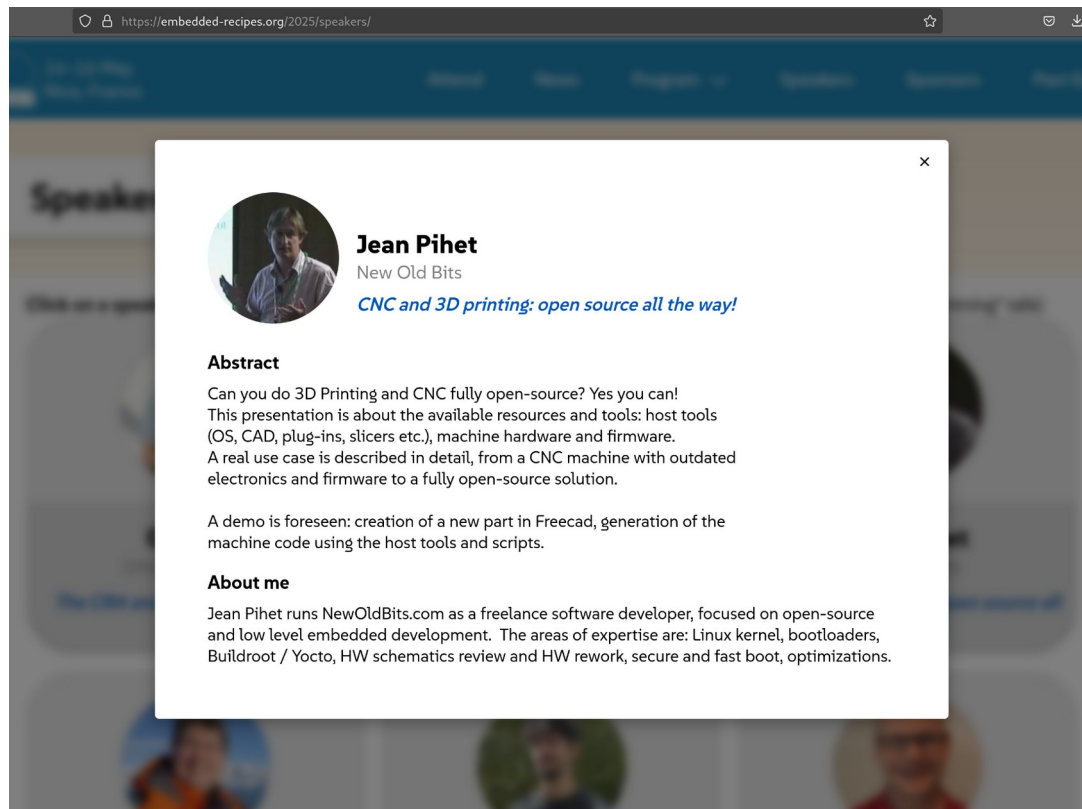


CNC and 3D printing: open source all the way!

- Introduction
- 3D printing
- CNC
- Host tools
 - Overview
 - FreeCAD
- Demo host tools for CNC
 - FreeCAD and scripts



https://embedded-recipes.org/2025/speakers/

Jean Pihet
New Old Bits
CNC and 3D printing: open source all the way!

Abstract
Can you do 3D Printing and CNC fully open-source? Yes you can!
This presentation is about the available resources and tools: host tools (OS, CAD, plug-ins, slicers etc.), machine hardware and firmware.
A real use case is described in detail, from a CNC machine with outdated electronics and firmware to a fully open-source solution.

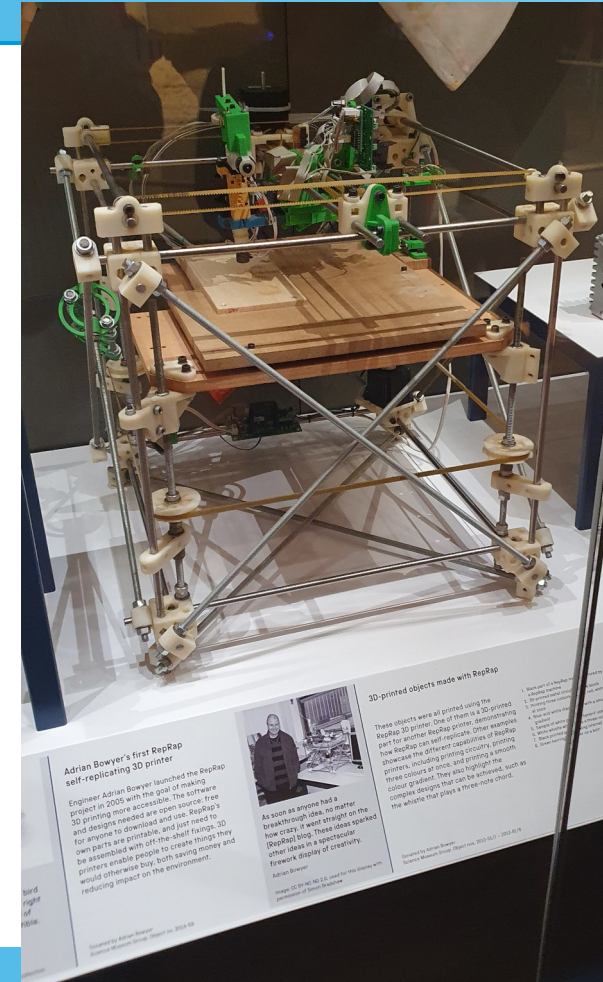
A demo is foreseen: creation of a new part in FreeCAD, generation of the machine code using the host tools and scripts.

About me
Jean Pihet runs NewOldBits.com as a freelance software developer, focused on open-source and low level embedded development. The areas of expertise are: Linux kernel, bootloaders, Buildroot / Yocto, HW schematics review and HW rework, secure and fast boot, optimizations.

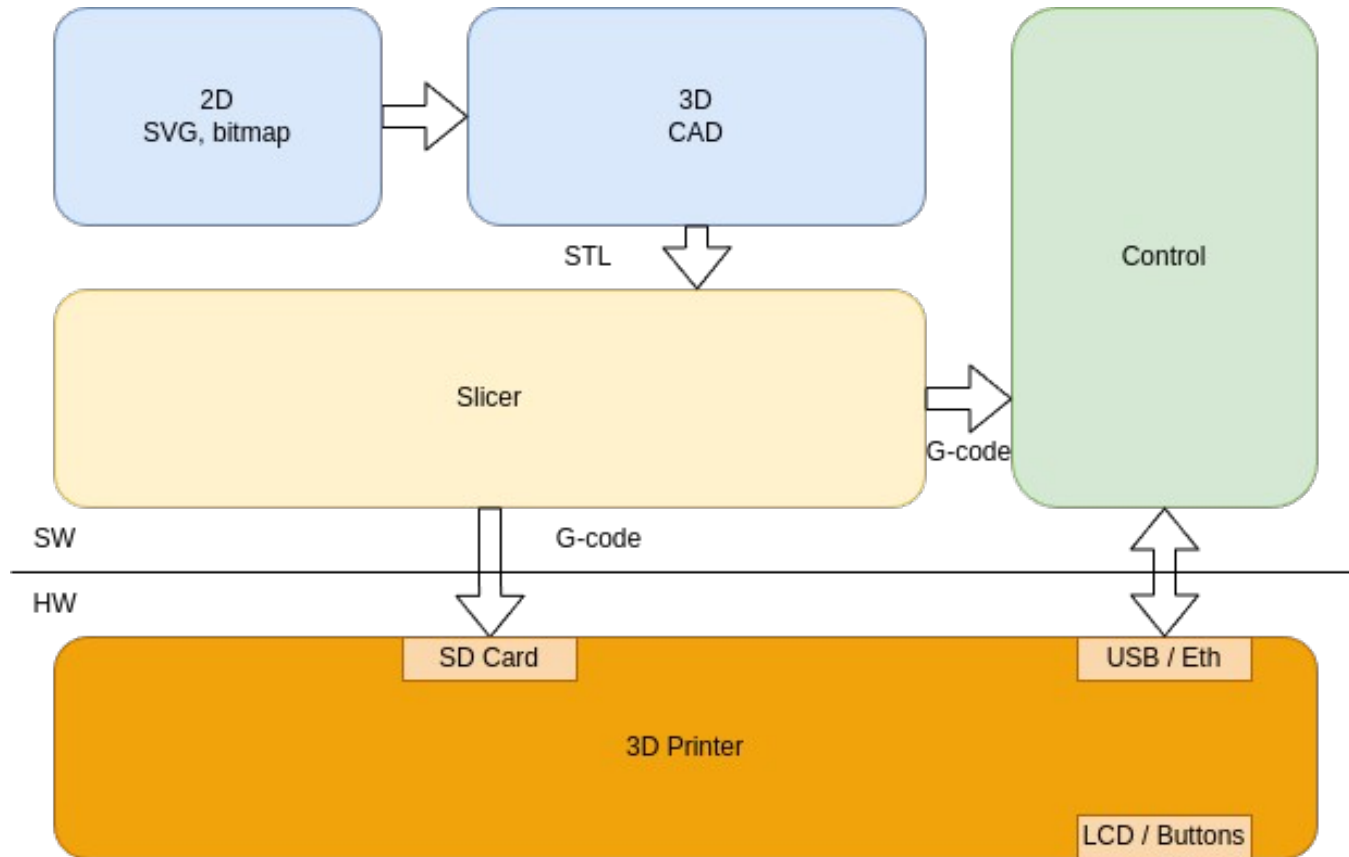
- Needs for 3D and CNC
 - FDM 3D printer, multi material, fast, 24/7
 - Light CNC: 3 axes, manual tool change and oiling
- Starting point
- Tools
- FreeCAD oriented

