

# 3D Printing for Fun and Profit

2015-01-21

# Subset of “Personal Manufacturing”

See Also: “Rapid Prototyping,” “Instant Manufacturing”,  
“Direct Manufacturing,” etc.

- ▶ Additive
  - ▶ 3D Printers
- ▶ Subtractive
  - ▶ CNC Routers
  - ▶ Die Cutters
  - ▶ Laser Cutters



Largely enabled by the proliferation of powerful, small, inexpensive stepper motors, drivers, and controllers, and the expiration of patents.

# 3D Printing

- ▶ Building an object up from stock material by following computer instructions
- ▶ “Two Cultures”
  - ▶ Professional “Rapid Prototyping” (>\$15,000)
  - ▶ Hobbyist (<\$5000)
- ▶ Many Technologies
  - ▶ One *extremely* dominant in the hobbyist space



# Photopolymer Resin/Stereolithography

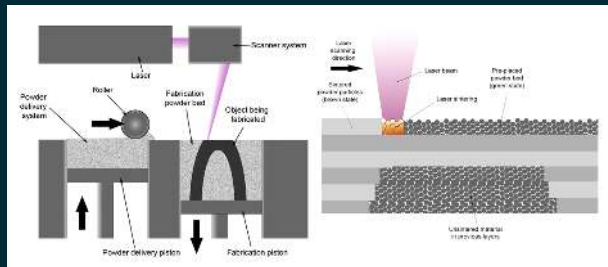
- ▶ Use a laser or DLP array to selectively expose UV-sensitive resin to light
- ▶ Free-Form, High precision
- ▶ Requires filling whole working volume with expensive ( \$100/L) resin.
- ▶ Variety of resins is limited
- ▶ \$4300 Form1+, \$100 PeachyPrinter kit



# Powder Bed

Three dominant subspecies

- ▶ Binder Jetting
  - ▶ easily colorized
- ▶ SLS: Selective Laser Sintering
- ▶ SLM: Selective Laser Melting



Core patents expired in Jan.2014, mid-powered lasers becoming affordable...

# FDM/FFF

Fused Deposition Modeling (<sup>TM</sup> Stratasys Inc.) or  
Fused Filament Fabrication

- ▶ Extrude a bead of semi-fluid material
- ▶ Most heads work heated plastic from a 0.35mm nozzle
  - ▶ 1.75mm or 3mm spooled filament
  - ▶ Common materials: PLA and ABS
  - ▶ Many "exotic" filaments
  - ▶ Or extrude gels or use a MIG welder head

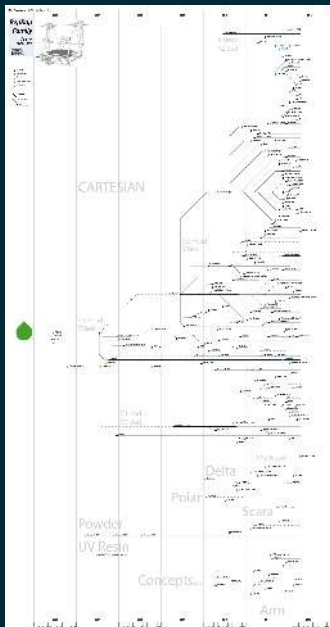


# Reprap Project

## Replicating Rapid Prototyper

- ▶ Started 2005 by Dr. Adrian Bowyer at the University of Bath
- ▶ Targets self-replication
- ▶ Open-source hardware, software, etc.
- ▶ Generations of [Arduino-based] electronics and firmware

Iterate, Iterate, Iterate!



# FFF Ante

- ▶ Printrbot Metal Simple (kit) \$540, 152x152x152mm
- ▶ MiniKossel (kit) \$650, 160mm Dia cylinder, 180mm high
- ▶ Makergear M2 \$1775, 200x250x200mm
- ▶ LulzBot Taz4 \$2,194.95, 298x275x250mm
- ▶ Standard filament \$25-35/kg spool





# Process

- ▶ Obtain 3D Model
- ▶ Slice
- ▶ Print

# Models

- ▶ Design in CAD tool
  - ▶ Free: OpenSCAD, FreeCAD, Heeks, Blender
  - ▶ Hobbyist: Inventor, 123D, Tinkercad, Simplify3D
  - ▶ Professional: ProE, AutoCAD
- ▶ Scan
  - ▶ Capture geometry from imaging or sampling
  - ▶ Models require cleanup to be printable
- ▶ Internet Sources
  - ▶ Thingiverse “Takerbot”
  - ▶ Youmagine

Requirement: Obtain .stl file.

