Building a Large Kossel Delta Printer – pt. 1: Parts and Planning

January 11, 2017 Mads Aasvik 3D Printing Projects, Mechatronics

Access to a 3D printer is very important for us in Norwegian Creations. Now we've decided that we want to upgrade our 3D printer park with a new big and fast printer. This time we're going all out with a top-of-the-line custom built **delta printer**!

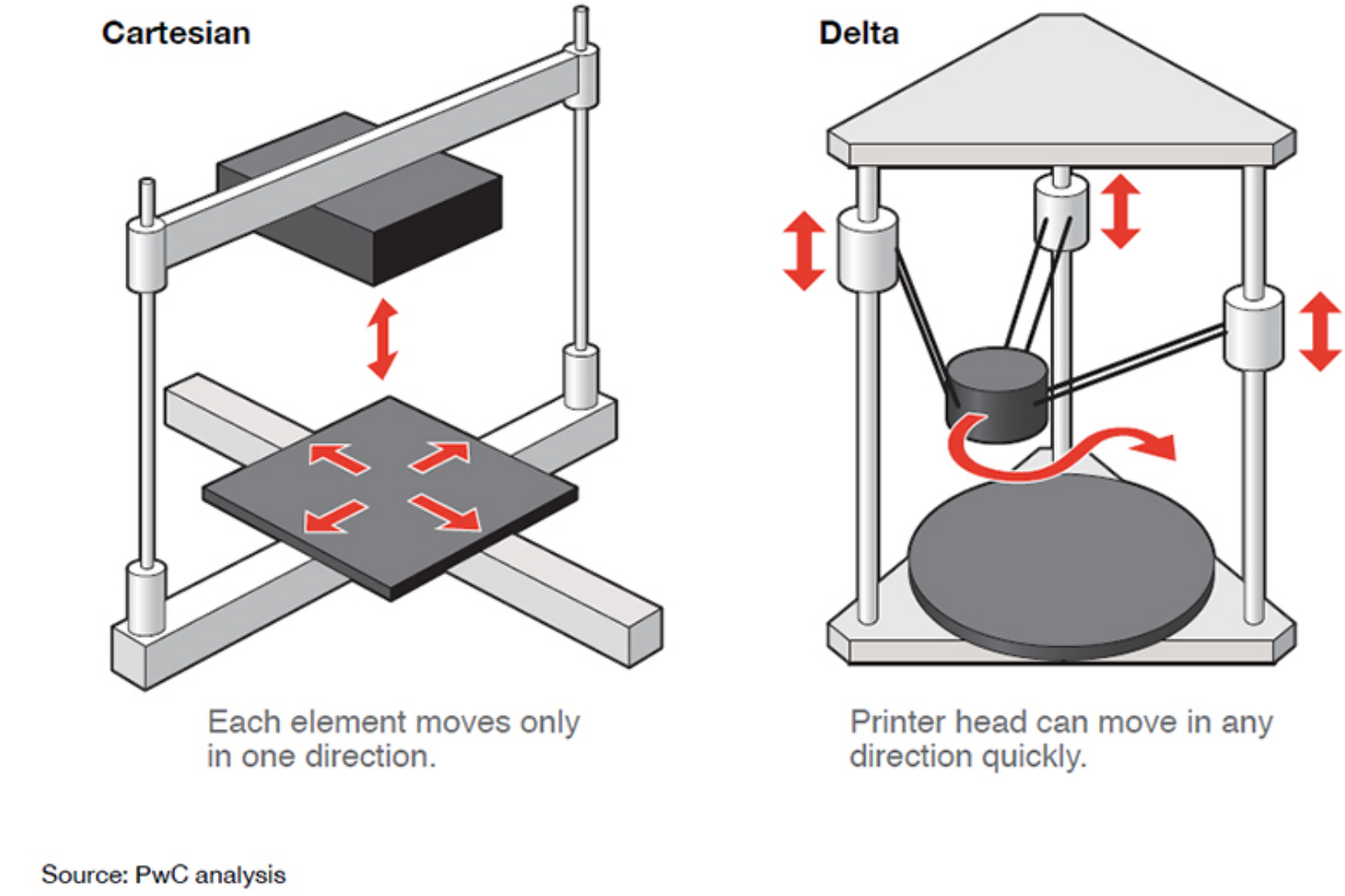
A render of an incomplete model of our Kossel build. Virtual banana for scale.

The Kossel Delta Printer

The **Kossel** printer is not one specific printer such as for instance the Ultimaker 3, but rather a general design which is both sold fully assembled by different outlets as well as used as a build-your-own blueprint. The Kossel printer is based on the **Rostock**, which again is based on the **Helium Frog**.

These printers are delta printers, which in design are quite different from the more common cartesian 3D printers. Instead of having the stepper motors controlling their own axes, the motors on delta printers must cooperate for each movement in every axis.

The biggest advantage with delta printers is that you get much faster movement due to the reduced moving weight. A couple of general disadvantages are that the frame is quite tall relative to effective print height and that it might be a bit more complex to set up and calibrate.



