DEGREE PROJECT

Versatile 3D printing platform for Indian market

Self-Sponsored

STUDENT: Annuai P

PROGRAMME: Bachelor of Design (B.Des)

Guide: Nachiketa Charkhwal & Akshay Anand

2021

INDUSTRIAL DESIGN

This Evaluation Jury recommends ANNUAI P for the Bachelor of Design Degree of the
National Institute of Design, Haryana
in INDUSTRIAL DESIGN

Herewith, for the project titled “VERSATILE 3D PRINTING PLATFORM FOR INDIAN CONSUMERS” On fulfilling the further requirements by*

Jury Chair
Members:

Jury grade:

*subsequent marks regarding fulfilling the requirements:

The project has been completed in ____________________ weeks.

Activity Chairperson, Education/Director ____________________________

Bachelor of Design, Industrial Design, 2017
National Institute of Design, Haryana, India.

Annuai P
UG Industrial Design
Graduation Prioject 2021

Email: annuai.annu@gmail.com

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Acknowledgement

The document is a consolidation of my learnings of the four years of education I have received at the National Institute of Design. I am overwhelmed in all humbleness and gratefulness to acknowledge my depth to all those who have helped me to put these ideas, well above the level of simplicity and into something concrete. I would like to express my special thanks of gratitude to my in-house guides Nachiketa and Akshay for helping me through the project through tough times.

My parents have been the best support system I could have throughout the project and I will forever be grateful to them for helping me and pushing me to keep going even when I had to go through some of the toughest times of my life.

I would like to thank all my friends, especially Eldho and all my batchmates who have helped me through project in gathering information and helping me find ways when I was stuck - they've helped this project become the unique one it is.

About NID, Haryana

National Institute of Design, Haryana, was established on November 15, 2016 as an autonomous institute under the Department for Promotion of Industry and Internal Trade (DPIIT), Ministry of Commerce and Industry, Government of India, to emerge as a global leader in Design Education and Research. The institute aims at becoming the torchbearer for innovative design directions in the industry, commerce and development sectors.
NID Haryana's multi disciplinary environment consisting of diverse design domains helps in creating an innovative and holistic ecosystem for design learning and delivering solutions focusing on the emerging needs of people integrated with digital and cutting edge technologies.
NID Haryana currently offers full-time four year Bachelor of Design (B.Des.) with specialization streams of Industrial design, Communication design and Textile & Apparel design.
The Bachelor of Design (B.Des.) commences with a two semester rigorous Foundation Program followed by six semesters of specialized courses. Teaching methodology incorporates Industry and Field exposure.

About Industrial Design

Industrial Design stands as the point of interaction between systems, products, engineering and end users. The user-centered approach is of highlight in all aspects of this field. Human factors, cognitive ergonomics, form studies, CAD, research methodologies, design management, materials and production processes - all become important parts of this field of Design.

Preface

As a part of the NID curriculum, final year students are expected to do a 4 to 6 month graduation project which is a full scale design project in the industry. It could be in the form of an internship or sponsored project. The graduate project is a complete demonstration of independent client service by the student and is expected to generate a professional design assignment with application and implementation capabilities. This exposes the student to a real life situation of working in the industry and helps them understand constraints and limitations of an organization. It involves understanding of the strengths and infrastructure of the organization. Analyzing the problem statement specific to the situation and respond with an appro- priate solution given the constraints and time limit. It also helps understand the role to play as a designer in a multidisciplinary team which involves pitching ideas to a non-designer and convincing them of its merits. Hence the degree projects helps a students understand his strengths and weaknesses before entering into the professional world of design.
I completed my degree project in a time frame of 6 months from July to December 2021 as a self-sponsored project. I worked to make it my best project yet and overtook all the important parts of the project myself over this period. I was able to work on the project while overcoming difficulties and planning appropriately when the times were difficult and the work was extremely sluggish due to circumstances.

3D printers at work in a printing farm
Photo by Minku Kang from Seoul, Korea

Contents

The major sections of contents are given here. On the beginning of each section is a sorted list of contents of the particular section.

Introduction

This project came about from me purchasing a 3D printer in 2018 and learning over time about it. A device that could simplify all my needs as a maker, the 3D printer has changed the way I look at solving problems. The fact that this technology is unknown to most people and mostly inaccessible is a problem I wanted to work on solving. The project had me looking at different opportunity areas into the future of 3D printing and settling down on helping these machines reach more people through better design. The project commenced in July 2021, at a time when COVID-19 was starting to slow down but had most of us at a standstill. The project was full of hurdles and involved much of research and understanding what people were looking for and what the issues in fact were.

Abstract

Three-Dimensional(3D) printing is an additive manufacturing process that creates physical objects from a digital design. 3D printers have shown their capabilities in many facets of life helping with prototyping, manufacturing, building machines to prosthetics, even in surgical implants.

3D printers are relatively new products that we started seeing more often only in the past decade. They have been gaining popularity over time with a large community of people working on open source 3D printers and various institutions have already understood the benefits of the technology and have been working on bringing the technology into their prototyping ecosystem.

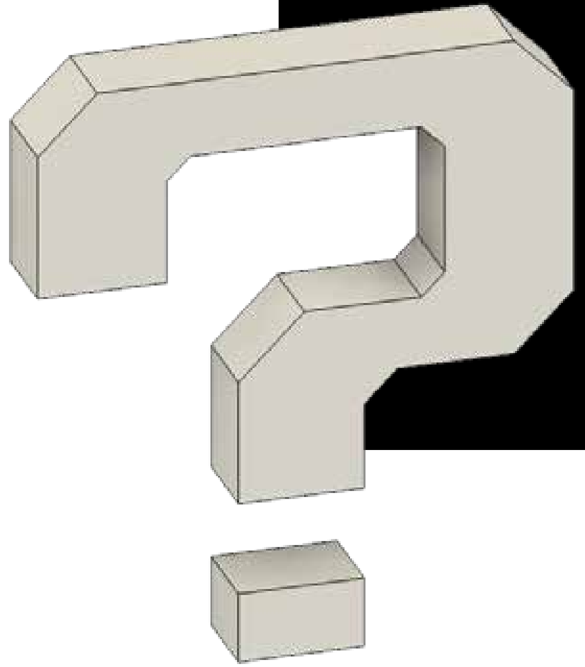
While making methods like welding, carpentry etc. are still highly relevant, they are limited to the skillsets of the individual. A 3D printer is a highly precise manufacturing machine that can replicate complex designs without the user requiring a complex skillset and experience. Anyone who wants their idea put into physical objects can use basic computer software and build their ideas to life in a matter of hours.

3D printing is redefining what is possible for makers to create at homes. The technology supports creators and enterpreneurs to achieve and execute their goals much faster than otherwise with limited amount of resources. The technology improves every year with significant progress in speed and efficiency of the machines. Designing a product that combines a simple user experience while retaining the overall upgradeability and customizability of these machines is the task at hand.

A creator looking at a 3D printer and getting intimidated by the complexity should be a thing of the past. We all deal with much more complex devices everyday and are all often easier to operate and safer overall.

The core objective of this project is to provide to the creator an inexpensive portable highly functional 3D printer that ensures to provide the best user experience through product design.

3D printing is already shaking our age-old notions of what can and can't be made.
- Hod Lipson(Robotics Engineer)



How do we design and develop a versatile 3D printer platform with the less technically acquainted user in mind? How can the Indian context be put into the idea of the machine. What is the scope of the audience for such machines in India and how can design be used to better cater to their requirements?

Design Process

Research
Brainstorm
Evolution of 3D printers
3D Printers in education
Maker Culture in India
Market Research
Study & analysic of components

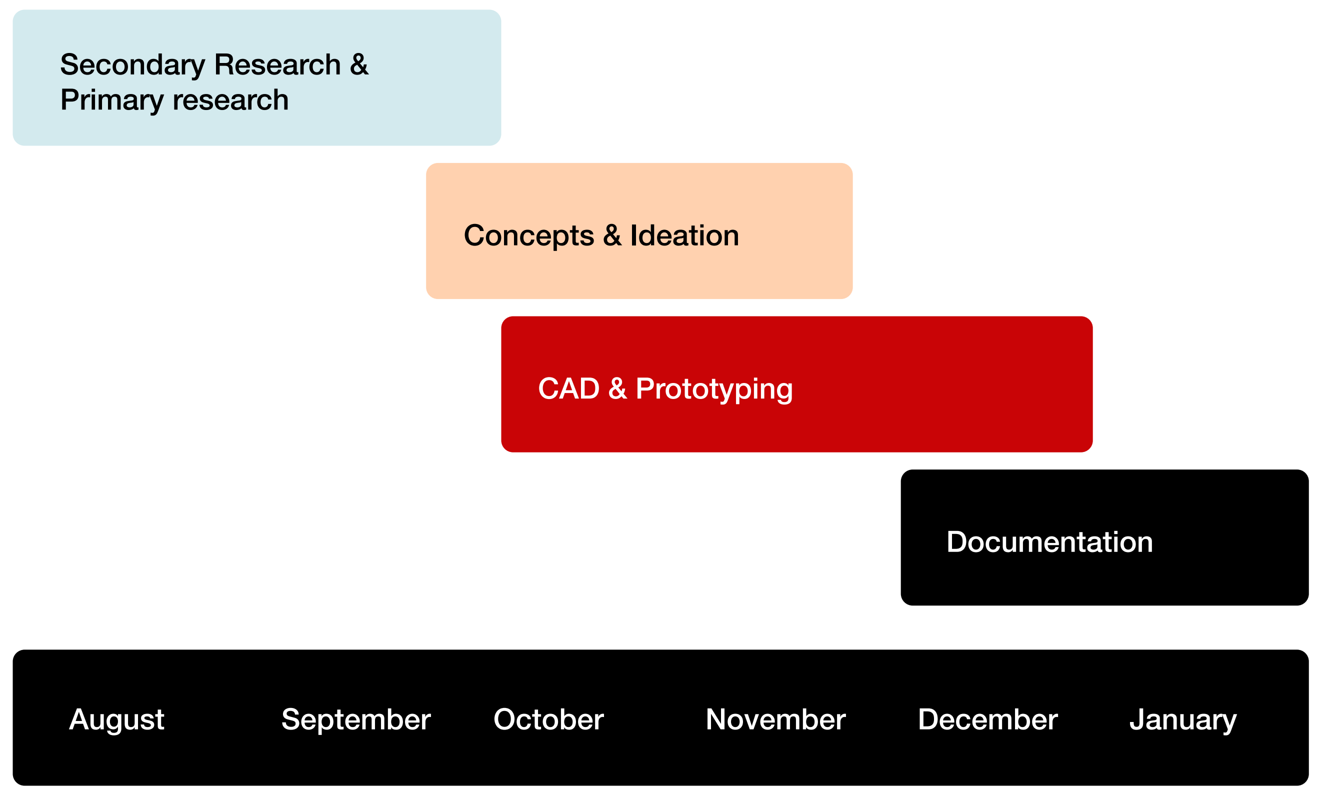
Primary Research
Interviews of industry professionals
Talks with hobbyists
User Personas
Task Flows

Synthesis
Insights and Analysis
Briefing
Design Decisions

Ideation
Concept Generation
Visualisation
Validation

Execution
CAD Prototyping
Proof of Concepts
Documentation

Timeline



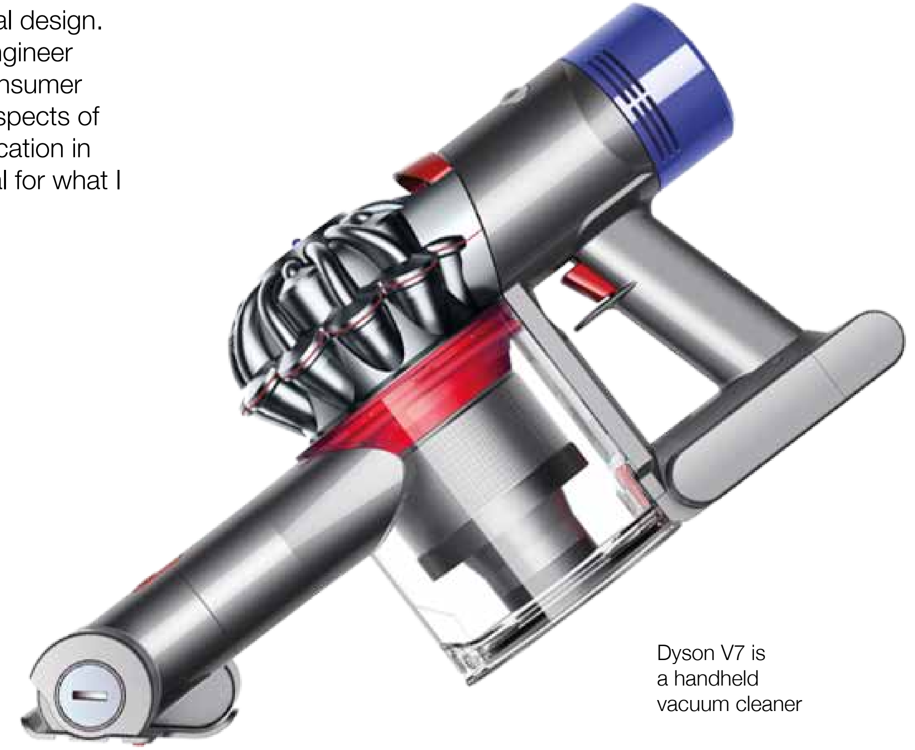
Dyson, Braun and Design Engineering

Good design hides its complexity from plain sight

Design engineers are problem solvers who bridge the gap between traditional engineering and Industrial design. The original goal of this project was to reverse engineer a 3D printer to fit economically into the Indian consumer market while still improving on the functionality aspects of the machine. The collaboration between my education in Design and a potential engineering skillset is ideal for what I believe is the the future.

Good design is about how something works, not just how it looks - Dyson

A combination of technical innovation, a new aesthetic, and a degree of user-friendliness that has been thought through down to the smallest detail - Braun



Dyson V7 is a handheld vacuum cleaner

Reverse Innovation

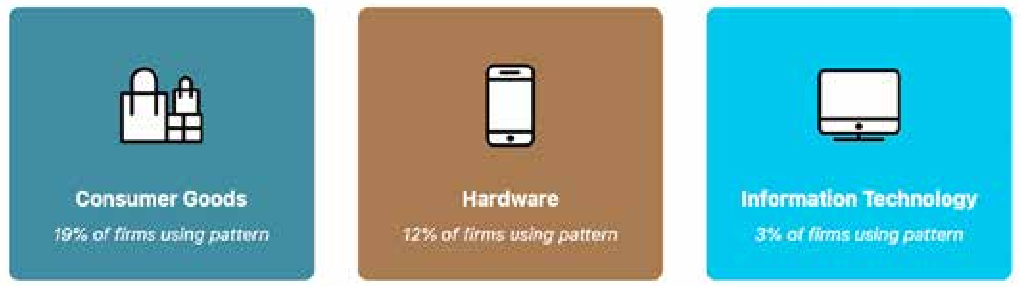
Reverse Innovation as defined by Vijay Govindarajan and Chris Trimble is the strategy of innovating in emerging (or developing) markets and then distributing/marketing these innovations in developed markets. Many companies are developing products in emerging countries like China and India and then distributing them globally.

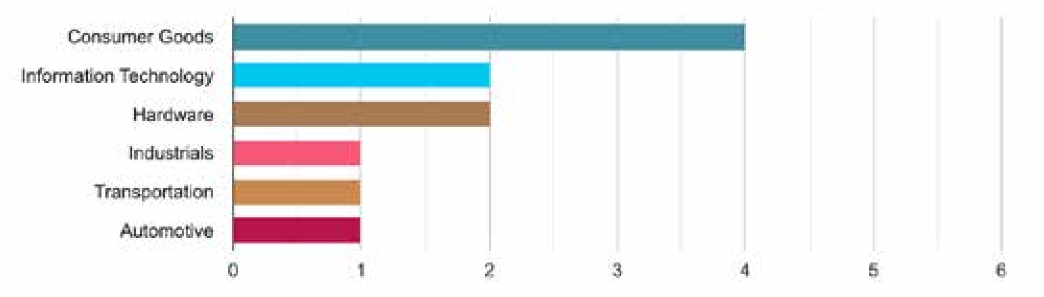
The primary goal often is to reduce the costs of these otherwise expensive technolgoies to be as economically plausible as it could be - so that the markets in the developing nations can still afford to purchase still while the concurrent benefits from the newly innovated design will eventually help sell the same product in a more developed country possibly with a different strategy altogether.

GE MAC 5500 is an ECG machine that costs ₹3 lakh

GE MAC 400 is a portable ECG machine that costs ₹40000 and was innovated at GE's Technology center at Bengaluru

Although designed for different markets- they both technically accomplish similar things

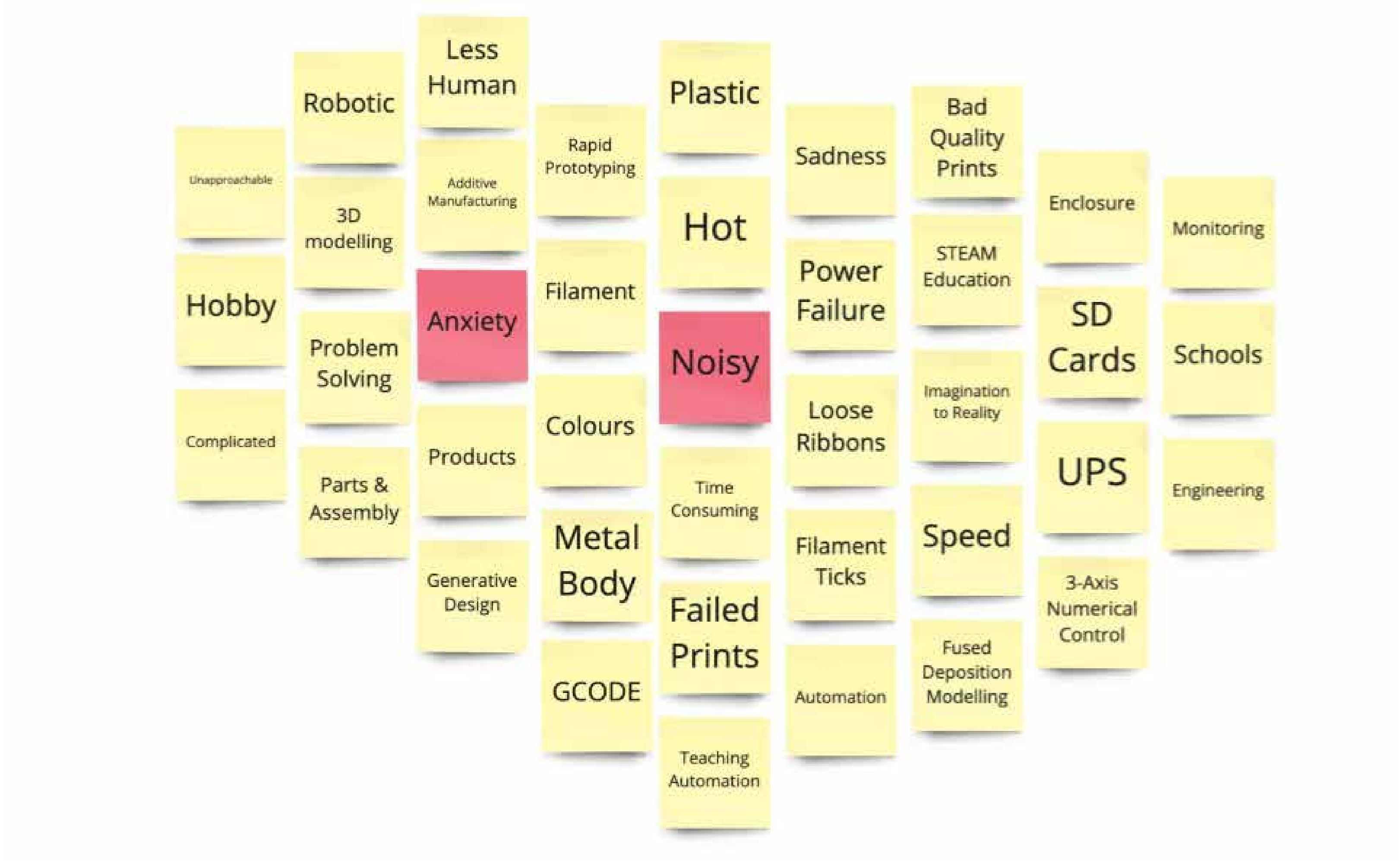




Secondary Research

Research intends to find the current status of 3D printing - both globally and locally in India, finding the common types of 3D printers and other important aspects to be looked upon throughout the project

Start with a Brainstorm



This brainstorm was done in two minutes to have a vague idea of consumer 3D printing from my perspective

There might be an opportunity on building a better printer for the upcoming 3D printer users in India - especially the young, maker-culture oriented audience. There might also be possibilities in the upcoming overhaul in education systems all over India to be including machines like 3D printers into the curriculum.

Questions to look for

The research began with penning down a set of questions that required the answers to. While most of the questions are to understand the industry and consumers, it eventually leads to more comprehensive understanding of the machine itself and later on into and then into micro details including the user experience of the machine.

- Does 3D printing have a future in education? What are the possibilities?
- How to make use of technology like 3D printer a more relevant tool for education in the future?
- How can a 3D printer help children with education?

- Is there a requirement of yet another 3D printer? What are the missing features of current machines?

- Most consumer 3D printer owners are hobbyists. Why?
- What is the future demographic of 3D printer users?

- What is limiting people from buying and using 3D printers?
- What are the present issues stopping more users from using 3D printing in their lives?
- What can be done with 3D printers? Do they have household applications?
- Can a 3D printer become a household appliance? What are the criteria for an appliance to become a household one?

- What is the history of 3D printers? How have they come to the point it is today?
- What are the technical components of a 3D printer?
- What is the costing of individual components of a 3D printer?
- What is the process of using a 3D printer?
- Is it complicated? How much training and education is required to use a 3D Printer?

A brief history of Additive Manufacturing

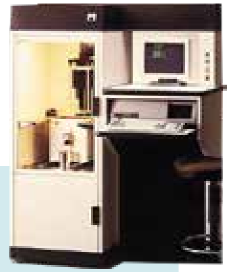
1980

Hideo Kodama files the first 3D printing patent application, describing a photopolymer rapid prototyping system that uses UV light to harden the material

1983

Charles Hull invents **stereolithography(SLA)** machine. Charles Hull is the founder of 3D Systems Inc

1987

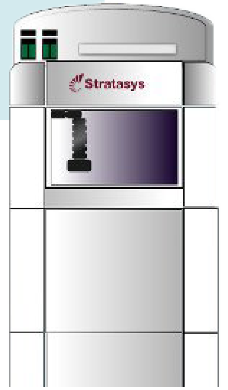


3D Systems SLA-1

3D Systems sell the first commercial rapid prototyping printer SLA-1

1989

Scott and Lisa Crump file for a patent for Fused Deposition Modelling(FDM). They go on to found Stratasys Inc.



Stratasys 3D modeler is the first FDM printer

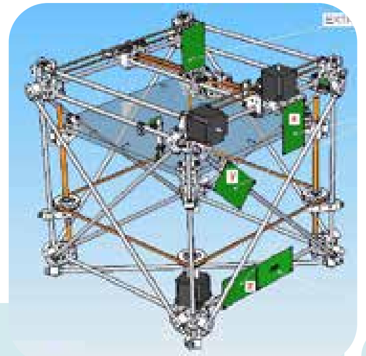
1999

Wake Forest Institute of Regenerative medicine grows the first 3D printed organ for transplant surgery - a lab grown urinary bladder

2005

RepRap(Replicating Rapid Prototyper) was founded by Dr. Adrian Bowyer at University of Bath, England

2008



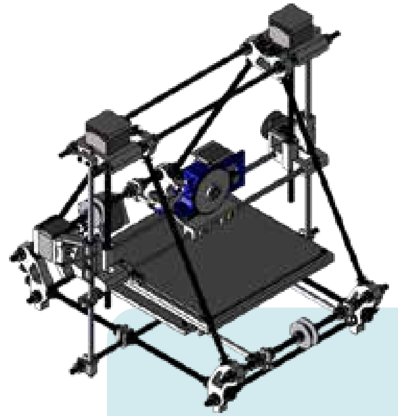
Darwin becomes the first commercially available 3D printer based on RepRap designs

2009

FDM patent held by Stratasys expires. This leads the average 3D printer price reducing from $10000 to under $1000

Makerbot Industries launches DIY kits for 3D printers for people who want to build their own printers

2012



A printer built by the **RepRap** project

Josef Prusa, a Czech inventor and maker starts Prusa Research - the maker of the most popular consumer 3D printers

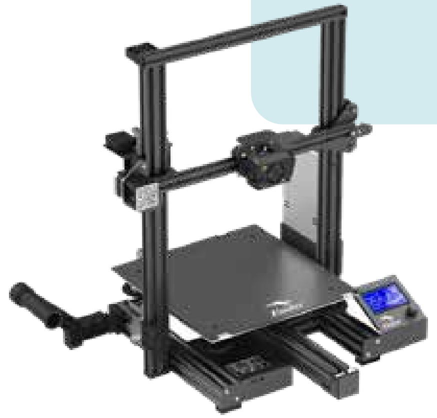
2013

Micro, a consumer 3D printer that supports PLA and ABS becomes the most funded campaign on Kickstarter after raising $3.4 million

Makerbot is acquired by Stratsys for $400 million

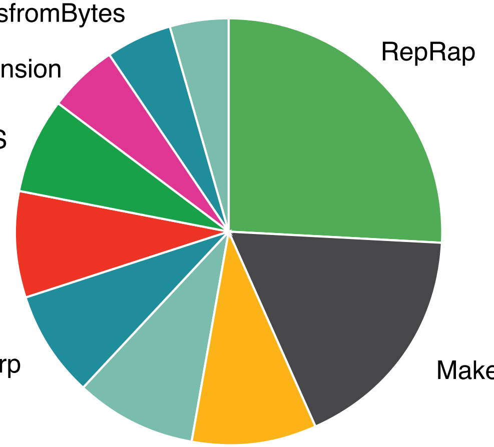
2018

Creality gains recognition with the launch of Ender 3 - the low-cost 3D printer



History of Additive Manufacturing
The role of open-source in the upbringing of 3D printing

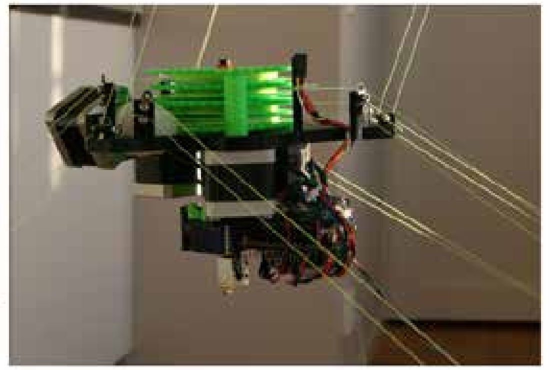
Mainstream consumer 3D printing as it is possible today is the product of an initiative called the RepRap, abbreviated from **Rep**licating **Rap**id Prototyper - the project started in England in 2005 as a University of Bath initiative to develop a low-cost 3D printer that can print most of its own components, but it is now made up of hundreds of collaborators worldwide.
RepRap not only made the first open-source FDM printer, but also led to many people and corporates investing into the open source ecosystem to collaboratively develop 3D printing.
Many advances has happened, thanks to the open source innovation made possible by collaborators all around the globe.
Today, hundreds of open source 3D printer designs help individuals choose the best kind they require and slowly building into the machine they require.



Global 3D printer marketshare as of 2013. Market has changed to a large extent - creality occupies a large chunk of the consumer market - creality printers are based off of RepRap
data from peerproduction.net

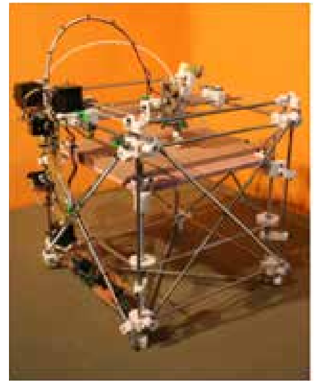
Printer that came out of the RepRap project

Prusa i3



Hangprinter

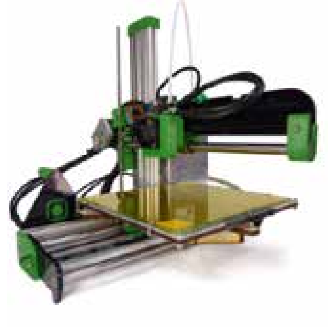
Reprap Fisher



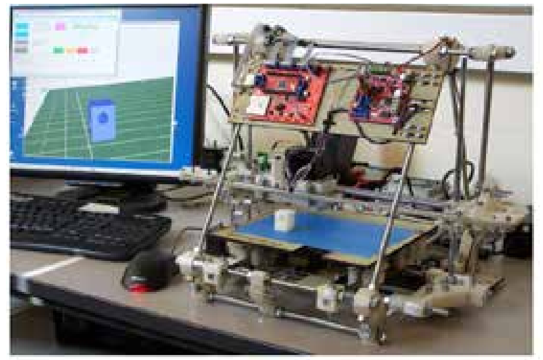
Reprap Darwin

Reprap Snappy

Reprap Morgan



Reprap Ormerod



Reprap Mendel

How to 3D print?

The process is similar for common printer types - but the process here is for Fused Deposition Modelling Printers

Create 3D model with modelling software (eg. Rhinoceros, Autodesk Fusion 360) or using 3D Scanning to make models of real life objects

Through a process called **Slicing**, the model is converted into GCODE using software (eg. Cura, PrusaSlicer, Simplify3D) - GCODE is a language that contains information of coordinates to print the object

The printer is **powered on** and put into **pre-heat** mode. Most printers have a heated bed that required to be around 60 degrees to be able to stick the printed object to the bed while printing

File is downloaded into the printer. Most printers use an SD card to do this - wireless and networked printers are also available - especially in the professional printing market

Printer starts printing the object - print time depends on the **speed, quality and size** of the object - this can range from minutes to hours to even days of printing for more complicated objects

Melted Filament is deposited **layer by layer** to form the object

Finished printed object is removed from the bed and is ready for post-processing like painting

Types of 3D printers

Stereolithography (SLA)

Cost	■■■□□
Speed	■■■□□
Mechanical properties	■■■■□
Material selection	■■■□□
Surface Finish	■■■■■
Community Support	■■□□□

Stereolithography (SLA) is the original industrial 3D printing process. SLA printers excels at producing parts with high levels of detail, smooth surface finishes, and tight tolerances. It's widely used in the medical industry and common applications include anatomical models and microfluidics.

Selective Laser Sintering (SLS)

Cost	■■□□□
Speed	■■■□□
Mechanical properties	■■■■■
Material selection	■■■□□
Surface Finish	■■■■■
Community Support	■■□□□

Selective laser sintering (SLS) melts together nylon-based powders into solid plastic. They are durable, suitable for functional testing, and can support living hinges and snap-fits. In comparison to SL, parts are stronger, but have rougher surface finishes. SLS is slower than other technologies.

PolyJet

Cost	■□□□□
Speed	■■■□□
Mechanical properties	■■■■■
Material selection	■■■■□
Surface Finish	■■■■■
Community Support	■□□□□

PolyJet is a 3D printing technology that builds parts by jetting thousands of photopolymer droplets onto a build platform and solidifying them with a UV light. It's one of the fastest and most accurate 3D printing technologies currently available. PolyJet is also known as MultiJet and Material Jetting by other manufacturers

Digital Light Processing (DLP)

Cost	■■■■□
Speed	■■■■□
Mechanical properties	■■■■□
Material selection	■■■□□
Surface Finish	■■■■■
Community Support	■■■□□

Digital light processing is similar to SLA in that it cures liquid resin using light. The primary difference between the two technologies is that DLP uses a digital light projector screen whereas SLA uses a UV laser. DLP is used for rapid prototyping, but the speed of DLP printing makes it suitable for low-volume production runs of plastic parts.

Fused Deposition Modeling (FDM)

Cost	■■■■■
Speed	■■■■□
Mechanical properties	■■■□□
Material selection	■■■■□
Surface Finish	■■■□□
Community Support	■■■■■

Fused deposition modeling (FDM) is a common desktop 3D printing technology for plastic parts. An FDM printer functions by extruding a plastic filament layer-by-layer onto the build platform. It's a cost-effective and quick method for producing physical models. There are some instances when FDM can be used for functional testing but the technology is limited due to parts having relatively rough surface finishes and lacking strength.

FDM is a more promising technology - being cost-effective, fast and having the better community for consumer printers among all the types available

Ultimaker S5
is a common professional FDM printer

Education and printing

Atal Innovation Mission has been bringing STEAM(Science, Technology, Engineering and Mathematics) education into the classrooms of India, investing into machines like 3D printers and other modern technologies. STEAM education will eventually get tightly integrated into the primary education ecosystem wherein students will get the opportunity to be makers and inventors directly from their schools.

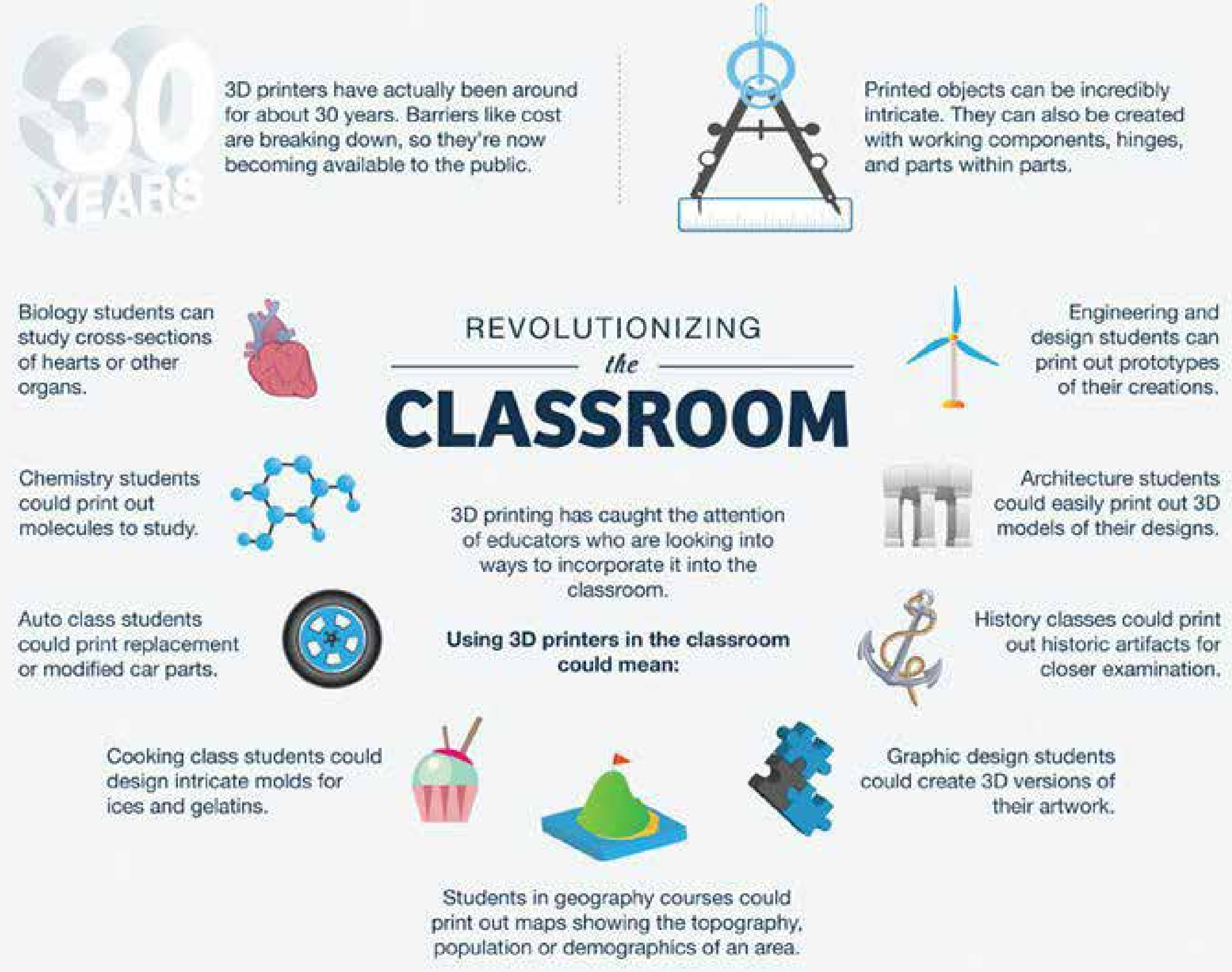
STEAM education can lead to innnovation and creativity and experiental learning is always a step ahead of theoretical learning. According to a joint survey conducted by NITI Aayog and AIM, more than 6 million students have access to STEAM education facilities in their schools in India alone.

STEAM education in India is promoting the culture of Start-ups and entrepreneurship right from the early age. The government is taking many initiatives, including the ATL Marathon contest, where the students have to come up with the solutions to tackle the existing problems in the society.

ATL is a workspace where young minds can give shape to their ideas through hands on do-it-yourself mode; and learn innovation skills. Young children will get a chance to work with tools and equipment to understand the concepts of STEM (Science, Technology, Engineering and Math). ATL would contain educational and learning 'do it yourself' kits and equipment on – science, electronics, robotics, open-source microcontroller boards, sensors and 3D printers and computers. Other desirable facilities include meeting rooms and video conferencing facility.

सत्यमेव जयते
NITI Aayog
ATAL INNOVATION MISSION

The 3D printers being used by ATL as of today are Shaperjets - which are technically inferior to the competition and not available for purchase online.



Maker culture in India

The maker culture is a contemporary subculture representing a technology-based extension of DIY culture that intersects with hardware-oriented parts of hacker culture and revels in the creation of new devices as well as tinkering with existing ones. The maker culture in general supports open-source hardware.

With the advent of internet and platforms like youtube, maker movement has taken much faster strides than ever in bringing the newer technologies to the mainstream.