3D printing - History

- 2005 Reprap: self replicating
- 2010 1st Prusa Mendel
- 2011 Ultimaker
- 2011 Marlin FW
- 2015 Prusa i3, printing farm
- Open source
 - FW: Sprinter, grbl, Marlin. Klipper
 - Electronics & HW: main board, extruder, heat & level bed
 - Host tools: Slic3r, PrusaSlicer, Ultimaker Cura. OctoPrint
 - Models: Printables.com, Thingiverse

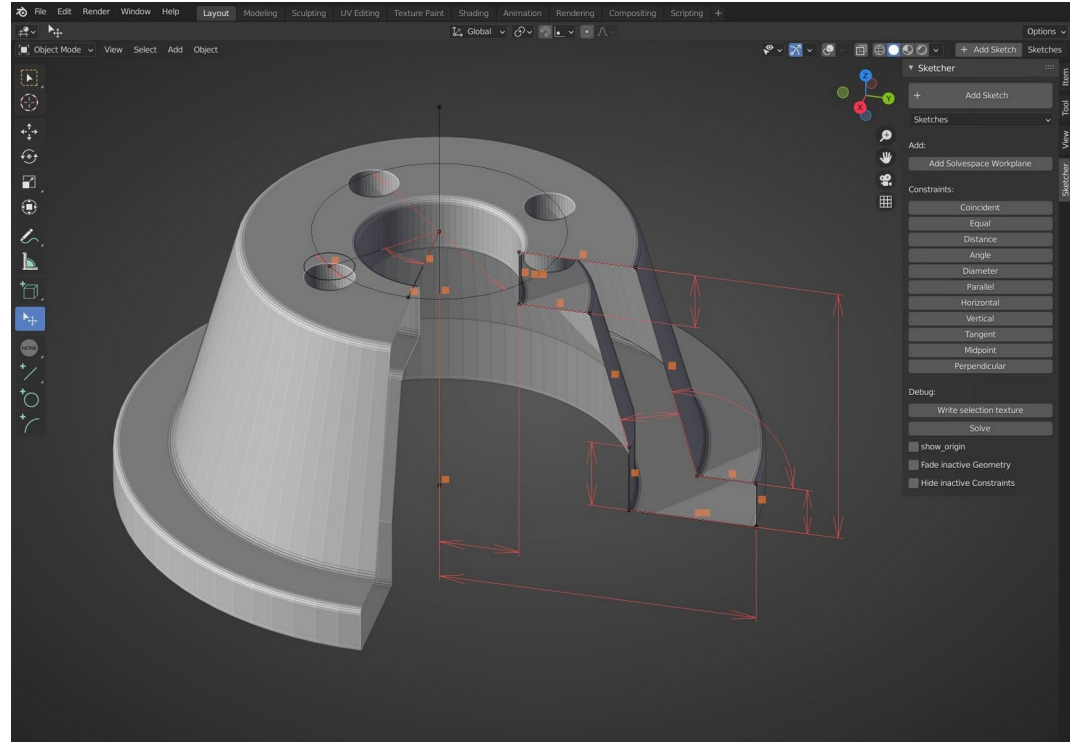


3D printing – Host tools



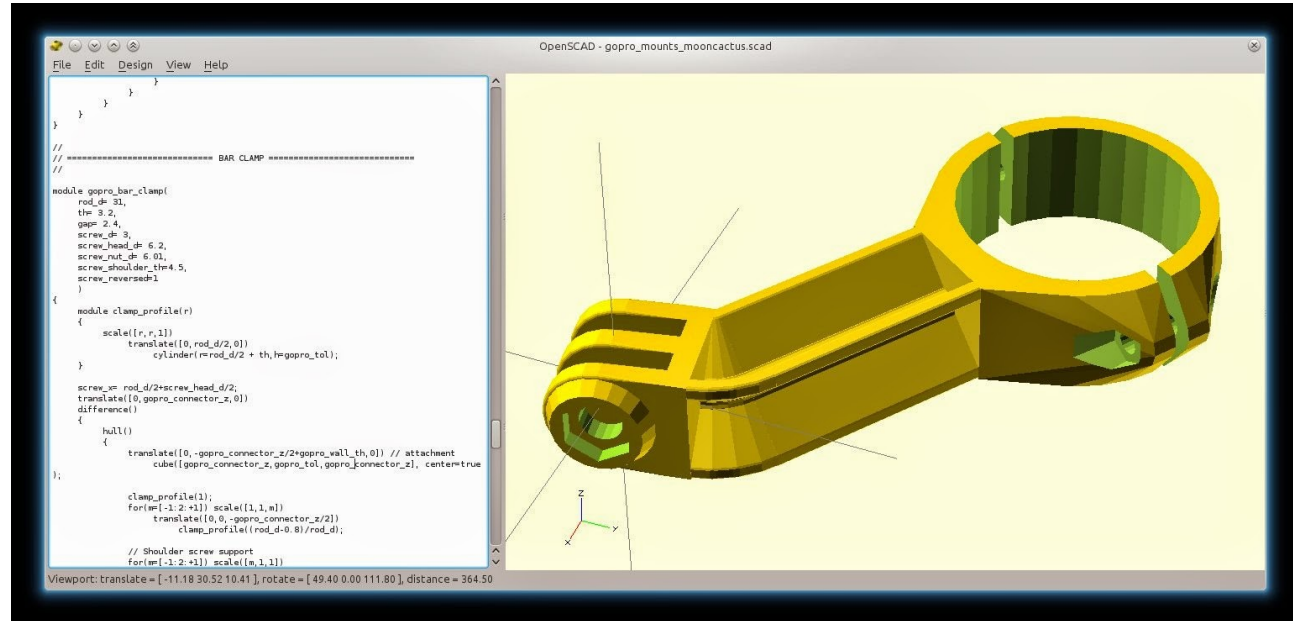
3D printing – Host tools

- 2D
 - Gimp, Inkscape: vectorize bitmap, drawing
- CAD: Blender
 - Originally for artwork and animation but useful for CAD
 - Lots of features
 - Destructive vs non-destructive modelling



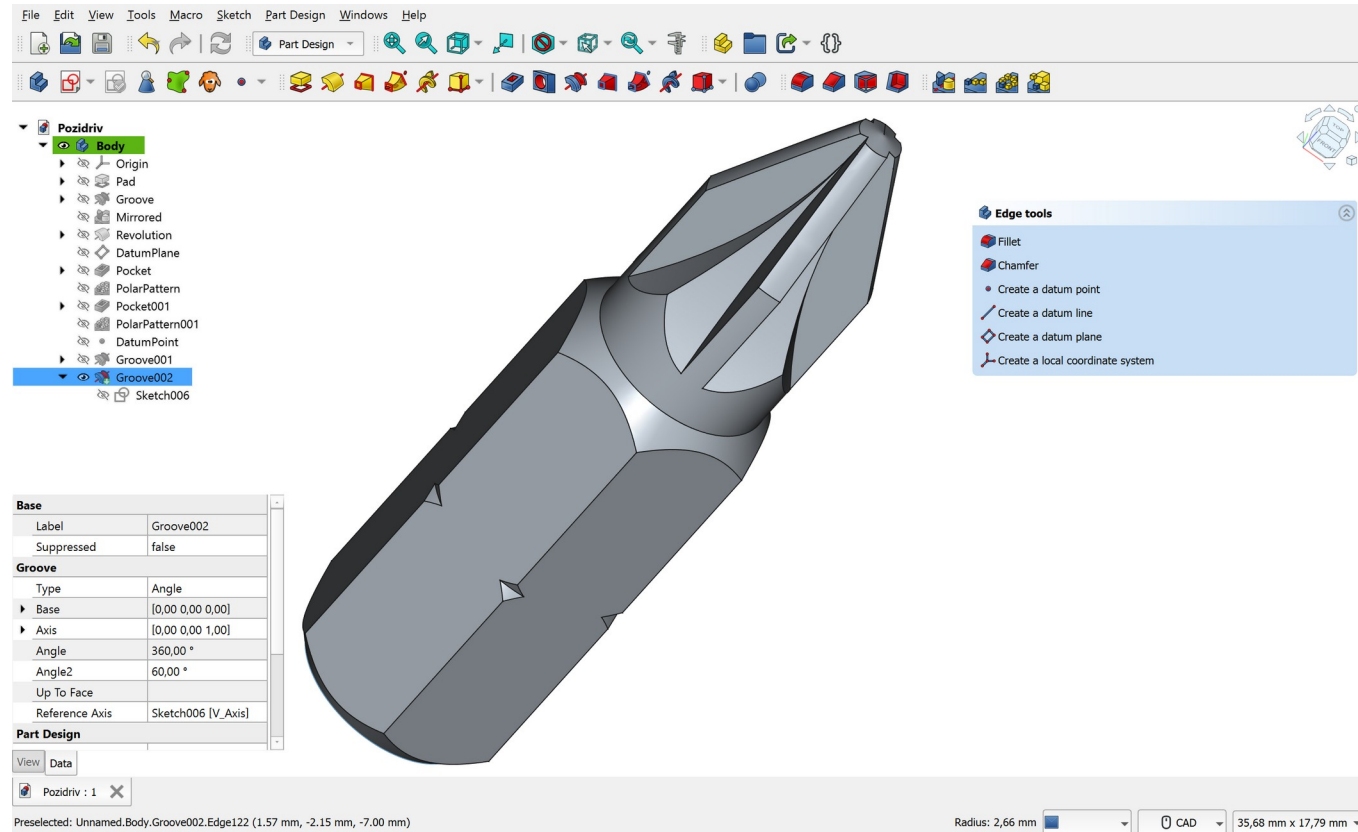
3D printing – Host tools

- CAD: OpenSCAD
 - script based
 - parametric
 - DXF, STL, OFF
 - Libraries available



