

Thrifty Elevator Assembly Guide

Last Updated 01/03/24 v1.2

The Thrifty Bot exists to provide lower cost, commonly used parts to FIRST Robotics teams. Our goal is to help address the sustainability issues of FRC by providing affordable parts to teams. We appreciate your support. If you run into any questions or issues during the build process, don't hesitate to send us a message at contact@thethriftybot.com We will do our best to help and appreciate your support. Thanks teams!

Things to Consider:

Thrifty Elevator is designed to work with the various brands of 2 in. x 1 in. aluminum box extrusion of any wall thickness on the market. Your team can work with what they like – Thrifty Grid Pattern Tubing, REV MAXTube, VEX VersaFrame, or simply plain 2x1 from your aluminum metal supplier of choice. You bring the 2x1 tubing, hex shaft, structural fasteners and gearboxes and we'll provide the rest.

Prior to cutting metal and jumping into assembly, consider the size of your robot frame perimeter and how the elevator assembly will integrate with the rest of your robot. The bottom rail of the base structure can be cut longer in order to interface with your drive base. We highly recommend referencing the CAD assembly in OnShape or by importing the STEP file into your CAD application of choice. OnShape provides an option to easily scale the elevator to fit your robot's needs.

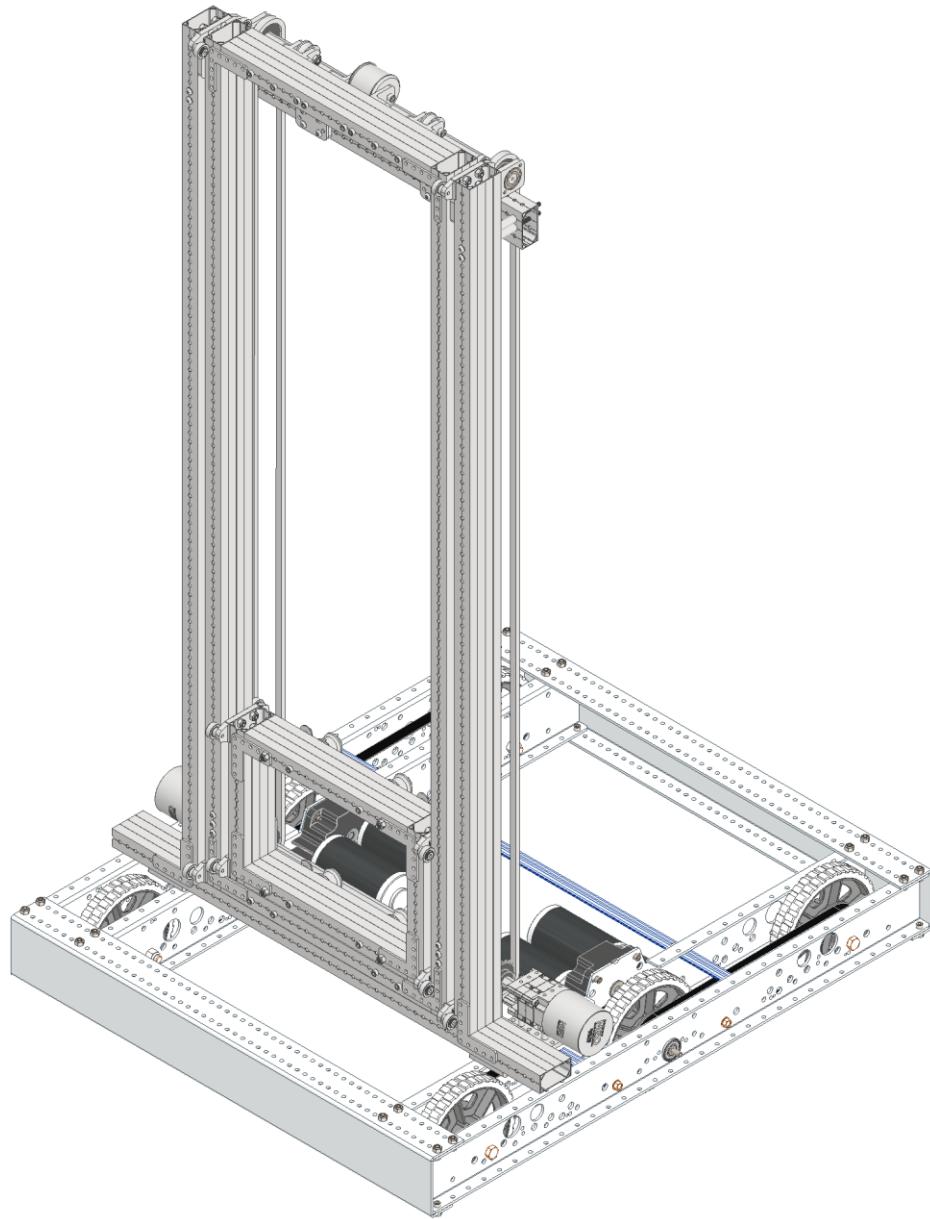


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Kit Contents

Part Name	QTY	Part Number
Sliding Elevator Bearing Block Kit (1 kit per stage)		TTB-ELEV-SLIDE
Sliding Bearing Block Plate v1.1	4	ELEV-SLIDE-001
1/4" Diameter x 1.75" Long Steel Dowel	4	ELEV-SLIDE-002
Bearing Block Shoulder Bolt Spacer	8	ELEV-SLIDE-003
1" Long 1/4-20 Button Head Screw	8	97763A267
1/4-20 Thin Locknut	8	90101A230
.50OD x .25ID x .188WD Bearing	8	TTB-0027
.75OD x .25ID x .28WD Bearing	8	TTB-0034
5/8" Long 10-32 Button Head Screw	16	13116
10-32 Thin Locknut	16	18196
Small 4" Zip Ties	4	ZIP



ZIP



ELEV-SLIDE-003



TTB-0034



ELEV-SLIDE-002



13116



TTB-0027



97763A267



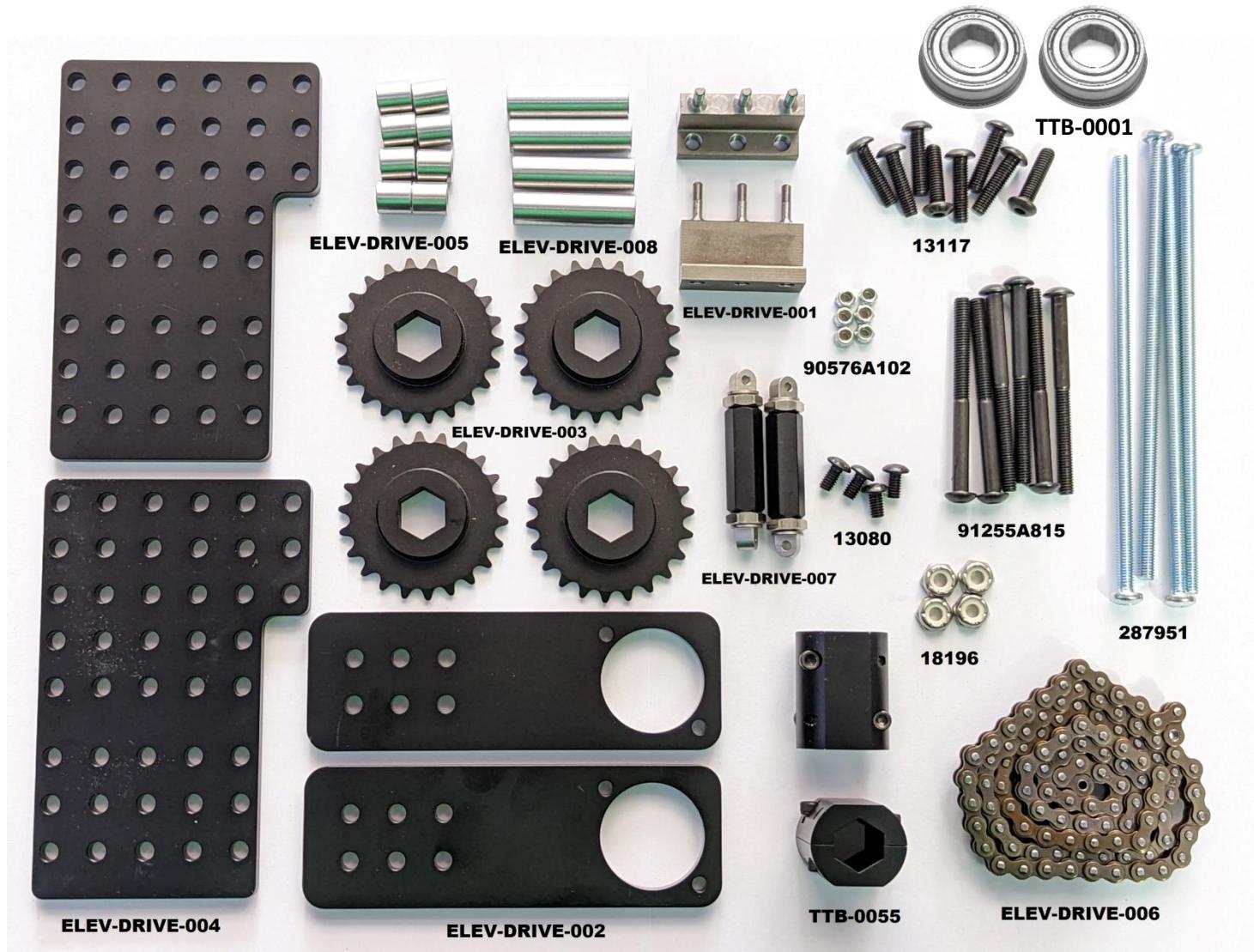
18196



90101A230

ELEV-SLIDE-001

Elevator #25 Chain Drive Kit (1 kit per elevator)	QTY	TTB-ELEV-DRIVE
25 Chain Attachment Part	2	ELEV-DRIVE-001
Top Elevator Bearing Plate	2	ELEV-DRIVE-002
25 Chain 22t 1/2" Hex Sprocket	4	ELEV-DRIVE-003
Thrifty Planetary Mount Plate	2	ELEV-DRIVE-004
Planetary Mount Spacer	8	ELEV-DRIVE-005
25H Chain 10 ft	2	ELEV-DRIVE-006
#25 Chain Tensioner	2	ELEV-DRIVE-007
1.375" Long Aluminum Spacers for Crossbar	4	ELEV-DRIVE-008
Half Inch Hex Coupler - TTB-0055	2	TTB-0055
M3 Locknuts	6	90576A102
Button head 10-32 Bolt 2.25" Long	6	91255A815
5/16" Long 8-32 Button Head Screw	4	13080
5 Inch Long 10-32 bolt	4	287951
1" Long 10-32 Socket Head Screw	8	5018
10-32 Thin Locknut	4	18196
Half Inch Hex Bearing	2	TTB-0001



Elevator Dyneema Pulley Kit (1-2 kits per elevator)	QTY	TTB-ELEV-PULLEY
4mm Dyneema Cable Pulley Bracket	2	ELEV-PULLEY-001
4mm Dyneema Cable Pulley Assembly	2	ELEV-PULLEY-002
Dyneema Tensioning CAM	2	ELEV-PULLEY-003
Cable Clamp Base Plate	1	ELEV-PULLEY-004
Cable Clamp Top Plate	1	ELEV-PULLEY-005
25 FT Dyneema Cable 4mm Diameter	1	TTB-0056
Socket Head 10-32 Bolt 1.25" Long	4	5019
Button head 10-32 bolt 3/8" Long	6	13113
Socket head 10-32 Bolt 2.25" Long	4	8230
Socket head 10-32 Bolt 2.5" Long	2	8231
Socket Head 10-32 Bolt 3" Long	2	8233
#10 Washer	2	7618
10-32 Thin Locknut	2	18196
Socket Head 1/4-20 Bolt 1.25" Long	2	5028
1/4-20 Thin Locknut	2	18197



Constant Force Spring Kit (1-2 kits per elevator)	QTY	TTB-ELEV-SPRING
Constant Force Spring Holder	2	ELEV-SPRING-001
Constant Force Spring 50" Travel 16.5 lbs	1	ELEV-SPRING-002
Constant Force Spring Spool	1	ELEV-SPRING-003
Constant Force Spring Retainer	2	ELEV-SPRING-004
Socket Head 10-32 Bolt 2.25" Long	4	8230
Socket Head 1/4-20 Bolt 2.25" Long	2	8034
1/4-20 Locknut	2	18197



ELEV-SPRING-002



ELEV-SPRING-001



18197



8034



8230



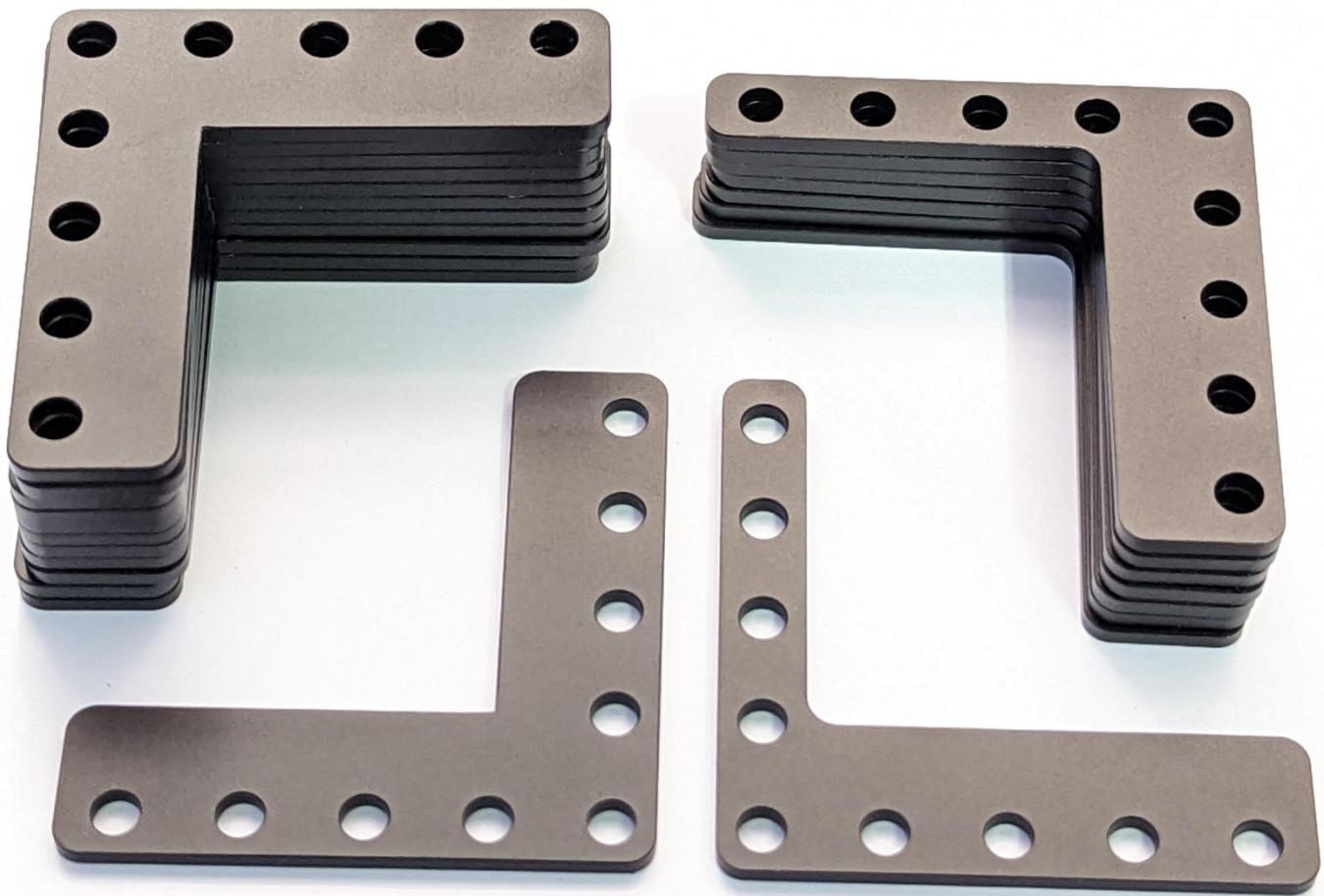
ELEV-SPRING-003



ELEV-SPRING-004



Elevator Gusset Kit (1 kit per elevator)	QTY	TTB-ELEV-GUSSETS
Regular 90 Degree Elevator Gussets	12	ELEV-GUSSETS-001
2nd Stage Elevator Gussets	8	ELEV-GUSSETS-002

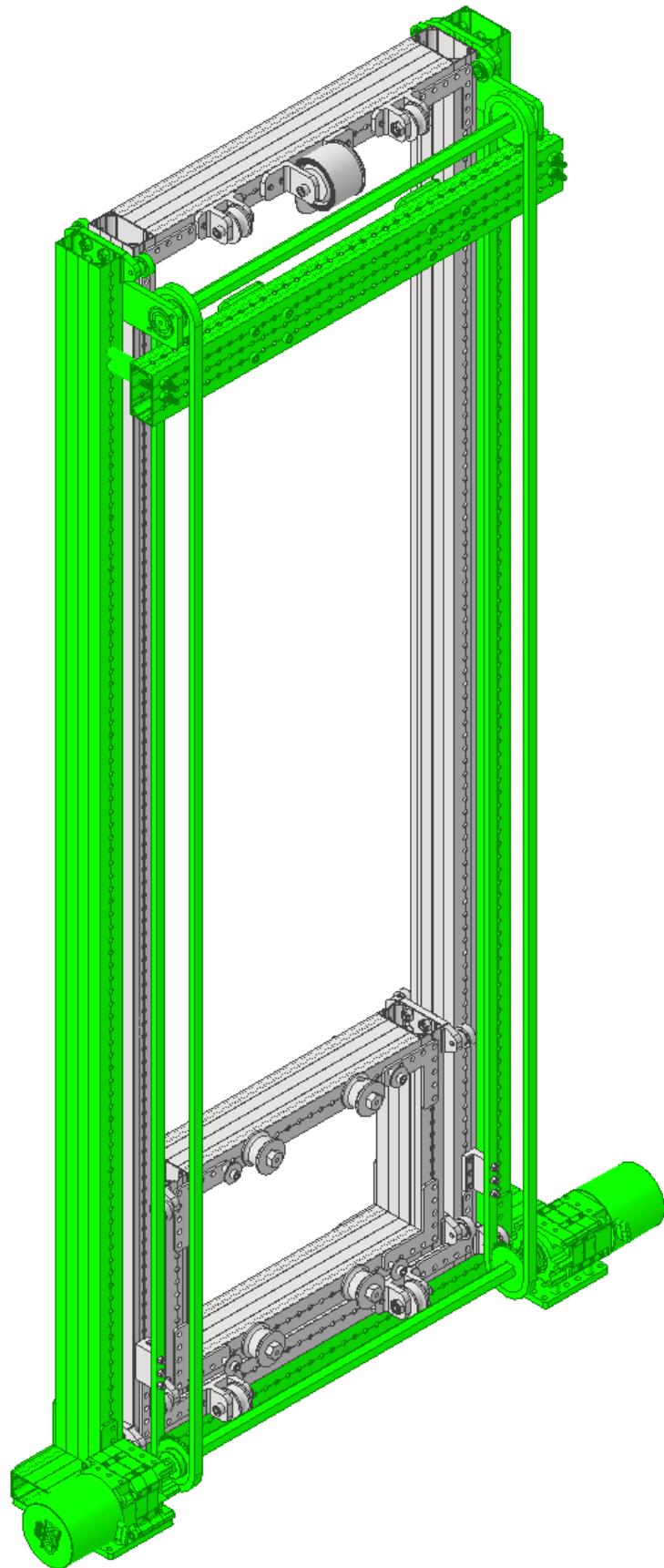


ELEV-GUSSETS-001

ELEV-GUSSETS-002

Base Stage Assembly

The following steps will focus on the green highlighted items shown below. This will be referred to as the base stage.

