Penn State Preliminary Design Review

LionTech Rocket Labs

Project Odyssey

November 4, 2016

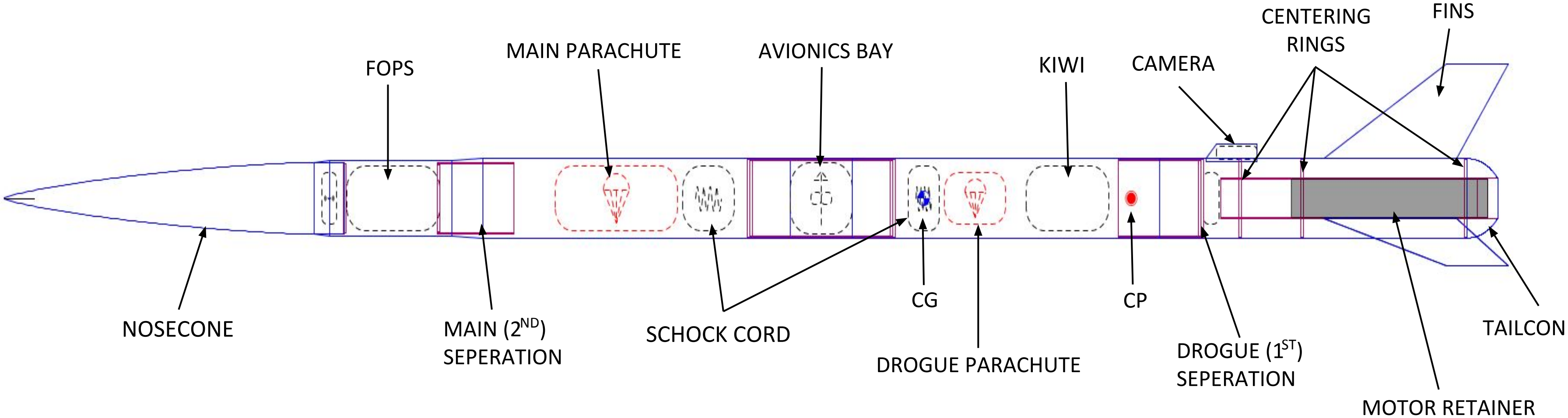
Overview

- Team introduction
- General overview
- Structures
  - Rocket design
- Avionics and Recovery
  - Recovery system
- Payload
  - FOPS
  - Kiwi
- Propulsion
  - Motor Choice
- Safety
- Mission Overview
  - Budget
  - Timeline
- Conclusion
- Appendix

Team Introduction

- Exec Committee
  - Luke Georges (President)
  - Evan Kerr (Vice-President)
  - Justin Hess (Treasurer)
  - Laura Reese (Safety Officer)
  - Brian Lodge (Outreach Chair)
- Structures Subsystem
  - Anthony Colosi
  - Kurt Lindhult
  - Kartik Singhal
- Avionics and Recovery Subsystem
  - Gretha Dos Santos
  - Evan Kerr
- Payload
  - Torre Viola
  - Daniel Yastishock
- Propulsion Subsystem
  - Alex Parkhill
  - Trevor Moser

General Overview



Structures – Vehicle Dimensions

- Total Length:
  - With Fins: 146.75” ≅ 12.25’
  - Nose Cone Tip to Tail Cone: 144.75”
- Outer Diameter: 6.079”
- Total Mass = 39.5 lb.

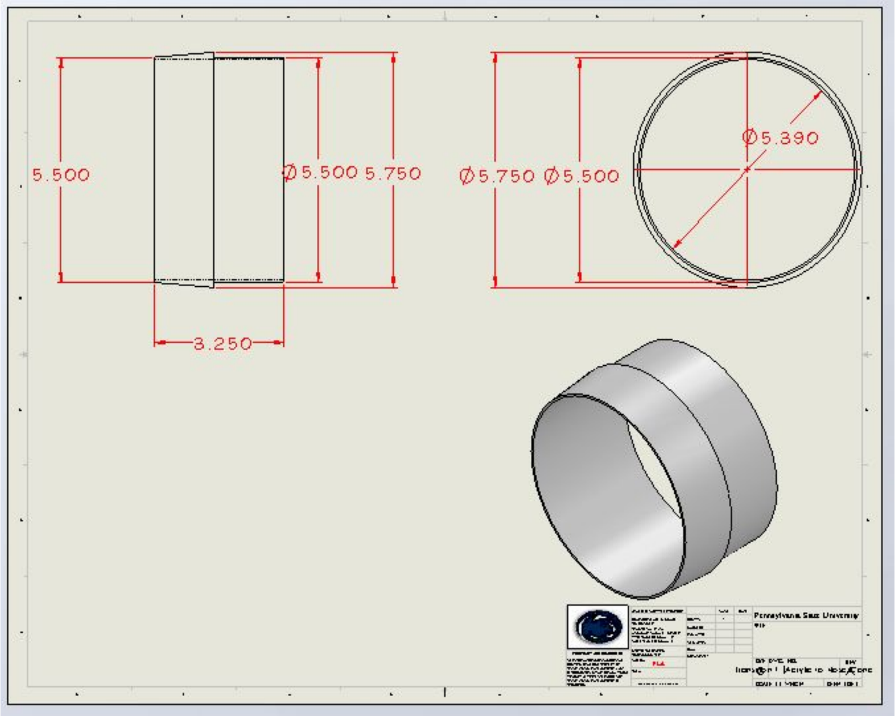
Structures – Material Selection

- Airframe
  - Blue Tube 2.0 vs. Fiberglass
- Centering Rings
  - Fiberglass vs. Plywood
- Bulkheads
  - Fiberglass vs. Plywood

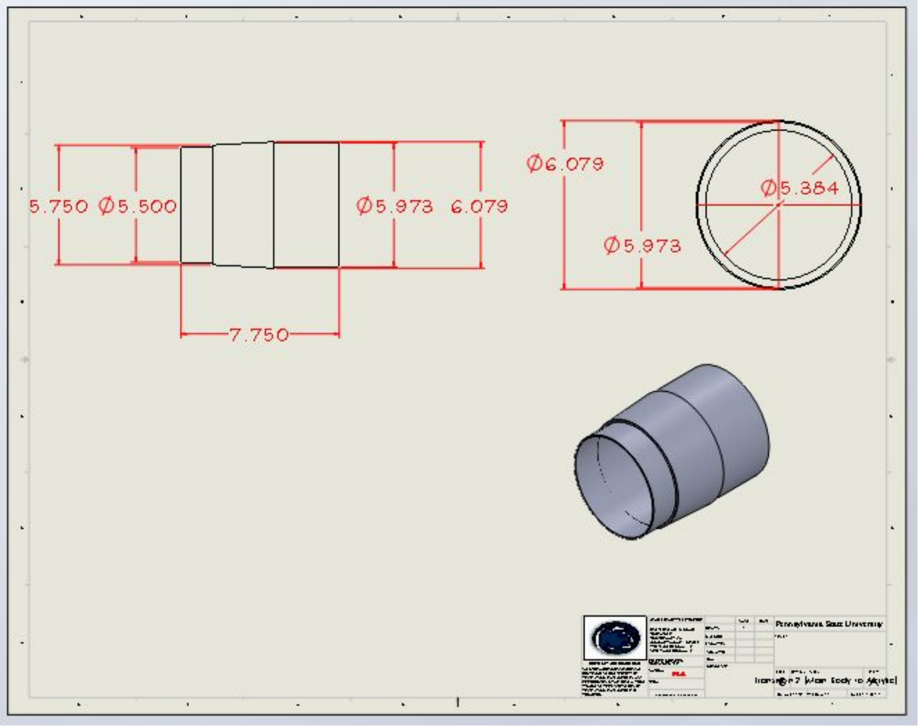
		Fiberglass		Blue Tube 2.0	
Attributes	**Weights**	**Rating**	**Weighted**	**Rating**	**Weighted**
Cost	35%	2	0.7	3	1.05
Strength	20%	3	0.6	2	0.4
Mass	20%	1	0.2	3	0.6
Handling	20%	2	0.4	4	0.8
Looks	5%	3	0.15	2	0.1
Total	100%		2.05		2.95

