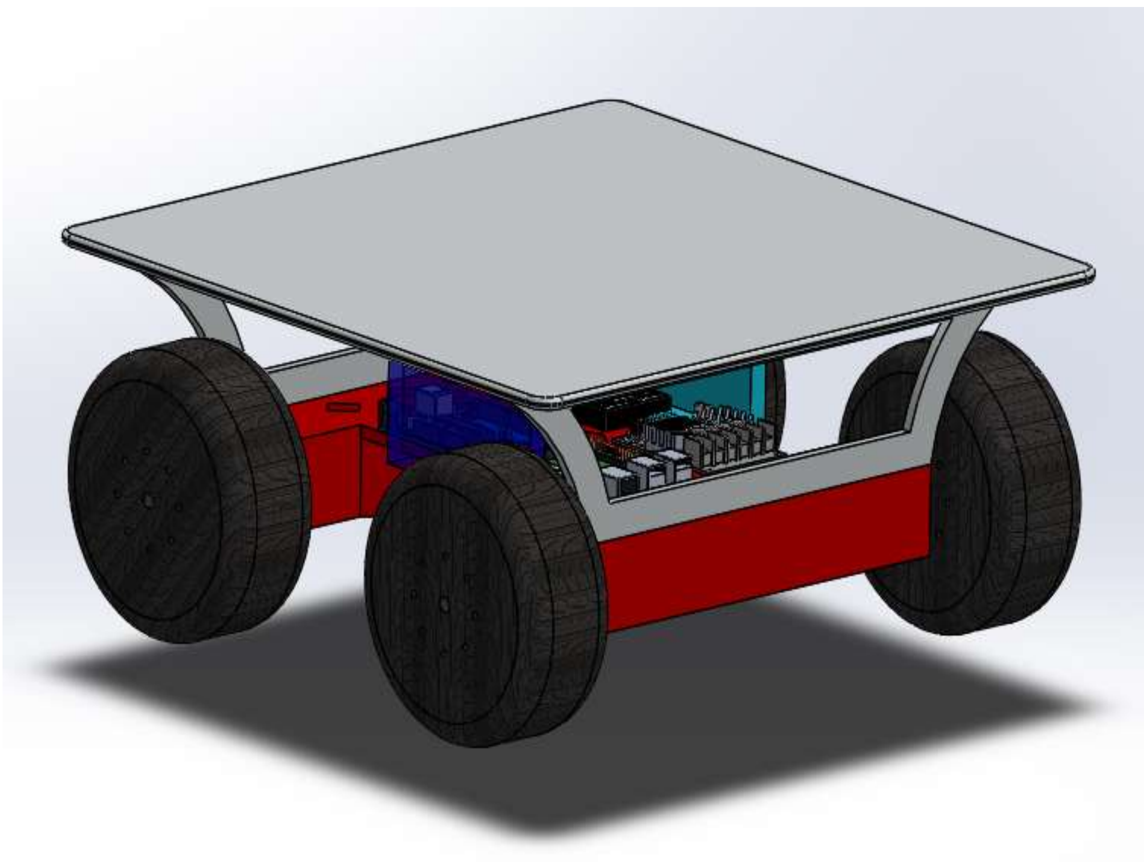
Robotic Chassis Design

RAD Lab



Gabriel Levin
MET- 450:102
04/29/2020

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Executive Summary

The Robotics and Data Science Lab at NJIT has many talented individuals that work together to create ground breaking systems in the subjects of computational and electrical work. Previously, they utilized commercially available kits to house their projects, allowing them to test their concepts in reality. Now, they need specifically designed mechanical systems to allow them to further their research. Now having a devoted mechanical engineer on the team, we as a lab can create systems that meet extremely specific design criteria and aesthetics. The current chassis of code name “Prowler” is basic in terms of not real potential in carrying large quantities of payload, thus only being a “road ready” system instead of having any chance of utilizing multiple harmonious systems. By creating a new chassis for this rover, inspired by the current UGV (Unmanned Ground Vehicle) systems, we can cut excess weight and allow for larger payloads. The end goal is to create a modular, multi-layer, multi-material system that passes all tests and meets all criteria.

Introduction

Concept

The main objective of this design project is to design mechanical enhancements that enable robot vehicles ready for real world applications.

Which Project Category did I pick?

- Mechanical Design for Drones and Robotics

- Where did the Concept come from?
    - This concept stemmed from an interest in design-based solutions that will aid the Robotics and Data Science research lab moving forward with complex electrical and computational advancements. By having me focus on the mechanical design problems of the drones and robots in the lab, I can create custom designs that fit the projects needs while also improving on my mechanical design skills.
- What is the need or area this specific concept will address?
    1) Design a robot chassis for the Prowler robot rover to house the internal circuitry and carry payload in an efficient way.
        a. The Prowler's current design uses a single plane chassis space rectangular in shape, this design is common among the Robotic Rover designs mainly that it is the most simple design
            i. Chassis are extremely bulky and rigid
            ii. Space is unorganized with wiring
            iii. Frame is excess weight thus reducing payload capacity

Background

- What is the broad Marketplace (e.g. Automotive, Medical, Aerospace, etc,)
    - Unmanned Ground Vehicles (UGV)
- What are examples of similar products?

- “SARGE”: 4-wheel drive ATV based on the frame of the Yamaha Breeze
- “TerraMax”: made by OshKosh Defense tank
- “The Talon”: specialized for Bomb disposal

- Who are the makers of similar products?
    - AION Robotics
    - Lockheed Martin
    - Endeavor Robotics
    - BAE Systems
    - ICOR Technology
- What do I hope to learn from pursuing this project?
    - I hope to create a chassis that creates the largest potential payload while changing the current rectangular staple that competing products repeatedly utilize.

Design Criteria

Design Criteria	Explanation
Weight	Chassis Design must weigh the least as possible to expand payload (weigh no more than 10lbs)
Layers	Chassis must have distinct layers separating motor/CPU/Payload
Protect Onboard Eq.	Chassis must protect all components from environmental risks
Strength	Must withstand deflection of 1/4in and support at least (40lbs)
MFG using Rapid Prototype	Chassis must be able to be 3D Printed successfully

Concept Design

- What Technology you expect is needed for the concept.

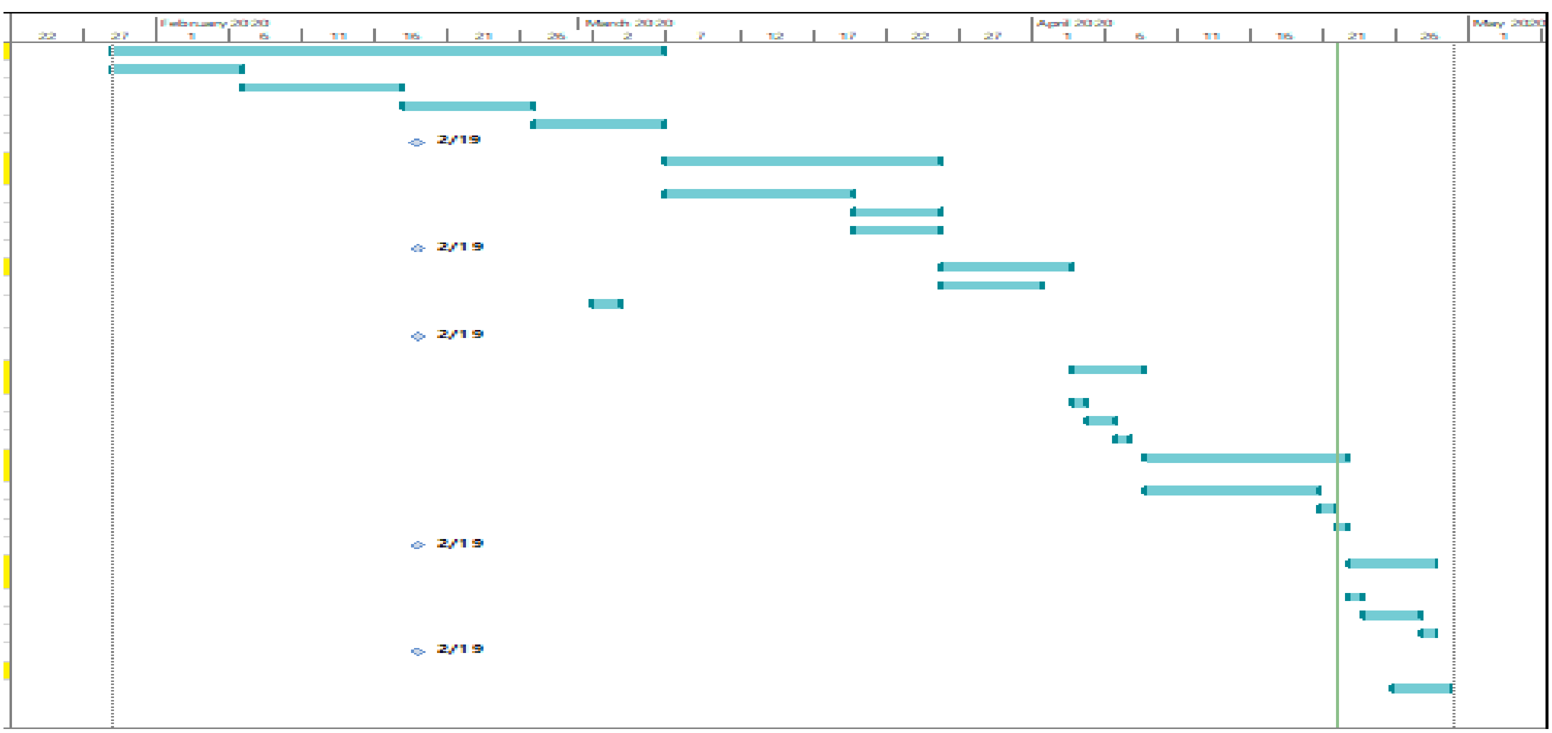
  - Solidworks CAD
  - Makerspace Laser cutting/3D printing
  - Soldering Kit
- Create a Table or List out a preliminary Bill of Materials and components to be designed.
  - ABS plastic
  - PetG plastic
  - PLA plastic
  - Circuit board standoffs
  - XT160 Connectors
  - To be designed:
    - Angle change to extend 3rd layer platform
    - 2nd layer CPU platform with hole
    - 1st layer chassis design
    - Quick disconnect mounting for Pick-n-place arm
- Your plan for Testing and Analyzing.
  - “Drop test”
    - Tests for chassis shape integrity drop at 2-3 feet
  - Scaled weight test
    - Creates statistics for layer by layer weight specs
  - Sharp turn test
    - Tests for center of gravity and tip over risk

