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HARDWARE USER MANUAL

RibEye™ Multi-Point Deflection Measurement System:

3-Axis Version for the WorldSID 5th Female ATD

Boxboro Systems LLC
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HARDWARE USER MANUAL
RibEye™ Multi-Point Deflection Measurement System: 3-Axis Version for the WorldSID 5th Female ATD

1.0 WorldSID RibEye Description

The RibEye for the WorldSID 5th anthropomorphic test device (ATD) provides X, Y, and Z position data for 18 light-emitting diodes (LEDs) mounted on the WorldSID ribs. Three LEDs are mounted on each of the six ribs. The RibEye for the WorldSID can be mounted on either side of the dummy to measure left-side or right-side impacts. Appendix A provides the RibEye measurement range and other specifications, including details on the cables and connector pinouts. Appendix B explains how to switch the WorldSID RibEye from left-side to right-side-impact.

Up to 25 seconds of data can be collected at a 10-kHz sample rate. Two types of non-volatile flash memory are installed in the controller: a Micro-SD card stores all 25 seconds of data from a test, and onboard flash memory stores 1.7 seconds of data (from –200 ms to 1500 ms) that is retained after power is turned off. If external power is lost, the RibEye will operate on internal batteries. Communication to the RibEye is via Ethernet.

Two sets of three sensors monitor the LED positions, as shown in Figure 1. The top set of sensors uses red optical filters and monitors the red LEDs mounted on the first three ribs: the shoulder rib, thoracic 1 rib, and thoracic 2 rib. The bottom set of sensors uses blue optical filters and monitors the blue LEDs mounted on the lower three ribs: the thoracic 3 rib, abdominal 1 rib, and abdominal 2 rib.

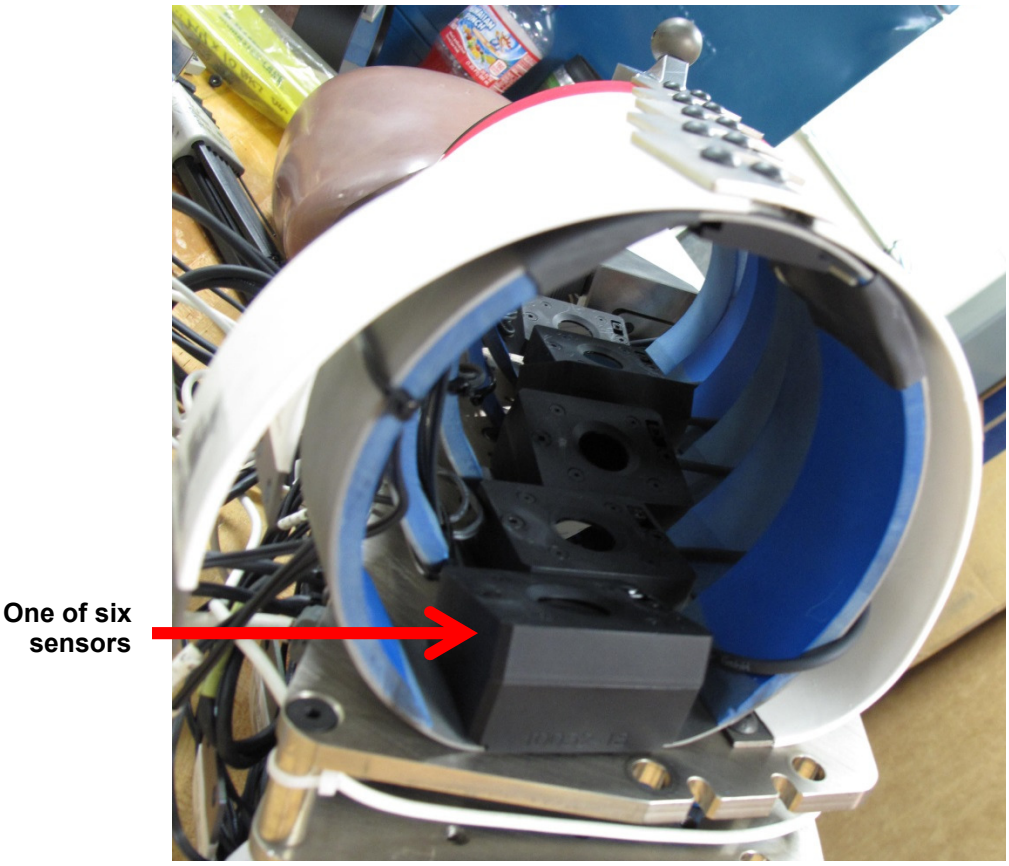

Figure 1. RibEye sensors mounted in the dummy (view from pelvis upward)

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Three RibEye LEDs are mounted on each rib. Figure 2 shows the RibEye LEDs installed in the WorldSID dummy. The center LEDs are lined up along the dummy's left or right side. The forward LEDs are closer to the front of the dummy and the rearward LEDs closer to the dummy's back.

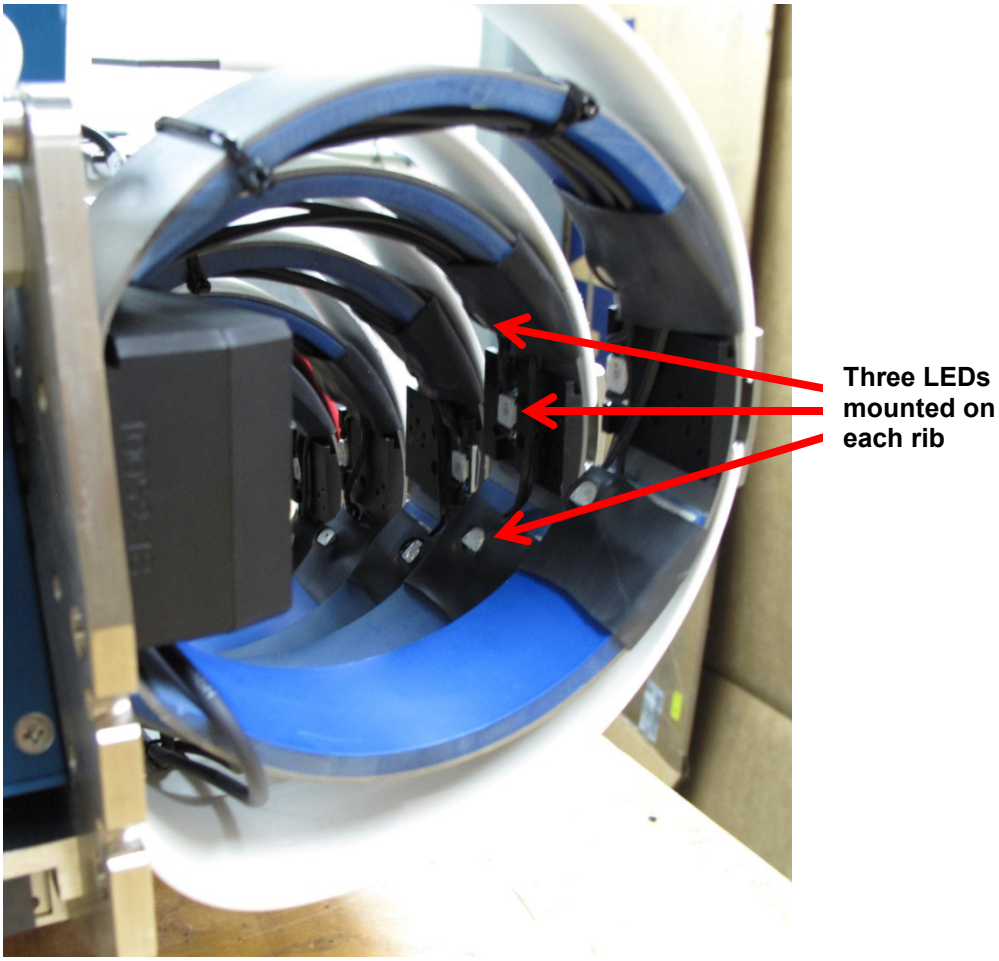

Figure 2. RibEye LEDs mounted in the dummy (view from pelvis upward)

The RibEye controller mounts on the non-struck side of the dummy. The controller enclosure also contains the RibEye's battery pack. Figures 3–6 show the following views of the controller:

- Figure 3 shows the controller as shipped, with connector covers installed at each end
- Figure 4 shows the controller with the two end covers removed
- Figure 5 shows the connectors for the sensors at one end of the controller
- Figure 6 shows the connectors for the LED cables, status cable, and dummy exit cable at the other end of the controller.

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Figure 3. RibEye controller with connector end covers in place

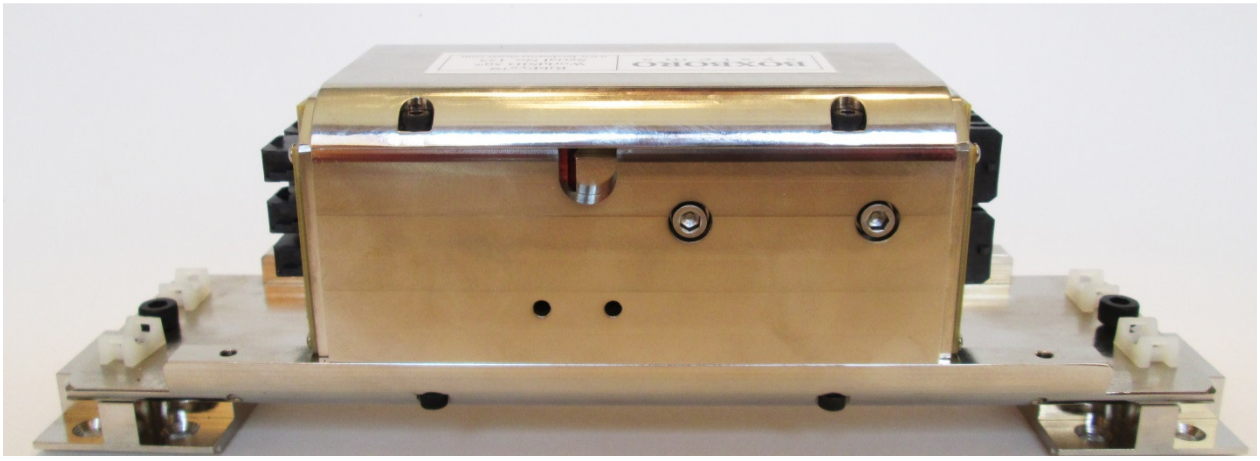

Figure 4. RibEye controller with connector covers removed

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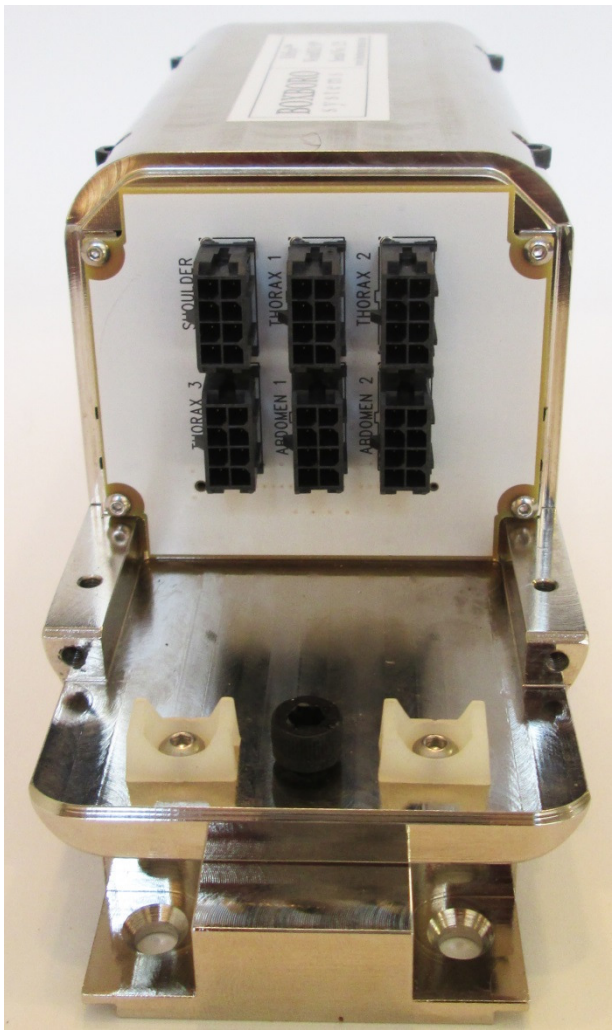

Figure 5. Controller sensor connectors

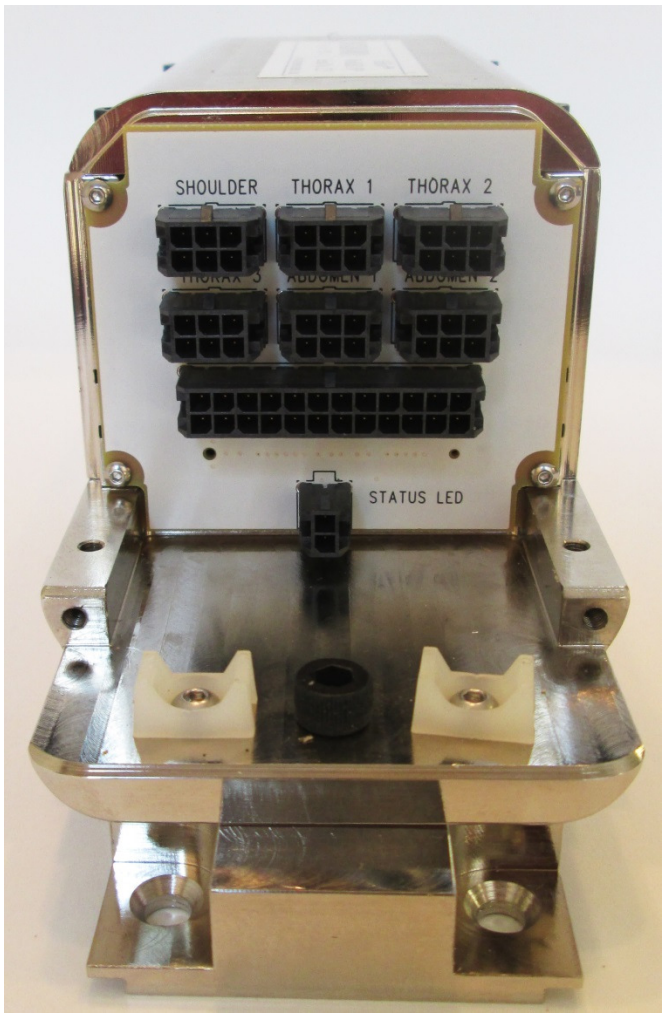

Figure 6. Controller connectors for LED cables, status cable, and dummy exit cable

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2.0 RibEye Installation

This section explains how to mount the RibEye components into the WorldSID 5th Female ATD. The instructions cover the installation of the LEDs, sensors, and controller, as well as the cable routing. Some components such as the LEDs are mounted before the ribs are assembled in the dummy, and others during or after rib assembly.

2.1 LED and sensor installation

2.1.1 Mounting the LEDs on the ribs

Figure 7 shows a LED assembly, with its lead cable attached. The LED is soldered onto a metal-clad printed circuit board (MCPCB). Figure 8 shows six LEDs mounted on the inner rib clamps.

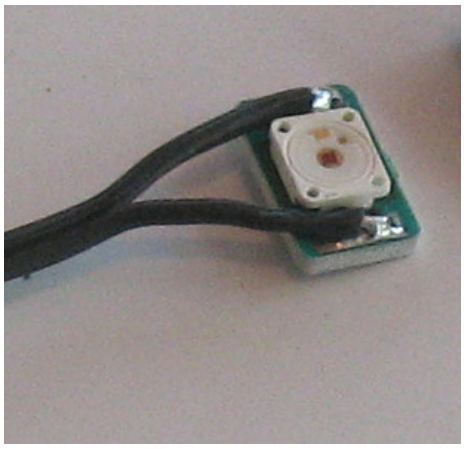

Figure 7. LED on MCPCB

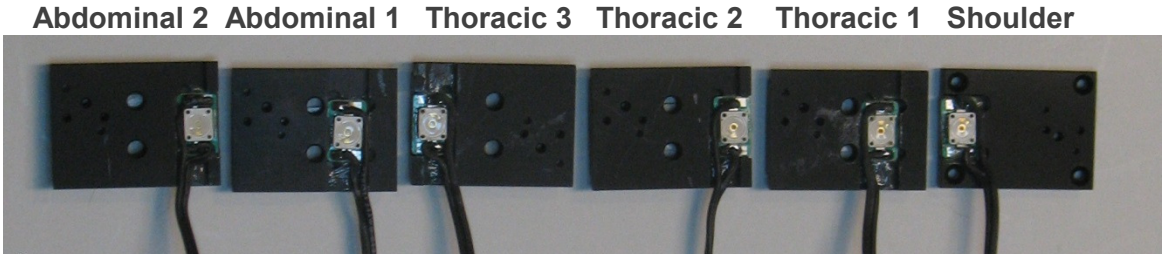

Figure 8. LEDs mounted on inner rib clamps

On the shoulder and thoracic 3 ribs, the LEDs are mounted on the bottom edge of the ribs. On the thoracic 2 and abdominal 2 ribs, the LEDs are mounted on the top edge of the ribs. On the thoracic 1 and abdominal 1 ribs, the LEDs are mounted near the center of the ribs.

This becomes more clear if you refer back to Figure 2, which shows three LEDs mounted on each rib. Details on LED positions and mounting methods for all 18 LEDs are provided later in this section.

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The shoulder rib assembly is shown in Figure 9. The center LED on the shoulder rib is glued to a LED mounting plate. The plate is attached to the inner rib clamp with four 2-56 x 1/4 flat-head cap screws. The inner rib clamp is attached to the rib by four M4 x 14 flat-head cap bolts. The bolts screw into the shoulder load cell, which is mounted outside the shoulder, or into the shoulder load cell replacer, which is mounted on the outside of the rib. If you have a load cell mounted inside the shoulder that must be removed, see section 2.3, Arm attachment/load cell replacer.

An optional shoulder foam stop is provided. This is mounted to the inner rib clamp using two M3 x 8 button head cap screws.

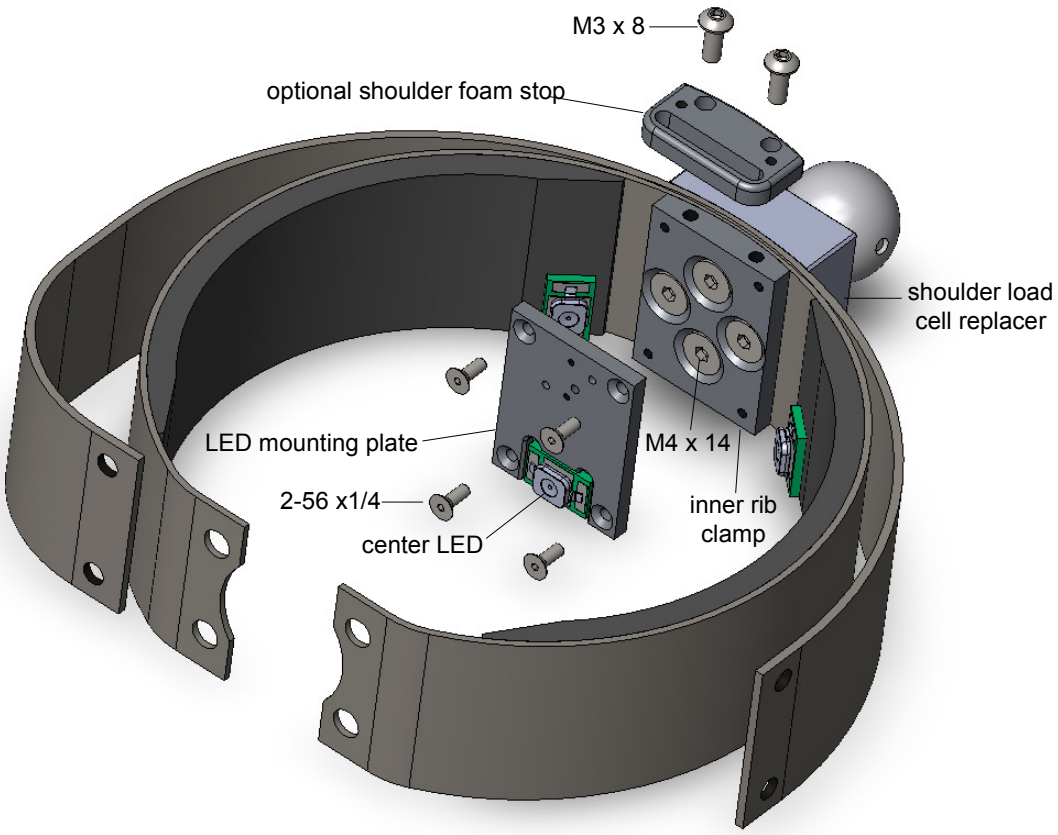

Figure 9. Shoulder rib assembly

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Although the inner rib clamps provide accelerometer mounting holes, it is not recommended that accelerometers be installed because they block and/or reflect light from the LEDs to the sensors, which corrupts RibEye data. If accelerometers must be used, it is recommended that only 7264 style accelerometers be installed, not 7268 style. If used, the 7264 accelerometers must be covered with adhesive-backed, light-absorbing flock paper to mitigate reflection of light. The 7268 accelerometers will definitely block light from the LEDs and must not be used.

