Penn State Critical Design Review

LionTech Rocket Labs

Project Odyssey

January 25th, 2016

Overview

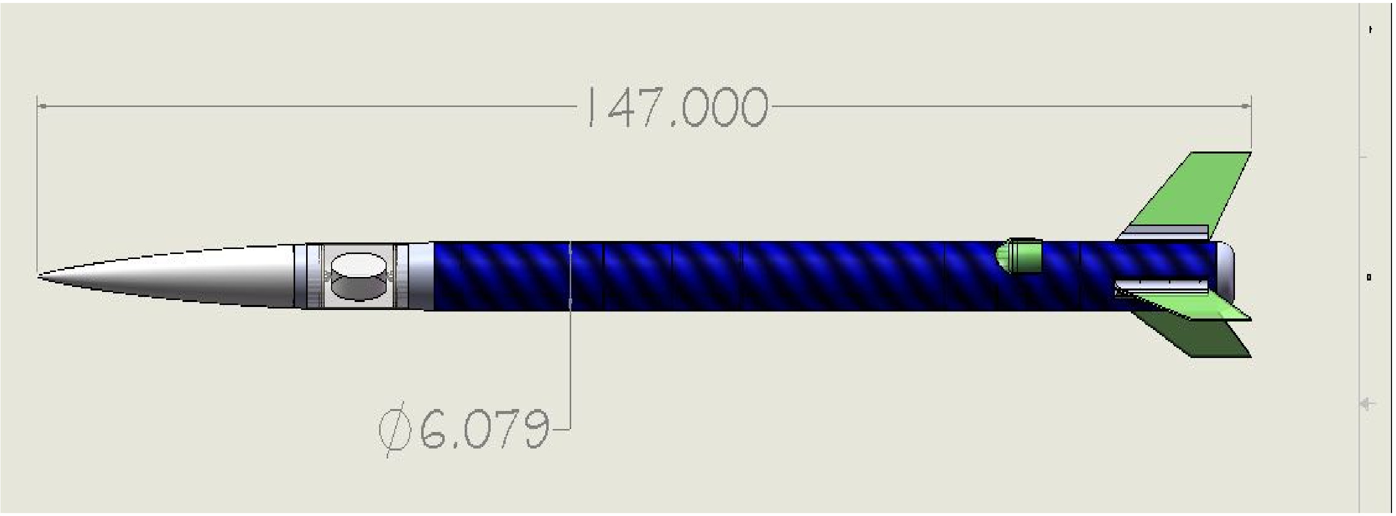
- Team introduction
- General overview
- Structures
  - Rocket design
- Avionics and Recovery
  - Recovery system
- Payload
  - FOPS
  - Kiwi
- Propulsion
  - Motor Choice
- Safety
- Mission Overview
  - Budget
  - Timeline
- Conclusion
- Appendix

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

Structures – Vehicle Dimensions

- Total Length:
  - With Fins: 147” ≅ 12.3’
  - Nose Cone Tip to Tail Cone: 146”
- Outer Diameter: 6.079”
- Total Mass = 38.69 lb



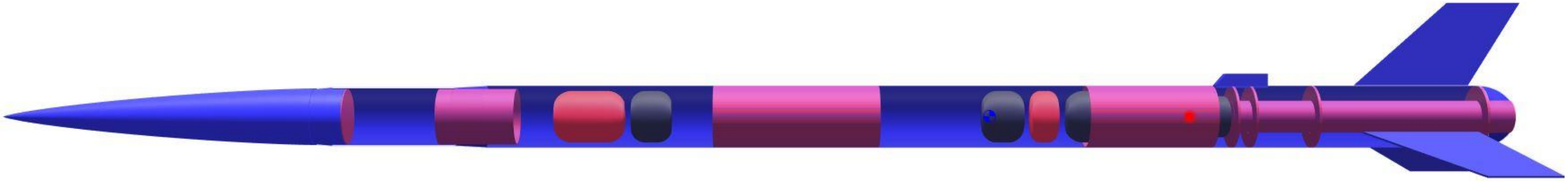
Structures – Mass Statement and Mass Margin

Component	Mass (oz)
Nosecone with aluminum tip	40
Airframe	79.7
Acrylic	18.2
FOPS	40
KIWI	19
Avionics Bay	28
Other (motor, fins, Hardware, epoxy)	362.1

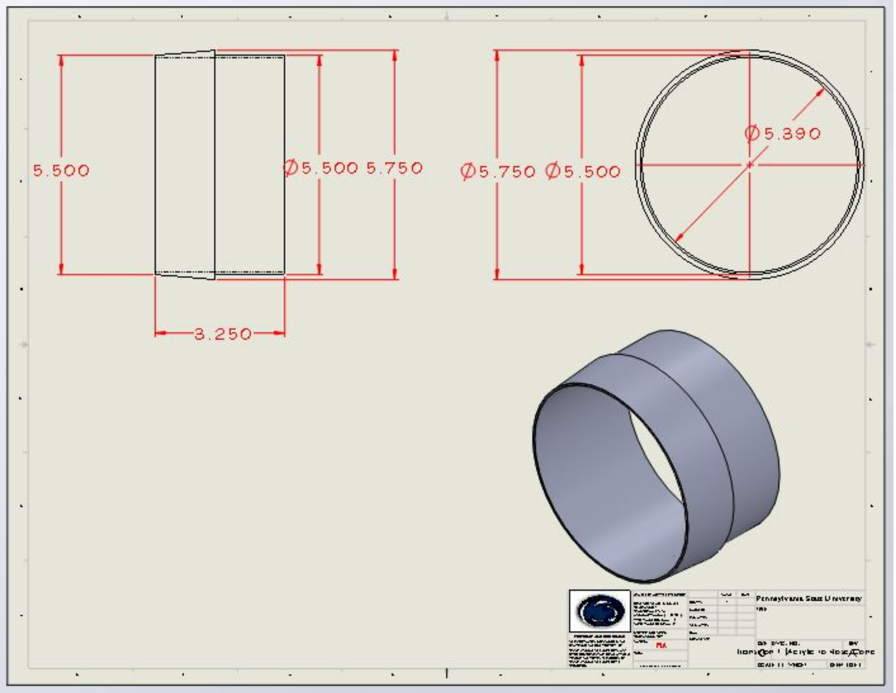
- Currently our design includes 10% margin of increase which can be increased or decreased prior to launch for unforeseen mass changes

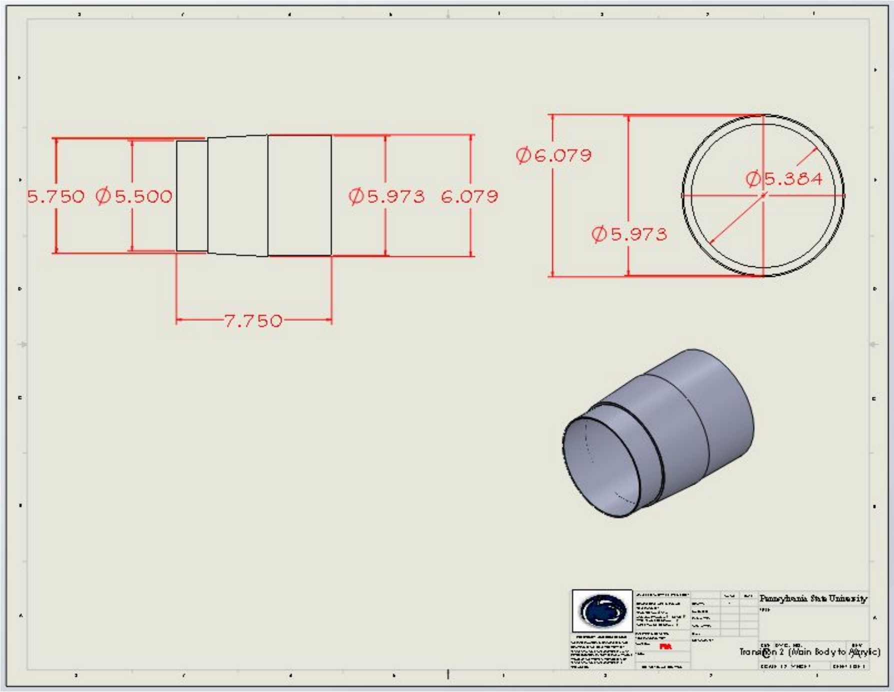
Structures – Key Design Features

- Von Karman nosecone
- Aluminum nosecone tip for durability
- External 3D printed fin brackets
- 3/16 inch fiberglass fins
- Blue Tube 2.0 airframe
- 6 inch coupler shoulders
- 3D printed coupler transitions

