NOVA Assembly Guide

A custom built 3D Printer inspired by the Creality Ender 5

https://github.com/billgeek/nova-custom-3dprinter

OVERVIEW & PURPOSE

The NOVA is a custom designed 3D printer inspired by the Creality Ender . While I borrowed a LOT of the principles of the printer, there are some fundamental differences in some of the movement components and all of the printed parts I designed myself.

SPECIFICATIONS

The NOVA has similar specifications to the Ender 5 Pro:

1. Build Volume of 310mm x 310mm x 350mm
2. 0.9 Degree Stepper Motors on the X and Y axes for improved accuracy
3. External MOSFET components to protect the mainboard from over current
4. Sensorless homing on X and Y axes and Proximity sensor for Z homing
5. SKR 1.4 Turbo mainboard with the TMC2209 stepper drivers
6. TFT35 E3 V3 3.5” touch display

OBJECTIVES

I had an Ender 3 for a few months before I found a handful of flaws that I tried to fix. I did my calculations for sourcing the parts and found that for a little more, I could probably build a new printer. And so I did! Below were my design objectives and considerations:

1. The bed should never move, other than up and down on the Z axis. Compared to the Ender 3 this should result in superior print quality.
2. All moving axes should be supported on at least two points. Unlike the Ender 3, dual lead screws are featured with the Nova for the Z axis. The Y axis runs on two belts like the Ender 5.
3. Superior electronic components should be used with clear future upgrade paths. I decided on the SKR 1.4 to allow multiple extruders with ease.

MATERIALS NEEDED

You can find the full Bill of Materials on this Google Sheet link.

BUILD PROCESS

The build process is divided into three groups: Aluminum work such as drilling holes and tapping threads, the assembly for the frame and moving components and finally the electronics.

Please note that I am a Software Developer by trade and 3D printing is merely a hobby for me. I am not a metal worker, engineer or professional in any of the various fields discussed here, so I most likely did a few things incorrectly.

In that spirit, please use this guide more as a reference instead of an instruction manual!

TIMELINE

This will completely depend on how quickly and effectively you can accurately perform all the steps outlined in this document. In my case, I kept detailed track of the entire build:

- Design and modelling: 3 weeks
- Drilling and tapping holes: 2 days
- Constructing the Frame: 3 days
- Installing Electronics: 3 days
- Configuring and fine tuning firmware: 2 days

In total from start to finish I spent exactly one calendar month (March 2021) completing my printer.

BUILD INSTRUCTIONS

STEP 1: 3D PRINTED PARTS

To build this printer you will need to print a handful of parts as per the GitHub repository or the Thingiverse page. The most up to date list of printed parts can be found in the BOM Google Sheet linked above:

File Name	Qty	Description	Notes
LeadScrewNutHolder.stl	2	Holder for Lead Screw nuts	
LowerAngleBracket.stl	4	Angle Bracket for connecting the four bottom sections	
UpperAngleBracket.stl	4	Angle Bracket for connecting the four top sections	
XAxisGantryPlate.stl	1	Left-hand plate used for the X Axis when facing the printer	
XMotorBracket.stl	1	Right-hand plate used for the X Axis when facing the printer and for attaching the X Axis motor	
YAxisCover.stl	2	Cover for the Y axis belt and pulley - Also contains the bearing	**Print one of these inverted for the right-hand side**
YMotorBracket.stl	1	Bracket for installing the dual-shaft Y axis motor	
ZAxisPlate.stl	4	"Gantry plates" used for Z Axis motion.	**Print 2 of these inverted - Two facing out, two facing in**
ZMotorBracket.stl	2	Brackets used to mount the Z motors.	**Print one inverted for the right-hand side**
X Tensioner	1	Tensioner for the X Axis Belt	**https://www.thingiverse.com/thing:2502801**
Y Tensioner	2	Tensioners for the Y Axis Belts	**https://www.thingiverse.com/thing:3270228** **Note that these should be picked carefully: Only one side of the tensioner will have space to go "over" the extrusion**

STEP 2: ALUMINUM WORK

You will need to drill and tap holes into the aluminum extrusions. Below is a list of holes required.

I have separated the extrusions into their respective functions as follows:

Extrusion	Qty	Purpose
2040 - 500mm	4	Upright Corners
2020 - 500mm	8	Top and Bottom edges
2020 - 600mm	1	X Axis
2020 - 450mm	2	Bed Platform
2020 - 500mm	2	Bed Platform

Upright Corners

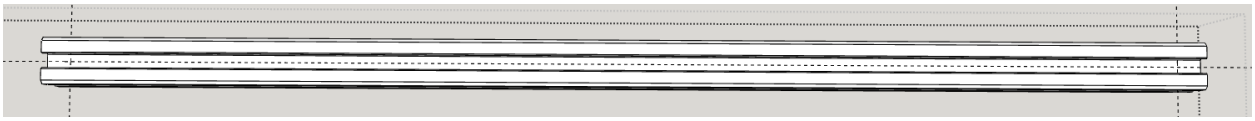
(2040 - 500mm)

- Use an M5 tap and create threads for both the “center holes” on the bottom side and one of the “center holes” on the top side.