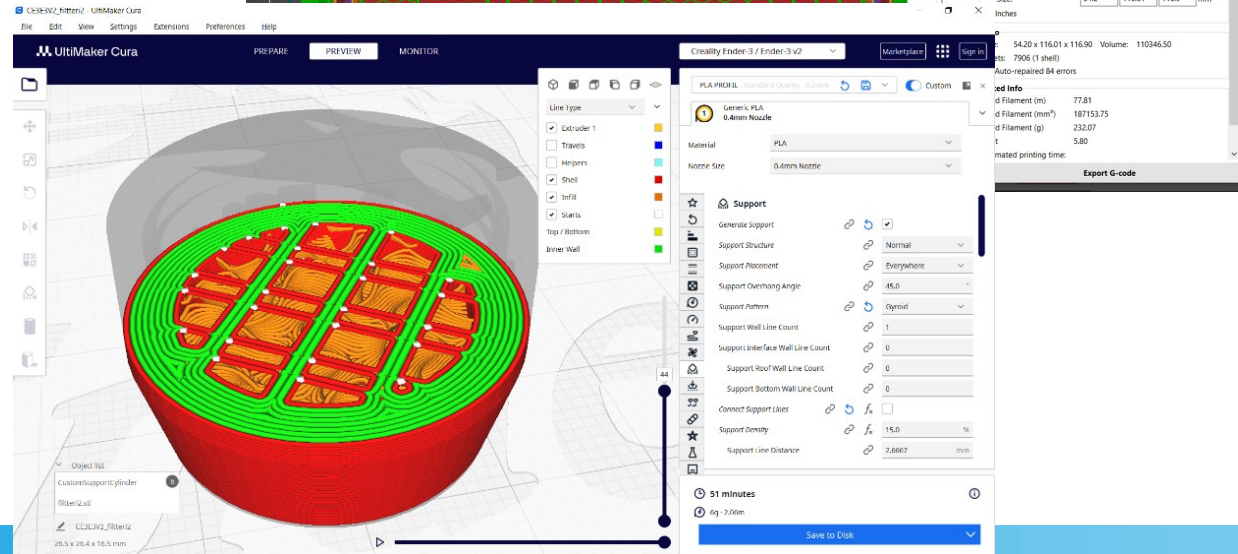
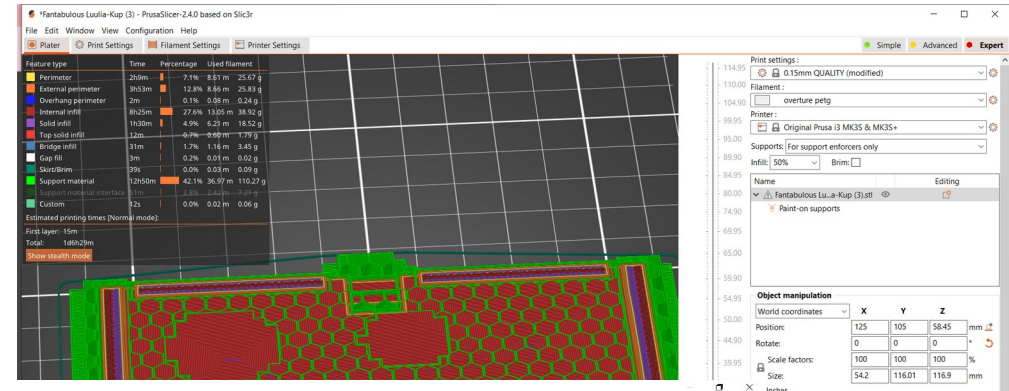
3D printing – Host tools

- CAD: FreeCAD
 - One-stop shop
 - Modules
 - Sketch
 - Model
 - Part
 - Assembly
 - CAM (→ CNC)
 - Workbench
 - Python API
 - Mature 0.19 - 1.0



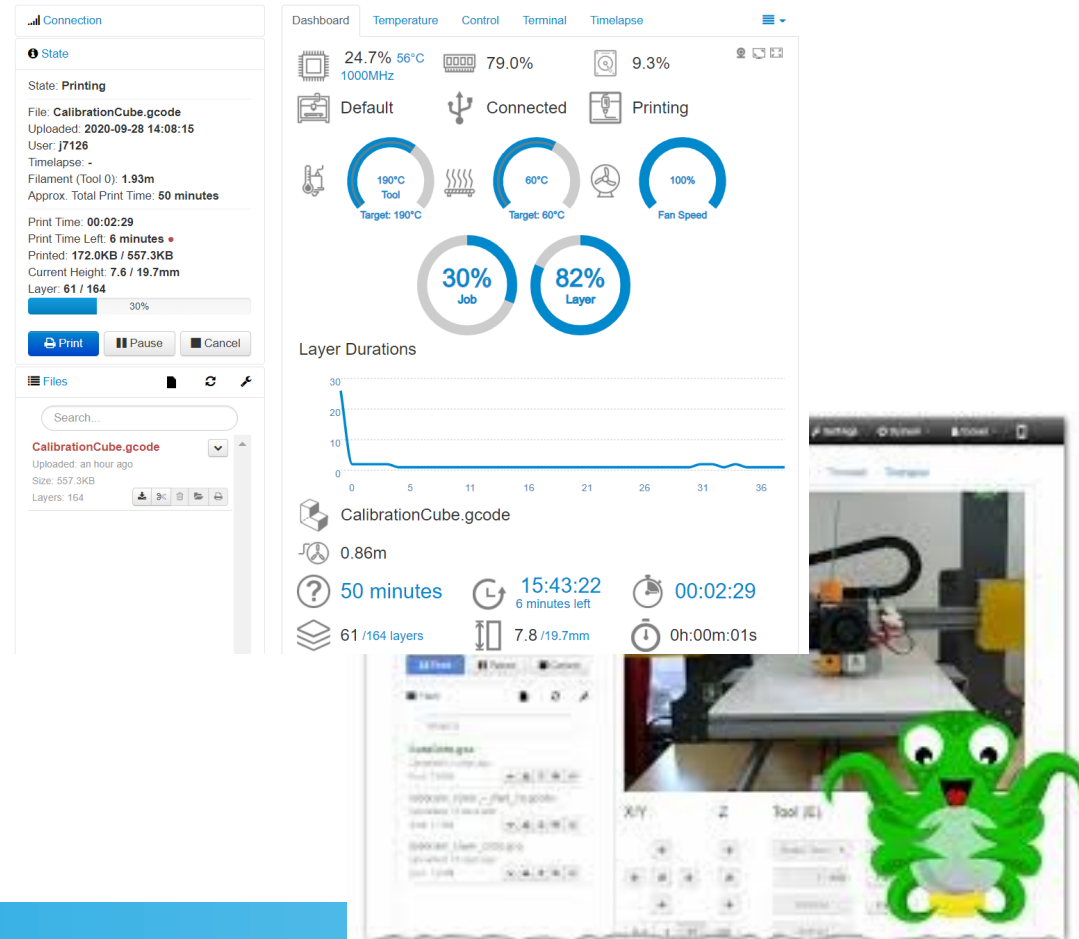
3D printing – Host tools

- Slicer: 3D → G-code
 - PrusaSlicer
 - Ultimaker Cura
 - Exotic slicers: S4_slicer, Infinite Z



