Next Generation 3D Printer

Final Project Proposal

Fahad Alahmari, Sebastian Arevalo, Brad Evans, Tomas Garcia,
Ben Gouveia, Jake Work

NORTHERN ARIZONA UNIVERSITY®

12/7/15

Novakinetics Aerosystems

Overview

- Introduction
- Needs Statement
- Project Goals
- Objective
- Constraints
- Quality Function Deployment (QFD)
- House of Quality
- State of the Art Research (SOTA)

Overview

- Project Plan
- Functional Diagram
- Criteria of Functions
- Relative Weights of Criteria
- Concept Generation
- Decision Matrix
- CAD Model
- Bill of Materials
- Conclusion

Introduction

- Client: Novakinetics - Manufactures aerospace composite parts
- Novakinetics is seeking a new way to manufacture their products
- The project goal is to aid Novakinetics in optimizing their manufacturing process
- Our team determined that a large scale 3D printer can be used to speed up their manufacturing process

Novakinetics.com

Novakinetics.com

Needs Statement

- Novakinetics is dissatisfied with the current lead time for creating molds and tooling and requires a different approach to creating their products.

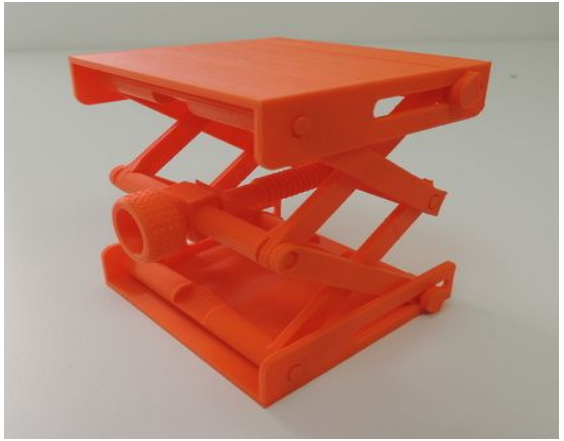
Project Goal

- The goal of the project is to aid Novakinetics in optimizing their manufacturing process by utilizing 3D printing

3D Printing

- Uses Fused Deposition Modeling (FDM)
- Objects are built layer by layer
- Common materials used
  - Acrylonitrile Butadiene Styrene (ABS)
  - Polylactic Acid (PLA)

fundable.com



thingiverse.com

Objectives

OBJECTIVE	MEASUREMENT	UNITS
Fast Print Speed	Filament / Time	mm/s
Accuracy	Length	mm
Maintenance	Time	Hours/Week
Safe to Operate	OSHA	Unitless
Ease of Use	Time to Proficiency	Hours
Economic	Cost	US Dollars

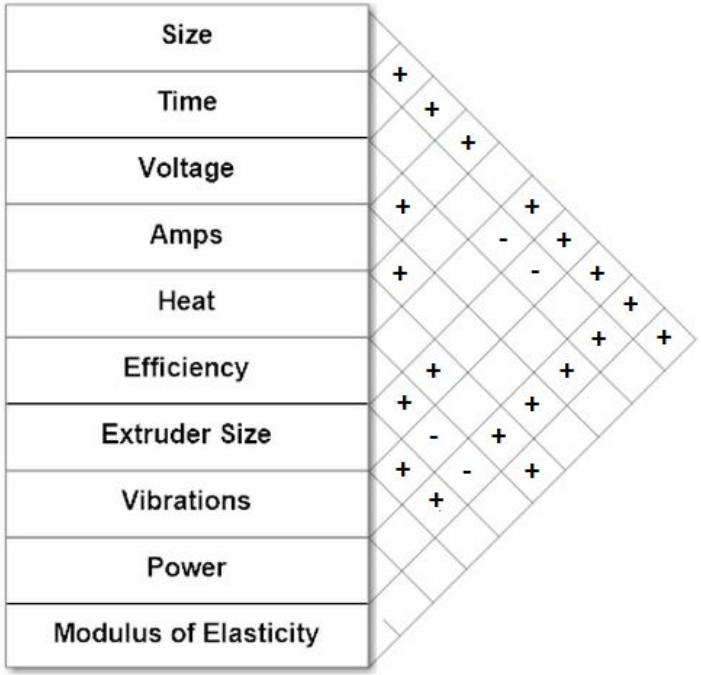
Constraints

- Part thickness $\geq$ 1.25mm
- Surface dimension tolerance of ±0.8mm
- Resolution < 0.5mm
- Print volume $\geq$ $1m^3$
- Power use $\leq$ 480V, 200A

