3D Printing for Fun and Profit (and for Amateur Radio)

Overview

- Introduction to low cost 3d printing
- FDM and Liquid Resin printers explained
- Hands on presentation
- Relevant to amateur radio?
- The importance of “crowd sourcing”
- Workflow
- Future directions

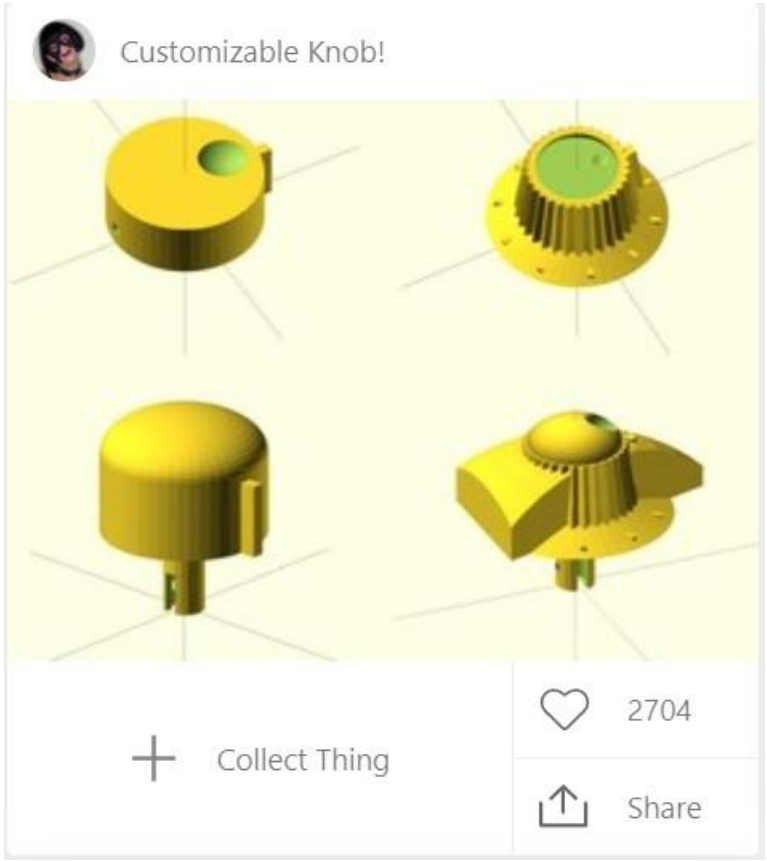
Stop hunting around for stuff

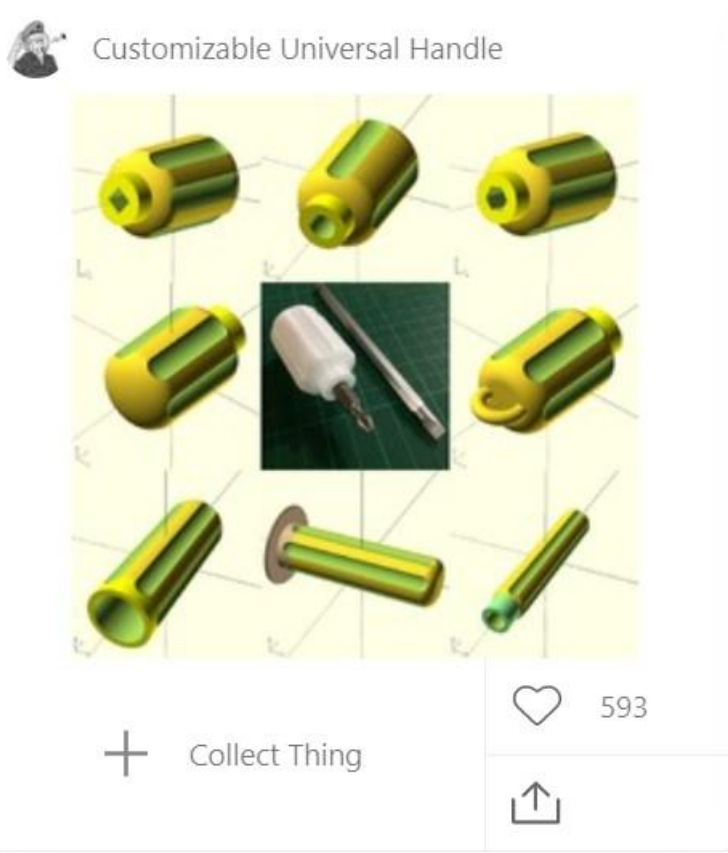
- How many times have you walked into the home center wandering through the aisles looking to repurpose some off the shelf item that you can use for a spacer, mount, bracket, (or whatever) for your own project?
- Instead - create and repair things with your 3d printer.

Stop Collecting Stuff

Make it on Demand

- You don’t have to be a CAD expert anymore!



