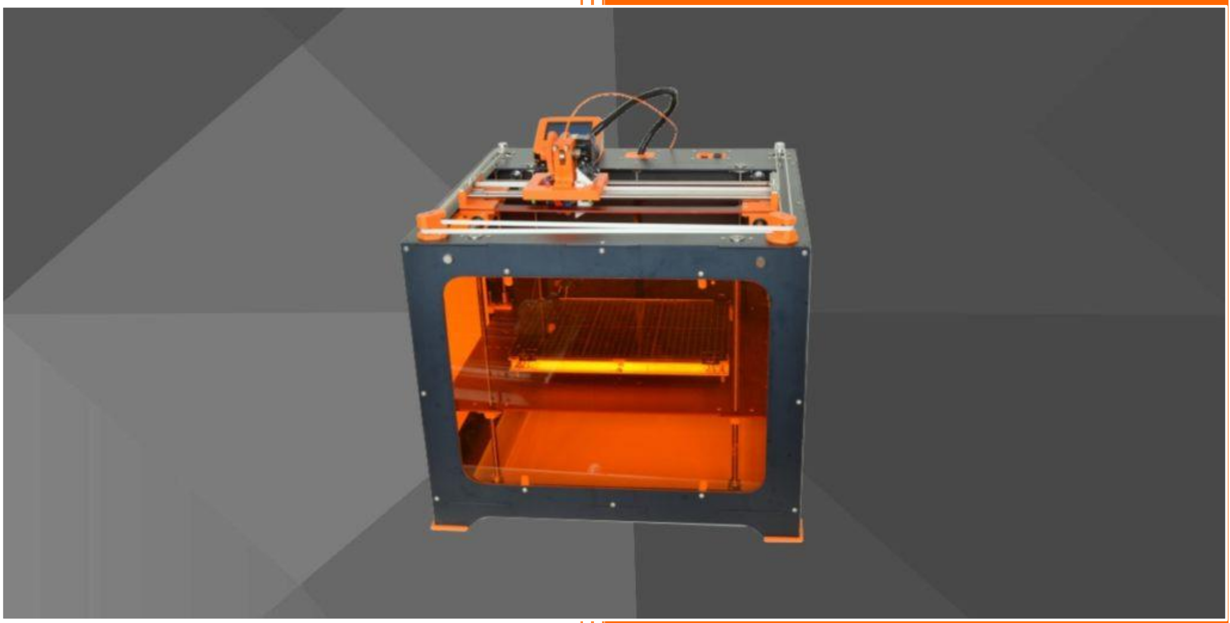
Project „3D-Printer"

KnutPlot_V6 technical description



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Abstract

This document describes the technical characteristics of the FDM-3D-Printer "Knut-Plot_V6". It is desired to give an overview over the overall system and technical details about the design. Further information can be found in:

- KnutPlot_V6 Production documentation
- KnutPlot_V6 Assembly and operation instructions

Table of content

1 Introduction

KnutPlot_V6 is a 3D-FDM-printer, designed to meet the requirements of professional users in FabLab's, research/education facilities and companies. Rather than focusing on a low-cost-design, the system developed to be modular, robust and easy to maintain.

The development of this printer started as a hobby project of Timo Birnschein and Christian Oekermann. The system has proofed his reliability, the first versions are in professional usage for 3 years now, almost on a daily bases. About 30 units of this printer have already been built by friends and colleagues. You can see the history here (page is not maintained): http://www.open-cnc.org/wiki/index.php/Main_Page

