OPEN LAB AUGSBURG

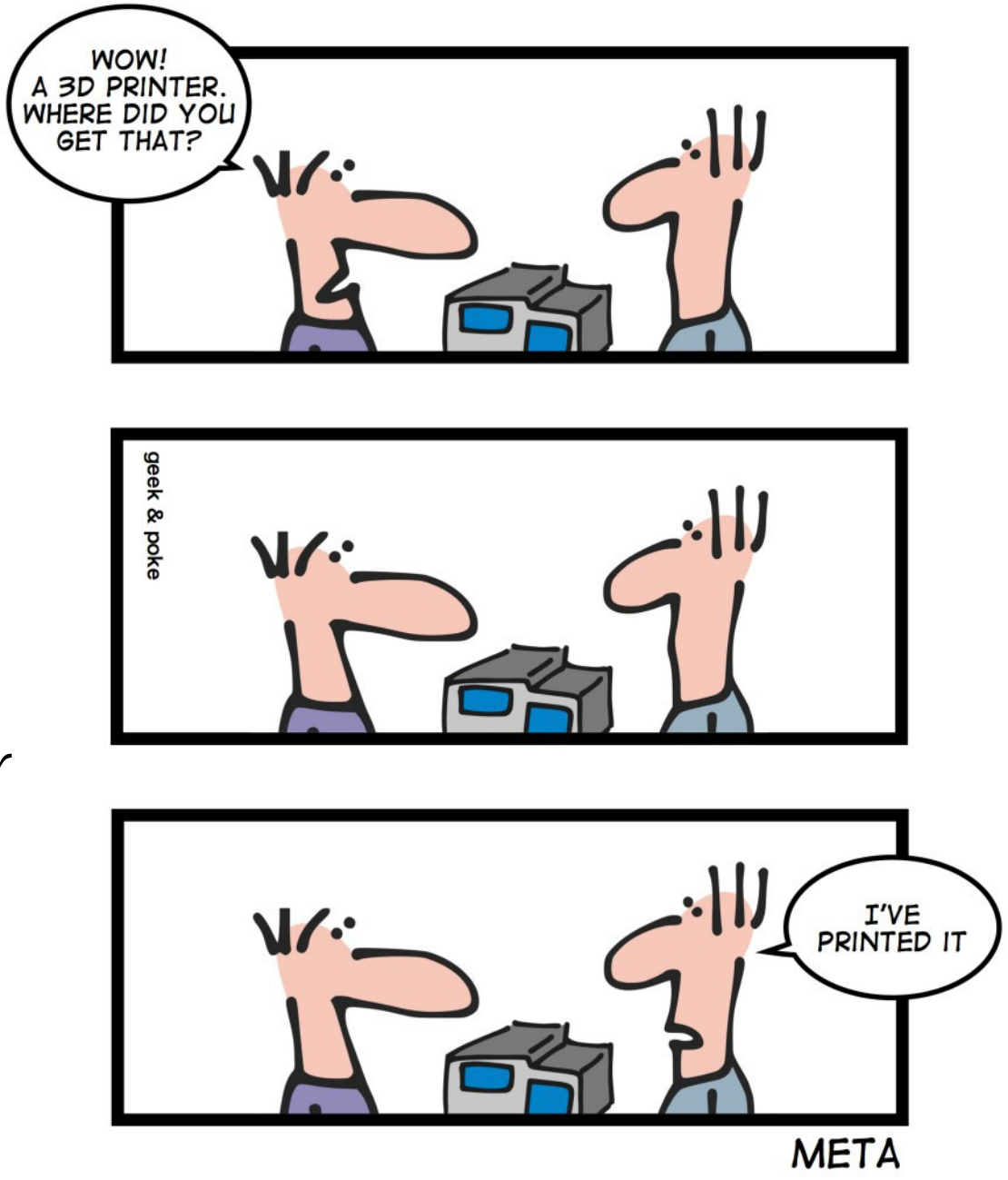
Reprap 3D Drucker

OpenHardware &

OpenSoftware

in idealer Kombination

Referent: Stefan Krister



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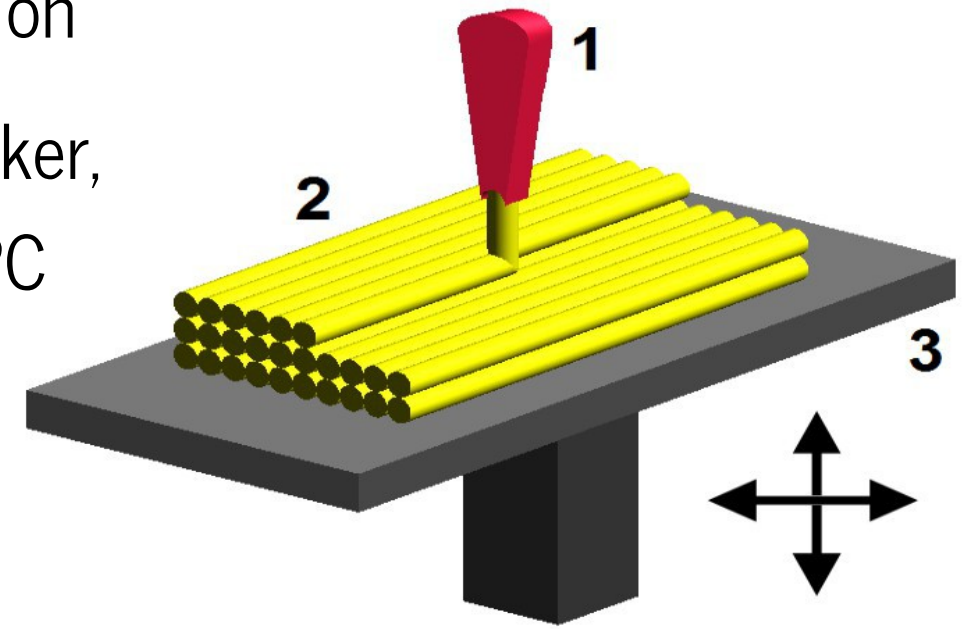
Reprap 3D Drucker

OpenHardware & OpenSoftware in idealer Kombination

- Abgrenzung 3D Druck allgemein / Reprap
- Bestandteile eines 3D Druckers
- Software Workflow
- Reprap Geschichte

Reprap 3D Drucker

- Abgrenzung 3D Druck / Reprap
  - Replicating Rapid Prototyper
  - Verwendung von thermoplastischen Kunststoffen
  - „Fused filament fabrication”
  - Mikrocontroller am Drucker, Druckaufbereitung am PC



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Reprap 3D Drucker

- Abgrenzung 3D Druck / Reprap
  - Entwicklung unter Linux, muss aber auch mit Windows/MacOS laufen
  - Kartesische Achsenausrichtung
  - Genauigkeit ≤ 0,1mm
  - Bauteile überall verfügbar (kaufen / drucken)

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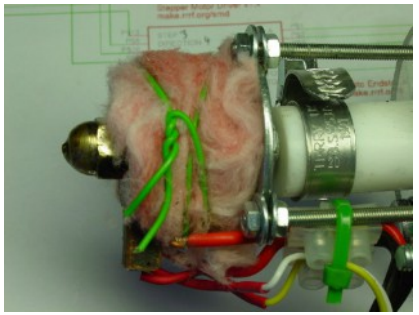
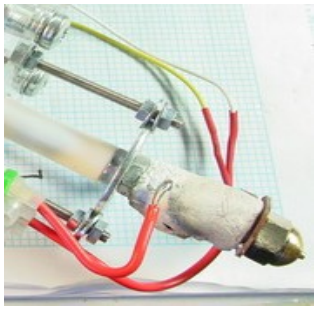
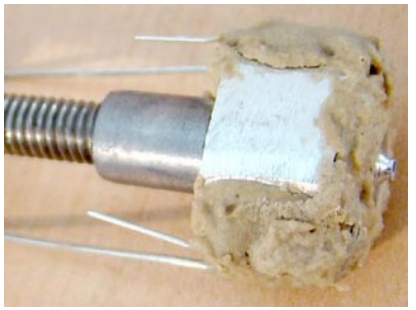
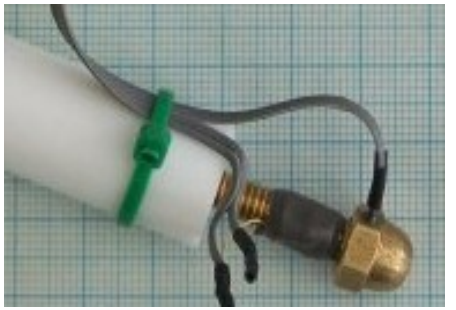
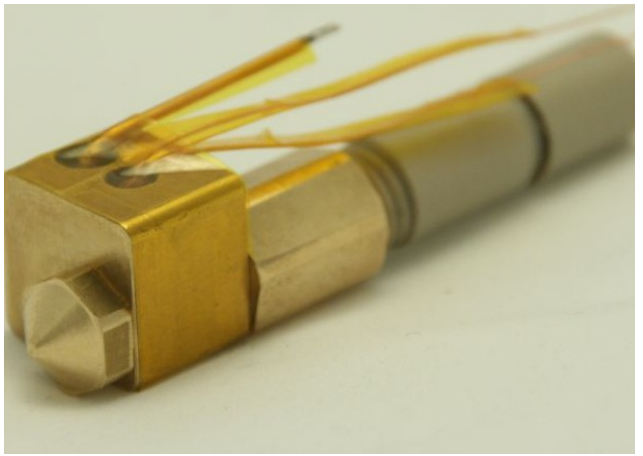
Reprap 3D Drucker

- beheizte Düse

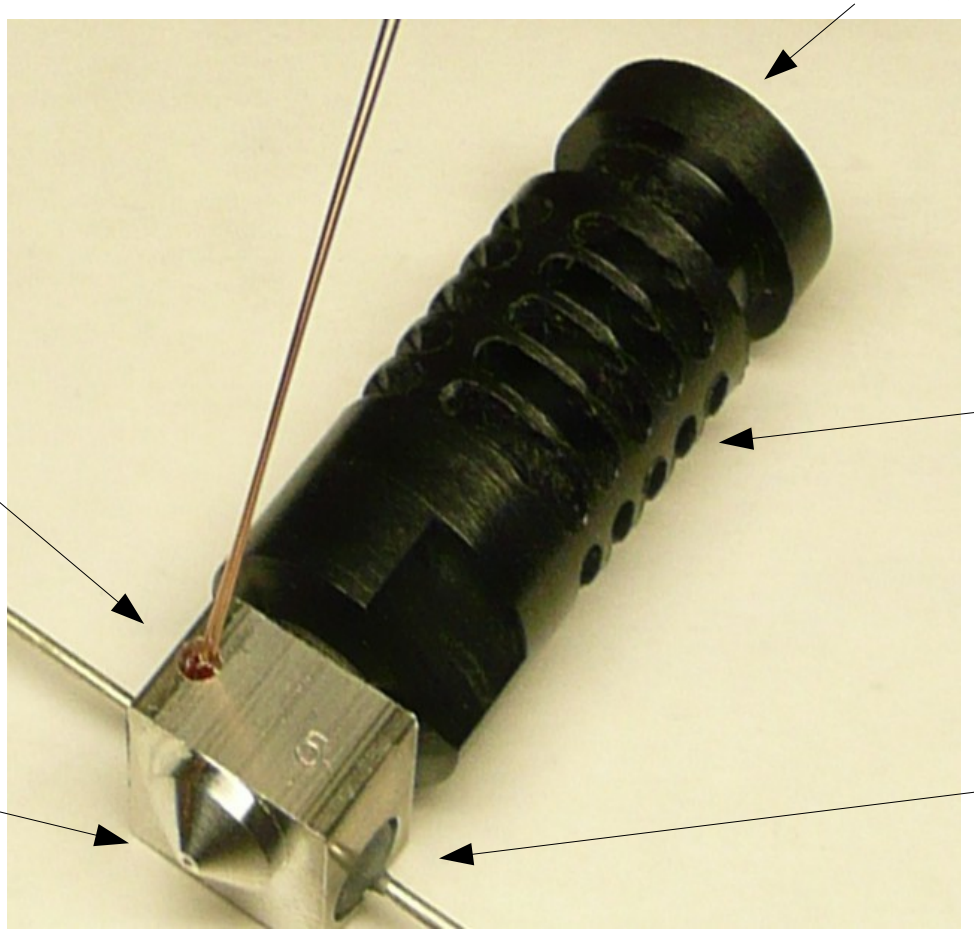



Reprap 3D Drucker

- beheizte Düse
  - J-Head MK5

Hülse aus Polytetra-fluorethylen (PTFE) / Teflon (innen)



Temperaturfühler (Thermistor)

Halter aus Polyether-etherketon (PEEK)

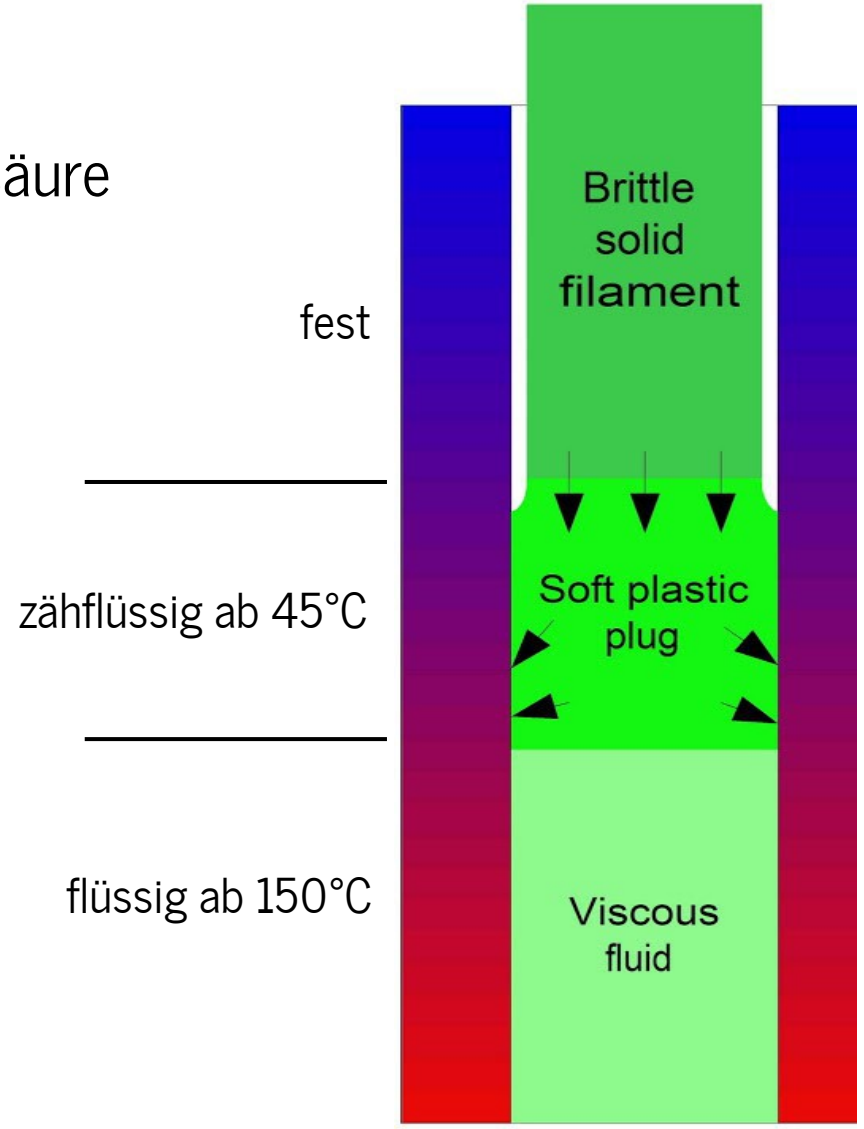
Düse aus Aluminium

Heizwiderstand

Reprap 3D Drucker

- beheizte Düse
  - Polylactide / Polymilchsäure (PLA)
  - Acrylnitril-Butadien-Styrol (ABS)

  Temperaturen je ca. 20°C höher



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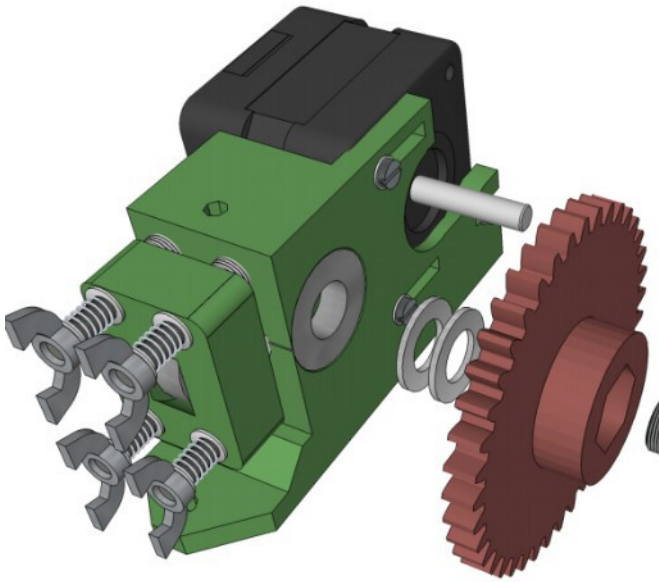
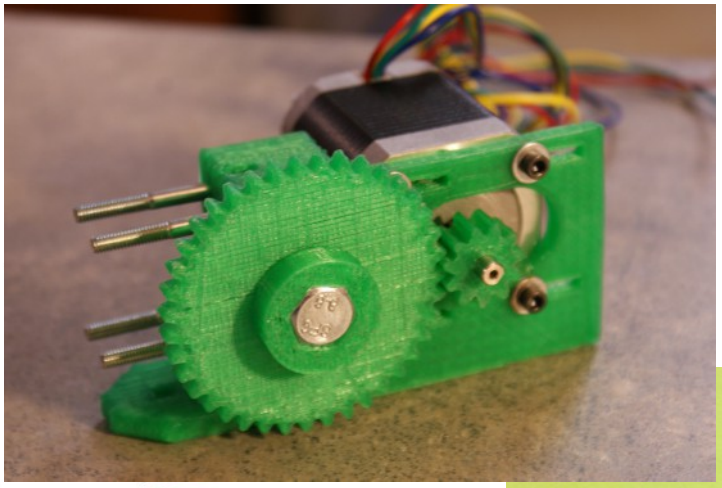
Reprap 3D Drucker

- steuerbarer Filamentvorschub





„Wade's Geared Extruder"
Übersetzung 11:39

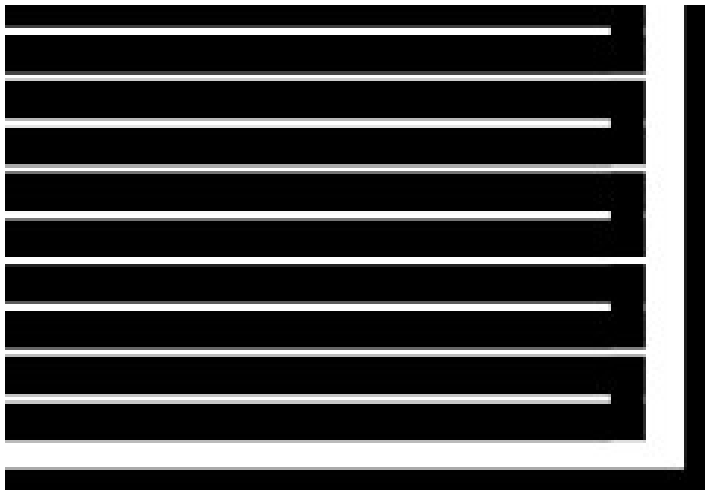
M8x80 Sechskantschraube
„Hobbed Bolt"