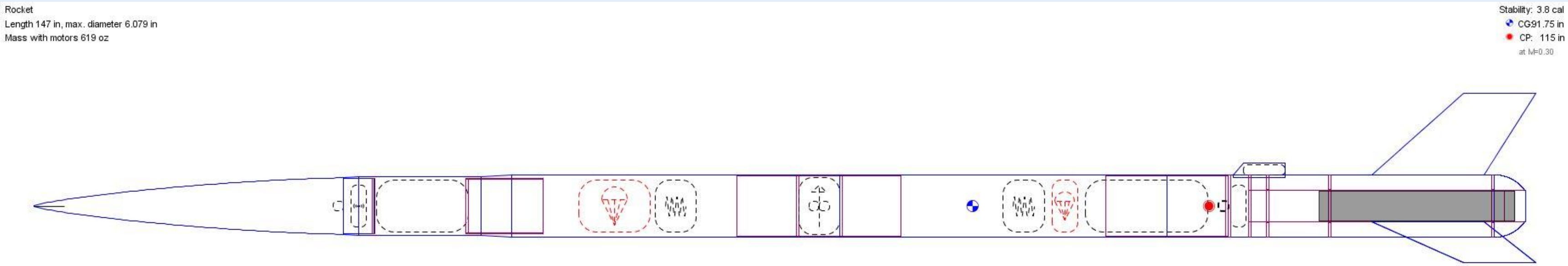


Structures – Transitions

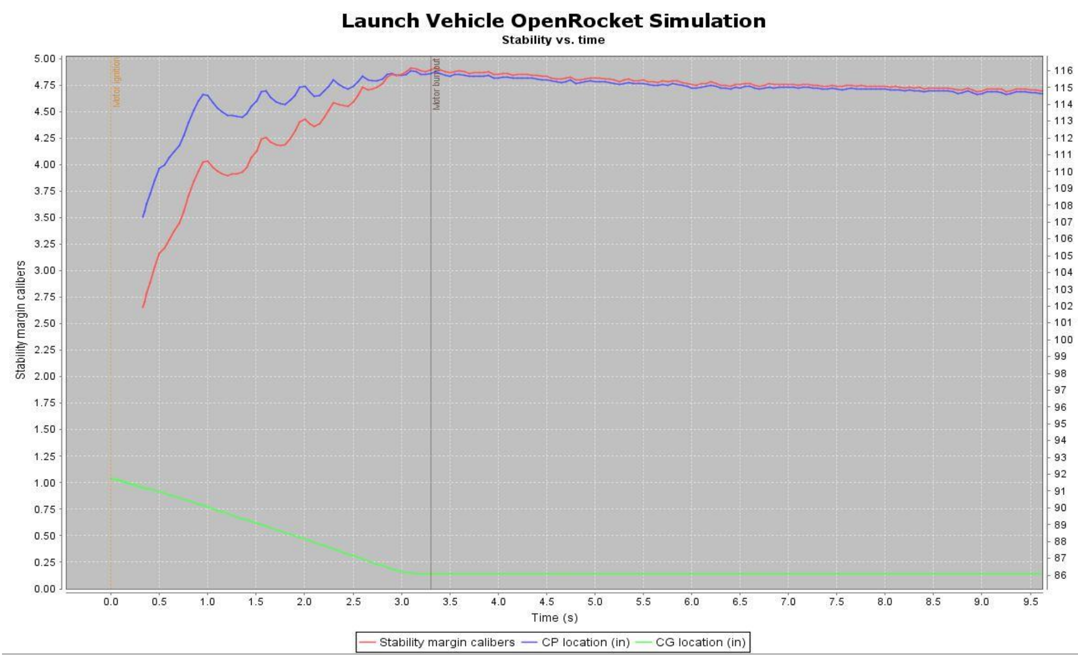




Structures – Stability Margin



- CG: 91.75 inches from the tip of nose cone
- CP: 115 inches from the tip of nose cone
- Static stability margin: 3.8 calibers
- 2.65 calibers off the launch rail
- Rail Exit Velocity: 75.8 ft/s
- Thrust to Weight: 7.83



Structures – Status of Verification: Structures

- Reusable Launch Vehicle Design
  - Modular & durable components for repair
- Four Section Design with Single Stage
  - Even mass distribution for uniform forces
- Preparation within 4 hours
  - Screws for rapid assembly/diagnostics

Structures – Upcoming Material Testing

- Tensile Testing with varying fastener placement
- Creation of 6061 Aluminum bulk plates for attachment
- Previous Testing on G12 Fiberglass airframe specimen

Avionics and Recovery – Subscale Flight Results

Summary:

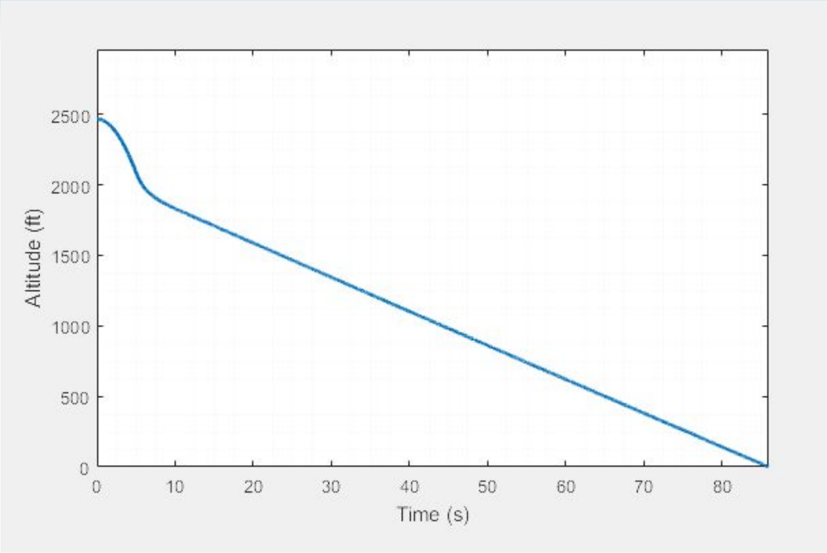
- Apogee: 2467 ft
- Descent Time: 95 seconds
- Deployment: Anomaly at apogee
    - Main and drogue deployed
    - Too few shear pins in the main coupler

Lessons Incorporated:

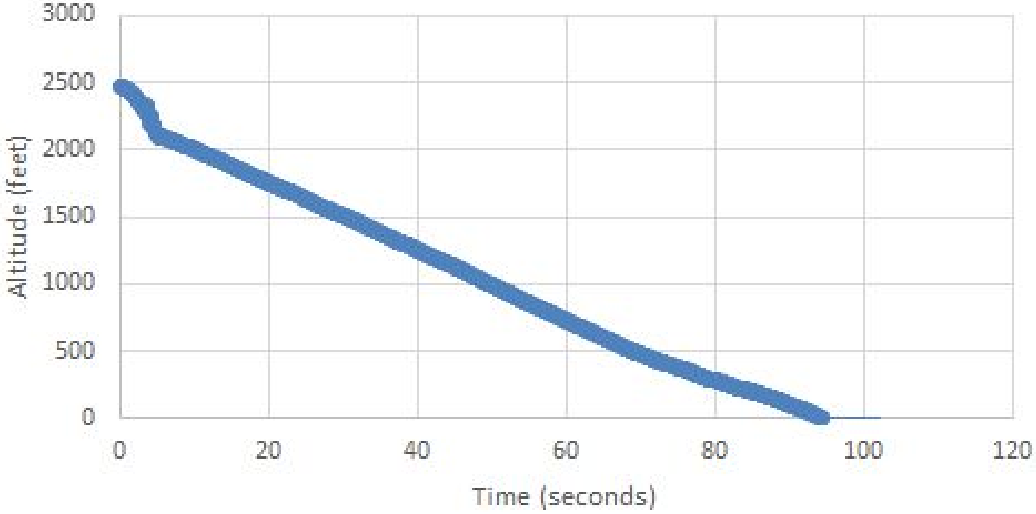
- Include more shear pins in main coupler
- Do more extensive ground testing

