

2.4 ASSEMBLY MANUAL

We build space shuttles with gardening tools
so anyone can have a space shuttle of their own

VERSION 2020.06.24

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Before you begin on your journey, a word of caution.

In the comfort of your own home you are about to assemble a robot. This machine can maim, burn, and electrocute you if you are not careful. Please do not become the first VORON fatality. There is no special Reddit flair for that.

Please, read the entire manual before you start assembly. As you begin wrenching, please check our Discord channels for any tips and questions that may halt your progress.

Most of all, good luck!
The VORON Team

By this time you should have already downloaded our STL files from the Voron GitHub. You might have noticed that we have used a unique naming convention for the files. This is how to use them.

PRIMARY COLOR

Example `z_joint_lower_x4.stl`

These files will have nothing at the start of the filename.

ACCENT COLOR

Example `[a]_tensioner_left.stl`

We have added "[a]" to the front of any STL file that is intended to be printed with accent color.

QUANTITY REQUIRED

Example `[a]_z_belt_clip_lower_x4.stl`

If any file ends with "_x#", that is telling you the quantity of that part required to build the machine.

STL OPTIONS

You have some options on the STL's you print for your Voron.

DIN BRACKETS or LEGACY

`VORON2.4\Electronics_Compartment`

DIN brackets are used for the current printer specification. Use this if you're doing a new build.

Legacy brackets are used to mount electronics to the frame if you are not using DIN rail.

DIRECT FEED or BOWDEN

`VORON2.4\Gantry\X_Axis\X_Carriage`

Direct feed is the standard setup for most new builds.

Bowden allows for an external extruder to be used. If in doubt, print the direct feed.

CABLE CHAIN or ZIP CHAIN

`VORON2.4\ZipChain`

We recommend using cable chain. You can check the sourcing guide for options.

If you prefer to print zip chain, you can find it in the folder listed above.

The Voron Team has provided the following print guidelines for you to follow in order to have the best chance at success with your parts. There are often questions about substituting materials or changing printing standards, but we recommend you follow these

FDM MATERIAL

VORON printers are ABS capable machines that run at impressive print speeds. For that reason we recommend only using ABS to build your printer.

LAYER HEIGHT

Recommended: 0.2mm

EXTRUSION WIDTH

Recommended: Forced 0.4mm

INFILL PERCENTAGE

Recommended: 40%

INFILL TYPE

Grid, Gyroid, Honeycomb, Triangle or Cubic

WALL COUNT

Recommended: 4

SOLID TOP/BOTTOM LAYERS

Recommended: 5

SUPPORTS REQUIRED

None at all.

PRINT IT FORWARD

Often times our community members have issues printing ABS will bootstrap themselves into a VORON using our Print It Forward program. This is a service where approved members with VORON printers can make you a functional set of parts to get your own machine up and running. Check Discord if you have any interest in having someone help you out.

If you need assistance with your build, we're here to help. Head on over to our Discord group and post your questions. This is our primary medium to help VORON Users and we have a great community that can help you out if you get stuck.



<https://discord.gg/xgXWctB>

THIS IS JUST A REFERENCE

This manual is designed to be a simple reference manual. Building a Voron can be a complex endeavour and for that reason we recommend downloading the CAD files off our Github repository if there are sections you need clarification on. It can be sometimes be easier to follow along when you have the whole assembly in front of you.

<https://github.com/vorondesign>

GitHub

VORON printers are amazing machines that take care and attention to assemble. Take your time! Little issues in the assembly phase tend to stack up and cause you trouble later on. If at any point you get stuck or are just not sure about something, please ask on Discord. There are

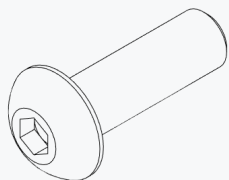
PRINTED PARTS

Not all prints come off the printer perfect and may require some finishing work. You may find that you need to do some light sanding to get some parts to sit flush with each other. Take your time to get the fitment right.

MAINS POWER

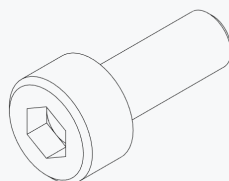
VORON printer builds require 110v/220v wiring work. It's important to understand what you're doing to avoid injury or death. Mains power can kill, and it will hurt the entire time you're dying from it. If in doubt we encourage you to ask questions. This is not something you want to guess your way through.

Best of luck on your build! The VORON Team looks forward to seeing your serial application soon!

**BUTTON HEAD CAP SCREW (BHCS)**

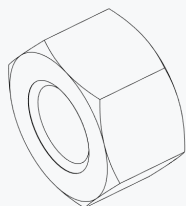
Metric fastener with a domed shape head and hex drive. Most commonly found in locations where M5 fasteners are used.

ISO 7380-1

**SOCKET HEAD CAP SCREW (SHCS)**

Metric fastener with a cylindrical head and hex drive. The Most common fastener used on the Voron.

ISO 4762

**HEX NUT**

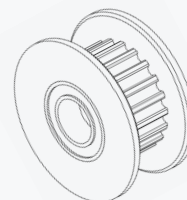
Hex nuts couple with bolts to create a tight, secure joint. You'll see these used in both M3 and M5 variants throughout this guide.

ISO 4032

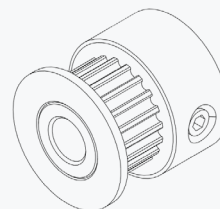
**SHIM**

Not to be confused with stamped washers. These are used in all M5 callout locations in this manual.

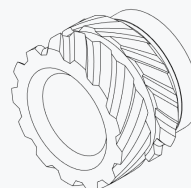
DIN 988

**IDLER**

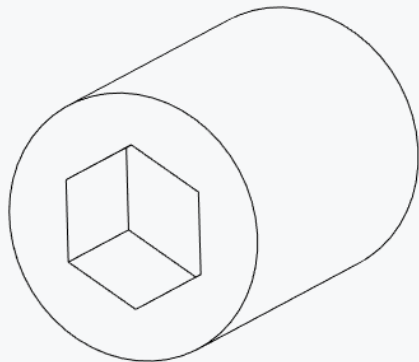
GT2 idler used in the motion system of the Voron. Used in two sizes for both 6mm and 9mm belt locations.

**PULLEY**

GT2 pulley used on the motion system of the Voron. Used in two sizes for both 6mm and 9mm belt locations.

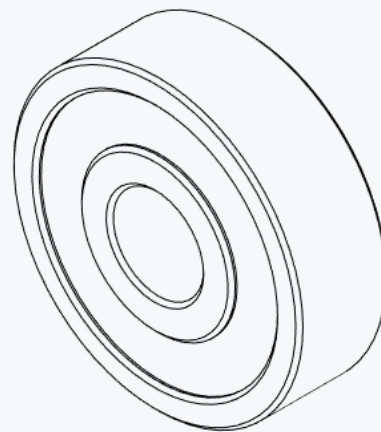
**HEAT SET INSERT**

Heat inserts with a soldering tip so that they melt the plastic when installed. As the plastic cools, it solidifies around the knurls and ridges on the insert for excellent resistance to both torque and pull-out.



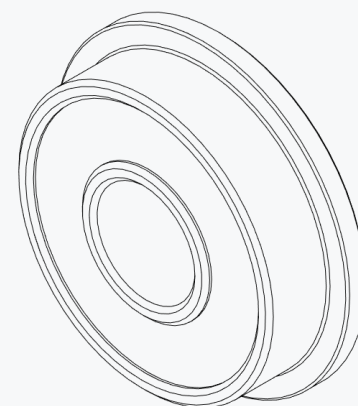
GRUB SCREW

Used to secure pulleys to stepper motor drive shafts. Take care to tighten these correctly and secure with thread lock compound.



625 BEARING

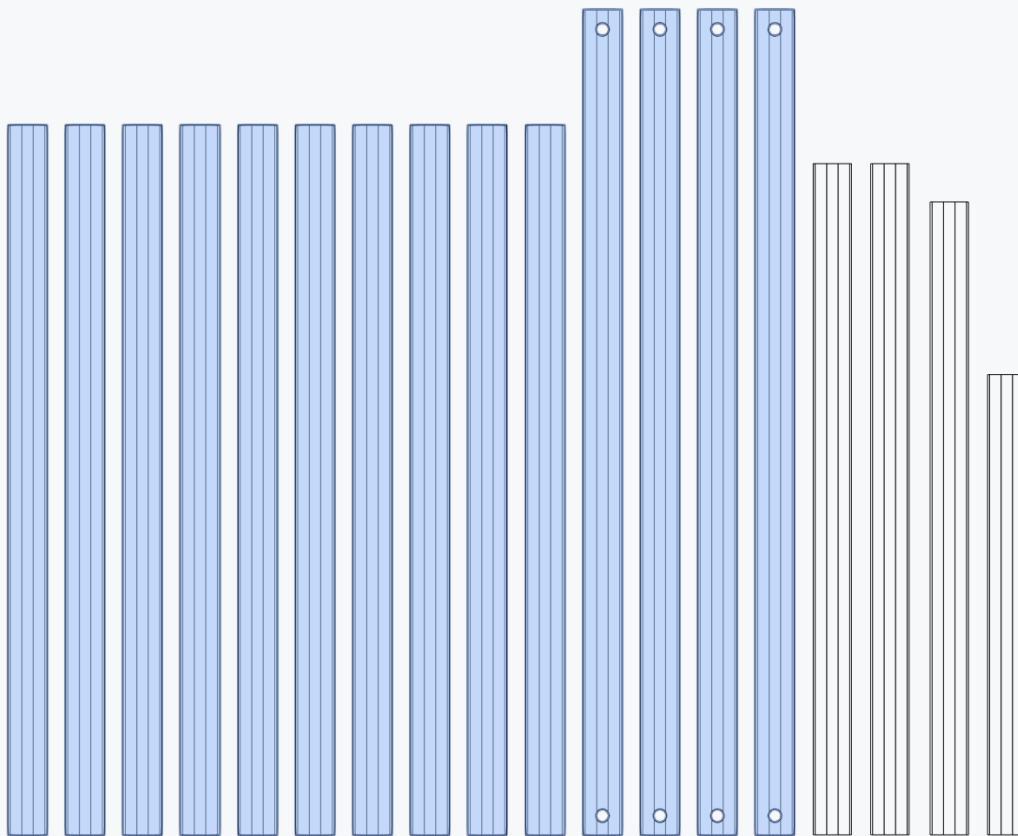
A ball bearing used on the Voron Z drives.



F695 BEARING

A thinner ball bearing with a flange used in various gantry locations.

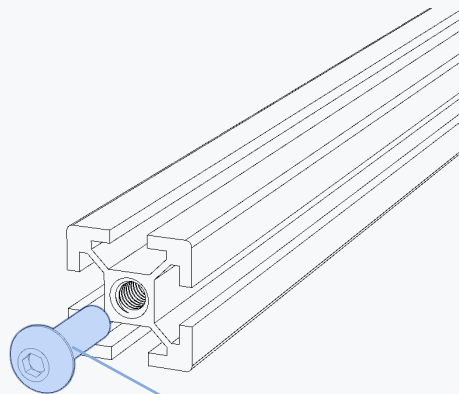
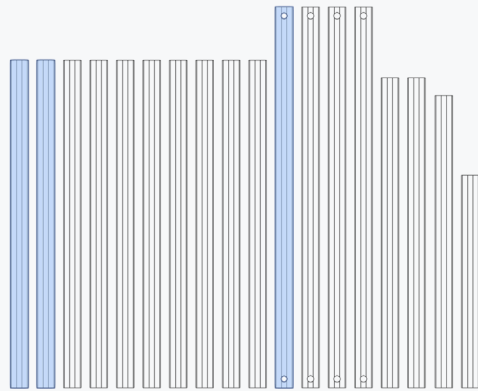


**GETTING EXTRUSIONS TOGETHER**

Separate the extrusions you're going to need for this section of the build. We've laid out all the parts you should have and highlighted the ones that will be used in the following sections.

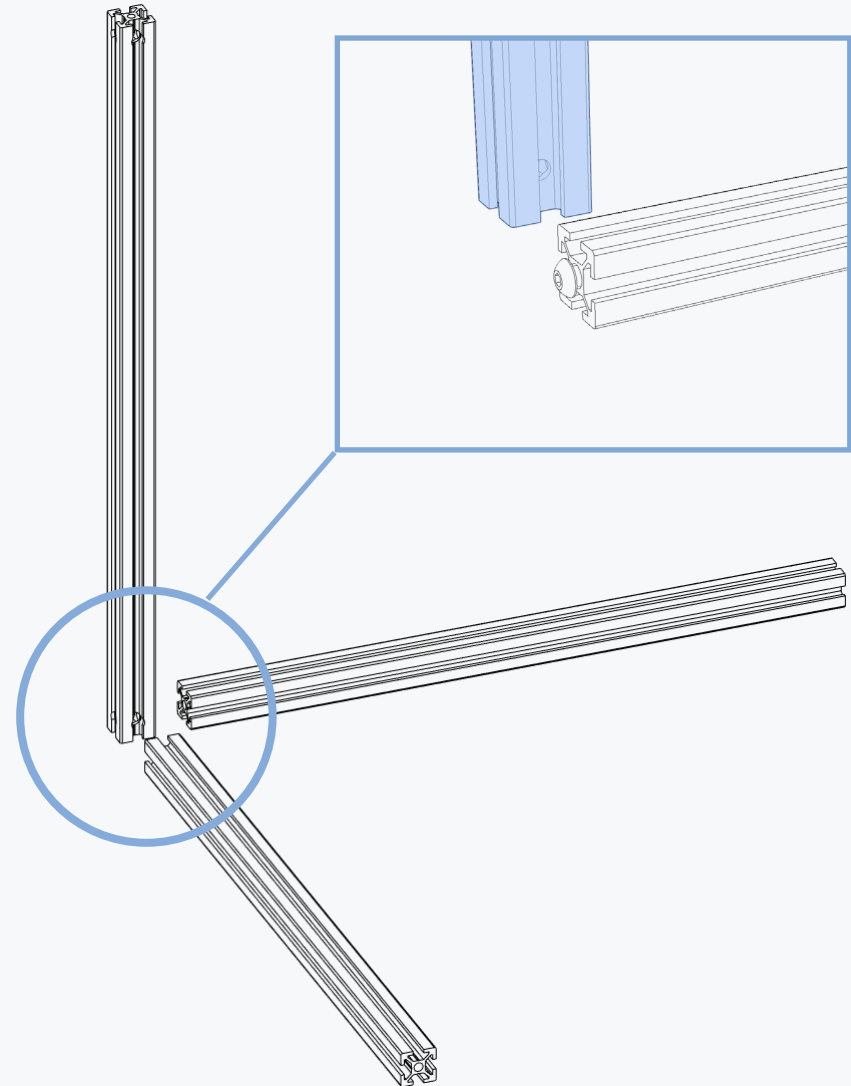
ASSEMBLE FIRST CORNER

VORONDESIGN.COM



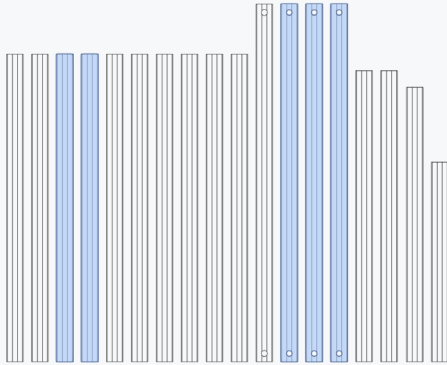
M5X16 BHCS

Use a low strength thread lock compound here.



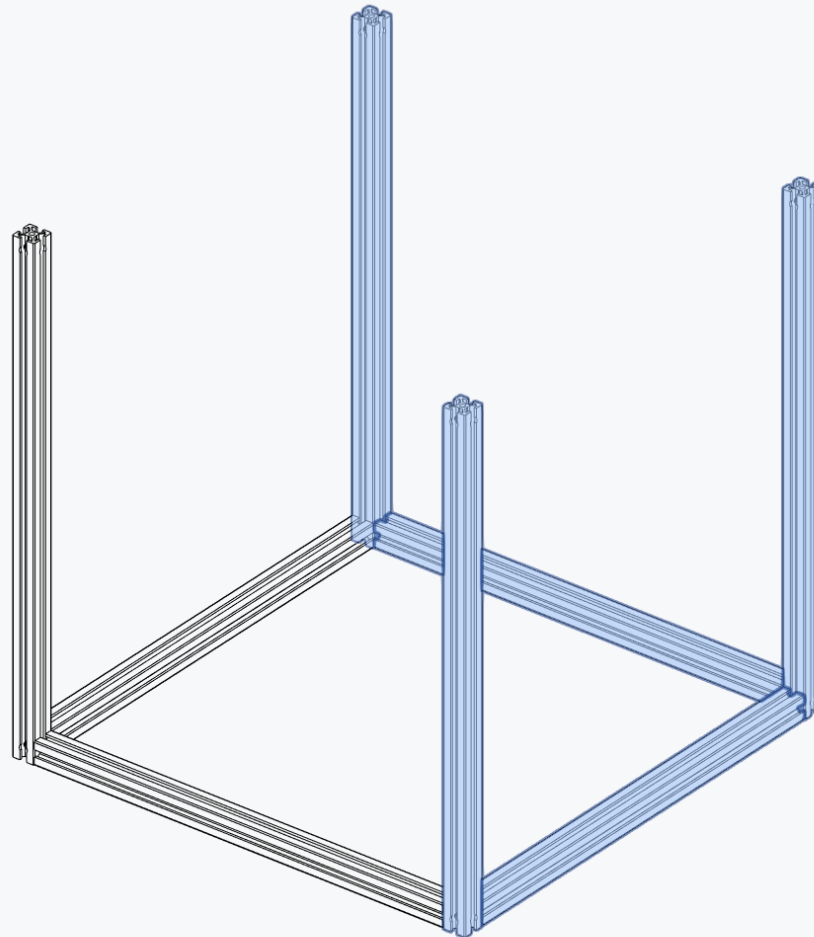
ATTACHING MIRROR SIDE

VORONDESIGN.COM



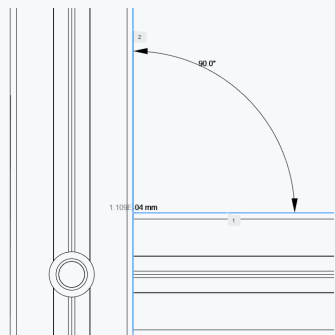
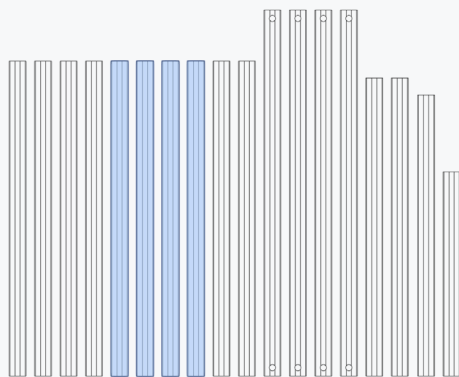
BUILDING SQUARE

It's not a bad idea to build this frame on a glass surface to ensure you can get it as square as possible.



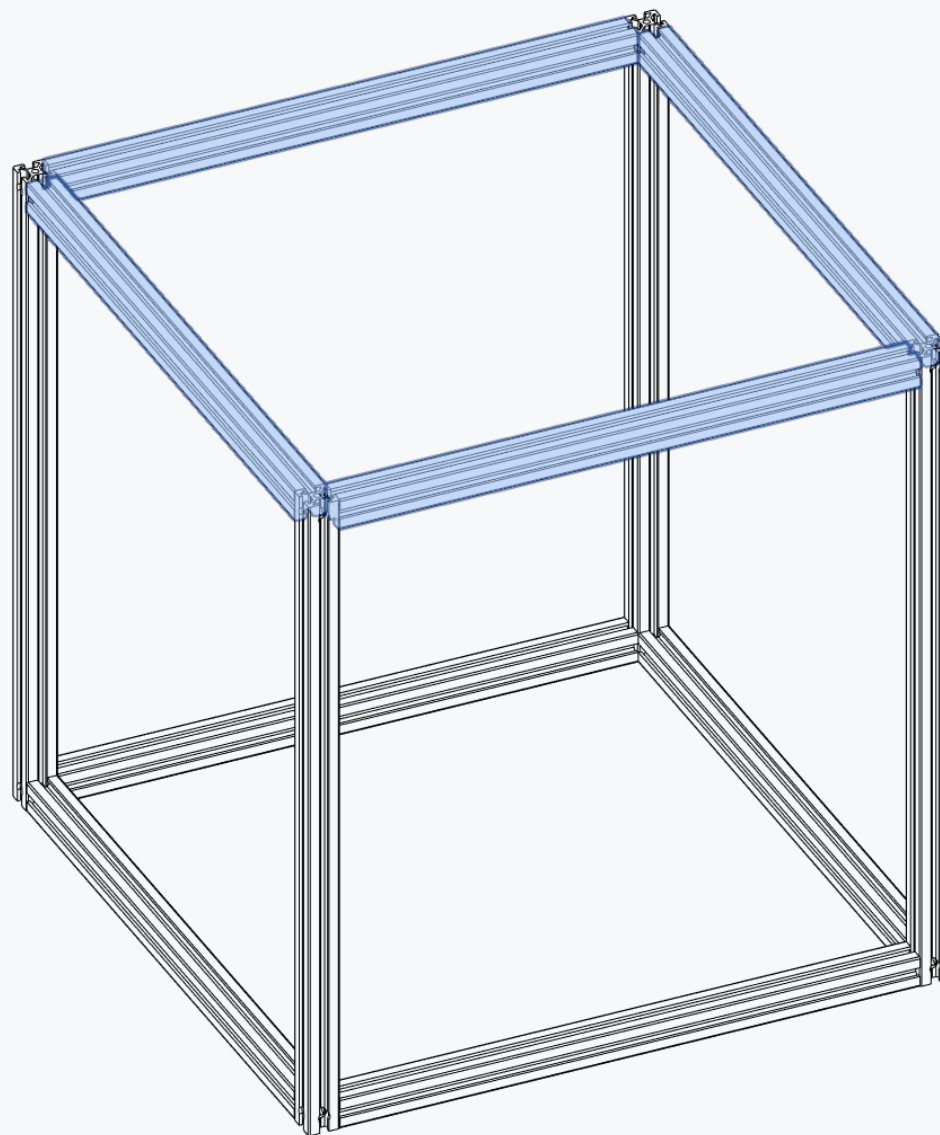
ASSEMBLE FRAME TOP

VORONDESIGN.COM



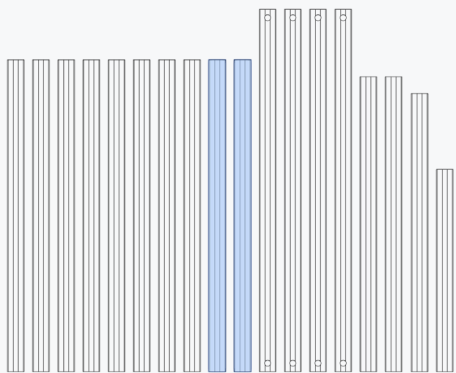
CHECK THE FRAME

Use a framing square and ensure all corners are as square as possible before moving on or you may have problems later on when you start printing.



BED EXTRUSIONS

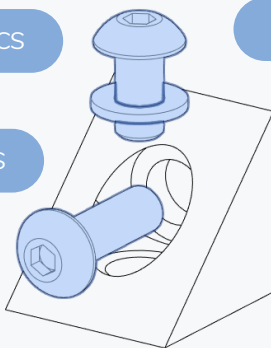
VORONDESIGN.COM



M5X10 BHCS

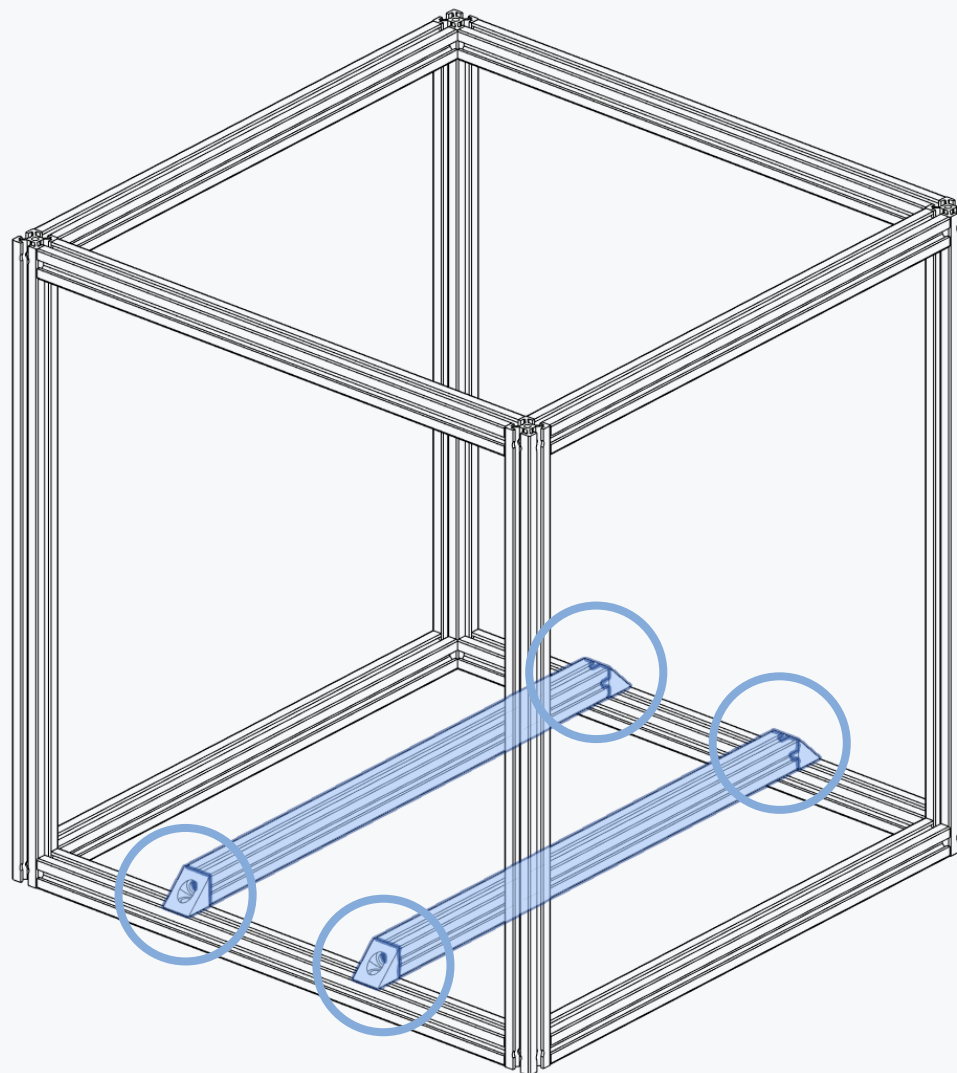
M5 Shim

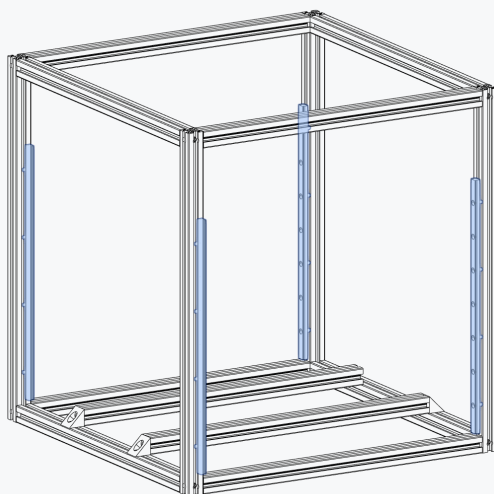
M5X16 BHCS



FASTENERS

Insert fasteners before you start. It makes attaching the bed extrusions to the frame easier. Don't tighten these down too hard at this stage. We'll want them loose when we install the heated bed assembly!

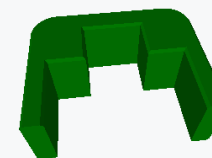
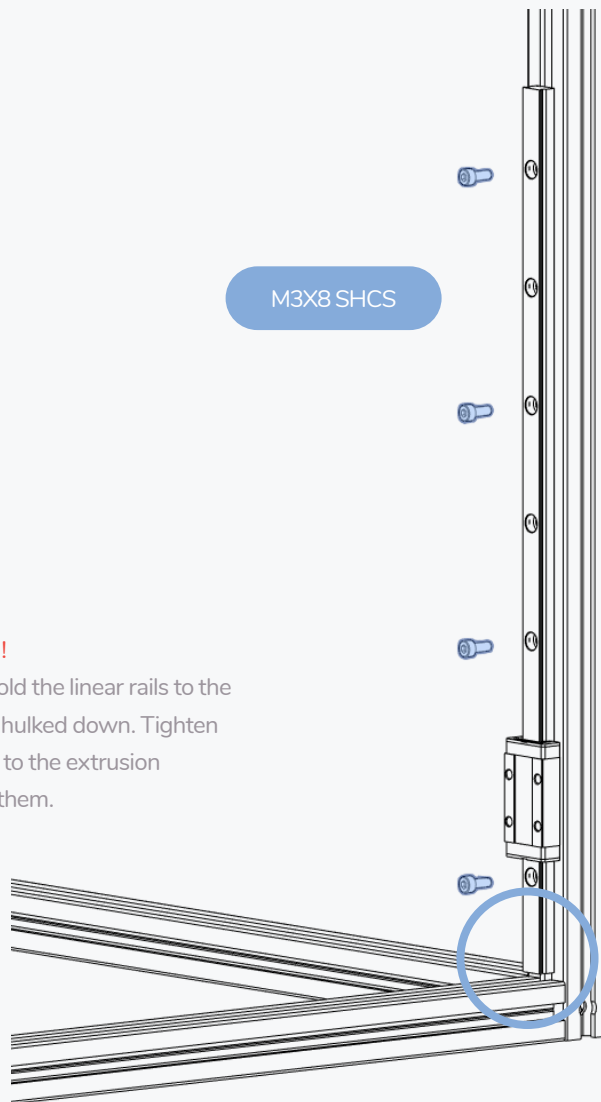




M3X8 SHCS

DON'T OVER TIGHTEN!

The M3 fasteners that hold the linear rails to the frame do not need to be hulked down. Tighten them sufficiently to hold to the extrusion without over tightening them.

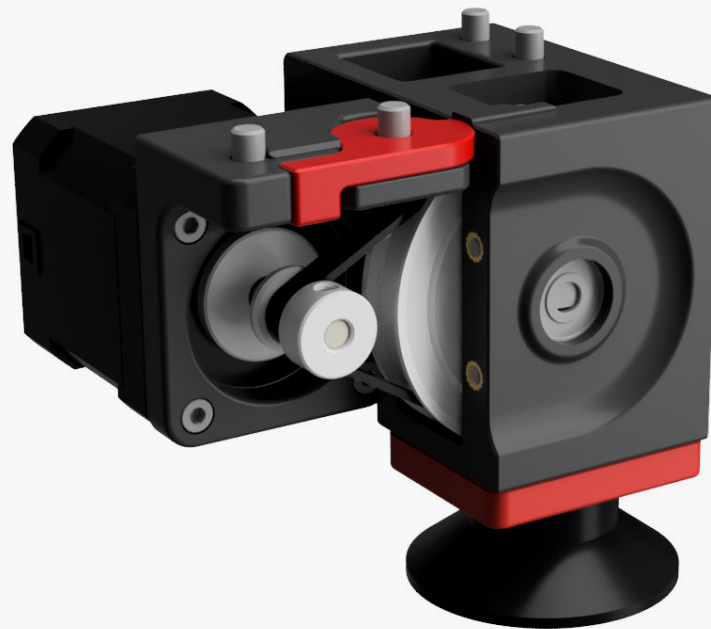
**CENTERED RAIL INSTALLATION GUIDE**

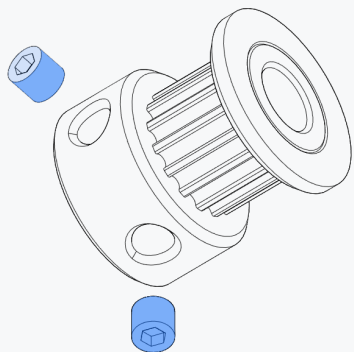
When tightening the fasteners to hold the linear rails in place, ensure that you have attached a centered rail installation guide to both the top and bottom. You should have two printed.

RAIL SPACING

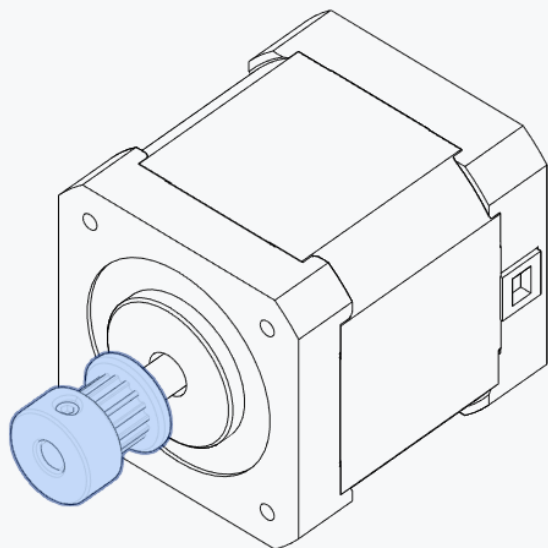
Make sure to space the rails 3mm off the bottom extrusions. This leaves room for the installation of belt covers later in the build.

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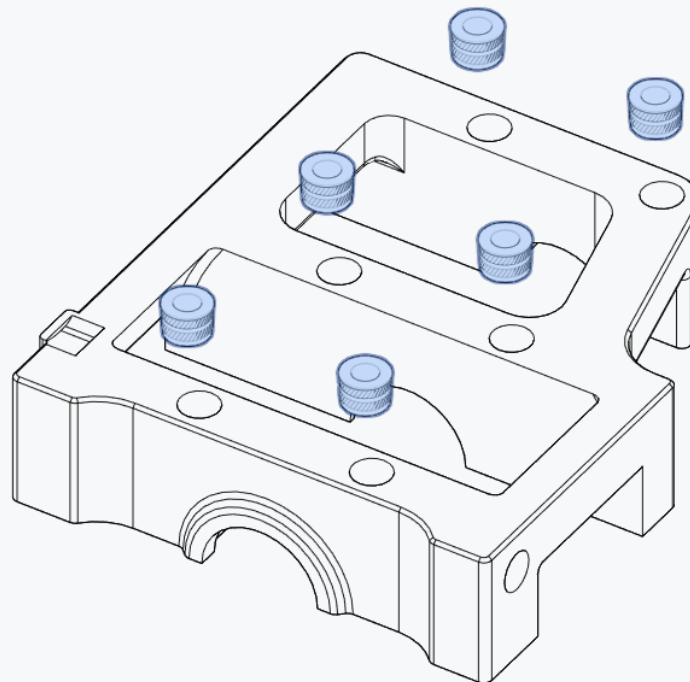


**APPLY THREAD LOCK COMPOUND**

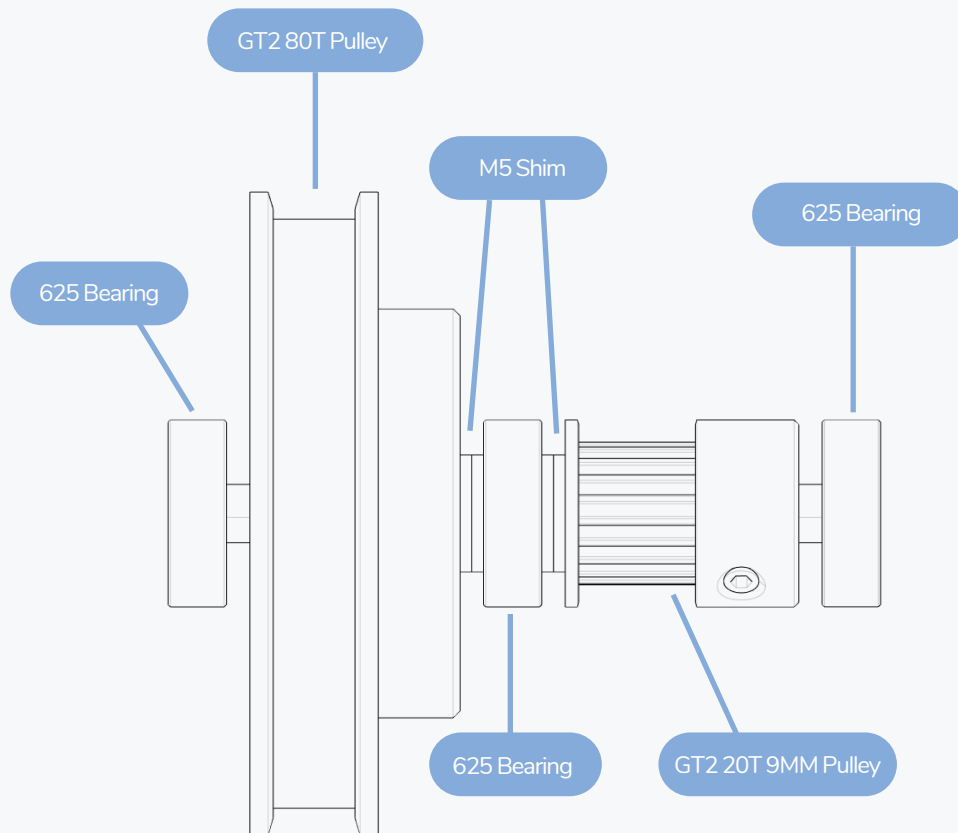
Make sure to apply thread lock compound to the grub screws.



GT2 16T Pulley

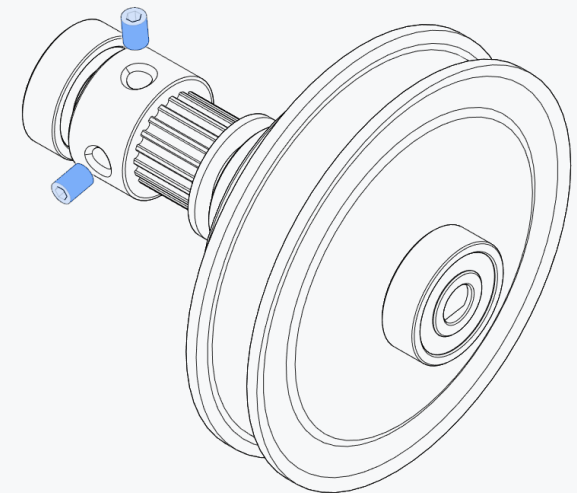
**INSTALL HEAT SET INSERTS**

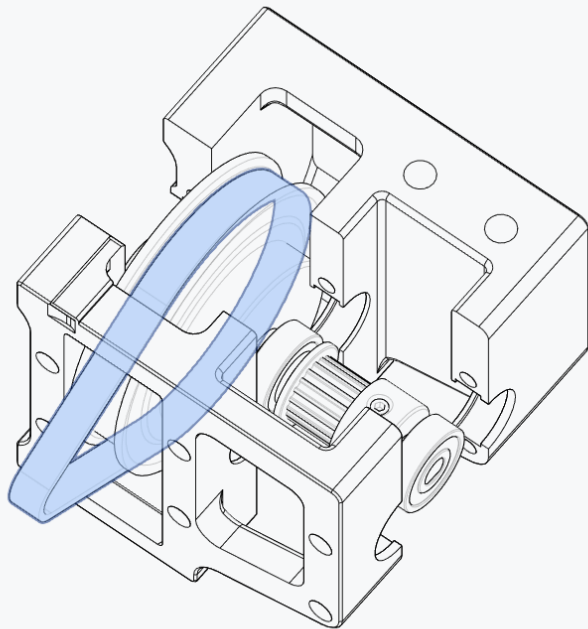
You will need to install heat set inserts into all four sets of Z drive housings. If you need help on the correct procedure, ask in Discord.



APPLY THREAD LOCK COMPOUND

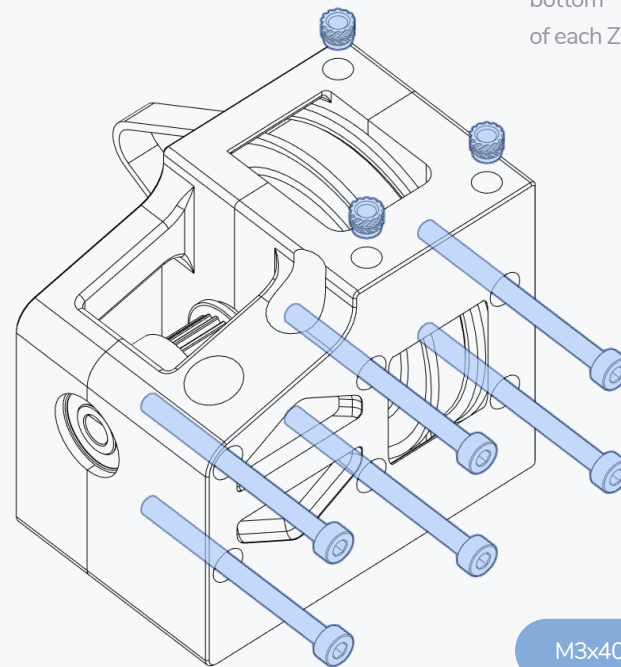
Make sure to apply thread lock compound not only to the 9mm pulley grub screws, but also the 80T pulley!





