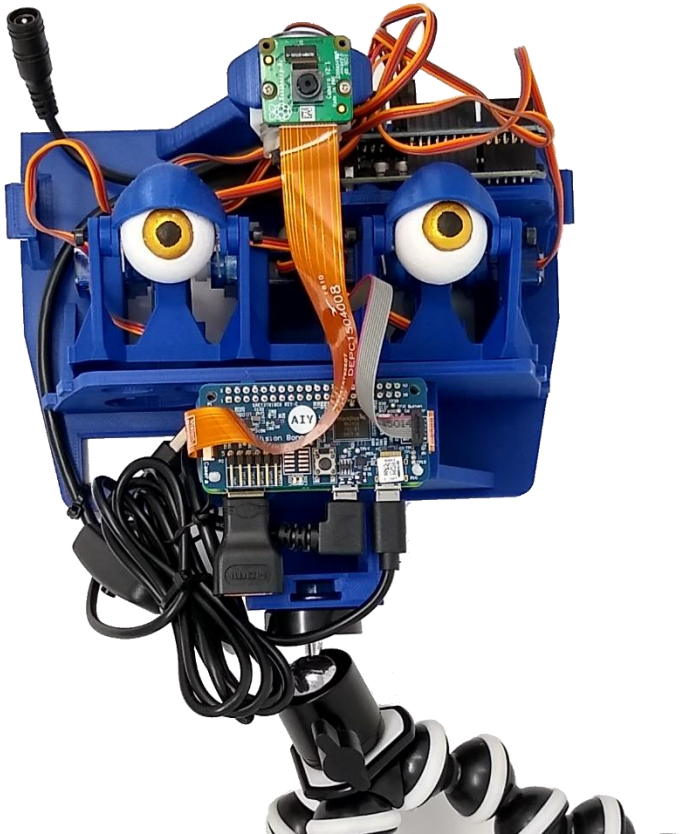
Mechanical Engineering Portfolio

Graham Jessup

The Watchman

Adding face tracking to animatronic eye mechanism

Personal Project, in work

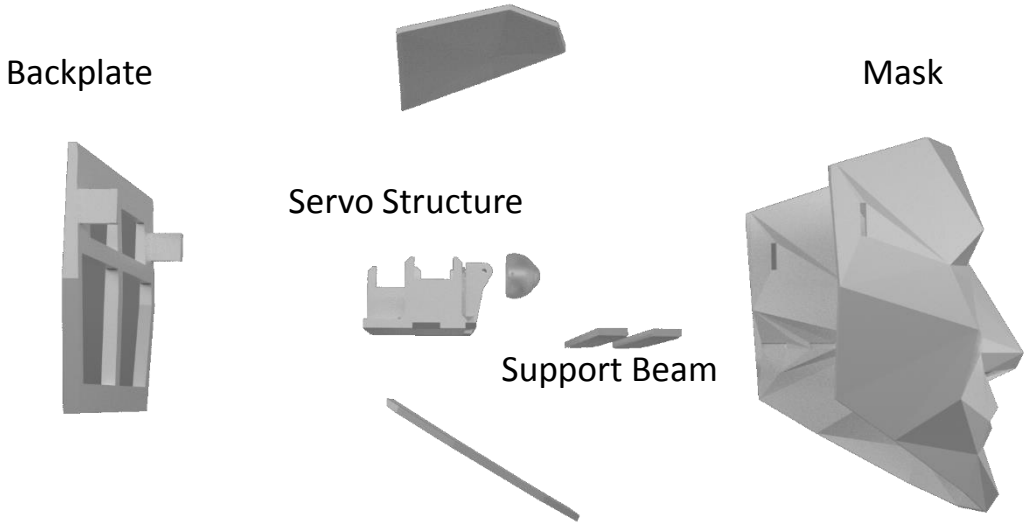


Problem Definition

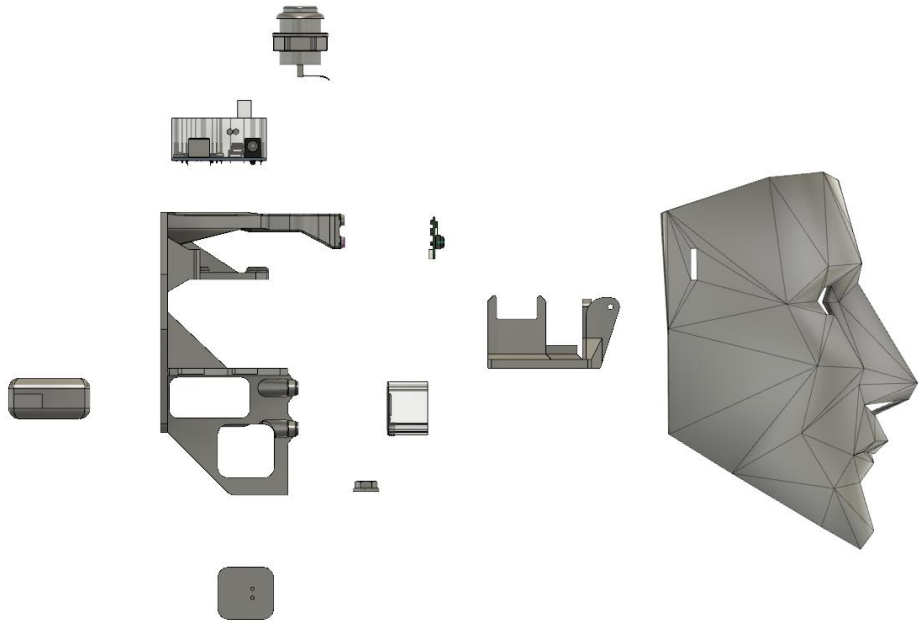
Tjahzi's Doorman project combines a 3D printed mask with an animatronic eye mechanism. In his project, eye movement is controlled via a pre-programmed script that is triggered by a motion sensor. I thought it would be neat if the eyes tracked me directly, rather than simply looking around.

Desired Upgrades:

- Eye tracking (facial tracking)
- Cohesive structure: able to remove mask to access internals without significant disassembly.
- Easily portable: battery powered/wireless



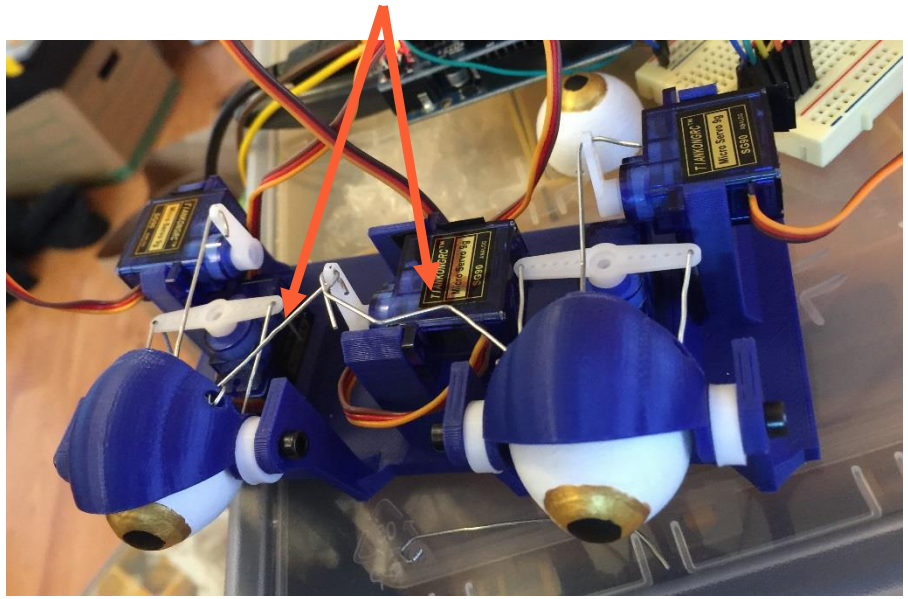
Tjhazi's Face Structure (image source)



