PURDUE UNIVERSITY

PROJECT WALKER

2019

500 Allison Road
West Lafayette, IN 47906

Table of Contents

Team Summary

1.1. Team Name and Mailing Address

Team Name	Purdue Space Program Student Launch (PSP-SL) a SEDS chapter
Team Size	There are 25 people on the PSP-SL 2019 Team
Mailing Address	107 MacArthur Drive, Room 150 West Lafayette, Indiana 47906

1.2. Team Lead Contact Information

Position	Name	Phone Number
Project Manager	Michael Repella	330-495-1270
Acting / Assistant Project Manager	Luke Perrin	219-798-7066
Safety Team Lead	Jory Lyons	219-252-2816
Avionics Team Lead	Bret Reser	779-400-6241
Payload Team Lead	Josh Binion	614-535-5223
Construction Team Lead	Zach Carroll	765-860-0861
Funding Team Lead	Sean Heapy	206-849-7329
Social Team Lead	Isaac Byely	765-631-5828

1.3. Mentor Contact Information and TRA/NAR Certifications

Mentor Name	Victor Barlow
Mentor Email / Cell	vmbarlow@purdue.edu / 765-414-2848
TRA/NAR Certifications	NAR 88988 L3CC, TRA 6839 TAP Level 3 Certified

2. Launch Vehicle Summary

2.1. Launch Vehicle Description

Launch Vehicle Name	5th Time's The Charm
Launch Vehicle Height [in]	120
Launch Vehicle Nominal Diameter [in]	5.15
Gross Lift-Off Weight (Wet Weight) [lbs]	42.5
Dry Weight [lbs]	34.45
Launch Vehicle Airframe / Nose Cone Material	Filament Wound Composite Fiberglass
Launch Vehicle Fin Material	FR-4 / G-10 Fiberglass
Launch Day Motor	AeroTech Rocketry L1520 Blue Thunder
Launch Day Motor Diameter [in]	2.95276
Launch Day Motor Grain Count	3
Launch Day Motor Total Impulse [N sec]	3,716
Launch Day Motor Burn Time [sec]	2.4
Launch Day Motor Total Thrust [N]	1,779
Launch Day Motor Propellant Weight [lbs]	4.09
Launch Day Motor Loaded Weight [lbs]	8.05

2.2. Recovery System Summary

Launch Vehicle Primary Altimeter	Altus Metrum - Telemetrum
Primary Altimeter Receiver	Altus Metrum - TeleDongle with Yagi 3 Arrow Antenna
Primary Altimeter Power Supply	3.7V LiPo Battery - 900 mAh
Launch Vehicle Secondary Altimeter	Missile Works - RRC3+ Sport
Secondary Altimeter Receiver	N/A
Secondary Altimeter Power Supply	Duracell 9V Battery

Drogue Parachute	SkyAngle Cert-III Drogue
Drogue Parachute Diameter [in]	24
Drogue Parachute Coef. of Drag	1.16
Altitude Deployment	Apogee
Main Parachute	SkyAngle Cert-III X Large
Main Parachute Diameter [in]	100
Main Parachute Coef. of Drag	2.59
Altitude Deployment AGL[ft]	700-900
Shock Cord Length [in]	40
Shock Cord Thickness [in]	1/2
Shock Cord Material	Tubular Kevlar
Shock Cord Weight Rating [lbs]	7,200
Launch Vehicle Rail Size [in]	1.5
Launch Vehicle Rail Length [ft]	12

2.3. Payload Description

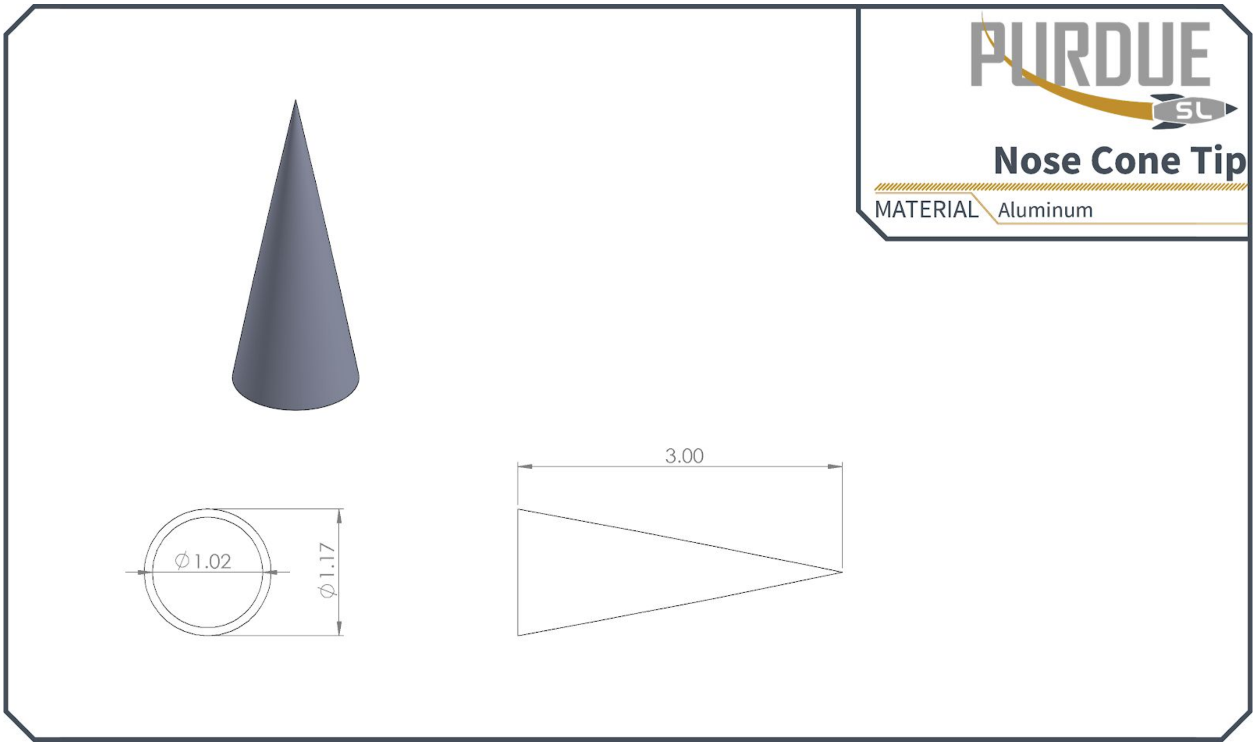
The experimental payload that will be flown in this launch vehicle will be known as the "Walker Texas Rover".

The PSP-SL team will launch an autonomous rover and soil sampling system as a payload. The rover will be deployed from the payload bay upon landing and must drive at least 10 feet away from any part of the rocket. This motion will employ a system of sensory data collection and execution of obstacle avoidance maneuvers. Once it has travelled at least the decided upon distance from the closest located rocket part, it will begin soil sampling.

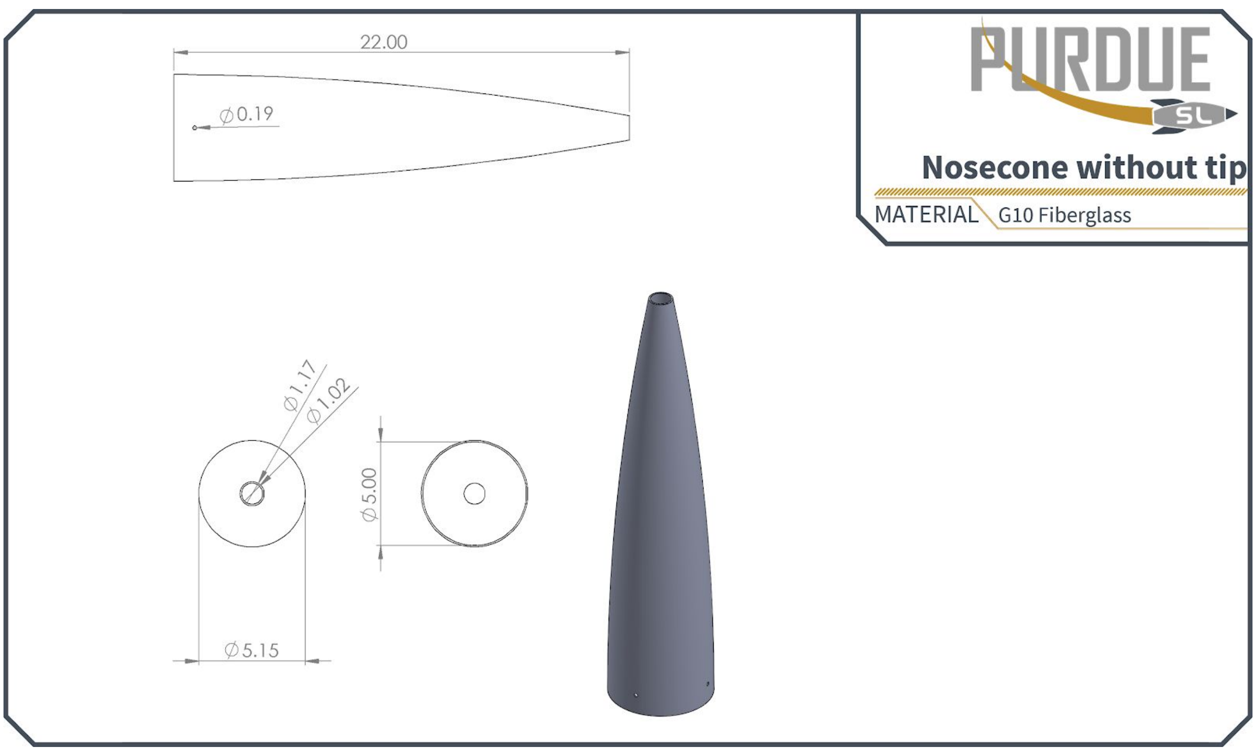
3. Launch Vehicle CAD

3.1. Nose Cone

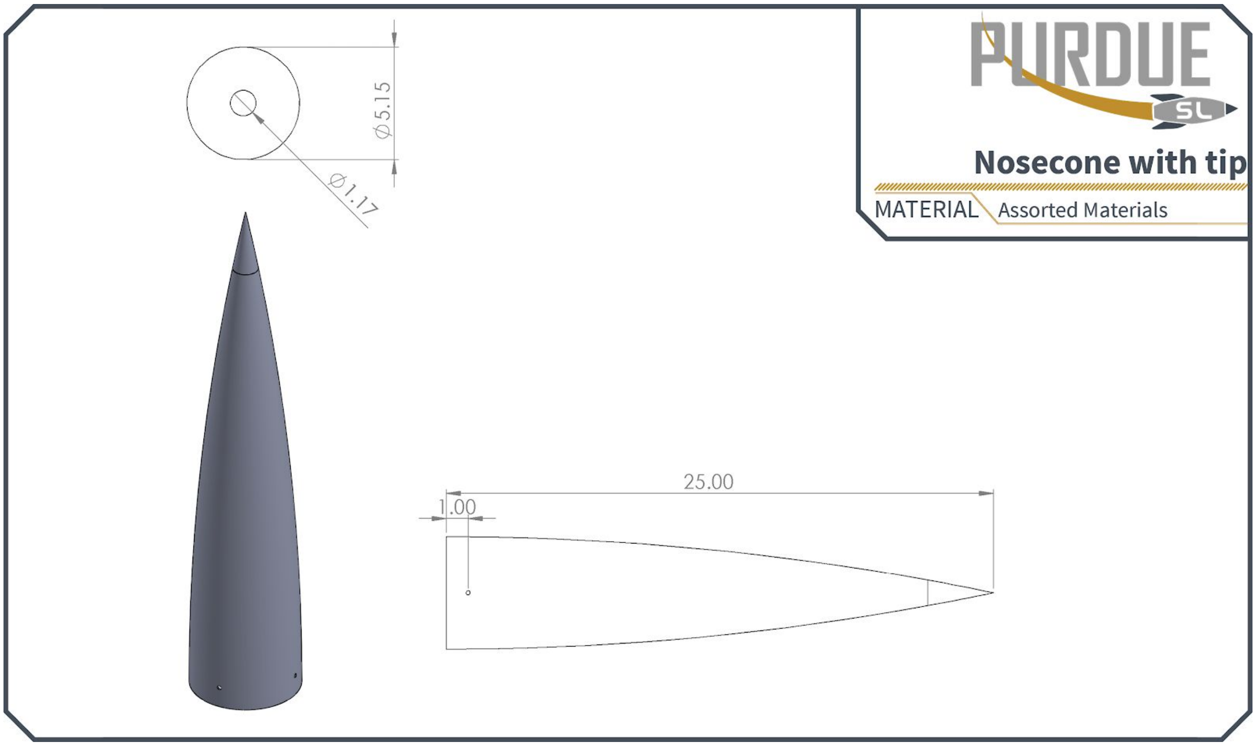
3.1.1. Nose Cone Tip



3.1.2. Nose Cone (without tip)



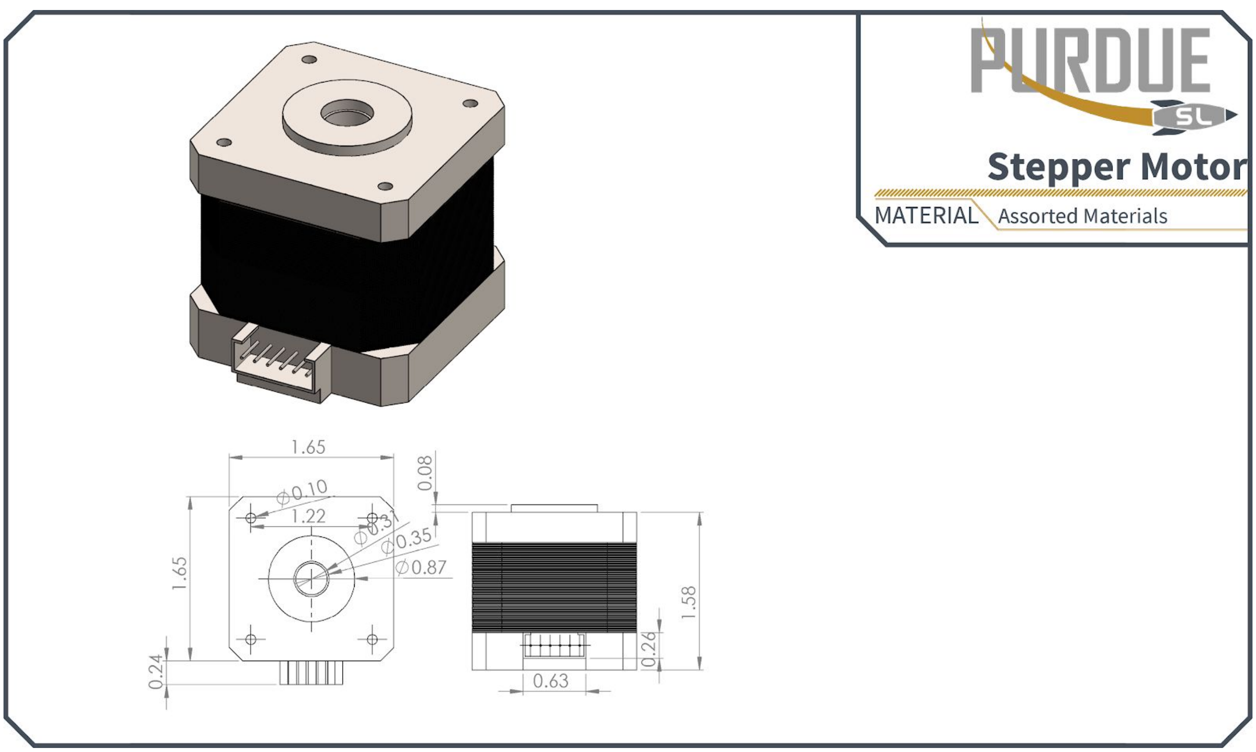
3.1.3. Nose Cone (with tip)



