Penn State
LionTech Rocket Labs

Preliminary Design Review

Presentation Overview

- Team Introductions
- Vehicle Design
- Motor Selection and Future Testing
- Recovery System
- Rover Design
- Safety
- Budget
- Timeline
- Questions

Team Introduction

Administrative:

President: Gregory Schweiker

Vice President: Kristi Roth

Safety Officer: Ben Akhtar

Treasurer: Andrew Blount

PR / Outreach: Gooderham McCormick

Technical Team:

Flight Systems Lead: Matt Easler

Payload Systems Lead: Joseph Weston

Structure Leads: Arya Roesler, Sam Loeffler

Propulsion Lead: Wilson Chiang

A & R Leads: Spencer King, Kyle Batra

Payload Leads: Logan Baker, Jaimin Patel

Vehicle Dimensions

- Length = 120 inches

- Total Mass = 31.2 pounds

- Inner Diameter = 6 inches

Component Masses

- Body tube masses are estimations.

- Calculate the volume ratio of the fiber, matrix, and voids.

- Use values to determine true density of each body tube.
  - Calculate mass in oz.

Component	Mass (oz)
Nose Cone	42.2
Payload Section	73.8
Payload-Drogue Coupler	9.5
Drogue Parachute Section	18.6
Drogue-Main Coupler	87.4
Main Parachute Section	23.1
Main-Booster Coupler	13.0
Booster Section	232.1

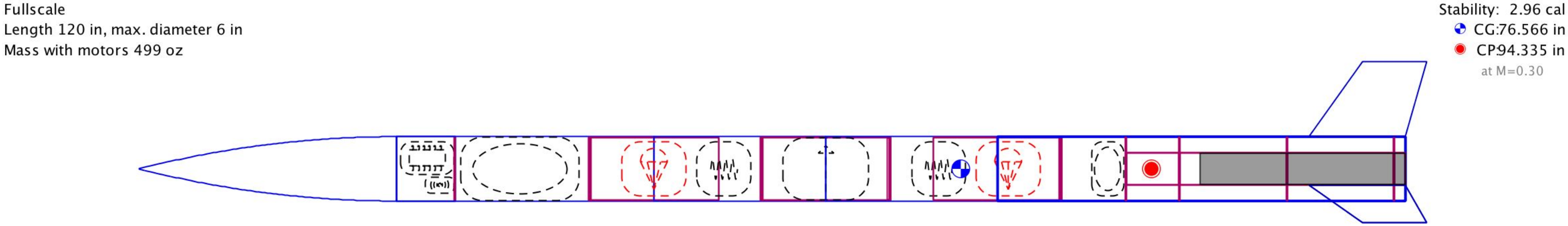
Stability, CG, CP, and Apogee

OpenRocket

- Stability = 2.96 calibers
- CG = 76.57 inches
- CP = 94.34 inches
- Apogee = 5377 feet

MATLAB

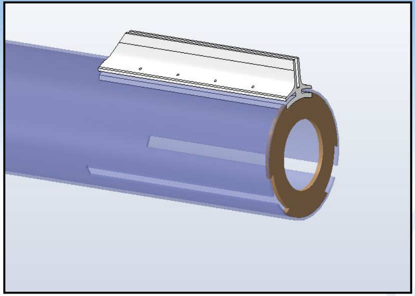
- Stability = 2.94 calibers
- CG = 75.89 inches
- CP = 93.54 inches
- Apogee = 5540 feet

