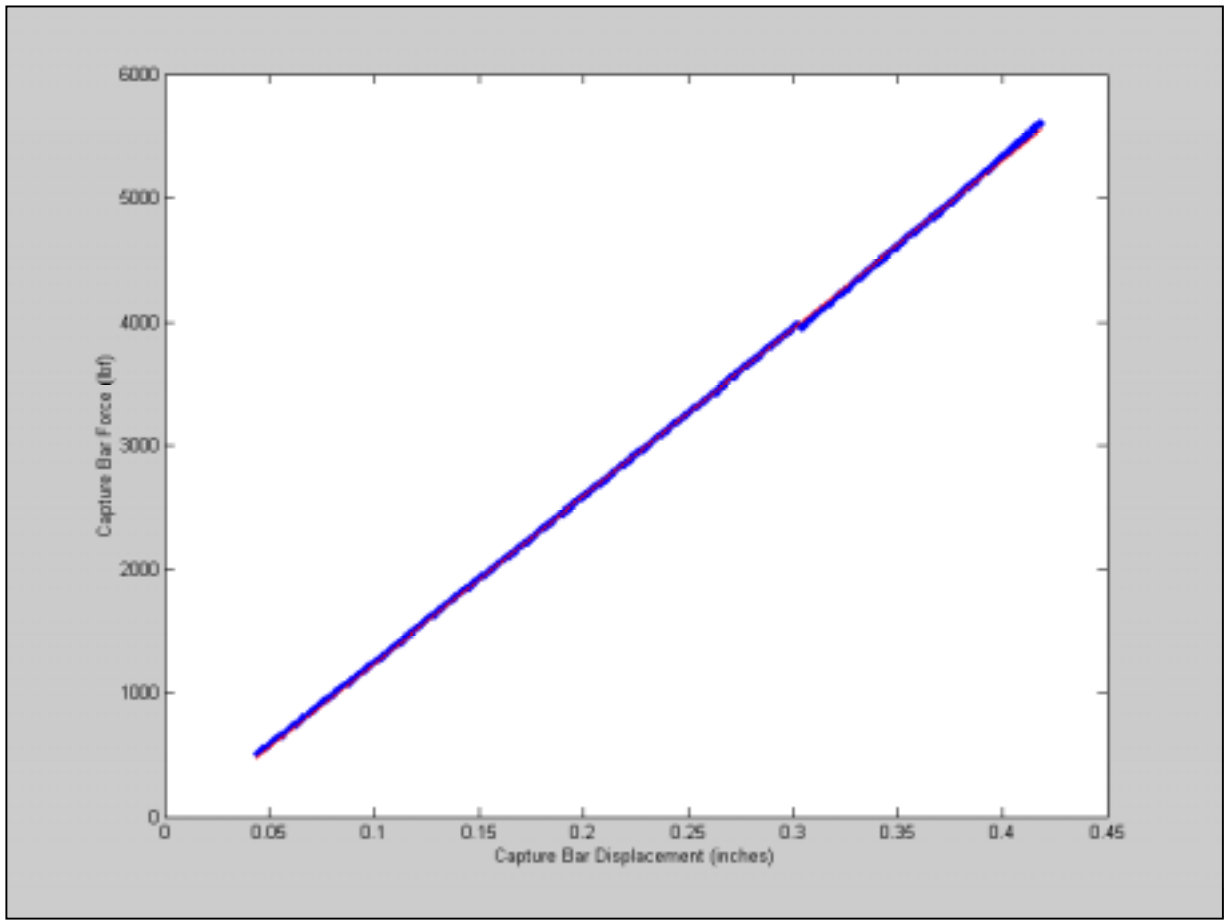
PASSIVE PAS STATIC TEST
FINAL CONFIGURATION
FINAL SPRING RATE

LOCKHEED MARTIN

Capture Bar Loaded to 5650 Nominal Preload to determine Spring Rate

Final Pin Position Criteria:

- Spring rate as Close to nominal as possible
- Level Capture Bar



Fitting a Least Squares straight line to the data between 500 LBF and 5650 LBF

Spring Rate:
K = 13568 LBF/IN

Capture Bar Angle (How Level)

Tested Load: 6.3867e+003

Delta: .020146 inches

Angle of C/B at max pre-load: .0996 Degrees

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AMS PAS Interface Verification Test (IVT)
March, 2003

Test Procedure Summary:

- The AMS Passive PAS was lifted to the Upper Inboard PAS number 2 Active PAS site
- The PAS 2 Capture Claw was closed on the AMS PAS Capture Bar
- The preload at full closure was measured
- The proximity of the PAS Capture Bar Mounting hardware to the EBCS Target Assembly was measured at Loaded Condition.
- The AMS Passive PAS Release Mechanism was used to unload the Capture Claw Preload. Proximity to Target was measured in Unloaded Condition
- The Capture Bar was removed demonstrating the required contingency capability to unload and remove the payload

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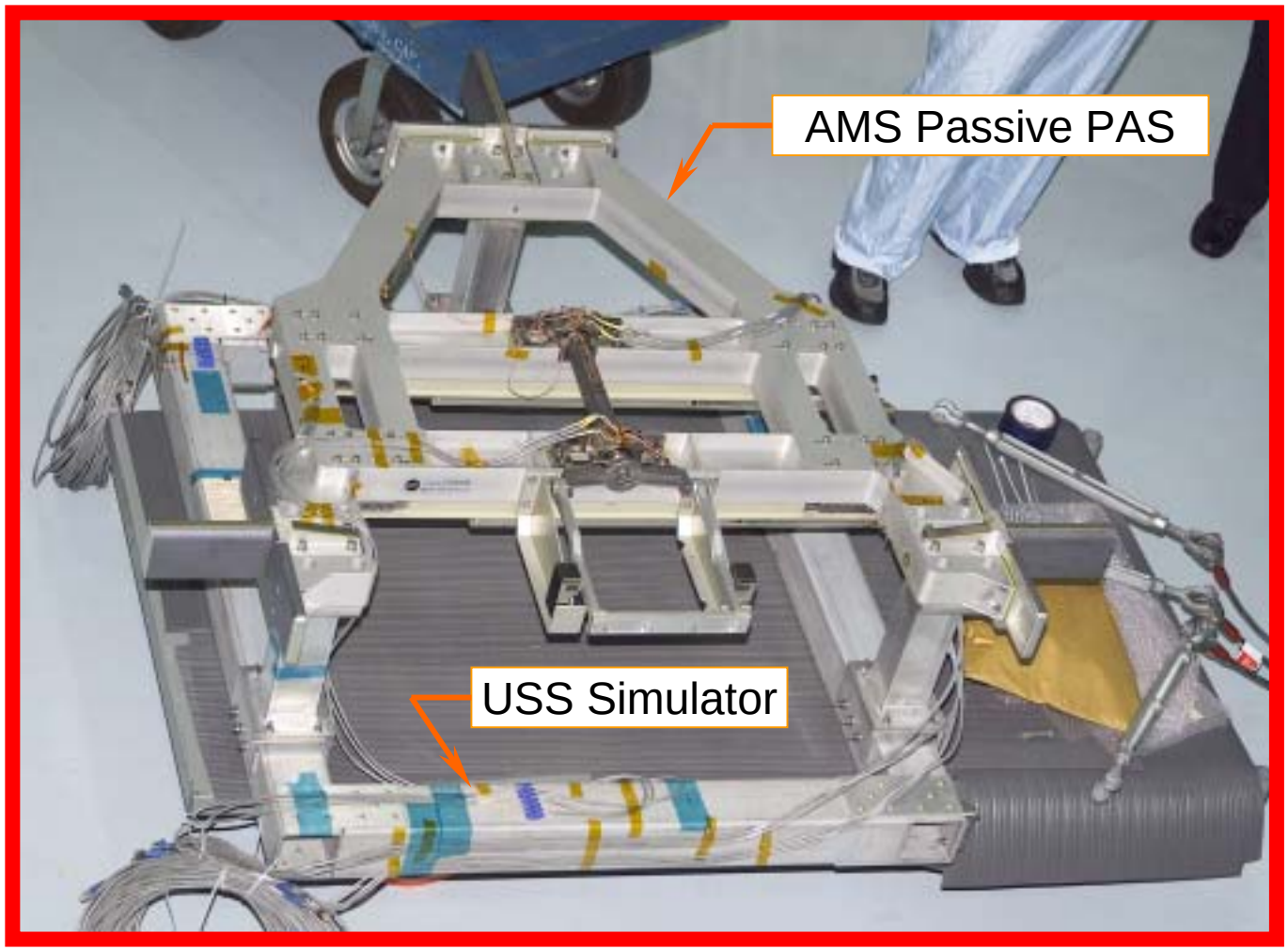
IVT Test
Test Configuration

IVT Configuration was identical to the AMS PAS Static Test



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AMS Passive PAS being lifted to the S3 Truss

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IVT Test
Berthing

The AMS Passive PAS on Berthing Approach to PAS site 2

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IVT Test
Berthed

The AMS Passive PAS Berthed to the S3 Active PAS 2

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IVT Test
EVA Unload

Removing the Preload with the EVA Release Mechanism

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AMS IVT
UNLOADING AND REMOVING THE CAPTURE BAR

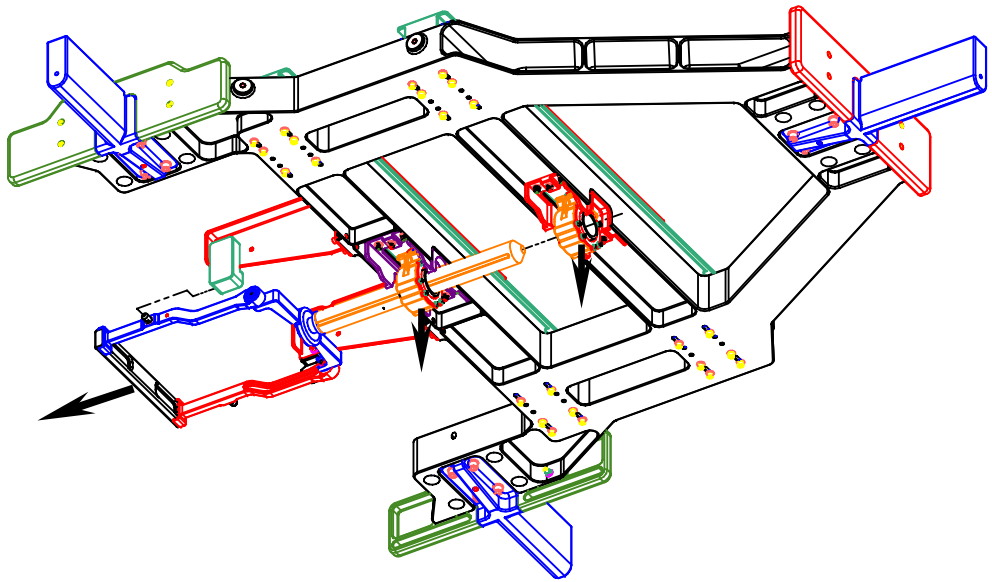
Requirements

- To Relieve the Capture Bar Preload Completely.
- SSP 57003 requires a minimum unload stroke of .71 inches
- To remove the Capture Bar from the Capture Claw

Results of Load Removal Test

The AMS Capture Bar was Lowered .71 inches as required using the AMS PAS Load release Mechanism Assembly. A visible gap of .033 was measured guaranteeing a Zero Preload

The Capture Bar was retracted Completely through the CLA and The payload was hoisted off of the S3 Truss.



Capture Bar lowered and retracted axially through the Bearing Assembly

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AMS IVT
CONCLUSIONS

- Preload was shown to be within 3.2 percent of the nominal load value defined in SSP 57003 Section 3.1.3.1.3.1
- Nominal Preload expected 5650 lb: Actual 5470 lb
- Capture Bar was Unloaded and removed from the CLA
- The preload was removed with a .71 inch stroke as specified in SSP 57003 Section 3.1.3.2.1 A visible Gap was measured
- The Loaded Capture Bar Proximity to BCS Target was within the AP envelope defined in SSP 57003 Section 3.1.3.1.1.1
- The Unloaded Proximity to the BCS Target was within AP Envelope Limits described in SSP 57003 Section 3.1.3.1.1.1

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AMS PASSIVE PAS FUTURE TESTING

Possible Thermal Chamber Test Demonstrating the Preload and the Unloadable Releasable Capture Bar function at Operating extremes of –120 Deg. F to 200 Deg. F

ACAS test (Active Common Attach Simulator): To support Pre-flight Checkout of the physical and functional interfaces of the Payload Attach System (PAS).

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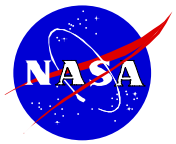

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AMS PASSIVE PAS CDR SUPPORTING INFORMATION CONTENTS

- Primary Design Requirement Documents
- Summary of Interface Requirements
- AMS Passive PAS Assembly Hardware Description
- EBCS Avionics Package
- Passive PAS Spring Rate Model
- Static Test
- Interface Verification Test
- As-Built Dimensions

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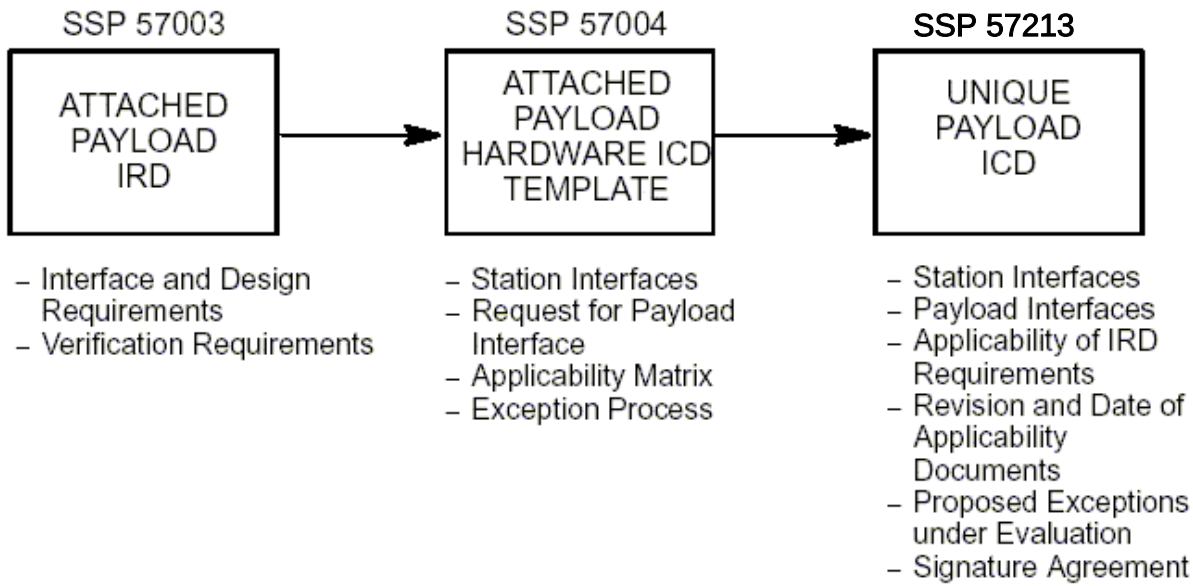
PRIMARY REQUIREMENTS DOCUMENTS

- SSP 57003 Attached Payload Interface Requirements Document: Current Revision A
- SSP 57004 Attached Payload Hardware ICD Template: Current Revision A
- SSP 42131 Space Station Program Integrated Truss Segments P3 and S3 to Attached Payloads and Unpressurized Cargo Carriers (UCC) Standard Interface Control Document: Current Revision D
- SSP 57213 Unique Payload ICD



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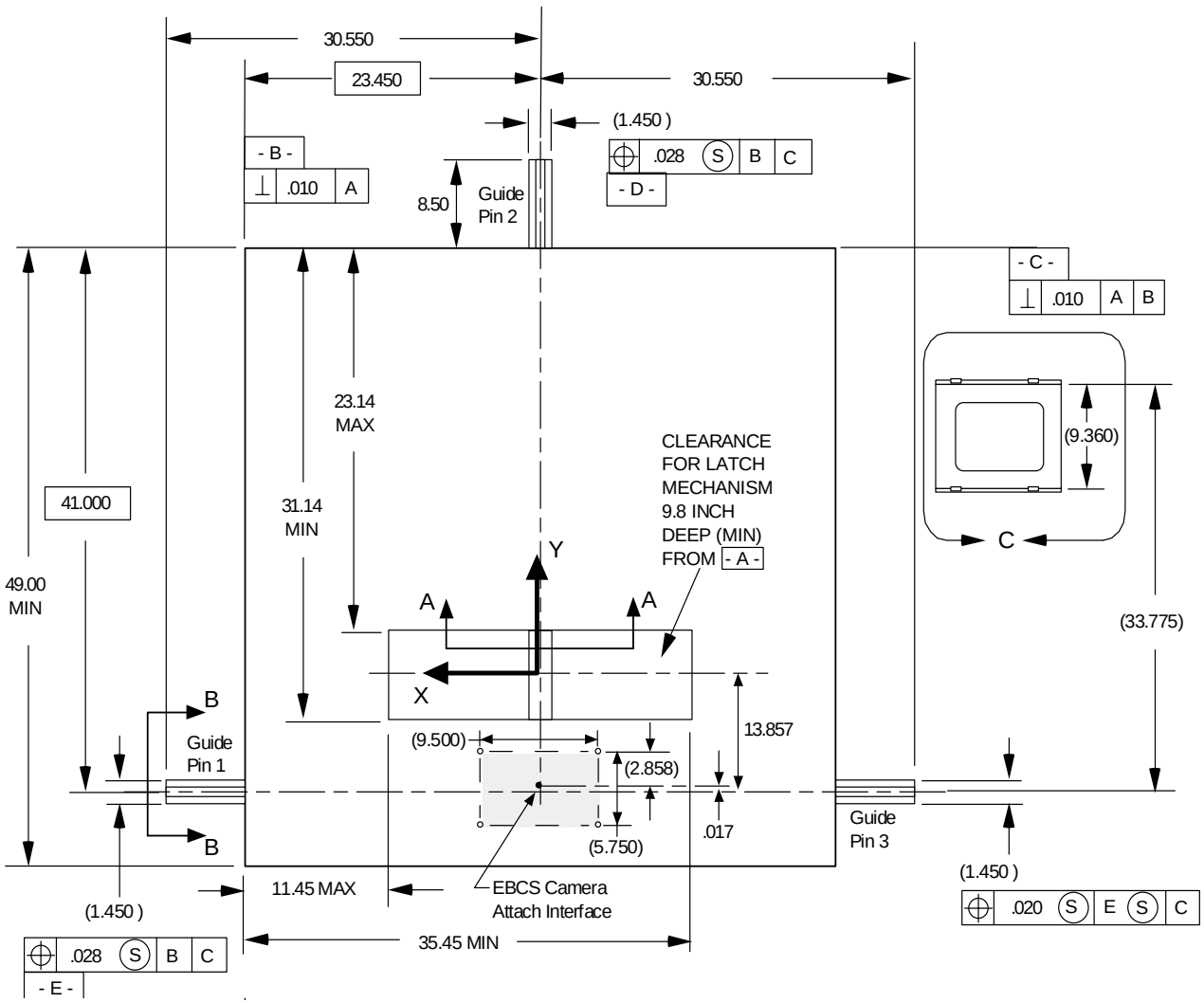
SUMMARY OF INTERFACE REQUIREMENTS
EXCERPTS FROM SSP 57004 IR TEMPLATE

IR Template:

Defines the Physical geometry Required to I/F Common Attach Sites

View Shows:

- Basic Sizing With Tolerances
- BCS keep Out Zones
- BCS Mounting Locations
- UMA Sizing and Positioning requirements



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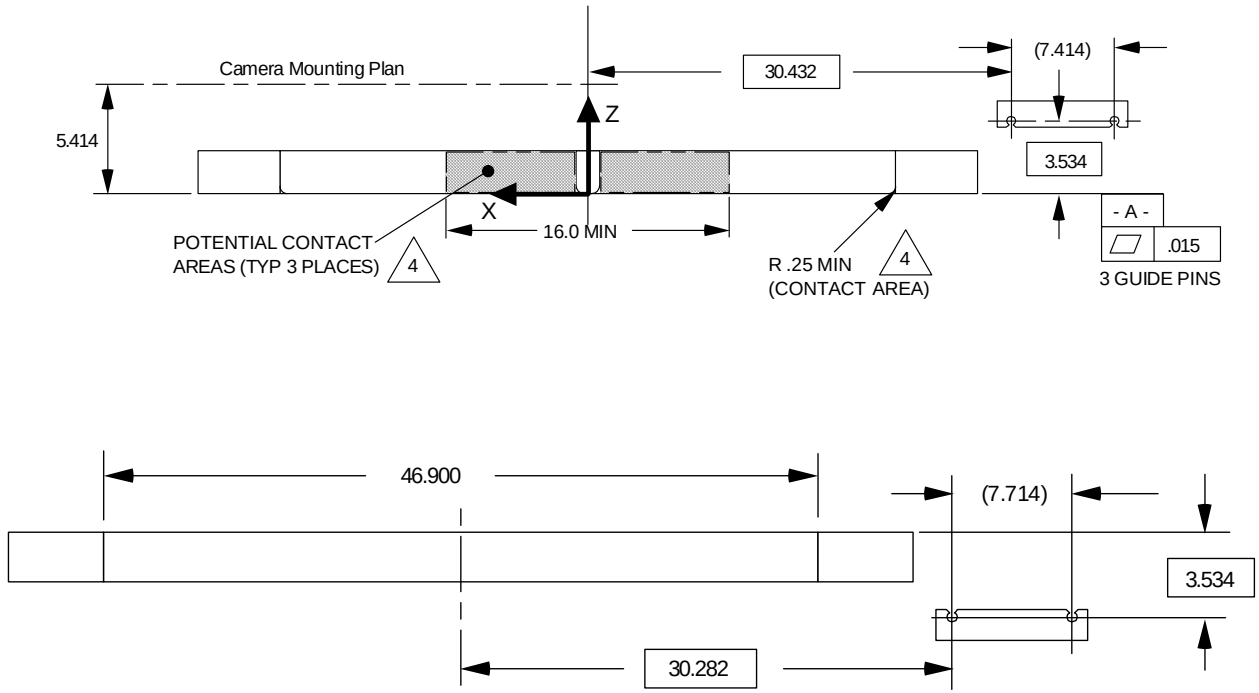
SUMMARY OF INTERFACE REQUIREMENTS
EXCERPTS FROM SSP 57004 IR TEMPLATE.

View Shows:

- Platform height With Tolerances
- BCS camera Mounting Plane
- Scuff Plate Sizing
- UMA Sizing Positioning requirements



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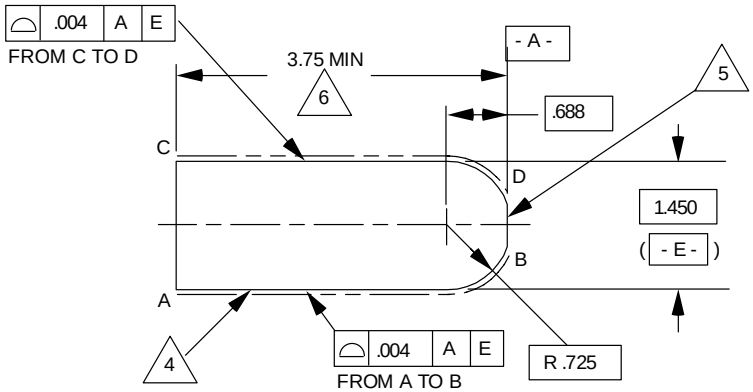
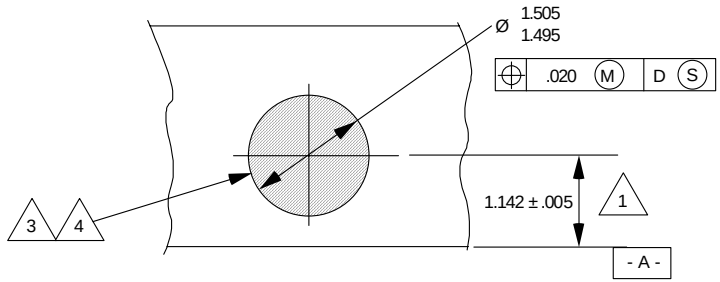
SUMMARY OF INTERFACE REQUIREMENTS
EXCERPTS FROM SSP 57004 IR TEMPLATE



VIEW B - B
(GUIDE PIN DETAIL - TYPICAL 3 PLACES)



SECTION A - A
(CAPTURE BAR)

View Shows:

- Guide Pin Sizing and tolerances
- Capture Bar Sizing and Tolerances

1. DIMENSION IS BASED ON SYSTEM PRELOAD REQUIREMENT 3.3.1.2.1.2.1.

2. SEE FIGURE 3.3.1-2 FOR THE ENTIRE PASSIVE HALF OPERATIONAL ENVELOPE.

3. SURFACE ROUGHNESS 63 MICROINCHES PER ANSI B46.1-1985.

4. APPLY MIL-L-46010, TYPE I LUBRICANT.

5. SURFACE SHALL BE FREE OF DRYLUBE. PASSIVATE PER QQ-P-35 IF CRES, OR CHEMICAL CONVERSION SURFACE PER MIL-C-5541, CLASS 3 IF ALUMINUM.