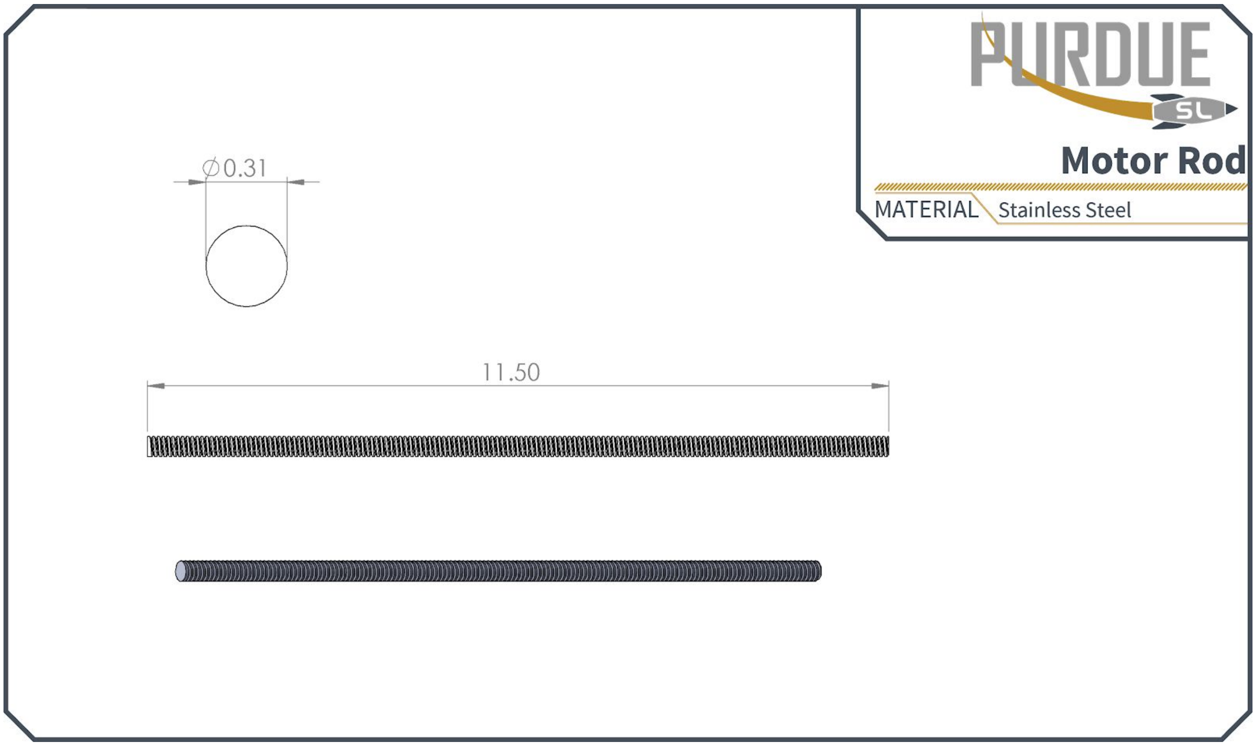
3.2. Payload

3.2.1. Payload Containment Bay

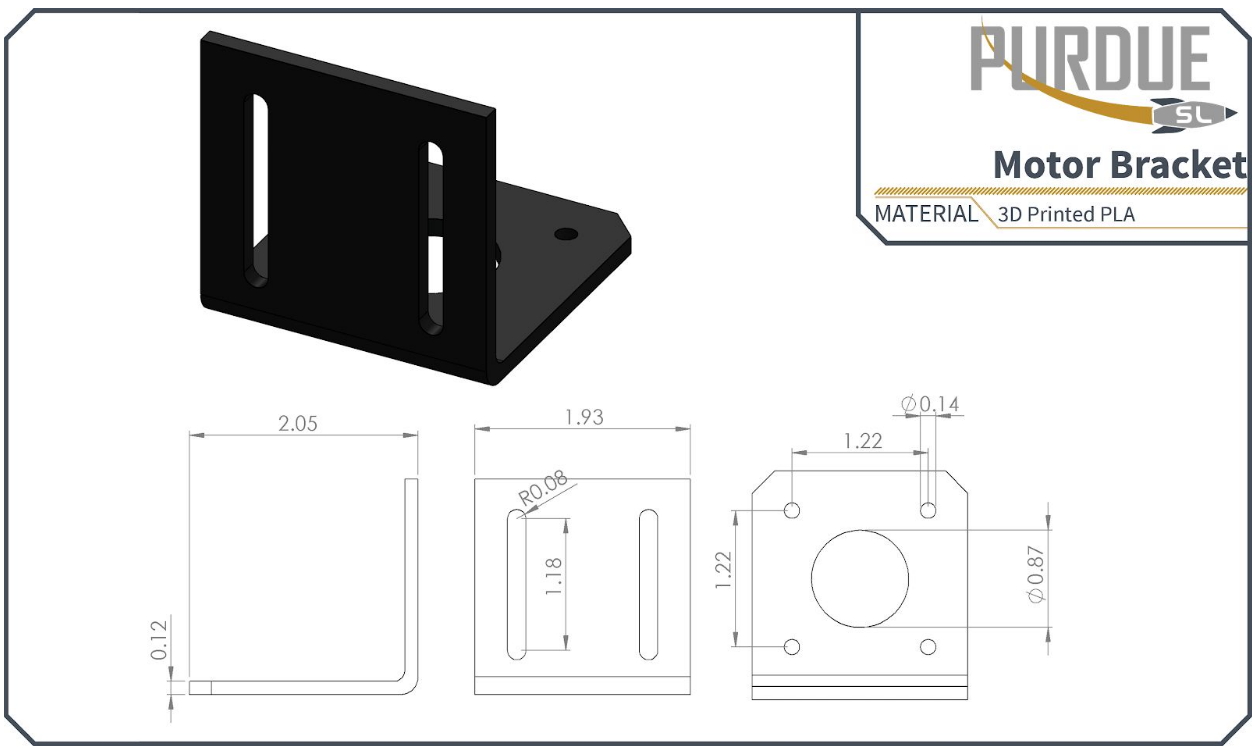
3.2.1.1. Stepper Motor



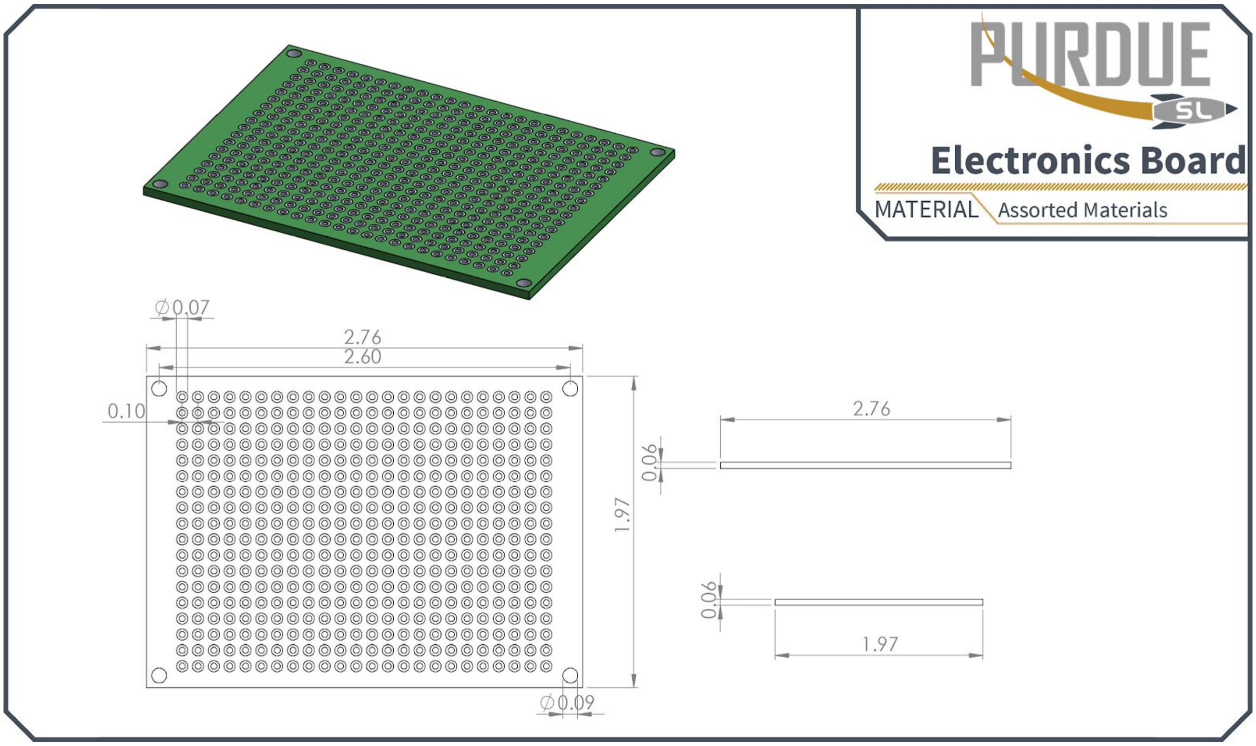
3.2.1.2. Stepper Motor Threaded Rod



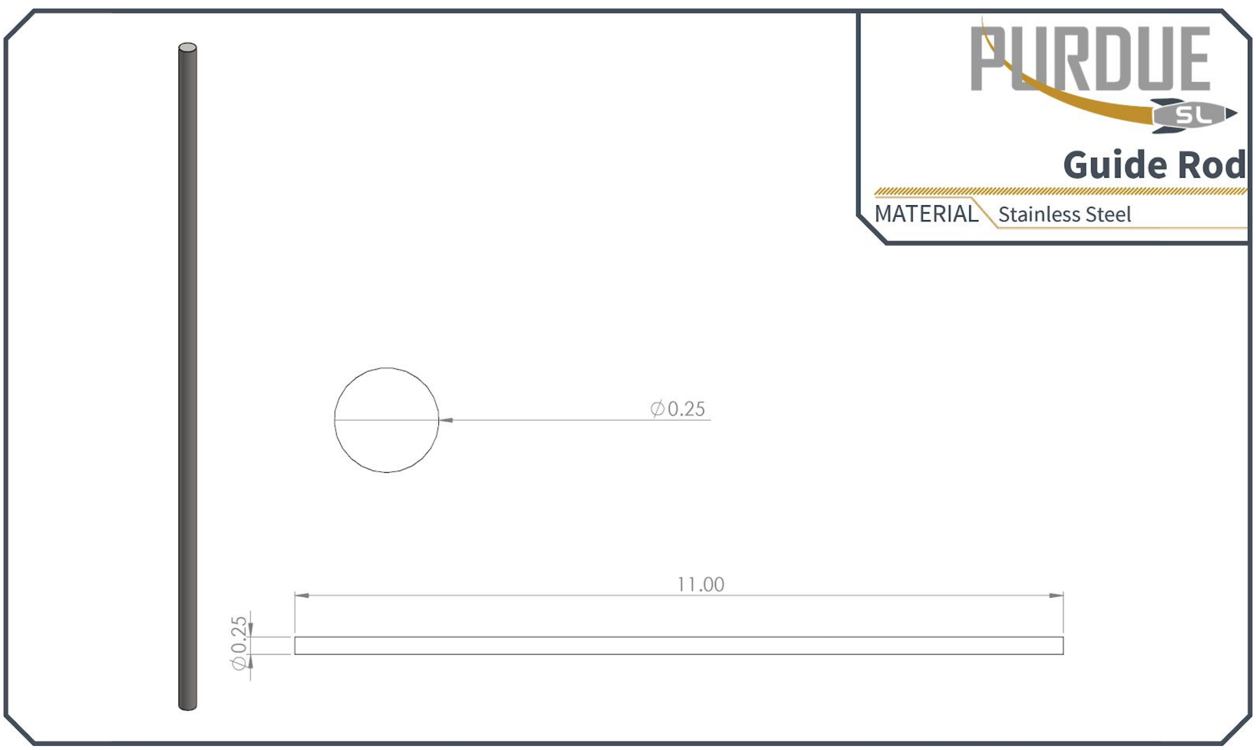
3.2.1.3. Stepper Motor Mount Bracket



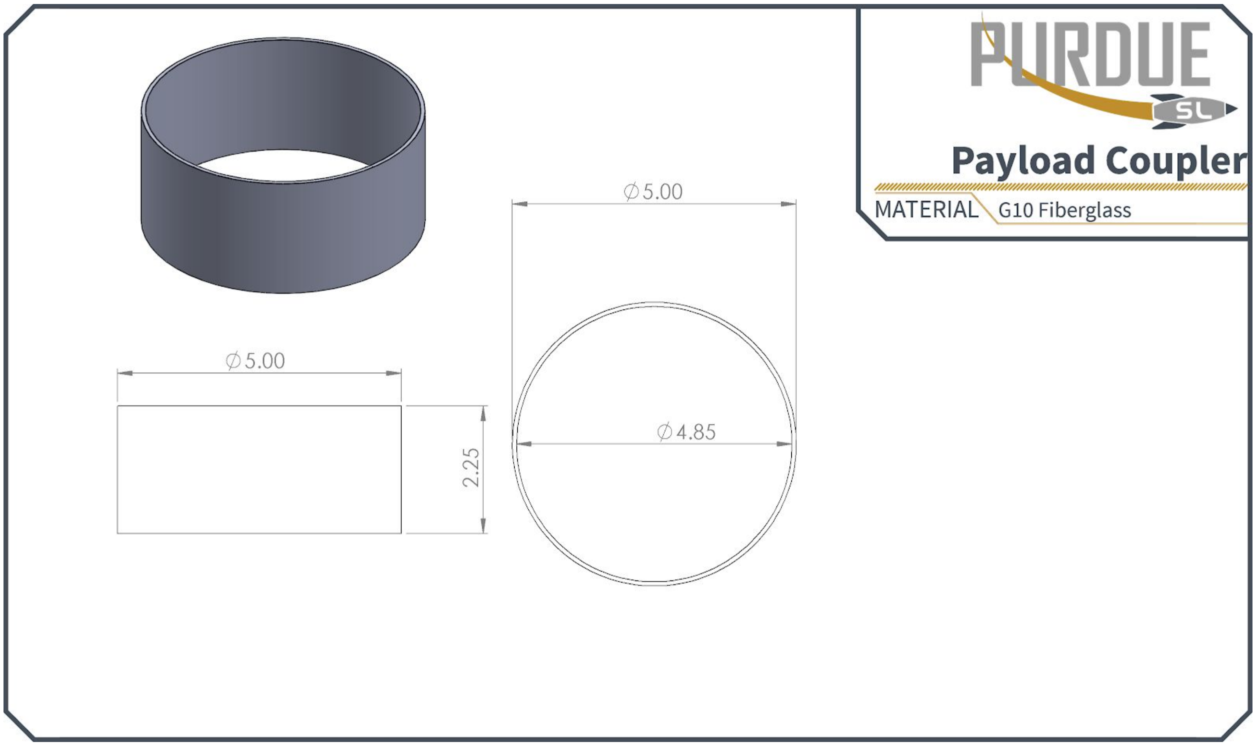
3.2.1.4. Electronics Board



3.2.1.5. Guide Rod

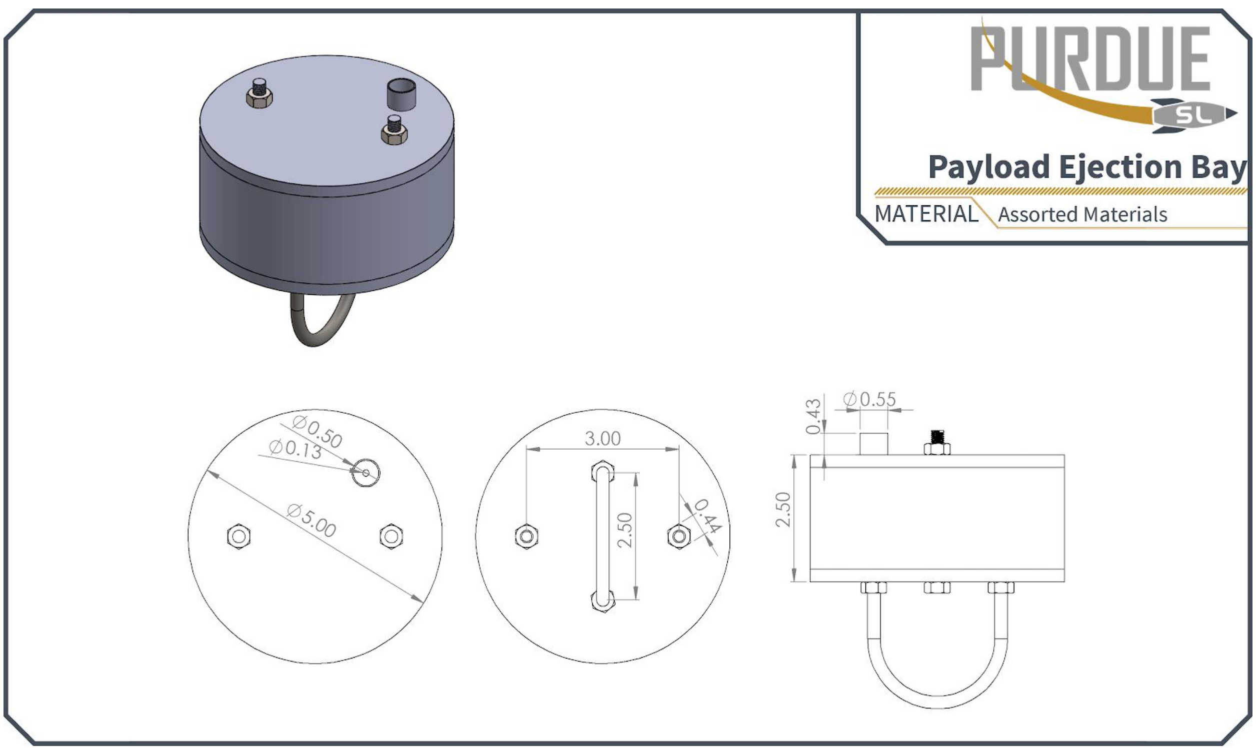


3.2.2. Payload Coupler

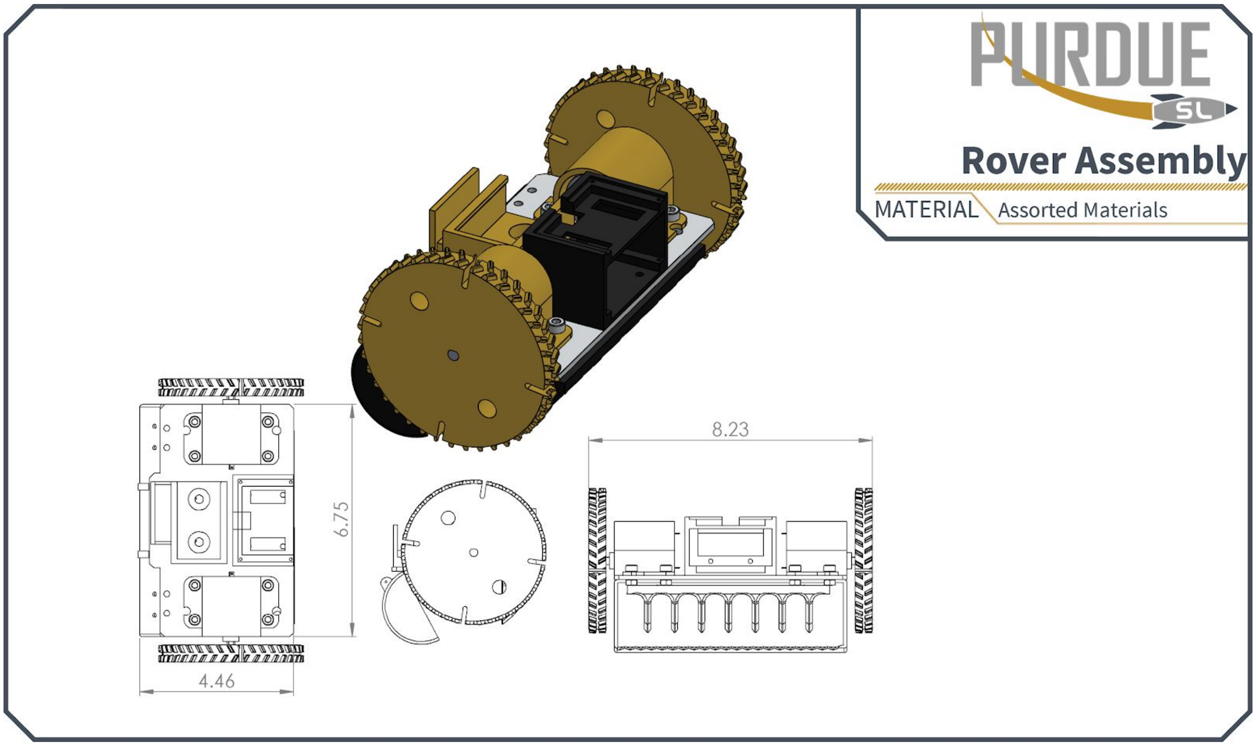


3.2.3. Payload Ejection

