Penn State
LionTech Rocket Labs

Critical Design Review

Presentation Overview

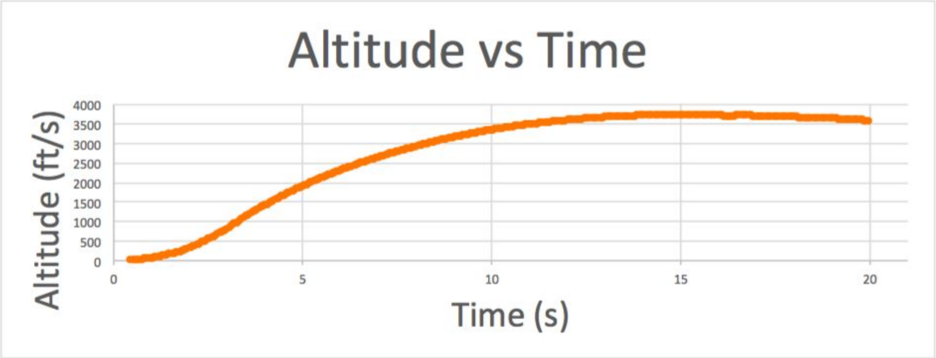
- Team Introductions
- Structures: Rocket Design
- Propulsion: Motor Selection and Future Testing
- A&R: Recovery System
- Payload: Rover Design
- Safety
- Budget
- Timeline
- Questions

Team Introduction

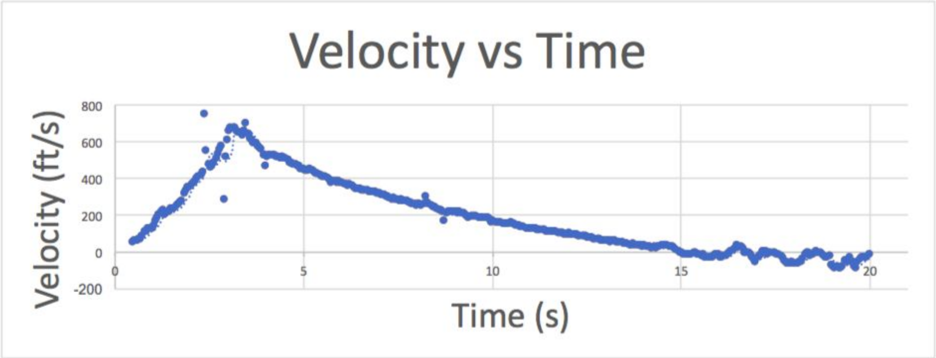
President:	Justin Hess
Vice President:	Torre Viola
Structures Leads:	Anthony Colosi
	Joshua Dubs
	Greg Schweiker
Propulsion Lead:	Matt Easler
A&R Leads:	Gretha Dos Santos
	Castle Leonard
Payload Leads:	Lawrence Lee
	Jackson Sizer
	Joey Weston
Safety Officer:	Laura Reese
Treasurer:	Kristi Roth

Subscale Results

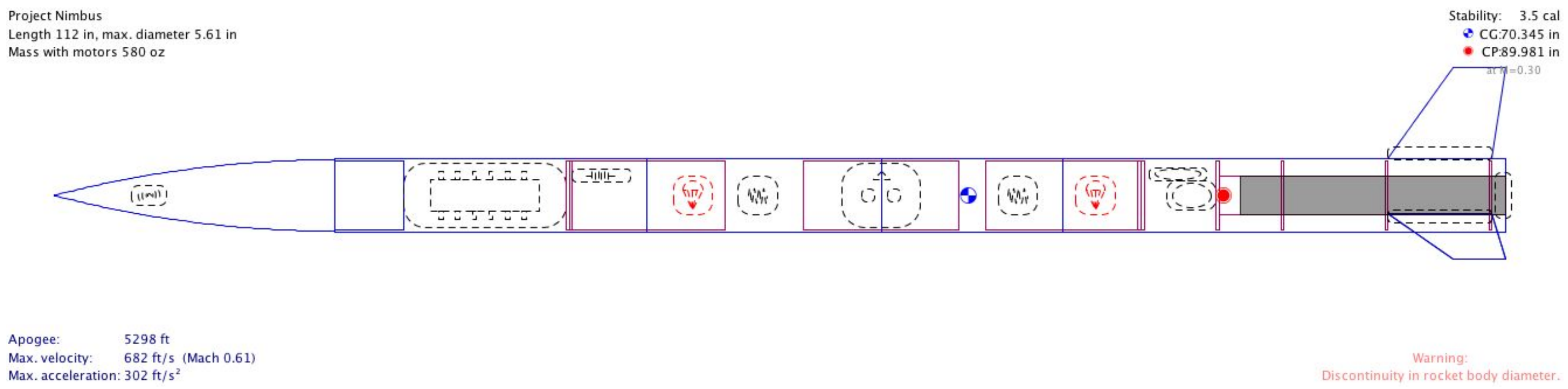
The launch vehicle reached an apogee of 3733 feet at 14.9 seconds into the flight.



The launch vehicle achieved a max velocity of 630 ft/s at 3.15 seconds into the flight.



Vehicle Characteristics



- Length = 112 inches
- Total mass = 38.5 pounds
- Outer Diameter = 5.61 inches

MATLAB

- Stability: 3.65 calibers
- CG: 68.99 inches
- CP: 89.49 inches

OpenRocket

- Stability: 3.5 calibers
- CG: 70.34 inches
- CP: 89.98 inches

Component Masses

Mass:

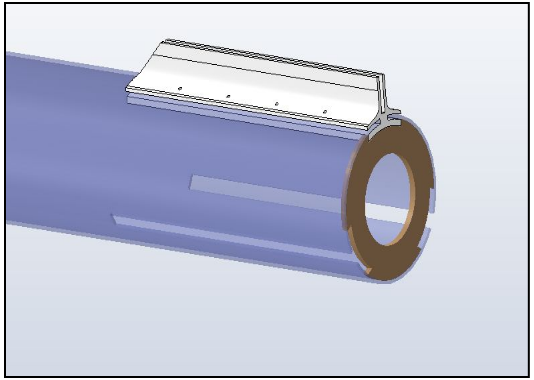
- Wrapped an 18 inch section of the full-scale body tube to calculate density
  - Found the volume and weight of this sample of CFWBT
- Extrapolated density to find the mass of all lengths and diameters of CFWBT body tubes.