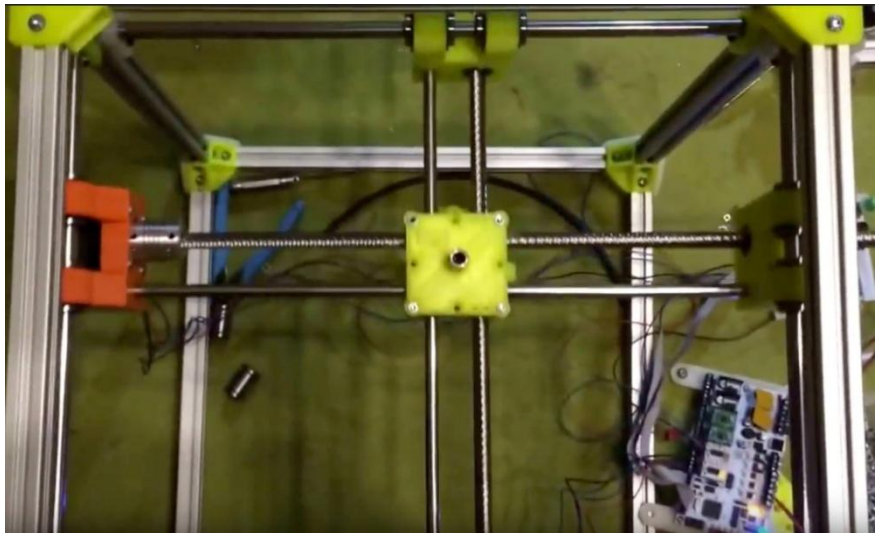


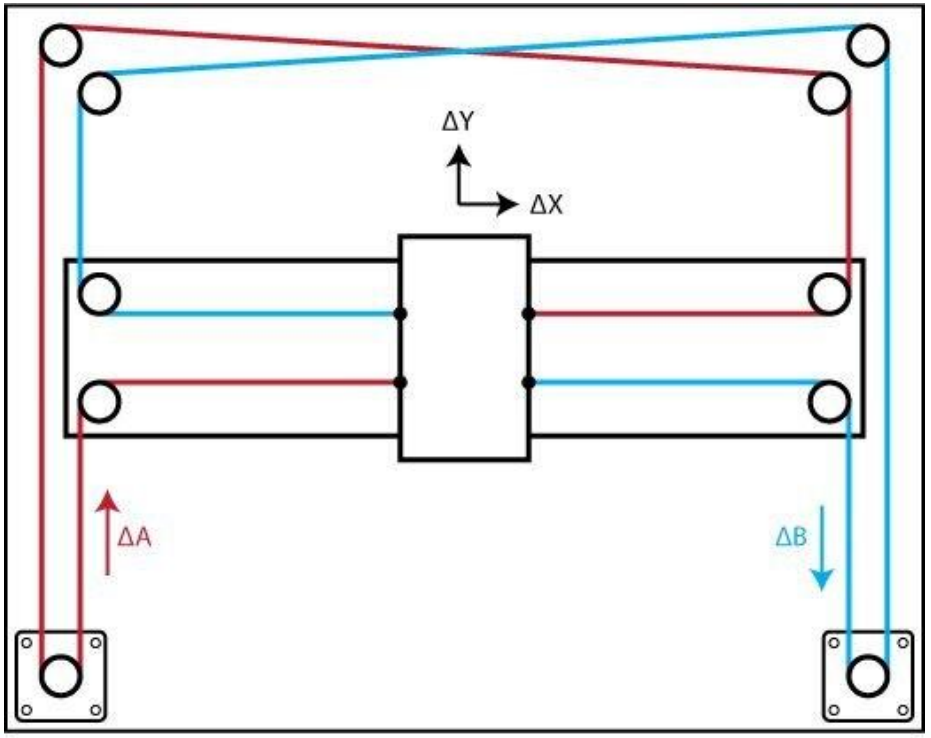
FDM or “Fused Filament” 3d printers

- This type is a more mature technology.
- Vast selection of materials.
- Lower cost for machine and materials.
- Well developed software, many choices for “slicers”, both free and commercial
- Much of the software is open sourced.
- Recommended printer type for beginners.

Lead Screws or “CoreXY”

- Lead screws are expensive.
- CoreXY lowers the costs by using toothed belts instead
- Many large format printers are CoreXY

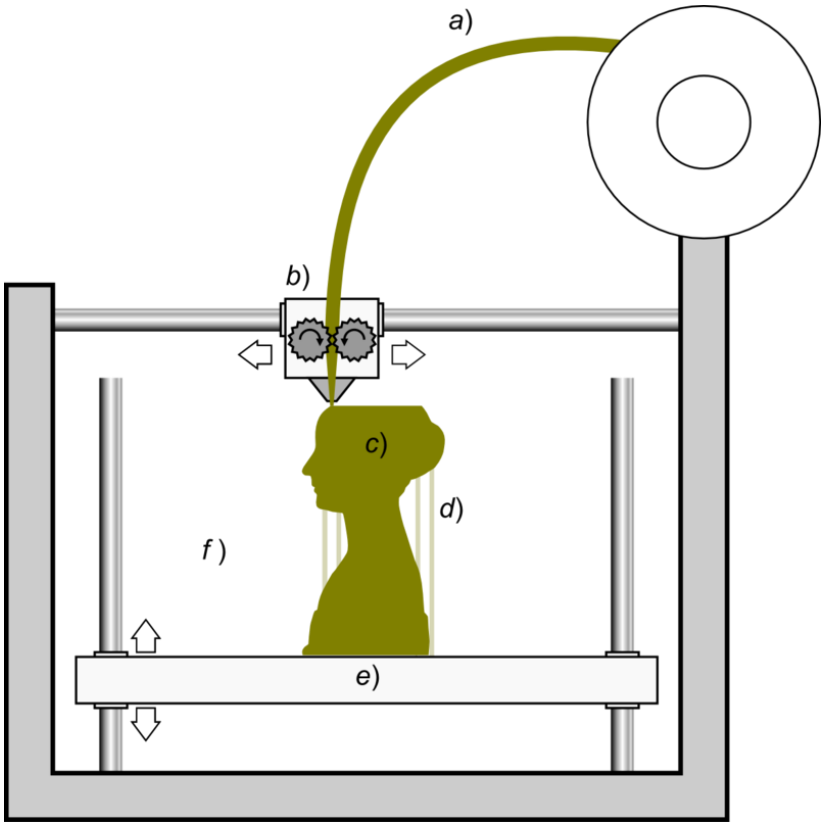




Various Styles of FDM printers

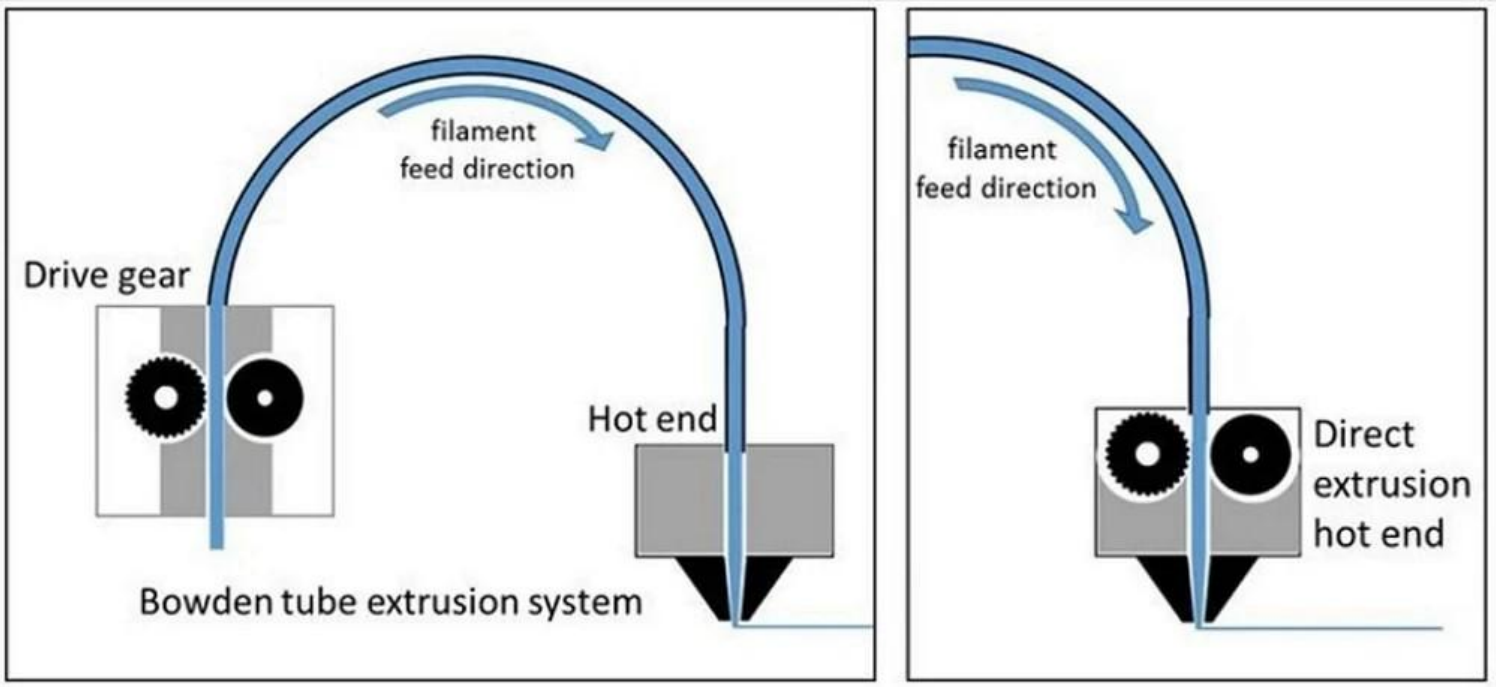
How the fused filament 3d printer works

- It’s a glorified glue gun!