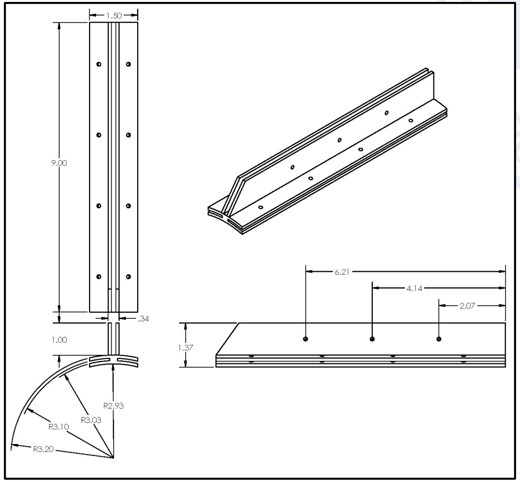


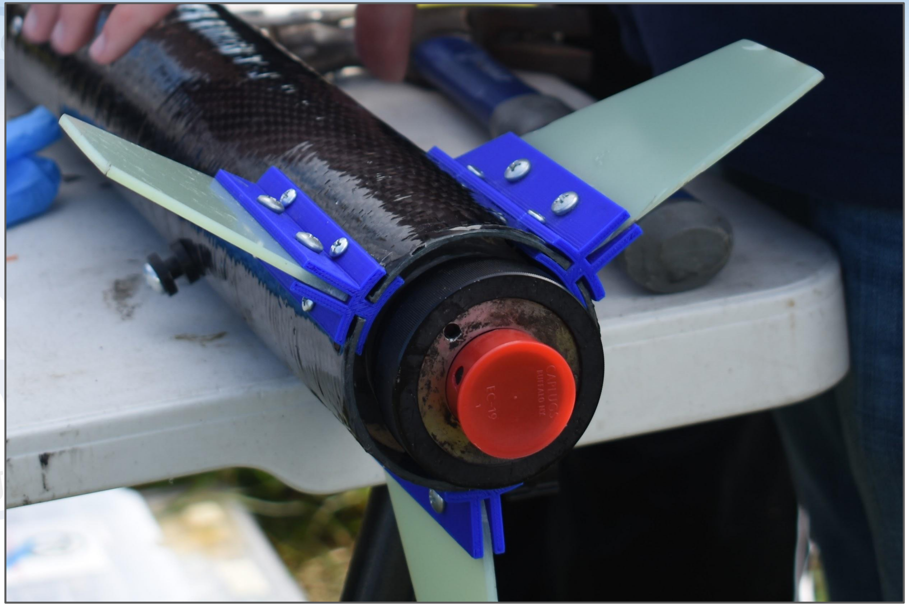
Airframe Selection

		Carbon Fiber (Shrink Tape)		Carbon Fiber (Vacuum Bagging)		Glass Fiber		Blue Tube	
Attributes	**Weight**	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
Strength	0.15	3	0.45	5	0.75	4	0.60	1	0.15
Cost	0.10	3	0.30	1	0.10	2	0.20	5	0.50
Workability	0.10	2	0.20	1	0.60	3	0.30	5	0.50
Material Weight	0.15	3	0.45	4	0.60	1	0.15	4	0.60
Educational Value	0.25	5	1.25	5	1.25	2	0.50	1	0.25
Safety	0.25	2	0.50	3	0.75	1	0.50	5	1.25
Total	1.00		**2.95**		**3.55**		**2.35**		**3.25**