Watchman Face Structure

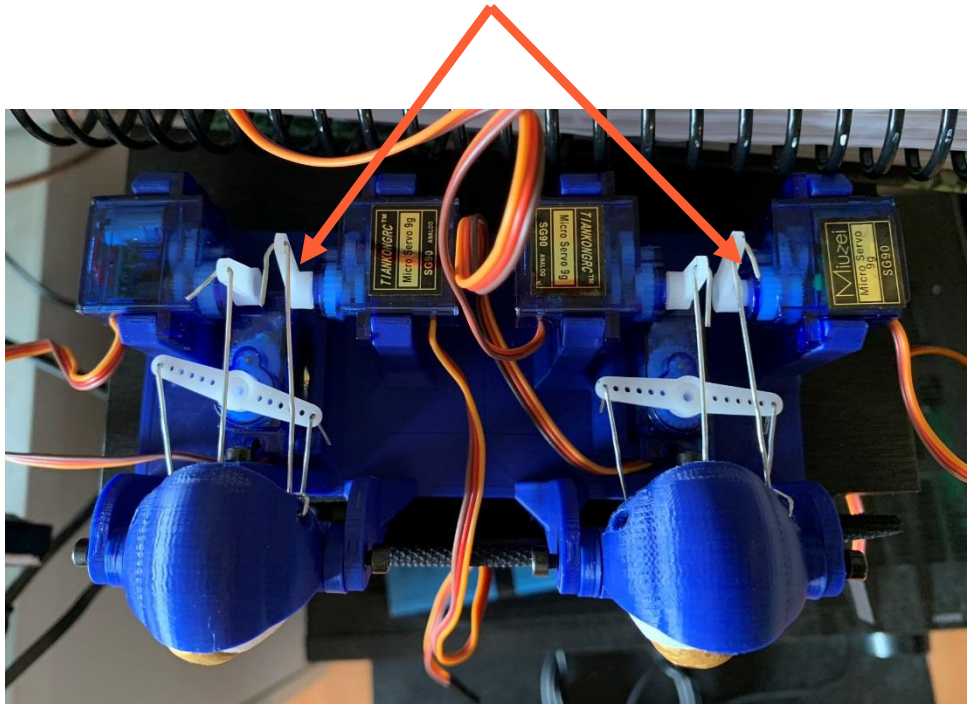
Development: Servo Mechanism

Single servo with asymmetric control arms:
Problem: Uneven eyelid movement



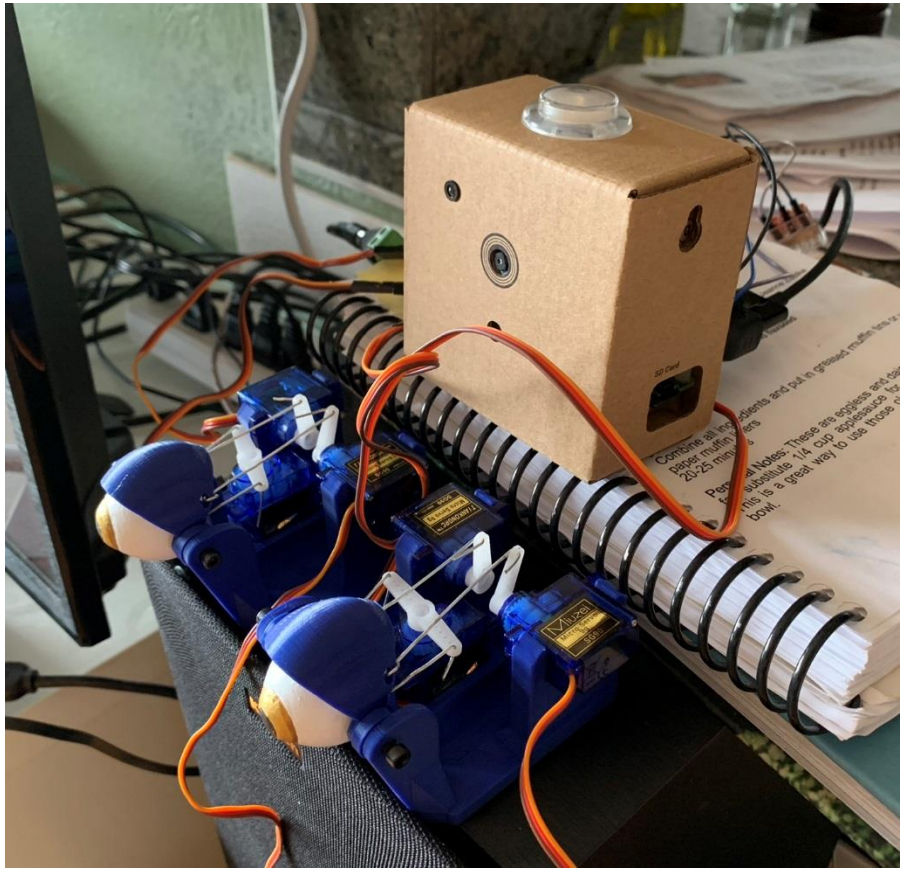
Tjhazi's five servo mechanism, with single eyelid servo

Dedicated eyelid servos allow consistent eyelid movement, independent eyelid movement possible.



Upgraded six servo mechanism

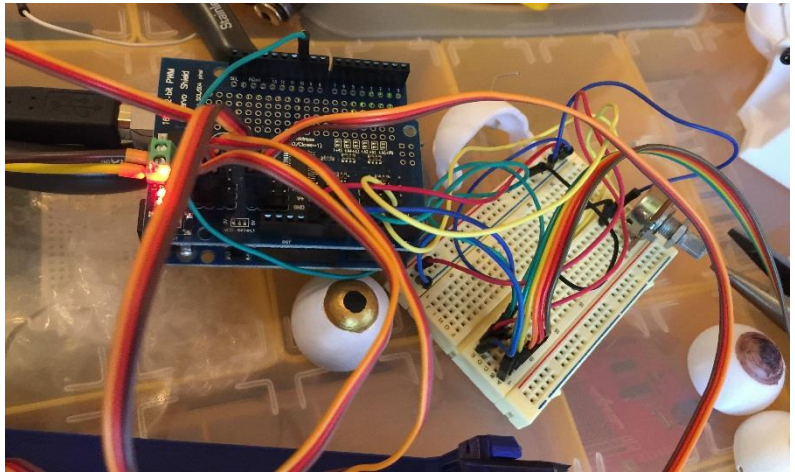
Development: Camera integration



First Test: AIY Vision kit running modified version of google's face detection demo. Servos are controlled with 4 PWM pins on AIY Vision Hat, with an external power supply.

Lessons learned:

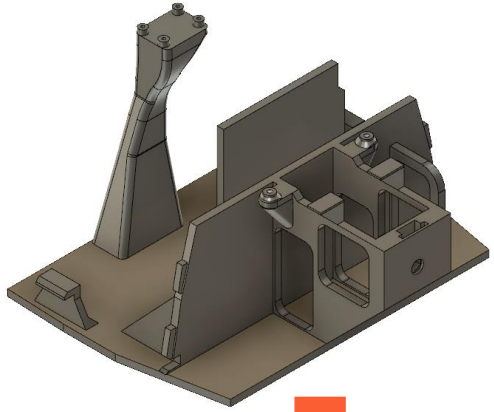
- Face detection runs quickly enough to provide effective face tracking
- **Too much servo jitter**, PWM pins on Pi are not suited to controlling six servos

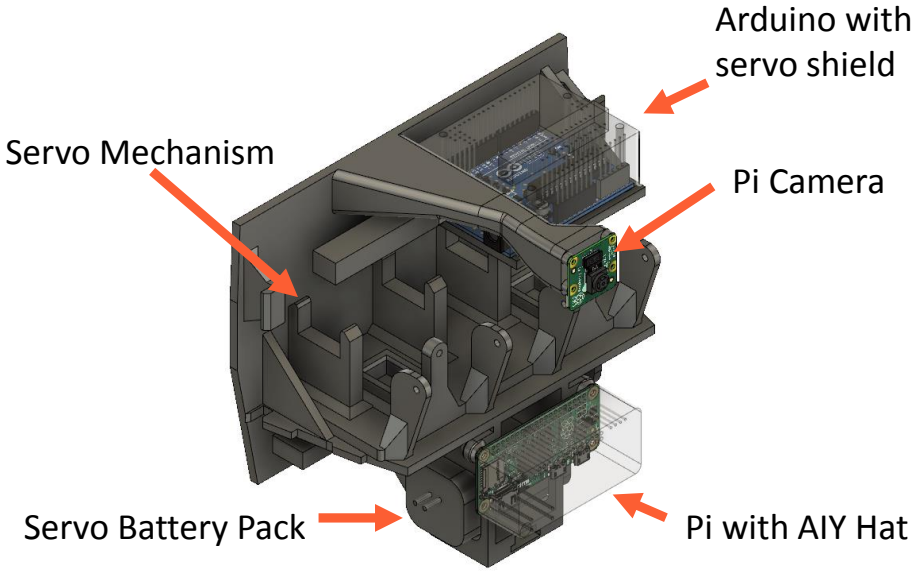


Solution: Add Arduino with servo shield to control servos

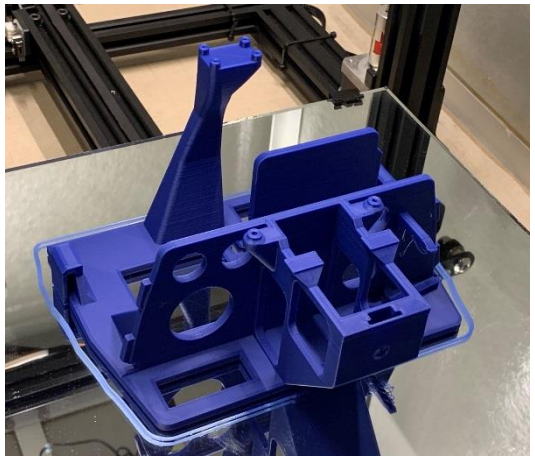
Development: Packaging Rev A

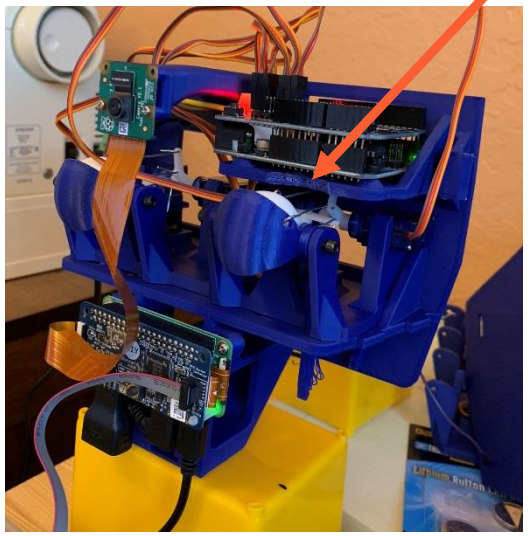
Integrating electronics into a serviceable package that fits within the mask.

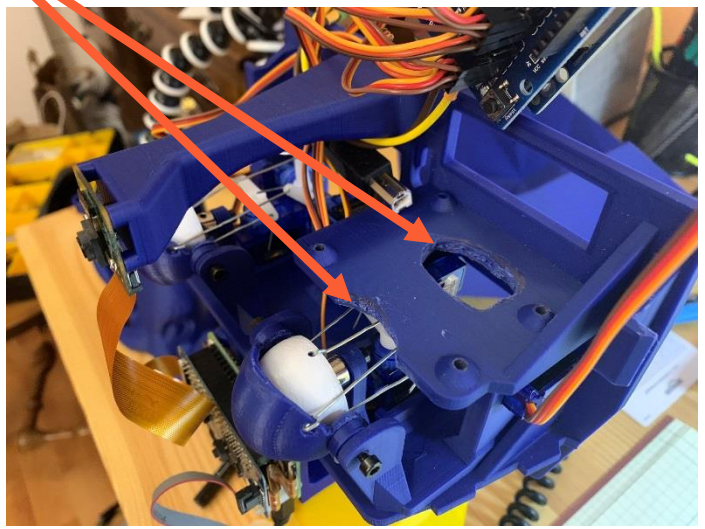




Problem: **Arduino Mount interferes with servo arms**, manual modification required