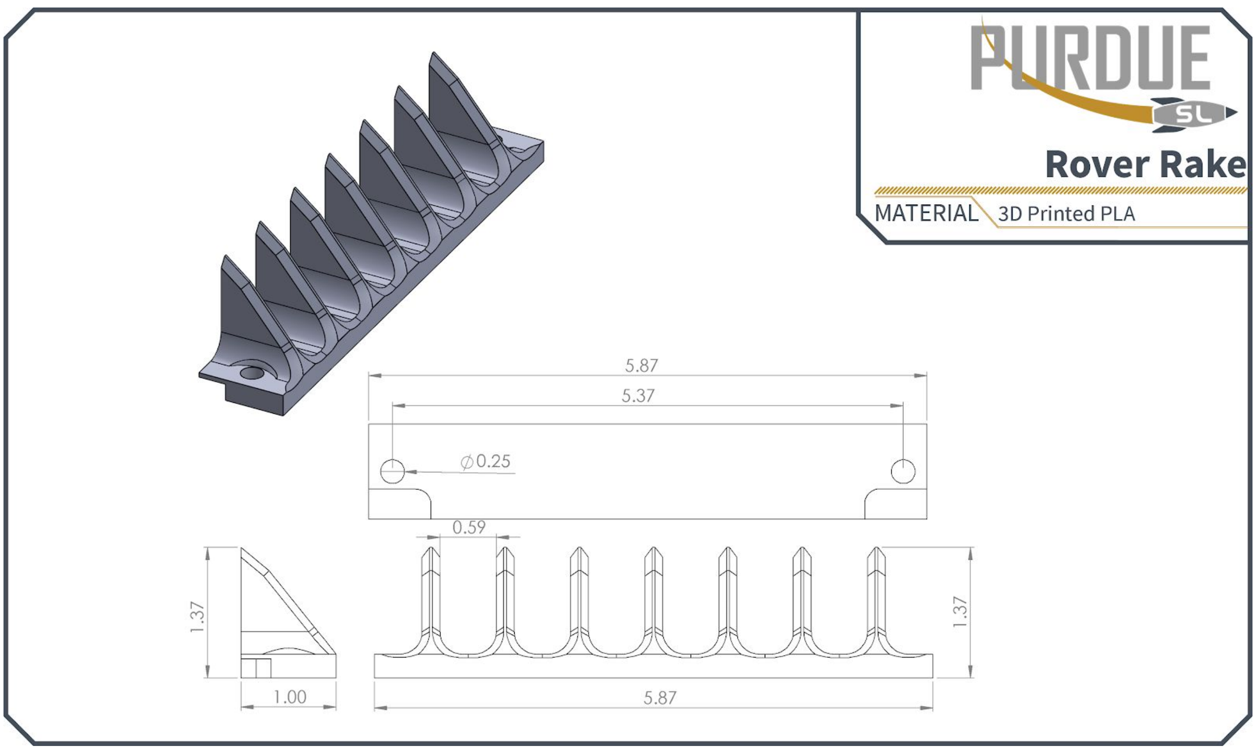
3.2.3.1. Payload Ejection Bay



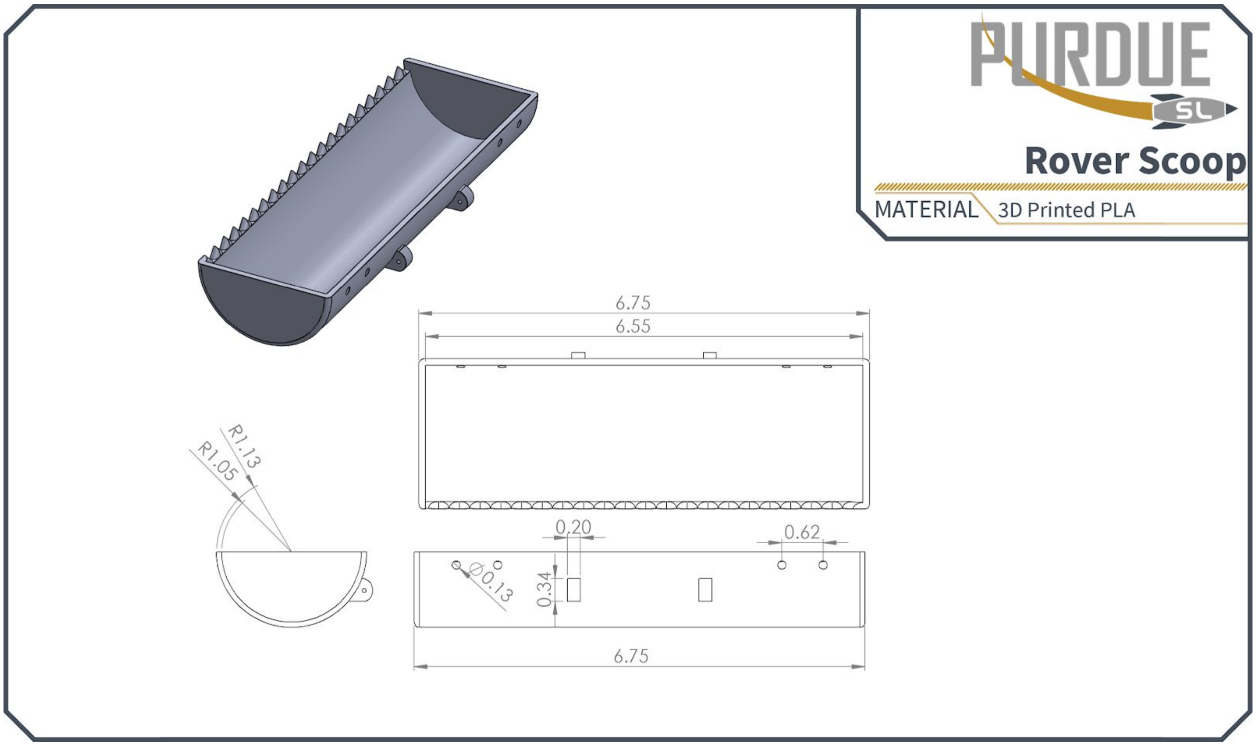
3.2.3.2. Rover



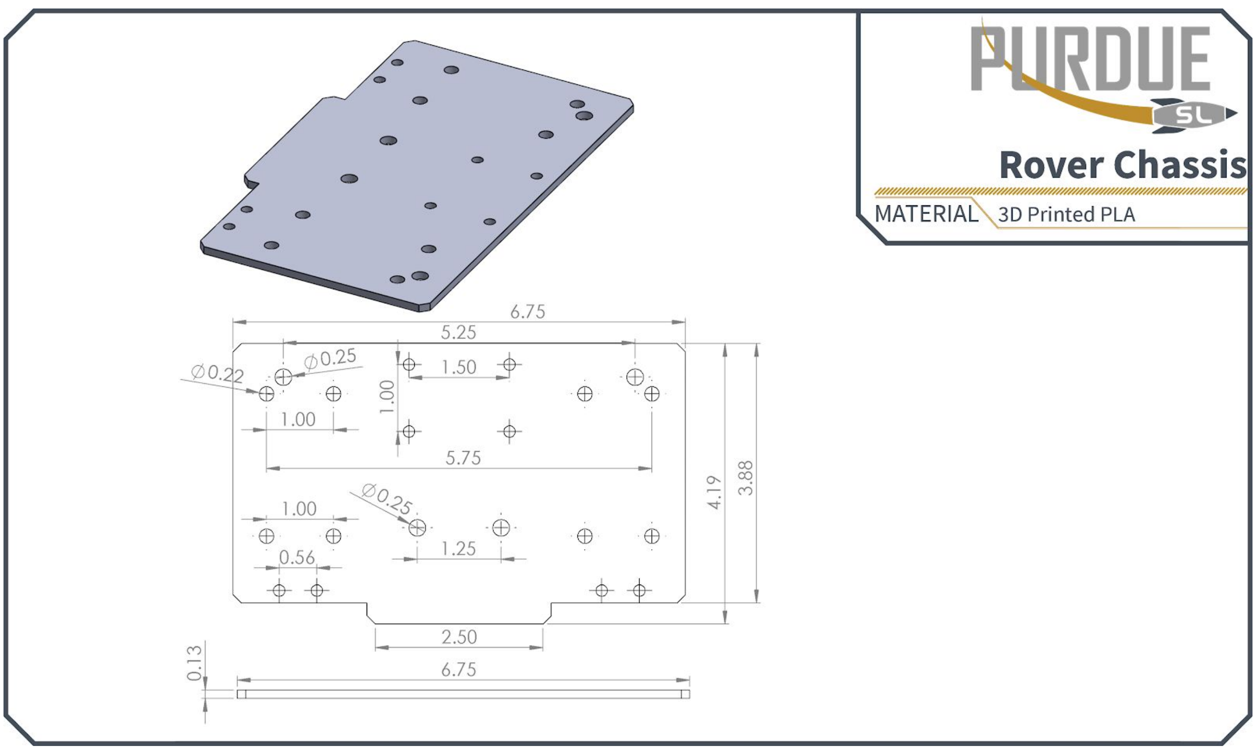
3.2.3.3. Rover Rake



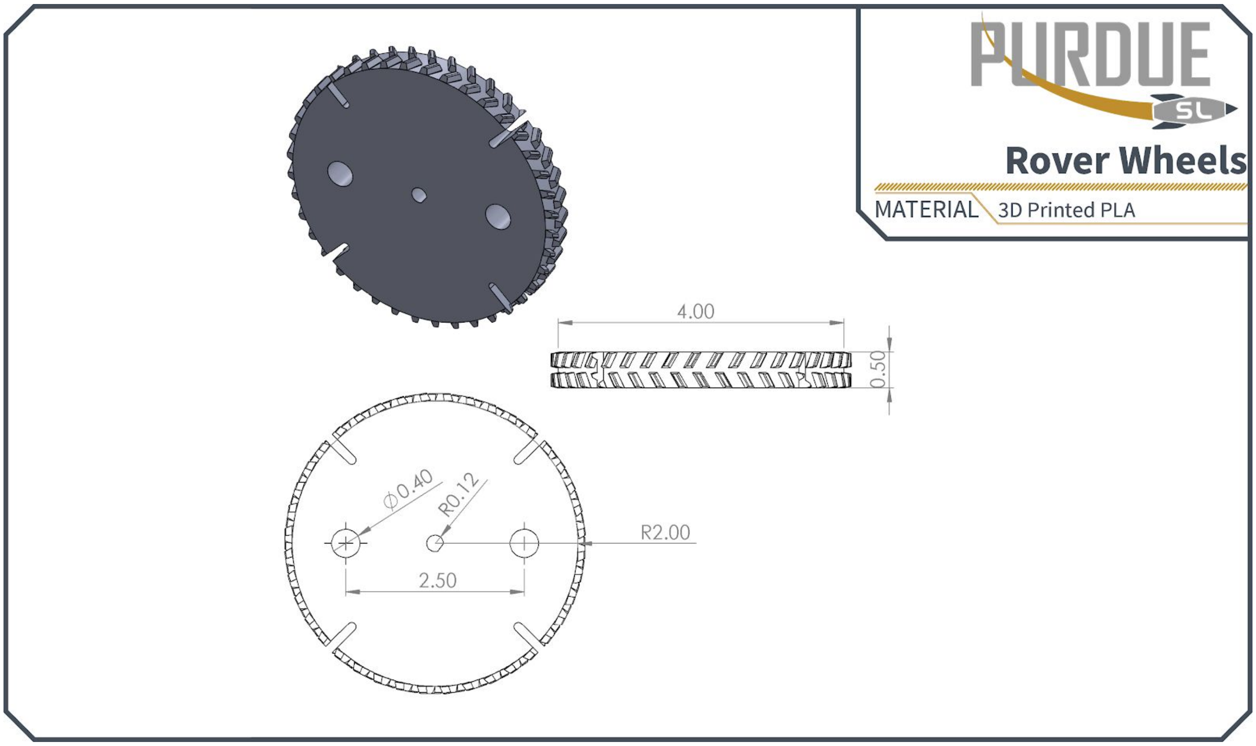
3.2.3.4. Rover Scoop



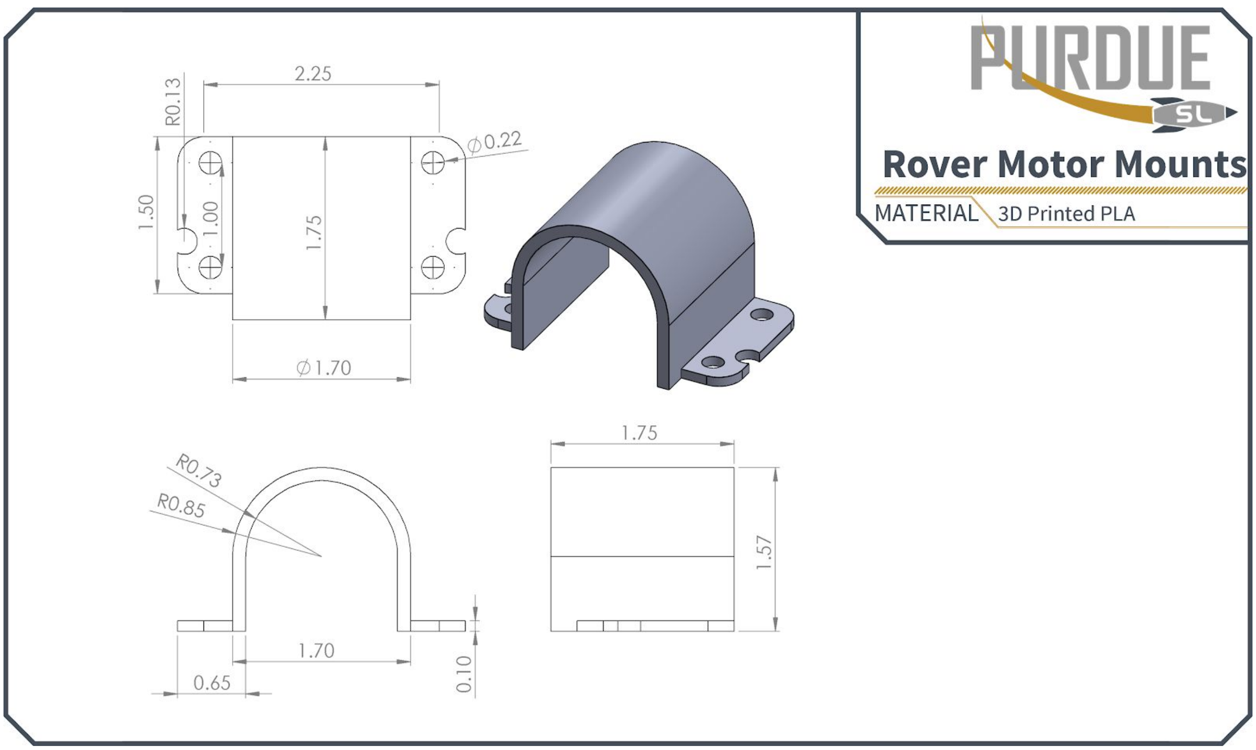
3.2.3.5. Rover Chassis



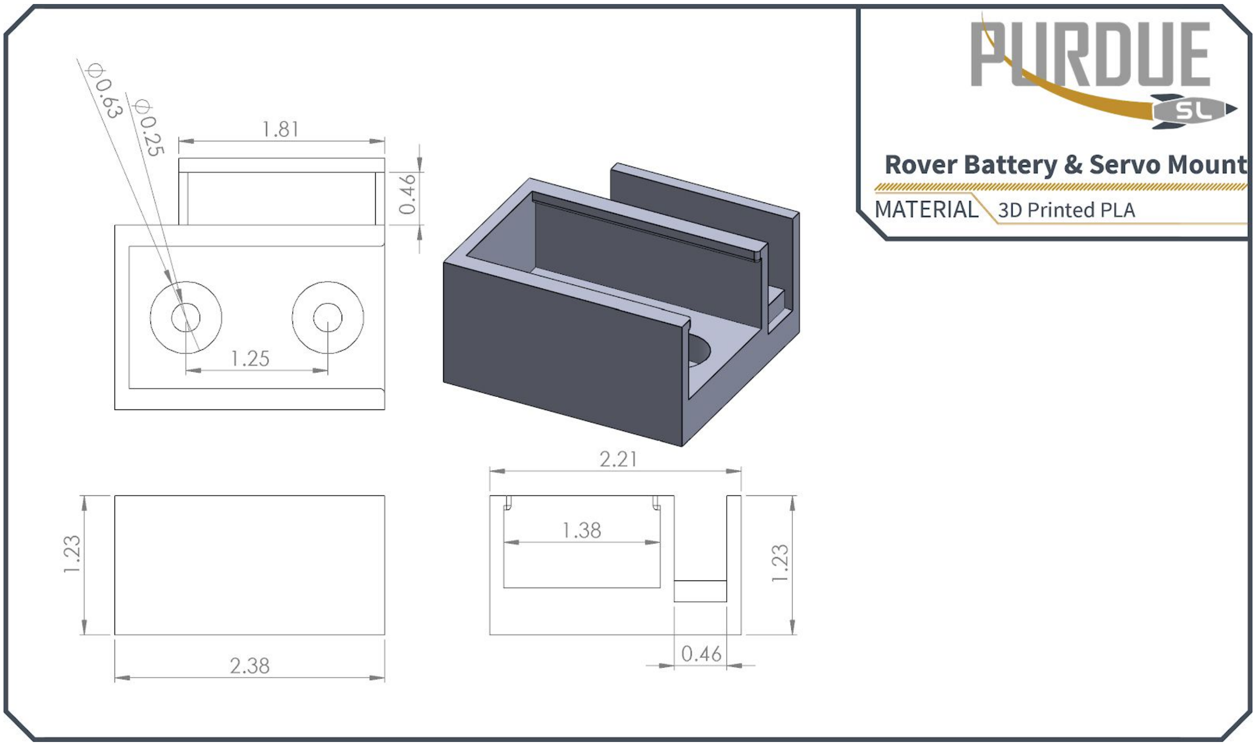
3.2.3.6. Rover Wheels



3.2.3.7. Rover DC Motor Mounts

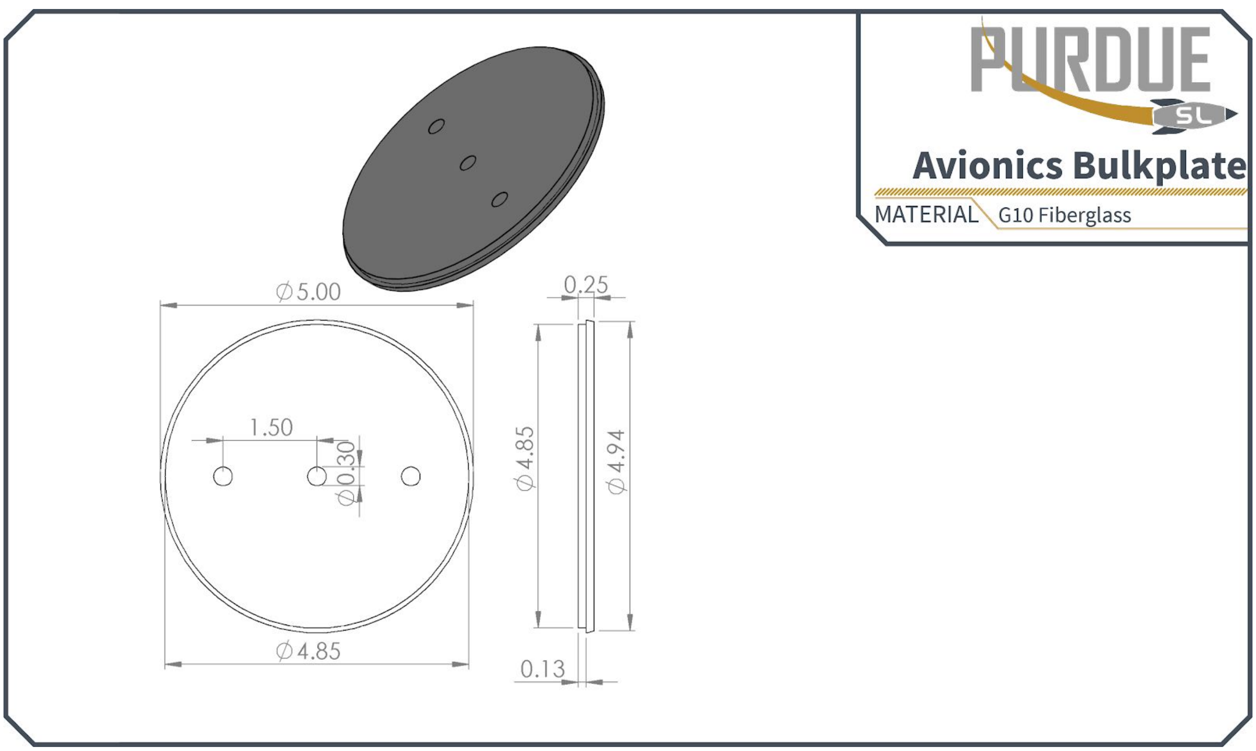


3.2.3.8. Rover Battery / Servo Mount

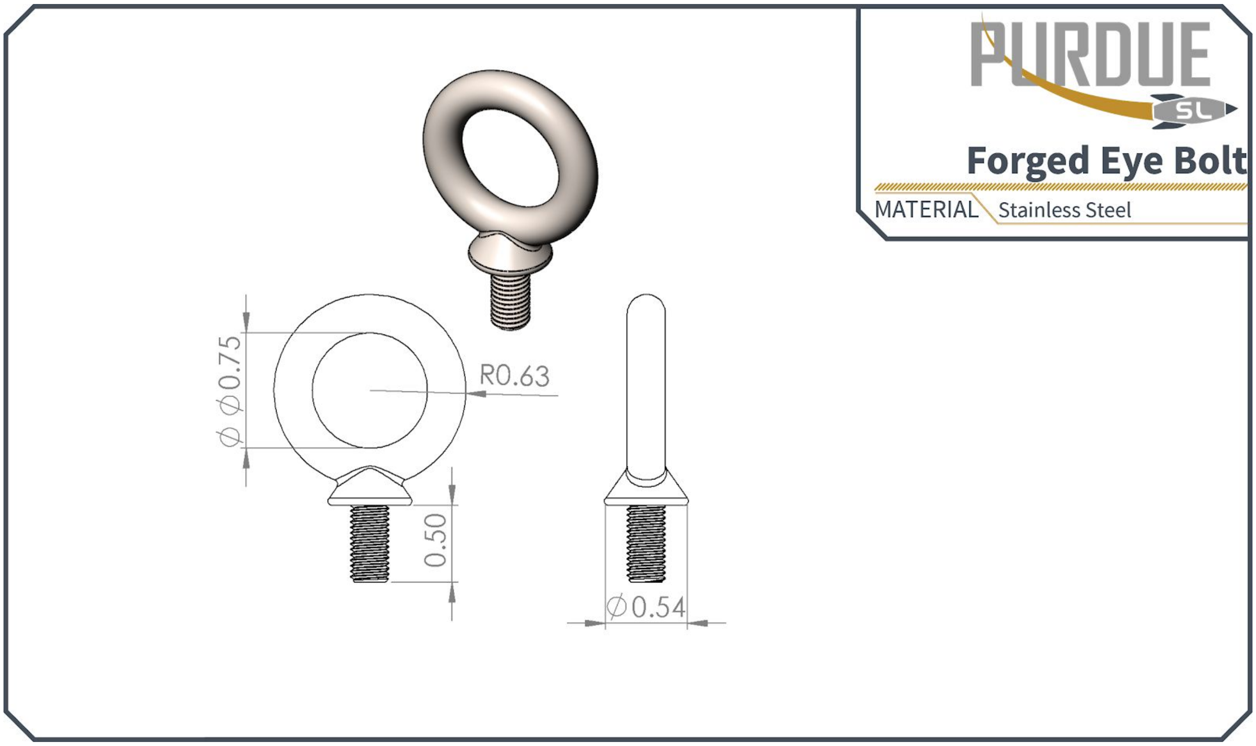


