

THOR 5th Percentile Female (THOR-05F)

Procedures for Assembly, Disassembly, and Inspection (PADI)

AUGUST 2025



THOR-05F PADI Manual

Table of Contents

Section 1. Introduction	3
1.1 Introduction	3
1.2 Getting Familiar with the PADI Manual	3
Section 2. Dummy Preparation and Use.....	5
2.1 General	5
2.2 Dummy Handling	8
2.3 Dummy Storage.....	9
2.4 H-Point Tool Assembly and Use	11
2.5 Dummy Posture Adjustments and Positioning	13
2.6 Joint Resistive Torque Adjustments	15
Section 3. Head.....	16
3.1 Description of Head Assembly and Features.....	16
3.2 Disassembly of the Head	18
3.3 Assembly of the Head.....	28
3.4 Adjustments for the Head and Face Assemblies.....	39
3.5 Electrical Connections and Requirements	39
Section 4. Neck Assembly.....	40
4.1 Description of the Neck Assembly and Features.....	40
4.2 Disassembly of the Neck	48
4.3 Assembly of the Neck.....	59
4.4 Assembly of the Neck to the Head	72
4.5 Assembly of the Neck to the Spine.....	73
4.6 Adjustments for the Neck Assembly	75
4.7 Electrical Connections and Requirements	78
Section 5. Thorax and Abdomen Assembly	79
5.1 Description of Thorax Assembly and Features.....	79
5.2 Disassembly of the Thorax and Abdomen.....	85
5.3 Assembly of the Thorax and Abdomen	104
5.4 Electrical Connections and Requirements	121
Section 6. Spine Assembly	122
6.1 Description of Spine Assembly and Features	122
6.2 Disassembly of Spine	130
6.3 Assembly of Spine.....	142
6.4 Assembly of the Spine to the Pelvis	156
6.5 Assembly of the Neck to the Spine.....	156
6.6 Adjustment Procedure for Lumbar Spine Pitch Change Assembly	156
6.7 Adjustment Procedure for Neck Pitch Change Mechanism.....	157
6.8 Adjustment Procedure for Tightening Flex Joint Cables.....	157
6.9 Electrical Connections and Requirements	157
Section 7. Shoulder Assembly.....	158
7.1 Description of Shoulder Assembly and Features.....	158
7.2 Disassembly of Shoulder	161
7.3 Assembly of Shoulder	163
7.4 Electrical Connections and Requirements	166
Section 8. Pelvis Assembly	167
8.1 Description of Pelvis Assembly and Features	167
8.2 Disassembly of the Pelvis.....	171

8.3	Assembly of the Pelvis	181
8.4	Assembly of the Pelvis to the Spine	197
8.5	Adjustments for the Pelvis Assembly	198
8.6	Wire Routing and Electrical Connections	198
Section 9. Upper Leg Assembly		199
9.1	Description of the Upper Leg Assembly and Features	199
9.2	Disassembly of the Upper Leg	206
9.3	Assembly of the Upper Leg	218
9.4	Assembly of the Upper Leg to the Pelvis	226
9.5	Assembly of the Lower Extremity to the Knee	227
9.6	Adjustments for the Femur Assembly	228
9.7	Electrical Connections and Requirements:	228
Section 10. Lower Extremity Assembly		229
10.1	Description of the Lower Extremity Assembly and Features	229
10.2	Disassembly of the Lower Extremity	236
10.3	Assembly of the Lower Extremity	252
10.4	Assembly of the Lower Extremity to the Knee	268
10.5	Adjustments for the Lower Extremity Assembly	269
10.6	Electrical Connections and Requirements:	270
Section 11. Arm Assembly		271
11.1	Description of Arm Assembly and Features	271
11.2	Disassembly of the Arm	274
11.3	Assembly of the Arm	283
11.4	Adjustments for the Arm Assembly	294
11.5	Electrical Connections and Requirements	294
Section 12. Jacket Assembly		295
12.1	Description of Jacket Assembly and Features	295
12.2	Assembly of the Jacket	295
12.3	Adjustments for the Jacket Assembly	298
12.4	Electrical Connections and Requirements	298
Section 13. Instrumentation and Wiring		299
13.1	Overview of Instrumentation	299
13.2	Instrumentation Cable Routing	301
13.3	Grounding	302
13.4	Cable Routing By Body Region	310
13.5	THOR-05F Instrumentation Polarity Check	328
13.6	Tilt Sensors and Readout Display	337
Section 14. IR-TRACC Calibration Overview		338
14.1	Instrument Wiring	340
14.2	Transducer Calibration	341
14.3	Measuring 3D IR-TRACC Assembly Reference (Intercept) Values	347
14.4	Calibration Summary	349
Section 15. THOR-05F IR-TRACC Processing		352
15.1	IR-TRACC Deflection Calculations	352
15.2	Data Collection Considerations	352
15.3	Required Channels	352
15.4	Convert the channels to engineering units and filter	353
15.5	Data channel polarity	353
15.6	Calculate the relative changes from the Zero Position (3D IRTRACC setup fixture)	353
15.7	Calculate anterior attachment point displacement in local coordinate system	355
15.8	Remove pre-event bias of channels at time zero	359
Section 16. THOR-05F Tester's Inspection Checklist		360

Section 1. Introduction

1.1 Introduction

This manual describes the procedures for assembly, disassembly, and inspection (PADI) of the Test device for Human Occupant Restraint 5th percentile female (referred to as THOR-05F herein) anthropomorphic test device (ATD). This manual applies to the THOR-05F defined in the THOR-05F drawing package¹. Pictures and illustrations are for reference only.

1.2 Getting Familiar with the PADI Manual

This manual serves as a technical reference book for the THOR-05F. This manual contains the following Sections:

- Introduction
- Dummy Preparation and Use
- Head Assembly
- Neck Assembly
- Spine Assembly
- Thorax Assembly
- Shoulder Assembly
- Upper Abdomen Assembly
- Lower Abdomen Assembly
- Pelvis Assembly
- Upper Leg Assembly
- Lower Extremity Assembly
- Arm Assembly
- Jacket and Clothing Assembly
- Instrumentation and Wiring
- 3D IR-TRACC Calibration Overview
- THOR-05F IR-TRACC Processing
- THOR-05F Tester's Checklist
- External Dimensions

¹ "Parts List and Drawings THOR-05F Advanced Frontal Crash Test Dummy: THOR-05F Male," (August 2018).

1.2.1 Section Organization

Each section of this manual contains the following subsections to provide a complete overview of each assembly:

- Description of Features
- Assembly of Component or Assembly
- Parts List
- Assembly Procedure
- Assembly of Component into THOR-05F
- Adjustments
- Wire Routing and Electrical Connections
- Inspection and Repairs

The assembly section of the manual assumes that the components have been disassembled to inspect or refurbish. Please refer to the THOR-05F Drawing Package for any details not covered in this manual.

1.2.2 Conventions used throughout this manual

Right-Hand and Left-Hand

The references to the right-hand and left-hand side of a component or assembly are relative to the dummy's right-hand or left-hand.

Front and Back

The references to front and back refer to the anterior and posterior sides of the part or assembly based on the dummy reference system.

Top and Bottom

The reference to top and bottom refer to the superior and inferior sides of the part or assembly based on the dummy reference system.

Dummy Coordinate System

All references made to the coordinate system and instrumentation polarities are based on the SAE Information Report SAE J1733². Manipulations to check instrumentation polarities are located in Section 0. The SAE sign convention utilized includes:

- + X is toward the anterior or front of the dummy
- + Y is laterally toward the right
- + Z is toward the inferior (towards the bottom (feet) of the dummy)

² SAE J1733: Sign Convention for Vehicle Crash Testing, SAE Surface Vehicle Recommended Practice, November 2007.

Section 2. Dummy Preparation and Use

2.1 General

2.1.1 Hardware and Fasteners

With very few exceptions, all hardware and fasteners used on the THOR-05F crash test dummy are metric sizes.

The following abbreviations used throughout this manual include:

SCREW ABBREVIATIONS:

FHCS	Flat Head Cap Screw
BHCS	Button Head Cap Screw
SHCS	Socket Head Cap Screw
SSS	Socket Set Screw
HHCS	Hex Head Cap Screw
SSFP	Set Screw Flat Point

MATERIAL ABBREVIATIONS:

CRS	Cold Rolled Steel
SS	Stainless Steel
AL	Aluminum

2.1.2 Tools Required

The following tool list includes the standard tools necessary for assembling the THOR-05F dummy (Figure 2-1). This list will allow the laboratory personnel to make any necessary adjustments and to perform standard disassembly and assembly procedures.



Figure 2-1. Required tools for assembly of the THOR-05F

- Set of “T” Handle Hex Wrenches (Ball End) Sizes: M1.5 to M8
- Set of “L” Handle Hex Wrenches (Ball End) Sizes: M1.5 to M8
- Set of Straight Hex Wrenches (Screwdriver Style) Sizes: M1.3 to M6
- Metric Socket Set
- Torque Wrench Sizes: Range 1.5 N-m to 70 N-m (1 to 52 ft-lb)
- Hex Bit Socket Set Size: M1.5 to M8
- Needle Nose Pliers
- Diagonal Cutters
- Flat Head Screwdriver

2.1.3 Bolt Torque Values

Table 2-1 through Table 2-4 indicates the torque settings for the various bolt sizes used in the THOR-05F dummy assemblies. Unless otherwise specified, utilize the torque settings below. For bolt sizes smaller than those listed, use engineering judgment to tighten enough to prevent the fastener from vibrating loose during impact.

Table 2-1. Torque Values for THOR-05F SHCS

BOLT SIZE METRIC	TORQUE (N-M)
M1.4	0.15
M1.6	0.29
M2	0.60
M2.5	1.21
M3	2.45
M4	5.85
M5	12.0
M6	20.3
M8	48.8
M10	97.5
M12	165.0
M16	300.0
M20	575.0
Neck Posture Adjustment Assembly	50.8
Lumbar Pitch Change Mechanism	68.0

Table 2-2. Torque Values for THOR-05F FHCS

BOLT SIZE METRIC	TORQUE (N-M)
M2.5	0.4
M3	1.2
M4	2.8
M5	5.5
M6	9.5
M8	24.0
M10	47.0
M12	82.0
M16	205.0
M20	400.0
M24	640.0

Table 2-3. Torque Values for THOR-05F BHCS

BOLT SIZE METRIC	TORQUE (N-M)
M3	1.2
M4	2.8
M5	5.5
M6	9.5
M8	24.0
M10	47.0
M12	82.0
M16	205.0

Table 2-4. Torque Values for THOR-05F SSS

BOLT SIZE METRIC	TORQUE (N-M)
M3	0.92
M4	2.2
M5	4.0
M6	7.2
M8	17.0
M10	33.0
M12	54.0
M16	134.0
M20	237.0
M24	440.0

2.2 Dummy Handling

The THOR-05F dummy cannot be lifted by the head or neck assemblies as the dummy's neck was not designed to support the full weight of the dummy in tension. Instead, a lifting strap is installed on back of the dummy above the first rib.

2.2.1 Installing Lifting Strap

- 2.2.1.1 Insert the Dummy Lifting Strap (472-3517) through the Lifting Strap Bracket (472-3115) (Figure 2-2).



Figure 2-2. THOR-05F lifting strap and mounting bracket

- 2.2.1.2 Install the two M5 X 0.8 X 10 BHCS through the lifting strap bracket into the Upper Thoracic Spine Box Weldment (472-3620) above the first rib (Figure 2-3).

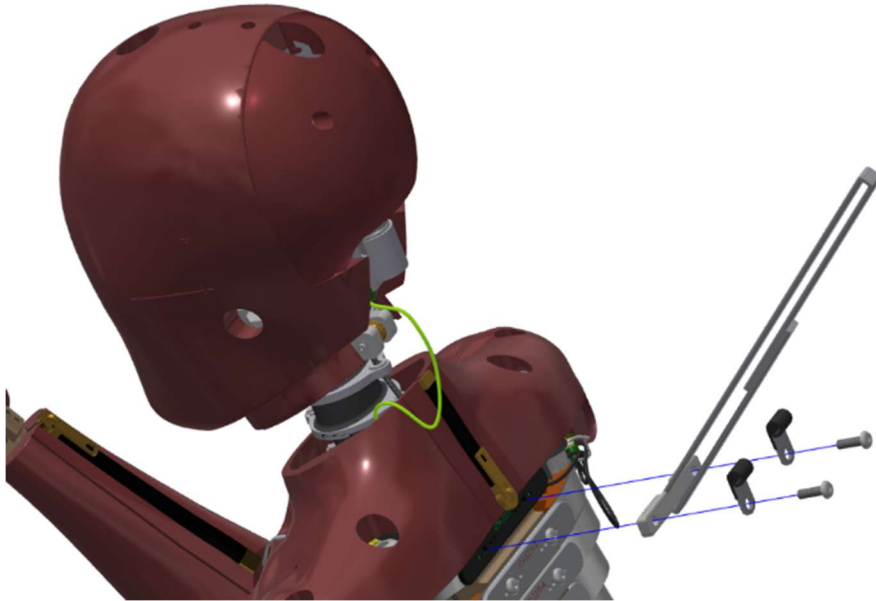


Figure 2-3. Install lifting strap bracket to upper thoracic spine box weldment

- 2.2.1.3 Use the THOR-05F lifting strap when handling and/or lifting the dummy.

2.3 Dummy Storage

Figure 2-4 illustrates an example of a storage chair for the THOR-05F. The chair uses a sling to support the THOR-05F with the dummy upright to minimize stress on the neck as well as the pelvis and lumbar spine areas (Figure 2-5).



Figure 2-4. Example of THOR-05F storage chair



Figure 2-5. Example of THOR-05F seated in storage chair

2.4 H-Point Tool Assembly and Use

The THOR-05F H-Point Tool (474-8510-A) provides a quick, accurate method to determine the location of the H-Point.

2.4.1 Parts List

Figure 2-6 shows an exploded view of THOR-05F H-Point Tool Assembly (474-8510-A) hardware. Table 2-5 lists the components that are included in the H-Point tool assembly.

Table 2-5. H-Point Gage Assembly (474-8510-A) Components

Part Description	Quantity	Part Number	Figure #	Item #
H-Point Tool, Expander	1	474-8511-A	Figure 2-6	1
H-Point Tool, Pin Assembly	1	474-8515-A	Figure 2-6	3
H-Point Tool, Plate	1	474-8512	Figure 2-6	2
Screw, SSNP M4 X 0.7 X 6	1	5001472	Figure 2-6	4

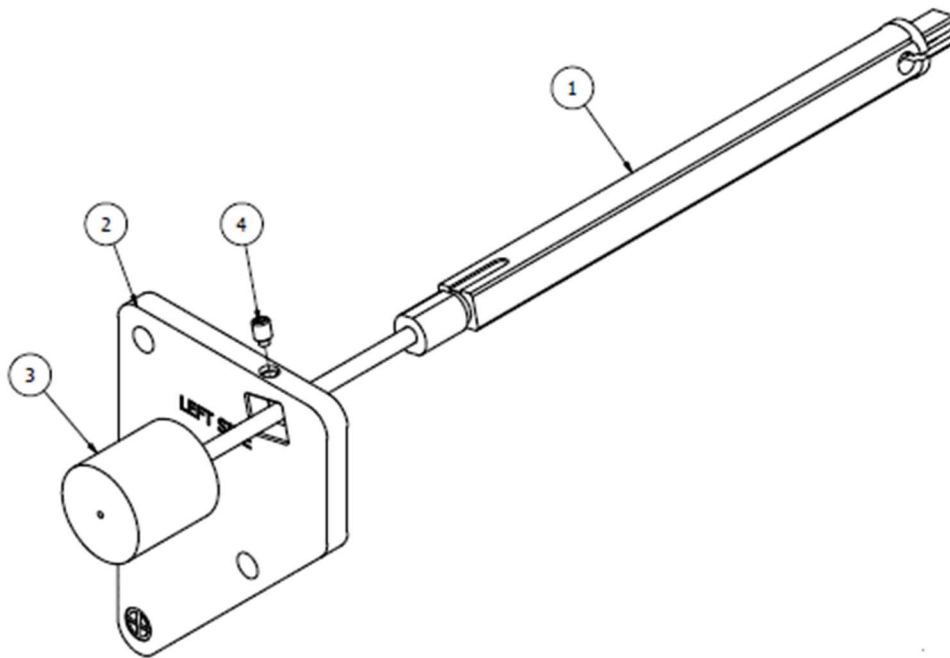


Figure 2-6. THOR-05F H-point tool (474-8510-A) (left-hand)

2.4.2 Installing the H-Point Tool

2.4.2.1 Figure 2-7 shows the components of the H-point tool.

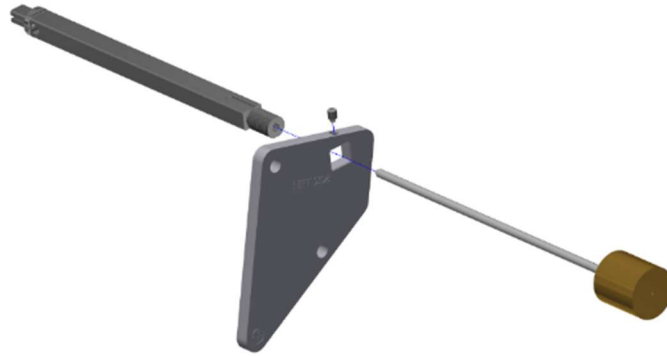


Figure 2-7. H-point tool components

2.4.2.2 To assemble, insert the H-Point Tool Expander (474-8511-A) into the square hole in the H-Point Tool Plate (474-8512) on the opposite side of the plate than the intended measure. Align the set screw recess on the expander with the set screw in the plate (Figure 2-8). Tighten the SSNP M4 X 0.7 X 6 set screw through the edge of the plate into the expander tool (Figure 2-9).



Figure 2-8. Install H-point tool expander into H-point tool plate



Figure 2-9. Tighten set screw into tool expander

- 2.4.2.3 With the pin assembly fully unscrewed, insert the expander end of the H-point tool into the pelvis H-point opening until the collar above the expander is fully seated internally against the pelvis. Turn the pin assembly clockwise until the expander engages firmly with the pelvis. Note that the top edge of the H-point tool is parallel to the pelvis angle (Figure 2-10).

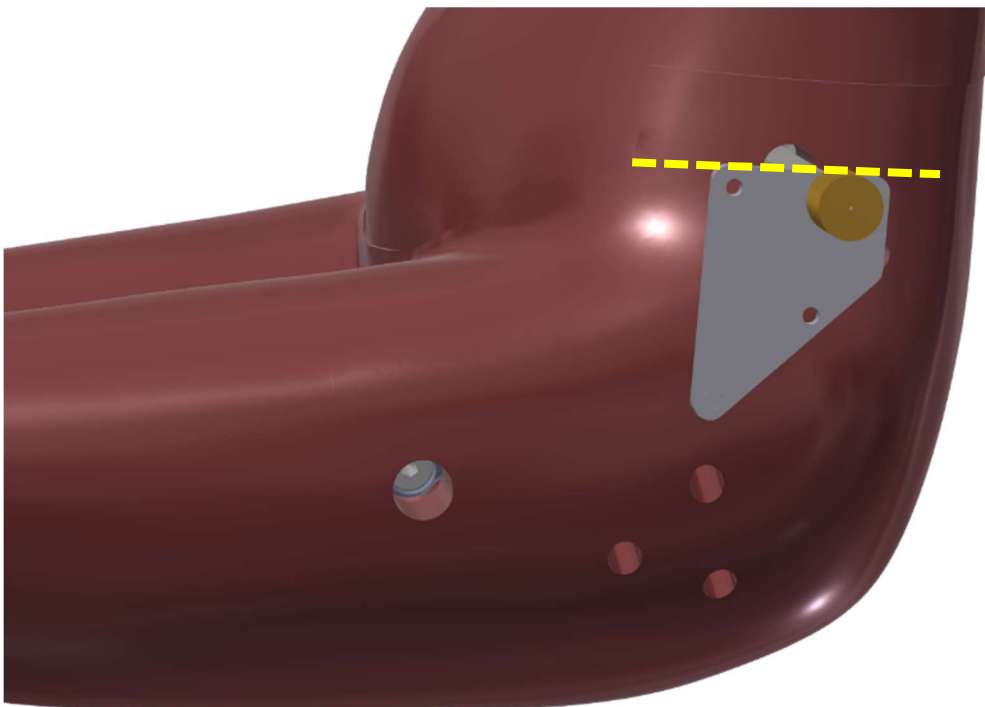


Figure 2-10. Top edge of H-Point tool is parallel to pelvis angle

2.5 Dummy Posture Adjustments and Positioning

The adjustment of the dummy's posture is largely dependent upon the specific positioning requirements of the test lab and the test series being performed. The positioning of

the dummy normally begins by marking the location of the H-Point and moving this point to the desired location in the testing environment. When installed into the pelvis, the top surface of the gage plate is parallel with the measurement plane (Figure 2-10) of the pelvis tilt sensor. The operation and function of the tilt sensors is explained in each assembly which includes a tilt sensor.

Anatomically, the angle measured by the tilt sensor about the Y-axis relates to line between the anterior superior iliac spine (ASIS) and posterior superior iliac spine (PSIS) landmarks by **Equation 2.1**.

Equation 2.1

$$ASIS-PSIS\ Angle = Pelvis\ Tilt\ Sensor\ Reading\ (About\ Y\ Axis) + 10^{\circ}$$

where ASIS-PSIS Angle is defined by the line between the ASIS and the PSIS anatomical landmarks and the Pelvis Tilt Sensor Reading (About Y Axis) is measured using either a) the pelvis tilt sensor assembly (472-3777-1 or 472-3777-2), or b) the angle of the H-Point Gage Assembly (472-8510-A), as measured by reading an inclinometer placed on the edge of the tool above the text “[Right/Left] Outer.”

At this point, the dummy can be placed in a “standard seating posture,” or the dummy posture can be further manipulated to accommodate various seating geometries or testing environments. Four major seating postures have been defined through a postural study (Reynolds), and the THOR-05F spine assembly is capable of adjusting into any one of these postures (or other positions if desired). The adjustment capability is provided by the neck and lumbar spine pitch change mechanisms. The neck pitch change mechanism is centered at the approximate location of the anthropomorphic landmark defined by the T6 / T7 joint. The lumbar spine pitch change assembly is centered at the approximate location of the anthropomorphic landmark defined by the T11 / T12 joint. The locations of these pitch change mechanisms are shown in Figure 2-11.

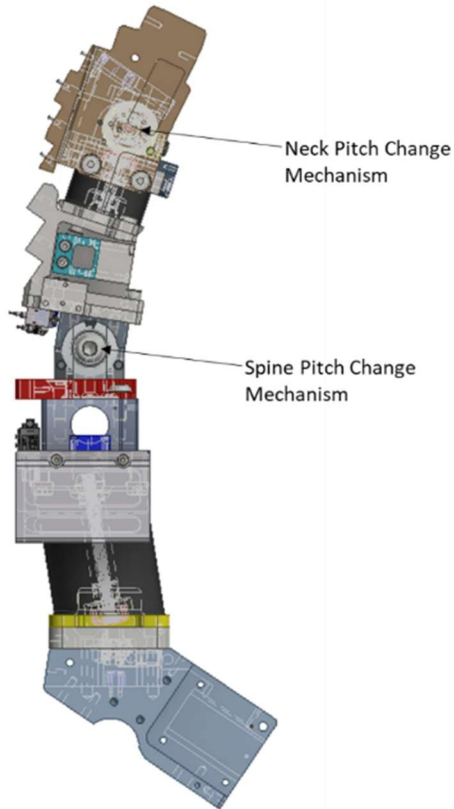


Figure 2-11. Pitch change locations

The seating posture of the THOR-05F dummy can be adjusted in 3° increments by rotating the spine segments with the pitch change mechanisms. The orientation of the lower thoracic pitch change mechanism is normally set in the “Slouched” position and the neck pitch change mechanism is normally set in the “Neutral” position; the procedure for adjusting the pitch change mechanisms is described in detail in Section 6.6 of this manual.

2.6 Joint Resistive Torque Adjustments

The joint resistive torque adjustments for the THOR-05F dummy are described under the various Sections to which they apply. The joints in the dummy which require adjustments include the shoulders, elbows, hips, and knees. Most of these adjustments are made in the same manner as those in the Hybrid III dummy. The goal of the adjustment is to provide a 1G joint friction torque. For example, the knee joint should be adjusted such that the dummy’s lower leg has just enough torque to maintain an extended position of the lower leg.

Section 3. Head

3.1 Description of Head Assembly and Features

The head assembly includes the head casting, skull cap, internal mounting plates, instrumentation, instrumentation mounting plates, and skin. The head instrumentation includes three uniaxial accelerometers at the CG of the head, three redundant uniaxial accelerometers below the CG, three angular rate sensors, and a dual axis tilt sensor. The tilt sensor is attached on the rear of the sensor mounting plate and is used to measure the angular orientation of the head about the X and Y-axes in a static (pre-test or post-test) mode. The angular rate sensors (ARSs) are used in conjunction with the three accelerometers at the CG to track six-degree-of-freedom motion of the head.

The face assembly includes the face insert and 5 compression load cells with impact plates (SA572-S124). The load cells are distributed across the entire face, one at each eye, cheek, and one at the center of the chin to measure the total load applied to the face. The face load cells can also be replaced with blanks (474-1005).

Table 3-1 lists the components that are included in the head and skull assemblies. Figure 3-1 illustrates the head assembly components.

Table 3-1. Head Assembly Components

Part Description	Quantity	Part Number	Figure #	Item #
Skull, Machined	1	474-1010	Figure 3-1	1
Face Load Cell, Replacement	5	474-1005	Figure 3-1	2
M3 X 0.5 X 10 LG. SHCS	20	5000119	Figure 3-1	3
Left Eye Load Cell Plate	1	474-1412-1	Figure 3-1	4
Left Cheek Load Cell Plate	1	474-1414-1	Figure 3-1	5
Right Eye Load Cell Plate	1	474-1412-2	Figure 3-1	6
Right Cheek Load Cell Plate	1	474-1414-2	Figure 3-1	7
Chin Load Cell Plate	1	474-1416	Figure 3-1	8
M3 X 0.5 X 8 LG. SHCS	20	5000119	Figure 3-1	9
Face Insert	1	474-1401	Figure 3-1	10
Chin Guard	1	474-1411	Figure 3-1	11
M4 X 0.7 X 25 LG. SHCS	2	5000461	Figure 3-1	12
Skull Cap, Machined	1	474-1022	Figure 3-1	13
M6 X 1 X 25 LG. SHCS	4	5000133	Figure 3-1	14
Cap Skin	1	474-1025	Figure 3-1	15
Head Skin, Molded	1	474-1008	Figure 3-1	16
DAS Mount	1	474-1051	Figure 3-1	17
M4 X 0.7 X 16 LG. SHCS	2	5000025	Figure 3-1	18
M3 X 0.5 X 35 LG. SHCS	4	5000988	Figure 3-1	19
M6 X 1 X 20 LG. LHCS	4	5001316	Figure 3-1	20

DAS Structural Replacement	1	474-1033	Figure 3-1	21
Sensor Mounting Plate, Head	1	474-1031	Figure 3-1	22
Tilt Sensor, Dual Axis	1	SA572-S44	Figure 3-1	23
M2 X 0.4 X 12 LG. CHMSS Zinc	2	5000253	Figure 3-1	24
Accel Mount, (7264C)	1	SA572-S167	Figure 3-1	25
M3 X 0.5 X 8 LG. SHCS	2	5000388	Figure 3-1	26
M1.4 X 0.3 X 3 LG. SHCS	12	5000068	Figure 3-1	28
6 Axis Accel/ARS Mount, (7264-2000)	1	SA572-S87	Figure 3-1	29
M2.5 X 0.45 X 16 LG. SHCS	2	5000069	Figure 3-1	30
M1.4 X 0.3 X 8 LG. SHCS	6	5000727	Figure 3-1	32
Uniaxial Piezoresistive Accelerometer	6	SA572-S4	Figure 3-1	33
Angular Rate Sensor	3	SA572-S58	Figure 3-1	34

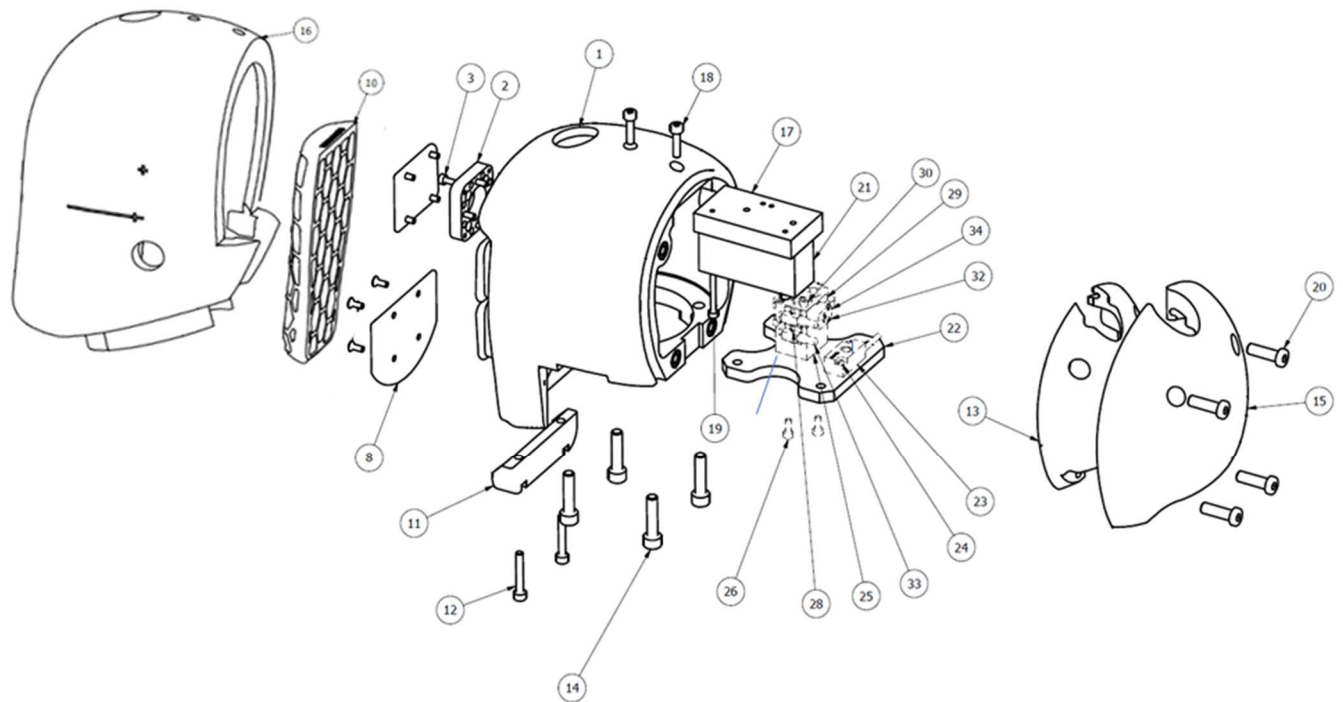


Figure 3-1. Head assembly components

3.2 Disassembly of the Head

The following is a step-by-step description of the disassembly procedure for the head components.

- 3.2.1 Remove the skull cap and cap skin (474-1022 and 474-1025) from the skull (474-1010) by removing four M6 X 1 X 20 LG. LHCS from the back of the head (Figure 3-2).

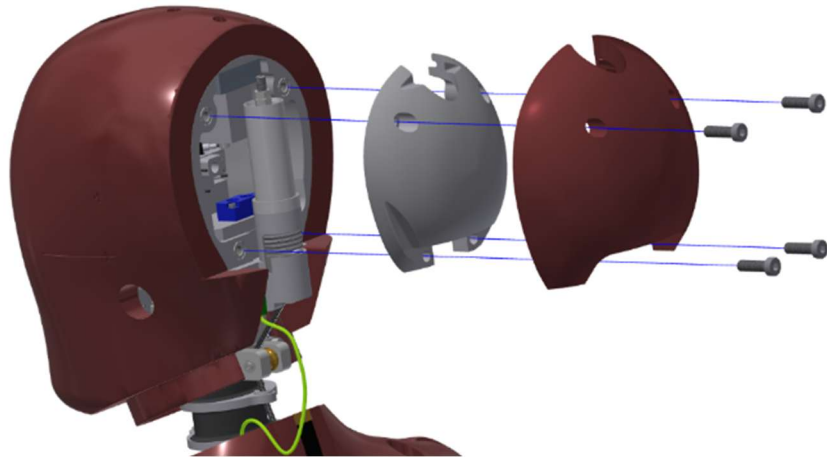


Figure 3-2. Skull, skull cap, and cap skin

- 3.2.2 Remove the ground strap from the back of the head by removing one M4 X 0.7 X 6 BHCS (Figure 3-3).

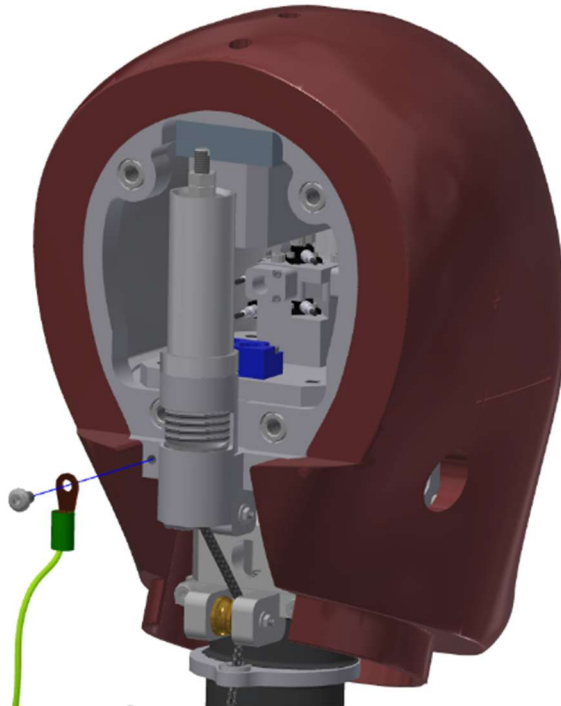


Figure 3-3. Head ground strap location

- 3.2.3 Remove the head skin (474-1008) from the skull (474-1010) by peeling the skin away from the groove in the back of the skull (Figure 3-4).

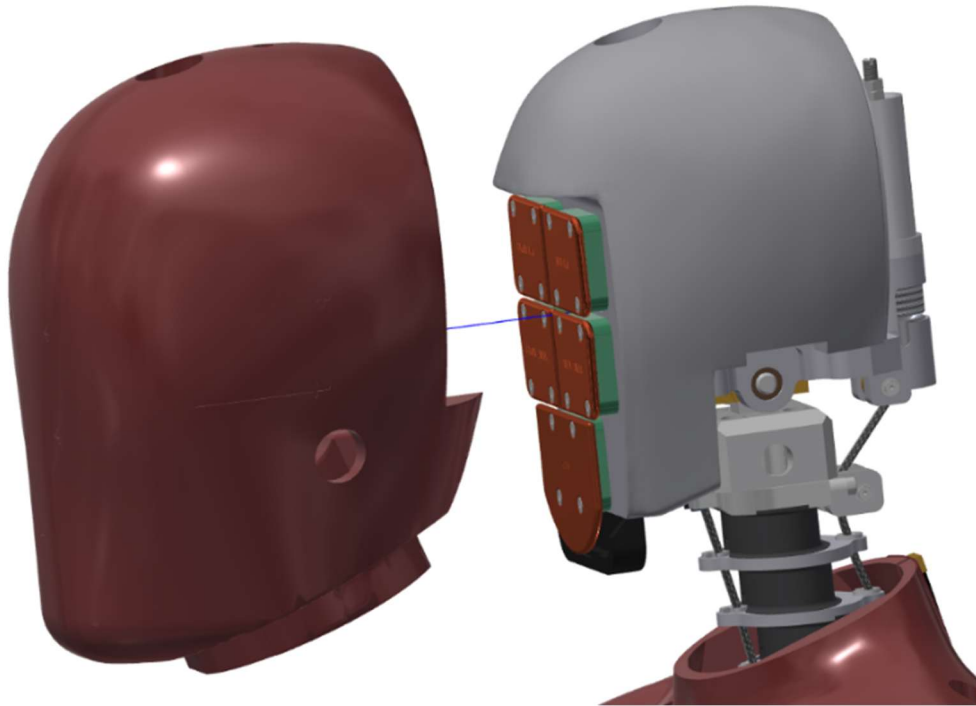


Figure 3-4. Head skin and skull

- 3.2.4 Remove the face insert (474-1401) from the head skin (Figure 3-5).

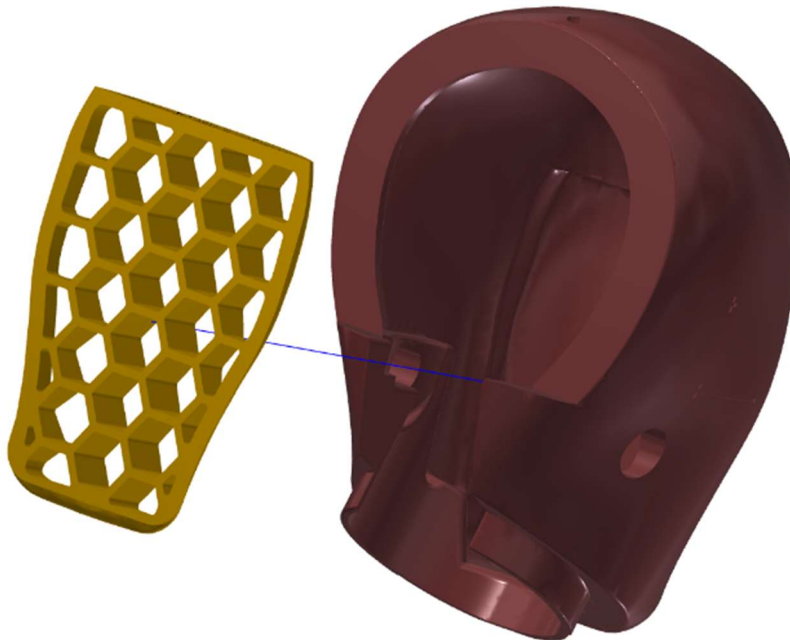


Figure 3-5. Face insert and head skin

- 3.2.5 Remove the neck from the torso by removing four M5 X 0.8 X 16 LG. SHCS from the spine assembly (474-3200) (Figure 3-6). Unzipping the shoulder pad (474-3559) can provide better access to the screws. Lift the head and neck assembly up from the torso.

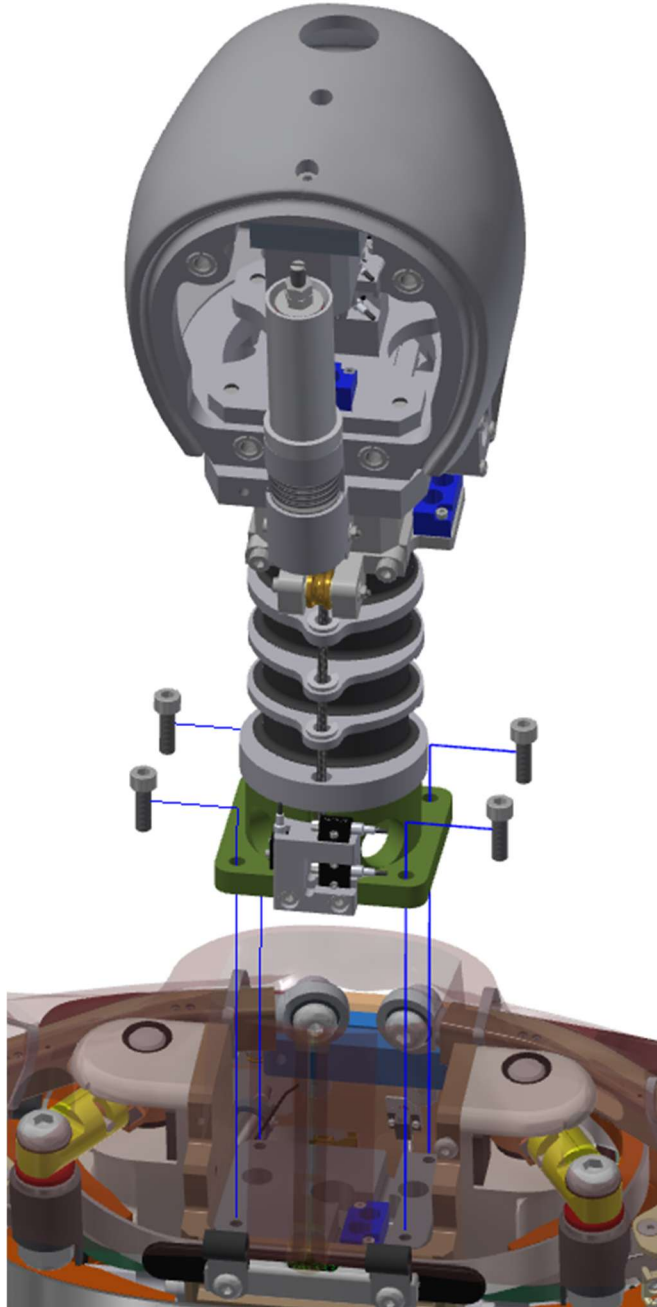


Figure 3-6. Head, neck, and upper thorax

3.2.6 Remove the strain relieving cable ties from the neck cable bundle (Figure 3-7).

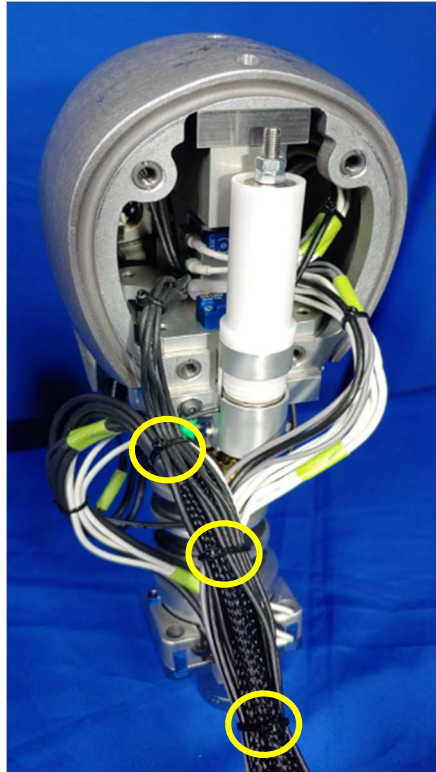


Figure 3-7. Strain relieving cable ties on the neck cable bundle

3.2.7 Remove the head from the neck assembly by removing four M6 X 1 X 25 LG. SHCS from the bottom side of the skull (474-1010) (Figure 3-8).

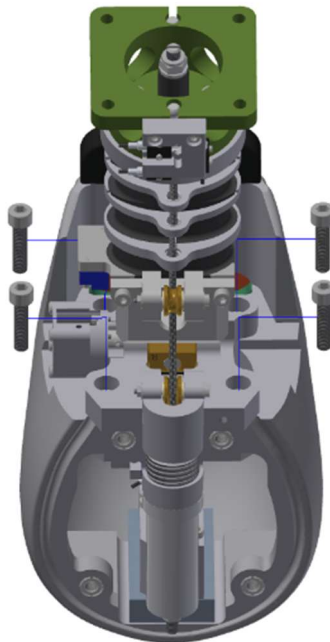


Figure 3-8. Head and neck assemblies

3.2.8 Separate the head, neck, and sensor mounting plate (474-1031) (Figure 3-9).

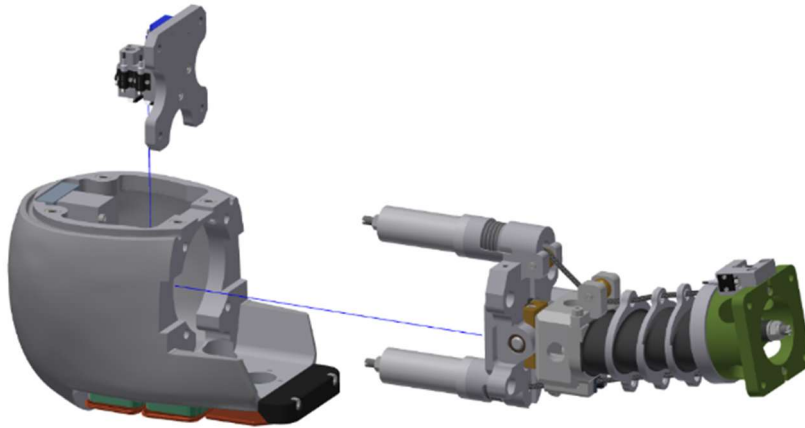


Figure 3-9. Head, neck, and sensor mounting plate

3.2.9 Remove the three strain relieving cable ties from the head instrumentation wires (Figure 3-10).

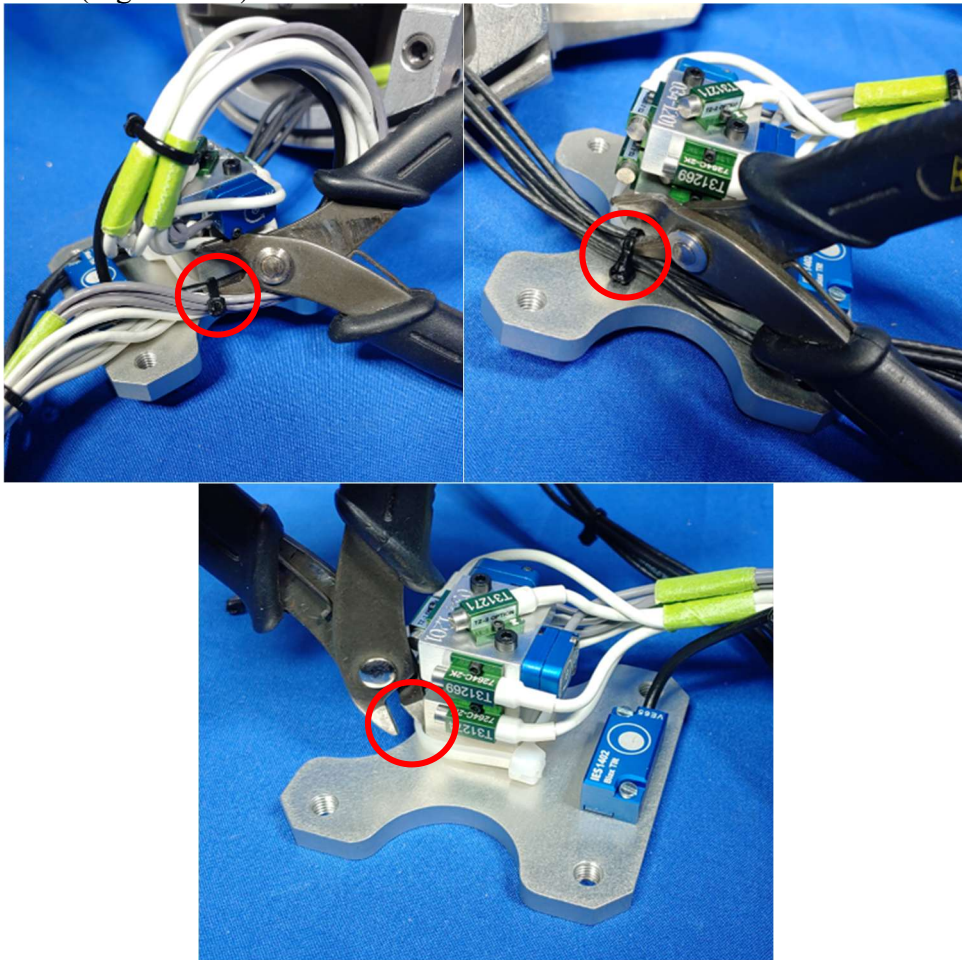


Figure 3-10. Strain relieving cable ties on the head sensor mounting plate

- 3.2.10 Remove the 6 axis accel/ARS mount from the accel mount by removing two M2.5 X 0.45 X 16 LG. SHCS (Figure 3-11).

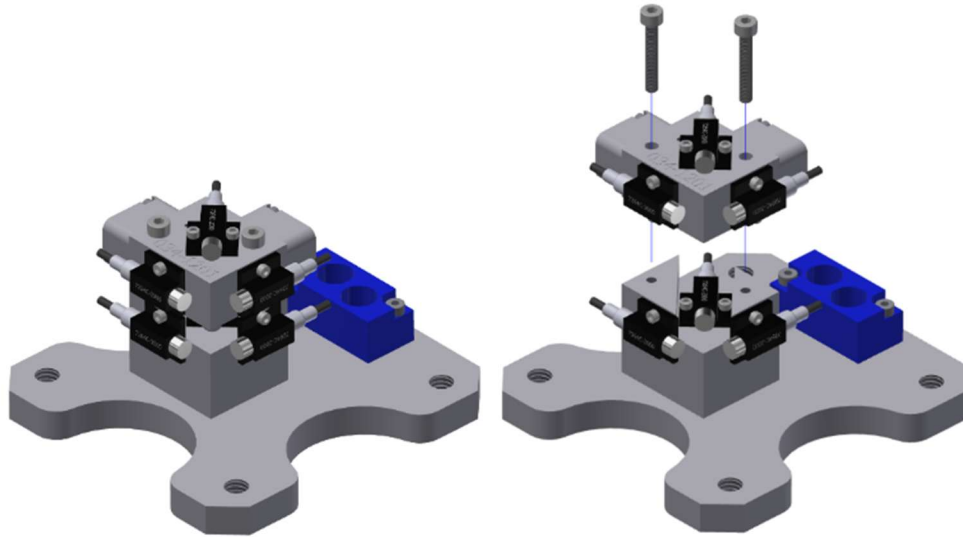


Figure 3-11. Head accel/ARS mount

- 3.2.11 Remove the 3 uniaxial accelerometers (SA572-S4) and three angular rate sensors (ARS) (S572-S58) from the 6 axis accel /ARS mount (SA572-S87) by removing two M1.4 X 0.3 X 3 LG. SHCS per accelerometer and two M1.4 X 0.3 X 8 LG. SHCS per ARS (Figure 3-12).

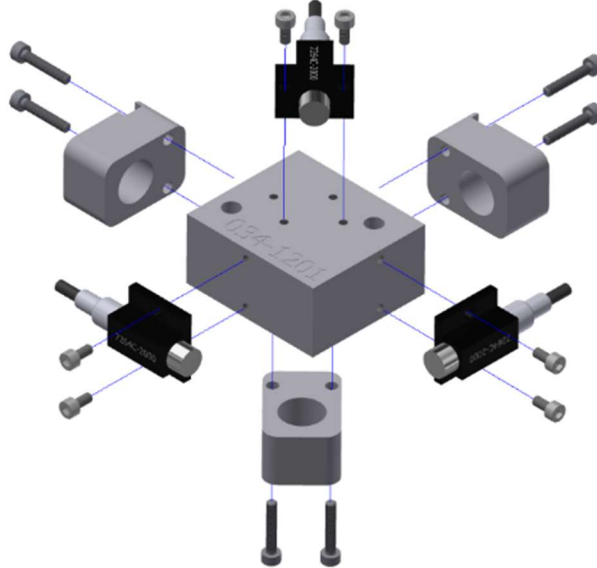


Figure 3-12. Exploded head accel/ARS mount

- 3.2.12 Remove the accel mount (SA572-S167) from the sensor mounting plate by removing two M3 X 0.5 X 8 LG. SHCS from the bottom of the sensor mounting plate (Figure 3-13).

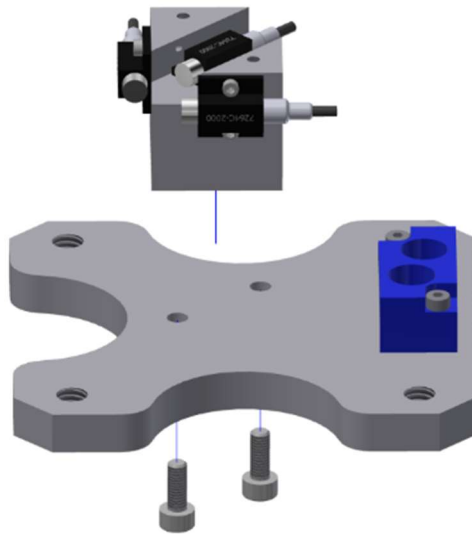


Figure 3-13. Head accel mount and sensor mounting plate

- 3.2.13 Remove three uniaxial accelerometers (SA572-S4) from the accel mount (SA572-S167) by removing two M1.4 X 0.3 X 3 LG. SHCS per accelerometer (Figure 3-14).

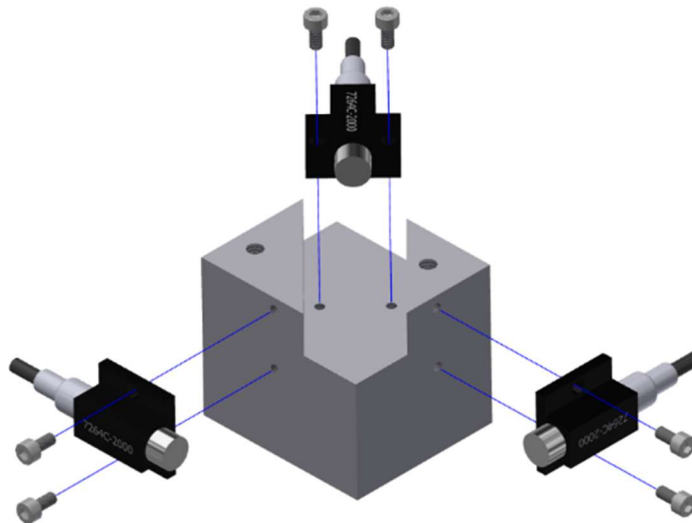


Figure 3-14. Exploded head accel mount

- 3.2.14 Remove one tilt sensor (SA572-S44) from the sensor mounting plate (474-1031) by removing two M2 X 0.4 X 12 LG. SHCS

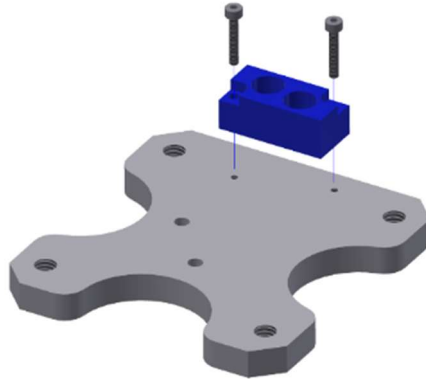


Figure 3-15. Head tilt sensor

- 3.2.15 Remove the five face load cell plates (474-1412-1, 474-1414-1, 474-1412-2, 474-1414-2, and 474-1416) by removing four M3 X 0.5 X 8 LG. FHCS per load cell plate (twenty screws total) (Figure 3-16).

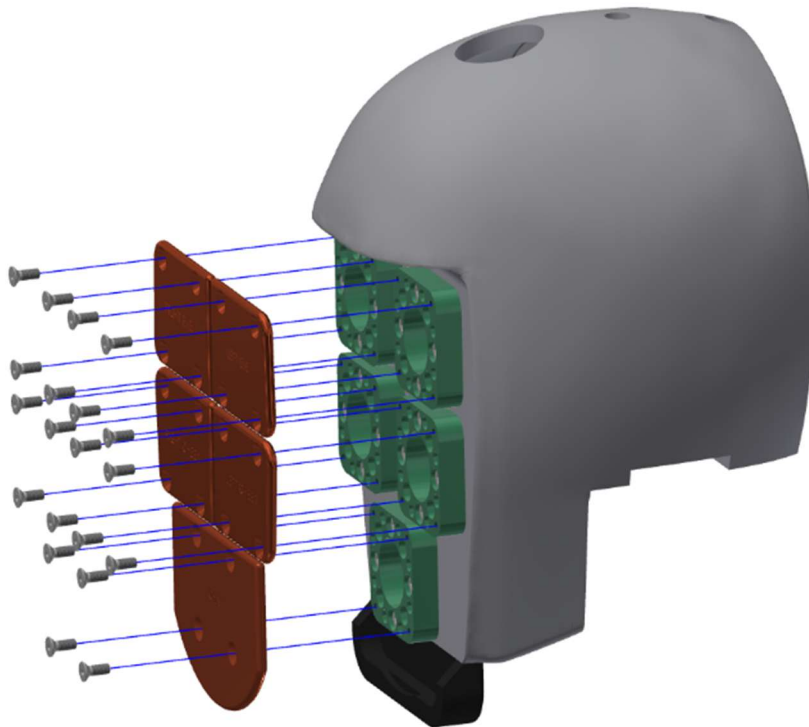


Figure 3-16. Face load cell plates

- 3.2.16 Remove the five face load cells by removing four M3 X 0.5 X 10 LG. SHCS per load cell (20 screws total) (Figure 3-17), and pull the face load cell wires through the hole in the face of the skull.

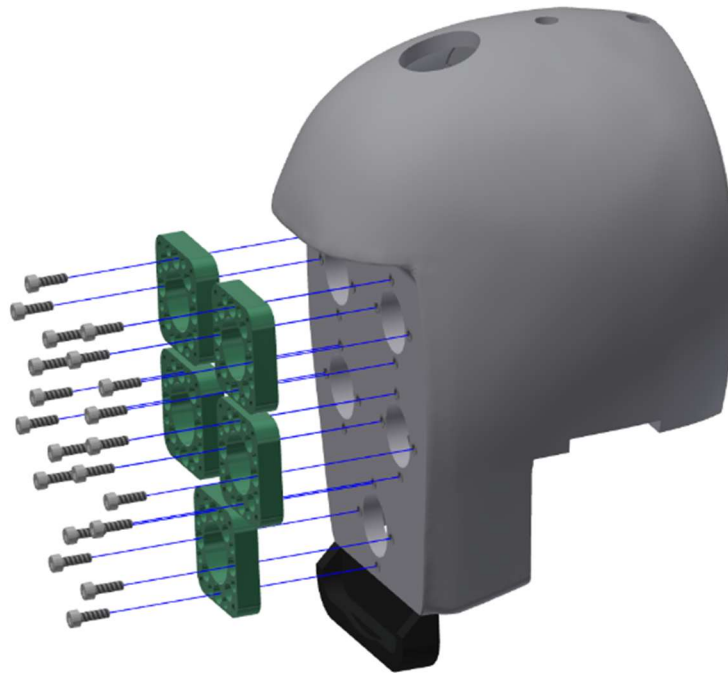


Figure 3-17. Face load cells

- 3.2.17 Remove the DAS mount (474-1051) from the skull by removing two M4 X 0.7 X 16 LG. SHCS from the top of the skull (Figure 3-18).



Figure 3-18. Skull and DAS mount

3.2.18 Remove the DAS structural replacement (474-1033) from the DAS mount (474-1051) by removing four M3 X 0.5 X 35 LG. SHCS (Figure 3-19).

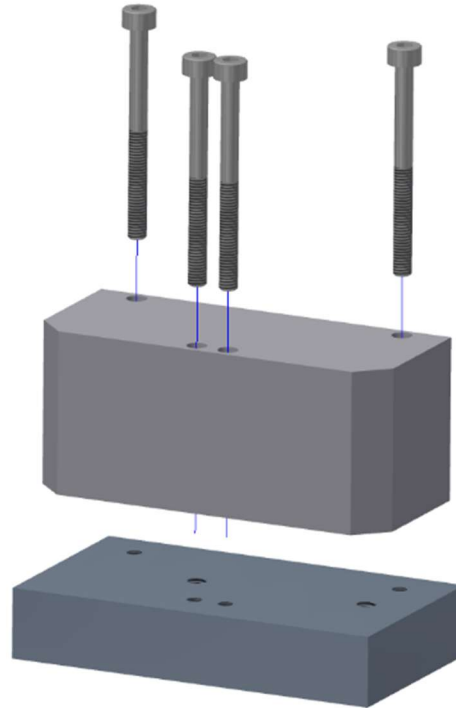


Figure 3-19. DAS structural replacement and DAS mount

3.2.19 Remove the chin guard (474-1411) by removing two M4 X 0.7 X 25 LG. SHCS (Figure 3-20).

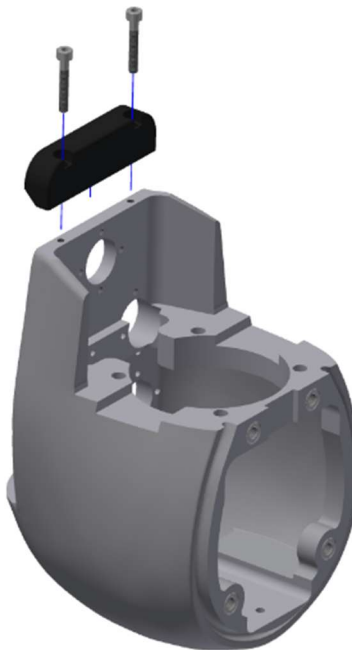


Figure 3-20. Chin guard and skull

3.3 Assembly of the Head

The following is a step-by-step description of the assembly procedure for the head components. Unless otherwise specified, tighten all bolts to the torque specifications provided in Section 2.1.3.

- 3.3.1 Install three uniaxial accelerometers onto the accel mount (SA572-S167) using two M1.4 X 0.3 X 3 LG. SHCS per accelerometer for redundant head acceleration channels. Orient the accelerometer units: +X to the front, +Y to the right, and +Z down (Figure 3-21).

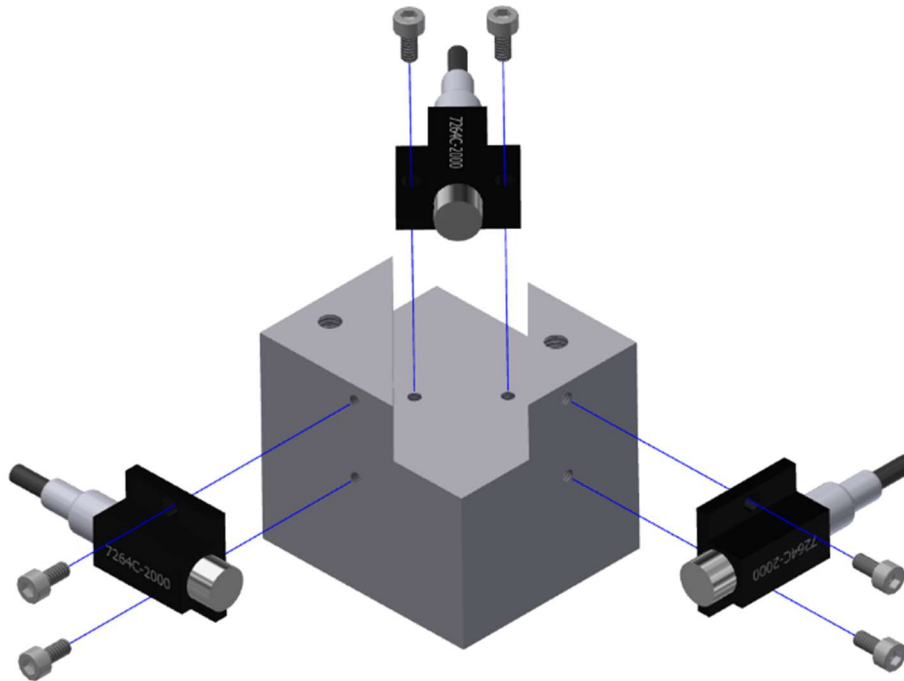


Figure 3-21. Exploded head accel mount

- 3.3.2 Install three uniaxial accelerometers (SA572-S4) and three ARSs (S572-S58) onto the 6 axis accel /ARS mount (SA572-S87) using two M1.4 X 0.3 X 3 LG. SHCS per accelerometer and two M1.4 X 0.3 X 8 LG. SHCS per ARS. Orient the three head CG accelerometer units: +X to the front, +Y to the right, and +Z down (Figure 3-22).

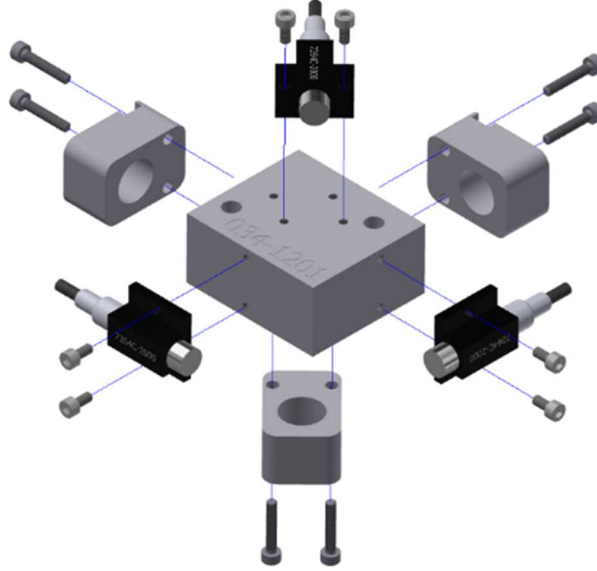


Figure 3-22. Exploded head accel/ARS mount

- 3.3.3 Attach the head tilt sensor (SA572-S44) to the sensor mounting plate (474-1031) using two M2 X 0.4 X 12 SHCS (Figure 3-23).

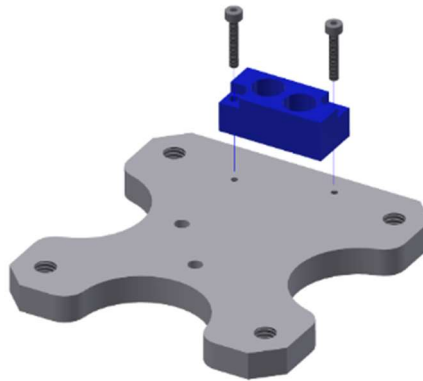


Figure 3-23. Head tilt sensor and sensor mounting plate

- 3.3.4 Install the accel mount (SA572-S167) onto the sensor mounting plate (474-1031) using two M3 X 0.5 X 8 LG. SHCS through the bottom side of the sensor mounting plate (Figure 3-24).

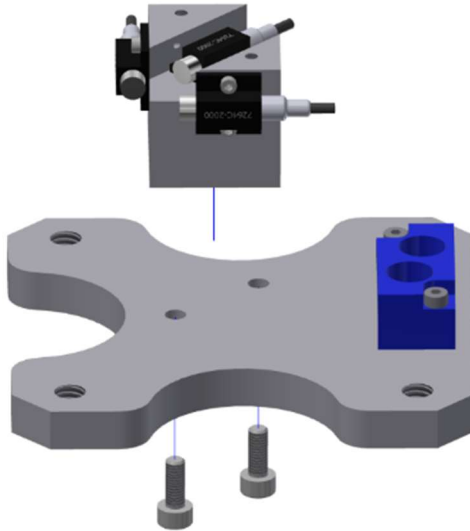


Figure 3-24. Head accel mount and sensor mounting plate

- 3.3.5 Install the 6 axis accel/ARS mount onto the accel mount using two M2.5 X 0.45 X 16 LG. SHCS (Figure 3-25).

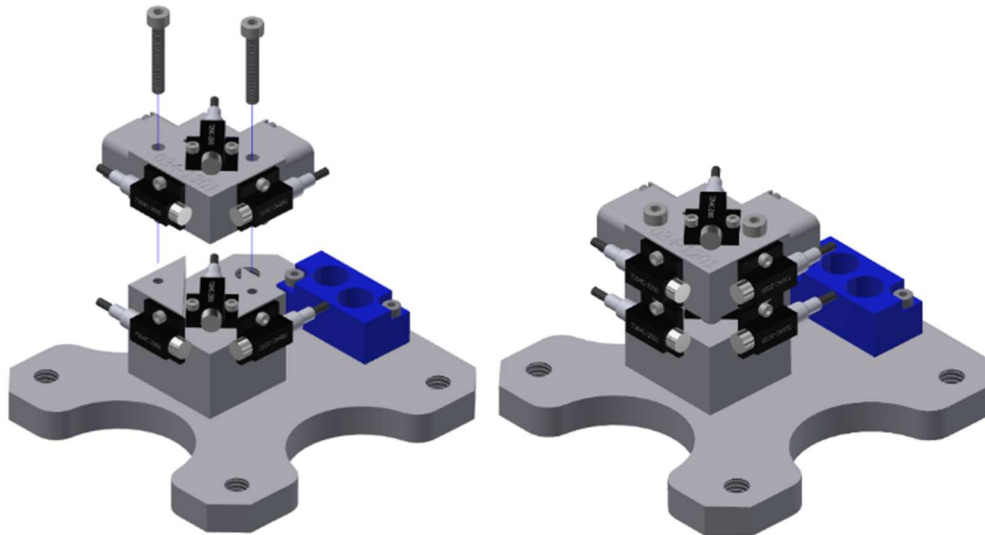


Figure 3-25. Head accel/ARS mount and sensor mounting plate assembly

- 3.3.6 Strain relieve the accelerometer, ARS, and tilt sensor wires with masking tape and cable ties according to Figure 3-26.



Figure 3-26. Head instrumentation wires strain relief

- 3.3.7 Attach the chin guard (474-1411) to the skull (474-1010) using two M4 X 0.7 X 22 SHCS (Figure 3-27).

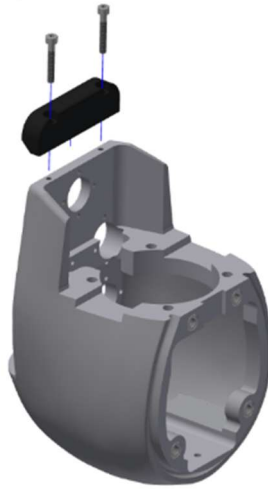


Figure 3-27. Chin guard and skull

- 3.3.8 Install the DAS structural replacement (474-1033) onto the DAS mount (474-1051) using four M3 X 0.5 X 35 SHCS (Figure 3-28).

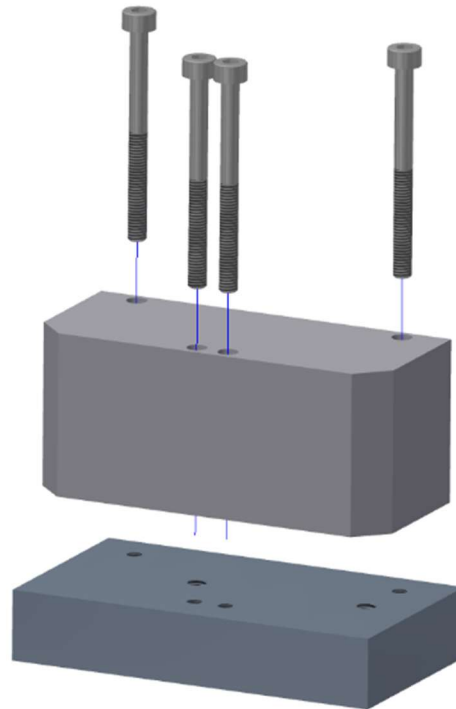


Figure 3-28. DAS structural replacement and DAS mount

- 3.3.9 Install the DAS mount (474-1051) to the skull (474-1010) using two M4 X 0.7 X 25 SHCS through the exterior top of the skull (Figure 3-29).

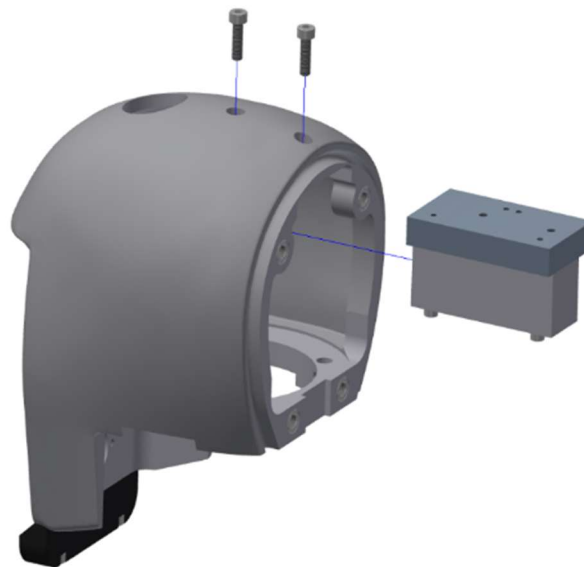


Figure 3-29. DAS mount and skull

- 3.3.10 Attach five face load cells (SA572-S124) or load cell substitutes (474-1005) to the skull (474-1010) using twenty M3 X 0.5 X 10 SHCS (Figure 3-30).
- 3.3.11 Route the face load cell wires through the skull.

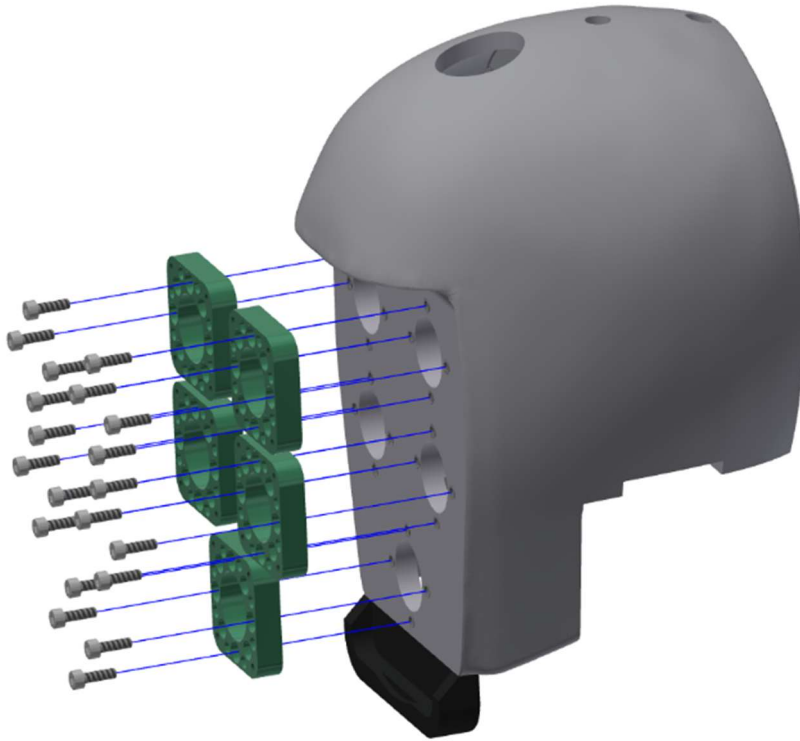


Figure 3-30. Secure the face load cells to face plate

- 3.3.12 Install the respective load cell plates (474-1412-1, 474-1412-2, 474-1414-1, 474-1414-2, 474-1416) onto the face load cells using four M3 X 0.5 X 8 FHCS per plate (total of 20) (Figure 3-31). Each load cell plate is shaped differently to match the contour of the front of the head casting. Labels on the load cell plates: “L-EYE”, “R-EYE”, “L-CHEEK”, “R-CHEEK”, and “CHIN” describe the load cell attachment location on the face.

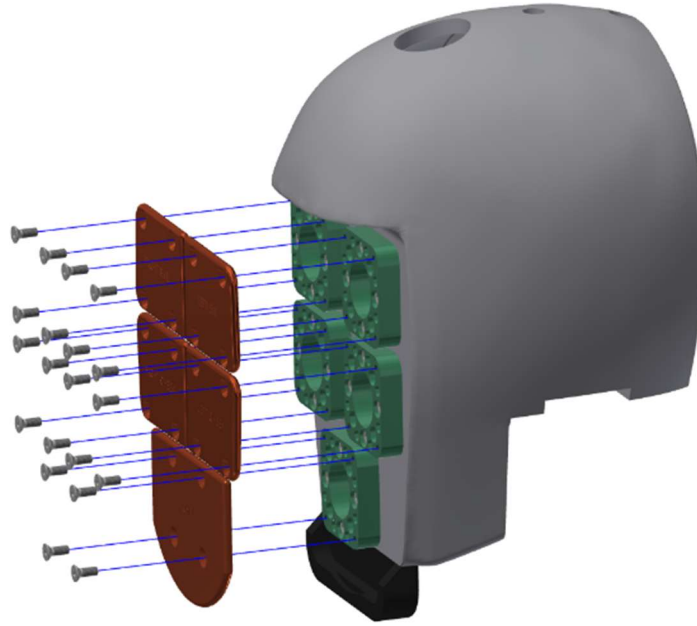


Figure 3-31. Face load cell plates

- 3.3.13 Orient the sensor mounting plate and the neck assembly so that the dual axis tilt sensor (SA572-S44) and the neck rear cable pulley are towards the rear of the head. Insert the sensor mounting plate into the skull (474-1010) and position the neck below the bottom of the head (Figure 3-32).

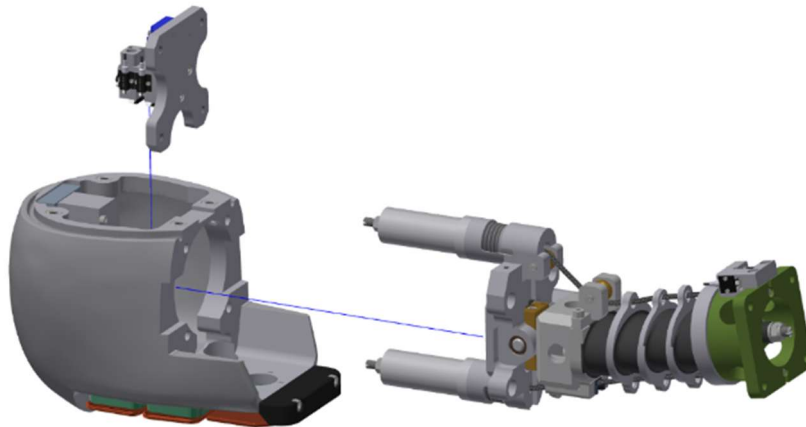


Figure 3-32. Head, neck, and sensor mounting plate assemblies

- 3.3.14 Fasten the head, neck, and sensor mounting plate (474-1031) together using four M6 X 1 X 25 SHCS from the underside of the head, through the sensor mounting plate (Figure 3-33)

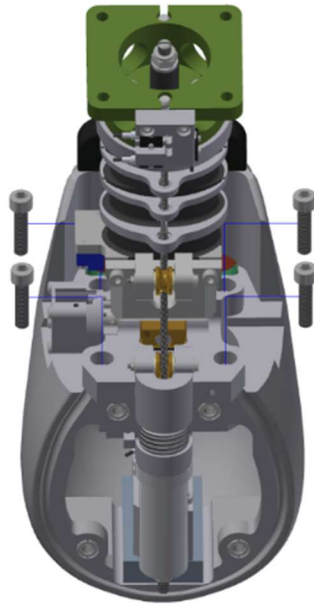


Figure 3-33. Head and neck assembly

NOTE: The neck must be oriented properly for installation within the head. The rear cable is easily identifiable by the presence of the cable pulley.

- 3.3.15 Route the instrumentation wires according to Figure 3-34.

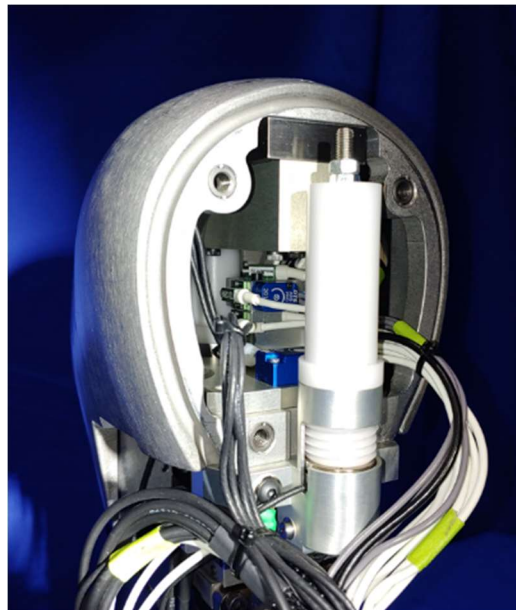


Figure 3-34. Head instrumentation wire routing

- 3.3.16 The head skin has a number of landmarks marked on the skin (Figure 3-35). The CG location on the molded head skin (474-1008) corresponds to the CG of the head and the head CG instrumentation. The centers of the facial load cells are indicated by crosses on the anterior part of the skin. The tragon and Frankfort landmarks are also indicated on both sides of the head skin.

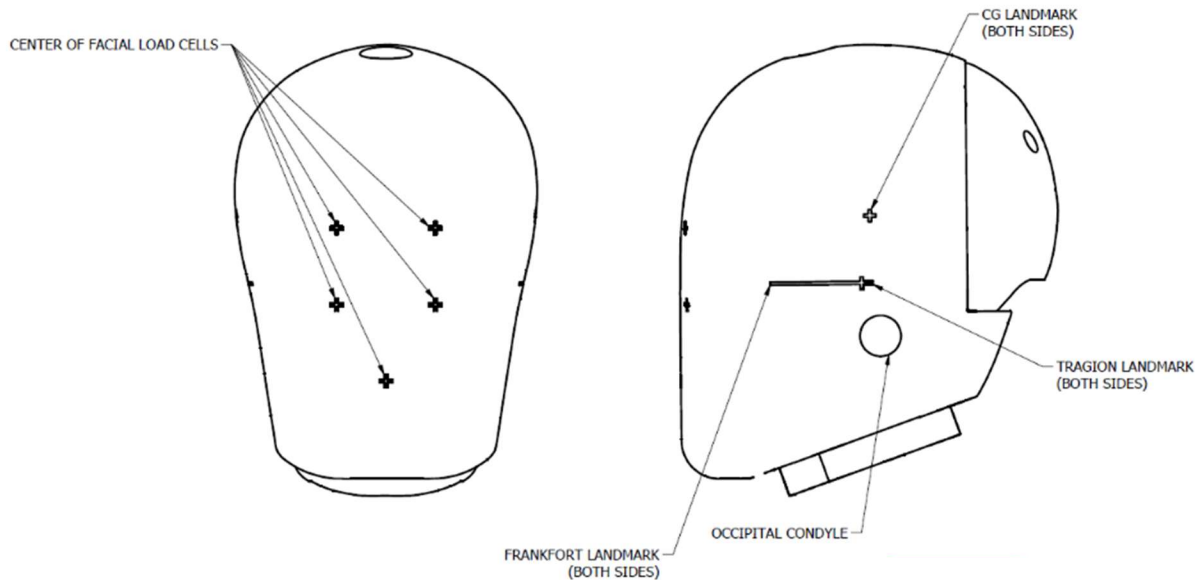


Figure 3-35. Landmarks on the head skin

- 3.3.17 Position the Face Insert (474-1401) inside the cavity in the Head Skin (474-1008) (Figure 3-36).

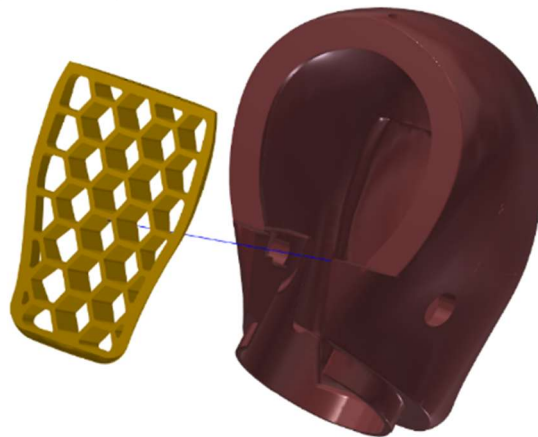


Figure 3-36. Install face insert (474-1401)

- 3.3.18 Install the head skin (with face insert installed) over the skull assembly. Position the posterior skin at the skull cap interface so that the skin seats into the grooved contour on the skull (Figure 3-37).

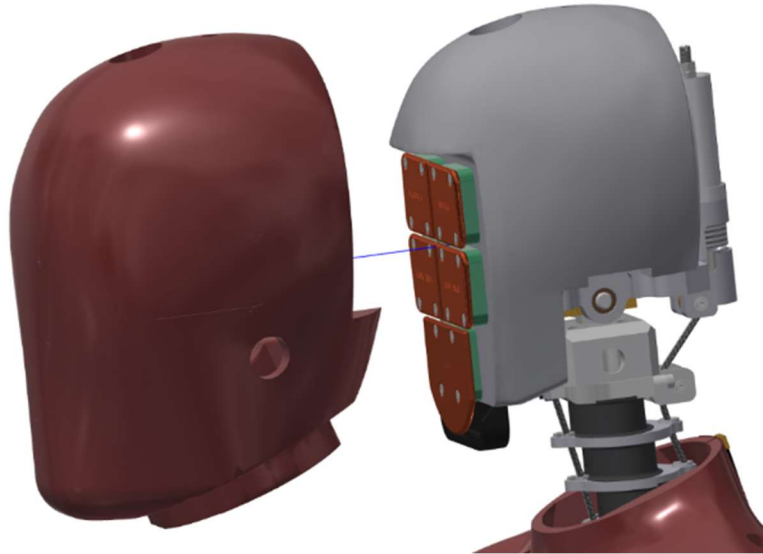


Figure 3-37. Install head skin into grooved contour on skull.

- 3.3.19 Attach the ground strap to the back of the head using one M4 X 0.7 X 6 BHCS (Figure 3-38).

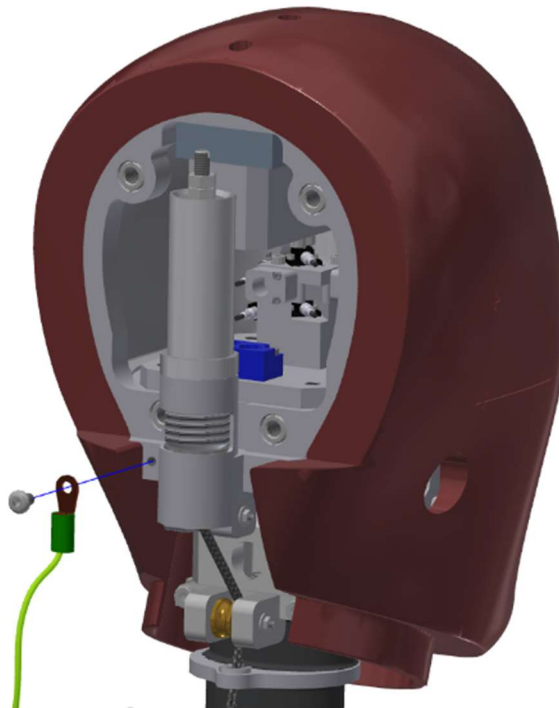


Figure 3-38. Head ground strap location

3.3.20 Route the instrumentation wires from the head and upper neck load cell as shown in Figure 3-39.



Figure 3-39. Routing cables for the head

3.3.21 Position the Cap Skin (474-1025) onto the Skull Cap (474-1022). Slide the head cap assembly on the rear of the skull while carefully routing the wire bundles out through the bottom sides of the cap (Figure 3 40). Take caution not to pinch any of the instrumentation wiring between the skull cap assembly and the skull during installation. Secure the cap into place using four M6 X 1 X 20 SHCS.

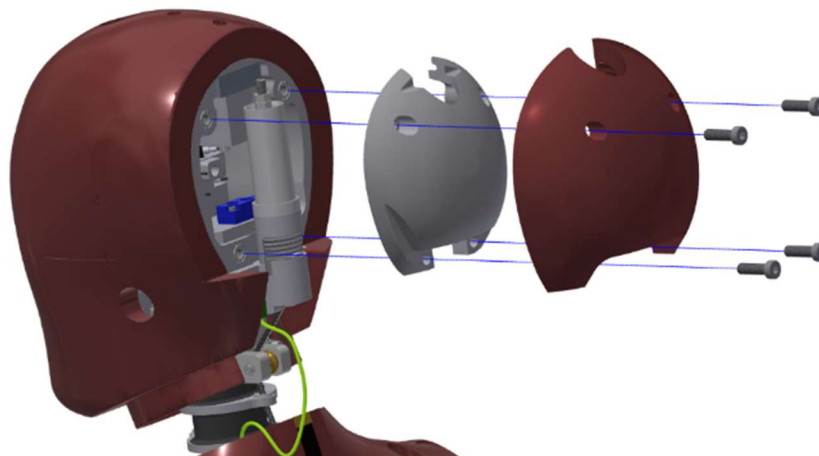


Figure 3-40. Install the skull cap

3.4 Adjustments for the Head and Face Assemblies

No adjustments are required for the head and face assemblies.

3.5 Electrical Connections and Requirements

Section 13.3 includes grounding information. Section 13.4 describes cable routing instructions.

Section 4. Neck Assembly

4.1 Description of the Neck Assembly and Features

The THOR-05F neck assembly consists of a series of aluminum plates and rubber pucks which are molded together using an epoxy resin system. The elliptical rubber pucks provide the desired frontal, lateral, and torsional bending responses for the neck assembly. Compression springs are in the fore and aft regions of the skull. In addition, rubber soft stops at the base of the neck aid in achieving the desired bending characteristics in both front and rear motion.

The instrumentation for the neck assembly includes a pair of skull spring load cells (SA572-S112), which measure the compression at the front and rear spring locations. In addition, six-axis load cells at the top (SA572-S105) and base (SA572-S106) of the neck measure the forces and moments developed at these locations, while a rotary potentiometer (SA572-S114) at the condyle pin measures the relative rotation between the head and top of the neck. Figure 4-1 illustrates the THOR-05F neck assembly.

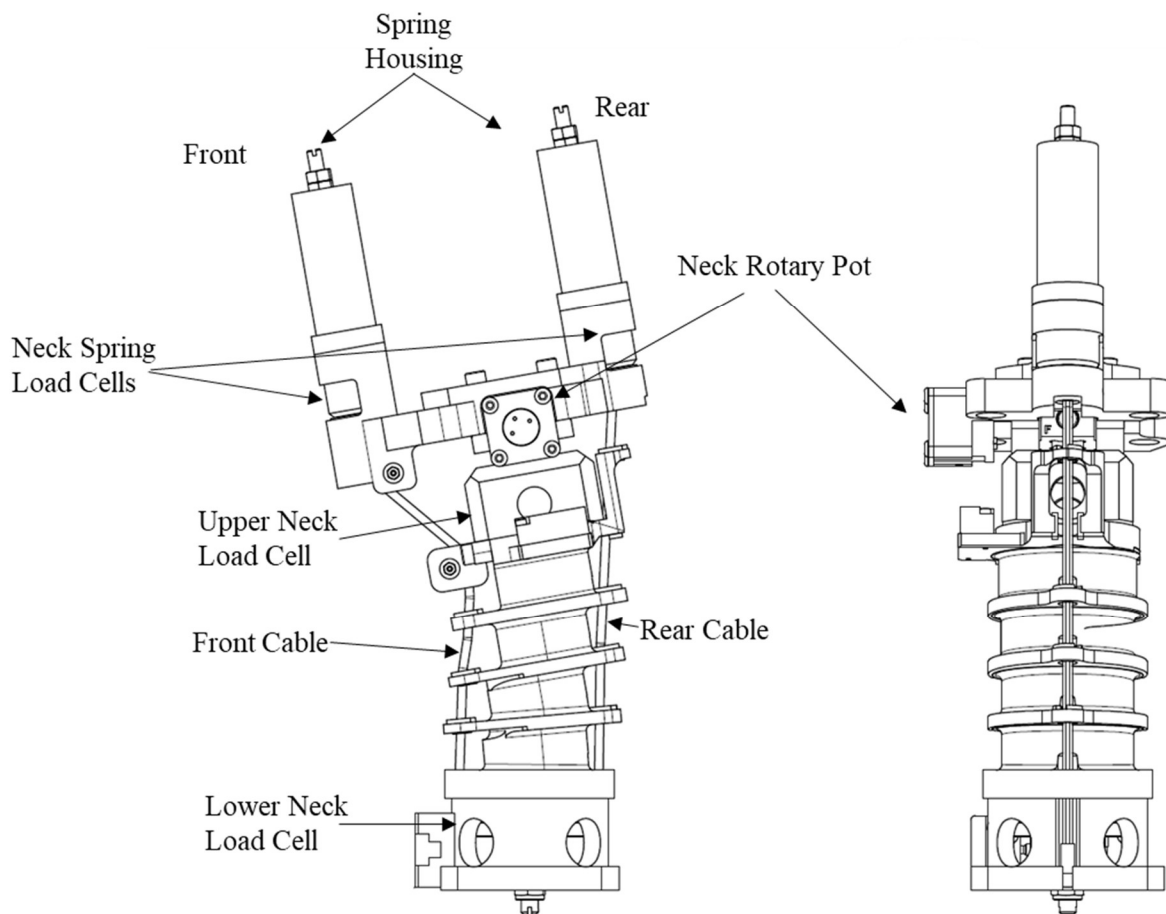


Figure 4-1. Neck assembly

Table 2-1 through Table 2-5 list the components that are included in the neck. Figure 4-2 through Figure 4-6 show drawings of the neck assemblies and hardware.

Table 4-1. THOR-05F Neck Assembly Components

Part Description	Quantity	Part Number	Figure #	Item #
Neck Column Assembly	1	474-2100	Figure 4-2	1
Head/Neck Platform Assembly	1	474-2300-A	Figure 4-2	2
Rotary Potentiometer Housing, Neck	1	472-2013	Figure 4-2	3
Rotary Potentiometer Clamp, Neck	2	472-2020	Figure 4-2	4
Rotary Potentiometer Washer, Neck	1	472-2021	Figure 4-2	5
Rotary Potentiometer Cover, Neck	1	472-2014	Figure 4-2	6
M2 X 0.4 X 6 Lg. SHCS	4	5000082	Figure 4-2	7
M3 X 0.5 X 35 LG. BHCS SS	2	5001313	Figure 4-2	8
M3 X 0.5 X 6 LG. BHSS SS	2	5000399	Figure 4-2	9
Pin, OC (Occipital Condyle)	1	474-2340	Figure 4-2	10
M3 X 0.5 X 3 LG. SSS Cone PT.	1	5001112	Figure 4-2	11
M5 X 0.8 Hex Nut Zinc	4	5000515	Figure 4-2	12
M4 X 0.7 X 6 LG. BHCS	1	5001075	Figure 4-2	13
M3 X 0.5 X 12 LG. SHCS	1	5001103	Figure 4-2	14
Screw, SHCS M2 – 0.4 X 12 mm Long	3	5000382	Figure 4-2	15
Tilt Sensor, Dual Axis	1	SA572-S44	Figure 4-2	16
T1 THOR 5 th 7264C Kit	1	474-2022	Figure 4-2	17

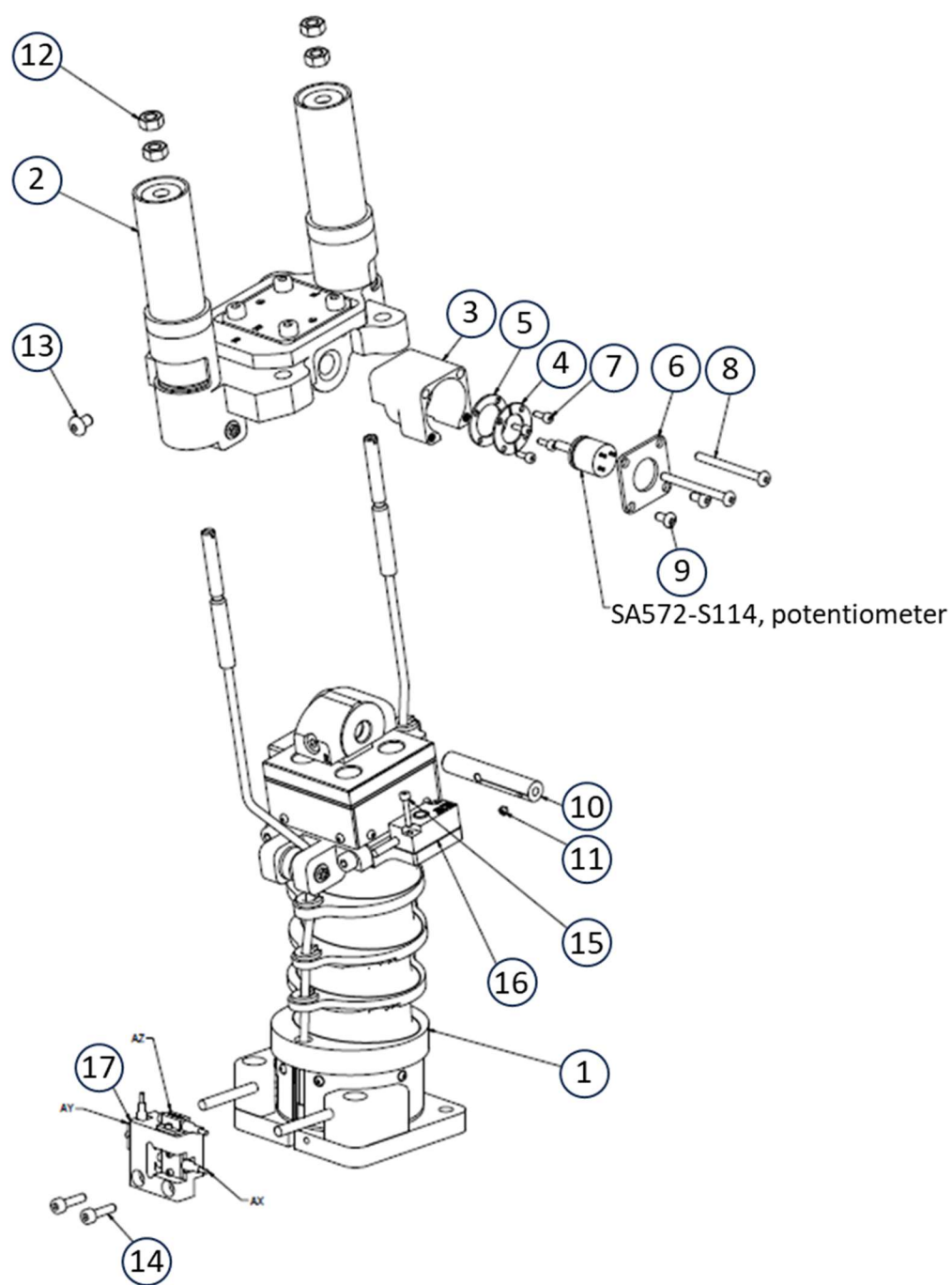


Figure 4-2. THOR-05F Neck Assembly (474-2000)

Table 4-2. THOR-05F Neck Column Assembly Components

Part Description	Quantity	Part Number	Figure #	Item #
Neck Assembly, Molded	1	474-2110	Figure 4-3	1
Center Cable Fixture	1	474-2334	Figure 4-3	2
Center Cable Assy., Neck	1	474-2600	Figure 4-3	3
Cover, Neck Cable	1	474-4333	Figure 4-3	4
M2.5 X 0.45 X 5 LG. FHCS	2	5000723	Figure 4-3	5
Compression Bushing, Neck Center Cable	1	474-2331	Figure 4-3	6
M6 X 1 Hex Lock Nut SS	1	5000503	Figure 4-3	7
M6 Flat Washer Plain Zinc	1	5000013	Figure 4-3	8
Structural Replacement, Lower Neck Load Cell	1	474-2325	Figure 4-3	9
Rear Pulley Assembly	1	474-2330	Figure 4-3	10
M4 X 0.7 X 14 LG. SHCS	2	5000459	Figure 4-3	11
M5 X 0.8 X 12 LG. SHCS	4	5000002	Figure 4-3	12
M5 X 0.8 X 14 LG. SHCS	4	5000300	Figure 4-3	13
Washer, M5 Split Lock	4	5001400	Figure 4-3	14
Neck Cable Assy., Front/Rear	2	474-2620	Figure 4-3	15
Cable Guide Half	7	474-2332	Figure 4-3	16
Structural Replacement, Upper Neck Load Cell	1	474-2326	Figure 4-3	17
OC Flexion-Extension CAM	1	474-2327	Figure 4-3	18
Occipital Condyle Screw	1	472-2016	Figure 4-3	19
M4 X 0.7 X 6 LG. SHCS	1	5000076	Figure 4-3	20
Top Plate Cable Guide, Neck	1	474-2341	Figure 4-3	21

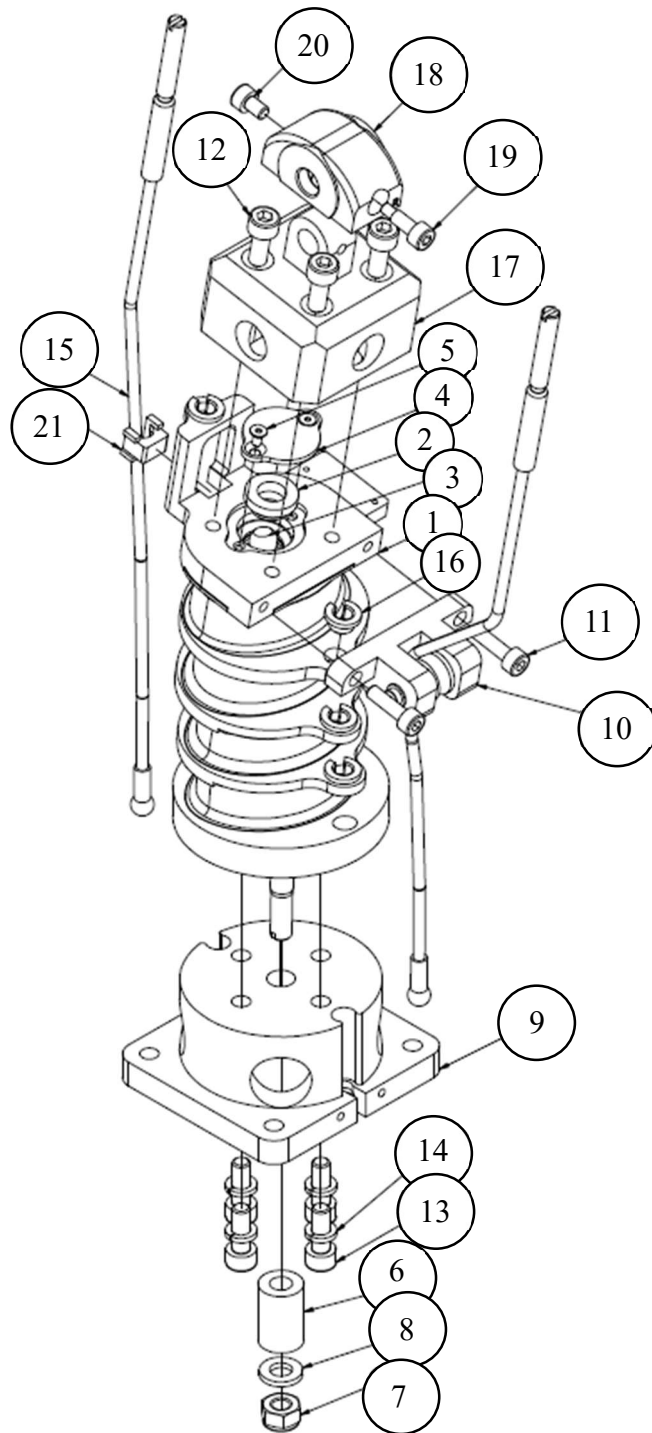


Figure 4-3. THOR-05F Neck Column Assembly (474-2100)

Table 4-3. THOR-05F Rear Pulley Assembly Components

Part Description	Quantity	Part Number	Figure #	Item #
Bracket, Rear Pulley	1	474-2329	Figure 4-4	1
Rear Cable Pulley Assy.	1	474-2308	Figure 4-4	2
M3 Flat Washer Plain SS	2	5000634	Figure 4-4	3
M3 X 25 LG. Prec. SHSS SS	1	5001395	Figure 4-4	4
M2 X 0.4 Hex Nut SS	1	5000764	Figure 4-4	5
M3 Flat Washer Plain PTFE	2	5001410	Figure 4-4	6

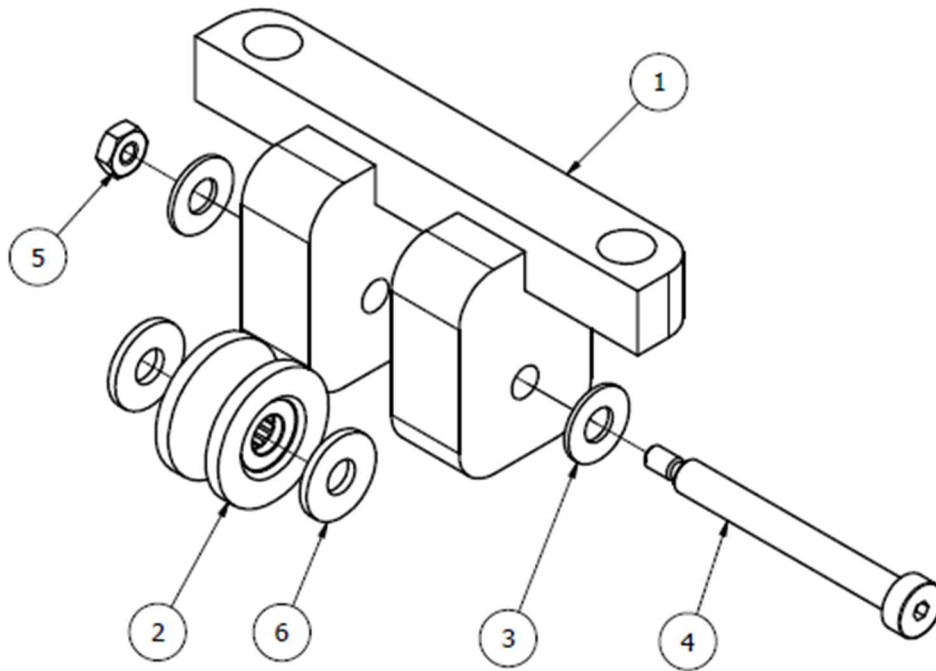


Figure 4-4. Rear Pulley Assembly (474-2330)

Table 4-4. THOR-05F Head/Neck Platform Assembly Components

Part Description	Quantity	Part Number	Figure #	Item #
Head/Neck Mounting Platform	1	474-2302-A	Figure 4-5	1
Flexion/Extension Stop Assembly	1	474-2115-A	Figure 4-5	2
Spring Assembly, Front	1	474-2305	Figure 4-5	3
Spring Assembly, Rear	1	474-2304	Figure 4-5	4
Spring Load Cell, S.R.	2	474-2306	Figure 4-5	5
Front/Rear Spring Tube	2	474-2303	Figure 4-5	6
Rear Cable Pulley Assy.	1	474-2308	Figure 4-5	7
M3 Flat Washer Plain PTFE	2	5001410	Figure 4-5	8
M3 Flat Washer Plain SS	2	5000634	Figure 4-5	9
M3 X 25 LG. Prec. SHSS SS	1	5001395	Figure 4-5	10
M2 X 0.4 Hex Nut SS	1	5000764	Figure 4-5	11
M4 X 0.7 X 10 LG. SHCS	4	5000151	Figure 4-5	12

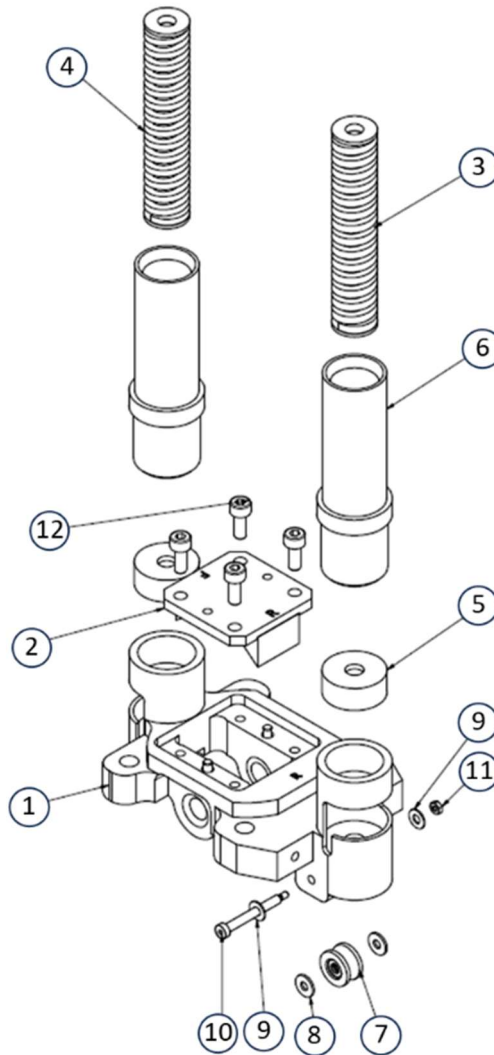


Figure 4-5. Head/Neck Platform Assembly (474-2300-A)

Table 4-5. THOR-05F Spring Assembly, Front and Rear, Components

Part Description	Quantity	Part Number	Figure #	Item #
Spring Bushing	2	474-2322	Figure 4-6	1
Front/Rear Spring Damping Tube	1	474-2323	Figure 4-6	2
Spring, Front or Rear	1	474-2925, 24	Figure 4-6	3

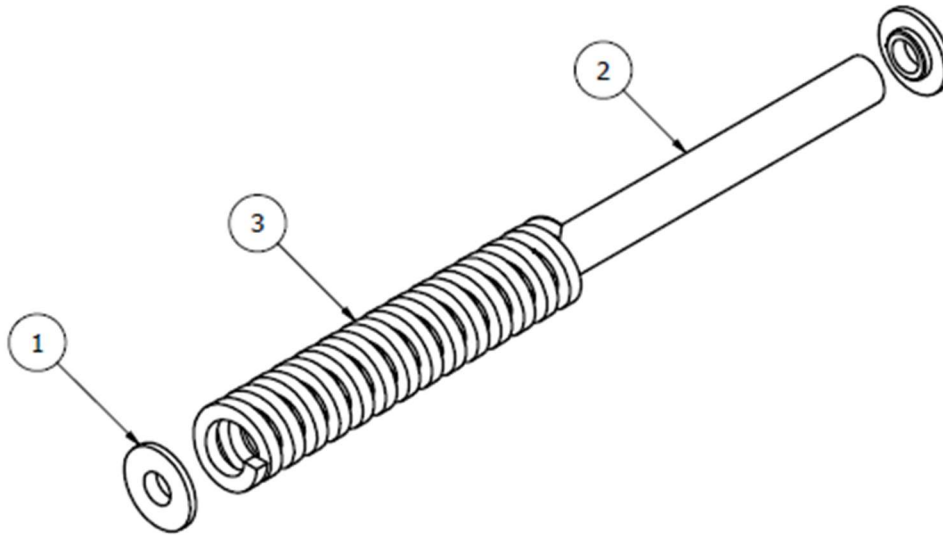


Figure 4-6. Spring Assembly, Front and Rear (474-2305 and 474-2304)

4.2 Disassembly of the Neck

The following is a step-by-step description of the disassembly procedure for the neck components.

- 4.2.1 Unscrew, by hand, the front and rear spring tubes (474-2303) from the head and neck mounting platform (474-2302-A) (Figure 4-7).



Figure 4-7. Unscrew the front and rear spring tubes (474-2303) from the head and neck mounting platform (474-2302-A)

- 4.2.2 Remove the four jam nuts (5000515) from the top of the front and rear neck cables (Figure 4-8). Remove the front and rear spring assemblies.

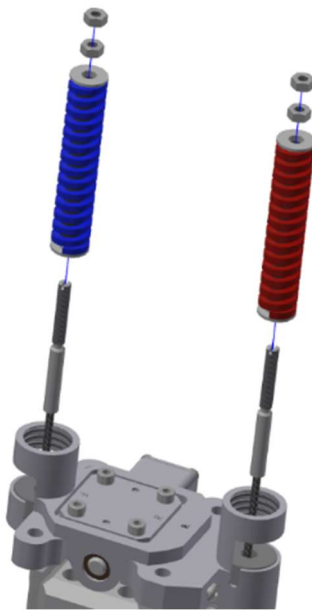


Figure 4-8. Jam nut removal

- 4.2.3 Remove the Flexion/Extension Stop Assembly (474-2115-A) by removing four M4 X 0.7 X 10 LG. SHCS (Figure 4-9).

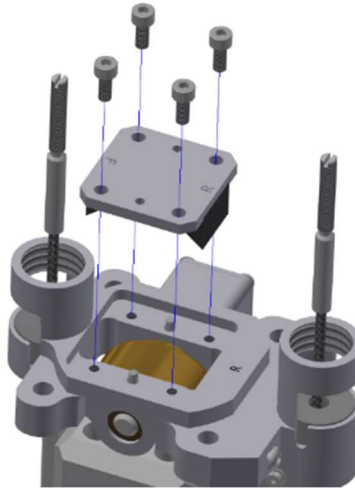


Figure 4-9. Remove the Flexion/Extension Stop Assembly (474-2115-A) by removing 4 M3 X 0.5 X 8 FHCS

- 4.2.4 Remove the cable tie from the neck cable bundle (Figure 4-10).



Figure 4-10. Remove the cable tie from the neck cable bundle

- 4.2.5 Remove the M3 X 0.5 X 3 LG. SSS Cone PT. from the OC potentiometer shaft (Figure 4-11).

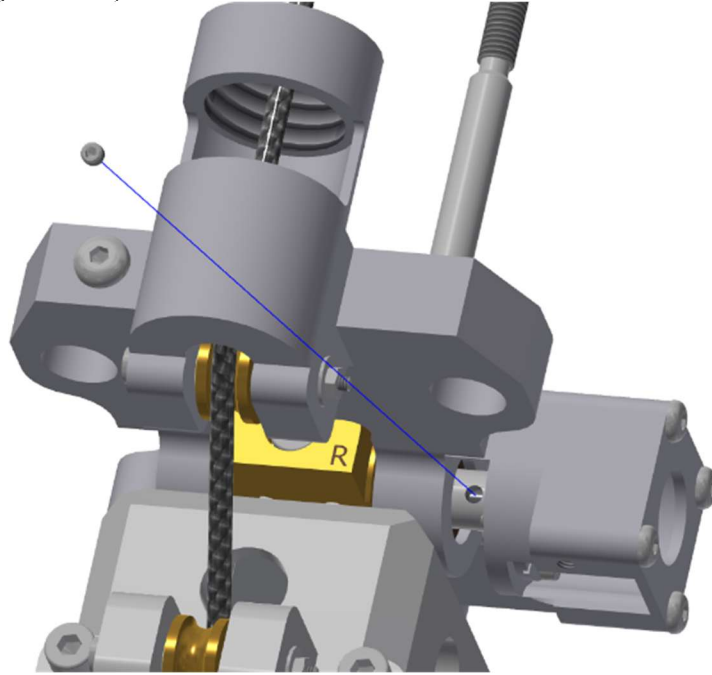


Figure 4-11. Remove the M3 X 0.5 X 3 LG. SSS Cone PT. from the OC potentiometer shaft

- 4.2.6 Remove the top two M3 X 0.5 X 35 LG. BHCS SS from the OC potentiometer housing and remove the OC pot with housing from the neck (Figure 4-12). To disassemble the OC pot, remove the bottom two M3 X 0.5 X 6 LG. BHCS (Figure 4-13). The rotary potentiometer cover (474-2014) can be removed now. Remove the four M2 X 0.4 X 6 LG. SHCS from the rotary potentiometer clamp (474-2020) (Figure 4-14). The rotary potentiometer (SA572-S114) can be removed from the housing.

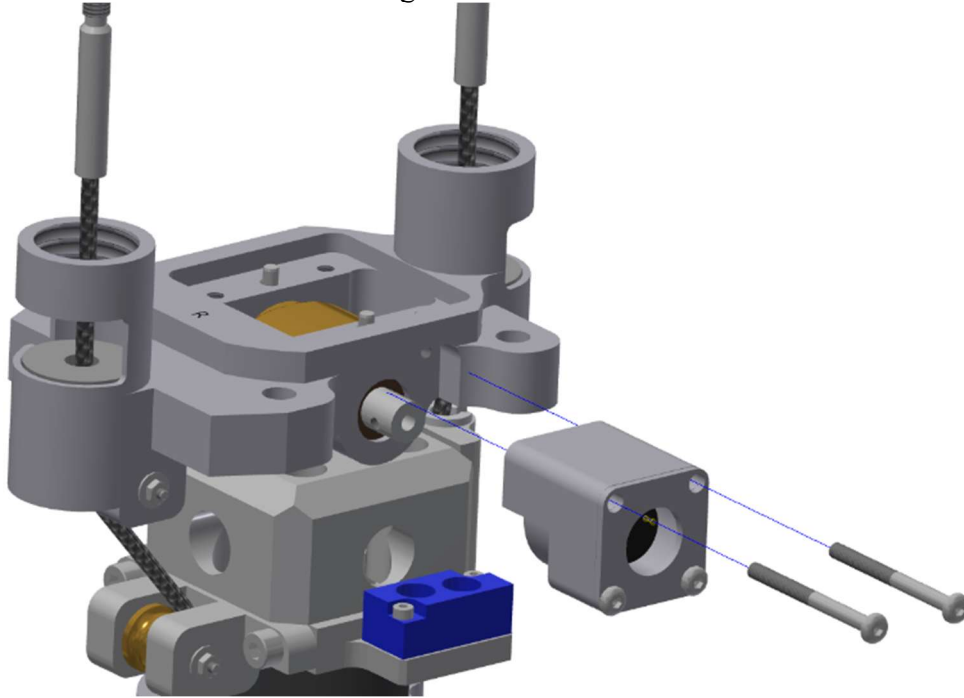


Figure 4-12. Remove the top two M3 X 0.5 X 35 LG. BHCS SS from the OC potentiometer housing

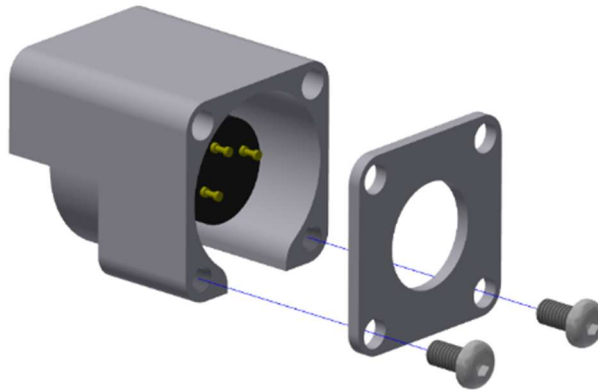


Figure 4-13. Remove the bottom two M3 X 0.5 X 6 LG. BHCS from the OC pot housing

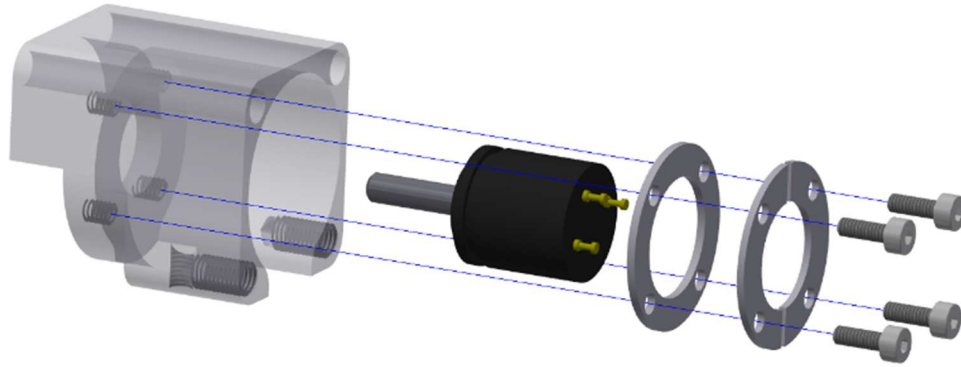


Figure 4-14. Remove the four M2 X 0.4 X 6 LG. SHCS from the rotary potentiometer clamp (474-2020)

4.2.7 Remove the Occipital condyle screw (472-2016) and M4 X 0.7 X 6 LG. SHCS from the OC Flexion-Extension Cam (474-2327) (Figure 4-15).

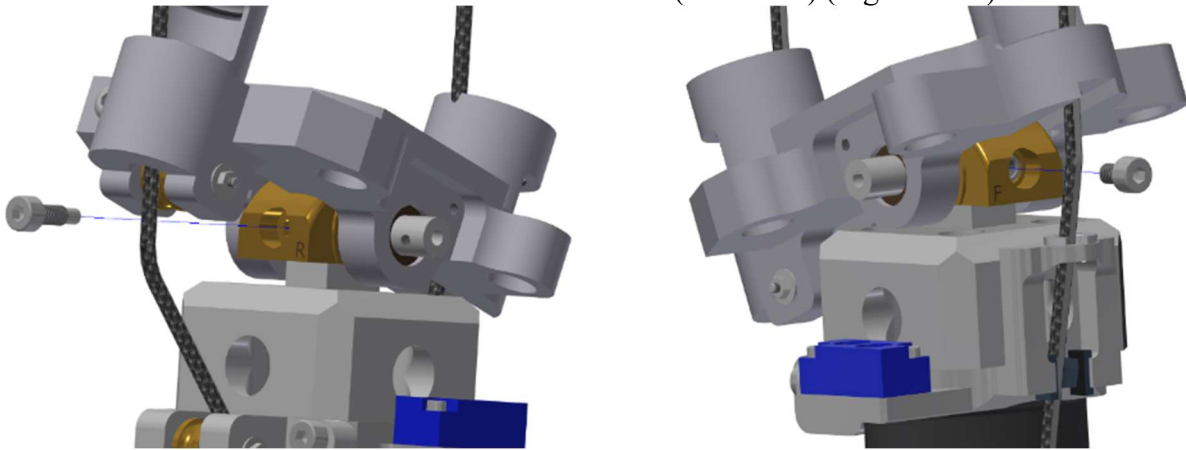


Figure 4-15. Remove the Occipital condyle screw (472-2016) and M4 X 0.7 X 6 LG. SHCS from the OC Flexion-Extension Cam (474-2327)

4.2.8 Remove OC pin (474-2340) from OC Flexion-Extension Cam (474-2327) (Figure 4-16). Head/neck mounting platform (474-2302-A) can be removed from neck assembly. The OC flexion-extension cam (474-2327) can also be removed from neck assembly.

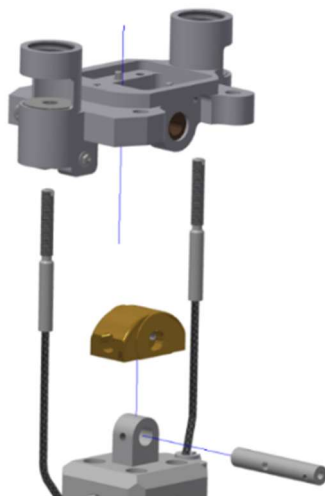


Figure 4-16. Remove OC pin (474-2340) from OC Flexion-Extension Cam (474-2327).

- 4.2.9 Remove spring tower load cells from the head/neck mounting platform (474-2302-A) (Figure 2-20). Remove the rear cable pulley assembly (474-2308) by removing the M3 X 25 LG. SHSS SS with the M2 X 0.4 Hex nut SS (Figure 4-18).

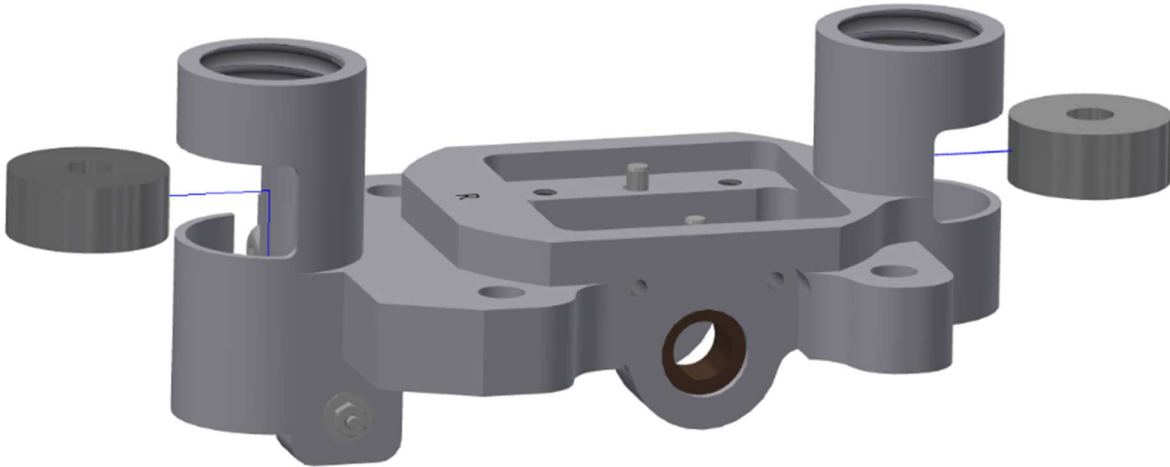


Figure 4-17. Remove spring tower load cells from the head/neck mounting platform (474-2302-A)

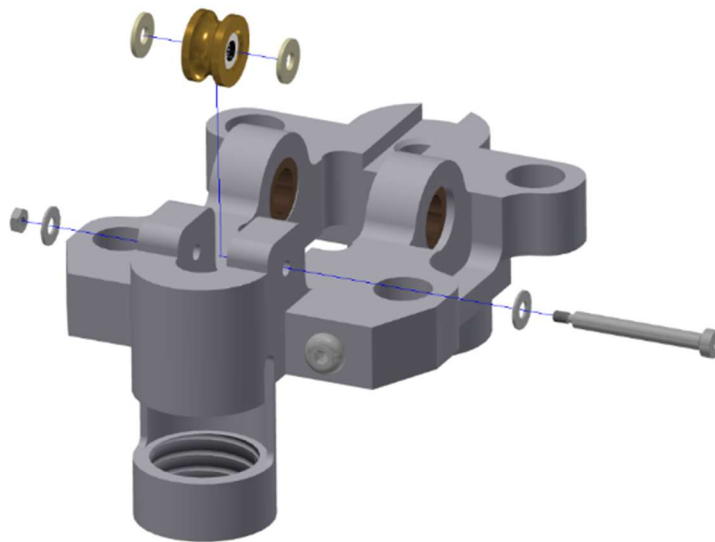


Figure 4-18. Remove the rear cable pulley assembly (474-2308) by removing the M3 X 25 LG. SHSS SS with the M2 X 0.4 Hex nut SS

4.2.10 Remove upper neck load cell by removing four M5 X 0.8 X 12 LG. SHCS (Figure 4-19).

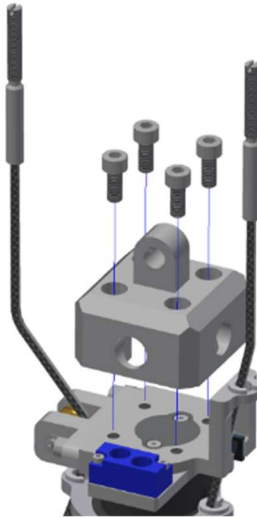


Figure 4-19. Remove upper neck load cell by removing four M5 X 0.8 X 12 LG. SHCS

4.2.11 Remove T1 accel mount (SA572-S168) from lower neck load cell by removing two M3 X 0.5 X 12 LG. SHCS (Figure 4-20). Remove the three accelerometers from the T1 accel mount by removing two M1.4 X 0.3 X 4 LG. SHCS per accel (Figure 4-21).