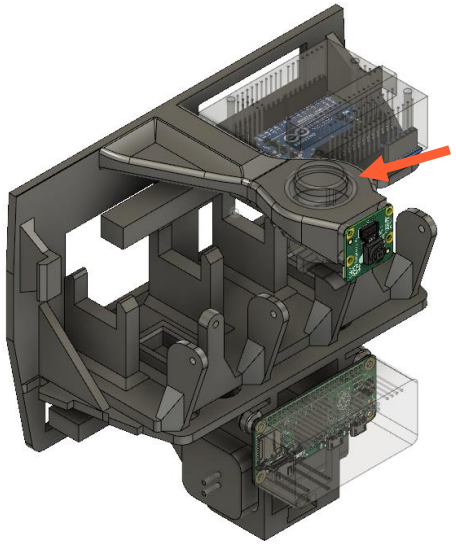




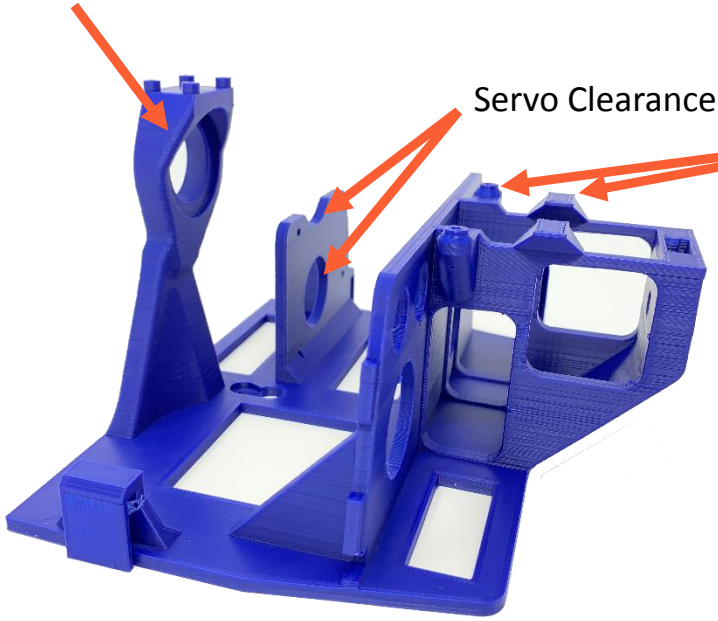


Development: Packaging Rev B

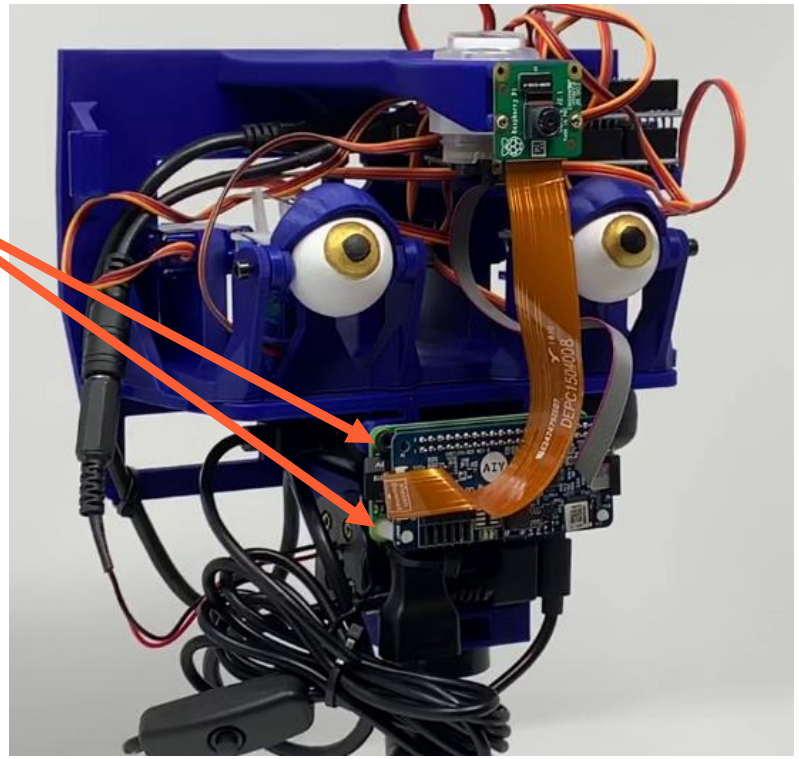
- Add AIY kit button to allow offline camera control – need to be able to start and stop eye mechanism without laptop + SSH.
- Fix Servo interference



Arcade Button Mount

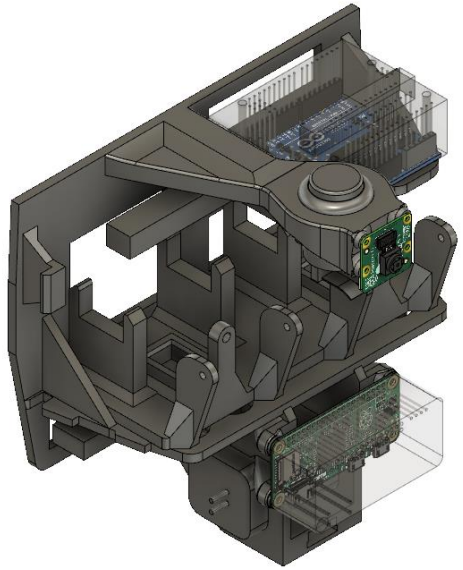


Problem: **Pi Mounting geometry is too weak**, removing/inserting HDMI cable breaks the pi mount standoffs.



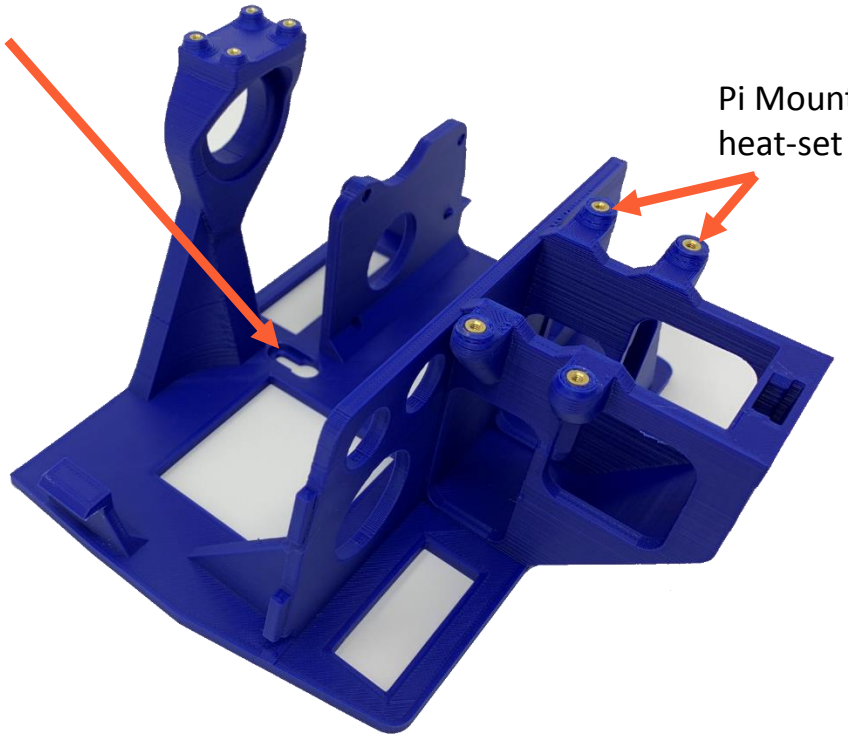
Development: Packaging Rev C

- Add AIY kit button to allow offline camera control – need to be able to start and stop eye mechanism without laptop + SSH.
- Fix Servo interference



Screw Slot for wall mount

Pi Mounting Bosses with heat-set inserts



Problems: TBD! So far so good…

Results

This project is ongoing, but here is a video showing the facial tracking in action.

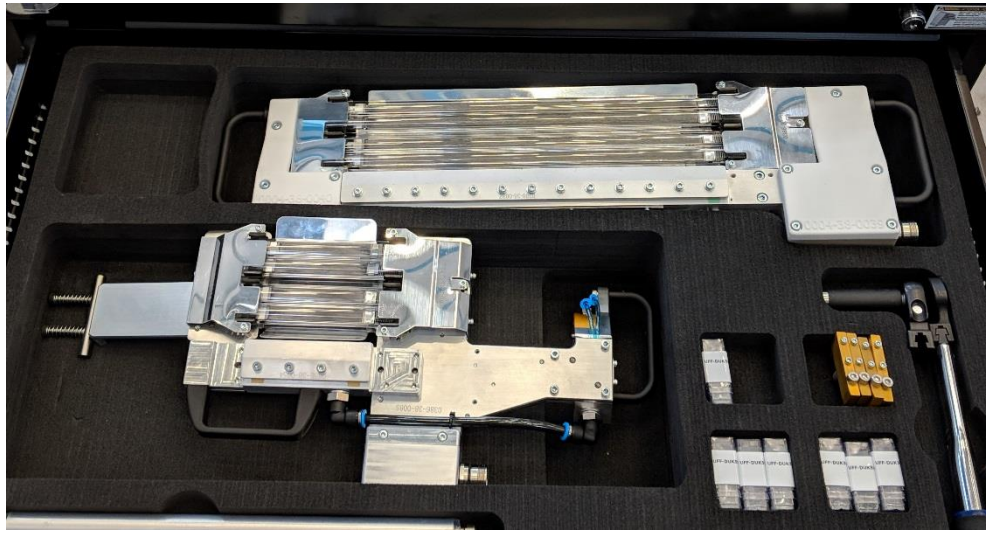
Next Steps:

1. Increase accuracy of eye tracking – mechanical improvements to servo control arms, better tuning.
2. Add emotes (winking, eye rolling, etc)

Video: https://www.youtube.com/watch?v=wyIk2ED0iFI

Infrared Heaters for Automatic Tape Laying (ATL) Head

Electroimpact Inc.



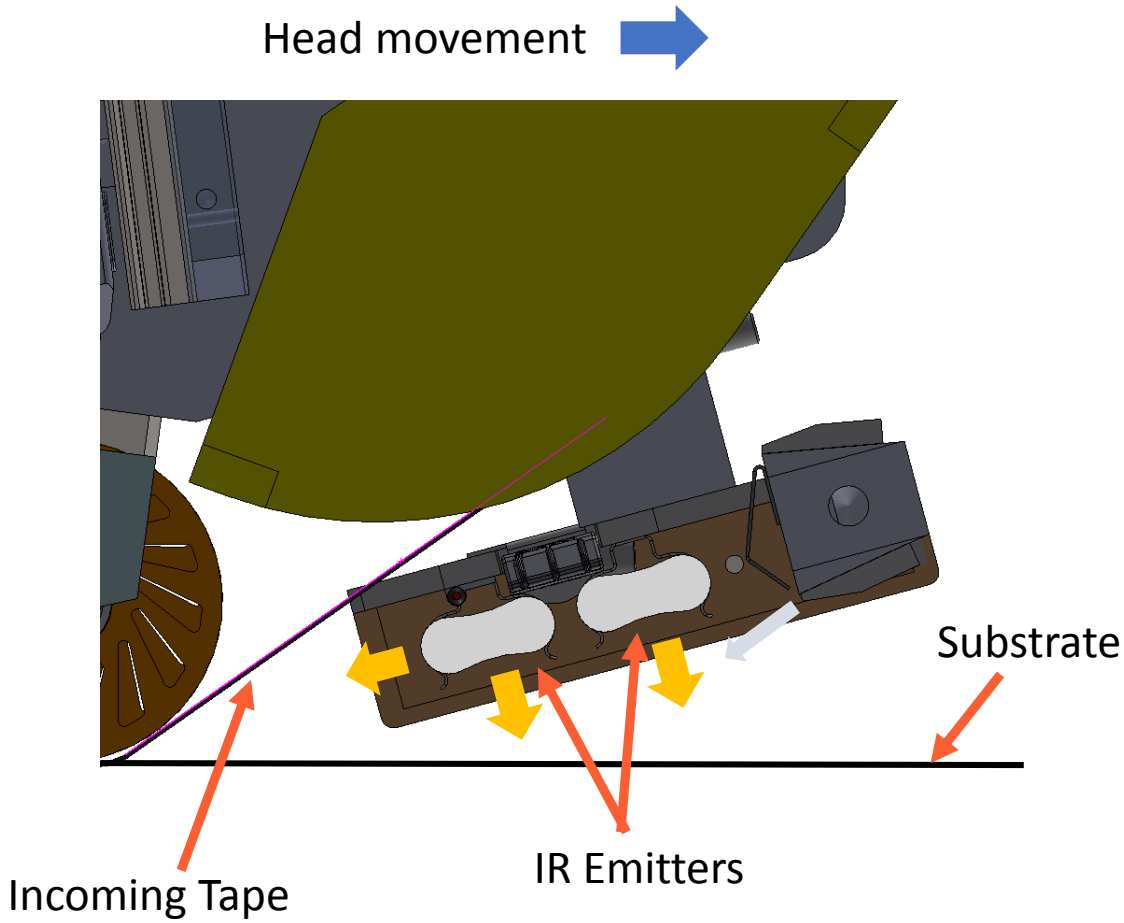
Problem Definition

Background:

To lay down strips of carbon fiber composites, an automated tape laying (ATL) head needs to make the carbon material stick to the prior layer of carbon. Heat is applied to the substrate to make the resin “tacky” and adhere to the incoming tape.

