Penn State
Lion Tech Rocket Labs

Preliminary Design Review

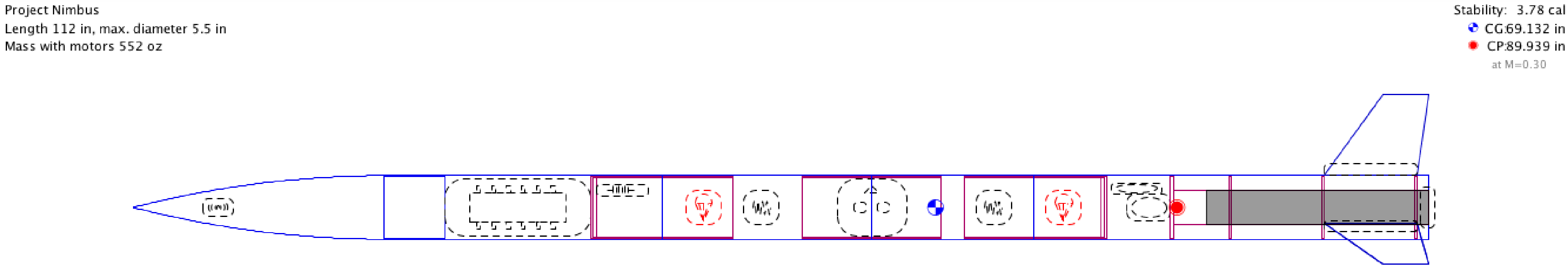
Presentation Overview

- 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
	Josh 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

Vehicle Characteristics



- Length = 112 inches
- Total mass = 34.25 pounds
- Outer Diameter = 5.5 inches

MATLAB

- Stability: 3.91 calibers
- CG: 68.491 inches
- CP: 90.001 inches

OpenRocket

- Stability: 3.78 calibers
- CG: 69.132 inches
- CP: 89.939 inches

Component Masses

Mass :

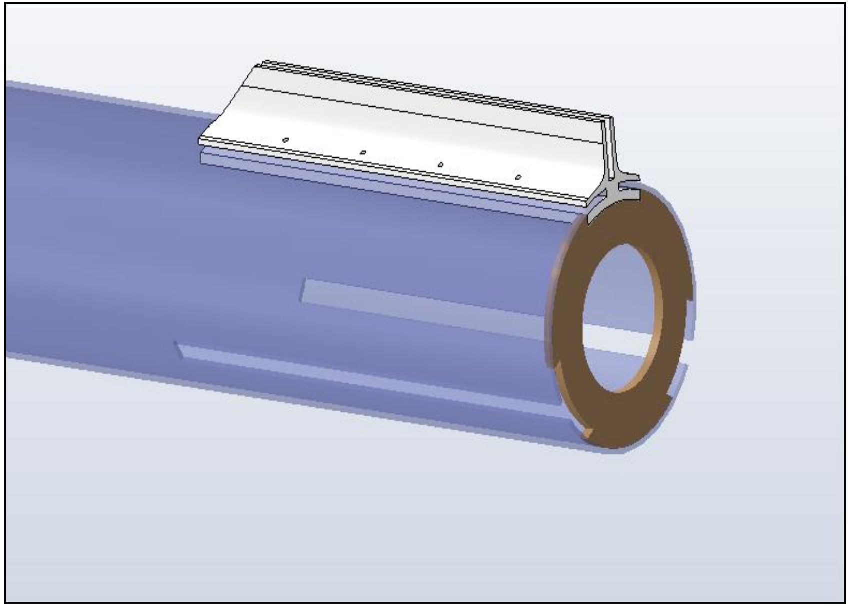
- took samples of material from subscale and calculated the density
  - Found the volume and weight of a sample of CFWBT
- Extrapolated density to find the mass of all lengths and diameters of CFWBT body tubes.

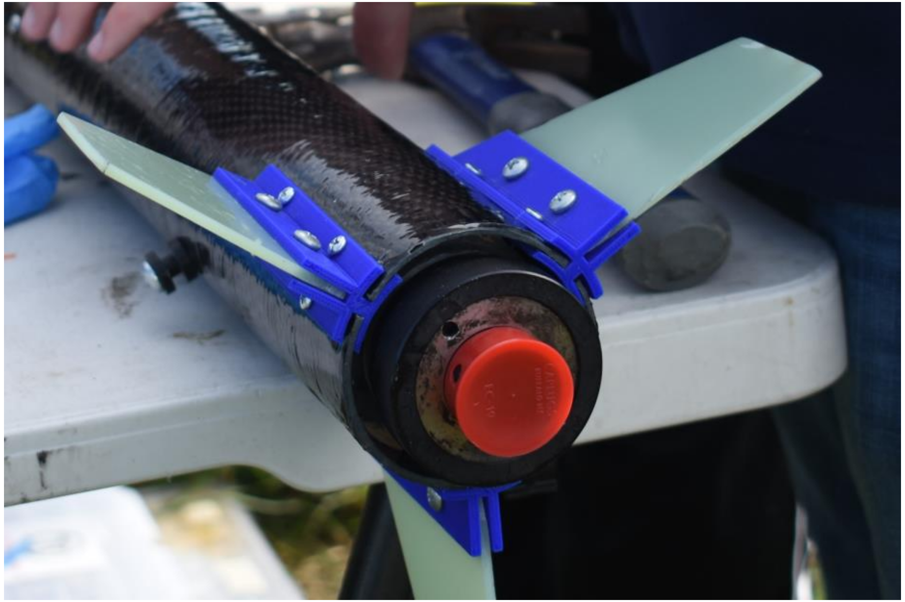
Component	Mass (oz)
Nose Cone	38.7
Payload Section	72.5
Payload-Main Coupler	11.4
Main Parachute Section	50
Main-Drogue Coupler	121
Drogue Parachute Section	25.1
Drogue-Booster Coupler	6.9
Booster Section	59.3
Fins (all three)	16.8
Fin Brackets (all three)	11.4