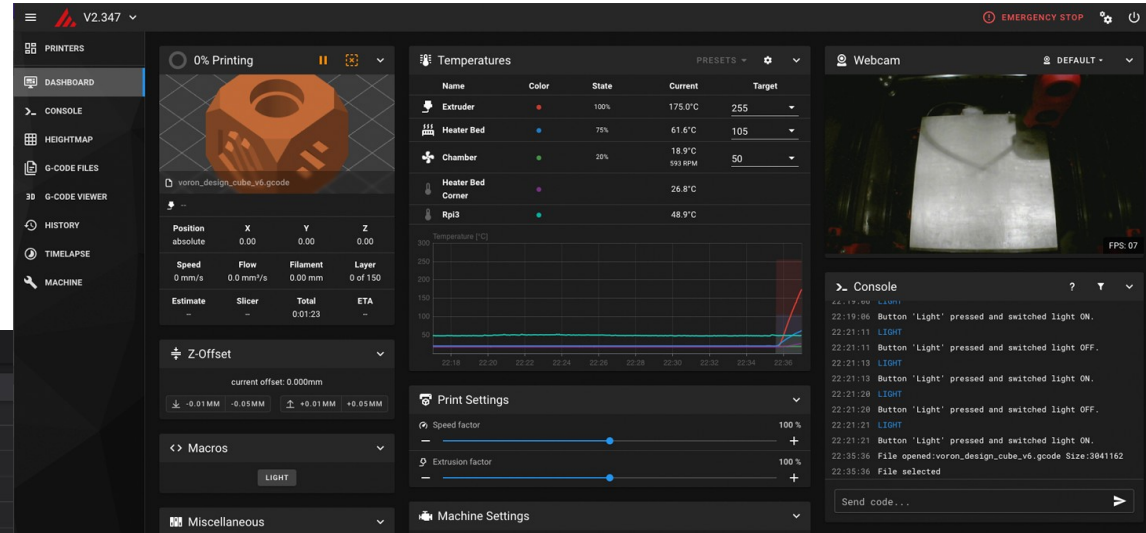
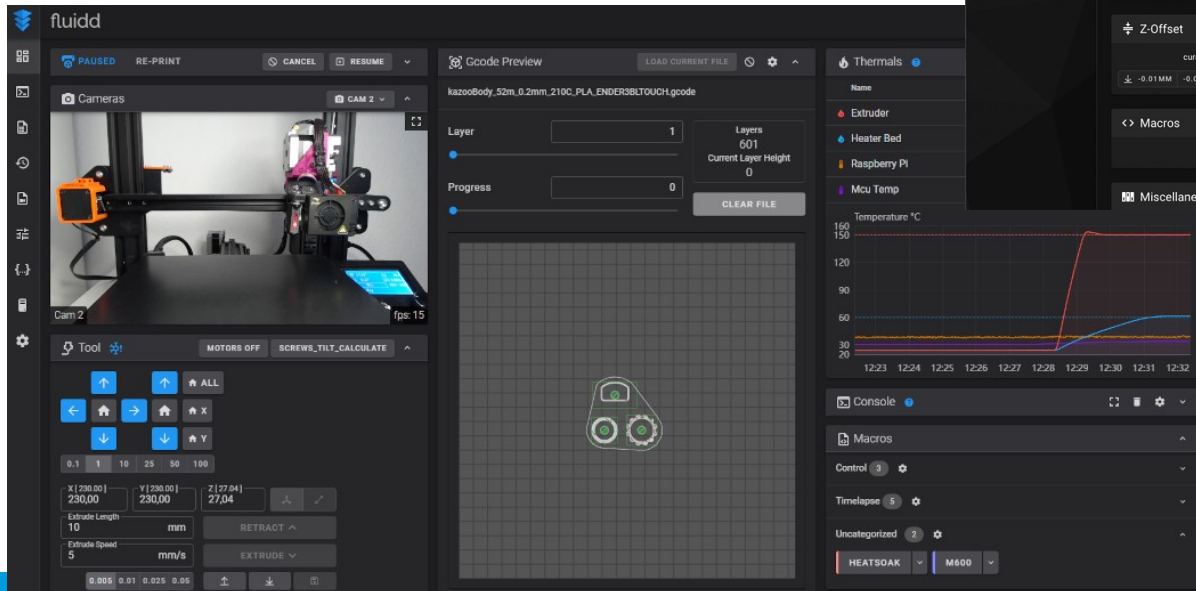
3D printing – Host tools

- Control
 - Setup and maintenance
 - Monitoring, logging
 - Image and videos, timelapse
 - Advanced features via plug-ins
 - Web server, manage files
- Firmware / Control
 - Marlin / OctoPrint



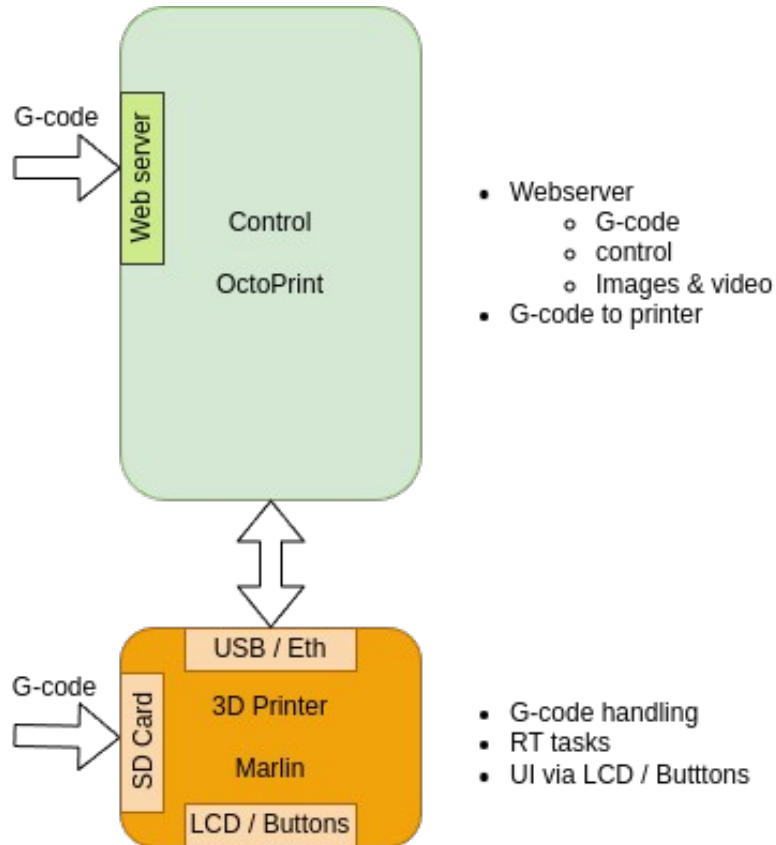
3D printing – Host tools

- Control
 - Firmware / Control
 - Klipper / Mainsail - Fluidt

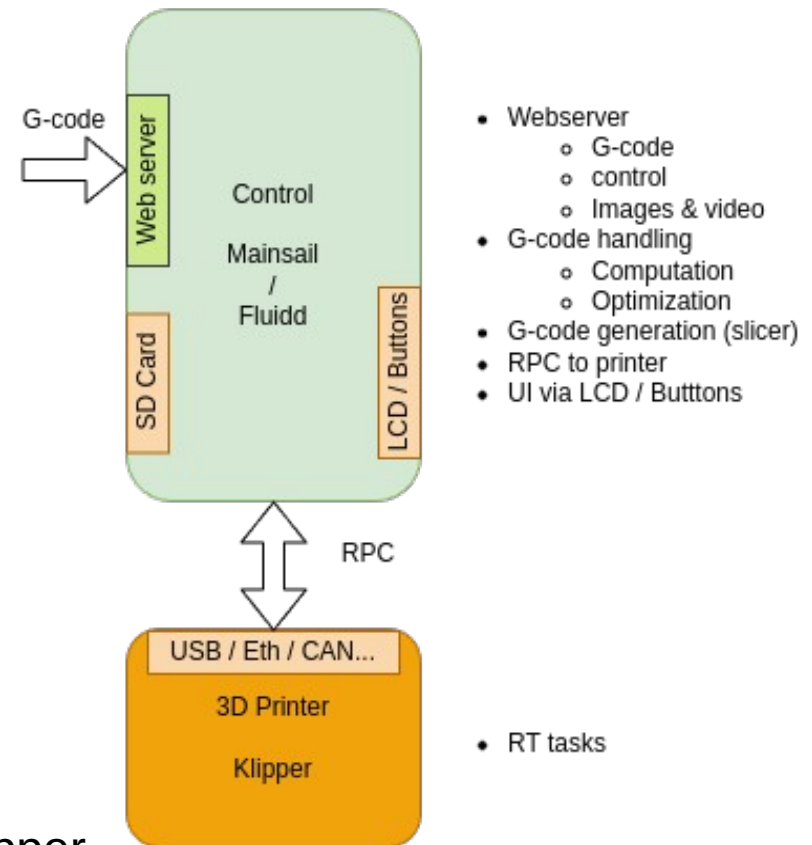


- Marlin
 - G-code handling: perform computation, run UI & RT tasks
 - Simple to configure (.h), build and install
 - Well supported
- Klipper
 - Separates computation and UI (RPI) from RT tasks (printer board)
 - Requires RPI
 - More efficient: faster, precise
 - More advanced features, multi-printer
 - Easy to configure without re-install

3D printing – Firmware



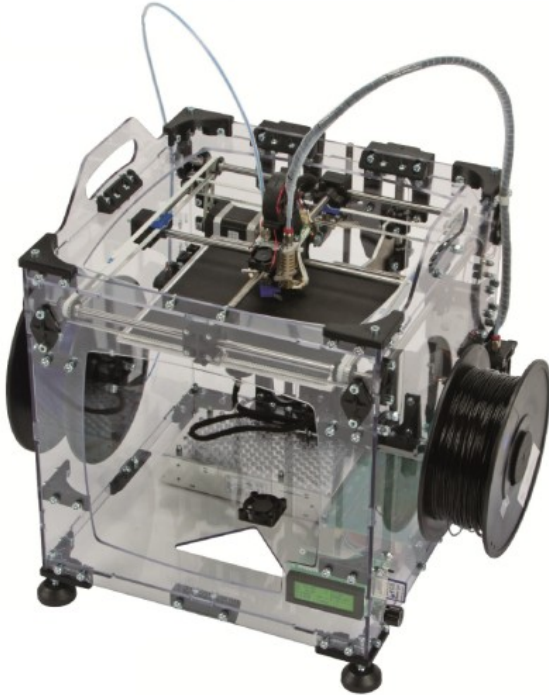
Marlin



Klipper

3D printing – Machine

- Lots of 'open-source' printers
- Velleman K8400

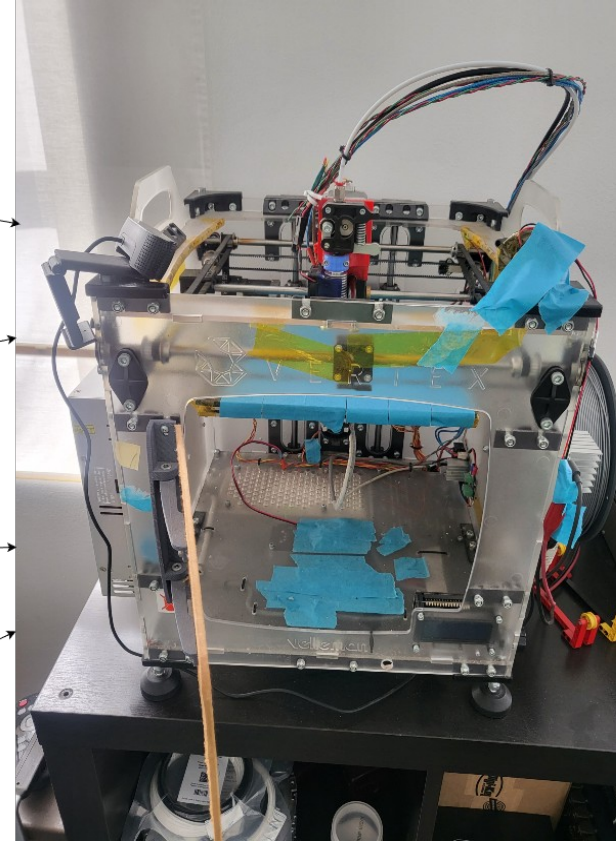


Re-designed head
- E3Dv6
- On-board extruder motor
- High-perf heater
- Thermocouple