Infrared (IR) Heater Requirements:

- Use medium-wave IR emitters
- Easily removable from ATL Head
- Cool itself to avoid overheating
- Rapidly cool the carbon fiber part when needed (to avoid overheating uncured material)
- Provide feedback of heater temperature
- Provide adequate part clearance
- Must provide two heaters (300mm and 75mm) for different tape widths

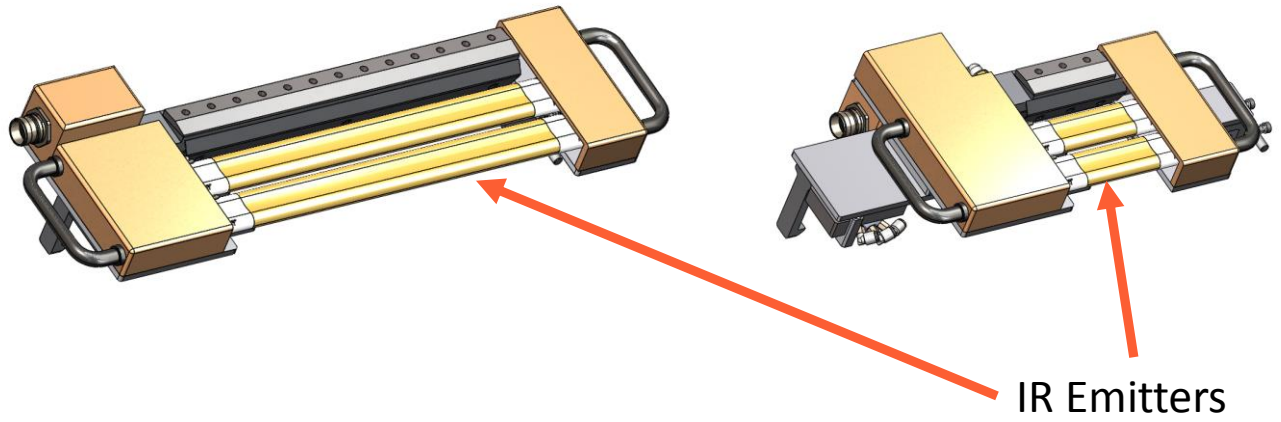


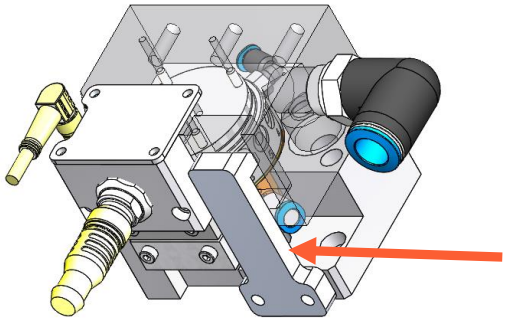
Initial Concepts

- Removable reflectors to allow IR emitters to heat both substrate and incoming tape.
- Tool changer mounted vertically, latch to prevent heater dropping in case of unintentional actuation.
- Large PEEK covers to make heater touch-safe.

300mm & 200mm IR Heater

75mm IR Heater





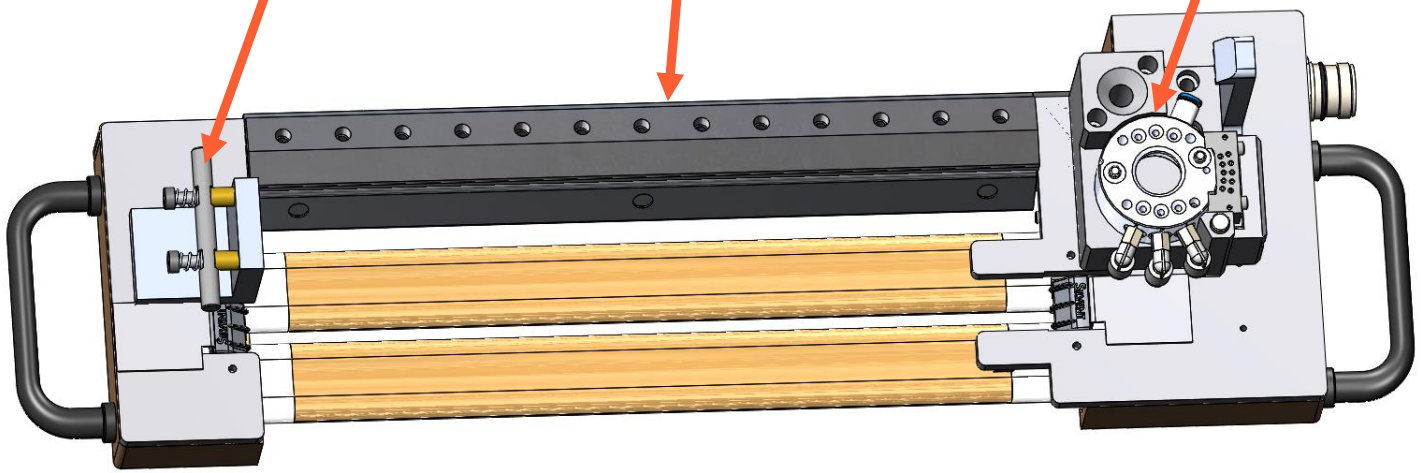
Latch to prevent drops: **Too complicated, fragile**

Vertical Tool Changer Mounting

Spring Mount

Double-sided air knife provides structure

Automatic Tool changer

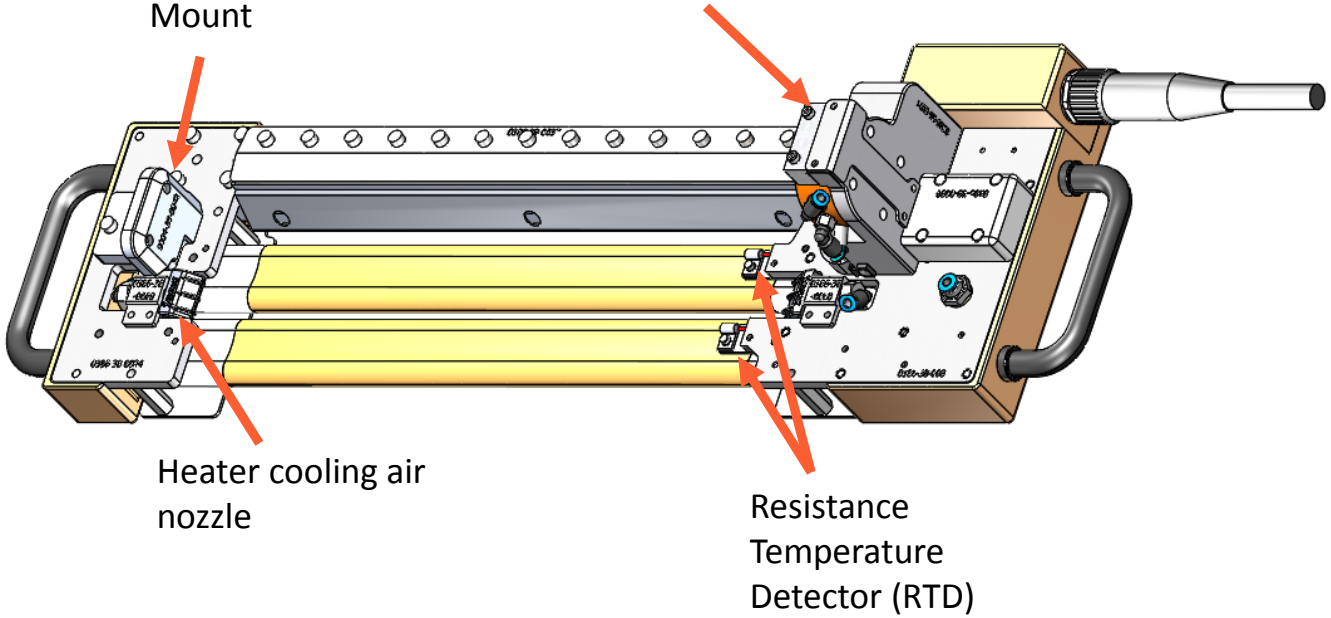


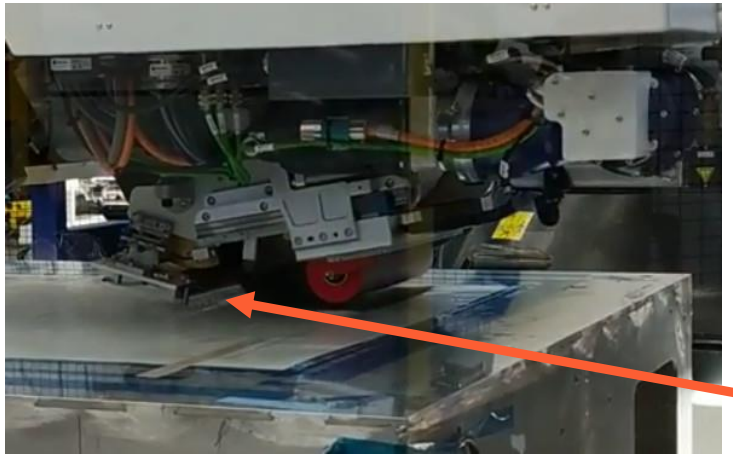
300mm & 200mm IR Heater

300mm Heater Rev A

- Changed tool changer orientation to horizontal, removing threat of accidental heater drop without an auxiliary catch.
- Large PEEK covers to make heater touch-safe.
- Two temperature sensors to allow redundant heater temperature feedback.