Makerspaces are not limited to modern technologies and electronics. They can be a point of interaction between the more traditional methods of making and the newer more advanced methods like laser cutting and 3D printing

The more famous definition of a maker space in current times ‘empowers’ the privileged, and over-looks the most essential part of the Maker Movement, building things. Knowingly or unknowingly, it’s teaching the ‘over-engineer everything’ mentality.
quoted from the medium.com article by Rishi Gaurav Bhatnagar

The maker movement in India gained traction thanks to a policy environment that supported the startup culture and turned Delhi, Mumbai and Bengaluru into innovation hubs. Makerspaces that initially attracted tech enthusiasts and hobbyists wanting to create something new for the fun of it gradually started attracting people who wanted to innovate for entrepreneurial motives, even to contribute something to society.
quoted from thewire.in article Makerspaces – a Less Known Way To Infuse a Culture of Innovation in Communities

The DIY electorncis space came to a full halt when the government announced the ban of imports and shipments from China in late 2020. Websites like Aliexpress were among the favorites of all DIY enthusiasts all over India - most of the makers often have a tight budget and it was a convenient market for the chinese to sell their inexpensively produced DIY good directly to India.

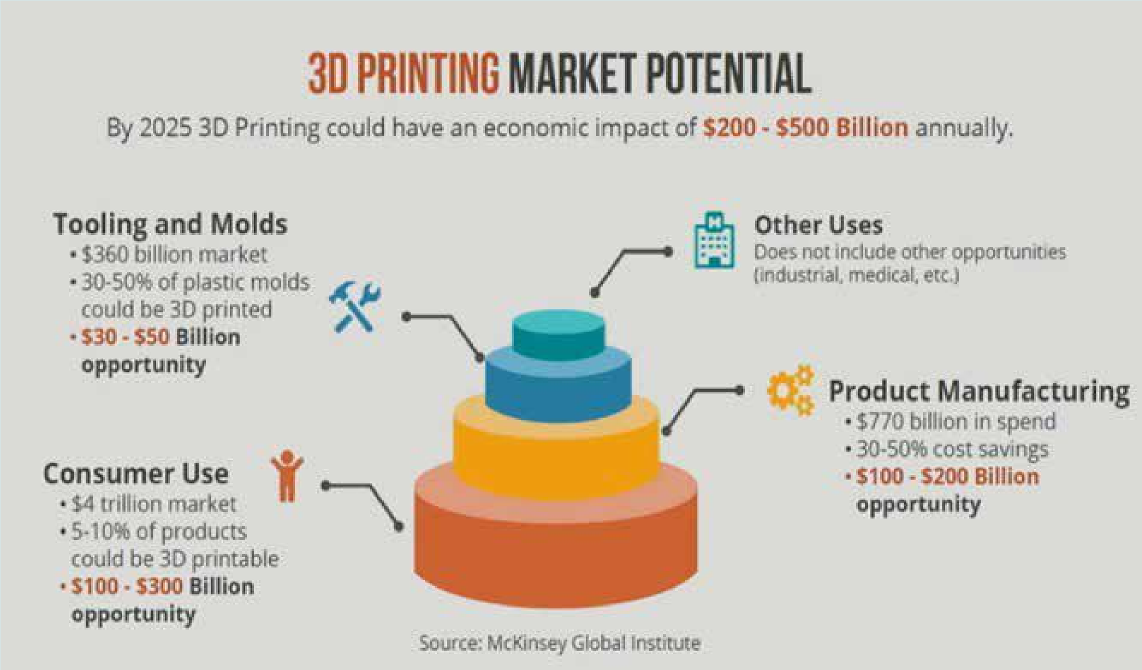
The DIY electronics industry picked up again with the lift of lockdown when a bunch of new companies started seeing the newly created opportunities in the space.

This in fact is an opportunity for a product like an Indian 3D printer when the Make In India is at its highest point since its inception

The largest DIY youtube channel in malayalam - M4Tech introducing a 3D printer. The video has 18 lakh views

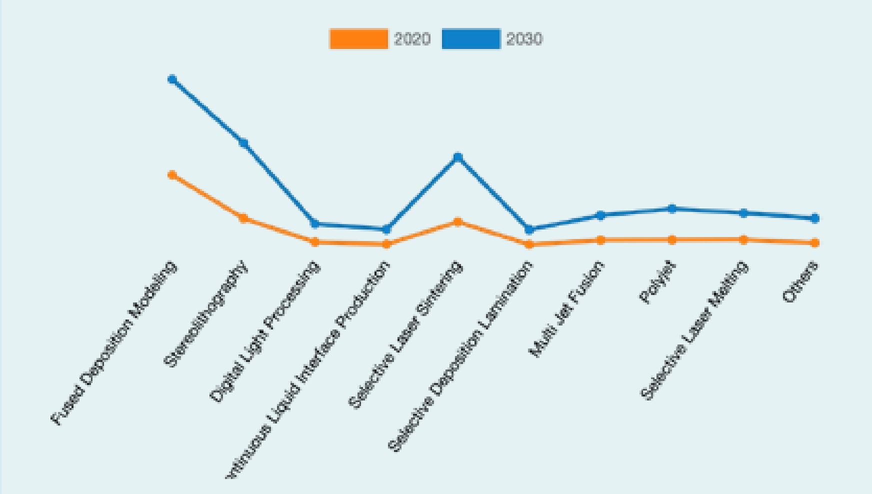
Laser cut toys at Maker Asylum, Mumbai

Global 3D printer market

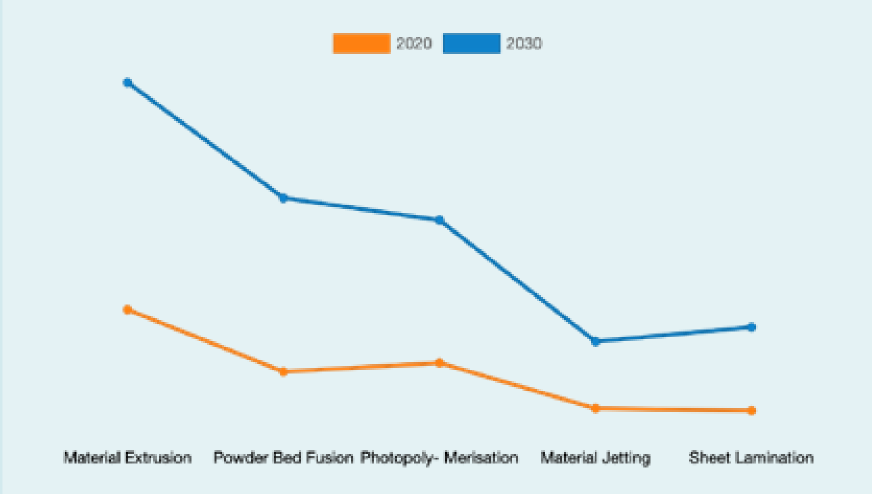


The amount of opportunities in the market are ever-increasing and the growth in South Asian markets are also catching up with the rest of the world. The lack of skilled labour is the major obstacle in jobs not being created in the market.

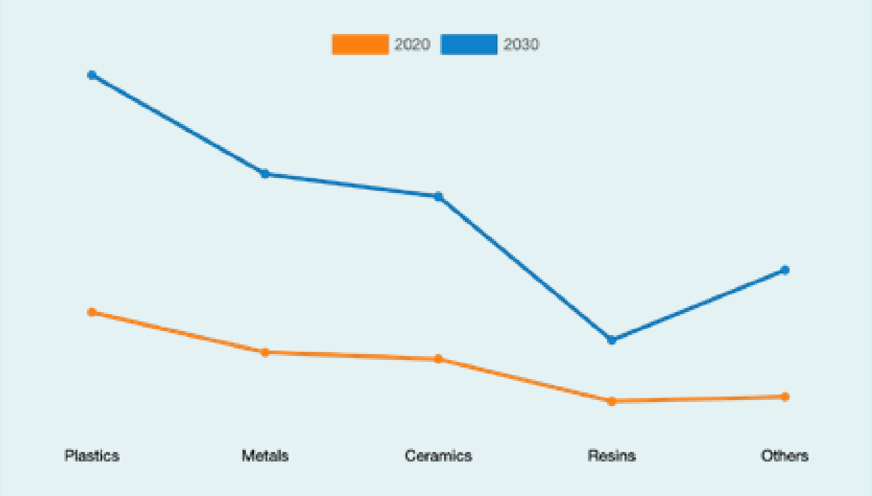
3D Printing 2020-2030 report by Allied Market Research



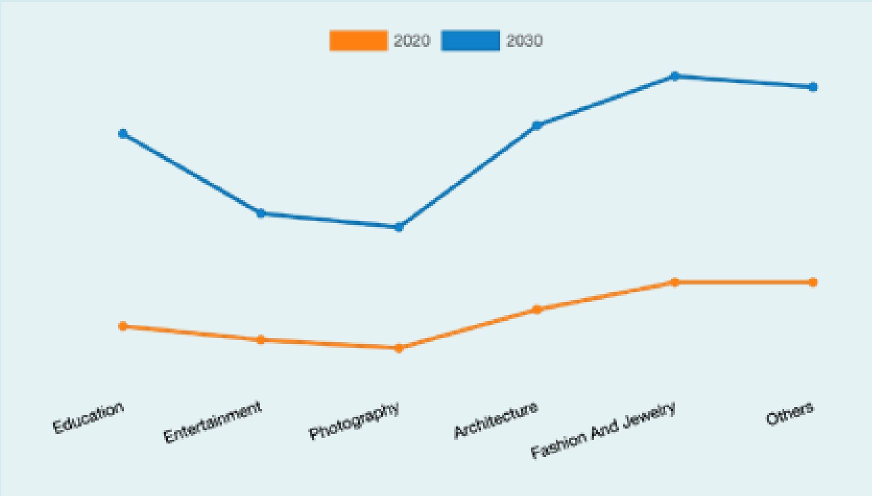
Fused Deposition Modeling segment will hold the highest market share



Material Extrusion segment will dominate the market



Plastics segment is expected to secure the leading position



Fashion and Jewelry segment is expected to secure the leading position

Understanding the current Indian market

3000 Ender 3’s get sold every month in India

Personal 3D printing is an emerging market in India with a large opportunity due to the largely vacant market in the low-budget segment and the costs driving purchase decisions more often than others

Ender 3

*Approximate calculation from amazon.in and hydrotech3dchennai.com sales figures

The market in India is growing at a rate of 20%. Automotive and electronics holds the highest share in Indian 3D printing market, while healthcare, aerospace and defense sectors are witnessing higher growth too. This technology allows designing without constraints, thus, enabling further creativity and innovation.
Most of the 3D printing market in India is currently limited to Industrial 3D printers making production and prototyping parts. There is also a much smaller but growing market for personal 3D printers that aren’t explored as much

> “Most of the people in India are still not aware of 3D printing. If you ask them about this, the very first impression that they get is printing 3D objects on a piece of paper. Well, you may find it hilarious but it is important to teach people and get them aware of this process which is capable of bringing a huge industrial revolution”
>
> Why is 3D printing not popular in india? - answered on quora

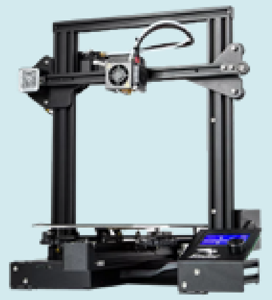
> “India has still not defined 3D printers as a product category. Due to this, 3D printers in India attract close to 40 percent excise duty, making it less accessible to Indian customers.”
>
> Make in India: World’s largest 3d printing firm sets up shop in India - article on The Economic Times

International Brands

Indian Brands

Companies currently in the Indian Market of 3D printers

Available printers in the market



Creality Ender 3

Cost
₹12000

Motion Platofrm
Cartesian

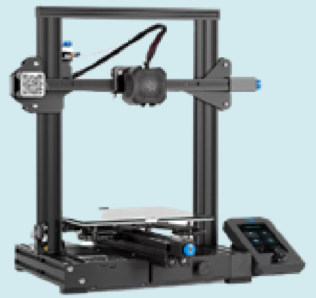
Extrusion Mechanism
Bowden Extruder

Bed Size
220x220x250mm

Printing Speed
80-130mm/s

Machine Size
440x440x465mm

Net weight
8KG



Creality Ender 3 v2

Cost
₹19000

Motion Platofrm
Cartesian

Extrusion Mechanism
Bowden Extruder

Bed Size
220x220x250mm

Printing Speed
80-150mm/s

Machine Size
440x440x465mm

Net weight
9.6KG

Creality Ender 5 Pro

Cost
₹25000

Motion Platofrm
H-Bot

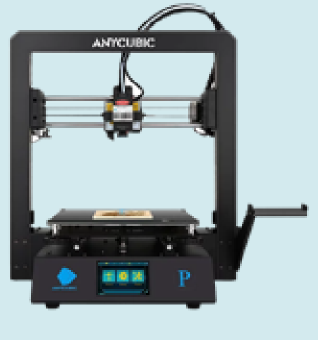
Extrusion Mechanism
Bowden Extruder

Bed Size
220x220x300mm

Printing Speed
120-150mm/s

Machine Size
552x485x510mm

Net weight
11.8kg



Anycubic Mega Pro

Cost
₹35000

Motion Platofrm
Cartesian

Extrusion Mechanism
Bowden Extruder

Bed Size
210x210x205mm

Printing Speed
20-100mm/s

Machine Size
405X410X453mm

Net weight
15kg

Mostly from the global manufacturer called CREALITY - the product selection is very limited in the market and there is only a handful options for a price range of less than ₹35,000

Flashforge Adventurer 3

Cost
₹39000

Motion Platofrm
H-Bot

Extrusion Mechanism
Bowden Extruder

Bed Size
150x150x150mm

Printing Speed
10-100mm/s

Machine Size
388x340x405mm

Net weight
9kg

Creality Ender 6

Cost
₹40000

Motion Platofrm
CoreXY

Extrusion Mechanism
Bowden Extruder

Bed Size
250x250x400mm

Printing Speed
150-200mm/s

Machine Size
495x495x650mm

Net weight
27kg

Creality Ender 5 Plus

Cost
₹44000

Motion Platofrm
H-Bot

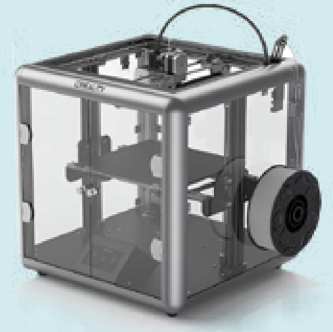
Extrusion Mechanism
Bowden Extruder

Bed Size
350x350x400mm

Printing Speed
80-150mm/s

Machine Size
632x666x619mm

Net weight
18.2kg



Creality Sermoon D1

Cost
₹50000

Motion Platofrm
H-Bot

Extrusion Mechanism
Direct-drive Extruder

Bed Size
280x260x310mm

Printing Speed
150-180mm/s

Machine Size
500x500x531mm

Net weight
20.5kg

So who are using printer and for what?

The primary users in India today are often a very technically acquainted audience who finds 3D printing interesting and decides to invest into the technology to understand it better.

In the more developed parts of the world - 3D printing is a part of curriculum called STEM education.
STEM education is the future of our education system wherein innovation and future will become a core component of the system. 3D printing will become a crucial component of the system because of the speed the technology can provide in bringing creative ideas to life.

Other major users of printers are professionals who use it for professional prototyping purposes.

Education in schools have already started adopting the machines, but costs of the machines are an issue they find difficult to deal with. The inexpensive printers available in the market do not offer the reliability and adequate performance for use in education.

Who could use it?
Some scenarios
A teacher who wants a physical model of an object to help with his teaching

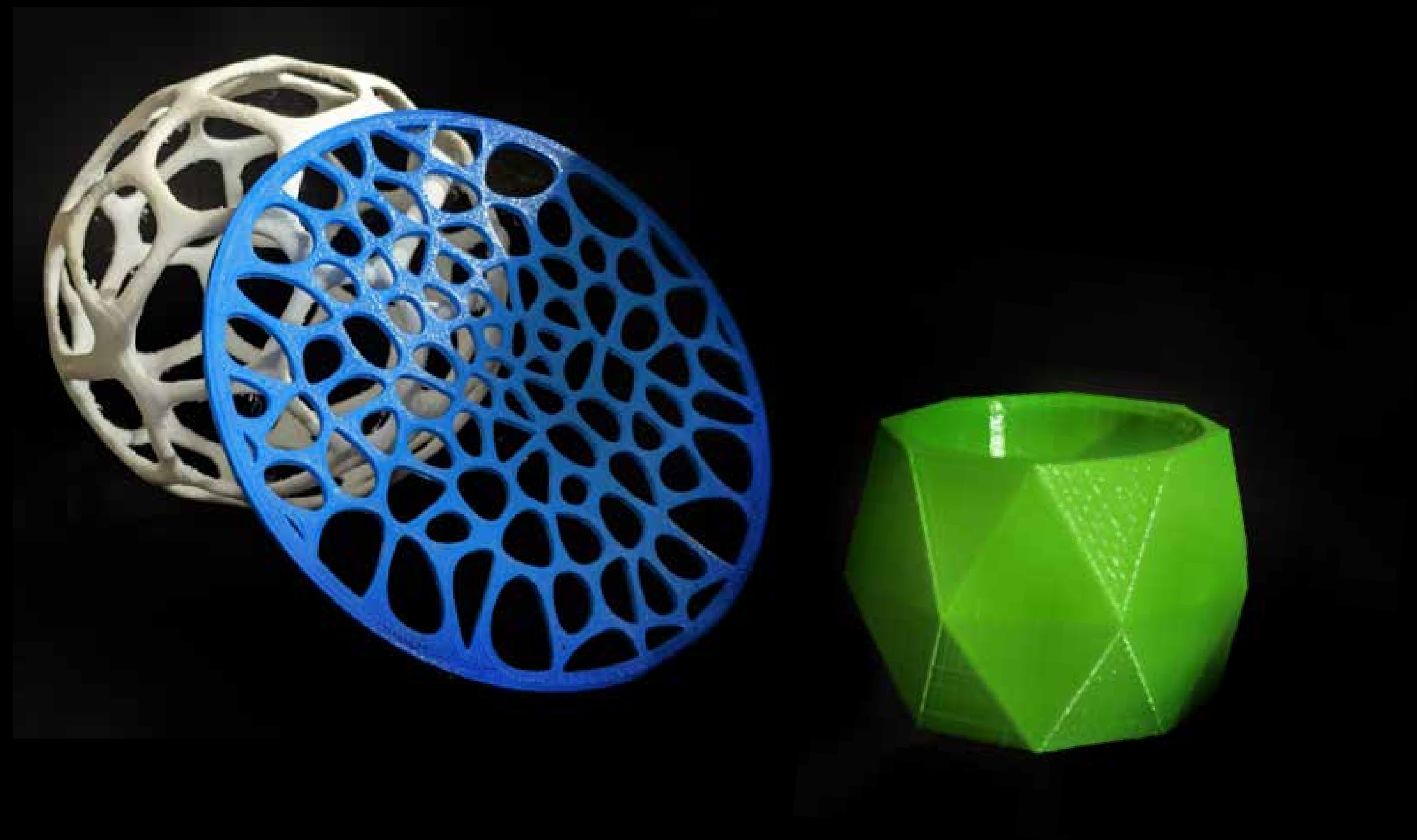
A maker who wants to make a new tool to help with something he is making

A designer looking for inexpensive prototyping tools

A craftsperson wanting to add custom parts to their craft

Possibilities are many with a 3D printer - the problem is often limited to the usability and cost

Some things I have printed



Primary Research

After an understanding of the scenario of printing in India - a set of methods were used to understand further the market itself and the machine and the issues surrounding it

Finding the problems
through Reddit

Reddit hosts one of the largest 3D printing communities in the world. The forum allows people to ask about the issues they are facing and find possible solutions as fast as possible.
Research through reddit is a much faster endeavour and the results were interesting.

19 responses were received for the query

Because fo the more technically inclined audience most of the answers were technical as well

unsurprisingly there were mentions of fire hazards and also user experience issues.

r/3Dprinting · Posted by u/Annuai 2 days ago

7

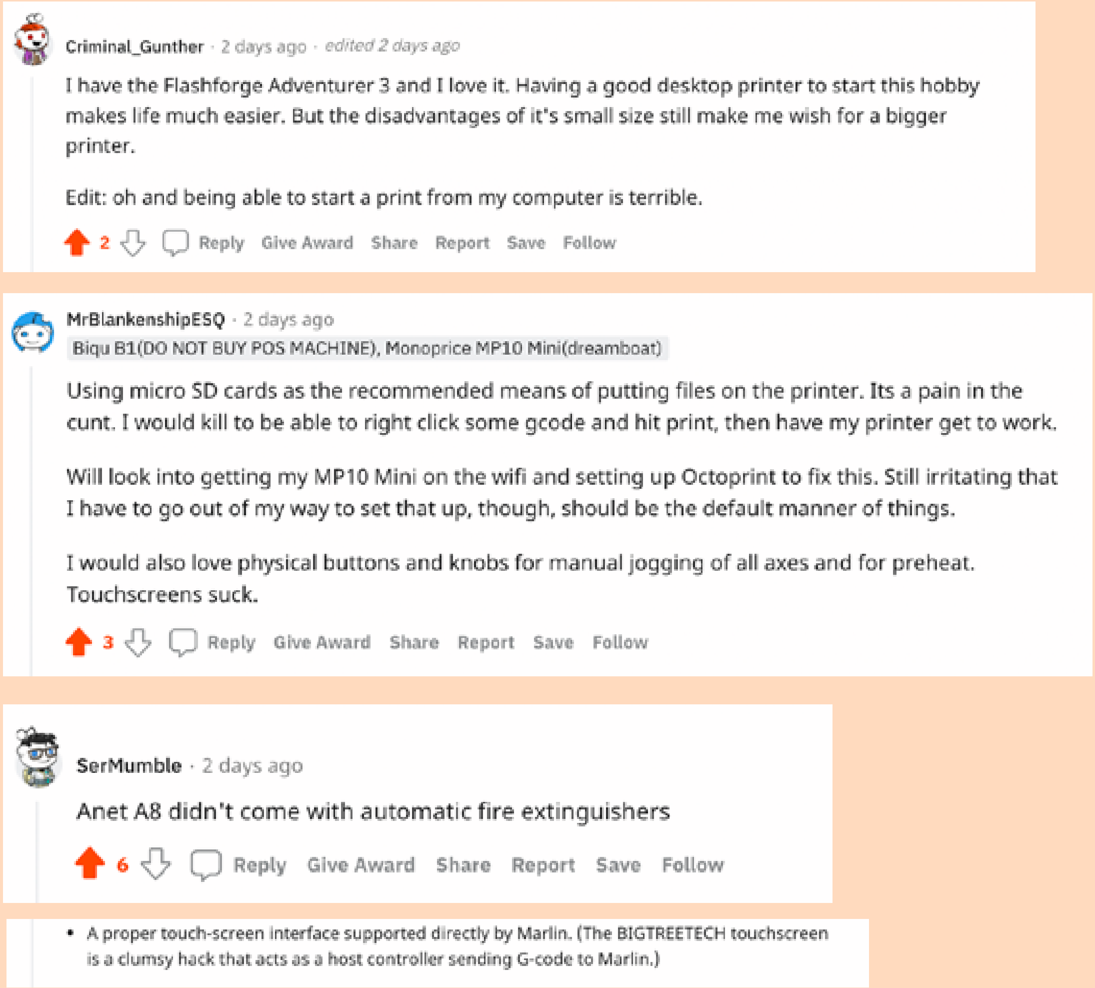
What issues do you face with your printers?

Discussion

Can people here tell the most common annoying issue you often face with your printer. Not the more common ones like a bed levelling issue but the more specific user experience issues that you would be much happier with if it wasn't the same. You could also mention something you would love to have in your printer that'd make your life much easier. For eg: I have a tevo tt pro and i wish I had physical preheat, pause and restart buttons. Add pictures if you could.

PS: I'm a design student and this is for a project I'm working on

19 Comments Share Save ...



Criminal_Gunther · 2 days ago · edited 2 days ago

I have the Flashforge Adventurer 3 and I love it. Having a good desktop printer to start this hobby makes life much easier. But the disadvantages of it's small size still make me wish for a bigger printer.

Edit: oh and being able to start a print from my computer is terrible.

2 Reply Give Award Share Report Save Follow

MrBlankenshipESQ · 2 days ago

Biqu B1(DO NOT BUY POS MACHINE), Monoprice MP10 Mini(dreamboat)

Using micro SD cards as the recommended means of putting files on the printer. Its a pain in the cunt. I would kill to be able to right click some gcode and hit print, then have my printer get to work.

Will look into getting my MP10 Mini on the wifi and setting up Octoprint to fix this. Still irritating that I have to go out of my way to set that up, though, should be the default manner of things.

I would also love physical buttons and knobs for manual jogging of all axes and for preheat. Touchscreens suck.

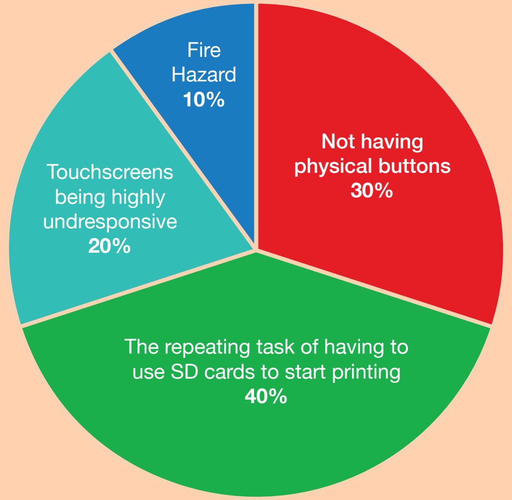
3 Reply Give Award Share Report Save Follow

SerMumble · 2 days ago

Anet A8 didn't come with automatic fire extinguishers

6 Reply Give Award Share Report Save Follow

- A proper touch-screen interface supported directly by Marlin. (The BIGTREETECH touchscreen is a clumsy hack that acts as a host controller sending G-code to Marlin.)



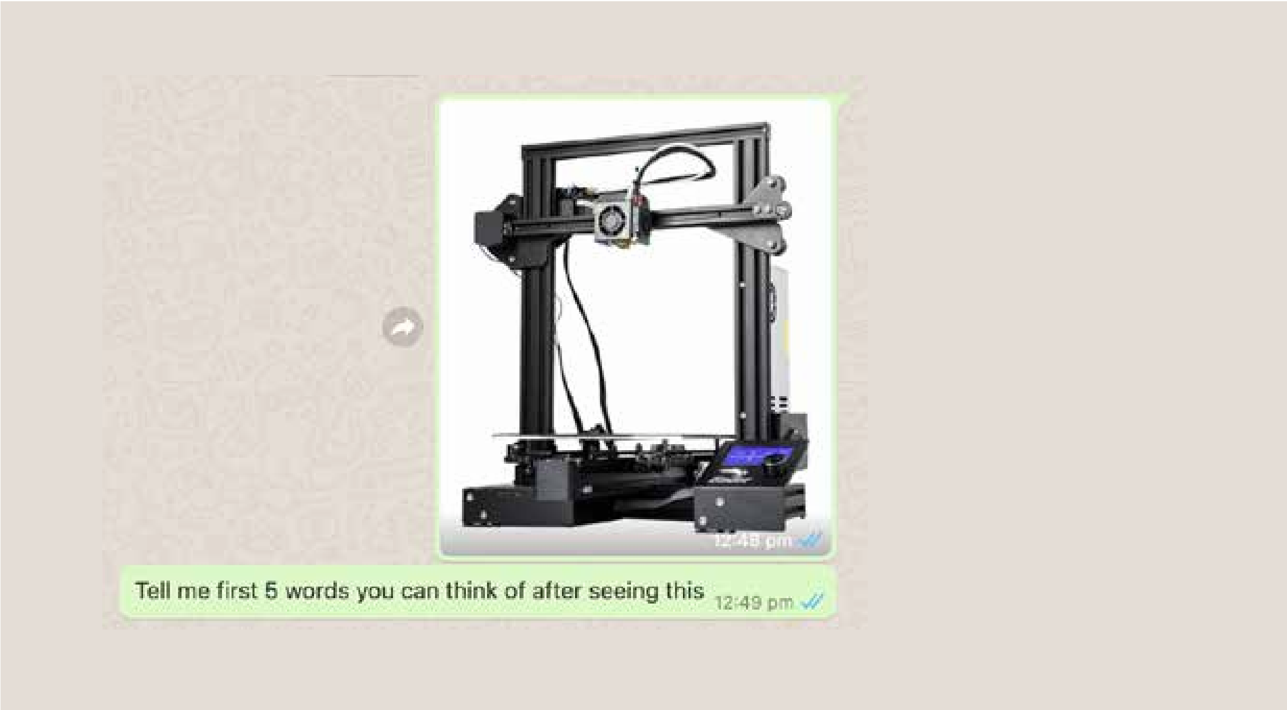
Mostly talking about the user experience of having to plug in SD cards, touch screens not having the required feedback, fire safety hazards in the past

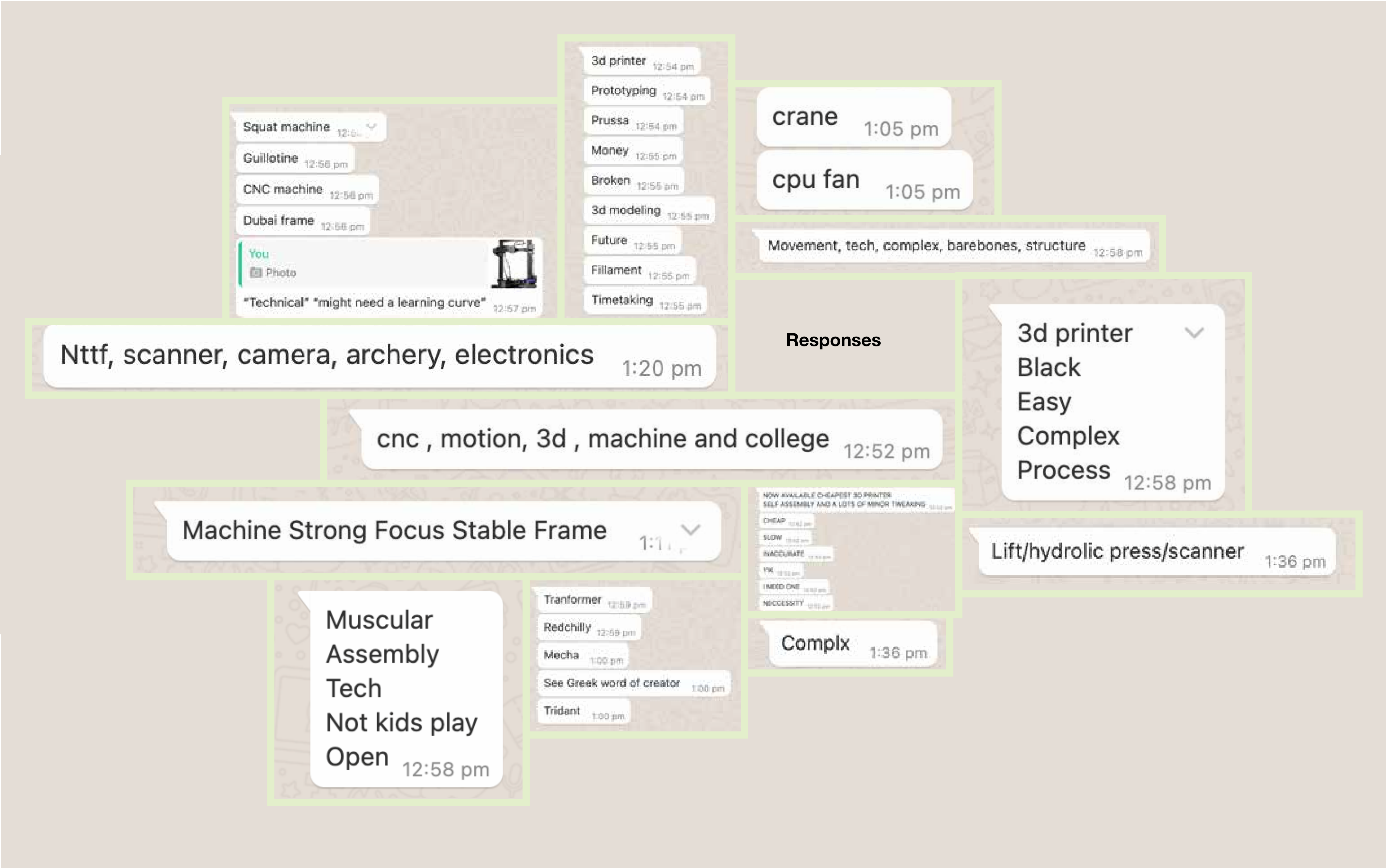
What people think of
when they see an ender 3

I asked people on Whatsapp to give me 5 keywords on seeing a picture of Ender 3 to understand what their thoughts were.

Since a lot of people I knew already knew what this machine was, they had the bias in them talking. So in the next the same question was asked to people with no technical background and possibly no understanding of a 3D printer.

The results were pointing out to the fact that the picture looks complicated, technical and probably requires some learning curve



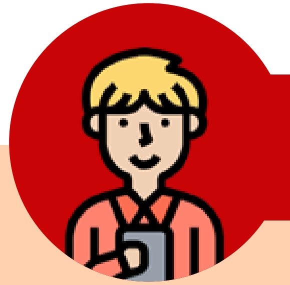


Interviews
with people from the Industry

The technology is not widely adopted by Indian companies and the smaller startups working on it are only a handful. From a list of all the Indian providers of 3D printing products, a few were contacted to get their insights on future of the technology in India and understanding more of the audience.

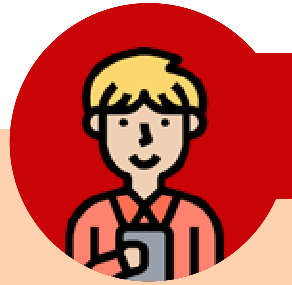
A set of formal questions were formulated for the same

- What do you think is the future of 3D printing? Is there a new technology somewhere?
- Where do you think is the next domain for 3D printers? I hear its good for educating children and that it will soon become a common commercially used manufacturing process. Where else could it become popular in?
- What do you think of 3D printer market in India? Is it possible we have a future where there is a 3D printer available in every small town?
- What is lacking in the current 3D printer? Does it have a domestic market at all? What are its technical problems?
- Do you think the printers of today are complicated? That there should be a printer as easy to operate as a printer that prints on paper?
- What do you think should be the 3D printer for India be like
  For e.g.
  Cost Considerations
  Ease of Use
  Language Availability
  Understanding
  Other possibilities?
- What do you think should be considered while developing a 3D printer?
- Is there something specifically important? Like testing or human interaction or safety?
- Something from your experience that you find a problem with modern printers?



Few pointers by Tanmay Shah and Nikhil Belsure, Imaginarium

- Do we really need a new 3D Printer to unlock more value in classrooms? Or is there something else to be developed (complementary innovations: curriculum, teacher training, school infra, easy design tools..) that can create this impact using existing 3D printers in the market?
- Is the problem stemming from Affordability, Complexity, Awareness, Expertise ? Or all / none of these factors?
- Is the analogy between computer labs in the 90s = 3D printing labs of today valid?
- Almost a 1000 schools in India now have at least 1 3D Printer - especially after the advent of the Atal Innovation Mission under the NITI Aayog and their initiative Atal Tinkering Labs. What has been the impact of these printers?



Harsha Alva - Engineer - used to work for Fracktal 3D - an Indian 3D printer manufacturer

- There are good 3D printers (mostly semi-assembled clone kits) imported from China available for as little as Rs. 20,000/- like Creality Ender 3.
- Building one from locally sourced components turns out to be expensive due to the pricing and availability of components.
- Ideally, you should start by learning about the different 3D printing technologies that are available for hobby, personal or small scale use. I'd recommend you to read more about Fused Deposition Modeling (FDM) technology.
- My work was on an industrial FDM 3D printer. I was part of a team and didn't do it alone. It took us just around a year to finish the machine.
- How much time do you have to finish your work? I'll be able to give you better advice based on this knowledge.

Harsha wasn't available anymore post the first reply

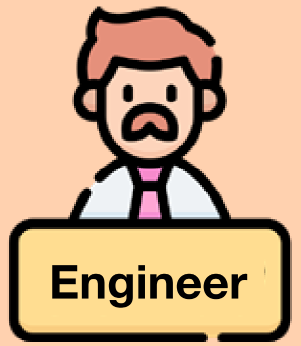
Companies
in the 3D printing Industry

Company	Website	Location	What do they do?
3DPrintronics	https://www.3dprintronics.com/	Noida	Assembles 3D Printers - Does research on Routers
Fraktal	https://fracktal.in/	Bangalore	Makes 3D Printers
Ethereal Machines	https://etherealmachines.com/careers	Bangalore	Makes CNC Machines - Also trying 3D Printers
Fabheads	https://www.fabheads.in/contact-us/	Chennai	Makes 3D Printers called Fibrbot
Kreate Labs	https://www.linkedin.com/company/kreatelabs	Pune	No Idea - No Information - but sounds very interesting
Brahma3	http://www.brahma3.com/contact	Bangalore	Makes one 3D Printer called Brahma3
Divide By Zero	https://www.divbyz.com/contact	Navi Mumbai	Makes 3D Printers
Imaginarium	https://www.imaginarium.io/careers	Mumbai	Professional prototyping services https://vimeo.com/192931520
3Ding	https://www.3ding.in/contacts	Chennai	Makes a printer called FabX
ShaperJet	http://www.shaperjet.com/about/	Delhi	Makes one 3D Printer
Think3d	https://www.think3d.in/	Hyderabad	Doesn't make 3D printers - 3D printing Internships

A list of companies working in India in the industry - mostly startups working in the professional prototyping space and companies providing prototyping as a service. There also a a set of filament manufacturers - who have been recently into the 3D printing business.

User Personas

Age: 18-35
Interested in Engineering, Tinkering etc
Financially stable
Wonders about future technology
Has a good understanding of technical things
Problem solving abilities
Has some experience with 3D



Age: 21-40
Wants to prototype parts and assemblies
Tolerance for error is low
Works possibly for a startup without a huge financial backing (hence can't afford commercial 3D printers)

Both people aren't looking for Ender 3's - they are on the lookout for a highly upgradeable machine that is well designed to adapt to their needs and requirements. While they enjoy the simplicity, they are also looking into taking the machine apart and building something else or maybe just personalising it to their taste (personalising 3D printers with printed parts are very common in the community)

Findings from previous research pointed out to craftspeople looking into 3D printing as an opportunity area for improving their work.
School Students already in programs like Atal Tinkering Labs are getting exposure to 3D printing.
Hobbyists and Engineers are the more mature user community - mostly formally educated (or from other sources like YouTube) about 3D printing previously.