# FFF Design Constraints

- ▶ Manifold model
- ▶ Material limitations
- ▶ 45° rule
- ▶ Limited surface resolution
- ▶ Tolerance
- ▶ Bed adhesion
- ▶ Warping
- ▶ Layer dwell time



# Slice

## “CAM” (Computer Aided Machining) Step

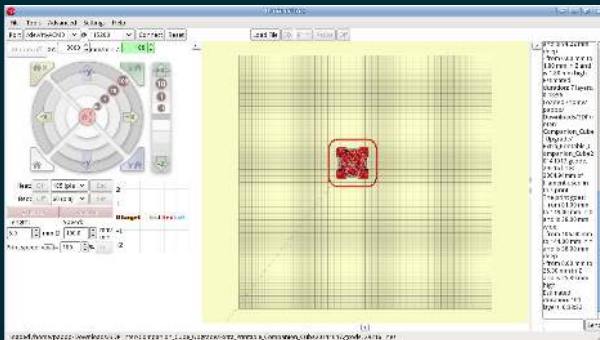
- ▶ Convert 3D model into a set of machine motions
- ▶ Infill and Support
- ▶ Free: Cura, Slic3r
- ▶ Hobbyist: Makerware, Simplify3D
- ▶ Proprietary vendor software
- ▶ Output is *machine specific*

Requirement: Obtain G-Code

# Print

Send G-Code to an embedded motion controller.

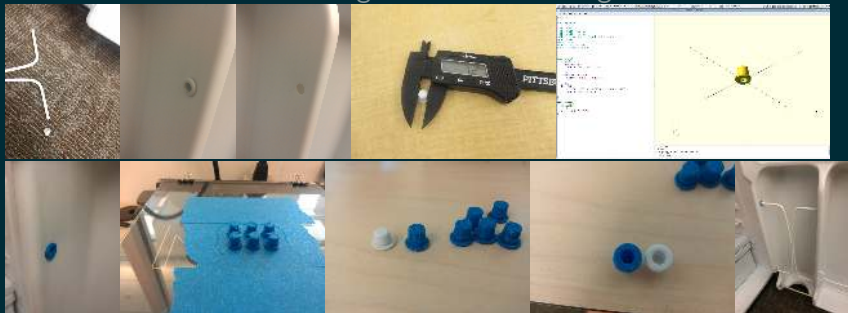
- ▶ Host software: Printron/Pronterface, Repitier Host
- ▶ Device Firmware: Marlin, Teacup, Smoothieware
- ▶ Check calibration, wait for bed temperature, wait for head temperature, prime head...



Host provides interface and sends serial stream, embedded motion controller converts to step/direction

# A Repair Project

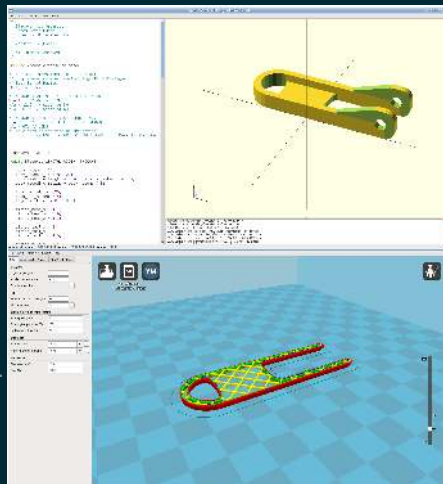
The lab mini-fridge had some bushings fail.



Fixed. With. Prejudice. (In about an hour)

# An Everyday Item

- ▶ Blade Key
- ▶ Available commercially:  
<http://bladekey.com/>
- ▶ Designer shared the parameterized OpenSCAD model <http://www.thingiverse.com/thing:10609>, free for personal use.
- ▶ Customize and print!



## My Bladekey



(just add #8-32x3/4 sex bolt)



Why didn't you run something overnight on the 3D printer?

I didn't have anything to run.

It doesn't matter!

Run something. Run anything! You have a cyber womb, and you can't decide what *make real*?

Well, what do you want?

Make a soap dish.

Do we need that...?

No, No. I guess not.

I guess we'll just keep putting our soap on the edge of the sink, like a couple of Goddamn morlocks.

# Image Sources

- ▶ Subtractive picture courtesy of: [shapeoko.com/](http://shapeoko.com/), [fslaser.com](http://fslaser.com), and [silhouetteamerica.com](http://silhouetteamerica.com)
- ▶ Stereolithography machines from [peachyprinter.com/](http://peachyprinter.com/) and [formlabs.com/](http://formlabs.com/)
- ▶ Powder printer from Wikimedia Commons
- ▶ FFF machines are marketing shots from [makergear.com](http://makergear.com), [printrbot.com](http://printrbot.com), [ultibots.com](http://ultibots.com), [lulzbot.com](http://lulzbot.com)
- ▶ Reprap family tree from [reprap.org](http://reprap.org)
- ▶ Comic closing from [pennyarcade.com](http://pennyarcade.com)
- ▶ All screen-shots and print examples from locally operated machines