Quality Function Deployment (QFD)

		Engineering Requirements									
		Size	Time	Voltage	Amps	Heat	Efficiency	Extruder Size	Vibrations	Power	Modulus of Elasticity
Customer Requirements	Machine Footprint	X				X	X	X	X	X	
	Print Material		X	X	X	X	X	X		X	X
	Large Print Volume	X	X	X	X		X	X	X	X	
	Multiple Print Heads	X	X	X	X	X	X	X	X	X	
	Ease of Maintenance	X	X								
	User Friendly		X								
	Print Material Compatability		X			X			X		X
	Rigidity of Print Material					X	X		X		X
	Faster Time to Produce Final Product	X	X				X	X			X
	Ability to Create Complex Parts	X	X			X		X	X		X
	Layer Height		X					X	X		X
	Print Process	X	X			X	X		X		X
	Precision		X			X	X	X	X		
	Print Surface Finish		X			X	X	X	X		
	High Resolution		X				X	X	X		

House of Quality



SOTA

BigRep.com

BigRep One

- Build Volume: 1.1m x 1.0m x 1.0m
- Minimum Layer Height: 100 microns
- Accuracy: 100 microns
- Cost: $30,000
- Print Speed: 150mm/s

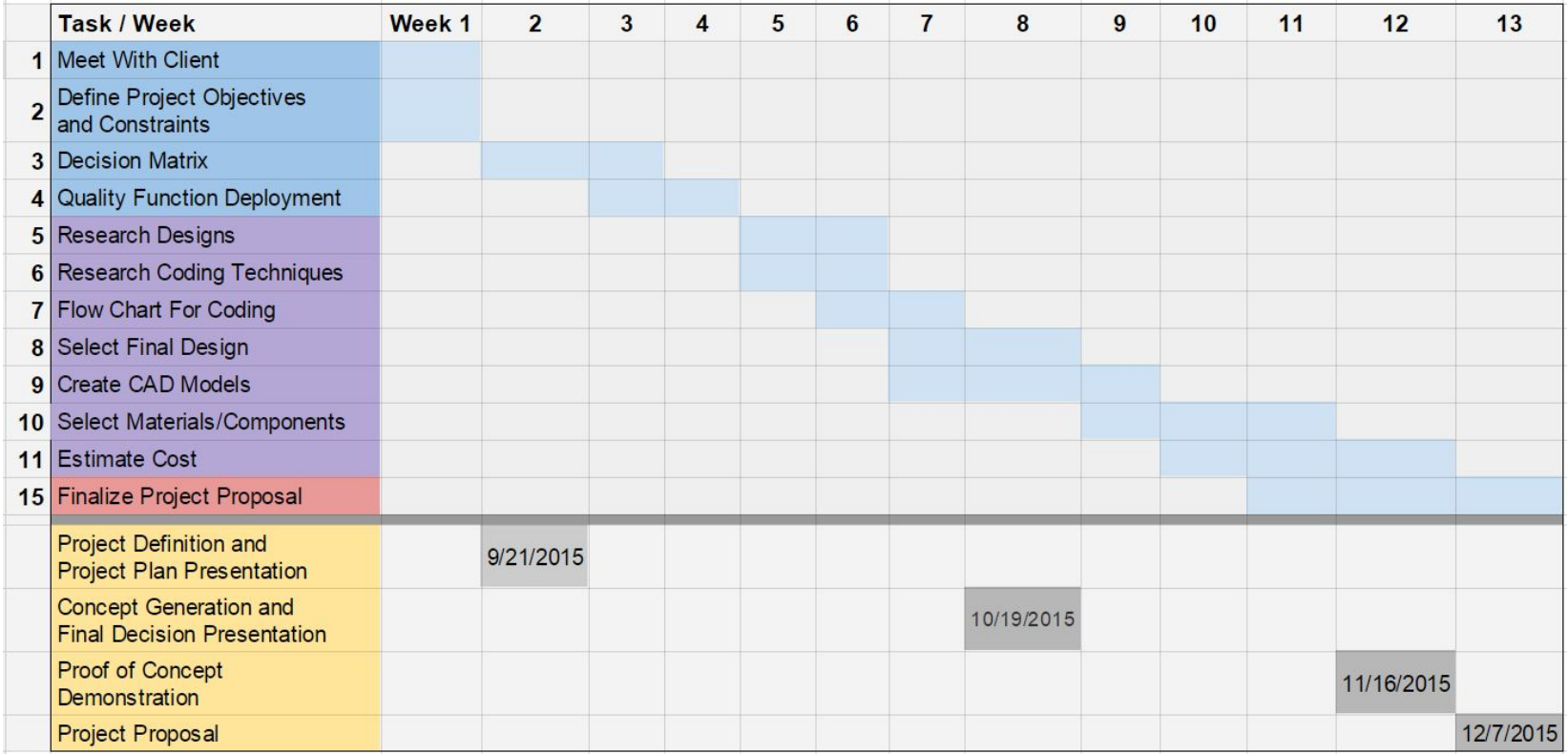
SOTA

Stratasys.com

Fortus 900mc

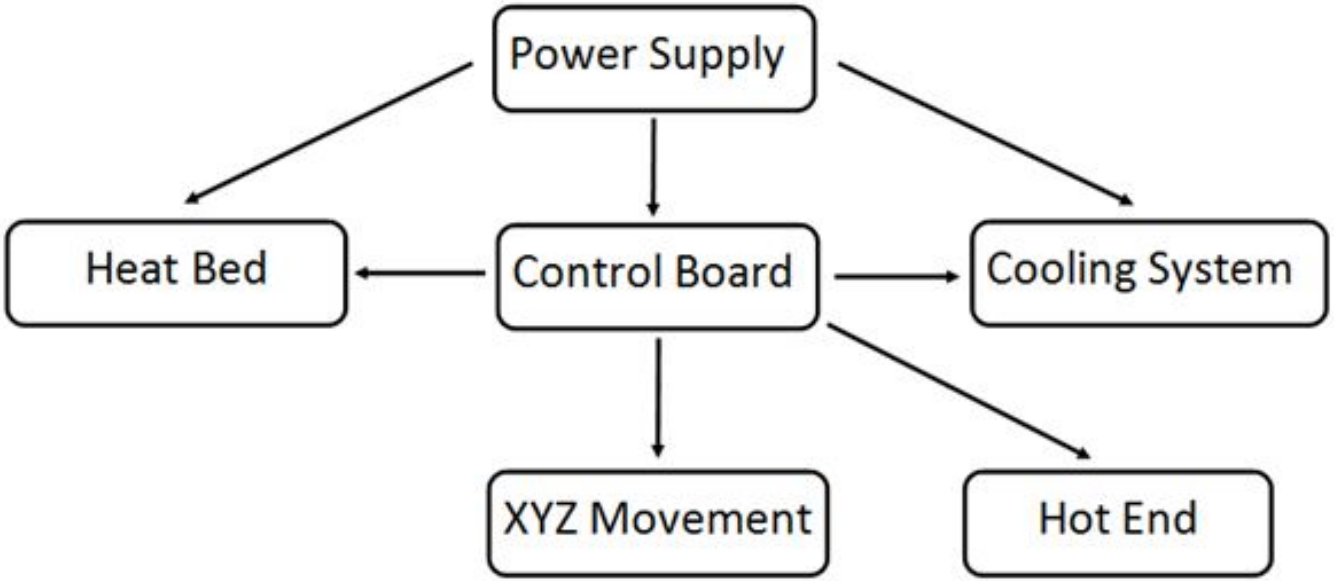
- Build Volume: 0.9m x 0.6m x 0.9m
- Minimum Layer Height: 178 microns
- Accuracy: 90 microns
- Cost: $200,000
- Print Speed: N/A