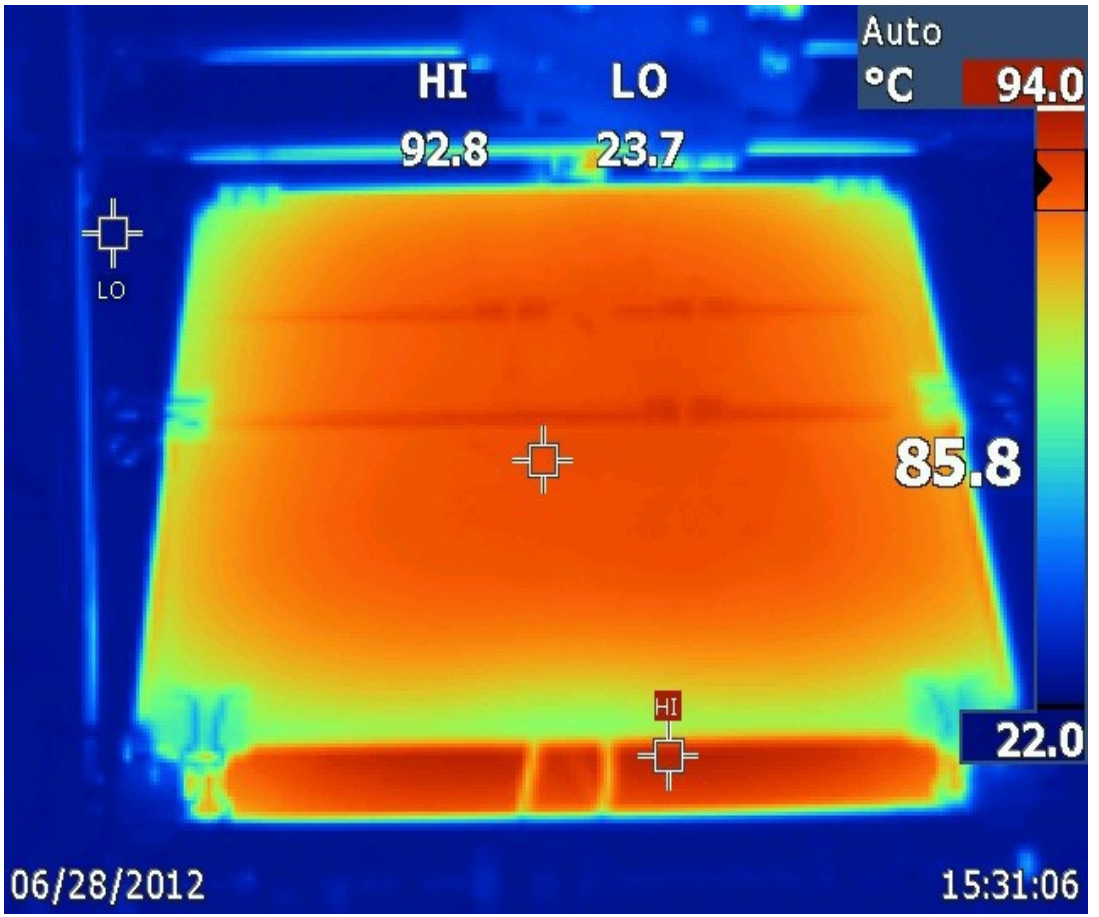
Reprap 3D Drucker

- (beheizbare) Unterlage auf der gedruckt wird

Reprap 3D Drucker

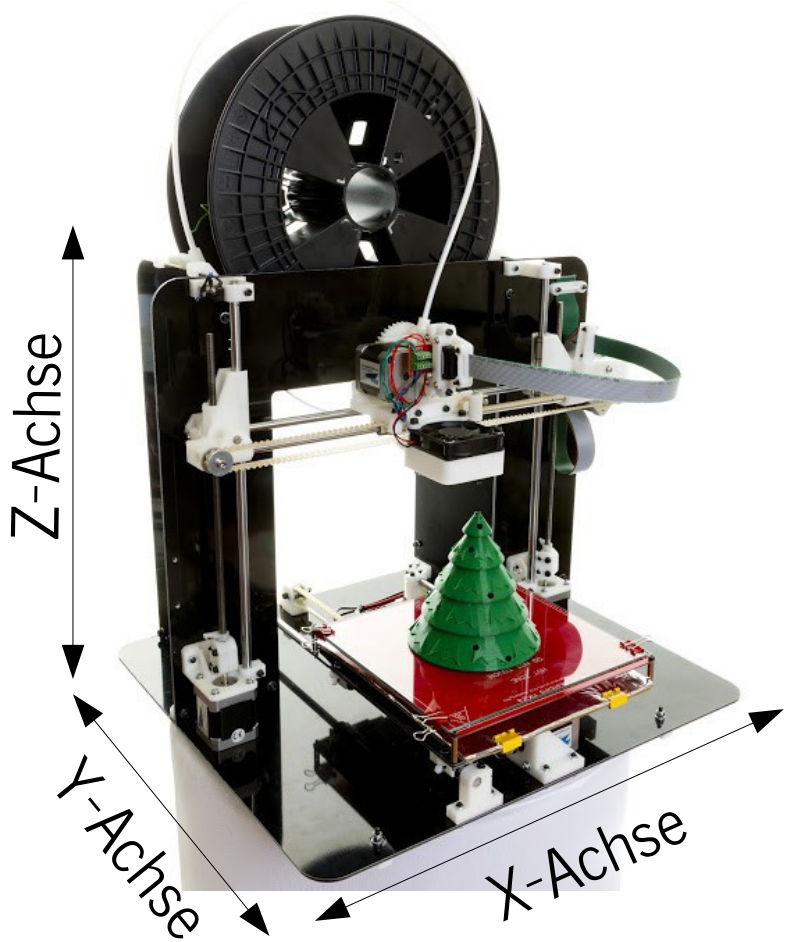
- (beheizbare) Unterlage auf der gedruckt wird

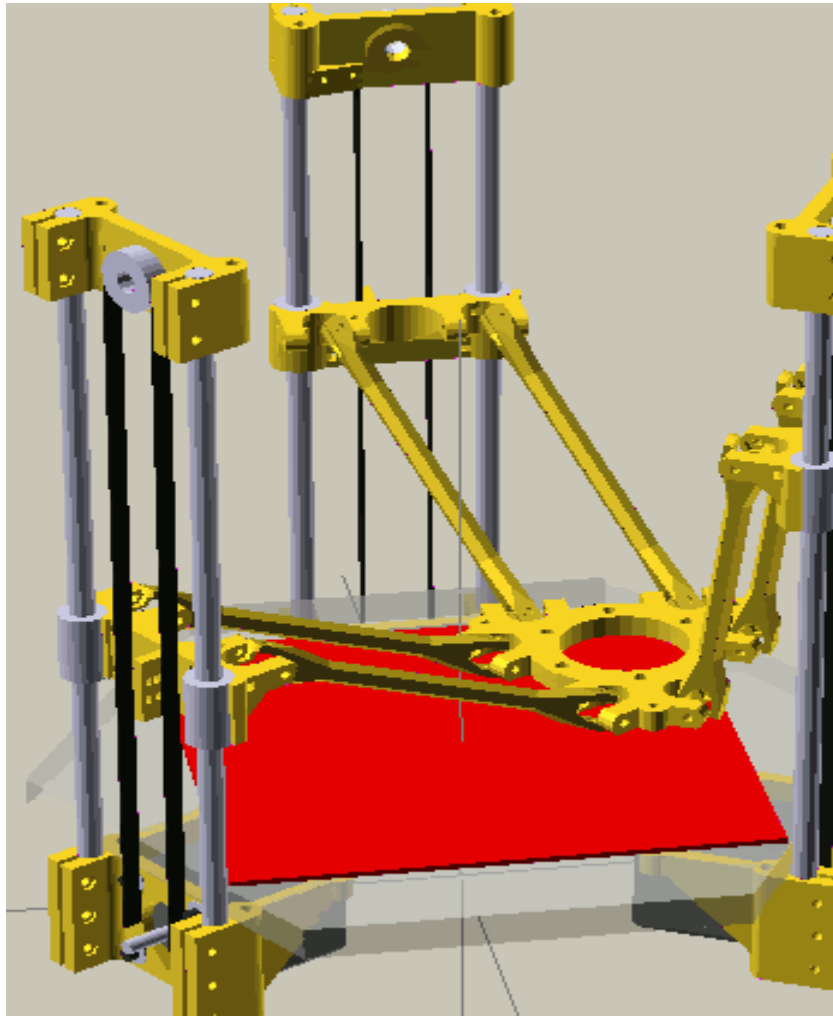




Reprap 3D Drucker

- kartesisch angeordnete X, Y und Z-Achsen





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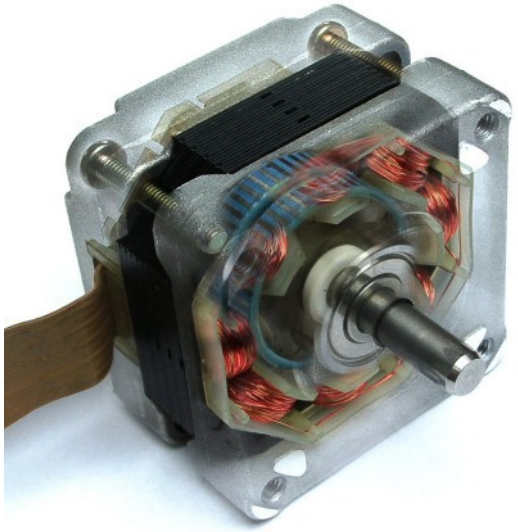
Reprap 3D Drucker

- Schrittmotor mit 1,8° Schrittwinkel/Vollschritt
  ≙ 200 Schritte/Umdrehung
- 16 Mikroschritte/Vollschritt
  ≙ 3200 Schritte/Umdrehung



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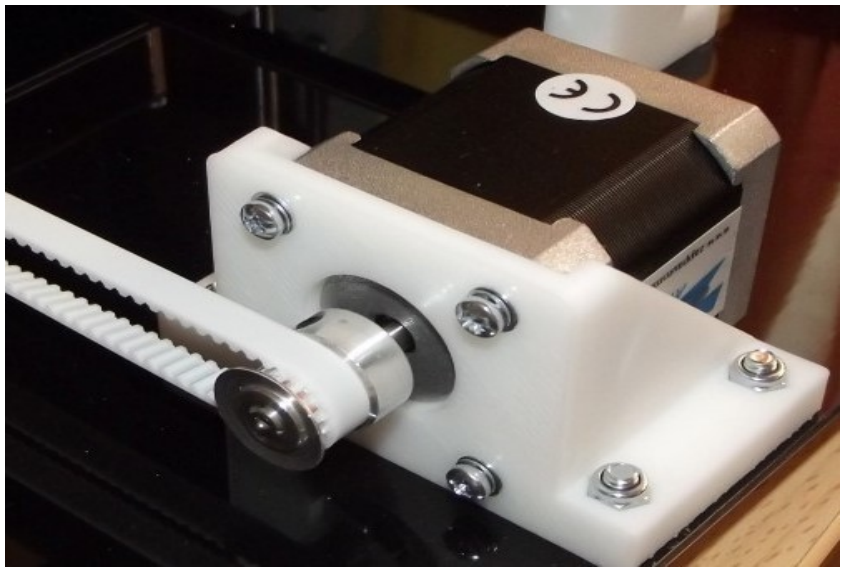
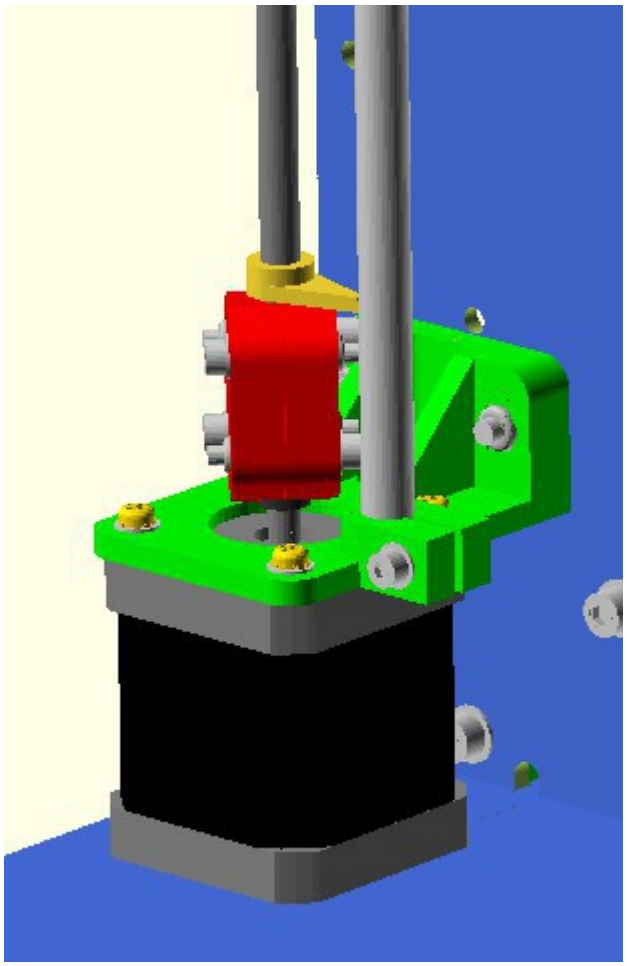
Reprap 3D Drucker

- Antrieb der Achsen
  - Zahnriemen / -räder
  - direkt / Gewindestange





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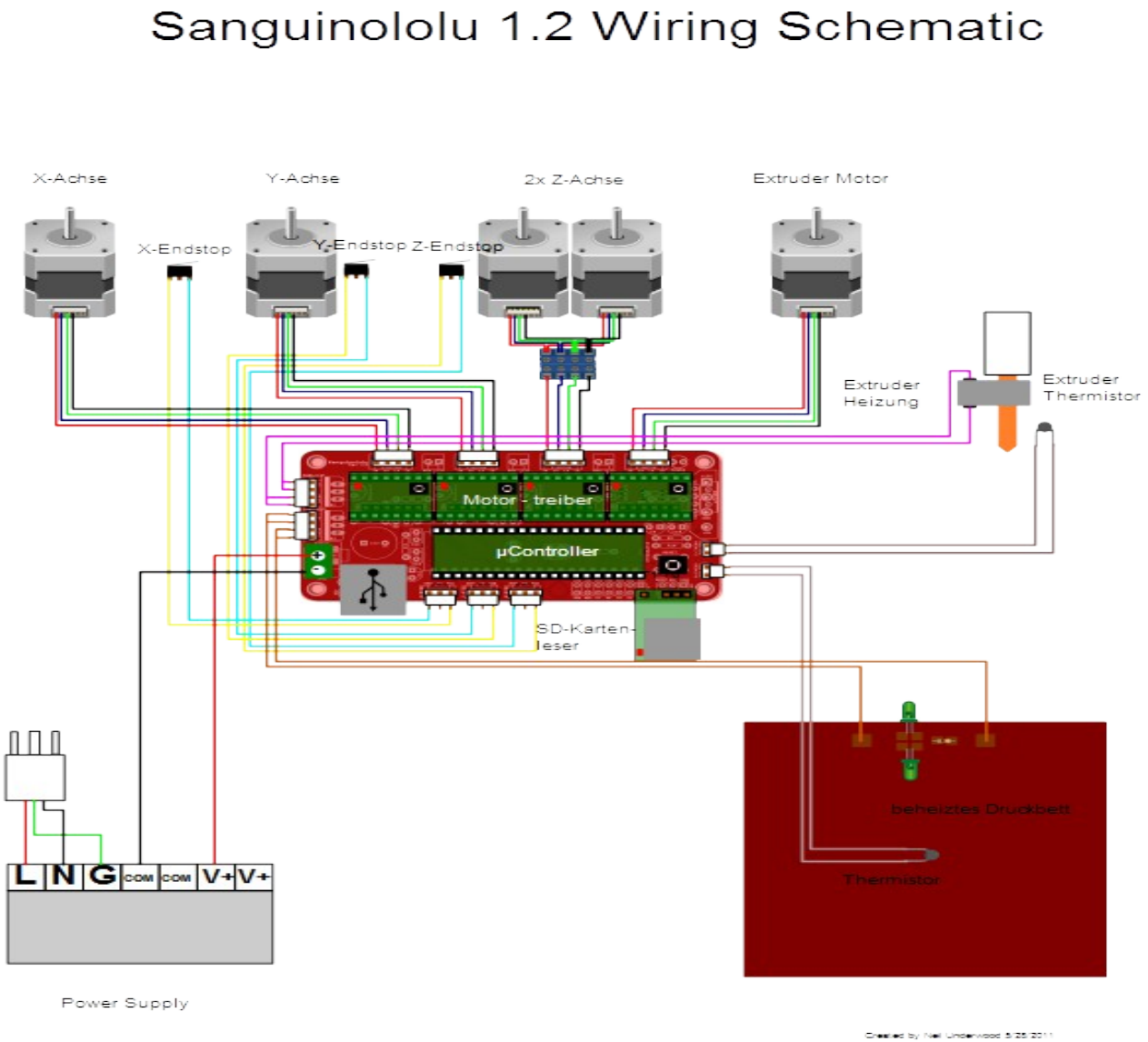
Reprap 3D Drucker

- Mikrocontroller
- Motortreiber
- Endstop X, Y und Z
- USB-Schnittstelle
- (SD-Kartenleser, Lüfter, LC-Display, Tastatur ...)



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Reprap 3D Drucker

- Anforderungen an den Mikrocontroller
  - 2 analoge Eingänge (Thermistor)
  - 3 digitale Eingänge (Endstops)
  - 3 PWM-Ausgänge (Heizbett, Extruder, Lüfter)

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Reprap 3D Drucker

- Anforderungen an den Mikrocontroller
  - 4 digitale Ausgänge (Achsen, Filamentvorschub)
  - ausreichend schnell (PID-Software-Regler, PC-Kommunikation, LCD, Extras)
  - ausreichend Speicher (ROM, RAM, EEPROM)

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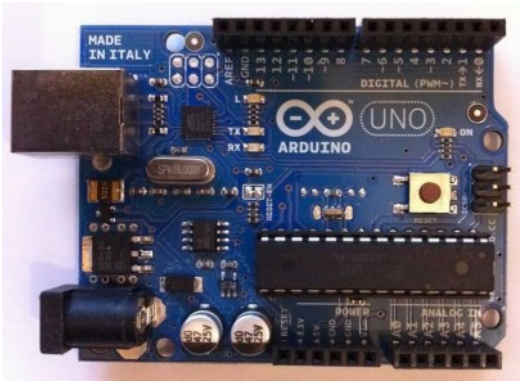
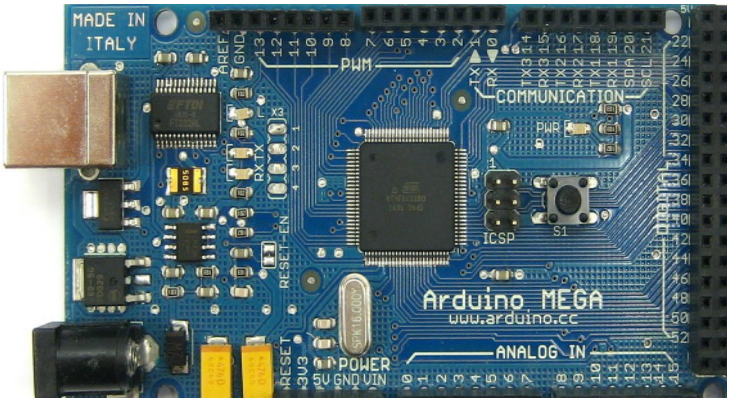
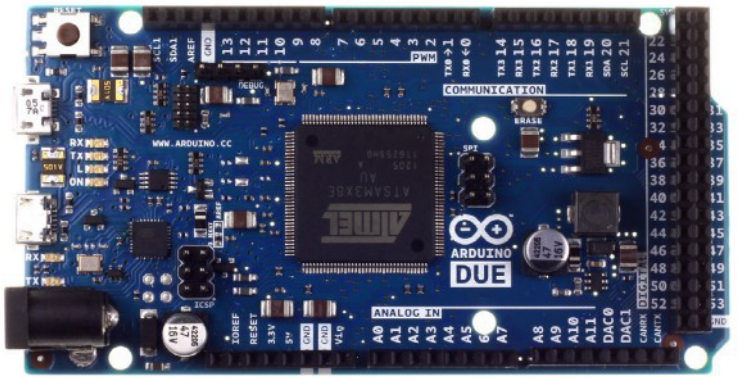
Reprap 3D Drucker

- Vergleich Arduino / Mega / Due

	µController	Flash	EEPROM	SDRAM	digitale Ein- / Ausgänge	analoge Eingänge
Arduino Uno	ATmega328	32 KiB	1 KiB	2 KiB	14	6
Arduino Mega	Atmega2560	256 KiB	4 KiB	8 KiB	54	16
Arduino Due	AT91SAM3X8E (32bit)	512 KiB	n.v.	96 KiB	54	12