Rev A heater assembled

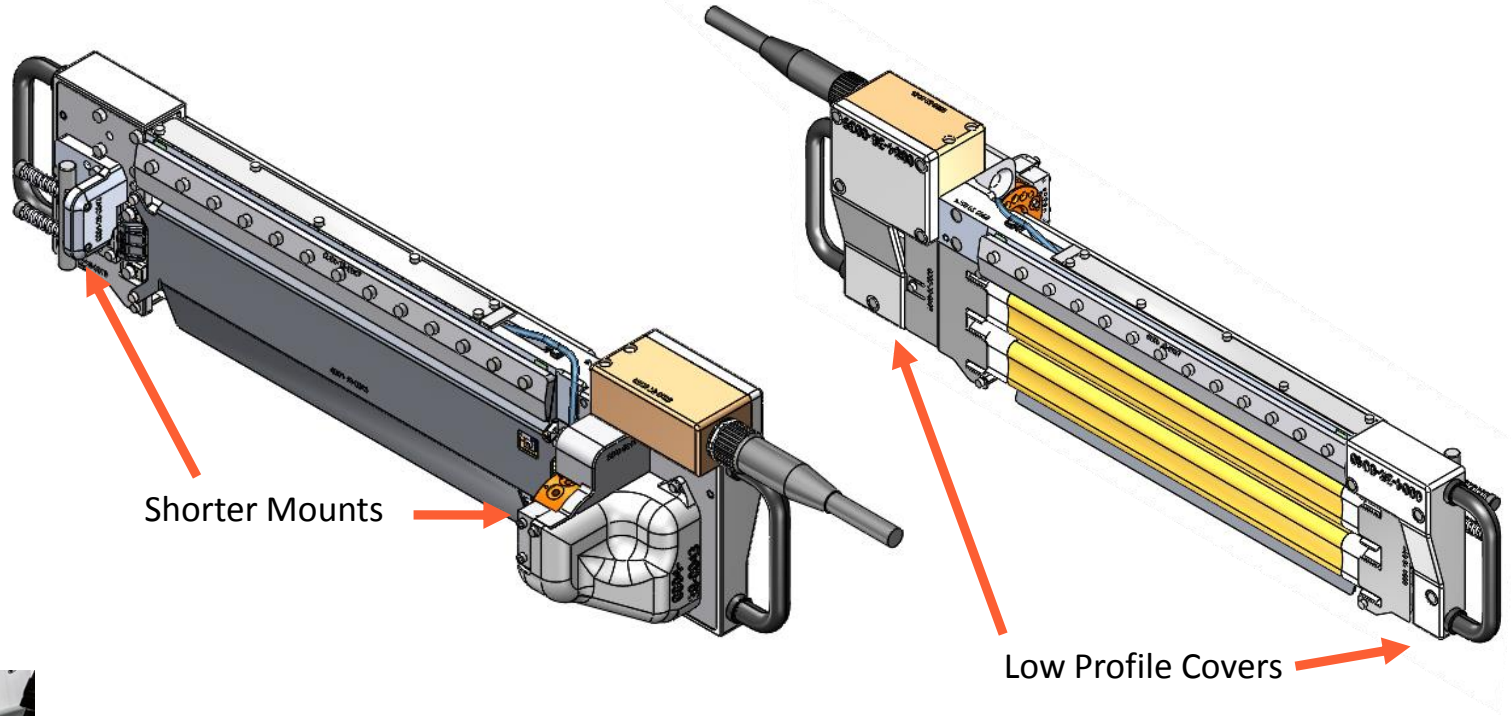


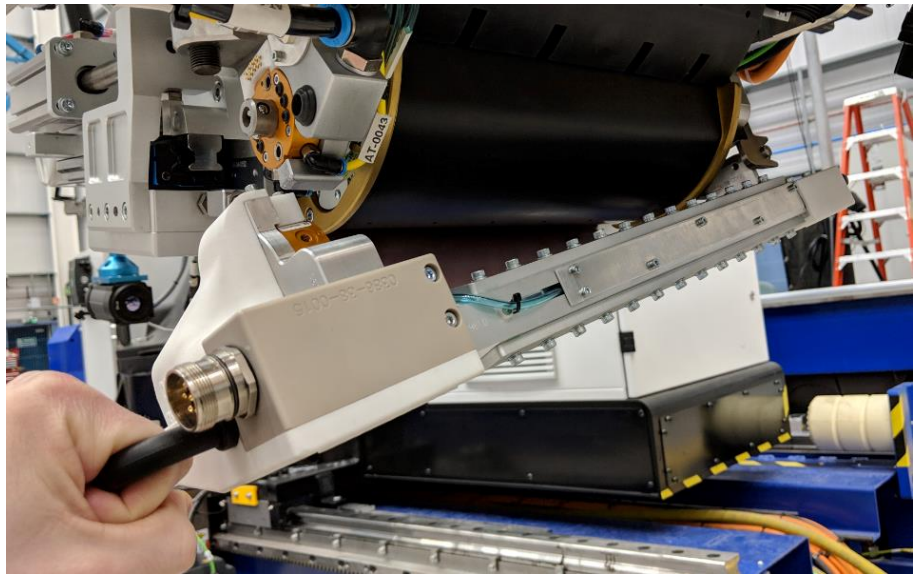


Testing heater with covers removed – **not enough part clearance!**

300mm Heater Rev B (Final Revision)

- Moved heater closer to head by reducing mounting geometry height.
- Two temperature sensors to allow redundant heater temperature feedback.





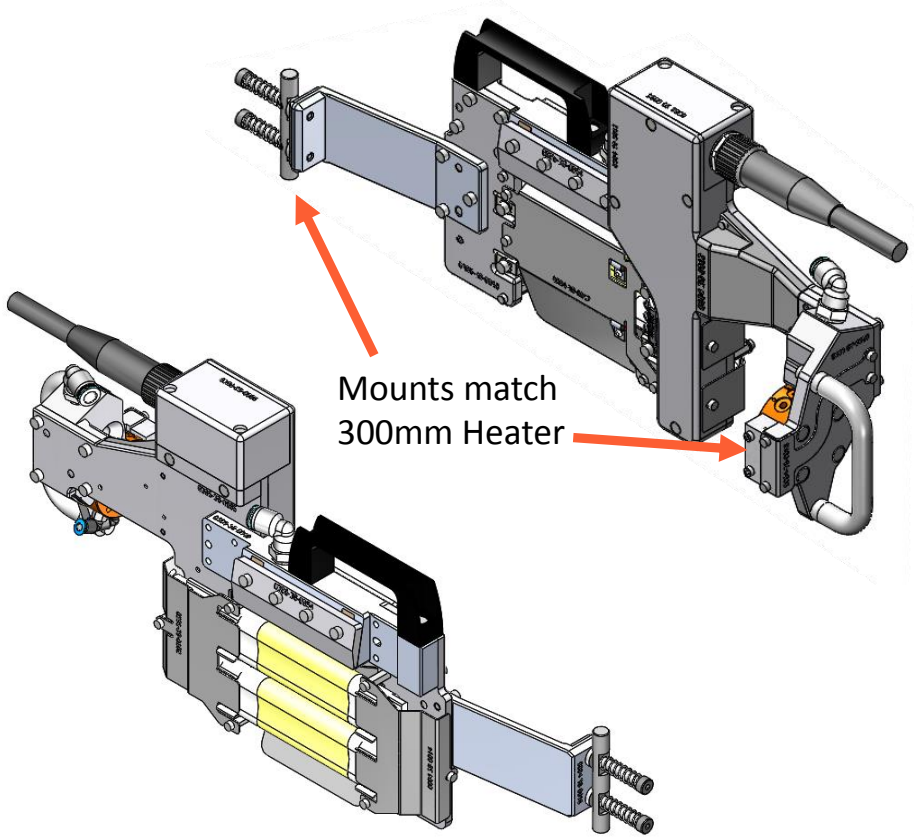
Removing heater from head

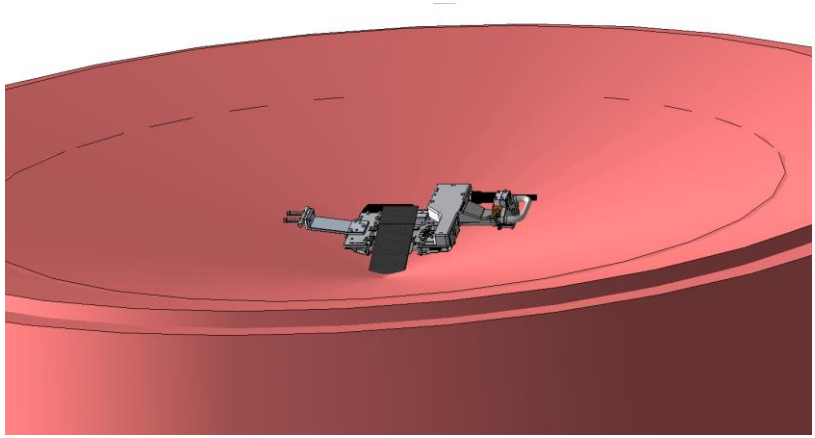
Running heater on part

Clearance is good. Success!

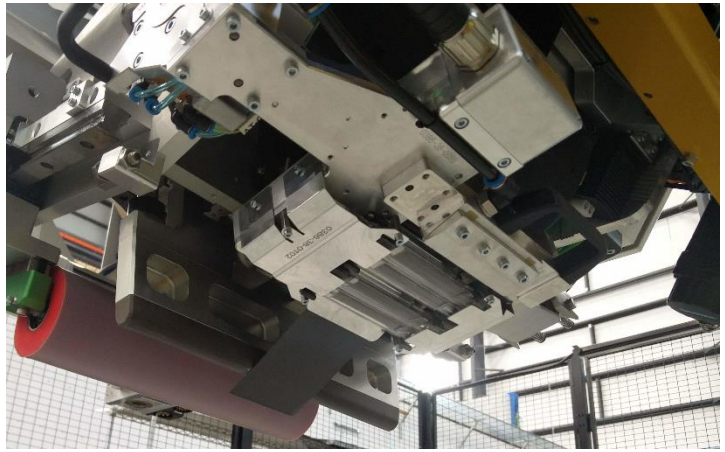
75mm Heater

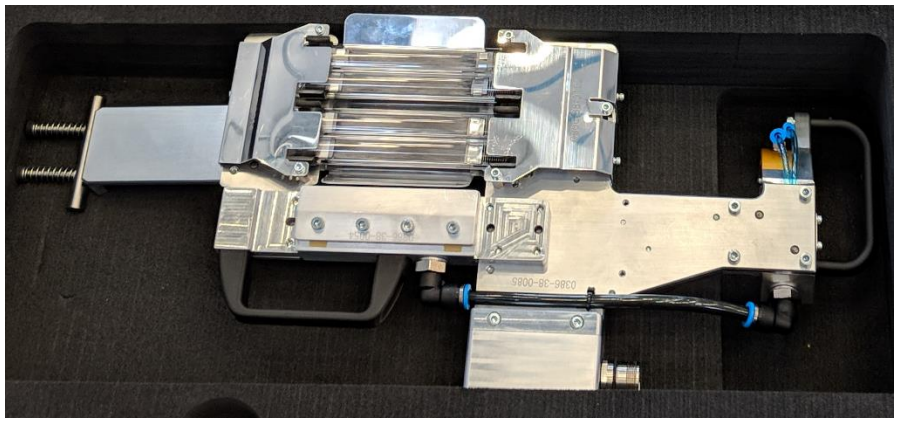
- The 75mm heater has to access tighter part clearances, and therefore needs to be slimmer.
- The 75mm heater needs to mount on the same geometry as the 300mm heater.