Project Plan



	Task / Week	Week 1	2	3	4	5	6	7	8	9	10	11	12	13
1	Meet With Client													
2	Define Project Objectives and Constraints													
3	Decision Matrix													
4	Quality Function Deployment													
5	Research Designs													
6	Research Coding Techniques													
7	Flow Chart For Coding													
8	Select Final Design													
9	Create CAD Models													
10	Select Materials/Components													
11	Estimate Cost													
15	Finalize Project Proposal													
	Project Definition and Project Plan Presentation		9/21/2015											
	Concept Generation and Final Decision Presentation								10/19/2015					
	Proof of Concept Demonstration												11/16/2015	
	Project Proposal													12/7/2015

Functional Diagram



Criteria of Functions

Power Supply

1. Ease of Implementation
2. 120V-240V
3. Cost

Hot End

1. Temperature
2. Nozzle Size
3. Reliability

Control Board

1. Open Source
2. Multiple Motor Drivers
3. Modular

XYZ Movement

1. Torque
2. Resolution
3. Rotations Per Minute (RPM)

Relative Weights of Criteria

Power Supply

Criterion	Relative Weight
Ease of Implementation	0.288
120V-240V	0.462
Cost	0.250

Control Board

Criterion	Relative Weight
Open Source	0.359
Multiple Motor Drivers	0.350
Modular	0.291

Hot End

Criterion	Relative Weight
Temperature	0.301
Nozzle Size	0.365
Reliability	0.334

XYZ Movement

Criterion	Relative Weight
Torque	0.434
Step Angle	0.366
RPM	0.200

Concept Generation - Power Supply

dgcomputers.co.in

ATX Power Supply

- Power Output: 500 W
- 16 AMPS
- 115V - 230V

geeetech.com

LED Strip Power Supply

- Power Output: 480 W
- 10 AMPS
- 115V - 230V

newegg.com

Universal Power Supply

- Power Output: 350 W
- 29 AMPS
- 110V - 220V

Decision Matrix - Power Supply

Power Supply	LED Strip PSU		Universal Power Supply		ATX Power Supply	
	Unweighted Score	Weighted Score	Unweighted Score	Weighted Score	Unweighted Score	Weighted Score
Ease of Implementation (0.288)	7	2.02	9	2.59	6	1.73
Power Output (0.462)	8	3.70	6	2.77	10	4.62
Cost (0.250)	6	1.50	7	1.75	10	2.50
Weighted Totals:	7.212		7.114		8.848	

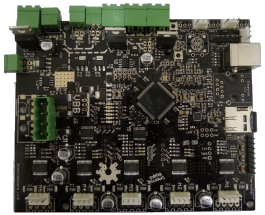
Scale: 1= Worst, 10 = Best

Concept Generation - Control Board

panucatt.com

Azteeg X3 Pro

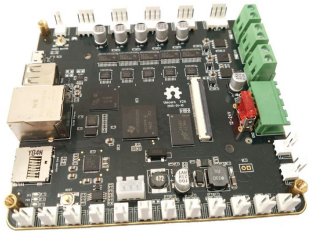
- 8 Stepper Motor Drivers
- 6 Endstops
- 3 Thermistors
- Arduino IDE



smoothieware.org

Smoothieboard

- 5 Stepper Motor Drivers
- 6 Endstops
- 4 Thermistors
- Smoothie Firmware



3dprintboard.com

FastBot BBP

- 6 Stepper Motor Drivers
- 6 Endstops
- 3 Thermistors
- FastBot Firmware

arduino.cc

Arduino Mega

- 4 Stepper Motor Drivers
- 6 Endstops
- 3 Thermistors
- Arduino IDE

Decision Matrix - Control Board

Control Board	Azteeg X3 Pro		Smoothie		Fastbot BBP		Arduino Mega Duet	
	Unweighted Score	Weighted Score	Unweighted Score	Weighted Score	Unweighted Score	Weighted Score	Unweighted Score	Weighted Score
Open Source (0.359)	8	2.87	7	2.51	9	3.23	8	2.87
Multiple Motor Drivers (0.350)	10	3.50	6	2.10	7	2.45	5	1.75
Modular (0.291)	10	2.91	7	2.04	8	2.33	5	1.46
Weighted Totals:	9.282		6.650		8.009		6.077	