Fin Brackets



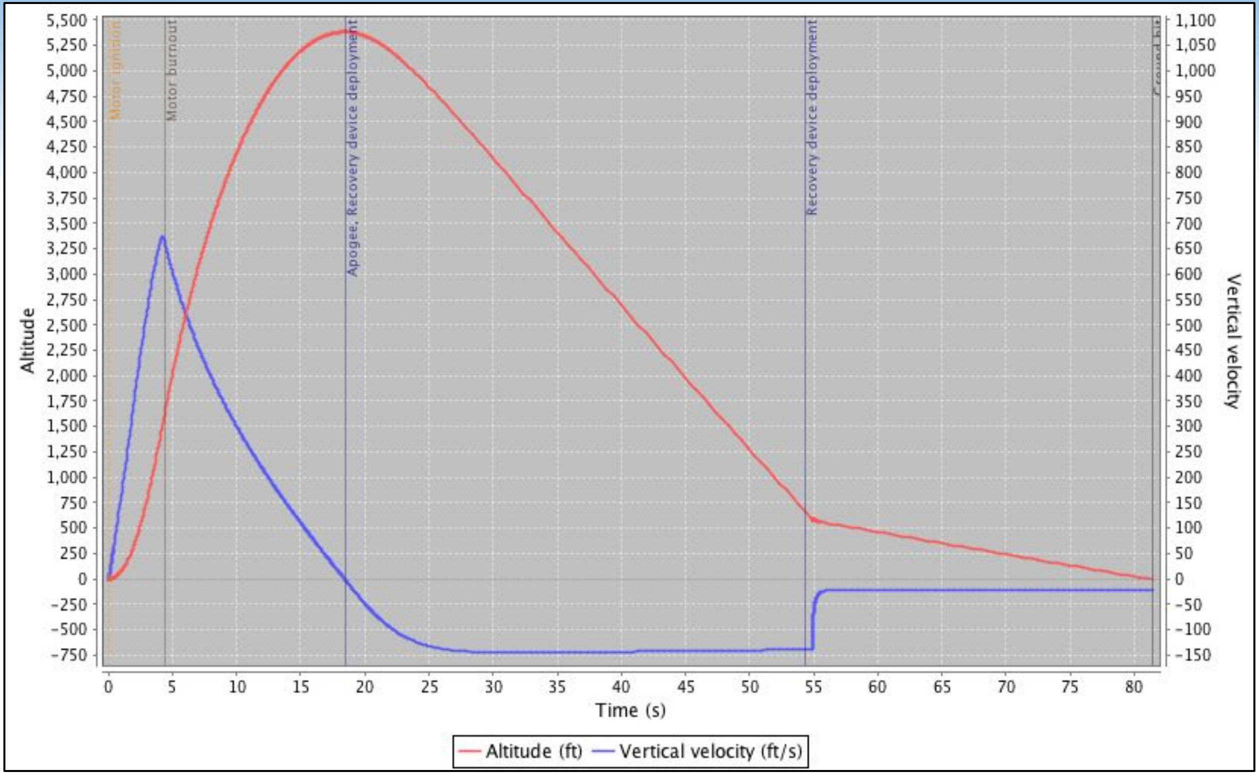




Motor Selection

Motor	Apogee (ft)	Velocity off the Rail (fps)	Thrust to Weight Ratio	Impulse (lbf*s)	Burn Time (s)	Mass (oz)
Cesaroni L1720	5487	87.6	13.1	831	2.11	118
Cesaroni L851	5316	58.7	11.7	827	4.32	134
Cesaroni L800	5563	65.6	7.6	839	4.63	124

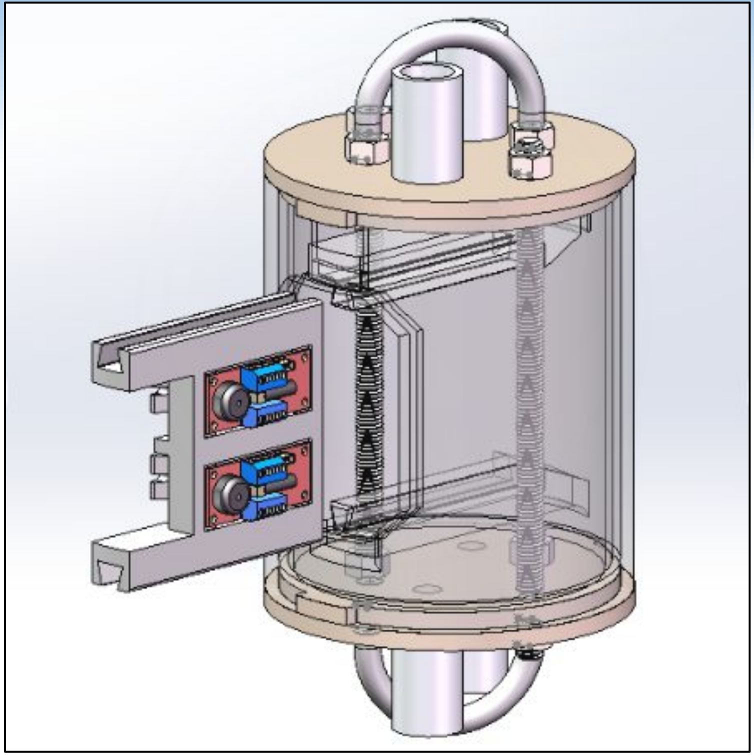
Primary Motor Flight Simulation



Future Testing

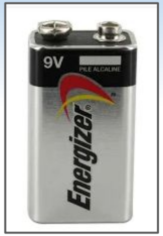
- Wind tunnel testing to determine drag acting on launch vehicle
- Load testing and calculations for correct amount of laminate layers
- Static motor testing for more accurate simulations