ASSEMBLE BELT DRIVE

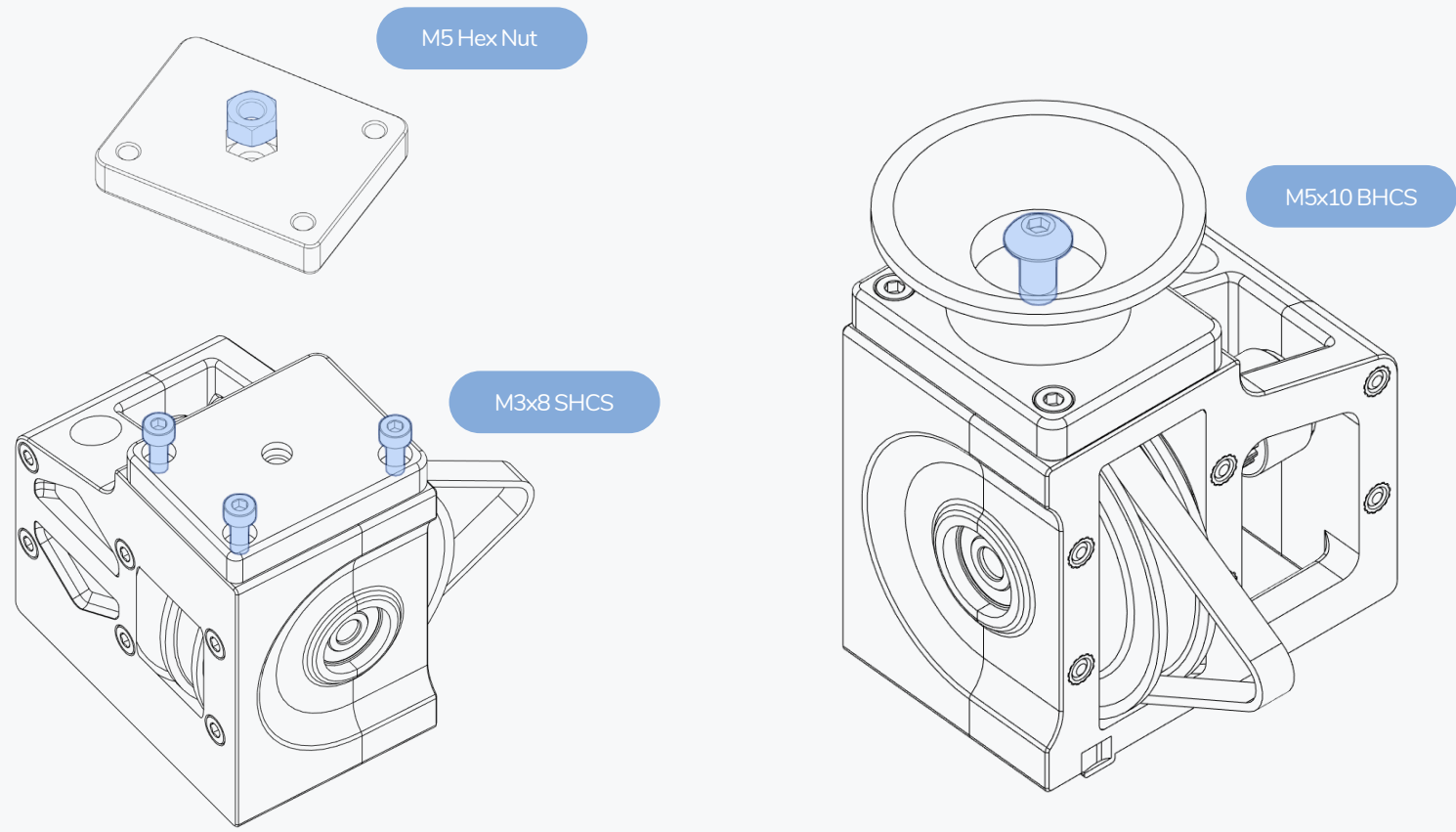
All four go together the same way. Don't forget to put the belt loop on!

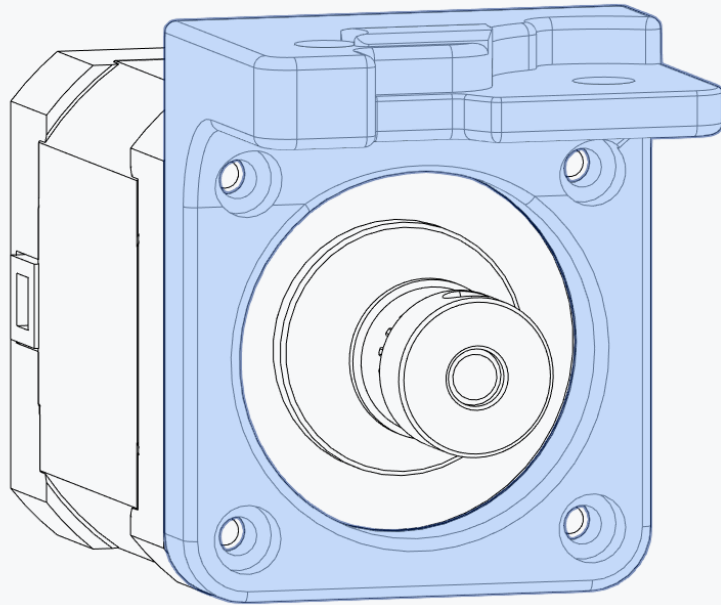


INSTALL HEAT SET INSERTS

Don't forget these ones on the bottom of each Z drive!

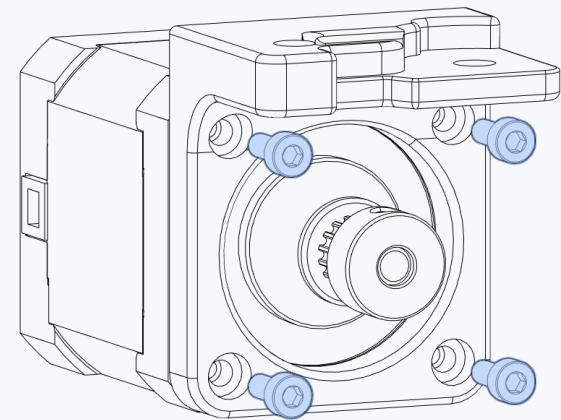
M3x40 SHCS



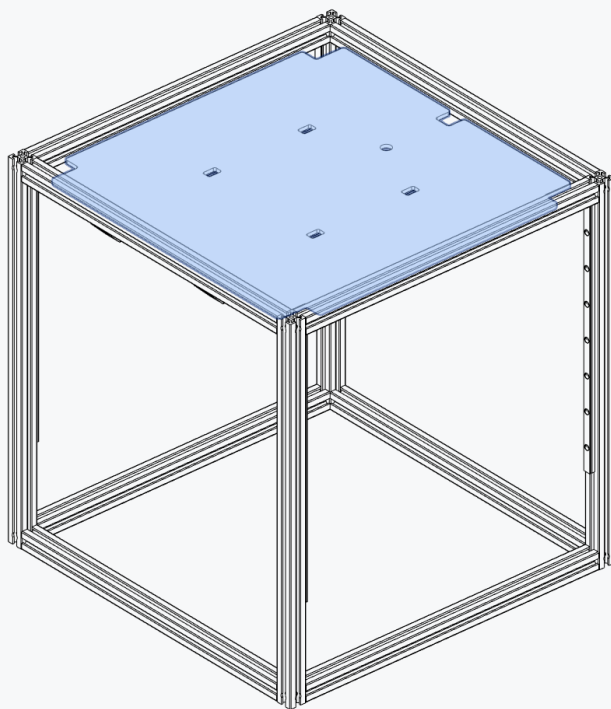


Attach Motor Mounts

Attach all 4 motor mounts to their stepper motors for your Z drive. You will need M3x8 SHCS for these.

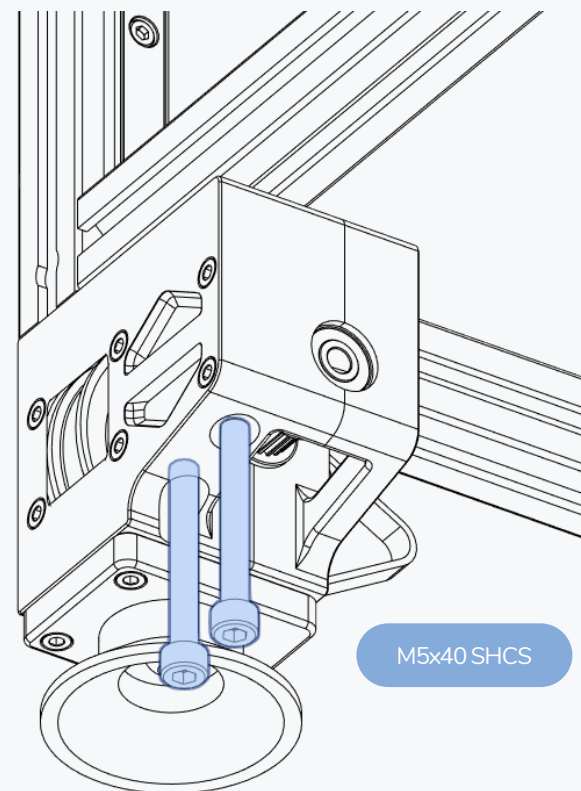


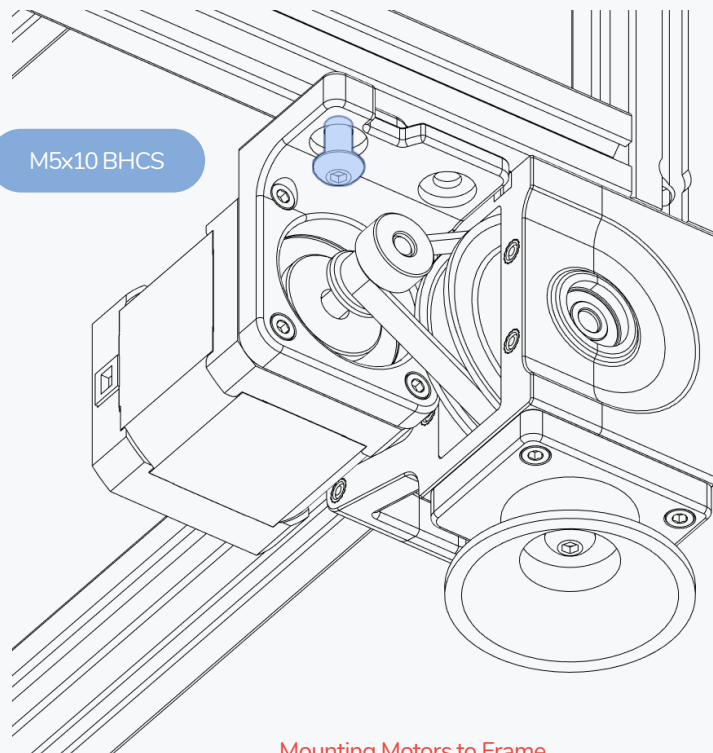
M3X8 SHCS



INSTALL BOTTOM DECK PANEL

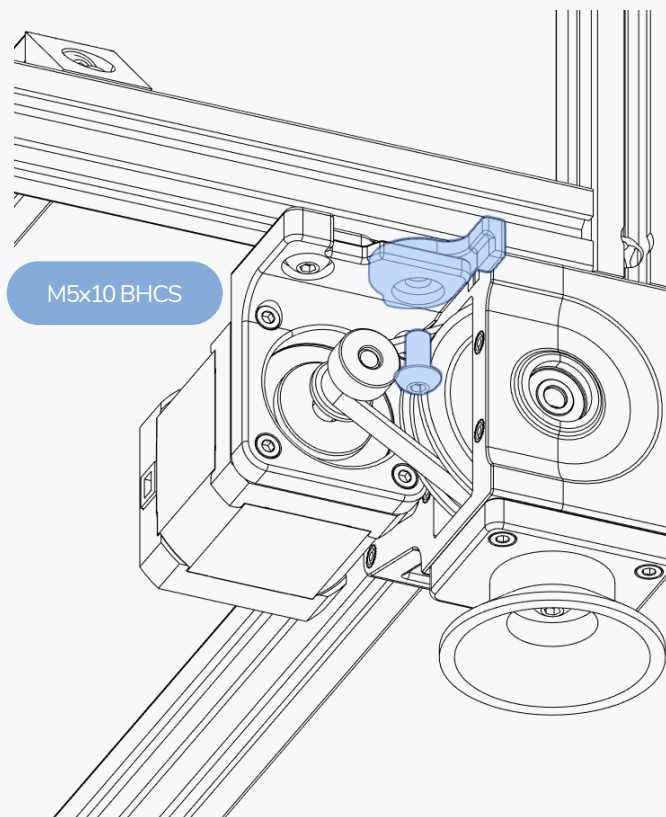
Flip the frame over and install the deck panel. We're going to be working inverted for a little bit. You probably want to tape the carriages in place so they don't fall off the ends of the rails when you flip the machine!



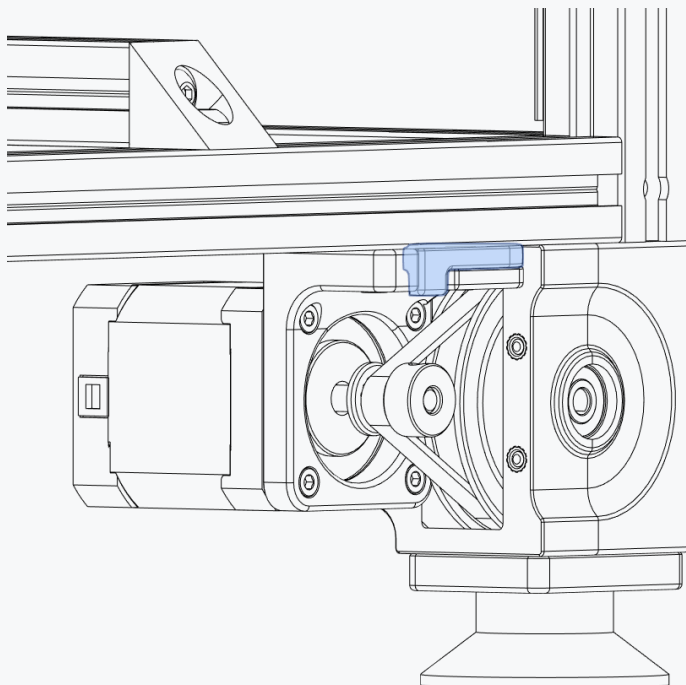


Mounting Motors to Frame

LIGHTLY secure the motor assemblies to the frame using the M5 fastener. We have more steps before we can fully tighten these.



4

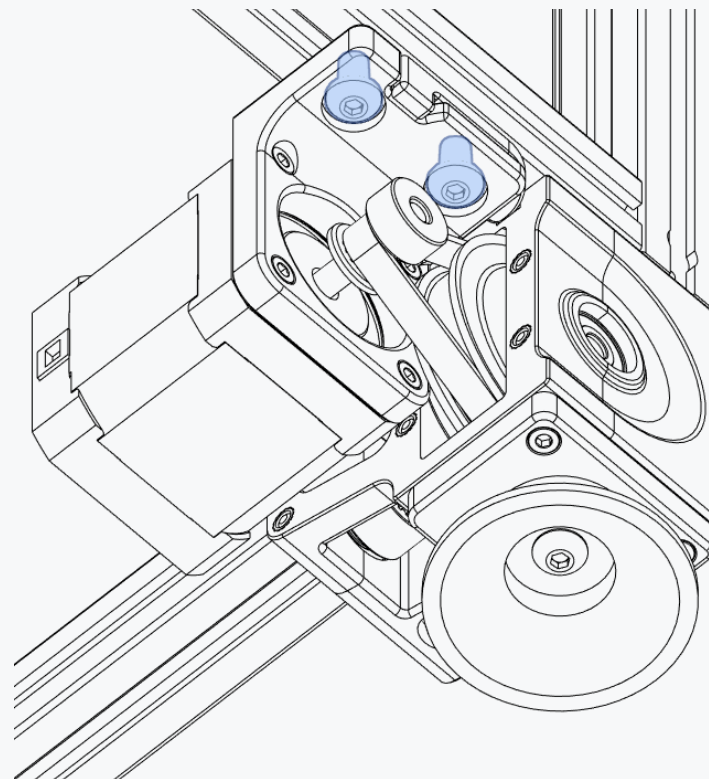


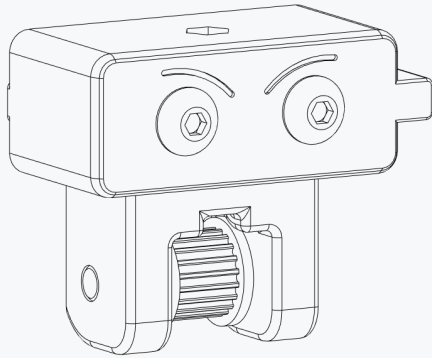
Close Belt Tensioner

Flip the belt tensioner latch closed. It should sit flush with the frame.

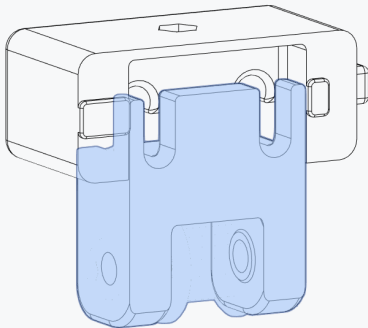
Tighten M5 Bolts

After closing the tensioner we can now tighten the M5 Bolts to secure the motor assembly.

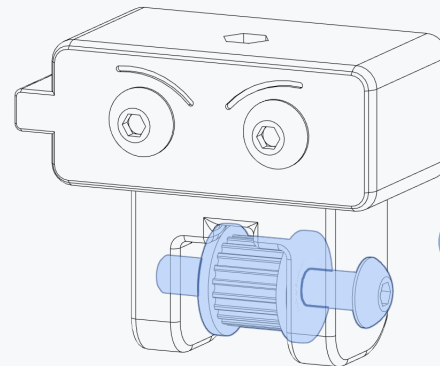
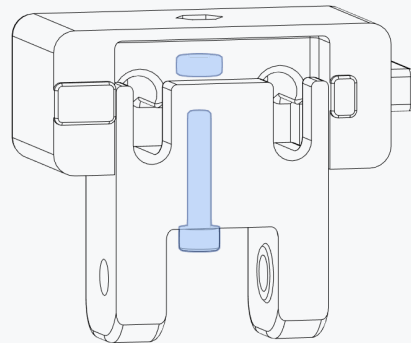




M3 Hex Nut

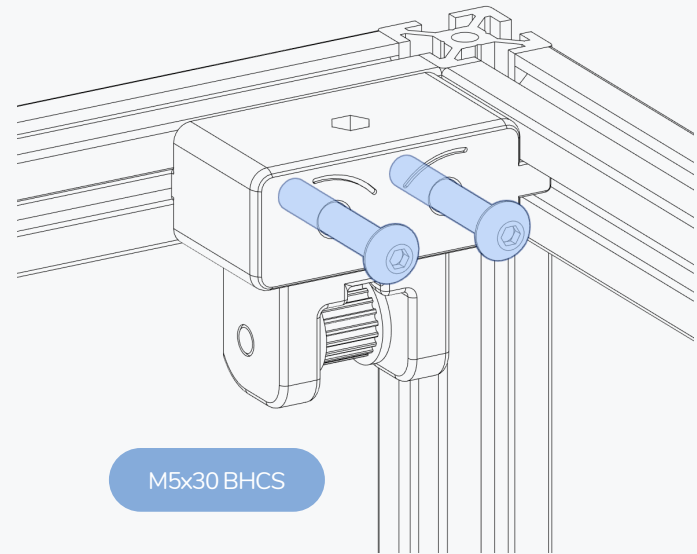
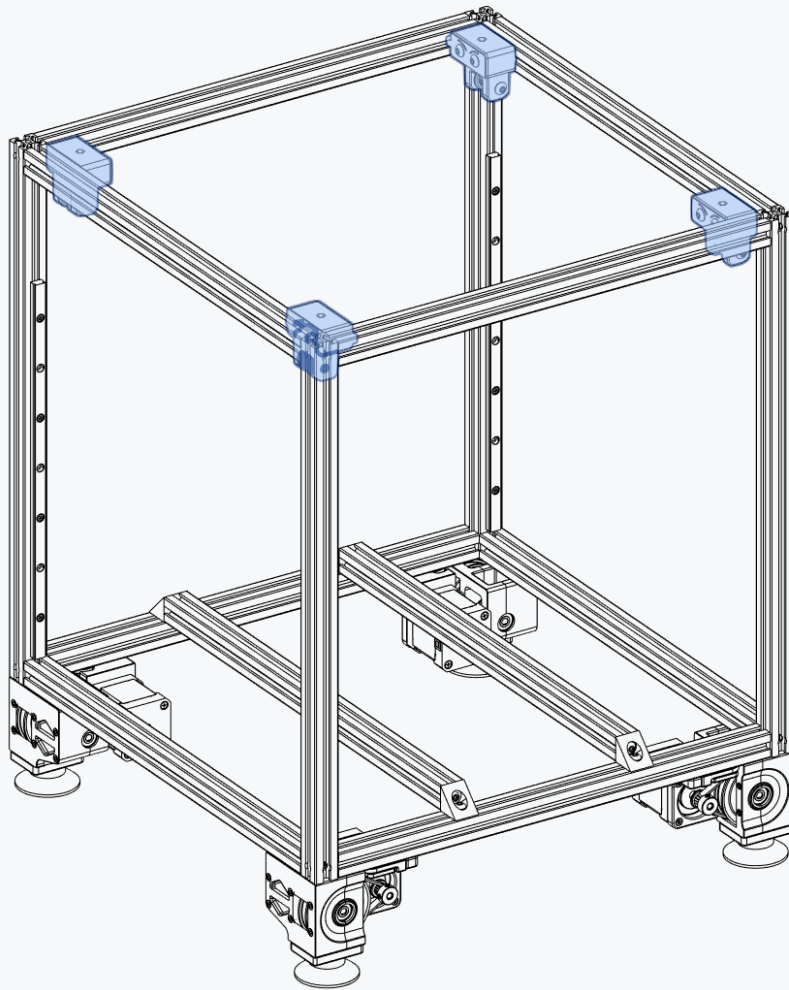


M3x16 SHCS

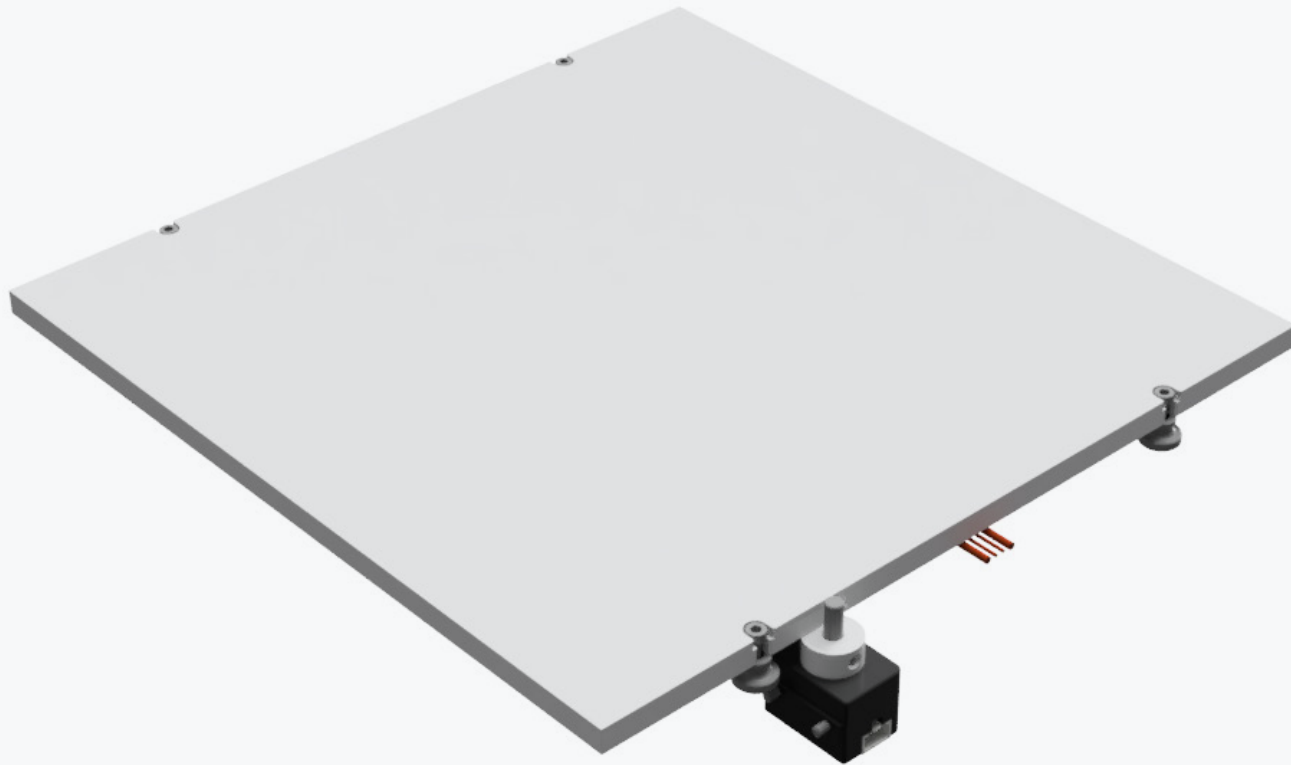


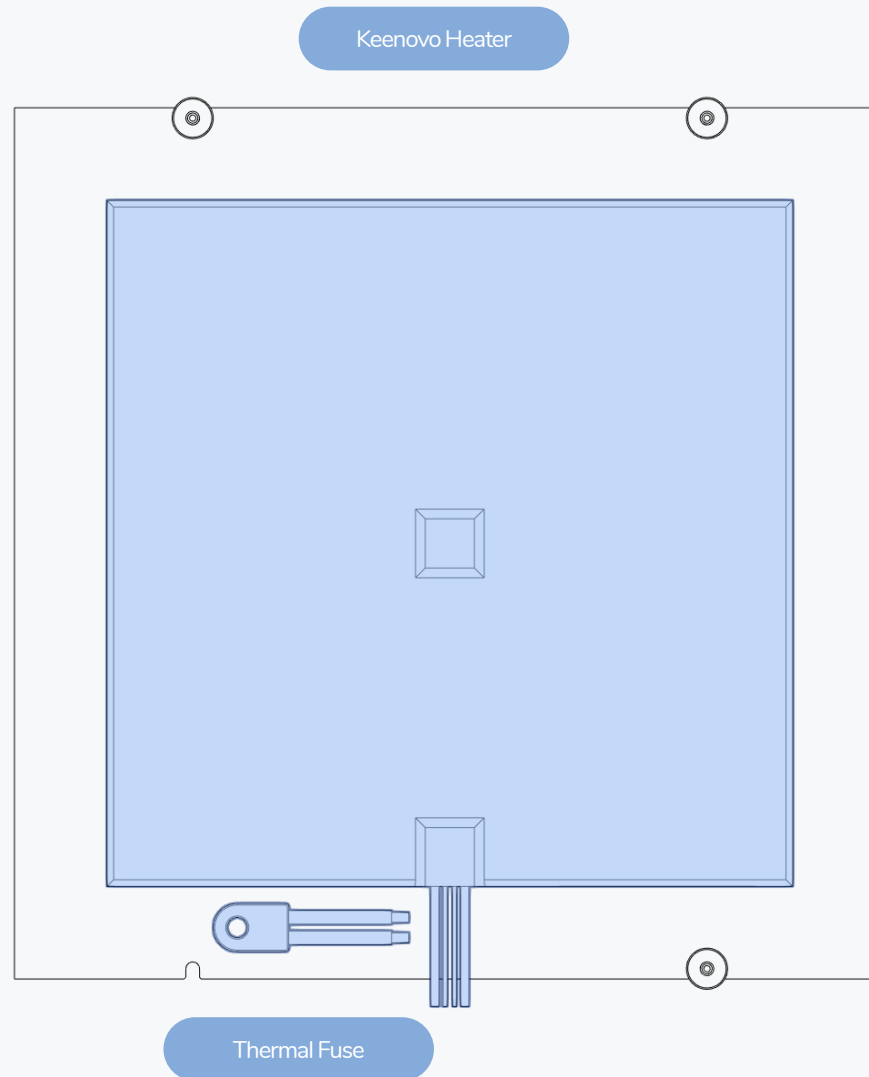
GT2 20T 9mm Idler

M5x30 SHCS



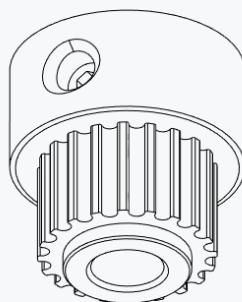
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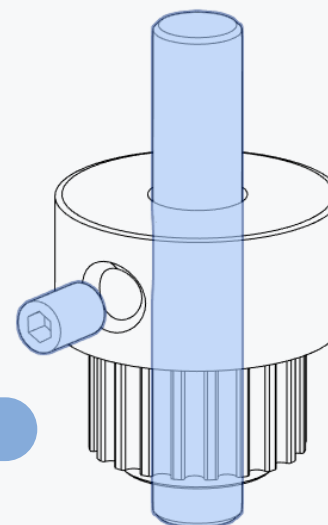


Deflange GT2 20T

Check our help videos in discord if you need help removing the flange for the 20T pulley.



33mm Shaft



Grub Screw

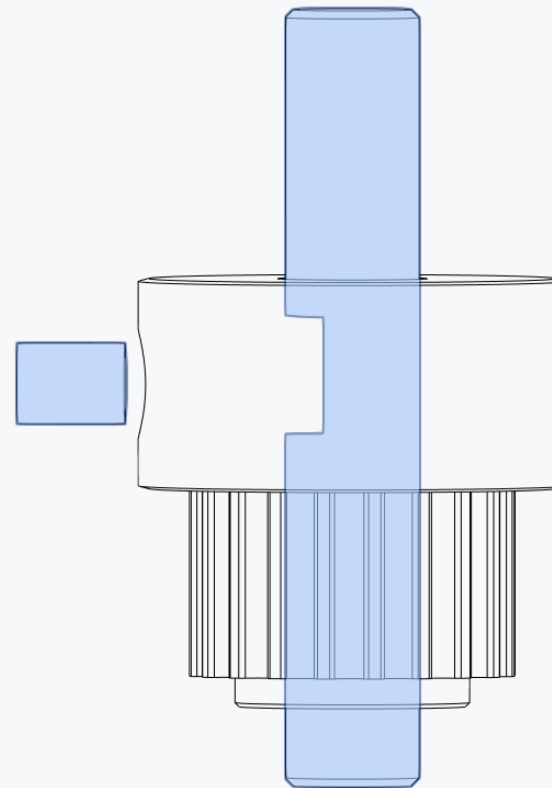
IMPORTANT NOTICE

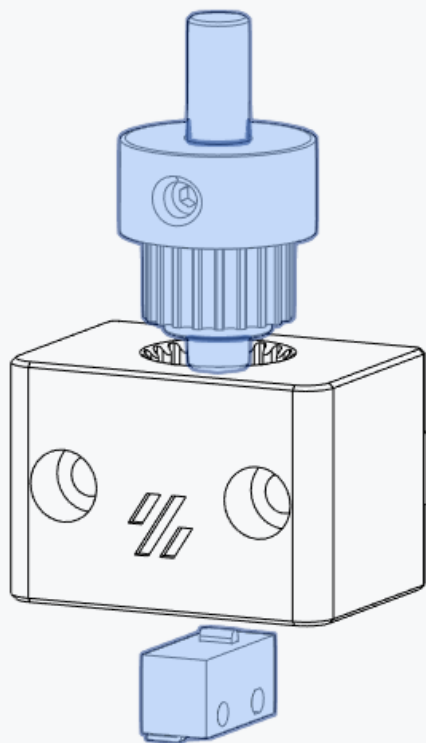
We have specified a notch to be cut into the Z endstop pin along with a grub screw. This is simply to prevent it from falling out if you tilt your machine to do work on it in the future. This does happen (even to the best of us) and can result in a nozzle strike with significant damage to the gantry.

It is recommended that you cut and size this pin as your last step in your build process. Build plate configurations are sometimes different based on removable build plates, PEI thickness etc. If the pin is too short you will strike the hot end housing on the build plate, but if it's too long you will hit it during prints.

When securing the grub screw, remember that the shaft has to move in order to hit the microswitch. It should not be tight to the shaft, but rather left loose to allow for movement. It is intended to be installed backed out slightly and held in place with retaining compound.

If you have questions, please ask in our Discord. This is one of the most critical steps to your build so please take care in assembly of this component.





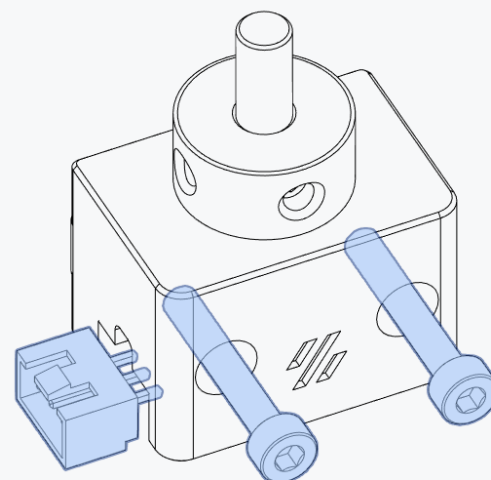
Microswitch

Endstop Microswitch

Secure the microswitch with two your M2 self tapping screws. Make sure to remove the lever from the microswitch as it will get

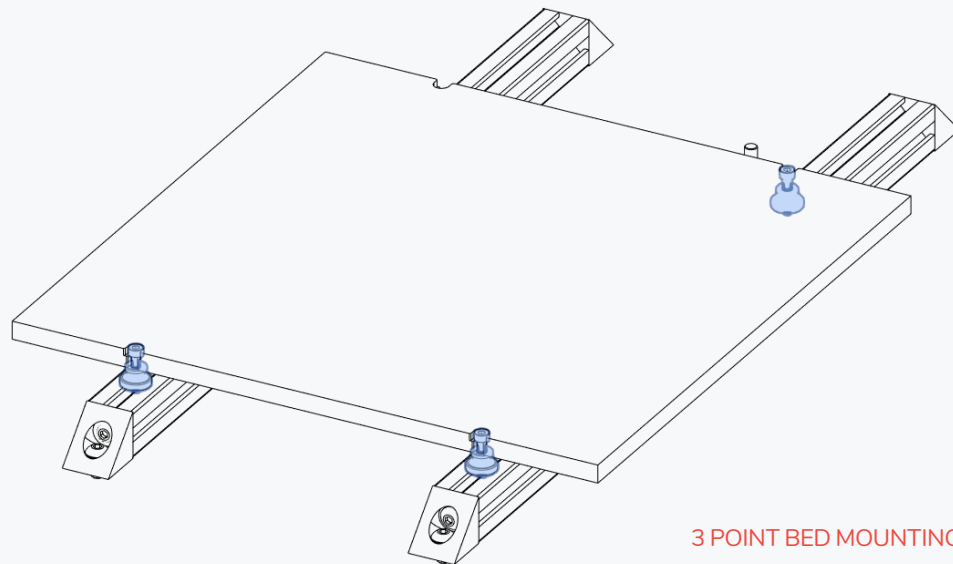
Solder Connector

It's possible to solder the JST connector directly to the microswitch if you wish.



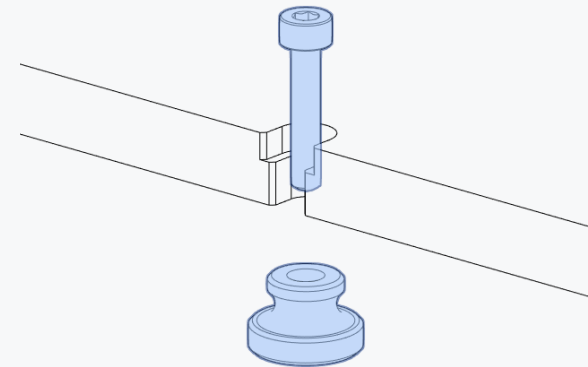
JST 3 Pin Connector

M3x20 SHCS

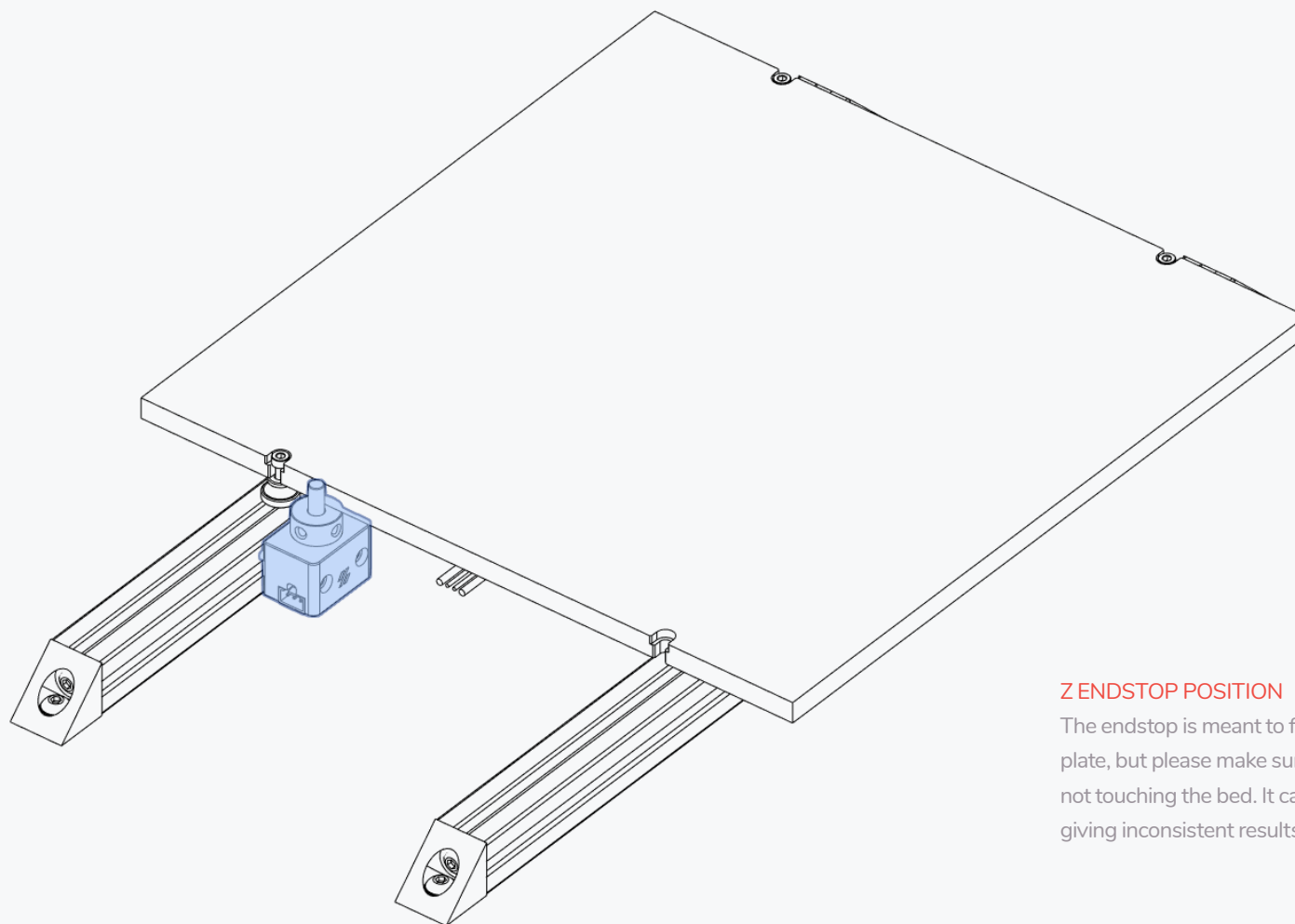
**3 POINT BED MOUNTING**

Some people have more luck doing a 3 point bed mount. It can help prevent bed warping.

M3x16 SHCS

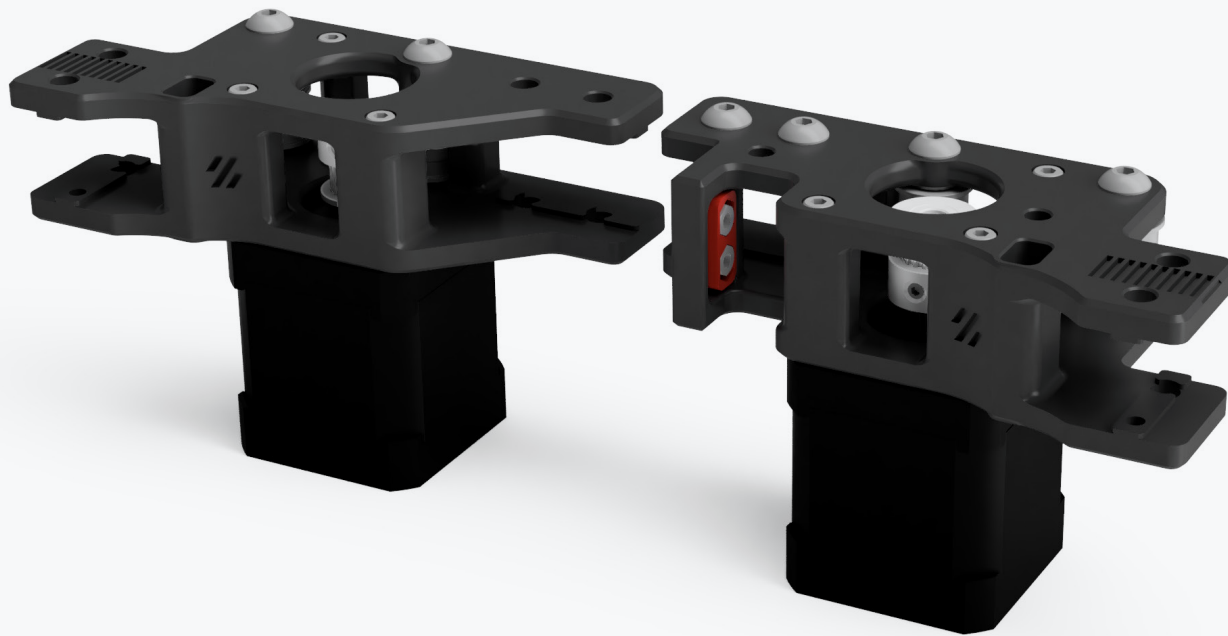


M4 Knurled Nut

**Z ENDSTOP POSITION**

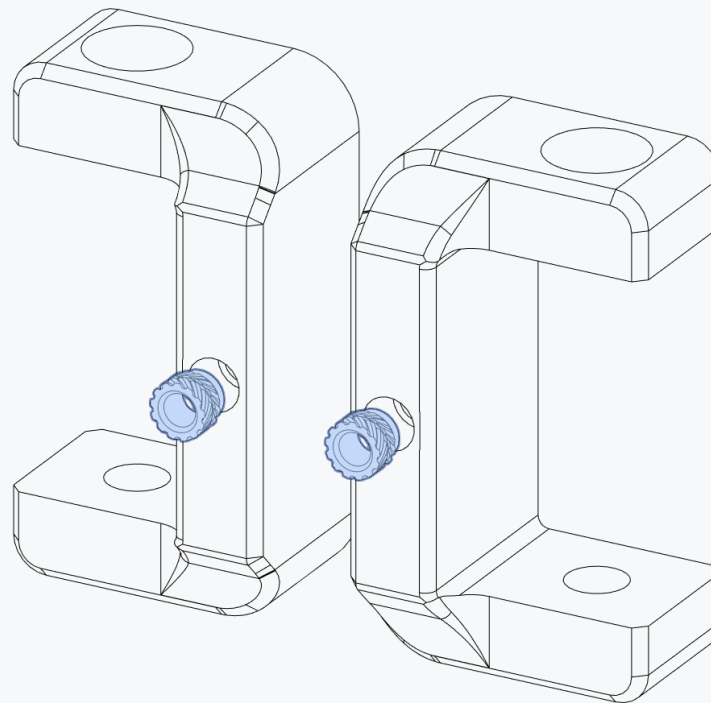
The endstop is meant to fit under the build plate, but please make sure that the pin is not touching the bed. It can transfer heat giving inconsistent results in Z probing.