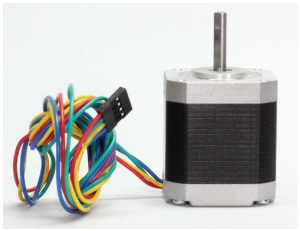
Scale: 1= Worst, 10 = Best

Concept Generation - XYZ Movement

reprap.org

RepRap Stepper Motor

- 12V DC
- 1.8 Degree Step Angle
- 200 RPM Max Speed
- 0.48 Newton Meters Torque



deltaprintr.com

Kysan 1124090

- 4.2V DC
- 1.8 Degree Step Angle
- 400 RPM Max Speed
- 0.54 Newton Meters Torque

newegg.com

Nema 23 23HS22-1504S

- 24V DC
- 1.8 Degree Step Angle
- 1.5 AMPS
- 1.16 Newton Meters Torque

Decision Matrix - XYZ Movement

XYZ Movement	RepRap Stepper Motor		Kysan 1124090		Nema 23-HS22-1504S	
	Unweighted Score	Weighted Score	Unweighted Score	Weighted Score	Unweighted Score	Weighted Score
Torque (0.434)	8	3.47	10	4.34	8	3.47
Step Angle (0.366)	5	1.83	5	1.83	10	3.66
RPM (0.200)	4	0.80	6	1.20	10	2.00
Weighted Totals:	6.102		7.370		9.132	

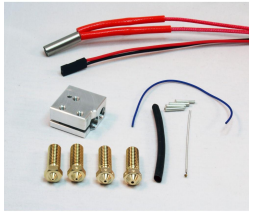
Scale: 1= Worst, 10 = Best

Concept Generation - Hot End

filastruder.com

E3D Cyclops

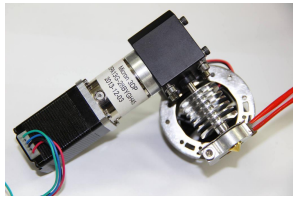
- 0.4mm Nozzle
- Multiple Material Feed
- Max Temp: 290 C



printedsolid.com

E3D Volcano

- Multiple Nozzles
- Up to +/- 0.1mm accuracy
- Max Temp: 290 C



3dprint.com

MICRON3DP

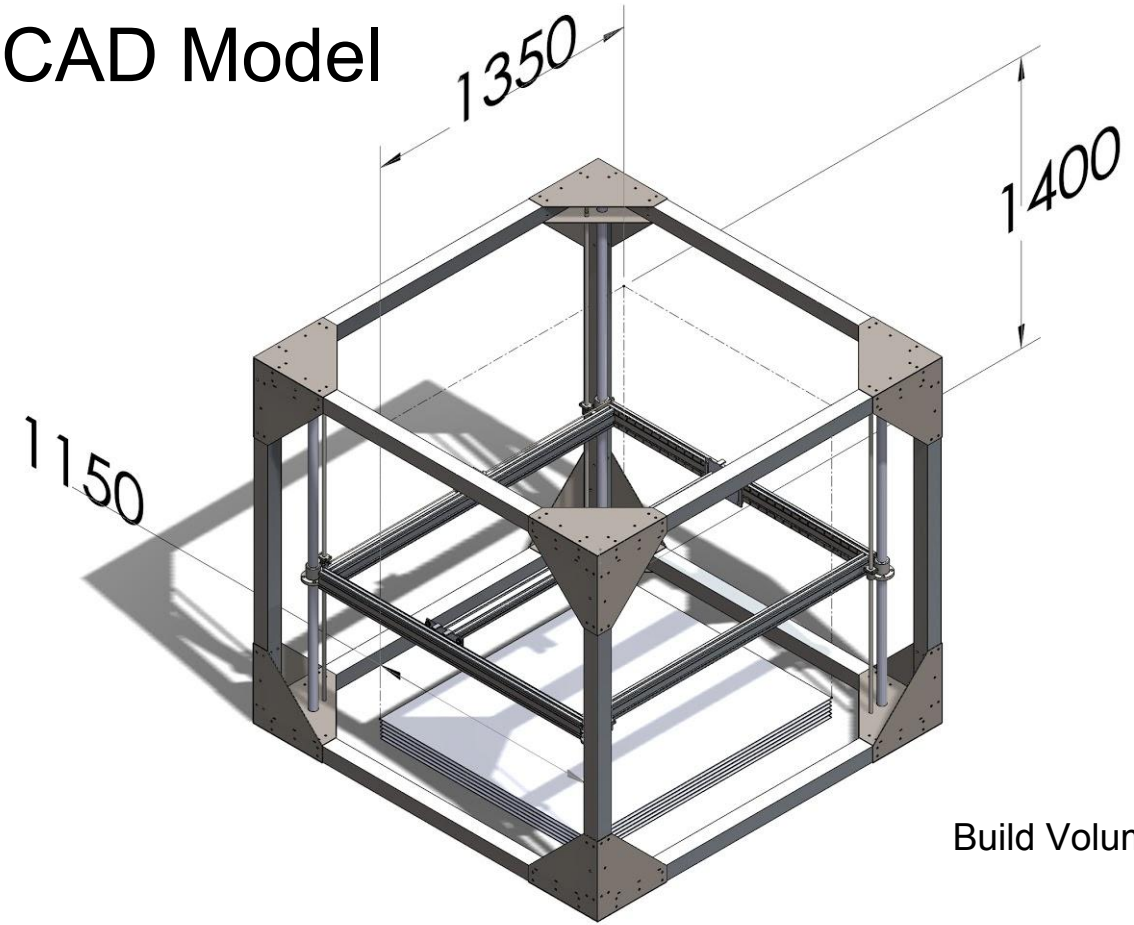
- 0.35mm or 0.5mm Nozzle
- All Metal Hot End
- Max Temp: 400 C