6. APPLIES TO HEIGHT OF GUIDE PIN ONLY. PLATFORM HEIGHT IS DEPENDENT UPON SYSTEM PRELOAD REQUIREMENT 3.3.1.2.1.2.1.

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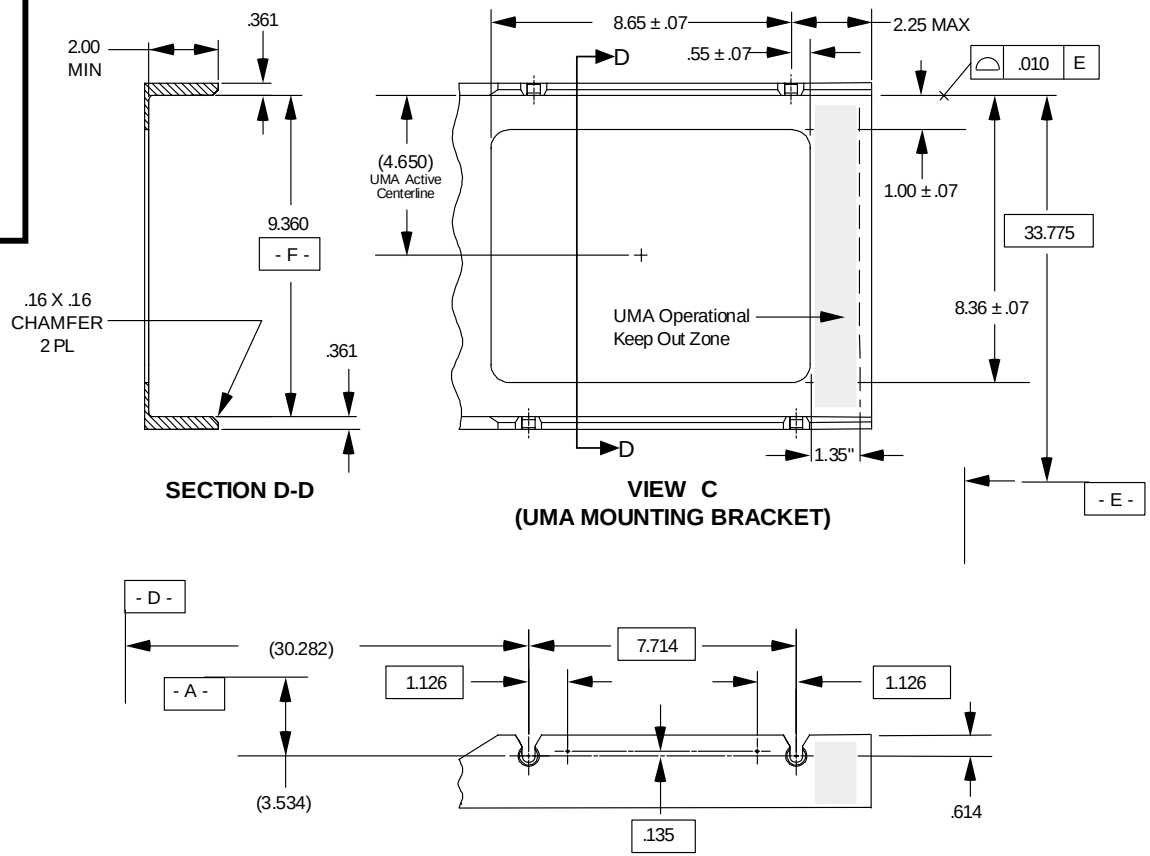
SUMMARY OF INTERFACE REQUIREMENTS
EXCERPTS FROM SSP 57004 IR TEMPLATE

View Shows:

- UMA sizing and Positioning



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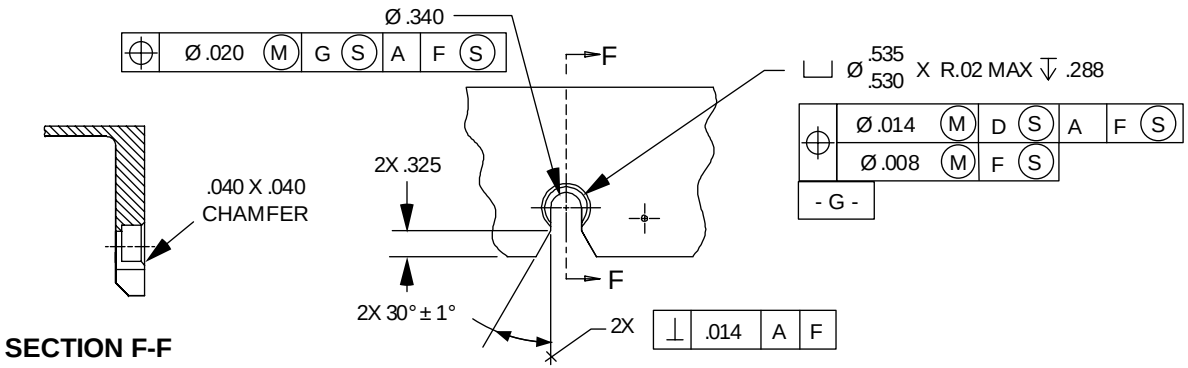
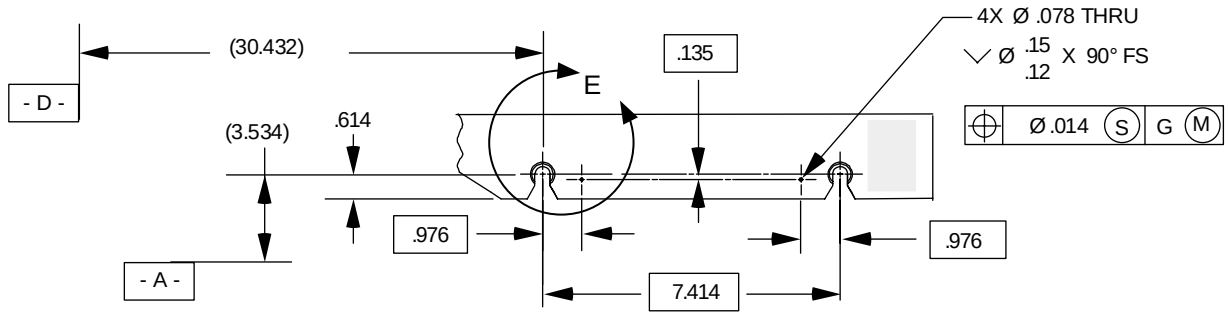
SUMMARY OF INTERFACE REQUIREMENTS
EXCERPTS FROM SSP 57004 IR TEMPLATE

View Shows:
- UMA sizing and Positioning





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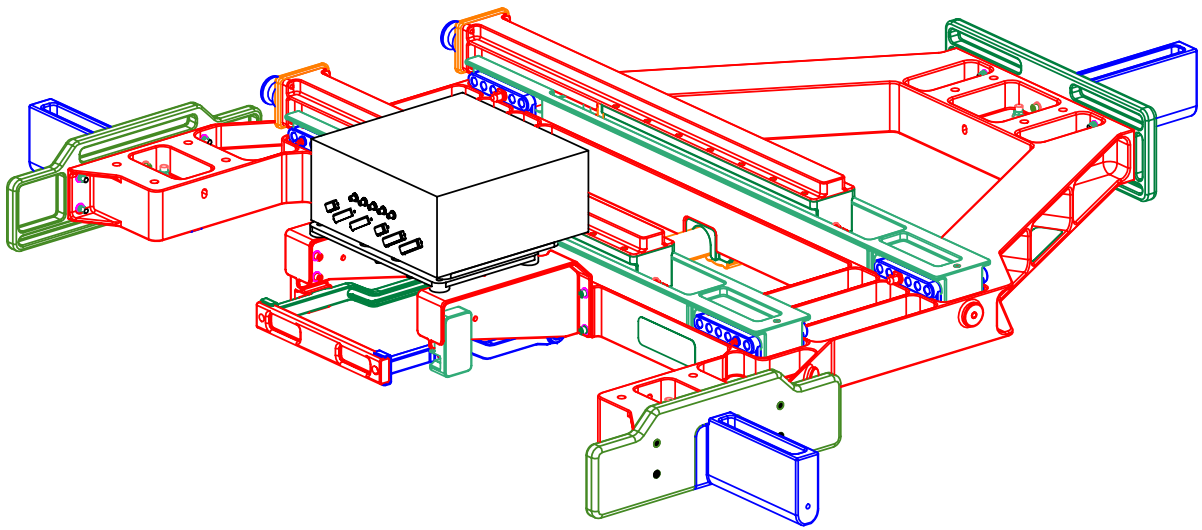
AMS PASSIVE PAS ASSEMBLY
HARDWARE DESCRIPTION

Key Features

- Guide Pins: Interface CAS Guide Vanes
- Scuff Plates: Berthing Operations
- BCS Avionics: Facilitate Berthing Operations
- Capture Bar
- Capture Bar Handle for EVA Contingency Operations
- EVA Load Release Screw
- Adjustable Spring Rate



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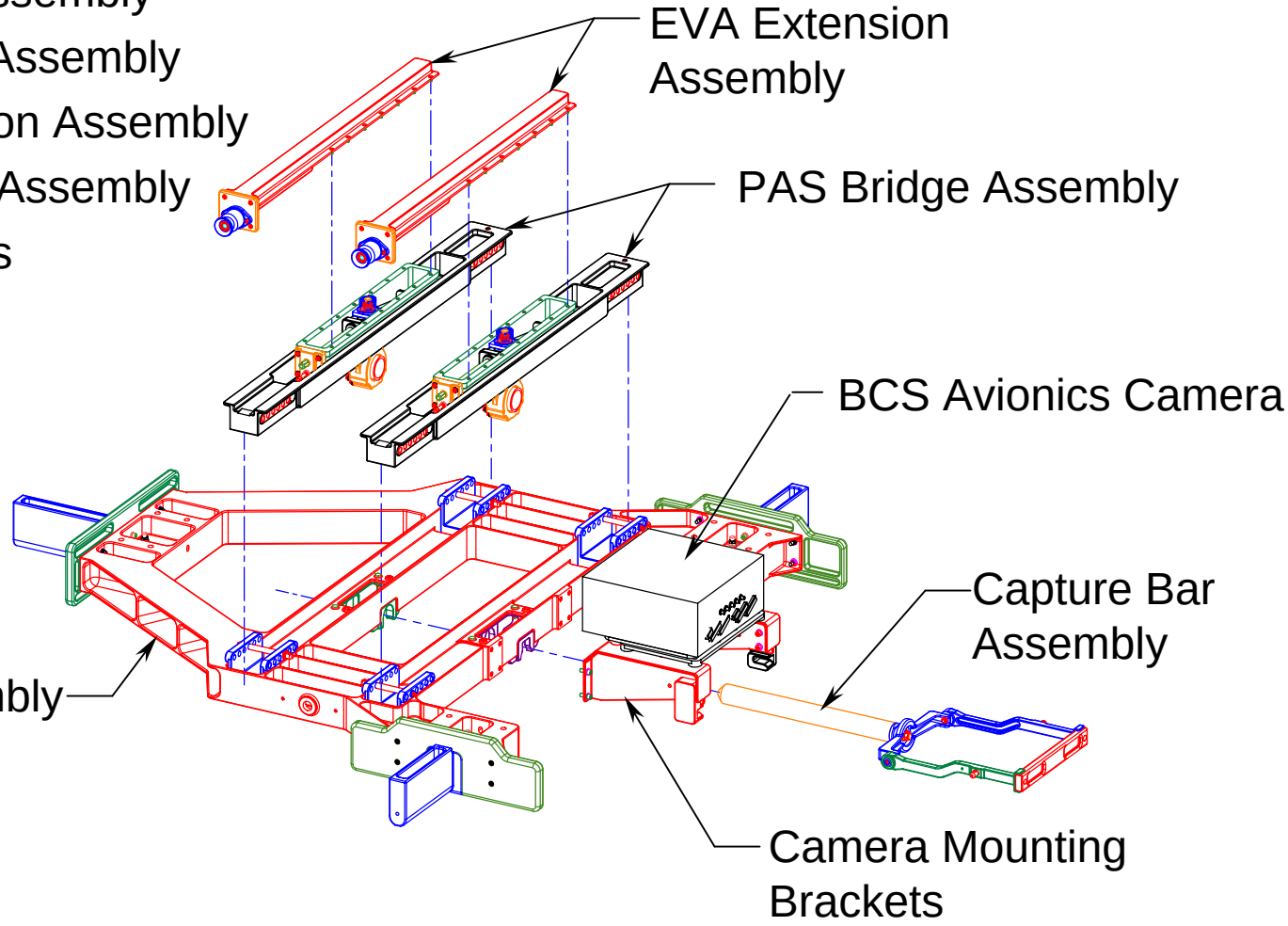
AMS PASSIVE PAS ASSEMBLY
HARDWARE DESCRIPTION

AMS Passive PAS is composed of 5 primary sub-assemblies

- PAS Base Assembly
- PAS Bridge Assembly
- EVA Extension Assembly
- Capture Bar Assembly
- BCS Avionics



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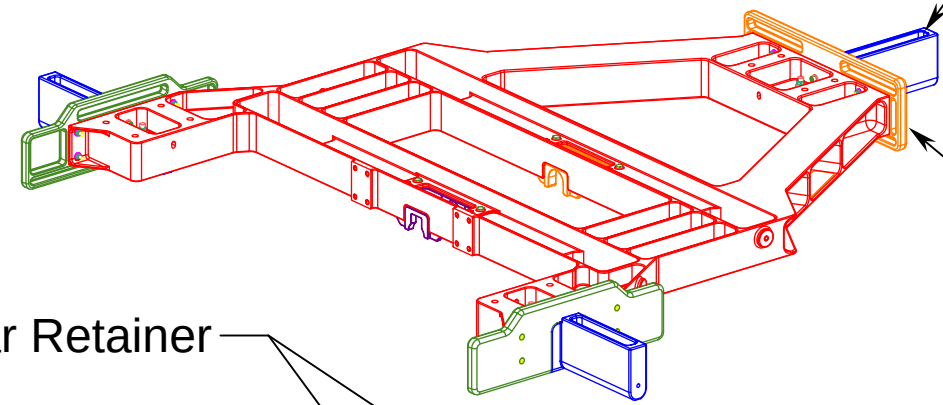
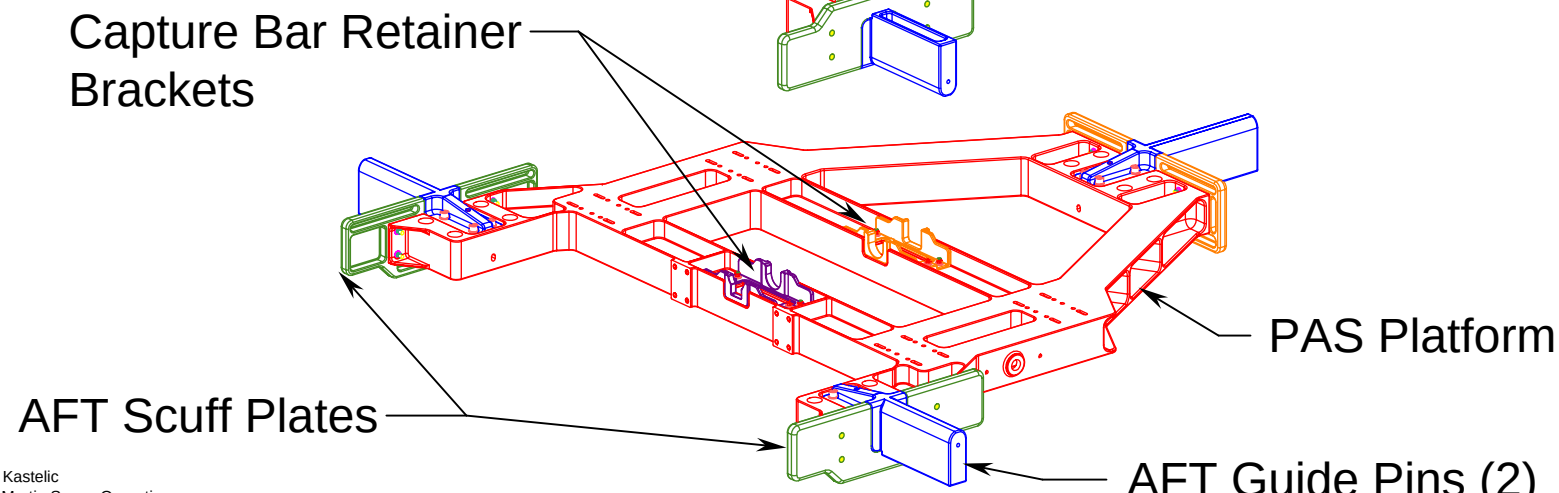
AMS PASSIVE PAS ASSEMBLY
HARDWARE DESCRIPTION
PAS BASE ASSEMBLY

PAS Base Assembly Components

- PAS Platform Assembly
- Guide Pins
- Scuff Plates
- Capture Bar Retainer Brackets





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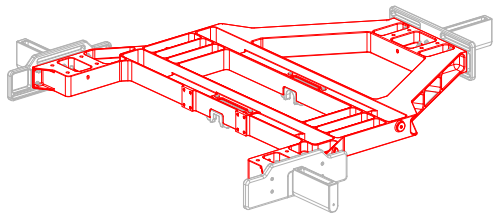
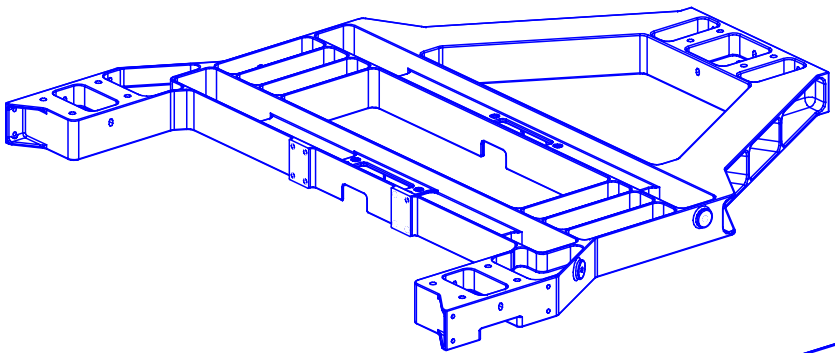
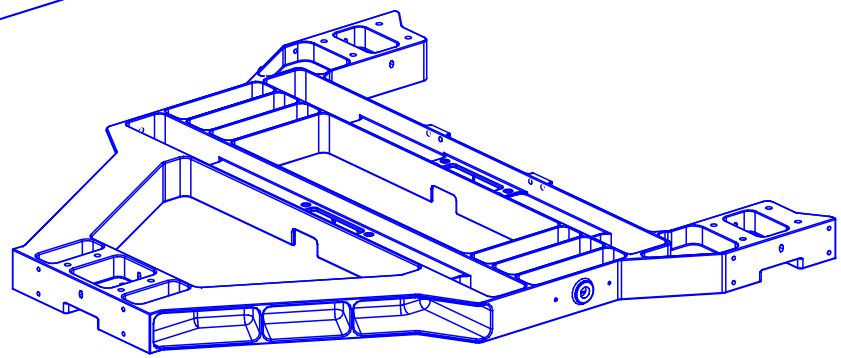
AMS PASSIVE PAS ASSEMBLY
HARDWARE DESCRIPTION
PAS PLATFORM ASSEMBLY

Drawing SEG39135817-301:

- Machined Aluminum 7050-T7451
- Ultrasonic and Fatigue Tested Material per BMS-7-323-C
- Clear Anodized to PRC 5006 Type II, Class 1
- Interface areas Nickel Plated to AMS3451/3 per AMS Process Control Drawing SKG39135893







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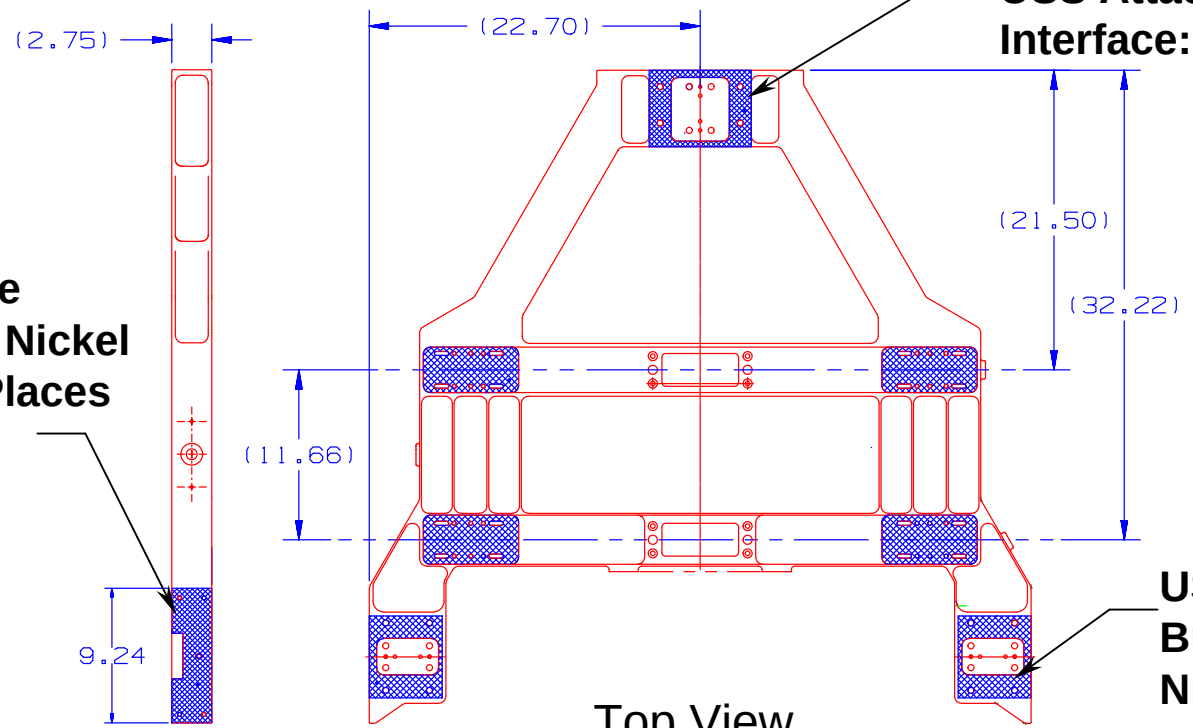
AMS PASSIVE PAS ASSEMBLY
HARDWARE DESCRIPTION
PAS PLATFORM ASSEMBLY

LOCKHEED MARTIN

Platform Design Considerations:

- Deflection Curve: Platform is a critical component of the total overall spring rate. Finite element model was the primary driver in specifying wall thickness and pocket locations.
- Tolerance Requirements: Tight tolerance requirements specified in SSP 57004 suggested a single machined component as opposed to built up structure.