Project Phases & Planned Schedule

Phase	Phase Objective	Tasks	Deliverables
Planning	Set design criteria and direction	• Discover all issues with current design	• Concise Design criteria that meets labs needs
Engineering Design 1st and 2nd layers	Ability to create sound prototypes	• Create design that meets lab standards and fulfils design criteria	• CAD Model of first two layers
Prototyping	Physical models ready to be tested	• Cardboard cutout of new chassis design	• Confirmation of measurements before 3D Printing and laser cutting
Testing & Analysis	If tests pass, move forward with third layer	• Test both layers with: Drop Test, weight, rigidity	• If testing passes, move to engineering design of 3rd layer
Engineering design 3rd layer	Create full design to pass all design criteria	• Create payload layer with all design criteria	• CAD model of 3rd layer
Final product	A sleek, efficient chassis able to carry 3 times its weight	• All three layers should be built and put together	• Final product

Robotic Chassis Design
RAD Lab
Gabriel Levin

ID		Task Mode	Task Name	Duration	Start	Finish	Predecessors	Resource Names
1			PLANNING	28 days?	Wed 1/29/2(	Fri 3/6/20		
2			Finalize Background Research	7 days	Wed 1/29/2(	Thu 2/6/20		
3			Develop Design Criteria	7 days	Fri 2/7/20	Mon 2/17/2(		
4			Establish Timline, Responsibilities, and Deliverables	7 days	Tue 2/18/20	Wed 2/26/2(		
5			Proposal Presentation	7 days	Thu 2/27/20	Fri 3/6/20		
6			Milestone:Design Criteria Set	0 days				
7			ENGINEERING DESIGN LAYER 1&2	14 days	Sat 3/7/20	Wed 3/25/20		
8			Establish Design Features	10 days	Sat 3/7/20	Thu 3/19/20		
9			Conduct Necessary Calculations	4 days	Fri 3/20/20	Wed 3/25/2(		
10			Establish testing Protocol	4 days	Fri 3/20/20	Wed 3/25/2(		
11			Milestone:Cad Drawings finished	0 days				
12			PROTOTYPING	7 days	Thu 3/26/20	Fri 4/3/20		
13			Manufacture Components	5 days	Thu 3/26/20	Wed 4/1/20		
14			Assemble Components	2 days	Mon 3/2/20	Tue 3/3/20		
15			MileStone: Cardboard/Set First layer & printed second layer	0 days				
16			TESTING AND ANALYSIS	4 days	Sat 4/4/20	Wed 4/8/20		
17			FEA Theoretical Testing	1 day	Sat 4/4/20	Sat 4/4/20		
18			Physical Testing	2 days	Sun 4/5/20	Mon 4/6/20		
19			Test Report	1 day	Tue 4/7/20	Tue 4/7/20		
20			ENGINEERING DESIGN LAYER 3	10 days	Thu 4/9/20	Wed 4/22/20		
21			Establish Design Features	8 days	Thu 4/9/20	Mon 4/20/2(		
22			Conduct Necessary Calculations	1 day	Tue 4/21/20	Tue 4/21/20		
23			Establish testing Protocol	1 day	Wed 4/22/2(	Wed 4/22/2(		
24			Cad Drawing Finished	0 days				
25			TESTING AND ANALYSIS	4 days	Thu 4/23/20	Tue 4/28/20		
26			FEA Theoretical Testing	1 day	Thu 4/23/20	Thu 4/23/20		
27			Physical Testing	2 days	Fri 4/24/20	Mon 4/27/2(		
28			Test Report	1 day	Tue 4/28/20	Tue 4/28/20		
29			All Layers assembled and weigh under 10lbs	0 days				
30			FINAL PRODUCT					
31			Design Evaluation Conclusion and Presentation	4 days	Sun 4/26/20	Wed 4/29/20		



Planned Project Logistics & budget

The Project Logistics include

- NJIT Rad Lab.
- NJIT Makerspace
- Solidworks, 3D Printer, Laser cutter, Soldering

All budget needs are taken care of by the Lab on NJIT Budget

Item	Cost
Laser Cut layer 1	$0
3D Printing layer 2	$20
Velcro tape	$5
3D printing internal chip set holder and battery compartment	$12
Payload layer (if metal) Payload layer (if 3D printed)	$25 $30
Short staffing for interlayer fastening	$15
Total	$77-$82 Budget can be set at $100

Design, Prototyping, Analysis, & Testing

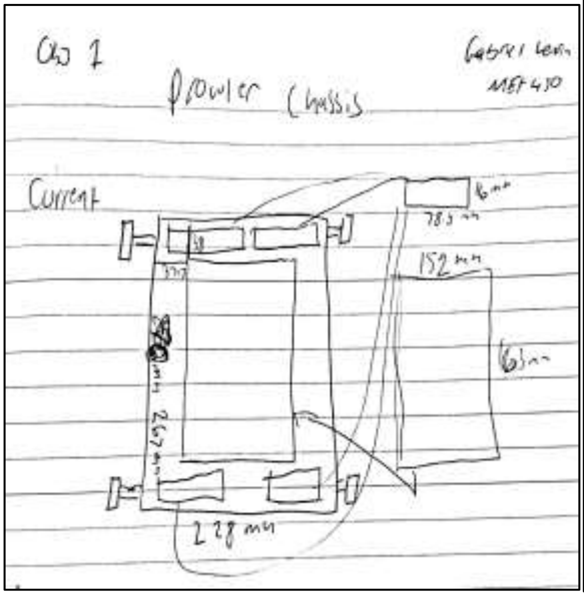
Engineering Design & Analysis (Layers 1 &2)

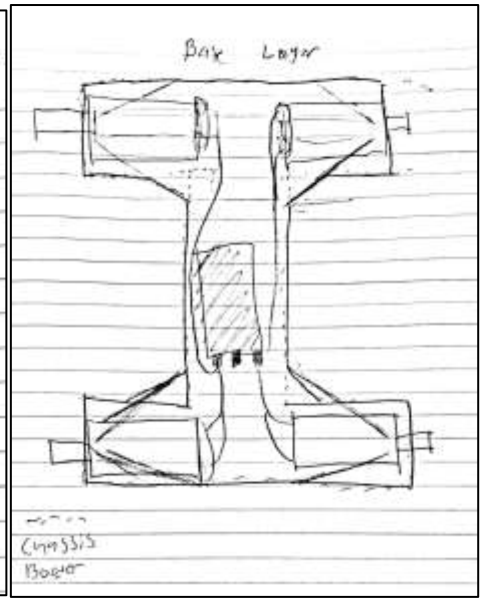
The first layer design criteria are to utilize the previous designs plastic and laser cutting the new shape out of it. The old plastics is ABS molded plastic. We need the shape to hold an end goal of a grand total of at least 40 pounds of stress and weight onto the shape without failure.

The second layers design is to work around the first layer's shape and create a housing for the motors and a flat surface for the onboard computing to be between the 2nd and 3rd layers.

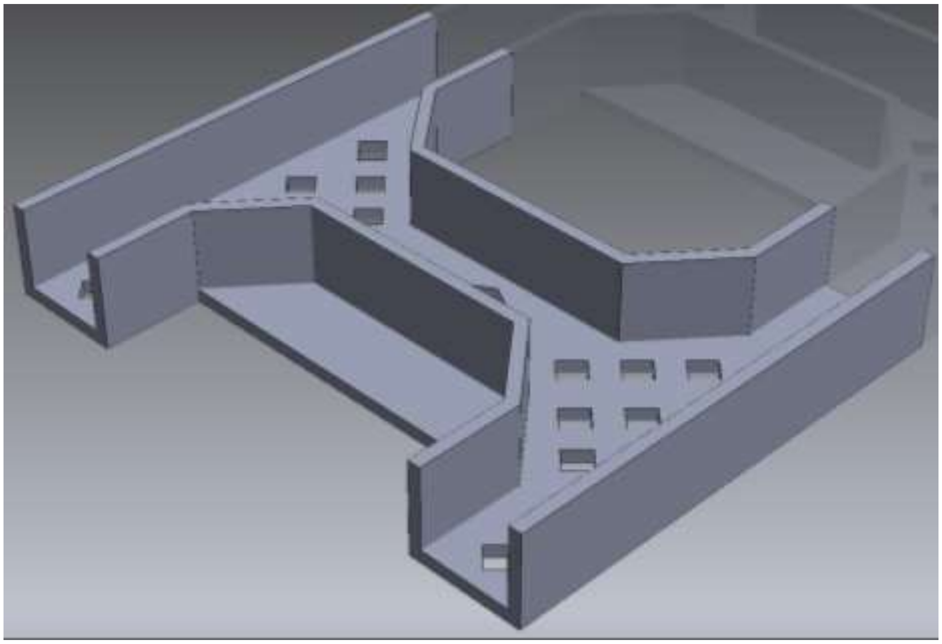
The third layer will need to be larger than the entire footprint of the rover including the wheels. Between the two layers is a battery clip to place the battery on top of the onboard computing. The Battery Clips top platform can be used to secure the third layer platform with screws.