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	0.3	5	0.75	1	0.15	3	0.525
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			**2.6**		**3.5**		**3.2**		**3.725**

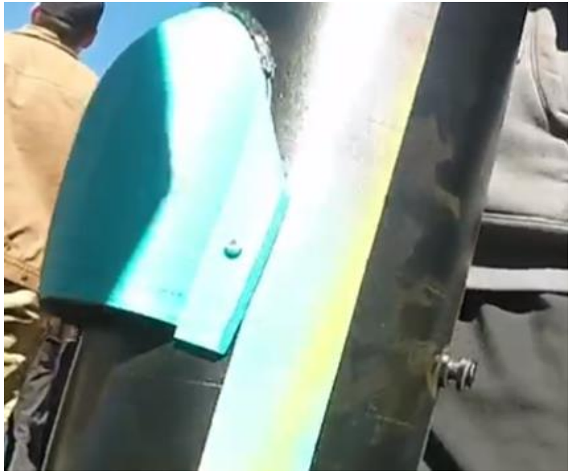
Fin Bracket Design





Camera Cover Design

2016-2017 Camera Cover

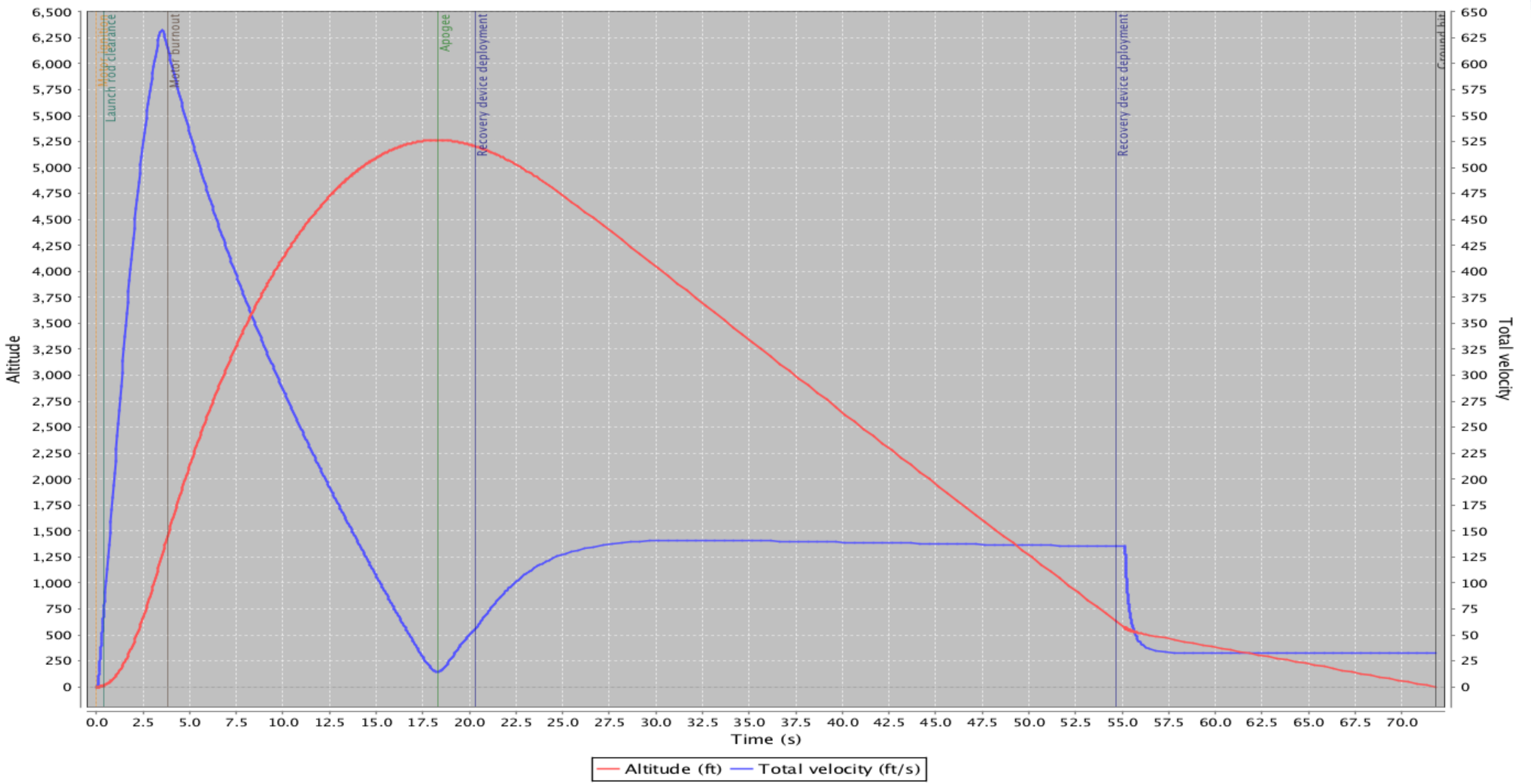


2017-2018 Camera Cover

Primary Motor Selection

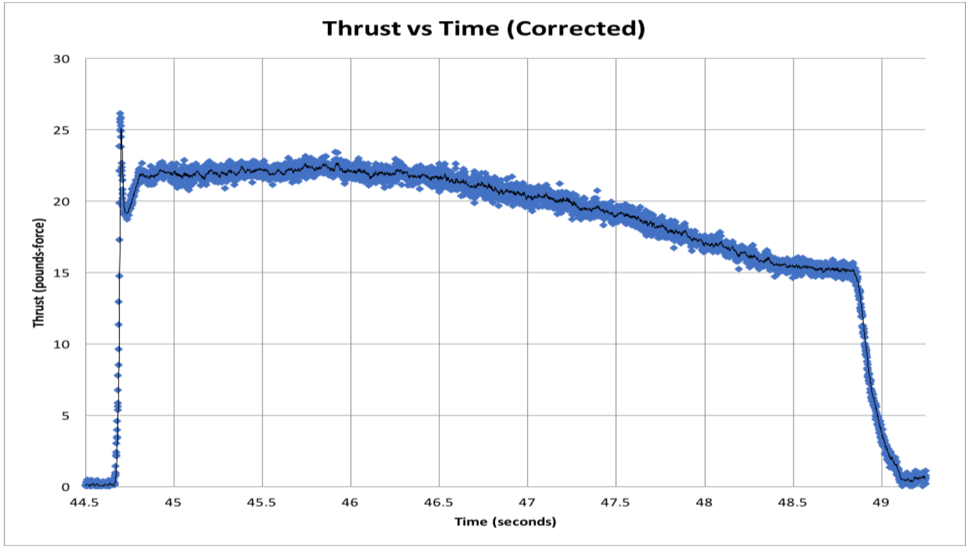
Motor	Apogee (ft)	Velocity off the Rail (fps)	Thrust to Weight Ratio	Impulse (lbf*s)	Burn Time (s)	Mass (oz)