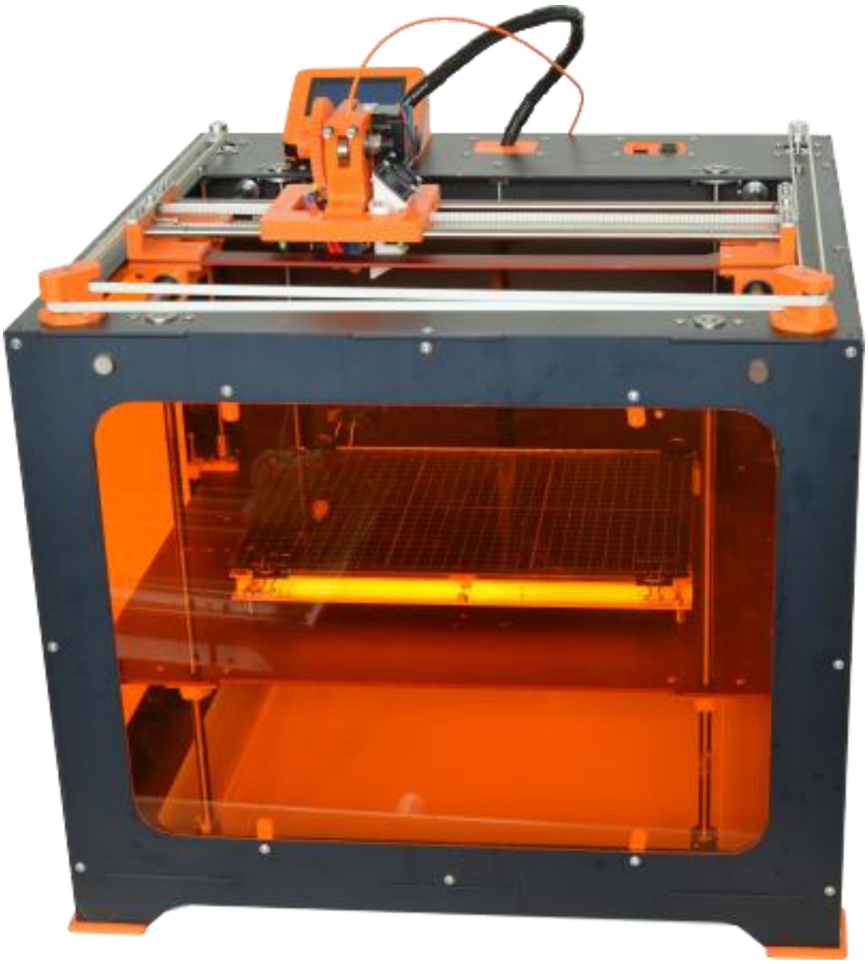


Figure 1 KnutPlot_V6

1.1 System overview

With the building volume of 300x200x300mm, the printer can be used for a wide range of applications. Due to its modular design, the user has the possibility to choose between various system-setups:

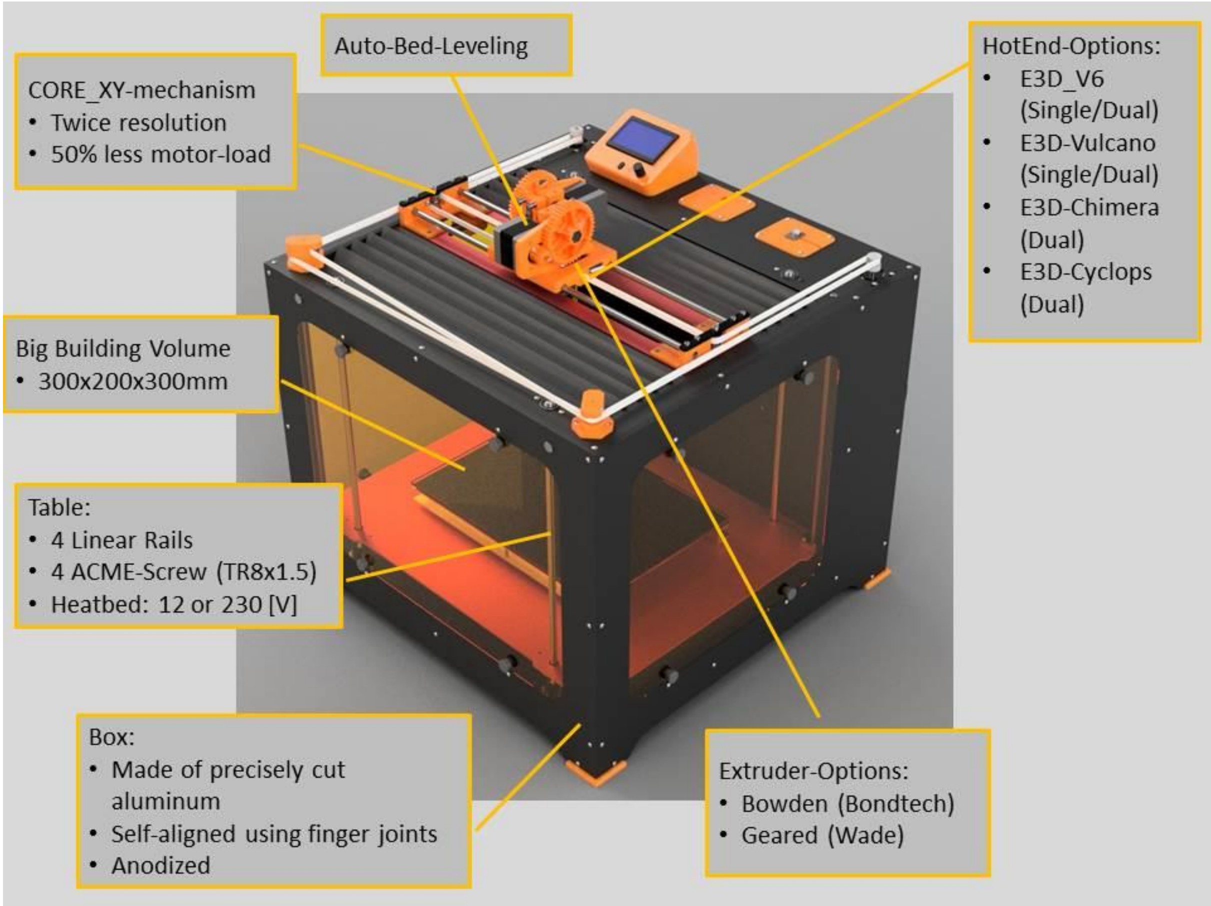
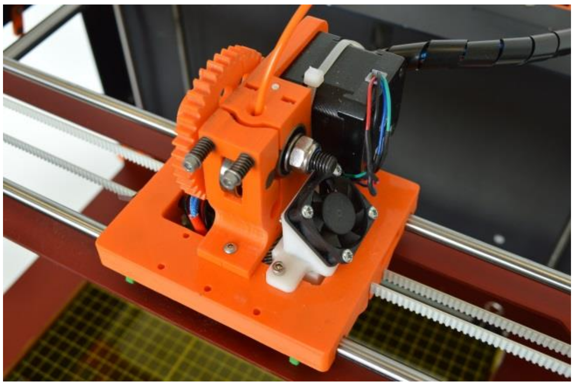


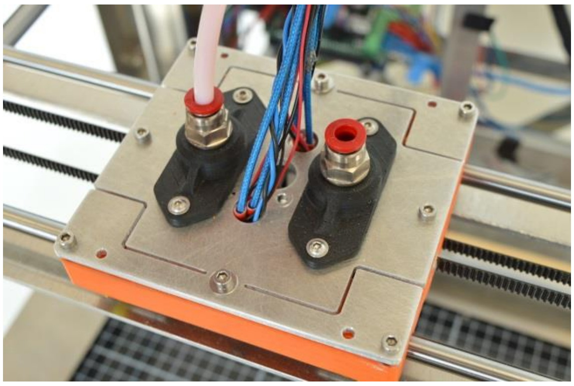
Figure 2 Printer Features

Each print-job is different, for high precision print's you need a different setup than for fast printing of a huge part. By using the E3D-Nozzle family, the user can use the optimal configuration for each job.

Two different setups, a “Singe-Wade-Extruder” and “Dual-Bowden-Extruder” are shown in Figure 3



Wade-Extruder



Dual-Bowden-Extruder

Figure 3 Nozzle setups

The carriage is designed to provide a easy-to-mount platform for various setups. It’s easy to install motors for cnc-milling, syringe-mechanisms or pick-and-place tool-heads.