USS Attachment Bracket Interface: Nickel Plated

Scuff Plate Interface: Nickel Plated 3 Places

USS Attachment Bracket Interface: Nickel Plated

Top View

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AMS PASSIVE PAS ASSEMBLY
HARDWARE DESCRIPTION
GUIDE PINS

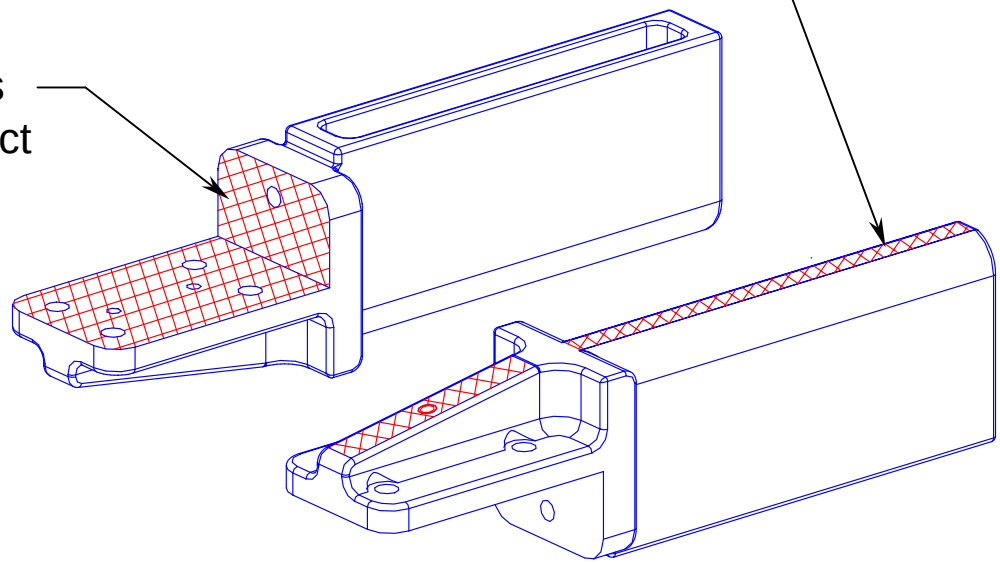
LOCKHEED MARTIN

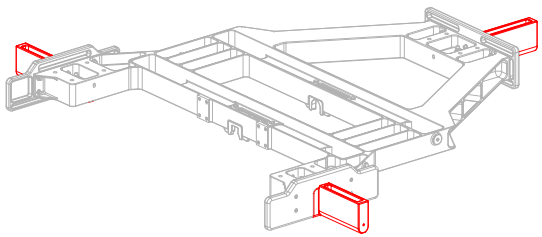
Nickel Plating: This area contacts the Active Guide Vane Assemblies and acts as the grounding path for a class R bond for the AMS structure. A requirement per SSP42131section 3.3.2.1.3.1.1.

Guide Pins

- Machined Aluminum Alloy 7050-T7451
- Clear Anodized to PRC 5006 Type II, Class 1
- Interface areas Nickel Plated to AMS3451/3 per AMS Process Control Drawing SKG39135893

Nickel Plating: This area is the primary grounding contact area to the PAS Platform





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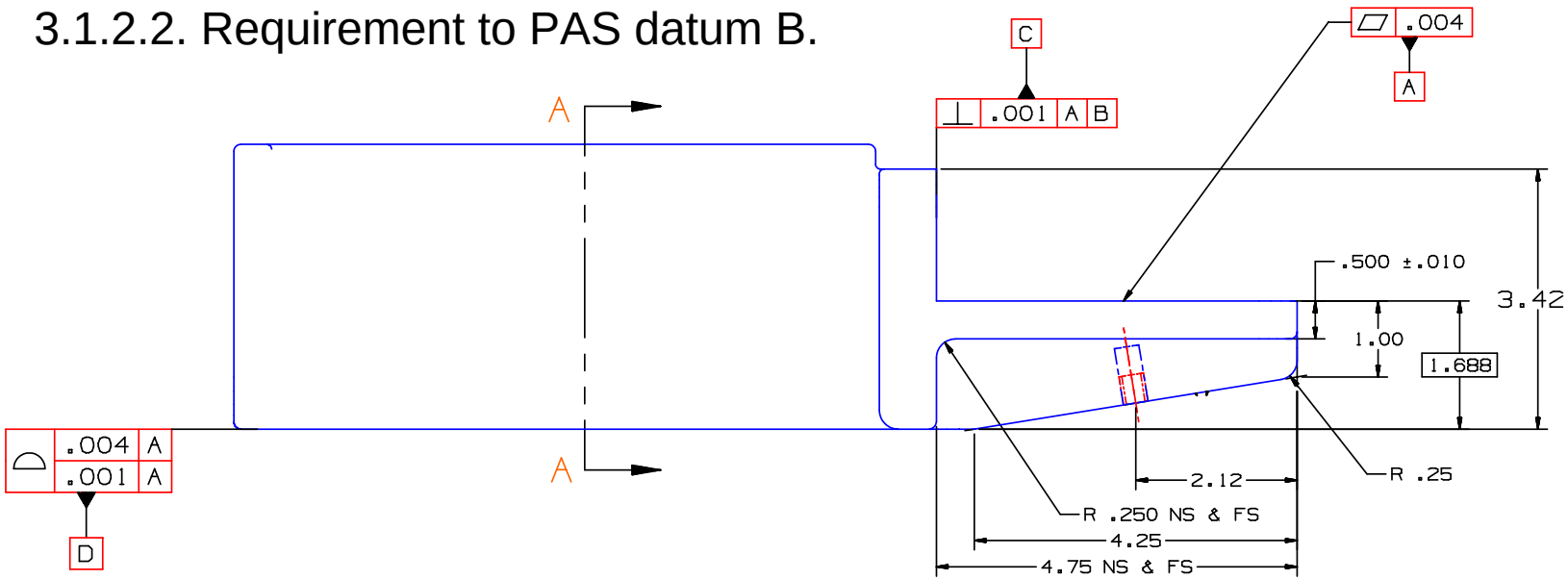
AMS PASSIVE PAS ASSEMBLY
HARDWARE DESCRIPTION
GUIDE PINS

Guide Pin Profile Geometry

- Guide Pin Height and Length requirements prevent interference to ITS Longeron and CAS Guide Vane RTL.
- Geometric requirements Per SSP 57003, SSP 57004.
- Apex Guide Pin Length 8.50 in. Per SSP 57004 Section 3.1.2.2. Requirement Relative to PAS datum C.
- Aft Guide Pin Length 7.10 in. Per SSP 57004 Section 3.1.2.2. Requirement to PAS datum B.



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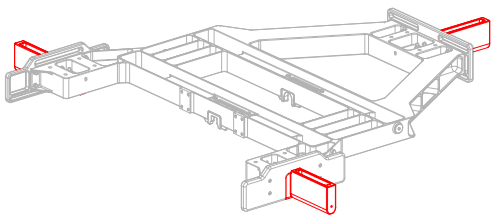
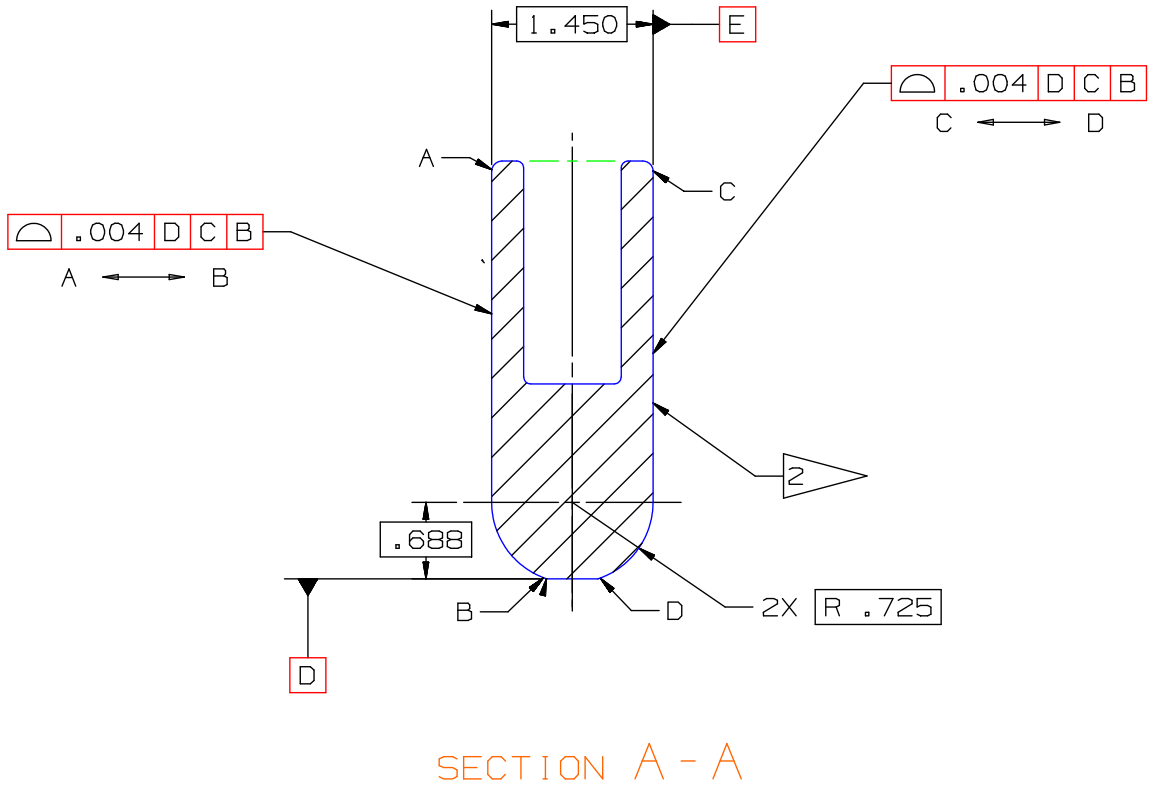
20 May 2004

AMS PASSIVE PAS ASSEMBLY
HARDWARE DESCRIPTION
GUIDE PINS

Guide Pin Profile Per SSP 57004 Section 3.1.2.2 Figure 3.1.2.2-1





SECTION A - A

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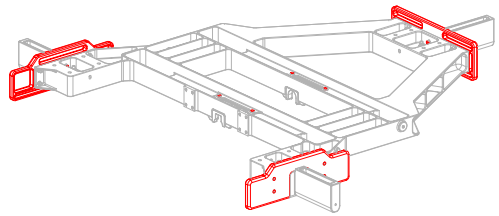
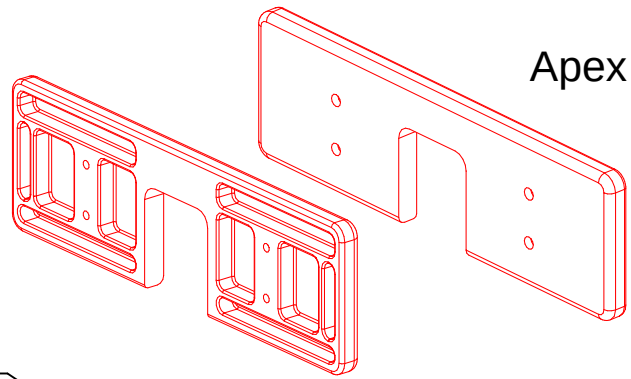
AMS PASSIVE PAS ASSEMBLY
HARDWARE DESCRIPTION
SCUFF PLATES

LOCKHEED MARTIN

Features

- Machined Aluminum 7075-T7351
- Clear Anodized to PRC 5006 Type II, Class 1.
- Dry Film coated on scuff surface per SSP 57004 Section 3.1.2.2



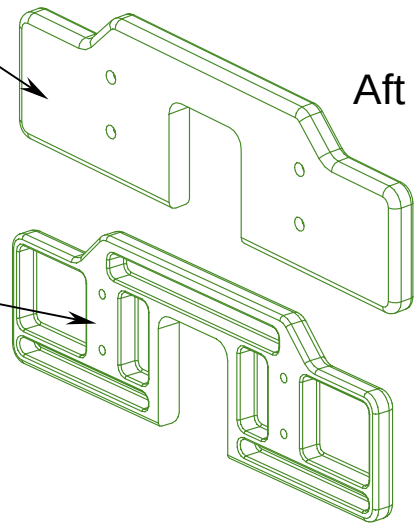


Apex Scuff Plate

Everlube 812 Dry Film Lubricated Surface.

- This surface acts as a potential contact surface to CAS guide Vane Assemblies during Berthing Operations

Nickel Plated interfaces to PAS Platform. Process per JSC PRC 5007



Aft Scuff Plate

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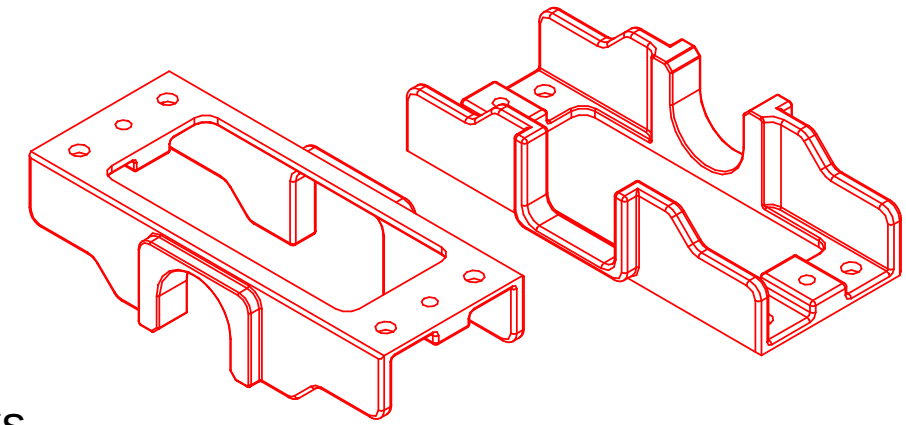
AMS PASSIVE PAS ASSEMBLY
HARDWARE DESCRIPTION
CAPTURE BAR RETAINER BRACKETS

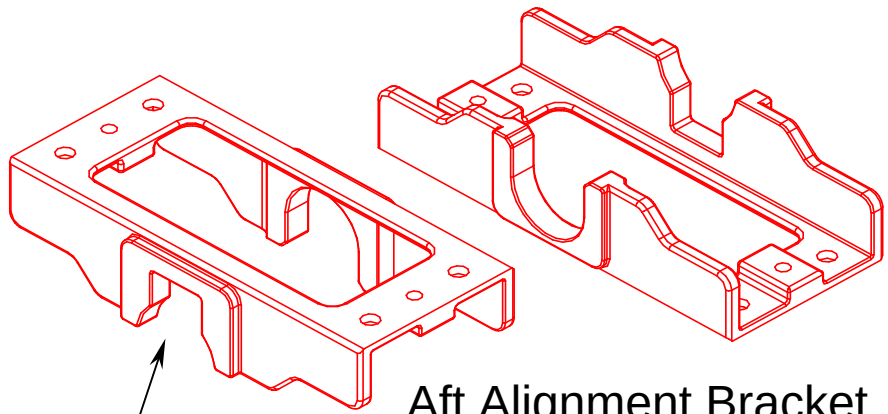
- Machined 15-5 PH age hardened to H1025 per NASA JSC PRC 2001. Passivated to PRC 5002 Type VI.

Brackets serve three purposes.

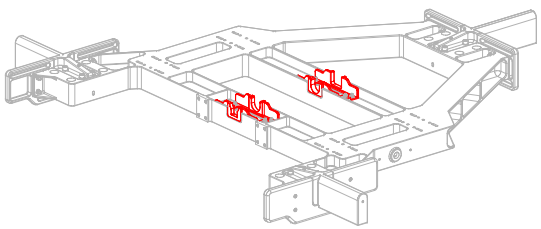
- Add stiffness to the PAS Platform.
- Maintains alignment of the Capture Bar per SSP 57004 section 3.1.2.2.
- Provides the keying feature that locks the Capture Bar in position until the bar is unloaded.

Apex Alignment Bracket





Aft Alignment Bracket



Capture Bar Keying feature

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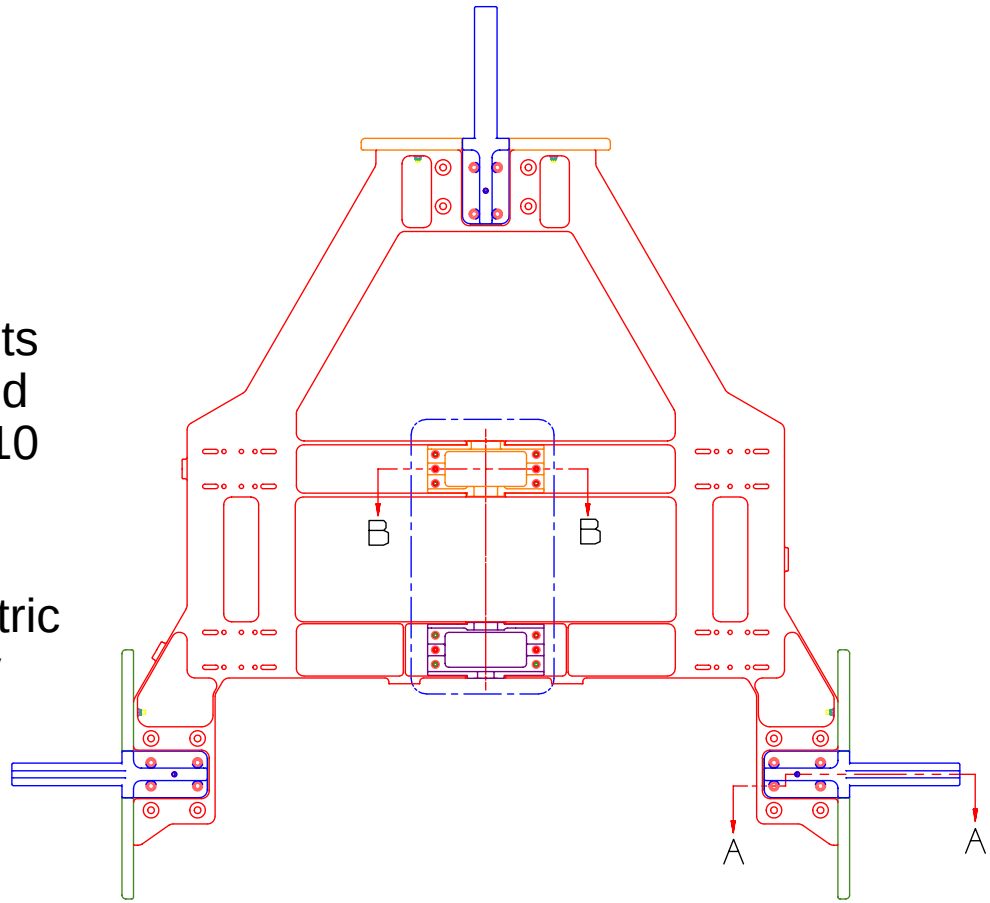
AMS PASSIVE PAS ASSEMBLY
HARDWARE DESCRIPTION
PAS BASE ASSEMBLY METHOD

- PAS Base Assembly serves to meet the Static Interface Requirements of SSP 57004 Section 3.1.2.2
- Guide Pins are shimmed, aligned, and pinned at the assembly level.
- Capture Bar Retainer Brackets are aligned, match drilled, and positioned using NAS6704U10 close tolerance hex head screws.
- Scuff Plates maintain geometric compliance to SSP 57004 by machining tolerances.



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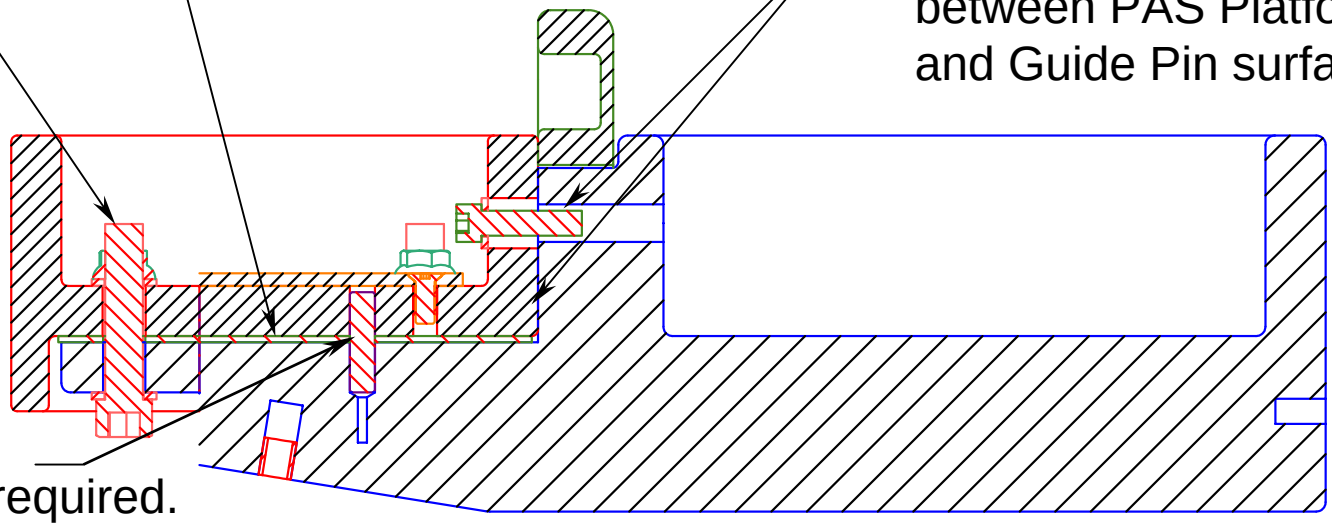
AMS PASSIVE PAS ASSEMBLY
HARDWARE DESCRIPTION
PAS BASE ASSEMBLY METHOD

3/8-24 UNJF Socket Head Cap Screws. (4) required per pin

Aluminum Shim Stock, peel type, .002 inch layers per SAE-AMS-DTL-22499

¼-28UNJF SHCS Preload maintains electrical bond between PAS Platform and Guide Pin surfaces.



SECTION A - A

Sheer Pins. 2 required. Guide Pin is shimmed, aligned, match drilled, and pinned to meet I/F requirements.