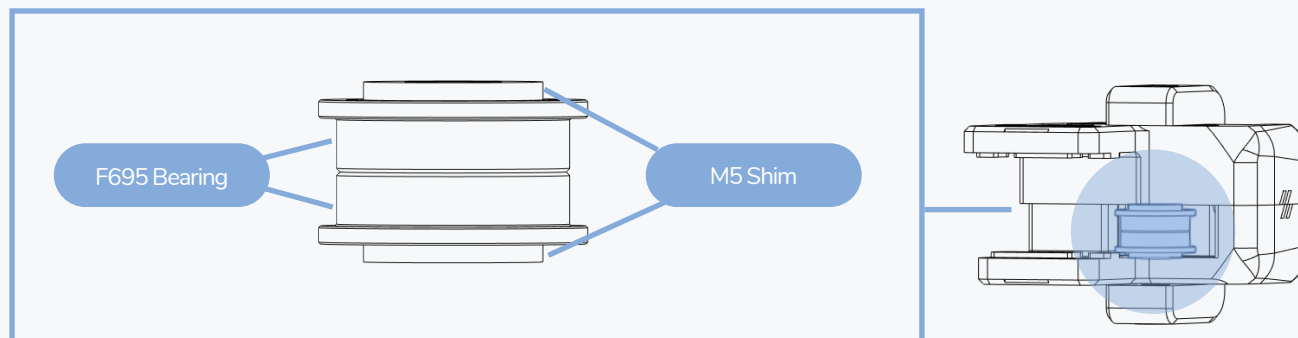
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INSTALL HEAT SET INSERTS

You will need to install heat set inserts into both Front Idler Tensioners. If you need help on the correct procedure, ask in Discord.

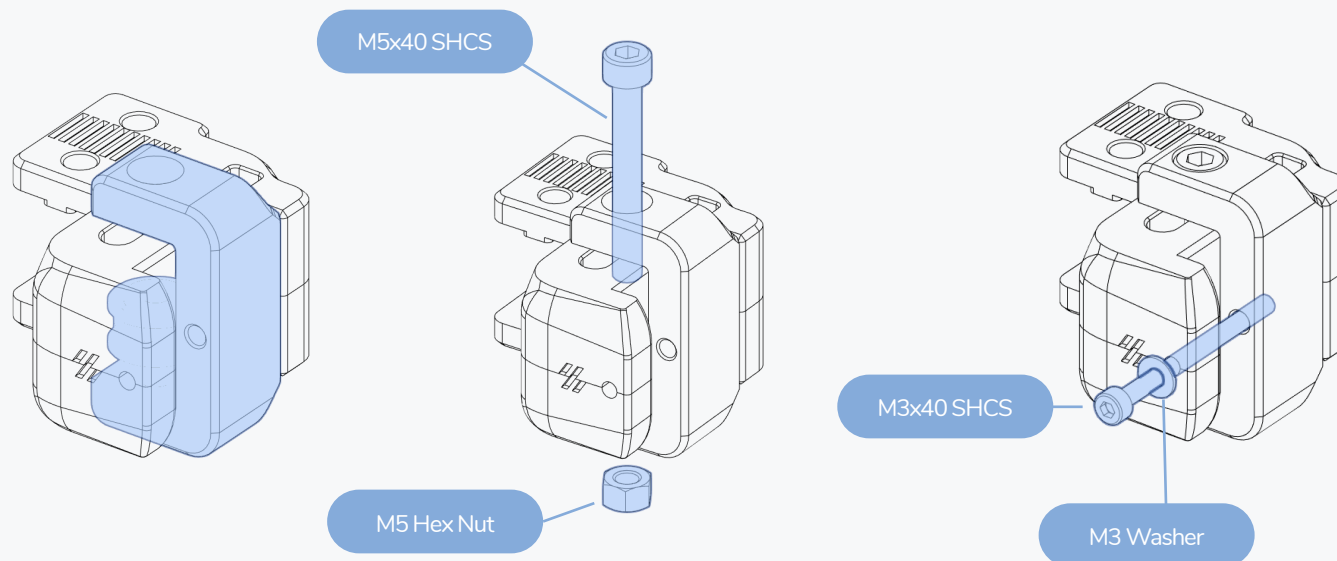


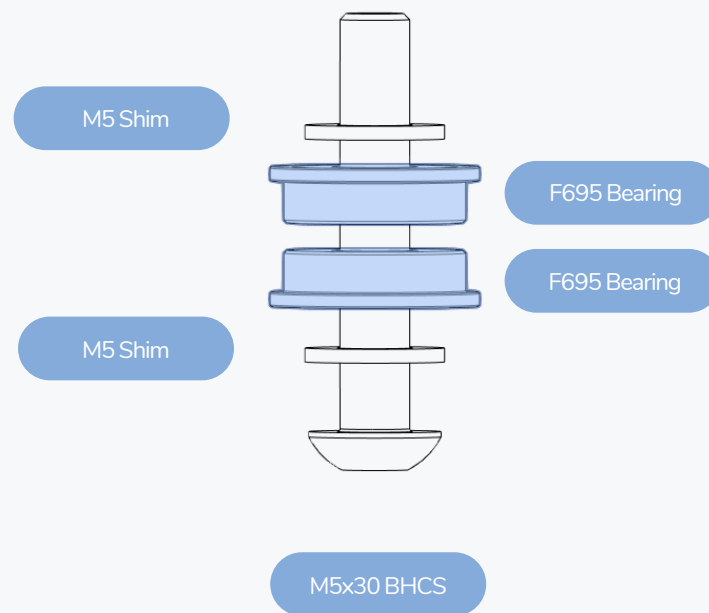
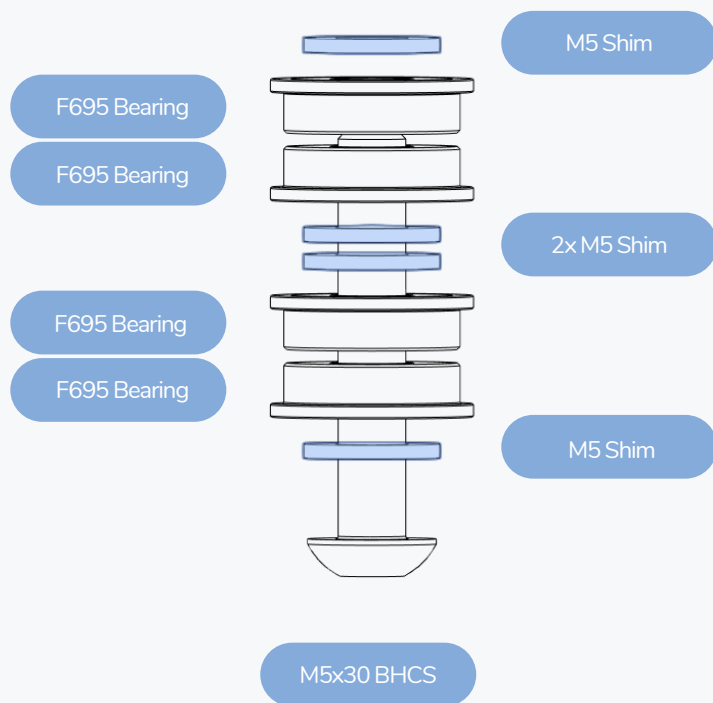
**M3 HOLE**

The bearing stack can be a little tricky to install. Sometimes it helps to use the M5x40 as a guide and feed the washers and bearings in one at a time.

BEARING STACK

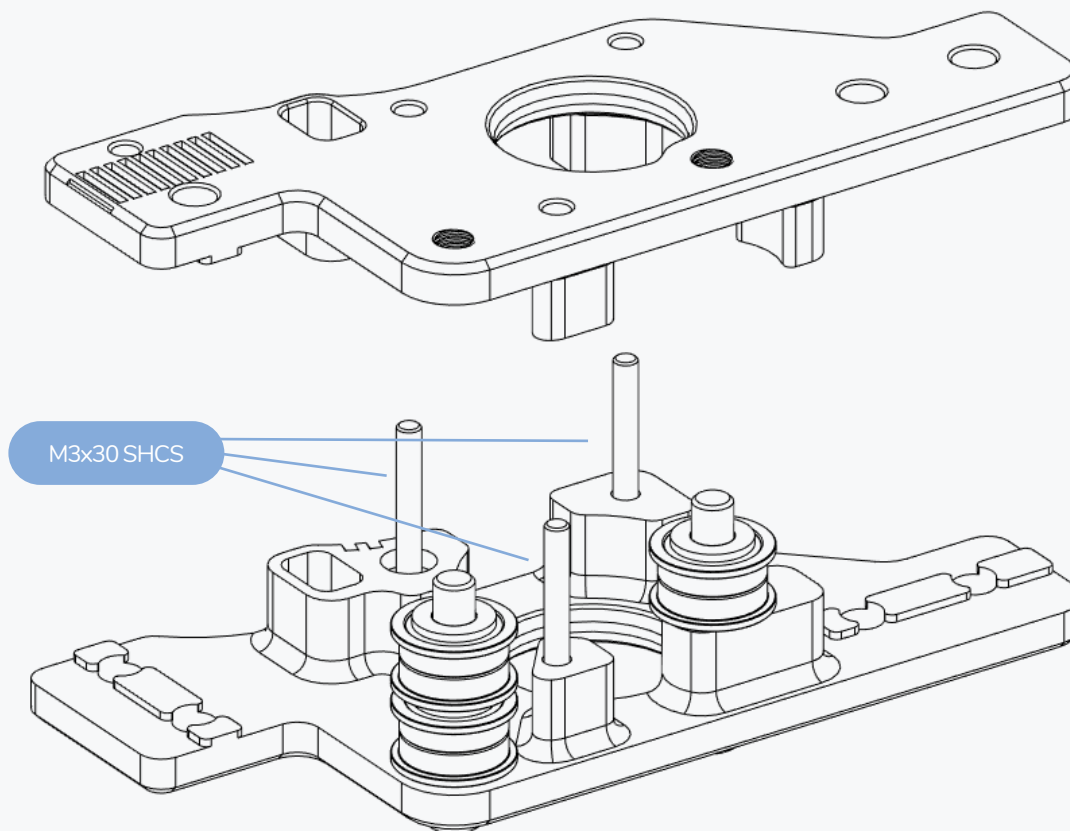
The bearing stack can be a little tricky to install. Sometimes it helps to use the M5x40 as a guide and feed the washers and bearings in one at a time.

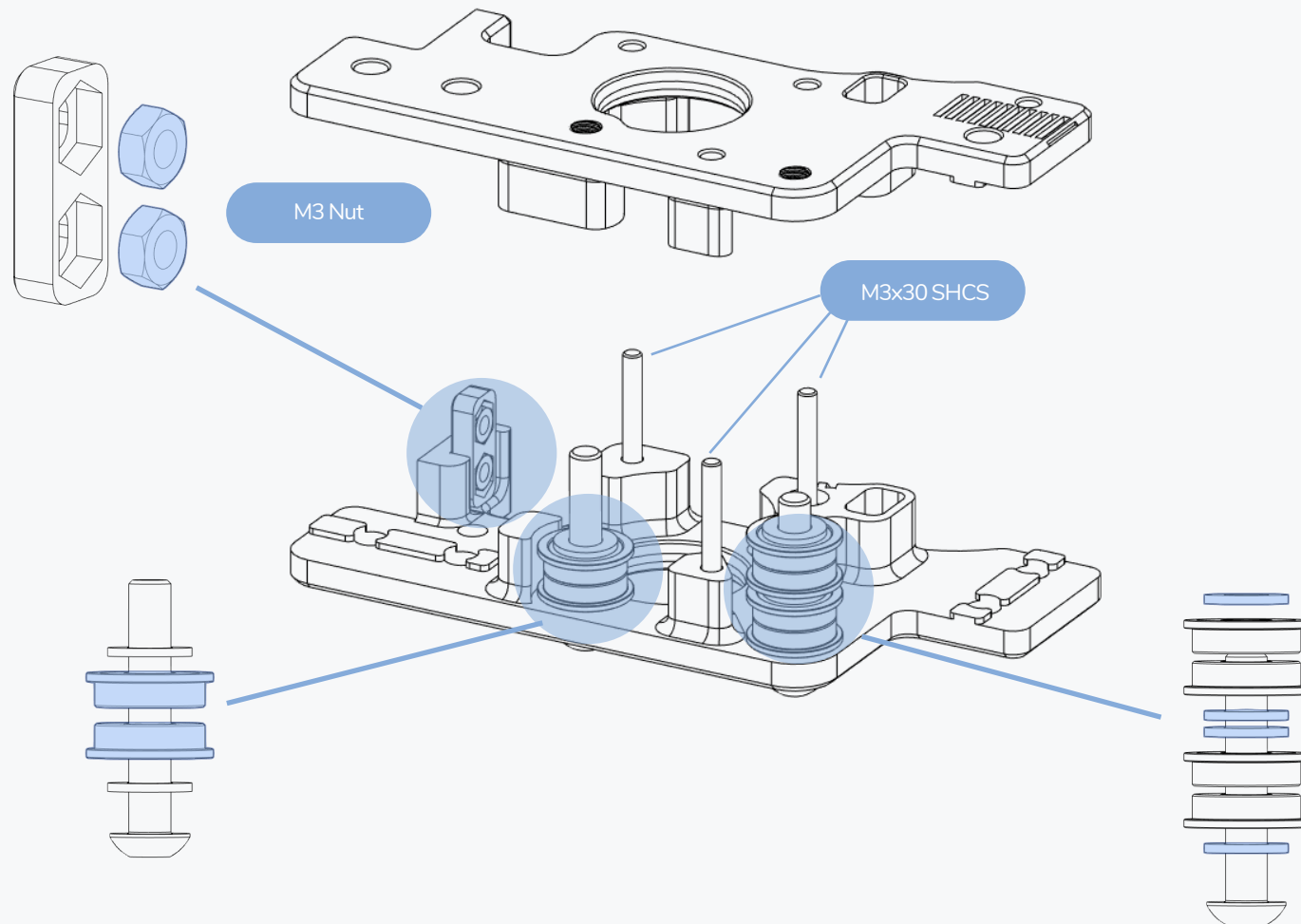




UPSIDE DOWN

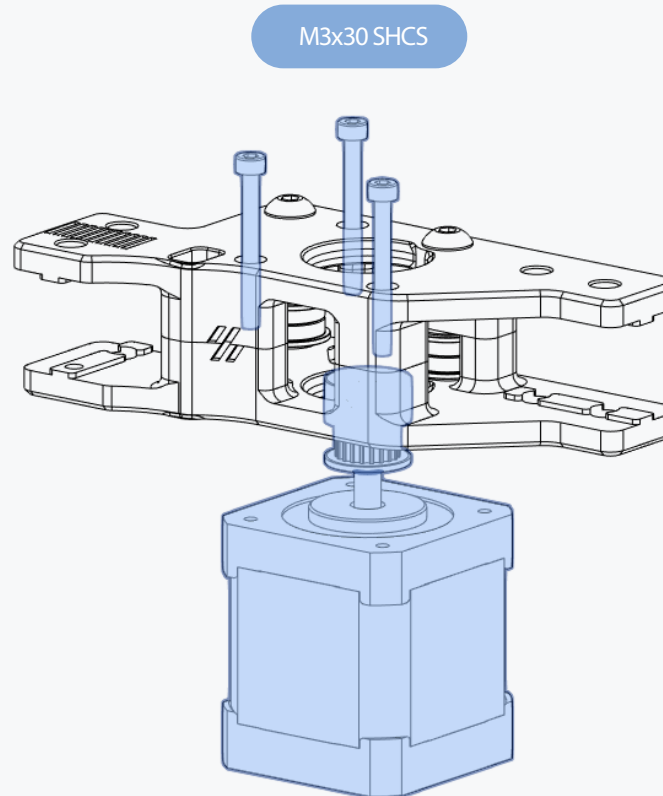
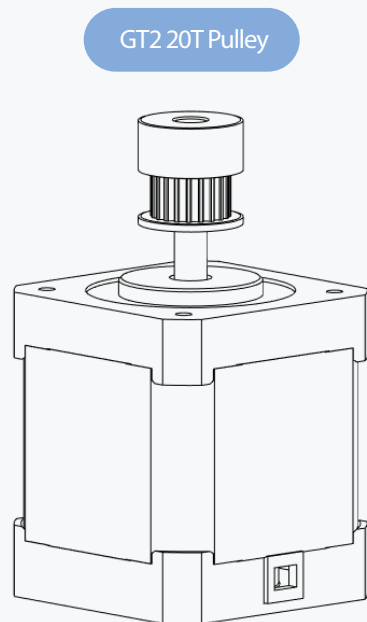
It's easier to build these upside down. Feed the M3 and M5 bolts through the top, flip it over and start building your bearing stacks.

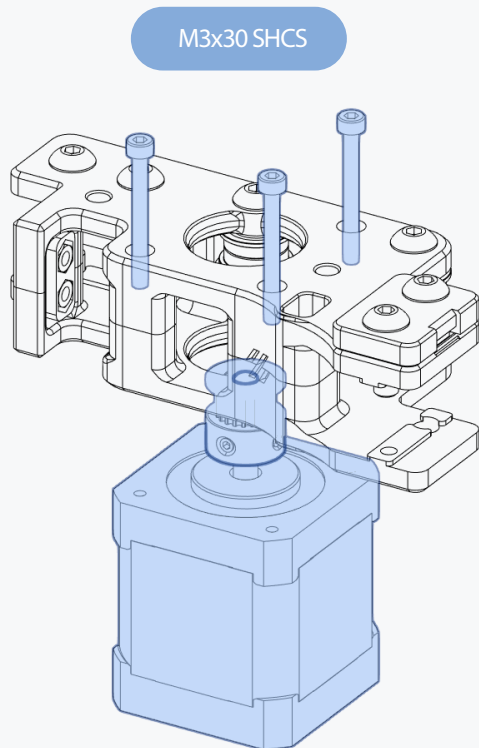




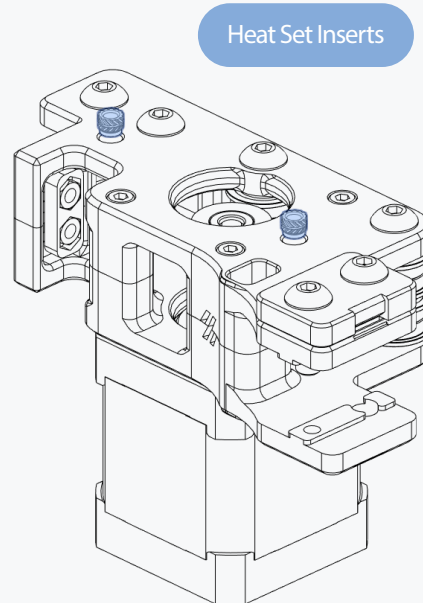
APPLY THREAD LOCK COMPOUND

Make sure to apply thread lock compound to the pulley grub screws.

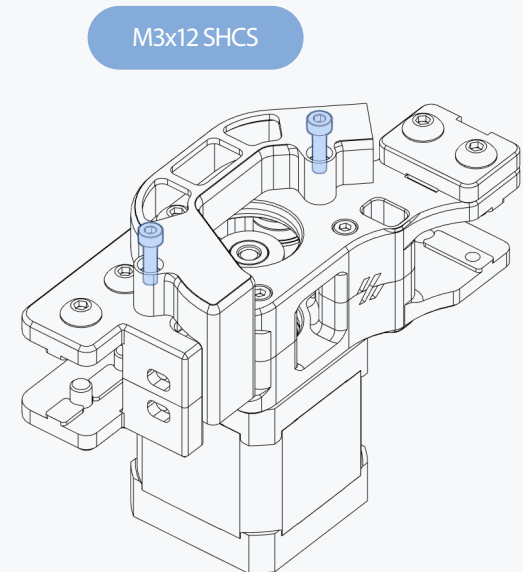




M3x30 SHCS



Heat Set Inserts

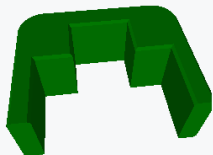
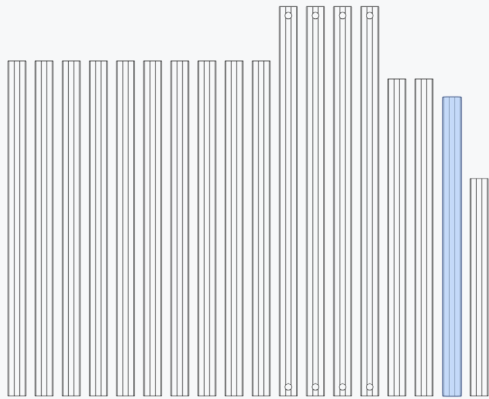


M3x12 SHCS

CHECK 20T PULLEY

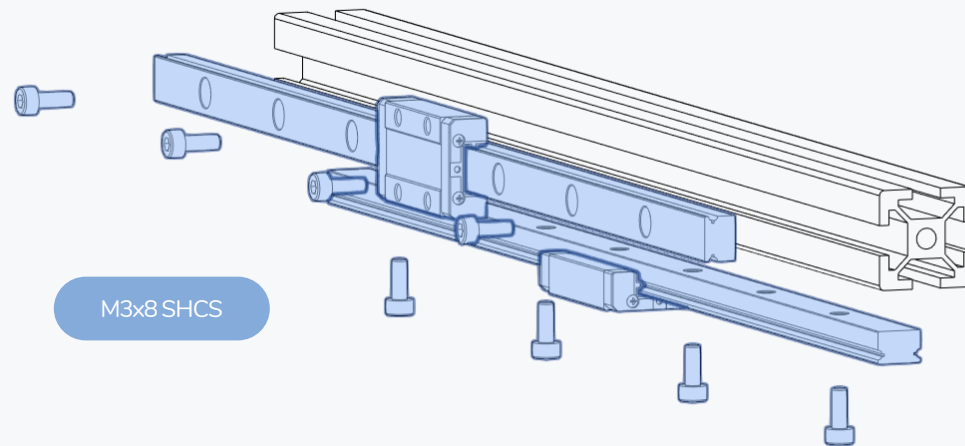
Make sure you mounted your 20T pulley on your A drive (right side image) opposite to the way we did the B drive (left side image).

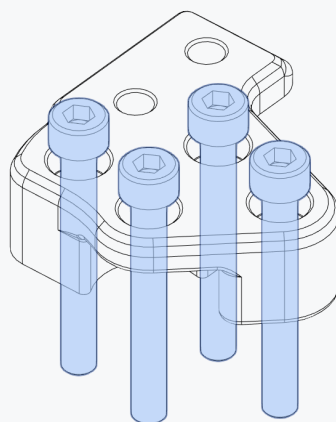
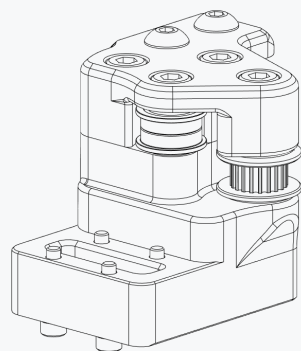




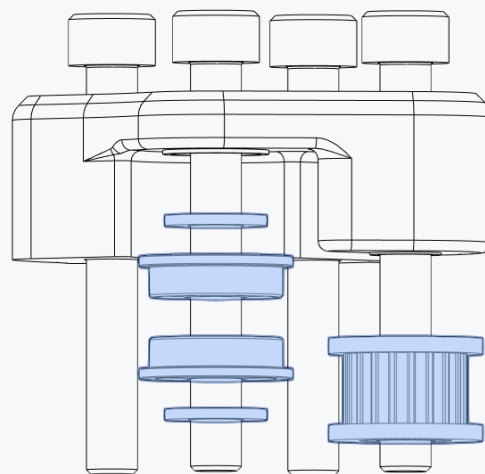
CENTERED RAIL INSTALLATION GUIDE

When tightening the fasteners to hold the linear rails in place, ensure that you have attached a centered rail installation guide to both the top and bottom. You should have two printed.





M5x40 SHCS

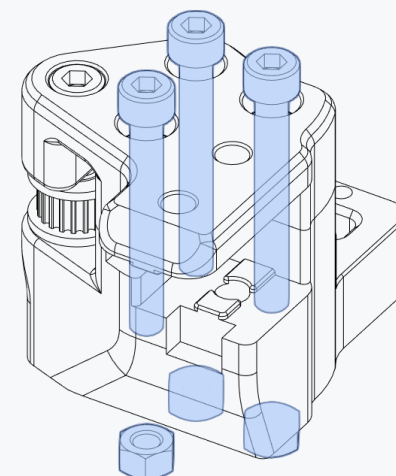


GT2 20T Idler

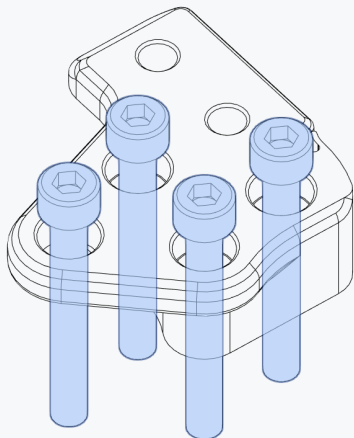
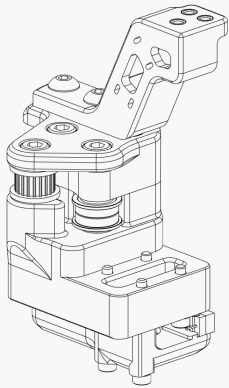
BEARING STACKS

See previous examples for how to assemble these.

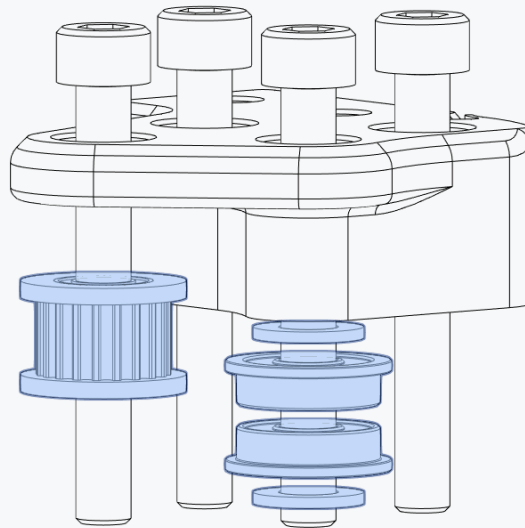
We use the same bearings and fasteners as used in other steps.



M5 Hex Nut



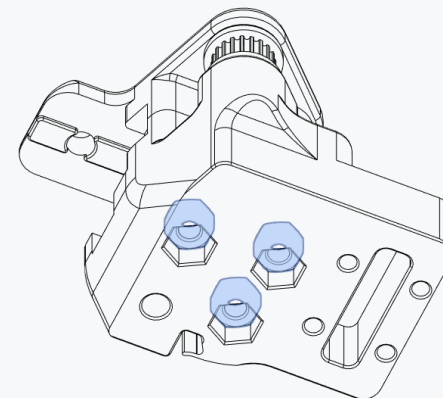
M5x40 SHCS



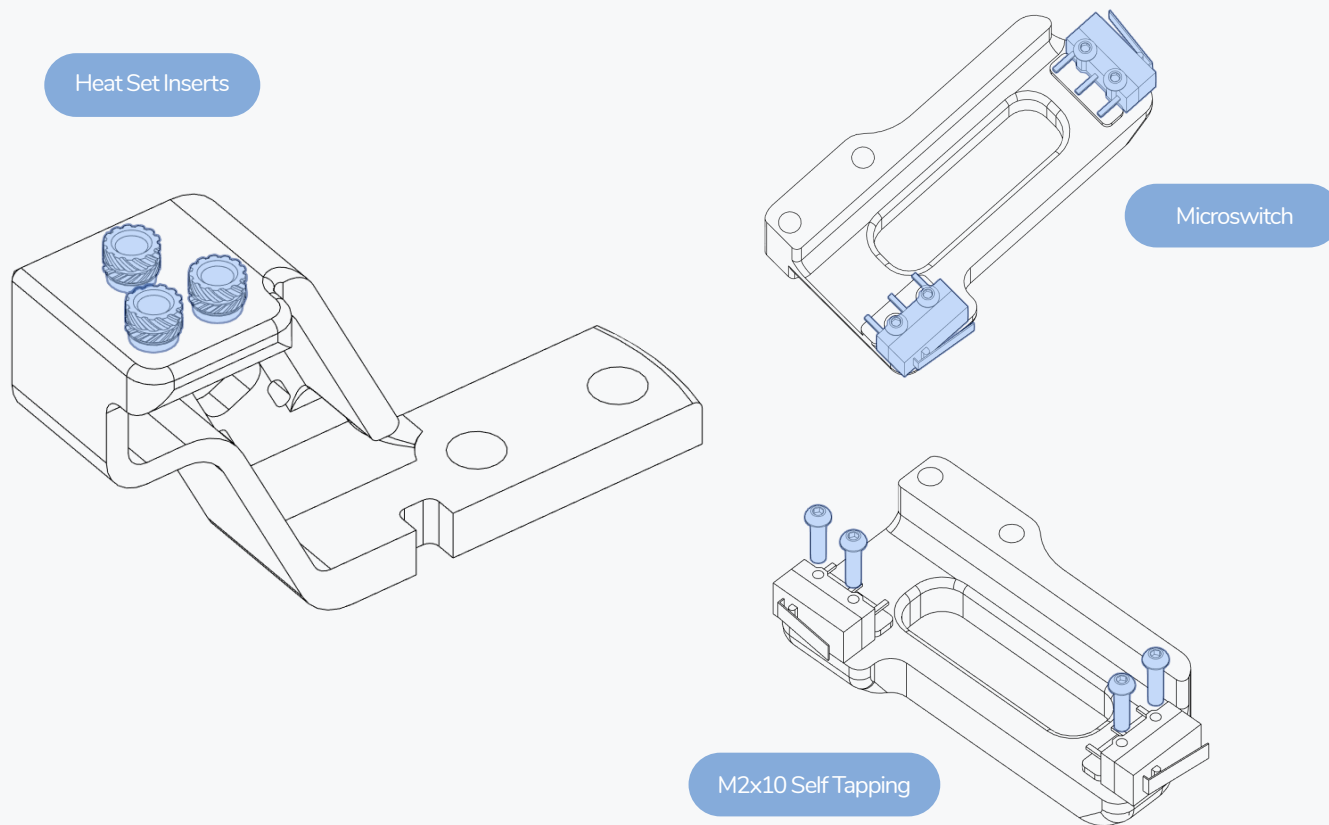
GT2 20T Idler

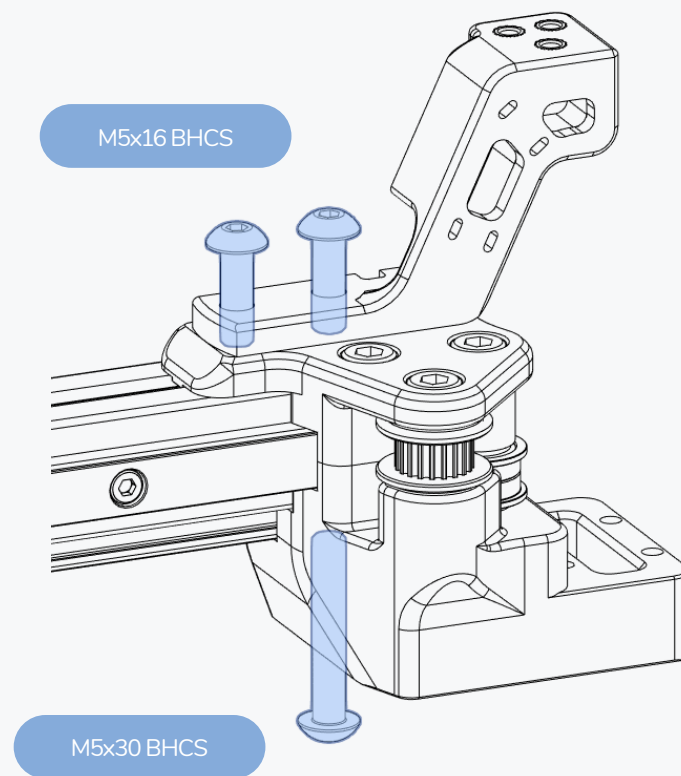
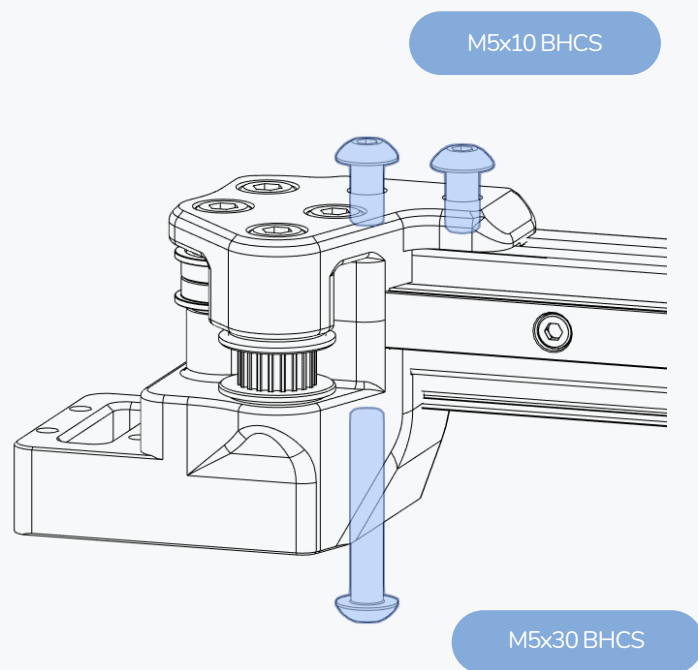
BEARING STACKS

See previous examples for how to assemble these. We use the same bearings and fasteners as used in other steps.

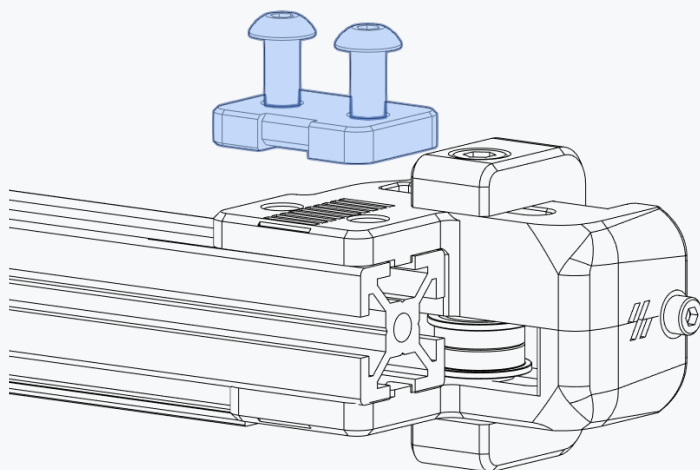


M5 Hex Nut



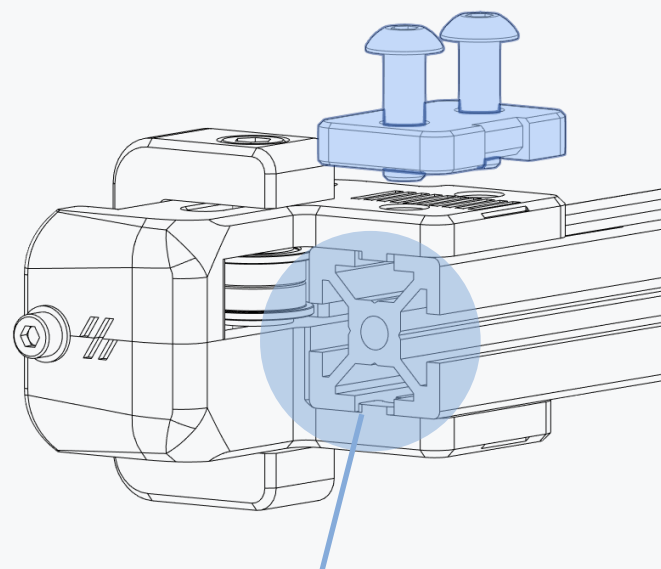


M5x16 BHCS

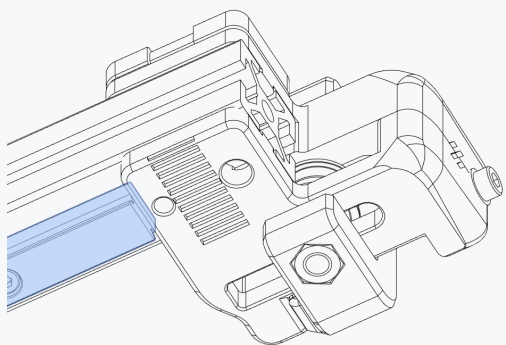
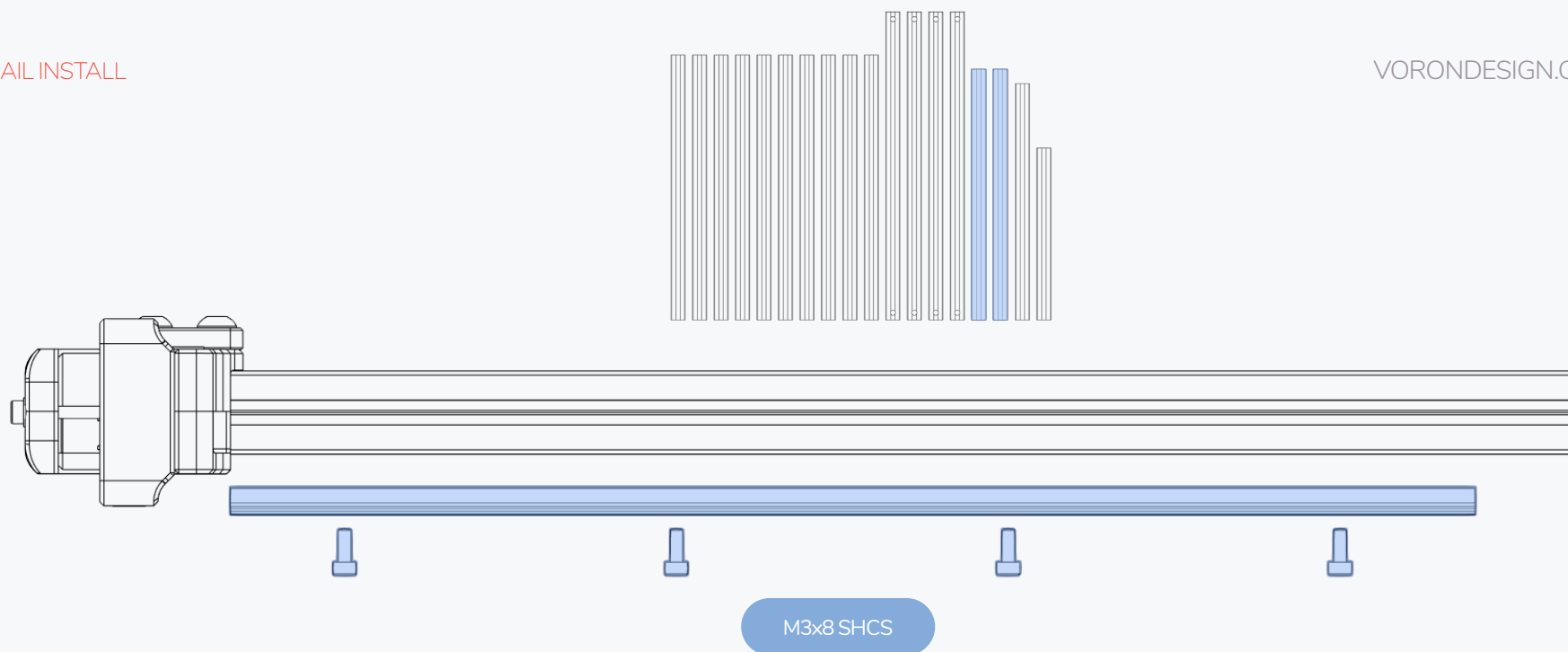
**LEFT IDLER**

Make sure you mounted your 20T pulley on your A drive (right side image) opposite to the way we did the B drive (left side image).

M5x16 BHCS

**FLUSH INSTALL**

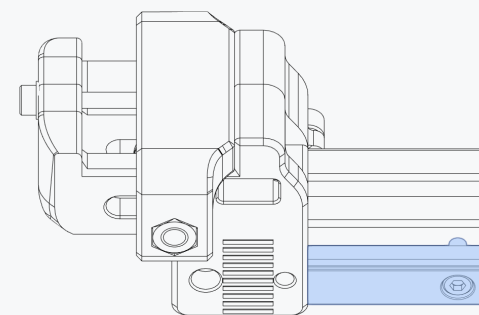
We are going to be indexing things off the front idlers moving forward. Take your time and ensure that both idlers are sitting flush to the end of both extrusions. Errors here can cause issues later on.