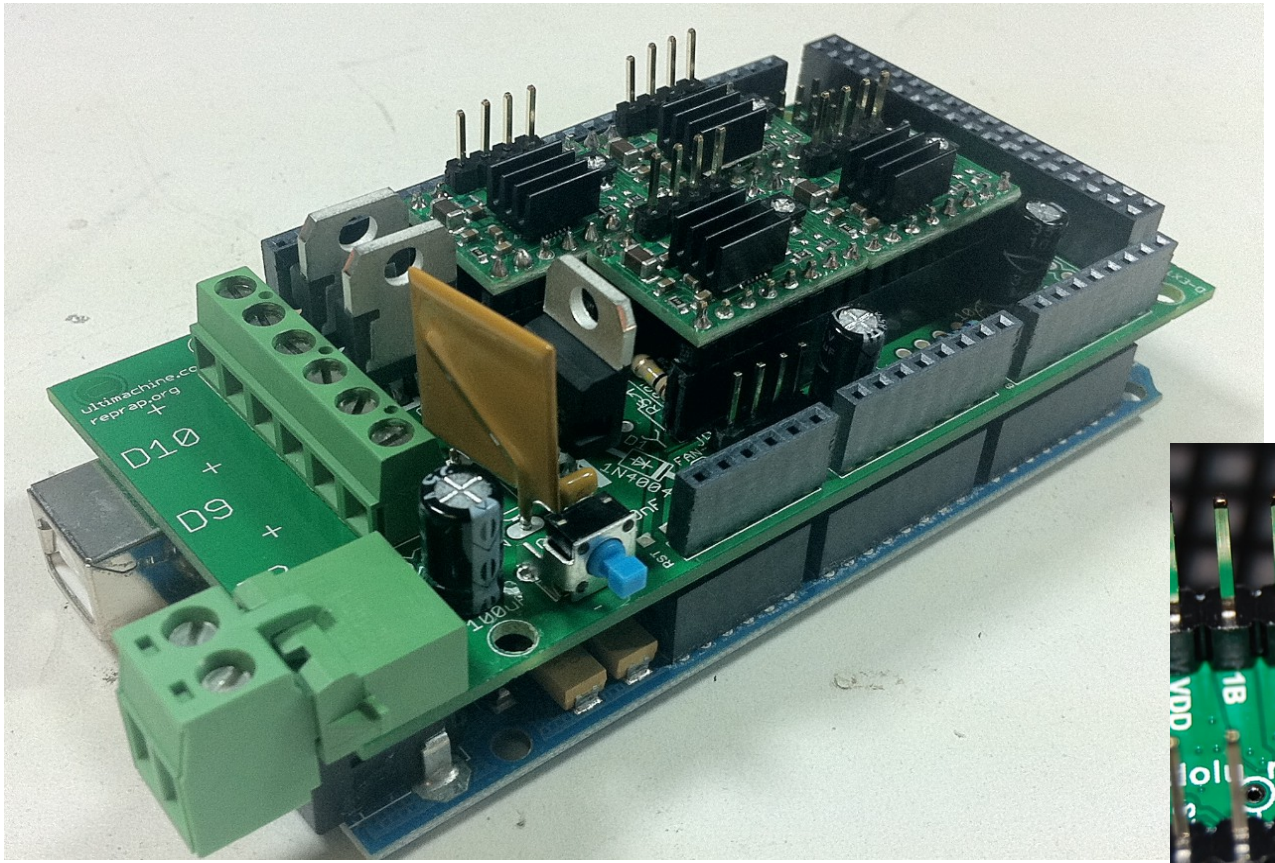


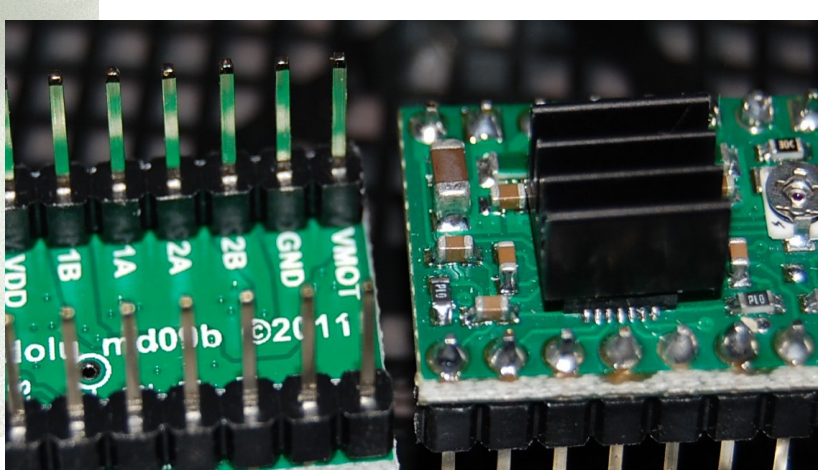




Reprap 3D Drucker

- Reprap Arduino Mega Pololu Shield (RAMPS)
  - ca. €50 + €30 + 4*10€ (Arduino, RAMPS, Pololus) = €120





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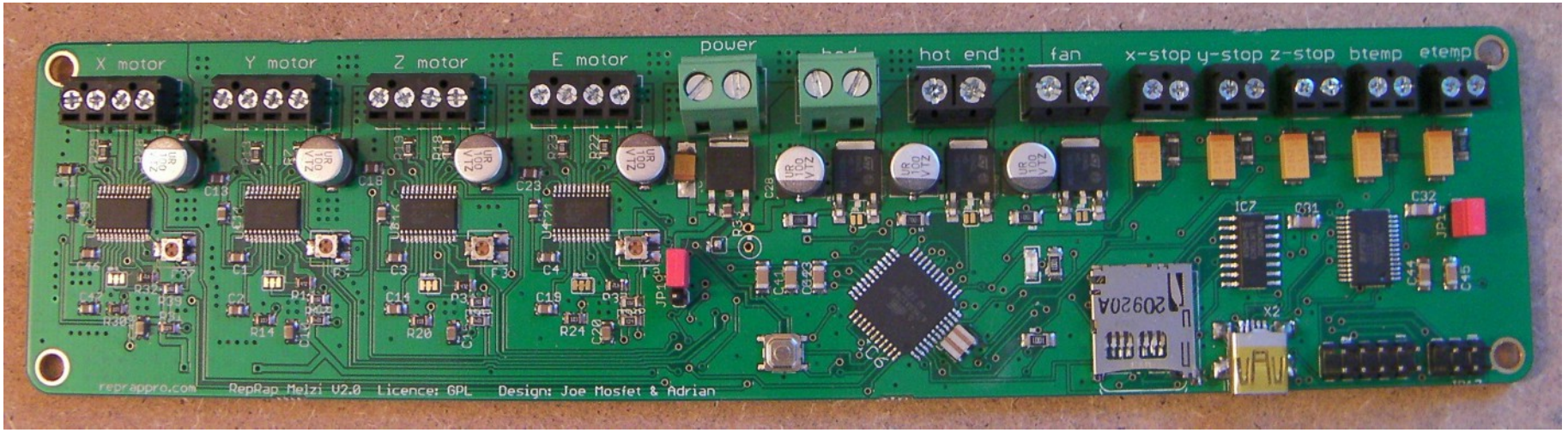
Reprap 3D Drucker

- Alternativen zum Arduino + RAMPS
  - Melzi-Board (ca. €120)



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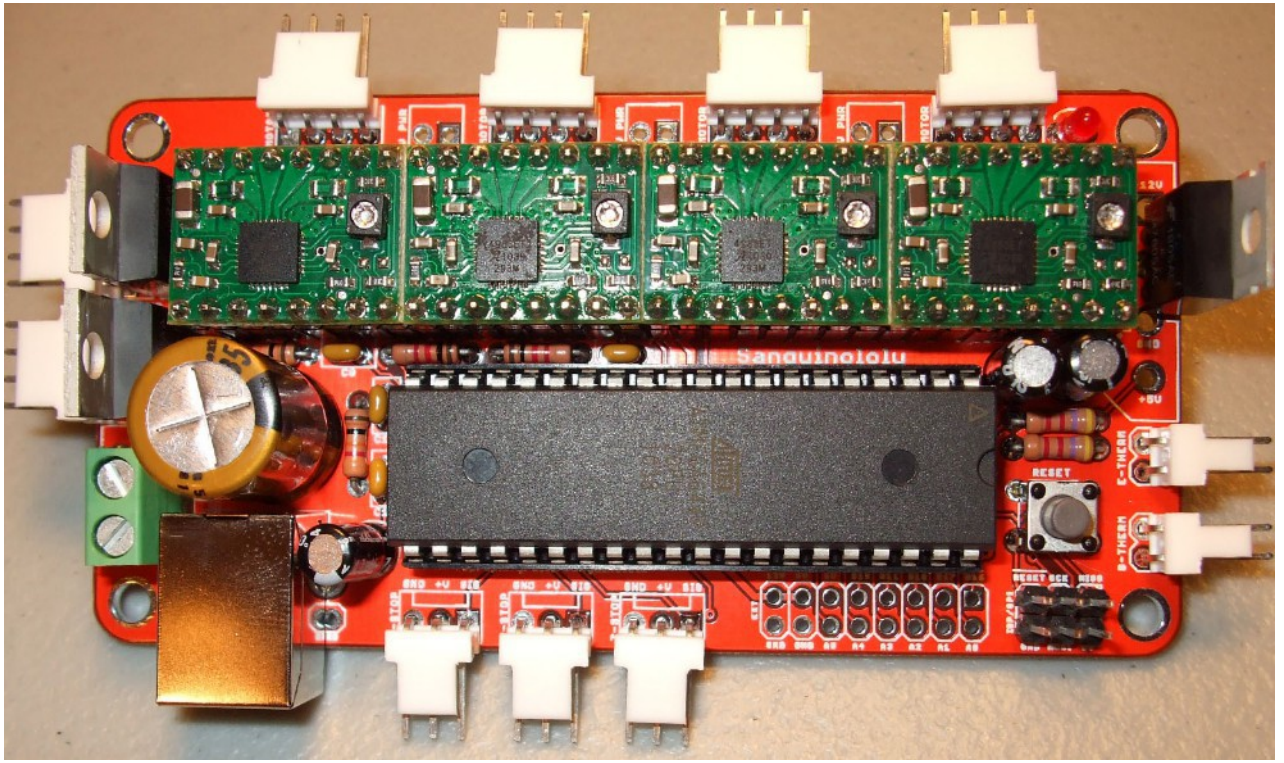
Reprap 3D Drucker

- Alternativen zum Arduino + RAMPS
  - Sanguinololu-Board (ca. €60 + 4x€10 = €100)



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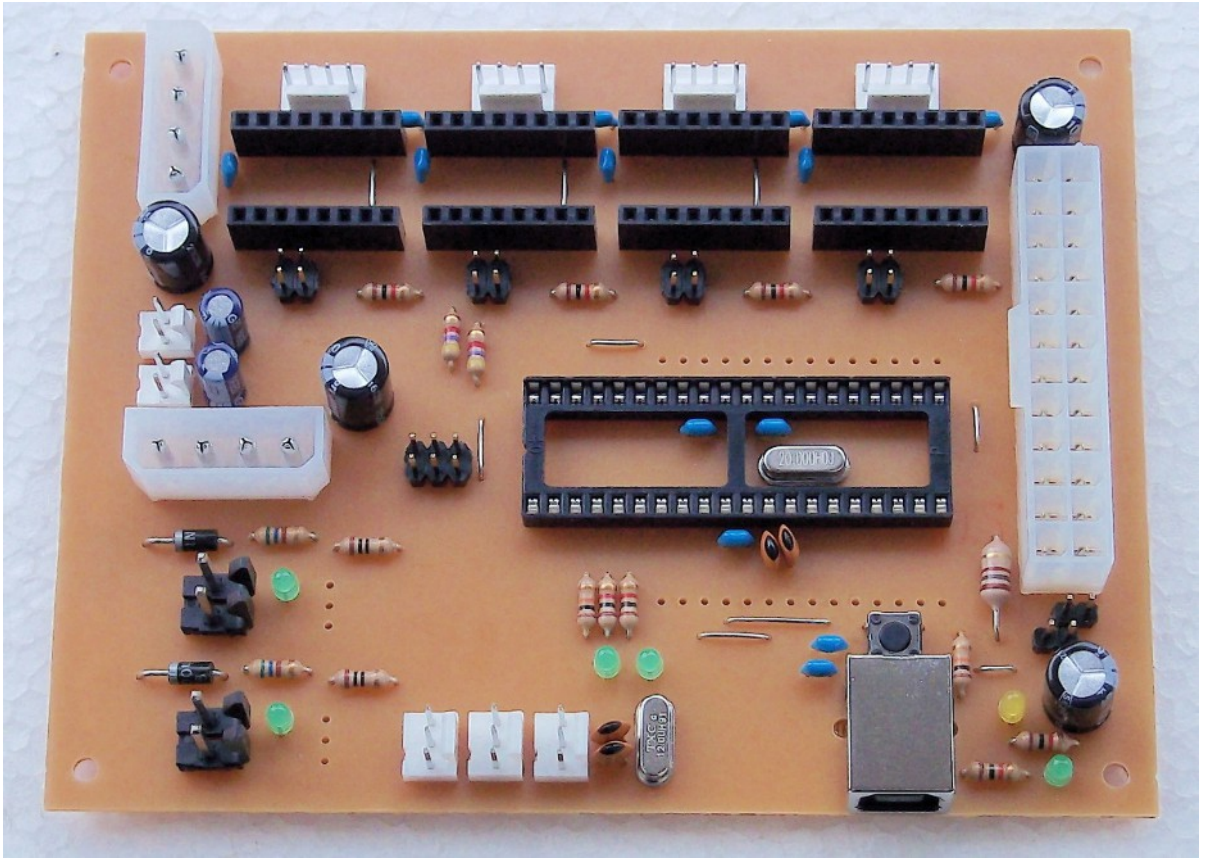
Reprap 3D Drucker

- Alternativen zum Arduino + RAMPS
  - Gen7-Board (Bausatz €60 + 4*€10 = €100)



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Reprap 3D Drucker

- rechnerischer Stromverbrauch
  - Elektrische Leistung (Gleichstrom) $P = \frac{U^2}{R}; P = U \cdot I$
  - Heizbett $\frac{12^2 V}{1{,}2\,\Omega} = 120\text{W}$
  - Extruder $\frac{12^2 V}{5{,}8\,\Omega} = 24{,}8\,W$
  - Schrittmotoren $4 \cdot 12\text{V} \cdot 1\text{A} = 48\text{W}$
  - Elektronik ca. 5W max.

Σ ca. 200W max.

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Reprap 3D Drucker

- tatsächlicher Stromverbrauch
  - Druckzeit: 6:45h
  - Anzeige am Wattmeter: 0,79 kWh
  - Ø Leistungsaufnahme:

    790Wh / 6,75h

    = 117 W

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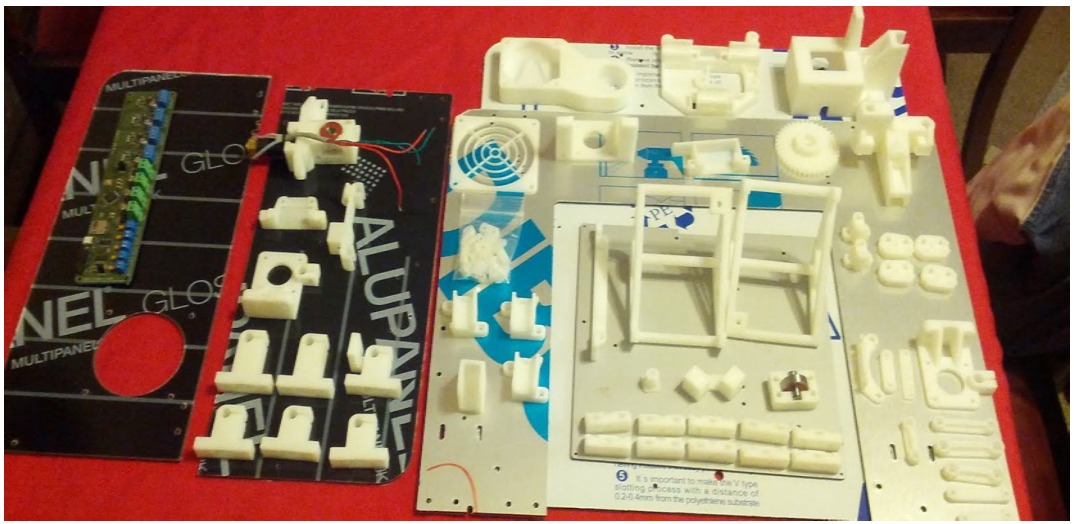
Reprap 3D Drucker

- Kosten (Mendel90)
  - Bausatz £ 499,00
  - Steuern £ 99,80
  - Porto £ 35,00
  - Summe <u>€ 781,25</u>



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Reprap 3D Drucker

- Weitere Materialien
  - diverse Werkzeuge (Schraubenschlüssel, -dreher, Innensechskant, Abisolierzange, Seitenschneider, Lötkolben)
  - Feinmechanik-Öl, Lithium-Fett
  - Aceton
  - Holzleim auf Polyvinylacetat-Basis, Klebestift, Malerkrepp

Reprap 3D Drucker

- Filament / Faberdashery.co.uk
  - 10x10m 3mm PLA div. Farben £ 30,00
  - 4x100m 3mm PLA div. Farben £ 111,00
  - 2x50m 3mm PLA div. Farben £ 30,50
  - Porto £ 14,00
  - Summe <u>€ 229,97</u>
















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Reprap 3D Drucker

- Software Workflow
  - 3D-Zeichenprogramm
  - Umwandeln in .stl Datei
  - Erzeugen der Druckschichten und Druckwege (slicing), speichern der .gcode Datei

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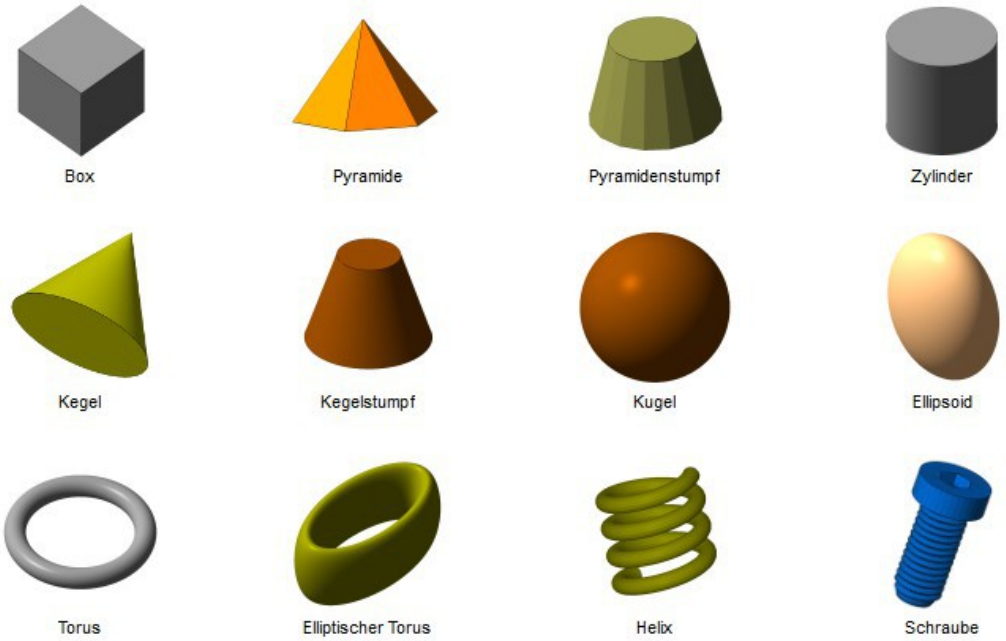
Reprap 3D Drucker

- Software Workflow
  - Übertragen der .gcode Datei an den Drucker (seriell/USB oder SD-Karte)
  - Drucker-Firmware interpretiert Kommandos und führt aus

Reprap 3D Drucker

- 3D-Zeichenprogramm
  - geometrische Grundkörper
  - Anordnen und Kombinieren
  - Funktionen
  - Programmierung
  - Export als .stl Datei



