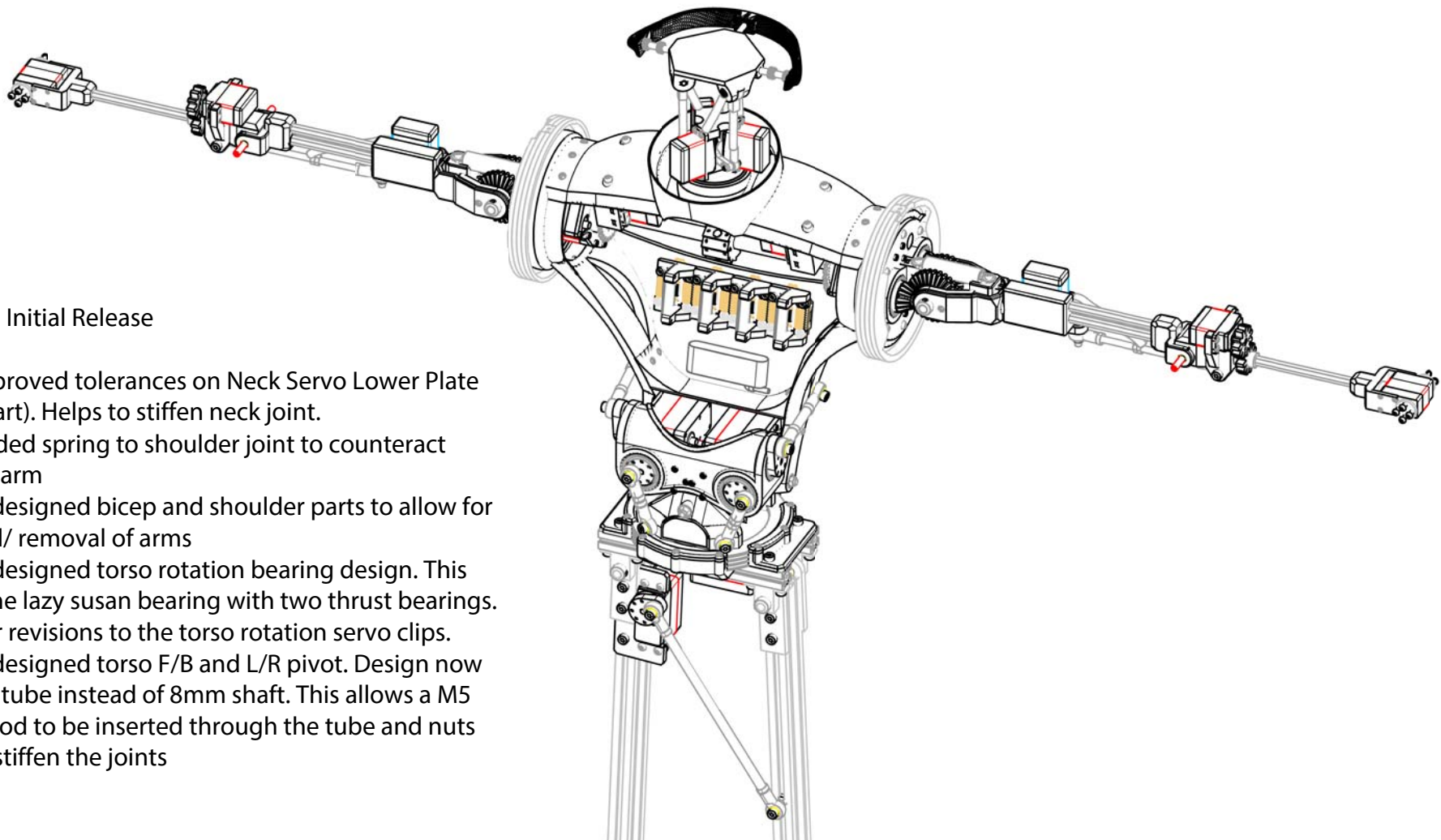


Animatronic C-3PO - Version 2 - 06/29/25

JesseM



Version 1: Initial Release

Version 2:

- Improved tolerances on Neck Servo Lower Plate (printed part). Helps to stiffen neck joint.
- Added spring to shoulder joint to counteract gravity on arm
- Redesigned bicep and shoulder parts to allow for easy install/ removal of arms
- Redesigned torso rotation bearing design. This replaces the lazy susan bearing with two thrust bearings. Also minor revisions to the torso rotation servo clips.
- Redesigned torso F/B and L/R pivot. Design now uses 8mm tube instead of 8mm shaft. This allows a M5 threaded rod to be inserted through the tube and nuts affixed to stiffen the joints

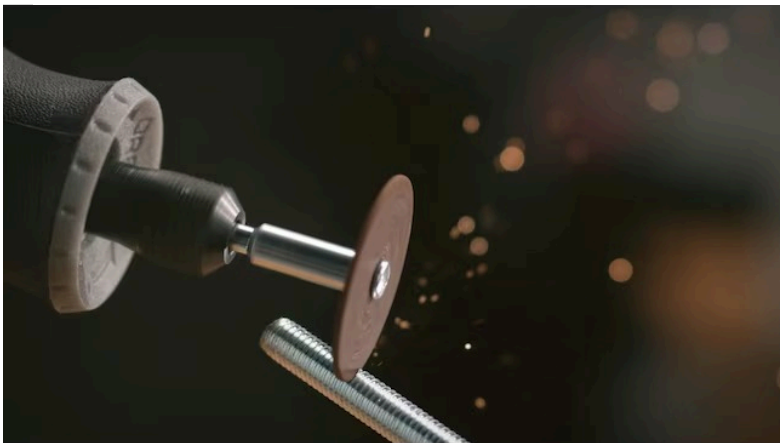
Cutting Metal

The intent of this design is to make this available to a broad range of makers, not just those with advanced robotics experience. That said, this build does require some level of metal cutting capabilities. Preferred tools include the following, but a simply Dremel tool with cutoff wheel can perform all the required cutting if that is all you have.

- Bandsaw or hacksaw
- Grinder w/ cutoff wheel
- Bench vise
- Bench sander

No portion of the metal fabrication for this build requires high precision.

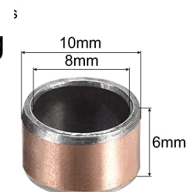
Use a cutoff wheel to cut the hardened steel shafts, tubing and all-thread rod for this build.



Use a hacksaw or bandsaw to cut the aluminum extrusions and flat bar only for this build. Do not use a hacksaw or bandsaw to cut the hardened steel shafts. The blades will not be able to cut the hardened steel and you will damage your blades.

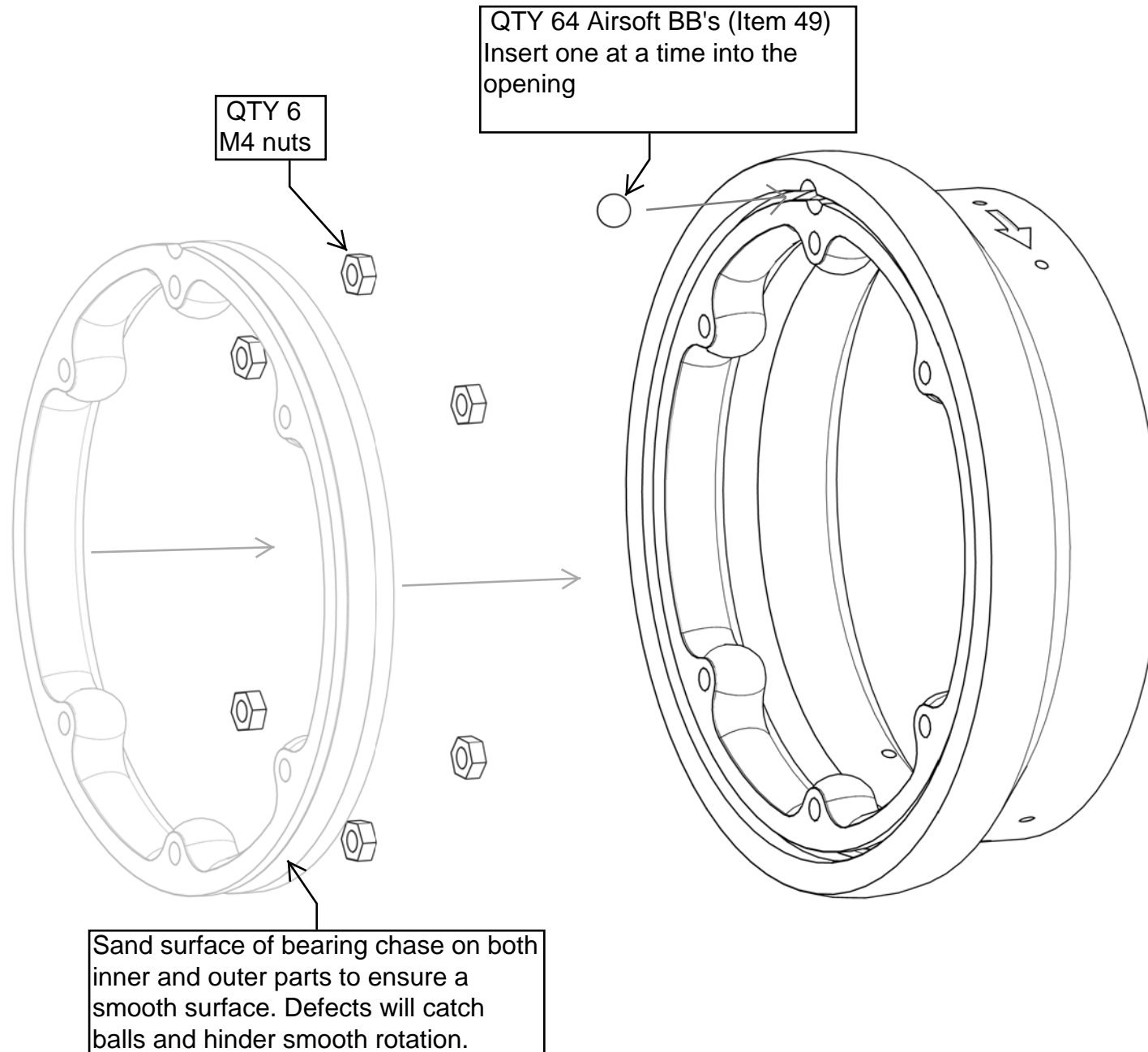


This build uses various sized 8mm sleeve bushings that are press fit into components. Sleeve bushings may require drilling to widen the openings after being press fit into place. Press fitting bushings will slightly compress them and prevent the adjoining shaft from being inserted or rotating inside the bushing properly. Test fit each bushing after pressing it in place. If the 8mm shaft does not properly insert or rotates with too much friction, then use a 8mm drill bit to slowly open the hole to allow smooth rotation of the shaft.



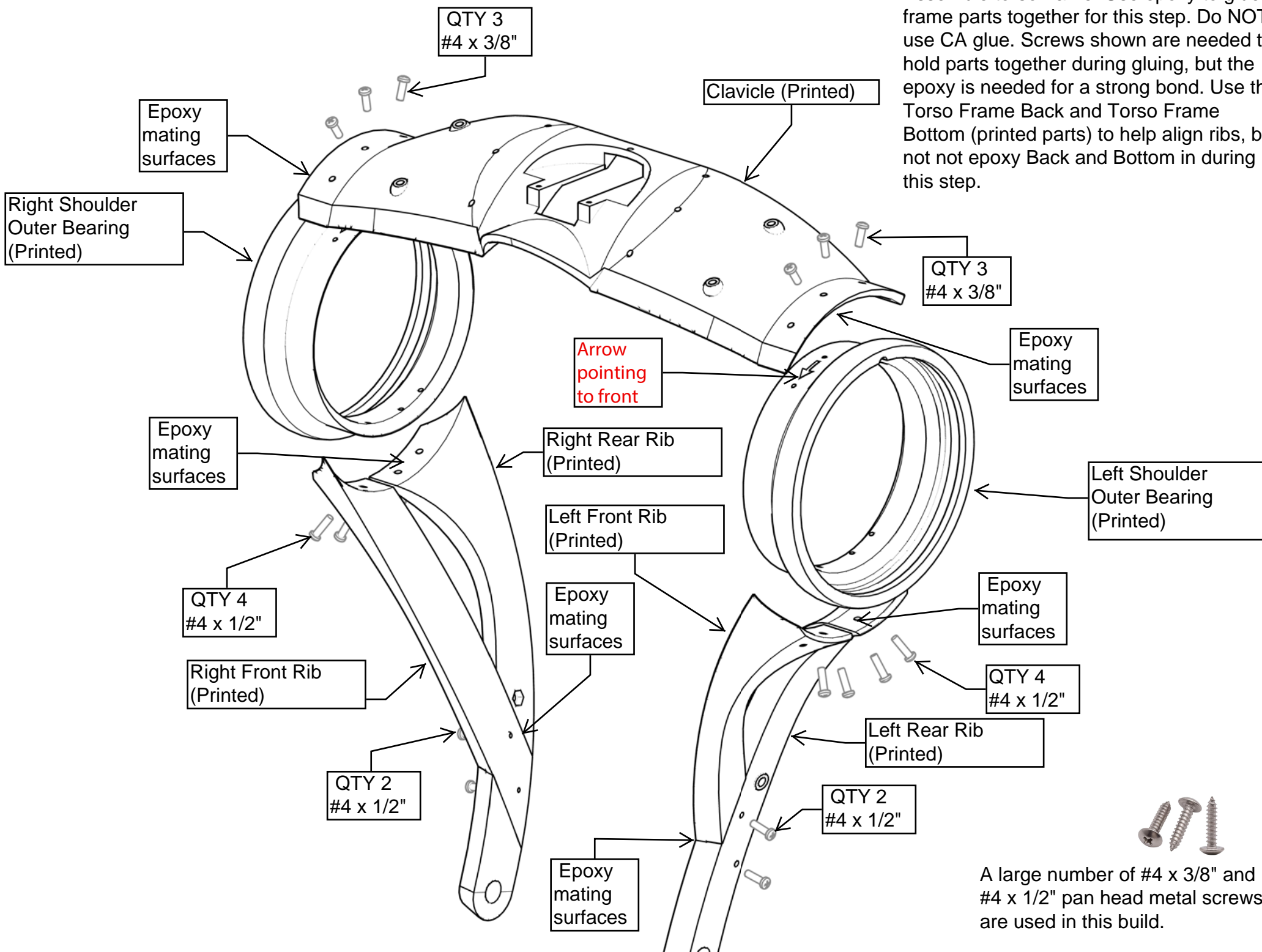
Step 0

Prepare Shoulder Bearings. Install Inner Bearing to Outer Bearing and insert BBs as noted. Test rotation for smooth operation. Disassembly not required if bearing is guarded during glue up in next step. If disassembly is desired, BBs can be pushed out of the opening from the gap on the opposite side.



Step 1

Assemble torso frame. Use epoxy to glue frame parts together for this step. Do NOT use CA glue. Screws shown are needed to hold parts together during gluing, but the epoxy is needed for a strong bond. Use the Torso Frame Back and Torso Frame Bottom (printed parts) to help align ribs, but not not epoxy Back and Bottom in during this step.



Step 2

Assemble Torso Frame Back and Torso Frame Bottom. Use epoxy to glue frame parts together for this step. Do NOT use CA glue. Screws shown are needed to hold parts together during gluing, but the epoxy is needed for a strong bond.

QTY 2, M5 nut

IMPORTANT, insert M5 nuts into ribs prior to glue up. Take care not to get epoxy into threads or into the adjoining hole in the Torso Frame Bottom. Recommend screwing a greased M5 screw into hole during glue up to prevent epoxy squeeze out from fouling the threads or hole.

Torso Frame Back (Printed)

View from rear

Epoxy
mating
surfaces

Epoxy
mating
surfaces

Epoxy
mating
surfaces

Epoxy
mating
surfaces

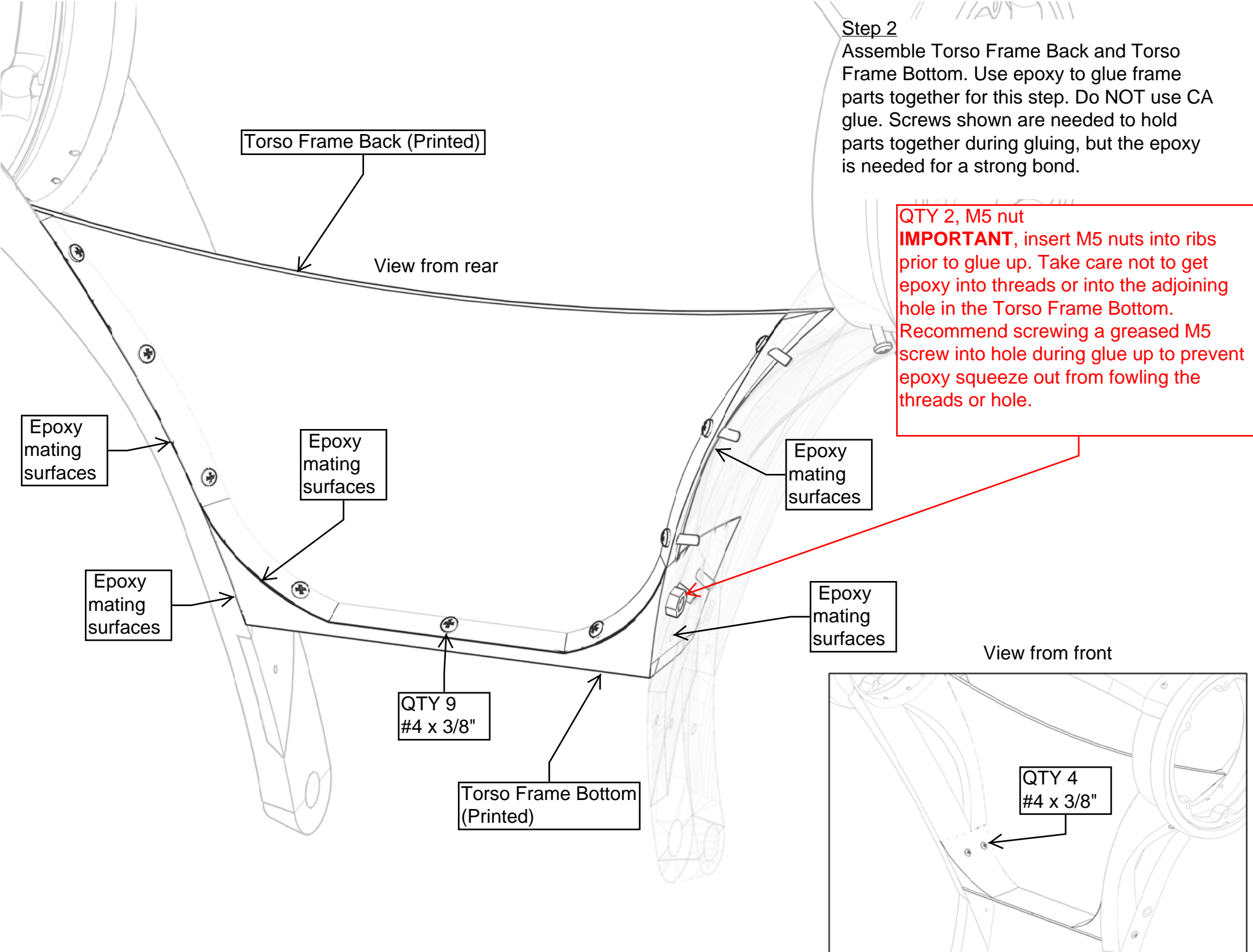
Epoxy
mating
surfaces

QTY 9
#4 x 3/8"

