3D Printer Auto Ejector

Senior Design Proposal submitted to the
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in Mechanical Engineering Technology

by

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Background Research

3D printers have limitations to automation. 3D printers traditionally have needed a human operator to manually remove parts by pulling them off the print bed or by flexing a magnetic plate. This can be a significant efficiency issue because it will require a person to be present to remove finished parts before new ones can be produced. The removal process can vary between different systems but the most common systems for part removal are a magnetic flexible bed or variable adhesion bed. The magnetic bed system consists of a flexible magnetic plate that can be removed from a 3d printer and manually bent by a person to break the parts off the bed. The variable adhesion bed consists of a bed made of material that have different adhesion properties depending on what temperature the bed is at, the printer bed will heat up before printing making the bed more adhesive and then cool down after a print is complete which cause the parts loose adhesion, after a print bed is cooled parts can just be pulled off by a person. Both systems have the need of a human operator to take the parts off the bed. This can lead to significant printer down time or a need to constantly have personnel present. Solutions for this now range from very expensive solutions using robots to fill in for humans or to simple mechanical tricks that use gravity. The problem with these kinds of solutions is that they normally don't consider the sacrificial material that a printer needs to put down in order to operate properly.

One part of the 3d printing process is that when a print job starts a printer must lay down a bit of sacrificial material called a skirt for a printer's flow to start properly before going on to the actual print. The skirt is usually just a single line of filament that is laid in a ring around the part, see image below. This single layer of filament is difficult to remove reliably using simple automated methods due to its small size and weight. If this sacrificial material is not removed during the automated process, it will damage the next part because the printer will attempt to overtop the skirt. This can cause parts to fail and could even do damage to the printer under the right circumstances.

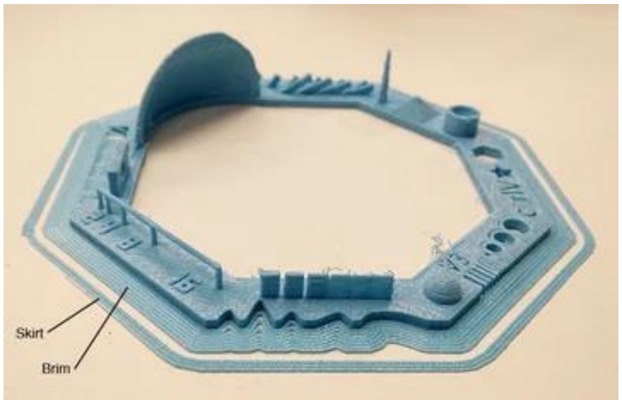


Figure 1 – picture of a skirt and brim

3D printing technology has improved exponentially over the past decade, and companies are taking interest in improving and automating additive manufacturing techniques. We aim to design a device that will eliminate/mitigate human intervention and reduce the failure-rates for high-volume prints.

- Material waste rates from printers: 35% to 45% (1)
- 3D printer market worldwide grew 49.4% in 2016
- A 3D printer can experience daily down time of up to 10 hours due to no operator being available in a small-scale industrial setting. A scenario like this would happen when all the workers have gone home for the day and the machine is still running once people have left.

3-D printing automation is needlessly limiting itself. With a method to remove a print from the bed of a printer it would increase high production efficiency. The sacrificial material that would be left over after the print would also be in the way if not removed properly. This solution would allow the creation of prints continuously without the need of an operator to be there for the completion of every print. It would also eliminate the necessity of sacrificial material removal after the print by the operator for single prints as well. This would help remove human error from the 3-D printing process even more.

State of the Art

Technology 1: OctoFarm

OctoFarm (2) is a simple program that commands the printer head to "sweep" the printing bed. This method used the printer own gantry as a ram to push part off a printer. The pros of this design are that it very cheap and easy to implement. The cons of this design is that it can only work with certain materials and print beds due the adhesion properties needed to make it work. This method also runs the risk of significant damage to the machine if an error does occur.

Technology 2: Creality CR 30

The Creality CR 30 (3) offers a completely new machine that uses a moving belt to create an automated system. This the CR 30 is a purpose built 3D printer with continuous printing in mind. The pros of the this design is that comes as a completed unit, no need to modify an existing printer. Another pro of this design is that it allows for the printing of very long part do to there being no limit in the Y axis. The cons of this design is that it uses a niche printing style that isn't viable for all kinds of print jobs. The software for this style of printing is also in its infancy and require a lot tinkering to get functioning properly.