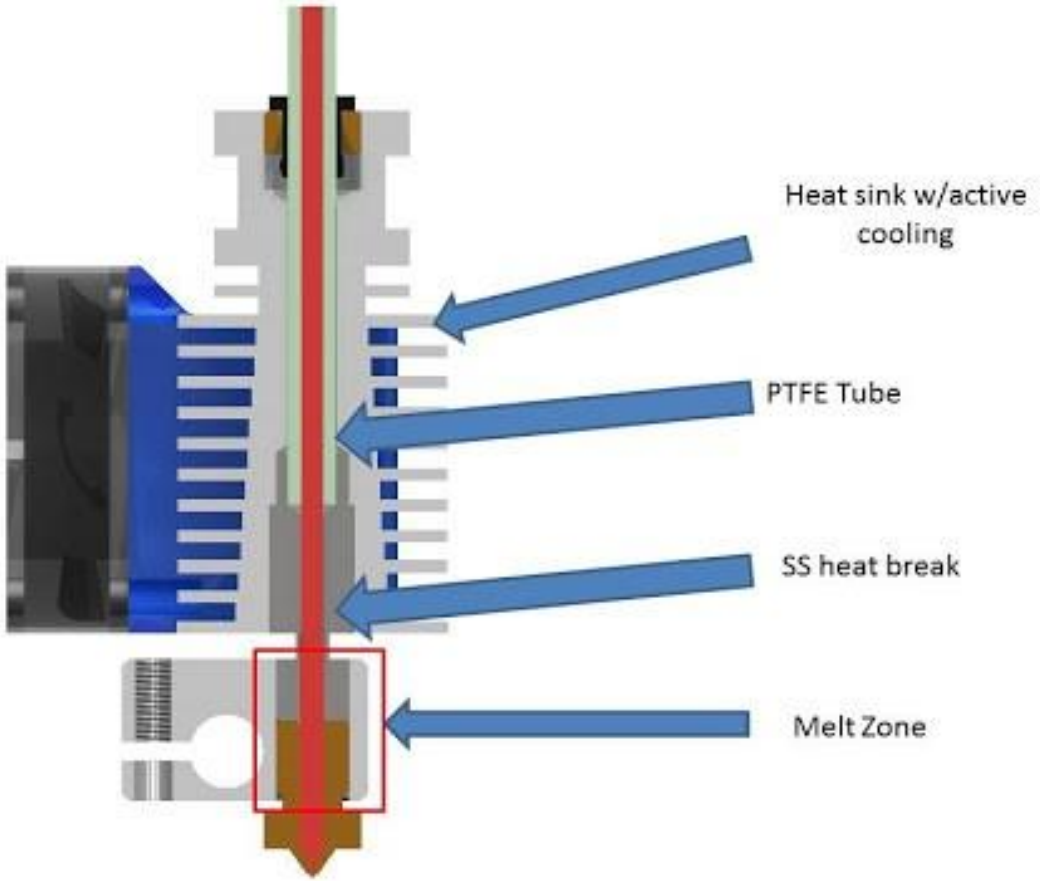


Extruders

- Two types of extruders – Direct Drive and Bowden Tube
- Flexible filament works better with Direct drive



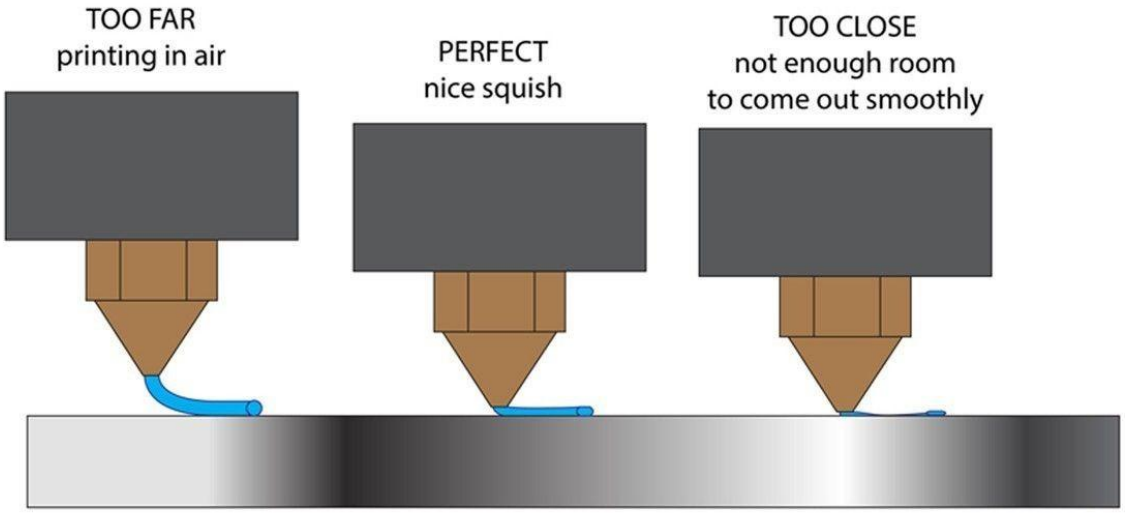
The Hot End



Build Surface and Heated Bed

- The build surface/bed is heated to minimize warping by keeping the part at a uniform temperature.
- Typical bed temperatures range from 60-110C depending on the type of material being printed.
- It is important to have a good bond between the part and the build surface.
- Printers will come with a textured plastic build sheet. This is good for beginners printing in PLA.
- More experienced users will use a sheet of glass for a build surface.
- Hair spray, glue stick, or “ABS” juice can be applied to enhance adhesion.

The Critical First layer



the GAP between your nozzle and build surface is too far! your filament is coming out in the air and not being squished into the bed, it will not get good adhesion, and probably will get dragged around corners and not lay down precisely.

the GAP between your nozzle and build surface is just right! your filament is being compressed between the nozzle tip and build surface as it is coming out. Your first layer will lay down precisely, complete fills nicely, and stick. This will make or break all future layers!

the GAP between your nozzle and build surface is too close! your filament is being compressed too much between the nozzle tip and build surface as it is coming out. This will create too thin of a first layer, inconsistent first layers,may prevent the filament from coming out, and may even block up the nozzle!