The first layer's shape needs to have rigidity but lose a lot of excess area.

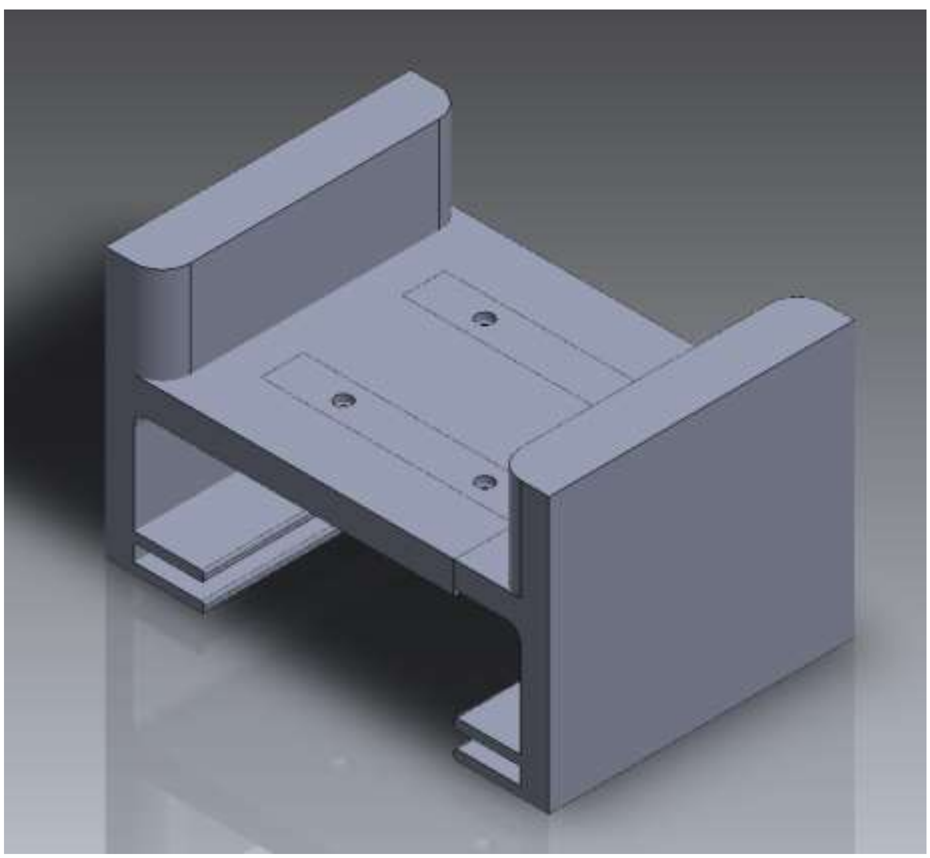




By mimicking the first layer shape we can utilize the rib cuts and save weight, bringing back the original rectangular shape but placing it on top for the onboard computing. This allows us to have the area we need but the weight we don't. (picture shows top facing bottom)



The battery compartment must sit on top of the second layer giving breathing room for the CPU's while not utilizing any extraneous fastening techniques.



Prototyping

The first layer's prototype used a simple logic; if the shape can hold base weight with a weak material, then it can perform successfully with a stronger material. Utilizing cardboard, the shape would prove to pass the weights of the motors attached to the shape, giving enough clearance to move forward with the shape in ABS plastic.

The second layer, since it will be 3D printed, must have dimensions that account for extruded material thickness. Since the lines in CAD have weight to them once 3D printed, crucial dimensions can be incorrect without this tolerance. Therefore, test prints might have to be utilized. Alterations to the print might also have to occur.

Once the first two layers are tested and road-ready, the project can move forward to designing, prototyping, and testing the third layer.

Testing & Analysis

The table below compares the main properties of PLA vs. ABS:

Properties*	ABS	PLA
Tensile Strength**	27 MPa	37 MPa
Elongation	3.5 - 50%	6%
Flexural Modulus	2.1 - 7.6 GPa	4 GPa
Density	1.0 - 1.4 g/cm^3	1.3 g/cm^3
Melting Point	N/A (amorphous)	173 °C
Biodegradable	No	Yes, under the correct conditions
Glass Transition Temperature	105 °C	60 °C
Spool Price*** (1kg, 1.75mm, black)	$USD 21.99	$USD 22.99
Common Products	LEGO, electronic housings	Cups, plastic bags, cutlery

*Sourced from MakeItFrom

**Sourced from Optimatter for a test specimen with 100% infill, 0.2mm layer height printed in a linear pattern

*** Sourced from Amazon ABS & PLA

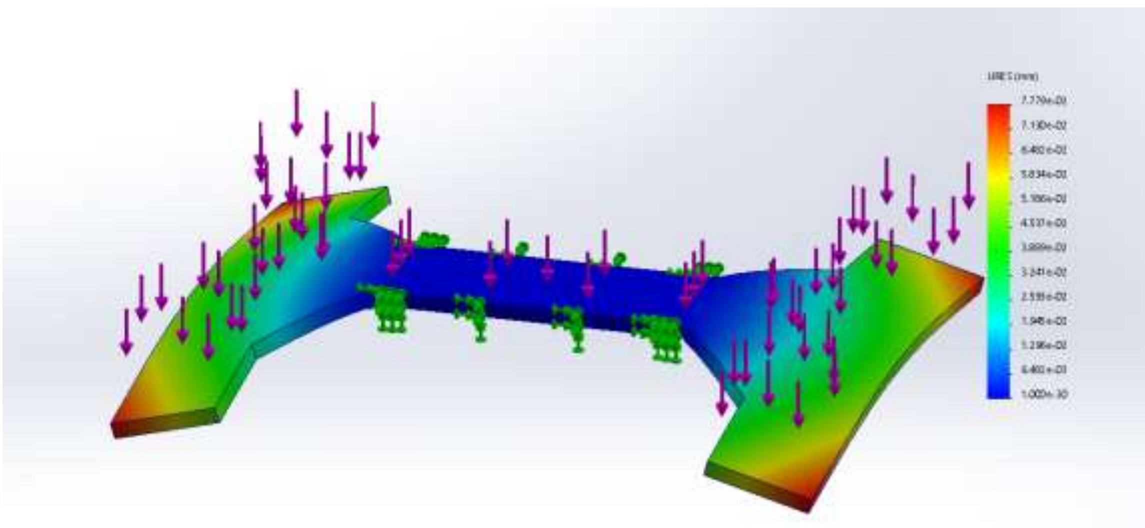
Polyethylene Terephthalate Glycol (PETG) Material Properties

PROPERTY	METRIC	UNITS	ENGLISH	UNITS
General				
Density	1.26e3 - 1.28e3	kg/m^3	0.0455 - 0.0462	lb/ft^3
Mechanical				
Yield Strength	4.79e7 - 5.29e7	Pa	6.95 - 7.67	ksi
Tensile Strength	6e7 - 6.6e7	Pa	8.7 - 9.57	ksi
Elongation	1.02 - 1.18	% strain	102 - 118	% strain
Hardness (Vickers)	1.41e8 - 1.56e8	Pa	14.4 - 15.9	HV
Impact Strength (un-notched)	1.9e5 - 2e5	J/m^2	90.4 - 95.2	ft.lbf/in^2
Fracture Toughness	2.11e6 - 2.54e6	Pa/m^0.5	1.92 - 2.31	ksi/in^0.5
Young's Modulus	2.01e9 - 2.11e9	Pa	0.292 - 0.306	10^6 psi
Thermal				
Max Service Temperature	51 - 64	°C	124 - 147	°F
Melting Temperature	81 - 91	°C	178 - 196	°F
Insulator or Conductor	Insulator		Insulator	
Specific Heat Capability	1.47e3 - 1.53e3	J/kg °C	0.352 - 0.366	BTU/lb. °F
Thermal Expansion Coefficient	1.2e-4 - 1.23e-4	strain/°C	66.8 - 68.1	µstrain/°F
Eco				
CO2 Footprint	3.22 - 3.56	kg/kg	3.22 - 3.56	lb/lb
Recyclable	Yes		Yes	

When examining the Material Data Sheets (MDS), we notice that by converting Mega-Pascals to inch/pound of force to determine if the material causes the chassis to fail or if there is another reason behind failure such as critical points or shape failure. We also can utilize the “Drop Test” at about 2 to 3 feet to see if the center or gravity allows for a straight fall and see if there are any points in the design that absorb too much impact and thus crack/fail. We can also further examine that PETG is stronger than PLA but is not as elastic thus we can utilize PETG sparingly especially in designs that need the strength.

