February 2016

Serialized Additive Manufacturing

CPE 496

Adaptive H.I.D.

Review - Terminology

Additive Manufacturing - Generally the process by which a component is built up layer by layer by depositing material.

Sometimes explained as a compliment to subtractive manufacturing - typical CNC routers and mills.

Also called “3D Printing” by many.

Additive manufacturing sounds more smarter-er.

Review - Terminology

FDM - Fused Deposition Modeling, what we're interested in. Operates by laying a molten bead (of plastic) to create discrete layers of an item.

SLA - Stereolithography. Uses a laser to cure liquid resin into discrete layers of an item.

SLS - Selective Laser Sintering. Cures layers of powder with lasers to form discrete layers of an item.

http://3dprintingfromscratch.com/common/types-of-3d-printers-or-3d-printing-technologies-overview/

Review - Beginnings

Originally designated as “Rapid Prototyping” methods, 3D printers first appeared in the 1980s.

Charles Hull invented the first SLA system in 1983; patented it in 1986.

In 1989 Scott Crump filed a patent for FDM technology.

Many derivative and bespoke processes followed throughout the 90's and early 2000's.

http://3dprintingindustry.com/3d-printing-basics-free-beginners-guide/history/

Review - Community Base

RepRap

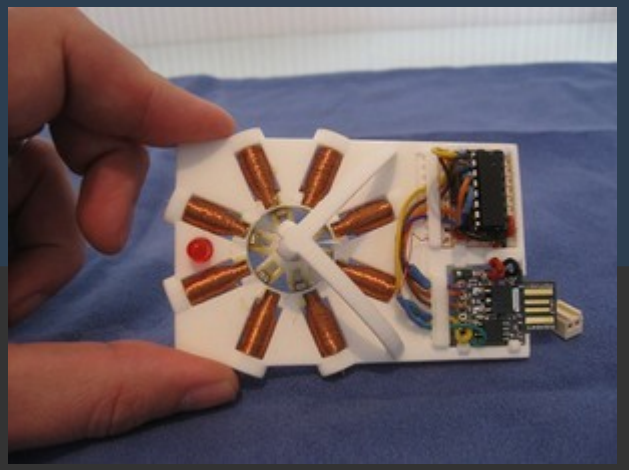
"Humanity's first general-purpose self-replicating manufacturing machine."

Objectives:

1. RepRaps create more RapRaps
2. …
3. The world, Mr. Bond. The world.

Because RepRaps tend to include electronics, they aren't inherently a typical FDM 3D printer. Except they are.

Review – Community Base



http://hackaday.com/2013/04/13/working-3d-printed-stepper-motor/

RepRap

But really, objectives:

1. Print structure (☑)
2. Create circuits (may omit ICs)
3. Create motors
4. Create hotends (?!)

5. Still needs things like wire, microcontroller, PSU.
   But the base case is there.

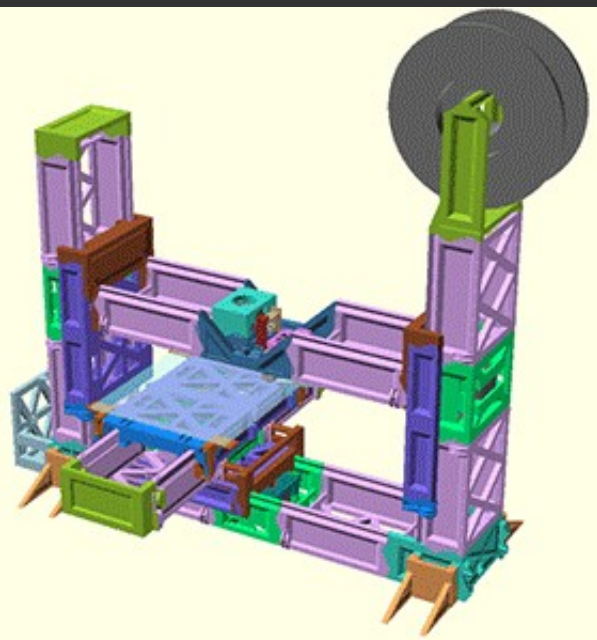
Review – Community Base

There are fewer great advancements in self-replication and community manufacturing.

I believe this will pick back up after commercialization / adoption.

RepRap “Snappy”

75% of frame printable

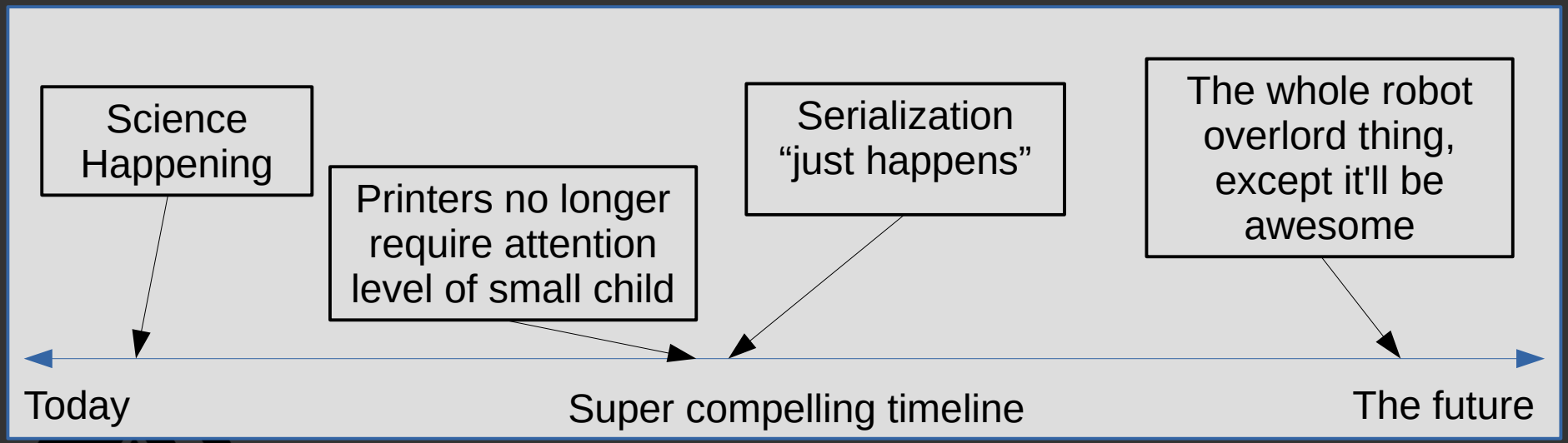


https://hackaday.com/2015/09/12/the-most-self-replicating-reprap-yet/

Review – Community Base

To be clear, I hate the idea of printers being pushbutton (Like, say, new cars or laundrymachines).

Instead, FDM machines need to be more robust, and the science of creating good parts should be integrated into the design. This is tricky in several ways.



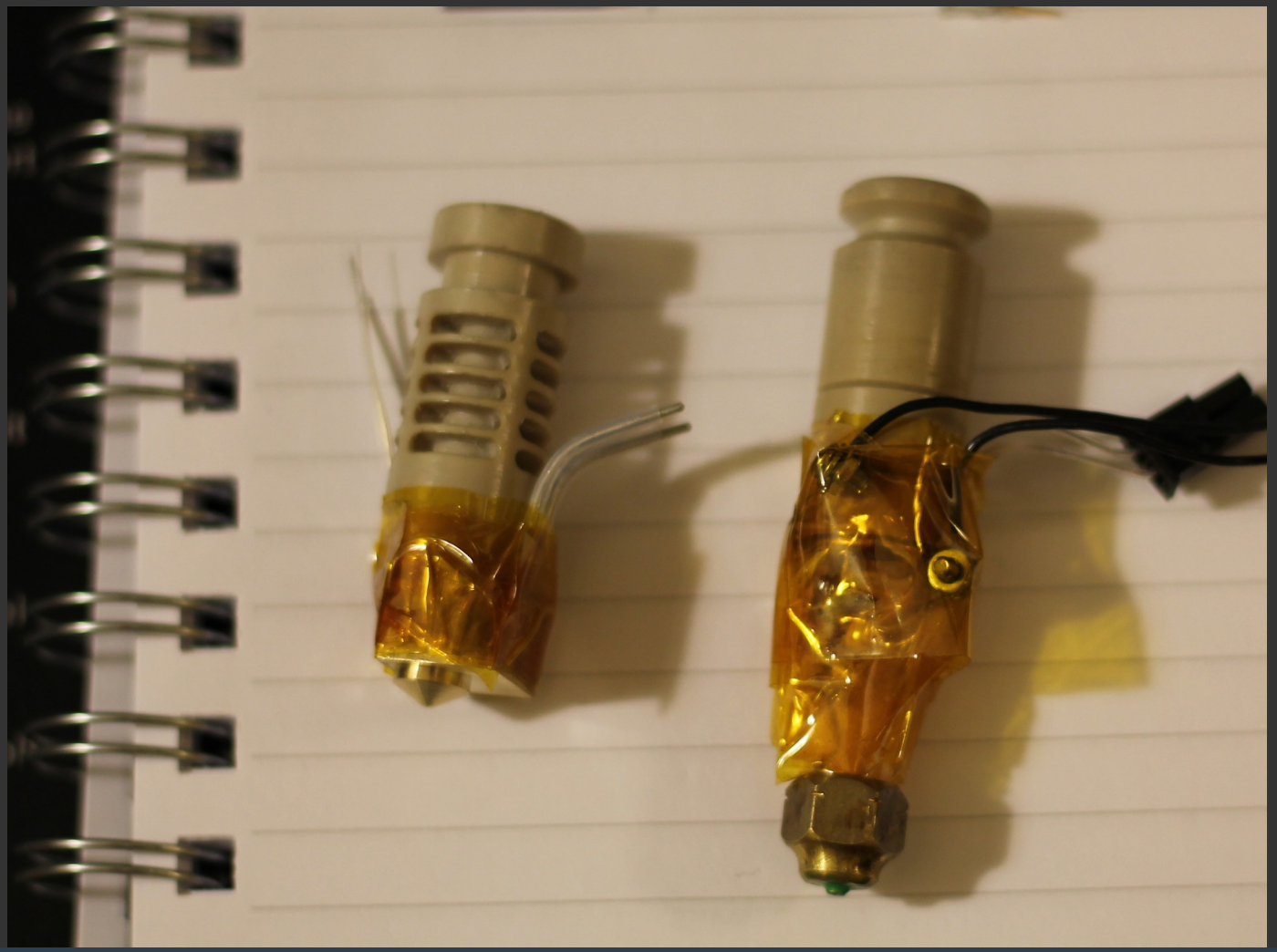
Challenges - Material Defects

There are currently very few standards for FDM filament. Quality control problems reign supreme.

Our very first reel of filament had such issues. The plastic had a synthetic polyester-like filler in the core which ruined an ubis hotend.

Challenges – Material Defects

We did try repairing it :(



Challenges – Mechanical Defects

This is a huge area.

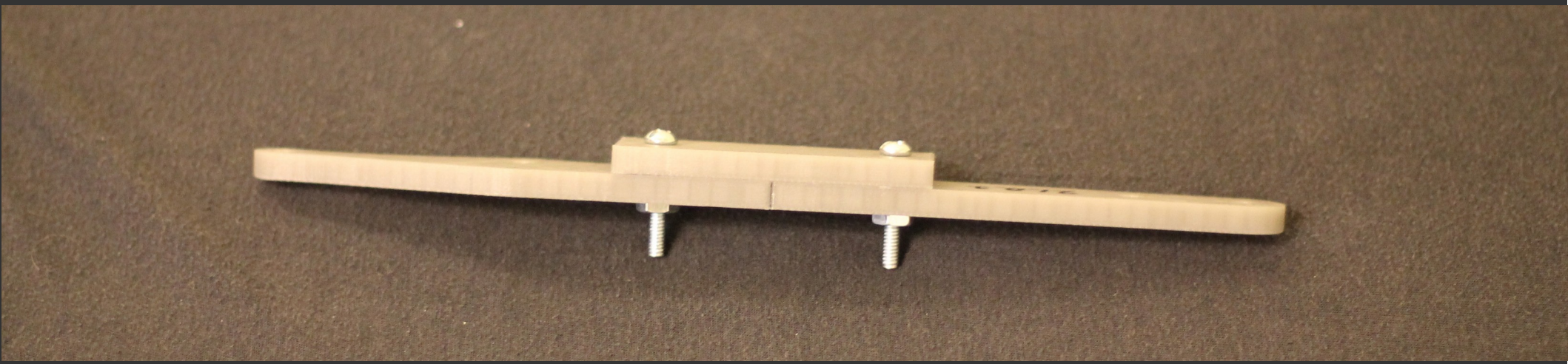
The science of printing is still very basic and loose. Speed, temperature, nozzle diameter, material, and many more factors play into creating a 'good' versus 'bad' print.