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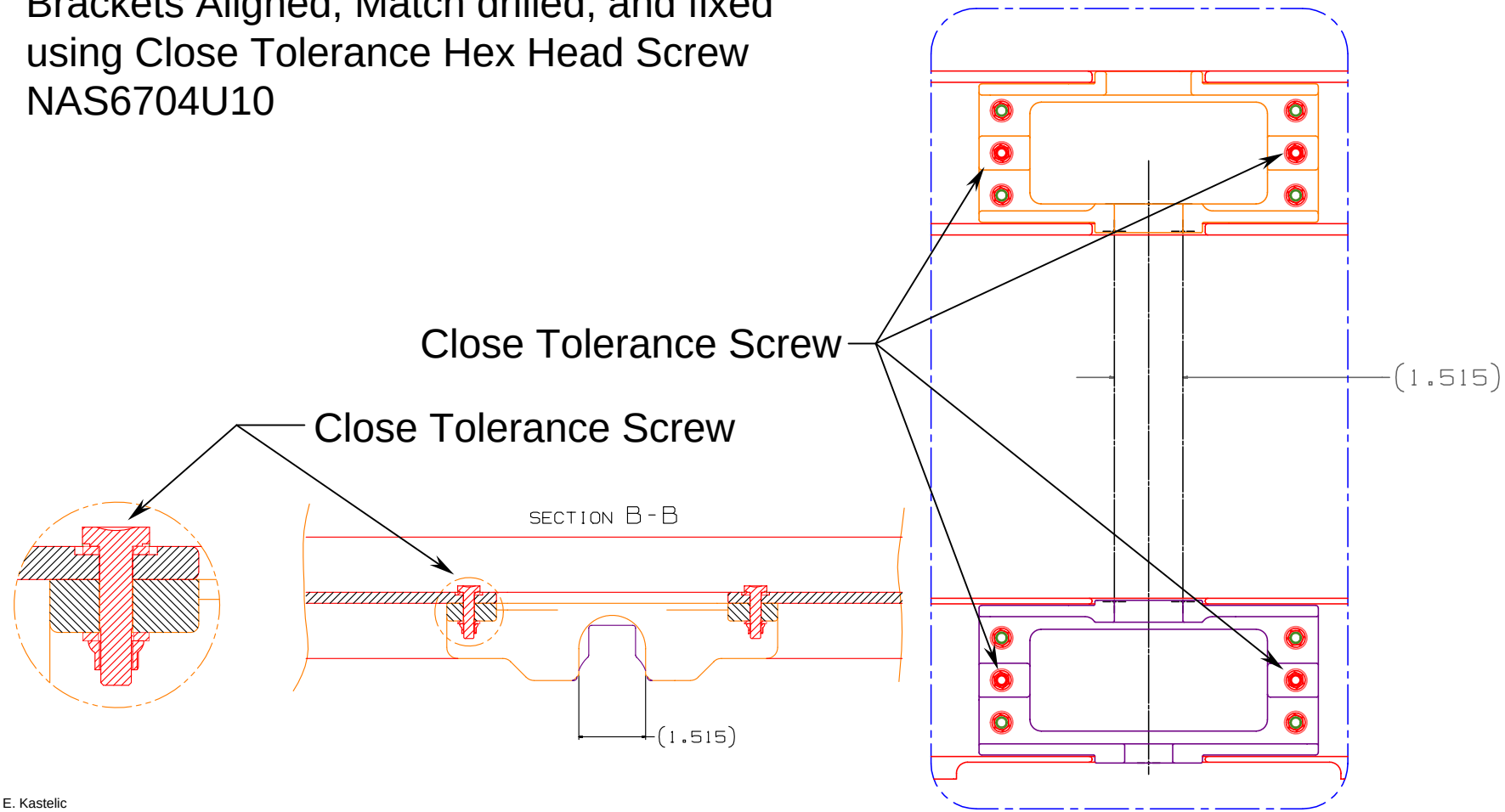
AMS PASSIVE PAS ASSEMBLY
HARDWARE DESCRIPTION
PAS BASE ASSEMBLY METHOD

Brackets Aligned, Match drilled, and fixed using Close Tolerance Hex Head Screw NAS6704U10



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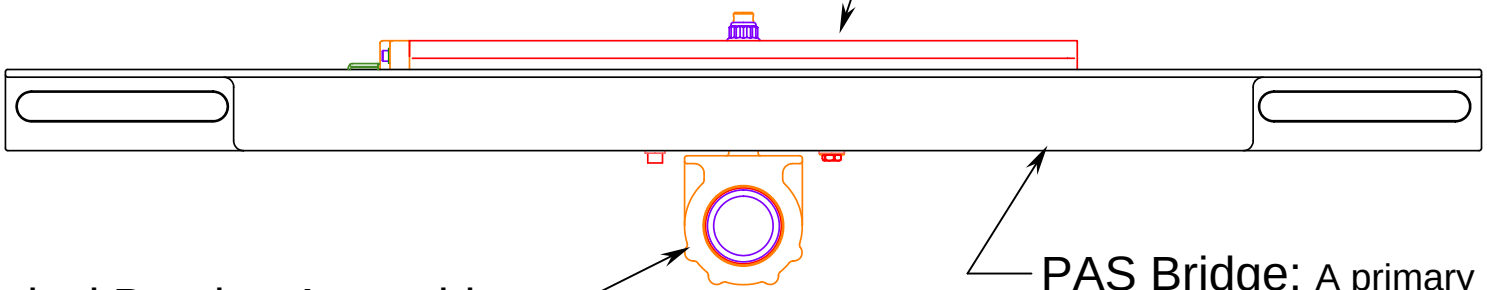
AMS PASSIVE PAS ASSEMBLY
HARDWARE DESCRIPTION
PAS BRIDGE ASSEMBLY

LOCKHEED MARTIN

Components

- **Bridge**
- **Release Mechanism Assembly**
  - **Housing**
  - **Bearing Assembly**
  - **Wedge**
  - **Slip Plate**
  - **Drive Screw**

Release Mechanism Assembly: SSP 57003 Requires an Unloadable Releasable Capture Bar. Release Mechanism allows the removal of preload using the a retractable wedge.



Spherical Bearing Assembly
The support structure for the Capture bar

PAS Bridge: A primary component of the AMS Passive PAS Spring System. Bridge Supports are adjustable allowing control of spring rate.

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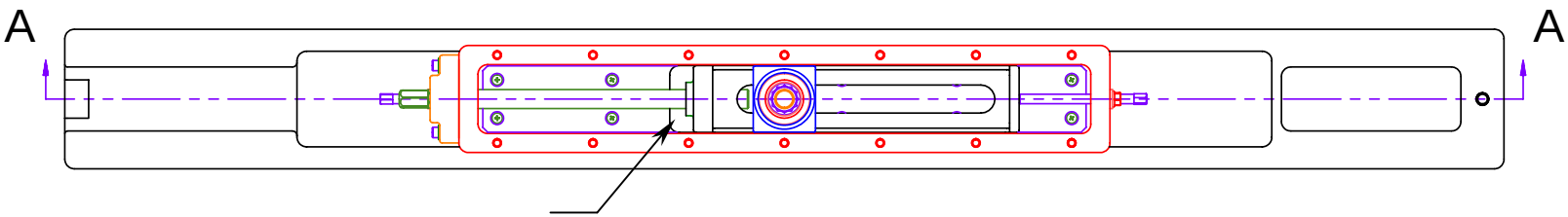
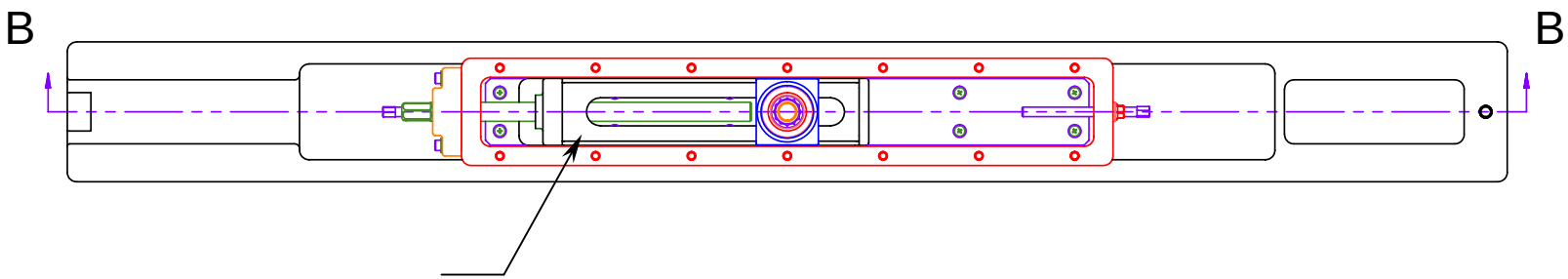
AMS PASSIVE PAS ASSEMBLY
HARDWARE DESCRIPTION
PAS BRIDGE ASSEMBLY

Top View of Release Mechanism mounted in Bridge



Wedge shown in Set Position as defined in SSP 57004
Capture Bar 1.142 +/- .005 from PAS Datum Z



Wedge Position shown retracted and in lowered position
(.71 inch minimum unload stroke per SSP 57003)
Mechanism has a one inch stroke capability.

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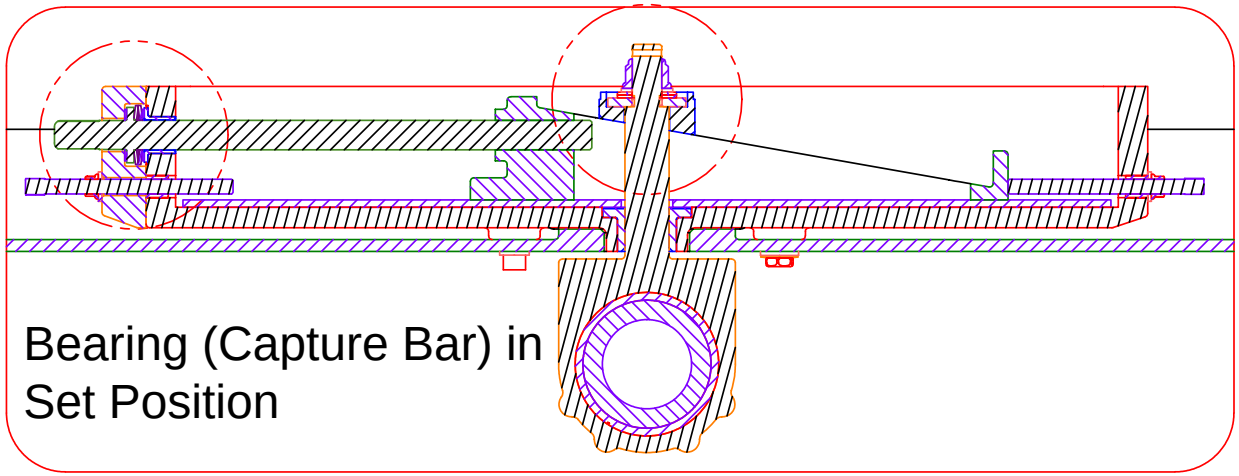
AMS PASSIVE PAS ASSEMBLY
HARDWARE DESCRIPTION
PAS BRIDGE ASSEMBLY

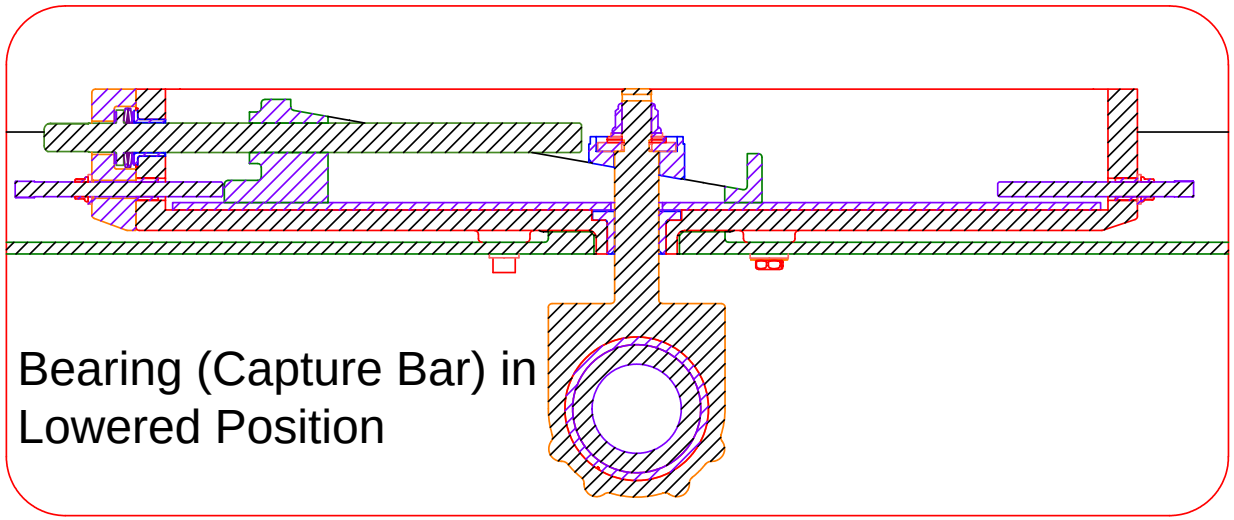
LOCKHEED MARTIN

Section view shows workings of Release Mechanism. 10 Degree Wedge shown set with bearing at required 1.142 inches from PAS Datum in Z direction. Wedge bears against Upper Travel Limiter.

Section A



Section view shows Release mechanism retracted in lowered position. Wedge bears against Lower Travel Limiter.



Section B

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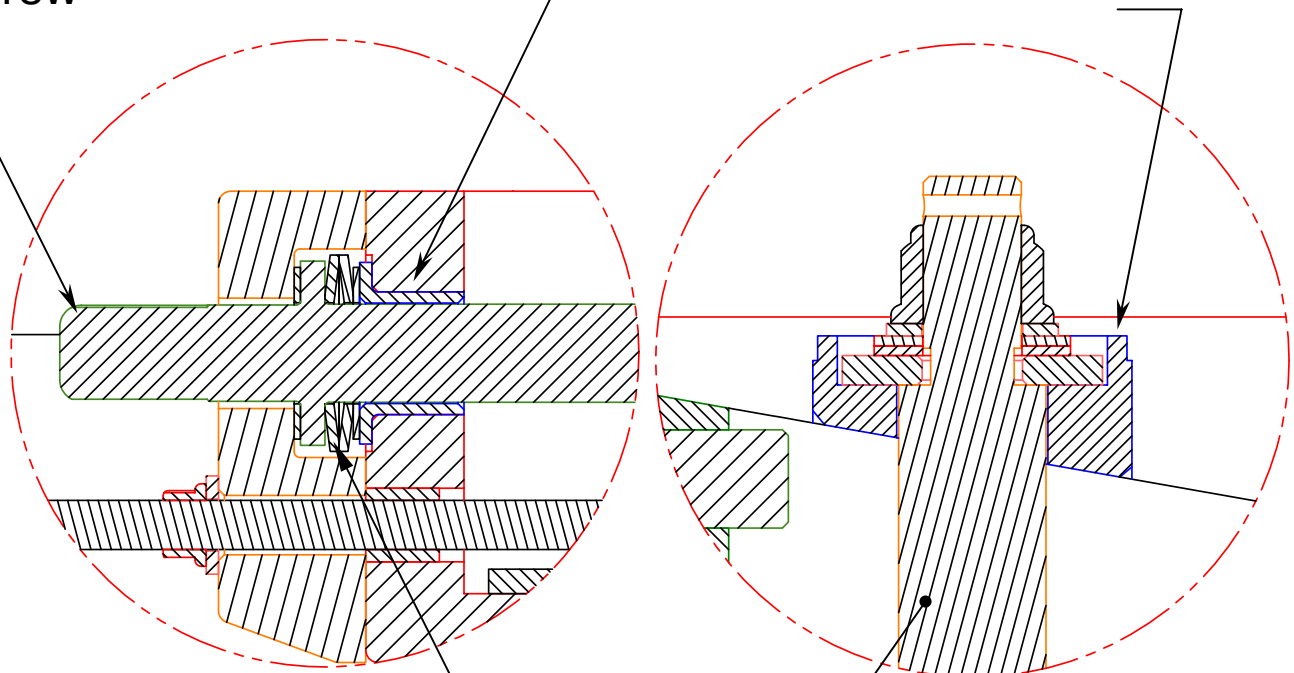
AMS PASSIVE PAS ASSEMBLY
HARDWARE DESCRIPTION
PAS BRIDGE ASSEMBLY

Drive Screw Bushing
Aluminum Bronze per AMS 9640

Release Mechanism drive Screw

Wedge Nut Electro-polished 15-5 PH. 10 degree angle applies Capture Bar preload to Wedge.



Bellville Washers

Provides Preload on Drive Screw

Bearing Assembly Shaft

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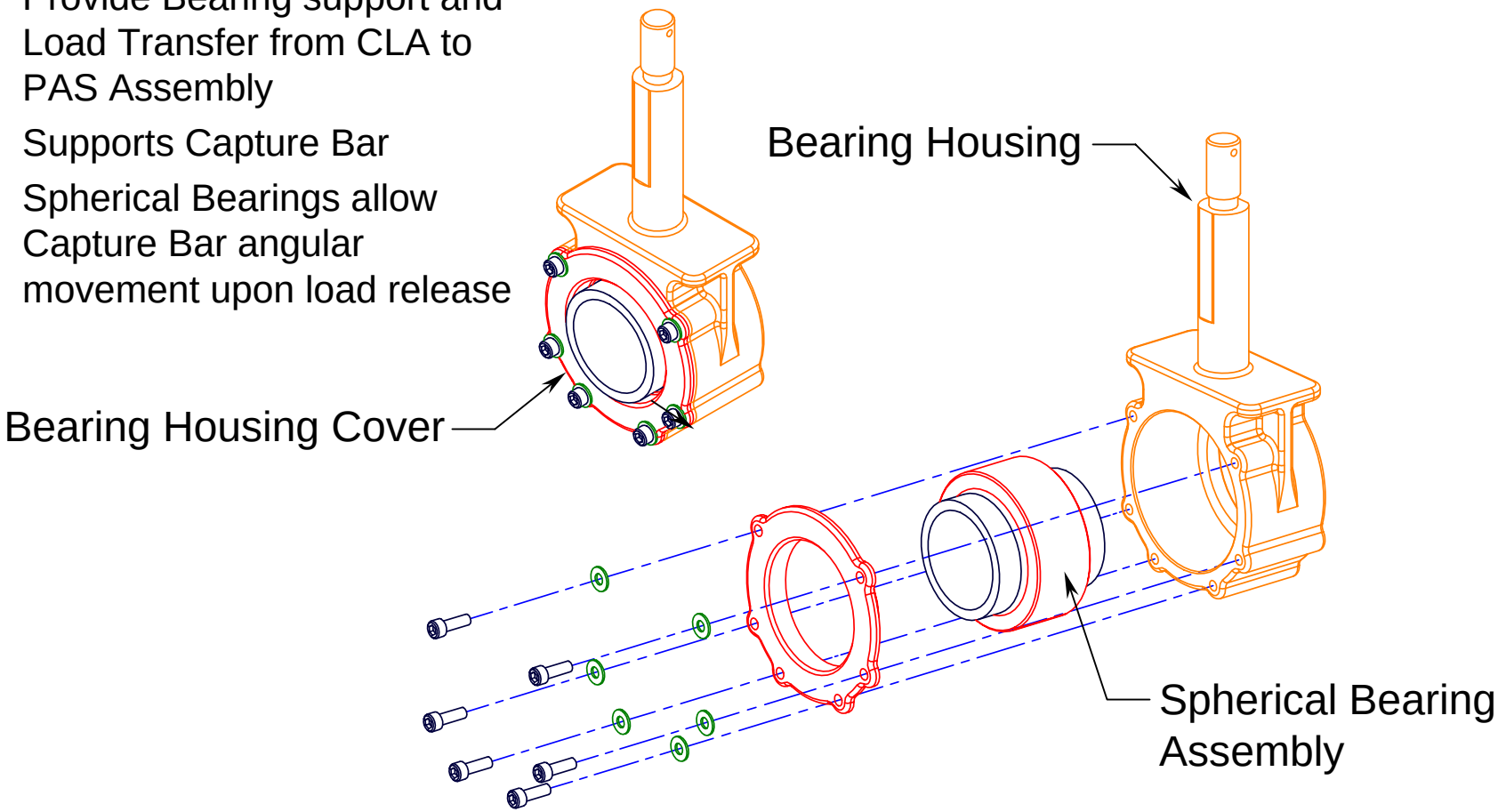
AMS PASSIVE PAS ASSEMBLY
HARDWARE DESCRIPTION
PAS BRIDGE ASSEMBLY

Bearing Assembly Description

- Provide Bearing support and Load Transfer from CLA to PAS Assembly
- Supports Capture Bar
- Spherical Bearings allow Capture Bar angular movement upon load release



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AMS PASSIVE PAS ASSEMBLY
HARDWARE DESCRIPTION
PAS BRIDGE ASSEMBLY

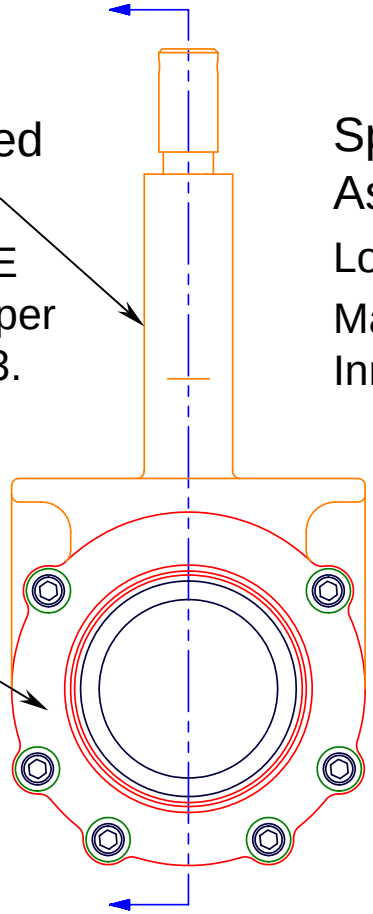
LOCKHEED MARTIN

Bearing Housing

Machined Age Hardened
15-5 PH CRES

Fracture Critical Part: NDE
Dye Penetrant Inspected per
PRC 6506, Type 1, level 3.