All of the inner rib clamps have holes for mounting 7264 style accelerometers. Figure 10 shows the abdominal 2 inner rib clamp plate with various holes as follows:

- White arrows indicate the inner rib clamp plate mounting holes, which are tapped for M4 screws installed from the outside of the rib
- Red arrows indicate the 7264 accelerometer mounting holes, which are tapped for 080 screws
- The other three holes are for 7268 accelerometers, which must not be used.

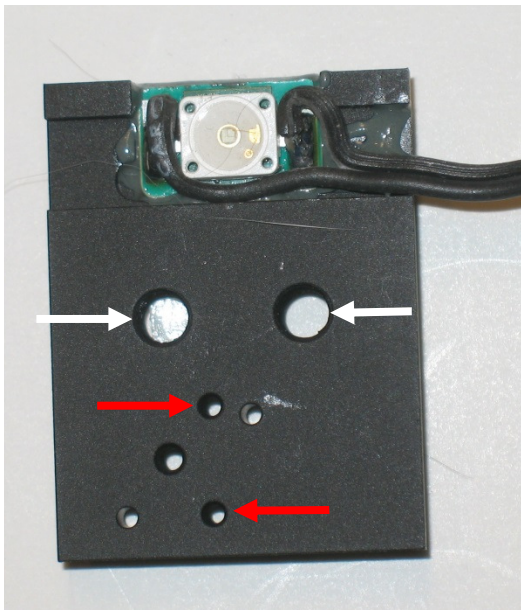

Figure 10. Inner rib clamp plate for abdominal 2 rib

As noted earlier, the forward LEDs are closer to the front of the dummy and the rearward LEDs closer to the dummy's back. These rearward and forward LEDs on all ribs are held in place with high-strength double-stick foam tape and heat-shrink tubing:

- The foam tape is 3M #4936, 1/2 inch wide, VHB acrylic tape
- The heat-shrink tubing is 1.25 inches in diameter, with a 2:1 shrink ratio and a recovered wall thickness of 0.90 mm (0.035 inch).

*NOTE: Do not use any **glue-lined** heat-shrink tubing because the glue can bubble out of the LED hole and cover the LED, blocking its light.*

Table 1 summarizes the LED positions and mounting methods for all 18 LEDs.

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Table 1. Summary of LED positions and mounting methods

Rib number (type)		Rearward LEDs	Center LEDs	Forward LEDs
Rib #1 (shoulder)	Position	Bottom edge of rib		
	Mounting	Tape and heat-shrink in place	LED assembly already glued to LED mounting plate; screw this plate to inner rib clamp plate	Tape and heat-shrink in place
Rib #2 (thoracic 1)	Position	Center of rib		
	Mounting	Tape and heat-shrink in place	LED assembly already glued to inner rib clamp plate	Tape and heat-shrink in place
Rib #3 (thoracic 2)	Position	Top edge of rib		
	Mounting	Tape and heat-shrink in place	LED assembly already glued to inner rib clamp plate	Tape and heat-shrink in place
Rib #4 (thoracic 3)	Position	Bottom edge of rib		
	Mounting	Tape and heat-shrink in place	LED assembly already glued to inner rib clamp plate	Tape and heat-shrink in place
Rib #5 (abdominal 1)	Position	Center of rib		
	Mounting	Tape and heat-shrink in place	LED assembly already glued to inner rib clamp plate	Tape and heat-shrink in place
Rib #6 (abdominal 2)	Position	Top edge of rib		
	Mounting	Tape and heat-shrink in place	LED assembly already glued to inner rib clamp plate	Tape and heat-shrink in place

NOTE: After rib assembly, nylon zip ties are added around the center LED clamp plates to secure the cables.

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The rearward and forward LEDs are typically mounted 20 mm from the center of the rib, as shown in Figure 11. The 20-mm dimension is the distance along the X axis of the dummy. The forward and rearward LEDs are approximately in the middle of the tapered section at the ends of the damping material, also shown in Figure 11.

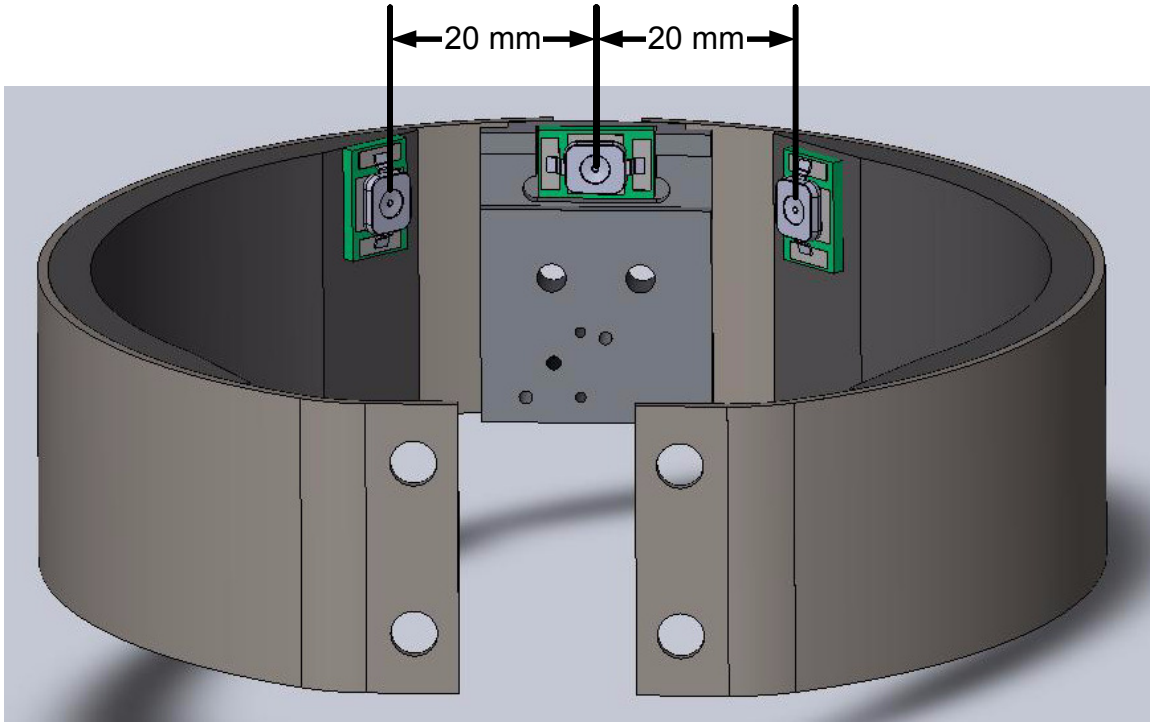

Figure 11. Rearward and forward LED locations (thoracic 2 rib or abdominal 2 rib shown)

As noted earlier, the LEDs must be mounted to the ribs before the ribs are installed in the dummy. The 18 LED cables are marked with the rib number (1–6) and one of three LED positions as follows:

	Forward	Center	Rearward
Rib #1 (shoulder)	F	C	R
Rib #2 (thoracic 1)	F	C	R
Rib #3 (thoracic 2)	F	C	R
Rib #4 (thoracic 3)	F	C	R
Rib #5 (abdominal 1)	F	C	R
Rib #6 (abdominal 2)	F	C	R

Thus, for example, the LED with the cable marked 4-R should be mounted on the thoracic 3 rib in the rearward position, on the bottom edge of the rib as indicated previously in Table 1.

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On each rib, the rearward LEDs should be mounted first, then the center LEDs, and finally the forward LEDs. The LEDs should be mounted according to the following procedure:

1. Rearward LEDs

Place a strip of 3M VHB double-stick tape on the rib at the rearward LED mounting location, as shown in Figure 12.

Figure 12. Tape placed at rearward LED location (thoracic 2 rib or abdominal 2 rib shown)

Cut a piece of 1.25-inch-diameter heat-shrink tubing 40 mm long (1.5 inches). Punch a hole in the tubing where the center of the LED will be, using a standard paper hole punch or similar tool. Figure 13 shows the cut and punched piece of heat-shrink tubing.

Figure 13. Heat-shrink tubing with hole punched

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Place the LED on the tape, and route the cable toward the front of the rib, over the tape, as shown in Figure 14. The LED cable should be placed so that it will not obstruct the center LED's position (see Figure 11 above).

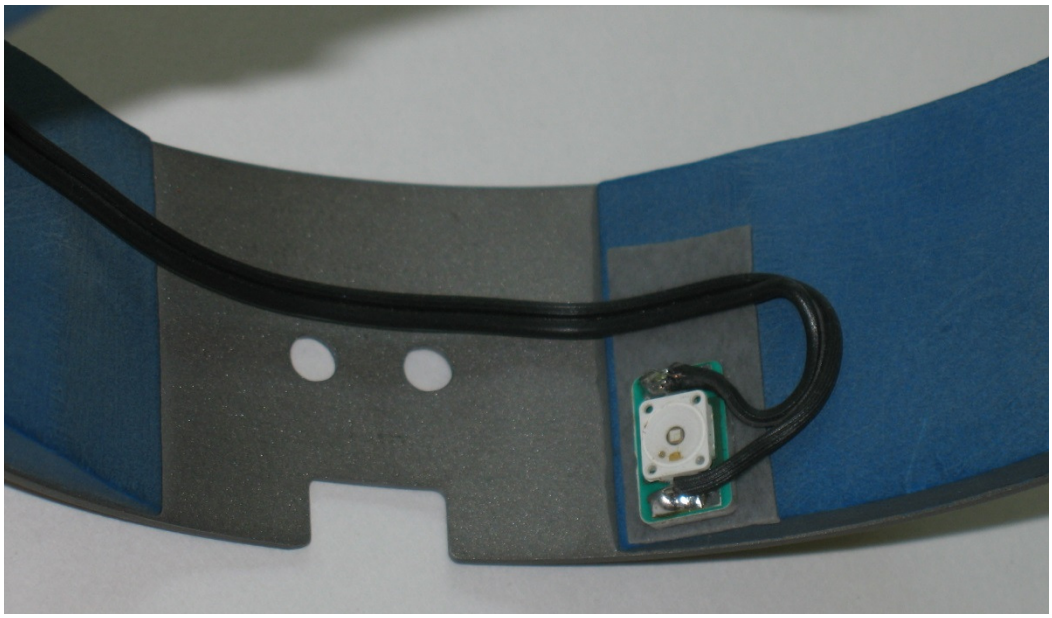

Figure 14. Rearward LED placed on tape

Slide the tubing over the rib and LED. Center the hole directly over the center of the LED, as shown in Figure 15.

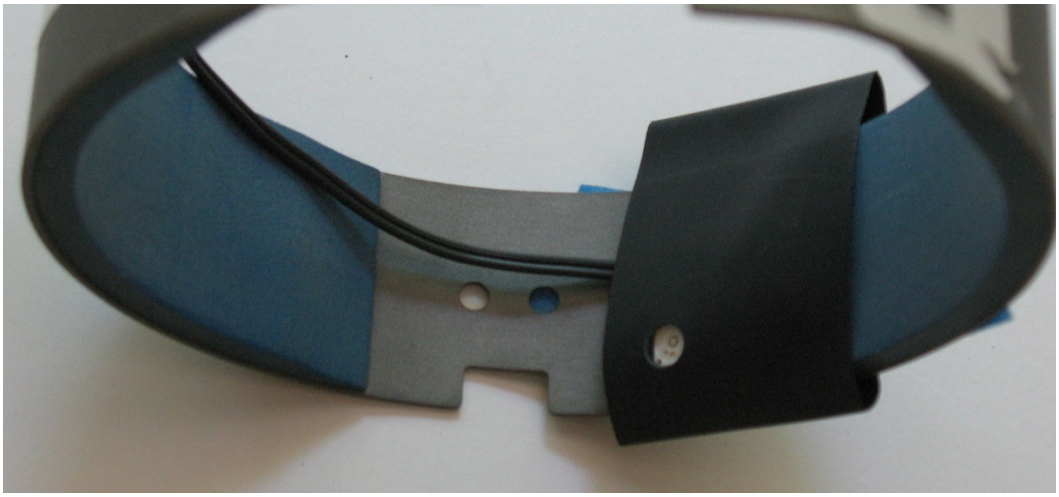

Figure 15. Heat-shrink tubing placed over rearward LED

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Use a heat gun to shrink the tubing. It helps to wear a welding glove or other temperature-proof glove so that you can hold the heat-shrink tubing in place while using the heat gun. Hold the hole in the heat-shrink tubing centered over the LED (see Figure 16).

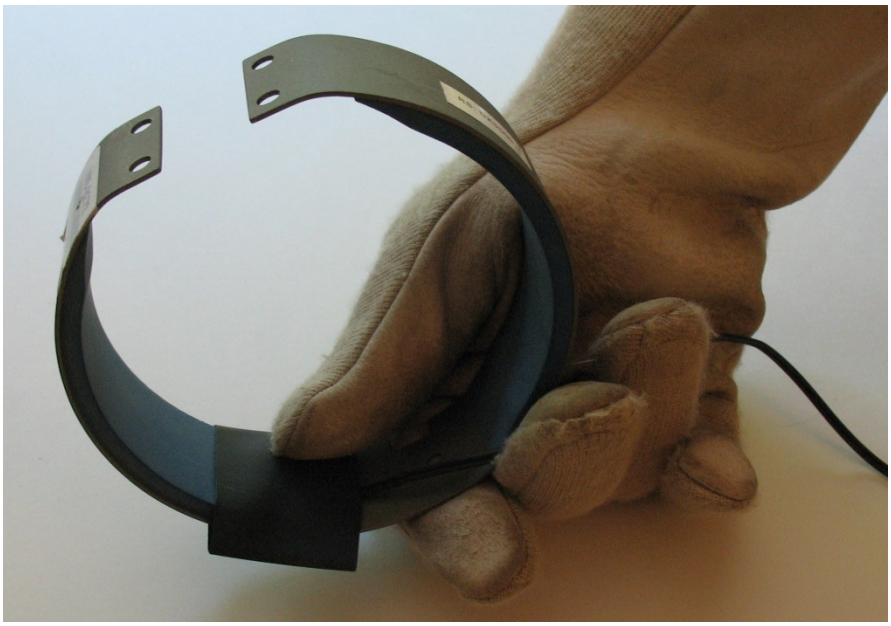

Figure 16. Heat-shrink tubing held in place with glove

Shrink the tubing on the outer side of the rib first, as shown in Figure 17.

Figure 17. Shrinking outer side of tubing

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Next apply heat to the tubing on the inside of the rib. Start with the areas that are farthest away from the LED, then apply heat gently around the edges of the LED hole, keeping the LED fully exposed, but do not apply too much heat directly to the LED.

The hole for the LED will expand when heat is applied. While the tubing is still warm, you can stretch the round hole with your finger so that it fits around the square edge of the LED. Do not touch the soft silicone face of the LED with sharp objects. Figure 18 shows a rearward LED after the tubing has been fully shrunk into place.

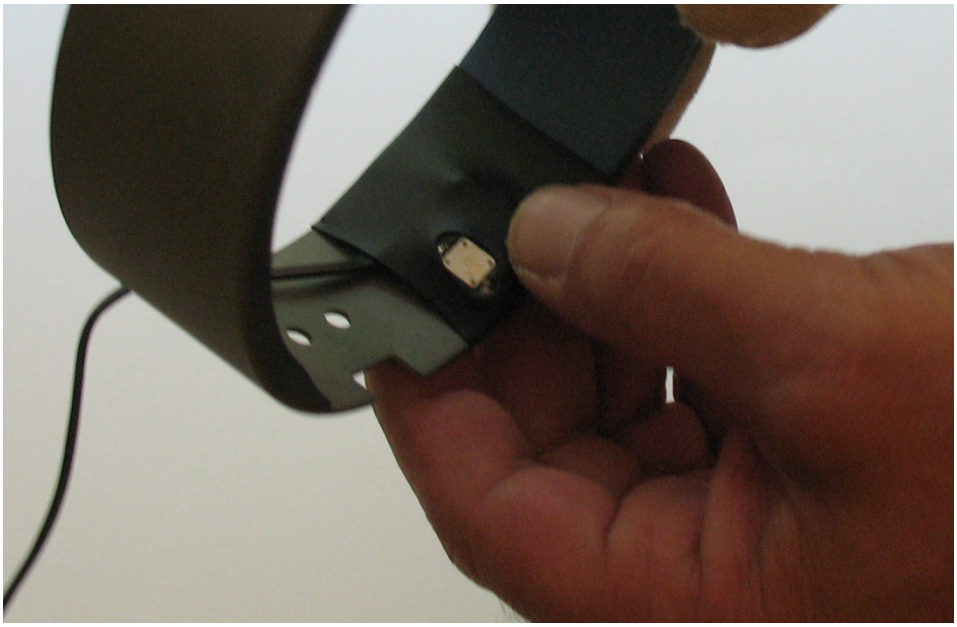

Figure 18. LED mounting complete with hole in tubing stretched around square LED body

NOTE: It takes a little practice to master the technique of mounting LEDs with heat-shrink tubing. You can always cut off the tubing and try again.

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2. Center and Forward LEDs

The next step is to install the center and forward LEDs and route the cables. As noted earlier, the center LED assemblies are mounted on the inner rib clamp plates, which already have the LED glued onto them.

Temporarily install the inner rib clamp with LED using the M4 button head screws. Then place the double-stick tape for the forward LED and route the cables from the center and rearward LEDs as shown in Figure 19. Note how the LED cables are routed to avoid crossing in front of any LEDs.

Figure 19. LED cable routing to front of rib

Place the forward LED in position on the double-stick tape and slide a piece of heat-shrink tubing over the LED. The tubing should also cover all three LED cables. Heat-shrink the tubing over the forward LED in the same way described above for the rearward LED. When heat-shrinking is complete, the tubing will hold the forward LED and all three LED cables in place.

Route all of the LED cables toward the front of the rib. Secure the cables in place with nylon ties.

Later, after the rib is assembled into the dummy (see Section 2.1.3 below), use nylon zip-ties to further secure the LED cables, preventing them from moving in front of the LEDs. Make sure that the rearward LED cable that passes over the inner rib clamp can not move to block the light from the center LED.

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2.1.2 Installing the sensors on the spine

The RibEye's sensor assemblies take the place of the existing rib-to-spine clamps. Each sensor assembly has a front piece that contains the electronics and a base for mounting to the spine. It is the sensor bases that act as the rib clamps. The bases are installed at this point, while the sensor front pieces are mounted to their bases later, after the ribs are in place inside the dummy (see Section 2.1.3).

Figure 20 shows the sensor bases mounted to the spine. The sensor bases are installed through the spine's existing rib-mounting holes using four M5 x 10 flat-head cap screws.