When these parameters don't align, nothing else matters. The print will fail.

Challenges – Mechanical Defects

Strong part adhesion.

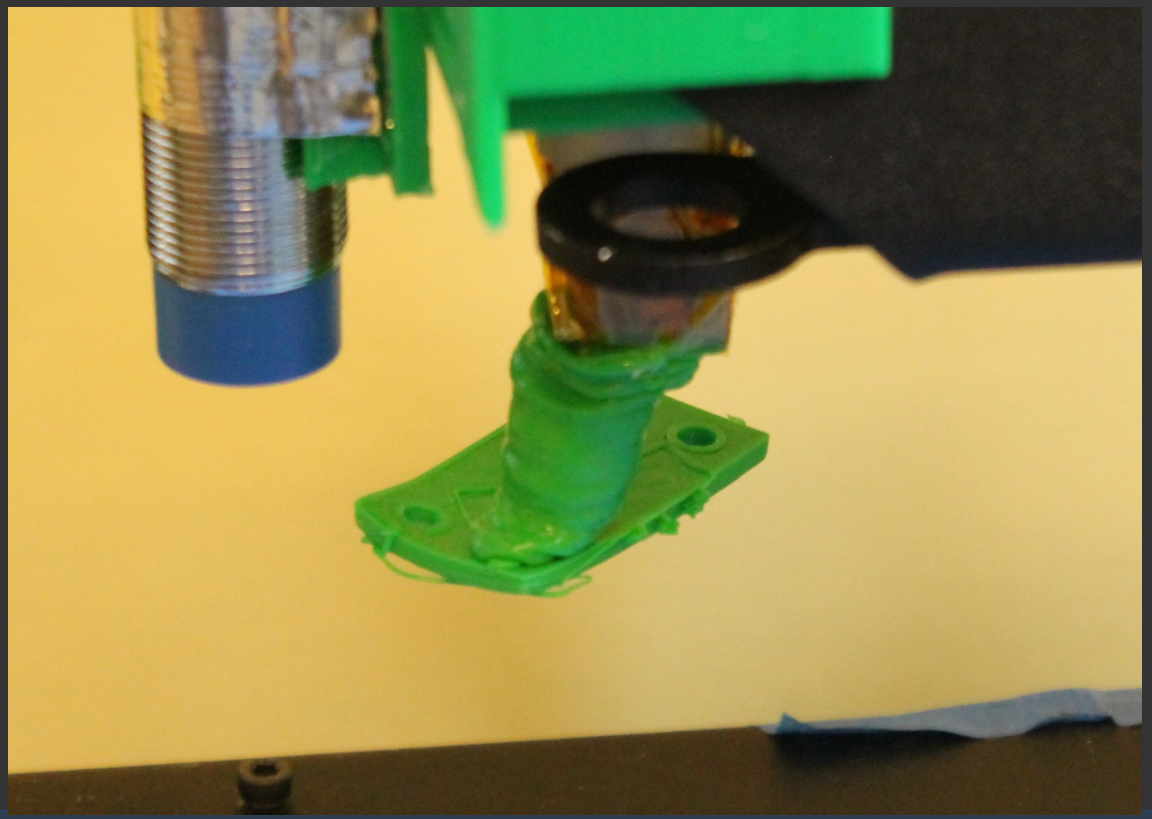
Base of part is flat, no warping or curling of edges.



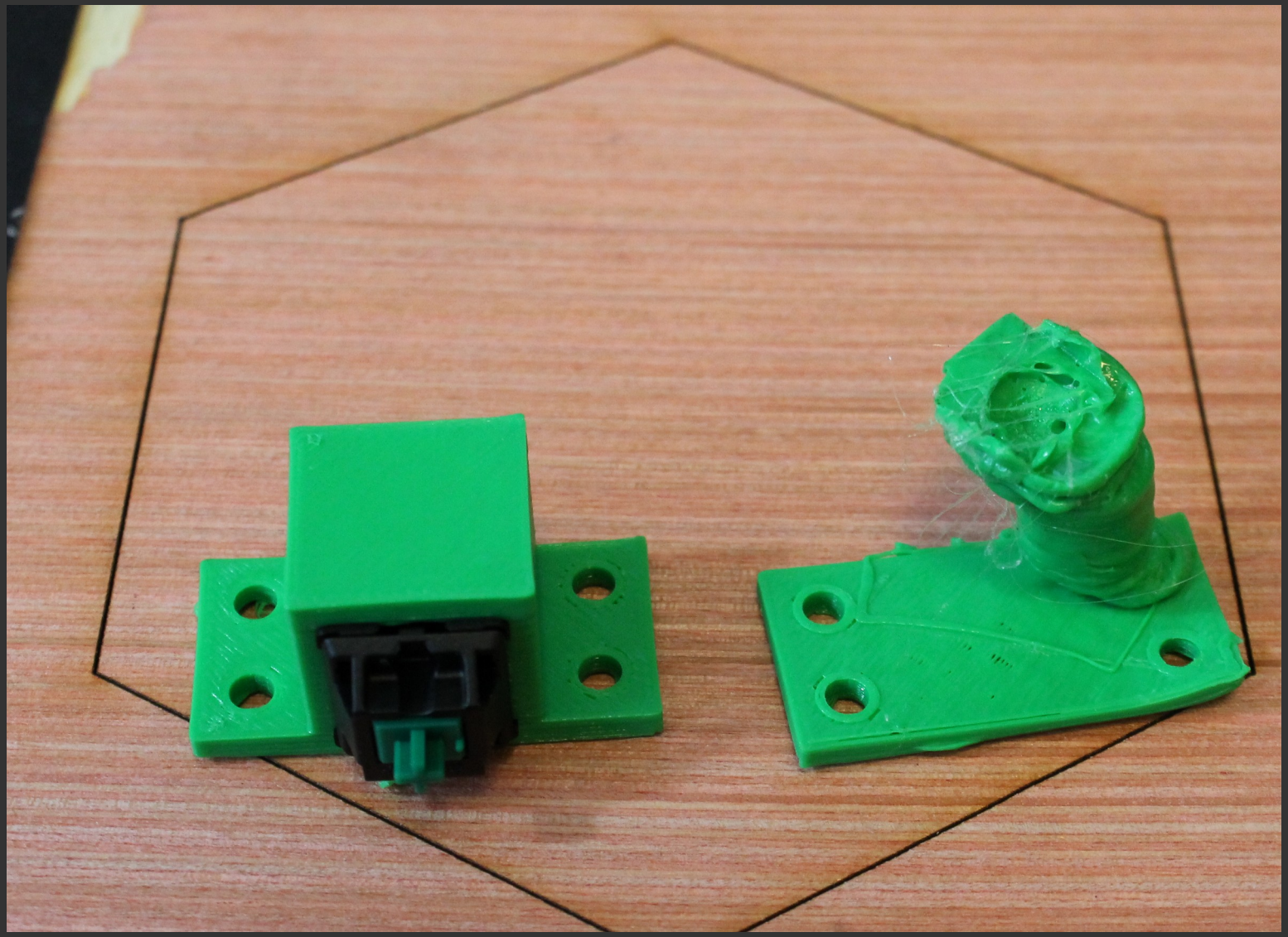
Challenges – Mechanical Defects

No part adhesion to the build surface.

Systems to detect this failure mode are required for serialization.



Challenges – Mechanical Defects



Challenges – Operator Overhead

Printing with most consumer grade FDM systems entails babysitting the printer while it is powered on and operating.

Imagine: If you had to sit there and watch every load of laundry and be ready to jump up and catch it when it starts spewing molten clothes around.

You now understand how consuming this task is.

Serialize

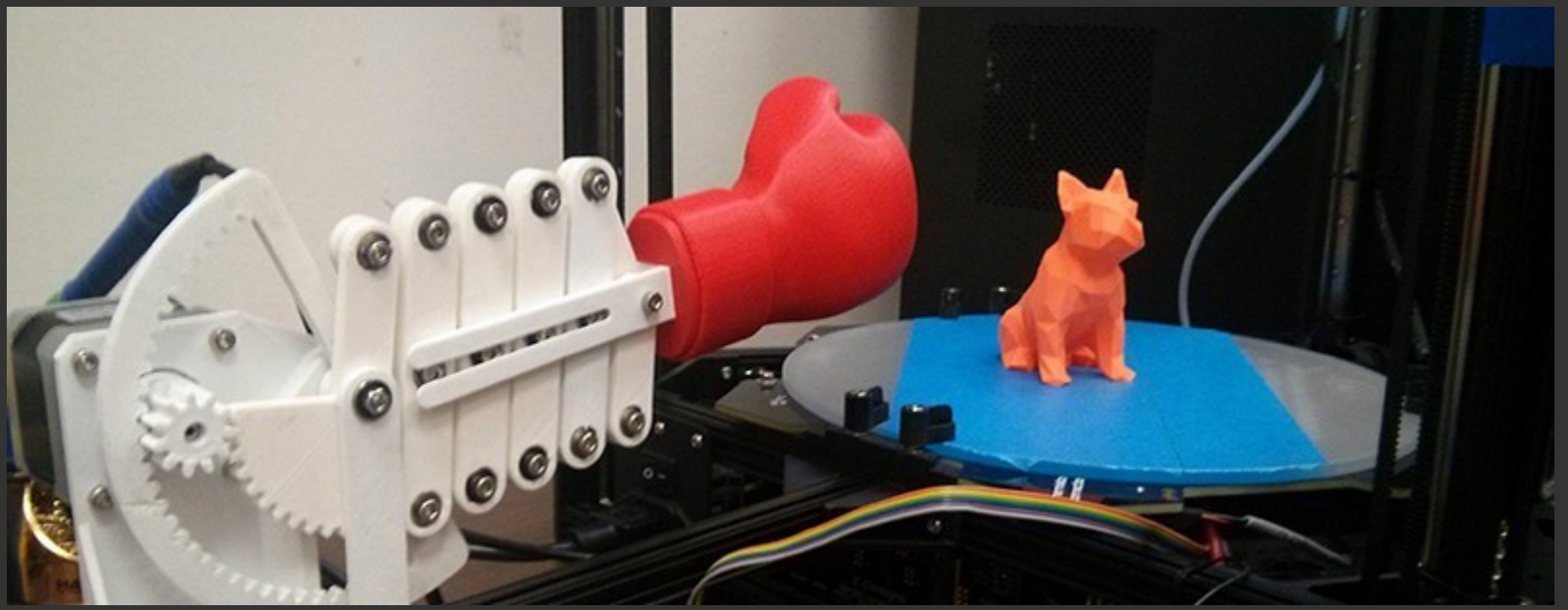
We want to investigate serialization for the purpose of maximizing output. More things printed -> more keyboards and tools for those who need them.

Our focus: automated build plate prep.

But really, serialization is the jumping off point to providing printers to soldiers and others in remote support situations (expeditions, space).