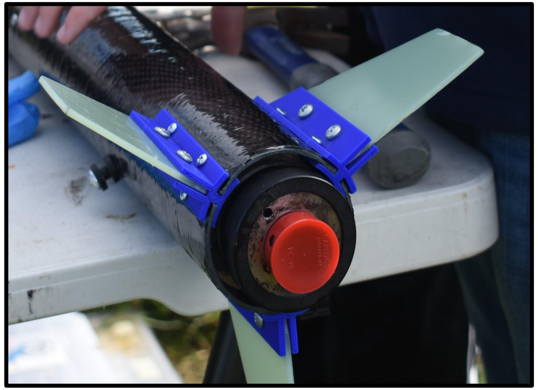
Component	Mass (oz)
Nose Cone	50.7
Payload Section	83.6
Payload-Main Coupler	11.4
Main Parachute Section	59.1
Main-Drogue Coupler	82.9
Drogue Parachute Section	37.4
Drogue-Booster Coupler	6.9
Booster Section	212.3
Fins (all three)	25.3
Fin Brackets (all three)	11.4

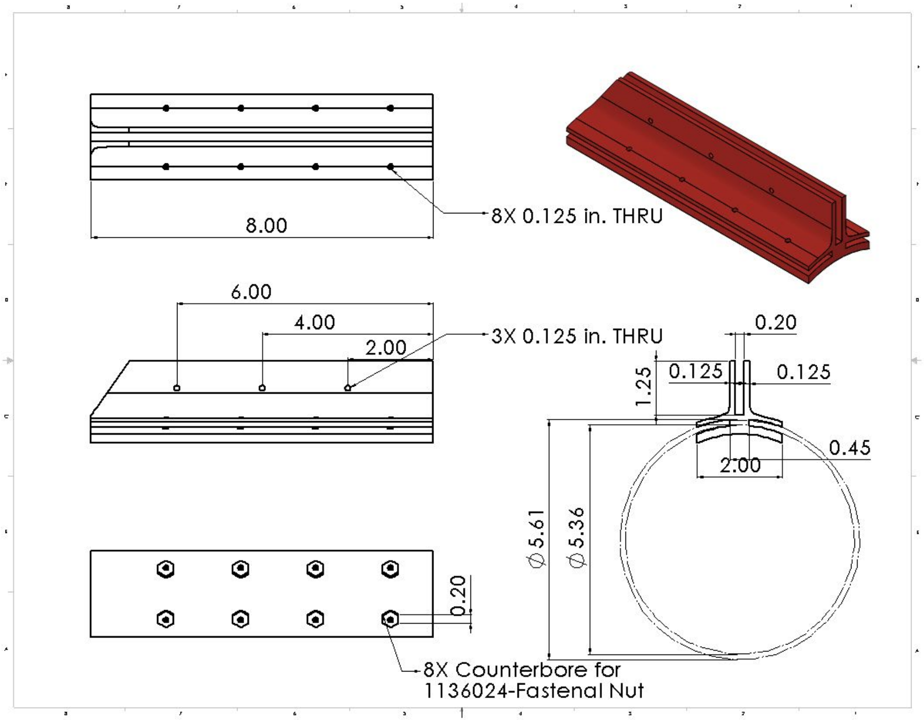
Airframe Selection

		Fiberglass		Blue Tube		Carbon Fiber		Carbon Fiber Wrapped Blue Tube	
Attributes	**Weight**	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
Strength	0.25	4	1	1	0.25	5	1.25	5	1.25
Cost	0.15	2.5	0.375	5	0.75	1	0.15	2.5	0.375
Workability	0.1	2	0.2	3.5	0.35	1	0.1	3	0.3
Weight	0.25	1	0.25	4	1	5	1.25	4	1
Appearance	0.05	5	0.25	3	0.15	5	0.25	5	0.25
Legacy	0.1	5	0.5	5	0.5	1	0.1	2	0.2
Hazardousness	0.1	1	0.1	5	0.5	1	0.1	2	0.2
Total			**2.675**		**3.5**		**3.2**		**3.575**