3.3. Avionics

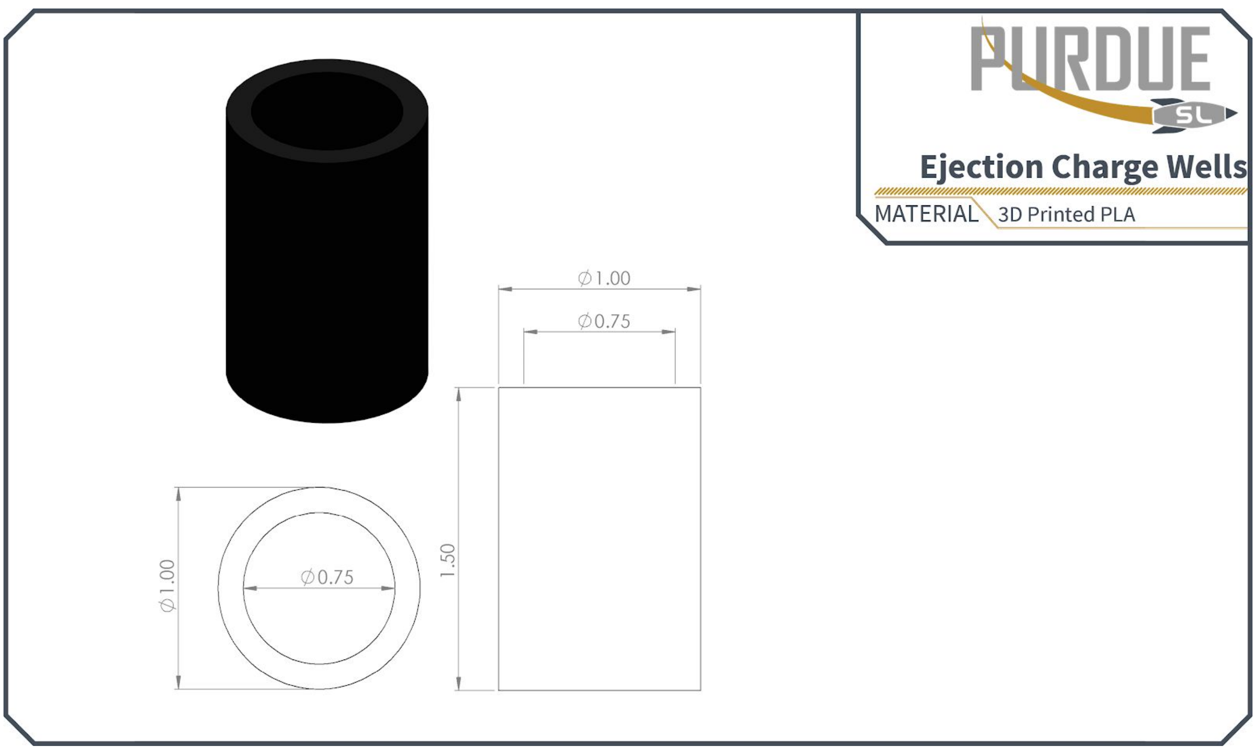
3.3.1. Avionics Bulk Plates



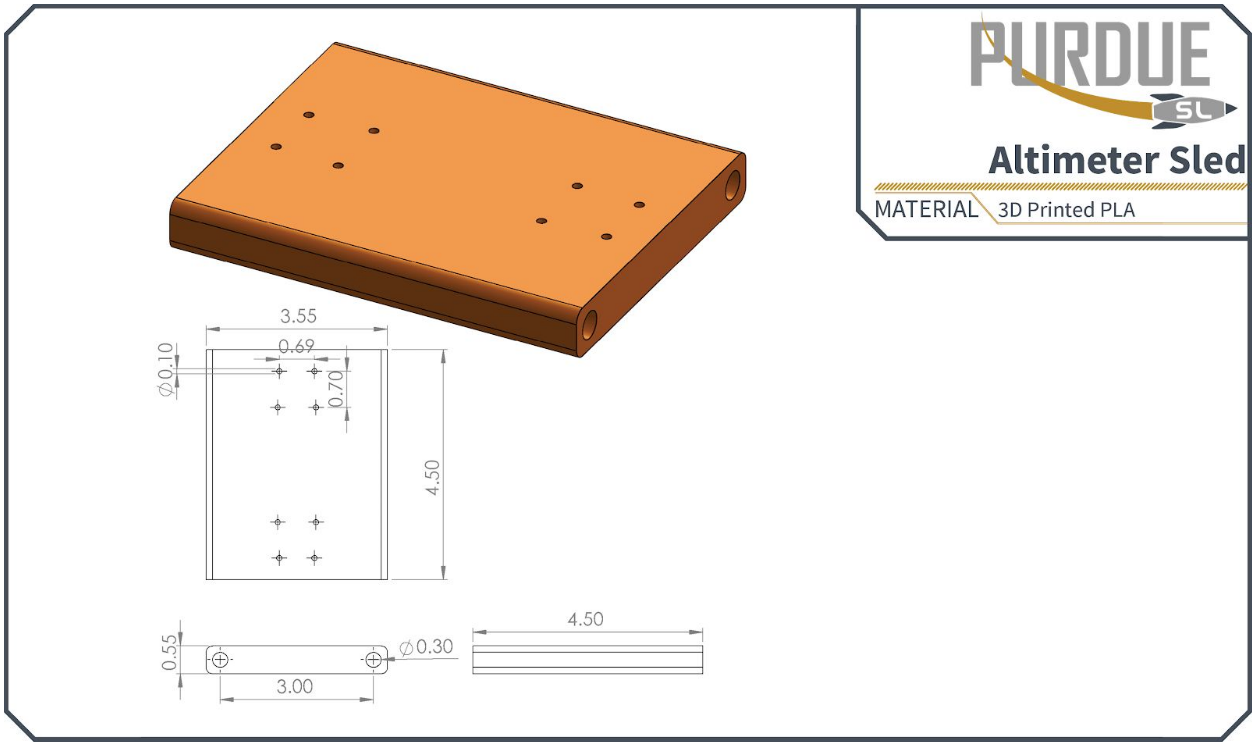
3.3.2. Forged Eye Bolt



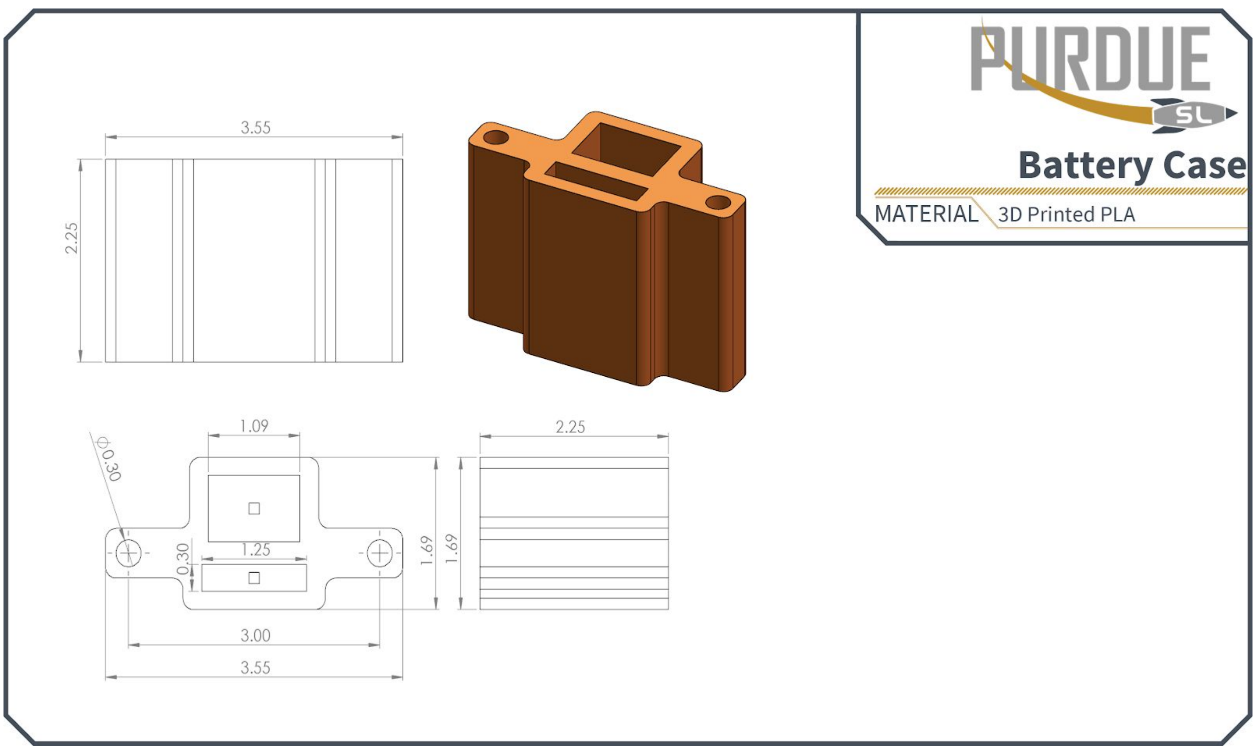
3.3.3. Ejection Charge Wells



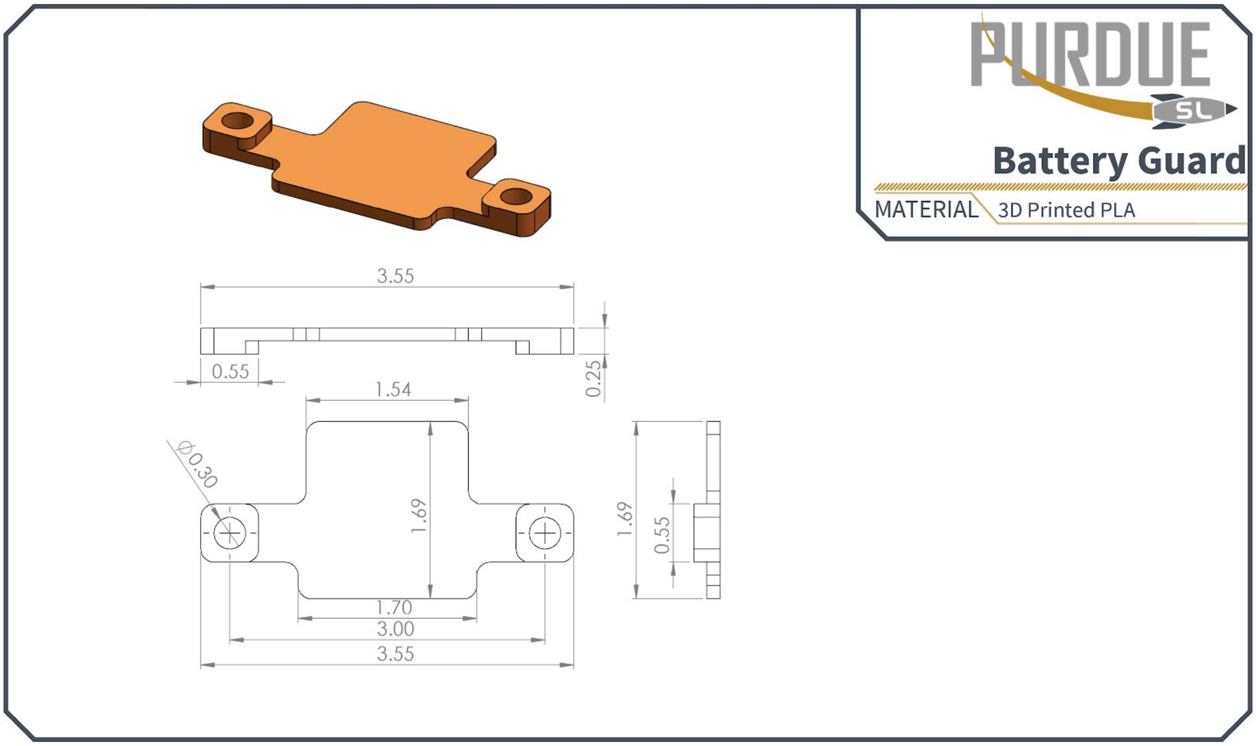
3.3.4. Altimeter Sled



3.3.5. Battery Case

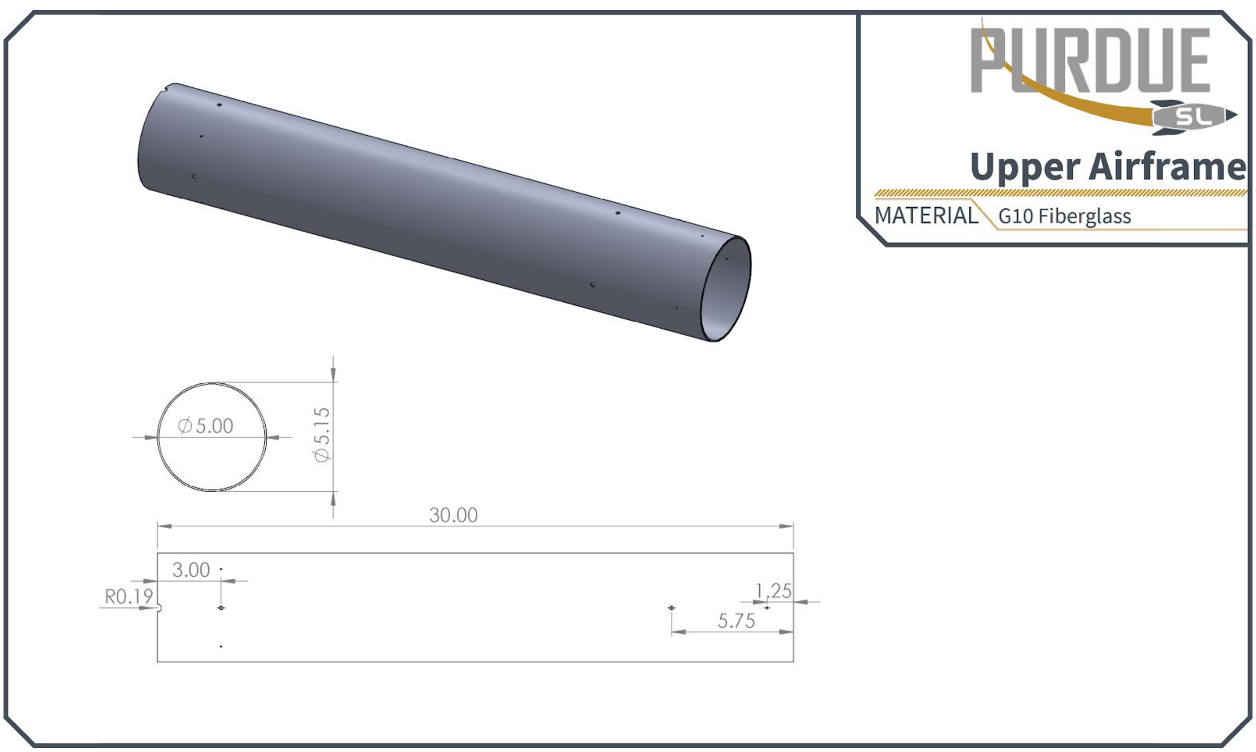


3.3.6. Battery Closure Piece

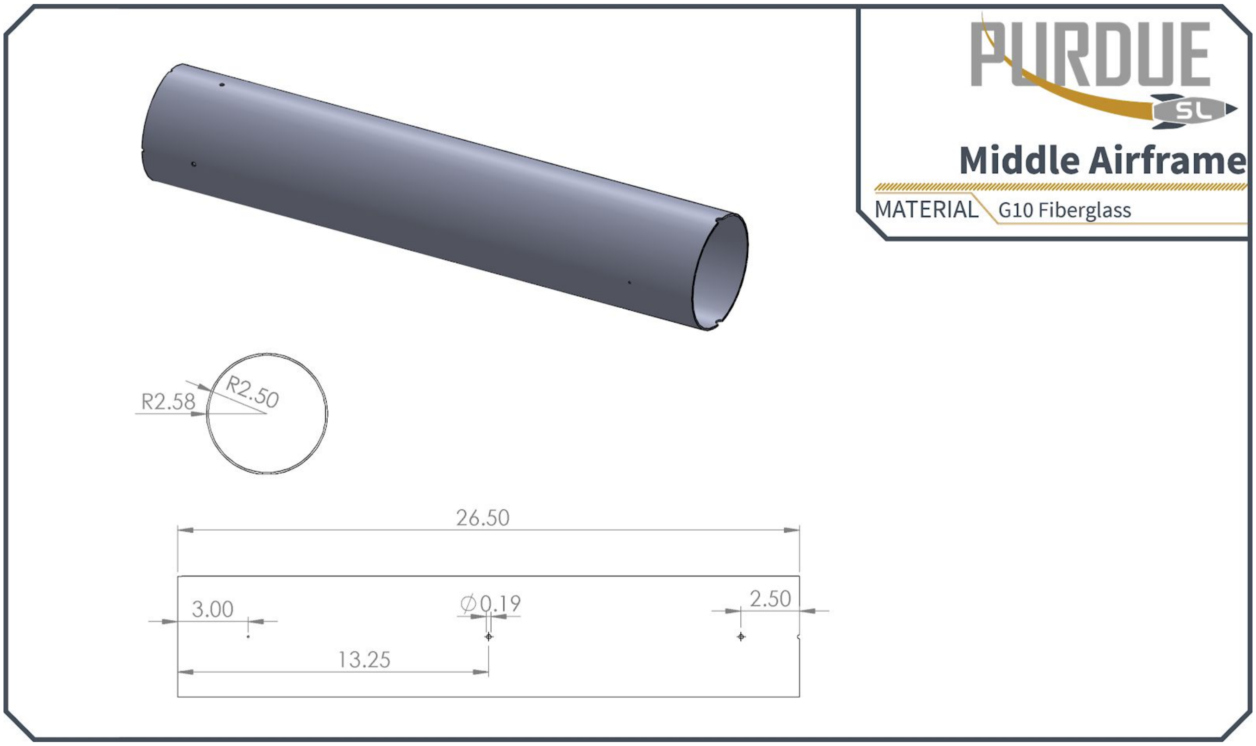


3.4. Launch Vehicle Body

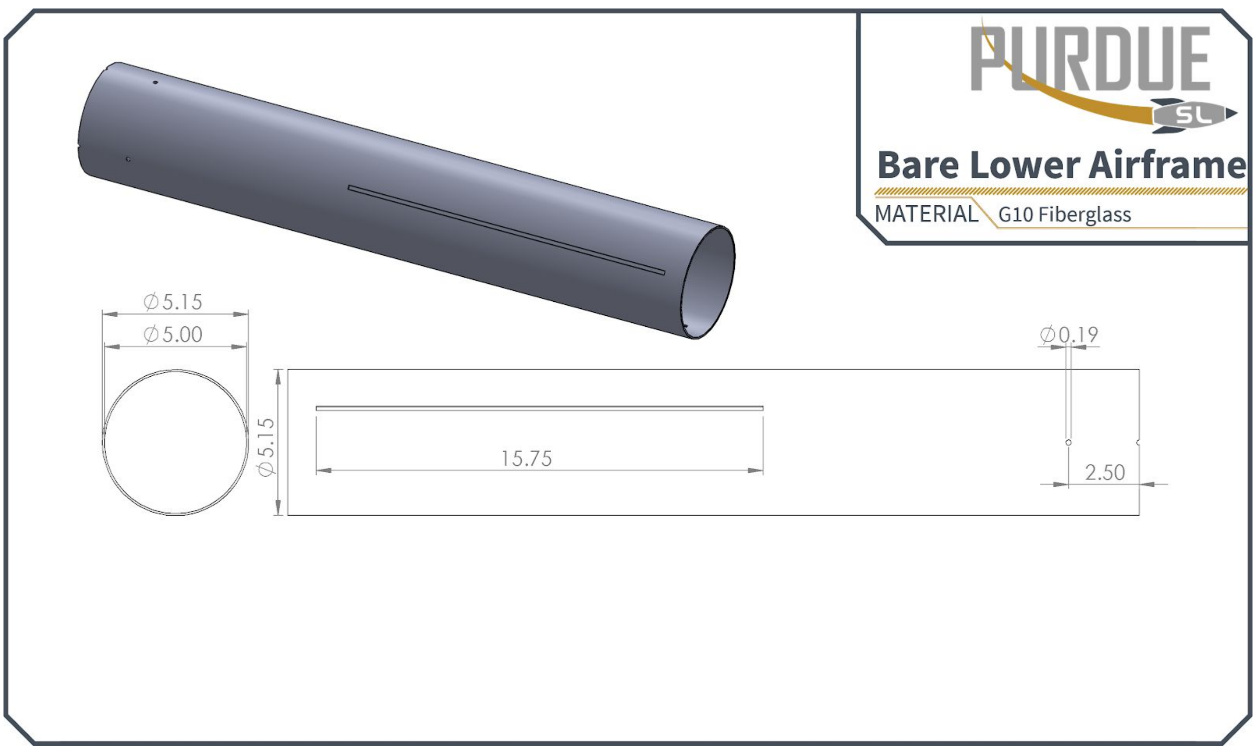
3.4.1. Upper Airframe