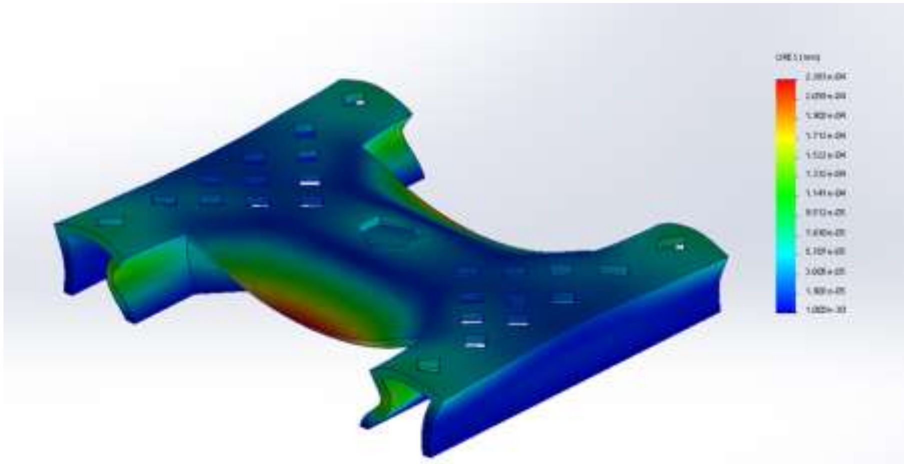
- "Drop test"
  - Tests for chassis shape integrity drop at 2-3 feet
- Scaled weight test
  - Creates statistics for layer by layer weight specs
- Sharp turn test
  - Tests center of gravity and any potential top-heavy issues

Layer 1 Deformation



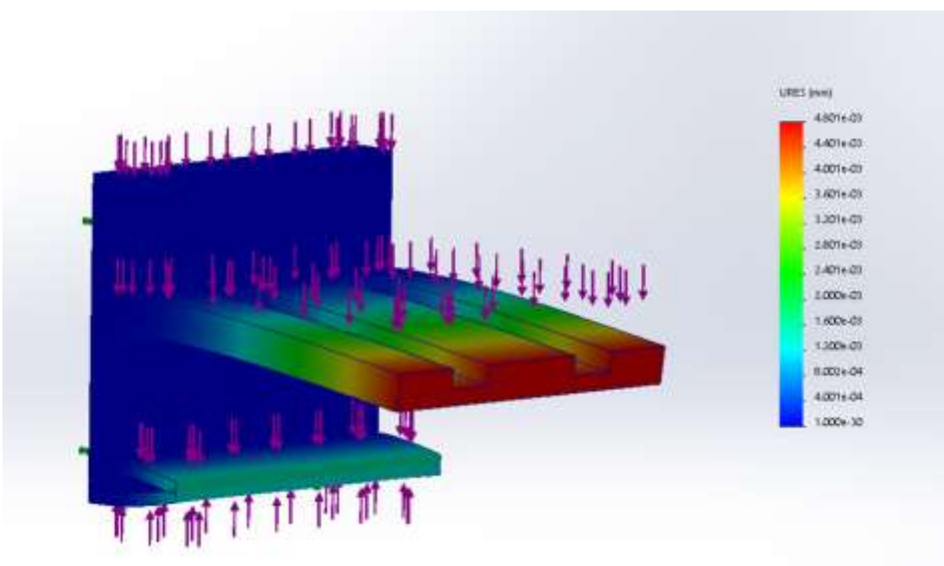
The deformation shown on Layer 1 is under a sample load of 1 N per each arrow in purple. This sample load shows how certain areas are under risk of failing in terms of being supported and their relation to the center of gravity. As shown, the end corners of the shape undergo the most deformation in perspective to the rest of the shape which is as expected.

Layer 2 Deformation

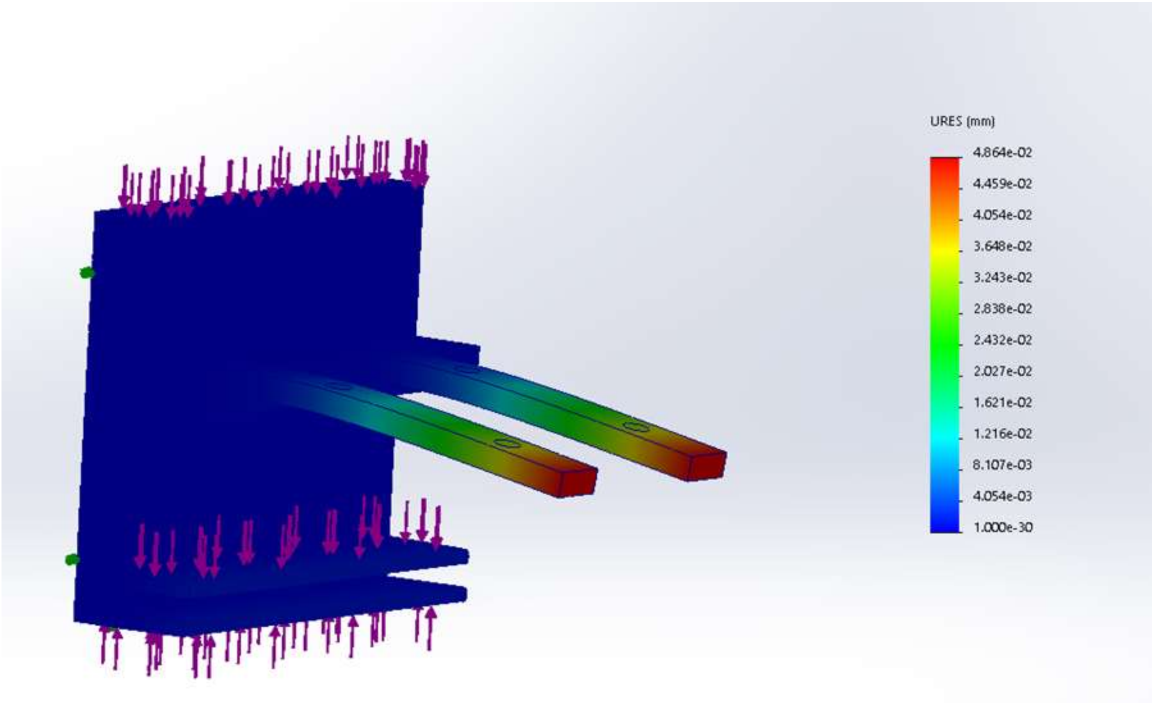


The material of PLA and the structure of the second layer is under the same sample load of 1 newton. Notice how the shape is much stronger in rigidity allowing for less deformation that Layer 1. It's not that deformation is a bad thing, more so describing the tolerance of allowable flexibility which benefits the first layer greater than the second.

Battery Clip 1 Deformation (Sample Load of 1 Newton)



Battery Clip 2 (Sample Load of 1 N)



Both Battery Clips undergo the most deformation away that can be considered a "Torque Arm". When the two clips are union, this arm goes away and the bridge moves toward the midpoint of the distance between the arms.

Hand calculations for Prowler design

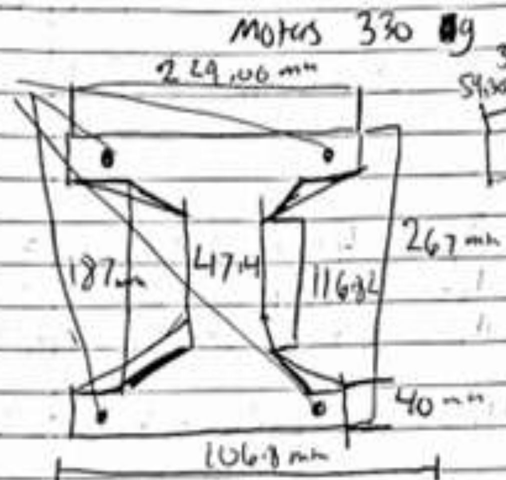
Layer 1 :

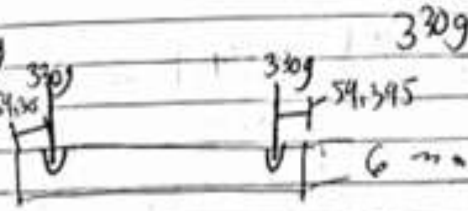
Given : ABS Plastic Tensile strength 22 MPa elongation 6%
Tensile modulus 1360 MPa ⌄E

$330g = 3.24 N$

motors
330g
x4

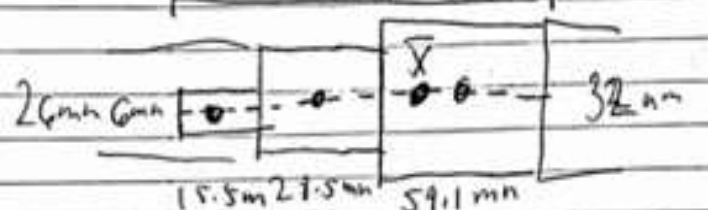
Motors 330 g





$\bar{X}_1 = 7.75$
$\bar{X}_2 = 29.75 mm$
$\bar{X}_3 = 73.05$

$$\bar{X} = \frac{7.75(93) + 29.75(741) + 73.75(1841)}{\sum A}$$



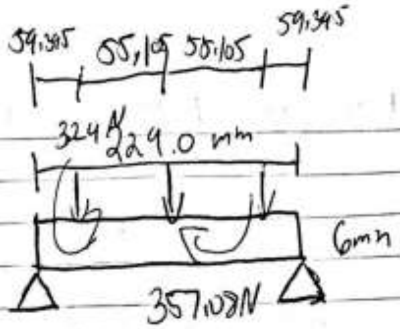
$$\bar{X} = \frac{161863.26}{2725.2} = 59.395$$

$V = \pi r^2 h$

V_1	$\pi(6)^2(15.5) = 558 mm^3$	0.645 %	0.0225 N
V_2	$\pi(26)^2(28.5) = 14266 mm^3$	23.49 %	0.77 N
V_3	$\pi(32)^2(59.1) = 60518.4$	75.33 %	2.44 N

$V_{tot} = 80342$

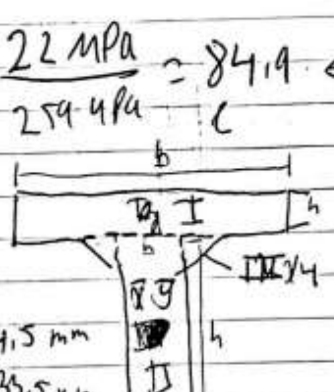
$A_1 = 6 \times 15.5 = 93 mm$
$A_2 = 28.5 \times 26 = 741 mm$
$A_3 = 59.1 \times 32 = 1891.2$



$3.24N \times 55.105 \times 2$

$\sigma = \dfrac{357.08}{229 \times 6mm} = 0.259\ N\ mm$ $\boxed{259\ KPa}$

$FS\ \dfrac{22\ MPa}{259\ KPa} = 84.9 \leftarrow$ LOTS of load potential



$\bar{X} = 114.5\ mm$
$\bar{Y} = 133.5\ mm$

$A_1 = 40mm \times 229\ mm = 9160\ mm^2$
$A_2 = 47.4mm \times 187mm = 8863.8\ mm^2$
$A_3 = (35.09 \times 41.74) / 2 = 732.3283$