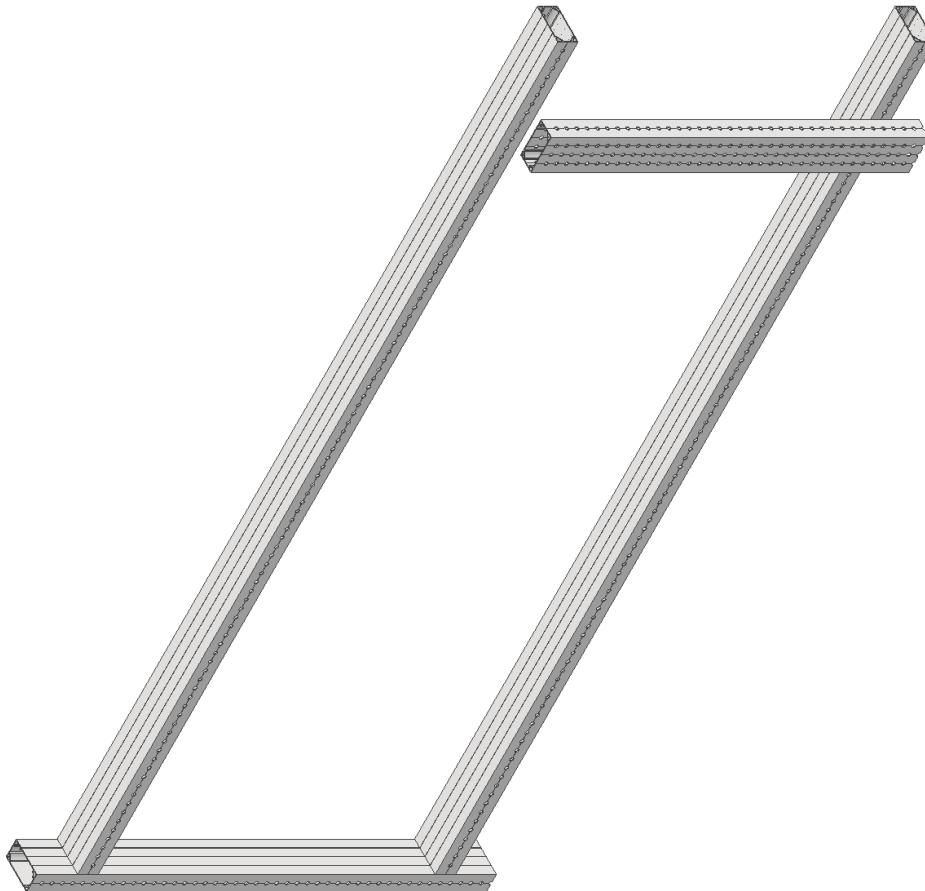


1. Choose and cut to size 2" x 1" aluminum box extrusion

Pick the 2 inch x 1 inch aluminum extrusion you want to use. For reference, this 2 stage elevator + carriage that we have built that uses two 47" tall side rails from REV Ion tubing requires 6 47" long sticks of REV Ion tube.

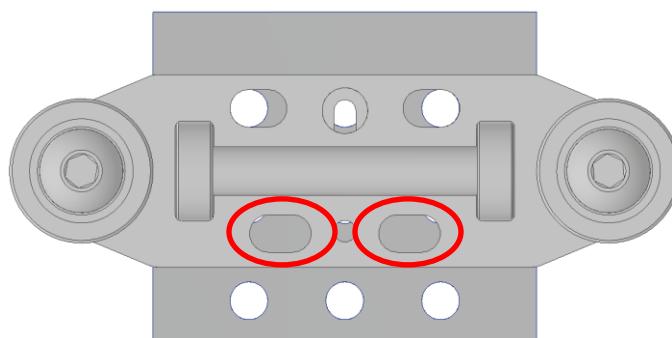
2. Cut the base piece, cross bar piece and base side rails to size

Size and measure your elevator rails accordingly so it will fit within your design. Cut the base rail, side rails and cross bar pieces.



3. Transfer Drill Bearing Block Holes

Clamp the bearing block to the end of your tube. Having the block flush with the top of the tube will provide the most amount of support for the elevator stages. Use a #11 or 3/16 drill bit and transfer drill the 2 holes using the plate as a transfer guide. Do this for both side rails.

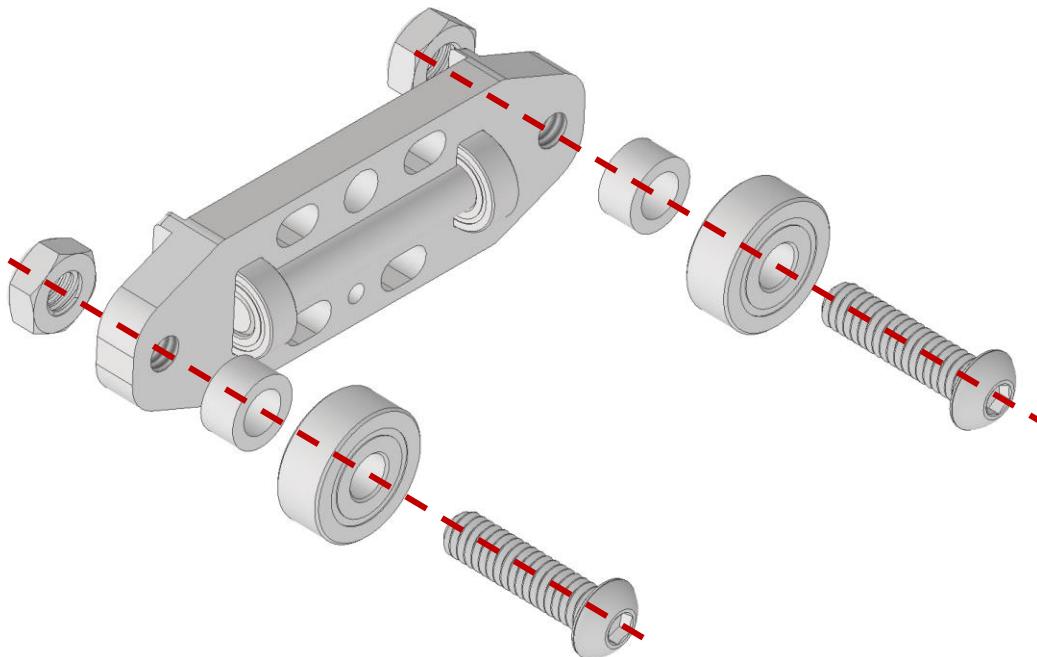


4. Assemble Elevator Bearing Blocks

Now is a great time to assemble all the bearing blocks for the full elevator. First insert the 1.75" long steel dowel pin and $\frac{1}{2}$ " OD bearings into the plate. Use the included zip tie and look it thru the holes and slot. Tighten the zip tie to retain the dowel rod and ensure the zip tie head is nested in the recess under the dowel rod.



Insert the $\frac{1}{4}$ -20 button head bolt thru the $\frac{3}{4}$ " OD bearing and the shoulder bolt spacer. Screw this into the 10-32 threaded holes on the outside of the plate. You will want to use blue threadlocker on these once they are ready to be used, but this can be applied at a later step.

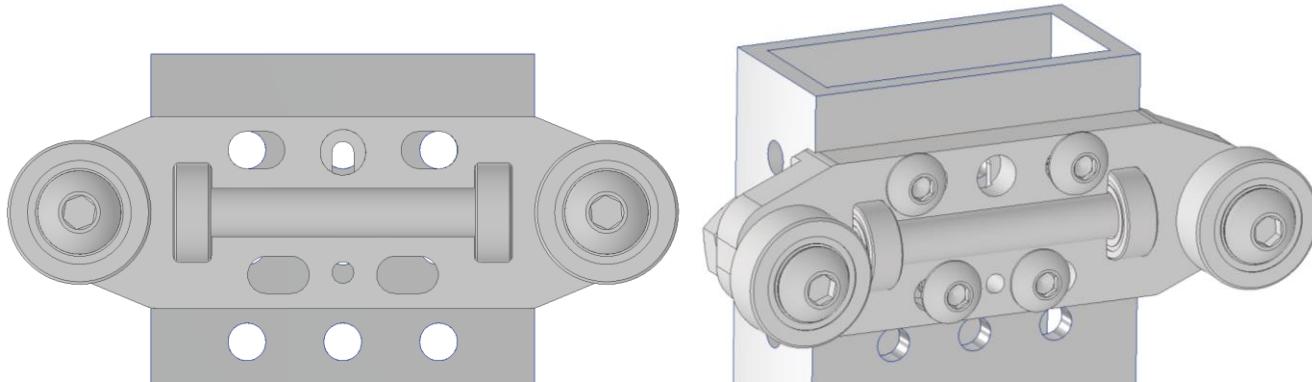


Once assembled the bearing blocks should look like this –



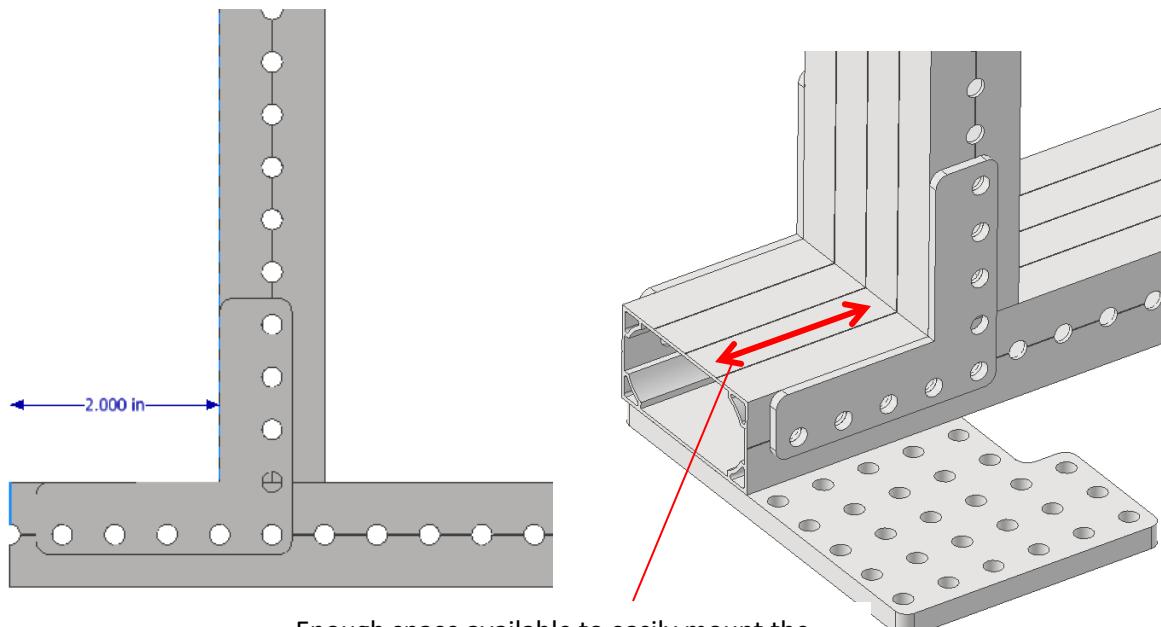
5. Mount Elevator Bearing Blocks

Use the provided 5/8" long button head screws and 10-32 locknuts to mount your bearing blocks. These holes are also sized for 3/16" rivets if you choose to use those instead. Do this for both side rails. The 2024 updated bearing blocks now fit with grid pattern tubing as well, but you will still need to drill 2 of the 4 holes out for this type of tubing.



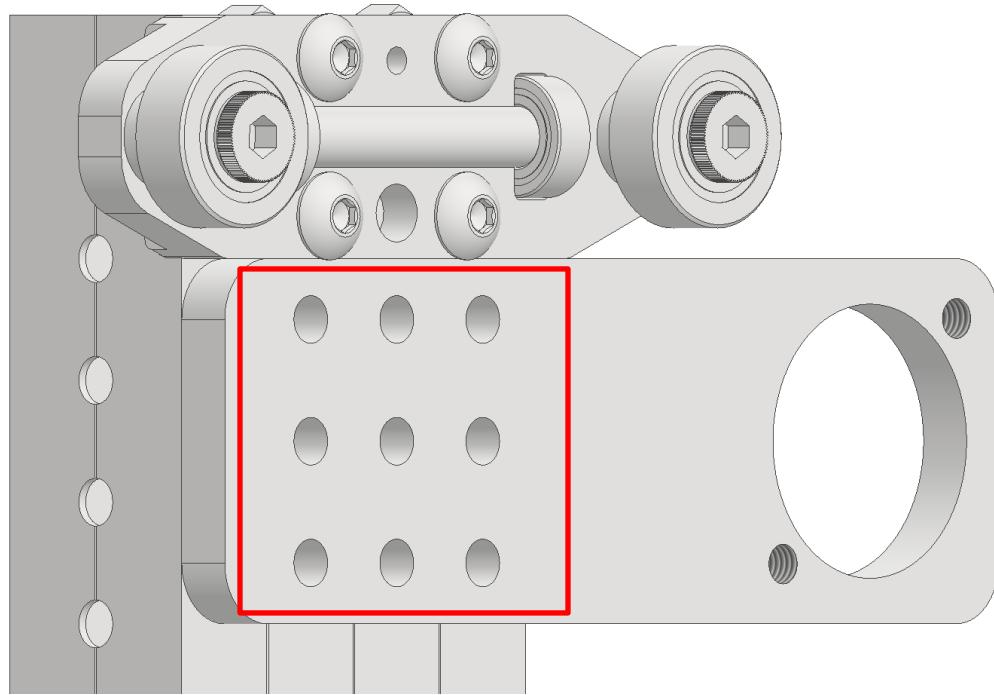
6. Begin Base Stage Frame Assembly

Position your outside base rail using the 90 degree elevator gussets. In this example, we positioned 2 inches away from the outside base rail. This gives you enough room to later mount the planetary gearbox mounting plate. We recommend using 3/16 rivets and the use of [temporary Cleco fasteners](#) to aid in building the various frame assemblies.



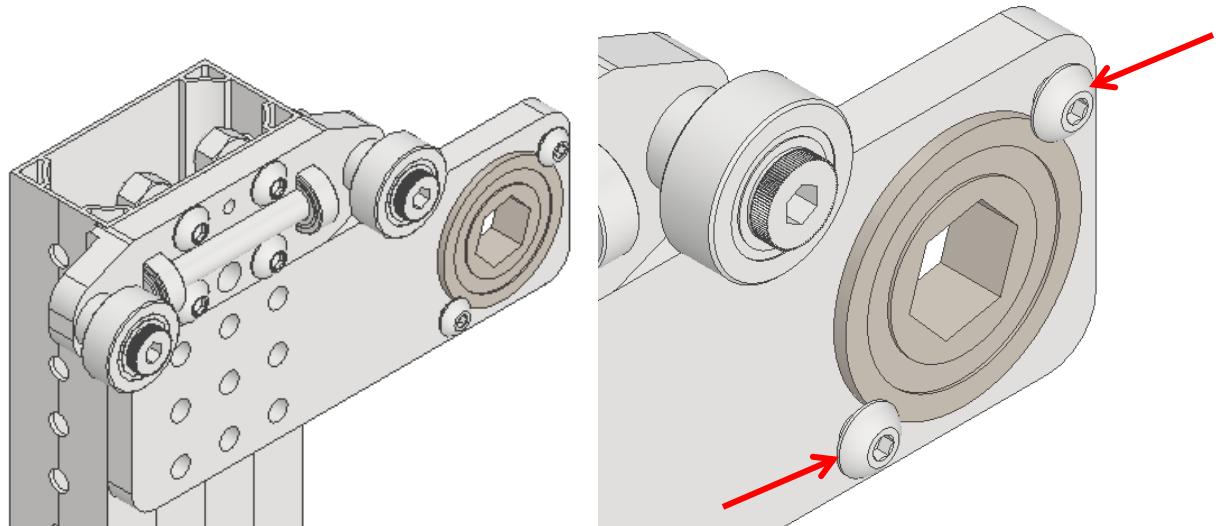
7. Mount Top Bearing Plate

Clamp the top bearing plate flush against the top elevator bearing block and flush against the 2x1 tube. Use the provided holes with a #11 drill bit to transfer drill the hole pattern. Mount with your choice of #10 size bolt or 3/16 rivets. We used rivets due to accessibility being difficult here, but you could drill access holes from the opposite side of the 2x1 tube.



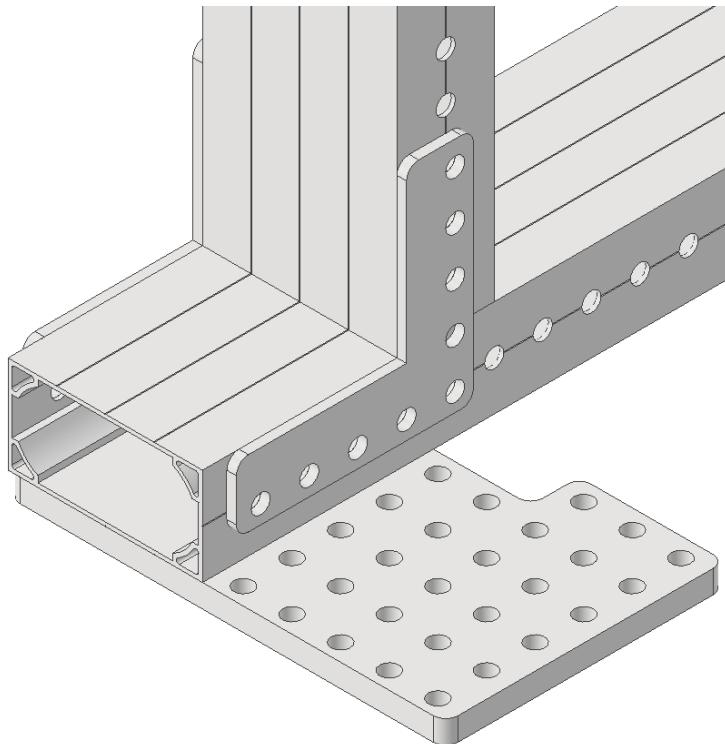
8. Insert and Secure Top Bearing

Choose either a $\frac{1}{2}$ inch hex bearing or a 13.75mm ID bearing (rounded hex, thunderhex) depending on the style of $\frac{1}{2}$ inch hex shaft you plan to use. Secure these bearings with the provided #8 5/16" long button head screws after applying blue threadlocker.