Serialize – Existing Systems

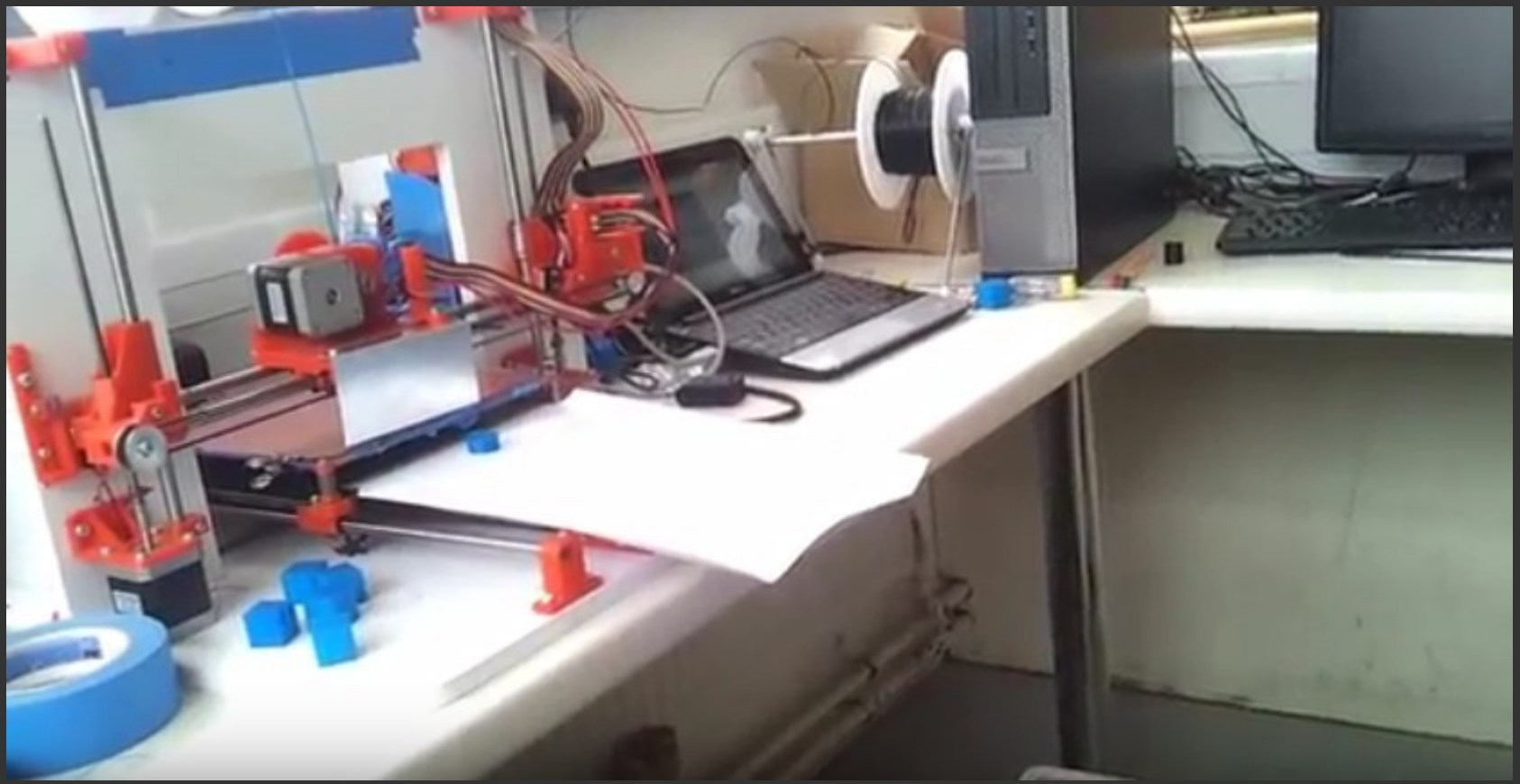
A recent video from online.



Scissor mechanisms: We want to increase robustness, not eliminate it!

Serialize – Existing Systems

Existing RepRap work:
Pretty much all one person.



SanjayM's part ejection system

Serialize – Existing Systems

Existing commercial work:
Pretty much all one company.

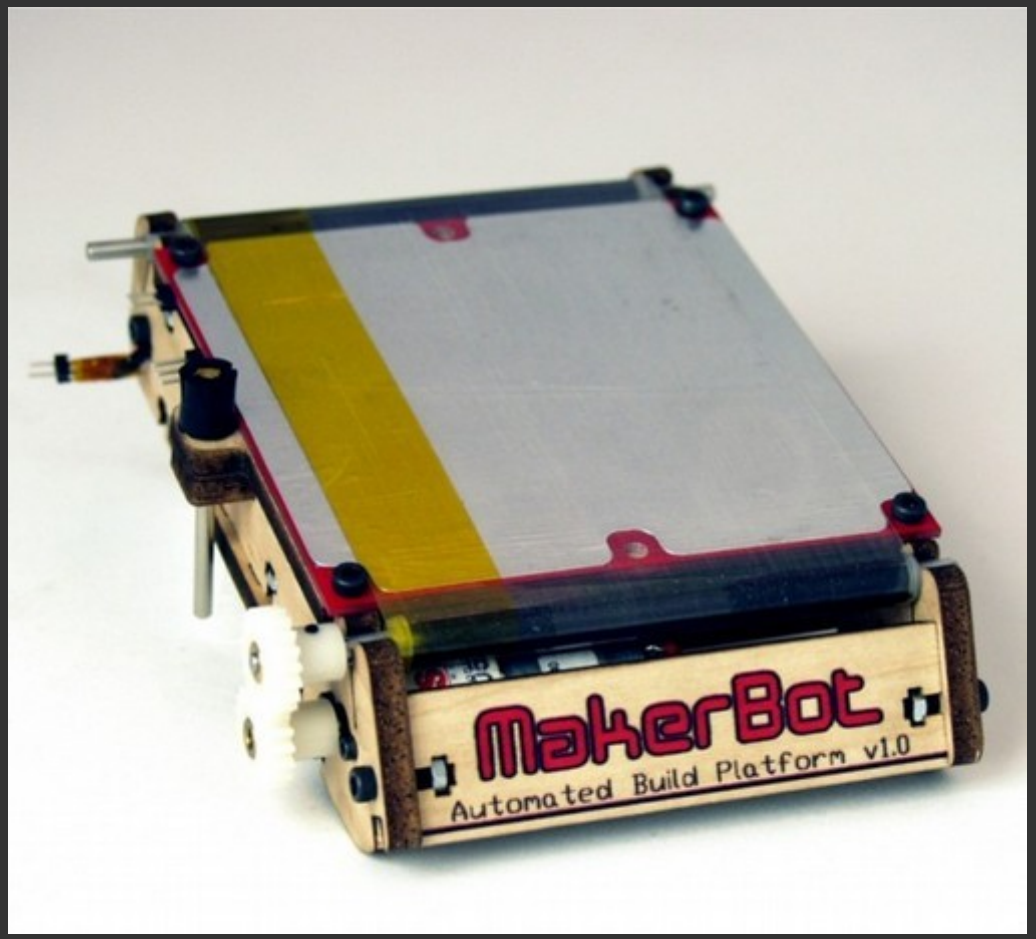
The NVPro

http://makezine.com/2013/09/26/worlds-first-fully-automated-3d-printer-for-schools/

Serialize - Existing Systems

There's also this black sheep.

MakerBot touted this Automated Build Platform around 2010, and then immediately discontinued it.



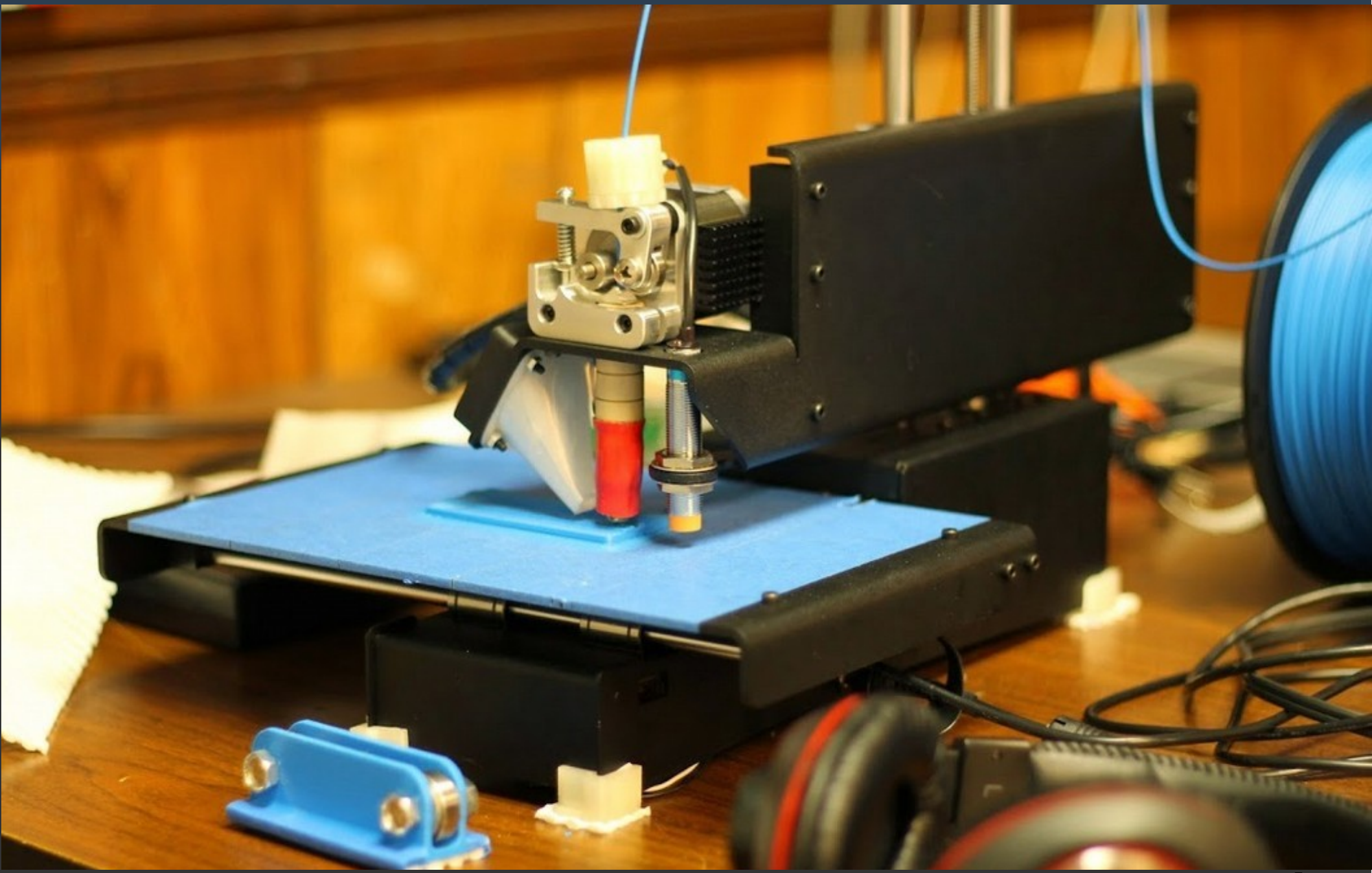
http://www.makerbot.com/blog/2010/09/13/makerbot-automated-build-platform