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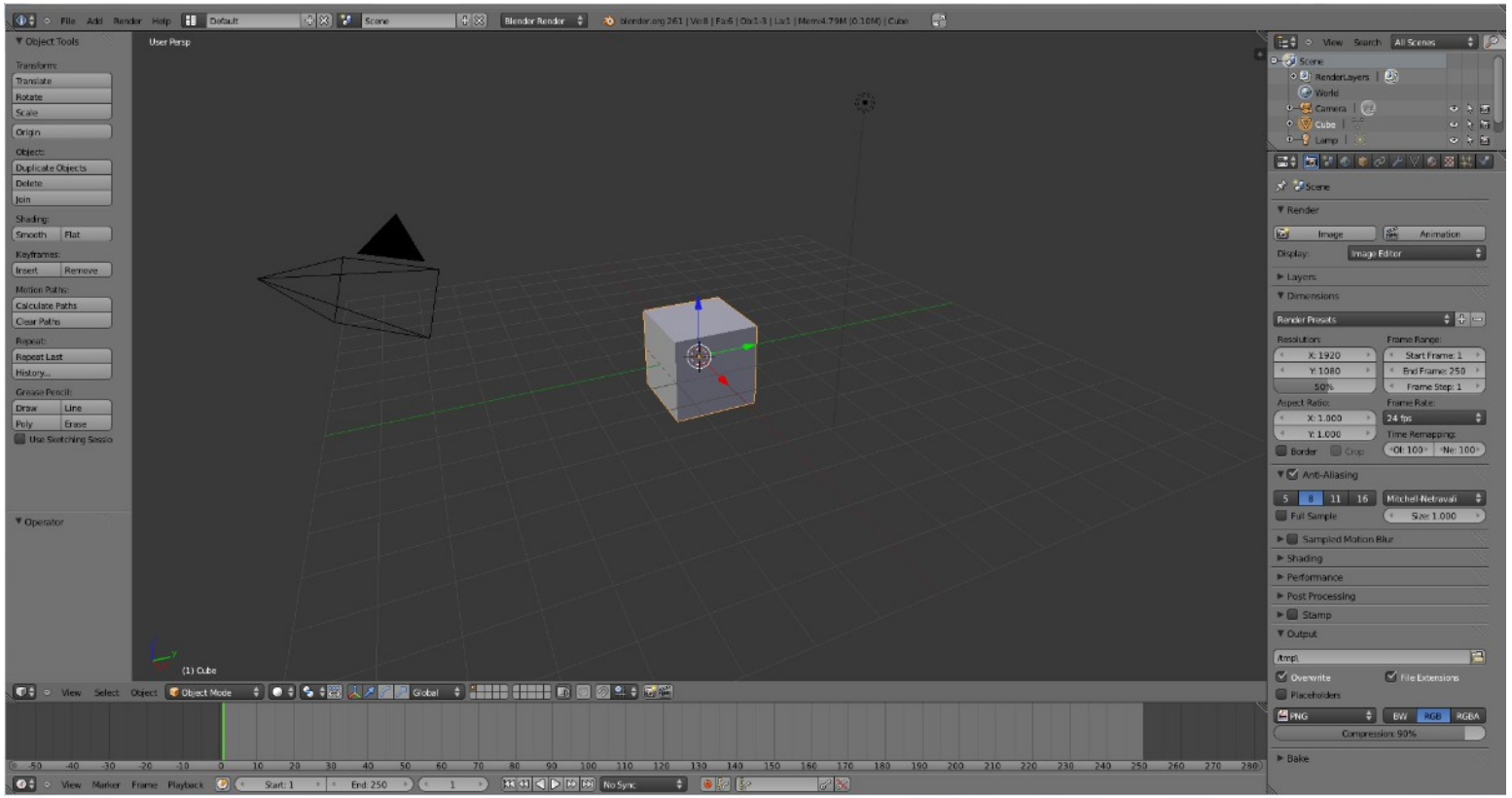
Reprap 3D Drucker

- 3D-Zeichenprogramm
  - Blender



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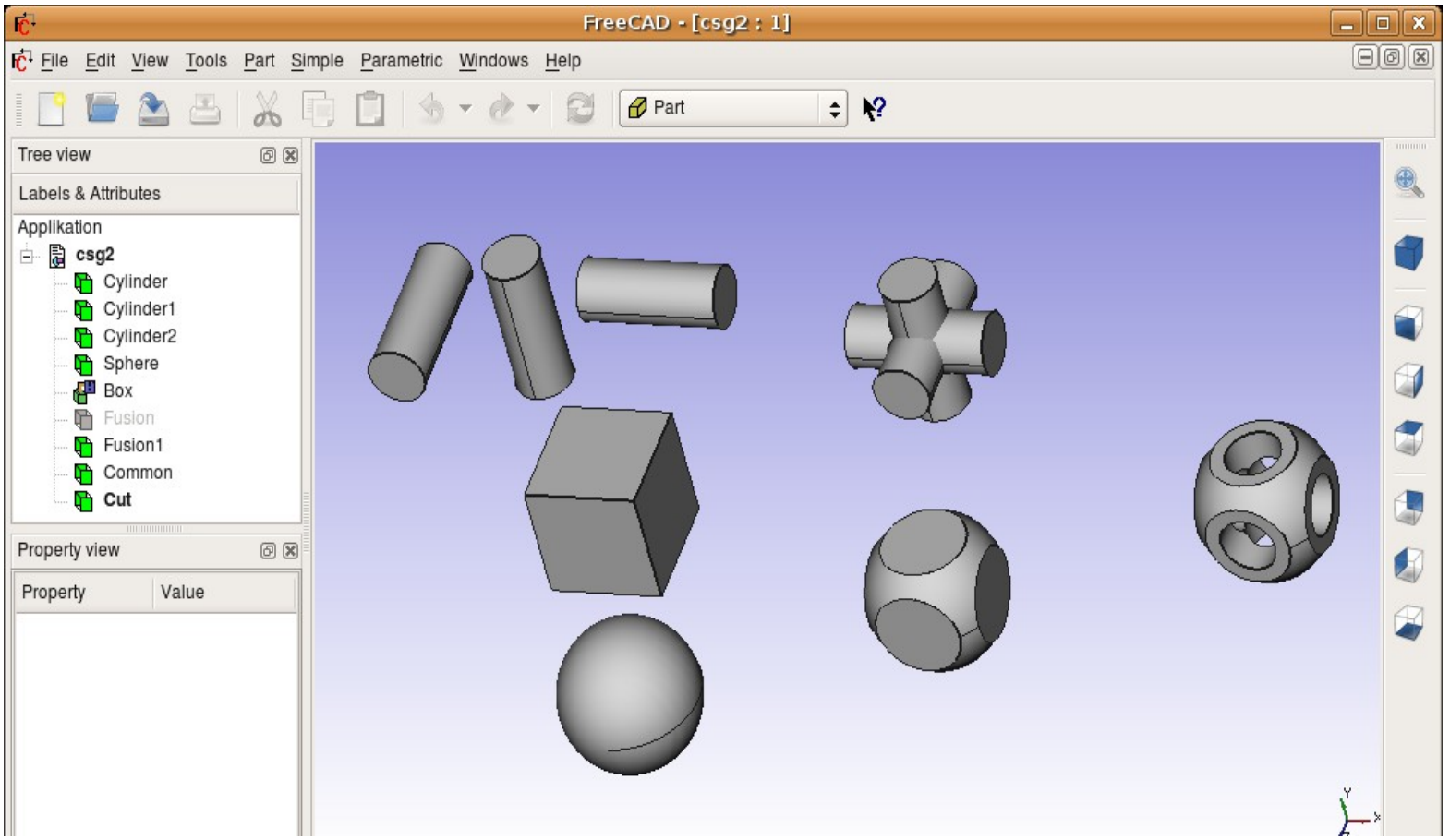
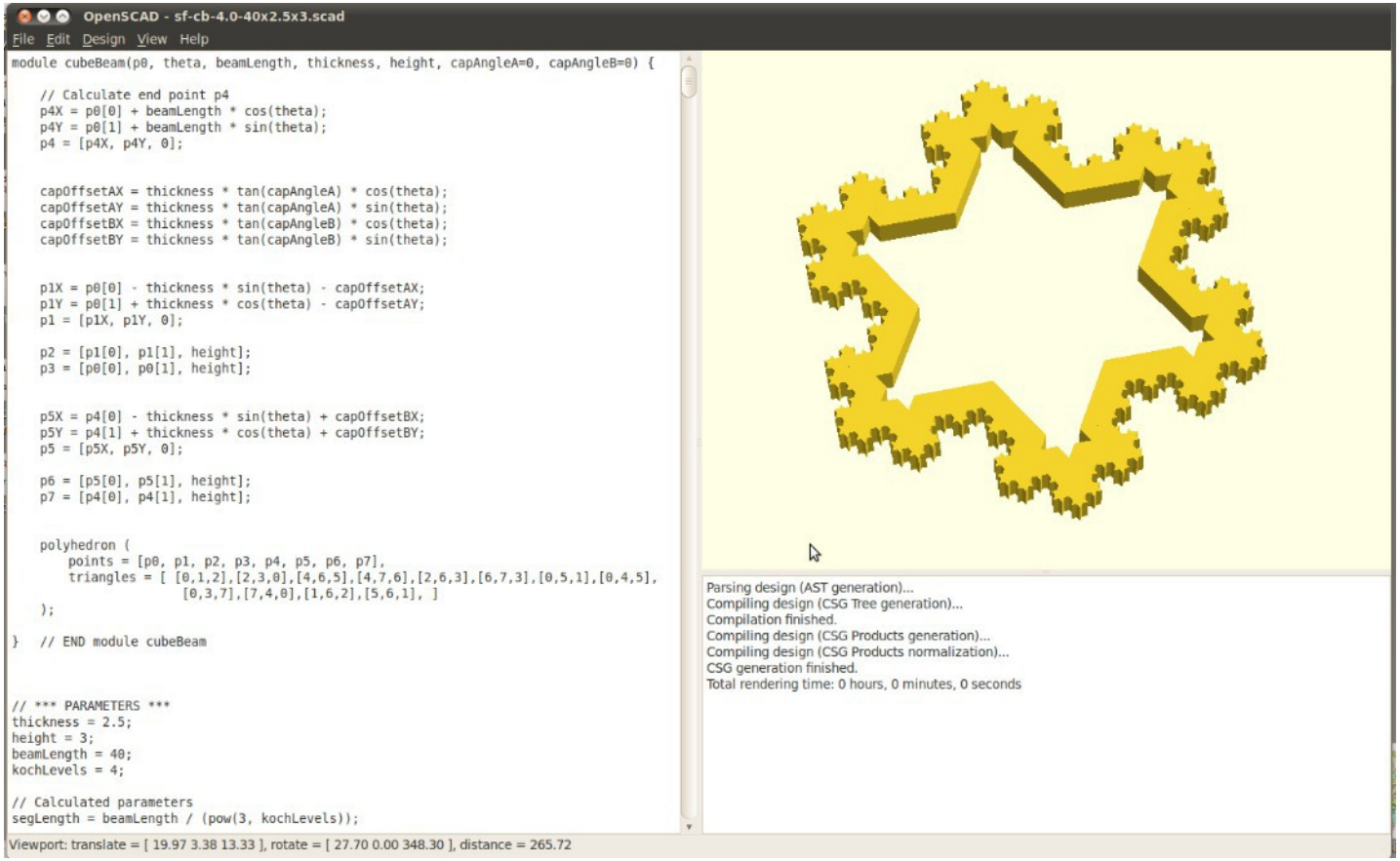
Reprap 3D Drucker

- 3D-Zeichenprogramm
  - FreeCAD



Reprap 3D Drucker

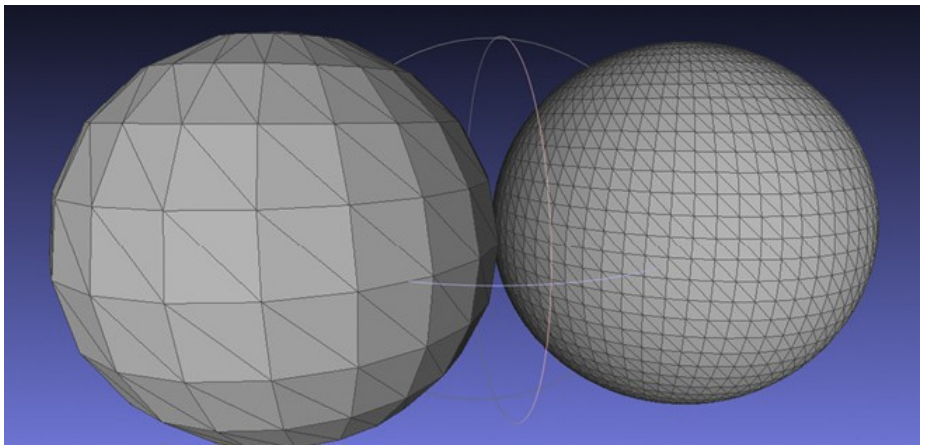
- 3D-Zeichenprogramm
  - OpenSCAD



Reprap 3D Drucker

- .stl Dateiformat
  - Enthält Dreieck-Koordinaten

```
solid name
 facet normal n1 n2 n3
  outer loop
   vertex p1x p1y p1z
   vertex p2x p2y p2z
   vertex p3x p3y p3z
  endloop
 endface
endsolid name
```



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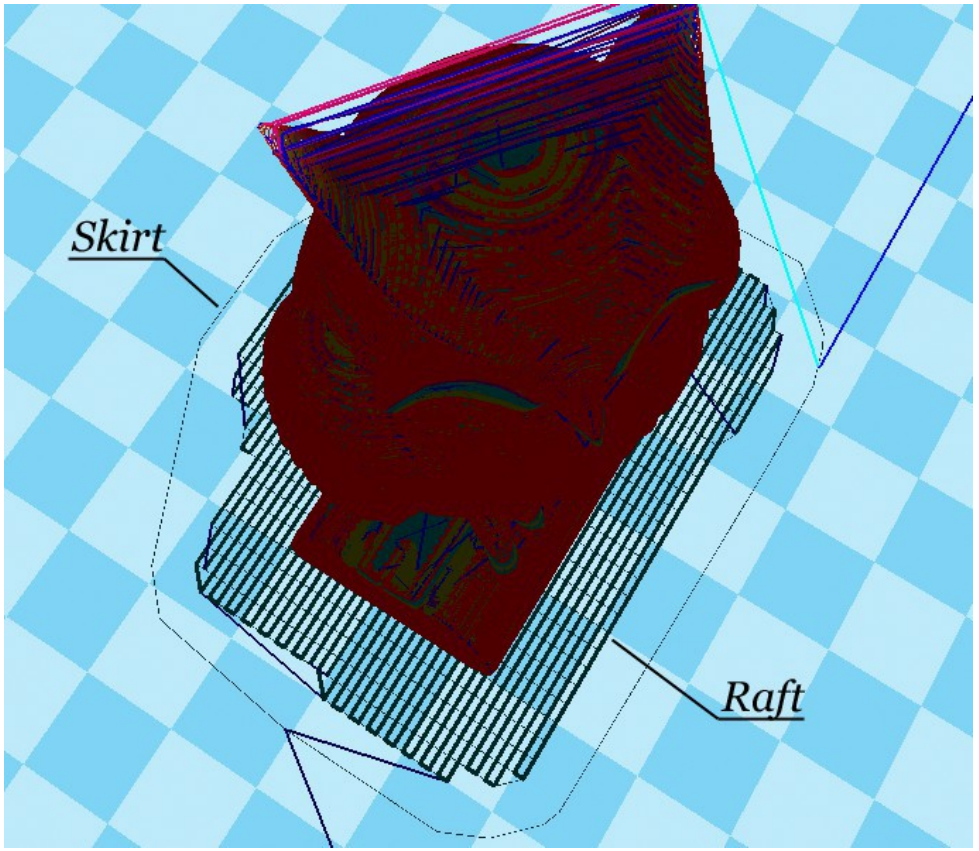
Reprap 3D Drucker

- Erzeugen der Druckschichten (slicing)
  - Profil (Drucker, Genauigkeit, Material)
  - Objekte
  - Skirt (optional)
  - Raft (optional)



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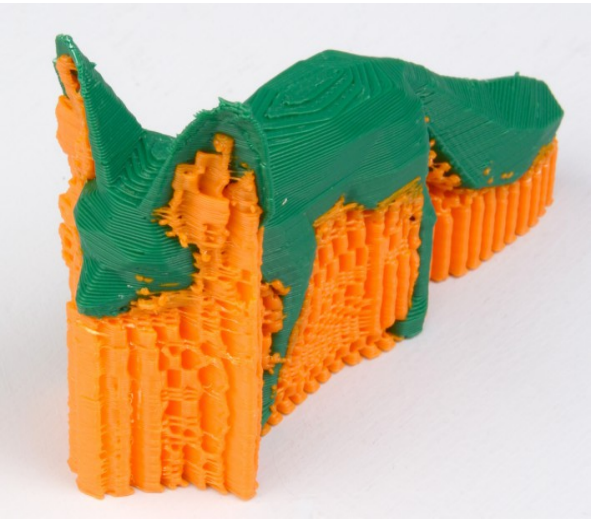
Reprap 3D Drucker

- Erzeugen der Druckschichten (slicing)
  - Brim (optional)

  - Support (je nach Objekt zwingend)



Reprap 3D Drucker

- Erzeugen der Druckschichten (slicing)
  - Infill (0-100%)
  - Perimeter
  - ... weitere 100 Parameter ...
  - Ausgabe .gcode-Datei

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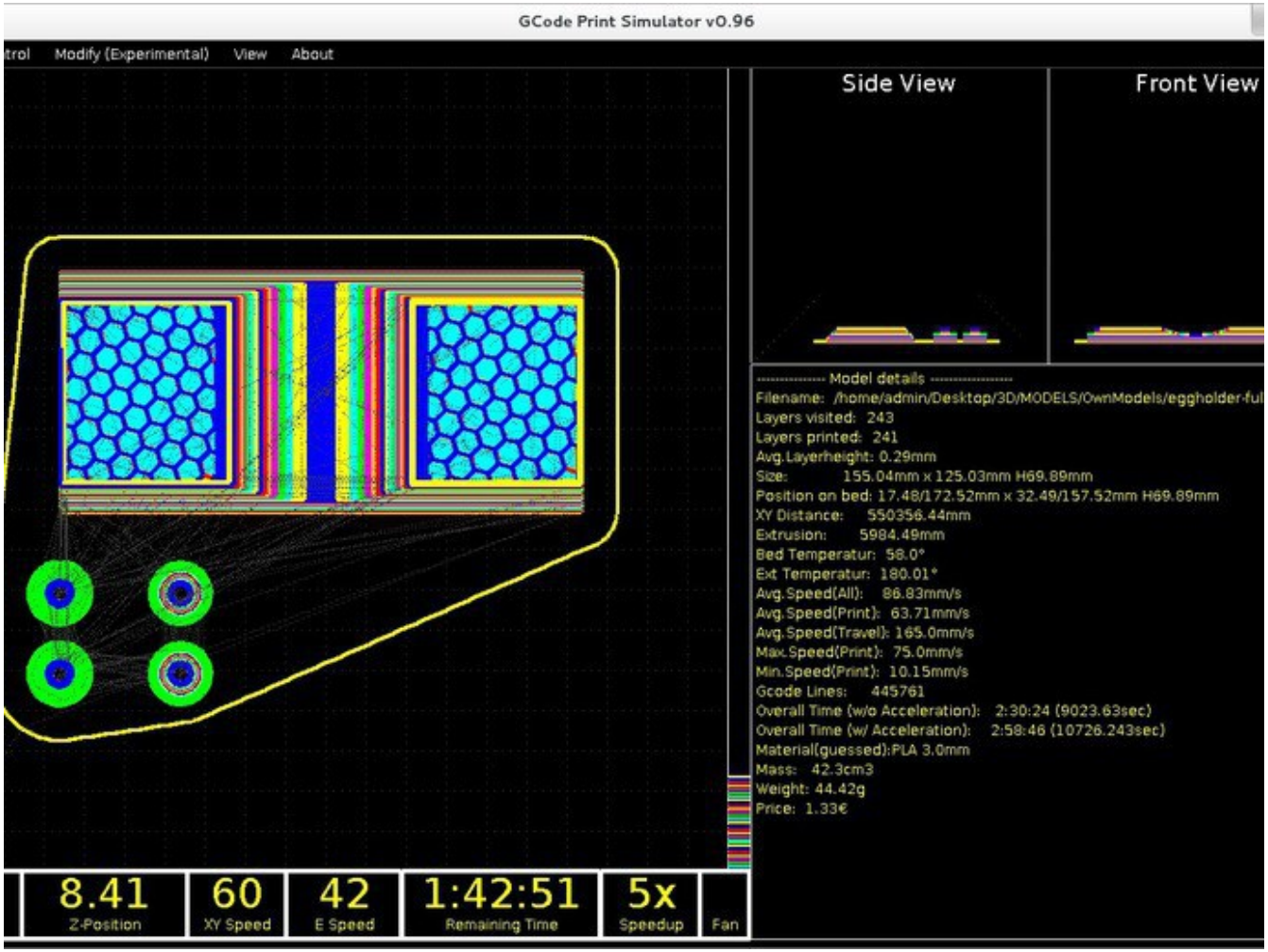
Reprap 3D Drucker