$A_{tot} = 2A1 + A2 + 4A3 = 30113.113\ mm^2$

$I_1 = \dfrac{b_1 h_1^3}{12} = \dfrac{(229mm)(40mm^3)}{12} = 1221333.333\ mm^4$

$I_2 = \dfrac{(47.4mm)(187mm)^3}{12}$ $25829851.85\ mm^4$

$I_3 = \dfrac{(41.74)(35.09\ mm)^3)}{12}$ $150284.96\ mm^4$

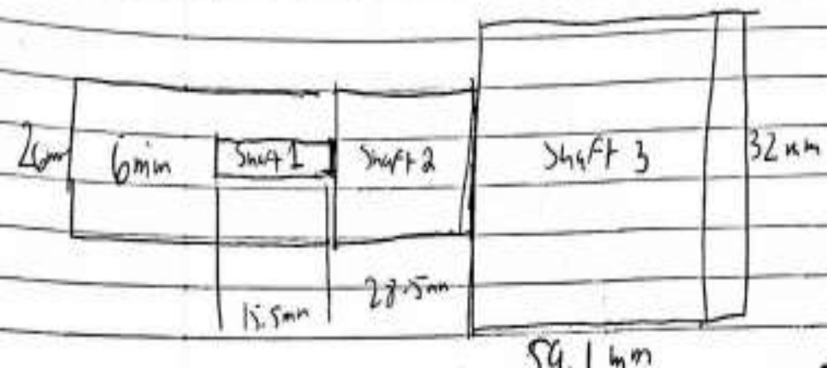
$I_{total} = 27201472.14\ mm^4$ $C = 114.5\ mm$

$259\ KPa = \dfrac{M\ 114.5mm}{27201472.14\ mm^4}$

$0.259\ N/mm^2 =$

$7045181.284\ N \cdot mm^2 \Rightarrow$ $M = 418755.579\ N\ mm$

Torsional Stress:



$T_{max} = 30$ kgf-cm

$= 2.94$ Nm

2940 Nmm

~~Shaft 1:~~ $\cancel{T_{max} = \frac{\pi}{16} \tau_{max} D^3 =}$

$\cancel{T_{max} = \frac{\pi}{16} (\ldots)(6mm)^3 = 34640\pi \text{ mm}}$

~~Shaft 2~~ $\cancel{T_{max} = \frac{\pi}{16} (2940)(26mm)^3}$

$2940 \text{ Nmm} = \frac{\pi}{16} \tau_{max} D^3$

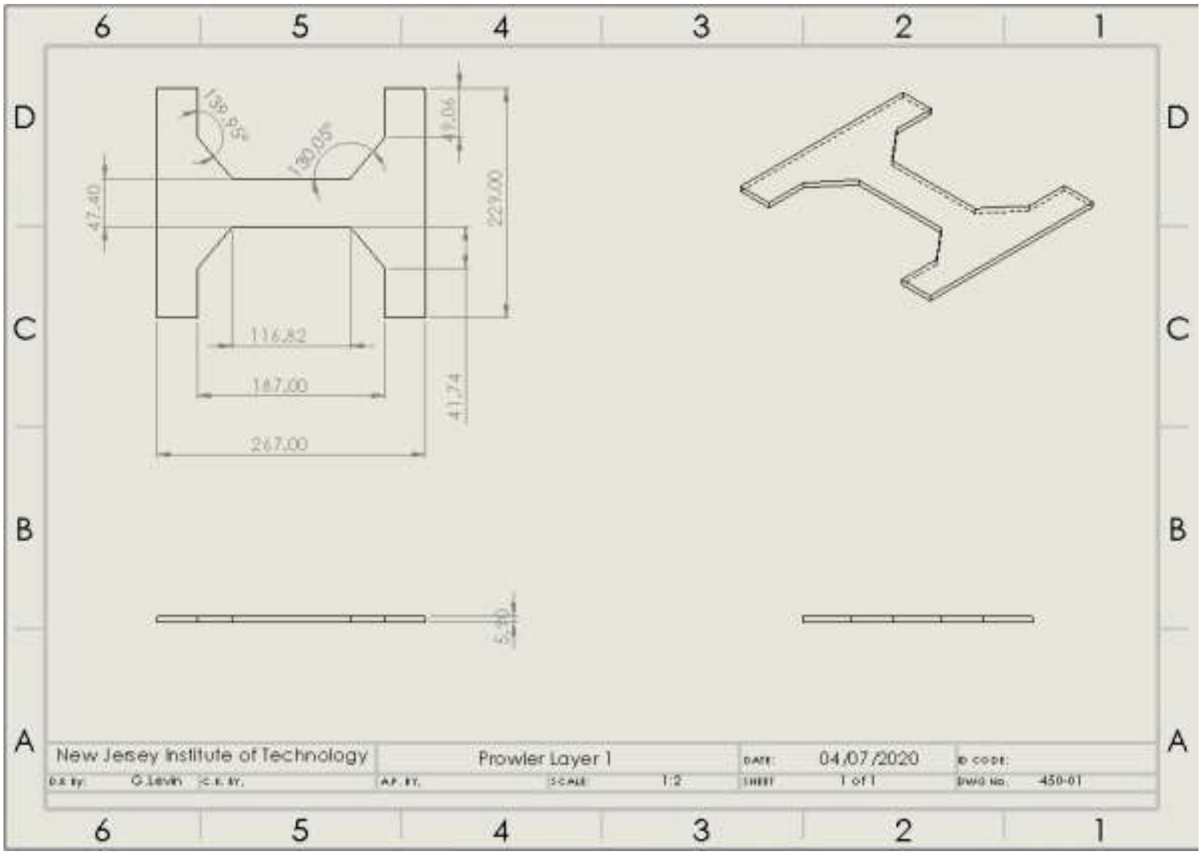
Shaft 1 $2940 \text{ Nmm} = \frac{\pi}{16} \tau_{max} 6^3 \Rightarrow \tau_{max} = 69.321 \text{ N/mm}^2$

Shaft 2 $2940 \text{ Nmm} = \frac{\pi}{16} \tau_{max} 26^3 \Rightarrow \tau_{max}$ 0.85 N/mm^2

Shaft 3 $2940 \text{ Nmm} = \frac{\pi}{16} \tau_{max} 32^3 =$ 0.45 N/mm^2

Total Shear Stress $= 70.62795 \text{ N/mm}^2$ or MPa

The hand calculations shown are to determine the material stress in regards to the first layer. The first layer is composed of ABS injection molded plastic. Given the plastic's ultimate strength, elastic modulus, and the forces applied to the layer, we can determine the factor of safety, moment of inertia, and stress that's behaving on the first layer. We can see that the layer is undergoing a low stress compared to the stress that it can handle. The factor of safety calculates to roughly 85. Once we add the rest of the model to the layer; (I.E: Layer 2, Layer 3, Battery clips, Circuits, battery), we can determine how much payload can be safely loaded onto the prowler assembly. The layer however, will not be where fracture will be experienced, but onto the axles of the motors themselves since the assembly is supported by four wheels. We also calculated the total shear stress that is created by the motors. This means that this is the stress applied to the layer if you hold the wheel in place, not allowing the wheel to spin.