Avionics and Recovery – Subscale Flight Results

Predicted Descent Profile



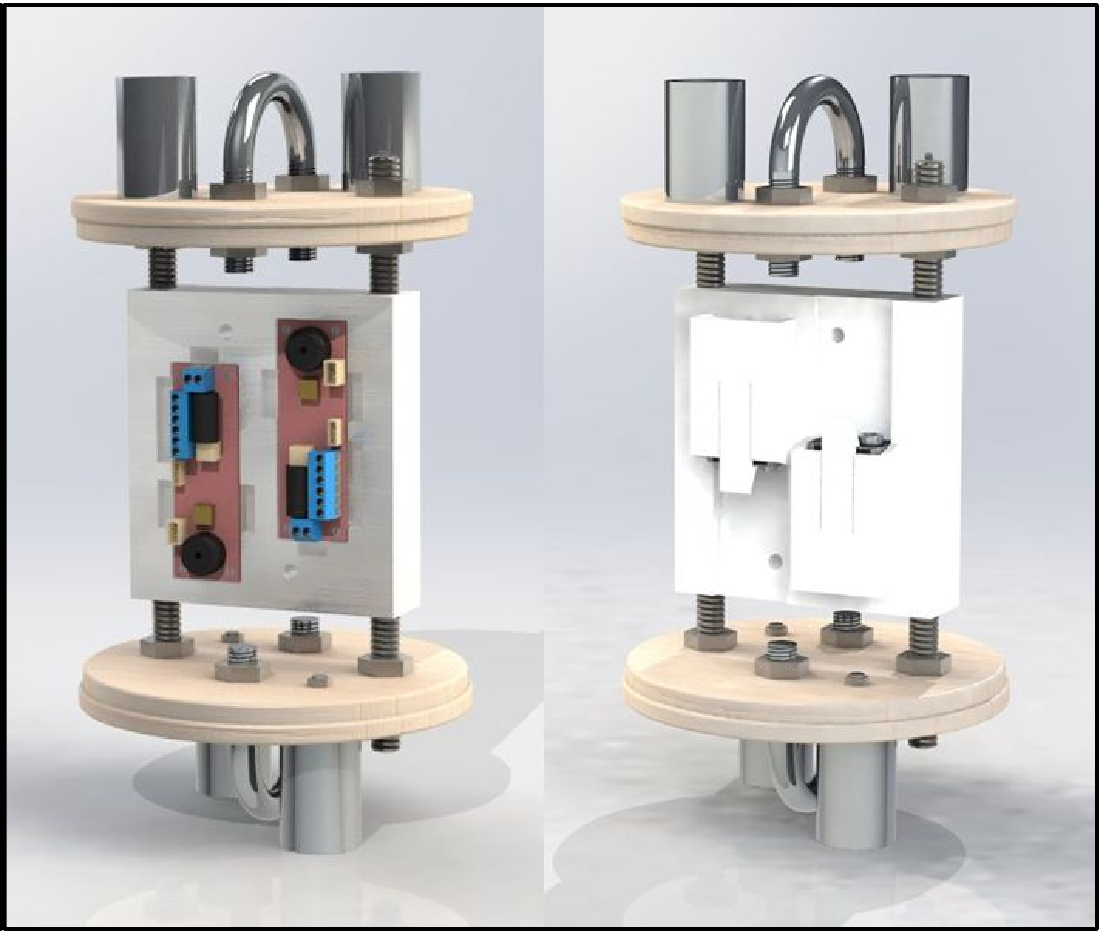
Actual Descent Profile



Avionics and Recovery – Avionics Bay Design

Fiberglass board

3D Printed Board Prototype

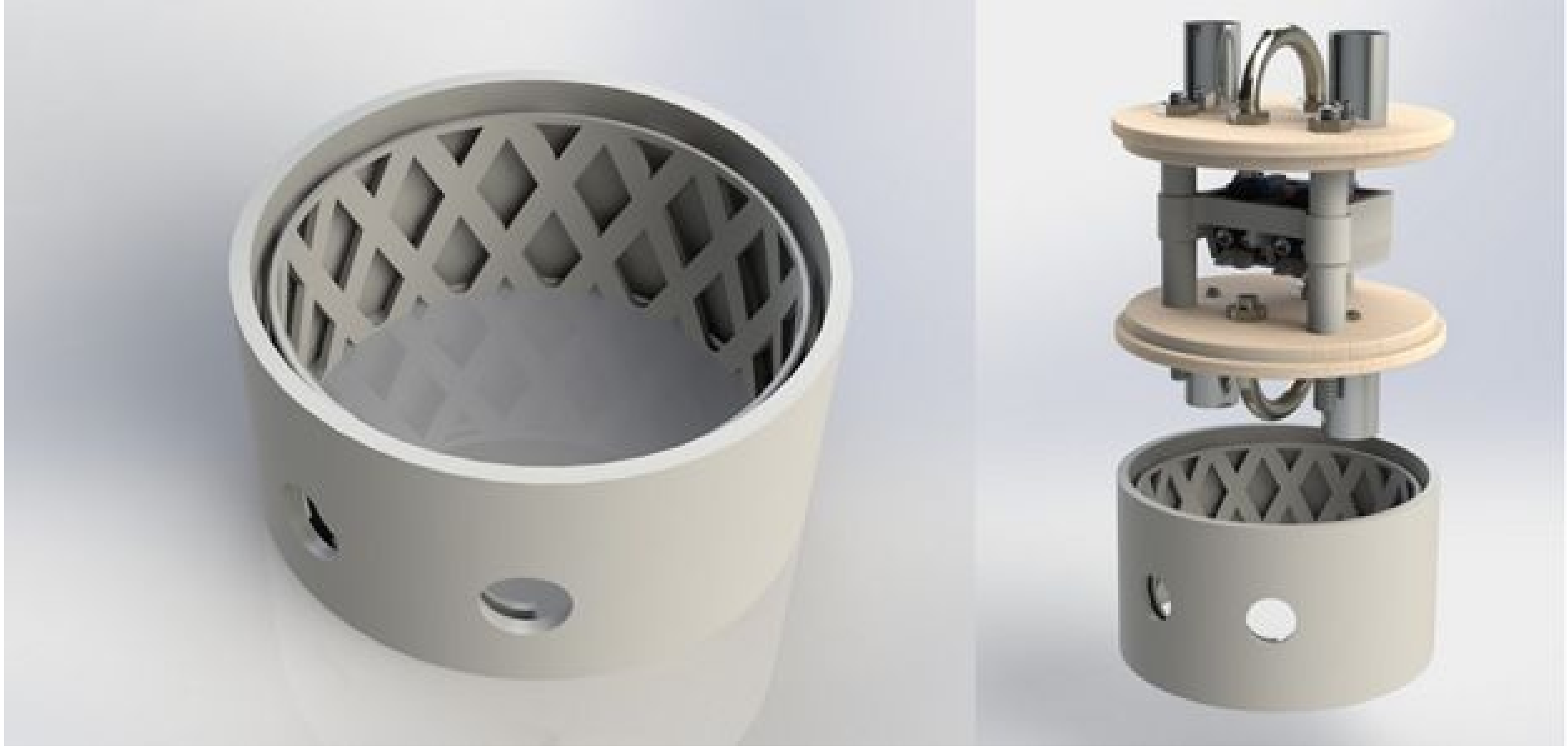


Avionics and Recovery – Avionics Bay Design

3D Printed board

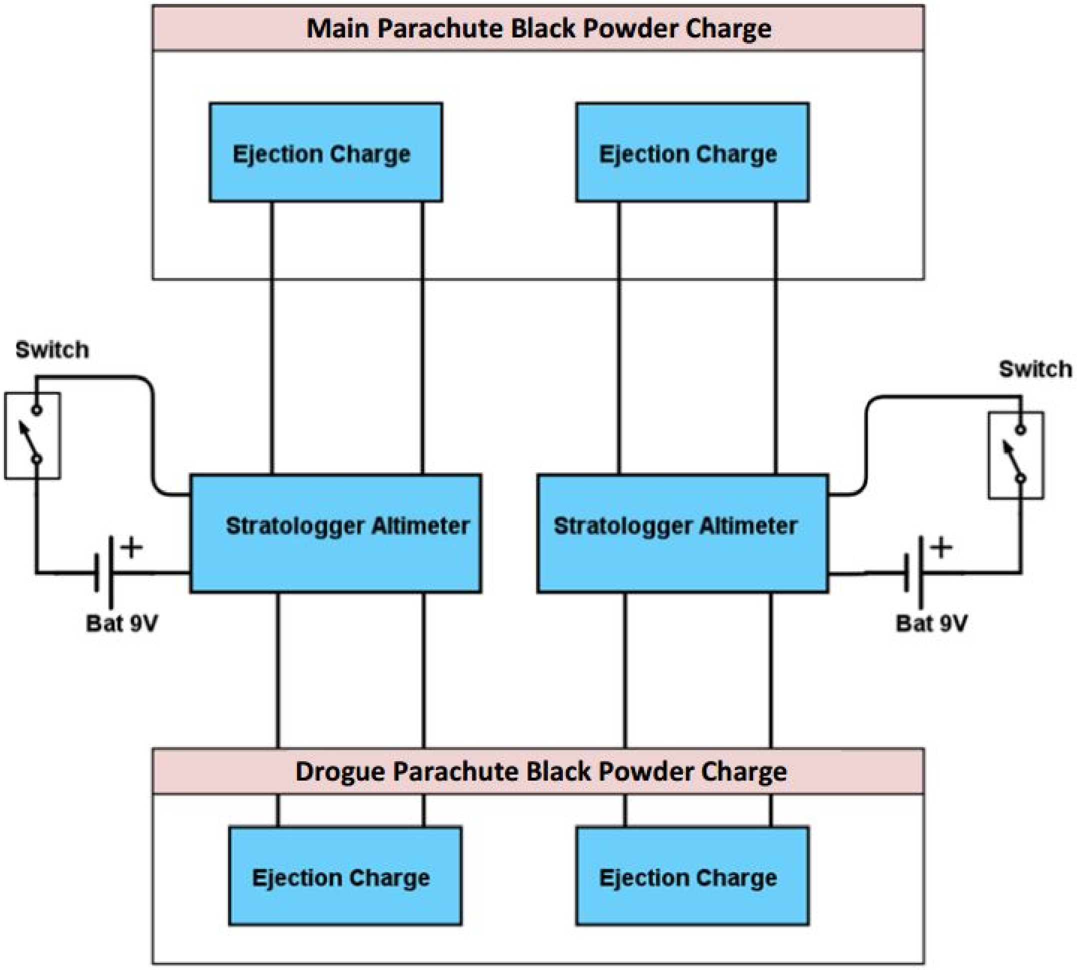
Avionics and Recovery – Avionics Bay Design