Preliminary Avionics Bay Designs



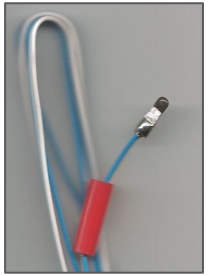
Avionics Bay Wiring

9V Battery

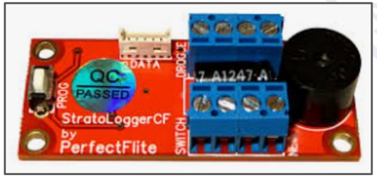


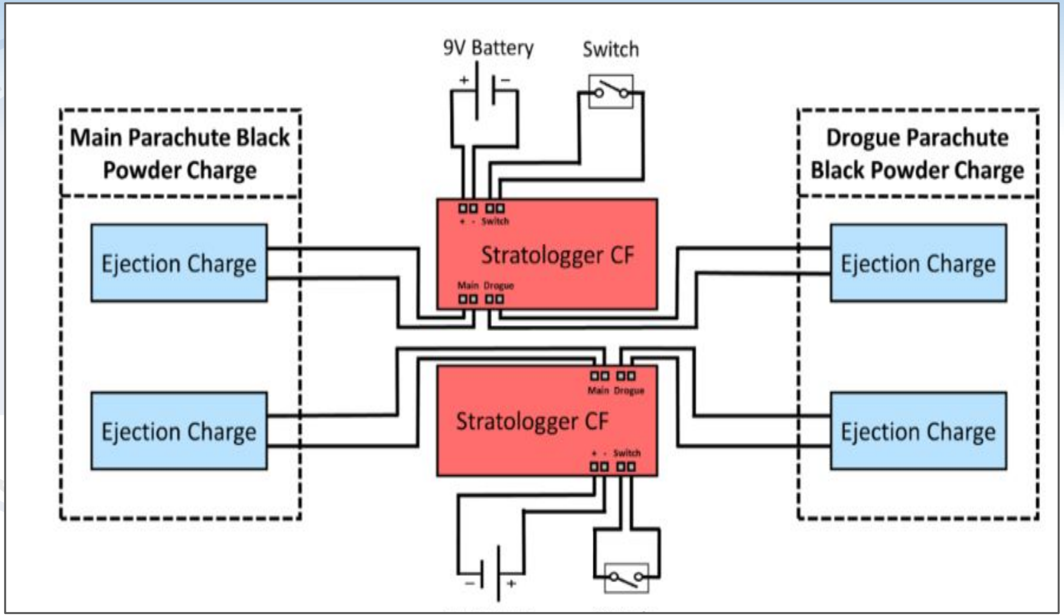
Switch

Initiator



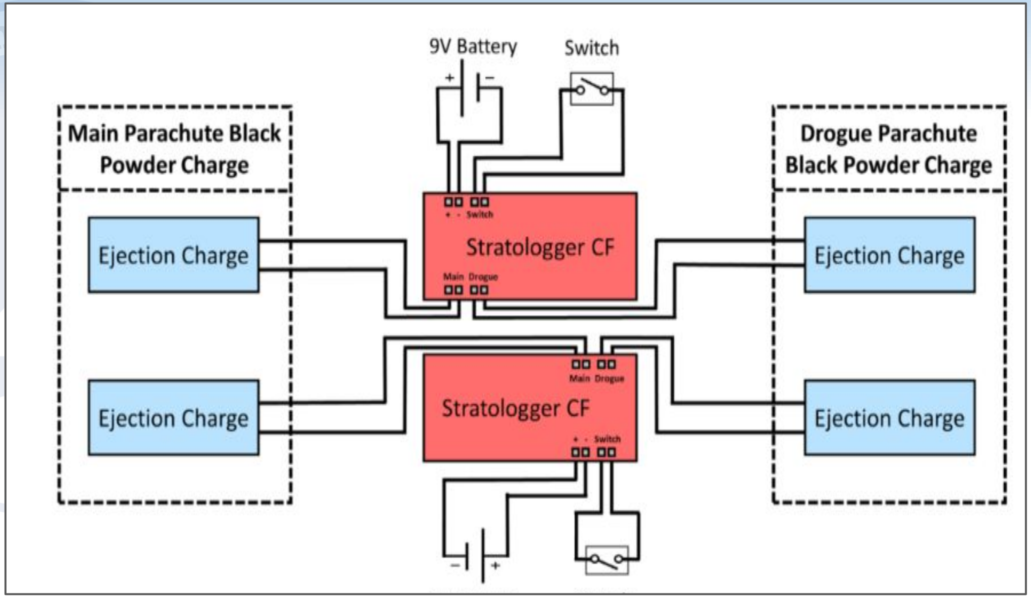
Altimeter