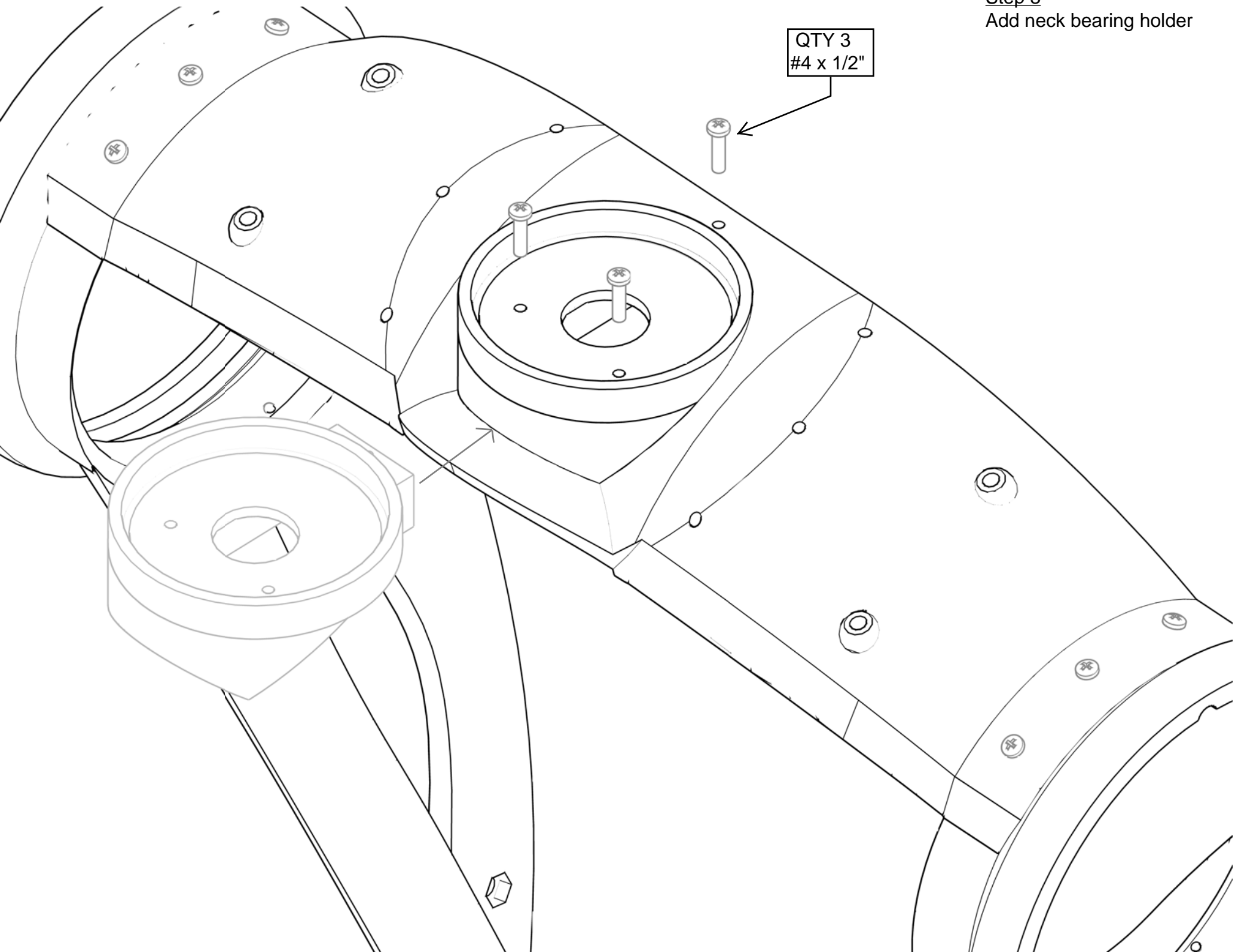
Torso Frame Bottom
(Printed)

View from front

QTY 4
#4 x 3/8"

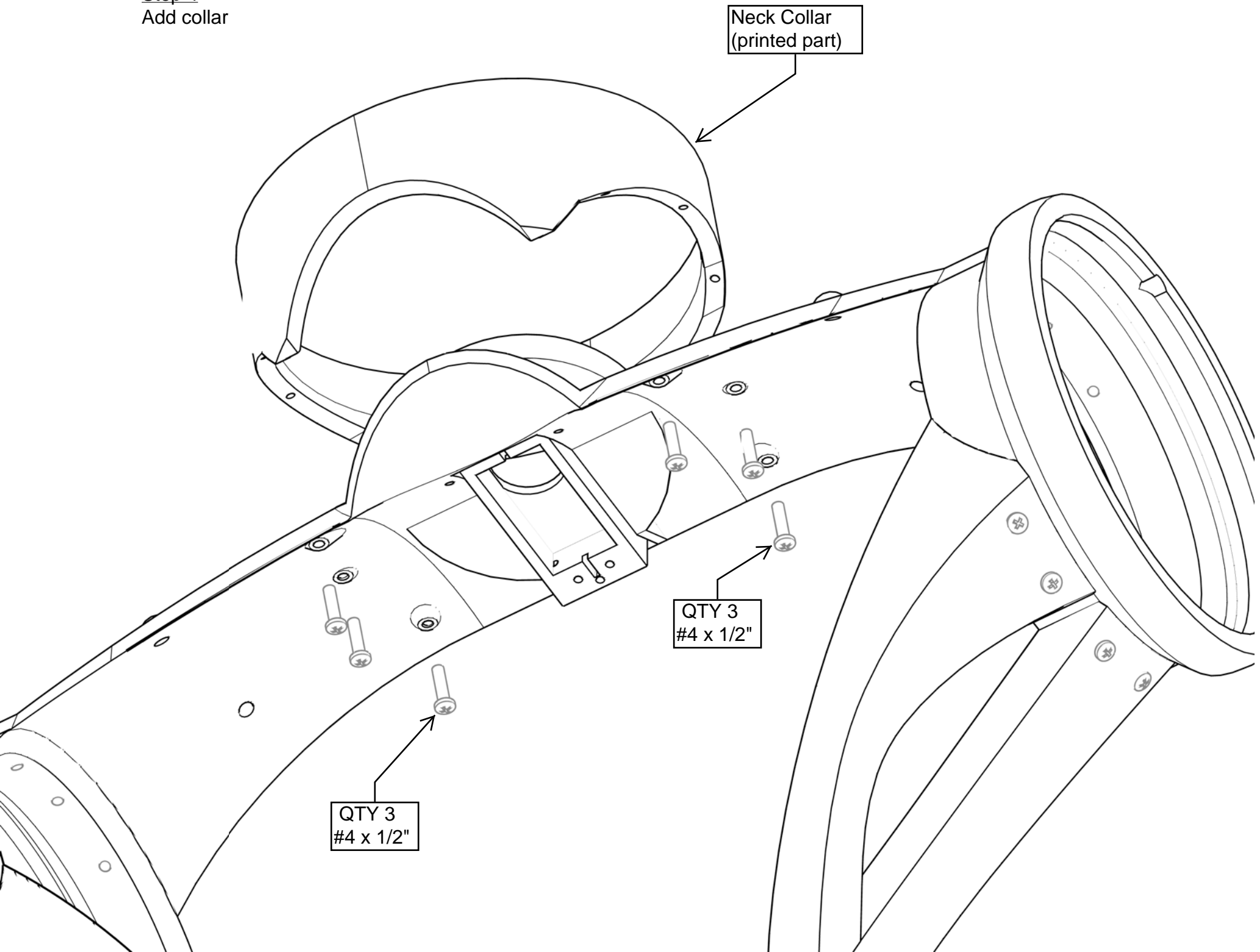


Step 3
Add neck bearing holder



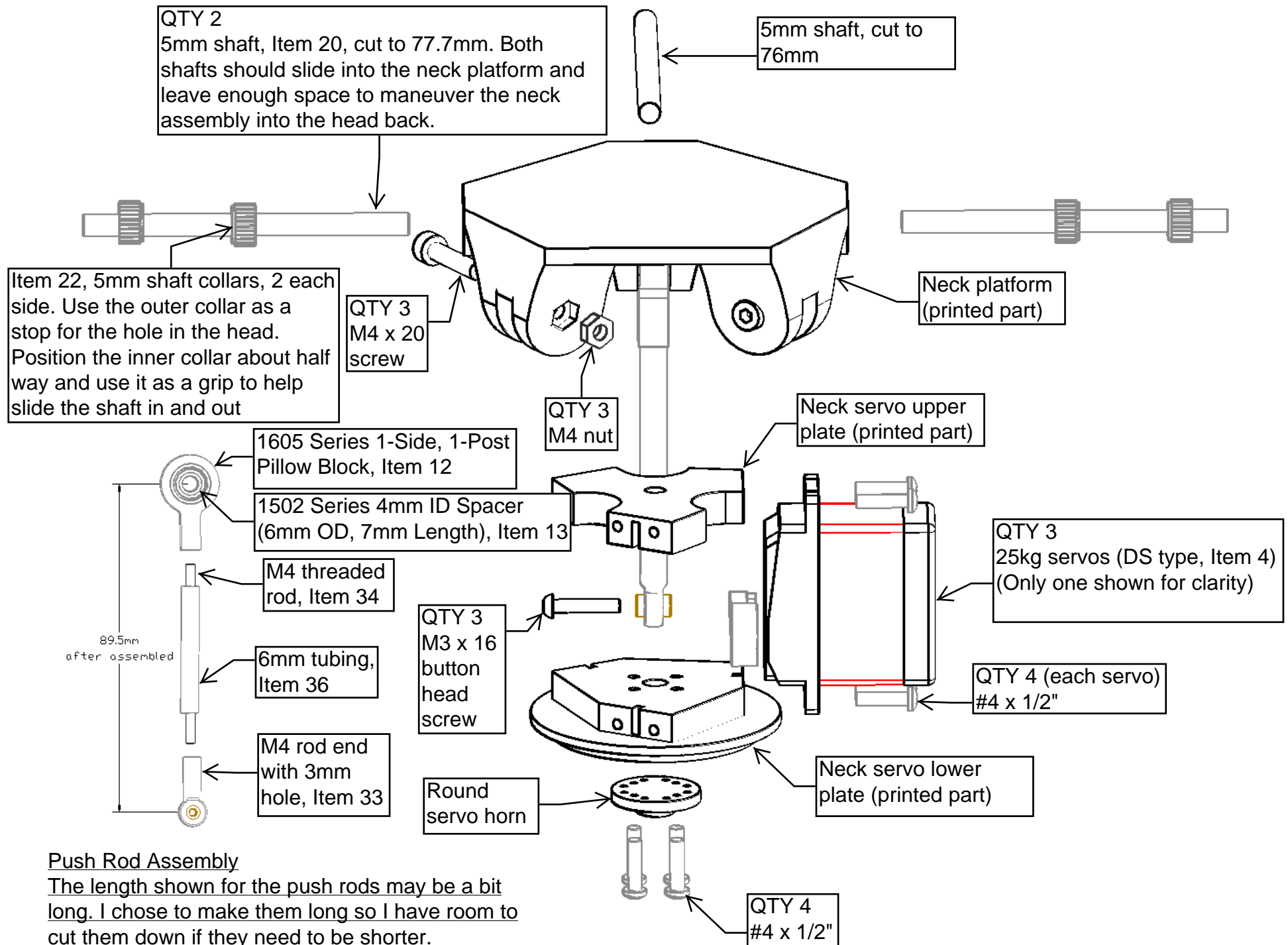
QTY 3
#4 x 1/2"

Step 4
Add collar



Step 5

Assemble neck assembly.



Step 6

Attach neck assembly to frame.

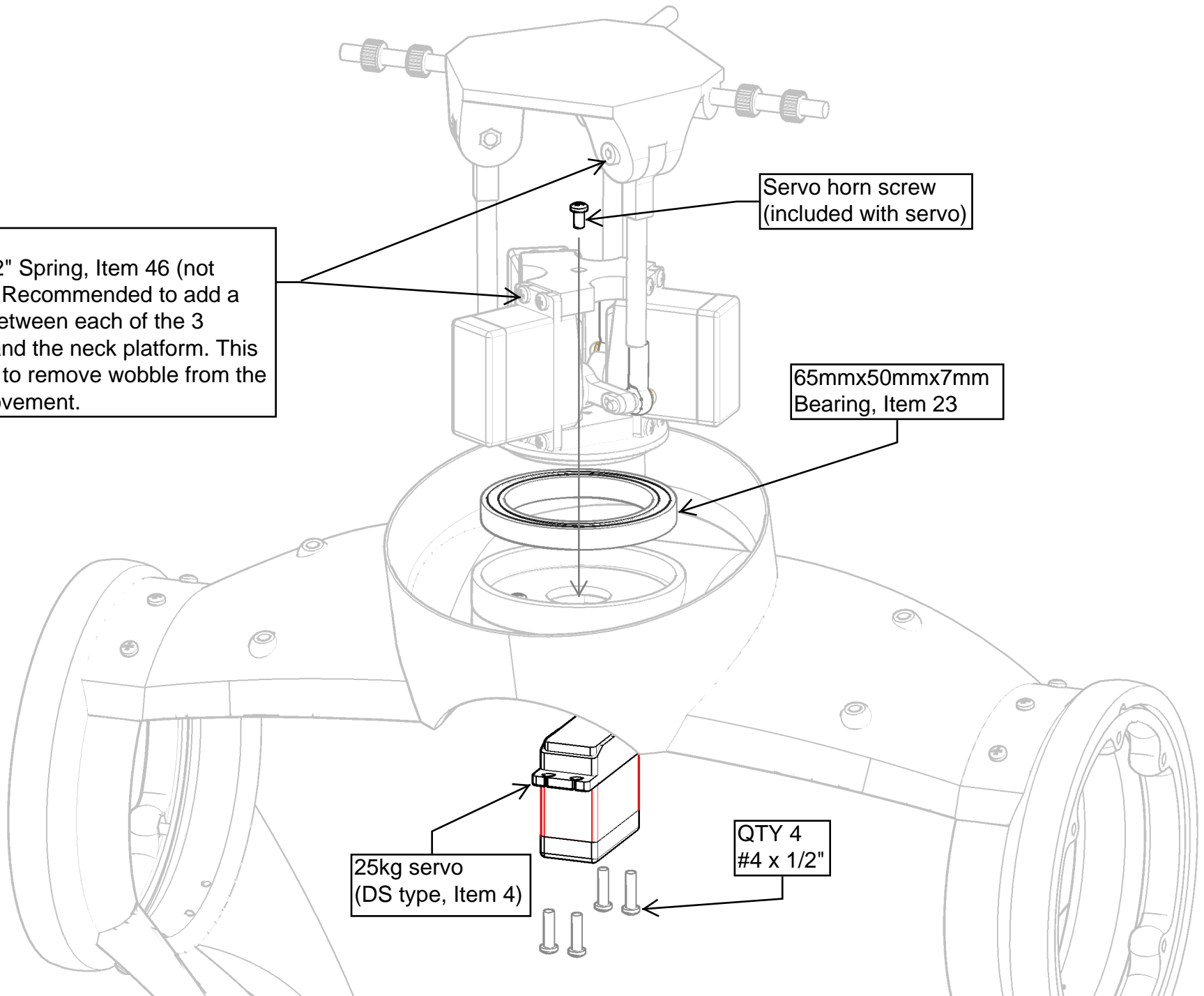
QTY 3
9/32" x 2" Spring, Item 46 (not shown). Recommended to add a spring between each of the 3 servos and the neck platform. This will help to remove wobble from the neck movement.

Servo horn screw
(included with servo)

65mmx50mmx7mm
Bearing, Item 23

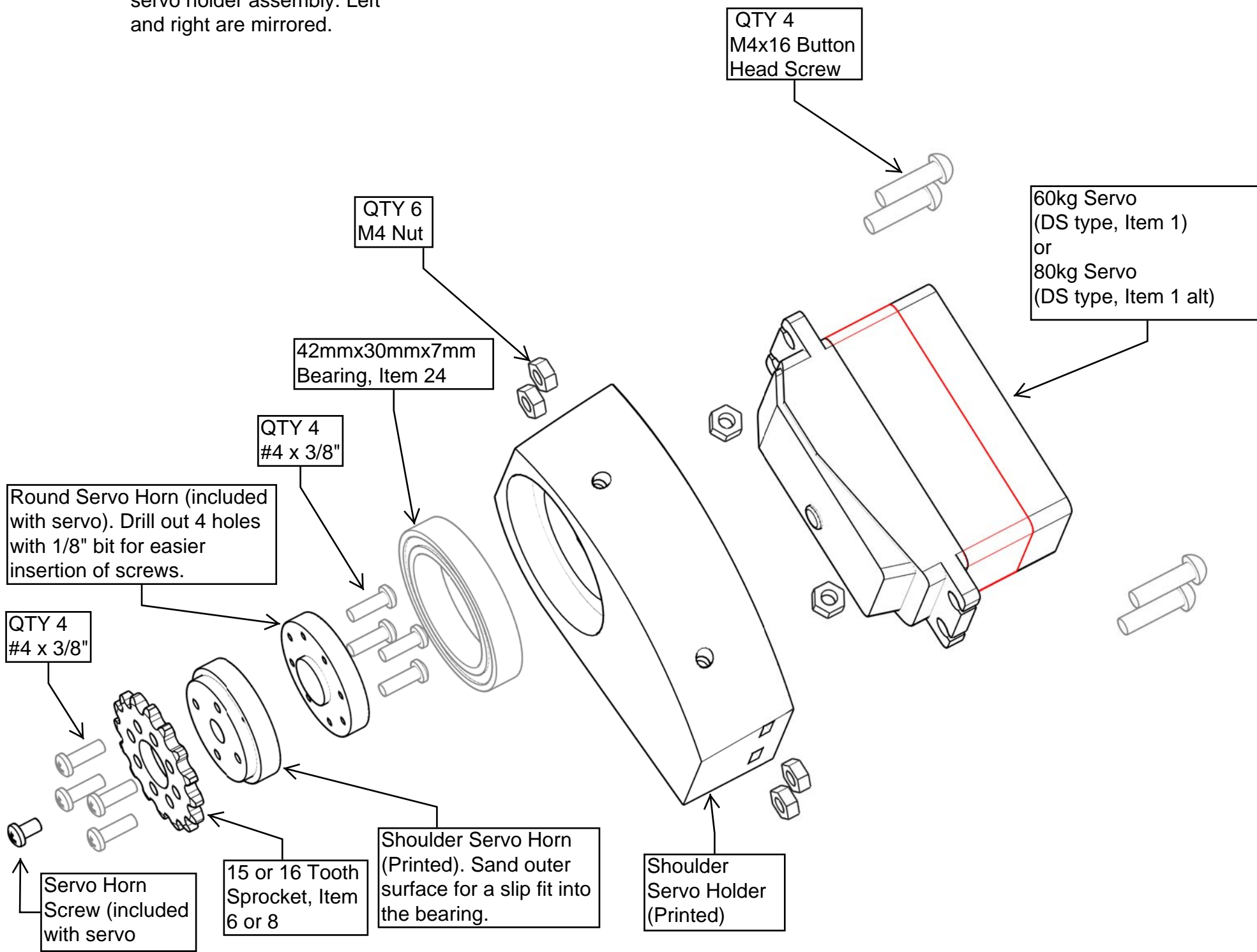
25kg servo
(DS type, Item 4)

QTY 4
#4 x 1/2"