75mm Part Clearance Check

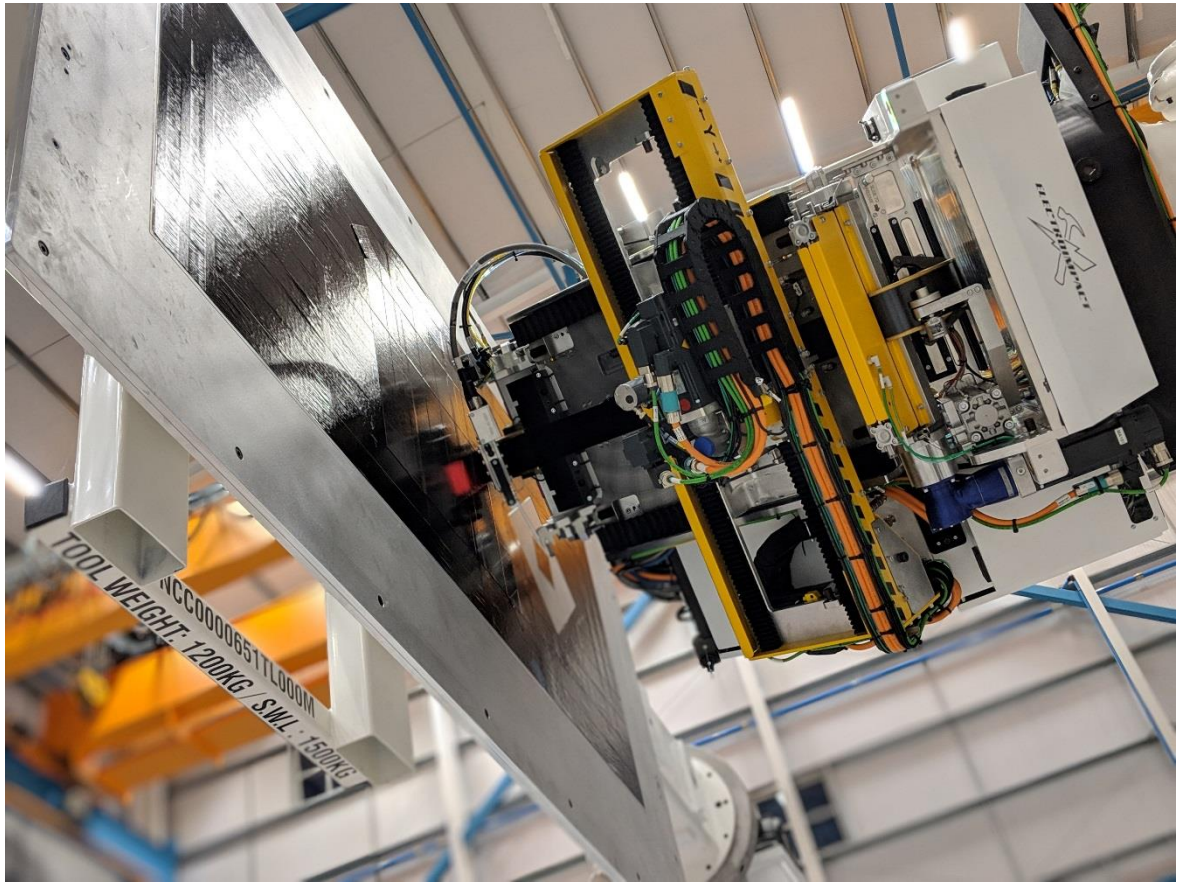




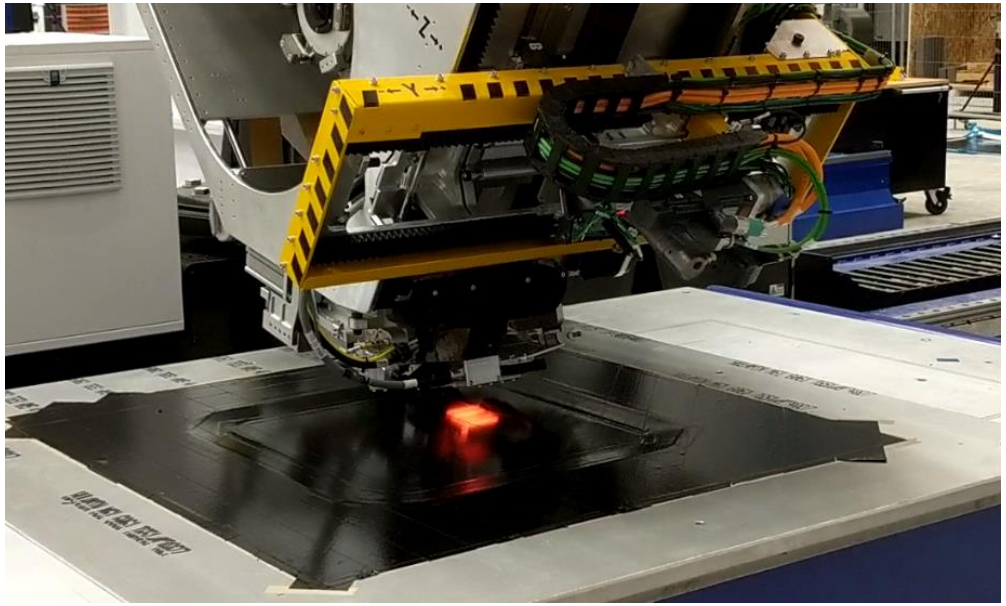
With lessons learned from 300mm IR heater, the **75mm IR Heater was successful in its first iteration**.

Results

300mm and 75mm IR heaters both provide sufficient heating and cooling, in modular and compact packaging.



75mm heater laying carbon on rotator



75mm heater

300mm heater

3D Printer Enclosure

Making my 3D printer a better roommate.

Personal Project

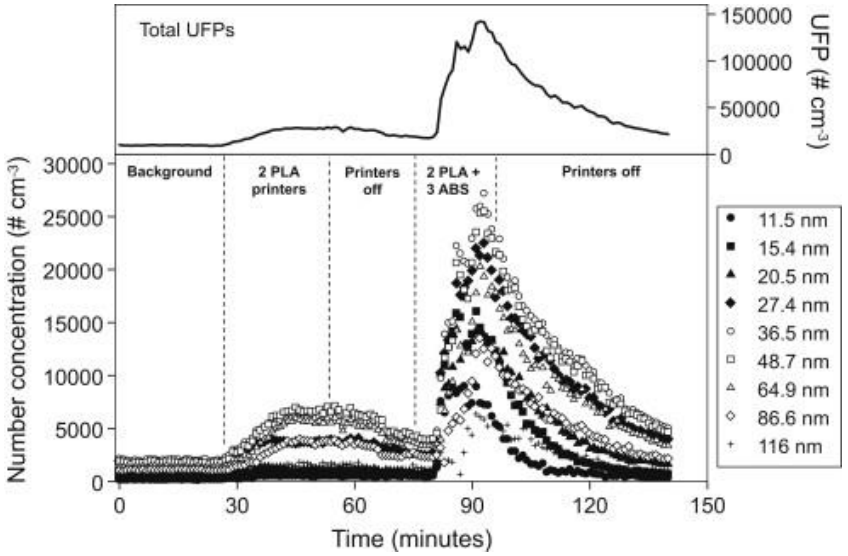
Problem Definition

Background:

3D printers are useful, but they emit harmful fumes and can catch on fire. In order to coexist with a 3D printer in my apartment, I needed to minimize fire risk and mitigate plastic fumes.

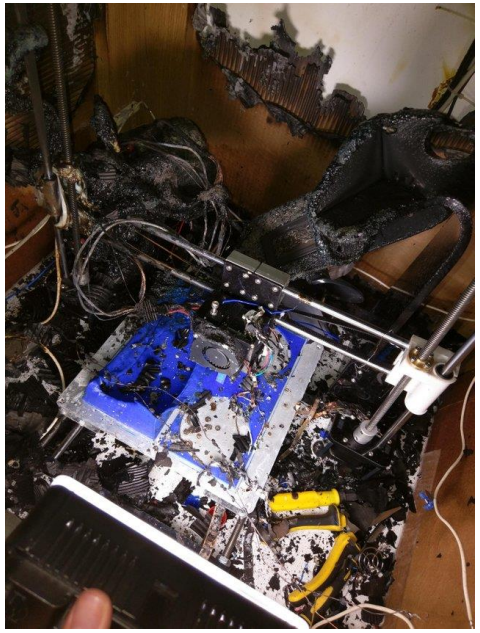
Printer Enclosure Requirements:

- Minimize fire risk.
- Eliminate unhealthy plastic fumes.
- Reduce printer noise.
- Fit through doorways and up stairways.
- Cost effective.



Ultrafine particles (UFP) Concentrations from 3D printing.
Figure source

A coworker's burnt printer

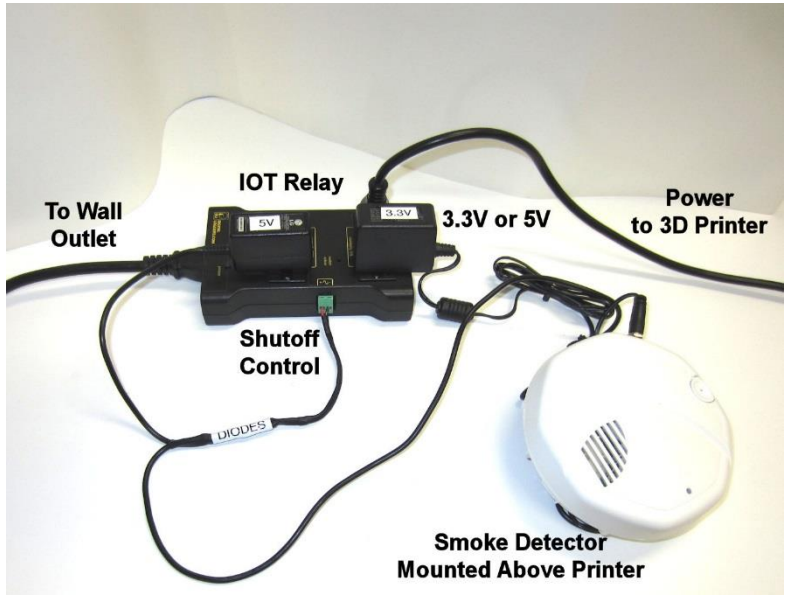


Printer fire aftermath
Image source

Initial concepts

- Minimize fire risk: → Disable heating elements if electrical fire occurs →
- Eliminate unhealthy plastic fumes → **Vent printer enclosure outside**
- Reduce printer noise
- Fit through doorways and up stairways.
- Cost effective

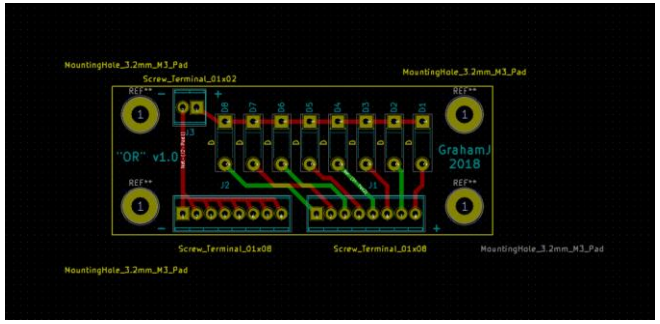
} **Fully enclose printer in fire-resistant enclosure** (not wood!). Buy used/surplus cabinet, modify to suit.