6
5
4
3
2
1
D
C
B
A
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130.05°
49.06
47.40
229.00
116.82
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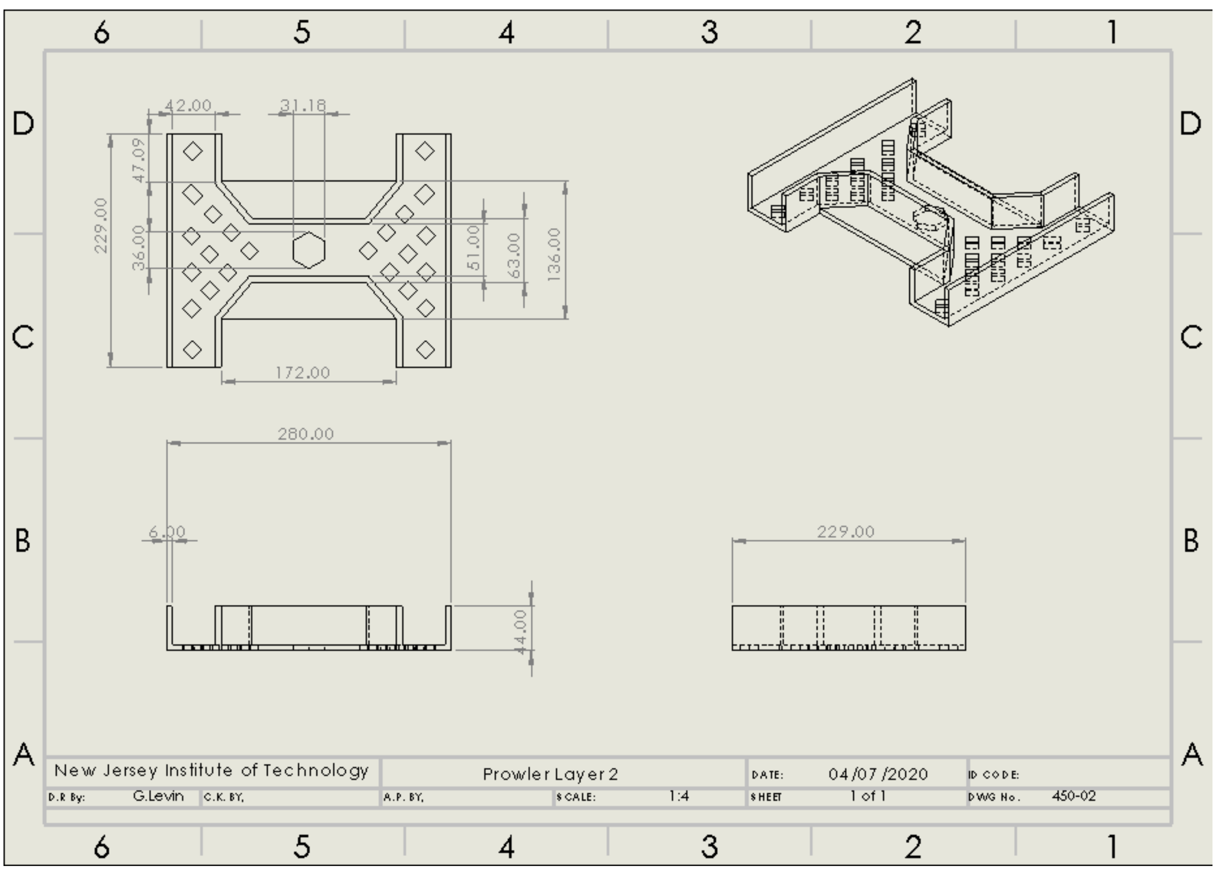
41.74
267.00
5.90
New Jersey Institute of Technology
Prowler Layer 1
DATE:
04/07/2020
ID CODE:
D.R By:
G.Levin
C.K. BY.
A.P. BY.
SCALE:
1:2
SHEET
1 of 1
DWG No.
450-01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New Jersey Institute of Technology
Prowler Layer 2
DATE:
04/07/2020
ID CODE:
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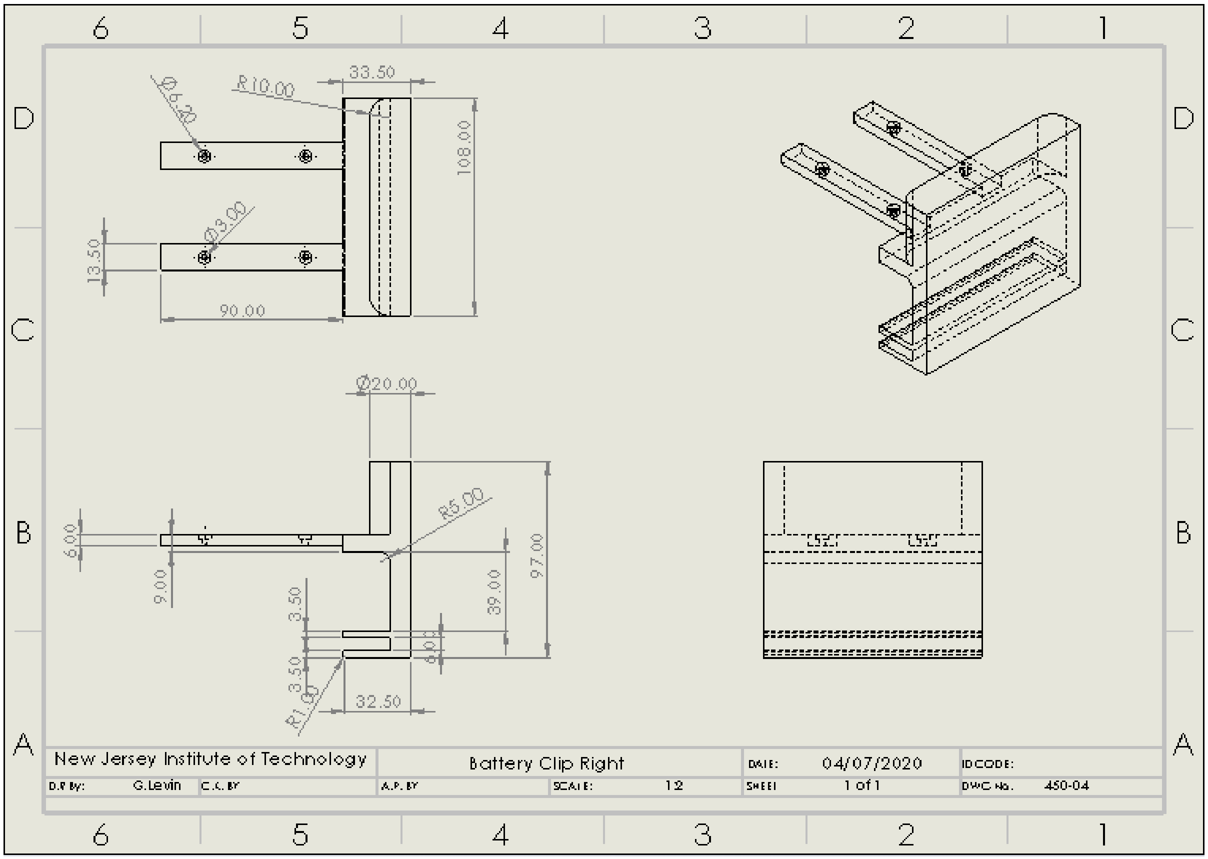
450-02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Battery Clip Right
DATE: 04/07/2020
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A.P. BY
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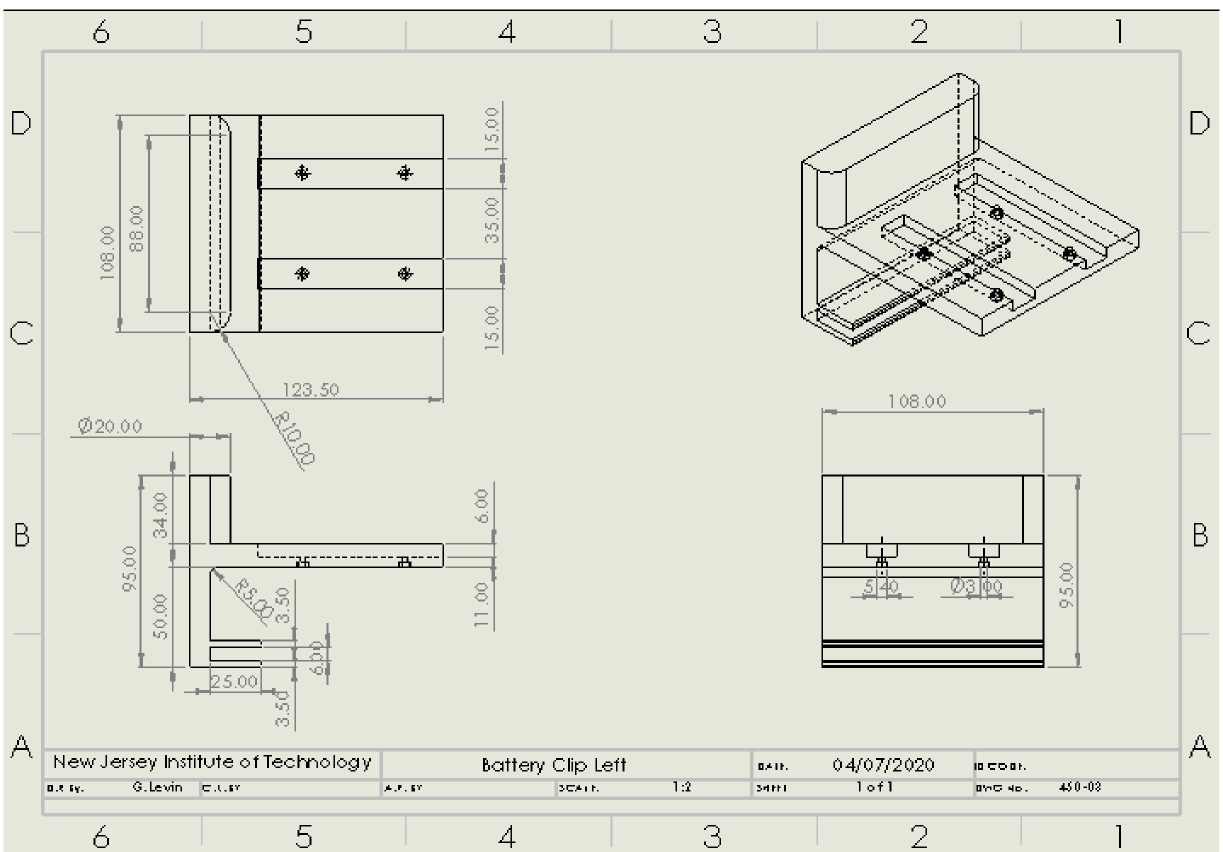
SHEET 1 of 1
DWG No. 450-04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R5.00
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3.50
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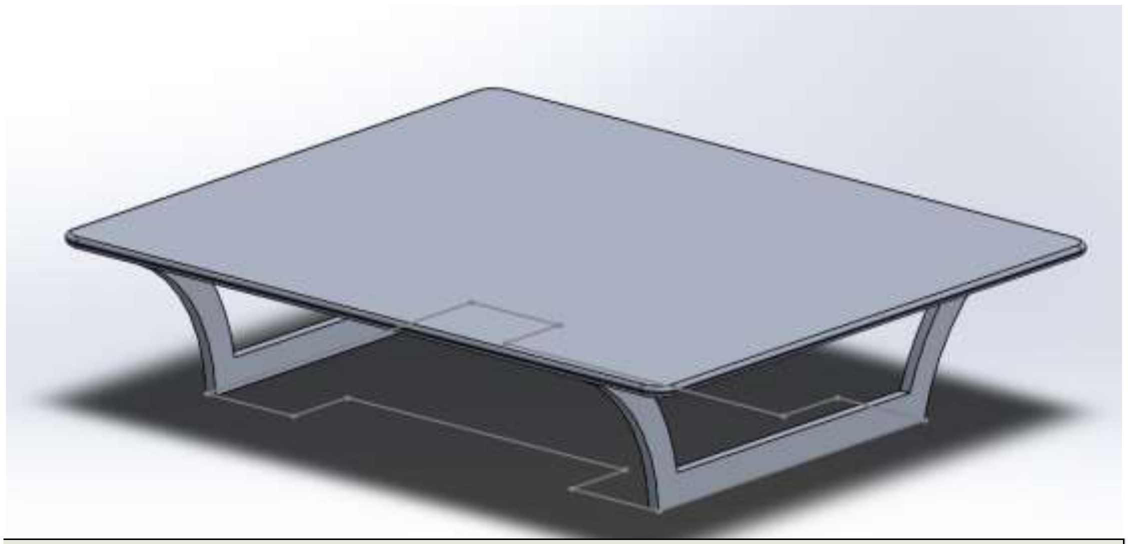
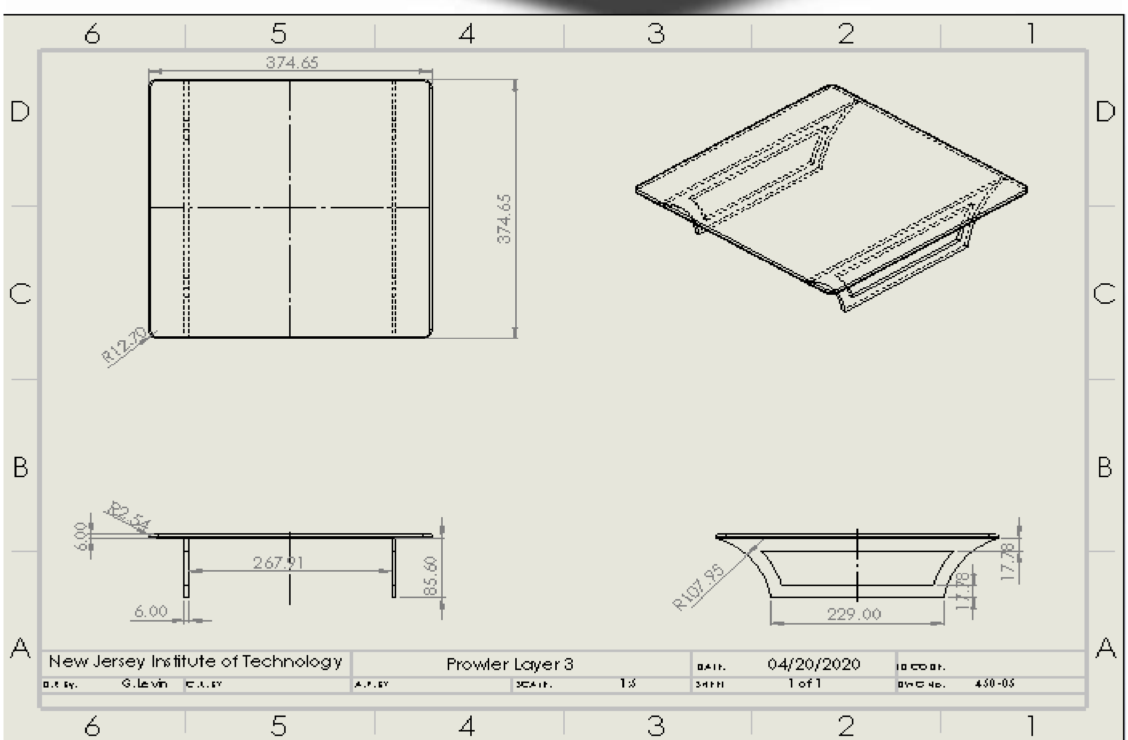
5.40
Ø3.00
95.00
New Jersey Institute of Technology
Battery Clip Left
DATE 04/07/2020
ID CODE
D.R BY. G.Levin
C.C. BY
A.P. BY
SCALE 1:2
SHEET 1 of 1
DWG NO. 450-03