Comparison between cartesian and delta 3D printers (source: http://www.pwc.com)

Our Kossel Build

First of all we want to thank Jardar Nordbø for all the advice and tips he gave us on how to build our own Kossel 3D printer! He has already built a Ø260 mm Kossel XL which we got a lot of inspiration from.

Our main goals with this build are:

- fast print speed,
- a large print area,

- tall build height,
- accurate prints, which implies good quality components.

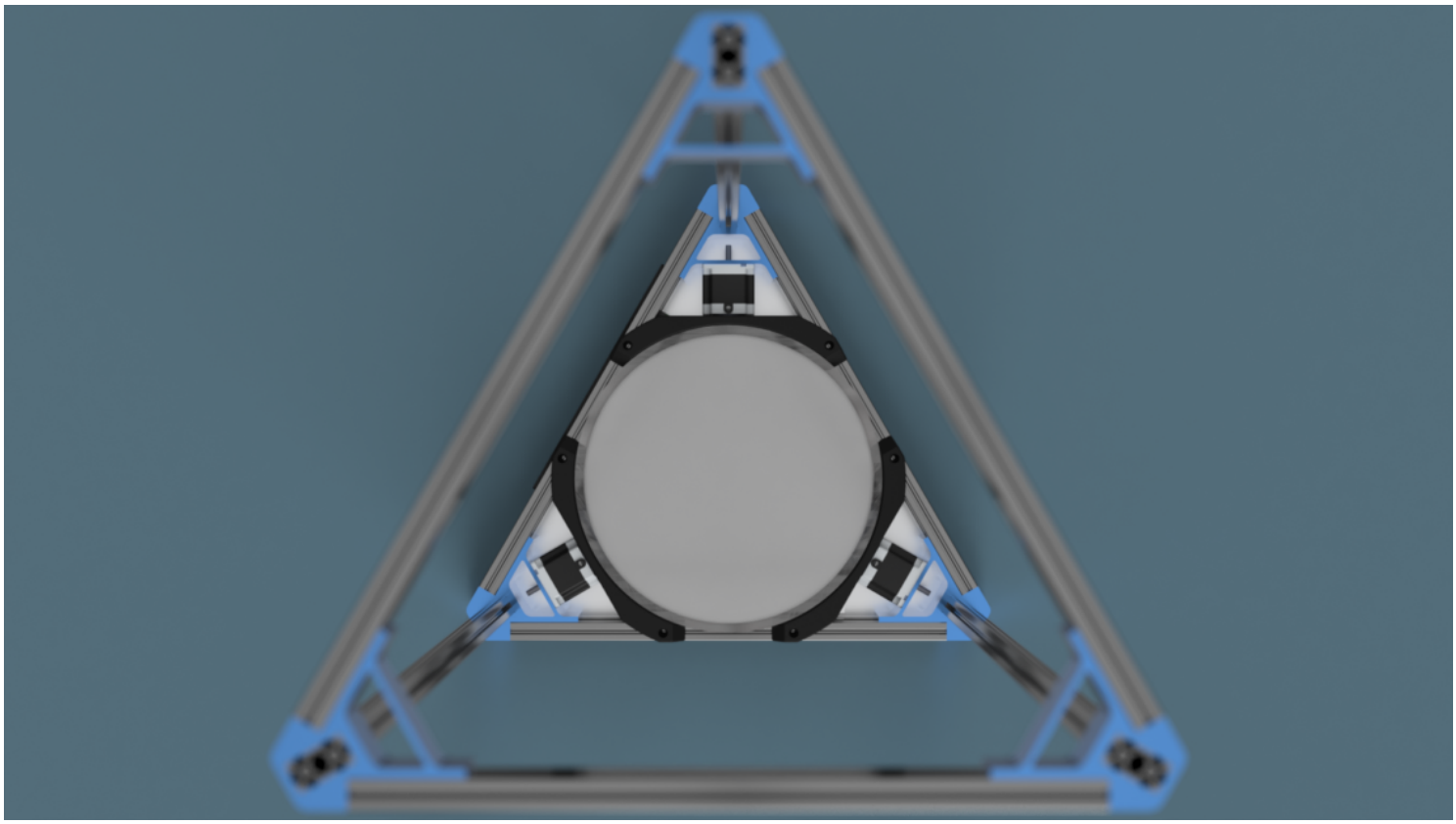
Dimensions

Build plate dimensions: **Ø330 mm with Ø310 mm printable area**. These dimensions were chosen based on what components and parts we could find.

We wanted the outer edge of the build plate to virtually touch the centerline of the horizontal frames and not exceed the frame as seen on many other Kossels. This led to **horizontal extrusion lengths at 471 mm.**