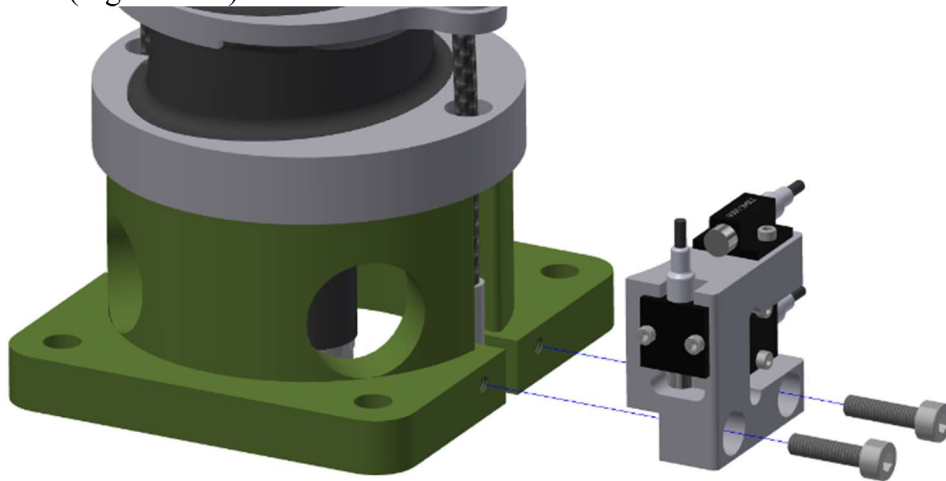


Figure 4-20. Remove T1 accel mount (SA572-S168) from lower neck load cell by removing two M3 X 0.5 X 12 LG. SHCS

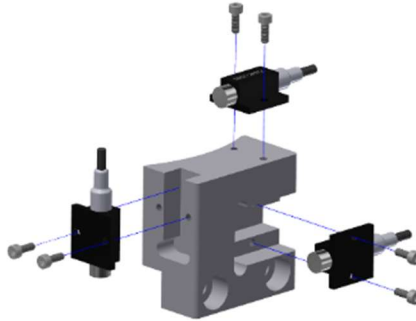


Figure 4-21. Remove the three accelerometers from the T1 accel mount (SA572-S168) by removing two M1.4 X 0.3 X 4 LG. SHCS per accel

4.2.12 Loosen the center cable (474-2600) using a flat head screwdriver and a shallow 10mm socket (Figure 4-22). Remove the M6 hex nut and washer.

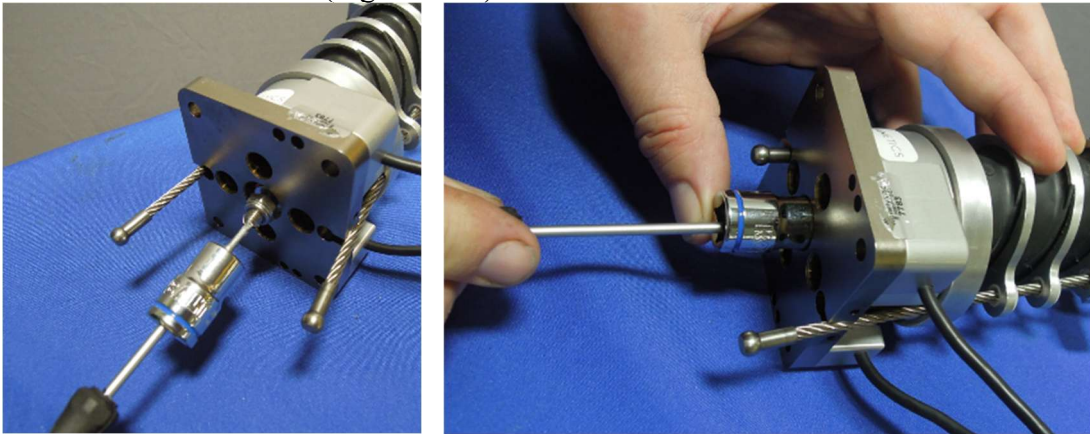


Figure 4-22. Loosen the center cable (474-2600) using a flat head screwdriver and a shallow M6 socket

4.2.13 Remove the lower neck load cell by removing four M5 X 0.8 X 14 LG. SHCS with washers (Figure 4-23). The compression bushing (474-2331) will come out when the lower neck load cell is removed.

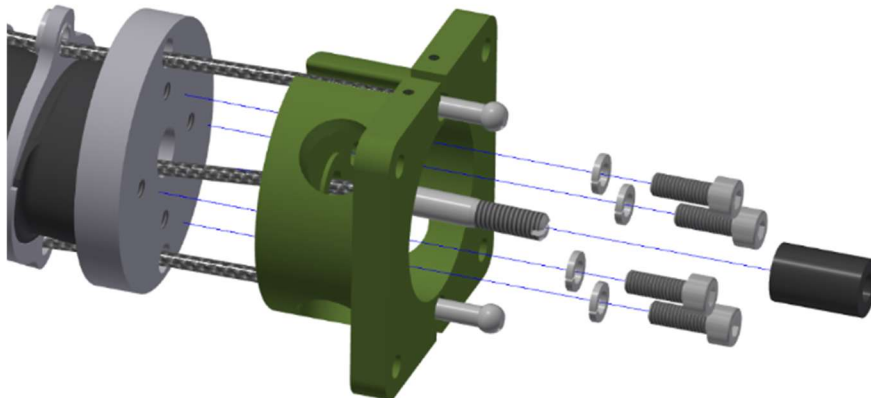


Figure 4-23. Remove the lower neck load cell by removing four M5 X 0.8 X 14 LG. SHCS with washers

- 4.2.14 Remove the center cable from the top of the neck column assembly (474-2100) by removing two M2.5 X 0.45 X 5 LG. FHCS from the neck cable cover (474-2333) on the top of the neck (Figure 4-24).

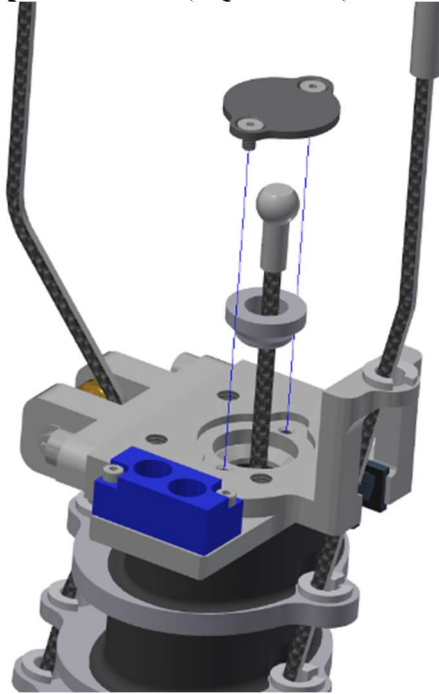


Figure 4-24. Remove the center cable from the neck column assembly (474-2100) by removing two M2.5 X 0.45 X 5 LG. FHCS from the neck cable cover (474-2333) on the top of the neck

- 4.2.15 Remove rear pulley assembly from rear neck cable by removing the M3 X 25 X LG. SHSS SS with the M3 X 0.4 hex nut (Figure 4-25).

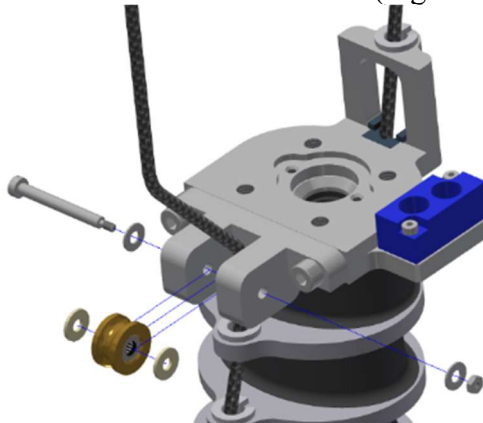


Figure 4-25. Remove rear pulley assembly from rear neck cable by removing the M3 X 25 X LG. SHSS SS with the M3 X 0.4 hex nut

- 4.2.16 Remove the rear pulley assembly (474-2330) from the top of the neck column assembly by removing two M4 X 0.7 X 14 LG. SHCS (Figure 4-26). See disassembled assembly in Figure 4-26.

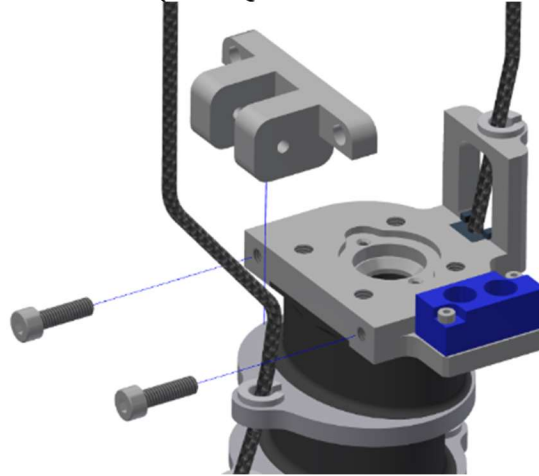


Figure 4-26. Remove the rear pulley assembly (474-2330) from the top of the neck column assembly by removing two M4 X 0.7 X 14 LG. SHCS

- 4.2.17 Remove seven plastic cable guides halves (474-2332) from front and rear of molded neck assembly. A flat head screwdriver can aid in prying the plastic guides from the cables (Figure 4-27). Remove the front and rear cables from the neck assembly by pulling them through the top of the neck column (Figure 4-28).

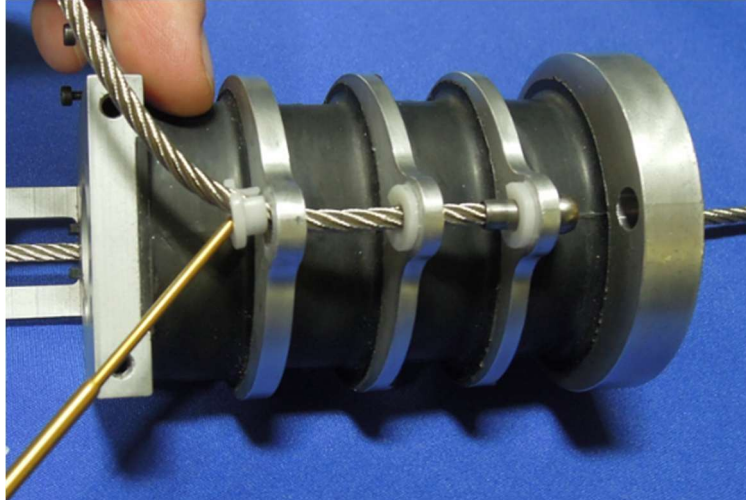


Figure 4-27. A flat head screwdriver can aid in prying the plastic guides from the cables

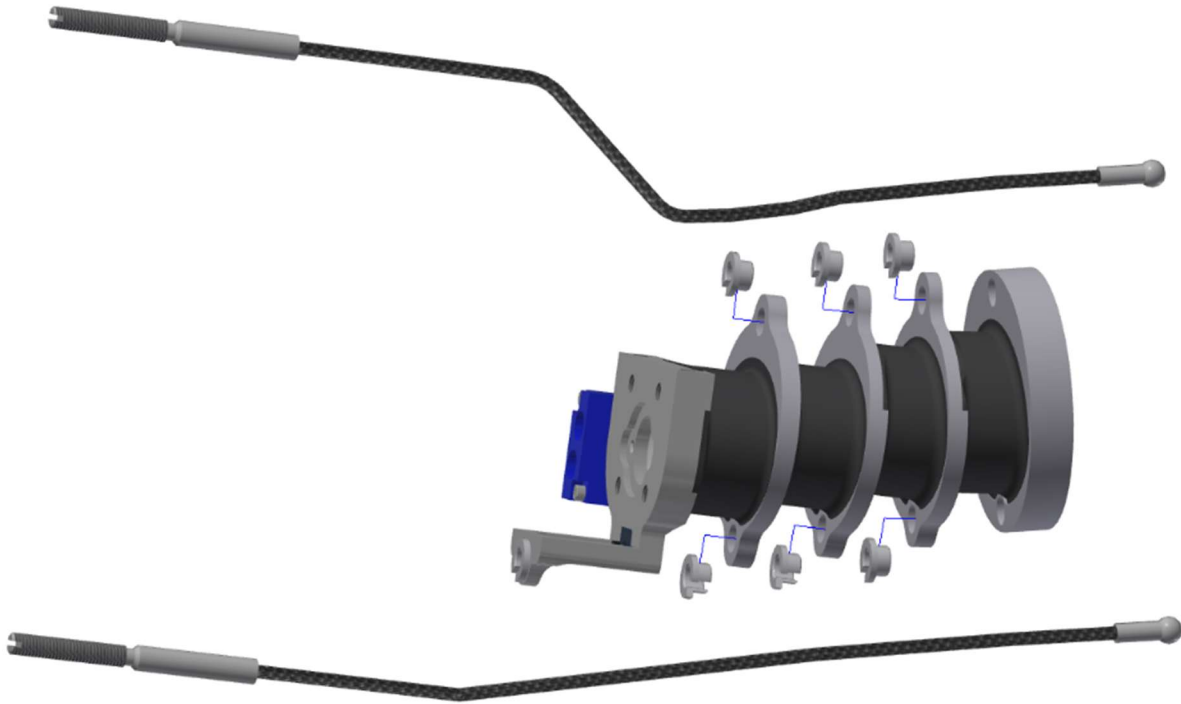


Figure 4-28. Removed rear neck cable with cable guide halves

4.3 Assembly of the Neck

The following procedure is a step-by-step description of the assembly procedure for the neck components. Unless otherwise specified, tighten all bolts to the torque specifications provided in Section 2.1.3.

- 4.3.1 To assemble the neck cables, pass the ball end of the Neck Cable Assembly (474-2620) from the top down through each of the neck plate holes on the front and rear of the neck (Figure 4-29). Slits on one side of the cable guide halves (474-2332) allow them to be stretched open and pressed onto the cable at each location (total of 7). Once each guide is on the cable, press it into the hole in each plate (Figure 4-30).

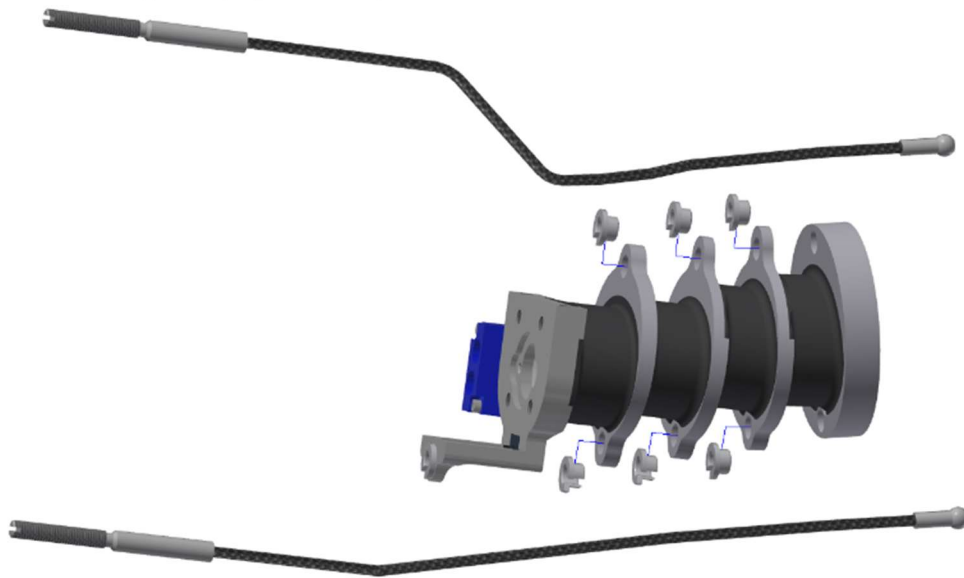


Figure 4-29. Pass the ball end of the Neck Cable Assembly (474-2620) from the top down through each of the neck plate holes. Then, press a cable guide into the hole in each plate

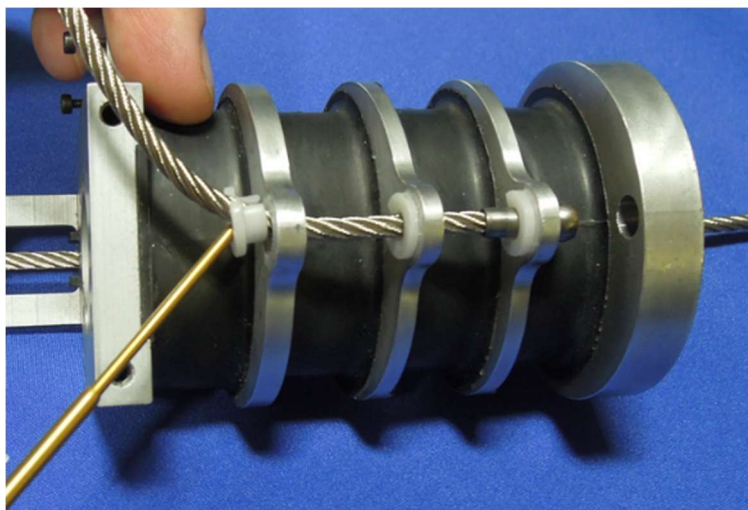


Figure 4-30. A flat head screwdriver can aid in seating the plastic guides from the cables

- 4.3.2 The anterior/top of the neck can be identified by the surface containing the machined vertical bracket. Install the Rear Cable Pulley Assembly (474-2308) to the posterior top of the neck using two M4 X 0.7 X 14 SHCS (Figure 4-31).

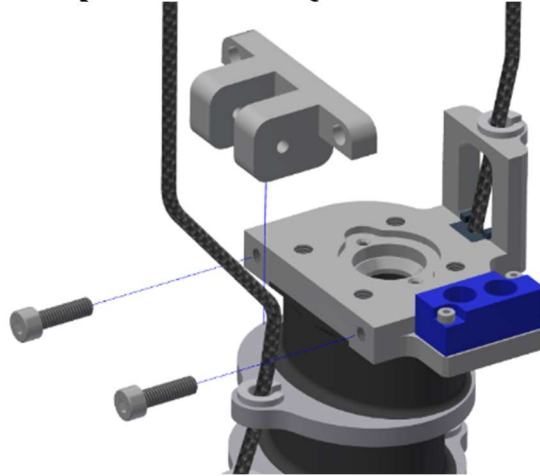


Figure 4-31. Install rear cable pulley bracket to neck

NOTE: During the assembly of the Neck Rear Pulley Bracket (474-2330), it is important to keep the Rear Neck Cable (474-2620) positioned between the Rear Cable Pulley (474-2308) and the Neck Rear Pulley Bracket (474-2308).

- 4.3.3 To assemble the Rear Pulley Assembly (474-2330), place a Teflon washer on each side of the assembly and on each side of the pulley (474-2308). Thread the M3 X 25 Precision SHSS SS through the assembly and fasten with an M2 X 0.4 Hex Nut on the other side (Figure 4-32).

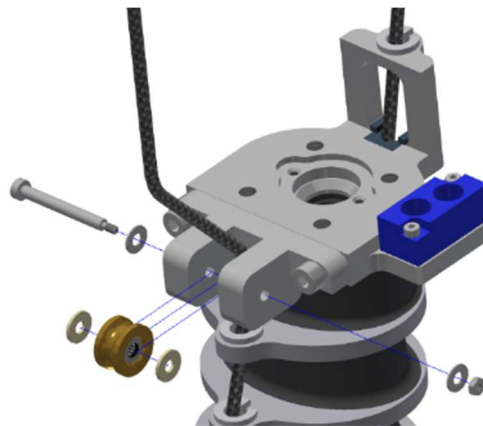


Figure 4-32. Assemble the Rear Pulley Assembly (474-2330)

- 4.3.4 Insert the threaded end of the Neck Center Cable Assembly (474-2600) through the Neck Center Cable Fixture (474-2334) and into the top of the neck. Install the Neck Cable Cover (474-2333) over the top of the neck center cable fixture and neck assembly (474-2110) using two M2.5 X 5 FHCS (Figure 4-33).

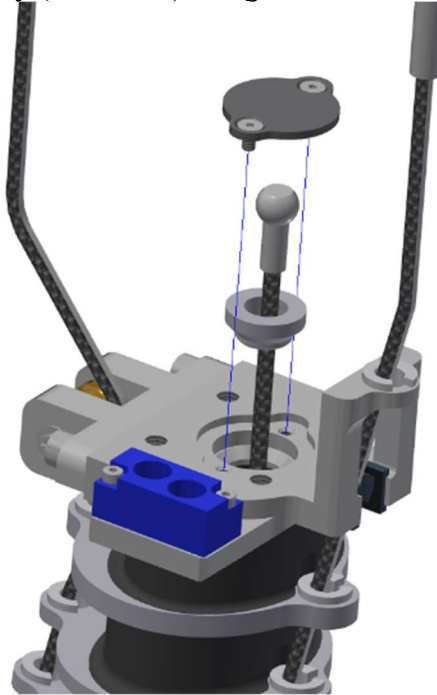


Figure 4-33. Insert neck center cable assembly

- 4.3.5 Attach the Lower Neck Load Cell (SA572-S106) to the bottom of the neck with the sensor wires toward the rear of the neck using four M5 X 0.8 X14 SHCS with M5 Split Lock Washers (Figure 4-34). Feed the center cable through the hole in the center of the load cell and slide the Compression Bushing (474-2331) on the end. The ball ends of the front and rear cables rest in the base of the lower neck load cell.

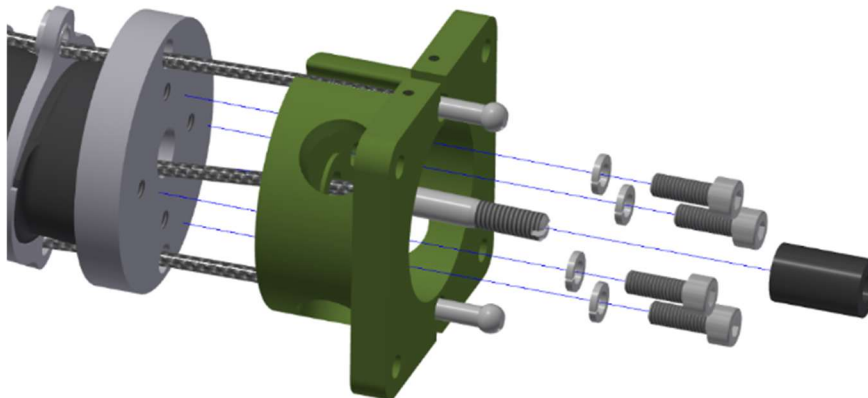


Figure 4-34. Install the Lower Neck Load Cell (SA572-S106)

- 4.3.6 Secure the neck center cable at the threaded end by installing an M6 flat washer and an M6 X 1 hex lock nut. For ease of installation of the M6 X 1 hex lock nut, insert a screwdriver into the 10 mm socket while the socket tightens the nut (Figure 4-35 and Figure 4-36). Tighten the hex lock nut 1/2 turn beyond contact.

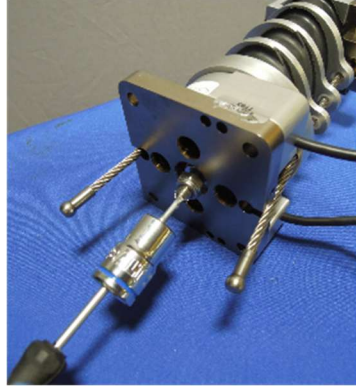


Figure 4-35. Technique for installing neck center cable



Figure 4-36. Install hardware for neck center cable

- 4.3.7 Instrument the T1 Accel Mount (SA572-S168) with three uniaxial accelerometers (SA572-S4) using two M1.4 X0.3 X 4 SHCS per accel (Figure 4-37).

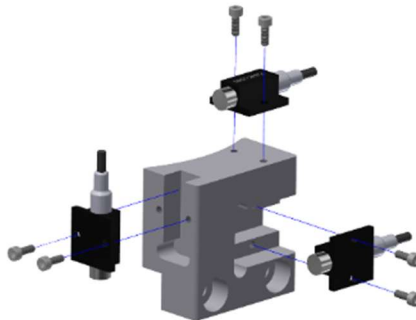


Figure 4-37. Instrument the T1 Accel Mount (SA572-S168) with three uniaxial accelerometers (SA572-S4)

- 4.3.8 Secure the T1 Accel Mount (SA572-S168) to the rear of the Lower Neck Load Cell (SA572-S106) using two M3 X 0.5 X 12 SHCS (Figure 4-38).

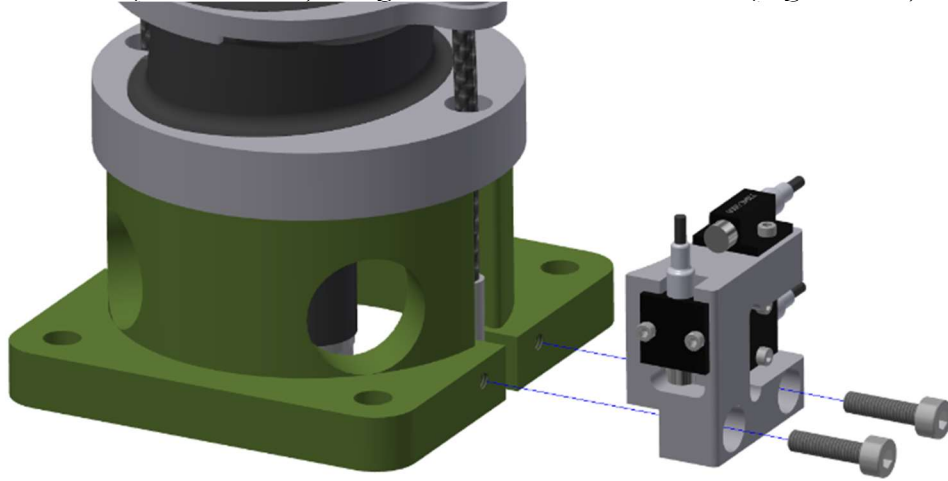


Figure 4-38. Secure the T1 Accel Mount (SA572-S168) to the rear of the Lower Neck Load Cell (SA572-S106)

- 4.3.9 Install the Upper Neck Load Cell (SA572-S105) (or Upper Neck Load Cell Structural Replacement 474-2326) to the top plate of the Molded Neck Assembly (474-2110) using four M5 X 0.8 X 12 SHCS (Figure 4-39). The Upper Neck Load Cell cables are assembled to the left side of the neck.

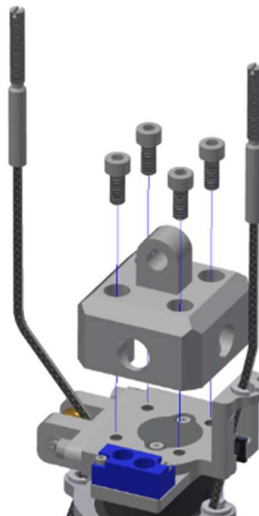


Figure 4-39. Install the upper neck load cell (SA572-S105)

- 4.3.10 Install the 0.850 diameter Skull Spring Load Cells (SA572-S112) into the Head/Neck Mounting Platform (474-2302-A) at the base of the front and rear spring towers (Figure 4-40).

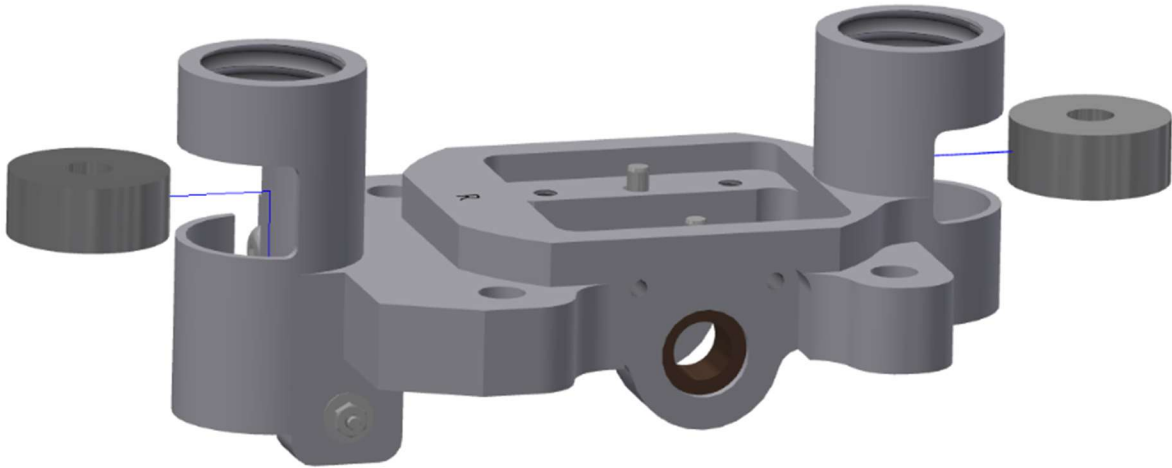


Figure 4-40. Insert skull spring load cells (SA572-S112) into neck mounting plate (474-2302-A)

- 4.3.11 Install the Rear Cable Pulley Assembly (474-2308) onto the Head/Neck Mounting Platform (474-2302-A). Two PTFE M3 Flat Washers go on either side of the pulley. Two SS M3 Flat Washers will be installed on either side of the head/neck mounting platform (474-2302-A). Thread the M3 X 25 Precision SHSS SS through the assembly and fasten with an M2 X 0.4 Hex Nut on the other side (Figure 4-41).

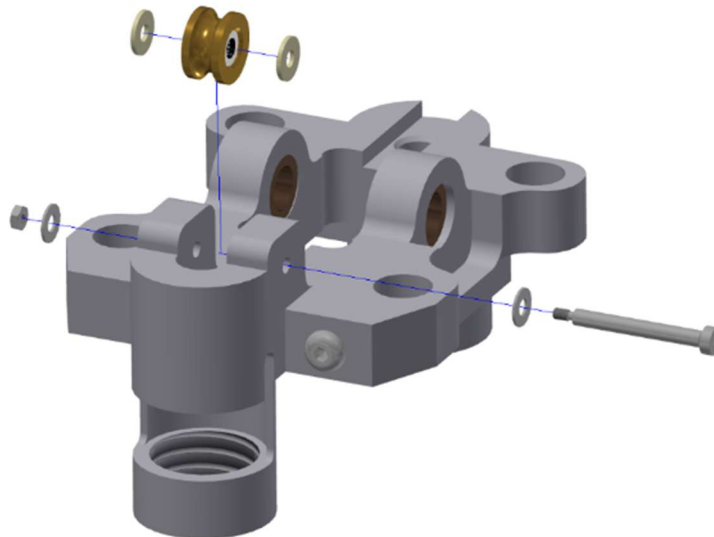


Figure 4-41. Install the Rear Cable Pulley Assembly (474-2308)

- 4.3.12 Place the Neck Occipital Condyle Cam (474-2327) over the upper neck load cell (SA572-S105) (Figure 4-42). Note that the cam must be properly oriented; the cam ends are engraved to aid in correct positioning. Loosely attach the cam to the upper neck load cell using the Occipital Condyle Screw (472-2016) on the rear and an M4 X 0.7 X 6 SHCS on the front.
- 4.3.13 Install the neck mounting platform on top of the neck occipital condyle cam. Pass the front and rear neck cables up through the Skull Spring Load Cells (SA572-S112) (Figure 4-42).
- 4.3.14 Insert the Neck Occipital Condyle Pin (474-2340) into the cam hole (Figure 4-42). Be certain that the pin is properly oriented within the hole so that the holes in the pin align with the occipital condyle screw in the rear.

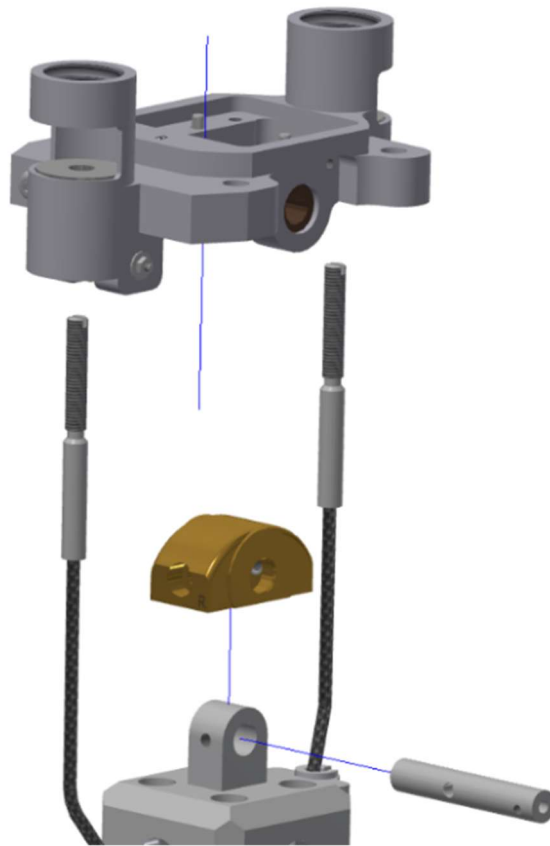


Figure 4-42. Assembly of Neck Mounting Platform and Occipital Condyle Flexion-Extension Cam (474-2327) onto the Upper Neck Load Cell (SA572-S105)

- 4.3.15 Tighten the occipital condyle screw on the rear (Figure 4-43 left) and then the M4 X 0.7 X 8 SHCS on the front (Figure 4-43 right) to secure the cam to the upper neck load cell (SA572-S105).

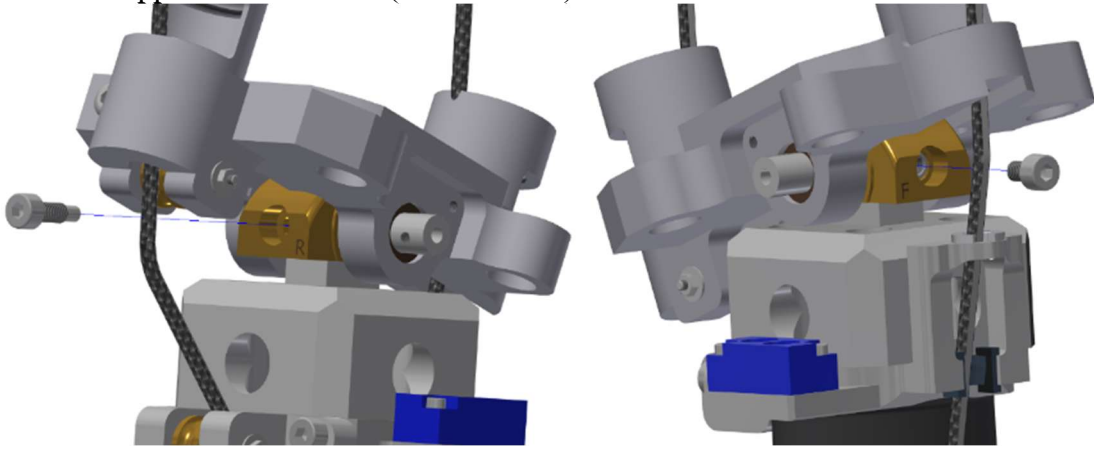


Figure 4-43. Secure O.C. Cam to Upper Neck Load Cell

- 4.3.16 Install the front and rear spring assemblies (474-2305 and 474-2304) onto the front and rear neck cables. They will sit on top of the spring load cells. Loosely screw both M5 X 0.8 thin profile adjustment nuts to the top of the front and rear spring cables (Figure 4-44). Both springs should not be under compression and the Head/Neck Mounting Platform (474-2302-A) is mostly free to rotate about the occipital condyle.

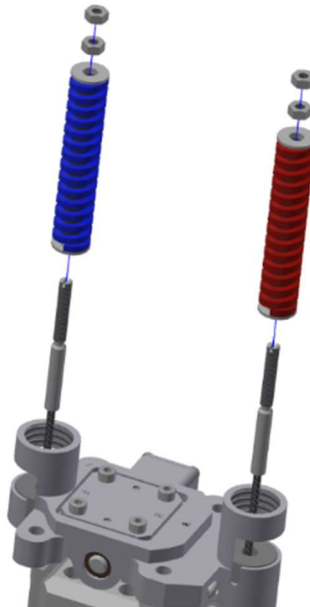


Figure 4-44. Insert neck springs onto cables

- 4.3.17 Attach the lower neck load cell (474-2325) to the 10° neck mounting plate (TF-200-2357) with four M5 X 0.8 X 16mm SHCS. Clamp the neck mounting plate clamped to a rigid, flat horizontal surface (Figure 4-45).

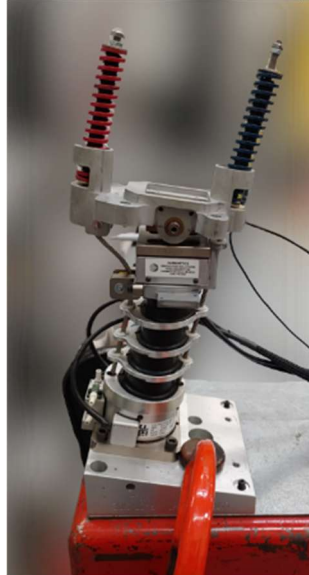


Figure 4-45. Install neck lower load cell (474-2325) to neck mounting plate. Clamp neck mounting plate to rigid, flat surface

- 4.3.18 Adjust and stabilize the neck mounting plate so an inclinometer reads $10.0 \pm 0.2^\circ$ about the Y-axis and $0 \pm 0.5^\circ$ about the X-axis (Figure 4-46).

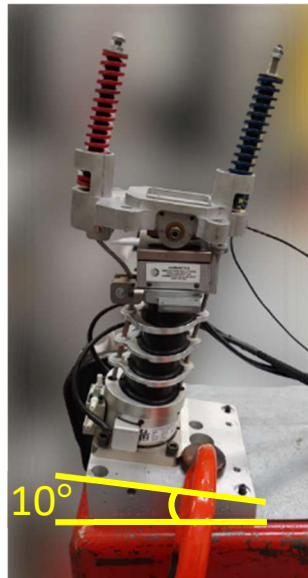


Figure 4-46. Adjust and stabilize the neck mounting plate so an inclinometer reads $10.0 \pm 0.2^\circ$ about the Y-axis and $0 \pm 0.5^\circ$ about the X-axis

- 4.3.19 Manipulate the neck bend and adjust the head/neck mounting platform (474-2302-A) until an inclinometer at the upper neck plate and on the top surface of the Head/Neck Mounting Platform are reading $0 \pm 0.2^\circ$ about the Y-axis and $0 \pm 0.5^\circ$ about the X-axis. The Upper Neck Tilt Sensor (SA572-S44) can be used instead of an inclinometer. Gently tighten the front and rear M5 X 0.8 adjustment nuts to temporarily hold mounting platform orientation. NOTE: Make sure neck bend is stable before continuing.



Figure 4-47. Inclinometer placement on top surface of Head/Neck Mounting Platform (474-2302-A) (left) and placement on upper neck plate (right)

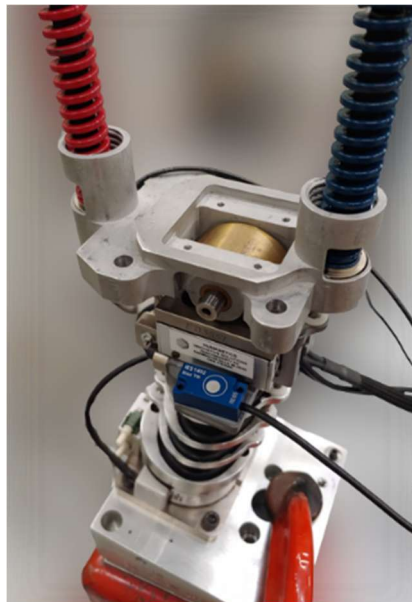


Figure 4-48. Measuring angle using Upper Neck Tilt Sensor

- 4.3.20 Insert the Flexion/Extension Stop Assembly (474-2115-A) into the head/neck mounting platform (474-2302-A) and secure with four M4 X 0.7 X 10 FHCS (Figure 4-49).

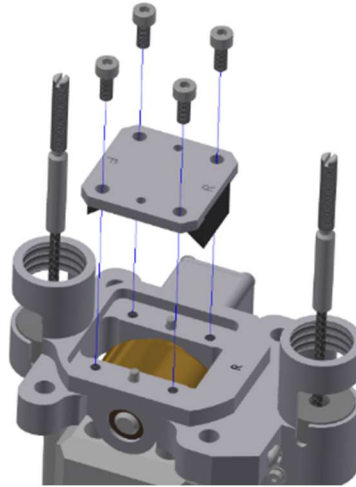


Figure 4-49. Place Flexion/Extension stop assembly into head/neck mounting platform (474-2302-A)

- 4.3.21 Loosen the front and rear M5 X 0.8 adjustment nuts so there is no spring compression and confirm that the head and neck are still $0 \pm 0.2^\circ$ about the Y-axis (using an inclinometer measured on the top surface of the Head/Neck Mounting Platform (474-2302-A) and the ledge on the right side of the Molded Neck Assembly (474-2110)). If not, repeat step 4.3.19. Ensure that the springs are properly seated on the front and rear neck cables (Figure 4-50 and Figure 4-51).

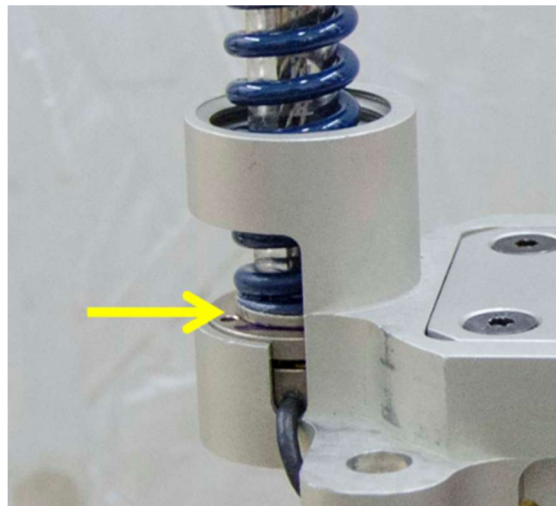


Figure 4-50. Front spring properly seated against spring load cell

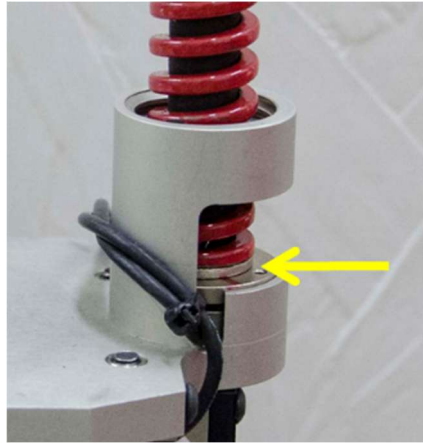


Figure 4-51. Rear spring properly seated against spring load cell

- 4.3.22 With zero compression on the front and rear neck cable load cells, acquire voltages for the front and rear skull spring load cells (SA572-S112). **NOTE:** *Load cells must have no applied pressure before balancing or else the output will be unintentionally offset.*
- 4.3.23 Gently tighten the front and rear M5 X 0.8 adjustment nuts evenly until they both have 0.5-1.5 lbs (2.2-6.7 N) of applied force.
- 4.3.24 Reinstall front and rear M5 X 0.8 jam nuts to lock adjustment nut position. **NOTE:** *Adjustment nut may move while jamming. Confirm that applied compression on both spring load cells is 0.5-1.5lbs (2.2-6.7N) with the head and neck Y-axis tilts still at $0 \pm 0.2^\circ$.*
- 4.3.25 Remove the neck assembly from the 10° Neck Mounting Platform.
- 4.3.26 Insert the Neck Rotary Potentiometer Washer (472-2021) into the Neck Rotary Potentiometer Housing (472-2013), then install the Occipital Condyle Rotary Potentiometer (SA572-S114) into the housing (Figure 4-52). Secure the two Neck Rotary Potentiometer Clamps (472-2020) over the base of the potentiometer and into the housing using four M2 X 0.4 X 6 SHCS.

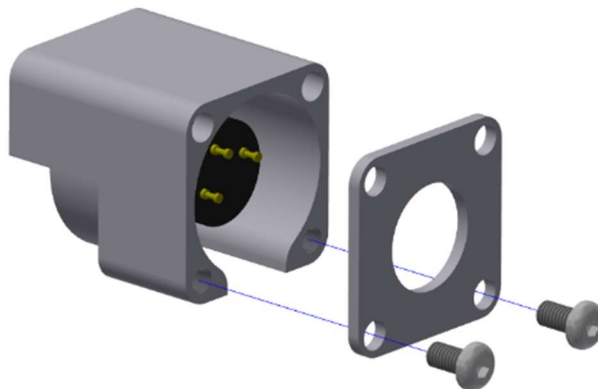


Figure 4-52. Install neck rotary potentiometer

4.3.27 Attach the Neck Rotary Potentiometer Cover (472-2014) with two M3 X 0.5 X 6 BHCS at the bottom of the housing (Figure 4-53).

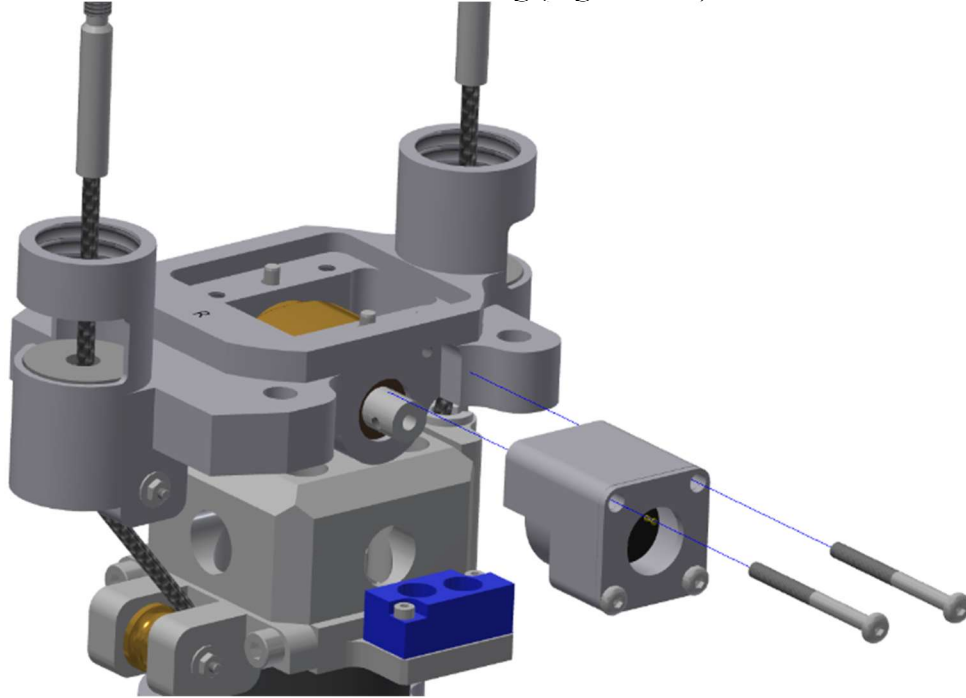


Figure 4-53. Attach rotary potentiometer cover

4.3.28 Loosely install the M3 X 0.5 X 3 mm SSS cone point set screw into the Neck Occipital Condyle Pin (474-2340) (Figure 4-54). The set-screw should not enter the shaft opening at this point in the assembly.

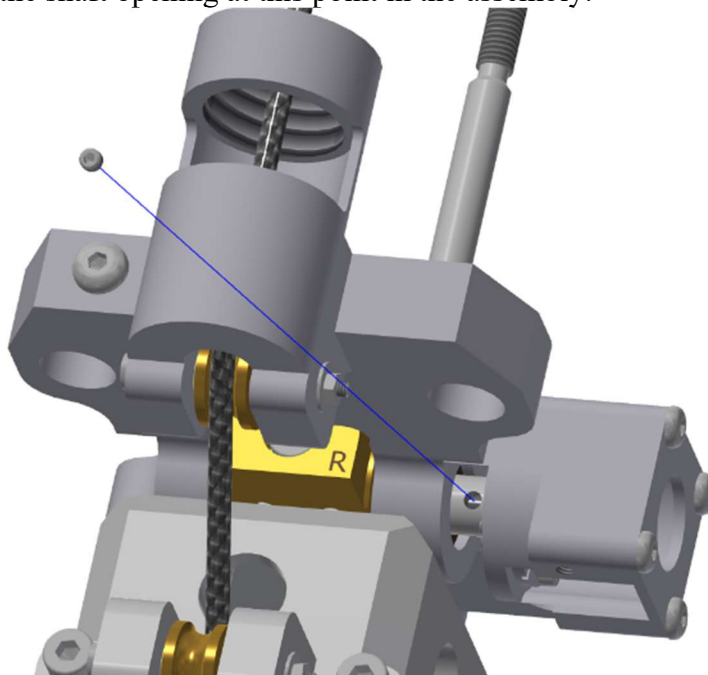


Figure 4-54. Loosely install set-screw into O.C pin

4.3.29 Screw on the Front and Rear Spring Tubes (474-2303) (Figure 4-55).



Figure 4-55. Screw on neck spring tubes

4.4 Assembly of the Neck to the Head

The following procedure is a step-by-step description of the assembly procedure used to attach the head to the neck. Unless otherwise specified, tighten all bolts to the torque specifications provided in Section 2.1.3.

- 4.4.1 To attach the head to the neck assembly, insert the completed Head /Neck Platform Assembly (474-2300-A) up through the bottom of the Head Assembly (474-1000). Tighten the four M6 X 1 X 25 FHCS from the underside of the head (Figure 4-56).

NOTE: The neck must be oriented properly for installation within the head. The rear cable is easily identifiable by the presence of the cable pulley.

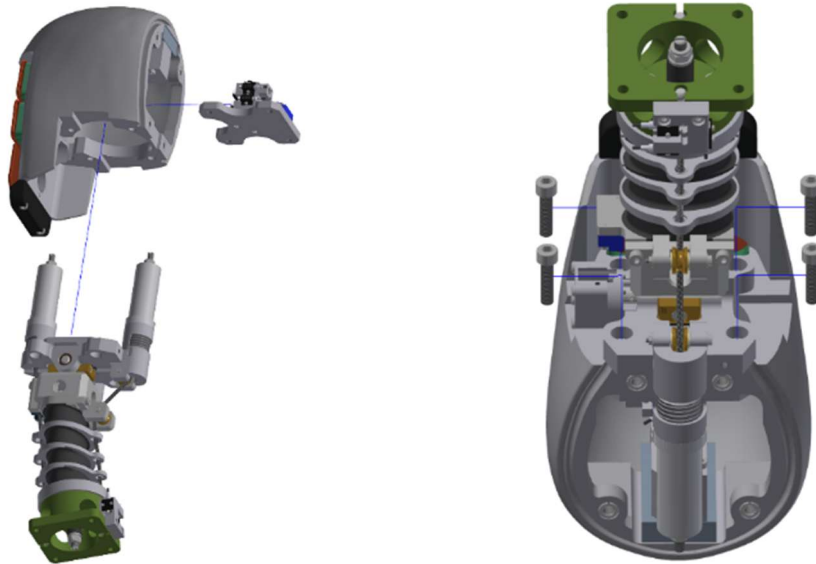


Figure 4-56. Install head/neck platform assembly (474-2300-A) to head

4.5 Assembly of the Neck to the Spine

The following procedure is a step-by-step description to install the head/neck assembly to the top plate of the neck posture adjustment assembly (474-3050). Unless otherwise specified, tighten all bolts to the torque specifications provided in Section 2.1.3.

- 4.5.1 Secure the Lower Neck Load Cell (SA572-S106) to the Neck Interference Plate (474-3058) of the Neck Posture Adjustment Assembly (474-3050) using four M5 X 0.8 X 16 SHCS as shown in Figure 4-57.

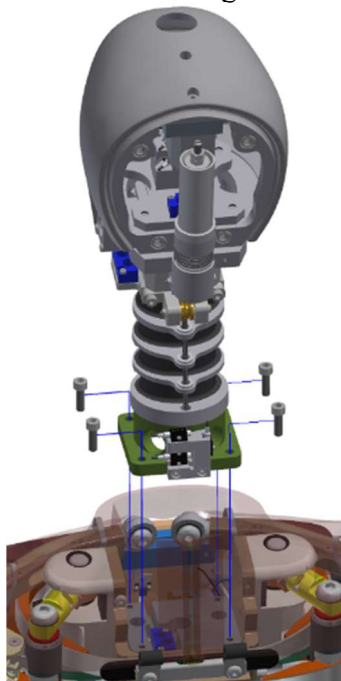


Figure 4-57. Secure lower neck load cell (SA572-S106) to neck pitch change mechanism

- 4.5.2 Route the lower neck load cell wires out through the holes at the top of the Upper Thoracic Spine Weldment (Figure 4-58). Rib #1 and the accompanying rib stiffener must be removed prior to routing the wire.



Figure 4-58. Routing wires for the lower neck load cell (SA572-S106).

4.6 Adjustments for the Neck Assembly

Before the neck qualification procedures are performed, the neck spring towers must be properly installed, adjusted, and locked in place using jam nuts at the top of the front and rear towers (Figure 4-59). *Once the spring tower adjustment has been made and neck qualification tests have been performed, do not adjust the spring towers again or new neck qualification tests must be performed.*

4.6.1 Spring Tower Adjustment

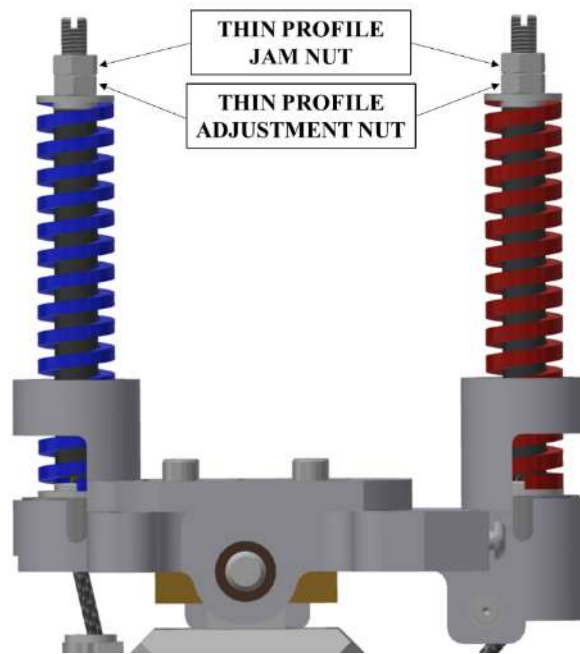


Figure 4-59. Neck spring tower jam nut configuration

- 4.6.1.1 Remove the head from the neck by removing four M6 FHCS from the bottom of the head/neck mounting platform (474-2302-A). Remove the front and rear spring tubes (474-2303) by unscrewing by hand from the head/neck mounting platform.
- 4.6.1.2 Remove *both* M5 X 0.8 thin profile nuts from the top of the rear spring cable.
- 4.6.1.3 Remove *both* M5 X 0.8 thin profile nuts from the top of the front spring cable.
- 4.6.1.4 Proceed to the *THOR 5th Percentile Female (THOR-05F) Qualification Procedures Manual* (July 2025) Section entitled *Pre-Test Neck Setup Procedure* for spring tower tension and neck setup procedures.
- 4.6.1.5 Once the neck cables are adjusted as above, the neck is ready for qualification testing. *The cables must not be adjusted after qualification testing as this may invalidate the qualification results.*

4.6.2 Neck Pitch Change Mechanism Adjustment

The neck pitch change mechanism connects the lower neck load cell (SA572-S106) to the upper spine box (474-3100). It allows adjustment of the angle of the base of the neck in 3° increments. There are three scribe lines marked on the left sprocket, which is fixed to the upper thoracic spine, and one scribe line setting marked on right sprocket, which rotates with the neck. To achieve a neutral setting, align the fixed scribe line with the superior, white scribe line on the left sprocket, as shown in Figure 4-60. The default posture is the neutral setting, which most closely resembles the Anthropometry of Motor Vehicle Occupants (AMVO)³ seated posture for a 5th percentile female occupant.

The following steps explain how to adjust the angle of the neck pitch change mechanism.

³ Schneider, L.W., Robbins, D.H., Pflug, M.A., Snyder, R. G., "Development of Anthropometrically Based Design Specifications for an Advanced Adult Anthropomorphic Dummy Family; Volume 1-Procedures, Summary Findings and Appendices, "U.S. Department of Transportation, DOT-HS-806-715, 1985.

- 4.6.2.1 Unzip the zippers on the right and left shoulders and the right and left sides of the jacket. If desired or convenient, remove the jacket completely.
- 4.6.2.2 Locate the M6 X 1 X 12 mm SHCS on the front of the upper thoracic spine, as indicated in Figure 4-60. With the dummy fully assembled, the SHCS can be accessed by inserting a T-handle through the access hole in the chest flesh, at the rib #2 level and into the head of the adjustment bolt (Figure 4-60 through Figure 4-62).

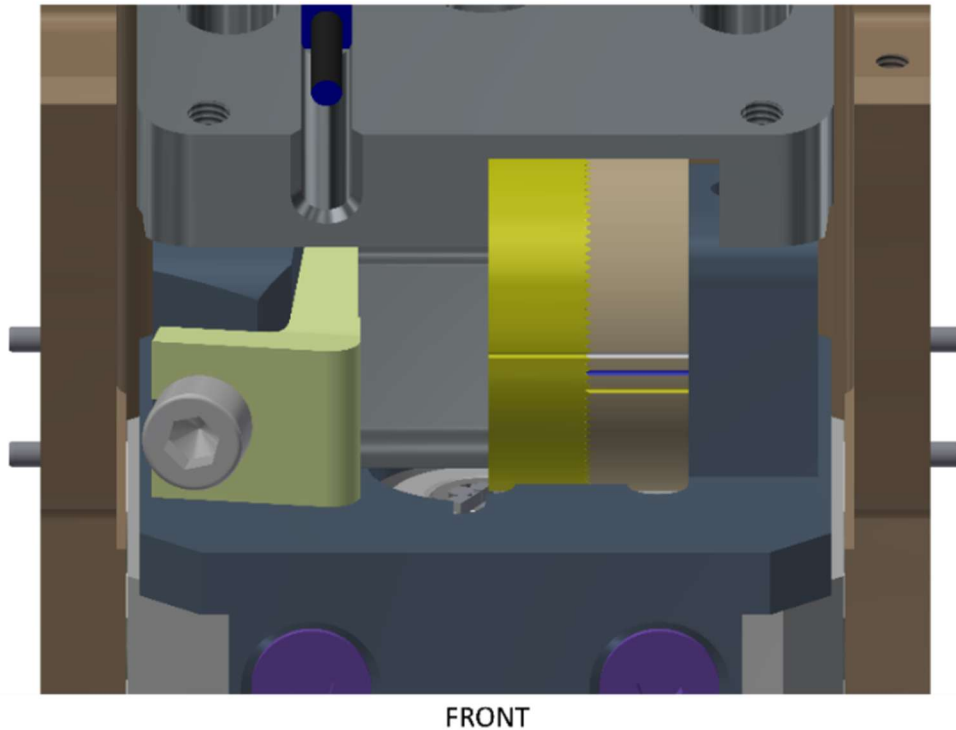


Figure 4-60. Neck posture adjustment assembly (474-3050) posture setting. Diagram shows neck in “neutral” position

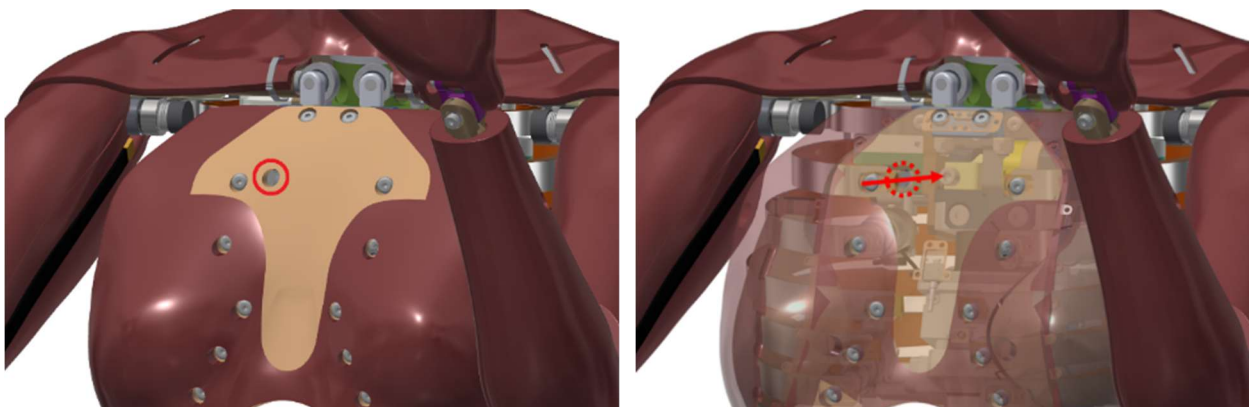


Figure 4-61. Access to the neck pitch change mechanism through chest flesh

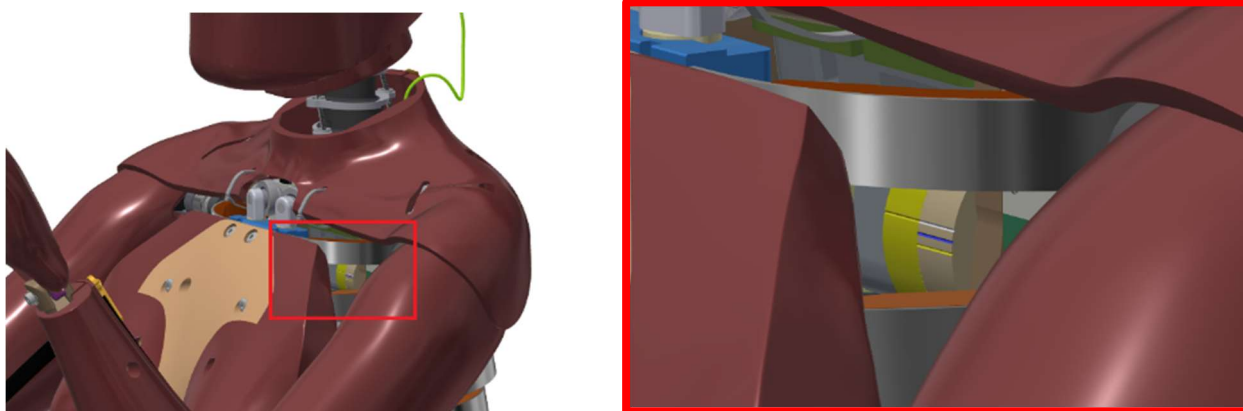


Figure 4-62. View of the neck pitch change mechanism through the upper thorax

- 4.6.2.3 Unscrew the M6 X 1 X 12 mm SHCS bolt at least two complete turns (720°) to loosen the wedge and disengage the sprockets.

WARNING: The sprockets of the pitch change unit will be seriously damaged if the adjustment is made *BEFORE* the teeth are completely disengaged.

- 4.6.2.4 Manipulate the neck to achieve the desired posture setting. Set the default position (“neutral”) as shown in Figure 4-60 by aligning the superior/white scribe line on the sprocket attached to the neck with the scribe line on the fixed sprocket. With the dummy fully-assembled, the scribed lines can be viewed by looking between ribs #1 and #2 from the front of the dummy (see direction indicated in Figure 4-61 and expected view in Figure 4-62).
- 4.6.2.5 Re-tighten the M6 X 1 X 12 mm SHCS and torque to 20.3 N-m (15.0 ft-lbf).

4.7 Electrical Connections and Requirements

Section 13.3 includes grounding information. Section 13.4 describes cable routing instructions.

Section 5. Thorax and Abdomen Assembly

5.1 Description of Thorax Assembly and Features

The thorax assembly of the THOR-05F dummy is an integrated assembly which includes components from the shoulder, spine, ribcage, and upper abdomen assemblies. This section of the manual describes the procedures to assemble the entire thorax of the THOR-05F dummy. Figure 5-1 illustrates the thorax.

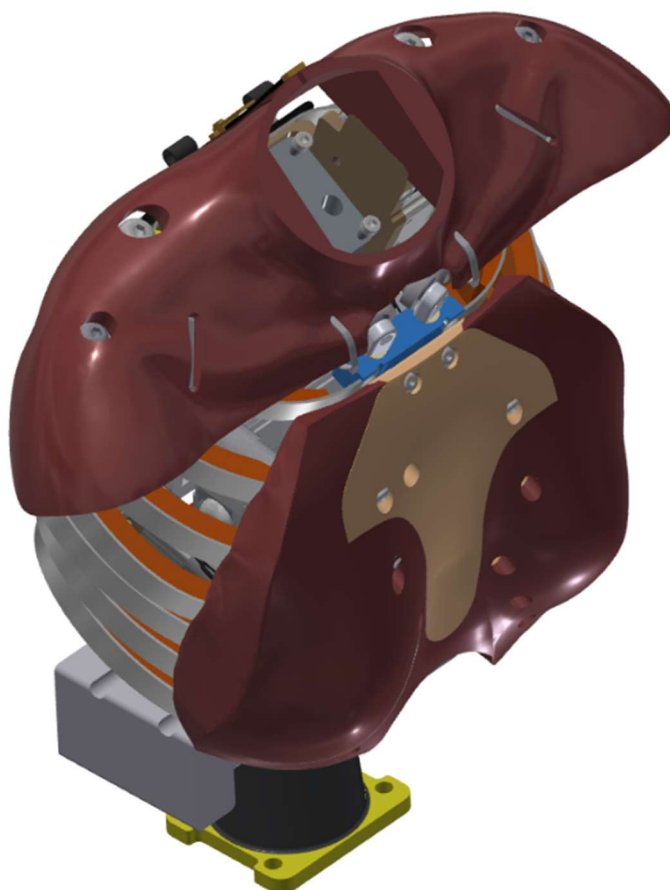


Figure 5-1. Thorax assembly

The advanced thorax assembly features extensive instrumentation to measure and record deflections, forces, and accelerations to the thorax (Figure 5-2). IR-TRACCs measure deflection of the ribcage at four distinct locations. These IR-TRACCs capture the three-dimensional position time-history of the ribs relative to the attached spine segment. Forces are measured at the T12 location, and a triaxial accelerometer array near the vertical center of gravity of the thorax measures acceleration of the spine. A uniaxial accelerometer positioned on the sternal plate measures acceleration at this location.

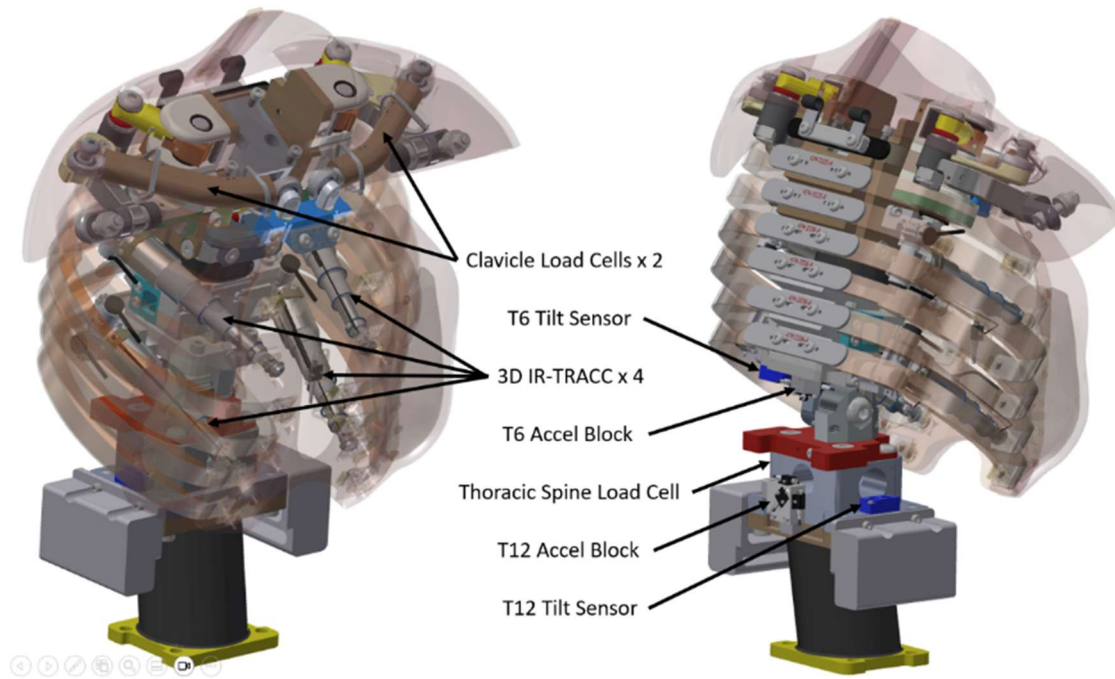


Figure 5-2. Thorax instrumentation locations

Table 5-1 through Table 1-3 list the components that are included in the Thorax Assembly. Figure 1-3 through Figure 1-5 show exploded views of the thorax assemblies and hardware.

Table 5-1. Thorax Mechanical Assembly Components

Part Description	Quantity	Part Number	Figure #	Item #
THOR Lift Strap	1	472-3116	Figure 5-3	1
On Board DAS Mounting Bracket	2	474-3001-A	Figure 5-3	2
Lower Spine Ballast, Left	1	474-3002-1-A	Figure 5-3	3
Lower Spine Ballast, Right	1	474-3002-2-A	Figure 5-3	4
On Board DAS Structural Replacement	2	474-3009-A	Figure 5-3	5
Lifting Strap Bracket	1	474-3025	Figure 5-3	6
Adaptor, Rib 1 to Sternum	1	474-3040-A	Figure 5-3	7
Clavicle Sternum Adaptor	2	474-3041-A	Figure 5-3	8
Mid-Spine Accelerometer Block	1	474-3066	Figure 5-3	9
Lumbar Accelerometer/ARS Block	1	474-3067	Figure 5-3	10
Spine Assembly	1	474-3200-A	Figure 5-3	11
Rib 1 Assembly	1	474-3301-A	Figure 5-3	12
Rib 2 Assembly	1	474-3302-A	Figure 5-3	13
Rib 3 Assembly	1	474-3303-A	Figure 5-3	14
Rib 6 Assembly	1	474-3306-A	Figure 5-3	15
Rib 7 Assembly	1	474-3307-A	Figure 5-3	16
Stiffener, Rib 1	1	474-3331	Figure 5-3	17
Stiffener, Rib 2, 3	2	474-3335-A	Figure 5-3	18

Stiffener, Rib 4, 5, 6, 7	4	474-3336-A	Figure 5-3	19
Rib 4 Assembly	1	474-3354-A	Figure 5-3	20
Rib 5 Assembly	1	474-3355-A	Figure 5-3	21
Shoulder Assembly Left	1	474-3500-1-A	Figure 5-3	22
Shoulder Assembly Right	1	474-3500-2-A	Figure 5-3	23
Shoulder Pad	1	474-3559	Figure 5-3	24
Chest Flesh-Sternum, Molded	1	474-3700	Figure 5-3	25
Tilt Sensor Structural Replacement	2	476-3604	Figure 5-3	26
M1.4 X 0.3 X 4 LG. SHCS	2	5000375	Figure 5-3	27
M2 X 0.4 X 10 LG. SHCS	4	5000215	Figure 5-3	28
M2.5 X 0.45 X 14 LG. SHCS	2	5001376	Figure 5-3	29
M2.5 X 0.45 X 16 LG. SHCS	2	5000069	Figure 5-3	30
M3 X 0.5 X 4 LG. BHCS	1	5001067	Figure 5-3	31
M3 X 0.5 X 60 LG. SHCS	4	5001056	Figure 5-3	32
M4 X 0.7 X 6 LG. BHCS	3	5001075	Figure 5-3	33
M4 X 0.7 X 8 LG. BHCS	1	5000103	Figure 5-3	34
M4 X 0.7 X 10 LG. BHCS	4	5001083	Figure 5-3	35
M4 X 0.7 X 12 LG. SHCS	4	5000152	Figure 5-3	36
M4 X 0.7 X 14 LG. SHCS SS	2	5000459	Figure 5-3	37
M4 X 0.7 X 35 LG. SHCS SS	4	5000549	Figure 5-3	38
M5 X 0.8 X 8 Lg. BHCS	12	5001278	Figure 5-3	39
M5 X 0.8 X 12 LG. BHCS	4	5000654	Figure 5-3	40
M5 X 0.8 X 14 LG. BHCS	12	5001411	Figure 5-3	41
M5 X 0.8 X 16 LG. BHCS	2	5000416	Figure 5-3	42
M5 X 0.8 X 16 LG. SHCS	4	5000020	Figure 5-3	43
M5 X 0.8 X 25 LG. SHCS	2	5000721	Figure 5-3	44
M6 X 1 X 16 LG. SHCS	2	5000081	Figure 5-3	45
M6 X 1 X 16 LG. LHCS	2	5000296	Figure 5-3	46
M6 Flat Washer Plain Zinc	2	5000013	Figure 5-3	47
M6 X 1 Hex Lock Nut Zinc	2	5000093	Figure 5-3	48
M8 X 1.25 X 16 LG. BHCS SS	2	5000563	Figure 5-3	49
M5 CLIP NUT	8	5001838	Figure 5-3	50
Cable Tie	1	6000004	Figure 5-3	51
Modified Cable Tie Mount, #4 screw	1	6002036-M	Figure 5-3	52
Cable Tie	1	6002121	Figure 5-3	53
M6 Flat Washer Plain Nylon	4	6003562	Figure 5-3	54
¼ Coated Cable Clamp	2	9003723	Figure 5-3	55
3D IR-TRACC Assembly, Upper Left	1	474-3550-A	Figure 5-3	56
3D IR-TRACC Assembly, Lower Left	1	474-3580-A	Figure 5-3	57
3D IR-TRACC Assembly, Upper Right	1	474-3560-A	Figure 5-3	58
3D IR-TRACC Assembly, Lower Right	1	474-3570-A	Figure 5-3	59

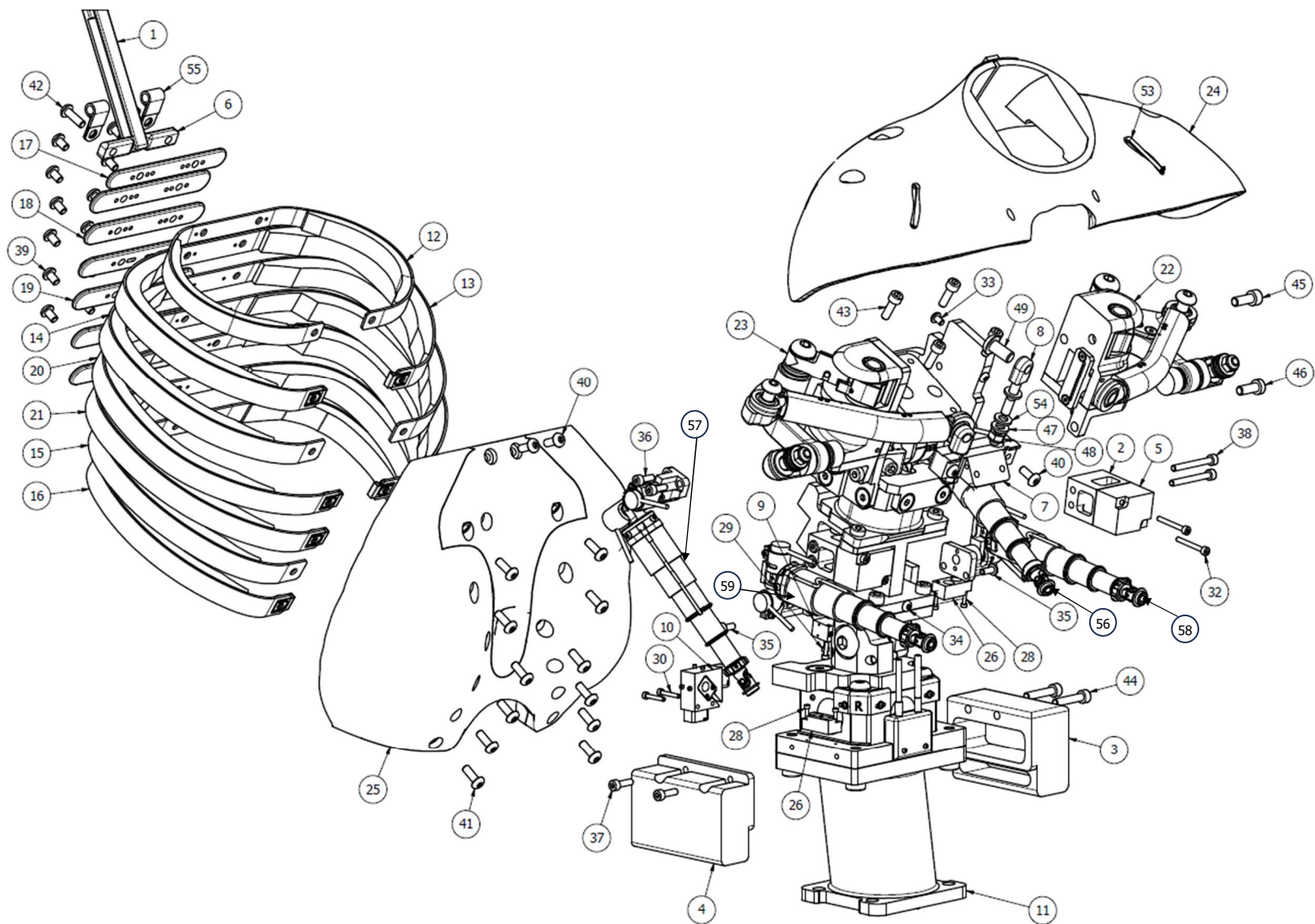


Figure 5-3 Upper Torso Assembly Components

Table 5-2. Upper (Left) IR-TRACC Assembly (474-3550-A) Components

Part Description	Quantity	Part Number	Figure #	Item #
IR-TRACC, THOR 5 th Upper Torso	1	SA572-S122	Figure 5-4	1
Potentiometer Assembly, Z-axis	1	SA572-S167	Figure 5-4	2
Potentiometer Assembly, Y-axis	1	SA572-S168	Figure 5-4	3
IR-TRACC Base	1	474-3754-1	Figure 5-4	4
IR-TRACC Arm Mounting Bracket, UL/LR	1	474-3756	Figure 5-4	5
M2 X 0.4 X 8 LG. SHCS	4	5000083	Figure 5-4	6
M2 Split Lock Washer SS	4	5001216	Figure 5-4	7
M2.5 X 0.45 X 3 LG. SSSCP Nylon	2	5001359	Figure 5-4	8
Flange Bearing (1/4" O.D. X 1/8" I.D.)	2	9002201	Figure 5-4	9
#6 Flat Washer Nylon 0.170 X 0.375 X 0.045	2	9004096	Figure 5-4	10

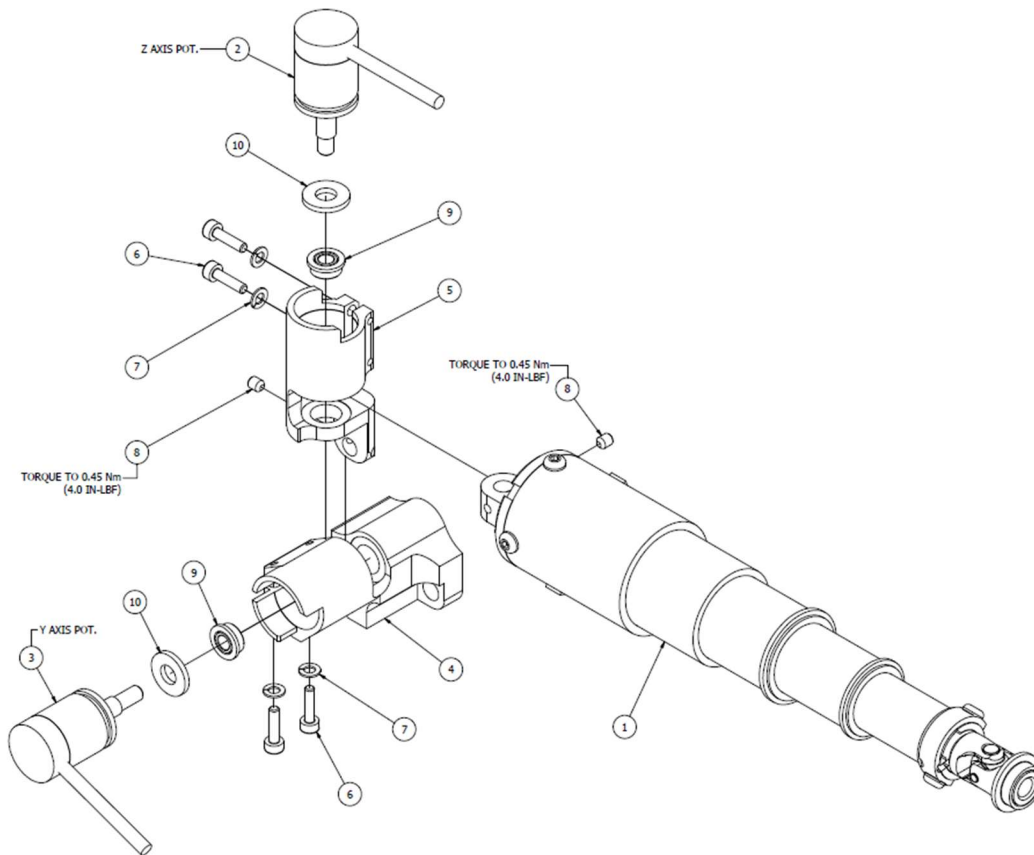


Figure 5-4. Upper Left 3D IR-TRACC Assembly (474-3550-A)

Table 5-3. Lower (Left) IR-TRACC Assembly (474-3580-A) Components.

Part Description	Quantity	Part Number	Figure #	Item #
IR-TRACC Base, Lower Left & Right	1	474-3762	Figure 5-5	1
Flange Bearing (1/4" O.D. X 1/8" I.D.)	2	9002201	Figure 5-5	2
Potentiometer Assembly, Y-axis	1	SA572-S168	Figure 5-5	3
IR-TRACC Arm Mounting Bracket, Lower Left	1	474-3763-1	Figure 5-5	4
#6 Flat Washer Nylon 0.170 X 0.375 X 0.045	2	9004096	Figure 5-5	5
Potentiometer Assembly, Z-axis	1	SA572-S167	Figure 5-5	6
IR-TRACC, THOR 5 th Upper Torso	1	SA572-S122	Figure 5-5	7
M2 X 0.4 X 8 LG. SHCS	4	5000083	Figure 5-5	8
M2 Split Lock Washer SS	4	5001216	Figure 5-5	9
M2.5 X 0.45 X 3 LG. SSSCP Nylon	2	5001359	Figure 5-5	10

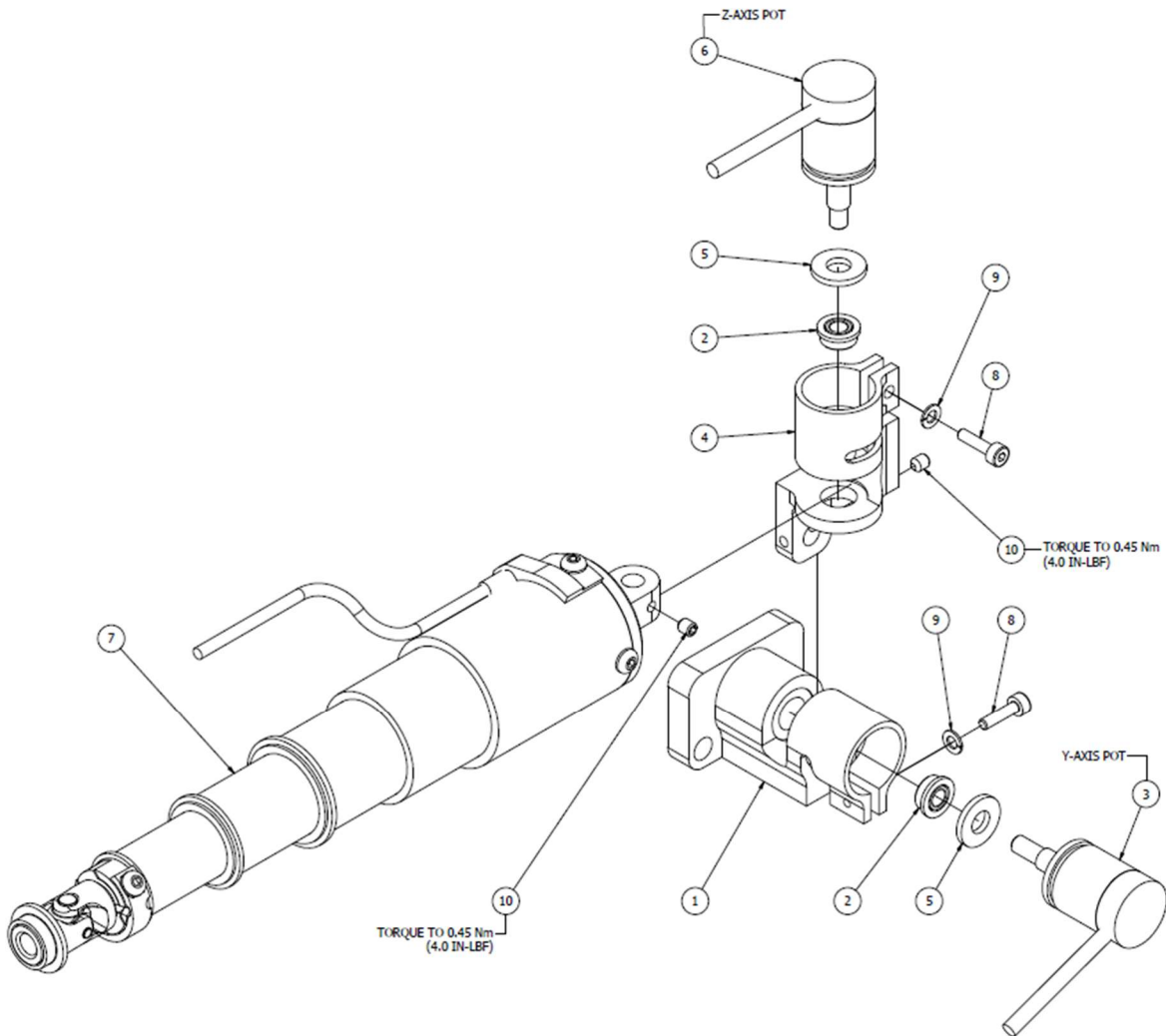


Figure 5-5. Lower Left 3D IR-TRACC Assembly (474-3580-A)

5.2 Disassembly of the Thorax and Abdomen

- 5.2.1 Remove the Shoulder Pad (474-3559-A) by cutting the 4 cable ties and removing two M8 X 1.25 X 25 LG. BHCS (Figure 5-6 and Figure 5-7).

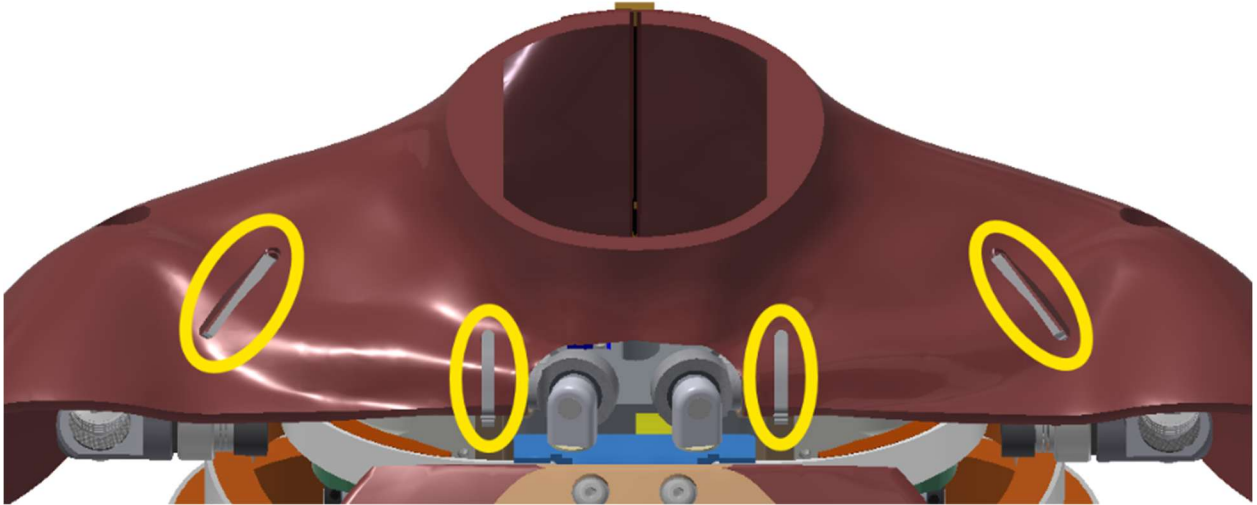


Figure 5-6. Cut four cable ties

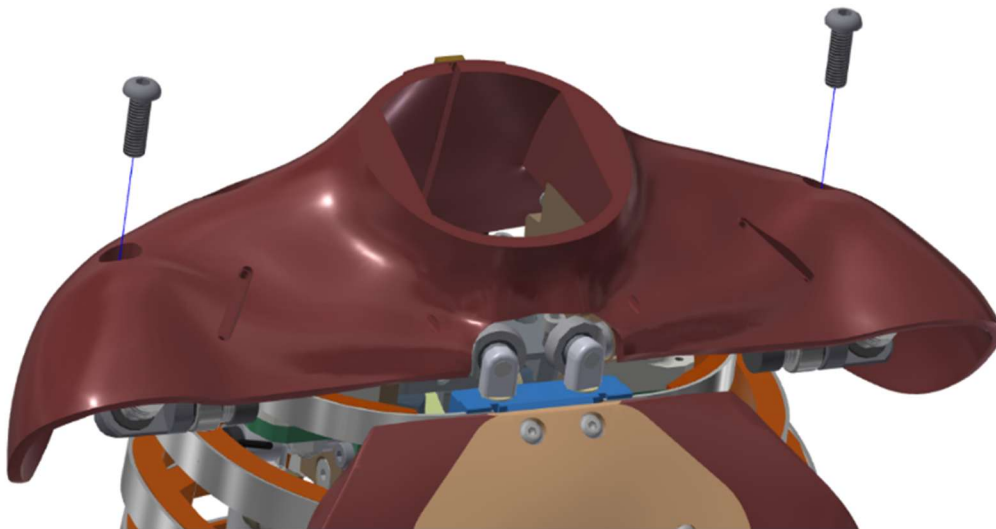


Figure 5-7. Remove two M8 X 1.25 X 25 LG. BHCS

- 5.2.2 Remove abdomen foam (474-4305) being careful not to tear it and rest it on the dummy's lap (Figure 5-8).

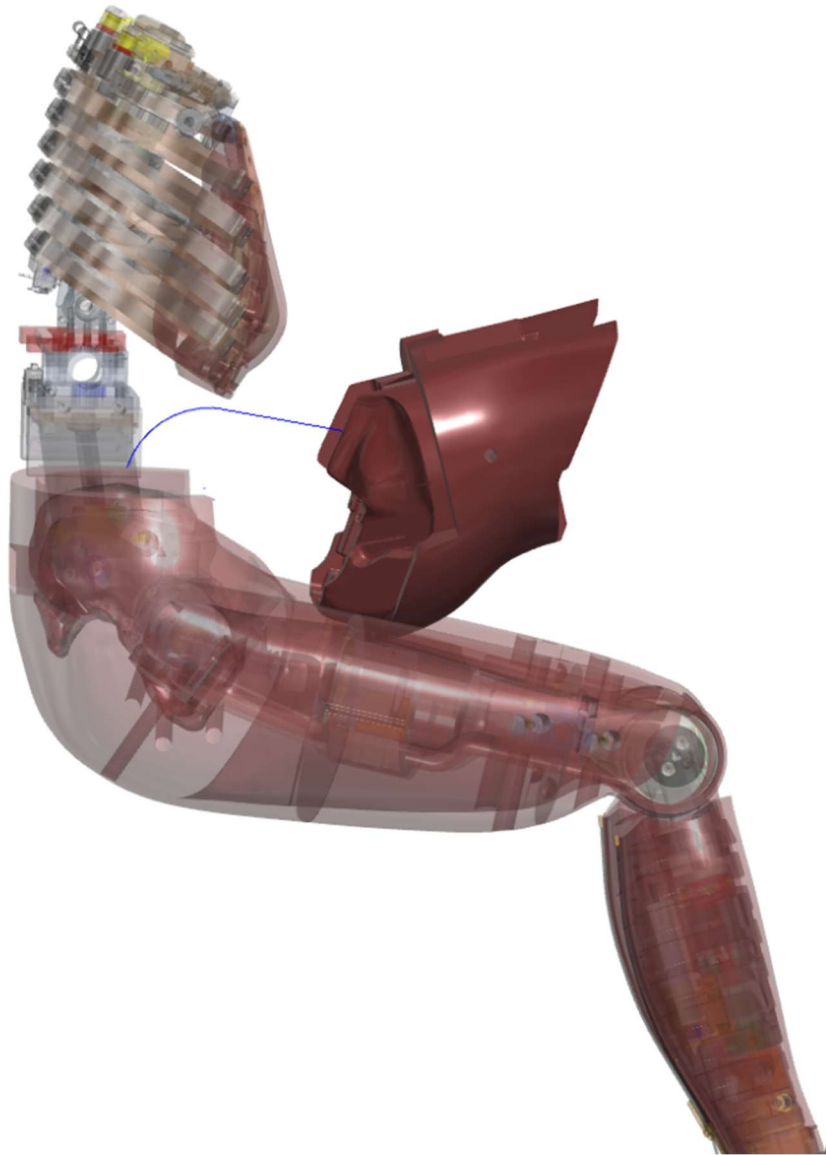


Figure 5-8. Remove the Abdomen Foam (474-4305)

5.2.3 Unclip the left and right pressure sensor wires (Figure 5-9).

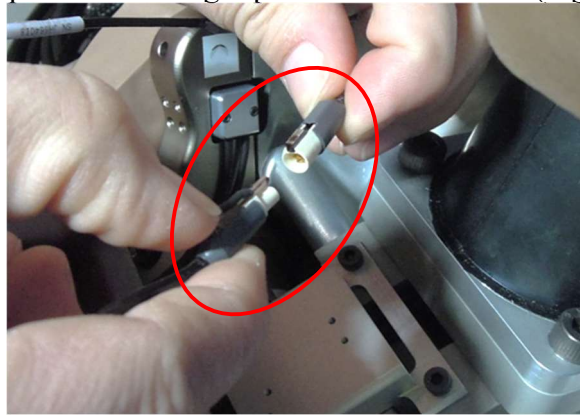


Figure 5-9. Unclip the left and right pressure sensor wires

5.2.4 Remove the APTS sensors (SA572-S162) from the Abdomen (474-4305) (Figure 5-10).

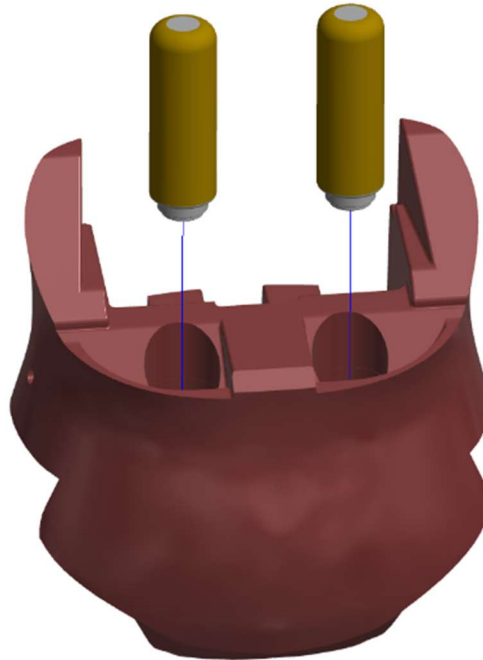


Figure 5-10. Remove the pressure sensors from the Abdomen (474-4305)

- 5.2.5 Remove the ground cable from the Lumbar Posture Adjustment Base Plate (474-3220-A) by removing one M4 X 0.7 X 6 LG. BHCS (Figure 5-11).

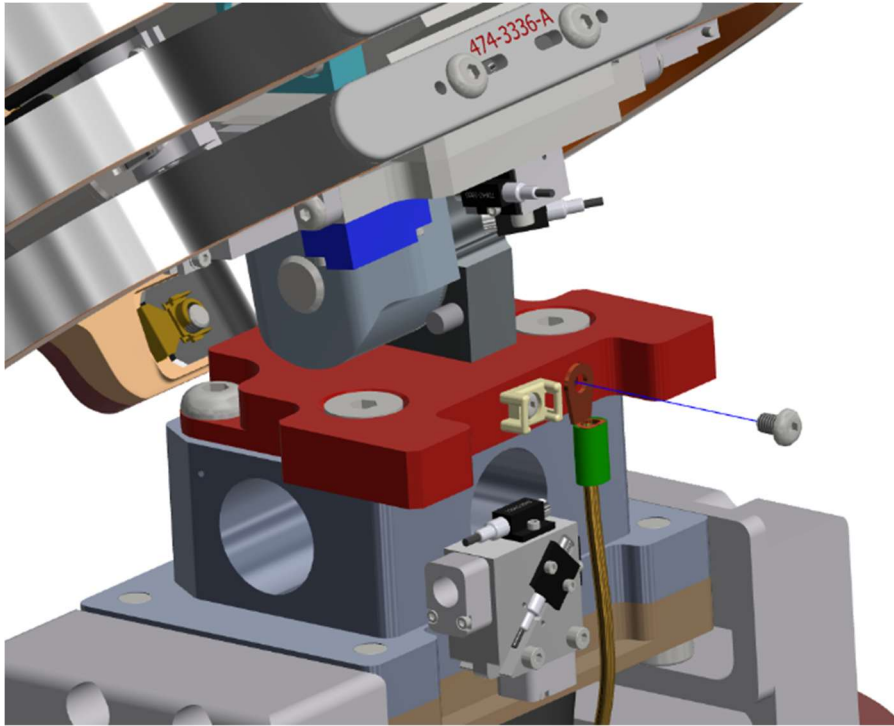


Figure 5-11. Remove the ground cable

- 5.2.6 Remove the Clavicle Assemblies (474-3508) from the Clavicle-Sternum Adaptor (474-3041-A) by removing two M8 X 1.25 X 16 LG. BHCS (Figure 5-12).

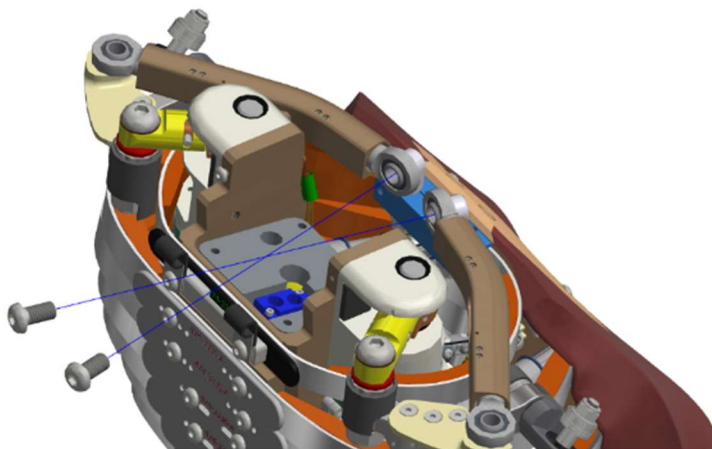


Figure 5-12. Remove the Clavicle Assemblies (474-3508) from the Clavicle-Sternum Adaptor (474-3041-A)

- 5.2.7 Remove the grounding straps from the left and right clavicle load cells by removing one M2 X 0.4 X 0.6 LG. BHCS from each load cell (Figure 5-13).

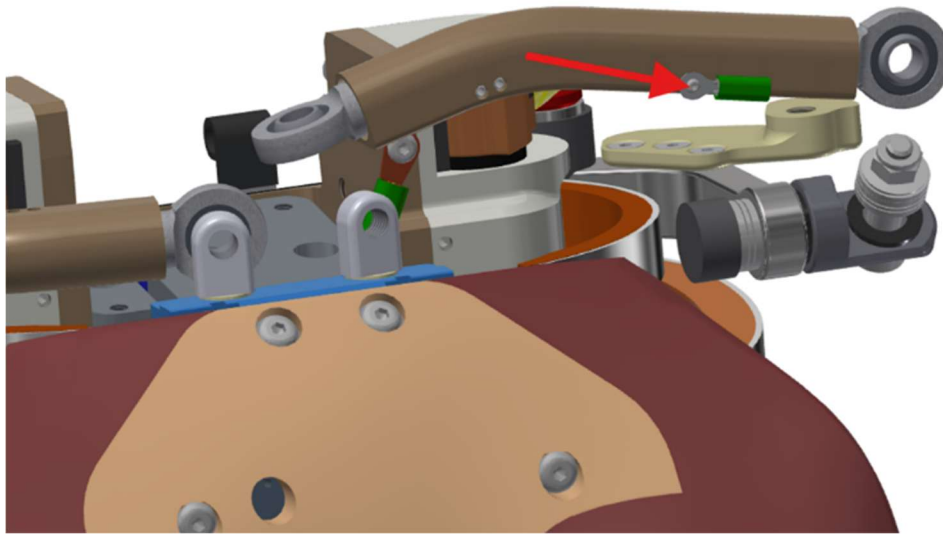


Figure 5-13. Remove the ground strap from the left and right clavicle load cell

- 5.2.8 Remove the Chest Flesh-Sternum, Molded (474-3730-A) by removing fourteen M5 X 0.8 X 12 LG. BHCS (Figure 5-14).

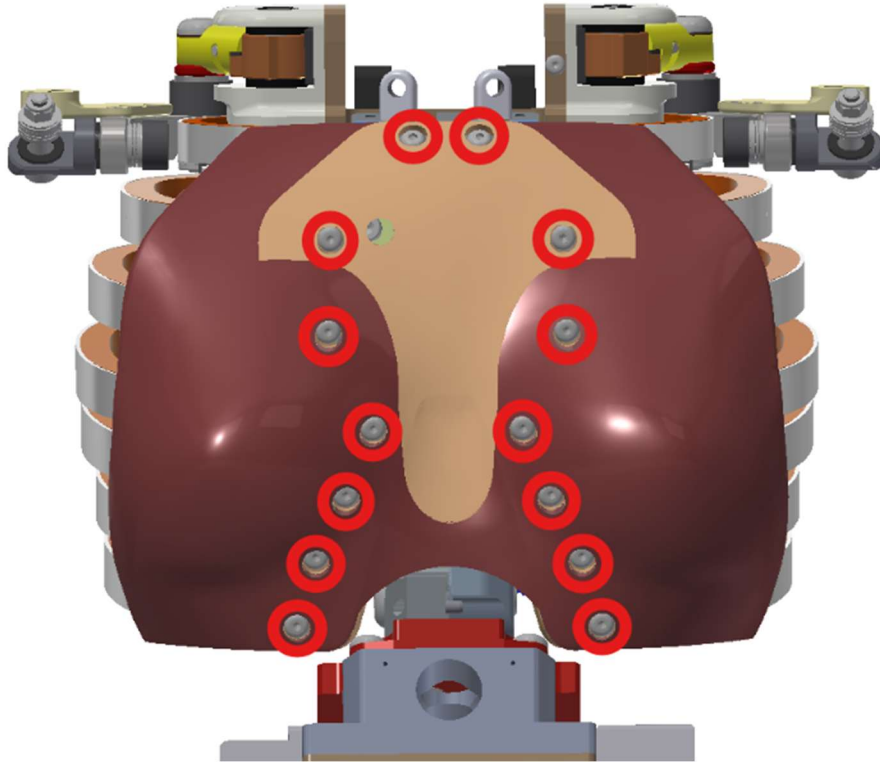


Figure 5-14. Remove the Chest Flesh-Sternum, Molded (474-3730-A)

- 5.2.9 Remove the chest accelerometer from the back side of the Chest Flesh Sternum, Molded (474-3730-A) by removing two M1.4 X 0.3 X 3 LG. SHCS (Figure 5-15).

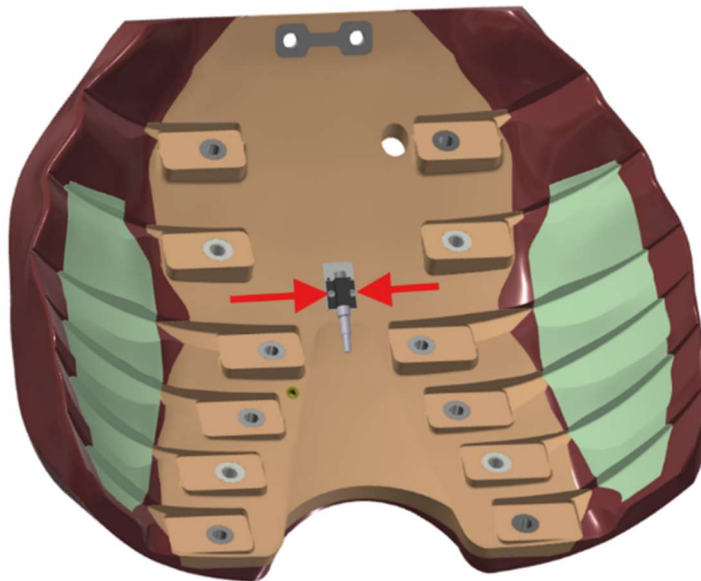


Figure 5-15. Remove the Sternum Accelerometer from the back side of the Chest Flesh

5.2.10 Protect the chest accelerometer from damage (Figure 5-16).



Figure 5-16. Protect the accelerometer after disassembly from the sternum

5.2.11 Remove the Rib 1 to Sternum Adaptor (474-3040-A) from Rib 1 (474-3301-A) by removing two M5 X 0.8 X 12 LG. BHCS (Figure 5-17).

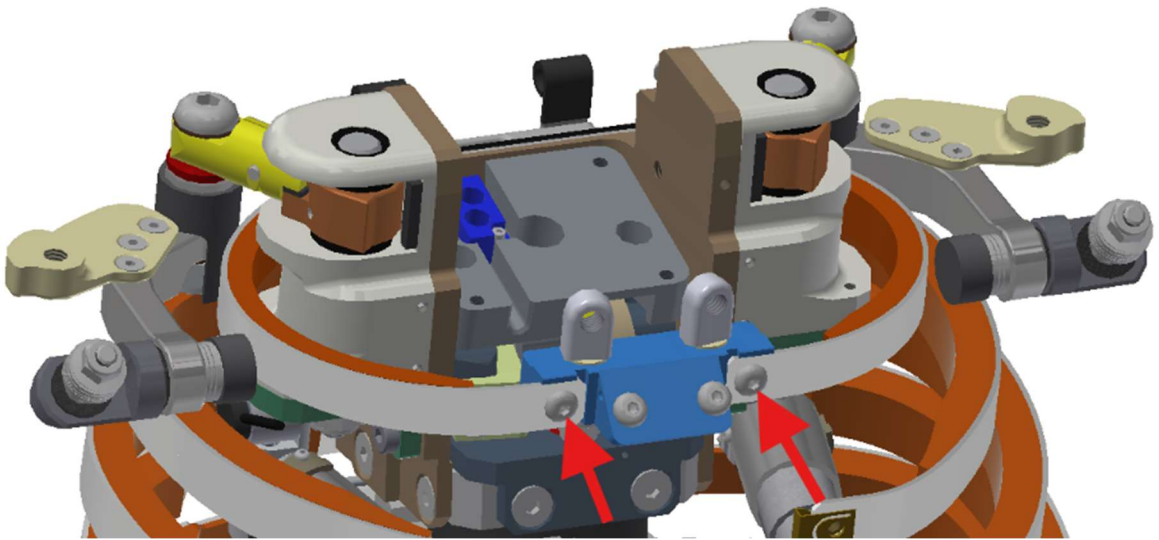


Figure 5-17. Remove the Rib 1 to Sternum Adaptor (474-3040-A) from Rib 1 (474-3301-A)

- 5.2.12 Remove the two Clavicle-Sternum Adaptor (474-3041-A) from the Adaptor, Rib 1 to Sternum (474-3040-A) by removing the M6 X 1 Hex Lock Nuts, M6 Flat Washers, and plastic M6 Flat Washers (Figure 5-18).

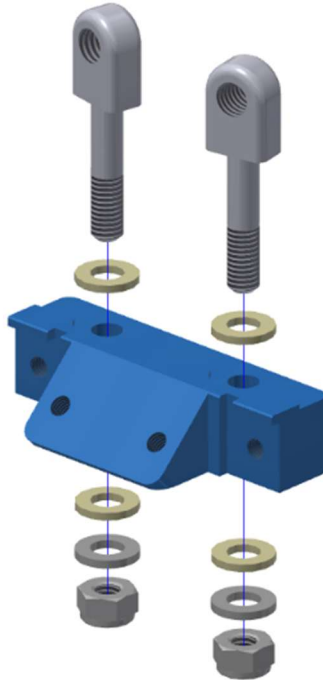


Figure 5-18. Remove the two Clavicle-Sternum Adaptor (474-3041) from the Adaptor, Rib 1 to Sternum (474-3040)

- 5.2.13 Remove rib 1 by removing two M5 X 0.8 X 16 LG. BHCS. Remove the remaining six ribs by removing the M5 X 0.8 X 8 LG. BHCS per rib (Figure 5-19).

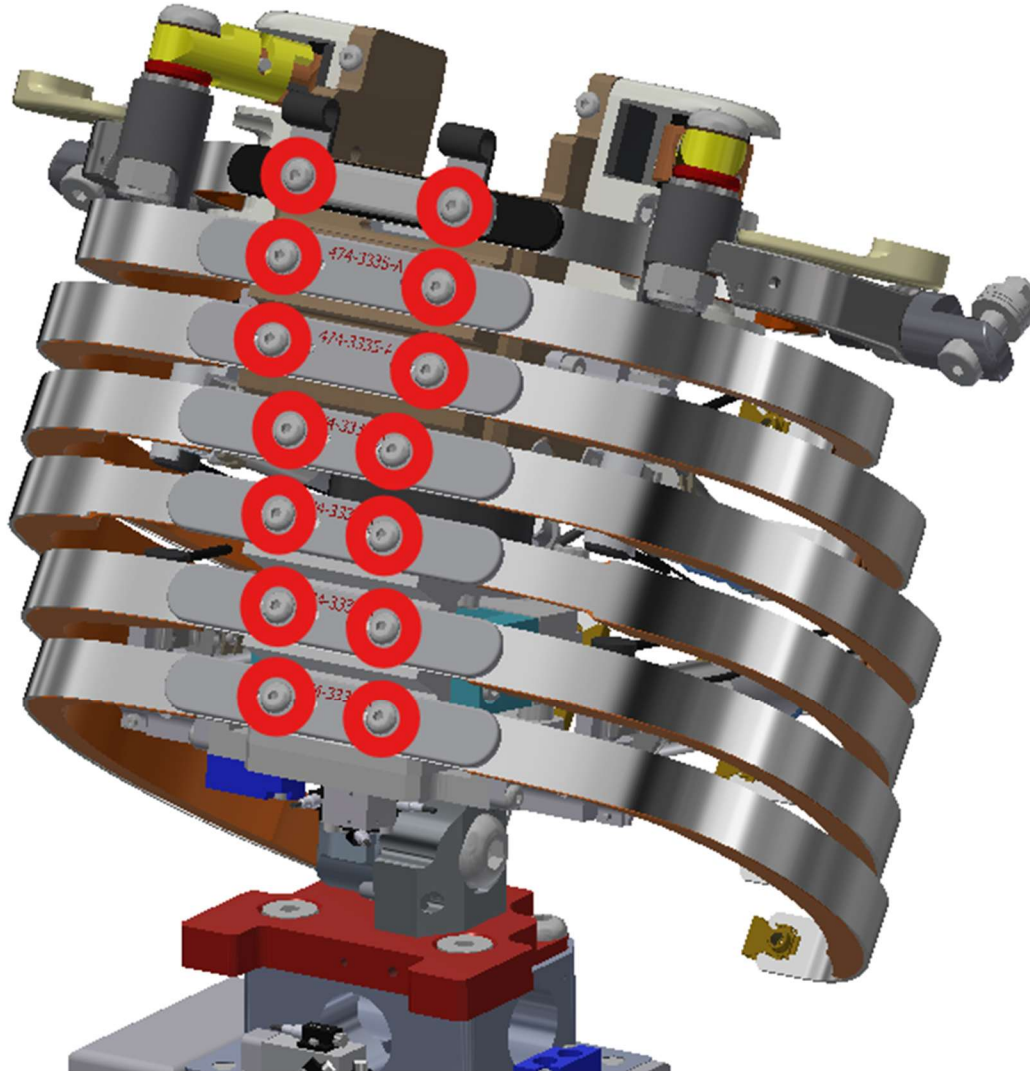


Figure 5-19. Remove the 7 Ribs from the Thorax by removing the two M5 X 0.8 X 8 LG. BHCS per rib

- 5.2.14 Remove the ground strap from the rear of the Left Shoulder Assembly (474-3500-1-A) and Right Shoulder Assembly (474-3500-2-A) by removing two M4 X 0.7 X 6 BHCS (Figure 5-20).

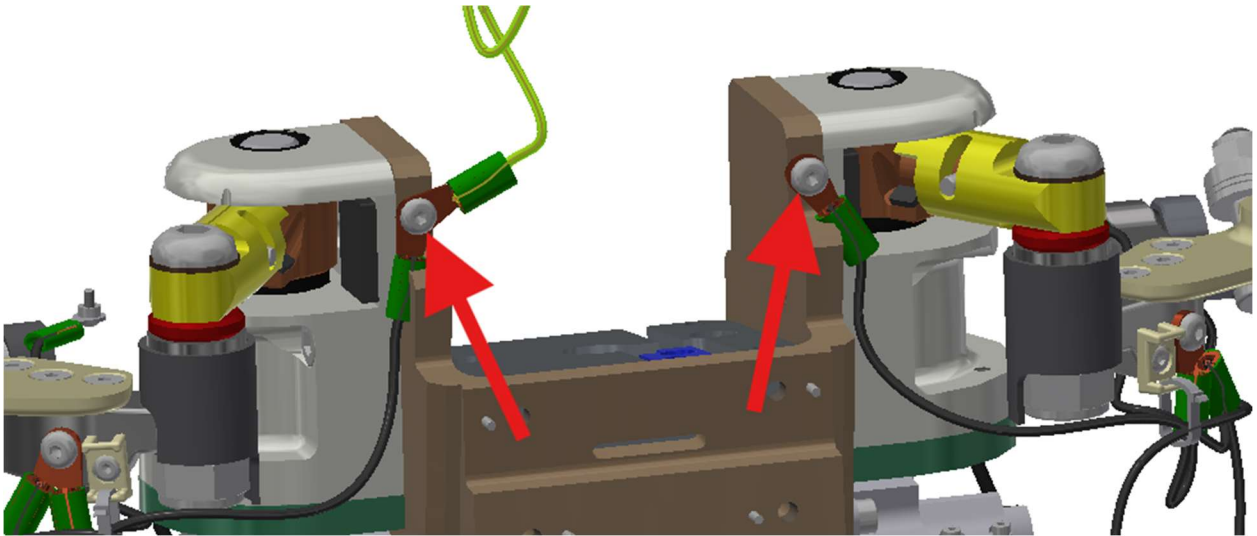


Figure 5-20. Remove the ground strap from the rear of the right Shoulder Assembly (474-3500-2-A)

- 5.2.15 Remove left Shoulder Assembly (474-3500-1) by removing two M6 X 1 X 16 LG. SHCS (Figure 5-21).

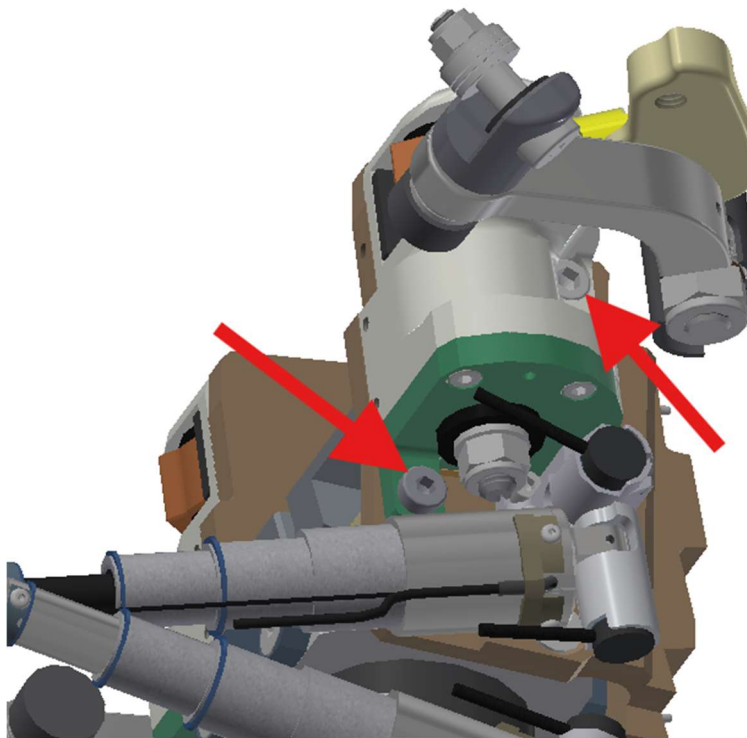


Figure 5-21. Remove two M6 X 1 X 16 LG. SHCS

- 5.2.16 Repeat step 5.2.15 for the removal of the right shoulder.
- 5.2.17 Remove the two Upper IR-TRACCs (474-3550-A and 474-3560-A) from the Spine Assembly (474-3200-A) by removing two M4 X 0.7 X 12 LG. SHCS per assembly (Figure 5-22).

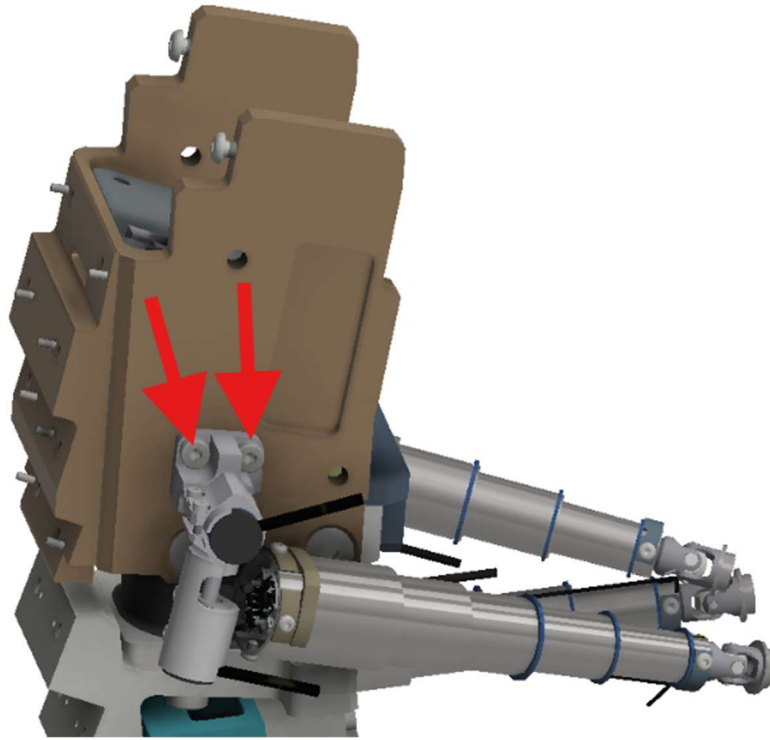


Figure 5-22. Remove the two Upper IR-TRACCs from the Spine Assembly (474-3200-A)

- 5.2.18 Begin disassembly the Upper IR-TRACCs (474-3550-A and 474-3560-A) by loosening the two M2.5 X 0.45 X 3 LG. SSSCP Nylock potentiometer shaft set screws per assembly (Figure 5-23).

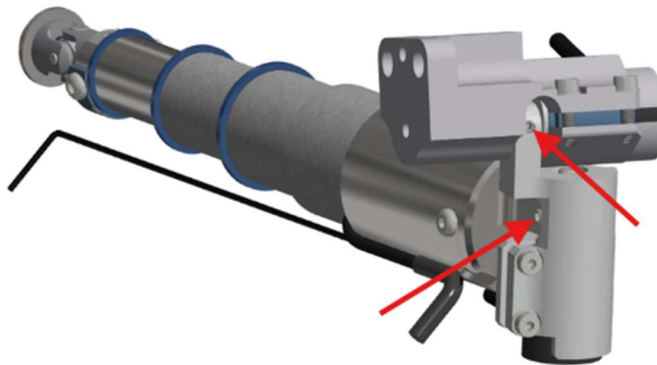


Figure 5-23. Loosen the potentiometer shaft set screws

- 5.2.19 Remove the M2 X 0.4 X 8 LG. SHCS and M2 Split Lock Washer SS from the IR-TRACC Base (474-3754) and the IR-TRACC Arm Mounting Bracket (474-3755 and 474-3756) per assembly (Figure 5-24).

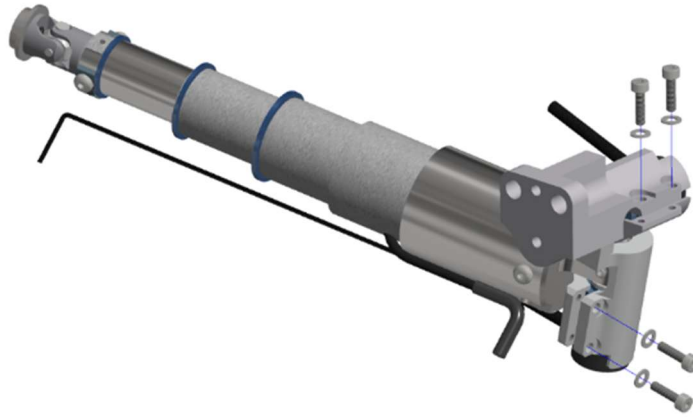


Figure 5-24. Remove the two M2 X 0.4 X 8 LG. SHCS from the potentiometer shafts

- 5.2.20 Remove the two potentiometers and two #6 Flat Washer Nylon 0.170 X 0.375 X 0.045 from the IR-TRACC Base (474-3754) and the IR-TRACC Arm Mounting Bracket (474-3755 and 474-3756) per assembly (Figure 5-25).



Figure 5-25. Remove potentiometers and washers from the assembly

- 5.2.21 Separate the IR-TRACC (SA572-S122), IR-TRACC Base (474-3754-1 and 474-3754-2), and IR-TRACC Arm Mounting Bracket (474-3755 and 474-3756) per assembly (Figure 5-26).

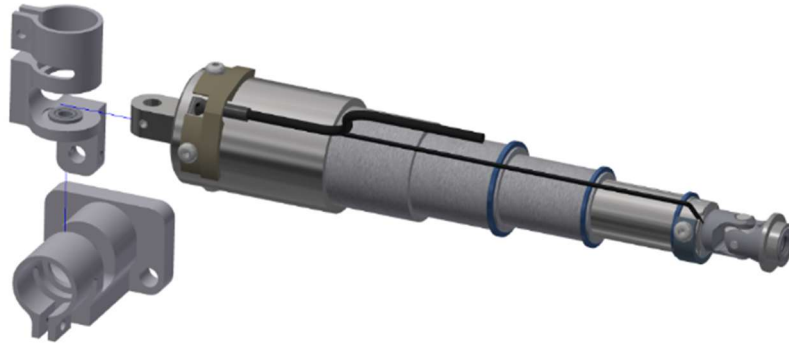


Figure 5-26. Separate IR-TRACC components

- 5.2.22 Remove the two Lower IR-TRACCs (474-3570-A and 474-3580-A) from the Spinebox Interface Plate (474-3072) by removing two M4 X 0.7 X 12 LG. SHCS per assembly (Figure 5-27).

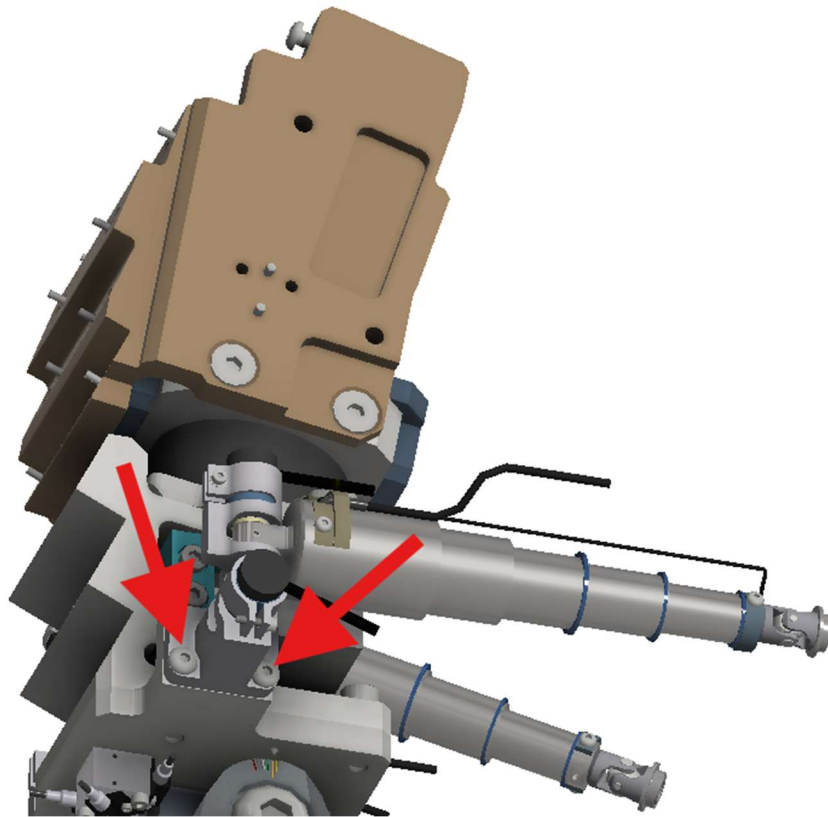


Figure 5-27. Remove the two Lower IR-TRACCs from the Spine Assembly (474-3200-A)

- 5.2.23 Begin disassembly of the Lower IR-TRACCs (474-3570-A and 474-3580-A) by loosening the two M2.5 X 0.45 X 3 LG. SSSCP Nylock potentiometer shaft set screws. (Figure 5-28).

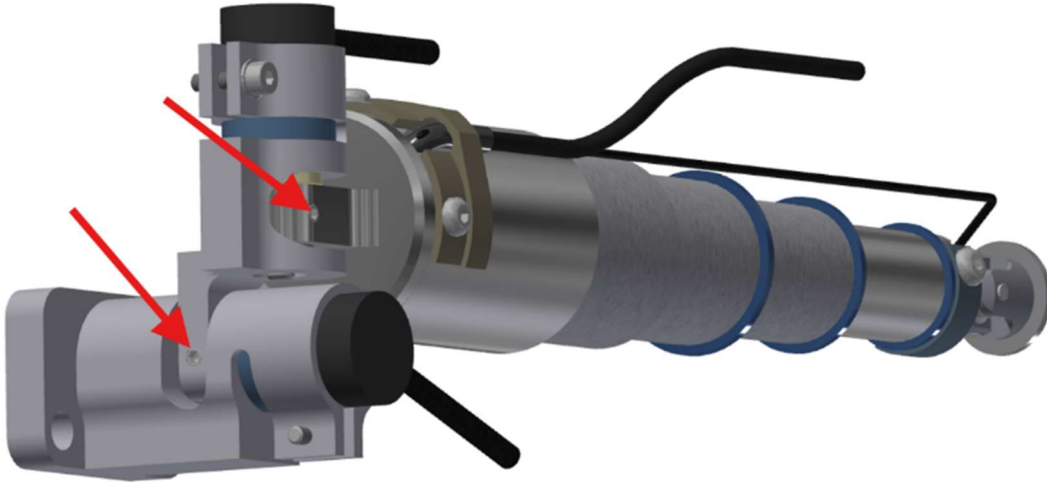


Figure 5-28. Loosen the potentiometer shaft set screws

- 5.2.24 Remove the M2 X 0.4 X 8 LG. SHCS and M2 Split Lock Washer SS from the IR-TRACC Base (474-3762) and the IR-TRACC Arm Mounting Bracket (474-3763) per assembly (Figure 5-29).