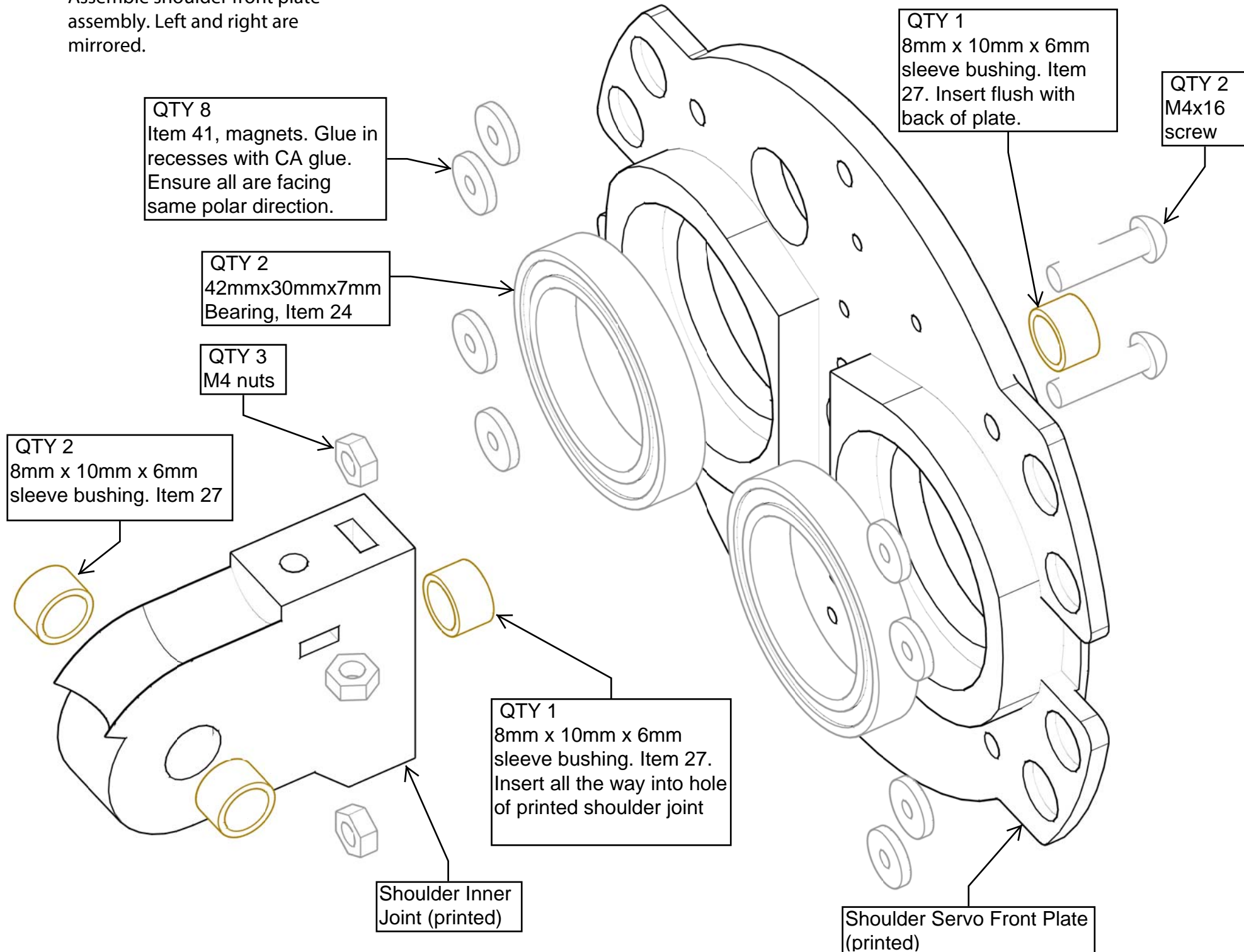
Step 7

Assemble shoulder rotation servo holder assembly. Left and right are mirrored.



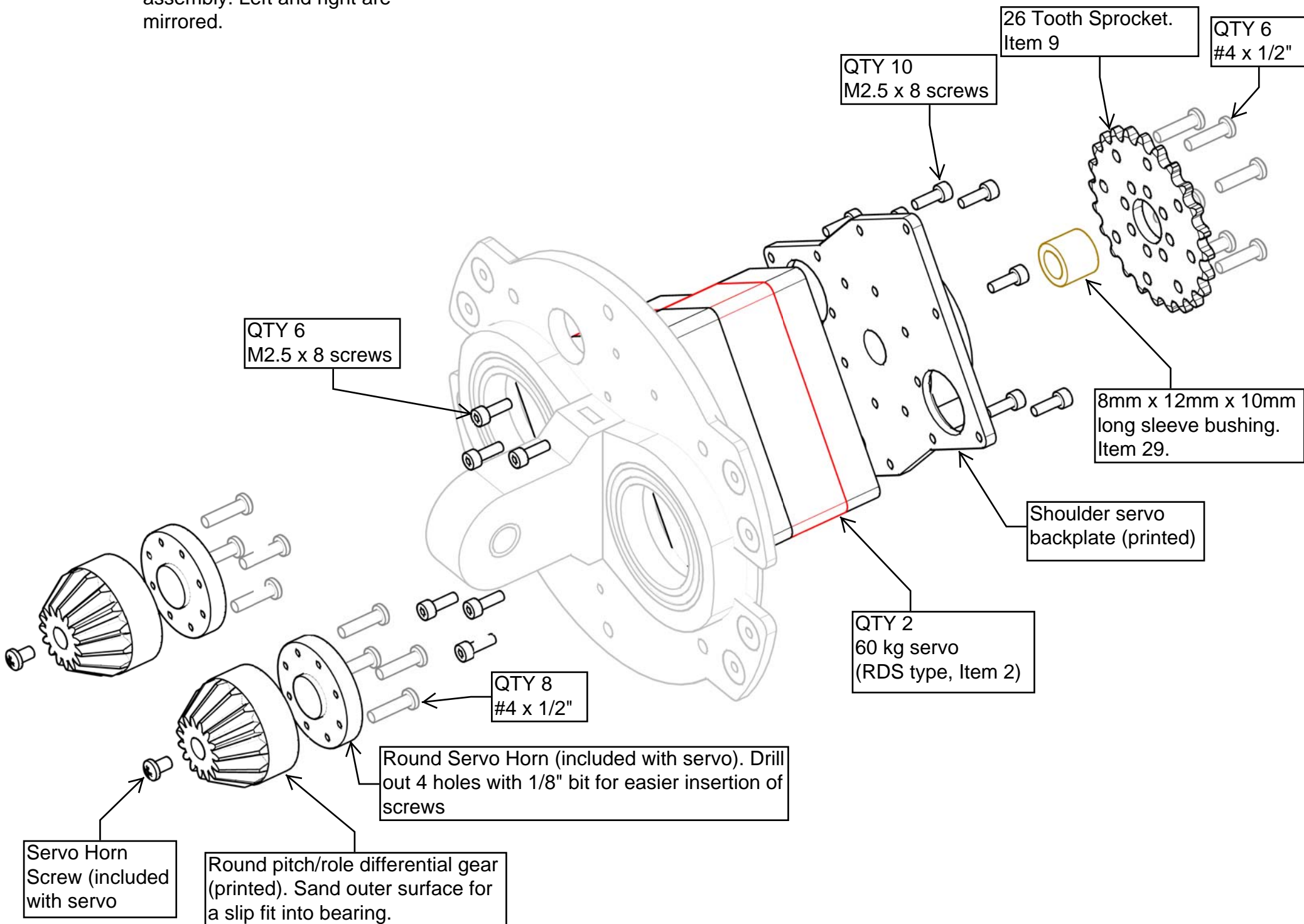
Step 8

Assemble shoulder front plate assembly. Left and right are mirrored.



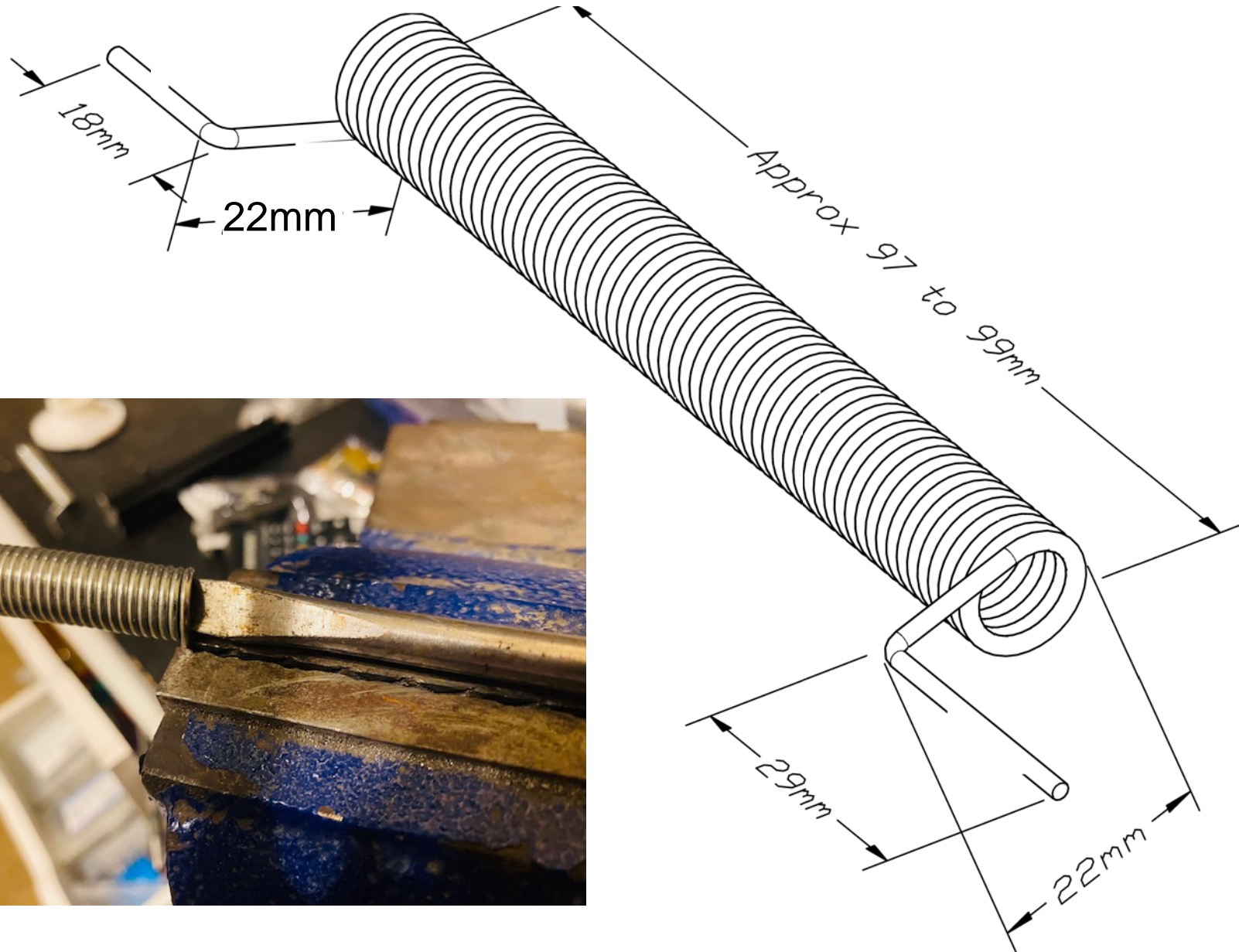
Step 9

Assemble shoulder rotation assembly. Left and right are mirrored.

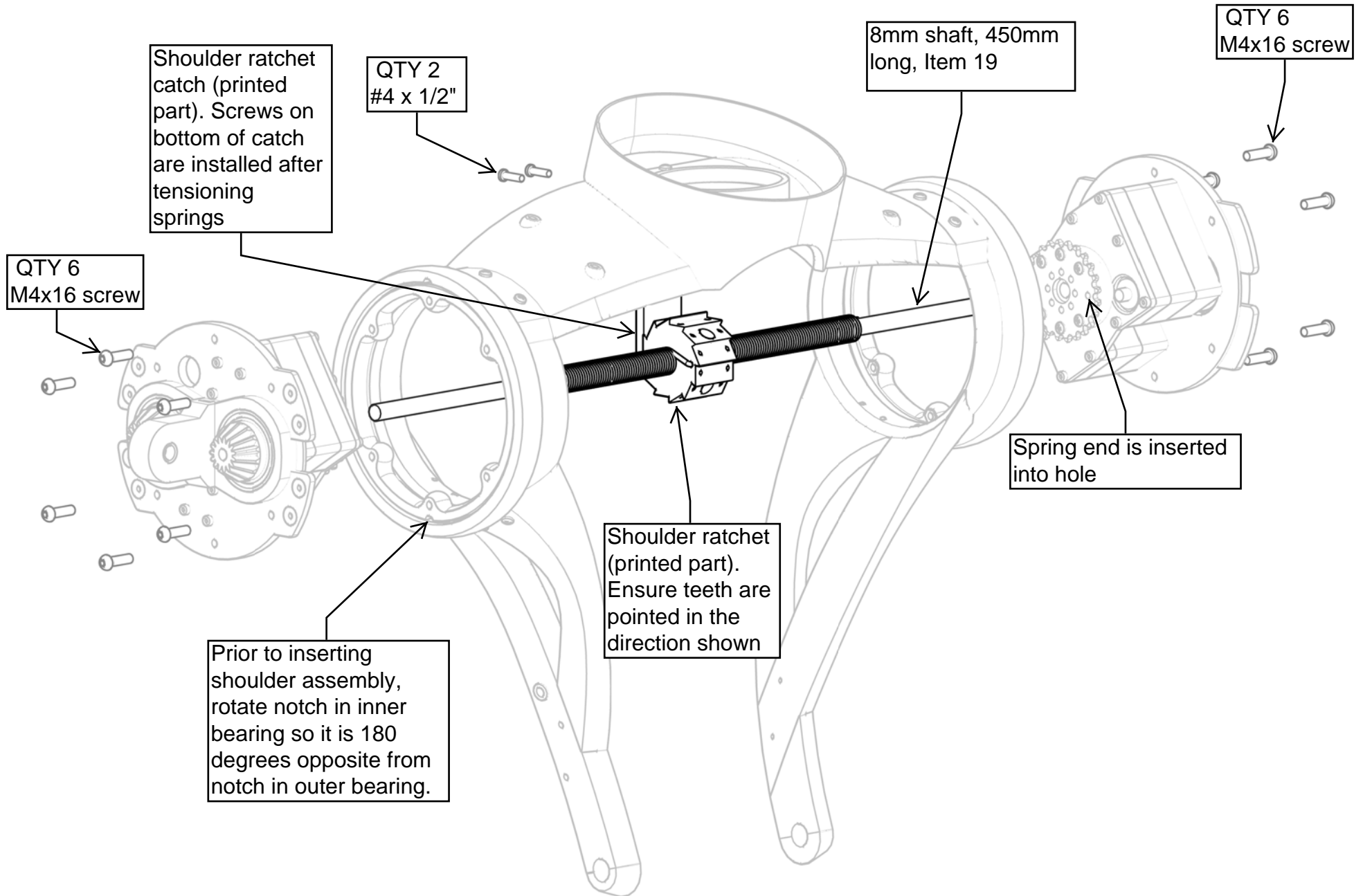


Step 10 Optional but Recommended

Fabricate torsion springs as follows. Cut a section of door spring (Item 42) to approximately 104mm long. Use a bench vise to hold the tip of one cut end securely. Insert a large, flat head screwdriver into the end and twist the screwdriver and spring to unwind a short section of spring wire (about 2mm). Reposition the spring end in the vise to grip the newly straighten section and repeat the process with the screwdriver. Unwind a total of 53mm of spring wire from one end and 60mm of spring wire from the opposite end. Measure and mark the dimensions for the 90 degree bend for each end and bend by hand. The spring wire is hard and can break if the bend is too sharp. Finally, cut off the excess from each end to the final dimension.

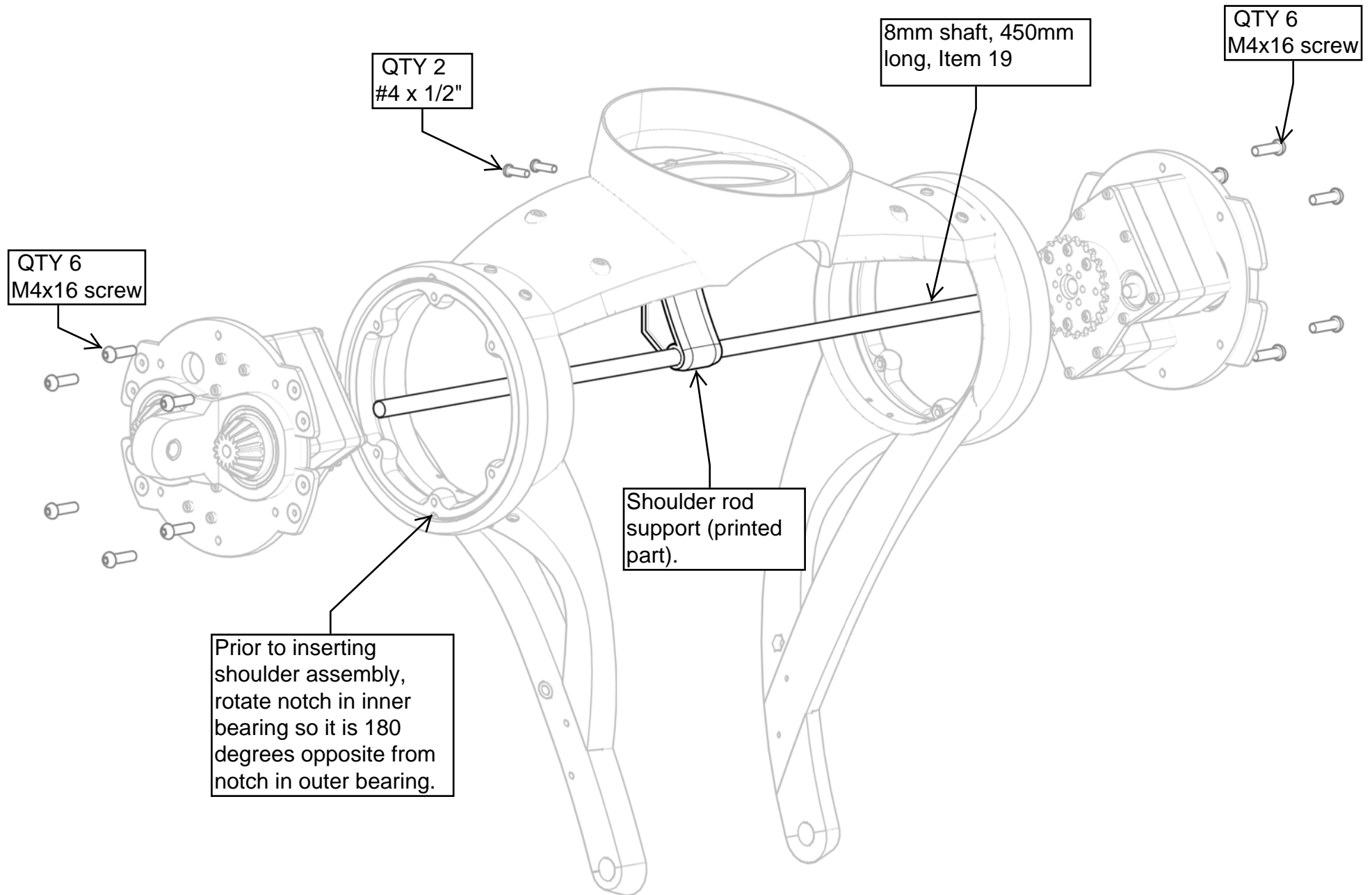


Step 11 (With Spring)
Assemble shoulders onto
rotation axis.