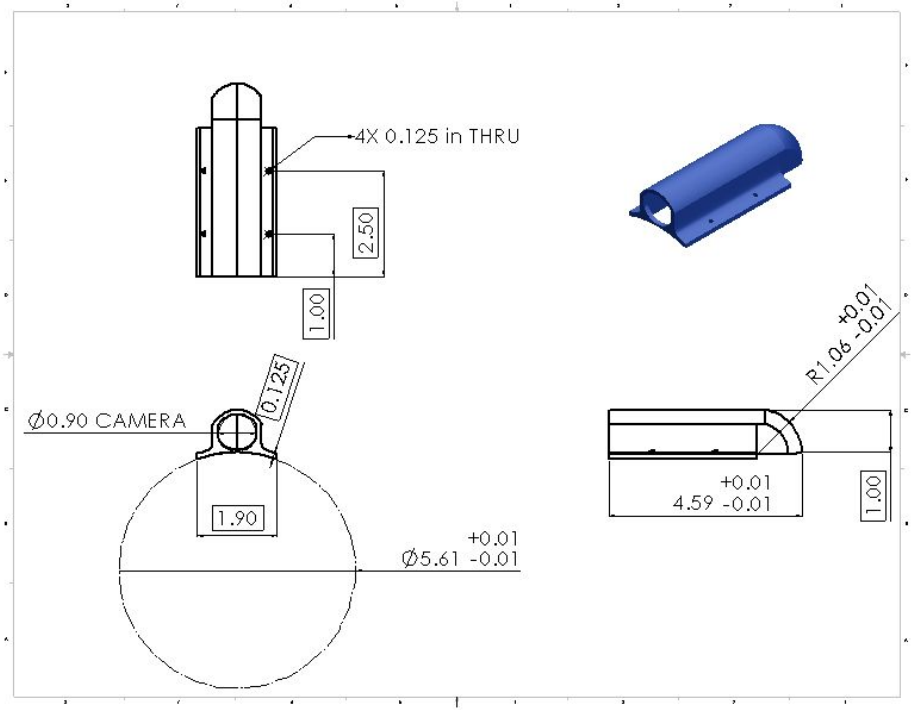
Fin Bracket Design





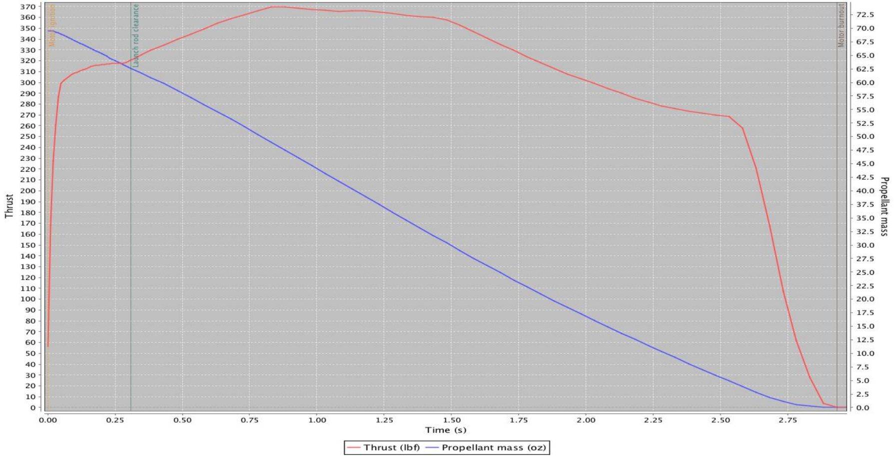


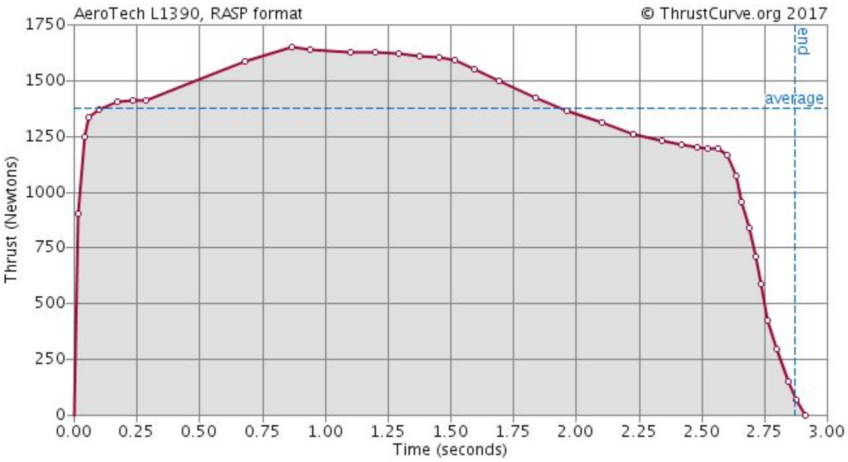
Camera Cover Design



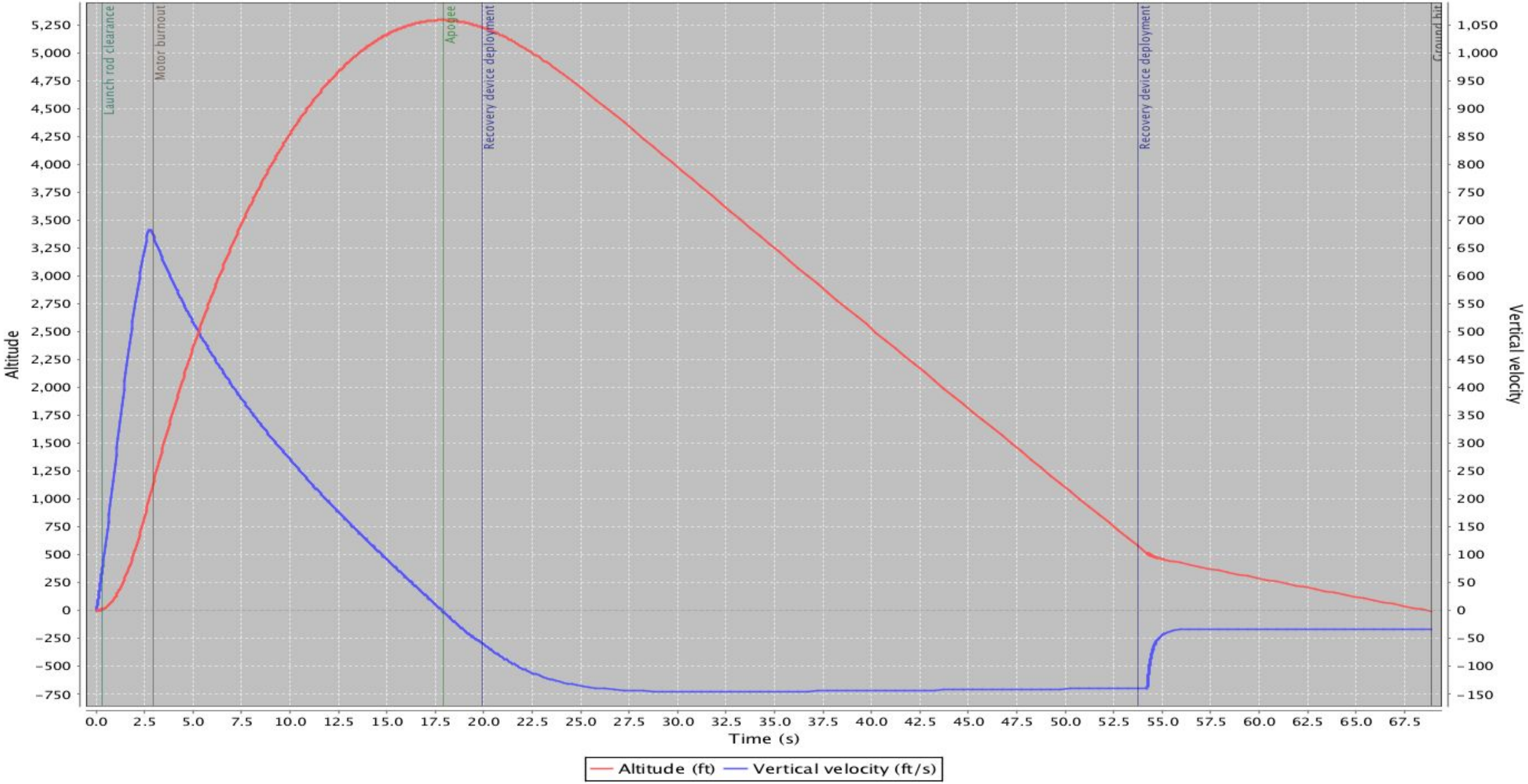
Primary Motor Characteristics

Motor	Apogee (ft)	Velocity off the Rail (fps)	Maximum Velocity (ft/s)	Thrust to Weight Ratio	Impulse (lbf*s)	Burn Time (s)	Mass (oz)
AeroTech L1390	5261	71.6	683	7.58	887	2.87	137



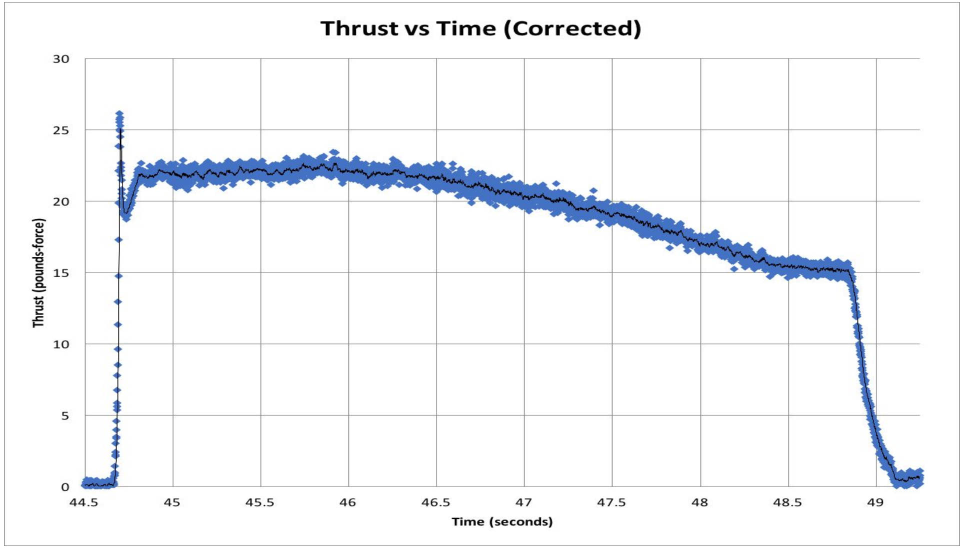


Primary Motor Flight Simulation



Motor Testing

- Static motor testing has been completed to calibrate test equipment and to validate procedures.
- More static motor testing will be performed on the primary motor (or a similar motor) to more accurately characterize it for simulations, while also providing opportunities to practice and refine operations procedures.