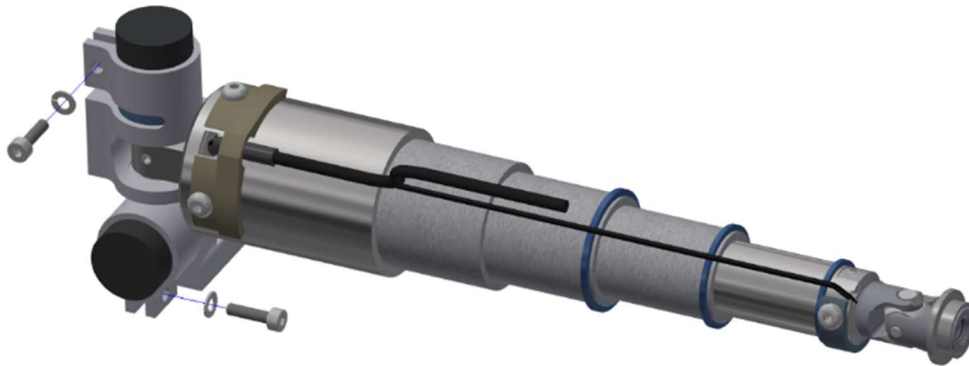


Figure 5-29. Remove the two M2 X 0.4 X 8 LG. SHCS from the potentiometer shafts

- 5.2.25 Remove the two potentiometers and two #6 Flat Washer Nylon 0.170 X 0.375 X 0.045 from the IR-TRACC Base (474-3762) and the IR-TRACC Arm Mounting Bracket (474-3763) per assembly (Figure 5-30).

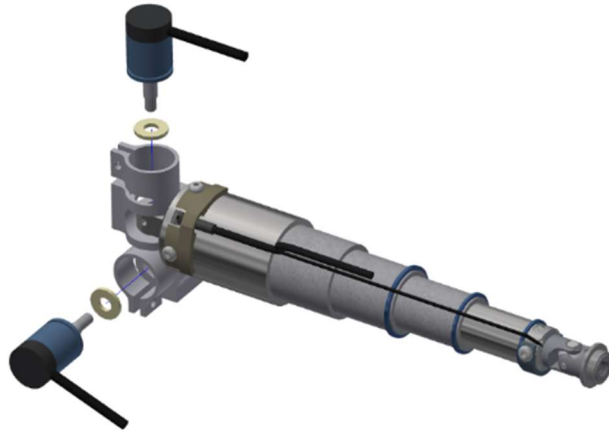


Figure 5-30. Remove potentiometers and washers from the assembly

- 5.2.26 Separate the IR-TRACC, IR-TRACC Base (474-3762), and IR-TRACC Arm Mounting Bracket (474-3763) per assembly (Figure 5-26).

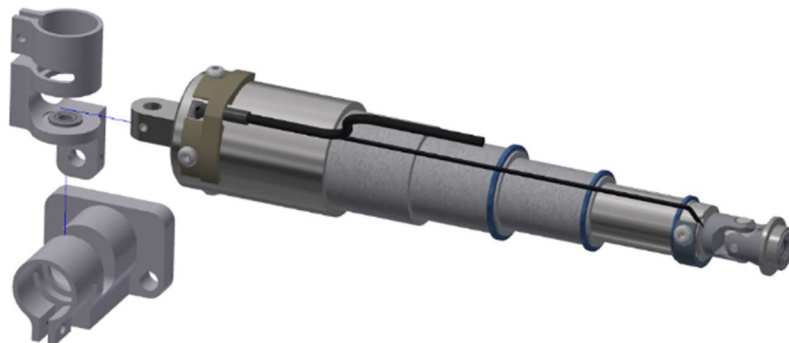


Figure 5-31. Separate the IR-TRACC, IR-TRACC Base, and IR-TRACC Arm Mounting Bracket

- 5.2.27 Remove the 7264C/ARS-1500 Mount (474-3067) from the rear of the spine assembly (474-3200-A) by removing two M2.5 X 0.45 X 16 LG. SHCS (Figure 5-32).

- 5.2.28 Remove the T12 Tilt Sensor (SA572-S44) from the Thoracic Spine Load Cell (SA572-S107) by removing two M2 X 0.4 X 10 LG. SHCS (Figure 5-32).

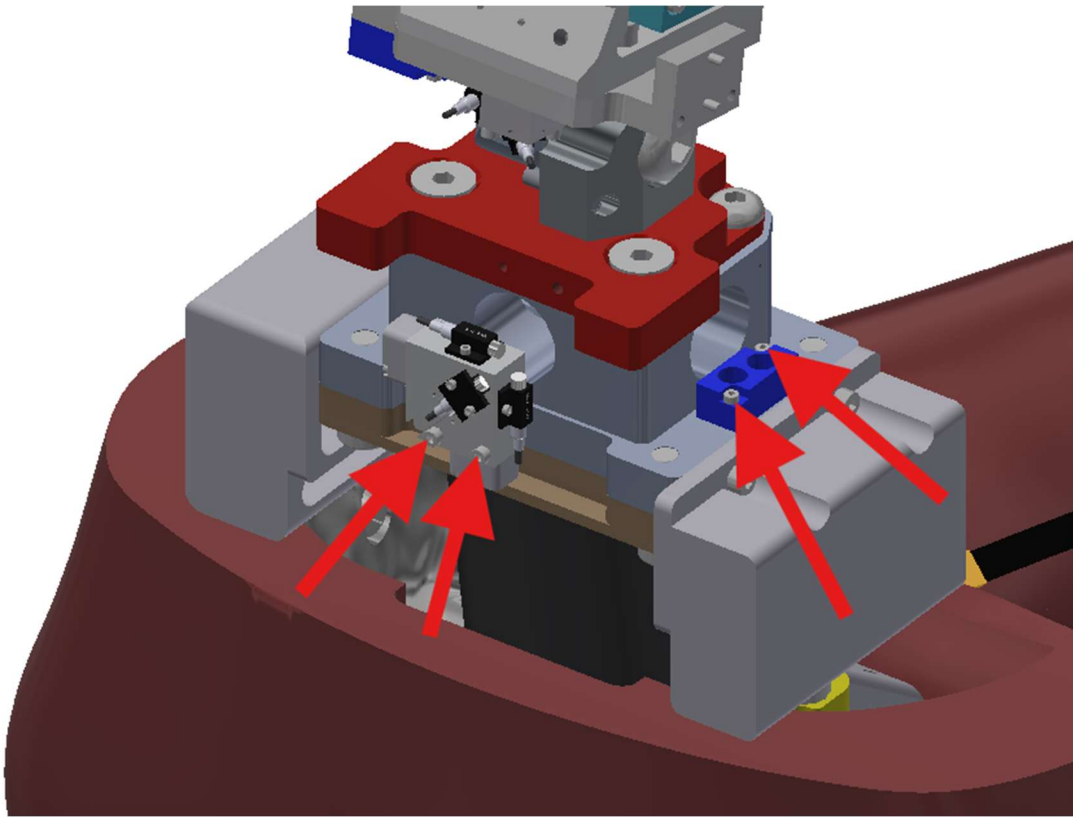


Figure 5-32. Remove the T12 tilt sensor (SA572-S44) and the 7264C/ARS-1500 Mount (474-3067) from the rear of the spine assembly (474-3200-A)

- 5.2.29 De-instrument the Mount (474-3067) by removing three ARSs (x2 M1.4 X 0.3 X 10 LG. SHCS) and three Accelerometers (x2 M1.4 X 0.3 X 4 LG. SHCS) (Figure 5-33).

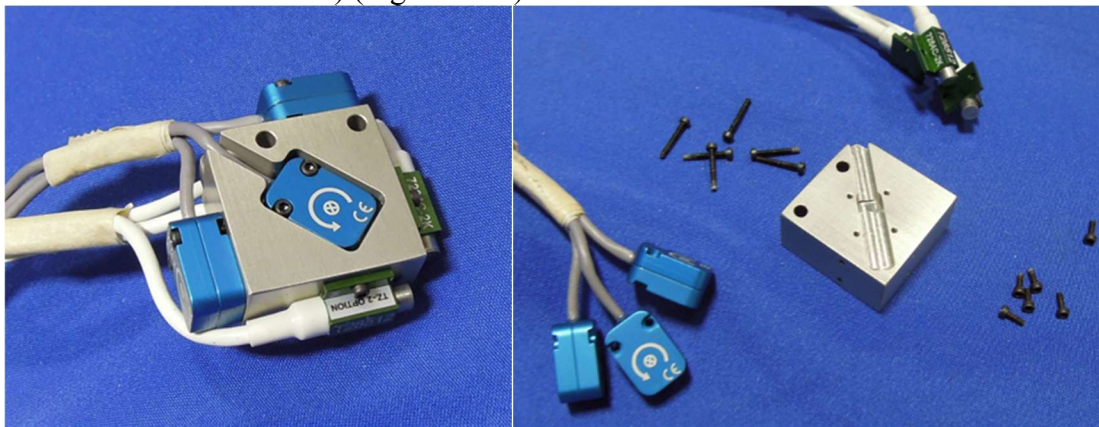


Figure 5-33. De-instrument the Mount (474-3067)

- 5.2.30 Remove the spine assembly (474-3200-A) from the pelvis (Figure 5-34) by removing four M8 X 1.25 X 20 LG. SHCS from the Lumbar Assembly (474-3223-A).

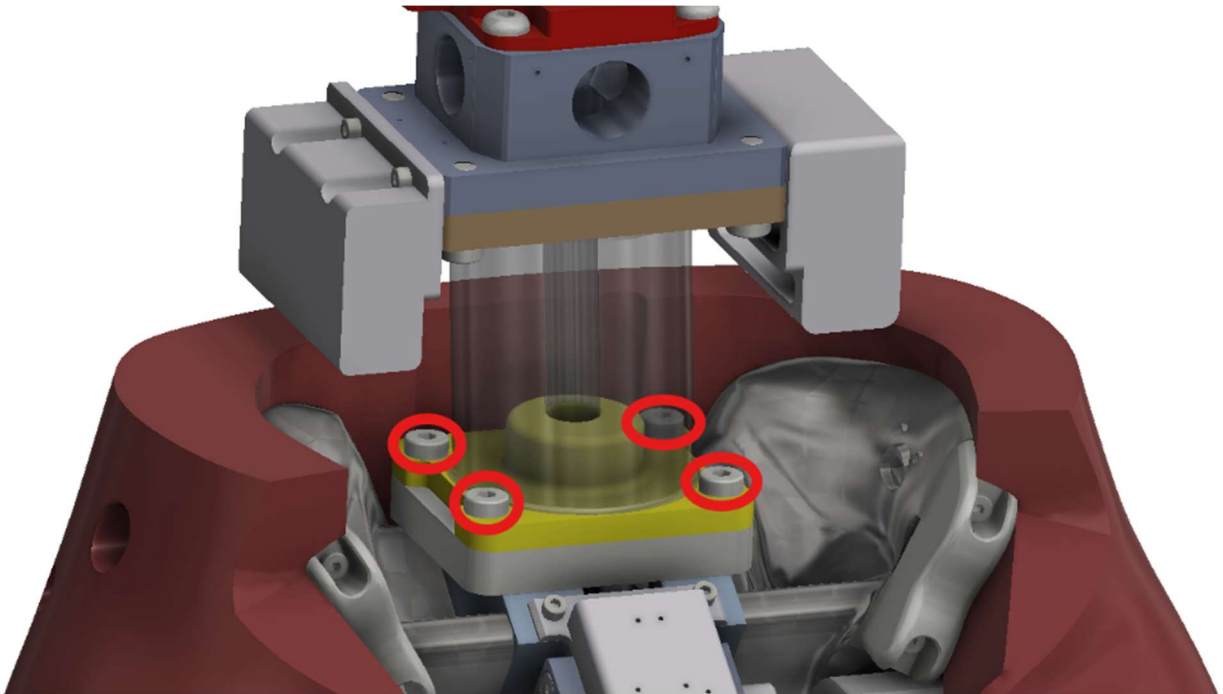


Figure 5-34. Remove four M8 X 1.25 X 20 LG. SHCS from the Lumbar Assembly (474-3223-A)

- 5.2.31 Remove the Mid-Spine Accelerometer Block (474-3066) from the underside of the Spinebox Interface Plate (474-3072) by removing two M2.5 X 0.45 X 14 LG. SHCS (Figure 5-35).

- 5.2.32 Remove the T6 tilt sensor (SA572-S44) from the underside of the Spinebox Interface Plate (474-3072) by removing two M2 X 0.4 X 10 LG. SHCS (Figure 5-35).

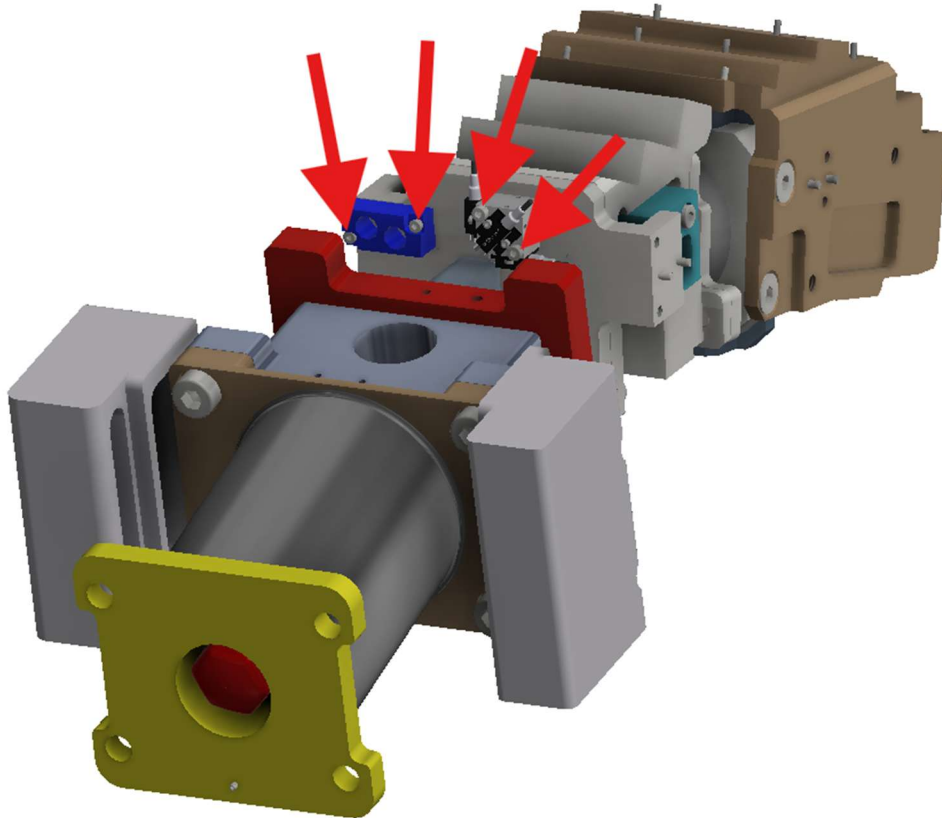


Figure 5-35. Remove the T6 tilt sensor (SA572-S44) and Mid-Spine Accelerometer Block (474-3066) from the underside of the Spinebox Interface Plate (474-3072)

- 5.2.33 Remove three accelerometers from the Mid-Spine Accelerometer Block (474-3066) by removing two M1.4 X 0.3 X 3 LG. SHCS per accel (Figure 5-36).

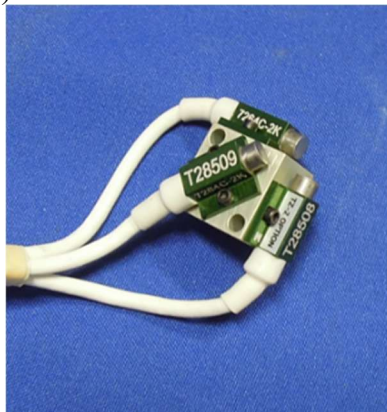


Figure 5-36. Remove three accelerometers from the Tri-Pack Block (SA572-S80M)

- 5.2.34 Remove the T1 Tilt Sensor (SA572-S44) from the Neck Posture Adjustment Assembly (474-3050) by removing two M2 X 0.4 X 10 LG. SHCS (Figure 5-37).

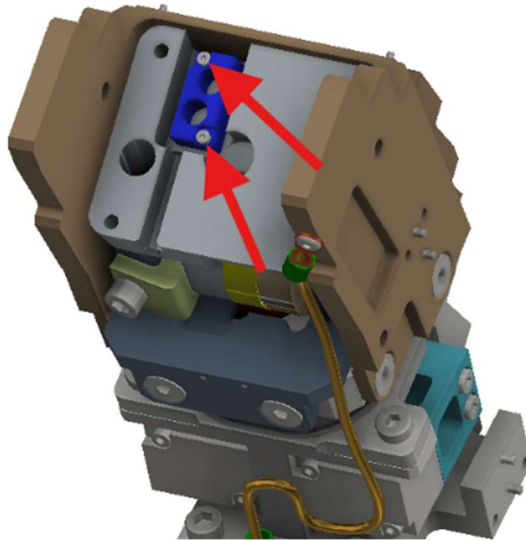


Figure 5-37. Remove the T1 Tilt Sensor (SA572-S44) from the Neck Posture Adjustment Assembly (474-3050)

- 5.2.35 Remove the thorax ground cable (Figure 5-38).



Figure 5-38. Remove the thorax ground cable

5.3 Assembly of the Thorax and Abdomen

The following procedure is a step-by-step description of the assembly procedure for the thorax components. This section must be completed after the Assembly of the Spine. Unless otherwise specified, tighten all bolts to the torque specification provided in Section 2.1.3.

- The thorax assembly includes: The Shoulder Assembly (474-3500), Spine Assembly (474-3200), and 7 rib assemblies (474-3301-A through 474-3307-A).
- There are four IR-TRACC assemblies in the thorax assembly. Each position in the thorax requires a different assembly:

IR-TRACC Position	Part Number
Upper Right	474-3560-A
Upper Left	474-3550-A
Lower Right	474-3570-A
Lower Left	474-3580-A

- 5.3.1 Attach three uniaxial accelerometers (SA572-S4) to an THOR-05F Mid-Spine Mounting Block (474-3066) using two M1.4 X 0.3 X 3 SHCS per accelerometer (Figure 5-39).

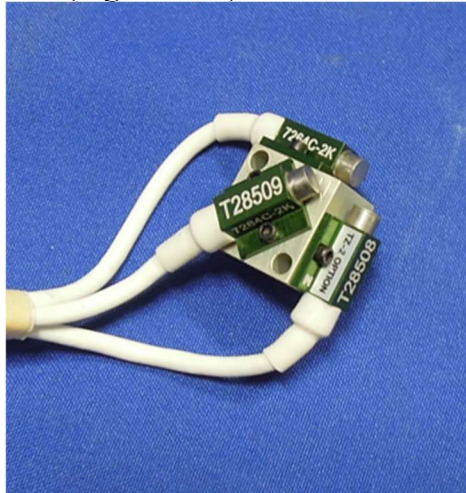


Figure 5-39. Attach three accelerometers to the Mid-Spine Mounting Block (474-3066)

- 5.3.2 Install the T6 Tilt Sensor to the Spinebox Interface Plate (474-3072) using two M2 X 0.4 X 10 LG. SHCS (Figure 5-40).

- 5.3.3 Attach the THOR-05F Mid-Spine Mounting Block (474-3066) to the Spinebox Interface Plate using two M2.5 X 0.45 X 14 LG. SHCS (Figure 5-40).

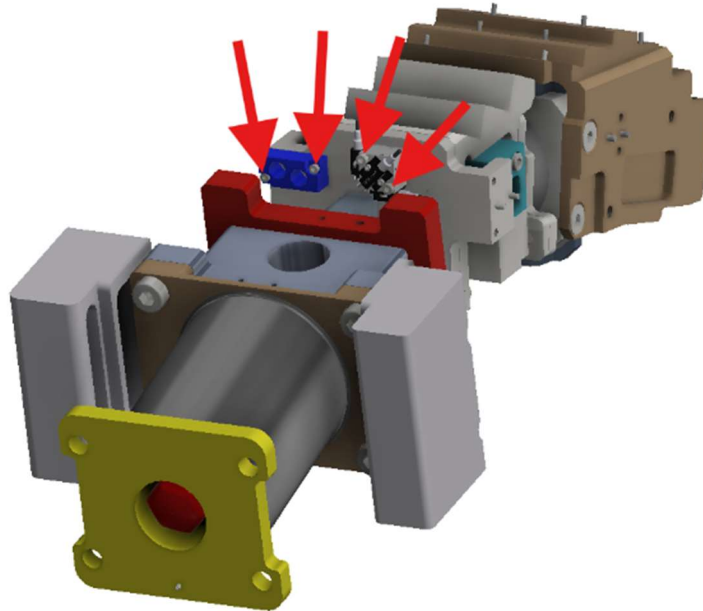


Figure 5-40. Install the T6 tilt sensor (SA572-S44) and Tri-Pack Block (SA572-S80M) to the underside of the Spinebox Interface Plate (474-3062)

- 5.3.4 At this time, attach the spine assembly (474-3200-A) to the pelvis (Figure 5-41). Use four M8 X 1.25 X 20 LG. SHCS to attach the Lumbar Assembly (474-3223-A), to the Pelvis Adaptor Plate (474-4004).

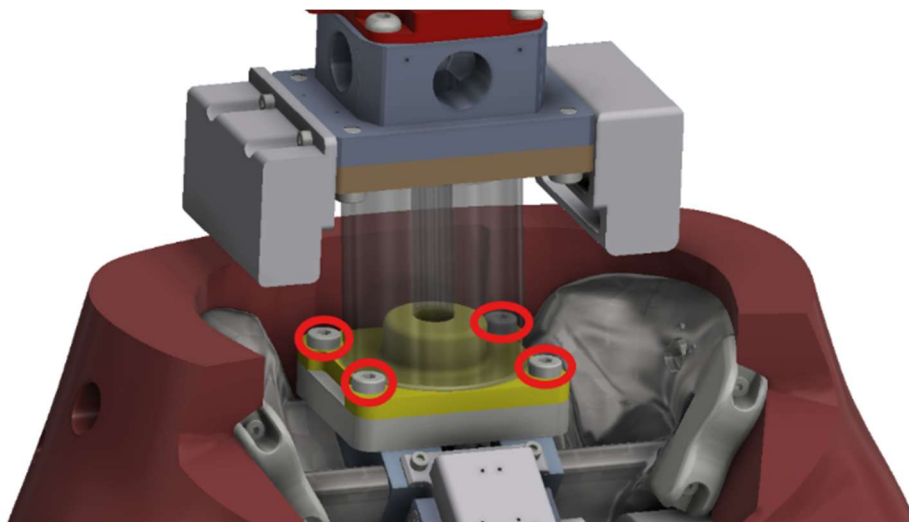


Figure 5-41. Use four M8 X 1.25 X 20 LG. SHCS to attach the Lumbar Assembly (474-3223-A)

- 5.3.5 Install the T12 Tilt Sensor (SA572-S44) to the Thoracic Spine Load Cell (SA572-S107) with two M2 X 0.4 X 10 LG. SHCS (Figure 5-42).
- 5.3.6 Install the 7264C/ARS-1500 Mount (474-3067) to the rear of the spine assembly (474-3200-A) with two M2.5 X 0.45 X 16 LG. SHCS (Figure 5-42).

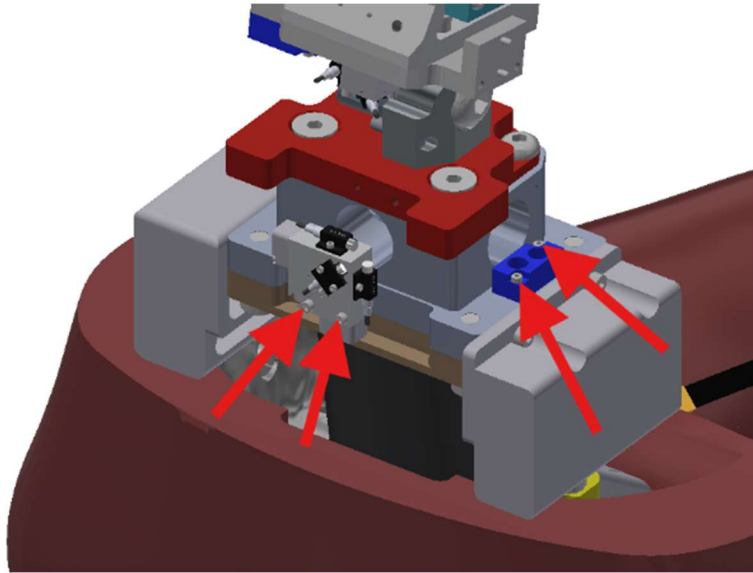


Figure 5-42. Install the T12 Tilt Sensor (SA572-S44) and the 7264C/ARS-1500 Mount (474-3067) to the Thoracic Spine Load Cell (SA572-S107)

- 5.3.7 Attach the thorax ground cable (Figure 5-43).



Figure 5-43. Attach the thorax ground cable

- 5.3.8 Install the T1 Tilt Sensor (SA572-S44) to the Neck Posture Adjustment Assembly (474-3050) with two M2 X 0.4 X 10 LG. SHCS (Figure 5-44).

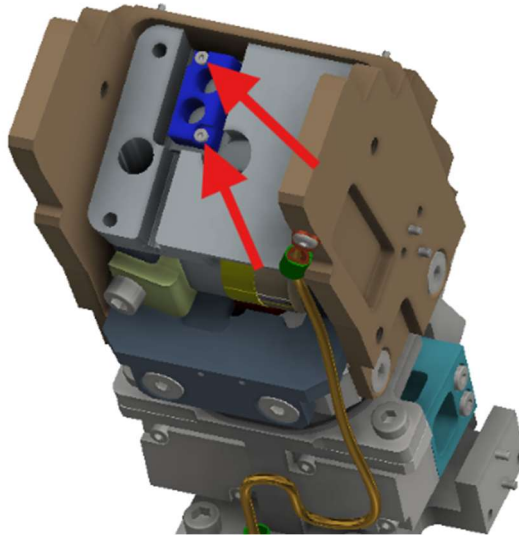


Figure 5-44. Install the T1 Tilt Sensor (SA572-S44) on the Neck Posture Adjustment Assembly (474-3050)

- 5.3.9 Assemble the Upper (Left) IR-TRACC Assembly (474-3550-A) by inserting the IR-TRACC (SA572-S122) into the IR-TRACC Arm Mounting Bracket (474-3756) (Figure 5-45).



Figure 5-45. Upper thorax IR-TRACC arm mounting bracket assembly

- 5.3.10 Assure that the rotary potentiometers will not pass through a dead band when moved through its range of motion in the thorax. Rotate the shaft until the potentiometer output voltage is approximately 0 volts so that the potentiometers are near mid-range. Once this is complete, insert the Potentiometer Assembly, Z-Axis (SA572-S167) and #6 FLAT WASHER NYLON 0.170 X 0.375 X 0.045 into the IR-TRACC Arm Mounting Bracket. (Figure 5-46)



Figure 5-46. Upper thorax IR-TRACC Z-axis potentiometer assembly

- 5.3.11 Install two M2 X 0.4 X 8 LG. SHCS and two M2 SPLIT LOCK WASHER SS into the IR-TRACC Arm Mounting Bracket to clamp onto the Potentiometer Assembly, Z-Axis (Figure 5-47).



Figure 5-47. Upper thorax IR-TRACC Z-axis potentiometer assembly clamp

- 5.3.12 Tighten the M2.5 X 0.45 X 3 LG. SSSCP NYLOK in the IR-TRACC onto the shaft of the Potentiometer Assembly, Z-Axis (Figure 5-48).



Figure 5-48. Upper thorax IR-TRACC Z-axis potentiometer shaft set screw

- 5.3.13 Insert the IR-TRACC Base (474-3754-1) onto the IR-TRACC Arm Mounting Bracket (Figure 5-49).

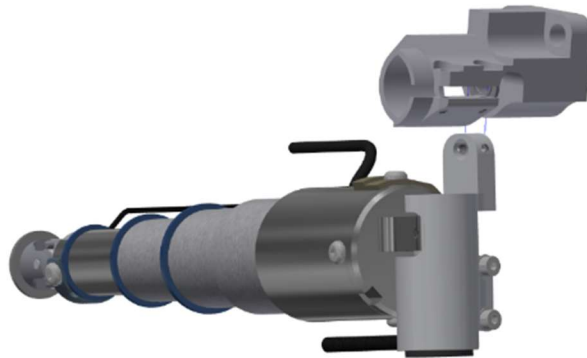


Figure 5-49. Upper thorax IR-TRACC Arm Mounting Bracket

- 5.3.14 Assure that the rotary potentiometers will not pass through a dead band when moved through its range of motion in the thorax. Rotate the shaft until the potentiometer output voltage is approximately 0 volts so that the potentiometers are near mid-range. Once this is complete, insert the Potentiometer Assembly, Y-Axis (SA572-S167) and #6 FLAT WASHER NYLON 0.170 X 0.375 X 0.045 into the IR-TRACC Base (Figure 5-50)



Figure 5-50. Upper thorax IR-TRACC Y-axis potentiometer assembly

- 5.3.15 Install two M2 X 0.4 X 8 LG. SHCS and two M2 SPLIT LOCK WASHER SS into the IR-TRACC Base to clamp onto the Potentiometer Assembly, Y-Axis (Figure 5-51).

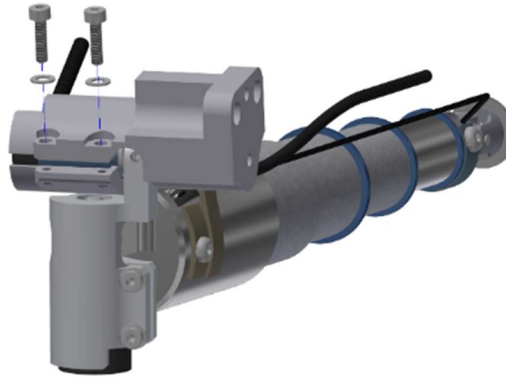


Figure 5-51. Upper thorax IR-TRACC Y-axis potentiometer assembly clamp

- 5.3.16 Tighten the M2.5 X 0.45 X 3 LG. SSSCP NYLOK in the IR-TRACC onto the shaft of the Potentiometer Assembly, Z-Axis (Figure 5-52).

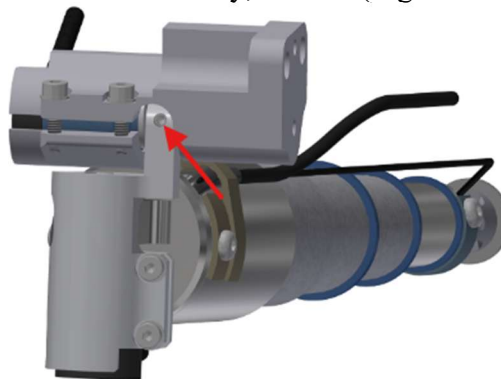


Figure 5-52. Upper thorax IR-TRACC Y-axis potentiometer shaft set screw

- 5.3.17 Repeat steps 5.3.95.3.1 through 5.3.16 for the Upper Right, Lower Right, and Lower Left IR-TRACC Assembly (474-3560-A, 474-3570-A, 474-3580-A).

- 5.3.18 Each time the 3D IR-TRACC assembly is re-assembled, the zero position for the Y-axis and Z-axis rotary potentiometers must be adjusted and the initial position offsets recorded.
- 5.3.19 To attach each of the Lower Thoracic IR-TRACC Assemblies to the Spinebox Interface Plate (474-3072) use two M4 X 0.7 X 12 LG. BHCS per assembly (Figure 5-53).

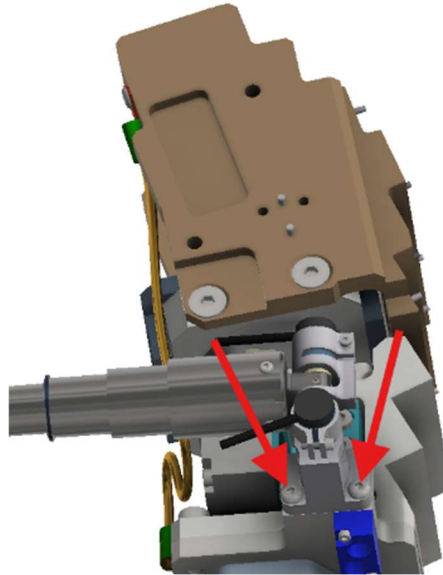


Figure 5-53. Attach lower thoracic IR-TRACCs to thoracic spine

- 5.3.20 To attach each of the Upper Thoracic IR-TRACC Assemblies to the Upper Spine Box (474-3100) use two M4 X 0.7 X 12 mm SHCS per assembly (Figure 5-54).

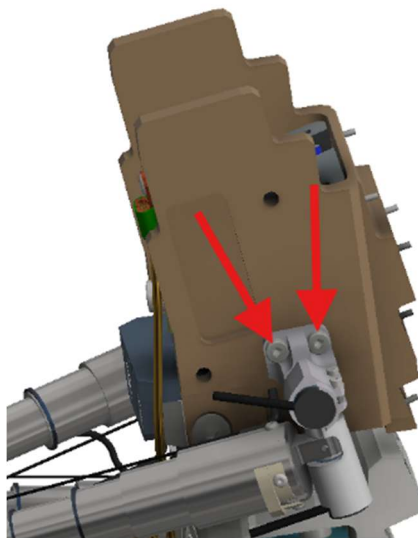


Figure 5-54. Attach upper thoracic IR-TRACCs to upper thoracic spine

- 5.3.21 Clip the left and right pressure sensor wires (Figure 5-55). Insert the APTS sensors (6004707) into the Abdomen Foam (474-4305) (Figure 5-56). The APTS sensors are installed with the instrumentation wires coming out of the bottom.

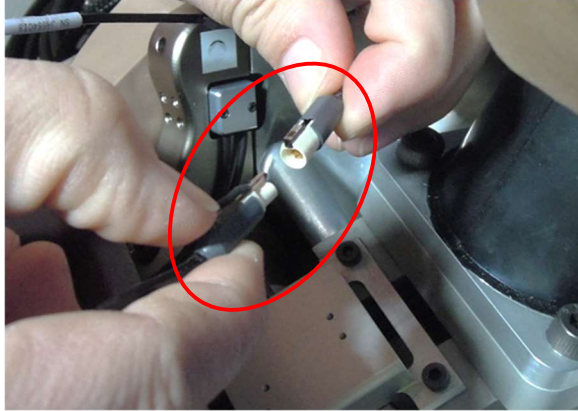


Figure 5-55. Clip the left and right pressure sensor wires

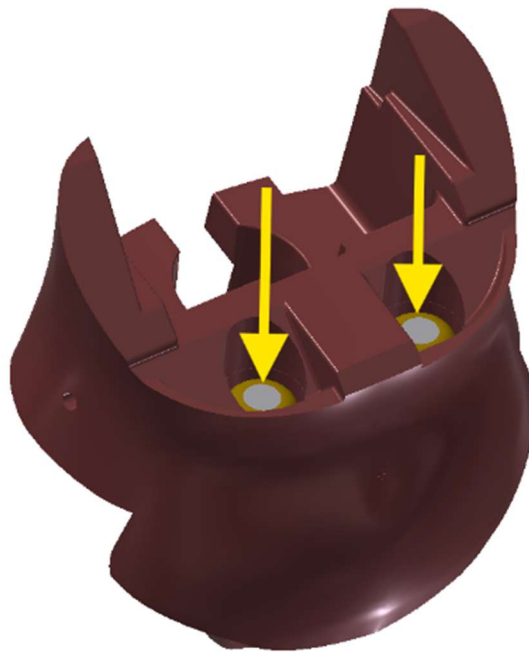


Figure 5-56. Insert the pressure sensors into the Abdomen (474-4305)

- 5.3.22 Insert the Abdomen Foam (474-4305) into the THOR-05F abdominal region (Figure 5-57).

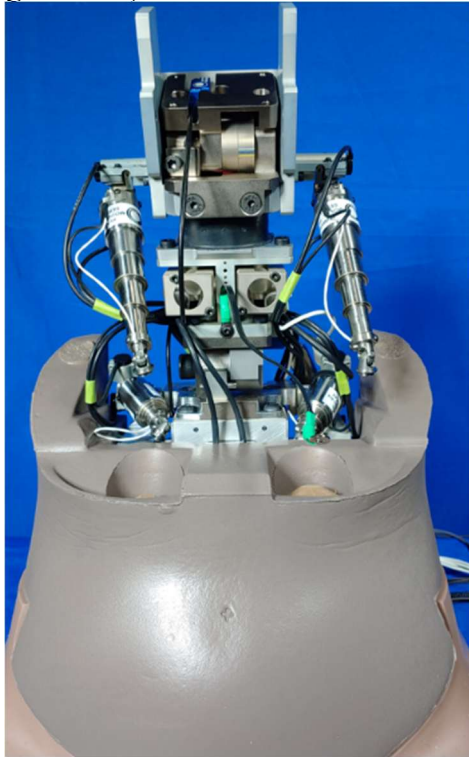


Figure 5-57. Insert the Abdomen Foam (474-4305)

- 5.3.23 Attach individual ribs, numbered 2 through 7 to the spine assembly (474-3200-A) with their respective Rib Stiffeners (each part is stamped with its respective position number) and two M5 X 0.8 X 8 LG. BHCS per rib assembly for all ribs (Figure 5-58). Note there are 3 different Rib Stiffeners (Table 5-4).

Table 5-4: Rib Assembly Details

Rib Position	Rib Part Number	Stiffener Part Number	Attachment Screw
1	474-3301-A	474-3331	M5 X 0.8 X 8 LG. BHCS
2	474-3302-A	474-3335-A	M5 X 0.8 X 8 LG. BHCS
3	474-3303-A	474-3335-A	M5 X 0.8 X 8 LG. BHCS
4	474-3304-A	474-3336-A	M5 X 0.8 X 8 LG. BHCS
5	474-3305-A	474-3336-A	M5 X 0.8 X 8 LG. BHCS
6	474-3306-A	474-3336-A	M5 X 0.8 X 8 LG. BHCS
7	474-3307-A	474-3336-A	M5 X 0.8 X 8 LG. BHCS

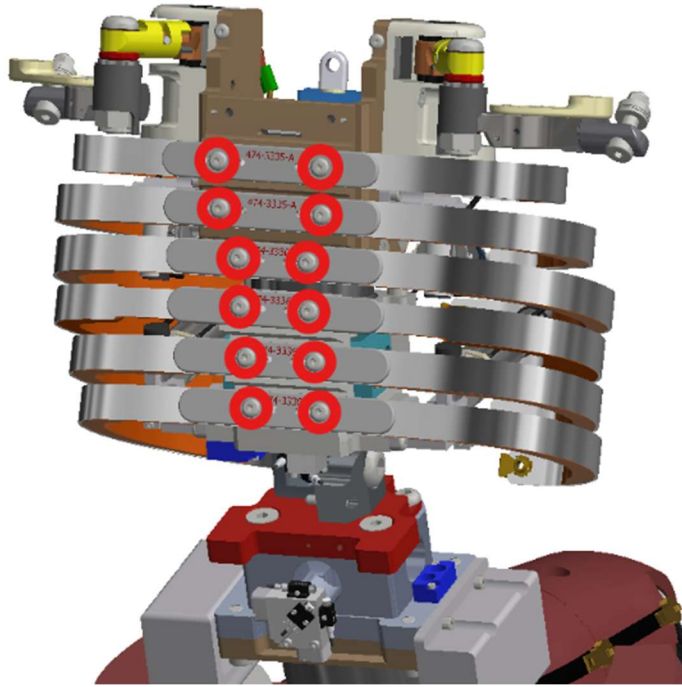


Figure 5-58. Attach Ribs 2-7, with their respective rib stiffeners

- 5.3.24 Attach Rib 1 (474-3301-A), Rib Stiffener (474-3331), Lifting Strap Bracket (474-3025), THOR Lift Strap (472-3116), and cable clamps (9003723) to the Spine Assembly (474-3200) using two M5 X 0.8 X 14 LG. BHCS (Figure 1-72 and Figure 5-60). Ensure that the lifting strap is installed between the Rib Stiffener and the Lifting Strap Bracket.



Figure 5-59. Install the Rib 1 Stiffener (474-3331), THOR Lifting Strap (472-3116), Lifting Strap Bracket (474-3025), and cable clamps (9003723)

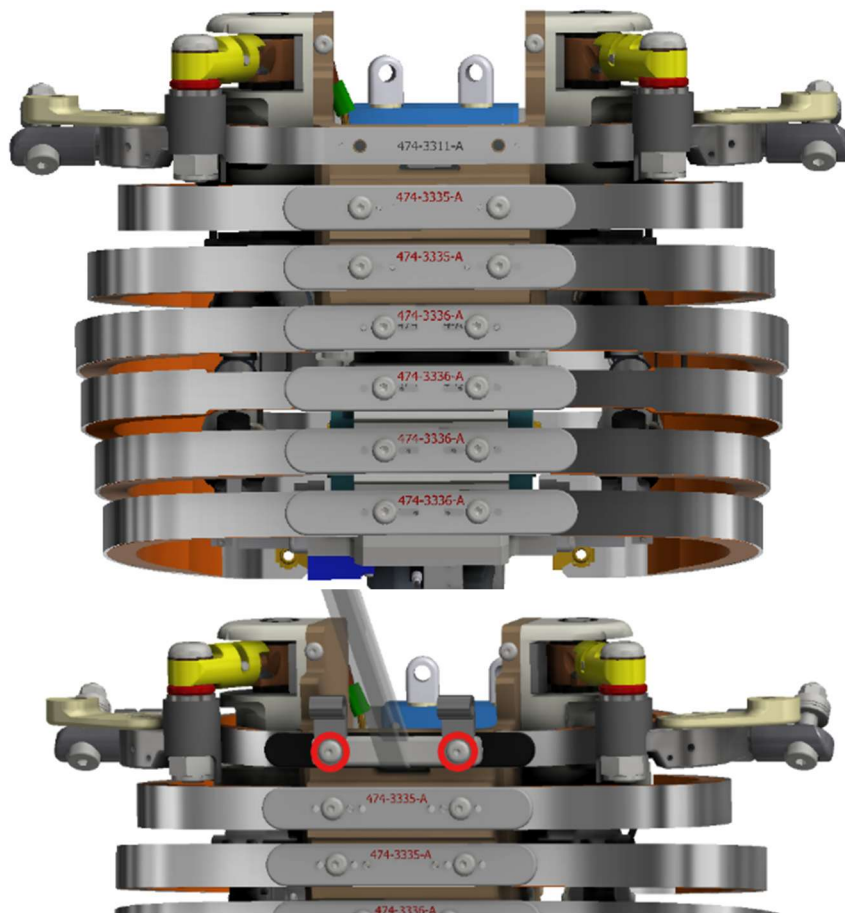


Figure 5-60. Install Rib 1 (474-3301-A)

- 5.3.25 Attach the two Clavicle-Sternum Adaptors (474-3041-A) to the Rib 1 to Sternum Adaptor (474-3040-A) with one M6 Flat Washer Plain Nylon, one M6 Flat Washer Plain Zinc, and a M6 X 1 Hex Lock Nut Zinc (Figure 5-61).

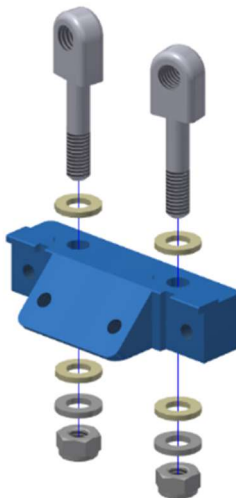


Figure 5-61. Attach the two Clavicle-Sternum Adaptors (474-3041) to the Rib 1 to Sternum Adaptor (474-3040-A)

5.3.26 Attach Rib 1 to Sternum Adaptor (474-3040-A) to the Rib 1 (474-3301-A) using two M5 X 0.8 X 8 LG. BHCS (Figure 5-62).

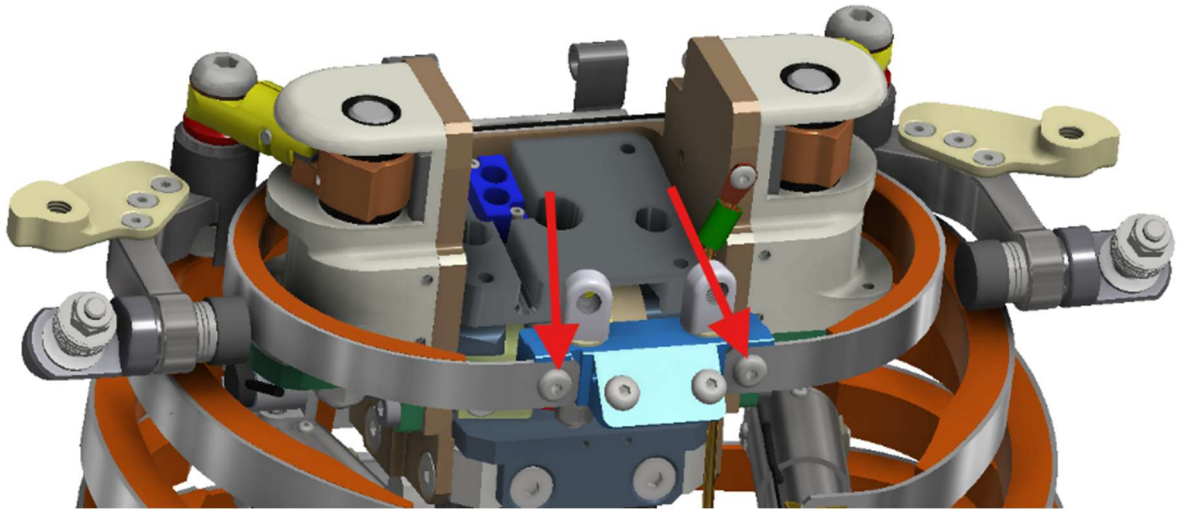


Figure 5-62. Attach Rib 1 to Sternum Adaptor (474-3040-A) to Rib 1 (474-3301-A)

5.3.27 Install the left Shoulder Assembly (474-3500-1-A) using two M6 X 1 X 16 LG. SHCS (Figure 5-63).

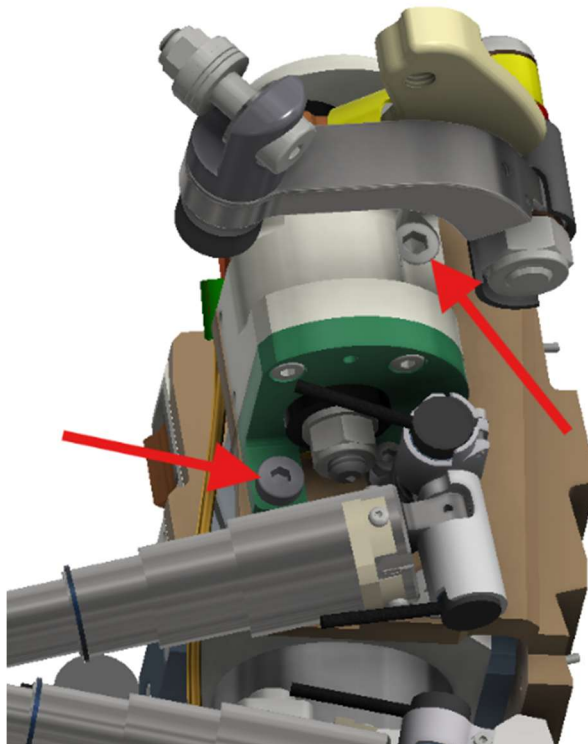


Figure 5-63. Insert two M6 X 1 X 16 LG. SHCS

- 5.3.28 Repeat step 5.3.27 to install the right Shoulder Assembly (474-3500-2-A).
- 5.3.29 Attach ground cables to the front of the left shoulder assembly (474-3500-1-A) and right shoulder assembly (474-3500-1,2-A) (Figure 5-64).

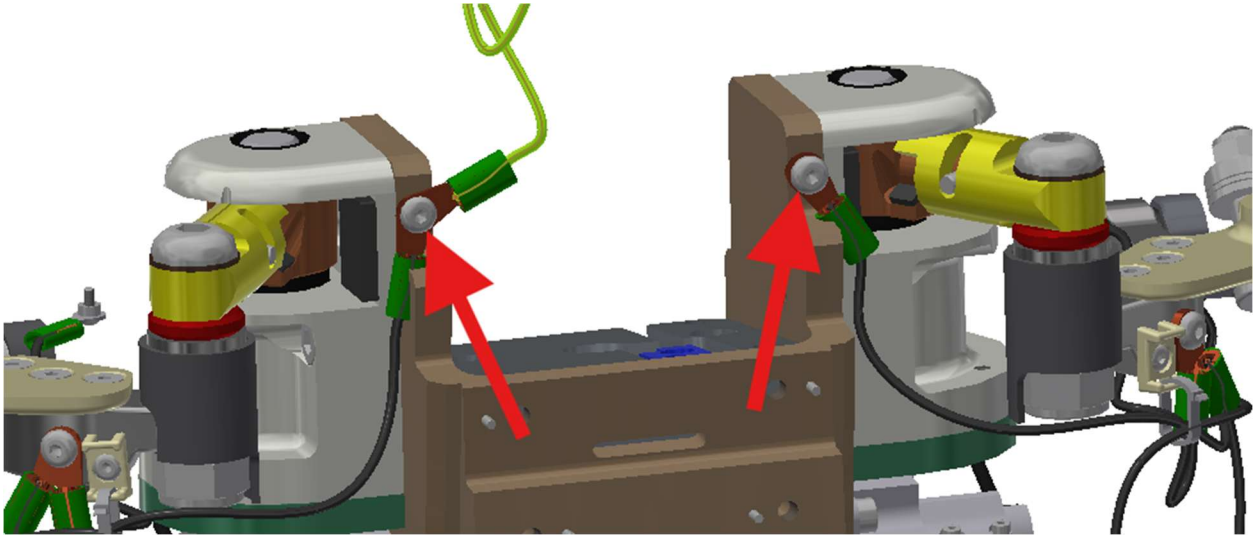


Figure 5-64. Attach ground cables

- 5.3.30 Attach one Uniaxial Piezoresistive Accelerometer (SA572-S4) to the back of the Sternum flesh (474-3700) with two M1.4 X 0.3 X 3 SHCS (Figure 5-65).

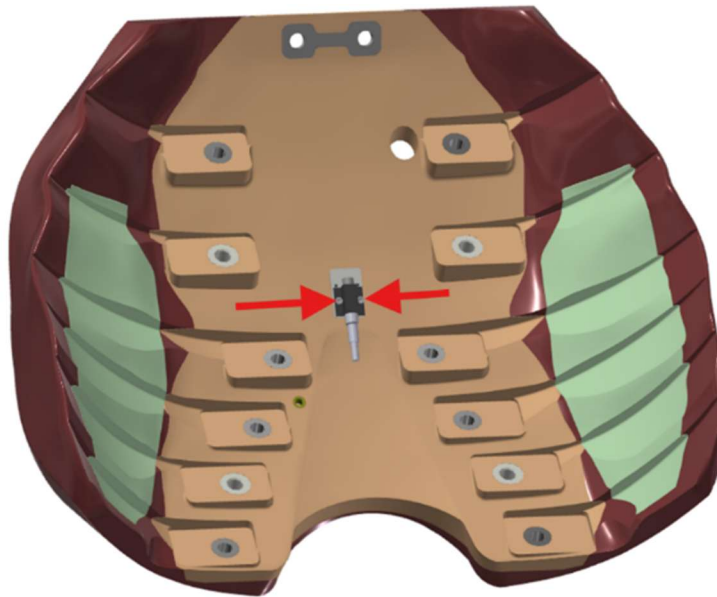


Figure 5-65. Attach one Uniaxial Piezoresistive Accelerometer (SA572-S4) to the back of the Sternum flesh (474-3730-A)

5.3.31 Attach the Molded Chest-Flesh Sternum (474-3730-A) to the front of the ribs using fourteen M5 X 0.8 X 12 LG. BHCS (Figure 5-66).

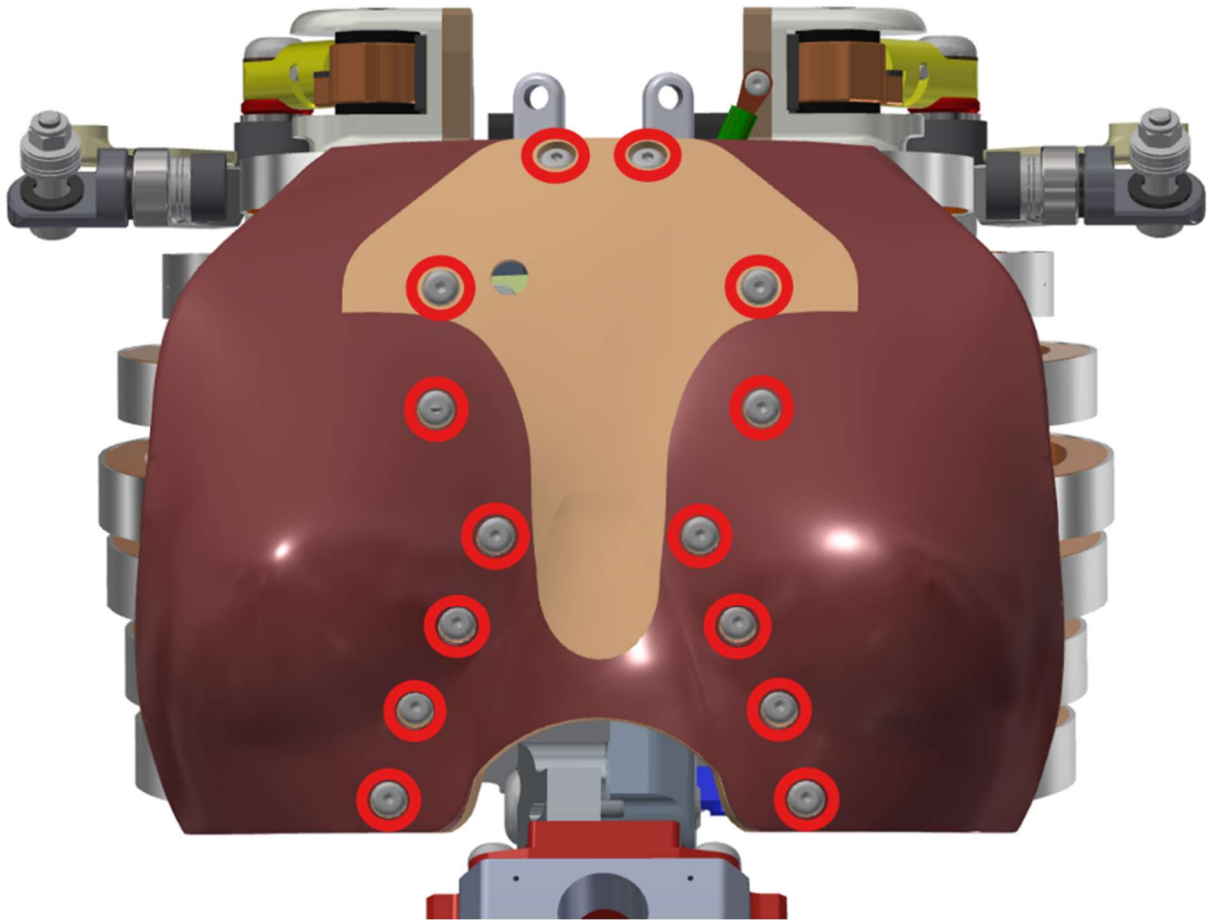


Figure 5-66. Attach the sternum to the front of the ribs

5.3.32 Attach ground cables to the left and right Clavicle Assemblies (474-3508) using a M4 X 0.7 X 6 BHCS and a washer (Figure 5-67).

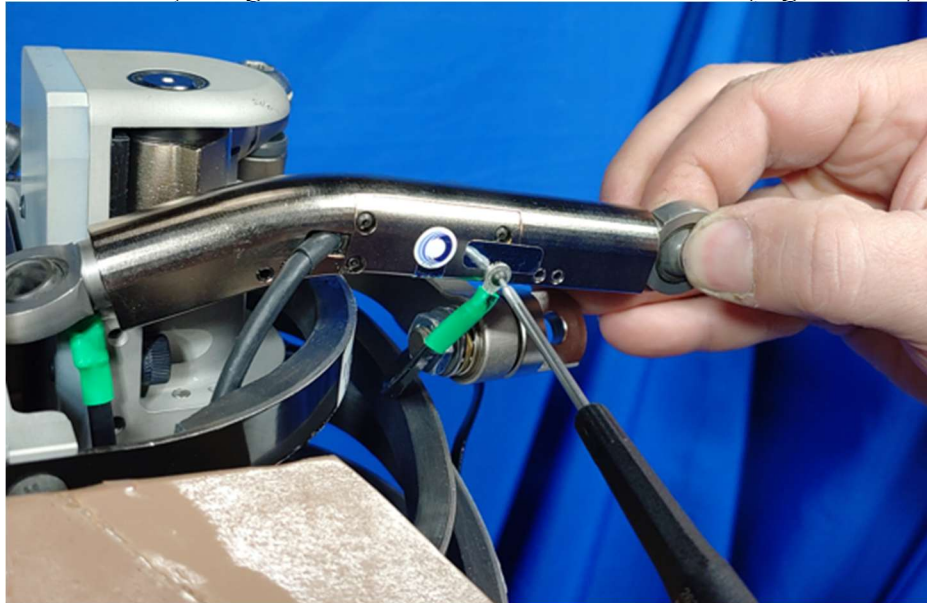


Figure 5-67. Attach ground cables to the left and right Clavicle Assemblies (474-3508)

5.3.33 Attach the Clavicle Assembly (474-3508) to the Clavicle-Sternum Adaptor (474-3041-A) using two M8 X 1.25 X 16 LG. BHCS (Figure 5-68).

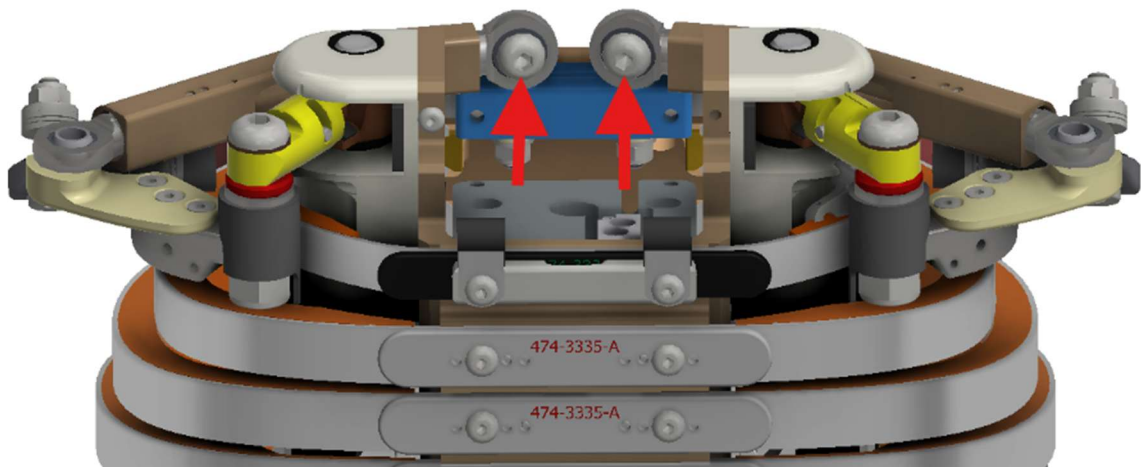


Figure 5-68. Attach the Clavicle Assembly (474-3508) to the Clavicle-Sternum Adaptor (474-3041-A)

- 5.3.34 Place the Shoulder Pad (474-3559-A) on top of the clavicle and shoulder assemblies (474-3508 and 474-3500-1,2). Attach the left and right Clavicle Assembly (474-3508) to the Upper Scapula (474-3506-1,2) with two M8 X 1.25 X 25 LG. BHCS through the Shoulder Pad (Figure 5-69).

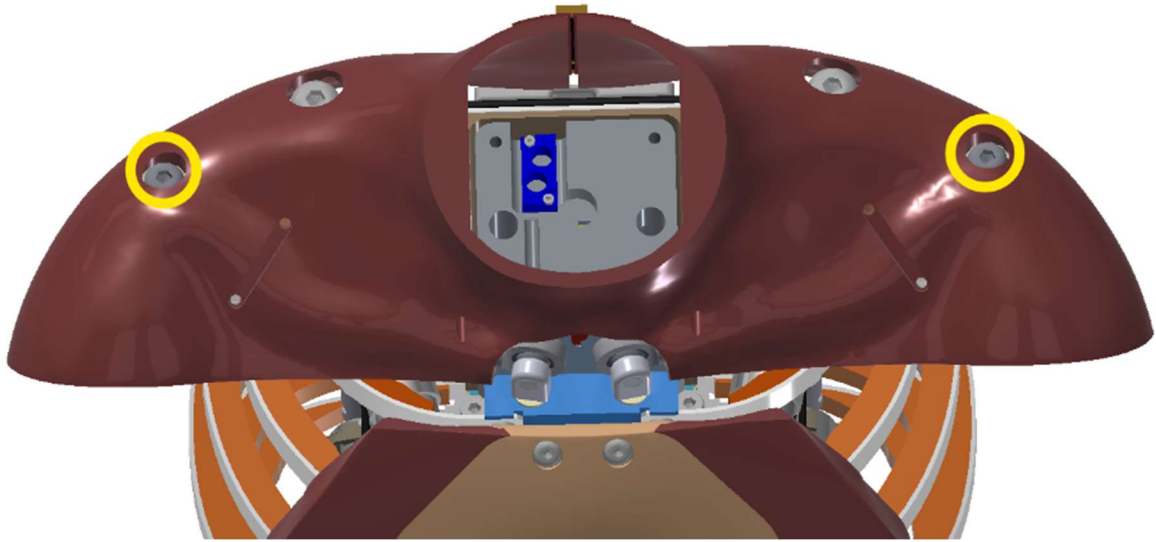


Figure 5-69. Install clavicle assembly (474-3508) to the Upper Scapula (474-3506-1,2) through the shoulder pad (474-3559-A)

- 5.3.35 Install 4 cable ties to fasten the Shoulder Pad (474-3559-A) to the Clavicle Assemblies (474-3508) (Figure 5-70).

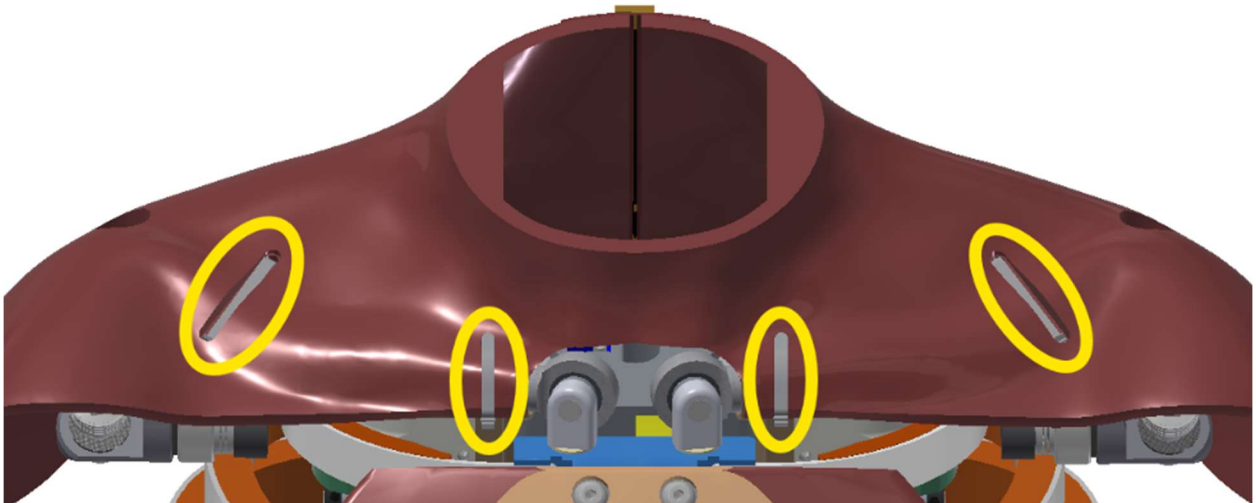


Figure 5-70. Install 4 cable ties to fasten the Shoulder Pad to the Clavicle Assemblies

5.4 Electrical Connections and Requirements

Section 13.3 includes grounding information. Section 13.4 describes cable routing instructions.

Section 6. Spine Assembly

6.1 Description of Spine Assembly and Features

The spine assembly (474-3200-A) for the THOR-05F dummy includes the mechanical components from the neck pitch change mechanism to the pelvis/lumbar mounting block (Figure 6-1). This advanced spine assembly includes the following features: two pitch change mechanisms; two flex joints; and instrumentation including a thoracic spine load cell, triaxial accelerometer assembly at T6, triaxial accelerometer and angular rate sensor assembly at T12, and three angular orientation (tilt) sensors (Figure 6-2).

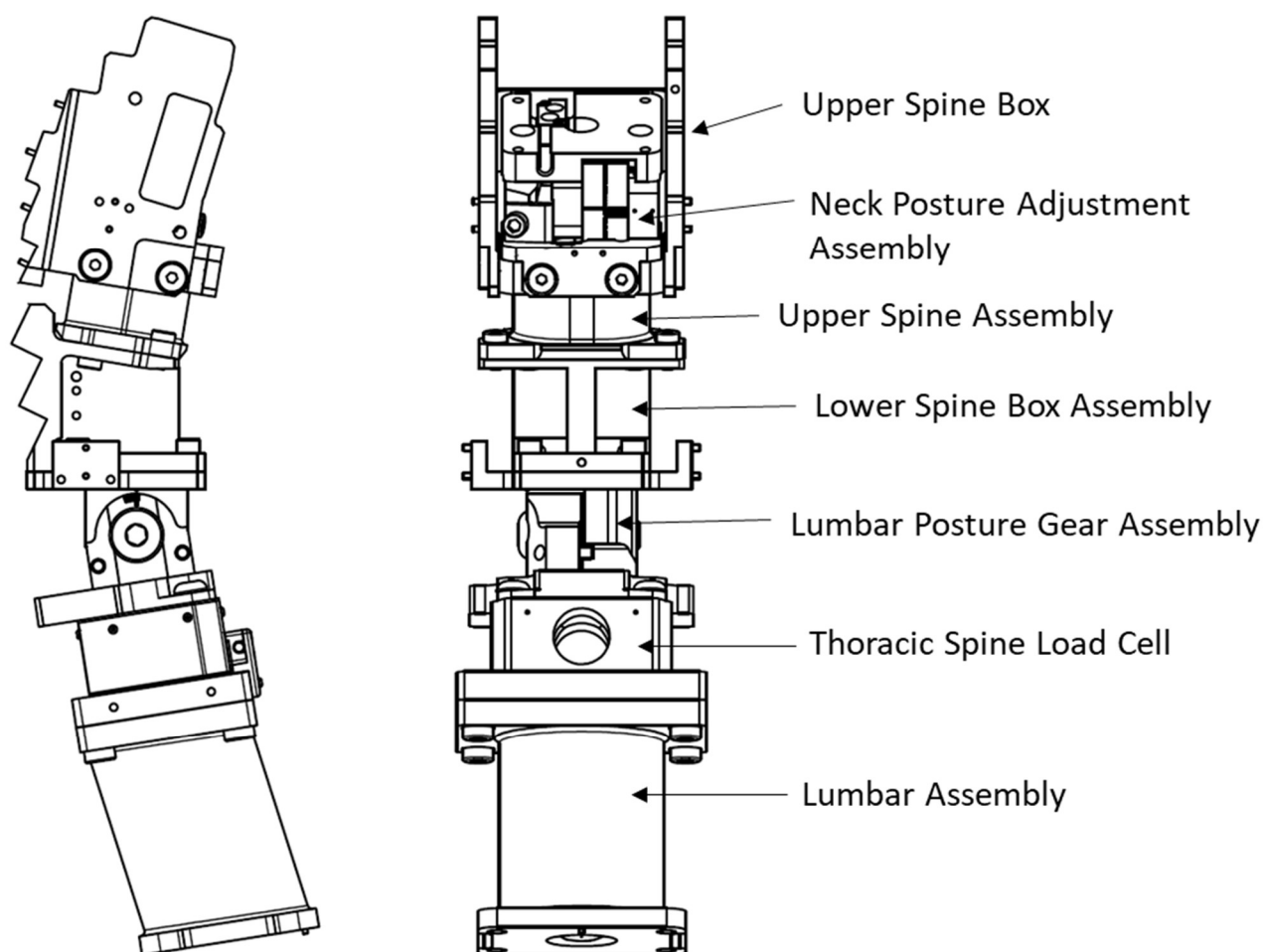


Figure 6-1. Complete spine assembly (474-3200-A)

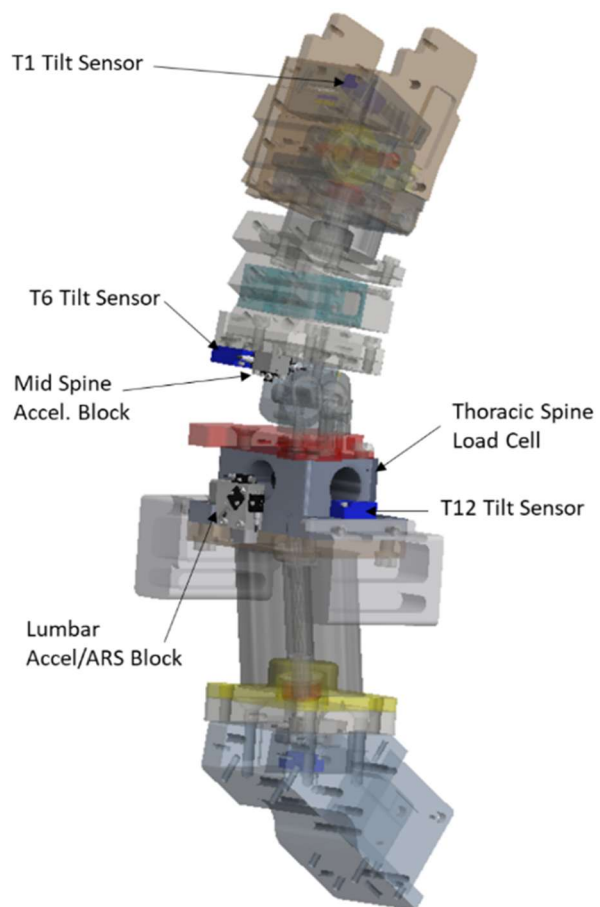


Figure 6-2. Spine instrumentation locations

Figure 6-3 through Figure 6-7 show illustrations of spine assembly (474-3200-A) components and hardware. Table 6-1 through Table 6-5 lists the components that are included in the spine assembly.

Table 6-1. Spine Assembly (474-3200-A) Components

Part Description	Quantity	Part Number	Figure #	Item #
Upper Spine Box	1	474-3100-A	Figure 6-3	1
Neck Posture Adjustment Assembly	1	474-3050	Figure 6-3	2
Structural Replacement, Thoracic Spine Load Cell	1	474-3202-A	Figure 6-3	3
Lower Spine Box		474-3101-A	Figure 6-3	4
Lumbar Spine Pitch Change Assembly	1	474-3220-A	Figure 6-3	5
Lumbar Assembly	1	474-3223-A	Figure 6-3	6
Upper Spine Assembly	1	474-3240	Figure 6-3	7
M8 X 1.25 X 20 LG. SHCS	4	5000075	Figure 6-3	8
M8 X 1.25 X 25 LG. FHCS	4	5000117	Figure 6-3	9
M6 X 1 X 12 LG. LHCS	4	5001041	Figure 6-3	10
M6 X 1 X 14 LG. SHCS	4	5000604	Figure 6-3	11
M6 X 1 X 12 LG. FHCS	4	5000139	Figure 6-3	12
M6 X 1 X 14 LG. FHCS	4	5001324	Figure 6-3	13
M8 X 1.25 X 18 LG. BHCS	2	5000704	Figure 6-3	14

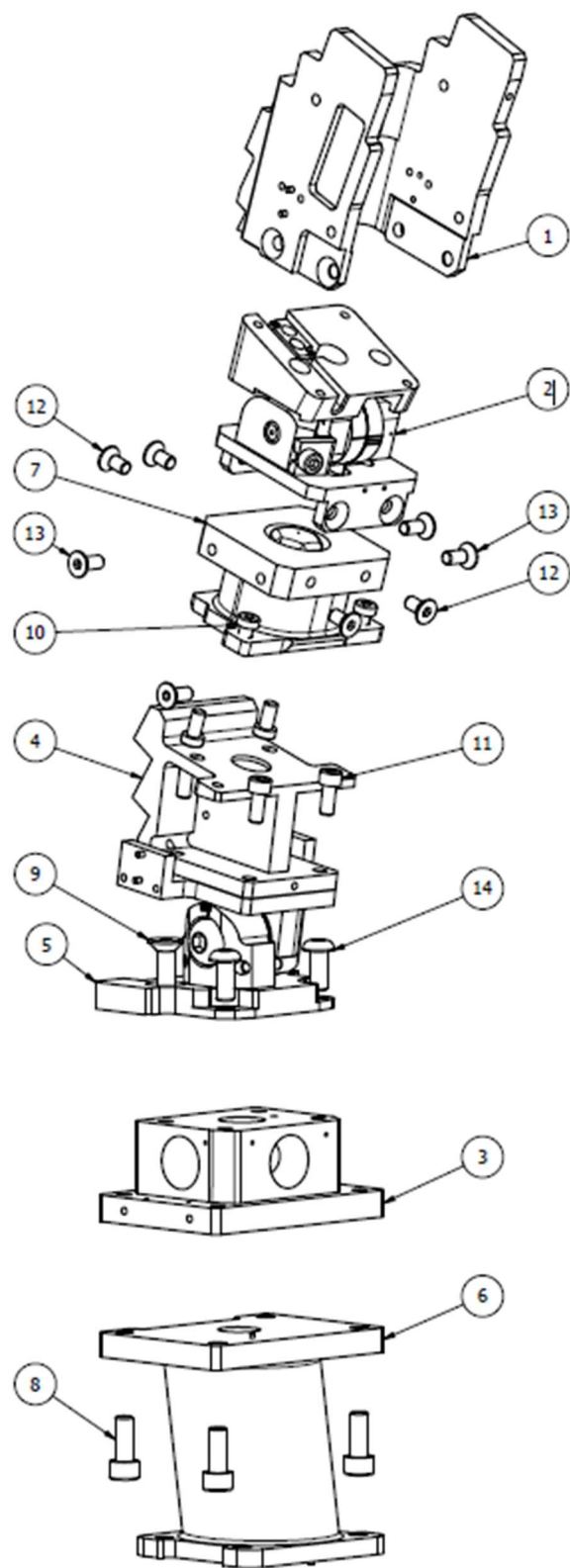


Figure 6-3. Spine Assembly (474-3200-A)

Table 6-2. Lumbar Assembly (474-3223-A) Components

Part Description	Quantity	Part Number	Figure #	Item #
Lumbar, Molded	1	474-3206-A	Figure 6-4	1
Bushing, Upper Neck	1	180-2004	Figure 6-4	2
Bushing, Neck Lower	1	180-2005	Figure 6-4	3
Lumbar Cable	1	474-3227	Figure 6-4	4
M12 Flat Washer Thick SS	1	5000804	Figure 6-4	5
M12 Hex Lock Nut, Modified	1	474-3228	Figure 6-4	6
Vinyl Cap Hex ¾ IW X 3/8 LG.	1	6005929	Figure 6-4	7

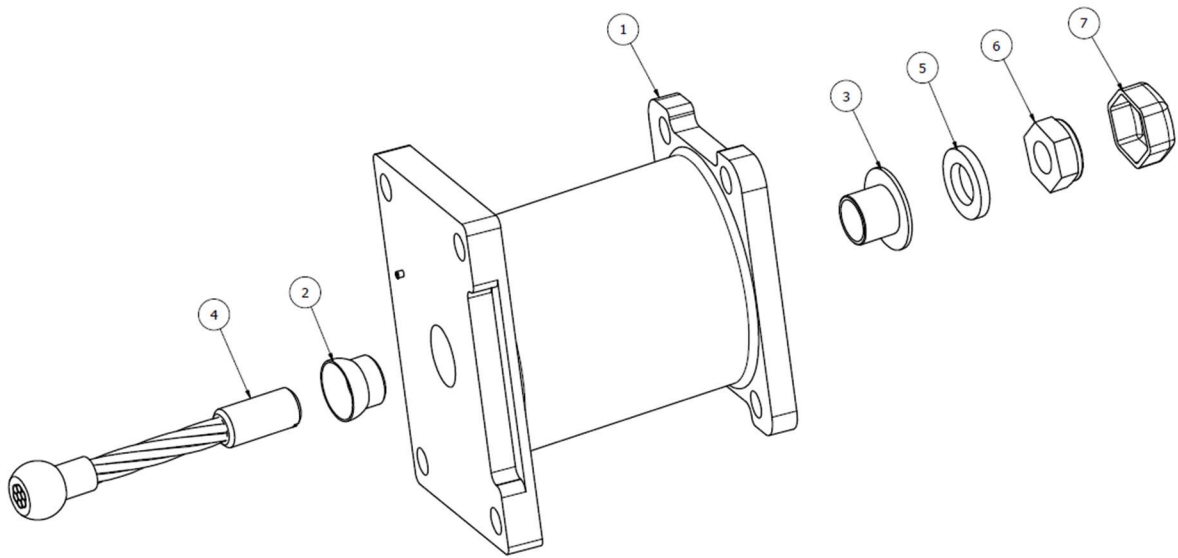


Figure 6-4. Lumbar Assembly (474-3223-A)

Table 6-3. Upper Spine Assembly (474-3240) Components

Part Description	Quantity	Part Number	Figure #	Item #
Upper Spine, Molded	1	474-3241	Figure 6-5	1
Bushing, Upper Neck	1	180-2004	Figure 6-5	2
Cable Bushing	1	474-3226	Figure 6-5	3
Upper Spine Cable	1	474-3224	Figure 6-5	4
M12 Flat Washer Thick SS	1	5000804	Figure 6-5	5
M12 Hex Lock Nut, Modified	1	474-3228	Figure 6-5	6
Vinyl Cap Hex 3/4 IW X 3/8 LG.	1	6005929	Figure 6-5	7

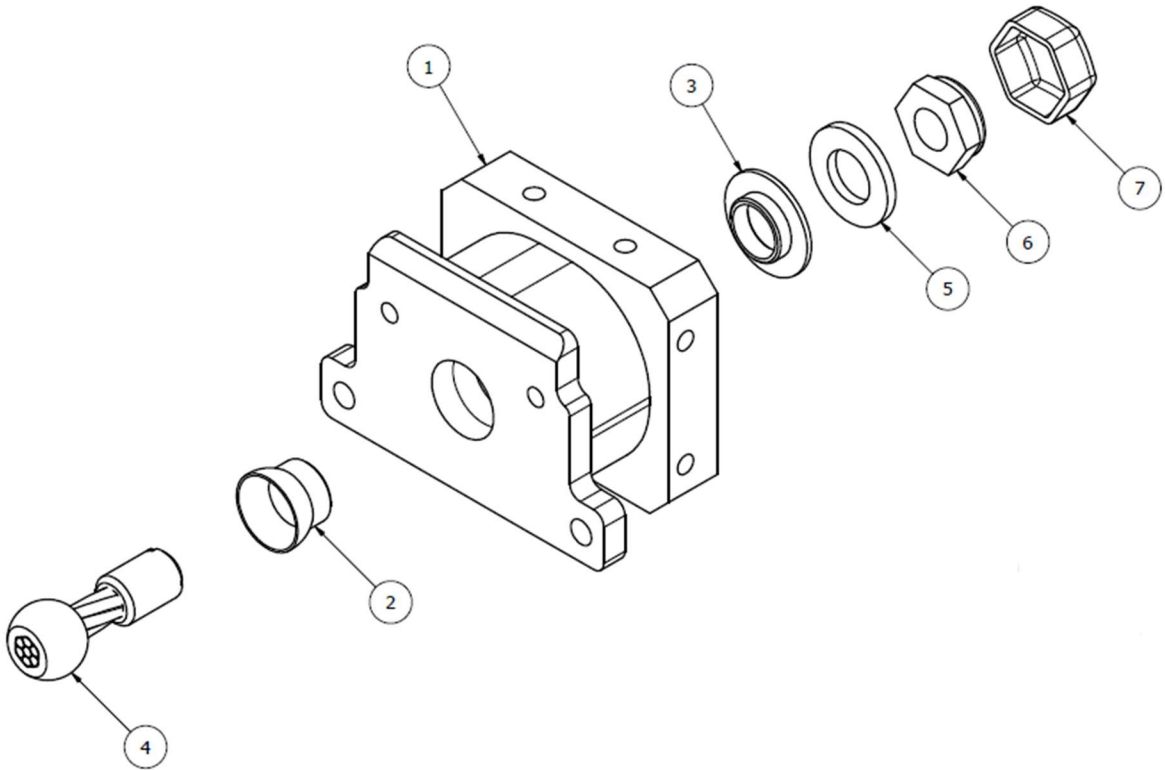


Figure 6-5. Upper Spine Assembly (474-3240)

Table 6-4. Neck Posture Adjustment Assembly (474-3050) Components

Part Description	Quantity	Part Number	Figure #	Item #
Base Plate, Neck Posture Adjustment	1	474-3051	Figure 6-6	1
Adjustment Wedge	1	474-3052	Figure 6-6	2
Modified M6 X 1 X 12 LG. SHCS	1	474-3053	Figure 6-6	3
Neck Adjustment Pivot Pin	1	474-3057	Figure 6-6	4
M5 Neck Pitch Change Screw	4	472-3638	Figure 6-6	5
M4 X 18 LG. Roll Pin	2	5001390	Figure 6-6	6
Neck Interface Plate, Neck Posture Adjustment	1	474-3058	Figure 6-6	7
Neck Posture Gear Assembly	1	474-3059	Figure 6-6	8
Spring Nested Wave Washer 17 X 24 X 4	1	5001718	Figure 6-6	9
Tilt Sensor, Dual Axis	1	SA572-S44	Figure 6-6	10
M2 X 0.4 X 10 LG. SHCS	2	5000215	Figure 6-6	11

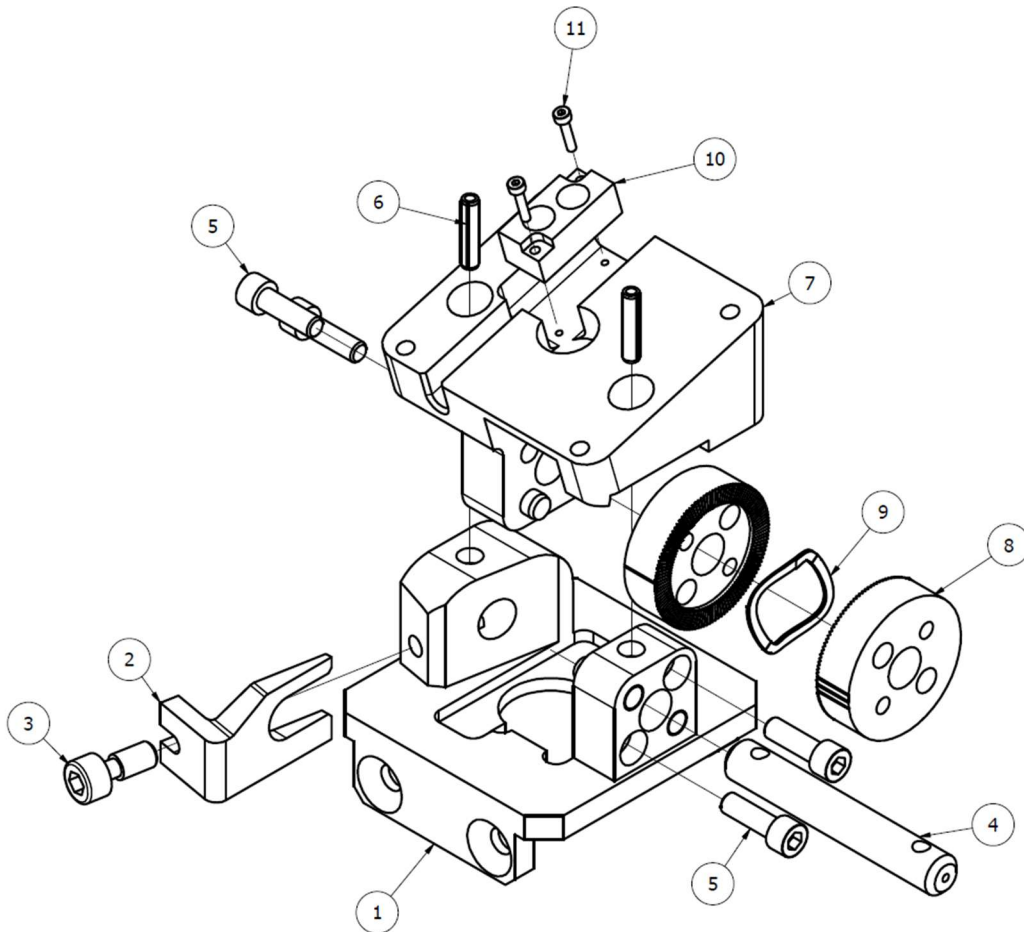


Figure 6-6. Neck posture adjustment assembly (474-3050) components

Table 6-5. Lumbar Spine Pitch Change Assembly (474-3220-A) Components

Part Description	Quantity	Part Number	Figure #	Item #
Base Plate, Lumbar Posture Adjustment	1	474-3071-A	Figure 6-7	1
Spinebox Interface Plate, Lumbar Posture Adjustment	1	474-3072	Figure 6-7	2
Lumbar Posture Gear Assembly	1	474-3068-A	Figure 6-7	3
M6 X 1 X 16 LG. FHCS	3	5000090	Figure 6-7	4
M6 X 1 X 20 LG. FHCS	3	5000089	Figure 6-7	5
Spring Nested Wave Washer 17 X 24 X 4	1	5001718	Figure 6-7	8
M12 X 1.75 X 45 LG. BHCS ZINC	1	5001835	Figure 6-7	9

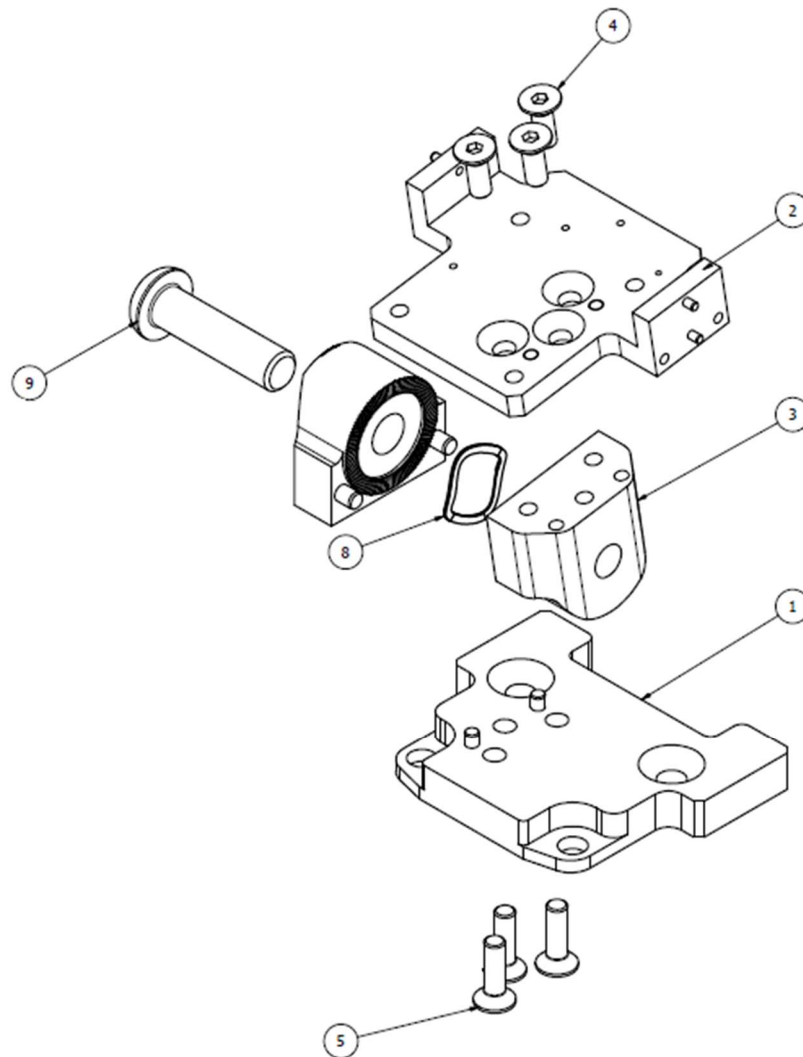


Figure 6-7. Lumbar Spine Pitch Change Assembly (474-3220-A)

6.2 Disassembly of Spine

The following is a step-by-step description of the disassembly procedure for the spine components.

- 6.2.1 Remove the Upper Spine Box (474-3100-A) from the Upper Spine Assembly (474-3240) by removing four M6 X 1 X 14 LG. FHCS (Figure 6-8).

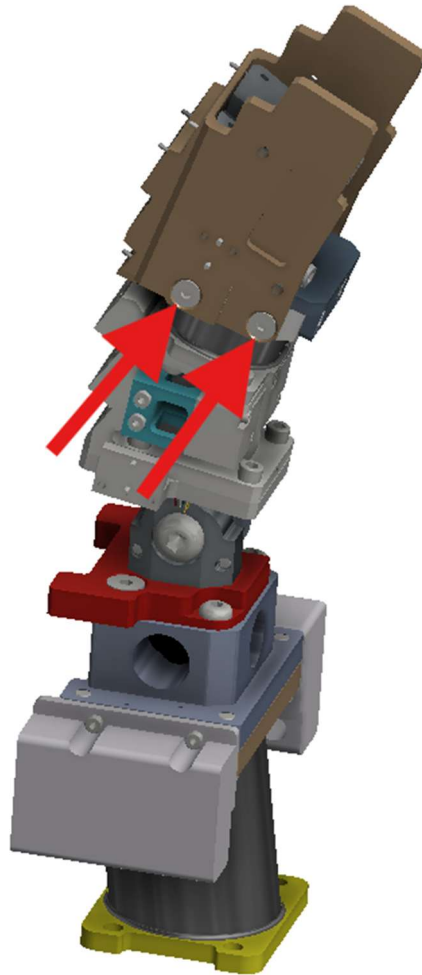


Figure 6-8. Remove the Upper Spine Box (474-3100-A) from the Upper Spine Assembly (474-3240)

- 6.2.2 Remove the Neck Posture Adjustment Assembly (474-3050) from the Upper Spine Assembly (474-3240) by removing four M6 X 1 X 12 LG. FHCS (Figure 6-9).

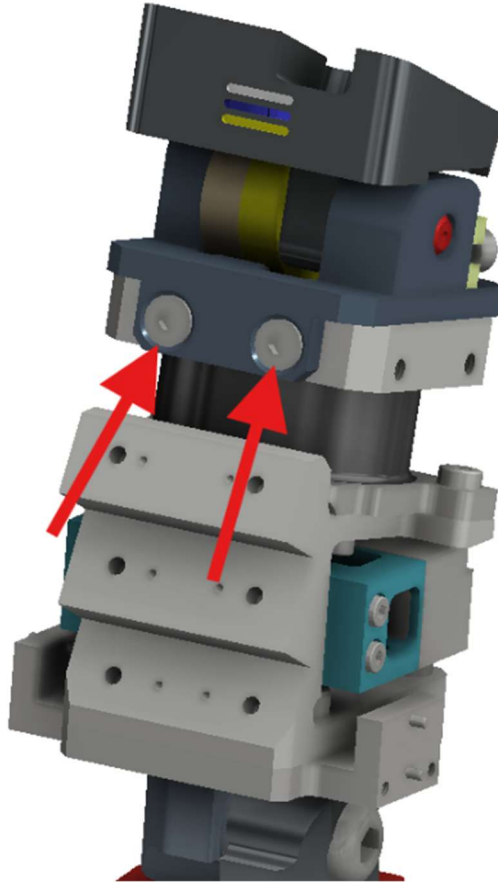


Figure 6-9. Remove the Neck Posture Adjustment Assembly (474-3050) from the Upper Spine Assembly (474-3240)

- 6.2.3 Remove the Adjustment Wedge (474-3052) from the Neck Posture Adjustment Assembly (474-3050) by removing one Modified M6 X 1 X 12 LG. SHCS (Figure 6-10).

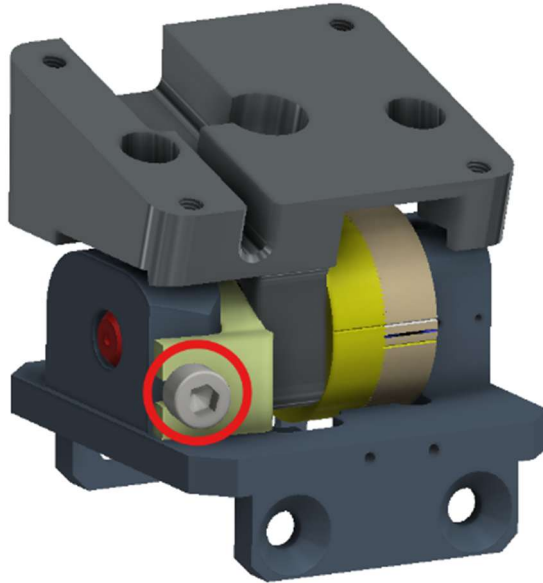


Figure 6-10. Remove the Adjustment Wedge (474-3052) from the Neck Posture Adjustment Assembly (474-3050)

- 6.2.4 Remove four M5 Neck Pitch Change Screws (472-3638) from the Neck Posture Adjustment Base Plate (474-3051) (Figure 6-11).

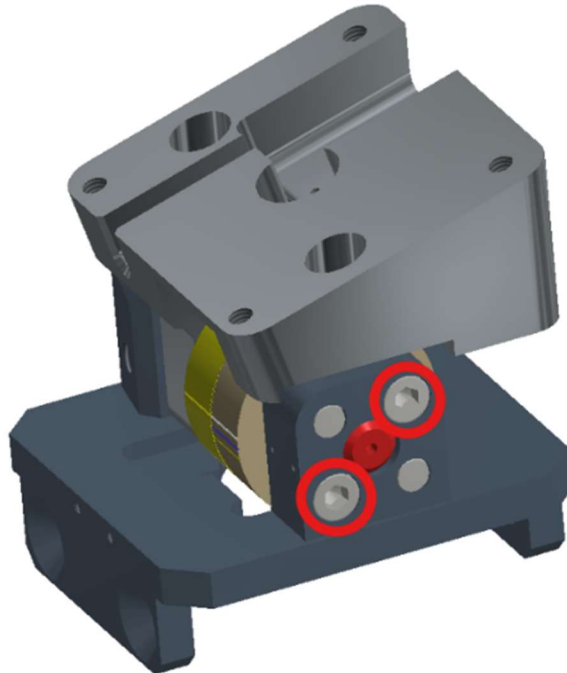


Figure 6-11. Remove four M5 Neck Pitch Change Screws (472-3638) from the Neck Posture Adjustment Base Plate (474-3051)

- 6.2.5 Remove the two M4 X 18 LG. Roll Pins from the bottom of the Neck Posture Adjustment Base Plate (474-3051) (Figure 6-12). Ensure the two plates are level so that the roll pin can be removed easily from the other plate. Slide the Neck Adjustment Pivot Pin (474-3057) from the Gear Assembly (474-3059) (Figure 6-13).

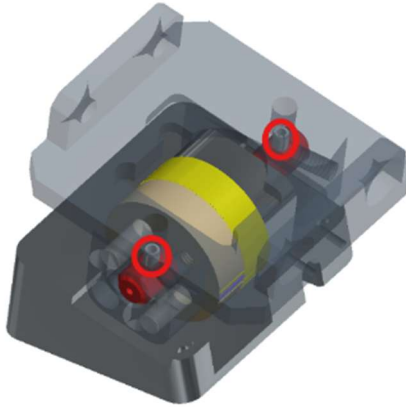


Figure 6-12. Remove the two M4 X 18 LG. Roll Pins from the bottom of the Neck Posture Adjustment Base Plate (474-3051)

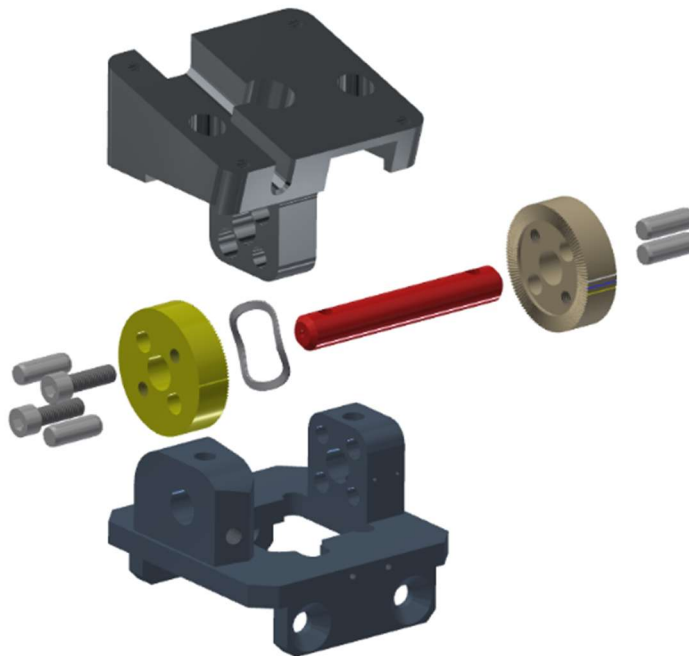


Figure 6-13. Slide the Neck Adjustment Pivot Pin (474-3057) from the Gear Assembly (474-3059)

- 6.2.6 Remove the two On Board DAS Structural Replacements and Mounting Brackets (474-3009-A and 474-3001-A) on either side of the Lower Spine Box (474-3101-A) by removing two M4 X 0.7 X 35 LG. SHCS SS (Figure 6-14).

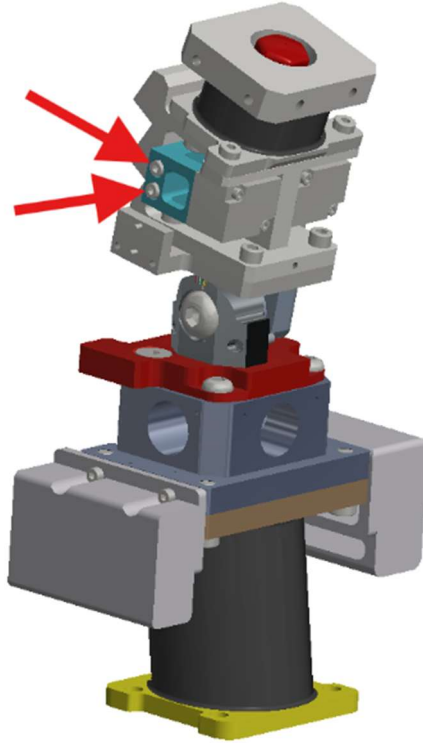


Figure 6-14. Remove the two On Board DAS Structural Replacements (474-8208)

- 6.2.7 Remove two M3 X 0.5 X 60 LG. SHSS from the On Board DAS Structural Replacement and Mounting Bracket (474-3009-A and 474-3001-A) (Figure 6-15).

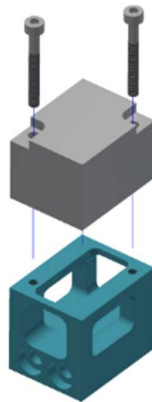


Figure 6-15. Remove two M3 X 0.5 X 60 LG. SHSS from the On Board DAS Structural Replacement and Mounting Bracket (474-3009-A and 474-3001-A)

- 6.2.8 Remove the Upper Spine Assembly (474-3240) from the Lower Spine Box Assembly (474-3101-A) by removing four M6 X 1 X 12 LG. LHCS (Figure 6-16).

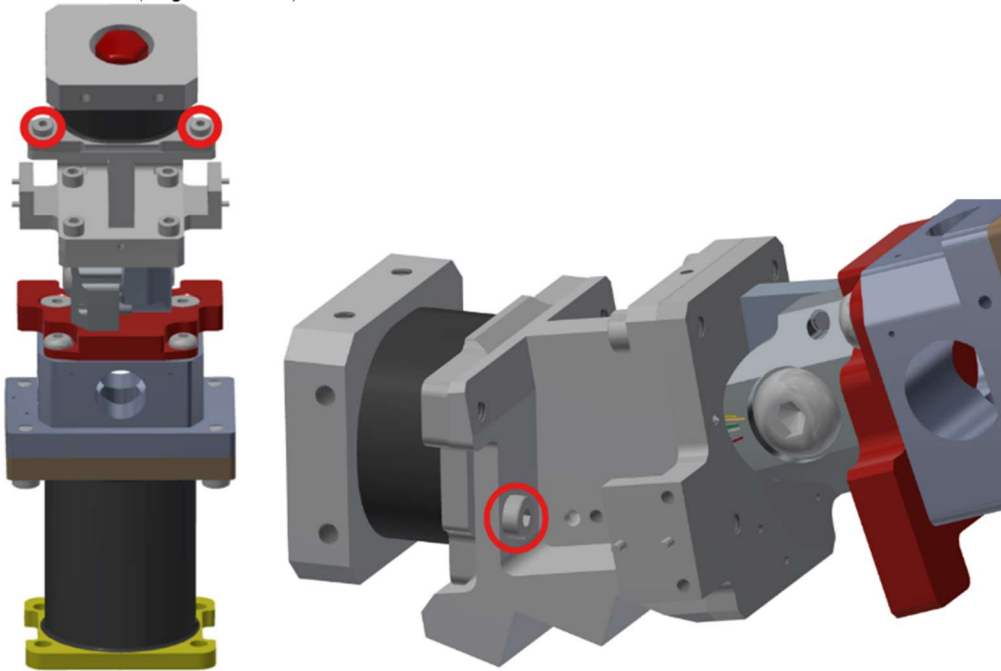


Figure 6-16. Remove the Upper Spine Assembly (474-3240) from the Lower Spine Box Assembly (474-3101-A)

- 6.2.9 In order to disassemble the Upper Spine Assembly (474-3240), remove the red cap (Figure 6-17). Remove the modified M12 Hex Lock Nut (474-3747) with a flat head screwdriver and a modified socket (Figure 6-18).

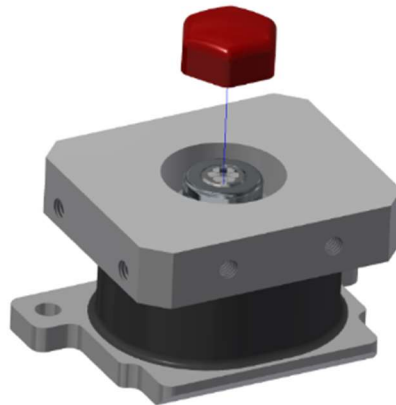


Figure 6-17. Remove the red cap



Figure 6-18. Remove the modified M12 Hex Lock Nut with a flat head screwdriver and a modified socket

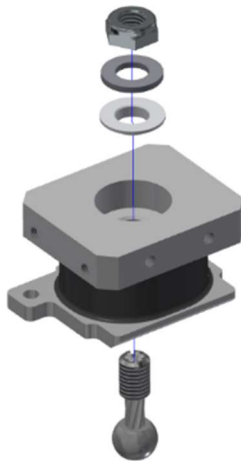


Figure 6-19. Separate the Upper Spine Assembly (474-3240)

- 6.2.10 Remove the Lower Spine Box (474-3101-A) from the Spinebox Interface Plate (474-3072) by removing four M6 X 1 X 14 LG. SHCS (Figure 6-20).

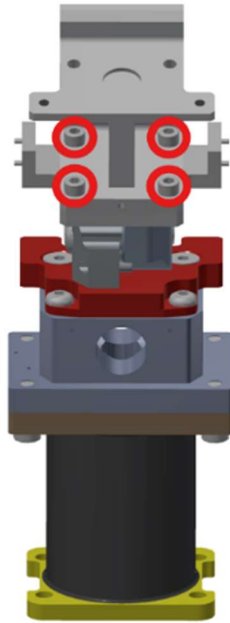


Figure 6-20. Remove the Lower Spine Box Assembly (474-3101-A) from the Spinebox Interface Plate (474-3072)

- 6.2.11 Remove the Lumbar Posture Adjustment Base Plate (474-3071-A) from the Thoracic Spine Load Cell (SA572-S107) by removing four M8 X 1.25 X 25 LG. FHCS (Figure 6-21).

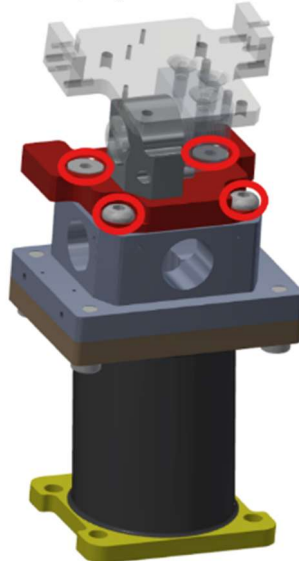


Figure 6-21. Remove the Lumbar Posture Adjustment Base Plate (474-3071-A) from the Thoracic Spine Load Cell (SA572-S107)

6.2.12 Remove the M12 X 1.75 X 45 LG. SHCS from the Lumbar Posture Gear Assembly (474-3068-A) (Figure 6-22).

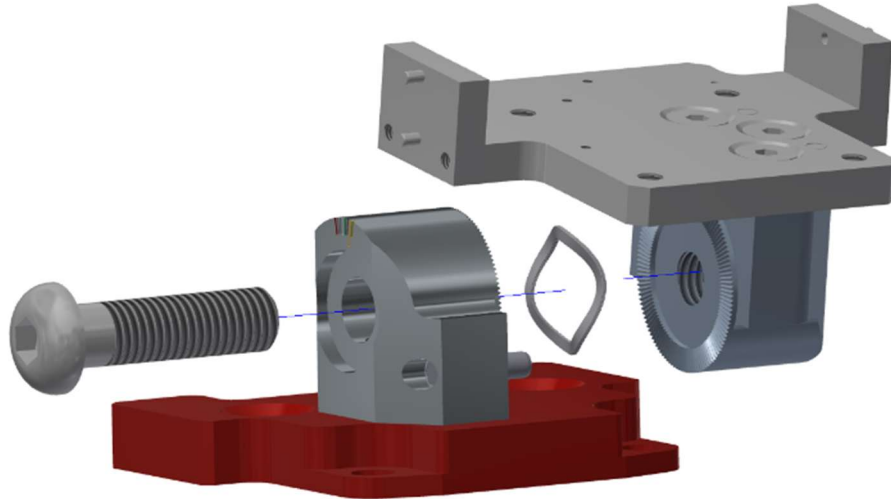


Figure 6-22. Remove the M12 X 1.75 X 45 LG. SHCS from the Lumbar Posture Gear Assembly (474-3068-A)

6.2.13 Remove the Lumbar Posture Gear Assembly (474-3068-A) from the Spinebox Interface Plate (474-3072) by removing three M6 X 1 X 16 LG. FHCS (Figure 6-23) and the Base Plate (474-3071-A) by removing three M6 X 1 X 20 LG. FHCS (Figure 6-24).

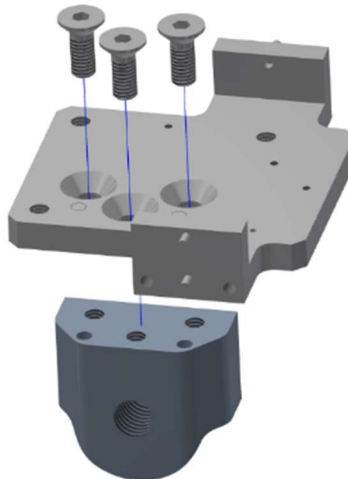


Figure 6-23. Remove the Lumbar Posture Gear Assembly (474-3068-A) from the Spinebox Interface Plate (474-3072) by removing three M6 X 1 X 16 LG. FHCS

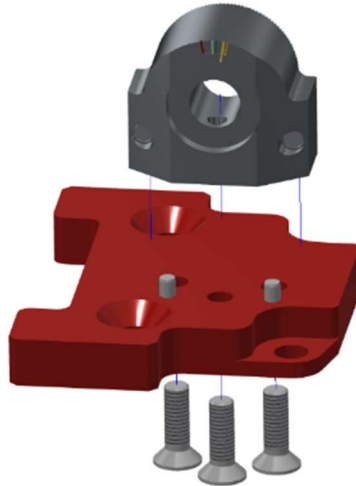


Figure 6-24. Remove the Lumbar Posture Gear Assembly (474-3068-A) from the Base Plate (474-3071-A) by removing three M6 X 1 X 20 LG. FHCS

6.2.14 Remove the Left Lower Spine Ballast (474-3002-1) by removing two M5 X 0.8 X 25 LG. SHCS. Then remove the Right Lower Spine Ballast (474-3002-2) by removing two M4 X 0.7 X 14 LG. SHCS (Figure 6-25).

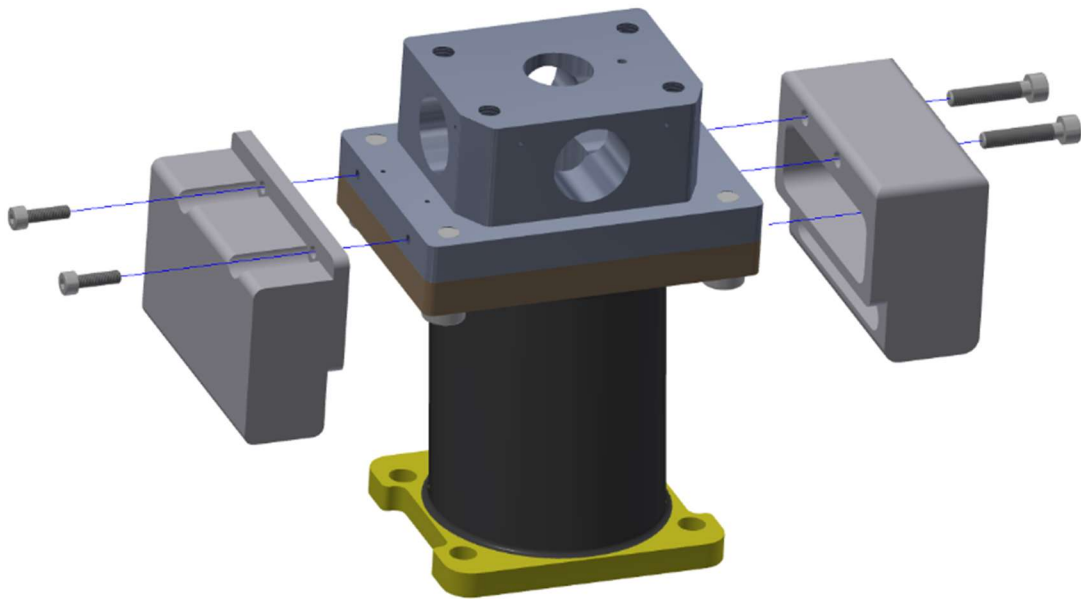


Figure 6-25. Remove the Structural Replacements, On Board DAS DB (474-3006)

- 6.2.15 Remove the Thoracic Spine Load Cell (SA572-S107) from the Lumbar Assembly (474-3223-A) by removing four M8 X 1.25 X 20 LG. SHCS (Figure 6-26).

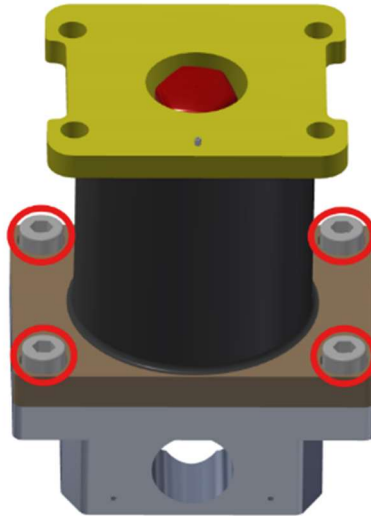


Figure 6-26. Remove the Thoracic Spine Load Cell (SA572-S107) from the Lumbar Assembly (474-3223) by removing four M8 X 1.25 X 20 LG. SHCS

- 6.2.16 In order to disassemble the Lumbar Assembly (474-3223-A), remove the red cap (Figure 6-27). Remove the modified M12 Hex Lock Nut (474-3228) with a flat head screwdriver and a modified socket (Figure 6-28).

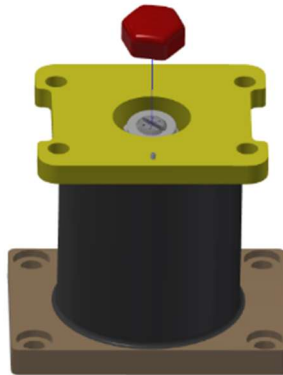


Figure 6-27. Remove the red cap

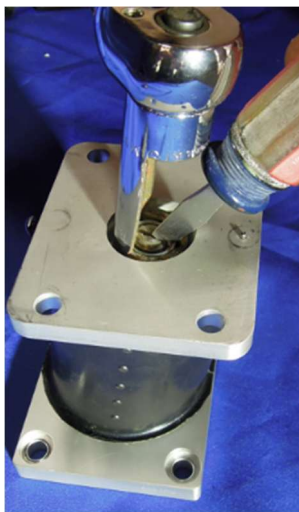


Figure 6-28. Remove the modified M12 Hex Lock Nut (474-3228) with a flat head screwdriver and a modified socket

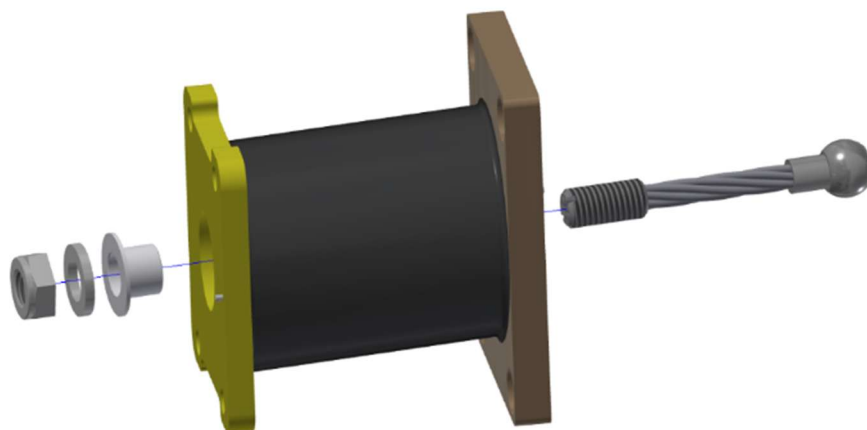


Figure 6-29. Separated Lumbar Assembly (474-3223-A)

6.3 Assembly of Spine

The following is a step-by-step description of the assembly procedure for the spine components. Unless otherwise specified, tighten all bolts to the torque specifications provided in Section 2.1.3.

- 6.3.1 Assemble the Lumbar Assembly (474-3223-A). Install an M12 Modified Lock Nut (474-3228), M12 Flat Washer, and a Neck Lower Bushing (180-2005) onto the threaded end of the lumbar cable (474-3227) (Figure 6-30). Use a screwdriver and socket head to tighten the nut without turning the cable (Figure 6-31). Tighten the nut to contact plus half of a turn.

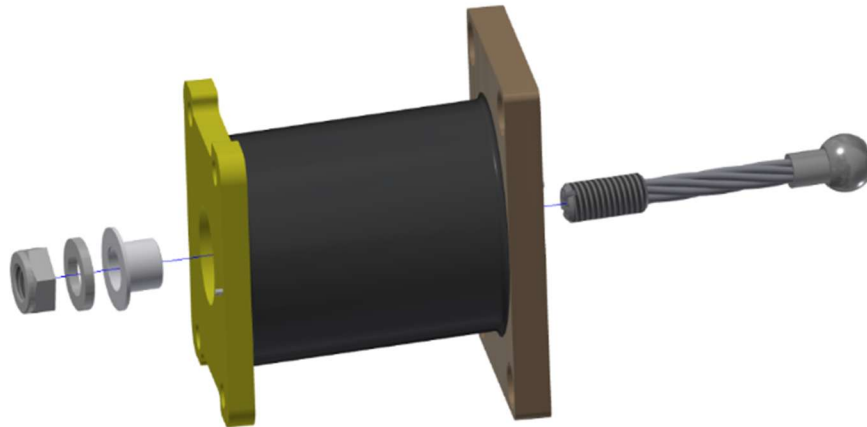


Figure 6-30. Lumbar Assembly (474-3223)



Figure 6-31. Install locknut to lumbar cable (474-3227)

6.3.2 Place the Vinyl Hex Cap over the modified locknut (Figure 6-32).

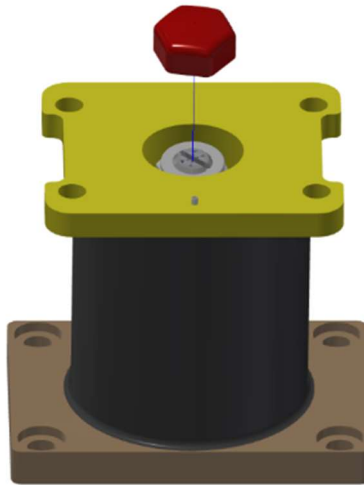


Figure 6-32. Vinyl nut cover over lumbar locknut

6.3.3 Secure the Lumbar Assembly (474-3223-A) to the Upper Torso to Pelvis Adaptor Plate (474-4004) using four M8 X 1.25 X 20 LG. SHCS (Figure 6-33).

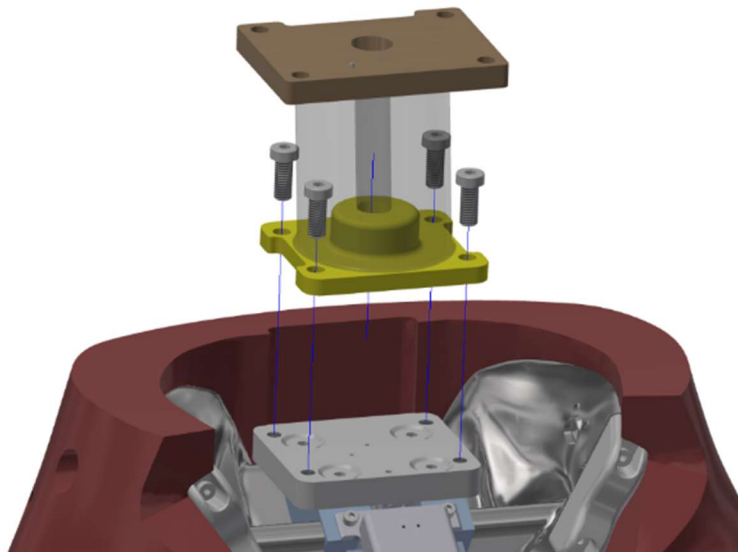


Figure 6-33. Secure the Lumbar Assembly (474-3223) to the Pelvis using four M8 X 1.25 X 20 LG. SHCS

- 6.3.4 Install the Thoracic Spine Load Cell (SA572-S107) onto the Lumbar Assembly (474-3223-A) using four M8 X 1.25 X 20 SHCS on the bottom of the top plate of the Lumbar Assembly (Figure 6-34).

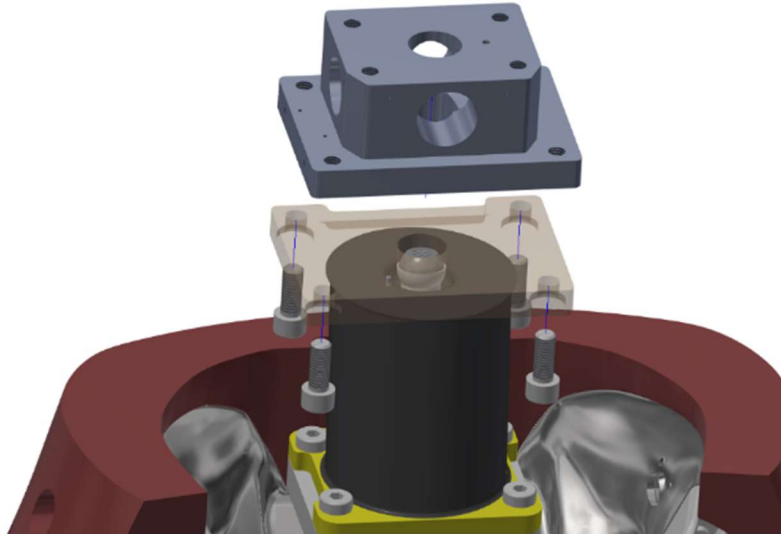


Figure 6-34. Install thoracic spine load cell (SA572-S107) to lumbar assembly (474-3223-A)

- 6.3.5 Attach the Left Lower Spine Ballast (474-3002-1) to the left side of the Thoracic Spine Load Cell (SA572-S107) using two M5 X 0.8 X 25 LG. SHCS and attach the Right Lower Spine Ballast (474-3002-2) to the right side of the Thoracic Spine Load Cell (SA572-S107) using two M4 X 0.7 X 14 LG (Figure 6-35).

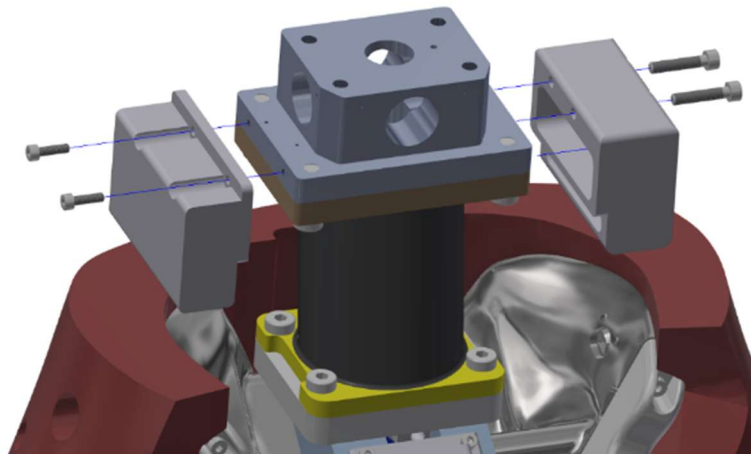


Figure 6-35. Attach the Right Lower Spine Ballast (474-3002-2) to the Thoracic Spine Load Cell (SA572-S107)

- 6.3.6 Attach the Bottom Lumbar Posture Gear (474-3063-A) to the Lumbar Posture Adjustment Base Plate (474-3071-A) using three M6 X 1 X 20 LG. FHCS (Figure 6-36).

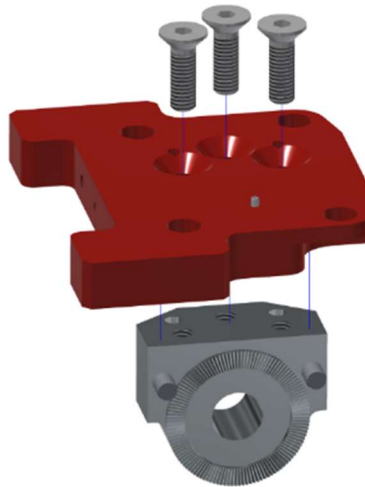


Figure 6-36. Attach the Bottom Lumbar Posture Gear (474-3063-A) to the Lumbar Posture Adjustment Base Plate (474-3071-A)

- 6.3.7 Attach the Top Lumbar Posture Gear (474-3065-A) to the Lumbar Posture Adjustment Spinebox Interface Plate (474-3072) using three M6 X 1 X 16 LG. FHCS (Figure 6-37).

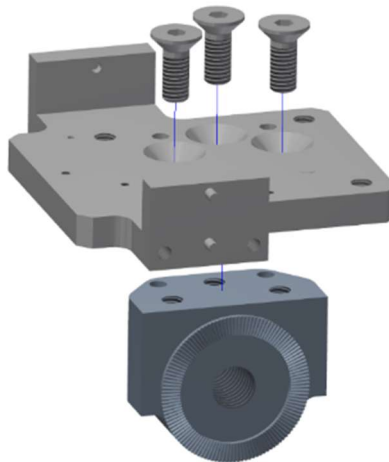


Figure 6-37. Attach the Top Lumbar Posture Gear (474-306-A5) to the Lumbar Posture Adjustment Spinebox Interference Plate (474-3072)

- 6.3.8 With a nested wave washer between the two gears, attach the top and bottom assemblies using an M12 X 1.75 X 45 mm SHCS adjustment bolt (Figure 6-38).

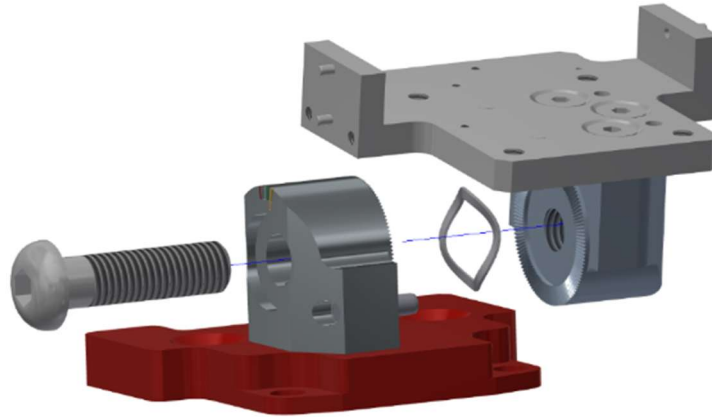


Figure 6-38. Lumbar Posture Gear Assembly (474-3068-A)

- 6.3.9 Attach the Lumbar Posture Adjustment Base Plate (474-3071-A) to the Thoracic Spine Load Cell (SA572-S107) using two M8 X 1.25 X 25 LG. FHCS and two M8 X 1.25 X 18 BHCS (Figure 6-39). Orient the head of the M12 X 1.75 X 45 mm SHCS adjustment bolt in the pitch change mechanism to the right-hand side of the spine assembly (474-3200-A). Install the two rear bolts helps to avoid interference with the Lumbar Posture Gear Assembly (474-3068-A). After achieving the desired lumbar angle, re-tighten the M12 adjustment bolt torque to 68.0 N-m (50.5 ft-lbf). For detailed instructions to set the lumbar angle, see Section 6.6.

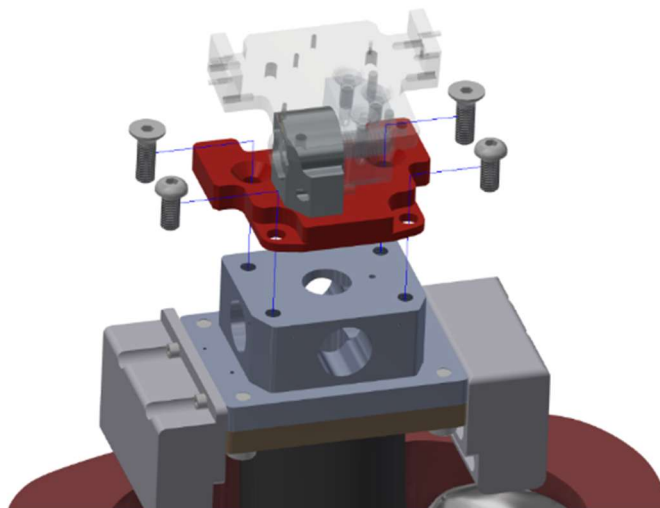


Figure 6-39. Secure lumbar spine pitch change assembly (474-3220-A) to thoracic spine load cell (SA572-S107)

- 6.3.10 Attach the Lower Spine Box Assembly (474-3101-A) to the Lumbar Posture Adjustment Spinebox Interference Plate (474-3072) using four M6 X 1 X 14 LG. SHCS (Figure 6-40).