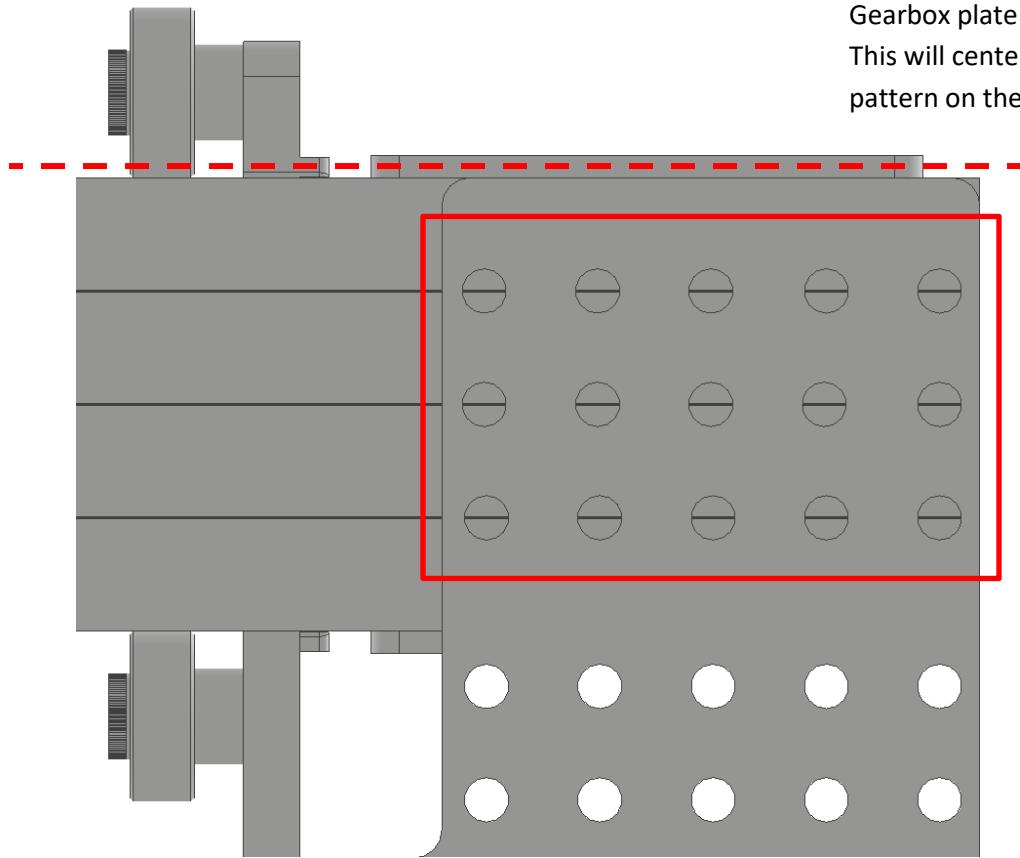


9. Mount Planetary Mount Plates

Clamp the planetary gearbox mount plates so that the back is flush with the tube. You'll want to ensure the planetary gearbox and plate will fit properly within your frame and frame perimeter. Transfer drill the mounting hole pattern and attach the plate with #10 hardware or 3/16 rivets.

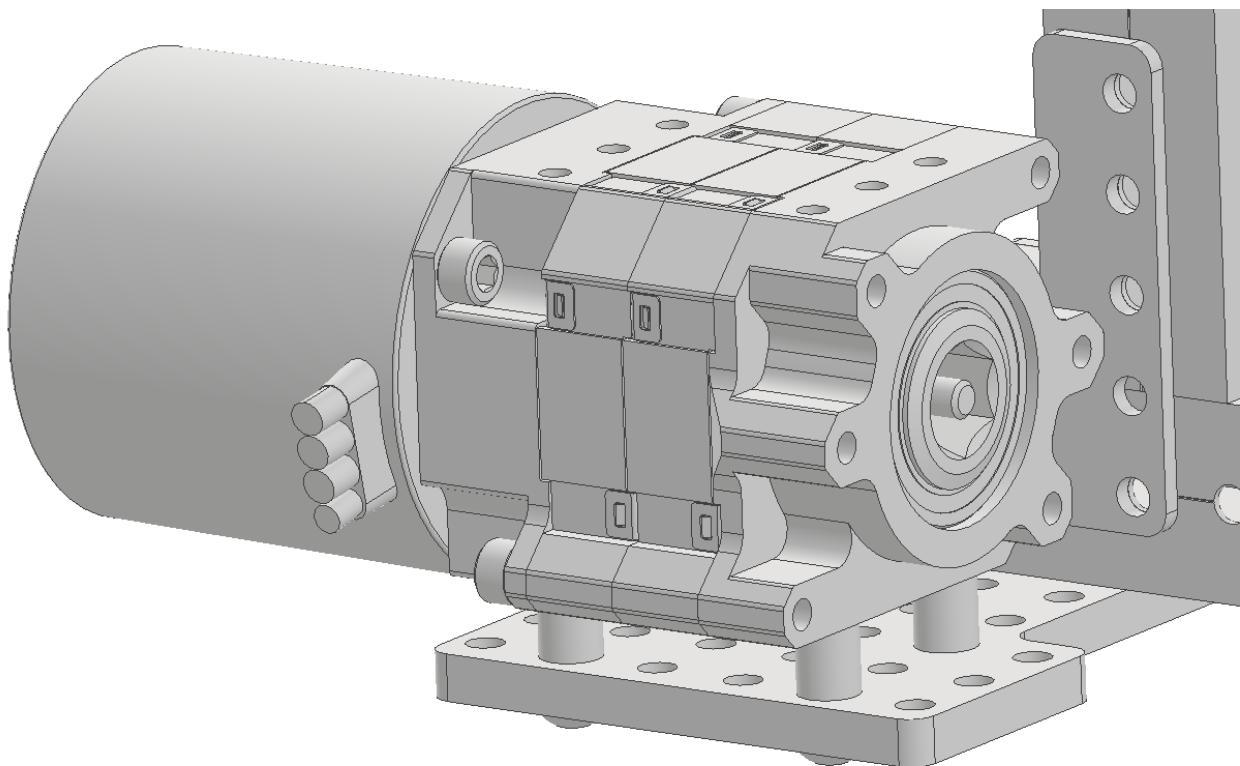


Gearbox plate is flush with rail.
This will center the hole
pattern on the 2x1.

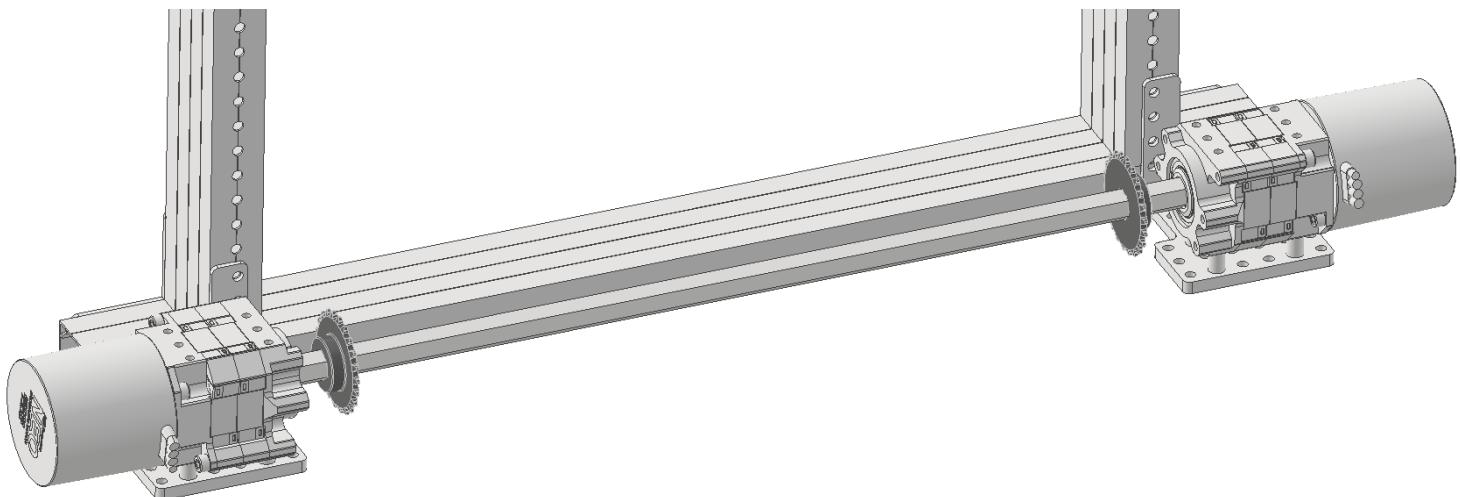


10. Mount Planetary Gearboxes, Base Hex Shaft and Sprockets

Thrifty Elevator supports running either REV MAX Planetary or VEX Versaplanetary gearboxes. Use the included #10 mounting hardware and .394" long aluminum spacers to mount either gearbox in configurations up to 3 stages long.



Your team will want to decide whether to use a $\frac{1}{2}$ " Hex Coupler (required for Versaplanetary use) or run the hex shaft end to end with the ends tapped and bolted in the case of the MAX Planetary. Measure and cut your $\frac{1}{2}$ " hex shaft to the correct size and insert it into the assembly. Now is also a good time to put the 22 tooth sprockets on the base hex shaft.



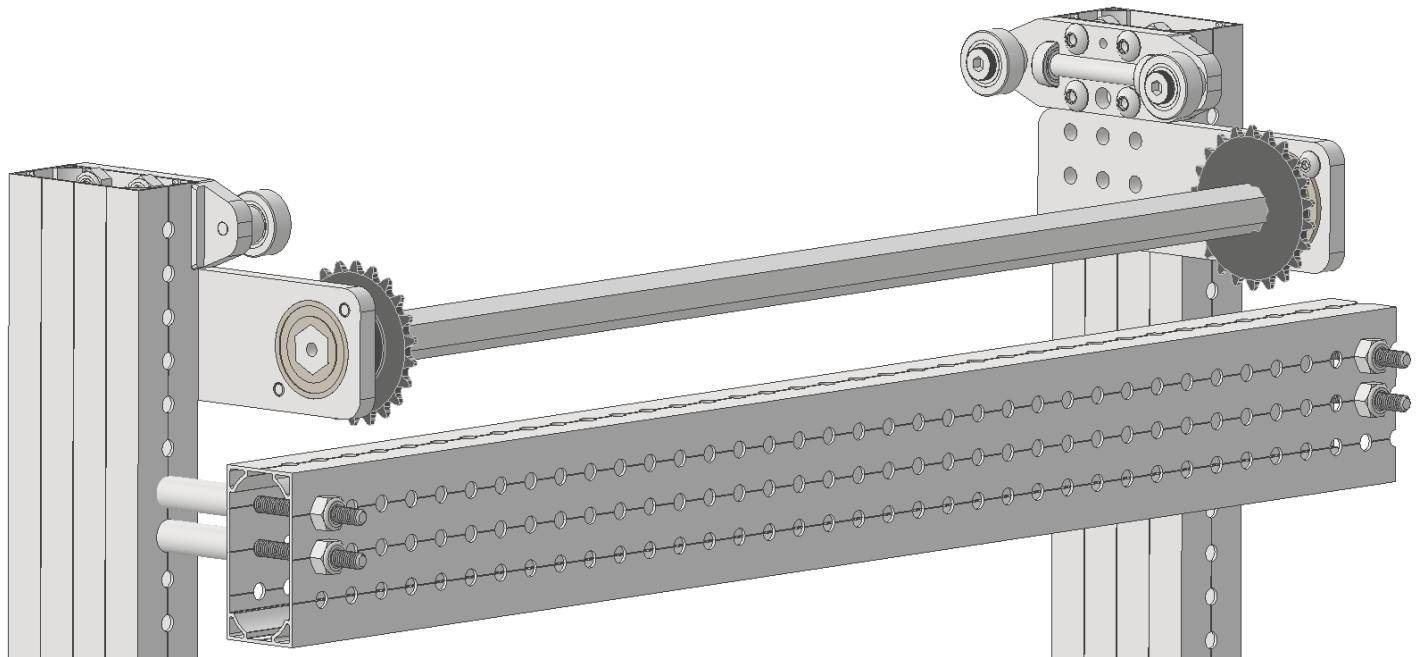
11. Mount Top Hex Shaft

Now is a fine time to insert the top hex shaft as well. Measure bearing to bearing to ensure you have enough length. You can oversize this if desired and use clamping collars to retain the shaft, or tap & thread the end of the hex shaft and use a washer & bolt to retain it on each end. Make sure to put the 22 tooth sprockets on the shaft prior to inserting it fully.



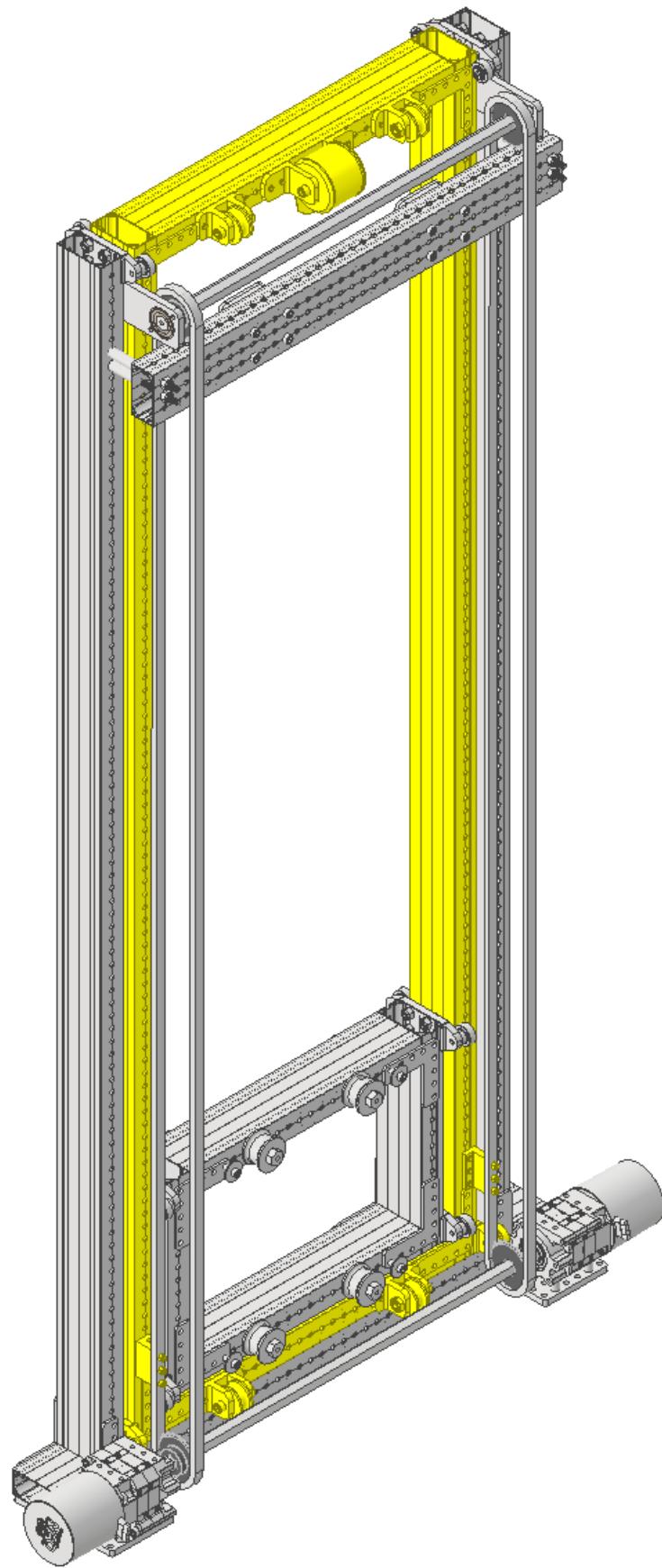
12. Mount Top Cross Structure Member

Go ahead and mount the top structure member after this as well. We like the REV grid pattern material for this part as it has holes readily available in the part. You'll want to space it so it sits below the hex shaft and doesn't interfere with the 22 tooth sprockets as they turn. Use the included 5" long 10-32 screws, 1.375" long aluminum spacers and 10-32 locknuts to space the top bar away from the side rails.



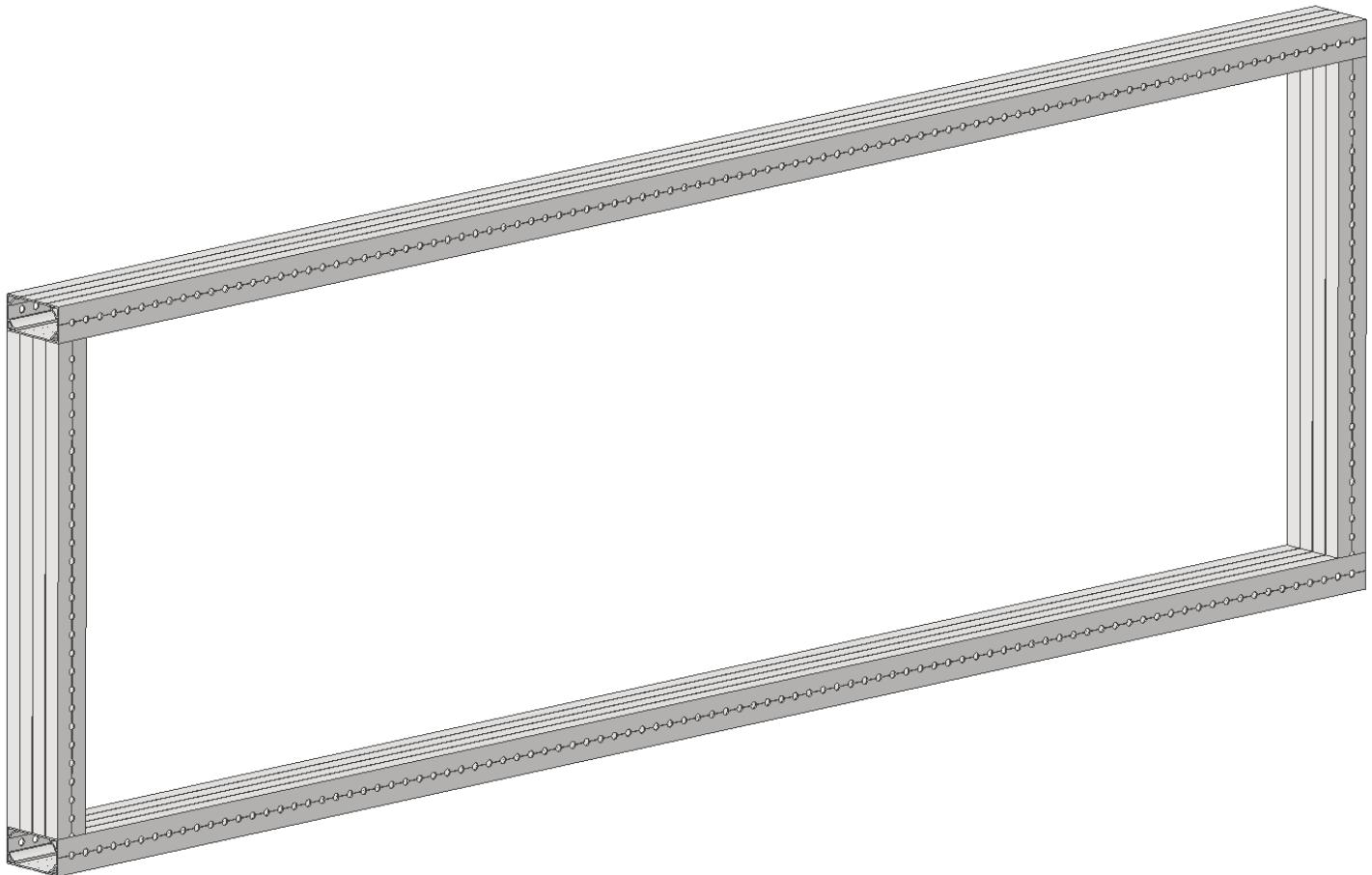
2nd Stage Assembly

The following steps will focus on the yellow highlighted items shown below. This will be referred to as the 2nd stage. In this case, the 2nd stage is fully enclosed for the carriage to move within it.