Step 12 (Without Spring)

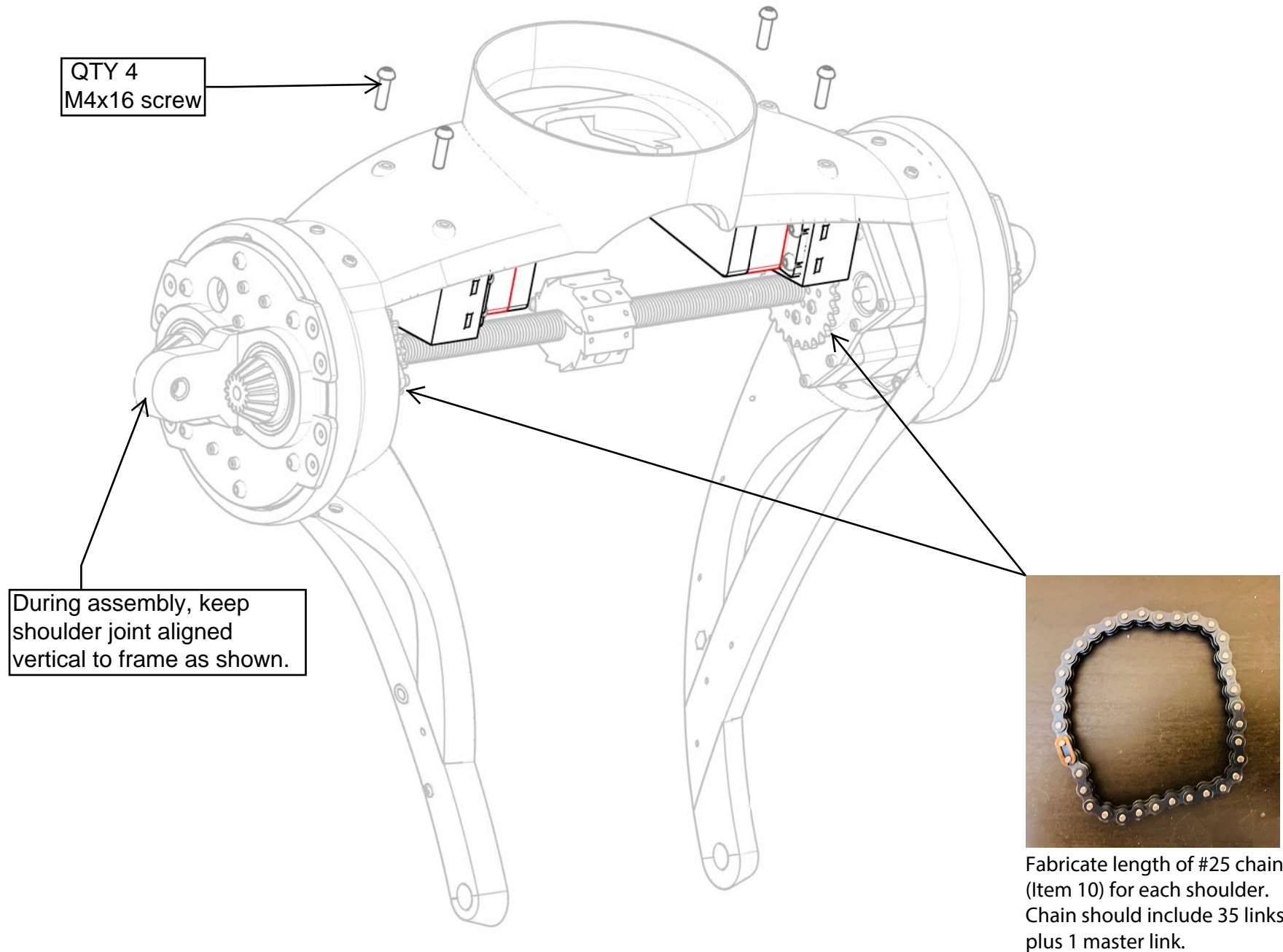
Assemble shoulders onto rotation axis.



Step 13

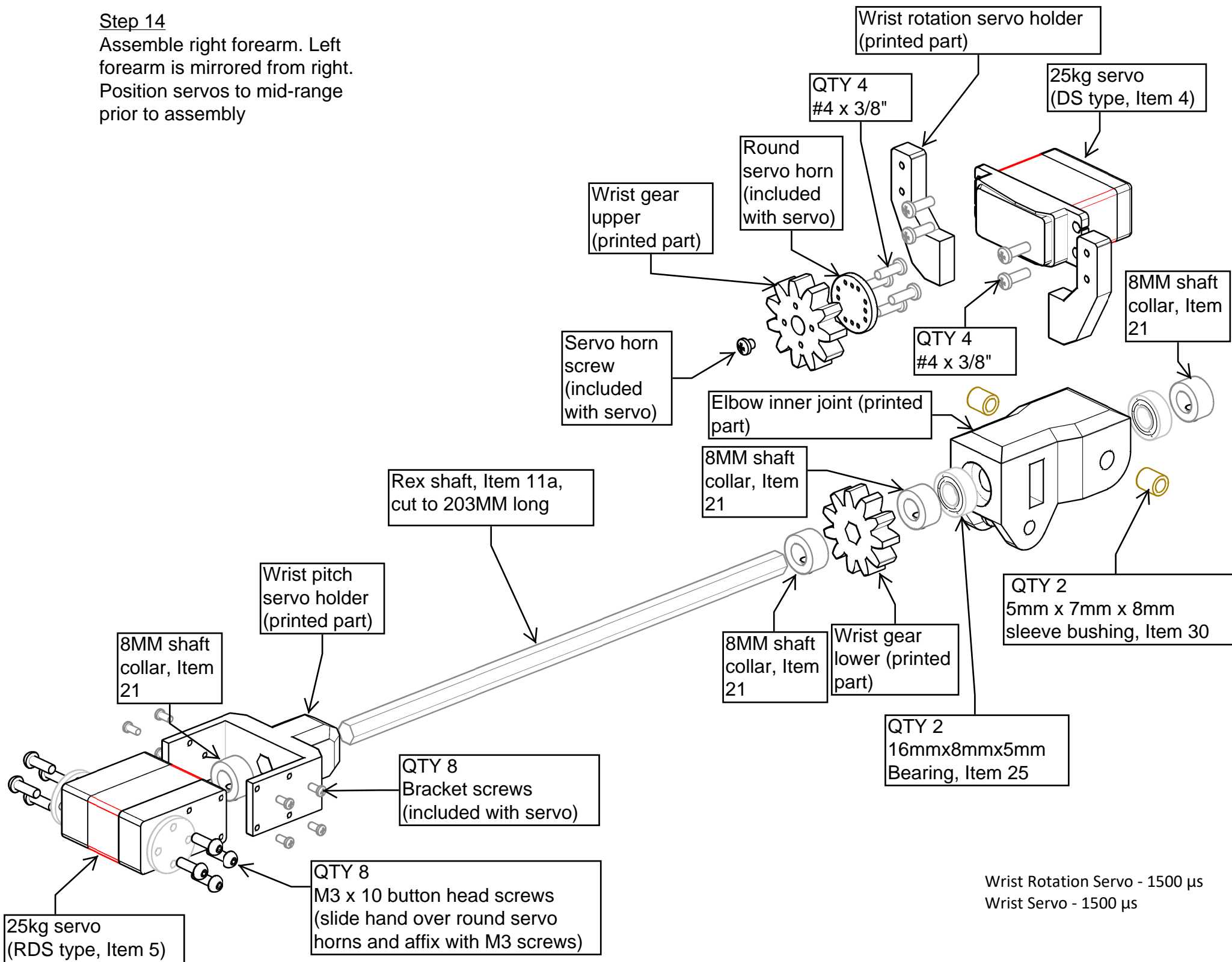
Install Shoulder Rotation Servo Holder Assemblies into frame.
Position servos as shown in the table to the right. Place chain
over sprockets prior to tightening screws.

Right Shoulder Rotation Servo - 2100 μ s
Left Shoulder Rotation Servo - 700 μ s



Step 14

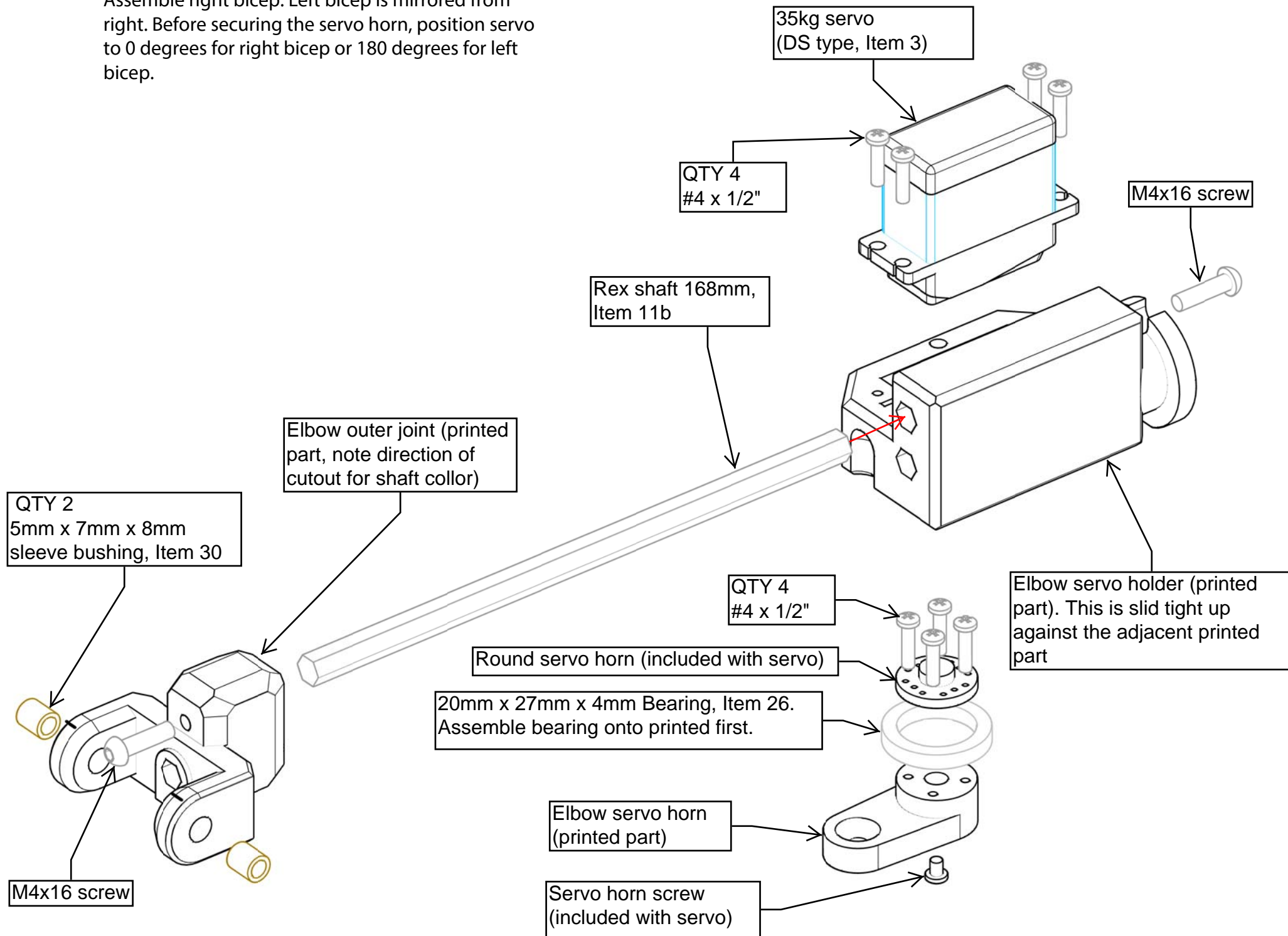
Assemble right forearm. Left forearm is mirrored from right. Position servos to mid-range prior to assembly



Step 15

Assemble right bicep. Left bicep is mirrored from right. Before securing the servo horn, position servo to 0 degrees for right bicep or 180 degrees for left bicep.

Left Bicep Servo - 500 μ s
Right Bicep Servo - 2500 μ s



Step 16

Assemble right forearm to bicep. Left is mirrored from right.
This view is from underneath. Note the location of all the shaft collars.

M5 threaded rod (Item 32). Cut to approx 132mm long. When servo horn is rotated 30 degrees inward, the elbow joint should be completely straight. When servo horn is rotated 180 degrees (toward shoulder), the elbow joint should be at 90 degrees.

M3x90mm standoff (file to 89mm long)

M5x30 screw

M5 nut

M5 rod end

QTY 2
M5 nut

M5 rod end

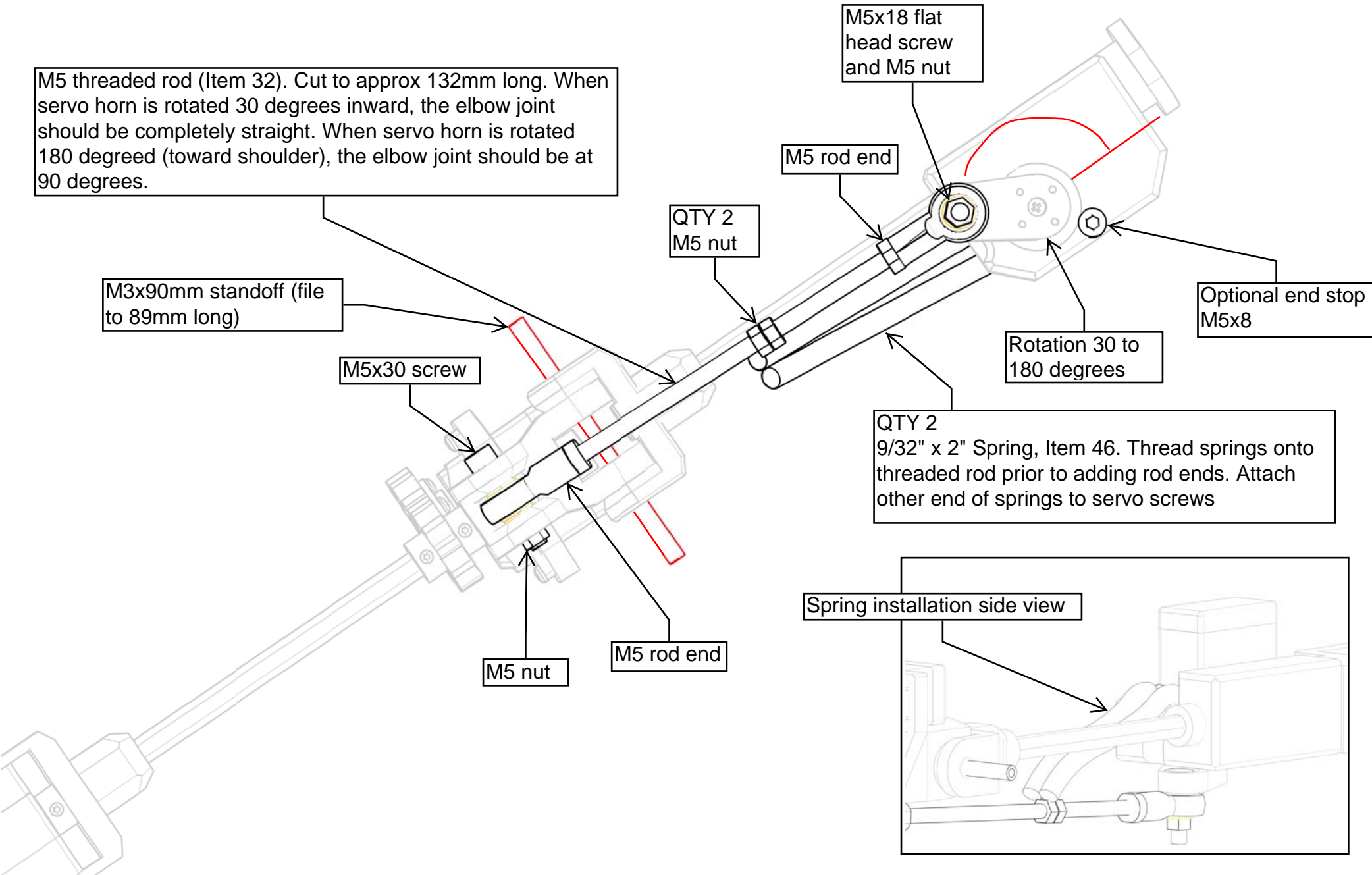
M5x18 flat
head screw
and M5 nut

Rotation 30 to
180 degrees

Optional end stop
M5x8

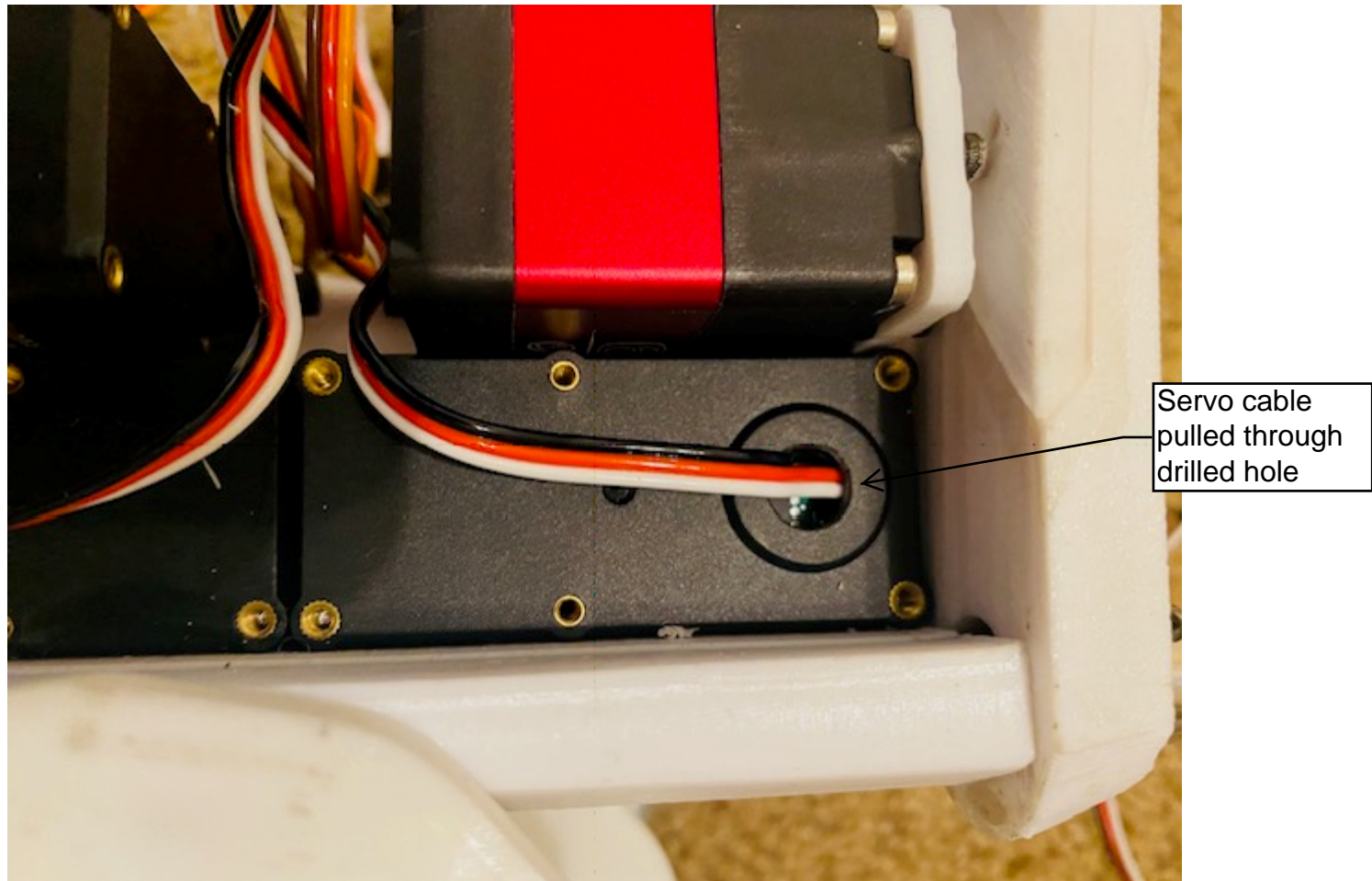
QTY 2
9/32" x 2" Spring, Item 46. Thread springs onto
threaded rod prior to adding rod ends. Attach
other end of springs to servo screws