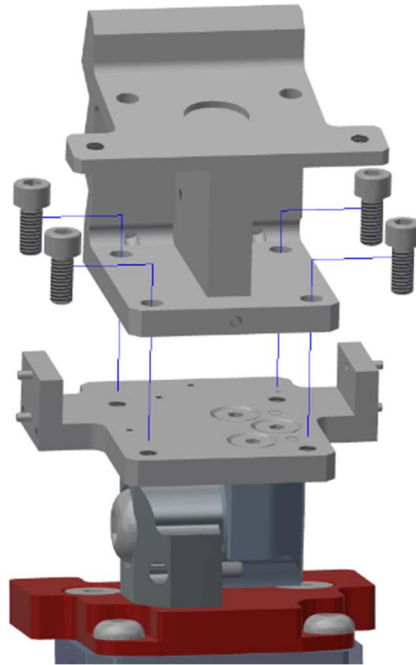


Figure 6-40. Install Lower Spine Box Assembly (474-3101-A) to the Lumbar Posture Adjustment Spinebox Interference Plate (474-3072)

- 6.3.11 Insert the Upper Spine Cable (474-3224) through the Upper Neck Bushing (180-2004) and the Upper Spine (474-3241). Install a Cable Bushing and M12 Flat Washer over the threaded portion of the cable (Figure 6-41).

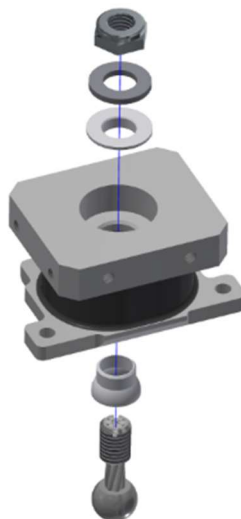


Figure 6-41. upper thoracic spine flex joint hardware

- 6.3.12 Install an M12 Modified Hex Lock Nut (472-3747) onto the threaded end of the Upper Spine Cable (474-3224). Use a screwdriver positioned through the socket head in order to tighten the nut without turning the cable (Figure 6-42). Tighten the nut to contact plus half of a turn. Cover the nut with M12 Hex Vinyl Cap (Figure 6-43).



Figure 6-42. Install locknut to upper spine cable (474-3224)

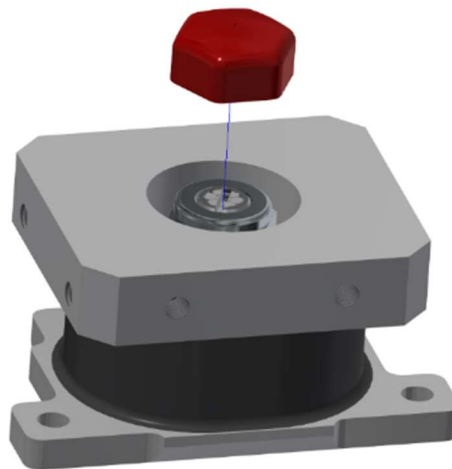


Figure 6-43. Vinyl cap for upper spine assembly locknut

- 6.3.13 Attach the Upper Spine Assembly (474-3240) to the Lower Spine Box Assembly (474-3101-A) using four M6 X 1 X 12 LG. LHCS (Figure 6-44). Install the front two LHCS from above and the rear two LHCS from the bottom. The flex joint must be oriented with the shape of the bottom plate matching the top of the Lower Spine Box (474-3101-A).

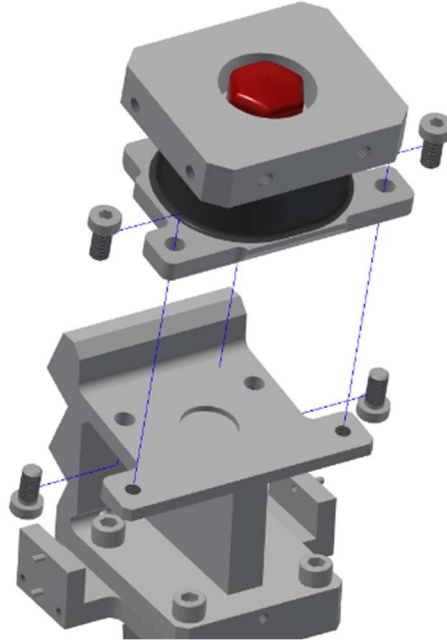


Figure 6-44. Upper flex joint assembled to lower thoracic spine assembly

- 6.3.14 Assemble the On Board DAS Structural Replacements (474-3009-A) to the Thorax On Board DAS Mounting Brackets (474-3001-A) using two M3 X 0.5 X 60 LG. SHCS per side (Figure 6-45).

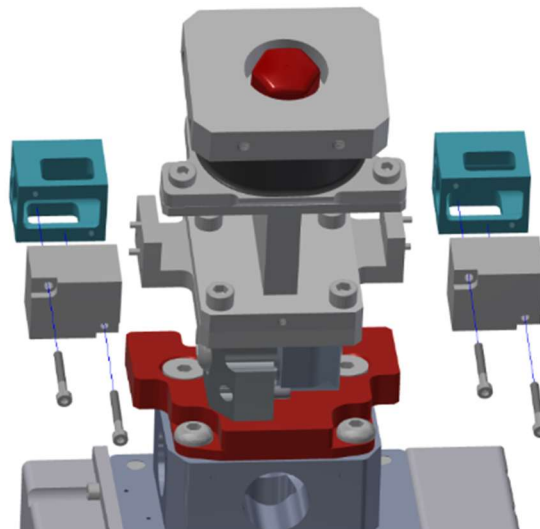


Figure 6-45. Assemble the On Board DAS Structural Replacements (474-3009-A) to the Thorax On Board DAS Mounting Brackets (474-3001)

- 6.3.15 Mount the Thorax On Board DAS Mounting Brackets (474-3001-A) to the left and right side of the Lower Thoracic Spine Assembly using two M4 X 0.7 X 35 LG. SHCS SS per side (Figure 6-46).

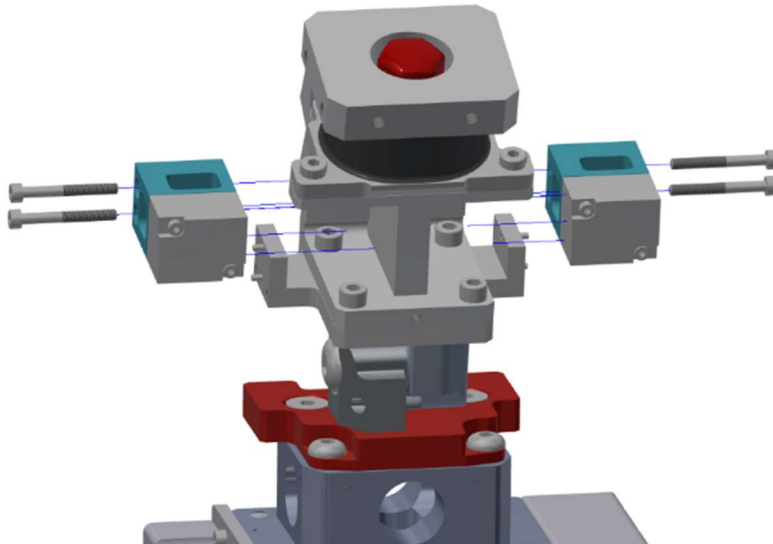


Figure 6-46. Mount the Thorax On Board DAS Mounting Brackets (474-3001-A) to the left and right side of the Lower Thoracic Spine Assembly

- 6.3.16 Assemble the Neck Posture Adjustment Assembly (474-3050) (Figure 6-47)

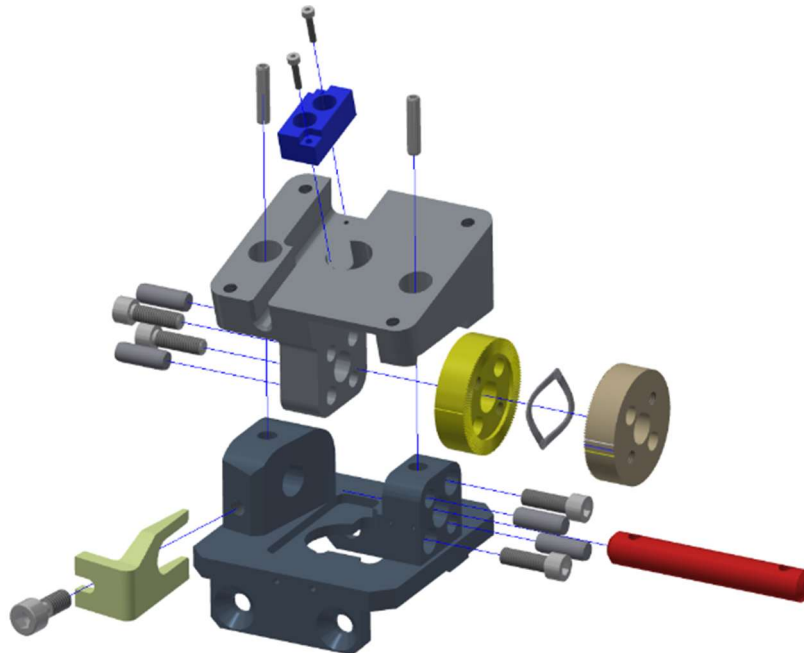


Figure 6-47. Neck posture adjustment assembly components

- 6.3.17 Install the Neck Posture Gear Assembly (474-3059) over the two Pull Out M6 X 16 Dowel Pins (5001266) on the Neck Posture Adjustment Base Plate (474-3050) and secure the gear using two M5 Neck Pitch Change Screws (472-3638) (Figure 6-48).

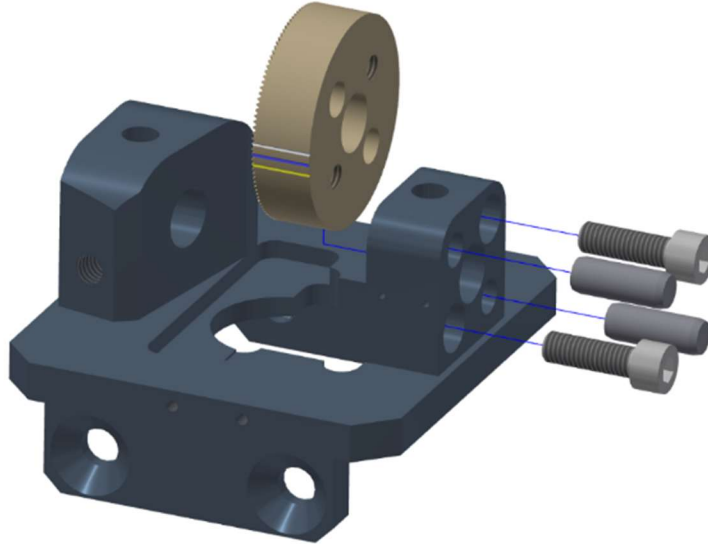


Figure 6-48. Install the Neck Posture Gear Assembly (474-3059) over the two Pull Out M6 X 16 Dowel Pins (5001266) on the Neck Posture Adjustment Base Plate (474-3050)

- 6.3.18 Install the Neck Posture Gear Assembly (474-3059) over the two Pull Out M6 X 16 Dowel Pins (5001266) on the Neck Posture Adjustment Neck Interference Plate (474-3058) and secure the gear using two M5 Neck Pitch Change Screws (472-3638) (Figure 6-49).

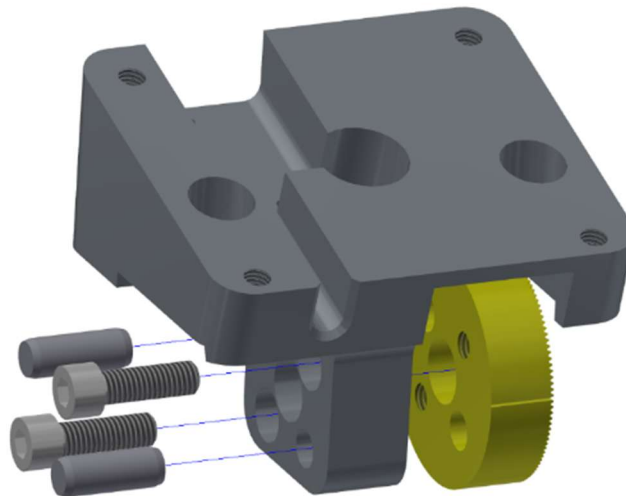


Figure 6-49. Install the Neck Posture Gear Assembly (474-3059) on the Neck Posture Adjustment Neck Interference Plate (474-3058)

- 6.3.19 Assemble the top and bottom plates together with a nested wave washer between the two gears. Align the indicator lines on each star pattern part to the desired position (the standard position is set to “neutral as shown in Figure 6-54). Be certain that the gears properly mate together so as not to damage the parts. Insert the Neck Adjustment Pivot Pin (474-3057) through the gears (Figure 6-50).

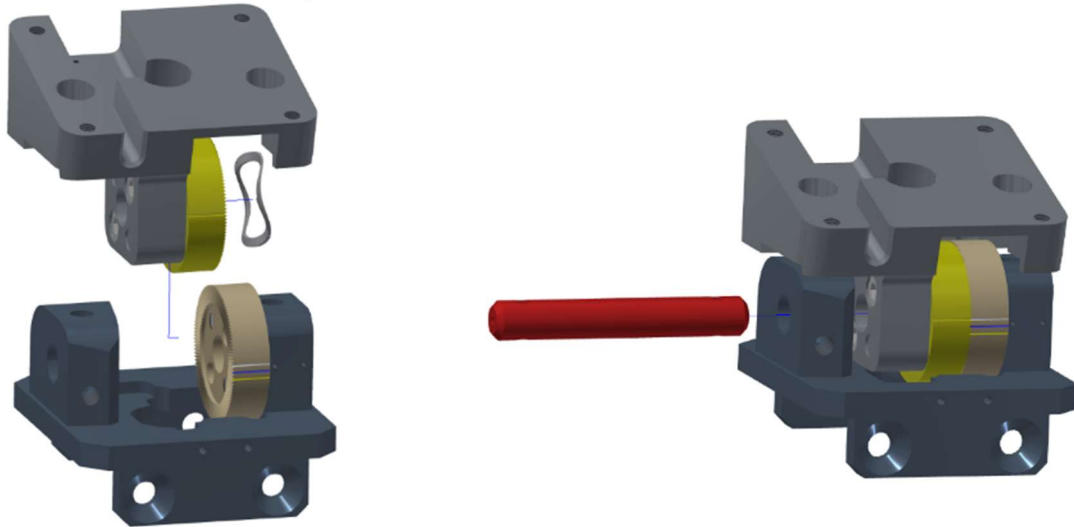


Figure 6-50. Align gears and install pivot pin (474-3057) into neck posture adjustment assembly (474-3050)

- 6.3.20 Insert two M4 X 18 LG. Roll Pins through the top of the Neck Interference Plate (474-3058) and through the Neck Adjustment Pivot Pins (474-3057) (Figure 2-64).

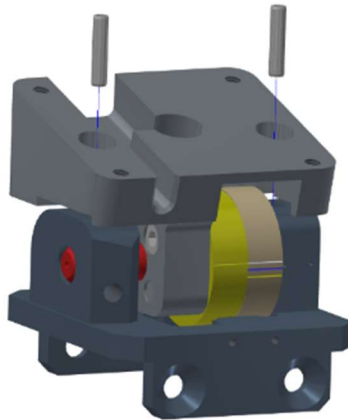


Figure 6-51. Insert two M4 X 18 LG. Roll Pins

- 6.3.21 Insert Adjustment Wedge (474-3052) into Neck Posture Adjustment Assembly (474-3050) and tighten with one Modified M6 X 1 X 12 LG. SHCS (Figure 6-52).

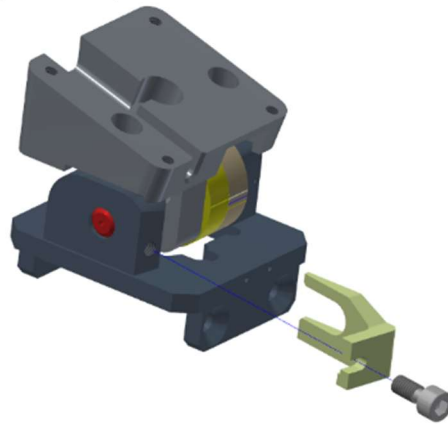


Figure 6-52. Insert Adjustment Wedge (474-3052)

- 6.3.22 Attach the Neck Posture Adjustment Assembly (474-3050) to the Upper Spine Assembly (474-3240) using four M6 X 1 X 12 LG. FHCS (Figure 6-53). The pitch change mechanism must be oriented with the adjustment wedge (474-3052) toward the front of the dummy. You may need to apply pressure to the top of the neck posture adjustment assembly to tighten the bolts because of the red vinyl cap.

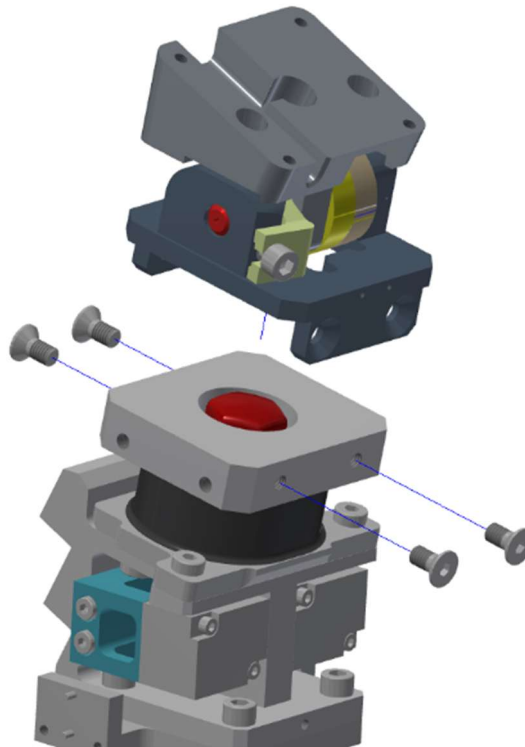


Figure 6-53. Neck Posture Adjustment Assembly (474-3050) assembled to Upper Spine Assembly (474-3240)

- 6.3.23 Figure 6-54 below shows the neck pitch mechanism set to “neutral.”
See Section 4.6.2 for details on adjusting the neck pitch.

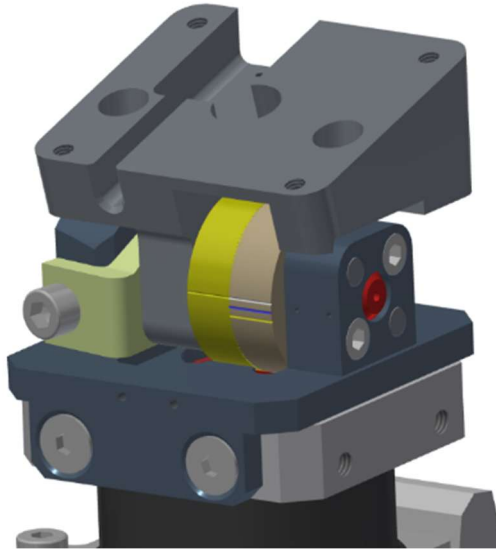


Figure 6-54. Neck pitch mechanism at “neutral” setting

- 6.3.24 Attach the Upper Spine Box (474-3100-A) to the Upper Spine Assembly (474-3240) using four M6 X 1 X 14 LG. FHCS (Figure 6-55).

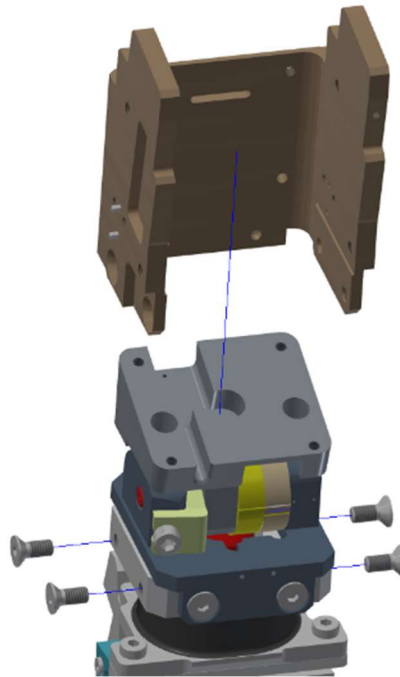


Figure 6-55. Secure the Upper Spine Box (474-3100-A) to the Upper Spine Assembly (474-3240)

- 6.3.25 Secure the Dual Axis Tilt Sensor (SA572-S44) to the Neck Interference Plate (474-3058) using two M2 X 0.4 X 10 SHCS (Figure 6-56).

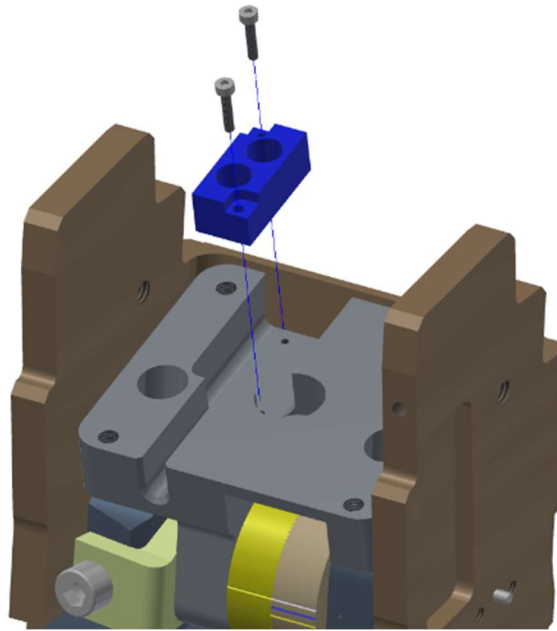


Figure 6-56. Attach tilt sensor (SA572-S44) to neck posture adjustment assembly (474-3050)

- 6.3.26 Attach ground cables from the back of the Lower Spine Box Assembly (474-3101-A) to the Upper Spine Box (474-3100-A) using two M4 X 0.7 X 6 BHCS (Figure 6-57). Secure the lumbar spine ground strap to the Thoracic Spine Load Cell Flex Joint Adaptor Plate using an M4 X 8 BHCS on the right side of the plate.

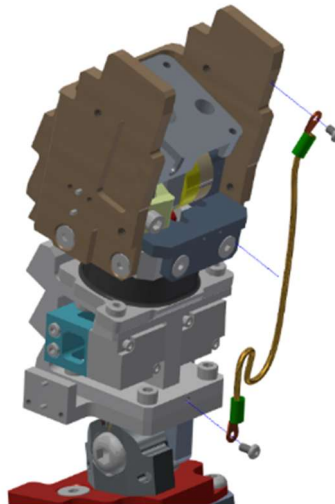


Figure 6-57. Attach ground cable

6.4 Assembly of the Spine to the Pelvis

For the procedure to assemble the pelvis to the spine, see Section 8.48.4.

6.5 Assembly of the Neck to the Spine

For the procedure to assemble the neck to the spine, see Section 4.5.

6.6 Adjustment Procedure for Lumbar Spine Pitch Change Assembly

The following is a step-by-step procedure for adjusting the seating posture of the THOR-05F dummy using the Lumbar Posture Gear Assembly (474-3068-A). The lumbar spine pitch change mechanism connects the upper (thoracic) and lower (lumbar) spine segments. It allows adjustment of the spine angle to four settings marked on the pitch change assembly, representing erect, neutral, slouched, and super-slouched postures. Slouched posture represents the default posture, as this most closely resembles the AMVO seated posture for a 5th percentile female occupant.

To adjust the lumbar spine pitch change mechanism angle, follow the steps below.

- 6.6.1 Unzip the zippers on the right shoulder and the right side of the jacket. If desired or convenient, remove the jacket completely.
- 6.6.2 Locate the M12 X 1.75 X 45 mm SHCS on the right side of the lower spine, as indicated in Figure 6-58.

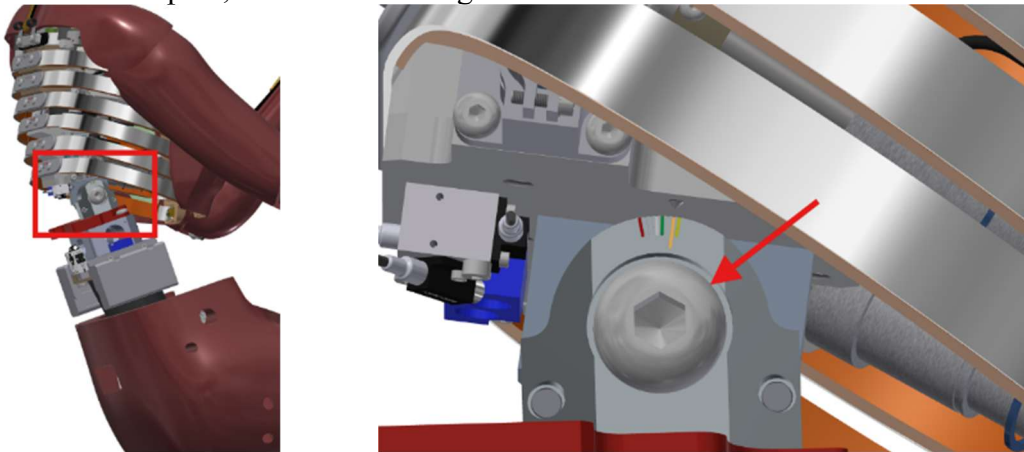


Figure 6-58. Lumbar spine pitch change mechanism adjustment SHCS (M12)

- 6.6.3 Loosen the M12 X 1.75 X 45 mm SHCS *at least* two complete turns (720°) to disengage the sprockets.

WARNING: The sprockets of the pitch change unit will be seriously damaged if the adjustment is made *BEFORE* the teeth are completely disengaged.

- 6.6.4 Manipulate the upper portion of the spine to achieve the desired posture setting, as shown in either Figure 6-59.

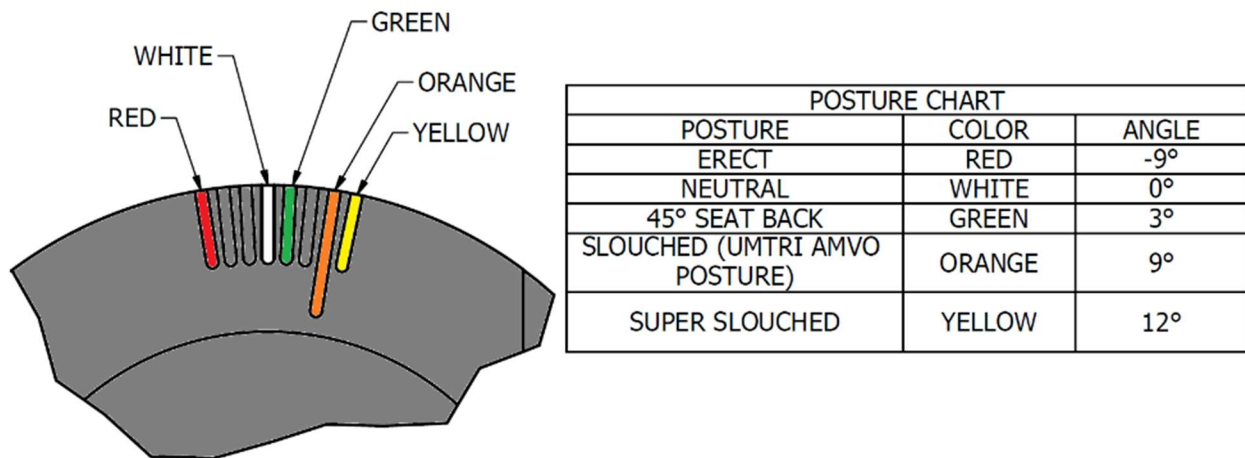


Figure 6-59. Lumbar spine pitch change indicator posture settings

WARNING: Be certain to properly mesh and engage the sprockets of the pitch change mechanism before proceeding.

- 6.6.5 Re-tighten the M12 X 1.75 X 45 mm SHCS and torque to 68.0 N-m (50.5 ft-lbf). Visually inspect from the rear of the dummy to verify teeth were successfully reengaged.

6.7 Adjustment Procedure for Neck Pitch Change Mechanism

- 6.7.1 For the procedure to adjust the neck pitch, see Section 4.6.2.

6.8 Adjustment Procedure for Tightening Flex Joint Cables

- 6.8.1 Section 6.3.1 details the adjustment procedure for correctly tightening the cables on the Lumbar Assembly (474-3223).
- 6.8.2 Section 6.3.12 details the adjustment for the Upper Spine Assembly (474-3240).

6.9 Electrical Connections and Requirements

Section 13.3 includes grounding information. Section 13.4 describes cable routing instructions.

Section 7. Shoulder Assembly

7.1 Description of Shoulder Assembly and Features

The shoulder assembly (474-3500-1,2-A) for the THOR-05F dummy includes the mechanical components to connect the arms to the spine and thorax assemblies (Figure 7-1). A primary goal of the shoulder assembly includes providing a human-like interaction between the shoulder belt restraint and the dummy. As such, the shoulder design resembles the geometry and motion of the human shoulder/clavicle complex. A shoulder pad conforms closely to the human shoulder geometry. A separate human-like clavicle linkage provides a more biofidelic interaction between the shoulder assembly and seat belt restraint systems. The clavicle loads the sternum and ribcage directly to produce more human-like loading conditions. The shoulder joint and linkage provides fore and aft, as well as “shrugging” motions similar to the human shoulder joint. Soft stops limit the range of motion to meet specifications on human range of motion.

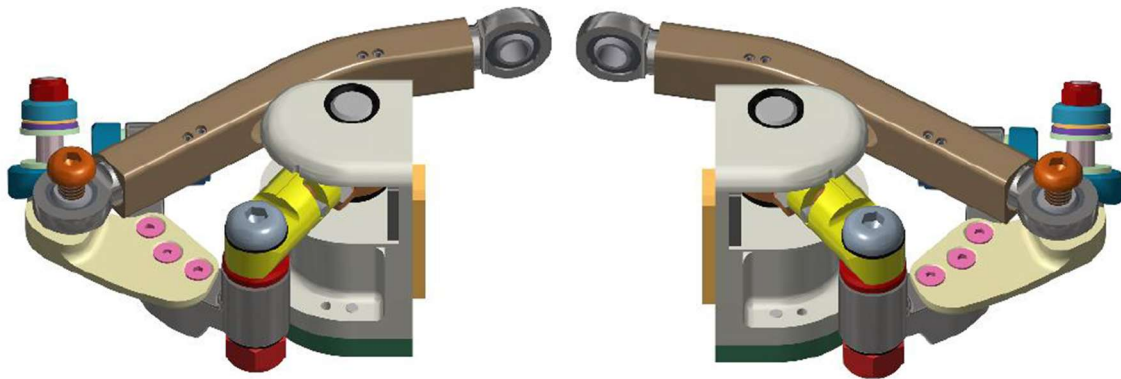


Figure 7-1. Shoulder assembly (474-3500-1,2)

Figure 7-1 and Figure 7-2 show assemblies and hardware for the shoulder. Table 7-1 and Table 7-2 lists the components that are included in the shoulder assembly.

Table 7-1. Shoulder Assembly (474-3500-1,2-A) Components

Part Description	Quantity	Part Number	Figure #	Item #
Spine-Shoulder Coupler Assembly	1	474-3524-1,2-A	Figure 7-2	1
M4 X 0.7 X 10 LG. FHCS	3	5000023	Figure 7-2	2
M10 X 1.5 Hex Lock Nut Zinc	1	5000149	Figure 7-2	3
Upper Scapula	1	474-3506-1,2	Figure 7-2	4
Shoulder Clevis	1	474-3504	Figure 7-2	5
Clavicle Assembly	1	474-3508	Figure 7-2	6
M8 X 1.25 X 25 LG. BHCS	1	5000255	Figure 7-2	7
Lower Scapula	1	474-3505-1,2	Figure 7-2	8
Spacer Washer, M10, Nylon	1	474-3534	Figure 7-2	9

Scapula Link Bearing	2	474-3583-A	Figure 7-2	10
M6 X 1 Hex Lock Nut	1	5000093	Figure 7-2	11
M8 X 20 LG. SHSS	1	5001154	Figure 7-2	12
Friction Washer	2	474-3533	Figure 7-2	13
Washer Belleville M8	2	5001388	Figure 7-2	14
M10 X 1.5 X 50 LG. BHCS SS	1	5001405	Figure 7-2	15
Bearing, Ball Thrust, 8 X 16 X 5 THK	2	5001520	Figure 7-2	16
M8 X 1.25 Hex Jam Nut	1	5001101	Figure 7-2	17
M8 Flat Washer	1	5000123	Figure 7-2	18
Posterior Lower Scapula Cover	1	474-3511-1,2	Figure 7-2	19
Medial Lower Scapula Cap	1	474-3512	Figure 7-2	20

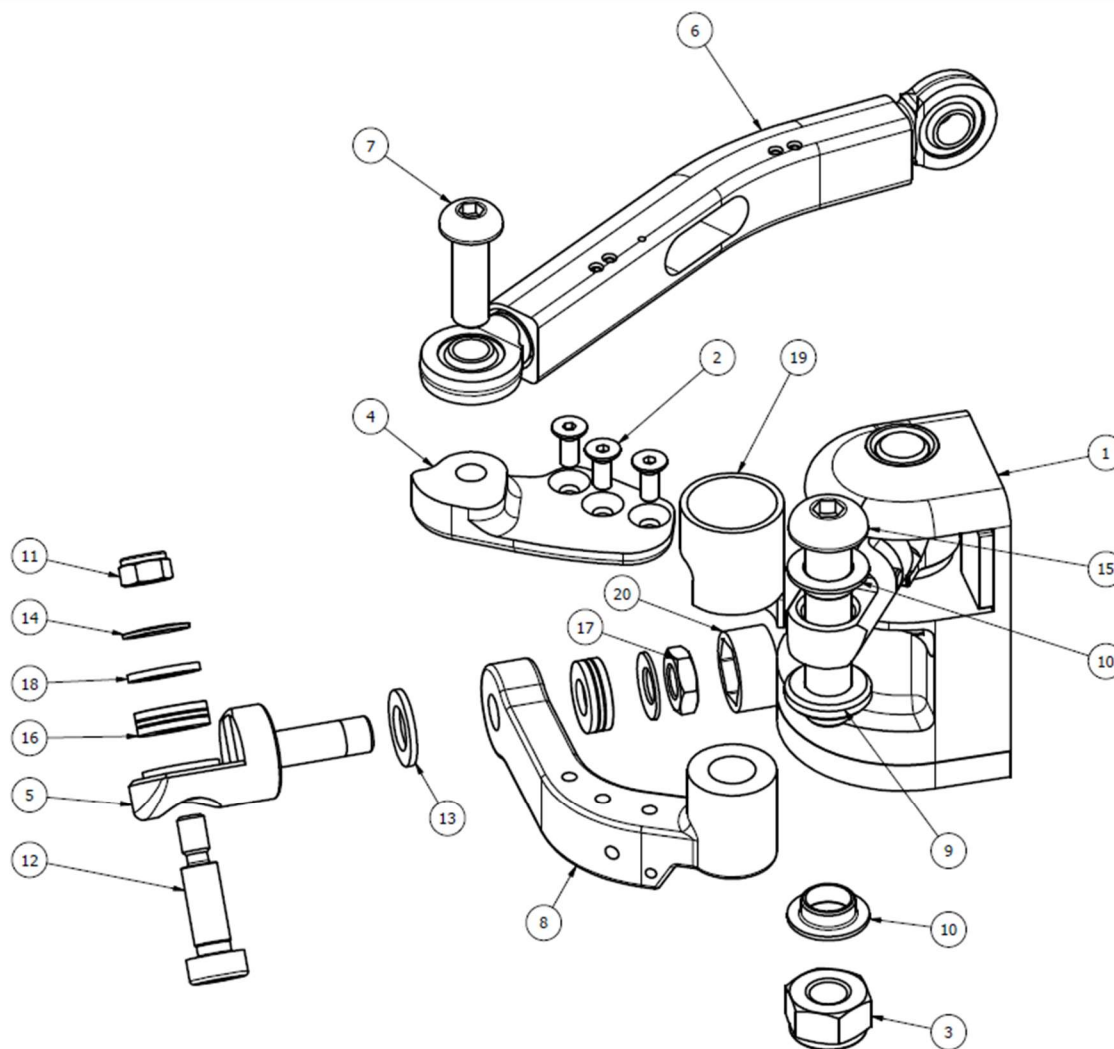


Figure 7-2. Left Shoulder assembly (474-3500-1-A) components

Table 7-2. Spine-Shoulder Coupler Assembly (474-3524-1,2-A) components

Part Description	Quantity	Part Number	Figure #	Item #
Spine-Shoulder Coupler, Top	1	474-3501-1,2-A	Figure 7-3	1
Spine-Shoulder Coupler, Bottom	1	474-3502-1,2-A	Figure 7-3	2
Spring, Shoulder	1	474-3582	Figure 7-3	3
Spring Retainer	1	474-3526	Figure 7-3	4
M3 X 0.5 X 10 LG. FHCS	2	5000203	Figure 7-3	5
Pin, Spring Tension	1	474-3519	Figure 7-3	6
M8 Flat Washer	1	5000123	Figure 7-3	7
Shaft Sleeve	3	474-3527	Figure 7-3	8
Rear Shoulder Stop	1	474-3529	Figure 7-3	9
Front Shoulder Stop	1	474-3558	Figure 7-3	10
M4 X 18 Lg. Dowel Pin	1	5000815	Figure 7-3	11
M3 X 24 LG. Roll Pin	1	5000140	Figure 7-3	12
Clevis, Left Scapula Link	1	474-3507-1,2	Figure 7-3	13
Scapula Link Bumper	2	474-3539	Figure 7-3	14
Scapula Link	1	474-3503-1,2	Figure 7-3	15
M8 X 1.25 Hex Lock Nut	1	5000318	Figure 7-3	16
M4 X 0.7 X 12 LG. SSSFP SS	2	5001813	Figure 7-3	17
M4 X 0.7 X 10 LG. SHCS SS	3	5000737	Figure 7-3	18

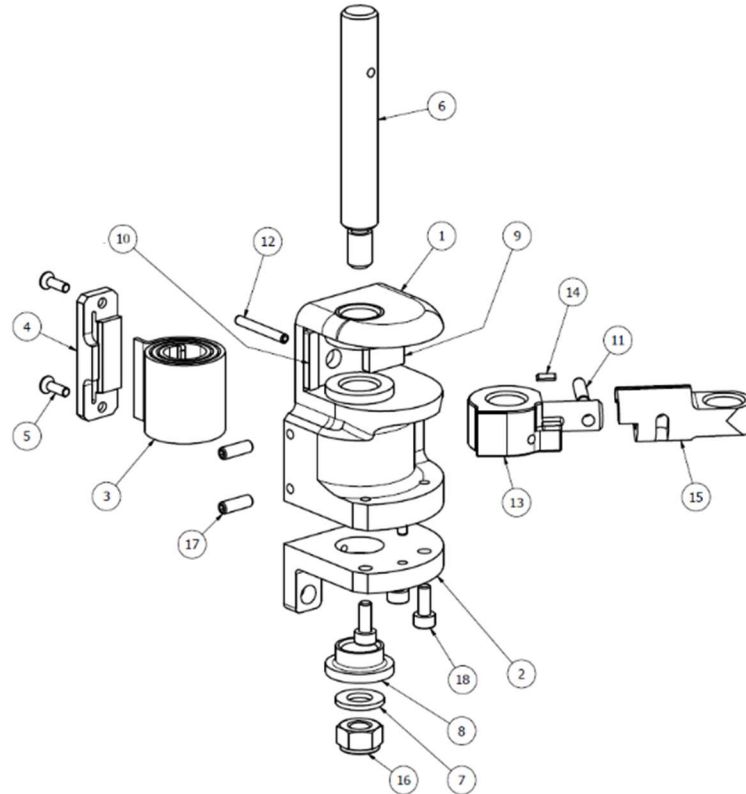


Figure 7-3. Spine-Shoulder Coupler Assembly (474-3524-1,2-A) components

7.2 Disassembly of Shoulder

The following procedure is a step-by-step description of the disassembly procedure for the shoulder components.

- 7.2.1 With the Shoulder Assemblies (474-3500-1,2-A) removed from the Spine Assembly (474-3200-A) (0) and the clavicle removed from the Shoulder Assembly (Section 5.2), separate the Lower Scapula (474-3505-1,2) from the Spine-Shoulder Coupler Assembly (474-3524-1,2-A) by removing one M10 X 1.5 X 50 LG. BHCS SS (Figure 7-4).

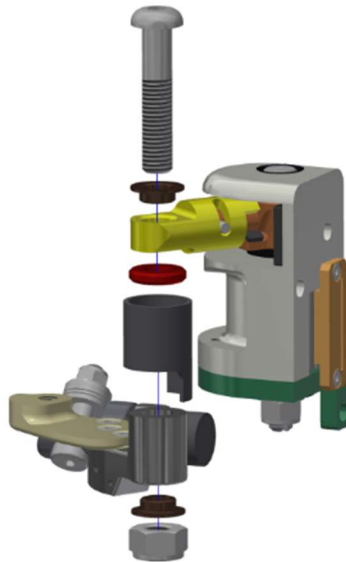


Figure 7-4. Separate the Lower Scapula (474-3505-1,2) from the Spine-Shoulder Coupler Assembly (474-3524-1,2-A)

- 7.2.2 Remove three M4 X 0.7 X 10 LG. FHCS separating the Upper Scapula (474-3506-1,2) from the Lower Scapula (474-3505-1,2) (Figure 7-5).

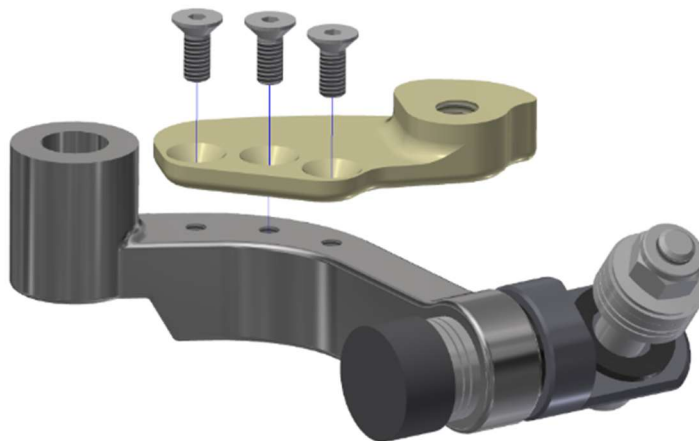


Figure 7-5. Separate the Upper Scapula (474-3506-1,2) from the Lower Scapula (474-3505-1,2)

- 7.2.3 Remove the M3 X 24 LG. Roll Pin from the Scapula Link Clevis (474-3507-1,2) (Figure 7-6).

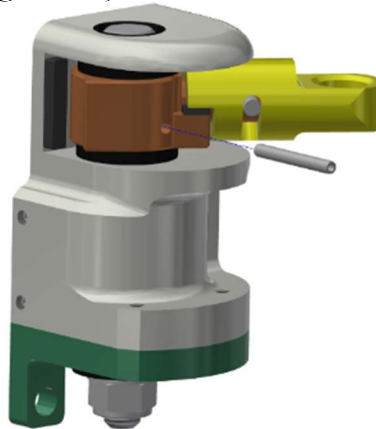


Figure 7-6. Remove the Roll Pin from the Scapula Link Clevis (474-3507-1,2)

- 7.2.4 Remove the Spring Tension Pin (474-3519) by removing the M8 X 1.25 Hex Lock Nut, M8 Flat Washer, and Shaft Sleeve (Figure 7-7).

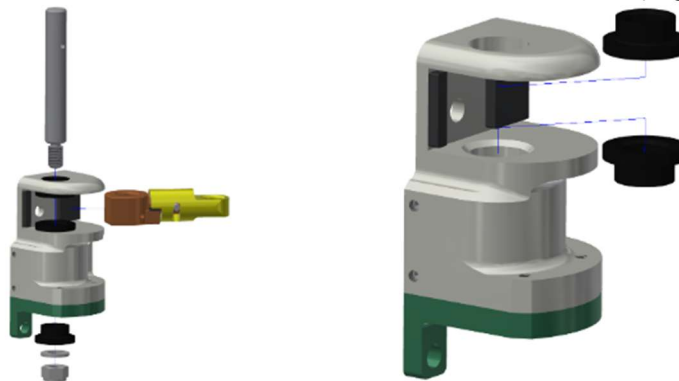


Figure 7-7. Remove the Spring Tension Pin (474-3519)

- 7.2.5 Remove the Spring Retainer (474-3526) from the bottom of the Spine-Shoulder Coupler, Top (474-3501-1,2-A) by removing two M3 X 0.5 X 10 LG. FHCS (Figure 7-8).

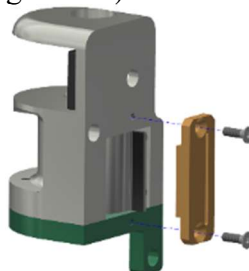


Figure 7-8. Remove the Spring Retainer (474-3526)

- 7.2.6 Remove two M4 X 0.7 X 20 LG. SSSFP SS from the Spine-Shoulder Coupler, Top (474-3501-1,2-A) (Figure 7-9).

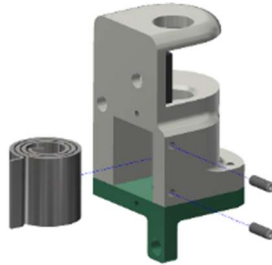


Figure 7-9. Remove two M4 X 0.7 X 20 LG. SSSFP SS

7.3 Assembly of Shoulder

The following procedure is a step-by-step description of the assembly procedure for the shoulder components. Unless otherwise specified, tighten all bolts to the torque specifications provided in Section 2.1.3.

- 7.3.1 Install two M4 X 0.7 X 20 LG. SSSFP SS to the Spine-Shoulder Coupler, Top (474-3501-1,2-A) (Figure 7-11).

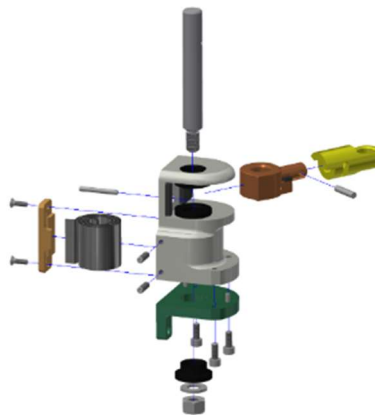


Figure 7-10. Separated Shoulder Assembly (474-3500-1,2-A)

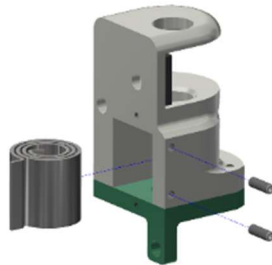


Figure 7-11. Install two M4 X 0.7 X 20 LG. SSSFP SS

- 7.3.2 Install the Spring Retainer (474-3526) to the bottom of the Spine-Shoulder Coupler, Top (474-3501-1,2-A) using two M3 X 0.5 X 10 LG. FHCS (Figure 7-12).

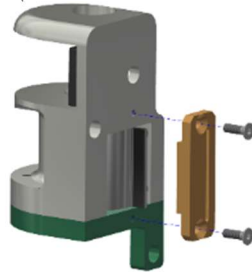


Figure 7-12. Install the Spring Retainer (474-3526)

- 7.3.3 Install the Spring Tension Pin (474-3519) using the M8 X 1.25 Hex Lock Nut, M8 Flat Washer, and Shaft Sleeve (Figure 7-13).

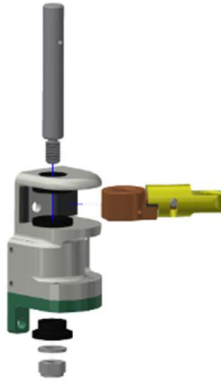


Figure 7-13. Install the Spring Tension Pin (474-3519)

- 7.3.4 Install the M3 X 24 LG. Roll Pin to the Scapula Link Clevis (474-3507-1,2) (Figure 7-14).

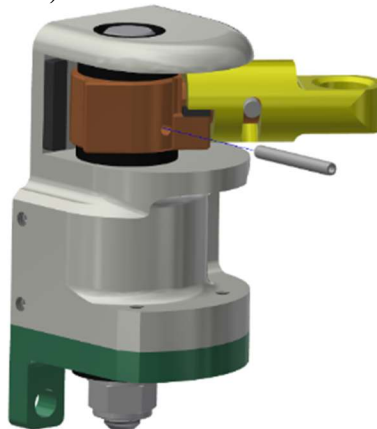


Figure 7-14. Install the Roll Pin to the Scapula Link Clevis (474-3507-1,2)

- 7.3.5 Attach three M4 X 0.7 X 10 LG. FHCS to connect the Upper Scapula (474-3506-1,2) to the Lower Scapula (474-3505-1,2) (Figure 7-15).

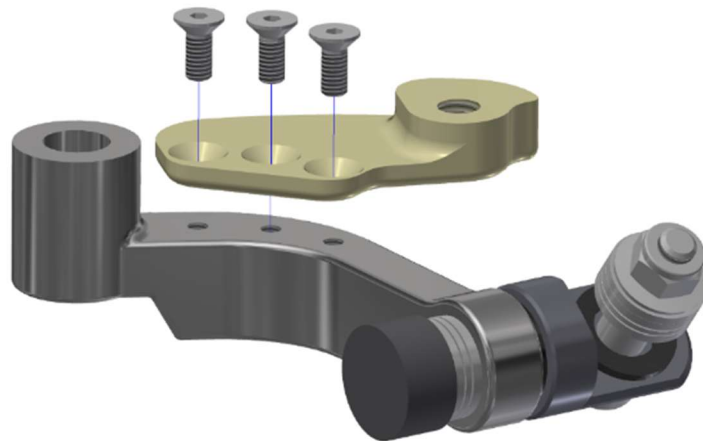


Figure 7-15. Connect the Upper Scapula (474-3506-1,2) to the Lower Scapula (474-3505-1,2)

- 7.3.6 Connect the Lower Scapula (474-3505-1,2) to the Spine-Shoulder Coupler Assembly (474-3524-1,2-A) using one M10 X 1.5 X 50 LG. BHCS SS (Figure 7-16).



Figure 7-16. Connect the Lower Scapula (474-3505-1,2) to the Spine-Shoulder Coupler Assembly (474-3524-1,2-A)

7.3.7 Connecting the Arms to the Shoulders

The procedure for connecting the arm to the shoulder is located in Section 11.3.19.

7.4 Electrical Connections and Requirements

Section 13.3 includes grounding information.

Section 8. Pelvis Assembly

8.1 Description of Pelvis Assembly and Features

The Pelvis Assembly (474-4000-A) of the THOR-05F dummy consists of a cold rolled steel base module and two aluminum wings, designed to approximate the geometry of the human pelvic bone structure. The locations of two important anthropomorphic landmarks have been carefully maintained: The H-points and the ASIS points. These landmarks provide locations that can be directly related to the human pelvis. The iliac wing accepts the pelvic box assembly, which holds the acetabular load cells and acetabular cups. The top of the pelvis base module accepts the lumbar/pelvis mounting block to allow attachment of the spine assembly. Figure 8-1 illustrates a drawing of the completed pelvic assembly with the pelvis skin and abdomen..

There are several different types of instrumentation sensors incorporated into the pelvic region. A tri-pack accelerometer in the rear cavity of the pelvis measures the accelerations of the (approximate) pelvic center of gravity in three axes. A dual-axis tilt sensor measures the static position of the pelvis about the X- and Y-axes. Two acetabular load cells measure the loads transferred through the femurs to the pelvic structure. Each anterior iliac wing accepts a dual-axis ASIS load cell. The ASIS load cell measures the force of a lap belt against the iliac spine of the pelvis in two locations (FX UPR and FX LWR) which provides an indication of the position of the belt on the pelvis.

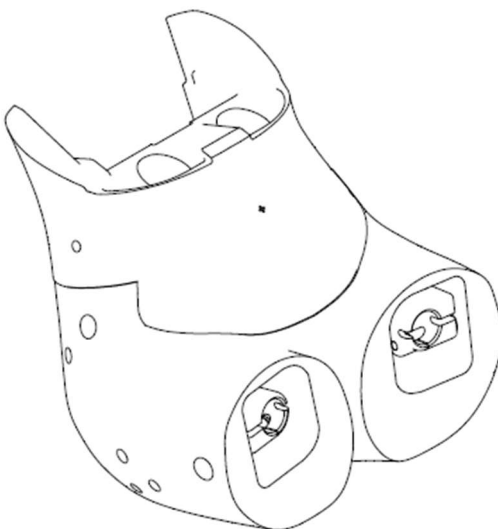


Figure 8-1. Pelvis Assembly (474-4000-A)

Figure 8-1 and Figure 8-2 show assemblies and hardware for the Pelvis Assembly (474-4000-A). Table 8-1 and Table 8-2 list the components that are included in the Pelvis Assembly.

Table 8-1. Pelvis Assembly (474-4000-A) Components

Part Description	Quantity	Part Number	Figure #	Item #
Pelvic Bone, Center	1	474-4541	Figure 8-2	1
Cover, Rear Pelvic Instrumentation	1	474-4001	Figure 8-2	2
Structural Replacement, Left Acetabulum Load Cell	1	474-4002-1	Figure 8-2	3
Femur Mounting Socket, Left	1	474-4003-1	Figure 8-2	4
Femur Mounting Socket, Right	1	474-4003-2	Figure 8-2	5
Femur Assembly, Left	1	474-4700-1	Figure 8-2	6
Femur Assembly, Right	1	474-4700-2	Figure 8-2	7
M5 X 0.8 X 10 LG. SHCS	6	5000291	Figure 8-2	8
Plate, Upper Torso to Pelvis Adaptor	1	474-4004	Figure 8-2	9
M8 X 1.5 X 30 LG. FHCS	4	5000605	Figure 8-2	10
M3 X 0.5 X 50 LG. SHCS	2	5001053	Figure 8-2	11
On Board DAS Mounting Plate, Pelvis	1	474-4005	Figure 8-2	12
M4 X 0.7 X 12 LG. FHCS	1	5001086	Figure 8-2	13
M5 X 0.8 X 14 LG. FHCS	5	5000864	Figure 8-2	14
M4 X 0.7 X 10 LG. SHCS	3	5000151	Figure 8-2	15
M3 X 0.5 X 10 LG. FHCS	2	5000203	Figure 8-2	16
Pubic Bone	1	474-4544	Figure 8-2	17
M4 X 0.7 X 14 LG. SHCS	3	5000459	Figure 8-2	18
M6 X 1 X 22 LG. SHCS	8	5000282	Figure 8-2	19
M4 X 0.7 X 10 LG. FHCS	4	5000023	Figure 8-2	20
M5 X 0.8 X 12 LG. SHCS	3	5000002	Figure 8-2	21
Coccyx, Molded	1	474-4546	Figure 8-2	22
On Board DAS Structural Replacement	1	474-8206	Figure 8-2	23
Iliac Wing, Machined, Left	1	474-4540-1-A	Figure 8-2	24
Iliac Wing, Machined, Right	1	474-4540-2-A	Figure 8-2	25
Ischium Bone, Molded, Left	1	474-4545-1	Figure 8-2	26
Ischium Bone, Molded, Right	1	474-4545-2	Figure 8-2	27
Structural Replacement, ASIS Load Cell	2	474-4547	Figure 8-2	28
M5 X 0.8 X 18 LG. LHCS	4	5000297	Figure 8-2	29
Structural Replacement, Right Acetabular Load Cell	1	474-4002-2	Figure 8-2	30
M8 X 1.25 X 18 LG. SHCS	2	5000209	Figure 8-2	31
M5 X 0.8 X 25 LG. FHCS	8	5000394	Figure 8-2	32
Structural Replacement, Acetabular Load Cell Strain Relief	2	474-4007	Figure 8-2	33
M2.5 X 0.45 X 8 LG. SHCS	4	5000458	Figure 8-2	34

M12 X 30 LG. SHSS	2	5000506	Figure 8-2	35
Pelvic Plunger Assembly	2	474-4315	Figure 8-2	36
Cable Cover, Pelvis	1	474-4006	Figure 8-2	37
Plate, Ischium Bone Mount	1	474-4542-A	Figure 8-2	38
M8 X 1.25 X 20 LG. LHCS	4	50001861	Figure 8-2	39
APTS Sensor	2	SA572-S162	Figure 8-2	40

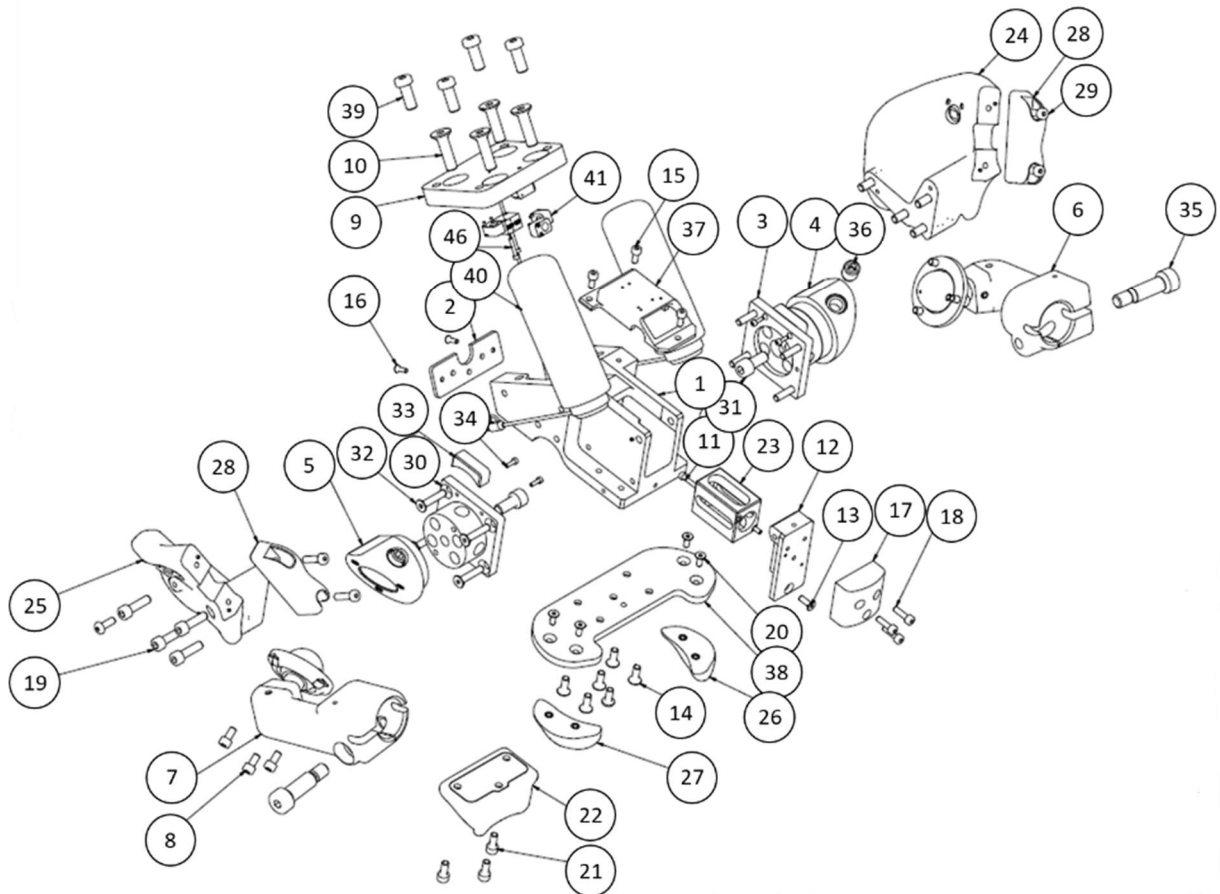


Figure 8-2. Pelvis Assembly (474-4000-A) Components

Table 8-2. Femur Assembly (474-4700-1/2) Components

Part Description	Quantity	Part Number	Figure #	Item #
Femur Ball Joint	1	474-4701	Figure 8-3	1
Femur Retaining Flange	1	474-4702	Figure 8-3	2
Femur, Left/Right	1	474-4703-1/2	Figure 8-3	3
Femur Shaft	1	474-4704	Figure 8-3	4
M5 X 30 LG. ROLL PIN SS	3	5000353	Figure 8-3	5

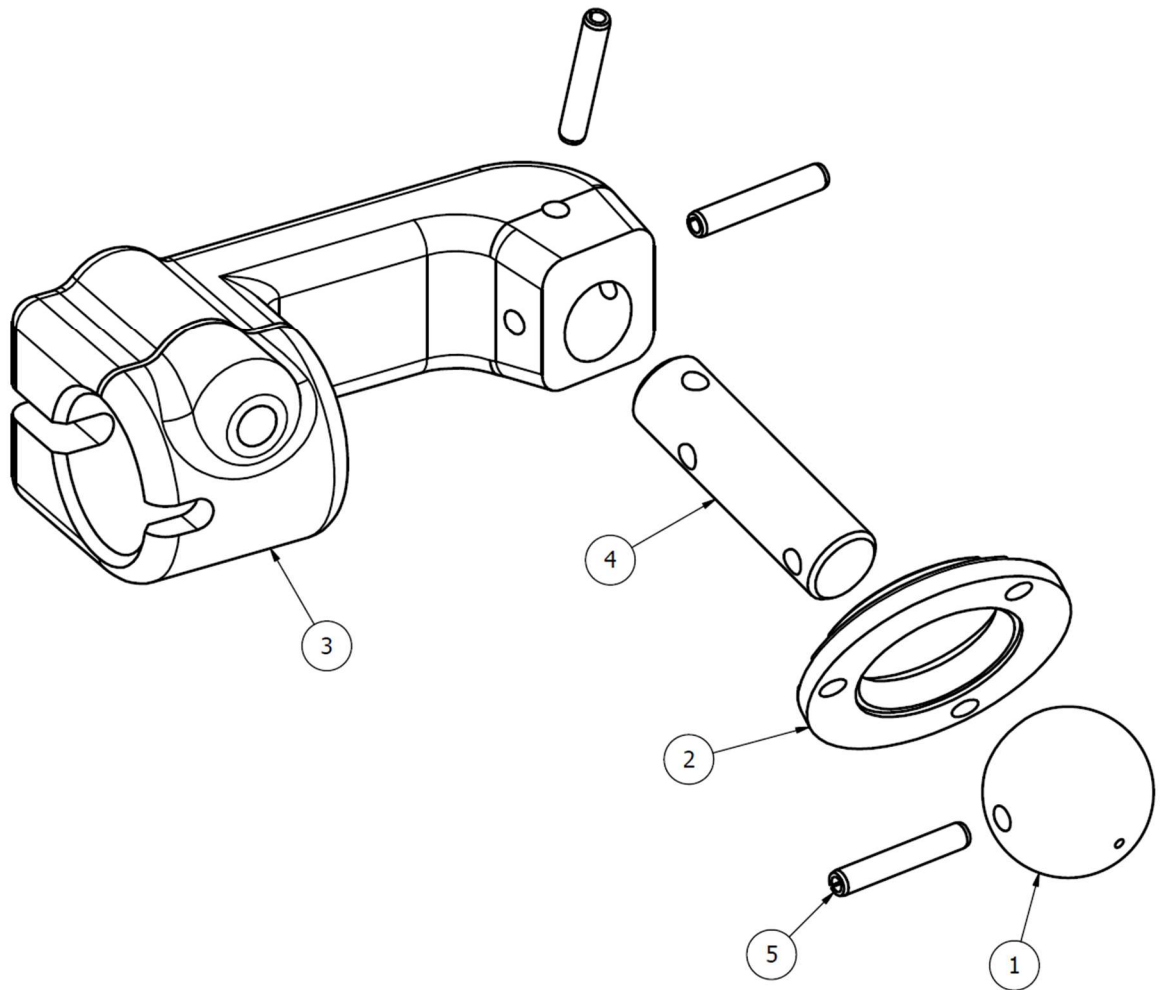


Figure 8-3. Left Femur Assembly (474-4700-1) components

8.2 Disassembly of the Pelvis

The following procedure is a step-by-step description of the disassembly procedure for the pelvis components.

- 8.2.1 After uninstalling the legs and torso, the pelvis can be disassembled. Start by loosening the left and right Pelvic Plunger Assembly (474-4315) (Figure 8-4).

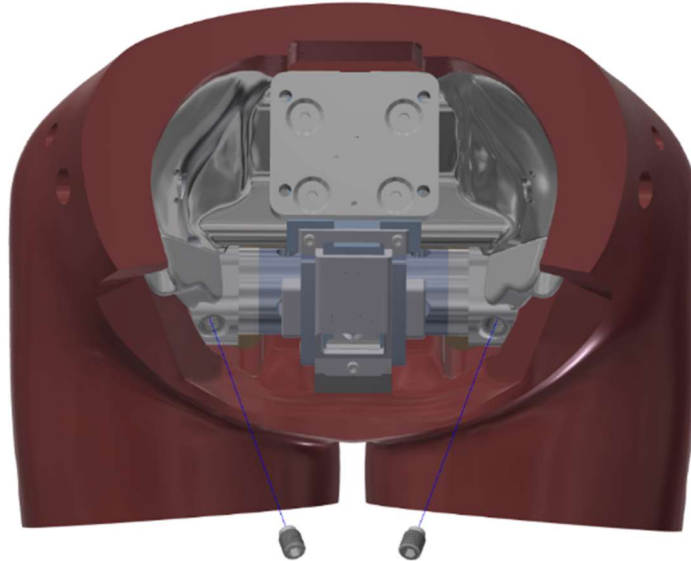


Figure 8-4. Loosen the left and right Pelvic Plunger Assembly

- 8.2.2 Remove three M5 X 0.8 X 10 LG. SHCS from the right and left Femur Assembly (474-4700-1,2) which are accessed by the three holes in the left and right sides of the Pelvis Flesh (474-4521-A) (Figure 8-5).

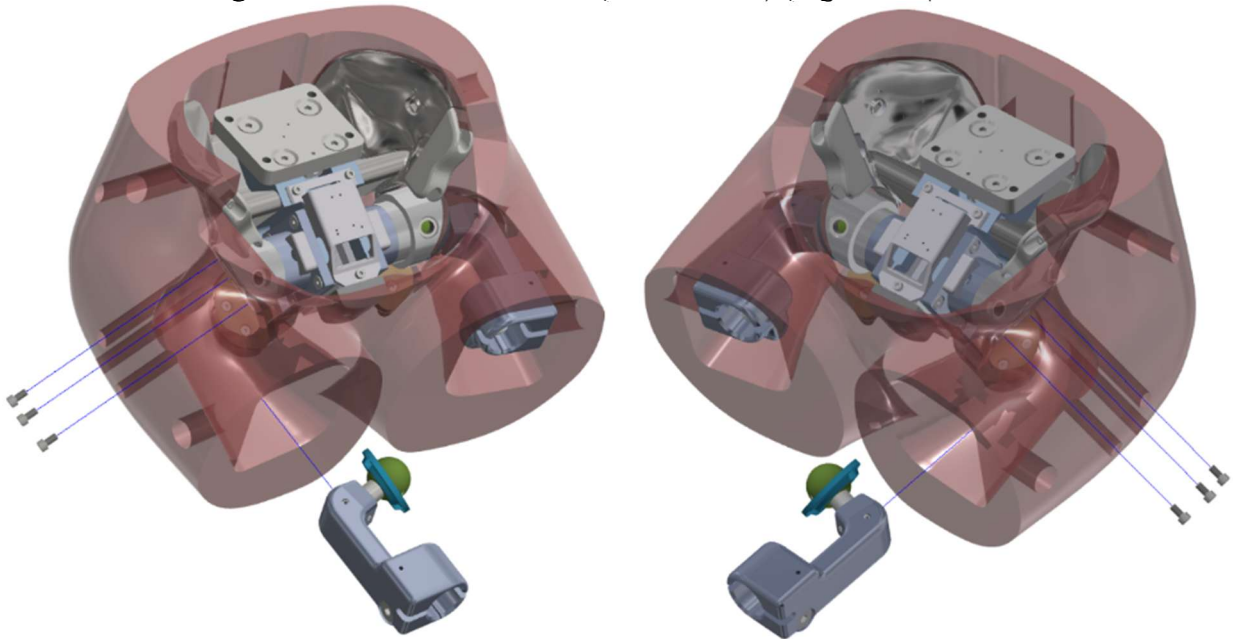


Figure 8-5. Remove three M5 X 0.8 X 10 LG. SHCS from the right and left Femur Assembly (474-4700-1,2)

8.2.3 Remove the ground cable from the Femur Assemblies (Figure 8-6).

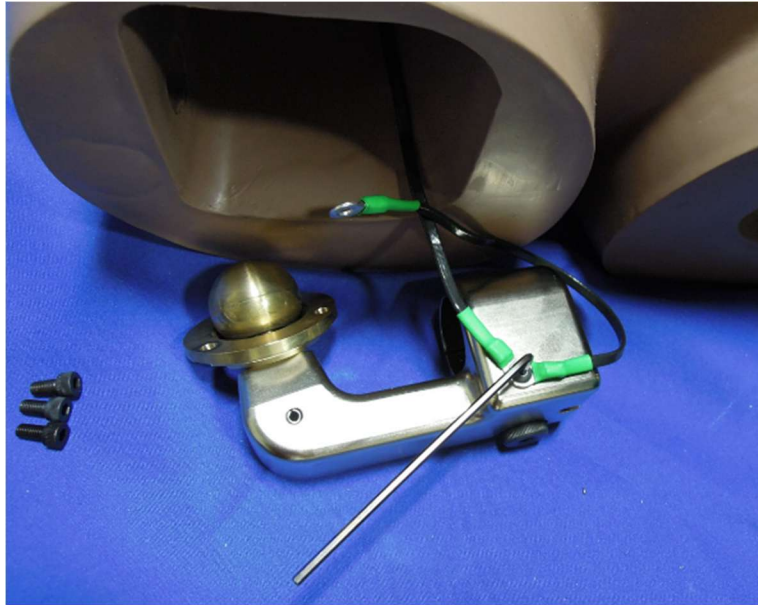


Figure 8-6. Remove the ground cable from the Femur Assemblies

8.2.4 Remove 3 fasteners (two M5 X 0.8 X 14 LG. BHCS and one M5 X 0.8 X 12 LG. BHCS) which secure the pelvis flesh to the pelvis bones.



Figure 8-7. Pelvis Flesh attachment bolts

- 8.2.5 Remove the Pelvis from the Pelvis Flesh (474-4521-A) (Figure 8-8). Remove the bundle of pelvis wires from the back of the pelvis flesh (Figure 8-9).

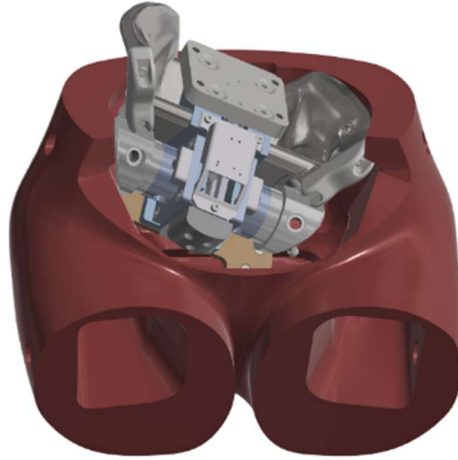


Figure 8-8. Remove the Pelvis from the Pelvis Flesh (474-4521-A)

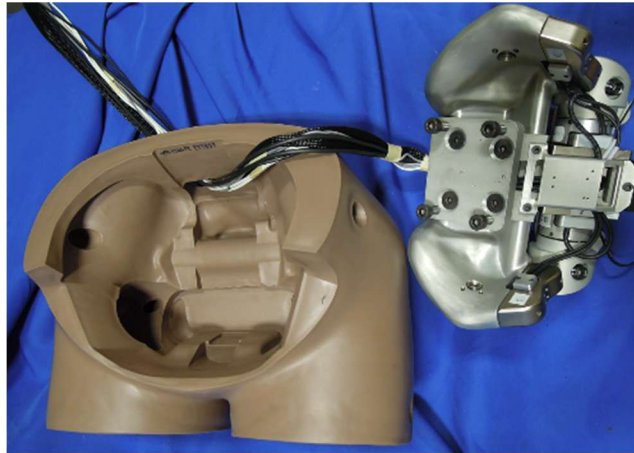


Figure 8-9. Remove the bundle of pelvis wires from the back of the pelvis flesh

- 8.2.6 Remove the ground cables from the pelvis (Figure 8-10).

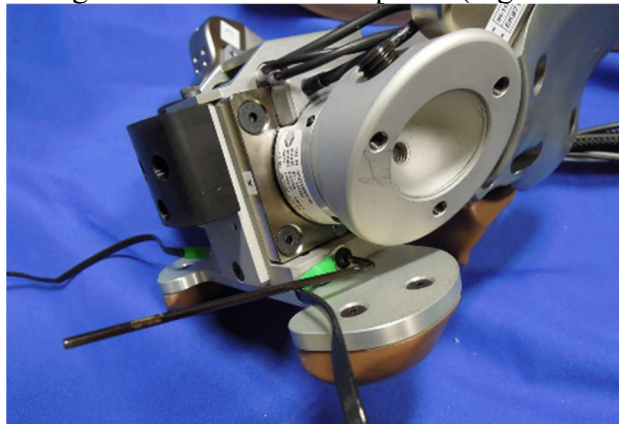


Figure 8-10. Remove the ground cables from the pelvis

- 8.2.7 Remove the Upper Torso to Pelvis Adaptor Plate (474-4004) by removing four M8 X 1.25 X 30 LG. FHCS (Figure 8-11).

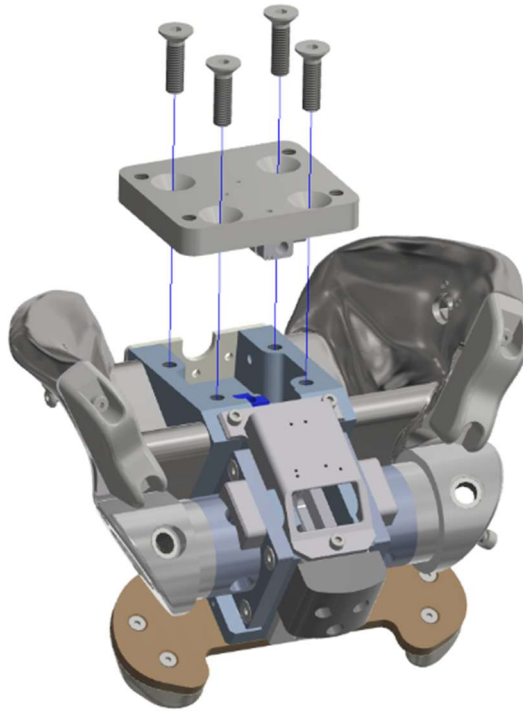


Figure 8-11. Remove the Upper Torso to Pelvis Adaptor Plate (474-4004)

- 8.2.8 Remove the Pelvis Cable Cover (474-4010) by removing three M4 X 0.7 X 10 LG. SHCS (Figure 8-12).

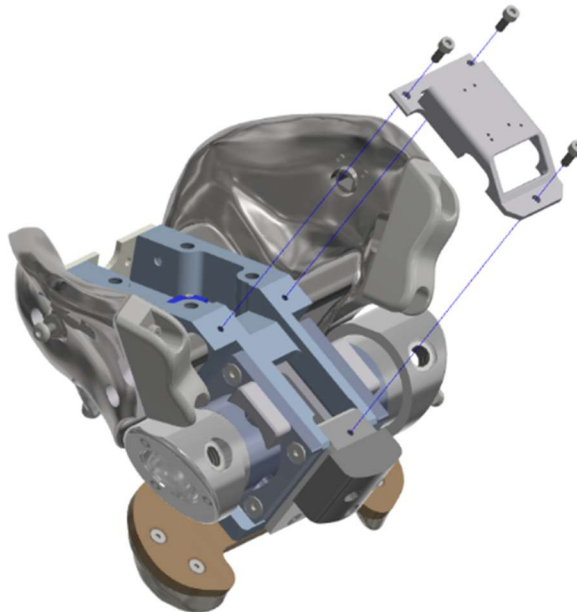


Figure 8-12. Remove the Pelvis Cable Cover (474-4010)

- 8.2.9 Remove the strain relieving cable tie from the Rear Pelvic Instrumentation Cover (474-4001) (Figure 8-13).

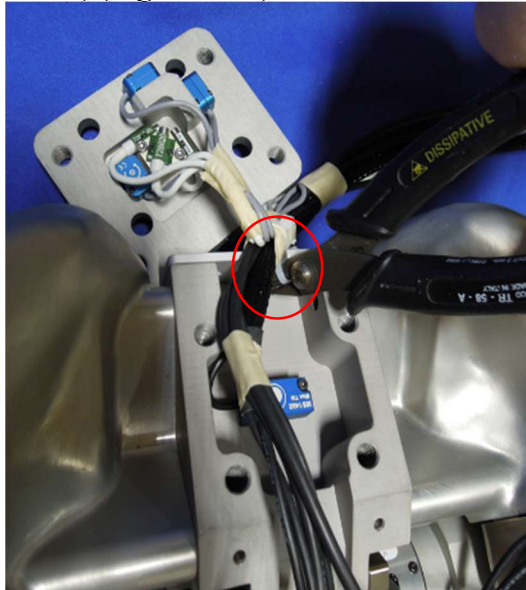


Figure 8-13. Remove the strain relieving cable tie from the Rear Pelvic Instrumentation Cover

- 8.2.10 Remove the left and right Iliac Wings (474-4540-1,2-A) by removing four M6 X 1 X 22 LG. SHCS per side (Figure 8-14).

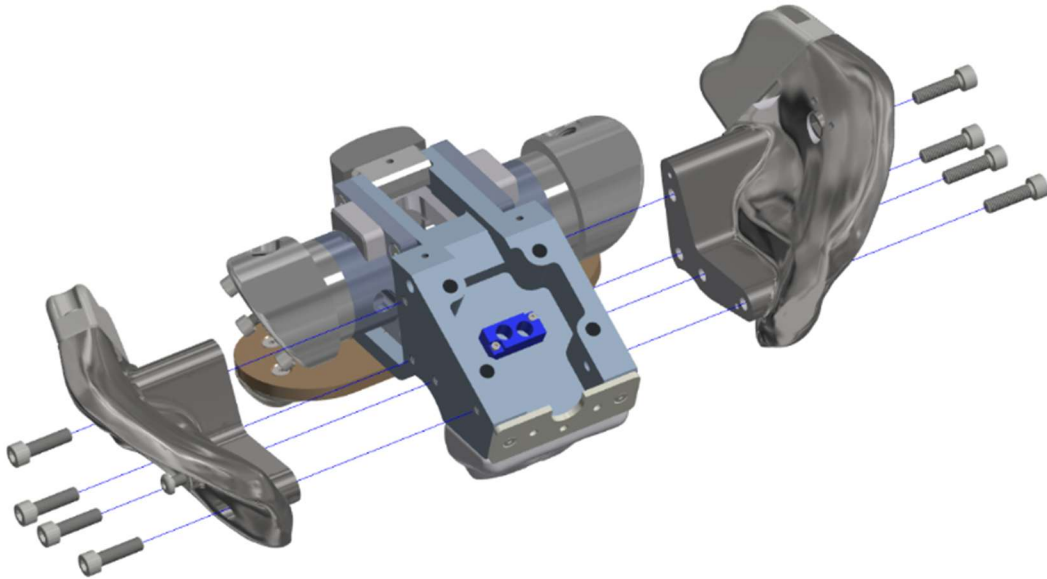


Figure 8-14. Remove the left and right Iliac Wings (474-4540-1,2-A)

8.2.11 Remove the ASIS Load Cells from the Left and Right Iliac Wings (474-4540-1,2-A) by removing two M5 X 0.8 X 18 LG. LHCS (Figure 8-15).



Figure 8-15. Remove the ASIS Load Cells from the Left and Right Iliac Wings (474-4540-1,2-A)

8.2.12 Remove the Left and Right Acetabulum Load Cell (SA572-S108 & SA572-S109) from the Pelvic Bone (474-4541) by removing four M5 X 0.8 X 25 LG. FHCS (Figure 8-16).

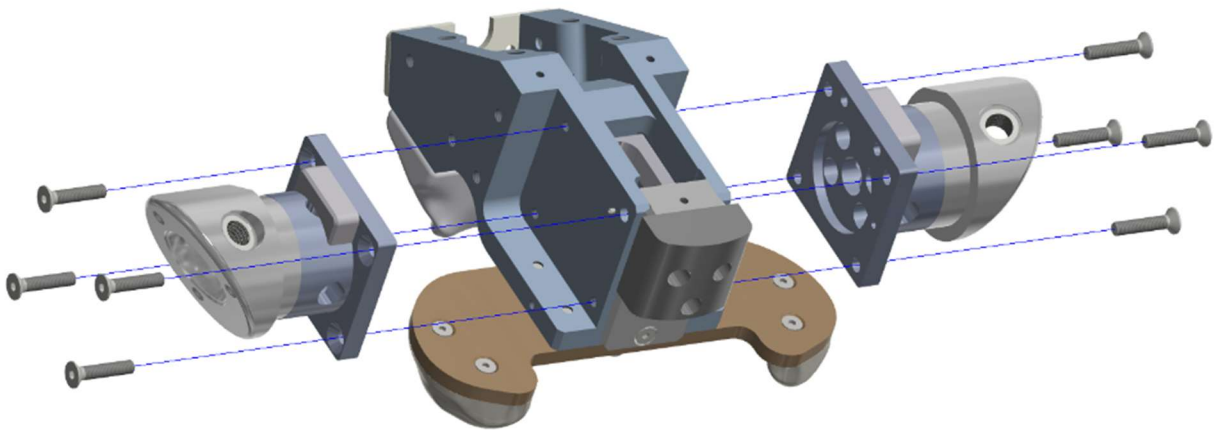


Figure 8-16. Remove the Left and Right Acetabulum Load Cell (SA572-S108 & SA572-S109) from the Pelvic Bone (474-4541)

- 8.2.13 Separate the Acetabulum Load Cell from the Femur Mounting Socket (474-4003-1,2) by removing the M8 X 1.25 X18 LG. SHCS from the center of the Load Cell (Figure 8-17).

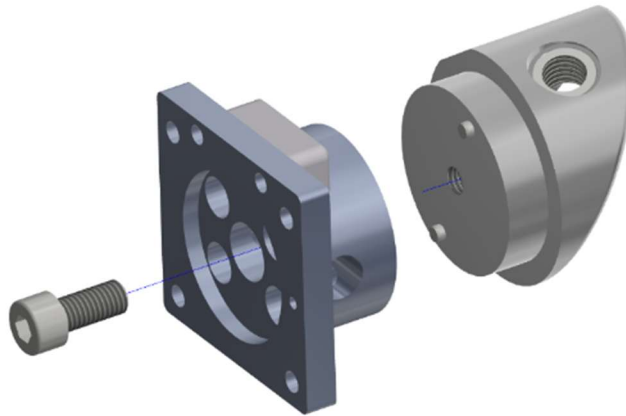


Figure 8-17. Separate the Acetabulum Load Cell from the Femur Mounting Socket (474-4003-1,2).

- 8.2.14 Remove one M4 X 0.7 X 12 LG. FHCS from the Pelvis Slice Stack Mounting Plate (474-4005) (Figure 8-18).

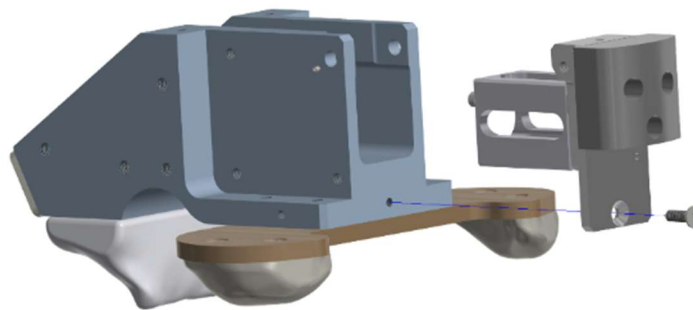


Figure 8-18. Remove one M4 X 0.7 X 12 LG. FHCS from the Pelvis Slice Stack Mounting Plate (474-4005)

- 8.2.15 Remove the On Board DAS Structural Replacement (474-8206) by removing two M3 X 0.5 X 50 LG. SHCS (Figure 8-19).

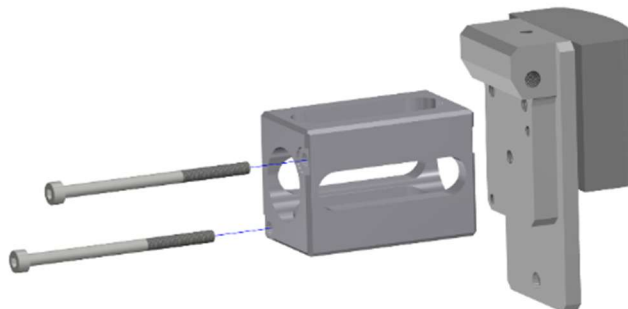


Figure 8-19. Remove the On Board DAS Structural Replacement (474-8206)

8.2.16 Remove three M4 X 0.7 X 14 LG. SHCS to separate the Pubic Bone (474-4544) from the Pelvis On Board DAS Mounting Plate (474-4005) (Figure 8-20).

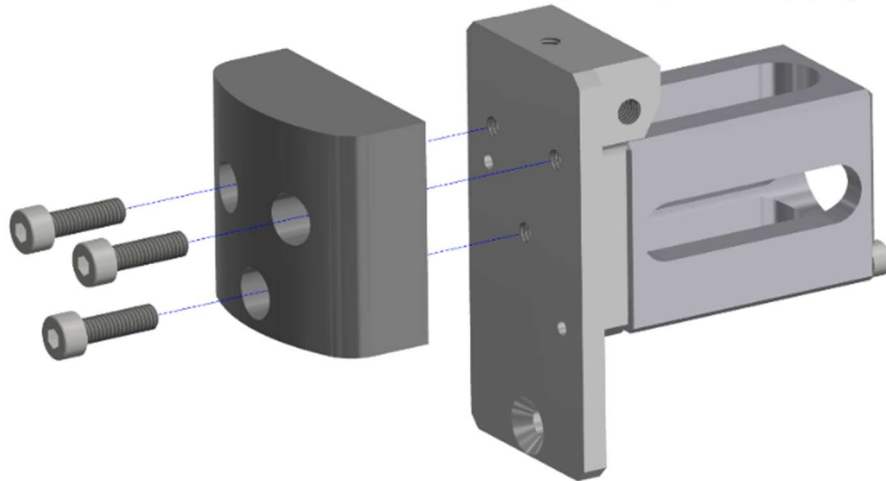


Figure 8-20. Separate the Pubic Bone (474-4544) from the Pelvis On Board DAS Mounting Plate (474-4005)

8.2.17 Remove the Tri-Pack Block (SA572-S80M) from the Upper Torso to Pelvis Adaptor Plate (474-4004) by removing two M2.5 X 0.45 X 14 LG. SHCS SS (Figure 8-21).

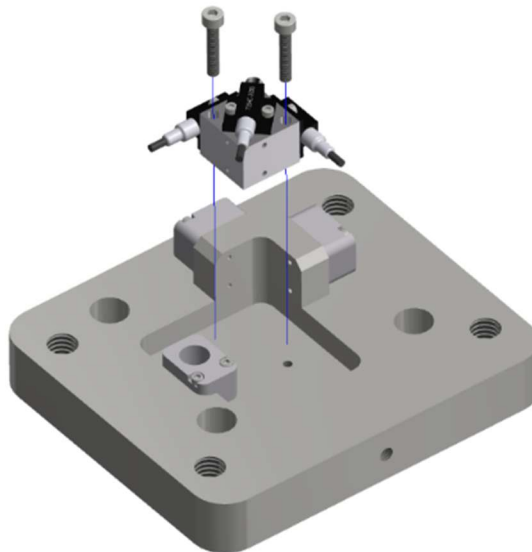


Figure 8-21. Remove the Tri-Pack Block (SA572-S80M) from the Upper Torso to Pelvis Adaptor Plate (474-4004)

8.2.18 Remove the three Accelerometers (SA572-S4) from the Tri-Pack Block (SA572-S80M) by removing two M1.4 X 0.3 X 3 LG. SHCS per accel.

8.2.19 Remove three Angular Rate Sensors (SA572-S58) from the Upper Torso to Pelvis Adaptor Plate (474-4004) by removing two M1.4 X 0.3 X 10 LG. SHCS per ARS (Figure 8-22).

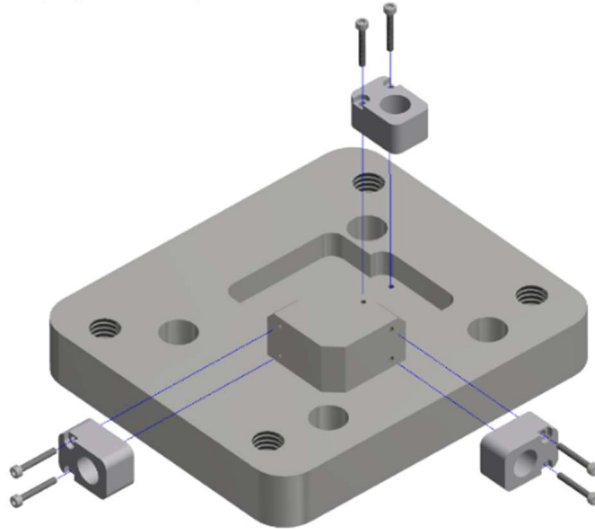


Figure 8-22. Remove three Angular Rate Sensors (SA572-S58) from the Upper Torso to Pelvis Adaptor Plate (474-4004)

8.2.20 Remove the Pelvis Tilt Sensor from the Center Pelvic Bone (474-4541) by removing two M2 X 0.4 X 10 LG. SHCS (Figure 8-23).

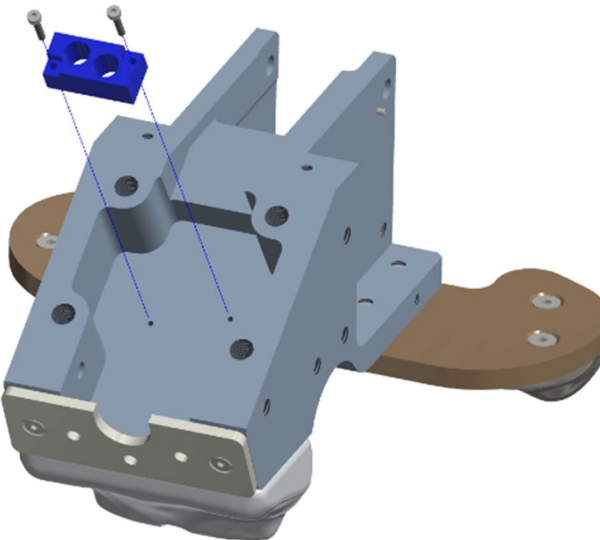


Figure 8-23. Remove the Pelvis Tilt Sensor from the Center Pelvic Bone (474-4541)

- 8.2.21 Separate the Ischium Bone Mount Plate (474-4542-A) from the Center Pelvic Bone (474-4541) by removing five M5 X 0.8 X 14 LG. FHCS (Figure 8-24).

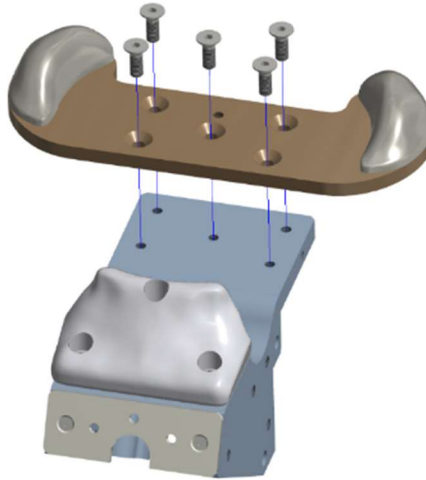


Figure 8-24. Separate the Ischium Bone Mount Plate (474-4542-A) from the Center Pelvic Bone (474-4541)

- 8.2.22 Remove the Coccyx (474-4546) from the bottom of the Center Pelvic Bone (474-4541) by removing three M5 X 0.8 X 12 LG. SHCS (Figure 8-25).

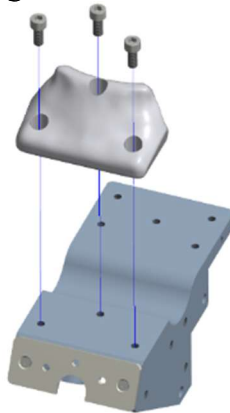


Figure 8-25. Remove the Coccyx (474-4546) from the bottom of the Center Pelvic Bone (474-4541)

- 8.2.23 Remove the Left and Right Ischium Bones (474-45451,2) from the Ischium Bone Mount Plate (474-4542-A) by removing two M4 X 0.7 X 10 LG. FHCS per side (Figure 8-26).



Figure 8-26. Remove the Left and Right Ischium Bones (474-45451,2) from the Ischium Bone Mount Plate (474-4542-A)

- 8.2.24 Separate the Rear Pelvic Instrumentation Cover (474-4001) from the Center Pelvic Bone (474-4541) by removing two M3 X 0.5 X 10 LG. FHCS (Figure 8-27).

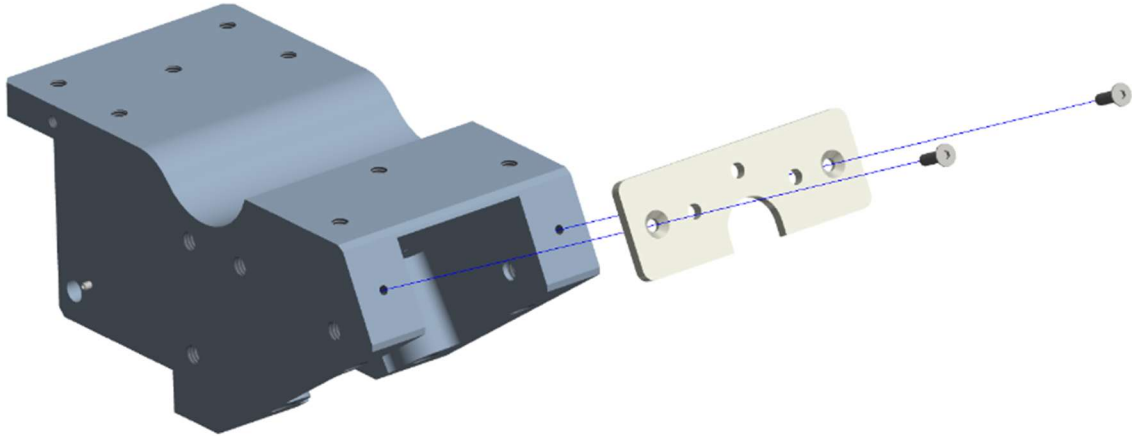


Figure 8-27. Separate the Rear Pelvic Instrumentation Cover (474-4001) from the Center Pelvic Bone (474-4541)

8.3 Assembly of the Pelvis

The following procedure is a step-by-step description of the assembly procedure for the pelvis components. Unless otherwise specified, tighten all bolts to the torque specifications provided in Section 2.1.3.

- 8.3.1 Attach the Rear Pelvic Instrumentation Cover (474-4001) to the Center Pelvic Bone (474-4541) using two M3 X 0.5 X 10 LG. FHCS (Figure 8-27).

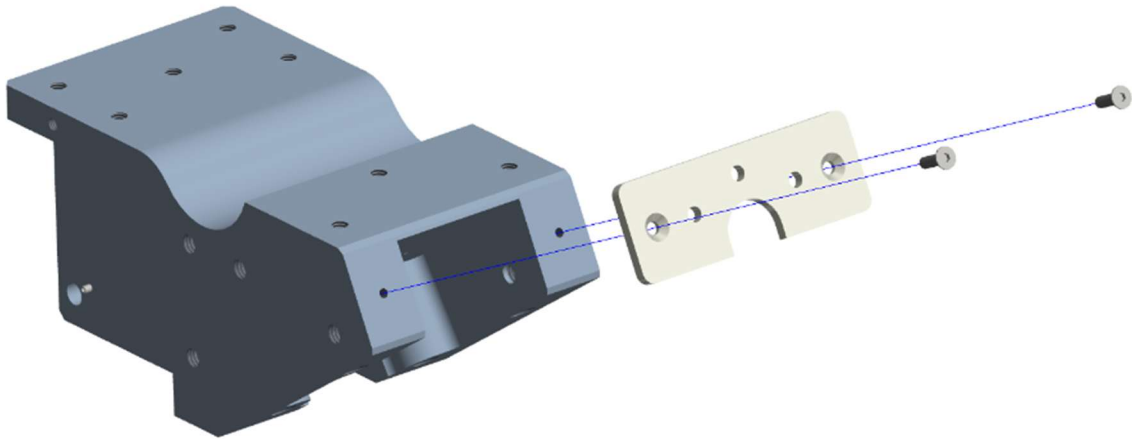


Figure 8-28. Attach the Rear Pelvic Instrumentation Cover (474-4001) to the Center Pelvic Bone (474-4541)

- 8.3.2 Attach the Coccyx (474-4546) to the bottom of the Center Pelvic Bone (474-4541) using three M5 X 0.8 X 12 LG. SHCS (Figure 8-29).

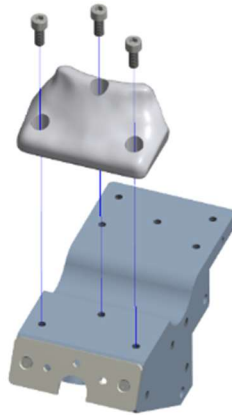


Figure 8-29. Attach the Coccyx (474-4546) to the bottom of the Center Pelvic Bone (474-4541)

- 8.3.3 Install the Left and Right Ischium Bones (474-4545-1,2) to the Ischium Bone Mount Plate (474-4542-A) with four M4 X 0.7 X 10 LG. FHCS (Figure 8-30).



Figure 8-30. Install the Left and Right Ischium Bones (474-4545-1,2) to the Ischium Bone Mount Plate (474-4542-A)

- 8.3.4 Attach the Ischium Bone Mount Plate (474-4542-A) to the Center Pelvic Bone (474-4541) with five M5 X 0.8 X 14 LG. FHCS (Figure 8-31).

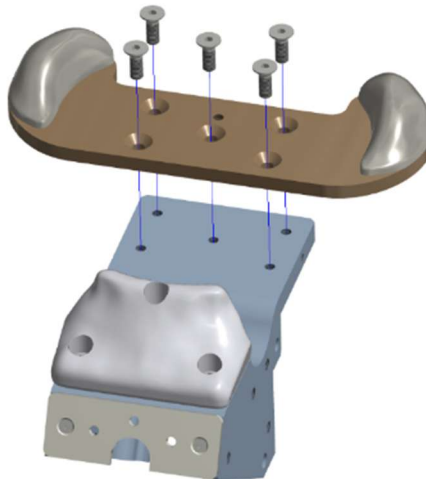


Figure 8-31. Attach the Ischium Bone Mount Plate (474-4542-A) to the Center Pelvic Bone (474-4541)

- 8.3.5 Attach the Pelvis Tilt Sensor from the Center Pelvic Bone (474-4541) using two M2 X 0.4 X 10 LG. SHCS (Figure 8-32).

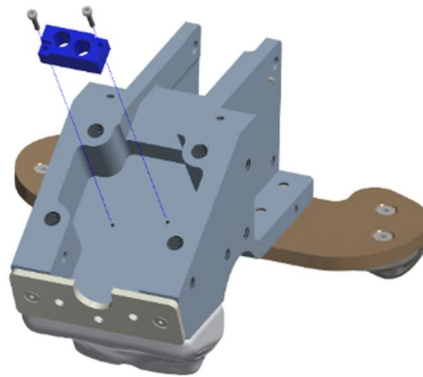


Figure 8-32. Attach the Pelvis Tilt Sensor to the Center Pelvic Bone (474-4541)

- 8.3.6 Attach the DAS Structural Replacement (474-8206) to the Pelvis DAS Mounting Plate (474-4005) with two M3 X 0.5 X 50 LG. SHCS (Figure 8-33).

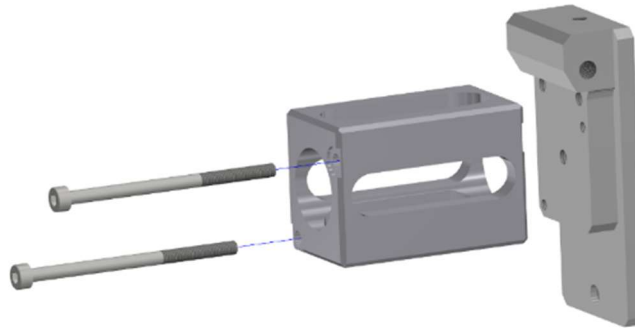


Figure 8-33. Install the DAS Structural Replacement (474-8206)

- 8.3.7 Attach the Pubic Bone (474-4544) to the Pelvis DAS Mounting Plate (474-4005) with three M4 X 0.7 X 14 LG. SHCS to (Figure 8-39).

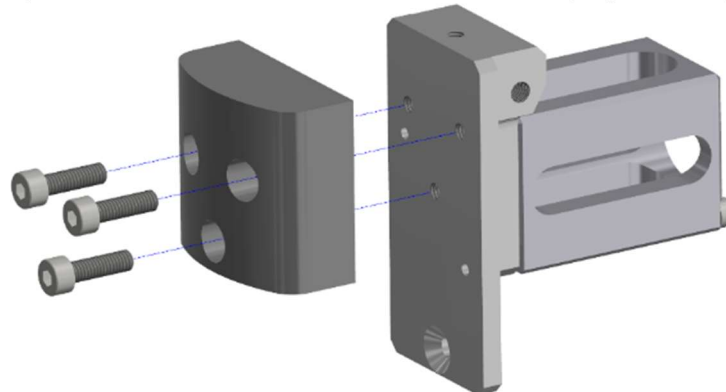


Figure 8-34. Attach the Pubic Bone (474-4544) from the Pelvis Slice Stack Mounting Plate (474-4005)

- 8.3.8 Install the Pelvis DAS Mounting Plate (474-4005) to the Center Pelvic Bone (474-4541) with one M4 X 0.7 X 12 LG. FHCS from (Figure 8-35).

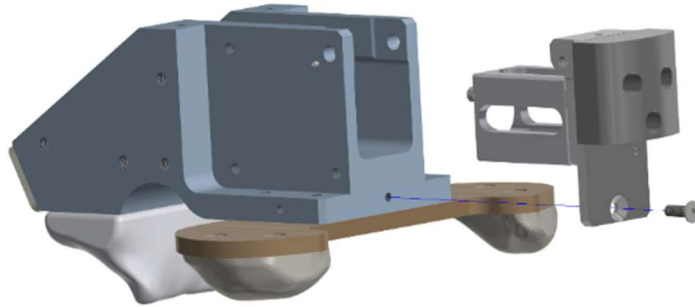


Figure 8-35. Install the Pelvis DAS Mounting Plate (474-4005) to the Center Pelvic Bone (474-4541)

- 8.3.9 Mount a Pelvic Plunger Assembly (474-4305) on each top hole of the Left and Right Femur Mounting Socket (474-4003-1 and 474-4003-2) (Figure 8-36).

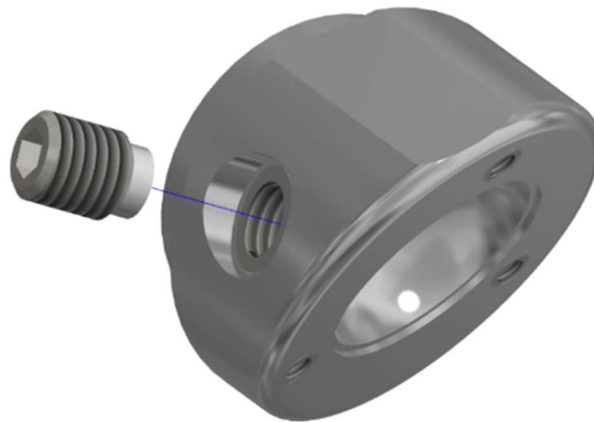


Figure 8-36. Mount a Pelvic Plunger Assembly (474-4305) on each top hole of the Left and Right Femur Mounting Socket

- 8.3.10 There are two alignment dowel pins on the medial side of the Femur Mounting Socket. Align the dowel pins with the respective dowel pin holes in the Acetabulum Load Cell as shown in Figure 8-37. Apply Loctite to the M8 X 1.25 X 18 SHCS. Once aligned, use an M8 X 1.25 X 18 SHCS with torque of 48.8 N-m (432 in-lb) to secure the Femur Mounting Socket (474-4002-1,2) to the Acetabulum Load Cell (SA572-S108) (Figure 8-39). Repeat process for other leg.

NOTE: The orientation of the acetabulum load cell axes and wiring is critical to proper assembly of the pelvis. Improper orientation will prevent the load cell from installation within the pelvis.

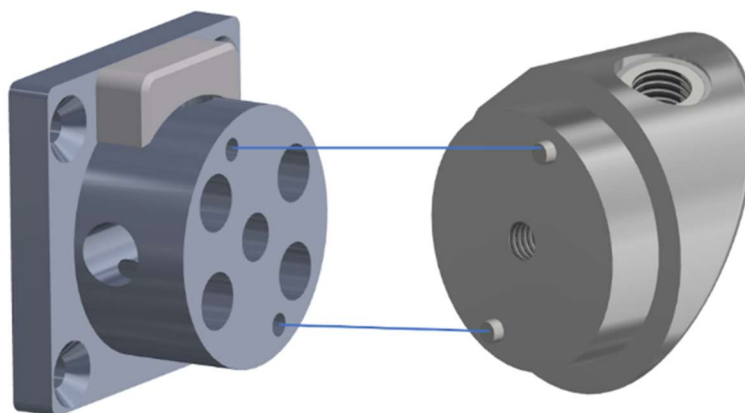


Figure 8-37. Align the pins with the respective holes in the Acetabulum Load Cell.



Figure 8-38. Apply Loctite to the M8 X 1.25 X 18 SHCS

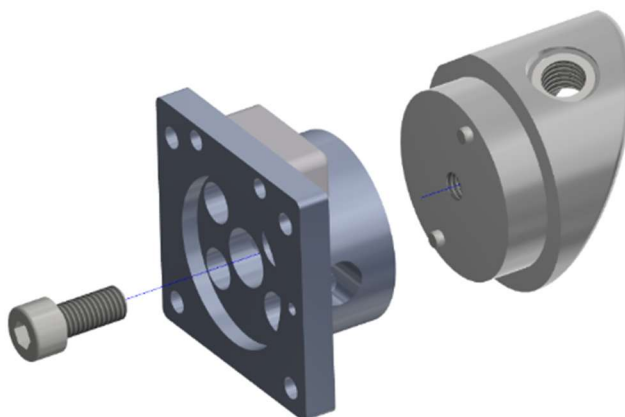


Figure 8-39. Attach femur mounting socket to acetabulum load cell

8.3.11 Bolt the Left and Right Socket/Load Cell Assemblies to the Center Pelvic Bone (474-4541) using four M5 X 0.8 X 25 LG. FHCS, as shown in Figure 8-40.

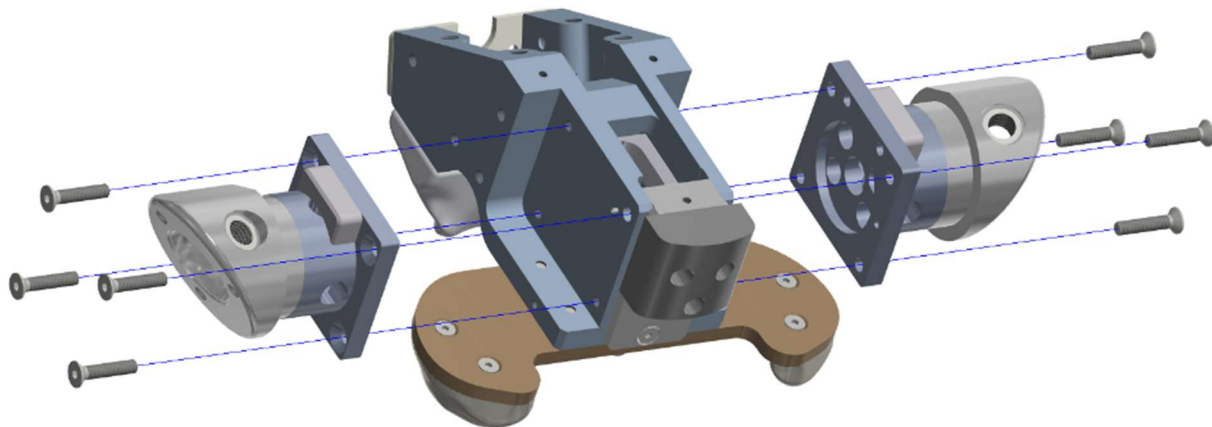


Figure 8-40. Bolt left and right load cell assemblies to Center Pelvic Bone

8.3.12 For the left and right sides, position the ASIS load cell as shown in Figure 8-41 and attach it to the iliac wing using two M5 X 0.8 X 18 LG. LHCS.

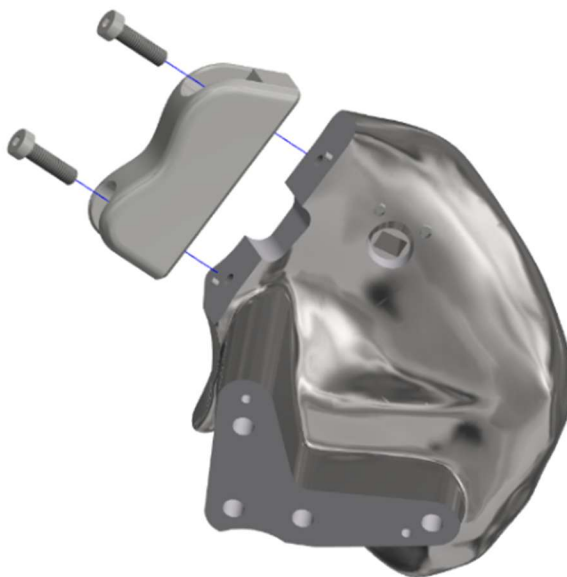


Figure 8-41. Install ASIS load cell

- 8.3.13 Attach the Left (474-4540-1-A) and Right (474-4540-2-A) Pelvis Wings to the left and right sides of the Center Pelvic Bone (474-4541) using four M6 X 1 X 22 LG. SHCS on each side (Figure 8-42).

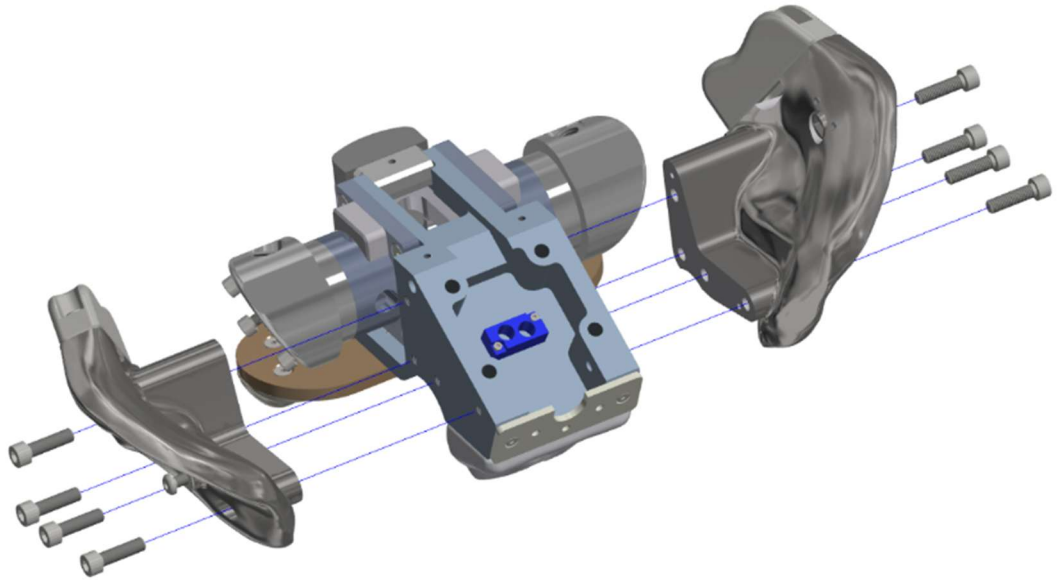


Figure 8-42. Attach screws through pelvis iliac wings into center pelvic bone

- 8.3.14 Route and strain relieve the instrumentation wires through the center pelvis channel (Figure 8-43). At this stage, route the abdomen pressure sensor wires through the channel as well, as shown in Figure 8-44.

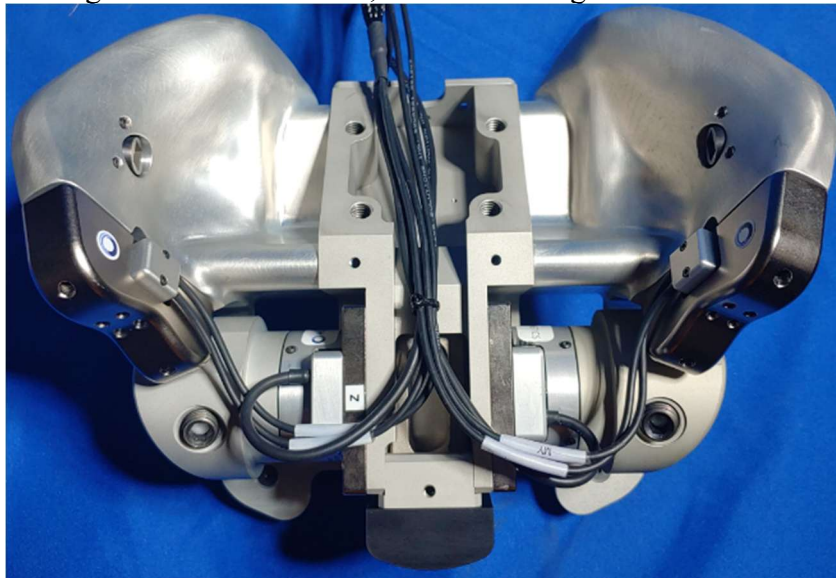


Figure 8-43. Route and strain relieve the instrumentation wires through the center pelvis channel

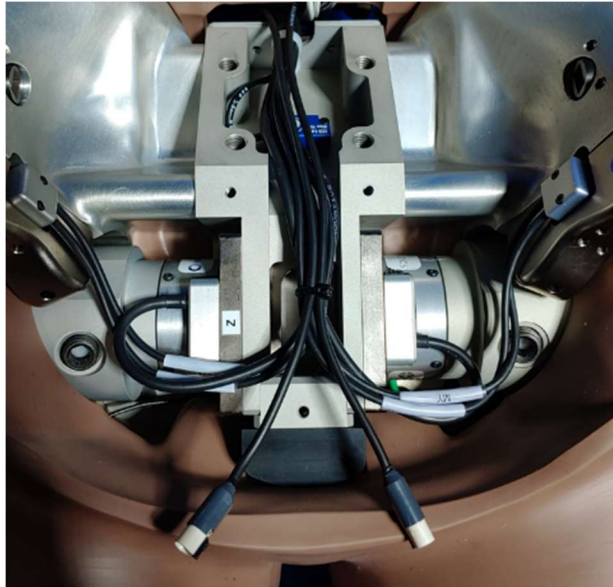


Figure 8-44. Route the abdomen pressure sensor wires through the center pelvic channel

8.3.15 Install the Pelvis Cable Cover (474-4010) to the Center Pelvic Bone (474-4541) with three M4 X 0.7 X 10 LG. SHCS. The wires from the Acetabulum and ASIS load cells are routed under the left and right sides of the Pelvis Cable Cover and exit under the rear of the Pelvis Cable Cover (Figure 8-45). Strain relieve the ASIS and Acetabulum Load Cell wires according to Figure 8-46.

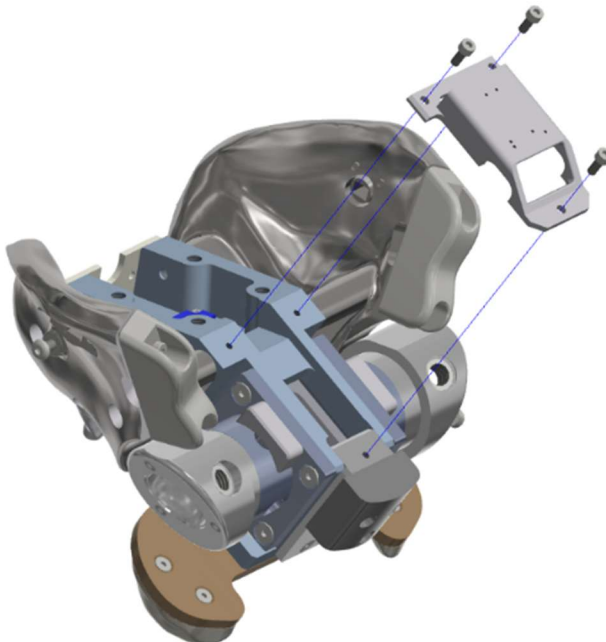


Figure 8-45. Install the Pelvis Cable Cover (474-4010) to the Center Pelvic Bone (474-4541) and route wires accordingly

- 8.3.16 Strain relieve the instrumentation wires to the Rear Pelvic Instrumentation Cover (474-4001) using two cable ties (Figure 8-46). One cable tie attaches to the cover, one to the wire bundle.



Figure 8-46. Strain relieve the instrumentation wires

- 8.3.17 Mount the X, Y, and Z angular rate sensors to the Upper Torso to Pelvis Adaptor Plate (474-4004) using two M1.4 X 0.3 X 10 SHCS per ARS (Figure 8-47).

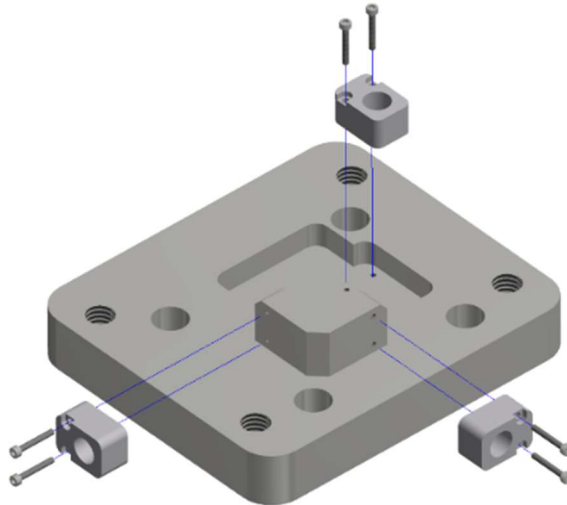


Figure 8-47. Mount the X, Y, and Z angular rate sensors to the Upper Torso to Pelvis Adaptor Plate (474-4004)

- 8.3.18 Mount the X, Y, and Z accelerometers to the Tri-Pack Block (SA572-S80M) block using two M1.4 X 0.3 X 3 SHCS per accelerometer (Figure 8-48). Strain relieve the three accelerometer wires together.

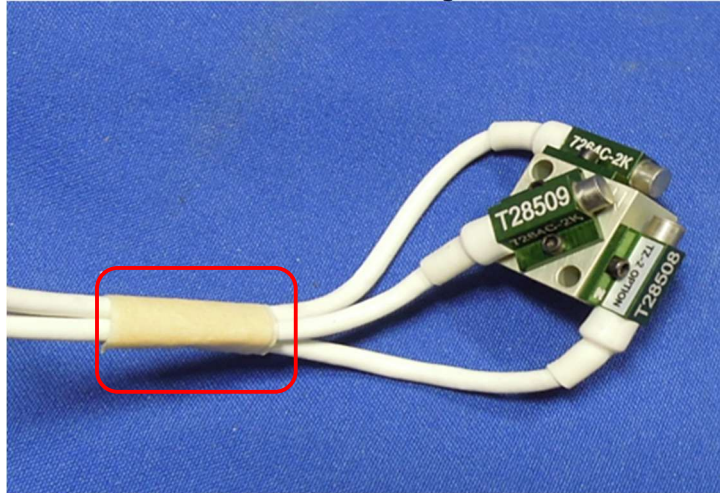


Figure 8-48. Attach accelerometers to block and strain relieve accelerometer wires

- 8.3.19 Secure the Tri-Pack Block (SA572-S80M) to the Upper Torso to Pelvis Adaptor Plate (474-4004) with two M2.5 X 0.45 X 14 SHCS (Figure 8-49). Strain relieve the three ARS wires together.

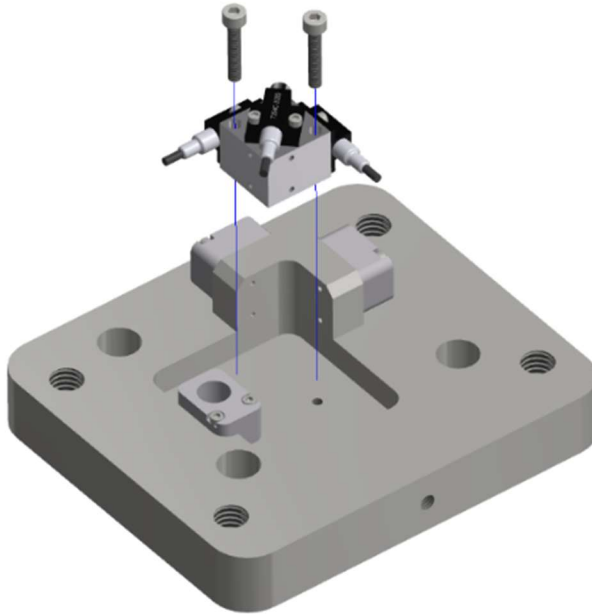


Figure 8-49. Secure to Upper Torso to Pelvis Adaptor Plate

8.3.20 Mount the Upper Torso to Pelvis Adaptor Plate (474-4004) to the Center Pelvic Bone (474-4541), using four M8 X 1.25 X 30 FHCS (Figure 8-50). The accelerometers are oriented in the following manner: +X forward, +Y right, +Z down. This sign convention agrees with the SAE coordinate system. The ARS and accelerometer wires will exit the back of the pelvis, in the cutout of the Rear Pelvic Instrumentation Cover (474-4001).

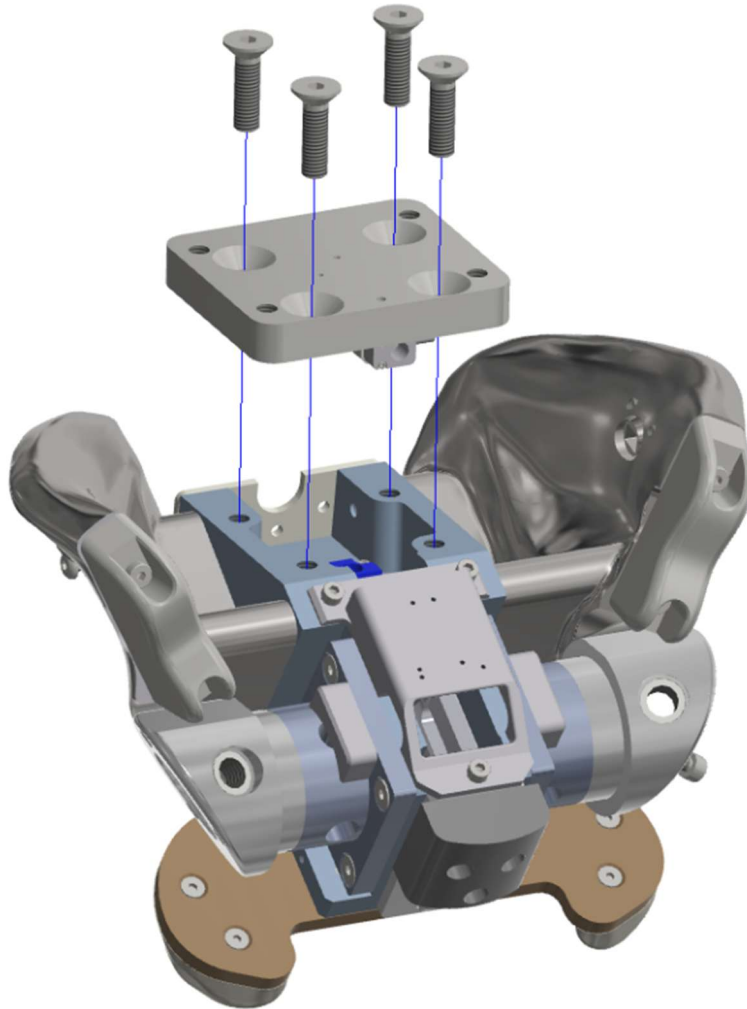


Figure 8-50. Mount Upper Torso to Pelvis Adaptor Plate (474-4004) to the Center Pelvic Bone (474-4541)

- 8.3.21 Install ground cables to the left and right sides of the center pelvic bone (Figure 8-51).

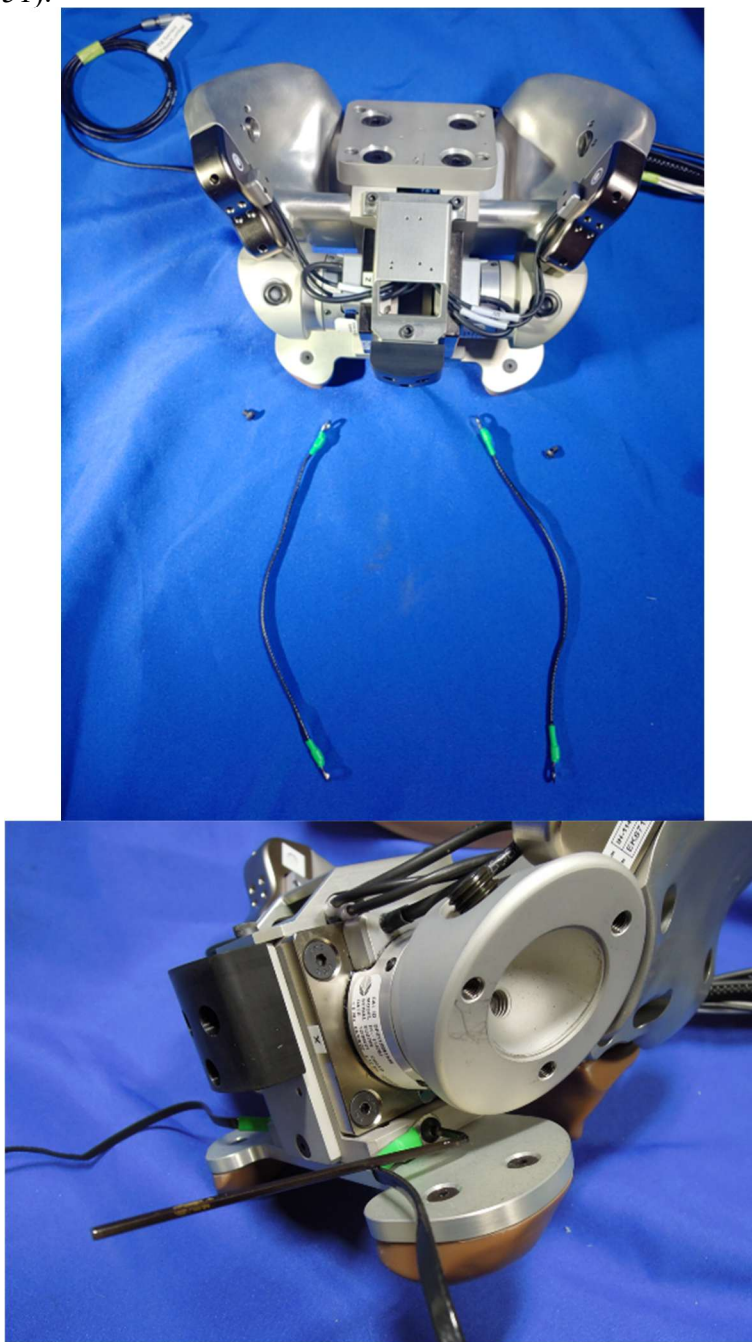


Figure 8-51. Install ground cables

8.3.22 Route the wiring (from inside to outside) through the hole in the back of the pelvis flesh (Figure 8-52).



Figure 8-52. Wiring routing

8.3.23 Install the completed mechanical pelvis assembly into the Pelvis Flesh (474-4520) (Figure 8-53). Route the ground cables through the leg holes (Figure 8-54).