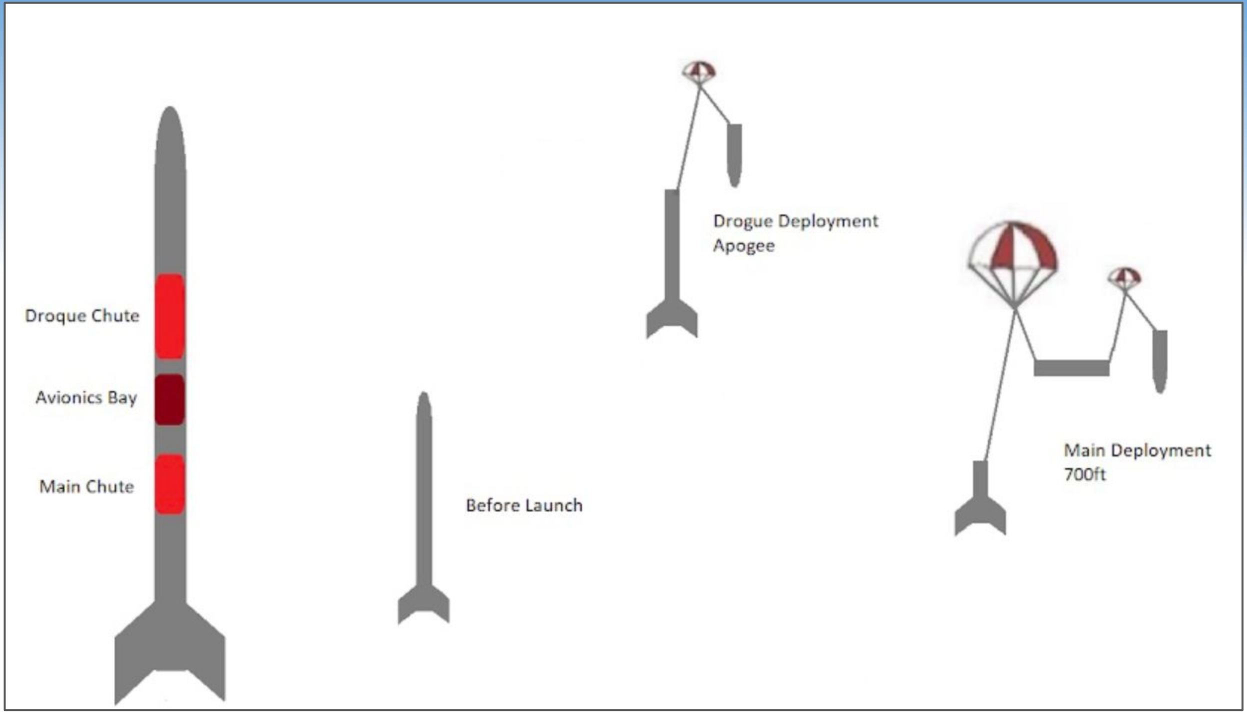


Avionics Bay Continued

- Two independently wired sets of altimeters, 9V batteries, ejection charges, and mechanical quick snap connector switches.
- Black powder ejection charges
- FAA approved initiators will be used