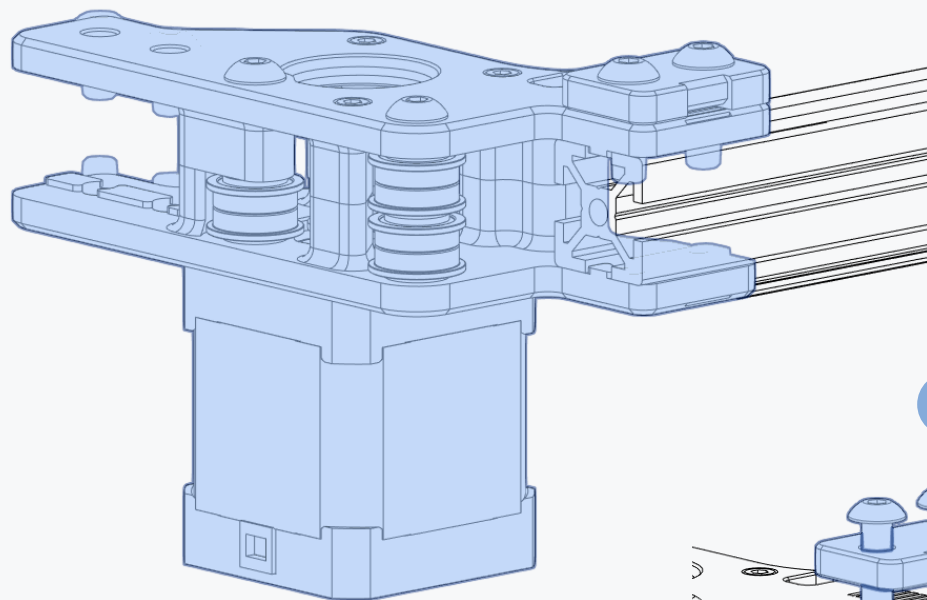


INSTALLING Y LINEAR RAILS

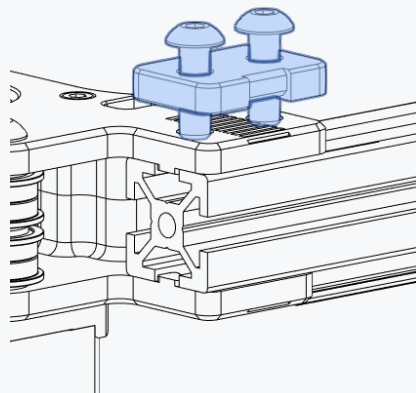
The front idlers are our index point for the Y rail installation. Confirm that both idlers are sitting flush with the end of the extrusion and then install the linear rails such that they are pressed firmly against the backs of the idlers.

Don't forget to use your rail center guide!

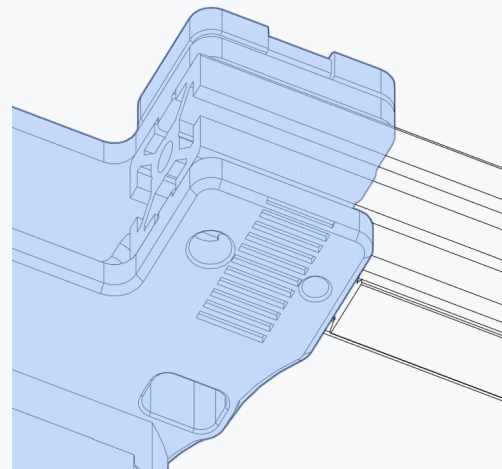




M5x16 BHCS

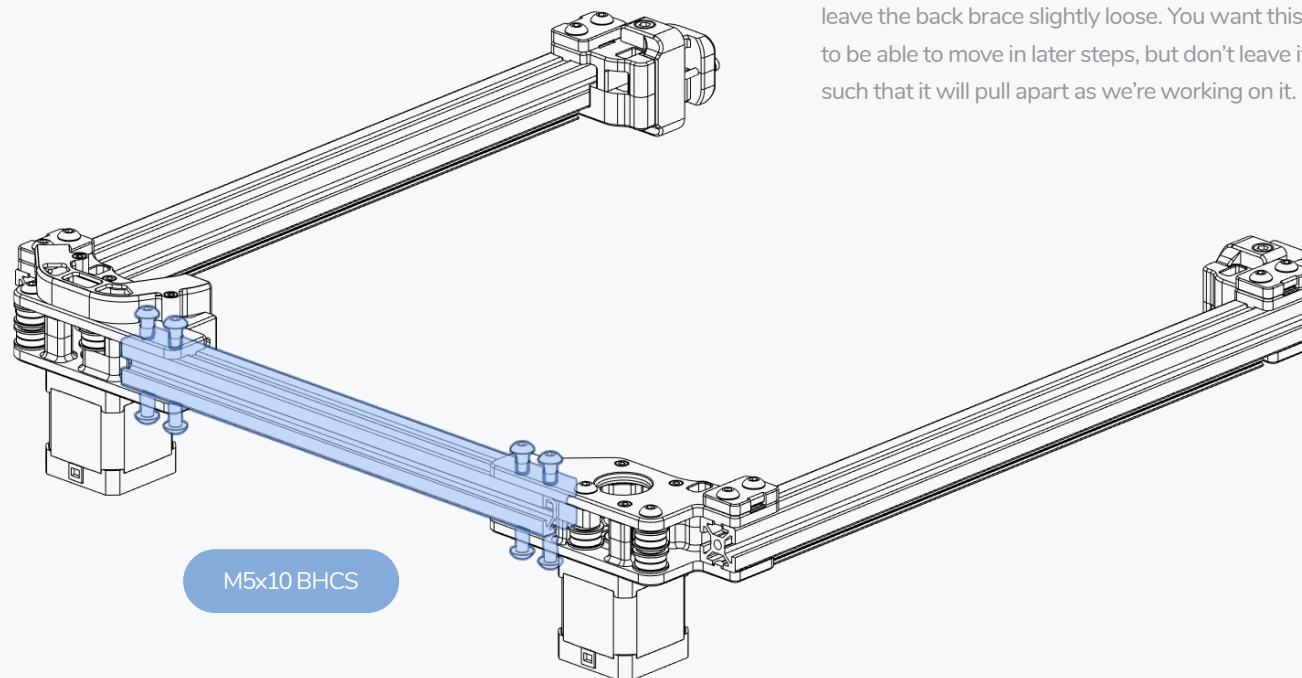
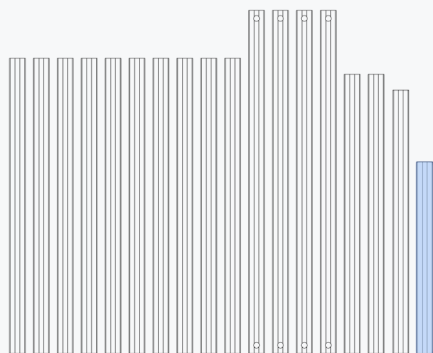
**INSTALLING AB DRIVE UNITS**

With your front idlers and linear rails on your Y extrusions, now we can install the AB Drive Units. Press these against the linear rail and secure from the top as per the diagram.



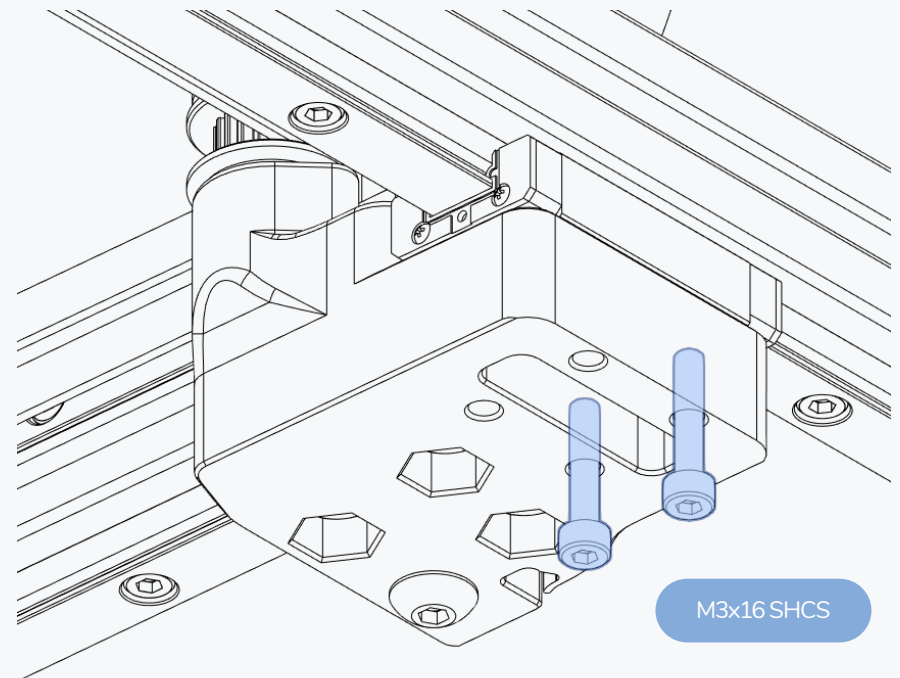
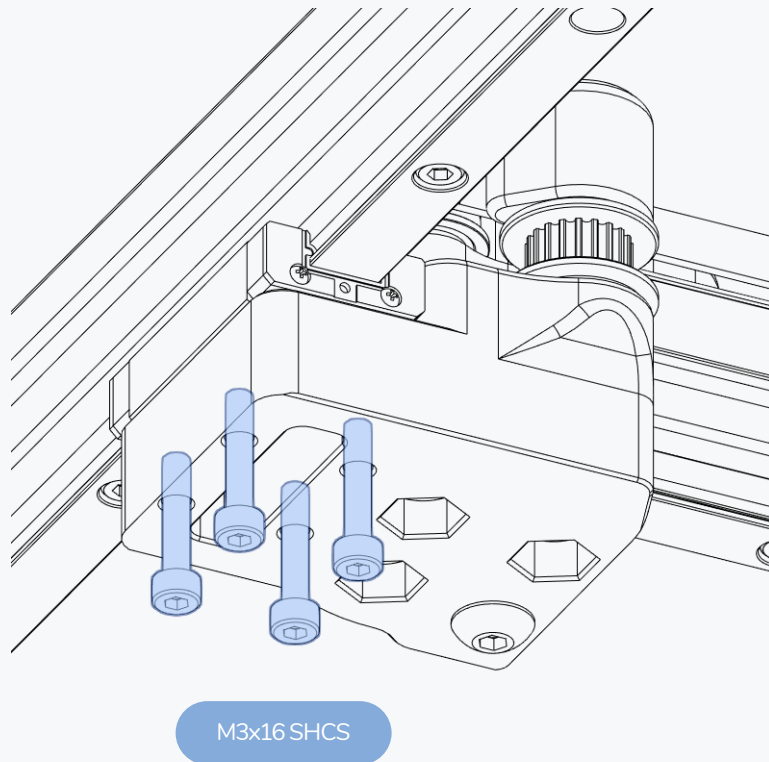
REAR BRACE

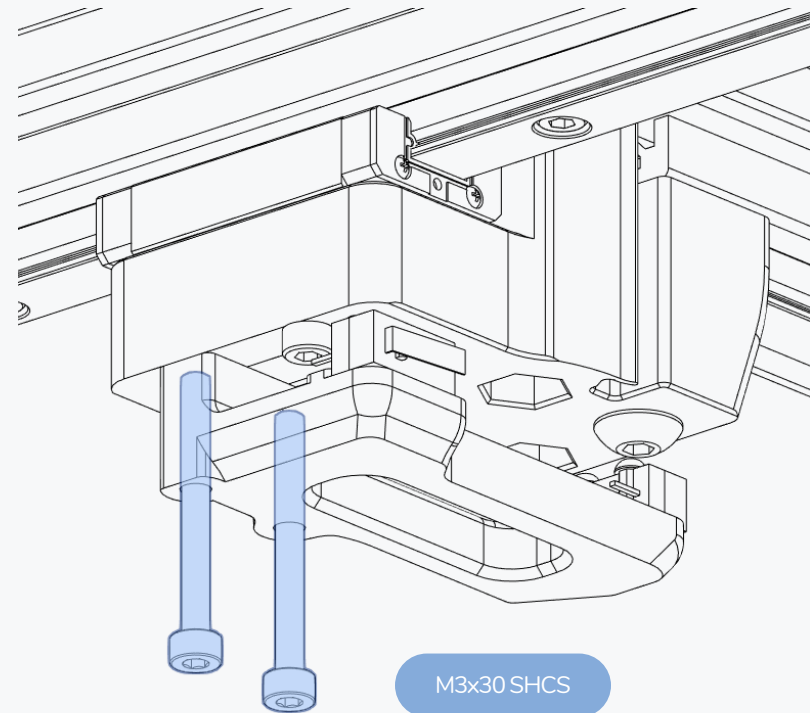
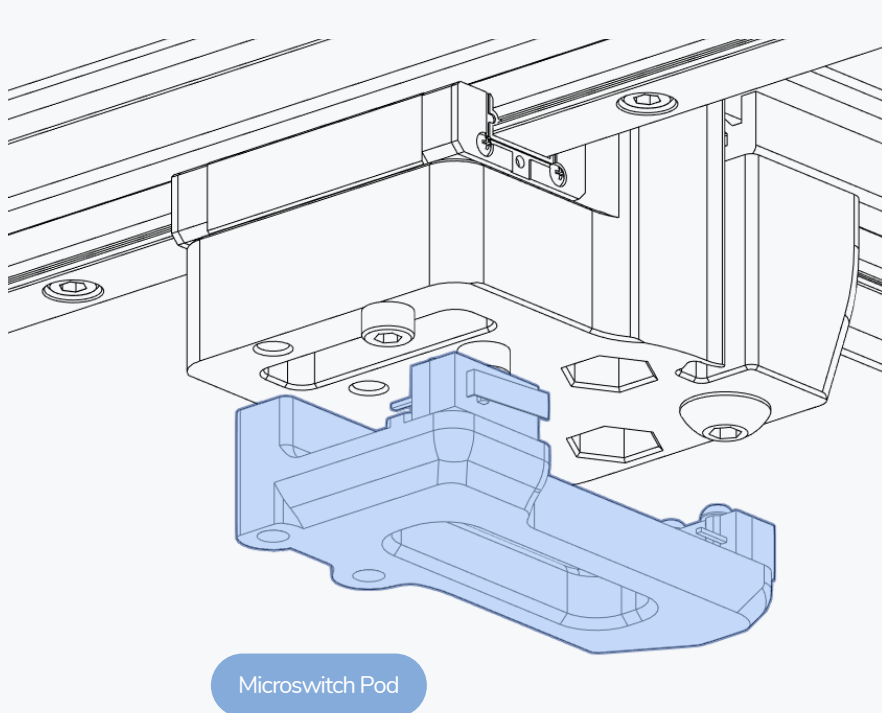
VORONDESIGN.COM



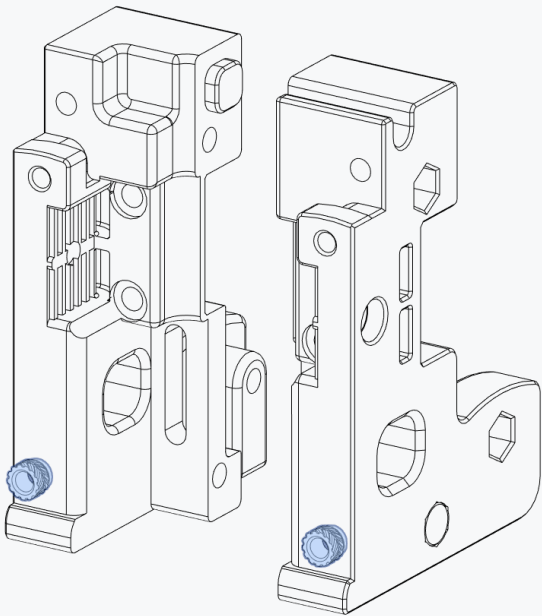
REAR BRACE EXTRUSION

When you install your M5x10 BHCS fasteners, leave the back brace slightly loose. You want this to be able to move in later steps, but don't leave it such that it will pull apart as we're working on it.





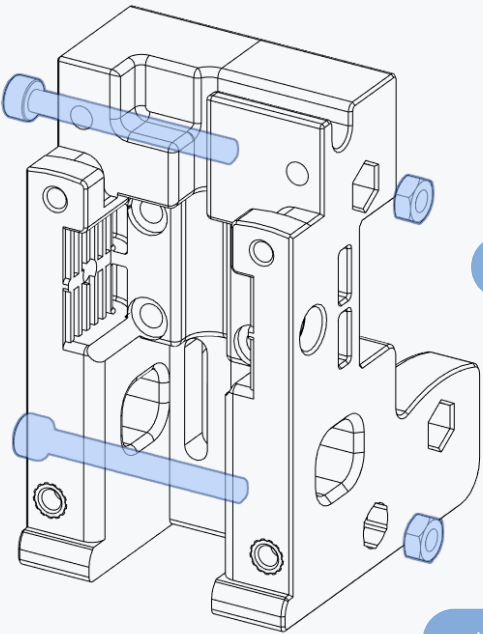




Heat Sets

M3x30 SHCS

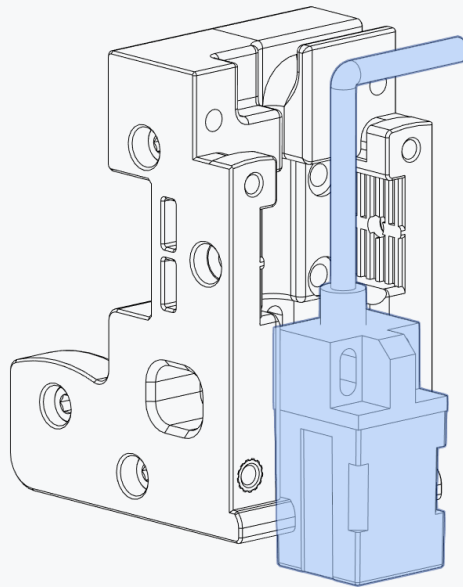
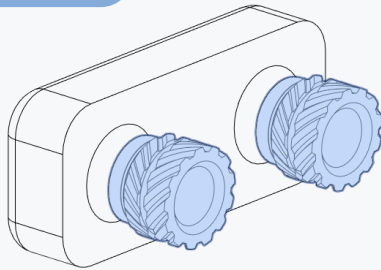
M3x30 SHCS



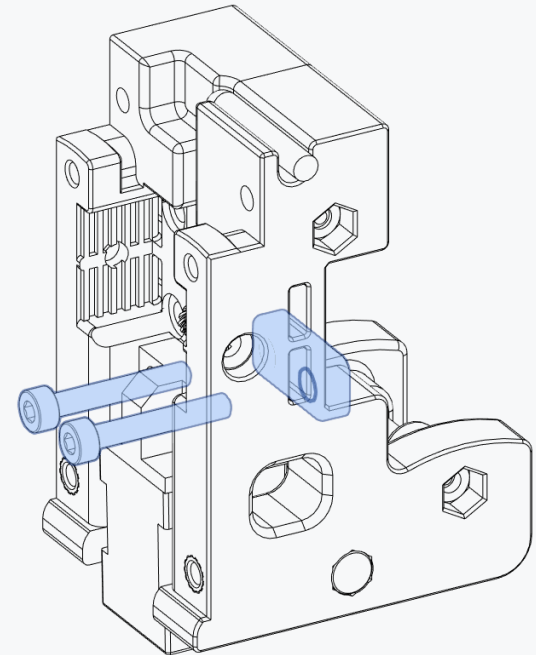
M3 Hex Nut

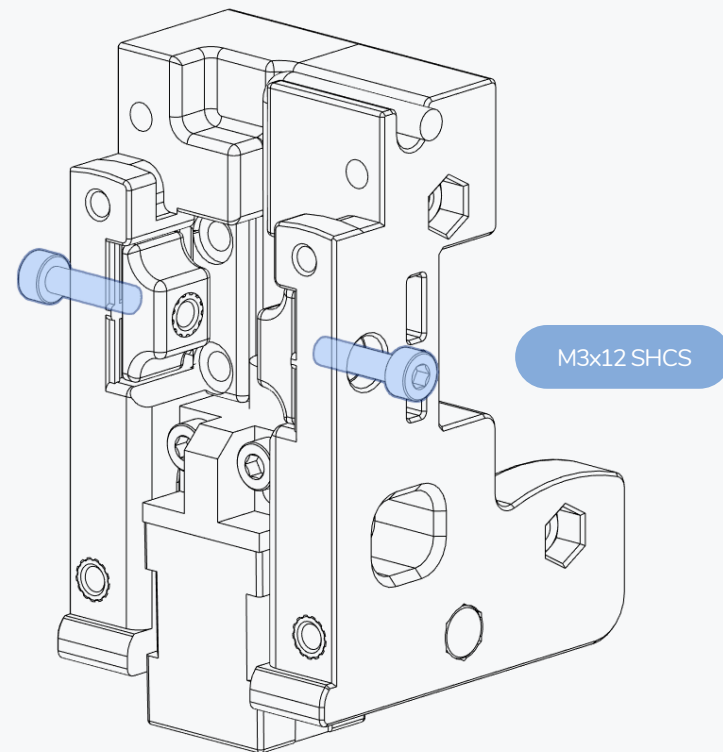
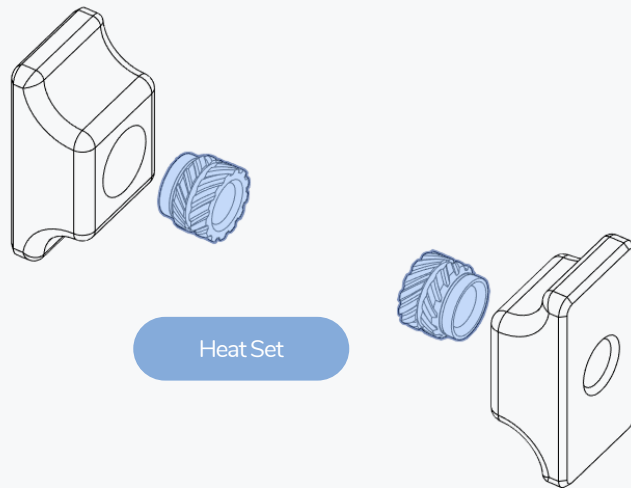
M3 Hex Nut

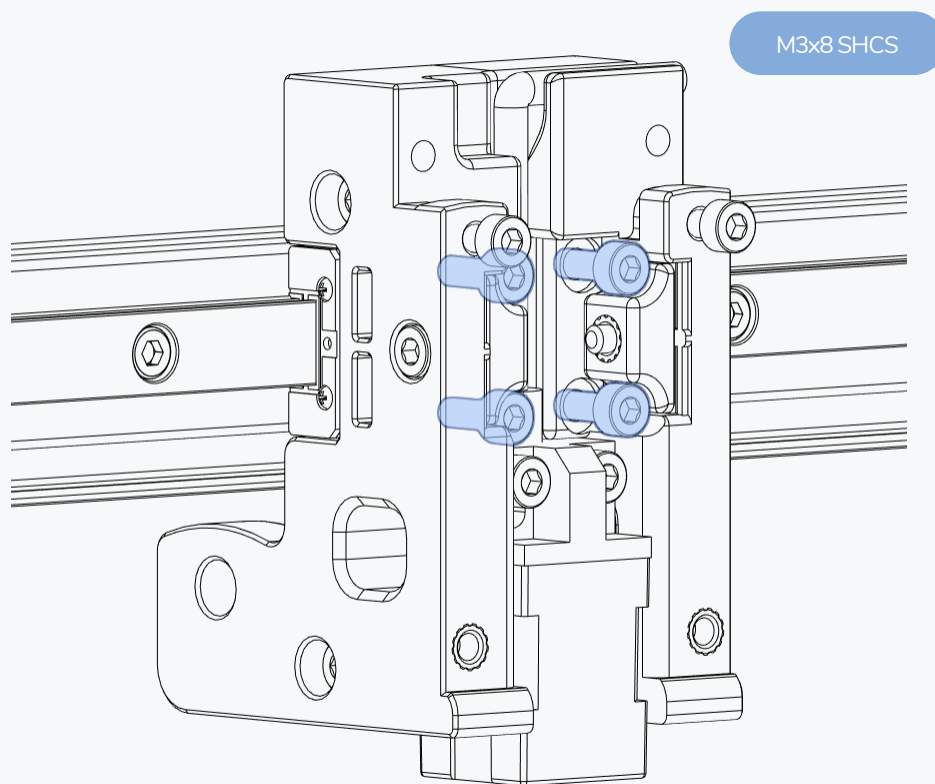
Heat Set



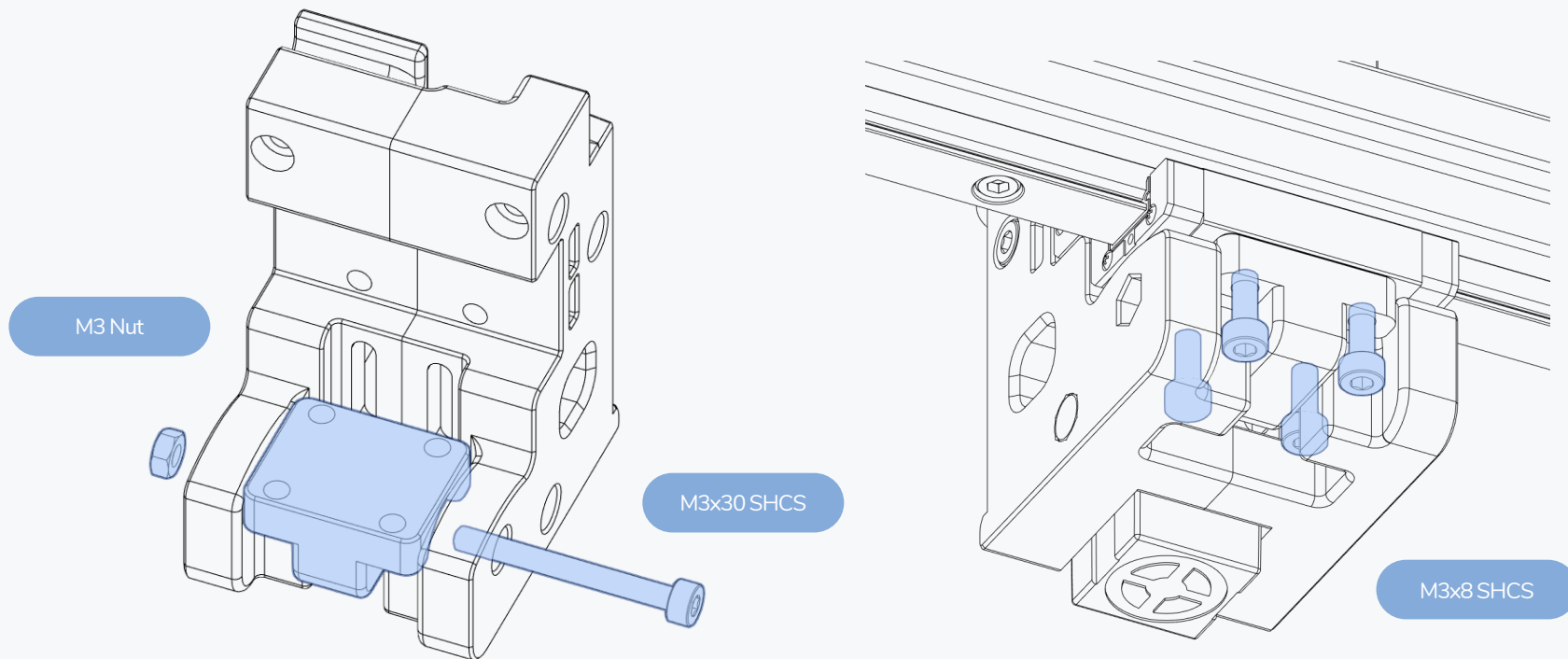
M3x20 SHCS

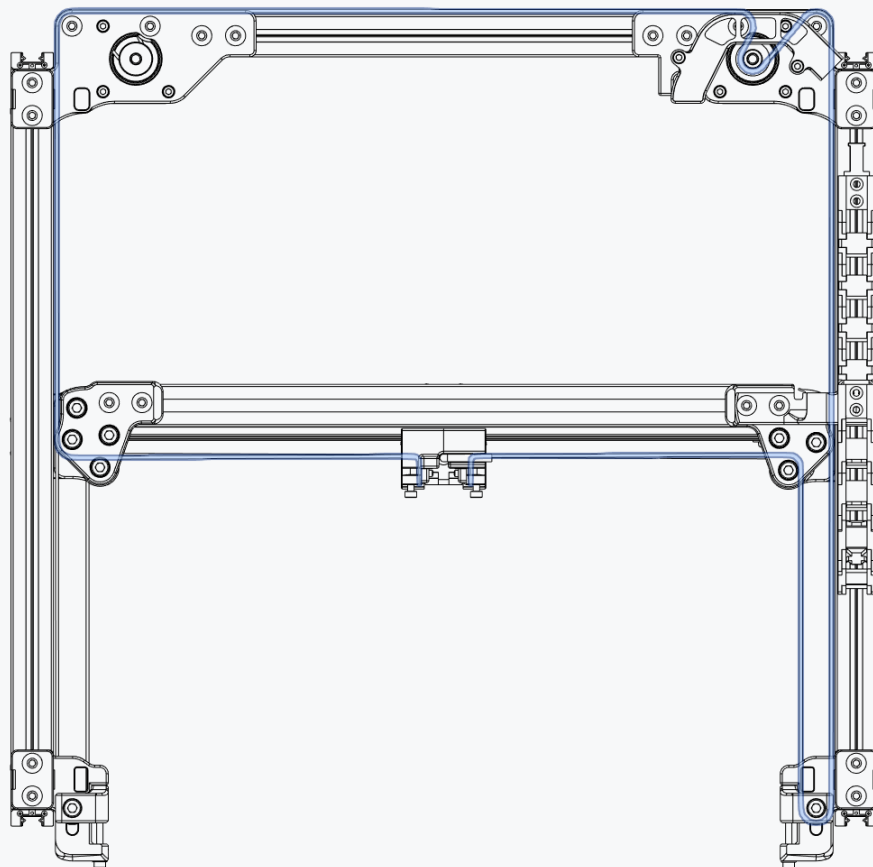




**BUTTON HEAD OPTION**

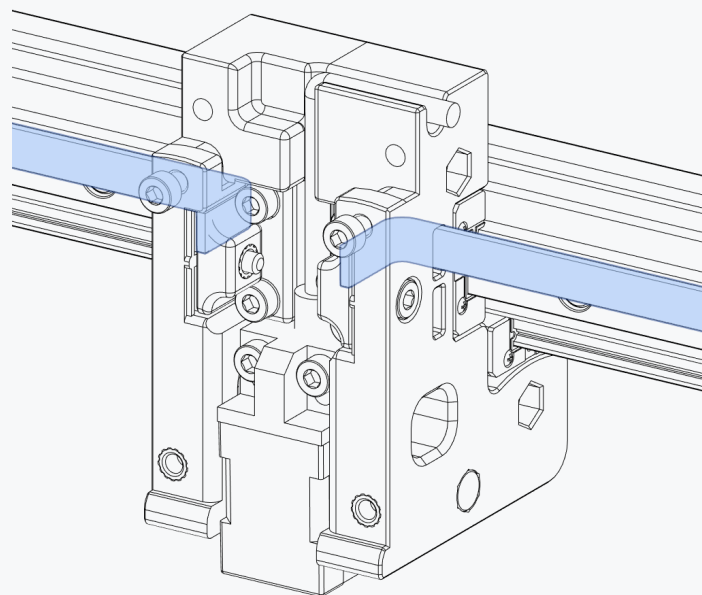
If you happen to have some M3x8 BHCS laying around you can use those here. It can make belting the gantry in later steps a little easier but it's not a big deal if you don't have them.

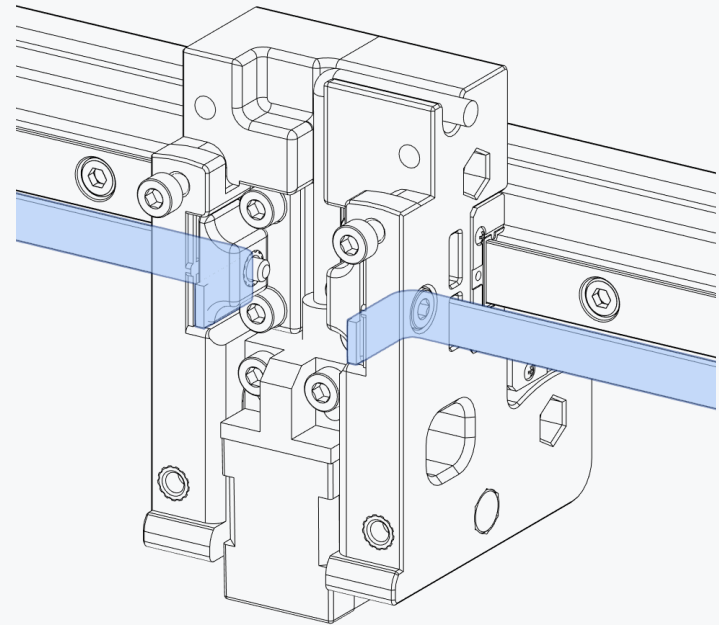
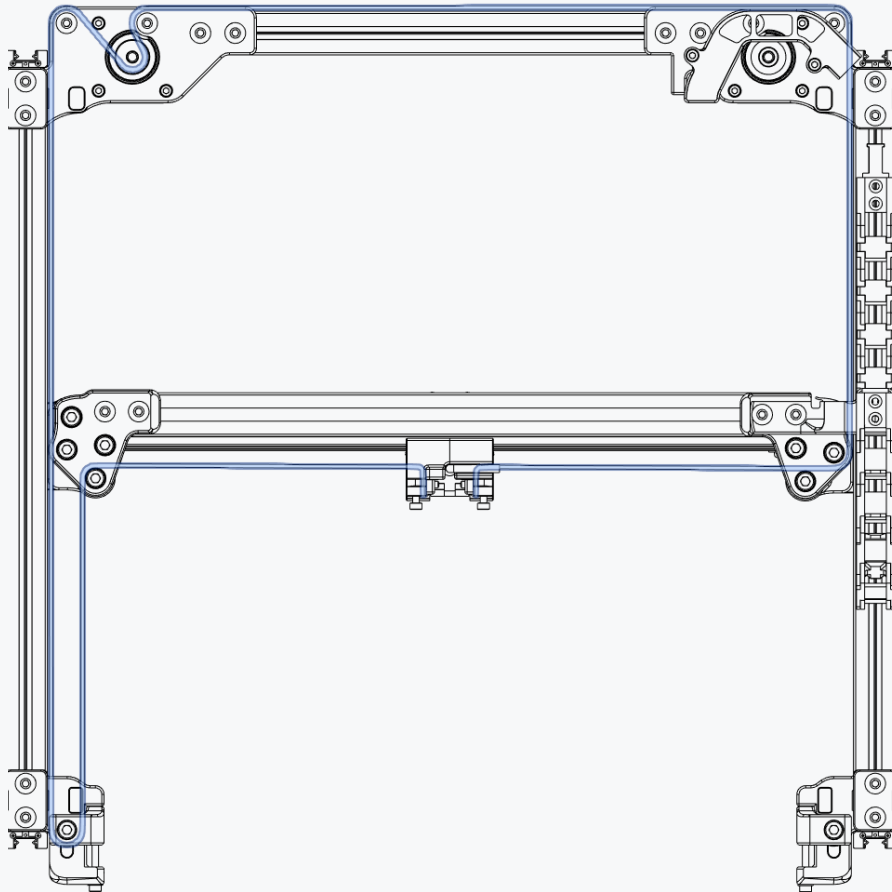




CUTTING BELTS

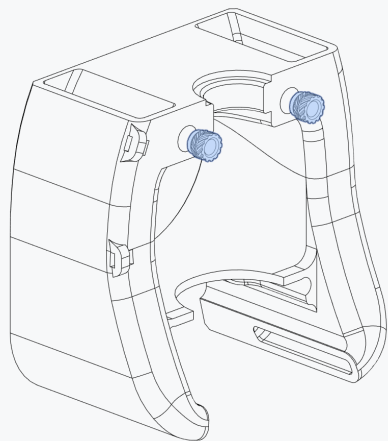
Best practice is to cut both XY belts the same length. You can pre-run one length and then cut the other using it as your guide.



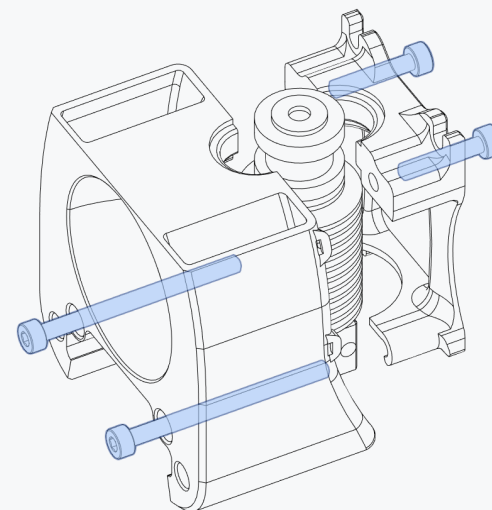
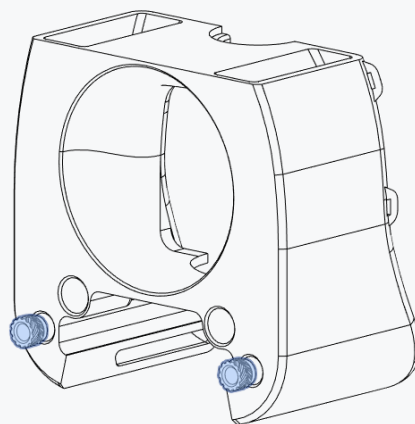


SECURING BELTS

Pick one side of the carriage and tighten the belts down flush with the front face. This allows you to pull the belts on the other side an equal length to help keep things square.