Structures - Transitions

Nosecone to Acrylic

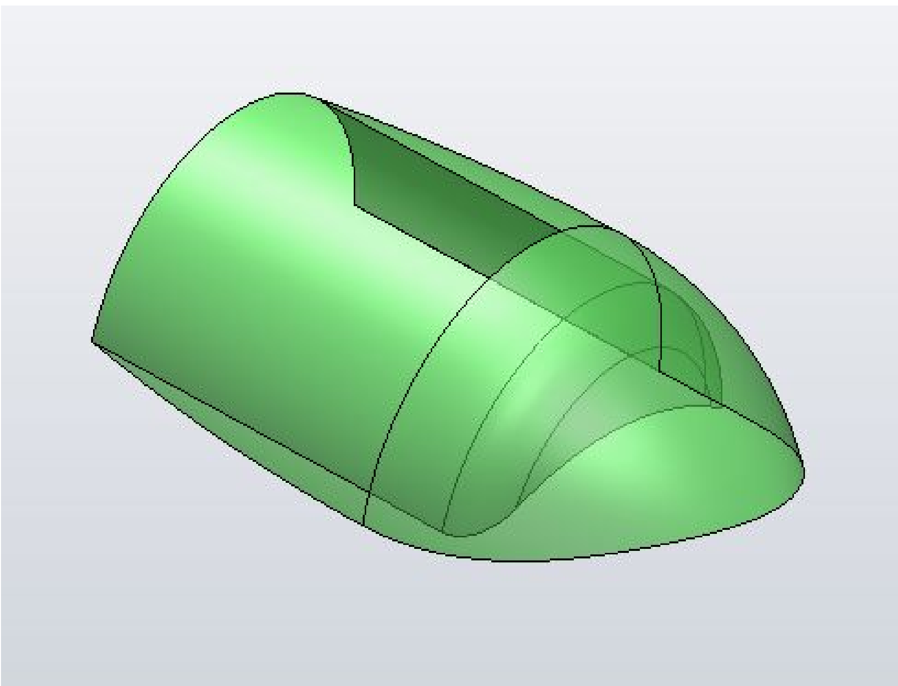


Acrylic to Main body tube

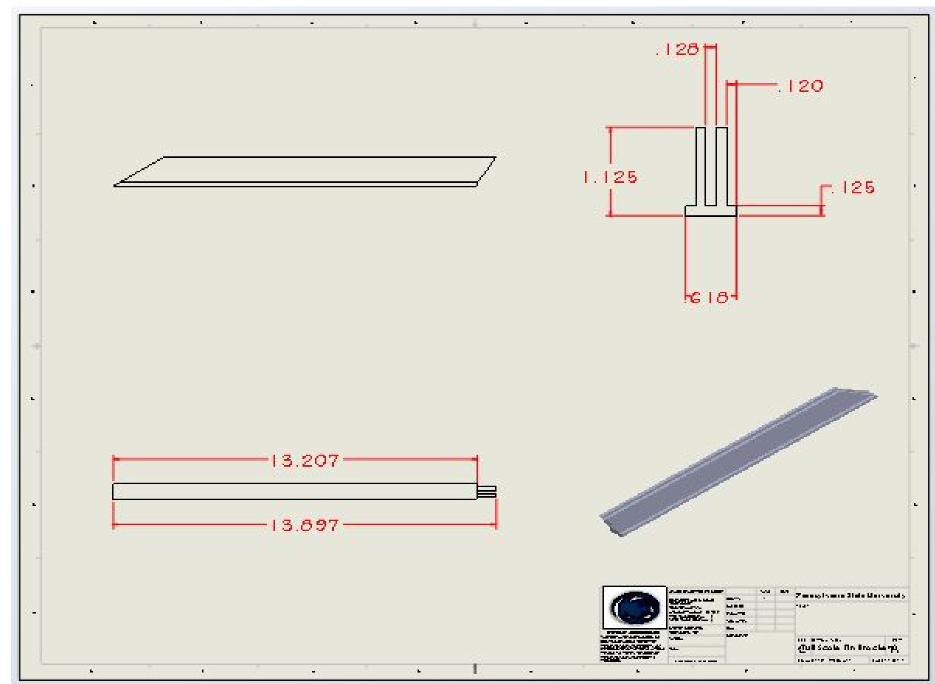


Structures – Figures

Camera Cover

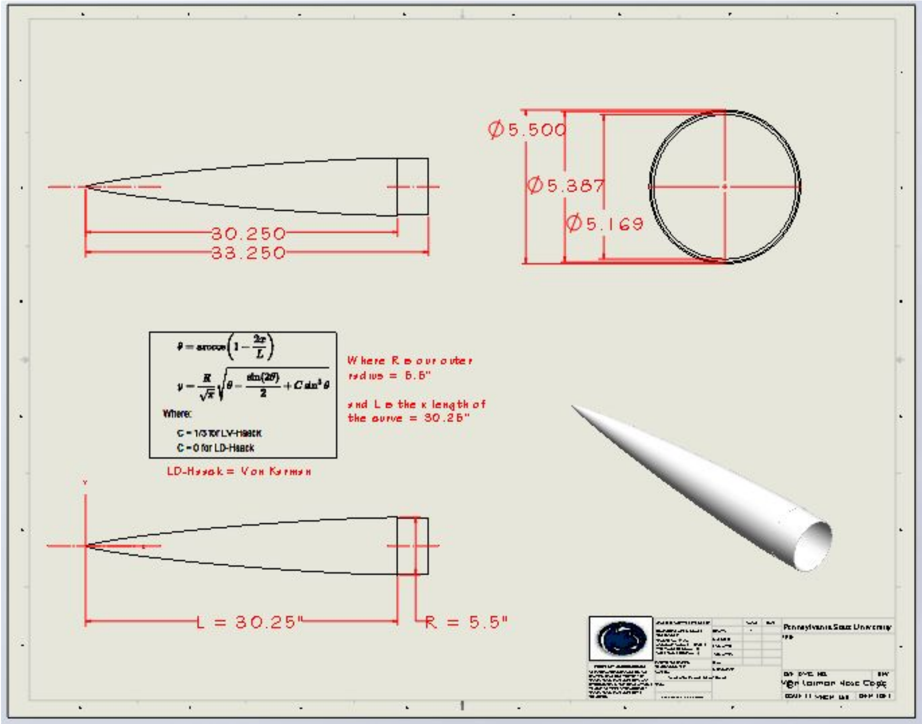


Fin Brackets

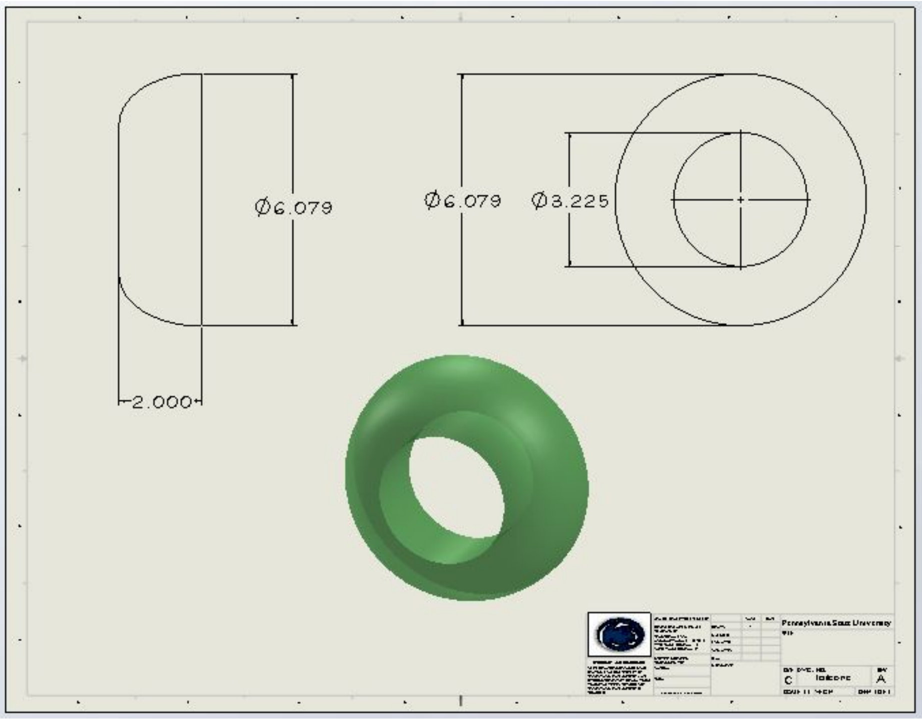


Structures – Figures

Nosecone