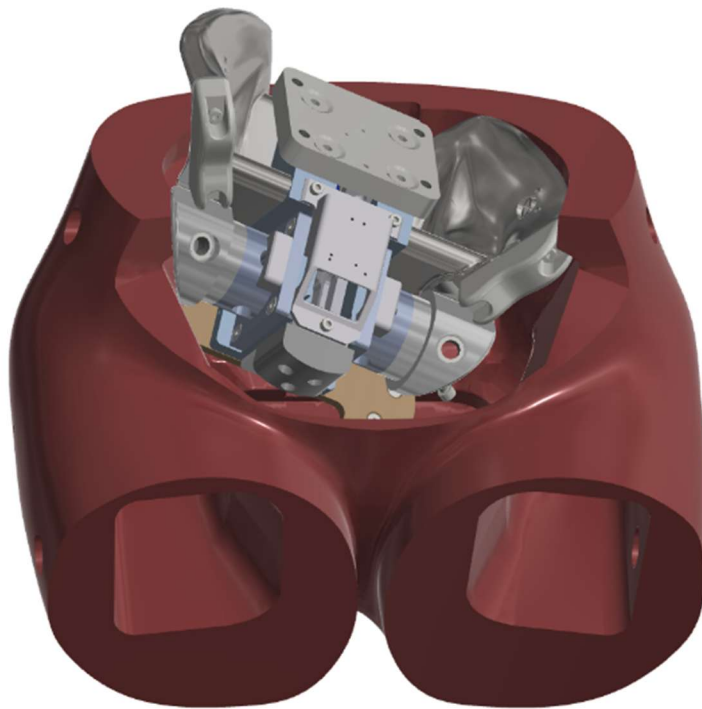


Figure 8-53. Insert pelvis assembly into pelvis flesh

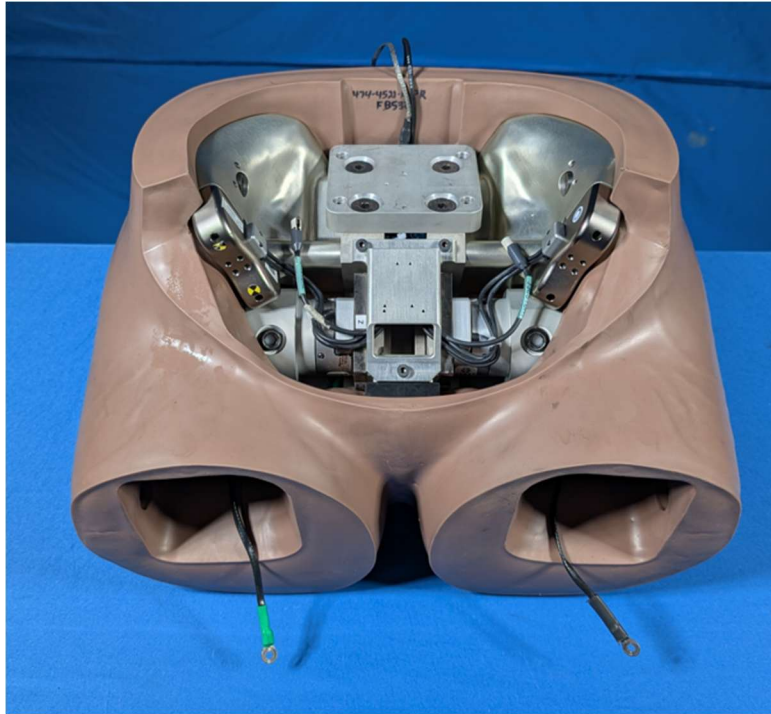


Figure 8-54. Route the ground cables through the leg holes

8.3.24 Attach the ground cable from the center pelvic bone to the left and right Femur Assemblies (474-4700-1,2). Attach the Upper Leg Ground cable to the same location, as shown in Figure 8-55.

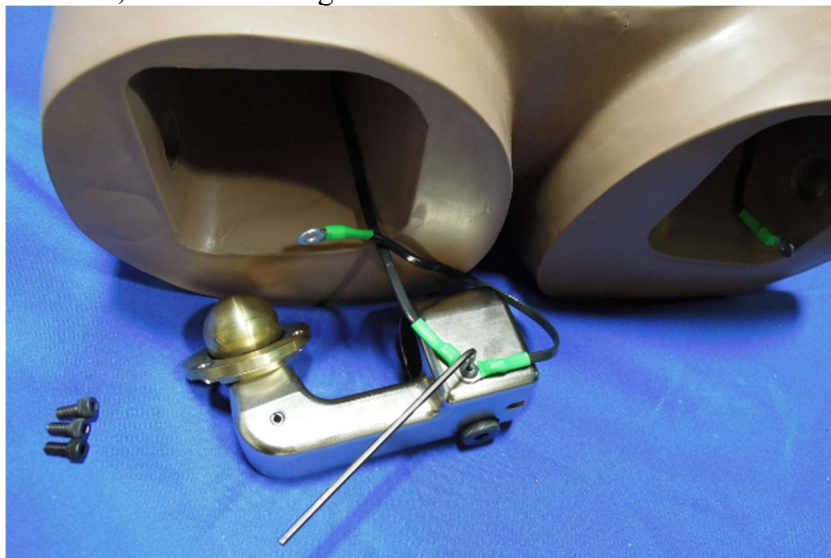


Figure 8-55. Attach the ground cables to the Femur Assemblies

- 8.3.25 Insert the Left and Right Femur Assembly (477-4700-1,2) into the femur pelvis flesh. Attach the femur assembly to the pelvis with three M5 X 0.8 X 10 LG. SHCS per side. Access the screws through the external openings on the pelvis flesh (Figure 8-56 through Figure 8-58).

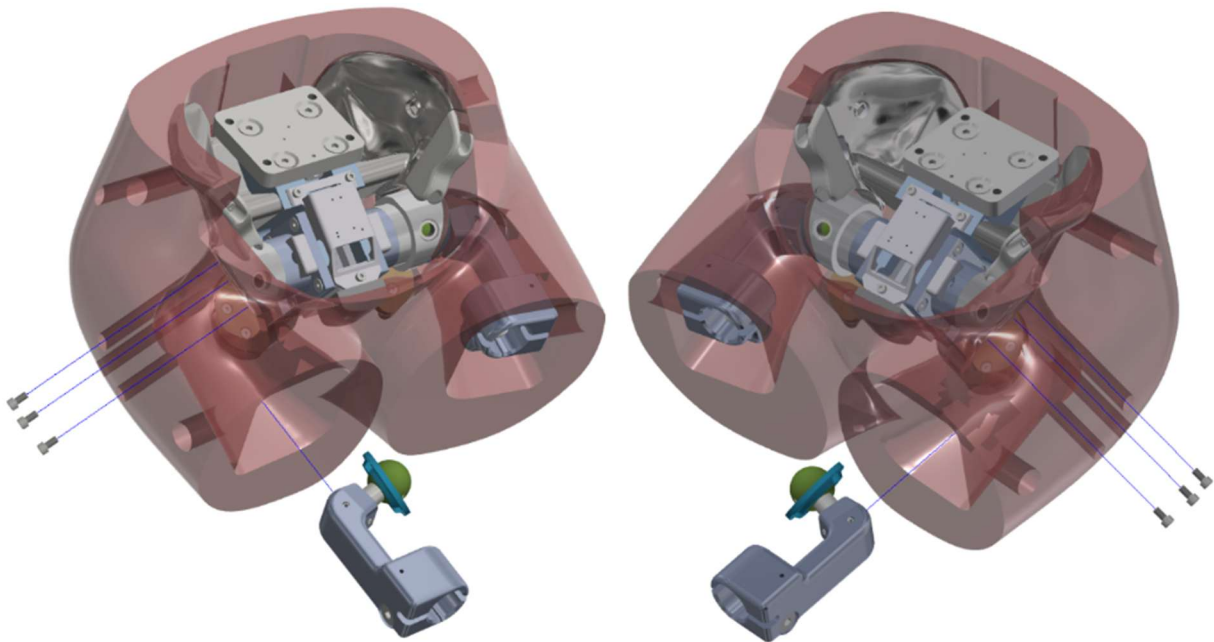


Figure 8-56. Attach femur ball joint to pelvis



Figure 8-57. Accessing holes for installing femur assemblies

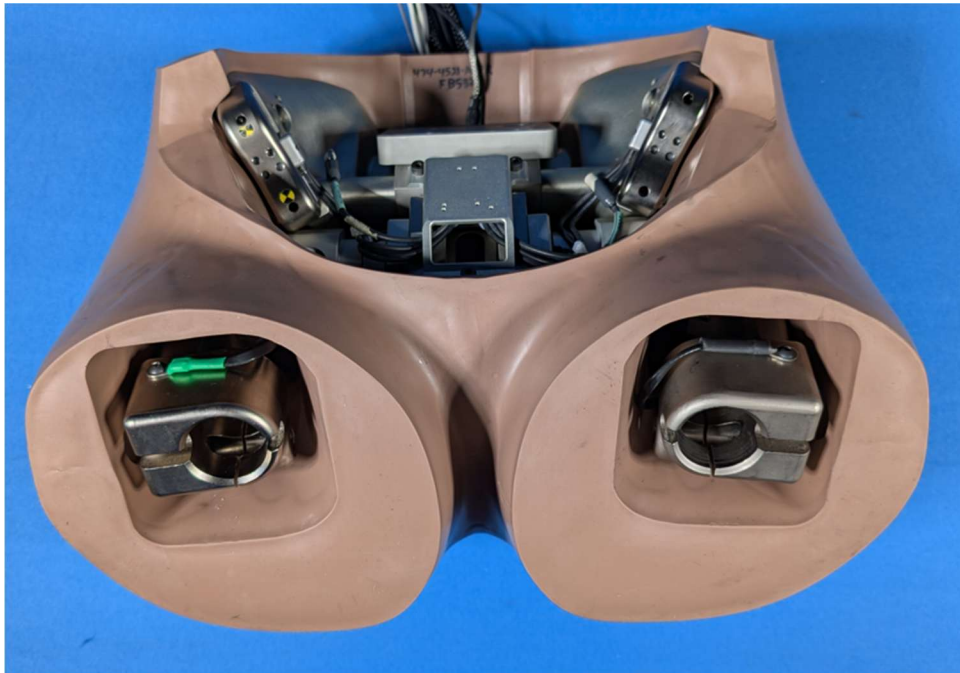


Figure 8-58. Installed Femur Assemblies

8.3.26 Tighten the Left and Right Pelvic Plunger Assemblies (474-4315) to adjust the hip joint torque setting (Figure 8-59).

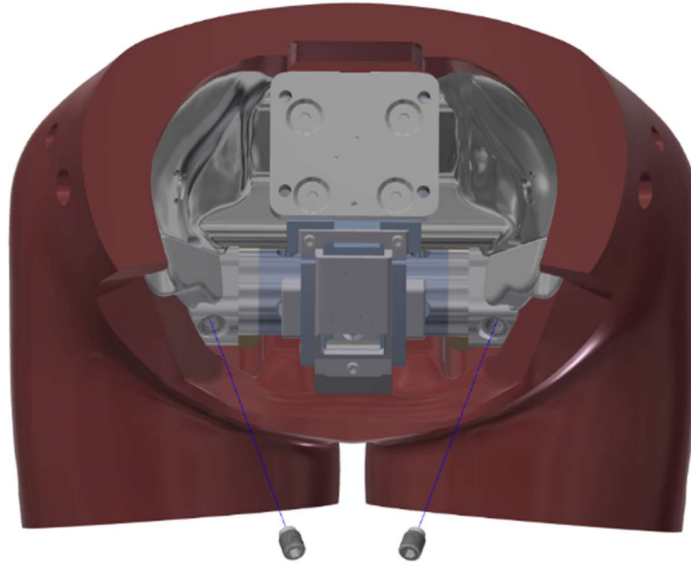


Figure 8-59. Tighten the Left and Right Pelvic Plunger Assemblies (474-4315)

8.4 Assembly of the Pelvis to the Spine

The following procedure is a step-by-step description used to install the completed spine assembly (474-3200) to the completed pelvis assembly (474-4000-A). Unless otherwise specified, tighten all bolts to the torque specifications provided in Section 2.1.3.

Install the Lumbar Assembly (474-3223) to secure the spine to the pelvis assembly using four M8 X 1.25 X 20 SHCS, two on each side of the flex joint (

8.4.1 Figure 8-60).

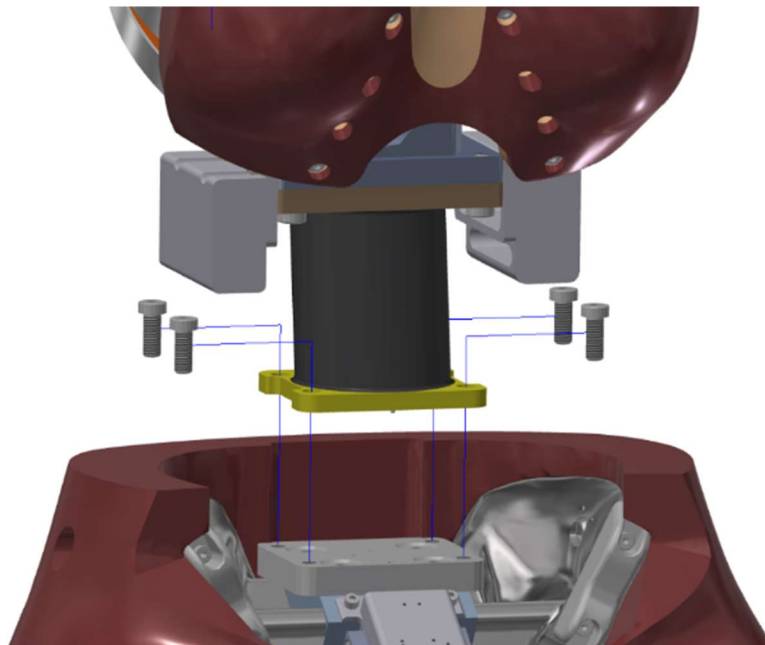


Figure 8-60. Install lumbar assembly to pelvis assembly

8.5 Adjustments for the Pelvis Assembly

The pelvis assembly requires a joint resistive torque adjustment for each acetabular cup. The goal of the adjustment is to provide a 1G joint friction torque by turning the femur plunger downward to press against the femur ball.

Check the adjustment by straightening the leg of the dummy and raising it in front of the dummy. The leg should remain in position, but move easily under external force. If needed, adjust the Pelvic Plunger Assemblies (474-4315) in order to achieve 1G joint friction torque.

8.6 Wire Routing and Electrical Connections

Section 13.3 includes grounding information. Section 13.4 describes cable routing instructions. Section 0 also shows cable routing instructions for the ASIS load cells.

Section 9. Upper Leg Assembly

9.1 Description of the Upper Leg Assembly and Features

The upper leg assembly of the THOR-05F dummy extends from the femur ball joint to the knee. At the upper end of the femur, a ball mates with the socket in the pelvis assembly to form the hip joint. At the lower end of the femur, a standard six-axis femur load cell connects the femur assembly to the machined knee. Figure 9-1 shows the constructed upper leg without the Femur Assemblies (474-4700-1 and 472-4700-2) which connect the femur shaft to the pelvis.

The THOR-05F femur axial compliant bushing design has been tuned to create a biofidelic response along the axis of the femur during a knee impact. The axial compression of the femur simulates the compressive response of human PMHS femurs. The compliant section is constrained on a square shaft that slides linearly within a square bushing. The square shaft and bushing assure a purely linear motion. There are end stop bumpers fixed to both ends of the shaft to prevent over-travel.

The upper leg instrumentation includes a six-axis femur load cell (SA572-S63). This sensor produces three output forces and three output moments.

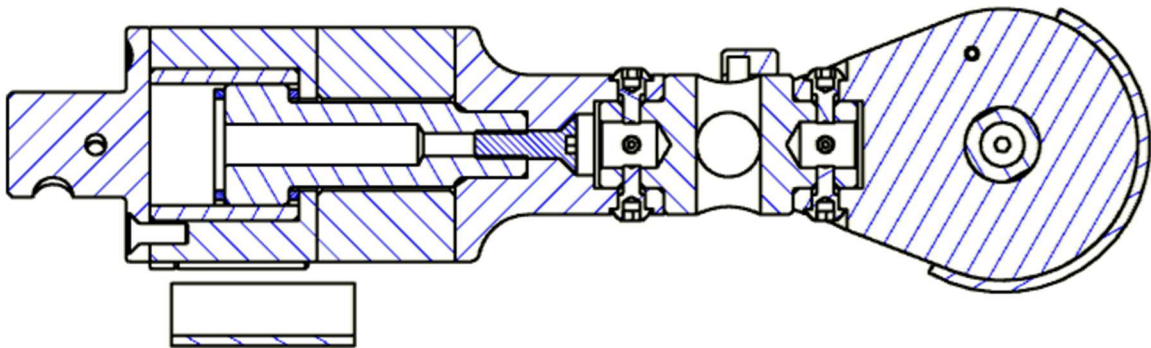


Figure 9-1. Constructed Upper Leg (474-5100-1,2-A)

Table 9-1 through Table 9-6 lists the components that are included in the upper leg assembly. Figure 9-2 through Figure 9-7 illustrates the upper leg assembly and hardware.

Table 9-1. Upper Leg Assembly (474-5100-1,2-A) Components

Part Description	Quantity	Part Number	Figure #	Item #
Knee Assembly	1	474-5400	Figure 9-2	1
Modified BHSS M6 Thread	8	W50-61042	Figure 9-2	2
Femur Assembly	1	474-5160-1,2	Figure 9-2	3
Structural Replacement, Femur Load Cell	1	474-5101	Figure 9-2	4
Structural Replacement, Femur Load Cell Strain Relief	1	474-5102	Figure 9-2	5
M3 X 0.5 X 45 LG. SHCS SS	4	5000679	Figure 9-2	6
On Board DAS Structural Replacement	2	474-8205	Figure 9-2	7
M2.5 X 0.45 X 10 LG. SHCS	2	5000456	Figure 9-2	8
Upper Leg Flesh	1	474-5122-1,2	Figure 9-2	9
Knee Flesh	1	474-5321-1,2	Figure 9-2	10
Cable Connector Guard	1	474-5107	Figure 9-2	11
M3 X 0.5 X 20 LG. SHCS	2	5000312	Figure 9-2	12
M4 X 0.7 X 8 LG. SHCS	4	5000989	Figure 9-2	13
Knee Cover, Left	1	474-5301-1-A	Figure 9-2	14
Knee Cover, Right	1	474-5301-2-A	Figure 9-2	15
M4 X 0.7 X 12 LG. FHCS	4	5001086	Figure 9-2	16
M4 X 0.7 X 8 LG. BHCS	2	5000103	Figure 9-2	17

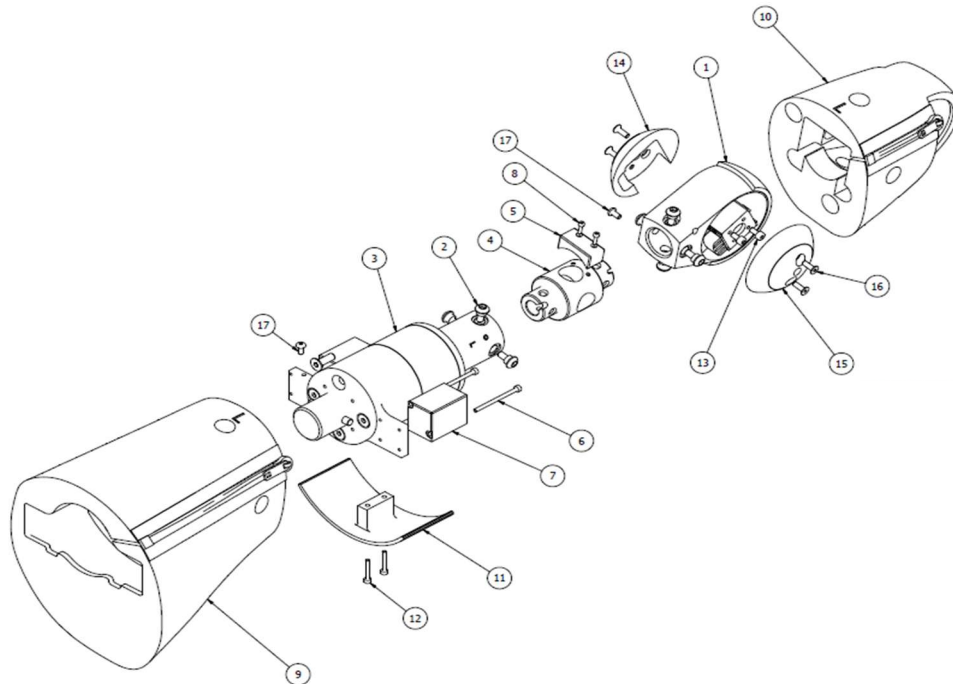


Figure 9-2. Upper Leg Assembly (474-5100-1,2-A) Components

Table 9-2. Femur Assembly (474-5160-1,2) Components

Part Description	Quantity	Part Number	Figure #	Item #
Femur Plunger Assembly	1	474-5166	Figure 9-3	1
Femur Bushing Assembly	1	474-5164	Figure 9-3	2
Femur Rubber	1	474-5172	Figure 9-3	3
Femur Attachment Plate	1	4745161	Figure 9-3	4
M6 X 1 X 18 LG. FHCS	4	5000108	Figure 9-3	5
M8 X 1.25 X 30 LG. FHCS	1	5000605	Figure 9-3	6
Femur End Cap	1	474-5173-1,2	Figure 9-3	7

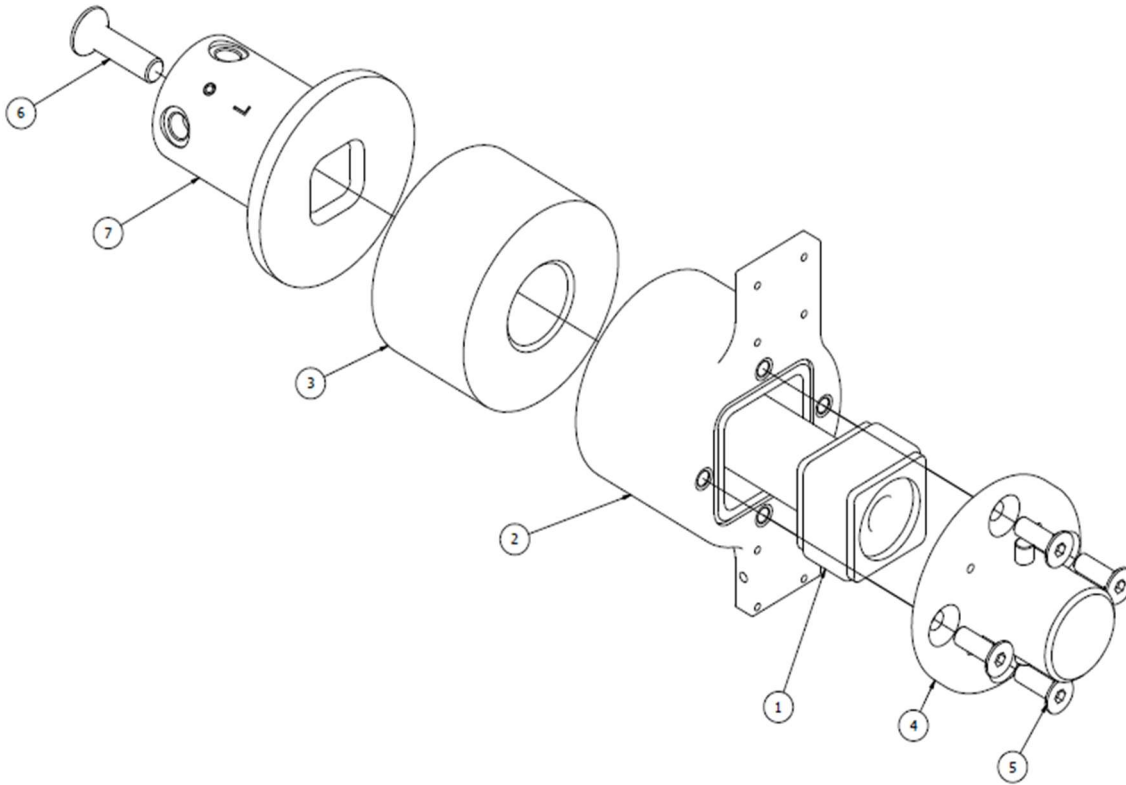


Figure 9-3. Femur Assembly (474-5160-1,2).

Table 9-3. Left Knee Slider Upper Assembly (474-5421) Components

Part Description	Quantity	Part Number	Figure #	Item #
Ball Bearing Separator	2	474-5394	Figure 9-4	1
Knee Slider Bumper Assembly	1	474-5415	Figure 9-4	2
Left Knee Slider Assembly, Molded	1	474-5422	Figure 9-4	3
Knee Slider Ball Retainer	2	474-5429	Figure 9-4	4
Ball 3/16" Dia.	10	EX593-19-DN	Figure 9-4	5
M2 X 0.4 X 4 LG. FHCS	8	5000595	Figure 9-4	6

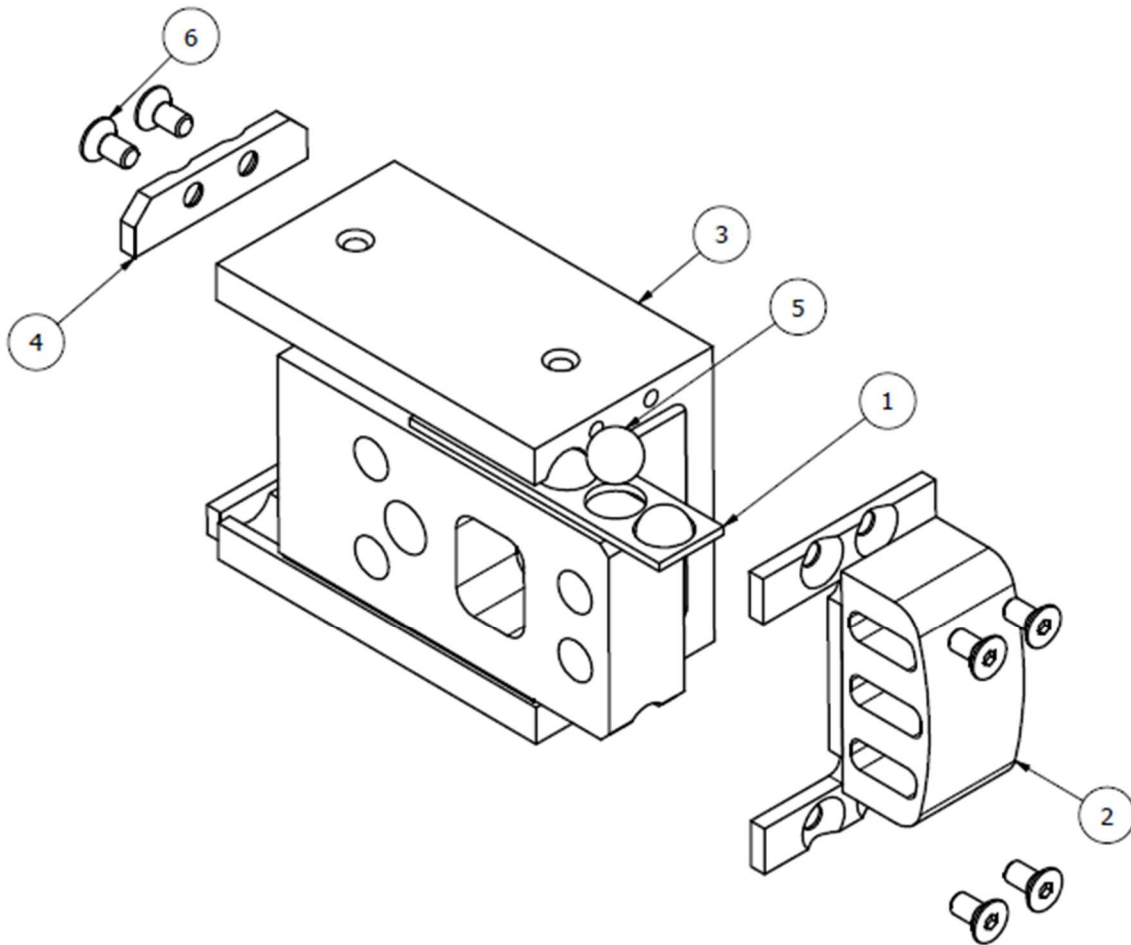


Figure 9-4. Left Knee Slider Upper Assembly (474-5421).

Table 9-4. Right Knee Slider Upper Assembly (474-5425) Components

Part Description	Quantity	Part Number	Figure #	Item #
Ball Bearing Separator	2	474-5394	Figure 9-6	1
Knee Slider Bumper Assembly	1	474-5415	Figure 9-6	2
Right Knee Slider Assembly	1	474-5426	Figure 9-6	3
Knee Slider Ball Retainer	2	474-5429	Figure 9-6	4
Ball 3/16" Dia.	10	EX593-19-DN	Figure 9-6	5
M2 X 0.4 X 4 LG. FHCS	8	5000595	Figure 9-6	6

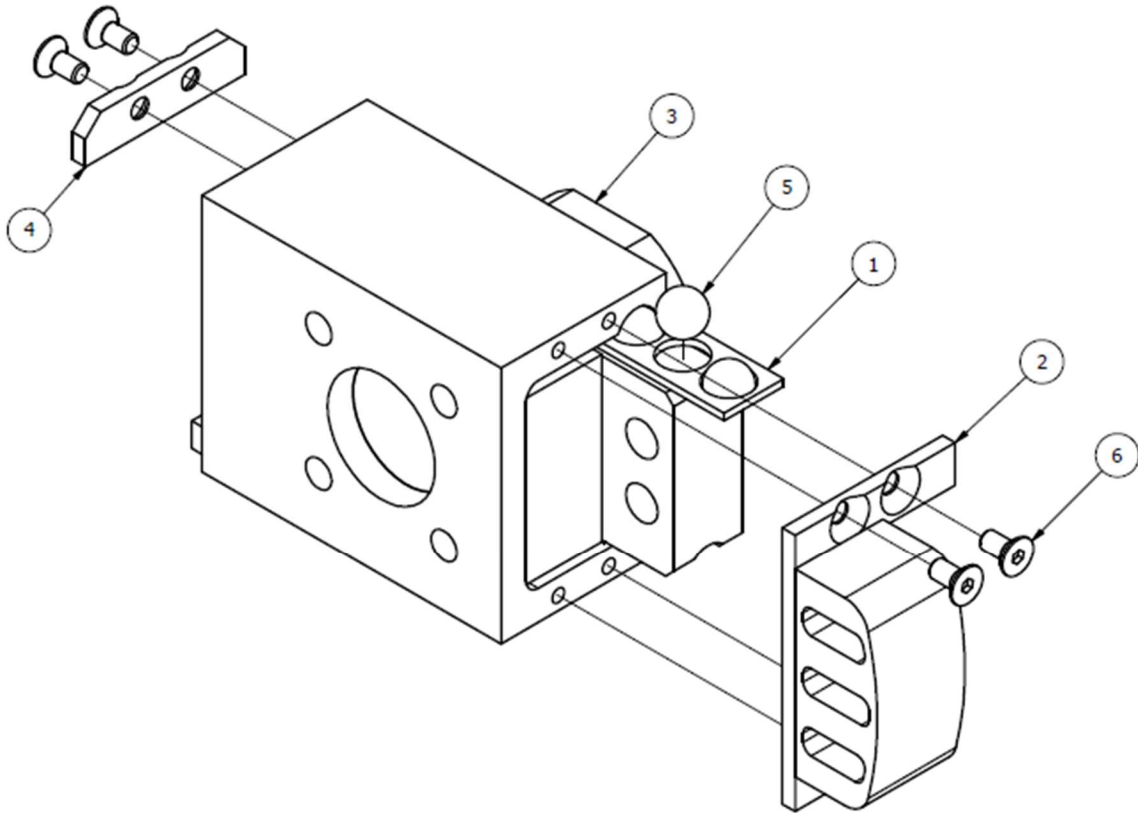


Figure 9-5. Right Knee Slider Upper Assembly (474-5425).

Table 9-5. Knee Slider Assembly (474-5420) Components

Part Description	Quantity	Part Number	Figure #	Item #
Knee Rotation Stop, Pot	1	474-5404		1
Knee Rotation Stop, No Pot	1	474-5405		2
Left Knee Slider Upper Assembly	1	474-5421	Figure 9-6	3
Right Knee Slider Upper Assembly	1	474-5425	Figure 9-6	4
M4 X 0.7 X 20 LG. BHCS	2	5000007	Figure 9-6	5

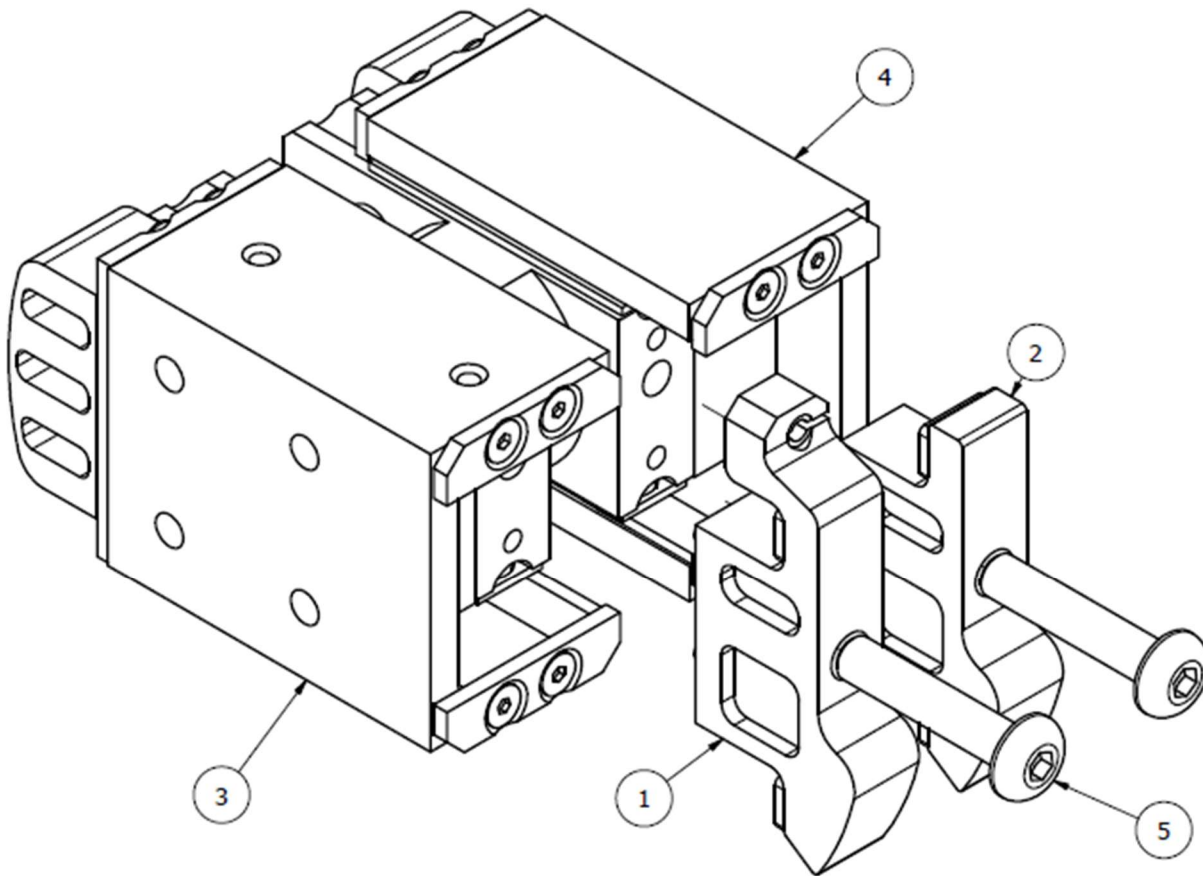


Figure 9-6. Knee Slider Assembly (474-5420).

Table 9-6. Knee Assembly (474-5400) Components

Part Description	Quantity	Part Number	Figure #	Item #
Plate, Mount	1	472-5305	Figure 9-7	1
Knee Compression Washer	1	474-5316	Figure 9-7	2
Knee Insert	1	474-5340	Figure 9-7	3
Knee Carbon Fiber Washer	2	474-5401	Figure 9-7	4
Knee Cap	1	474-5410	Figure 9-7	5
Knee Slider Assembly	1	474-5420	Figure 9-7	6
M2.5 X 0.45 x4 LG.FHMSP ZINC	2	5001866	Figure 9-7	7
M8 X 10 LG. SHSS	1	5001332	Figure 9-7	8
5/16 FLAT WASHER PTFE - A	1	9004093	Figure 9-7	9

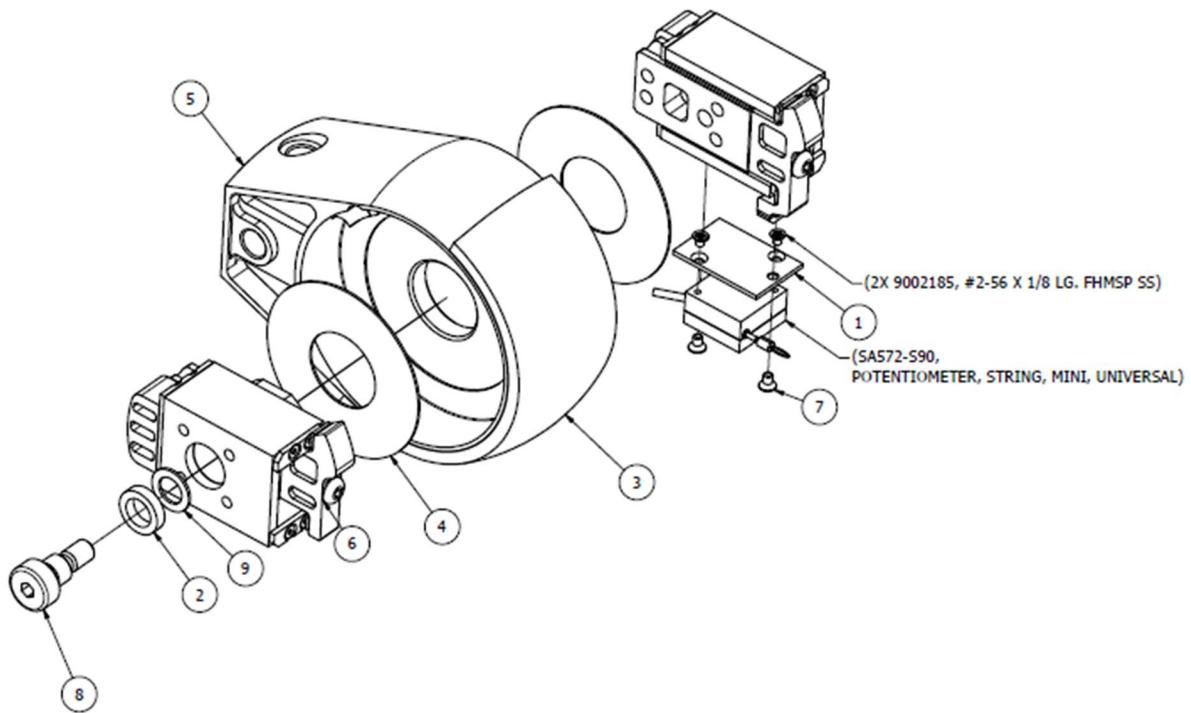


Figure 9-7. Knee Assembly (474-5400).

9.2 Disassembly of the Upper Leg

The following procedure is a step-by-step description of the disassembly procedure for the upper leg (femur) components. Only the left upper leg disassembly is illustrated. The right upper leg disassembly follows identical procedures.

- 9.2.1 Remove the ground cable from the top of the Femur Assembly (474-4700-1,2) (Figure 9-8).

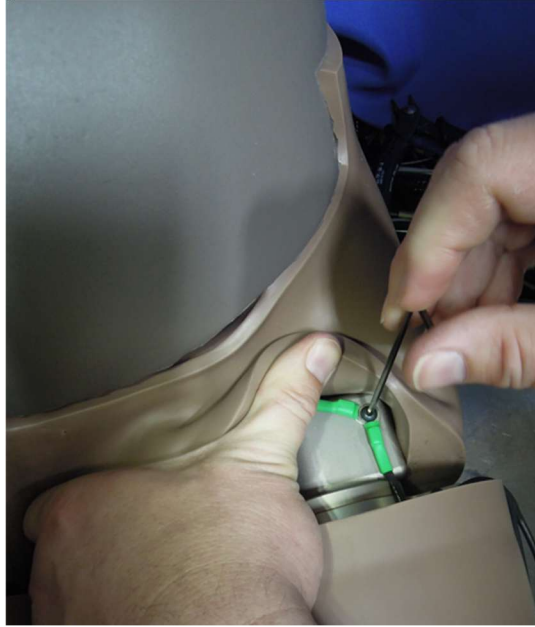


Figure 9-8. Remove the ground cable from the top of the Femur Assembly (474-4700-1).

- 9.2.2 Remove the leg from the Femur Assembly by removing the M12 X 30 LG. SHSS (Figure 9-9).

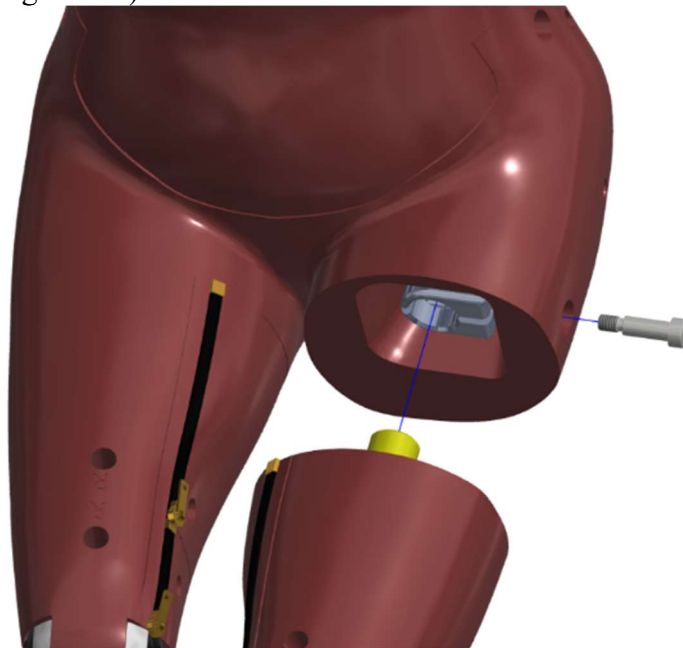


Figure 9-9. Remove the leg from the Femur Assembly by removing the M12 X 30 LG. SHSS.

9.2.3 Unzip the Upper Leg Flesh (474-5122-1,2) (Figure 9-10).

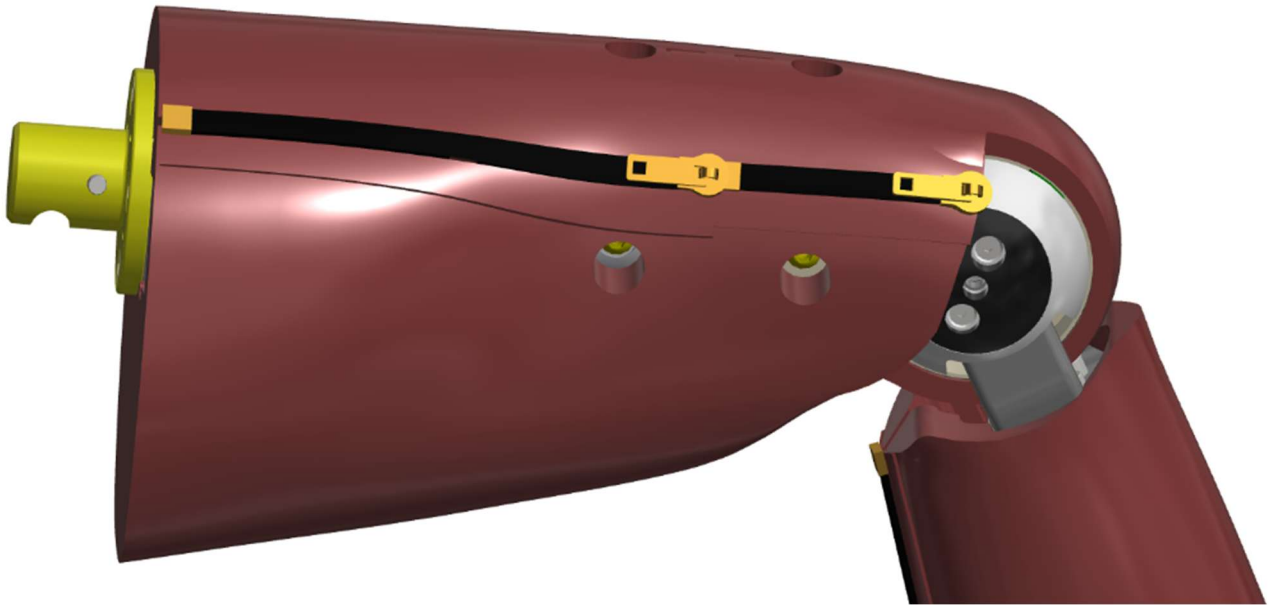


Figure 9-10. Unzip the Upper Leg Flesh (474-5122-1,2)

9.2.4 Remove the Left and Right Knee Covers (474-5301-1,2-A) by removing the two M4 X 0.7 X 12 LG. FHCS (Figure 9-11) on each side.

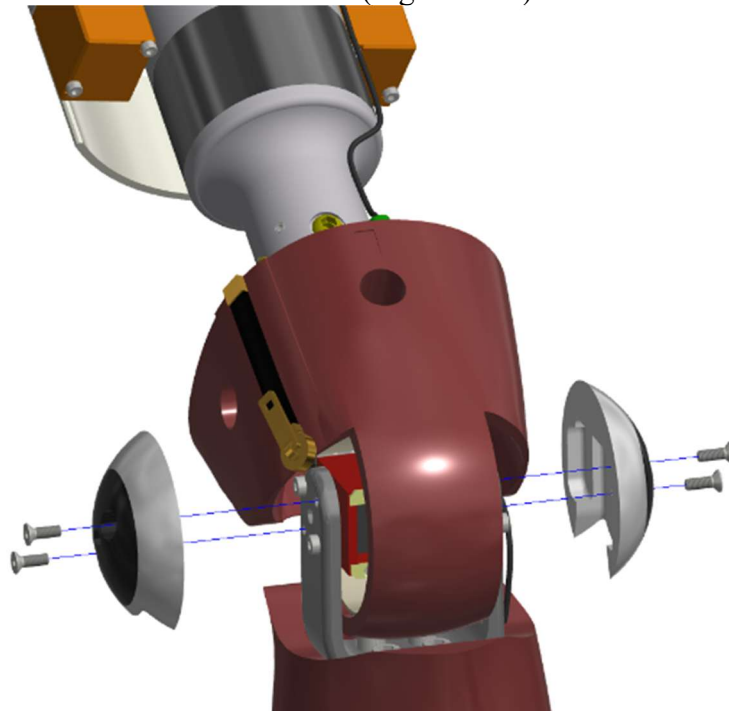


Figure 9-11. Remove the Left and Right Knee Covers (474-5301-1,2-A) by removing the two M4 X 0.7 X 12 LG. FHCS

- 9.2.5 Remove the two M4 X 0.7 X 8 LG. SHCS from both sides of the Knee Clevis (474-5517-1,2) (Figure 9-12).

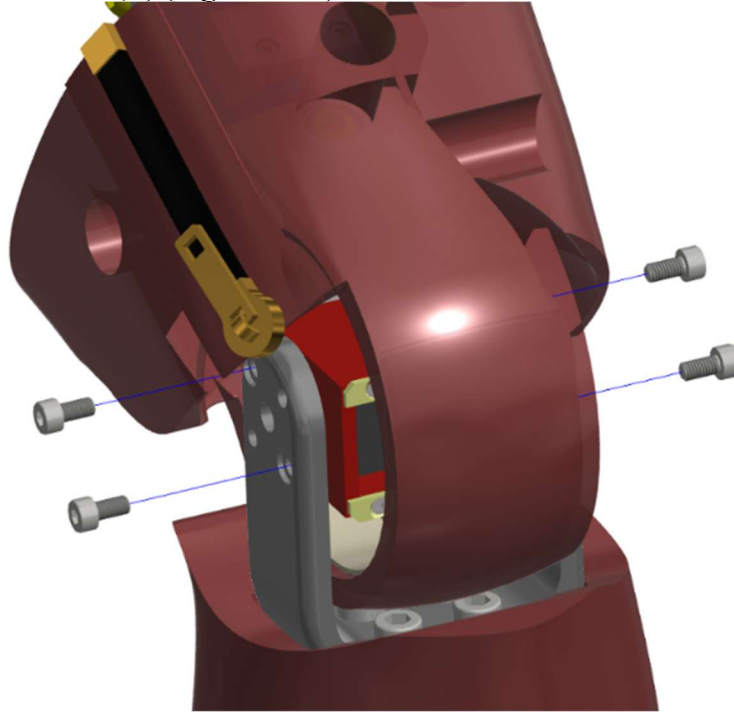


Figure 9-12. Remove the two M4 X 0.7 X 8 LG. SHCS from both sides of the Knee Clevis (474-5517-1,2)

- 9.2.6 Unzip the Lower Leg Flesh (474-5520-1,2) (Figure 9-13).

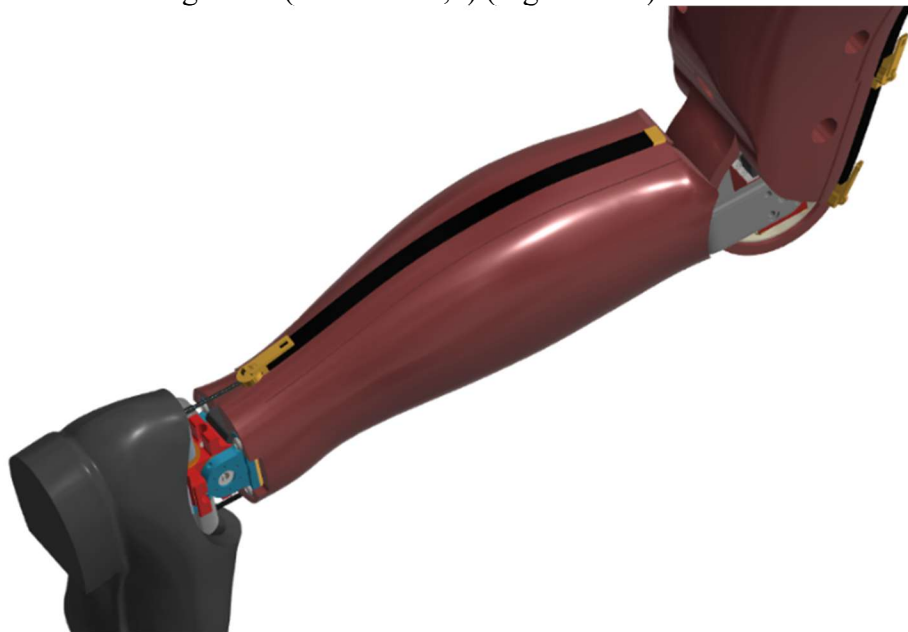


Figure 9-13. Unzip the Lower Leg Flesh (474-5520-1,2)

9.2.7 Remove the ground cable connecting the lower leg to the Femur Load Cell (Figure 9-14).

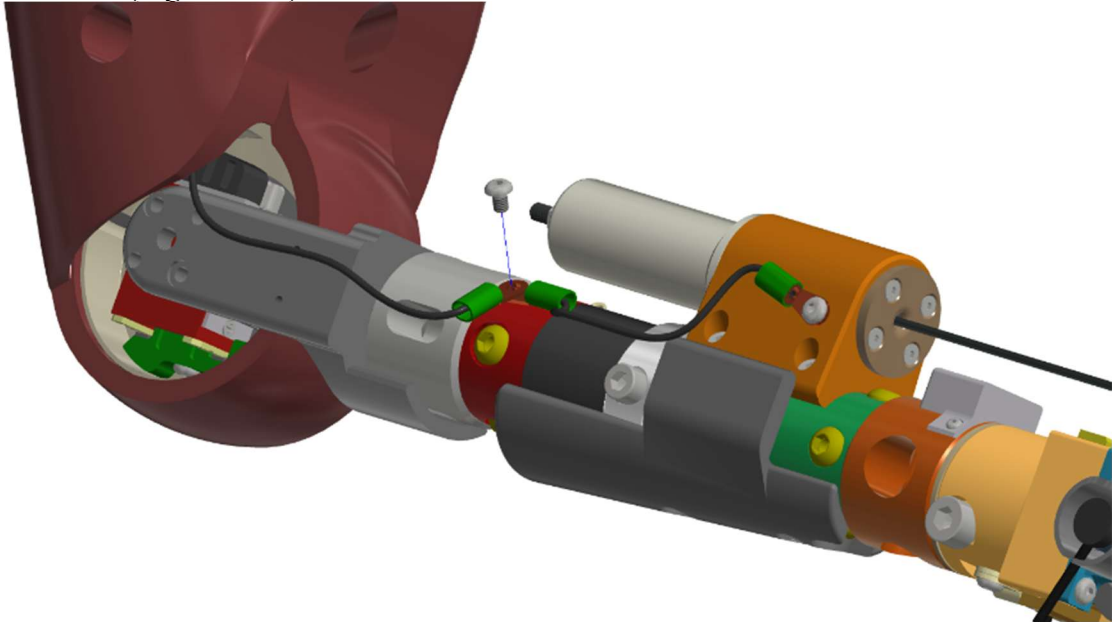


Figure 9-14. Remove the ground cable connecting the lower leg to the Femur Load Cell

9.2.8 Separate the upper leg from the lower leg (Figure 9-15).

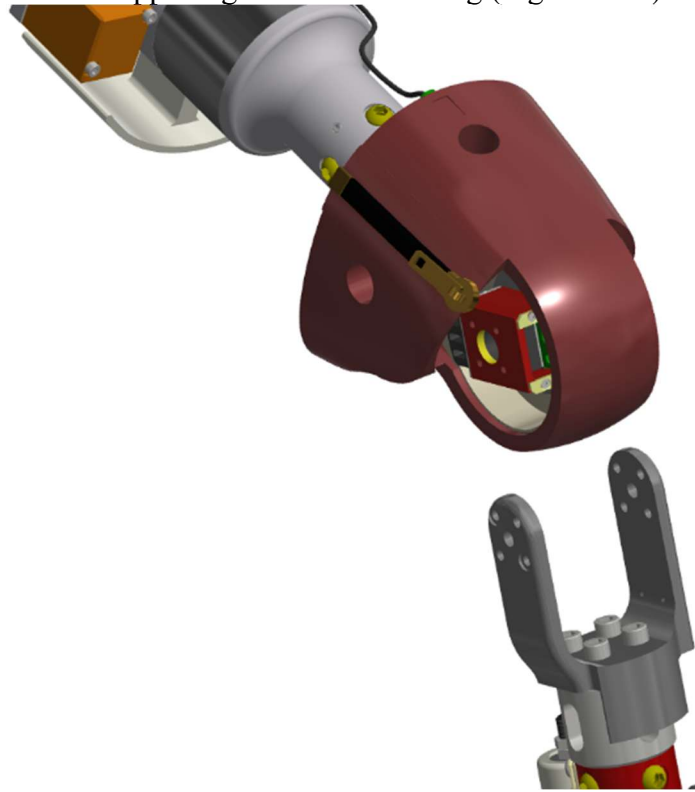


Figure 9-15. Separate the upper leg from the lower leg

9.2.9 Unzip the Knee Flesh (474-5321-1,2) (Figure 9-16).

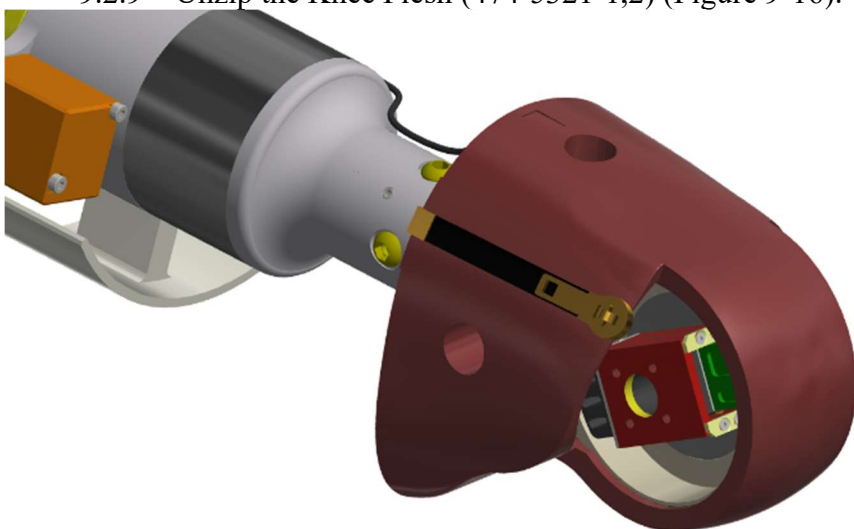


Figure 9-16. Unzip the Knee Flesh (474-5321-1,2)

9.2.10 Remove the Knee Insert (474-5340) from the Knee Flesh (Figure 9-17).

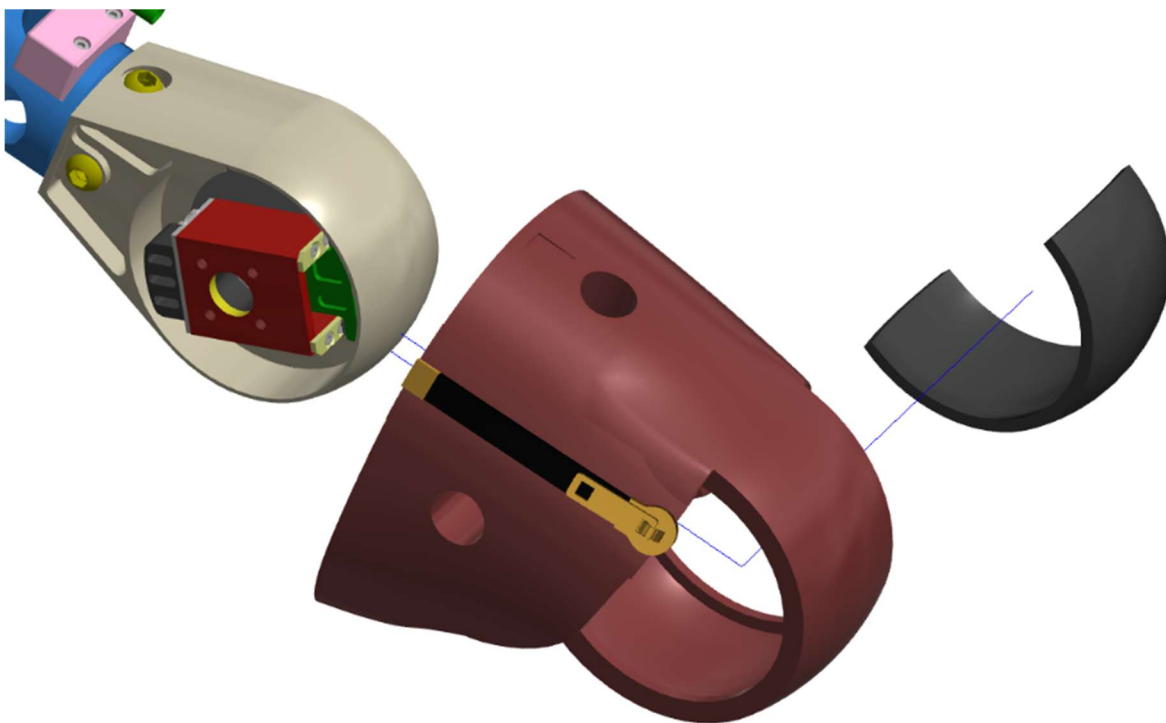


Figure 9-17. Remove the Knee Insert (474-5340)

9.2.11 Remove the ground wires from the Structural Replacement Femur Load Cell Strain Relief (474-5102) (Figure 9-18).

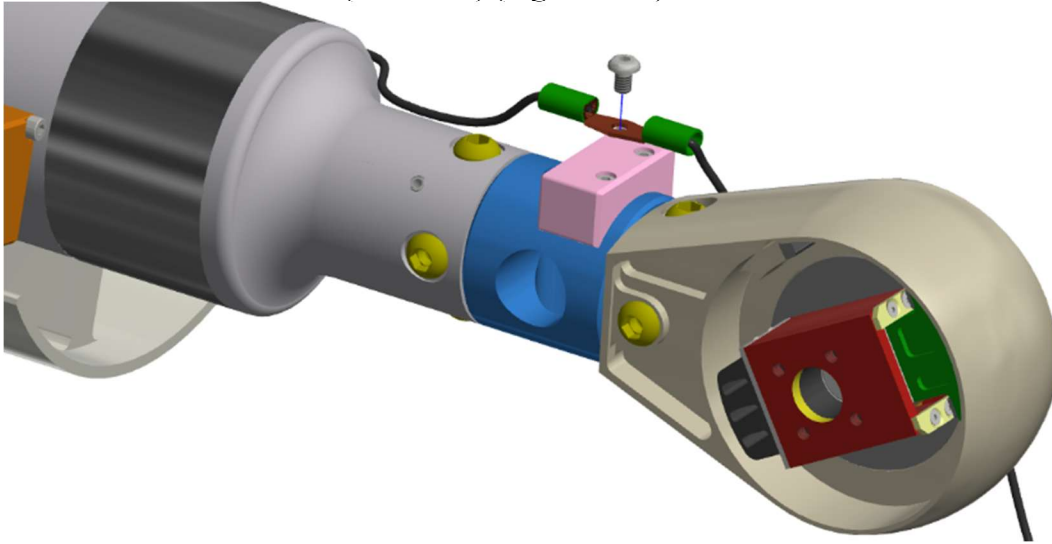


Figure 9-18. Remove the ground wires from the Structural Replacement Femur Load Cell Strain Relief (474-5102)

9.2.12 Remove four Modified BHSS M6 Thread from the Knee Assembly (474-5400) (Figure 9-19).

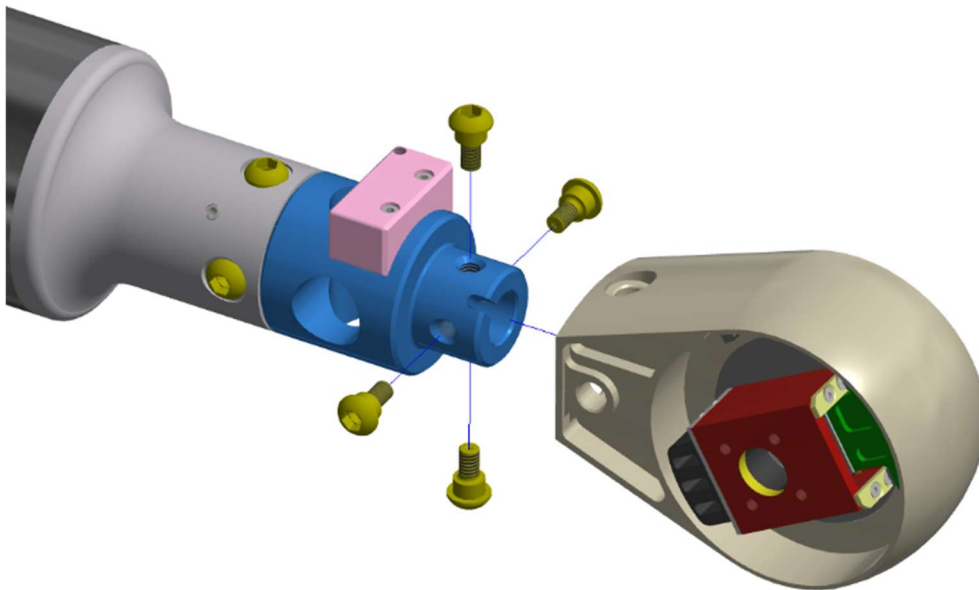


Figure 9-19. Remove four Modified BHSS M6 Thread from the Knee Assembly (474-5400)

- 9.2.13 Remove the M8 X 10 LG. SHSS from the right side of the Knee Assembly (474-5400) (Figure 9-20). The bolt is on the same side of the knee for both the left and right legs.

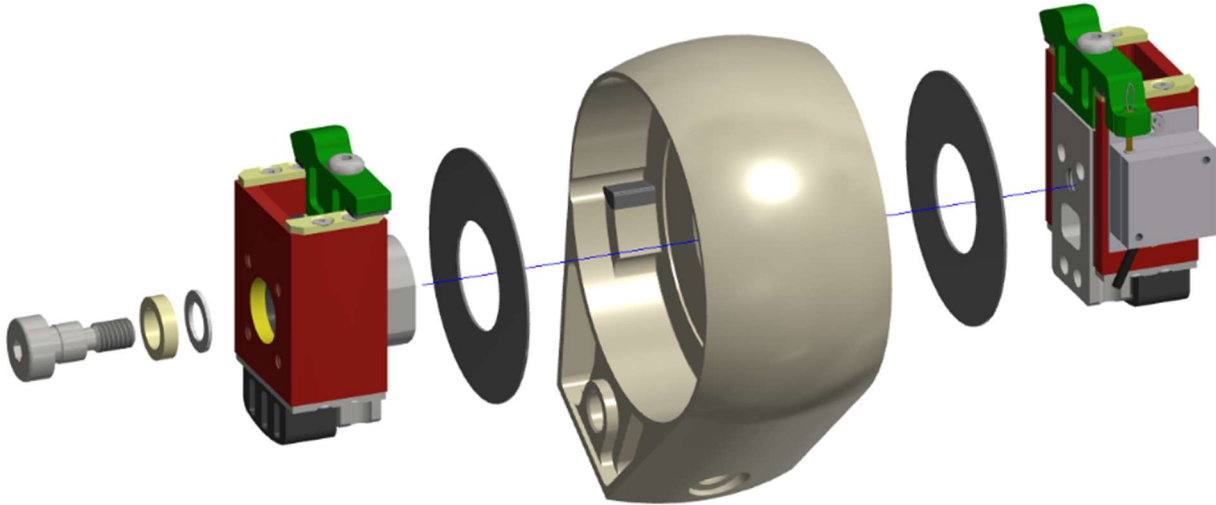


Figure 9-20. Remove the M8 X 10 LG. SHSS from the right side of the Knee Assembly (474-5400)

- 9.2.14 Remove the Knee Rotation Stop No Pot (474-5405) from the Right Knee Slider Assembly (474-5425) by removing the M4 X 0.7 X 20 LG. BHCS as shown in (Figure 9-21).

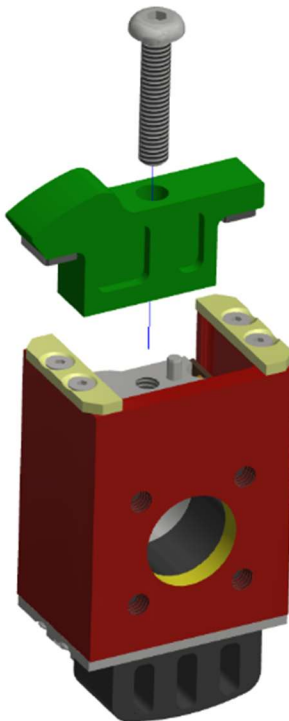


Figure 9-21. Remove Knee Rotation Stop from the Right Knee Slider Assembly

- 9.2.15 On the left side of the knee assembly, remove the potentiometer wire from the slot on the Knee Rotation Stop Pot (474-5404) so that the looped end will return back against the pot housing (Figure 9-22). Remove the Knee Rotation Stop Pot (474-5404) from the Left Knee Slider Upper Assembly (474-5421) by removing one M4 X 0.7 X 14 LG. BHCS (Figure 9-23).

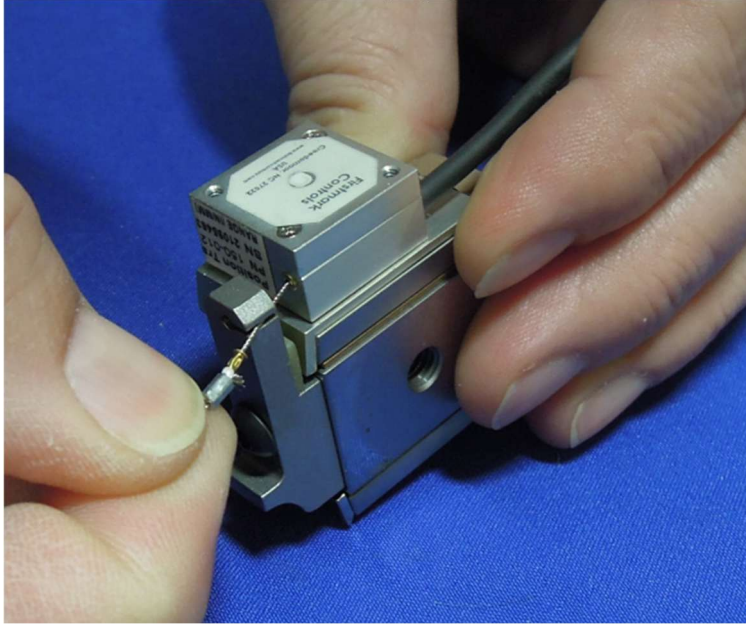


Figure 9-22. Remove wire from Knee Rotation Stop Pot (474-5404)

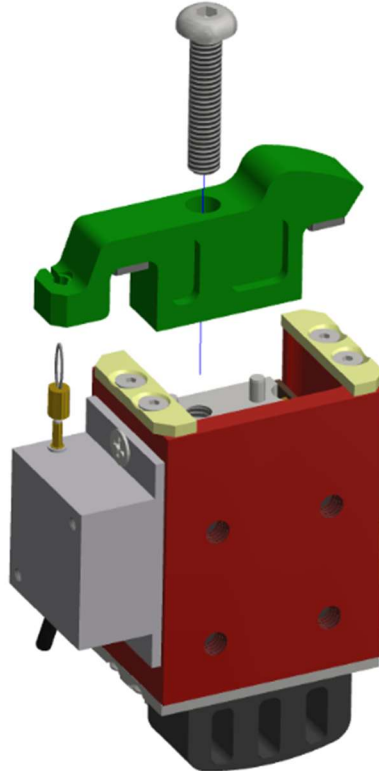


Figure 9-23. Remove Knee Rotation Stop from the Left Knee Slider Assembly

9.2.16 Detach the String Pot and String Pot Mount Plate from the Left Knee Slider Assembly (474-5422) by removing two M2.5 X 0.45 X 4 LG. FHMSF as shown in Figure 9-24.

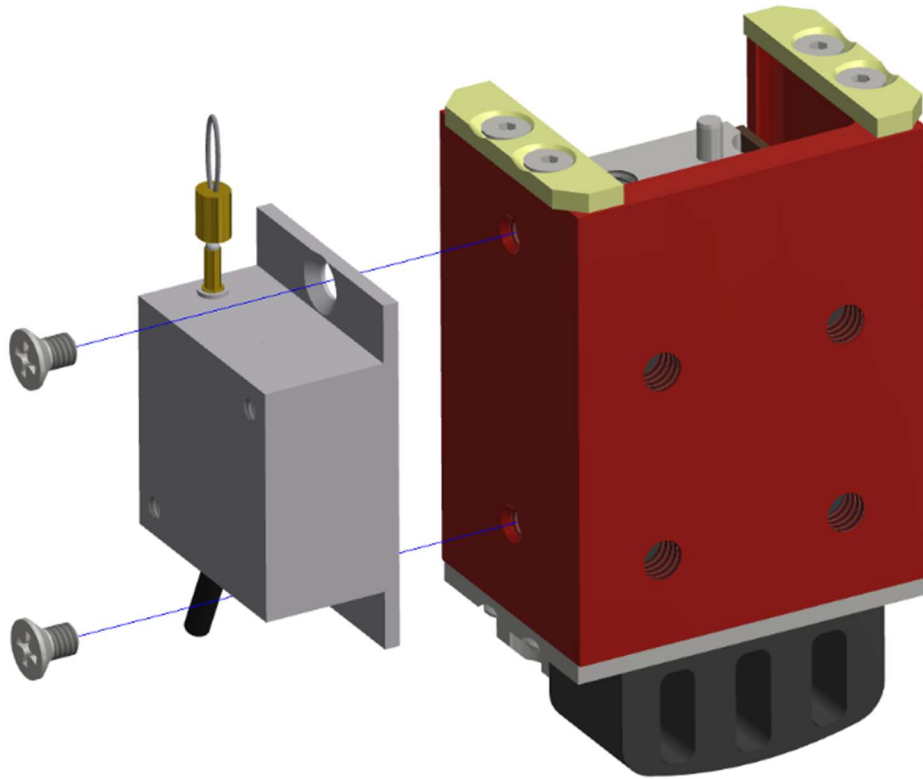


Figure 9-24. Detach String Pot and String Pot Mount Plate from the Left Knee Slider Assembly

9.2.17 Separate the Mini String Pot (SA572-S90) from the String Pot Mount Plate (474-5305) by removing two #2-56 X 1/8" FHMSF as shown in Figure 9-25.

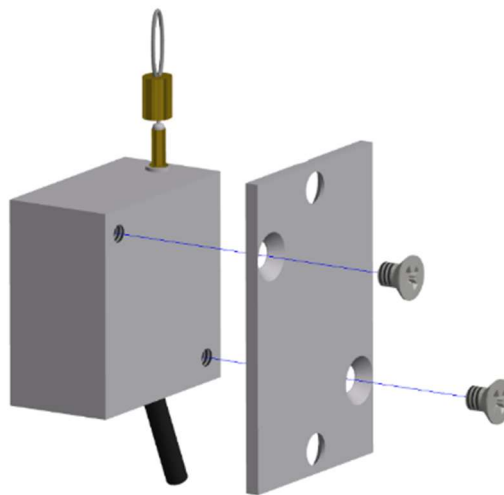


Figure 9-25. Install String Pot Mount Plate (474-5305) to String Pot Assembly (SA572-S90)

9.2.18 Remove the four Modified BHSS M6 Thread from the Femur Assembly (474-5160-1,2) connecting the Femur Load Cell (Figure 9-26).

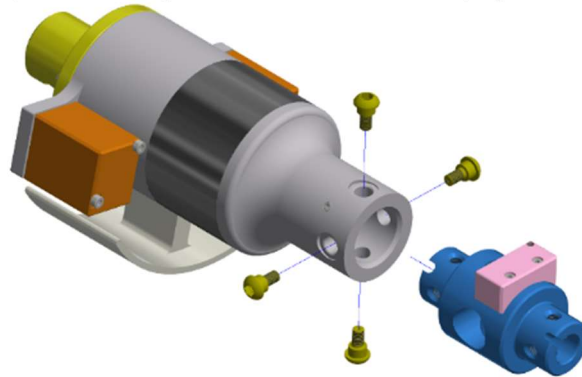


Figure 9-26. Remove the four Modified BHSS M6 Thread from the Femur Assembly (474-5160-1,2) connecting the Femur Load Cell

9.2.19 Remove the Femur Attachment Plate (474-5161) by removing four M6 X 1 X 18 LG. FHCS (Figure 9-27).

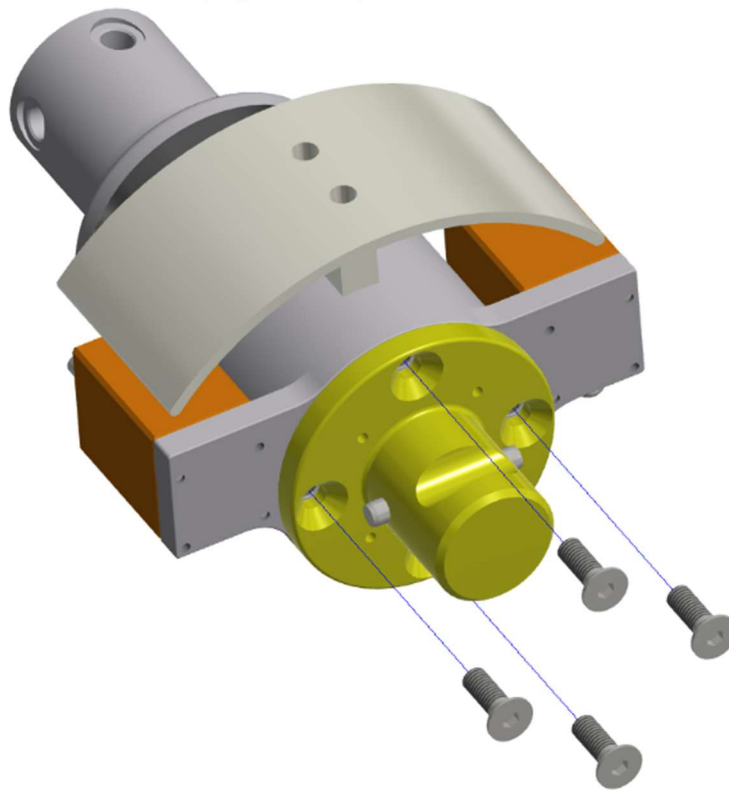


Figure 9-27. Remove the Femur Attachment Plate (474-5161) by removing four M6 X 1 X 18 LG. FHCS

9.2.20 Remove the Cable Connector Guard (474-5107) by removing two M3 X 0.5 X 20 LG. SHCS (Figure 9-28).

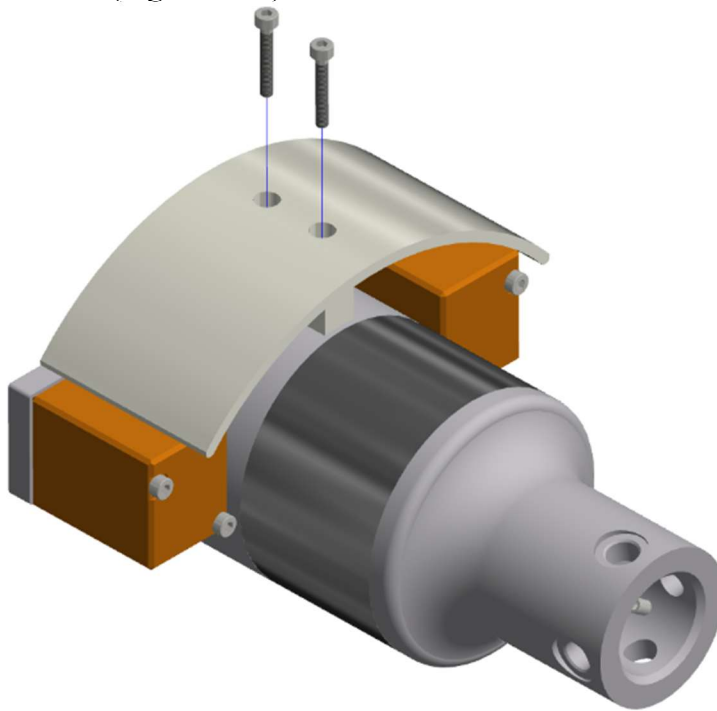


Figure 9-28. Remove the Cable Connector Guard (474-5107) by removing two M3 X 0.5 X 20 LG. SHCS

9.2.21 Remove the two On Board DAS Structural Replacements (474-8205) by removing two M3 X 0.5 X 45 LG. SHCS SS per replacement (Figure 9-29).

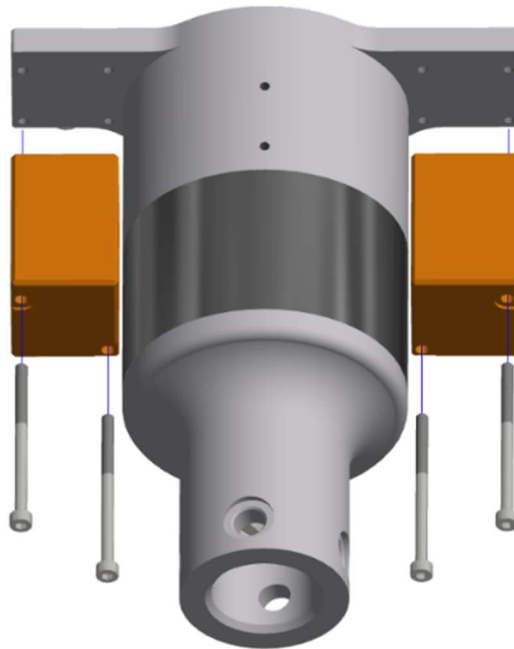


Figure 9-29. Remove the two On Board DAS Structural Replacements (474-8205)

9.2.22 Remove the M8 X 1.25 X 30 LG. FHCS from the center of the Femur End Cap (474-5173-1,2) (Figure 9-30). Separate the Femur Assembly (474-5160-1,2) (Figure 9-30).

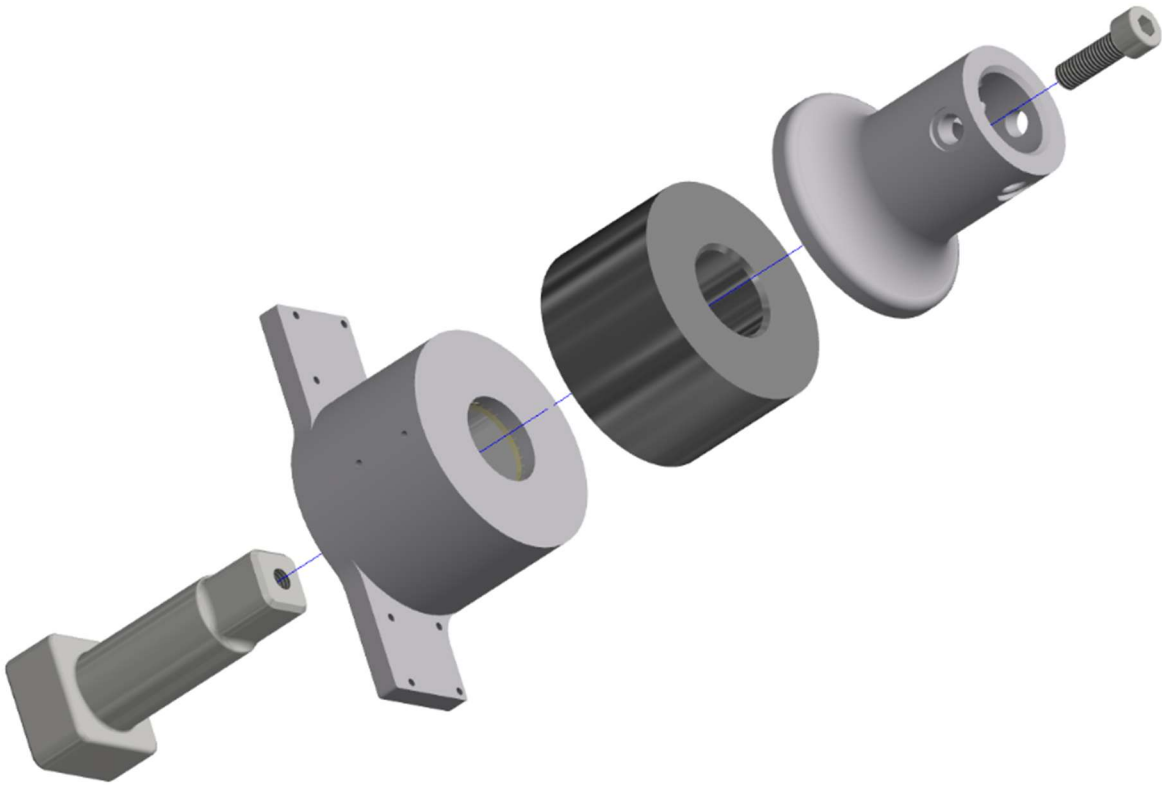


Figure 9-30. Remove the M8 X 1.25 X 30 LG. FHCS from the center of the Femur End Cap (474-5173-1,2)

9.3 Assembly of the Upper Leg

The following procedure is a step-by-step description of the assembly procedure for the upper leg (femur) components. Unless otherwise specified, tighten all bolts to the torque specifications provided in Section 2.1.3. Only the left upper leg assembly is illustrated. The right upper leg assembly follows identical procedures.

- 9.3.1 Slide the Femur Plunger Assembly (474-5166) into the Femur Bushing Assembly (474-5164) (Figure 9-31). Completely seat the femur plunger assembly into the femur bushing assembly. Slide the Femur Rubber (474-5172) over the shaft of the Femur Plunger Assembly (Figure 9-31). Place the Femur End Cap (474-5173-1,2) onto the femur rubber; attach the end cap by inserting one M8 X 1.25 X 25 SHCS into the center of the femur end cap (Figure 9-31).

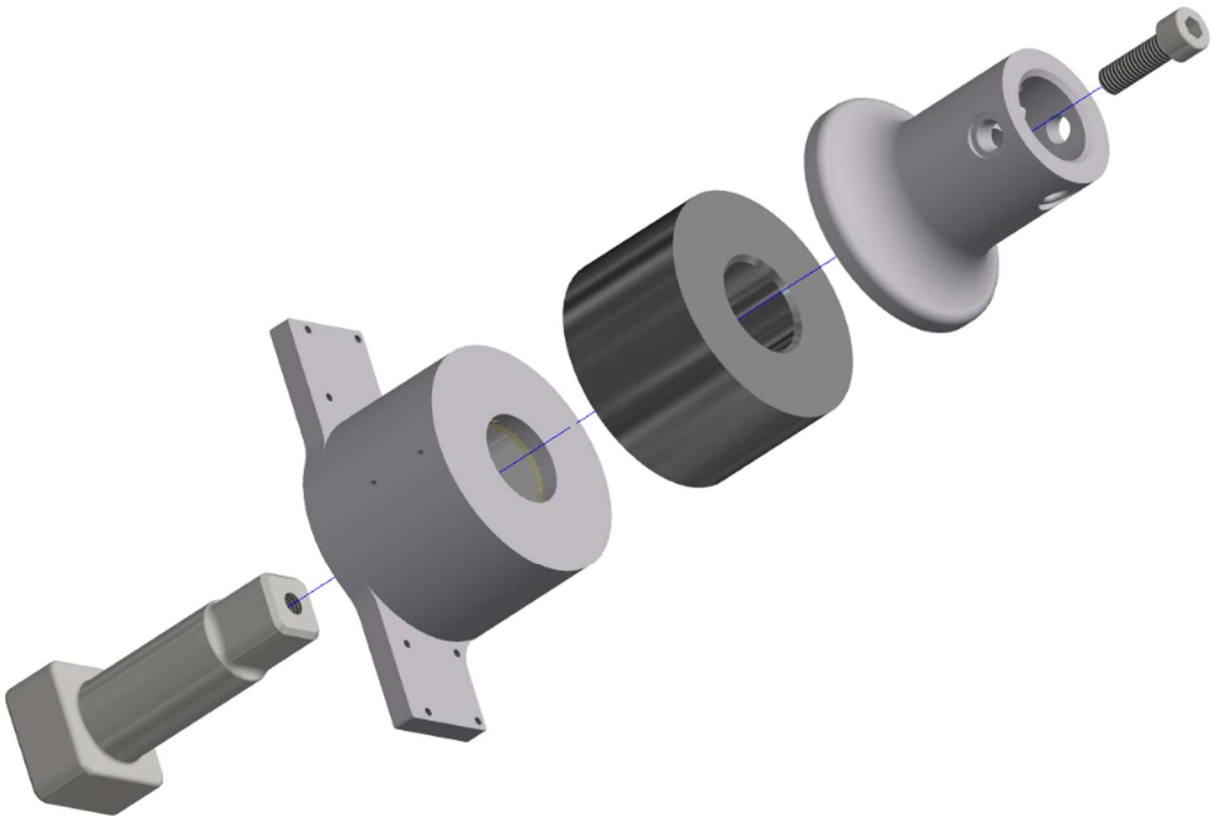


Figure 9-31. Femur Bushing Assembly (474-5164) and Femur Plunger (474-5166)

- 9.3.2 Attach the two On Board DAS Structural Replacements (474-8205) using two M3 X 0.5 X 45 LG. SHCS SS per replacement (Figure 9-32).

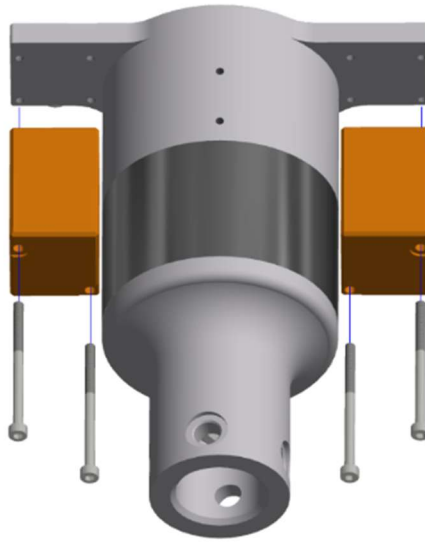


Figure 9-32. Attach the two On Board DAS Structural Replacements (474-8205)

- 9.3.3 Attach the Cable Connector Guard (474-5107) using two M3 X 0.5 X 20 LG. SHCS (Figure 9-33).

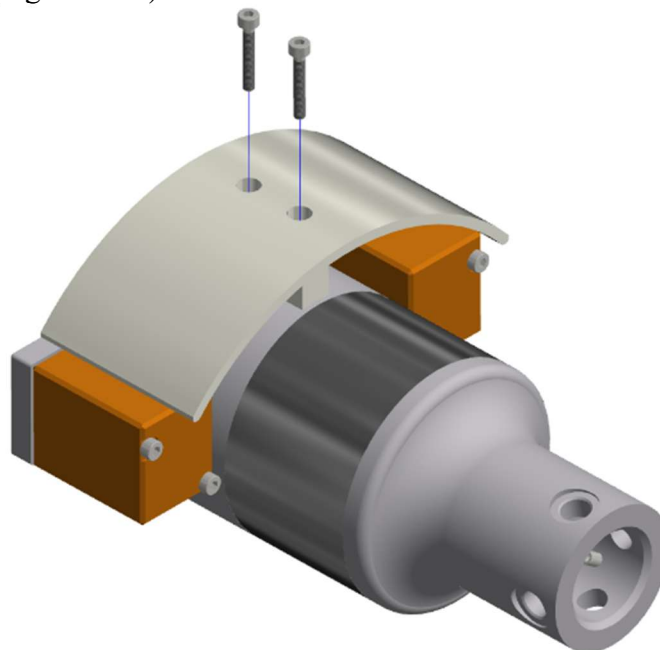


Figure 9-33. Attach the Cable Connector Guard (474-5107) using two M3 X 0.5 X 20 LG. SHCS

- 9.3.4 Assemble the Femur Attachment Plate (474-5161) to the Femur Bushing Assembly (474-5164) by installing four M6 X 1 X 18 FHCS (Figure 9-34). Ensure the notch on the Femur Attachment Plate is in the same direction as the two bolt holes on the Femur Bushing Assembly (Figure 9-34).

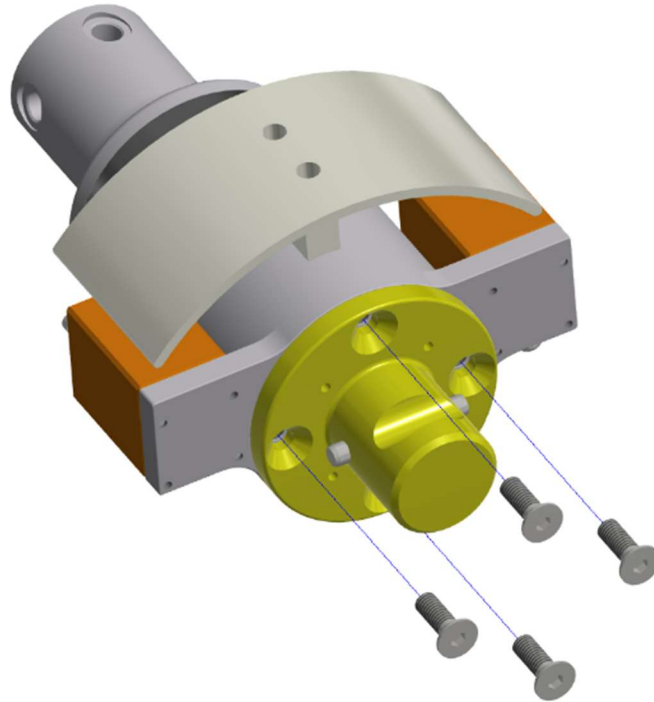


Figure 9-34. Secure Femur Attachment Plate (474-5161)

- 9.3.5 Install the Mini String Pot (SA572-S90) to the String Pot Mount Plate (474-5305) using two #2-56 X 1/8" FHMSF as shown in Figure 9-35.

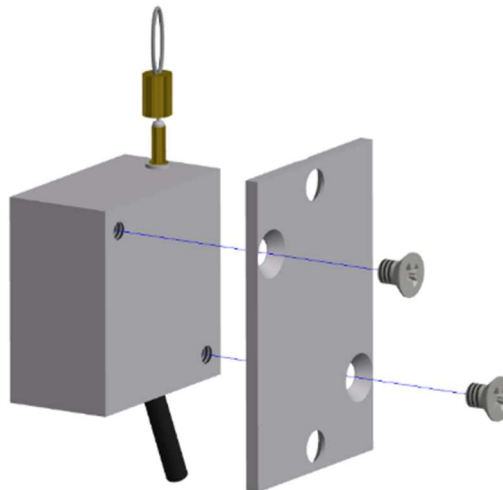


Figure 9-35. Install String Pot Mount Plate (474-5305) to String Pot Assembly (SA572-S90)

- 9.3.6 Attach the String Pot and String Pot Mount Plate to the Left Knee Slider Assembly (474-5422) using two M2.5 X 0.45 X 4 LG. FHMSF as shown in Figure 9-36.

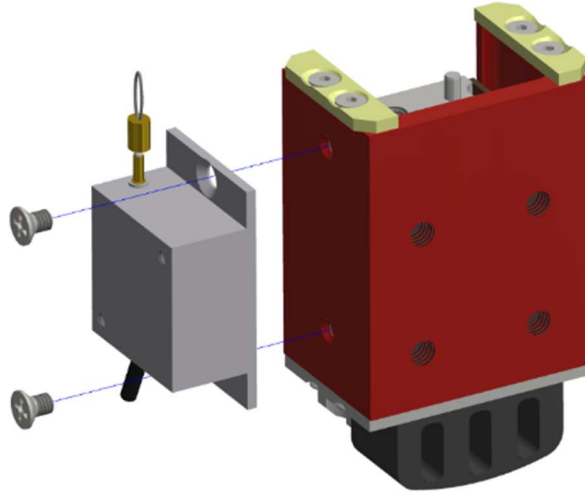


Figure 9-36. String Pot Assembly and Molded Left Knee Slider (484-5422)

- 9.3.7 Attach the Knee Rotation Stop Pot (474-5404) to the Left Knee Slider Upper Assembly (474-5421) using one M4 X 0.7 X 14 LG. BHCS (Figure 9-37). Place the wire into the slot on the Knee Rotation Stop Pot (474-5404) so that the looped end will not return back against the pot housing (Figure 9-38).

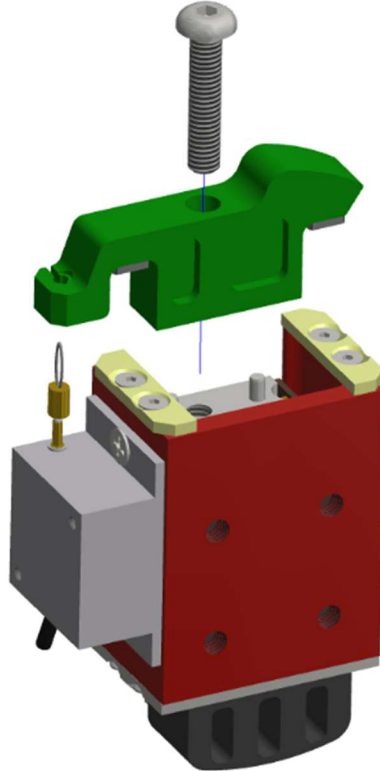


Figure 9-37. Attach the Knee Rotation Stop (474-5404) to the Left Knee Slider Upper Assemble (474-5421)

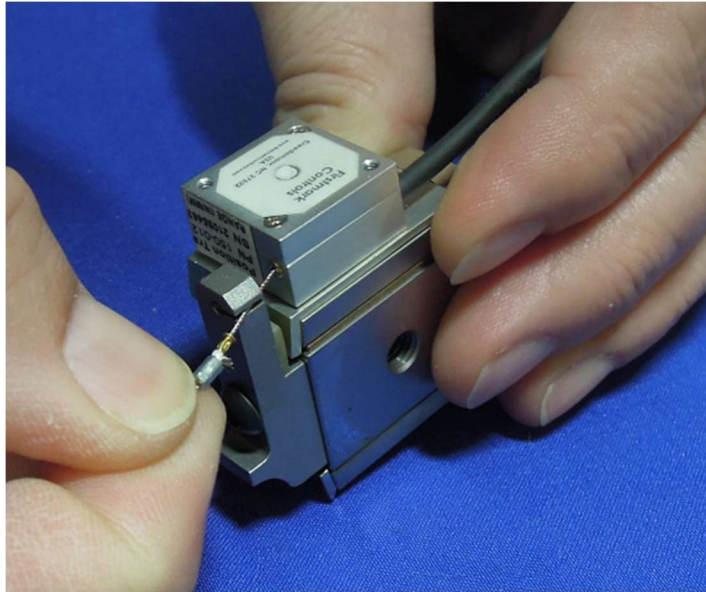


Figure 9-38. String Pot in notch in Knee Rotation Stop Pot (474-5404)

- 9.3.8 Attach the Knee Rotation Stop No Pot (474-5405) to the Right Knee Slider Assembly (474-5425) using a M4 X 0.7 X 20 LG. BHCS as shown in Figure 9-39.

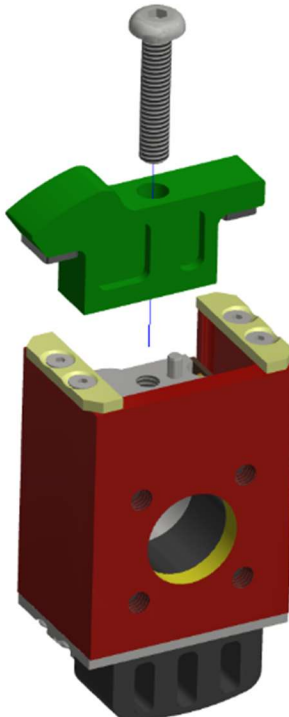


Figure 9-39. Attach the Knee Rotation Stop (474-5405) to the Left Knee Slider Upper Assemble (474-5425)

- 9.3.9 Install the left and right halves of the Knee Slider Assembly (474-5420) to the Knee Cap (474-5410) using one M8 X 10 LG. SHSS, Knee Compression Washer (474-5316), a 5/16 Flat Washer PTFE, and two Knee Carbon Fiber Washers (474-5401) (Figure 9-40). The bolt is on the same side of the knee for both the left and right legs.

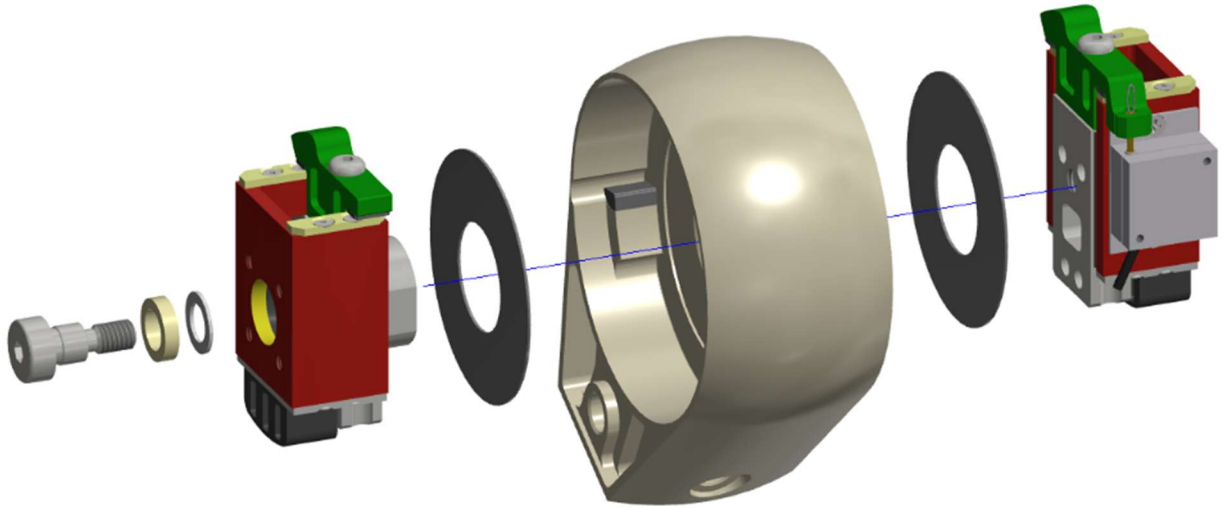


Figure 9-40. Separated knee

- 9.3.10 Connect the Femur Load Cell (SA572-S63) to the Femur Assembly (474-5160-1,2) using four Modified BHSS M6 Thread (Figure 9-41). Connect the Knee Assembly (474-5400) to the distal end of the Femur Load Cell using four Modified BHSS M6 Thread (SA572-S63) (Figure 9-42).

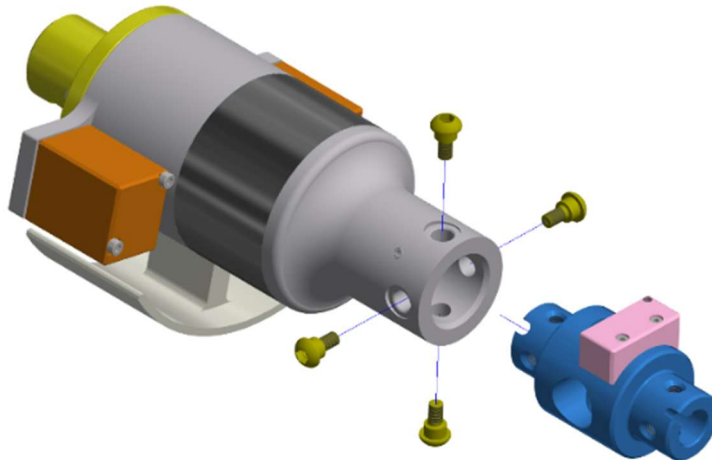


Figure 9-41. Attach the four Modified BHSS M6 Thread from the Femur Assembly (474-5160-1,2) connecting the Femur Load Cell

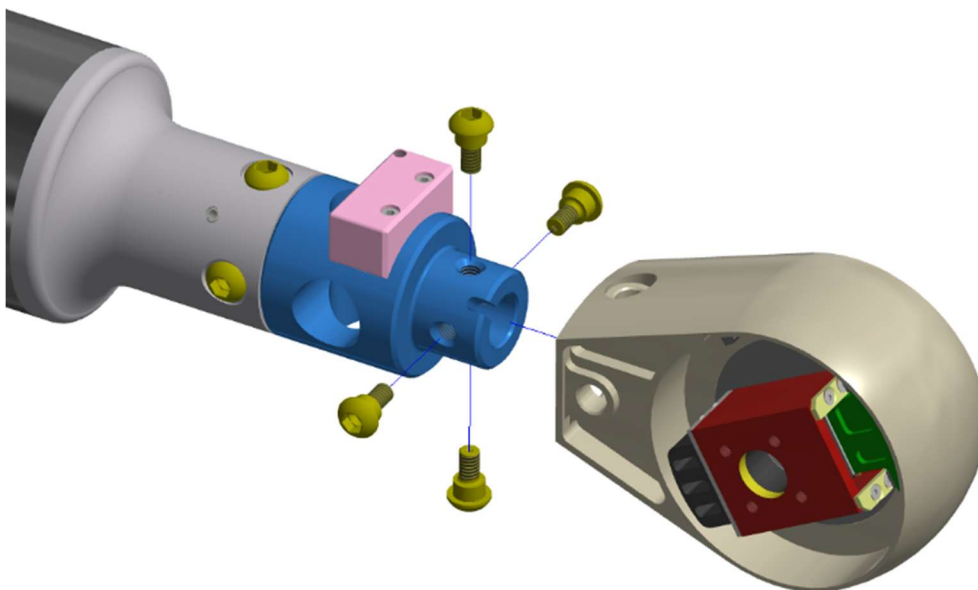


Figure 9-42. Connect the Knee Assembly (474-5400) to the distal end of the Femur Load Cell

9.3.11 Attach the ground wires to the Femur Load Cell Strain Relief (474-5102) (Figure 9-43).

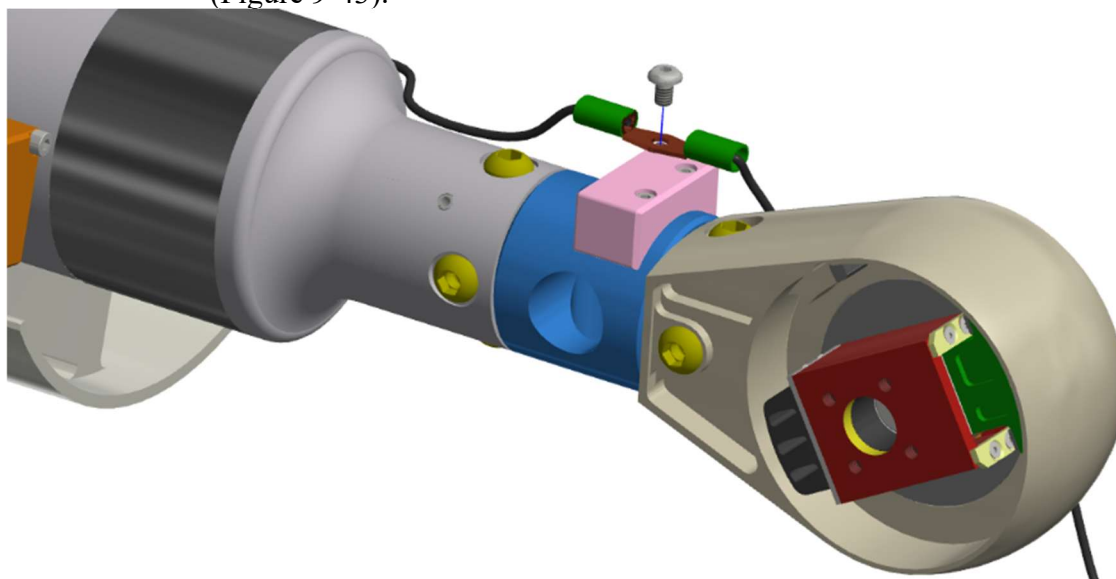


Figure 9-43. Attach the ground wires to the Femur Load Cell Strain Relief (474-5102)

9.3.12 Install the Knee Insert (474-5340) in the Knee Flesh (Figure 9-44). Zip the Knee Flesh (474-5321-1,2) around the Knee Assembly (Figure 9-45).

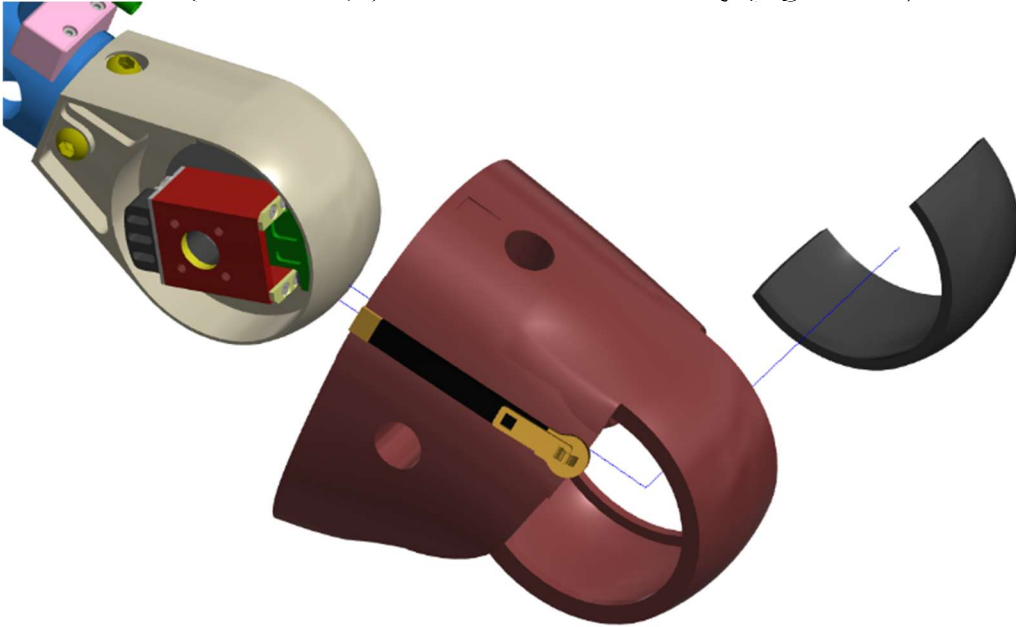


Figure 9-44. Install the Knee Insert (474-5340)

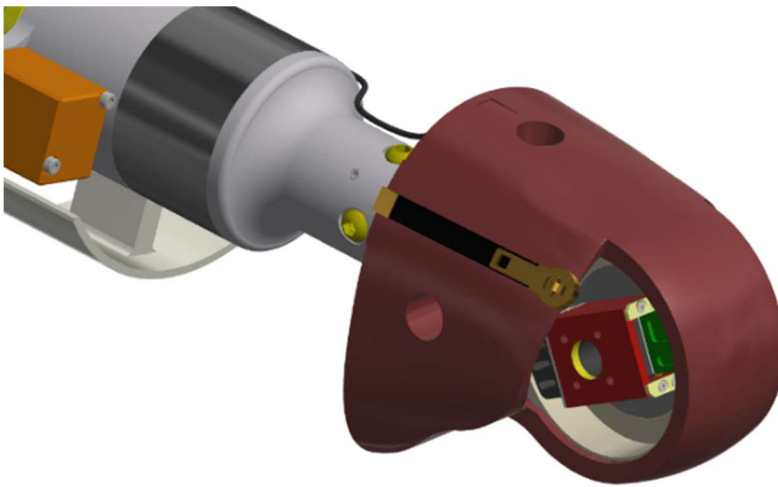


Figure 9-45. Install and zip the Knee Flesh 474-5321-1,2)

- 9.3.13 Zip the Upper Leg Flesh (474-5122-1,2) around the Upper Leg Assembly (Figure 9-46).

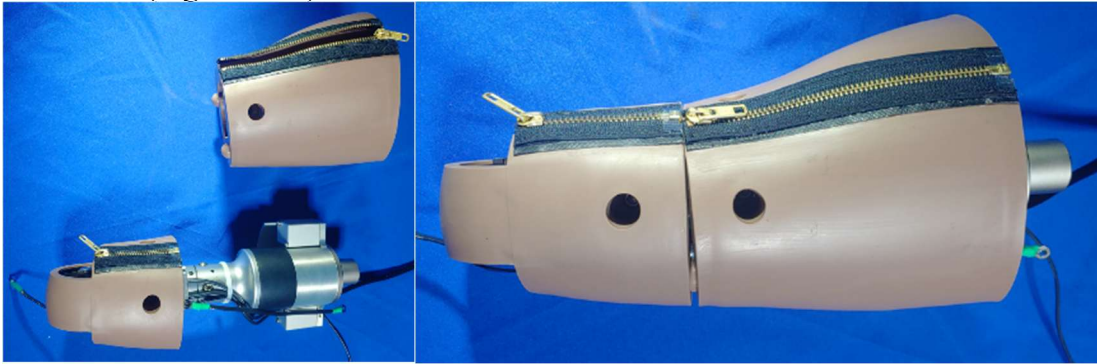


Figure 9-46. Zip the Upper Leg Flesh (474-5122-1,2) around the Upper Leg Assembly

- 9.3.14 Repeat the process for the other Upper Leg Assembly (472-5100-1,2-A).

9.4 Assembly of the Upper Leg to the Pelvis

The following procedure is a step-by-step description used to install the Upper Leg Assembly (474-5100-1,2-A) to the Pelvis Assembly (474-4000-A). Unless otherwise specified, tighten to the torque specifications provided in Section 2.1.3.

- 9.4.1 Slide the Left Femur Attachment Plate (474-5161) into the Left Femur Assembly (474-4700-1) so that dowel pins on the attachment plate lock into the slots on the hip cylinder (Figure 9-47). Secure the upper leg with an M12 X 30 LG. SHSS inserted on the outer pelvis flesh (Figure 9-48).

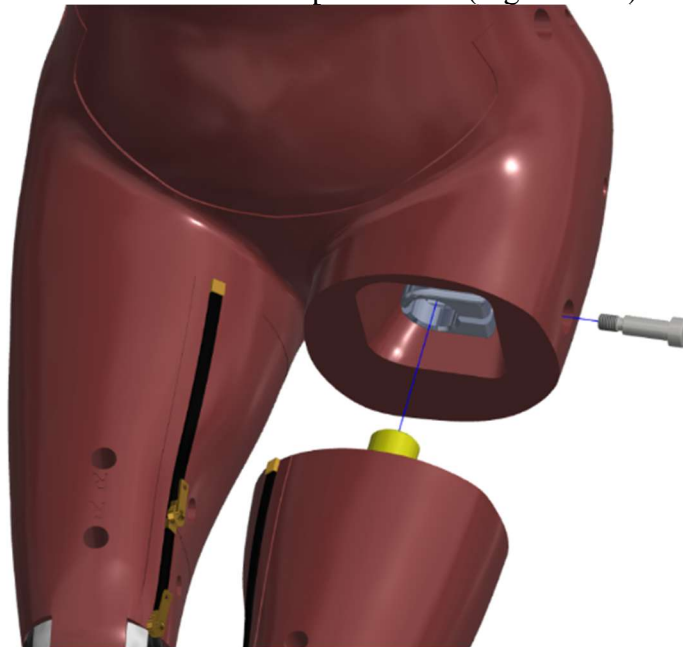


Figure 9-47. Insert upper leg into pelvis for attachment

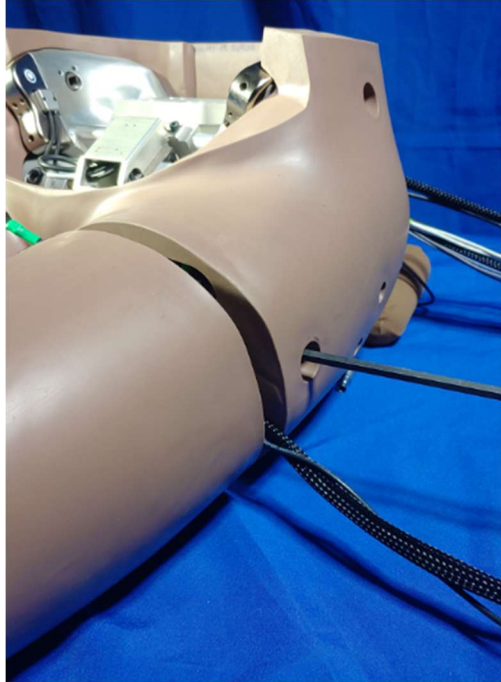


Figure 9-48. Install upper leg to pelvis

- 9.4.2 Attach the femur and pelvis ground wires to the Femur Assembly (474-4700-1,2) (Figure 9-49).

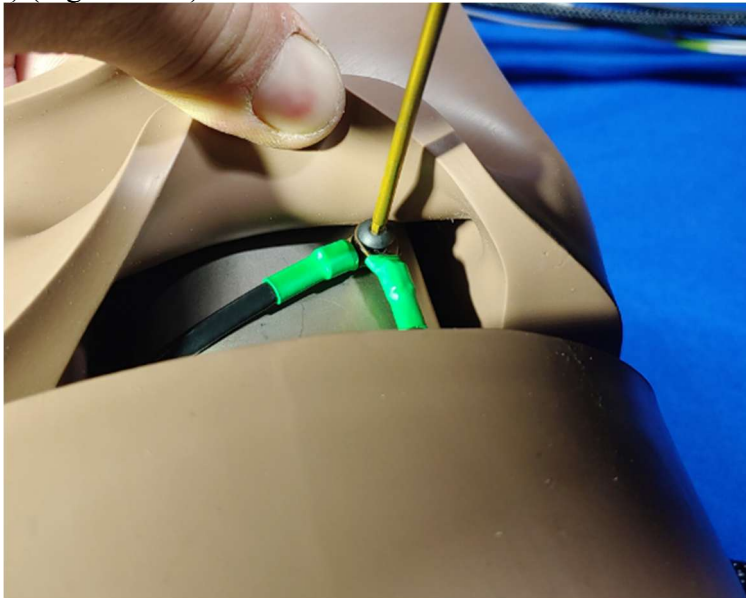


Figure 9-49. Attach the femur and pelvis ground wires to the Femur Assembly (474-4700-1,2).

9.5 Assembly of the Lower Extremity to the Knee

The assembly of the lower extremity to the knee can be found in Section 10.4.

9.6 Adjustments for the Femur Assembly

The femur assembly does not require any adjustments.

9.7 Electrical Connections and Requirements:

Section 13.3 includes grounding information. Section 13.4 describes cable routing instructions.

Section 10. Lower Extremity Assembly

10.1 Description of the Lower Extremity Assembly and Features

The mechanical design of the THOR-05F lower extremity provides several advances over previous lower extremity designs. A compliant section in the tibia shaft, similar to the THOR-05F compliant femur section, provides more biofidelic force transmission from the heel to the knee complex. The spring damper Achilles tendon system aids in producing the desired ankle motion and torque characteristics. The ankle design provides correct range of motion, joint axes placement, and biofidelic torque vs. angle response for the two primary axes (dorsi/plantar-flexion and inversion/eversion). Soft stop elements provide more biofidelic stiffness at the extremes of motion. Figure 10-1 illustrates the THOR-05F lower extremity assembly.

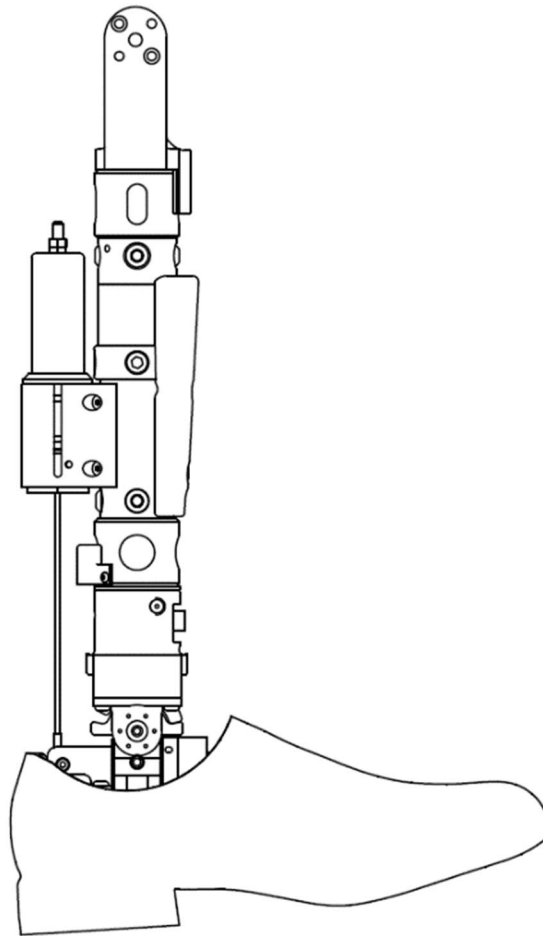


Figure 10-1. Lower extremity assembly (depicted without leg flesh)

The lower extremity includes sensors to measure injury parameters. Five-channel upper (SA572-S103) and lower tibia load cells (SA572-S104) are incorporated into the design to provide force and moment data of the tibia shaft. A uniaxial compression load cell (SA572-S127) implemented into the Achilles tendon housing provides a direct measurement of the contribution of the Achilles to the overall ankle joint torque. Three rotary potentiometers measure the rotation of the individual ankle joints, thereby providing kinematic data. Finally, two uniaxial accelerometers on the tibia and three 6-axis accelerometers and an ARS on the upper shoe allow the transformation of the measured tibia moment to the calculated ankle moment.

Table 10-1 through Table 10-3 list the components included in the lower leg assembly. Figure 10-1 through Figure 10-4 illustrate the components of lower leg assembly and hardware.