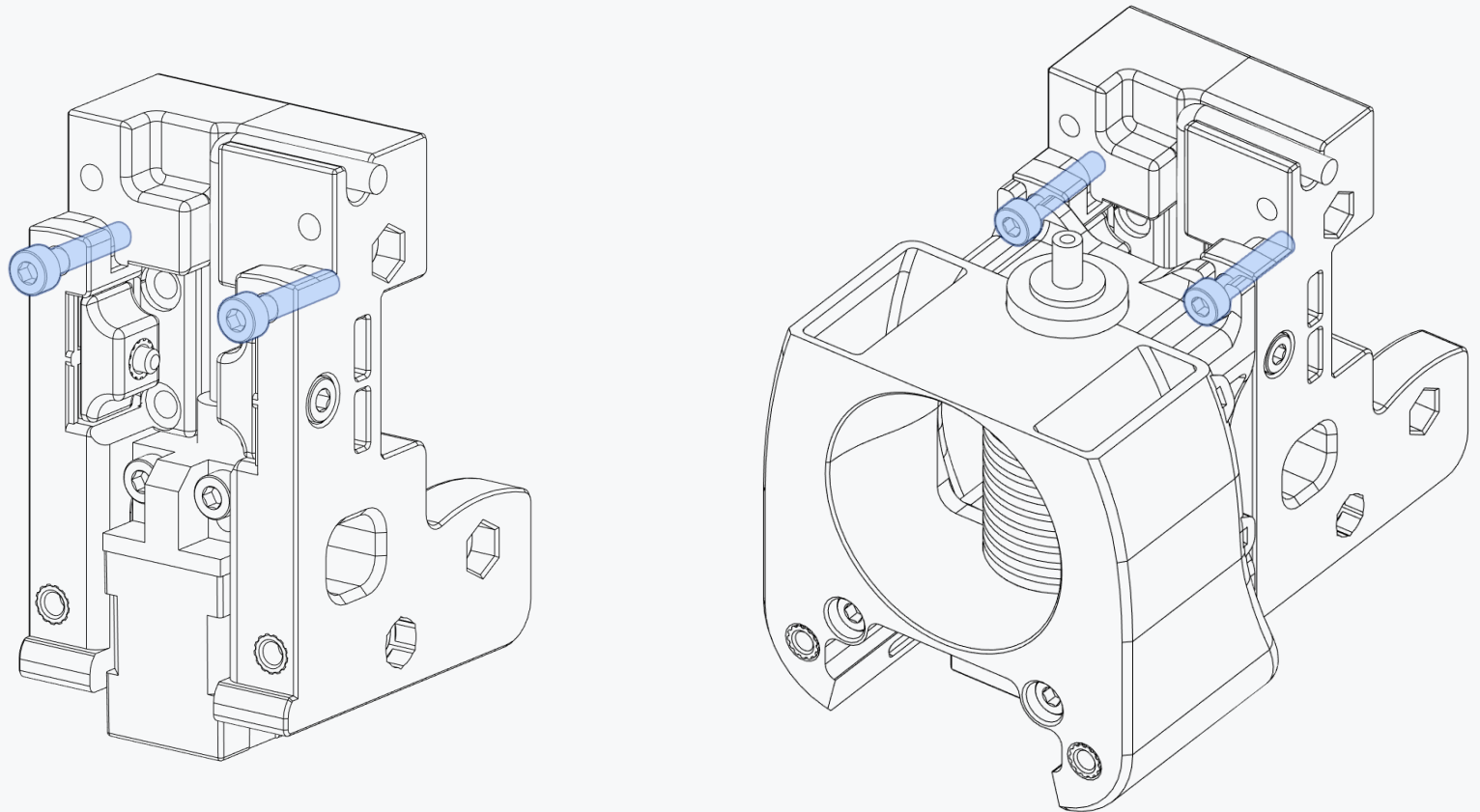
Heat Set

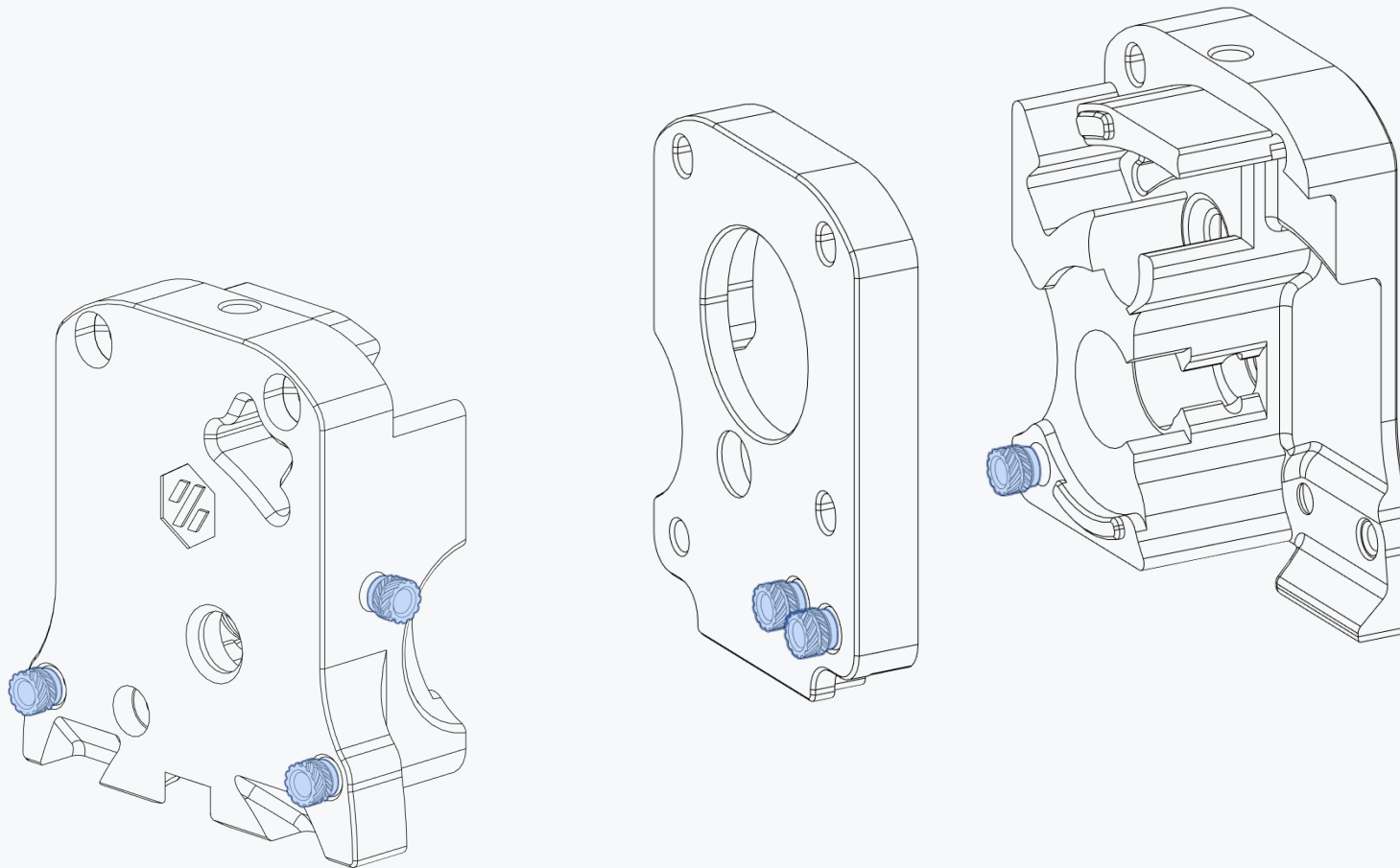


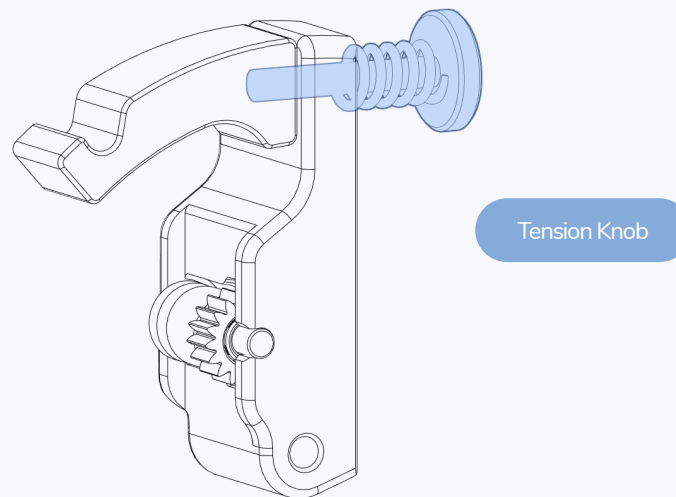
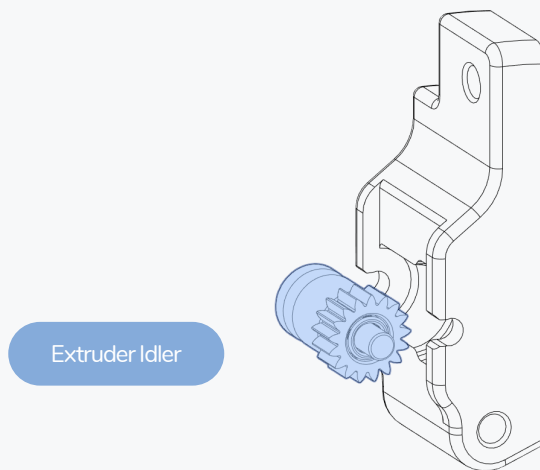
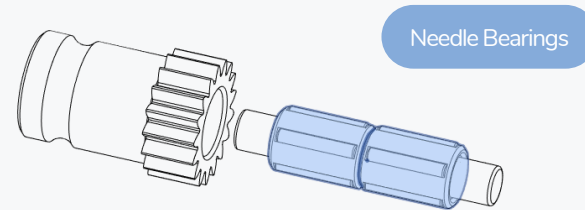
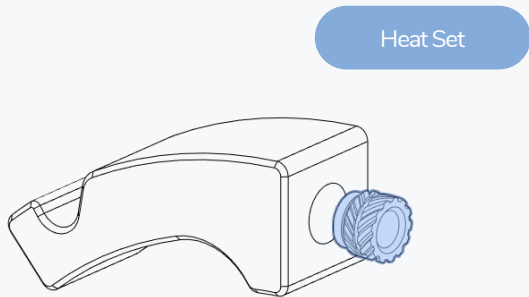
M3x16 SHCS

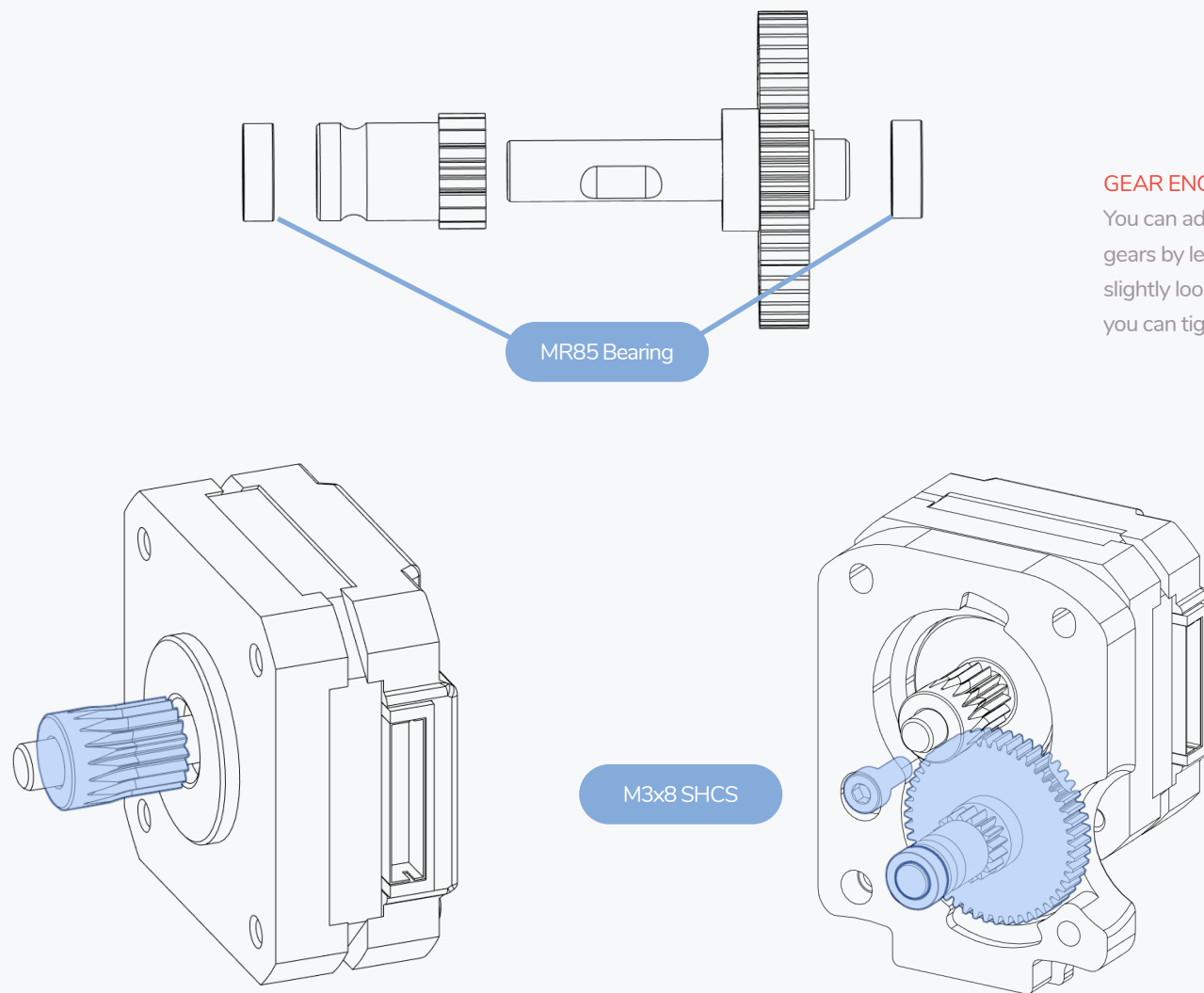
M3x40 SHCS

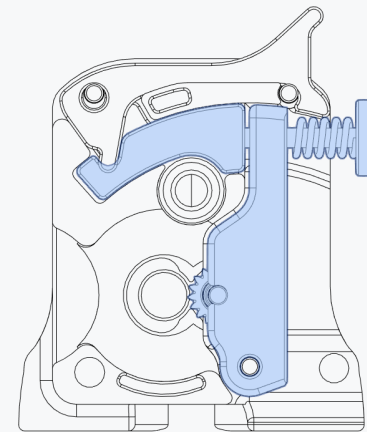
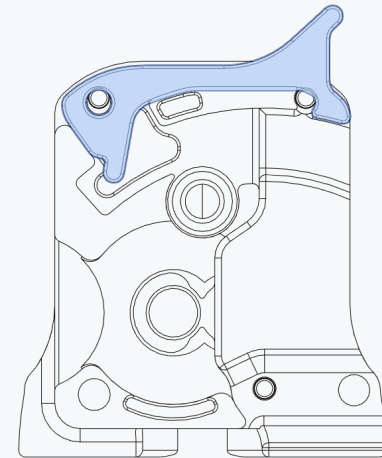
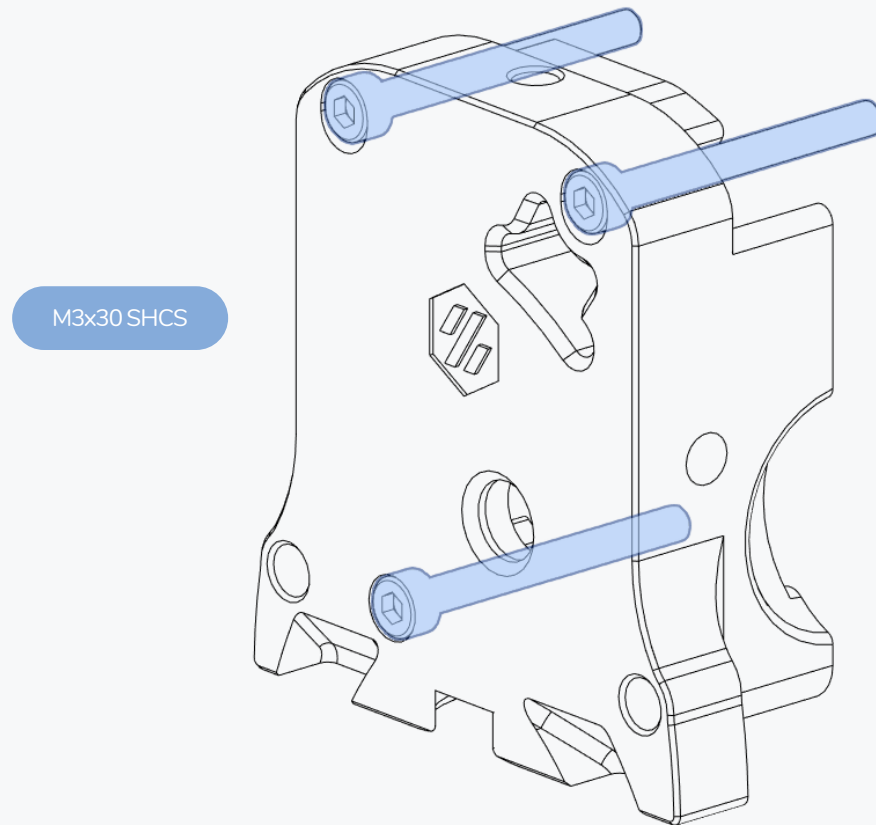
M3x16 SHCS

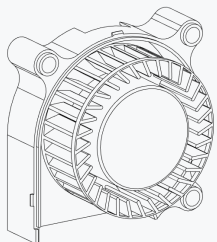




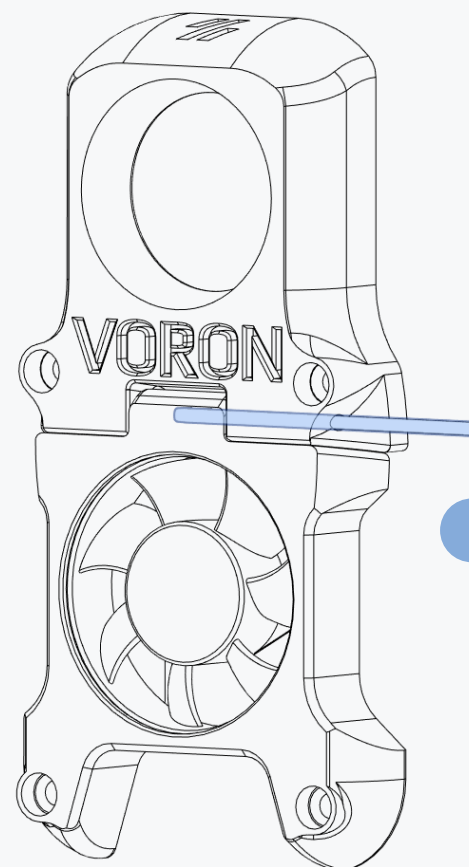
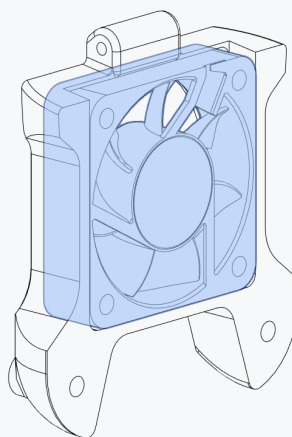
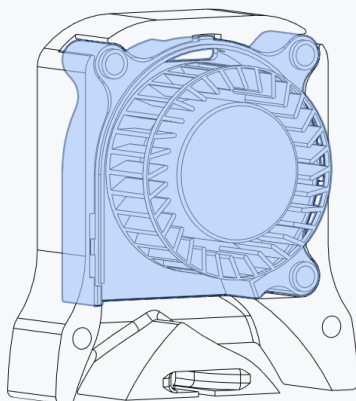




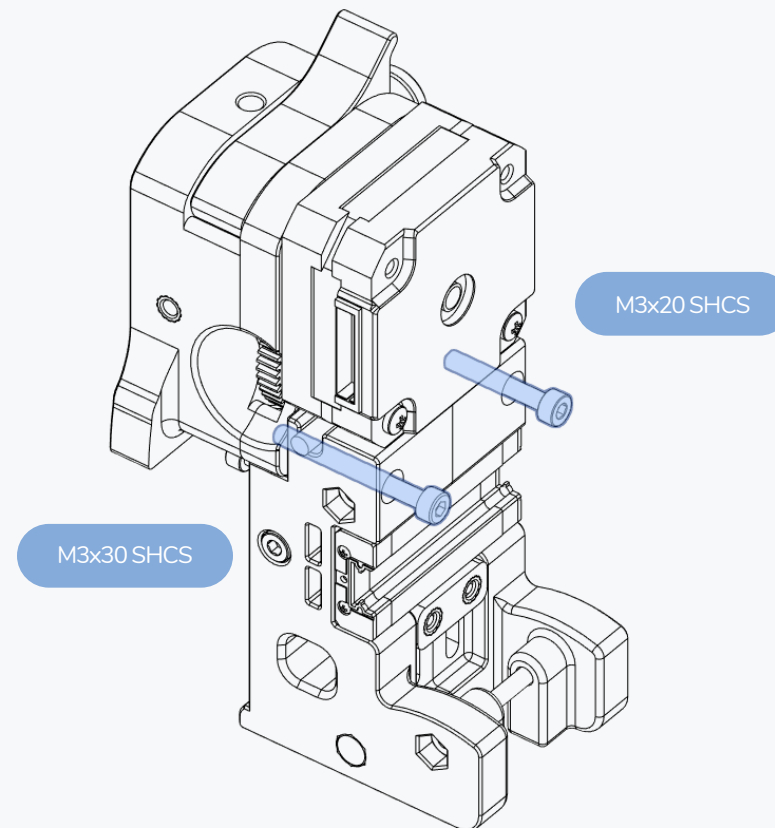
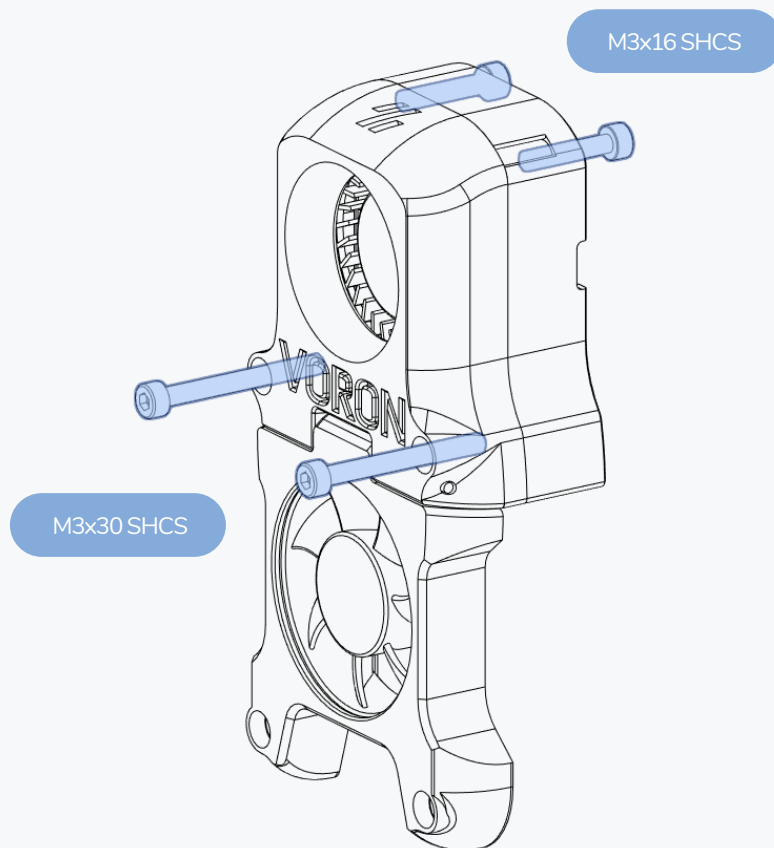


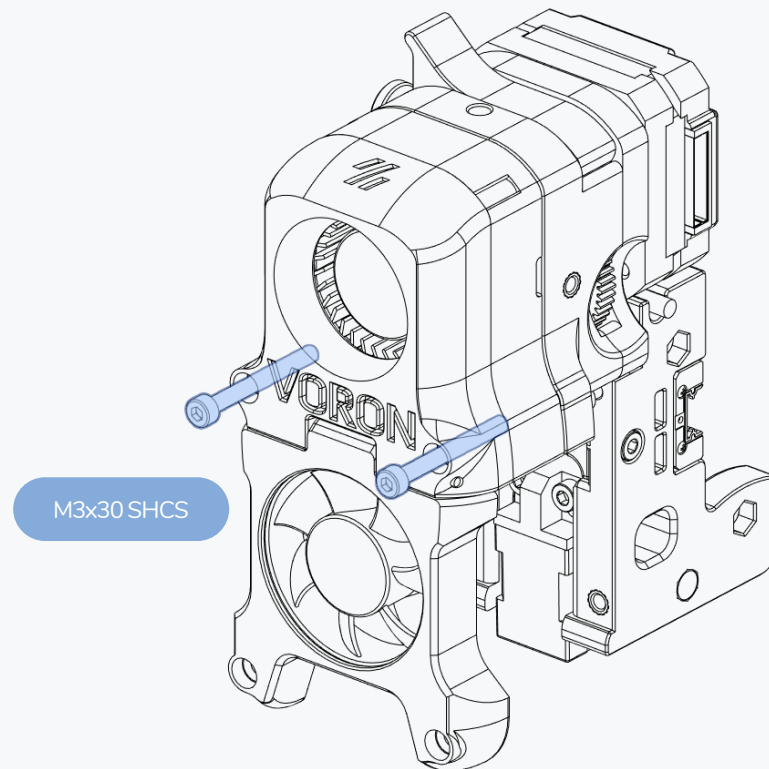
**SEPERATE BLOWER HOUSING**

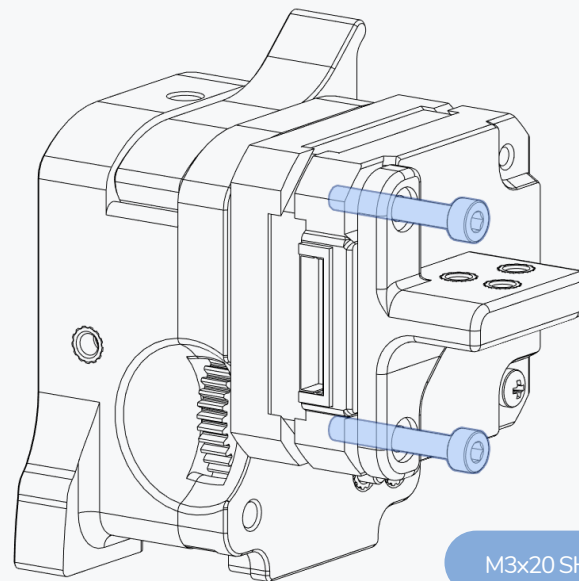
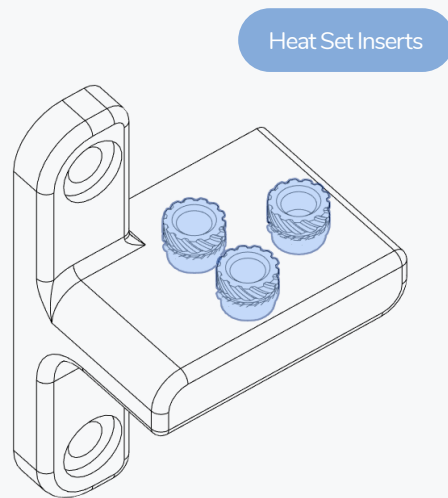
You will have to remove the front of the blower housing before install. You can do this easily by prying the tabs up gently that hold it in place.



1.75MM Filament

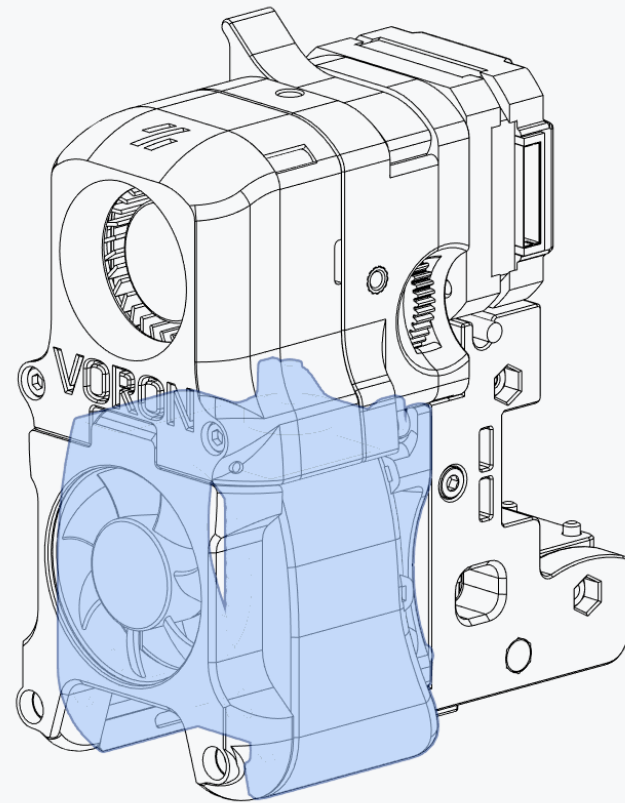
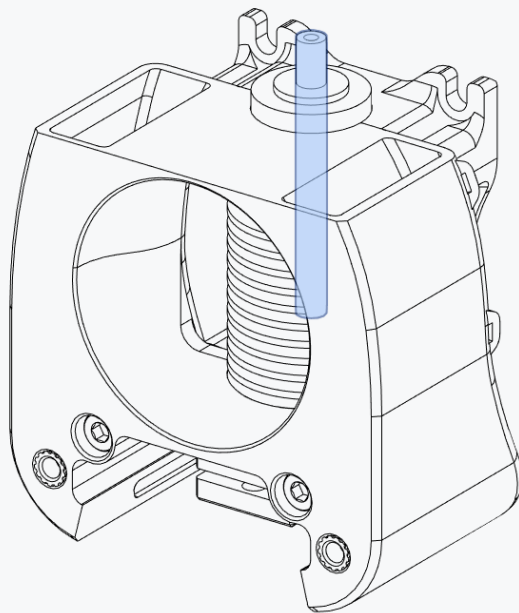


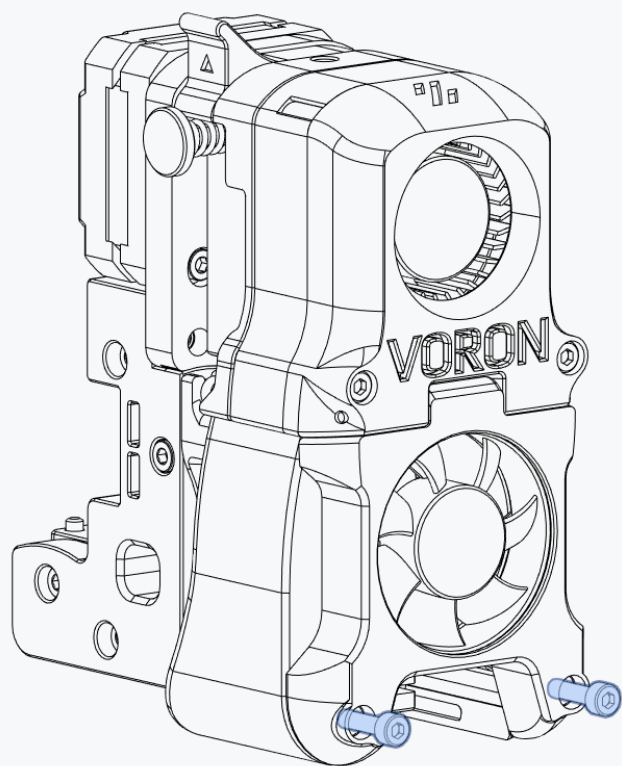


**SWAP FASTENERS**

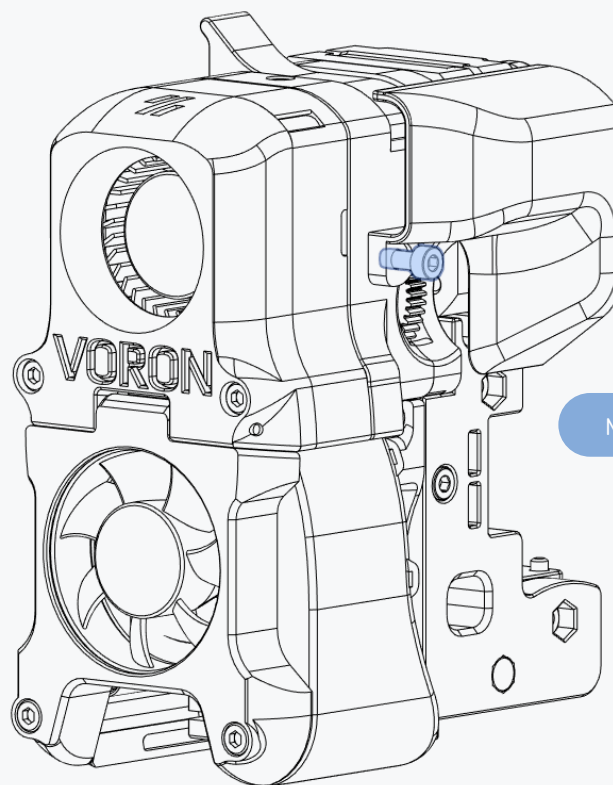
You will be swapping the fasteners that come with the stepper motor in the spots listed here.

Bowden Tube

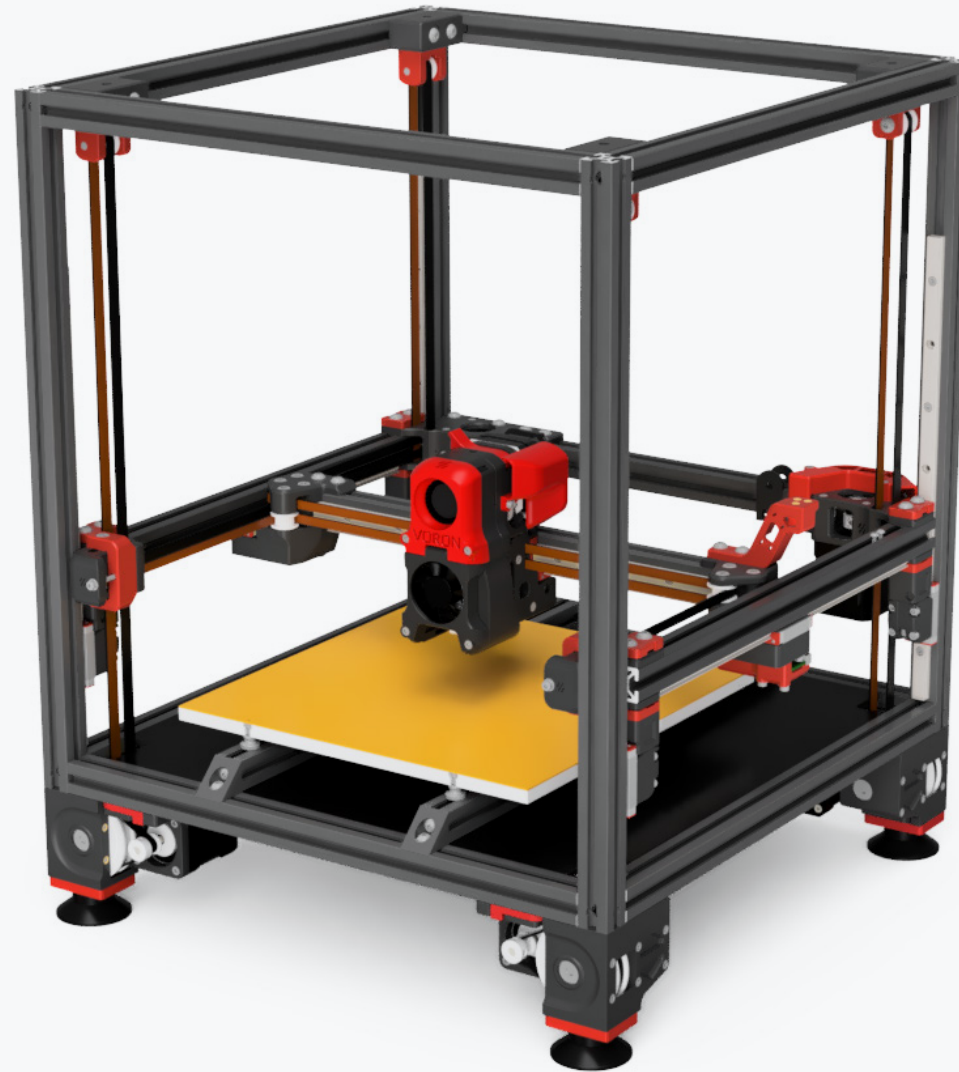


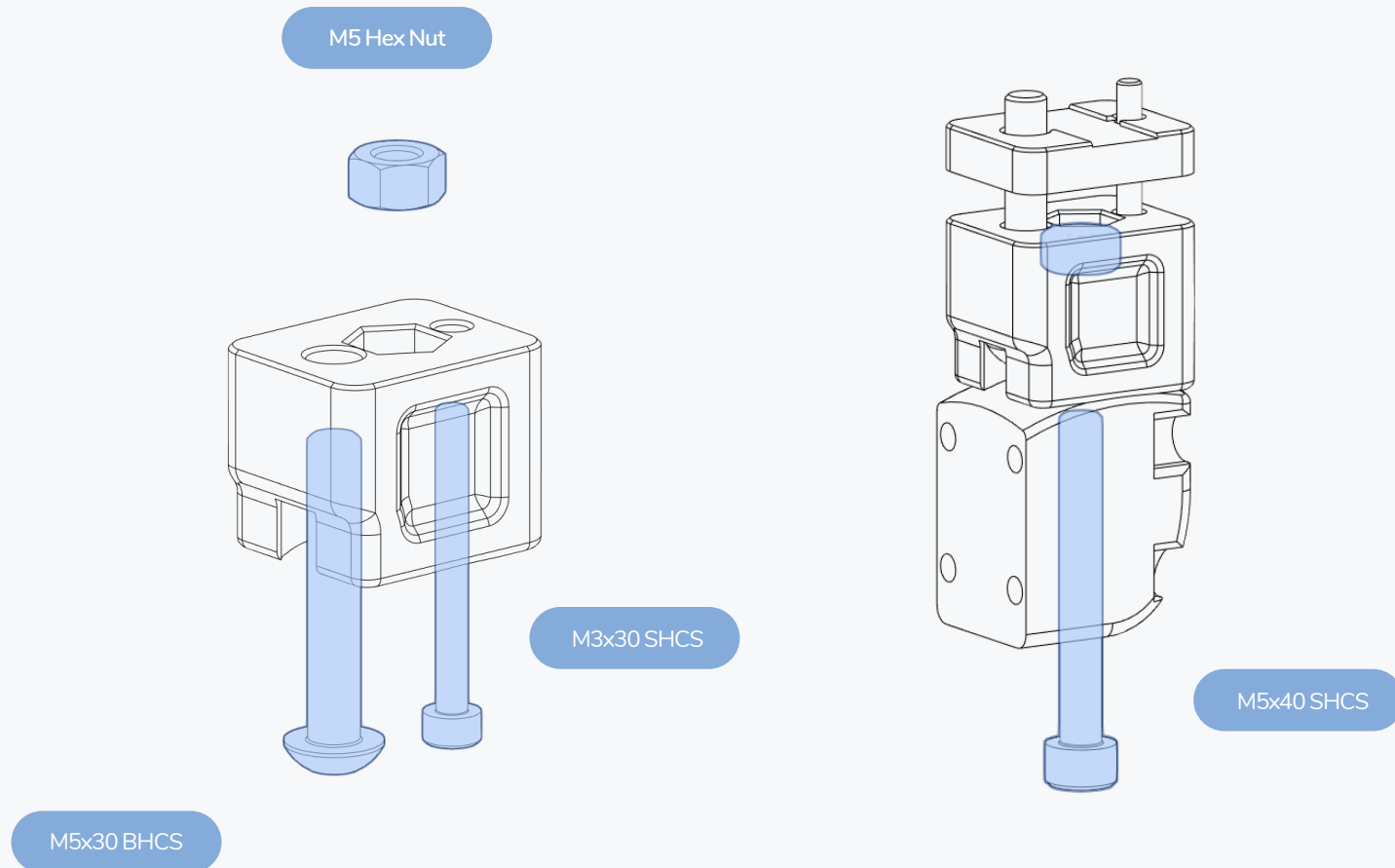


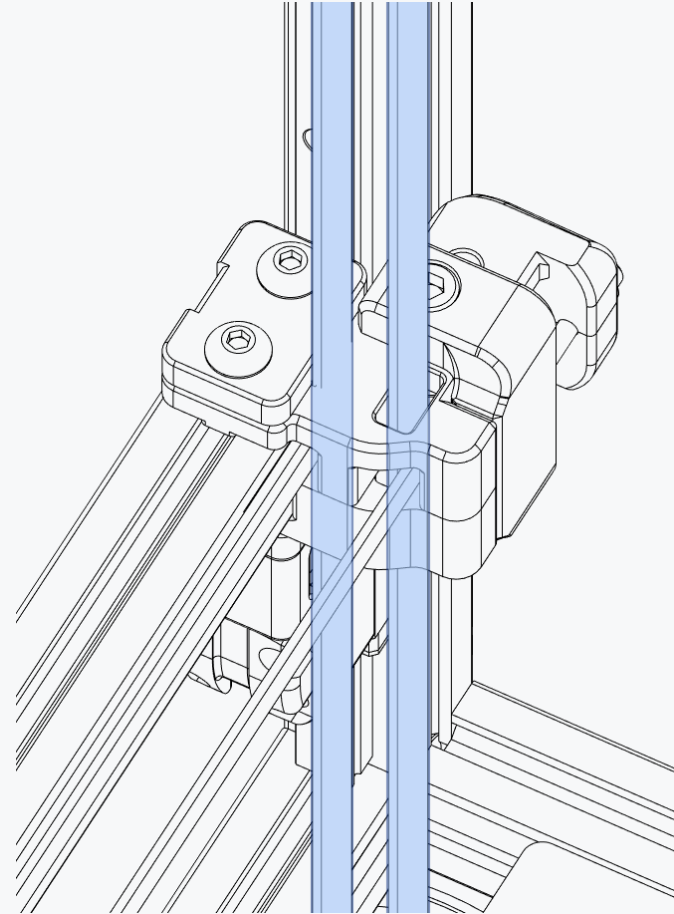
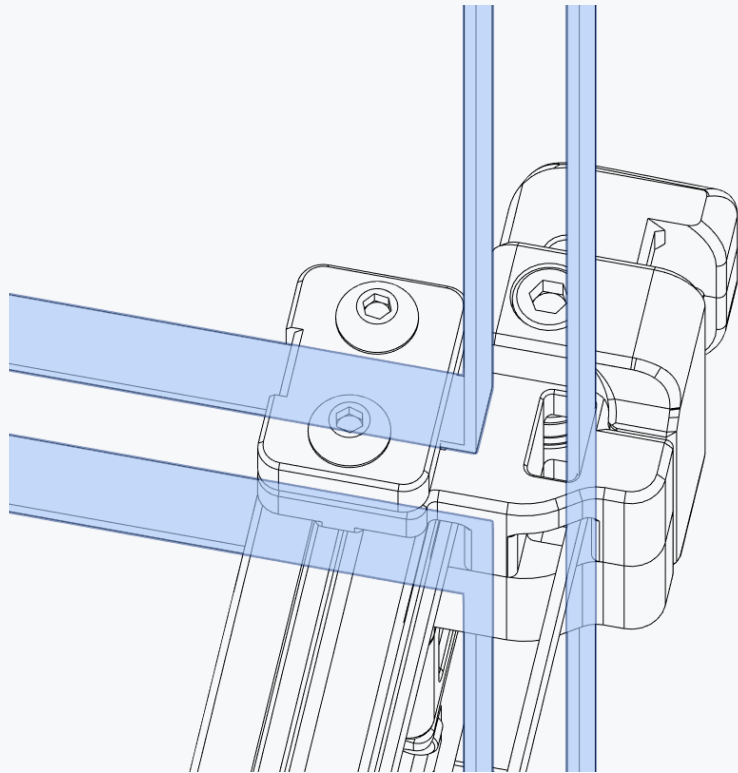
M3x12 SHCS

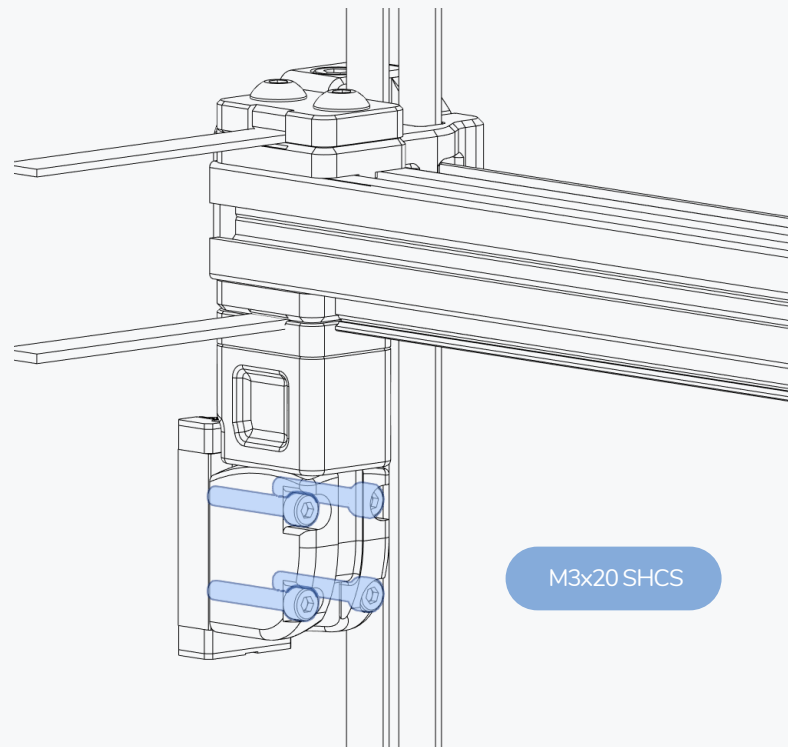
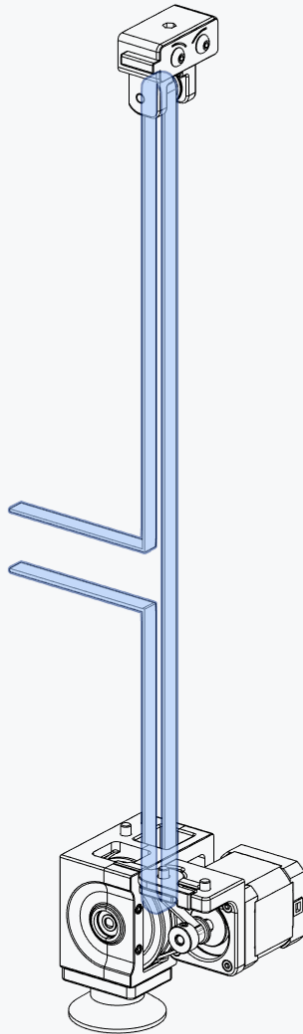