Top and Bottom Edges

(2020 - 500mm) - ***NOTE: Only six of the pieces are to be used for this step! Leave the remaining two for later***

- Drill two M5 holes into the six extrusions, each hole being 10mm from either edge.

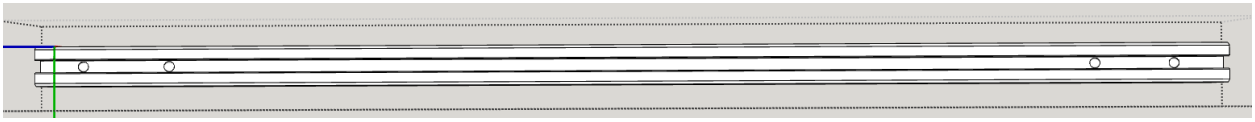


X Axis

(2020 - 600mm)

- Drill two M5 holes from the left edge: The first at 25mm and the second at 65mm.
- Drill two holes from the right edge: The first at 25mm and the second at 65mm.

You should have four holes in total: Two from either side.



Build Platform

Before we start drilling holes for the bed platform, go ahead and measure the distance between the mounting holes of your heated bed. In my case, the holes on my heated bed were 240mm apart from center to center.

(2020 - 500mm)

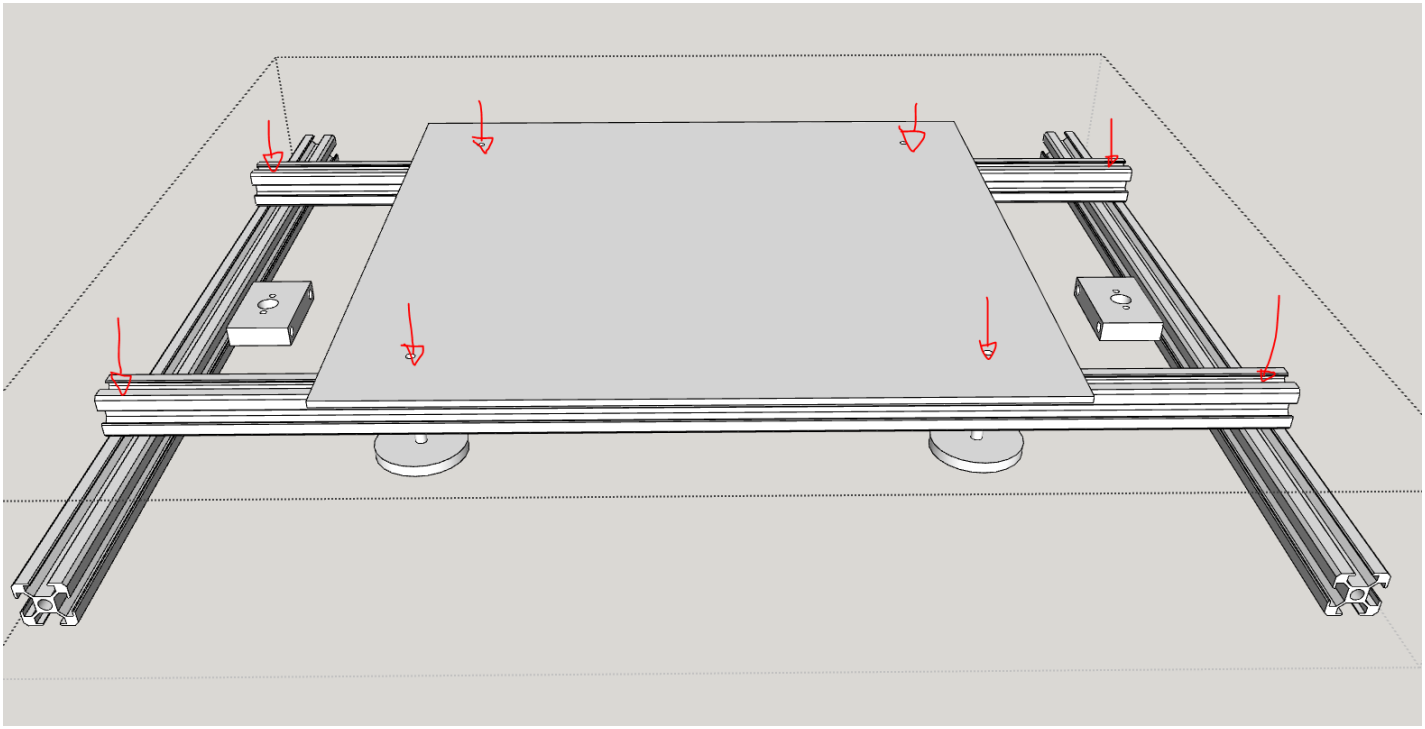
- Drill an M5 hole from either edges (2 holes in total)
- Drill an M4 hole <130mm> from either edge. You need to substitute 130mm with your own bed dimensions using this formula:

```
[Distance from Edge] = ([Total Width] - [Bed Hole Distance]) / 2
```

In my case that would be:

```
130mm = (500mm - 240mm) / 2
```

Please refer to the below picture and please DO NOT DRILL THROUGH YOUR HEATED BED! This picture simply shows where the holes are that were referred to in the instructions above.