Technology 3: Quinly

The Quinly (4) system involves a print bed made of a special material and mounting brackets that orients a printer at 45 degrees. Quinly also uses the print gantry to push parts off the bed similarly to technology 1. The pros of this system are it has an easy install process and can integrated into an existing printer with very few modifications. The cons of this design are the limited material options that can be used on the print bed and the high price of the system.

One of the major gaps in state-of-the-art technology is that many of the products that exist can only be integrated into one model of 3D printer or are a completely new machine. This lack of modularity restricts the market to only the most popular 3D printers. The current solutions are also expensive compared to the printers that they are attempting to automate with some being more expensive than that printer itself.

Applicable Standards

During the research there were no standards found that pertain to this kind of product. There are however safety guides that are relevant to the 3D printing industry including a safety document from EHRS(5). A relevant standard that all electrical components used in the design is the NFPA 70 electrical standards (6)

End User

The end user needs a relatively easy way to automate a mass 3-D printing process. They need a reliable method to remove a printed part as well as the sacrificial material from the bed of the printer without an operator present. The current technology used to solve this can be expensive or damaging to the equipment.

Summary of Research

Current solutions are limited to specific machines or dedicated platforms. They lack modularity, and they are expensive. Gaps in the state of the art include need for a low-cost solution, production being available, and lack of modularity and adaptability.

Customer Features:

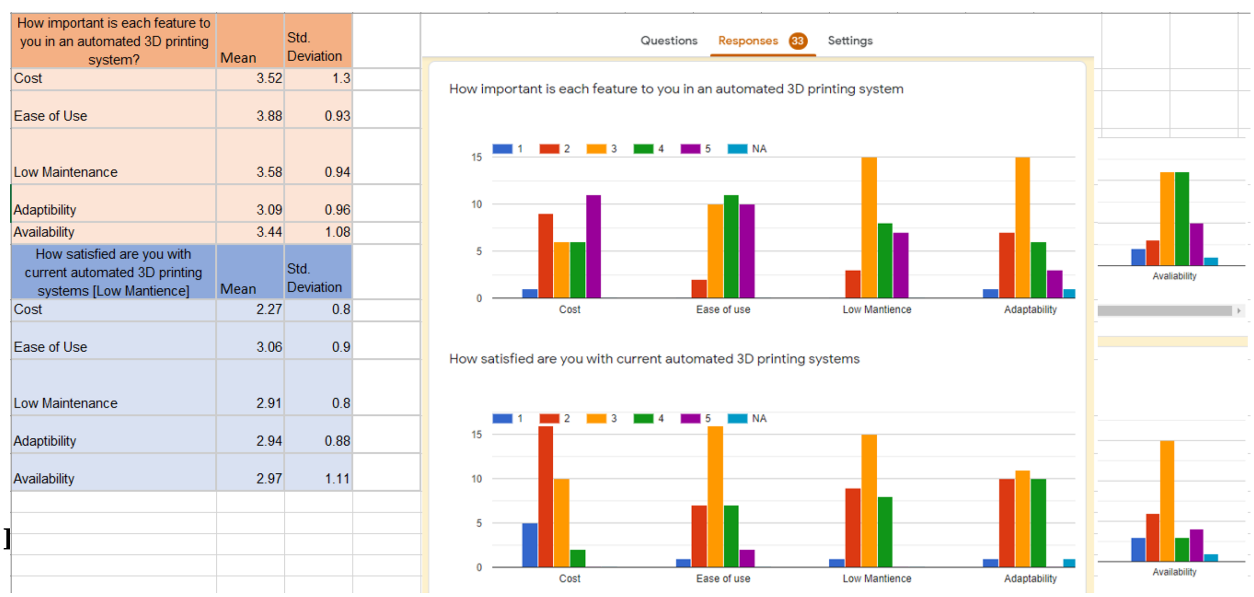
- Easy to use
- cost-effective
- low repair/maintenance cost
- adaptability

Engineering Characteristics:

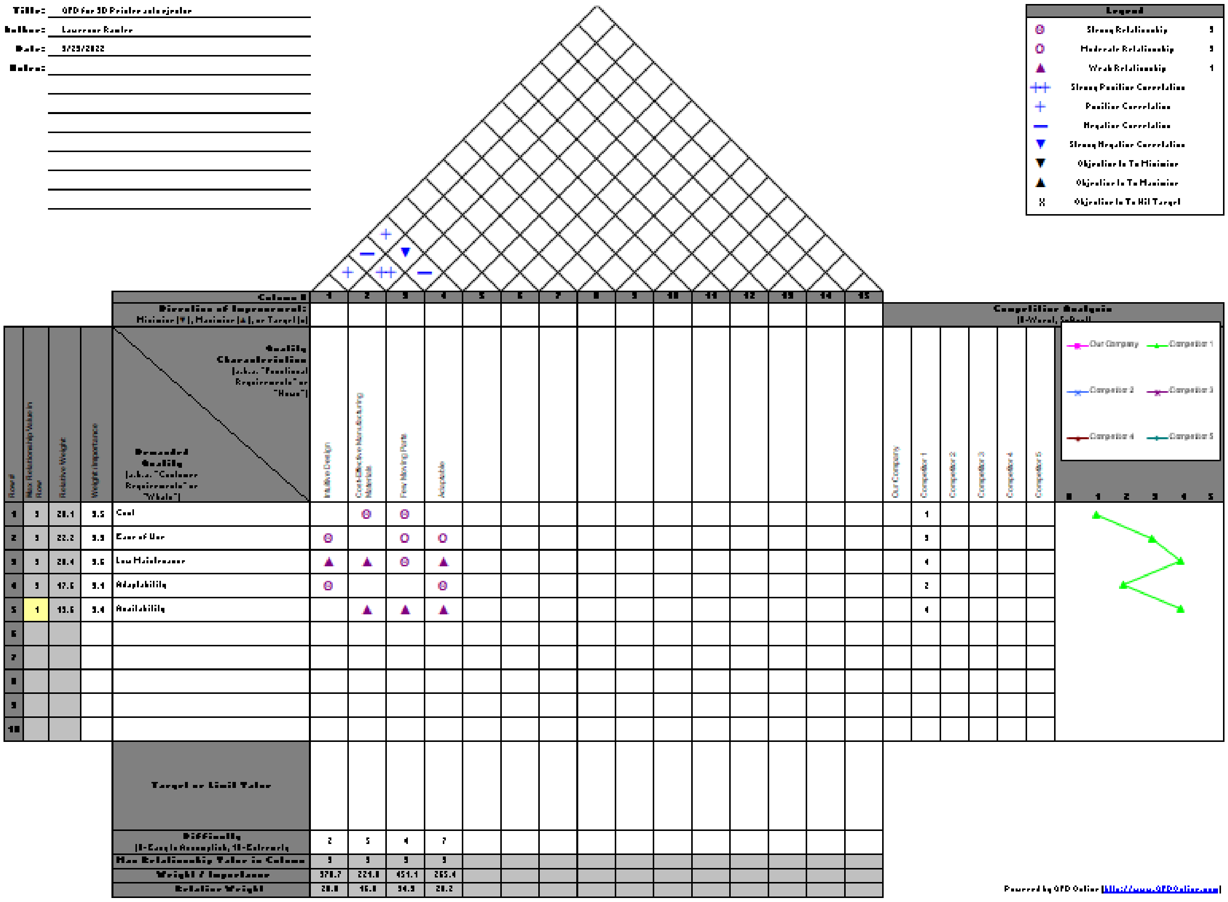
- Ease of Use: We aim to design our solution to be intuitive to first time users, and to be easy to install on virtually any 3D printer.
- Cost: Use low-cost material without sacrificing durability of the design. Find the cheapest material that will be able to get the job done within the design's safety factor.
- Minimize Maintenance: Use as little moving parts as possible to decrease likelihood of them breaking down/requiring maintenance. The goal of using as few parts as possible goes hand-in-hand with our goal of intuitive design.
- Adaptability: With one of the major gaps in the current state of the art being that systems are restricted to a single system an important characteristic is that the system can be adapted to work with any FDM 3D printer
- Availability: The product is made with materials that can be easily sourced.

Survey Results

The survey was conducted via a Google Sheets survey and was sent out to people that may encounter 3D printing in their careers. 34 surveys were collected. The survey asked the responder to address the engineering characteristics above; Cost, Ease of Use, Low Maintenance, Adaptability, and Availability. First, they were asked how important these factors were when considering the purchase of 3D printer accessories. Next, they were asked to rate how satisfied they were with the current products currently available on the market.