*Hypothetical personas were derived from the research as far. All scenarios here are gender-neutral.

Age: 30-50
Not technically acquainted. Can use smartphones. Wants to 3D print as a an addition to their craft.
Learning interfaces are difficult - not a lot of computer experience

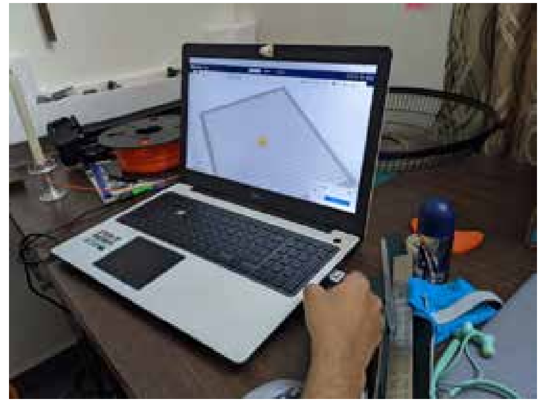
Age: 10-18
Curious about technology
Wants to understand things
Possibly not very technically inclined(Could be otherwise also)
Can understand basic computers and solve simple problems
Understands simple Graphical User Interfaces
Could be a future engineer or designer

Anything that works easy works for them. Not looking forward to reading maintenance manuals to get their printers working. Looking for a machine that just delivers with a simple interface and maintanenance that can be done without wrenches and multimeters.

Taskflow
Printing an object

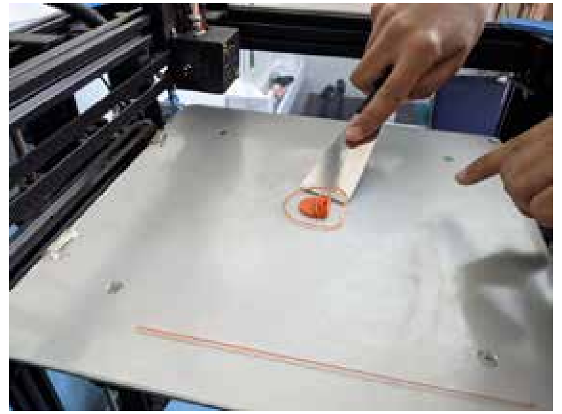

Step 1: Printer is turned on with the power switch


Step 2: Model is downloaded from internet and sliced using Cura


Step 3: Plug in in SD Card into laptop and copy sliced file


Step 7: Printing starts with preheating

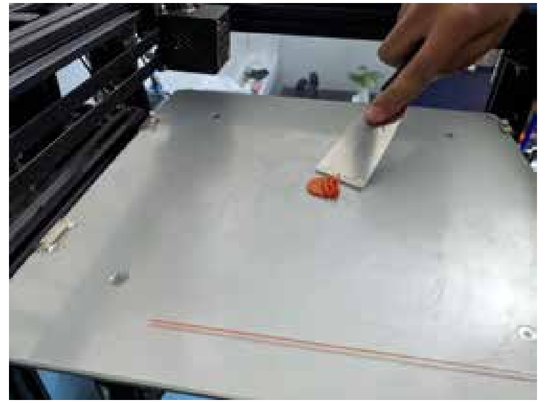

Step 8: Printing has ended and toolhead has moved to home position


Step 9: Removing the print from the bed is a difficult task


Step 5: Plug in in SD Card with the copied file into the printer


Step 6: Select the file from printers menu


Step 6: Select Print to start printing


Step 10: Still trying to remove the part


Step 11: Printed object is put to use

Key Takeaways
Ender 6 is a CoreXY printer that doesn't have wireless printing. Using SD cards make it difficult to print since the added repeating steps are time consuming and easily resolvable.

Cleaning the nozzle

Step 1: Moving the Z-axis up by hand

Step 2: Put printer into pre-heat mode - this is done to melt the filament in the hotend to help remove nozzle without damaging components

Step 3: Using a spanner to remove the hot nozzle

Step 1: Remove the nozzle with a wrench. This takes a lot of fiddling due to inaccessibility in this particular printer

Step 2: Heat the nozzle to melt leftover filament and residue

Step 3: nozzle cleaner needle is inserted into the nozzle

Step 4: Printer is put into cooldown mode - to cooldown the half-unbolted nozzle

Step 5: Removed nozzle is then cleaned using alcohol and brush and put back in a similar manner

Step 4: Leftover filament in the nozzle is pulled out along with the needle

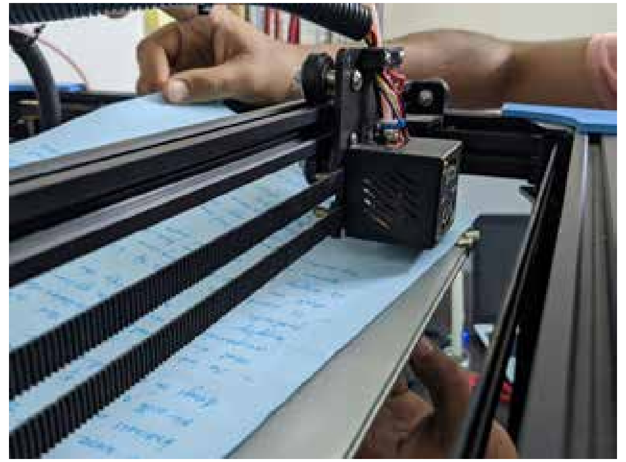
Step 6: Immersed in cooking oil, the nozzle is heated, this forms a layer of solidified oil around the nozzle preventing filament from sticking onto nozzle - this is a common procedure and is done with many different types of oils

Key Takeaways
Nozzle cleaning requires around 15 minutes of overall time and the interface needs to be used multiple times to pre-heat and cooldown to remove and reinsert the nozzle. The process has an opportunity to be simplified.

Levelling the bed

Step 1: This printer comes with a levelling setting in the interface. Turn it on to enter levelling mode

Step 2: The mode moves the position of the hotend to different predefined locations for better levelling



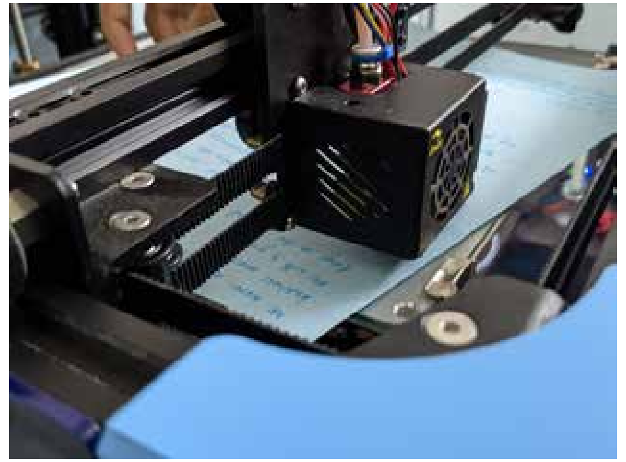
Step 3: Paper is used to check level by placing it under the nozzle and seeing if the paper is too loose or too tight when sliding out

Step 1: Moving the Z-axis up by hand

Step 2: Using a sheet of paper to check level by placing it under nozzle and seeing if its too tight or loose

Step 3: Turning levelling knobs one by one to level each side and checking again with paper.

Step 4: Knob is turned as required clockwise to move down and counter-clockwise to move up.

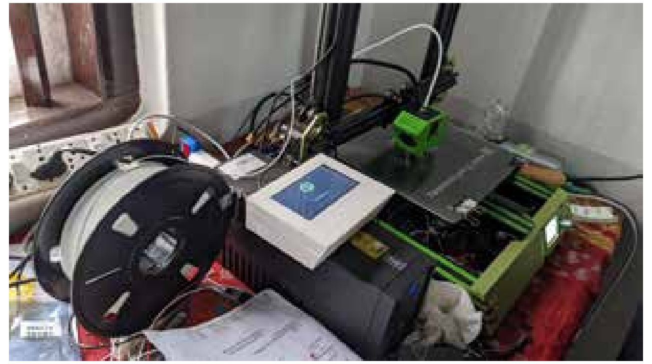


Step 5: The process is repeated for all 5 different defined in the interface

Key Takeaways
Bed levelling is a hard and time consuming process. It takes a level of expertise and understanding to get the bed to level fast. Most printers available do not come with automatic bed levelling systems.

Turning directions are confusing. User often forgets which direction to turn to get to the desired position

Changing FIlament



Step 1: Printer is turned on

Step 2: Turn on pre-heat mode

Step 3: Pulls filament out after clicking on the extruder spring tensioner. The tensioner is right handed.

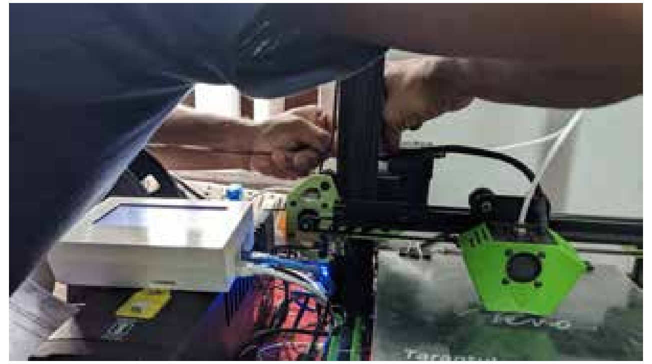
Step 1: Printer is put into pre-heat mode

Step 2: Extrude filament a bit

Step 3: Press onto the extruders spring tensioner and pull filament out. The tensioner is left handed.

Step 4: Tries to put in new filament, doesn't go in because of blunt rounded ends from melting

Step 4: Cuts end of filament for easier changing



Step 5: Push the new filament all the way in

Key Takeaways
Changing filament is a fairly simple process and can be done in under two minutes - including the preheat time. The repeating task is number of steps to the preheat option on the interface.

Step 5: Cuts the end of filament for cleaner sharper edges

Step 6: Puts the new filament back in again

Step 7: Push the filament all the way through till hotend

7.5.4. Other Observations

Printer: Tevo Tarantula Pro

Filament spools placed outside in the open

Poor Cable management

Damaged bowden tube

Filament waste is accumulating around the printer

Key Takeaways
There is in fact a huge room for improvement in the user experience of budget printers. The cable management, FIlament waste accumulation should be key considerations.

Printer: Creality Ender 6

Waste filament accumulating

Wiring harness tube cut off

Bowden tube bent and broken

Glass bed clips loose over time fixed with tape

Key Takeaways
Filament accumulation has been repeating. Bed clips could be a good consideration. Broken bowden tube is seen repeating.

More Research

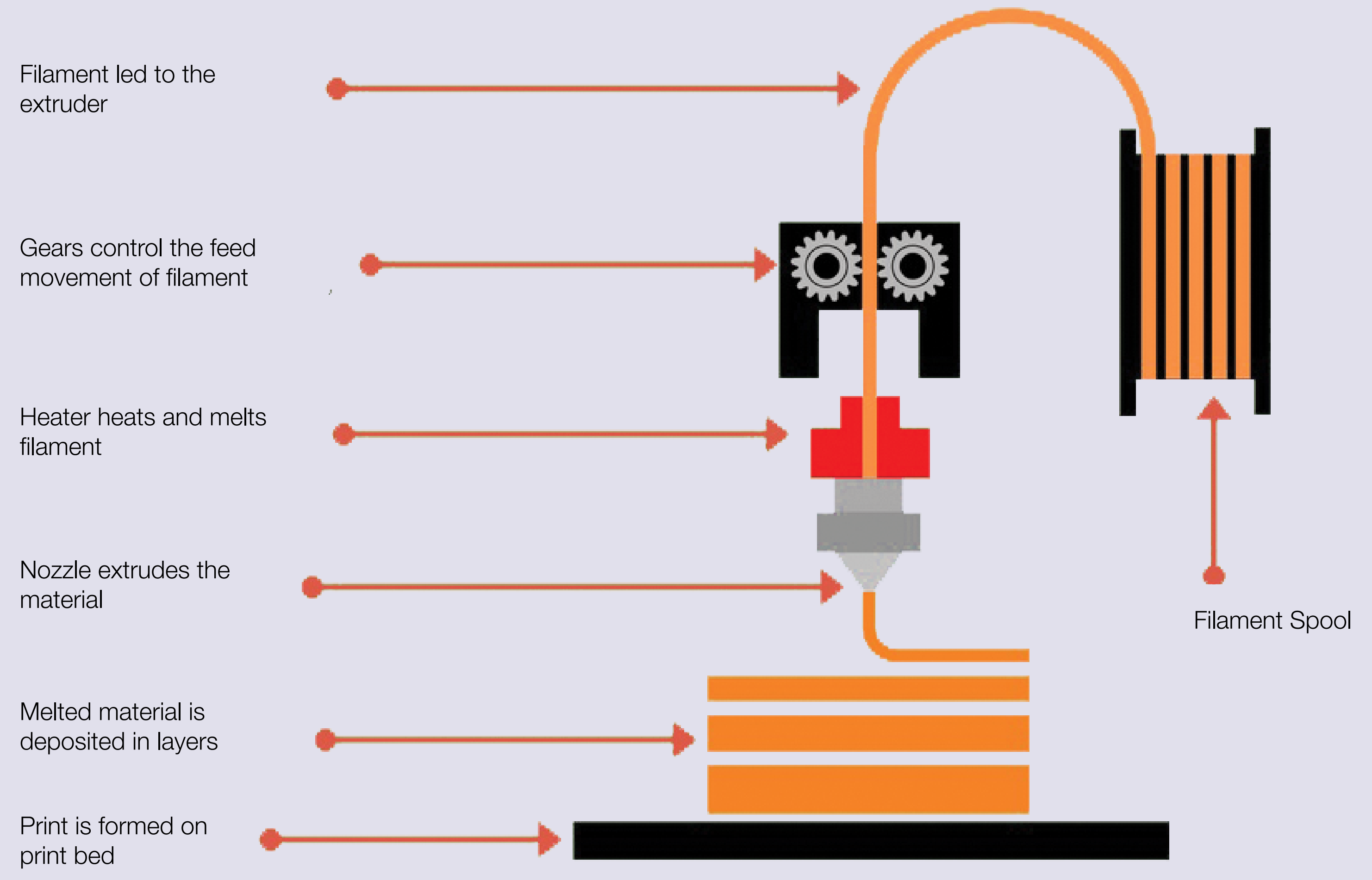
More research mostly consisting of understanding FDM printers and their components and other aspects involved in printing

Fused Deposition Modelling
The process

FDM is not the oldest 3D printing technology - but it is the most popular one. Fused Deposition Modelling enjoys its popularity possibly due to the simplicity in its mechanism of aciton. FDM printers simply melt filament and lay it down in predefined paths to create printed objects. Compared to other processes like DLP and SLA, FDM is much easier to understand and the printers are much easier to work with and manufacture.

FDM also enjoys a wide variety of materials - mostly plastics, but some even work with metals and even wood infused filaments exist.

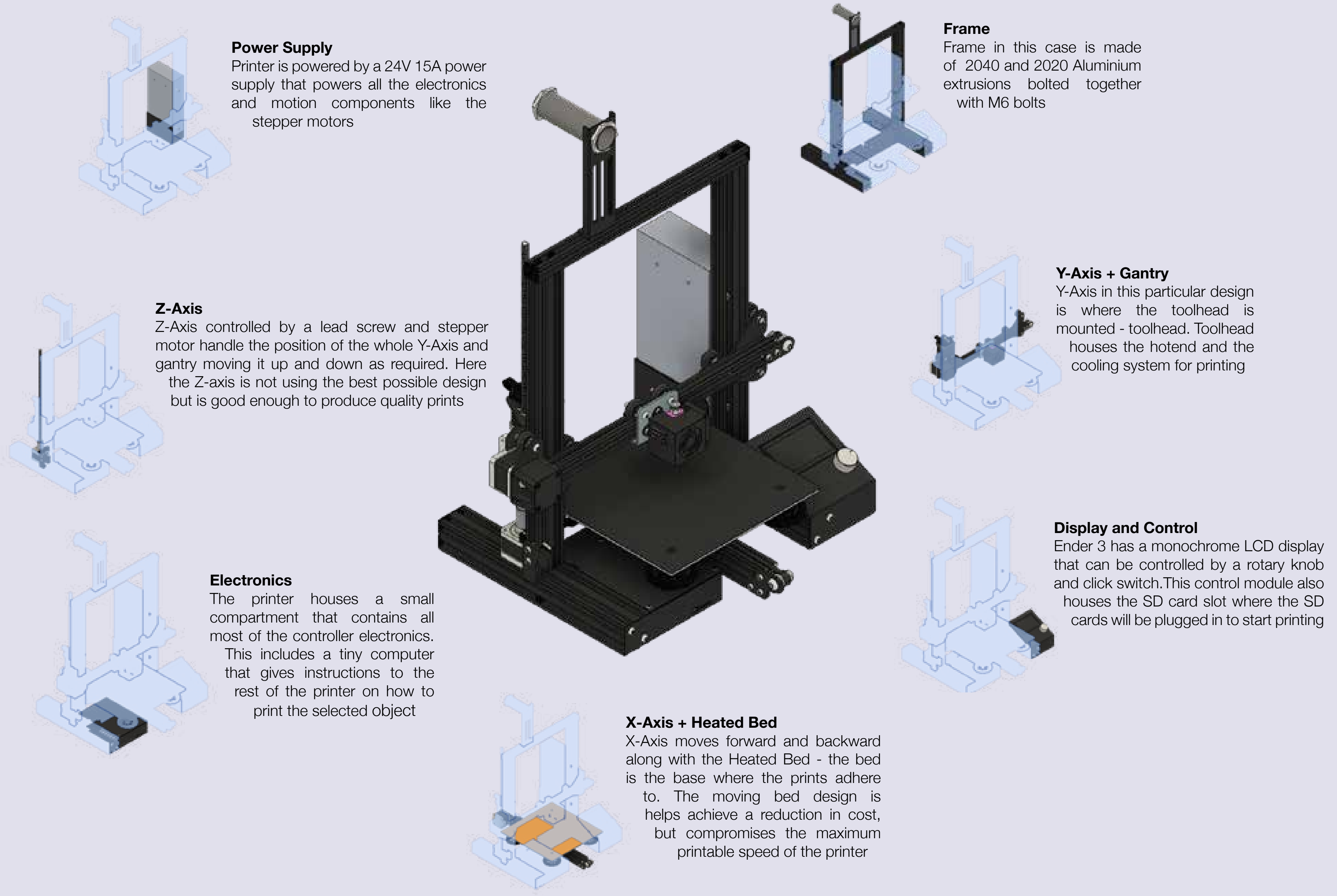
This printing technology has become as popular as it did mainly due to the inexpensive nature of the printers, the community support that came out of open sourcing of the machines from RepRap project and the ease of maintenance due to the easily available components. In fact most consumer grade 3D printers use components that are shared with each other - including the software.
One other important thing with 3D printers that work with FDM are their capability to work with other processes as well. This is thanks to the fact they are all using motion systems that are shared with other machines like CNC mills and Laser Cutters. This is mostly limited to FDM printers because other kinds generally do not have a gantry that can reach any point of the printbed - they often use lights and lasers.



Understanding the components
of an FDM printer

An FDM printer is a small computer controlled robot. Although it doesn't resemble a real robot in its appearance - it is built with a motion control system for movement in three dimensions - technically making it a 3-axis robot - the movement is controlled by stepper motors - which are highly precise motors that can control their movement by upto three decimal points.

Frame	Motion System
Electronics	Bed Assembly
Toolhead Assembly	Extruder
User Interface	Software
Cooling System	



Motion Platform

Types of FDM Printers

Cartesian
Cartesian printers rely on one or more motors on each axis to to independently move in that particular axis. Cartesian is the most popular printing platform and enjoys a large support community. Most popular printers belong to this category.

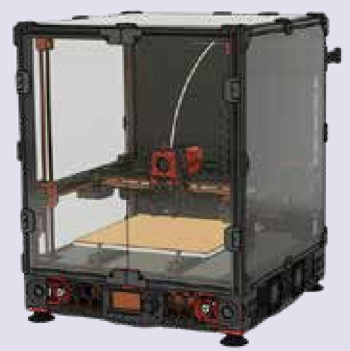
PROS
Relatively cheap
Simple to understand and implement
Comparatively easy to upgrade and fix
Lots of community support

CONS
Large and heavy frame
Relatively slow
Limited print height

H-Bot
H-bot printers use belts to move the printhead within the XY plane. H-Bots also belong to the Cartesian system. H-Bots are often confused with CoreXY printers. An H-bot's belts will form, well, an 'H', while a CoreXY forms more of a boxy 'A'

PROS
Large print space for footprint
Relatively stable
Lightweight parts
Few vibrations

CONS
Relatively expensive
Large machine size
Limited community support

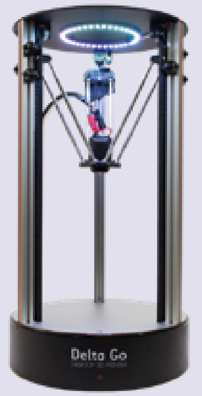


CoreXY
The belt system on a CoreXY is distinctly different from an H-Bot. Two motors that control two different belts run the printers X and Y axis together

PROS
Large print space for footprint
Relatively stable
Lightweight parts
Few vibrations (even compared to an H-bot)
Relatively high accuracy

CONS
Relatively expensive
Requires a powerful controller board
Energy inefficient
Higher risk of print failures

Less conventional platforms



Delta
Delta 3D printers work with three (or sometimes even more) arms attached to vertical rails. The printhead is connected to the end of each arm with hinges, and the arms work together to adjust the printhead's position.

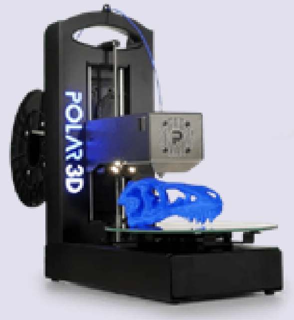
PROS
Relatively fast
High print quality
Generally capable of tall prints

CONS
Difficult to fix and upgrade
Less compatible with direct drive extrusion
Typically small build volume

SCARA
SCARA 3D printers are a more complicated type of FDM printer that uses Selective Compliance Assembly Robot Arm (SCARA) technology to function. The technology was first used in 2013 by RepRap Morgan.
SCARA printers also use a Cartesian coordinate system, but they form their own category due to their unique mechanical setup.

PROS
Good for industrial printing
Relatively fast

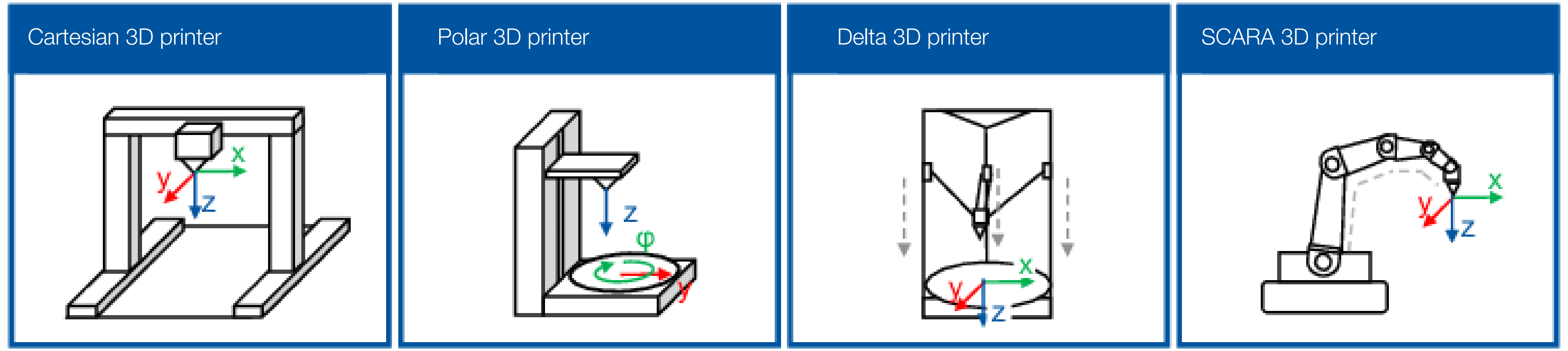
CONS
Relatively imprecise
Relatively obscure
Limited community support



Polar
Polar 3D printers are unlike the other FDM printers due the utilization of the polar coordinate system. Polar 3D printers also differ from other classes because the printhead is connected to a single arm. Lastly, they use a spinning bed, which no other type of printer uses.

PROS
Relatively inexpensive
Fewer motors and less noise

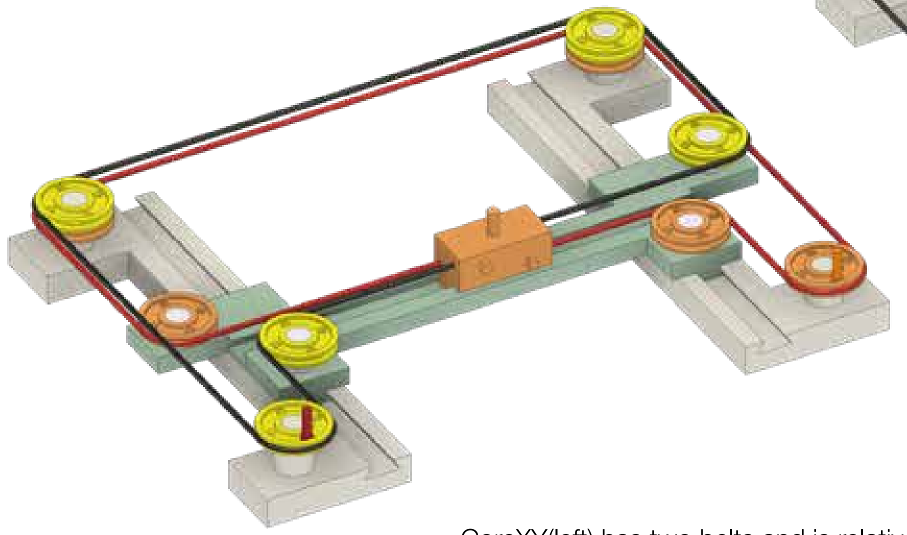
CONS
Low print quality
Relatively slow
Relatively obscure
Limited community support

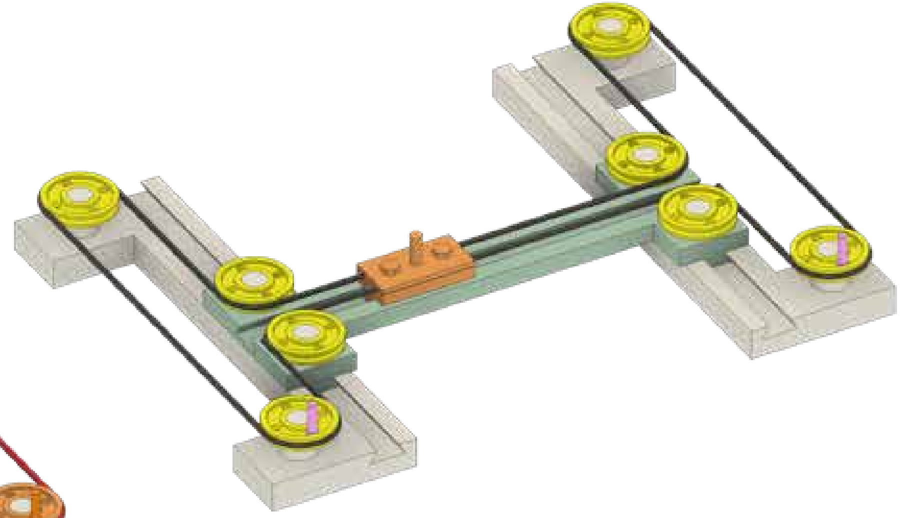


Movement x → y → z → Relative Movement : - - →

Visually simplified explanation of motion platforms

CoreXY vs H-Bot





CoreXY(left) has two belts and is relatively more complex than the H-Bot. Both belts are running parallel to each other and pulling at each other. The rate of pulling by motors on both ends decide the amount of movement on each axis.

CoreXY is relatively highly precise
It can achieve much higher speeds with precision

H-Bot(right) is a much simpler system and has only one belt. It gets the gantry moving using simple cartesian motion wherein the motors pull or push together to move and the carriage in the x-plane and push or pull together to move the carriage in the y-plane.

In an H-Bot high precision can only be achieved theoretically
H-Bots cannot print at high speeds precisely

CoreXY and its significance

A CoreXY printer will have a square, cartesian design, which is different from a Prusa in that the print bed moves only on the vertical Z axis, while the print head moves on the horizontal X and Y axes. It is distinguished from the similar H-Bot printer because the much longer belt and pulley system used in a CoreXY system eliminates the excess torque that causes faster wearing in the belts and gantry.

Another advantage of having a bed that moves vertically, CoreXY printers are able to offer the same build volume while having smaller overall dimensions. This is a feature shared by certain designs like the H-bot.

Tools are the transformers which couple our imagination to reality. CoreXY provides a fundamental building block of many computerized fabrication tools - cartesian motion - in a simple and adaptable format.

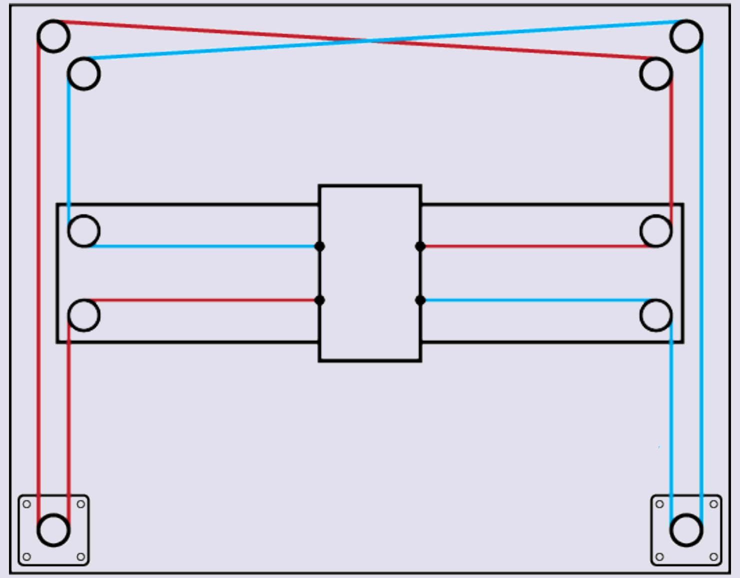
CoreXY is a technique, not an implementation. We sketch the concept and give a few examples as a platform that enables you to build new tools that are as unique as your ideas.

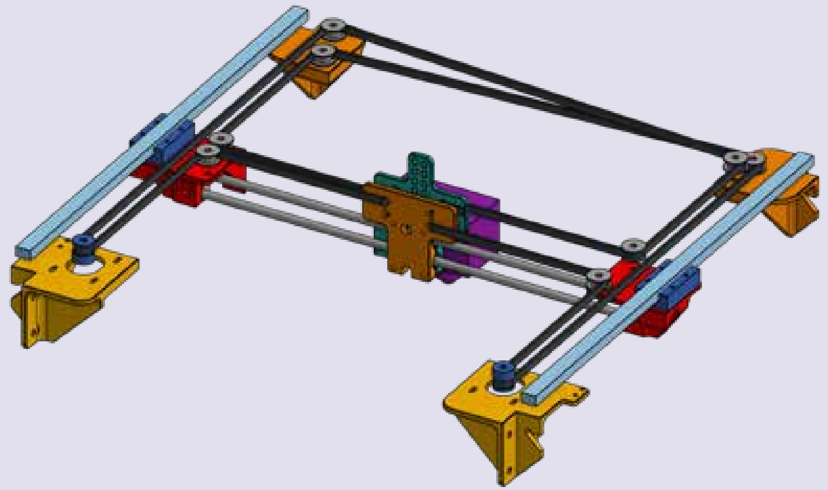
Fast. We believe in speed. CoreXY's (mostly) parallel kinematics mean that the motors, typically the largest source of inertia on a DIY-grade stage, are stationary. This permits rapid accelerations.

Simple. CoreXY can be implemented with only three structural plates, all of which can nest during fabrication.

Flexible. Whether your medium is fabric or aluminum, the principle behind CoreXY permits motion stages to be rendered in a variety of materials and a wide range of sizes.

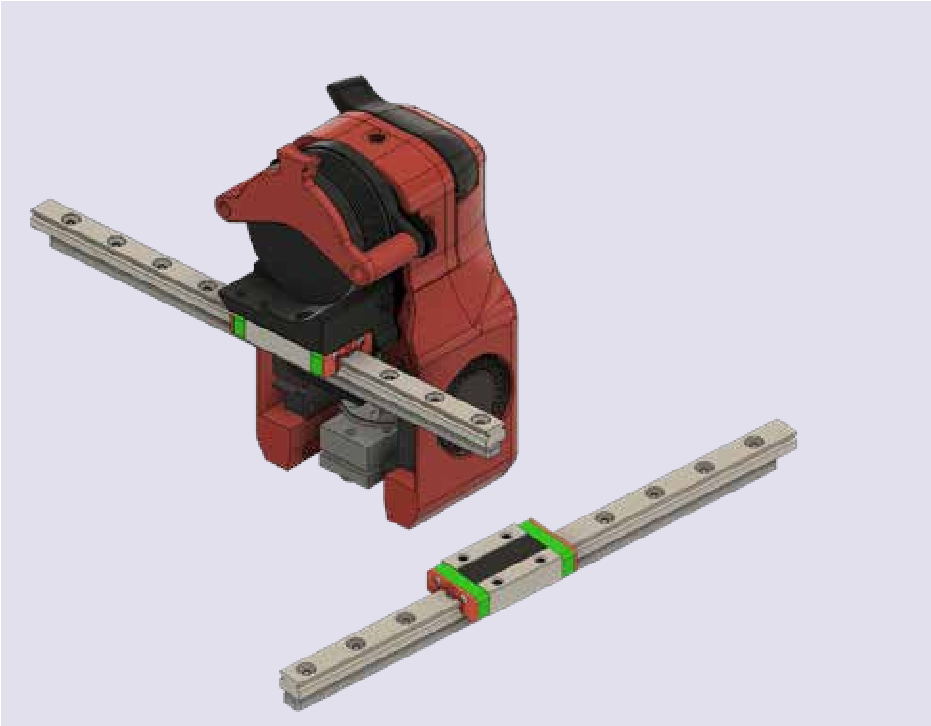
Excerpt from https://corexy.com/theory.html

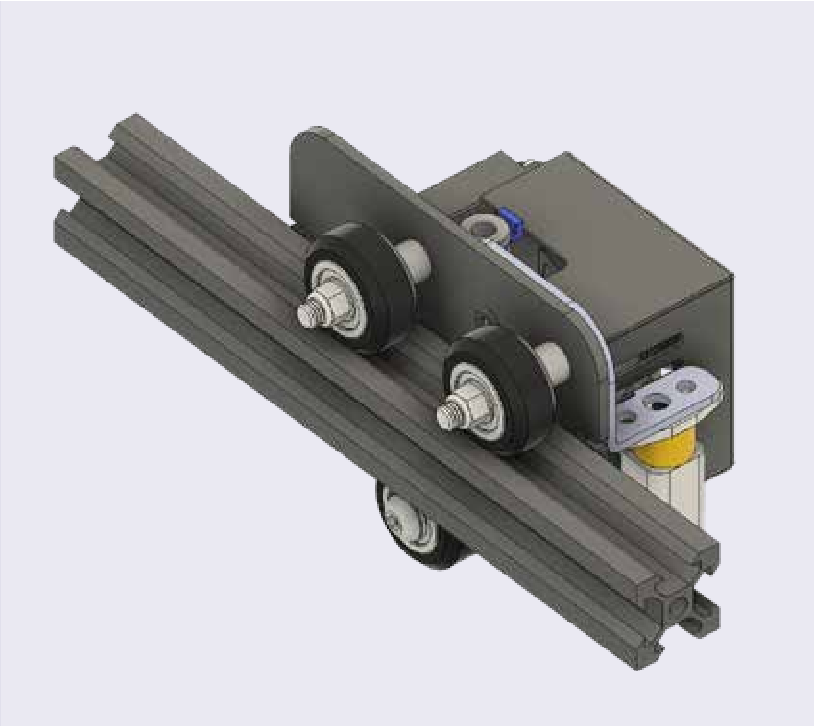




CoreXY has two belts running in parallel to each other - the belts are in always in a tug of war with each other and the right amount of pulling on both takes the carriage to the desired position

Linear Rails, Linear Rods and V-Wheels





Linear Rails
Linear Rails are a precise motion mechanism that rarely has any play and gives highly accurate print results. Linear rails has one big disadvantage that they are extremely expensive,

V-Wheels
V-Wheels fit into V-Slotted Aluminium profiles - they have less accuracy and give more play in the process - but unlike the other two motion platforms, v-wheels can be adjusted for tightening and loosening when required. V-Wheels are the cheapest among them.

Linear Rods
Linear rods are commonly used in many machines to drive carriages. Linear rods can give excellent print results when the rods are of good quality. Linear rods are relatively inexpensive and can provide results as good or better than V-wheels but not as accurate as Linear Rails

Although linear rods are often the less prefered choice, here linear rods present the best fit overall requirements - being inexpensive, precise, simple and small in overall size. High end accuracy is not a concern for the budget and the users requirements

Extruder Assembly

Bowden v/s Direct-drive

There are two major types of extruder assemblies based on where they are mounted on the printer.

A bowden drive is a system where the extruder is seperately installed on the printer and a bowden tube(PTFE tube) connects the extruder with the hotend assembly

A direct-drive on the other hand is an assembly where the bowden tube ceases to exist and the hotend and extruder are assembled together.