M3x8 SHCS



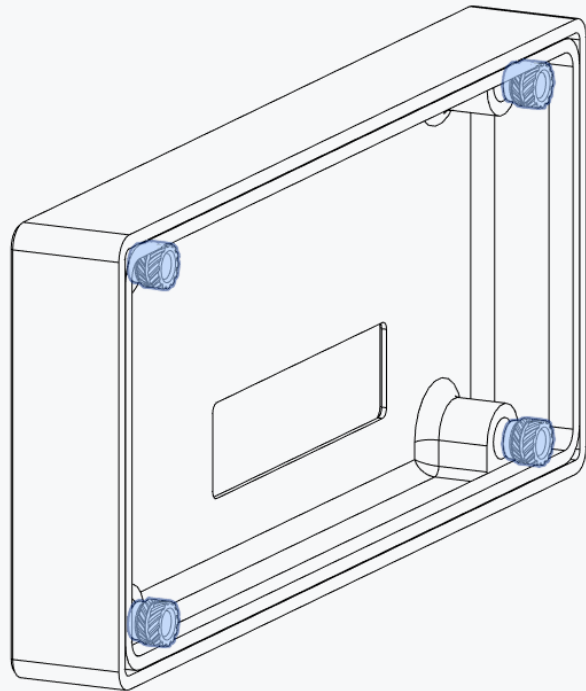




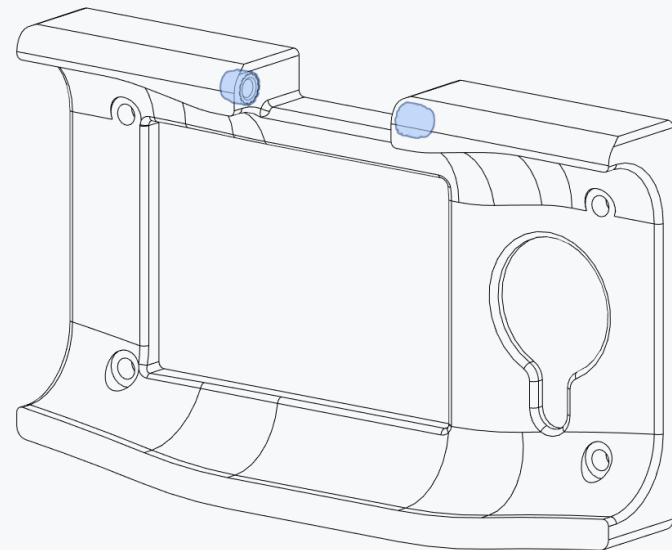


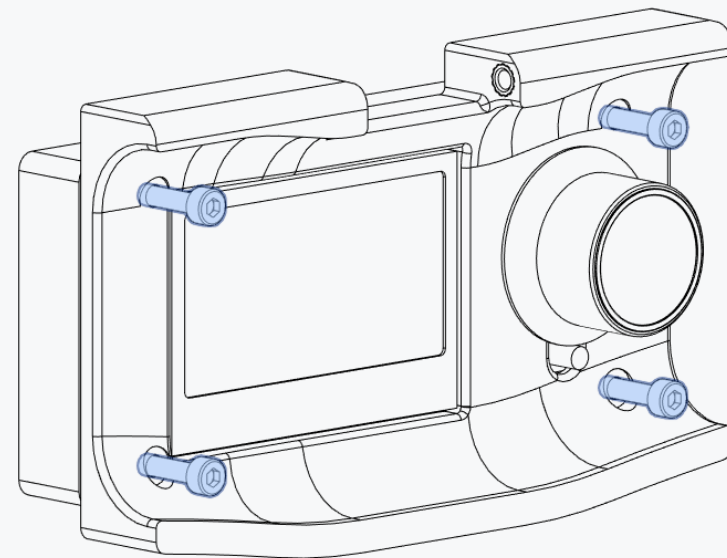
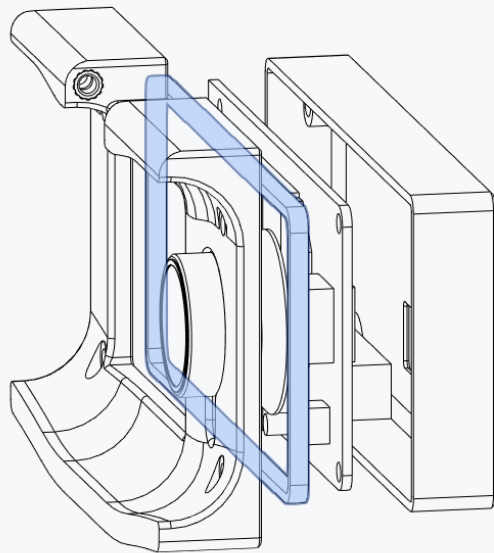
M3x20 SHCS



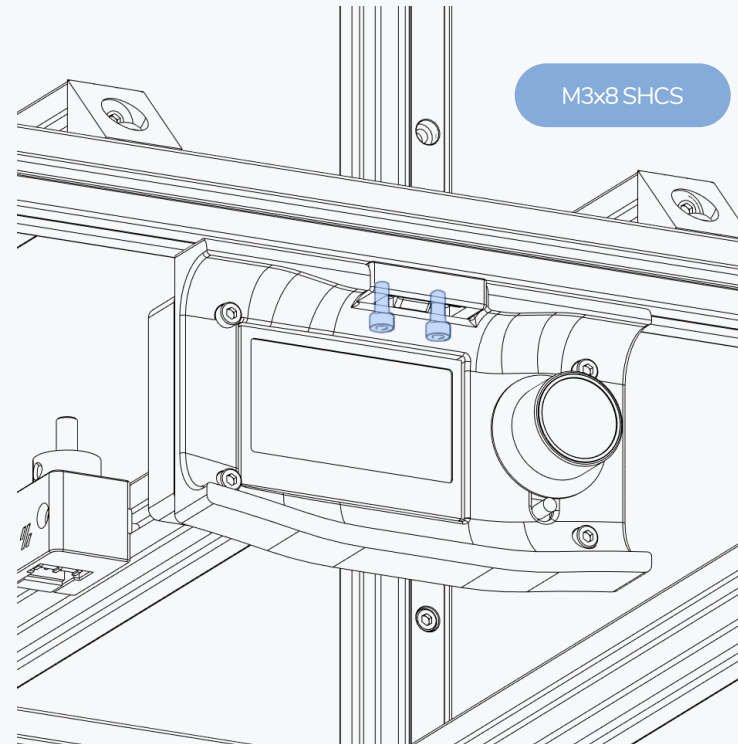
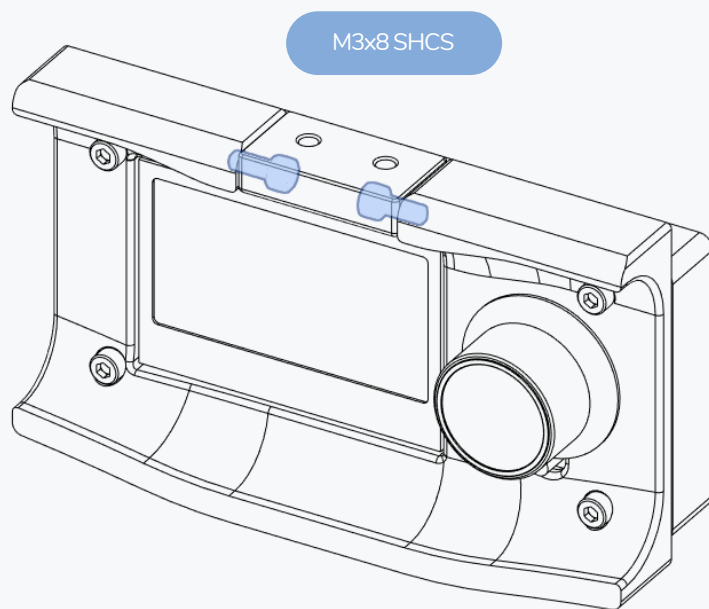


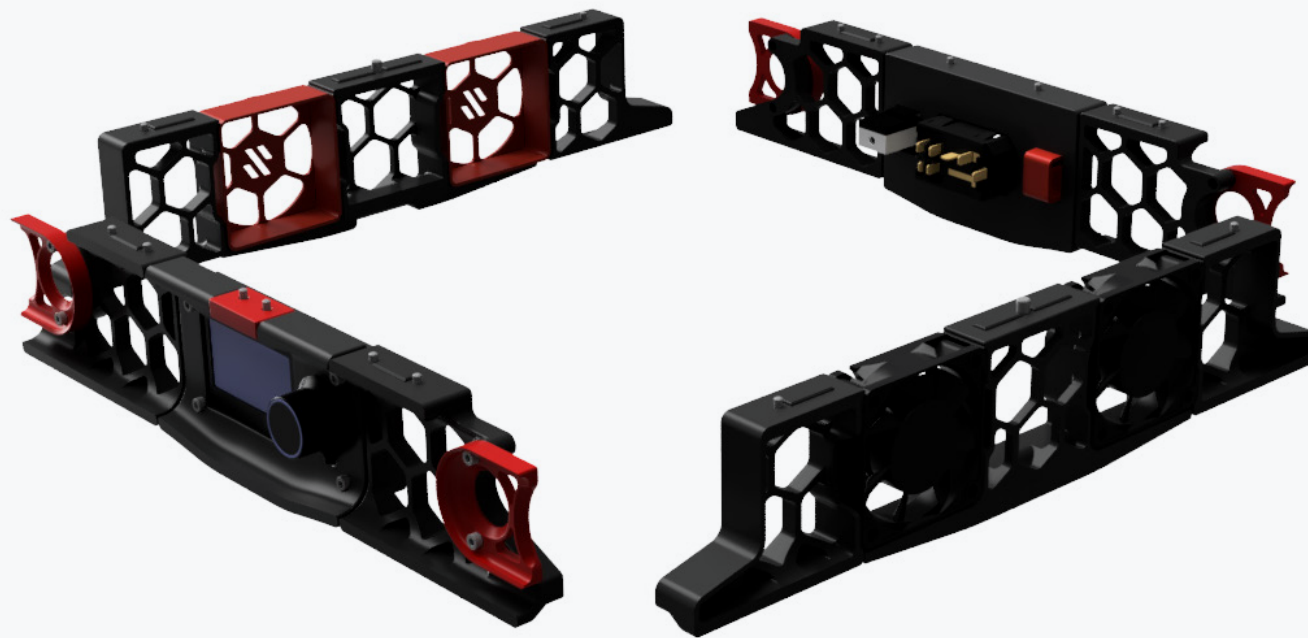
Heat Set Inserts

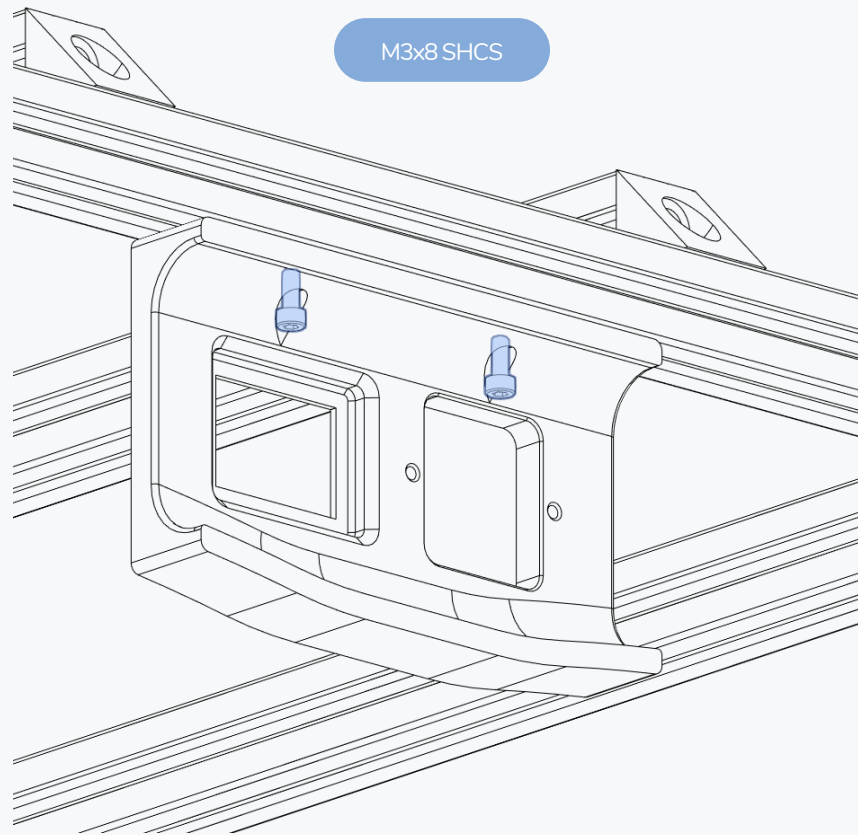


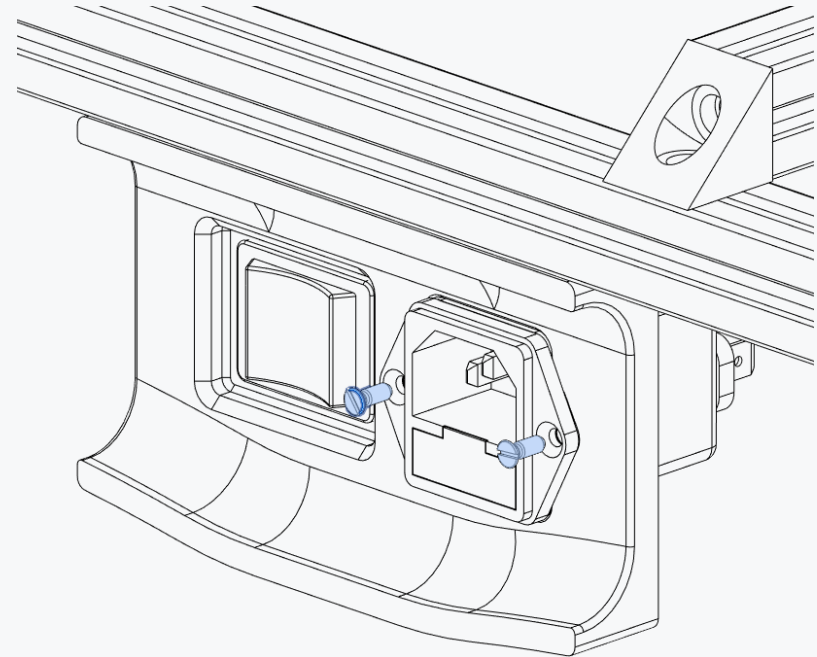
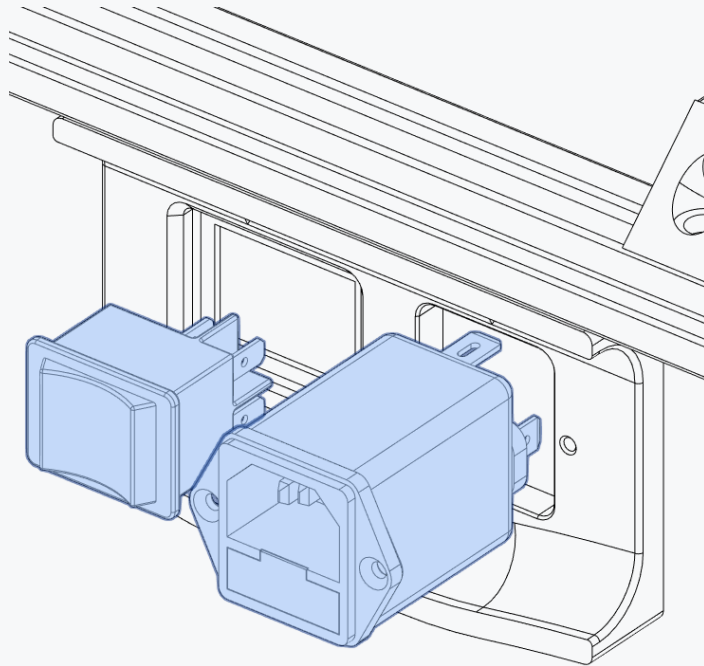


M3x12 SHCS



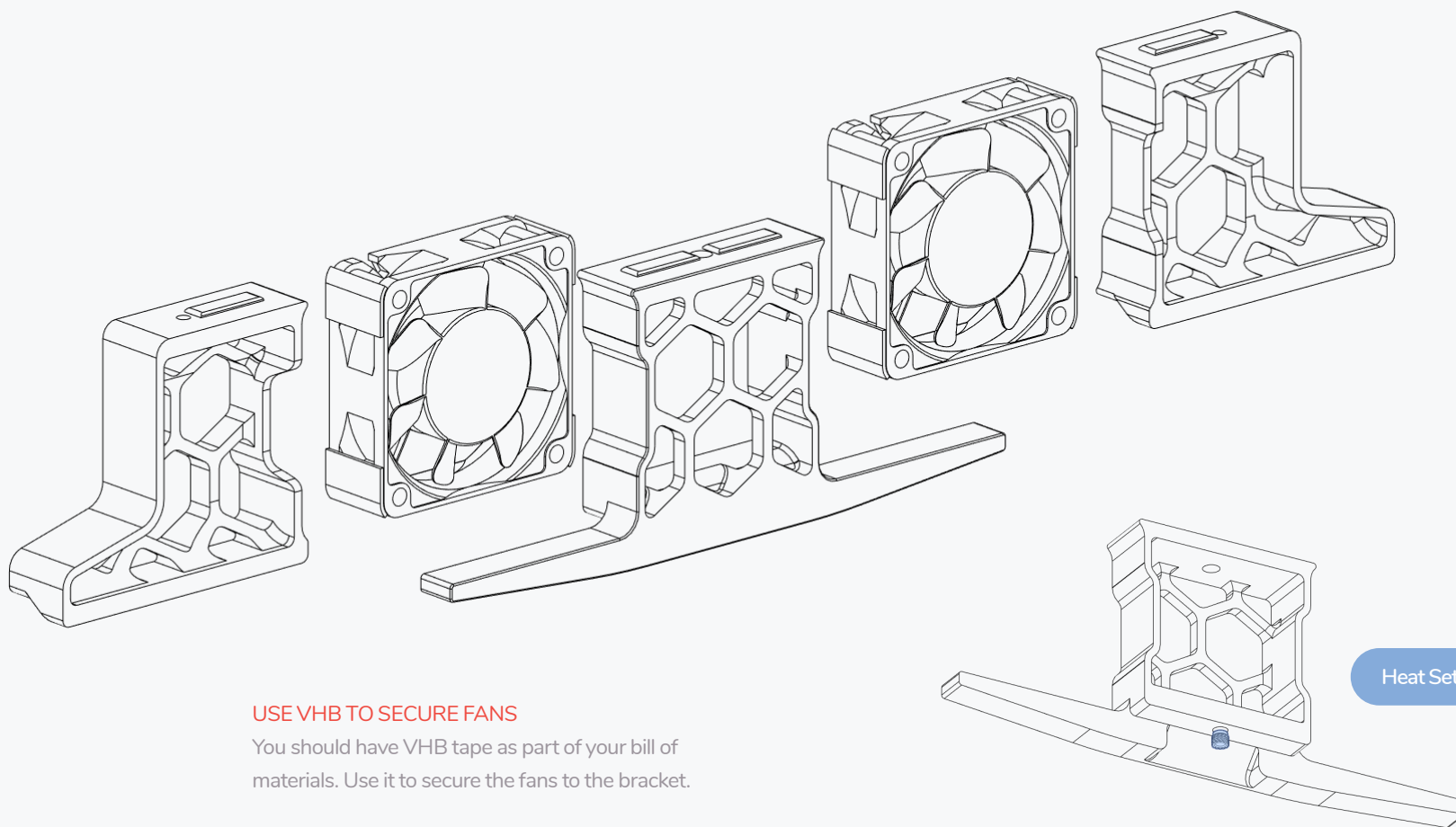




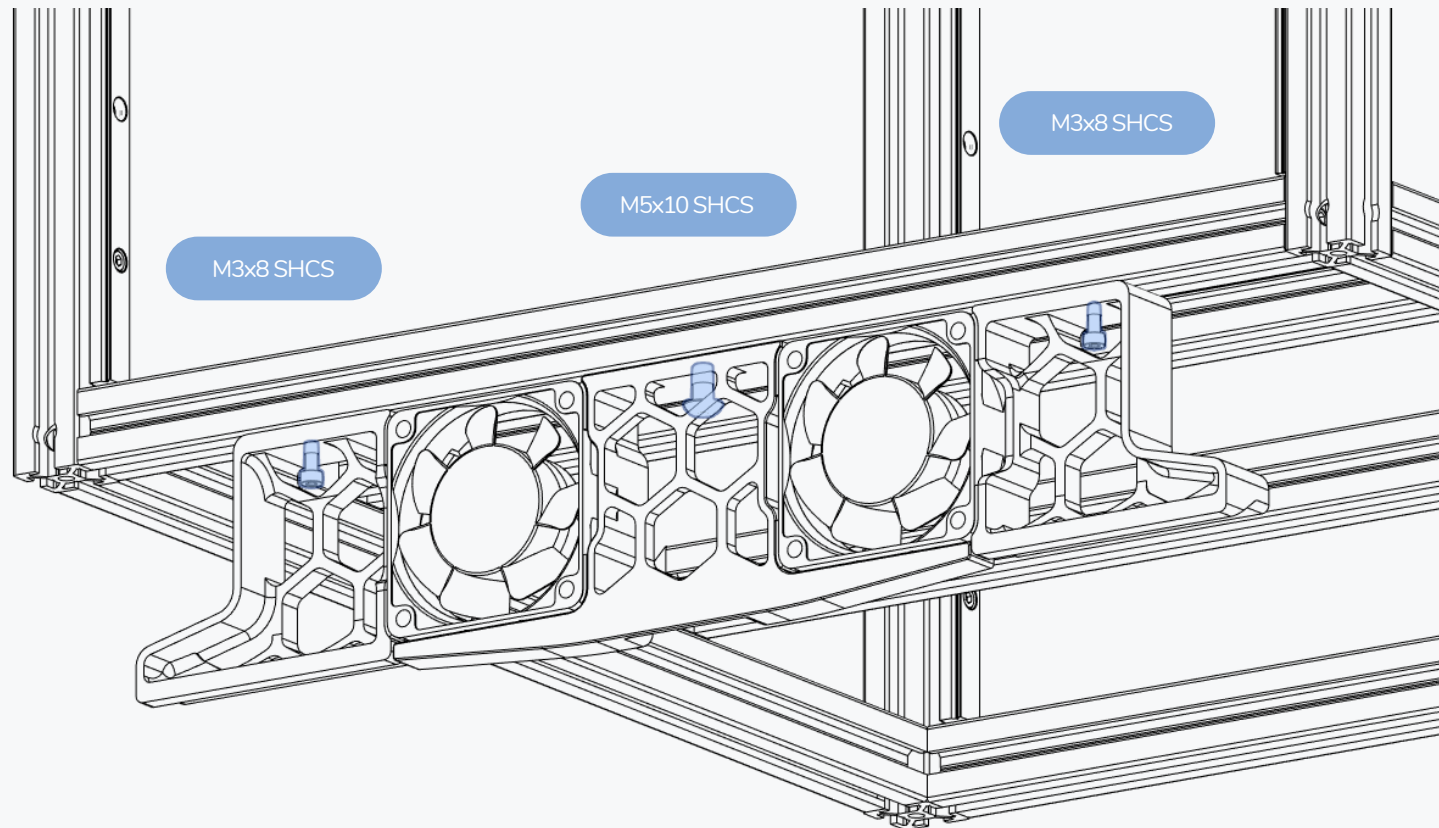


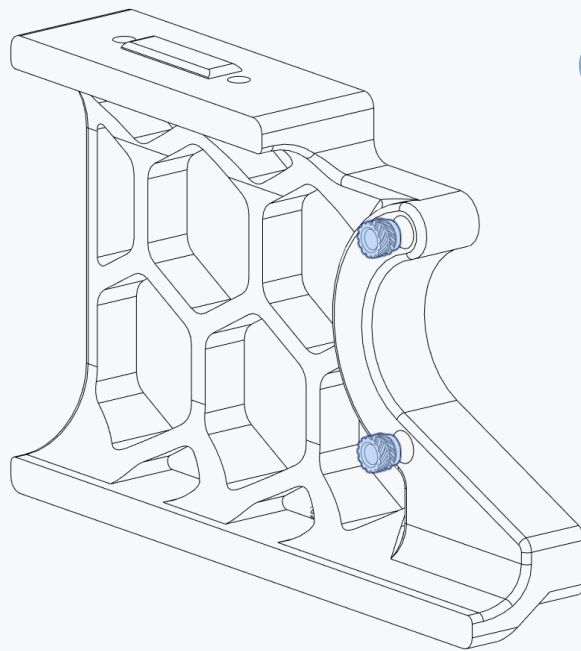
#4 X 3/8 FLAT HEAD SELF TAPPING

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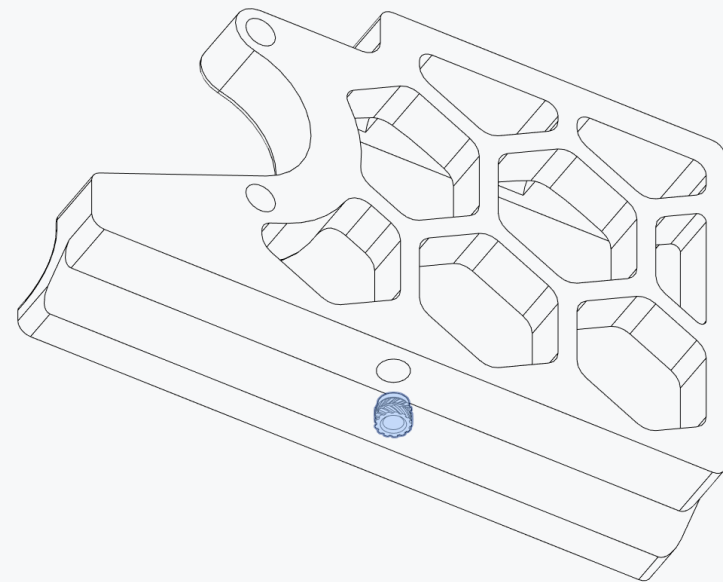
**USE VHB TO SECURE FANS**

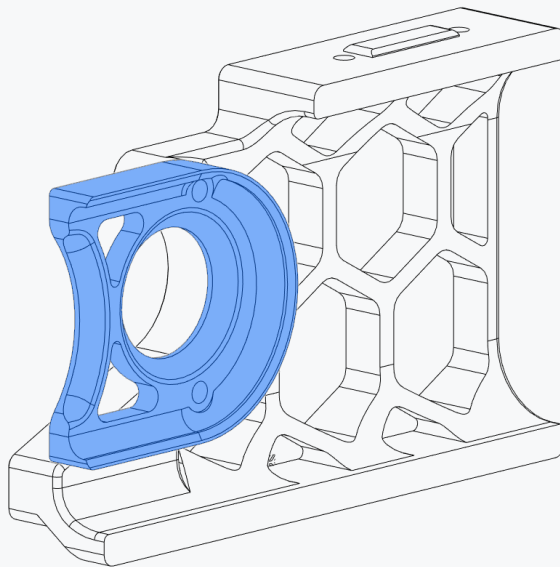
You should have VHB tape as part of your bill of materials. Use it to secure the fans to the bracket.



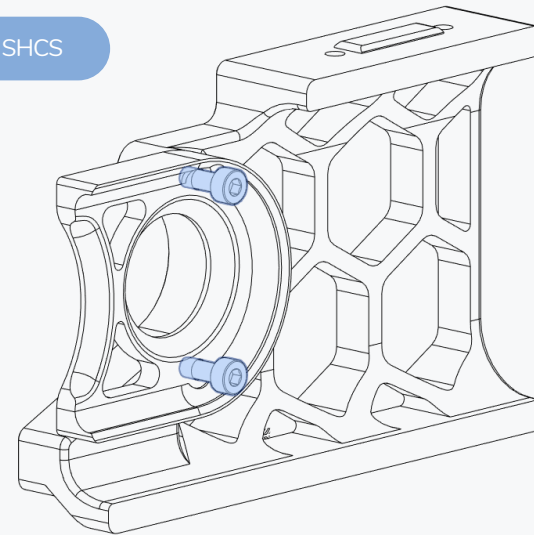


Heat Set Inserts

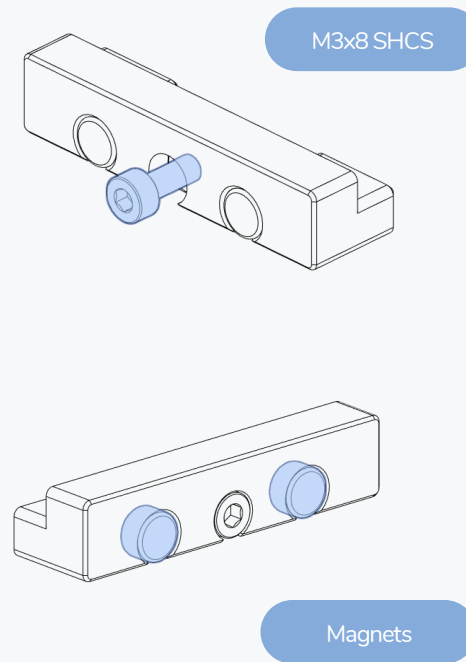
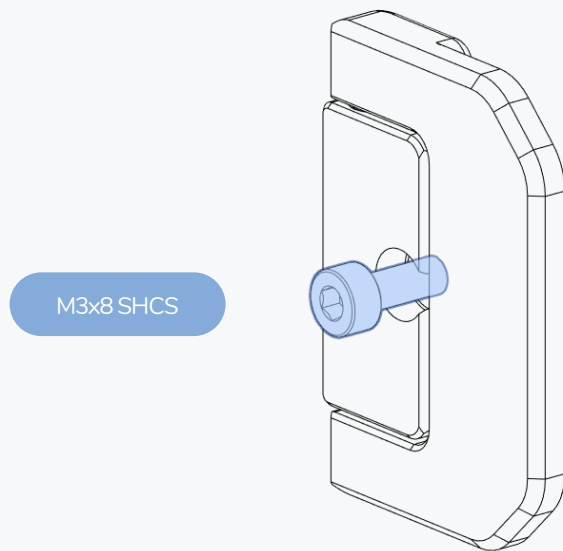


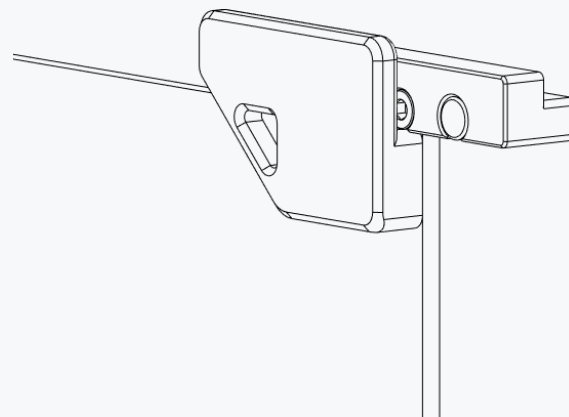
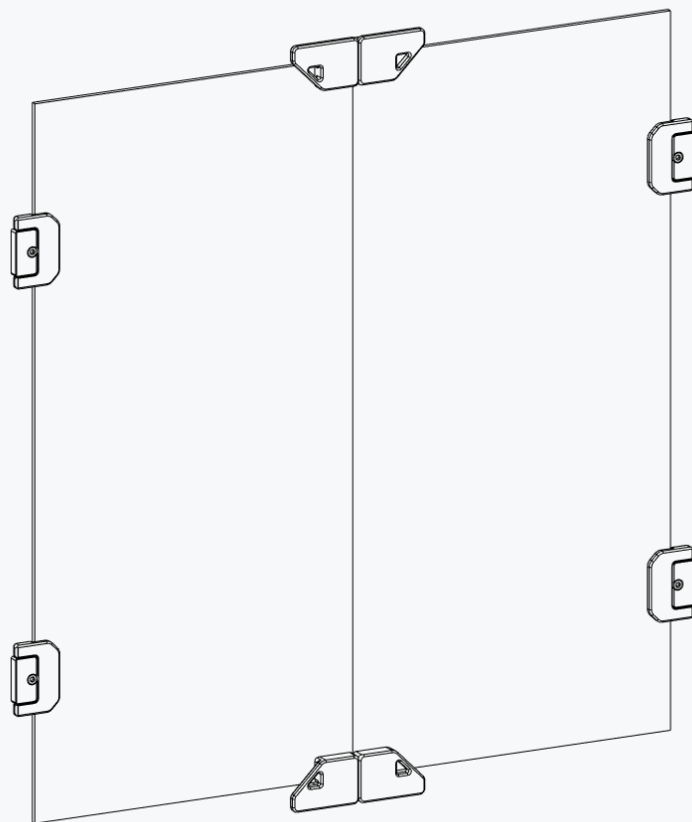


M3x8 SHCS



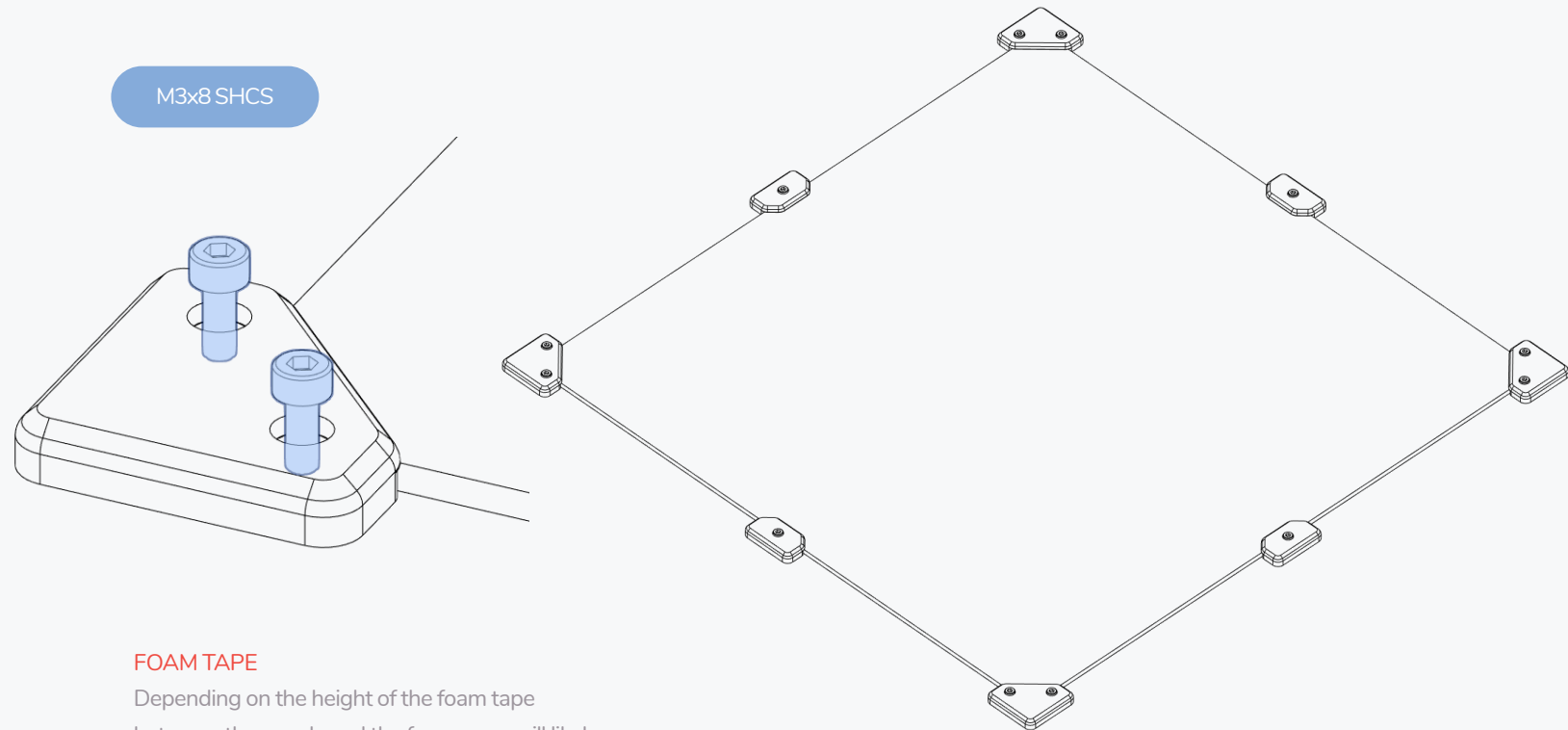




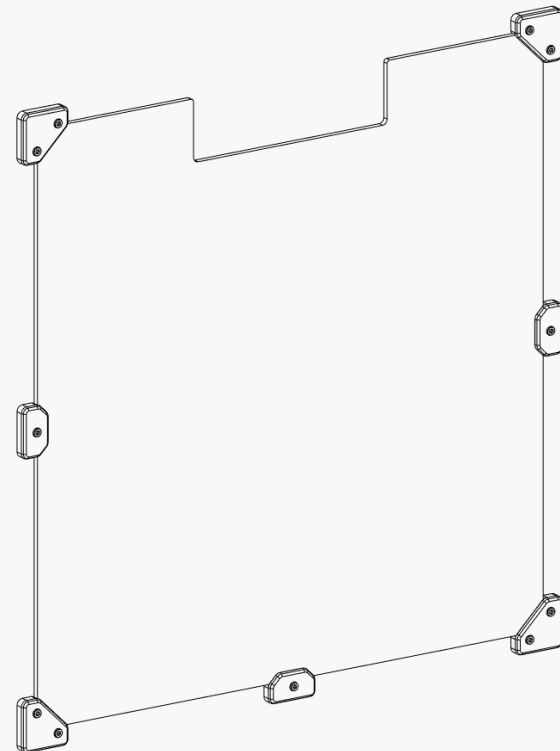
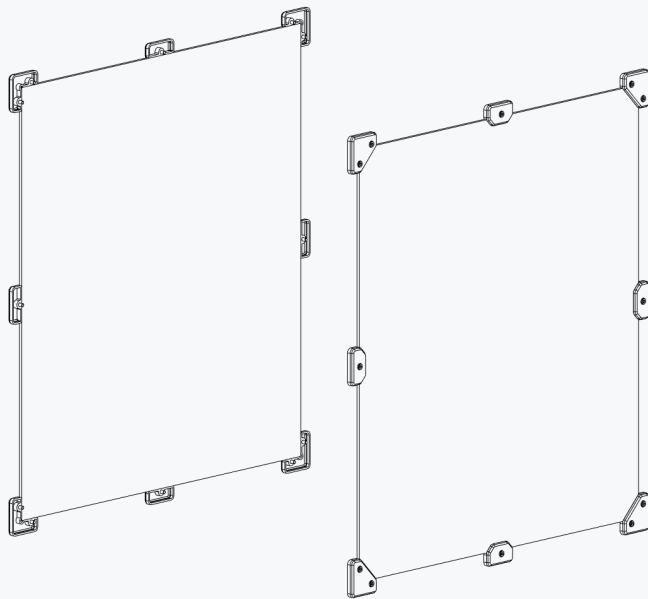


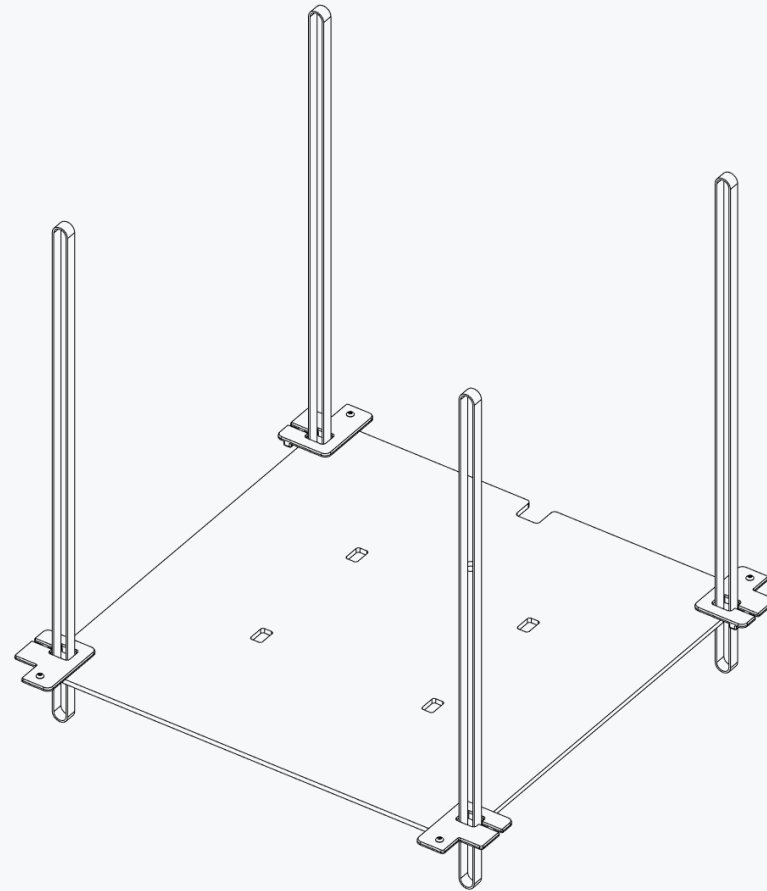
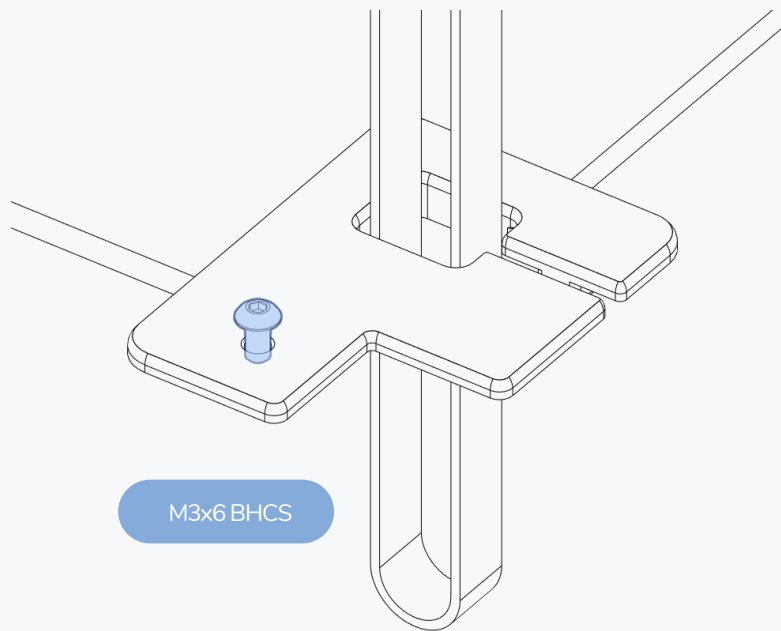
USE VHB TO ATTACH LATCHES

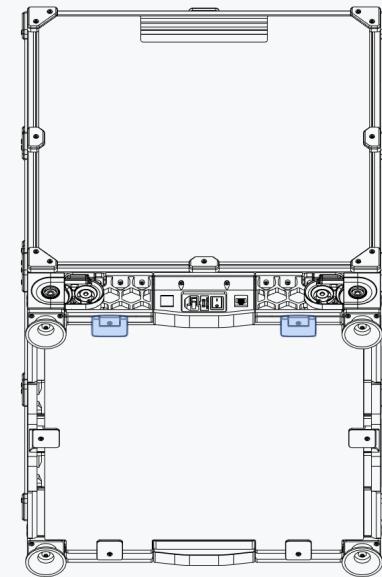
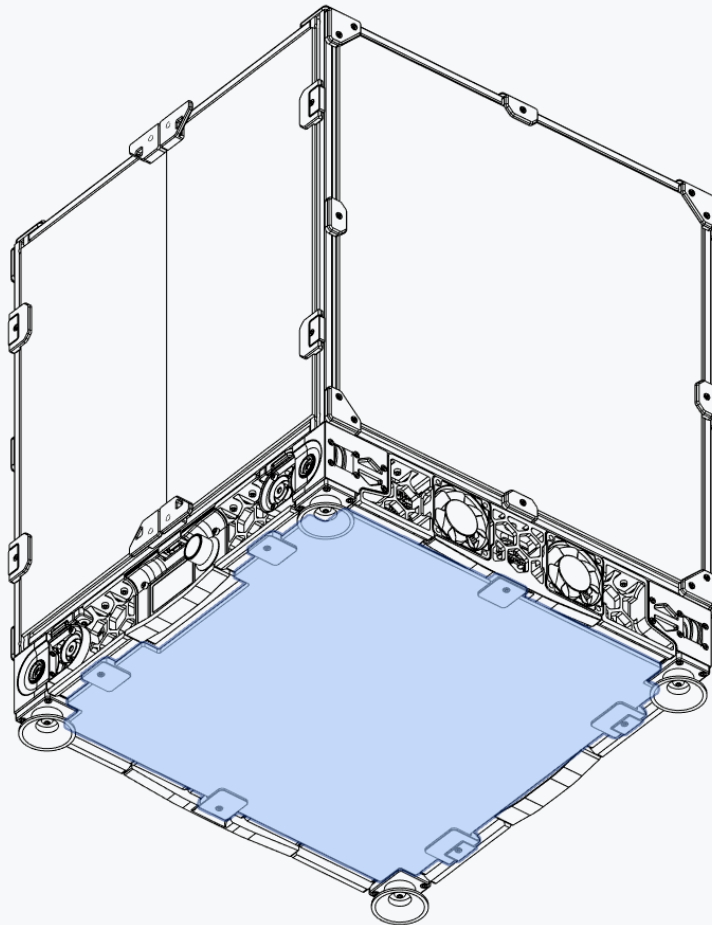
You should have VHB tape as part of your bill of materials. Use it to secure the panel latches to the polycarb panels.