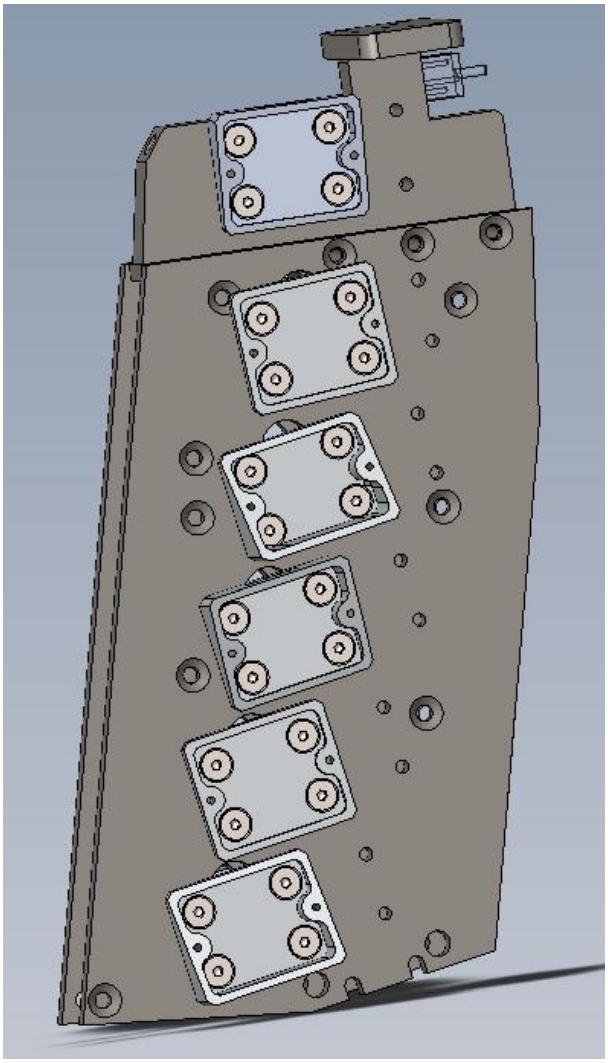

Figure 20. RibEye sensor bases mounted to spine (ribs not shown)

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The sensor bases have different angles depending on the mounting positions (Table 2).

Table 2. Sensor base part numbers and angles

Rib	Sensor Base Part Number	Base Angle, degrees
Shoulder	10052-12.5	12.5
Thoracic 1	10052-0	0 (flat)
Thoracic 2	10052-27	27
Thoracic 3	10052-18	18
Abdominal 1	10052-0	0 (flat)
Abdominal 2	10052-18	18

The sensor bases have a sticker on the inside with the RibEye serial number (S/N), rib number, and an arrow showing the "up" direction. Figure 21 shows the back side of the sensor front piece with the label showing the rib it must be installed on. Note that the sensor front pieces must be installed so that the cable is oriented to the rear of the dummy.

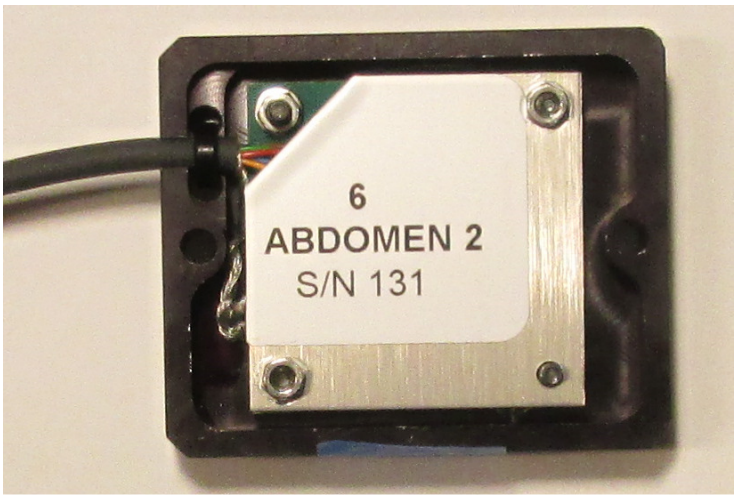

Figure 21. RibEye sensor front piece showing label on back

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The sensor front piece containing the electronics (Figure 22) will be attached to the sensor base by two M3 x 16 flat-head cap screws. Although the sensor front pieces look identical, each piece is marked with the number of the rib that it was calibrated on, and the sensor front piece must be installed on that rib.

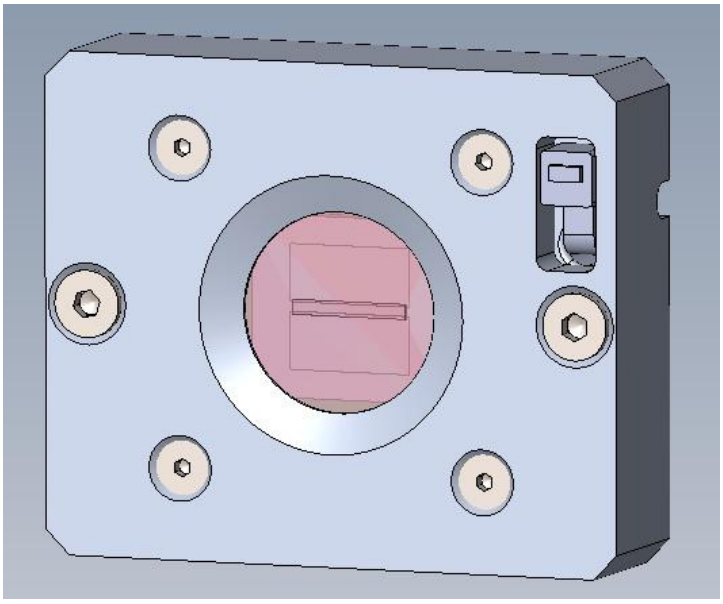

Figure 22. RibEye sensor front piece

WARNING: ***Never remove the sensor printed circuit board or loosen the circuit-board mounting nuts. Doing so will ruin the calibration of the RibEye.***

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Figure 23 shows the spine with the entire sensor assemblies installed (bases and front pieces). However, as noted above, the sensor front pieces are not mounted to their bases until the ribs are in place inside the dummy (see Section 2.1.3).

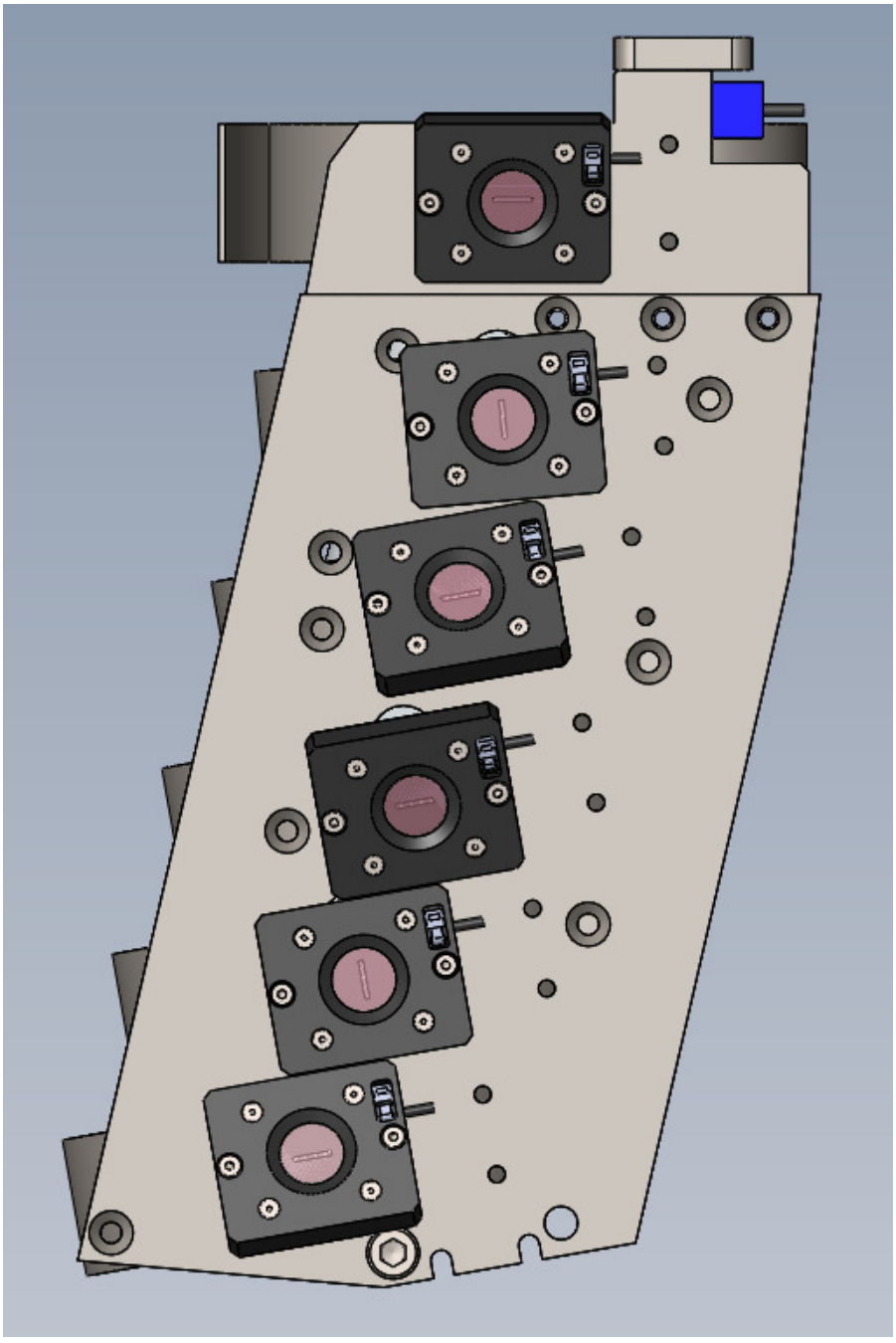

Figure 23. RibEye sensor assemblies mounted to spine (ribs not shown)

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2.1.3 Order of assembly (LEDs, ribs, and sensors)

1. Mount the LEDs on the ribs as described above in section 2.1.1.
2. Mount the ribs to the spine as follows:
   a. Install the outer ribs first
   b. Attach the inner ribs to the outer ribs
   c. Attach the inner ribs and sensor bases to the spine.
3. Add nylon zip-ties around the inner and outer ribs on the forward side of the inner rib clamps to make sure that the rearward LED wires can not move to block the light from the center LED.
4. Attach the sensor front pieces to the bases.

Note again that each sensor base number must match the rib where it belongs, and each sensor front piece must match the rib for which it was calibrated.

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2.2 Controller installation

The RibEye controller is installed on the non-struck side of the dummy. In existing WorldSID dummies, the RibEye controller takes the place of the battery enclosure. To install the controller, remove the shoulder rib on the non-struck side, the string pot assembly, and the battery enclosure.

2.2.1 Mounting the adaptor plates

The controller mounts to two adaptor plates that take the place of the rib clamps on the non-struck side of the thoracic 1 rib and the abdominal 2 rib (Figures 24 and 25). The adaptor plates are installed by removing the four rib clamp bolts (M5 x 10 flat-head cap screws), removing the rib clamp plates, and then installing the adaptors using four M5 x 20 flat-head cap screws.

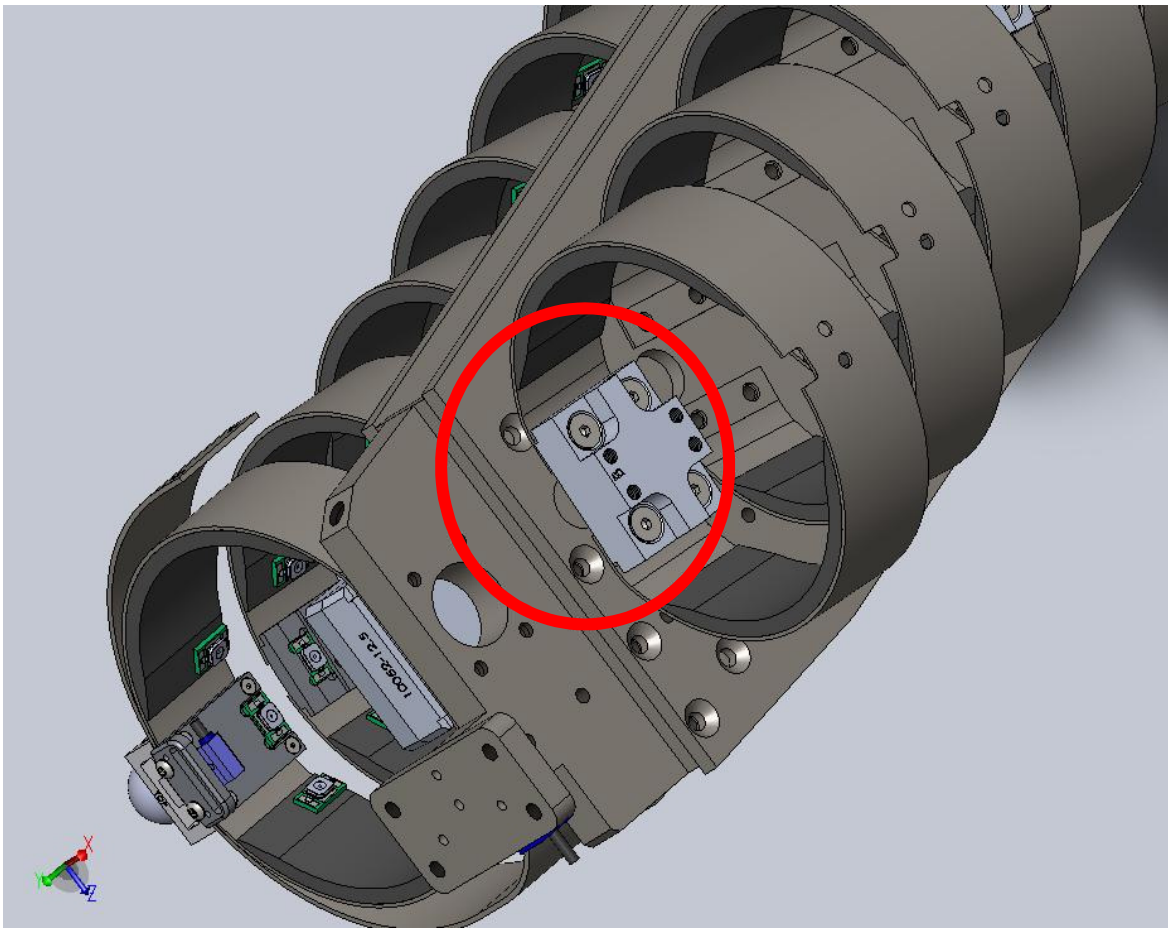

Figure 24. Controller adaptor installed on thoracic 1 rib

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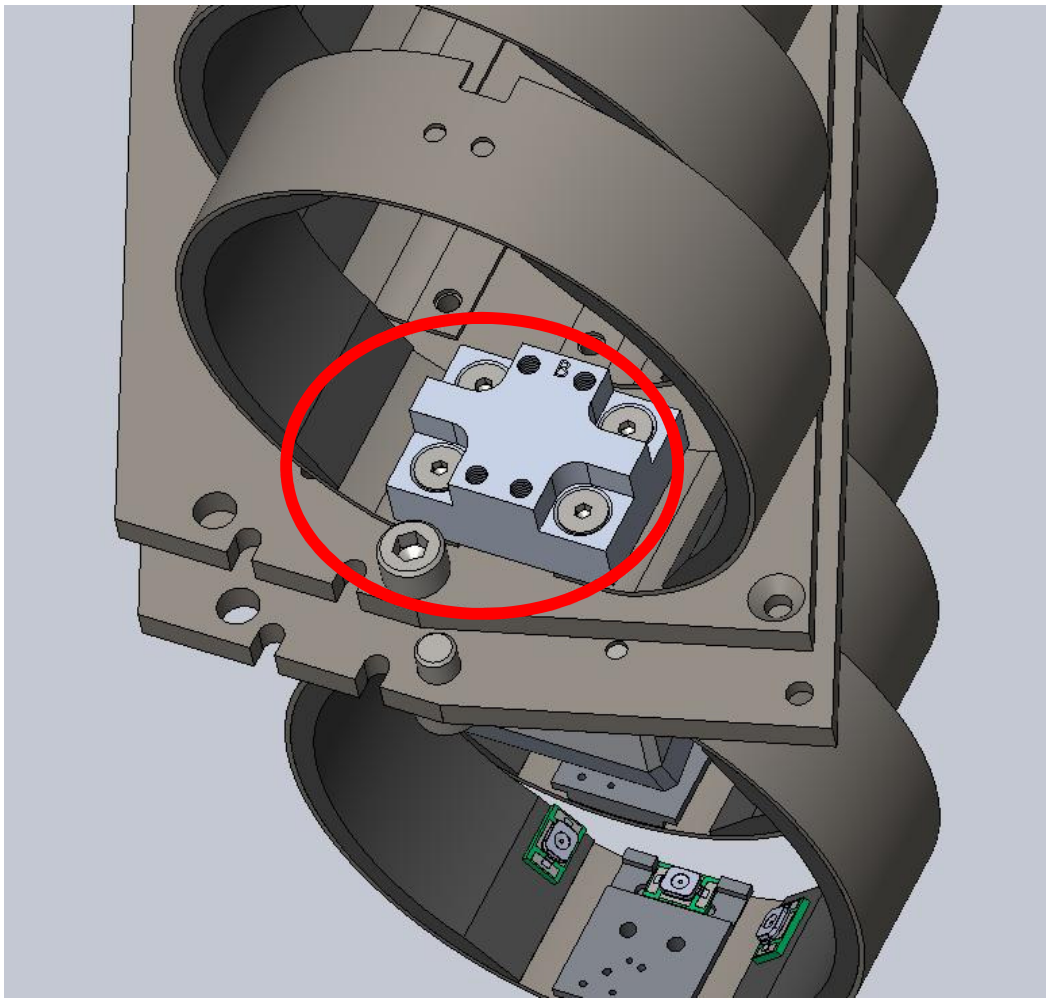

Figure 25. Controller adaptor installed on abdominal 2 rib

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2.2.2 Removing the controller end covers

The controller is shipped with two covers screwed in place, one at each end (shown previously in Figure 3). The covers protect the connectors for the RibEye sensors on one end (Figure 5) and the connectors for the LED cables, status cable, and dummy exit cable at the other end (Figure 6).

To install the controller, the two end covers must be removed by unscrewing two M3 x 50 socket-head cap screws from the top of each cover and two M3 x 10 socket-head cap screws from the end of each cover. Figure 26 shows the locations of the four cover attachment screws on one of the covers.

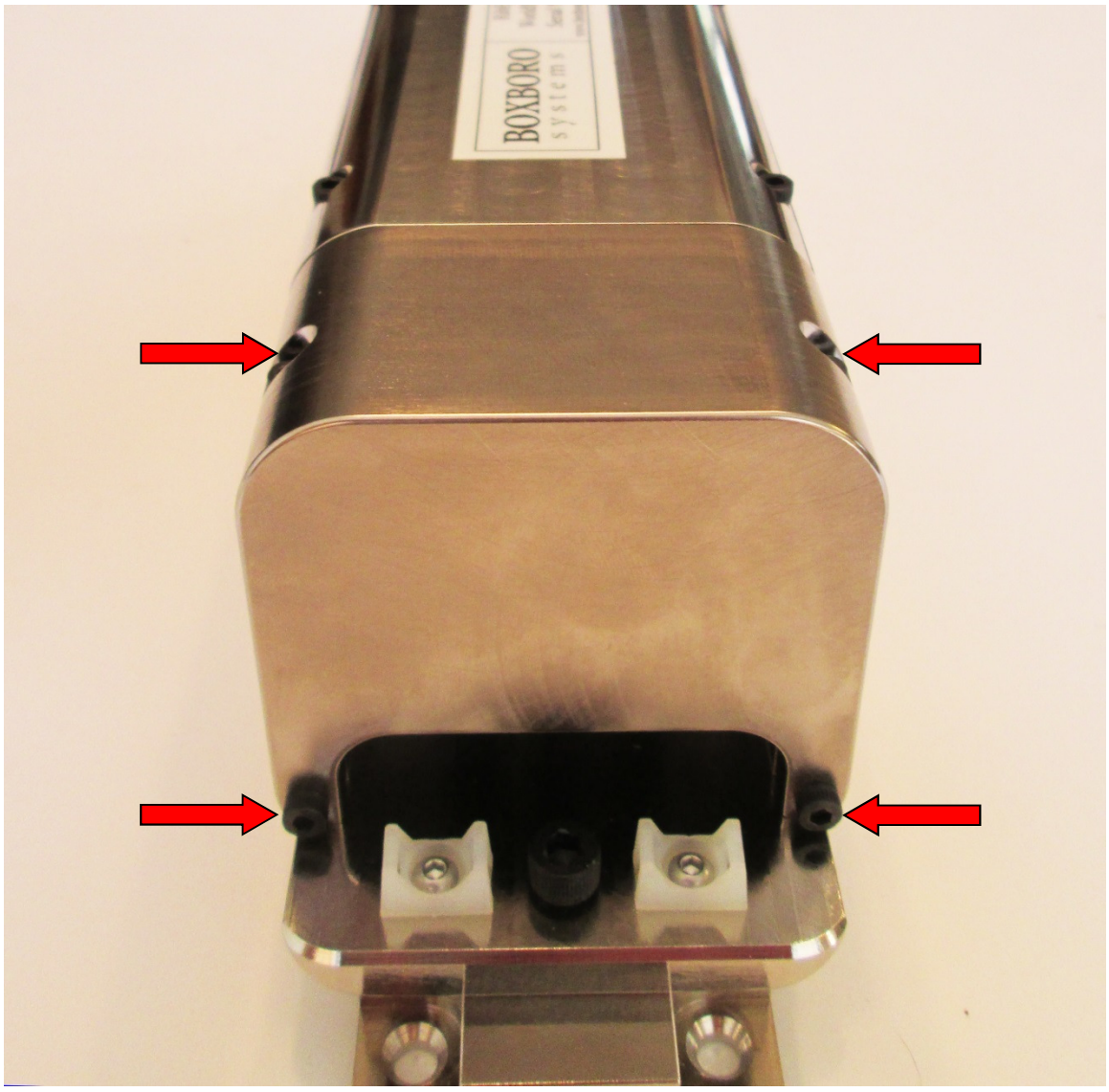

Figure 26. Controller end cover attachment screws

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2.2.3 Attaching the controller

When the covers have been removed, slide the controller into the non-struck side of the ribs from the pelvis end of the dummy. The sensor connector panel should face toward the dummy's head, and the cable connector panel (connections for LED, status, and dummy exit cables) should face toward the pelvis.