3D Printed Faraday Cage Sleeve



Avionics and Recovery – Wiring Diagram

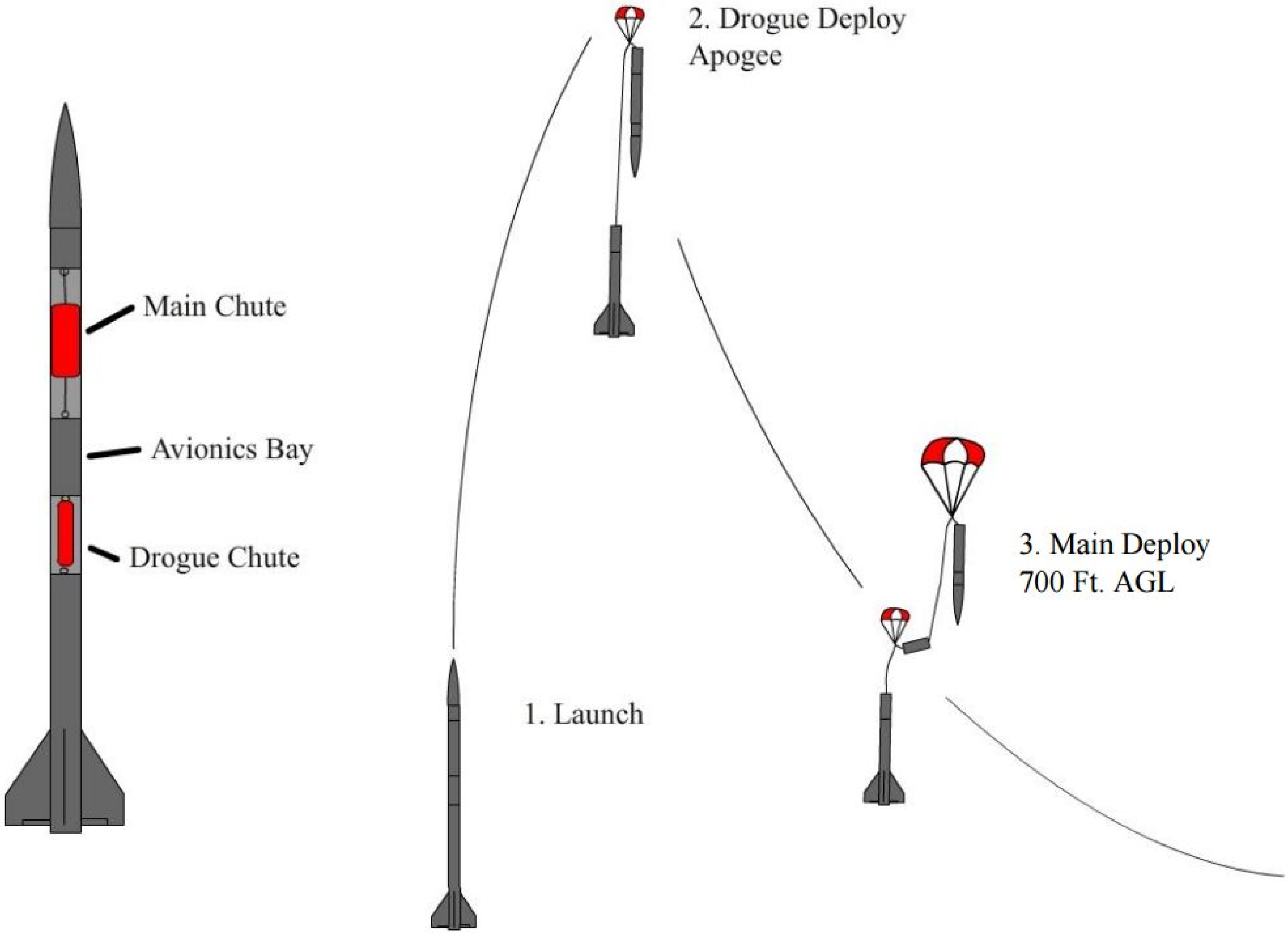
- Two independent altimeters
- Redundant Altimeter will be at a delay



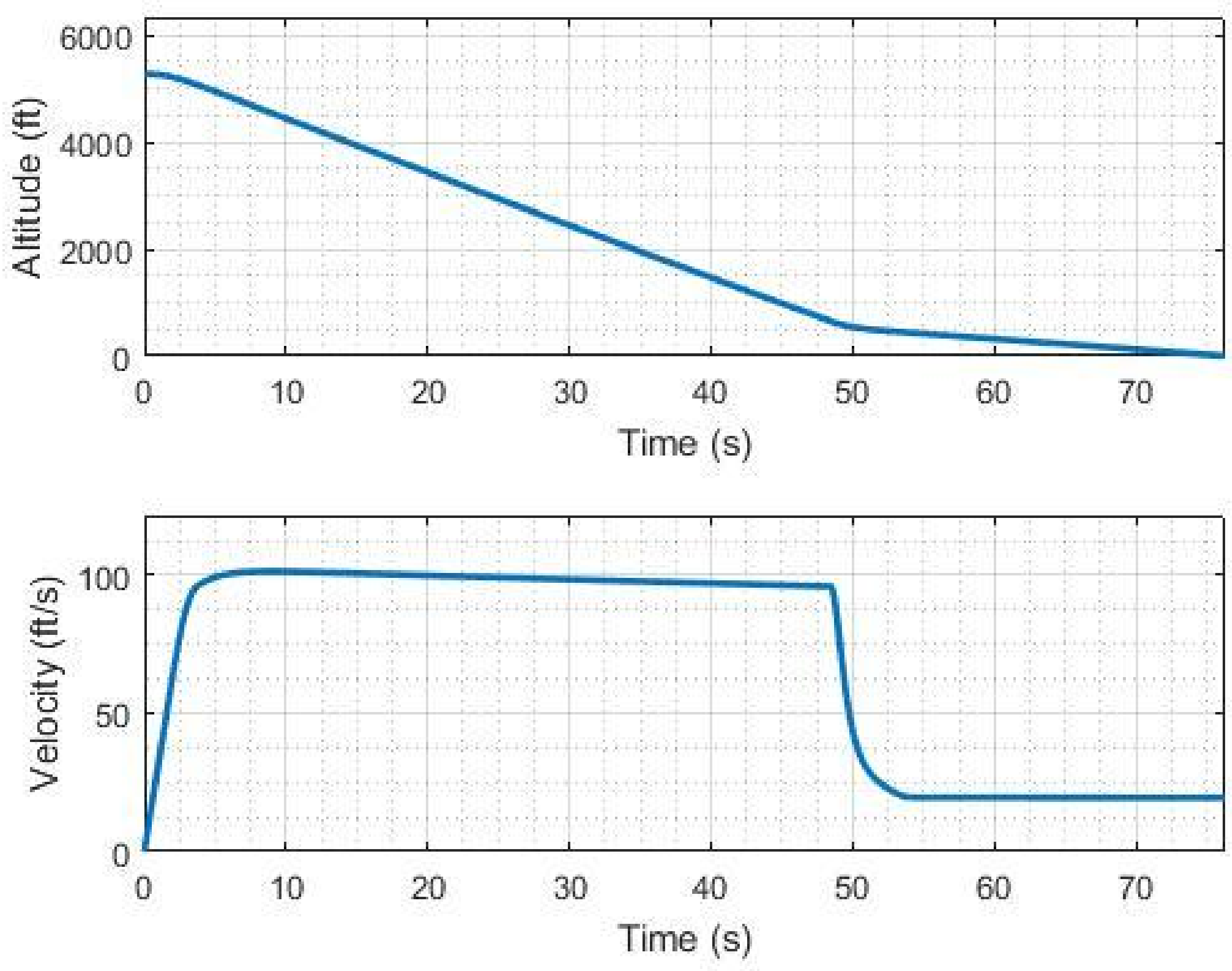
Avionics and Recovery – Parachute selection