AeroTech L1150	5003	69.3	8.22	784.36	3.04	130
Cesaroni L995	5263	73.7	8.03	814.05	3.63	127
Cesaroni L1720	5512	84	11.61	830.89	2.11	118

Primary Motor Flight Simulation

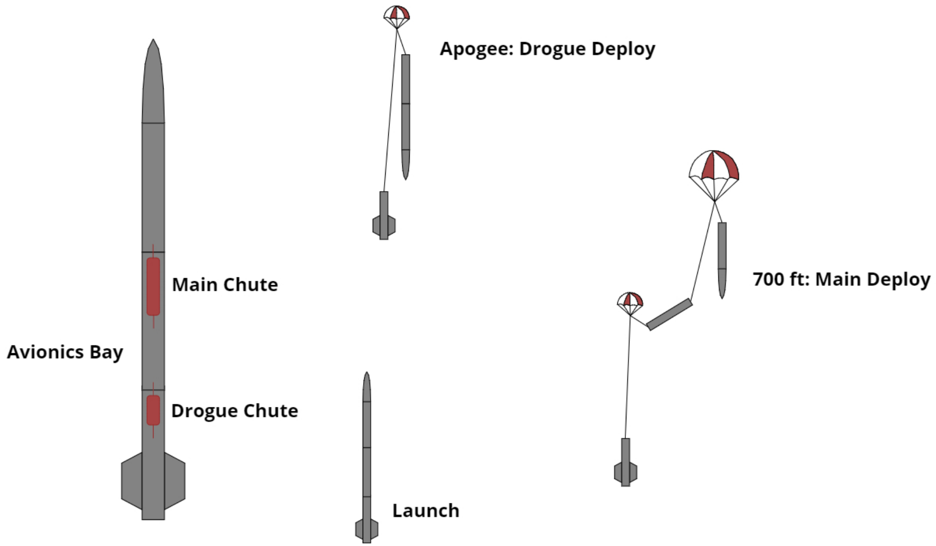


Testing

- Wind tunnel testing will be performed on subscale to obtain an accurate coefficient of drag.
- Static motor testing has been completed to calibrate test equipment and validate procedures.
- More static motor testing will be performed on the primary motor to more accurately characterize it for simulations.