The controller is attached to the two adaptor plates on the ribs using two M5 x 16 socket-head cap screws, one at each end, as shown in Figures 27 and 28.

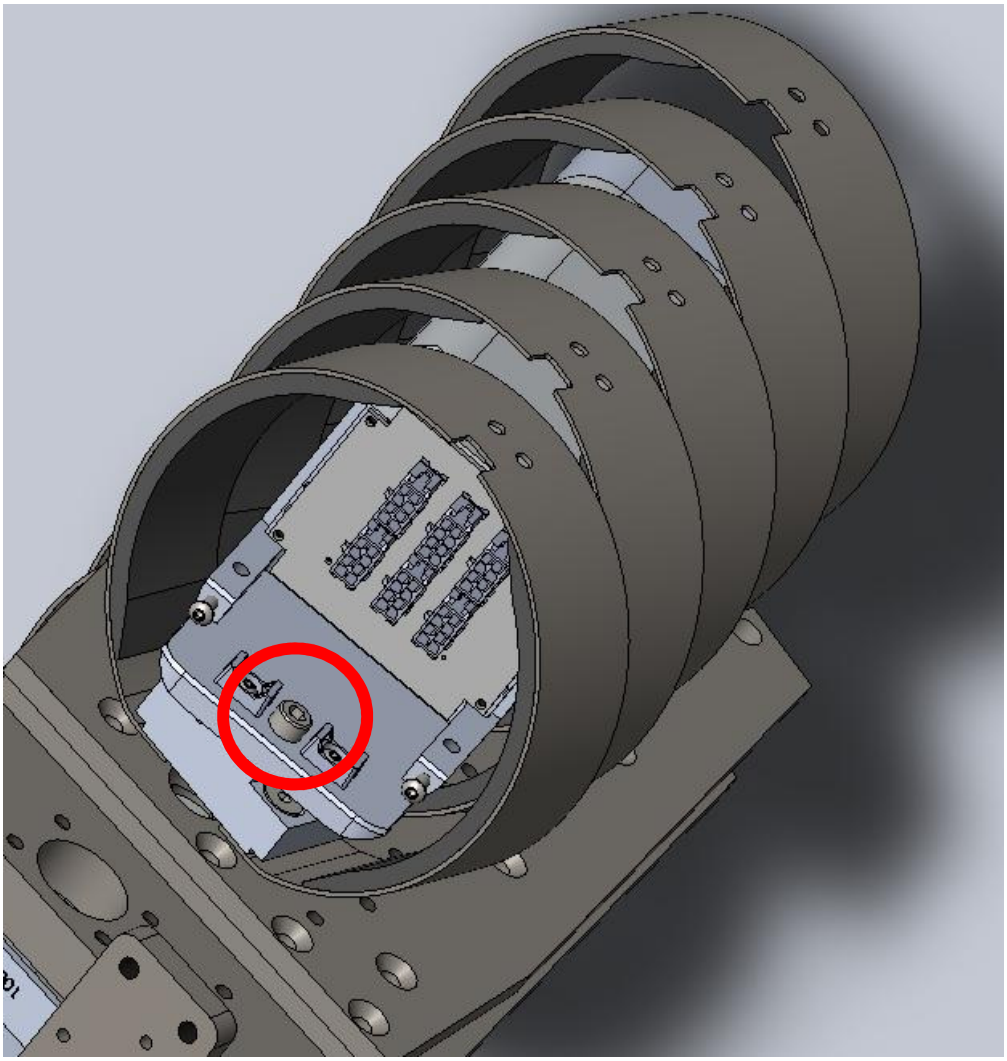

Figure 27. Controller (sensor connector end) attached to adaptor at thoracic 1 rib

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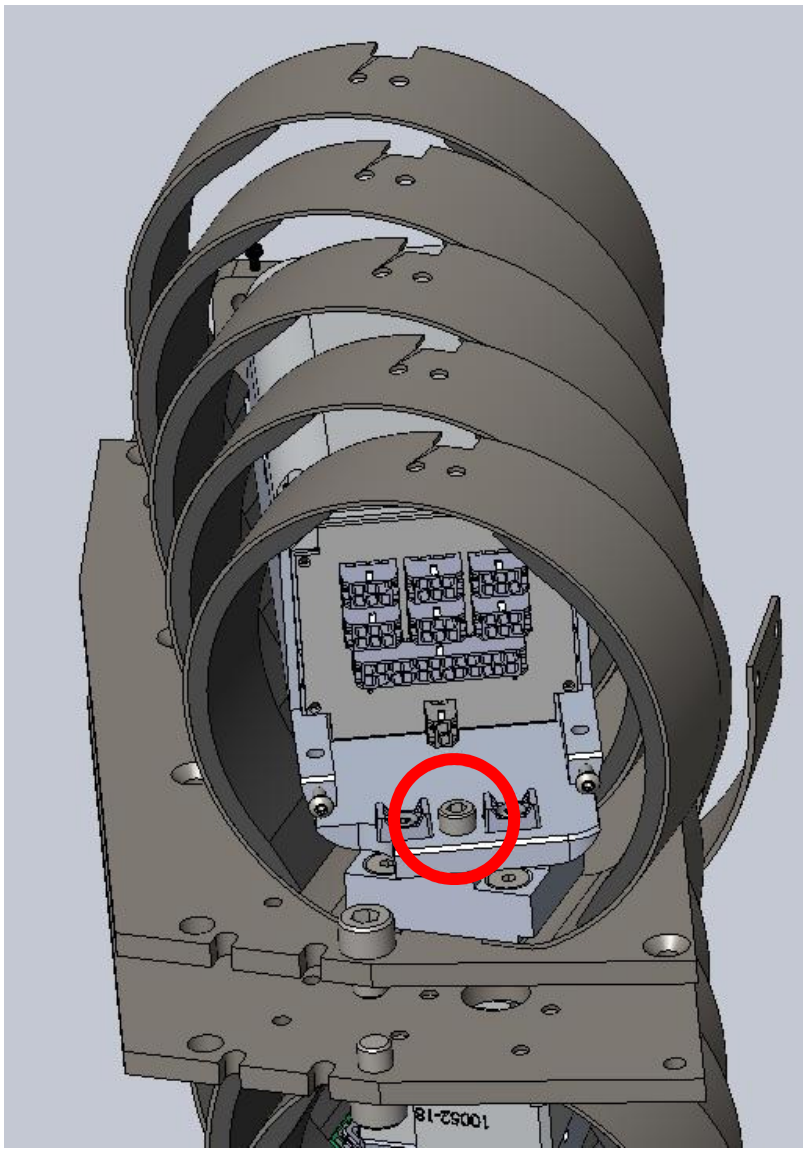

Figure 28. Controller (cable connector end) attached to adaptor at abdominal 2 rib

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2.3 Arm attachment/load cell replacer

WorldSID 5th ATDs shipped to date have used an arm attachment, a shoulder load cell, and a shoulder string pot:

- Figure 29 shows the arm assembly attached to the shoulder load cell
- Figure 30 shows the shoulder load cell assembly with the arm removed from the pivot ball
- Figure 31 shows the string pot mounted on the non-struck side of the dummy.

The original shoulder load cell, mounted inside the shoulder rib, must be removed to install the RibEye. The string pot assembly must also be removed – the RibEye will provide more accurate shoulder deflection information. The dummy manufacturer has prototyped a new shoulder load cell that mounts on the outside of the rib.

Until the outside-mounted load cell is readily available, Boxboro Systems provides a new arm mount assembly and shoulder load cell replacer, shown in Figure 32 with the dummy manufacturer's arm clamp and pivot ball attached. Figure 33 shows the shoulder load cell replacer with the arm clamp and pivot ball removed. Note that the pivot ball is attached to the load cell replacer with a dowel.

To install the load cell replacer, the arm clamp and pivot ball must be removed from the original load cell by driving out the dowel pin. Then install the arm clamp and pivot ball on the load cell replacer using the same dowel.

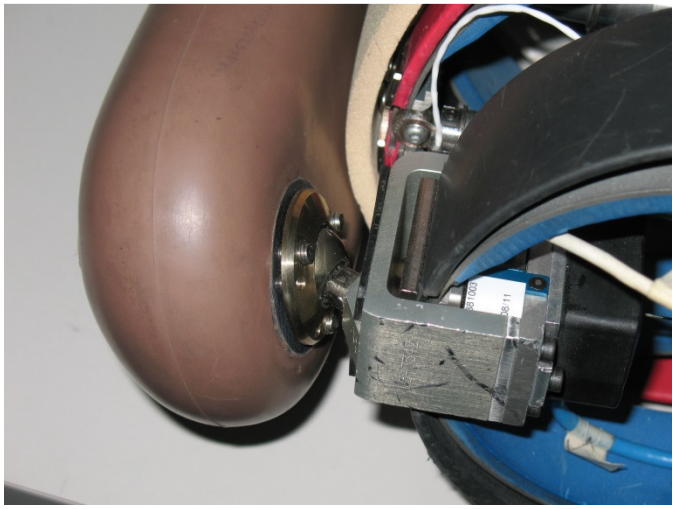

Figure 29. Arm assembly attached to shoulder load cell

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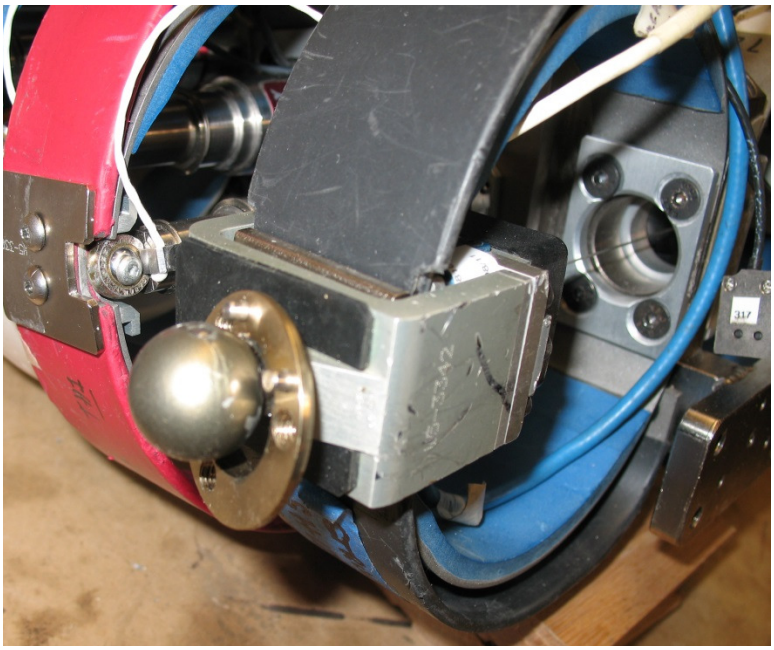

Figure 30. Shoulder load cell with arm removed

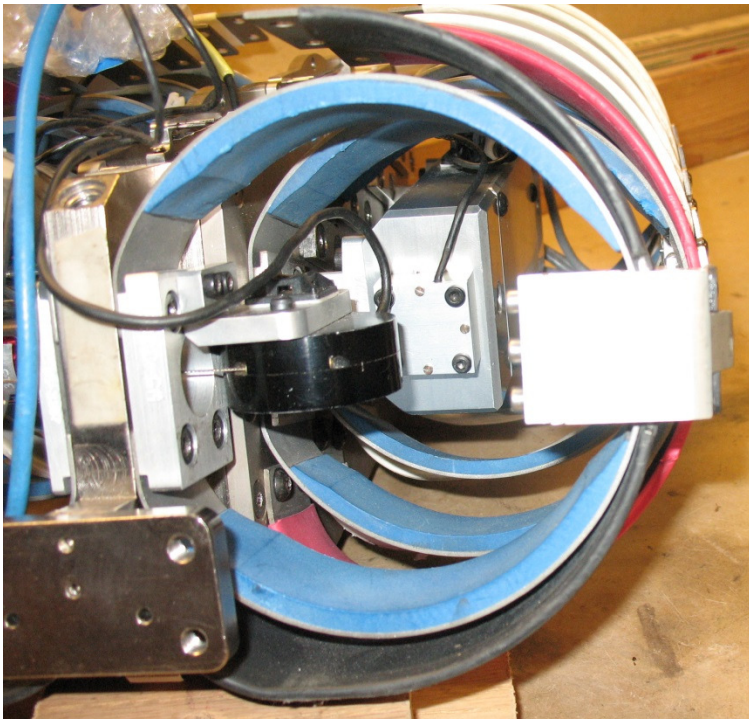

Figure 31. Shoulder string pot mounted on non-struck side of dummy

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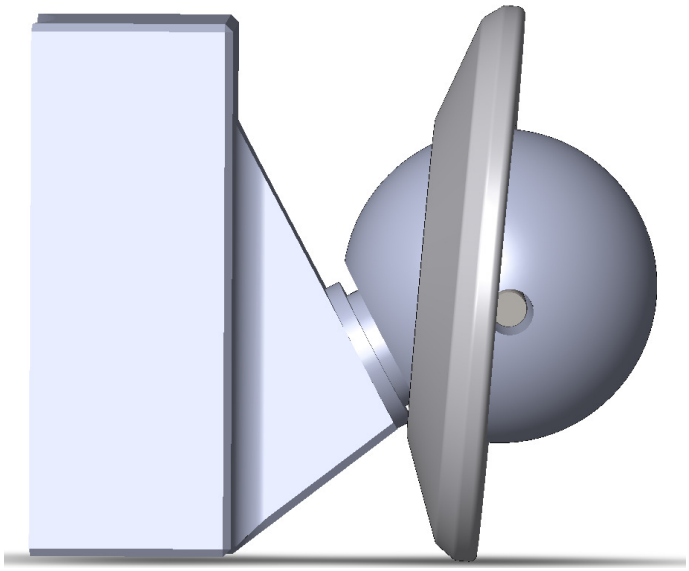

Figure 32. Load cell replacer with arm clamp and pivot ball attached

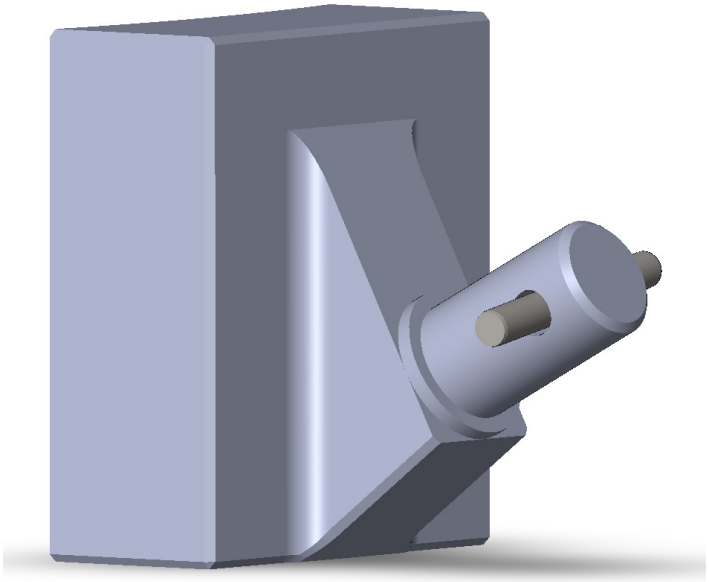

Figure 33. Load cell replacer with arm clamp and pivot ball removed

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2.4 Cable routing

2.4.1 Status cable

First, plug in the status cable at the 2-pole connector at the bottom end of the controller. This cable is routed to the outside of the dummy. It has a LED on it that flashes at different rates so you can see that the RibEye is working and what state it is in (see Section 3.2).

2.4.2 Dummy exit cable

The WorldSID RibEye controller, when mounted in the dummy, needs connections for power, trigger, and Ethernet. All external connections to the RibEye controller come from the 24-pole "Exit Cable" connector on the lower end of the controller, shown in Figure 34.

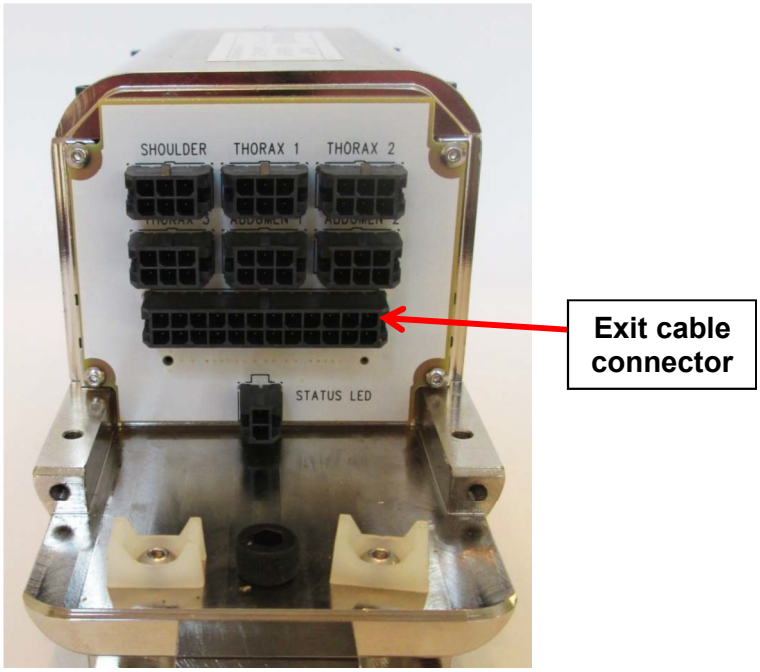

Figure 34. Exit cable connector in RibEye controller

The dummy exit cable's 24-pin Microfit plug should be plugged into the exit cable connector and tied to the strain relief saddle with a nylon zip tie. Boxboro Systems provides several cable options to connect the RibEye controller to the customer's equipment to get power, trigger, and Ethernet connections. You must specify the cable option you need when ordering the RibEye.

For customers with DTS TDAS G5 in-dummy DAS with external DTS Distributor (see Figure 35)

Exit cable #70011 connects to the RibEye controller at one end and to an extension cable #70100 at the other end. The 70100 is the same extension cable used to connect the G5 DAS units to the DTS distributor. This cable set uses the RibEye high-impedance trigger input compatible with the DTS trigger output.

For customers with Kistler NXT32 in-dummy DAS (see Figure 36)

Exit cable #70020 connects to the RibEye controller at one end and at the other end, to the last NXT32 module in the chain of modules in the dummy. This cable uses the RibEye opto-isolated trigger input compatible with the Kistler Crashlink trigger.

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For customers with other types of internal or external DAS (see Figures 37 and 38)

Separate exit and breakout cables

Exit cable #70025 connects to the RibEye controller at one end and to a breakout cable #70201 at the other end. The breakout cable is terminated in pigtails for power, opto-isolated trigger, and an armed output. The Ethernet connection is a standard RJ45 plug for connecting to an Ethernet hub/switch.