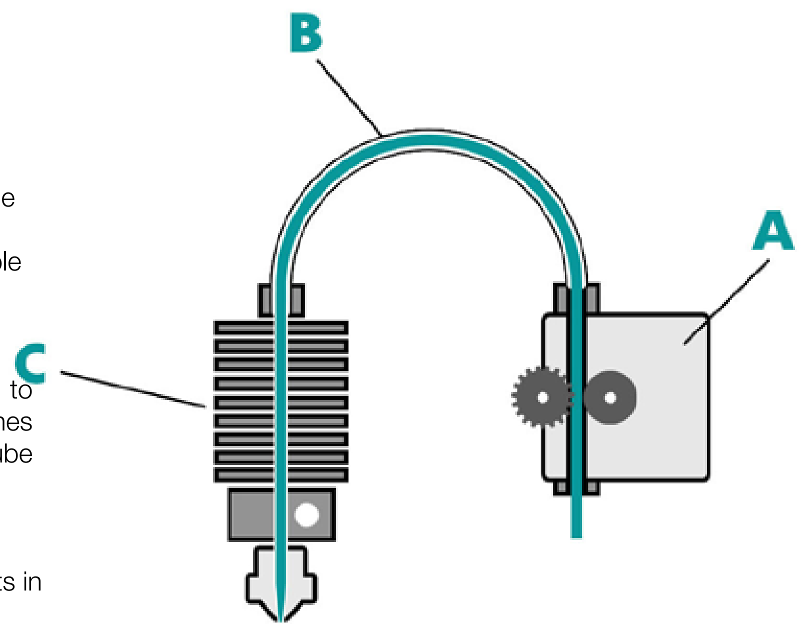
There are advantages and disadvantages to both appproaches.

Although Bowden tends to have better overall performance, direct drive is more emotionally desirable because of the added features and print quality it provides

Bowden Extruder

A Bowden cable is a type of flexible cable used to transmit mechanical force or energy by the movement of an inner cable relative to a hollow outer cable housing. This is similar to bicycle brake lines.

The Bowden extruder (A) is attached to the frame of the 3D printer and pushes the filament (B) through a long PTFE tube (Bowden tube) into the hotend (C).



Advantages

Less weight on the printhead. This results in

- Clean movements
- Increased printing speed
- Nice prints due to reduced vibration on the printhead

Disadvantages

- More powerful motor needed - A Bowden extruder requires a more powerful motor with more torque to control the filament because it has to be pulled through the PTFE tube.
- Slower response time
- Increased friction in the Bowden hose leads to a reduced reaction time. Bowden extruders require longer and faster retraction to avoid tension.
- Smaller range of compatible filaments
- Flexible or abrasive filaments can wear out more in the Bowden hose and are processed more poorly than with the direct drive extruder due to the longer conveying path.

Direct Extruder

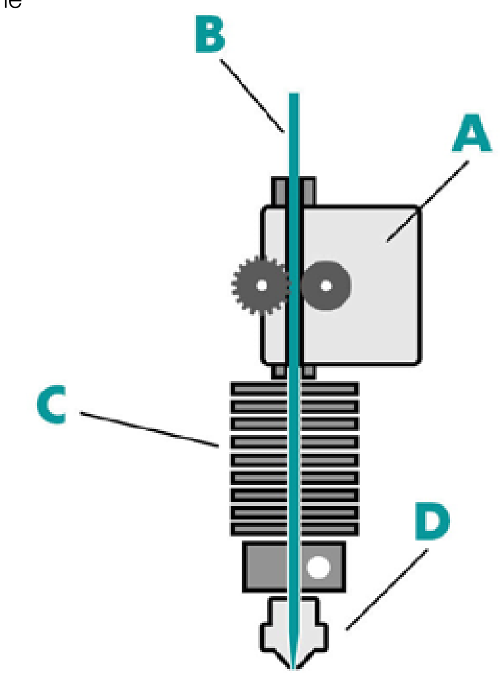
Direct extruder(A) is attached directly to the hotend. There is no PTFE tube involved and in a way its a less complicated compared to the Bowden system.

Advantages

- Better extrusion - Since the extruder is located directly on the print head, the motor can simply push the filament through the nozzle.
- Faster retraction - Due to the proximity of the extruder and nozzle, the filament can be retracted quickly; in many cases, no retraction setting is necessary.
- Weaker, smaller motors are possible - Because of the short distance between extruder and nozzle, less torque is required from the motor to push the filament.
- Wider range of compatible filaments - Direct extruders are compatible with a wide range of filaments - they print reliably even with abrasive and flexible materials.

Disadvantages

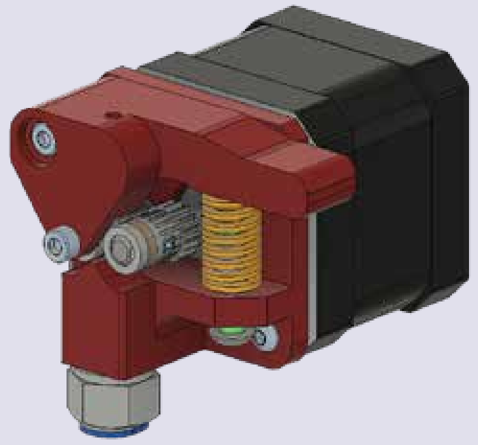
- More weight on the printhead - Since the extruder is mounted on the hotend, it has more weight. The increased weight has the following disadvantages.
- Increased wear on toothed belts and bearings
- Printing speed is reduced
- More complex maintenance
- After the feed and the hotend are built directly together, maintenance such as cleaning the nozzle proves to be more difficult.



Hotends and Extruders

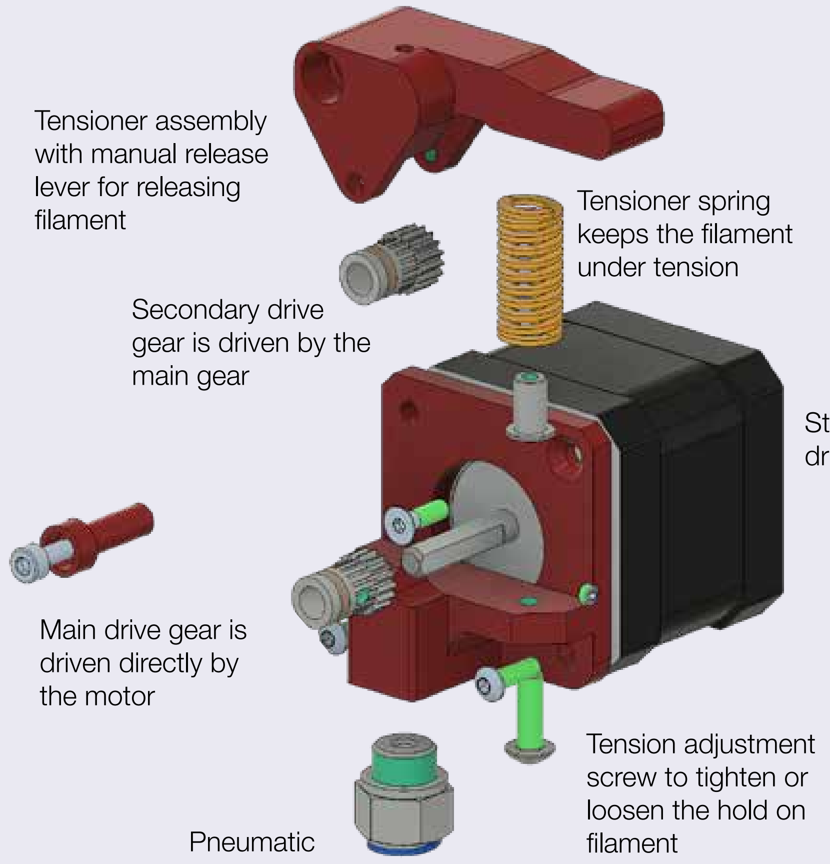
Hotends play a crucial role in printing - it is the point of contact between the object being printed and melted filament. Hotends job is to melt the filament consistently as it comes through from the extruder and extrude it.
Currently filaments are 1.75mm in diameter and most printers come with a 0.4mm nozzle attached to the hotend.
Hotends have to keep heat loss at the minimum to attain optimum power efficiency, reduce filament overflow due to increase in pressure and continously transfer heat into the filament. For a simple device thats a lot of things to get right and only a few designs can get it right. Most of the designs are in fact open-source - leading to clones available even for the best hotends in the market. High performance hotends are required to print with higher temperature materials.

Extruders, like their name suggests extrude filament in precisely controlled amounts. This is often done using geared assemblies and steper motors. Some extruders employ gear ratios to attain higher precision while the more inexpensive ones just use simple systems. The print quality difference of an extruder with gear ratio and the ones with no ratio are neglible as well. Extruders



Assembled view

Pictured here is a
CR-10 Dual gear extruder. It does not employ the use of reduction gears.



Hotends

E3D V6
has proven itself capable of producing high-quality prints across a vast range of materials. V6 Hotend can work on most materials without a problem and is highly upgradeable with a solution for almost anything you'd want to do with your printer

CR10
Hotend of choice for almost all of Creality's printers - this hotend is inspired by other designs but has proved itself to be highly reliable and simple piece of hardware. CR10 hotend visually looks very similar to the Micro Swiss hotend almost to the point we could say its a clone - the micro swiss verison, however performs way better and is a ton expensive in comparison. CR10 is not the best, but it works.

The choice will be between **E3D V6** and **CR10**

Mosquito
This design from Slice Engineering takes hotend design to the next level with a design that practically eliminates heat creep(heat transferrring out of the hotend into other components. Mosquito is functionally brilliant but not for everyones budget. It is an expensive premium that costs more than ₹7000

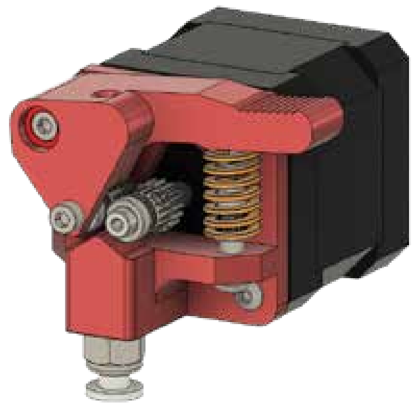
Extruders

The choice will be between **MK8** and **CR10**

Sherpa Mini is an extruder designed by Annex Engineering. It uses a smaller stepper motor and is a lightweight alternative for faster direct-drive printers.

Mobius M4 is an extruder designed by the Voron project. Largest in size, Mobius is designed to be used as a Bowden system and uses mostly 3D printed parts. It has a gear ratio that helps in achieving more accurate extrusion rates.

MK8 extruder is among the most common extruder assemblies. The extruder is available as a DIY kit in most Indian DIY websites and is a simple gearless system that uses the least number of components.



CR10 Dual gear extruder is commonly found in Creality printers and is the more efficient cousin to the MK8. Its dual gear drive system helps achieve less slippage on extrusions and much faster overall speeds.

Materials

and printability

3D printing filamets should be chosen according to the properties of their finishes products. The three major factors to be considered are

- Object Strength
- Surface Quality
- Dimensional Accuracy

FDM printing supports a large variety of materials - some printers can even print high strength metal parts, although with slightly varying and more complicated processes

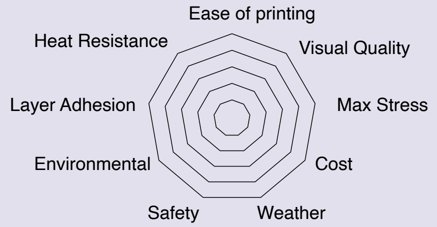
The most common material used in 3D printing is a thermoplastic polymer called PLA(Polylactic Acid). PLA is derived from sugarcane and is a relatively biodegradable material that has highly appropriate properties suitable for 3D printing

PLA can be used to print both functional and aesthetic parts and is much easier to work with compared to other more conventional materials like ABS and PETG. While PLA is plenty strong for household use, it isn't the best for working components. ABS easily replaced PLA in that matter. ABS and PETG have excellent mechanical properties compared to PLA but are much more complicated to print with and have much higher failure rates relatively.

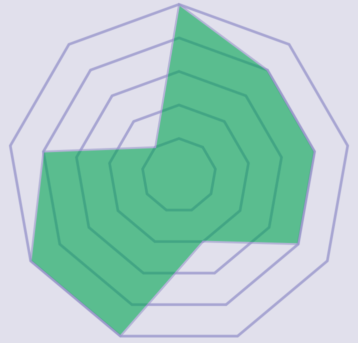
PLA lacks durability and exposure to sunlight weakens parts. Moisture can also damage mechanical properties of PLA parts.

ABS is a much more common material we see in a lot of highly durable plastic products. ABS requries higher print temperatures and produces harmful fumes while printing - this often makes ABS printing difficult for consumers. ABS is also sunlight sensitive, but is relatively much more tolerant to temperature.

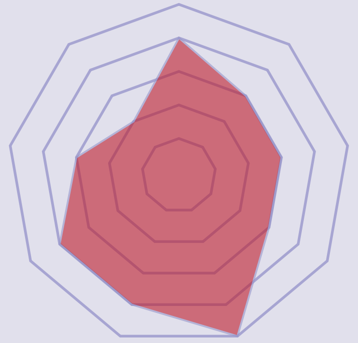
ABS and PLA are the most important materials to be considered in printing - mainly because of their cost-effectiveness and printability. While ABS is an unsafe material considering the fumes produced, PLA is relatively safer as studies suggest



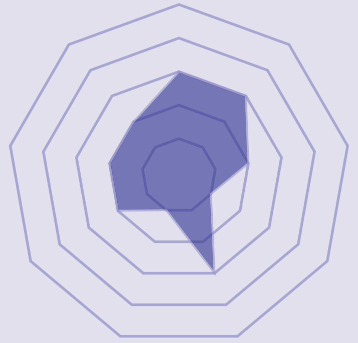
Materials here are graded by a set of properties they exhibit in real life.
It is to be noted that some of them have their own special properties that make them more useful than others in certain scenarios. For e.g. HIPS is a dissolvable filament and TPU is flexible.



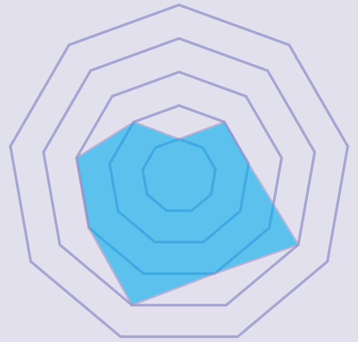
PLA
Polylactic Acid



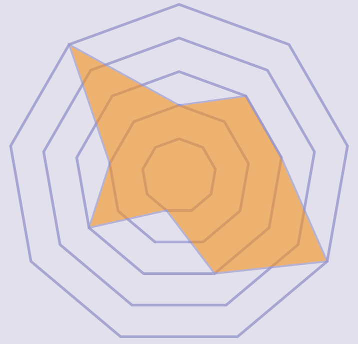
PETG
Polyethylene terephthalate glycol



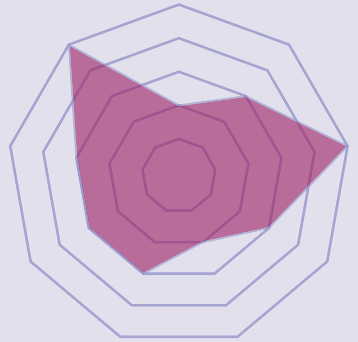
NYLON



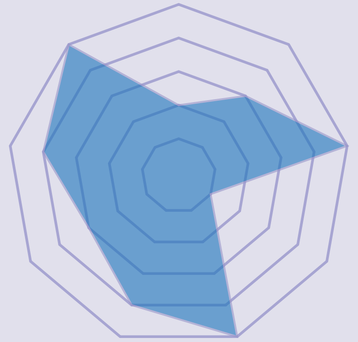
TPU
Thermoplastic polyurethane



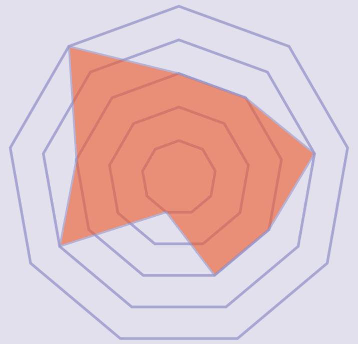
ABS
Acrylonitrile Butadiene Styrene



PC
Polycarbonate



PEEK
Polyether ether ketone



HIPS
High Impact Polystyrene

Environmental Factors
Weather and Moisture

Printers react to temperature and moisture variations by a reasonable margin. Cold weather could cause less bed adhesion and issues with layer adhesion. High moisture environments are highly likely to ruin PLA - PLA absorbs moisture and becomes brittle - making it difficult to print with. ABS is even more sensitive to temperature variations.
A humidity reading of more than 50% is fatal to most available filaments that are kept in the open. The filament gets damaged in a few days and needs a long revival process with heat to be able to print again.

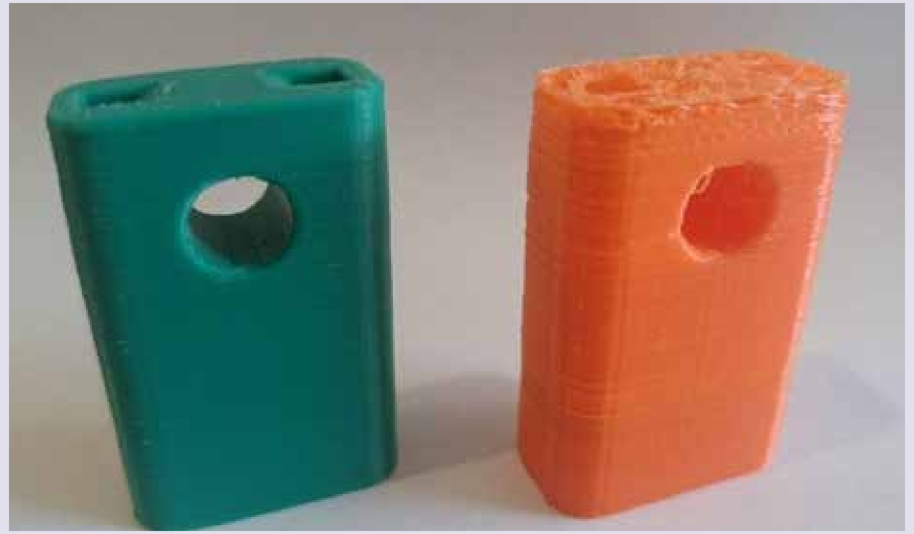
> Moisture Absorption in filaments could be a significant cause of failure in 3D printing

Printing in hot temperatures is often fatal to most printer components - printer components need to keep themselves cool while they do their work. They are often not enclosed because of this issue alone - overheating motors can have a relatively lower lifespan.

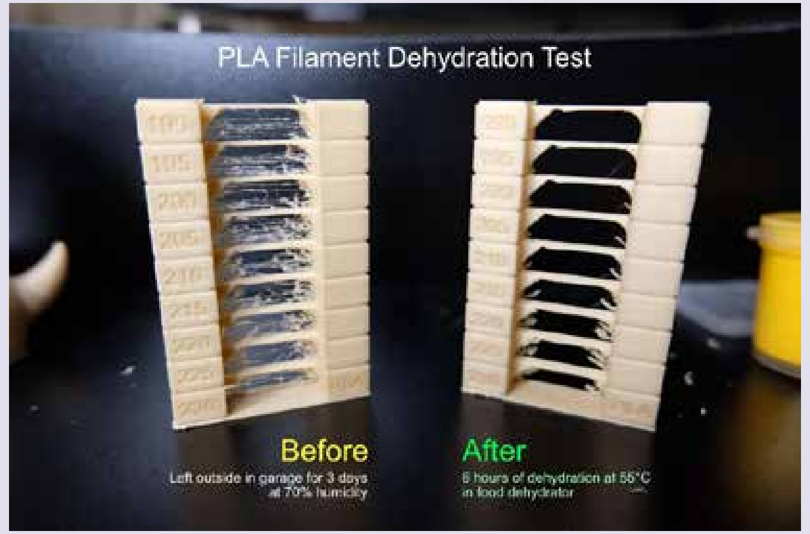
Moisture can lead to the following problems
- Brittleness and breakage of filament,
- Diameter inconsistency
- Hissing steam or bubbling when filament reaches the hot-end,
- Filament degrading or lose tensile strength,
- Higher extruding temperature

One available solution is a filament dryer

Left: Printed on Wet PLA



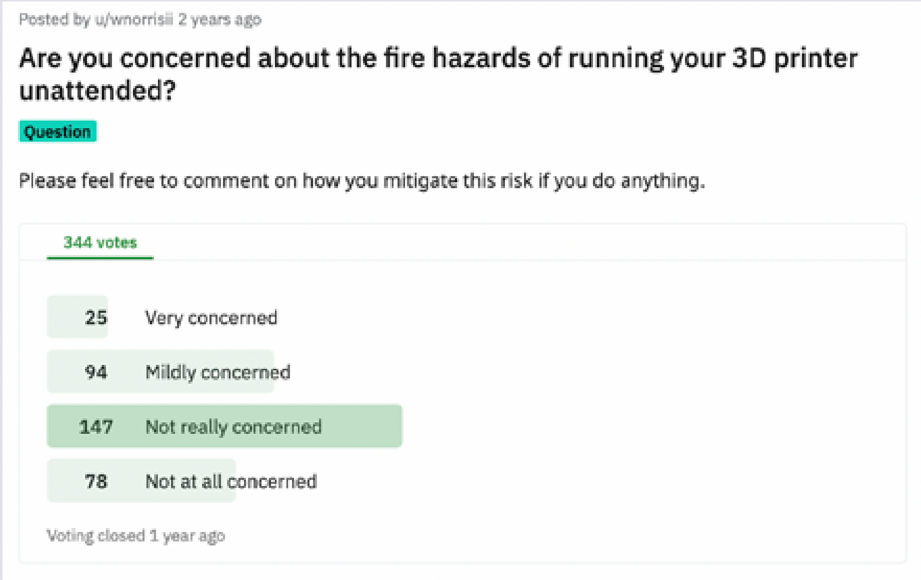
Orange filament was not dry before printing



Safety

Fires, fumes and electricity

Consumer 3D printers are no less dangerous than their Industrial counterparts - the inexpensive machines have cheaper components - which might be of inadequate quality and have been reported in the past for causing fire accidents. FDM printers use heat to melt filament(possibilities of fire hazards and electricity is no less unsafe when handled improperly). Safety while 3D printing might not be a huge concern for many users - as proven by a poll conducted on reddit in 2019. 3D printers are relatively safe machines with ciritical fire prevention mechanisms built into software to make sure an accident doesn't happen. This came about from the accidents certain printers caused in the past - at a time when printers did not have a safety mechanism called Thermal Runaway Protection. It makes sure the printers heating systems are totally under control and the closed loop systems shut themselves down when the software suspects an error. Fire Hazards are not a concern when the printers are **designed appropriately.**



Two major fire incidents from the Intenet

Fumes are the most important indirect safety concern that affects users directly when a 3D printer is at work. Certain filaments release fumes when printing - especially ABS and PEEK. Studies have found that ABS fumes are in fact carcinogenic in nature and causes other health problems in the long run. It is hence advised to print with ABS in open environments with ventilation and contain the fumes using enclosures.
Although PLA is considered safe, PLA isn't the safest material either. PLA still produces fumes that are harmful, its just that the quantity of harmful fumes produced are a negligible amount.

Fumes from 3D printing are a long-term health hazard

Electronics

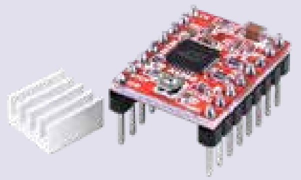
Controller Board

Controller boards are an important parts of the puzzle. A cheap controlboard with poor quality components could be the sole reason a printer doesn't produce good quality prints. They need to be capable enough to handle the hardware and should have the architecture to support the available software. There are a huge number of options varying in features and prices. The right control board can help reduce noise, run the printer faster and help with easier troubleshooting and higher reliability of the machine.

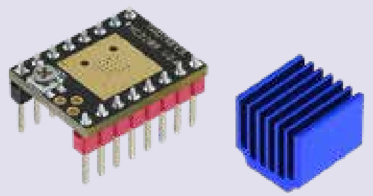
Most control boards are from Chinese manufacturers and they are the current standard for consumer printers. Most economical printers come with boards from Makerbase or BigTreeTech - but there are always newer more innovative players taking the lead.

Most controlboards have similar featuresets, except for extra features that aren't as important for the functioning(like added LED light controls) - the variations are mainly on the processing power and the number of motors they can handle. Certain printer designs have much higher number of motors to increase precision and speed. In those cases extra motor drivers will definitely be of help.

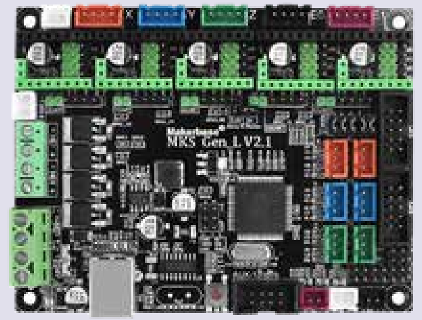
Most boards do not come preinstalled with motor drivers. Stepper motors are driven by another small microcontroller which has to be plugged in seperately to the controller board. This is often done because of the upgradeability of that particular component. The amount of noise a stepper motor produces depends on the quality of stepper drivers being used. The higher the quality of a driver is, higher the cost.



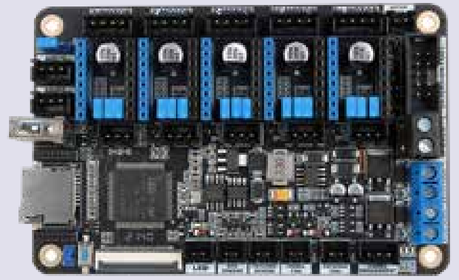
A4988 is an inexpensive stepper driver module that does the work but produces a lot of noise



TMC 2209 Silent is a driver that is nearly three times more expensive as the A4988 but does its job incredibly well without the added noise

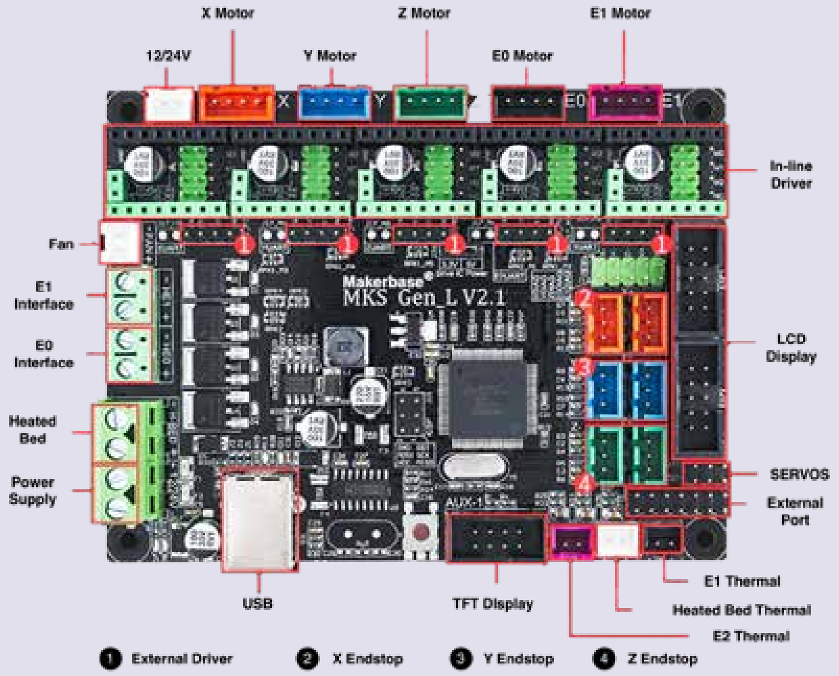


MKS GEN L v2.1 is the most prominent 8-bit controller board in the market. It is cheap, durable and reliable but is extremely underpowered



Lerdge-Z V1 is a relatively new performance board with even more features than an SKR Mini but at the same price range. Lerdge is a promising new controller but the community support at the moment is lacking

BIGTREETECH SKR E3 Mini V3 is a level up board for most budget 3D printers - it is not the cheapest but is incredible value for money because of the silent drivers and 32-bit processor



Connection Diagram of an MKS GEN L

In-line driver is where stepper drivers will be installed. E(E0,E1) refers to Extruder.

Software and experience

How to find the right one?

The brain of a printer is in the code that controls it. All the functions are controlled by software programs, generally called firmware. Firmware is software that's embedded in a piece of hardware - here referring to the control board of the printer. You can think of firmware simply as "software for hardware."

Most of the software used in consumer 3D printing are open source and developed by open communities and developers all over the world.

Firmwares that run on most of the popular printers is Marlin - an open source project that started in 2011 - but there are a bunch of other options available in the space

Most 3D printer manufacturers adopt Marlin as their firmware and add on features to Marlin to make it unique.

Some of the popular firmware options

- Marlin
- Repetier
- Prusa Firmware
- Klipper
- Smoothieware
- RepRap Firmware

What does Marlin do?

Marlin Firmware runs on the 3D printer's main board, managing all the real-time activities of the machine. It coordinates the heaters, steppers, sensors, lights, LCD display, buttons, and everything else involved in the 3D printing process.

Finding the right firmware

Firmwares are complex pieces of software. The ease of use and reliability end up being the most important parts to consider when selecting the right firmware.

While the options are many, a lot of components like the processors in the controller, the setup of the machine, the kinematics in use - all contribute to what firmware is compatible and useful.

The right firmware also needs the right hardware - this decision also directly affects the cost of the controlboards used in the printer design.

Marlin

Most advanced features
Smartmotion system with linear acceleration, interrupt-based movements, and look ahead features.
Easy to install and use
Best for powerful controllers
Controls LCD that supports 30 languages.
Linear advance extrusion.
Print counter and print job timer.
Enjoys much larger community support owing to the fact that Marlin has been around for around a decade.

Klipper

Klipper is relatively new.
Instead of the microcontroller performing the algorithms, all calculations are done by the host like Raspberry Pi. Klipper is faster with very advanced features that help the overall print quality
Simple configuration.
Smooth advance pressure that reduces extruders oozing.
Supports auto bed leveling, delta calibration, temperature sensors, thermal heat protection, and cooling system.
Supports 'Input Shaping' to reduce vibrations and eliminate ringing while 3D printing.
Klipper features offer a great 3D printing quality experience and reliability.

Marlin is the more apt solution mainly due to the user being inexperienced and less technically acquainted. The system will still require upgradeability to Klipper as an added feature for more advanced users

Touch screen interface on Klippper.
Klipper lacks support for older interfaces

Conventional non-touch interface on Marlin

Octoprint and Touchscreens

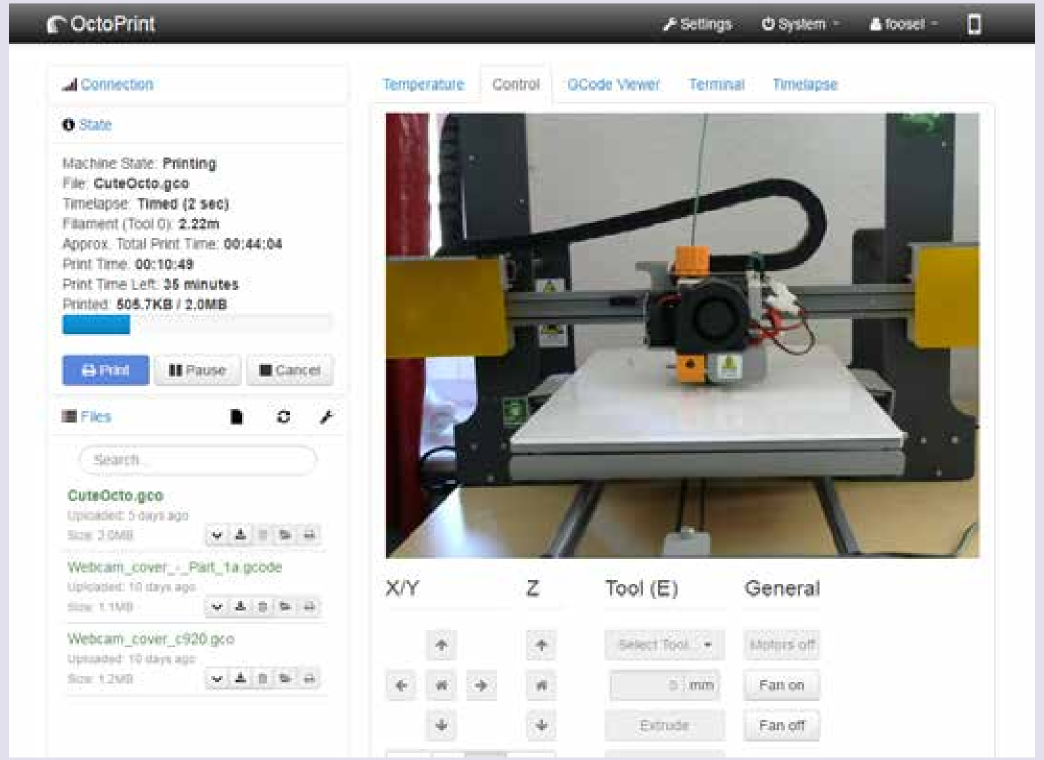
Bringing touch Interfaces and more user-friendly features like wireless support requires even more control systems and software.

The good part is most of these already exist and they're all open source!

OctoPrint is an open source 3D printer controller application, which provides a web interface for the connected printers. It displays printers' status and key parameters and allows user to schedule prints and remotely control the printer.

There are no alternatives available that are as feature-rich and expandable as octoprint.

Octoprint was started by Gina Häußge in 2012 as a hobby project to develop a web interface for 3D printers. Today octoprint is the largest of its kind with community support from all over the globe.



Web Interface available on Octoprint

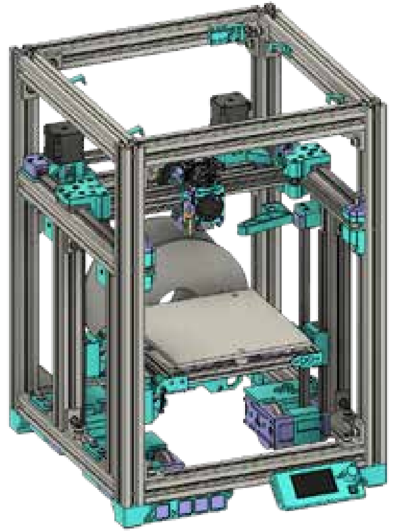
Touch Screen Display Interface

Open-Source Projects

Some of the interesting 3D printer designs

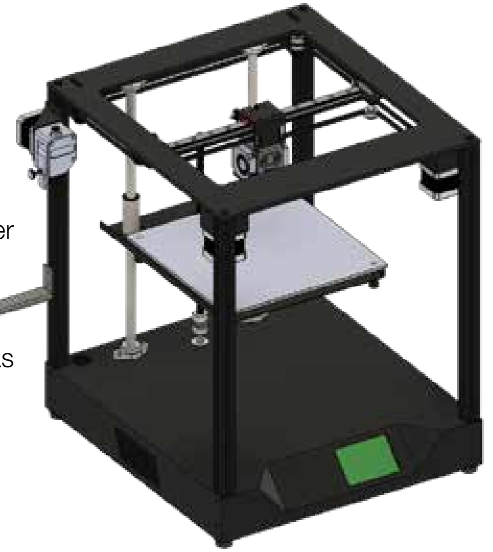
HevORT is an upgrade to a very popular printer design called the HyperCube Evolution

https://hevort.com/



SnakeOil is an open-source printer that takes inspiration from a lot of printer designs

https://github.com/SnakeOilXY/SnakeOil-XY



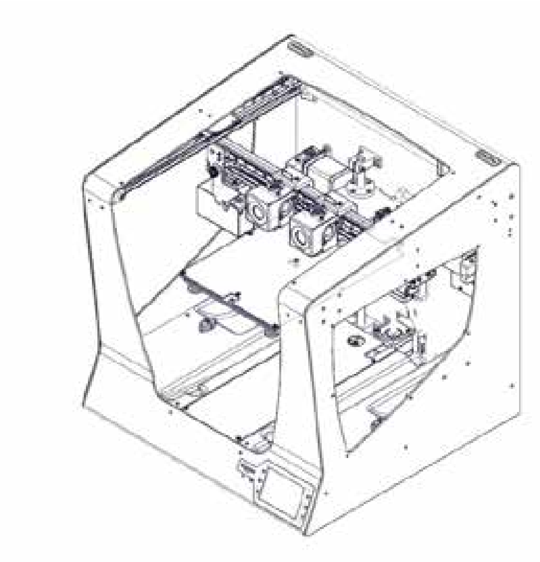
Two trees Saphire Pro is a printer made and open sourced by the chinese manufacturer TwoTrees. It is very cost-effective printer design with the overall printer cost as low as ₹27000

Voron project is one of the most succesful 3D printer designs. It has made a huge community of builders and the designs have experimented with features consumer printers haven't ever attempted.

https://vorondesign.com/

Eva-3D is a project has explored printable extruder and hotend designs

https://main.eva-3d.page/



BCN3D Sigma is a dual extruder 3D printer that uses a metal sheet chassis

https://github.com/BCN3D/BCN3DSigma-Mechanics

Synthesis

A brief understanding of what has happened so far along with a redefinition of the requirements and keywords for product ideation

Market Insights

Overall cost is one of most important driving factors of buying decisions	Modularity is preferred by hobbyist printers - already a part of some printers but only partly succesful	Beginners who are students or craftspeople are relatively rare - the product gets introduced by a knowledged acquaintance
Maker culture is inviting opportunity for 3D printers that are more versatile and could potentially work with multiple materials	Component availability has to be considered because most components aren't readily available for replacement	Market is dominated by printers below ₹20,000 price range
Printers used by STEAM educators are underpowered and highly overpriced	Most FDM printers in the market can only work with PLA material	Most FDM printers in the market can only work with PLA material

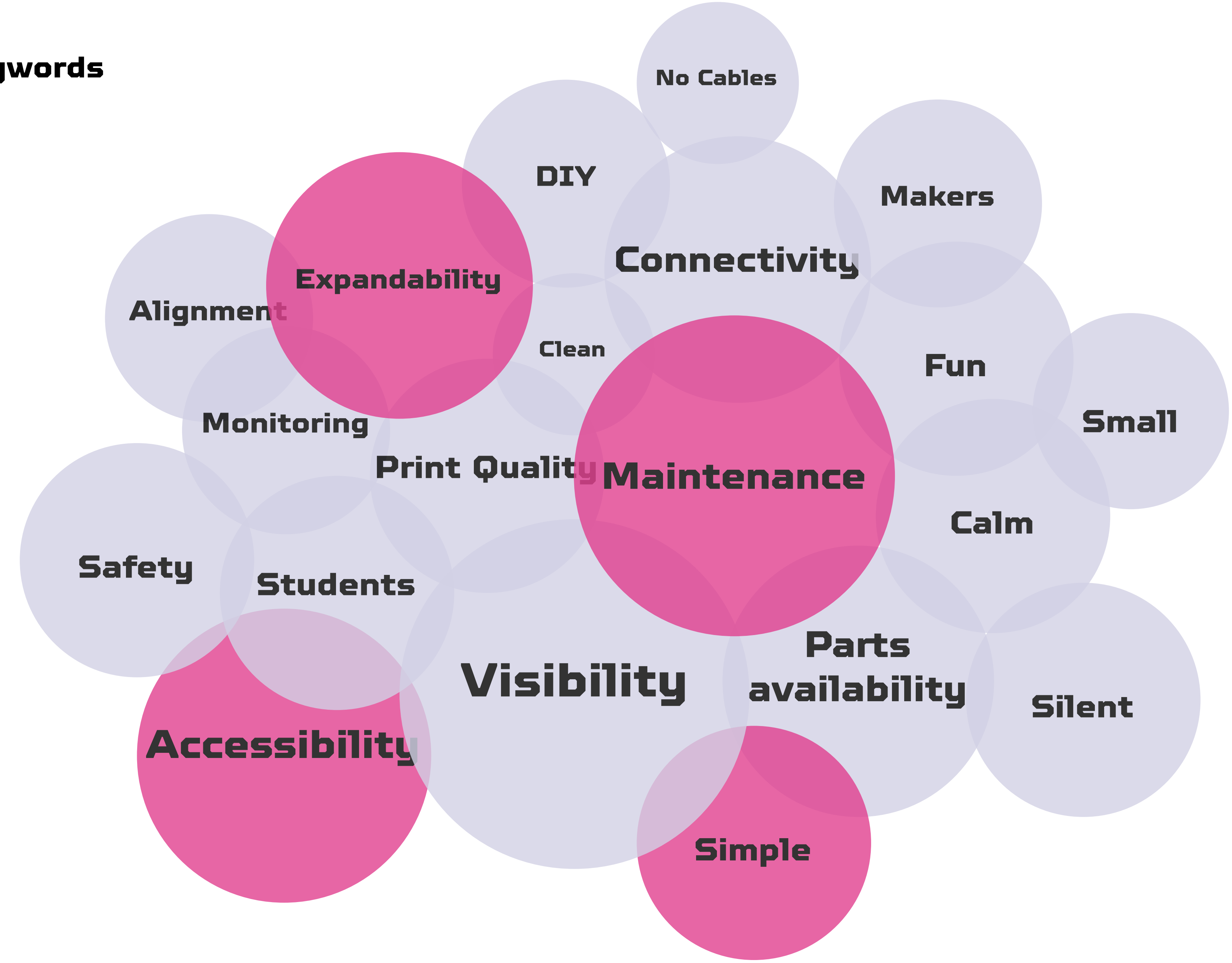
Hypothetical Scenario

The current market highly caters to the technically acquainted users and avoiding them should not be the choice - the idea is to be more inclusive than it already is - making what exists an inch better could potentially result in a more succesful product. A first time buyer of a 3D printer after seeing what is in fact possible would always be looking for a window into the market that is not complicated and straightforward - giving that person the right path into the complexity can reduce his pain on the way - as long as he enjoys the process of onboarding, the user will not worry about his purchase decision. The market is is dull and stubborn mainly due to the products available that do not cater to everyone - even the smallest step to bring them in could be a successful. The idea is not to make a craftsperson a professional-level 3D printing expert, but to onboard a relatively non-technical individual slowly into an ecosystem where life isn't as easy as printing on paper but still can adapt to and persist.