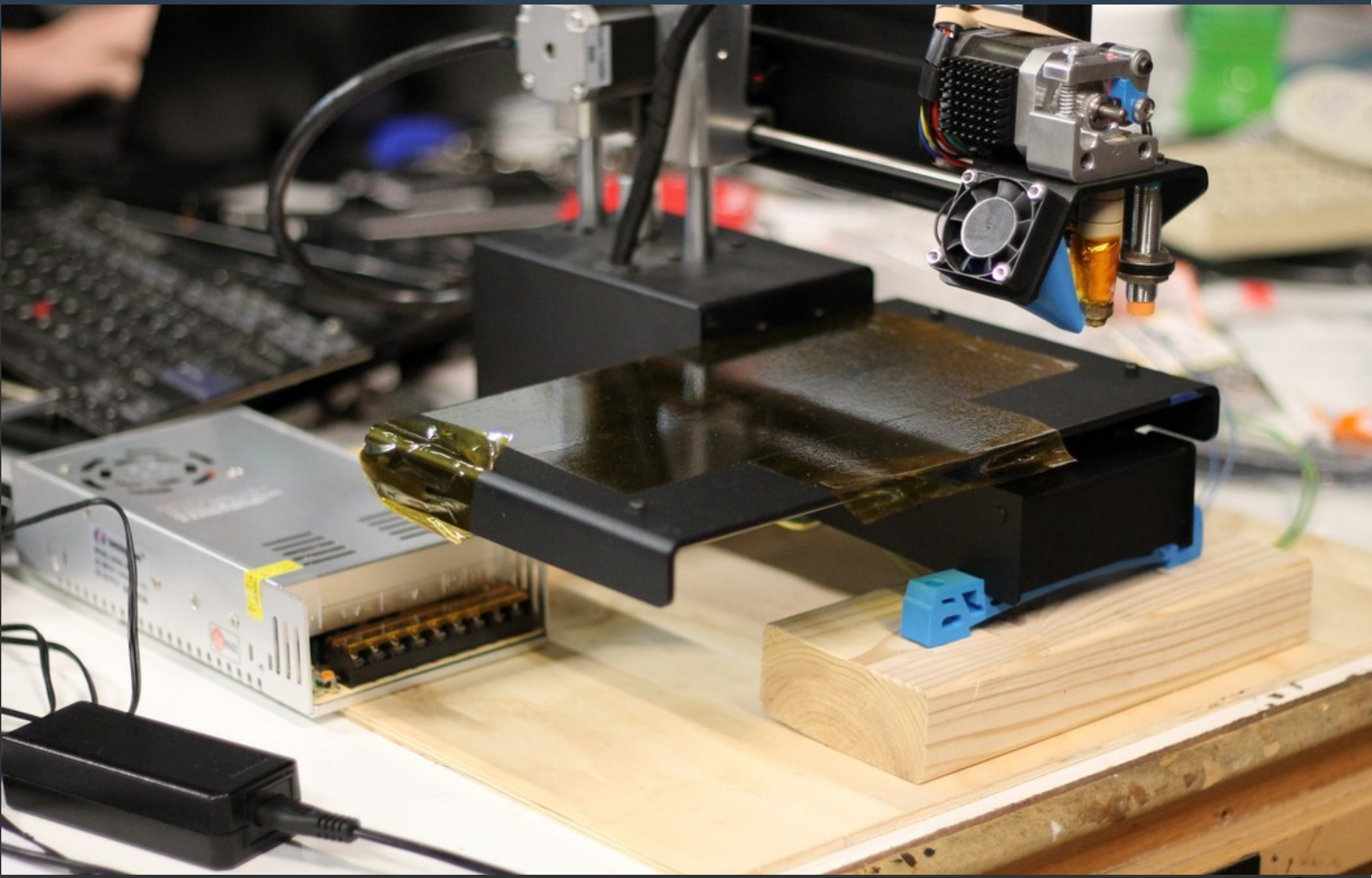
Serialize - Our Work

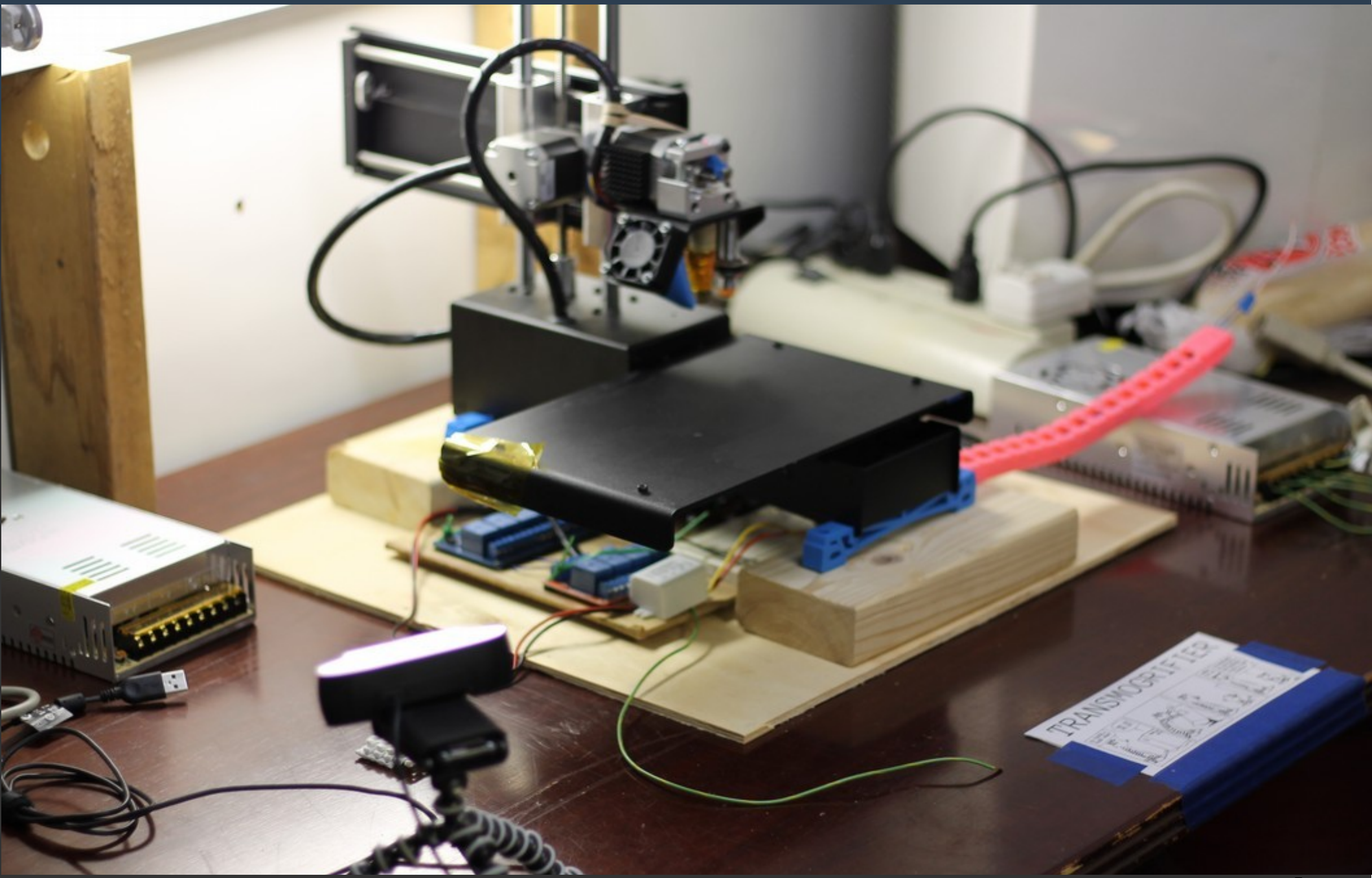
OK, we want to make printers automatically eject finished prints.

Let's dive right in!

We're going to need a printer...

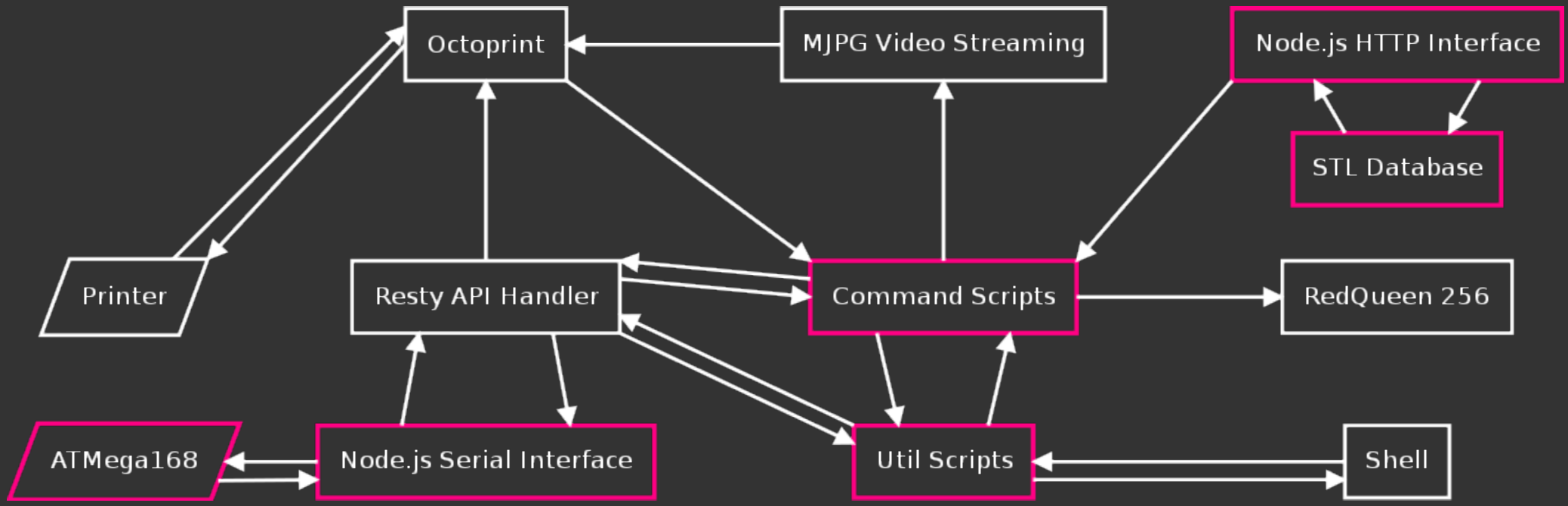





TRANSMOGRIFIER

Serialize – Our Work

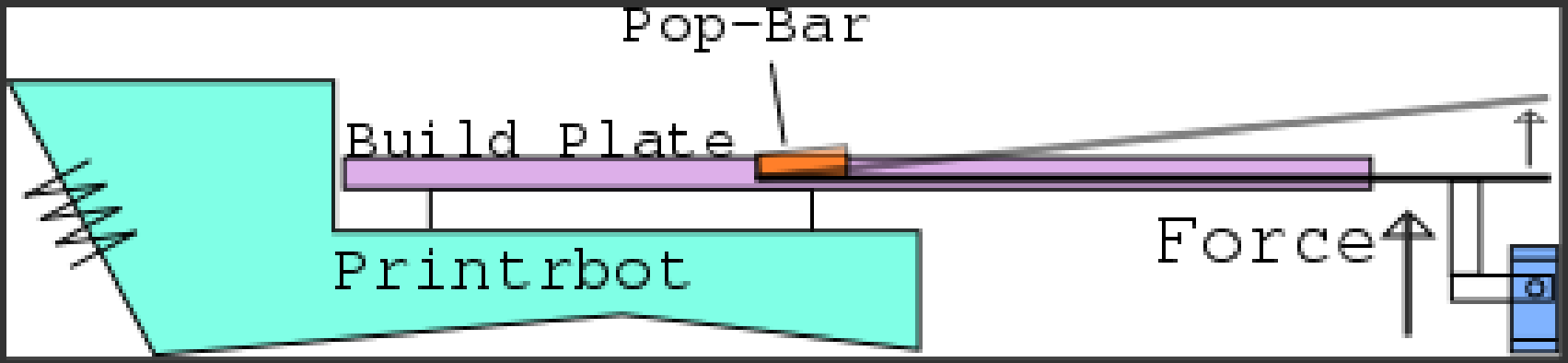
Cool. Now we need software.



Serialize - PopBar

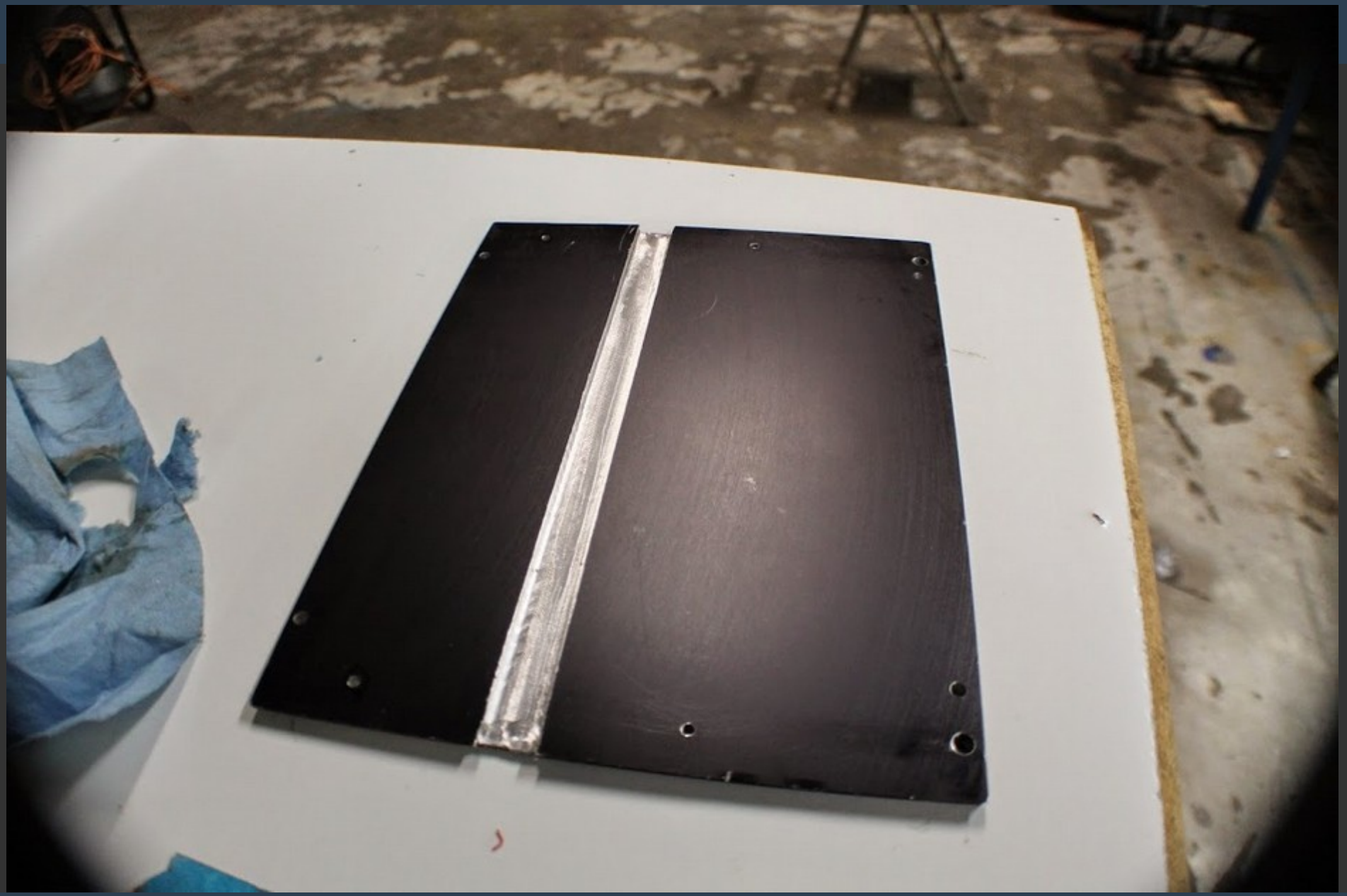
What about a bed-of-nails approach?