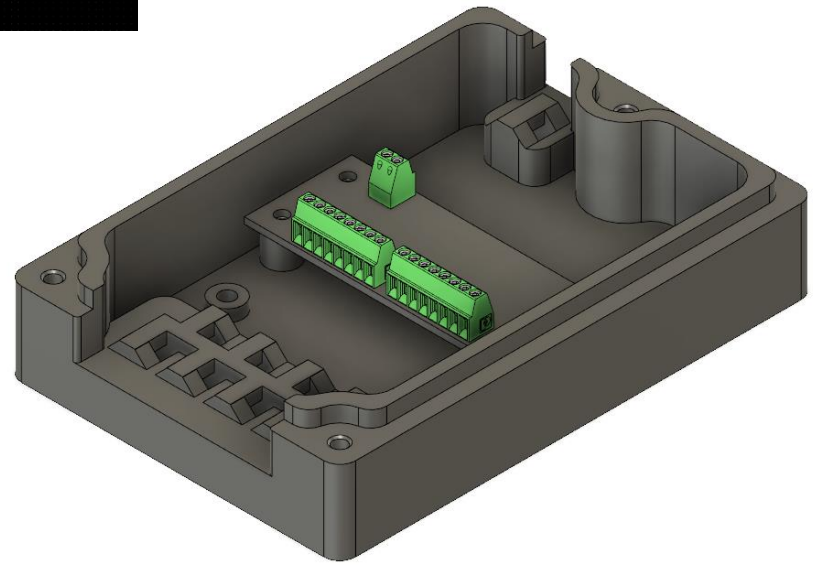
Henry Arnold's smoke alarm shutdown (link) – a useful printer shutoff, but not enough inputs for two-tier smoke alarm system. To adapt to my system, **Need "OR" logic to allow multiple inputs to trigger smoke alarm shutoff.**

Smoke Alarm Shutdown: “OR” Gate

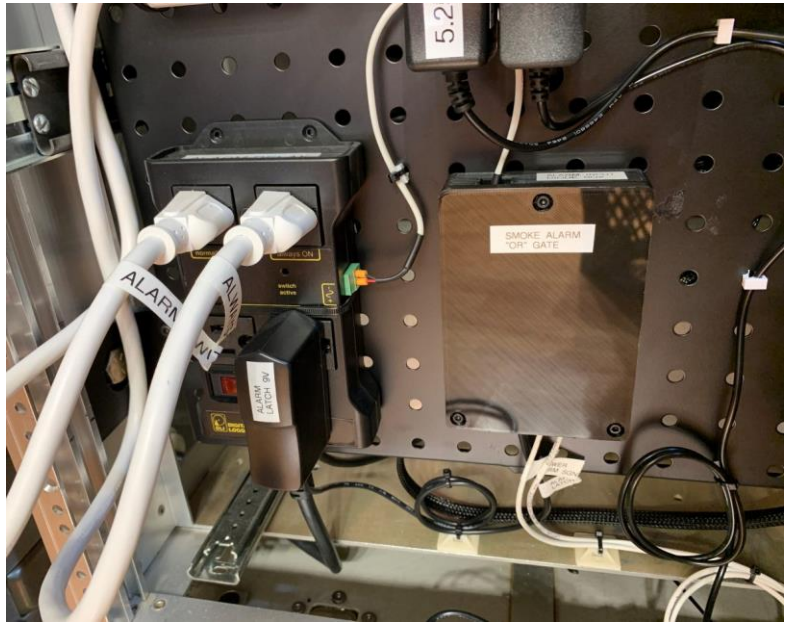
When smoke is detected by the smoke alarms, the alarm signal from the smoke detector is used to open a relay that controls the printer power. To allow multiple inputs to the power relay, I needed an “OR” gate.



KiCad Diode board design

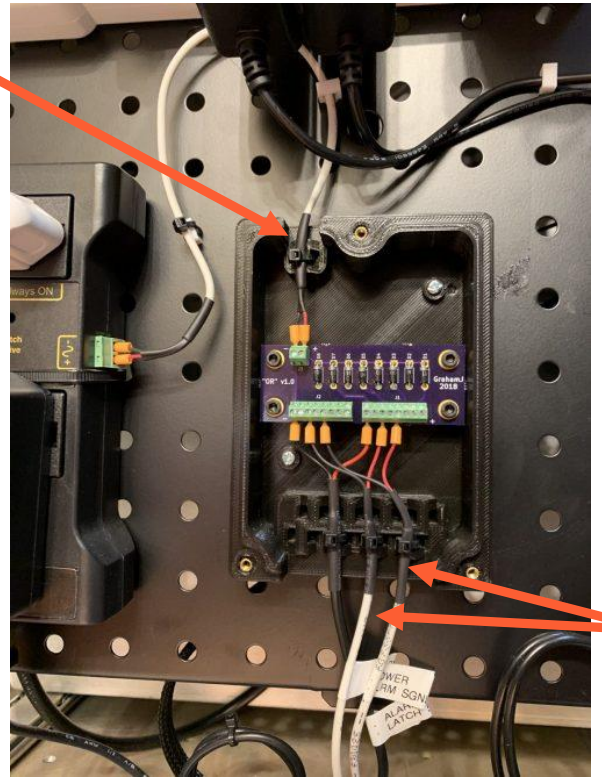


Enclosure CAD



PCB enclosure with power relay

Output to relay

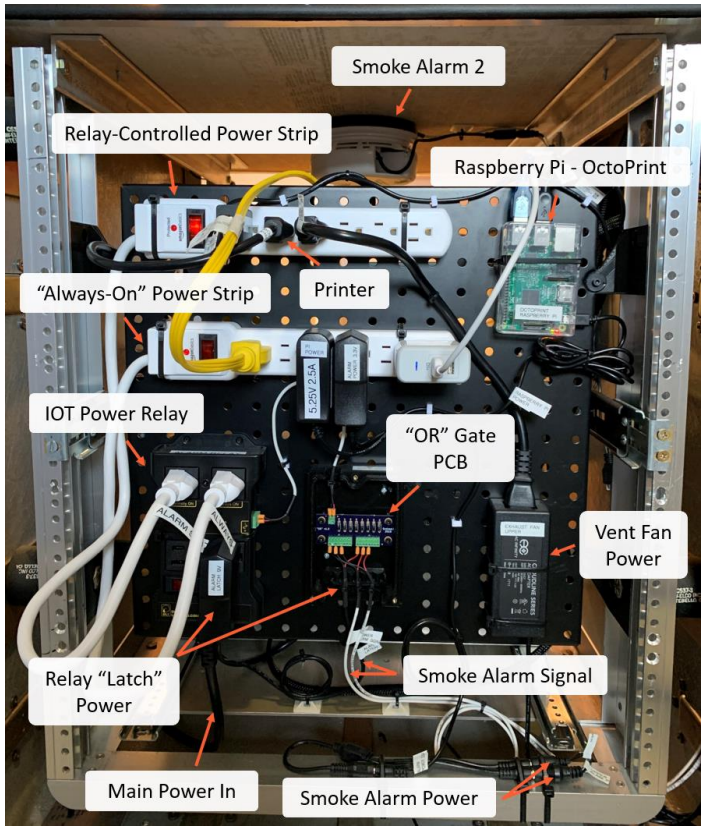


Alarm Inputs

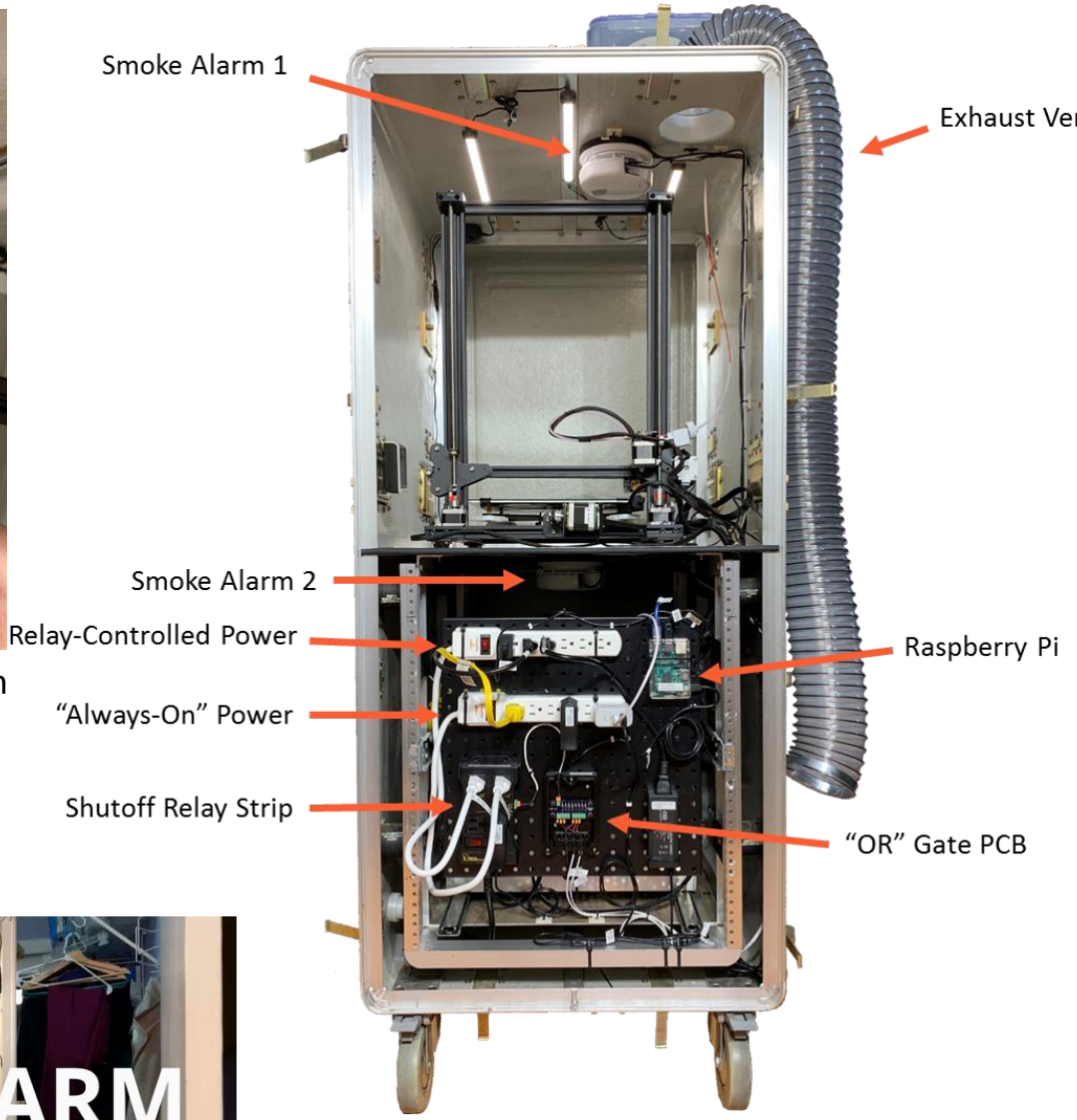
PCB installed in enclosure

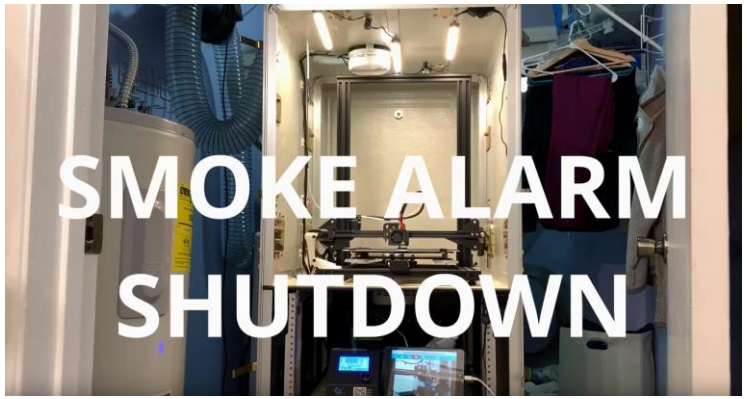
Smoke Alarm Shutdown: System

The printer enclosure is divided into two zones, top and bottom. The printer is in the top zone, and the control box is in the bottom. Each zone has its own smoke alarm.