FDM Materials

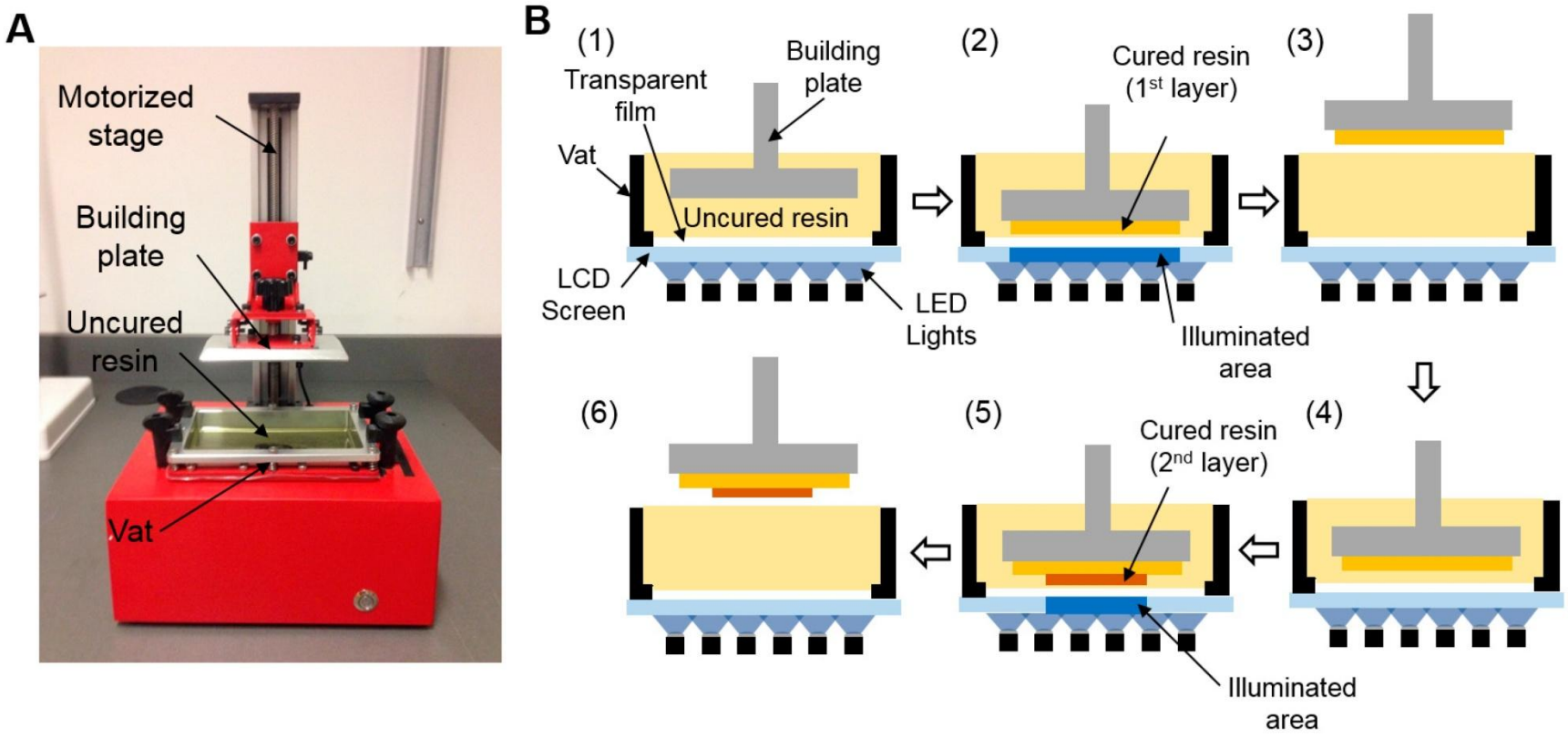
Material		Printing with enclosure	Dry box recommended	Hardened nozzle required	Nozzle temperature (+-10 °C)	Bed temperature (+-10 °C)	Printable on powder coated sheet	Printable on smooth PEI sheet	Soluble with common solvents	Heat deflection temperature (avg. °C)	Impact resistance Charpy (kJ/m^2)	Tensile strength (Mpa)	Price
› PLA	(12)	No	No	No	210 - 215 °C	60 °C	✓	✓	✗				
› PETG	(7)	No	No	No	240 - 270 °C	90 °C	✓	✓ with window cleaner	✗				
› PETG HT	(1)	No	No	No	270 °C	110 °C	✓	✓ with window cleaner	✗				
› ASA	(2)	Yes recommended	No	No	260 - 265 °C	95 - 110 °C	✗ not recommended	✓	✓				
› ABS	(5)	Yes recommended	No	No	240 - 255 °C	110 °C	✗ not recommended	✓	✓				
› PC (Polycarbonate)	(2)	Yes recommended	No	No	270 - 275 °C	115 °C	✓ with glue stick	✗ not recommended	✗				
› CPE	(1)	No	No	No	275 °C	90 °C	✓	✓ with window cleaner	✗				
› PVA / BVOH	(2)	No	Yes	No	195 - 215 °C	60 °C	✓	✓	✓				
› HIPS	(1)	No	No	No	220 °C	110 °C	✓	✓	✓				
› PP (Polypropylene)	(1)	Yes	Yes	No	220 °C	100 °C	✗ not recommended	✓ with PP tape	✗				
› Flex	(4)	No	No	No	230 - 260 °C	50 - 85 °C	✓	✓ with glue stick	✗				
› nGen	(1)	No	No	No	240 °C	90 °C	✓	✓ with window cleaner	✗				
› Nylon	(1)	Yes recommended	Yes	No	250 °C	90 °C	✓ with glue stick	✗ not recommended	✗				
› Carbon filled	(1)	No	No	Yes	260 °C	90 °C	✓	✓	✗				
› Wood / metal filled	(7)	No	No	-	190 - 220 °C	60 °C	✓	✓	✗				

UV Resin 3d printers

- Less mature technology (for the hobbyist)
- High precision prints.
- Limited software choices.
- Small build volume.
- Limited material selection.
- Material cost is high.
- Useful for special applications “Transparent Parts”
- Messy.

Many styles $200 and up

How does an LCD UV resin 3d printer work?



Maximizing UV Resin Printing

- Because each layer takes the same amount of exposure time, it makes sense to “gang” print multiple parts at a time on a resin printer

Work flow for 3d printing

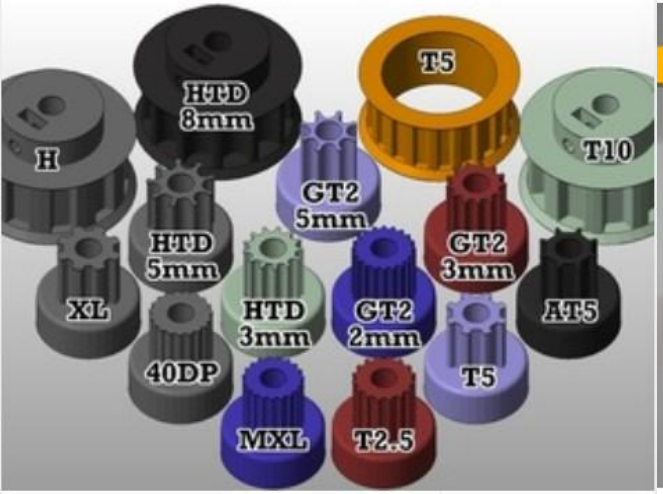
- A 3d model is obtained, either designed by yourself or retrieved from an online repository (usually the latter).
- The model is then processed through “slicing” software to be prepared for the printer.
- The model is 3d printed – takes time.
- The model is “post processed”.