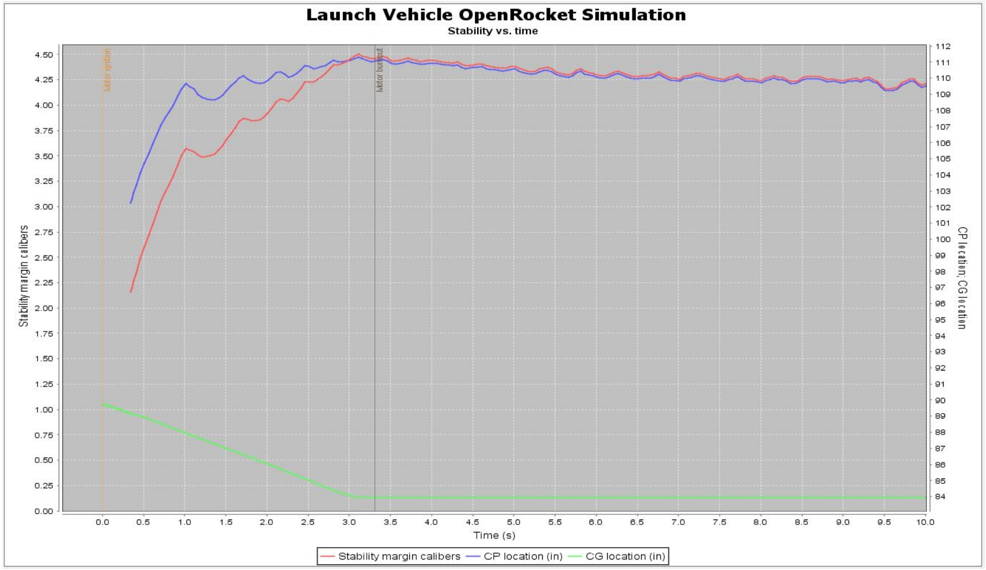


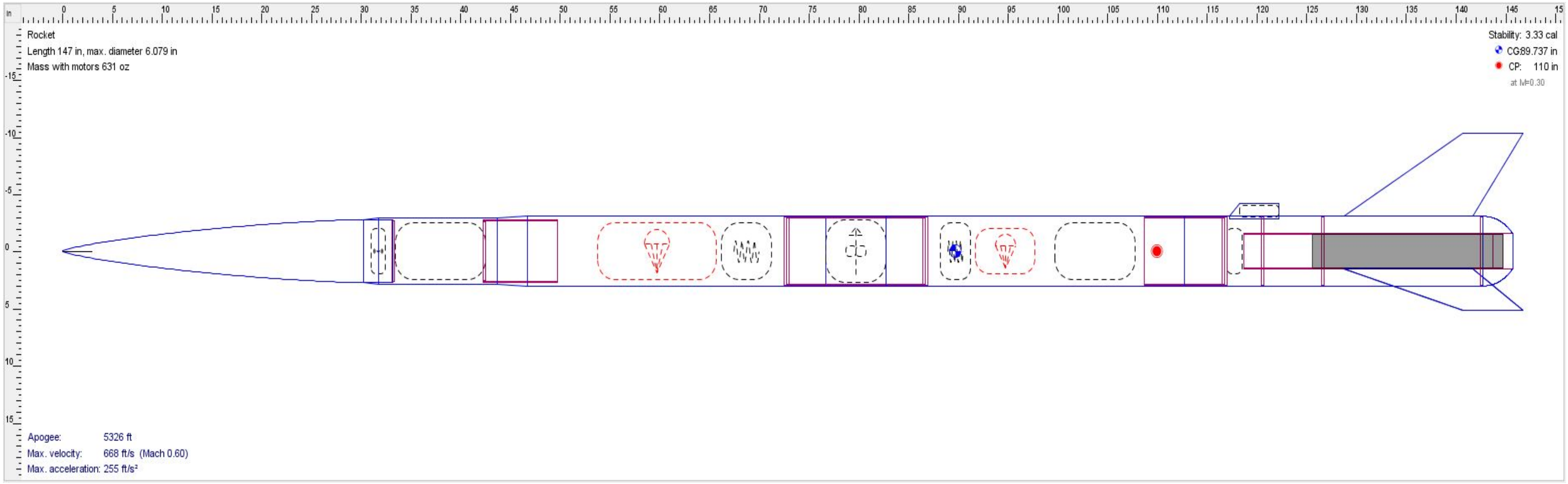
Tailcone



Structures – Stability Margin

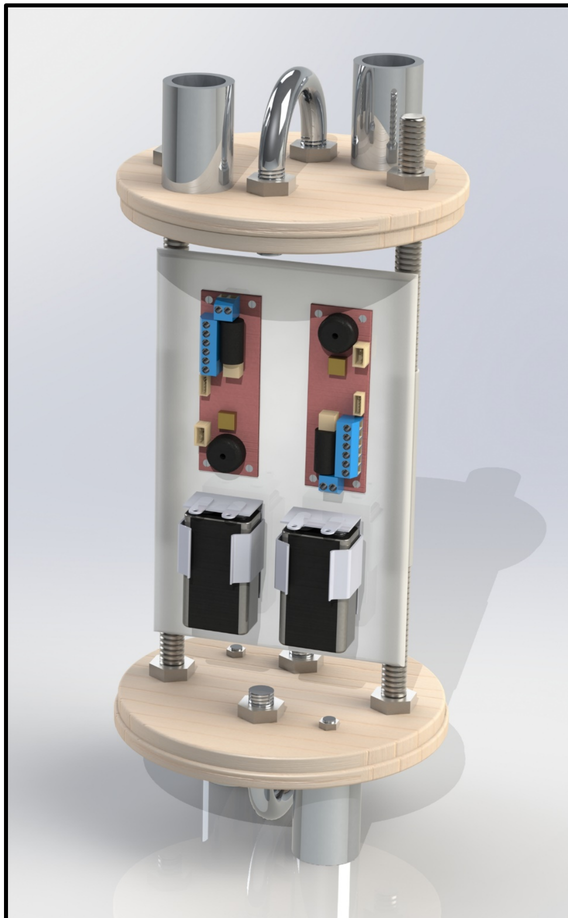
- CG: 89.7 inches from the tip of nose cone
- CP: 110 inches from the tip of nose cone
- Static stability margin: 3.33 calibers
- 2.25 calibers off the launch rail