Research Insights

Maintenance and Accessibility is a major concern for consumer printers. They often require more maintenance - removal of components to perform maintenance	Using an SD Card to print is time consuming and often change of files are required resulting in a huge amount of buffer time wasted in the process. Newer methids could be helpful.	More inviting Exterior styling could be helpful for less technically acquainted community of users.	Extensibility of components could be helpful for multiple users having different use cases.
Bad cable management could be contributing to the idea of complexity of the machine - it also causes difficulty in cleaning.	Waste filament Accumulation is a commonly observes issue - printers that do not have enclosures are very difficult to clean mainly due to many locations in the printer frame that can accumulate dust and filament waste	Higher visibility while printing helps with predicting failure rates of prints beforehand to save time and filament wastage.	Printability of components are a welcome addition to hobbyists - has been in many printers of past
Filament Spools out in the open causes damage to filament due to moisture absorption - weathering of filament is a concern.	Component availability has to be considered because most components aren't readily available for replacement	Broken Bowden Tube requires a replacement every few months for ease of further maintenance and to keep the system easier to work with.	
Safety from Fumes is a primary concern	Displays are often placed at inconvenient locations and orientations	Wiring Harness tubes has to be broken off to gain access to wires	

Keywords



Functional Requirements
from the research

The important requirements for the machine were

- Print Volume (Minimum) **200x200x200 (mm)**
- Motion Platform Type **CoreXY**
- Extruder Type **Direct-Drive**
- Motion Platform Material **Linear Rods**
- **Fully Enclosed**
- **Versatile highly functional user interface**
- **Maintenance without tools**

Additional Requirements

- Safety from Fumes
- Filament Storage
- Clean Cable Management
- High Visibility Visual Design
- Reduced Noise
- Easy availability of components

Briefing
Settling the research down

To develop an inexpensive, extensible 3D printer targeting the tinkerers, designers and hobbyist audience

Identifying the future market of additive manufacturing to create a new product that would serve as the medium to the transition from today to the future

Developing an inexpensive 3D printer for the masses that eliminates all the complexities of existing printers and turns it into a device as simple as any other household appliance

Understanding what needs to be taught and the difficulties in teaching about 3D printing(additive manufacturing) to children to create a product that merges the gap between education about 3D printing and institutions

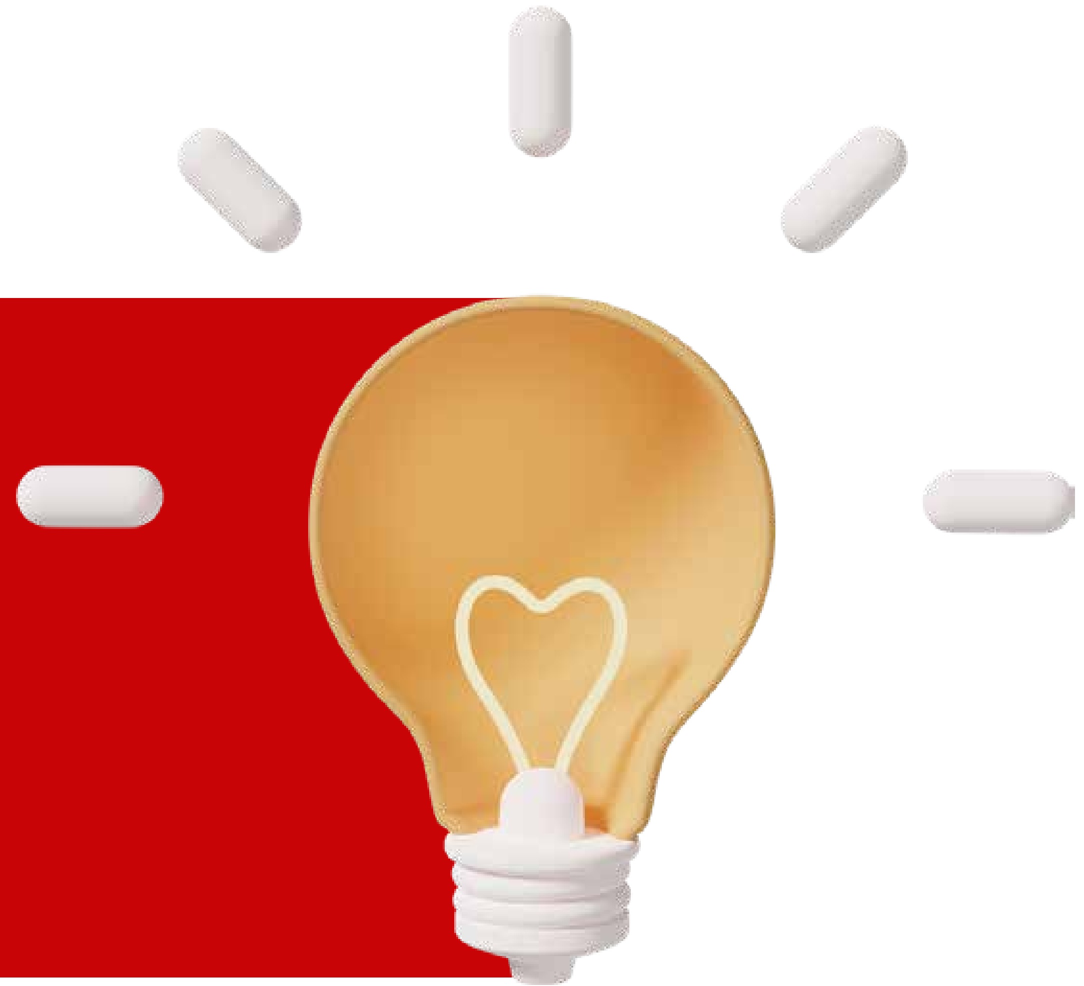
Brief
Develop a cost-effective CoreXY based highly extensible 3D printing platform with accessibility, maintenance and simplicity at the core

Target Audience
Beginners, Hobbyists and Students

Objectives
Fit into a budget segment of ₹30000
Should print PLA and ABS
Low-maintenance
Connectivity Features
Safety from fumes
No noise design

Ideas

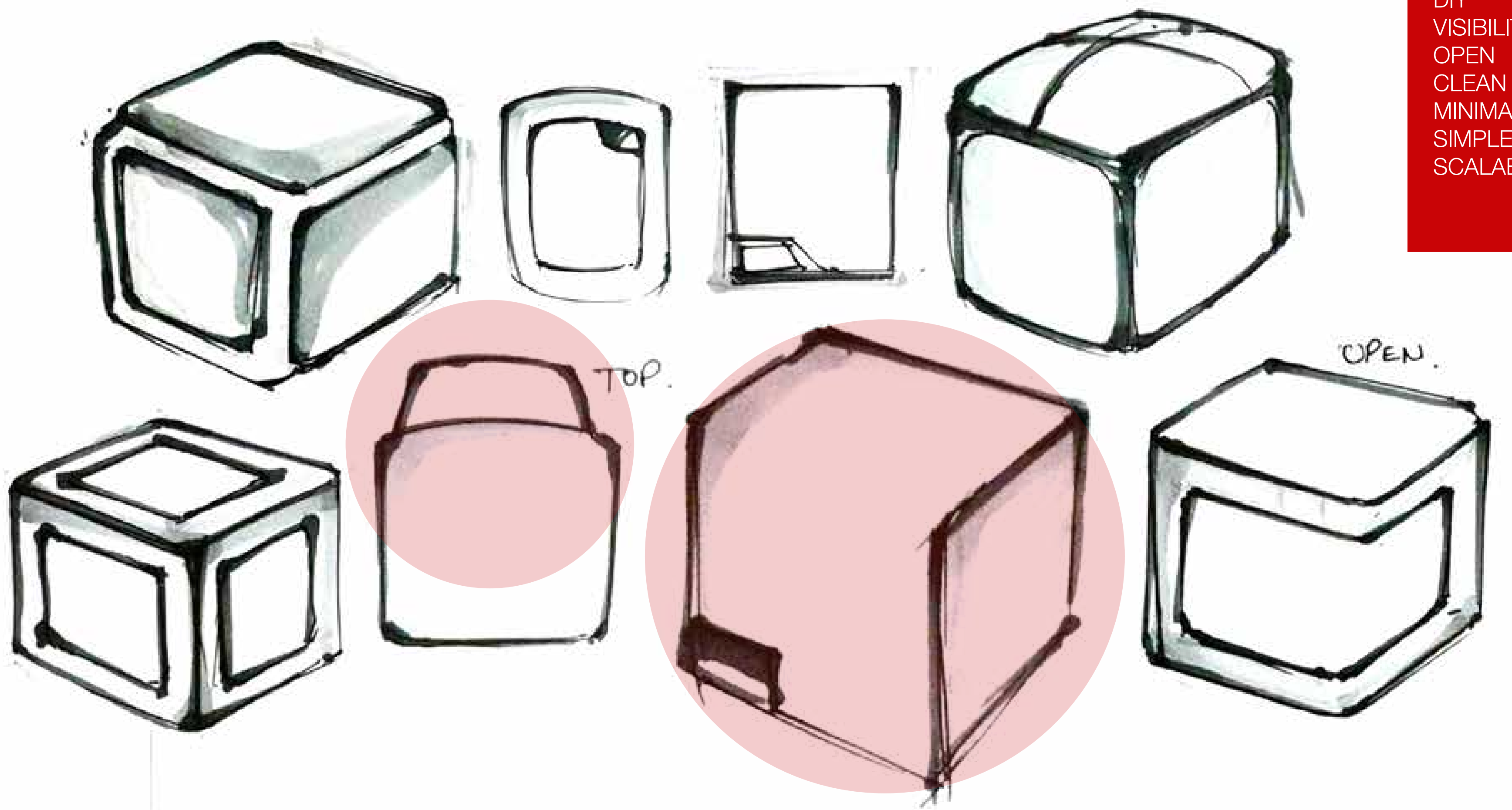
New ideas and concepts for both the working components of the printer and the exterior styling including proof of concepts for most of them.

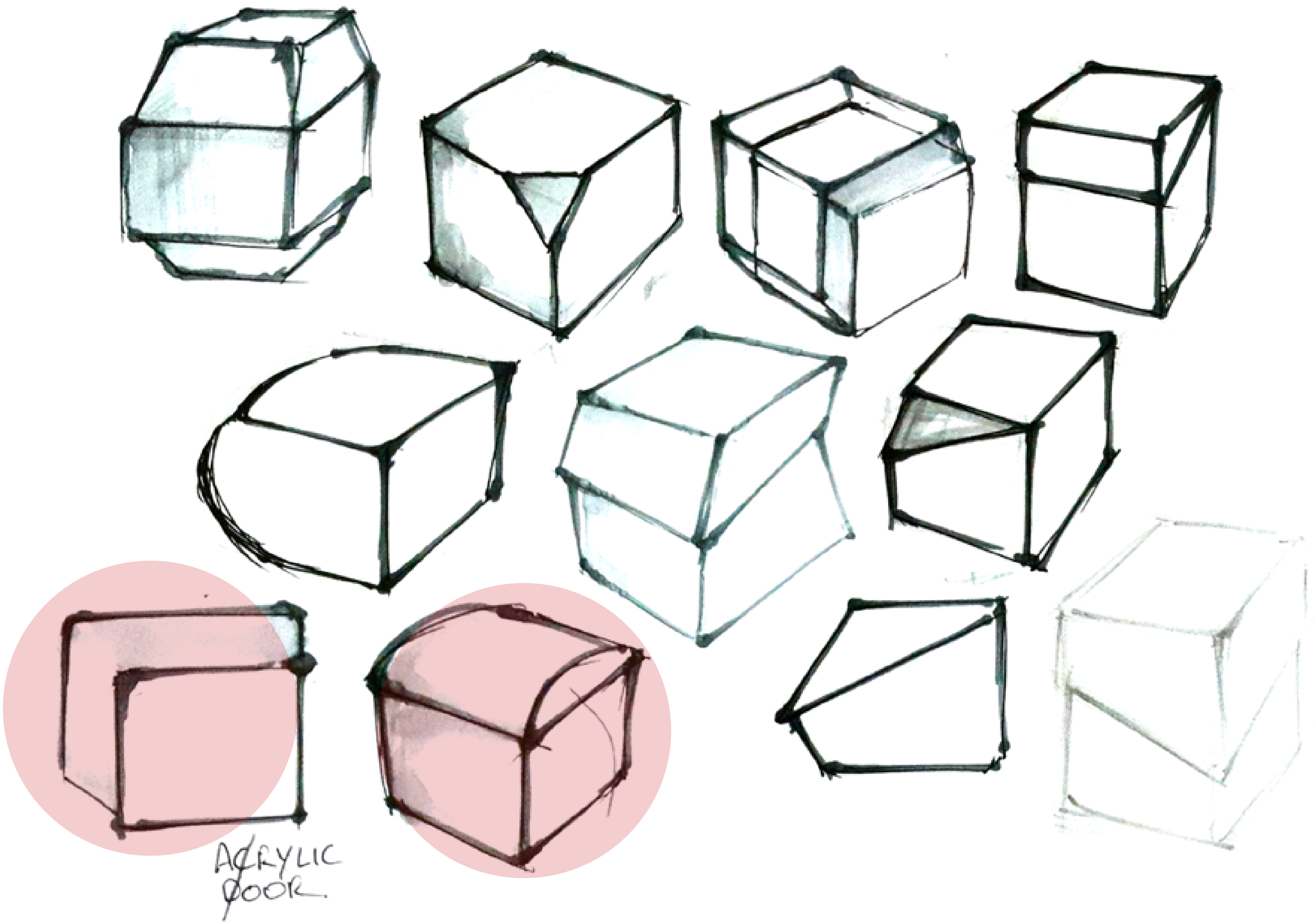


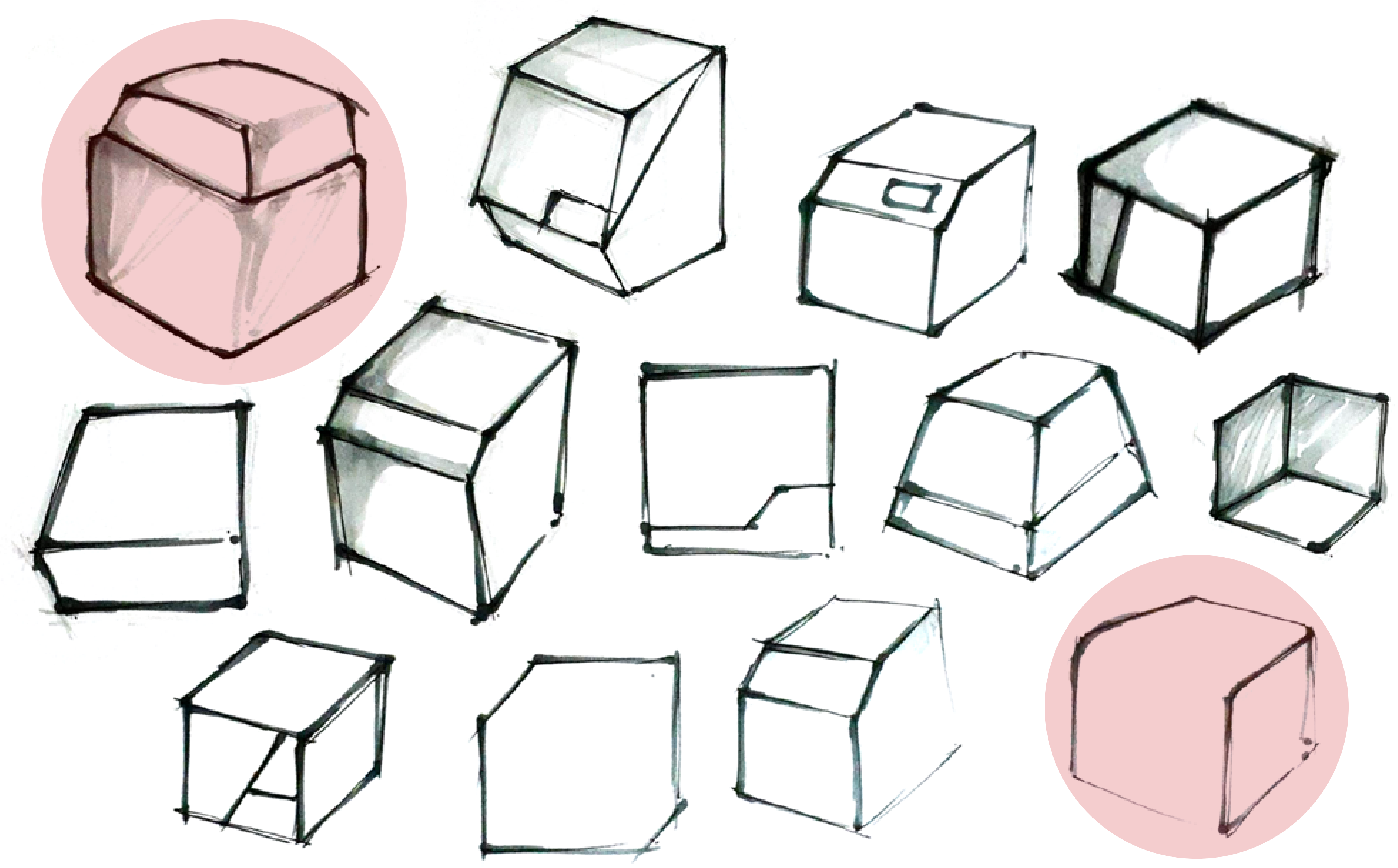
Design Moodboard

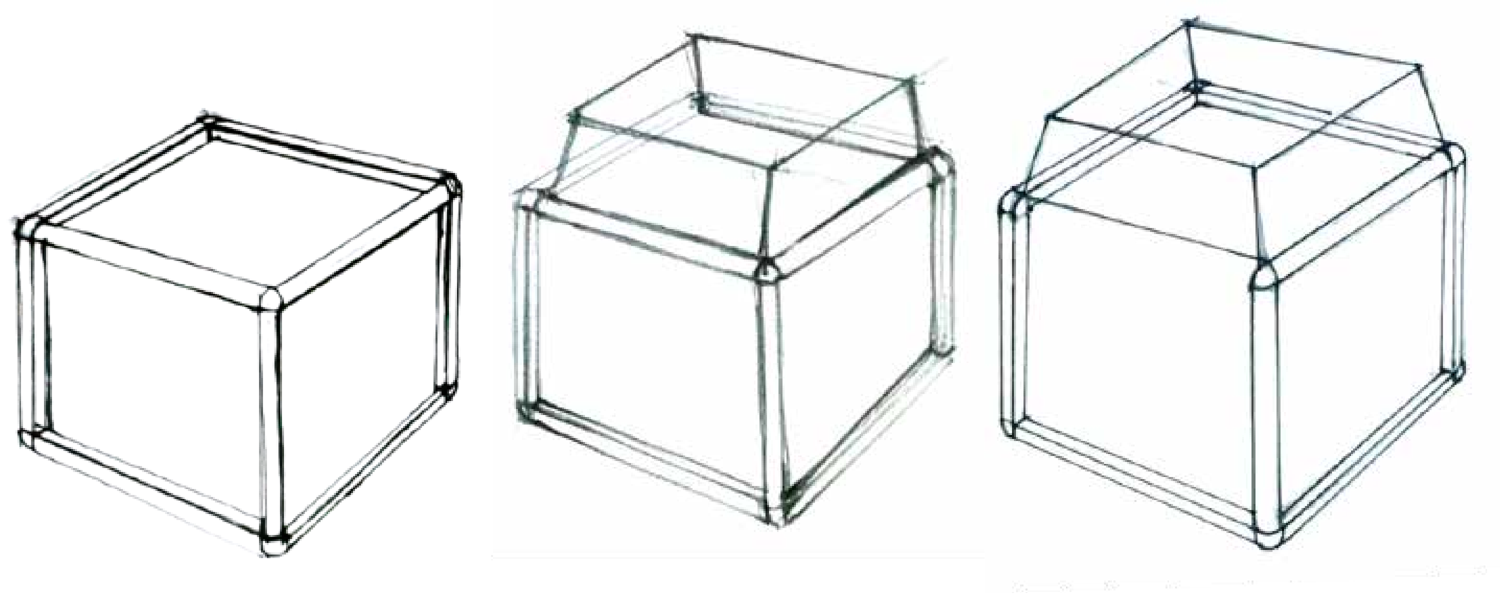
Enclosure Design

Keywords
DIY
VISIBILITY
OPEN
CLEAN
MINIMAL
SIMPLE
SCALABLE

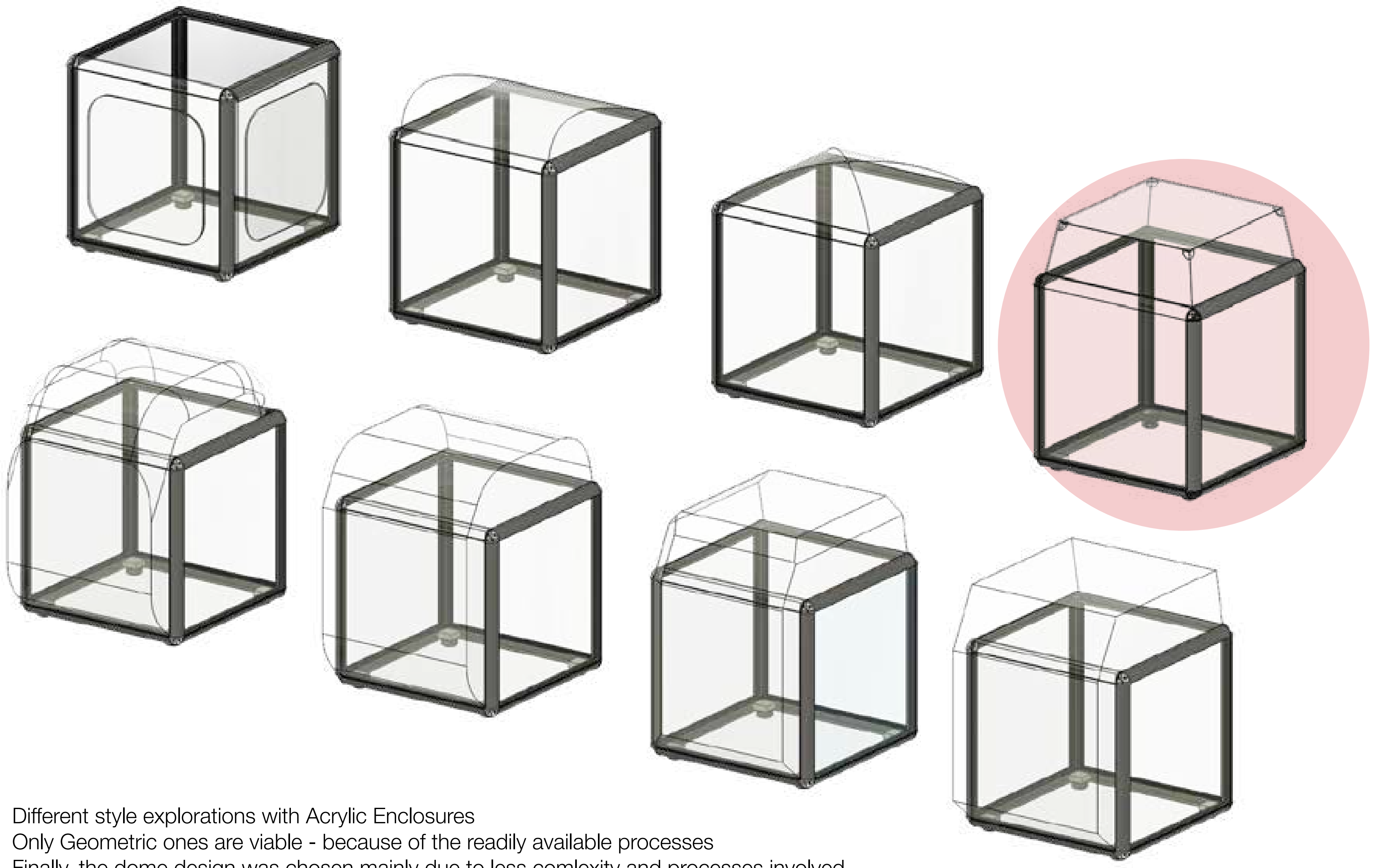




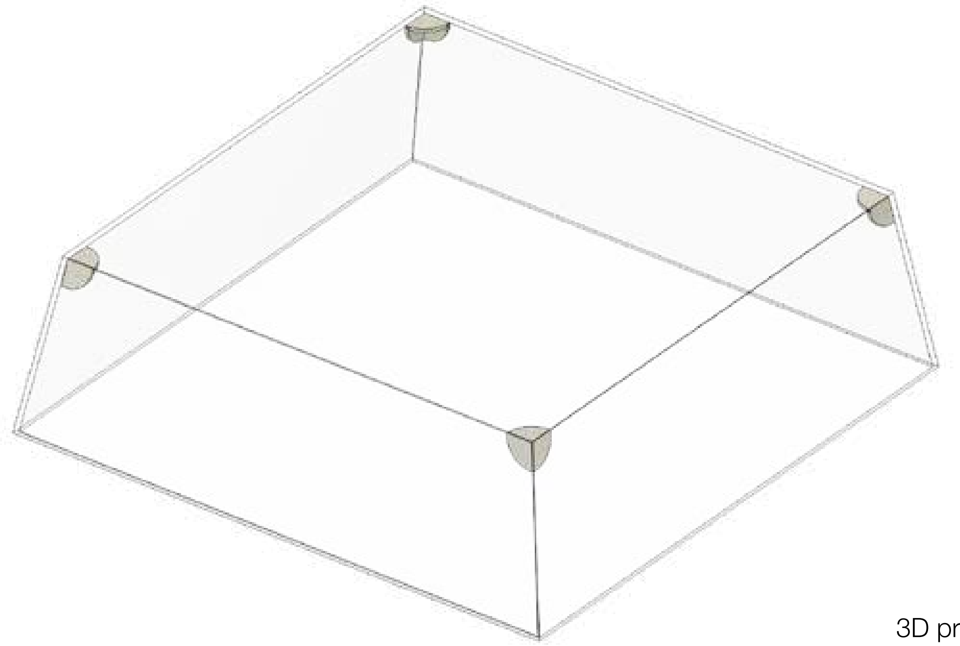




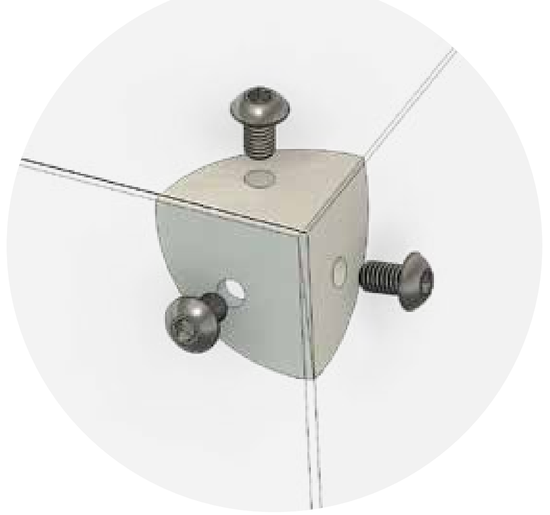
The simplest functional form that increased visibility, maintains Do-It-Yourself capabilities and stays functional while being aesthetically pleasing was derived from the exploration. The final idea is to move forward with an enclosure made of 2020R aluminium extrusion profiles for the frame and clear acrylic sheets for the enclosure



Different style explorations with Acrylic Enclosures
Only Geometric ones are viable - because of the readily available processes
Finally, the dome design was chosen mainly due to less comlexity and processes involved



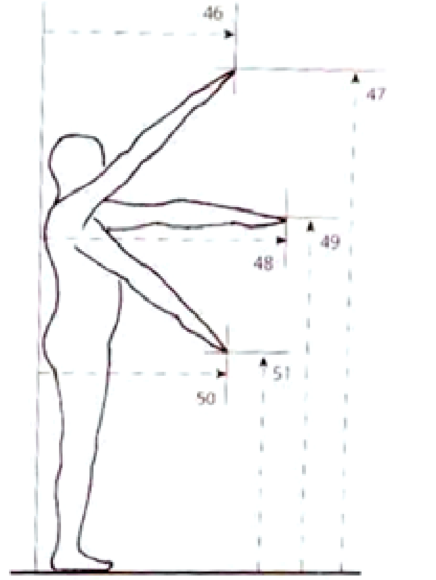
Printable parts are used throughout the design for easier replacement of components in case of failure by simply 3D printing those particular components.



3D printed corner connectors are assembled together with M3 6mm bolts

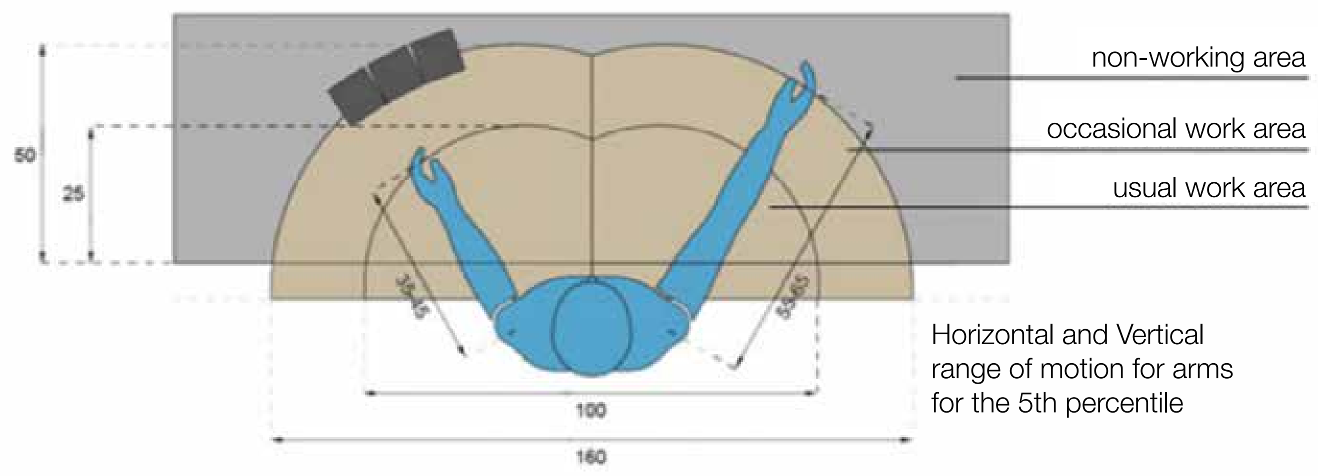
The prototypes are made with 3D printing to ensure the parts can be 3d printed as well - on a production run, the same parts will be made using more traditional and economical processes like injection molding or sheet metal bending

Enclosure Dimensions



From Indian Anthropometric dimensions by Debkumar Chakraborty and Design for Ergonomics by Francesca Tosi - arm dimensions of typical adults(combined - male and female) were used to conclusively select a dimension for the printer - the conclusion was to keep the dimensions under 40cmx40cm(widthxlength). Since the required print volume was 20cmx20cm - the printer could be fit into a 36cmx36cm frame. This could be helpful to student users who have armspans less than that of adults.

dimensions in cm



Horizontal and Vertical range of motion for arms for the 5th percentile

Why is the frame a Cube?

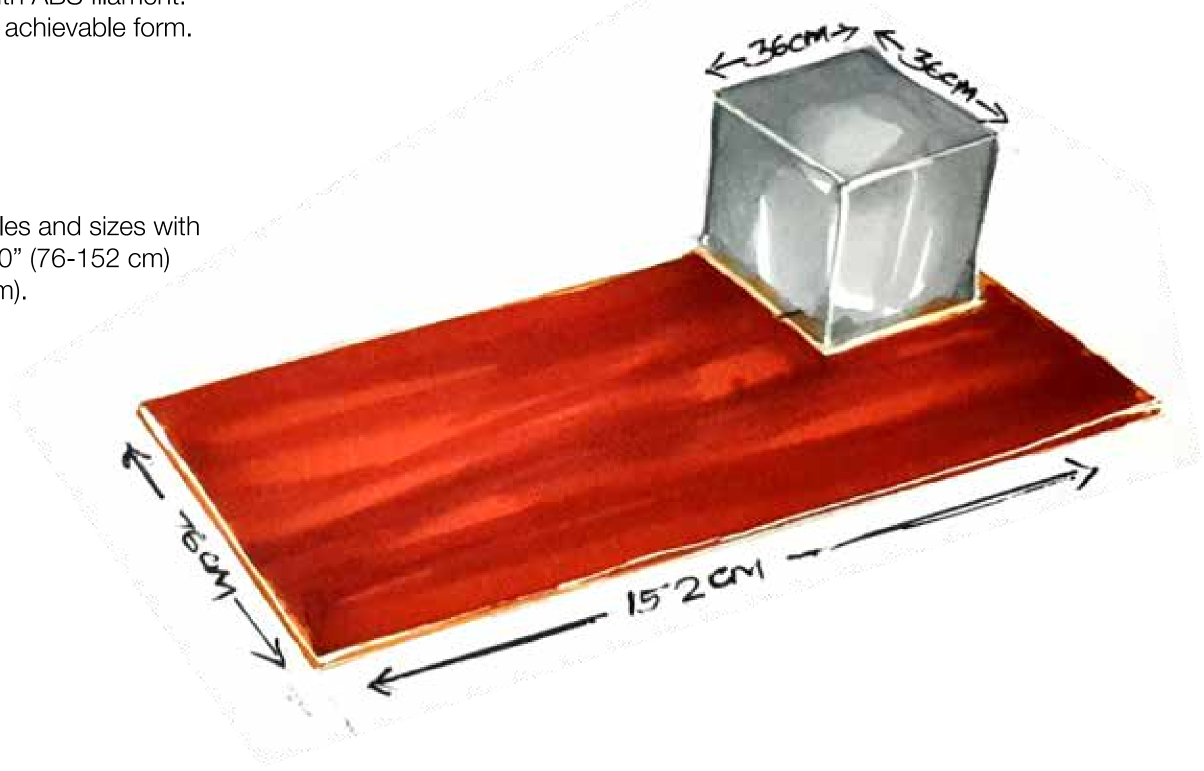
- CoreXY requires a fixed rectangular frame.
- Enclosure is required for printing with ABS filament.
- Cube is the easiest cost-effectively achievable form.

How big is a work desk?