**FOAM TAPE**

Depending on the height of the foam tape between the panels and the frame, you will likely have to use larger sized clips depending on it's thickness.





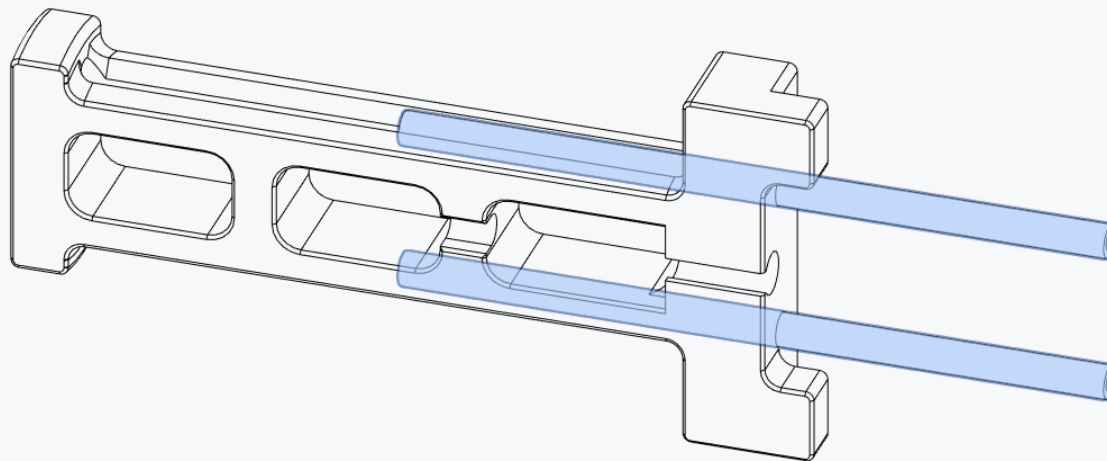


HINGES

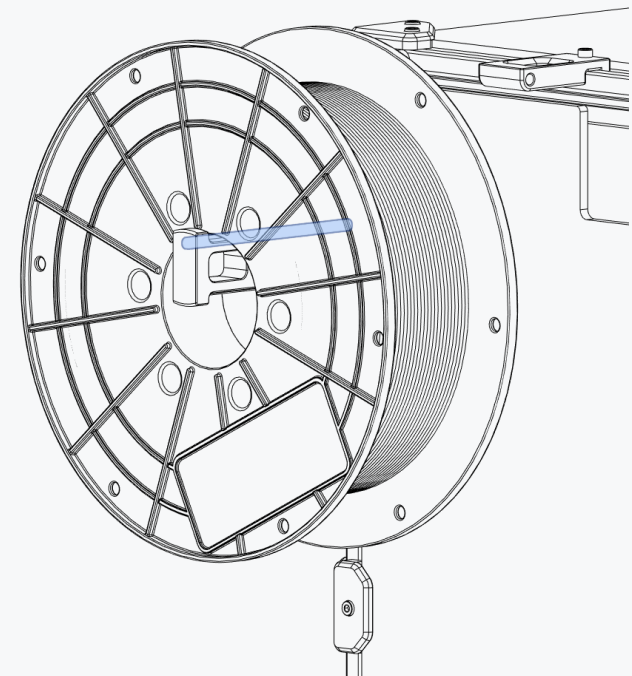
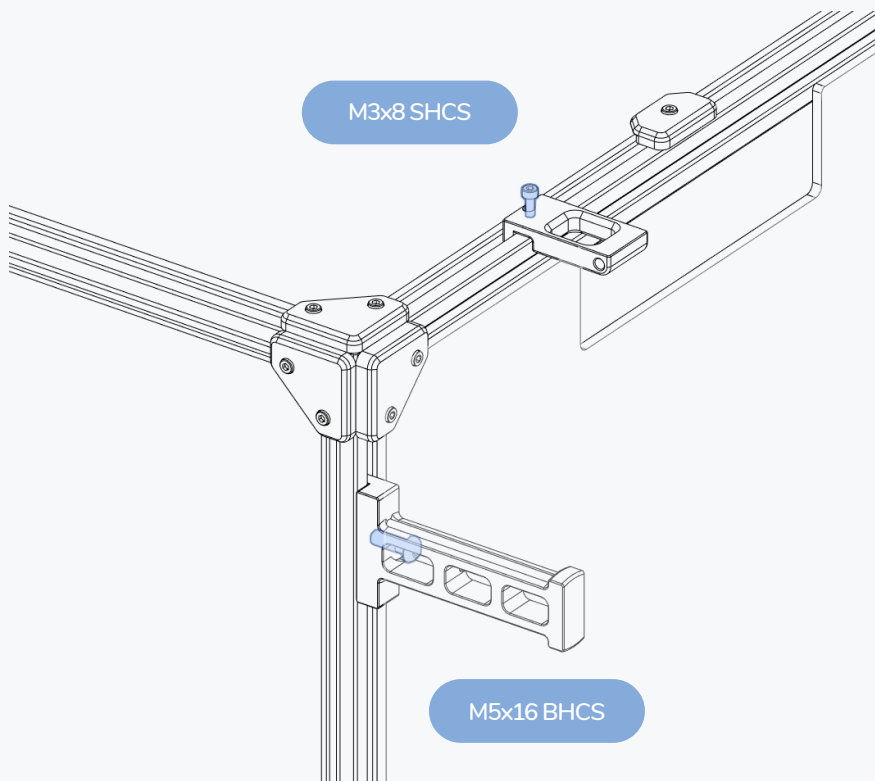
Remember to place the hinges on the rear of the machine.

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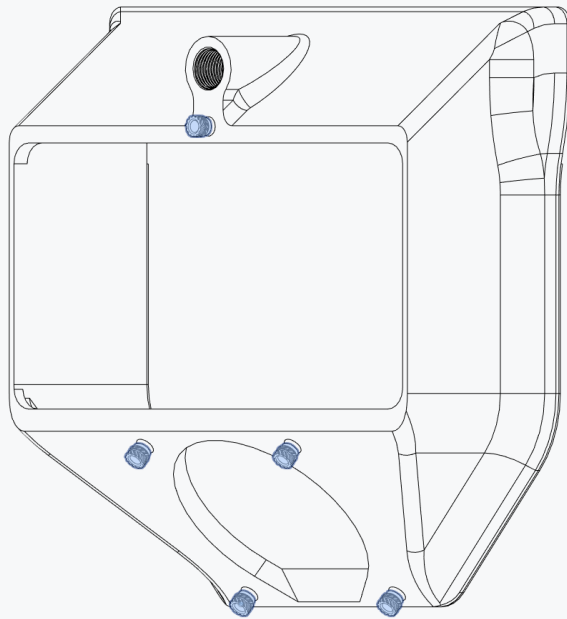


PTFE Insert

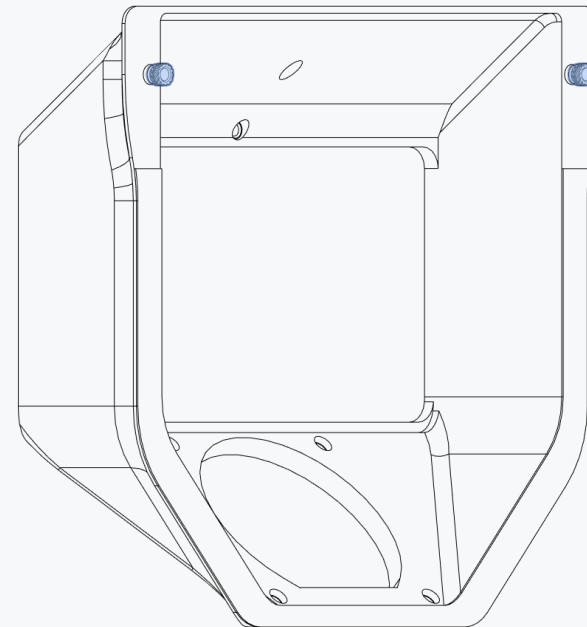


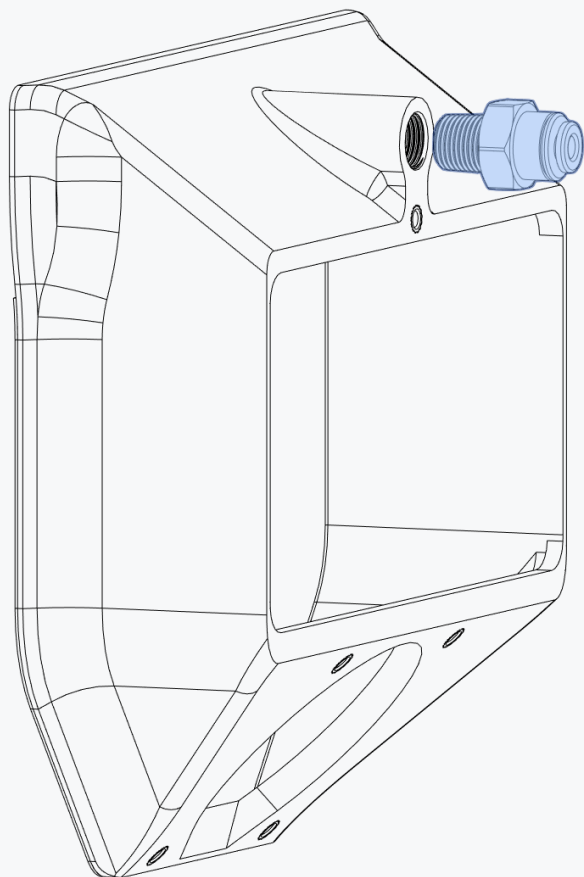
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Heat Set Inserts

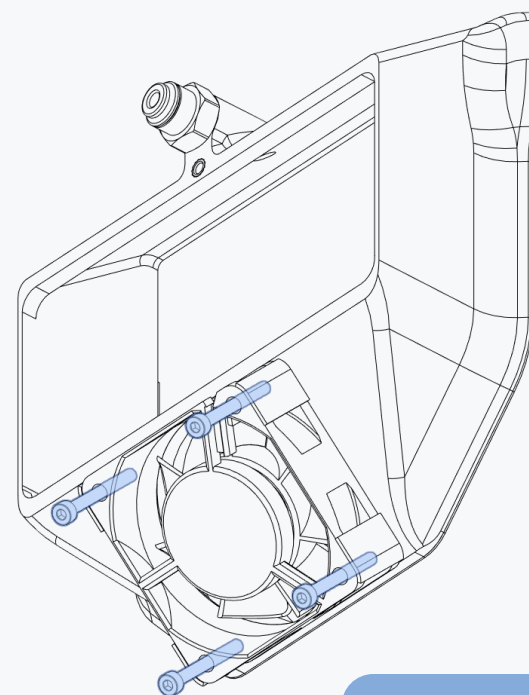




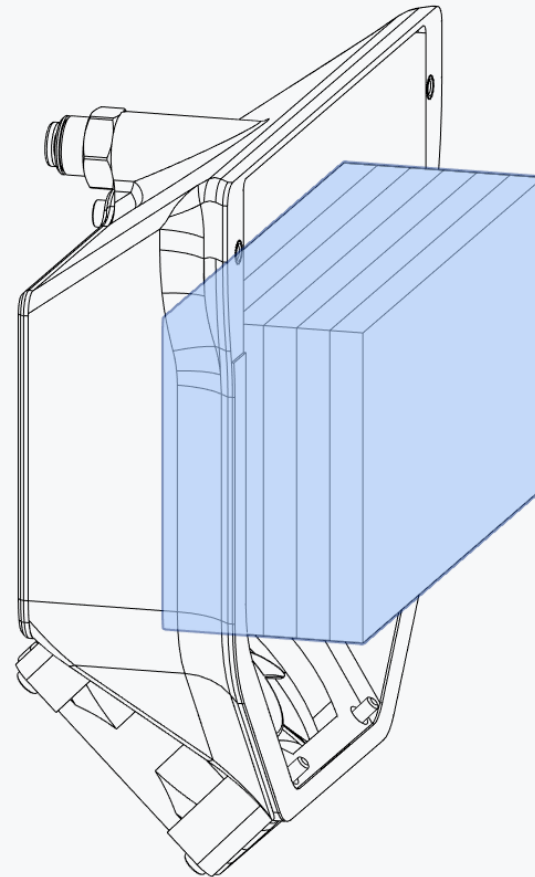
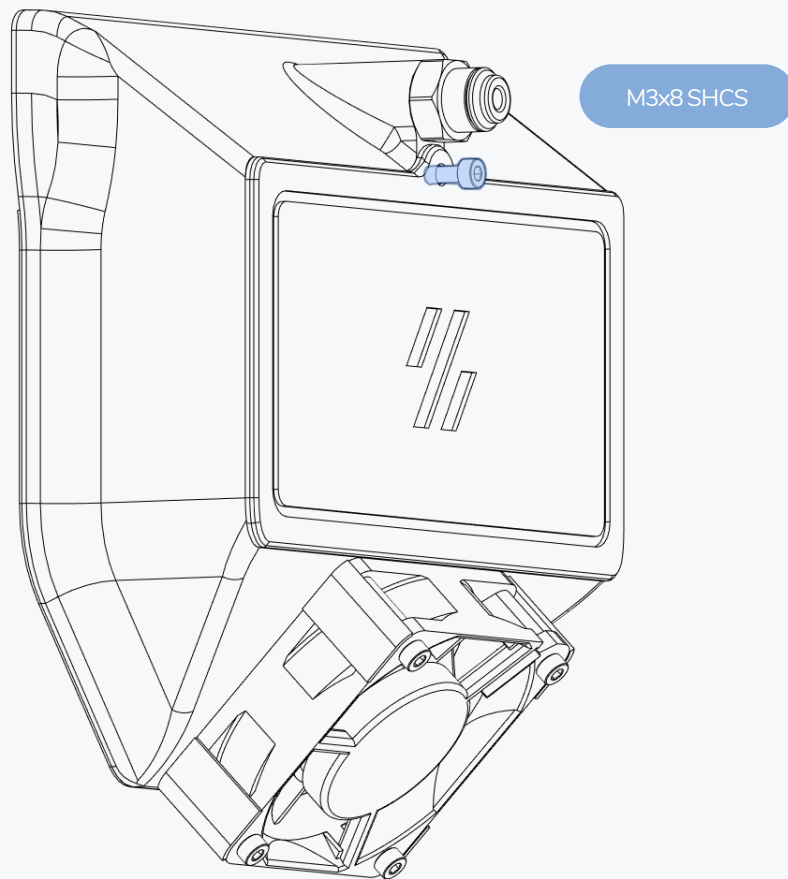
BSP Adapter

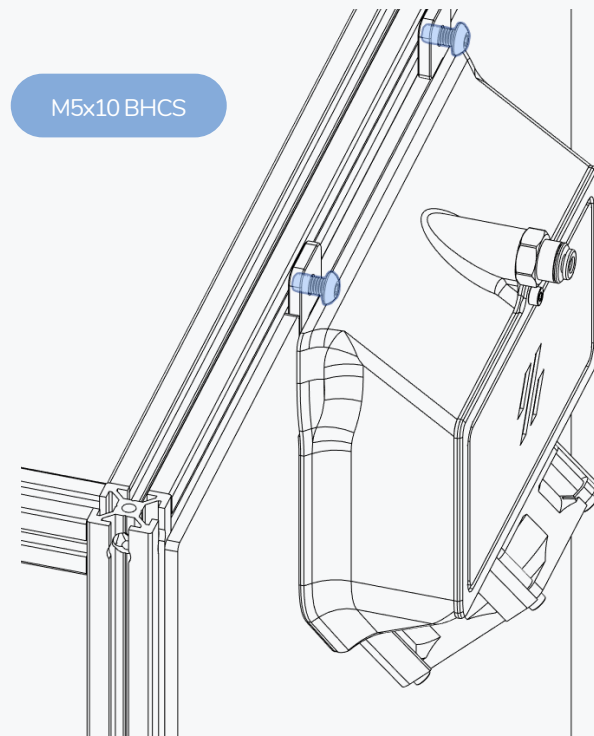
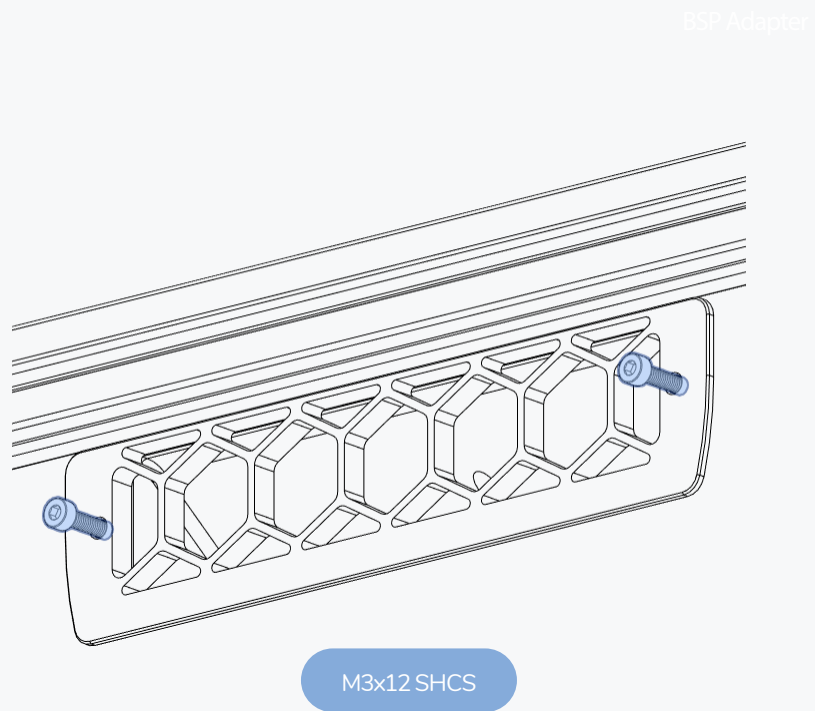
DRILL ADAPTER

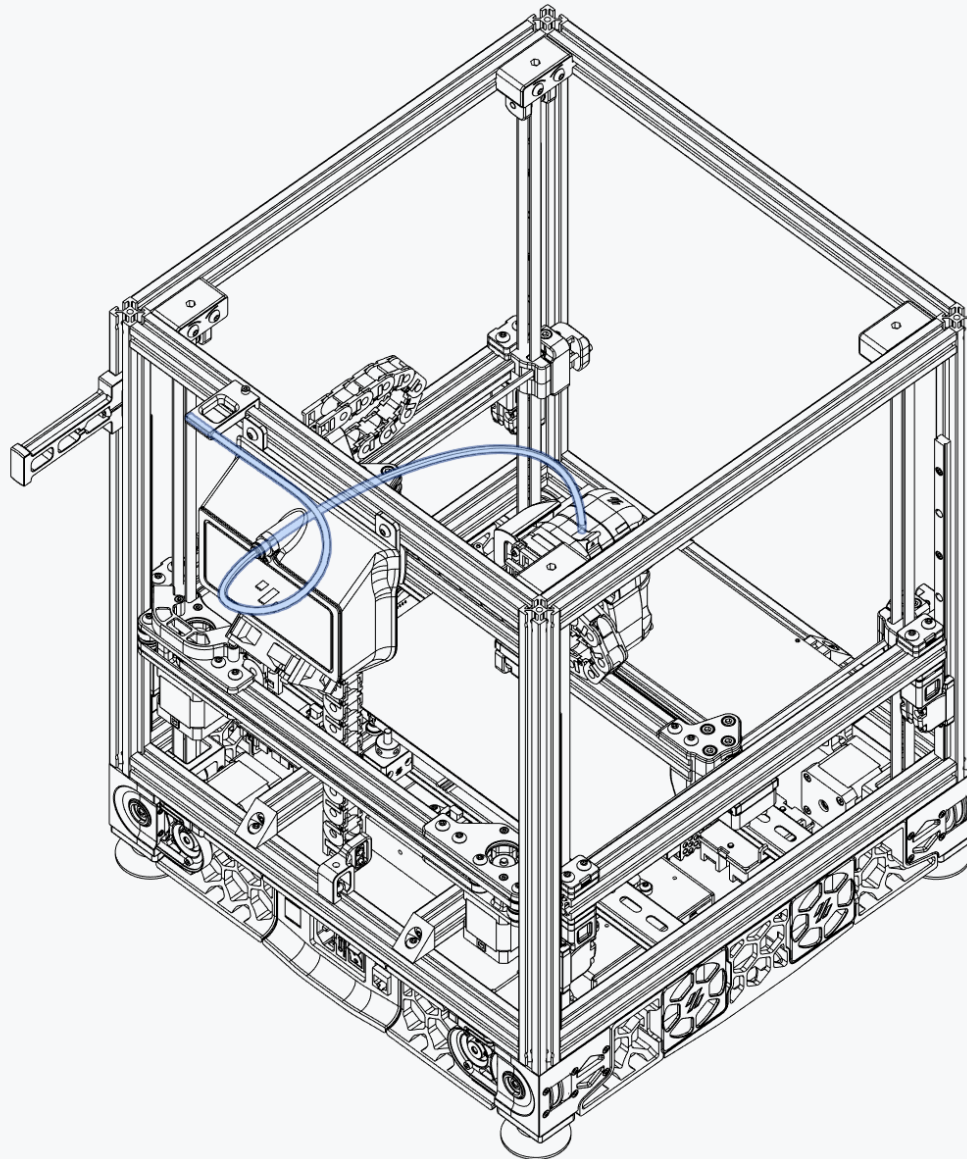
Bowden tube won't fit though some BSP adapters depending on the source. You'll have to drill these out.

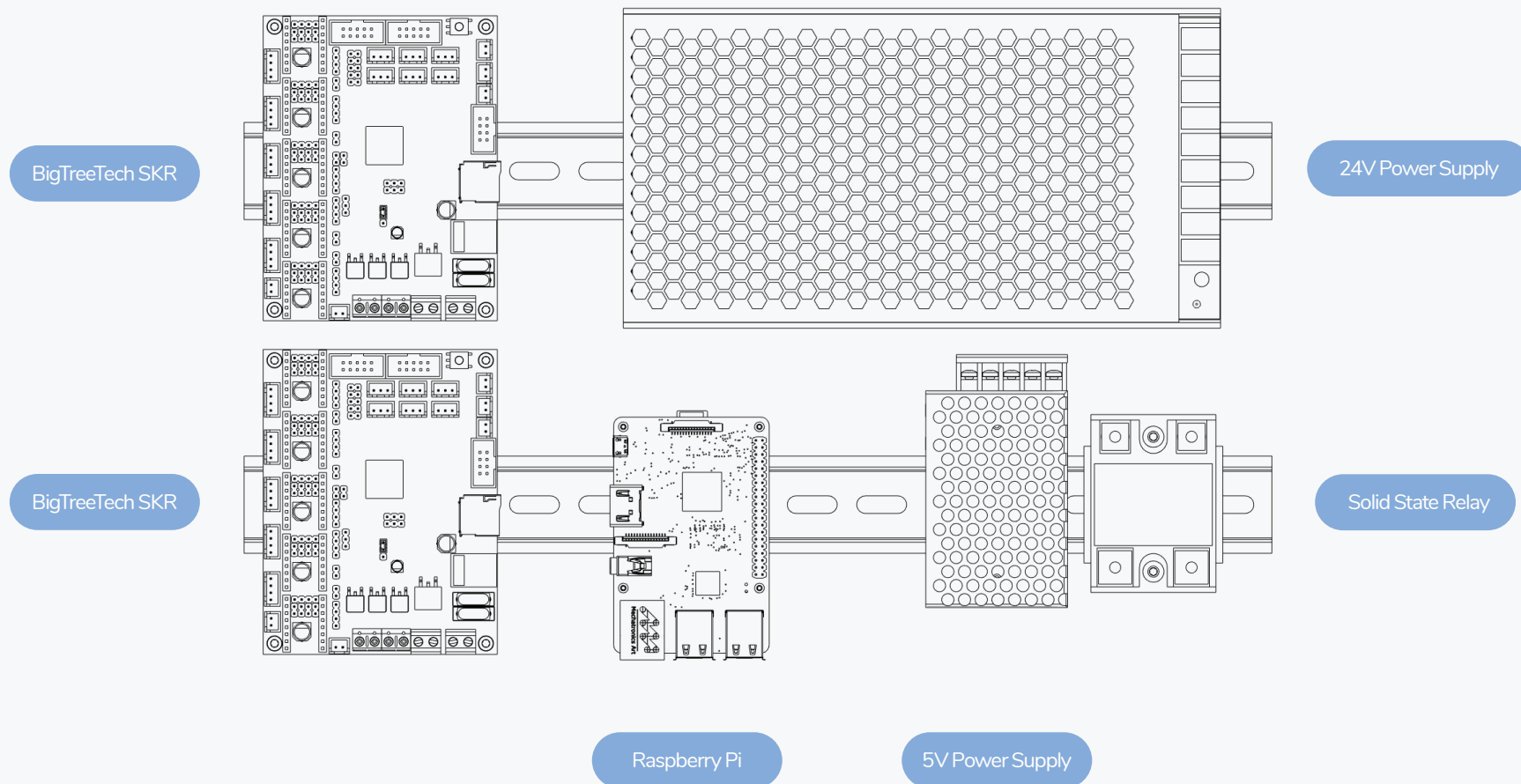


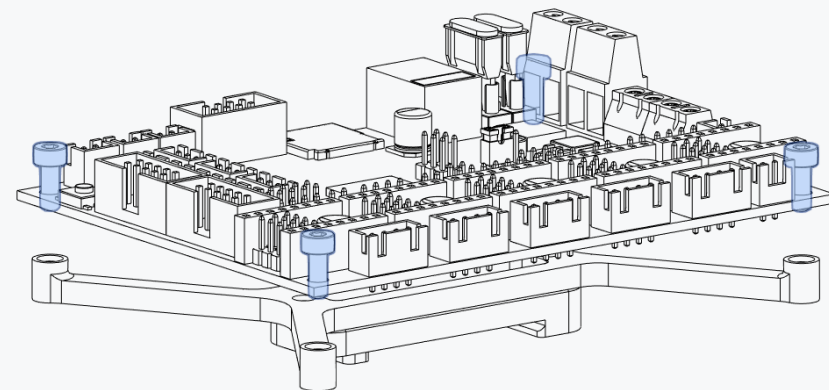
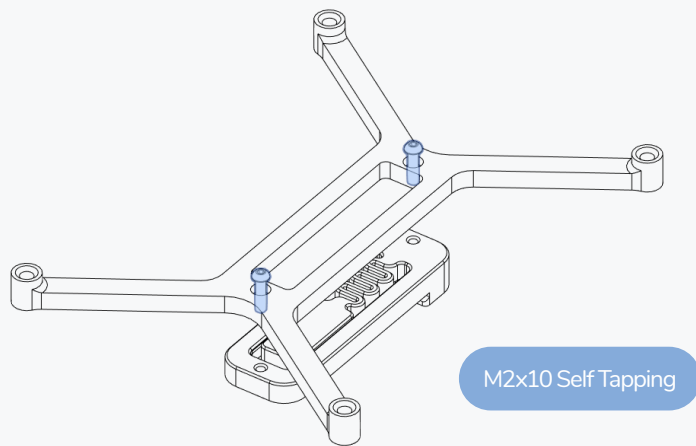
M3x30 SHCS

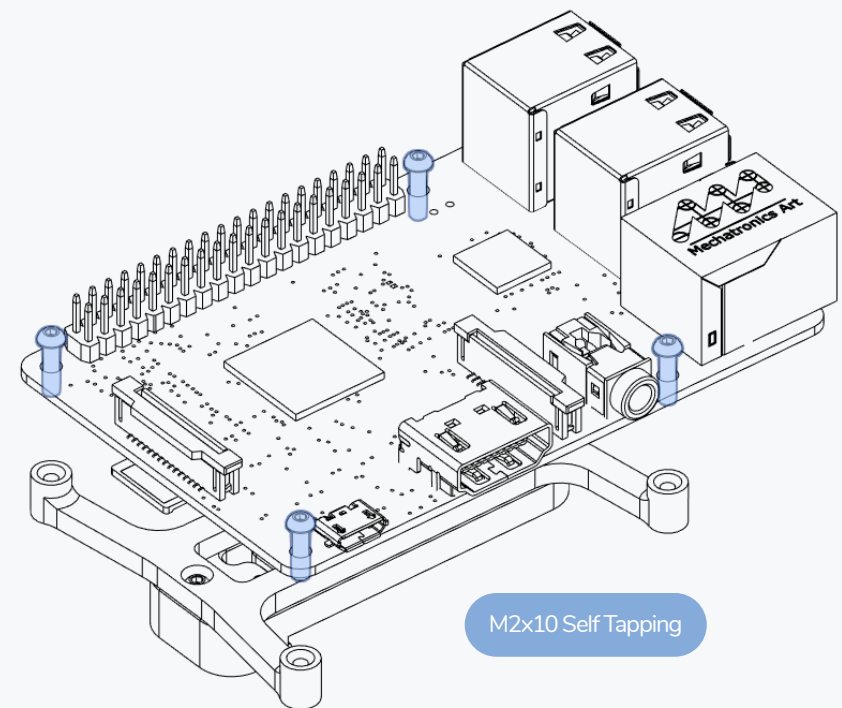
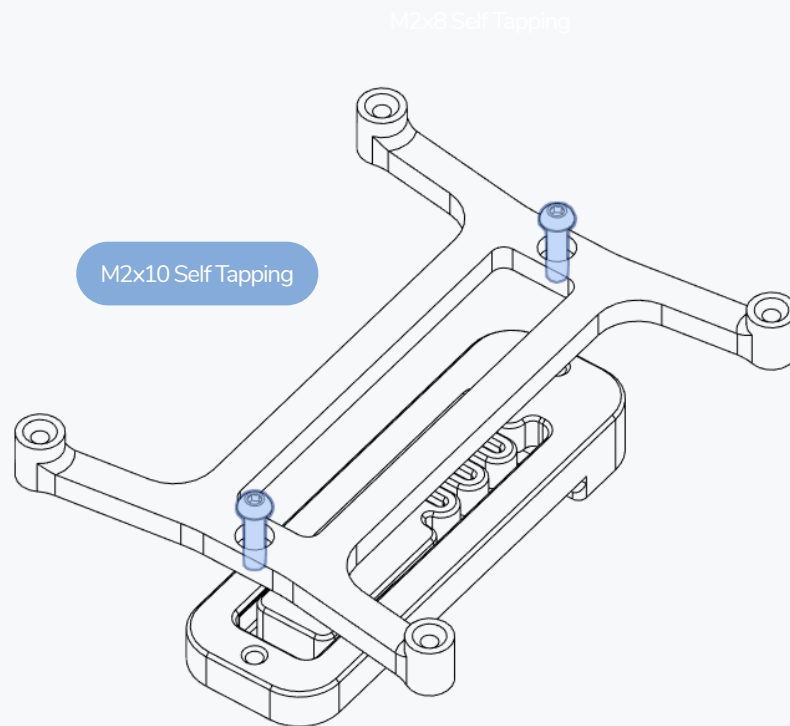


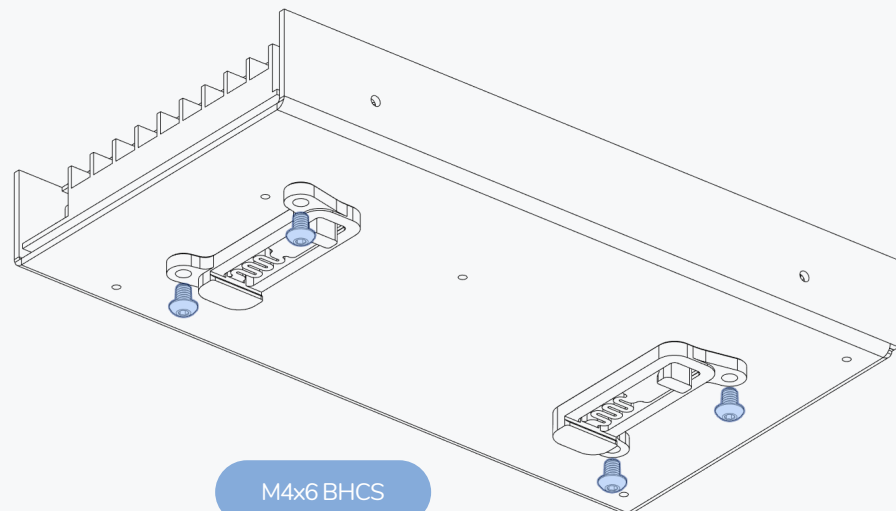
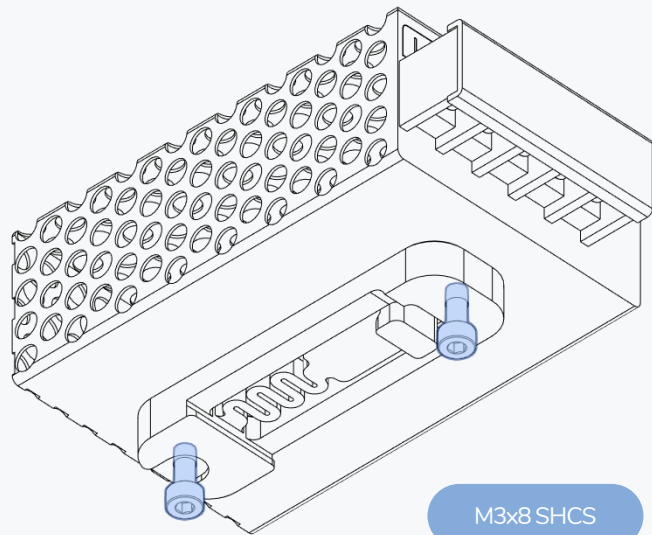


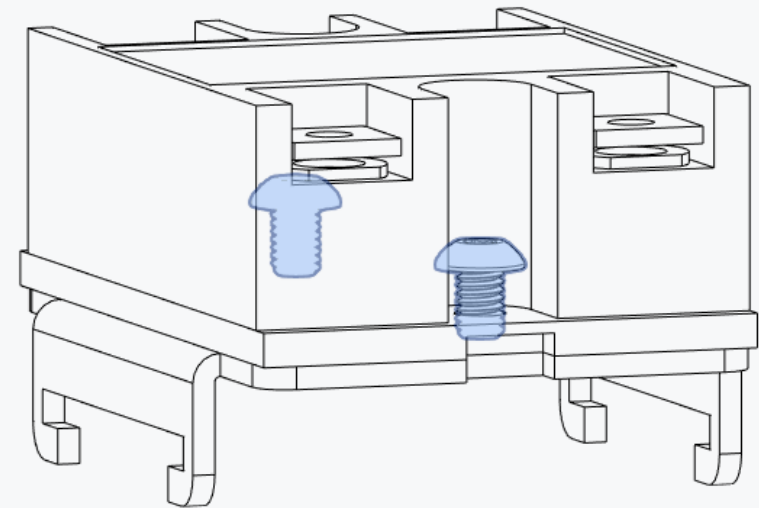
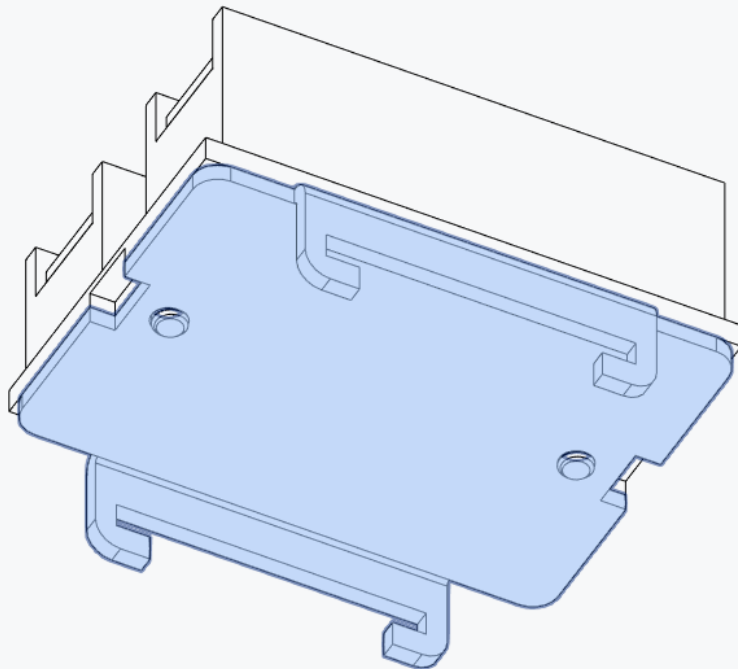




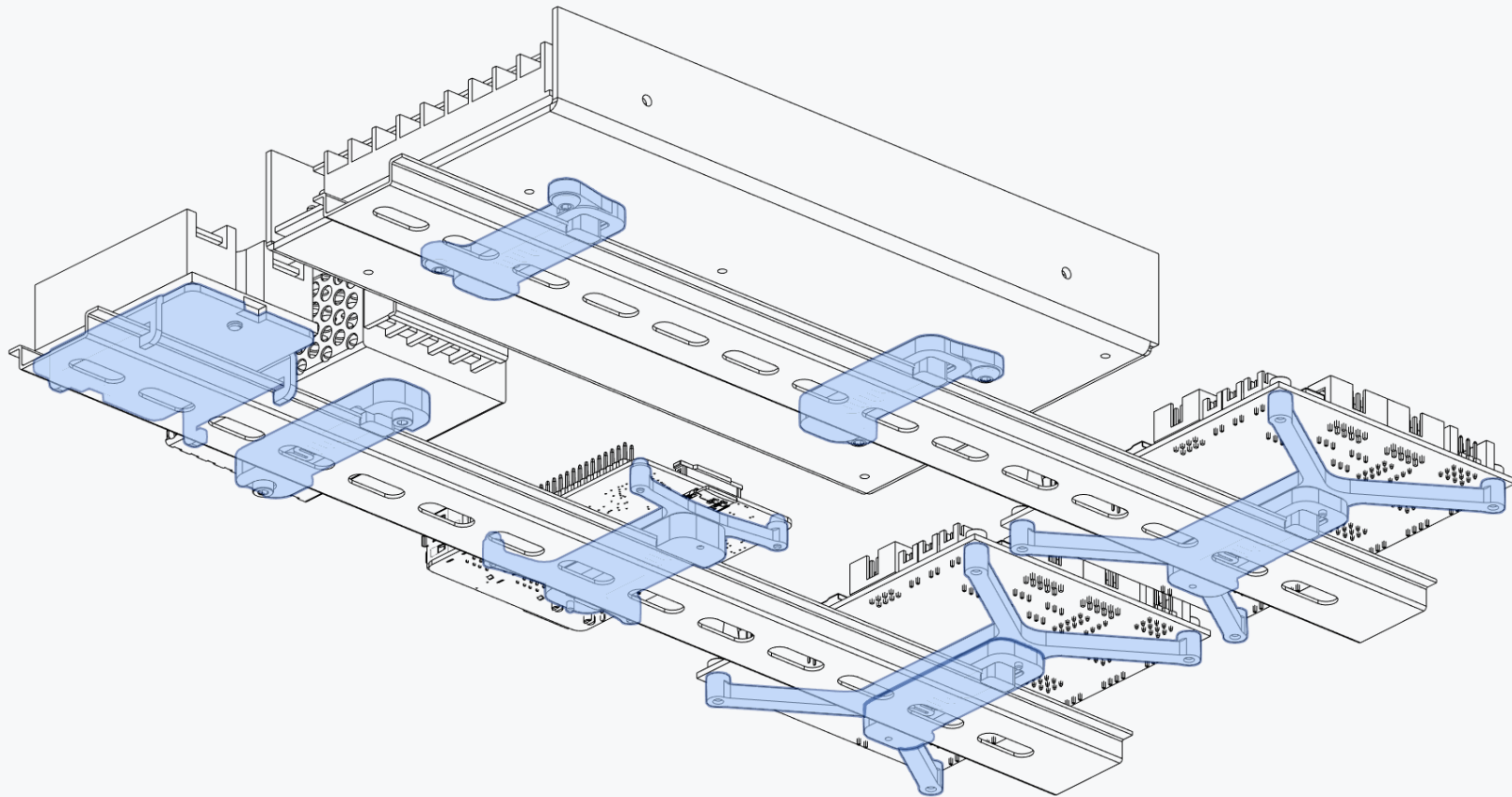








M4x6 BHCS

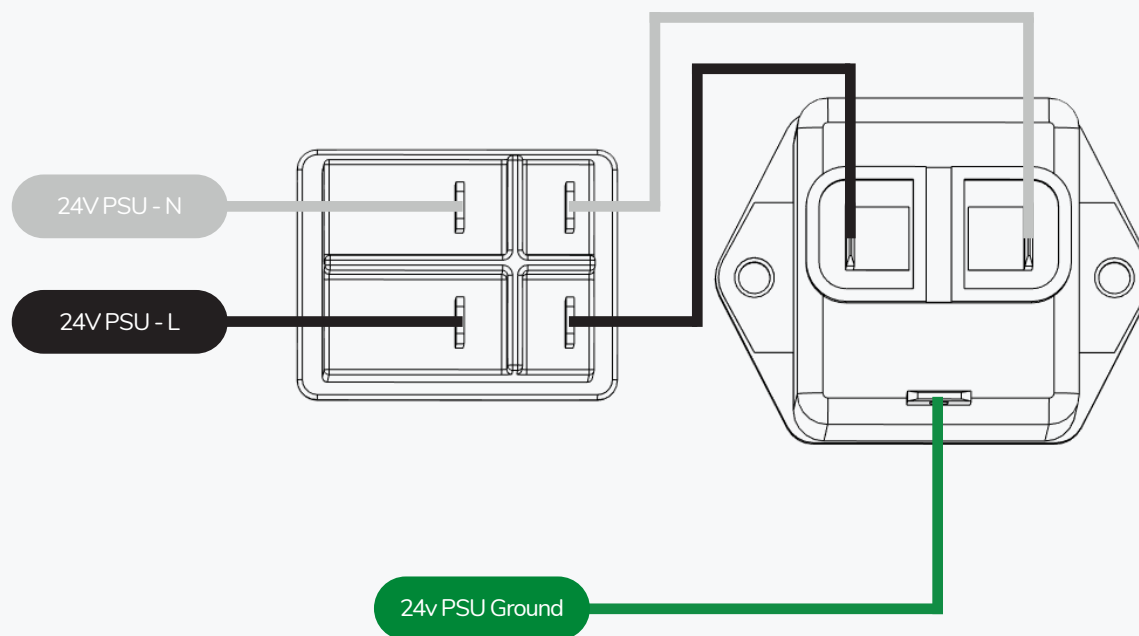




You are about to start working with electrical wiring that can cause serious injury or death.