How important is each feature to you in an automated 3D printing system?	Mean	Std. Deviation
Cost	3.52	1.3
Ease of Use	3.88	0.93
Low Maintenance	3.58	0.94
Adaptibility	3.09	0.96
Availability	3.44	1.08
How satisfied are you with current automated 3D printing systems [Low Mantience]	Mean	Std. Deviation
Cost	2.27	0.8
Ease of Use	3.06	0.9
Low Maintenance	2.91	0.8
Adaptibility	2.94	0.88
Availability	2.97	1.11



The info gathered in the survey was used to construct the house of quality. The results of the this showed that the engineering characteristic with the most importance is few moving parts. This is closely followed by intuitive design.

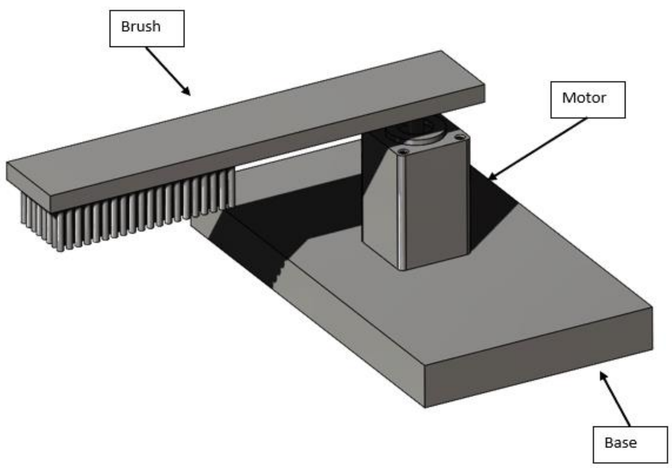
For the competitor info only one is filled out, due to it being the only product that is sold. The other state of the art designs found in research are custom built solutions that are not sold at market, so it was not possible to customer opinions on them.

Product Objectives

With the survey results showing that cost and ease of use were the most important things to consider the concepts were designed with these things in mind. Our overall objective is to make a concept that would consider all of our engineering characteristics with emphasis on cost and ease of use. With these objectives in mind we had to design our concepts around these conditions and consider them for our final decision

Concepts Drawings

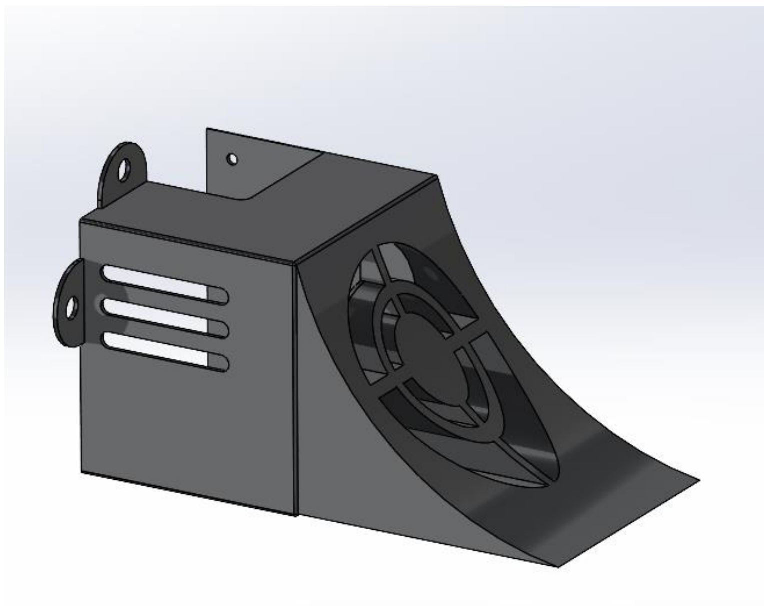
Concept 1



Move a brush that can scraper plastic off a print bed. The brush will be a basic metal wire brush on an arm. The motor will be mounted on the base and will provide power to the arm. The base will hold the rest of the assembly. It will have a mounting point to be attached to a 3D printer or an external holding source like suction cups. The only function will be to move the brush to contact a print bed to remove plastic from the bed.

This concept will be a low cost with the most expensive component being the motor. The biggest impact on the ease of use will be that the motor will need to be installed into the 3D printers control board. This won’t be overly complicated, but it won’t be as easy as some other solutions. Maintenance should be low with the addition of only 1 moving part that should be easy to replace in case of failure. This design should be adaptable to all kinds of 3D printers thanks to its external mounting solution. The only limiting factor will be if the printer's control board will have an additional motor port. The components for this design are easily sourced and widely available.