Table 10-1. Lower Leg (474-5500-1,2) Complete Assembly Components

Part Description	Quantity	Part Number	Figure #	Item #
Ankle Assembly	1	474-5800-1,2	Figure 10-2	1
Bolt & Sleeve Assembly – Ankle	1	472-7563	Figure 10-2	2
M4 X 0.7 X 16 LG. SHCS	4	5000025	Figure 10-2	3
Molded Shoe Assembly	1	474-5903-1,2	Figure 10-2	4
Shin Guard, Molded	1	474-5518-1,2	Figure 10-2	5
M5 X 0.8 X 12 LG. BHCS	2	5000654	Figure 10-2	6
Tibia Assembly	1	474-5507-1,2	Figure 10-2	7
Knee Clevis	1	474-5517-1,2	Figure 10-2	8
M6 X 1 X 16 LG. SHCS	4	5000081	Figure 10-2	9
Lower Leg Flesh	1	483-5521-1,2	Figure 10-2	10

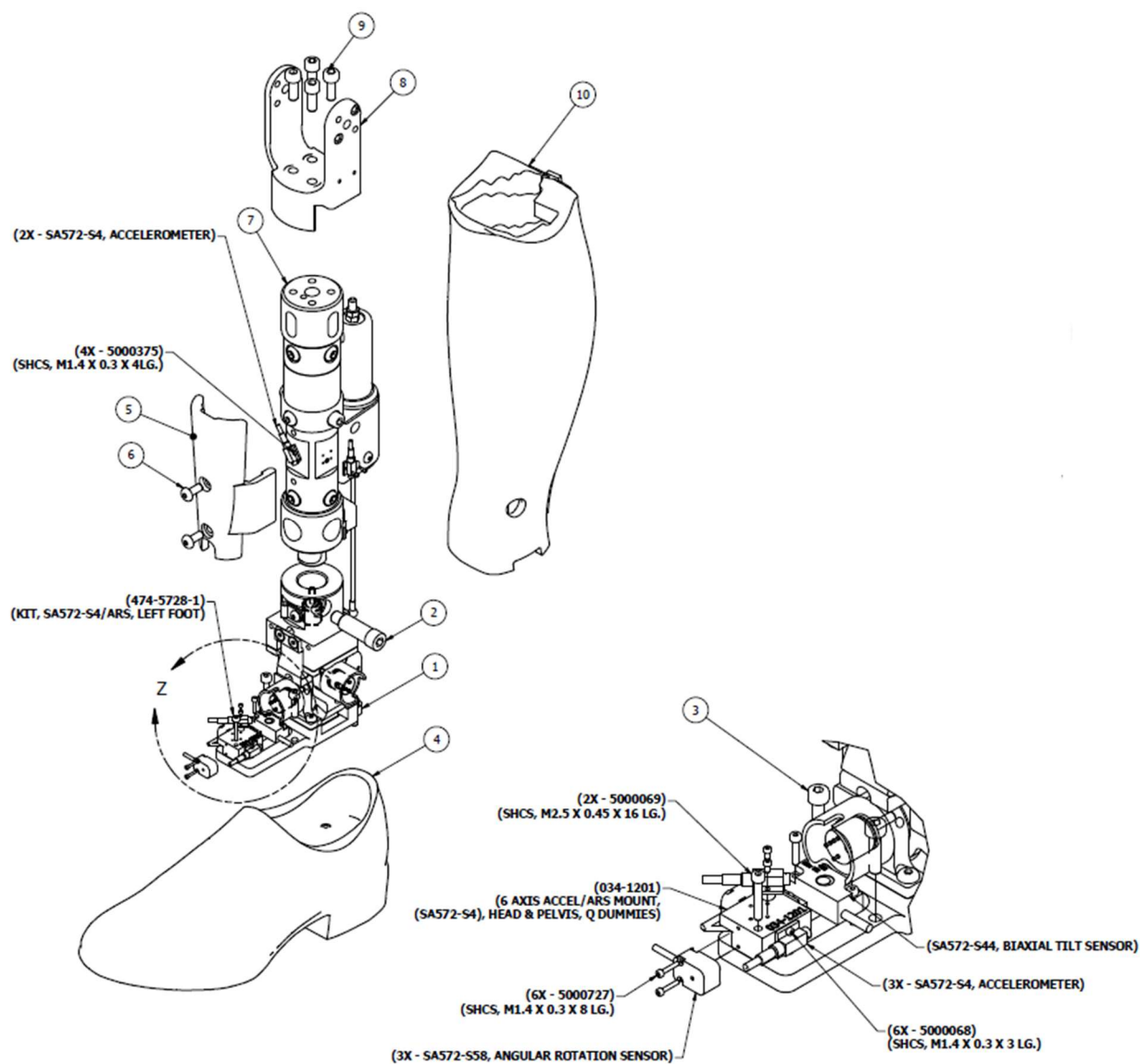


Figure 10-2. Lower Leg (474-5500-1,2) Complete Assembly Components

Table 10-2. Tibia Assembly (474-5507-1,2) Components

Part Description	Quantity	Part Number	Figure #	Item #
Tibia Compliant Element Assembly	1	474-5508	Figure 10-3	1
Modified BHSS M6 Thread	8	W50-61042	Figure 10-3	2
M6 X 1 X 10 LG. FHCS	1	5000204	Figure 10-3	3
M6 X 1 X 10 LG. BHCS	1	5000891	Figure 10-3	4
Tibia Plunger Pin, Modified M6 SHCS	2	474-5512	Figure 10-3	5
Lower Achilles Spring Housing	1	474-5504	Figure 10-3	6
Mock Achilles Load Cell	1	472-7359	Figure 10-3	7
Spring Cap, Bottom	1	474-5526	Figure 10-3	8
Achilles Spring Damping Tube	1	474-5513	Figure 10-3	9
Upper Achilles Spring Housing	1	474-5525	Figure 10-3	10
Spring Compression 0.295 X 0.032 X 0.551 SS	1	6005232	Figure 10-3	11
Primary Load Washer	1	474-5529	Figure 10-3	12
M5 X 0.8 Hex Nut Zinc	2	5000515	Figure 10-3	13
Achilles Cable	1	474-5530	Figure 10-3	14
Achilles Cable Eyelet Guide	2	474-5531	Figure 10-3	15
M3 X 0.5 X 6 LG. FHCS	4	5000098	Figure 10-3	16
M4 X 0.7 X 12 LG. LHCS	4	5001054	Figure 10-3	17
Lower Tibia Shaft	1	474-5540-1,2	Figure 10-3	18
M4 X 0.7 X 6 LG. BHCS	3	5001075	Figure 10-3	19
Spring Front	1	474-2925	Figure 10-3	20
Spring Bushing	1	474-2322	Figure 10-3	21
Structural Replacement, Upper Tibia Load Cell	1	474-5550	Figure 10-3	22
Structural Replacement, Lower Tibia Load Cell	1	474-5822	Figure 10-3	23
M3 X 0.5 X 3 LG. SSSNP	1	9010447	Figure 10-3	24

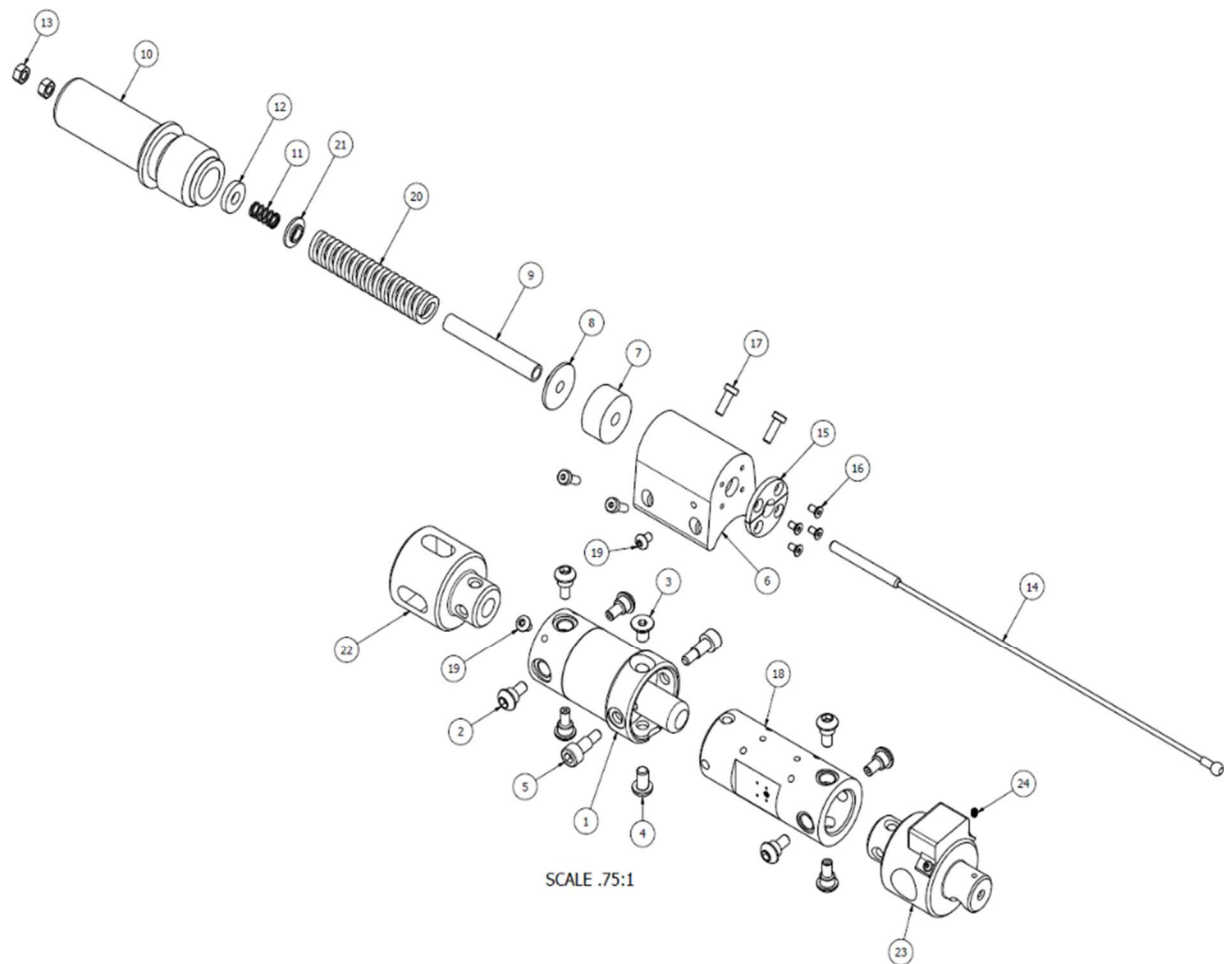


Figure 10-3. Tibia assembly (474-5507-1,2) components

Table 10-3. Ankle Assembly (474-5800-1,2-B) Components

Part Description	Quantity	Part Number	Figure #	Item #
Upper Ankle Adaptor	1	474-5820-1,2	Figure 10-4	1
M4 X 0.7 X 8 LG. BHCS	1	5000103	Figure 10-4	2
M4 X 0.7 12 LG. BHCS	8	5000005	Figure 10-4	3
Ankle Center Block Assembly	1	474-5824-A	Figure 10-4	4
Clamp, Nylon Loop	1	9005135	Figure 10-4	5
Potentiometer Clamp	2	472-7581	Figure 10-4	6
M2 X 0.4 X 8 LG. SHCS	12	5000083	Figure 10-4	7
Ankle Thrust Washer	4	474-5720	Figure 10-4	8
M4 X 0.7 X 10 LG. FHCS	4	5000023	Figure 10-4	9
Plantar Stop Assembly	1	474-5810	Figure 10-4	10
Dorsi Stop Assembly	1	474-5807	Figure 10-4	11
Lower Ankle Plate	1	474-5806-1,2	Figure 10-4	12
Eversion Stop Assembly	1	474-5813-A	Figure 10-4	13
Inversion Stop Assembly	1	474-5816-A	Figure 10-4	14
Plate, Ankle Bushing	3	474-5826	Figure 10-4	15
Achilles Cable Retainer	1	474-5828	Figure 10-4	16
M3 X 0.5 X 12 LG. SHCS	1	5001103	Figure 10-4	17
M3 X 0.5 X 6 LG. FHCS	4	5000098	Figure 10-4	18
Potentiometer Cap	2	483-5825	Figure 10-4	19
M3 X 0.5 X 3 LG. SSSNP	2	9010447	Figure 10-4	20
Potentiometer Inner Mount	1	474-5831	Figure 10-4	21
Potentiometer Clamp	1	474-5832	Figure 10-4	22
M2 X 0.4 X 5 LG. FHCS	2	5000753	Figure 10-4	23

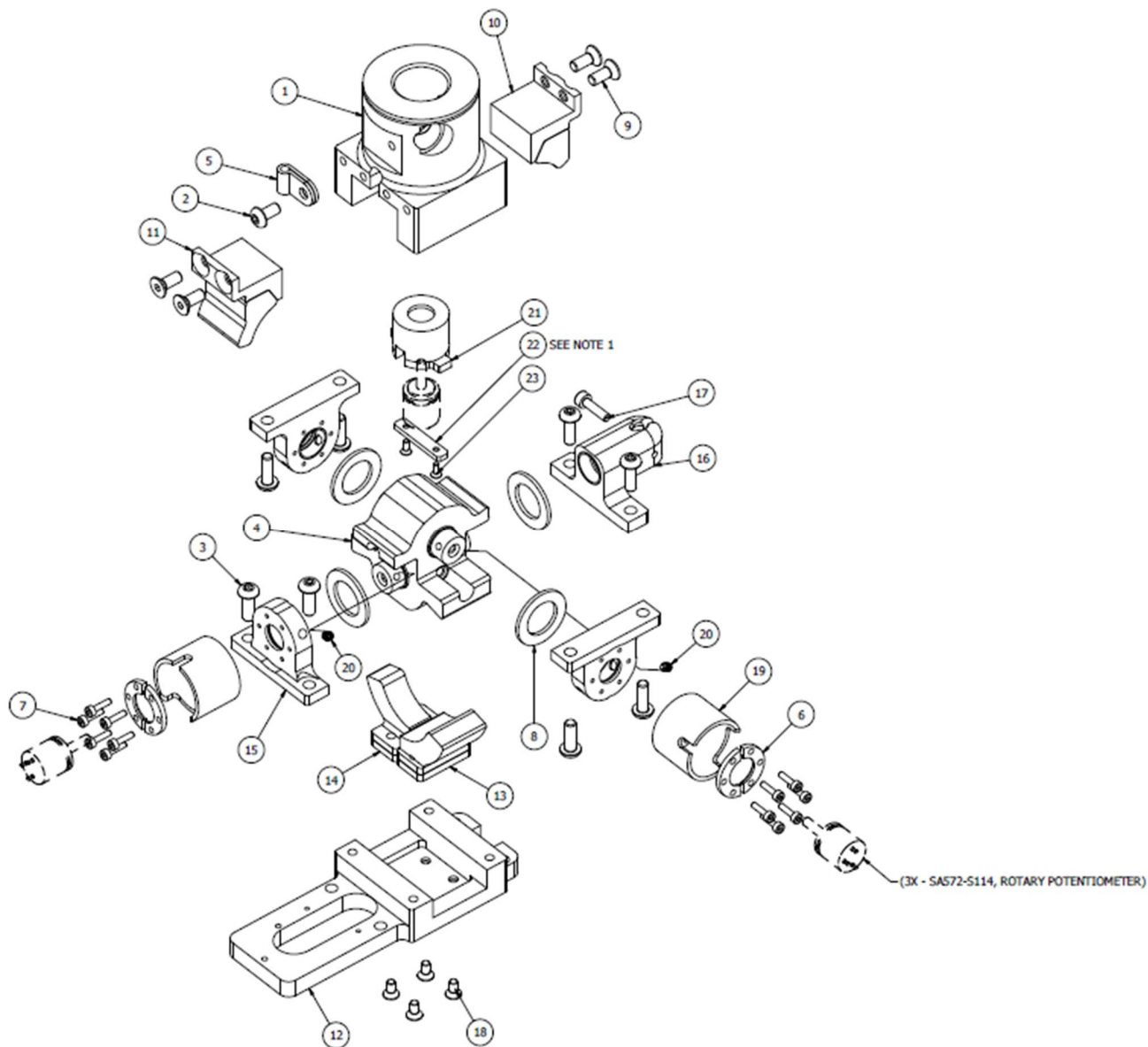


Figure 10-4. Ankle Assembly (474-5800) Components

10.2 Disassembly of the Lower Extremity

The following procedure is a step-by-step description of the disassembly procedure for the lower extremity components. Only the left lower leg disassembly is illustrated. The right lower leg disassembly follows identical procedures.

- 10.2.1 After the lower leg has been separated from the upper leg (Steps 9.2.4 - 9.2.8), remove the cable ties connecting the wire bundles to the lower leg (Figure 10-5).

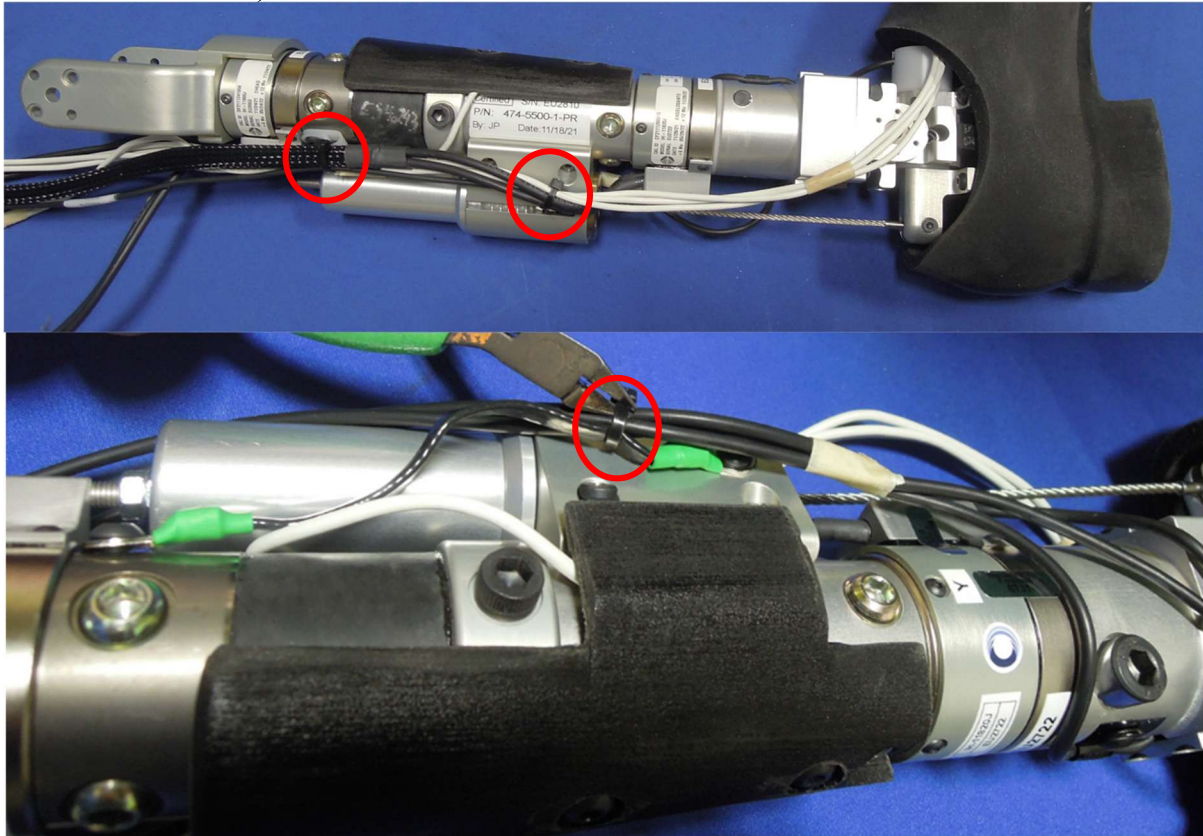


Figure 10-5. Remove the cable ties connecting the wire bundles to the lower leg

10.2.2 Remove the ground cable from the Lower Achilles Spring Housing (Figure 10-6).

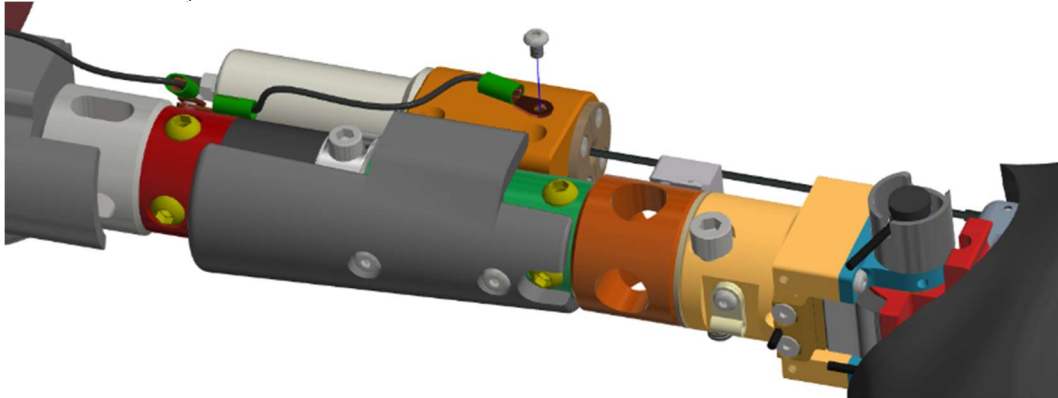


Figure 10-6. Remove the ground cable from the Lower Achilles Spring Housing

10.2.3 Remove the Achilles Assembly from the lower leg by removing four M4 X 0.7 X 12 LG. LHCS (Figure 10-7).

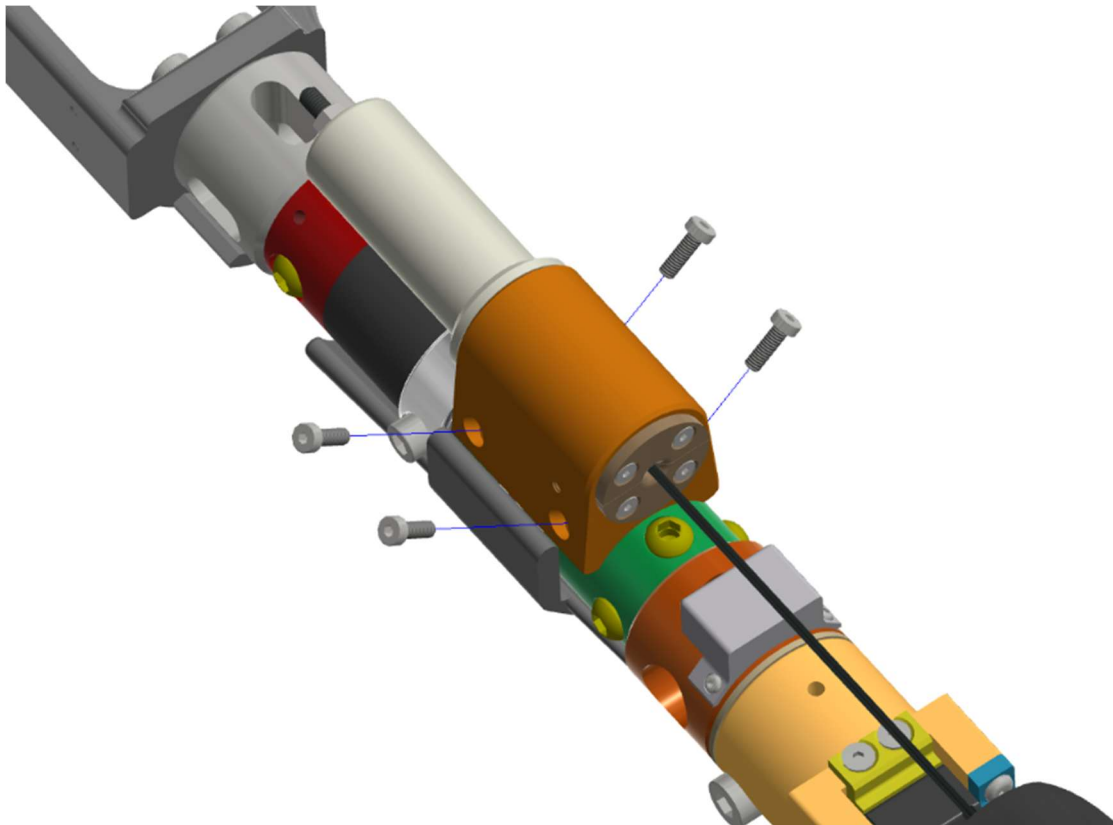


Figure 10-7. Remove the Achilles Assembly from the lower leg by removing four M4 X 0.7 X 12 LG. LHCS

10.2.4 Separate the Upper Tibia Load Cell (SA572-S103) from the Tibia Compliant Element Assembly (474-5508) by removing four Modified BHSS M6 Thread (Figure 10-8).

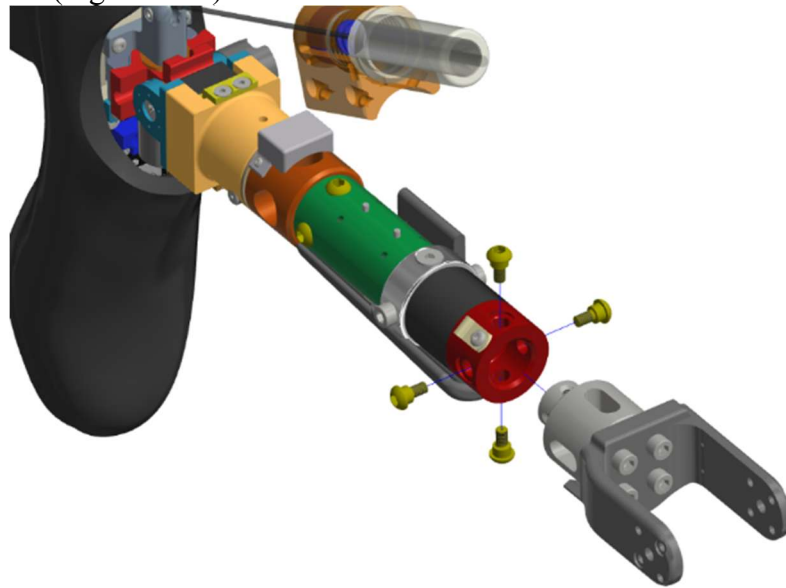


Figure 10-8. Separate the Upper Tibia Load Cell (SA572-S103) from the Tibia Compliant Element Assembly (474-5508)

10.2.5 Separate the Lower Tibia Load Cell (SA572-S104) from the Upper Ankle Adaptor (474-5820-1,2) by removing the Ankle Bolt & Sleeve Assembly (472-7563) (Figure 10-9).

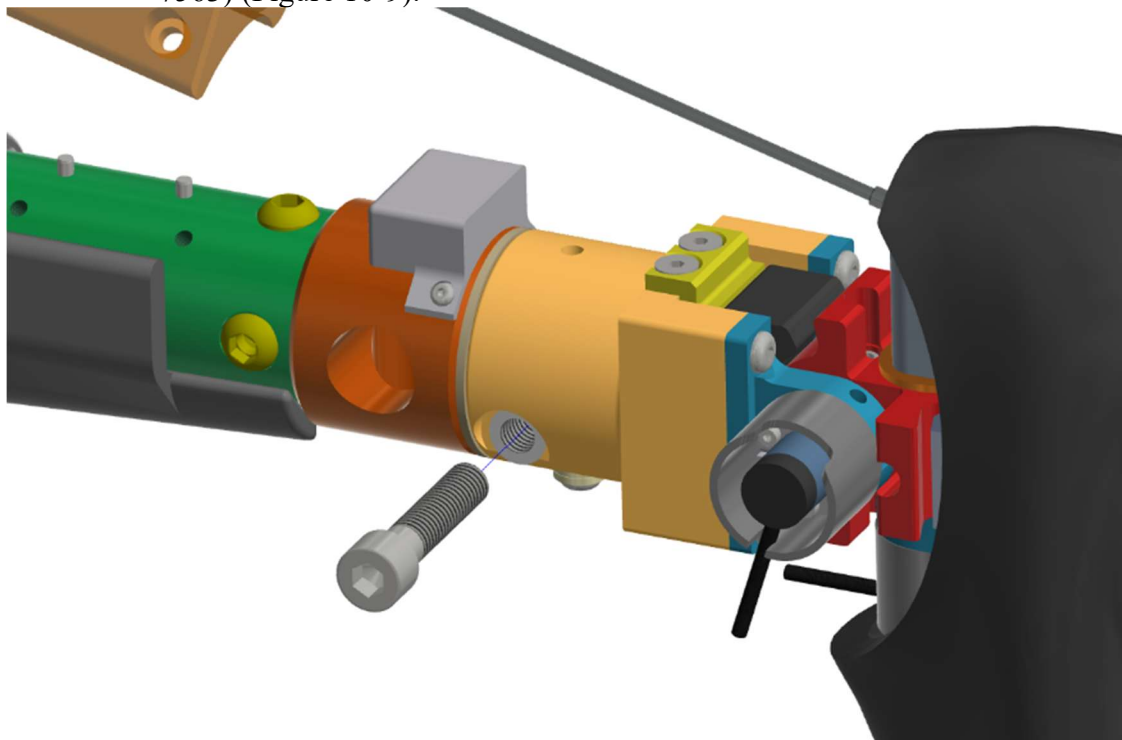


Figure 10-9. Separate the Lower Tibia Load Cell (SA572-S104) from the Upper Ankle Adaptor (474-5820-1,2)

10.2.6 Loosen the M3 X 0.5 X 3 LG. SSSNP from the Lower Tibia Load Cell (Figure 10-10).

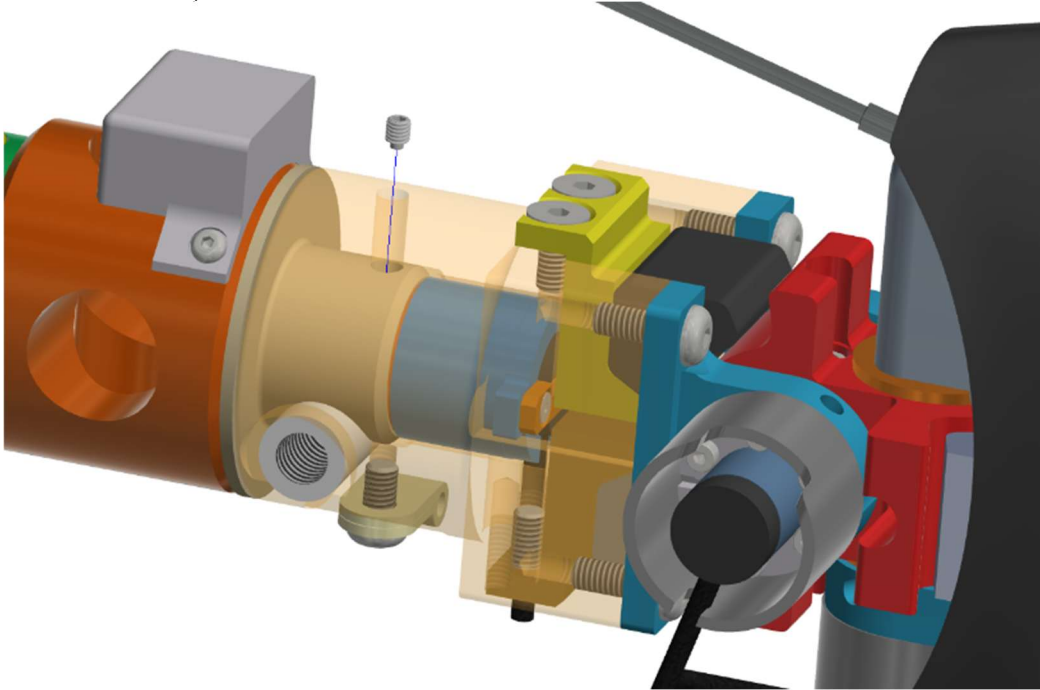


Figure 10-10. Loosen the M3 X 0.5 X 3 LG. SSSNP from the Lower Tibia Load Cell

10.2.7 Separate the Knee Clevis (474-5517-1,2) from the Upper Tibia Load Cell (SA572-S103) by removing four M6 X 1 X 16 LG. SHCS (Figure 10-11).

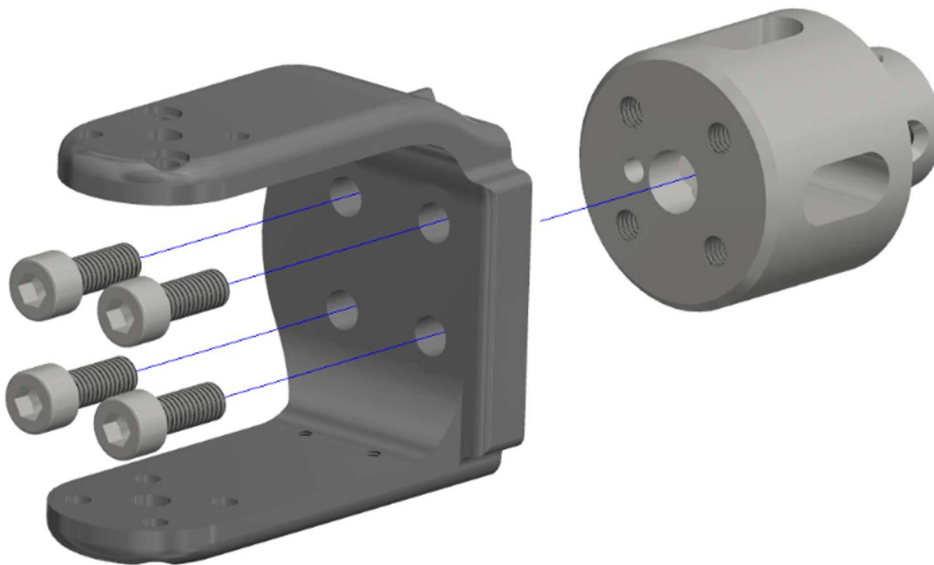


Figure 10-11. Separate the Knee Clevis (474-5517-1,2) from the Upper Tibia Load Cell (SA572-S103)

10.2.8 Remove the Shin Guard (474-5518-1,2) by removing two M5 X 0.8 X 12 LG. BHCS (Figure 10-12).

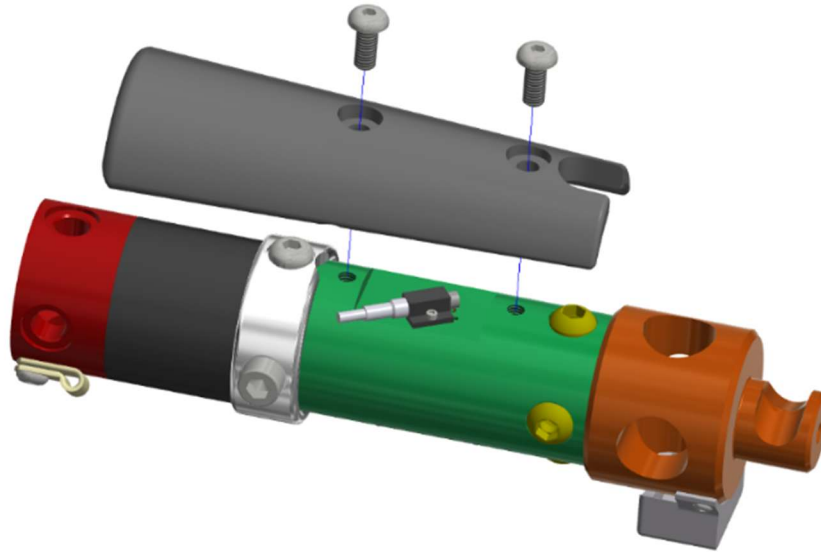


Figure 10-12. Remove the Shin Guard (474-5518-1,2)

10.2.9 Remove the Lower Tibia Load Cell (SA572-S104) by removing four Modified Thread M6 BHSS (Figure 10-13).

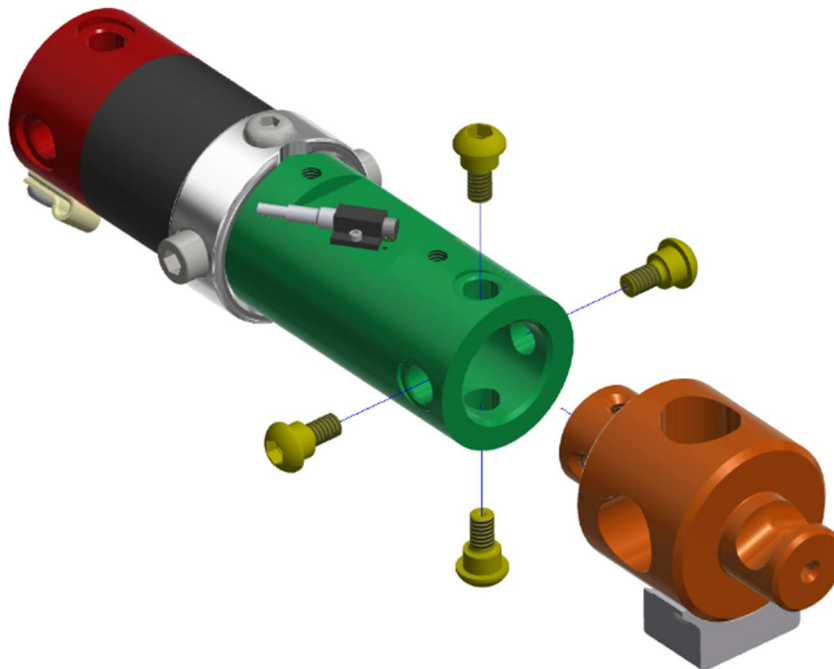


Figure 10-13. Remove the Lower Tibia Load Cell (SA572-S104)

10.2.10 Separate the Tibia Compliant Element Assembly (474-5508) from the Lower Tibia Shaft (474-5540-1,2) by removing one M6 X 1 X 10 LG. FHCS, one M6 X 1 X 10 LG. BHCS, and two Tibia Plunger Pins (474-5512) (Figure 10-14).

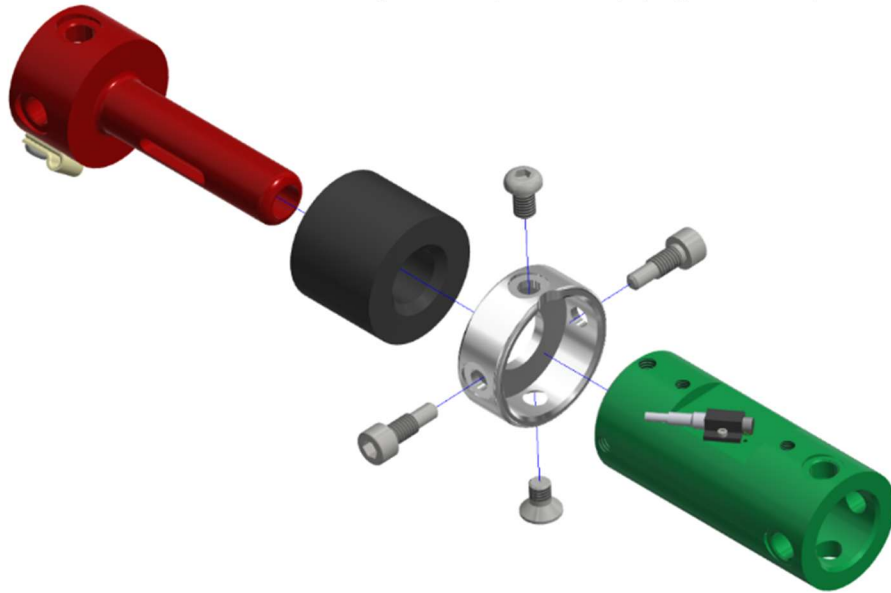


Figure 10-14. Separate the Tibia Compliant Element Assembly (474-5508) from the Lower Tibia Shaft (474-5540-1,2)

10.2.11 Remove the two accelerometers from the Lower Tibia Shaft by removing two M1.4 X 0.3 X 4 LG. SHCS per accel (Figure 10-15).

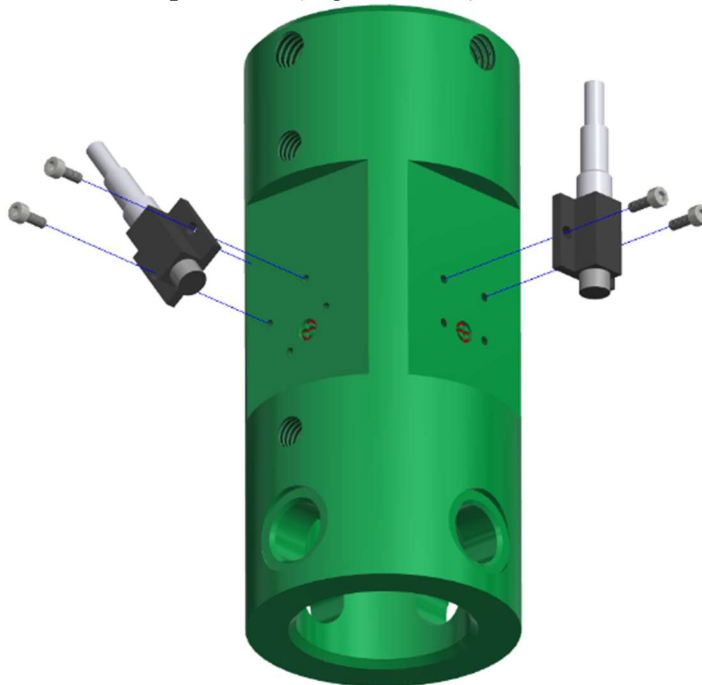


Figure 10-15. Remove the two accelerometers from the Lower Tibia Shaft

- 10.2.12 Remove the M3 X 0.5 X 12 LG. SHCS in the Achilles Cable Retainer (474-5828) then remove the ball end of the Achilles Cable (Figure 10-16).



Figure 10-16. Remove the M3 Bolt in the Achilles Cable Retainer (474-5828)

- 10.2.13 Remove the two M5 Hex Nuts from the Achilles Cable (474-5530) (Figure 10-17).

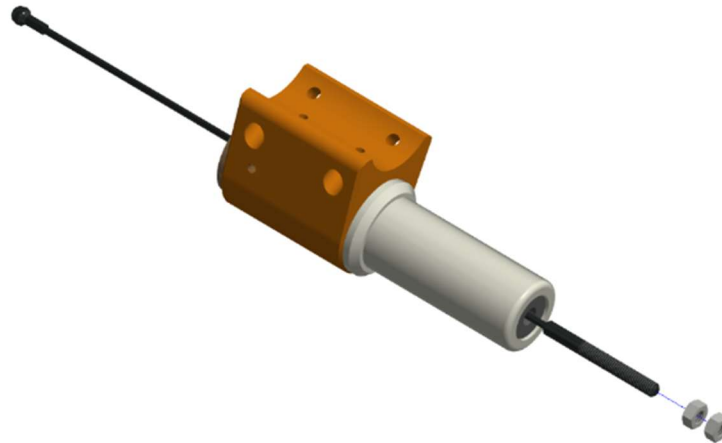


Figure 10-17. Remove the two M5 Hex Nuts from the Achilles Cable (474-5530)

- 10.2.14 Unscrew the Upper Achilles Spring Housing (474-5525) from the Lower Achilles Spring Housing (474-5504) (Figure 10-18).

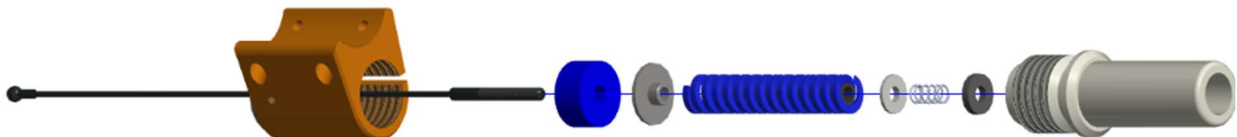


Figure 10-18. Unscrew the Upper Achilles Spring Housing (474-5525) from the Lower Achilles Spring Housing (474-5504)

10.2.15 Remove four M3 X 0.5 X 6 LG. FHCS from the Achilles Cable Eyelet Guide (474-5531) on the end of the Lower Achilles Spring Housing (Figure 10-19).

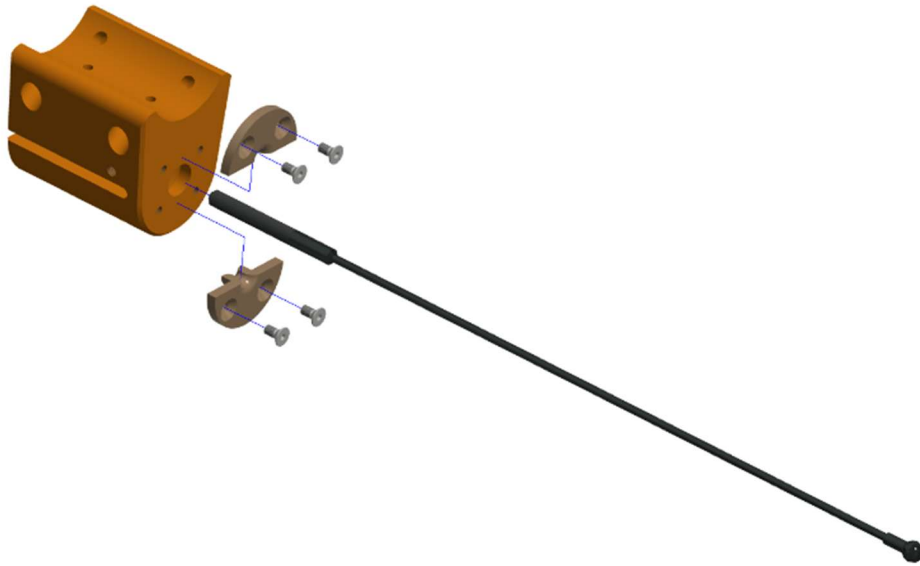


Figure 10-19. Remove four M3 X 0.5 X 6 LG. FHCS from the Achilles Cable Eyelet Guide (474-5531)

10.2.16 Remove the Molded Shoe Assembly (474-5903-1,2) from the ankle by removing four M4 X 0.7 X 16 LG. SHCS (Figure 10-20).

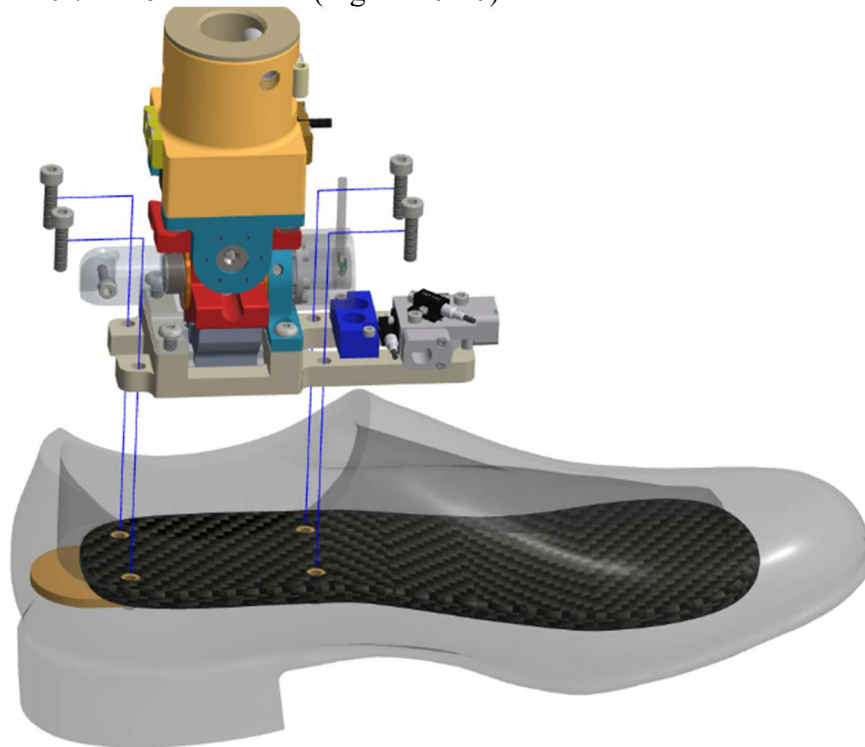


Figure 10-20. Remove the Molded Shoe Assembly (474-5903-1,2)

10.2.17 Remove the foot 6-Axis Accel/ARS Mount (474-5728-1,2) by removing two M2.5 X 0.45 X 16 LG. SHCS (Figure 10-21).

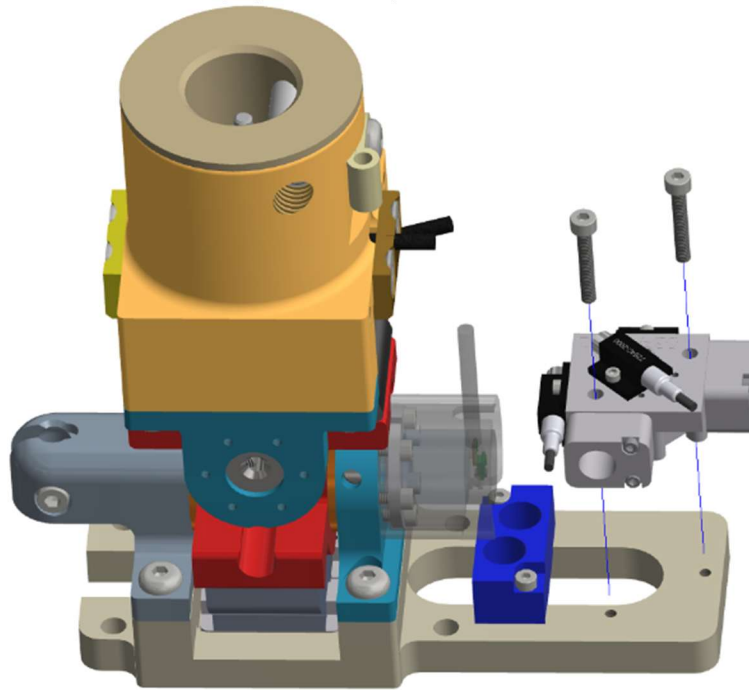


Figure 10-21. Remove the foot 6-Axis Accel/ARS Mount

10.2.18 Remove the tilt sensor from the lower ankle plate (474-5806-1,2) by removing two M2 X 0.4 X 10 LG. SHCS (Figure 10-22).

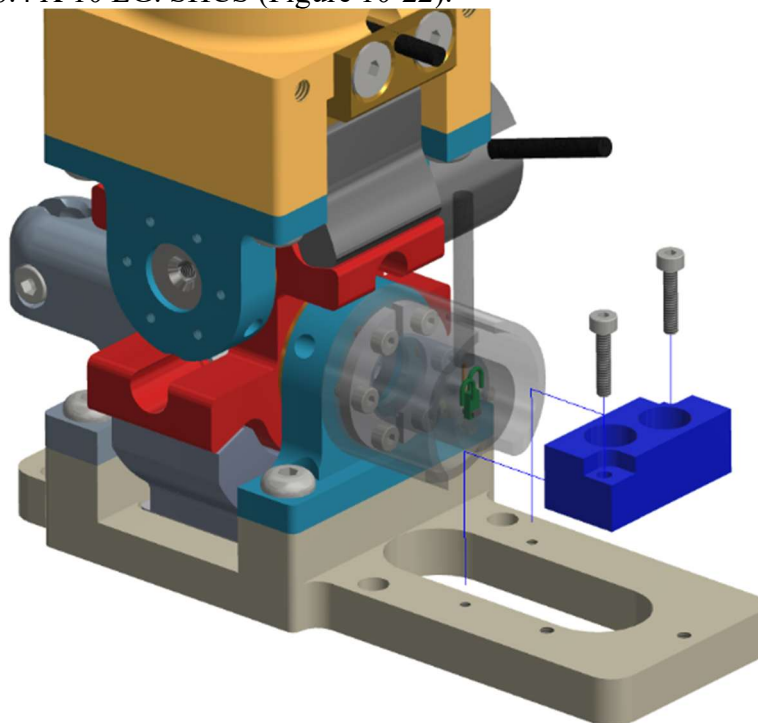


Figure 10-22. Remove foot tilt sensor

10.2.19 Remove the Accelerometers from the mount (034-120) by removing two M1.4 X 0.3 X 3 LG. SHCS per accel (Figure 10-23). Remove the ARSs from the mount by removing two M1.4 X 0.3 X 8 LG. SHCS per ARS (Figure 10-23).

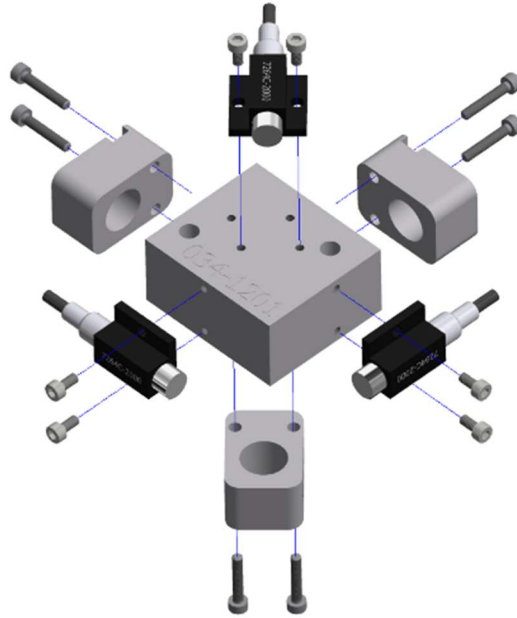


Figure 10-23. Remove the Accelerometers and ARSs from the mount

10.2.20 Separate the Lower Ankle Plate (474-5806-1,2) from the ankle by removing four M4 X 0.7 X 12 LG. BHCS (Figure 10-24).

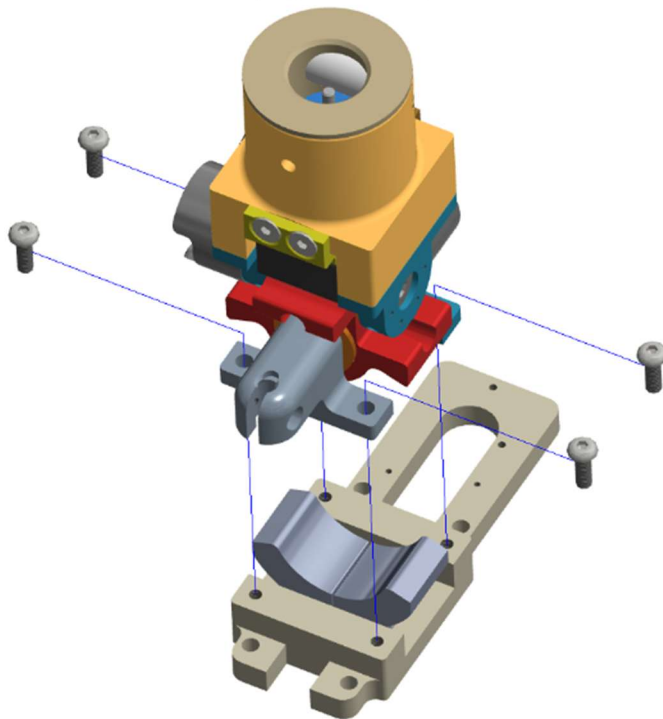


Figure 10-24. Separate the Lower Ankle Plate (474-5806-1,2) from the ankle

10.2.21 Slide the Achilles Cable Retainer (474-5828) and Ankle Thrust Washer (474-5720) from the Ankle Center Block Assembly (474-5824-A) (Figure 10-25).

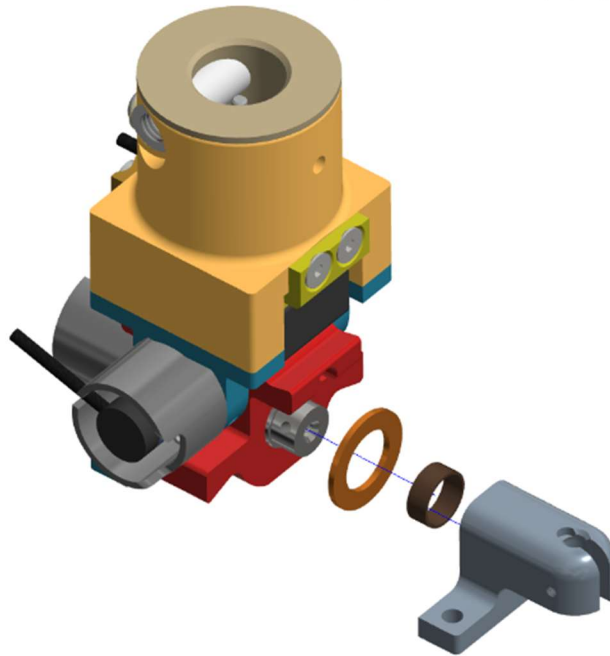


Figure 10-25. Achilles cable retainer

10.2.22 Remove the Inversion and Eversion Stop Assembly (474-5813-A and 474-5816-A) by removing four M3 X 0.5 X 6 LG. FHCS from the bottom of the Lower Ankle Plate (Figure 10-26).

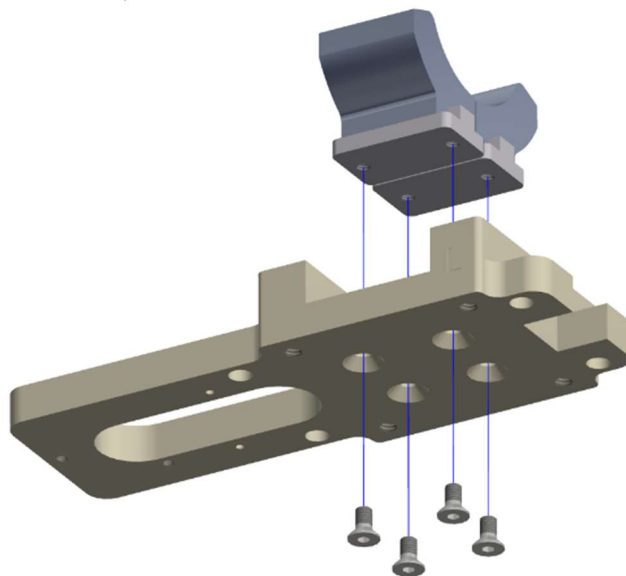


Figure 10-26. Remove the Inversion and Eversion Stop Assembly (474-5813-A and 474-5816-A)

- 10.2.23 Loosen the M3 X 0.5 X 3 LG. SSSNP from the X-Axis Potentiometer (Figure 10-27). Then slide the X-Axis Potentiometer from the Ankle Center Block Assembly.

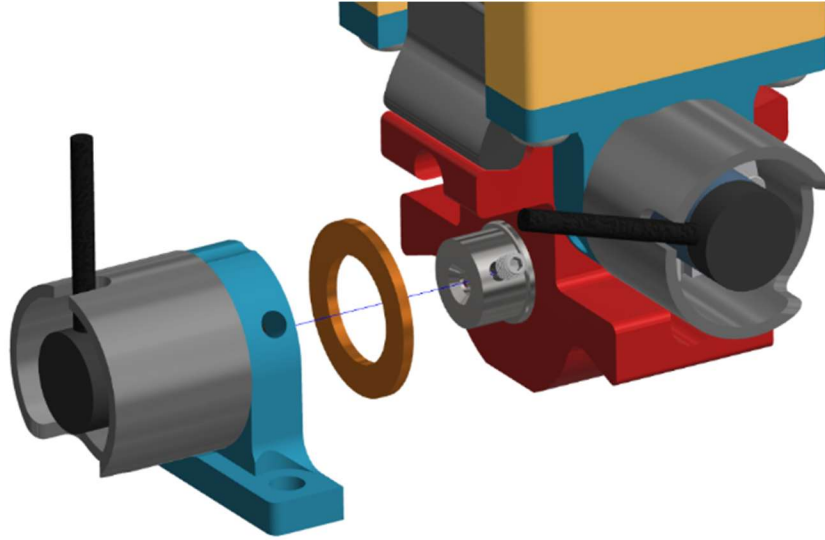


Figure 10-27. Loosen the M3 X 0.5 X 3 LG. SSSNP from the X-Axis Potentiometer.

- 10.2.24 Remove the Potentiometer Clamp (474-7581), the X-Potentiometer, and the Potentiometer Cap (483-5825) from an Ankle Bushing Plate (474-5826) by removing six M2 X 0.4 X 8 LG. SHCS (Figure 10-28).

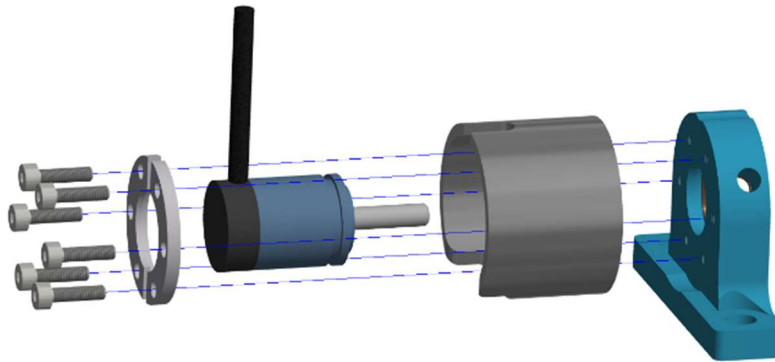


Figure 10-28. Remove the Potentiometer Clamp (474-7581)

10.2.25 Remove the two remaining Ankle Bushing Plates (474-5826) and the Ankle Center Block Assembly (474-5824-A) by from the Upper Ankle Adaptor (474-5820-1,2) by removing four M4 X 0.7 X 12 LG. BHCS

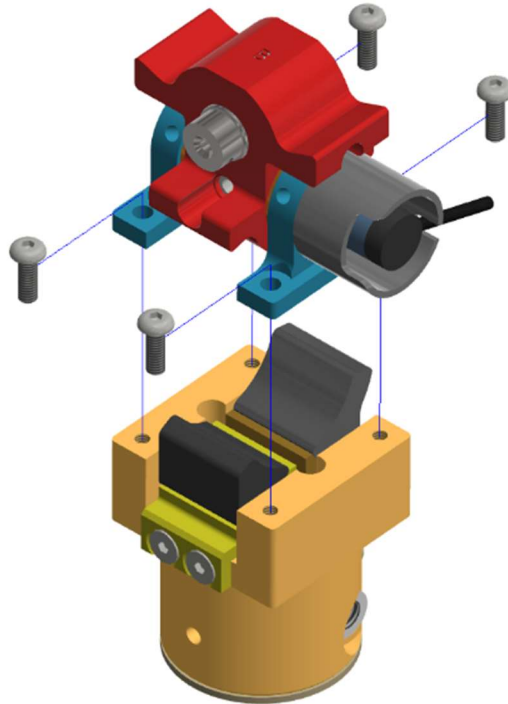


Figure 10-29. Remove the two remaining Ankle Bushing Plates (474-5826) and the Ankle Center Block Assembly (474-5824-A) from the Ankle Adaptor

10.2.26 Loosen the M3 X 0.5 X 3 LG. SSSNP on the Y-Axis Potentiometer (Figure 10-30).

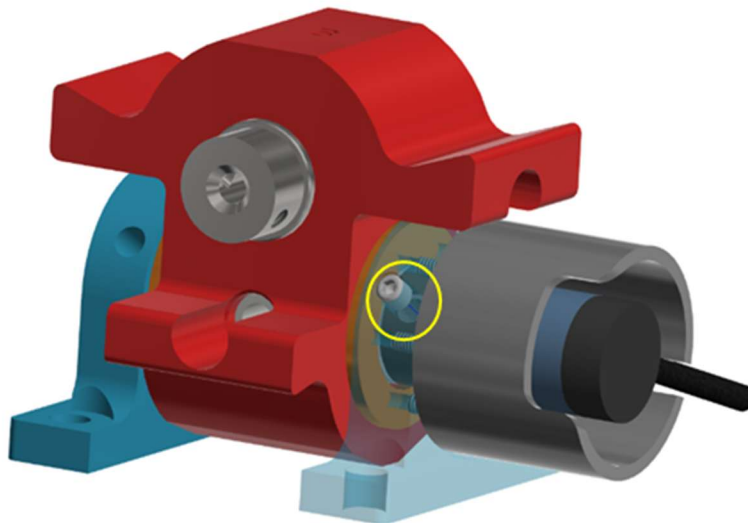


Figure 10-30. Loosen the M3 X 0.5 X 3 LG. SSSNP on the Y-Axis Potentiometer

10.2.27 Slide the two Ankle Bushing Plates off the Ankle Center Block Assembly (474-5824-A) (Figure 10-31).

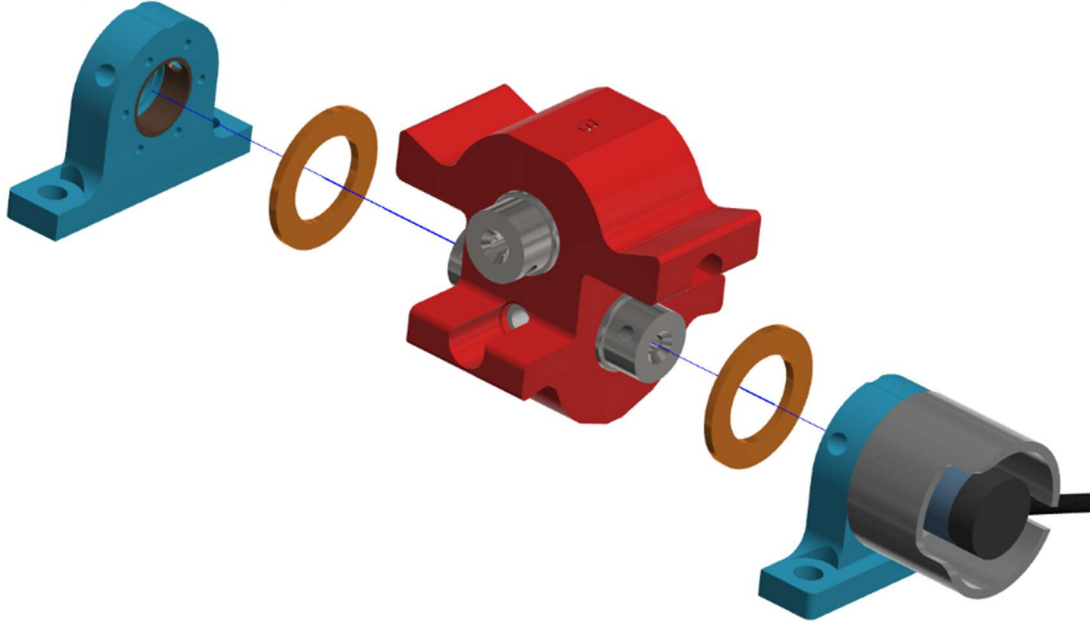


Figure 10-31. Ankle bushing plates and ankle block assembly

10.2.28 Unscrew the six M2 X 0.4 X 8 LG. SHCS, removing the Potentiometer Clamp (472-7581) from the Potentiometer Cap (483-5825) from the Ankle Bushing Plate (474-5826) (Figure 10-32)

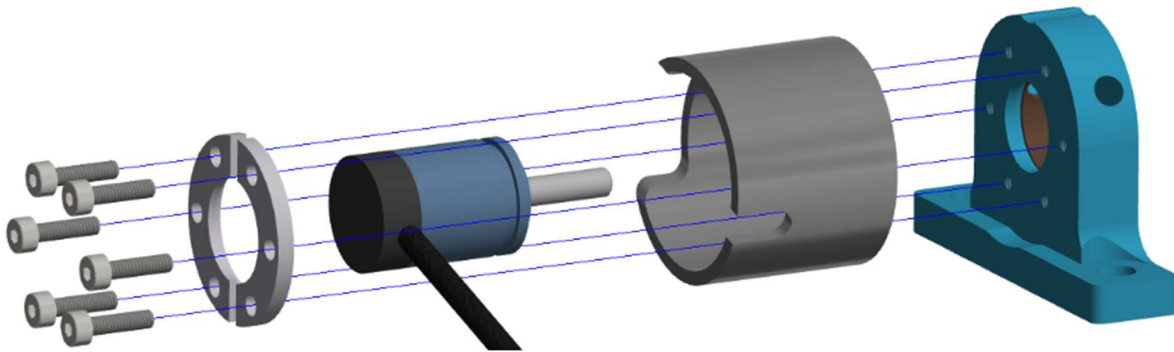


Figure 10-32. Slide the two Ankle Bushing Plates off the Ankle Center Block Assembly

10.2.29 Remove the Plantar and Dorsi Stop Assemblies (474-5810 and 474-5807) from the Upper Ankle Adaptor (474-5820-1,2) by removing two M4 X 0.7 X 10 LG. FHCS per side (Figure 10-33).

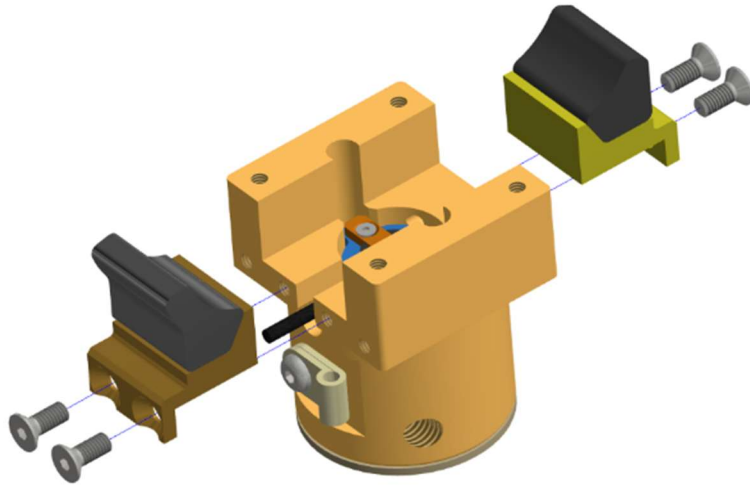


Figure 10-33. Remove the Plantar and Dorsi Stop Assemblies (474-5810 and 474-5807)

10.2.30 Remove the strain relief from the Upper Ankle Adaptor (474-5820-1,2) by removing a M4 X 0.7 X 8 LG. BHCS and slide the Z-Axis Potentiometer from the Adaptor (Figure 10-34).

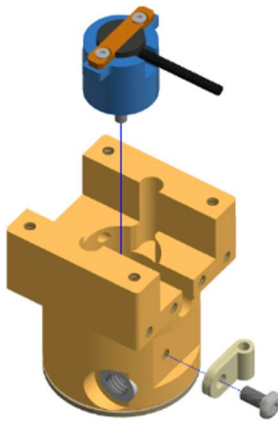


Figure 10-34. Ankle Z-Axis Potentiometer and Strain Relief

10.2.31 Remove the two M2 X 0.4 X 5 LG. FHCS from the Z-Axis Potentiometer Clamp and Inner Mount (474-5832 and 474-5831) (Figure 10-35).

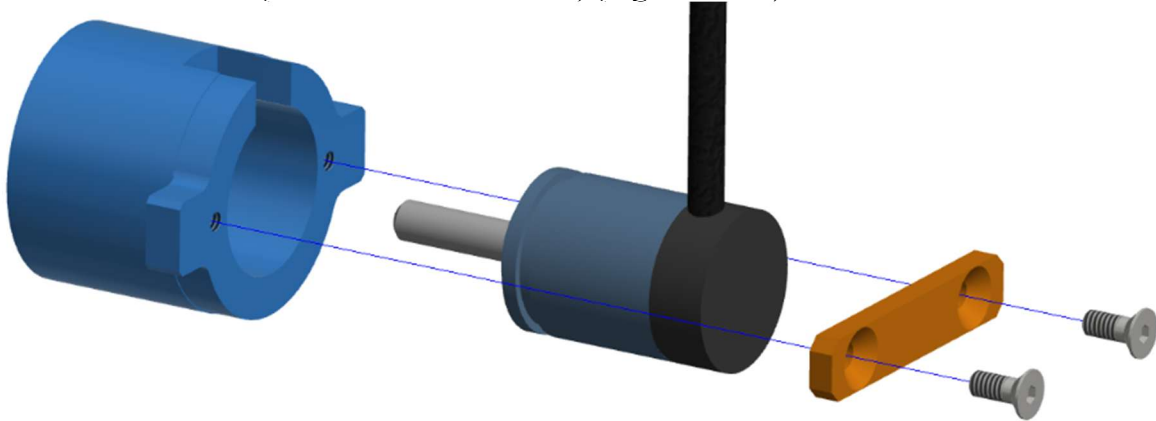


Figure 10-35. Remove the two M2 X 0.4 X 5 LG. FHCS from the Z-Axis Potentiometer Clamp and Inner Mount (474-5832 and 474-5831)

10.3 Assembly of the Lower Extremity

The following procedure is a step-by-step description of the assembly procedure for the lower extremity components. The photos illustrate a left leg assembly. The right leg is similar, with noted exceptions. Unless otherwise specified, tighten all bolts to the torque specifications provided in Section 2.1.3.

- 10.3.1 Using two M2 X 0.4 X 5 LG. FHCS, attach the Z-Axis Potentiometer Clamp and Inner Mount (474-5832 and 474-5831) (Figure 10-36).

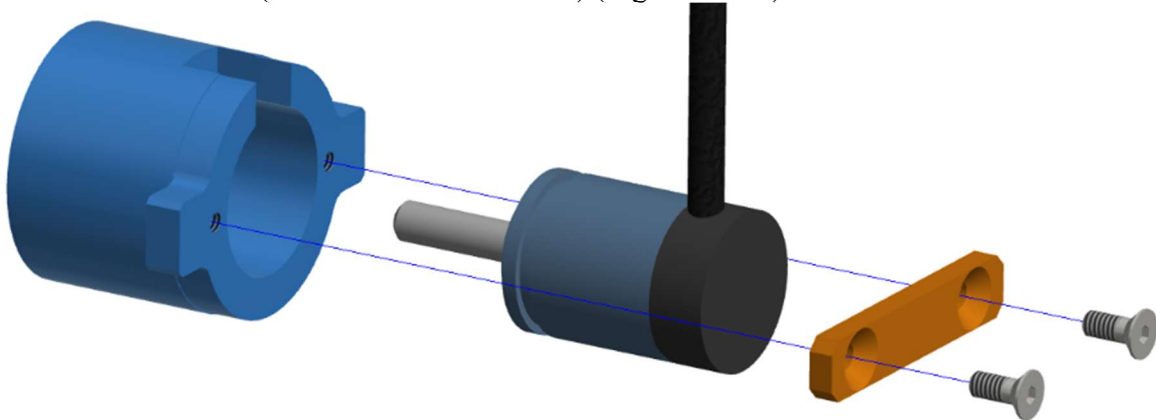


Figure 10-36. Use two M2 X 0.4 X 5 LG. FHCS to attach the Z-Axis Potentiometer Clamp and Inner Mount (474-5832 and 474-5831)

- 10.3.2 Slide the Z-Axis Potentiometer into the Ankle Adaptor (474-5820-1,2) and attach the strain relief to the Adaptor (474-5820-1,2) using a M4 X 0.7 X 8 LG. BHCS (Figure 10-37).

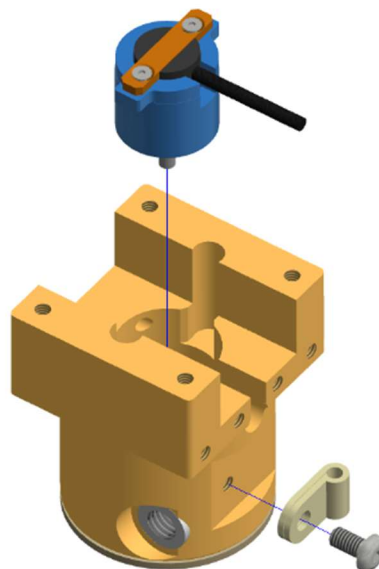


Figure 10-37. Assemble Ankle Z-Axis Potentiometer and strain relief to Ankle Adaptor

- 10.3.3 Attach the Plantar and Dorsi Stop Assemblies (474-5810 and 474-5807) to the Upper Ankle Adaptor (474-5820-1,2) using two M4 X 0.7 X 10 LG. FHCS per side (Figure 10-38).

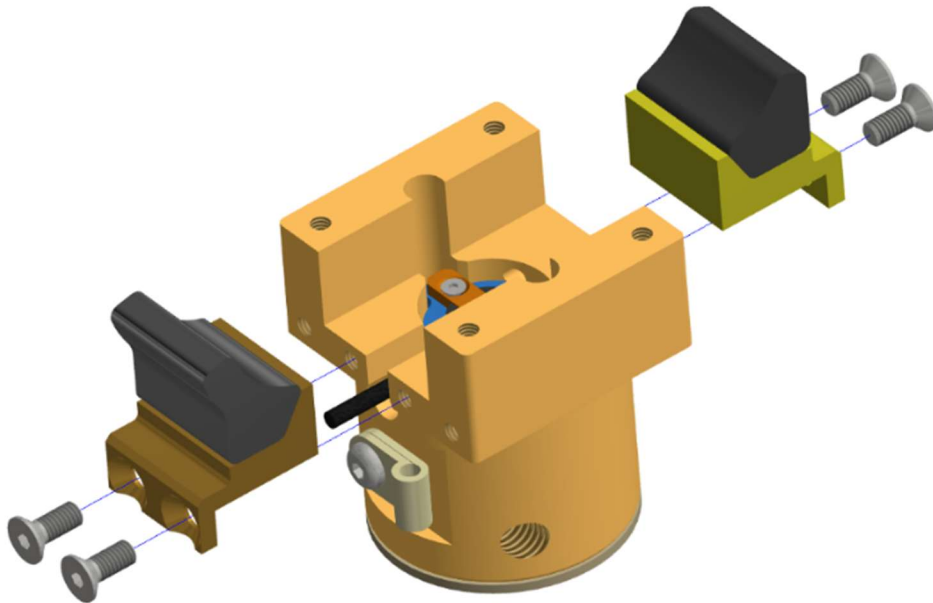


Figure 10-38. Attach the Plantar and Dorsi Stop Assemblies (474-5810 and 474-5807)

- 10.3.4 Attach the Y-potentiometer to the Ankle Bushing Plate (474-5826) using a Potentiometer Cap (483-5825), a Potentiometer Clamp (472-7581), and six M2 X 0.4 X 8 LG. SHCS (Figure 10-39).

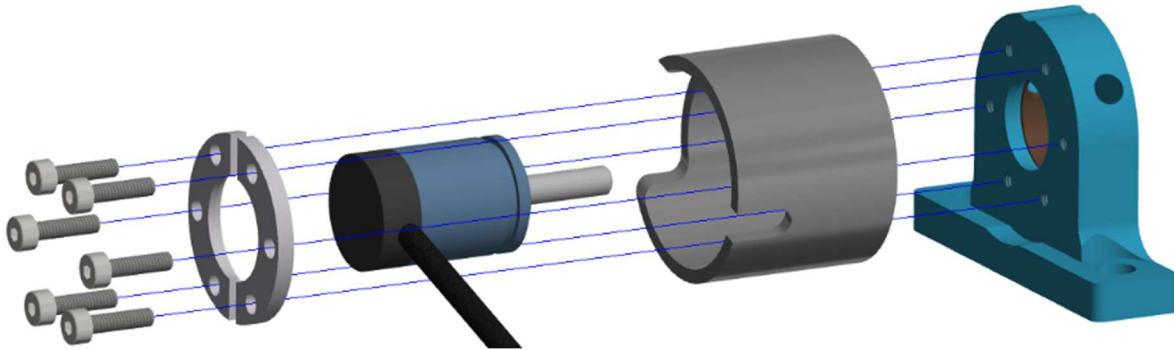


Figure 10-39. Attach the Y-potentiometer to the Ankle Bushing Plate (474-5826)

10.3.5 Slide the two Ankle Bushing Plates (472-7581), on with the Y-pot attached, on to the Ankle Center Block Assembly (Figure 10-40).

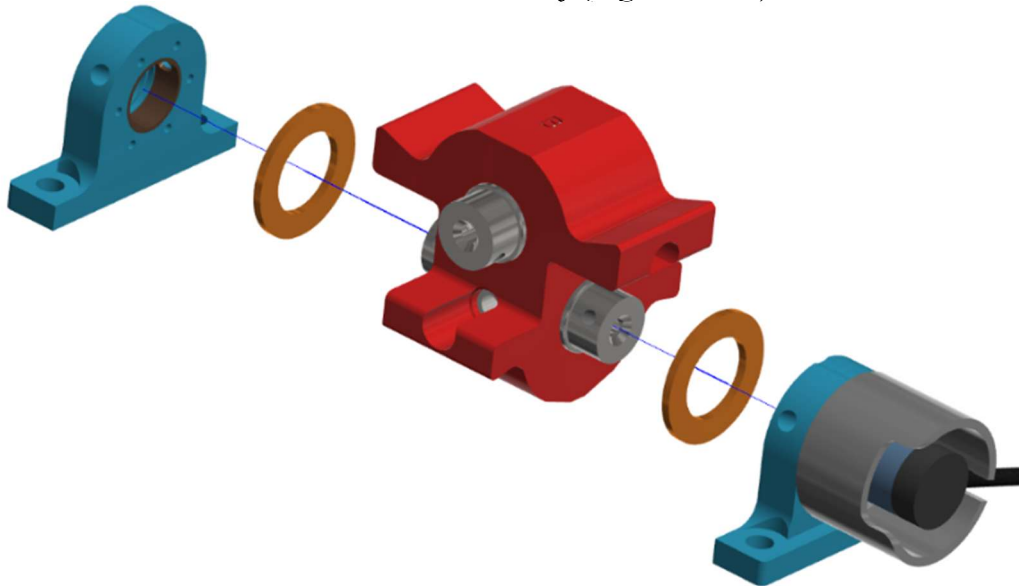


Figure 10-40. Ankle bushing plates and ankle block assembly

10.3.6 Tighten the M3 X 0.5 X 3 LG. SSSNP on the Y-Axis Potentiometer (Figure 10-41).

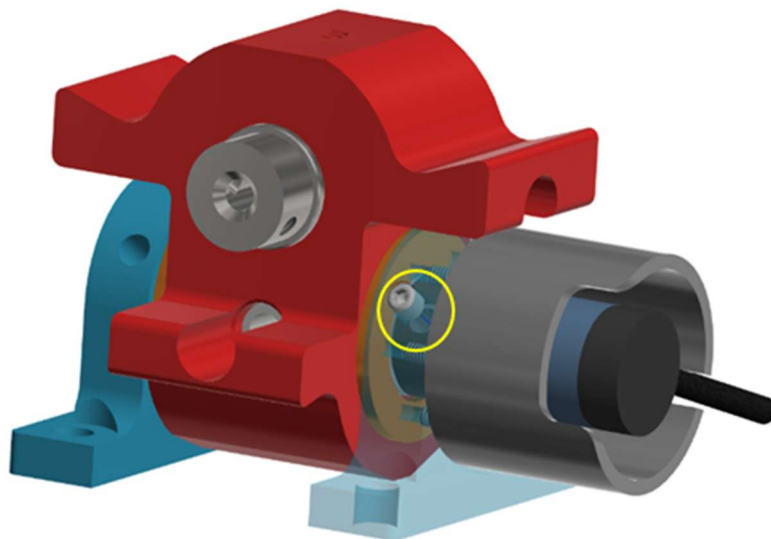


Figure 10-41. Tighten the M3 X 0.5 X 3 LG. SSSNP on the Y-Axis Potentiometer

10.3.7 Assemble the two Ankle Bushing Plates (474-5826) and the Ankle Center Block Assembly (474-5824-A) to the Upper Ankle Adaptor (474-5820-1,2) using four M4 X 0.7 X 12 LG. BHCS (Figure 10-42).

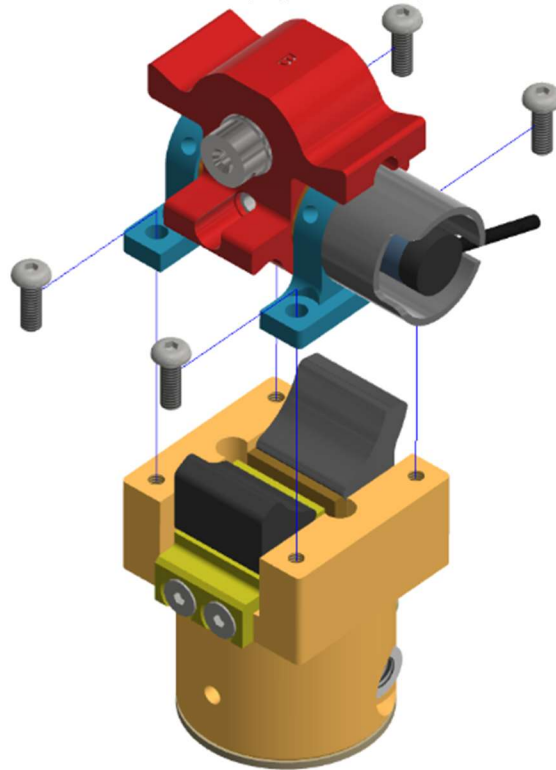


Figure 10-42. Assemble Ankle Bushing Plates (474-5826) and the Ankle Center Block Assembly (474-5824-A) to the Ankle Adaptor (474-5820-1,2)

10.3.8 Attach the X-potentiometer to the Ankle Bushing Plate (474-5826) using a Potentiometer Cap (483-5825), a Potentiometer Clamp (472-7581), and six M2 X 0.4 X 8 LG. SHCS (Figure 10-43).

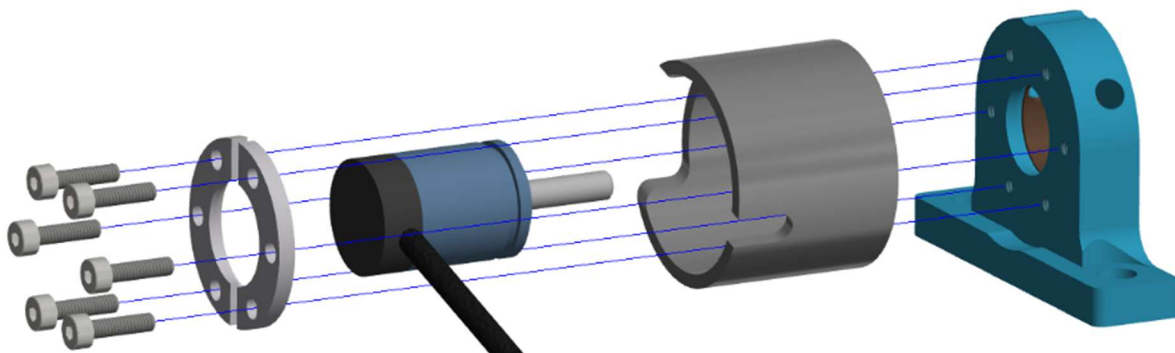


Figure 10-43. Attach the X-potentiometer to an Ankle Bushing Plate (474-5826)

- 10.3.9 Slide the X-Axis Potentiometer with the Ankle Plate Bushing on to the Ankle Center Block Assembly (474-5824-A). Tighten the M3 X 0.5 X 3 LG. SSSNP from the X-Axis Potentiometer (Figure 10-44).

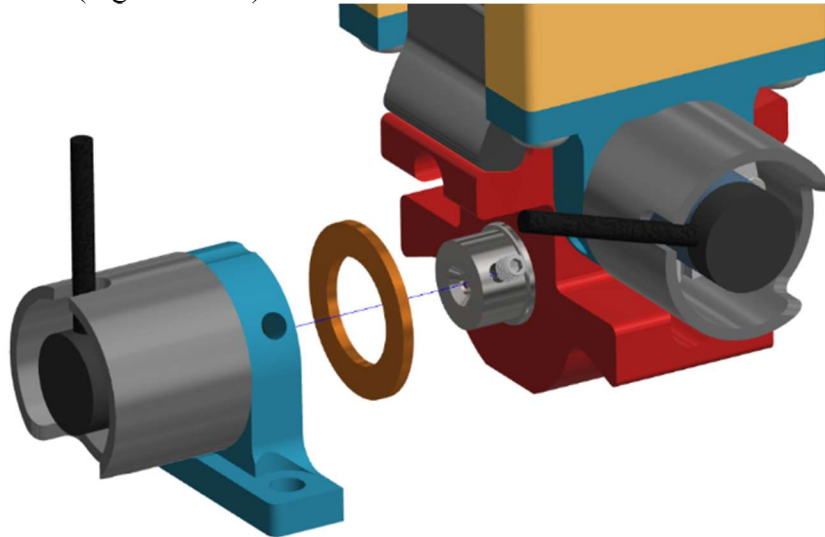


Figure 10-44. Slide the X-Axis Potentiometer with the Ankle Plate Bushing on to the Ankle Center Block Assembly

- 10.3.10 Install the Inversion and Eversion Stop Assembly (474-5813-A and 474-5816-A) using four M3 X 0.5 X 6 LG. FHCS on the bottom of the Lower Ankle Plate (Figure 10-45).

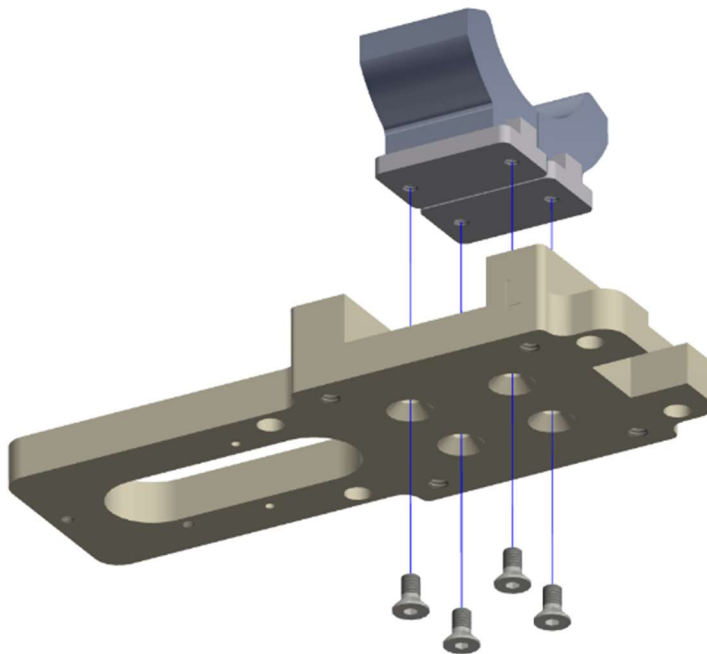


Figure 10-45. Install the Inversion and Eversion Stop Assembly (474-5813-A and 474-5816-A)

10.3.11 Slide the Achilles Cable Retainer (474-5828) and Ankle Thrust Washer (474-5720) on to the Ankle Center Block Assembly (474-5824-A) (Figure 10-46).

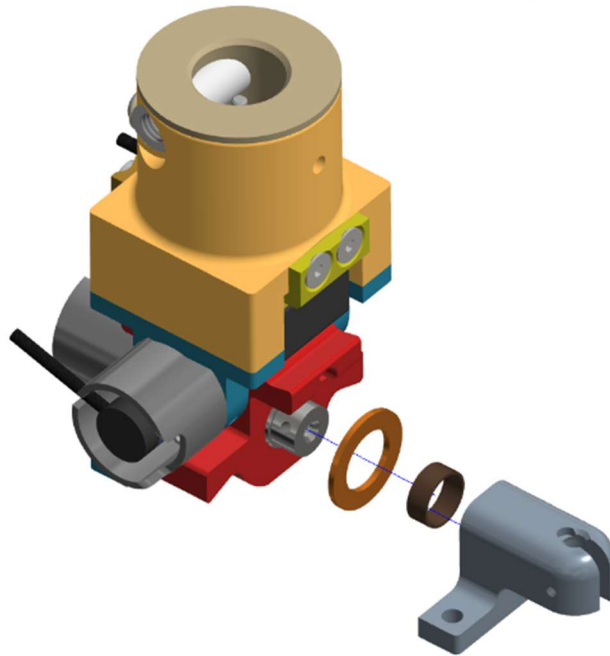


Figure 10-46. Achilles cable retainer

10.3.12 Assemble the Lower Ankle Plate (474-5806-1,2) to the ankle using four M4 X 0.7 X 12 LG. BHCS (Figure 10-47).

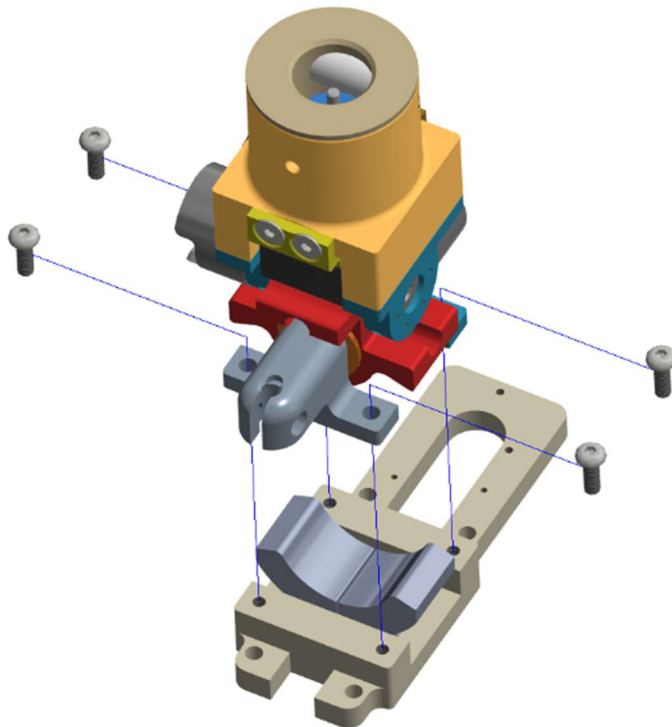


Figure 10-47. Assemble the Lower Ankle Plate (474-5806-1,2) to the ankle

- 10.3.13 Attach three Accelerometers to the mount (034-1201) using two M1.4 X 0.3 X 3 LG. SHCS per accel (Figure 10-48). Attach three ARSs to the mount using two M1.4 X 0.3 X 8 LG. SHCS per ARS (Figure 10-48).

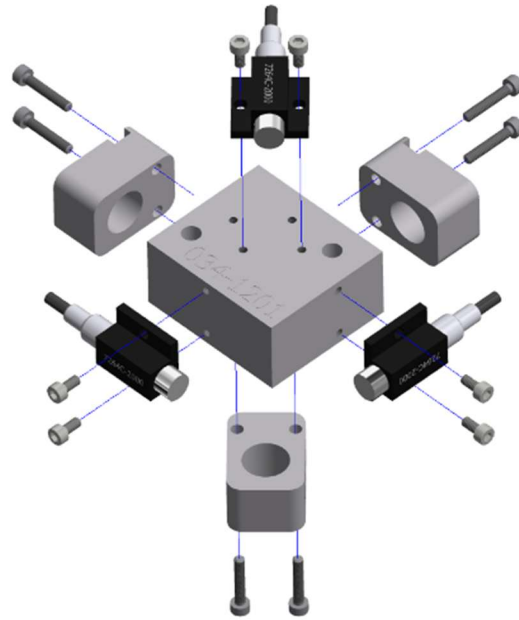


Figure 10-48. Attach the Accelerometers and ARSs to the mount

- 10.3.14 Attach the tilt sensor to the lower ankle plate (474-5806-1,2) using two M2 X 0.4 X 10 LG. SHCS (Figure 10-49).

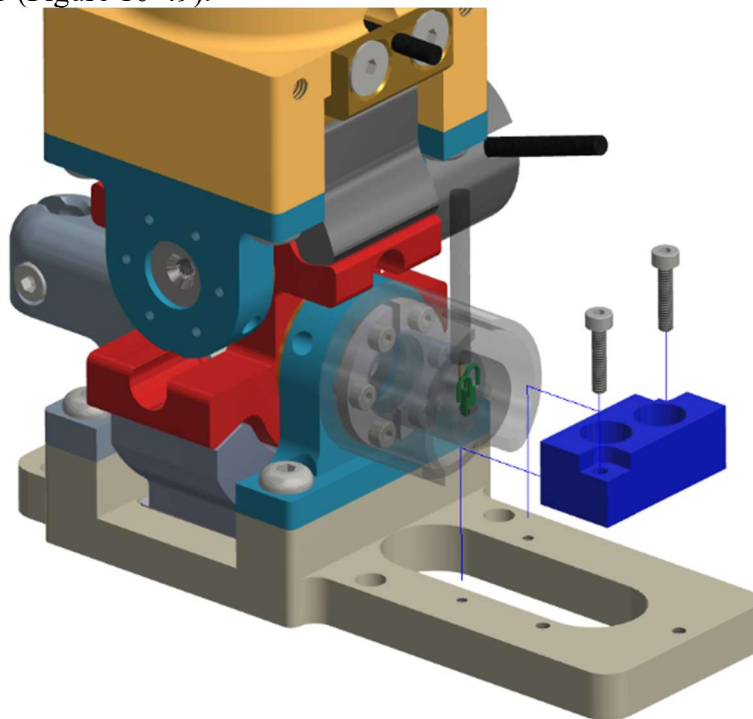


Figure 10-49. Attach foot tilt sensor

10.3.15 Attach the foot 6-Axis Accel/ARS Mount (474-5728-1,2) using two M2.5 X 0.45 X 16 LG. SHCS (Figure 10-50).

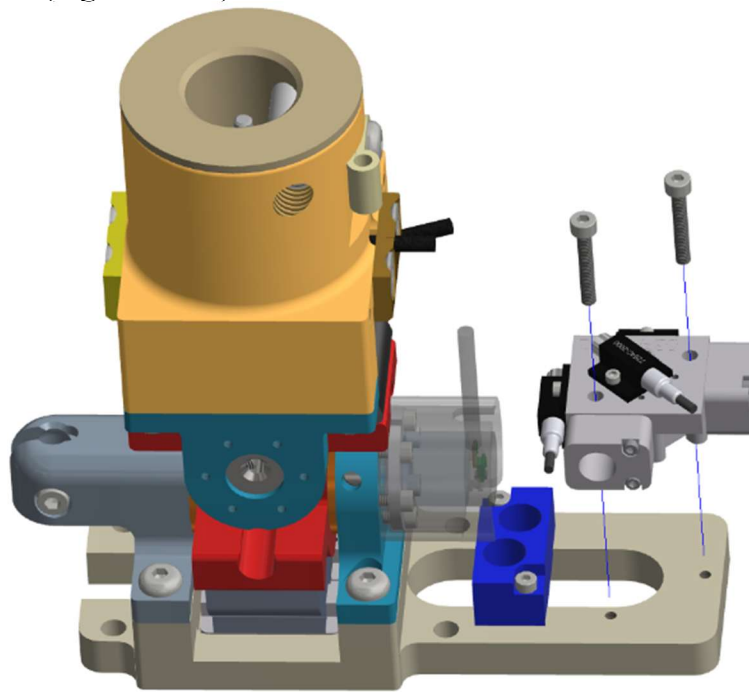


Figure 10-50. Attach the foot 6-Axis Accel/ARS Mount

10.3.16 Attach the Molded Shoe Assembly (474-5903-1,2) to the ankle using four M4 X 0.7 X 16 LG. SHCS (Figure 10-51).

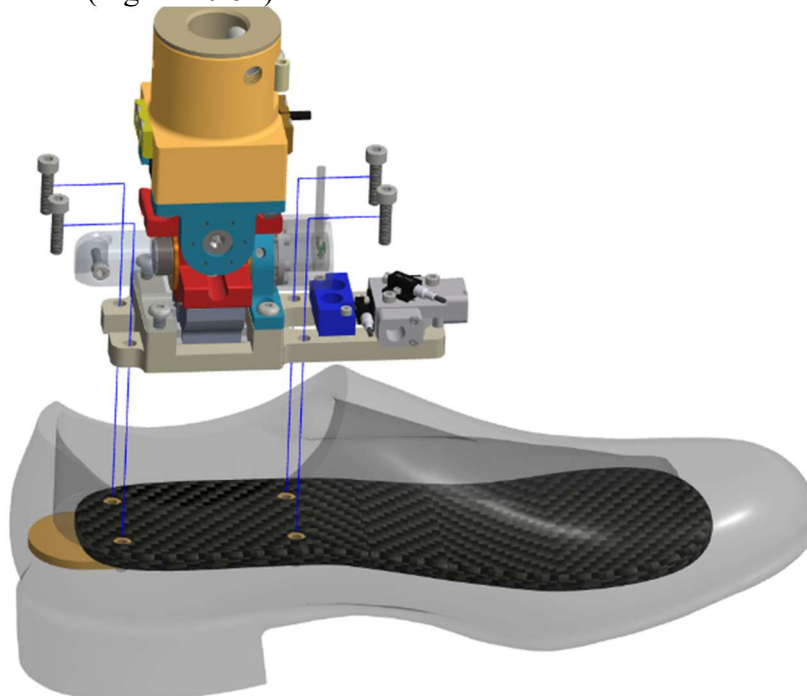


Figure 10-51. Attach the Molded Shoe Assembly (474-5903-1,2)

- 10.3.17 Attach the Achilles Cable (474-5530) and the Achilles Cable Eyelet Guide (474-5531) to the end of the Lower Achilles Spring Housing (474-5504) using four M3 X 0.5 X 6 LG. FHCS (Figure 10-52).

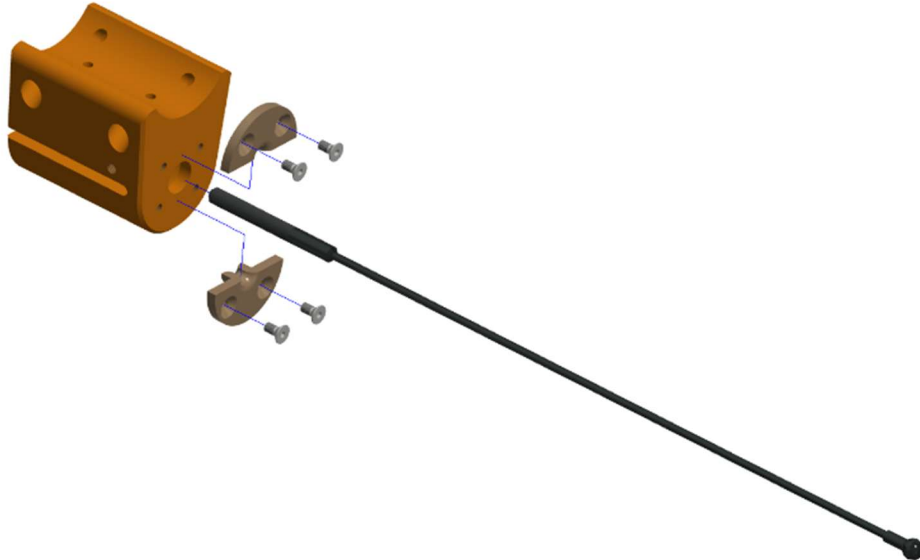


Figure 10-52. Attach the Achilles Cable and the Eyelet Guide to the Lower Achilles Spring Housing

- 10.3.18 Thread the Achilles Load Cell (SA572-S126) or the Achilles Load Cell Blank (472-7359), Bottom Spring Cap (474-5526), Achilles Spring Assembly (474-5523), Spring Bushing (474-2322), Compression Spring (6005232), and Primary Load Washer (474-5529) on to the Achilles Cable as shown in Figure 10-53. Seat the parts inside the Lower Achilles Spring Housing (474-5504) and screw on the Upper Achilles Spring Housing (474-5525) (Figure 10-53).

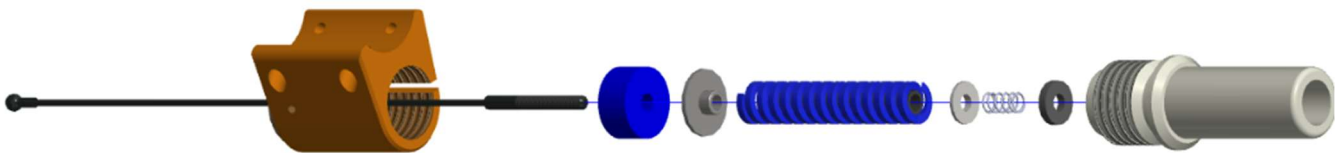


Figure 10-53. Assemble Upper Achilles Spring Housing (474-5525) to the Lower Achilles Spring Housing (474-5504)

- 10.3.19 Apply the two M5 Hex Nuts to the top end of the Achilles Cable (474-5530) (Figure 10-54).

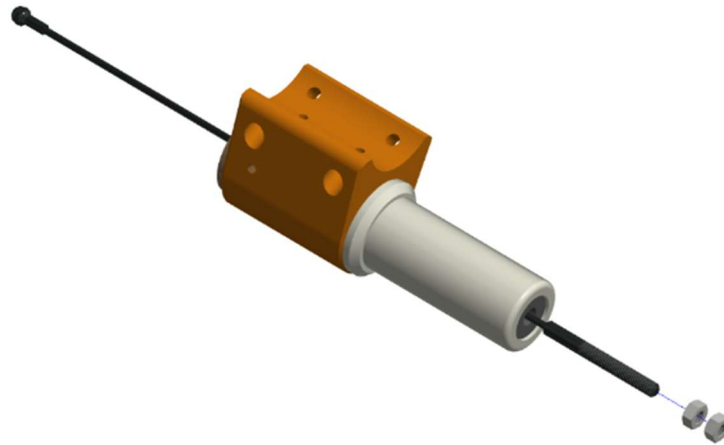


Figure 10-54. Apply the two M5 Hex Nuts to the Achilles Cable (474-5530)

- 10.3.20 Place the ball end of the Achilles Cable in the Achilles Cable Retainer (474-5828) and install the M3 X 0.5 X 12 LG. SHCS (Figure 10-55).



Figure 10-55. Attach the Achilles Cable to the Achilles Cable Retainer (474-5828)

- 10.3.21 Attach the two accelerometers to the Lower Tibia Shaft (474-5540-1,2) using two M1.4 X 0.3 X 4 LG. SHCS per accel (Figure 10-56).

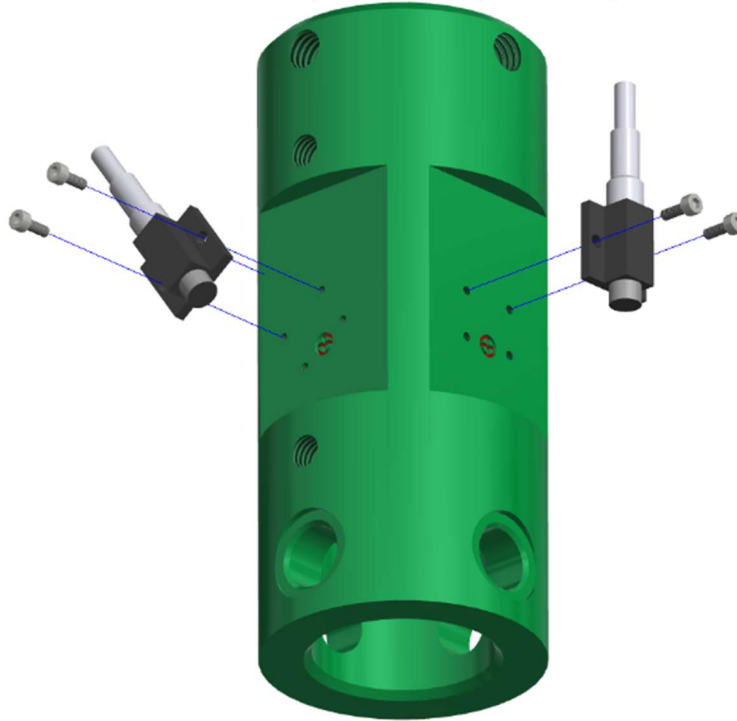


Figure 10-56. Attach the two accelerometers from the Lower Tibia Shaft

- 10.3.22 Assemble the Tibia Compliant Element Assembly (474-5508) to the Lower Tibia Shaft (474-5540-1,2) using one M6 X 1 X 10 LG. FHCS, one M6 X 1 X 10 LG. BHCS, and two Tibia Plunger Pins (474-5512) (Figure 10-57).

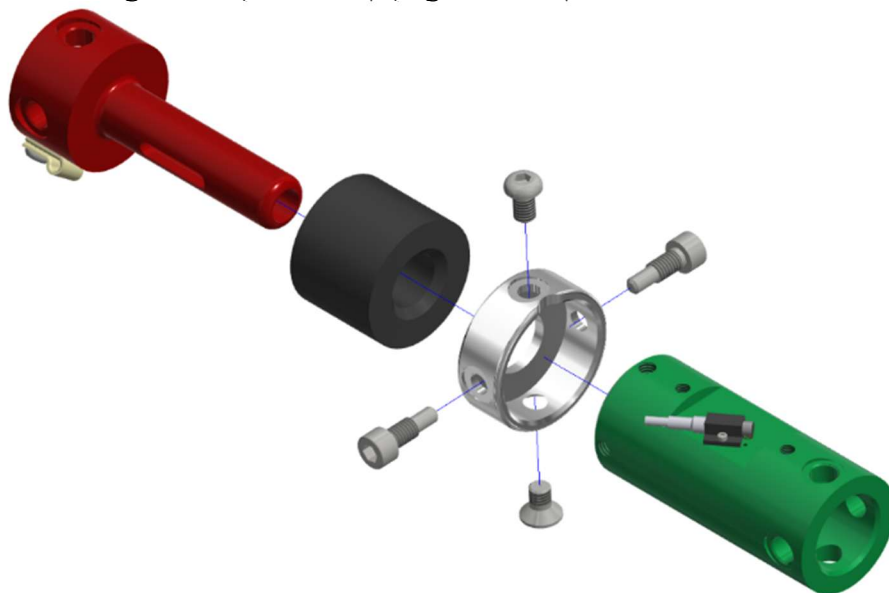


Figure 10-57. Assemble the Tibia Compliant Element Assembly (474-5508) from the Lower Tibia Shaft (474-5540-1,2)

10.3.23 Attach the Lower Tibia Load Cell (SA572-S104) using four Modified Thread M6 BHSS (Figure 10-58).

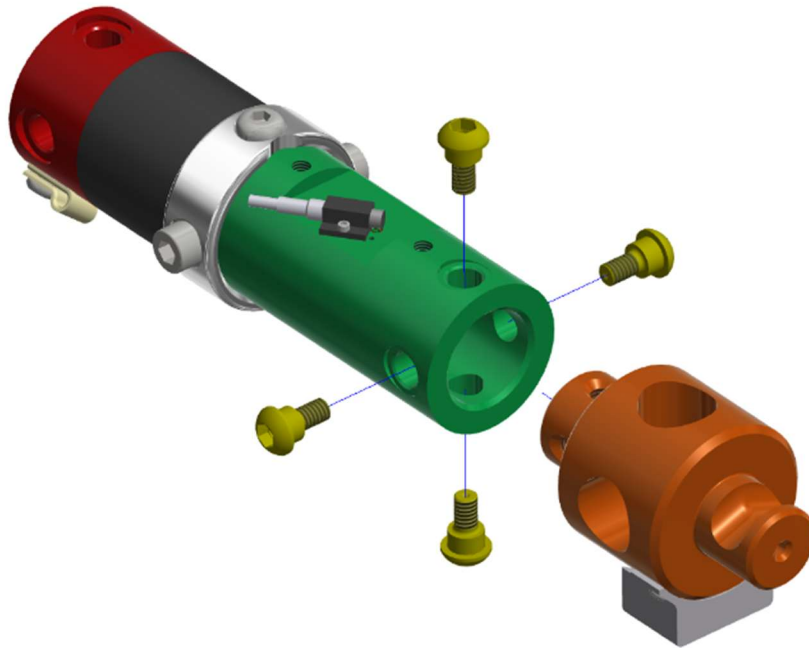


Figure 10-58. Attach the Lower Tibia Load Cell (SA572-S104)

10.3.24 Attach the Shin Guard (474-5518-1,2) to the Lower Tibia Shaft (474-5540-1,2) using two M5 X 0.8 X 12 LG. BHCS (Figure 10-59).

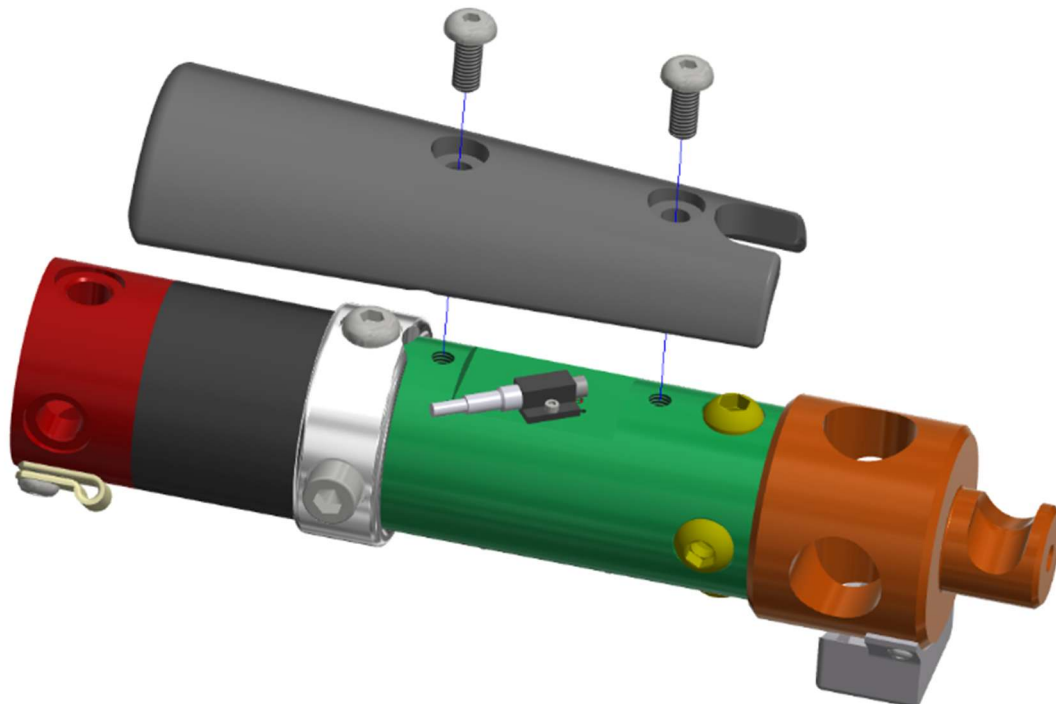


Figure 10-59. Attach the Shin Guard (474-5518-1,2)

10.3.25 Assemble the Lower Tibia Load Cell (SA572-S104) to the Upper Ankle Adaptor (474-5820-1,2) using the Ankle Bolt & Sleeve Assembly (472-7563) (Figure 10-60).

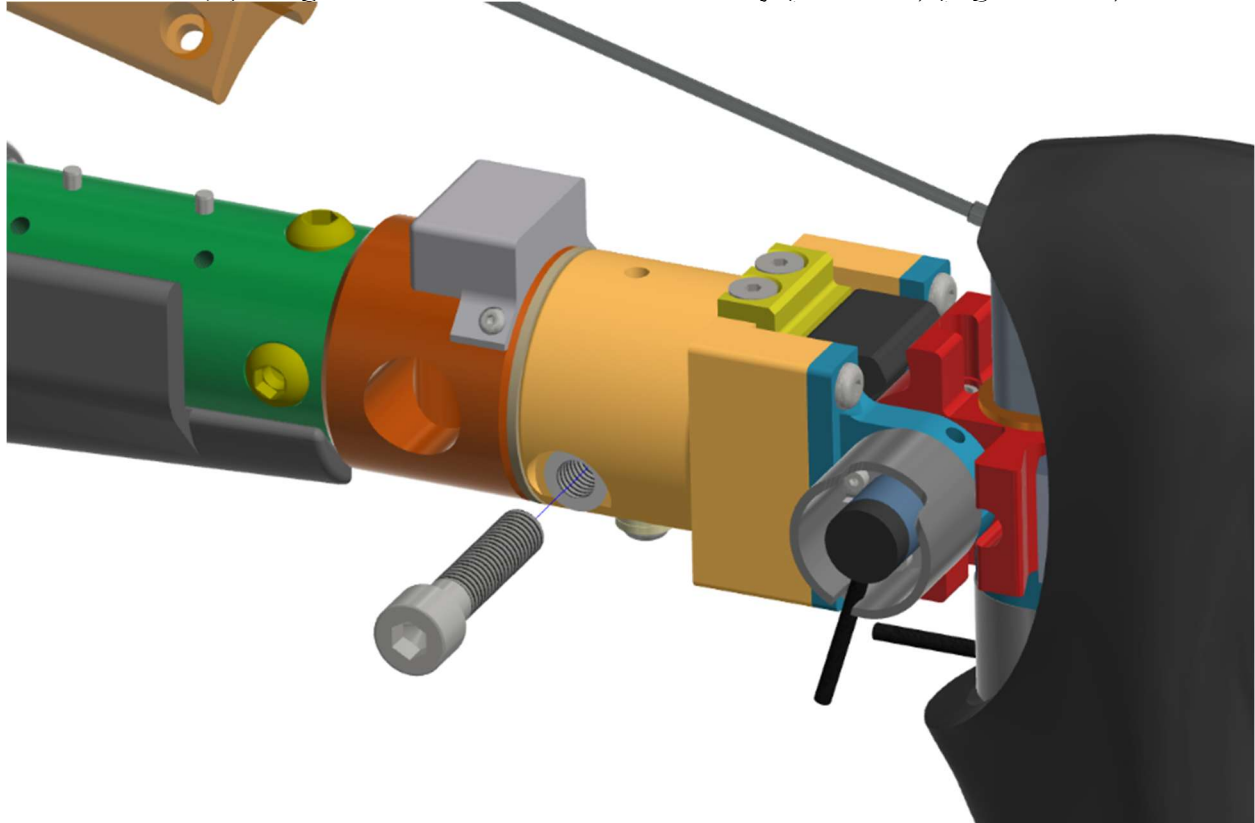


Figure 10-60. Assemble the Lower Tibia Load Cell (SA572-S104) to the Upper Ankle Adaptor (474-5820-1,2)

10.3.26 Tighten the M3 X 0.5 X 3 LG. SSSNP in the Lower Tibia Load Cell (Figure 10-61).

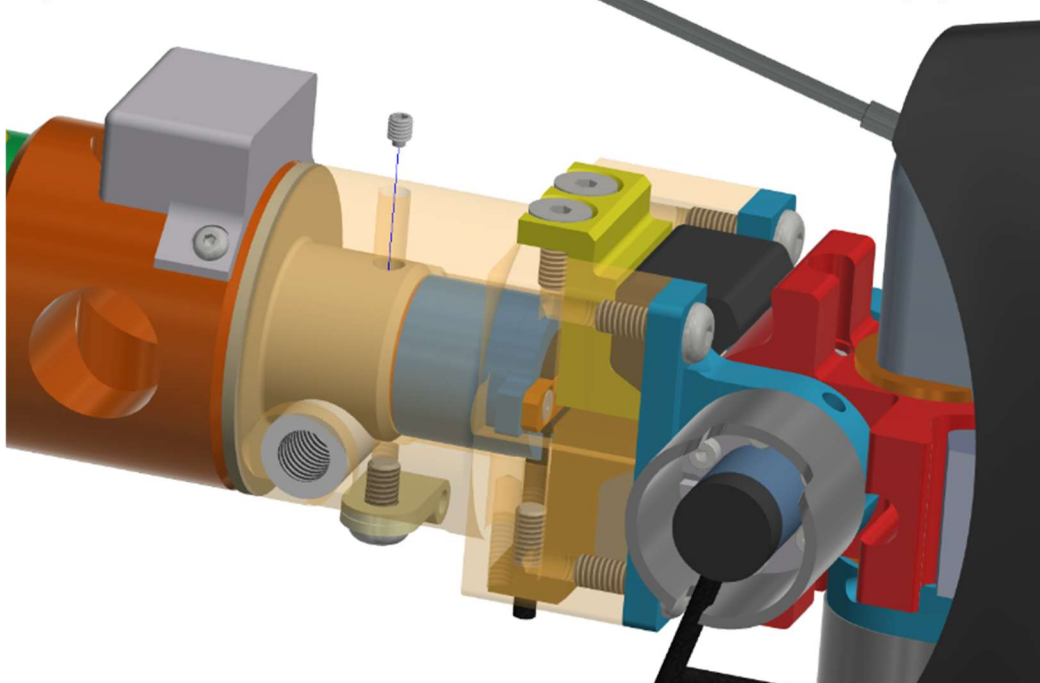


Figure 10-61. Tighten the M3 X 0.5 X 3 LG. SSSNP in the Lower Tibia Load Cell

10.3.27 Assemble the Knee Clevis (474-5517-1,2) to the Upper Tibia Load Cell (SA572-S103) using four M6 X 1 X 16 LG. SHCS (Figure 10-62).

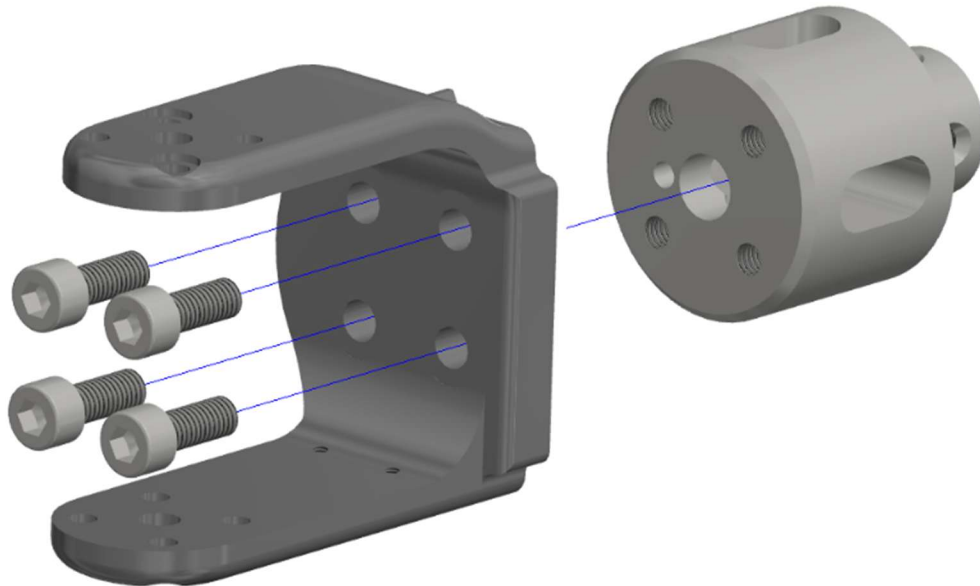


Figure 10-62. Assemble the Knee Clevis (474-5517-1,2) to the Upper Tibia Load Cell (SA572-S103)

10.3.28 Attach the Upper Tibia Load Cell (SA572-S103) to the Tibia Compliant Element Assembly (474-5508) using four Modified BHSS M6 Thread (Figure 10-63).

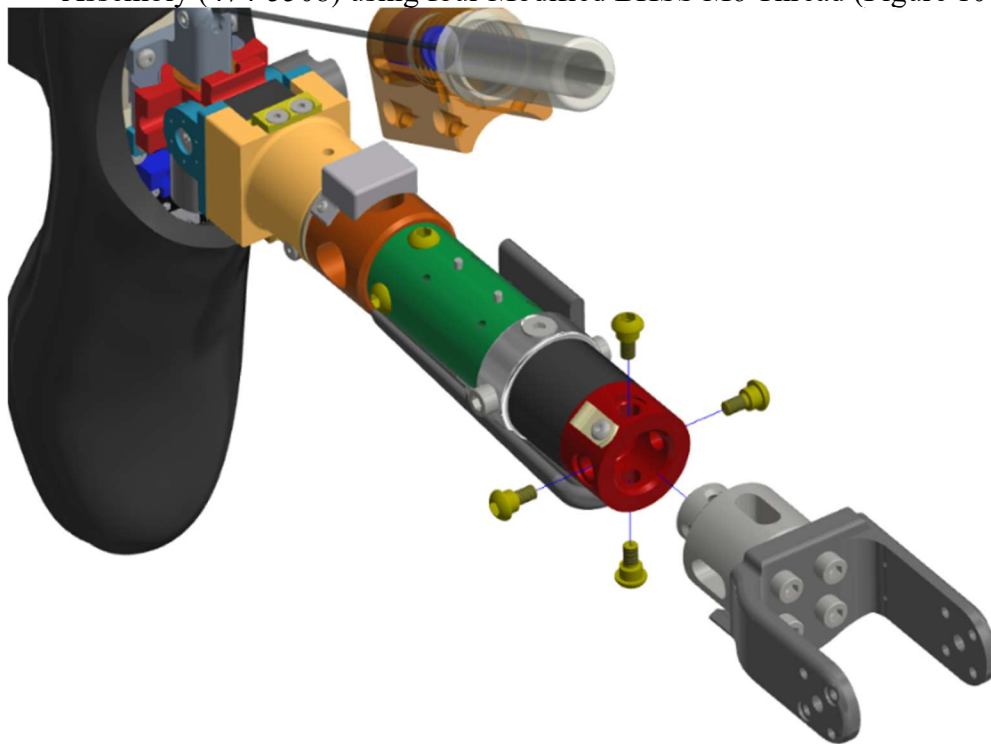


Figure 10-63. Attach the Upper Tibia Load Cell (SA572-S103) to the Tibia Compliant Element Assembly (474-5508)

10.3.29 Attach the Achilles Assembly to the lower leg using four M4 X 0.7 X 12 LG. LHCS (Figure 10-64).

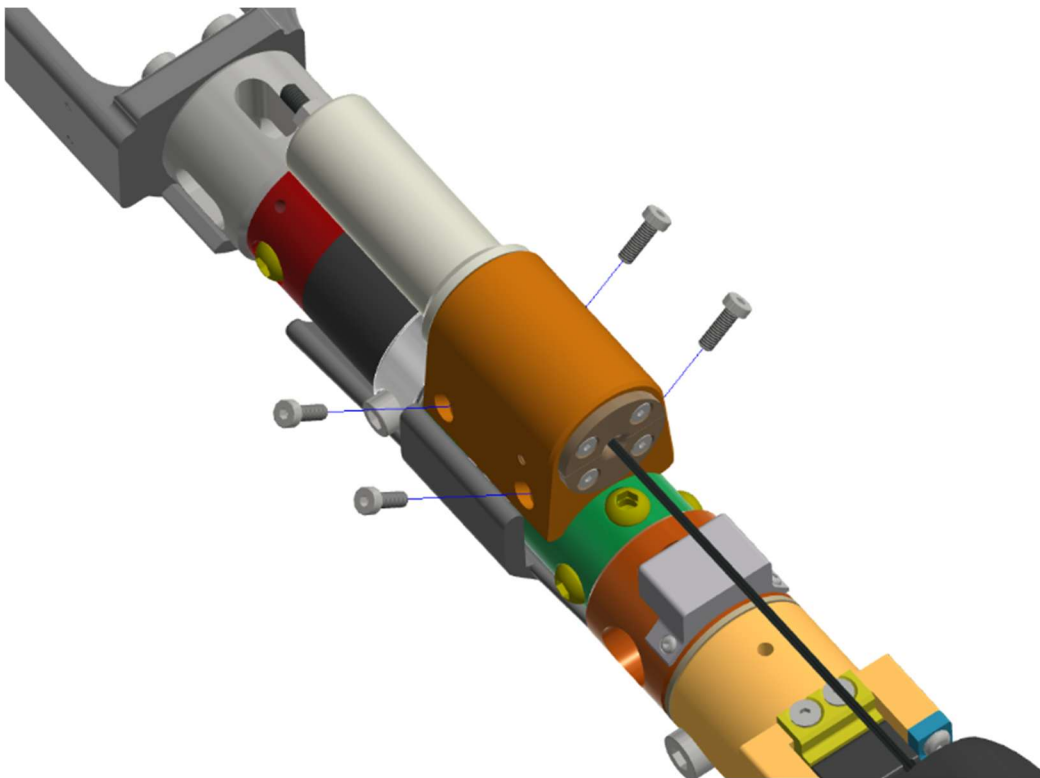


Figure 10-64. Attach the Achilles Assembly to the lower leg using four M4 X 0.7 X 12 LG. LHCS

10.3.30 Install the tibia ground cable to the Lower Achilles Spring Housing (474-5504) and Tibia Compliant Element Assembly (474-5508) using two M4 X 0.7 X 6 LG. BHCS (Figure 10-65).

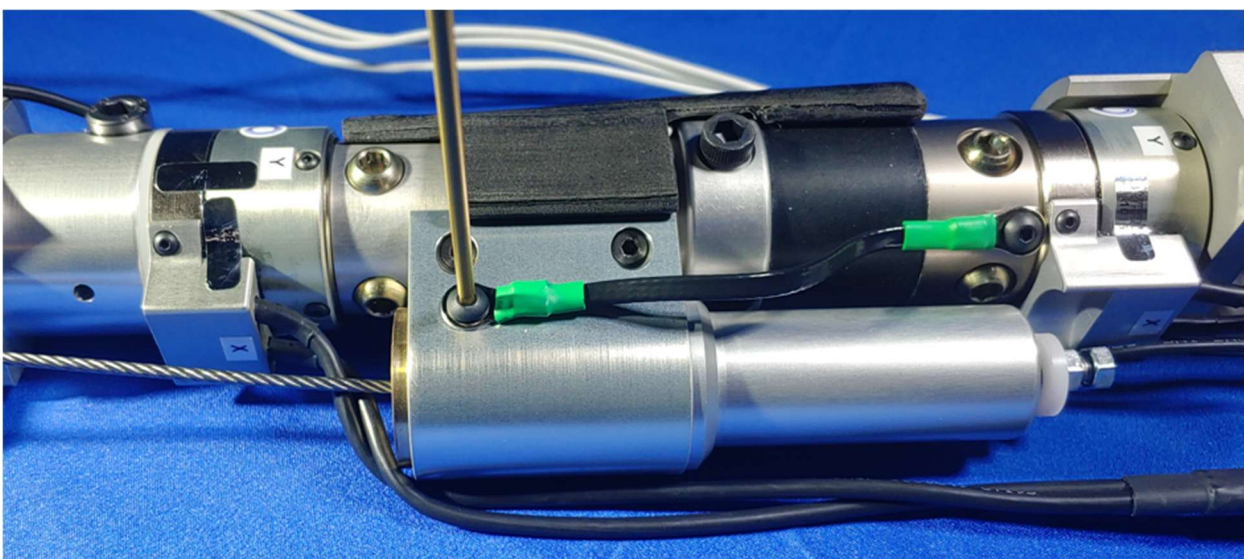


Figure 10-65. Install the tibia ground cable to the Lower Achilles Spring Housing (474-5504) and Tibia Compliant Element Assembly (474-5508)

- 10.3.31 Install cable tie attachment using one BHCS (Figure 10-66). Bundle the lower leg instrumentation wires and route upwards along the inner tibia and out at the upper tibia (Figure 10-67).

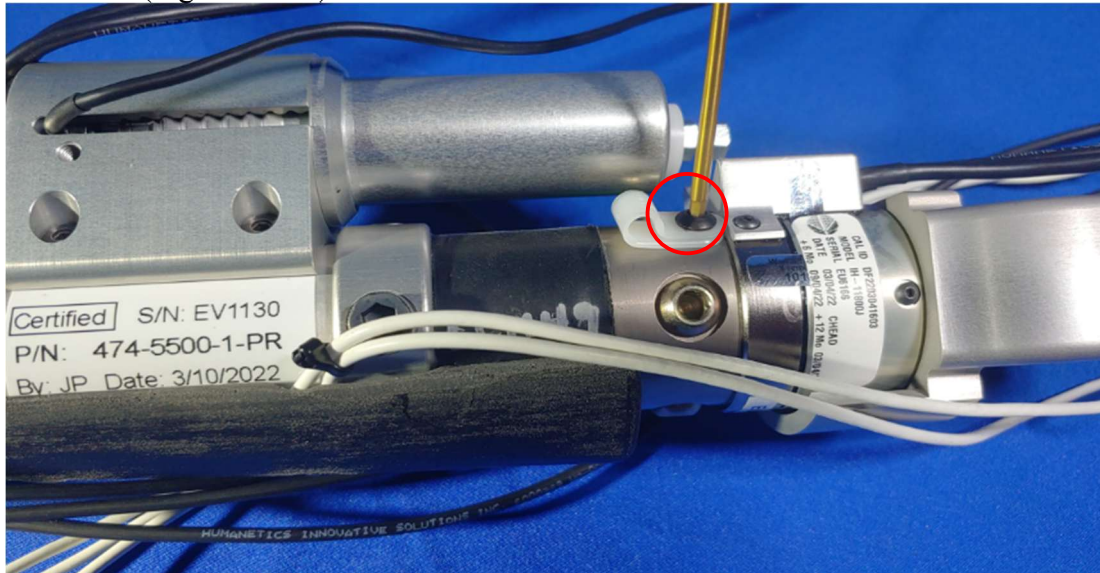


Figure 10-66. Install cable tie attachment.