Single exit/breakout cable

Exit/breakout cable #70026 connects to the RibEye controller at one end. The other end is terminated in pigtails for power, opto-isolated trigger, and an armed output. The Ethernet connection is a standard RJ45 plug for connecting to an Ethernet hub/switch.

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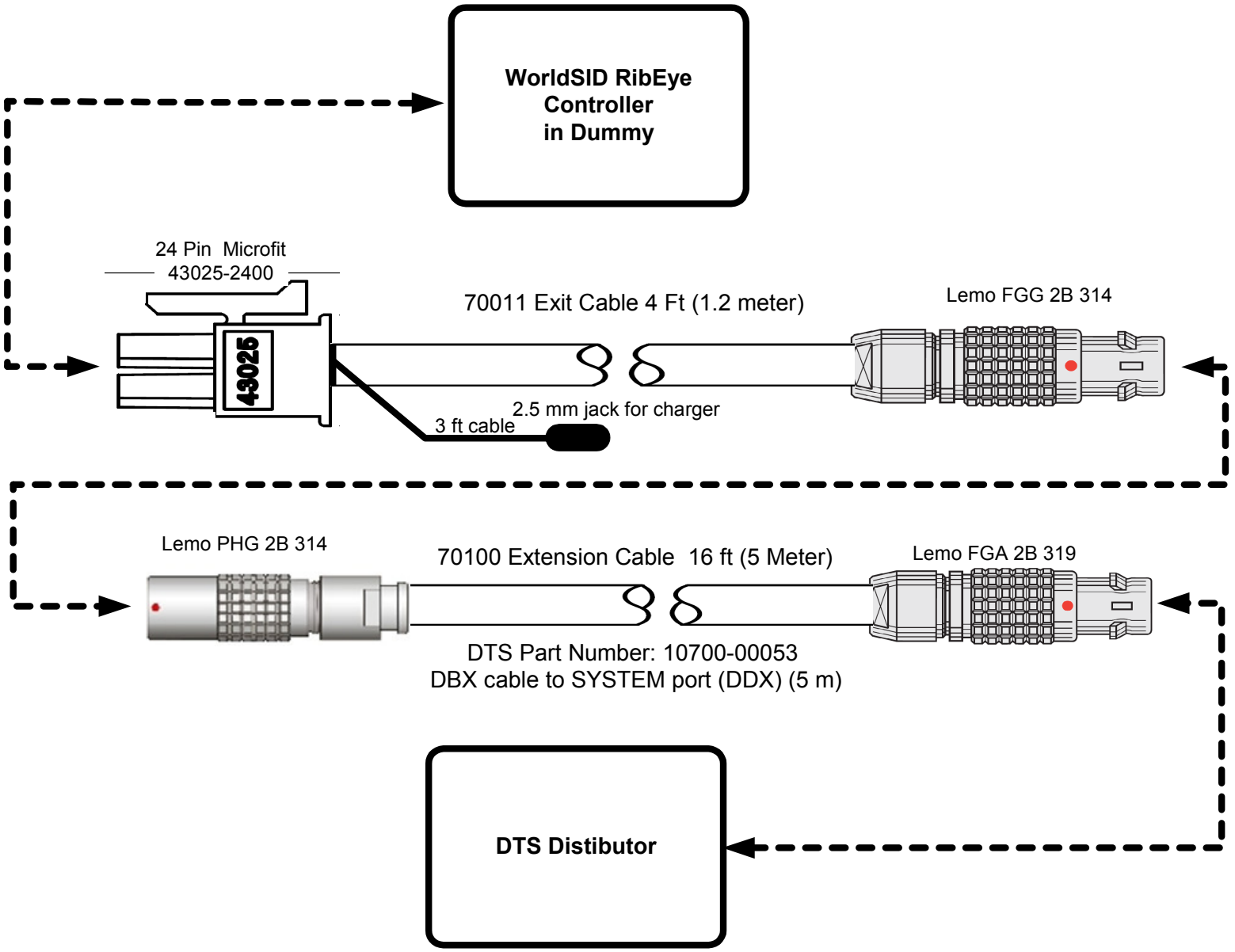

Figure 35. Option for DTS DAS – exit cable 70011 and extension cable 70100

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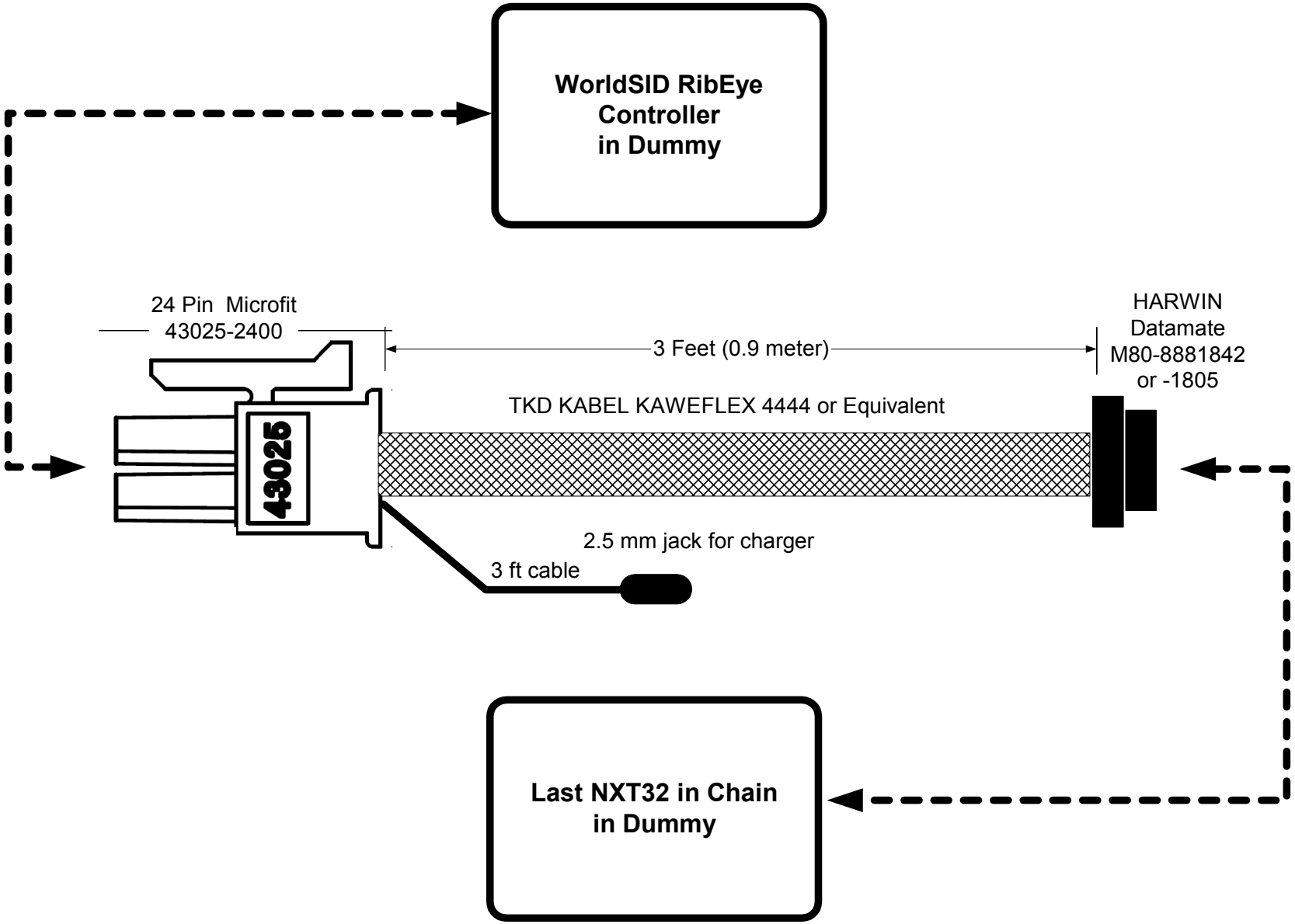

Figure 36. Option for Kistler NXT32 DAS – exit cable 70020

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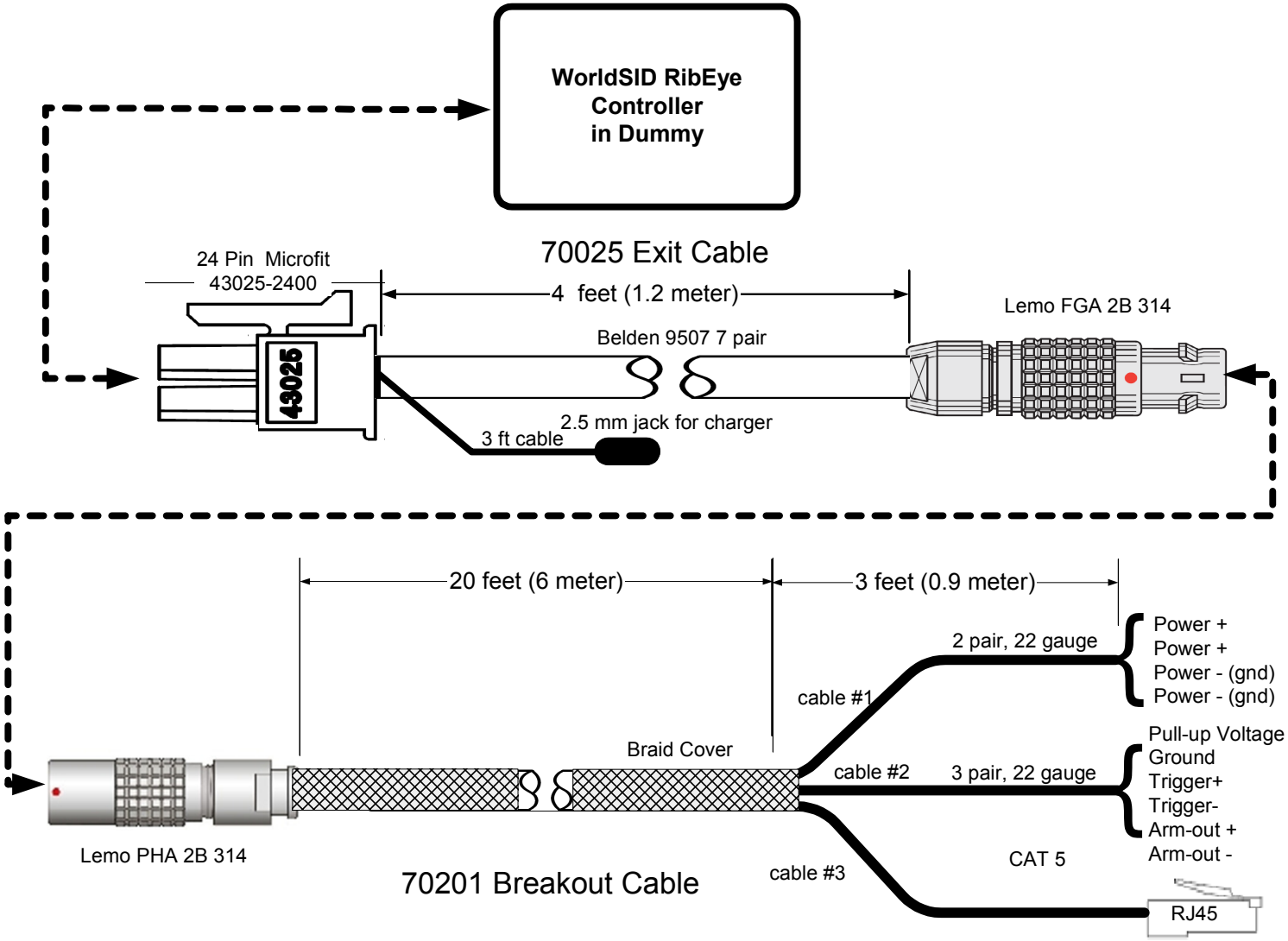

Figure 37. Option for generic DAS– exit cable 70025 and breakout cable 70201 with opto isolated trigger input and armed output
(see Table 3 below for pigtail connection wire colors)

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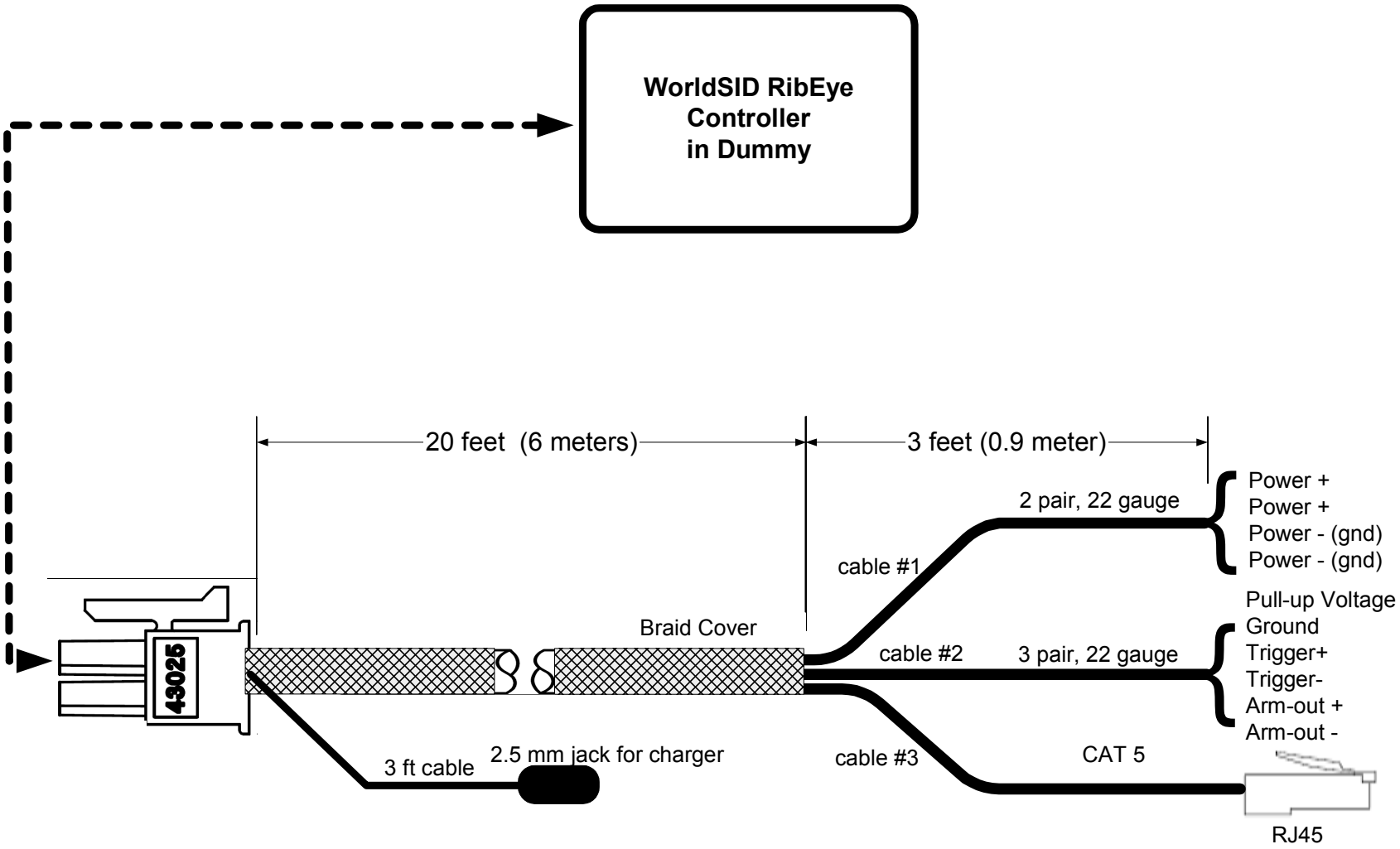

Figure 38. Option for generic DAS– exit/breakout cable 70026 with opto isolated trigger input and armed output
(see Table 3 below for pigtail connection wire colors)

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Table 3. Wire colors for breakout cable 70201 and exit/breakout cable 70026

Cable #1 (two-pair)		Cable #2 (three-pair)	
Power+	red	Pull-up Voltage	red
Power+	white	Ground	black (paired with red)
Power– (ground)	black (paired with red)	Trigger +	white
Power– (ground)	black (paired with white)	Trigger –	black (paired with white)
		Arm-out +	green
		Arm-out –	black (paired with green)

2.4.3 LED cables

Route the rib LED cables between the ribs and over the front of the dummy, under the sternum, then downward to the bottom end of the controller. The LED cables exit from the six ribs as follows:

- Shoulder (rib #1): LED cables exit from the bottom of the rib and go between the shoulder rib and the thoracic 1 rib to the non-struck side.
- Thoracic 1 (rib #2): LED cables exit from the top of the rib and go between the shoulder rib and the thoracic 1 rib to the non-struck side.
- Thoracic 2 (rib #3): LED cables exit from the top of the rib and go between the thoracic 1 rib and the thoracic 2 rib to the non-struck side.
- Thoracic 3 (rib #4): LED cables exit from the bottom of the rib and go between the thoracic 2 rib and the thoracic 3 rib to the non-struck side.
- Abdominal 1 (rib #5): LED cables exit from the bottom of the rib and go between the abdominal 1 rib and the abdominal 2 rib to the non-struck side.
- Abdominal 2 (rib #6): LED cables exit from the top of the rib and go between the abdominal 1 rib and the abdominal 2 rib to the non-struck side.

Tie the LED cables together on the non-struck side and tie the cable bundle to the inside of the ribs along the side of the controller. Then plug the connectors into the LED sockets on the bottom end of the controller and zip-tie the bundle to one of the cable tie-downs on the end of the controller. Zip-tie the dummy exit cable and the status cable to the other cable tie-down at the end of the controller.

After all the LED cables and the dummy exit cable are connected, the cover on the bottom end of the controller can be re-installed. Two M3 x 50 socket-head cap screws attach the cover top to the base. Two M3 x 10 socket-head cap screws attach the cover at the end of the controller. The cover screw locations were shown previously in Figure 26.

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2.4.4 Sensor cables

Route the sensor cables between the ribs toward the back of the dummy, as shown in Figure 39.
Then route the cables along the inside of the outer ribs toward the dummy's head, as shown in Figure 40.
Zip-tie the cables to the inside of the outer rib as close to the spine plate as possible.