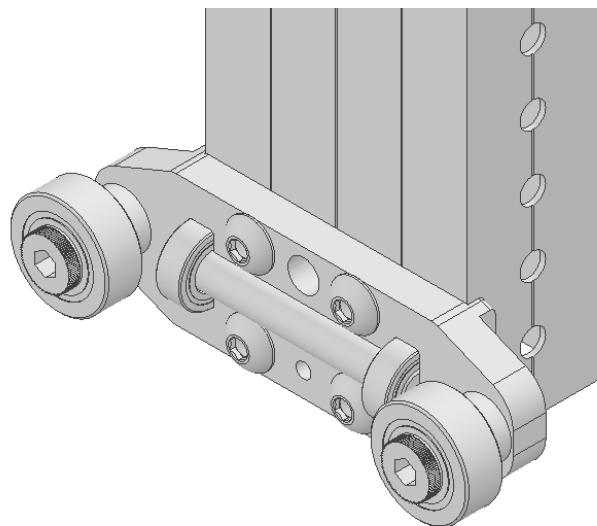
1. Cutting Frame Pieces

Similar to the previous stage, you'll want to measure out the frame stages and assemble them in a way that the longer end rails are accessible (open ends) so that the bearing blocks can be mounted or accessed as needed. In our example here, we left the side rails stock length (REV 47" long) and cut the horizontal spanners to 13.5" long, but make sure to size everything to fit your robot design.



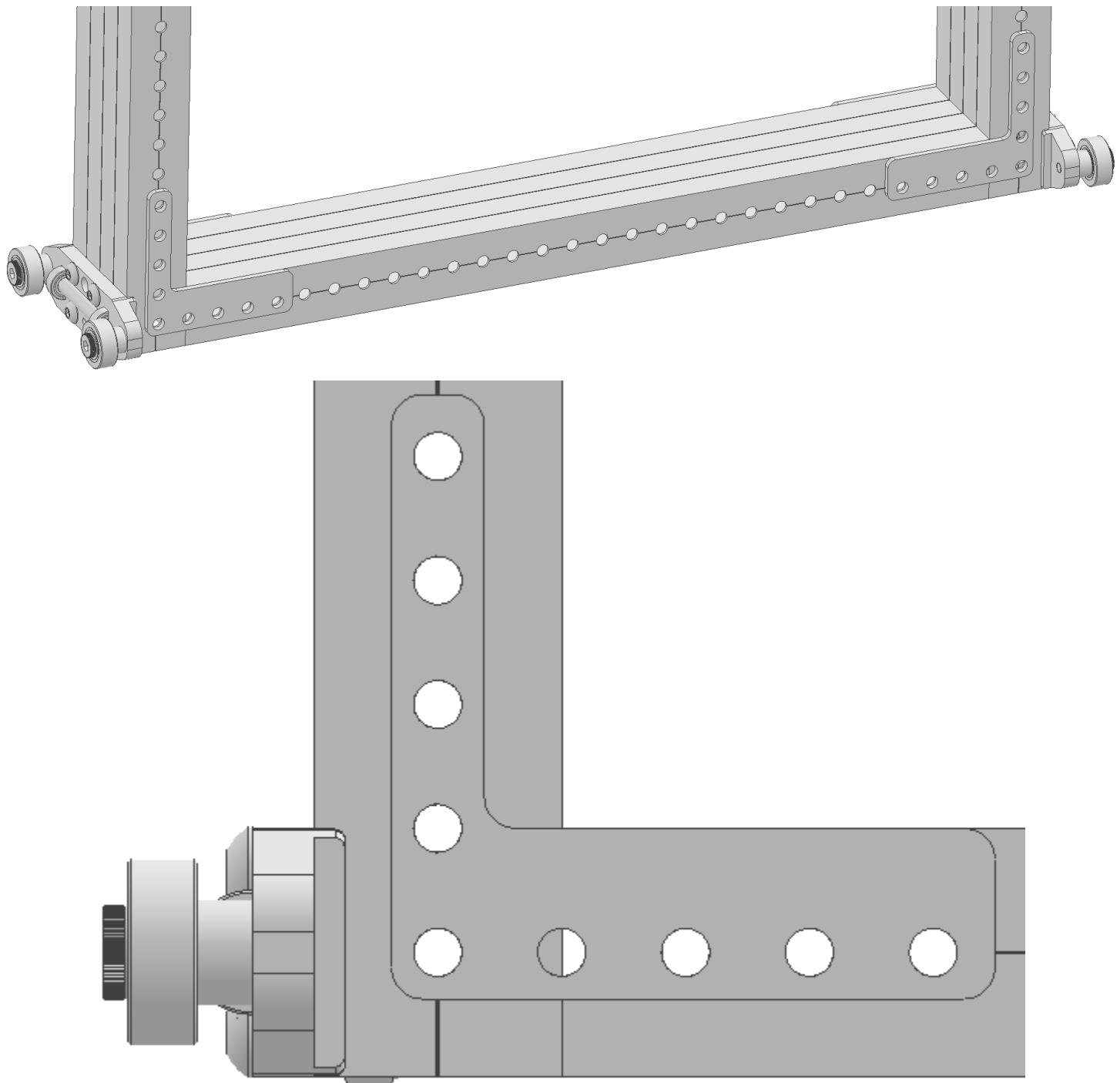
2. Mount the Sliding Bearing Blocks

Use the bearing blocks to transfer drill holes and mount the 2 lower sliding bearing blocks to the 2nd stage side rails.



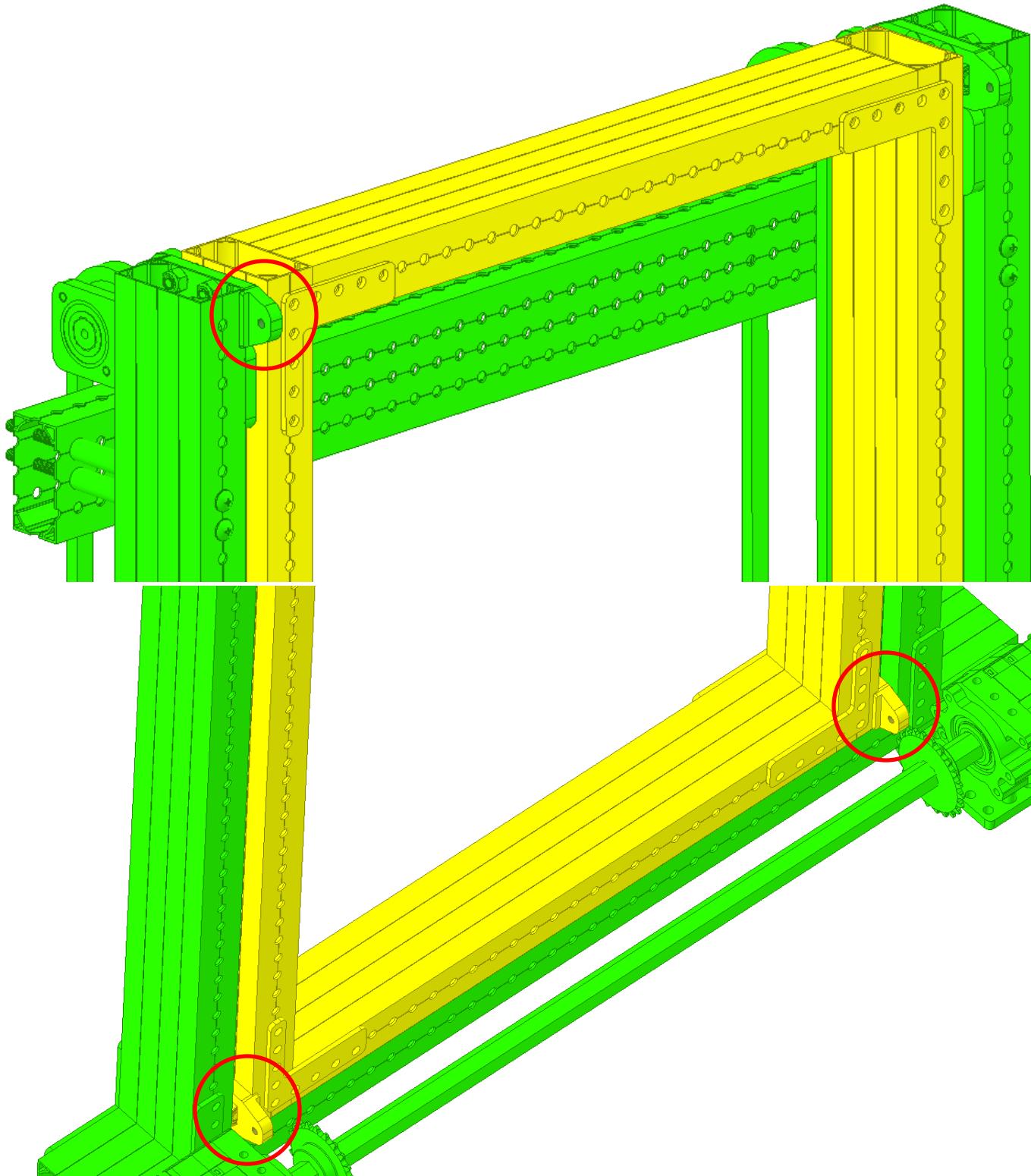
3. Frame Out 2nd Stage

Use elevator gussets to frame out the 2nd stage structure. These gussets are thinner for the parts that attach to the side rails in order to allow the elevator bearings to freely travel up and down the rails unimpeded. We recommend using 3/16 rivets throughout the structure.

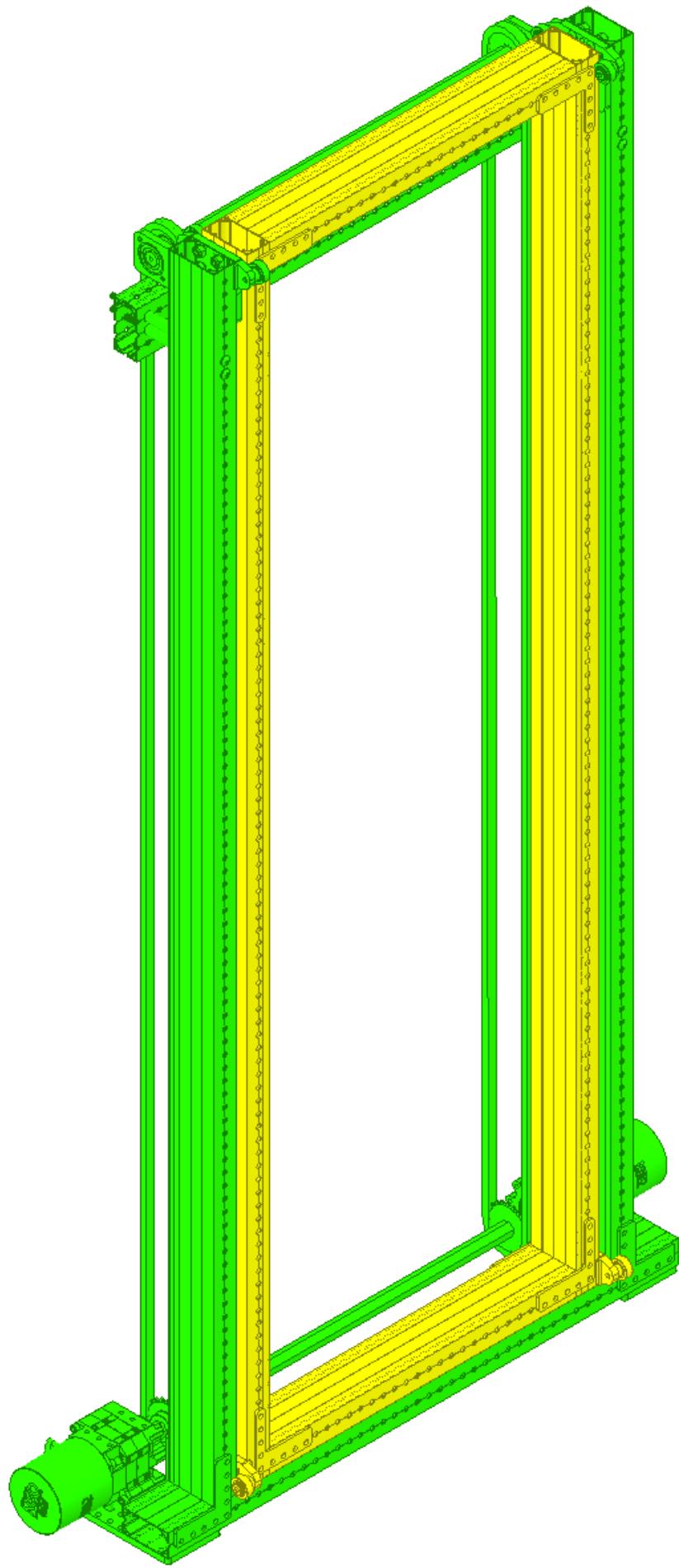


4. Insert 2nd Stage Frame into Base Stage

Now is a great time to put the 2nd stage frame into the base stage. To easily do this, remove the forward set of shoulder bolts from the top of the base stage and the rear set of shoulder bolts from the 2nd stage. The two stages should then go together with minimal effort. Re-install the shoulder bolts and the 2nd stage will be captured within the base stage. Try moving it up and down by hand to ensure it moves freely.



The 2nd stage should now be seated within the base stage as shown below –

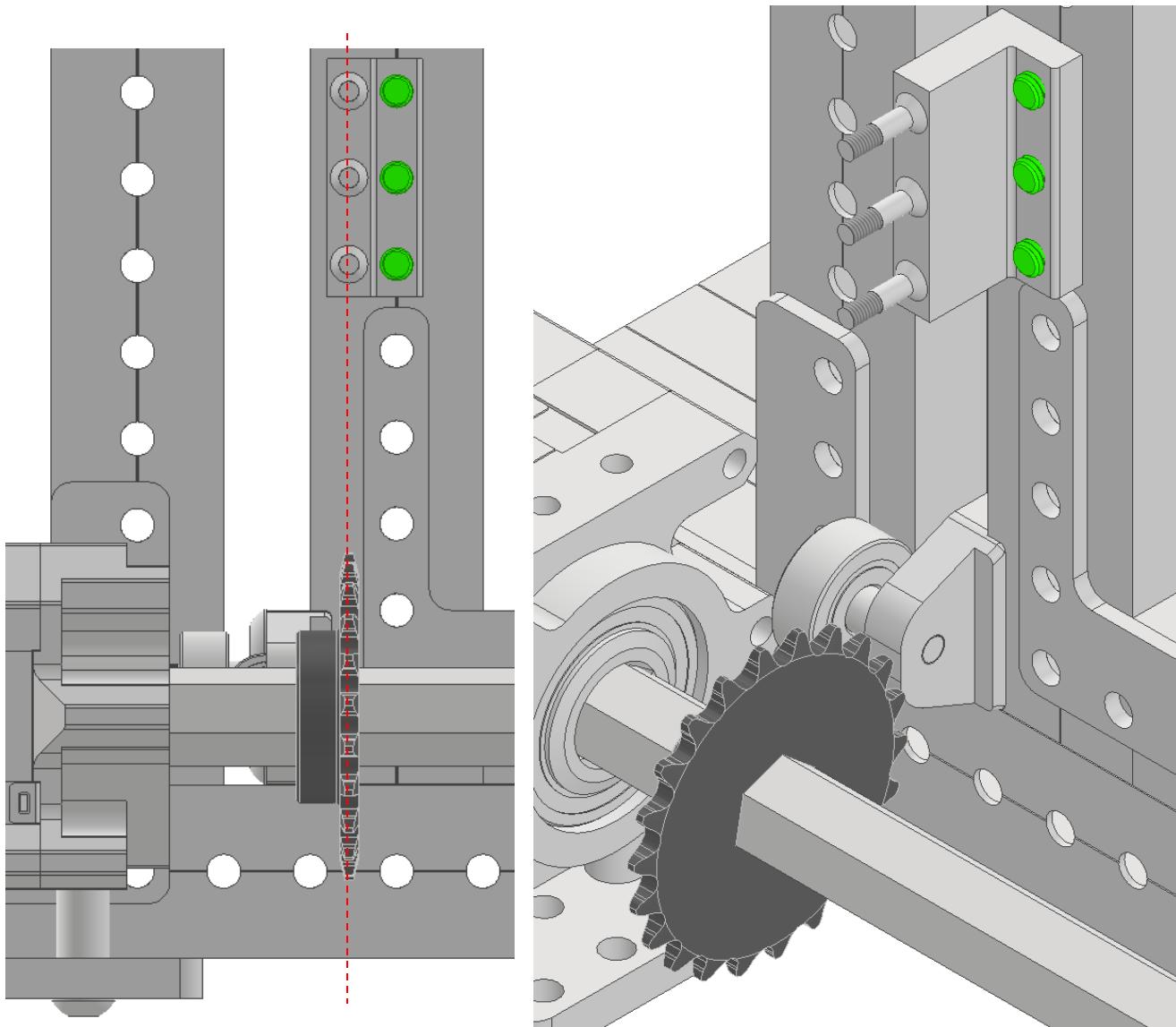


5. Attach #25 Chain Attachment Parts

This custom steel part will serve as an interface between the #25H chain links and the 1st stage of your elevator. It has 3 threaded studs perfectly spaced and sized to fit between #25H chain link openings.