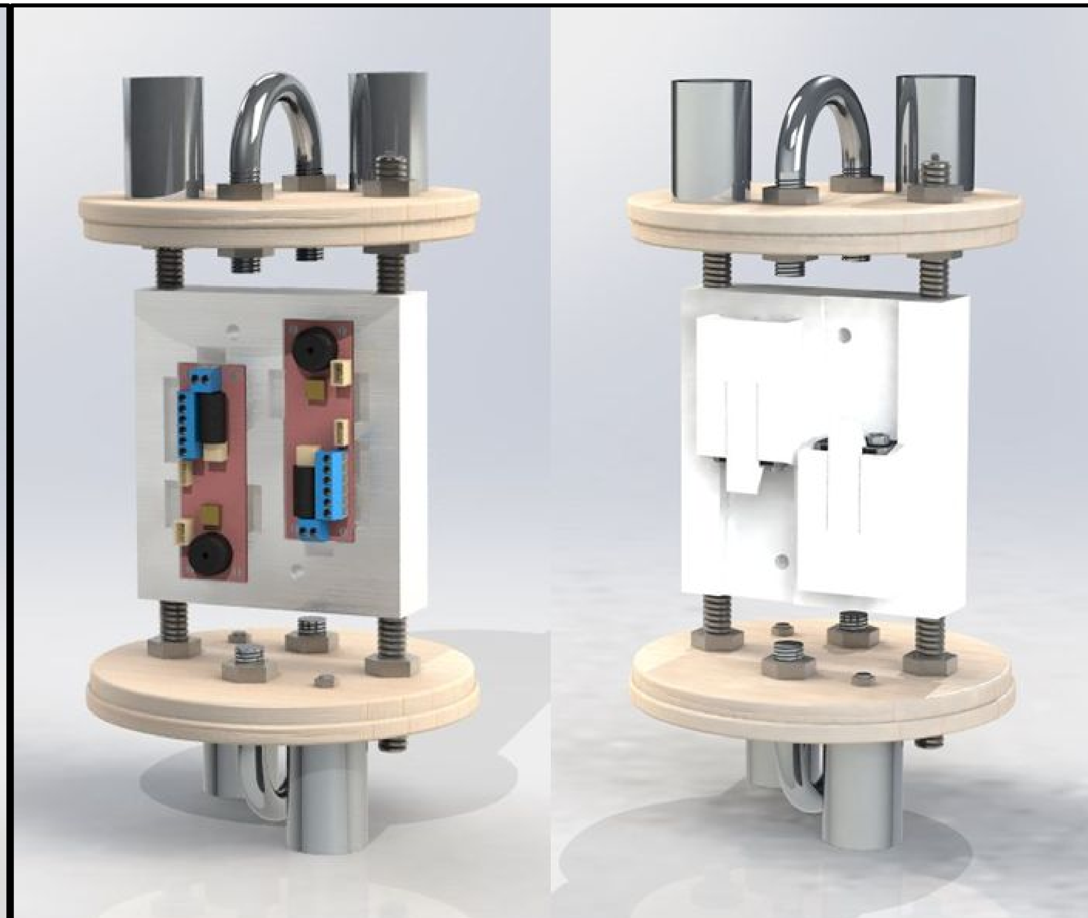


Avionics and Recovery – Avionics Bay Design

Fiberglass board

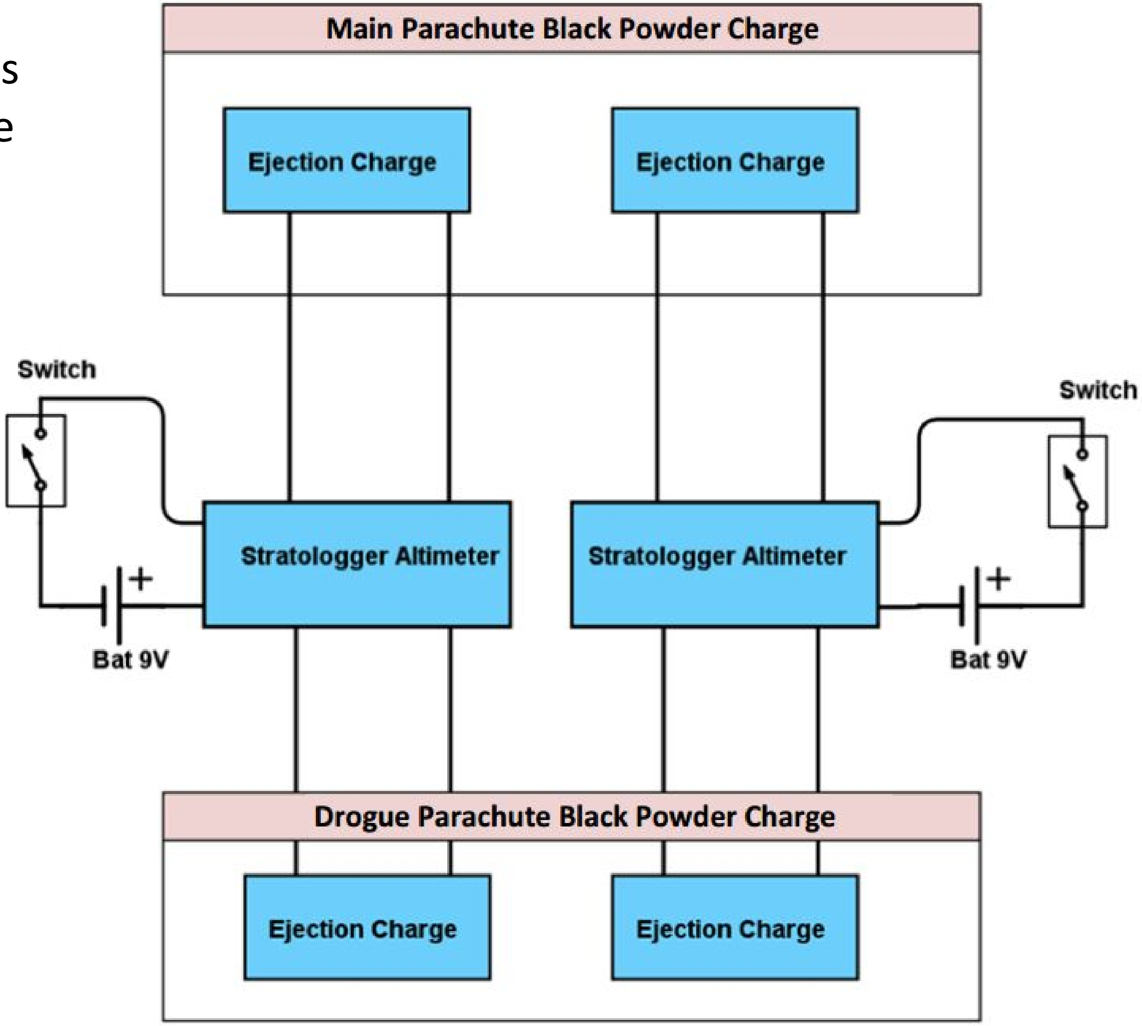


3D Printed board



Avionics and Recovery – Wiring Diagram

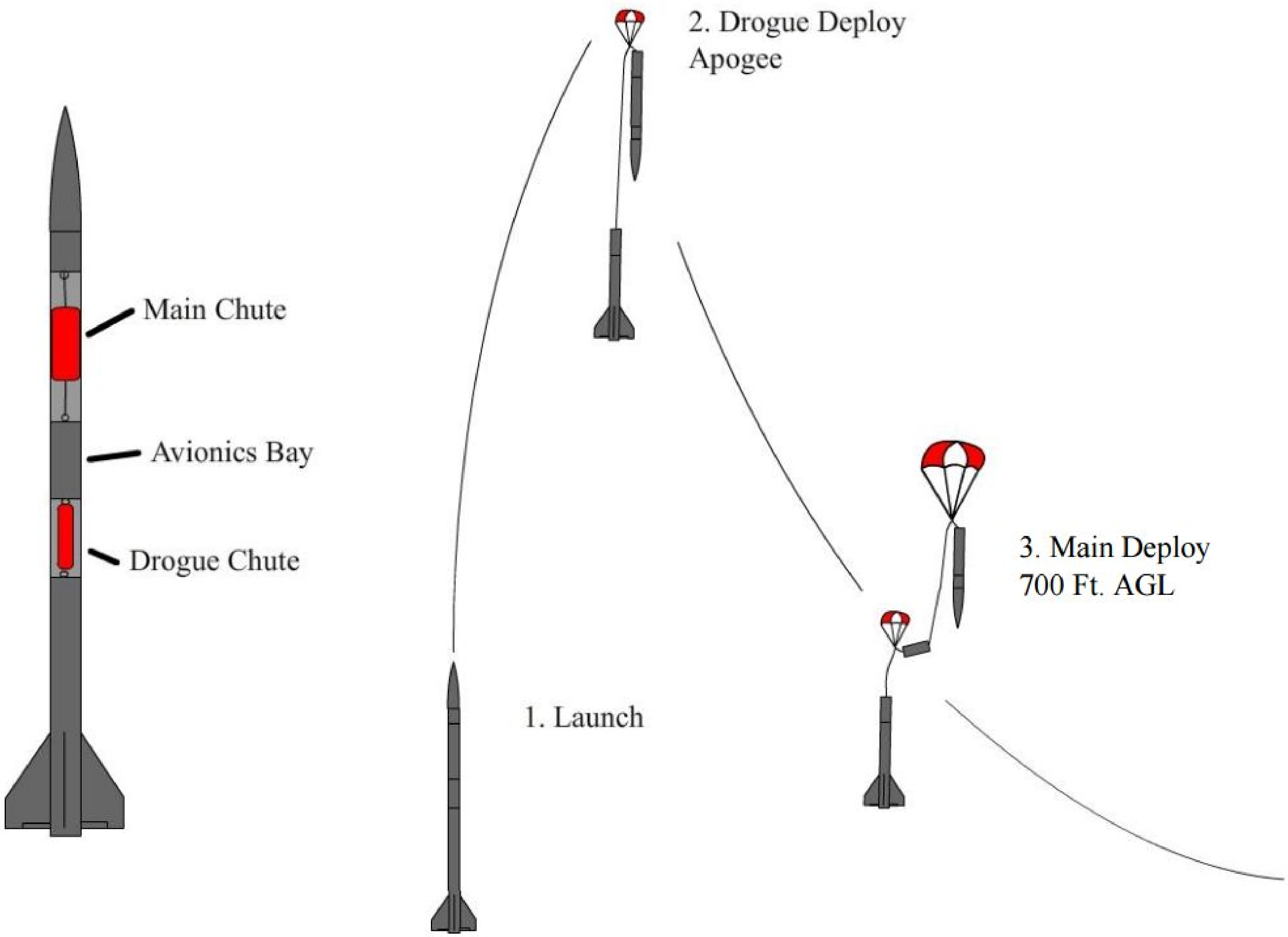
- Two independent altimeters
- Redundant Altimeter will be at a delay