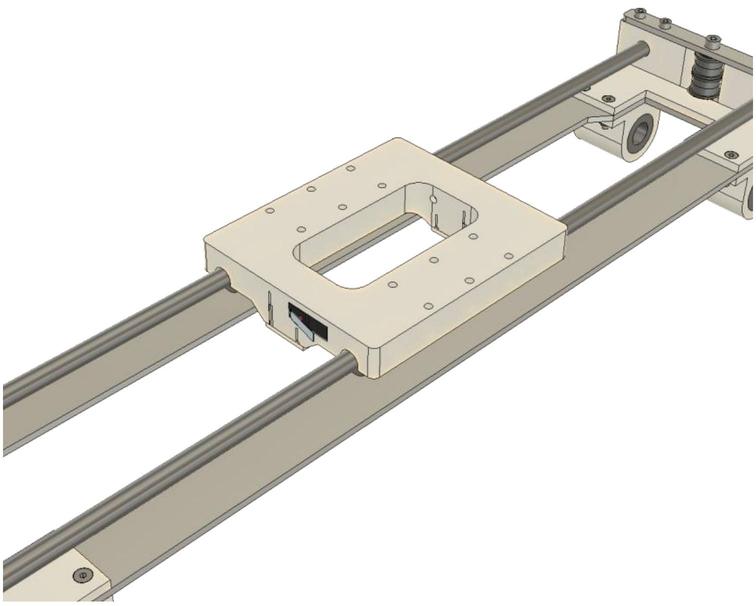
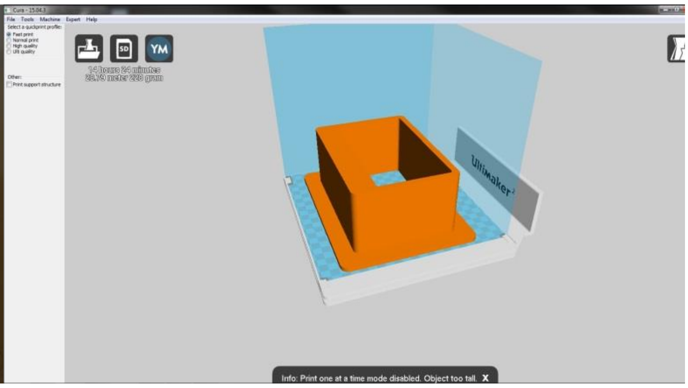


Figure 4 Carriage design

1.2 Applications

With a variation of the nozzle-size, the user can set the printer to be very precise for small parts as well very fast for huge objects. Especially using big Nozzles like E3D-Volcano greatly reduces print time:

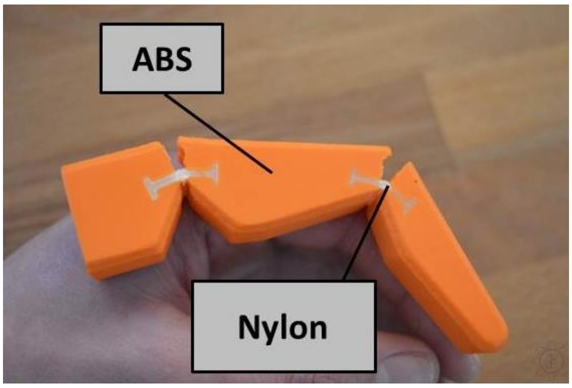
Precision print
Working double-planetary gear
0.3mm Nozzle



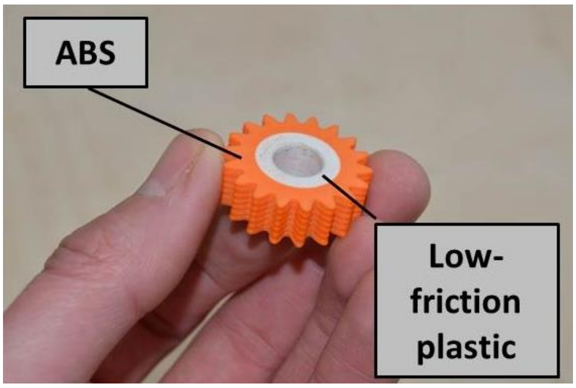
Big-Part (200x160x90mm)
With 0.4mm Nozzle ≈14h
With 1.0 mm Nozzle: ≈6h