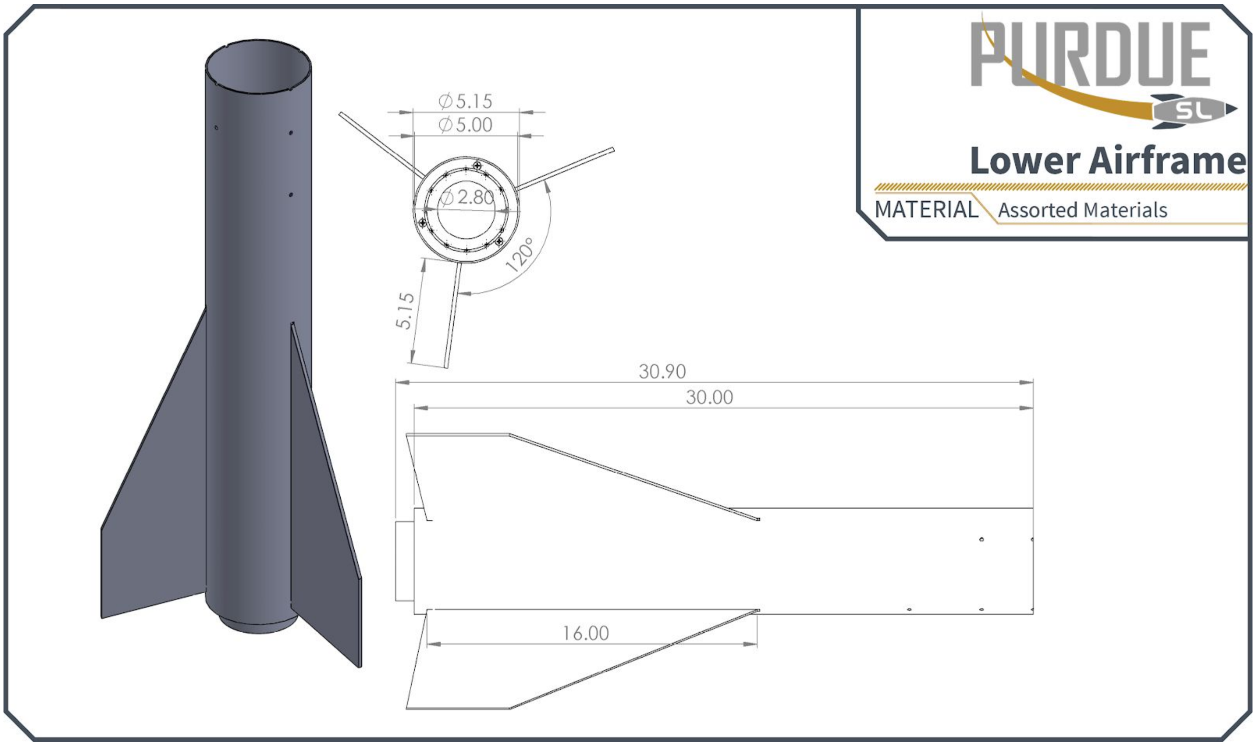
3.4.2. Middle Airframe



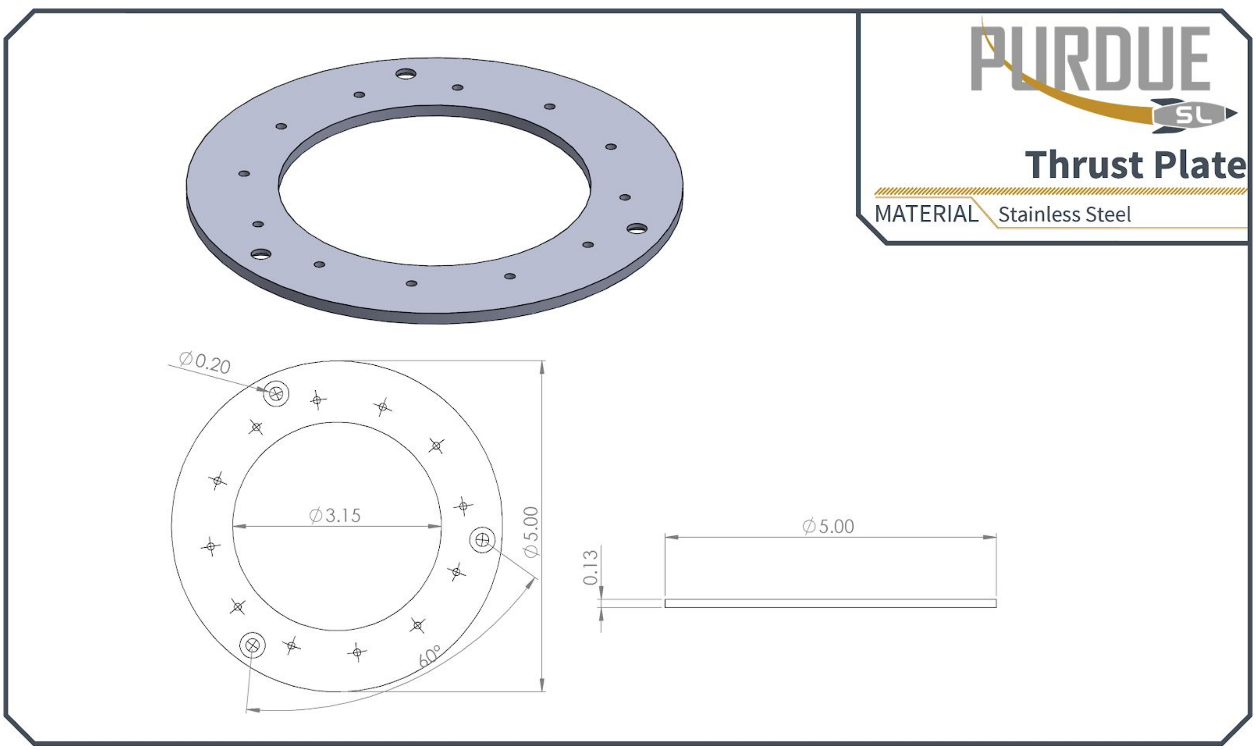
3.4.3. Bare Lower Airframe



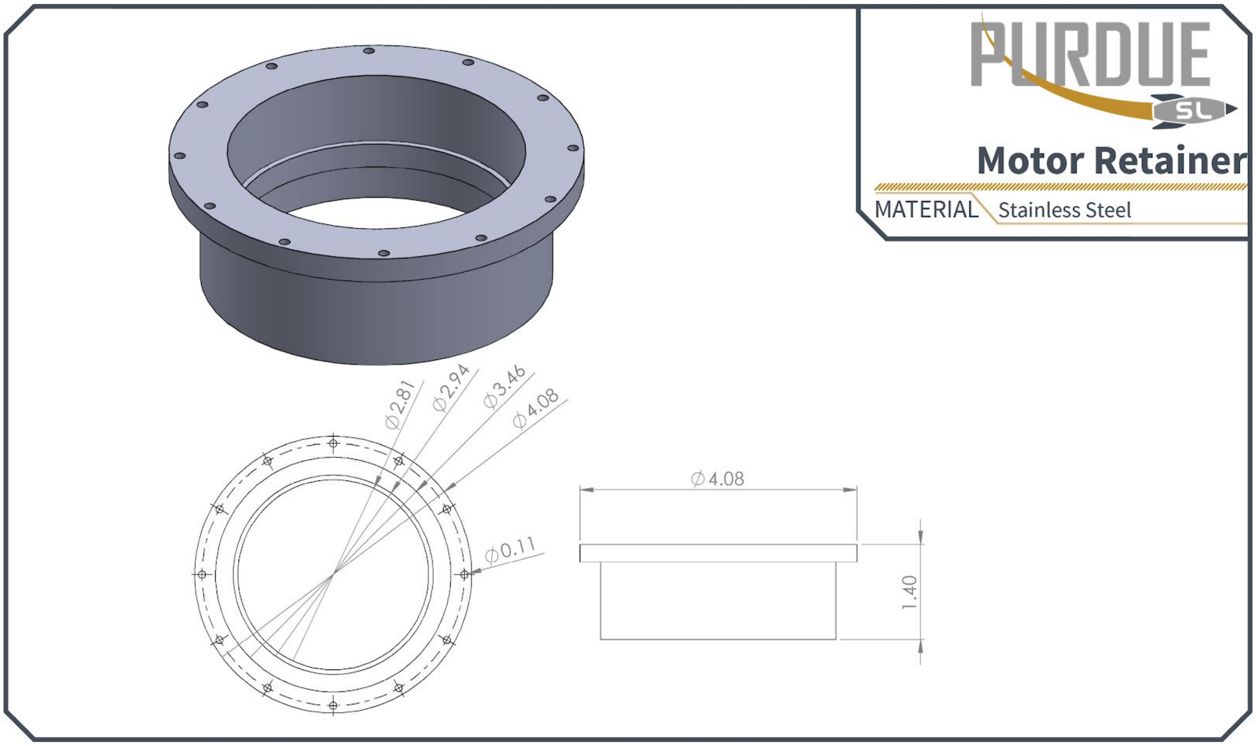
3.4.4. Lower Airframe



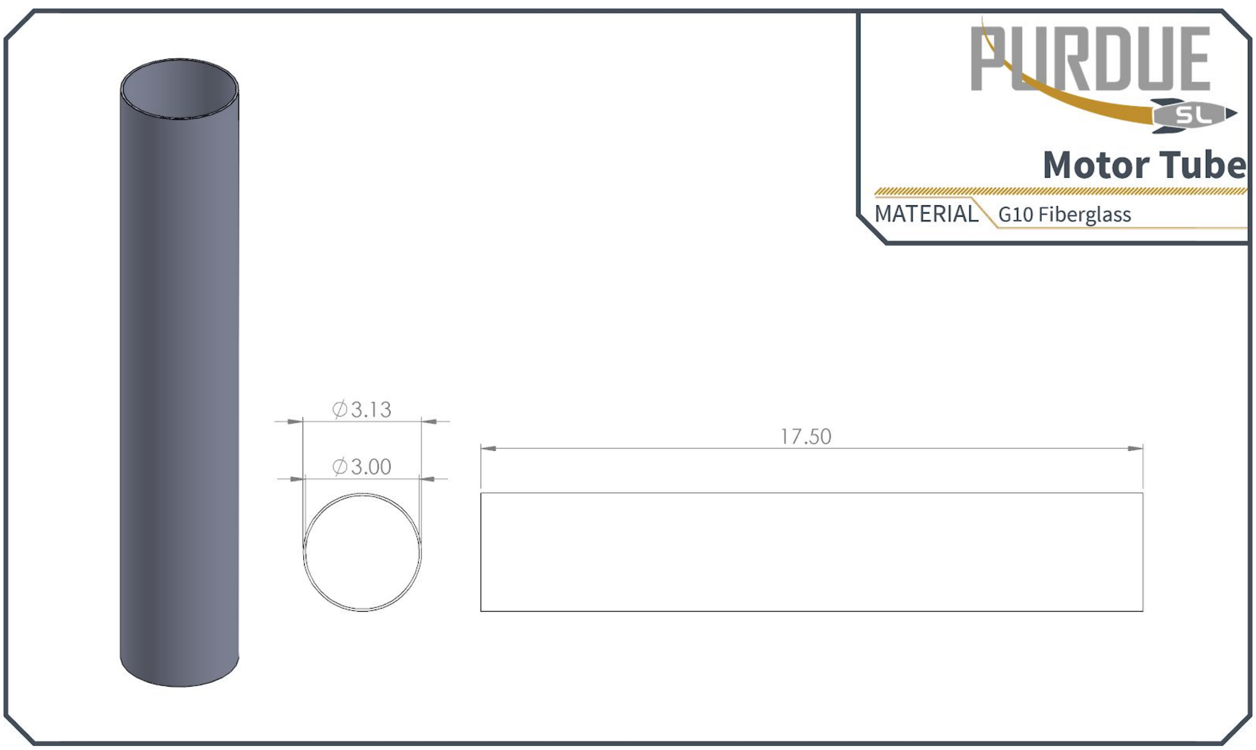
3.4.5. Thrust Plate



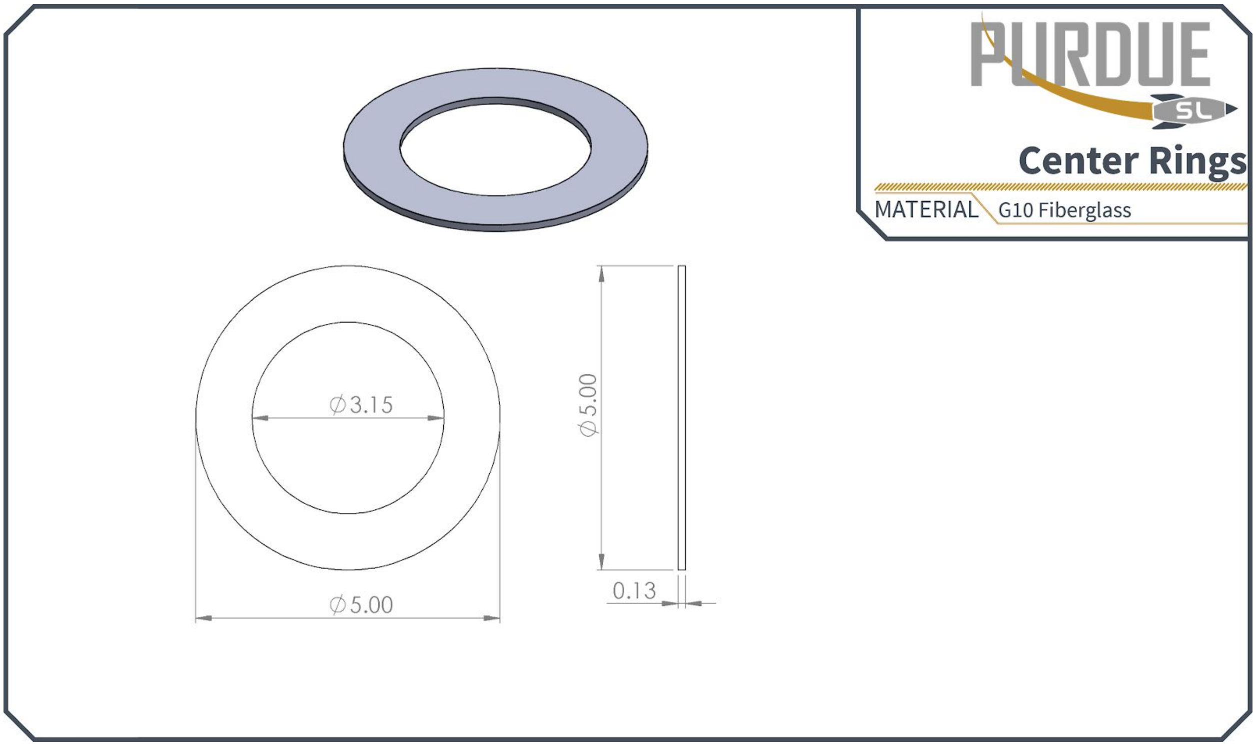
3.4.6. Motor Retainer



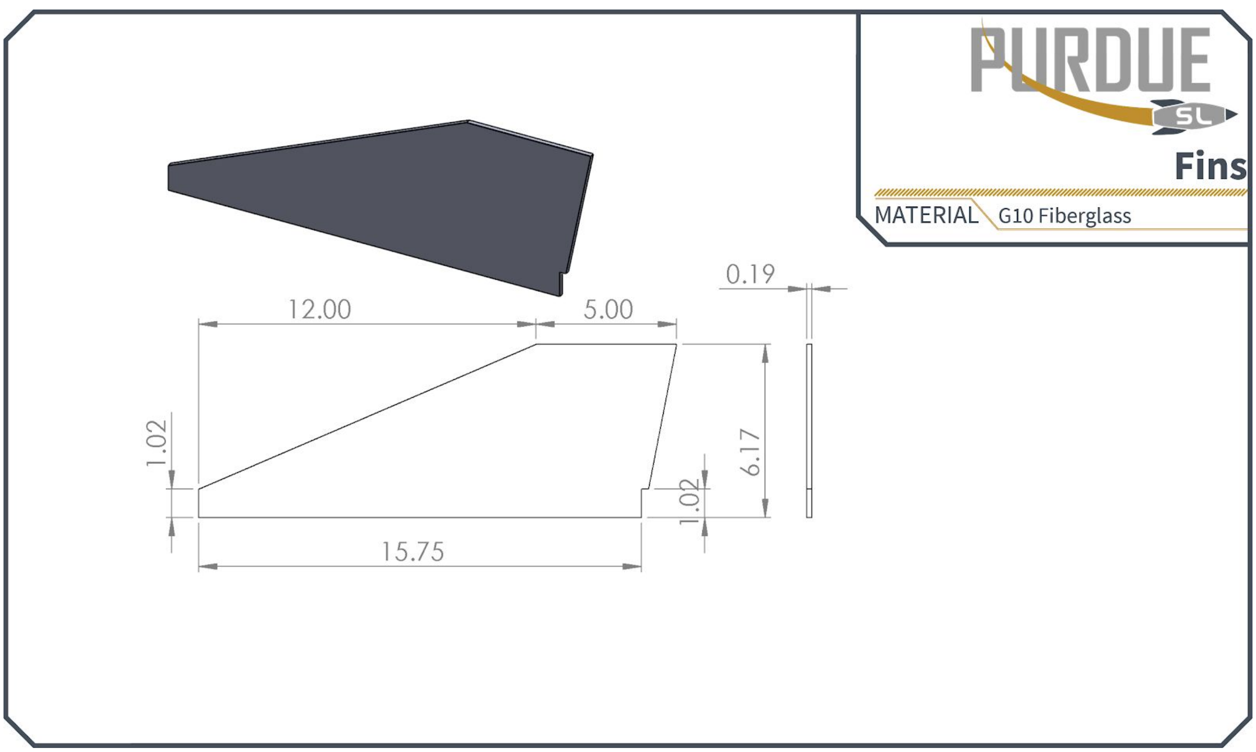
3.4.7. Motor Tube



3.4.8. Center Rings

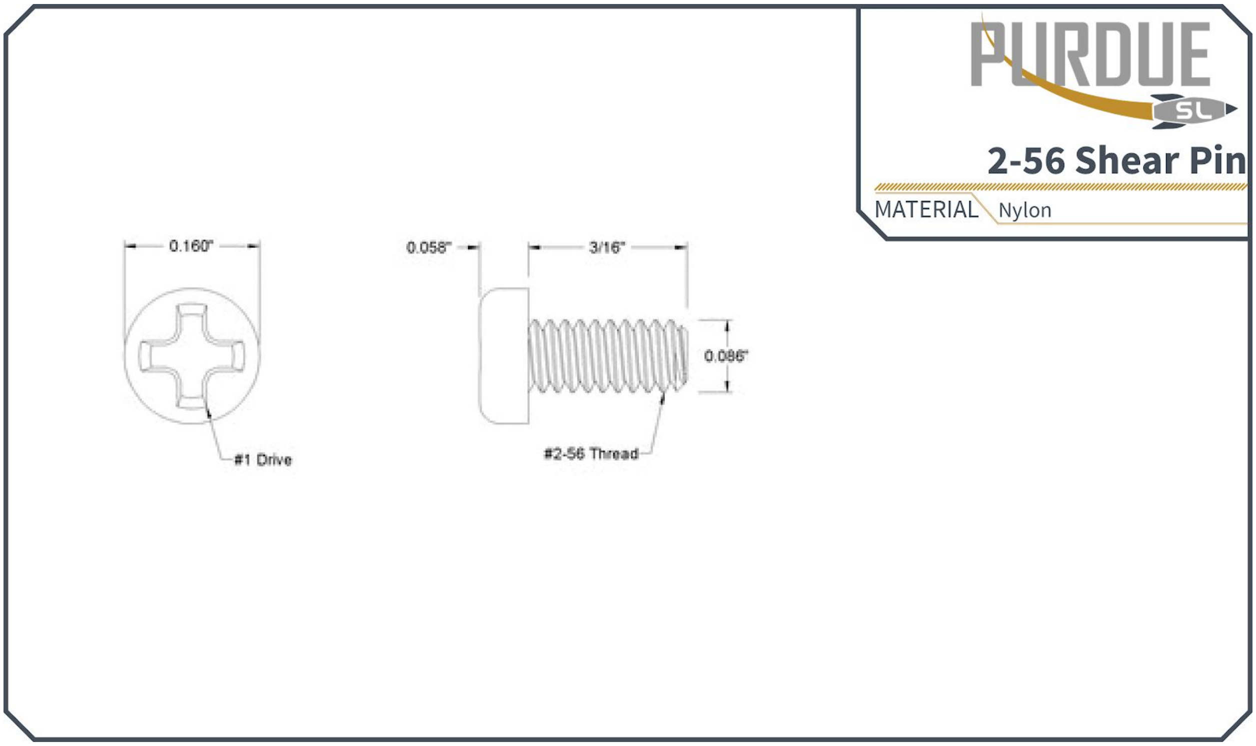


3.4.9. Fins

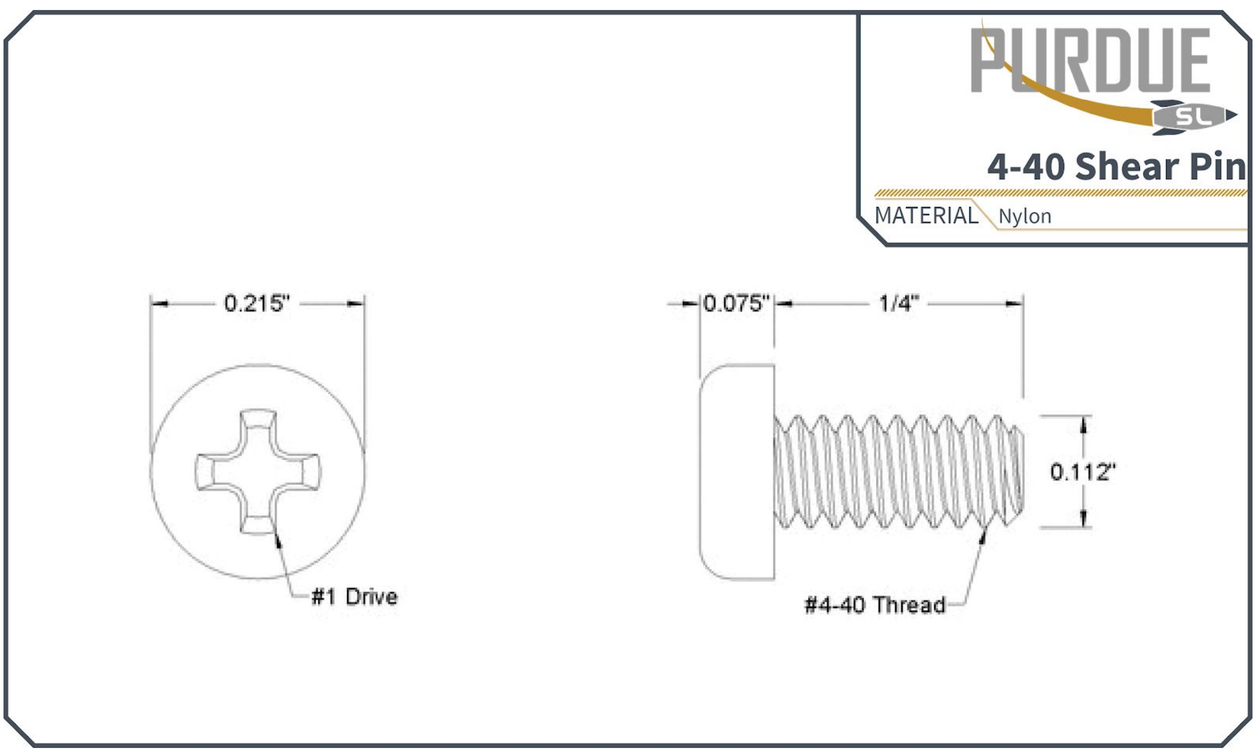


3.5. Miscellaneous