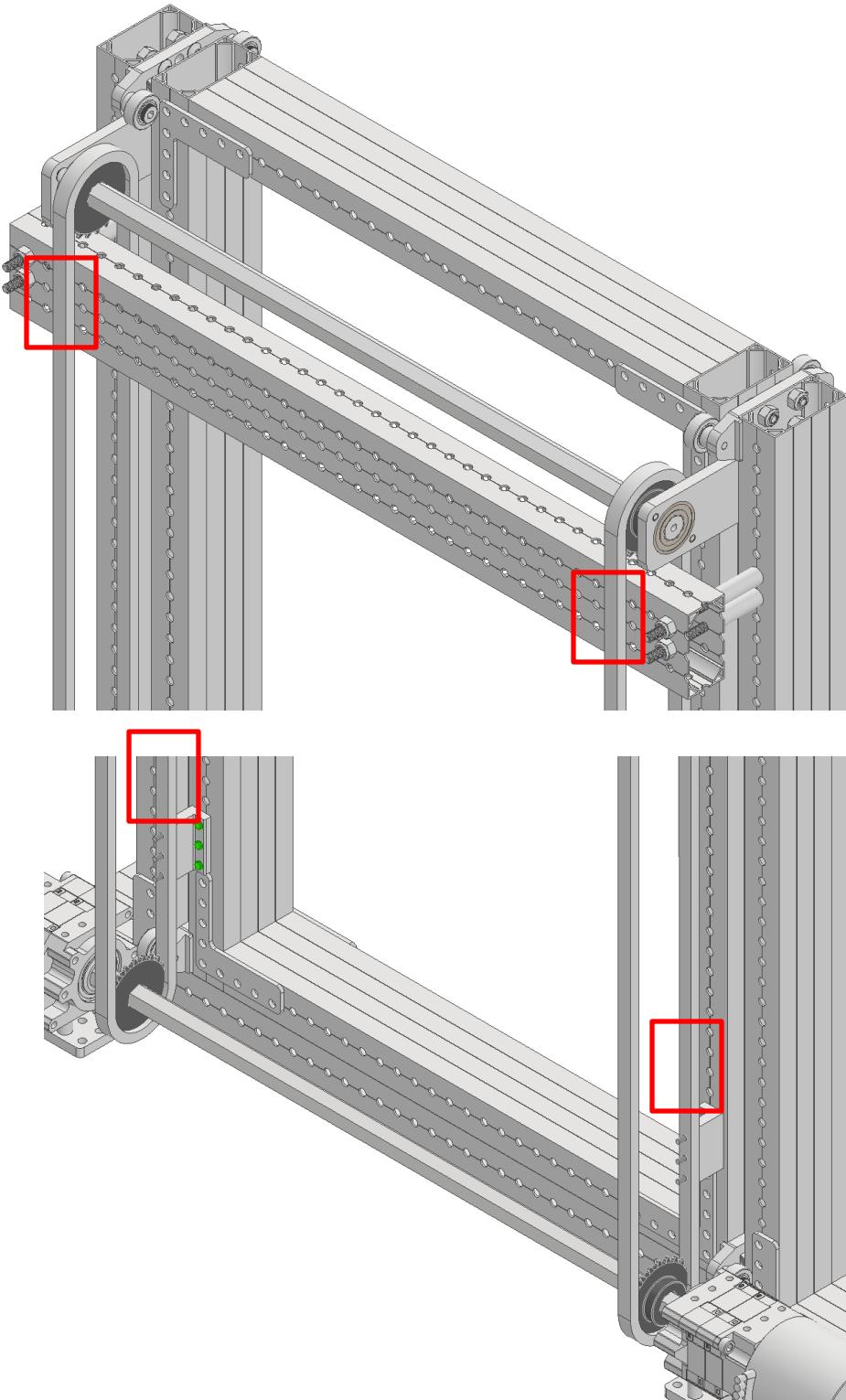


Use the included six 10-32 bolts that are 2.25 inches long to secure the chain attachment parts. The base of the block includes threaded 10-32 holes. Use blue threadlocker to ensure the block does not loosen over time. Align the stud posts with the #25 sprockets on your top and bottom hex shafts.



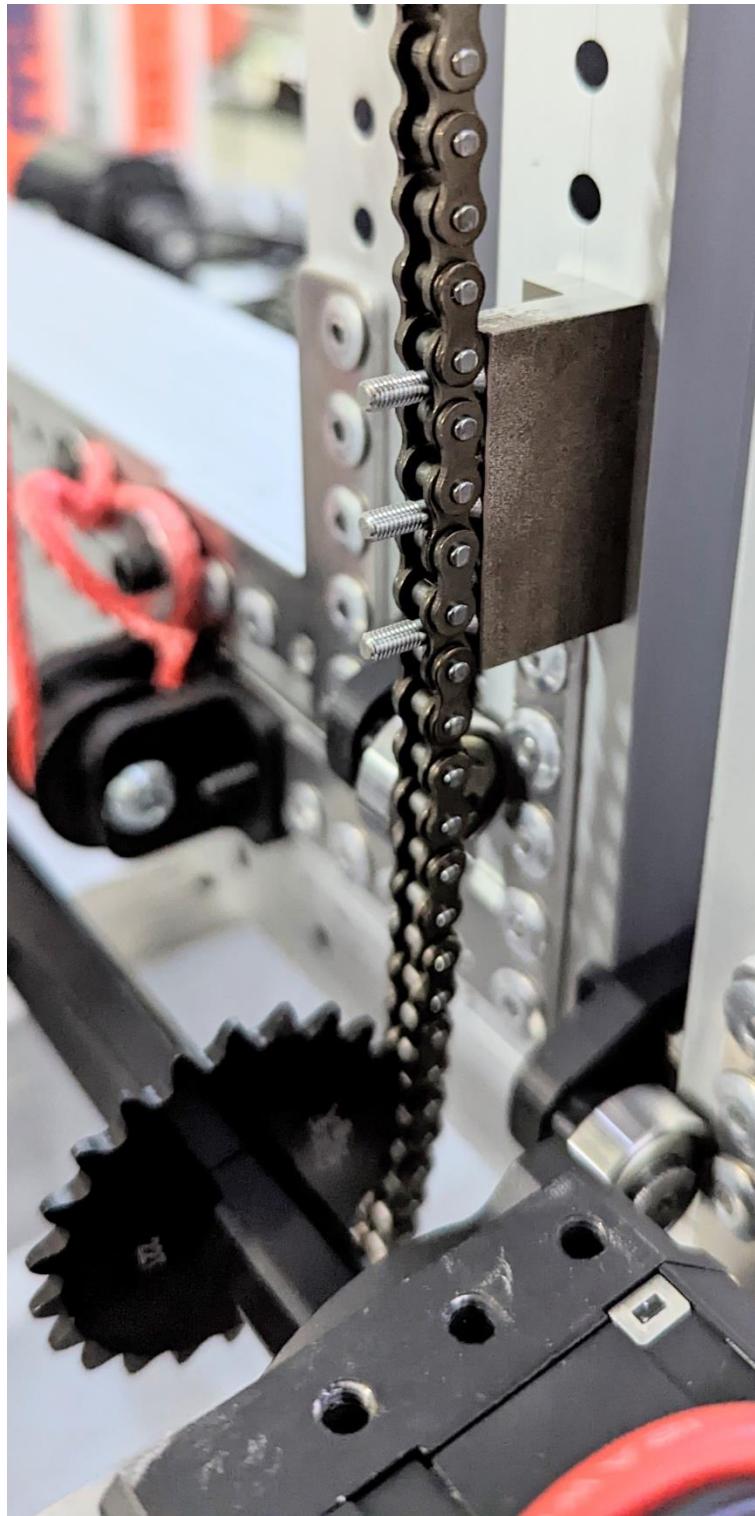
Chain Attachment

Included are two 10 ft lengths of #25H chain. You will need a chain break tool if you intend to use the included chain tensioner that integrates with the #25H chain links. We like the [VEX #25 Chain tool](#) and have used it successfully for the following steps. Another item to consider is the location of your chain tensioner. The elevator will need to run and not have the tensioner interfere with chain's motion on the hex sprockets. Two locations we have found to work are shown below -

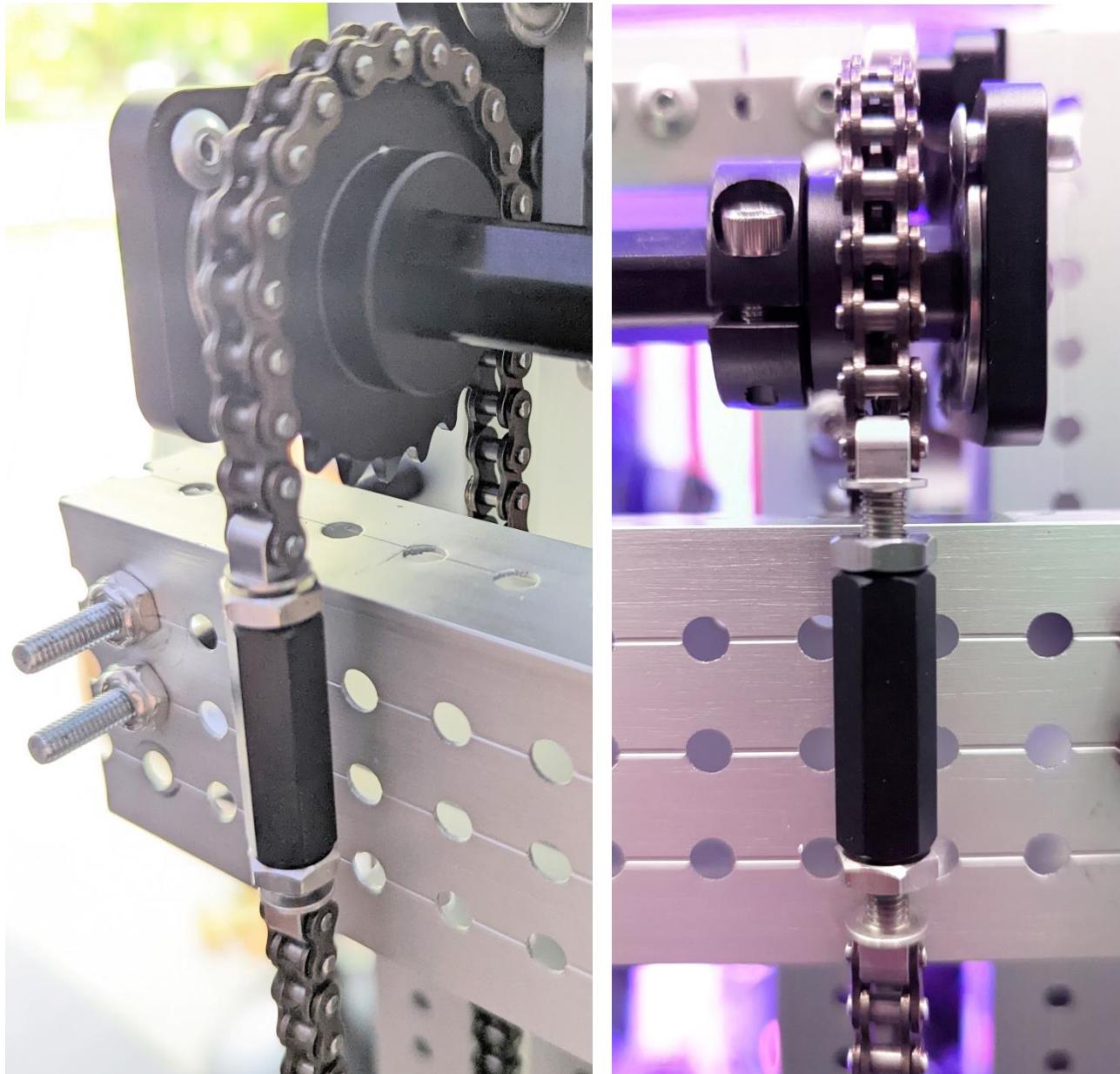


1. Determine the Correct Length of Chain

The stock length of chain will likely be too long and you'll need to remove some of the extra length. Wrap the chain around the top and bottom sprockets and slide it onto the chain attachment posts. Ensure the chain is straight up and down thru the entire length and that everything is aligned properly. Use a long straight edge if needed to see if the chain is skewed to the left or the right.



You'll need to remove enough chain so there's space for the chain tensioner to come in later as well. This turnbuckle style tensioner pulls the 2 sections of chain together and allows you to adjust it within about 1 inch worth of travel. If you remove too much chain, you won't be able to connect the two ends of the tensioner, but if you don't remove enough the chain won't be tight enough.



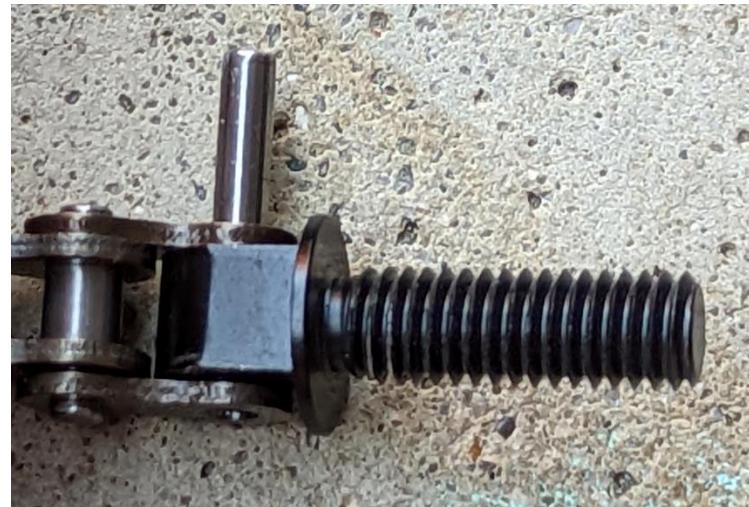
Note that one side of the chain tensioner is left hand threaded and one side is right hand threaded. This will allow the two sides to pull together by twisting the coupler. The two included nuts should be tightened to the coupler when the desired tensioned is reached.

2. Install chain tensioners

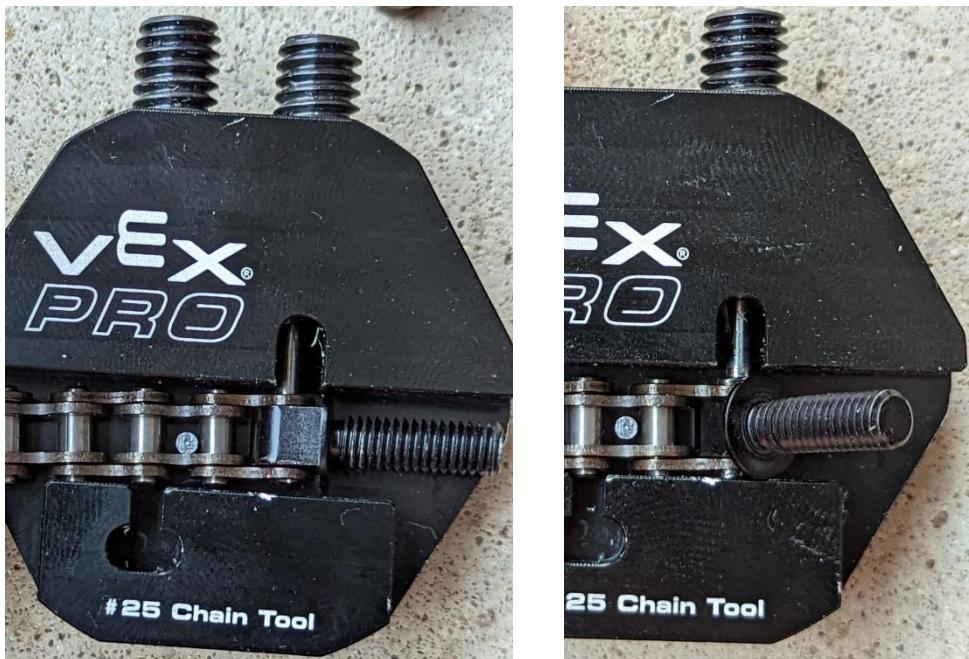
Press the pin out of the chain ends so there are open links.



Insert the two link attachment screws between the open links -

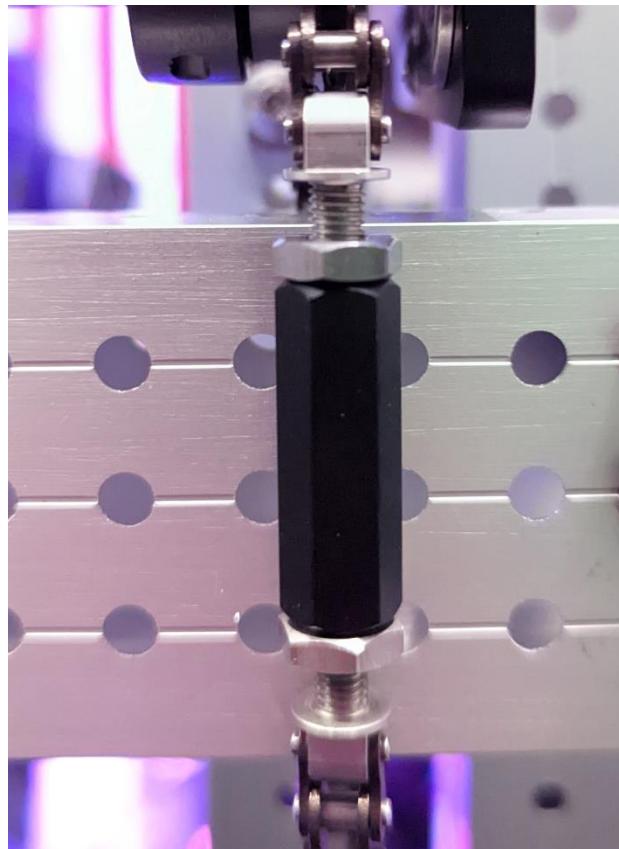


Use the right press tool to push the pin back thru the attachment screw. Ensure that it fully goes thru both links. You may need to swap the tool & use the left pin press to fully seat it.