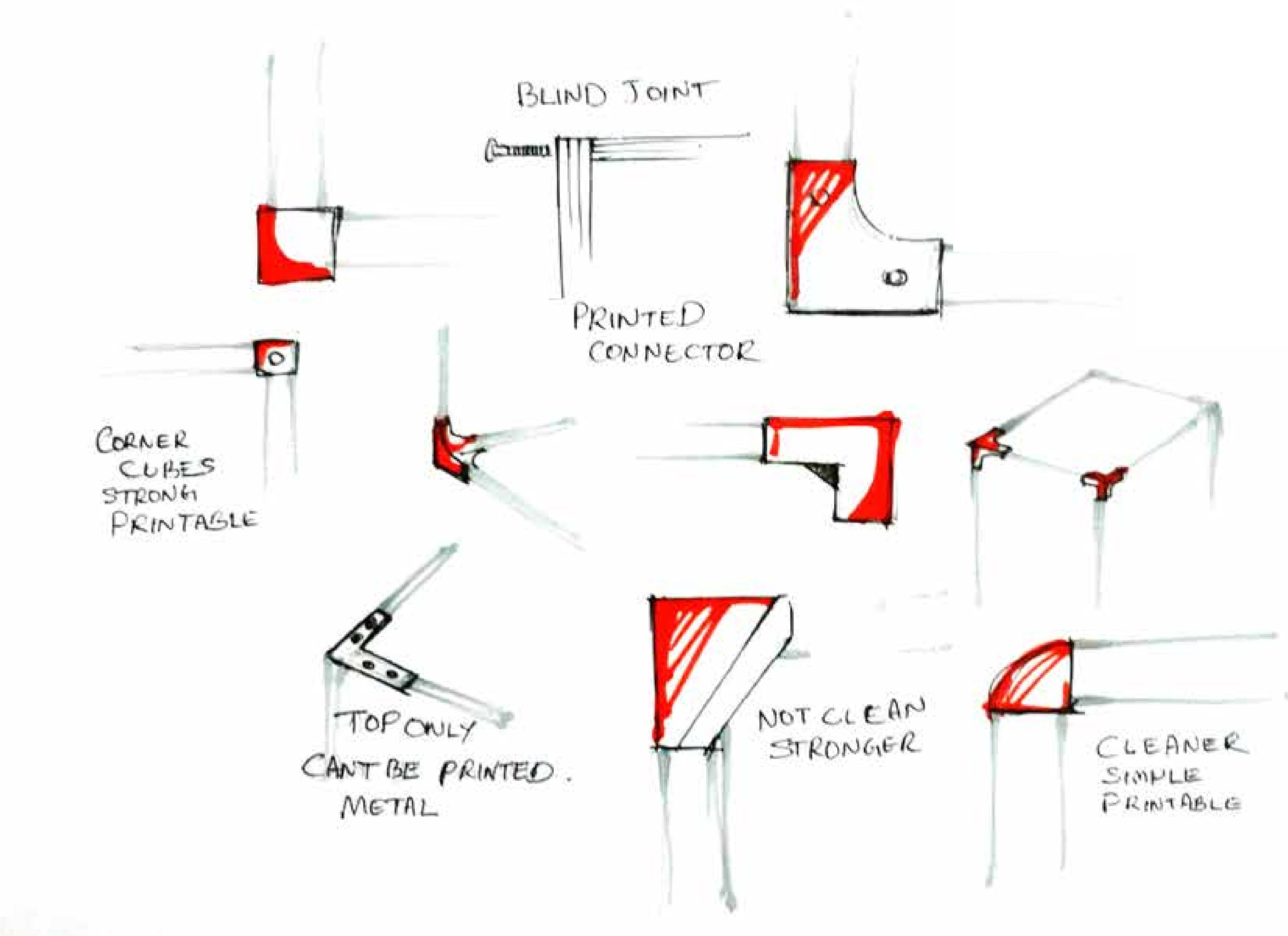
Desks are designed with a range of styles and sizes with common overall widths between 30”-60” (76-152 cm) and depths between 20”-36” (51-91 cm).

Data from dimensions.com

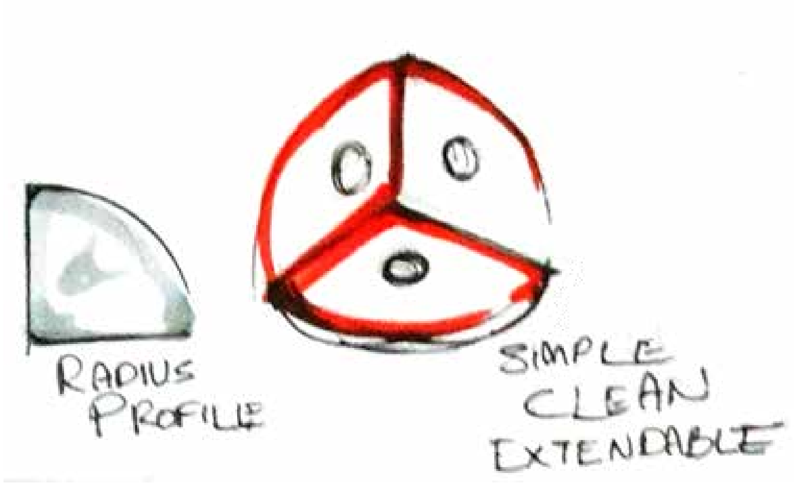
The overall requirement is to build a small overall size printer that can print a minimum volume of 200x200x200 - this came about from market research of print volumes of competitors in the price segment.

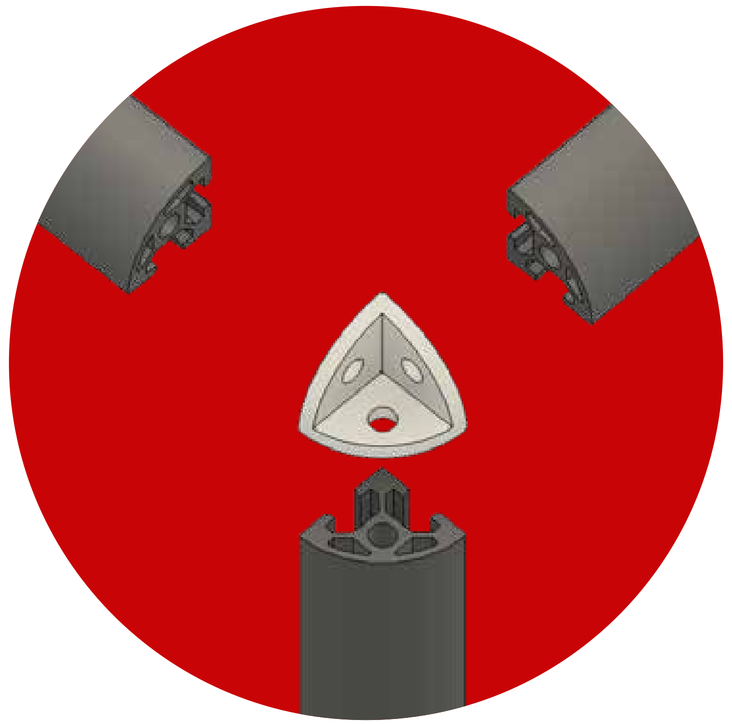


Corner connectors



Keywords
CLEAN
SIMPLE
EXTENDABLE
PRINTABLE



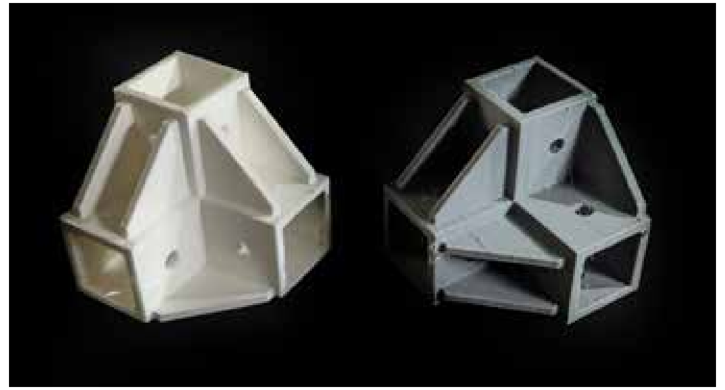


Corner connectors of this kind exist already as a casted aluminium version but has never been used or tested as a 3D printed version. These connectors are very simple, highly extensible - because of its open top design, making it ideal for the enclosure.

Printable connectors are inexpensive and extendable - requirements from insights.

Corner connectors prototypes

Final prototypes of Corner Connectors - since 2020R profiles weren't available a 3D printed version was used to check compatibility and was found satisfactory

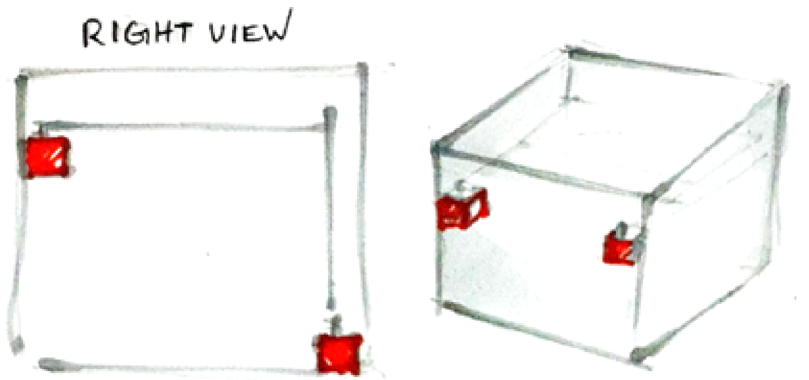


Corner connectors printed in PLA(White) and PETG(Grey). PETG is more difficult to print with and is often much stronger - but for this case PLA was found to be plenty strong for the prototype

3D printed version of Corner Cubes were also found to be efficient as corner connectors. Printed in PETG

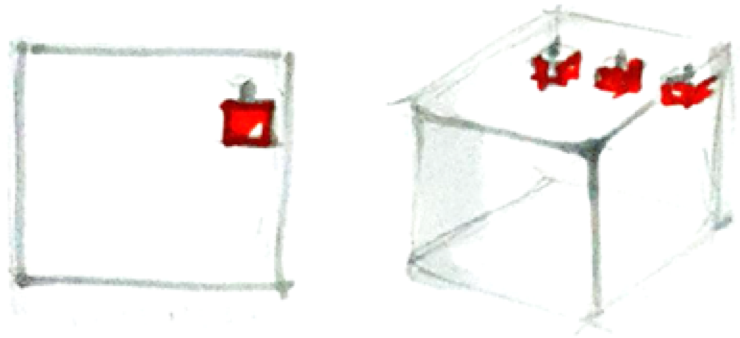
Motion Platoform

Motor placement



Old: Front mounted X,Y axis and Bottom mounted Z motor

The traditional design of CoreXY design uses motors mounted on the front and a Z-axis motor mounted at the bottom.
Obstructs Visibility
Motors mounted far from each other requires longer cables and causes difficulty in cable management

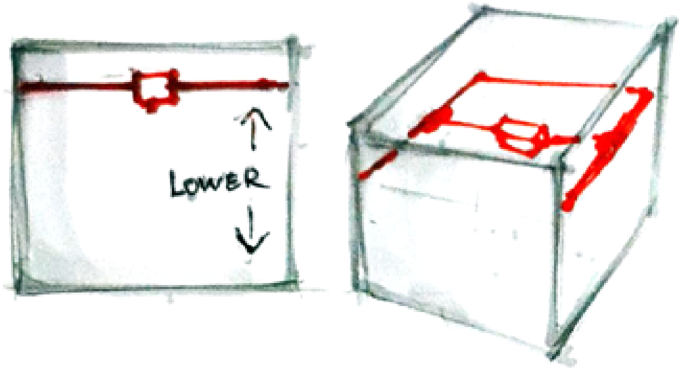


New: Motors mounted Inline - All three X,Y and Z axis

The improved design uses motors mounted at the back on top in an inline arrangement - reducing cable length required and easier cable management and gives **more visibility** in the front.

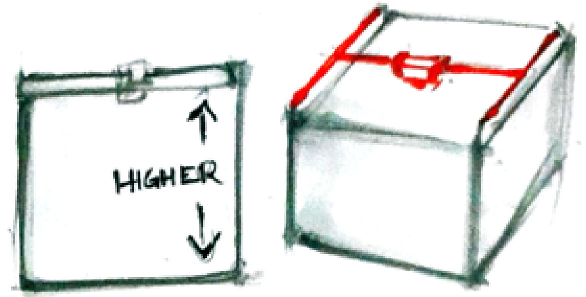
Maintenance and upgrades can be easier due to the ease of access to the motors

Motion Platform Placement



Old: Motion Platform lowered into the frame

Traditionally enclosed printers use a platform embedded inside the frame - mainly due to the ease of enclosing such a design. This results in difficulty in access to components of the printer. The reduction in visibility also obstructs the users firsthand view of the process and results in a less satisfactory user experience.

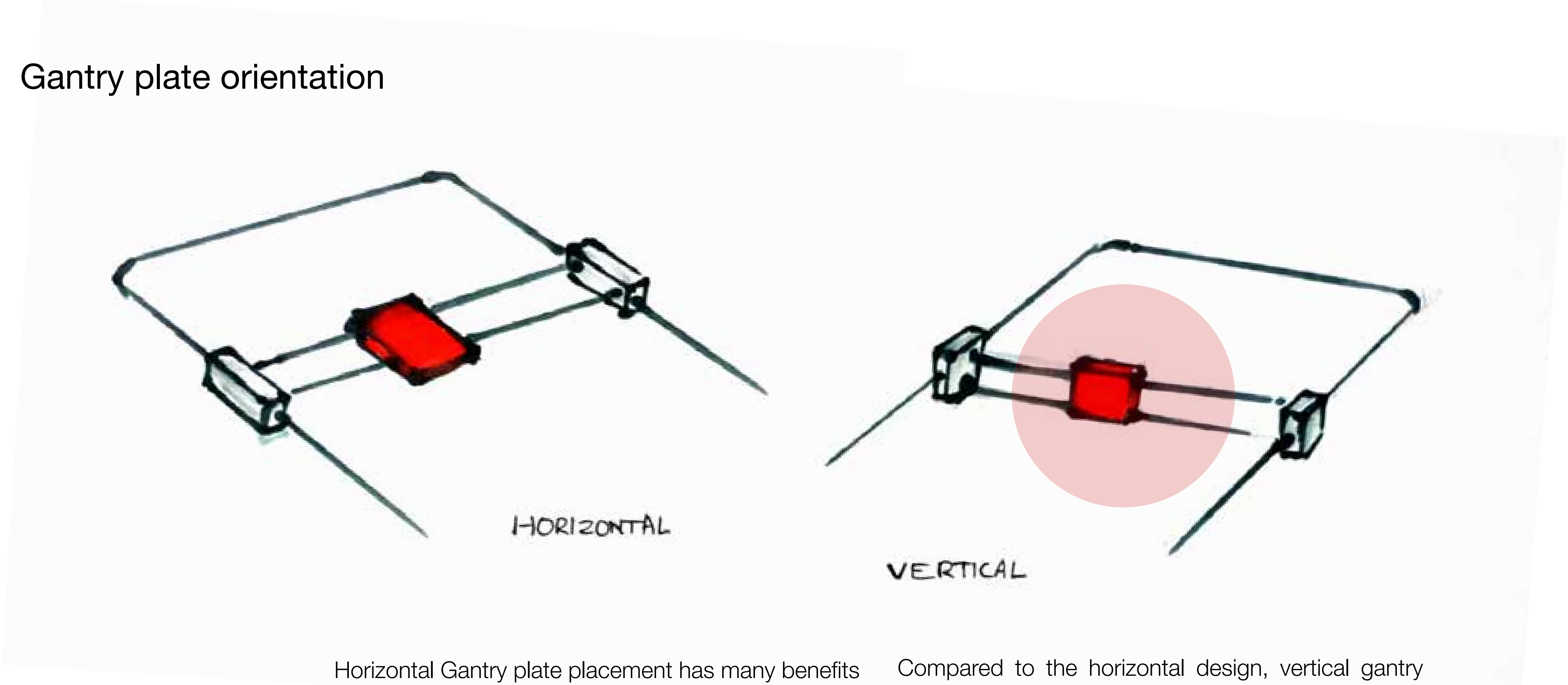


New: Motion Platform elevated above the frame

The new design uses an elevated outward mounted platform design - helping with maintenance and upgradeability and also increases the visibility of the overall machines process - an added benefit is the cleaner and simpler design of the components

High visibility, ease of maintenance are key pointers that lead to the rethinking of traditional placement. The pointers came about from primary research.

Gantry plate orientation

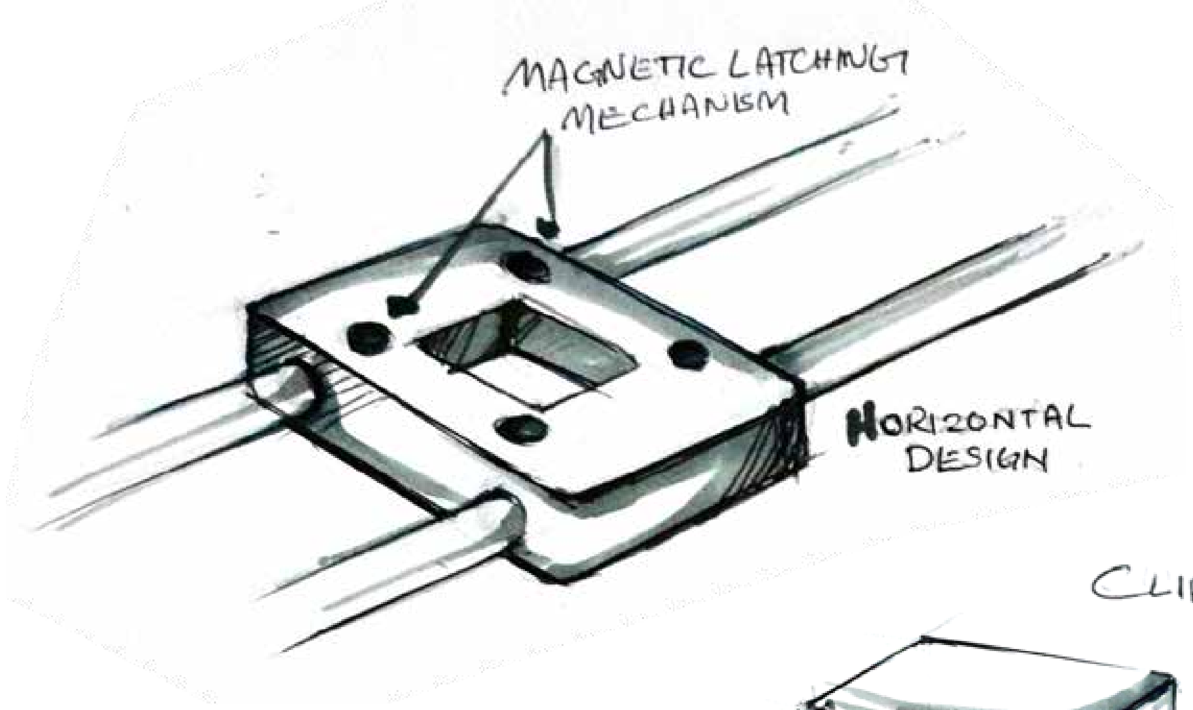


Horizontal Gantry plate placement has many benefits that include increased stability, easier placement for toolheads etc. The problem lies in the overall dimensions and other features of the printer especially the print volume and overall printer size. The design originally used a horizontal system that was later changed due to inherent benefits of the latter. Other printers that use a similar system are T-Bot and Z-Morph Fab

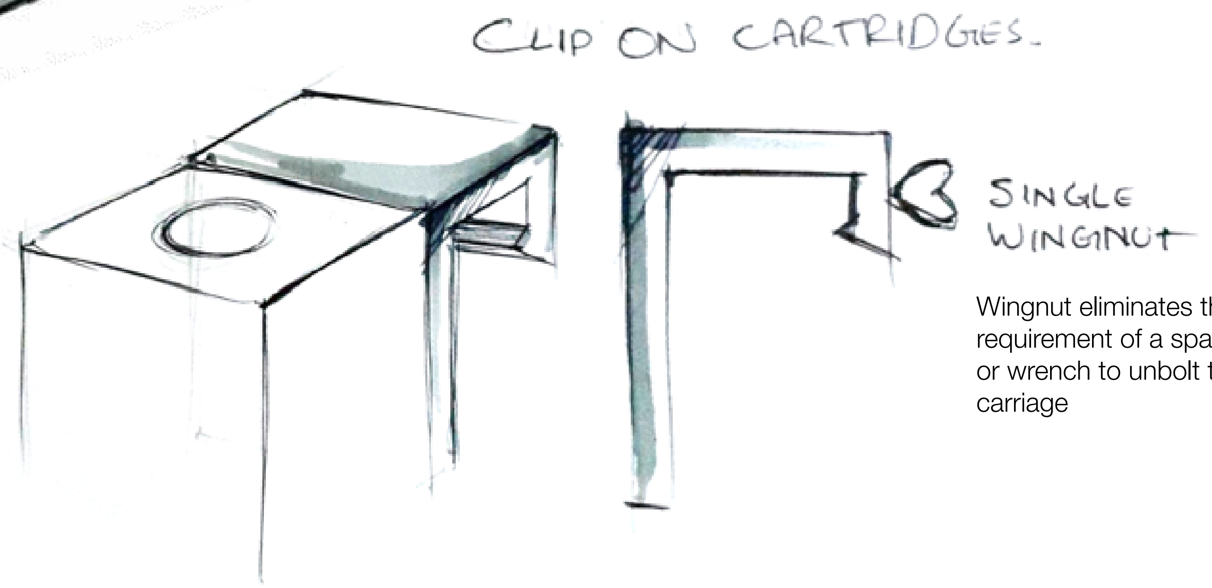
Compared to the horizontal design, vertical gantry uses more space in the z-axis but less in the y-axis. This helps the design use the same printer enclosure dimensions to achieve the print volume of 200mmx200mm. Another benefit of a vertical design is that more toolheads can be a easily fitted onto the system without a major loss in y-axis area. Vertical is also more beneficial because of the fact that loss in Z-height can be compensated for by changes in the design of gantry mounts.

Key requirements were to build a small overall size printer that is also highly extendable - both are satisfied in the vertical arrangement.

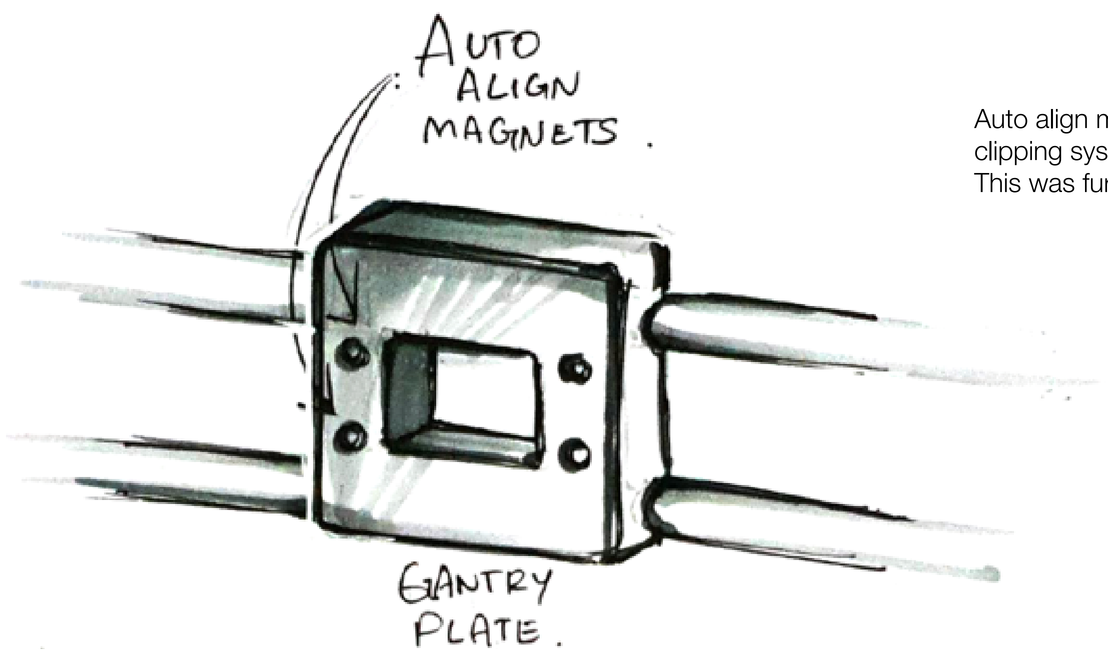
A new kind of extruder assembly



Magnetic Latching mechanism is used to latch onto newer toolheads without mounting bolts. The idea was later dropped because temperature variations can cause magnets to lose their ability, the design was updated to a clip on system where the toolheads are slided into the base plate



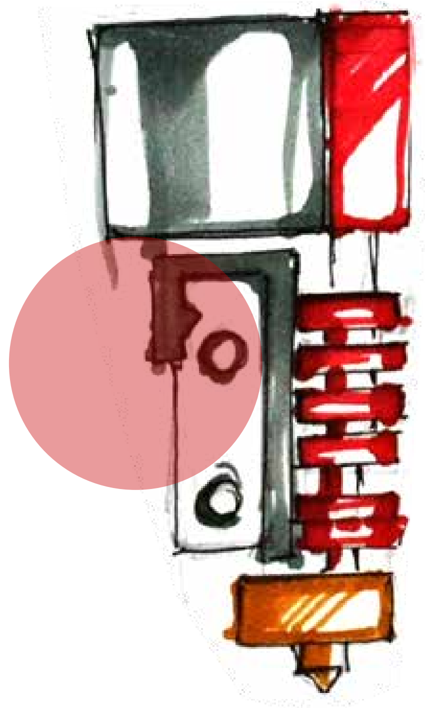
Wingnut eliminates the requirement of a spanner or wrench to unbolt the carriage



Auto align magnets are used to align the clipping system to be bolted together easily. This was further updates to the clip-on system

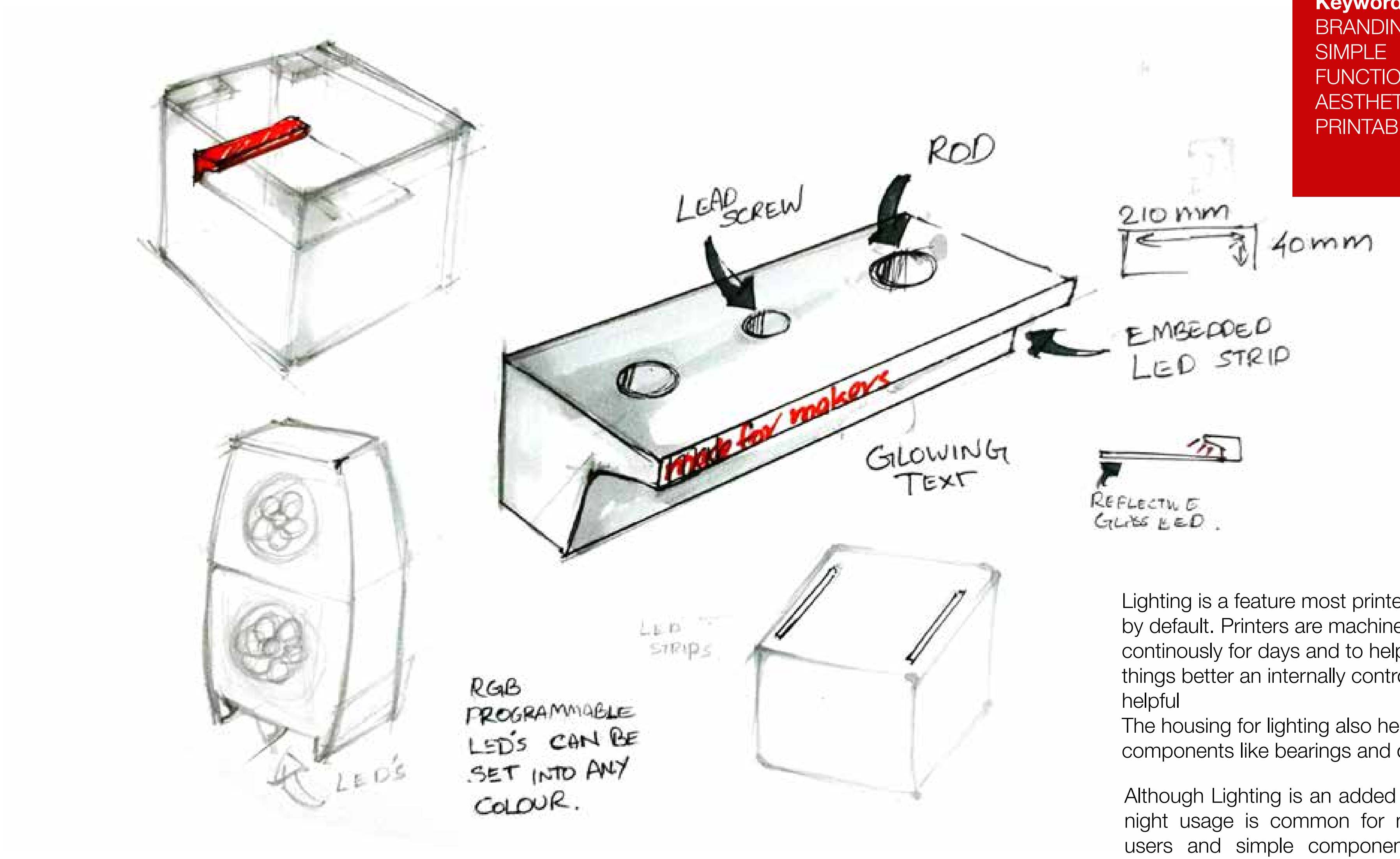
Clip on system will efficiently clip toolhead to the gantry plate while making it easily removable and replaceable - especially in a future case when printhead requires replacement or the printhead is replaced with a laser engraving head.

Modularity is an additional value addition and a feature that adds more user-friendliness to the platform. Being highly modular helps the user change toolheads as and when required. This also helps the printer be more attractive to a larger market audience.



Lighting

Keywords
BRANDING
SIMPLE
FUNCTIONAL
AESTHETIC
PRINTABLE



Lighting is a feature most printers do not have by default. Printers are machines that often run continously for days and to help with monitoring things better an internally controlled light will be helpful
The housing for lighting also help hide components like bearings and connectors

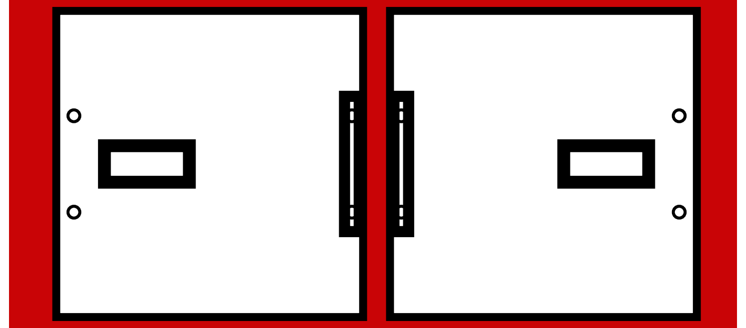
Although Lighting is an added feature, late night usage is common for most printer users and simple components make it more fail-safe as well.

Doors

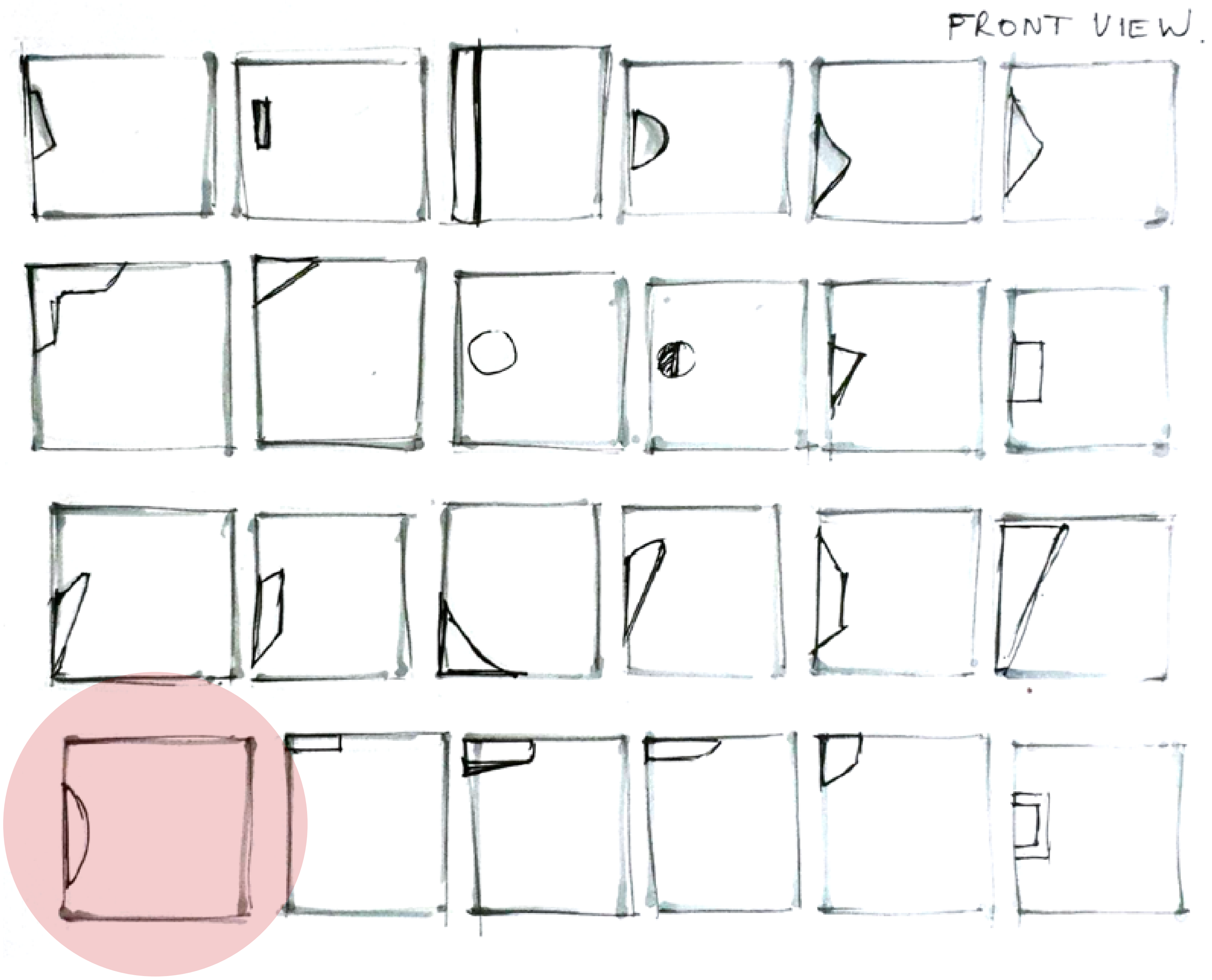
Closing and opening doors

Doors open in different directions. Preferences of door opening to the right or left do not make life more difficult to the left handed user(who is a minority, but they might prefer otherwise.
Being inclusive is added value for a platform designed to be upgradeable.

Left handed and right handed doors are more of a personal preference. A left handed person finds it easier to open and deal with a door that opens to the left. Me being a right handed person also found it easier to open the door to the left in case of the oven.

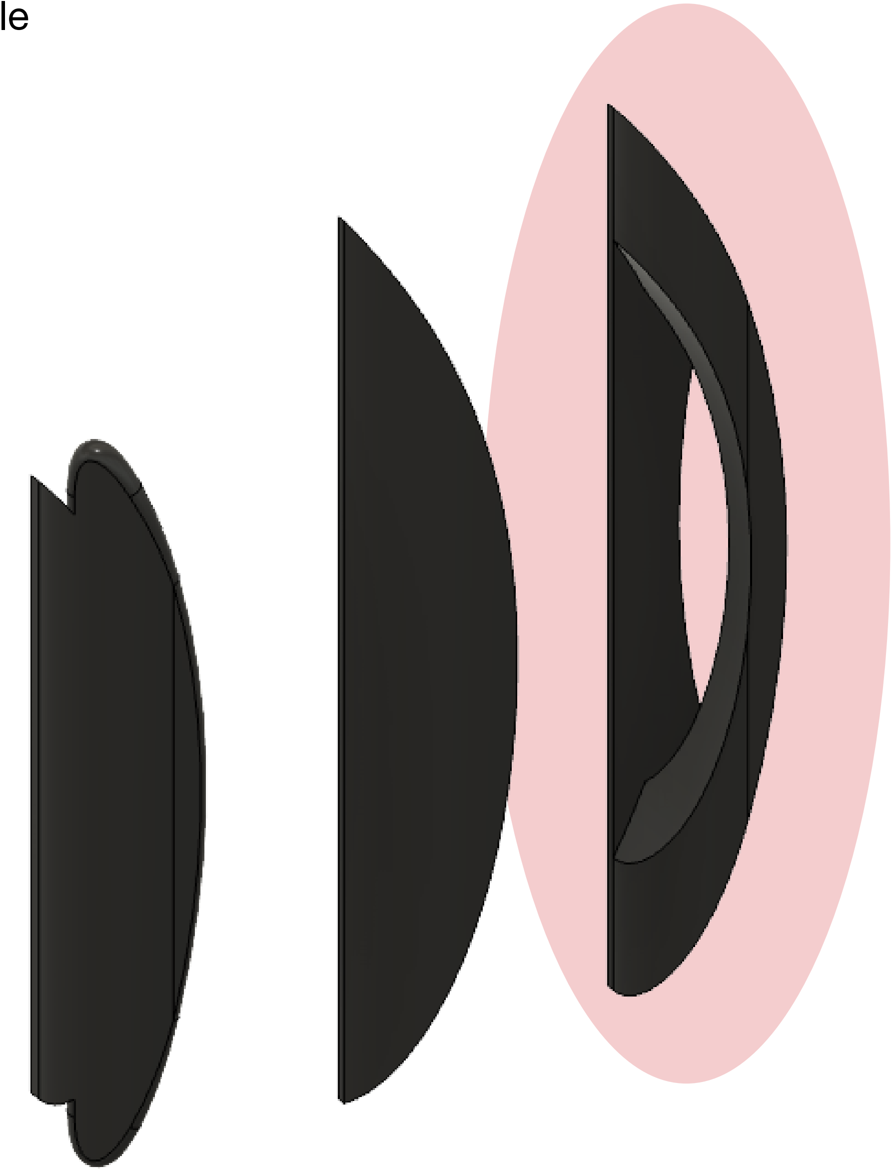


By keeping the screwholes and parts symmetric, the door parts can switch to the other side when required. It could also help in changing door direction with ease when its required (for e.g. when the printer is moved to a different side,when the user changes to a leftie etc.