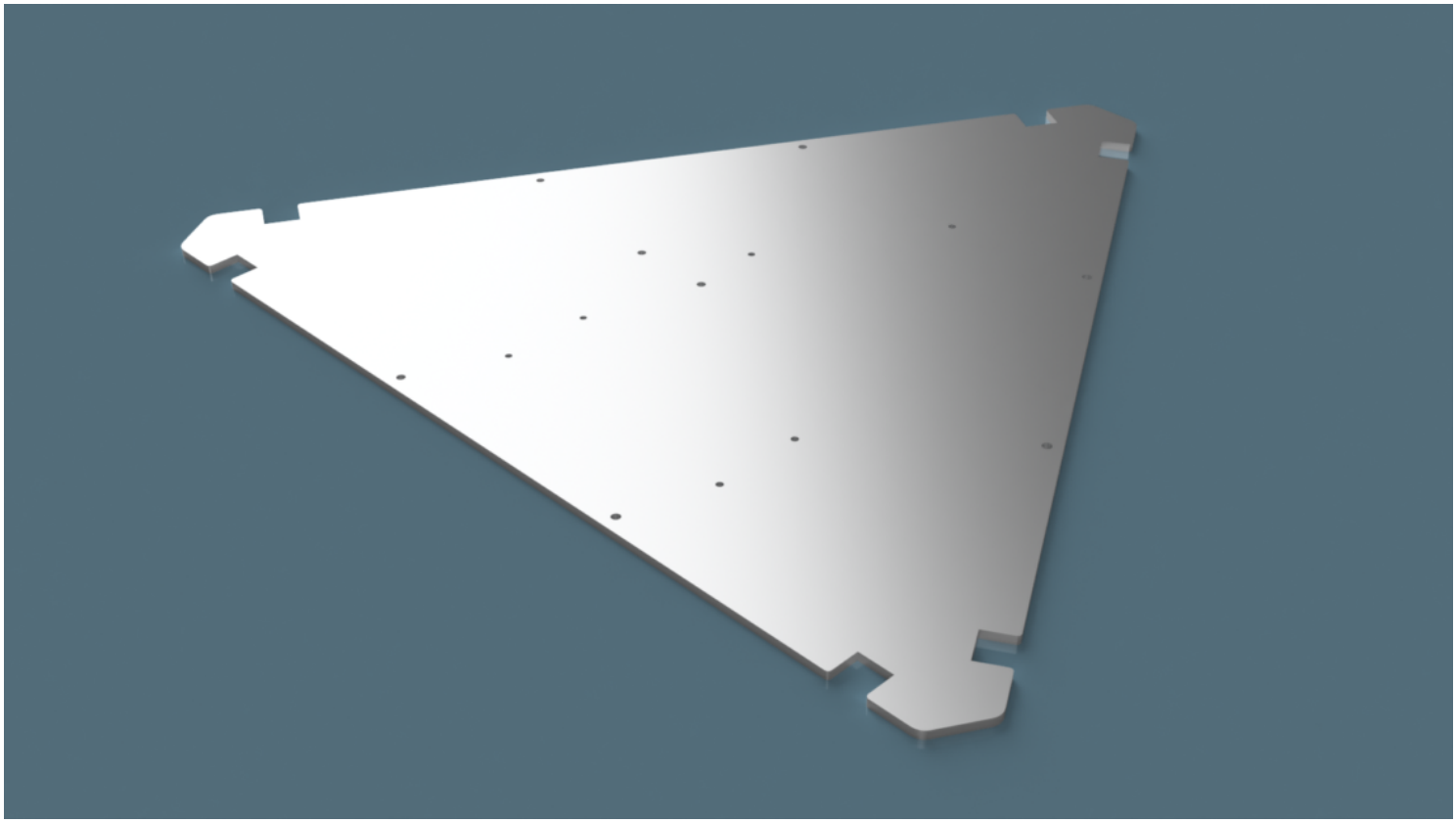
The length of the horizontal extrusions decides roughly how long the rods out to the effector need to be. Here we landed on **400 mm**. This length will let the nozzle reach the outer limit of the printable area with a rod angle of around 20°, taking into account both effector joint and rail offset. 400 mm is 82% of the tower center to tower center distance which is not far from the 80% rule of thumb which is mentioned in several forums.

Height-wise we landed on a **1 m tall frame**, which gives us a maximum print height of somewhere between 400 and 500 mm.



Frame Parts

The frame (depending on how you define it) consists of aluminium extrusions and corners as well as a custom aluminium baseplate. The baseplate is not completely necessary, but it gives a nice "floor" to mount parts to as well as working as a heatsink for SSR and PSU.



The custom aluminium baseplate with cutaways for vibration dampers.

Frame BOM:

- 6 pcs 471mm 20×20 extrusions (bottom horizontal)
- 3 pcs 471mm 20×40 extrusions (top horizontal)
- 3 pcs 1000mm 20×40 extrusions (vertical)
- A set of **aluminium corners**
- 5mm Aluminium base plate

We chose **Misumi** as supplier for the extrusions. A local company will laser cut the baseplate.