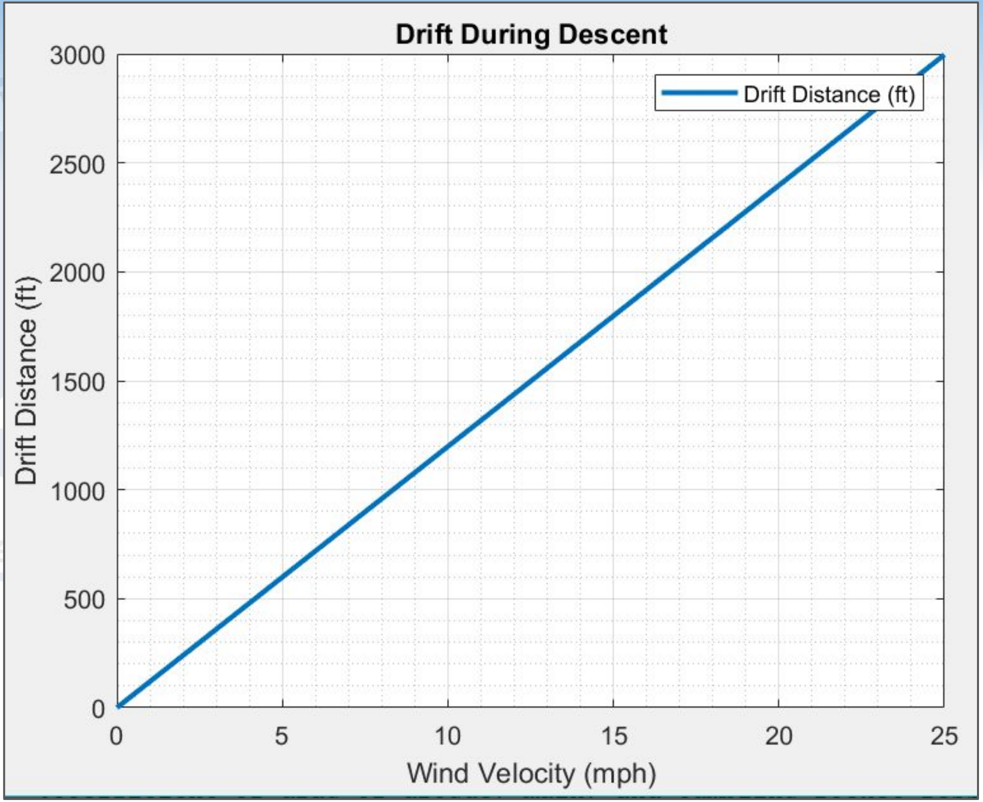
Parachute Sizes and Descent



Drogue Parachute	Main Parachute
12” Fruity Chutes Classical Ultra	72” Fruity Chutes Iris Ultra

Drift Distance Calculations

Wind Velocity	Drift Distance
5 mph	598.9 ft
10 mph	1197.8 ft
15 mph	1796.7 ft
20 mph	2395.6 ft

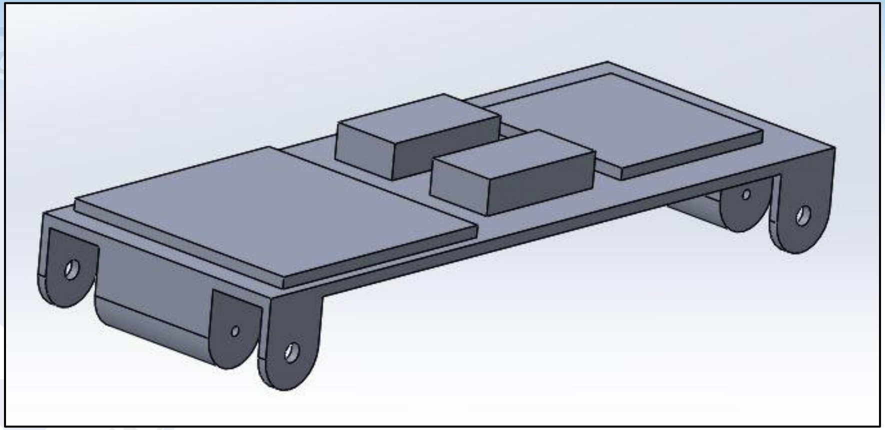


Kinetic Energy Calculations for Component

Section	Mass	Kinetic Energy at landing (Matlab)	Kinetic Energy at landing (Openrocket)
Nose	125.5 oz	54.85 ft*lbs	58.78 ft*lbs
Avionics	123.3 oz	53.89 ft*lbs	57.75 ft*lbs
Booster	167.0 oz	72.99 ft*lbs	78.21 ft*lbs