	Drogue	Main
Parachute Type	18" Classic Elliptical	72" Iris Ultra Standard
Parachute Cd	1.5	2.2
Harness Type	½" Tubular Kevlar	½" Tubular Kevlar
Harness Length	30'	40'
Charge mass (black powder)	4g	5g

Avionics and Recovery – Deployment Method



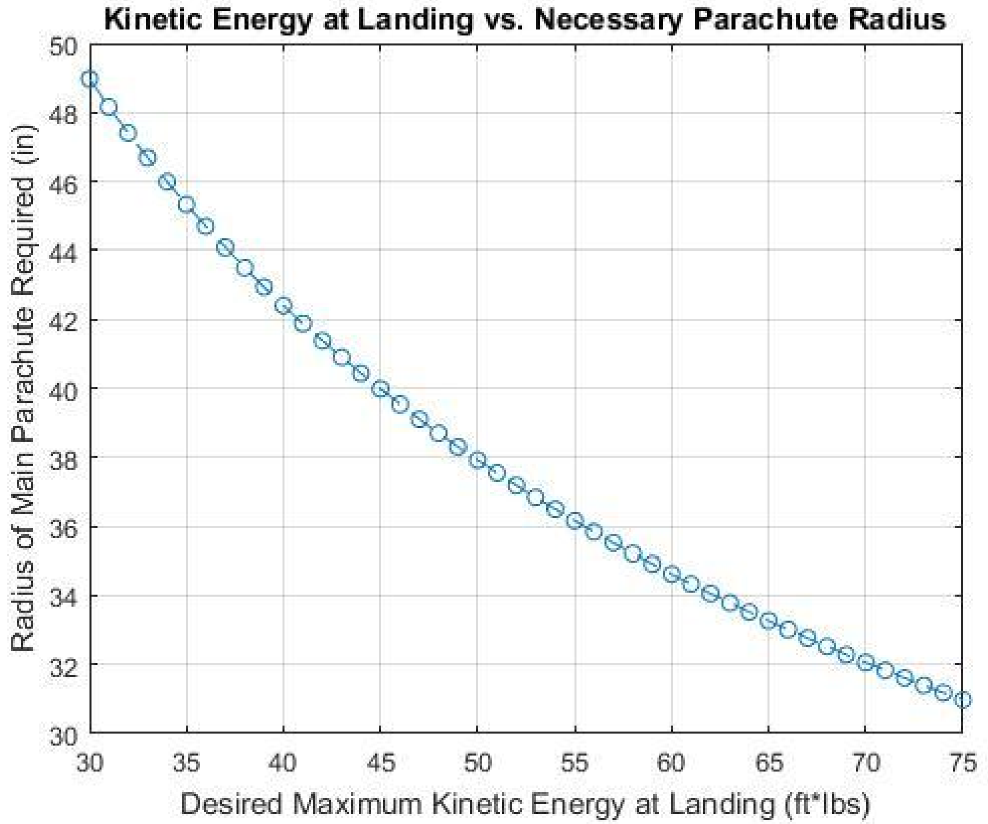
Avionics and Recovery – Velocity and Altitude Models



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



Avionics and Recovery – Testing

Deployment Charge Testing

- Ground test black powder charges prior to launch
- Testing occurs at either High Pressure Combustion Lab (HPCL) or at launch field
    - Under supervision from mentor/level 2 NAR member

Avionics Bay Simulations

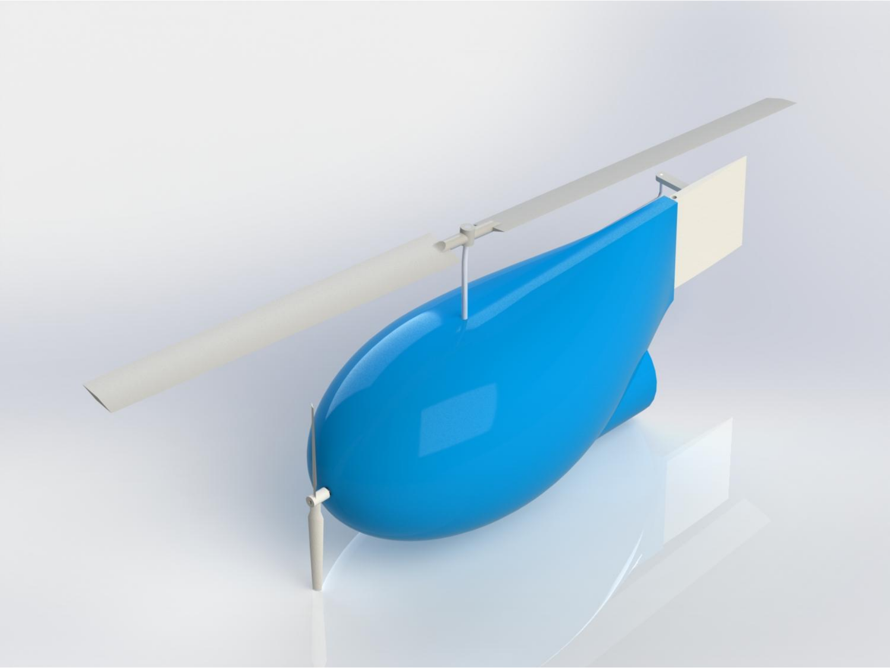
- Use vacuum chamber to test fully integrated avionics bay
- Determine pressure port sizes and test for altimeter functionality prior to launch

Payload – FOPS Design Overview

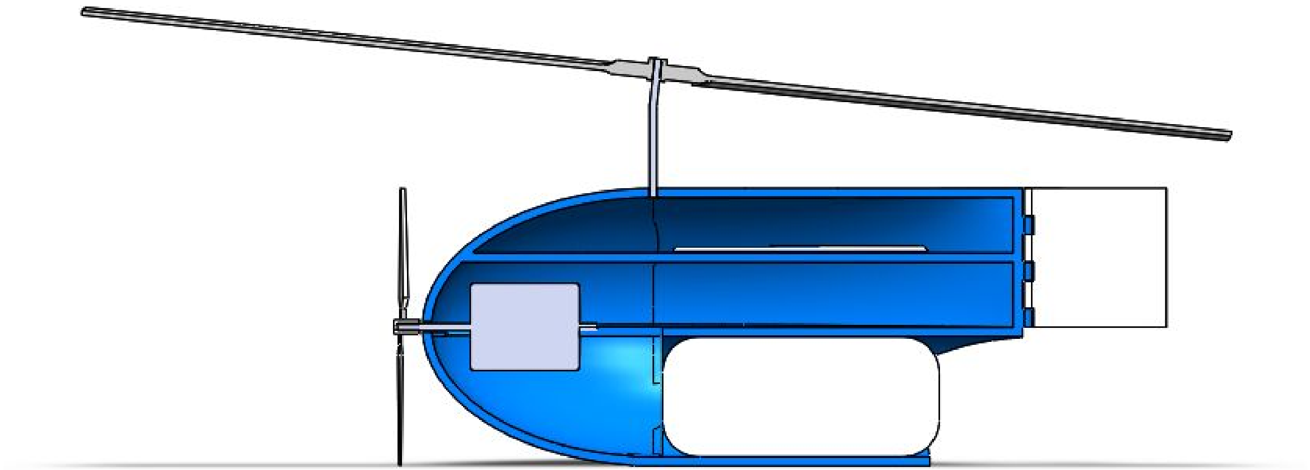
- Reservoir balloon fills main chamber once specimen is loaded
- Elastic bands restrain holding chamber movement
- Clear chamber allows for observation of payload

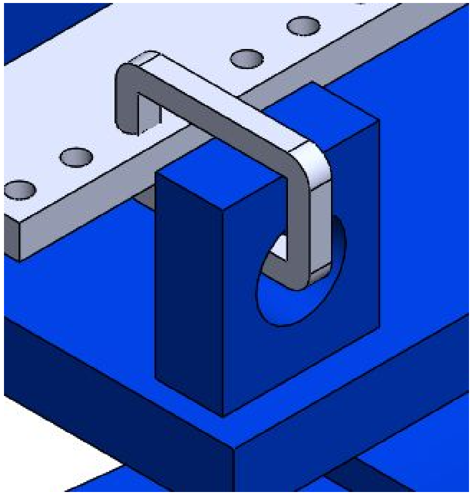
Payload – Kiwi Design Overview

- Autogiro design ensures stability
- GPS and IMU direct Kiwi to predetermined landing point
- Parachute will be used at altitude of 100’ or in case of emergency
- Will be ejected from rocket at apogee