Figure 5 Big and small print-jobs

Especially using dual-extruders allow a wide field of new applications. Not only for mixing colors, also by combining different materials, the designer can use completely new design-strategies:



Finger-Prostheses:
Combining hard material (ABS) with elastic material (Nylon) for flexure



Gear with bearing
Combining hard material (ABS) with low-friction bearing material (Igus IP180)

Figure 6 Multi-material-prints

When combining different Materials, a unique temperature for each HotEnd is required. That's why KnutPlot_V6 uses two separated HotEnd's. You can use the E3D-chimera which is very compact but only available for 1,75 mm diameter Filament or two E3D_V6 HotEnd's

There is a wide range of materials available, KnutPlot_V6 can be configured to use almost any of them be using different HotEnd-setups.

2 Mechanical design

The printer concept offers some unique design features, which could also be used for other printers or cnc-mashines.

2.1 Box

The printers "housing" is made of precisely lasercut aluminum sheet metal. Finger-joints are used to align the plates, "mounting-cubes" are used to connect the plates. All the holes for bearings, rods etc. are readily cut into the metal.

Advantages:

- Self-aligning, no more measurement etc. required during assembly
- Very precise
- Robust and stable
- Few parts required
- Less material consumption: About 35% lighter than a comparable design with aluminum extrusions
- Anodized for surface protection and nice finish

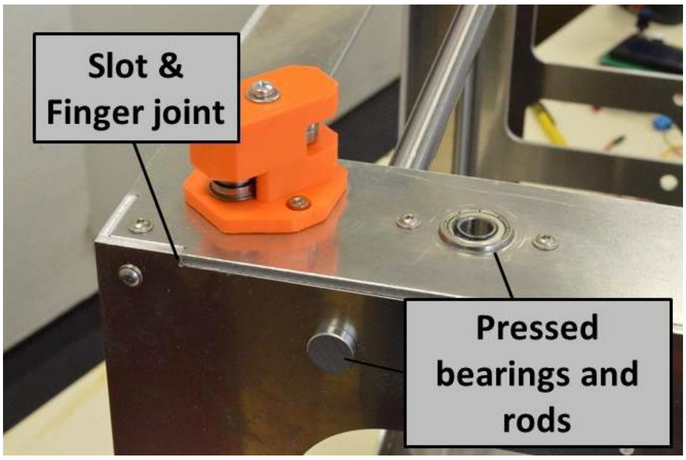


Figure 7 Box design with finger-joints

2.2 Mechanics

CORE-XY

The printer uses a so called CORE-XY mechanism. This parallel kinematic system combines the movement of both, the x-axis motor and the y-axis motor to control the xy-movement of the carriage. Since both motors are installed in the box, a lightweight gantry design is possible (low moving mass). Additionally, the setup works like a gear, the resolution is doubled and the required motor force is reduced by 50%

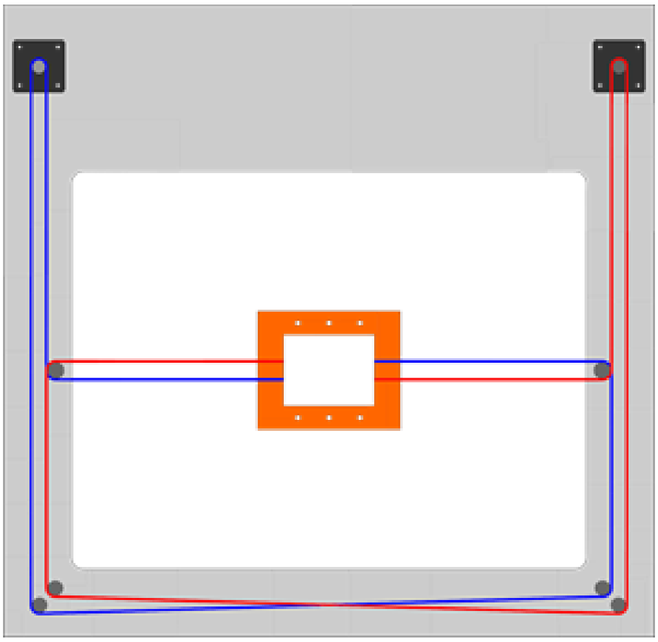


Figure 8 CORE-XY mechanism

2.3 Table Bearing

Instead of using a bearing on just one side of the table, four linear rails (one in each corner) are used to support the table. This allows a very stable design and prevents vibration.