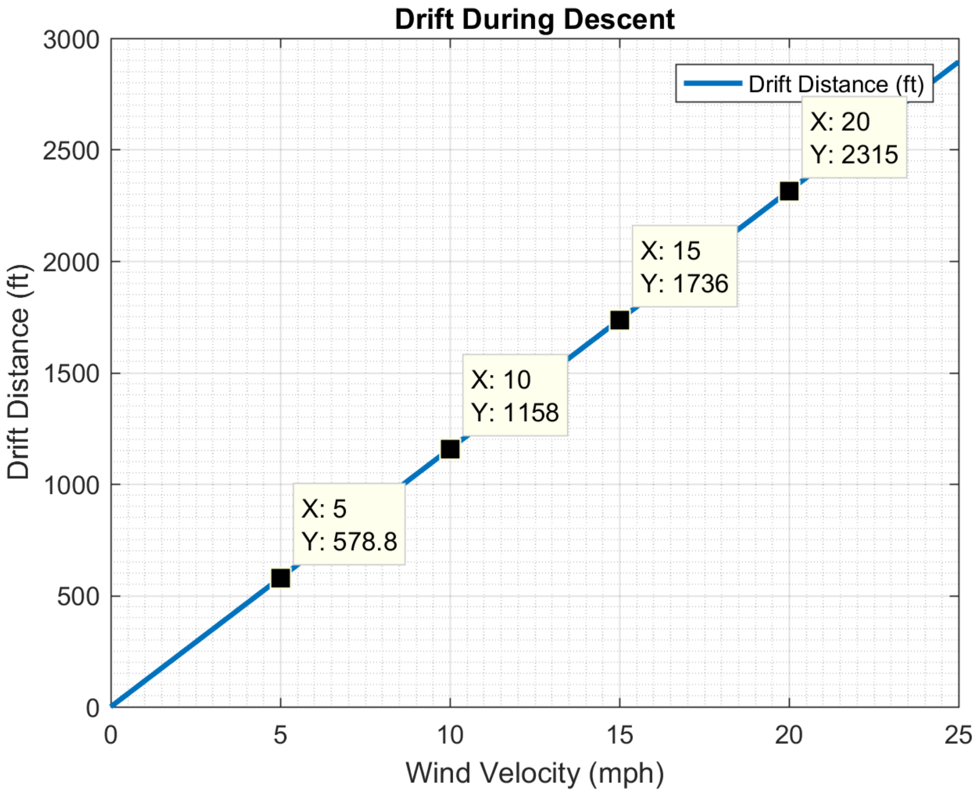
Parachute Sizes and Landing Diagram



Drogue Parachute	Main Parachute
12” Fruity Chutes Classical Elliptical	84” Fruity Chutes Iris Ultra

Drift Calculations

Wind Speed (mph)	Drift Distance (ft) C_D = 2.2
0	0
5	596.2
10	1192.4
15	1788.6
20	2384.8



Kinetic Energy of Each Component

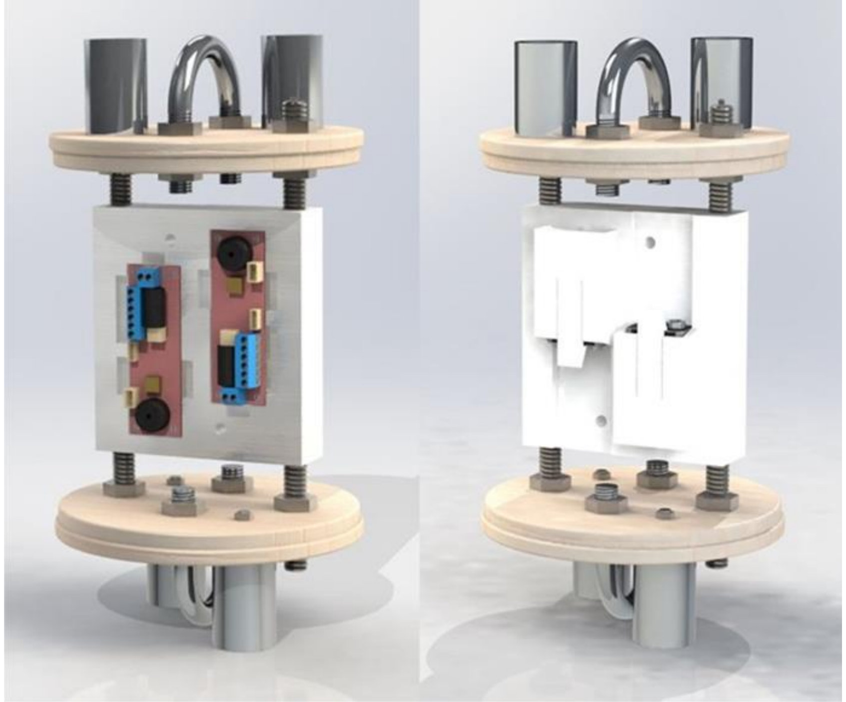
According to OpenRocket

Section	Mass (lbf)	Kinetic Energy (ft-lb) $C_D = 2.0$	Kinetic Energy (ft-lb) $C_D = 2.2$
Nose cone	8.88	59.98	54.74
Avionics bay	7.67	51.76	47.24
Booster	10.27	69.36	63.30

According to MATLAB Model

Section	Mass (lbf)	Kinetic Energy (ft-lb) $C_D = 2.0$	Kinetic Energy (ft-lb) $C_D = 2.2$
Nose cone	8.88	42.74	38.69
Avionics bay	7.67	36.89	33.63
Booster	10.27	49.42	45.05