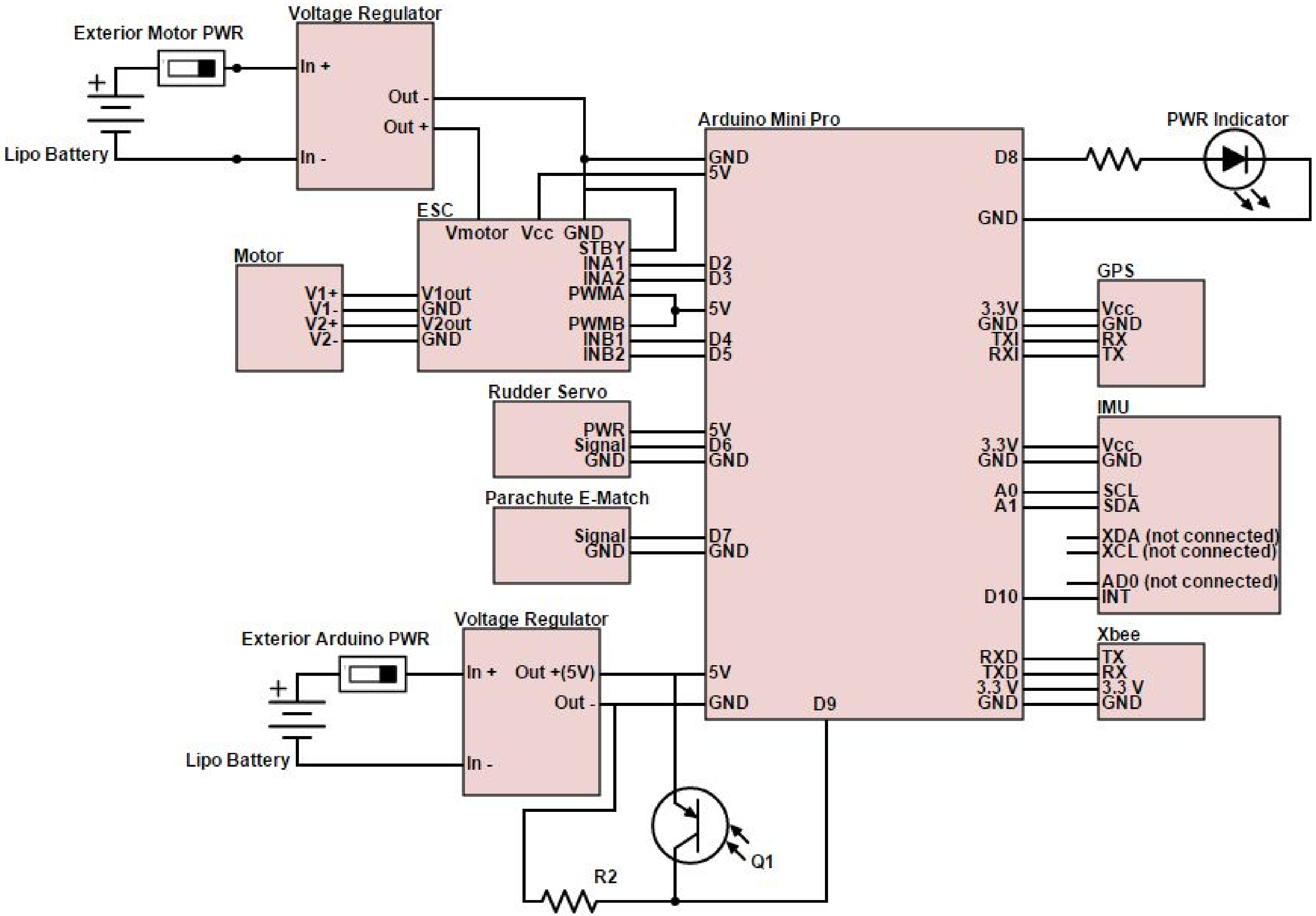


Payload – Kiwi Sectional View





Payload – Kiwi Electronic Schematics



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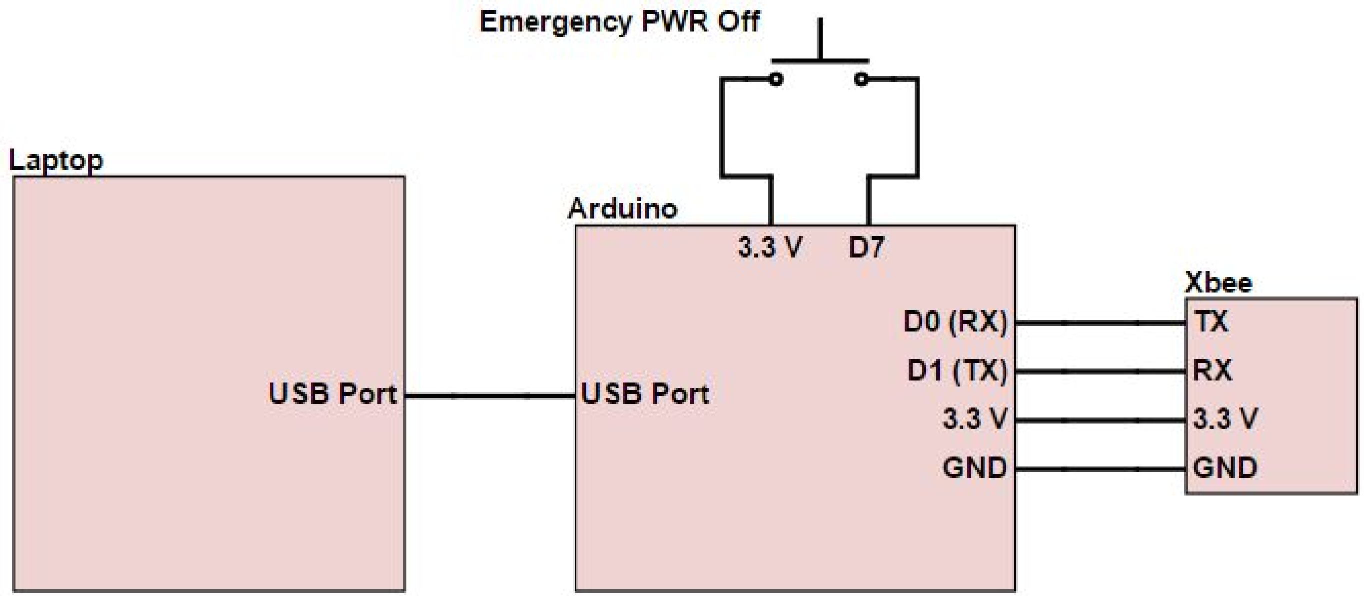
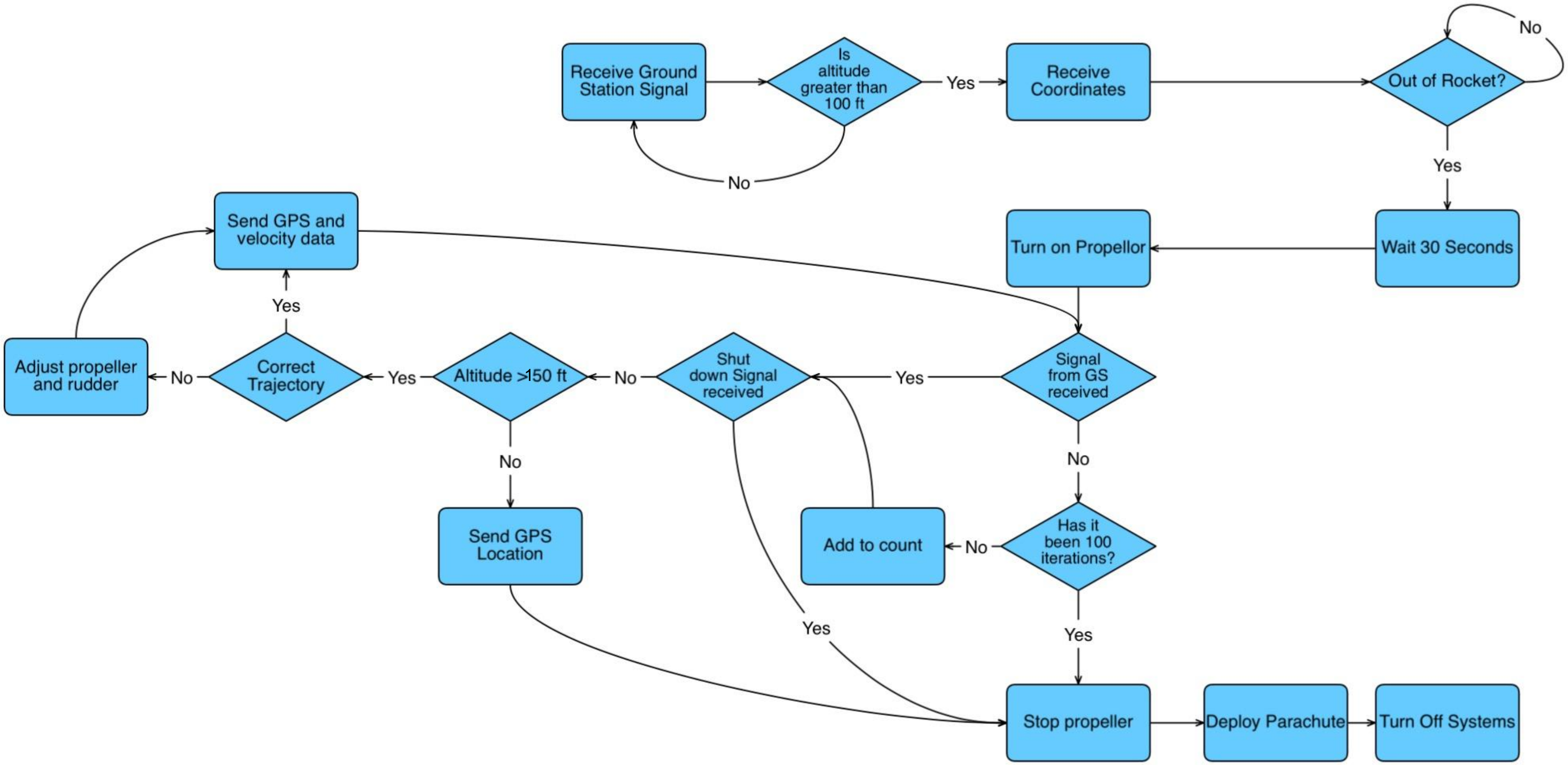
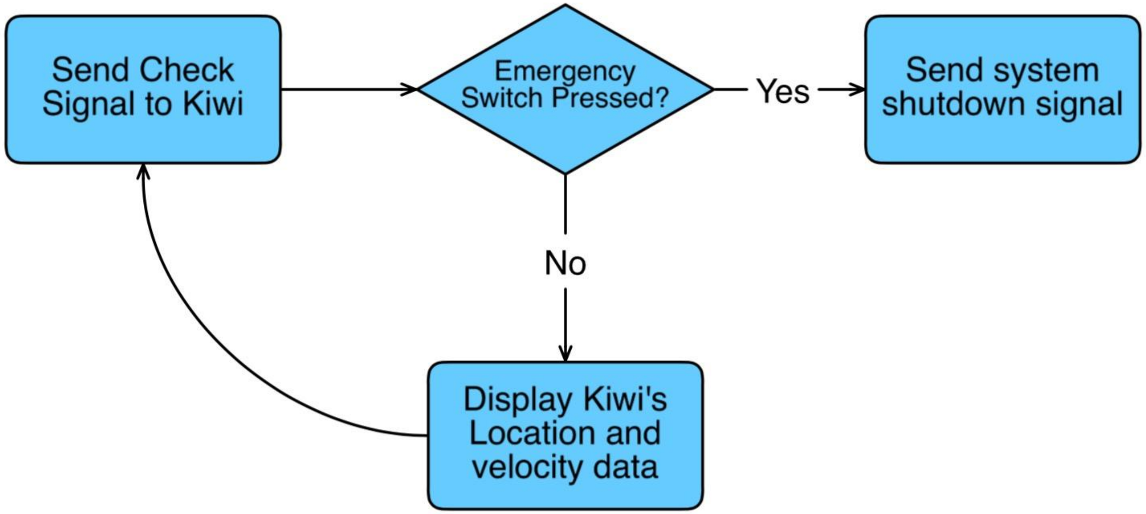