(2020 - 450mm)

- Drill two M5 holes from the left edge: One at 10mm and the other at 30mm.
- Repeat this on the right-hand edge: An M5 hole at 10mm and another at 30mm.
- Rotate the extrusion 90 degrees so that the following set of holes are drilled perpendicular to the previous holes. In other words, the existing holes should now face back to front and new holes should be drilled top to bottom.
- Drill two M5 holes <105mm> from either edge. You need to substitute 105mm with your own bed dimensions using this formula:

```
[Distance from Edge] = ([Total Width] - [Bed Hole Distance]) / 2
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In my case that would be:

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105mm = (450mm - 240mm) / 2
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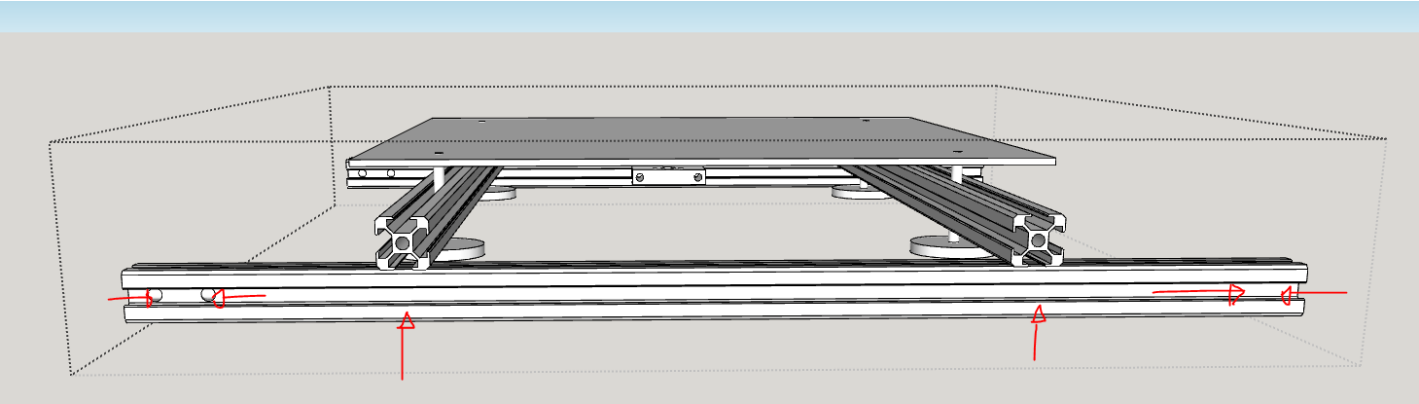
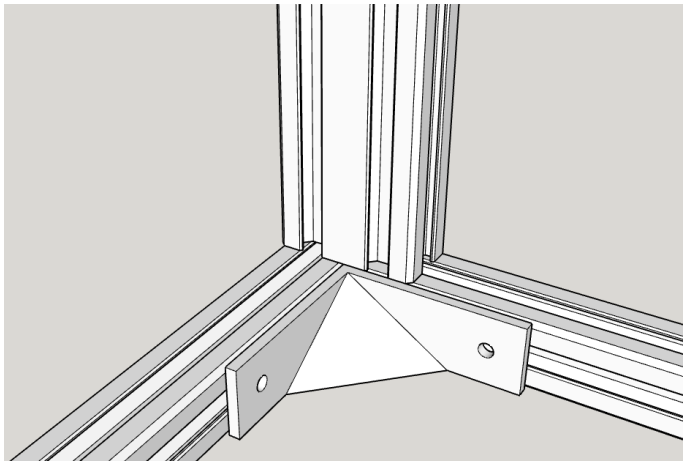
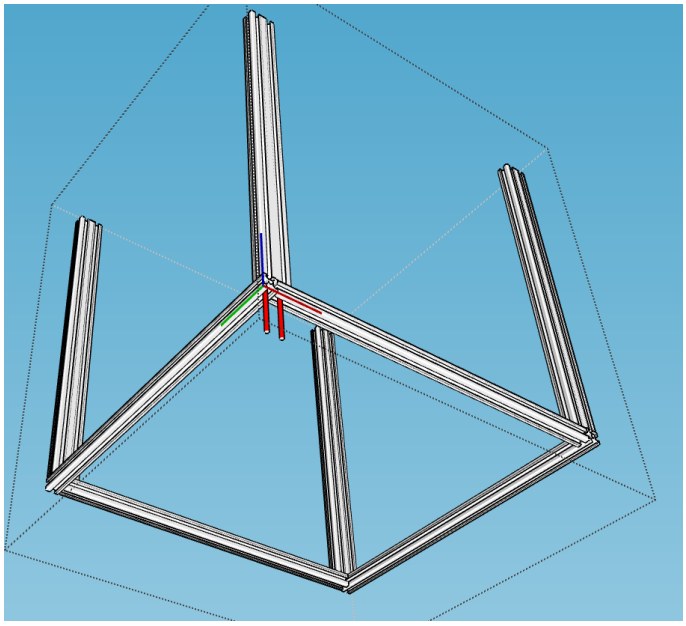


This step will also be broken into six individual sections listed below. Some of these steps could prove quite tricky, especially on the Y axis.

Frame Base (Bottom Section)

• Arrange four of the 2020 extrusions in a square, ensuring the front and back sections are between the left and right sections. In other words, you will end up with an assembled printer that is 540mm wide.	
• Attach the parts together using printed “LowerAngleBracket.stl” parts and two M3x10mm screws and TNuts per part.	

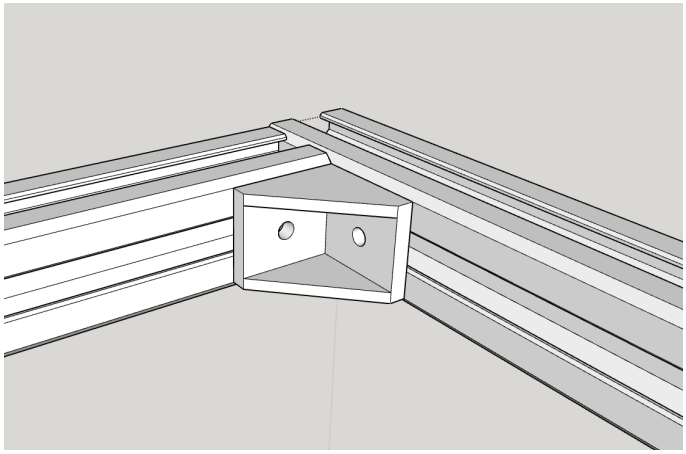
- Attach the four corner upright parts (2040 extrusions) to each corner using two M5x45mm screws. Note that the top hole with the tapped threads should face the inside of the printer.