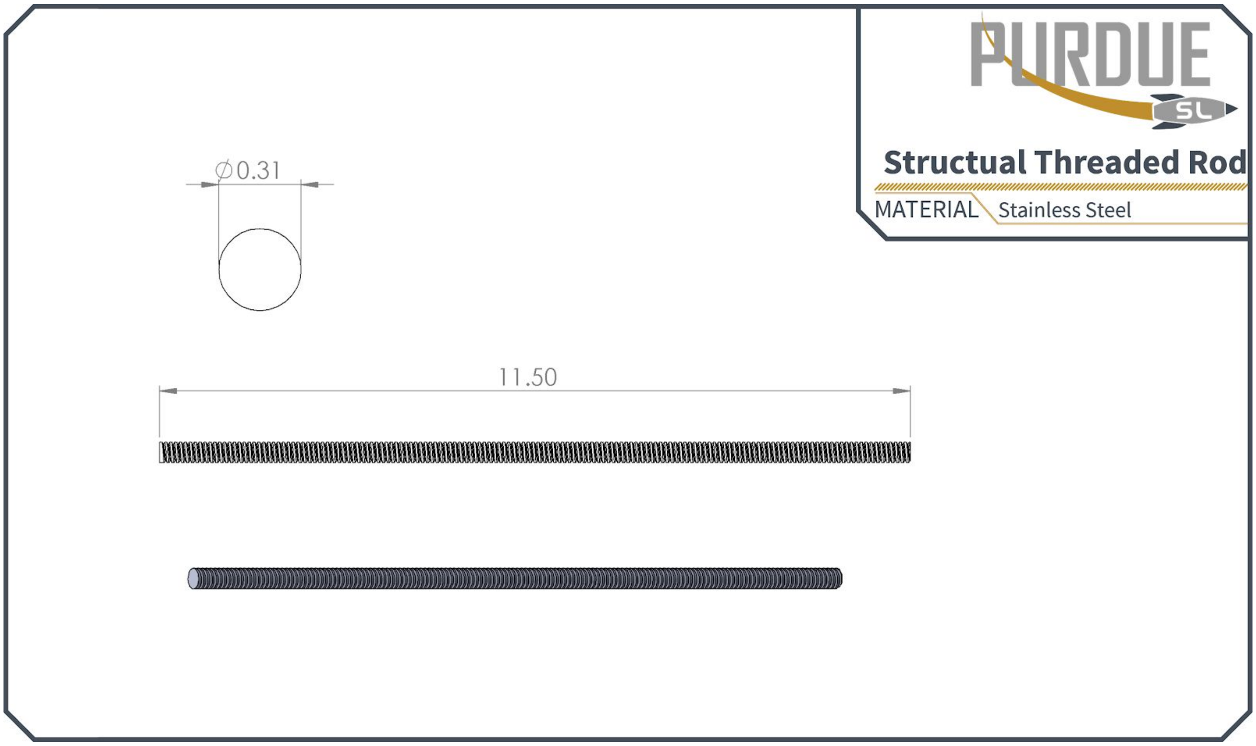
3.5.1. 2-56 Shear Pin



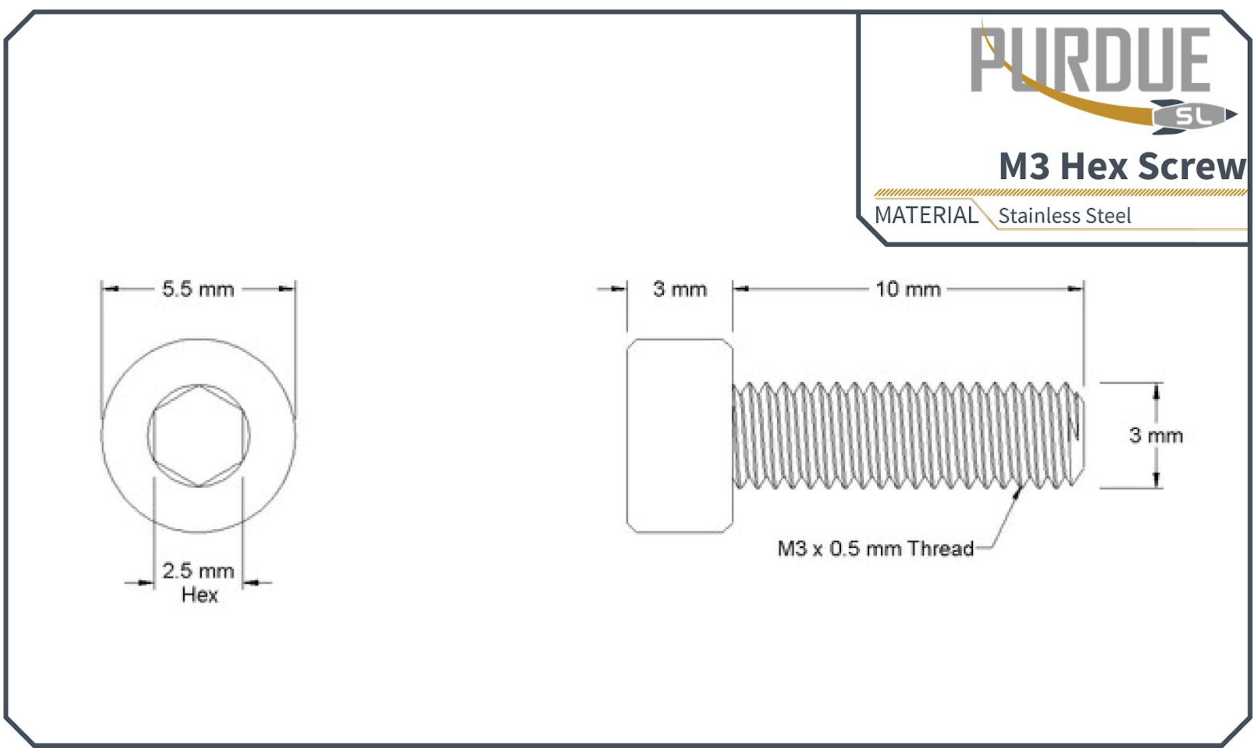
3.5.2. 4-40 Shear Pin



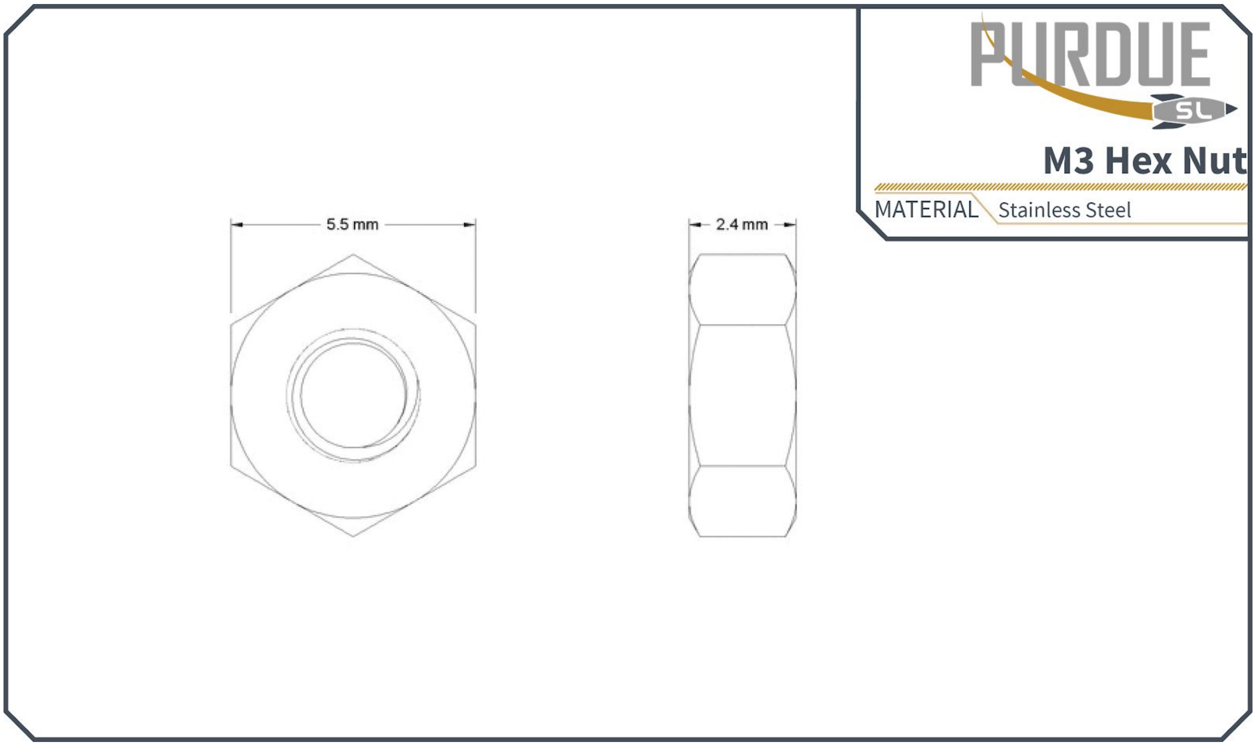
3.5.3. Structural Threaded Rod ("⅛")



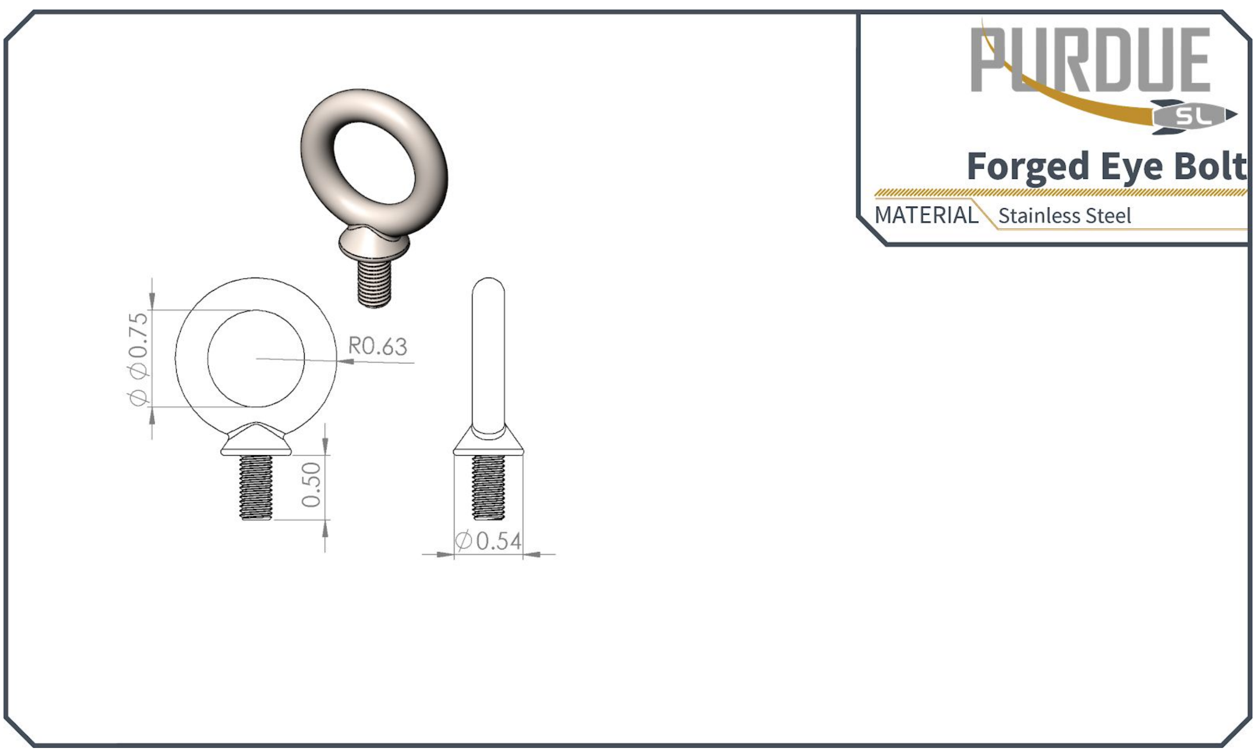
3.5.4. Hex Screw (M3)



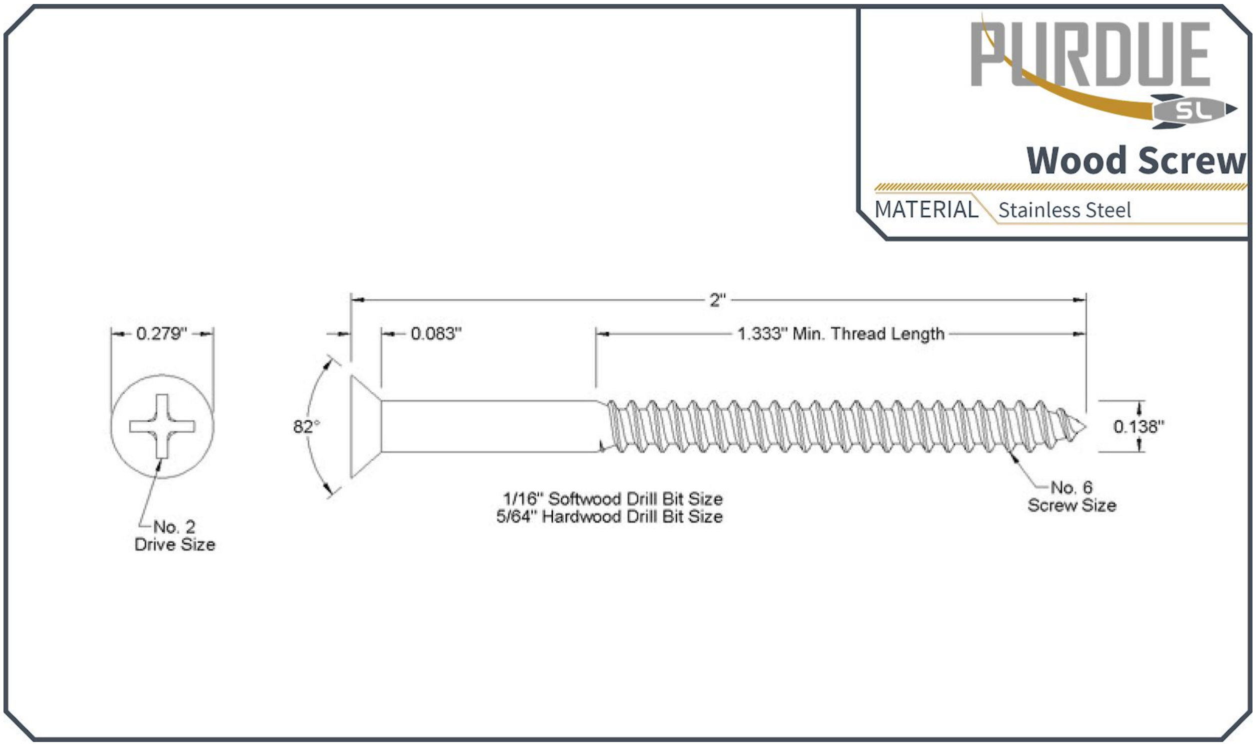
3.5.5. Hex Screw Nut (M3)



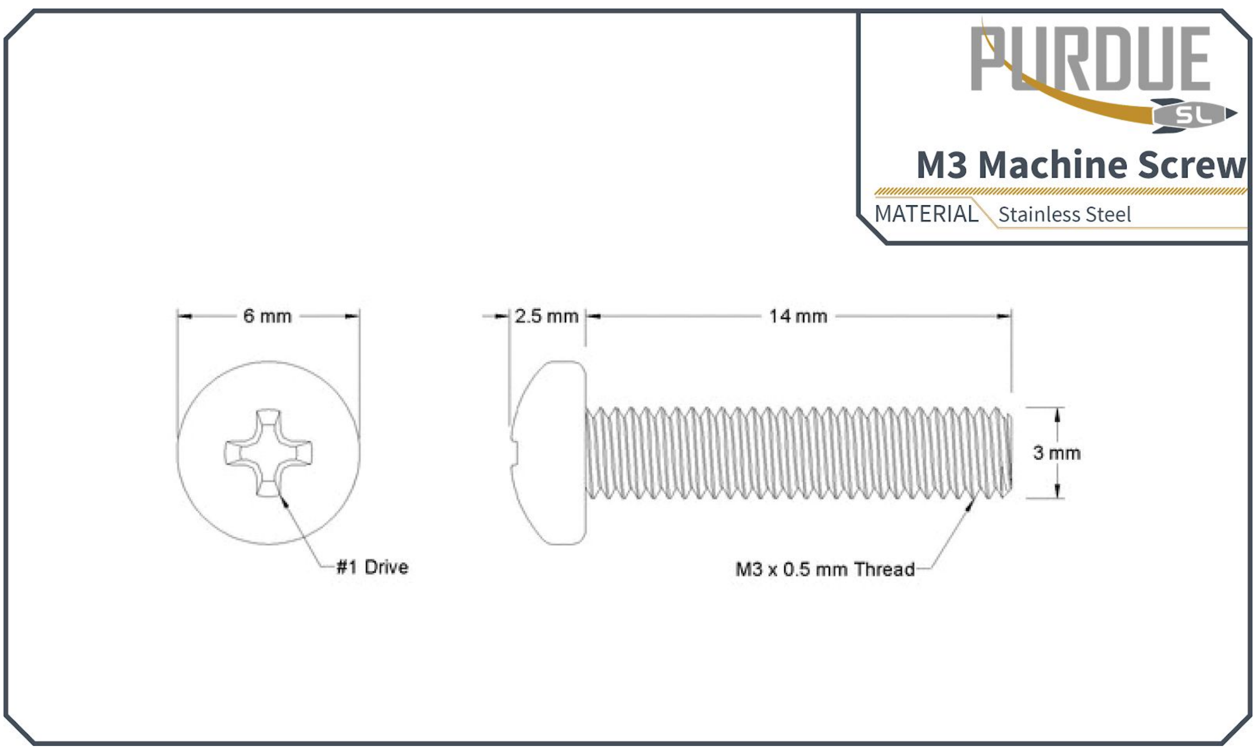
3.5.6. Forged Eye Bolt



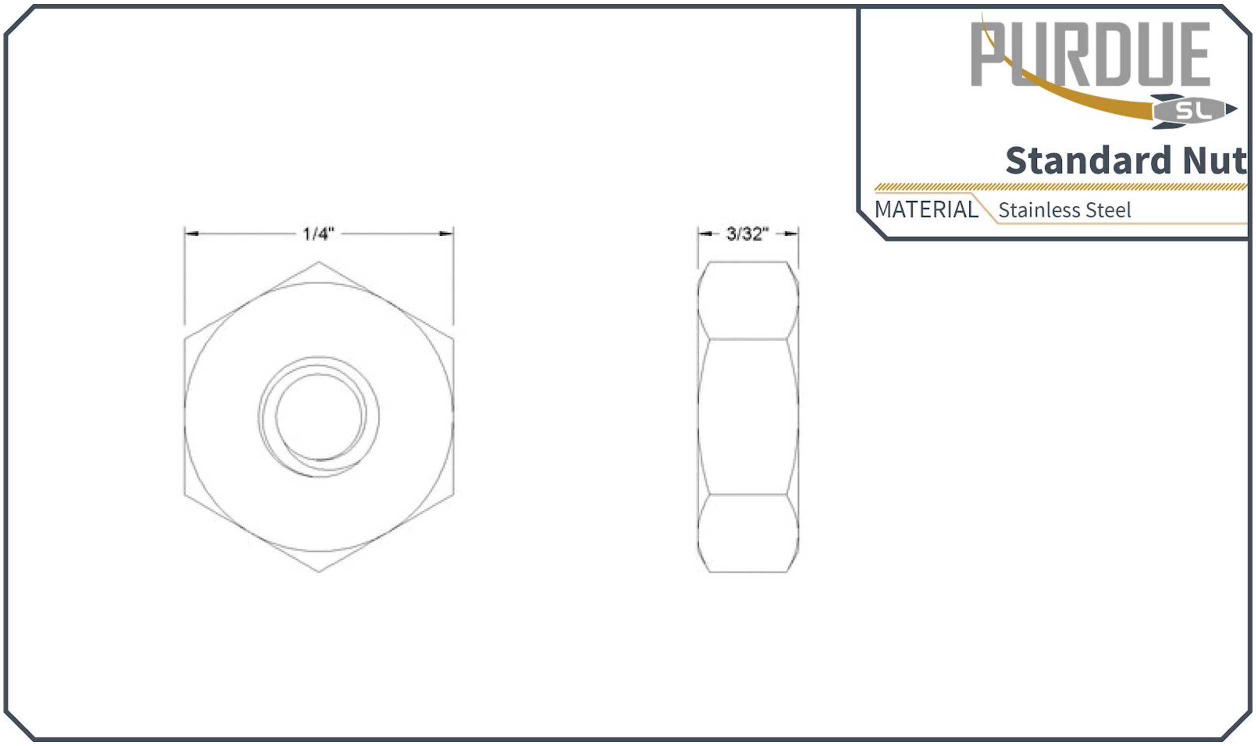
3.5.7. Wood Screw



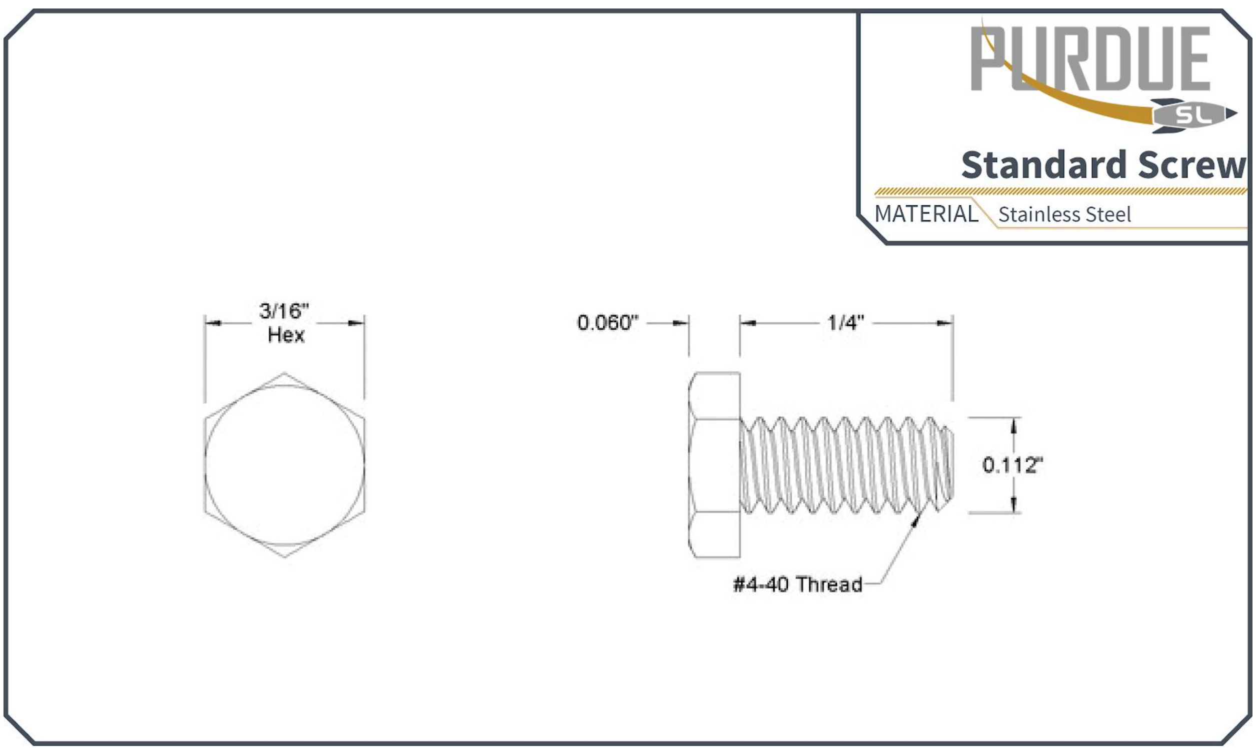
3.5.8. Machine Screws (M3)