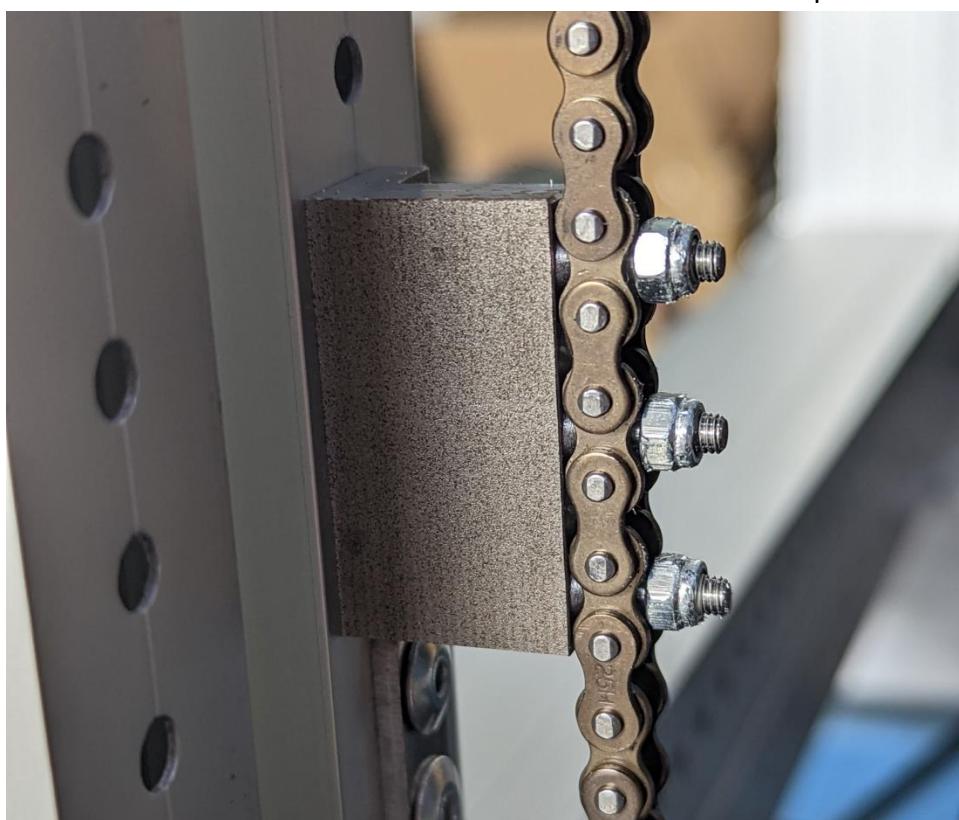


3. Attach the Coupler Ends and Secure Chain to Chain Attachment Part

Twist the coupler to have both ends of the chain attachment links start to screw into the coupler. Ensure both nuts are on the chain attachment links, that the chain is seated on both sprockets and that the chain is still on the threaded chain attachment posts. When the chain is tight, tighten the nuts down to the coupler.



Use an M5.5 driver to secure the M3 locknuts on the chain attachment part for both sides.

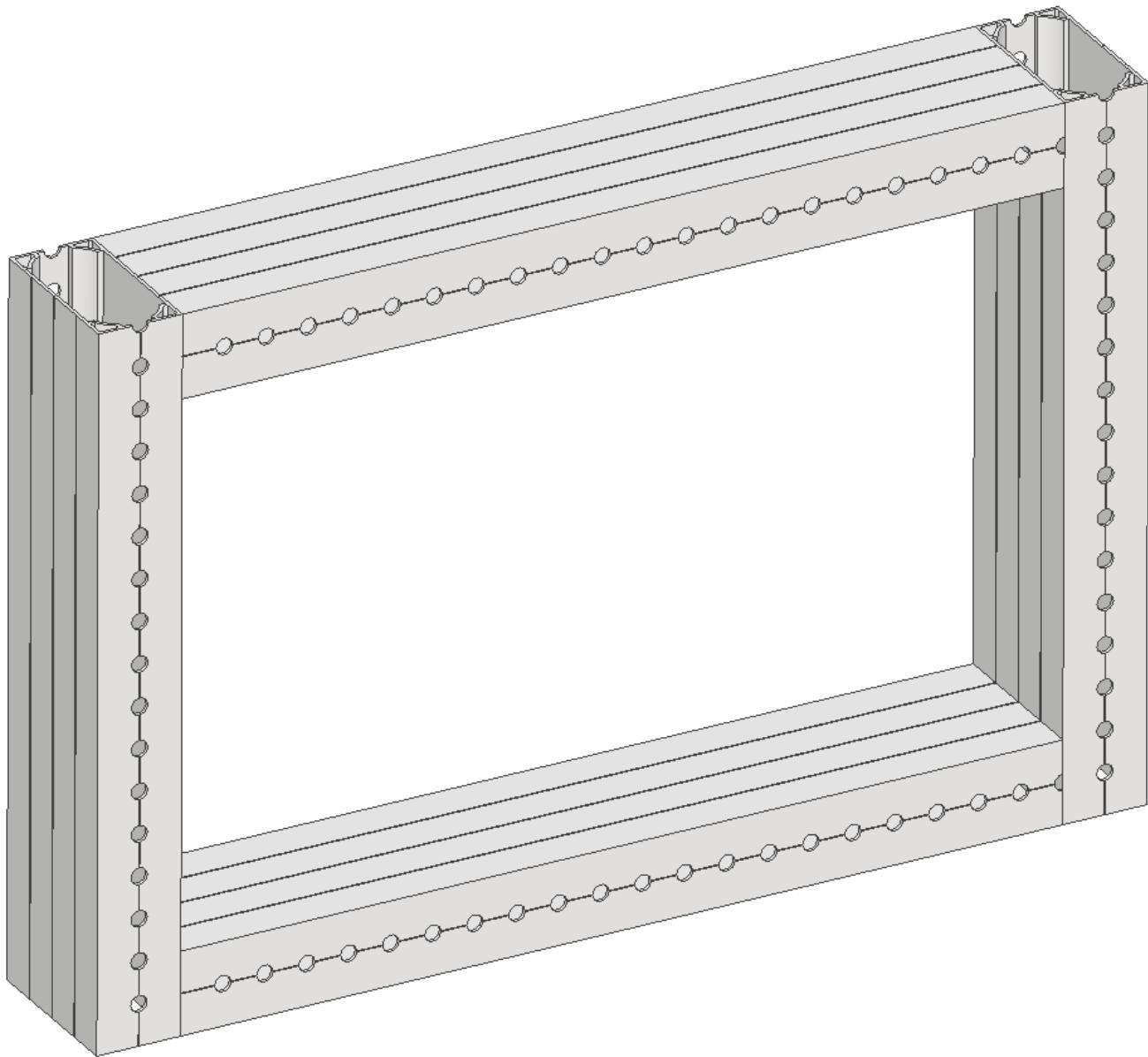


Carriage Stage Assembly

The carriage stage can be sized specifically to fit your application. We cut our 4 structural pieces as shown below. Similar to the previous stages, the bearing blocks will be mounted flush to the top and bottom for maximum support against the rails during travel.

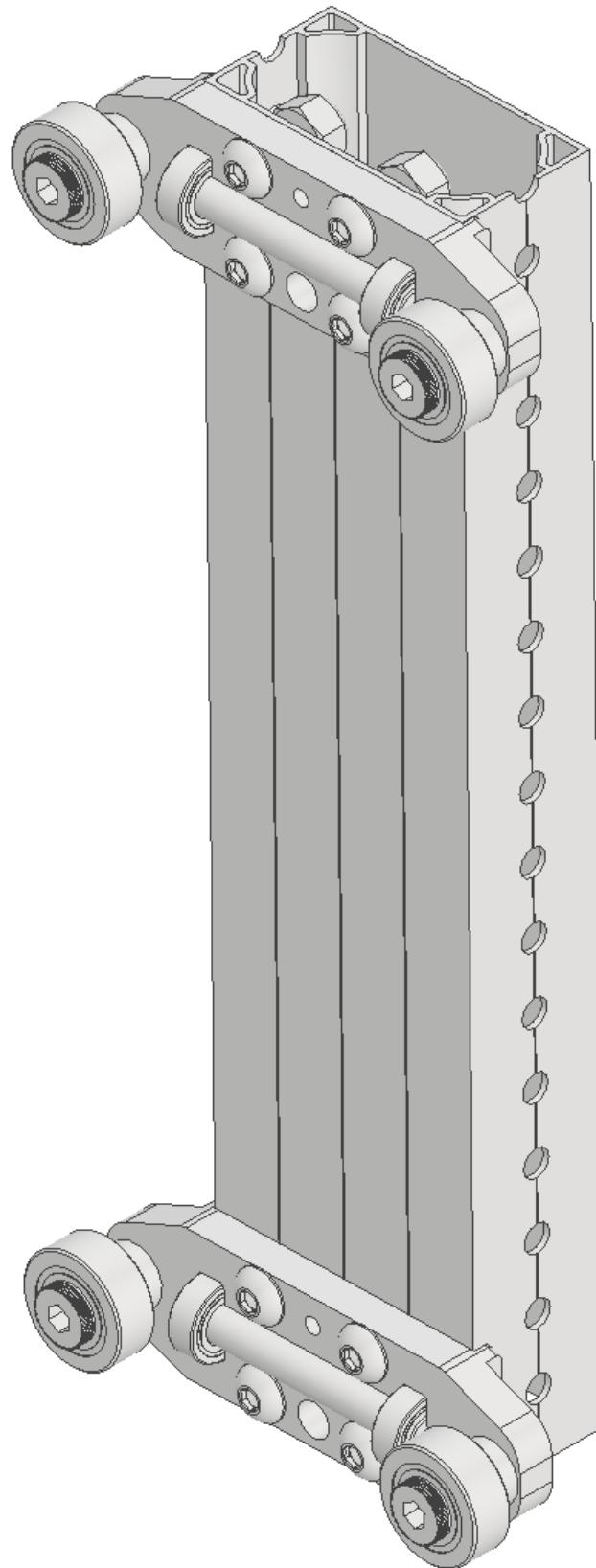
1. Cut carriage structure pieces

Ensure the carriage will fit between the 1st stage. Remember that the bearing blocks create half an inch of spacing with the bearings themselves between each stage on each side. Size your pieces accordingly.



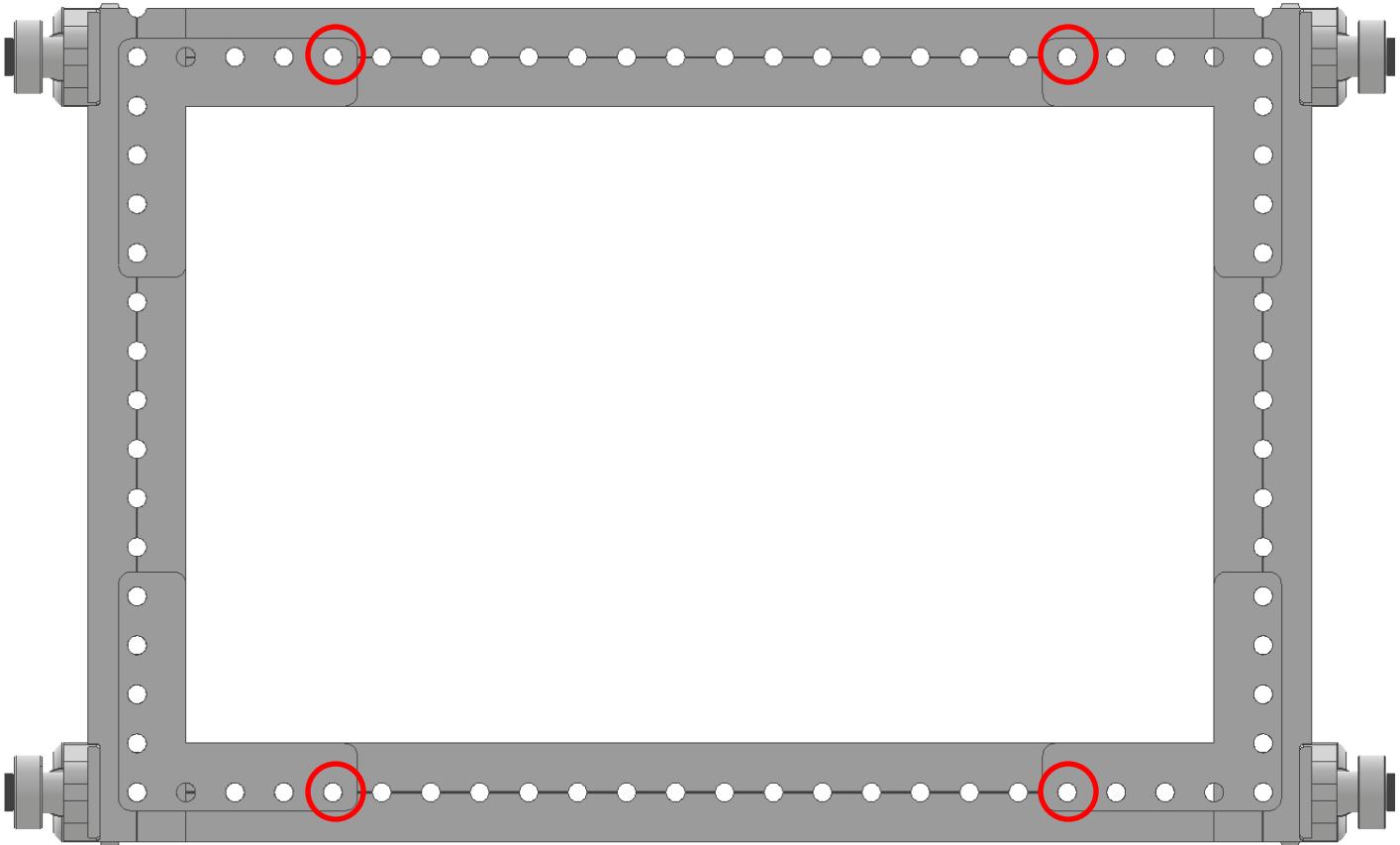
2. Transfer Drill and Mount Bearing Blocks

Similar to previous steps, use the bearing blocks to transfer drill your holes and mount them to the top and bottom of both side frame pieces.



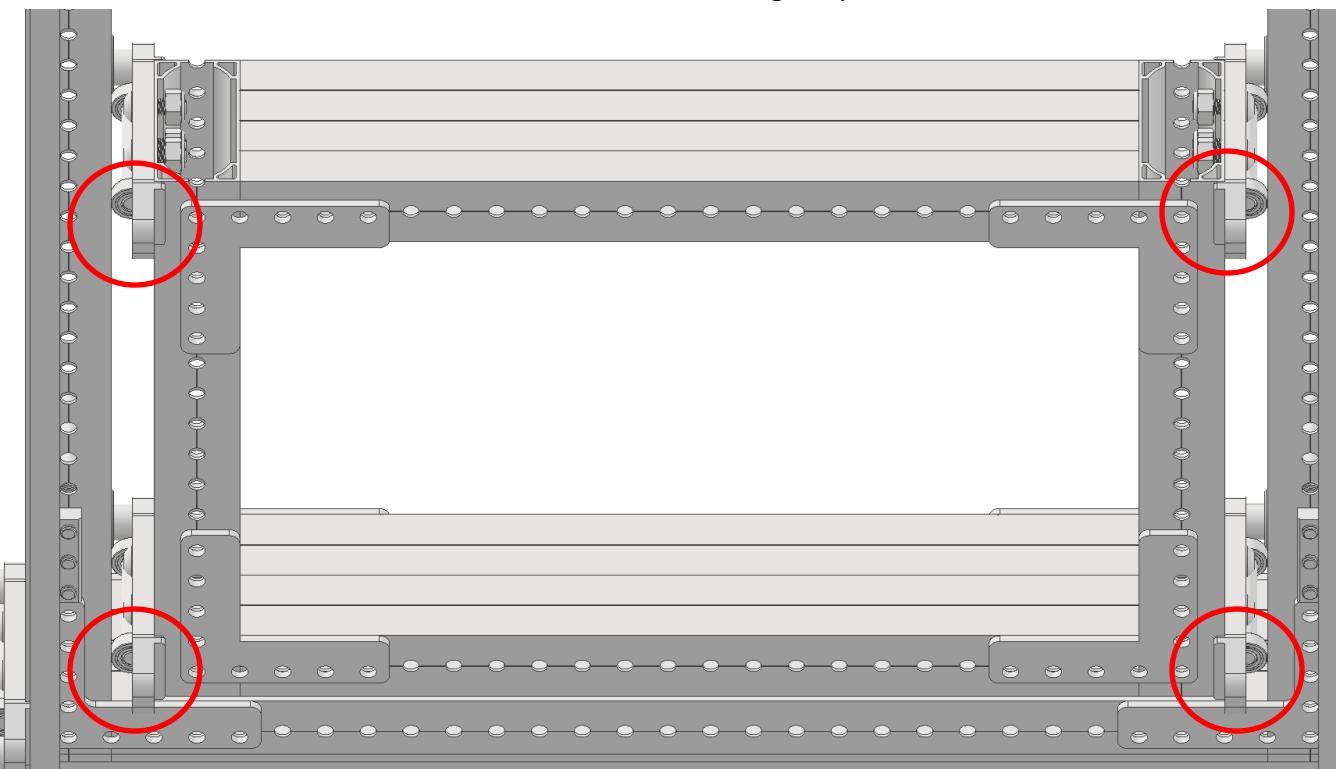
3. Frame Carriage Out with Gussets

Use the 8 regular elevator gussets to frame out your carriage. Leave this hole open later for cable tensioning purposes.



4. Insert Carriage into 1st Stage

Similar to the previous step where you inserted the 1st stage into the base stage, remove the outside shoulder bolts on one face and slip the carriage into the 1st stage. Reinstall the shoulder bolts to secure the carriage in place.