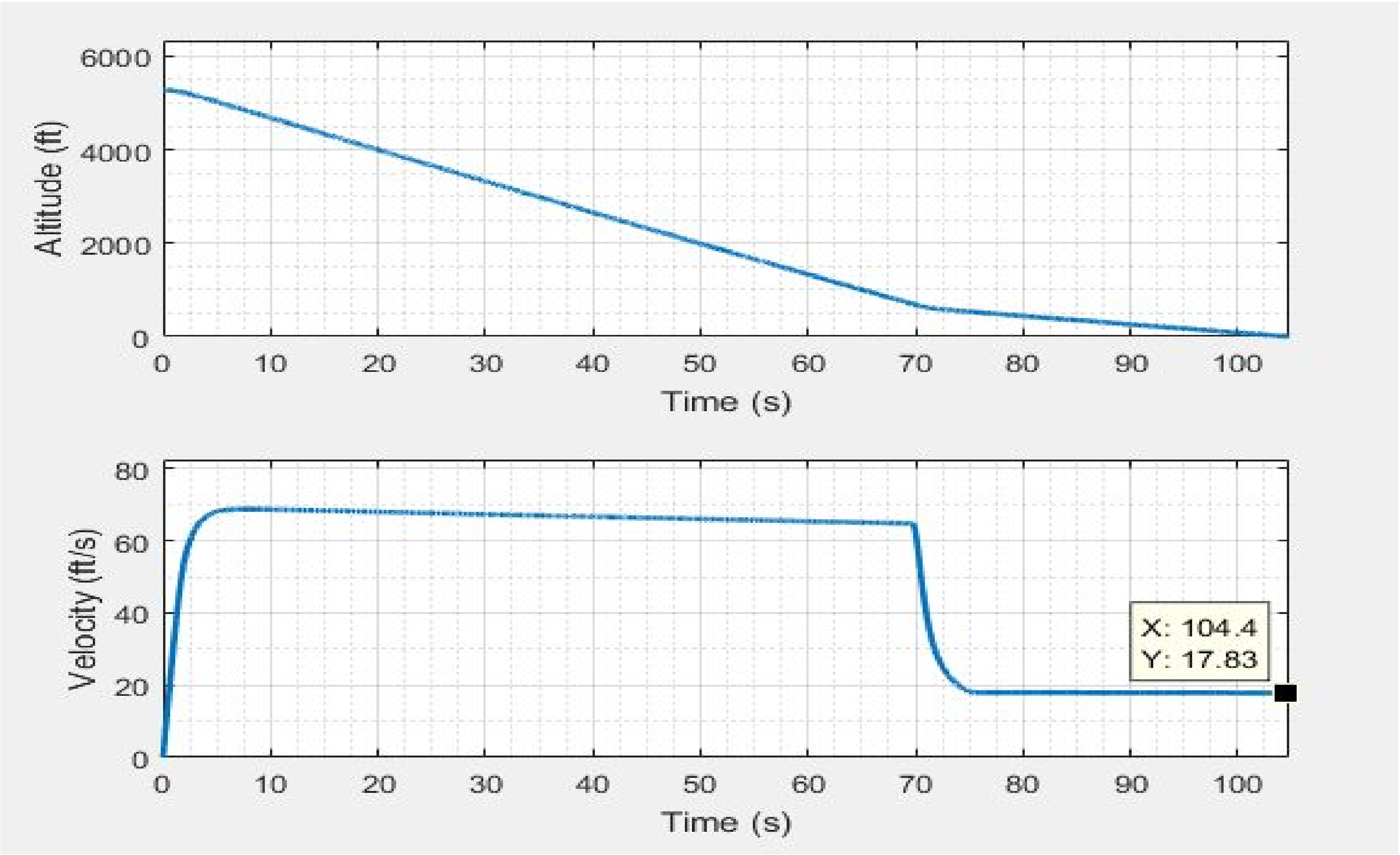
Avionics and Recovery – Parachute selection

Drogue Parachute	Main Parachute
36” Classic Elliptical	96” Iris Ultra

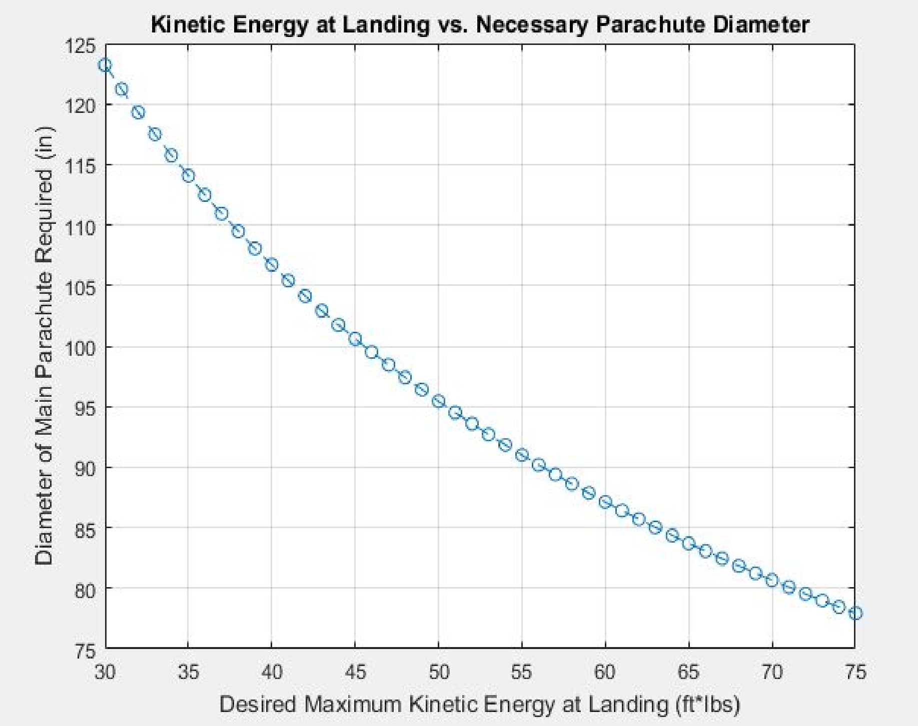
Avionics and Recovery – Deployment Method

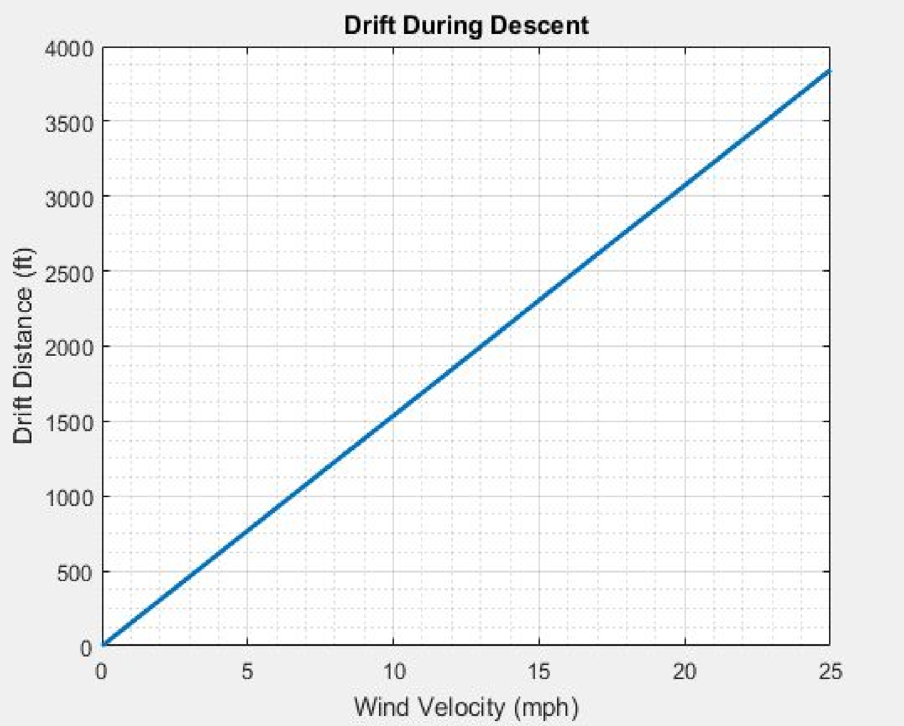


Avionics and Recovery – Velocity and Altitude Models



Avionics and Recovery – Kinetic Energy





Section	Weight (lbf)	Kinetic Energy (ft*lbs.)
Nosecone	8.40	41.5
Central Body	9.26	45.7
Booster Section	6.72	41.5