Obtaining the Model

- You don’t need to know CAD unless you want to build something very specific. Consider altering an existing model first.
- The amount of freely available 3d models is practically infinite. “There is nothing new under the Sun”
- Search online first before designing your own,
- Parametric models cover a wide range of applications.
- OpenSCAD is a free tool that allows you to easily manipulate the parametric models.
- Models can be scaled to various sizes in the slicer if required.

Examples of Parametric Models

Parametric pulley - lots of tooth pro...



Collect Thing

27471

Share

The Ultimate Parametric Box

Collect Thing

5498

Share

Getriebe Bibliothek für OpenSCAD /...

Collect Thing

3607

Share

Model Websites

- Thingiverse.com
- TurboSquid.com
- GrabCAD.com
- gallery.autodesk.com
- Many more…

And for Amateur Radio?

- There are over 100 models on thingiverse resulting from the key word search “Baofeng”
- Thousands of models related to amateur radio
- Name tags, Power Pole connectors, antenna designs, radio accessories, special mounts for radios in vehicles…
- List goes on. Number of Models are growing geometrically!

“Yagi”

MakerBot Thingiverse

yagi

Remix Mavic Mini Yagi.Uda antenna...

Collect Thing 129 Share

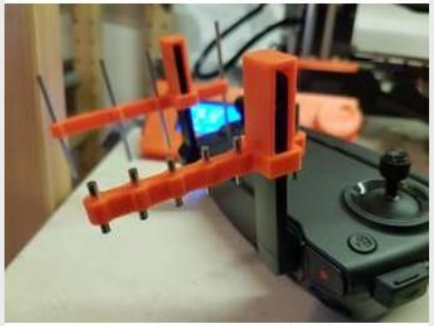
2.4Ghz WIFI Antenna Yagi

Collect Thing 160 Share

Retractable yagi antenna parts

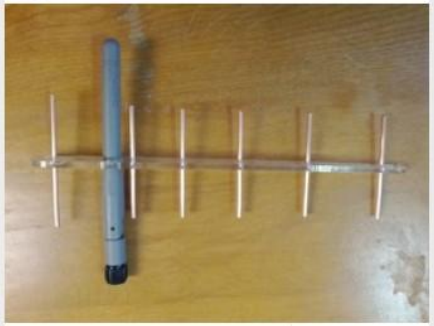
Collect Thing 81

Mavic Mini Yagi antenna 2mm rod



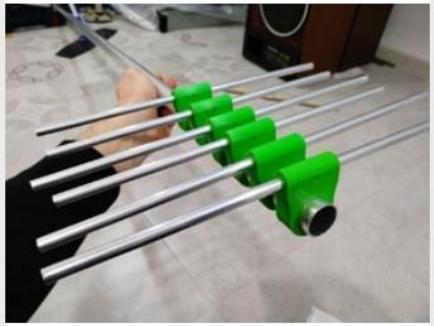
Collect Thing 117 Share

Yagi WLAN Antenna Booster - Laser...



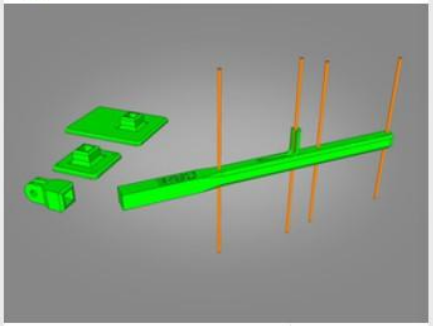
Collect Thing 103

Yagi antenna kit



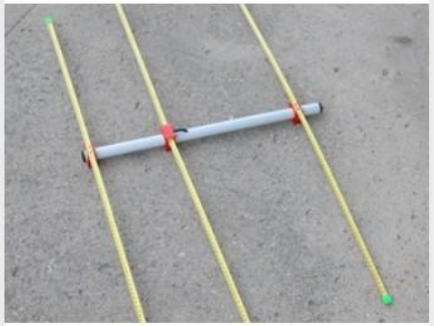
Collect Thing 43

Yagi Antenna FPV 1.2GHz with assor...



Collect Thing 49

3 element 2m (145 MHz) ultra porta...



Collect Thing 89

“PowerPole”

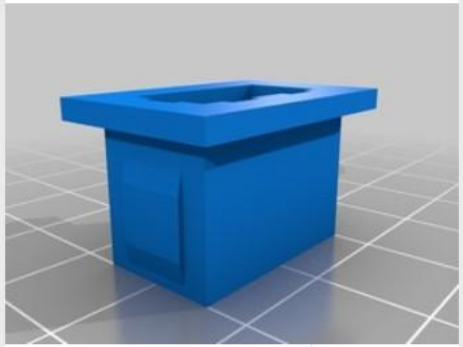
MakerBot Thingiverse

powerpole

Anderson Powerpole 15-45Amp co...

Collect Thing 102 Share

Powerpole mount

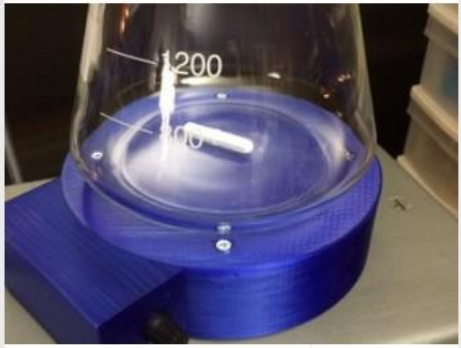


Collect Thing 51 Share

Fused Powerpole Distribution

Collect Thing 91 Share

Magnetic Stir Plate 120mm



Collect Thing 258 Share

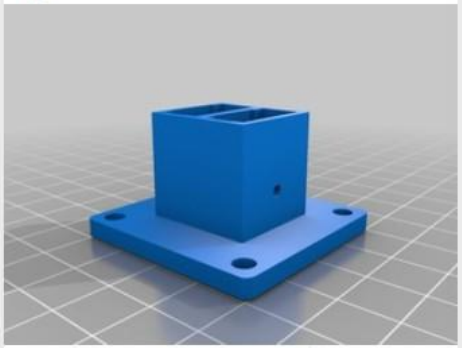
Anderson Powerpole Shroud

33

Surface Mount SB50 Anderson Pow...

71

Anderson Power Pole Panel Mount -...



Collect Thing 55

Anderson powerpole 3way splitter

Collect Thing 20

“Yaesu”

MakerBot Thingiverse

Yaesu

Yaesu FT-817 Anderson Power Pole ...

Collect Thing

102

Share

Yaesu FT-857D Remote Mount

Collect Thing

98

Share

Ad to Support Thingiverse

Why do we show ads on Thingiverse?