Concept 2

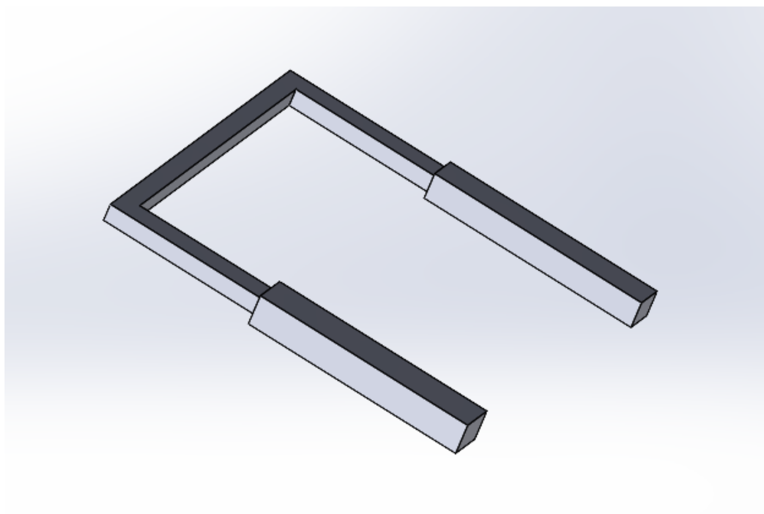


The wedge will scrape across the whole printing plate. My part will be a replacement cover to 3-D printer nozzles to add a wedge for part removal. The wedge will help with scraping off the sacrificial material at the end, instead of just slamming into the part it will carefully press against the plate and scrape across to remove all material.

The wedge would be very cheap to manufacture. The only thing the customer has to do is replace the vented cover on the nozzle. This is a singular part replacement so there would be no real maintenance only replacing the wedge cover if it becomes too dull. This product is not very adaptable as a new head would have to be made for each type of machine. The product would be available for every major 3-D printer model.

We believe this is the simplest solution to the problem. It is very cost effective, easy to use and requires very little maintenance. Those characteristics were found to be the 3 most important for this design based on our QFD. This product would not be very adaptable and would only be available in printers we specifically made it for, but we believe that would be fixed as we make more designs for all the major models.

Concept 3



This design is a retractable arm that can swing around the part and knock it off of the base. Because it is a retractable arm instead of a limited framework size, it is able to sweep any sized part off of the printer base. As not seen in the design (lack of 3D modeling experience), the ends of the frame would have some sort of clip that would easily attach to the inside framework of the printer. The ends of the frame on the arm would be able to freely rotate in the clips, so it can avoid running into the actual 3D printer.

This is not terribly expensive (dependent on how much customization is needed). It is very easy to use once it is set up and some maintenance is needed to ensure the arm stays intact. It is very adaptable due to the retractable arm that can move depending on 3D printed part size and can be made available for every printer size.