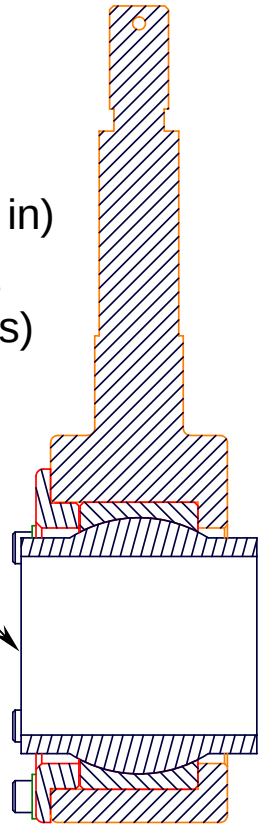
Bearing Housing Cover
Machined Age Hardened
15-5 PH per AMS 5659



Spherical Bearing
Assembly

Low Profile OD (2.4375 in)

Maximum Misalignment
Inner Race (5.3 Degrees)



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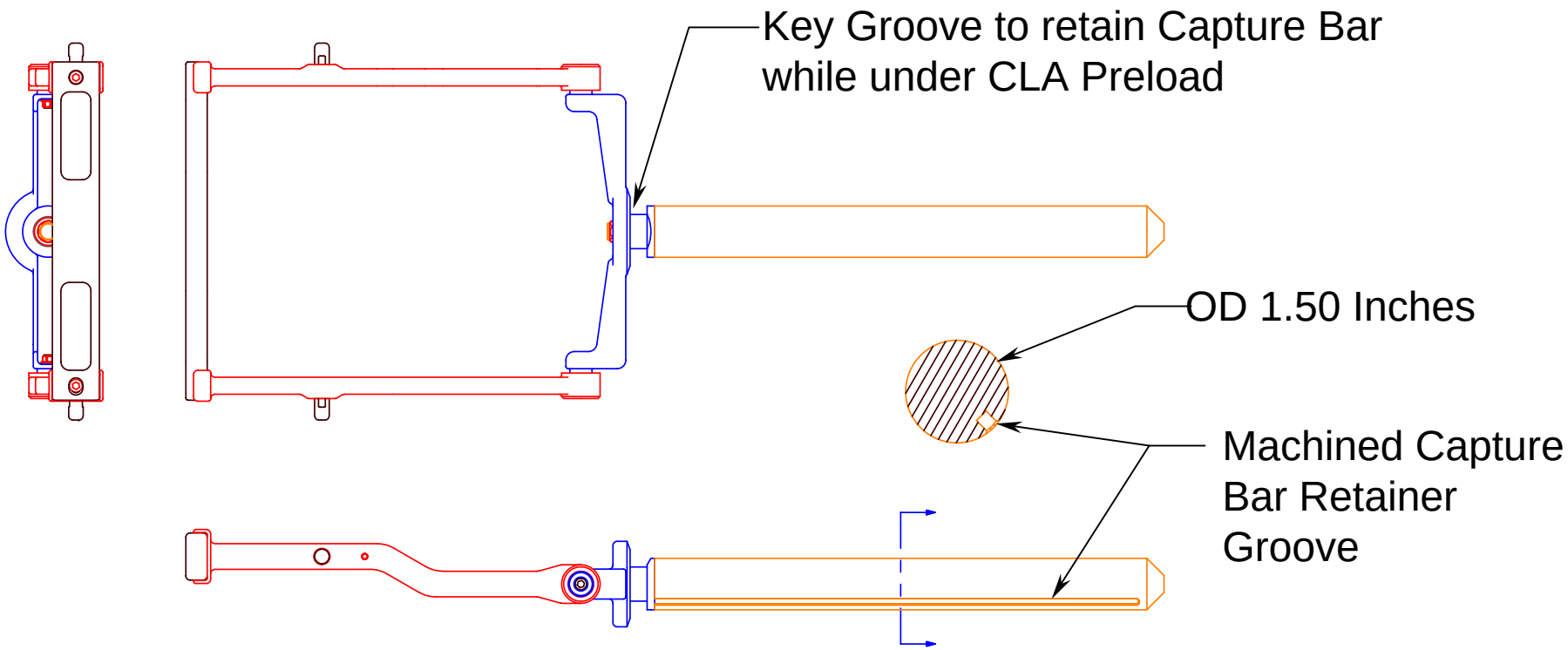
AMS PASSIVE PAS ASSEMBLY
HARDWARE DESCRIPTION
CAPTURE BAR ASSEMBLY



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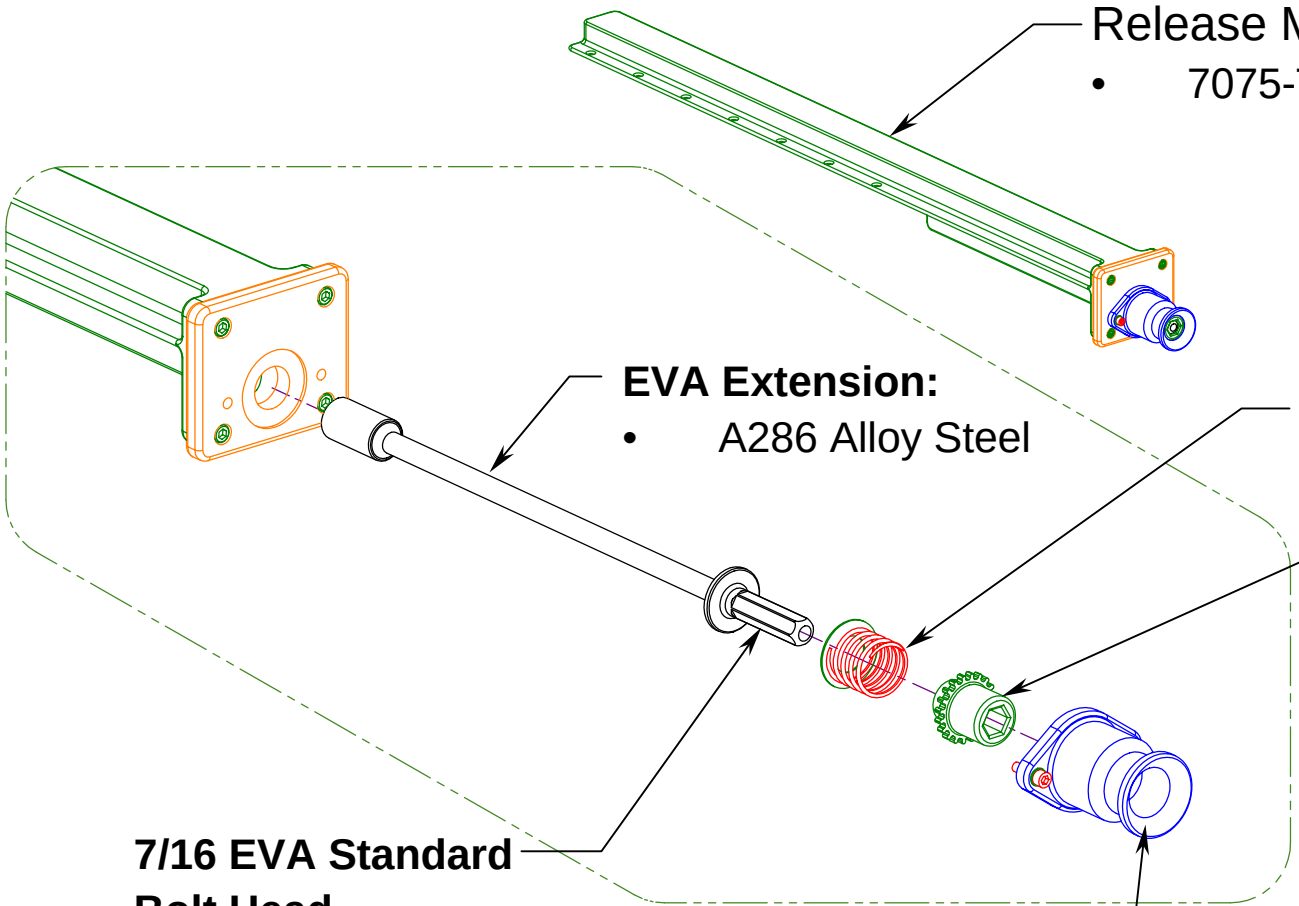
AMS PASSIVE PAS ASSEMBLY
HARDWARE DESCRIPTION
EVA EXTENSION ASSEMBLY



Release Mechanism Cover:
- 7075-T7351 Aluminum Alloy

EVA Extension:
- A286 Alloy Steel

Compression Spring
- Spring Rate: 6.2 Lb/in

Locking Retractor
- A286 CRES

7/16 EVA Standard Bolt Head

Locking Mechanism Base
- A286 Alloy Steel

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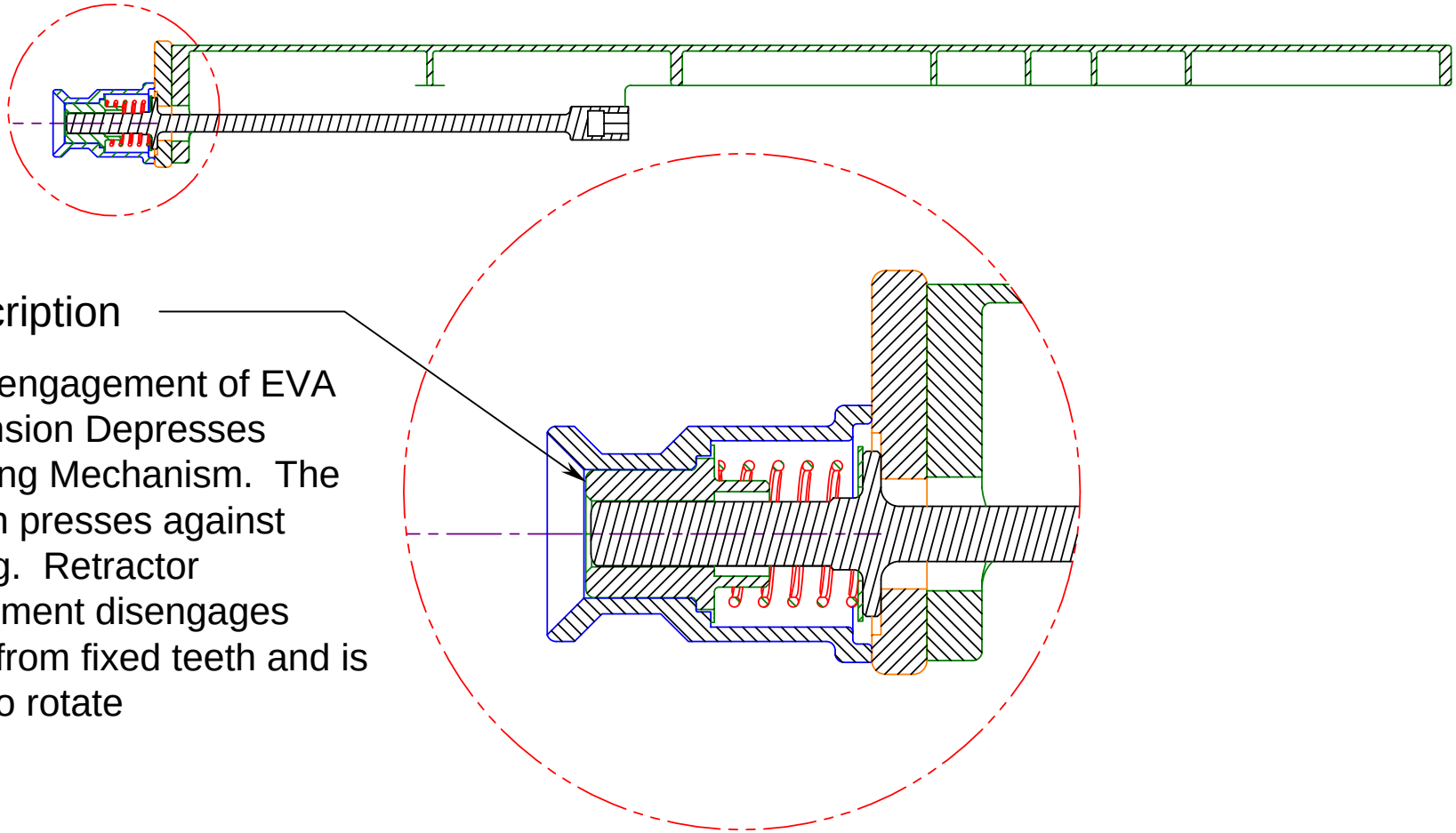
AMS PASSIVE PAS ASSEMBLY
HARDWARE DESCRIPTION
EVA EXTENSION ASSEMBLY



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

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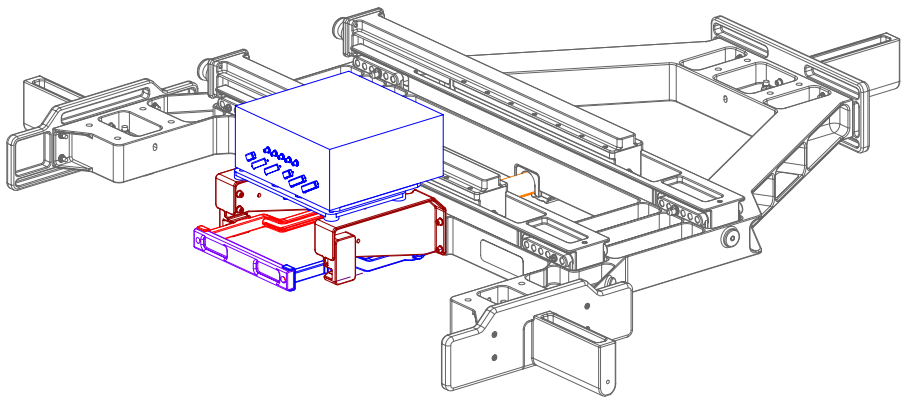
EXTERNAL BERTHING CUES SYSTEM (EBCS) AVIONICS PACKAGE

EBCS Avionics

- BCS Provide Visual cues to robotic workstation monitors to assist ISS Mobile Servicing System operators in berthing ISS external payloads.
- System is comprised of an Avionics Package which contains primary, secondary video cameras, and a BCS Target which is mounted on the CAS site.
- BCS Avionics mounting is the responsibility of the attached payload.
- Mounting Requirements are defined in SSP 57003 section 3.7.6.1, SSP 57004 figures 3.1.2.2-1 and SSP 57004 figures 3.7.1-1. Additional data per MDR-BCS-SG-5822 Development Specification produced by MD Robotics per NASA contract NAS9-00089.
- BCS Electrical Services include video, video sync, power, heater power, and payload power.



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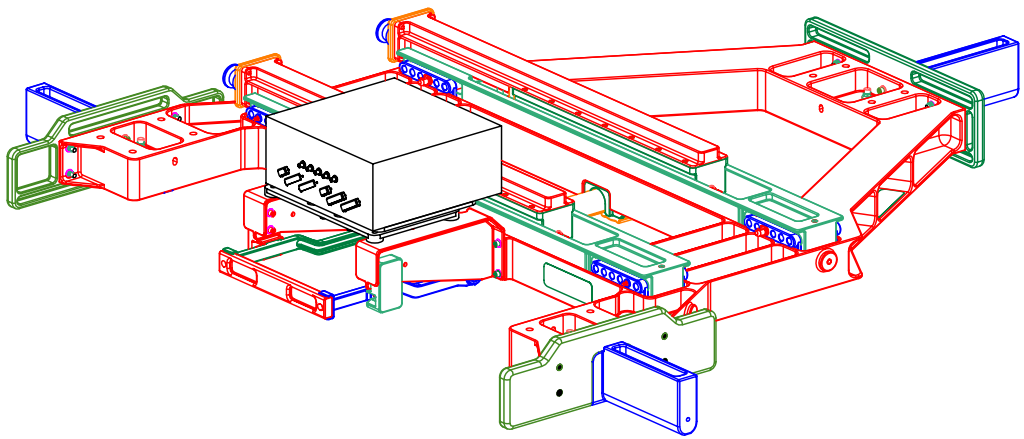
PAS SPRING RATE MODEL OVERVIEW

The AMS Passive PAS is a design solution for the passive half of the Common Attach System. It's primary purpose is secure an attached payload to the Passive Integrated Truss Segment Payload Attach Site located on the S3 Truss of the International Space Station. It is an assembly produced to provide a solution to a number of simultaneous geometric and performance based requirements defined in Space Station Documents SSP 57003 and SSP 57004.

In an effort to accommodate the stringent spring rate criteria defined in SSP 57003 and to allow for future variations in this requirement the design allows for the adjustability of the spring rate using a simple variable length beam principle. This section summarizes the design criteria, the predicted values, and the as-built tested results.



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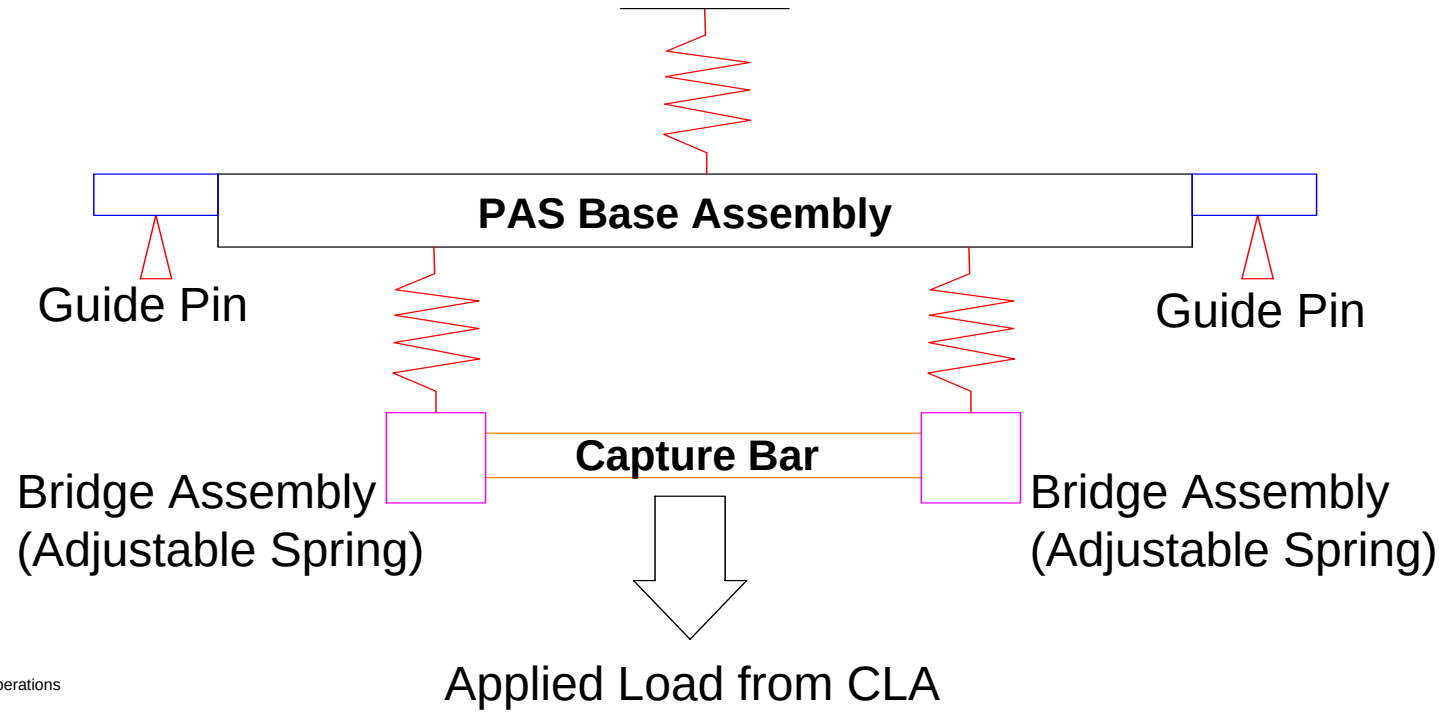
PAS SPRING RATE MODEL
SPRING RATE SCHEMATIC

The AMS Passive PAS utilizes the predictable nature of simply supported beams with the ability to control the support locations on each beam.

The system is comprised of a machined platform of a fixed geometry that acts to satisfy the geometric interface requirements of SSP 57003, with two variable geometry Bridge Beams in a series configuration with the PAS platform. The beams act in a parallel configuration with each respective beam. The Primary components to the spring system are the PAS Base and the Bridge Assemblies.



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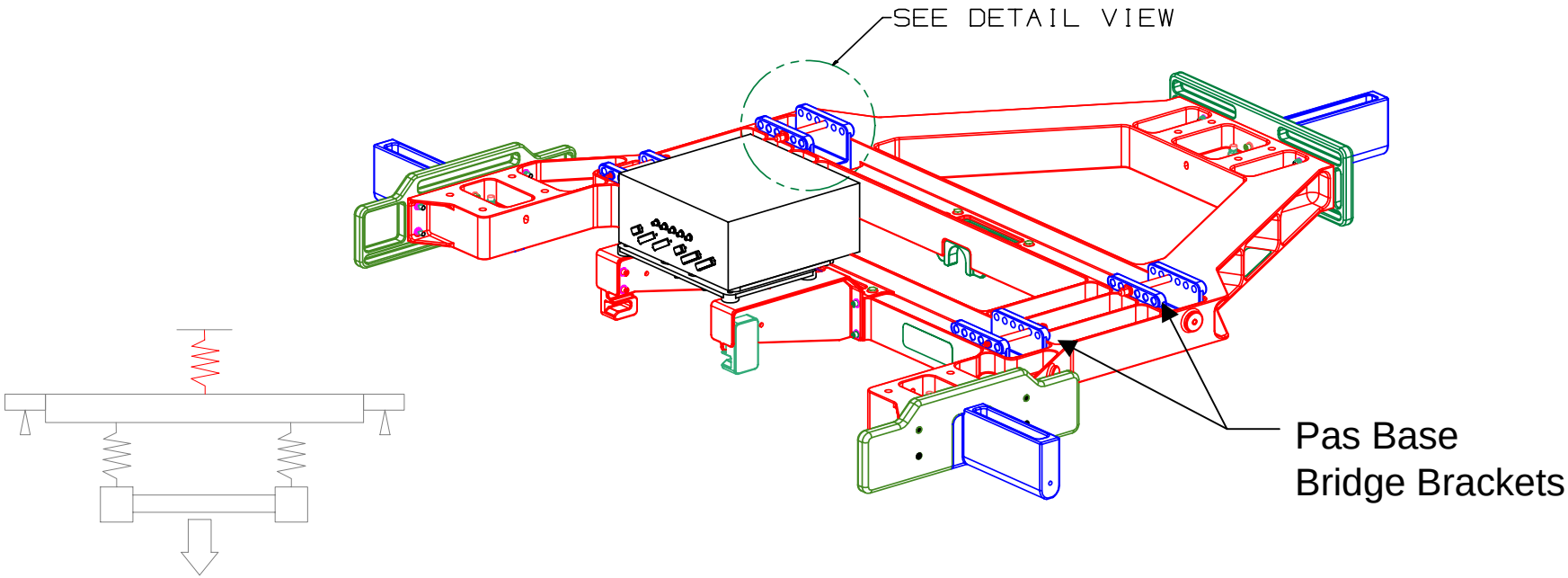
PAS SPRING RATE MODEL
PAS BASE ASSEMBLY

Platform Features

- The PAS Platform acts as the primary geometry that interfaces the Active PAS. It serves to support the Bridge Assemblies with a pinned connection.
- The Bridge assemblies are attached to the Platform using 4 PAS Base Bridge Brackets. These brackets have three possible mounting locations on the PAS Platform. Location A, B, and C.