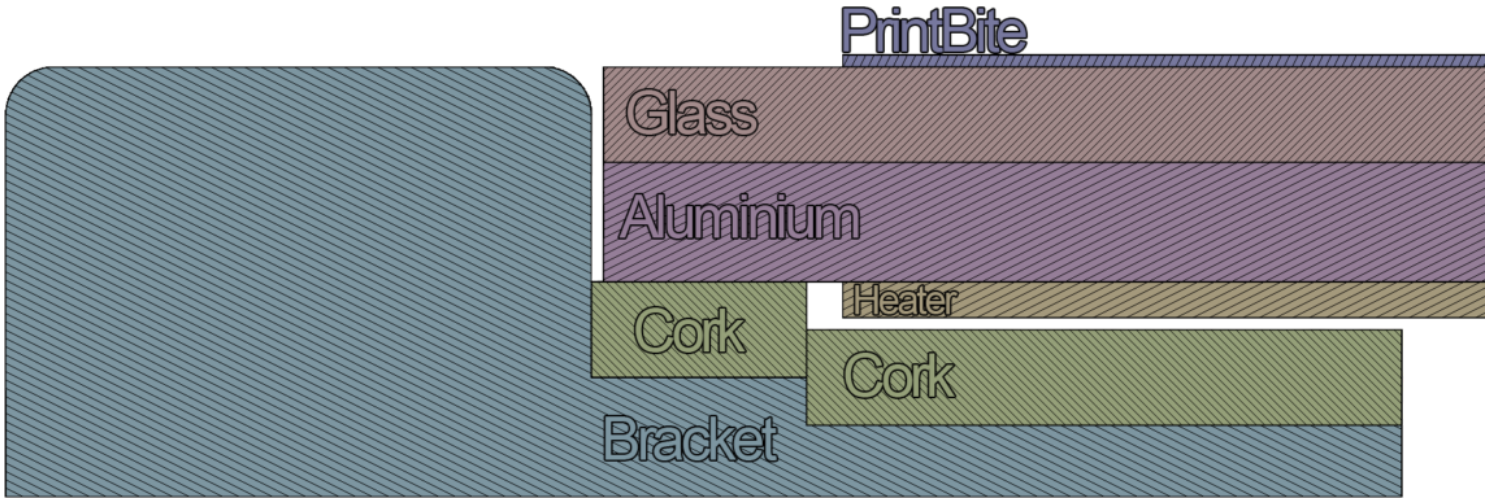
Build Plate

For the heater we wanted a powerful one in silicone (not Kapton), and with 230V we can draw current directly from the mains. We ended up with a **Ø310 mm 550 W heater** from Aliexpress which will give us plenty of power.

The heater will be fastened to the underside of a **Ø330 mm x 5 mm aluminium disc** which will be laser cutted by the same local company which does the baseplate. On top of the aluminium disc we'll have an easily swapable glass plate. The reason for this is to more quickly start a new print after the last one is finished. This way we don't have to wait for the glass to cool down. The glass will be **Ø330 mm x 4 mm borosilicate glass plates**, found on Aliexpress. These plates are made for delta 3D printers.

We also want to have a nice print surface so that we don't need to use glue, hairspray or other adhesive to keep the print in place. We will use **Ø310 mm Printbite** sheets that will be glued to the glass plates. Printbite is compatible with IR-probes, which is required for this build.

Between the aluminium and the 3D printed build plate bracket we'll glue 4 mm thick cut **cork** to protect the plastic from the heat.



The layout of the build plate assembly (current revision).

Build plate BOM:

- **Bed heater**
- Aluminium disc
- 2 pcs **borosilicate glass plates**
- 2 pcs **Ø310 mm Printbite sheets**
- Cork

Motion

Motor-wise we chose relatively powerful **NEMA 23** stepper motors with **0.9°/step** instead of the more commonly used NEMA 17. The 0.9°/step will give us better resolution than the more common 1.8°/step. We'll use standard **GT2 belts and pulleys** which we've used in several other machines earlier.

The rails will be **800mm long MGN12-1H** rails with *H-carriages* ordered from RobotDigg. The brackets on the carriages will be the point of fastening for both the belts and rods.

Good **rods** are important for delta printers. We've chosen to go for *Haydn's Carbon Fiber Arms* from Blue Eagle Labs. These arms are high-precision, lightweight and strong, and comes with magnetic ball joints instead of the more common rod ends. As mentioned these will be 400 mm long. Blue Eagle Labs delivers custom length rods.