FT817 FT818 YAESU Protector

Collect Thing

40

Share

Yaesu FT-60 Wall Mount

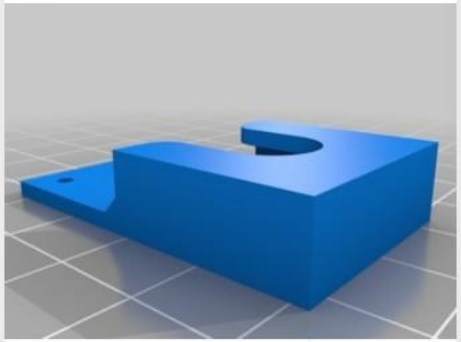
Collect Thing

44

Ad to Support Thingiverse

Why do we show ads on Thingiverse?

CB/Ham Radio Mic Holder



Collect Thing

179

Yaesu FT-817 3x18650 battery holder

Collect Thing

83

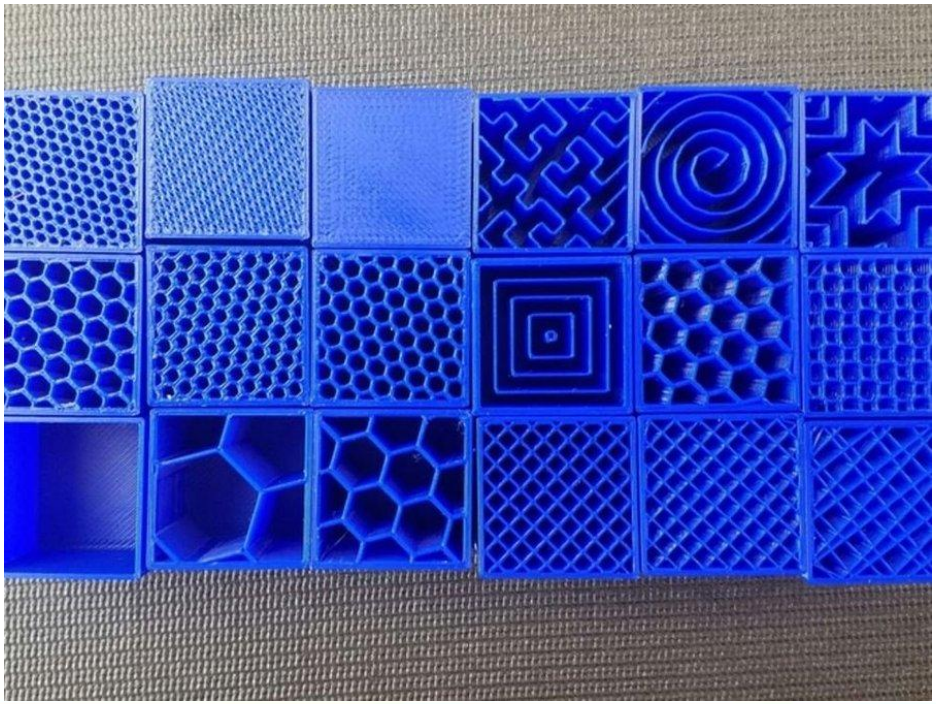
Share

Slicing

- The 3d model must now be loaded into “slicing software” to break the model down into individual layers and translated into code that the printer understands.
- Many options are set regarding the material used. For FDM - temperatures, flow rates, print speeds, layer thickness. For UV Resin - exposure time, off time , lifting distance, etc..
- Fortunately there are many “pre-canned” configurations regarding the different materials. Often suggested settings can be found online.
- Other options include support generation and whether the model is printed solid or hollow with “infill” and the number of outer shells.
- UV resin printers usually print the models solid.

Slicing FDM - Infill

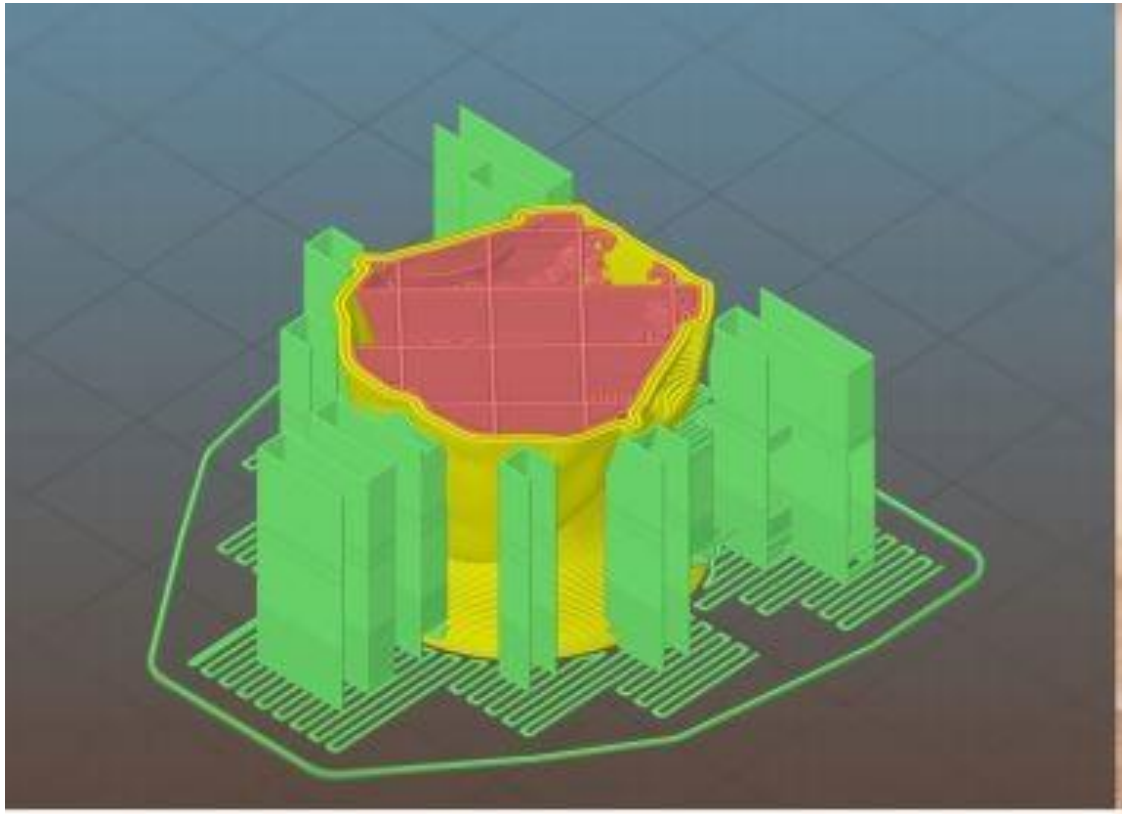
- Infill saves material, speeds FDM printing.
- Strength in not compromised very much.
- When printing flexible polyurethane, durometer can be altered with infill



Slicing FDM - Support

- Support is required for areas of the model that “overhang”.
- In general the slicer does a good job at auto-generating support. But you can also edit/add support yourself.
- Support adds time to the print.
- It (usually) breaks free easily from the finished printed model.
- The printer can manage a 45 degree overhang before support is needed.
- Often support is not needed.