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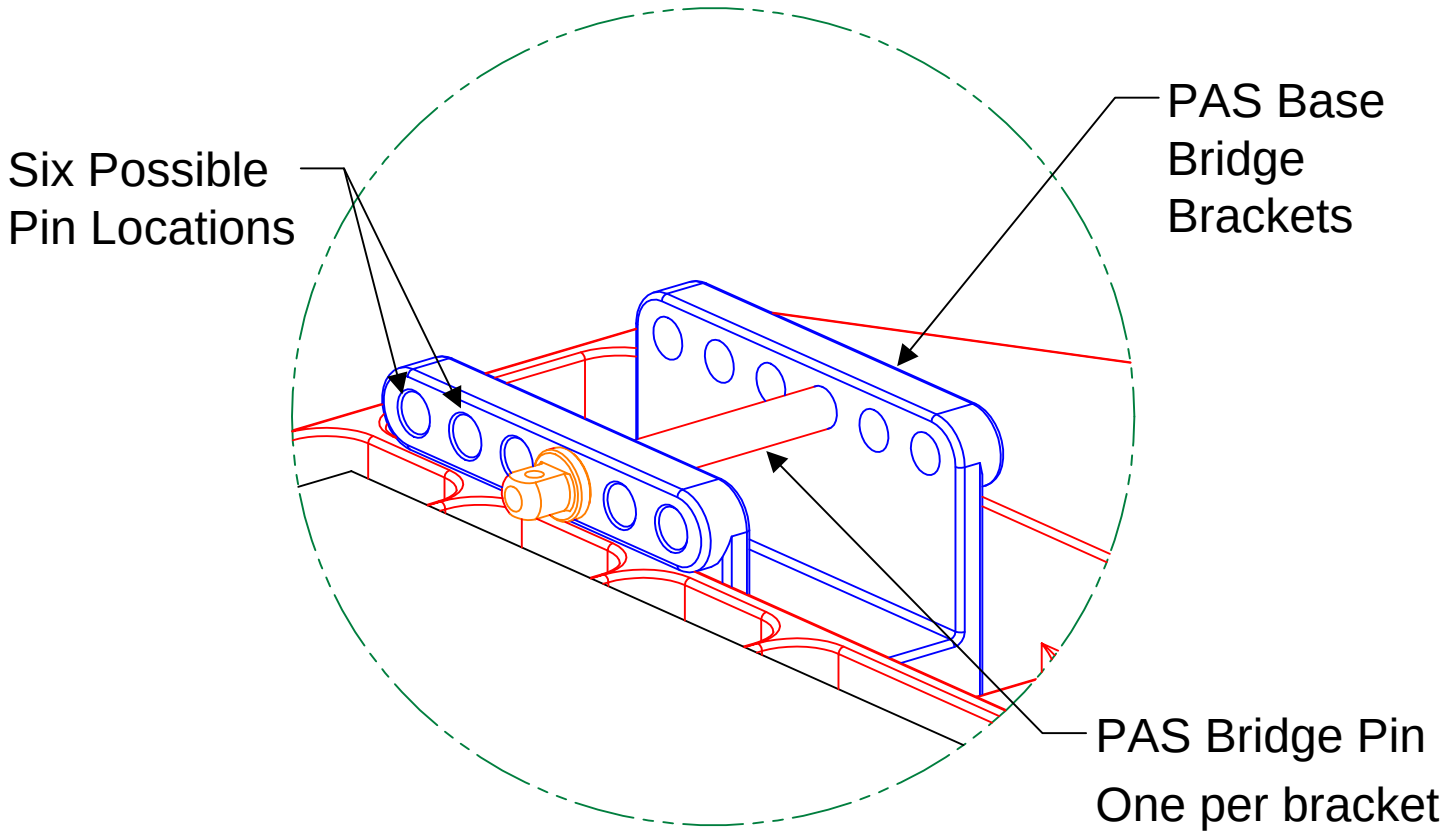
PAS SPRING RATE
PAS BASE ASSEMBLY
PAS BASE BRIDGE BRACKETS



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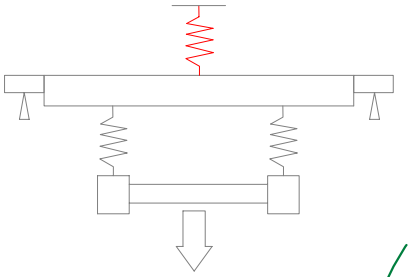
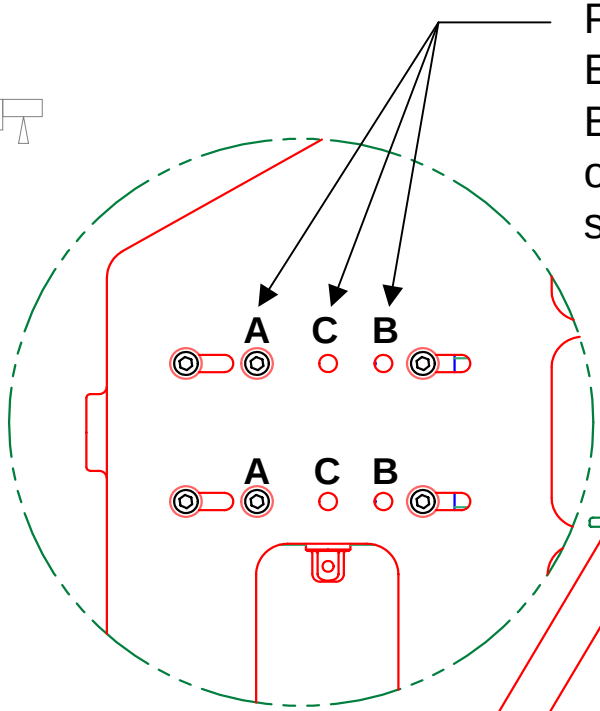
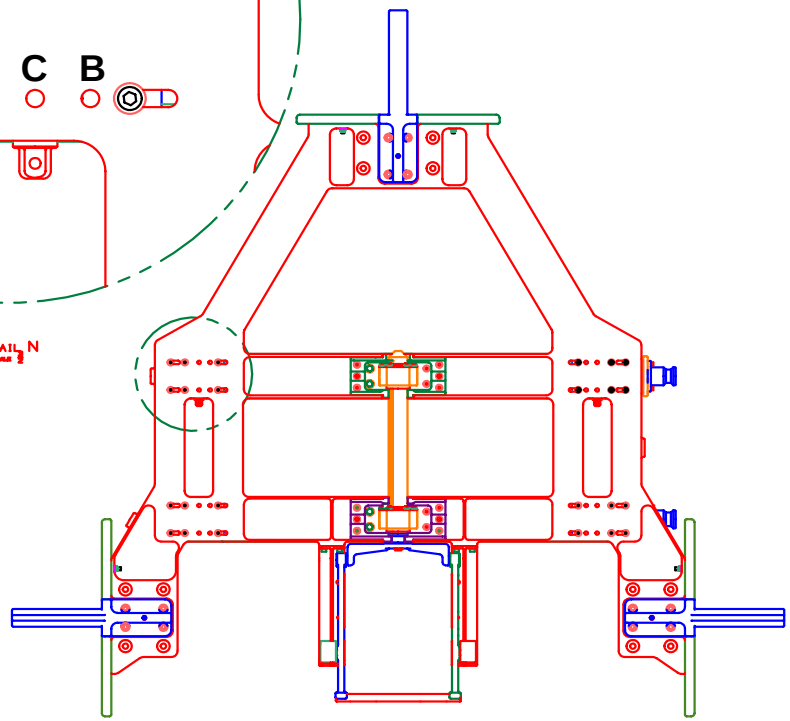
20 May 2004

PAS SPRING RATE
PAS BASE ASSEMBLY
BRACKET MOUNTING OPTIONS





PAS Bridge Bracket positions A, B, and C
Each Position Offsets the
Bridge Bracket by.25 inches changing the overall span by .5 inches for a symmetrical system



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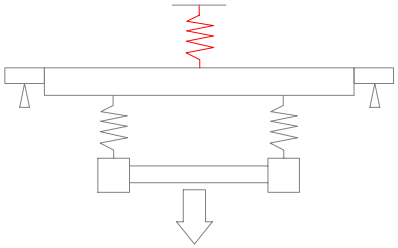
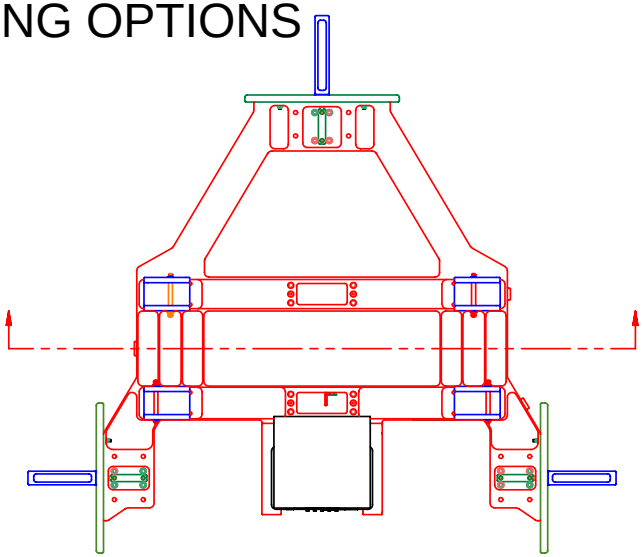
PAS SPRING RATE MODEL
PAS BASE ASSEMBLY
BRACKET MOUNTING OPTIONS



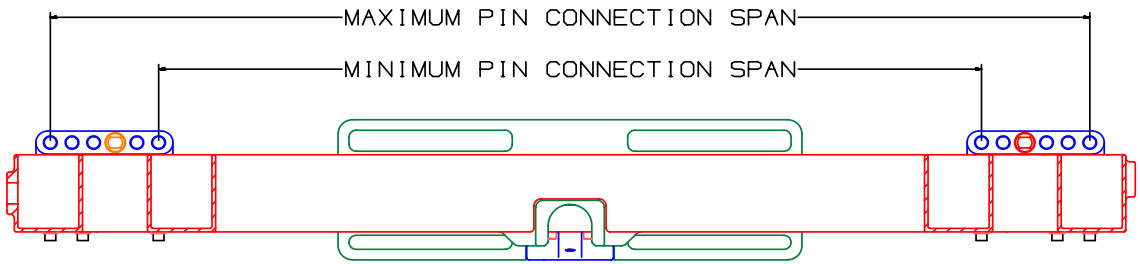


MAXIMINUM SPAN AT BRACKET POSITIONS A, B, AND C.

POSITION A: 36.00 INCHES
POSITION B: 35.50 INCHES
POSITION C: 35.00 INCHES

MINIMUM SPAN AT BRACKET POSITIONS A, B, AND C.

POSITION A: 28.50 INCHES
POSITION B: 28.00 INCHES
POSITION C: 27.50 INCHES



PAS Bridge End Connection Options

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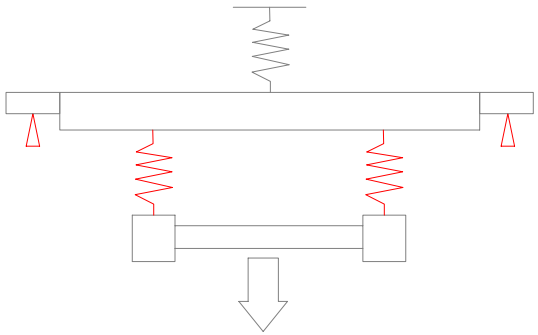
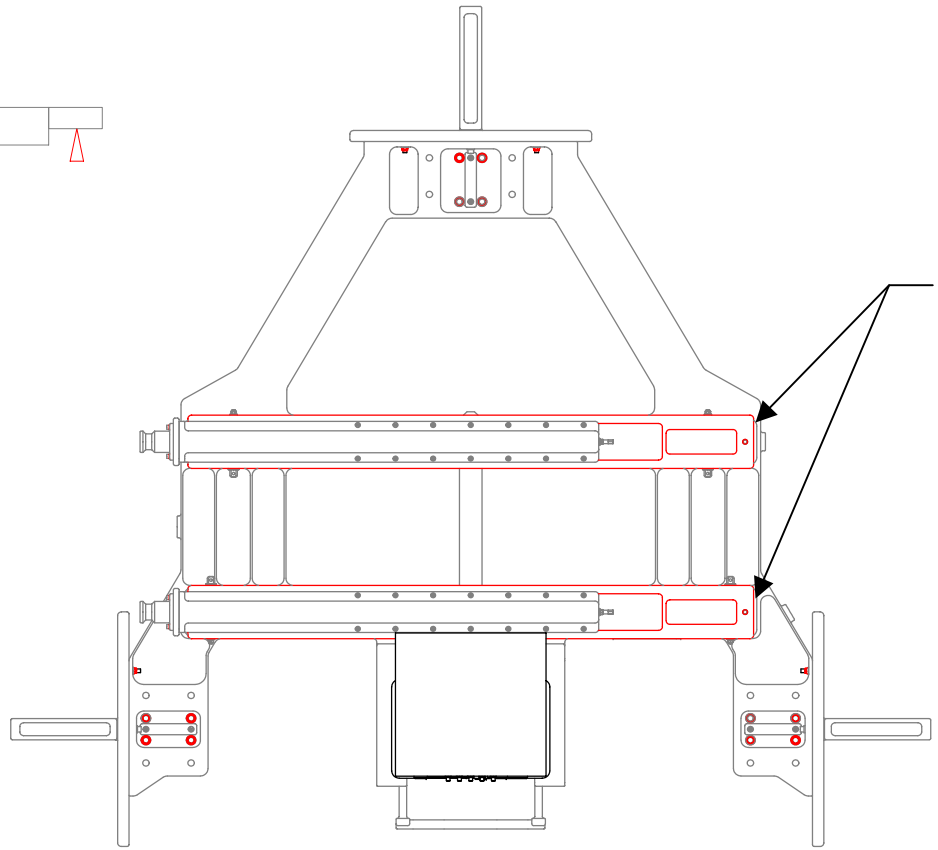
PAS SPRING RATE MODEL
PAS BRIDGE ASSEMBLIES

LOCKHEED MARTIN

The PAS Bridge Assemblies

- Function as the Secondary Spring System
- Bridge Span (Spring rate) is adjustable
- Fixed Via pinned connections to PAS Base Assembly





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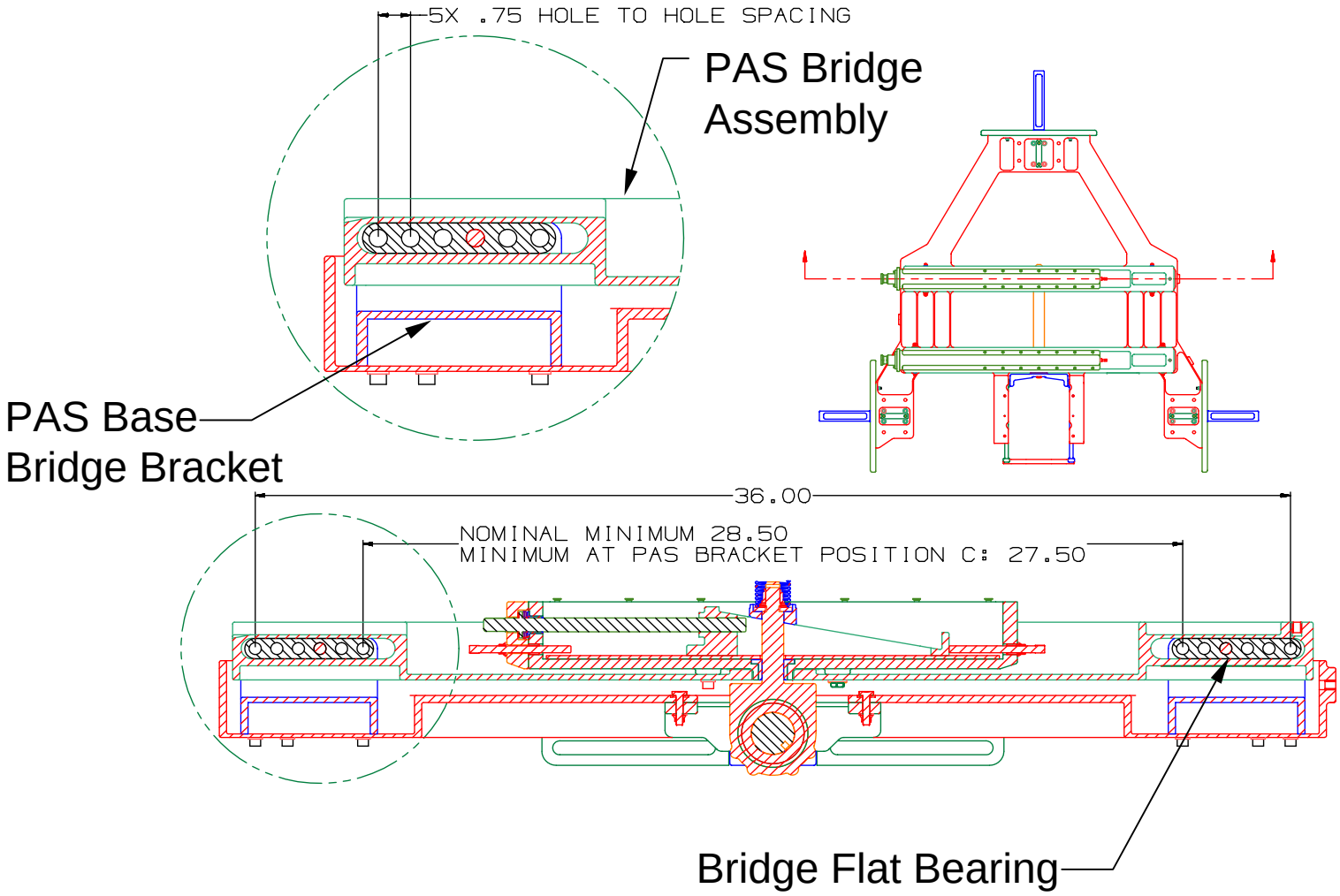
PAS SPRING RATE MODEL
PAS BRIDGE ASSEMBLIES



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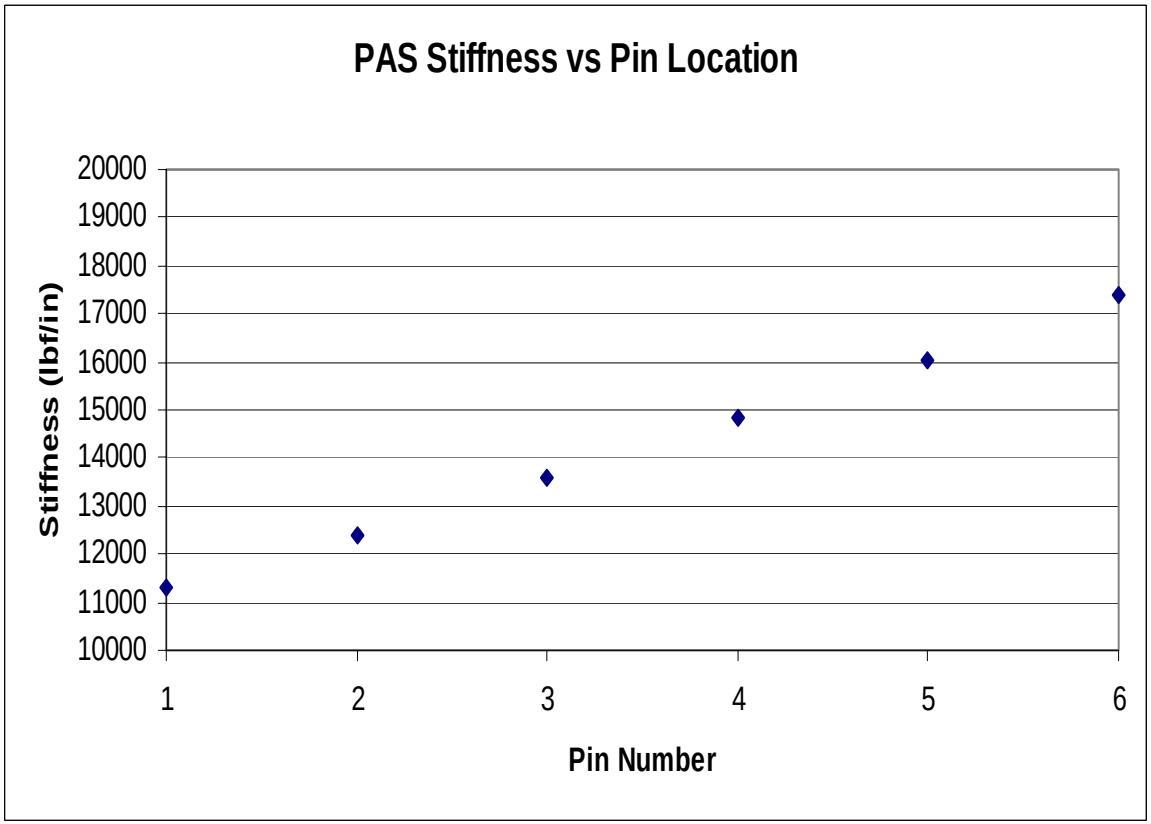
PAS SPRING RATE MODEL
PREDICTED PAS STIFFNESS VS PIN LOCATION



System Stiffness			
Pin Number	Bushing	Bridge Length	Stiffness NASTRAN
6	C	27.5	18618
6	B	28.0	17955
6	A	28.5	17398
5	C	29.0	16913
5	B	29.5	16472
5	A	30.0	16056
4	C	30.5	15650
4	B	31.0	15246
4	A	31.5	14839
3	C	32.0	14428
3	B	32.5	14016
3	**A**	**33.0**	**13604**
2	C	33.5	13197
2	B	34.0	12797
2	A	34.5	12408
1	C	35.0	12029
1	B	35.5	11656
1	A	36.0	11283

Note: Spring Rate Requirement is 13500 +/- 10% (SSP 57003)

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PAS SPRING RATE MODEL
PREDICTED RESOLUTION OF SPRING RATE

System Stiffness Predicted					
Pin Number	Bushing	Bridge Length	Stiffness NASTRAN	Resolution	Resolution: Staggered Pins lb/in (.25 inch offset)
6	C	27.5	18618	663	331.5
6	B	28.0	17955	557	278.5
6	A	28.5	17398	485	242.5
5	C	29.0	16913	441	220.5
5	B	29.5	16472	416	208
5	A	30.0	16056	406	203
4	C	30.5	15650	404	202
4	B	31.0	15246	407	203.5
4	A	31.5	14839	411	205.5
3	C	32.0	14428	412	206
3	B	32.5	14016	412	206
3	**A**	**33.0**	**13604**	407	203.5
2	C	33.5	13197	400	200
2	B	34.0	12797	389	194.5
2	A	34.5	12408	379	189.5
1	C	35.0	12029	373	186.5
1	B	35.5	11656	373	186.5
1	A	36.0	11283		

Refined resolutions with an asymmetrical change in pin location. (Example:Apex Bridge pins are located in the adjacent pin position .25 inches offset from the Aft Bridge: Apex Bridge Location 6A, Aft Pin location in 6B)

Note: further Refinement could be done staggering the pin locations on each separate bridge (Example: Aft Bridge Left Pin in 6A, right Pin in 6B)

Predicted change in spring rate with a symmetrical change in pin location. (Each Pin is in the same position)

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PREDICTED CAPTURE BAR DEFLECTION

Design Criteria:

- Maximum Preload: 6430 LB *
- Minimum Preload: 4900 LB *
- Nominal Preload: 5650 LB
- Nominal Stiffness 13500 +/- 10% **
- Nominal Capture Bar Deflection 5650/13500 LB = .419 inches (Total Deflection of the Capture Bar)

*per SSP 57003 Section 3.1.3.1.3.1

**per SSP 57003Section 3.1.3.1.3.2

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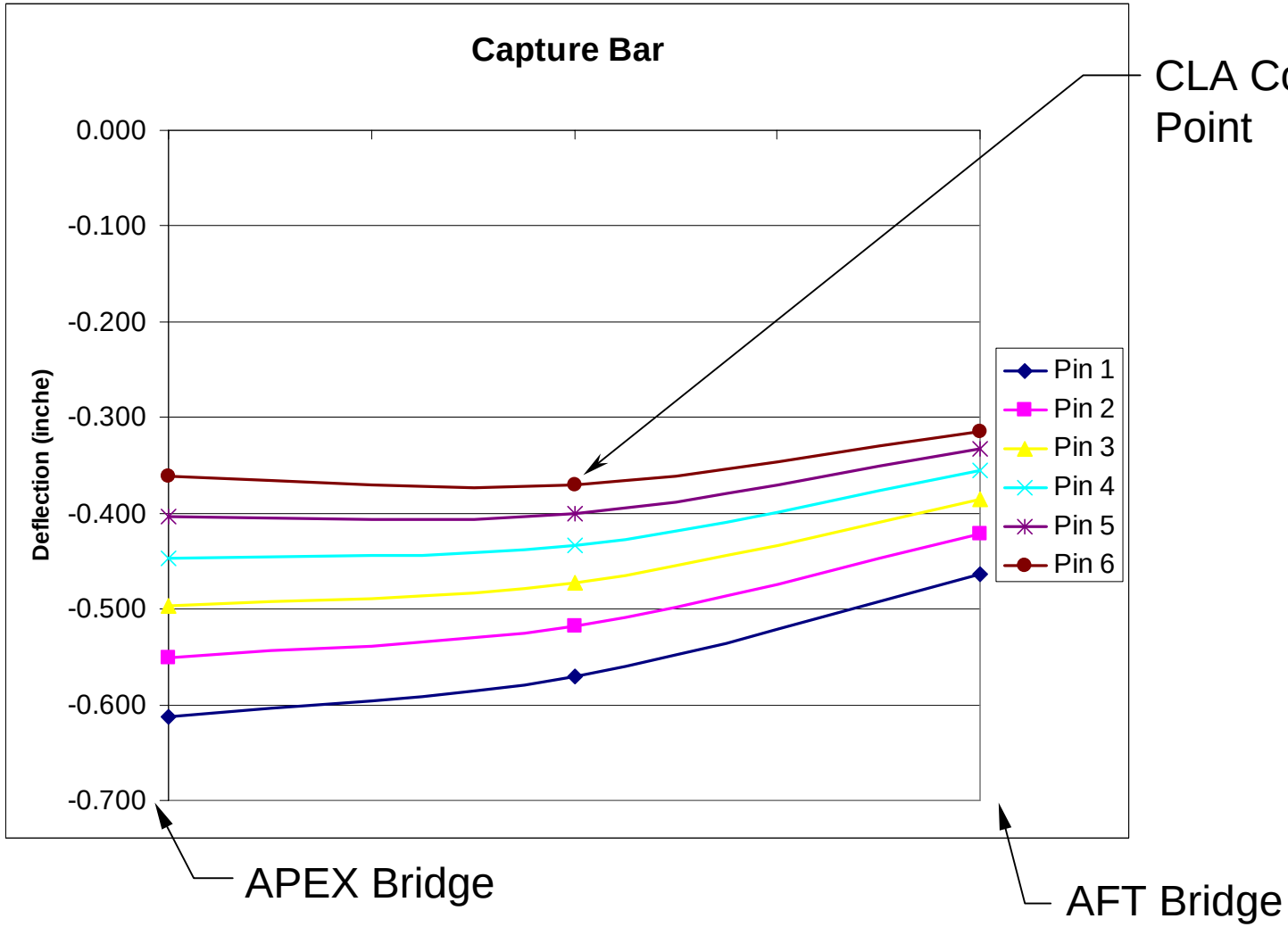
PREDICTED CAPTURE BAR DEFLECTION
BASED ON SYMMETRICAL PIN SPACING



Note: Capture Bar Deflects More in the Apex Bridge due to Platform effects. This suggests an effort to level the Capture Bar upon loading using offset pin locations.