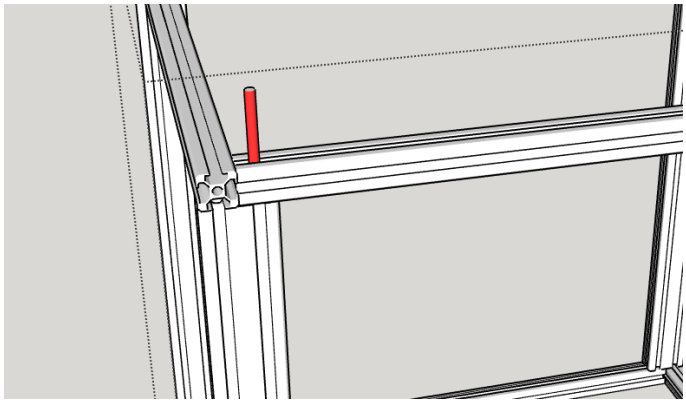
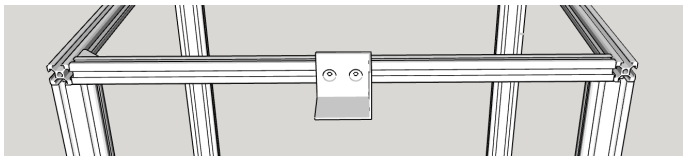
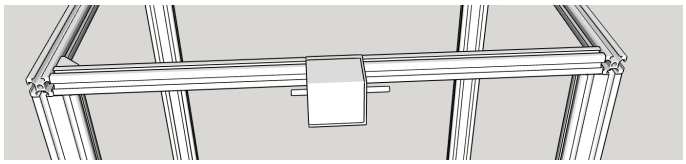


Frame Top (X and Y axes)

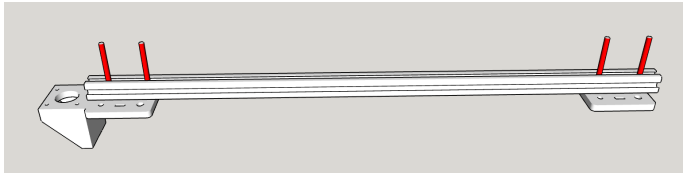
- Arrange four of the 2020 extrusions in a square, ensuring the front and back sections are between the left and right sections.

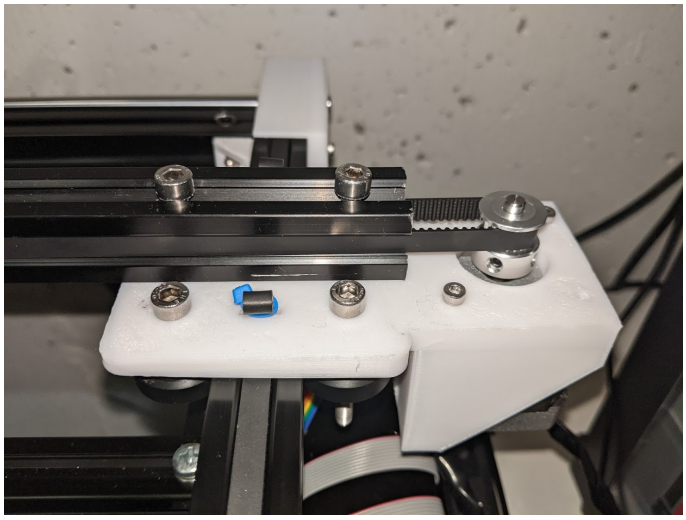
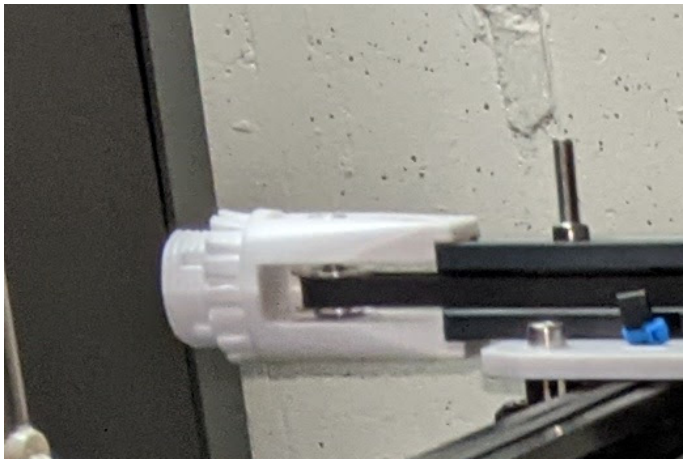
- Attach the parts together using printed “UpperAngleBracket.stl” parts and two M3x10mm screws and TNuts per part.

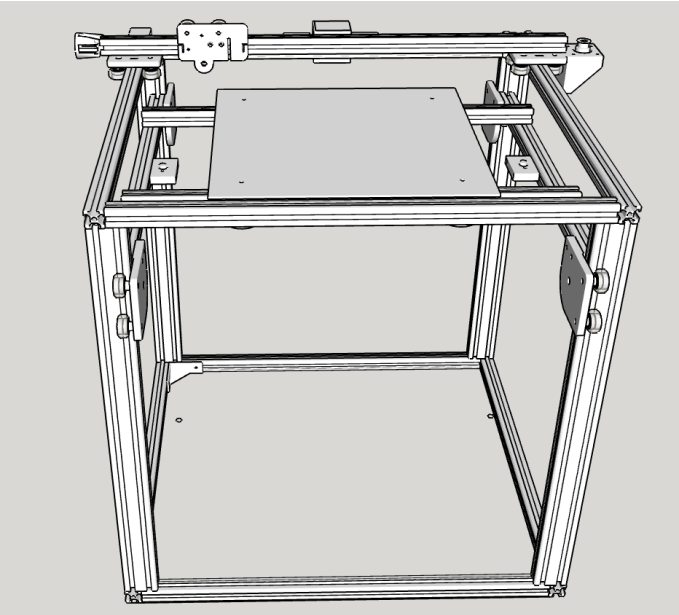


• Temporarily attach what you currently have assembled (the upper frame) to the lower frame using two M5x45mm screws.	
• Attach the printed “YMotorBracket.stl” part to the center of the back extrusion using two M3x10mm screws and TNuts.	
• Install your dual shaft stepper motor into the Y motor bracket.	

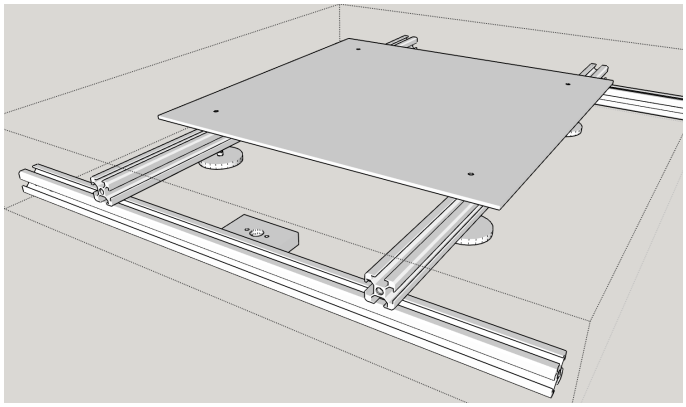
X Axis

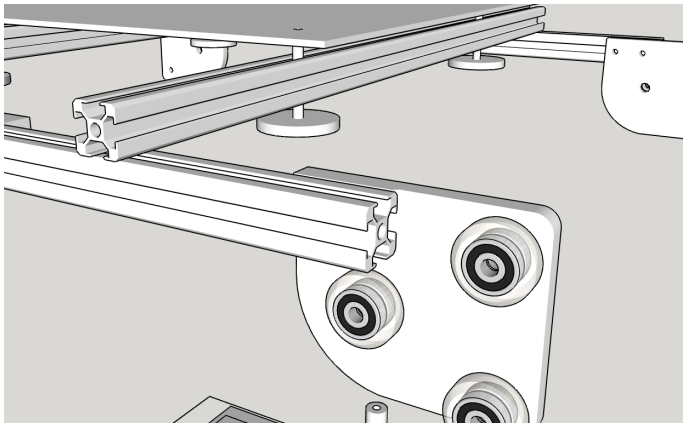
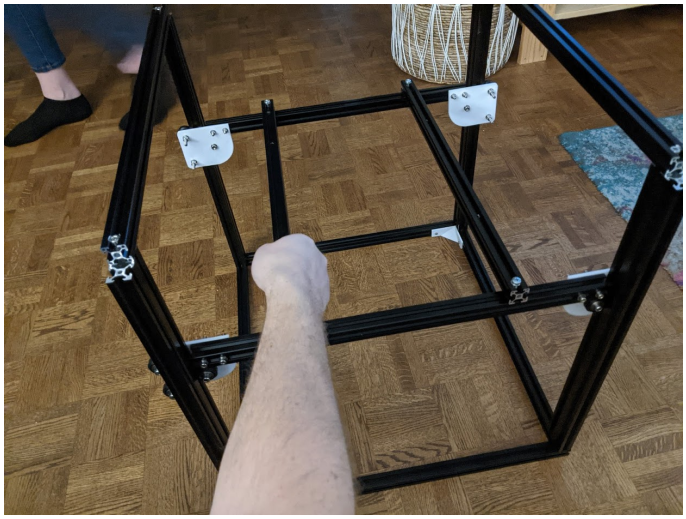
• Attach the printed “XMotorBracket.stl” and “XAxisGantryPlate.stl” parts to the 600mm 2020 extrusion using four M5x45mm screws and nyloc nuts.	

• Attach the X stepper motor to the motor bracket.	
• Install a toothed pulley to the stepper motor.	*Refer to the above picture.*
• Install the hotend gantry plate to the extrusion. Depending on which gantry plate you have, you may need to either remove one of the side plates, or remove a POM wheel on the gantry plate to install it.	
• Add a smooth pulley into the printed tensioner for the X Axis.	