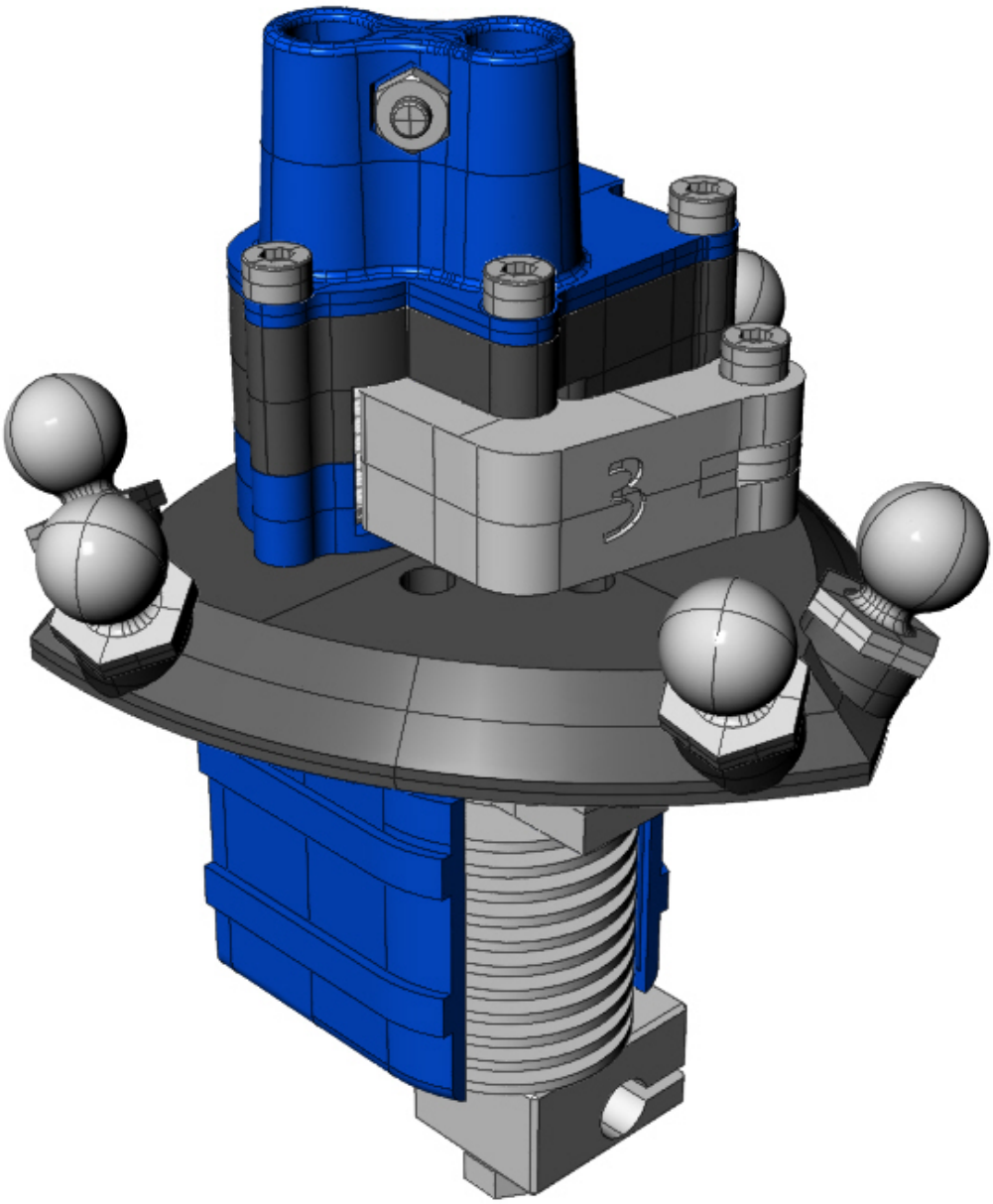
The rods we're going to use (source: Blue Eagle Labs)

Motion BOM:

- 3 pcs **stepper motors**
- 3 pcs **guide rail sets**
- 1 complete set of **rods**, including 6 rods as well as cups and ball studs.
- 6 pcs GT2 pulleys and enough GT2 belt.

Effector and Extruder

The **effector** is the main moving piece in the center of the printer. We've chosen the **4th gen Flex3Drive for Kossel XL**.



Render of the effector (source: https://flex3drive.com/flex3drive/f3d-kossel-mag/)

This effector comes with a flexible shaft which combines the best from both traditional direct and **Bowden** extruders: you don't have to mount the extruder motor on the effector, and you also won't have to deal with Bowden extruders' poor retract abilities. The extruder motor is mounted on the frame and rotates a flexible shaft that goes out to the effector where the filament is fed down the hotend. We'll either use a **NEMA 17** or **NEMA 14 stepper motor** for extrusion.

This effector is also compatible with both the rods we've chosen as well as the hotend we'll talk about below.

Effector and Extruder BOM:

- **Effector**
- Stepper motor

Hotend

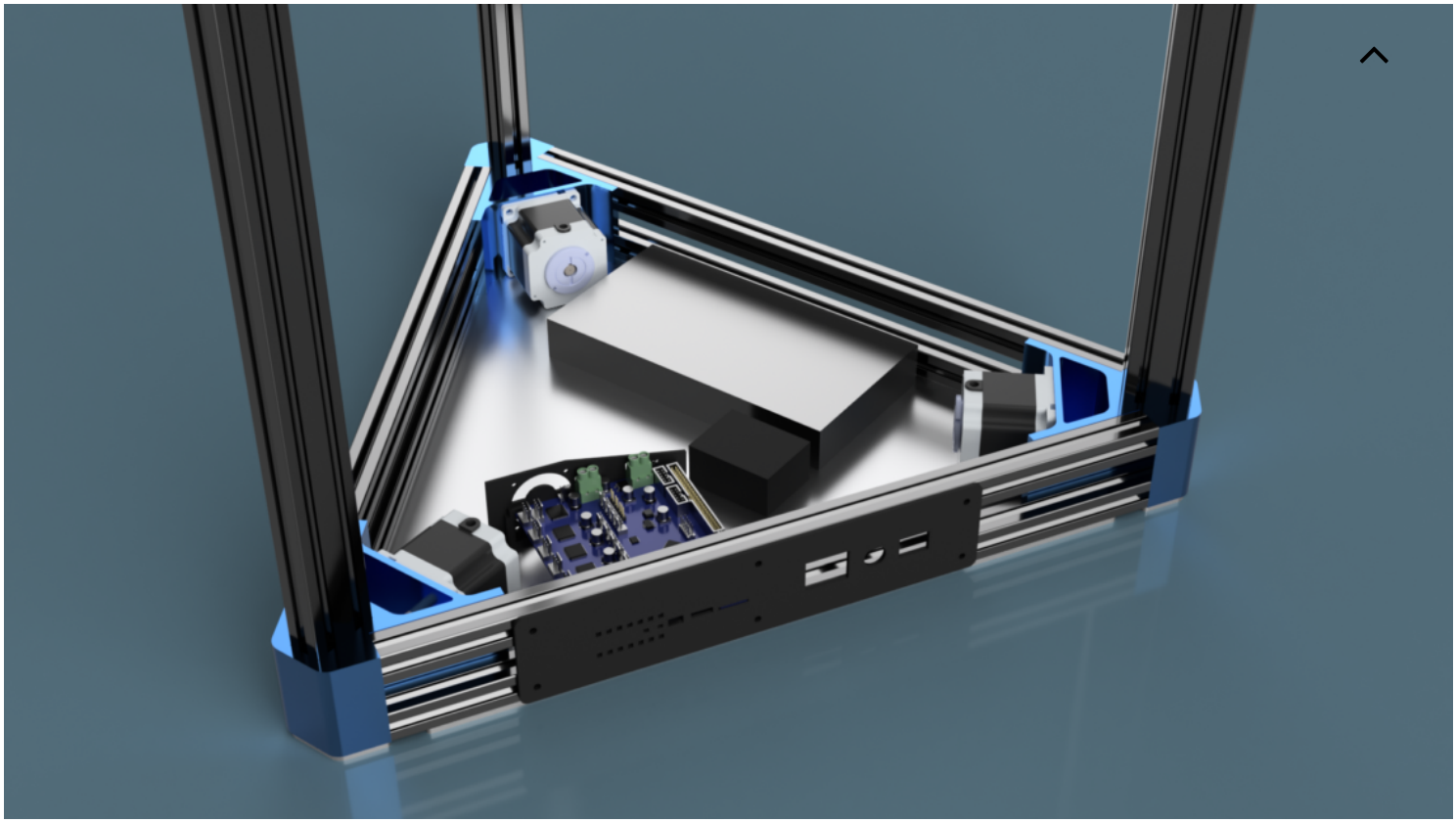
To be able to print parts quickly we want to be able to use large nozzles while also have the ability to switch to smaller nozzles for more detailed prints. **E3D's Volcano** hotend became our choice to meet these requirements. E3D delivers complete packs with everything you need (hotend-wise). However, we wanted PT100 sensor and 40 W heater cartridge, which isn't part of the volcano pack, and therefore it was cheaper for us to buy the parts seperately.

Hotend BOM:

- **Heatsink**
- 3 pcs **fans**
- **Heat break**
- **Temperature sensor**
- **Heater block**
- **Heater cartridge**
- **Fan duct**
- 1.75 mm **nozzles** (0.4, 0.6, 0.8. 1.0 and 1.2 mm)

Electronics

In the world of delta printers, the **DuetWifi** controller board is the superior choice. We'll hook up a **touch screen with PanelDue** to easily control the machine without the need for a connected PC. We'll also have an **IR probe** near the hotend as well as a **PT100 daughterboard**. All of these components can be ordered from the **duet3D website**.



The planned layout below the build plate. The grey box is the PSU while the black box is the SSR. We'll mod the DuetWifi bracket to fit a blow fan.