Reducing the mechanical complexity leaves us with a lever embedded in the build platform.

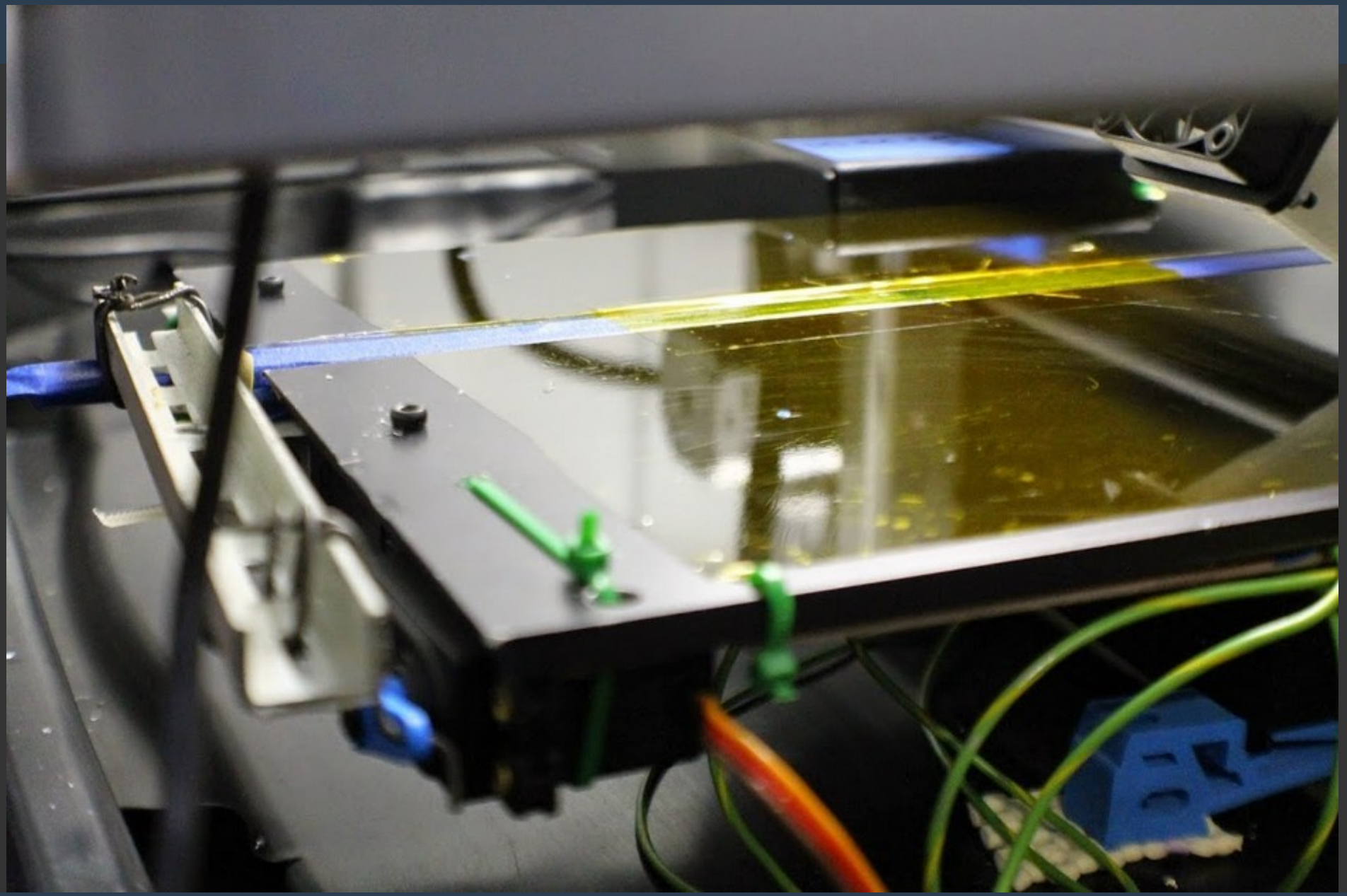


Serialize – PopBar

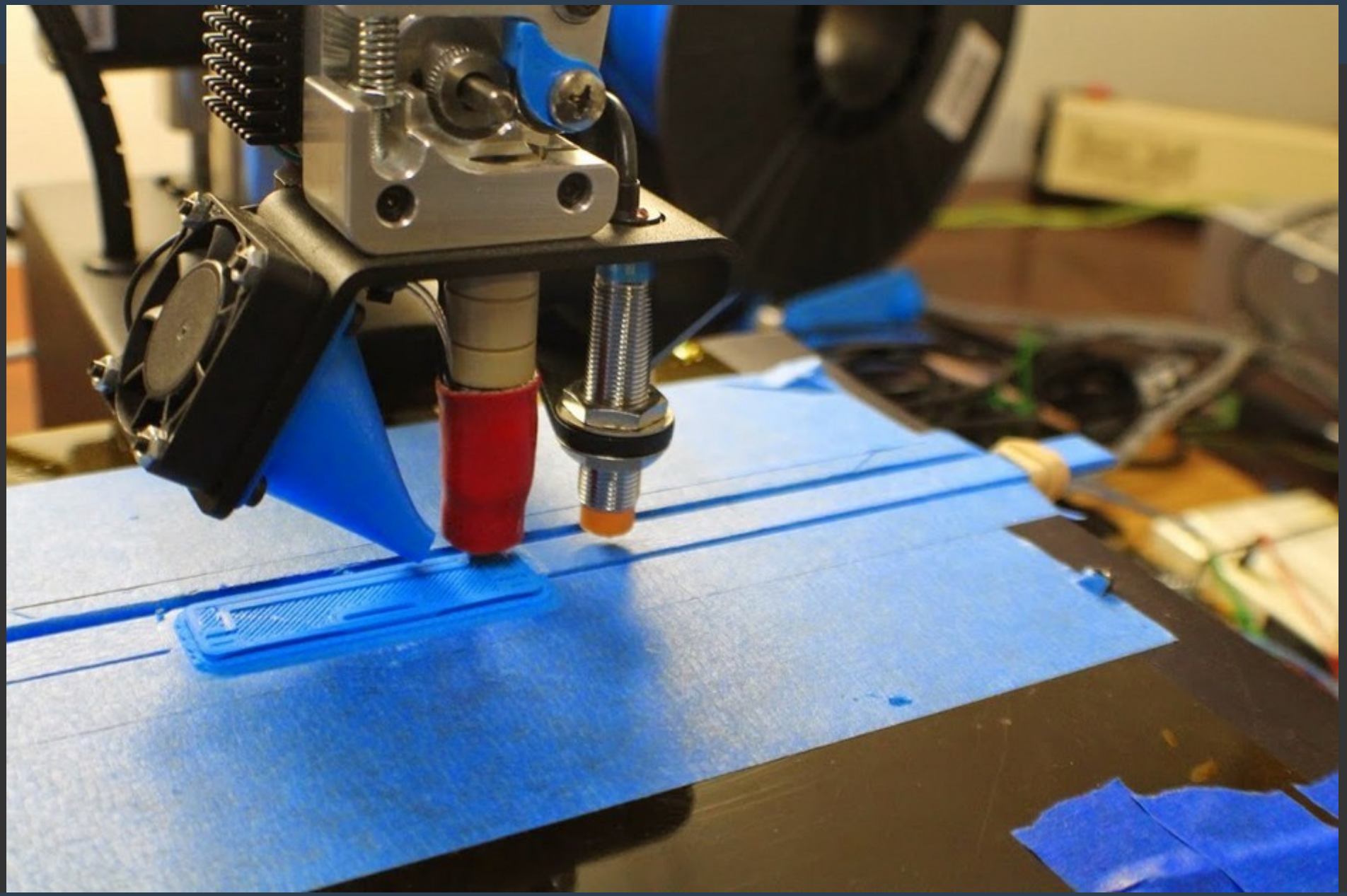
Serialize – PopBar



Serialize – PopBar



Serialize – PopBar



Serialize - PopBar

Build Plate Pop-Bar:

- Much more robust than expected, inconclusive since this is a draft.

- If mis-configured will destroy a hotend.

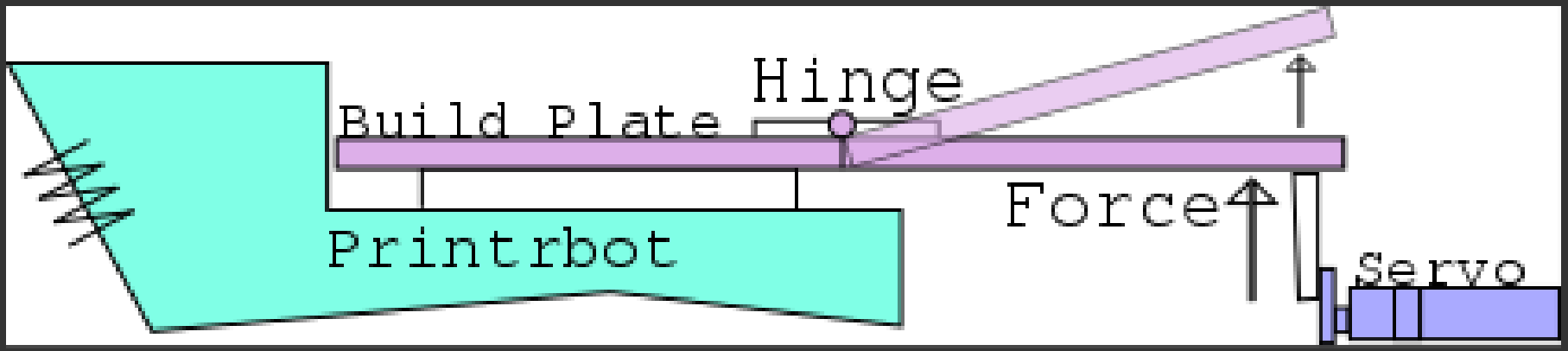
- Won't work with a heated bed, due to warping

- Didn't work with an inductive probe due to differences in metals.

Serialize - Hinge

Pop-Bar is out, what if the mechanism was larger?

We never got around to building this.