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20 May 2004

PASSIVE PAS STATIC TEST

LOCKHEED MARTIN

Static Test Description: The AMS Passive PAS Static Test was conducted to achieve the following objectives:

- To Correlate the NASTRAN Model with the flight hardware in terms of stiffness and stress.
- To demonstrate the Maximum Preload Capability
- To “set” the PAS stiffness as close as possible to the required stiffness per SSP 57003
- To demonstrate the ability to off-load the Capture Bar Preload using the Capture Bar Release Mechanism .
- To use the adjustability of the spring system to level the Capture Bar.
- To Determine the Final Configuration

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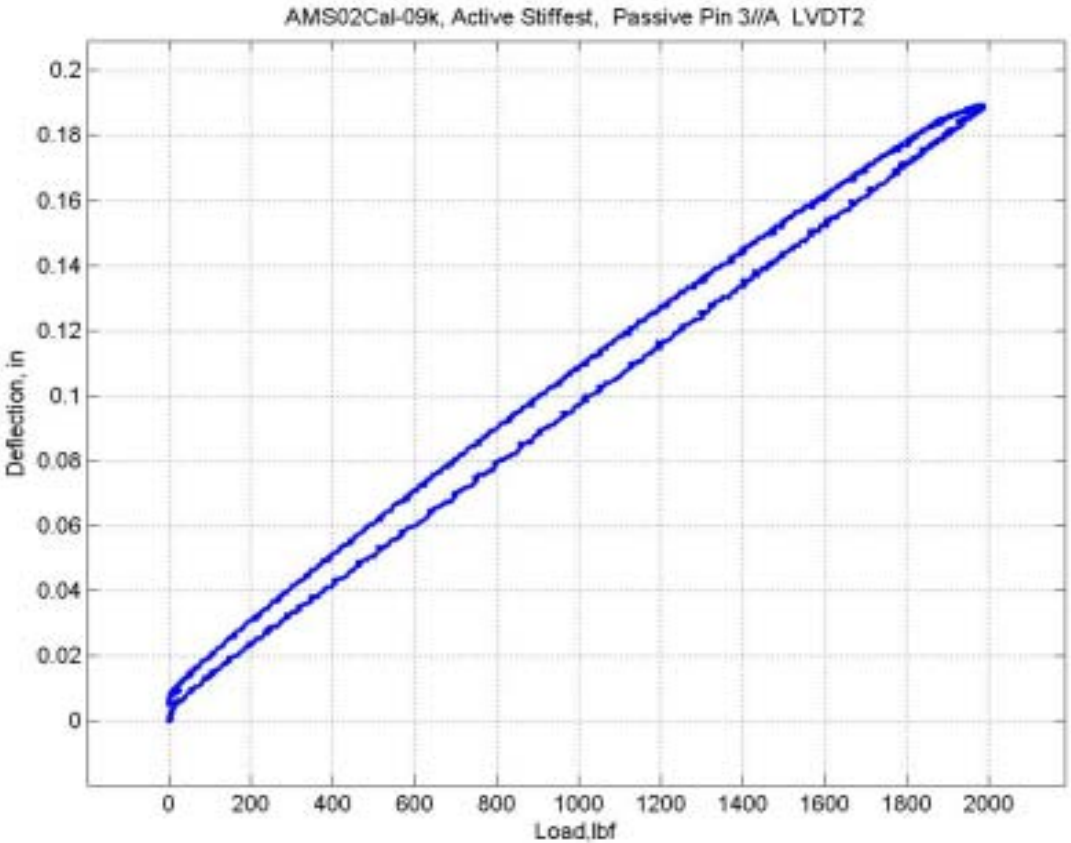
PASSIVE PAS STATIC TEST

Correlate the NASTRAN Model with the flight hardware in terms of stiffness.

SOFTEST PIN SETTING
Load VS Deflection



Graph shows Capture Bar Loaded to 2000 LBS. Deflection is at center of Capture Bar.

Pins Located at Location 1A (Softest)

Approximate Spring Rate:
Using Least Squares Fit: SR = 10837 lb/in
Predicted Value: 11283 Lb/in
(4% variation)

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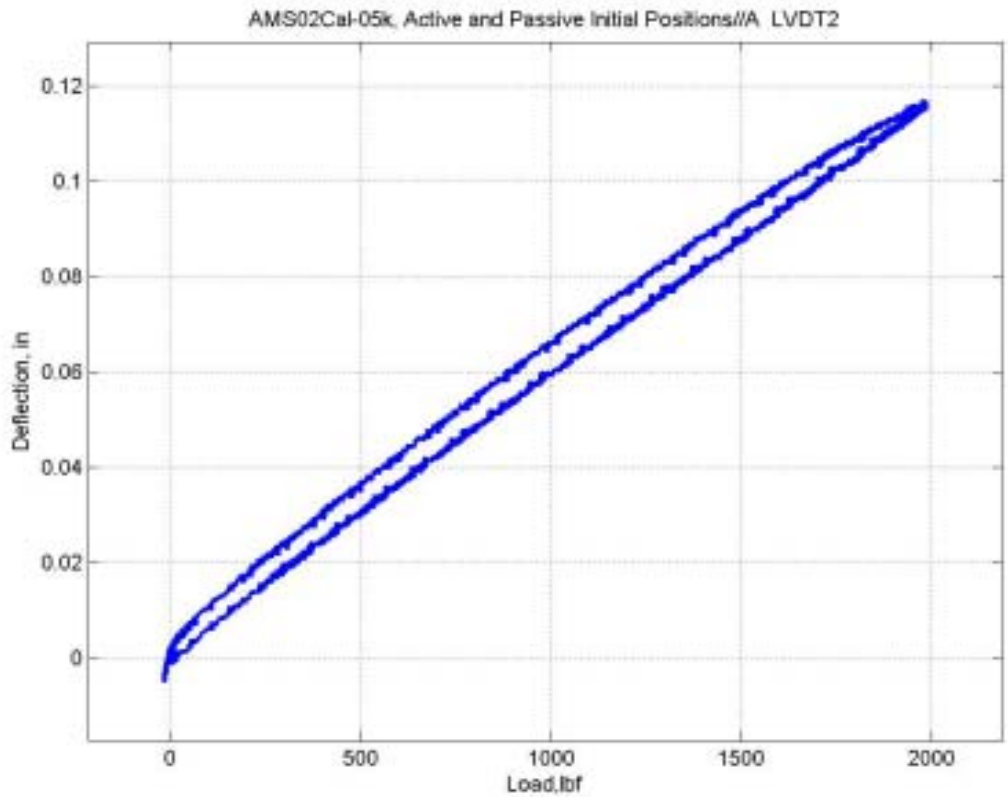
PASSIVE PAS STATIC TEST

Correlate the NASTRAN Model with the flight hardware in terms of stiffness.

STIFFEST PIN SETTING
Load VS Deflection



Graph shows Capture Bar Loaded to 2000 LBS. Deflection is at center of Capture Bar.

Pins Located at Location 6A (Stiffest)

Approximate Spring Rate:
Using Least Squares Fit: SR = 17538 lb/in
Predicted Value: 17398 Lb/in
.80% variation

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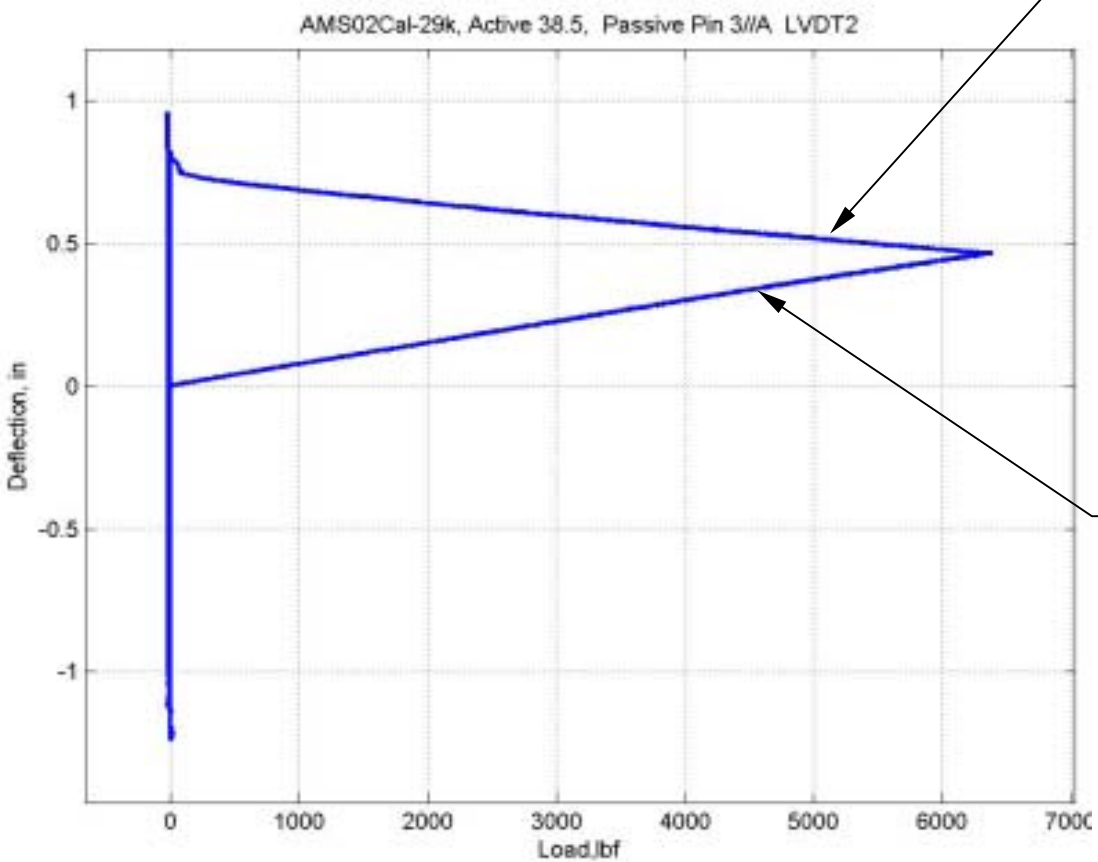
PASSIVE PAS STATIC TEST

CAPTURE BAR LOADED TO 6430 LB MAXIMUM PRELOAD OFFLOADING USING RELEASE MECHANISM

Max Preload defined in SSP 57003 Section 3.1.3.1.3.1



Unloaded to Zero using PAS Release Mechanism

Loaded to 6430 lb

Load VS Deflection

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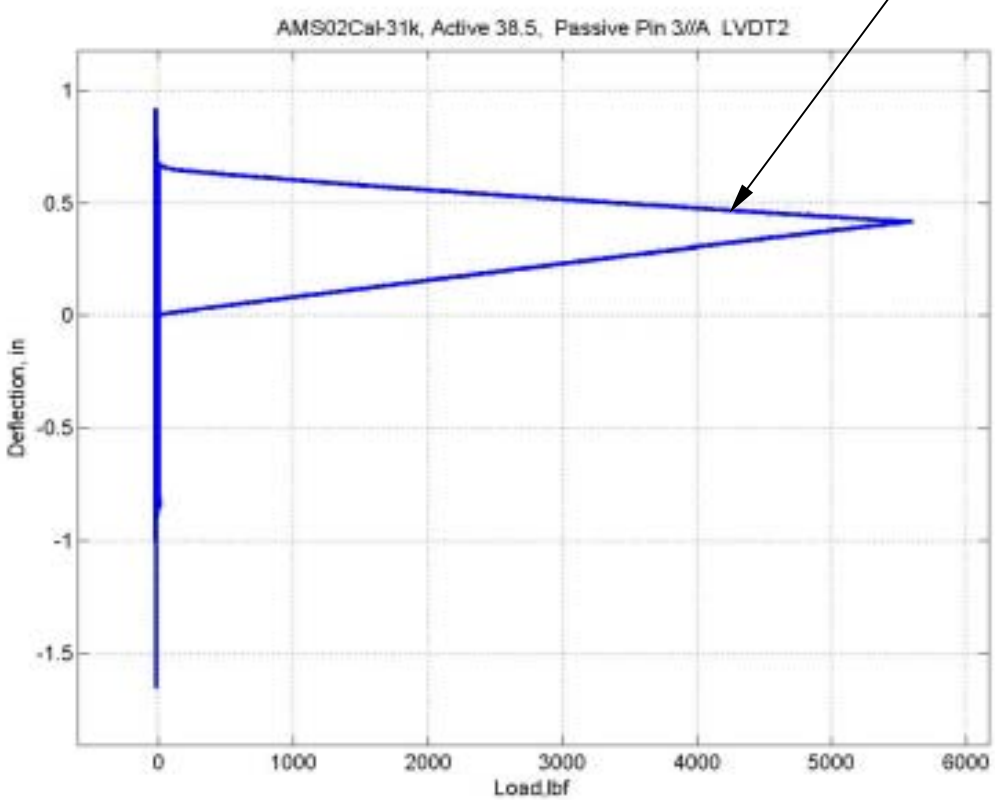
PASSIVE PAS STATIC TEST
FINAL CONFIGURATION

- Loading the Capture Bar to 5650 lb Nominal Preload
- Setting the final position of the Bridge Pins for Spring Rate and a level Capture Bar
- Off-loading Load using Release Mechanism

Preload Release



Procedure:

Pin adjustments were predicted and made to achieve the desired spring rate and to demonstrate a reasonably level Capture Bar under load.

System was loaded to 5650

Preload and Deflection Measurements were taken and recorded

Bridge Pin Final Location

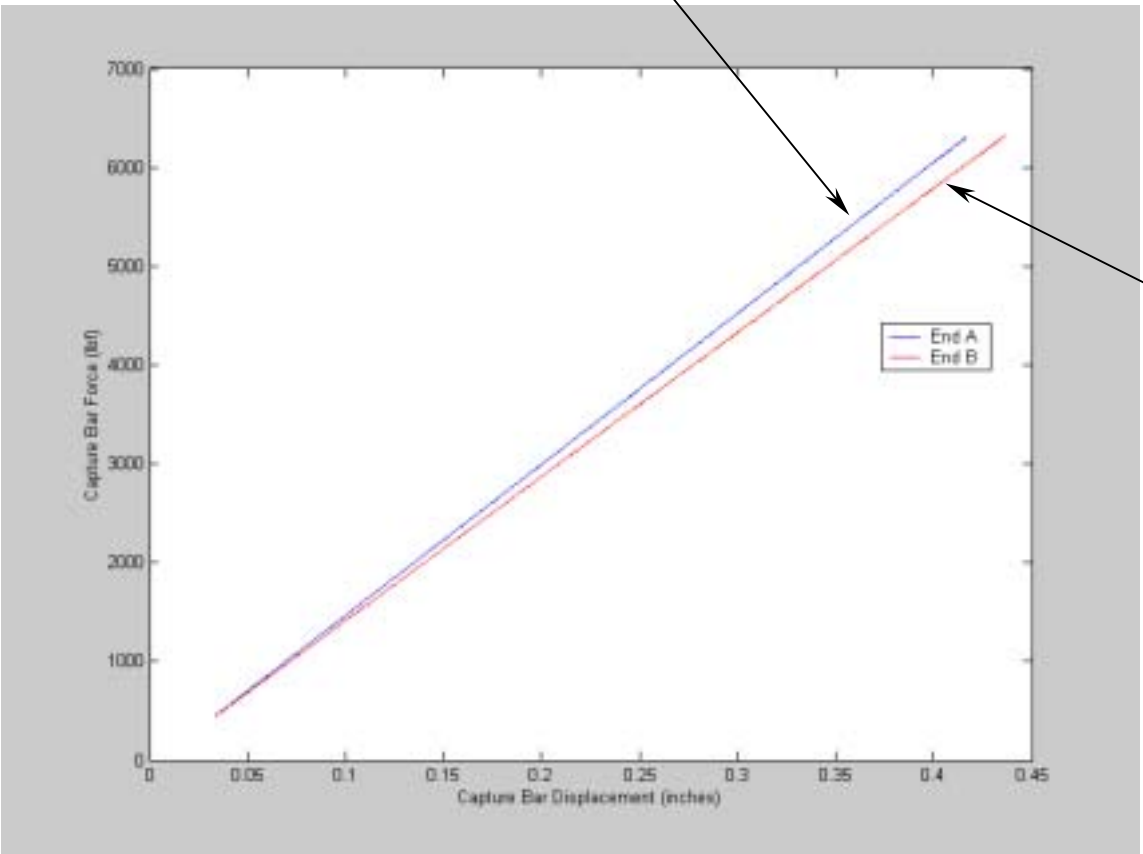
Apex Bridge: Location 4A

Aft Bridge: Location 2A

Jos
Loc
Tel

PASSIVE PAS STATIC TEST
FINAL CONFIGURATION
FINAL PIN SETTINGS FOR A LEVEL CAPTURE BAR

Deflection of Capture Bar
Aft Bearing (LVDT 5)



Deflection of Capture Bar
Apex Bearing (LVDT 6)

Tested Load: 6.3867e+003

Delta Deflection: .020146

Angle of Capture Bar at Load:

.0996 Degrees

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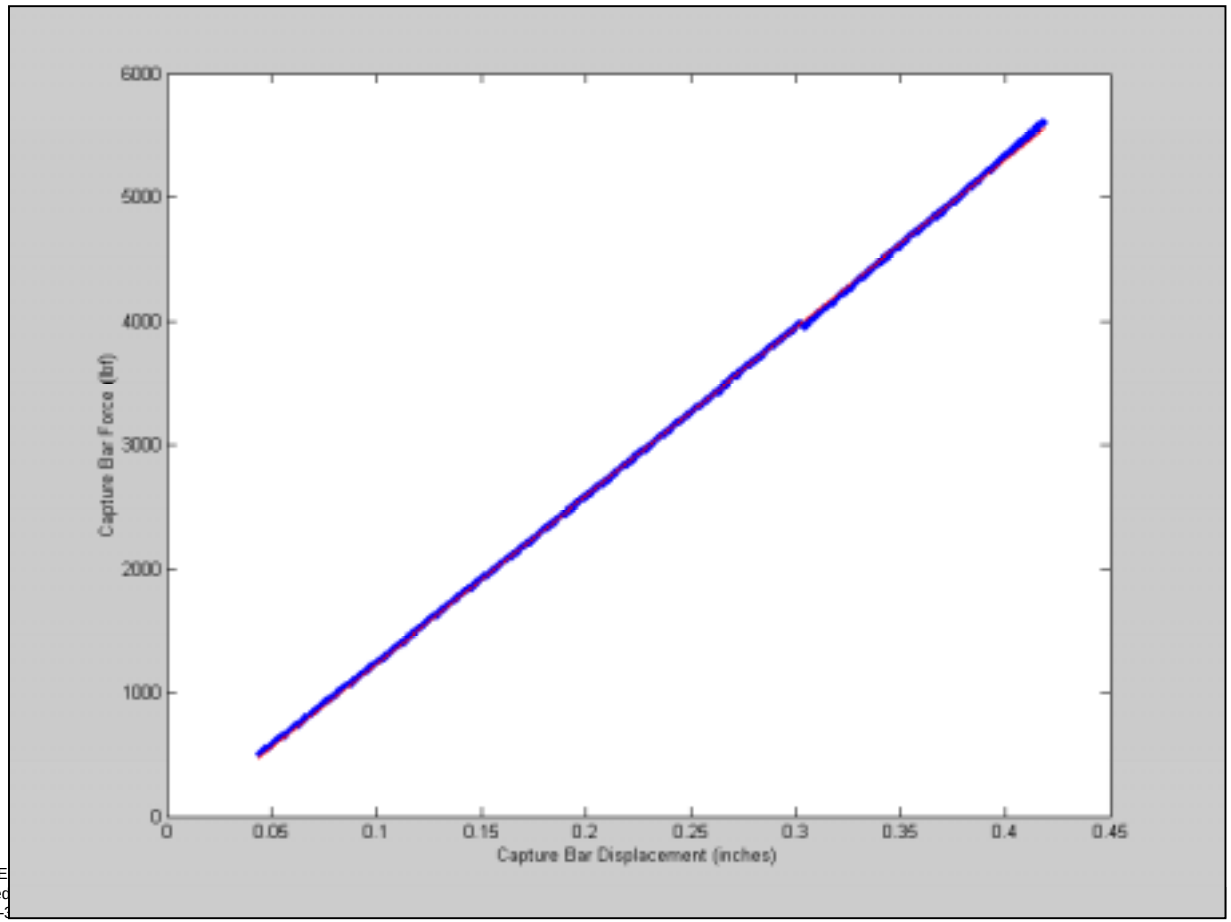
PASSIVE PAS STATIC TEST
FINAL CONFIGURATION
FINAL SPRING RATE

LOCKHEED MARTIN

Pins in final Position

Capture Bar Loaded to 5650 Nominal Preload



Fitting a Least Squares straight line to the data between 500 LBF and 5650 LBF

Spring Rate:
K = 13568 LBF/IN

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Lockheed
Tel. 281-3

AMS PAS Interface Verification Test (IVT)

Description: In March of 2003 the AMS Passive PAS was fitted to the S3 Zenith Inboard PAS 2 site in the Space Station Processing Facility High Bay at Kennedy Space Center for a flight to flight evaluation of the Preload and Release Mechanism.

Though not an official verification the test did validate the design concept and the considerable effort in developing the Interface Requirements specified in SSP 57003, SSP 57004 and SSP 42131.

Test Procedure Summary:

- The AMS Passive PAS was hoisted to the Upper Inboard PAS number 2 CAS site.
- The PAS 2 Capture Claw was closed on the AMS PAS Capture Bar.
- The preload at full closure was measured
- The proximity of the PAS Capture Bar Mounting hardware to the EBCS Target Assembly was measured at Loaded Condition.
- The AMS Passive PAS Release Mechanism was used to unload the Capture Claw Preload. Proximity to Target was measured in Unloaded Condition
- The Capture Bar was removed demonstrating the required contingency capability to unload and remove the payload.