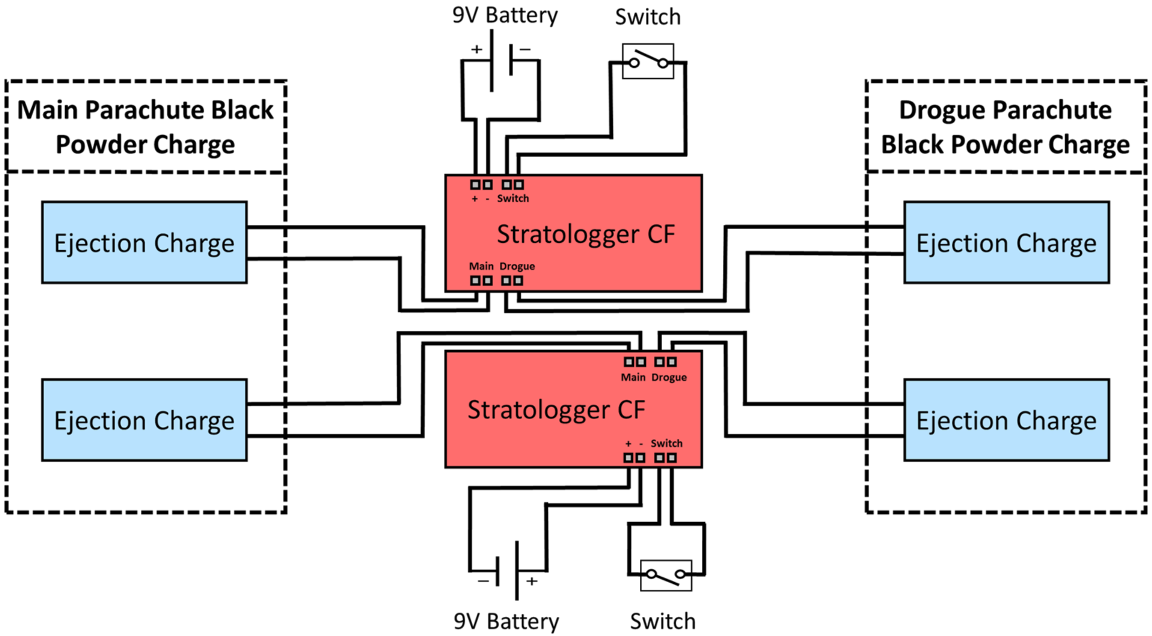
Avionics Bay Preliminary Designs

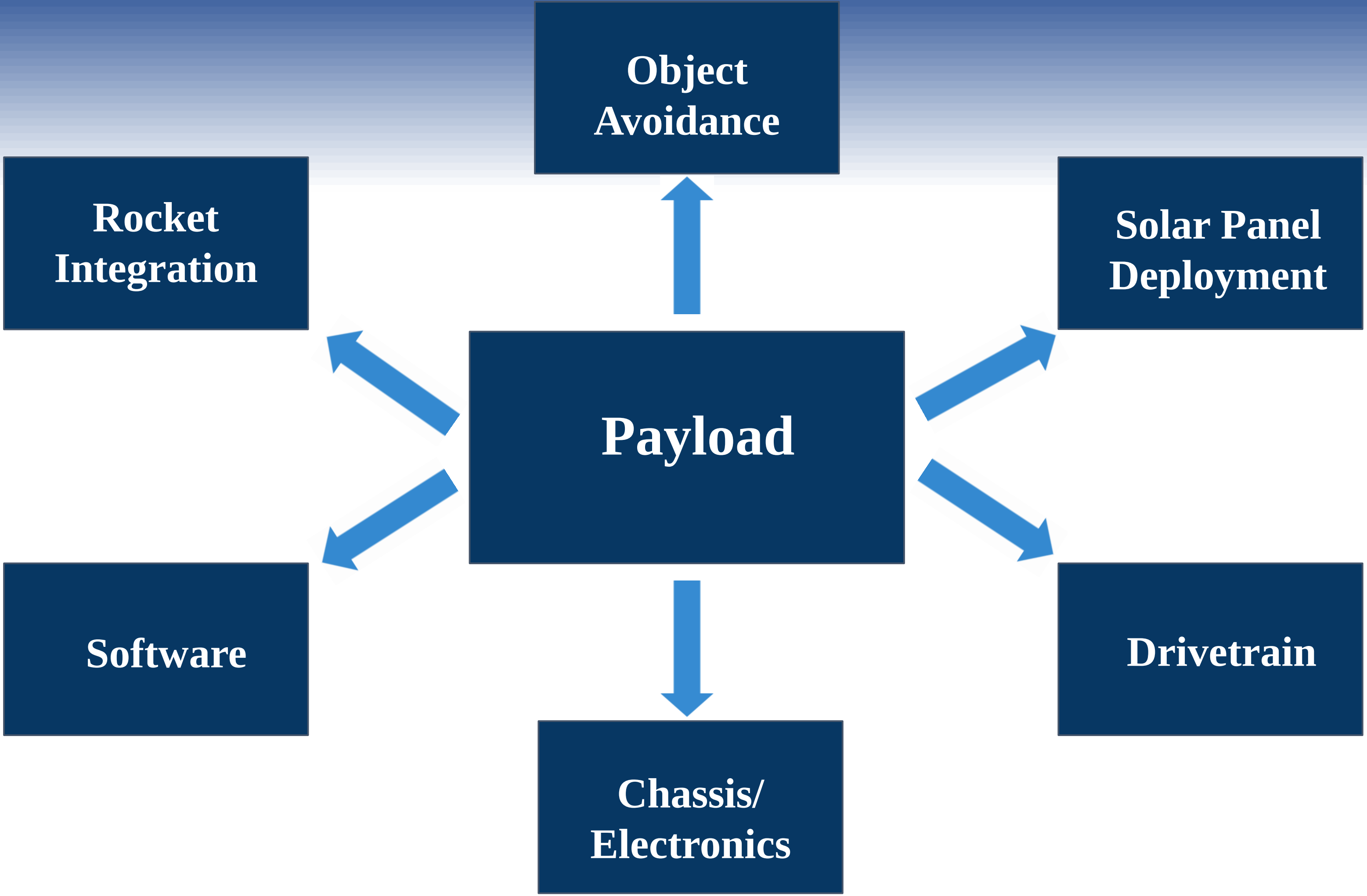


Avionics Bay Wiring Diagram

Features:

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





Payload

Object Avoidance

Solar Panel Deployment

Drivetrain

Chassis/ Electronics

Software

Rocket Integration

Payload - Object Avoidance Concepts

- Sensors
  - Use infrared sensors to scan for obstacles in path and change path to avoid them
- Plow
  - Mount conic shaped plow on front of rover to push obstacles out of path
- Parallelogram Shape
  - Design body of rover to have parallelogram shaped profile to climb over obstacles easier