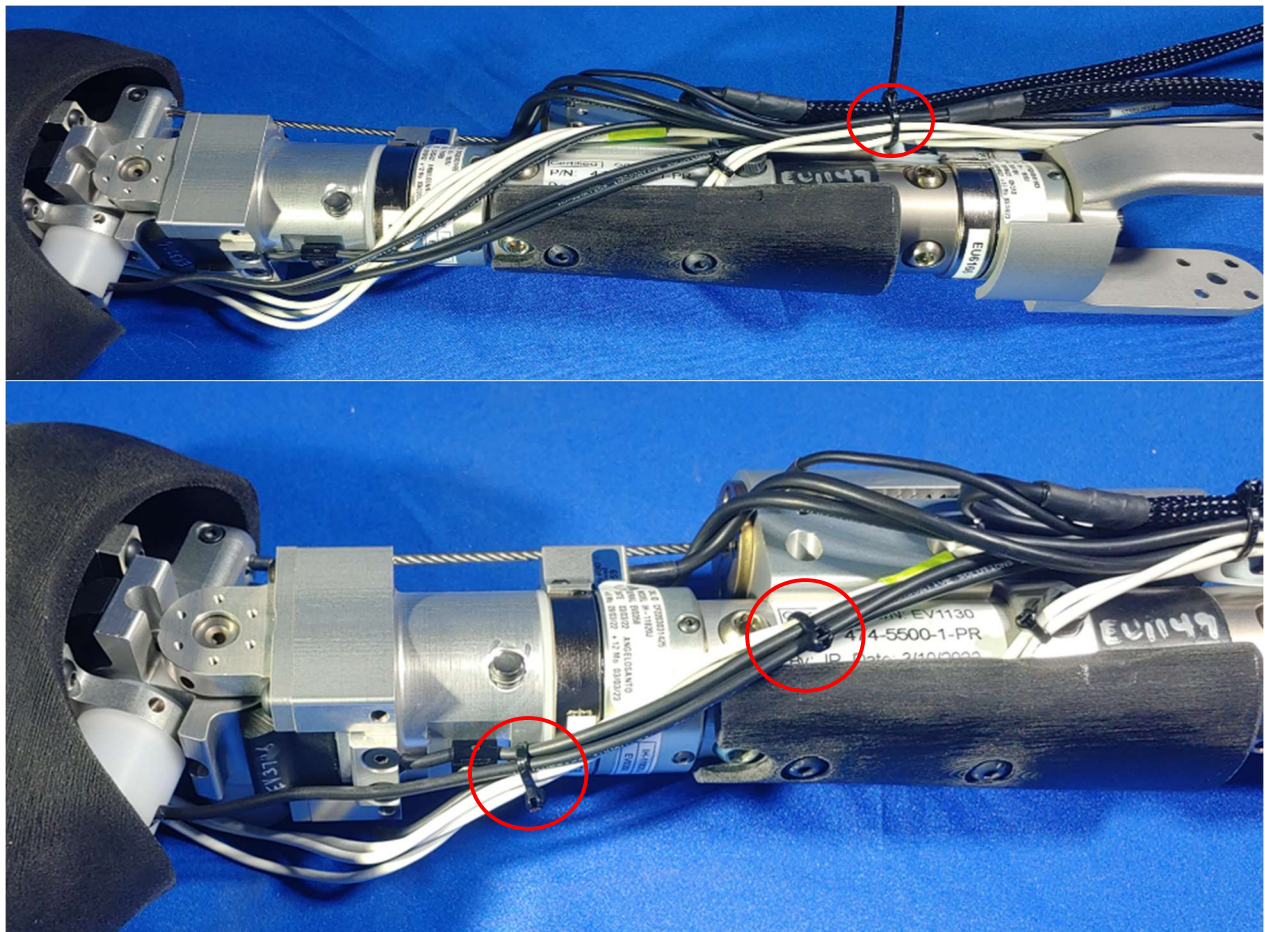


Figure 10-67. Route and strain relieve lower leg instrumentation

- 10.3.32 Install and zip the Lower Leg Flesh (474-5520-1,2) to complete the lower leg assembly (Figure 10-68). Route the lower extremity wiring out at the top of the zipper.

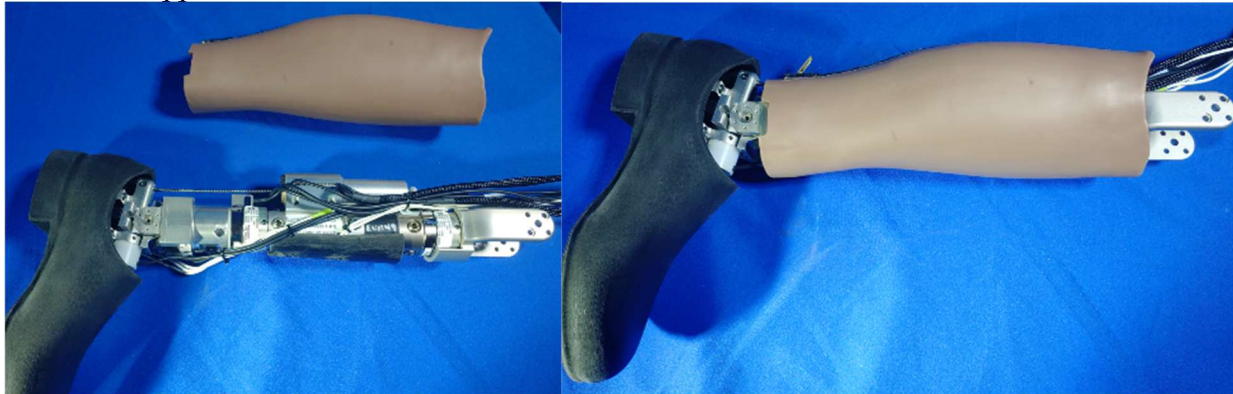


Figure 10-68. Install and zip the Lower Leg Flesh (474-5520-1,2) to the lower leg

NOTE: The upper tibia load cell X-axis **MUST** be oriented towards the anterior (front) of the lower extremity as it is assembled.

10.4 Assembly of the Lower Extremity to the Knee

The following procedure is a step-by-step description used to install the (Left) Lower Extremity Assembly (472-7000-1) to the completed femur/knee assembly. Unless otherwise specified, tighten all bolts to the torque specifications provided in Section 2.1.3.

- 10.4.1 With the lower leg perpendicular to the upper leg, align the holes of the knee clevis (attached to the Lower Extremity) with the threaded holes in the knee assembly. Secure the clevis to the knee using four M6 X 1.0 X 10 FHCS (two per side) (Figure 10-69).

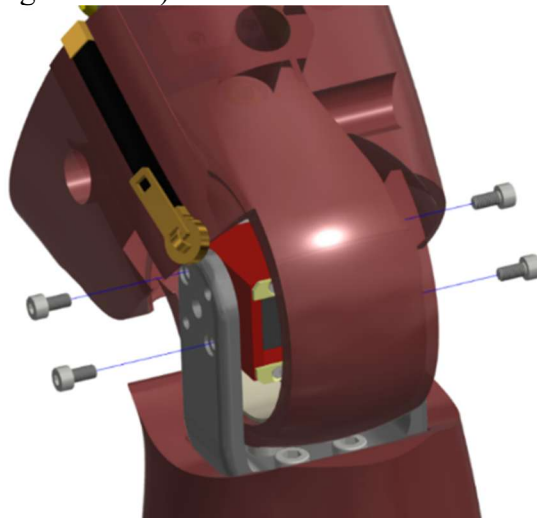


Figure 10-69. Attach the lower leg to the upper leg

- 10.4.2 Install the Knee Covers (474-5301-1,2-A) on both sides of the knee with two M4 X 0.7 X 12 LG. FHCS per side (Figure 10-70).

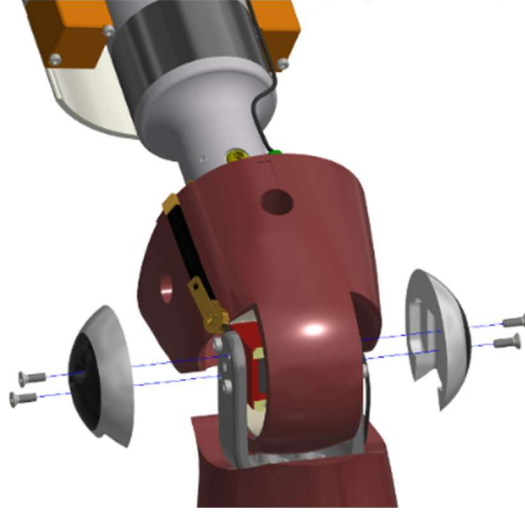


Figure 10-70. Attach the Left and Right Knee Covers (474-5301-1,2-A) using four M4 X 0.7 X 12 LG. FHCS

- 10.4.3 Repeat the procedure for the Right Lower Extremity Assembly (472-7200-2).

10.5 Adjustments for the Lower Extremity Assembly

10.5.1 Ankle Rotary Potentiometer Zeroing Procedure

Proceed to the *THOR 5th Percentile Female (THOR-05F) Qualification Procedures Manual* (July 2025) Section entitled *Ankle Rotary Potentiometer Zeroing Procedure* for ankle zeroing procedures.

10.5.2 Achilles Cable Adjustment Procedure

Proceed to the *THOR 5th Percentile Female (THOR-05F) Qualification Procedures Manual* (July 2025) Section entitled *Achilles Cable Adjustment Procedure* for Achilles tension procedures.

10.5.3 Knee Joint Torque Settings

The lower leg assembly requires a joint resistive torque adjustment for each knee joint. Check the adjustment by straightening the lower leg of the dummy and raising it in front of the dummy (Figure 10-71). The leg should remain in position but move easily under external force. If needed, adjust the Shoulder Bolt (472-5302) on the outboard side of the knee to achieve 1G joint friction torque.



Figure 10-71. Setting the knee to 1G

10.6 Electrical Connections and Requirements:

Section 13.3 includes grounding information. Section 13.4 describe cable routing instructions.

Section 11. Arm Assembly

11.1 Description of Arm Assembly and Features

The THOR-05F arm is comprised of an upper arm assembly, lower arm assembly, and molded hand. Table 11-1 through Table 11-3 list the components that are included in the arm assembly. Figure 11-1 through Figure 11-3 show components of (left) arm assembly and hardware.

Table 11-1. Arm Assembly (474-6000-1,2-A) Components

Part Description	Quantity	Part Number	Figure #	Item #
Upper Arm Assembly	1	484-6100-1,2	Figure 11-1	1
Lower Arm Assembly	1	474-6500-1,2	Figure 11-1	2
Hand, Molded	1	474-6900-1,2	Figure 11-1	3

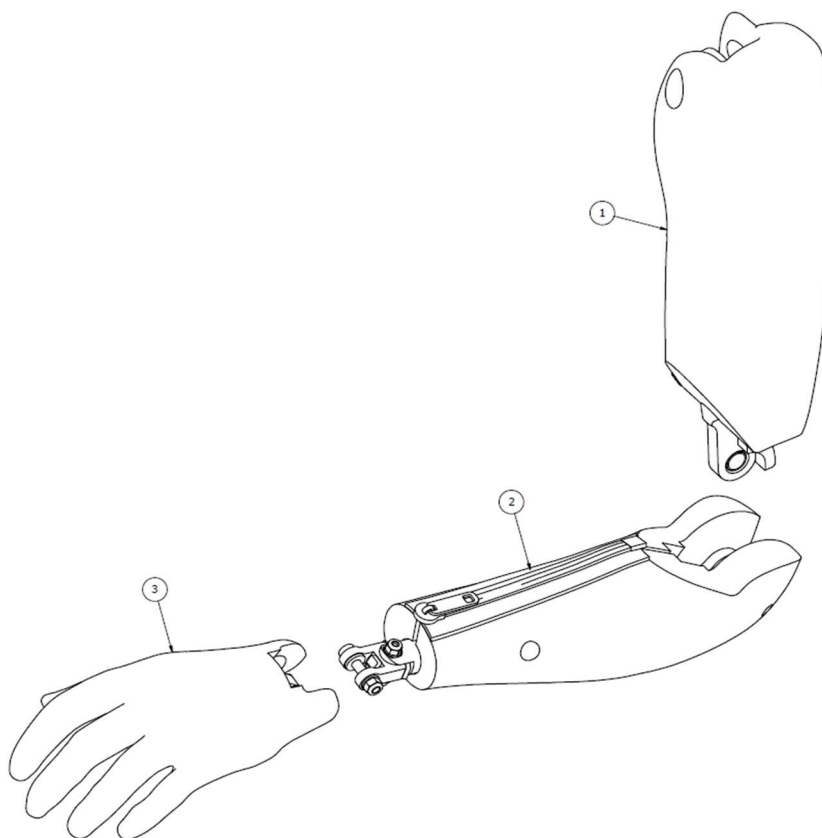


Figure 11-1. Arm Assembly (474-6000-1,2-A) Components.

Table 11-2. Upper Arm Assembly (484-6100-1,2) Components

Part Description	Quantity	Part Number	Figure #	Item #
Distal Upper Arm Tube	1	484-6110-1,2	Figure 11-2	1
Elbow Friction Plate	1	474-6116-A	Figure 11-2	2
M6 Flat Washer Plain Nylon	1	6003562	Figure 11-2	3
Distal Upper Arm Tube Assembly	1	474-6115-1,2	Figure 11-2	4
Modified BHSS M6 Thread	8	W50-61042	Figure 11-2	5
Upper Arm Load Cell Adaptor	1	484-6112	Figure 11-2	6
M6 X 1 X 12 LG. BHCS	1	5000356	Figure 11-2	7
Arm Rotation Bushing	1	474-6121	Figure 11-2	8
M3 X 14 LG. Prec. SHSS SS	1	5001372	Figure 11-2	9
Upper Arm Flesh	1	484-6120-1,2	Figure 11-2	10
Cable Tie Mount, #4 Screw	1	6002036	Figure 11-2	11
M2.5 X 0.45 X 4 LG. BHCS	1	5001305	Figure 11-2	12
Arm Bolt Sleeve	1	474-6111	Figure 11-2	13
M6 X 1 X 30 LG. LHCS	1	5001443	Figure 11-2	14
M2.5 X 0.45 X 25 LG. BHCS	2	5001325	Figure 11-2	15
On Board DAS Structural Replacement	1	481-6106	Figure 11-2	16
M3 X 0.5 X 4 LG. BHCS	1	5001067	Figure 11-2	17

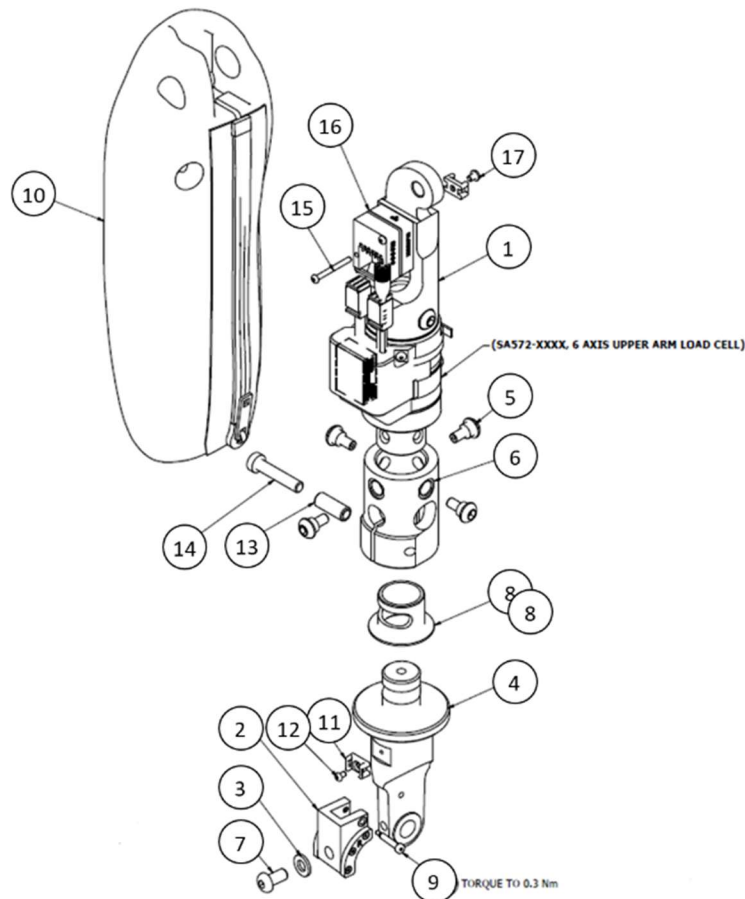


Figure 11-2. Upper Arm Assembly (484-6100-1,2) Components.

Table 11-3. Lower Arm Assembly (474-6500) Components

Part Description	Quantity	Part Number	Figure #	Item #
Proximal Lower Arm Tube	1	474-6501-1,2	Figure 11-3	1
Modified BHSS M6 Thread	8	W50-61042	Figure 11-3	2
Lower Arm and Wrist Assembly	1	474-6700-1,2	Figure 11-3	3
Structural Replacement, Upper-Lower Arm Load Cell	1	484-6106	Figure 11-3	4
Lower Arm Flesh	1	474-6525-1,2	Figure 11-3	5
Cable Tie Mount, #4 Screw	1	6002036	Figure 11-3	6
M2.5 X 0.45 X 4 LG. BHCS	1	5001305	Figure 11-3	7
Structural Replacement, Connector Block	1	474-6113	Figure 11-3	8
M2.5 X 0.45 X 10 LG. SHSS	2	5000456	Figure 11-3	9
M10 X 20 LG. SHSS	1	5001162	Figure 11-3	10
Washer, Upper-Lower Arm	1	474-6502	Figure 11-3	11
Wrist Rotator Clevis	1	474-6717-1,2	Figure 11-3	12
Wrist Insert	1	474-6705-A	Figure 11-3	13
M5 Wave Washer SS	1	5001374	Figure 11-3	14
M5 X 18 LG. SHSS SS	1	5001483	Figure 11-3	15
M5 X 0.8 X 25 LG. SHCS	1	5000721	Figure 11-3	16
Bearing, Flanged 8mm OD X 5mm ID X 5mm LG	1	6004820	Figure 11-3	17
M3 X 0.5 X 5 LG. SSSDP	1	5001799	Figure 11-3	18
M5 Flat Washer Plain Zinc	1	5000566	Figure 11-3	19
M5 X 0.8 HEX LOCK NUT ZINC	1	5000522	Figure 11-3	20

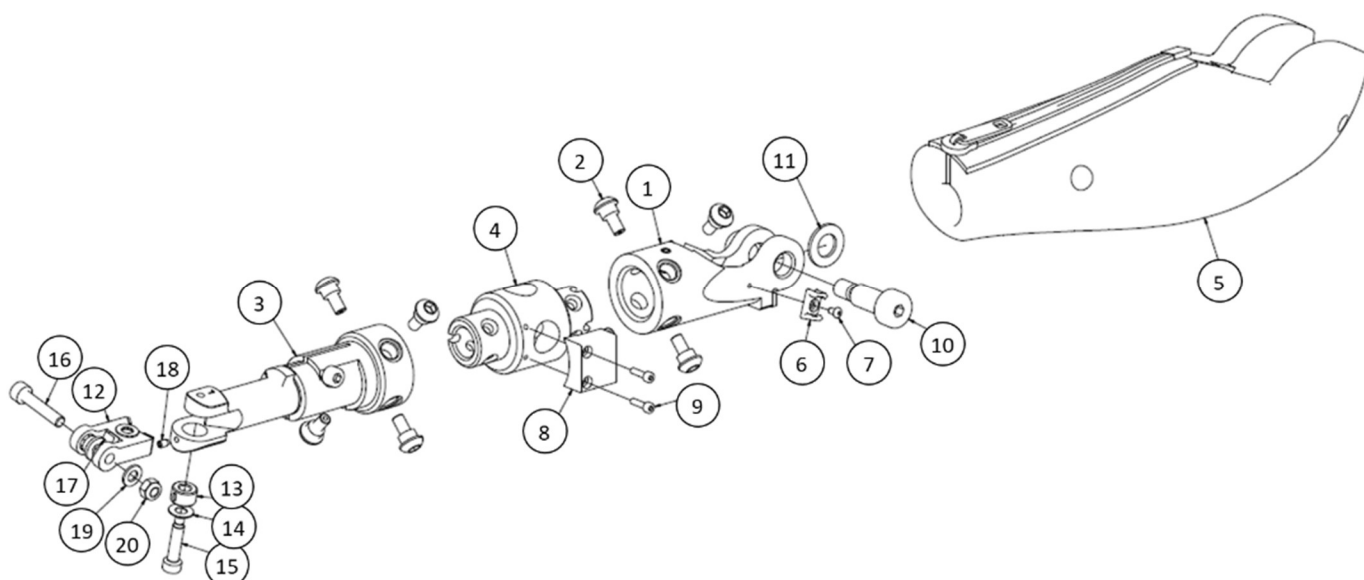


Figure 11-3. Lower Arm Assembly (474-6500) Components.

11.2 Disassembly of the Arm

The following procedure is a step-by-step description of the disassembly procedure for the arm components. Only the left arm disassembly is illustrated. The right arm disassembly follows identical procedures.

- 11.2.1 Remove the Shoulder Clevis (483-3504) from the Lower Scapula (474-3505-1,2) by loosening the M8 X 1.25 Hex Lock Nut on the medial side of the arm (Figure 11-4).

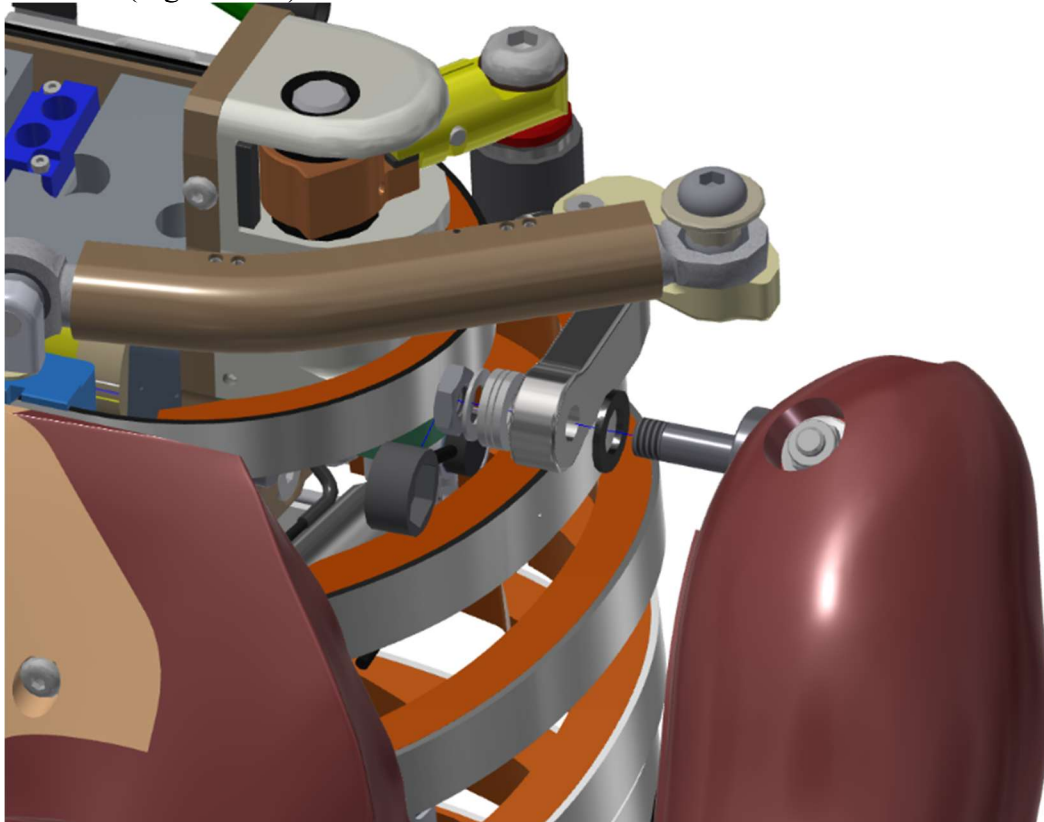


Figure 11-4. Remove the Shoulder Clevis (483-3504) from the Lower Scapula (474-3505-1,2)

11.2.2 Unzip the Upper Arm Flesh (484-6120) (Figure 11-5).

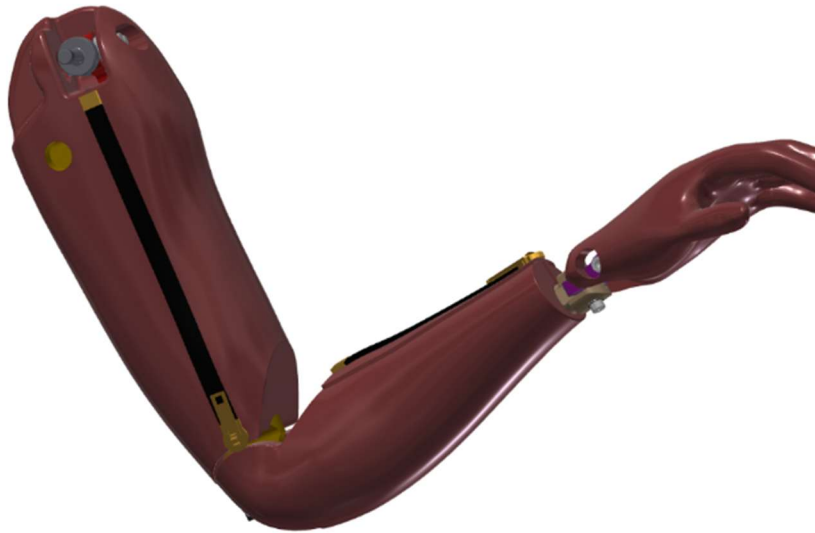


Figure 11-5. Unzip the Upper Arm Flesh

11.2.3 Remove the cable tie from the ground wire (yellow circle in Figure 11-6 below) and unscrew the ground wire (red circle in Figure 11-6 below) from the upper arm (Figure 11-6).

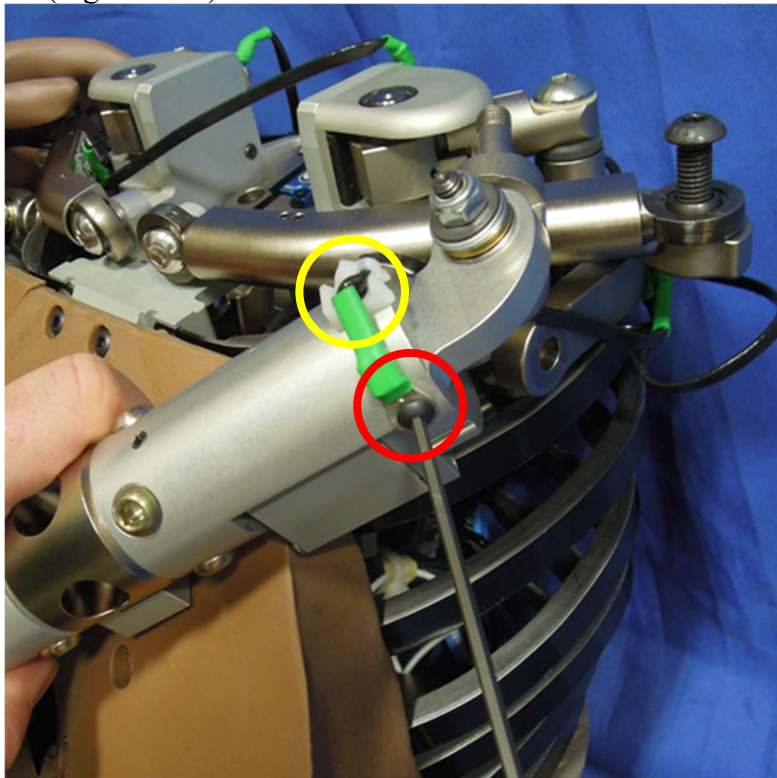


Figure 11-6. Remove the cable tie from the ground wire (yellow) and unscrew the ground wire (red) from the upper arm

11.2.4 With the arm completely detached from the body, unzip the Lower Arm Flesh (474-6525) (Figure 11-7).

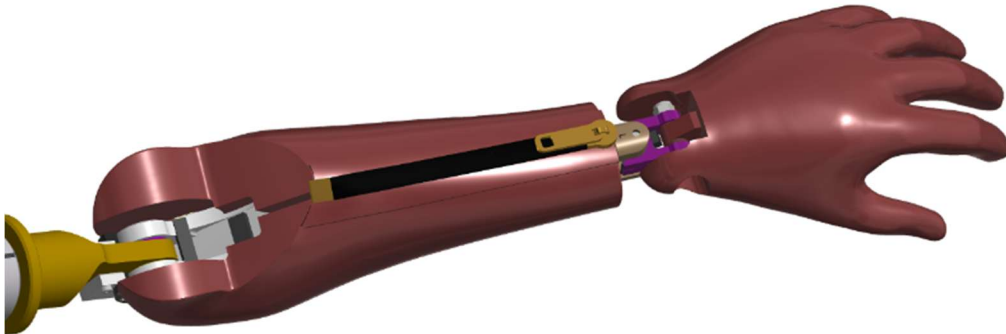


Figure 11-7. Unzip the Lower Arm Flesh

11.2.5 Remove the elbow joint, M10 X 20 LG. SHSS and Upper-Lower Arm Washer (474-6502) (Figure 11-8).

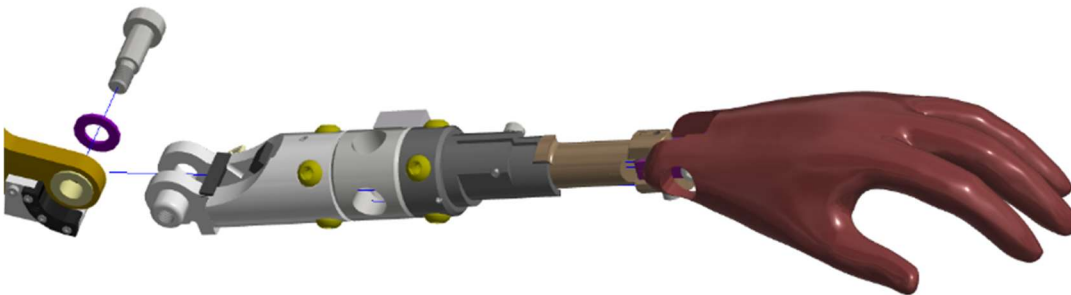


Figure 11-8. Remove the elbow joint, M10 X 20 LG. SHSS and Upper-Lower Arm Washer (474-6502)

11.2.6 Remove the four Modified BHSS M6 Thread (W50-61042) from the Distal Upper Arm Tube (484-6110-1,2) connecting to the Upper-Lower Arm Load Cell Structural Replacement (484-6106) (Figure 11-9).

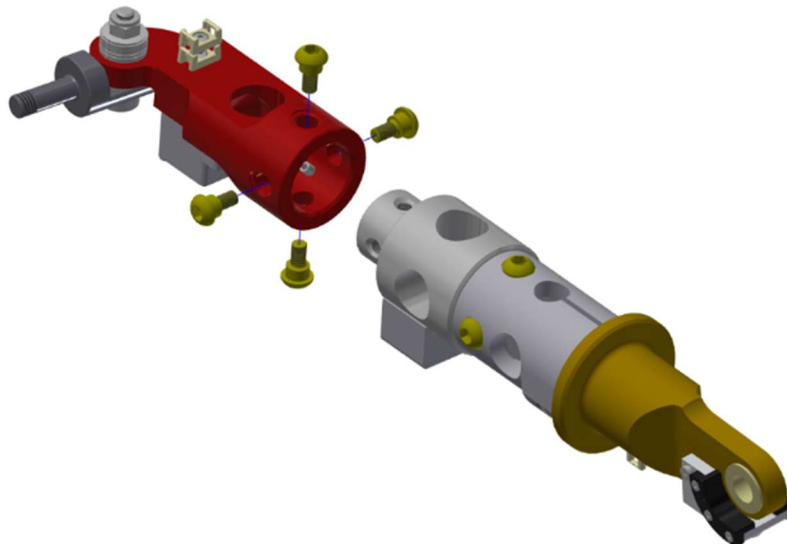


Figure 11-9. Remove the four Modified BHSS M6 Thread (W50-61042) from the Distal Upper Arm Tube (484-6110-1,2)

11.2.7 Remove the Upper Arm On Board DAS Bracket (481-3602) by removing two M3 X 0.5 X 10 LG. BHCS (Figure 11-10).

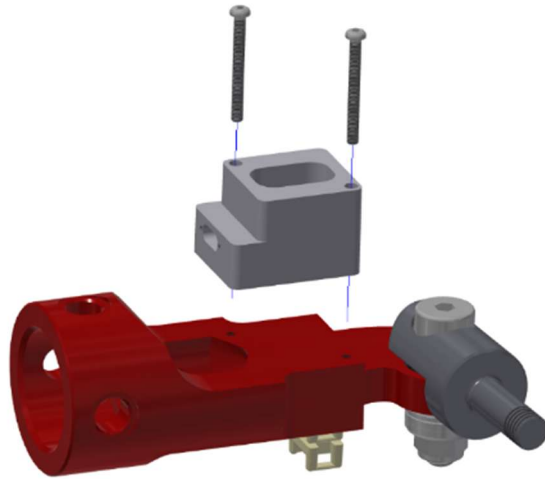


Figure 11-10. Remove the Upper Arm On Board DAS Bracket (474-6118) by removing two M3 X 0.5 X 10 LG. BHCS

11.2.8 Separate the Shoulder Clevis (483-3504) from the Distal Upper Arm Tube (484-6110) by removing the M8 X 20 LG. SHSS and M6 X 1 Hex Lock Nut (Figure 11-11).

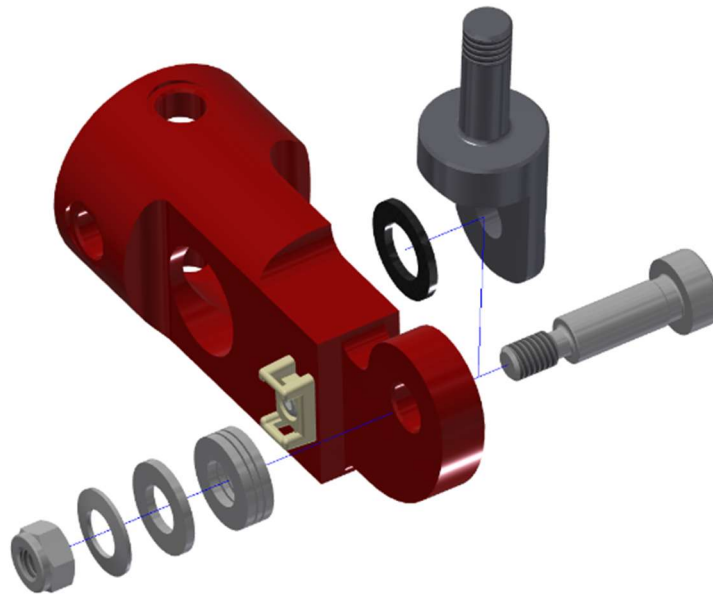


Figure 11-11. Separate the Shoulder Clevis (483-3504) from the Distal Upper Arm Tube (484-6110)

- 11.2.9 Remove the four Modified BHSS M6 Thread (W50-61042) from the Upper Arm Load Cell Adaptor (484-6112) connecting to the Upper Arm Load Cell Structural Replacement (484-6106) (Figure 11-12).

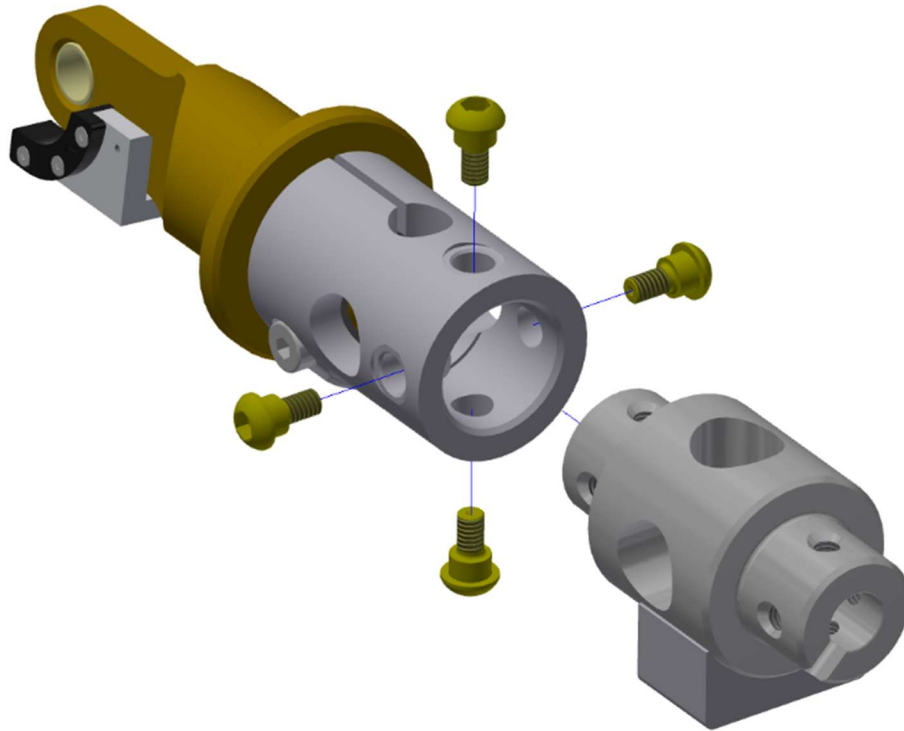


Figure 11-12. Remove the four Modified BHSS M6 Thread (W50-61042) from the Upper Arm Load Cell Adaptor (484-6112)

- 11.2.10 Separate the Connector Block Structural Replacement (474-6113) from the Upper-Lower Arm Load Cell Structural Replacement (484-6106) by removing two M2.5 X 0.45 X 10 LG. SHCS (Figure 11-13).

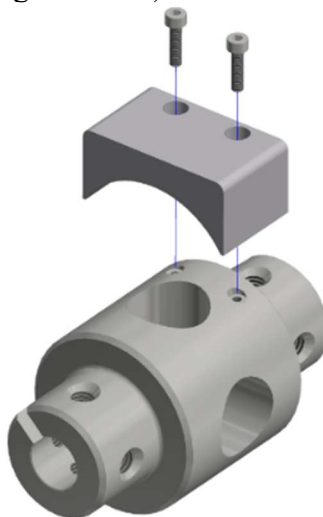


Figure 11-13. Separate the Connector Block Structural Replacement (474-6113) from the Upper-Lower Arm Load Cell Structural Replacement (484-6106)

- 11.2.11 Remove the M6 X 1 X 30 LG. LHCS to separate the Upper Arm Load Cell Adaptor (484-6112) from the Distal Upper Arm Tube Assembly (474-6115) (Figure 11-14).

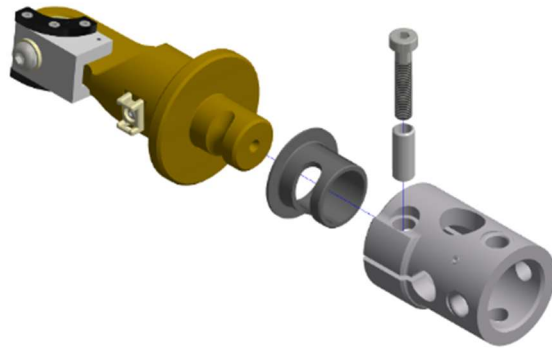


Figure 11-14. Remove the M6 X 1 X 30 LG. LHCS to separate the Upper Arm Load Cell Adaptor (484-6112) from the Distal Upper Arm Tube Assembly (474-6115)

- 11.2.12 Remove the Elbow Friction Plate (474-6116-A) from the Distal Upper Arm Tube Assembly (474-6115) by removing one M6 X 1 X 12 LG. BHCS with M6 Nylon Flat Washer and one M3 X 14 LG. Prec. SHSS SS (Figure 11-15 and Figure 11-16).

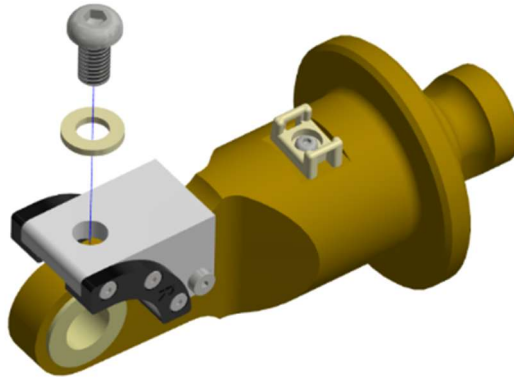


Figure 11-15. Remove the Elbow Friction Plate (474-6116-A) from the Distal Upper Arm Tube Assembly (474-6115) by removing one M6 X 1 X 12 LG. BHCS with M6 Nylon Flat Washer

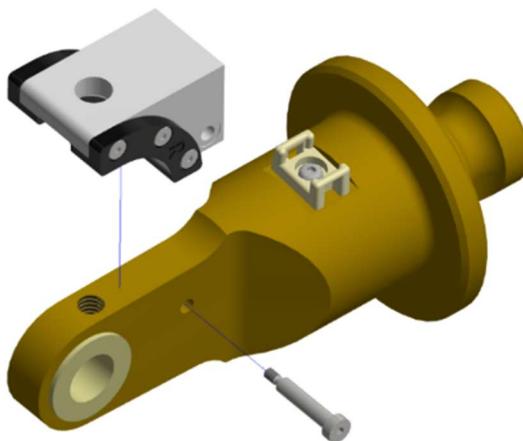


Figure 11-16. Remove the Elbow Friction Plate (474-6116-A) from the Distal Upper Arm Tube Assembly (474-6115) by removing one M3 X 14 LG. Prec. SHSS SS

11.2.13 Remove the Cable Tie Mount (6002036) from the Distal Upper Arm Tube Assembly (474-6115) by removing the one M2.5 X 0.45 X 4 LG. BHCS (Figure 11-17).

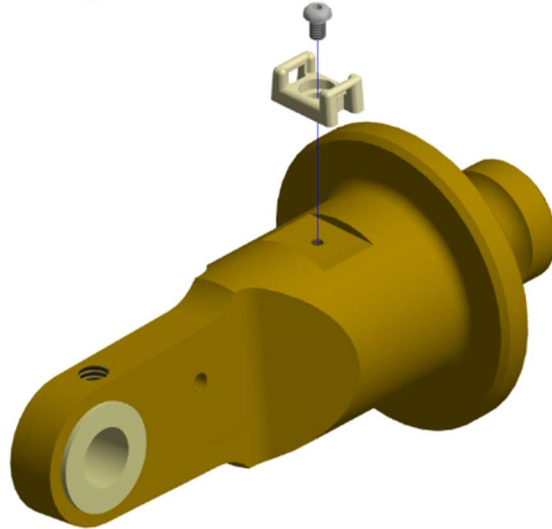


Figure 11-17. Remove the Cable Tie Mount (6002036)

11.2.14 Separate the hand from the lower arm by removing the M5 X 18 LG SHSS SS, a M3 X 0.5 X 5 LG. SSSD, and washers (Figure 11-18).

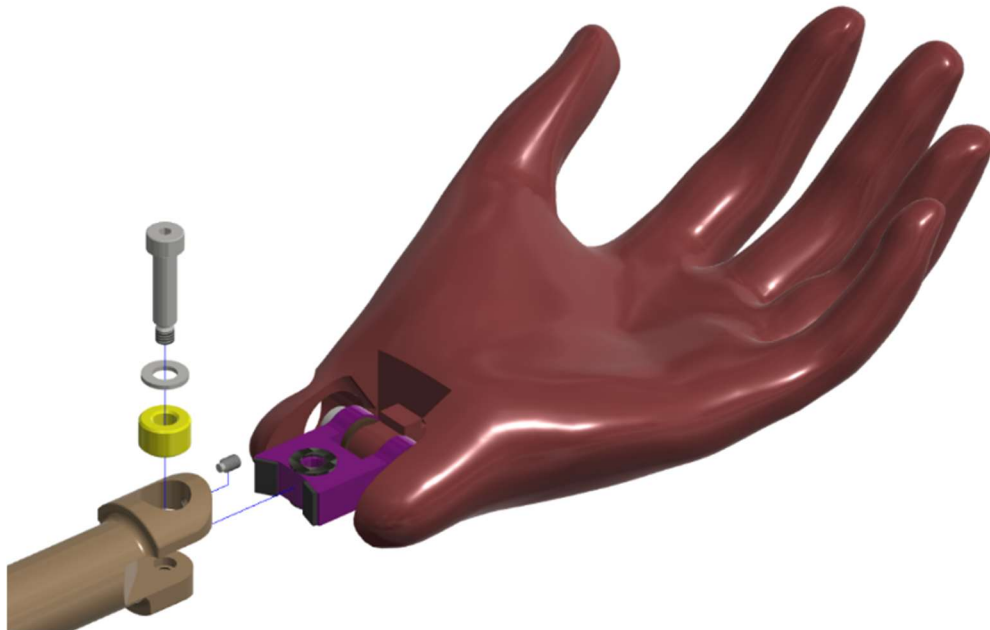


Figure 11-18. Separate the hand from the lower arm

11.2.15 Remove the four Modified BHSS M6 Thread (W50-61042) from Proximal Lower Arm Tube (474-6501-1,2) (Figure 11-19).

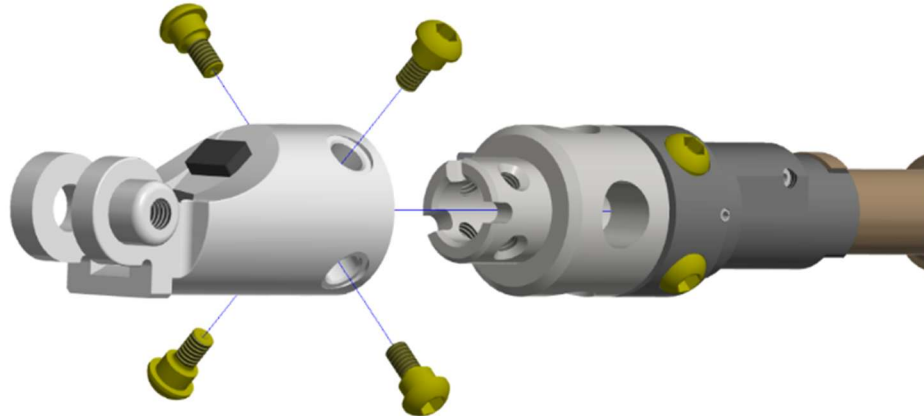


Figure 11-19. Remove the four Modified BHSS M6 Thread (W50-61042) from Proximal Lower Arm Tube (474-6501-1,2)

11.2.16 Remove the Cable Tie Mount (6002036) from the Proximal Lower Arm Tube (474-6501-1,2) by removing the one M2.5 X 0.45 X 4 LG. BHCS (Figure 11-20).

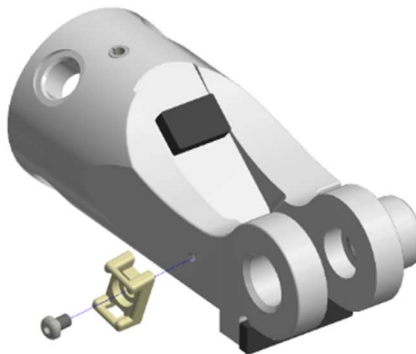


Figure 11-20. Remove the Cable Tie Mount (6002036)

11.2.17 Remove the four Modified BHSS M6 Thread (W50-61042) from the Lower Arm and Wrist Assembly (474-6700-1,2) (Figure 11-21).

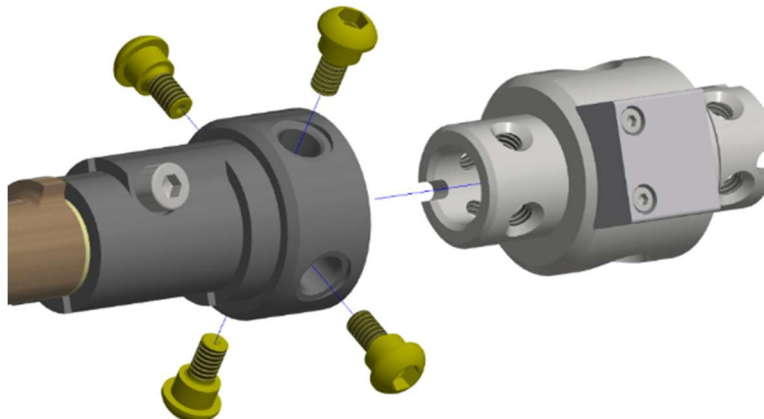


Figure 11-21. Remove the four Modified BHSS M6 Thread (W50-61042) from the Lower Arm and Wrist Assembly (474-6700-1,2)

11.2.18 Remove the Distal Lower Arm Bolt Assembly (474-6704) from the Distal Lower Arm Tube (474-6701-1,2) (Figure 11-22). Remove the M6 X 8 LG. SHSS SS from the center of the Distal Lower Arm Tube (Figure 11-22).

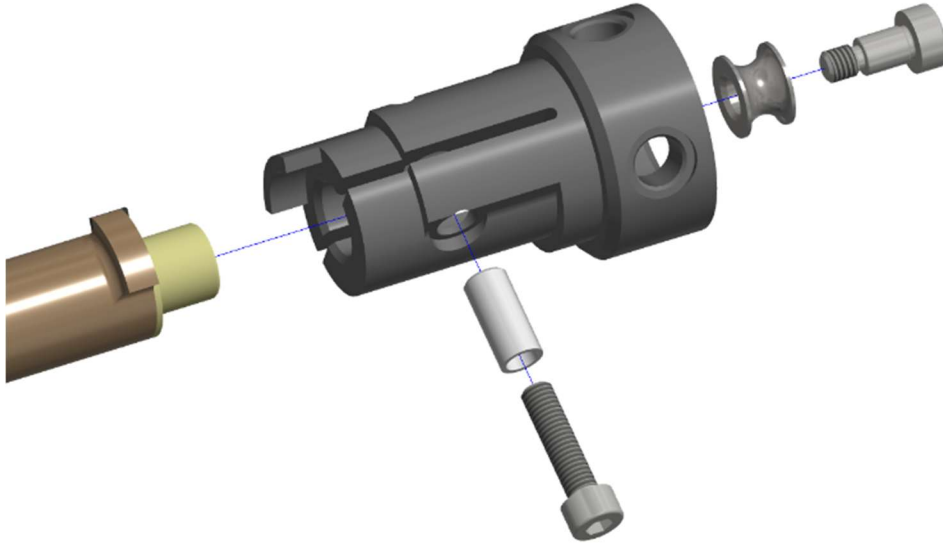


Figure 11-22. Remove the Distal Lower Arm Bolt Assembly (474-6704) from the Distal Lower Arm Tube (474-6701)

11.2.19 Remove the M5 X 0.8 X 25 LG. SHCS, M5 X 0.8 Hex Lock Nut, Zinc M5 Flat Washer, and Flanged Bearing (6004820) from the wrist (Figure 11-23).



Figure 11-23. Separated wrist

11.3 Assembly of the Arm

The following procedure is a step-by-step description of the assembly procedure for the arm components. Only the left arm assembly is illustrated. The right arm assembly follows identical procedures. Unless otherwise specified, tighten all bolts to the torque specifications provided in Section 2.1.3.

- 11.3.1 Install Wrist Rotator Clevis (474-6717-1,2) to the Molded Hand (474-6900-1,2) using an M5 X 0.8 X 25 LG. SHCS, a Flanged Bearing (6004820), M5 Flat Washer Plain Zinc, and an M5 X 0.8 Hex Lock Nut (Figure 11-24).



Figure 11-24. Install Wrist Rotator Clevis (474-6717-1,2) into Molded Hand (474-6900-1,2)

- 11.3.2 Assemble the Lower Arm and Wrist Assembly (474-6700-1,2) (Figure 11-25). Connect the Wrist Insert (474-6712-1,2-A) to the Distal Lower Arm Tube (474-6701-1,2). Install the M6 X 8 LG. SHSS SS into the center of the Distal Lower Arm Tube, through the Wrist Rotation Guide (474-6553) (). Screw the Distal Lower Arm Bolt Assembly (474-6704) into the Distal Lower Arm Tube (Figure 11-25).

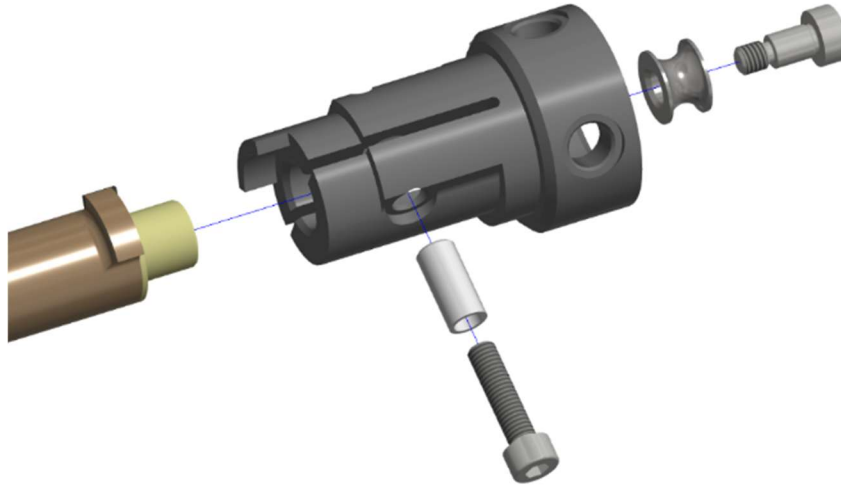


Figure 11-25. Lower Arm and Wrist Assembly (474-6700-1,2)

- 11.3.3 Connect the Lower Arm Load Cell Structural Replacement (484-6106) to the Lower Arm and Wrist Assembly (474-6700-1,2) using four Modified BHSS M6 Thread (W50-61042) (Figure 11-26).

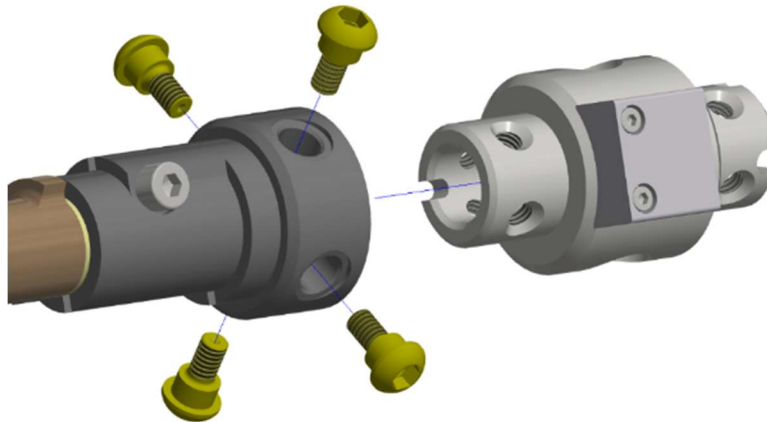


Figure 11-26. Connect the Lower Arm Load Cell Structural Replacement (484-6106) to the Lower Arm and Wrist Assembly (474-6700)

- 11.3.4 Attach the Cable Tie Mount (6002036) to the Proximal Lower Arm Tube (474-6501) using one M2.5 X 0.45 X 4 LG. BHCS (Figure 11-27).

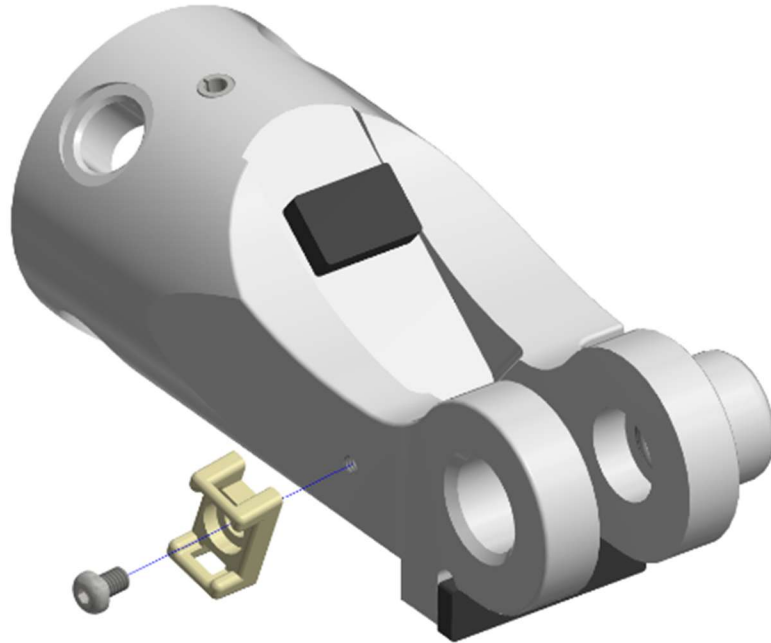


Figure 11-27. Attach the Cable Tie Mount (6002036)

- 11.3.5 Connect the Lower Arm Load Cell Structural Replacement (484-6106) to the Proximal Lower Arm Tube (474-6501-1,2) using the four Modified BHSS M6 Thread (W50-61042) (Figure 11-28).

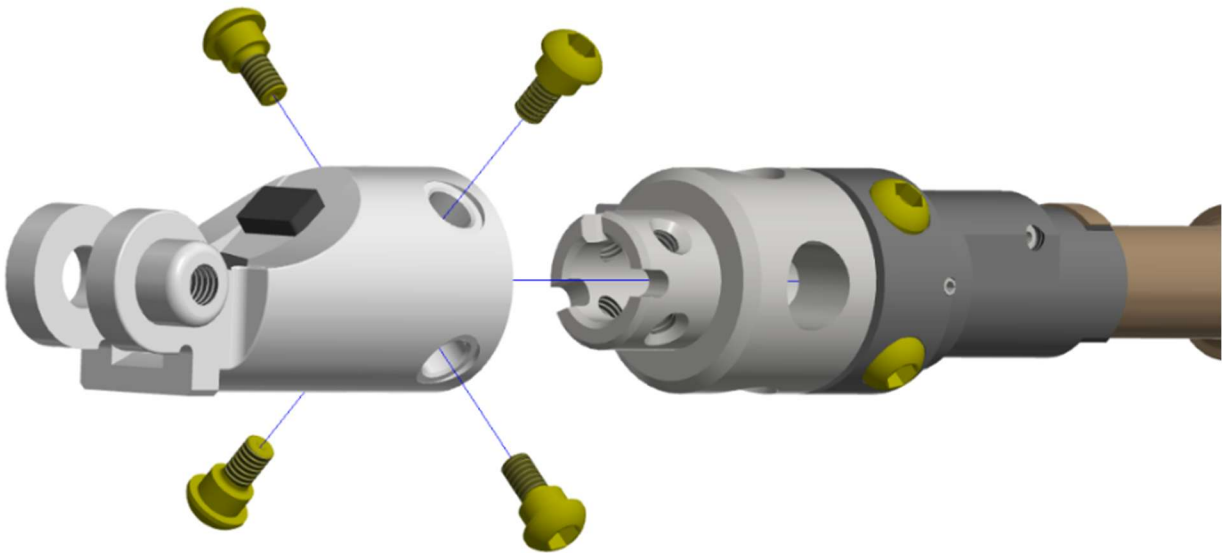


Figure 11-28. Connect the Lower Arm Load Cell Structural Replacement (484-6106) to the Proximal Lower Arm Tube (474-6501-1,2)

- 11.3.6 Attach the hand to the lower arm with one M5 X 18 LG. SHSS SS, a M3 X 0.5 X 5 LG. SSSD, and washers (Figure 11-29).

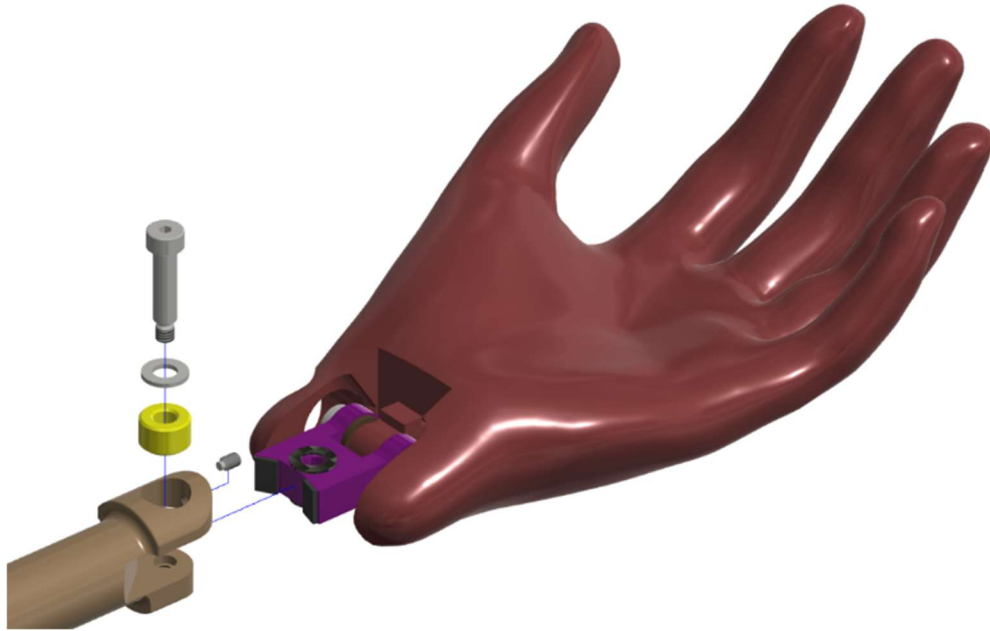


Figure 11-29. Attach hand to lower arm

- 11.3.7 Attach the Cable Tie Mount (6002036) to the Distal Upper Arm Tube Assembly (474-6115-1,2) with one M2.5 X 0.45 X 4 LG. BHCS (Figure 11-30).

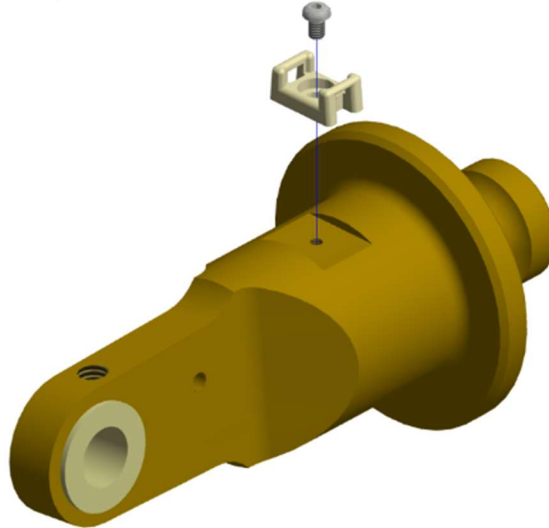


Figure 11-30. Attach the Cable Tie Mount (6002036)

- 11.3.8 Attach the Elbow Friction Plate (474-6116-A) to the Distal Upper Arm Tube Assembly (474-6115-1,2) with one M3 X 14 LG. Prec. SHSS SS (Figure 11-31) and one M6 X 1 X 12 LG. BHCS, M6 Nylon Flat Washer (Figure 11-32).

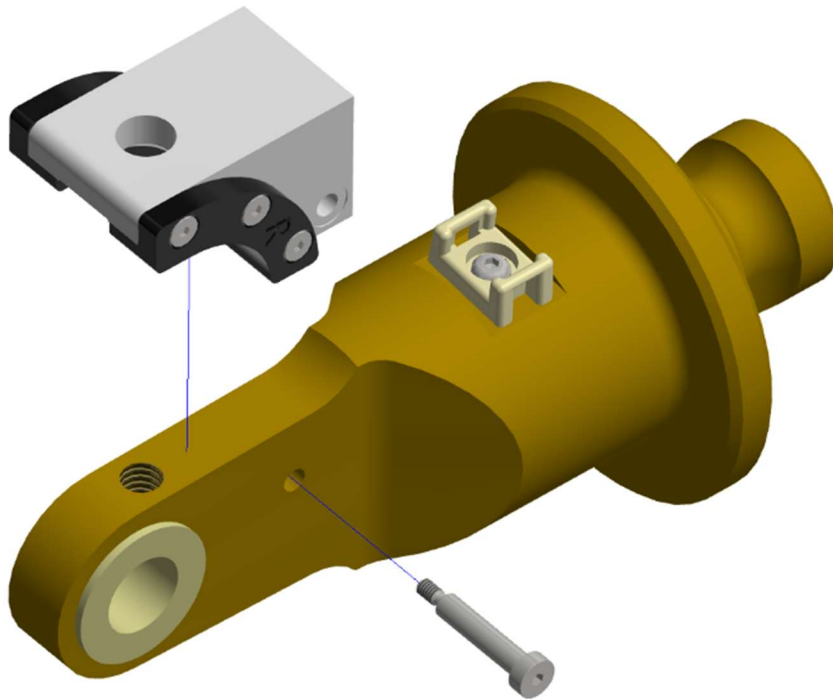


Figure 11-31. Attach the Elbow Friction Plate (474-6116-A) to the Distal Upper Arm Tube Assembly (474-6115-1,2) with one M3 X 14 LG. Prec. SHSS SS

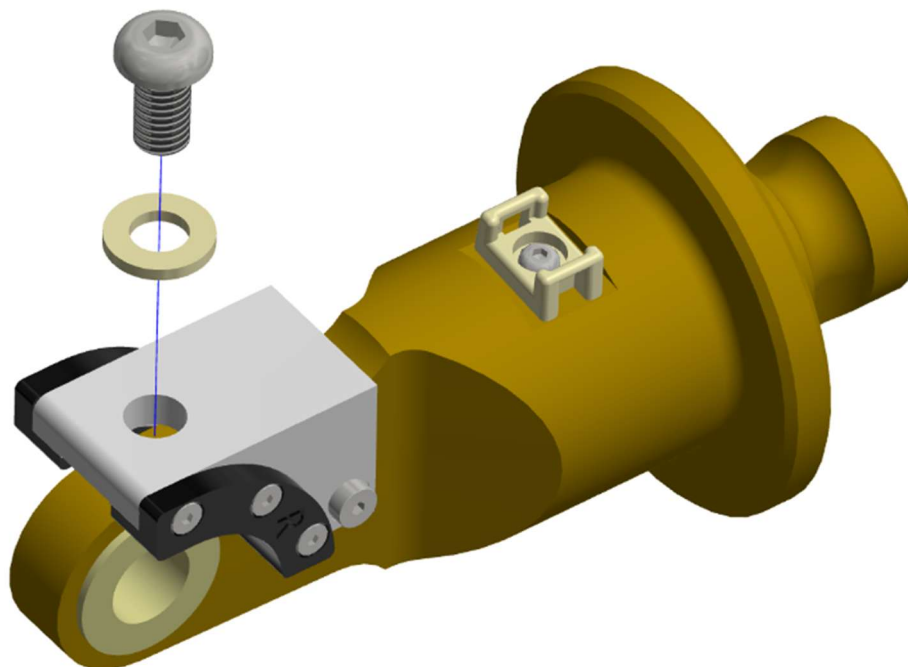


Figure 11-32. Elbow Friction Plate and Distal Upper Arm Tube Assembly

- 11.3.9 Attach the Arm Rotation Bushing (474-6121) to the Distal Upper Arm Tube Assembly (474-6115-1,2). Attach the Upper Arm Load Cell Adaptor (484-6112) to the Distal Upper Arm Tube Assembly (474-6115-1,2) using one M6 X 1 X 30 LG. LHCS (Figure 11-33).

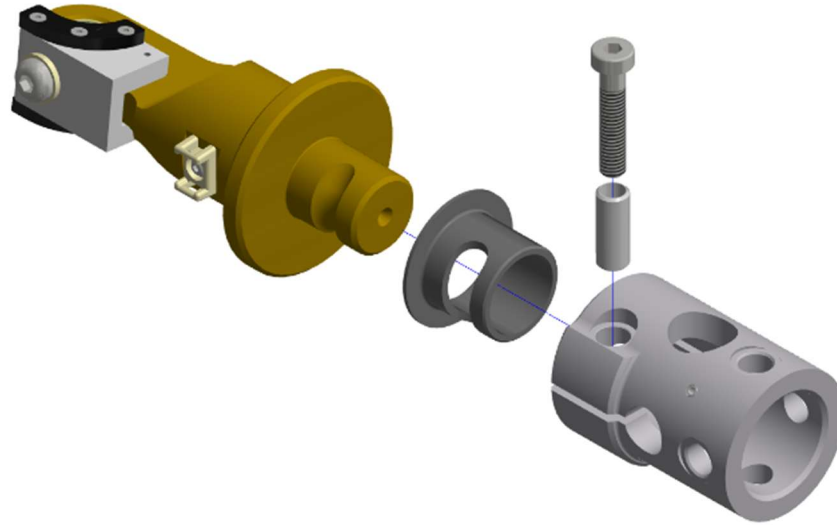


Figure 11-33. Upper Arm Load Cell Adaptor (484-6112), Distal Upper Arm Tube Assembly (474-6115-1,2), and Arm Rotation Bushing (474-6121)

- 11.3.10 Install the Connector Block Structural Replacement (474-6113) to the Upper-Lower Arm Load Cell Structural Replacement (484-6106) using two M2.5 X 0.45 X 10 LG. SHCS (Figure 11-34).

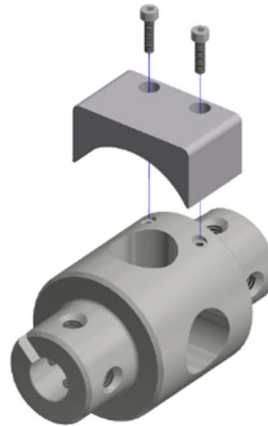


Figure 11-34. Install the Connector Block Structural Replacement (474-6113) to the Upper-Lower Arm Load Cell Structural Replacement (484-6106)

- 11.3.11 Attach the Upper Arm Load Cell Adaptor (484-6112) to the Upper-Lower Arm Load Cell Structural Replacement (484-6106) using four Modified BHSS M6 Thread (W50-61042) (Figure 11-35).

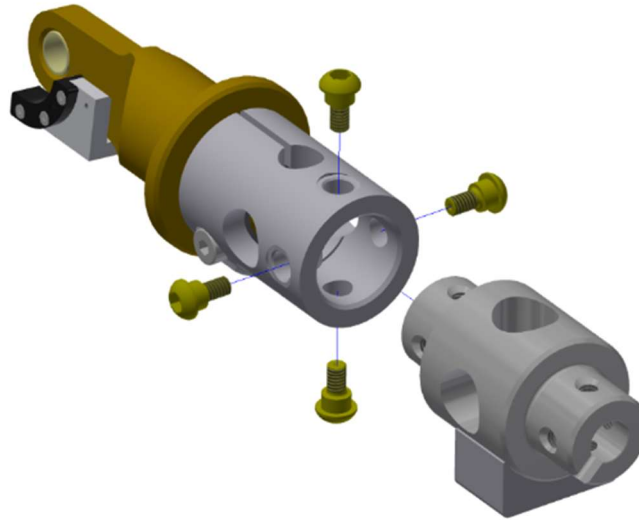


Figure 11-35. Attach the Upper Arm Load Cell Adaptor (484-6112) to the Upper-Lower Arm Load Cell Structural Replacement (484-6106)

- 11.3.12 Assemble the Shoulder Clevis (483-3504) to the Distal Upper Arm Tube (484-6110-1,2) with the M8 X 20 LG. SHSS, four washers, and M6 X 1 Hex Lock Nut (Figure 11-36). A Friction Washer (474-3533) sits between the clevis and the arm tube. The remaining stack of washers include a 8 X 16 X 5 THK. Ball Bearing Thrust Washer (5001520), a M8 Plain Washer (5000123), and a M8 Belleville Washer (5001388).

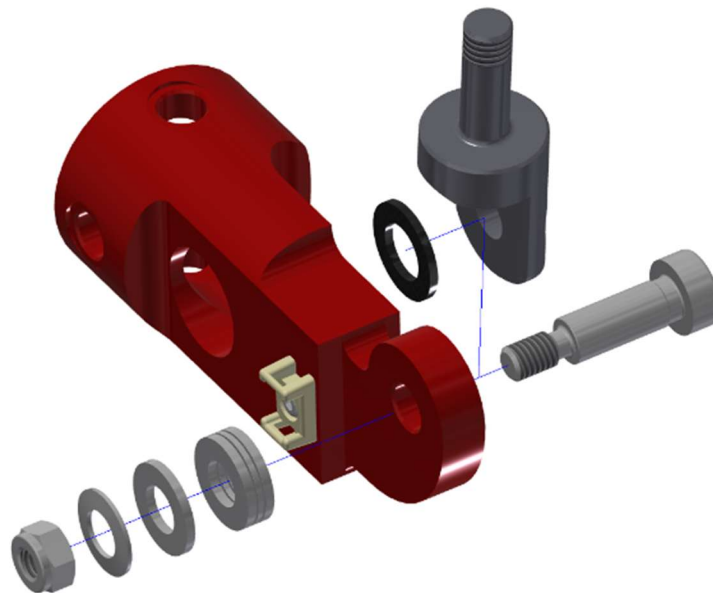


Figure 11-36. Assembly of Shoulder Clevis (483-3504) and Distal Upper Arm Tube (484-6110-1,2)

11.3.13 Install the Upper Arm On Board DAS Bracket (481-3602) to the Distal Upper Arm Tube (484-6110-1,2) using two M3 X 0.5 X 10 LG. BHCS (Figure 11-37).

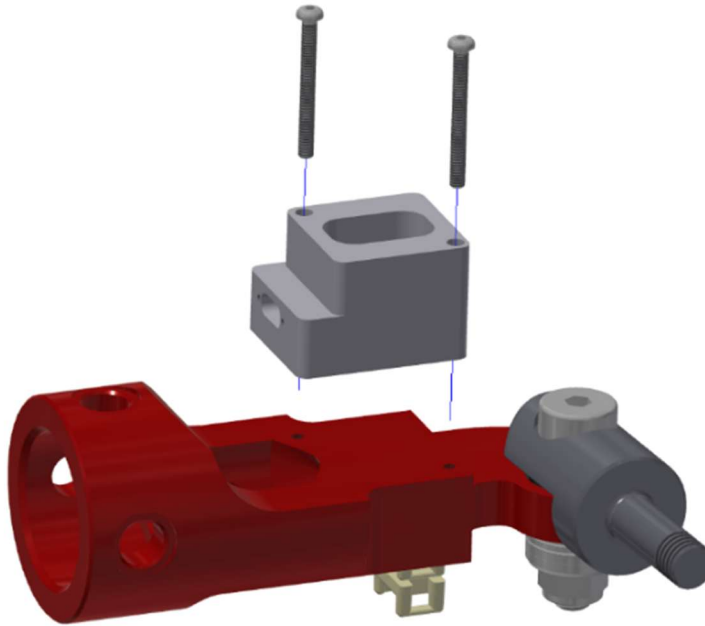


Figure 11-37. Install the Upper Arm On Board DAS Bracket (474-6118) to the Distal Upper Arm Tube (484-6110-1,2)

11.3.14 Attach the Distal Upper Arm Tube (484-6110-1,2) to the Upper-Lower Arm Load Cell Structural Replacement (484-6106) using four Modified BHSS M6 Thread (W50-61042) (Figure 11-38).

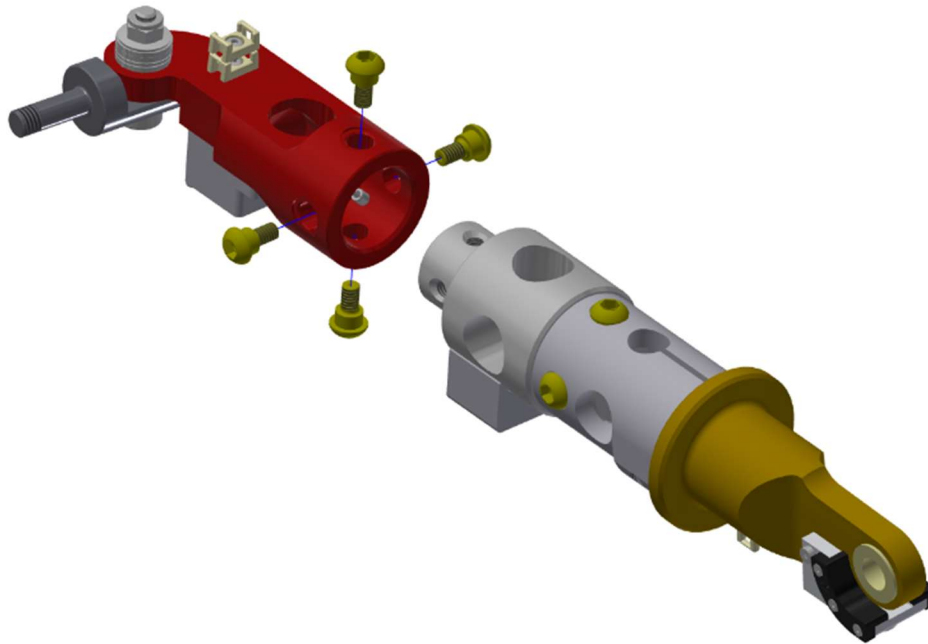


Figure 11-38. Attach the Distal Upper Arm Tube (484-6110-1,2) to the Upper-Lower Arm Load Cell Structural Replacement (484-6106)

11.3.15 Secure the M10 X 20 LG. SHSS and Upper-Lower Arm Washer (474-6502) to join the upper arm and lower arm at the elbow (Figure 11-39).

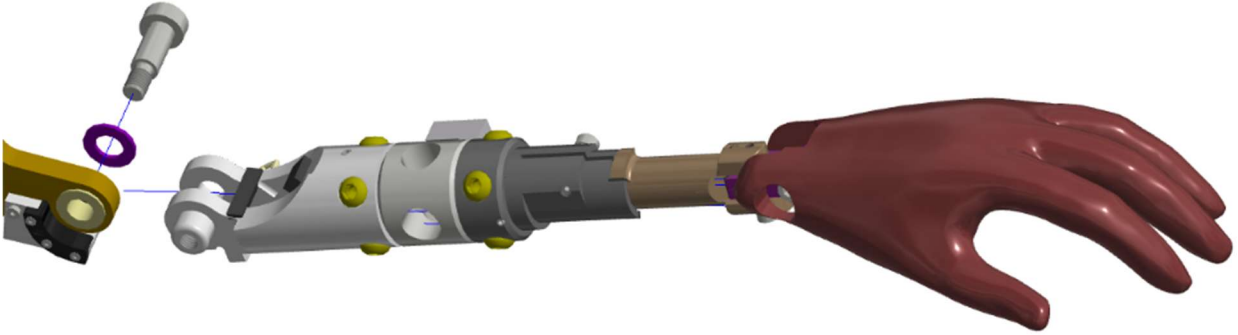


Figure 11-39. Attach the elbow joint, M10 X 20 LG. SHSS and Upper-Lower Arm Washer (474-6502)

11.3.16 Zip the Lower Arm Flesh (474-6525-1,2) onto the Lower Arm (Figure 11-40).

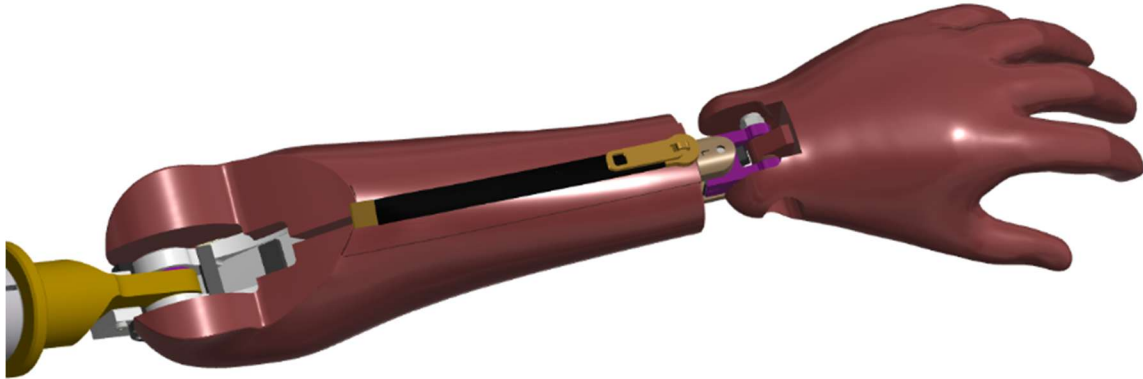


Figure 11-40. Zip the Lower Arm Flesh (474-6525-1,2)

- 11.3.17 Attach a cable tie to the ground wire (yellow circle in Figure 11-41 below) and screw the ground wire (red circle in Figure 11-41 below) to the upper arm (Figure 11-41).

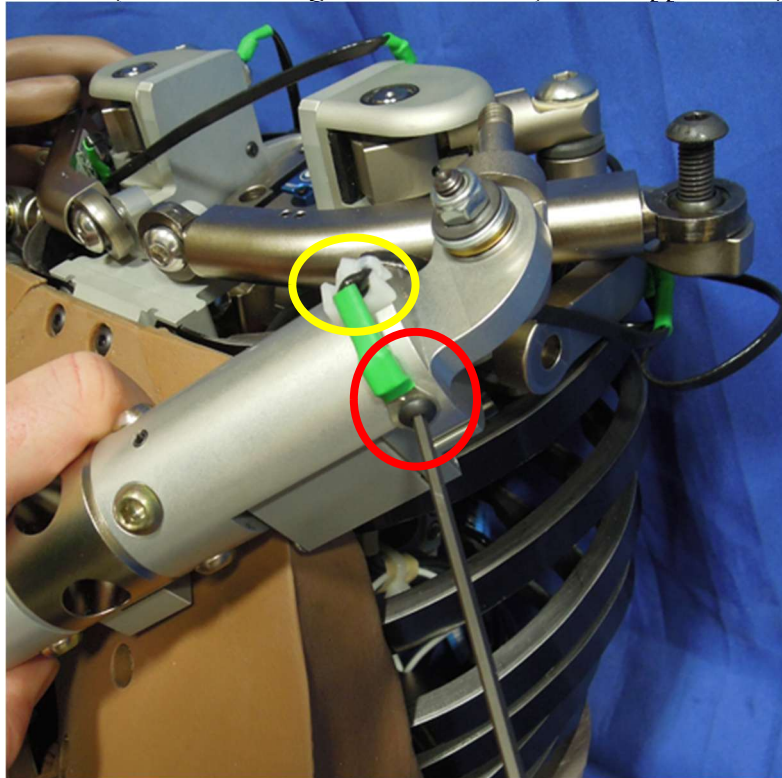


Figure 11-41. Attach a cable tie from the ground wire (yellow circle) and screw the ground wire (red circle) from the upper arm

- 11.3.18 Zip the Upper Arm Flesh (484-6120-1,2) (Figure 11-42).

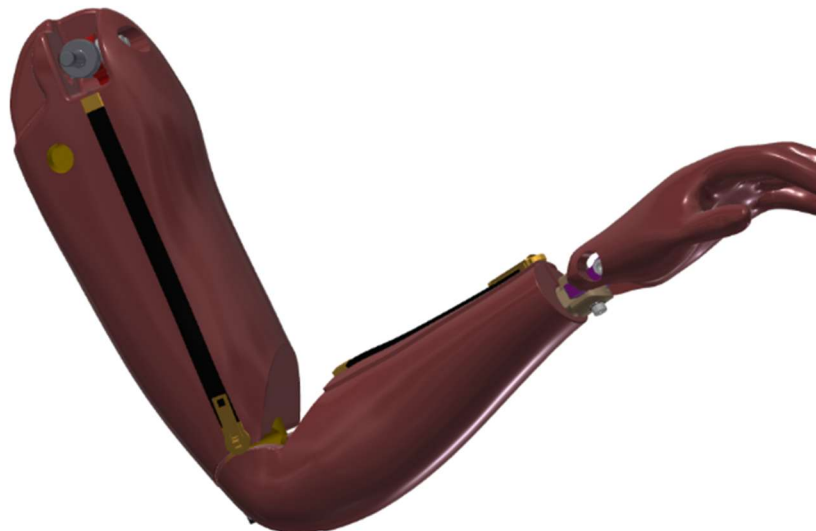


Figure 11-42. Zip the Upper Arm Flesh (484-6120-1,2)

11.3.19 To attach the arm to the shoulder, insert the Shoulder Clevis (483-3504) into the Lower Scapula (474-3505) by tightening an M8 X 1.25 Hex Lock Nut on the medial side of the arm (Figure 11-43 and Figure 11-44).

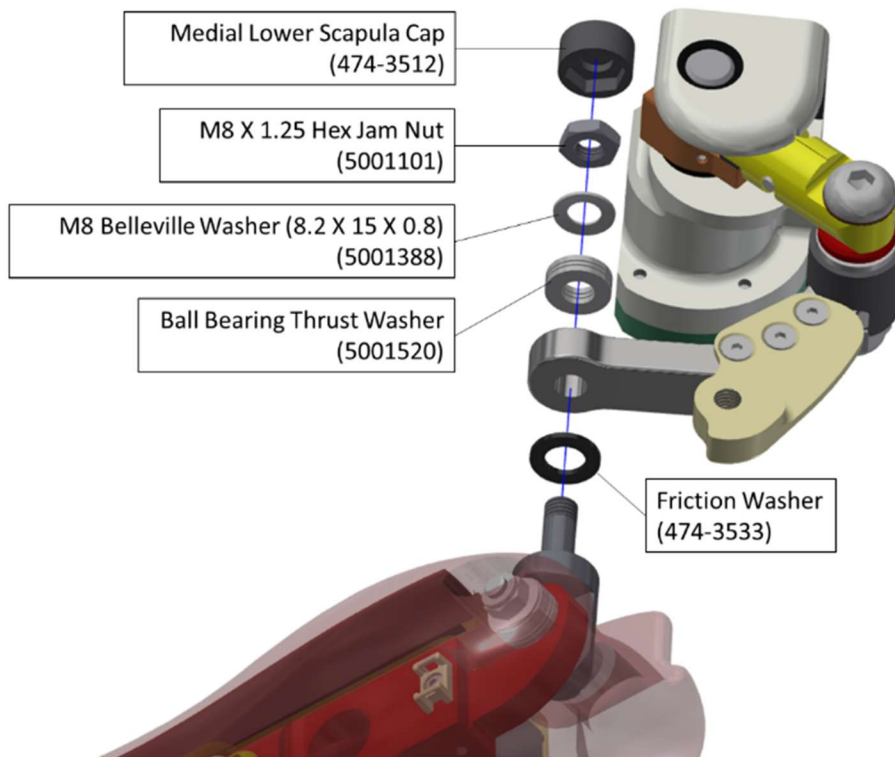


Figure 11-43. Secure the hardware as shown

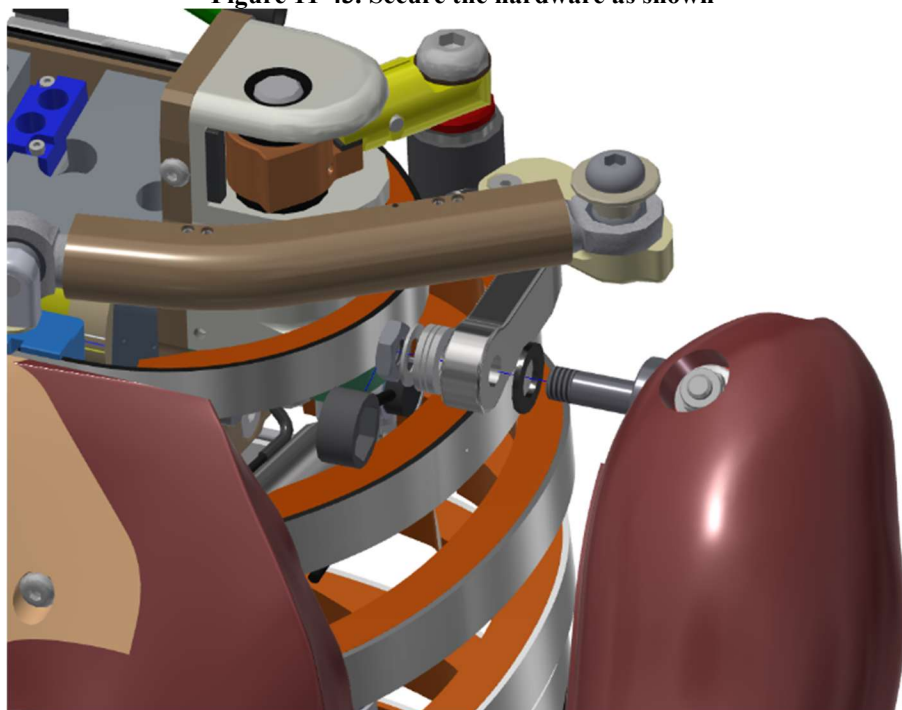


Figure 11-44. Attach the Shoulder Clevis (483-3504) to the Lower Scapula (474-3505).

11.4 Adjustments for the Arm Assembly

11.4.1 Arm and Elbow Joint Torque Settings

- 11.4.1.1 Position the left hand as shown in Figure 11-45. Adjust the torque of the M5 X 0.8 X 25 LG. SHCS at the wrist joint such that the hand remains in this position under its own mass but falls once any additional mass or force is added. Repeat for right hand.



Figure 11-45. Wrist orientation for setting joint torque to 1G

- 11.4.1.2 Position the left lower arm as shown in Figure 11-46. Adjust the torque of the M10 X 20 LG. SHSS at the elbow joint such that the lower arm remains in this position under its own mass but falls once any additional mass or force is added. Repeat for right elbow.

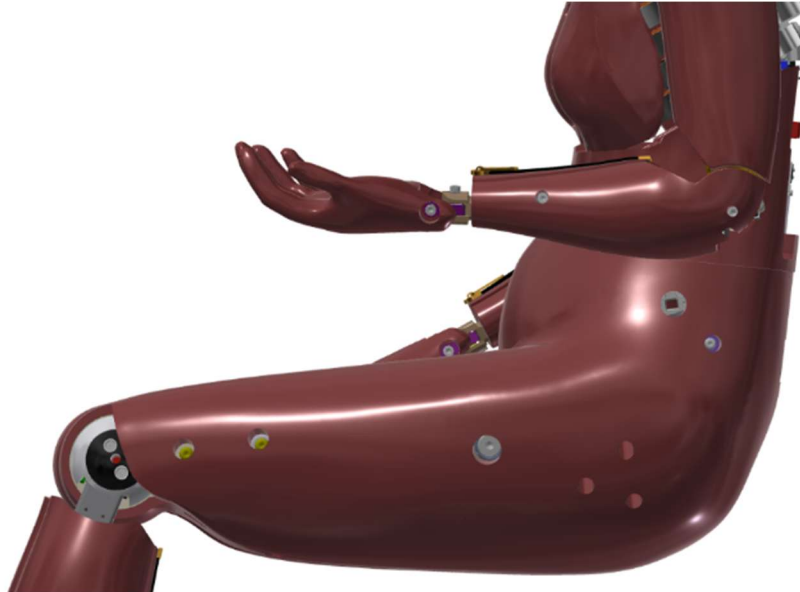


Figure 11-46. Elbow orientation for setting joint torque to 1G

11.5 Electrical Connections and Requirements

There is no instrumentation in the arm assembly.

Section 12. Jacket Assembly

12.1 Description of Jacket Assembly and Features

The THOR-05F jacket assembly is comprised of the front panel assembly and the rear panel assembly. The crotch strap assists in keeping the jacket in place and prevents bunching of the jacket due to belt loading.

An added feature of the jacket is the strategic location of the four zippers, two located on the side of the thorax and two on the posterior shoulder. The locations allow the jacket to open from either side for internal inspection; if needed, the entire jacket assembly can be removed from the dummy with little movement of the dummy. The zippers have Velcro® coverings that aid in keeping the zippers in place and provide a smooth, continuous surface over the entire Jacket assembly.

As an integral part of the thorax assembly, the jacket enhances the response of the thorax during testing. The jacket design also prevents metal-to-metal contact between THOR-05F instrumentation and the testing environment.

12.2 Assembly of the Jacket

Table 12-1 and Figure 12-1 show the components of the jacket assembly.

Table 12-1. Jacket (474-3900-A) Assembly

Part Description	Quantity	Part Number	Figure #	Item #
Front Body Assembly	1	474-3950	Figure 12-1	1
Rear Body Assembly	1	474-3910	Figure 12-1	2

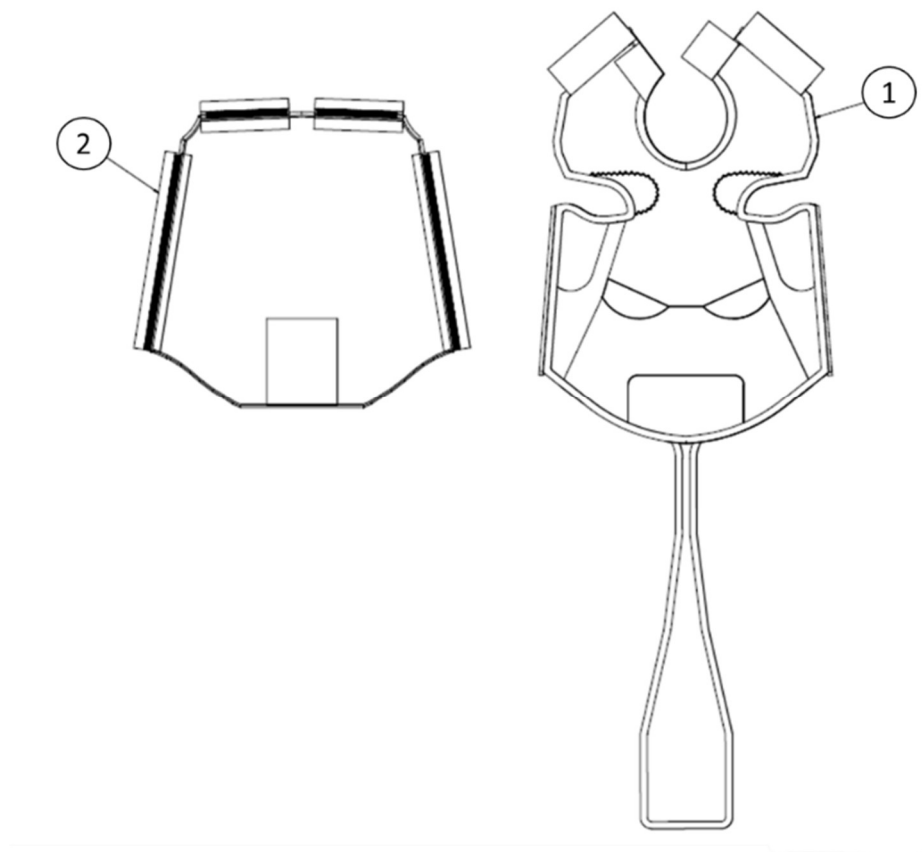


Figure 12-1. Jacket (474-3900-A) Assembly Components

- 12.2.1 Install the Jacket onto the thorax of the dummy by draping the Front Panel (474-3950) and Rear Panel (474-3910) of the jacket over the front and rear of the dummy's thorax and closing the left and right shoulder zippers. Adhere the Velcro on the shoulders to cover the zippers (Figure 12-2).



Figure 12-2. Drape front and rear panels over dummy then zipper shoulders

12.2.2 Zipper the left and right sides of the jacket (Figure 12-3).



Figure 12-3. Zipper left and right sides of jacket

Warning: The following step requires lifting of the dummy by the dummy lift strap. Avoid lifting by the head/neck area to prevent damage.

- 12.2.3 Lift the dummy. While the dummy is suspended, slide the Crotch Strap between the legs underneath the pelvis. Lower the dummy and attach the Velcro® on the crotch strap to the Velcro® on the bottom of the jacket rear panel (474-3910) (Figure 12-4).



Figure 12-4. Lift dummy and install crotch strap

12.3 Adjustments for the Jacket Assembly

The jacket assembly does not require any adjustments.

12.4 Electrical Connections and Requirements

The jacket assembly does not require any electrical connections.

Section 13. Instrumentation and Wiring

13.1 Overview of Instrumentation

When fully instrumented, the THOR-05F measures 115 separate (dynamic measurement) sensor channels. In addition, five tilt sensors establish the static orientation of the dummy. Table 13-1 and Figure 13-1 show locations of the instrumentation for THOR-05F. Table 13-2 below describes the instrumentation by body region.

Table 13-1. THOR-05F Sensor/Load Cell Locations

Part Description	Quantity	Part Number	Figure #	Item #
Head Accelerometer/ARS Kit	1	474-1034	Figure 13-1	1
Skull Spring Load Cell	2	SA572-S112	Figure 13-1	2
Rotary potentiometer (OC)	1	SA572-S114	Figure 13-1	3
Dual Axis Tilt Sensor (Head)	1	SA572-S44	Figure 13-1	4
Upper Neck Load Cell	1	SA572-S110	Figure 13-1	5
Lower Neck load Cell	1	SA572-S111	Figure 13-1	6
Dual Axis Tilt Sensor (T1)	1	SA572-S44	Figure 13-1	7
Face Load Cells	5	SA572-S161	Figure 13-1	8
T1 Accelerometer Kit	1	474-2022	Figure 13-1	9
Dual Axis Tilt Sensor (T6)	1	SA572-S44	Figure 13-1	10
Mid-Spine Accelerometer Kit	1	474-3066	Figure 13-1	11
Thoracic Spine Load Cell	1	SA572-S107	Figure 13-1	12
Dual Axis Tilt Sensor (T12)	1	SA572-S44	Figure 13-1	13
Left Clavicle Load cell	1	SA572-S165	Figure 13-1	14
Left Clavicle Load cell	1	SA572-S166	Figure 13-1	15
Upper Arm Load Cell (left & right)	2	SA572-XX	Figure 13-1	16
Lower Arm Load Cell (left & right)	2	SA572-XX	Figure 13-1	17
Upper Left IR-TRACC	1	474-3550-A	Figure 13-1	18
Upper Right IR-TRACC	1	474-3560-A	Figure 13-1	19
Lower Left IR-TRACC	1	474-3580-A	Figure 13-1	20
Lower Right IR-TRACC	1	474-3570-A	Figure 13-1	21
Mid-Sternum Accelerometer	1	SA572-S4	Figure 13-1	22
Left ASIS Load Cell	1	SA572-S159	Figure 13-1	23
Right ASIS Load Cell	1	SA572-S160	Figure 13-1	24
Left Acetabulum Load Cell	1	SA572-S109	Figure 13-1	25
Right Acetabulum Load Cell	1	SA572-S108	Figure 13-1	26
Abdomen Pressure Sensor (APTS) (left & right)	2	SA572-S162	Figure 13-1	27
Head Accelerometer/ARS Kit	1	474-4008	Figure 13-1	28
Dual Axis Tilt Sensor (Pelvis)	1	SA572-S44	Figure 13-1	29
Femur Load Cell (left & right)	2	SA572-S63	Figure 13-1	30

Mini String Potentiometer (left & right knee)	2	SA572-S90-R,L	Figure 13-1	31
Upper Tibia Load Cell (left & right)	2	SA572-S103	Figure 13-1	32
Tibia Accelerometers (left & right)	4	SA572-S4	Figure 13-1	33
Achilles Load Cell (left & right)	2	SA572-S126	Figure 13-1	34
Lower Tibia Load Cell (left & right)	2	SA572-S104	Figure 13-1	35
Rotary potentiometer (left & right ankle)	6	SA572-S114	Figure 13-1	36
Foot Accelerometer/ARS Kit (left & right)	2	474-5728-1,2	Figure 13-1	37
Dual Axis Tilt Sensor (left & right foot)	2	SA572-S44	Figure 13-1	38

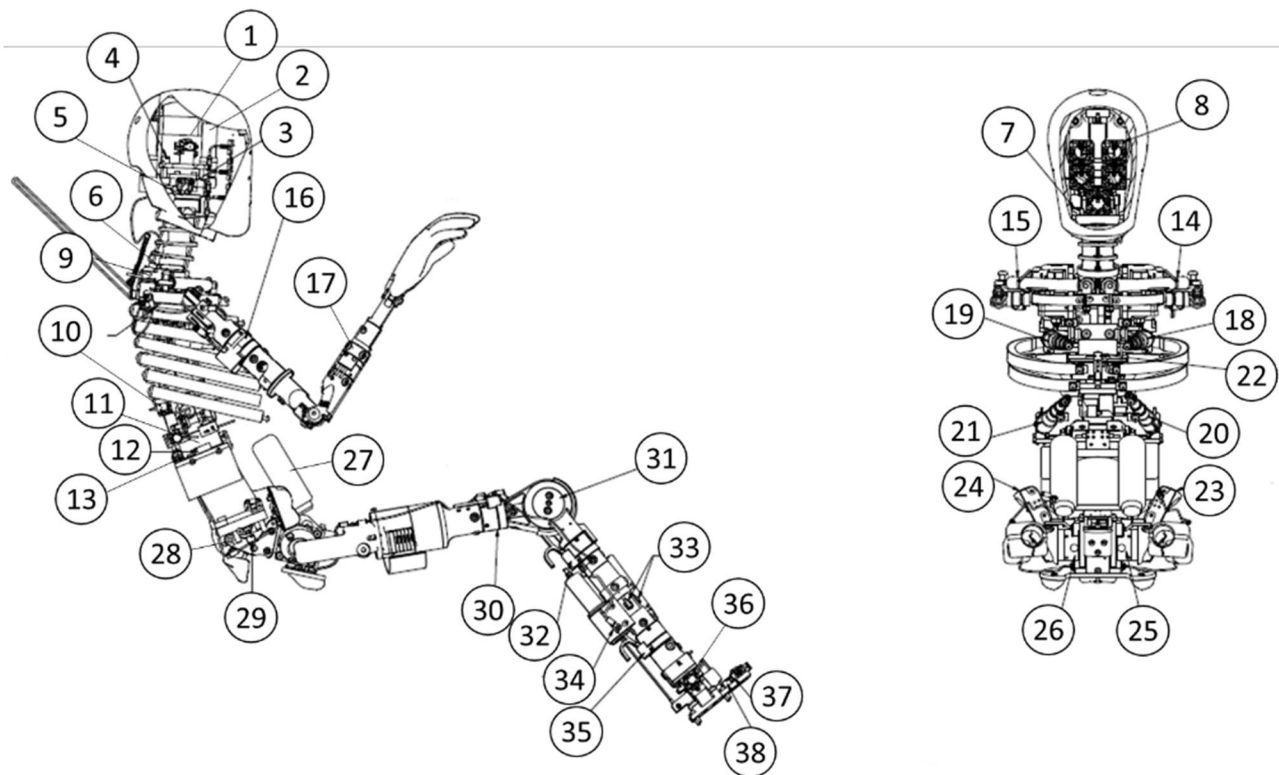


Figure 13-1. THOR-05F sensor locations

Table 13-2. THOR-05F Available Instrumentation

Head	3 Uniaxial Accelerometers at the C.G 3 Angular Rate Sensors 1 Biaxial Tilt Sensor
Face	5 Uniaxial Load Cells
Neck	Upper Neck Load Cell (6-axis) Lower Neck Load Cell (6-axis) Front Neck Spring Load Cell Rear Neck Spring Load Cell Head Rotation Potentiometer 1 Biaxial Tilt Sensor
Thorax	3D IR-TRACC Deflection Units - 3D Thoracic Deflection Measurement (4 units - 3 channels each)
Mid-Sternum	1 Uniaxial Accelerometer
Abdomen	2 APTS
Spine	1 tri-pack Accelerometer at the T1 location 1 tri-pack Accelerometer at the T12 location Thoracic Load Cell (5-axis) 3 Biaxial Tilt Sensors
Pelvis	Acetabular Load Cell (left and right, 3-axis each) ASIS Load Cells (left and right) 1 Triaxial Accelerometer at the C.G. 1 Biaxial Tilt Sensor
Femur	Femur Load Cell (left and right, 6-axis each)
Knee	Displacement string potentiometer (left and right)
Lower Leg	Upper Tibia Load Cell (left and right, 5-axis each) Lower Tibia Load Cell (left and right, 5-axis each) Tibia Accelerometer (left and right, biaxial each) Achilles' Load Cell (left and right) Ankle Joint Rotation Potentiometers (left and right, 3 each) Foot tri-pack Accelerometer (left and right, 3 each) 2 Biaxial Tilt Sensors (left and right)

13.2 Instrumentation Cable Routing

The THOR-05F dummy contains provisions for mounting numerous electronic instruments to evaluate various types of occupant restraint systems. Typically, the instruments are connected to the data acquisition system using long cables. The instrumentation cables must be routed in and around the dummy in a manner that ensures that the dummy's motion is not affected by the cables while also being careful not to place the cables in a position where they are susceptible to damage from the test event. While there may be other acceptable methods of cable routing, especially in different loading environments or instrumentation configurations, this guide provides best practices for cable routing in frontal and frontal oblique test modes with a fully-instrumented THOR-05F dummy.

13.3 Grounding

To reduce the possibility of static electricity discharge and subsequent noise in the data acquisition system, it is necessary to provide electrical conductivity between sections of the dummy that are electrically isolated from the primary grounding cable exiting the dummy. Figure 13-2 shows an example of an instrumentation channel which is not properly grounded. The signal is characterized by spikes which have very short duration. Although poor grounding will not likely damage either instrumentation or harm the user, the signal output will include unwanted static spikes.

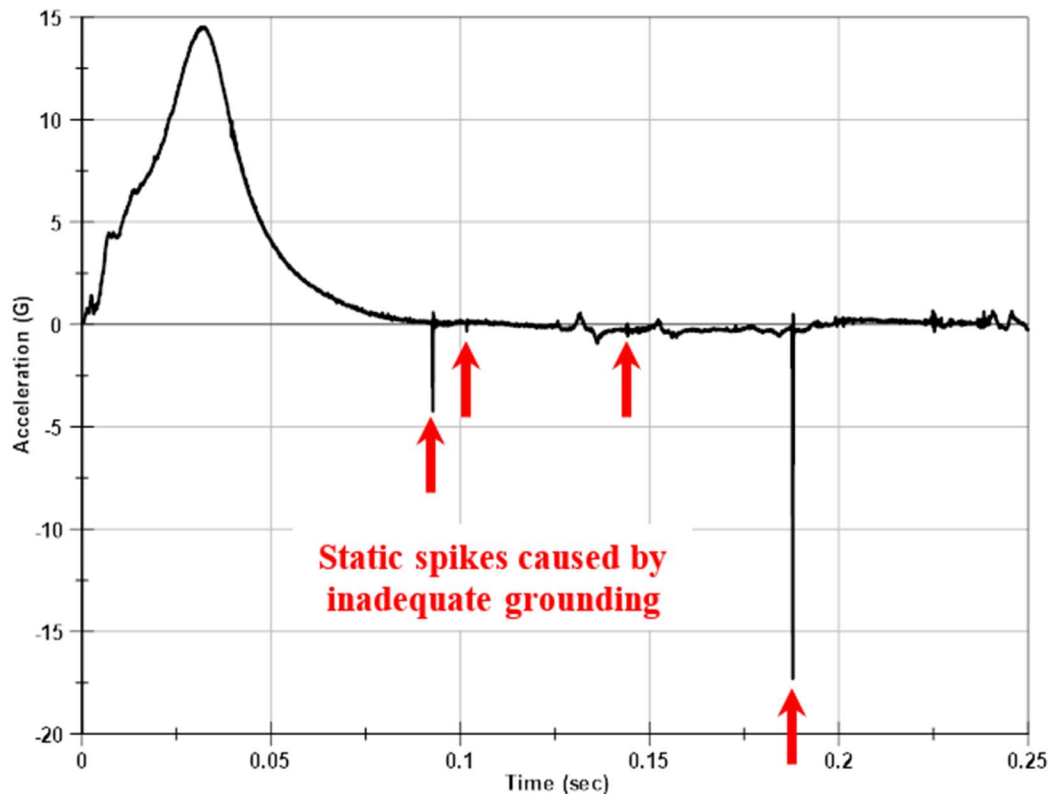


Figure 13-2. Example of instrumentation channel with poor grounding

Grounding is achieved by using multiple ground cables typically attached to the head, spine, shoulders, clavicles, arms, pelvis, femurs, and tibias. These grounding straps are described in Table 13-3 and Figure 13-3.

Table 13-3. THOR-05F Ground Cables

Part Description	Quantity	Part Number	Figure #	Item #
Ground Cable, Head/Neck, Upper Leg, Tibia/Knee, Femur/Pelvis	5	474-8700-230	Figure 13-3	1
Ground Cable, Lower Leg/Torso	2	474-8700-110	Figure 13-3	2
Ground Cable, Upper Leg, Tibia/Knee, Femur/Pelvis, Lumbar/Chest	4	474-8700-210	Figure 13-3	3
Ground Cable, Exit	1	474-8700-3000	Figure 13-3	4
Ground Cable, Shoulder	2	474-8701	Figure 13-3	5
Ground Cable, Clavicle	2	474-8702	Figure 13-3	6
Cable Tie Mount, #4 Screw	3	6002036	Figure 13-3	7
M4 X 0.7 X 6 LG. BHCS	11	5001075	Figure 13-3	8
M3 X 0.5 X 4 LG. BHCS	3	5001067	Figure 13-3	9
Cable Tie 7.4	2	6000004	Figure 13-3	10

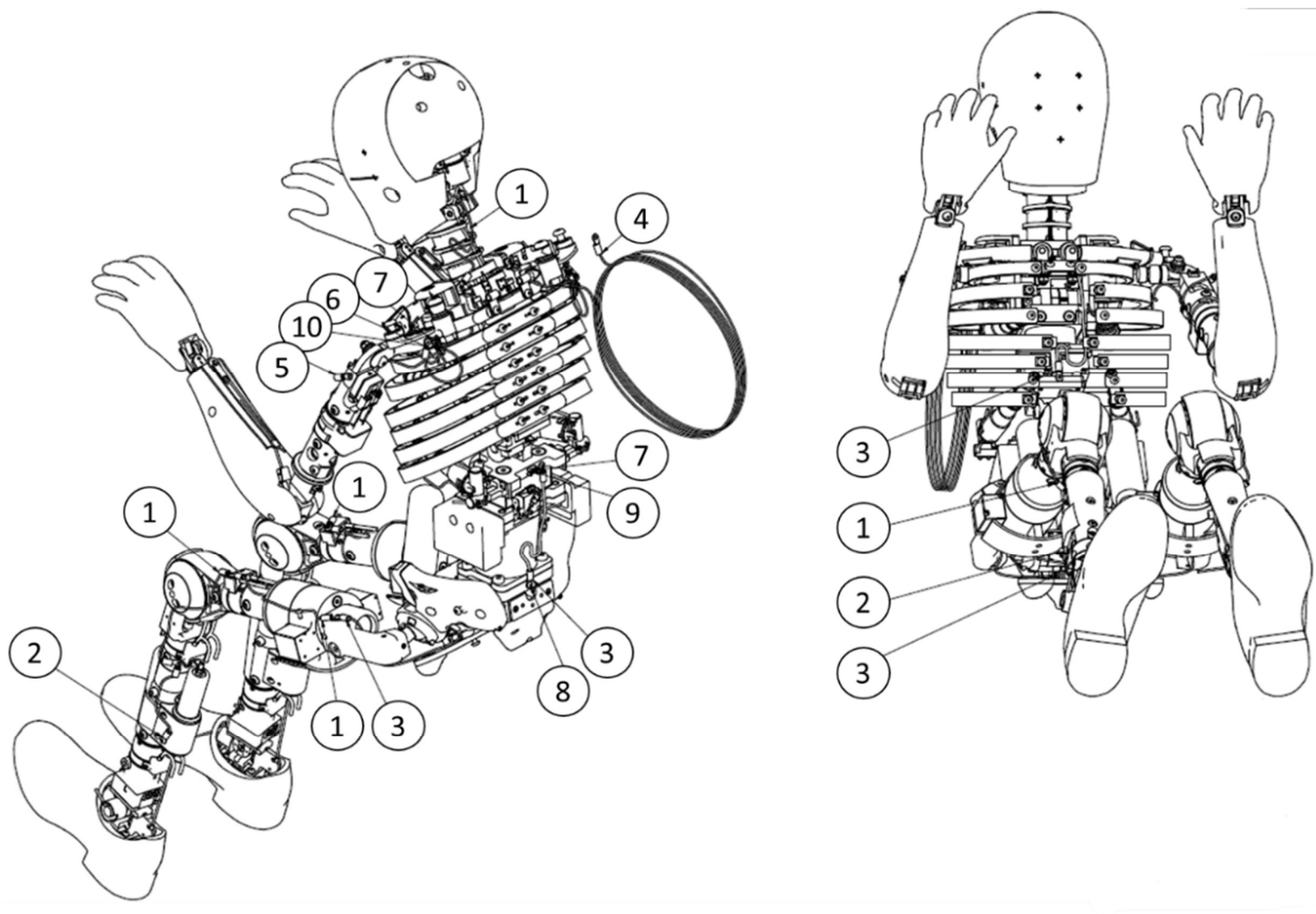


Figure 13-3. Ground straps on the THOR-05F

Descriptions and illustrations of the grounding straps installed on the THOR-05F are found in Table 13-4 and in Figure 13-4 through Figure 13-13.

Table 13-4. Ground Cable Attachment Details

Attachment #1		Attachment #2		Quantity	Figure
Part Name	Part No.	Part Name	Part No.		
Skull	474-1010	Upper Spine Box (posterior)	474-3100-A	1	Figure 13-4
Upper Spine Box (posterior)	474-3100-A	Lower Scapula	474-3505-1,2	2 (left and right)	Figure 13-5
Distal Upper Arm Tube	484-6110-1,2	Lower Scapula	474-3505-1,2	2 (left and right)	Figure 13-6
Clavicle	474-3509	Lower Scapula	474-3505-1,2	2 (left and right)	Figure 13-7
Upper Spine Box (anterior)	474-3100-A	Lower spine box (anterior)	474-3101-A	1	Figure 13-8
Lumbar Posture Adjustment Base Plate (posterior)	474-3071-A	Upper Torso to Pelvis Adaptor Plate (posterior)	474-4000	1	Figure 13-9
Center Pelvic Bone	474-4541	Femur	474-4703-1,2	2 (left and right)	Figure 13-10
Femur	474-4703-1,2	Femur Load Cell or SR	474-5102	2 (left and right)	Figure 13-11
Femur Load Cell or SR	474-5102	Tibia Compliant Element Plunger	474-5509	2 (left and right)	Figure 13-12
Tibia Compliant Element Plunger	474-5509	Lower Achilles Spring Housing	474-5504	2 (left and right)	Figure 13-13

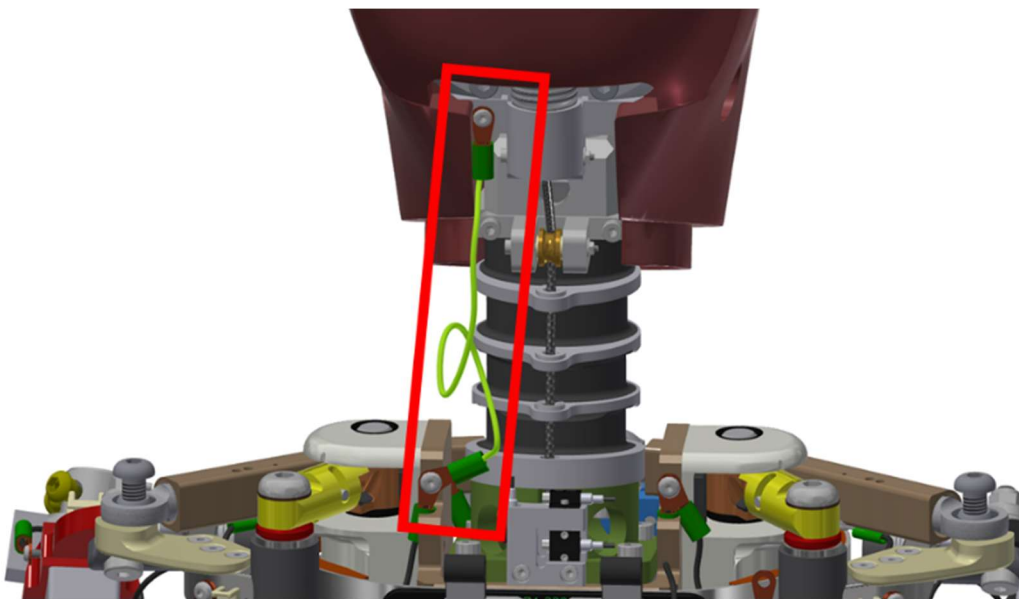


Figure 13-4. Skull-to-Upper Spine Box Grounding Cable

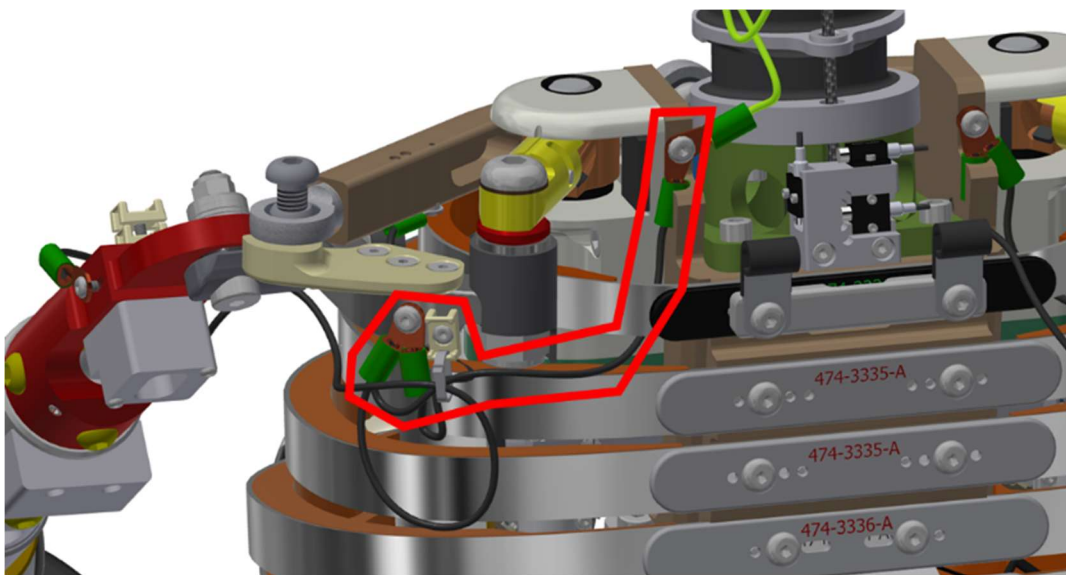


Figure 13-5. Upper Spine Box-to-Scapula Grounding Cable (Left shown, right is symmetric)

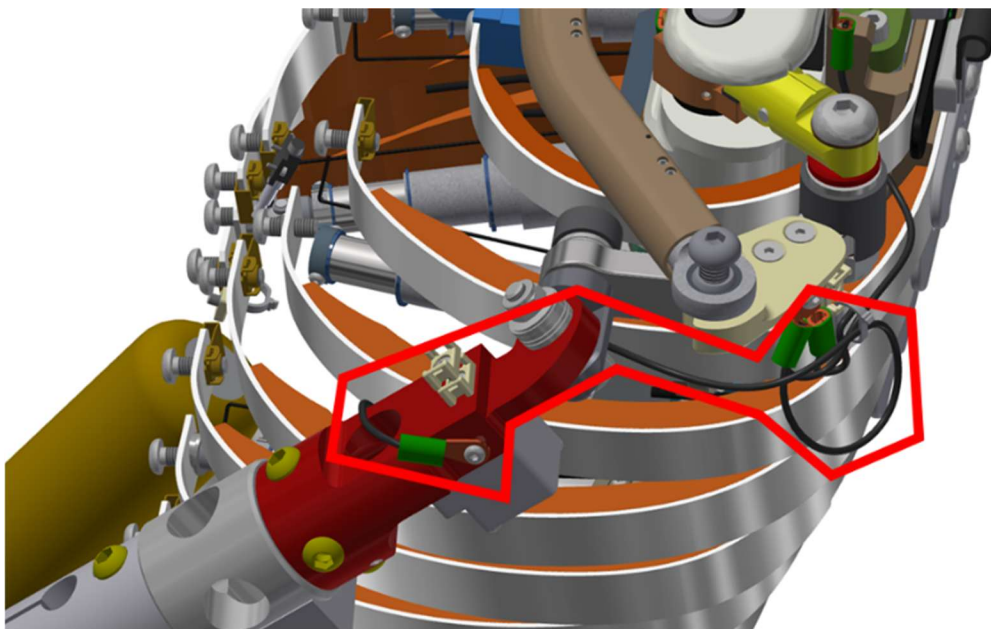


Figure 13-6. Upper Arm Tube-to-Scapula Grounding Cable (Left shown, right is symmetric)

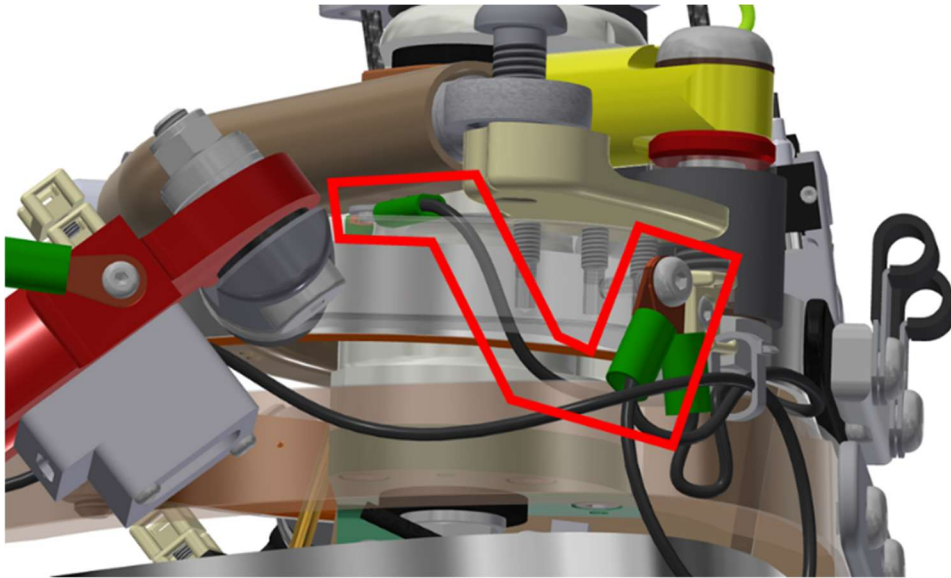


Figure 13-7. Clavicle-to-Scapula Grounding Cable (Left shown, right is symmetric)

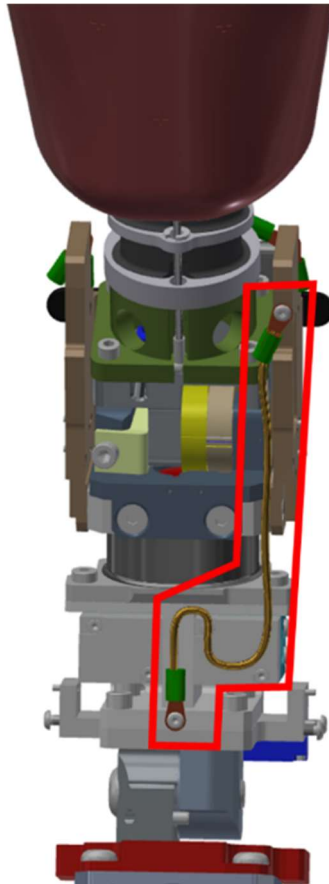


Figure 13-8. Upper Spine Box-to-Lower Spine Box Grounding Cable

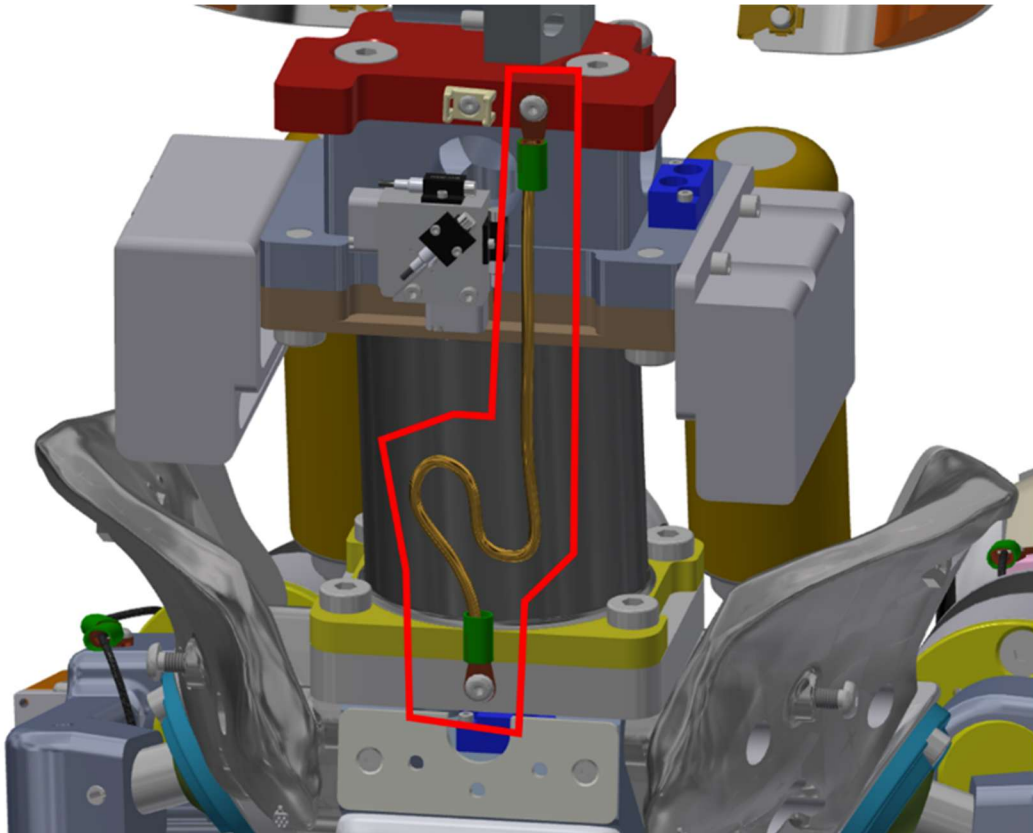


Figure 13-9. Lumbar Spine-to-Pelvis Grounding Cable

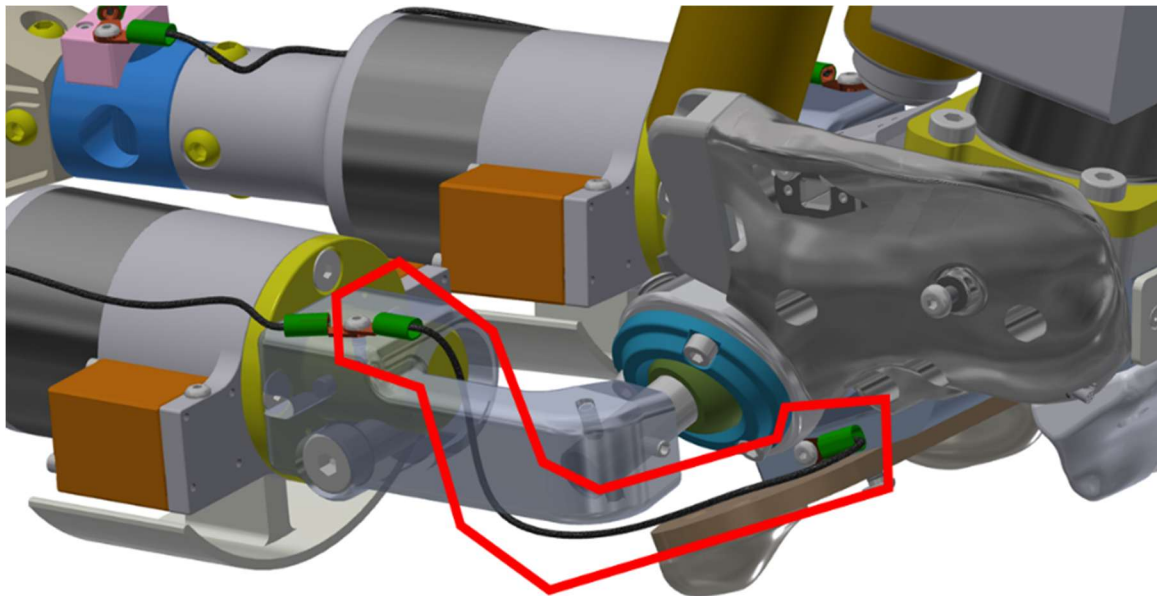


Figure 13-10. Pelvis Bone-to-Femur Grounding Cable (Left shown, right is symmetric)

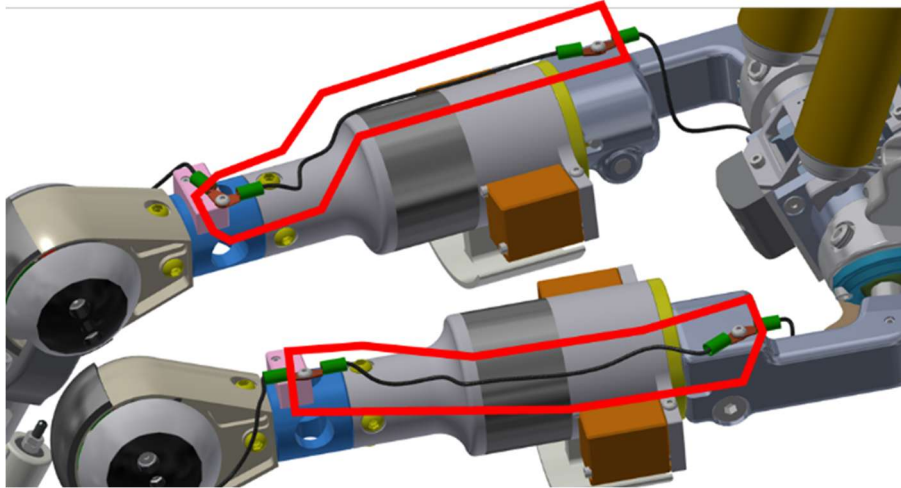


Figure 13-11. Femur-to-Femur Load Cell Grounding Cable (Left and right shown)

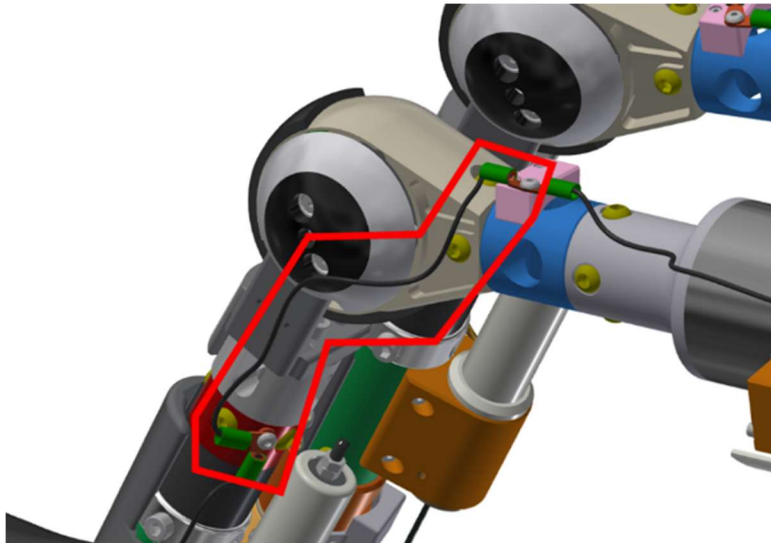


Figure 13-12. Femur Load Cell-to-Tibia Grounding Cable (Left shown, right is symmetric)

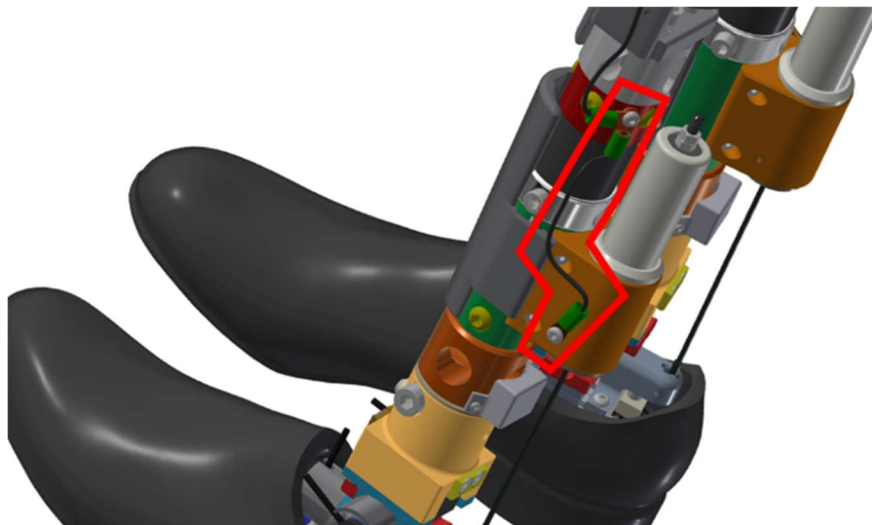


Figure 13-13. Tibia-to-Achilles Spring Housing Grounding Cable (Left shown, right is symmetric)

13.4 Cable Routing By Body Region

13.4.1 Head and Neck Cable Routing (head accelerometers, ARS sensors, upper and lower neck load cells, head tilt sensor, front and rear spring tower load washers, occipital condyle pot)

- 13.4.1.1 After installing the accelerometers and tilt sensor on the head plate, gather the wiring from the three accelerometers and bundle with a tie-wrap, leaving enough slack so that the wires don't turn sharply from the base of each sensor and cause damage (Figure 13-14).