Decision Matrix - Hot End

Hot End	Cyclops		Volcano		Micron 3DP	
	Unweighted Score	Weighted Score	Unweighted Score	Weighted Score	Unweighted Score	Weighted Score
Temperature (0.301)	7	2.11	7	2.11	10	3.01
Nozzle Size (0.365)	6	2.19	10	3.65	5	1.83
Reliability (0.334)	8	2.67	8	2.67	7	2.34
Weighted Totals:	6.969		8.429		7.173	

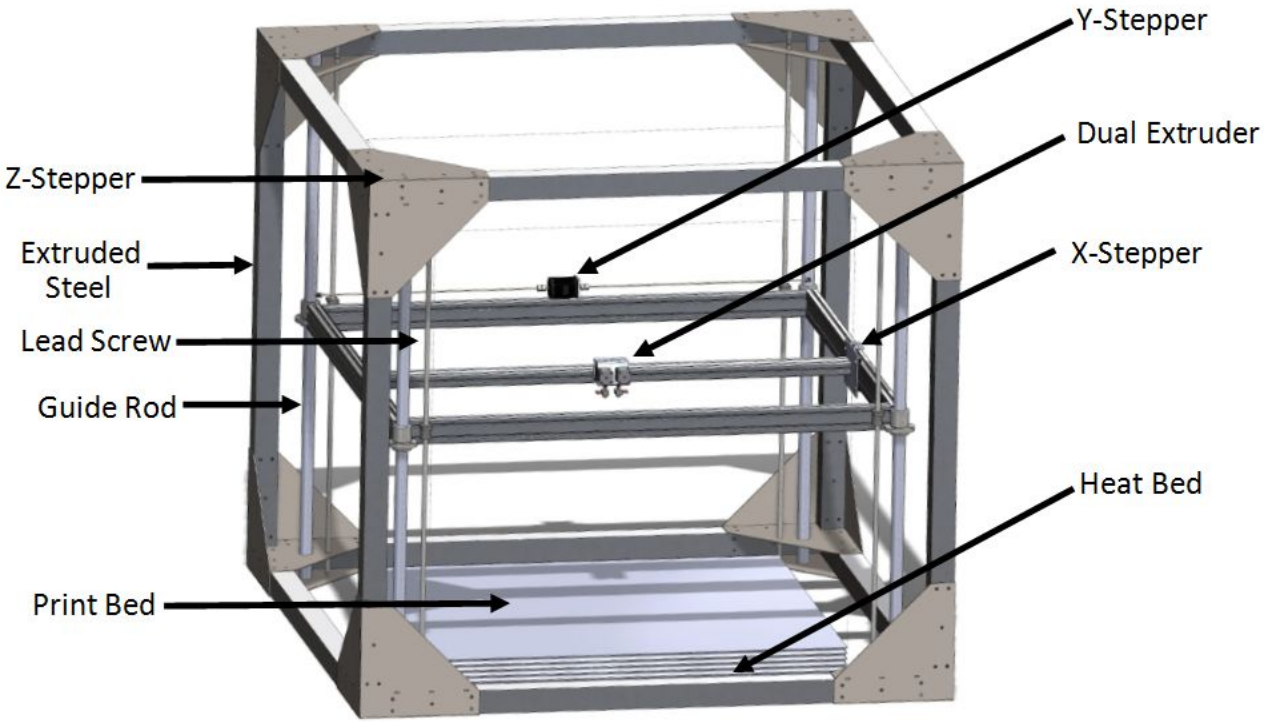
Scale: 1= Worst, 10 = Best

Design - CAD Model



Build Volume: 2.17 m^3

Design - CAD Model



Stages of Manufacturing

1. Build outer frame
2. Build gantry system
3. Install electrical components

Bill of Materials - Electrical

Component	Product	Quantity	Price (Dollars/Unit)	Total Price (Dollars)
Stepper Motor	Nema 23 23HS22-1504S	2	$16.00	$32.00
Stepper Motor	Nema 34 WO-8718S-01	1	$139.00	$139.00
Heat Bed	Keenovo	4	$69.99	$279.96
Control Board	Azteeg X3 Pro	1	$220.00	$220.00
Hot End	E3D Volcano	2	$55.00	$110.00
Power Supply	Dell ATX Power Supply	1	$10.00	$10.00
Computer	Dell Optiplex 755	1	$5.00	$5.00
TOTAL:				$795.96

Bill of Materials - Mechanical (Frame)

Component	Product	Quantity	Price (Dollars/Unit)	Total Price (Dollars)
Outside Support Frame	Steel Square Tubing (2x2x13 GA)	12	$26.22	$314.64
Fabricated Gussets	Sheet Metal (Mild Steel)	36	$10.50	$252.20
Guide Rods	Multipurpose 6061 Aluminum Rods	4	$75.66	$302.64
Gantry Lead Screws	Lead Screws	4	$96.43	$385.72
Hardware	Fasteners	N/A	N/A	~$200.00
Total:				$1455.20

Bill of Materials - Mechanical (Gantry)

Component	Product	Quantity	Cost (Dollars/Unit)	Total Price (Dollars)