Z-mechanism

To control the z-axis, four leadscrews (TR8x1.5) are used. Some printers also use these, although the pitch of 1.5 mm/rotation leads to new problems. The resolution of the stepper-motors often leads to errors in the z-height.

Example:

Direct-drive: 1/16 step driver, 1.8° stepper-motor, desired layer-height 0.2mm →required steps: **426.666** This is not good! Error for 100mm part: 1,25mm!

To overcome this problem, a reduction gear (timing belt) is used to match stepper resolution to desirable layer-heights.

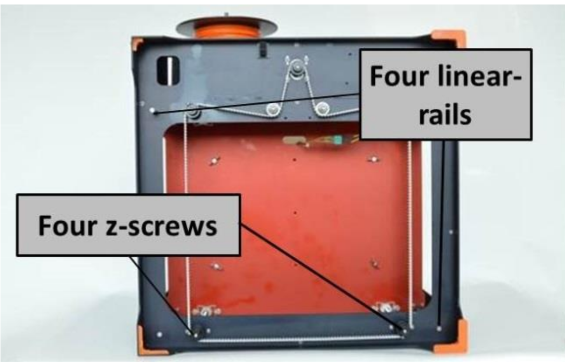
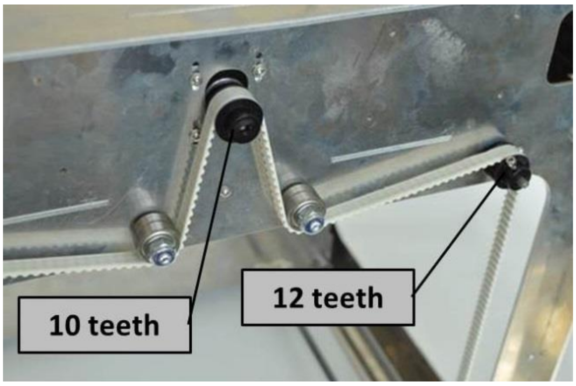


Table – Bearing Details



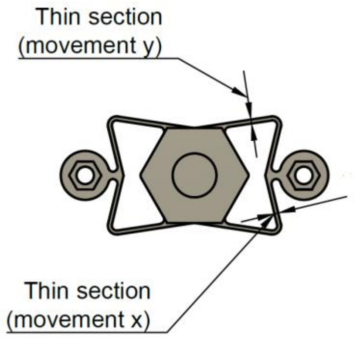
z-screw gear

Figure 9 z-mechanism details

2.4 Flexure bearings

z-screw nut

To compensate non-straight leadsrews, an elastic nut is used (printed of Nylon). This nut-holder is designed to be elastic in x- and y-direction, but offers a good stiffness against torsion.



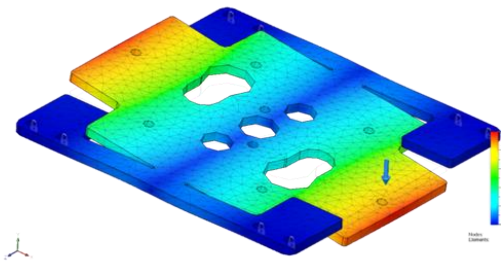
Elastic nut design

Nut installation

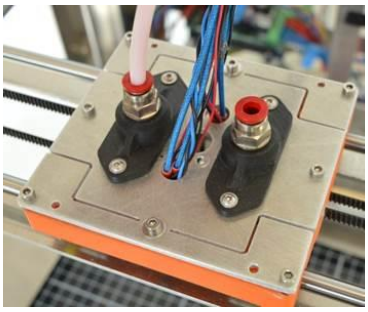
Figure 10 z-mechanism details

Dual Extruder height adjustment

A flexible Aluminum-plate is used for easy and precise nozzle-height adjustment



Simulation



Installation

Figure 11 z-Nozzle height adjustment

3 Components

Electronics

In the standard configuration, a Ramps 1.4 board is used. Drivers: DRV8825. Of course, other electronics like Smoothieboard can be used. There is enough space to use powerful ATX or server Power-supplies.