Spring installation side view



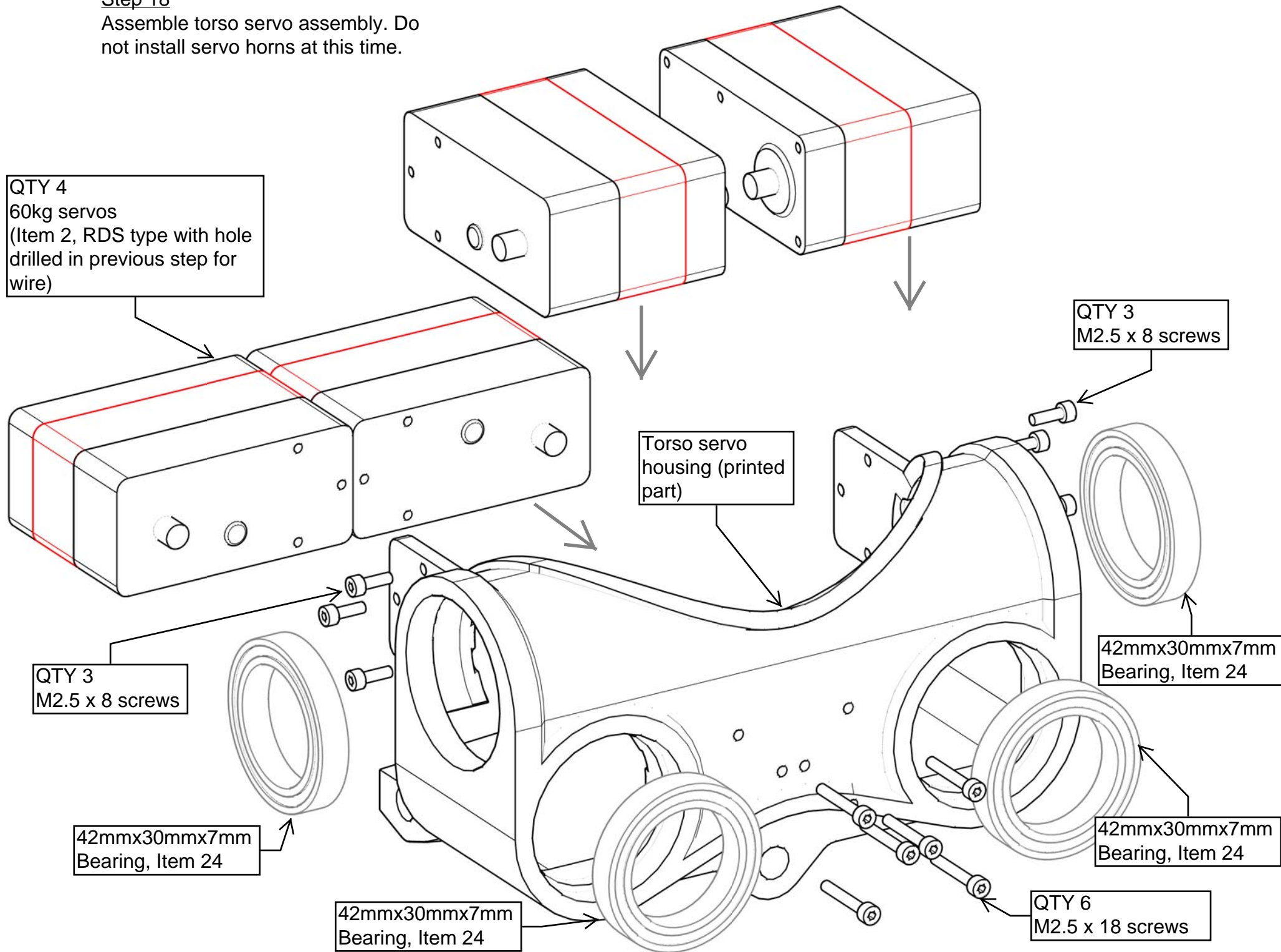
Step 17

Prepare servos for mounting in torso servo assembly. In this step, you will modify the torso servos to change where the servo wires exit the servo. Unscrew and remove the bottom housing of four (4) of the RDS style, 60kg servos. Drill out the plastic post with a 8mm or larger drill bit. Reassemble the bottom housing taking note to pull the servo cable through hole as you reassemble.



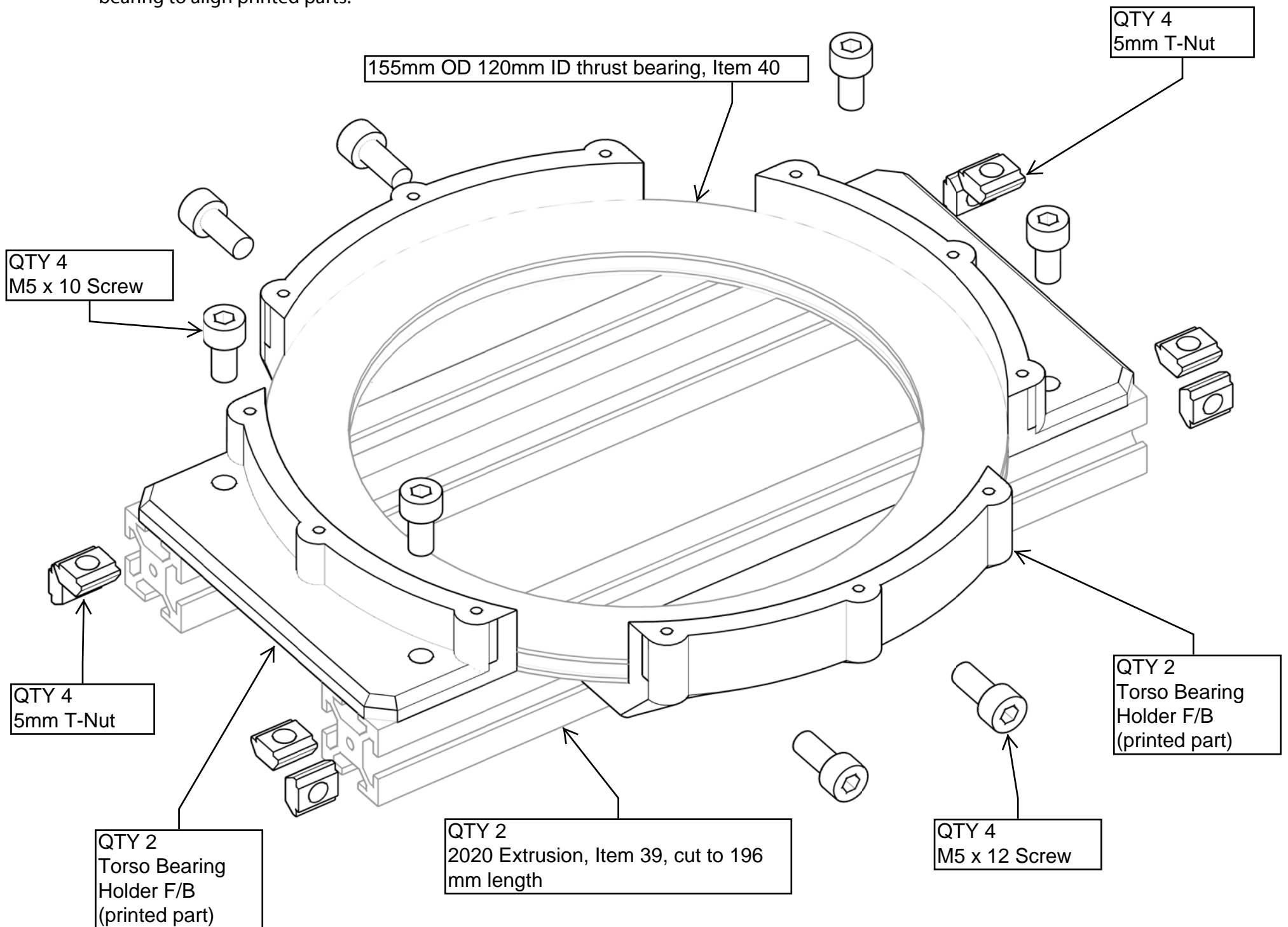
Step 18

Assemble torso servo assembly. Do not install servo horns at this time.



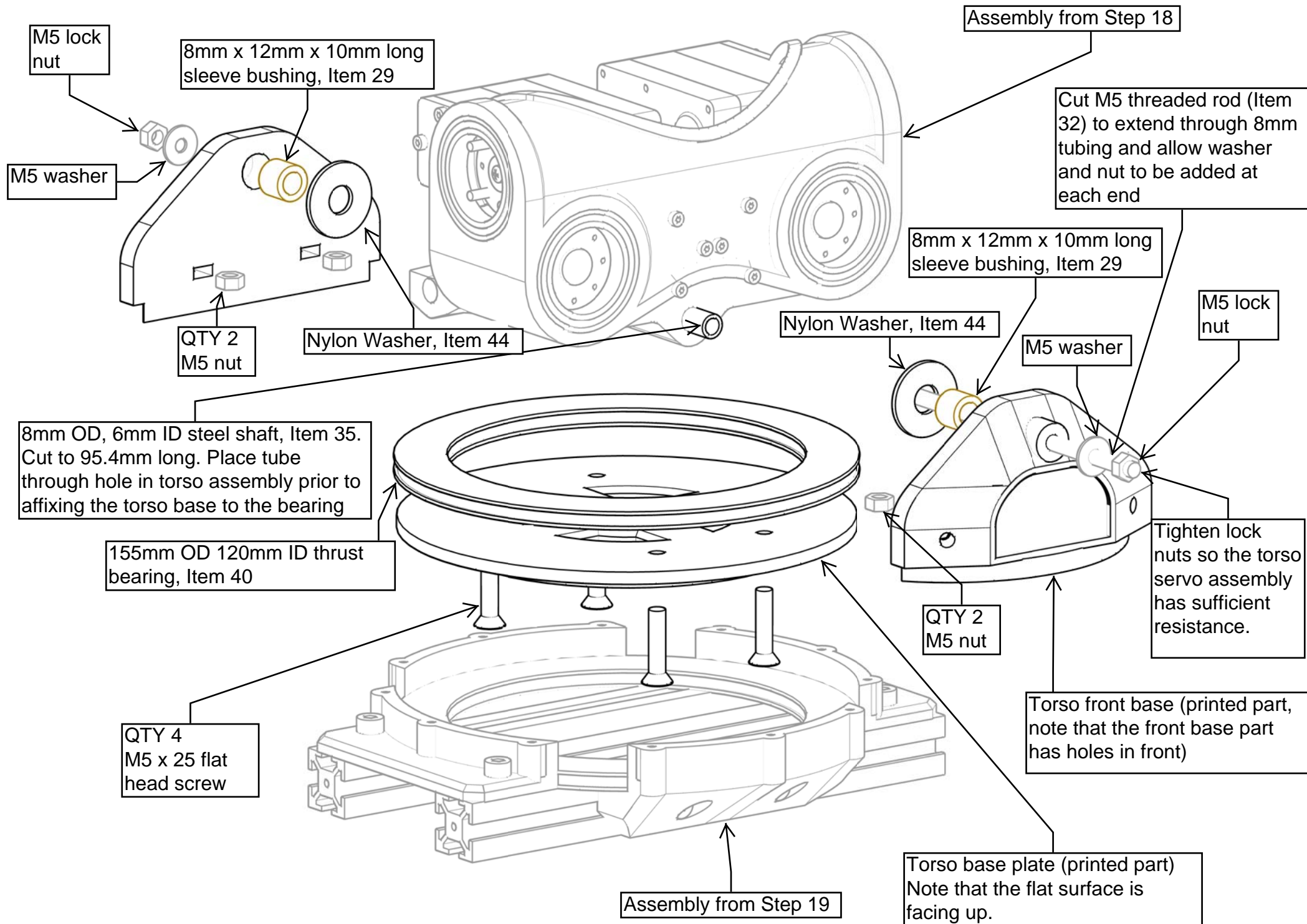
Step 19

Assemble torso frame. Use lower bearing to align printed parts.



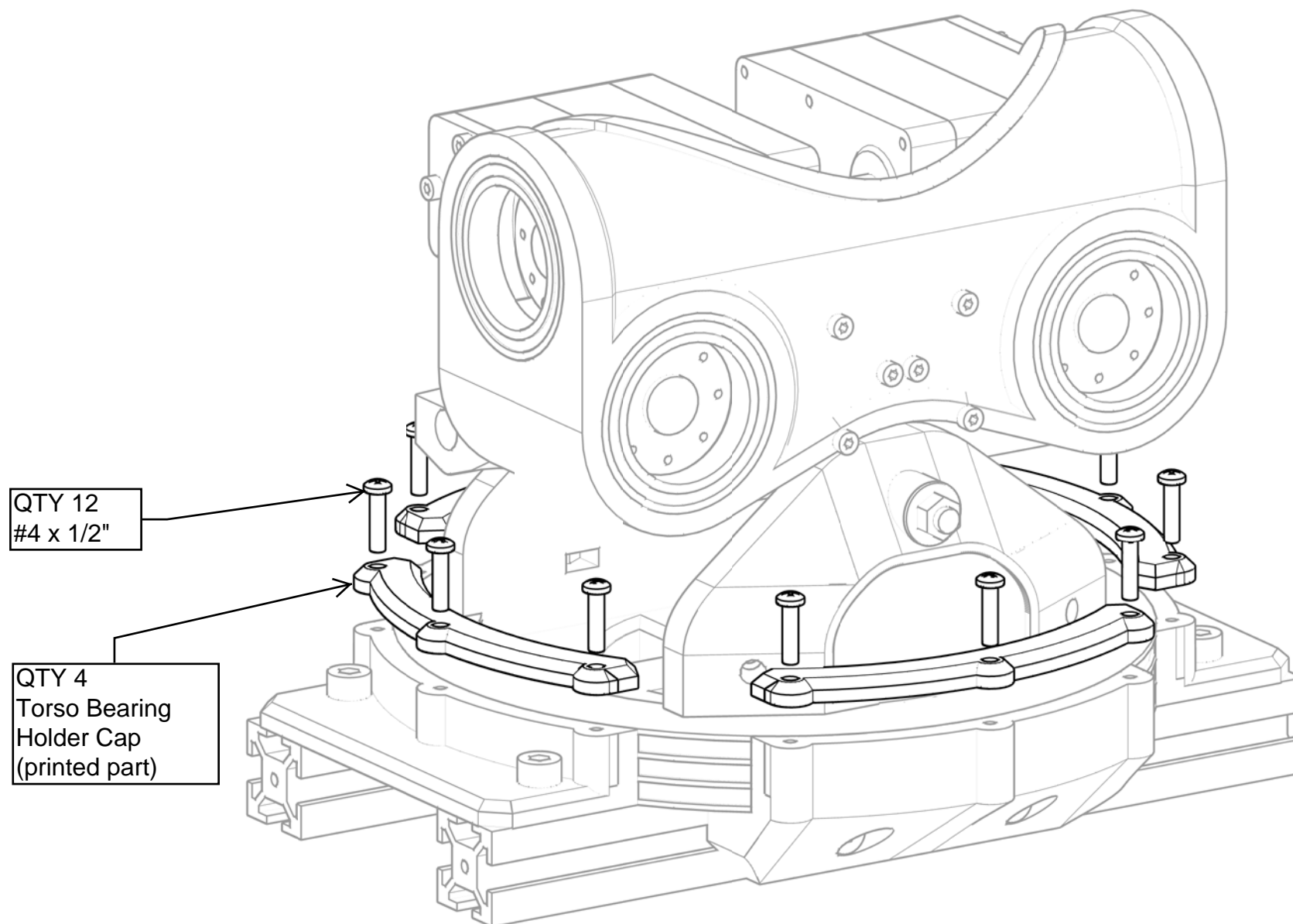
Step 20

Continue assembly of torso bearing assembly.



Step 21

Secure torso bearing assembly. Note, the printed caps are intended to clamp the thrust bearings firmly.

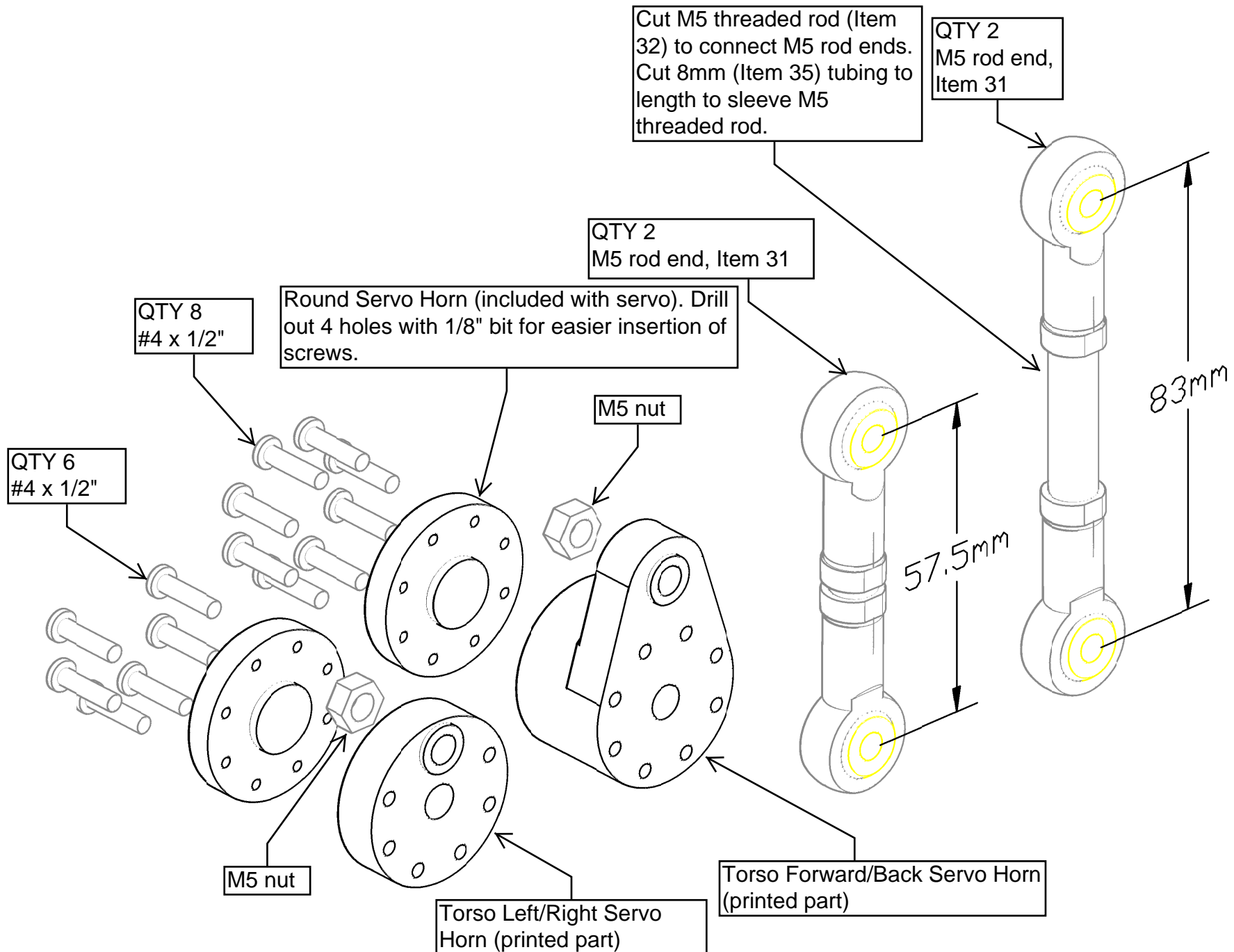


Step 22

Assemble torso servo horns and linkages.