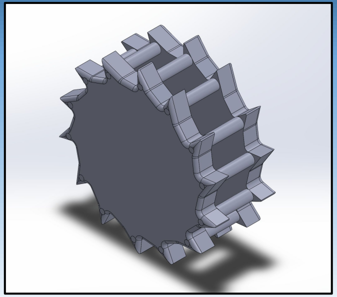
Preliminary Rover Design

- 3D printed DC motor mounts
- 3D printed / fiberglass frame
- Mounts for Arduino, batteries, radio module, and motor drivers
- Built in axle supports

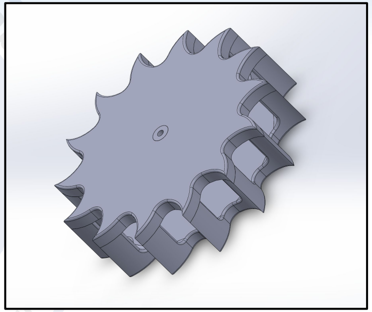


Wheel Designs

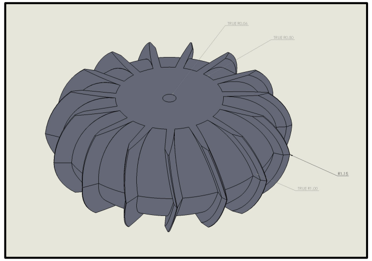
- Designed to operate well in soft soil



- 3D printed for ease of manufacturing, prototyping, and customization

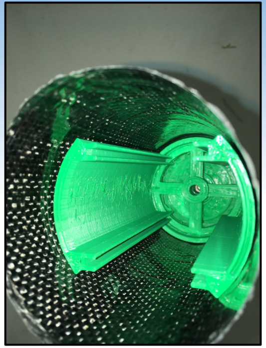


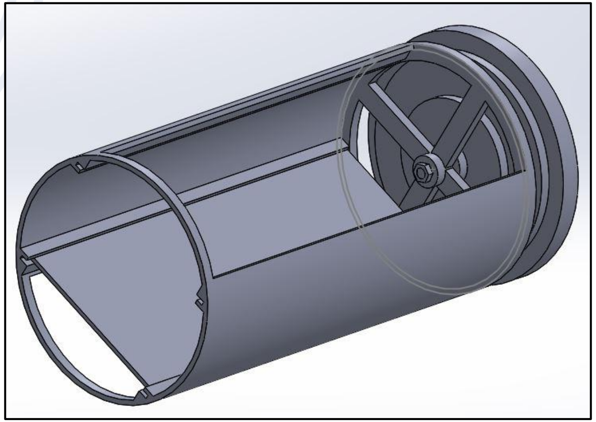
- Currently testing to determine the optimal design based on performance, weight, and durability



Preliminary Containment Mechanism Design

- Rotating mechanism with counterweight to hold rover upright
- 3D printed for ease of prototyping and manufacturing
- Wood/fiberglass shelf to hold deployment electronics
- Solenoid lock to hold the rover in place during flight





Deployment Mechanism

- The rover will be deployed from the rocket by a black powder charge after the rocket has safely landed.
- The deployment mechanism will contain a LoRa RFM radio module and an initiator to ignite the separation charge.
- A ground control GUI will be made using MATLAB to communicate with the rocket and deploy the rover.

Electronics and Software

- The preliminary choice for the microcontroller is an Arduino nano
- Electronics components on board include 2 dual shaft DC motors, motor drivers, 9 volt batteries, LoRa RFM radio module, and a servo motor
- Once the rover has landed, a release and drive sequence will be executed so that it can drive 10 feet and recover a soil sample

Soil Sample Recovery

- Table 1 to the right shows the preliminary choices for the soil sample recovery system

- Testing and prototyping will be conducted to determine the most effective method

	Description	
Auger	The auger will be powered by a servo. This will pull the soil up into a container to retain the soil.	
Wheel	The separate wheel will pull the soil up as it turns. The soil will be directed into a container built onto the rover.	
Scoop	A mechanical scoop will dig into the earth and deposit the soil into a container on the rover.	