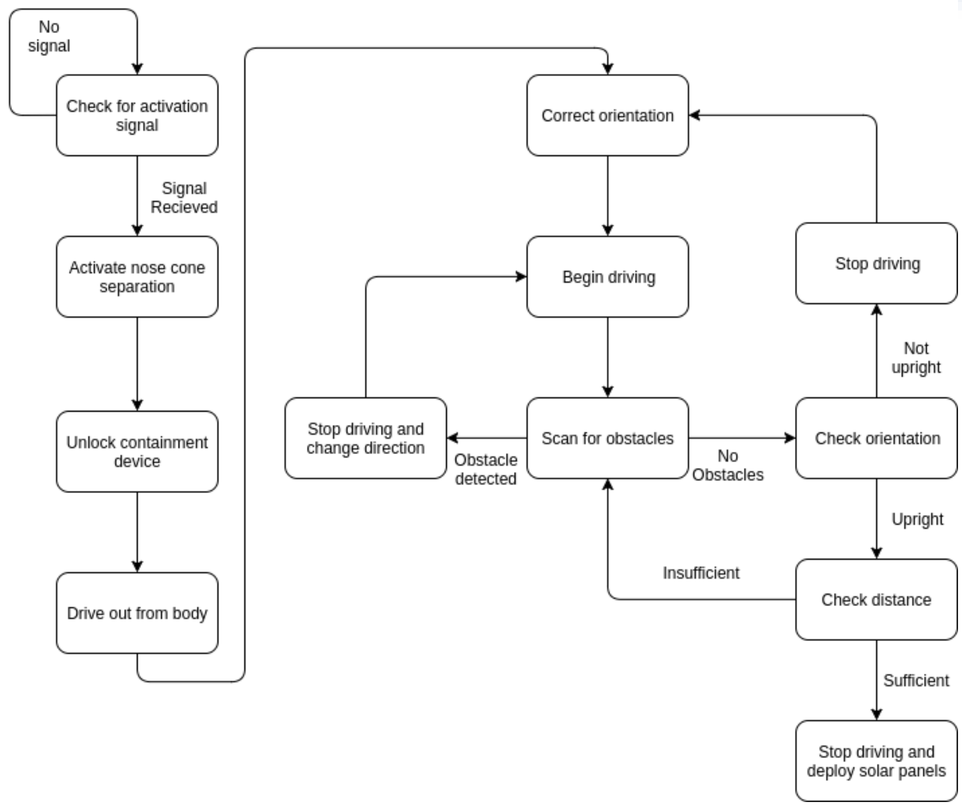
Payload - Object Avoidance Mechanism Selection Matrix

	Weight	Sensors	Parallelogram Shape	Plow
Range	0.168	4	1	3
Light	0.054	5	4	3
Effective	0.326	3	2	4
Agility	0.236	3	1	3
Low Power	0.032	2	5	4
Small	0.185	5	4	3
		3.613	2.169	3.358

Payload - Rocket Integration

- Door
  - Locking mechanism to keep rover inside until activation
- Internal locking mechanism
  - Rover will latch on to inside of its containment chamber

Payload - Software Flowchart



Payload - Distance Measurement Concepts

- Accelerometer
  - Use accelerations in x, y, and z to generate displacement vector
- GPS
  - Use coordinates to determine distance between initial and active location
- Wheel Encoder
  - Convert number of wheel revolutions into a displacement
- String on Pin
  - Mount a string of length > 5 ft to a removable pin on rover that disengages drivetrain when fully extended

Payload - Distance Measurement Device Selection Matrix

	Weight	Accelerometer	GPS	Wheel Encoder	String on Pin
Accurate	0.555	4	2	3	4
Low Risk	0.370	4	2	3	1
Adaptable	0.076	5	3	4	2
Total		4.076	2.076	3.076	2.739

Payload - Drivetrain Concepts

- Spurred Wheels
  - Side mounted star shaped wheels that are capable of gripping terrain
  - Powered by servos or differentials
- Augers
  - Side mounted screws that rotate transverse to direction traveled
  - Powered by servos or differentials
- Tracks
  - Wide base, flexible tracks that distribute weight to generate traction
  - Powered by DC motor

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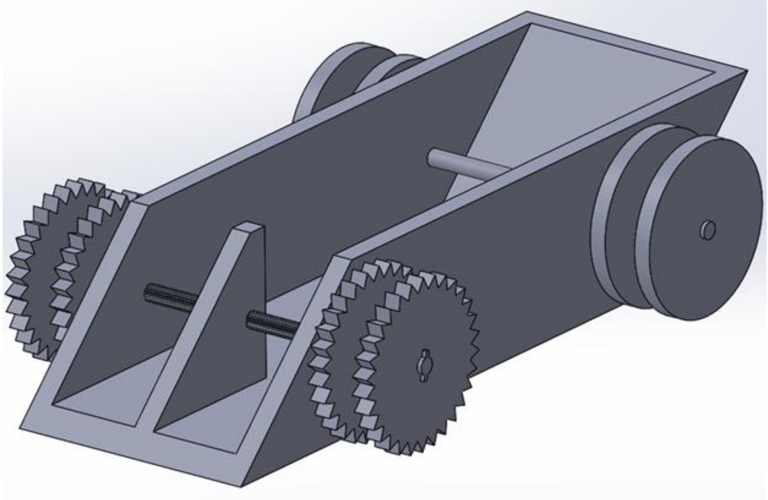