Carbon Fiber Wrapped Blue Tube

- Will wrap a piece of blue tube in three layers of carbon fiber weaving
- Testing tensile strength of each wrap using a load cell in order to mitigate potential zippering during parachute deployment

Status of Requirements Verification

- The vehicle will deliver the payload to an apogee altitude of 5,280 feet above ground level.
  - Accurate OpenRocket simulations have been conducted.

- The launch vehicle will be designed to be recoverable and reusable.
  - Durable materials
  - Modular design for localized repair

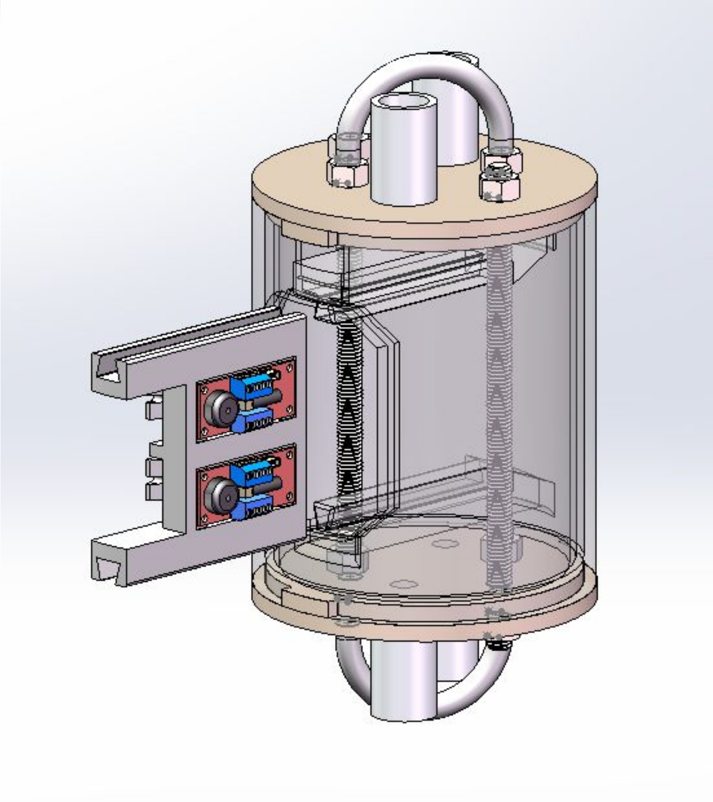
- The launch vehicle will have a maximum of four (4) independent sections.
  - Four sections being designed

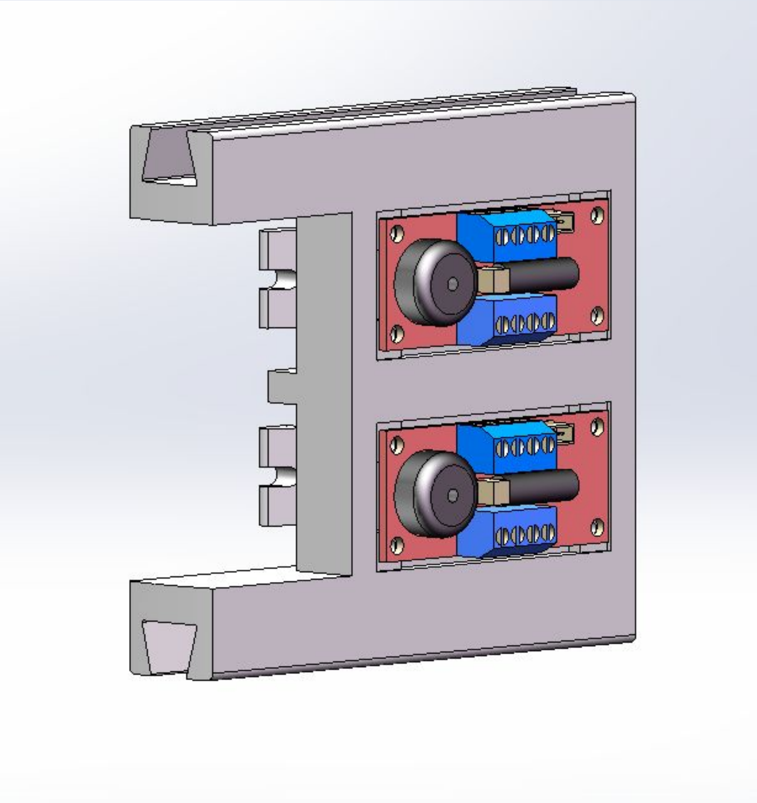
Status of Requirements Verification (cont)

- The launch vehicle will be prepared for flight at the launch site within 3 hours of the time the Federal Aviation Administration flight waiver opens.
  - Sectional design for easy transport
  - Majority of construction done prior to launch day

- The launch vehicle will have a minimum static stability margin of 2.0 at the point of rail exit.
  - Payload located towards the front brings CG forward.
  - Large fins pull CP towards tail end.