QTY 2 each below are required.

Sand outer surface of servo horns for a slip fit into bearings.



Step 23

Assemble upper torso to lower torso.

Important, set servos to mid range prior to attaching servo horns. Servo horns should have a slip fit into the bearings. If the fit is too tight, the horns will have trouble mating with the spur on the servo. If you have trouble getting the horns to mate with the servos, try loosening the screws holding the servo in place to allow the servos to move around slightly.

When servo is at mid range, servo horn should be at approximately 20 deg forward from vertical

Tighten lock nuts so the torso servo assembly has sufficient resistance.

Torso L/R Lean Servos - 1500 μ s
Torso F/B Lean Servos - 1500 μ s

QTY 2
M5 x 25 screws

QTY 2
M5 x 16 screws

8mm OD, 6mm ID steel tube, Item 35. Cut to length such that the tube is slightly inset to the frame on both ends

QTY 2
M5 Washer

QTY 2
M5 lock Nut

Cut M5 threaded rod (Item 32) to extend through 8mm tubing and allow washer and nut to be added at each end

QTY 2
8mm x 12mm x 10mm long sleeve bushing, Item 29.

QTY 2
Nylon Washer, Item 44 (one washer each side, between frame and torso assembly)

QTY 2
Servo horn screw (included with servo)

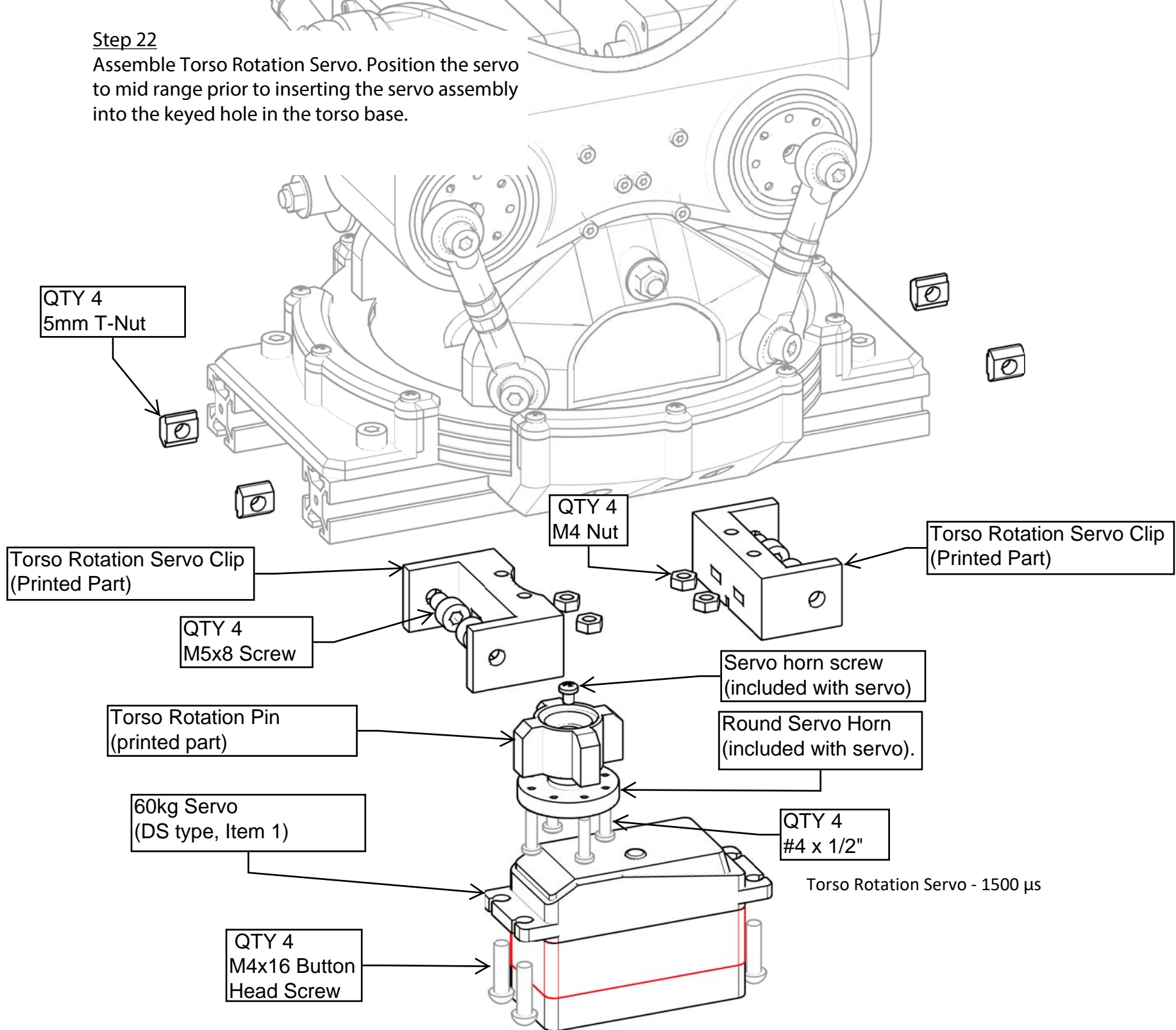
QTY 2
M5 x 16 screws

QTY 2
M5 x 25 screws

QTY 2
Servo horn screw (included with servo)

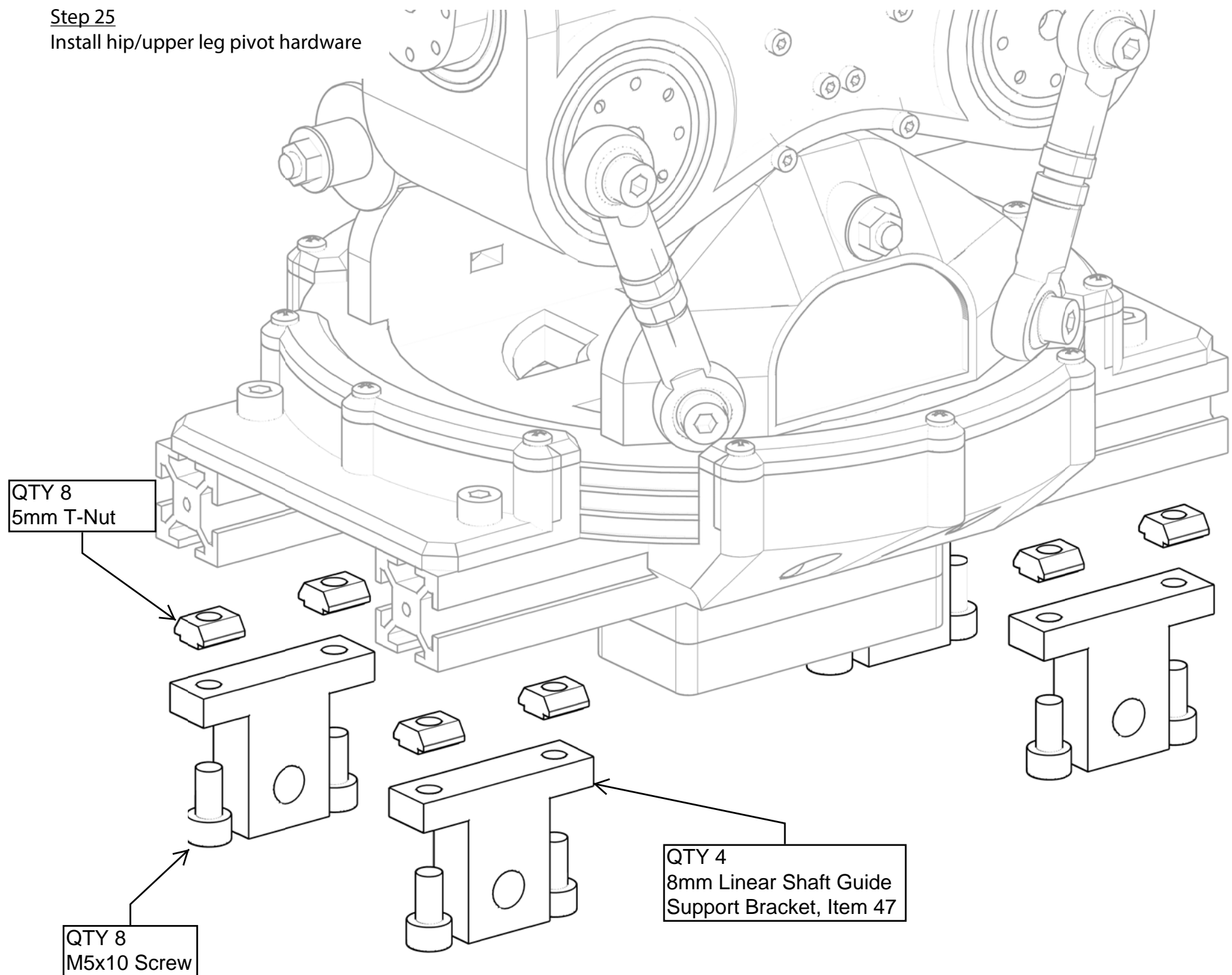
Step 22

Assemble Torso Rotation Servo. Position the servo to mid range prior to inserting the servo assembly into the keyed hole in the torso base.



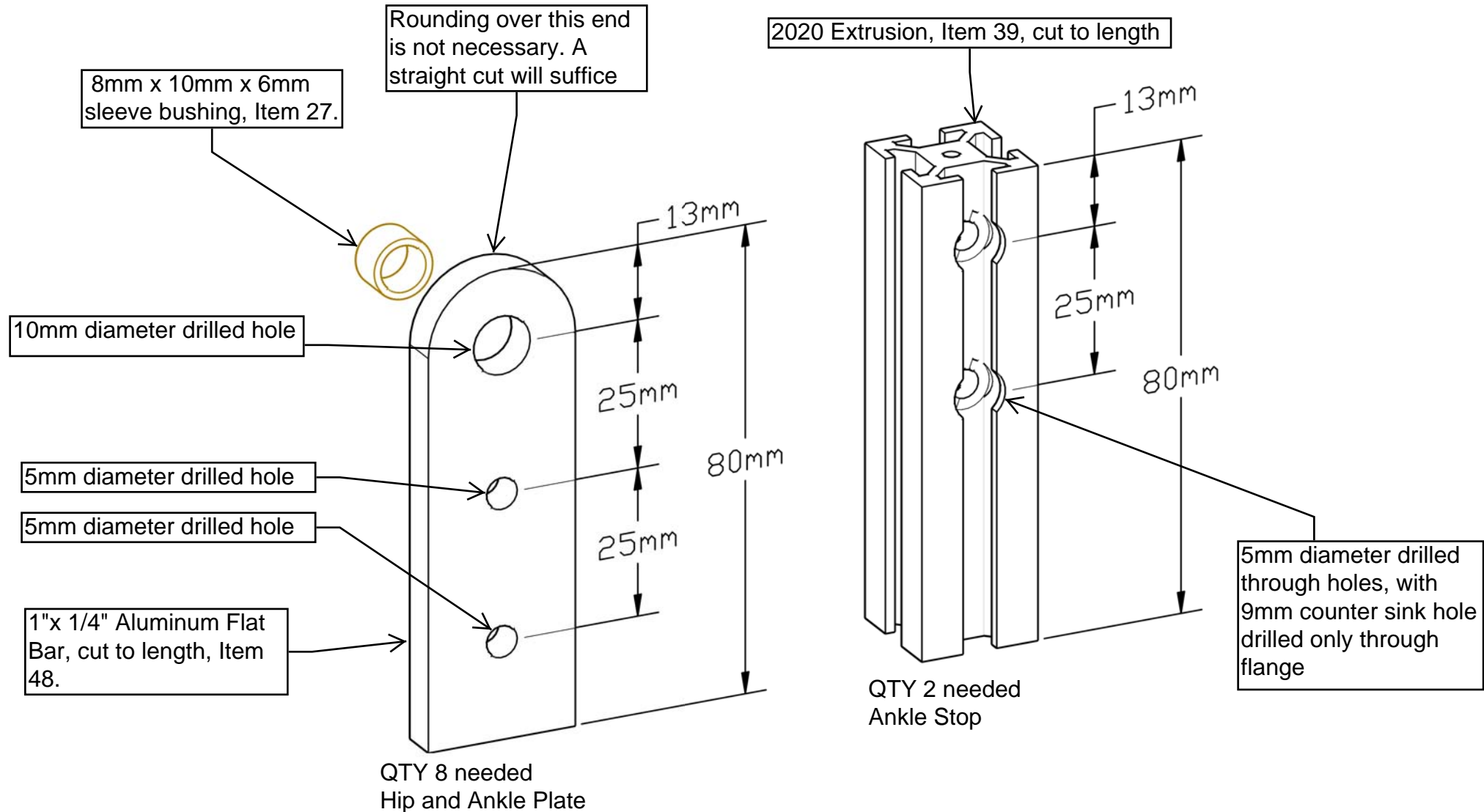
Step 25

Install hip/upper leg pivot hardware



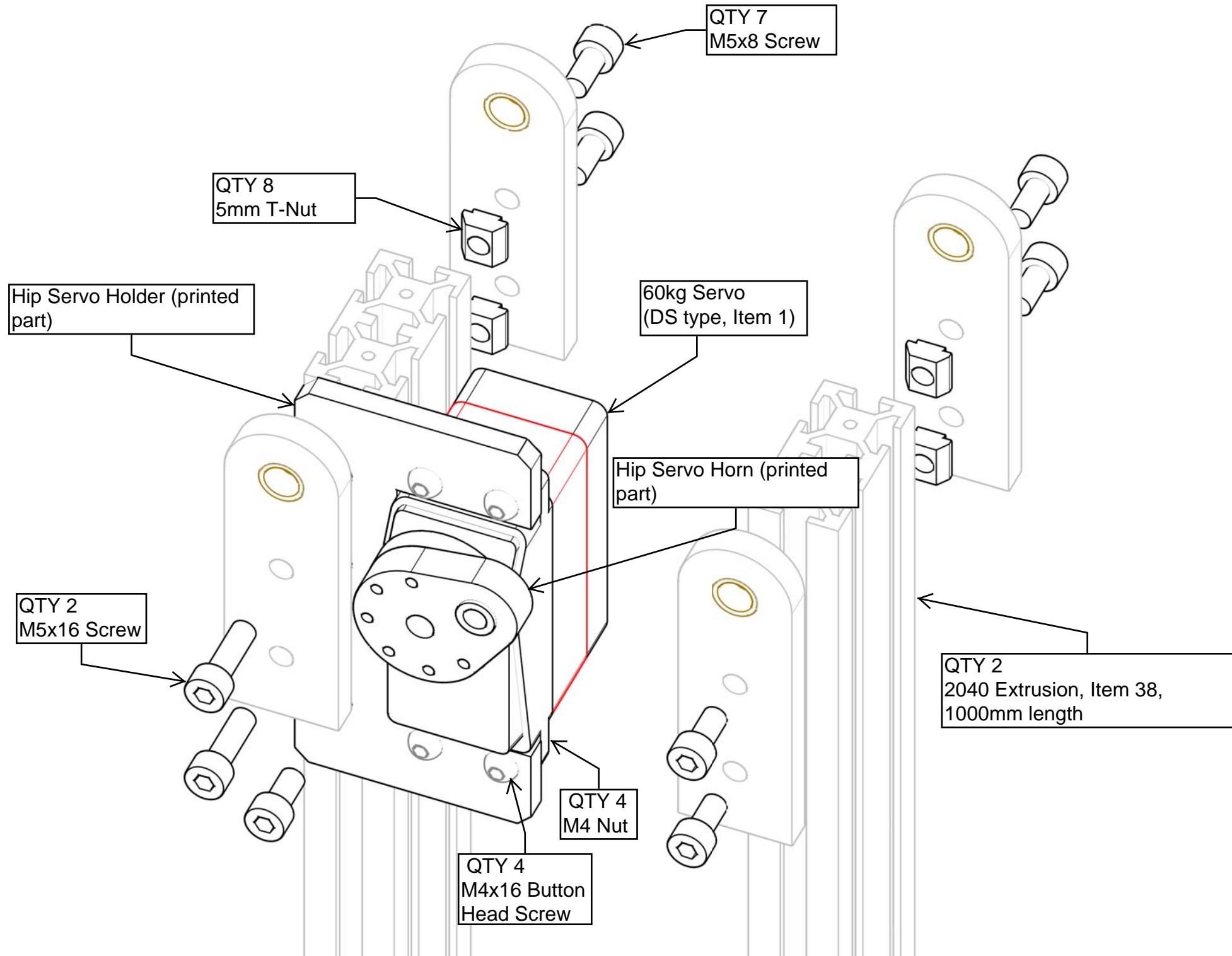
Step 26

Fabricate Hip and Ankle Plates and Ankle Stops. The fabrication dimensions shown are not extremely critical. Ankle Stops are highly recommended to prevent the whole body from falling over in the event that the Hip Servo linkage comes loose.