Heatbed

300x200mm; either “RepRap-Style” PCB-heatbed (12V or 24V) or lasercut aluminum-plate (incl. hardcoat against scratches) with 230V silicon heater.

Extruders

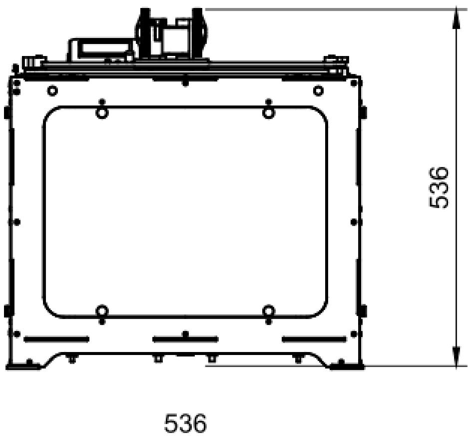
Wade Extruder or Bondtech

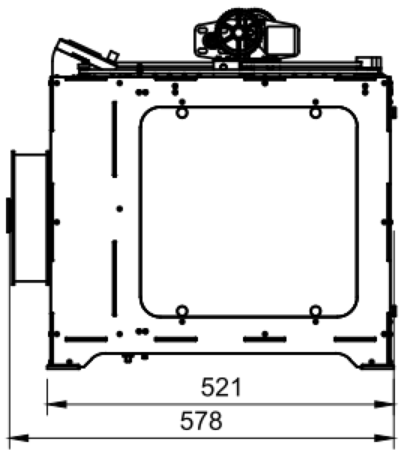
Hotends

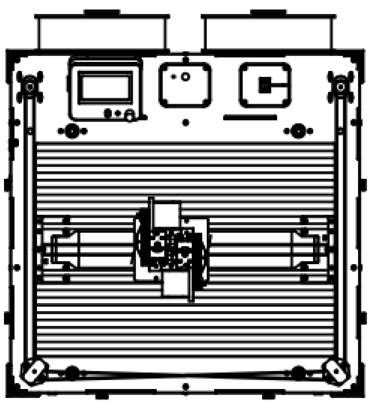
E3D Nozzles

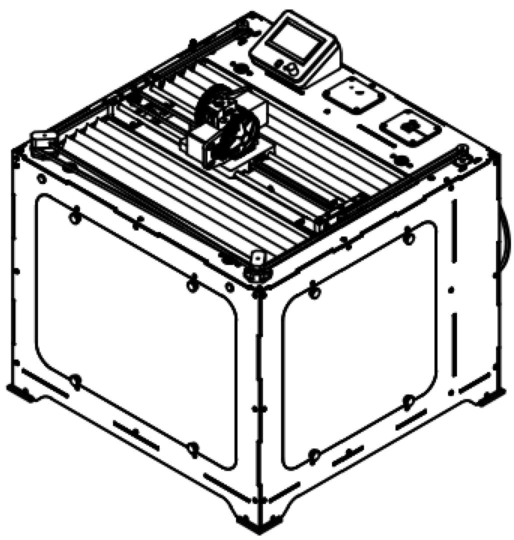
4 Physical Properties

Technical Data	
Technology	FDM
Build-Volume	300x200x300 [mm]
Filament-Diameter	1.75 or 2.85
Resolution (stepsize: 1/32; Motor: Nema 17; 0.9°/step)	X: 3.125 micron (320 steps/mm) Y: 3.125 micron (320 steps/mm) Z: 0.098 micron (10240 steps/mm)
Dimensions (Body)	≈ 550x600x550 [mm]









5 References

A special thanks to Timo Birnschein!

Construction:

http://www.instructables.com/id/How-to-Build-your-Everything-Really-Really-Fast/

Mechanism:

http://corexy.com/

Firmware:

https://github.com/MarlinFirmware/Marlin

More coming soon!