Camera

Highly optimized heat flow

4 power supplies



Bed fan

Heated bed
24V

Optimized Z axis

RPI / OctoPrint

3D printing – Machine

- Hacked for:
 - Robustness
 - Print speed
 - Print size
 - High Temp, multi mat.
 - Better control, remote
- Patch on Marlin
 - 40 LOC ;-)

```
//if the machine is idle, and the temperature over MINTEMP, ever
y couple of SECONDS some filament is extruded
//#define EXTRUDER_RUNOUT_PREVENT
#define EXTRUDER_RUNOUT_MINTEMP 190
#define EXTRUDER_RUNOUT_SECONDS 30.
#define EXTRUDER_RUNOUT_ESTEPS 14. //mm filament
#define EXTRUDER_RUNOUT_SPEED 1500. //extrusion speed
#define EXTRUDER_RUNOUT_EXTRUDE 100

//These defines help to calibrate the AD595 sensor in case you g
et wrong temperature measurements.
//The measured temperature is defined as "actualTemp = (measured
Temp * TEMP_SENSOR_AD595_GAIN) + TEMP_SENSOR_AD595_OFFSET"
//JPI Measured on-board and interpolated. Note: the board runs o
n 4.2V
// instead of 5V so the ADC ref is wrong
#define TEMP_SENSOR_AD595_OFFSET (-0.2707)
#define TEMP_SENSOR_AD595_GAIN (0.8428)

//This is for controlling a fan to cool down the stepper drivers
//it will turn on when any driver is enabled
//and turn off after the set amount of seconds from last driver
being disabled again
#define CONTROLLERFAN_PIN 2 //Pin used for the fan to cool contr
oller (-1 to disable)
#define CONTROLLERFAN_SECS 60 //How many seconds, after all moto
rs were disabled, the fan should run
#define CONTROLLERFAN_SPEED 255 // == full speed

// When first starting the main fan, run it at full speed for the
e
// given number of milliseconds. This gets the fan spinning rel
iably
// before setting a PWM value. (Does not work with software PWM
for fan on Sanguinololu)
//#define FAN_KICKSTART_TIME 100

// Extruder cooling fans
// Configure fan pin outputs to automatically turn on/off when t
he associated
@@@

// Temperature sensor settings:
// -2 is thermocouple with MAX6675 (only for sensor 0)
// -1 is thermocouple with AD595
// 0 is not used
// 1 is 100k thermistor - best choice for EPCOS 100k (4.7k pull
up)
// 2 is 200k thermistor - ATC Semitec 204GT-2 (4.7k pullup)
// 3 is Mendel-parts thermistor (4.7k pullup)
// 4 is 10k thermistor !! do not use it for a hotend. It gives
bad resolution at high temp. !!
// 5 is 100k thermistor - ATC Semitec 104GT-2 (Used in ParCan &
J-Head) (4.7k pullup)
// 6 is 100k EPCOS - Not as accurate as table 1 (created using
a fluke thermocouple) (4.7k pullup)
// 7 is 100k Honeywell thermistor 135-104LAG-J01 (4.7k pullup)
// 71 is 100k Honeywell thermistor 135-104LAF-J01 (4.7k pullup)
// 8 is 100k 0603 SMD Vishay NTC50603E3104FXT (4.7k pullup)
// 9 is 100k GE Sensing AL03006-58.2K-97-G1 (4.7k pullup)
// 10 is 100k RS thermistor 198-961 (4.7k pullup)
// 11 is 100k beta 3950 1% thermistor (4.7k pullup)
// 12 is 100k 0603 SMD Vishay NTC50603E3104FXT (4.7k pullup) (c
alibrated for Makibox hot bed)
// 20 is the PT100 circuit found in the Ultimainboard V2.x
// 60 is 100k Maker's Tool Works Kapton Bed Thermistor beta=395
0
//
// 1k ohm pullup tables - This is not normal, you would have
to have changed out your 4.7k for 1k
// (but gives greater accuracy and mor
e stable PID)
// 51 is 100k thermistor - EPCOS (1k pullup)
// 52 is 200k thermistor - ATC Semitec 204GT-2 (1k pullup)
// 55 is 100k thermistor - ATC Semitec 104GT-2 (Used in ParCan
& J-Head) (1k pullup)
//
// 1047 is Pt1000 with 4k7 pullup
// 1010 is Pt1000 with 1k pullup (non standard)
// 147 is Pt100 with 4k7 pullup
// 110 is Pt100 with 1k pullup (non standard)

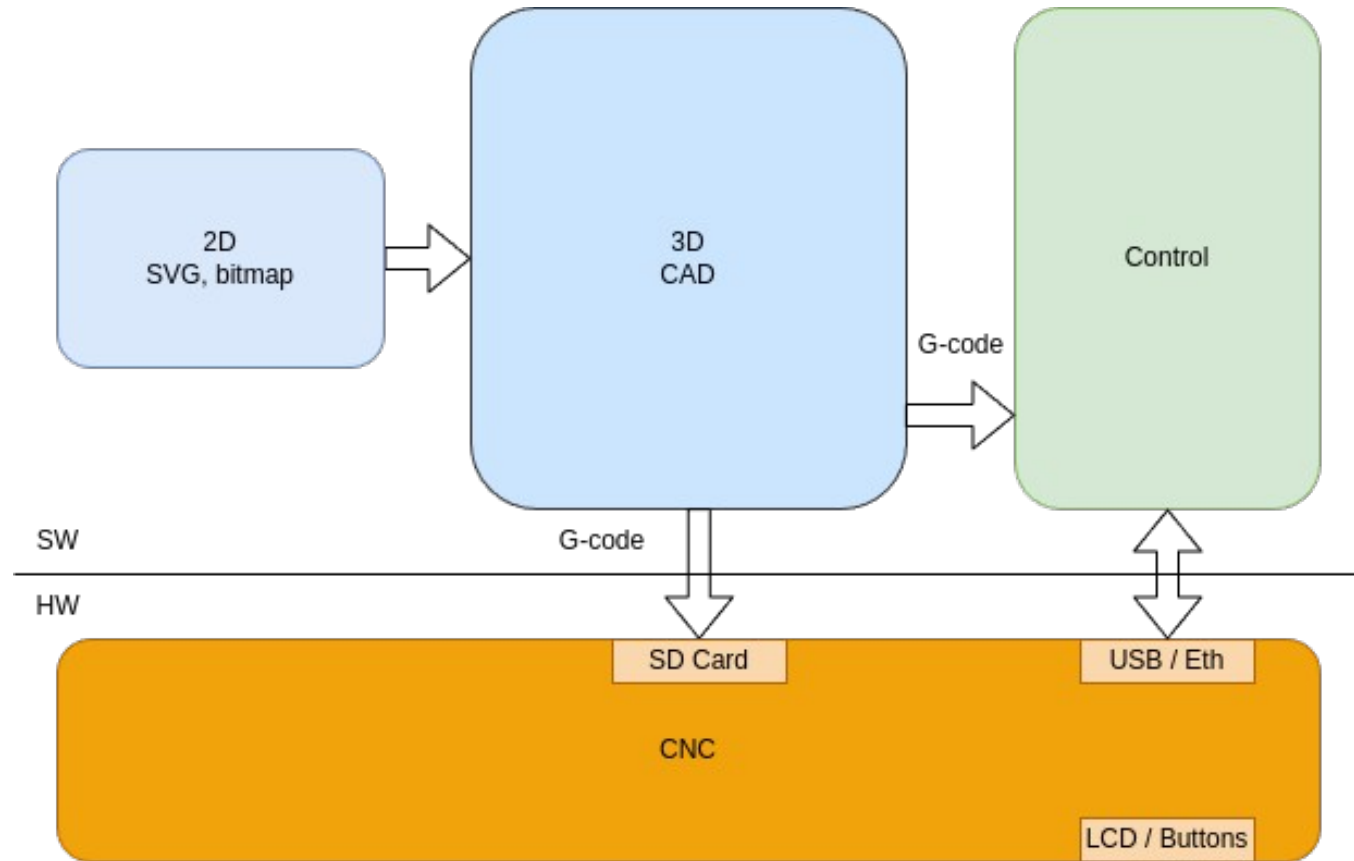
#define TEMP_SENSOR_0 -1
```

Differs from 3D Printing

- Less common
- Host tools CNC / CAM
- 'Slicer'
- Interaction with model
- Start reference point