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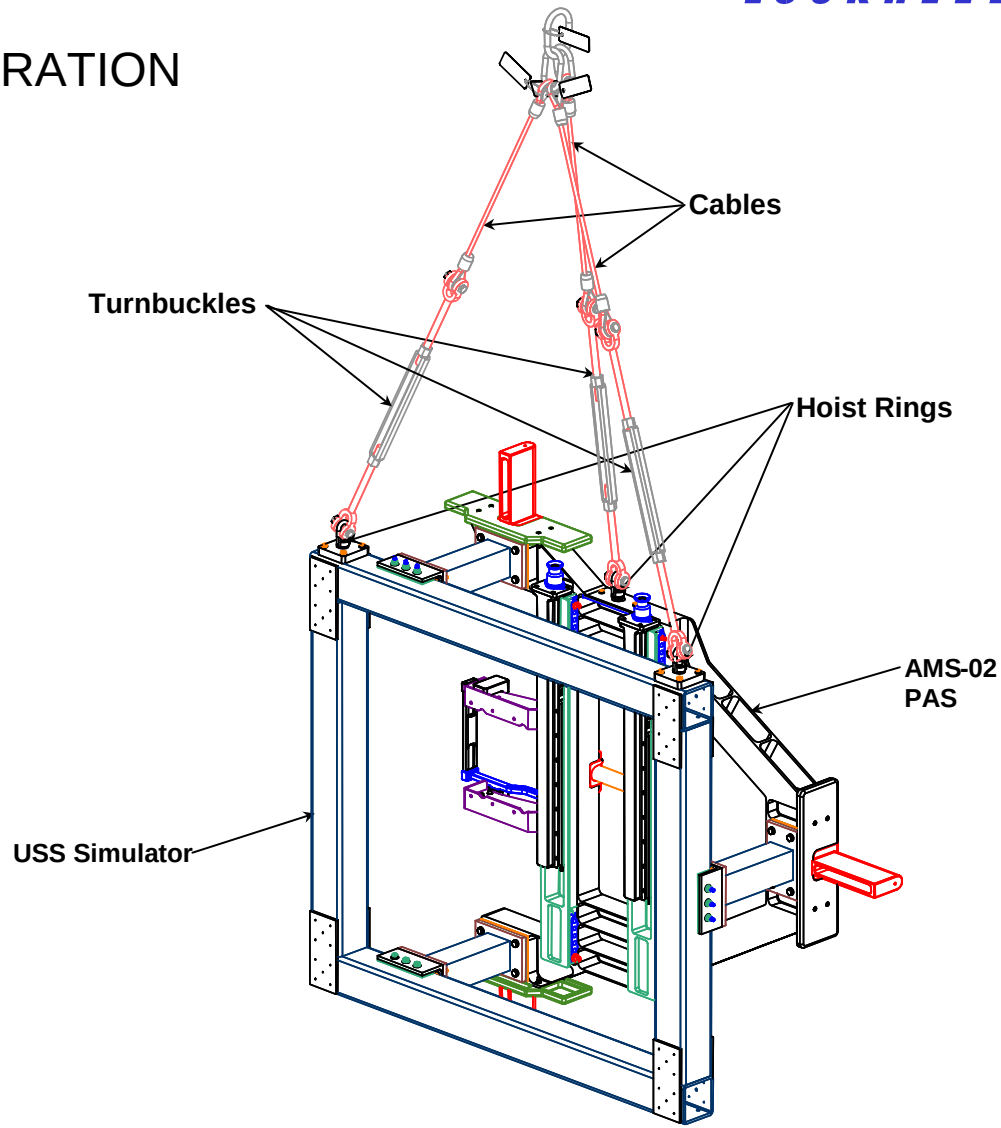
AMS IVT
PAS CONFIGURATION



USS Simulator: Used to simulate the effect on Spring Rate of the AMS Lower USS structure

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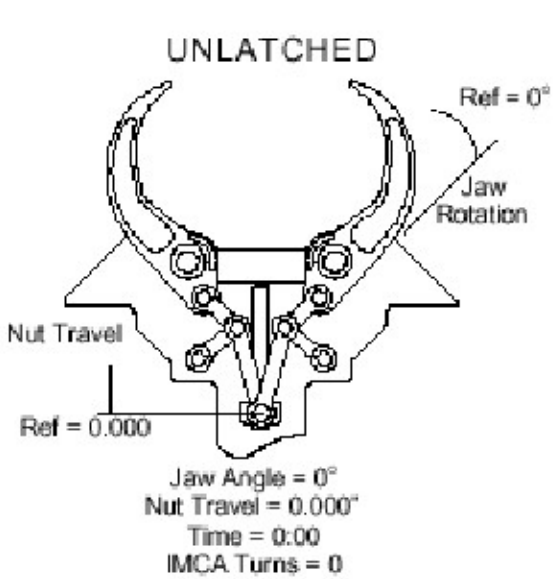
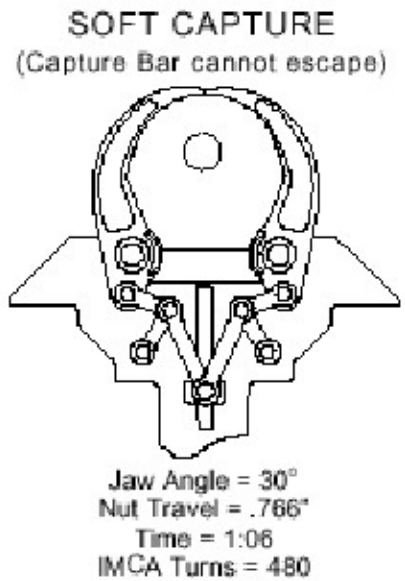
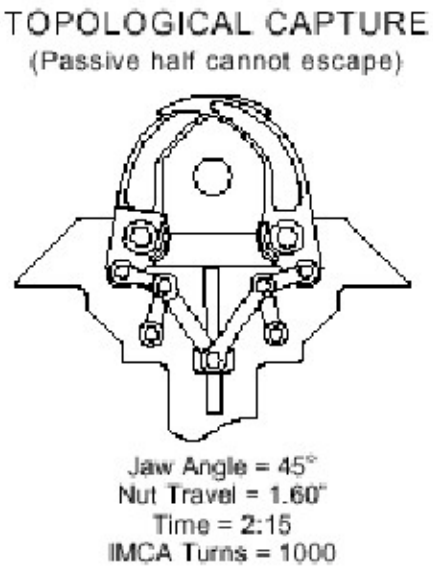
AMS IVT
CAPTURE CLAW PRELOADS THE CAPTURE BAR







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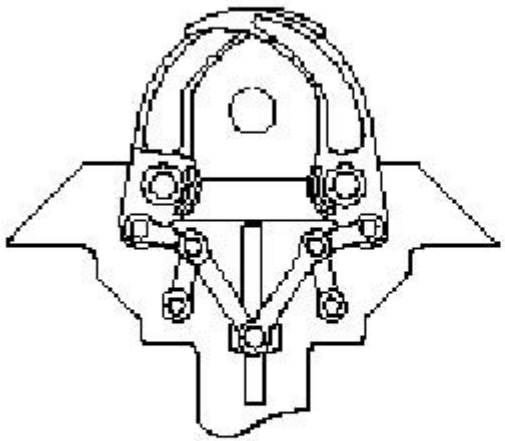
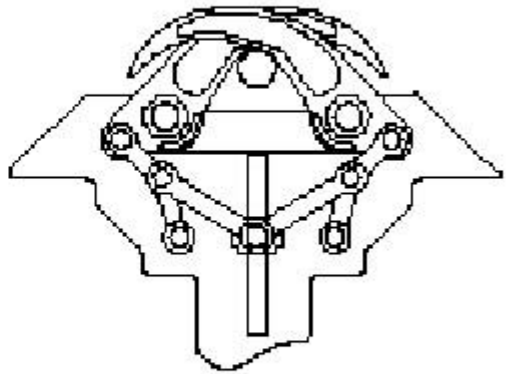
AMS IVT
CAPTURE CLAW PRELOADS THE CAPTURE BAR

TOPOLOGICAL CAPTURE



Jaw Angle = 45°
Nut Travel = 1.60"
Time = 2:15
IMCA Turns = 1000

READY TO BEGIN PRELOAD



Jaw Angle = 83°
Nut Travel = 2.60"
Time = 3:40
IMCA Turns = 1630

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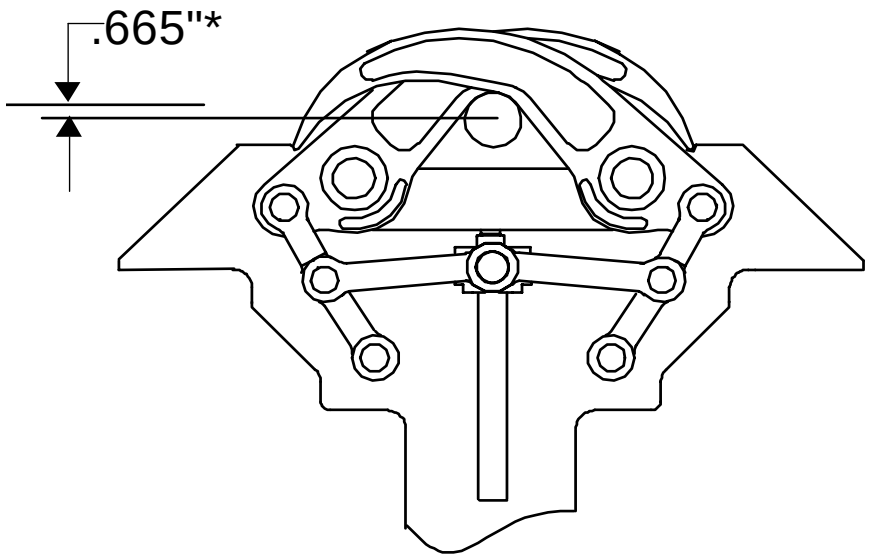
AMS IVT
CAPTURE CLAW PRELOADS THE CAPTURE BAR

FULLY
LATCHED



Predicted Preload: 5650 LBF

Actual Preload per TPS BCP-S3-T037

Cycle 1: 5470

Cycle 2: 5472

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AMS IVT
PROXIMITY TO TARGET

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Preloaded Condition

Actual Gap per TPS BCP-S3-T037

Actual: .325

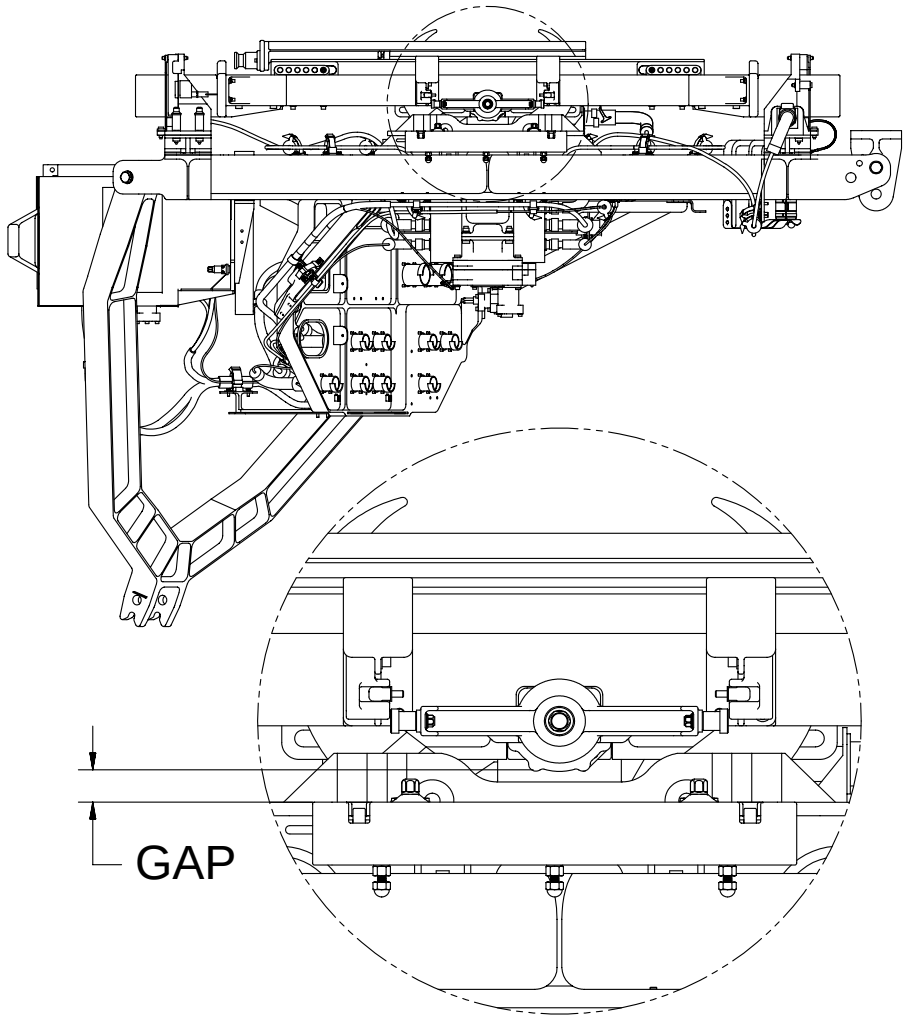
Minimum Allowed Per SSP 57003 AP Envelope: .250

Unloaded Condition

Actual Gap per TPS BCP-S3-T037

Actual: .209

Minimum Allowed Per SSP 57003 AP Envelope: .200



View Along Y-axis (PAS coordinate System)

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AMS IVT
Unloading and Removing the Capture Bar

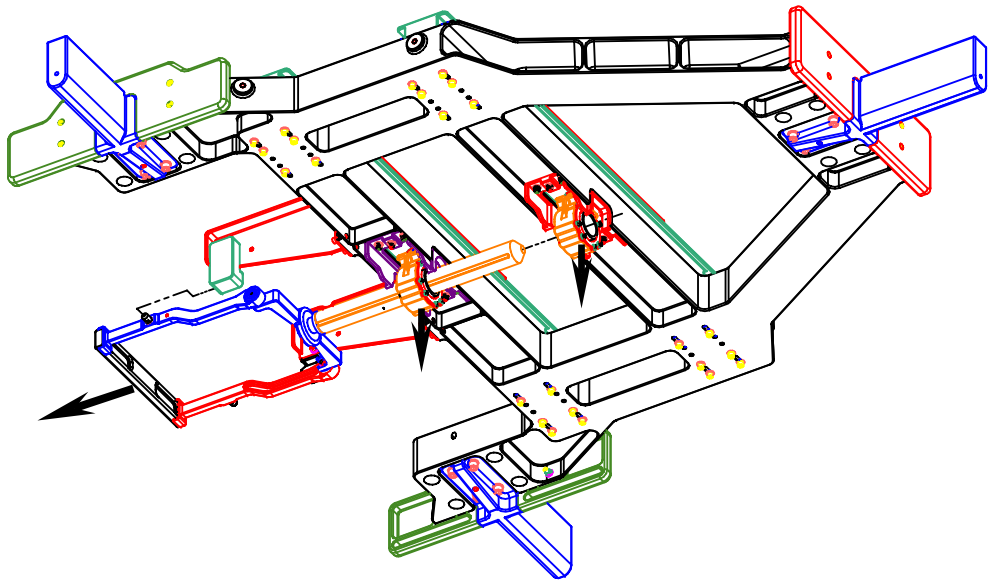
Requirements

- To Relieve the Capture Bar Preload Completely.
- SSP 57003 requires a minimum unload stroke of .71 inches
- To remove the Capture Bar from the Capture Claw

Results of Load Removal Test

The AMS Capture Bar was Lowered .71 inches as required using the AMS PAS Load release Mechanism Assembly. A visible gap of .033 was measured guaranteeing a Zero Preload

The Capture Bar was retracted Completely through the CLA and The payload was hoisted off of the S3 Truss.



Capture Bar lowered and retracted axially through the Bearing Assembly

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Preload was shown to be within 3.2 percent of the nominal load value defined in SSP 57003 Section 3.1.3.1.3.1

Nominal Preload expected 5650 lb: Actual 5470 lb

Capture Bar was Unloaded and removed from the CLA

The preload was removed with a .71 inch stroke as specified in SSP 57003 Section 3.1.3.2.1 A visible Gap was measured

The Loaded Capture Bar Proximity to BCS Target was within the AP envelope defined in SSP 57003 Section 3.1.3.1.1.1

The Unloaded Proximity to the BCS Target was within AP Envelope Limits described in SSP 57003 Section 3.1.3.1.1.1

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AMS Passive PAS As Built Dimensions

AMS Passive PAS As-Built Dimensions and Stiffness

This document describes the as-built dimensions of the AMS Passive PAS Assembly and those that comply with the Interface Requirements Template SSP57004RA. This document also includes the tested stiffness values as required in Space Station document SSP 57003.

Responsible Engineer:
Joseph Kastelic 2/21/03
Quality Engineer:
David Elmore 2/31/03

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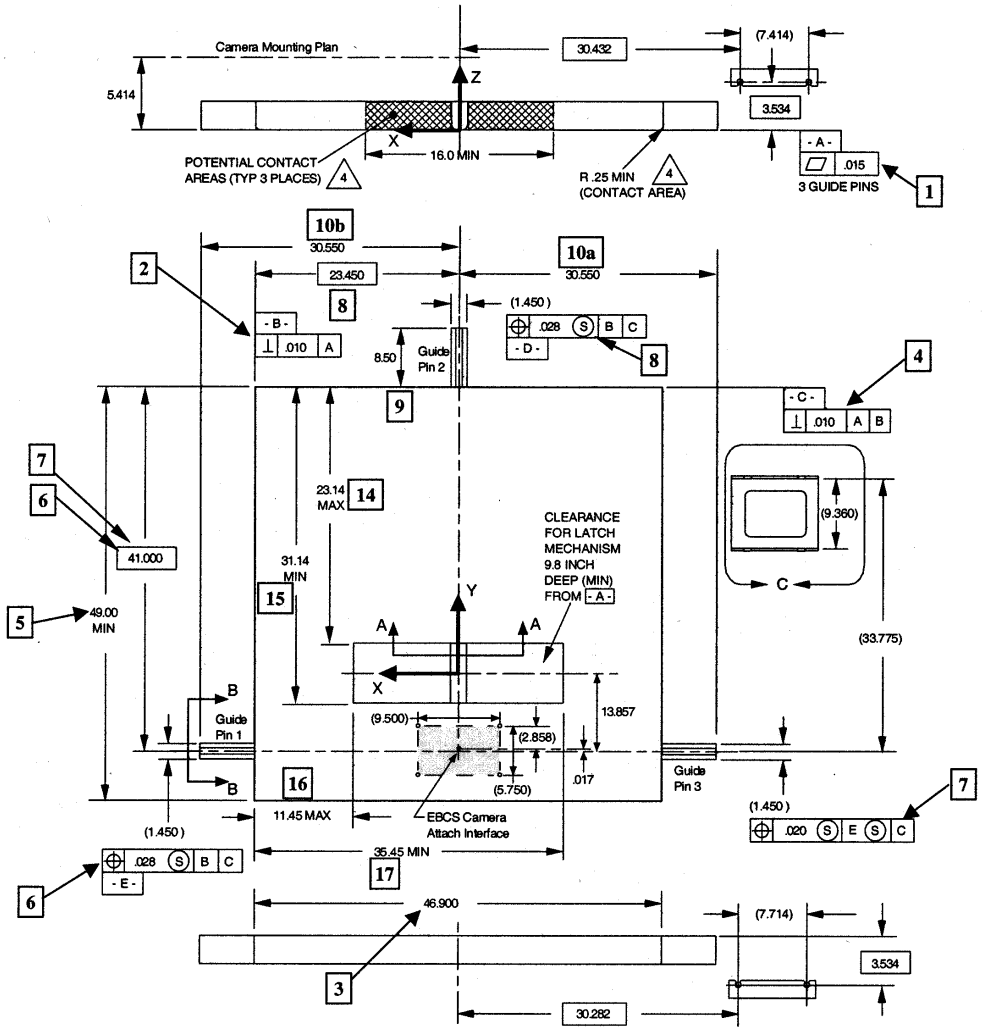
AMS Passive PAS As Built Dimensions



SSP 57004RA REQUIREMENTS DOCUMENT

FIGURE 3.3.2-1 PAS/UCCAS PASSIVE HALF INTERFACE (1 of 3)

(Figure 3 of 3 not required)

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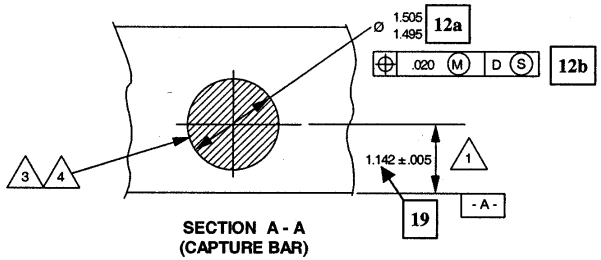
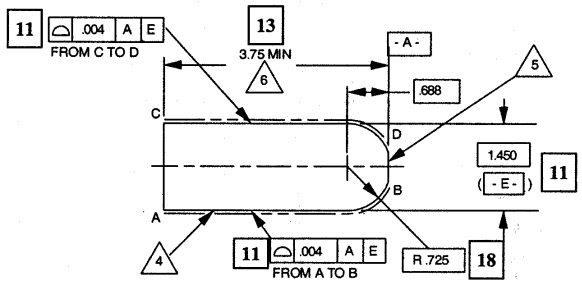
AMS Passive PAS As Built Dimensions



SECTION A - A
(CAPTURE BAR)



VIEW B - B
(GUIDE PIN DETAIL - TYPICAL 3 PLACES)

1. DIMENSION IS BASED ON SYSTEM PRELOAD REQUIREMENT 3.3.1.2.1.2.1.

2. SEE FIGURE 3.3.1-2 FOR THE ENTIRE PASSIVE HALF OPERATIONAL ENVELOPE.

3. SURFACE ROUGHNESS 63 MICROINCHES PER ANSI B46.1-1985.

4. APPLY MIL-L-46010, TYPE I LUBRICANT.

5. SURFACE SHALL BE FREE OF DRYLUBE. PASSIVATE PER QQ-P-35 IF CRES, OR CHEMICAL CONVERSION SURFACE PER MIL-C-5541, CLASS 3 IF ALUMINUM.

6. APPLIES TO HEIGHT OF GUIDE PIN ONLY. PLATFORM HEIGHT IS DEPENDENT UPON SYSTEM PRELOAD REQUIREMENT 3.3.1.2.1.2.1.

SSP 57004RA REQUIREMENTS DOCUMENT
FIGURE 3.3.2-1 PAS/UCCAS PASSIVE HALF INTERFACE (2 of 3)
(Figure 3 of 3 not required)

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AMS Passive PAS As Built Dimensions

Item	Actual	Document	Quality Approval
1	Flat to.003	(10) Direct Measurement	2/21/03
2	Perp to .0016	(3,8,9) Tol Stack up	
3	46.9064	(3,8,9) Tol Stack up	
4	Perp to A and B by .0023	(3,4,8,9) Tol Stack up	
5	49.0285	(10) Direct Measurement	
6	41.004 To B and C	(10) Direct Measurement	
7	41.003 To C .001 to E	(10) Direct Measurement	
8	23.452 To B and C	(10) Direct Measurement	
9	8.4960	(4,8,9,2) Tol Stack up	
10a	30.5540	(1,2,3,9,10) Tol Stack up	
10b	30.5515	(1,2,3,9,10) Tol Stack up	
11 pin1	1.4500	(1) Direct measurement	
11 pin2	1.4490	(2) Direct measurement	
11 pin3	1.4500	(1) Direct measurement	
12a	1.4990	(0) Direct measurement	
12b	Diam pos'n .018 @1.499	(10, 5,6,0) Tol Stack Up	
13 pin 1	3.755	(1) Direct	
13 pin 2	3.755	(2) Direct	
13 pin 3	3.755	(1) Direct	
14	23.131	(9,4) Tol Stack up	
15	31.1635	(9,4) Tol Stack up	
16	11.179	(9,3) Tol Stack up	
17	35.7232	(9,3) Tol Stack up	
18 pin1	.725	(1) Direct measurement	
18 pin2	.725	(2) Direct measurement	
18 pin3	.725	(1) Direct measurement	
19	1.142 2 places	(7) Direct Measurement	
20	Tested Stiffness Range 13400-13800 Lb/in *		
	(*Based on preliminary tested Data, Best curve fit TBD		
	Stiffness Requirements 13500 Lb/in +/- 10% per SSP 57003)		

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AMS Passive PAS As Built Dimensions

2/21/03

Documents:

LMSO Inspection Sheets

0.	Capture Bar	SO15134
1.	Guide Pin AFT	SO15104
2.	Guide Pin Apex	SO15103
3.	Scuff Plates Aft	SO15106
4.	Scuff Plates Apex	SO15105
5.	Capture bar Retainer Bracket Aft	SO15107
6.	Capture bar Retainer Bracket Fore	SO15108
7.	AMS Passive PAS Assembly	SO15102

Procured Items

8. PAS Platform ASSY SDG39135817 Aircraft Engineering Corp. C of C
9. PAS Platform ASSY SDG39135817 Aircraft Engineering Corp. CMM Report
10. PAS Base Assembly SEG39135816 Rothe Joint Venture (RJV) C of C (Inspection Report)

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