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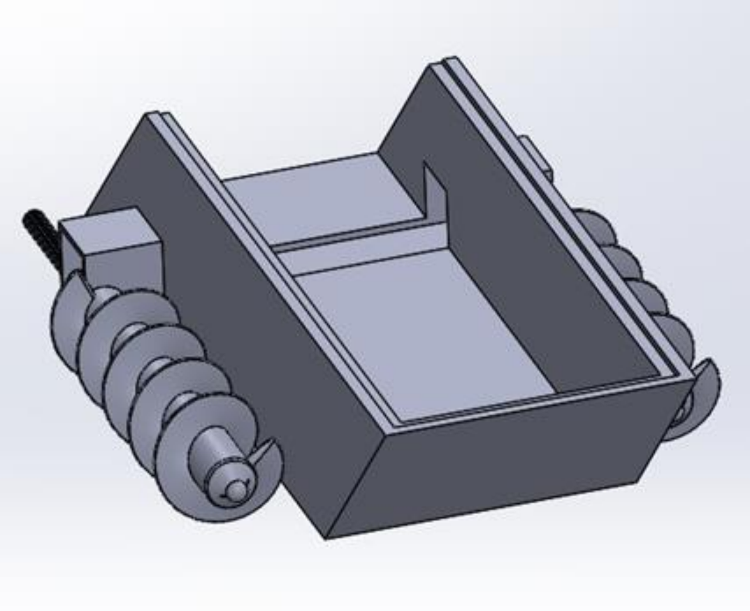

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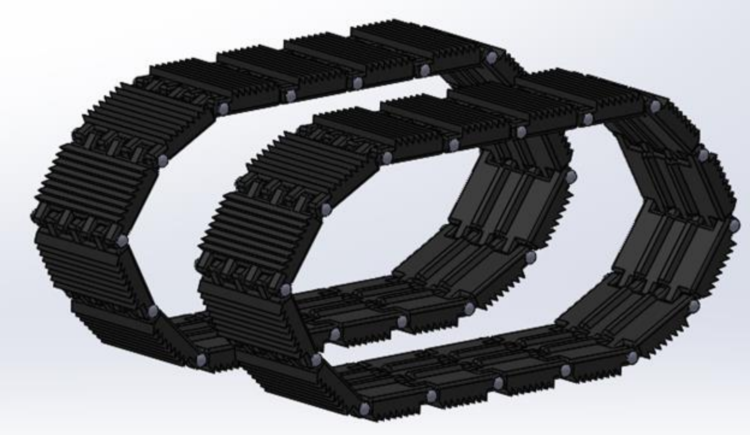
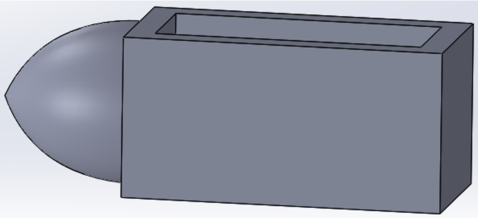


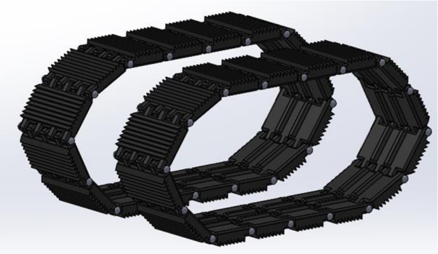
Payload - Drivetrain Selection Matrix

	Weight	Wheels	Treads	Auger
Maneuverable	0.259	2	4	3
Low Risk	0.064	3	3	2
Traction	0.268	2	4	4
Torque Output	0.296	2	3	2
Durable	0.080	2	4	3
Weight	0.033	4	2	1
Total		2.131	3.573	2.841

Payload - Rover Design Summary

- A rover that will be remotely deployed and autonomously navigate 5 feet from the rover to deploy solar panels.
- **Treads** will be the driving mechanism.
- An **accelerometer** will be used to determine the distance travelled from the rocket.
- **Sensors** will be used to determine where obstacles are so that the rover can avoid them. An additional front-end mounted **plow** will be used to push aside obstacles that are harder to detect with sensors.





Payload - Testing / Verification

- Drivetrain - A sample rover of similar weight and size will be tested using the tread design on similar terrain to that of the launch site.

- Distance Measurement - The accelerometer method will be tested to ensure that it is accurate enough to get the rover the appropriate distance from the rocket.

- Object Avoidance - Infrared and Sonar sensors will both be tested to see which provides a more effective obstacle avoidance.

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 CO2 canisters
  - Control software triggers premature detonation of CO2 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