• Holding the assembled tensioner in its place against the end of the X Axis (the side with the Y plate, not the X motor mount) measure out the belt you will need and install the belt.	

• Install four POM wheels on both plates, making sure to use two eccentric nuts on either on the inside.	
• Remove the top frame and slide the X axis over the side edges. This may be a tricky step and you may need to remove the “front” bar of the top frame assembly to achieve this.	
• Once the X axis is moving freely on the top frame, go ahead and temporarily attach the top frame again.	

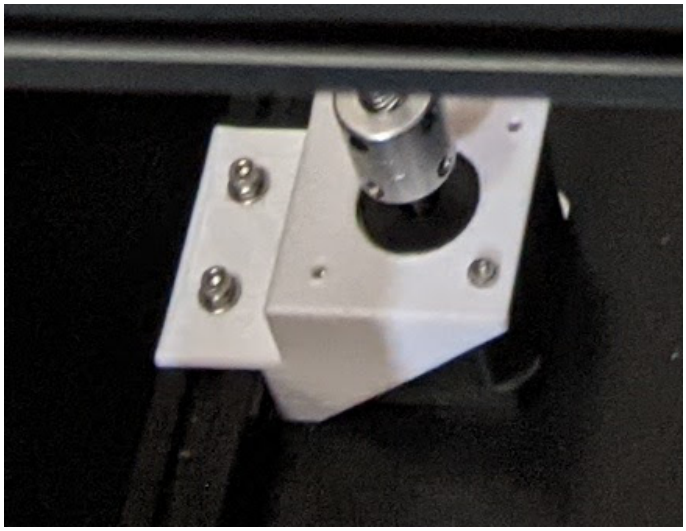
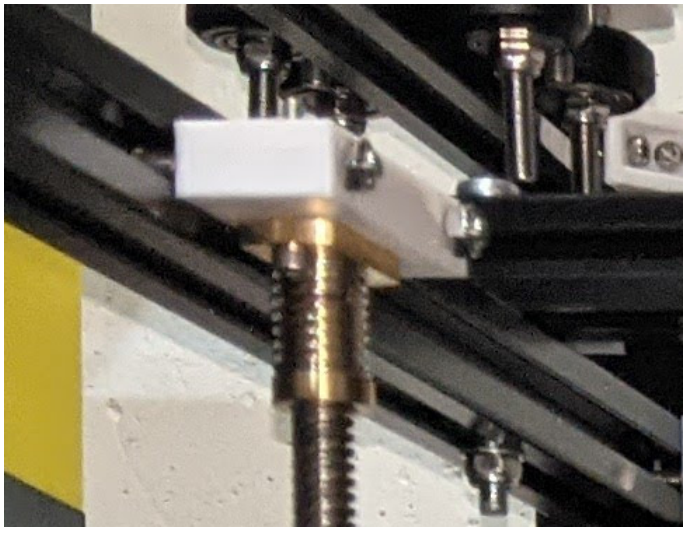
Build Platform

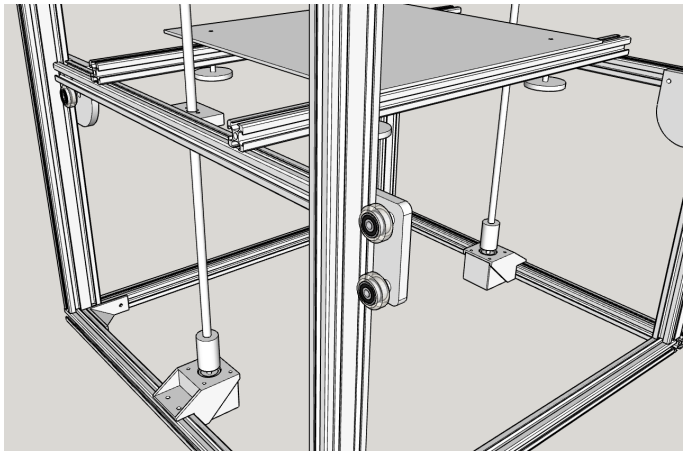
• Place the 400mm 2020 extrusions 500mm apart in parallel, then place the remaining two 500mm extrusions across the two pieces. Attach them using M5 screws and nuts. (Hint: Do not install your heated bed as yet as this may make the next few steps harder)	
• Attach the two printed "LeadScrewNutHolder.stl" parts to the center of each of the shorter sides. Do not be too concerned if they're not exactly in the center as you will likely need to adjust them shortly.	*Refer to the above picture.*
• For each of the printed "ZAxisPlate.stl" parts, install three POM wheels. Make sure to install the "inner" wheel using an eccentric nut for adjustments later on.	

• Attach an assembled Z plate with wheels to each protruding edge of the assembled build platform. **NOTE:** Ensure that the plates face the right way! Each plate has a raised area with two smaller holes which need to be attached to the INSIDE of the protruding section with the POM wheel below the extrusion.	