- Erzeugen der Druckschichten (slicing)
  - .gcode Dateiformat

```
M83 ; use relative distances for extrusion
G28 ; move to home position
G1 X5 Y99 F9000 ; Go to the middle of the front
G1 Z0.05 ; close to the bed
M104 S200 ; set extruder temp to 200°C
M190 S55 ; set bed temp to 55°C & wait
M109 S200 ; wait for extruder temp is 200°C
G1 E5 F50 ; extrude a blob
G1 X40 F4000 ;wipe 40mm along the edge of the bed
G1 Z0.3 ;lift Z
```

Reprap 3D Drucker

- Erzeugen der Druckschichten (slicing)
  - Kontrolle der .gcode Datei



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Reprap 3D Drucker

- Hostsoftware am PC
  - Steuerung / Bedienung des Druckers
  - Übertragung der .gcode Datei
  - Anordnen der Objekte auf dem Druckbett
  - Slicer und .gcode-Visualisierung
  - Kontrolle während dem Druck

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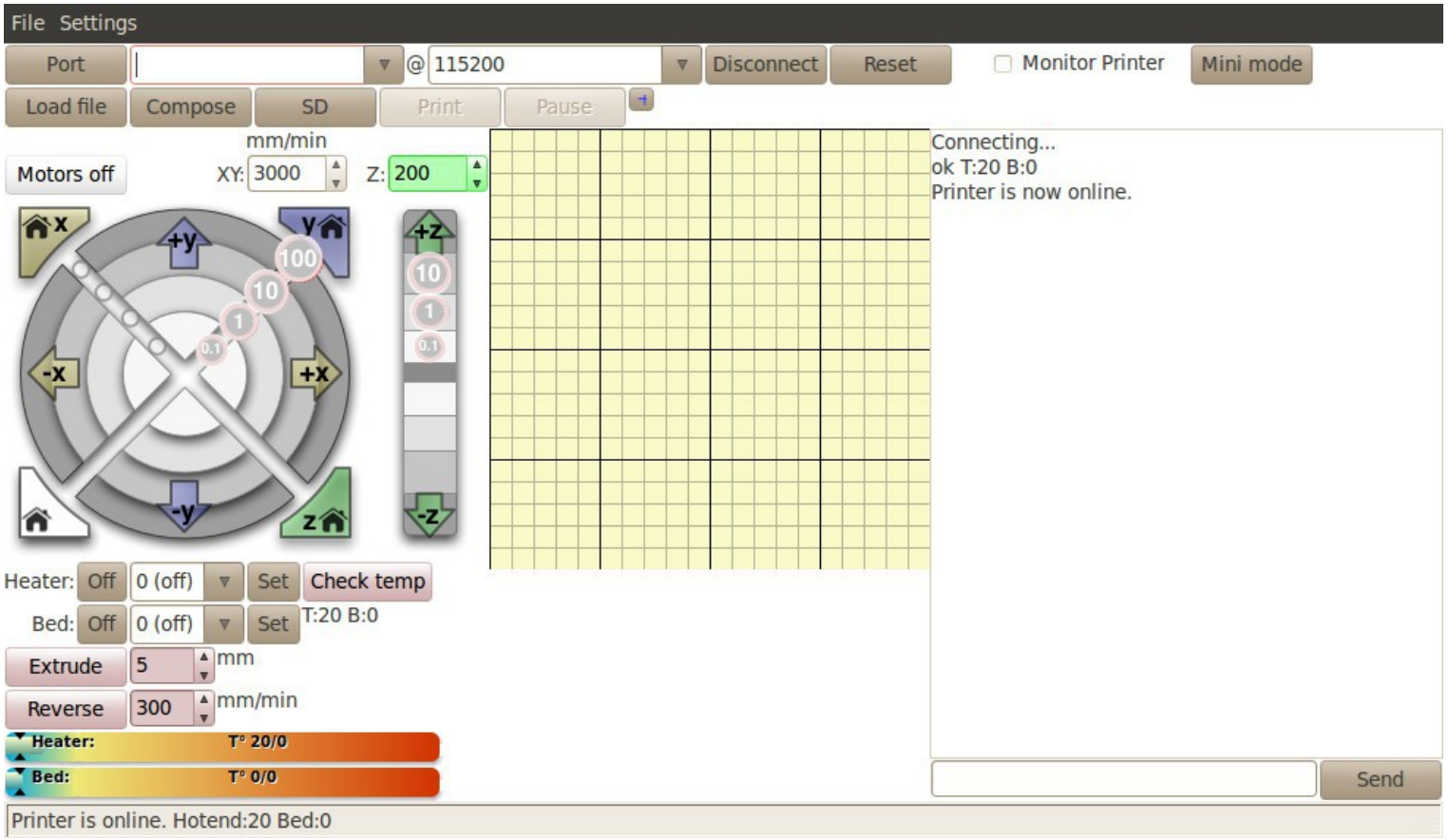
Reprap 3D Drucker

- Hostsoftware am PC
  - Pronterface



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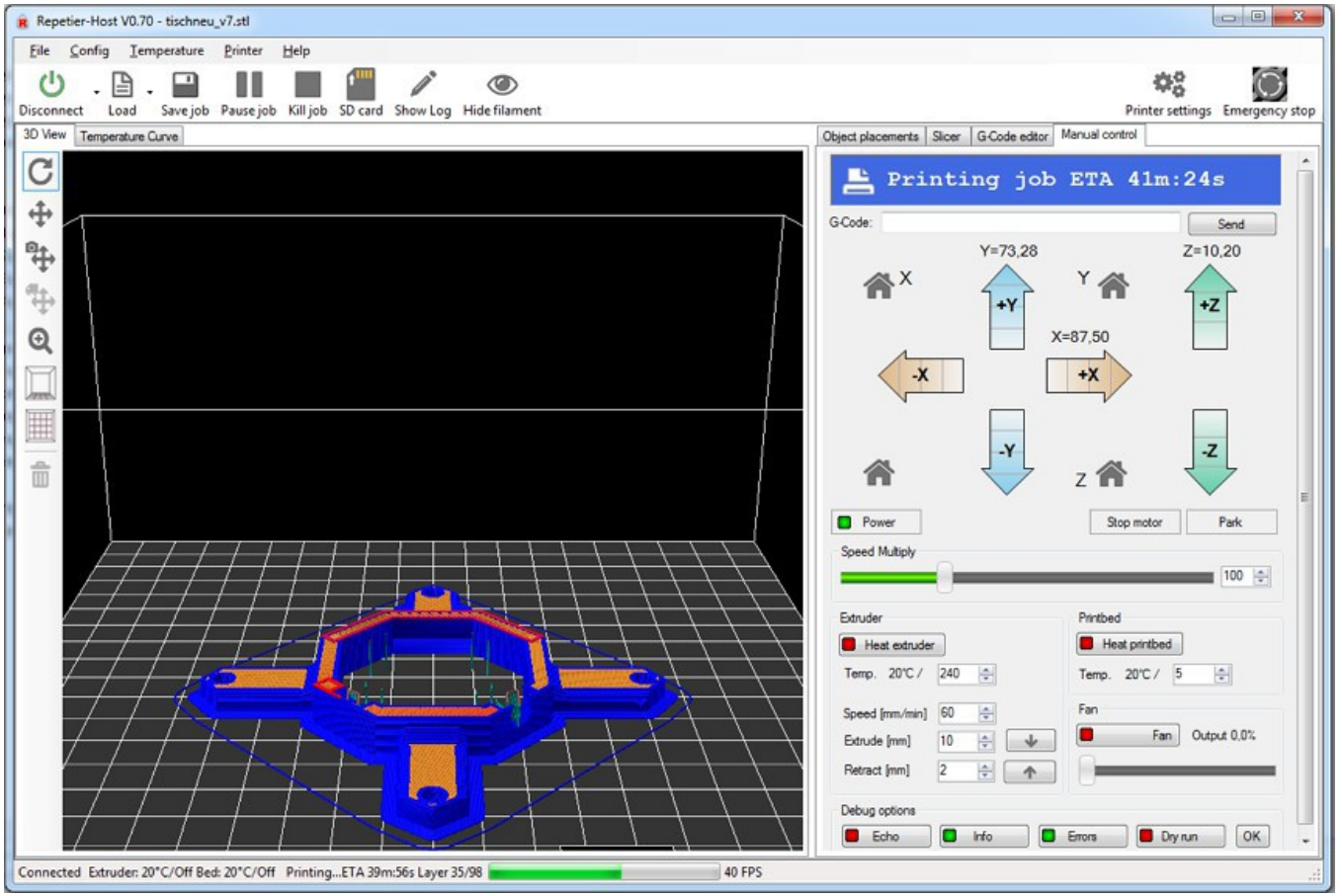
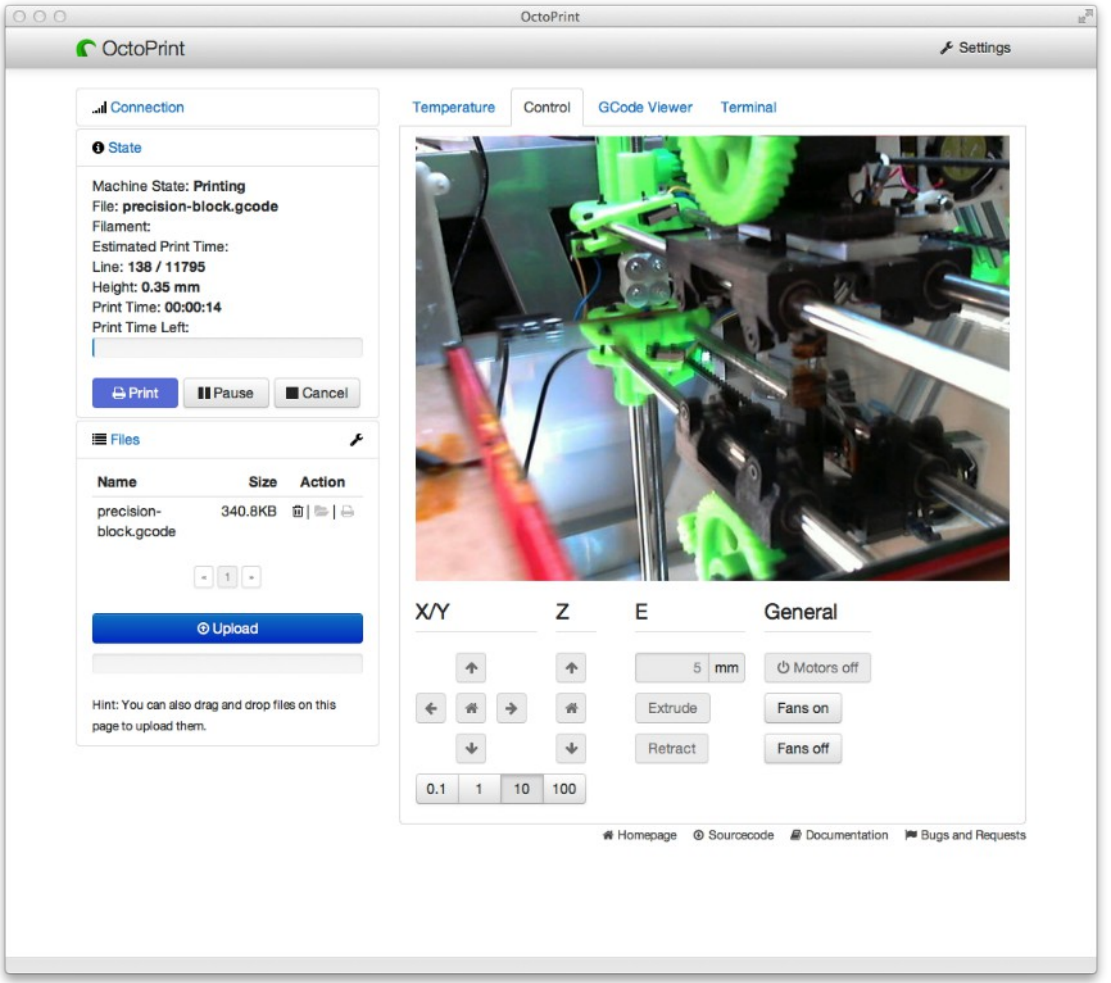
Reprap 3D Drucker

- Hostsoftware am PC
  - Repetier Host



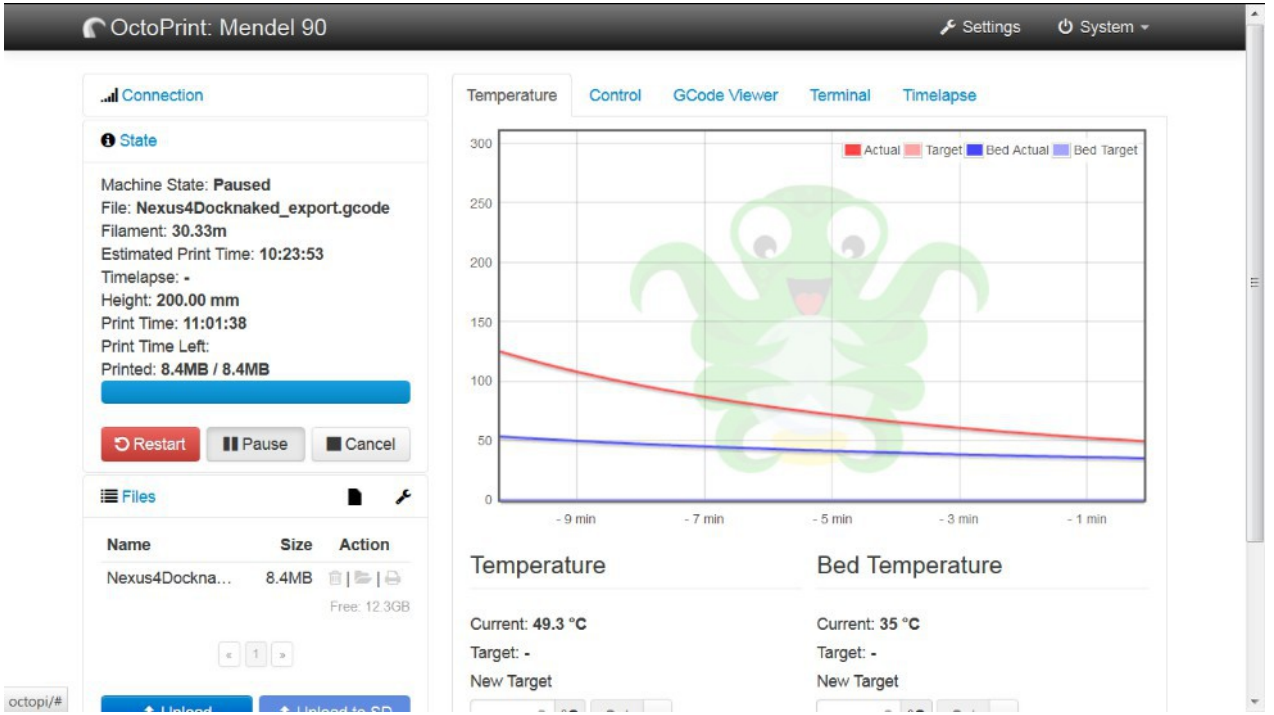
Reprap 3D Drucker

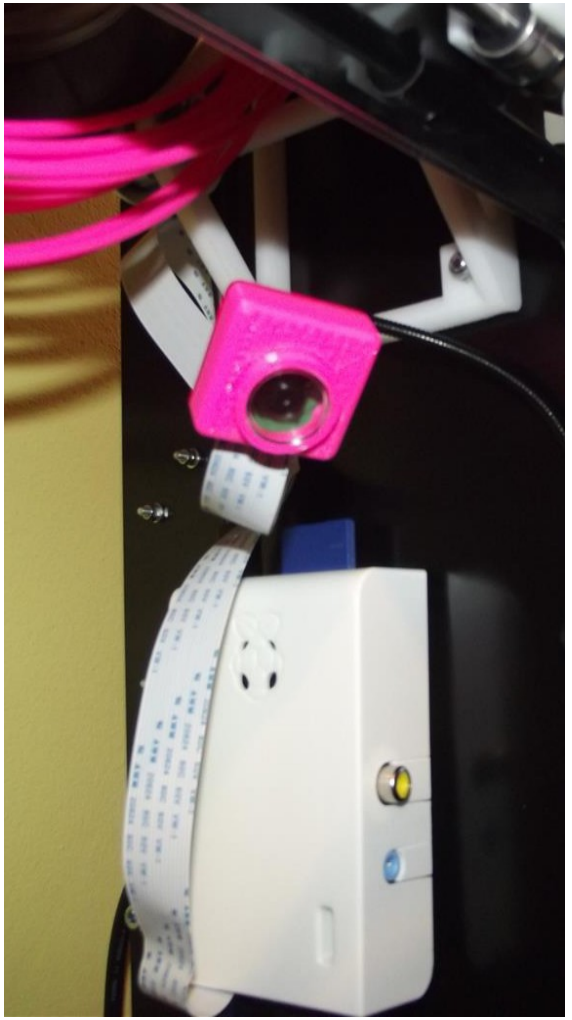
- Hostsoftware Spezialfall „OctoPrint”
  - Beobachten während dem Druck
  - Zeitrafferfilme
  - Netzwerk



Reprap 3D Drucker

- Hostsoftware + Hardware Spezialfall „OctoPi”
  - Raspberry Pi (+ PiCam) + Linux
    + Octoprint





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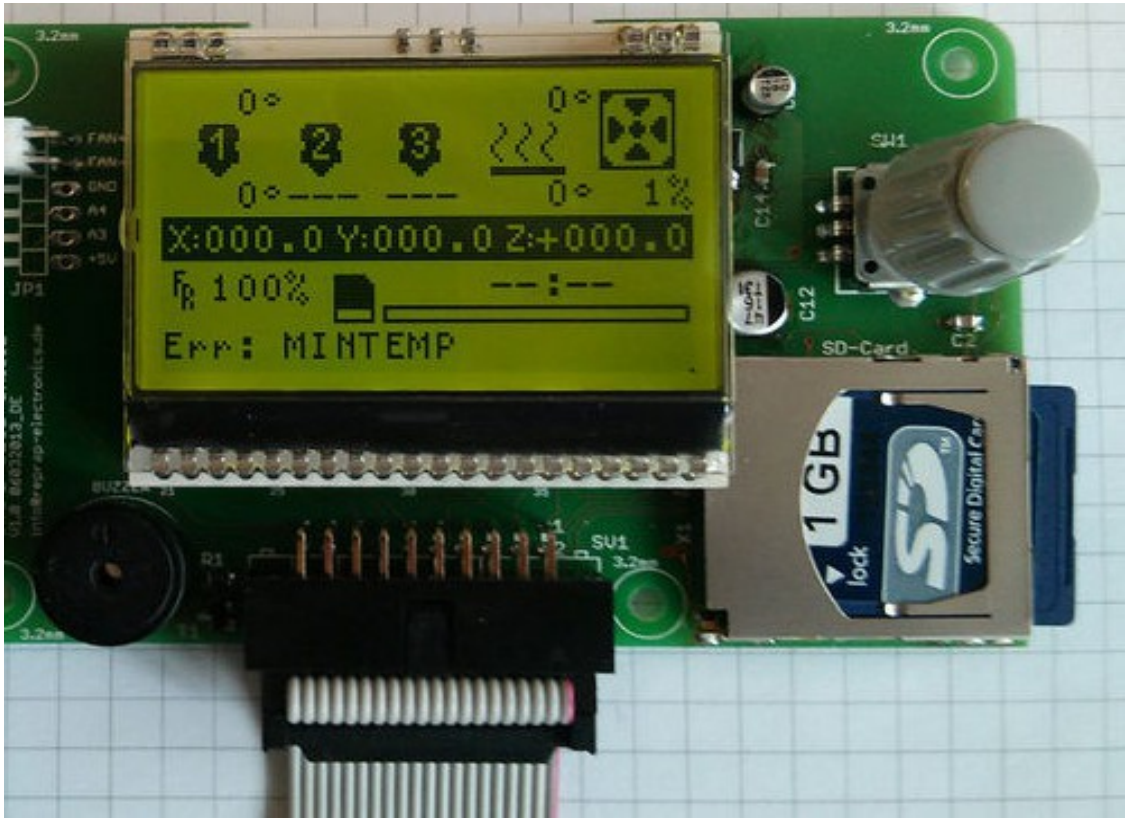
Reprap 3D Drucker