Engineering Design & Analysis (Layer 3)

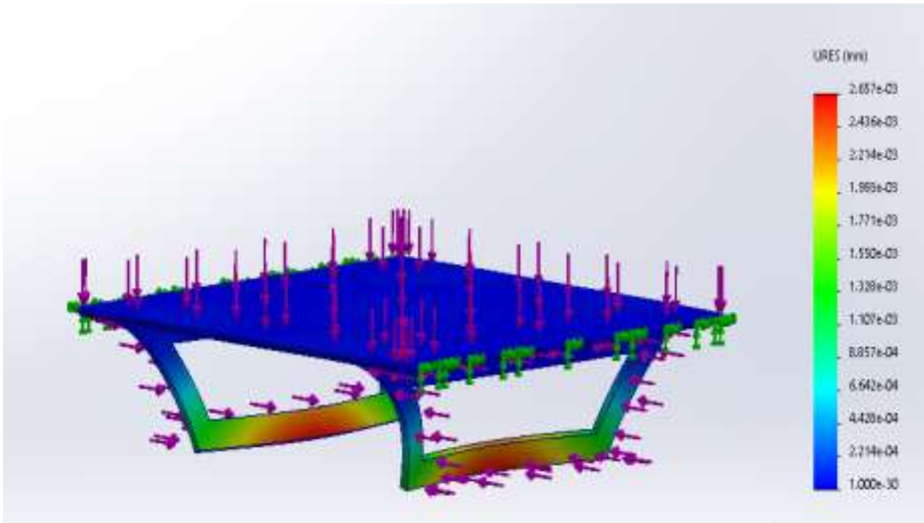
The criteria for Layer 3 are that it must support as much payload as possible. The design's footprint covers the entire footprint of the model from wheel to wheel in boxed. The front and back walls as shown protect any sensor contact wires from damage as well as support loads furthest from the center point of the platform. The shape allows for no interference with the wheels acting as hub. A



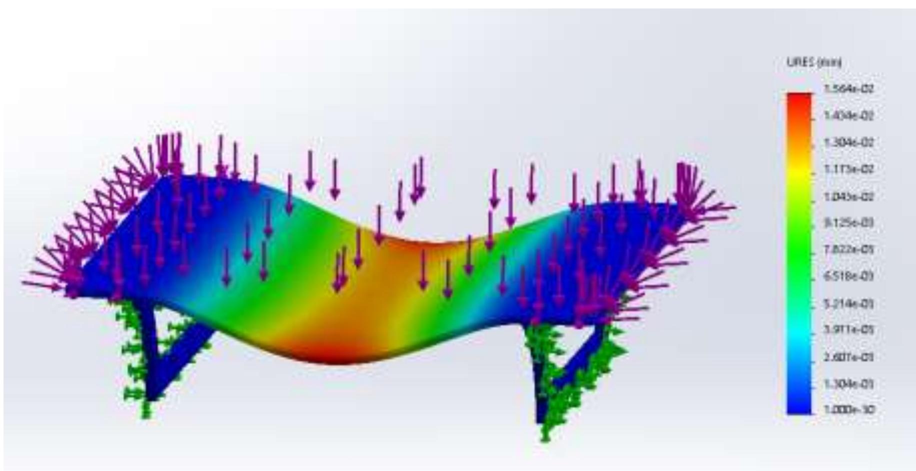


small “L” bracket will be installed between Layers 2 & 3 to keep the walls in place. Four screw holes will be tapped and utilized to attach the platform to the battery clips.

Layer 3 Displacement (Sample load of 1N each arrow)

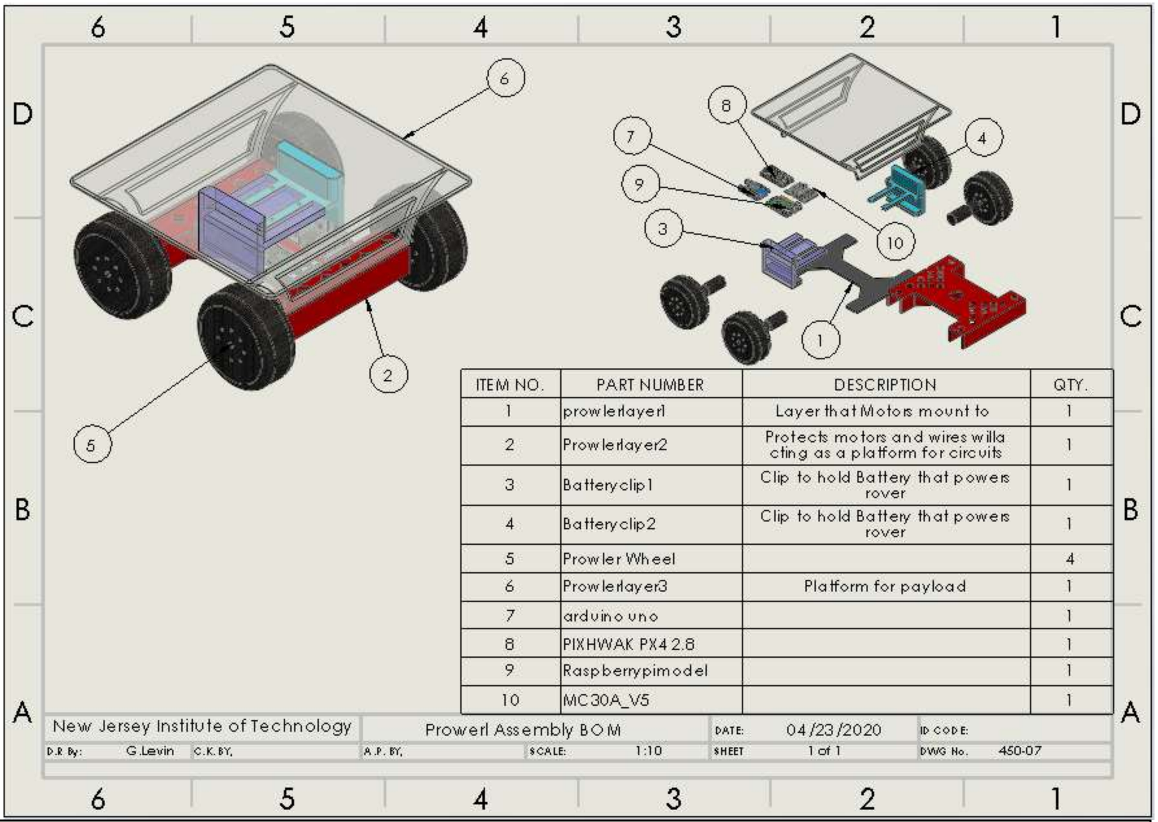


Layer 3 Displacement (40 lbf total on platform)