• Remove the top of the frame from the bottom frame and slide the assembled bed platform over the corner uprights. Note that the wheels should run on the inner VSlot groves of the upright components. You need to take your time here. If the bed does not fit with a reasonable amount of pushing and “forcing”, you need to make sure your frame is accurately squared.	
• Temporarily attach the top frame to the bottom frame again.	

Z Motors and Lead Screws

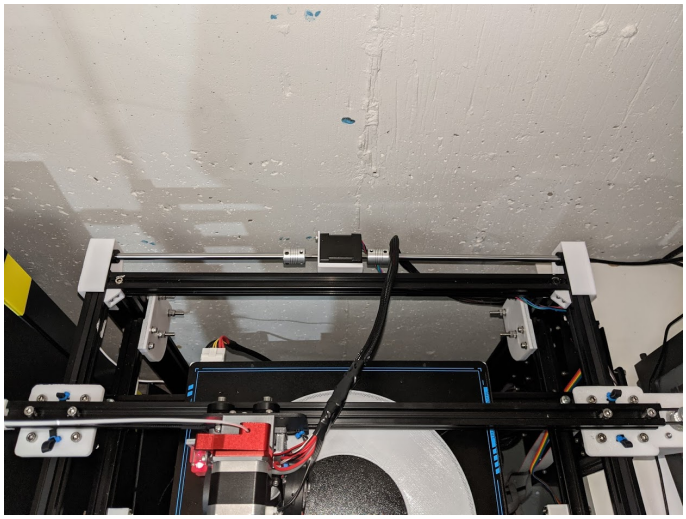
• Install a stepper motor into each of the printed “ZMotorBracket.stl” parts. Ensure the cabling or cable connector faces the intended direction.	

• Attach each of the assembled Z axis motor brackets to the center of each side using two M3x10mm screws and TNuts. Don't be too concerned if they're not precisely in the middle, this will be adjusted later.	
• Install a 5mm to 8mm coupler on each motor shaft.	*Refer to the above picture.*
• Attach the anti backlash nuts for the lead screw to each of the lead screw holders on the build platform.	
• Insert a lead screw through the top of the lead screw holder and nut and into the stepper motor coupler. Do this on both sides.	
• Move the build platform as high as it needs to go. The build platform will likely not stay here, so this is again a bit of a	

tricky step.	