- Ohne Host
  - LCD + SD-Karte + Drehgeber



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Reprap 3D Drucker

- Drucker-Firmware
  - Sprinter, Teacup, sjfw, Marlin, Sailfish, Repetier, aprinter, RepRap Firmware ...
  - stammen teilweise voneinander ab

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Reprap 3D Drucker

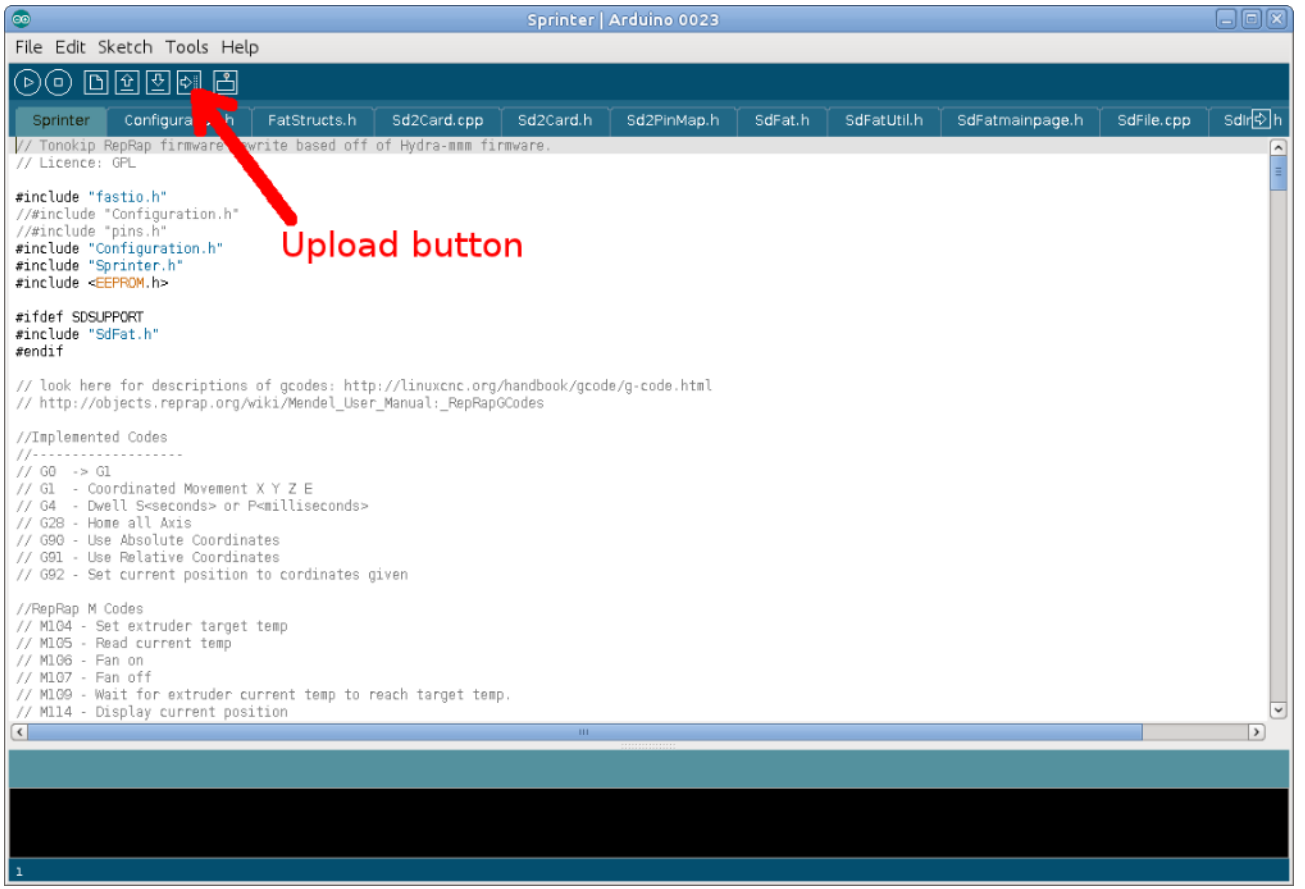
- Drucker-Firmware
  - druckerspezifische Konfiguration in Configuration.h (470 Zeilen bei aktueller Marlin-Firmware)

```
// The following define selects which electronics
// board you have. Please choose the one that
// matches your setup
// 33 = RAMPS 1.3
// 6  = Sanguinololu < 1.2
// 63 = Melzi

#ifndef MOTHERBOARD
#define MOTHERBOARD 63
#endif
```

Reprap 3D Drucker

- Drucker-Firmware
  - Compilieren und Aktualisieren über die Arduino-Umgebung



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Reprap 3D Drucker

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Reprap 3D Drucker

- Reprap Geschichte
  - Beginn: Erster Blogeintrag 23.03.2005
  - Gründer: Adrian Bowyer,
    Universität Bath, England

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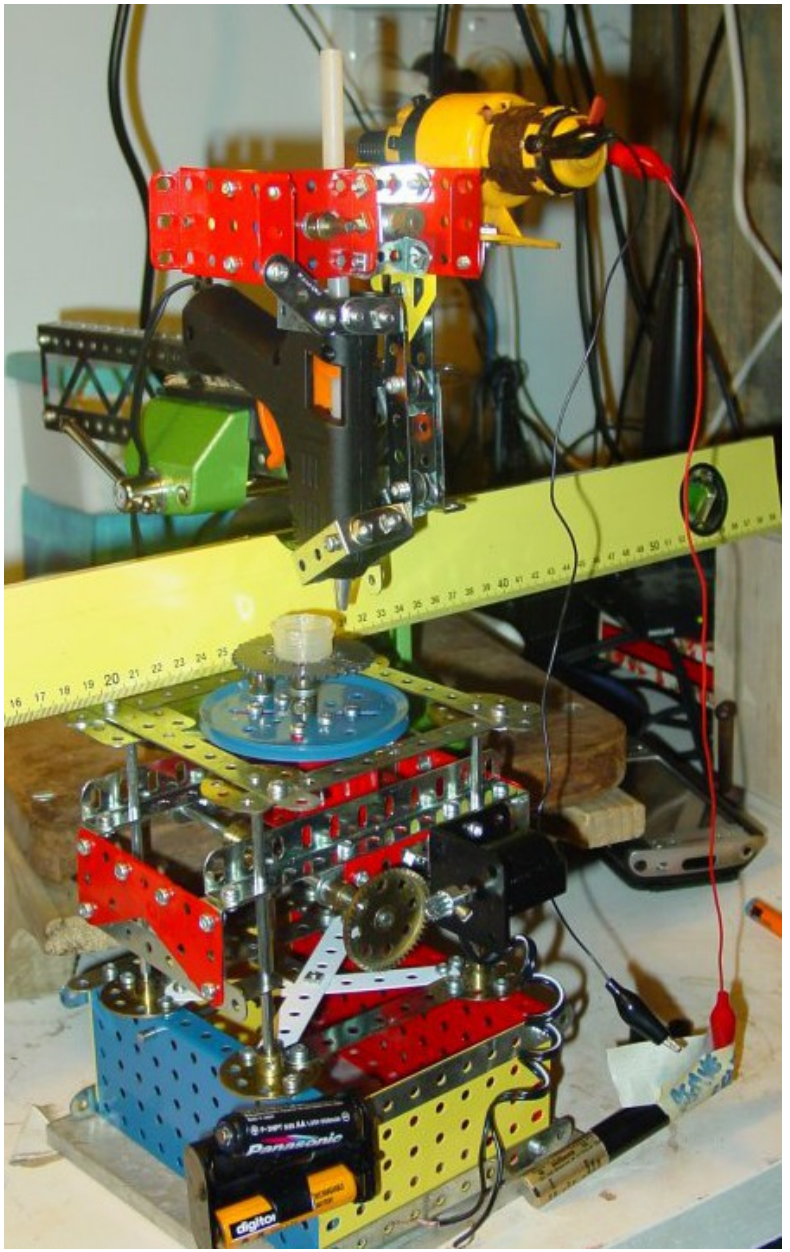
- Reprap Geschichte
  - 13. April 2005

    „Meccano”

    Vik Olliver



Reprap 3D Drucker

- Reprap Geschichte
  - 28. Mai 2005 M4 Schraube wird zur Düse

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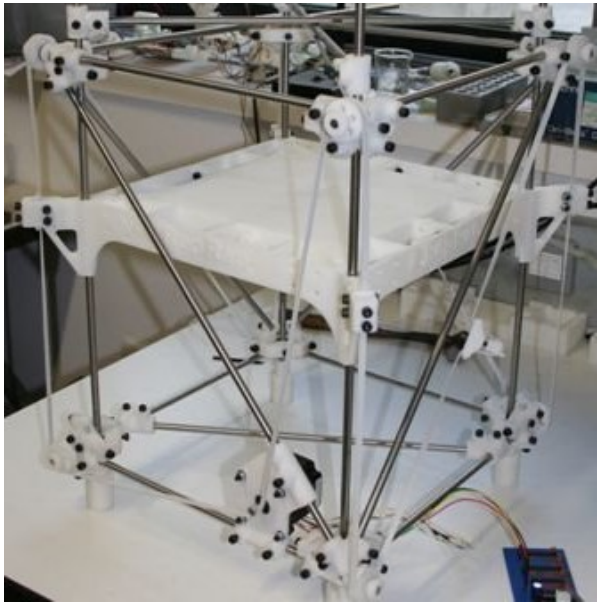
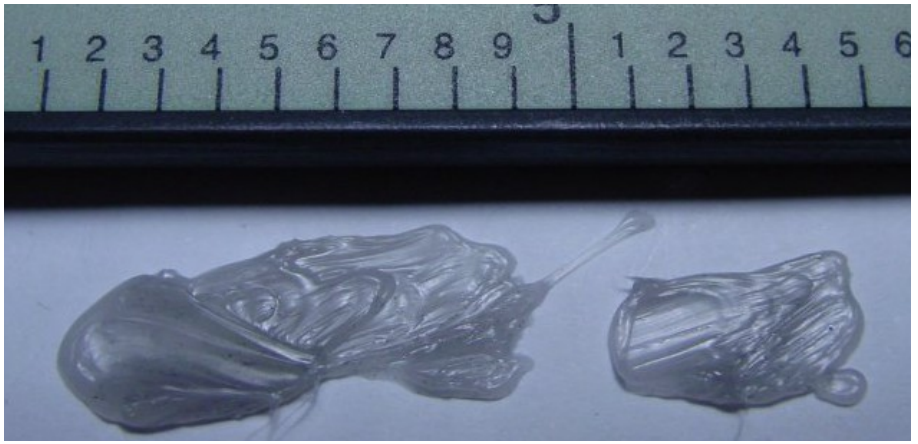
Reprap 3D Drucker

- Reprap Geschichte
  - April 2006: ARNIE
  - Mai 2006: Ein sechseckiges und ein quadratisches Objekt





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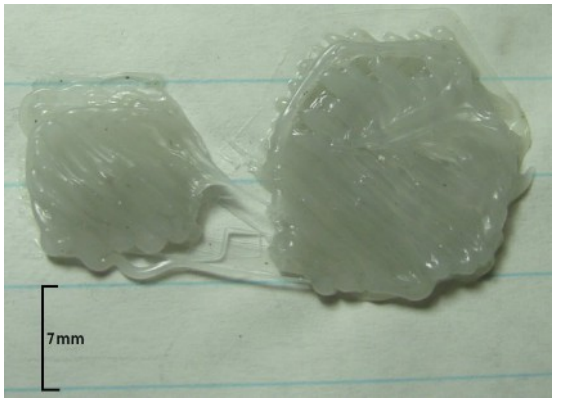
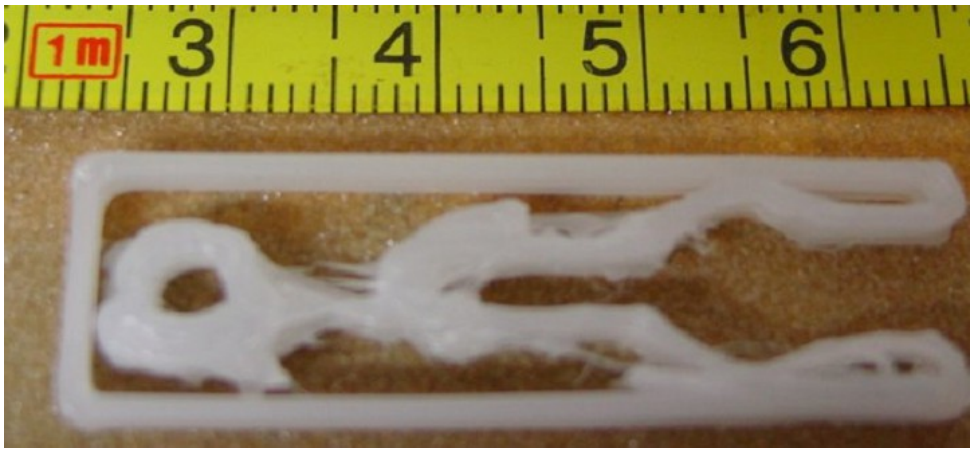
- Reprap Geschichte
  - Einen Tag später:



  - 9. Juli 2006 - erster Versuch "Gripley" zu drucken



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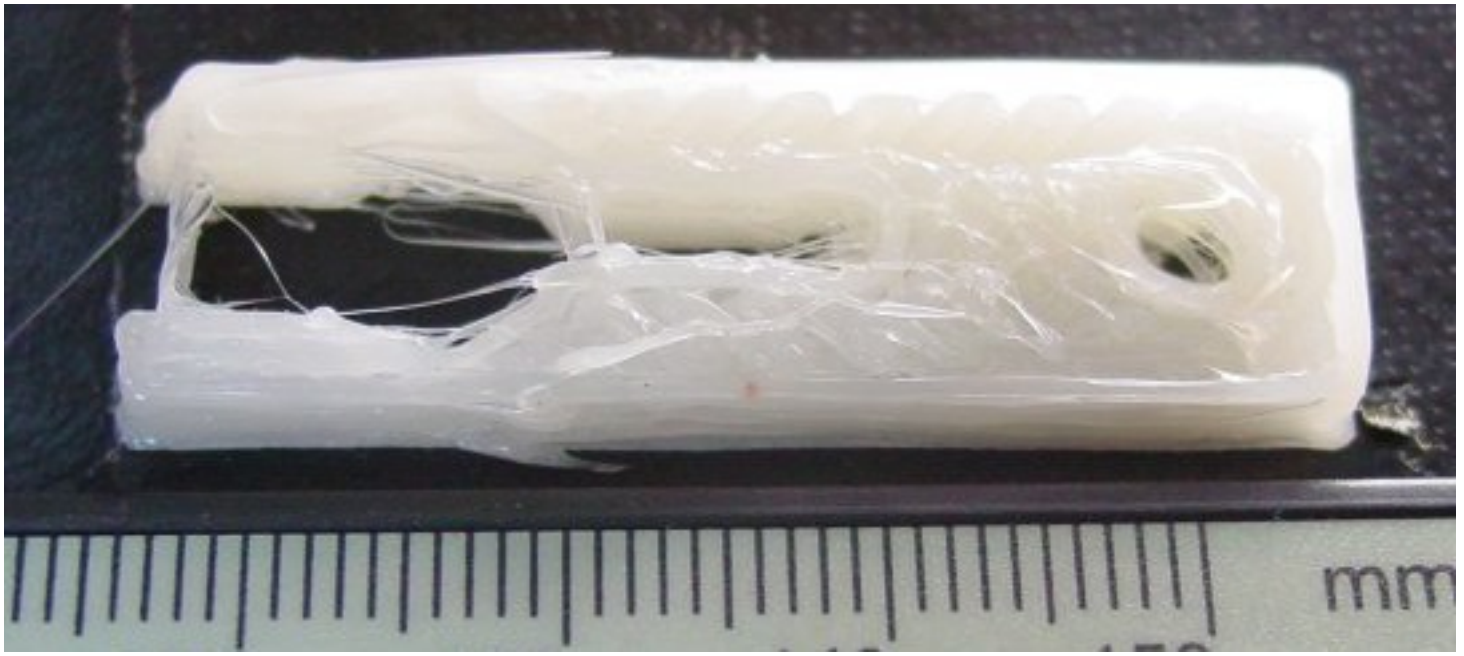
Reprap 3D Drucker

- Reprap Geschichte
  - 17. August 2006 - Gripley zweiter Versuch



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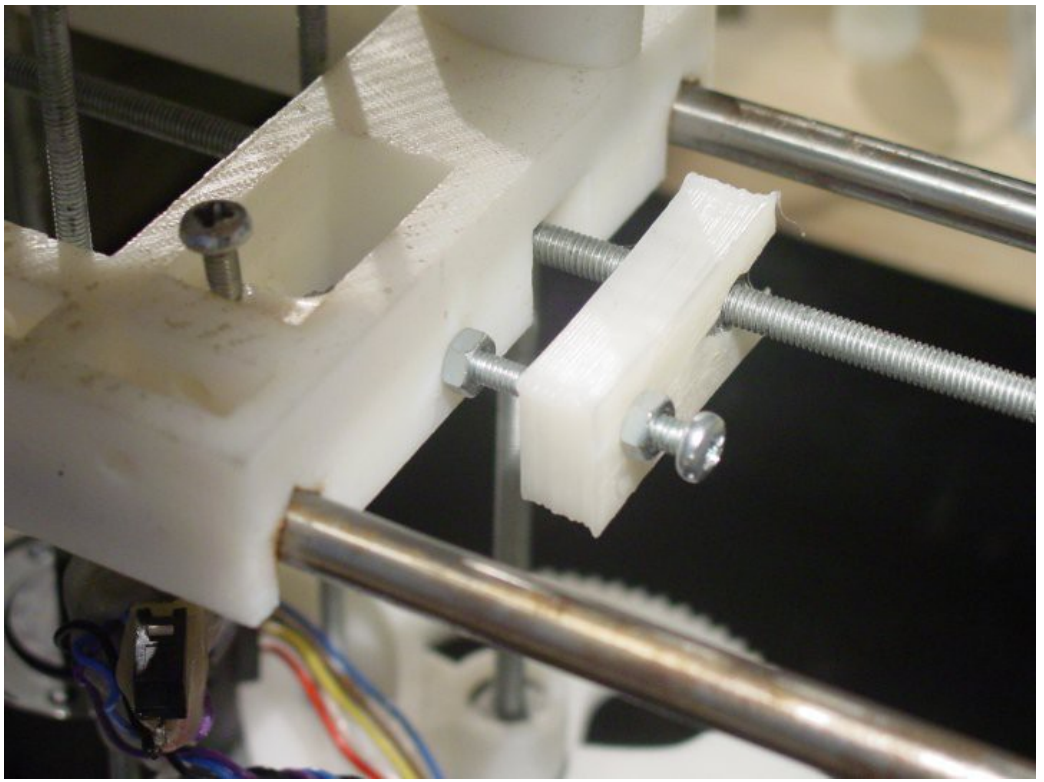
Reprap 3D Drucker

- Reprap Geschichte
  - 23. September 2006 Gripley dritter Versuch. Erstes gedrucktes Bauteil findet Verwendung in einem 3D-Drucker