Keywords
SIMPLE
PRINTABLE
MODULAR
ERGONOMIC
SYMMETRIC
INCLUSIVE

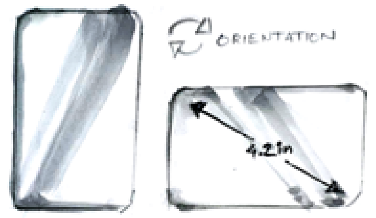
Door handle



Door Handle had to comply with the reversibility requirements - the part has been designed to be able to switch sides by being symmetric

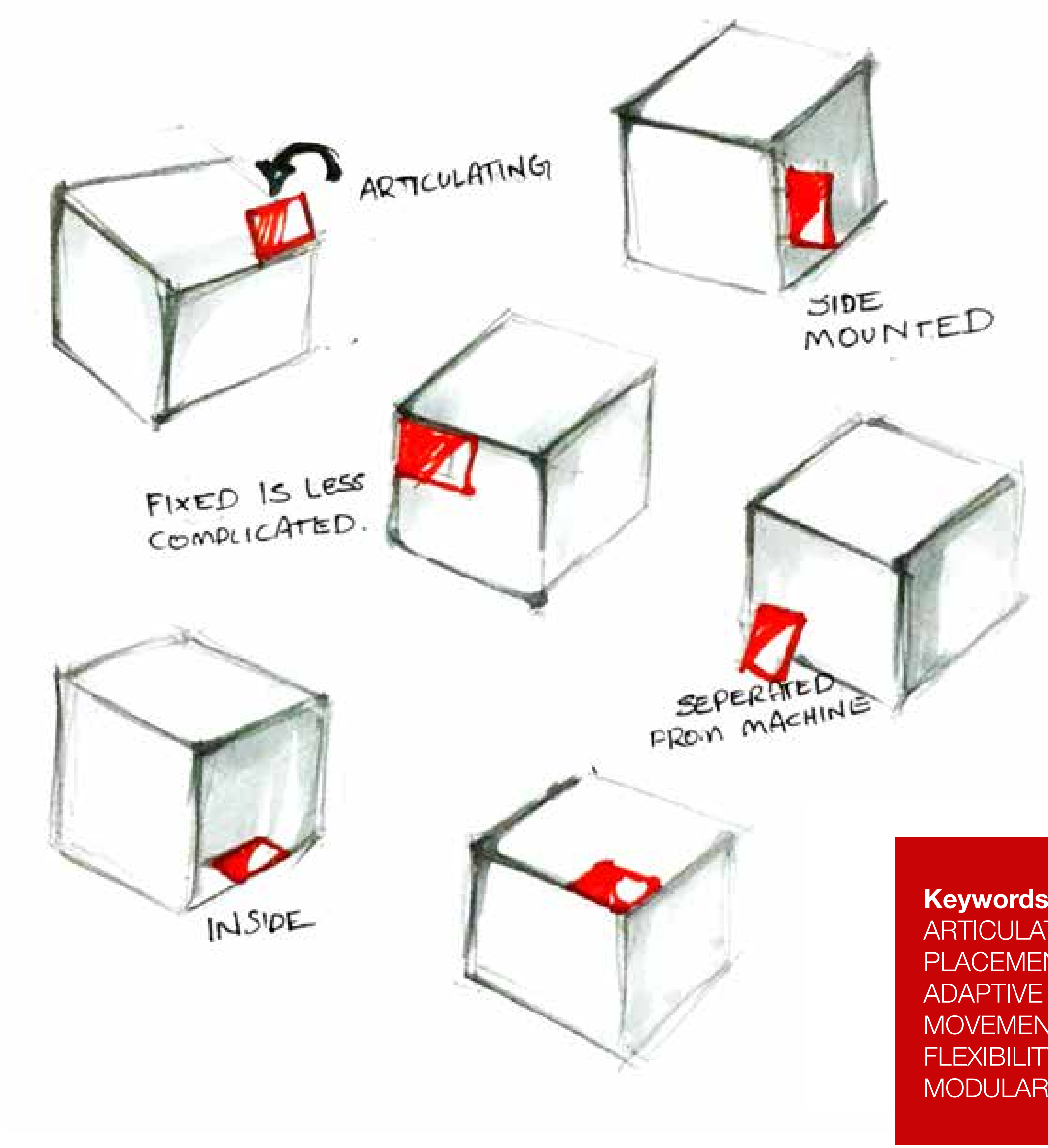
The door handle has been designed to be more inclusive for different kinds of users - could make it attractive to a larger set of users and also being modular helps the part be upgraded or replaced easily.

User Interface
Display

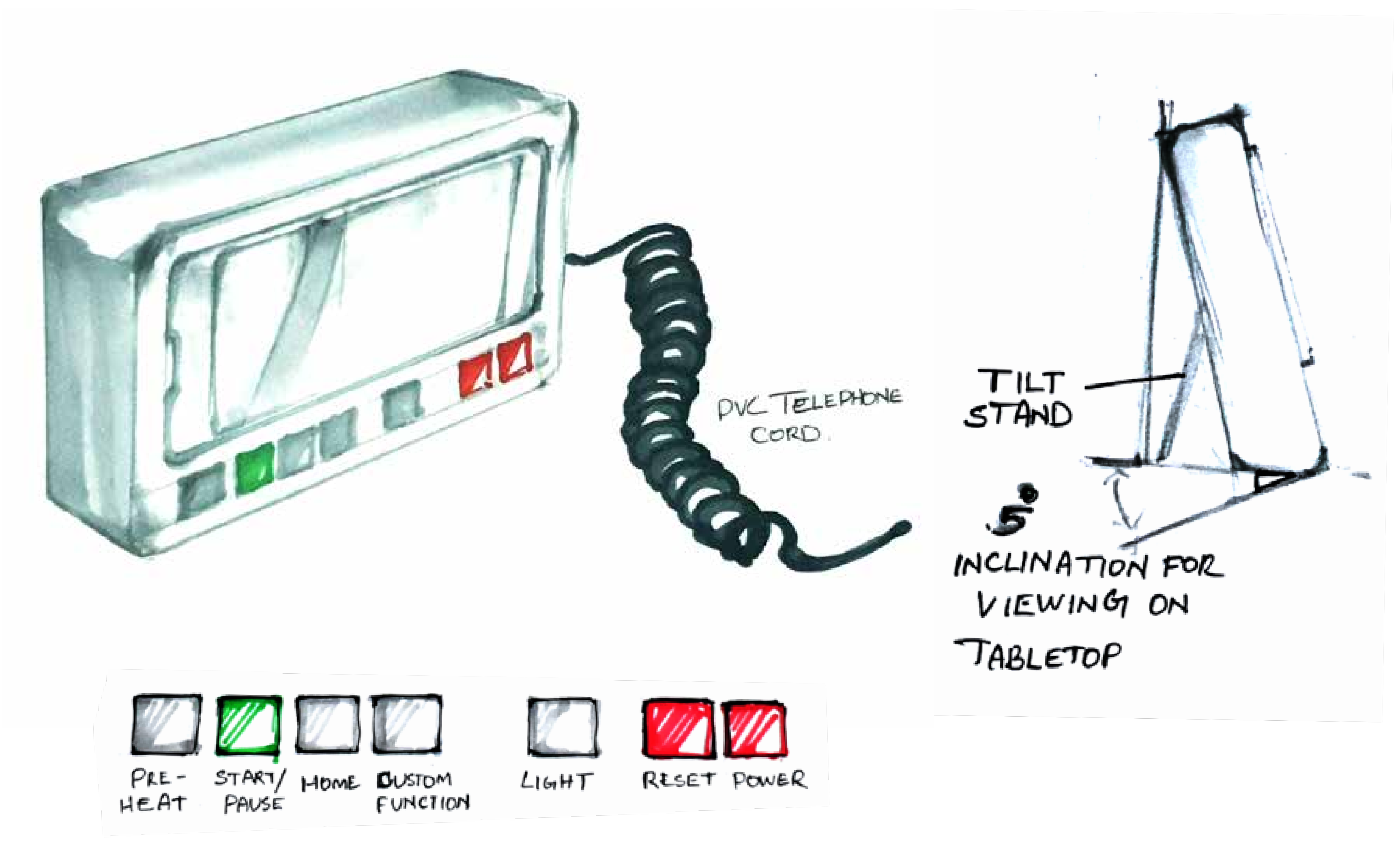


Display should be able to comfortably change orientation as the user prefers to

Location of the display is a personal preference - a movable display is more inclusive, modular and the internal design keeps upgradeability at the core



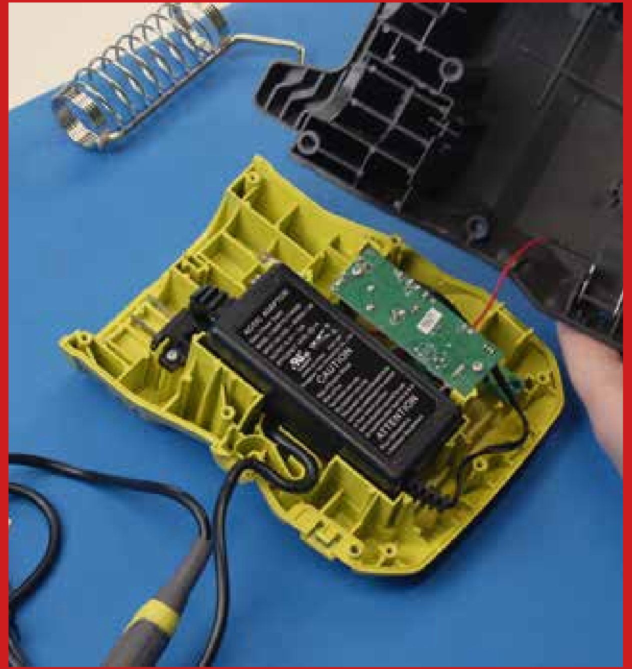
Keywords
ARTICULATION
PLACEMENT
ADAPTIVE
MOVEMENT
FLEXIBILITY
MODULAR



Smartphone Control

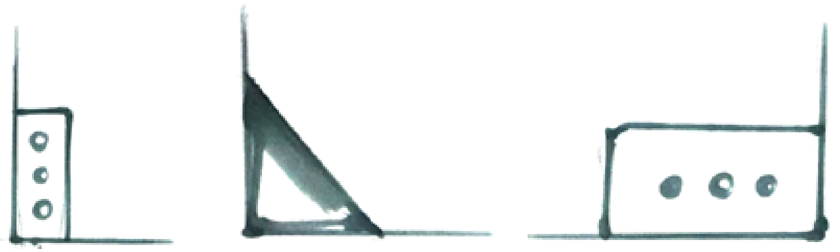
Bringing touch Interfaces and more user-friendly features like wireless support requires even more control systems and software.

The good part is most of these already exist and they're all open source!

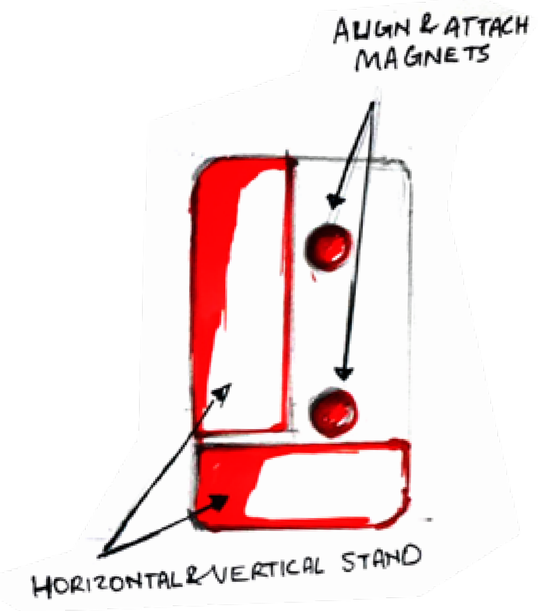


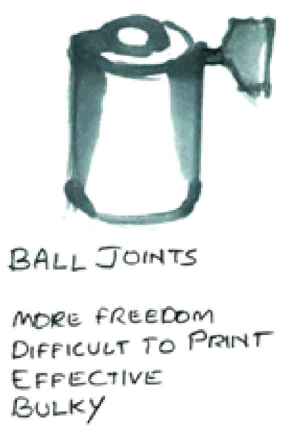
Soldering station from Ryobi uses a premade power adapter as is. This method helps with saving time and reducing costs. Use of an inexpensive smartphone will aid in the overall cost reduction and smartphones already come with very high processing power and very small upfront costs.

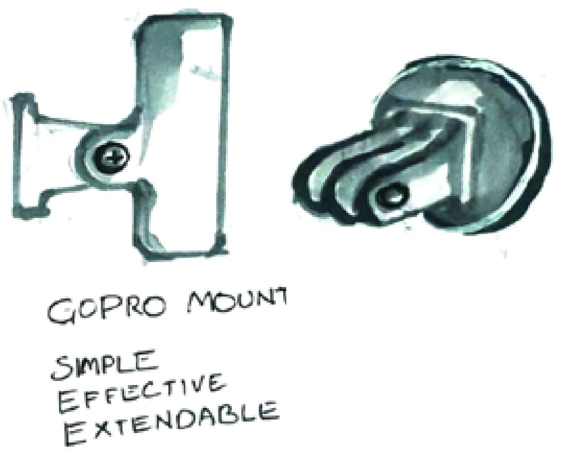
Holder Assembly



Because the display already had a tilt stand for use on the desktop - this part was initially made to keep it on the printers door. This was added complexity for a component that whose function was barely used. This idea was dropped for the better idea of using GoPro mounts.

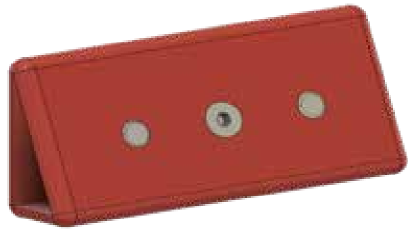






GoPro mounts are easily available and are extremely cheap. They are highly extendable and can be directly 3D printed as well. The idea of using magnets and stands were dropped for the more robust gopro mount design.

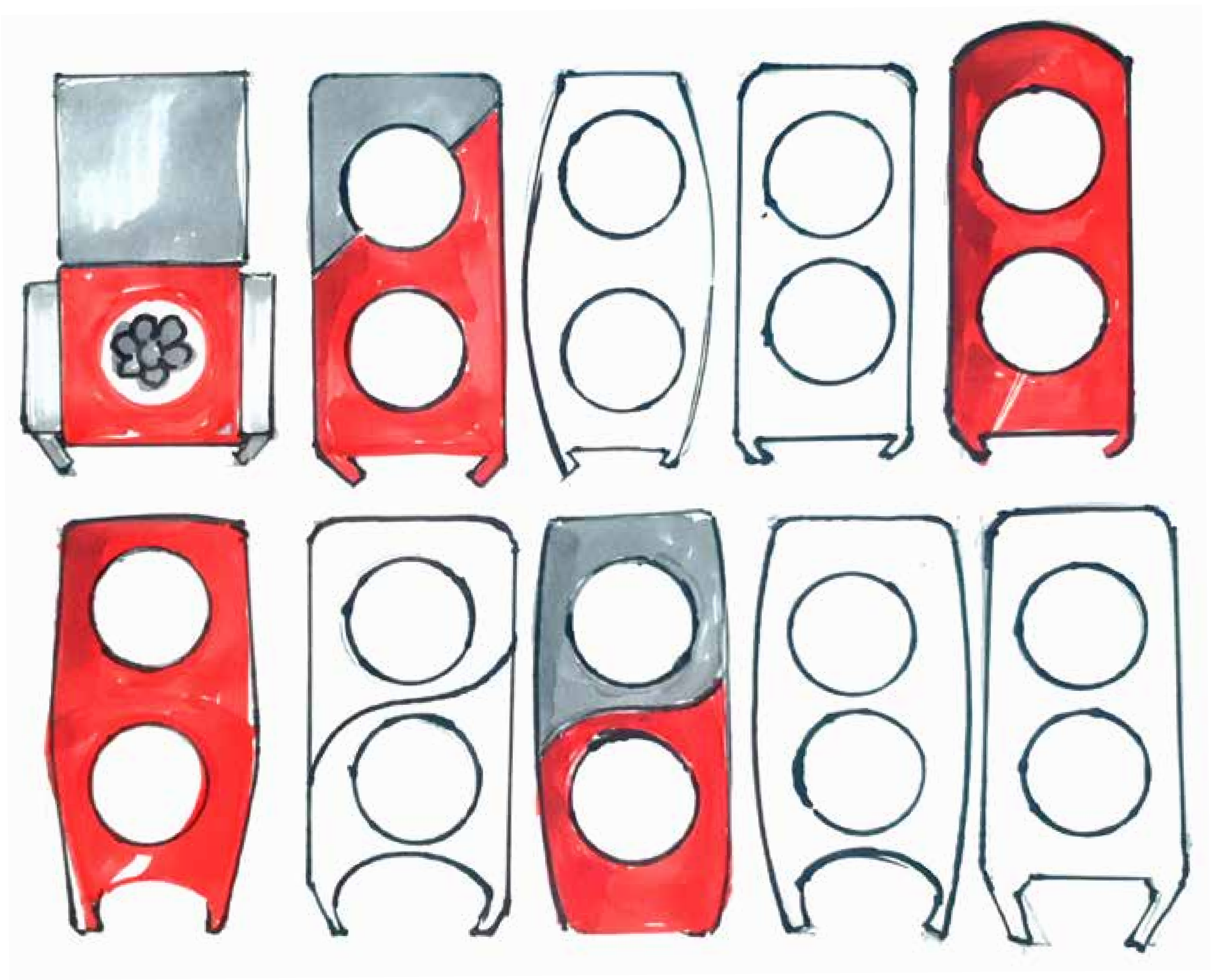
Unforgiving requirements like the ability to work in two orientations and fastened with a single bolt required the design to be minimal.



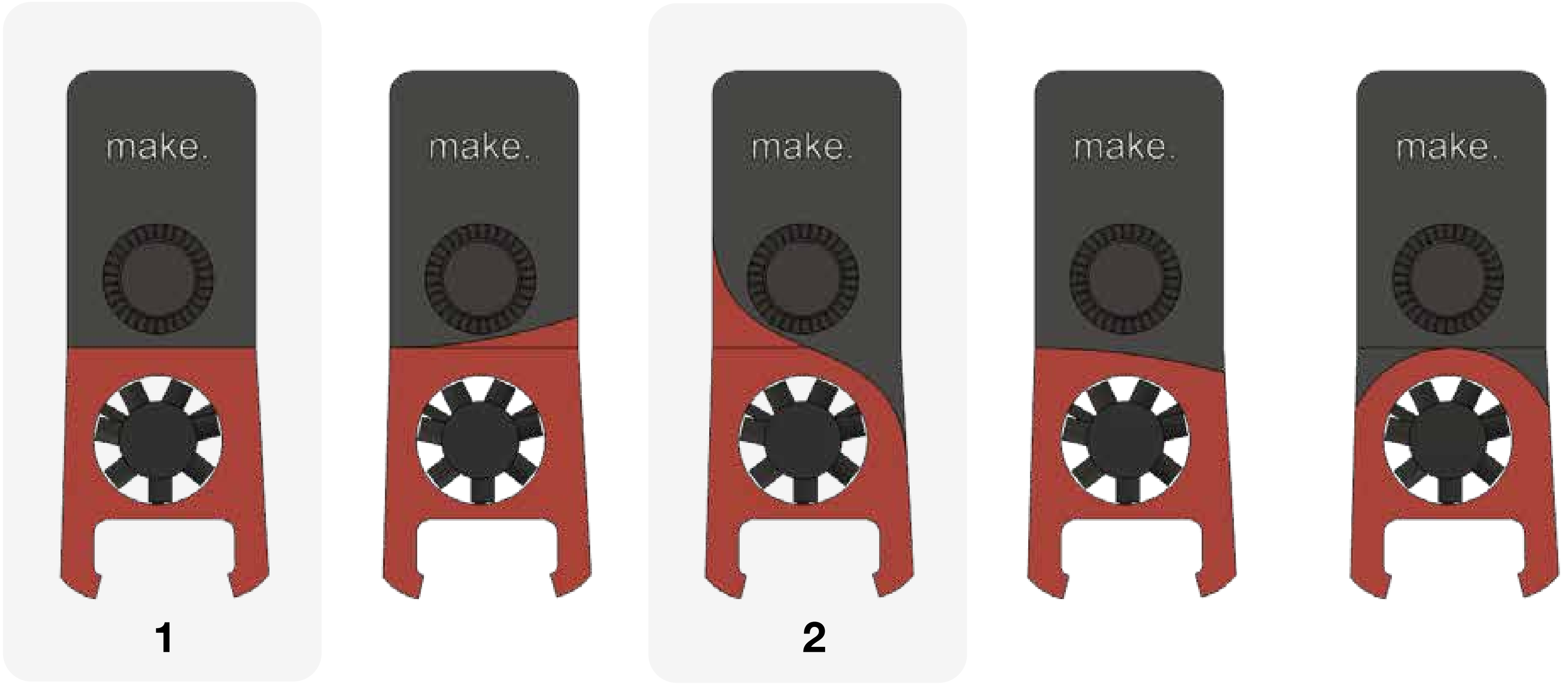
The finally chosen design uses much simpler gopro mounting system. This has the added benefit that it can be put onto a tripod or any other mount when required

Although the holder is of the least importance among the parts worked on, it still holds importance in user experience. The holder has to hold the display in place firm and safe while remaining rotatable and fitting into the door assembly as a works when flipped component. The bolt placement is hence important and the dimensions have to match with the display as well.

Fan Shroud
Visual Design



Keywords
FUNCTIONAL
DUAL COLOR
PRINTABLE
MINIMAL
CURVED
SIMPLE



1 - Simple, much easier to print and assemble and equally effective.
2 - Complex, aesthetically pleasing - much more difficult to print and assemble

The choice was to use 1

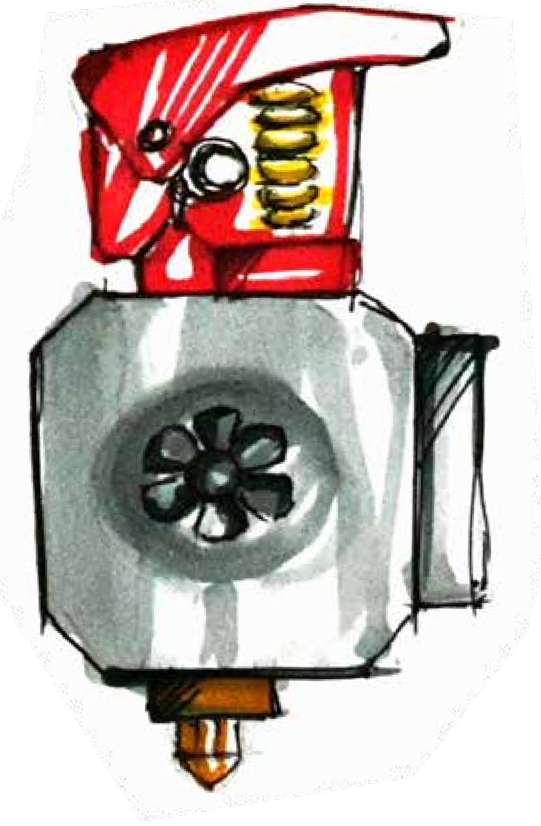
A visually pleasing, dual-tone fan-shroud assembly that is highly functional with the airvents running through its body helps keep the visual simplicity while still providing an important function to the component

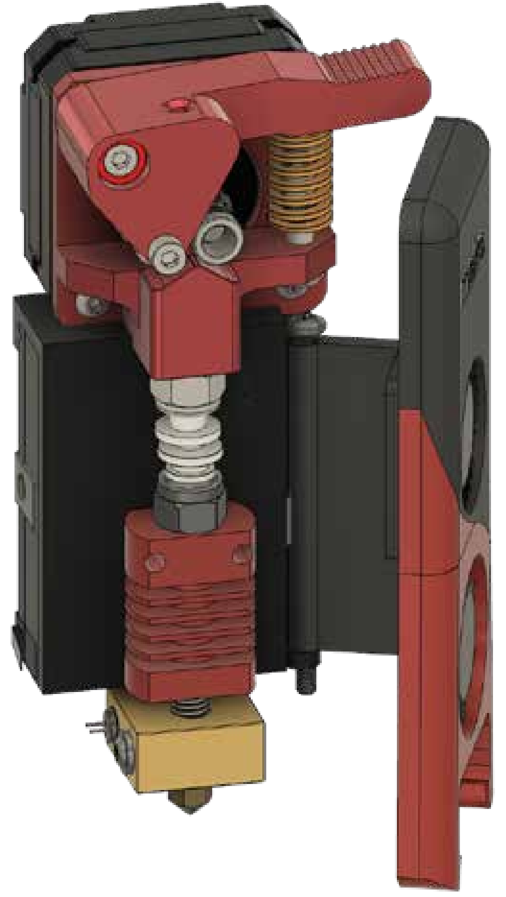
Increasing accessibility

This idea would not work in the existing design due to the lack of locations such a system could latch onto - the current clip-on mechanism takes all the space on top to itself

A traiditonal system where the system uses extra space on the sides due to part cooling fan placement on the right and the unecnlosed extruder shows technical complexity

Instead of custom building metal components that will have benefits like smaller sizes - readily available components are combined to reduce costs.





Final render of the proposed system

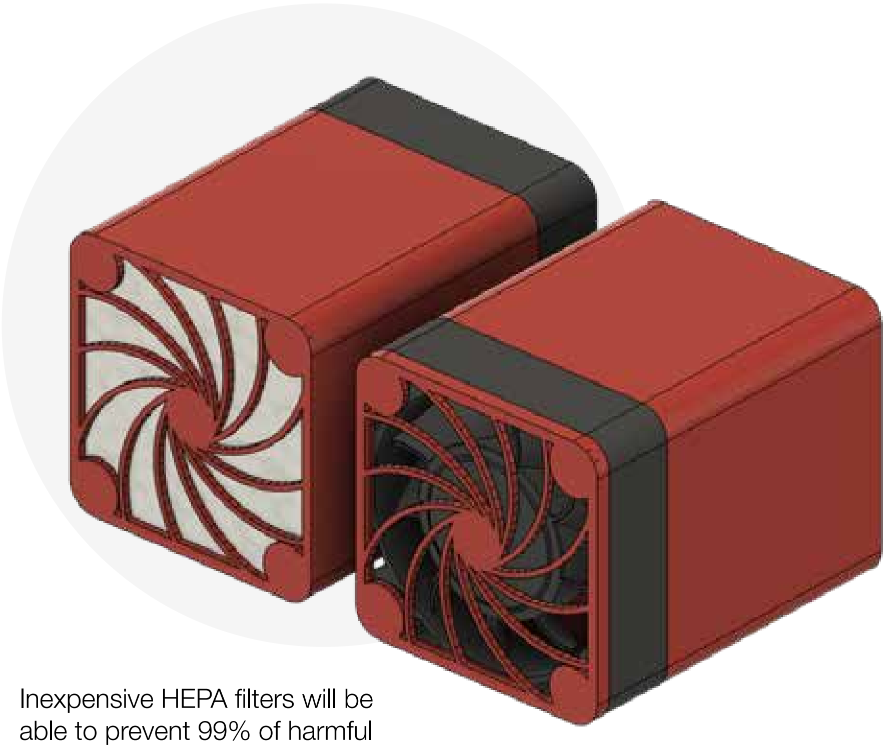
Safer printing

Putting an air filter into the printer to prevent harmful fumes escaping into the environment is a tried and tested method found in most professional printers. The method has been succesfully used in many consumer printers as an external upgrade as well.

The idea is simple and straight forward. Put a 4040(40mmx40mmx10mm) fan and a HEPA filter to filter out the air inside the enclosure - provides sure-shot safety from fumes produced by most conventional materials like PLA, ABS.

One important aspect that had to be researched on was where to put the filter. There can be two main configurations - filter first or fan first
Filter first will help the fan from accumulating dust, fan first doesn't look like it has any inherent benefits.
From an in-depth research article, it was found that the fan-first approach is the more acceptable choice since the configuration will produce less noise and help the fan run without turbulance

Data from https://smartairfilters.com/en/blog/air-purifier-filter-on-the-front-or-back/



Inexpensive HEPA filters will be able to prevent 99% of harmful particles from escaping into the air

Weather-proofing filament

Prevention of filament going bad has some of the easiest solutions that we often overlook. Store filament in an airtight container with a bunch of dessicants. Although not airtight, the easiest way to achieve this in the printer is to store filament directly inside the printer. Throwing in a few desicant bags by default simply eliminates moisture accumulating in the chamber and thus preventing filament going bad.

Another solution is to make use of heating properties of the printer. An enclosed printer can bring its inside temperature to 50 degrees at ease. This is exactly what a filament dryer does - keep the temperature high enough to eliminate any moisture buildup - a software modification to maintain temperature inside the enclosure could easily solve the moisture problem with hydrogenic filaments like PLA and ABS.

Current design of the enclosure can hold upto 4 spools of filament without issues.
An average 3D printer user generally keeps upto 10-15 filament spools at once - this isn't the ideal solution, but its definitely better than no solution at all.
data from https://www.reddit.com/r/3Dprinting/comments/8slauu/how_many_spools_of_filament_do_you_have/

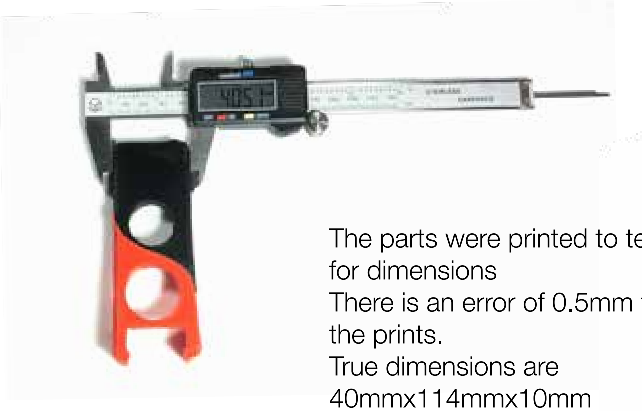
Proof of Concepts

Some ideas have been prototyped into physical models to be tested and improved upon

Fan Shroud

Print Details
Resolution: 0.3mm
Speed: 60mm/s
Time: 1 hour 20 minutes
Supports:No
Rafts:No

Parts fit well together and the dimensions match well with other components



The parts were printed to test for dimensions
There is an error of 0.5mm for the prints.
True dimensions are 40mmx114mmx10mm

The two parts are printed seperately and glued together in this case

Functional prototype of the hotend + extruder assembly. This was made from DIY kits for the same

Door Handle

Print Details
Resolution: 0.3mm
Speed: 60mm/s
Time: 2 hours 20 minutes
Supports:Yes
Rafts:No

Printed prototypes 1 and 2: 1 was too small for hands to fit in ergonomically. The same design was refined to be bigger from reference door handle drawings to have an opening of at least 3cm

Original Prototype (1) uses 15g of filament.

Refined prototype (2) uses 22g

Actual printing takes 32g of filament

Of that 9g is wasted for support material

The refined design uses 37% more filament than before. A huge increase and 28% (9g) of the whole filament used in printing goes to waste as support material in the process.

Filament Spool Holder

1 First prototype was printed flat on bed - design is oriented towards a single side - this is weak
2 changed to sideways orientation for printing - increased strength
3 prototype did not fit into 2020 profile (locking mechanism printed too large
4 final prototype works

Spool holder is a component most printer manufactuers overlook and fail to include - they are crucial because it affects the overall user experience - a first-time user will struggle with not having a spool holder and will have to find alternate temporary methods until they print one for themselves.

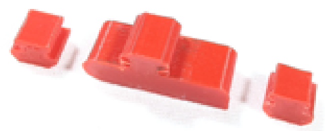
Filament Spool holder had 5 iterations till the final part. Initially the idea was to use nuts and bolts and use multiple components. The idea was changed to a single part helping reduce complexity, assembly time and cost. Nuts and bolts were adding cost to the product - hence, the third iteration was to use a printed locking mehcanism that doesn't require bolts Final concept uses the printed mechanism in a single part and doesn't require any assembly

The triangular hollow patterns on the side are added to decrease the amount of filament required - and helps in printing without support - it also contributes in adding a visual quality to the part - making it more transparent and helps matching with the overall idea of the printer

Pirinting the part oriented to its side helps increase the load-bearing capacity of the holder since the layer lines are towards the load.

Print Details
Resolution: 0.3mm
Speed: 60mm/s
Time: 2 hours 30 mins
Supports:No
Rafts:No

Locking mechanism for V-Slot profiles were tested by printing small components.



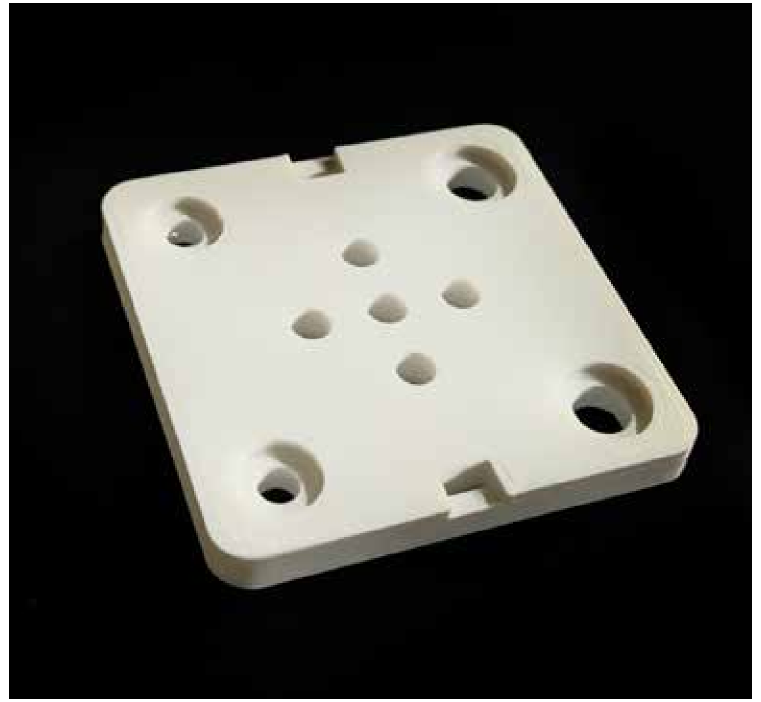
Finished part installed into working printer for testing. The part is able to hold a filament spool without problems.

One unresolved issue with the part is the overhang whileprinting. This only affects two surfaces where quality of the print is slightly deteriorated.