Similar to 3D Printing

- G-code export
- Control



CNC – Host tools

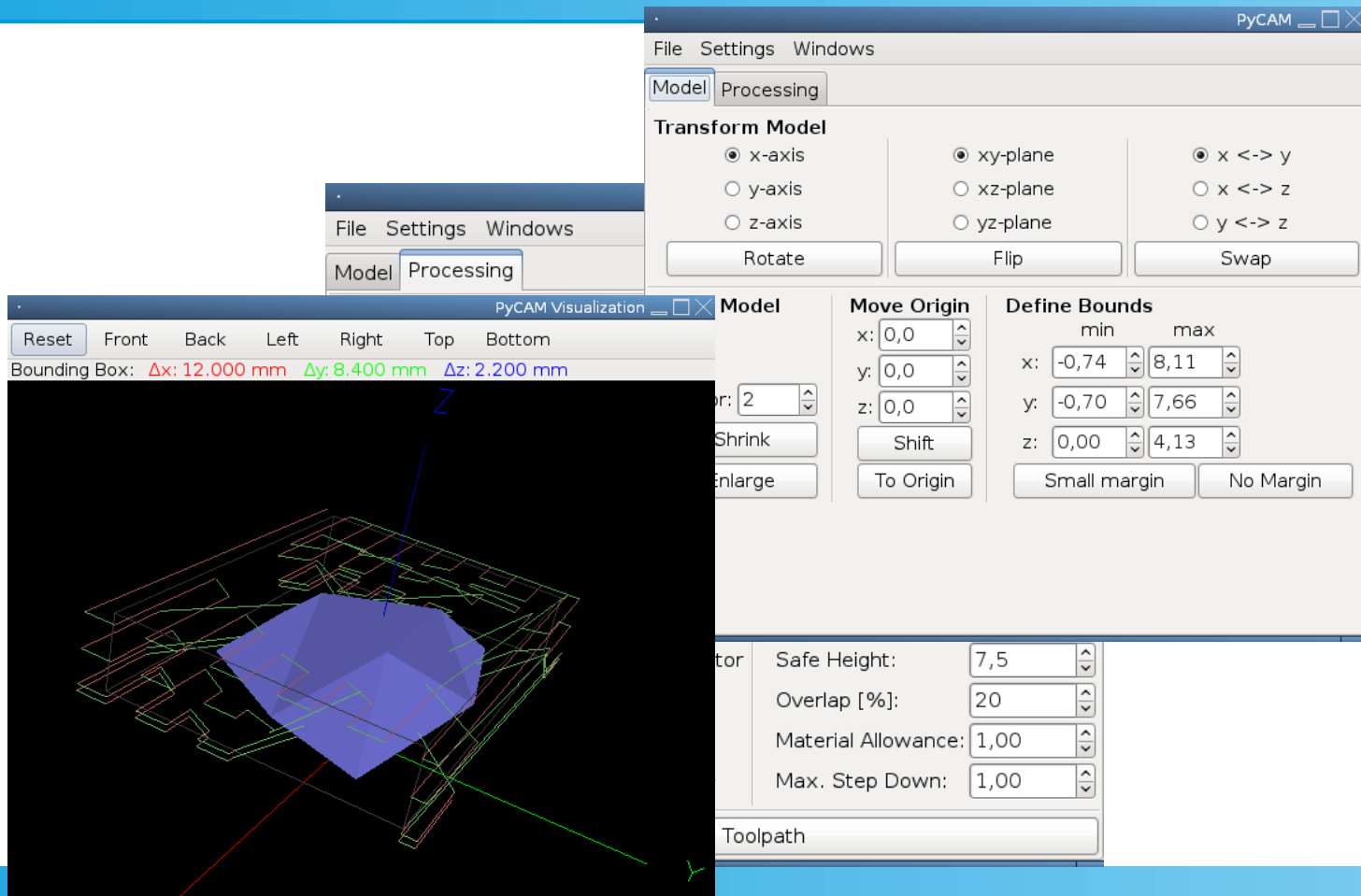
PyCAM

- Python app
- Basic CNC, text...
- Not maintained

Linux CNC dist.

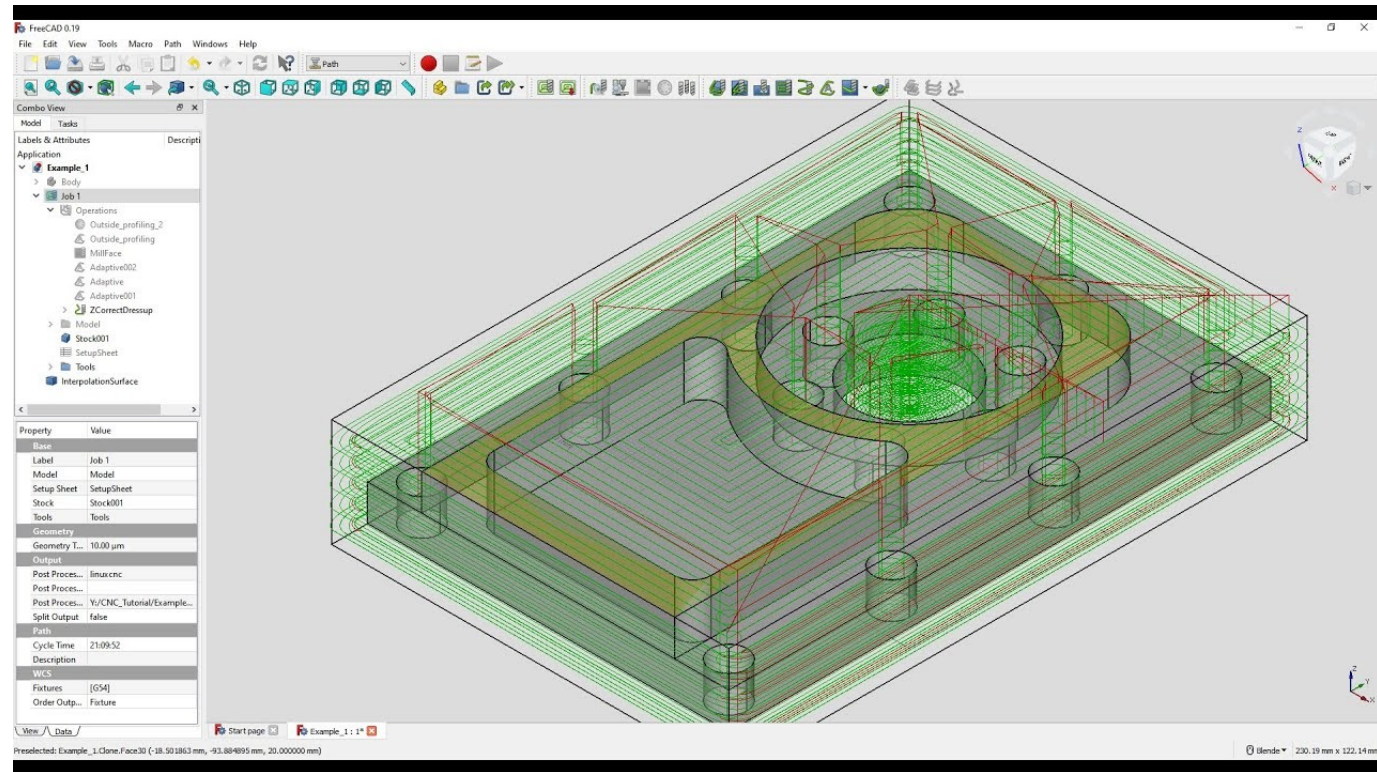
CNC Toolkit

- Multi axis



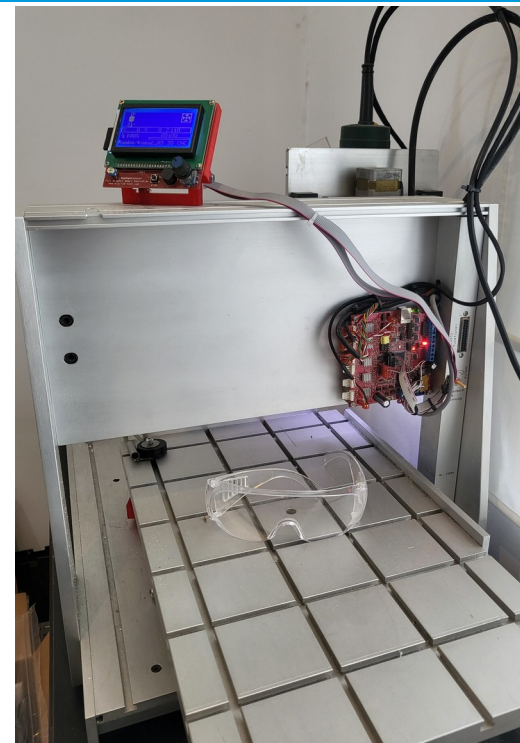
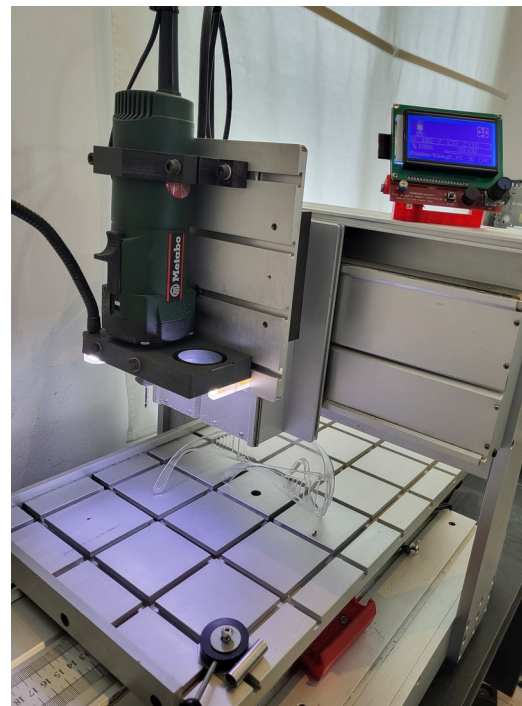
FreeCAD