• Now you will need to loosen and move around the lead screw nut holder and z motor brackets on either side. These components need to be in line with one another and should not tilt, warp, buckle or bend when the bed moves. To ensure this is the case, you may need to move your build platform up and down a few times from minimum to maximum to ensure that the lead screws are installed perfectly straight and aligned correctly.	

Y Axis

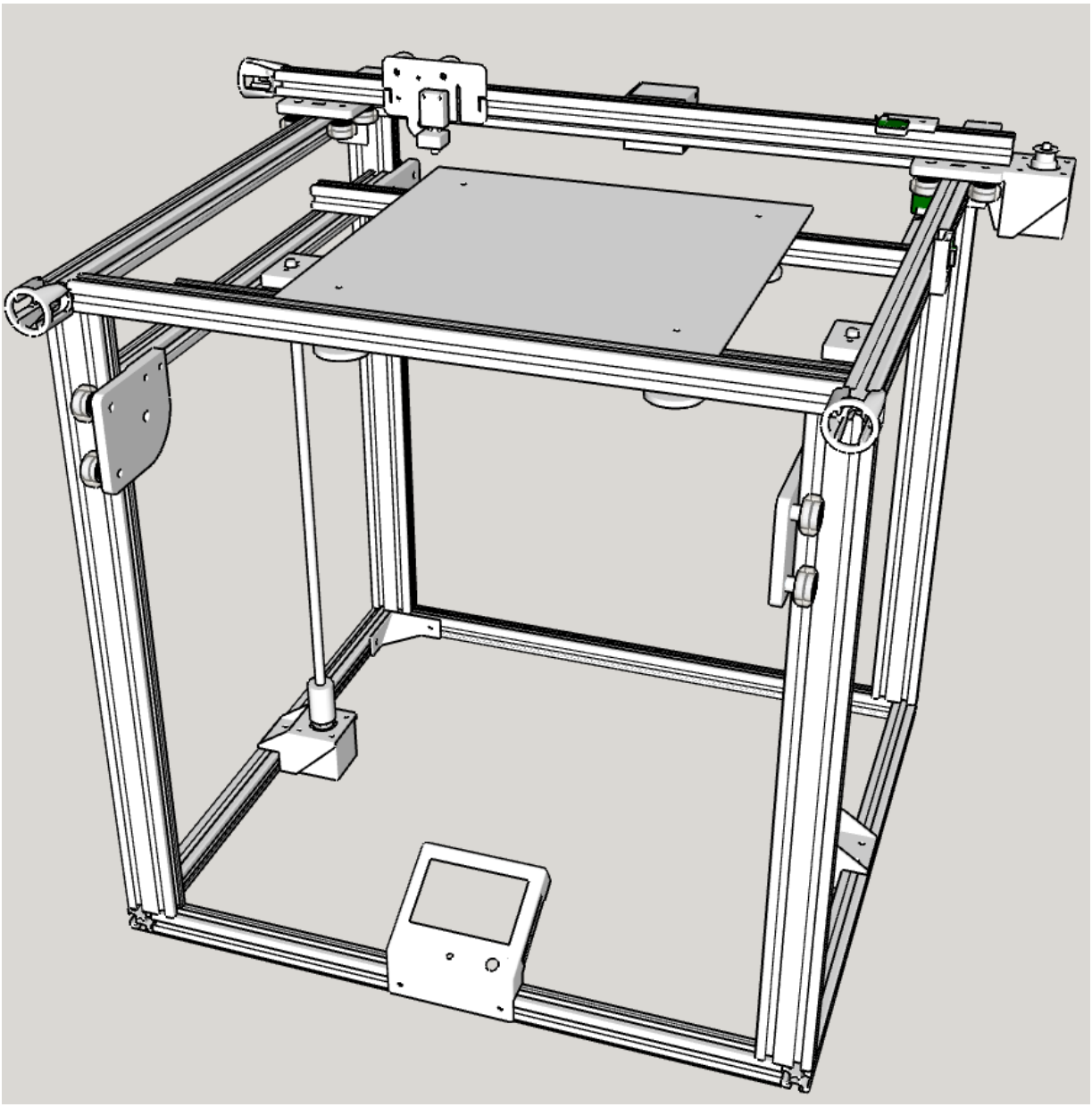
• Remove the top frame from the bottom frame assembly.	
• Insert a 608 bearing into each of the “YAxisCover.stl” printed parts.	
• Add two M3x10mm screws with TNuts to each of the Y covers.	
• Place a 5mm to 8mm coupler on each of the shafts from the Y stepper motor.	

• Add a toothed 8mm pulley to each smooth rod and attach the smooth rods to the couplers of the Y axis motor.	
• With the rods installed, install the Y Axis cover. The smooth rod should go through the pulley and the cover should only be installed using the top M3 screw for now. NOTE: These rods should be parallel to the top back edge. If these are not parallel you may wear out some of the components much quicker. (Specifically the couplers and the bearings)	
• Install a GT2 belt in a similar fashion as you did for the X axis: Assemble the tensioners using smooth pulleys, hold them in place and measure out your belts. Attach them to the X motor mount and X axis plate.	
• Attach the top frame to the bottom frame “permanently” using four M5x45mm screws.	
• Finally attach the Y axis cover to the	

upright extrusions by tightening the TNut screws.	

Finally

The very last step would be to install your heated bed using tapered M4 screws, bed springs and bed levelling knobs of your choice.



STEP 4: ELECTRONICS