Gantry Frame	2040 V Slot Extruded Aluminum	5	$19.50	$97.50
Y Movement Rod	Stainless 316 Steel	2	$6.16	$12.32
Extruder Carriage	Aluminum	1	$85.00	$85.00
Gantry Bracket	Universal V-Slot Gantry Set	2	$35.95	$71.90
Hardware	Belts, Pulleys, Fasteners, V-Slot Wheels, Mounts	N/A	N/A	~$150.00
Total:				$416.72

Bill of Materials - Mechanical (Gantry)

Section	Cost
Electrical	$795.96
Frame	$1455.20
Gantry	$416.72
Total:	$2667.88

Conclusion

- The client is Novakinetics.
- Novakinetics requires a more efficient manufacturing process in order to reduce lead time for molds & tooling
- This can be achieved with 3D printing by scaling up the size
- The objectives therefore are to create a large, fast 3D printer while maintaining accuracy and affordability
- The print volume must be larger than $1m^3$
- SOTA Research revealed that current large scale 3D printers lack either speed, or affordability

Conclusion

- In order to create the 3D printer, the team had to formulate concepts for each function
- The team created a functional diagram to identify the critical functions of a 3D printer
- Criteria were defined for each function
- The team conducted research for each function to find suitable components
- Using relative weights for the criteria and decision matrices, components were selected
- With components selected, the team created a CAD model
- From the CAD model, a bill of materials was created

References

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Questions?