Avionics Bay

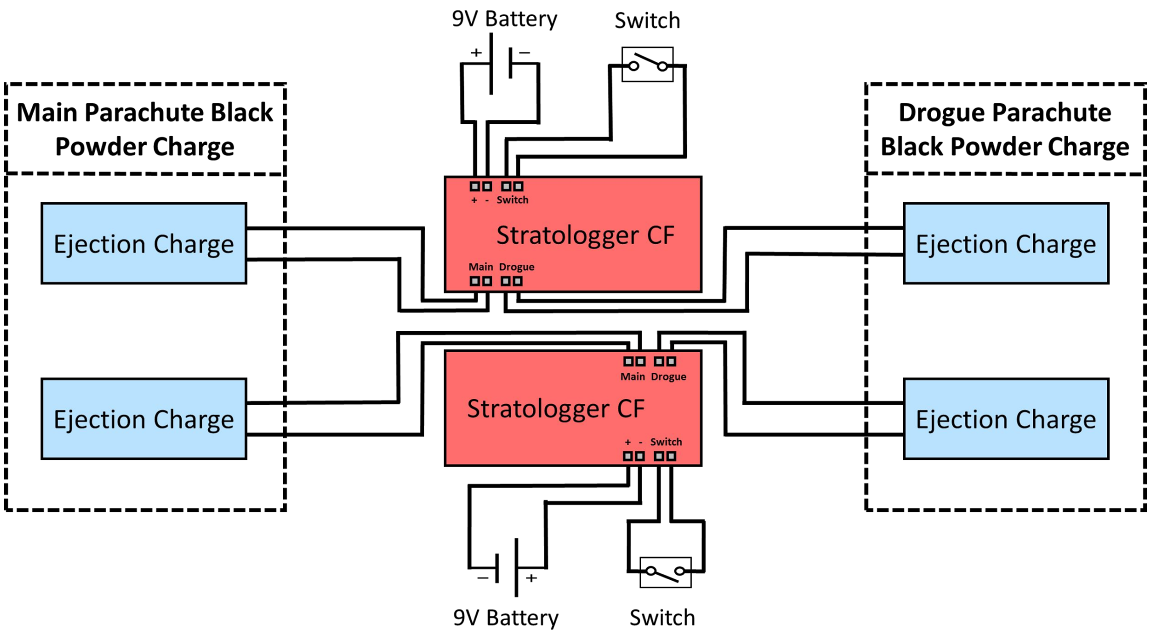




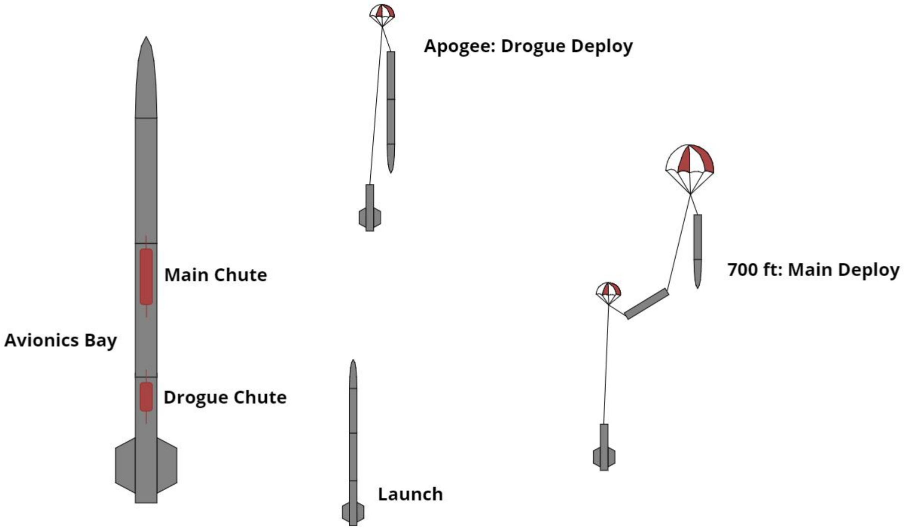
Avionics Bay Wiring Diagram

Features:

- Two independent sets of altimeters, batteries, ejection charges, switches
- Mechanical switch
- Ejection charges will be black powder
- FAA approved initiators will be used



Parachute Sizes and Recovery Harness Lengths



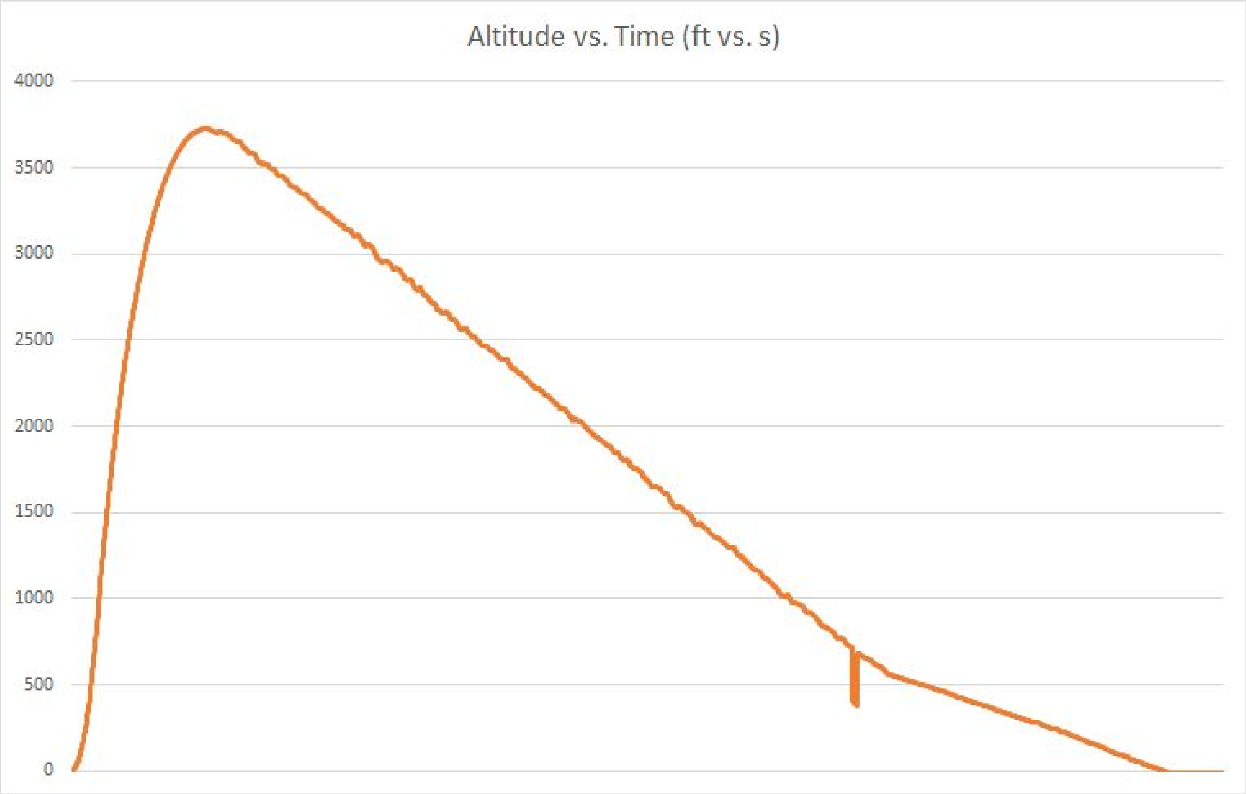
Drogue Parachute	Main Parachute
12” Fruity Chutes Classical Elliptical and 30 ft Recovery Harness	84” Fruity Chutes Iris Ultra and 40 ft Recovery Harness

Kinetic Energy and Drift

Section	Mass (oz)	KE After Main Deployment (ft-lb)	KE Right Before Landing (ft-lb)
Nose cone	146.7	1778	46.06
Avionics bay	152.7	1854	47.97
Booster	199	2416	62.50

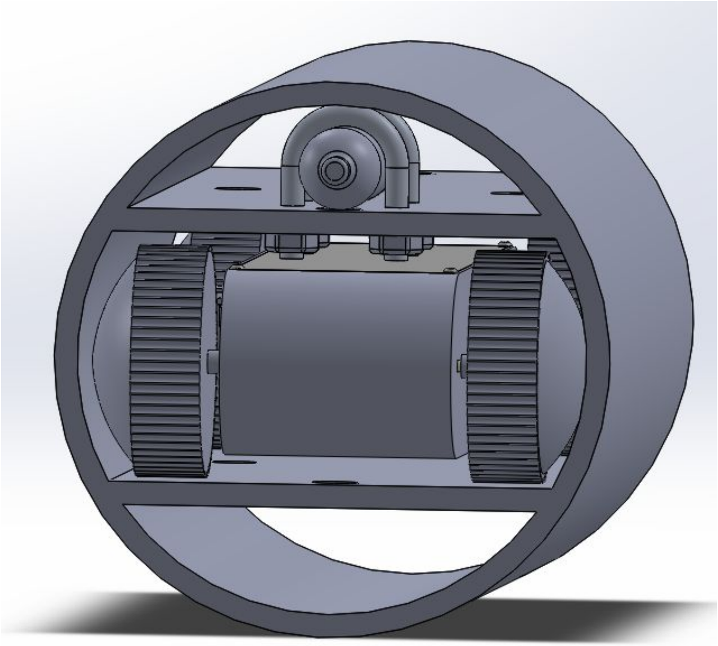
Wind Speed (mph)	Drift Distance (ft) $C_D = 2.2$
0	0
5	568.5
10	1137
15	1705
20	2274