Table 1: Design options for soil sample recovery

Safety Overview

- Hazardous materials identified and hazard mitigation plans developed for each material
- Major personal and environmental hazards were identified and preliminary mitigation plans were developed
- Major failure modes were identified and preliminary mitigation plans were developed
- All members take safety training course modules offered by EHS

Hazardous Materials and their Effects

- Carbon Fiber
  - Severe respiratory problems if fibers inhaled
- Epoxy Resin
  - Can cause serious eye damage and toxic if swallowed
- Isopropyl alcohol
  - Can cause flash fire and can cause skin or respiratory irritation
- Fiberglass
  - May cause severe respiratory problems and skin and eye irritation

Failure Modes and Mitigation

- Motor is not retained
  - Ejection charges push motor out of the rear of the rocket
  - Motor does not undergo controlled descent with the rest of the rocket
  - Use of active motor retention
  - Use of a lower impulse motor
- Bulkhead separation from the body tube
  - Insufficient epoxy strength results in premature separation of the rocket, potentially followed by ballistic descent
  - Visual inspection
  - Preflight check

Failure Modes and Mitigation

- Nose Cone ejection through early ejection charge from faulty wiring
  - Test for continuity and wiring for charges before launch
  - Perform through rigorous testing on the control software to prevent premature triggering
  - Build software and hardware guards for the separation trigger to prevent accidental activation
- Ejection charges failing to go off or failing to separate the rocket
  - Would cause ballistic descent
  - Use fresh batteries for each launch and check altimeter continuity before each launch
  - Calculate the amount of explosive power necessary to separate the rocket

Budget

Expected Outflow

Budget	Total Cost
Fullscale	$2,031.85
Subscale	$867.69
Travel	$8,000.00
Outreach	$300.00
Miscellaneous	$500.00
Total	**$11,699.54**

Expected Inflow

Donor	Requested Amount
Penn State Aerospace Engineering Department	$2,000.00
Penn State Mechanical Engineering Department	$1,500.00
Club Fundraising	$1,250.00
University Park Allocations Committee	$10,000.00
Engineering Undergraduate Council	$1,000.00
Pennsylvania Space Grant Consortium	$2,000.00
The Boeing Company	$500.00
Total	**$18,250.00**

Project Plan

LionTech Rocket Labs

2018-2019 Student Launch Gantt Chart

Legend
- Actual Date
- Planned Date

Project Milestones	Plan Start	Plan Duration	Actual Start	Actual Duration	Progress
Fullscale Initial Design	9/2/18	2 weeks	9/2/18	2 weeks	100%
Payload Initial Design	9/2/18	2 weeks	9/2/18	2 weeks	100%
Proposal	9/2/18	3 weeks	9/9/18	4 weeks	100%
Subscale Design	9/9/18	2 weeks	9/9/18	3 weeks	100%
Payload Design	9/16/18	4 weeks	9/16/18	8 weeks	50%
Subscale Construction	9/23/18	3 weeks	9/16/18	4 weeks	100%
PDR	9/23/18	4 weeks	10/21/18	4 weeks	100%
Subscale Flight	11/11/18	1 week	N/A	N/A	0%
Redesign	11/18/18	1 week	N/A	N/A	0%
CDR	11/4/18	8 weeks	N/A	N/A	0%
Fullscale Testing	1/20/19	7 weeks	N/A	N/A	0%
Payload Constuction	1/27/19	8 weeks	N/A	N/A	0%
FRR	1/13/19	11 weeks	N/A	N/A	0%
Payload Integration	2/17/19	6 weeks	NA	NA	0%
Competition Preparation	3/17/19	3 weeks	NA	NA	0%
LRR	3/31/19	1 week	NA	NA	0%
Competition Launch	3/31/19	1 week	N/A	N/A	0%