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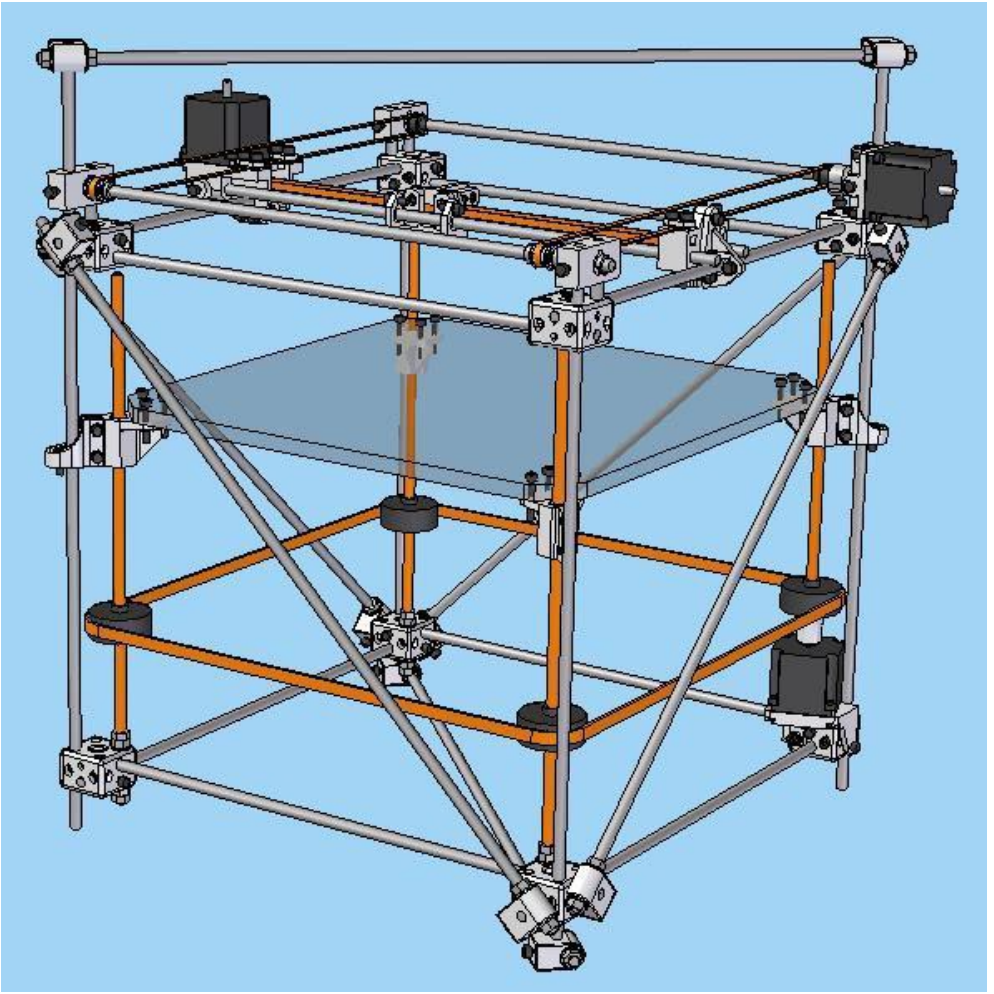
Reprap 3D Drucker

- Reprap Geschichte
  - 8. Januar 2007
    Darwin als CAD
    Modell fertig
    gezeichnet



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Reprap 3D Drucker

- Reprap Geschichte
  - 23. Januar 2007 - Elektronik für Darwin
  - 2. Februar 2007 - ARNIE funktioniert
  - 5. März 2007 - DARWIN bewegt sich
  - 9. April 2007 - DARWIN Bauanleitung online
  - 6. Juni 2007 - erste Version einer Host-Software

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Reprap 3D Drucker

- Reprap Geschichte
  - 12. Januar 2008 - Portierung der Firmware auf Arduino
  - 29. März 2008 - Arduino wird offizielle Hardware für Reprap Drucker

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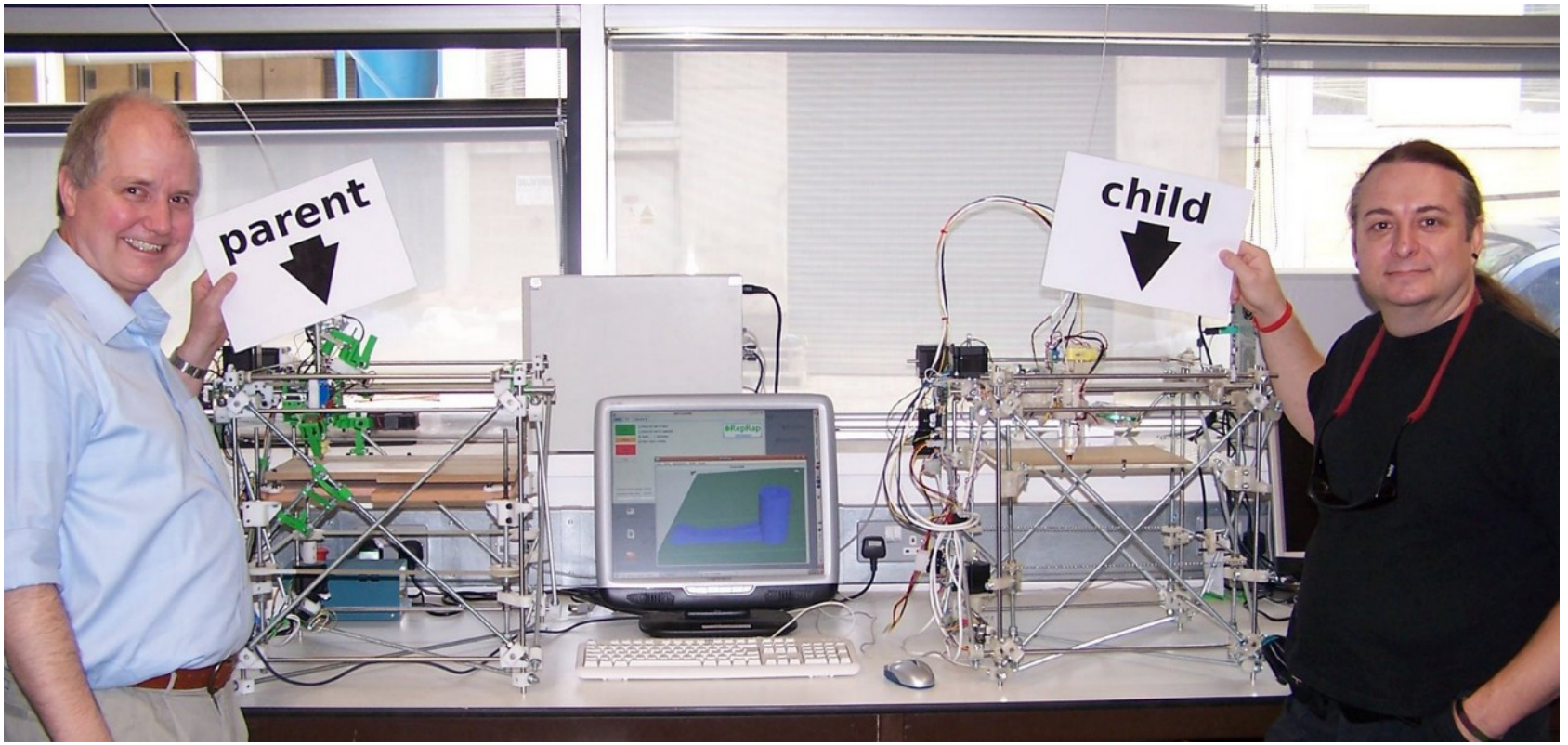
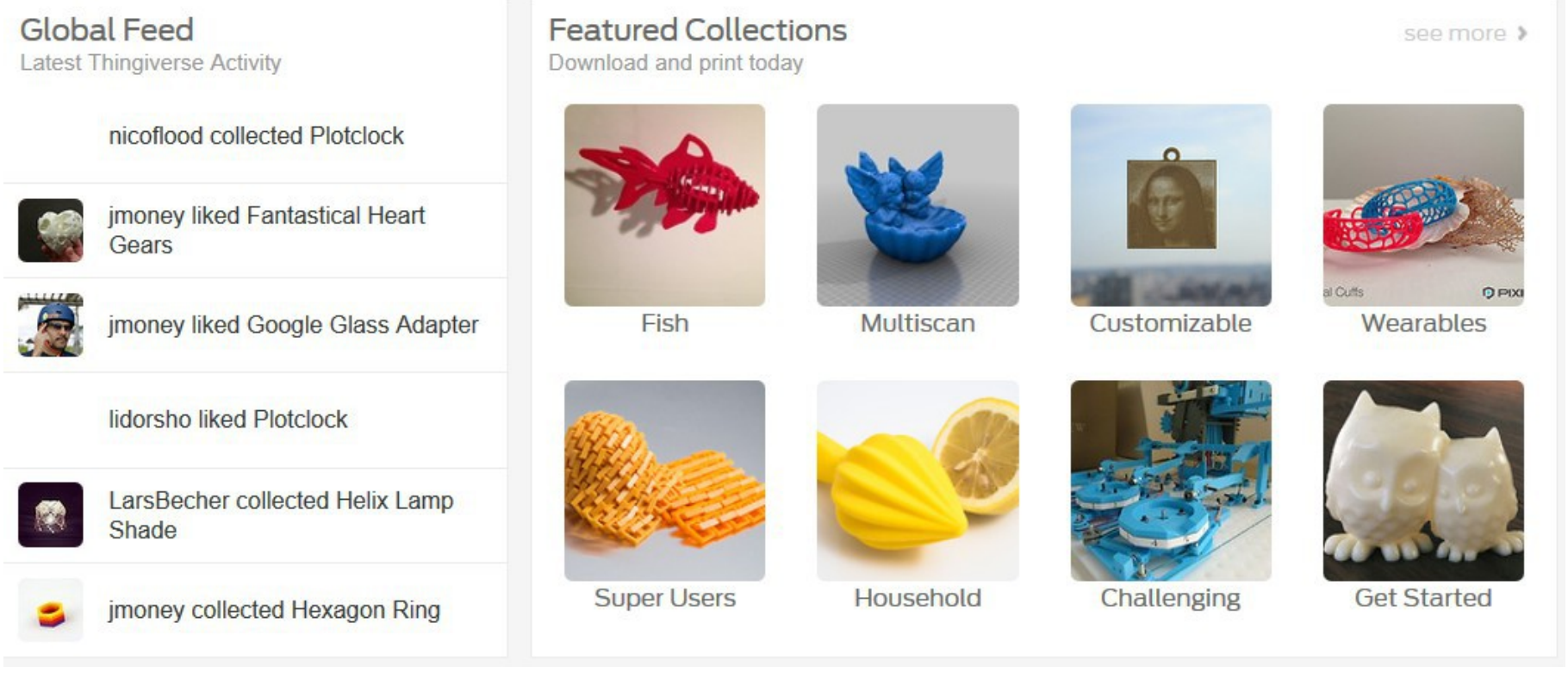
Reprap 3D Drucker

- Reprap Geschichte
  - 3. Juni 2008 - Reprap druckt Teile für einen Klon



Reprap 3D Drucker

- Reprap Geschichte
  - November 2008 - Start von thingiverse.com
  - Juni 2013 - 100.000 Objekte verfügbar



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Reprap 3D Drucker

- Reprap Geschichte
  - Januar 2009 - Diskussion über einen Darwin Nachfolger - Mendel
  - 17. September 2009 - Mendel Dateien
  - 2. Oktober 2009 - Mendel druckt

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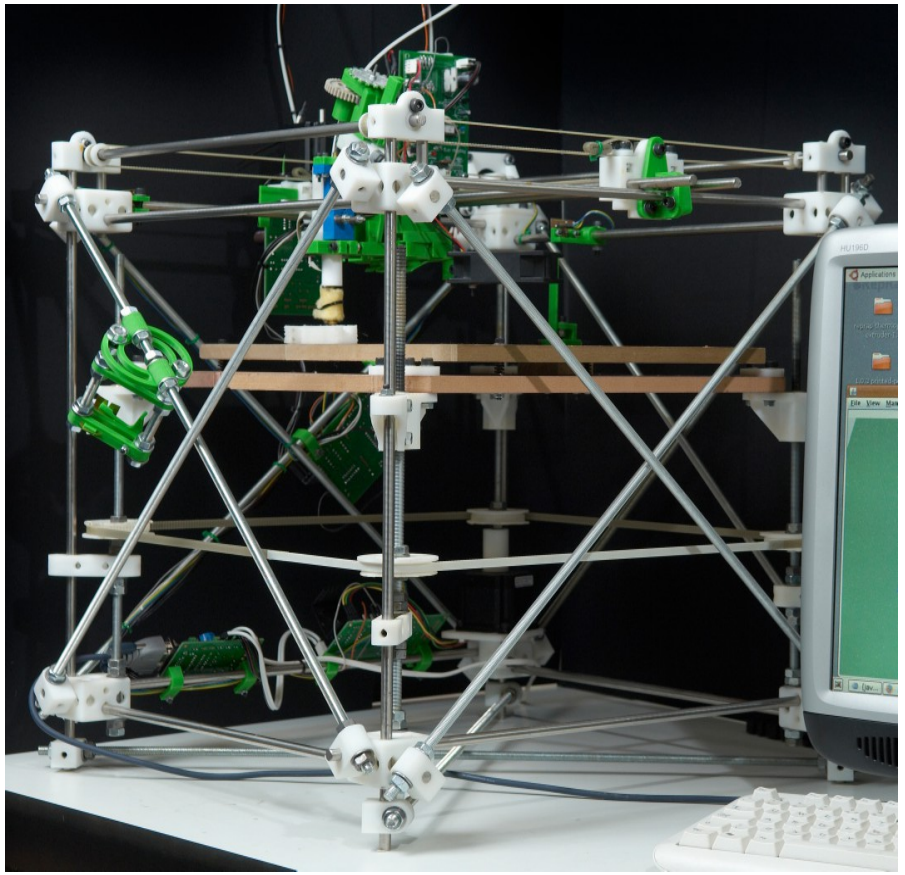
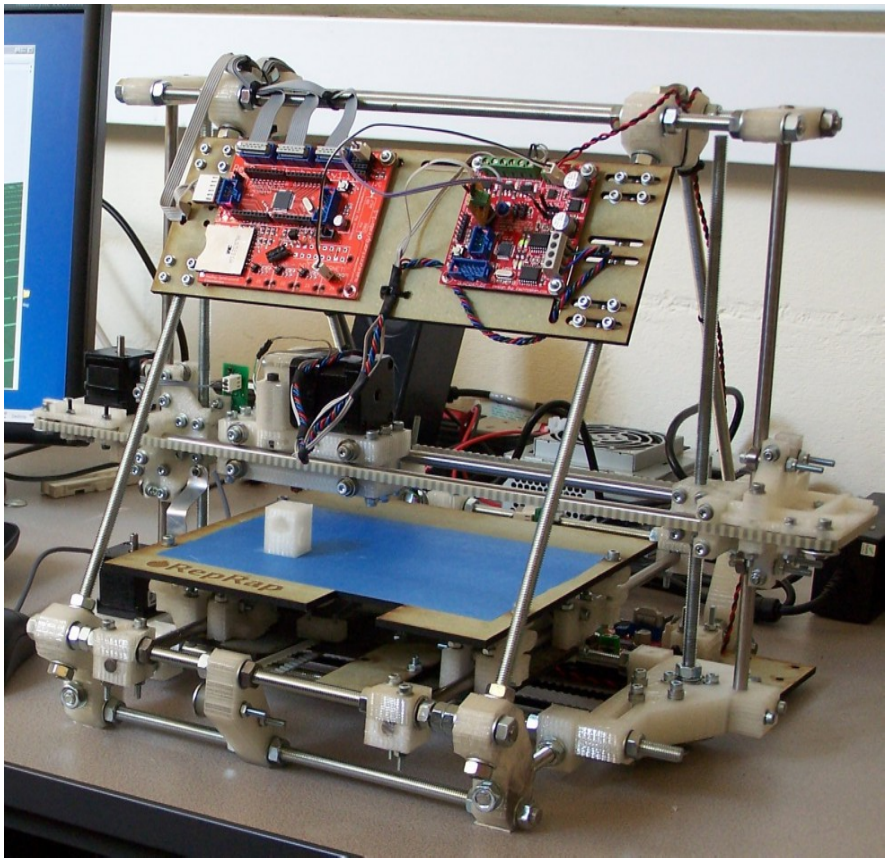
Reprap 3D Drucker

- Reprap Geschichte





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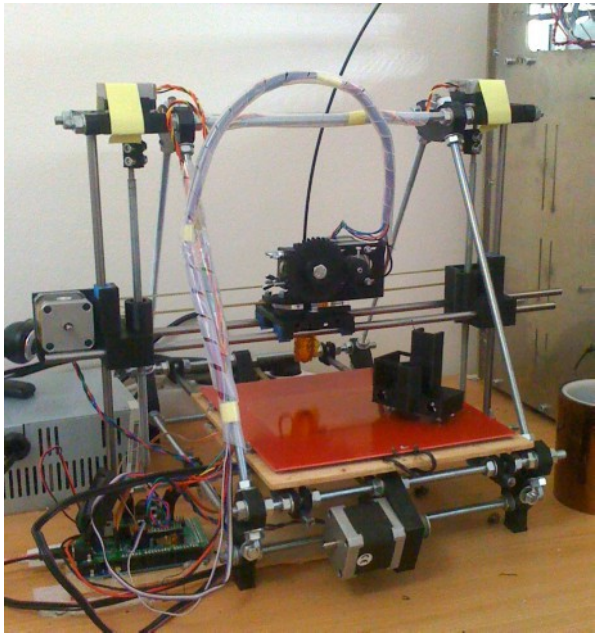
- Reprap Geschichte
  - 4. Oktober 2010 Prusa-Mendel (Josef Prusa)
  - 11. November 2011 Prusa-Mendel Iteration 2



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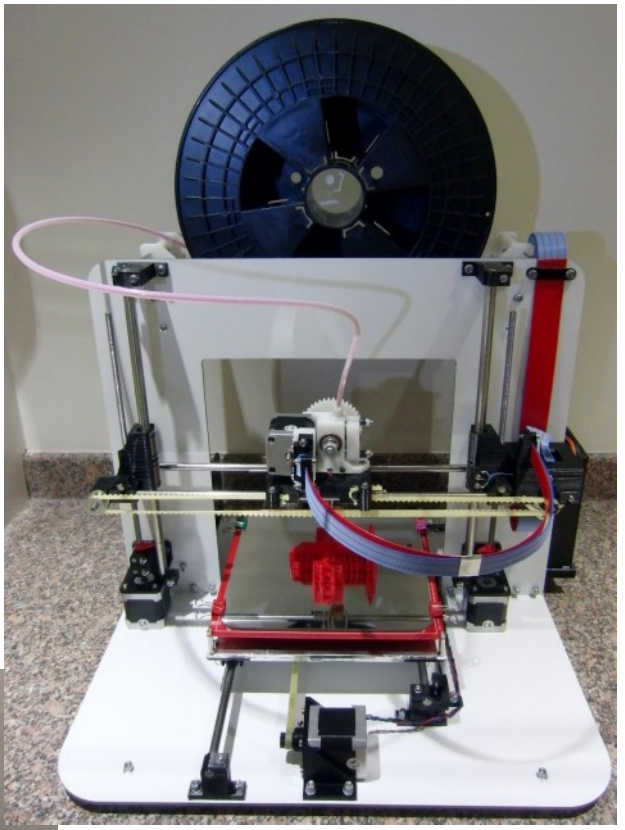
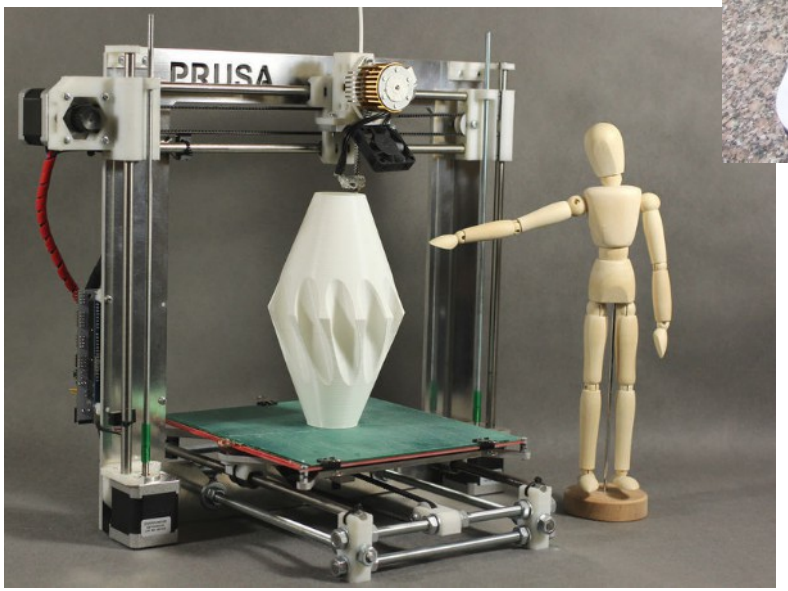
- Reprap Geschichte
  - 26. Juli 2012 Mendel90 (Chris Palmer)
  - 1. November 2012 Prusa I3