Subscale Flight Results



Payload: Rover Design

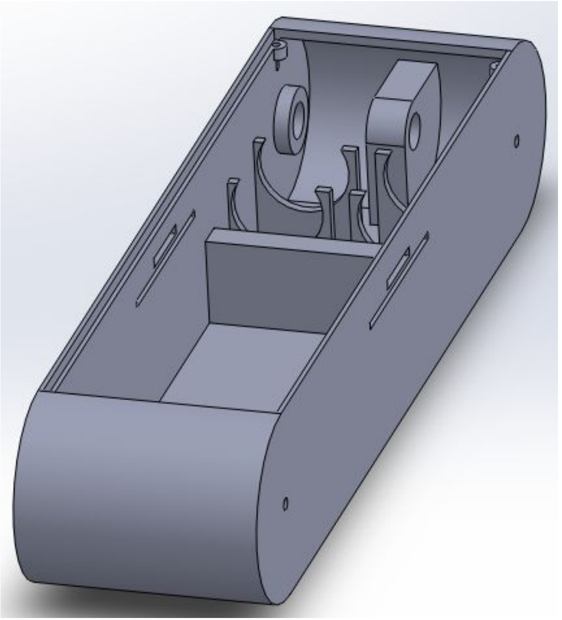
Final Payload Dimensions



- Autonomous rover
- CO_2 separation mechanism

Payload: Rover Design

Body



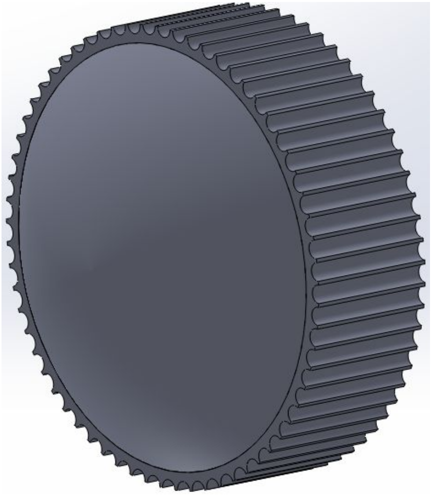
Key Design Features:

- Slots for solar panel deployment
- Motor mounts
- Rounded edges

Payload: Rover Design

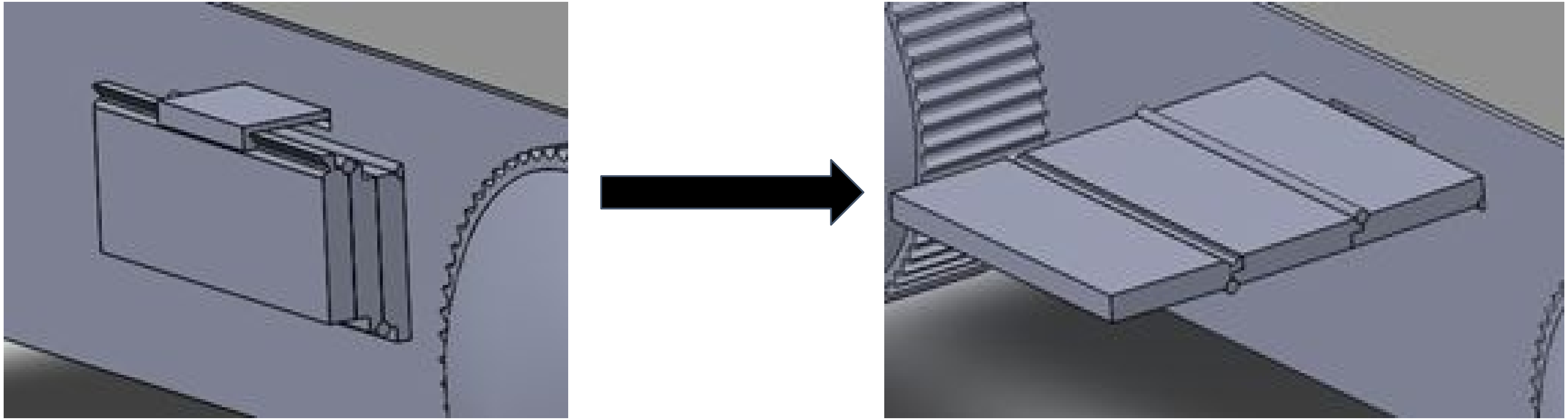
Drivetrain

- Rugged wheels
- Rubber coating
- Two 12V micro-metal gearmotors
- Rounded hubcaps