Wind Velocity (mph)	Drift Distance (ft)
0	0
5	768.4
10	1537
15	2305
20	3774

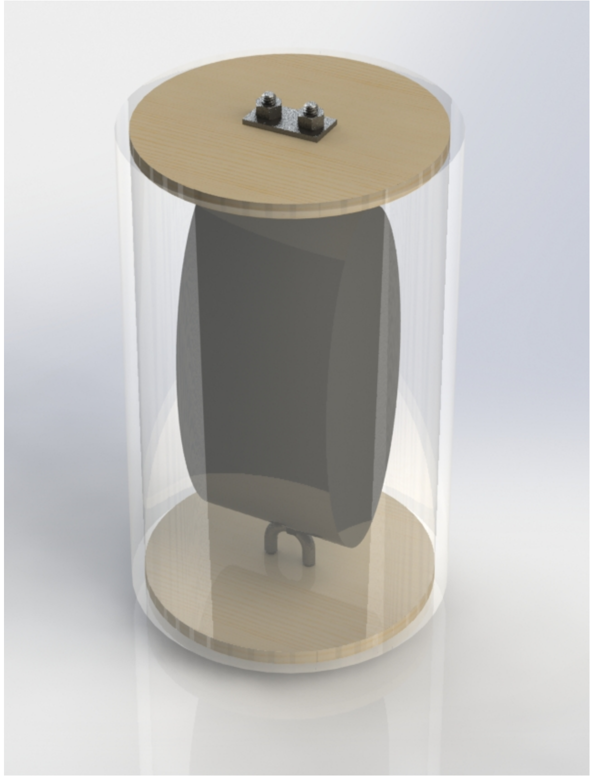
Payload – FOPS: Selection Matrix

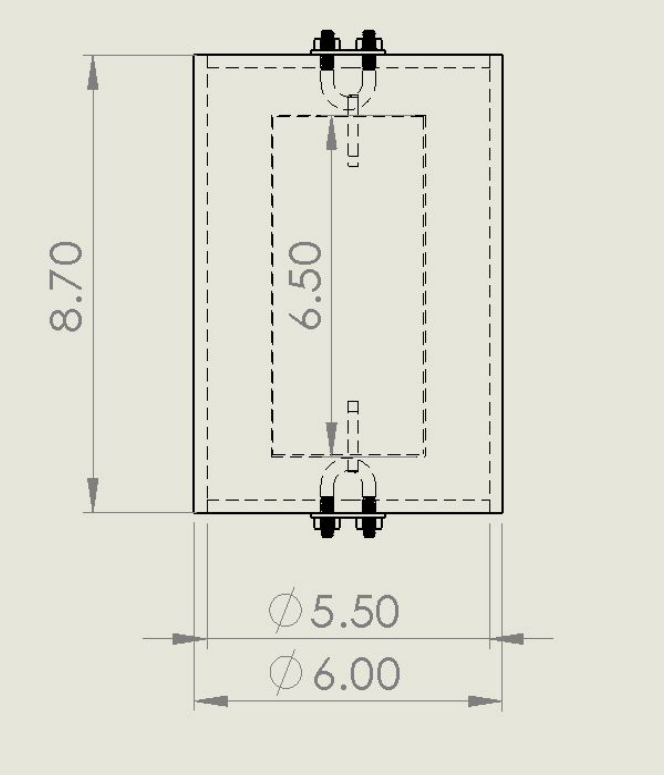
Criteria	Weight	Dilatant Suspension		Magnetic Suspension		Acceleration Control		Elastic Suspension	
Impact Protection	30%	5	1.5	2	0.6	2	0.6	4	1.2
Acceleration Protection	30%	4	1.2	4	1.2	5	1.5	1	0.3
Reliability	20%	4	0.8	2	0.4	1	0.2	5	1.0
Ease of Construction	20%	4	0.8	2	0.4	1	0.2	5	1.0
Total		**<u>4.3</u>**		**2.6**		**2.5**		**3.5**	

Payload – FOPS: Design

Fragile materials will be suspended in an expandable plastic bag filled with shear thickening liquid

Open-cell foam will be placed between the bag and the exterior of the payload bay to allow for bag expansion while preventing excessive lateral movement (Not pictured)





Payload – FOPS Verification

Stage 1: A materials bay copy will be dropped from increasing height with fragile objects such as eggs and potato chips

Stage 2: A miniature materials bay will be loaded with fragile objects during subscale launches to ensure operation within rocket

Stage 3: The full-size materials bay will be tested with multiple fragile objects during full-scale verification flights

Payload – Kiwi Design

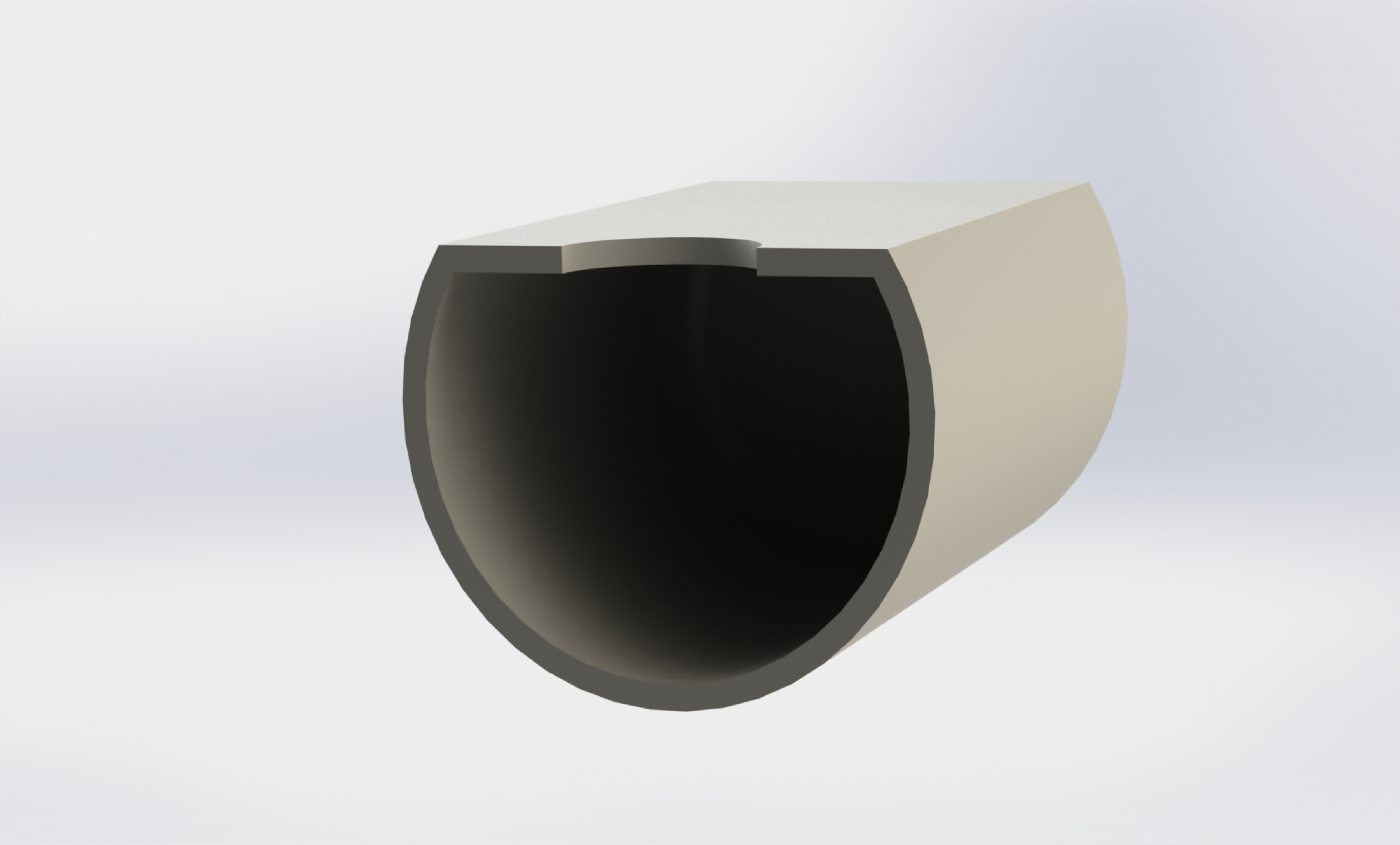
A Coaxial Helicopter released from vehicle during flight that will autonomously navigate to a predetermined location