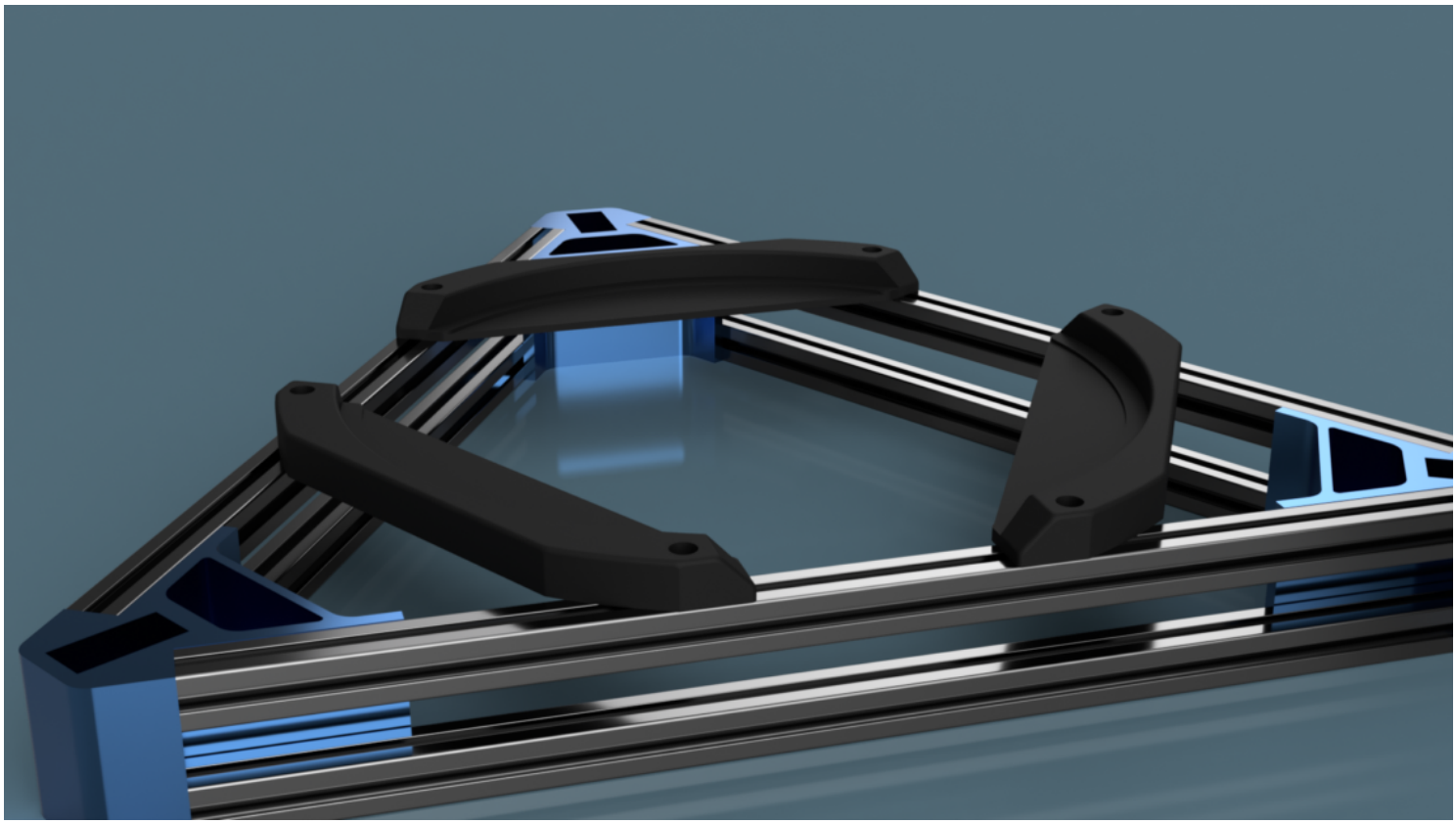
We also need a **24V PSU** and a relatively beefy **solid-state relay (SSR)** for the bed heater, as well as connectors near the hotend to make it easier to swap out parts. To acheive good cooling we'll probably mount a blow fan by the controller board as well as apply thermal paste between the baseplate and SSR and PSU as well as between motors and corners.

Electronics BOM:

- DuetWifi
- Touch screen
- PanelDue
- IR probe
- PT100 daughterboard
- PSU
- SSR
- Blow fan
- 3 pcs end-stop switches
- Connectors

3D Printed Parts

Several parts need to be 3D printed. Some of the designs we'll print straight out of Thingiverse, while we'll design others ourselves.



The current revision of the build plate brackets which we'll 3D print.

3D printed parts BOM:

- 3 pcs brackets for build plate
- 3 pcs brackets for guide rail carriages
- Fan bracket for the hotend
- 3 pcs end-stop switch brackets
- Screen bracket
- **Electronics bracket and panel** (we'll mod the bracket for different fan mounting)
- Extruder motor bracket
- Filament holder
- 6 pcs **vibration dampers**

Continue reading about this 3D printer in **part 2** where we start building!

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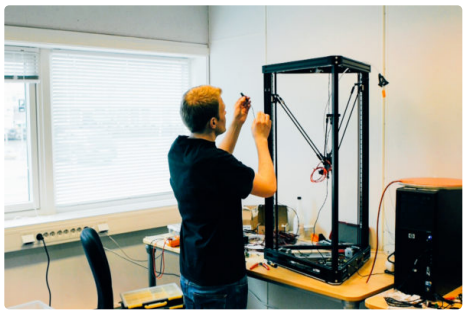

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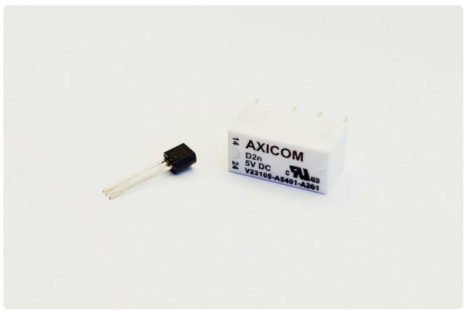
June 15, 2017



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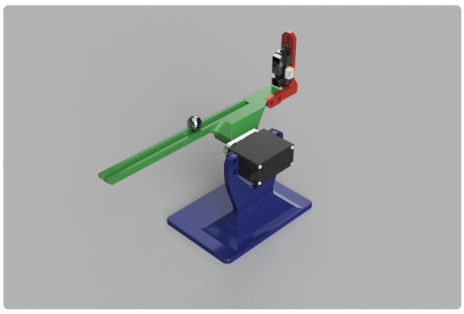

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There's not really a max. height on these. You do need long enough linear guide rails, though. Remember that you lose a lot of effective printable height due to the rods. Our printer structure is 1 m tall, but it can only print around 40 cm tall prints.

What materials it can print might depend on what hot-end (and extruder) you're using. Make sure they can handle your material. Maybe nylon is a trivial material to print, but we don't have any experience with this. Information about materials should be easy to find around the interwebs.