- One-stop shop
- CAM module
 - Profile / Contour
 - Drilling
 - Engraving
- Highly configurable
- Python scripting
- Mature



Kosy A3

- ~1992
- Robust HW & Electronics
 - Stepper motors, end stops
 - Power supply 24V
- Outdated mainboard, firmware
 - Non standard protocol
- Limited host tools
 - not open-source / free
 - OS



CNC – Machine

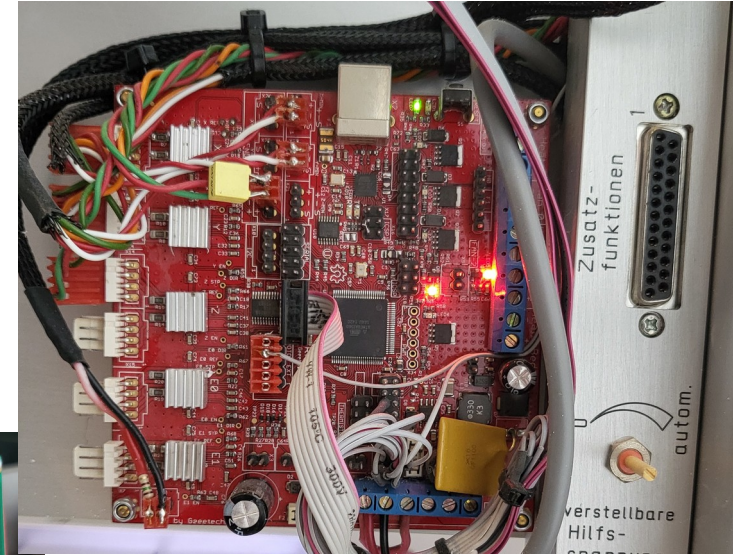
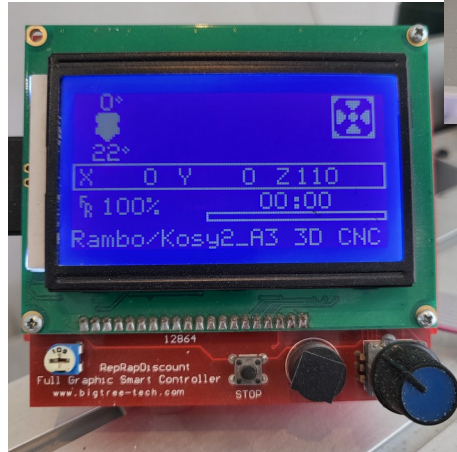
Solution

- Leverage HW & Electronics
- Leverage 3D Printing HW & firmware

Rambo board

- 24V
- Reprap / Arduino / Marlin
- USB

Reprap LCD / SD Card / Buttons

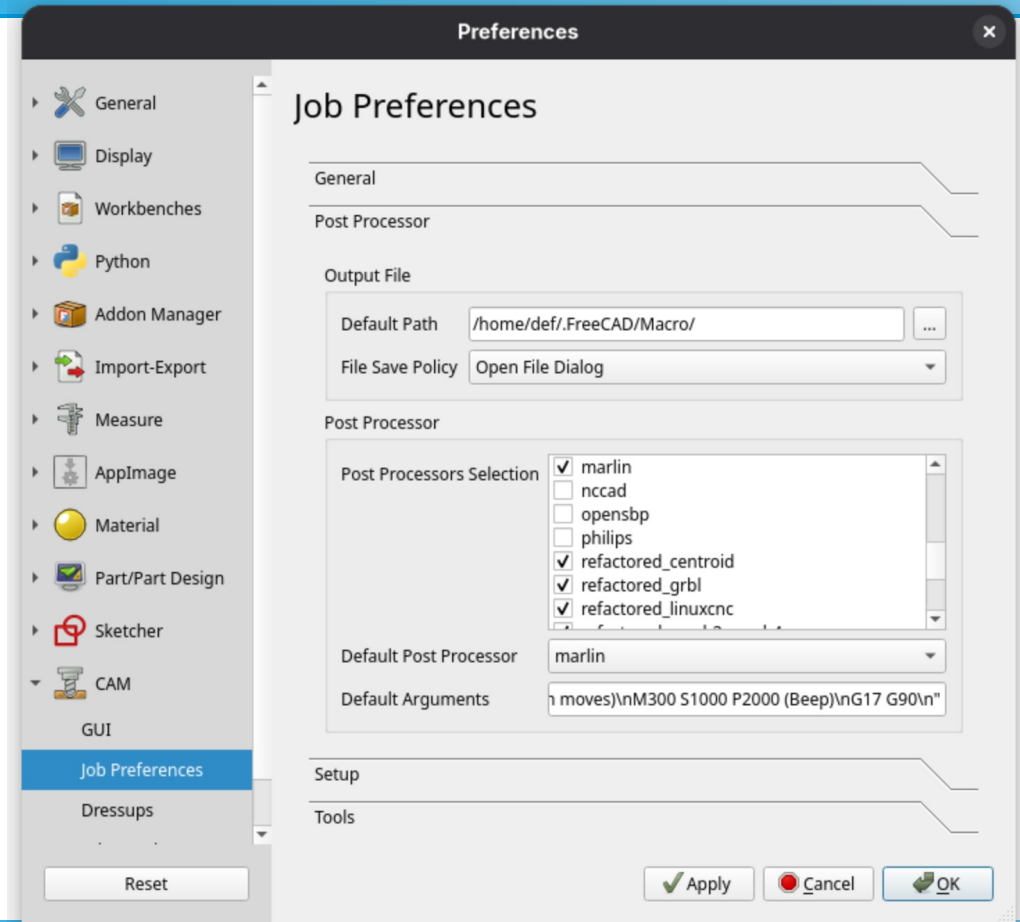


Marlin - patch

- Main board
 - Stepper motors: max current, resolution
 - End stops / Bed size
 - Spindle control
 - LCD / SD / Buttons
-
- ~40 LOC ;-)
 - Cf. github repo for scripts and doc

FreeCAD – Parameters & Scripts

- Pre and post-amble G-code
 - Start reference point G92
 - Spindle control M3 / M5
- Marlin G-code post-processor
 - `~/.FreeCAD/Macro/marlin_post.py`
 - Fixes for syntax, fast moves G0, units
 - Progress display

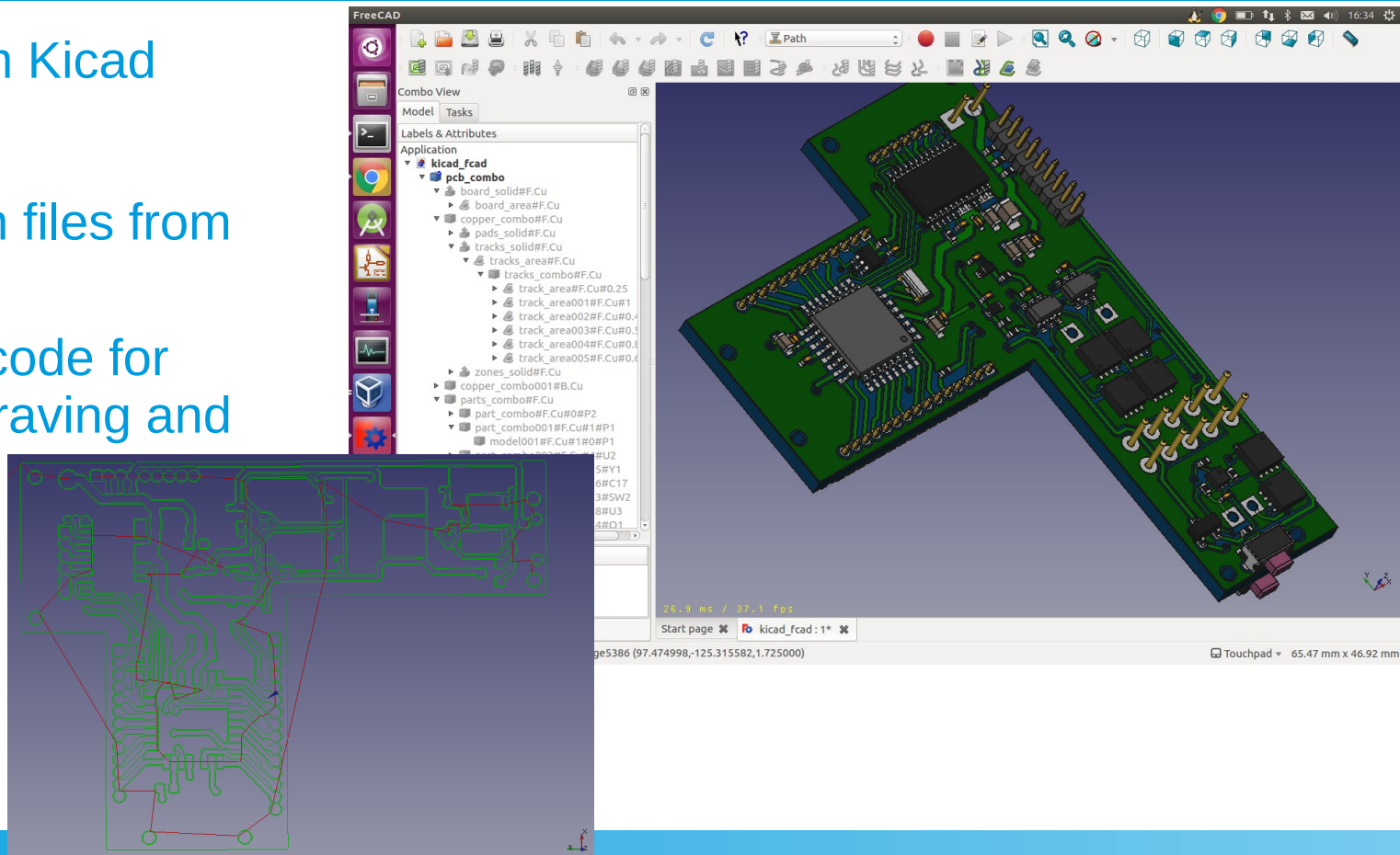


CNC – PCB with FreeCAD

FreeCAD - PCB from Kicad

fcad_pcb plugin:

- Import design files from Kicad
- Generate G-code for profiling, engraving and drilling



Open source for 3D Printing

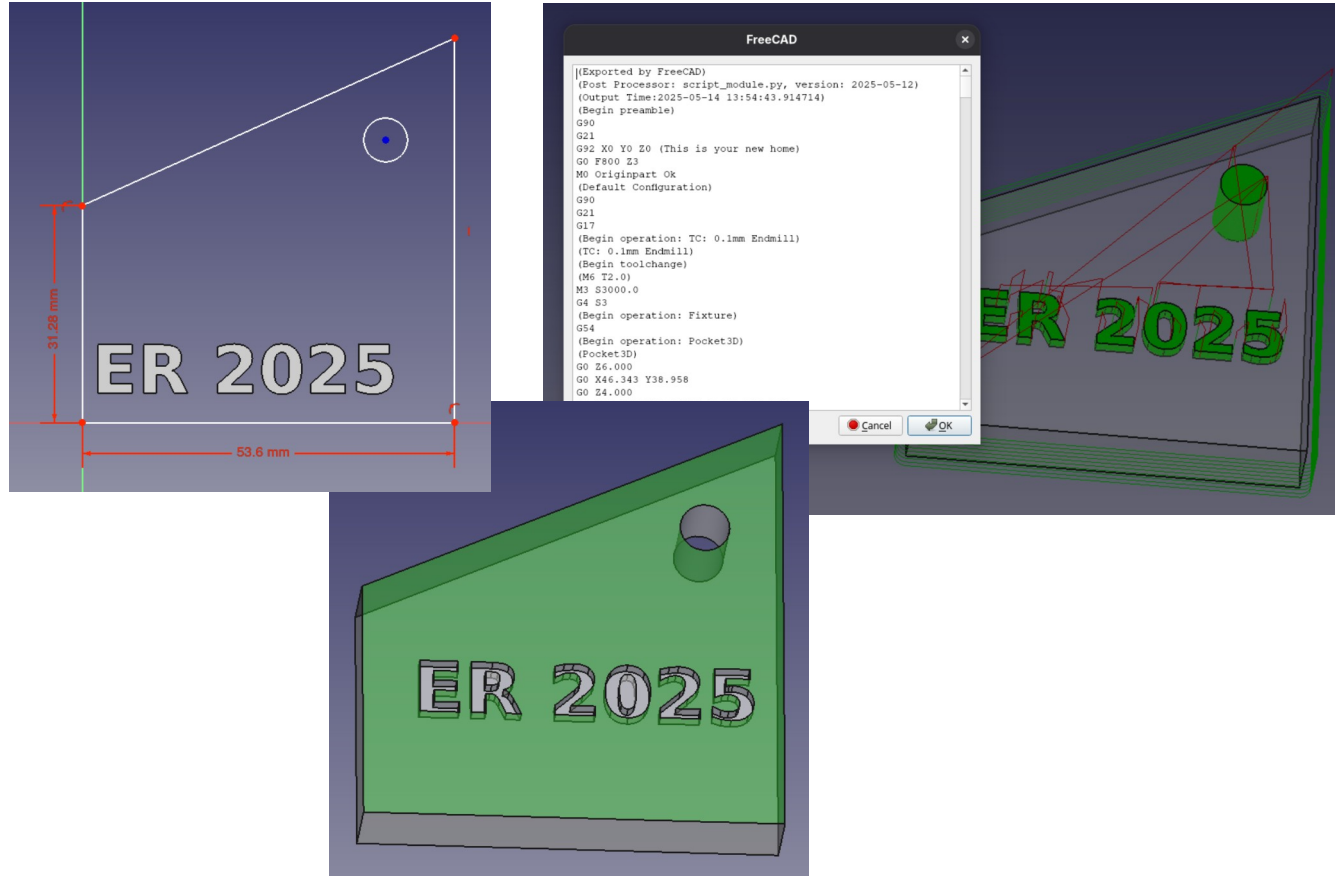
- Mature
- Robust - 24/7
- Fully featured
- Choice is key: printers, firmware, slicers, host tools

Open source for CNC

- Less common but still supported
- Maturity > OK
- Solution for small companies: freedom, \$

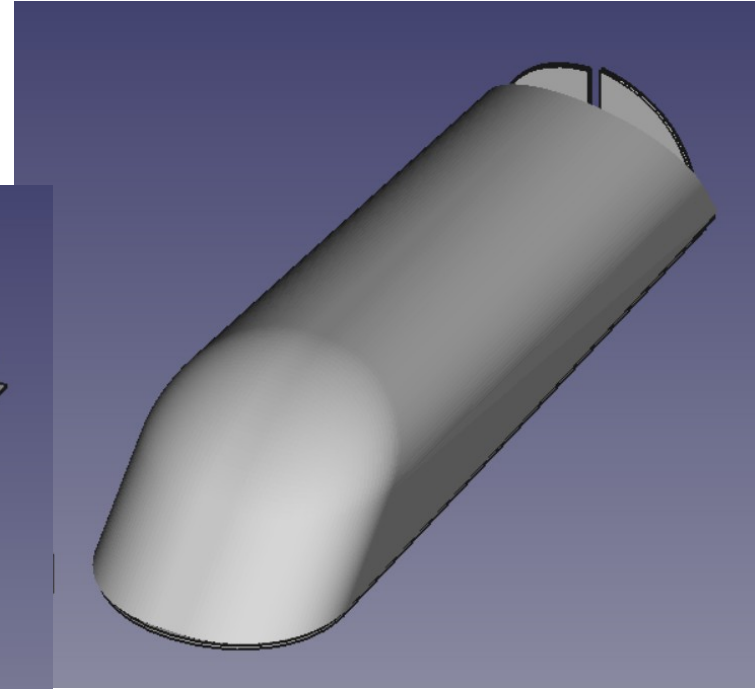
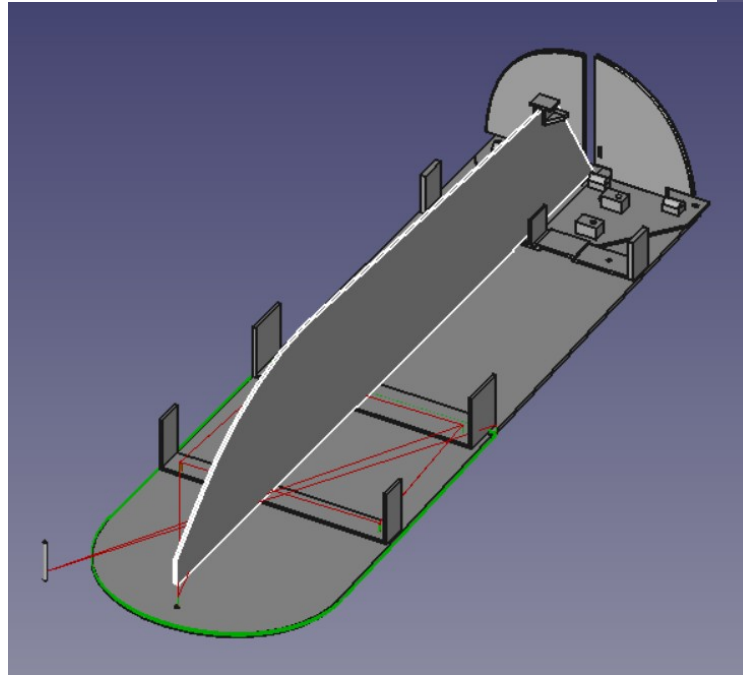
Demo – FreeCAD CNC

- Setup / parameters
- Sketch / Part
- CAM
 - Job
 - Tools
 - Operations: profile, engrave
 - Export G-code



Demo – FreeCAD CNC

- Combination of 3D Printing & CNC



Questions

- Questions or remarks ?
- Other open-source CAD / CAM packages ?

- <https://reprap.org/wiki/RepRap>
- https://www.prusa3d.com/page/our-story_875/
- https://www.prusa3d.com/page/open-source-at-prusa-research_236812/
- <https://github.com/prusa3d/Prusa-Firmware-Buddy>
- <https://marlinfw.org/>, <https://www.klipper3d.org/>
- <https://ultimaker.com/learn/three-reasons-for-open-source-tech-in-your-3d-printing-classroom/>
- <https://openscad.org/>
- <https://github.com/mainsail-crew/mainsail>
- <https://docs.fluidt.xyz/>

- <https://www.freecad.org/>
- <https://octoprint.org/>
- <https://www.prusa3d.com/>
- <https://ultimaker.com/>
- <https://vorondesign.com/voron2.4>
- <https://www.mekanika.io/blog/learn-1/how-to-use-freecad-with-your-cnc-milling-machine-71>
- <https://www.geeetech.com/wiki/index.php/Rambo>
- https://github.com/jeanpihet/FreeCAD_CNC
- PCB in Freecad from Kicad: https://github.com/realthunder/fcad_pcb