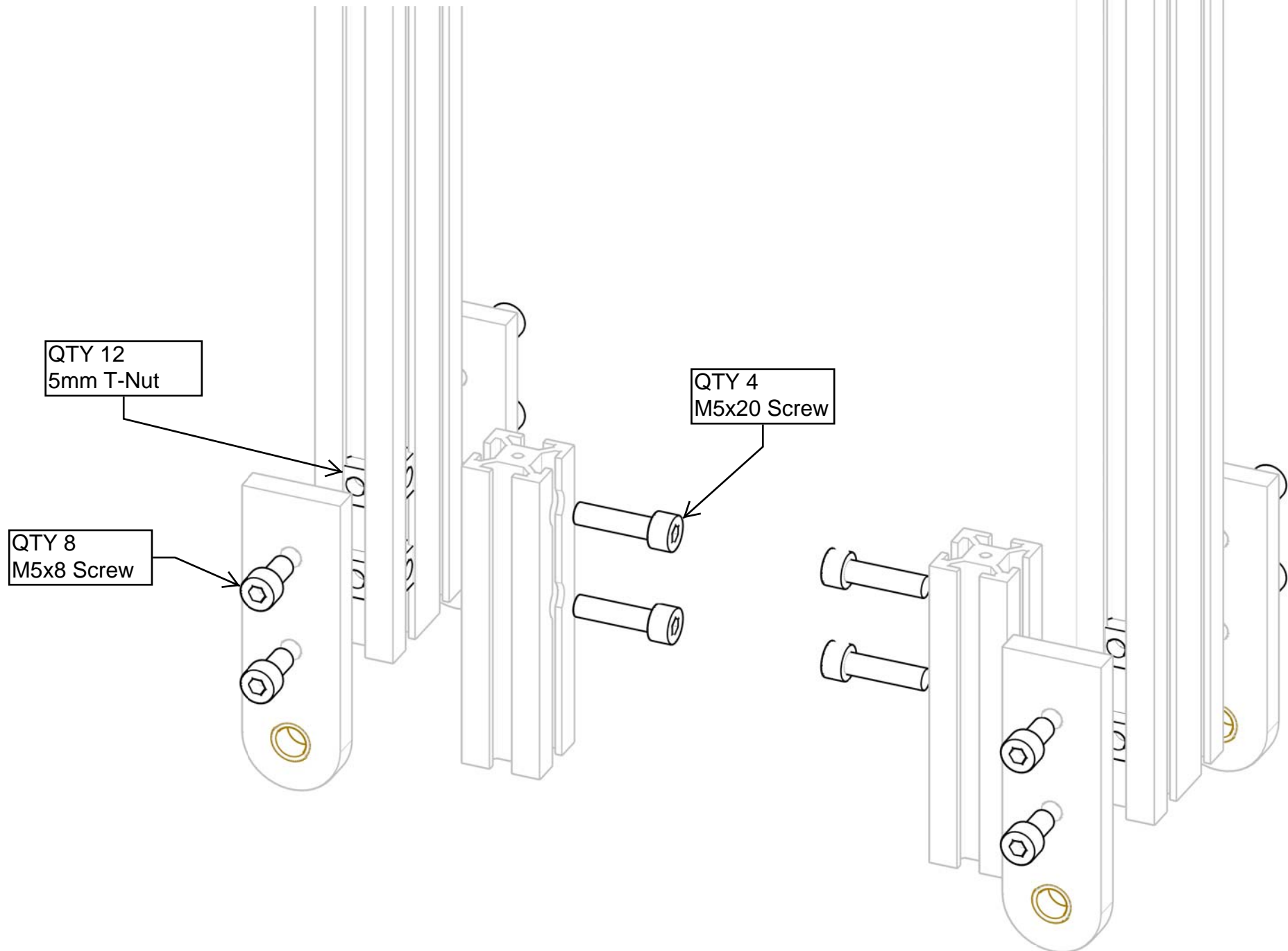
Step 27

Install Hip Plates and Hip Servo to upper legs



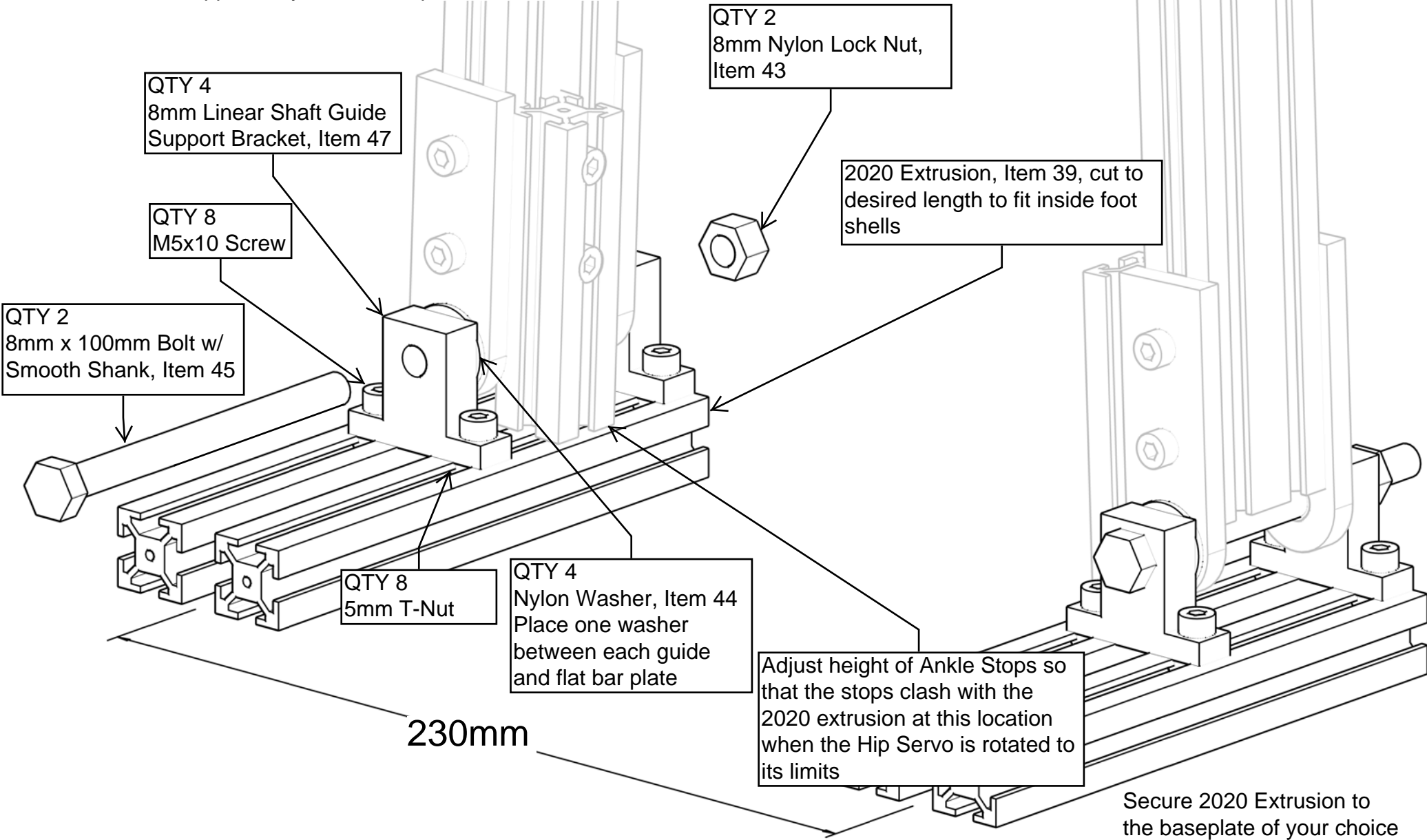
Step 28

Install Ankle Plates and Ankle Stops to lower legs



Step 29

Assemble feet components and secure feet to base. Tighten ankle bolts sufficiently to provide resistance but still allow ankles to rotate. Tightening these bolts will reduce the amount of wobble in the upper body when the hips move from side to side.



Step 30

Install upper body onto legs. Position the hip servo to mid range and secure horn and linkage at the angle shown.

QTY 4
8MM shaft
collar, Item 21

QTY 2
8mm steel shaft, Item 19.
Cut to 98mm length.

Cut M5 threaded rod (Item 32) to connect M5 rod ends.
Cut 8mm tubing (Item 35) to length to sleeve M5 threaded rod. Total assembled length center-to-center of the rod ends should be approx 245mm.

M5x16 Screw

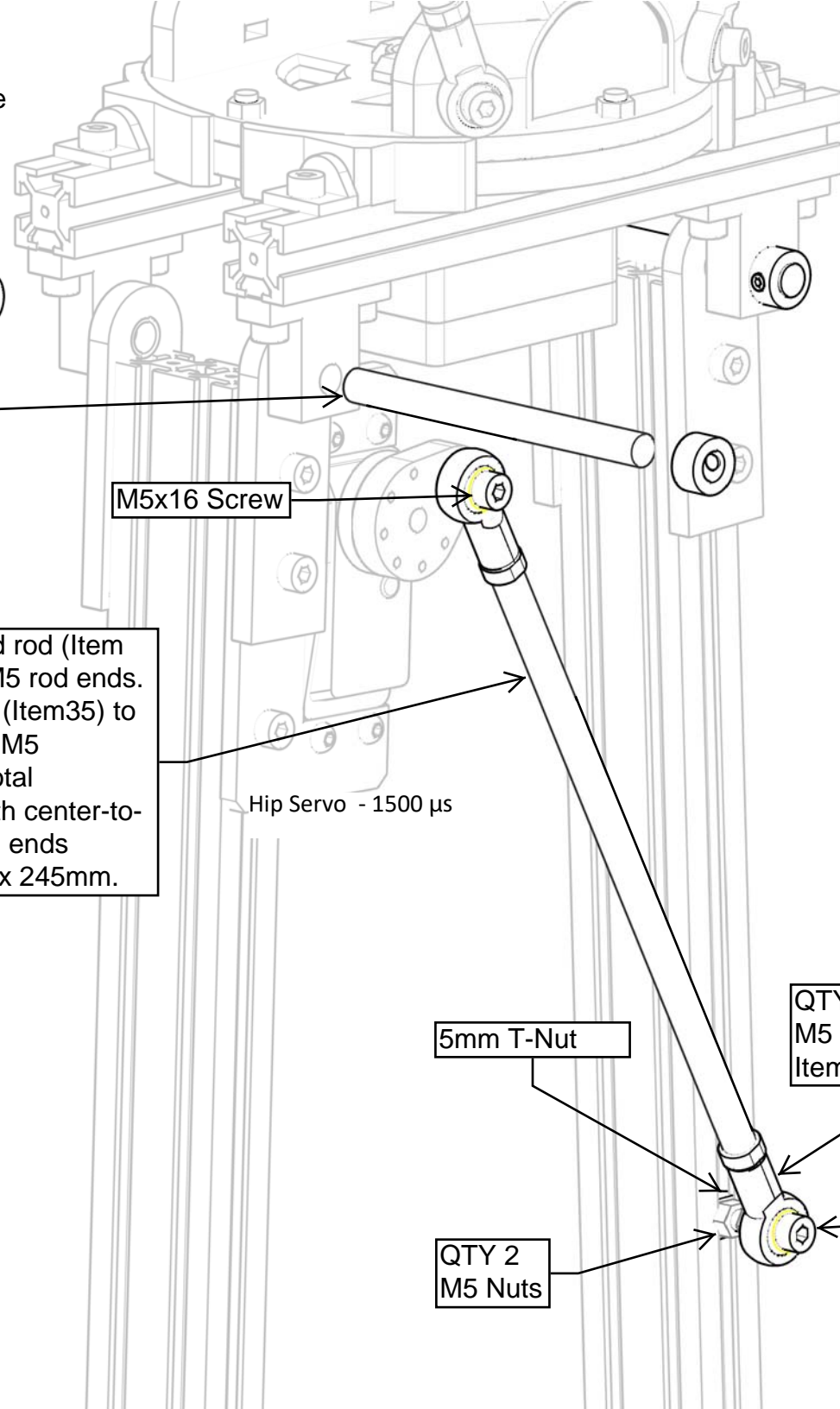
Hip Servo - 1500 μ s

5mm T-Nut

QTY 2
M5 rod end,
Item 31

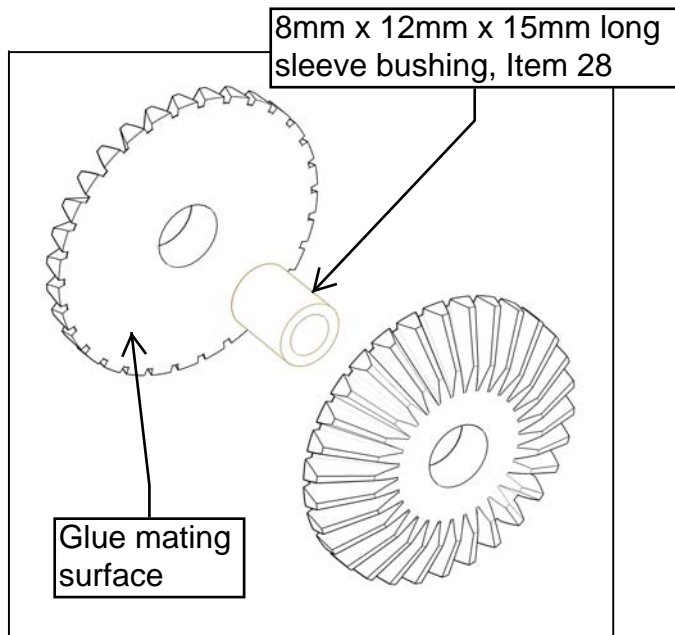
QTY 2
M5 Nuts

M5x25 Screw

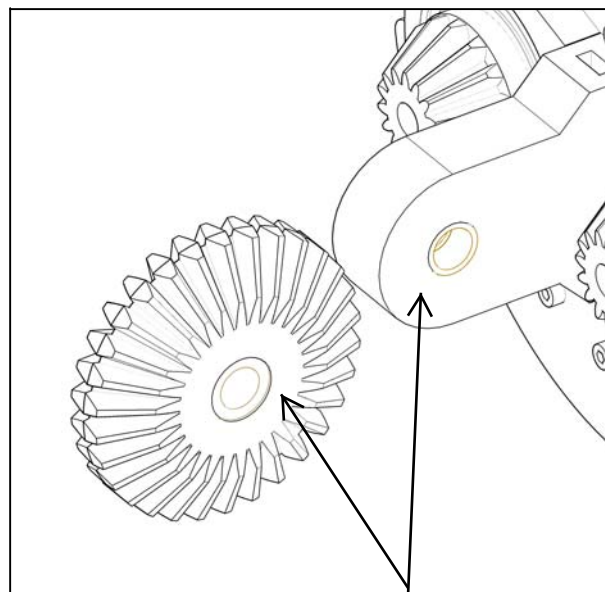


Step 31

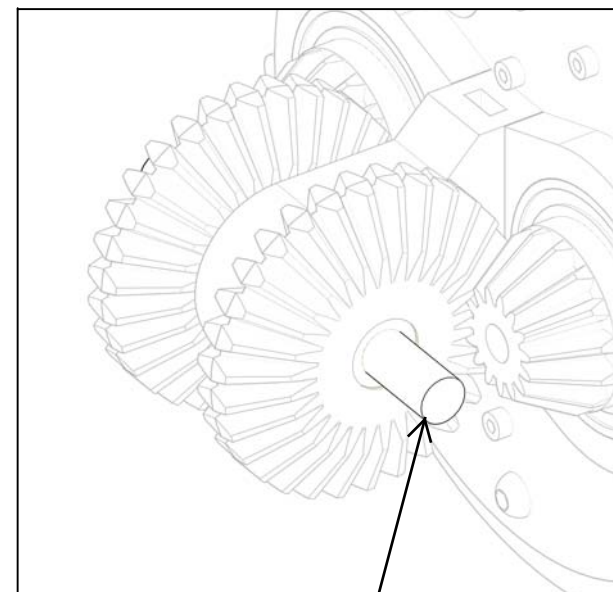
Glue up and fit up Shoulder Gears. Glue the Large Shoulder Gear halves together with CA glue. Use the sleeve bushing to align parts during glue up. Once dry, test fit the gears into their position. Sand surfaces as required so that each gear slots straight into place.



QTY 4 Required
Large Shoulder Gear



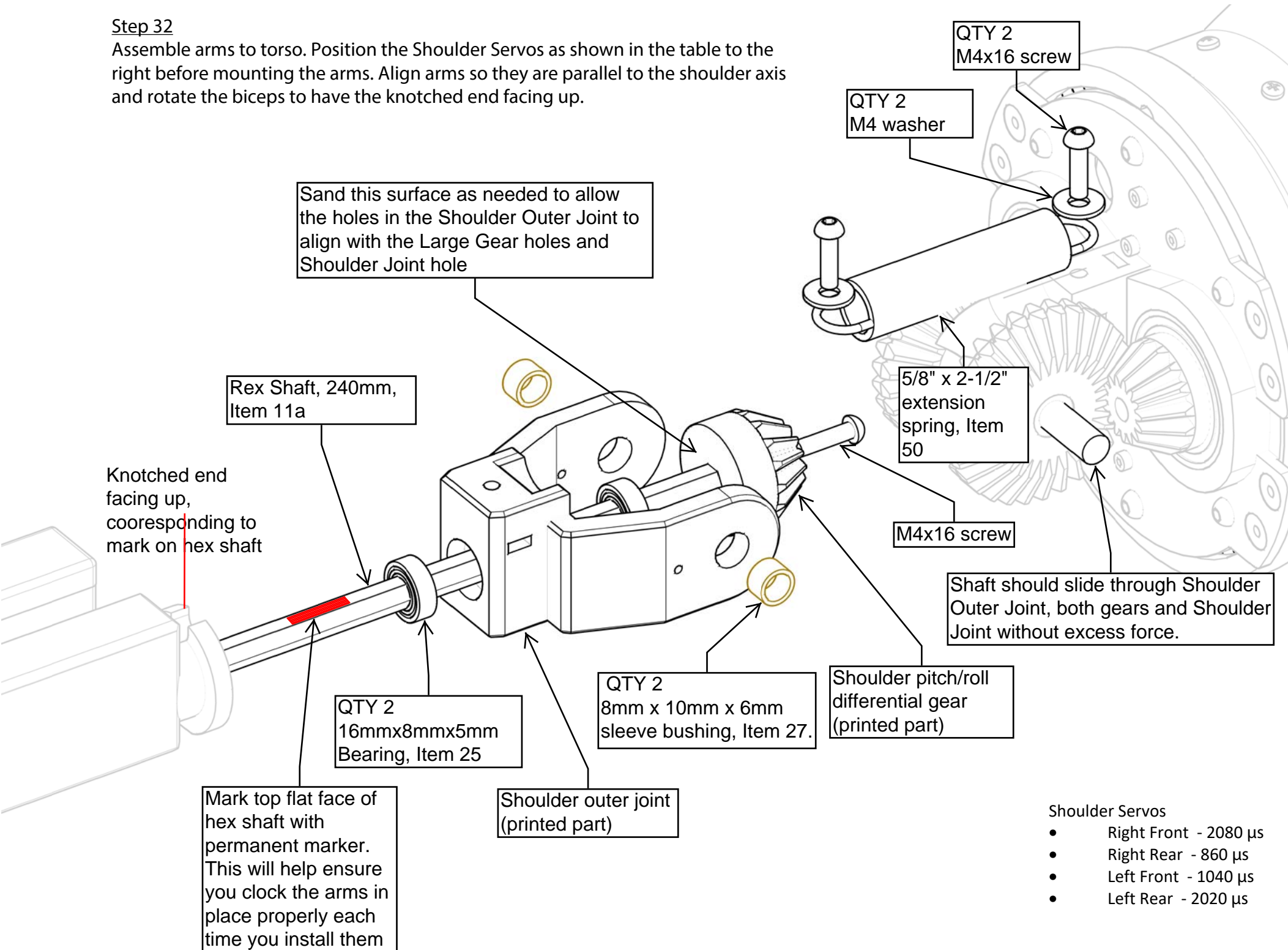
Sand this surface and opposite side as needed to allow smooth fit up of gear into position shown



8mm steel shaft, Item 19. Cut to 83mm long. Test fit with shaft in this step. Shaft should slide through both gears without excess force.