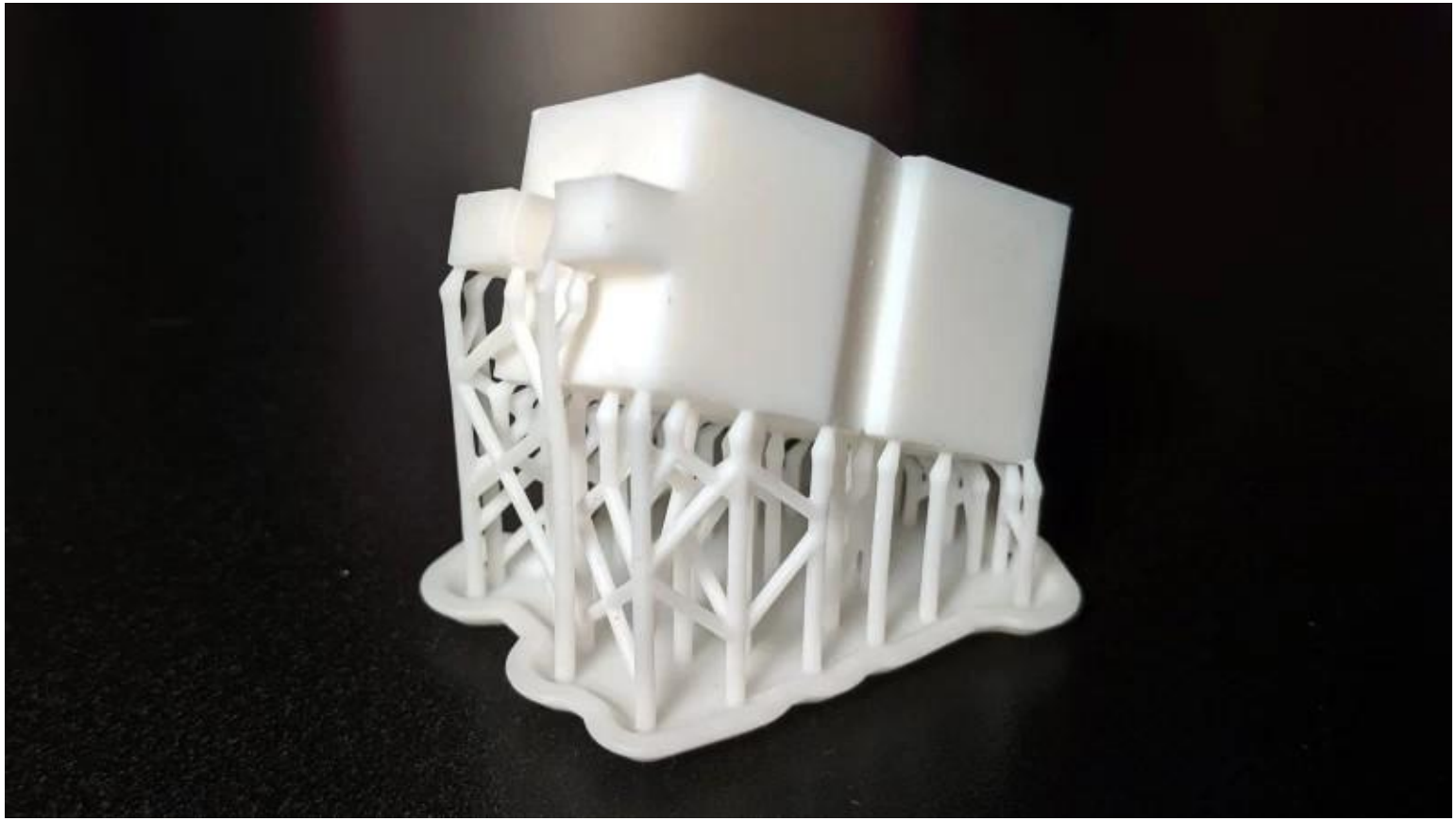
Slicing FDM - Support



Slicing UV Resin - Support

- With resin printers it is more aptly called “suspend” since the model prints upside down.
- Without support overhanging portions would “float away” in the vat of resin
- Auto-generation of support in resin slicers is not yet mature. Better to add it manually, but this requires expertise and patience.

Slicing UV Resin - Support



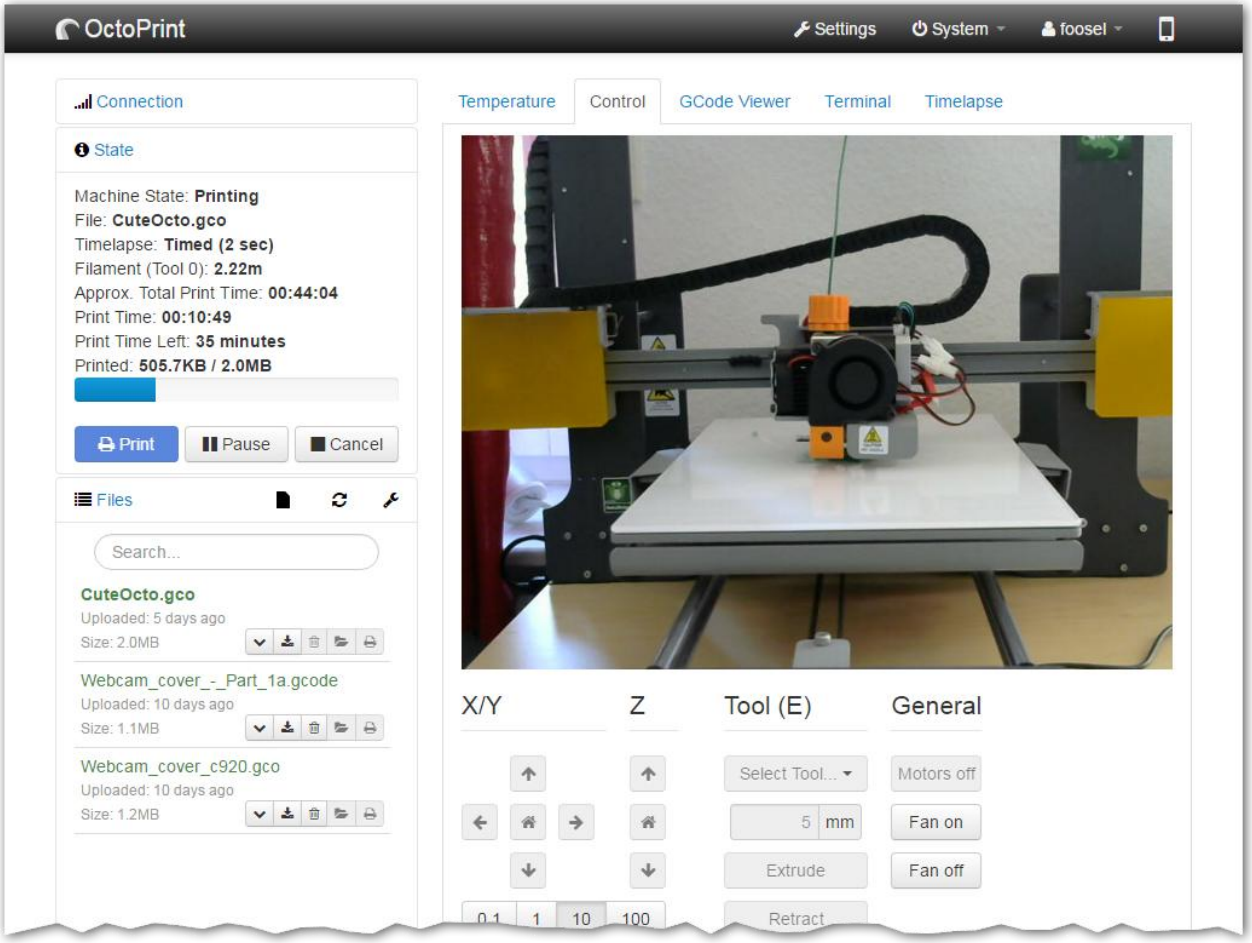
Print it!