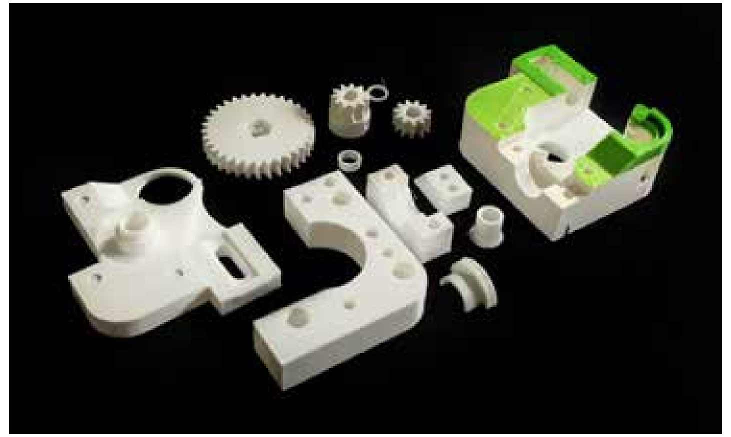
Display Assembly

A functional prototype of the smart controller made using Raspberry Pi 3A+, Waveshare 4.2in LCD display and a Enclosure was found on Thingiverse (this enclosure is not the same as in the actual product)

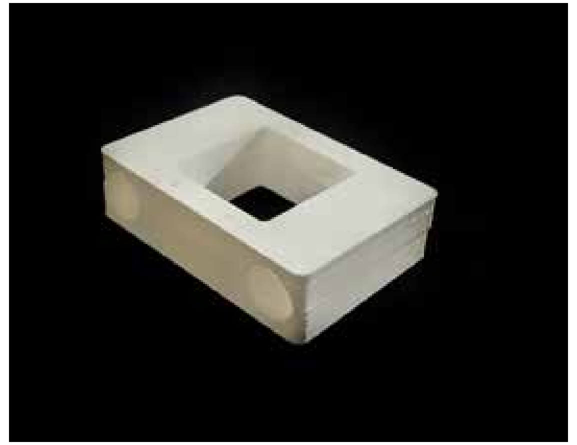
Others



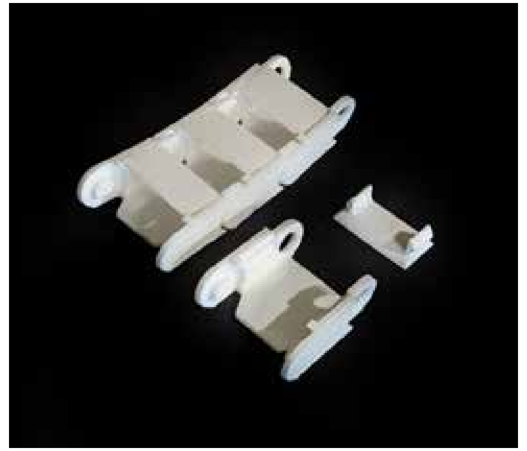
Prototype of a gantry plate printed on PLA was made to test the functionality of such a module. The prototype is strong and can hold the weight of the extruder without an issue



Two extruder systems were printed but couldn't be completed due to the non-availability of components Both are sourced from Thingiverse



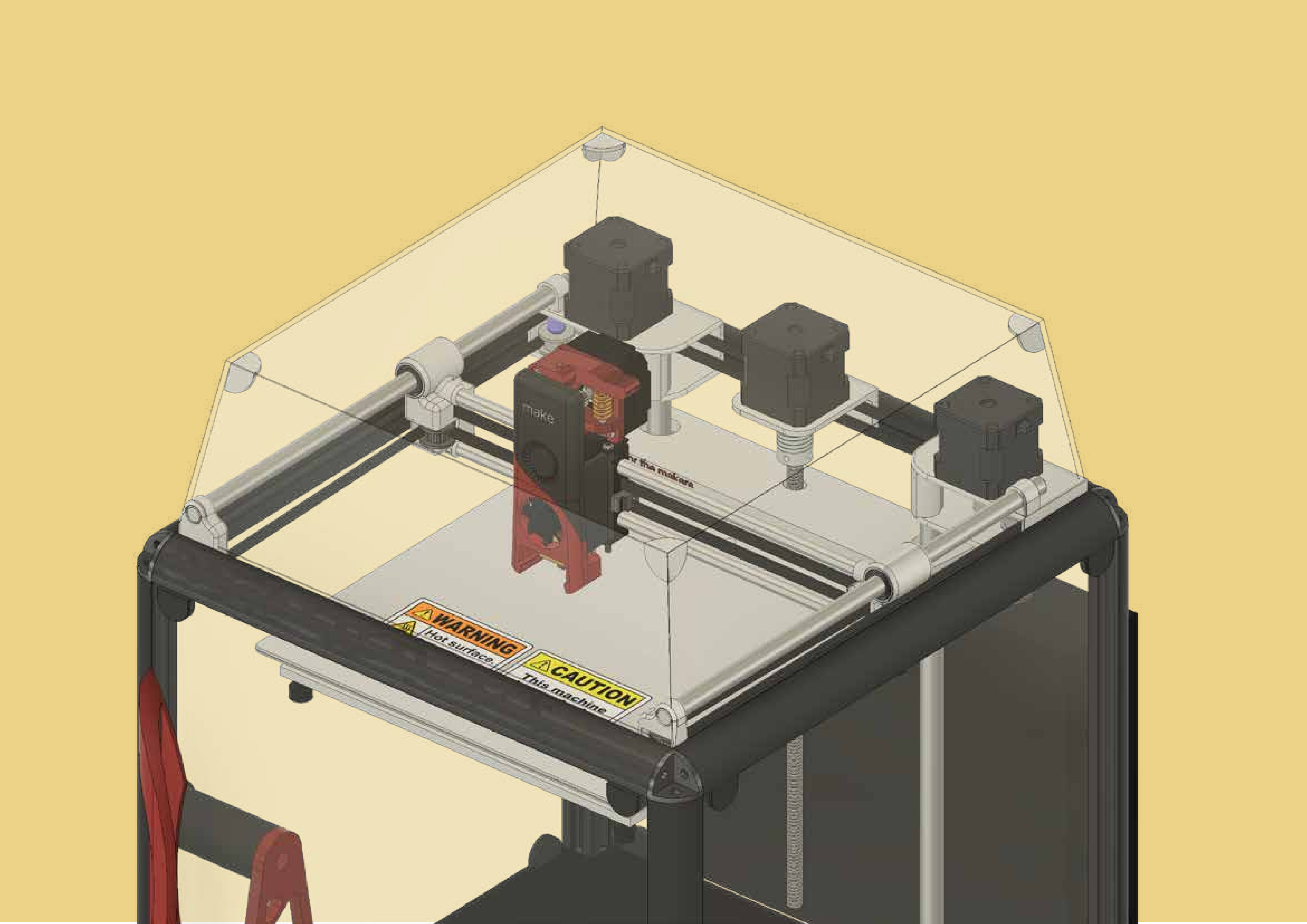
Prototypes of Original magnetic gantry plates - they were replaced with the clip-on design.



Prototypes of a drag chain for wire management. Makes use of two printed parts that can be connected together to the desired length. This approach is time consuming and cost-inefficient. The economical alternative is PVC wire harness tubing.

Final Product

Final product renders along with specifications and other documentation required to produce one

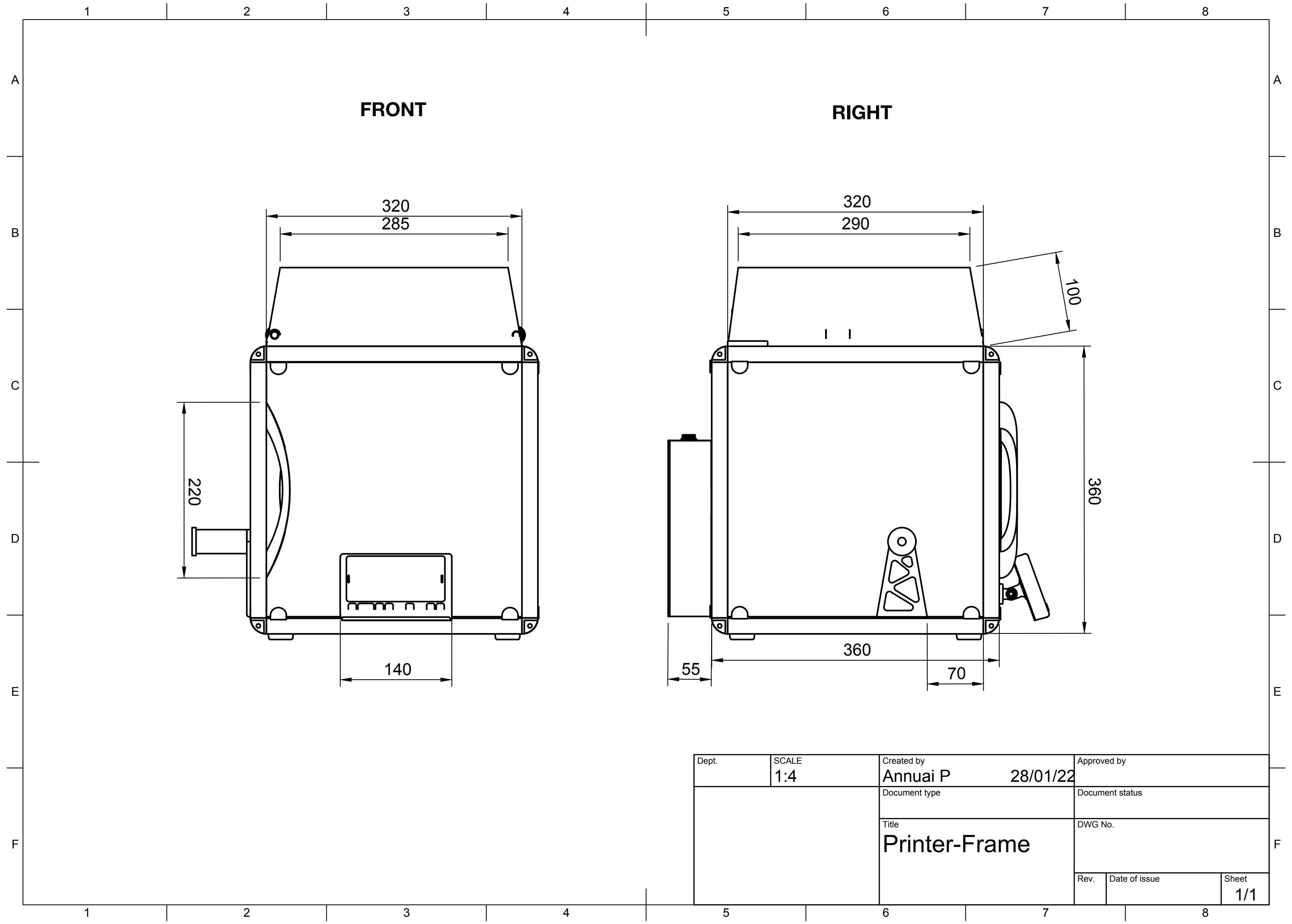

make
WARNING
Hot surface.
CAUTION
This machine

FRONT

RIGHT

BACK

TOP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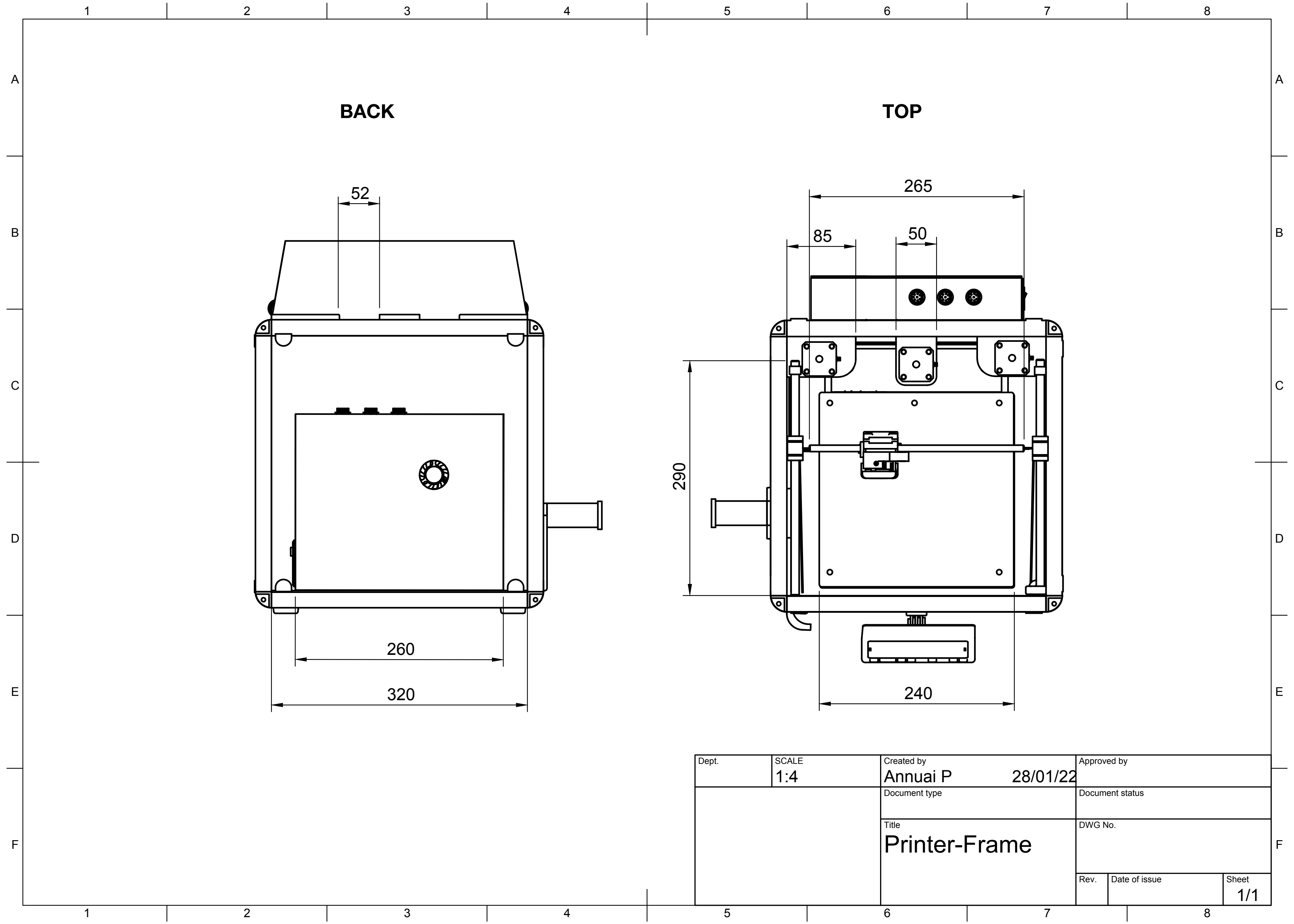
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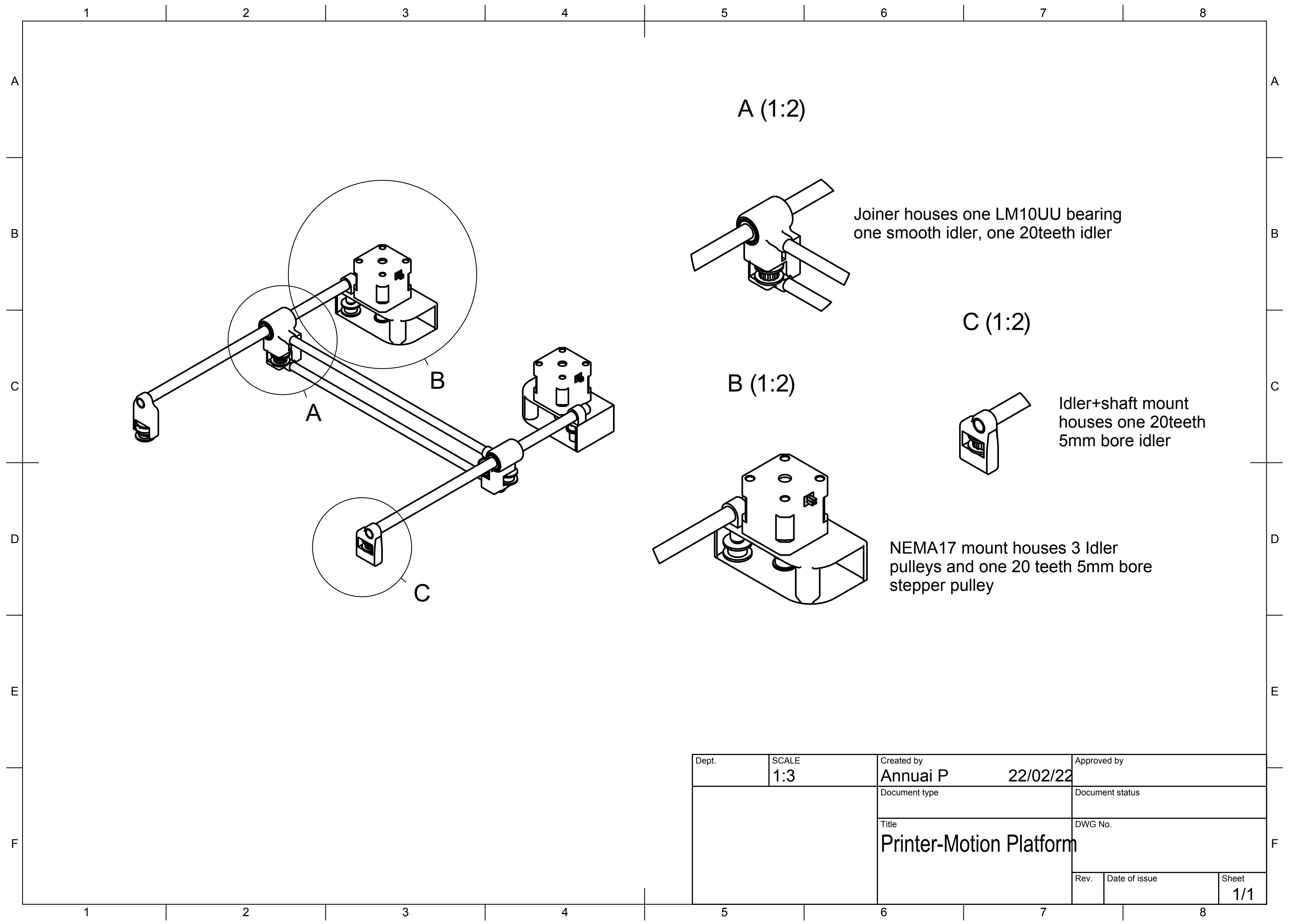
A (1:2)
Joiner houses one LM10UU bearing
one smooth idler, one 20teeth idler
B (1:2)
NEMA17 mount houses 3 Idler
pulleys and one 20 teeth 5mm bore
stepper pulley
C (1:2)
Idler+shaft mount
houses one 20teeth
5mm bore idler
A
B
C
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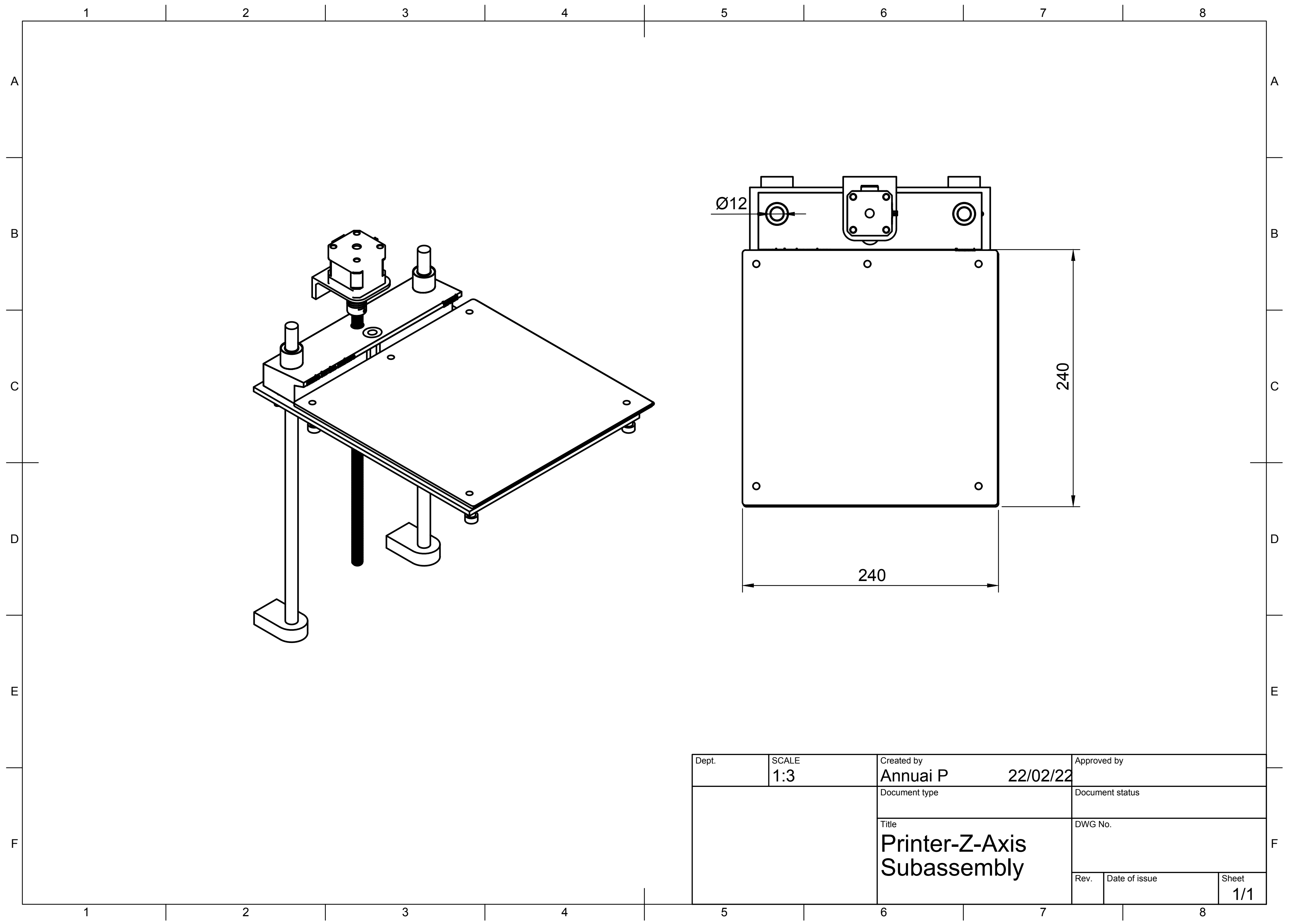
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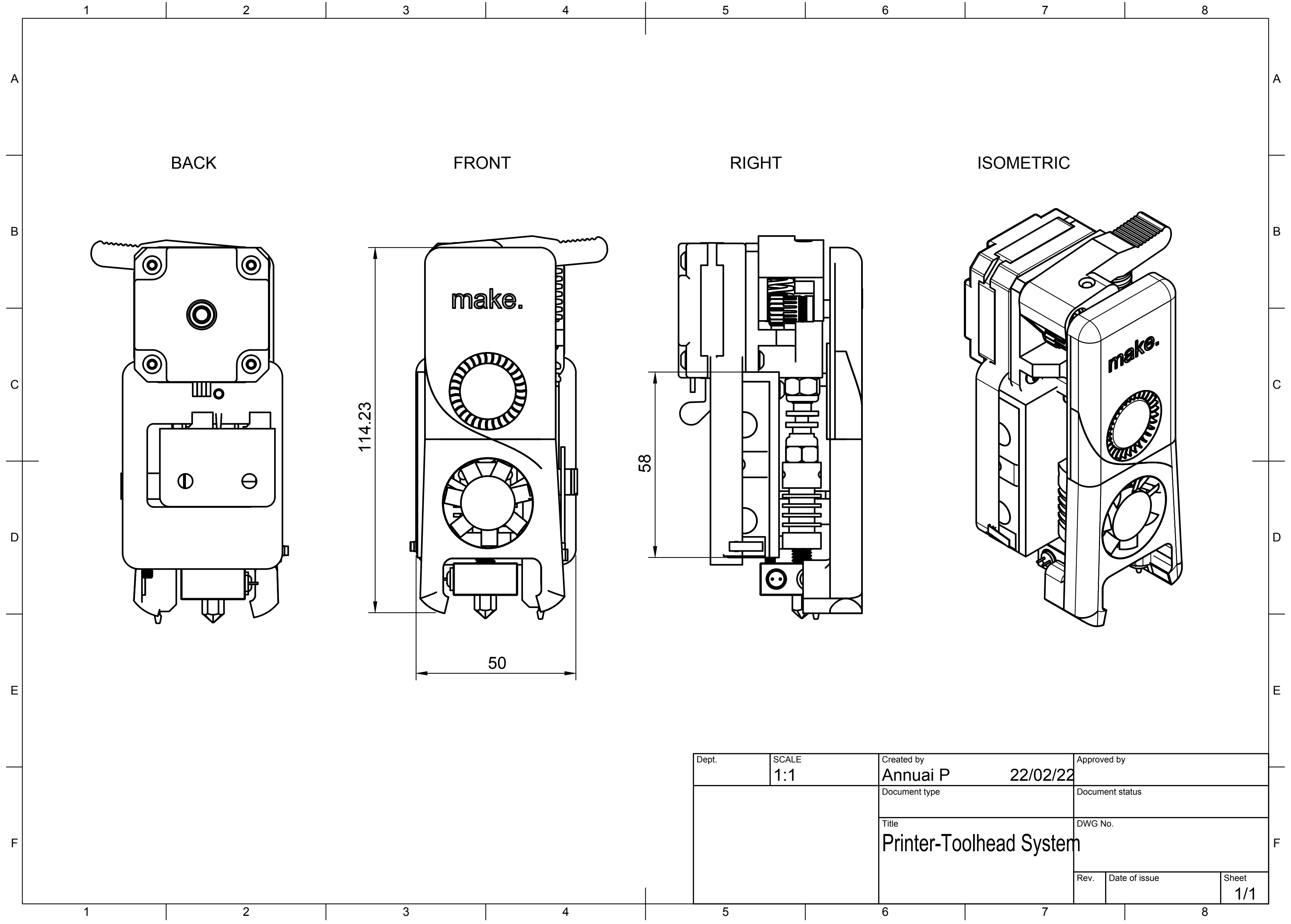

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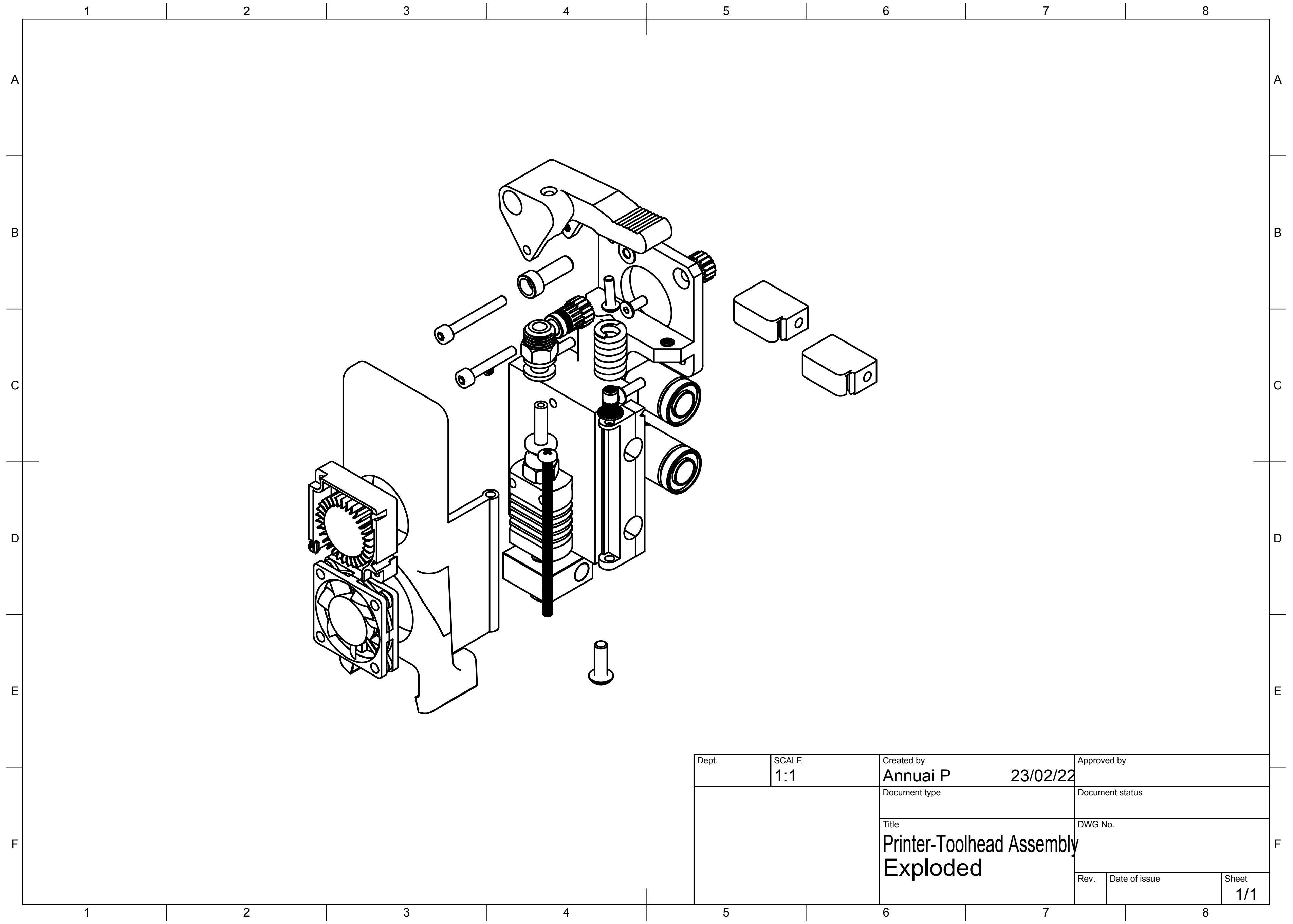

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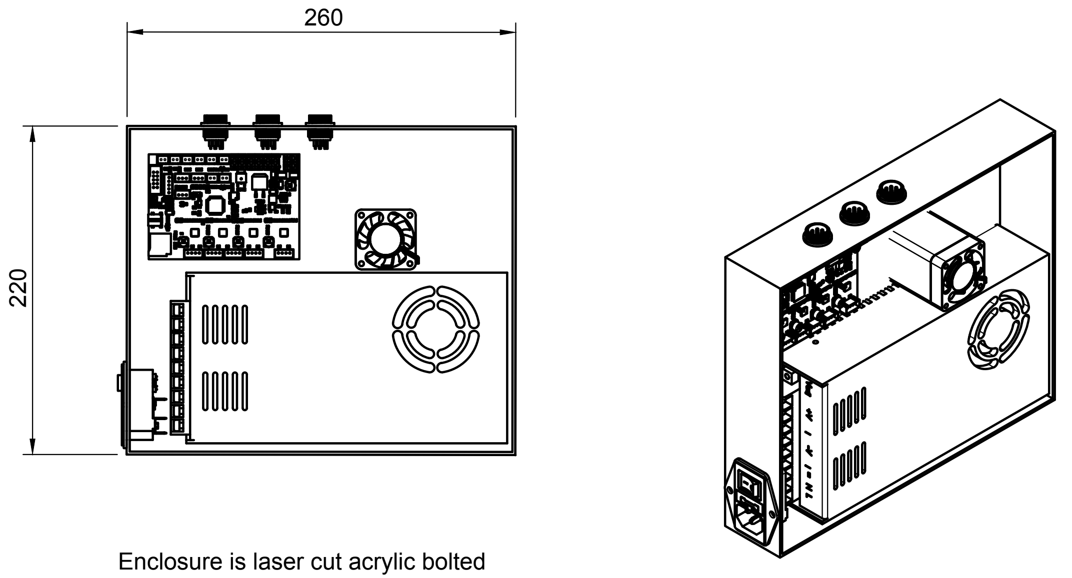

Enclosure is laser cut acrylic bolted together

All major active electronic componentsare enclosed to keep awa from dust and heat

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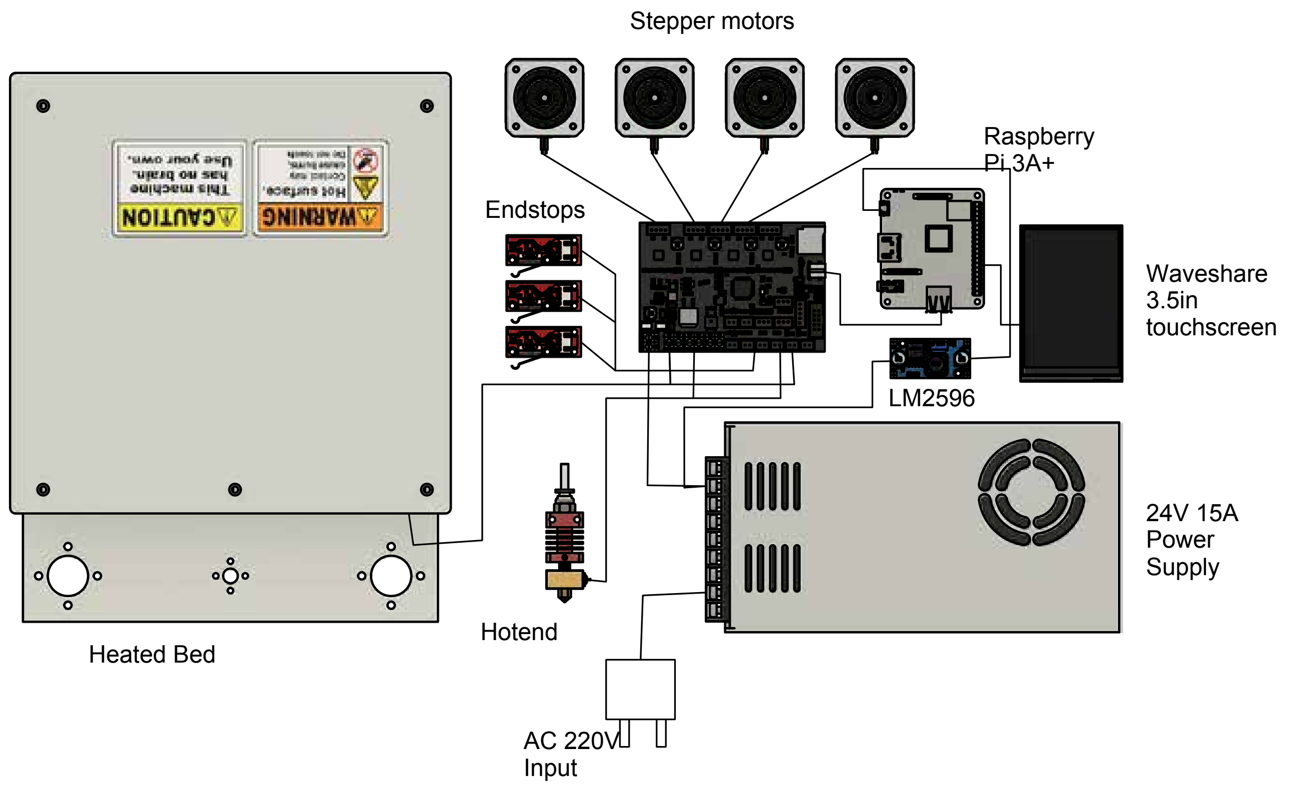
		Title: Printer-Electronics Enclosure	DWG No.
			Rev. / Date of issue / Sheet 1/1



Main Controller used here is SKR Mini E3 V2

The diagram has been simplified for basic understanding of component connections - the actual connections will have multiple terminals and connectors involved.

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		Document type	Document status
		Title: Printer-Electronics	DWG No.
			Rev. / Date of issue / Sheet 1/2

Indented Bill of Materials and Processes

Item No.	Item	Quantity	Price per unit (₹)	Total (₹)
	Motion Platform subassembly			
1	Linear Rod - 8mm - 400mm	2	225	450
2	Linear Rod - 10mm - 400mm	2	235	470
3	Linear Rod - 12mm - 400mm	2	245	490
4	LMK12UU Linear Bearing	2	149	298
5	LM8UU Linear Bearing	2	90	180
6	LM10UU Linear Bearing	2	99	198
7	608Z Bearing	2	47	94
8	Flexible Shaft Coupling 5mm to 8mm	1	130	130
9	Timing Belt 6mm - 5m	1	586	586
10	GT2 Aluminium Pulley 20 teeth	2	81	162
11	GT2 Aluminium Pulley without 20 teeth	10	81	810
12	GT2 Pulley 5mm Bore	2	100	200
13	Trapezoidal Lead Screw 8mm with Brass Nut	1	350	350

Item No.	Item	Quantity	Price per unit (₹)	Total (₹)
	Frame&Enclosure subassembly			0
14	2020 Extrusion - 400mm	12	210	2520
15	M5 Bolts 30mm	16	7	112
16	Corner Bracket	10	400	4000
17	Acrylic Sheet	8	215	1720
				0
	Electronics subassembly			0
18	24V Power Supply	1	1200	1200
19	CR10 Hotend	1	790	790
20	4020 Blower 24V	1	155	155
21	4010 Fan	1	200	200
22	SKR E3 V2	1	4300	4300
23	Stepper Motors	4	590	2360
24	Raspberry Pi 3A+	1	2249	2249
25	3.5 inch Display	1	1270	1270
26	Dual Gear Extruder	1	800	800
27	Aviation Connector 8 pin	1	50	50
28	Aviation Connector 4 pin	1	40	40
29	Aviation Connector 5 pin	1	40	40

Item No.	Item	Quantity	Price per unit (₹)	Total (₹)
30	Power Socket with Fuse	1	130	130
31	PTFE Tube 1m	1	200	200
32	DC 24V Fan 4010	1	180	180
	Fasteners			0
32	M3 T-Nut	30	6	180
33	M3 20mm Screws	30	5.5	165
34	M3 30mm Screws	20	4	80
35	M3 Nuts	20	3	60
36	M5 Bolts 30mm	20	4	80
	Heated Bed subassembly			
37	Heated Bed	1	830	830
38	Heated Bed Springs	4	25	100
39	Heated Bed Spring M3 Screws 30mm	4	4	16
40	Heatset Insert M3	4	3	12
41	Heated Bed Baseplate Acrylic 5mm	1	300	300
			Total	28557

Overall product cost with all the parts sourced from Indian retail stores excluding any labour, transportation come to around ₹32000

Prices are sourced from major DIY part resellers - including robu.in, novo3d.in, electronicspices.com, electronicscomp.com, rhydolabz.com

Epilogue

Conclusion

How does product development work? What steps does it have?
How are new products created?
How can they be designed for the better?

All the questions that I did not have clear answers to 6 months ago, I'm a little closer to than I've ever been.

Technical knowhow of producing CAD models and prototypes in 3D were gained.
Understanding of what can and cannot be 3D printed.
Learning what software is better for what purposes.

Learning how a self-sponsored project's tight budget affects product outcomes and improvisation to cope-up with it and move on.

This project has taken me as a learner, designer and maker to a new dimension wherein today, as I conclude this project I believe I have become a step closer to designing and producing user-friendly problem solving machines for the time to come.

Citations

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Interviews

Harsha Alva - https://alvaharsha.com/ - Used to work for Fracktal 3D
IMIK Technologies - Arya - http://imik3dp.imiktechnologies.in/ - +(91)-8903943323, support@imiktechnologies.in - Sells and developed a 3D printer in Coimbatore
Tanmay Shah - Imaginarium - Innovations - Leadership Team - tanmay@imaginarium.io
Nikhil Belsure - Imaginarium - Medical Applications Specialist - nikhil.b@imaginarium.io

Images & Icons

Desireé Bolívar - thenounproject.com
Casual Life 3D - icons8.com/illustrations/style--casual-life-3d
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Software

Autodesk Fusion 360
Adobe InDesign
Adobe Illustrator
Adobe Photoshop

Colophon

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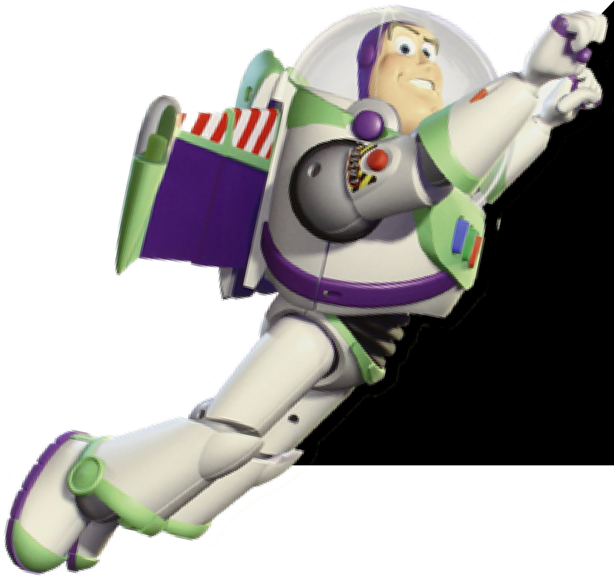

To infinity and beyond...