Coaxial Helicopter

- Flight Computer: Raspberry Pi
- Equipped with an onboard GPS
- Equipped with emergency parachute system
  - Accelerometer
  - Small parachute

- Deployed at apogee with the drogue chute
- The drogue chute will push the helicopter out of the rocket when deployed
- Helicopter protected from impact by foam cylinders

Payload – Kiwi Isolation System

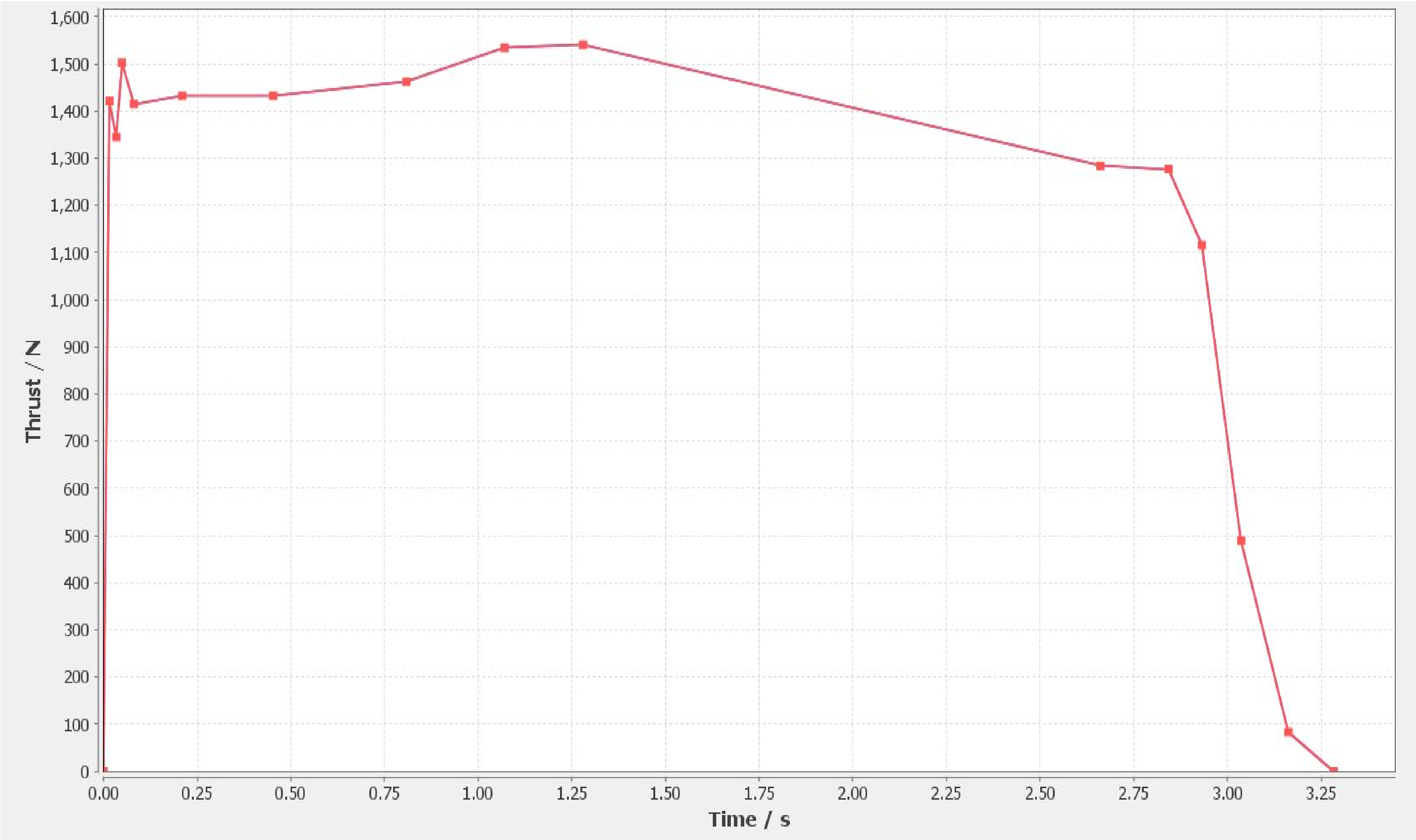


Propulsion – Preliminary Motor Selection

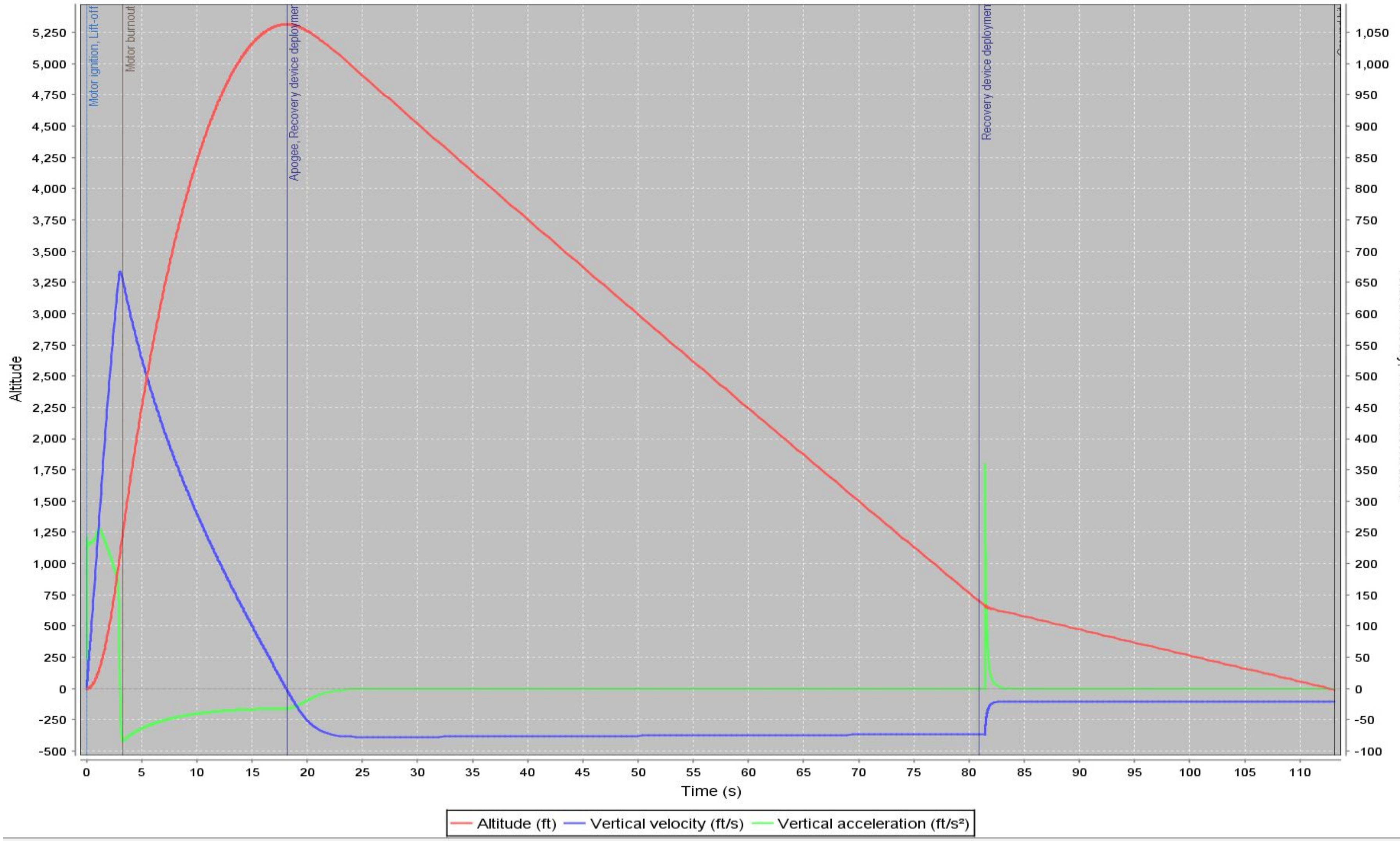
Designation	Rating	Apogee (ft.)	Velocity off rail (ft./s)	Impulse (lbf-s)	Weight (oz.)	Thrust/Weight Ratio
Cesaroni L1350 (3 Gr.)	Primary	5315	76.6	962	125.92	7.68
Cesaroni L1395 (4 Gr.)	Secondary	6090	73.6	1100	152.48	8.00
Cesaroni L1355 (4 Gr.)	Secondary	4649	73.7	905	174.4	7.20

L1350 was selected based upon projected apogee, and its suitable thrust curve.