Project Management
Prototyping: Lawrence Ramler

CAD: Lawrence Ramler

Electronics: Lawrence Ramler

Sourcing: Lawrence Ramler

Key Dates
21-Oct Select a concept

28-Oct FBD, Loading conditions, calculations

4-Nov Material Selection

11-Nov Standard components

18-Nov Manufacturing drawings

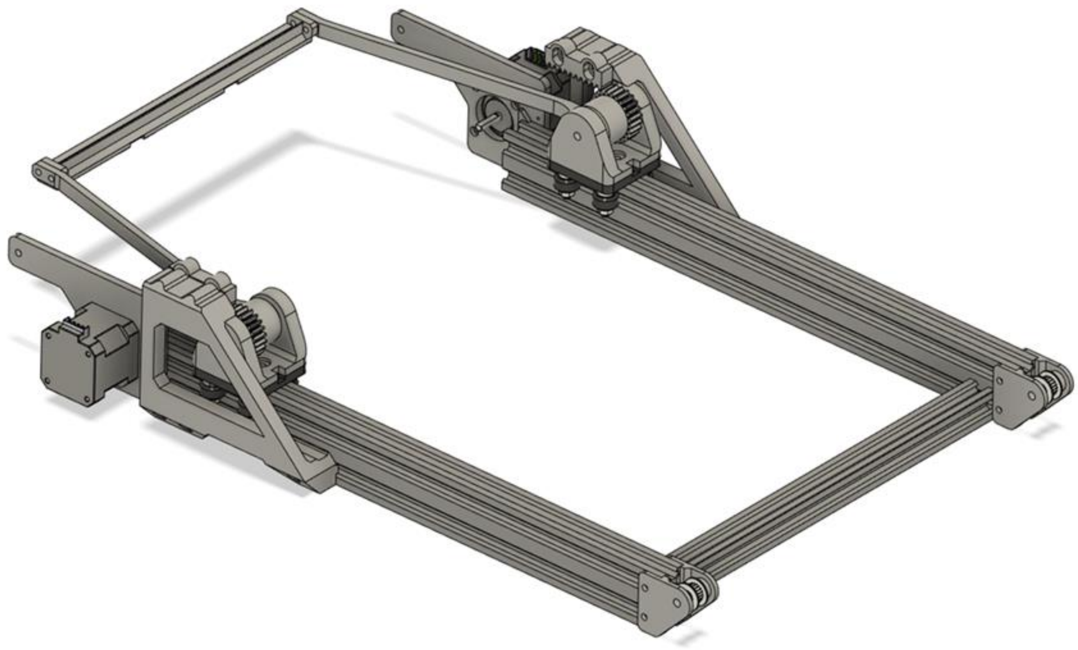
18-Nov Budget schedule

2-Dec Power point presentation

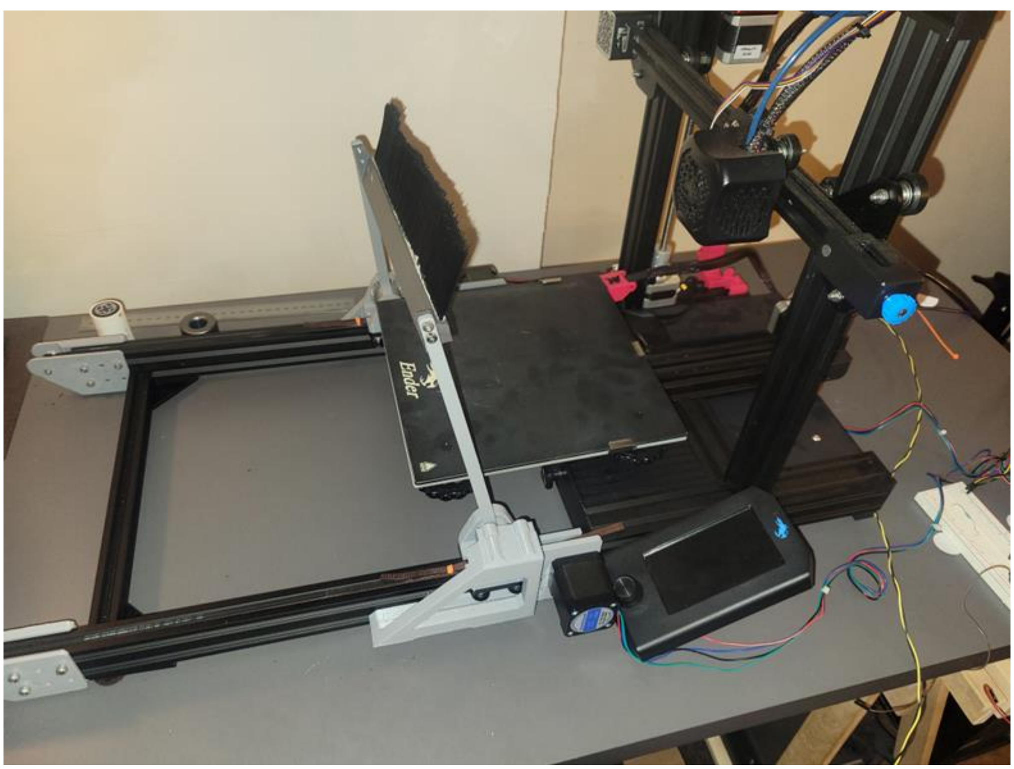
Budget

Mecanical Parts	$400
Electronics	$300
Tools	$100
Misc	$100
Total	$900

Final Product



Above is the matured version of the bar concepts. The system utilizes a bar that is mounted to two belt driven gantries. A gear rack is used to swing the part out of the ways during operation.



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