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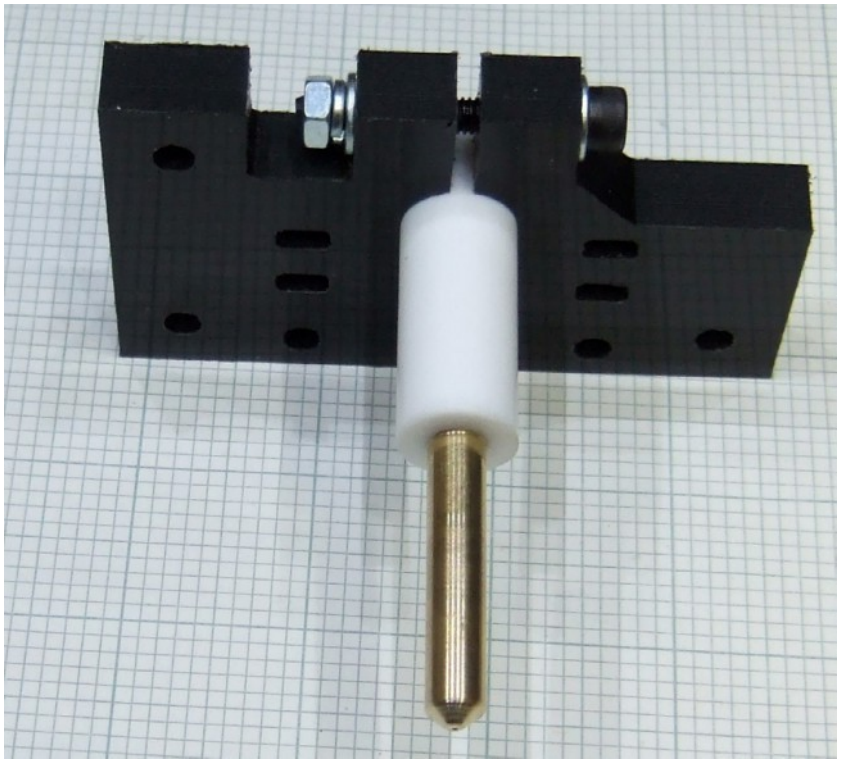
- Reprap Geschichte
  - Ein Hotend entsteht (Juli 2007)



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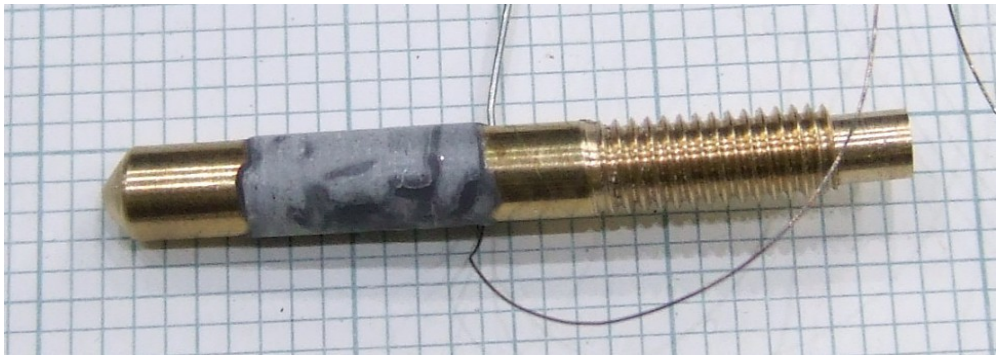

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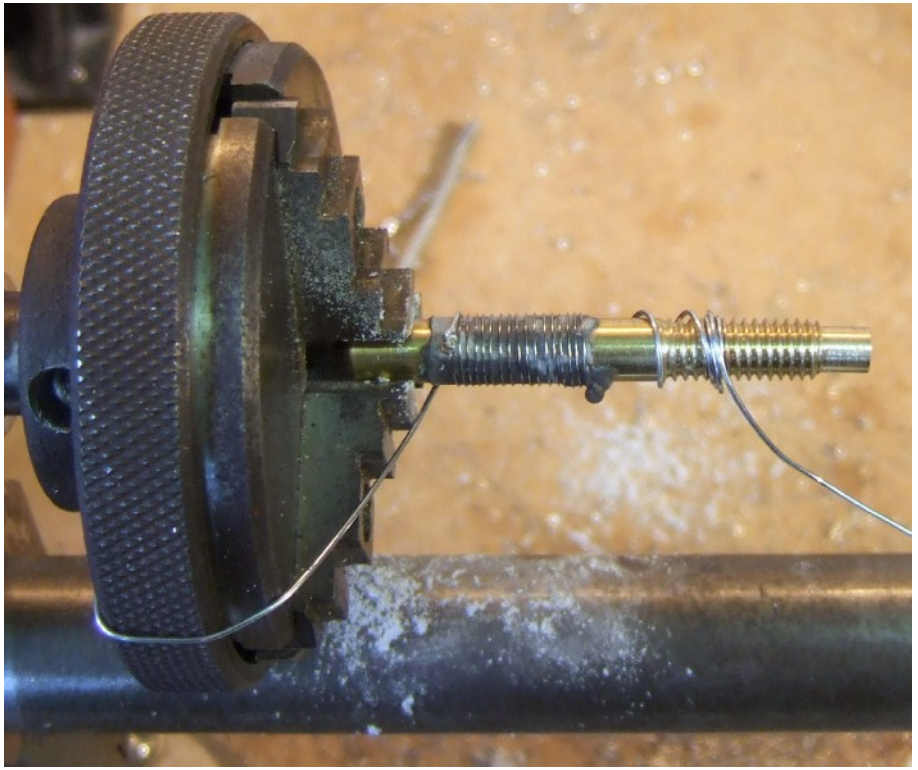
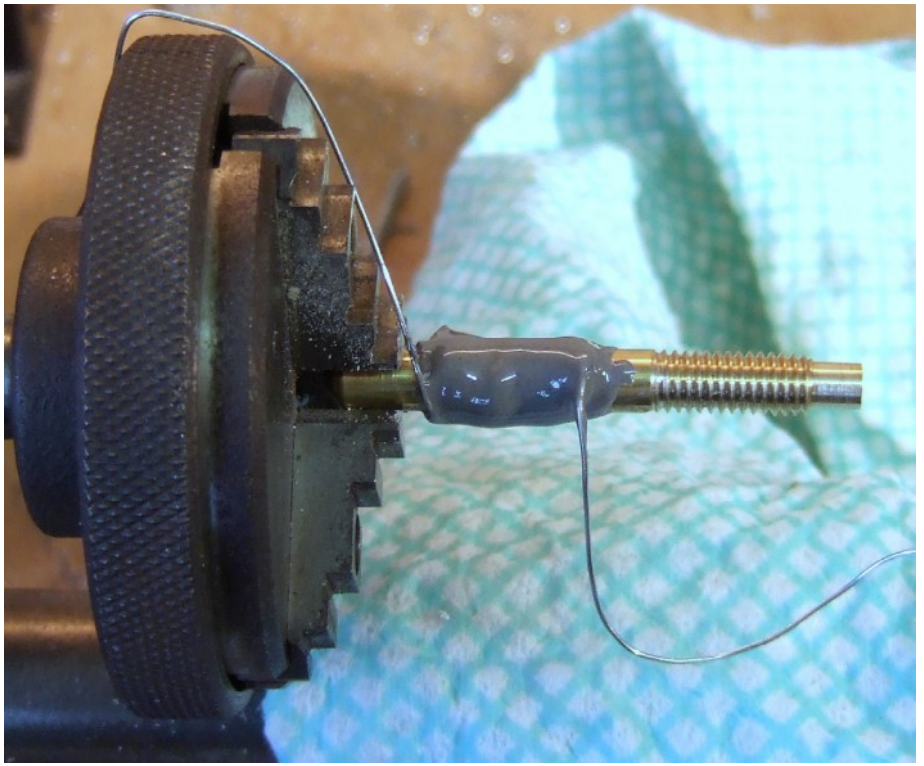
  - Ein Hotend entsteht (Juli 2007)





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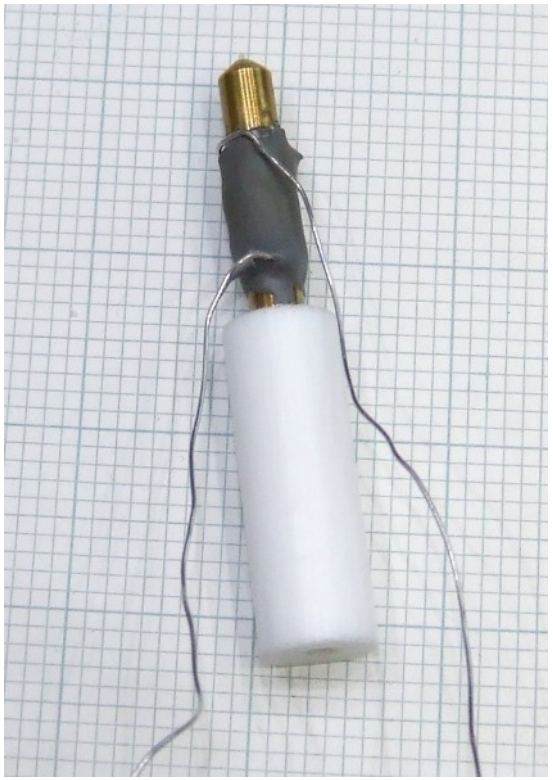
- Reprap Geschichte
  - Ein Hotend entsteht (Juli 2007)



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- Reprap Geschichte
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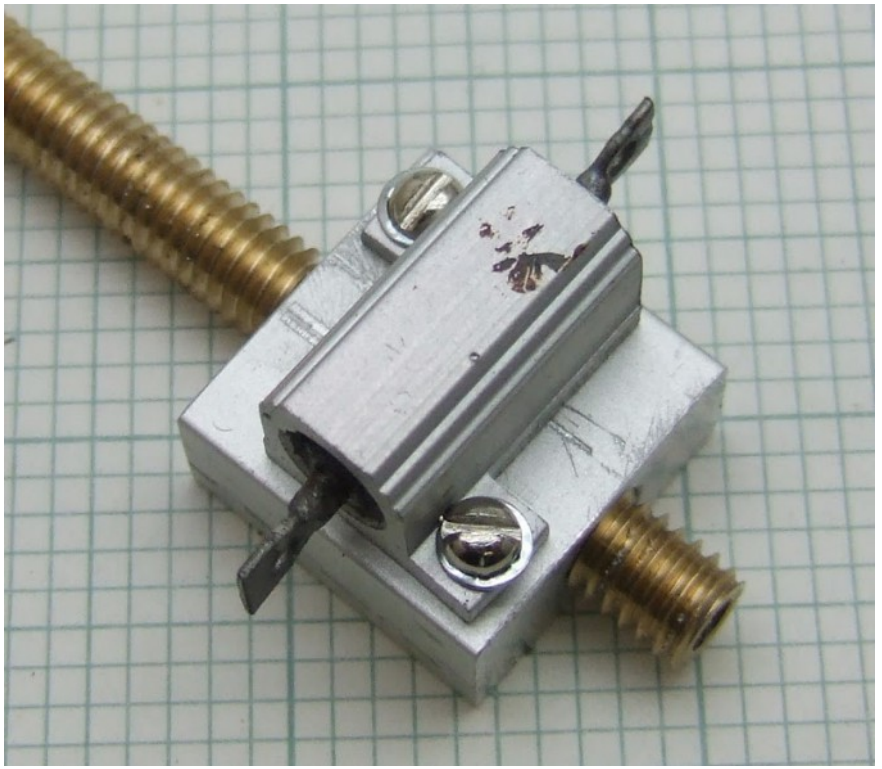

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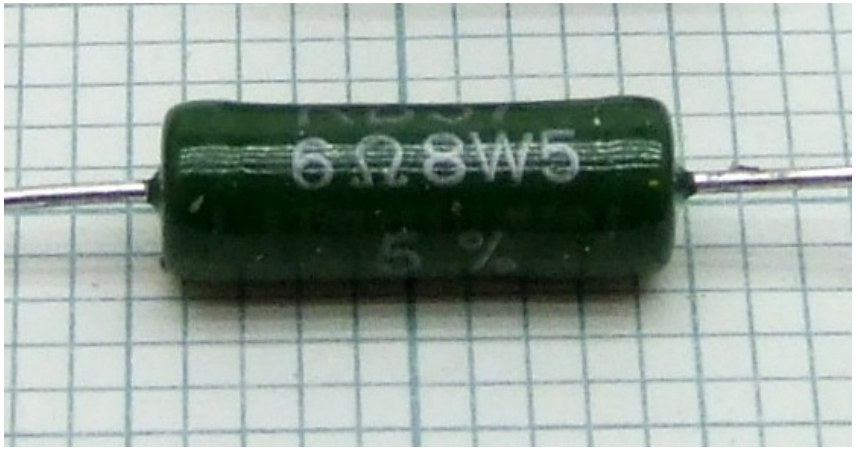
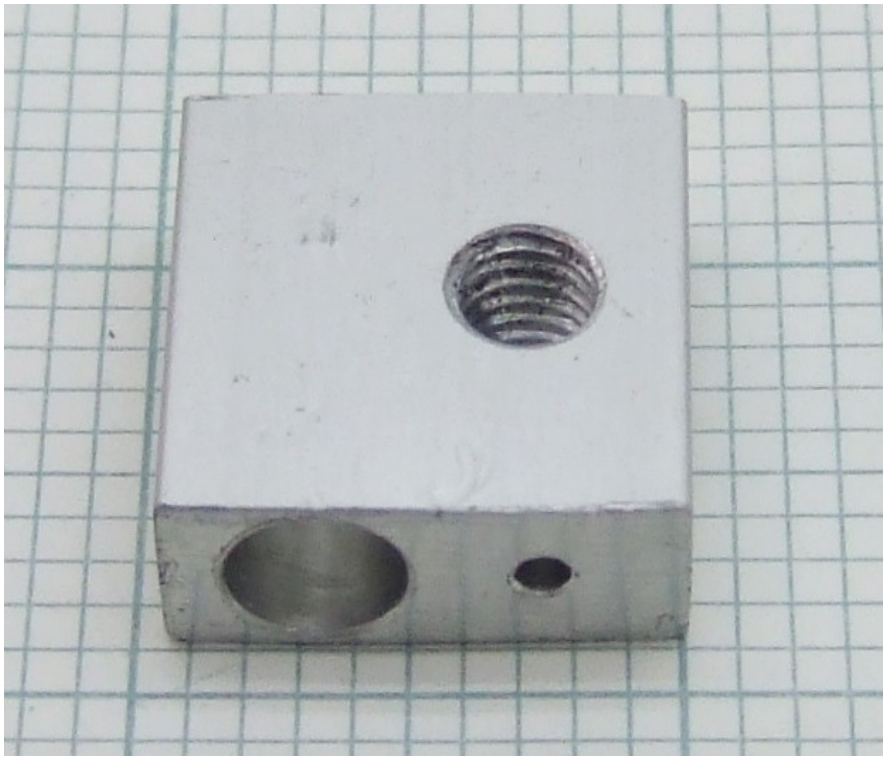
- Reprap Geschichte
  - Ein Hotend entsteht (Januar 2009)





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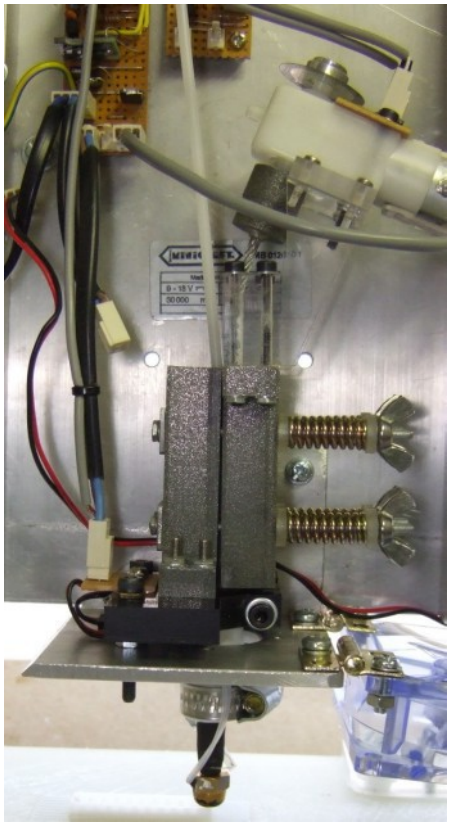
Reprap 3D Drucker

- Reprap Geschichte
  - Filament-Vorschub



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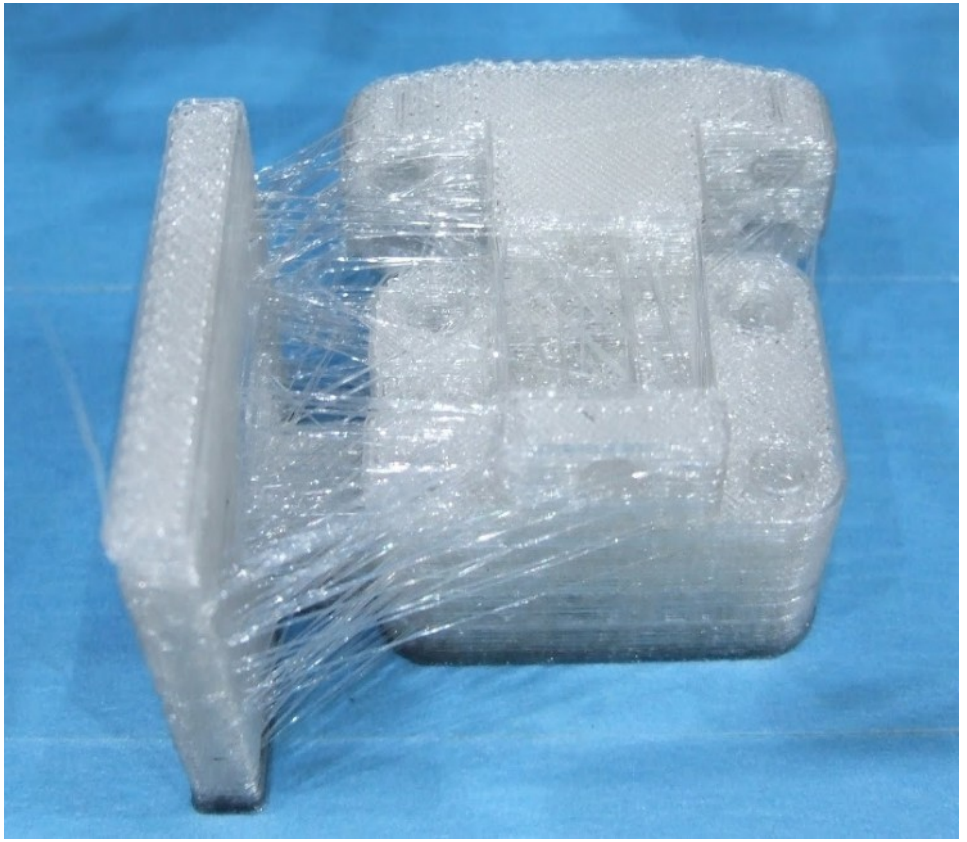
- Reprap Geschichte
  - Filament-Vorschub



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- Reprap Geschichte
  - Filament-Vorschub (März 2009)

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Reprap 3D Drucker

Vielen Dank für Ihre Aufmerksamkeit!

Besuchen Sie doch mal das OpenLab:

Jeden Mittwoch,
ab 18:00 Uhr,
Augsburg, Elisenstraße 1,
Innenhof

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http://airwolf3d.staging22.gigasavvy.net/wp-content/uploads/2012/08/3d-printer-hobbed-bolt1.jpg / mit freundlicher Genehmigung von airwolf3d.com

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