3.5.9. Standard Nut



3.5.10. Standard Bolt



4. PSP-SL Launch Vehicle Launches

4.1. PSP-SL Subscale Launch

On December 5th, the PSP-SL Team launched the teams 0.45 scale launch vehicle. The weather for the flight in the West Lafayette area was mostly overcast, adding on to that with snowfall on the days before the launch, there was still snow on the ground. There was a constant wind coming from the West at 14 mph, which was taken into consideration for the launch, which possibly influenced the path of the rocket after launch. The overall measured temperature for that day was varying between 27 - 29 degree Fahrenheit and a typical humidity of 72%. Overall there weren't any extreme weather conditions that impacted the launch, besides the wind. For this flight, the Missile Works RRC3+ Sport was the primary altimeter and the Jolly Logic AltimeterOne was used for redundancy. This allowed assurance that the team understood how the RRC3+ Sport operated and to verify that the max altitude was accurate. On the RRC3+ Sport the altimeter reached a max altitude of 895 ft and the AltimeterOne reached a max altitude of 884 ft. The main reason that these are slightly off is that the AltimeterOne was attached to the shock cord at a lower resting height than the AltimeterOne. Another possible reason for the differences is how the sampling rate on the RRC3+ Sport is higher than that of the AltimeterOne. For this flight, the team was within 60 feet of the simulated apogee. Overall the launch was a success and the team learned a ton from this first flight.

4.2. PSP-SL Full Scale Flight #1

On March 17th, 2019, the PSP-SL Team launched the full-scale launch vehicle. The weather for the flight in the area was good for launch. The skies were almost completely clear, the wind speed was slow (~5-7 mph) with gusts (~10-12 mph) of wind. The temperature was varying between high teens and low thirties (~17-31) degrees Fahrenheit and an overall humidity of 40%. For this flight, the Telemetrum was the primary altimeter and the RRC3+ Sport was the redundant altimeter, with a 1 sec delay. The primary altimeter recorded an altitude of 4325 ft AGL, and the redundant altimeter recorded 4263 ft AGL. The drogue and main parachutes both deployed correctly. Overall the avionics system performed as expected. Unfortunately, the payload was severely damaged when the shock of the main parachute caused the nose-cone shear pins to break prematurely, during flight. The nose cone remained intact. Rebuilding the payload and improving the nose cone retention system were the main focus after this first full-scale flight, with additional focus on reducing the weight of the launch vehicle to increase the apogee altitude.

4.3. PSP-SL Full Scale Flight #2

On March 17th, 2019, the PSP-SL Team launched the full-scale launch vehicle a second time. The weather for the flight in the area was good for launch. It was mostly sunny, with partial clouds. The temperature was 17°F-30°F with a constant wind speed of roughly 6-7 mph and occasional gusts of up to 10-12 mph. Once again, the Telemetrum was the primary altimeter and the RRC3+ Sport was the redundant altimeter, with a 1 sec delay. The primary altimeter recorded an altitude of 4568 ft AGL, and the redundant altimeter recorded 4492 ft AGL. The drogue and main parachutes both deployed correctly. Overall the avionics systems performed as expected. The new nose cone retention system, which used stronger shear pins with a redundant tether in case of premature separation, worked as designed, and the nose cone was successfully ejected on the ground, after the flight. Overall the payload bay systems performed as expected.

4.4. Full Scale Flight Altimeter Data

Full Scale Flight #1

RRC3+ Sport

Apogee (Height AGL)	4263 ft
Drogue Deploy Altitude	4241 ft
Main Deploy Altitude	646 ft
Drogue Descent Velocity	88 ft/s
Main Descent Velocity	18 ft/s

Telemetrum

Apogee (Height AGL)	4325 ft
Drogue Deploy Altitude	3890 ft
Main Deploy Altitude	890 ft
Maximum Boost Acceleration	284 ft/s^2 or 8.83 G
Average Boost Acceleration	229 ft/s^2 or 7.12 G
Drogue Descent Velocity	88 ft/s
Main Descent Velocity	22 ft/s
Total Drift Distance	~1950 ft

Drift Displacement	630 ft

Full Scale Flight #2

RRC3+ Sport:

Apogee (Height AGL)	4492 ft
Drogue Deploy Altitude	4460 feet
Main Deploy Altitude	644 feet
Drogue Descent Velocity	80 ft/s
Main Descent Velocity	35 ft/s

Telemetrum:

Apogee (Height AGL)	4568 ft
Drogue Deploy Altitude	4060 ft
Main Deploy Altitude	791 ft
Maximum Boost Acceleration	297 ft/s^2 or 9.22 G
Average Boost Acceleration	231 ft/s^2 or 7.17 G
Drogue Descent Velocity	78 ft/s
Main Descent Velocity	36 ft/s
Total Drift Distance	~700 ft
Drift Displacement	512 ft

5. PSP-SL Outreach Summary

In order to reach out to a majority of K-12 students as well as others, team members participated in the annual Purdue Space Day on Saturday, October 27, where they were randomly placed in teams in charge of various groups consisting of 10-90 students. The students created model rockets, astronaut arms, solar sails, and many other space-related projects with the help and supervision of team members. Team members showed the students the physics and reality of propulsion using systems such as dry ice rockets, and also showed the students the different organizations around Purdue that were involved in STEM related projects. This allowed for the students to have an understanding of space exploration as well as the impact Purdue University has on the space industry.

At Purdue Space Day, Astronaut Charles D. Walker (pictured above) interacted with the kids in attendance and gave a presentation on the benefits of STEM involvement and the excitement of space exploration. At this event, the children were broken up into groups of 30 - 50 and participated in a variety of STEM related activities which varied by age range which were coordinated and led in part by PSP-SL members.

The STEM Engagement Activity Reports which were filled out by the team members who attended Purdue Space Day can be found in the following location: https://drive.google.com/drive/folders/1Eu2VYxXYnDArzS3gj4UYcuKABaqxSReR?usp=sharing

Team members who participated in Purdue Space Day were unable to see the evaluation reports the children gave to Space Day officials at the end of the day, but through word of mouth the team heard that feedback was very positive in terms of both enjoyment and concepts learned. Team members also report that, in person, the kids made design choices with good judgement after being taught background information on their projects and were very excited to complete the activities which were set up for them and see their work in action, such as when their dry ice rockets launched. The students used their initial experience from the dry ice rockets to make changes and learned that creating a higher internal pressure would allow the cap to pop off at a higher required force and therefore provide more thrust. The students overall were extremely excited by creating these rockets and shared their joy after learning from team members by pondering how they would similarly launch from home and if they were able to learn more on rocket science.

Through establishing relationships with Purdue University, outreach organizations like Mini-Maker Faire in the Lafayette area, and student organizations like AIAA and SEDS, Purdue's PSP-SL team plans on continuing their education and engagement of youth in the Lafayette and West Lafayette area.

6. Team Photos

6.1. Entire Team Photo

Pictured (Left to Right): Zach Carroll, Mason Hazzard, Isaac Byely, Josh Binion, Matthew Heapy, Sean Heapy, Luke Hecht, Michael Esry, Pranav Patel, Martin Degener, Morgan Harris, Skylar Harlow, Lauren Smith, Wellington Froelich, Katelin Zichittella, Thomas Fu, Vladimir Zeltsman, Richard Fu, Hicham Belhseine, Bret Reser, Luke Perrin, Jory Lyons **Not Pictured:** Michael Repella and Victor Barlow

6.2. Launch Week Team Photo

Pictured (Left to Right): Zach Carroll, Isaac Byely, Josh Binion, Sean Heapy, Luke Hecht, Matthew Rumple, Pranav Patel, Martin Degener, Skylar Harlow, Lauren Smith, Wellington Froelich, Katelin Zichittella, Thomas Fu, Hicham Belhseine, Bret Reser, Luke Perrin, Jory Lyons **Not Pictured:** Michael Repella and Victor Barlow

6.3. Team Lead Photo

Pictured (Left to Right): Luke Perrin, Isaac Byely, Zach Carroll, Bret Reser, Jory Lyons, Josh Binion, Sean Heapy **Not Pictured:** Michael Repella

6.4. Team Lead Individual Photos & Bios

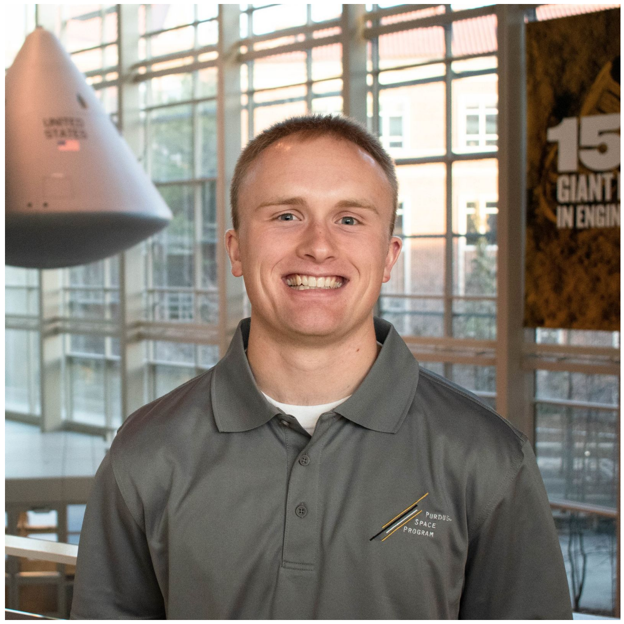
6.4.1. Project Manager

Name	Michael Repella
Class Standing	Junior (Class of 2020)
Degree	Aeronautical & Astronautical Engineering
Summer Plans	Engineering at Sierra Nevada Corporation
Role Within Team	"As project manager my responsibility has been to make sure the project is falling into place as it should. I ensure communication is flowing well between sub teams and that everyone has what they need in order to do their job. I also delegate tasks to the sub teams, organize meetings, and work to resolve any problems that might arise within the team. Since moving away from Purdue at the start of 2019 to begin a co-op program, acting project manager Luke Perrin has taken over a great majority of this responsibility and I can't thank him and the team enough for their hard work."

6.4.2. Acting Project Manager

Name	Luke Perrin
Class Standing	Junior (Class of 2020)
Degree	Aeronautical & Astronautical Engineering
Summer Plans	Engineering at US Government
Role Within Team	"As assistant project manager my responsibility was to serve as a liaison between the project manager and sub team leads. As acting project manager, I directly lead and oversee construction or the launch vehicle, payload bays, payload, and avionics bay. I also supervise all tests and offer opposing viewpoints where necessary. I plan agendas and lead weekly meetings to coordinate and facilitate efforts amongst individuals."

6.4.3. Payload Team Lead



Name	Josh Binion
Class Standing	Junior (Class of 2020)
Degree	Electrical Engineering
Summer Plans	Engineering at John Deere
Role Within Team	"I am responsible for overseeing the successful completion of our payload system. More specifically I make decisions about the hardware that will be used, and develop software for our system."

6.4.4. Construction Team Lead

Name	Zach Carroll
Class Standing	Junior (Class of 2020)
Degree	Aeronautical & Astronautical Engineering
Summer Plans	Engineering at Northrop Grumman
Role Within Team	"I am responsible for building both the subscale and full scale rockets. Having a dedicated team allows us to focus on making sure the rocket is as well-built as possible. In the meantime, our team focuses on helping out the other teams to make sure all technical documents are above and beyond what's required."

6.4.5. Safety Team Lead

Name	Jory Lyons
Class Standing	Junior (Class of 2020)
Degree	Aeronautical & Astronautical Engineering
Summer Plans	Engineering at Air Force Research Lab (AFRL)
Role Within Team	"As Safety Team Lead, I am responsible for enforcing and creating guidelines and policies to establish a safe work environment to prevent accidents from happening. These goals are accomplished by utilizing detailed risk analysis tables, step-by-step procedures on how to accomplish various tasks related to the project, and checklists to use on launch day, among other things."

6.4.6. Avionics & Recovery Team Lead

Name	Bret Reser
Class Standing	Sophomore (Class of 2021)
Degree	Electrical Engineering
Summer Plans	Undecided
Role Within Team	"I am responsible for ensuring that our team's avionics and recovery systems are going to work every flight, since a recovery system failure would mean the loss of everyone's hard work. To accomplish this, redundancy is crucial. Not only in the team's physical systems, but also in the methods of checking everything for proper functionality before every flight."

6.4.7. Funding Team Lead

Name	Sean Heapy
Class Standing	Junior (Class of 2020)
Degree	Aeronautical & Astronautical Engineering
Summer Plans	Undecided
Role Within Team	"I am in charge of funding all expenses for the team, as well as managing all business-related team matters. I am currently working on organizing and scheduling local fundraising events such as skip-a-meals. I also look forward to funding the majority of the team's expenses through non-profit grants and company sponsorships."

6.4.8. Social / Outreach Team Lead

Name	Isaac Byely
Class Standing	Sophomore (Class of 2021)
Degree	Aeronautical & Astronautical Engineering
Summer Plans	Working In Hometown
Role Within Team	“As social team lead, I help organize the teams educational engagement throughout the year. I assist our parent organizations social lead in keeping our teams information up-to-date. I also take on the responsibility of collecting pictures and videos of all team build days, launch days, and meetings. Beyond this I also am in charge of ensuring that our teams booth at the rocket fair is set up properly and in a way that best represents the team.

6.4.9. Student Mentor

Name	Mason Hazzard
Class Standing	Senior (Class of 2019)
Degree	Aeronautical Engineering Technology
Summer Plans	Engineering at Pratt & Whitney
Role Within Team	“Advise team where necessary throughout construction and simulation.”

6.5. Subteam Team Photos

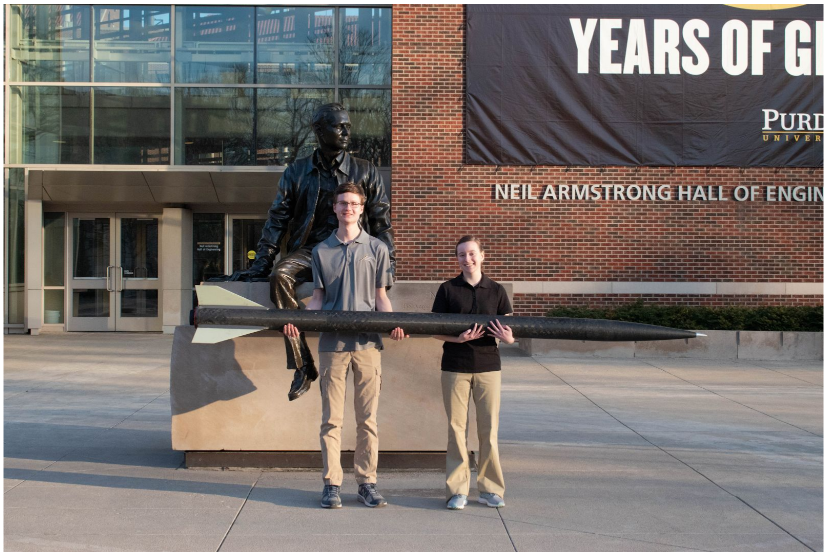
6.5.1. Payload Team

Pictured: Michael Esry, Morgan Harris, Martin Degener, Luke Hecht, Pranav Patel, Skylar Harlow, Wellington Froelich, Hicham Belhseine, Vladimir Zeltsman

6.5.2. Construction Team

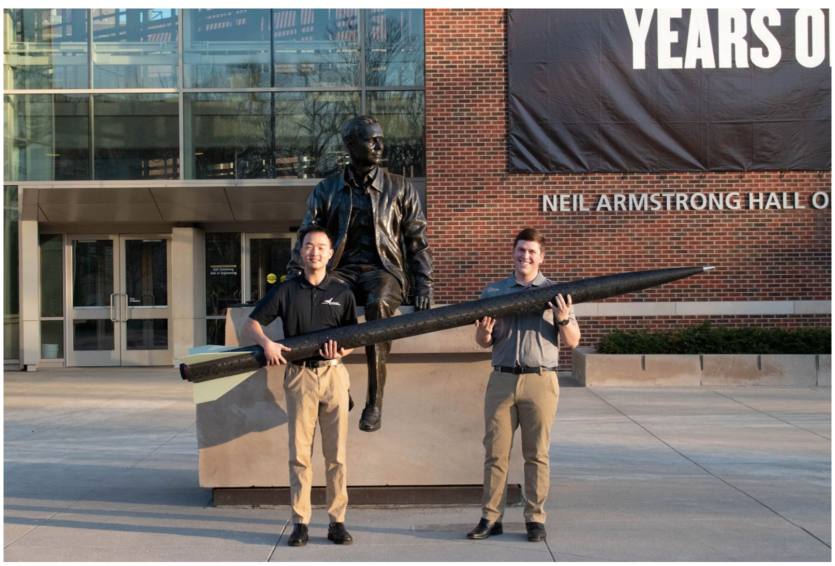
Pictured: Zach Carroll, Matthew Rumple, Lauren Smith, and Thomas Fu

6.5.3. Avionics Team



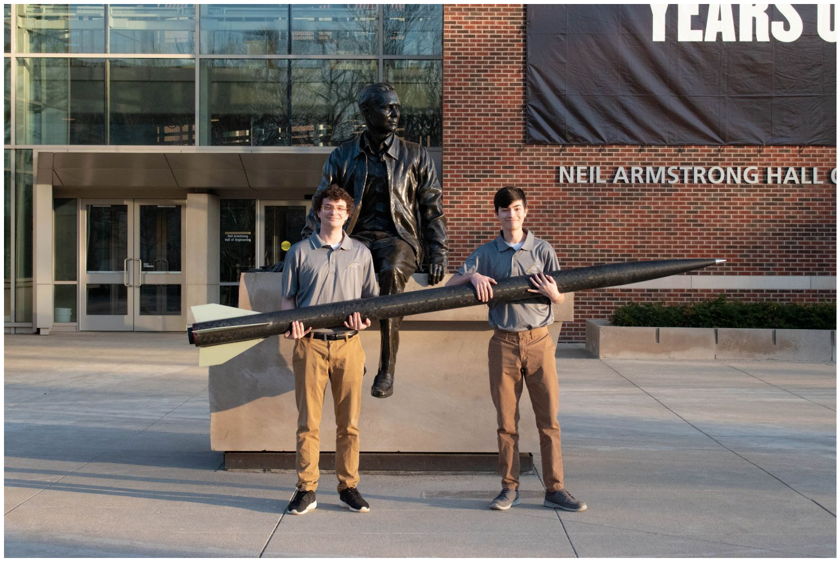
Pictured: Bret Reser and Katelin Zichittella