Payload – Kiwi Flight Software Flowchart



Payload – Kiwi Flight Software Flowchart



Payload – Subscale Launch Analysis

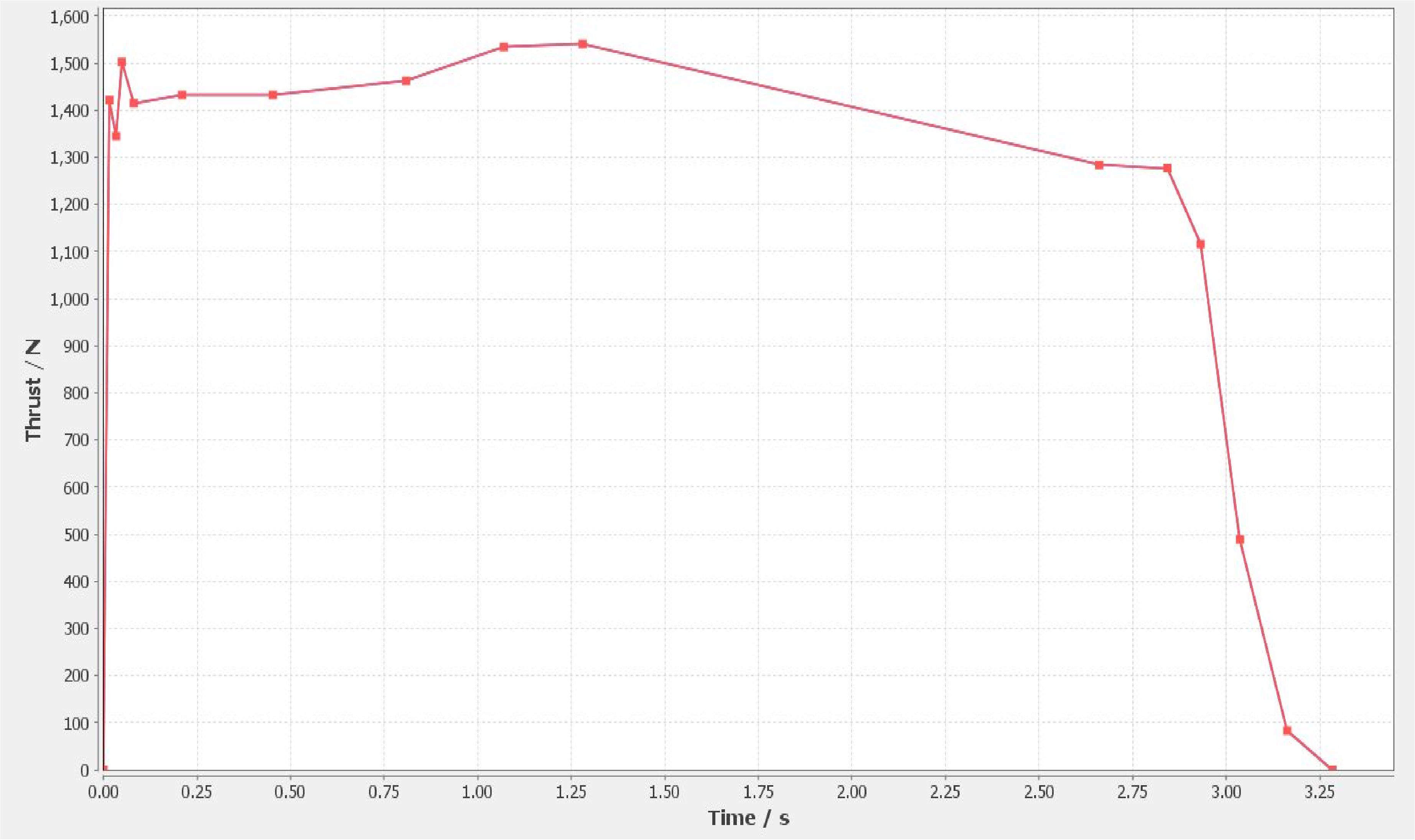
- A scoop-shaped corn chip used as a test subject did not survive launch and recovery
- Difficulty loading the chip is considered to be the cause of breakage
- After discussion, a new loading method was determined to be the most likely solution

