Penn State Flight Readiness Review

Project Odyssey

March 6, 2016

Overview

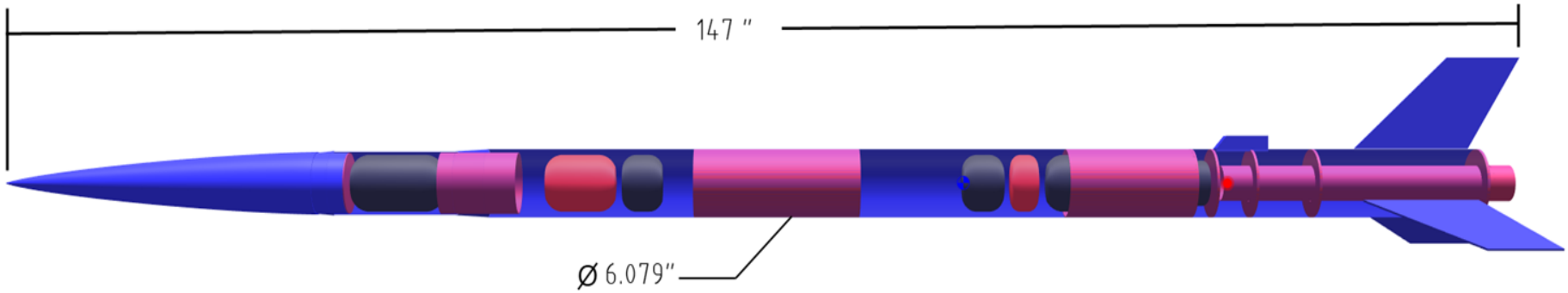
- Team introduction
- General overview
- Structures
  - Rocket design
- Avionics and Recovery
  - Full scale flight results
  - Recovery system
- Payload
  - FOPS
  - Kiwi
- Propulsion
  - Motor Choice
- Mission Overview
  - Budget
  - Timeline
- Conclusion
- Appendix

Team Introduction

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

Vehicle Dimensions

- Total Length:
  - With Fins: 147” ≅ 12.3’
  - Nose Cone Tip to Motor Retainer: 146”
- Outer Diameter: 6.079”
- Total Mass = 41.5 lbm