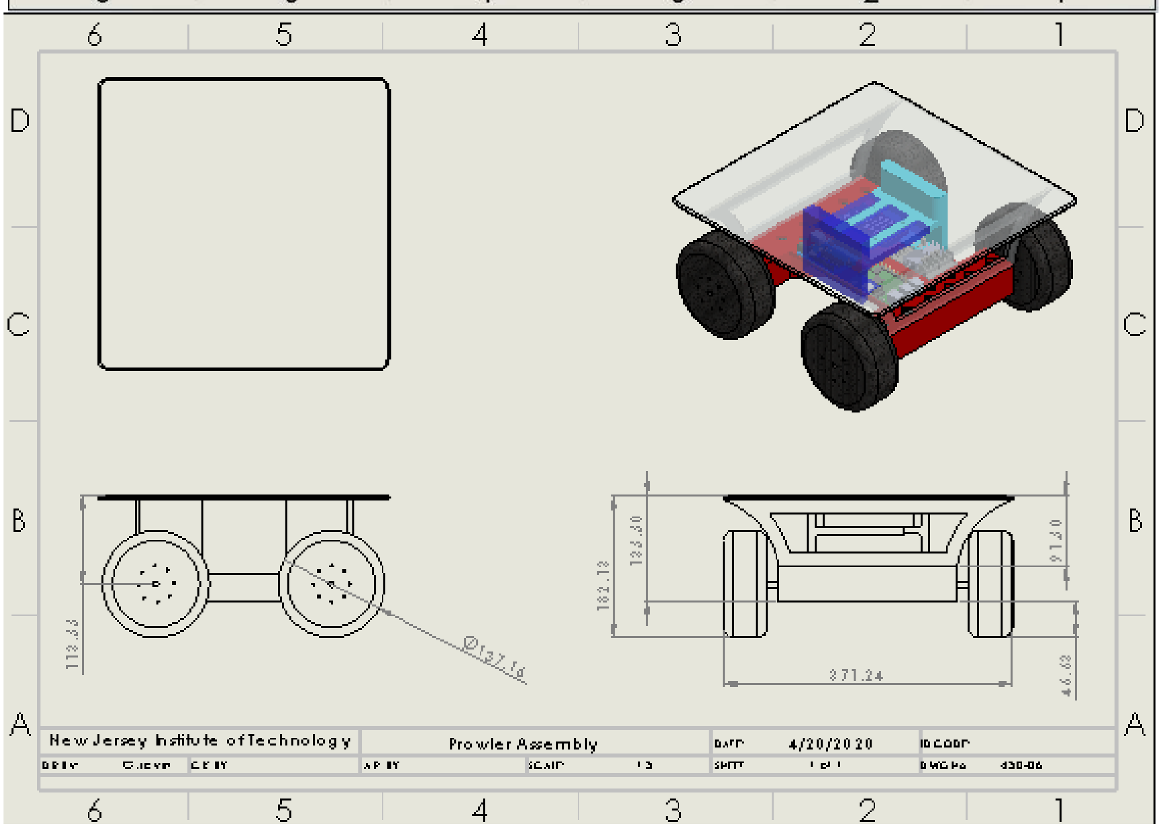


As shown above, the stress of 40 lbf which is the goal of payload under desired design criteria is safely supported by the design of Layer 3 and it also maintains the under ¼ inch deflection goal.

Robotic Chassis Design
RAD Lab
Gabriel Levin



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	prowlerlayer1	Layer that Motors mount to	1
2	Prowlerlayer2	Protects motors and wires will a cting as a platform for circuits	1
3	Batteryclip1	Clip to hold Battery that powers rover	1
4	Batteryclip2	Clip to hold Battery that powers rover	1
5	Prowler Wheel		4
6	Prowlerlayer3	Platform for payload	1
7	arduino uno		1
8	PIXHWAK PX4 2.8		1
9	Raspberrypimodel		1
10	MC30A_V5		1



Actual Project Schedule

ID		Task Mode	Task Name	Duration	Start	Finish	Predecessors
1			PLANNING	28 days?	Wed 1/29/20	Fri 3/6/20	
2			Finalize Background Research	7 days	Wed 1/29/20	Thu 2/6/20	
3			Develop Design Criteria	7 days	Fri 2/7/20	Mon 2/17/20	
4			Establish Timline, Responsibilities, and Deliverables	7 days	Tue 2/18/20	Wed 2/26/20	
5			Proposal Presentation	7 days	Thu 2/27/20	Fri 3/6/20	
6			Milestone:Design Criteria Set	0 days			
7			ENGINEERING DESIGN LAYER 1&2	7 days	Sat 2/29/20	Sat 3/7/20	
8			Establish Design Features	2 days	Tue 2/18/20	Wed 2/19/20	2,3
9			Conduct Necessary Calculations	2 days	Tue 3/3/20	Wed 3/4/20	
10			Establish testing Protocol	4 days	Thu 3/5/20	Tue 3/10/20	
11			Milestone:Cad Drawings finished	0 days	Mon 3/9/20	Mon 3/9/20	3,4,5
12			PROTOTYPING	7 days	Sat 3/7/20	Mon 3/16/20	
13			Manufacture Components	5 days	Sat 3/7/20	Thu 3/12/20	
14			Assemble Components	2 days	Thu 3/12/20	Fri 3/13/20	
15			MileStone: Cardboard/Set First layer & printed second layer	0 days	Fri 3/20/20	Fri 3/20/20	3,8
16			TESTING AND ANALYSIS	4 days	Sat 3/21/20	Wed 3/25/20	
17			FEA Theoretical Testing	1 day	Sat 3/21/20	Sat 3/21/20	
18			SolidWorks SIM Testing	2 days	Wed 4/22/20	Thu 4/23/20	
19			Test Report	1 day	Mon 3/9/20	Mon 3/9/20	11
20			ENGINEERING DESIGN LAYER 3	10 days	Sat 3/28/20	Thu 4/9/20	
21			Establish Design Features	8 days	Sat 3/28/20	Wed 4/8/20	
22			Conduct Necessary Calculations	1 day	Wed 4/8/20	Wed 4/8/20	
23			Establish testing Protocol	1 day	Thu 4/9/20	Thu 4/9/20	
24			MileStone:Cad Drawing Finished	0 days	Fri 4/24/20	Fri 4/24/20	11,18,21
25			TESTING AND ANALYSIS	4 days	Sat 4/11/20	Wed 4/15/20	
26			FEA Theoretical Testing	1 day	Sat 4/11/20	Sat 4/11/20	
27			Physical Testing	2 days	Sun 4/12/20	Mon 4/13/20	
28			Test Report	1 day	Tue 4/14/20	Tue 4/14/20	
29			All Layers assembled and weigh under 10lbs	0 days			
30			FINAL PRODUCT				
31			Design Evaluation Conclusion and Presentation	9 days	Sat 4/18/20	Wed 4/29/20	

The actual project schedule compared to the planned project schedule is different to a number of reasons. The first and foremost reason is that due to COVID-19, the project could not take place in the Makerspace or on campus. The project was converted to a virtual setting. Fortunately, the project was completed physically all the way up to engineering the third layer. Unfortunately, the testing was not applicable in any physical way. All testing and analysis were done through Solidworks simulations. The project schedule was also updated due to the timeline being ahead of schedule. The first and second layers were completed including the project being “drivable” on March 20th, which was three weeks ahead of the planned schedule. This was because there weren’t many issues or delays when it came to fabricating parts. At first, we thought it would be difficult to book a time to use the platform 3D printer in the Makerspace and have a successful print but we were able to accomplish that early on.

Actual Project Logistics & Budget

The Project Logistics include

- NJIT Rad Lab
- NJIT Makerspace
- Solidworks, 3D Printer, Laser cutter, Soldering

All budget needs are taken care of by the Lab on NJIT Budget

Item	Cost
Laser Cut layer 1	$0
3D Printing layer 2	$20
Velcro tape	$5
3D printing internal chip set holder and battery compartment	$15
Payload layer 2x 6061 alloys 18”x18” .025” thick	$50
Total	$90

The set budget was $100. We utilized logistics as stated for the entire project except for the payload layer which has not been fabricated due to COVID-19. We did however stay under budget.

Discussion & Conclusion

Even with COVID-19 and other unpredictable delays in the project schedule, our timing was completed in terms of project development. We didn’t have the means to fabricate our final third layer, but the rover is in driving condition, simply lacking a payload platform. Now that the platform is developed, we can fabricate within a day.

In terms of design criteria, the chassis was successfully 3D printed and separated with distinct layers isolating components from each other. The chassis protects motors and circuitry from any indoor environmental risks. According to the Solidworks analysis, the deflection is well within ¼ in deflection as well as supporting well outside of 40 pounds. The Solidworks analysis also estimates the design to be under 15 pounds. This is outside of the goal of no more than ten pounds but this is only an estimate. Once we have access to weigh the chassis in person, we can confirm or deny that analysis.

This project has taught me that there are many approaches to engineering designs that don’t require physical implementation. The importance of the utilization of Computer Aided Engineering and simulations, directs efficiency towards resources and saves for less physical investment that could potentially be wasteful. By working through adversity, creating plans for fabrication, and determination, one could create instantly when the time permits.