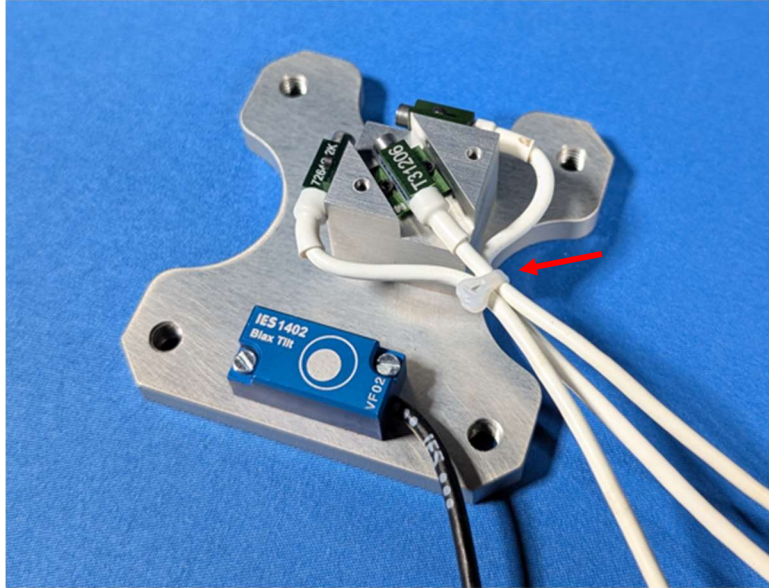


Figure 13-14. Tie-wrap for head plate instrumentation

- 13.4.1.2 After installing three accelerometers and three ARSs on the 6-axis Accelerometer/ARS Mount (SA572-S87), gather the wiring from the three accelerometers and bundle with a tie-wrap. Do the same for the three ARS sensors, leaving enough slack so that the wires don't turn sharply from the base of each sensor and cause damage (Figure 13-15).

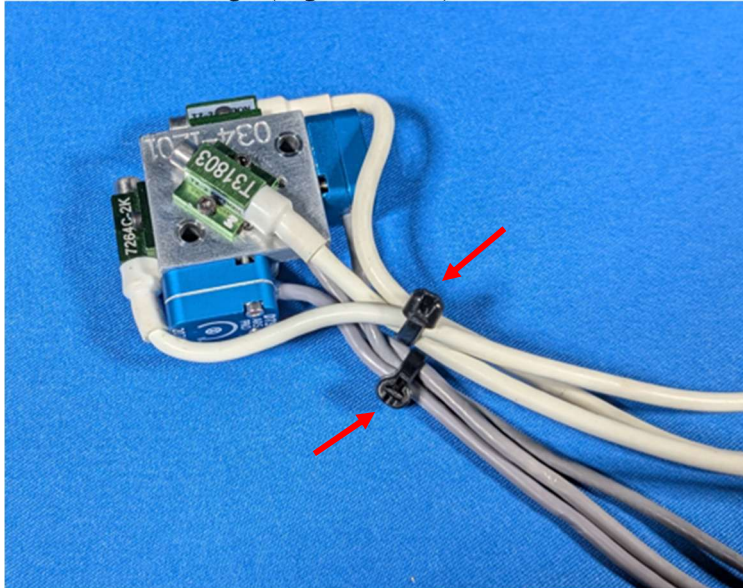


Figure 13-15. Wiring for the head accel/ARS mount

- 13.4.1.3 Install the 6 axis accel/ARS mount to the accel mount and route the cables from the six accelerometers and the three ARSs together and through the space between the mount and tilt sensor. Tie wrap all wires into a bundle (Figure 13-16).

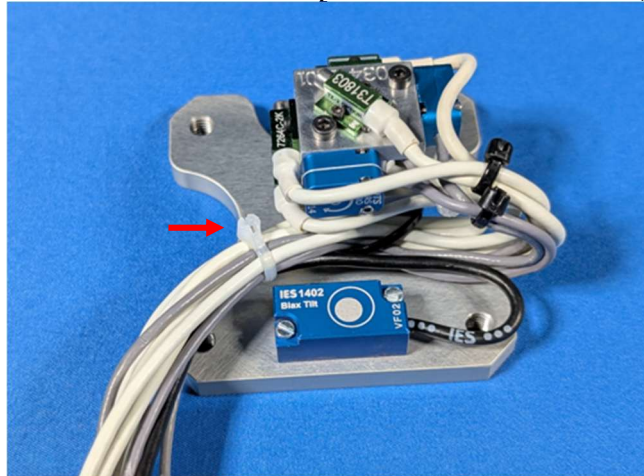


Figure 13-16. Wiring for all head accels and ARSs

- 13.4.1.4 Route the neck spring load cell wires down the left side of the neck assembly. Bundle the two wires and add a tie wrap before bundling the spring load cell wires with the upper neck load cell wires and adding another tie wrap as shown (Figure 13-17). Loop the bundle up to the rear of the neck and add a tie wrap that includes the neck grounding strap (Figure 13-18).

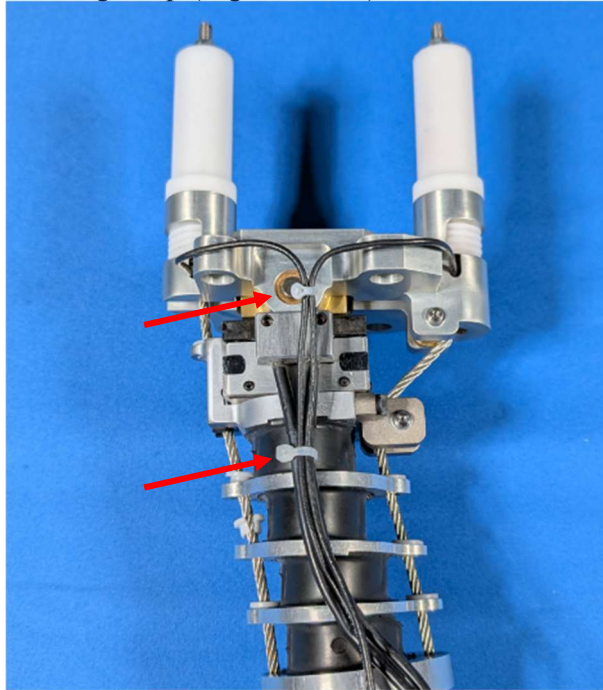


Figure 13-17. Spring tower load cell wire routing

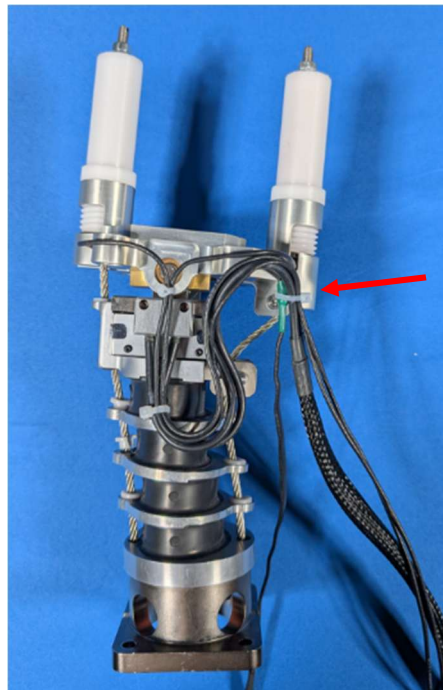


Figure 13-18. Spring tower load cell and head plate wire routing

13.4.1.5 After the OC potentiometer has been installed, route the cable to the rear of the neck and add a tie wrap to the existing neck bundle (Figure 13-19).

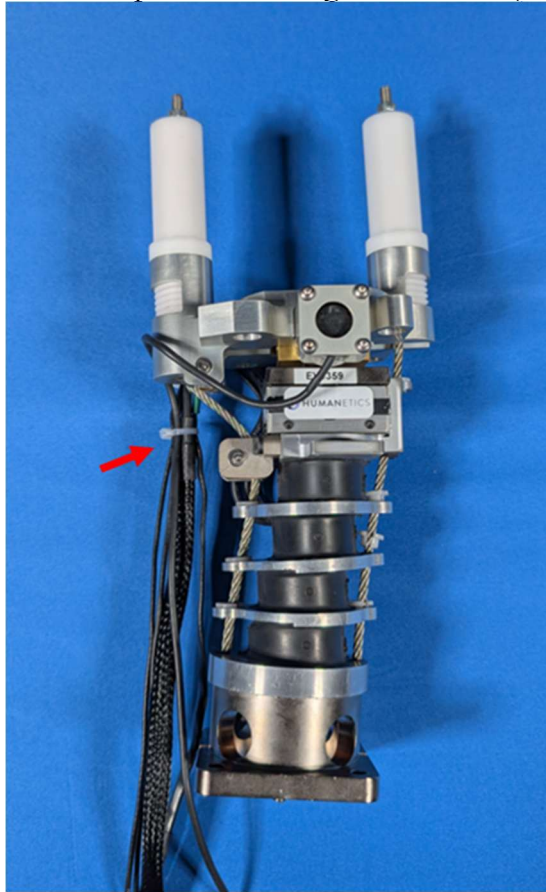


Figure 13-19. OC potentiometer wire routing

13.4.1.6 Install the head instrumentation into the head. Strain-relieve the head bundle (Figure 13-20 Left). Next, install the rear neck cable/spring assembly (Figure 13-20 Center). Place the internal instrumentation wires from the head to the dummy's right, behind the spring tower. Combine the head and neck bundle and attach a tie wrap (Figure 13-20 Right).

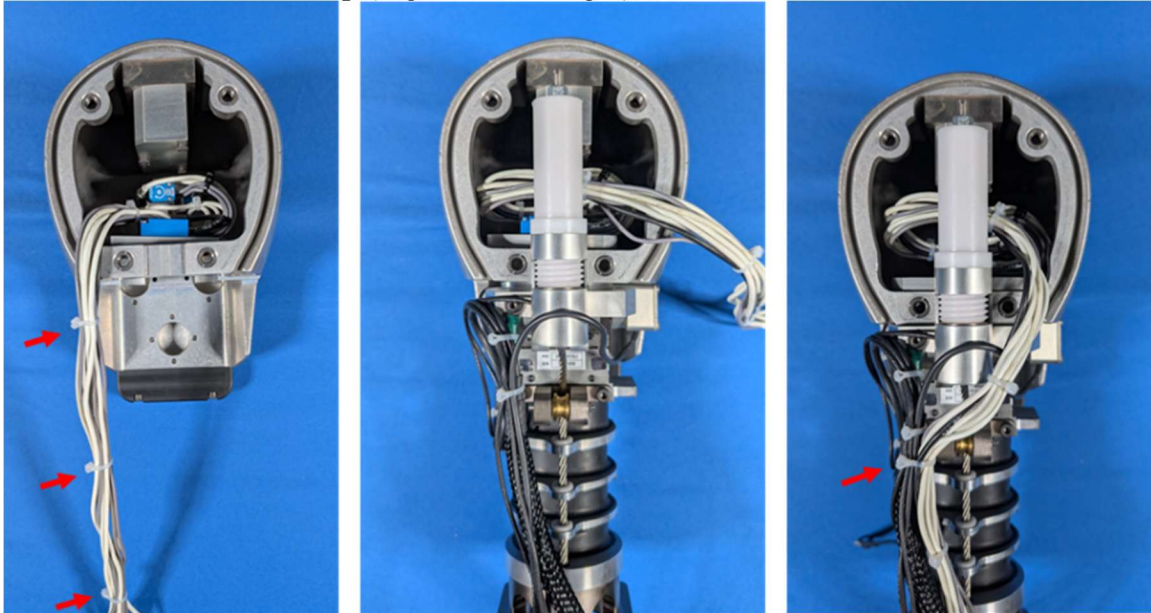


Figure 13-20. Wire routing for head and neck instrumentation

13.4.1.7 To install the skull cap, move any cable wiring towards the neck spring tower, away from the area where the skull cap screws into the skull; this will ensure that the cables exiting the head are not pinched by the skull cap (Figure 13-21).

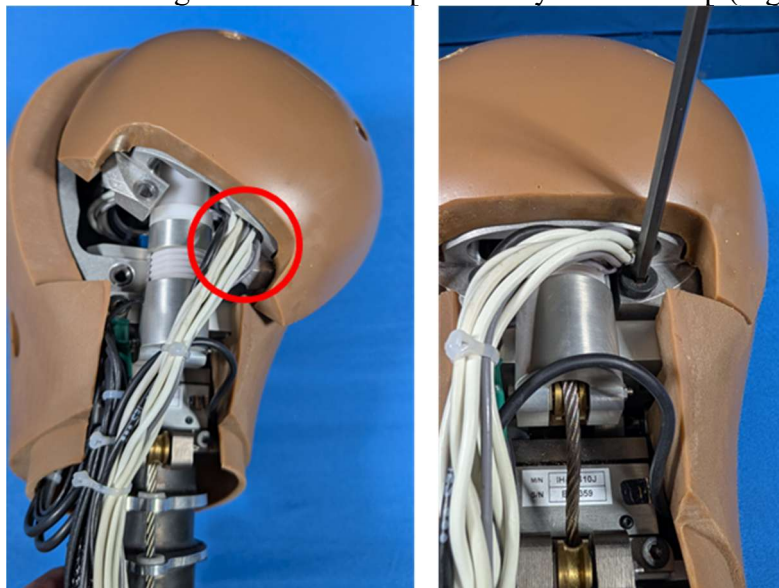


Figure 13-21. Skull cap installation with wire bundles

13.4.2 Thorax Cable Routing (IR TRACCs, tilt sensors, abdomen pressure sensors, thoracic spine load cell, ARSs, accelerometers)

13.4.2.1 Route the thoracic load cell wires, tilt sensor wires, and all four IR-TRACC assembly wires down through the front of the spine and out the rear, left side, next to the lumbar spine pitch change assembly as shown (Figure 13-22).

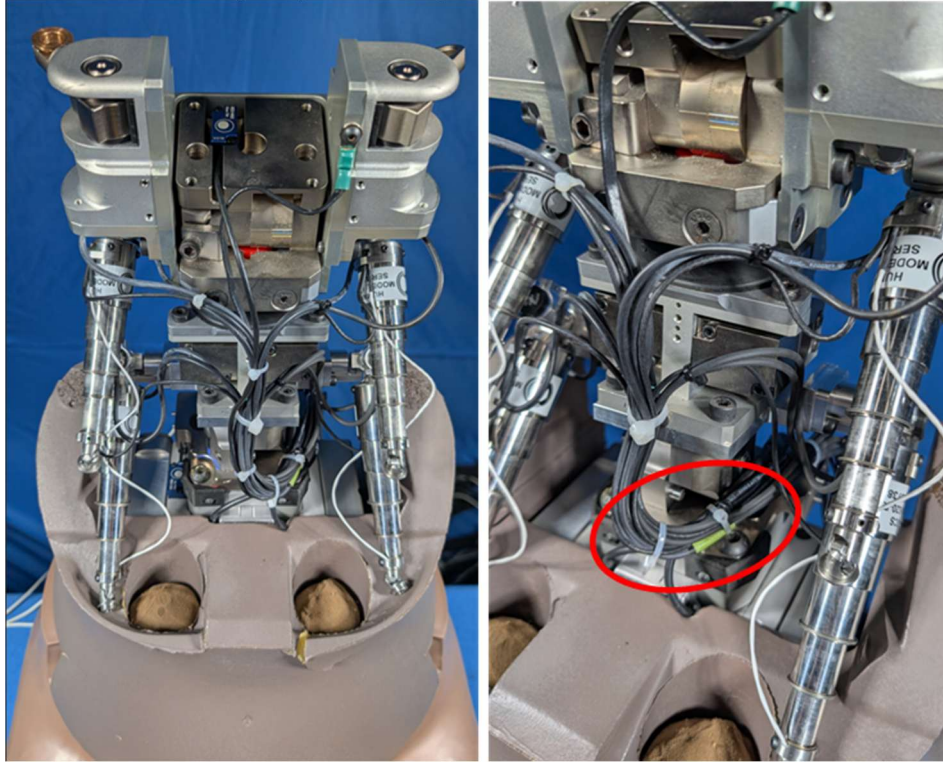


Figure 13-22. Wiring routing for thorax instrumentation

13.4.3 Pelvis Cable Routing (acetabulum load cells, ASIS load cells, accelerometers, ARSs, tilt sensor)

13.4.3.1 After installing the accelerometers and ARSs on the upper torso to pelvis adaptor plate, gather the wiring and secure it with tie wraps. Leave sufficient slack so the wires do not form sharp bends at each sensor base, which could cause damage (Figure 13-23).

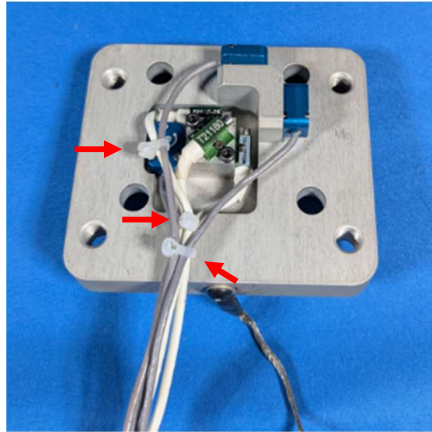


Figure 13-23. Accelerometer and ARS wiring bundled on the upper-torso-to-pelvis adapter plate with slack for strain relief

13.4.3.2 Route the ASIS and acetabulum load cell wires up through the channel in the pelvic bone. Add tie wraps as required to secure the wires without pinching them (Figure 13-24).

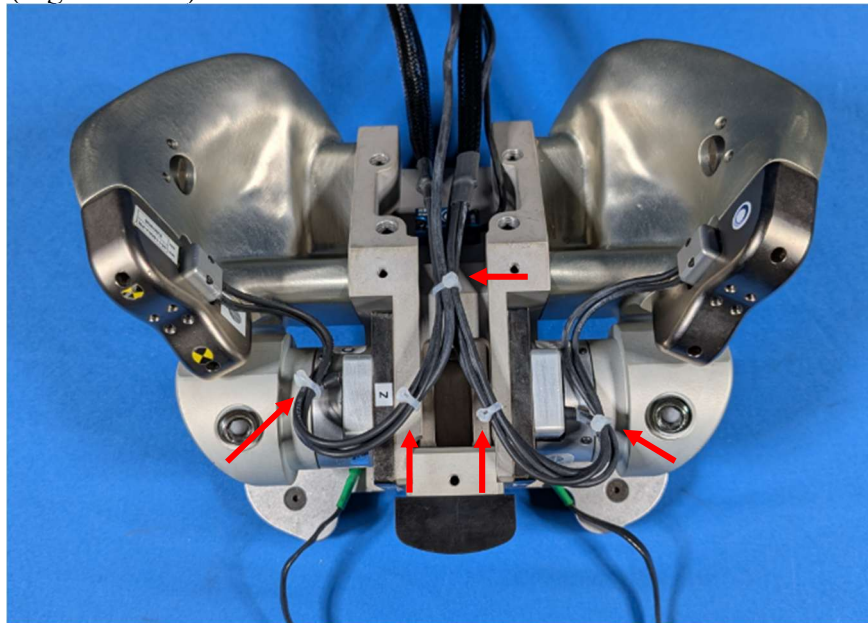


Figure 13-24. ASIS and acetabulum load-cell wires routed through the pelvic bone channel with tie wraps

13.4.3.3 Add the two abdomen-pressure sensor wires (with connectors) into the central instrumentation bundle and secure with a tie wrap (Figure 13-25).

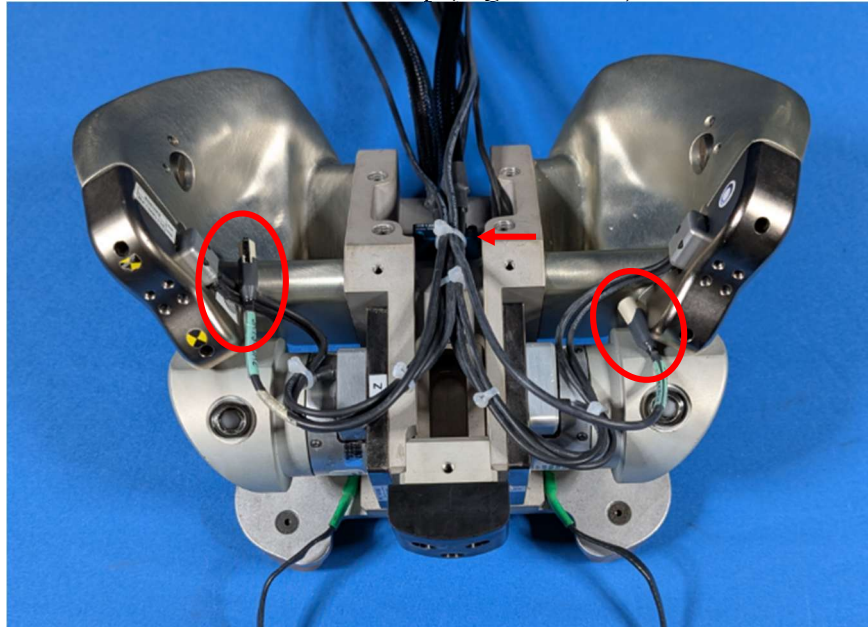


Figure 13-25. Abdomen pressure sensor wires added to the central instrumentation bundle

13.4.3.4 Install the pelvis cable cover, ensuring all wires are routed through the designated channels to prevent pinching during and after assembly (Figure 13-26).

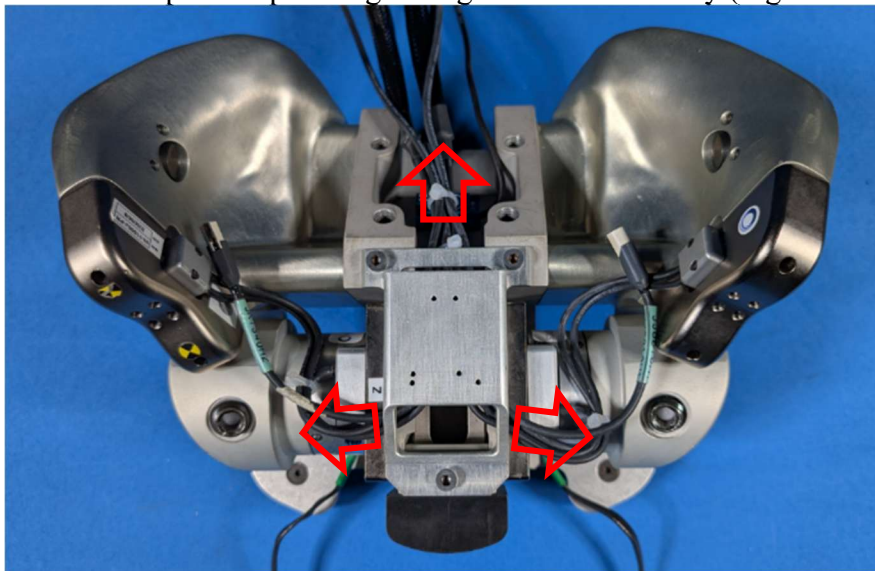


Figure 13-26. Pelvis cable cover installed with instrumentation routed through designated channels to prevent pinching

13.4.3.5 After installing the pelvis tilt sensor on the pelvic bone, route the existing instrumentation bundle to right side of the sensor (Left, Figure 13-27). Also route the wires from the upper-torso-to-pelvis adapter plate to the right-side exit of the pelvic bone (Right, Figure 13-27).

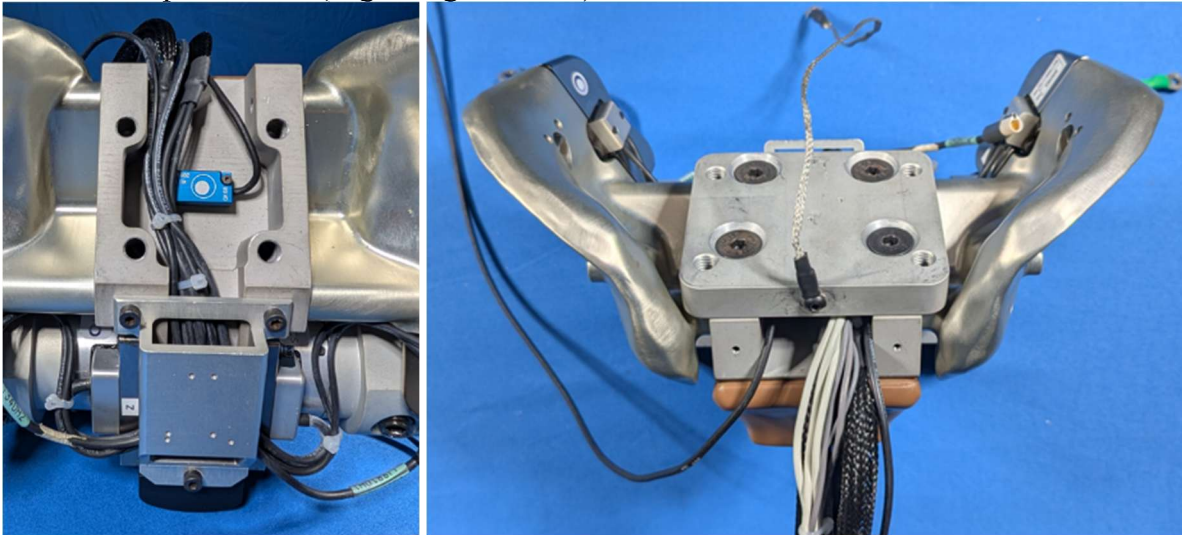


Figure 13-27. Pelvis tilt sensor installed with instrumentation bundle routed to the right side of the sensor

13.4.3.6 Take care to not pinch wires while installing the rear pelvic instrumentation cover (Figure 13-28).

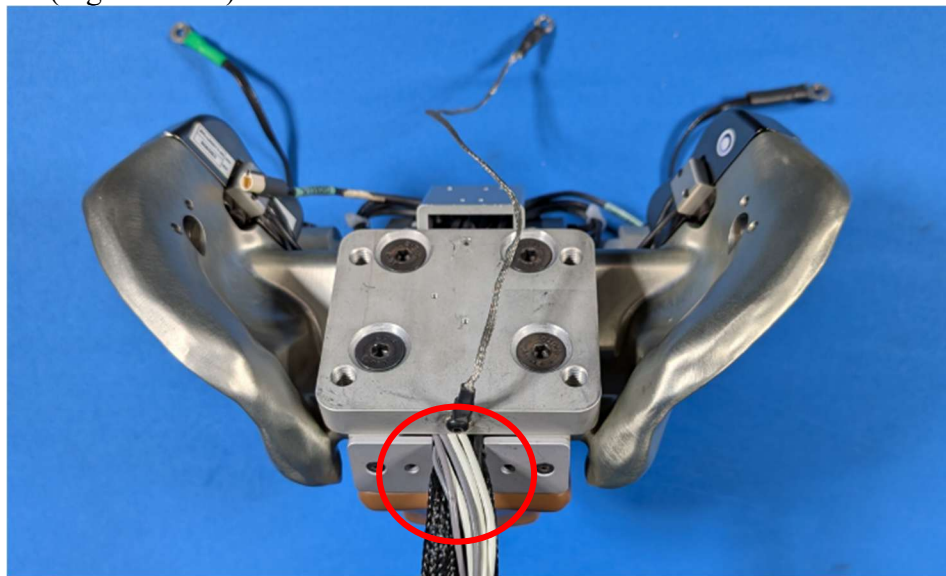


Figure 13-28. Rear pelvic instrumentation cover installed with proper wire clearance to prevent pinching

13.4.3.7 When installing the pelvis bone into the pelvis flesh, route the grounding cables through the femur holes (Figure 13-29) and thread the instrumentation bundle through the hole in the rear of the pelvis flesh (Figure 13-30). Route the tilt-sensor wire and grounding-strap cable along the inside of the pelvis flesh as illustrated (Figure 13-31).

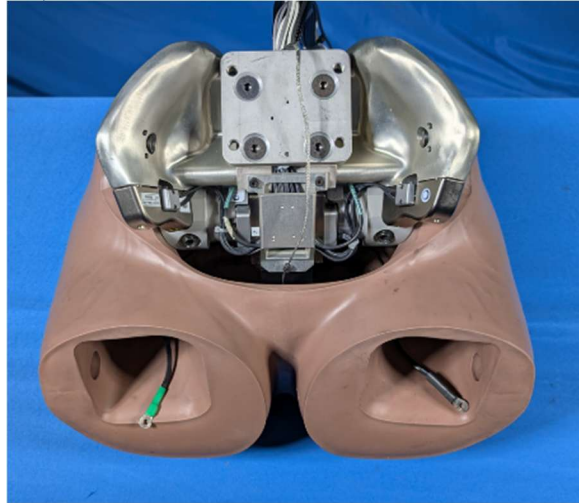


Figure 13-29. Grounding cables routed through femur holes during pelvic bone installation into pelvis flesh

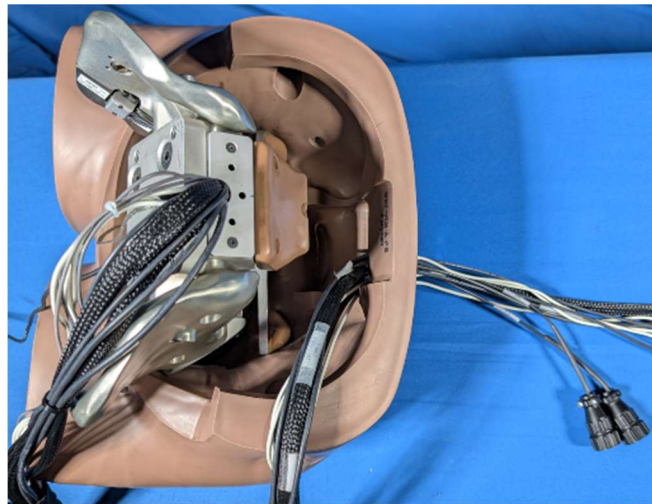


Figure 13-30. Instrumentation bundle threaded through rear pelvis-flesh hole before final seating of pelvis assembly

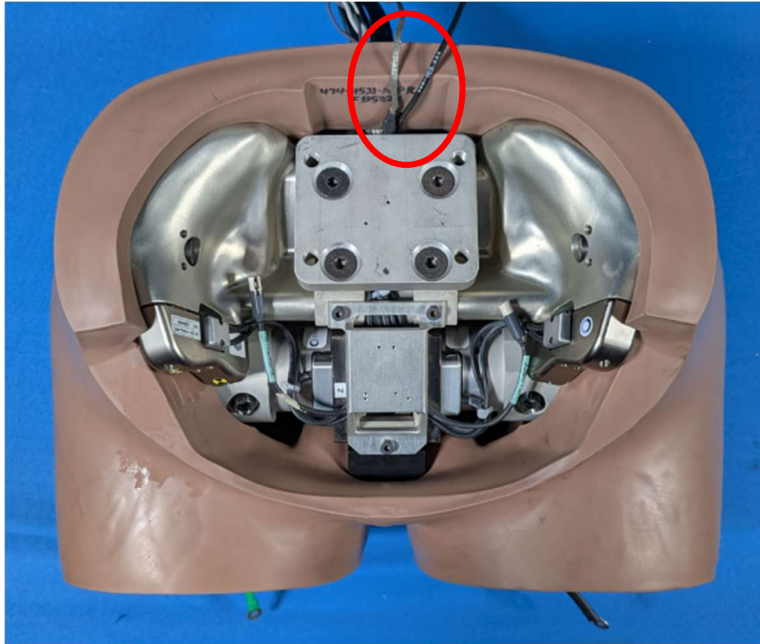


Figure 13-31. Tilt-sensor wire and grounding strap cable r

13.4.4 Leg Cable Routing (femur load cell, knee potentiometer, accelerometers, upper tibia load cell, lower tibia load cell, Achilles load cell, ARSs, ankle potentiometers, tilt sensor)

13.4.4.1 Route the ankle and leg instrumentation wires up the inside of the tibia, add tie wraps as necessary (Figure 13-32 and Figure 13-33).

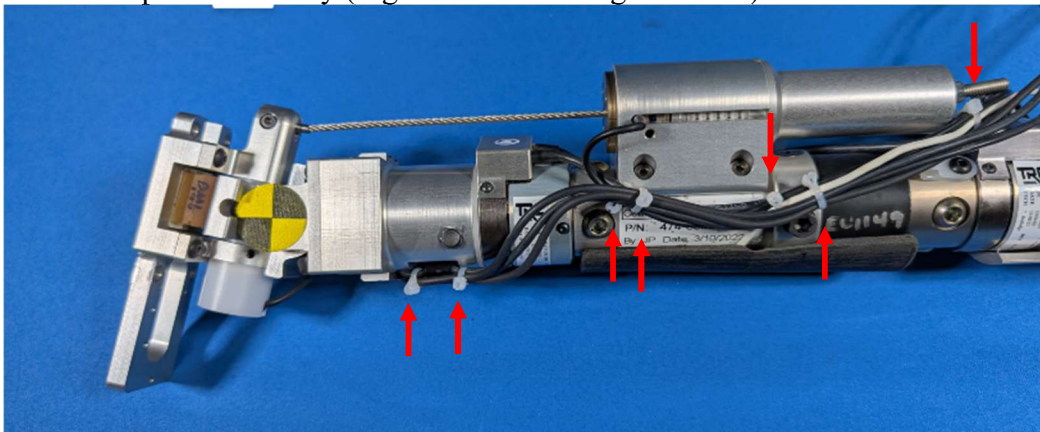


Figure 13-32. Tie-wrap locations for lower leg and ankle instrumentation (lateral view)

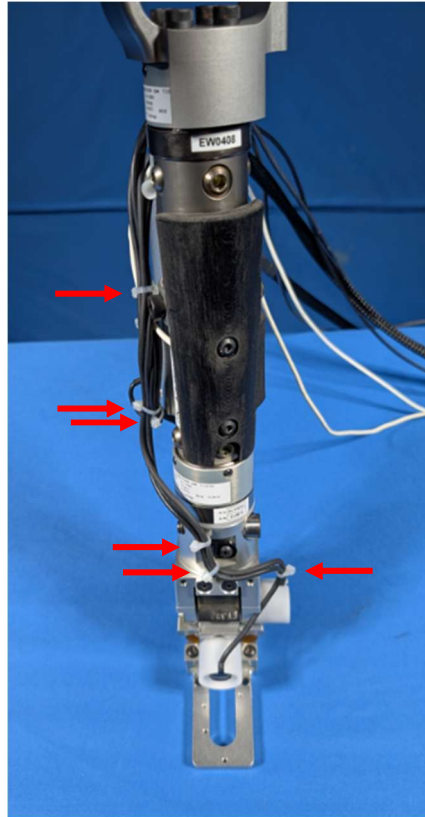


Figure 13-33. Tie wrap locations for lower leg and ankle instrumentation (frontal view)

13.4.4.2 Route the upper tibia load cell wires down and under the Achilles housing and strain relieve them to the rest of the lower leg instrumentation bundle with a tie wrap (Figure 13-34).

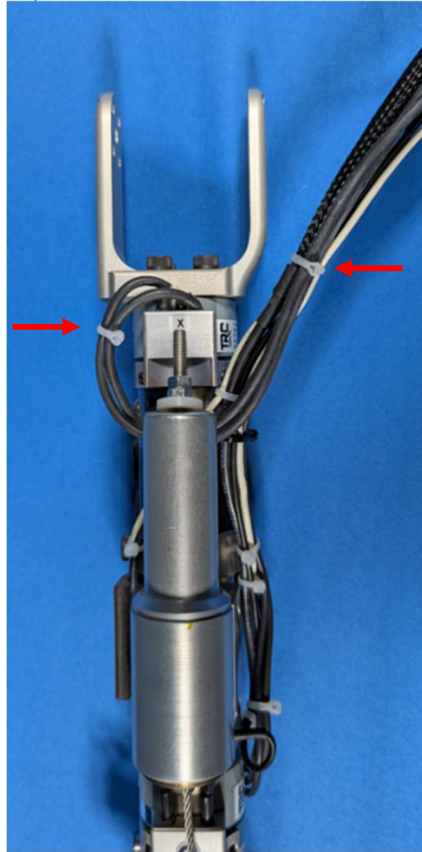


Figure 13-34. Upper tibia load cell wire routing and strain relief at the lower-leg bundle

13.4.4.3 After installing the 6 axis accel/ARS mount (474-5728-1,2) to the foot, gather the wiring from the instrumentation and bundle with tie-wraps, leaving enough slack so that the wires do not turn sharply from the base of each sensor and cause damage (Figure 13-35).

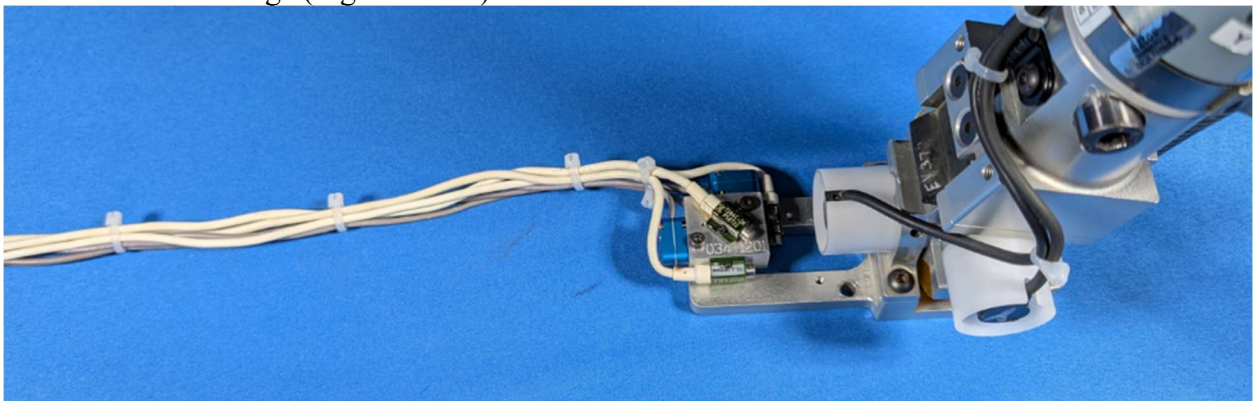


Figure 13-35. Foot instrumentation wiring slack and tie-wrap bundle at the 6-axis mount

13.4.4.4 Route the foot wiring up the outside of the ankle, then across the front of the lower tibia load cell and into the existing lateral lower-leg bundle. Secure with tie wraps as needed (Figure 13-36 and Figure 13-37).

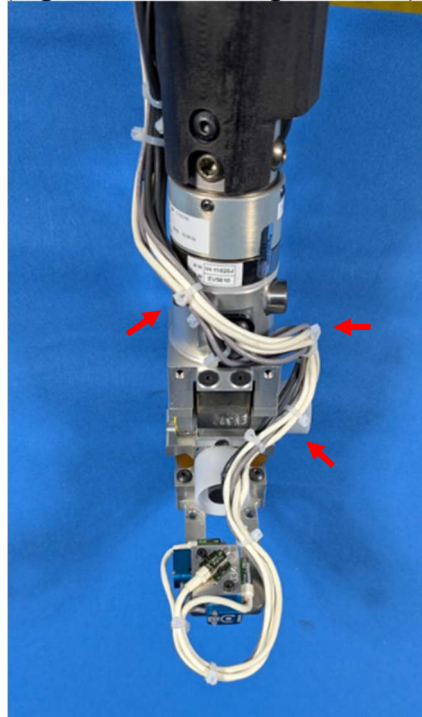


Figure 13-36. Foot wiring routed up the ankle and joined to the lateral lower-leg bundle (frontal view)

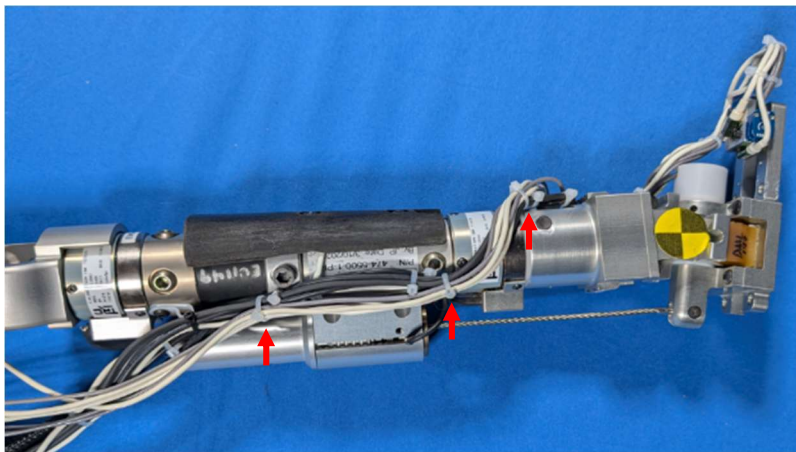


Figure 13-37. Foot wiring routed up the ankle and joined to the lateral lower-leg bundle (lateral view)

13.4.4.5 When installing the shoe, ensure the foot wire bundle is positioned out of the way to avoid pinching. After the shoe is installed, place the bundle along the outside of the X-axis potentiometer housing (Figure 13-38 and Figure 13-39).



Figure 13-38. Foot wire bundle clearance during shoe installation



Figure 13-39. Foot wire bundle clearance during shoe final placement

13.4.4.6 Install a tie wrap around the femur to strain relieve the femur load cell wires as shown in Figure 13-40. Add the knee slider wire to the previously established bundle and route these wires to the inside of the leg (Figure 13-41). When strain relieving the knee slider, ensure that the knee slider is in the fully extended position.

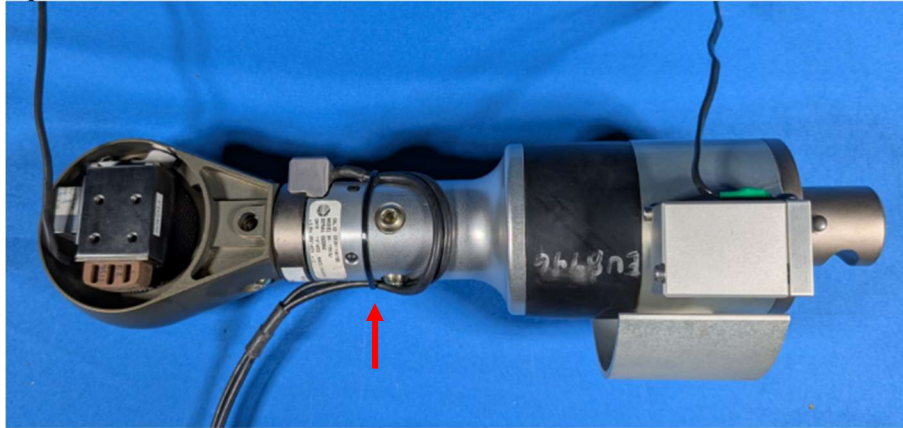


Figure 13-40. Femur load cell wire strain relief



Figure 13-41. Knee slider wiring added to bundle and routed inside the leg (slider fully extended)

13.4.4.7 After installing the knee and thigh flesh and the lower leg, join the upper leg bundle with the lower leg bundle (Figure 13-42Figure 13-43). Then install the lower leg flesh (). Ensure the lower-leg wire bundle exits at the back of the lower-leg flesh

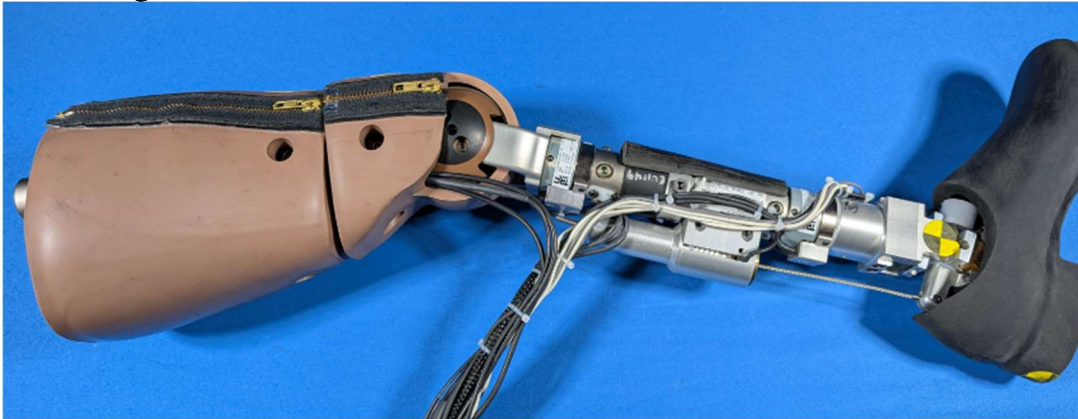


Figure 13-42. Upper and lower leg bundles combined



Figure 13-43. Lower-leg bundle rear exit path

13.4.5 Overall Cable Routing

- 13.4.5.1 Combine the thorax bundle with the pelvis bundle using a tie-wrap (Figure 13-44) to form the main “umbilical” cable.

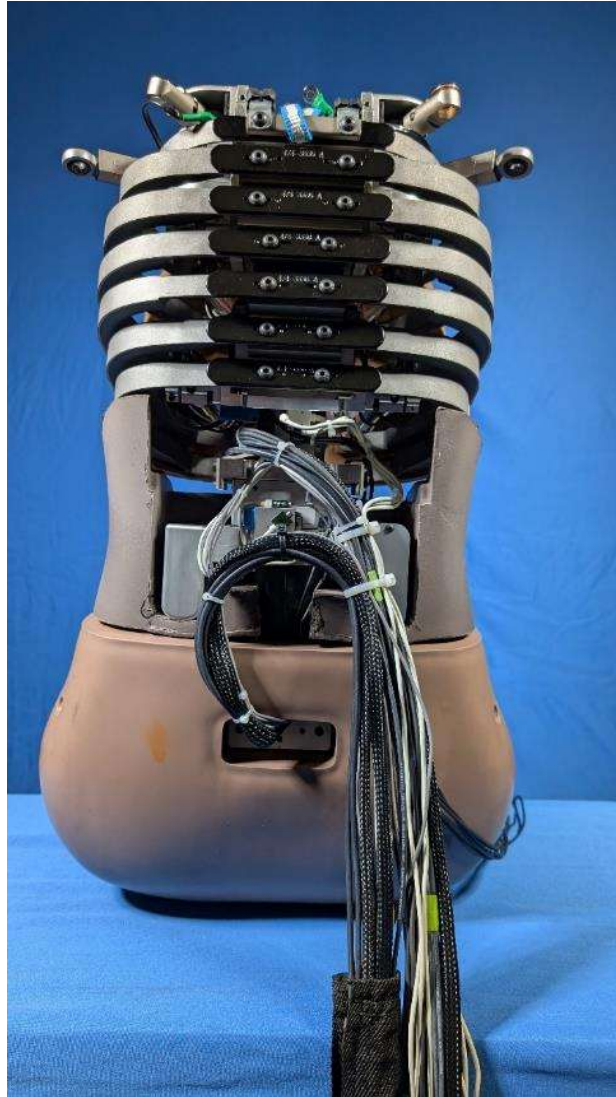


Figure 13-44. Tie the thorax and pelvis bundles together

13.4.5.2 To complete the umbilical cable, tie wrap the leg bundles into the bundle containing the thorax and pelvis wires.

13.4.5.3 Hold the wiring in the “umbilical” cable together using additional masking tape and/or tie-wraps (Figure 13-45).



Figure 13-45. Final bundling of the "umbilical" cable

13.5 THOR-05F Instrumentation Polarity Check

A polarity check should be conducted each time the THOR-05F is connected to a data acquisition system. Polarity checks are important because not all of the instrumentation in the THOR-05F is oriented, as installed, in accordance with SAE J211⁴. Furthermore, conducting a pre-test polarity check will rule out wiring errors to ensure proper data collection.

To conduct the polarity check, connect the instrumentation to the data acquisition system, ideally in the same plugin configuration used for the test series. Open a live view of the data channel in question (see the manual for your data acquisition system's interface software for more information). Apply the manipulation listed in the “Motion” column for each row in the Polarity Checklist table and observe the response (Table 13-5 through Table 13-11). If the response does not match the “SAE J211 Polarity” column, the channel must be inverted in your data acquisition system's software or test setup file. You might find it useful to print this section to facilitate this procedure.

The complexity of the 3D IR-TRACC assemblies in the thorax require a more detailed polarity check procedure (see Section 13.5.1).

⁴ SAE J211: Instrumentation for Impact Test Part 1 - Electronic Instrumentation, SAE Surface Vehicle Recommended Practice, August 2022.

Table 13-5. Head and Neck Polarity Check for THOR-05F

Instrument	Direction	Motion	SAE J211 Polarity	Recorded Polarity	Flip?
Head Accelerometers (CG)	Ax	Impact rear of head in forward direction	+		
	Ay	Impact left side of head in rightward direction	+		
	Az	Impact top of head in downward direction	+		
Head CG Angular Rate Sensor	ω_x	Rotate right ear toward right shoulder	+		
	ω_y	Rotate chin toward sternum	-		
	ω_z	Rotate chin toward right shoulder	+		
Upper Neck Load Cell	Fx	Move head rearward, chest forward	+		
	Fy	Move head leftward, chest rightward	+		
	Fz	Move head upward, chest downward	+		
	Mx	Rotate left ear toward left shoulder	+		
	My	Rotate chin toward sternum	+		
	Mz	Rotate chin toward left shoulder	+		
Lower Neck Load Cell	Fx	Move head rearward, chest forward	+		
	Fy	Move head leftward, chest rightward	+		
	Fz	Move head upward, chest downward	+		
	Mx	Rotate left ear toward left shoulder	+		
	My	Rotate chin toward sternum	+		
	Mz	Rotate chin toward left shoulder	+		
Front Neck Spring	Fz	Rotate head rearward	+		
Rear Neck Spring	Fz	Rotate chin toward chest	+		
O.C. Rotary Pot	θ_y	Rotate chin toward chest	-		
Face Load Cells	Fx	Hold back of head, push face rearward	-		

Table 13-6. Spine and Thorax Polarity Check for THOR-05F

Instrument	Direction	Motion	SAE J211 Polarity	Recorded Polarity	Flip?
T1 Accelerometer	Ax	Impact rear of thorax in forward direction	+		
	Ay	Impact left side of thorax in rightward direction	+		
	Az	Impact top of thorax in downward direction	+		
Mid Sternum Accelerometer	Ax	Impact rear of thorax in forward direction	+		
T6 Accelerometer (Chest CG)	Ax	Impact rear of thorax in forward direction	+		
	Ay	Impact left side of thorax in rightward direction	+		
	Az	Impact top of thorax in downward direction	+		
T12 Accelerometer	Ax	Impact rear of thorax in forward direction	+		
	Ay	Impact left side of thorax in rightward direction	+		
	Az	Impact top of thorax in downward direction	+		
T12 Load Cell	Fx	Move chest rearward, pelvis forward	+		
	Fy	Move chest leftward, pelvis rightward	+		
	Fz	Move chest upward, pelvis downward	+		
	Mx	Rotate left shoulder toward left hip	+		
	My	Rotate sternum towards front of legs	+		

Table 13-7. Abdomen Polarity Check for THOR-05F

Instrument	Direction	Motion	SAE J211 Polarity	Recorded Polarity	Flip?
Abdomen pressure sensor (APTS)	P	Compress abdomen	+		

Table 13-8. Pelvis Polarity Check for THOR-05F

Instrument	Direction	Motion	SAE J211 Polarity	Recorded Polarity	Flip?
Pelvis CG Accelerometer (tri-pack)	Ax	Impact rear of pelvis in forward direction	+		
	Ay	Impact left side of pelvis in rightward direction	+		
	Az	Impact top of pelvis in downward direction	+		
Pelvis CG ARS	ω_x	Move left leg upward and right leg downward	+		
	ω_y	Lift both legs up	+		
	ω_z	Move upper legs rightward	+		
L Acetabular LC	Fx	Move femur forward, pelvis rearward	-		
	Fy	Move femur rightward, pelvis leftward	-		
	Fz	Move femur upward, pelvis downward	+		
R Acetabular LC	Fx	Move femur forward, pelvis rearward	+		
	Fy	Move femur rightward, pelvis leftward	+		
	Fz	Move femur upward, pelvis downward	-		
L ASIS	Fx	Push towards back of pelvis	-		
	My	Push top of ASIS towards back of pelvis	+		
R ASIS	Fx	Push towards back of pelvis	-		
	My	Push top of ASIS towards back of pelvis	+		

Table 13-9. Femur Polarity Check for THOR-05F

Instrument	Direction	Motion	SAE J211 Polarity	Recorded Polarity	Flip?
Left Femur Load Cell	Fx	Move knee upward, upper femur downward	+		
	Fy	Move knee rightward, upper femur leftward	+		
	Fz	Move knee forward, femur rearward	+		
	Mx	Push knee leftward, hold upper femur	+		
	My	Push knee upward, hold upper femur	+		
	Mz	Rotate tibia leftward, hold pelvis	+		
Right Femur Load Cell	Fx	Move knee upward, upper femur downward	+		
	Fy	Move knee rightward, upper femur leftward	+		
	Fz	Move knee forward, femur rearward	+		
	Mx	Push knee leftward, hold upper femur	+		
	My	Push knee upward, hold upper femur	+		
	Mz	Rotate tibia leftward, hold pelvis	+		

Table 13-10. Left Lower Extremity Polarity Check for THOR-05F

Instrument	Direction	Motion	SAE J211 Polarity	Recorded Polarity	Flip?
Knee Shear Displacement	Dx	Hold femur, move tibia forward	+		
Upper Tibia Load Cell	Fx	Move tibia forward, knee rearward	+		
	Fy	Move tibia rightward, knee leftward	+		
	Fz	Move tibia downward, knee upward	+		
	Mx	Push tibia leftward, hold knee	+		
	My	Push tibia forward, hold knee	+		
Lower Tibia Load Cell	Fx	Move ankle forward, knee rearward	+		
	Fy	Move ankle rightward, knee leftward	+		
	Fz	Move ankle downward, knee upward	+		
	Mx	Push ankle leftward, hold knee	+		
	My	Push ankle forward, hold knee	+		
Tibia Accelerometer	Ax	Impact back of tibia in forward direction	+		
	Ay	Impact left of tibia in rightward direction	+		
Achilles Load Cell	Fz	Hold tibia, move toes upward	+		
Ankle Rotation	θ_x	Hold tibia, push right side of foot to the left	+		
	θ_y	Hold tibia, pull toe upward	+		
	θ_z	Hold tibia, push toe rightward	+		
Foot Acceleration	Ax	Impact back of foot in forward direction	+		
	Ay	Impact left of foot in rightward direction	+		
	Az	Impact top of foot in downward direction	+		

Table 13-11. Right Lower Extremity Polarity Check for THOR-05F

Instrument	Direction	Motion	SAE J211 Polarity	Recorded Polarity	Flip?
Knee Shear Displacement	Dx	Hold femur, move tibia forward	+		
Upper Tibia Load Cell	Fx	Move tibia forward, knee rearward	+		
	Fy	Move tibia rightward, knee leftward	+		
	Fz	Move tibia downward, knee upward	+		
	Mx	Push tibia leftward, hold knee	+		
	My	Push tibia forward, hold knee	+		
Lower Tibia Load Cell	Fx	Move ankle forward, knee rearward	+		
	Fy	Move ankle rightward, knee leftward	+		
	Fz	Move ankle downward, knee upward	+		
	Mx	Push ankle leftward, hold knee	+		
	My	Push ankle forward, hold knee	+		
Tibia Accelerometer	Ax	Impact back of tibia in forward direction	+		
	Ay	Impact left of tibia in rightward direction	+		
Achilles Load Cell	Fz	Hold tibia, move toes upward	+		
Ankle Rotation	θ_x	Hold tibia, push right side of foot to the left	+		
	θ_y	Hold tibia, pull toe upward	+		
	θ_z	Hold tibia, push toe rightward	+		
Foot Acceleration	Ax	Impact back of foot in forward direction	+		
	Ay	Impact left of foot in rightward direction	+		
	Az	Impact top of foot in downward direction	+		

13.5.1 IR-TRACC Polarity

In order to reduce the risk of damage to instrumentation, do not disconnect the 3D IR-TRACC units from the rib cage to conduct the polarity tests. This Section describes an alternate procedure for checking the 3D IR-TRACC polarity. Note that due to the use of a standardized IR-TRACC setup fixture to determine potentiometer offsets, the polarity of the rotational potentiometers in the IR-TRACC assemblies as installed in the THOR-05F will not correspond with SAE J211 polarity. Instead, potentiometer polarities will match those measured as installed in the *THOR 3D IR-TRACC Setup Fixture*, which in turn match the inherent polarity of the potentiometers. The expected polarities are for the thorax are shown in Figure 13-46.

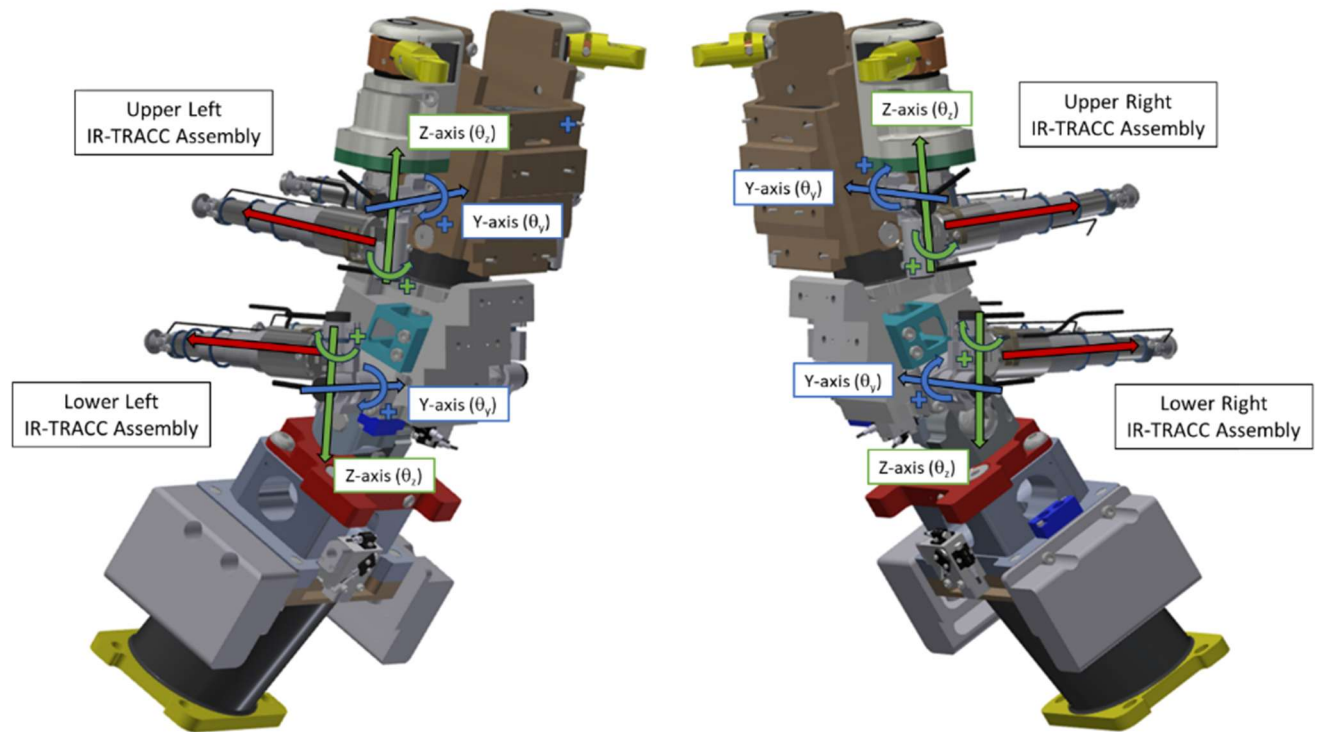


Figure 13-46. Sign conventions for 3D IR-TRACCs installed in THOR-05F thorax

13.5.1.1 Using the data acquisition system control software, open a live view of each channel. If possible, view the DX, RY, and RZ components of a given quadrant simultaneously.

13.5.1.2 Record the initial reading of each channel

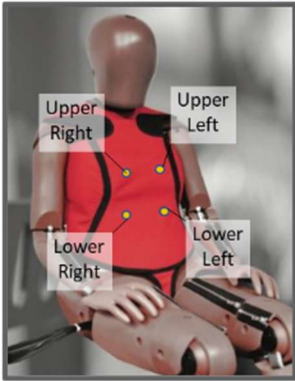
13.5.1.3 Perform the following motions on each of the four thoracic rib attachment locations (Table 13-12).

Table 13-12. Polarity Manipulations for 3D IR-TRACC Assemblies

Location	Instrumentation	Motion
DX	IR-TRACC	Push inward (front-to-back)
RY	Rotational potentiometer	Push downward (head-to-pelvis)
RZ	Rotational potentiometer	Push rightward (left-to-right)

- 13.5.1.4 Record the final reading of each channel Table 13-13.
- 13.5.1.5 If the final reading represents an increase from the initial reading, record “Increase” in the box to the right. If the final reading represents a decrease from the initial reading, record “Decrease” in the box to the right.
- 13.5.1.6 If the “Measured” value (increase or decrease) does not match the “Expected” value, invert the polarity of the channel.

Table 13-13. Polarity Manipulation Results for Thoracic 3D IR-TRACCs

				<i>Note that due to the use of a standardized IR-TRACC setup fixture to determine potentiometer offsets, the polarity of the rotational potentiometers in the IR-TRACC assemblies as installed in the THOR-05F will not necessarily correspond with SAE J211 polarity.</i>			
UR				UL			
Channel	Initial	Final	Measured Expected	Channel	Initial	Final	Measured Expected
DX (V)			Increase	DX (V)			Increase
RY (Deg)			Increase	RY (Deg)			Decrease
RZ (Deg)			Decrease	RZ (Deg)			Decrease
LR				LL			
Channel	Initial	Final	Measured Expected	Channel	Initial	Final	Measured Expected
DX (V)			Increase	DX (V)			Increase
RY (Deg)			Increase	RY (Deg)			Decrease
RZ (Deg)			Increase	RZ (Deg)			Increase

13.6 Tilt Sensors and Readout Display

Tilt sensors mounted to the head, lower neck, T6, T12, and pelvis provide a complete orientation of the dummy's posture in static (pre- or post-test) mode. Connect the tilt sensors to a digital device such as a laptop, etc. with the tilt sensor software installed, via the interface, which accepts the signals from the five tilt sensors. The serial number, ID, and calibration information for each tilt sensor are stored in the software in order to display the appropriate angles.

Section 14. IR-TRACC Calibration Overview

This Section describes the calibration procedures for the chest deflection instrumentation of the THOR-05F. Prior to installation in the dummy, each 3D IR-TRACC assembly must be calibrated. Each of the three sensors (IR-TRACC and two rotary potentiometers) are calibrated separately. The entire assembly is then installed into the 3D IR-TRACC Setup Fixture to zero the rotary potentiometers and determine the initial offset values.

The THOR-05F chest deflection measurement uses an IR-TRACC and two rotary potentiometers (Y-axis and Z-axis) installed in a double-gimbaled assembly to measure IR-TRACC compression and IR-TRACC Y-axis and Z-axis rotations (Figure 14-1). Post-test processing of these three measurements can then be used to calculate X-axis, Y-axis and Z-axis displacement of the pivoting end of the IR-TRACC. The gimbaled end of the assembly attaches to the spine and the pivoting end of the IR-TRACC attaches to the component to be measured. Four of these IR-TRACC assemblies are used in the THOR-05F dummy including two in the upper thorax (left and right) and two in the lower thorax (left and right).

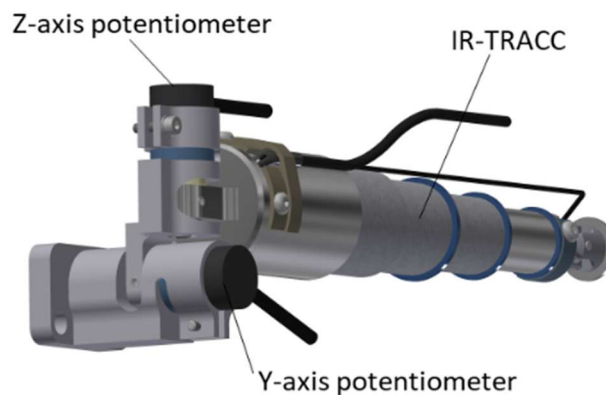


Figure 14-1. THOR-05F 3D IR-TRACC assembly

Before the 3D IR-TRACC assembly can be used in a dummy, it must be disassembled so that the three transducers (IR-TRACC, Y-axis rotary potentiometer and Z-axis rotary potentiometer) can be individually calibrated. The rotary potentiometers are each calibrated in a rotary potentiometer calibration fixture to determine their sensitivity in engineering units (mV/V°). The IR-TRACC is calibrated in a linear displacement calibration fixture to determine the relationship between output voltage and compression distance. Since the IR-TRACC operates according to the inverse-square law where the intensity of light at the receiver end of the IR-TRACC is inversely proportional to the square of the distance from the light source end of the IR-TRACC, the relationship between output voltage and IR-TRACC compression distance will be non-linear. Therefore, the IR-TRACC output voltage must first be linearized using a linearization exponent before the IR-TRACC sensitivity (mm/V) can be calculated. The IR-TRACC calibration process includes the following steps:

1. Record IR-TRACC voltage output vs. compression distance in a linear displacement calibration fixture.
2. Determine the *optimized linearization exponent* that best linearizes the IR-TRACC voltage output vs. IR-TRACC compression distance relationship (Step 14.2.2.4).
3. Calculate the IR-TRACC sensitivity (mm/V).

After calibrating the transducers, they are re-assembled into the 3D double-gimbaled assembly. Before the assembly can be installed in the dummy, it must be installed in the *THOR 3D IR-TRACC Setup Fixture* to determine reference (intercept) values. These intercept values account for the geometry and orientation of the sensors in their as-installed configuration and allow calculation of the absolute 3D position of the anterior attachment point in the local spine coordinate system. The IR-TRACC intercept converts the measured compression to a pivot-to-pivot length (Figure 14-2) and the Y-axis and Z-axis rotational potentiometer intercepts zero the measured angles when the assembly is oriented such that the pivot-to-pivot measurement is parallel to the X-axis of the local spine coordinate system (Figure 14-3) for the upper spine coordinate system).

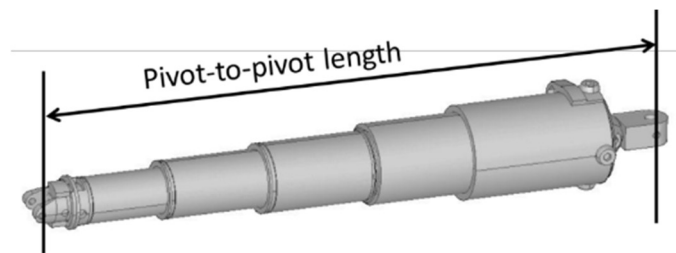


Figure 14-2. Pivot-to-pivot length of IR-TRACC sensor

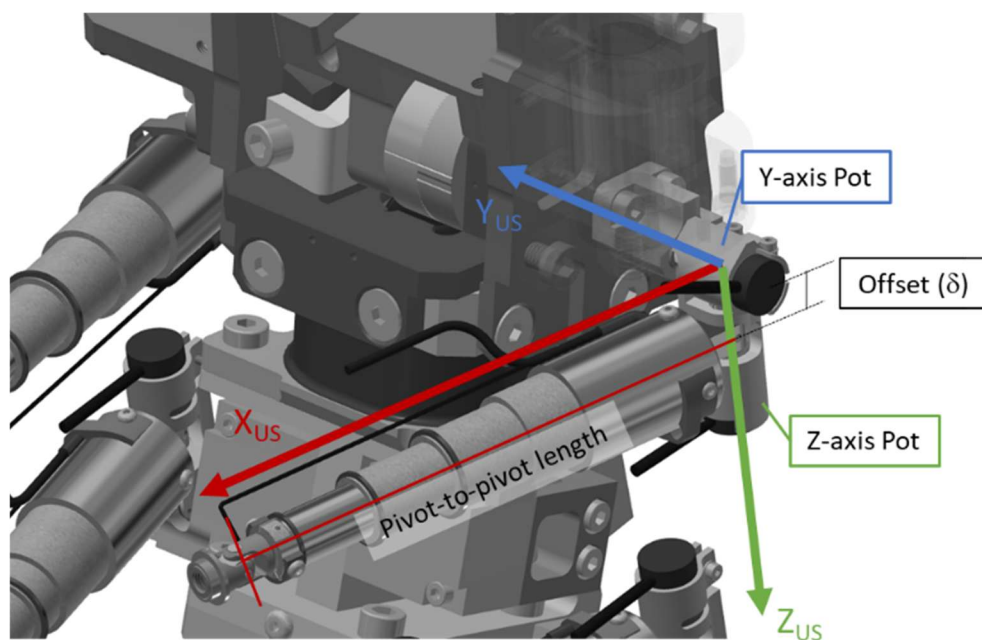


Figure 14-3. Orientation of IR-TRACC assembly parallel to local spine coordinate system

These intercepts, along with IR-TRACC calibration parameters, are documented on the “THOR 3D IR-TRACC Calibration Summary Sheet” (Figure 14-15). These values are then used in conjunction with the equations in Section 15, to output 3D position time-histories of thoracic and abdominal deflection in the local spine coordinate system.

14.1 Instrument Wiring

A consistent transducer wiring scheme is required to maintain standardized 3D IR-TRACC assembly polarities. Polarity checks should still be performed prior to testing to verify expected data channel polarities (see Section).

14.1.1 Potentiometer Wiring

The Y-axis and Z-axis potentiometers are wired so that a counter-clockwise rotation of the potentiometer shaft (looking from the shaft end of the potentiometer) produces a more positive voltage output. Completion resistors are added to the potentiometer so that it operates as a full-bridge transducer. A schematic diagram is shown in Figure 14-4. The wiring pin-outs for the IR-TRACC are included in Table 14-1.

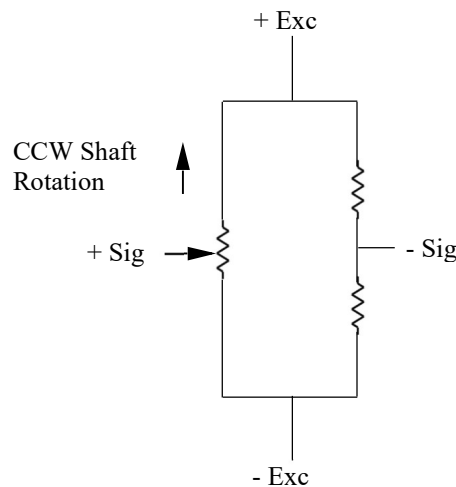


Figure 14-4. Potentiometer wiring schematic

Table 14-1. Potentiometer Wiring Pin-Outs

Wire Color	Pin
Red	+Excitation
Green	+Signal
Orange	Channel ID
Shield	Ground
White	-Signal
Black	-Excitation

14.1.2 IR-TRACC Wiring

The IR-TRACC is wired and powered according to the manufacturer's instructions. The IR-TRACC un-scaled and non-linearized output should be a positive voltage that increases as the IR-TRACC is compressed. The wiring pin-outs for the IR-TRACC are included in Table 14-2.

Table 14-2. IR-TRACC Wiring Pin-Outs	
Wire Color	Pin
Red	+Excitation
Green	+Signal
Orange	Channel ID
Shield	Ground
White	-Signal
Black	-Excitation

14.2 Transducer Calibration

14.2.1 Potentiometer Calibration

14.2.1.1 Remove the potentiometer from the double-gimbaled assembly and install it into the rotary potentiometer calibration fixture. A typical rotary potentiometer calibration fixture is shown in Figure 14-5.

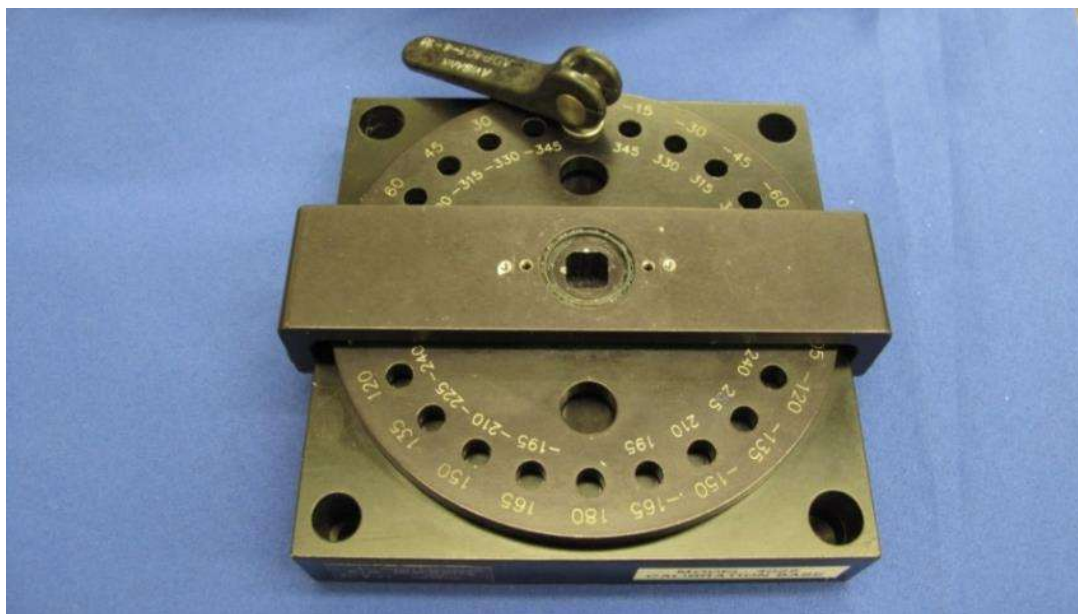


Figure 14-5. Example potentiometer calibration fixture

- 14.2.1.2 Set the calibrator to the 0° position. Before the potentiometer is fastened into the fixture, rotate the shaft until the potentiometer output voltage is approximately 0 volts so that the potentiometer is near mid-range. Fasten the potentiometer body and shaft into the fixture in this position.
- 14.2.1.3 Record the potentiometer output voltage at 15° increments from -75° to +75°. Calculate the slope (Potentiometer Sensitivity) of the potentiometer output voltage vs. potentiometer rotation angle using a linear regression function. Using the results of the linear regression function and the recorded calibration voltages, calculate the angle at each of the calibration positions. Determine the non-linearity error as a percentage of the full-scale range. Refer to SA572-S114 for performance requirements. An example rotary potentiometer calibration summary is shown in Figure 14-6.
- 14.2.1.4 Repeat this procedure for both potentiometers and then re-install them into the 3D IR-TRACC assembly. Before tightening the potentiometer shaft set-screw, see the assembly Section for the IR-TRACC location, for potentiometer shaft positioning instructions.

NHTSA Vehicle Research and Test Center

Rotary Potentiometer Calibration

Model Number: PD210-4B
Serial Number: DG5916
Technician: R. Waldeck

Date: 11/7/2013
Temperature: 71 F
Humidity: 50 %
Excitation: 10 V

$$\frac{|Rotation - Calculated Rotation|}{Range (150)} \times 100$$

Rotation (Degrees)	Sensor Output (V)	Sensor Output Zeroed (V)	Calculated Rotation (Degrees)	% F.S. Error
-75	-2.3360	-2.3019	-75.2	0.14
-60	-1.8834	-1.8493	-60.4	0.28
-45	-1.4202	-1.3861	-45.3	0.19
-30	-0.9465	-0.9124	-29.8	0.12
-15	-0.4875	-0.4534	-14.8	0.12
0	-0.0341	0.0000	0.0	0.00
15	0.4187	0.4528	14.8	0.14
30	0.8707	0.9048	29.6	0.29
45	1.3304	1.3645	44.6	0.28
60	1.7953	1.8294	59.8	0.15
75	2.2619	2.2960	75.0	0.02

Sensor Output
- Sensor Output @ 0 degrees

Sensor Output Zeroed $\times$ 1000
Sensitivity $\times$ Excitation

Max. Linearity Error (Max. Allowable is .5 %): 0.29 %

Sensitivity: 3.0604 mV/V/deg

Approved By: _____

Figure 14-6. Example rotary potentiometer calibration sheet

14.2.2 IR-TRACC Calibration

- 14.2.2.1 Remove the IR-TRACC from the double-gimbaled assembly and install it into a linear displacement calibration fixture DL472-6000 as shown in Figure 14-7 .

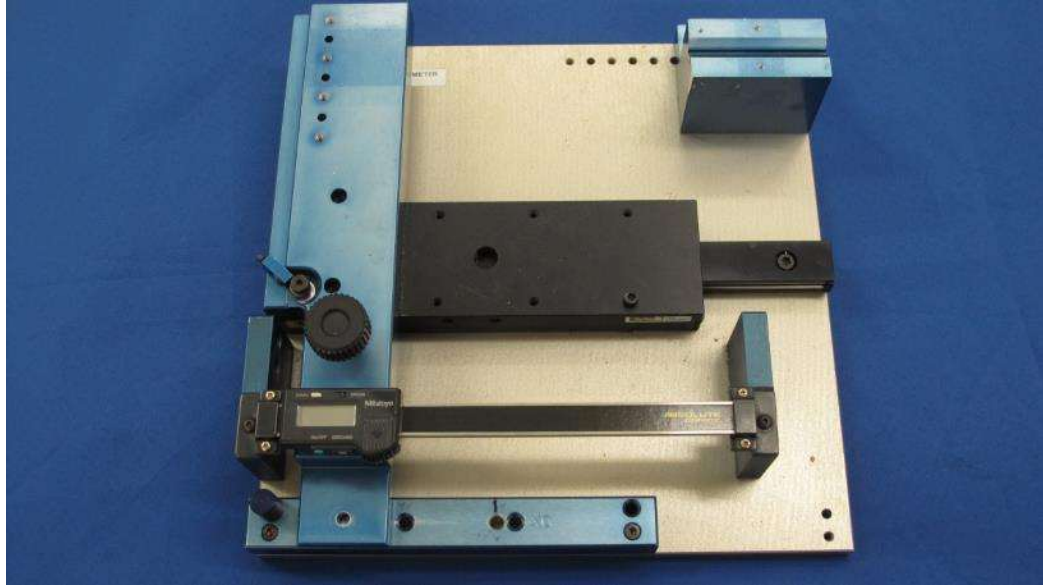


Figure 14-7. Linear Displacement Calibration Fixture

- 14.2.2.2 Fully extend the IR-TRACC and zero the measurement reference at the fully extended position. Compress the IR-TRACC to 5 mm. The 5 mm position will be the first calibration data point. Record the IR-TRACC voltage output in this position.
- 14.2.2.3 Record the IR-TRACC output voltage at 5 mm increments until it is fully compressed (87 mm for thorax IR-TRACCs and 117 mm for abdomen IR-TRACCs).
- 14.2.2.4 Calculate the linearization exponent and sensitivity that minimize the error between the actual value and the value measured by the IR-TRACC. Refer to instrumentation drawings (SA572-S117 for thorax IR-TRACCs or SA572-121 for abdomen IR-TRACCs) or manufacturer's instructions for allowable linearity and full-scale error requirements. See Table 14-3 for more information. An example rotary IR-TRACC calibration sheet is shown in Figure 14-8.
- 14.2.2.5 Re-install the IR-TRACC into the 3D IR-TRACC assembly.

Table 14-3. IR-TRACC calibration process details

Parameter	Description	Calculation
IR-TRACC Calibration		
IR-TRACC Known Displacement (mm)	Known displacement (compression) of IR-TRACC tube as measured by fixture or caliper. The origin of displacement occurs when the IR-TRACC tube is fully-extended	D_{known}
IR-TRACC Output (V)	Voltage measured from the IR-TRACC	V_{IR}
Linearization Exponent	Exponent which minimizes full-scale error. Minimum value is -0.500 based on inverse square law.	LE
Linearized Output (V)	Voltage calculated by raising the sensor output to the power of the linearization exponent	$V_L = (V_{IR})^{LE}$
IR-TRACC Calibration Slope (V/mm) & Intercept (V)	Linear Regression of V_L vs. D_{known} calculated using the LE which minimizes full-scale error	S_{cal} I_{cal}
IR-TRACC Sensitivity (mm/V)	Inverse of the IR-TRACC slope	$IR_{sens} = -\frac{1}{S_{cal}}$
IR-TRACC Calculated Displacement (mm)	Displacement (compression) of IR-TRACC tube calculated using the IR-TRACC calibration slope and intercept	$D_{IR} = \frac{V_L - I_{cal}}{S_{cal}}$
% F.S. Error	Error between calculated displacement and known displacement, expressed as a percentage of full measurement (75 mm for IR-TRACCs)	$\% F.S. Error = \frac{ D_{known} - D_{IR} }{75mm} \times 100\%$
Offsets From Reference Fixture		
IR-TRACC Absolute Intercept (mm)	Calculated offset such that when IR-TRACC assembly is in Position #1 in <i>THOR 3D IR-TRACC Setup Fixture</i> , D_{abs} equals the known fixture length (115.0 mm for thorax IR-TRACC)	$I_{abs} = 115.0 - IR_{sens} * (V_{IR @ P1})^{LE}$
Y-axis Potentiometer Intercept (deg)	Calculated offset such that when IR-TRACC assembly is in Position #1 in <i>THOR 3D IR-TRACC Setup Fixture</i> , Y-axis potentiometer angle equals zero	$I_Y = \frac{-Y_{meas@P1}}{Y_{sens} \times Y_{excitation}}$
Z-axis Potentiometer Intercept (deg)	Calculated offset such that when IR-TRACC assembly is in Position #1 in <i>THOR 3D IR-TRACC Setup Fixture</i> , Z-axis potentiometer angle equals zero	$I_Z = \frac{-Z_{meas@P1}}{Z_{sens} \times Z_{excitation}}$
Post-Test Processing Software		
Non-coincident potentiometer correction	Where the Y-axis and Z-axis potentiometers are not coincident an offset correction must be applied to the coordinate systems.	Upper thorax 3D IR-TRACC (δ) = -18.71 mm Lower thorax 3D IR-TRACC (δ) = 15.40 mm
IR-TRACC absolute compression	The absolute distance from the center pin of the universal joint at the anterior attachment point to the intersection of the IR-TRACC tube with the Z-axis potentiometer (see Figure 14-2)	$r_t = V_L \times IR_{sens} + I_{abs}$
Absolute Position (mm)	Resulting position of the anterior attachment point of the IR-TRACC assembly with respect to the intersection between the Z-axis and Y-axis potentiometers in the local spine coordinate system; example shown for lower left thorax IR-TRACC assembly.	$X_{abs} = r_t * \cos([\theta_Z + I_Z]) * \cos([\theta_Y + I_Y]) + \delta$ $\quad \quad \quad * \sin([\theta_Y + I_Y])$ $Y_{abs} = r_t * \sin([\theta_Z + I_Z])$ $Z_{abs} = -r_t * \cos([\theta_Z + I_Z]) * \sin([\theta_Y + I_Y])$ $\quad \quad \quad + \delta * \cos([\theta_Y + I_Y])$

NHTSA Vehicle Research and Test Center

IR-TRACC Calibration

Model Number:
Serial Number:
Technician:

Date: 02/01/2024
Temperature: 21.2° C
Humidity: 34%
Excitation: 5.0 V

$$\% F.S. Error = \frac{|D_{known} - D_{IR}|}{75mm} \times 100\%$$

Displacement (mm) D_{known}	Sensor Output (V) V_{IR}	Linearized Output (V) V_L	Calculated Displacement (mm) D_{IR}	% F.S. Error
0	0.0618	3.5146	0.3604	0.48
5	0.0687	3.3506	5.1495	0.20
10	0.0769	3.1835	10.0274	0.04
15	0.0868	3.0153	14.9392	-0.08
20	0.0985	2.8481	19.8229	-0.24
25	0.1129	2.6777	24.7965	-0.27
30	0.1307	2.5061	29.8065	-0.26
35	0.1532	2.3326	34.8728	-0.17
40	0.1811	2.1631	39.8233	-0.24
45	0.2178	1.9902	44.8728	-0.17
50	0.2667	1.8160	49.9572	-0.06
55	0.3337	1.6415	55.0547	0.07
60	0.4288	1.4657	60.1878	0.25
65	0.5693	1.2896	65.3288	0.44
70	0.7838	1.1163	70.3893	0.52
75	1.0656	0.9717	74.6107	-0.52

$$V_L = (V_{IR})^{LE}$$

$$D_{IR} = \frac{V_L - I_{cal}}{S_{cal}}$$

Max. Linearity Error (Max. Allowable is 2%): 0.52 %

Sensitivity (S_{IR}): 29.1994 mm/V

Linearization Exponent (LE): -0.45150

Approved By: _____

Figure 14-8. Example IR-TRACC calibration sheet

14.3 Measuring 3D IR-TRACC Assembly Reference (Intercept) Values

After the potentiometers and the IR-TRACC are calibrated using the procedures described in Section 14.2.1, Potentiometer Calibration, and Section 14.2.2, IR-TRACC Calibration, the 3D double-gimbaled assembly is installed in the *THOR 3D IR-TRACC Setup Fixture* (474-6000), as shown in Figure 14-9 and Figure 14-10, to obtain intercept values, verify calibration/setup parameters and to check sensor wiring polarities. The setup fixture uses both sides of the base plate to accommodate all four of the THOR-05F 3D IR-TRACC positions. The top side of the plate is used for the upper right thorax and lower left thorax 3D IR-TRACC assemblies and the bottom side is used for upper left thorax and lower right thorax (see Figure 14-9 and Figure 14-10, respectively).

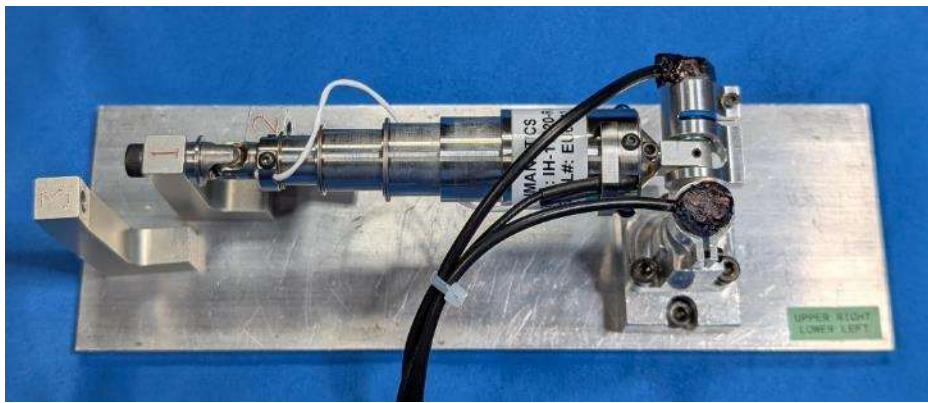


Figure 14-9. THOR-05F 3D IR-TRACC setup fixture for upper right and lower left

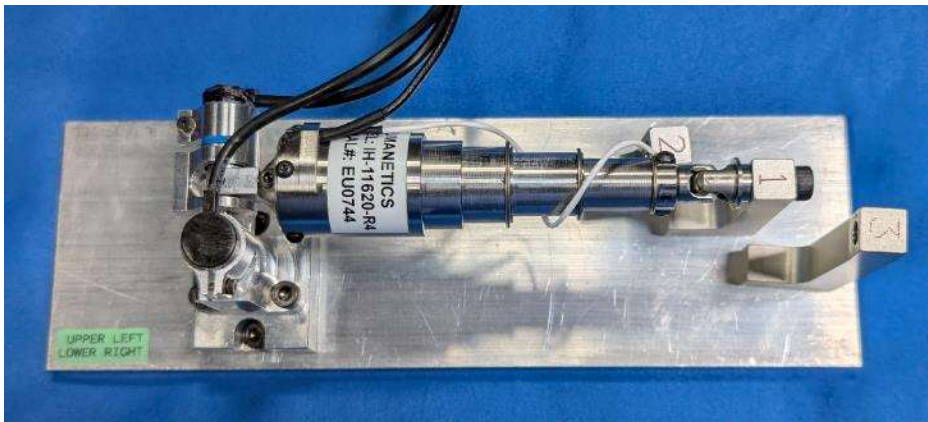


Figure 14-10. THOR-05F 3D IR-TRACC setup fixture for upper left and lower right

Figure 14-11 through Figure 14-14 below show each of the four THOR-05F 3D IR-TRACC assembly types installed in the setup fixture. All of the setup fixture posts and spacers use dowel pins with unique spacing to ensure that they can be installed only in the correct location and orientation.

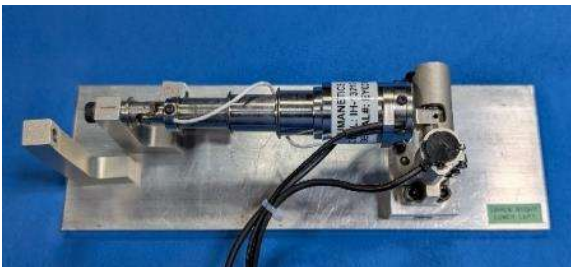


Figure 14-11. Upper right thorax

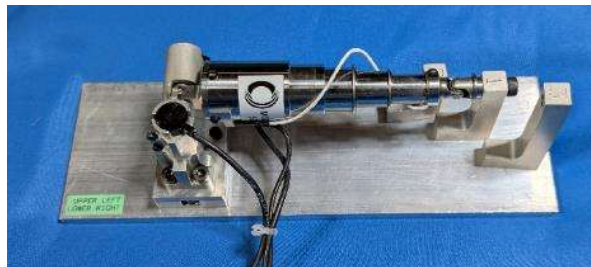


Figure 14-12. Upper left thorax



Figure 14-13. Lower right thorax

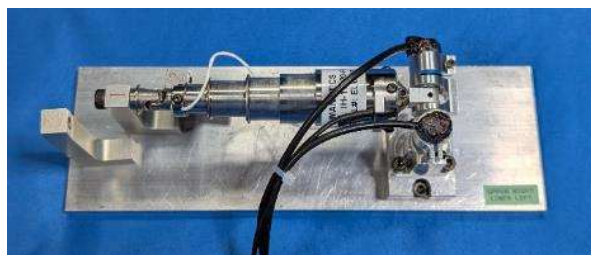


Figure 14-14. Lower left thorax

After the 3D IR-TRACC assembly is installed in the setup fixture, the *THOR 3D IR-TRACC Calibration Summary* spreadsheet, shown in Figure 14-15, can be used to record all required information. The spreadsheet fields that require user input are shaded in blue. The information fields for **3D IR-TRACC Location in THOR** use drop-down menus to provide all applicable field entry choices. The information fields in the **Calibration Factors** section can be copied from the individual sensor calibration sheets obtained in Sections 14.2.1 and 14.2.2 (see Figure 14-6 and Figure 14-8). The sensor output voltages are recorded in the **THOR 3D IR-TRACC Setup Fixture Calibration** section of the spreadsheet. First, place the IR-TRACC in Position 1 on the fixture and record the IR-TRACC and potentiometer output voltages in the appropriate spreadsheet fields (Figure 14-16). Repeat this process in Position 2 and Position 3 of the fixture. Using the sensor calibration factors, the spreadsheet will calculate the sensor output in engineering units. These outputs will be compared with expected outputs based on sensor location and a pass/fail indication will be shown. The expected outputs for each 3D IR-TRACC assembly in each position on the fixture is shown in Table 14-4.

A failing test could result from a scaling error or an incorrect polarity. If the calculated engineering output has the correct sign but incorrect magnitude, check the sensitivity and excitation voltage being used. If the calculated engineering output has the correct magnitude, but incorrect sign, check the sensor wiring for possible polarity issues. Note that the *THOR 3D IR-TRACC Calibration Summary* spreadsheet polarity check only checks the sensor for correct wiring. Depending on the location of the 3D IR-TRACC assembly within the THOR-05F dummy, some sensors will require a polarity change to conform to SAE J1733 polarity requirements (Section 13.5.1).

The **Processing Software Setup Values** section of the *THOR 3D IR-TRACC Calibration Summary* spreadsheet contains all of the information that is required for post-test processing software. Using the equations in Section 15, 3D position time-histories of thoracic and abdominal deflection in the local spine coordinate system can be calculated.

14.4 Calibration Summary

1. Remove the potentiometers and IR-TRACC from the 3D assembly
2. Calibrate both potentiometers
3. Calibrate the IR-TRACC
4. Re-install the potentiometers and IR-TRACC into the assembly
5. Install 3D assembly into the *THOR 3D IR-TRACC Setup Fixture*
6. Record information in the *THOR 3D IR-TRACC Calibration Summary* spreadsheet to verify sensitivities, polarities and to obtain intercept (setup) values.

THOR 3D IR-TRACC Calibration Summary

Date	
Technician	

3D IR-TRACC Location in THOR	
Left or Right Side	Left
Upper or Lower (n/a for Abdomen)	Upper
Thorax or Abdomen	Thorax

|IR_{sens}|

LE

Calibration Factors					
IR-TRACC Model Number		Y Pot Model Number		Z Pot Model Number	
IR-TRACC Serial Number		Y Pot Serial Number		Z Pot Serial Number	
IR-TRACC Excitation	5	Y Pot Excitation (V)	5	Z Pot Excitation (V)	5
IR-TRACC Sensitivity (mm/V)	29.6587	Y Pot Sensitivity (mV/V/°)	3.0369	Z Pot Sensitivity (mV/V/°)	3.0461
IR-TRACC Exponent	-0.4981				

$(V_{IR@Pn})^{LE} * |IR_{sens}| - (V_{IR@P1})^{LE} * |IR_{sens}|$

$(V_{Y@Pn} - V_{Y@P1}) / (Y_{sens} * Y_{Vex} / 1000)$

$(V_{Z@Pn} - V_{Z@P1}) / (Z_{sens} * Z_{Vex} / 1000)$

Where:

P_n is the fixture position number

V_{Y@Pn} is the output voltage of Y-potentiometer at the designated fixture position

Y_{sens} is the sensitivity of the Y-potentiometer

Y_{Vex} is the excitation Voltage of the Y-potentiometer

Z_{sens} is the sensitivity of the Z-potentiometer

Z_{Vex} is the excitation Voltage of the Z-potentiometer

V_{Z@Pn} is the output voltage of Z-potentiometer at the designated fixture position

THOR 3D IR-TRACC Setup Fixture Calibration												
Fixture Position	IR-TRACC				Y-Axis Potentiometer				Z-Axis Potentiometer			
	Out (V)	Actual	Expected	Pass/Fail	Out (V)	Actual	Expected	Pass/Fail	Out (V)	Actual	Expected	Pass/Fail
1	0.0980		0		0.0762		0		0.0107		0	
2	0.1587	-20.13	-20	Pass	-0.0011	-5.09	-5	Pass	-0.0646	-4.94	-5	Pass
3	0.0669	19.76	20	Pass	0.1530	5.06	5	Pass	0.0883	5.10	5	Pass

Processing Software Setup Values			
Transducer	Exponent	Sensitivity (mm/V)	Intercept
IR-TRACC	-0.4981	29.6587	45.48
Y-Axis Potentiometer			-5.02
Z-Axis Potentiometer			-0.70

I_{abs}

I_Y

I_Z

IR-TRACC Processing

IR-TRACC Length (pivot-to-pivot) = ((V_{IR-TRACC})^{Exponent} * Sensitivity) + Intercept

Potentiometer Processing

Y Angle_(THOR) = Y Angle_(recorded by DAS) + Intercept

Z Angle_(THOR) = Z Angle_(recorded by DAS) + Intercept

PASS/FAIL Requirements

Rotary Pots: Expected ± 0.75°

IR-TRACC: Expected ± 2.0 mm

Data Acquisition System Setup

IR-TRACC and potentiometer channels used in the THOR 3D IR-TRACC assembly should be setup in the DAS so that the transducer bias is not removed prior to testing since initial positions of these transducers are required to calculate X, Y and Z-axis displacements in post-test processing software

Figure 14-15. THOR-05F 3D IR-TRACC Calibration Summary Spreadsheet

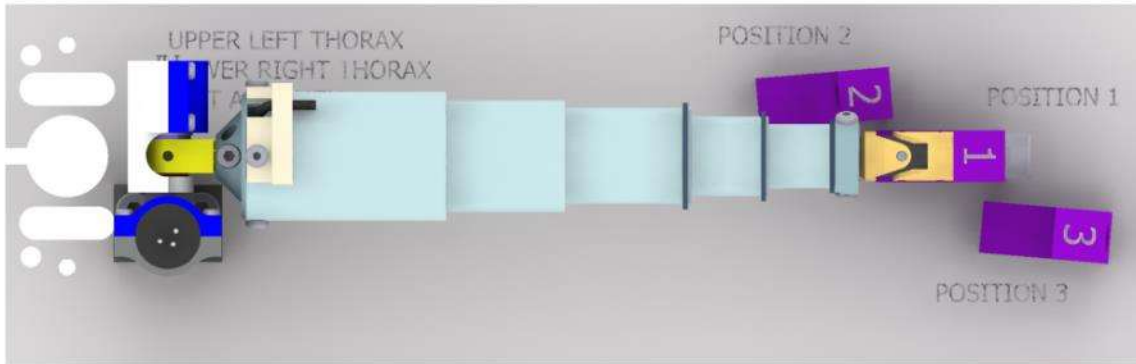


Figure 14-16. Setup to obtain expected sensor output

Table 14-4. Expected Sensor Output

3D IR-TRACC Assembly	Position 1			Position 2			Position 3		
	Θ_y (°)	Θ_z (°)	ΔL (mm)	Θ_y (°)	Θ_z (°)	ΔL (mm)	Θ_y (°)	Θ_z (°)	ΔL (mm)
Upper Left Thorax	0	0	0	-6.20	-6.20	-19.40	+6.20	+6.20	+20.80
Upper Right Thorax	0	0	0	+6.20	+6.20	-19.40	-6.20	-6.20	+20.80
Lower Left Thorax	0	0	0	+6.20	+6.20	-19.40	-6.20	-6.20	+20.80
Lower Right Thorax	0	0	0	-6.20	-6.20	-19.40	-6.20	-6.20	+20.80

Section 15. THOR-05F IR-TRACC Processing

Note that this manual covers processing for IR-TRACCs only. Dummies with alternative but equivalent instrumentation may require different data processing.

15.1 IR-TRACC Deflection Calculations

The double gimbaled IR-TRACCs that are installed in the thorax of the THOR dummy require special data collection and processing methods to calculate the X, Y, and Z linear displacements.

The axes of the Y-axis and Z-axis potentiometers that are mounted to the thorax 3D IR-TRACCs are offset from one another, and require an offset value (δ) to be applied during the calculations to shift the output displacements into the correct coordinate system.

- Upper Thorax 3D IR-TRACC (δ) = -18.71 mm
- Lower Thorax 3D IR-TRACC (δ) = 15.40 mm

***Note that all numbered equations must be followed to properly calculate the X, Y, and Z linear displacements, and the equations that are not numbered are intermediate steps that derive the numbered equations.**

15.2 Data Collection Considerations

Prior to performing any testing, verify that each 3D IR-TRACC assembly has been installed into the 3D IR-TRACC setup fixture, and that a calibration summary has been generated for each assembly within the specified calibration interval (Section 14.4).

The formulas in this Section require the IR-TRACCs to be recorded in raw voltage, and the pre-event bias of the IR-TRACCs **must not** be removed at any time during data collection. The potentiometers may be recorded in voltage, or in engineering units, but the pre-event bias **must not** be removed at any time from the channels during data collection.

15.3 Required Channels

At a minimum, the following channel time histories are required as inputs to calculate the displacements for a given 3D IR-TRACC assembly:

- IR-TRACC Voltage
- Y-Axis Angular Displacement
- Z-Axis Angular Displacement

15.4 Convert the channels to engineering units and filter

If the potentiometer time-history is output in engineering units from the DAS, then it is unnecessary to perform Equation 1 or Equation 2, but it is still necessary to convert the IR-TRACC (Equation 3) data because the time-history of the channel is recorded in voltage.

15.4.1 Convert the potentiometer voltage time-history to engineering units:

where:

$V\theta_y$ is the raw Y-axis potentiometer voltage time-history

$V\theta_z$ is the raw Z-axis potentiometer voltage time-history

Y_{sens} is the sensitivity of the Y-axis potentiometer (in deg/V)

Z_{sens} is the sensitivity of the Z-axis potentiometer (in deg/V)

θ_y is the scaled time-history of the Y-axis potentiometer

θ_z is the scaled time-history of the Z-axis potentiometer

Equation 1

$$\theta_y = |Y_{sens}| * V\theta_y$$

Equation 2

$$\theta_z = |Z_{sens}| * V\theta_z$$

15.4.2 Convert the IR-TRACC voltage time-history to engineering units:

where:

V_{IR} is the raw IR-TRACC voltage time-history

IR_{sens} is the sensitivity for the IR-TRACC (in mm/V)

LE is the linearization exponent for the IR-TRACC

R is the linearized and scaled absolute time-history of the IR-TRACC

Equation 3

$$R = |IR_{sens}| * (V_{IR})^{LE}$$

15.4.3 Filter θ_y , θ_z , and R to the required filter class.

15.5 Data channel polarity

Prior to performing any calculations, ensure that the polarities of the time histories listed in the required channels list (Section 15.3) comply with the polarity requirements outlined in Section 13.5.1; if a channel does not comply with the polarity requirements then it must be inverted prior to performing any of the following calculations.

15.6 Calculate the relative changes from the Zero Position (3D IRTRACC setup fixture)

where:

I_Y is the “Intercept” value of the Y-axis potentiometer, as shown on the Calibration Summary (Section 14.4)

I_Z is the “Intercept” value of the Z-axis potentiometer, as shown on the Calibration Summary (Section 14.4)

I_{abs} is the “Intercept” value of the IR-TRACC, as shown on the Calibration Summary (Section 14.4)

θ'_y is the time-history of the relative change from the zero position of the Y-axis potentiometer

θ'_z is the time-history of the relative change from the zero position of the Z-axis potentiometer

r is the time-history of the relative change from the zero position of the IR-TRACC

Equation 4

$$\theta'_y = \theta_y + I_Y$$

Equation 5

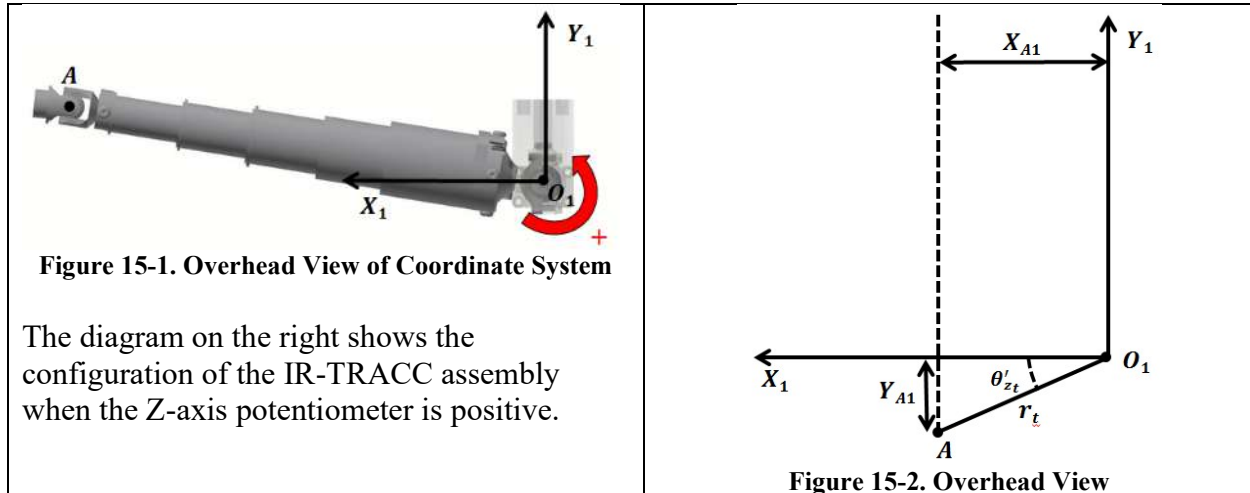
$$\theta'_z = \theta_z + I_Z$$

Equation 6

$$r = R + I_{abs}$$

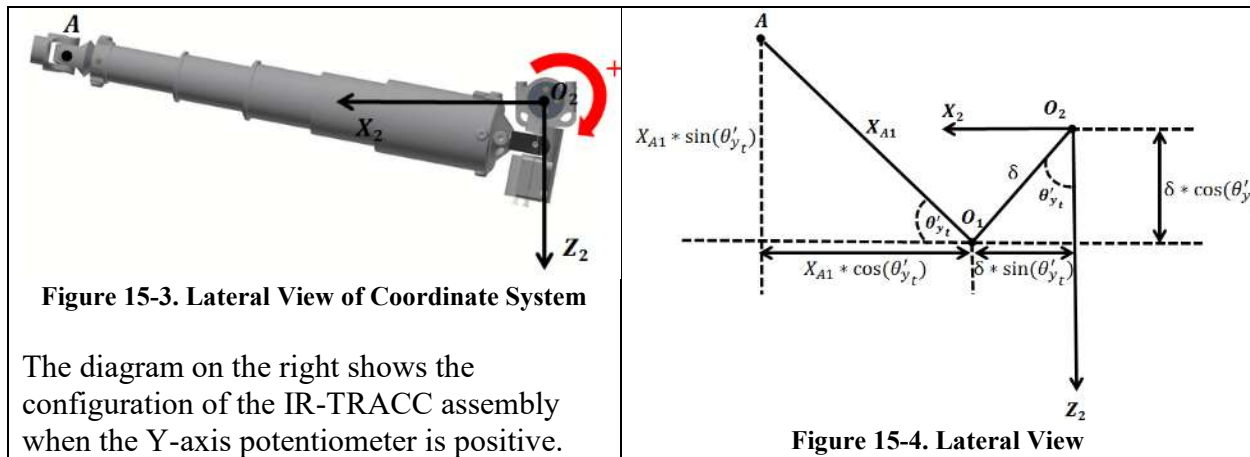
15.7 Calculate anterior attachment point displacement in local coordinate system

15.7.1 Upper Left Thorax



$$X_{A1} = r * \cos(\theta'_z)$$

$$Y_{A1} = -r * \sin(\theta'_z)$$



Equation 7- Upper Left Thorax X

$$X = \delta * \sin(\theta'_y) + r * \cos(\theta'_z) * \cos(\theta'_y)$$

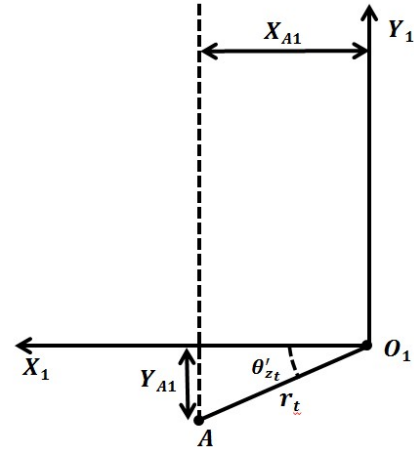
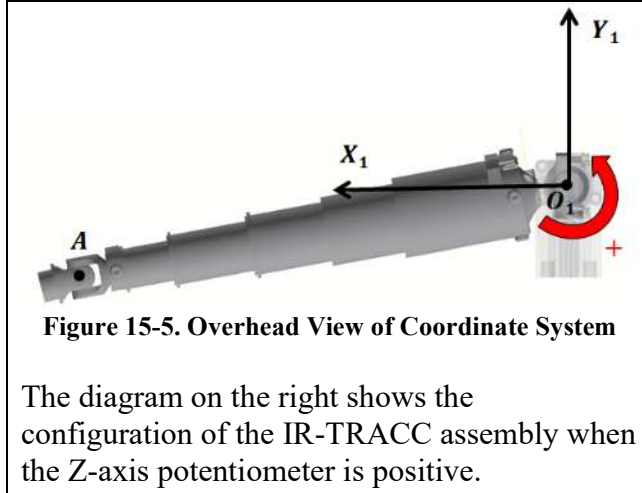
Equation 8- Upper Left Thorax Y

$$Y = -r * \sin(\theta'_z)$$

Equation 9- Upper Left Thorax Z

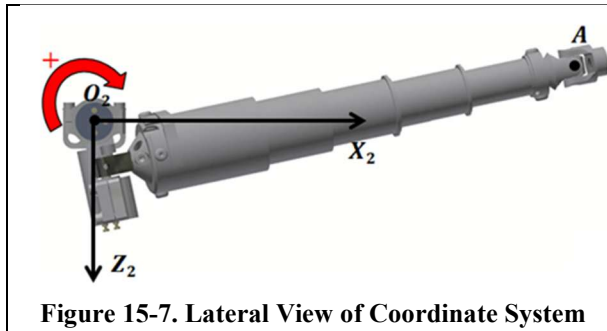
$$Z = \delta * \cos(\theta'_y) - r * \cos(\theta'_z) * \sin(\theta'_y)$$

15.7.2 Upper Right Thorax

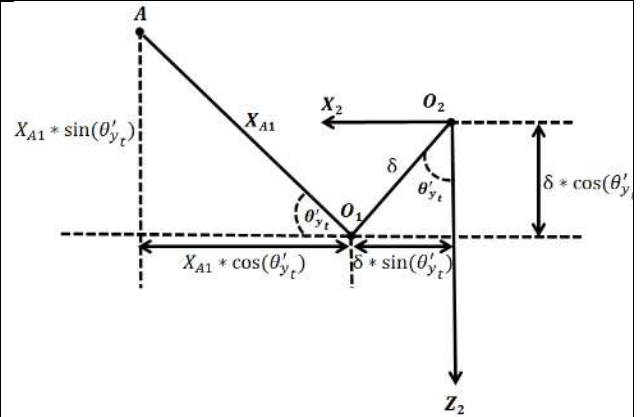


$$X_{A1} = r * \cos(\theta'_z)$$

$$Y_{A1} = -r * \sin(\theta'_z)$$



The diagram on the right shows the configuration of the IR-TRACC assembly when the Y-axis potentiometer is negative.



Equation 10- Upper Right Thorax X

$$X = -\delta * \sin(\theta'_y) + r * \cos(\theta'_z) * \cos(\theta'_y)$$

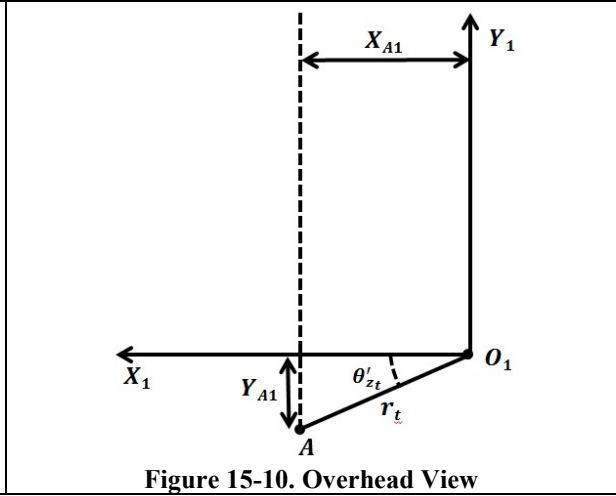
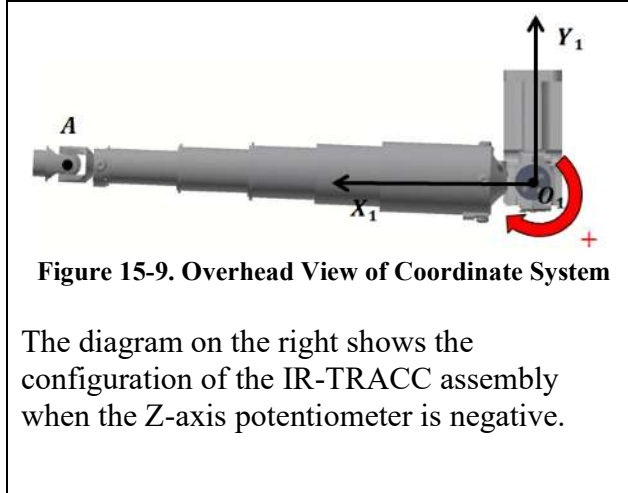
Equation 11- Upper Right Thorax Y

$$Y = -r * \sin(\theta'_z)$$

Equation 12- Upper Right Thorax Z

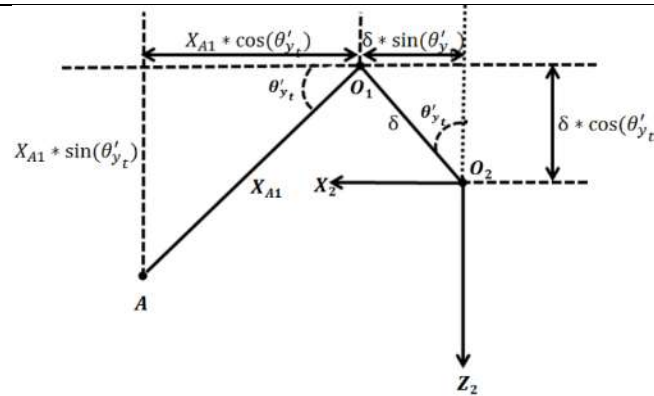
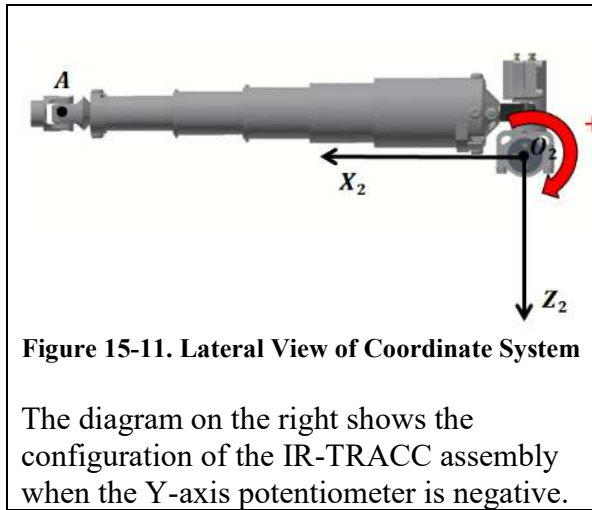
$$Z = \delta * \cos(\theta'_y) + r * \cos(\theta'_z) * \sin(\theta'_y)$$

15.7.3 Lower Left Thorax



$$X_{A1} = r * \cos(\theta'_z)$$

$$Y_{A1} = r * \sin(\theta'_z)$$



Equation 13- Lower Left Thorax X

$$X = -\delta * \sin(\theta'_y) + r * \cos(\theta'_z) * \cos(\theta'_y)$$

Equation 14- Lower Left Thorax Y

$$Y = r * \sin(\theta'_z)$$

Equation 15- Lower Left Thorax Z

$$Z = -\delta * \cos(\theta'_y) - r * \cos(\theta'_z) * \sin(\theta'_y)$$

15.7.4 Lower Right Thorax

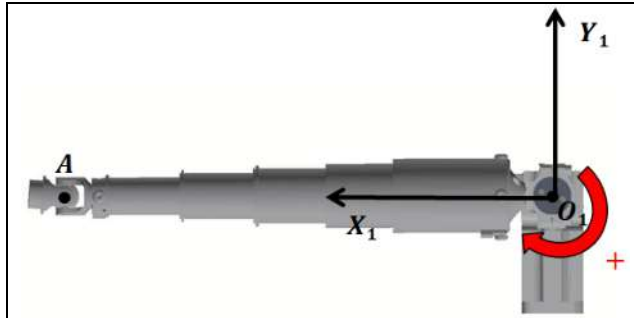


Figure 15-13. Overhead View of Coordinate System

The diagram on the right shows the configuration of the IR-TRACC assembly when the Z-axis potentiometer is negative.

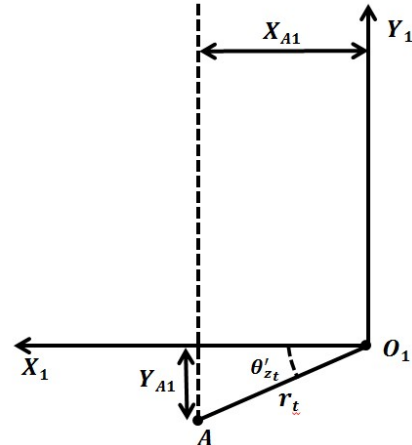


Figure 15-14. Overhead View

$$X_{A1} = r * \cos(\theta'_z)$$

$$Y_{A1} = r * \sin(\theta'_z)$$

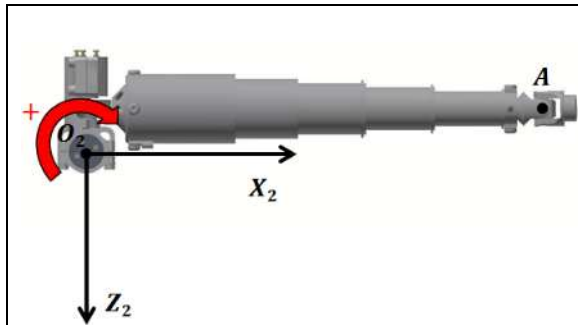


Figure 15-15. Lateral View of Coordinate System

The diagram on the right shows the configuration of the IR-TRACC assembly when the Y-axis potentiometer is positive.

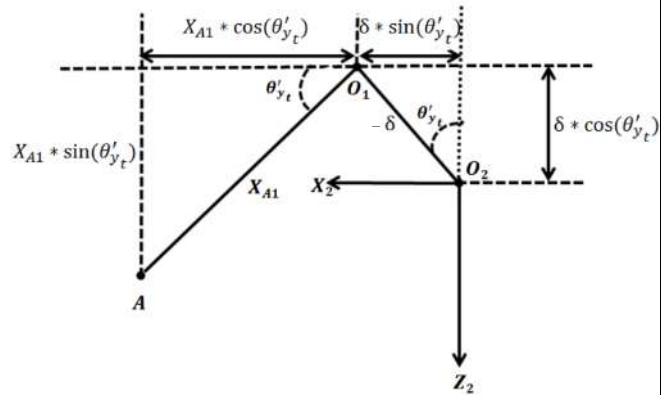


Figure 15-16. Lateral View

Equation 16- Lower Right Thorax X

$$X = \delta * \sin(\theta'_y) + r * \cos(\theta'_z) * \cos(\theta'_y)$$

Equation 17- Lower Right Thorax Y

$$Y = r * \sin(\theta'_z)$$

Equation 18- Lower Right Thorax Z

$$Z = -\delta * \cos(\theta'_y) + r * \cos(\theta'_z) * \sin(\theta'_y)$$

15.8 Remove pre-event bias of channels at time zero

where:

D_X is the time-history deflection in the X-axis

D_Y is the time-history deflection in the Y-axis

D_Z is the time-history deflection in the Z-axis

X_{t0} is the average value of X data samples over the period between (.050 s) and (.010 s) prior to contact at time-zero

Y_{t0} is the average value of Y data samples over the period between (.050 s) and (.010 s) prior to contact at time-zero

Z_{t0} is the average value of Z data samples over the period between (.050 s) and (.010 s) prior to contact at time-zero

Equation 19

$$D_X = X - X_{t0}$$

Equation 20

$$D_Y = Y - Y_{t0}$$

Equation 21

$$D_Z = Z - Z_{t0}$$

Section 16. **THOR-05F Tester's Inspection Checklist**

Once a THOR-05F is assembled using the procedures in this PADI, it is inspected using the checklist found in Table 16-1 before every test.

Table 16-1. Testing Checklist for THOR-05F

Body Segment	Important items to verify <i>before</i> testing	PADI Section	Check
Head	Ensure that no wires are in the pinch points between the skull cap and the skull	3	
Neck	Ensure spring tower jam nuts are tight	4	
Neck	Ensure instrumentation cable slack will allow full forward flexion and rearward extension	4	
Neck	Ensure that all neck cable guide inserts are installed and firmly seated	4	
Neck	Ensure that the neck pitch change angle is set to neutral	4	
Shoulder	Ensure flesh cover is free from tears	7	
Shoulder	Ensure bolts are not bent	7	
Spine	Ensure that the lumbar pitch change mechanism angle is set to proper position (varies by test, but usually slouch)	6	
Spine	Check upper thoracic spine flex joint for delamination	6	
Spine	Check lumbar flex joint for tears	6	
Spine	Check lifting strap for fraying and damage	2	
Thorax	Check ribs for delamination (pay additional attention to the areas near stiffeners and near attachment points at sternum)	5	
Thorax	Check rib adaptors for significant damage (cosmetic scratches are not a concern)	5	
Thorax	Check clavicle load cells for damage to wiring and the medial attachments	5	
Thorax	Ensure that the wire that attaches the two ends of the IR-TRACC is aligned in the same plane at each end	5	
Thorax	Ensure that IR-TRACC pins at bib end U-joints are configured to prevent binding	5	
Thorax	Ensure that IR-TRACC wires that attach ends are aligned in the same plane	5	
Thorax	Ensure that IR-TRACC potentiometer set screws are tight	5	
Thorax	Check IR-TRACC assemblies for damaged pot housings and sheared pots	5	
Thorax	Check IR-TRACC assemblies for contact with spine components and load cell wires	5	
Abdomen	Check abdomen foam for tears	5	
Abdomen	Ensure APTS are not in contact with ribs and that they are seated in the bottom of the cavity	5	
Pelvis	Ensure pelvis bone is properly seated in the flesh by checking H-point access	8	
Pelvis	Ensure that the acetabulum load cells are tightly installed	8	
Lower Arm	Ensure elbow stoppers are not broken	11	
Lower Leg	Remove knee covers and visually inspect knee sliders to ensure no damage	10	
Lower Leg	Ensure Achilles jam nuts are tight	10	
Lower Leg	Ensure that washer in the Achilles assembly is seated properly	10	

Lower Leg	Ensure that the ankle pot set screws are tight	10	
Full ATD	Ensure that all limbs joints are set to 1G	7, 9, 10, 11	
Full ATD	Ensure grounding cables are present and installed appropriately	13	