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Themistokles V • a month ago

can i enlarge my anycubic kossel by replacing the frame parts , rods and heatbed with larger ones and just custom setting the bed size in the slicing soft ware?thank you

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Norwegian Creations Mod → Themistokles V • a month ago

Yes, but you also have to change the calibration parameteres and rod length in the controller config. Make sure you are able to do this before investing in a lot of expensive parts. :)

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Martin • 2 months ago

Hello guys, is it possible to publish the baseplate files ? I would like to lasercut my own.

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Norwegian Creations Mod → Martin • 2 months ago

You can find dxf for the bottom plate here: https://www.norwegiancreati...

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Brendon • 5 months ago

I was going to try and do a scratch delta build but this one checked all the boxes. Why reinvent the wheel. I have the frame built, rails and arms installed, motors installed. Now waiting for my budget to catch up so i can order more parts, great build guys

Reply • Share ›

Norwegian Creations Mod → Brendon • 5 months ago

Awesome, Brendon! :D

Good luck with your build!

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Jonathan Cohen • 10 months ago

Do you have a BOM for the printer, including all the fastener sizes that were used.

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Norwegian Creations Mod → Jonathan Cohen • 10 months ago

Hi Jonathan,

The closest you'll get to a BOM is this post and the latest one (https://www.norwegiancreati....

Regarding fasteners, we've used a lot of M5 and some M3 post assembly spring nuts for 2020 aluminium profiles together with M5x10mm bolts. You'll find the former cheap on AliExpress. We might have used a few M4 spring nuts as well.

We also needed some conical M5x10mm bolts for the frame corners and some M3 brass inserts for a few of the custom 3D printed parts.

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Jonathan Cohen ➚ Norwegian Creations • 10 months ago

Thanks for the information. I'm building a similar printer but with slightly shorter horizontal extrusions (455mm) and assuming a minimum effector angle of 20°. Going with a bit less than 20 mm for the carriages, I've calculated an arm length of 405mm (330 mm bed and 300 mm printable). How does the printer fare at the edges of the printable space ? Thanks.

Reply • Share ›

Norwegian Creations Mod ➚ Jonathan Cohen • 10 months ago

Cool!

We haven't discovered any problems when moving along the outer perimeters of our build plate.

Good luck with your build project!

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Bertrand Poncin • 10 months ago

Great job for your delta XXL, i'm building a similar Delta XXL and i would know if it's possible to share your bed support. Thanks in advance.

Reply • Share ›

Norwegian Creations Mod ➚ Bertrand Poncin • 10 months ago

See here: https://www.norwegiancreati...

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Jonathan Cohen ➚ Bertrand Poncin • 9 months ago

How much tolerance did you build in for the bed supports between the aluminum plate and the walls of the supports ? I redesigned them to fit a slightly smaller base (455 mm vs 471 mm) and left 2mm from the aluminum bed edge and the supports (334 mm for 330 mm bed). Thanks.

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Kaleb Eubank • 10 months ago

Any chance of a release of all the files needed to build this guy? I'm wanting to build one and it pretty

much hits all the things I want, so all the files like the baseplate and stuff would be awesome.

▲ | ▼ • Reply • Share ›

Norwegian Creations Mod ➚ Kaleb Eubank • 10 months ago

See this post: https://www.norwegiancreati...

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Charles-Edouard Peugnet • a year ago

Hello,

I'm currently building almost the same delta, and found your 3 build posts very interesting. I aim to get those 2040 vertex corner, and laser cut top and bottom plate. So I'm currently designing a 3D model of my prototype but I'm totally unable to find a 3D model of these corner or even blueprint to model them myself in Fusion 360.

#1 Could you share the 3D model of these corner ? or at least the top plan view of this piece in svg ?

Also you've written "400 mm is 82% of the tower center to tower center distance which is not far from the 80% rule of thumb which is mentioned in several forums."

#2 How did you calculate the distance between the center of the plate and the face of the tower which is toward this center ? With your 3D model ? Robotdigg 2040 vertex seem to push the tower toward the center compare to classic 2020 corner.

#3 Are you satisfied with printbite ? especially for ABS

Sorry many questions :p thanks in advance for your help :)

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Norwegian Creations Mod ➚ Charles-Edouard Peugnet • a year ago

Hi Charles-Edouard,

#1 We used the bottom drawing on this page (http://www.robotdigg.com/pr... for modelling the 2040 and 2060 corners. The models ended up being accurate with this drawing as a base.

#2 Yes, we used our 3D model assembly to calculate different distances. This was vital in dimensioning the machine.

#3 We have only tried Printbite with PLA as of this time. We have tested it on three different printers and the results have been excellent across the board.

A new blog post on this subject is right around the corner, so stay tuned!

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Charles-Edouard Peugnet ➚ Norwegian Creations • a year ago

Thanks a lot for your advices ! Hope the best for your next post

I definitly need to finish modeling my prototype then :)

▲ | ▼ • Reply • Share ›

Norwegian Creations Mod ➚ Charles-Edouard Peugnet • a year ago

No problem **@Charles-Edouard Peugnet** =D Good luck with the building!

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