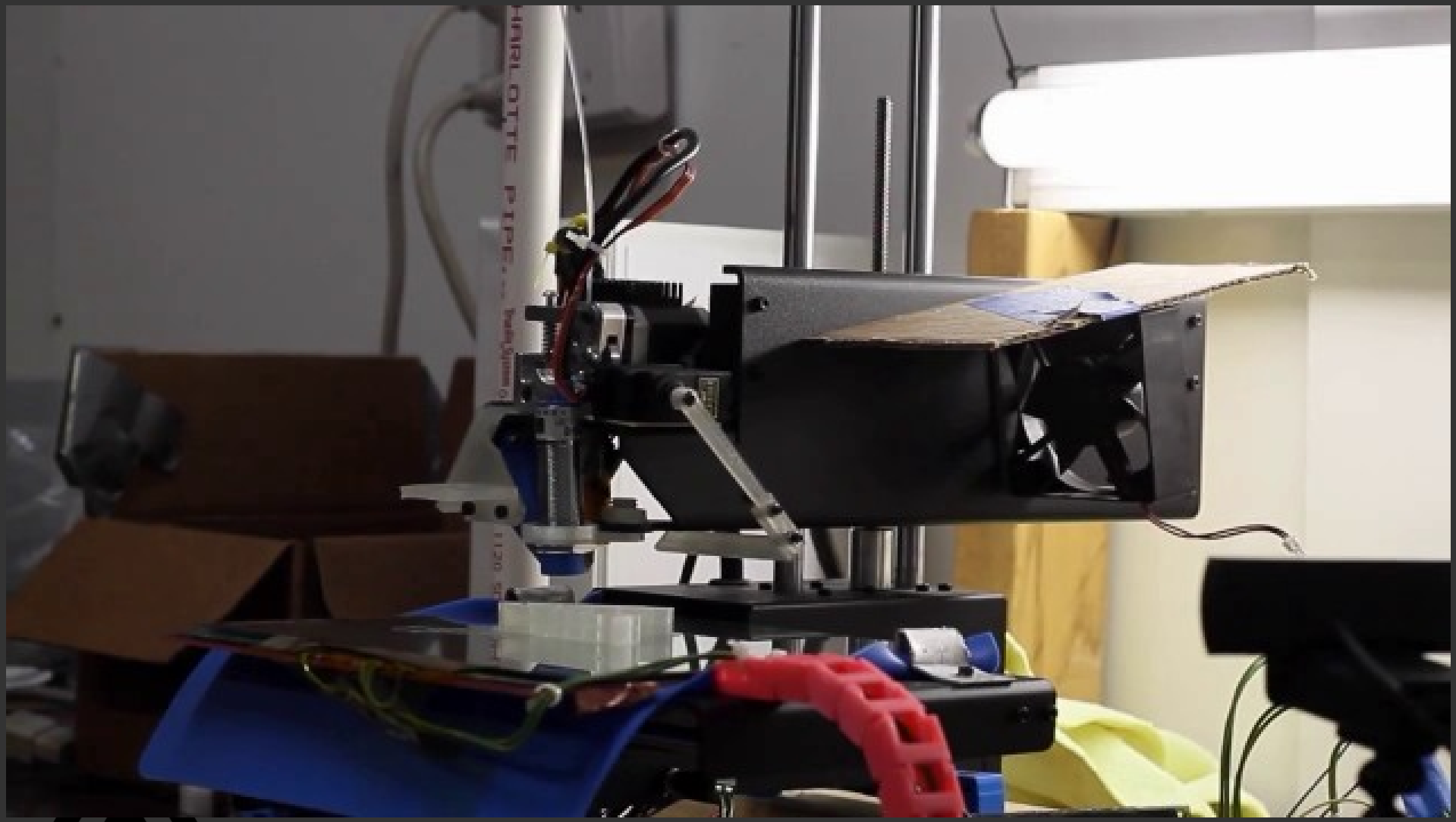


Serialize - Bulldozer

Extruder mounted bulldozer:

- possibly too weak, esp if quieter steppers are used.
- Same destructive capabilities as the punching glove.
- Decreases robustness of system. Keeping the extruder calibrated becomes a larger challenge.

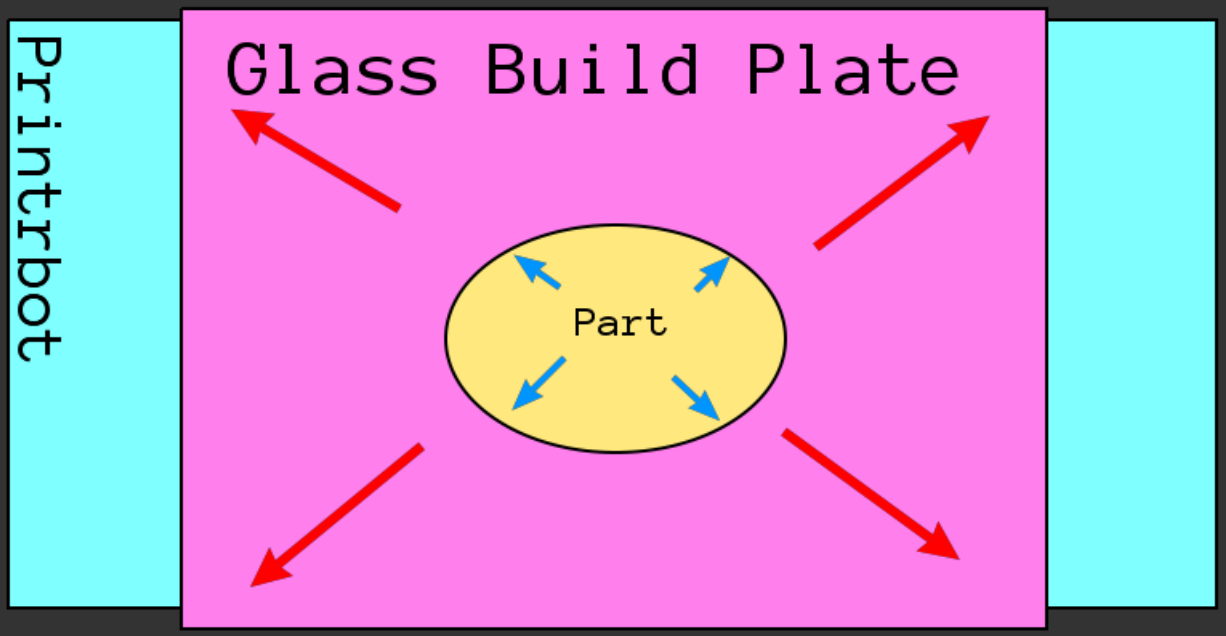
Serialize – Bulldozer



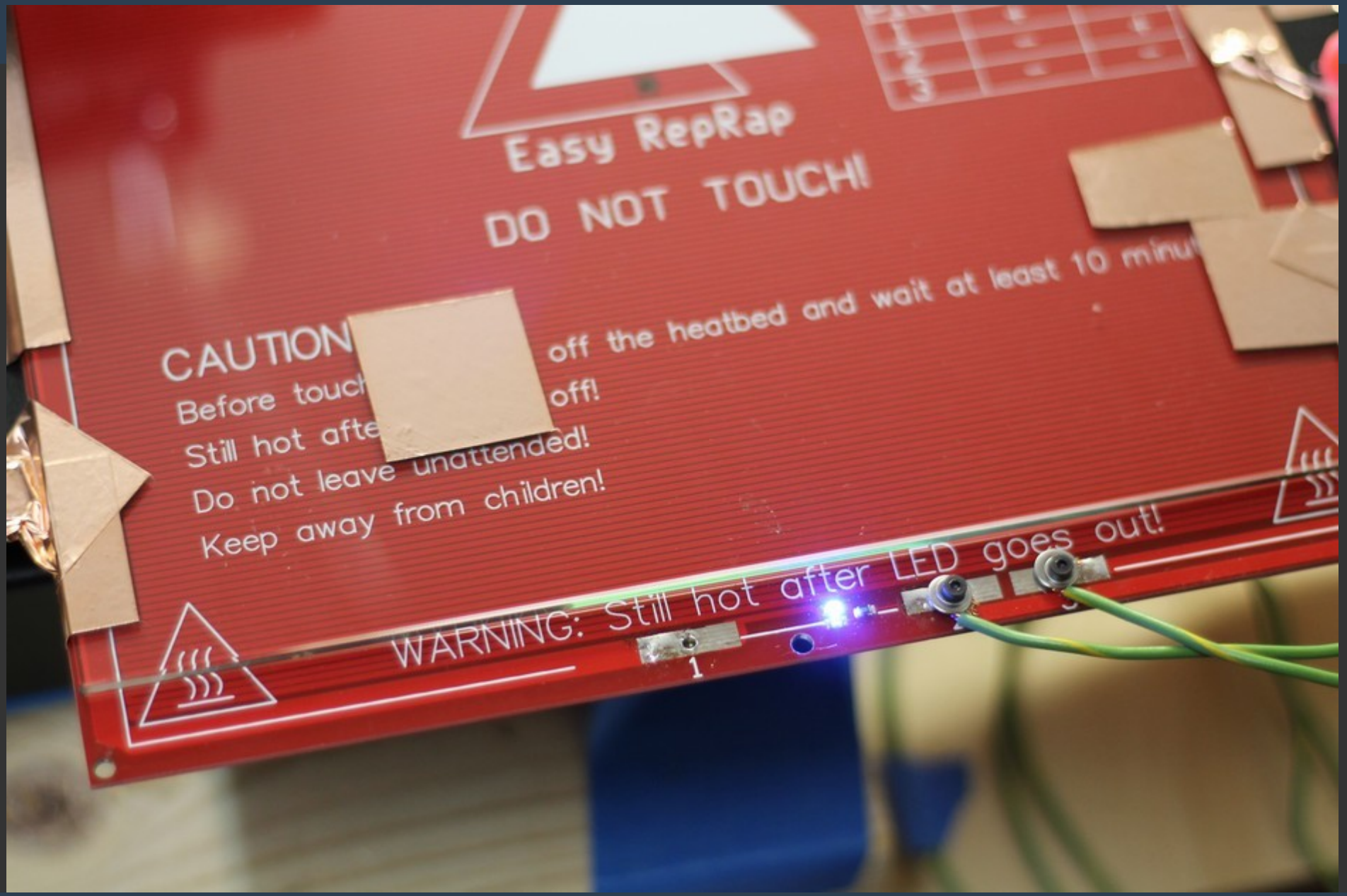
Serialize - HGBP

The ultimate frustration in FDM land:
What material to make the build plate from?

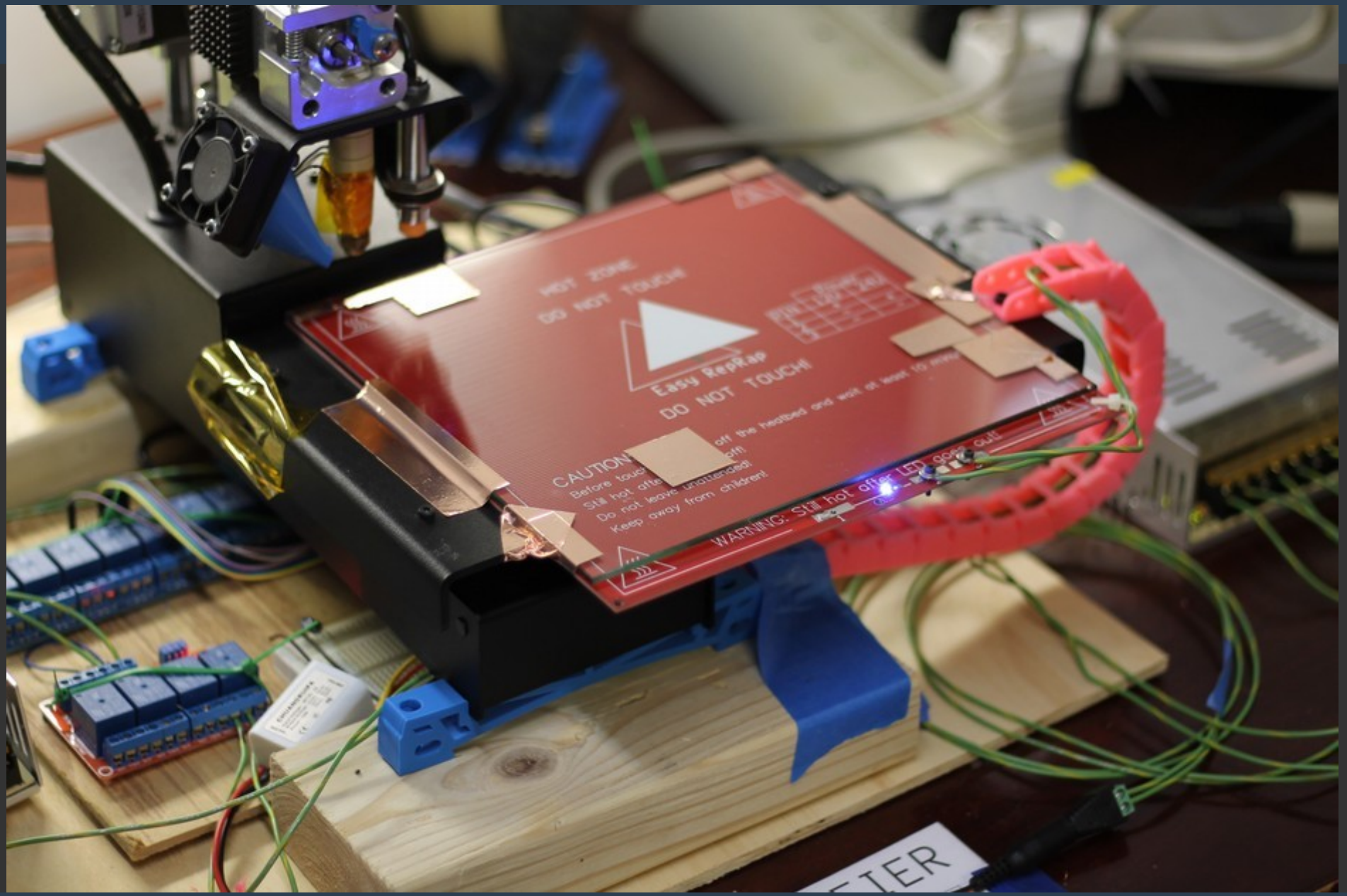
Well, on forums some people discuss how nice glass is because parts will separate more easily after cooling..