Hard-wired smoke alarm with printed mount bracket

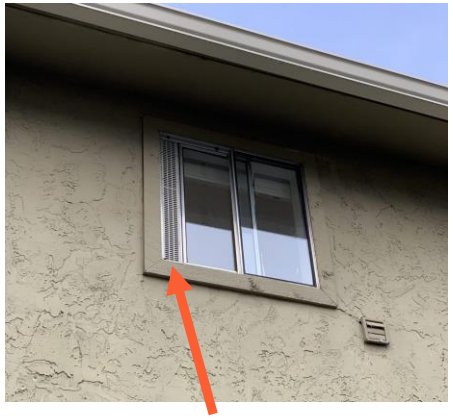




For a more detailed explanation (and short video) of the smoke alarm system, check out: https://grahamjessup.com/smoke-alarm-shutdown/

Printer enclosure vent

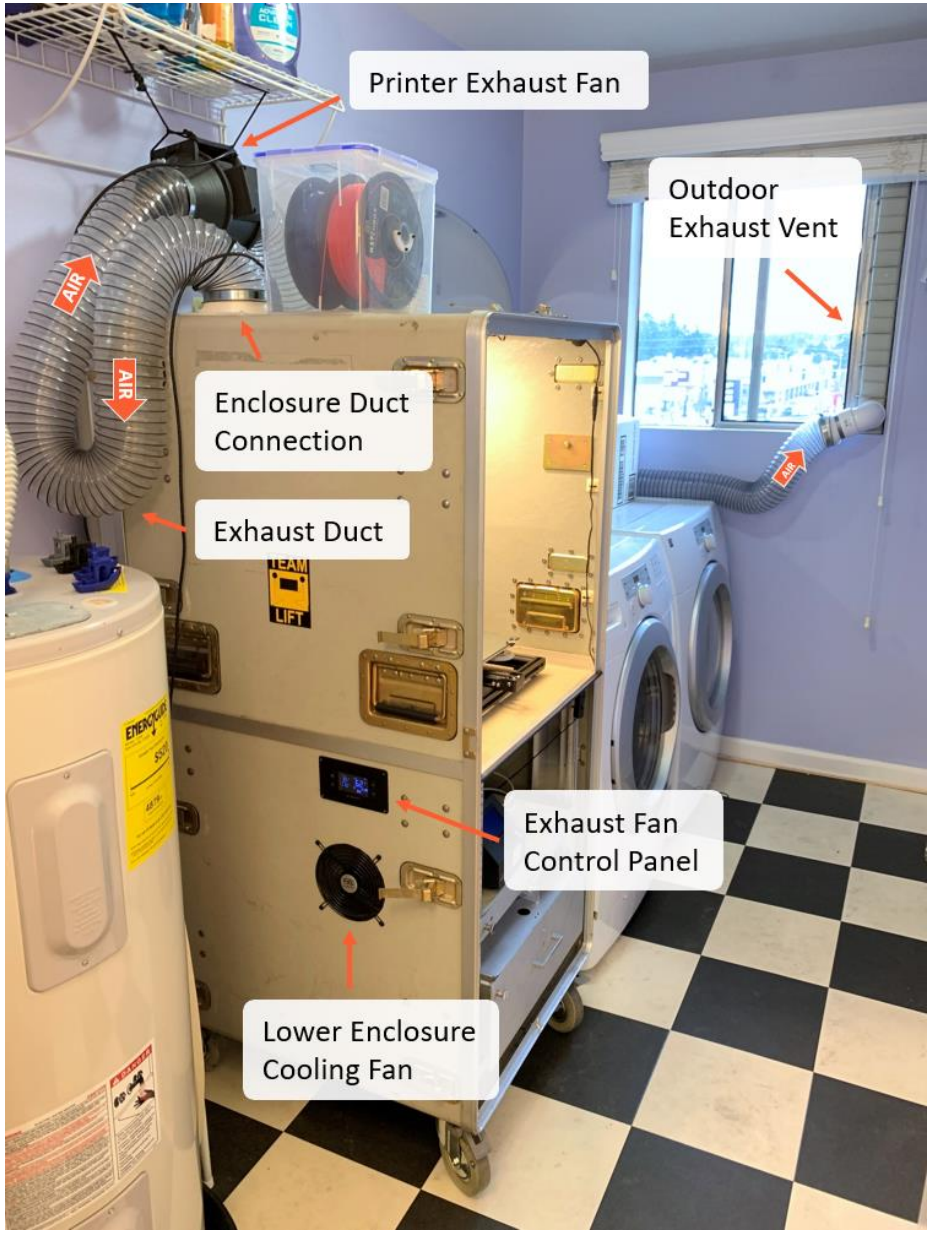
To remove harmful fumes from my printer, I vented the upper enclosure outdoors. The challenge with venting was to create a system that was quiet, easily removable, and blends in.



Exterior vent

Printer moved for attic access

Quiet DC exhaust fan, suspended to mute vibrations

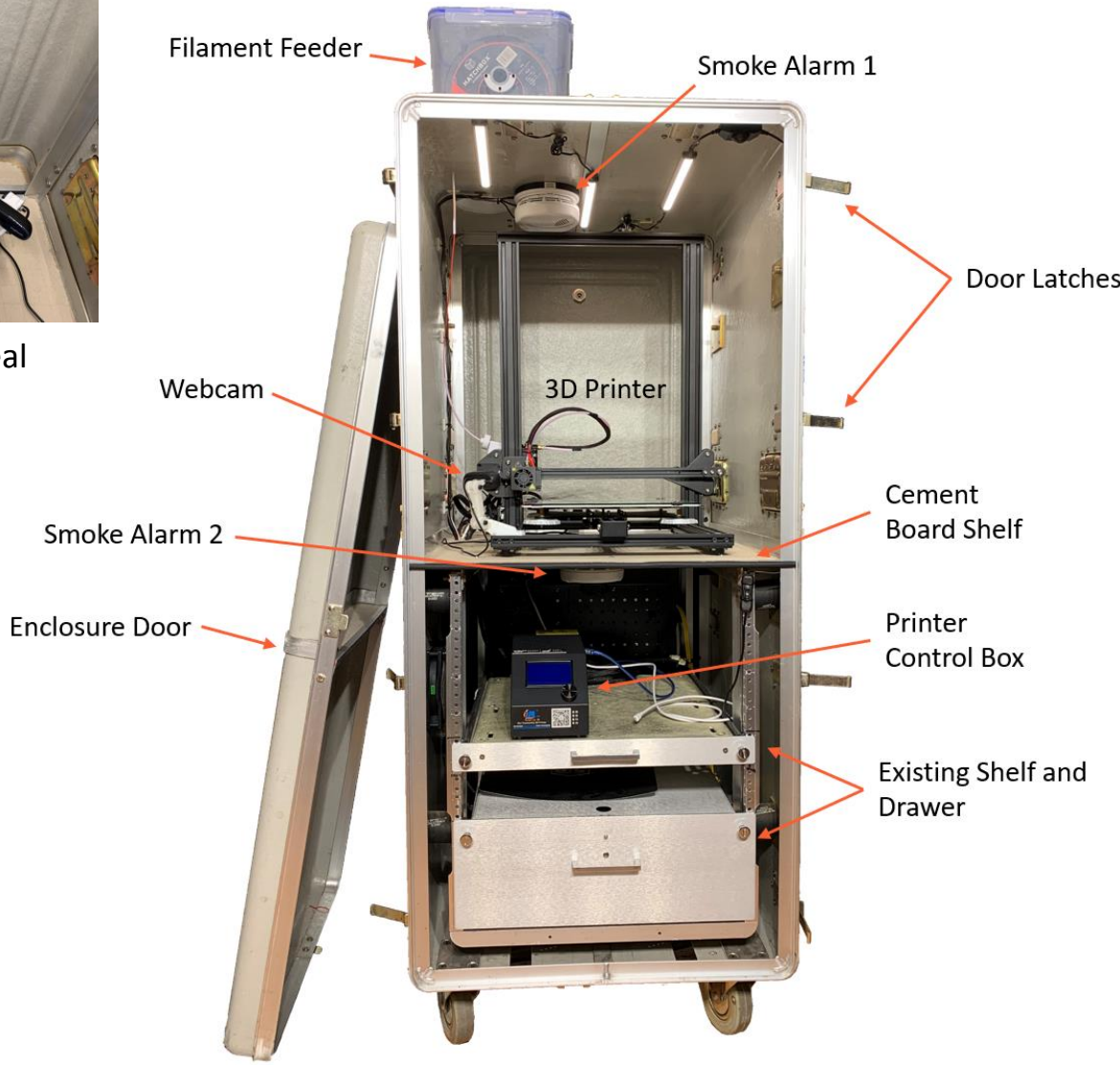


For a more detailed explanation of the enclosure vent system, check out: https://grahamjessup.com/enclosure-vent/

Printer enclosure structure

I purchased a surplus fiberglass and aluminum equipment case to modify for my printer enclosure. Wherever possible, I used fire-proof or flame-retardant materials to modify the enclosure. The enclosure is divided into top and bottom zones that are sealed from one another.

Printer shelf door seal



For a more detailed explanation of the enclosure structure, check out: https://grahamjessup.com/enclosure-structure/

Results

- No “hot plastic” smells while printing.
- Quiet printer.
- Increased peace of mind for 24hr + prints.
- Rolls, and can be carried.

Enclosure with doors on.

Printer in its laundry room home.

Printing for my personal projects!

This project demonstrates that increasing 3D printer fire safety is within the reach of a hobbyist. The enclosure also provides a valuable controlled environment for printing temperature sensitive materials, a win-win.