Payload: Rover Design

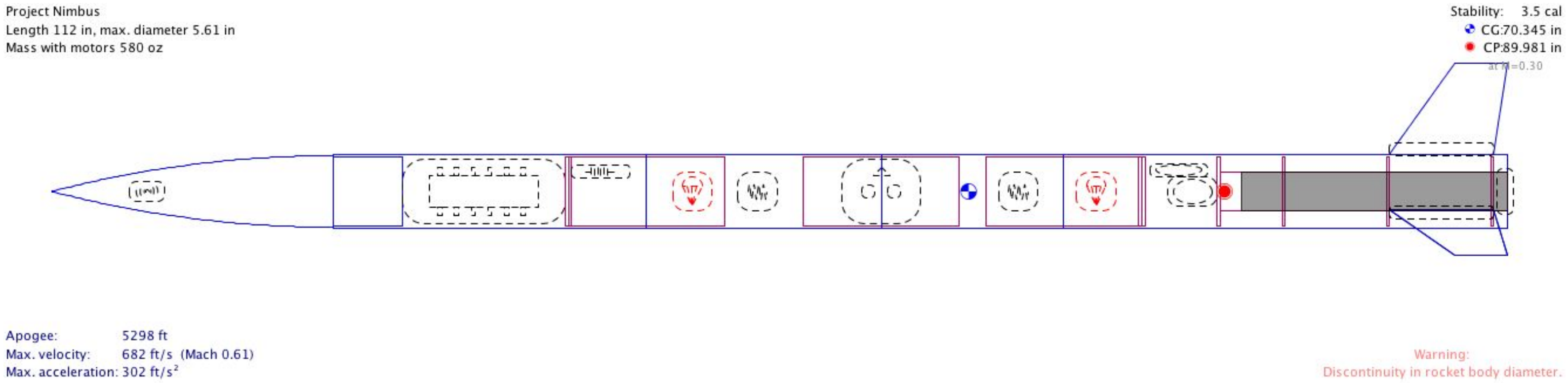
Solar Panel Deployment



Payload: Rover Design

Nose cone separation

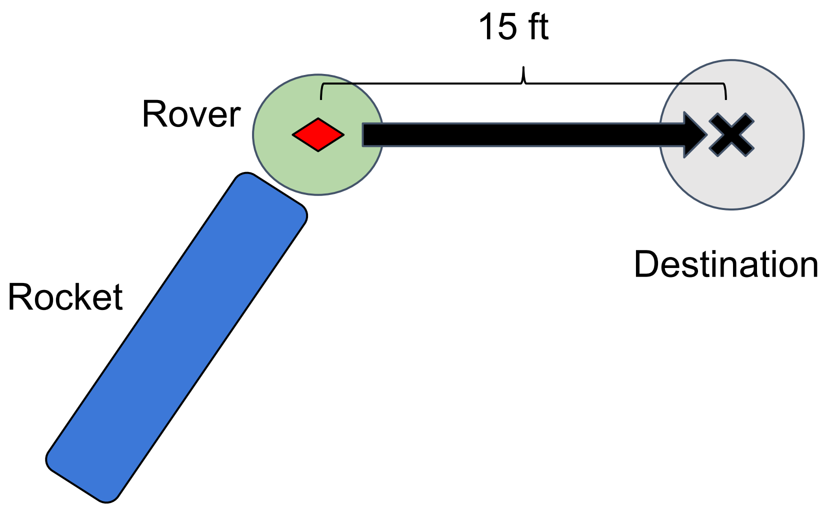
- Upon landing, nose cone is ejected via detonation of Carbon Dioxide canister
- Holes are drilled through shelves to stabilize pressure



Payload: Rover Design

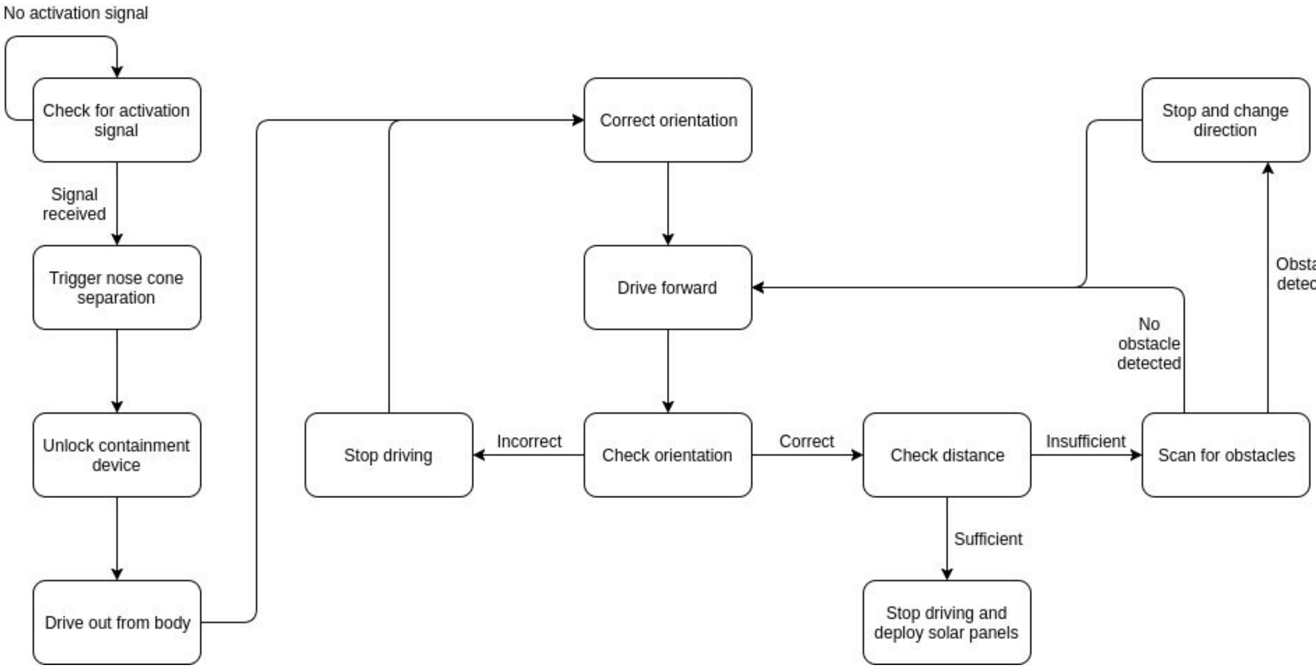
Distance Measurement

- Once out of rocket, obtain current coordinates of rover via GPS
- Identify point 15 ft away from current location
- Once arrived at location, deploy solar panels