Mains power can kill, and it will hurt the entire time you're dying from it. If in doubt we encourage you to ask questions.

This is not something you want to guess your way through.



MAINS VOLTAGE WIRING

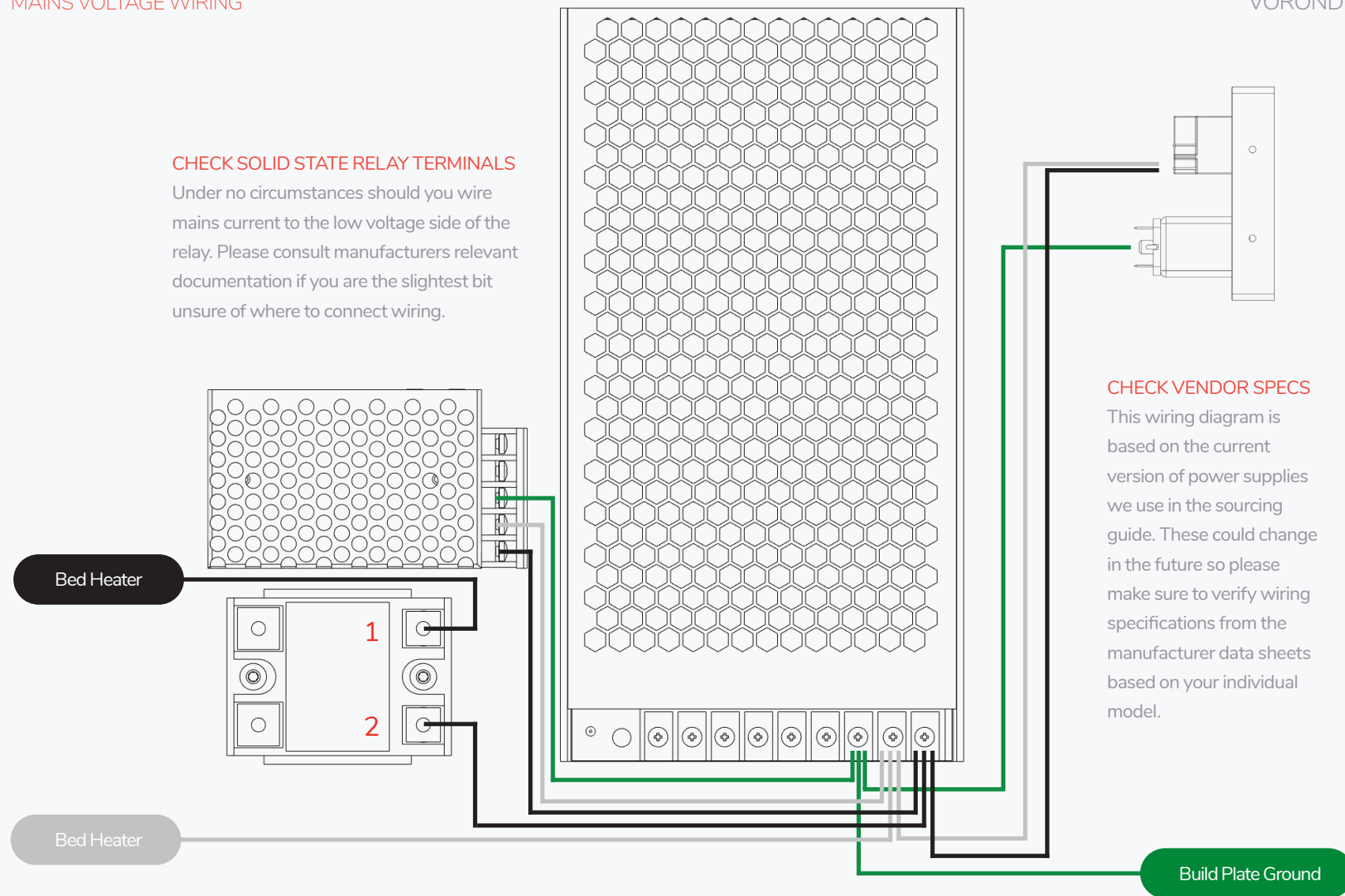
VORONDESIGN.COM

CHECK SOLID STATE RELAY TERMINALS

Under no circumstances should you wire mains current to the low voltage side of the relay. Please consult manufacturers relevant documentation if you are the slightest bit unsure of where to connect wiring.

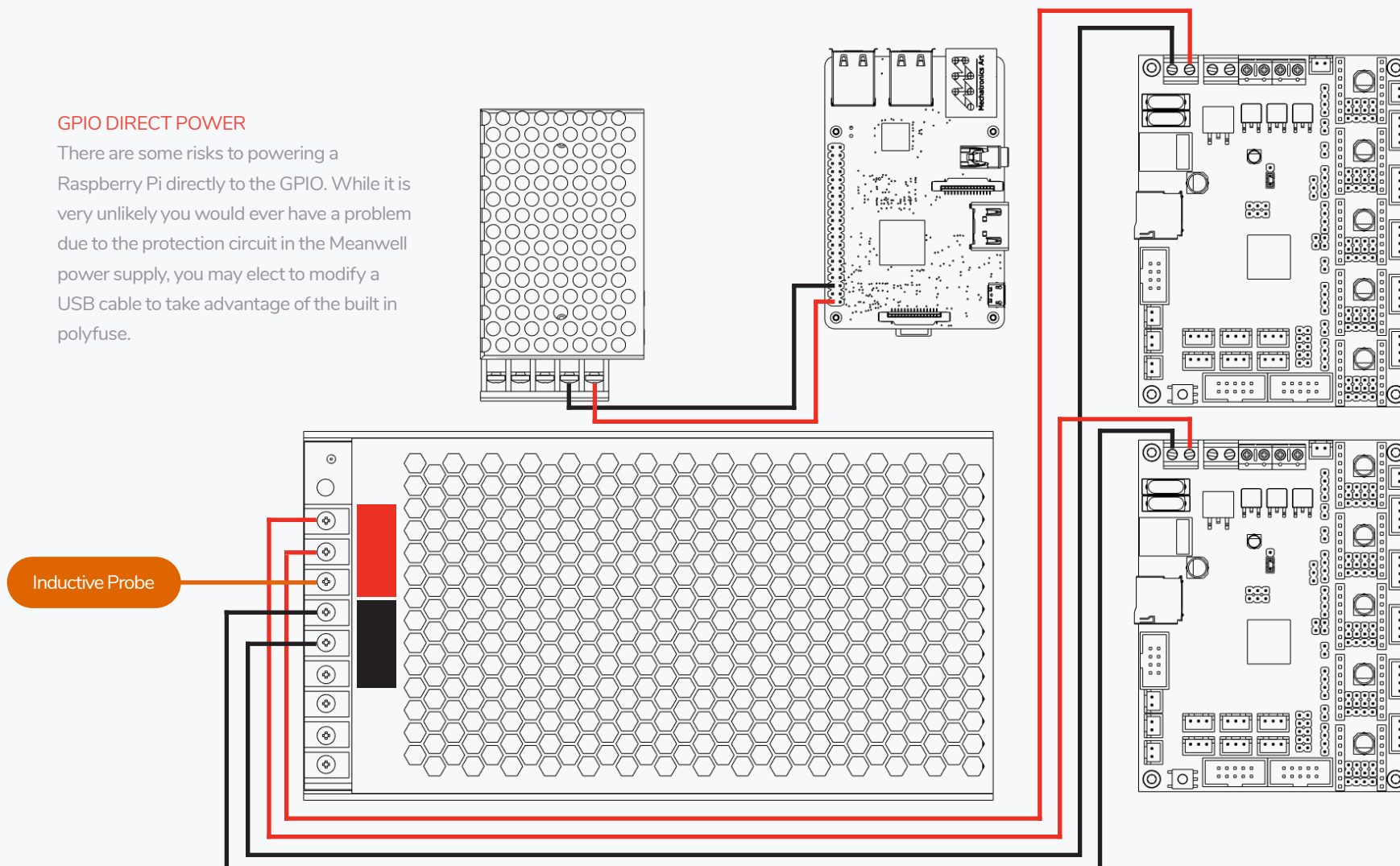
CHECK VENDOR SPECS

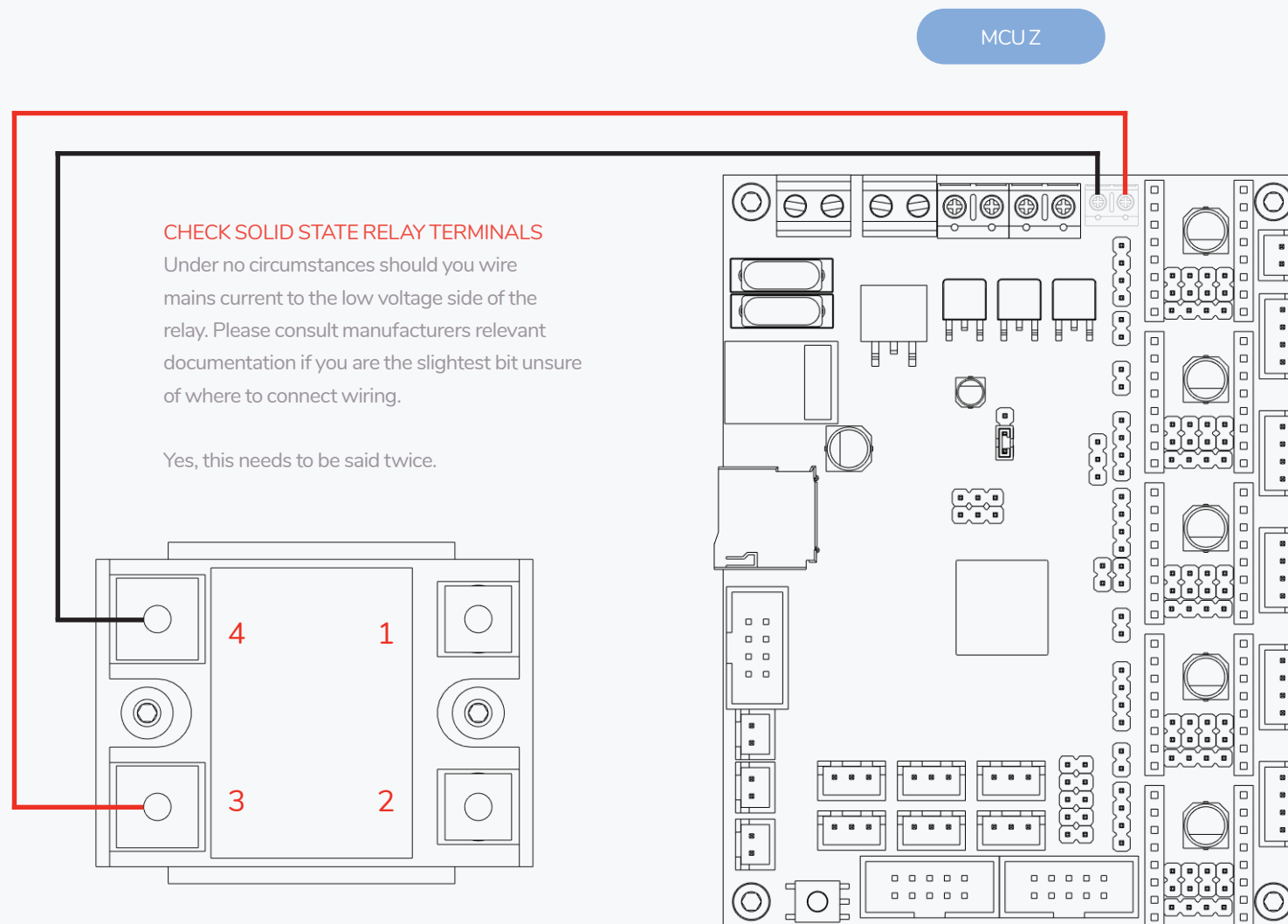
This wiring diagram is based on the current version of power supplies we use in the sourcing guide. These could change in the future so please make sure to verify wiring specifications from the manufacturer data sheets based on your individual model.



GPIO DIRECT POWER

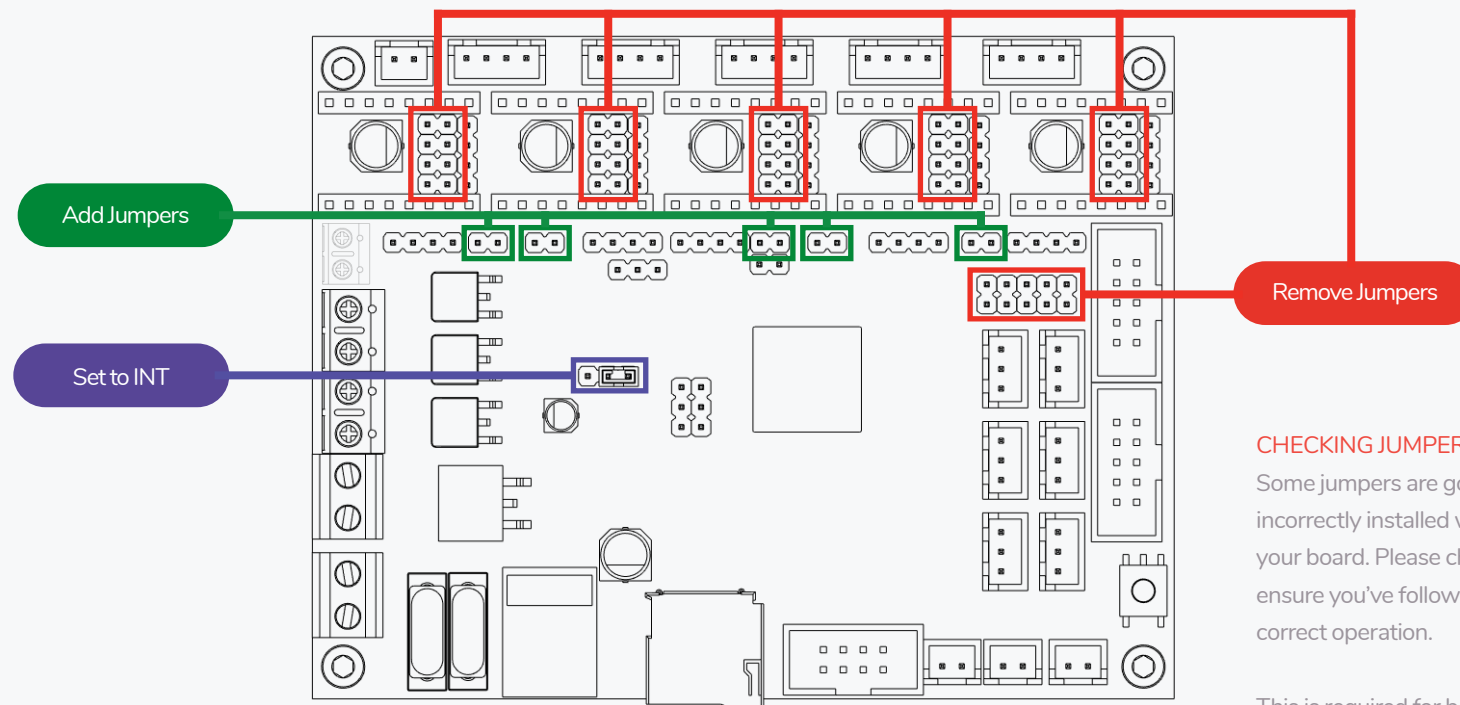
There are some risks to powering a Raspberry Pi directly to the GPIO. While it is very unlikely you would ever have a problem due to the protection circuit in the Meanwell power supply, you may elect to modify a USB cable to take advantage of the built in polyfuse.





SKR 1.3 Reference

Please note that this guide uses a SKR 1.3 wiring standard. An updated guide for the 1.4 boards will be out shortly. Please check discord if you are running a newer board.



CHECKING JUMPERS

Some jumpers are going to be incorrectly installed when you get your board. Please check it over and ensure you've followed this layout for correct operation.

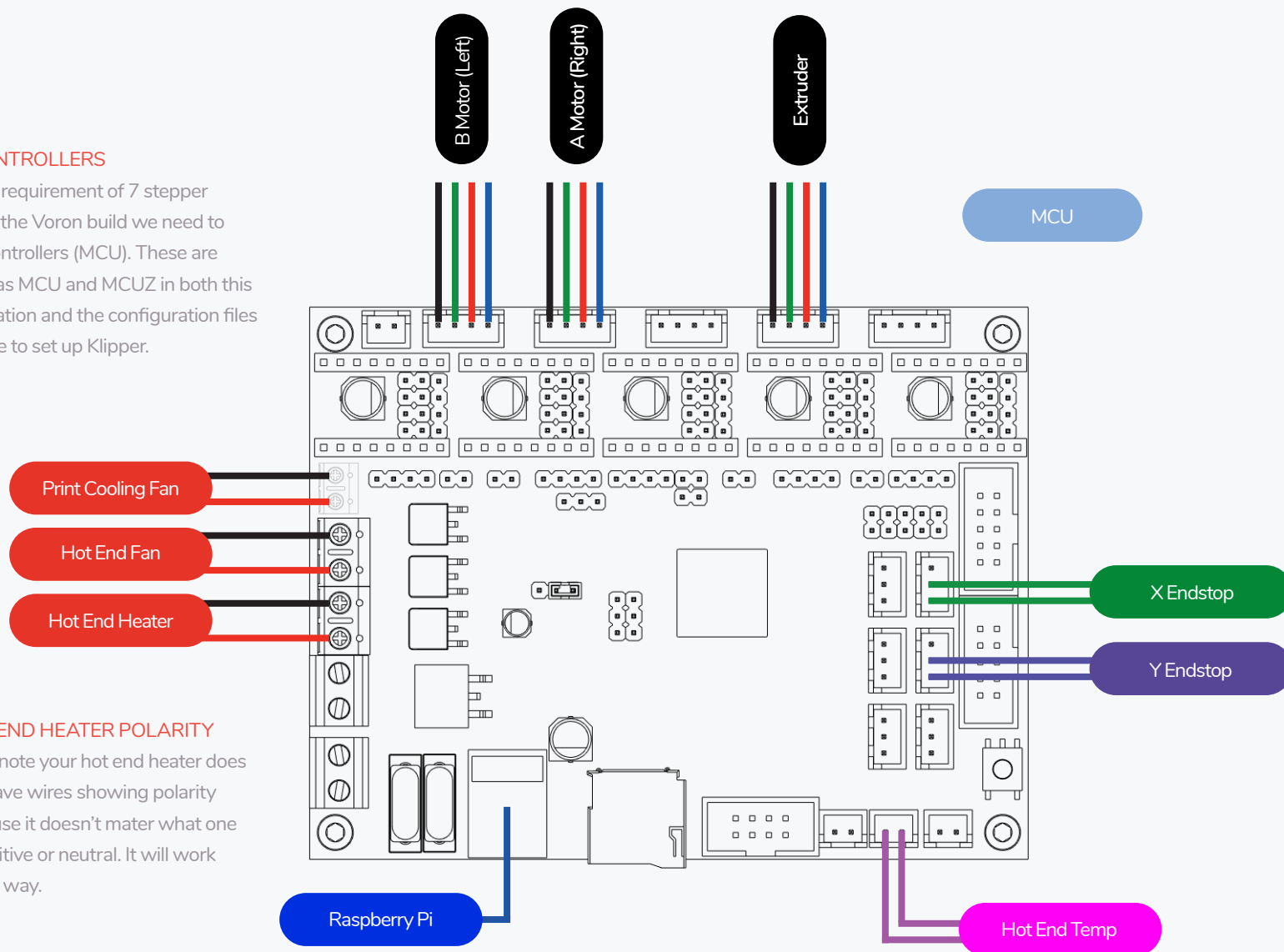
This is required for both controllers.

DUAL CONTROLLERS

Due to the requirement of 7 stepper motors for the Voron build we need to use two controllers (MCU). These are referred to as MCU and MCUZ in both this documentation and the configuration files you will use to set up Klipper.

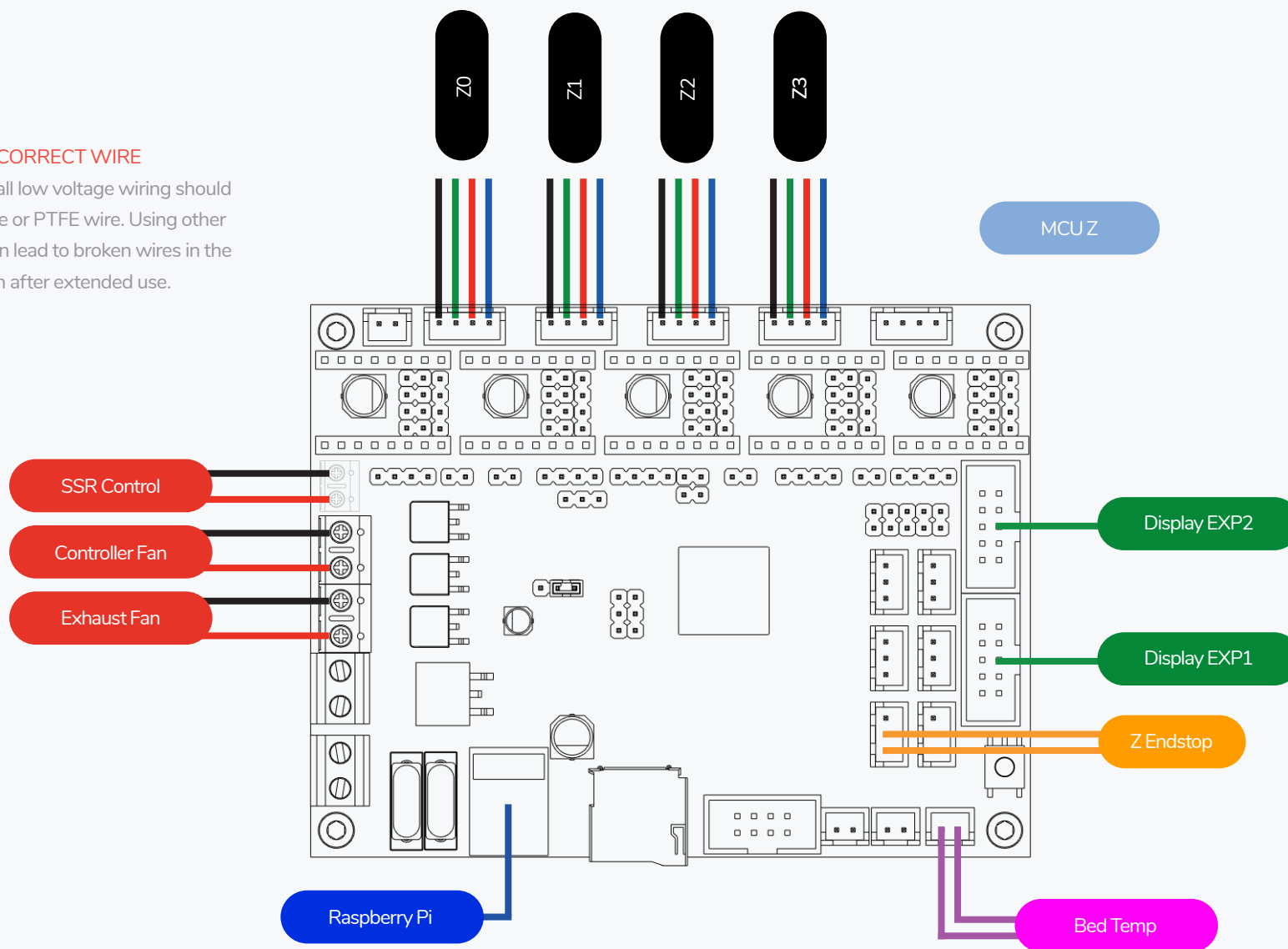
HOT END HEATER POLARITY

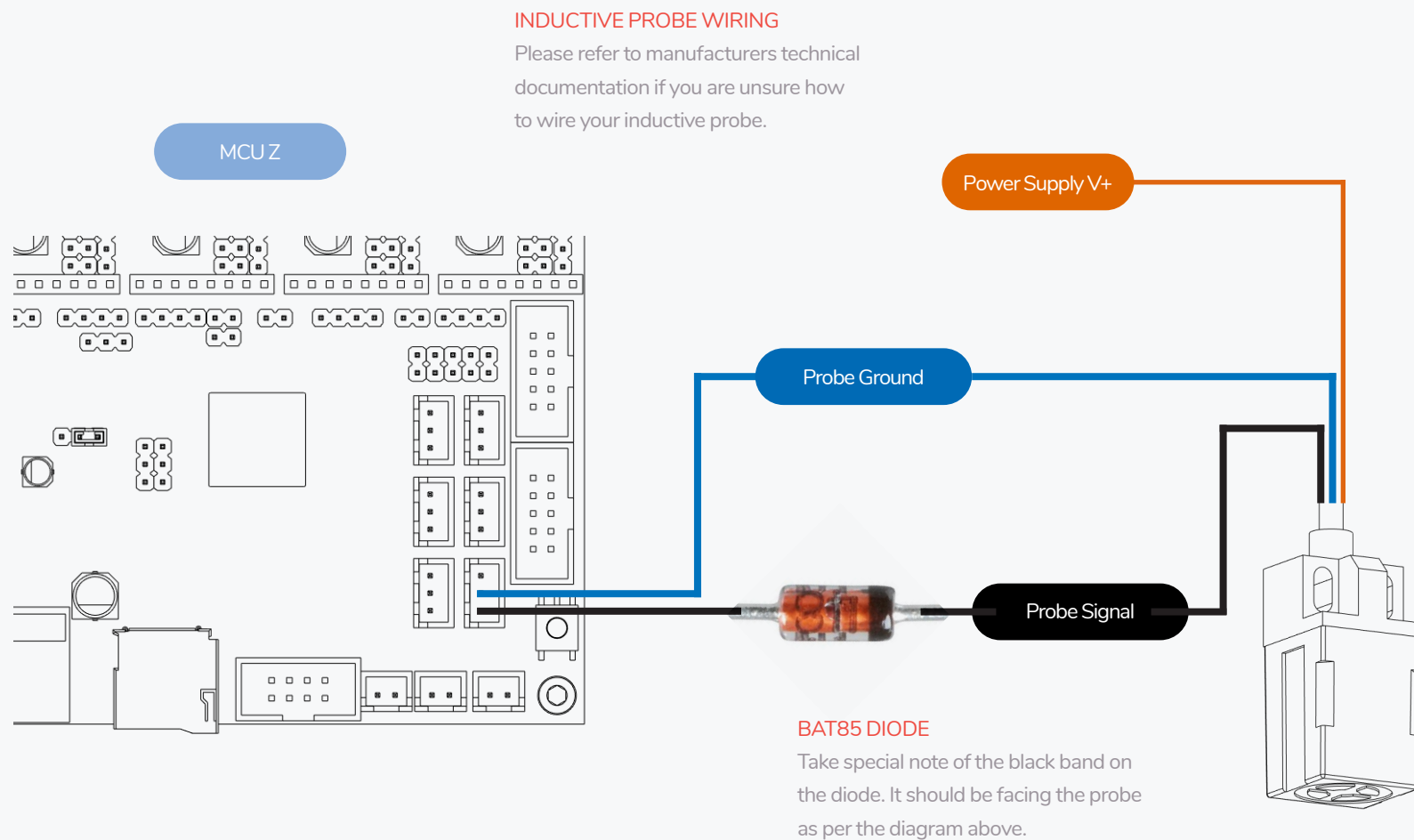
You'll note your hot end heater does not have wires showing polarity because it doesn't matter what one is positive or neutral. It will work either way.

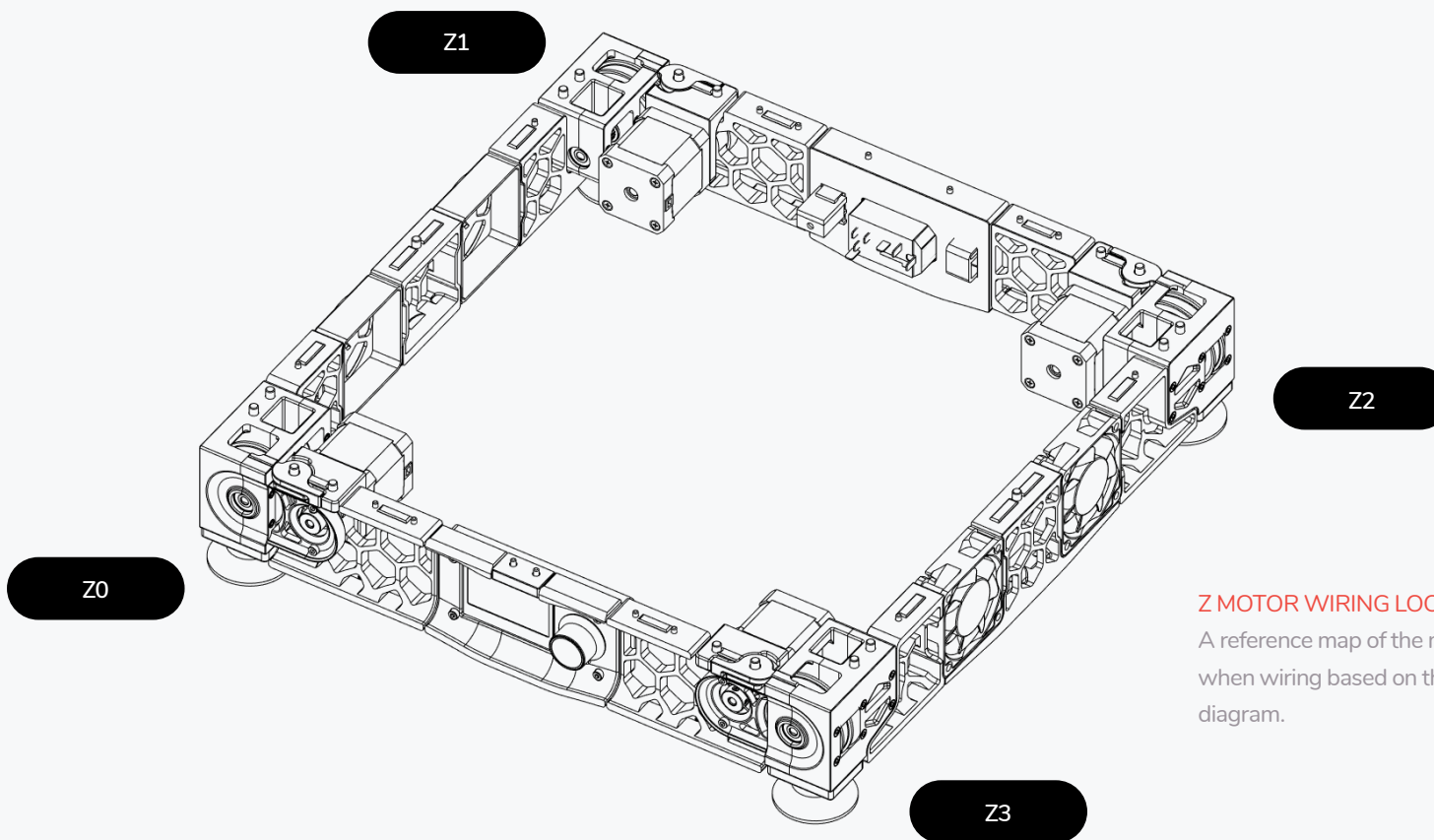


USE THE CORRECT WIRE

Note that all low voltage wiring should use silicone or PTFE wire. Using other options can lead to broken wires in the cable chain after extended use.





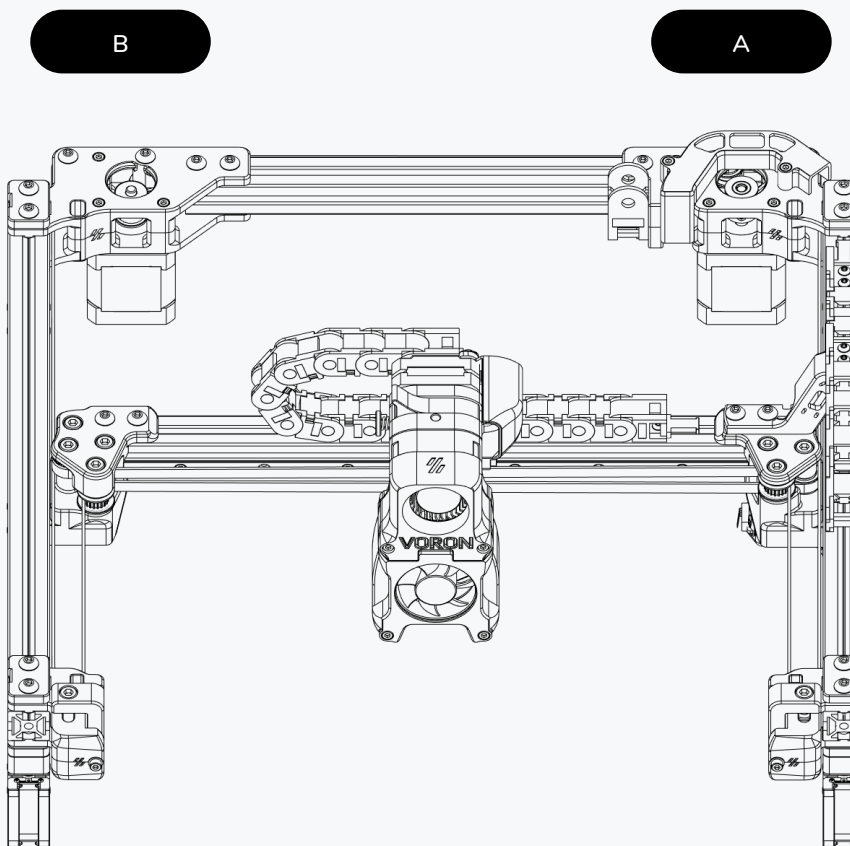


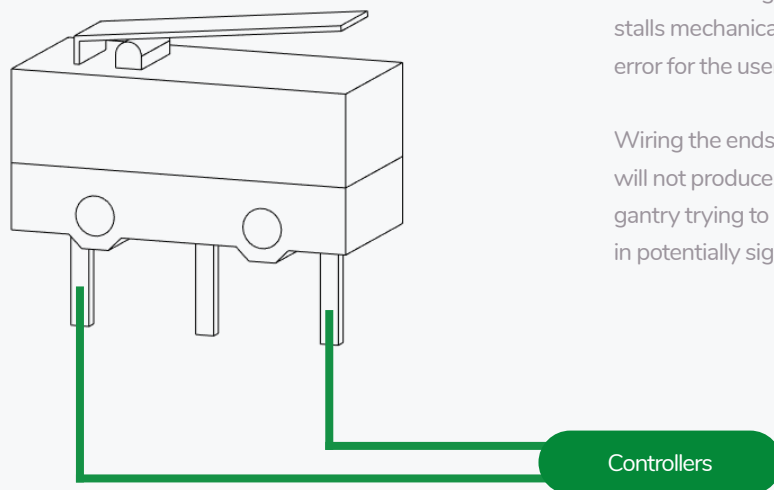
Z MOTOR WIRING LOCATIONS

A reference map of the motor locations when wiring based on the SKR MCU Z diagram.

XY MOTOR WIRING LOCATIONS

A reference map of the motor locations when wiring based on the SKR MCU diagram.





WIRING ENDSTOPS

For the purpose of endstops in the Voron - It is safer to wire in the NC configuration as a fault in the endstop or it's wiring stalls mechanical movement in the machine and produces an error for the user to investigate.

Wiring the endstop in NO configuration, a fault in the endstop will not produce an error and may result in the toolhead or gantry trying to move further than physically possible resulting in potentially significant damage to your machine.

MAINS WIRING

Now is a good time to go back and have a careful look at your mains wiring. Mistakes here can mean bad news so it's best to get some fresh eyes on things. Verify that your wiring conforms to the previous guide steps.

LOW VOLTAGE WIRING

Double check that your low voltage wiring has been completed correctly. It's not a bad idea to use a multimeter and spend some time tracing things to ensure that things are connected as they should be.

KLIPPER CONFIG

Verifying that things are connected in Klipper is very straightforward. Kevin has written a fantastic guide on what steps to perform. You can find his guide on the official Klipper Github, located at the link below.

https://github.com/KevinOConnor/klipper/blob/master/docs/Config_checks.md

TEST PRINTS & SERIAL

Once you're ready to start printing you might want to have a look in STL folder for some prints we use to tune our machines. Once you're successfully printing we would be happy to see your serial request. Check our Discord for more information.



Website
www.vorondesign.com

Github
<https://github.com/>

Discord
<https://discord.gg/xgXWctB>