Propulsion – Primary Motor Thrust Curve



Propulsion – Primary Motor Flight Simulation

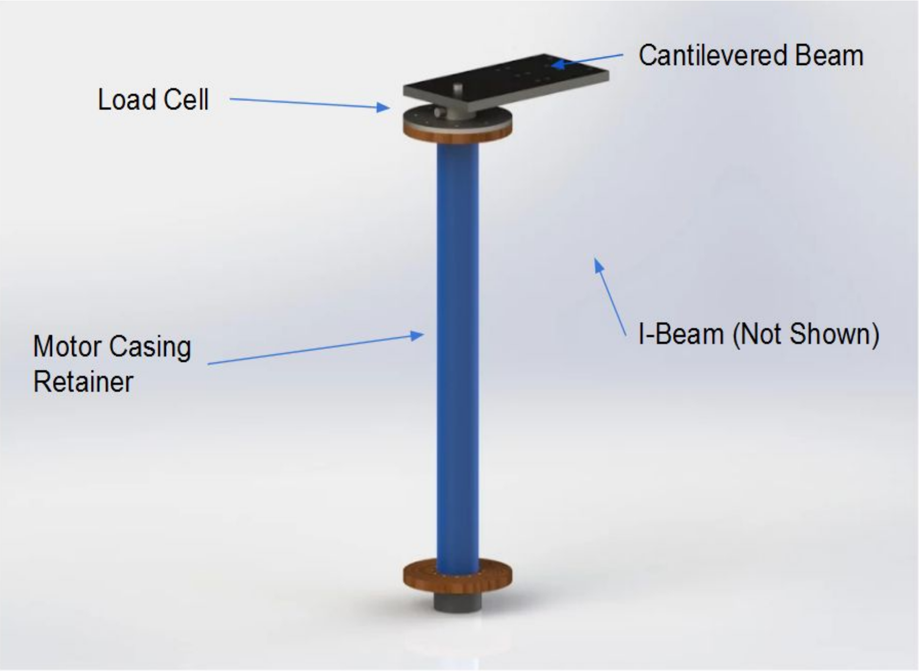


Propulsion – Testing

Wind tunnel testing will be conducted on a subscale model when space is available.

Static Motor Testing will be conducted in the coming weeks for calibration of test equipment

Static Motor Testing



Safety – Overview

- All subsystems have created launch checklists to be filled out before subscale and fullscale launches
- Major risks and failure modes were identified and mitigation plans were developed
- Member safety training and lab safety are being improved

Safety – 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
- Fracture cracks develop in bulkheads
  - Structural failure
  - Pressure leakage preventing parachute deployment followed by ballistic descent
  - Visual inspection and pre-flight check
- Kiwi loses balance
  - Kiwi guided section falls to the ground
  - Low density to reduce kinetic energy at impact
  - Ballast to prevent sudden attitude change
- Ejection charges failing to go off
  - Would cause ballistic descent
  - Use fresh batteries for each launch and check altimeter continuity before each launch

Safety – Member Safety Training

- Updated safety training for members and officers
  - Now utilize Penn State Environmental Health and Safety (EHS) online training modules
  - Officers will also receive further in person training from EHS staff
- Will be creating Unit Safety Plan for the LionTech laboratory

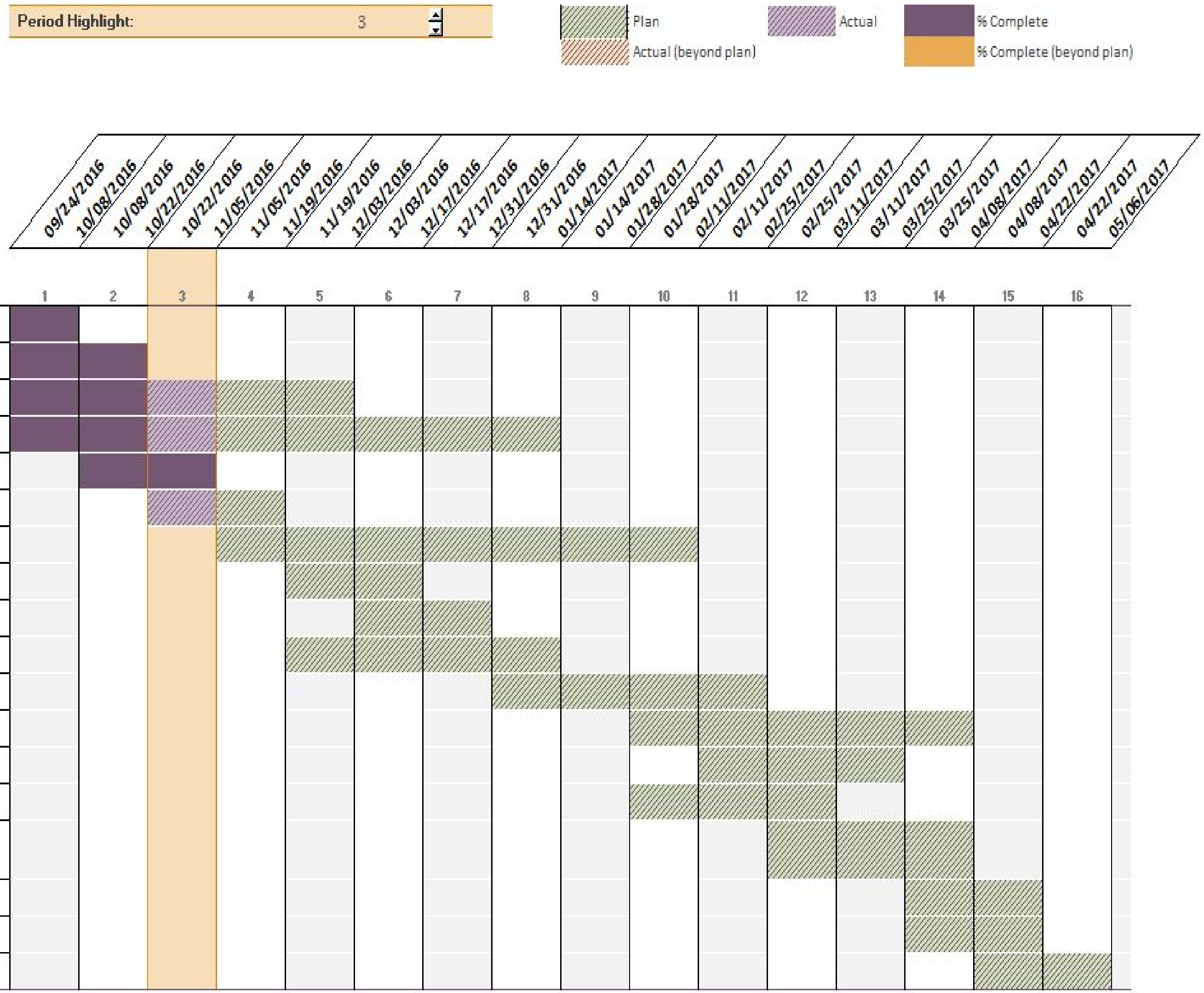
Mission Overview - Budget

Expected Costs: 2016-2017	
Fullscale	$847.04
Subscale	$277.65
Propulsion	$1,045.64
Travel	$5,000.00
Outreach	$300.00
Miscellaneous Equipment	$1,095.82
Total	$8,566.15

Expected Income 2016-2017	
Aerospace Engineering Department	$5,000.00
UPAC	$3,500.00
Club Fundraising	$1,500.00
The Boeing Company	$500.00
Total	$10,500.00

Mission Overview - Timeline

2016-2017 USLI Gantt Chart



ACTIVITY	PLAN START	PLAN DURATION	ACTUAL START	ACTUAL DURATION	PERCENT COMPLETE
Proposal	1	1	1	1	100%
Subscale Design	1	2	1	2	100%
Full-scale Design	1	5	1	3	70%
Payload Design	1	8	1	3	70%
PDR	2	2	2	2	100%
Subscale Fabrication	3	2	3	1	0%
Payload Construction	4	7	0	0	0%
Subscale Testing	5	2	0	0	0%
Redesign	6	2	0	0	0%
CDR	5	4	0	0	0%
Full-scale Fabrication	8	4	0	0	0%
Payload Integration	10	5	0	0	0%
Full-scale Testing	11	3	0	0	0%
FRR	10	3	0	0	0%
Pre Launch Modifications	12	3	0	0	0%
LRR	14	2	0	0	0%
USLI Competition	14	2	0	0	0%
PLAR	15	3	0	0	0%

Questions?