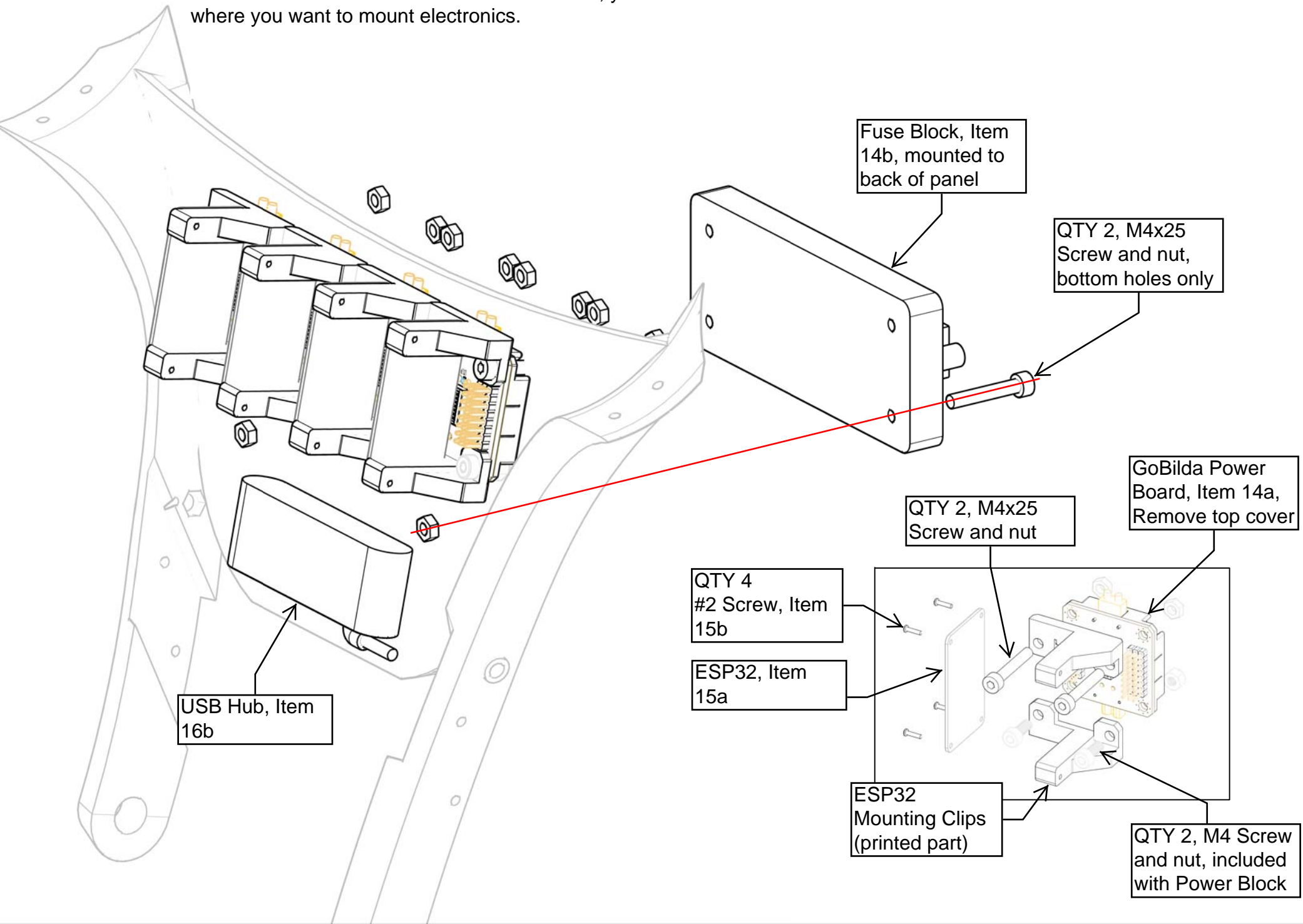
Step 32

Assemble arms to torso. Position the Shoulder Servos as shown in the table to the right before mounting the arms. Align arms so they are parallel to the shoulder axis and rotate the biceps to have the knotted end facing up.



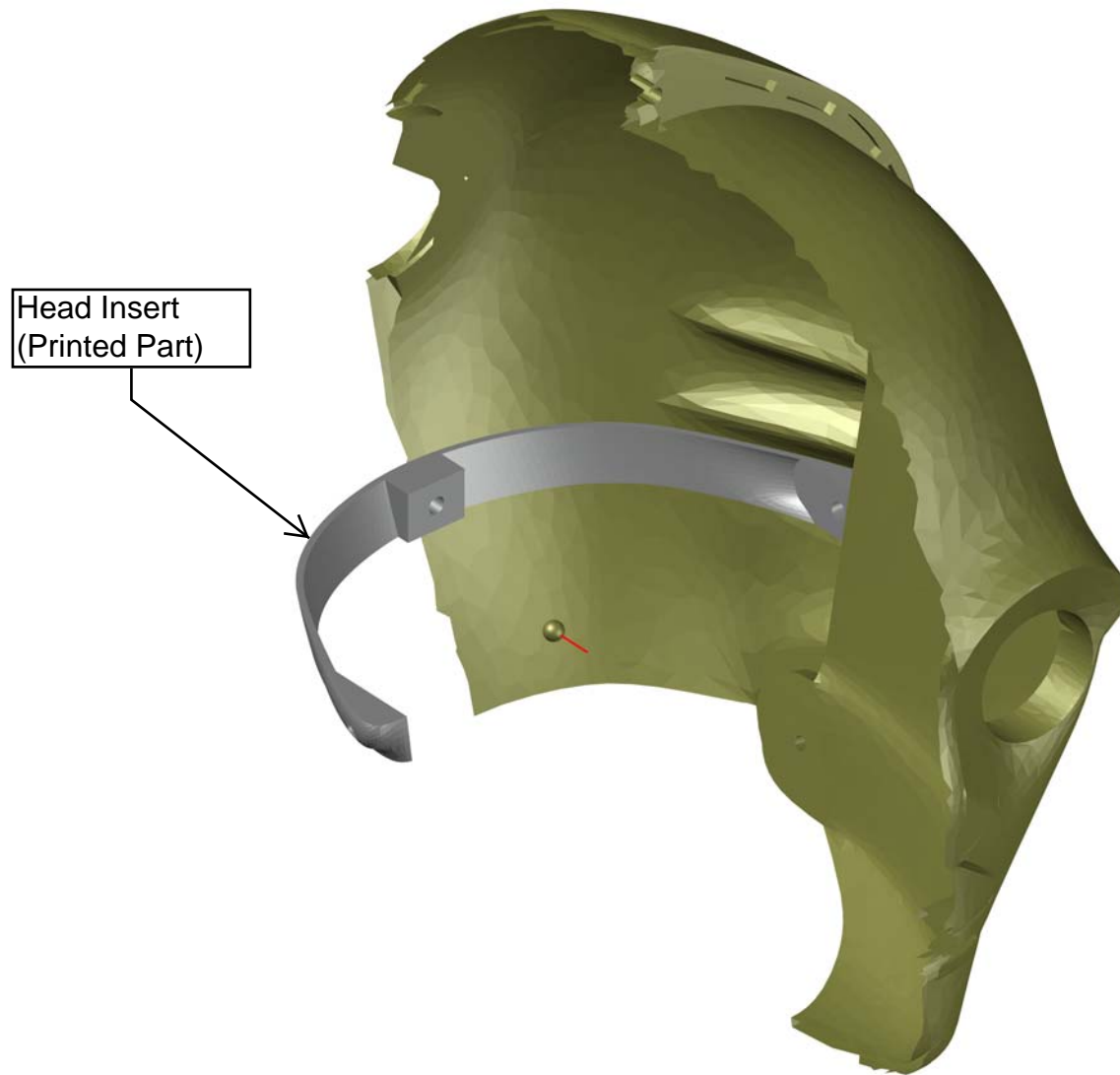
Step 33

Suggested power and controls mounting. The back panel of the torso has been left blank to allow user customization. As such, you will need to drill holes where you want to mount electronics.

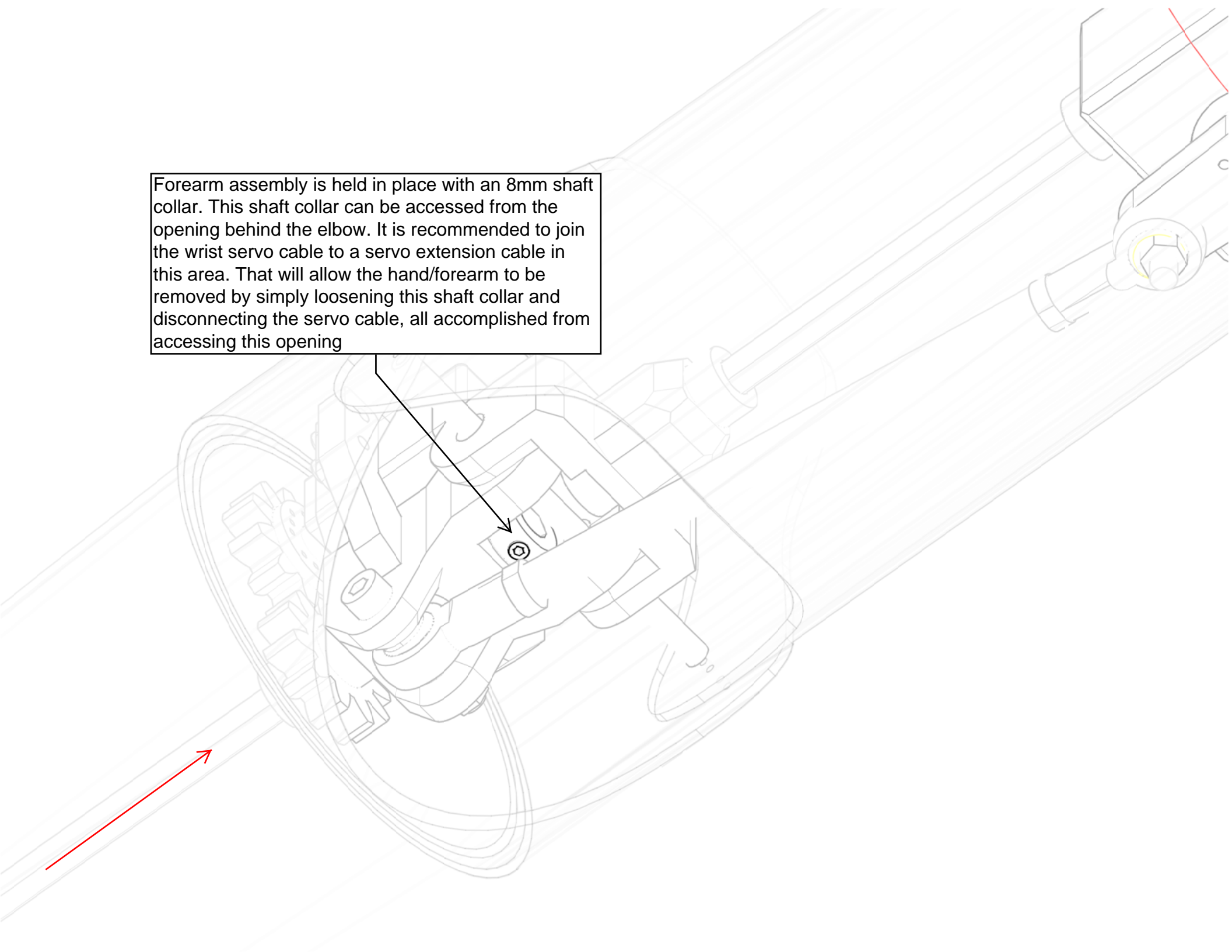


Step 34

Glue Head Insert. Two versions of the Head Insert part are included, corresponding to the version of head you have printed. I recommend using hot glue rather than another type of permanent glue to adhere the Insert into the head. This will allow for removal later if desired. The head insert should fit perfectly into the lower notch of the back of the head as shown here.



Forearm assembly is held in place with an 8mm shaft collar. This shaft collar can be accessed from the opening behind the elbow. It is recommended to join the wrist servo cable to a servo extension cable in this area. That will allow the hand/forearm to be removed by simply loosening this shaft collar and disconnecting the servo cable, all accomplished from accessing this opening

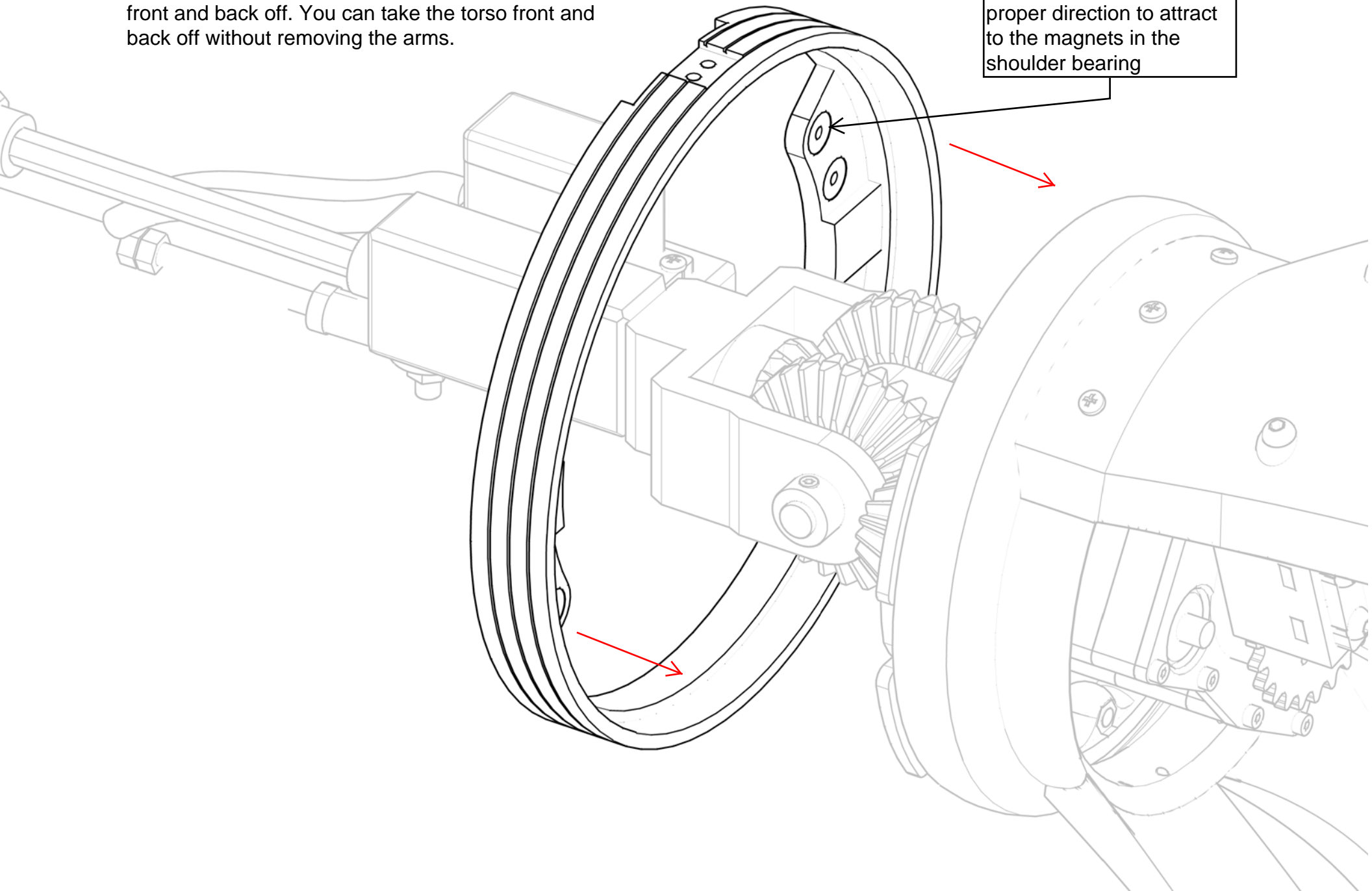


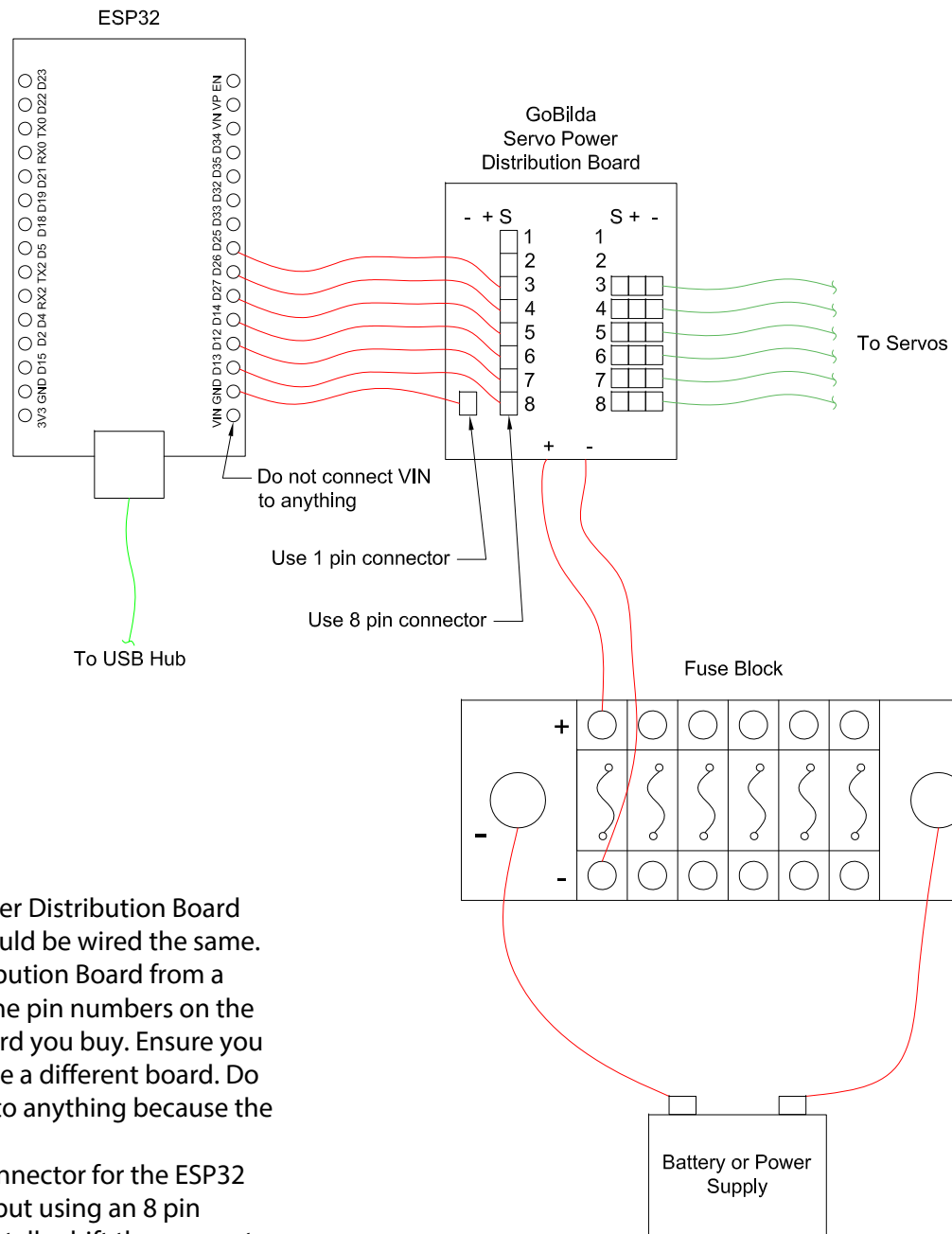
Step 35

Glue magnets into shoulder bearing. This design allows the animatronic to rotate the shoulder bells along with the arms. It also allows the shoulder bells to be pulled away from the torso without needing to take the arms off. This makes it easier to take the torso front and back off. You can take the torso front and back off without removing the arms.

QTY 8

Item 41, magnets. Glue in recesses with CA glue. Ensure all are facing the proper direction to attract to the magnets in the shoulder bearing





Typical Wiring Diagram

Only one ESP32 and GoBilda Servo Power Distribution Board are shown for simplicity but all four should be wired the same. Power each GoBilda Servo Power Distribution Board from a separate fuse on the fuse block. Note, the pin numbers on the ESP32 may vary based on the exact board you buy. Ensure you use pins that are PWM capable if you use a different board. Do NOT connect the VIN pin on the ESP32 to anything because the board gets its power through the USB.

I recommend using an 8 pin Dupont connector for the ESP32 signal wiring. Some pins will be empty but using an 8 pin connector will ensure you don't accidentally shift the connector and send wrong signals to the servos.