As there are many, many instructions online on 3D printer electronic components, I won't be going into detail here. I will mention a "high-level" to-do though:

- Install the hotend and extruder of your choice. I decided on a stock Creality Ender 3 hotend for now (future upgrade opportunity here!) and the Hero Me Gen 5 system with Direct Drive. You can find all of this on Thingiverse. (https://www.thingiverse.com/thing:4460970)
- If you're using a proximity sensor, inductive probe, BLTouch or ABL, install this to the hotend assembly too.
- Print and install an electronics enclosure of your choice. Again, there are tons of options available on Thingiverse and I chose this one: https://www.thingiverse.com/thing:4338524 I will likely design a custom one for my printer in the future.
- Install the mainboard and MOSFET components into the enclosure.
- Plug the five motors into the mainboard.
- Print an LCD cover of your choice. As with the above steps, there are many options available online. For my components I decided on this one: https://www.thingiverse.com/thing:4547059
- Install the LCD to the printer wherever and however you prefer and plug it into the mainboard too.
- Wire up the power supply to the mainboard and the MOSFET modules.
- Connect the heated bed and hotend to the MOSFET modules.
- If you're using any form of ABL, remember to hook this up to the mainboard too.

Finally you will need to configure your firmware of choice. I decided on Marlin and have included the configuration files I have for my completed build in my github repository. (Link in the header of this document)