- 3d printing takes time. The slicer will provide an estimate.
- If you can tolerate infill then definitely use it to reduce printing time.
- Things can go wrong when you are starting out. Work with small models at first.
- Typically a failure requires starting all over again.

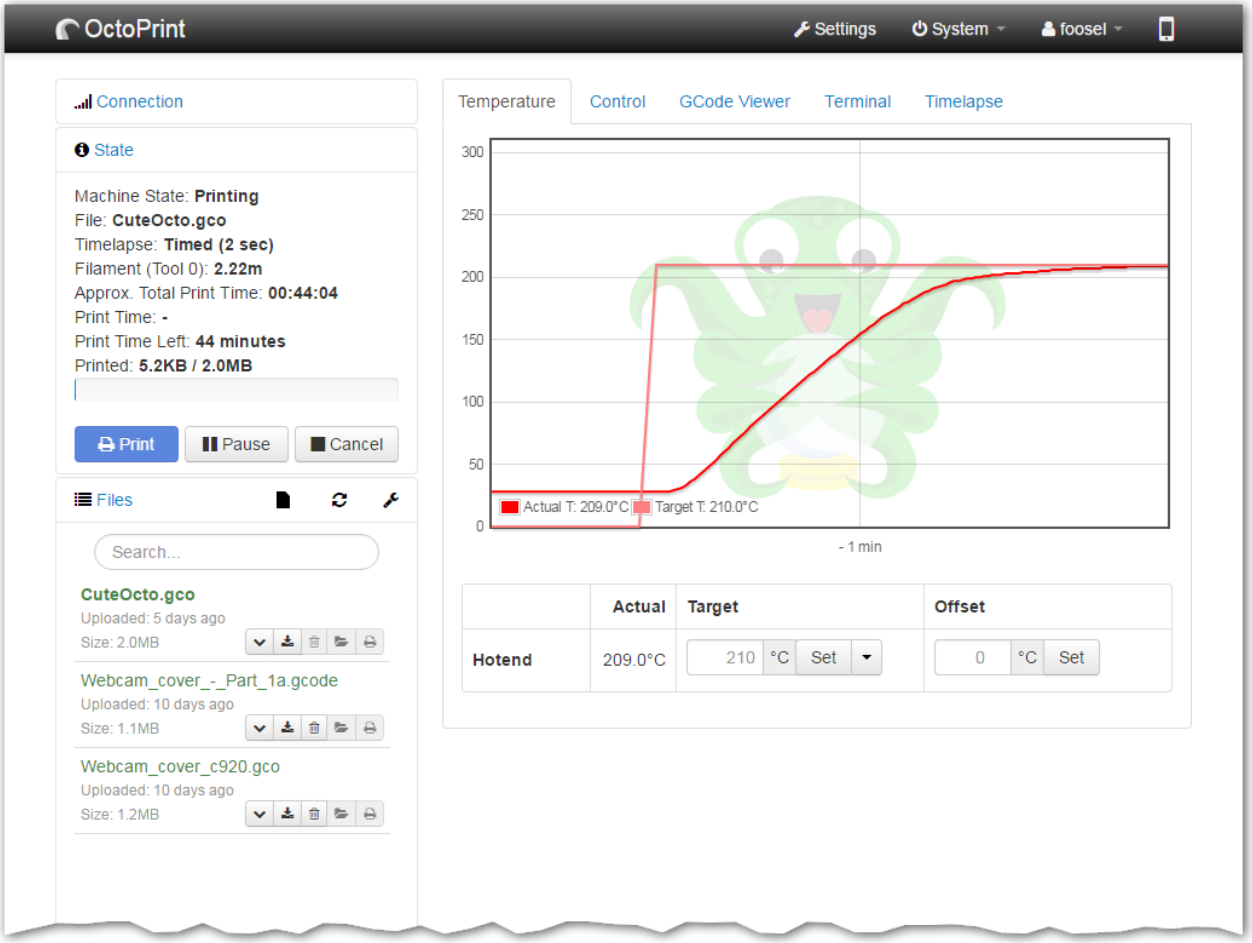
OctoPrint – Monitor and Manage your FDM Printing

- Octoprint is a web based application that runs on a Raspberry Pi that is connected to the FDM printer controller via USB
- Allows you to wirelessly manage you 3d printer.
- A camera may be connected so you can remotely watch the printer from other devices through a web browser.
- Many “plug-ins” are available to control other additions to the 3d printer, such as a plugin to pause the printer when it detects the spool runout switch has been tripped.
- Octoprint does not yet work liquid resin printers.

OctoPrint Screenshots



OctoPrint Screenshots



FDM Post Processing

- FDM prints are removed from the build surface (after bed has cooled)
- Support is removed. Some can be removed by hand. Support in tight spots might need to be removed with fine needle nose pliers.
- Part may be sanded or painted.
- ABS smoothing, Annealing, or Salt Melting

ABS Acetone Vapor Smoothing

- FDM prints can be placed into a container with acetone. Vapor will blend the plastic together.

Annealing FDM prints

- Many plastics will benefit from heating after the part is printed.
- Annealing with allow the part to handle higher heat in service and will make the part stronger.
- The downside is that the part will experience dimensional changes during annealing proccess.

Salt Melting

- The FDM part can be encased into fine salt. The part/encasement is then placed into the oven and the temperature is raised to the melting temperature of the plastic. The result is a solid crystallized part that is much stronger.

Liquid Resin Post Processing

- The part is not fully cured when removed from the printer. It is considered “green”
- Typically the part is washed in Isopropyl Alchohol to remove residual resin.
- The part is then placed into a UV curing chamber to attain “full cure”.
- After an hour or more, the part can then be removed and the support separated from the model.
- Cleaning/Curring machines are available but you can also improvise.
- Part can then be sanded (if needed) or painted.

Important Links

- Thomas Sandlander https://www.youtube.com/user/ThomasSanladerer
- 3dPrintingPro https://www.youtube.com/channel/UCbv2mDrRqXovPdahRyoCFhA/videos
- How to Series at MatterHackers https://www.matterhackers.com/
- IdeaMaker FDM Slicing Software https://www.raise3d.com/ideamaker/
- Cura FDM Slicing Software https://ultimaker.com/software/ultimaker-cura
- CHITUBOX Free UV Resin Slicing software https://www.chitubox.com/en/download/chitubox-free
- OpenSCAD https://openscad.org/

Questions?

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