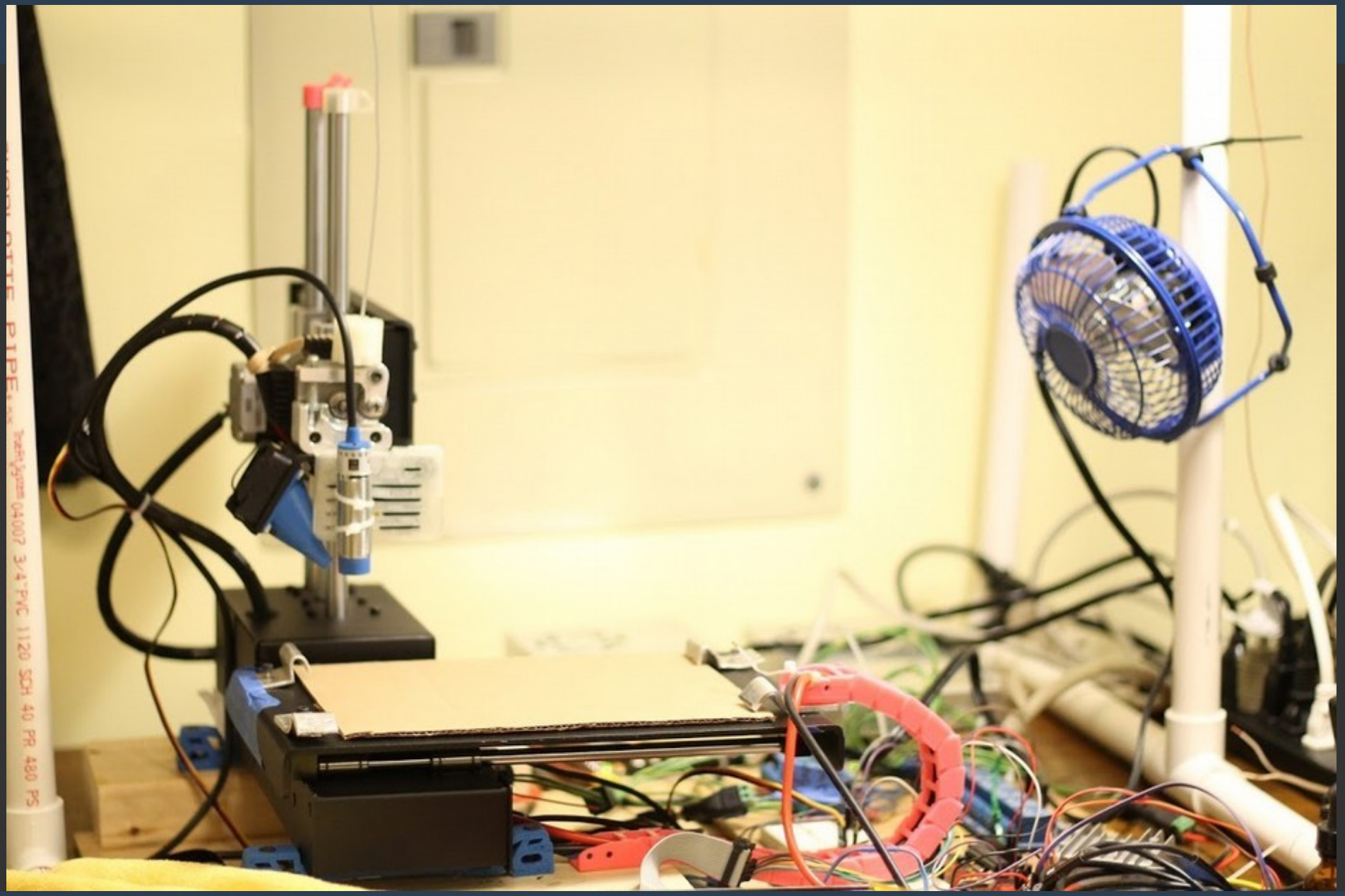
Serialize – HGBP



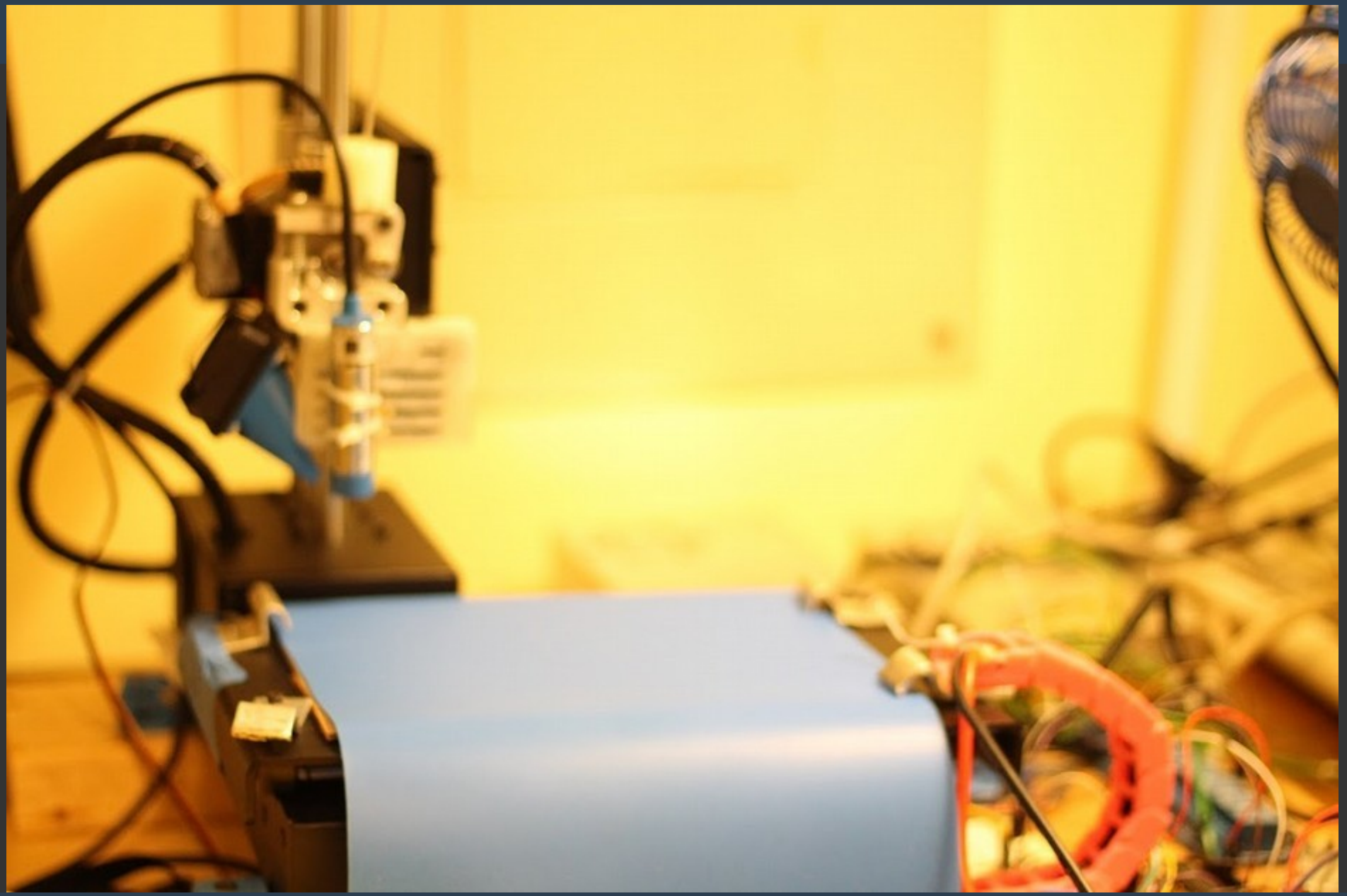
Serialize – HGBP



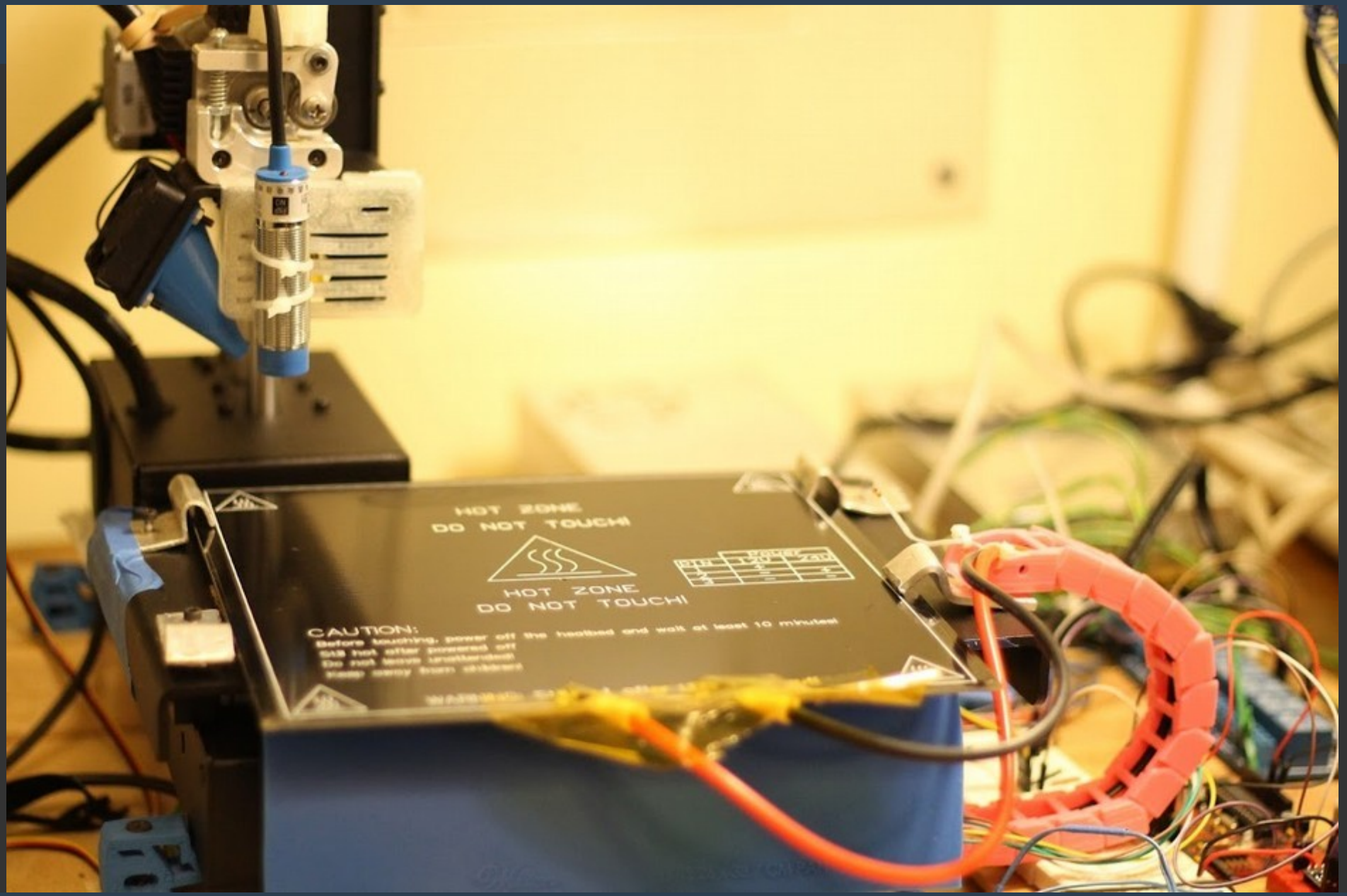
Serialize – HGBP (v3)