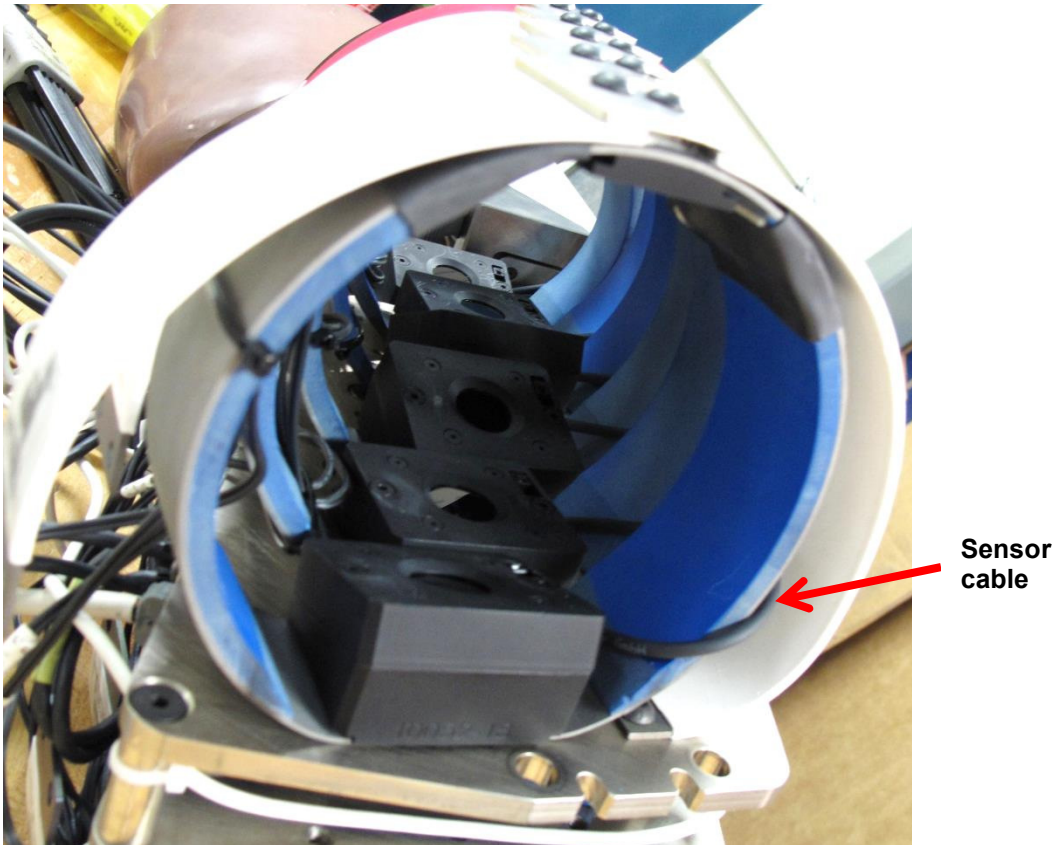

Figure 39. Sensor cables routed to back of dummy

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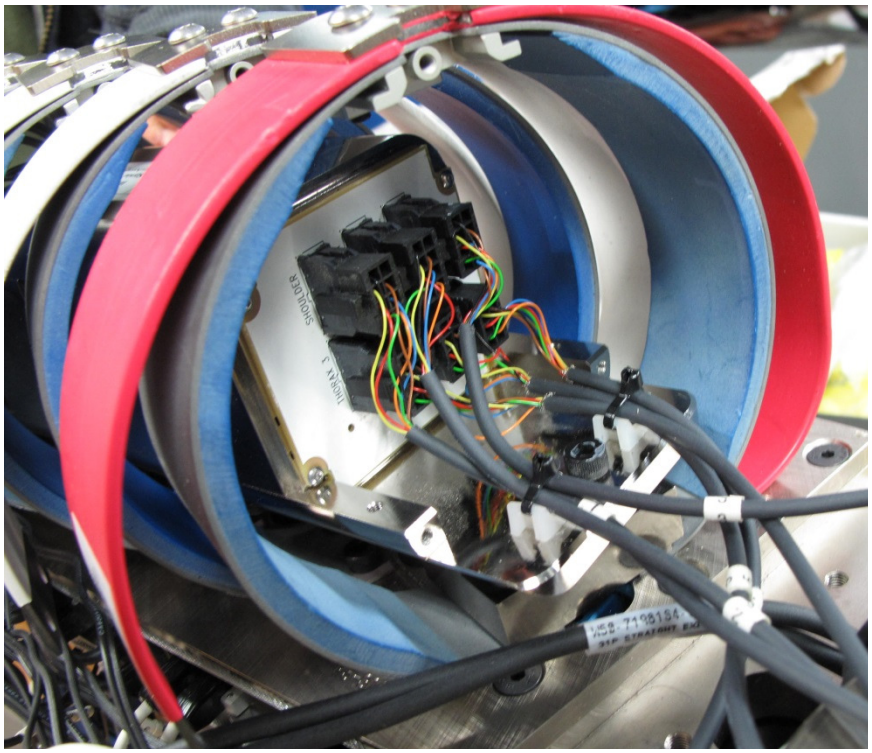

Figure 40. Sensor cables plugged into controller and tied to cable tie-downs

The bundle of sensor cables should go above the top sensor and below the bottom of the neck assembly. On the non-struck side, zip-tie the sensor cables to the shoulder rib.

Plug the sensor cables into the sensor sockets at the top end of the controller. Plug in the cables in the following order:

1. Abdominal 2 rib (cable #6)
2. Abdominal 1 rib (cable #5)
3. Thoracic 3 rib (cable #4)
4. Thoracic 2 rib (cable #3)
5. Thoracic 1 rib (cable #2)
6. Shoulder rib (cable #1)

Zip-tie the cables to the cable tie-downs on the end of the controller. Then re-install the cover on the top end of the controller using two M3 x 50 socket-head cap screws and two M3 x 10 socket-head cap screws.

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3.0 RibEye Operation

This section describes the operation, coordinate systems, and connections used in the RibEye. The RibEye for the WorldSID can be mounted on either side of the dummy to measure left-side or right-side impacts. If the RibEye will be used for right-side impacts, it must be calibrated for the right side. When ordering the RibEye, specify left, right, or both side impacts.

Please refer to the RibEye Software User Manual for software details and instructions on how to change the RibEye network's IP address. The manual is included on the disk shipped with the RibEye and can also be downloaded from our website, www.boxborosystems.com.

3.1 Data coordinate systems

As noted earlier, two sets of three sensors monitor the LED positions. The top set of sensors monitors the red LEDs mounted on the first three ribs (shoulder, thoracic 1, and thoracic 2). The bottom set of sensors monitors the blue LEDs mounted on the lower three ribs (thoracic 3, abdominal 1, and abdominal 2).

Position data from each sensor set is reported with respect to a coordinate system that has its origin in the center (middle) sensor of each set:

- For the top three ribs, the center of the coordinate system is the center of the inside face of the lens in the sensor mounted on the thoracic 1 rib. Note that the inside face of the sensor lens is 2 mm from the outside face of the sensor lens. The X-axis is parallel to the rib, the Y-axis is perpendicular to the spine plate, and the Z-axis is perpendicular to the rib.
- For the lower three ribs, the center of the coordinate system is the center of the inside face of the lens in the sensor mounted on the abdominal 1 rib. The X, Y, and Z axes are the same as for the upper sensor set (X parallel to the rib, Y perpendicular to the spine plate, and Z perpendicular to the rib).

Table 4 shows the nominal positions of the LEDs with the RibEye mounted on the left side of the dummy. The forward and rearward LEDs might vary slightly from these positions, as they are mounted with double-stick tape and heat-shrink tubing. The data in Table 4 was collected from a used set of ribs that had passed the thorax impact tests. A new set of ribs will have larger Y values, typically from 3 mm to 8 mm larger than shown.

For R&D testing, the LEDs can be placed anywhere within the RibEye's measurement range (see Appendix A, section A-1). For example, a user could place nine LEDs on a single rib to show the shape of the rib.

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Table 4. Nominal LED positions with RibEye mounted on dummy left side

LED	X	Y	Z
	mm		
Shoulder Rear	–28.4	–71.8	–43.4
Shoulder Center	–5.8	–75	–41.6
Shoulder Forward	14.6	–73	–45.7
Thoracic 1 Rear	–15.6	–87.6	–1.6
Thoracic 1 Center	4.3	–93.3	–7.5
Thoracic 1 Forward	24.5	–86.2	–2.1
Thoracic 2 Rear	–1.4	–86.2	36.1
Thoracic 2 Center	21.1	–94.7	32
Thoracic 2 Forward	41	–89.5	40
Thoracic 3 Rear	–36.9	–85.4	–33.3
Thoracic 3 Center	–16.1	–91.4	–27.8
Thoracic 3 Forward	2.9	–84.3	–30.1
Abdominal 1 Rear	–19.3	–82.1	0.5
Abdominal 1 Center	3	–90.9	–7.1
Abdominal 1 Forward	21.4	–83.4	–3.1
Abdominal 2 Rear	2	–84.1	33.7
Abdominal 2 Center	19.8	–90.2	30.6
Abdominal 1 Forward	36.8	–85.5	35.3

3.2 Status indicator

The status light flashes at varying rates to indicate that the RibEye is operating and what it is doing:

- 0.5 Hz = idle with data in memory
- 1.0 Hz = idle with memory erased
- 2.0 Hz = acquiring data
- 5.0 Hz = storing data in NOR flash memory
- 10 Hz = erasing flash memory or downloading data
- 20 Hz = writing to SD card flash memory

3.3 Ethernet link and activity lights

There are two lights on the side of the controller. The green light is the Ethernet link light, and the orange light is the Ethernet activity light.

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3.4 Batteries and chargers

There is one battery pack in the RibEye controller enclosure. It can be accessed by removing the top cover of the controller. Figure 41 shows the battery pack inside controller with the top cover removed (and end covers also removed).

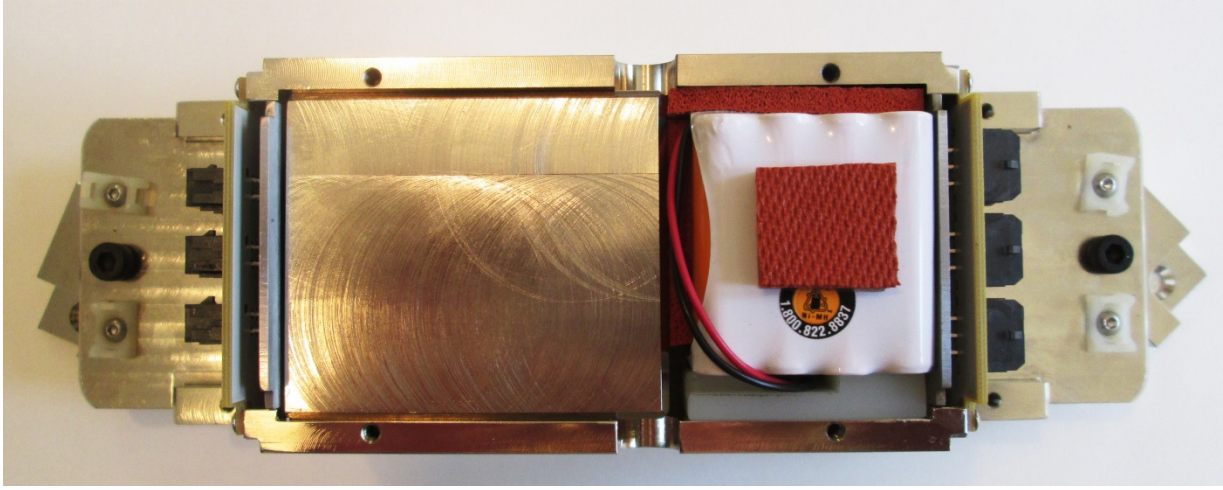

Figure 41. Battery pack

The RibEye battery pack consists of 12 AAA NiMH batteries. It is plugged directly into the controller with a connector under the white nylon spacer. The RibEye batteries are turned on only when the RibEye is armed or storing collected data to flash memory. They will provide a minimum of 20 minutes of run-time. Whenever the charger is plugged in, the RibEye will automatically disconnect the batteries from the RibEye circuits to allow the charger to function properly, even if the RibEye is armed.

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The charger for the RibEye battery pack is a Cell-Con Model 452115-01071-3311. A LED on the charger indicates its current mode, as shown in Table 5. Figure 42 shows the charger and the exit cable charger receptacle. Please refer to the Cell-Con Manual, which is supplied with the charger, for information on safety, operation, maintenance, etc.

Table 5. Cell-Con battery charger modes

LED Color	Mode
Orange	Battery not connected
Orange	Battery initialization and analysis (7 seconds)
Red	Fast charge
Green with intermittent orange flash	Top-off charge
Green	Trickle charge
Alternating Red-Green	Error

Figure 42. RibEye battery pack Cell-Con charger and exit cable charger receptacle

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3.5 Error codes

If the RibEye cannot calculate a LED position, the software will insert error codes in the data. If an error code occurs, data from all three axes, X, Y, and Z, will be forced to the same error code.

Usually error codes occur when the light from a LED is blocked and cannot reach one of the sensors. Typically, this results when a loose cable gets between the LED and the sensor. Also, if the center rib on either set of three ribs compresses significantly more than the upper or lower ribs of the set, it can block the light from the upper or lower rib LEDs to one of the sensors. Too much ambient light can also cause the RibEye to generate error codes.

If an error code occurs, you must discount the data for a few milliseconds before and after the drop-out in the plots. Before and after the light is completely blocked, the obstacle partially blocks light, which confuses the sensor and causes bad data to be reported. That's why a few milliseconds of data must be discounted before and after the blockage and drop-out.

NOTE: ***The error codes can get masked by filtering the data. Therefore, we strongly recommend reviewing and saving a copy of the unfiltered data so that the error codes are preserved.***

The error codes for each sensor set are as follows:

1. The top sensor is blocked or sees too much ambient light
2. The bottom sensor is blocked or sees too much ambient light
3. Both top and bottom sensors are blocked or see too much ambient light
4. The middle sensor is blocked or sees too much ambient light
5. The middle and top sensors are blocked or see too much ambient light
6. The middle and bottom sensors are blocked or see too much ambient light
7. All three sensors are blocked or see too much ambient light
8. A divide-by-zero condition occurred in the data processing
9. Out of range error.

The out-of-range error, code 9, occurs when the data from the sensor goes beyond the end of a calibration curve, indicating that the LED moved significantly out of the RibEye's guaranteed range.

To verify that a LED has moved out of range, create X-Y or Z-Y plots of the RibEye's absolute data and overlay the range limits on the plot. An example for a WorldSID 50th RibEye is shown in Figure 43.

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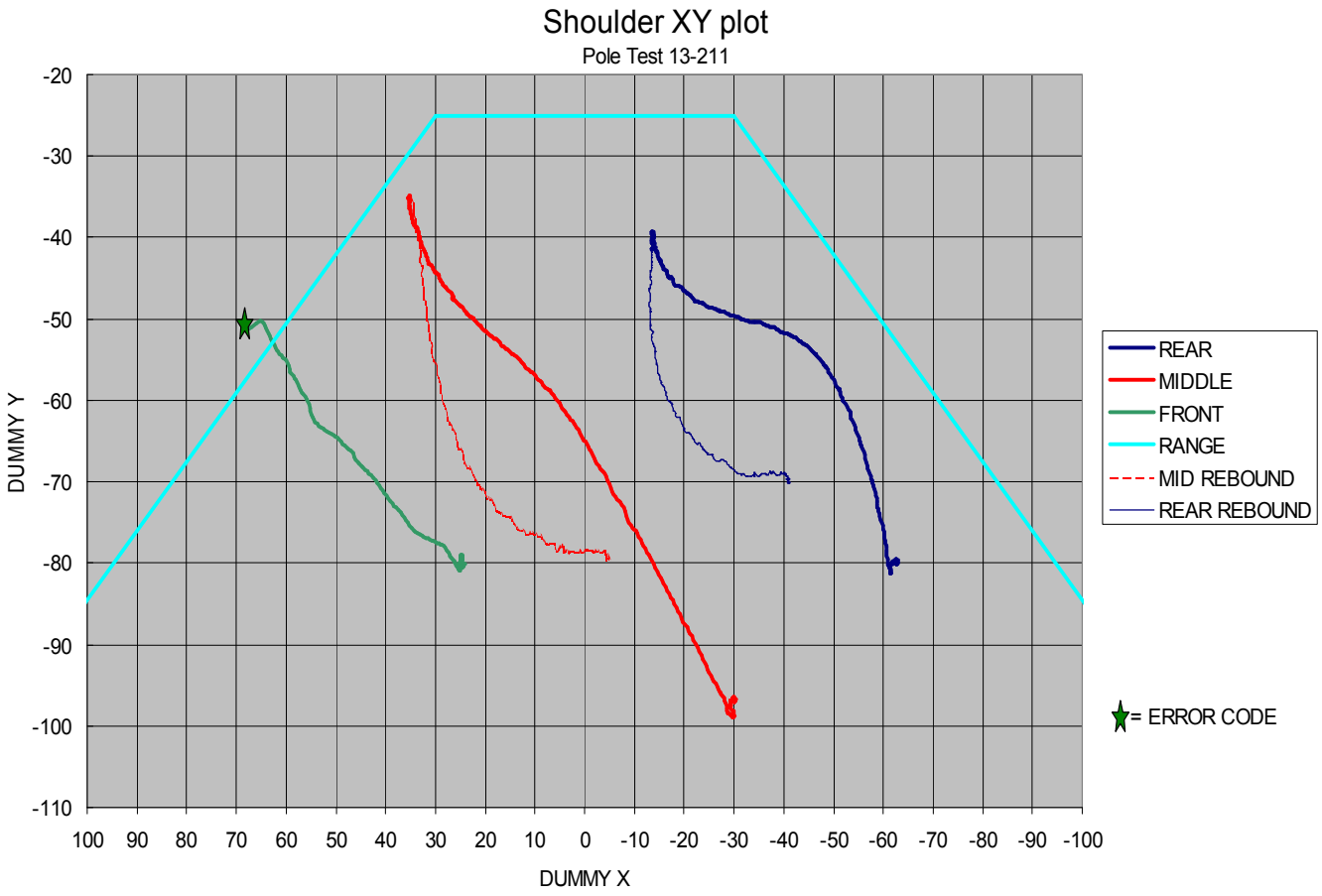

Figure 43. Plot overlay verifying whether LED moved out of range

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4.0 RibEye Maintenance

The only maintenance required for the RibEye is to keep the sensor lenses clean.

A dirty camera lens will create a fuzzy photo, and smudged eyeglasses will distort vision. The same holds true for RibEye: If the lenses are not clean, the data will be less accurate.

Make sure that the lenses are clean before each and every test.

If the lenses need to be cleaned, follow this procedure:

1. Blow dust off the lenses with clean, dry air.
2. If there is grease or dirt on the lenses, clean them with eyeglass or camera-lens cleaning solution and lens cleaning paper or a lens cleaning cloth. You can also use isopropyl alcohol (70 vol %).
3. Make sure there is no residue from the cleaning solution remaining on the lens.

WARNING: ***DO NOT USE cotton-tipped swabs like Q-Tips. They leave fibers on the lens.***

Note: If you can't get enough light into the thorax to see the lenses well, you can arm the RibEye to turn on the LEDs.

DANGER: ***Do not look directly at the LEDs, as they are very bright.***

Also clean the inside of the dummy to remove all loose debris such as dirt, pieces of foam, and zip-tie ends. Any objects, even very small, that are flying around inside the dummy during a test can interfere with the light from the LEDs to the sensors, causing spikes in the data.

WARNING: ***Never remove the sensor printed circuit board or loosen the circuit-board mounting nuts. Doing so will ruin the calibration of the RibEye.***

4.1 Dummy maintenance for RibEye

The inside of the thorax must be kept clean. Dirt and other particles can fly though the field of view between the LEDs and the sensors during a test, causing data spikes and anomalies. We recommend vacuuming or blowing out the thorax to remove and loose particles.

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Appendix A. RibEye Specifications and Cable Details

A-1. Measurement accuracy and range

The RibEye meets the requirements of SAE J211/1 (July 2007) as a combined sensor and data acquisition system. It also meets the ISO 6487-2000 specifications.

Figure A1 shows the RibEye measurement range in the X-Y plane for the upper three ribs (shoulder, thoracic 1, and thoracic 2). The upper three ribs use red LEDs and red filters on the sensors. The plot also shows the center LED positions for each of the ribs.

Figure A2 shows the RibEye measurement range in the Y-Z plane for the upper three ribs. The plot also shows the positions for all of the upper three rib center LEDs.

Figure A3 shows the RibEye measurement range in the X-Y plane for the lower three ribs (thoracic 3, abdominal 1, and abdominal 2). The lower three ribs use blue LEDs and blue filters on the sensors. The plot also shows the center LED positions for each of the ribs.

Figure A4 shows the RibEye measurement range in the Y-Z plane for the lower three ribs. The plot also shows the positions for all of the lower three rib center LEDs.

The maximum error for the Y and Z data is less than 1 mm for both the upper (red) and lower (blue) systems. The maximum X error is less than 1.5 mm for the upper (red) system and less than 2 mm for the lower (blue) system.