Propulsion – Preliminary Motor Selection

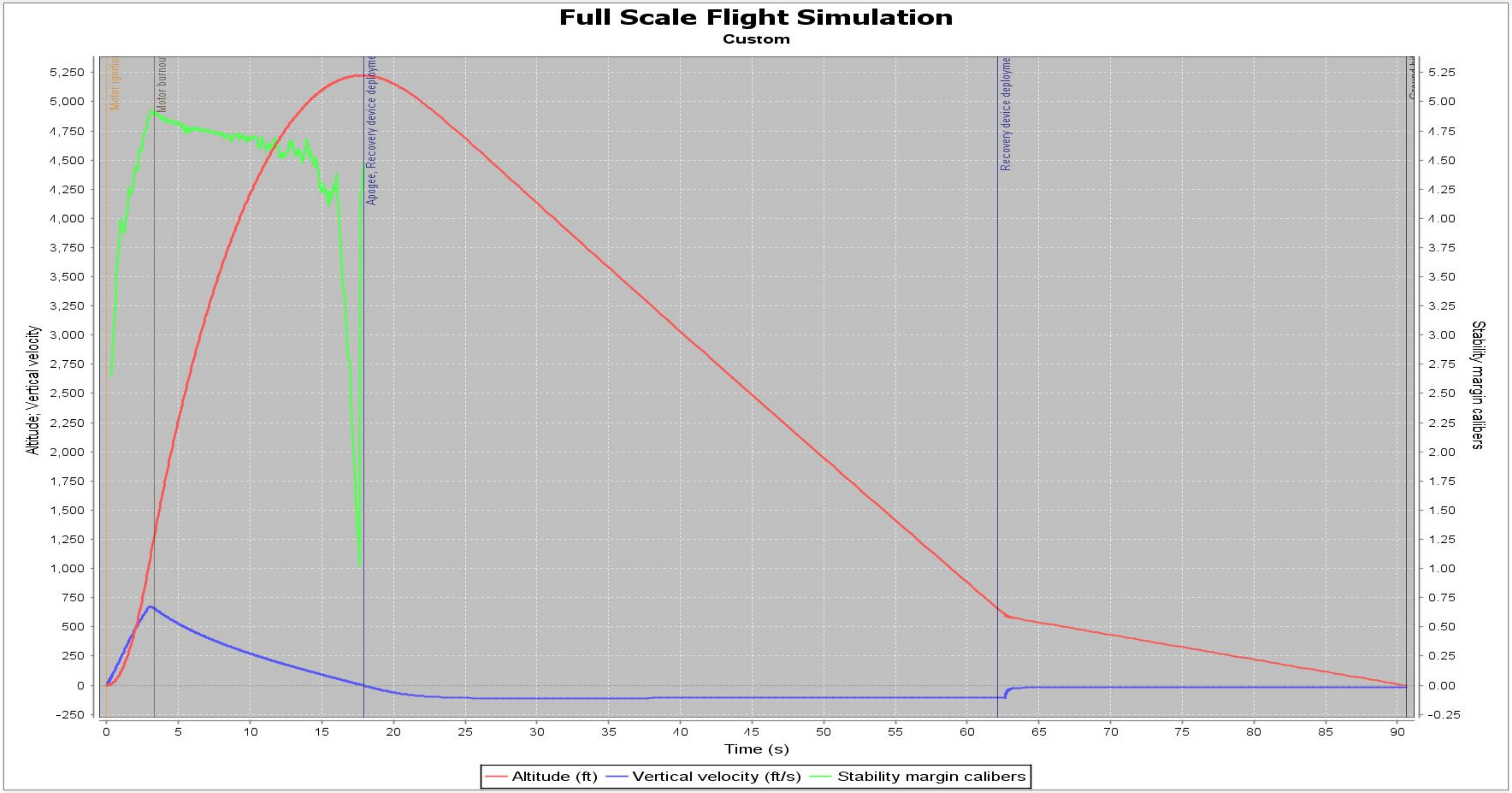
Designation	Apogee (ft.)	Velocity off rail (ft./s)	Impulse (lbf-s)	Weight (oz.)	Thrust/Weight Ratio
Cesaroni L1350 (3 Gr.)	5231	75.8	962	125.92	7.83

The L1350 is the Cesaroni motor that achieves a simulated apogee closest to the goal of 5280 feet.

Propulsion – Primary Motor (L1350) Thrust Curve



Propulsion – Full Scale Flight Simulation



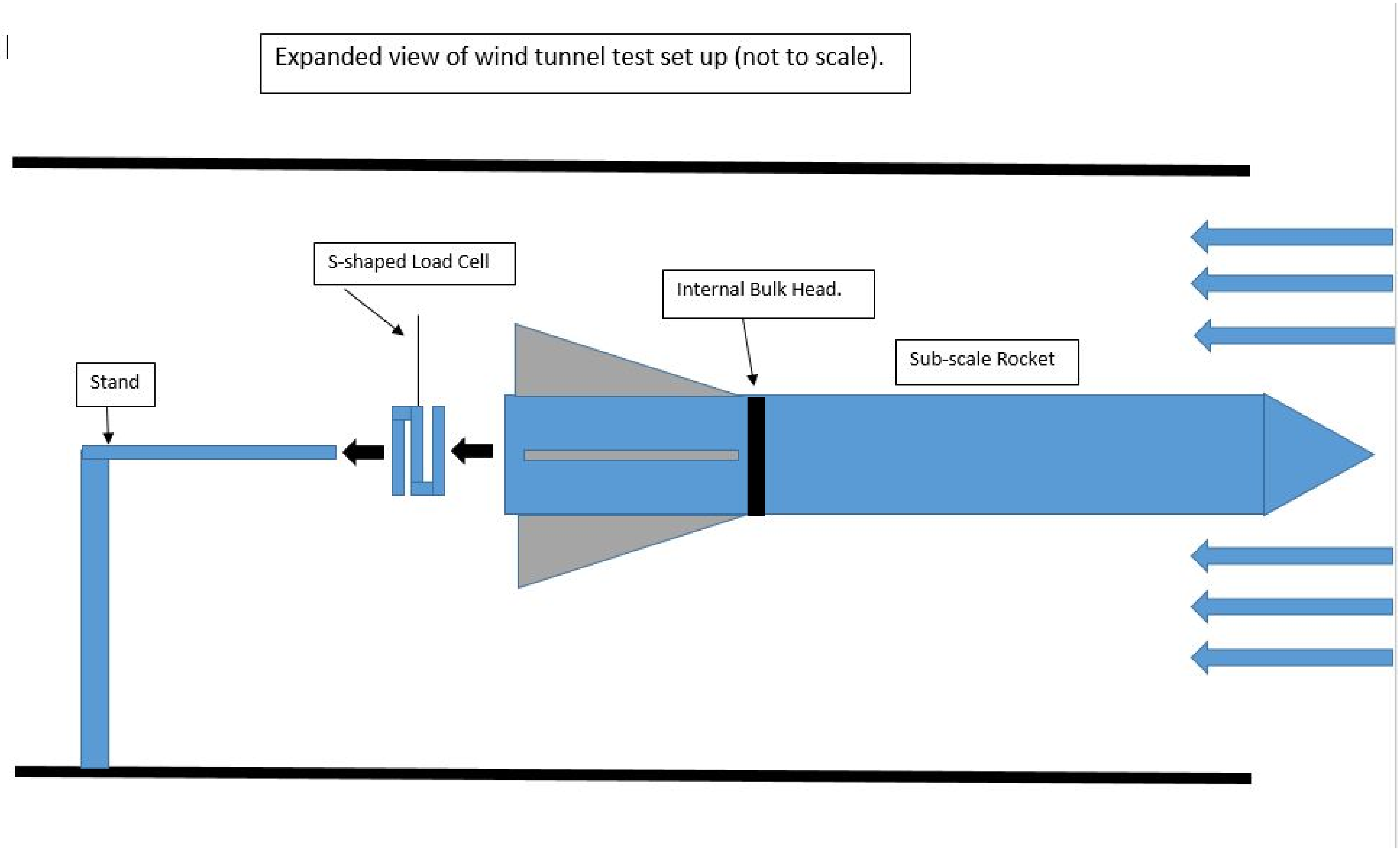
Propulsion – Static Motor Testing

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

Static Motor Testing

Propulsion – Wind Tunnel Testing

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



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
  - All Leads and Executives have official lab training from the Penn State Environmental Health and Safety (EHS) Office
  - All members take online EHS lab safety modules

Mission Overview - Budget

Expected Costs: 2016-2017	
Fullscale	$1,776.35
Subscale	$277.65
Propulsion	$1,183.00
Travel	$7,000.00
Outreach	$300.00
Miscellaneous Equipment	$750.82
Total	**$11,287.82**

Expected Income 2016-2017	
Aerospace Engineering Department	$5,000.00
Mechanical Engineering Department	$1,000.00
Samuel A. Shuman Endowment in Engineering	$8,700.00
Club Fundraising	$1,500.00
The Boeing Company	$500.00
Total	**$16,700.00**

Questions?