6.5.4. Safety Team



Pictured: Richard Fu and Jory Lyons

6.5.5. Social / Funding Team



Pictured: Isaac Byely and Sean Heapy

7. Team Resources

7.1. PSP-SL Funding Summary

7.1.1. Line Item Budget

7.1.1.1. Full Scale Budget

Rocket Parts	Unit Cost	Quantity	Total (including shipping)
5:1 5" Von Karman FWFG Nosecone	$108.95	1	$108.95
5" Stepped AL Avionics bay lids	$16	6	$96
5" FWFG Airframe, 30" long	$85	3	$255
Custom Airframe Slotting, 3/16" wide, 15" long	$6	3	$18
5" FWFG Switch Band, 2" long	$7	2	$14
5" FWFG Coupler, 12" long	$53	2	$106
3" FWFG Motor Tube, 30" long	$50	1	$50
1/8" G10 FG Centering Ring	$9	2	$18
1/2" Plywood Centering	$5	2	$10
3/16" G10 FG Fins 6" tall, 15" root, 4" tip, 10" sweep	$20	3	$60
Skyangle Cert 3 XL Parachute	$189	1	$189
Skyangle Cert 3 Drogue Parachute	$27.50	1	$27.50
18" x 18" Nomex Parachute Protector	$10.95	2	$21.90
40' Long Double Looped Kevlar Tether	$61	2	$122
Large Rivet Package	$4.5	2	$9
1515 Series Rail Button Package of 4	$7.95	1	$7.95
75mm AeroPac Flanged Motor Retainer	$50	1	$50
5"/75mm SC Precision Thrust Plate	$55.59	1	$55.59
Aerotech 75mm 3G Hardware Set	$290	1	$290
Aerotech 75mm 3G L1520-T Reload	$199	2	$380

Aerotech 75mm 3G L1520-T Reload	$162	2	$324
0.187” x 24” x 24” Natural FR4 Epoxy/Glass Laminate Sheet	$87.35	1	$127.80
			$2340.69

7.1.1.2. Subscale Budget

Item	**Unit Cost**	**Quantity**	**Total**
Wildman Jr. Rocket Kit	$125.99	1	$125.99
Wildman Recon Recovery 30” Shute	$35.95	1	$35.95
H115-DM Motor	$35.99	1	$35.99
			$197.93

7.1.1.3. Avionics Budget

Item	**Unit Cost**	**Quantity**	**Total (including shipping)**
TeleMetrum - Altus Metrum Altimeter	$300.00	1	$300.00
TeleDongle - Altus Metrum	$100.00	1	$100.00
RRC3+ Sport - Missile Works Altimeter	$70.00	1	$70.00
Electronic Match	$1.00	25	$25.00
Jolly Logic AltimeterOne Altimeter	$58.19	1	$58.19
ALTIMETER MOUNTING POSTS	$3.68	2	$7.36
6g Charge Well	$8.50	2	$17.00
Missile Works USB Interface Module	$32.95	1	$32.95
Pair Programming / Debug Cable	$5.00	1	$5.00
9V Battery Clip	$1	1	$1
9V Battery - Duracell	$6.00	4	$24.00
9V Battery Holder	$2.50	1	$2.50
Dual Altimeter Wiring Kit - Binder Design	$20.00	1	$20.00
3/4" Panel-Mount Key Switch - McMaster-Carr	$14.10	2	$28.20
National Hardware 1 Count 1/4-in to 20 x 2.5-in Stainless Steel Plain Eye Bolt with Hex Nut	$1.00	4	$4.00

Hillman 0.375-in x 36-in Standard (SAE) Threaded Rod	$2.90	2	$5.80
900mAh LiPo Battery Pack	$16.29	1	$16.29
Terminal Block	$7.10	2	$11.85
8g Charge Well	$8.95	4	$45.25
Solid Plywood Block (¼”X2’X4’)	$16.99	1	$16.99
Acrylic Sheet	$22.98	1	$22.98
Polyseamseal Sealant	$4.06	2	$8.12
			$823.48

7.1.1.4. Payload Budget

Item	**Unit Cost**	**Quantity**	**Total**
Arduino Pro Mini	$13.00	5	$65.00
7.4V 1550mAh 35C 2S LiPo Battery Pack	$12.99	1	$12.99
HOBBYMATE Imax B6 Clone Lipo Battery Balance Charger	$34.90	1	$34.90
LIDAR-Lite v3	$130.00	1	$130.00
Standard Gearmotor - 303 RPM (3-12V)	$24.95	2	$83.78
Servo Motor SG-90	$1.70	2	$3.40
Redrex Nema 17 Stepper Motor	$26.95	1	$26.95
XBee-PRO 60mW (802.15.4)	$37.95	3	$113.85
MPU 6050	$30.00	1	$30.00
Dual TB6612FNG	$4.95	1	$4.95
A4988 stepper motor driver	$5.95	1	$5.95
KY-019 5V DC Relay	$1.80	2	$3.60
Black Powder (1 lb)	$20.00	1	$20.00
3D Printed Material	$25.00	1	$25.00
			$560.37

7.1.1.5. Branding Budget

Item	**Unit Cost**	**Quantity**	**Total**

Polos	$25	22	$550
			$550

7.1.1.6. Travel Budget

Item	Unit Cost	Quantity	Total (plus tax)
Hotel Room (3 Nights)	$312	5	$1824
Gas (Rough Estimate)	$40	18	$720
			$2544

7.1.1.7. Budget Total

Budget Section	Total Cost	Discount	Final Total
Full Scale	$2340.69	$2071.34	$269.35
Subscale	$197.93	$0	$197.93
Avionics	$823.48	$470	$353.48
Payload	$560.37	$0	$560.37
Branding	$550	$550	$0
Travel	$2544	$0	$2544
	$7016.47	$3091.34	**$3925.13**

Budget Justification

- **Full Scale and Subscale:** Parts for both the full and subscale rocket have been purchased at this point, and all parts are fully detailed on the line item budget. A Wildman Junior kit was used for the subscale rocket, requiring for very few other parts to be purchased in order to construct the subscale rocket. A Wildman Junior case was used as it was provided by SEDS. An exception to this case is parts required for a future test launch, where certain purchases may be necessary to accommodate a new launch. A $2071.34 discount has been applied, this accounts for parts purchased in previous years, and a donation of one of the motors and the associated hardware.

- **Avionics:** All items in the avionics section have also been purchased. The avionics line item budget should be complete. Two of the altimeters purchased for the team, in addition to the Teledongle, were purchased last year. As a result, a $470 discount has been applied.
- **Payload:** Although parts have been purchased for the payload section, due to the recent failure of payload tests, more parts for the payload section will likely be purchased. The budget currently reflects all necessary purchases without performing an additional test.
- **Branding:** The branding section includes now only polos required by members to wear during the competition in Huntsville, these polos will be purchased by the members of the team. An estimated 22 individuals will be attending the trip to Huntsville, and thus the amount on the line item budget it based on this quantity. A discount of the full cost has been applied due to members purchasing the polos with their own funds.
- **Travel:** Travel costs include hotel room reservations and gas costs (if traveling by car). With an estimated 22 individuals attending, 5 rooms will be necessary for 3 nights (quantity 15 total). Gas costs associated with driving over are estimated to be roughly $700. Alternatively, if funding permits, all individuals attending can fly to Huntsville, bringing the estimated cost in this section up to $6472. It is unlikely that this option will be able to be funded, although the amount is known in case it becomes a possibility.

7.1.1.8. Funding Plan

7.1.1.8.1. Sources Of Funding

Assuming that the team requires around $4000, there will be five (not including company sponsorship) primary ways funds will be raised to support the NASA Student Launch project:

1. Skip-a-meals (Restaurant Socials): Skip-a-meals are social events where individuals can mention the name of SEDS or Purdue's NASA Student Launch at a designated food establishment and a percentage (usually a quarter) of money they spend at the establishment will be given to the team. These events usually last for a whole afternoon or the rest of the business day as collectively determined by the establishment and team.
2. Levy Restaurant Services Fundraising Program: Levy Restaurants, a service that hosts concession stands at Purdue, has agreed to let us volunteer at the stands in return for a portion of the funds they generate.
3. Company Sponsorship: The team has been unsuccessful as of so far in finding any company willing to provide a portion of the necessary funds, but is still making inquiries.

4. Crowdfunding: The crowdfunding campaign will begin in the week of January 15th, and will continue with the anticipation of receiving roughly $800 assuming adequate advertising and campaigning. Currently, just over $600 has been generated from the crowdfunding campaign.
5. SEDS Treasury: The parent organization is providing $1000 towards funding the project.
6. AAE Travel Grant: The Aeronautical & Astronautical Engineering Department of Purdue has graciously agreed to give us $1600 to go towards travel costs associated with the competition.

Below is an updated chart with the anticipated funds from each of the sources.

Funding Source	Funds Generated
Restaurant Socials (3 throughout year)	$600 ($200 each)
Levy Restaurant Fundraiser	$300 (estimate)
Crowdfunding Campaign	$800
SEDS Treasury	$1000
AAE Travel Grant	$1600
TOTAL:	**$4300 ($300 margin)**

Procurement of funds has changed slightly since preliminary design review. Below is a Gantt chart identifying when funds will be generated from each of the methods above. Colored spaces indicate inbound funds. Notably, funds from the Indiana Space Grant Consortium (INSGC) Grants has specifically been allocated towards travel costs, which is a requirement by INSGC.

Both restaurant fundraisers and the crowdfunding campaign, as funding sources that will result in us receiving funds sooner, will be used to reimburse costs for the subscale rocket, and to pay for the full scale rocket. Funds from the INSGC grants will largely be used to pay for travel costs, but may also be allocated nominally to purchasing materials for the full scale rocket. Below is an ideal date to receive a company sponsorship, but no true date has been confirmed.

Week of:	Jan. 22nd	Jan. 29th	Feb. 5th	Feb. 12th	Feb. 19th	Feb. 26th	Mar. 5th	Mar. 9th	Mar. 16th
Restaurant Fundraisers									Last Fundraiser Ends
AAE Travel					Funds				

Grant					in Pocket				
Crowdfunding Campaign							$600 Withdrawn		

7.1.1.8.2. Allocation of Funds

With changes from the preliminary design review in mind, a specific location to which all of the funds have been allocated has been devised.

Full Scale Rocket: The full scale rocket was almost entirely constructed using parts from last year's rocket, only a few additional purchases have taken place in this section.

Subscale Rocket: The majority of parts for the subscale rocket have been provided to us by the parent organization, SEDS. SEDS has provided us with a Wildman Jr. kit and motor to construct the subscale with, thus no funds are directly allocated towards this area.

Avionics: Parts for the avionics bay have been purchased mostly using funds from the SEDS treasury and restaurant fundraisers. Certain parts in the avionics (specifically the Telemetrum and RRC3+ Sport altimeters, as well as the Teledongle) were from last year's rocket, and thus no funds have been allocated specifically for these parts.

Payload: Parts required for the payload bay, including the payload itself, will be funded by the restaurant fundraisers, crowdfunding campaign, and potentially the SEDS treasury allocated to it. Due to the possibility of more parts to be purchased in this section in the future, additional funds may be required.

Branding: Team matching polos have been designed, and are purchased individually by members on the team itself, thus no funds are allocated to this category, which only includes the aforementioned polos.

Travel: Travel costs will be partially funded by the AAE travel grant. Additional costs shall be paid for by potential fundraisers, specifically the fundraiser with Levy Restaurants.

7.1.1.8.3. Material Acquisition

All materials for the subscale rocket were parts contained within the Wildman Junior kit, with the exception of the motor, which was purchased separately. Individuals who made purchases for the team will be reimbursed using funds from the SEDS Treasury, crowdfunding campaign, and restaurant fundraisers. All funds generated for the team are deposited into the SEDS bank account and are then used to purchase materials or reimburse students if they purchased materials individually. Materials for the full scale rocket in particular were all reused from Purdue's unlaunched NASA Student Launch rocket from last year. Most, if not all, materials for the avionics bay have already been purchased from various vendors. Most avionics purchases were completed by individual team members, who have been reimbursed through the SEDS bank account.

7.2. PSP-SL Timeline

The color-coded timeline outlines events in these categories: general team meetings, meetings or teleconferences with NASA officials, launch opportunities, deadlines, and miscellaneous events.

Date	Event
08/31-09/03/2018	AIRFest 24 @ Argonia, Kansas Rocket Pasture
09/02/2018	Purdue SL general meeting
09/03/2018	LABOR DAY
09/09/2018	Indiana Rocketry Launch
09/09/2018	Purdue SL general meeting
09/16/2018	Purdue SL general meeting
09/19/2018	Proposal due to project office by 3PM CDT
09/23/2018	Purdue SL general meeting
09/29-09/30/2018	ROCI HPR Sport Launch @ AMA Aeromodeling Center in Muncie
09/30/2018	Purdue SL general meeting
10/04/2018	Awarded proposals announced
10/07/2018	Purdue SL general meeting
10/08-10/09/2018	OCTOBER BREAK
10/12/2018	Kickoff, PDR Q&A
10/13/2018	ROCI HPR Sport Launch @ Federal Rd. Field in Cedarville
10/14/2018	Purdue SL general meeting
10/14/2018	Indiana Rocketry Launch
10/20/2018	ROCI HPR Sport Launch @ AMA Aeromodeling Center in Muncie
10/21/2018	Purdue SL general meeting
10/26/2018	Web presence established, URLs sent to project office by 8AM CDT

10/27/2018	ROCI HPR Sport Launch @ Federal Rd. Field in Cedarville
10/28/2018	Purdue SL general meeting
11/01-11/03/2018	SEDS SpaceVision @ San Diego
11/02/2018	PDR reports, slides, and flysheet posted online by 8AM CDT
11/02-11/04/2018	Midwest Power Launch
11/04/2018	Purdue SL general meeting
11/05/2018	PDR video teleconferences start
11/10/2018	ROCI HPR Sport Launch @ Federal Rd. Field in Cedarville
11/11/2018	Purdue SL general meeting
11/11/2018	Indiana Rocketry Launch
11/18/2018	Purdue SL general meeting
11/19/2018	PDR video teleconferences end
11/21-11/24/2018	THANKSGIVING BREAK
11/24/2018	ROCI HPR Sport Launch @ Federal Rd. Field in Cedarville
11/25/2018	Purdue SL general meeting
11/27/2018	CDR Q&A
12/2/2018	Purdue SL general meeting
12/05/2018	PSP-SL Subscale Launch
12/08/2018	Quad Cities Rocket Society (QCRS) Launch
12/09/2018	Purdue SL general meeting
12/09/2018	Indiana Rocketry Launch
12/15-01/06/2019	WINTER BREAK
01/03/2019	Final day for subscale launch
01/03/2019	Final motor choice made for launch
01/04/2019	CDR reports, slides, and flysheet posted online by 8AM CDT
01/06/2019	Possible Purdue SL general meeting
01/07/2019	CDR video teleconferences start
01/13/2019	Purdue SL general meeting
01/13/2018	Indiana Rocketry Launch
01/20/2019	Purdue SL general meeting
01/21/2019	MLK JR. DAY
01/22/2019	CDR video teleconferences end
01/25/2019	FRR Q&A
01/27/2019	Purdue SL general meeting

02/03/2019	Purdue SL general meeting
02/10/2019	Purdue SL general meeting
02/10/2019	Indiana Rocketry Launch
02/17/2019	Purdue SL general meeting
02/24/2019	Purdue SL general meeting
02/25/2019	PSP-SL Full Scale Launch #1
03/03/2019	Purdue SL general meeting
03/03/2019	Final day for full scale launch/Vehicle Demonstration Flight
03/04/2019	Vehicle Demonstration Flight data reported to NASA
03/04/2019	FRR reports, slides, and flysheet posted online by 8AM CDT
03/07/2019	FRR video teleconferences start
03/09/2019	Purdue SL general meeting
03/10/2019	Indiana Rocketry Launch
03/11-03/16/2019	SPRING BREAK
03/17/2019	PSP-SL Full Scale Launch #2
03/19/2019	Purdue University FRR Presentation
03/21/2019	FRR video teleconferences end
03/24/2019	Purdue SL general meeting
03/25/2019	Payload Demo Flight/Vehicle Demonstration Re-flight deadlines
03/25/2019	FRR Addendum submitted to NASA by 8:00 AM CDT (if needed)
03/31/2019	Purdue SL general meeting
04/03/2019	Travel to Huntsville, Alabama
04/03/2019	OPTIONAL – LRR for teams arriving early
04/04/2019	Launch week kickoff and activities
04/04/2019	Official LRRs if not done on 04/03
04/05/2019	Launch week activities
04/06/2019	Launch day
04/06/2019	Awards Ceremony
04/07/2019	Backup launch day
04/07/2019	Possible Purdue SL general meeting
04/14/2019	Purdue SL general meeting
04/21/2019	Purdue SL general meeting
04/26/2019	PLAR posted online by 8AM CDT

7.3. PSP-SL Facilities & Equipment

7.3.1. Zucrow Propulsion Labs

Zucrow Propulsion Labs is a facility with various research capabilities that encompass many disciplines within aeronautical and astronautical engineering. The team will be utilizing this facility (and more specifically the High Pressure Labs within Zucrow) to store hazmat materials such as the motors or other energetic devices (black powder, CO2 canisters, ignition supplies, etc.). The team will also be using the area to conduct deployment charge ground tests to ensure proper separation of the vehicle components at apogee and main parachute deployments. The team's contact for the site is Professor Scott Meyer, who is the Zucrow Managing Director, and is the only required personnel for the building. As a safety precaution to limit liability to team personnel, he will be the sole person with access into the secure areas where supplies will be stored in a safe and controlled environment. He will be available between 7 A.M. and 5 P.M.

Hours of Operation	7 A.M. - 5 P.M. or by appointment
Required Personnel	Scott Meyer for access, Safety Officer for safety
Necessary Equipment	Equipment specified by Scott Meyer and on-site instructions.
Safety Precaution	Limited access through Scott Meyer, climate controlled environment, and secured areas
General Use	Storage of potentially dangerous materials, such as high energy devices (motor, compressed gas, igniters, black powder, etc.)

7.3.2. Aerospace Science Labs (ASL)

The Aerospace Science Labs (henceforth referred to as ASL) is an annex attached to the Purdue University Airport that specializes in manufacturing and wind tunnel testing. It is also where Purdue SEDS has their storage area. Although the building is only publicly open between the hours of 7 A.M. and 5 P.M., the team will have full access around the clock thanks to Ben Walbaum, current Purdue SEDS president and Chris Nilsen who is last years president of the Purdue SEDS Executive Board and has a keypad code to the doors. The team will use this area for general assembly as it is where the majority of the team's parts, building supplies, and tools will be stored. The team will be utilizing basic manufacturing equipment such as drill presses, table saws, rotary tools, and vertical bandsaws. The team will also have access to construction equipment including adhesives, abrasives, craft knives, and common hand tools (pliers, screwdrivers, wrenches, taps, etc.).

Hours of Operation	Around the clock access with use of key
Required Personnel	Chris Nilsen for access, Safety officer for safety
Necessary Equipment	Drill presses, table saws, vertical bandsaws, adhesives, abrasives, and common hand tools
Safety Precaution	Team members must be briefed on proper safety precautions for using the ASL's equipment by the safety officer before being allowed to use the building's resources. PPE in the form of earplugs and safety glasses is available on-site.
General Use	Vehicle assembly, light manufacturing

7.3.3. Bechtel Innovation Design Center (BIDC)

The Bechtel Innovation Design Center (BIDC) is an advanced prototyping facility and machine shop which is located on campus and is available to all Purdue students. All students who enter the shop must take a series of online quizzes for each type of tool or machine they wish to use, and will be paired with a teaching assistant or Purdue employed machinist for the duration of their project. These rules, safety concerns, and safety protocols will be applied to all machining and safety for every location used by the team (Zucrow, ASL, etc.) to where all must be briefed before working with construction or operations. The BIDC is only open from 9 A.M. to 5 P.M. during the business week since a trained professional must always be present to minimize safety hazards. The team will use equipment such as sandblasters, mills, CNC's, paint booths, laser cutters, belt sanders, routers, and similar manufacturing machines at this facility for fabrication of custom or complex parts. All proper PPE will be worn in addition to the machinery having emergency protocols with emergency stop buttons and guards.

Hours of Operation	9 A.M. - 5 P.M.
Required Personnel	TA supervisor or Purdue employed machinist

Necessary Equipment	Sandblasters, mills, CNC's, paint booths, laser cutters, belt sanders, routers, etc.
Safety Precaution	TAs or employed machinists must always be present when using machines, team members must take quizzes and undergo training before using machines
General Use	Fabrication of custom or complex parts

7.3.4. Purdue BoilerMAKER Lab

The Purdue BoilerMAKER Lab specializes in additive manufacturing. The team will be using their lab space and equipment in order to rapidly prototype parts. This can be done for testing tolerances and function, creating tool guides and jig assemblies, or creating mounting surfaces for the payload and electronics systems. The makerspace operates between the hours of 10 A.M. to 7 P.M. from Monday through Thursday and 10 A.M. to 4 P.M. on Friday, and is closed for the weekends. Due to the high temperatures associated with 3D printing, the team will be letting the lab assistants and technicians handle the machinery and parts as they are being produced. The team member who designs a part will then be responsible for going and retrieving the part from the lab.

Hours of Operation	10 A.M. - 7 P.M. M-Th, 10 A.M. - 4 P.M. Fr
Required Personnel	Lab assistants, part designer
Necessary Equipment	3D Printer, various types of plastic filament, CAD software, computer station
Safety Precaution	Lab assistants will handle the machinery and parts during production to avoid burns to the team members and will oversee the machines to ensure no problems arise
General Use	Rapid prototyping and development