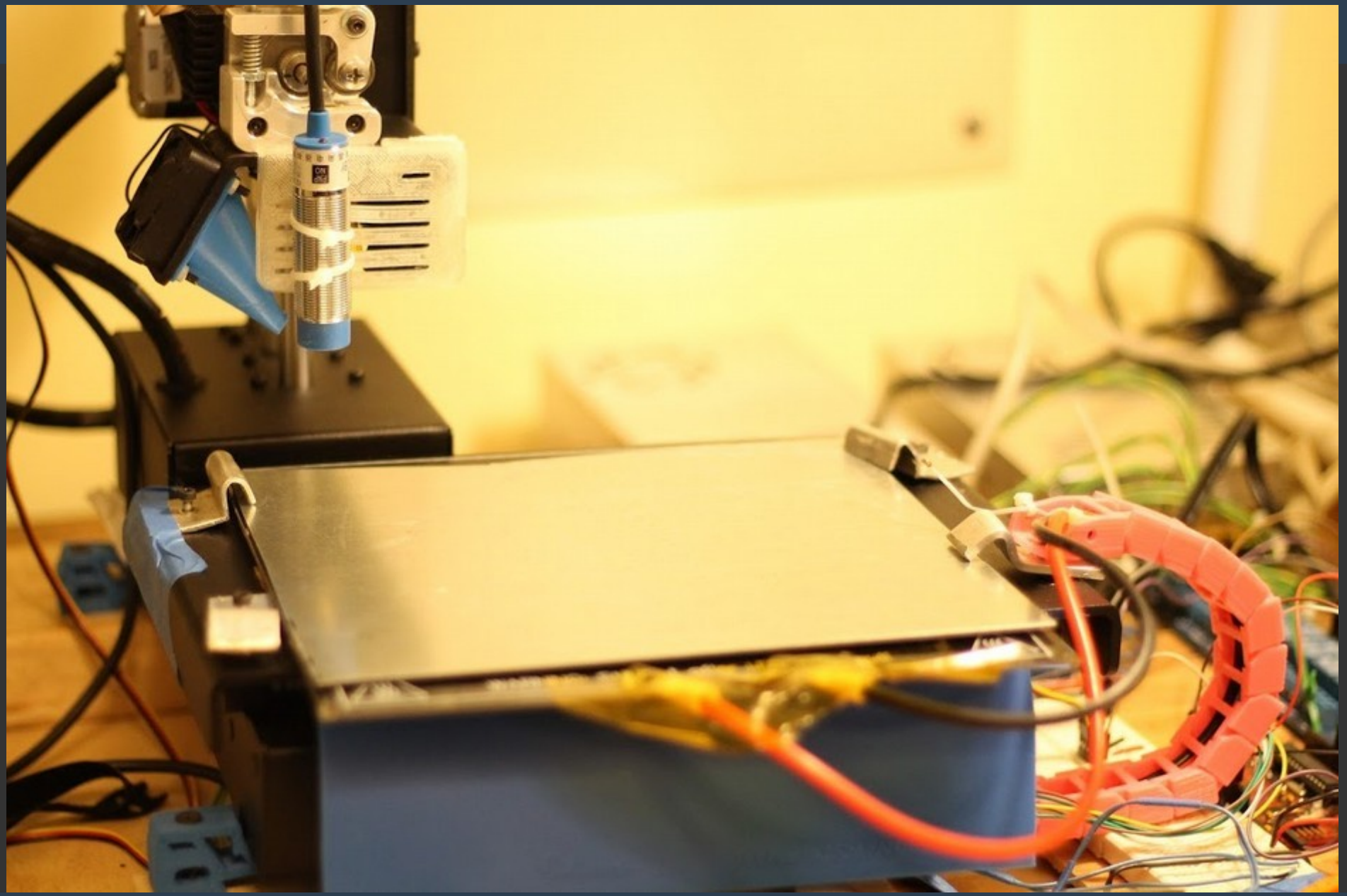
Serialize – HGBP



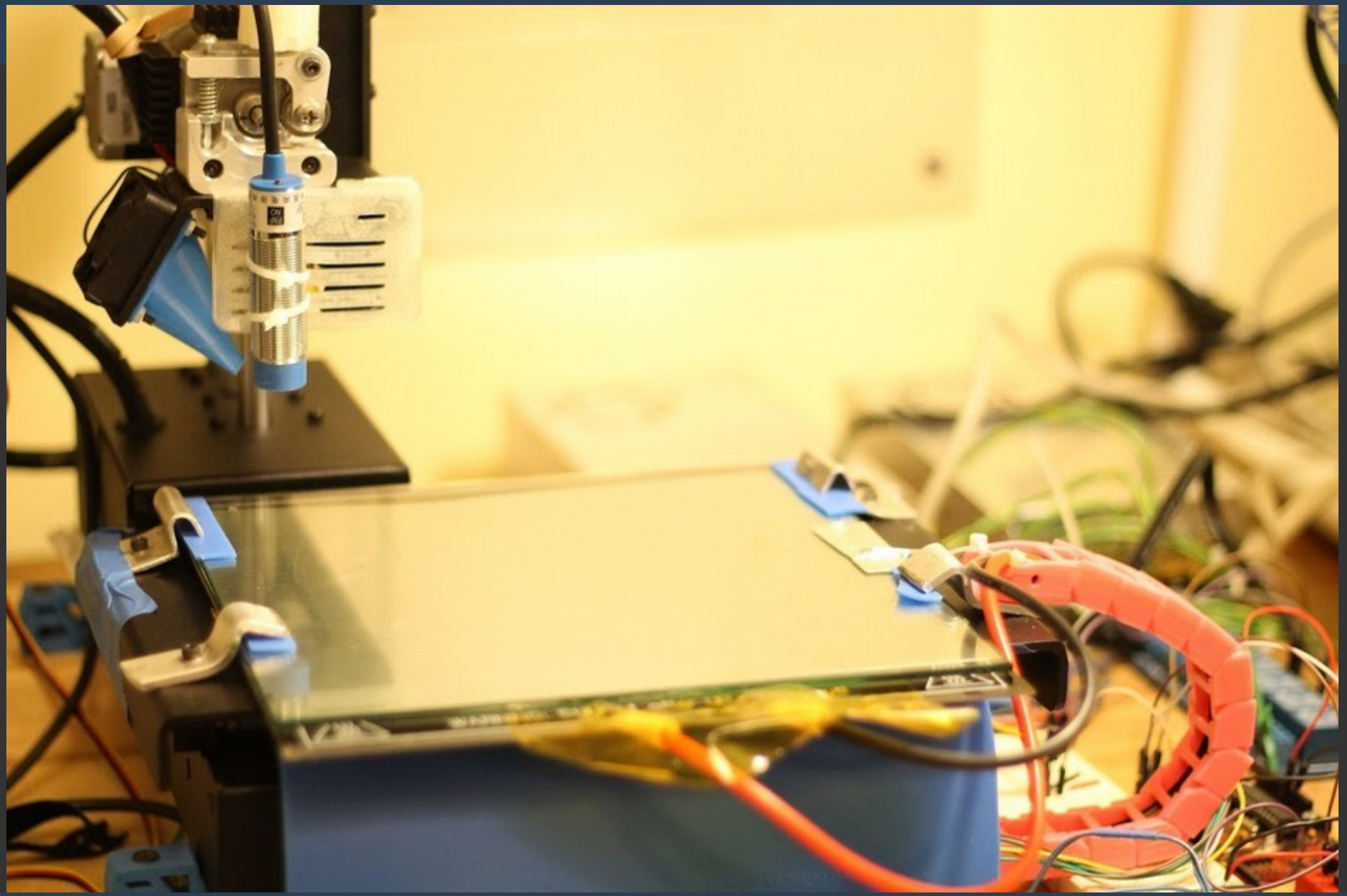
Serialize – HGBP



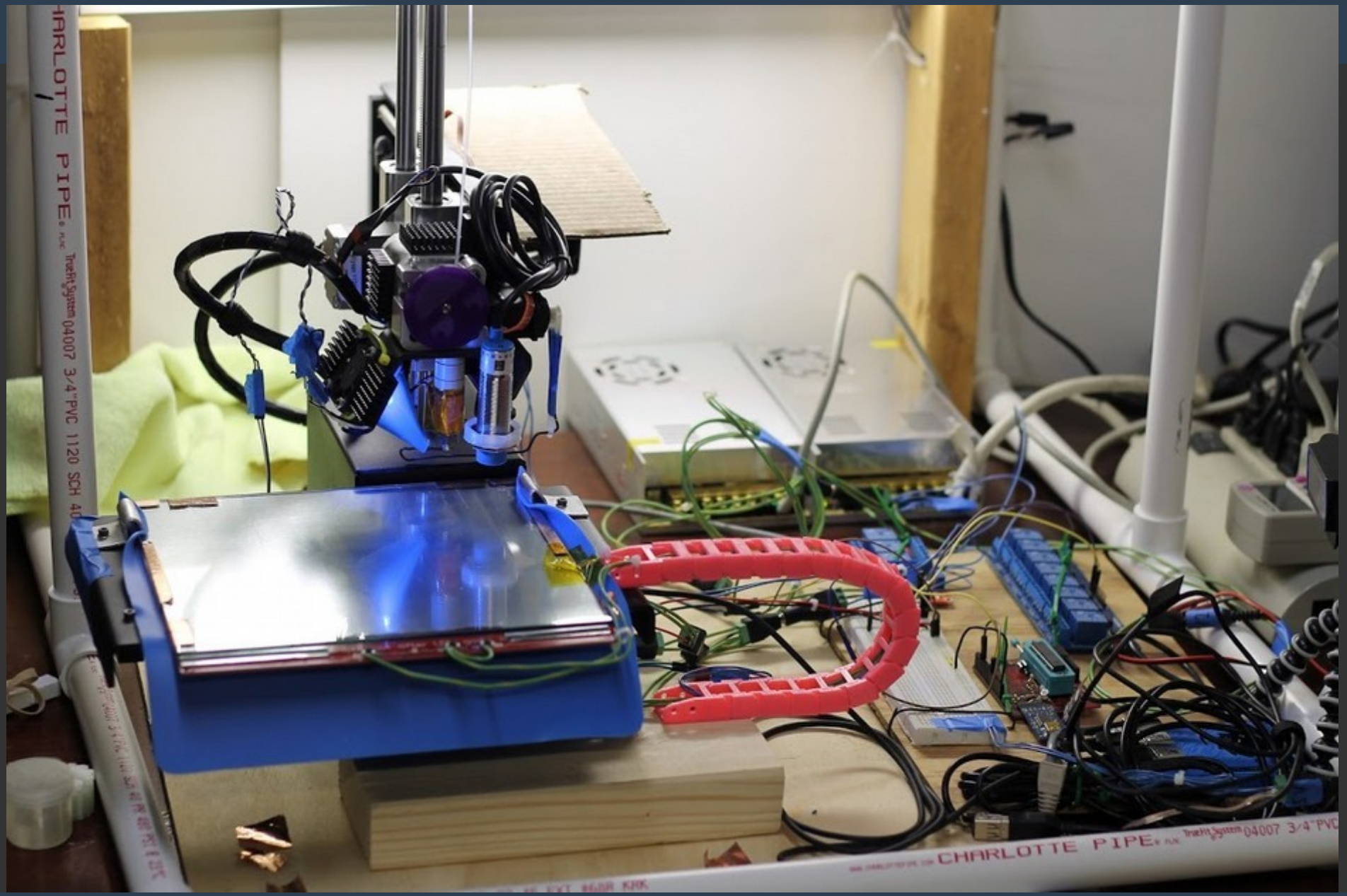
Serialize – HGBP



Serialize – HGBP



Serialize – HGBP



Serialize - HGBP

Glass Build Platform Pitfalls:

- The borosilicate glass plate isn't perfectly flat. Easily fixed with proper sourcing.

- Had to retrofit the new induction sensor.

- Parts now come free perfectly. Sometimes even before the print is done.

FIN

Sources are linked at the bottom of each page.

That's all folks!