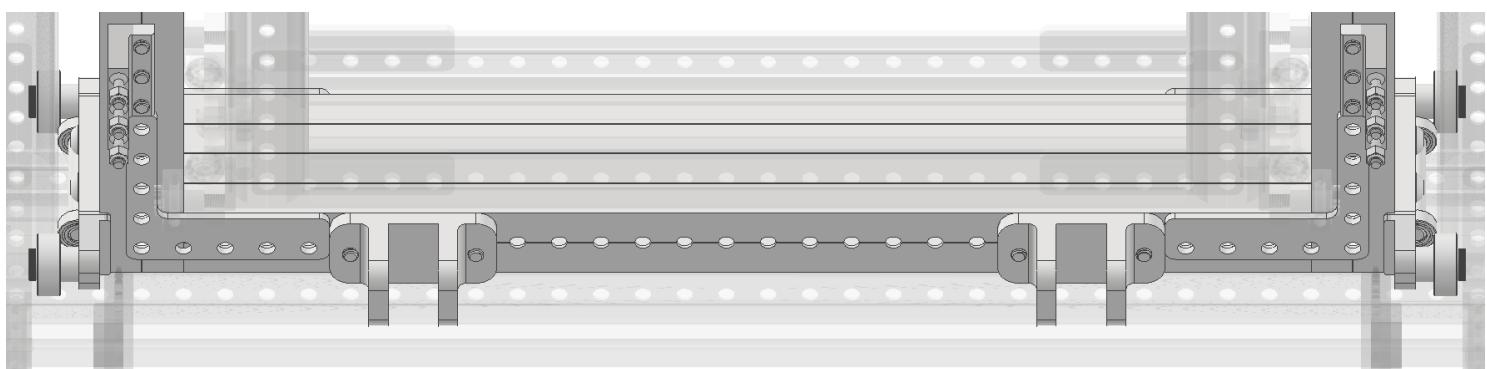
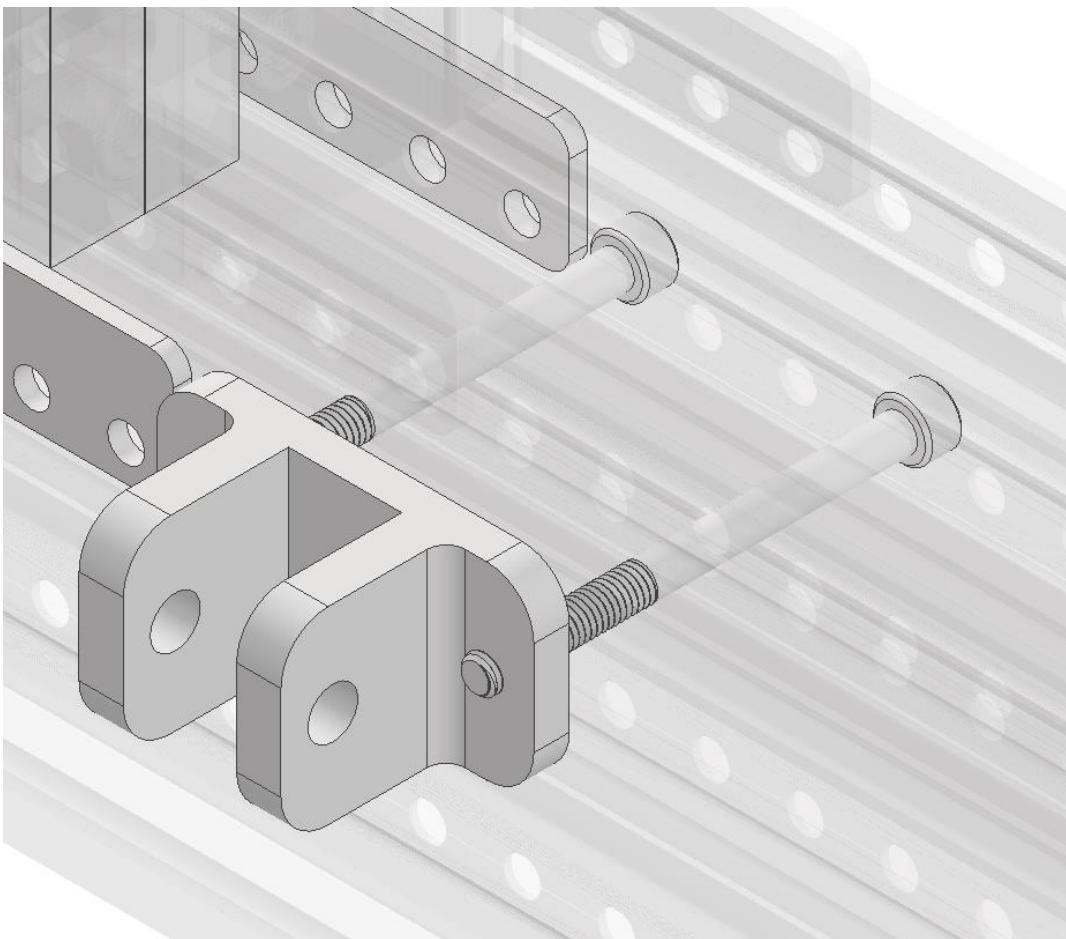
Pulley Installation and Cable Rigging

1. Install Pulley Brackets and Pulleys

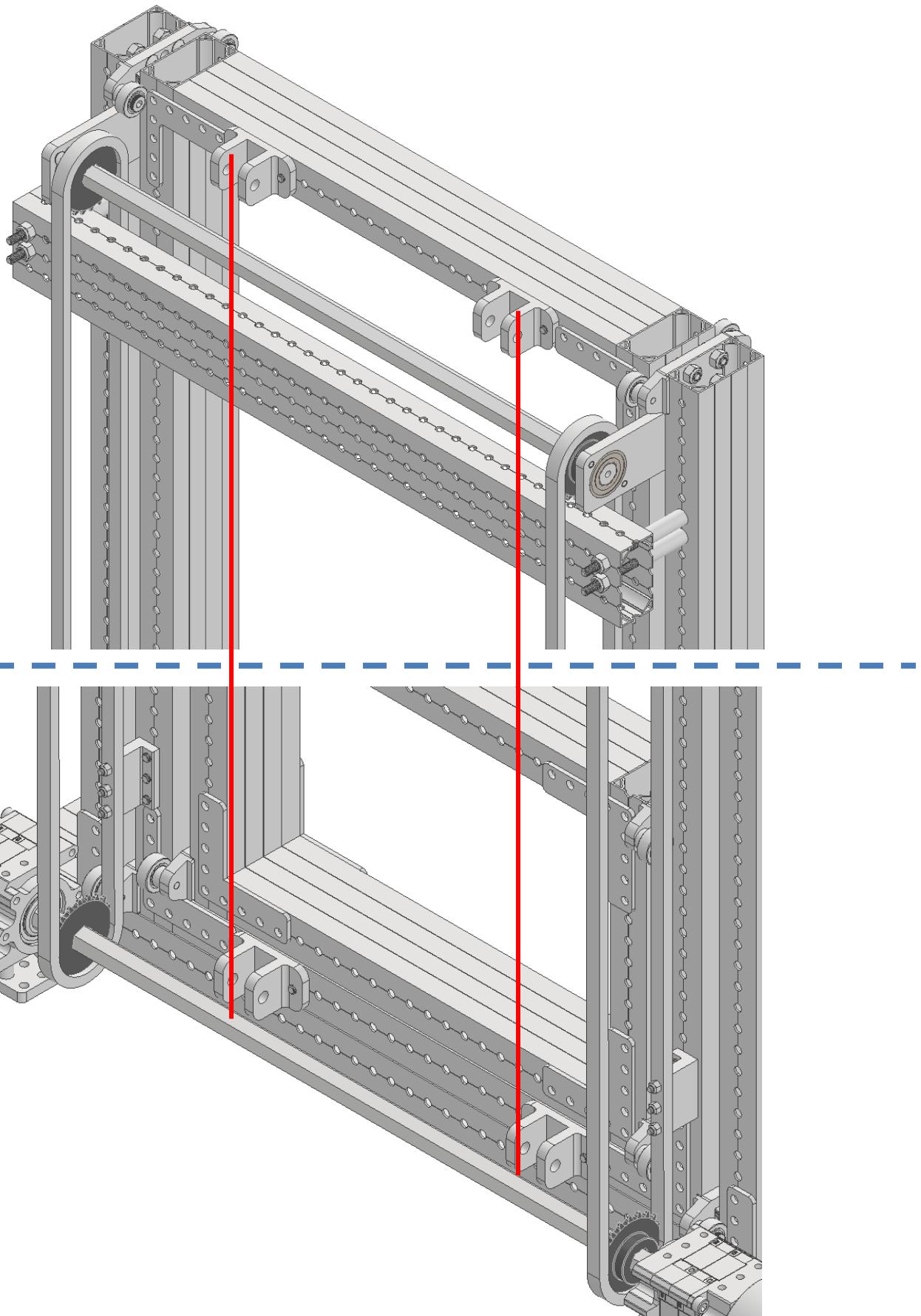
You have the option to run just 1 pulley and one length of Dyneema cable, but we will show how to run 2 pulleys and 2 cables in our setup.

Use the included 2.25" long 10-32 bolts and install them through the 1st stage frame and into the pulley brackets. The brackets have threaded 10-32 holes so no additional hardware is needed. Use blue threadlocker to ensure the bolts do not back out.

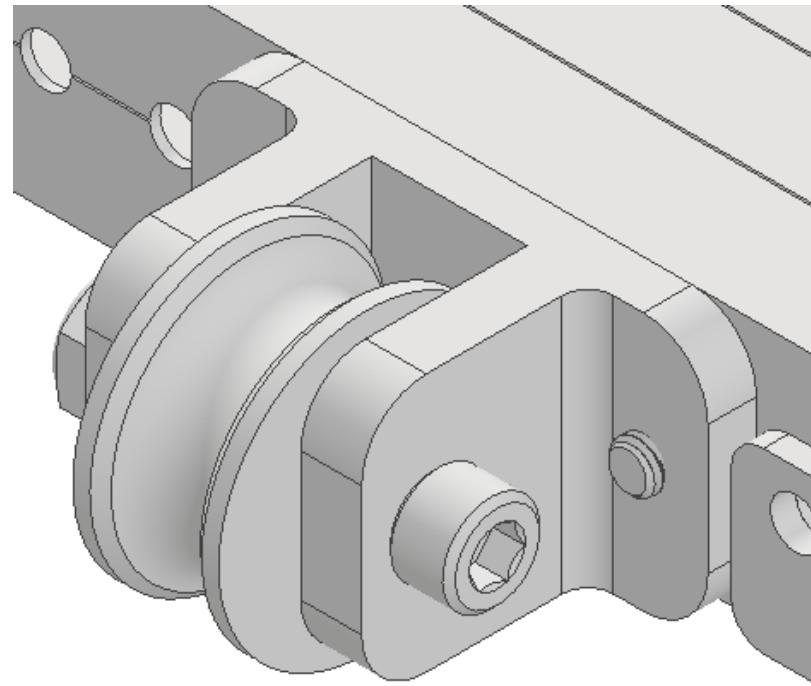
Mount these on the top and bottom of the stages so that they are aligned with one another.



Ensure the brackets are aligned so that the dyneema cable will later be straight -



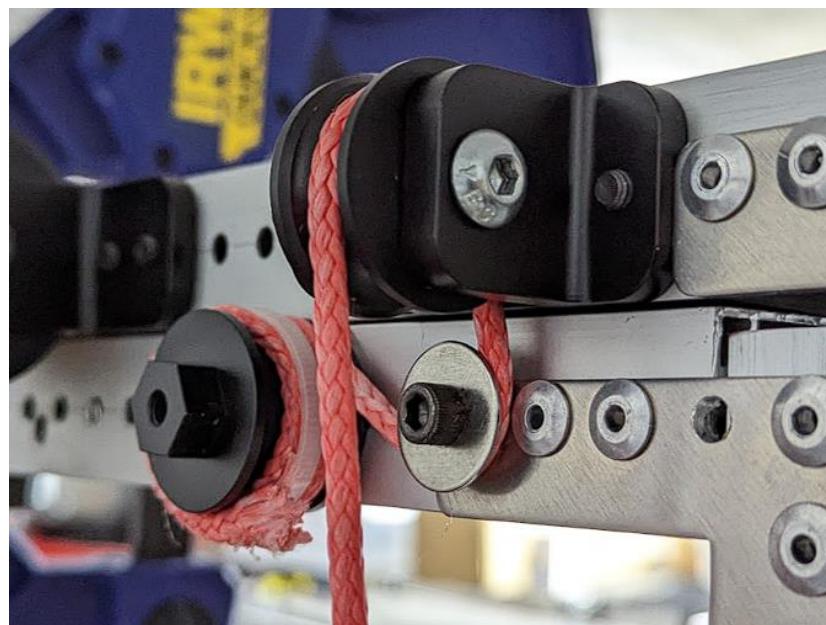
Insert the 1.25" long $\frac{1}{4}$ -20 screw through the pulley and secure it with the included $\frac{1}{4}$ -20 thin nylon lock nut. The pulley should spin freely after being installed. Do this for all pulleys in your design.



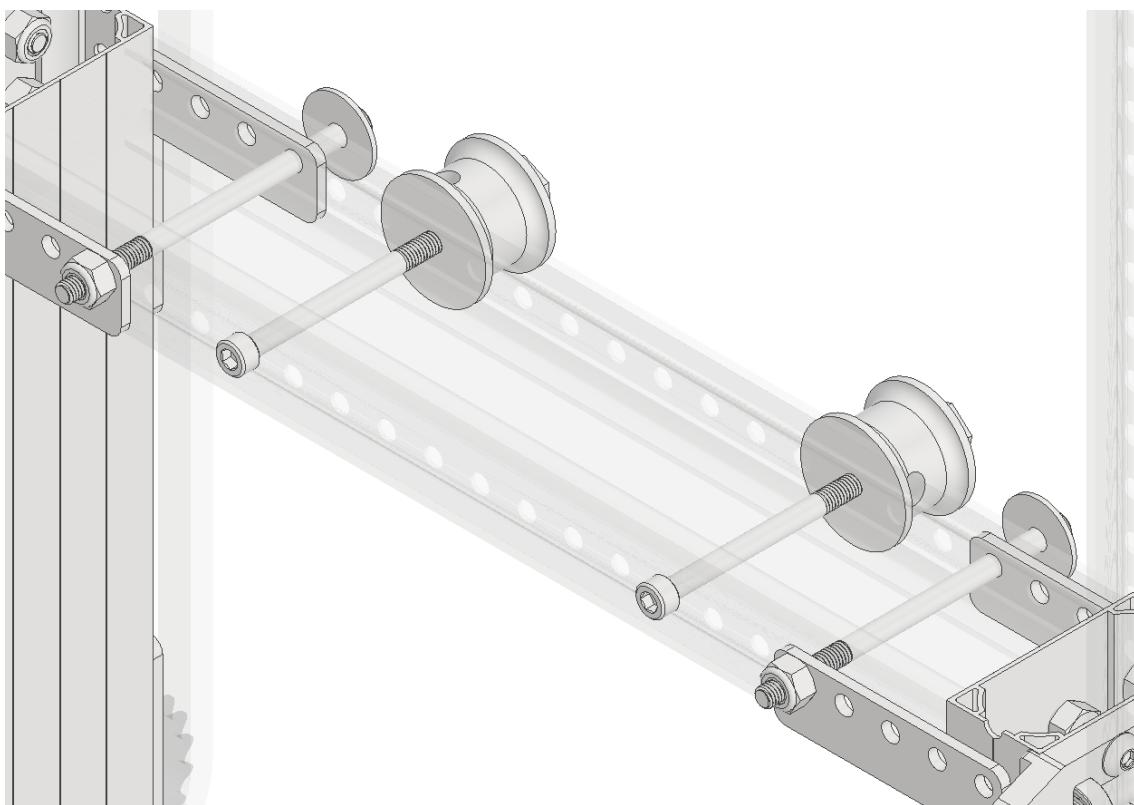
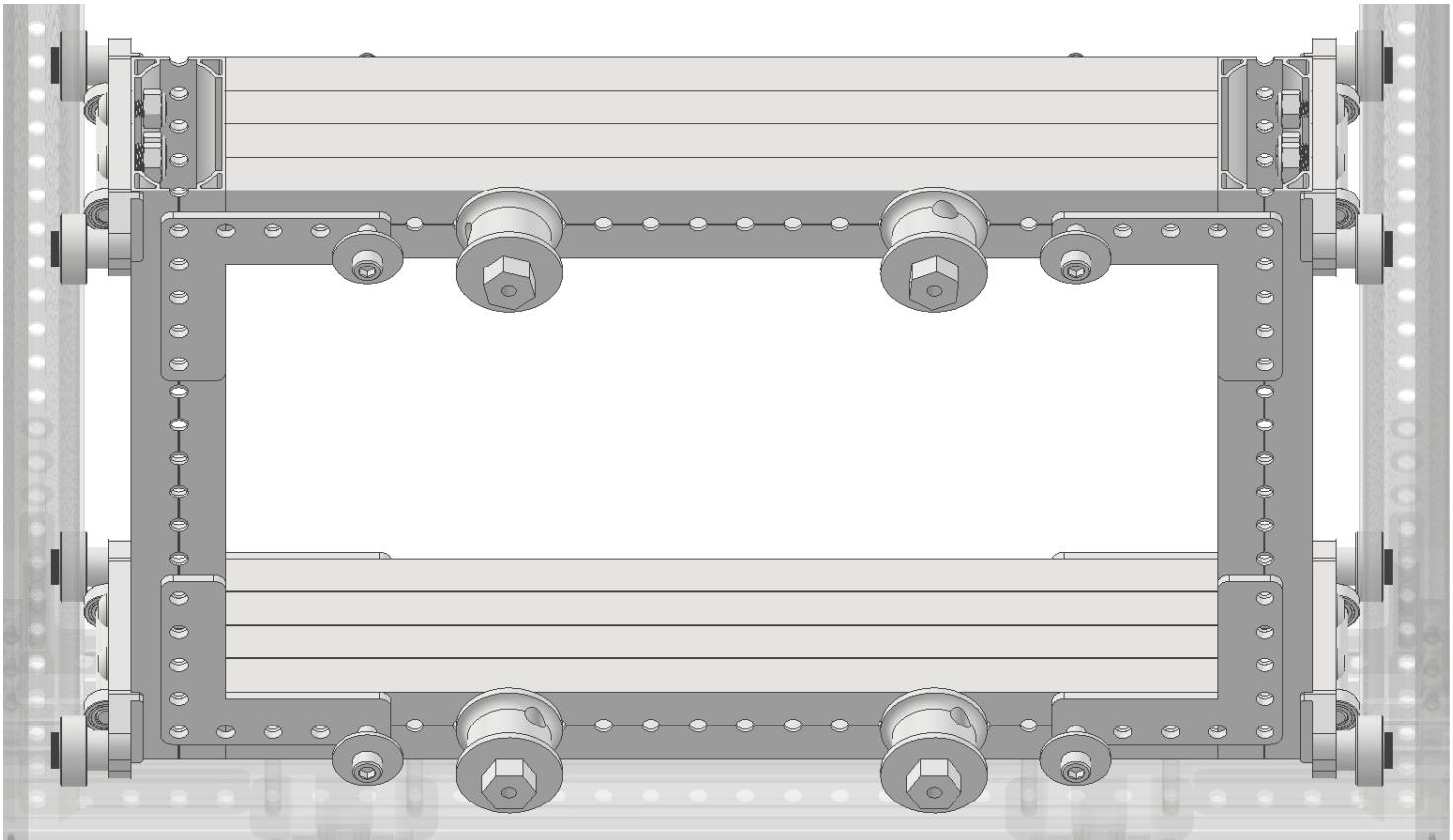
2. Install the Cable Tensioner CAM Pulleys and Directing Bolts

The cable tension CAM pulleys are designed to have the dyneema cable inserted through it. They are threaded for a 10-32 bolt and have a $\frac{1}{2}$ " hex shaft for a wrench to easily tension cables.

The method for tensioning cable is to wrap 1 loop of cable around the #10 bolt with the washer and then send it through the hole in the CAM pulley. We recommend stringing some excess cable through the CAM just to make retention easier.