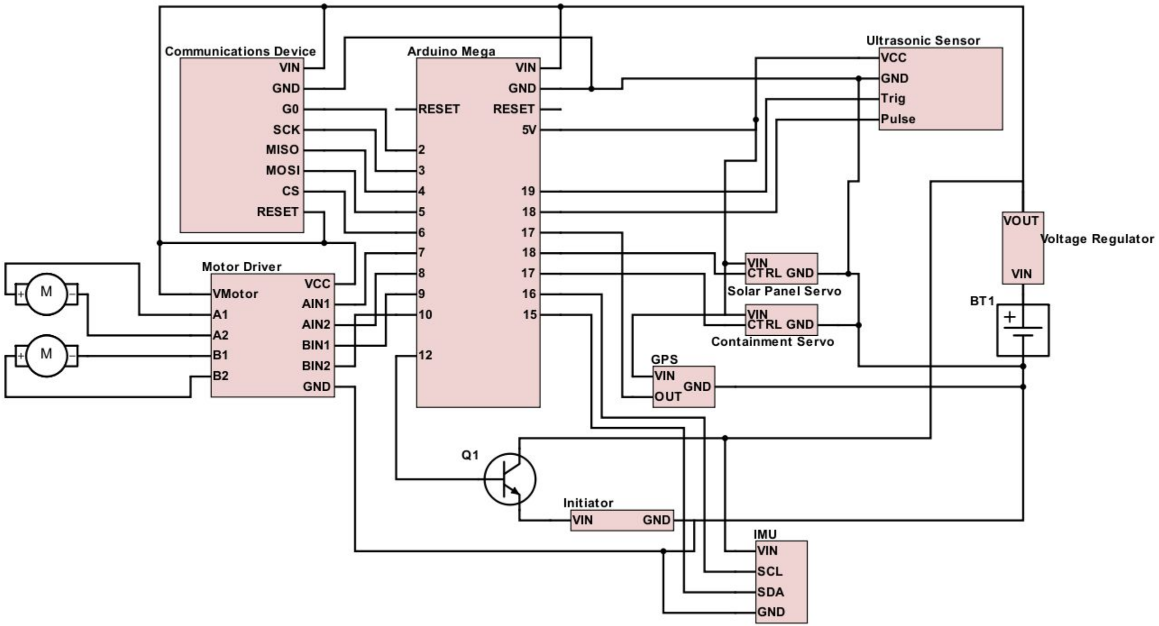
Payload: Rover Design

Software and Electronics



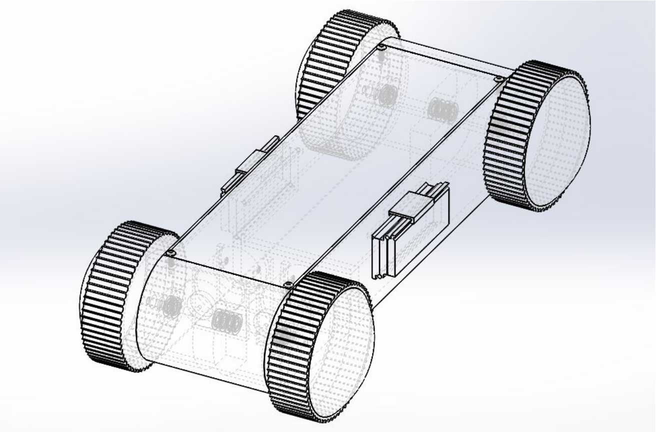
Payload: Rover Design

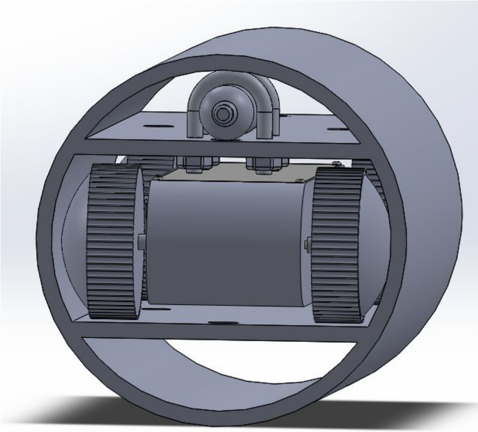
Software and Electronics

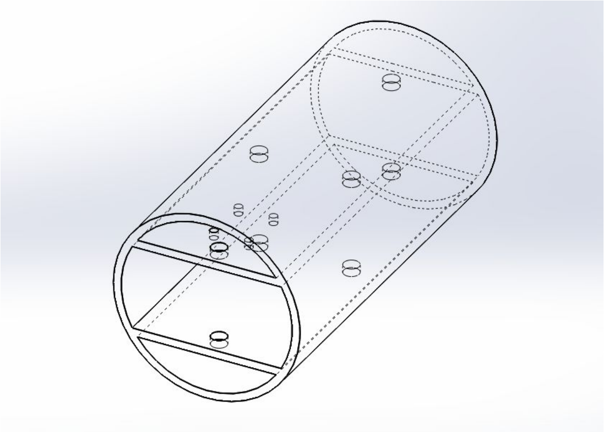


Payload: Rover Design

Final Payload Design Overview







Payload: Rover Design

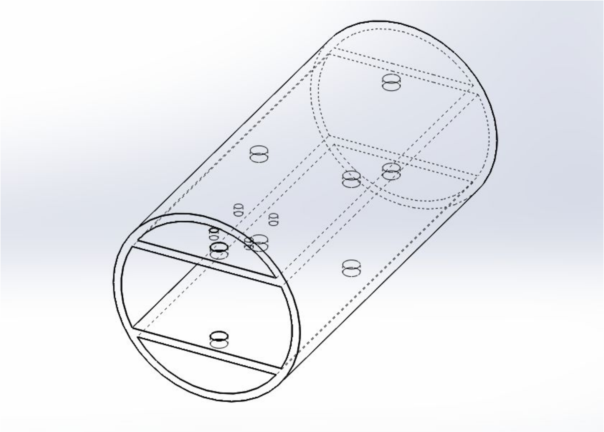
Test Plans and Procedures (Software and Hardware)

- Communications Testing
- Ejection Mechanism
- Rover Maneuvering
- Containment Mechanism

Payload: Rover Design

Payload Integration

- Containment System
  - Must be mounted to the bulkhead at the end of the payload bay
- Shelves
  - Must be mounted to the inside of the rocket
- Ejection and Deployment
  - Requires separating the rocket via CO_2 cartridge



Payload: Rover Design

Status of Requirements Verification

- Completed
    - Communications
    - Test location scouting
    - High-level software design

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

- New hazardous material: carbon fiber wrapping

Material	Hazards	Mitigations
Carbon fiber wrapping	Airborne fibers can cause severe respiratory irritation. Electrically conductive airborne fibers can cause short circuits in electrical systems.	Limit airborne fiber production during machining operations. Wear a dust mask when machining carbon fiber wrapping.
FibreGlast 2060 60 minute epoxy cure	Causes serious eye damage. Toxic if swallowed or inhaled. Can cause skin and respiratory tract irritation. Chronic exposure can result in harm to the liver, kidneys, eyes, skin or lungs.	Always wear gloves when applying the epoxy and epoxy cure.
FibreGlast 2000 epoxy resin	Skin and eye irritation	Wear gloves while handling.

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

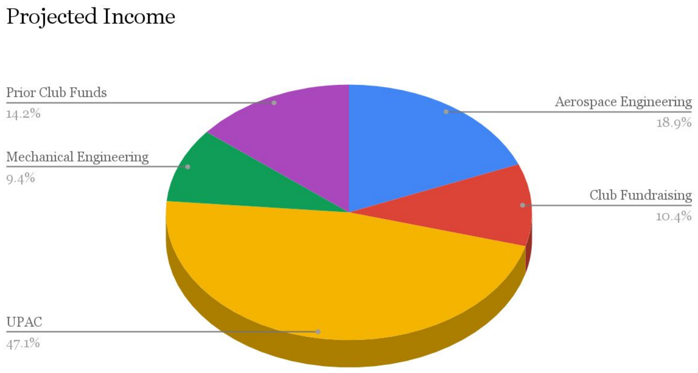
Failure Modes and Mitigation

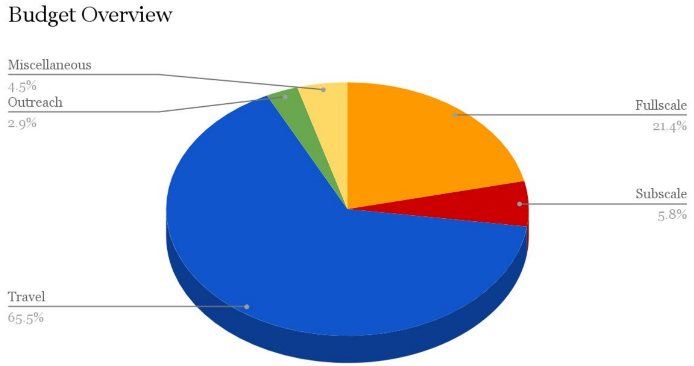
- Premature activation of CO_2 canisters
  - Control software triggers premature detonation of CO_2 canisters
  - Nose cone of the rocket separates prematurely
  - Perform thorough rigorous testing on the control software to prevent premature triggering
  - Build software and hardware guards for the 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	$2,253.74
Subscale	$604.37
Travel	$6,880.01
Outreach	$300.00
Miscellaneous	$469.49
Total	**$10,507.61**





Expected Inflow

Donor	**Requested Amount**
Penn State Aerospace Engineering Department	$2,000.00
Penn State Mechanical Engineering Department	$1,000.00
University Park Allocations Committee	$5,000.00
Club Fundraising	$1,105.00
Prior Club Funds	$1,502.59
Total	**$10,607.59**