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Figure A1. RibEye measurement range in X-Y plane – upper three ribs

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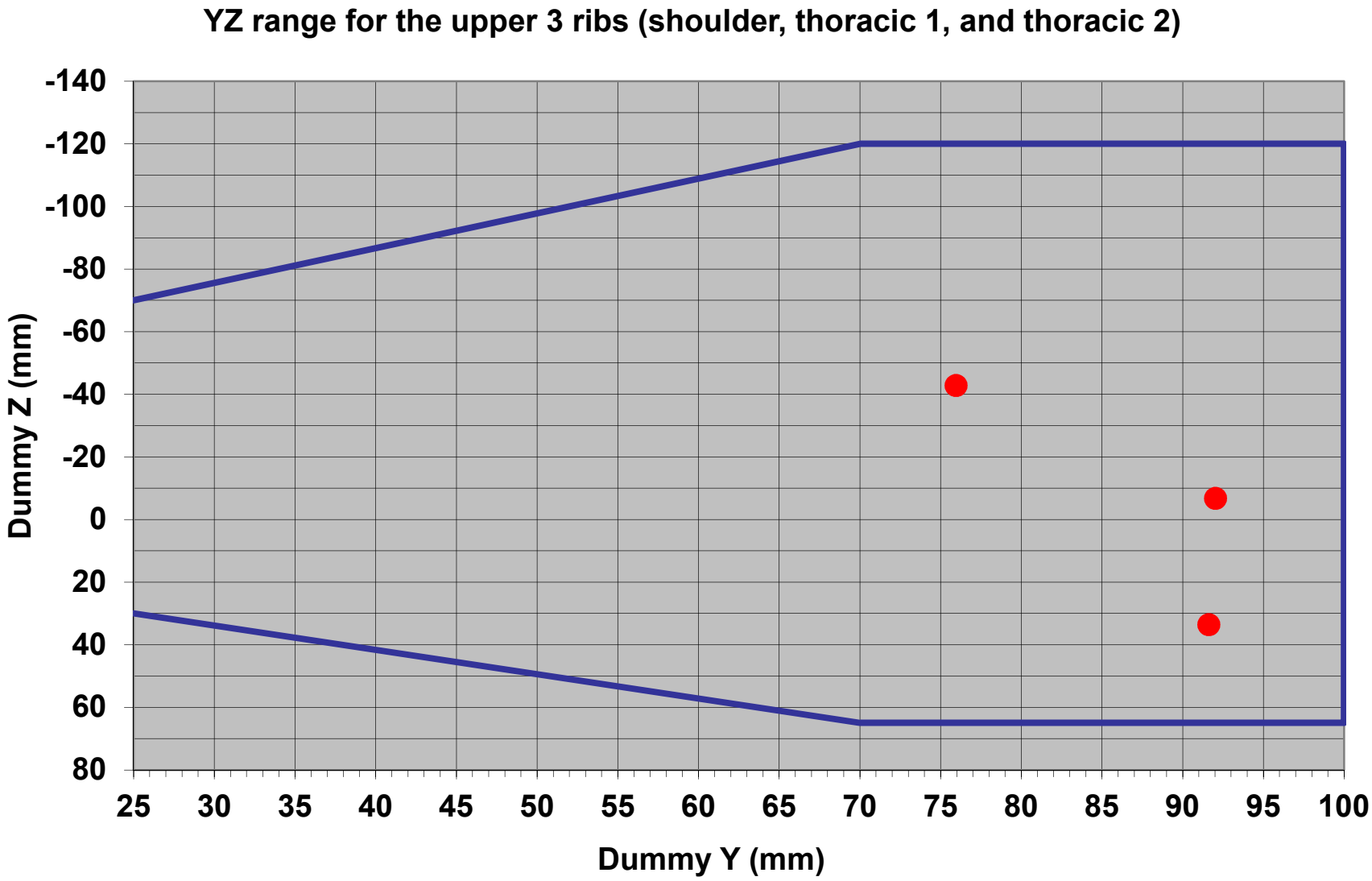

Figure A2. RibEye measurement range in Y-Z plane – upper three ribs

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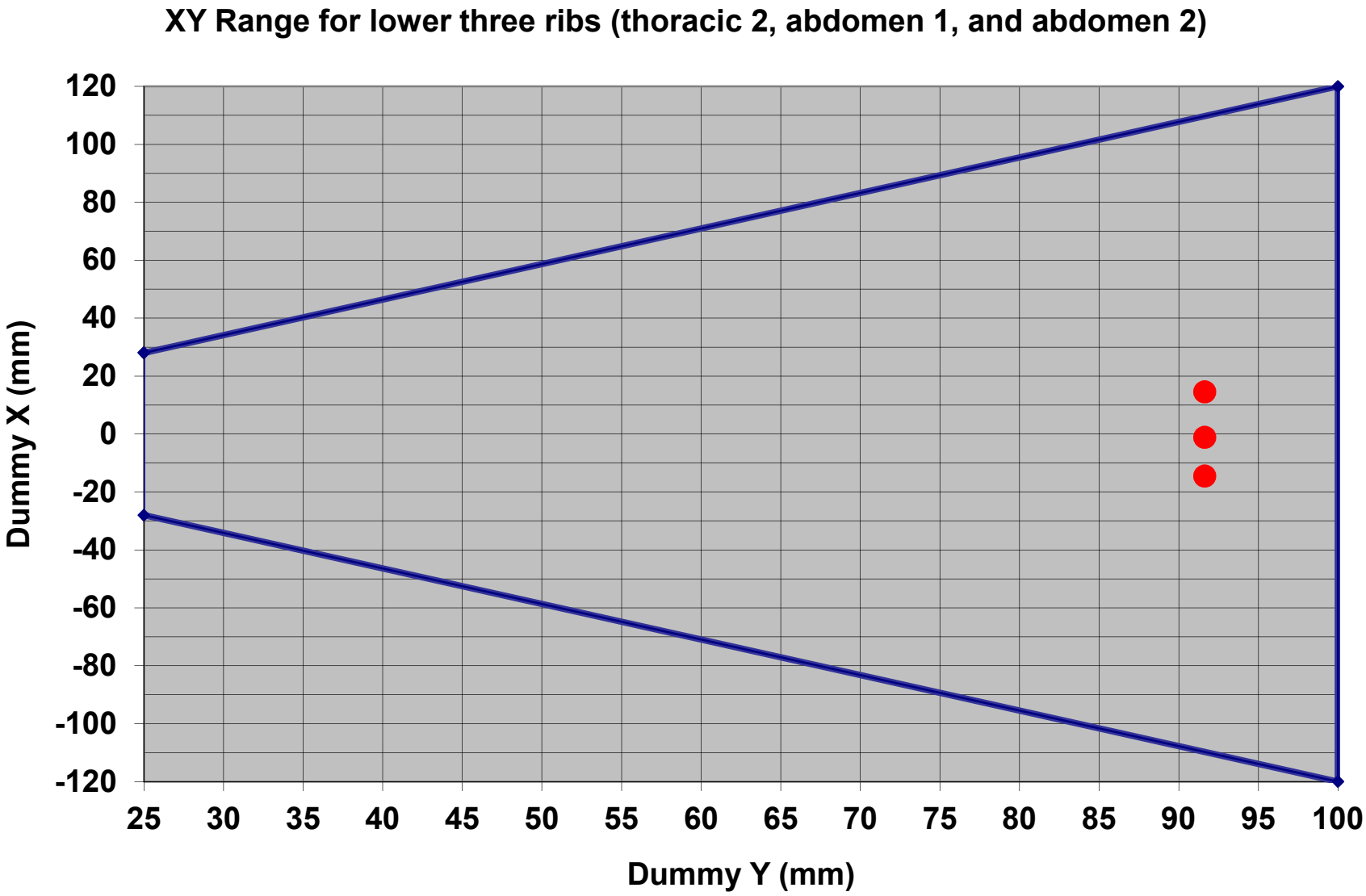

Figure A3. RibEye measurement range in X-Y plane – lower three ribs

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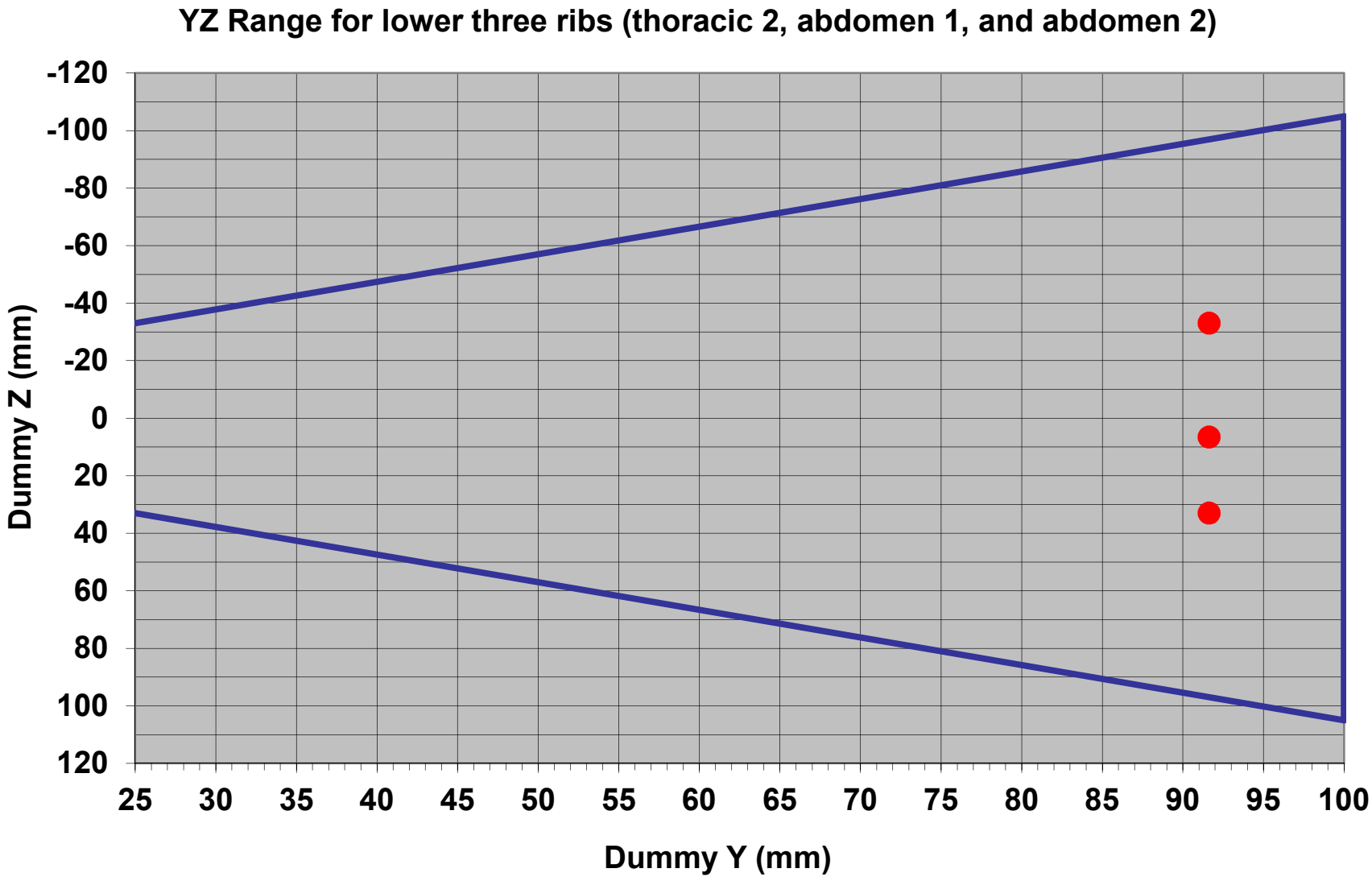

Figure A4. RibEye measurement range in Y-Z plane – lower three ribs

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A-2. Power requirements

The RibEye can be powered by a high-quality DC voltage source from 12 to 36 Volts. At idle, the RibEye draws 8 Watts. When collecting data, it draws 12 Watts typically and up to 20 Watts maximum. If all LEDs were blocked and driven to full power, the RibEye could draw up to 40 Watts.

When the batteries are fully charged, the backup battery pack can power the RibEye while collecting data for at least 20 minutes. After running the RibEye on batteries for 20 minutes, it will take about 4 hours to fully recharge the batteries.

The RibEye controller has a self-resetting polymer fuse on its power input. If this fuse ever opens, it can take up to 4 hours to self-reset.

A-3. Data acquisition and storage

Data is collected to RAM memory and stored post-test in flash memory.

Sample rate: 10,000 samples per second per LED (10 kHz)

Modes: Linear or circular buffer

Total acquisition time: 25 seconds

Data storage:

- 25 seconds in RAM
- 25 seconds in SD card flash (non-volatile)
- 1.7 seconds in backup flash (non-volatile)

A-4. Ethernet communication

Communication between the RibEye and the PC software is via 10/100 MBS Ethernet. The IP address can be set by the user. (Factory default = 192.168.0.240.)

Please refer to the RibEye Software User Manual for software details and instructions on how to change the RibEye network's IP address. The software manual is included on the disk shipped with the RibEye and can also be downloaded from our website, www.boxborosystems.com.

The RibEye communicates with the PC software using port 3000. An open protocol is used to send commands to the RibEye and to receive data. See the RibEye Communications Protocol document on our website for more information.

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A-5. Trigger circuits

The trigger circuit can be configured for a variety of options including a high-impedance input or a lower impedance, optically isolated input. Please contact Boxboro Systems for your requirements.

Figure A5 shows the generic trigger circuit inside the RibEye controller.

Figure A6 shows the trigger input configured for connection to an external DTS Distributor using Boxboro Systems cable #70011 and extension cable #70100.

Figure A7 shows the trigger input configured for a Kistler NXT32-supplied trigger using Boxboro Systems cable #70020.

Figure A8 shows the trigger input configured for generic pigtail cable assembles using Boxboro Systems exit cable #70025 and breakout cable #70201 or Boxboro Systems exit/breakout cable #70026.

A-6. Armed-out circuit

Boxboro Systems exit cable #70025 and breakout cable #70201 or exit/breakout cable #70026 have an "Armed-out" signal that turns on when the RibEye is armed and turns off when the RibEye has completed storing the data for the test in flash memory.

Figure A9 shows the Armed-out circuit.

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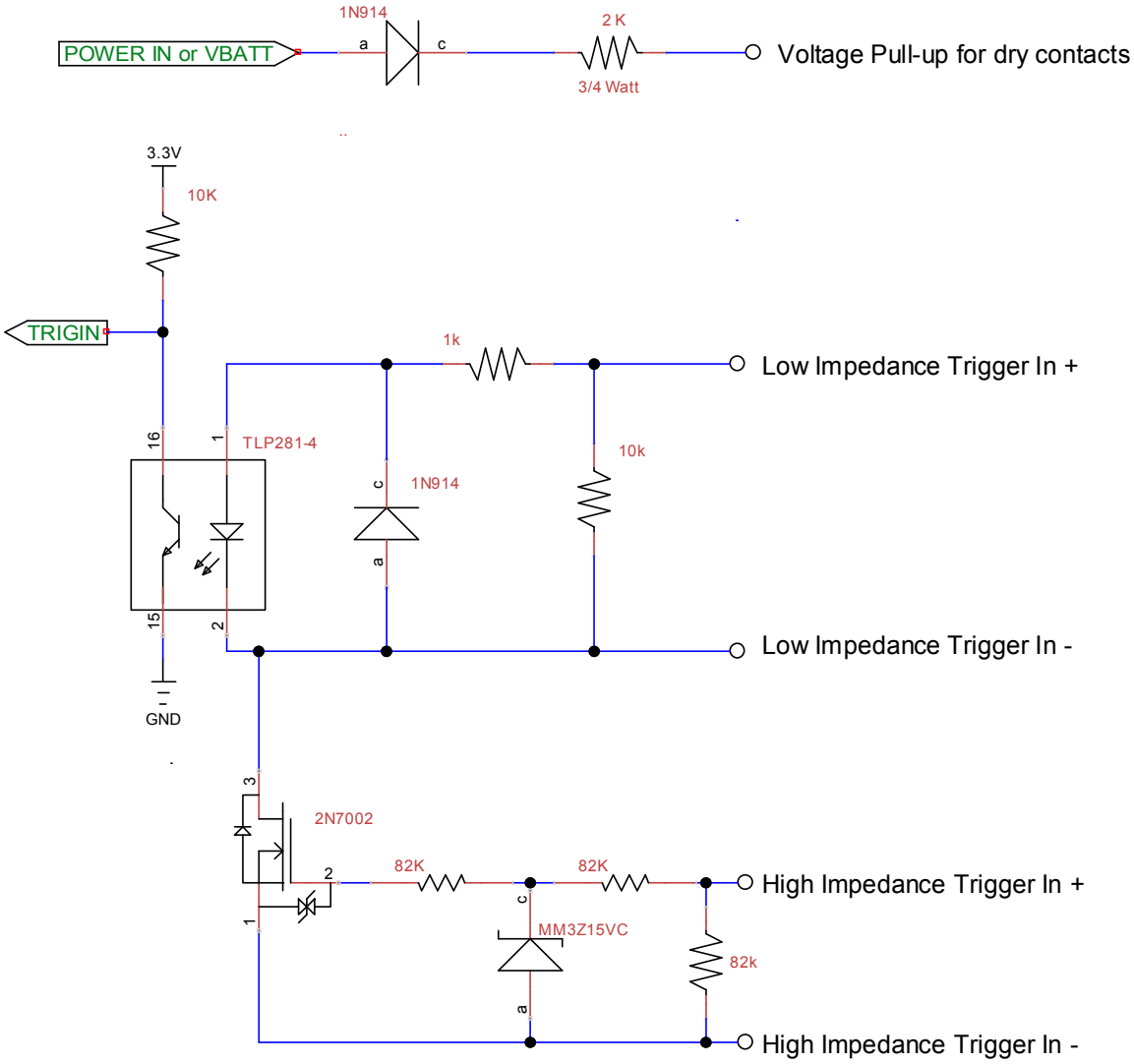

Figure A5. Trigger input circuits

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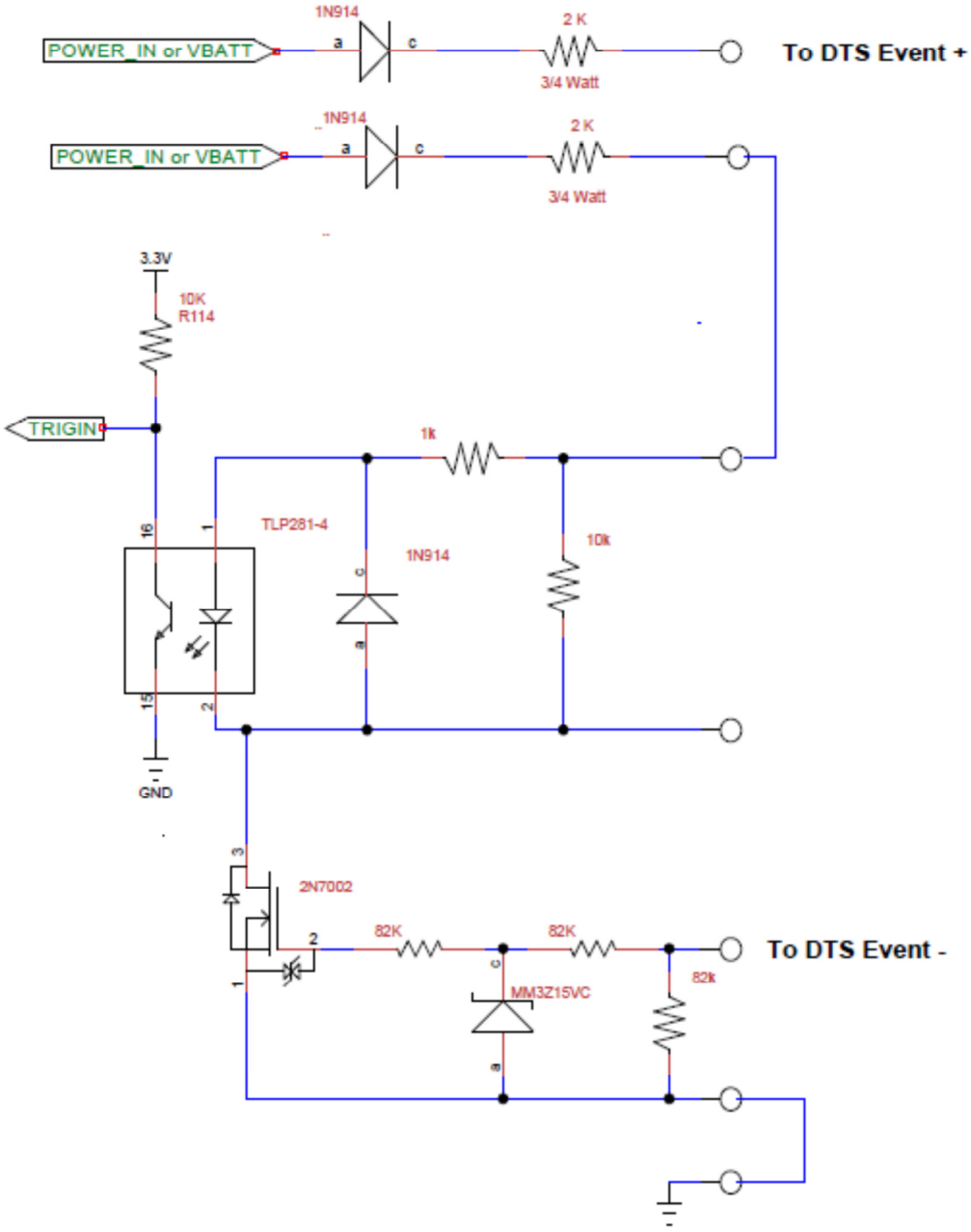