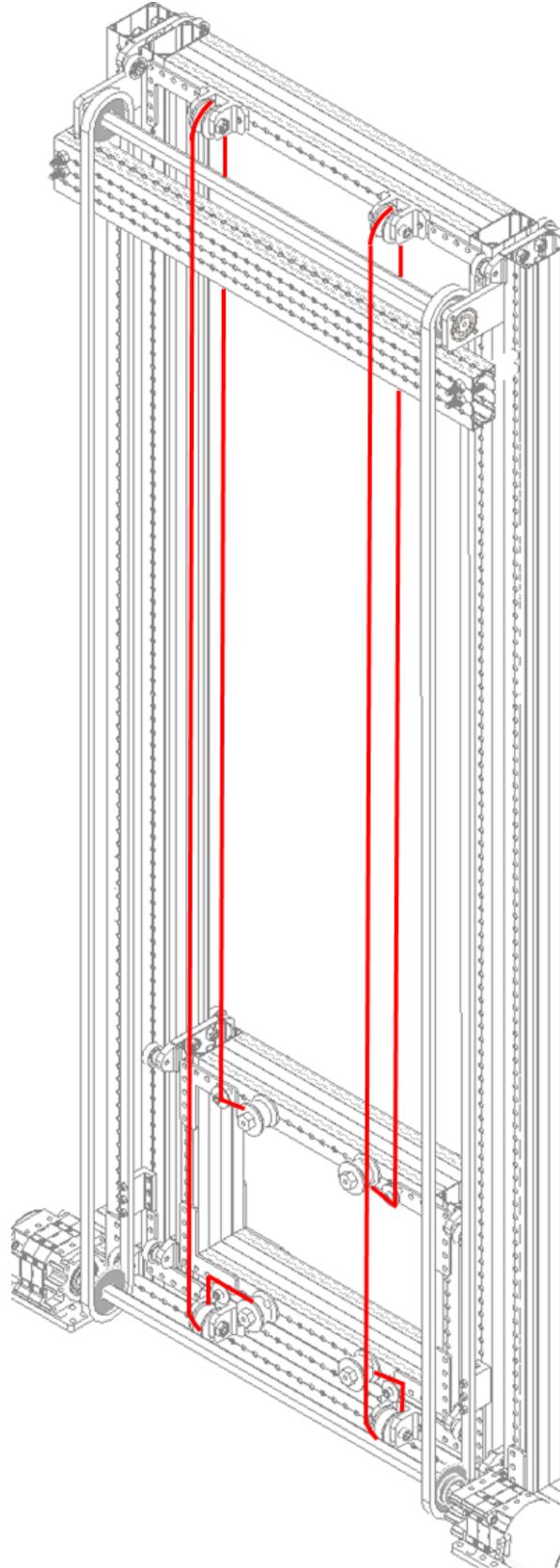


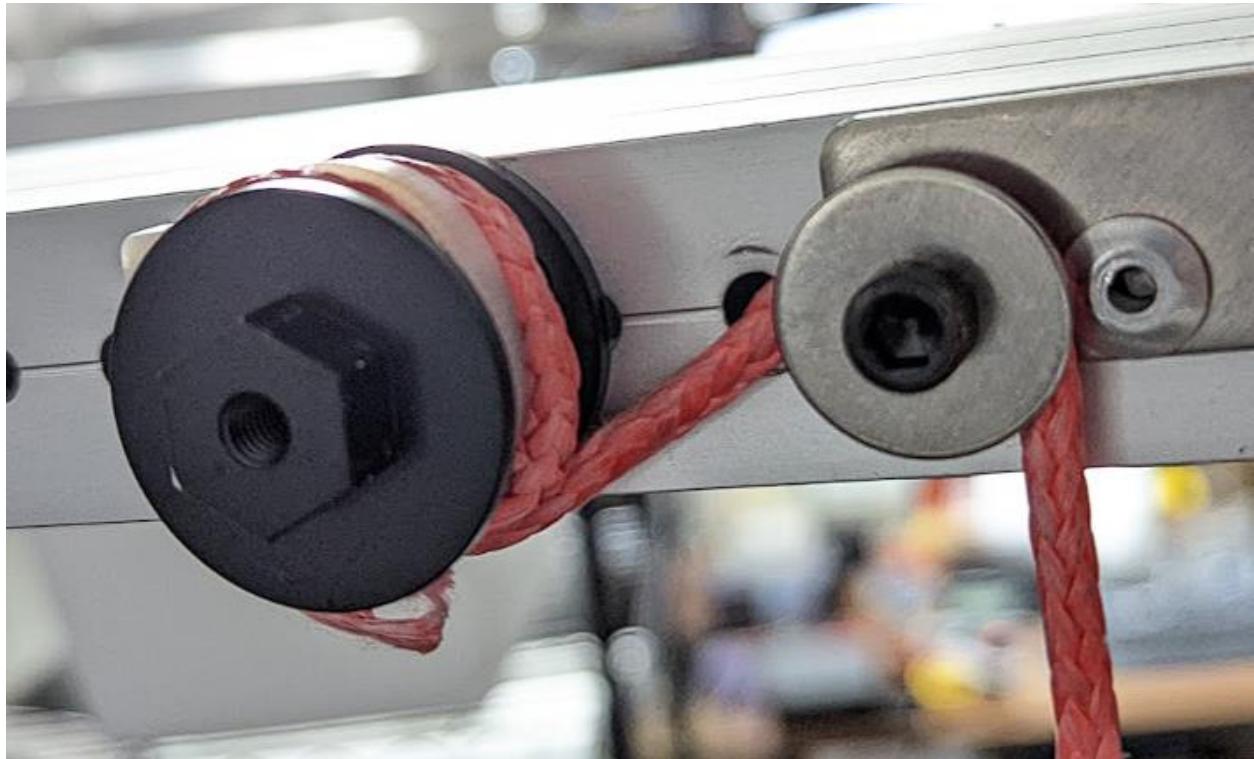
Install the tensioning pulleys and directing bolts where it makes sense in your design on the carriage. We installed them as shown below. Use the 3 inch long 10-32 bolt and add a washer on it on the pulley side. Secure it with a 10-32 locknut, but don't clamp it all the way down yet. Insert the 2.5" long 10-32 bolt into the pulley CAM from the opposite side, not fully tightening it yet either.



3. Running the Dyneema Cable

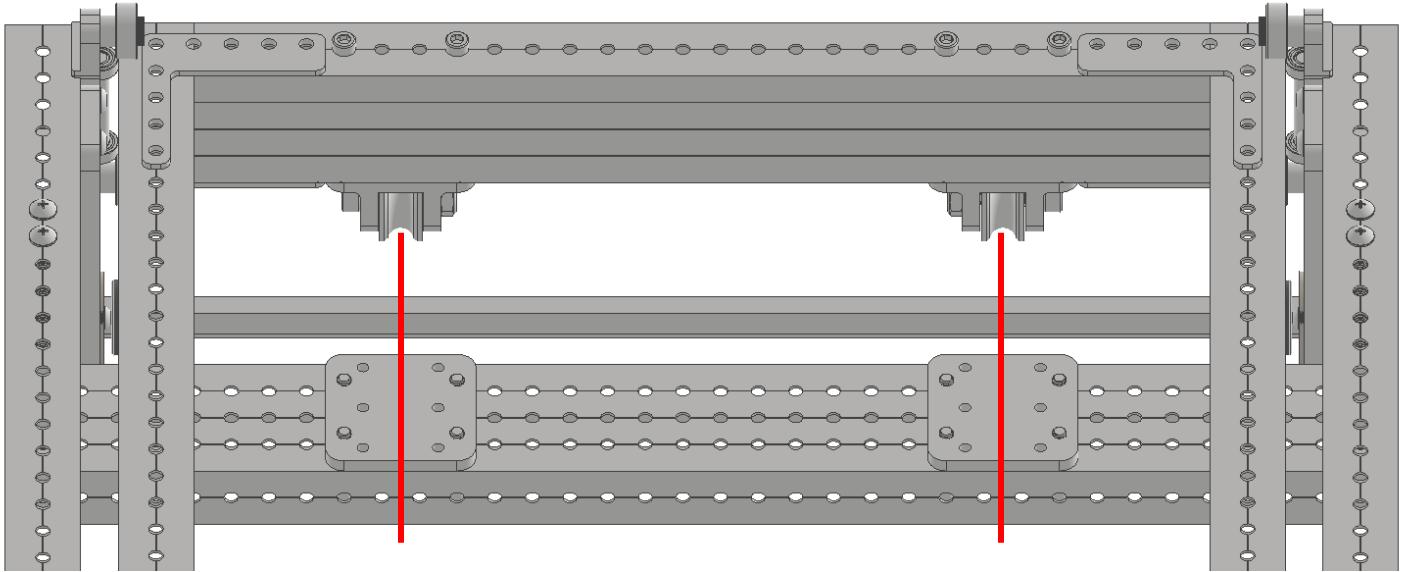
See the image below. The cable needs to run thru both pulleys and feed into the cable tension pulleys after wrapping once around the 10-32 directing bolt. Tighten the tensioning CAM bolt and then use a $\frac{1}{2}$ " wrench to start tensioning your dyneema cable. Once you get to the point of the carriage starting to raise from the cable tension you are tight enough. Fully secure all #10 bolts and use a zip tie to secure the excess cable on the tensioning pulley.





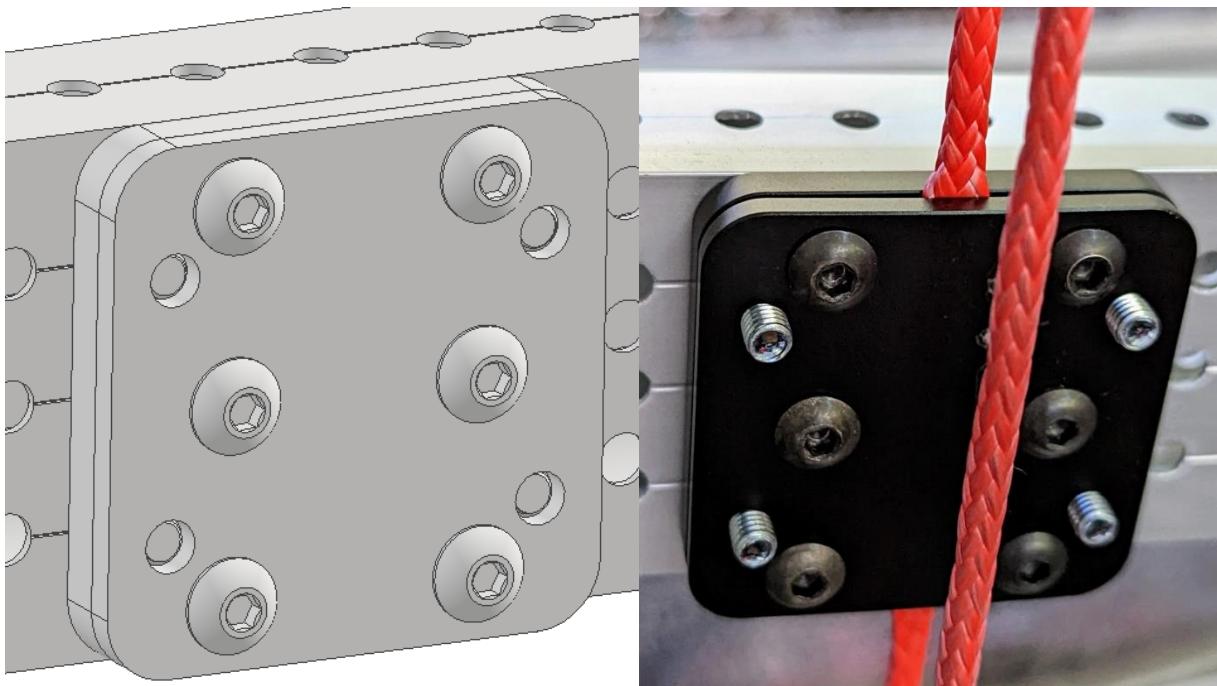
4. Install Top Cable Clamp Plates

Use the top cross bar to install the 10-32 threaded clamp base plate. Align them so that the cable running out of the pulley passes thru the center of the plate. Mount them with the 4 included 1.25" 10-32 bolts.



5. Clamp the Cables

Secure the cable runs by clamping them with the top clamp plate and included six 3/8" long 10-32 bolts. Before fully clamping the securing plate, now is a good time to check the cable tension and adjust it. When the cables are tensioned, fully clamp the plate.



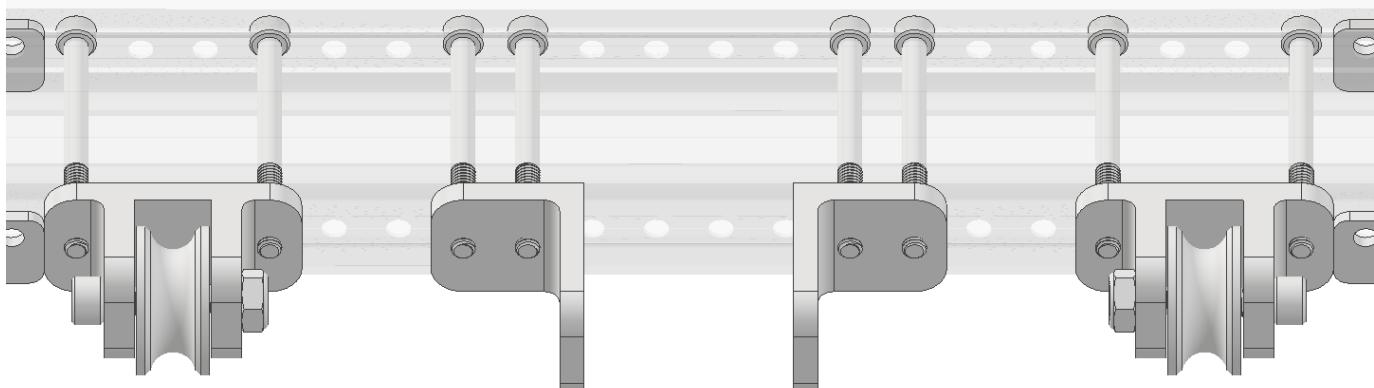
Constant Force Spring Kit Assembly and Installation

The constant force spring kit is designed to work with springs as large as nearly 2" in diameter and 50" in extension length. The included spring provides 16.5 pounds of load to counterbalance the weight of the carriage and anything within the carriage. This will allow your motors to do less work and allow you to use a faster gear ratio for quicker travel. The included spring has a hole for a #10 bolt to attach to your carriage structure.

**Warning: Be aware that constant force springs have sharp edges.
Use gloves while handling them and do not stretch them out by hand as they can snap back without warning.**

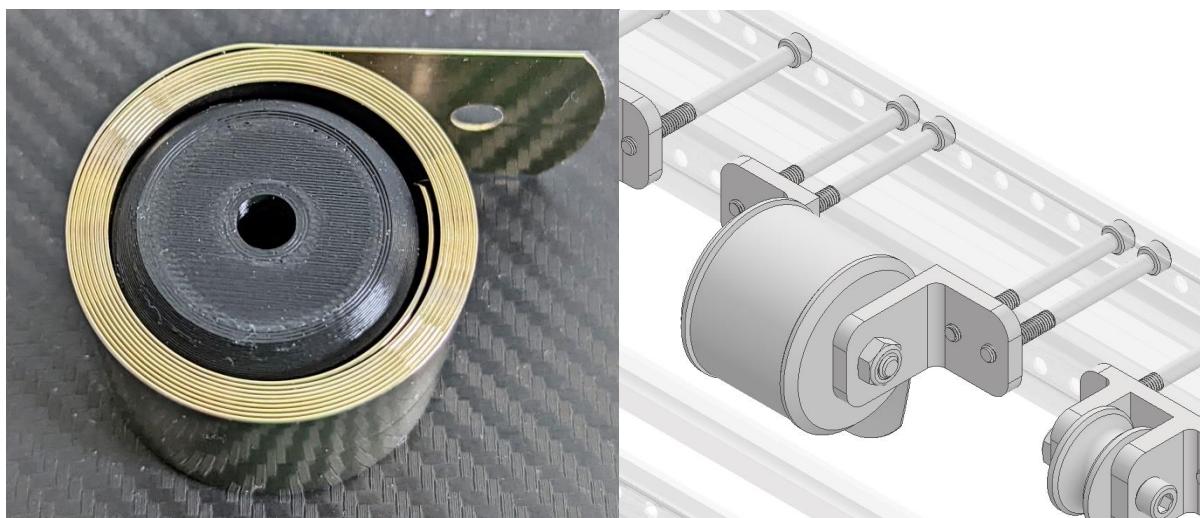
1. Install Pulley Brackets and Pulleys

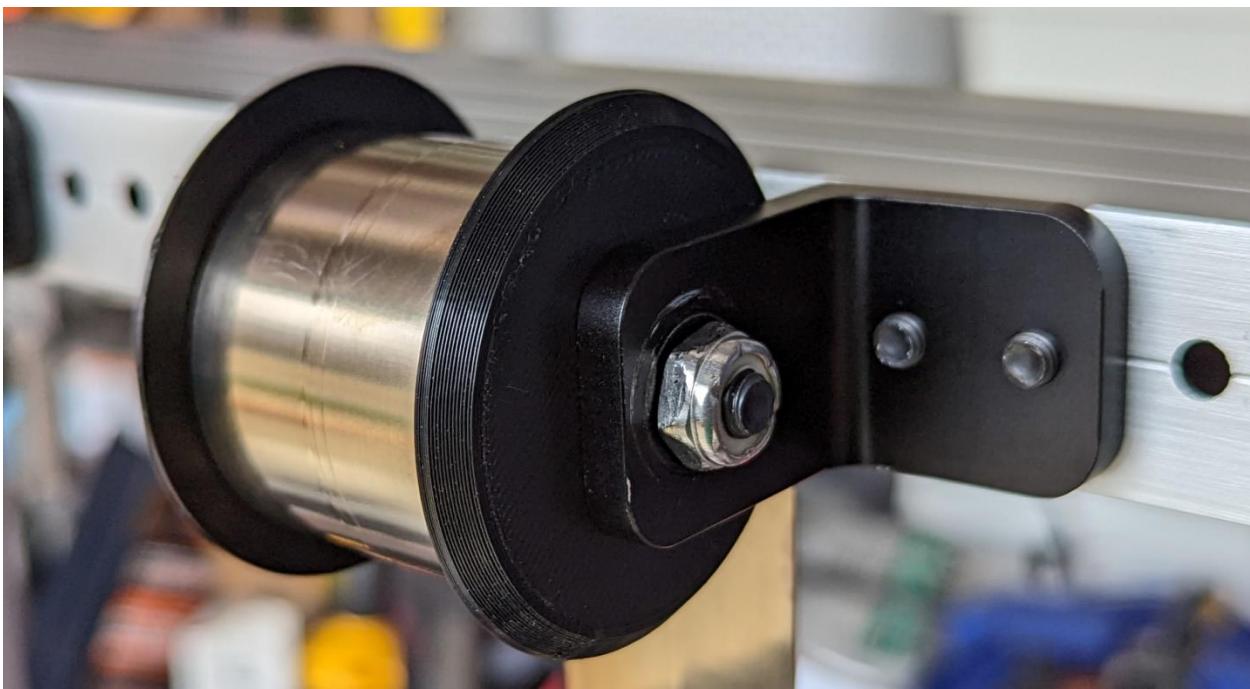
Use the included 2.25" long 10-32 bolts and screw them into the Constant Force Spring Bracket



2. Install the Constant Force Spring

Place the Constant Force Spring spool inside the spring itself and run the 2.25" $\frac{1}{4}$ -20 bolt thru the bracket, spring retainer, spring spool and thru the opposite spring retainer and bracket. Secure it with the included $\frac{1}{4}$ -20 locknut. Make sure the spring is oriented correctly facing the carriage so it will easily attach to the carriage.





3. Bolt the Constant Force Spring to the Carriage

Raise the carriage to the top and clamp it so it does not fall down. If needed transfer drill a hole thru the carriage for a #10 bolt and then secure the spring to the carriage with a 2.5" long 10-32 bolt and locknut.