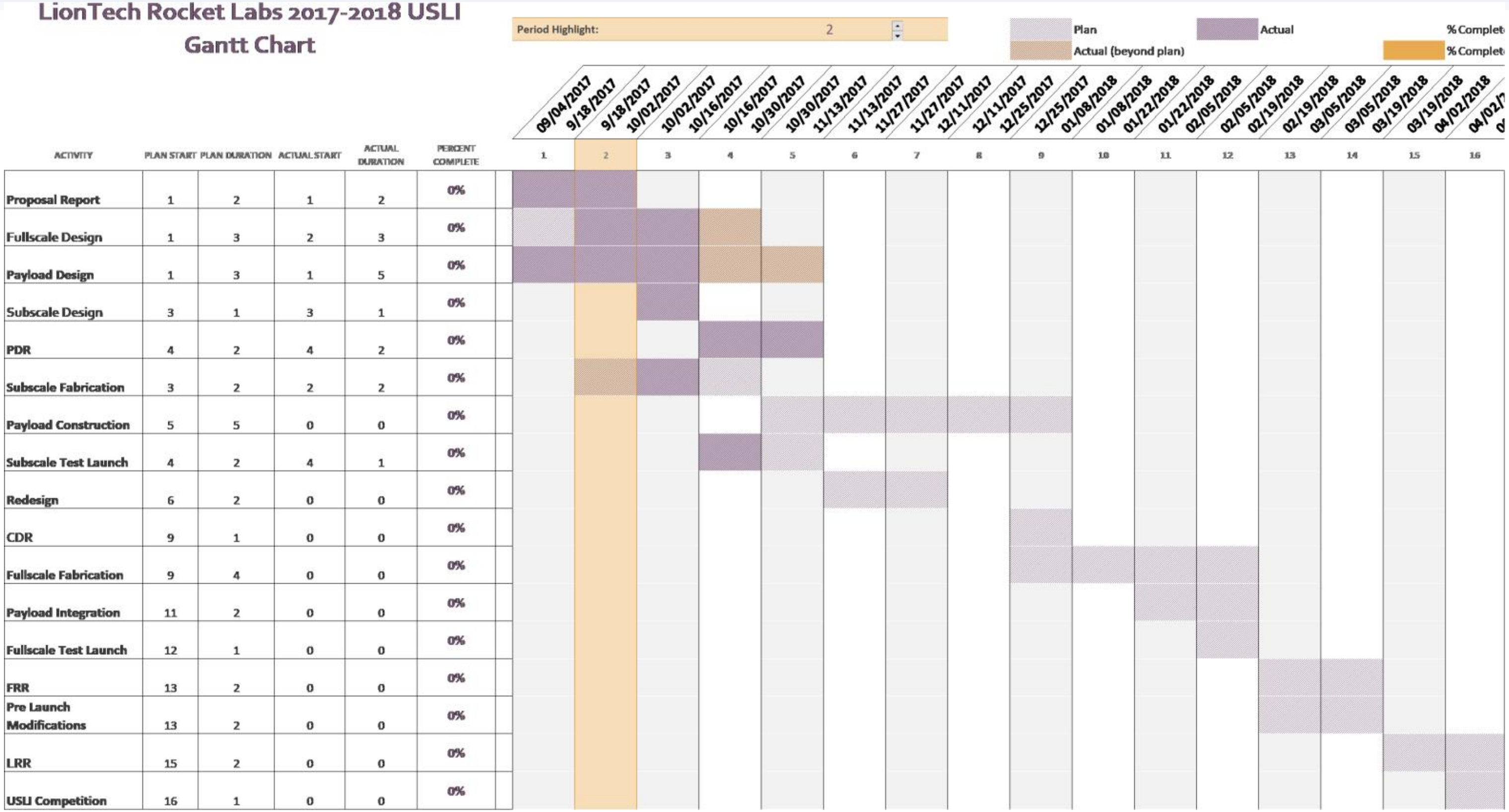
Expected Outflow

Budget	**Total Cost**
Fullscale	$2,554.31
Subscale	$604.37
Travel	$8,000.00
Outreach	$300.00
Miscellaneous	$500.00
Total	**$11,458.68**

Expected Inflow

Donor	**Requested Amount**
Penn State Aerospace Engineering Department	$5,000.00
Penn State Mechanical Engineering Department	$1,000.00
Club Fundraising	$1,100.00
University Park Allocations Committee	$5,000.00
Engineering Undergraduate Council	$3,000.00
Total	**$15,100.00**

Project Plan



LionTech Rocket Labs 2017-2018 USLI Gantt Chart

Period Highlight: 2

▨ Plan
■ Actual
▧ Actual (beyond plan)
% Complet
🟧 % Complet

ACTIVITY	PLAN START	PLAN DURATION	ACTUAL START	ACTUAL DURATION	PERCENT COMPLETE	09/04/2017 9/18/2017 1	9/18/2017 10/02/2017 2	10/02/2017 10/16/2017 3	10/16/2017 10/30/2017 4	10/30/2017 11/13/2017 5	11/13/2017 11/27/2017 6	11/27/2017 12/11/2017 7	12/11/2017 12/25/2017 8	12/25/2017 01/08/2018 9	01/08/2018 01/22/2018 10	01/22/2018 02/05/2018 11	02/05/2018 02/19/2018 12	02/19/2018 03/05/2018 13	03/05/2018 03/19/2018 14	03/19/2018 04/02/2018 15	04/02/ 16
Proposal Report	1	2	1	2	0%	■	■														
Fullscale Design	1	3	2	3	0%	▨	■	■	▧												
Payload Design	1	3	1	5	0%	■	■	■	▧	▧											
Subscale Design	3	1	3	1	0%			■													
PDR	4	2	4	2	0%				■	■											
Subscale Fabrication	3	2	2	2	0%		▧	■	▨												
Payload Construction	5	5	0	0	0%					▨	▨	▨	▨	▨							
Subscale Test Launch	4	2	4	1	0%				■	▨											
Redesign	6	2	0	0	0%						▨	▨									
CDR	9	1	0	0	0%									▨							
Fullscale Fabrication	9	4	0	0	0%									▨	▨	▨	▨				
Payload Integration	11	2	0	0	0%											▨	▨				
Fullscale Test Launch	12	1	0	0	0%												▨				
FRR	13	2	0	0	0%													▨	▨		
Pre Launch Modifications	13	2	0	0	0%													▨	▨		
LRR	15	2	0	0	0%															▨	▨
USLI Competition	16	1	0	0	0%																▨