Figure A6. Trigger input configured for DTS MDB-supplied trigger
(Note: Power-in and ground are supplied from the DTS MDB)

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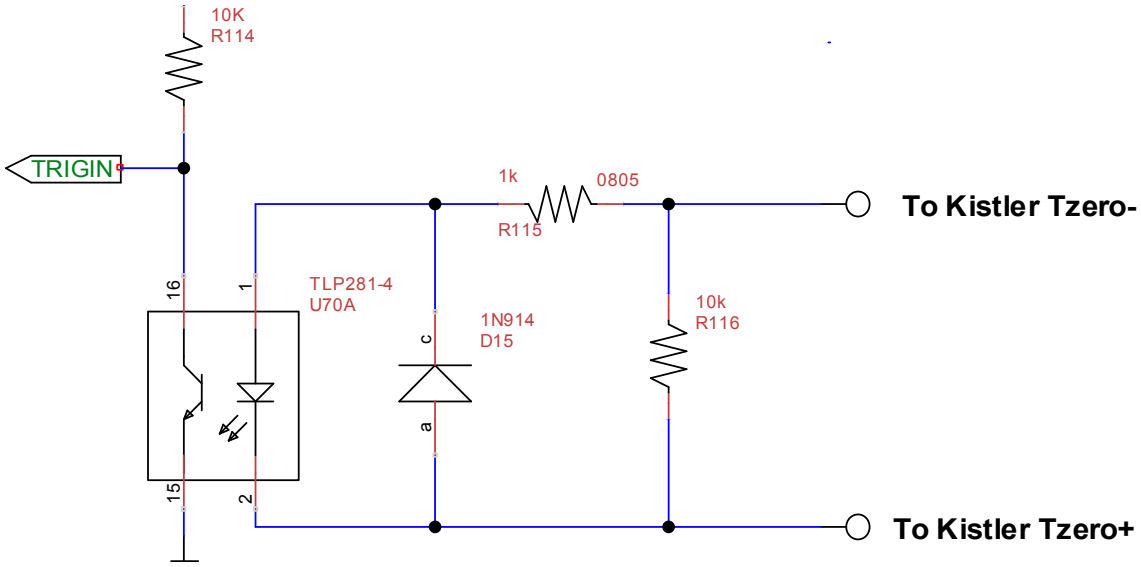

Figure A7. Trigger input configured for Kistler NXT32-supplied trigger

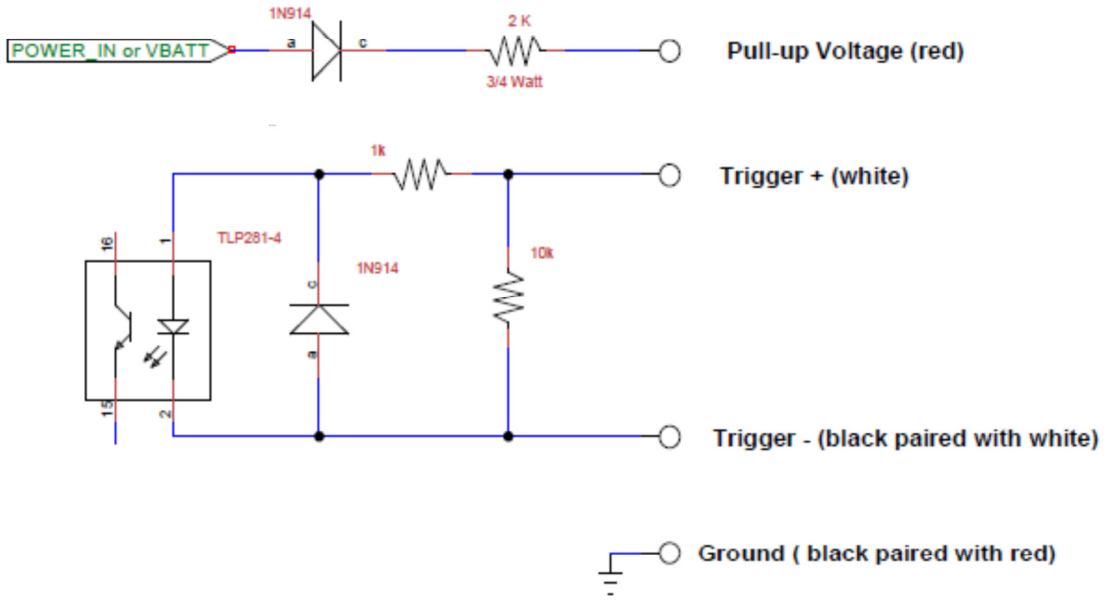

Figure A8. Trigger input configured for generic pigtail cable assemblies

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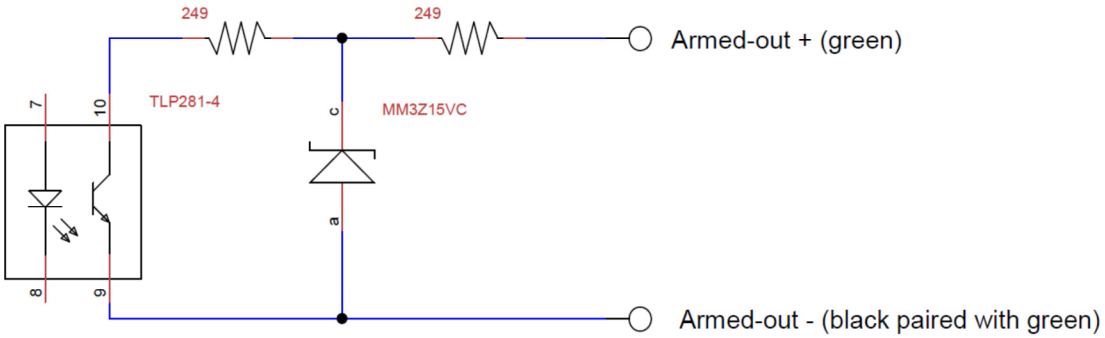

Figure A9. Armed-out circuit for generic pigtail cable assemblies
(Note: The opto-isolated output transistor turns on
when the RibEye is armed and collecting or storing data)

WARNING: ***The maximum current through the circuit must be less than 20 milliamps.***

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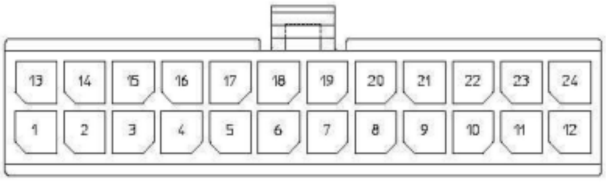
A-7. RibEye cable details

This section contains the connector wiring for the various RibEye cables to facilitate field-repair of damaged cables.

Table A1. DTS DAS cable 70011

Microfit connector	43025-2400
Microfit crimp terminals	43030-0009, 20-24 gauge
Lemo connector	FGG.2B.314.CLAD82
Cable type	Belden 9507

Microfit connector, view from mating plug side



Microfit #	RibEye Name	Wire Color	Lemo 14 #	DTS Name
1	ERx+	orange	7	ETHERNET RX+
2	ETx+	green	5	ETHERNET TX+
3	GND	brown	8	MAIN PWR– (GND)
4	Voltage Pull-up 2	red jumper to 9		
8	15V PULLUP	white	9	EVENT+
9	LO I TRIGIN+	red jumper to 4		
10	HI I TRIGIN+	black (white)	10	EVENT–
11	GND	black (brown)	4	MAIN PWR– (GND)
12	+Vin	black (red)	1	MAIN PWR+
13	ERx–	black (orange)	3	ETHERNET RX–
14	ETx–	black (green)	6	ETHERNET TX–
16	BAT CHARGE – C+	center term on 2.5 mm jack		
20	GND	black jumper to 22		
22	HI I TRIGIN–	black jumper to 20		
23	GND – C–	outer term on 2.5 mm jack		
24	+Vin	red	2	MAIN PWR+

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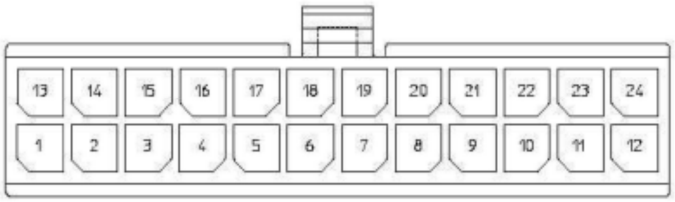
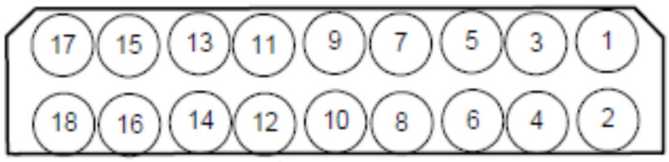
Table A2. Kistler DAS cable 70020

Microfit connector	43025-2400
Microfit crimp terminals	43030-0009, 20-24 gauge; 43030-0012, 26-30 gauge
Harwin Datamate connector	M80-8881842
Cable type	Kaweflex 4444

Microfit connector,
view from mating plug side



Harwin connector,
view from wire side



Microfit #	RibEye Name	Wire Color (Kaweflex 4444)	Wire Size mm^2/ approx AWG	NXT32 Pin#	NXT32 Name
1	ERx+	grey (grey/pink pair)	0.14 / 26	2	ETx+
2	ETx+	purple (purple/ yellow pair)	0.14 / 26	4	ERx+
9	LO I TRIGIN+	black (red/black pair)	0.14 / 26	8	Tzero–
10	HI I TRIGIN+				
11	GND	white (white/blue pair)	0.25 / 23	15	PWR Return
12	+Vin	brown/green stripe	0.25 / 23	18	PWR+
13	ERx-	pink (grey/pink pair)	0.14 / 26	1	ETx–
14	ETx–	yellow (purple/yellow pair)	0.14 / 26	3	ERx–
15	GND	charger cable/ 2.5 mm jack white dashed lead, center terminal on jack	24		
16	BAT CHARGE +	charger cable/ 2.5 mm jack white dashed lead, center terminal on jack	24		
21	LO I TRIGI–	red (red/black pair)	0.14 / 26	7	Tzero+
23	GND	blue (white/blue pair)	0.25 / 23	16	PWR Return
24	+Vin	white/green stripe	0.25 / 23	17	PWR+

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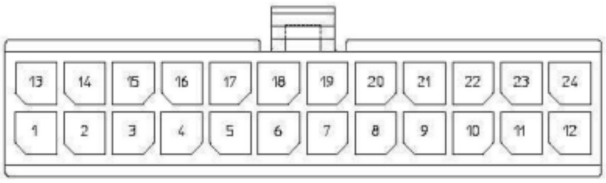
Table A3. Generic DAS exit cable 70025

Microfit connector	43025-2400
Microfit crimp terminals	43030-0009, 20-24 gauge
Lemo connector	FGA.2B.314.CLAD72
Cable type	Belden 9507

Microfit connector, view from mating plug side



RibEye Name	Microfit	Wire Color	Lemo
ERx+	1	orange	1
ETx+	2	green	3
PULLUP V	8	brown	5
LO I TRIGIN+	9	white	9
HI I TRIGIN+	10	black jumper to 22 *	
GND	11	black (yellow)	14
+Vin	12	yellow	12
ERx–	13	black (orange)	2
ETx–	14	black (green)	4
GND	15	2.5 mm socket outer *	
BAT CHARGE	16	2.5 mm socket center *	
CTRL COM	17	black (blue)	8
ARM OUT+	19	blue	7
GND	20	black (brown)	6
LO I TRIGIN–	21	black (white)	10
HI I TRIGIN–	22	black jumper to 10 *	
GND	23	black (red)	13
+Vin	24	red	11
		drain wire	case

* not in Belden cable

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Table A4. Generic DAS breakout cable 70201

RibEye Name	Lemo PHA.2B.314.CLDD99Z	Cable 1 Power Alpha 2212C	Cable 2 Trigger Alpha 2213C	Cable 3 CAT5e Ethernet Assmann DK-1511-025/BL
ERx+	1			3 ETH_RX+ white/green
ERx–	2			6 ETH_RX– green
ETx+	3			1 ETH_TX+ white/orange
ETx–	4			2 ETH_TX– orange
PULLUP V	5		red	
GND	6		black (red)	
ARM OUT+	7		green	
ARMOUT–	8		black (green)	
LO I TRIGIN+	9		white	
LO I TRIGIN–	10		black (white)	
+Vin	11	red		
+Vin	12	white		
GND	13	black (red)		
GND	14	black (white)		
	case	drain	drain	

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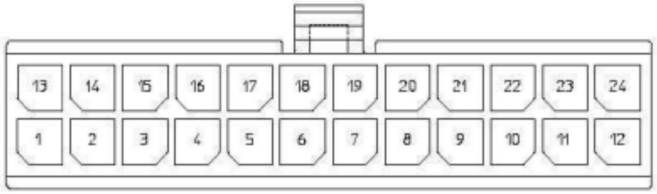
Table A5. Generic DAS exit/breakout cable 70026

Microfit connector	43025-2400
Microfit crimp terminals	43030-0009, 20-24 gauge

Microfit connector, view from mating plug side



RibEye Name	Microfit 43025-2400	2.5 mm charger socket and jumpers	Cable 1 Power Alpha 2212C	Cable 2 Trigger Alpha 2213C	Cable 3 CAT5e Ethernet Assmann DK-1511-025/BL
ERx+	1				3 ETH_RX+ white/green
ETx+	2				1 ETH_TX+ white/orange
PULLUP V	8			red	
LO I TRIGIN+	9			white	
HI I TRIGIN+	10	black jumper to 22			
GND	11		black (red)		
+Vin	12		red		
ERx–	13				6 ETH_RX– green
ETx–	14				2 ETH_TX– orange
GND	15	2.5 mm socket outer			
BAT CHARGE	16	2.5 mm socket center			
ARM OUT–	17			black (green)	
ARM OUT+	19			green	
GND	20			black (red)	
LO I TRIGIN–	21			black (white)	
HI I TRIGIN–	22	black jumper to 10			
GND	23		black (white)		
+Vin	24		white		

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Table A6. LED cables 70001-70006

Microfit connector	43025-0600
Microfit crimp terminals	43030-0009 20-24 gauge

RibEye Name	Microfit 43025-0600
rear LED cathode	1
middle LED cathode	2
front LED cathode	3
rear LED anode	4
middle LED anode	5
front LED anode	6

View from mating side

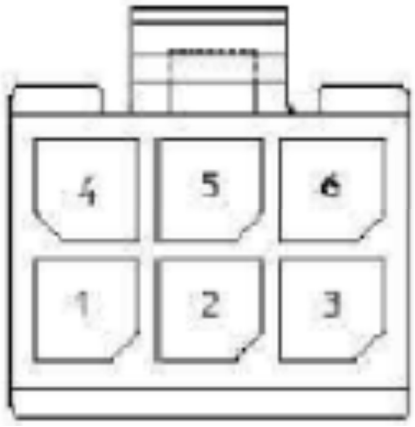

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Table A7. Sensor cables 70001-70006

Microfit connector	43025-0800
Microfit crimp terminals	43030-0012, 26-30 gauge

Wire Color	Microfit 43025-0800
shield	1
brown	2
blue	3
orange	4
black	5
yellow	6
red	7
green	8

View from mating side

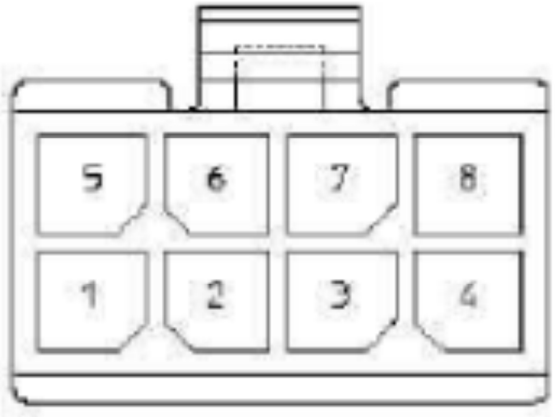

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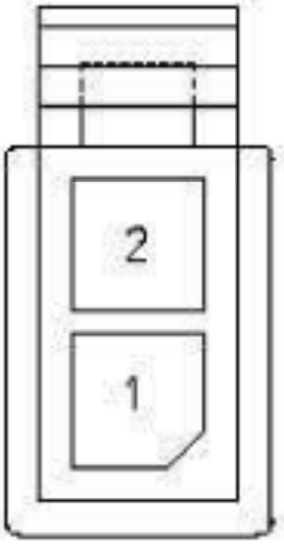
Table A8. Status LED cable

Microfit connector	43025-0200
Microfit crimp terminals	43030-0009, 20-24 gauge

RibEye Name	Microfit 43025-0600
LED cathode	1
LED anode	2

View from mating side



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Appendix B. Switching RibEye WorldSID from Left-Side to Right-Side Impact

For right-side impact, all RibEye components are mounted in a similar way as they are for left-side impact. For right-side impact, the sensor cables exit toward the front of the dummy (Figure B1). The red arrow in Figure B1 points to the sensor cables. Instead of routing the cables between the inner and outer rib bands as in the left-side impact setup, bundle the sensor cables as shown in Figure B1. Use black zip-ties to bundle the cables. Make sure that the cables can not move in front of the sensors.

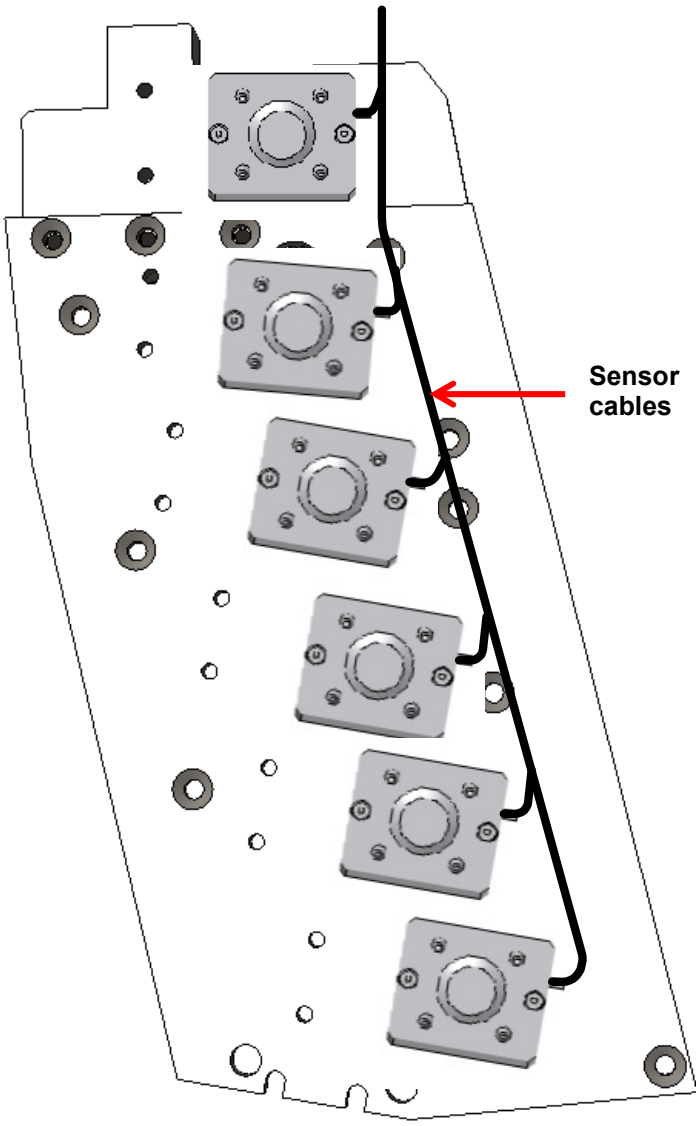

Figure B1. RibEye sensor positions and cable routing for right-side impact

Also, different calibration curves are used for left-side and right-side impact. To load the correct calibration curve to the RibEye, see the Software User Manual Version 4.0, Section 2.6, "RibEye Pointed Toward Dummy" Field.

Normally, a WorldSID RibEye is provided with only left-side impact calibration curves. If you plan to install the RibEye for right-side impact, please request that the RibEye be calibrated for right-side impact when you order the RibEye.

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