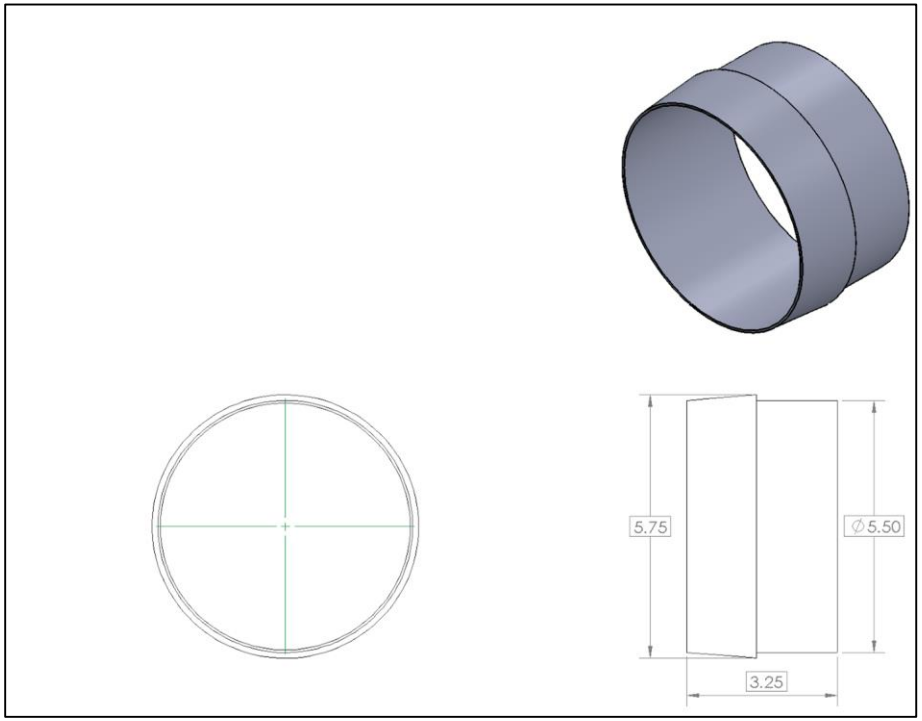
Mass Statement of Launch Vehicle

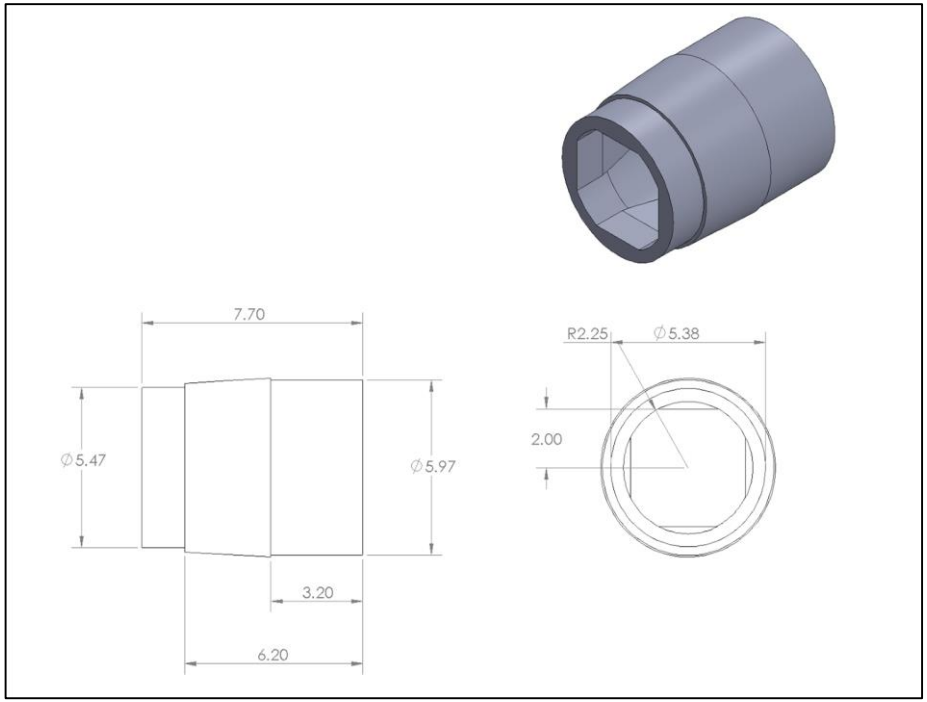
Component	Mass (oz)
Nosecone with aluminum tip	50.2
Airframe	98.2
Acrylic	37.1
FOPS	53
KIWI	19
Avionics Bay	28
Other (motor, fins, Hardware, epoxy)	378.5

Key Design Features

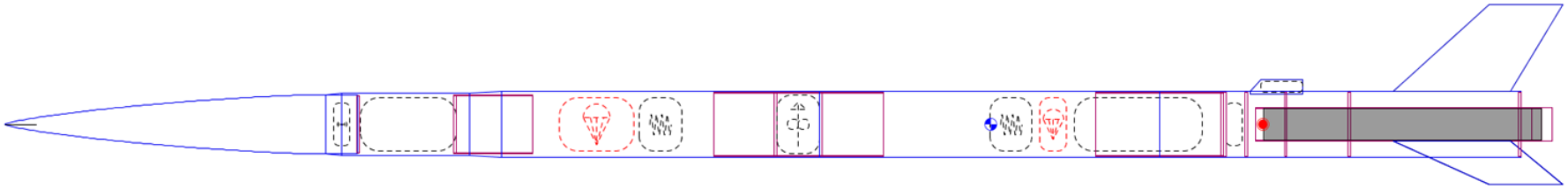
- Von Karman nosecone
- Aluminum nosecone tip for durability
- External 3D printed fin brackets
- 3/16 inch fiberglass fins
- Blue Tube 2.0 airframe
- 6 inch coupler shoulders
- 3D printed coupler transitions

Transitions

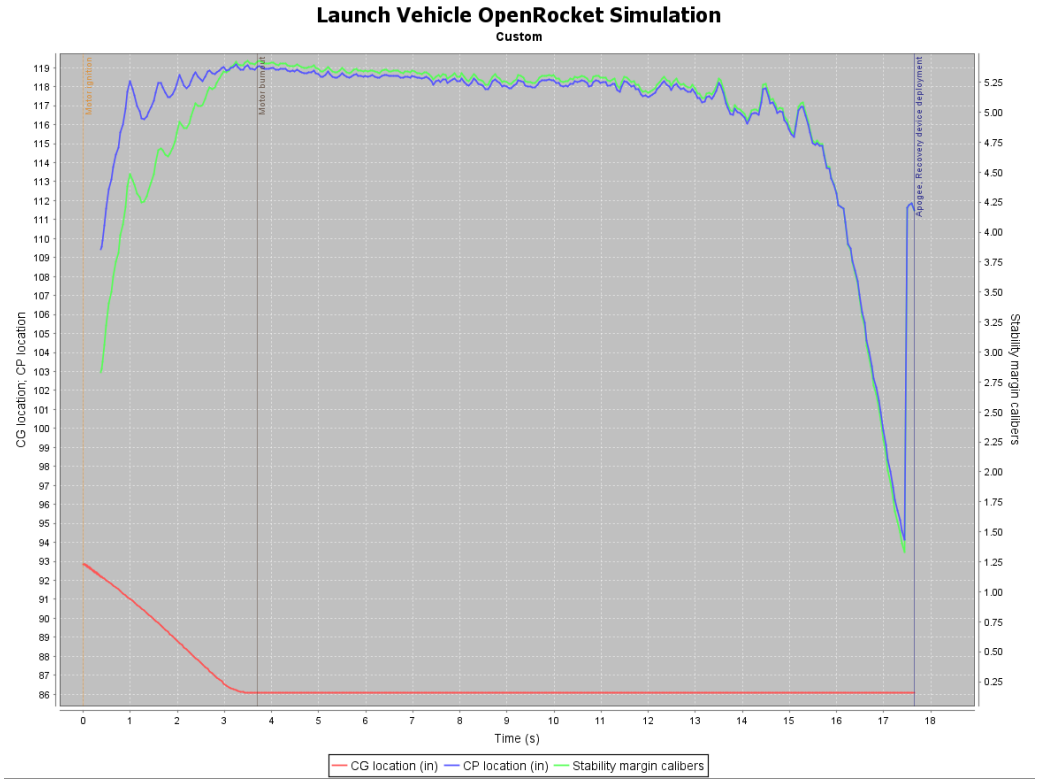




Stability Margin



- CG: 92.86 inches from the tip of nose cone
- CP: 118 inches from the tip of nose cone
- Static stability margin: 4.2 calibers
- 3.1 calibers off of 12 ft. launch rail



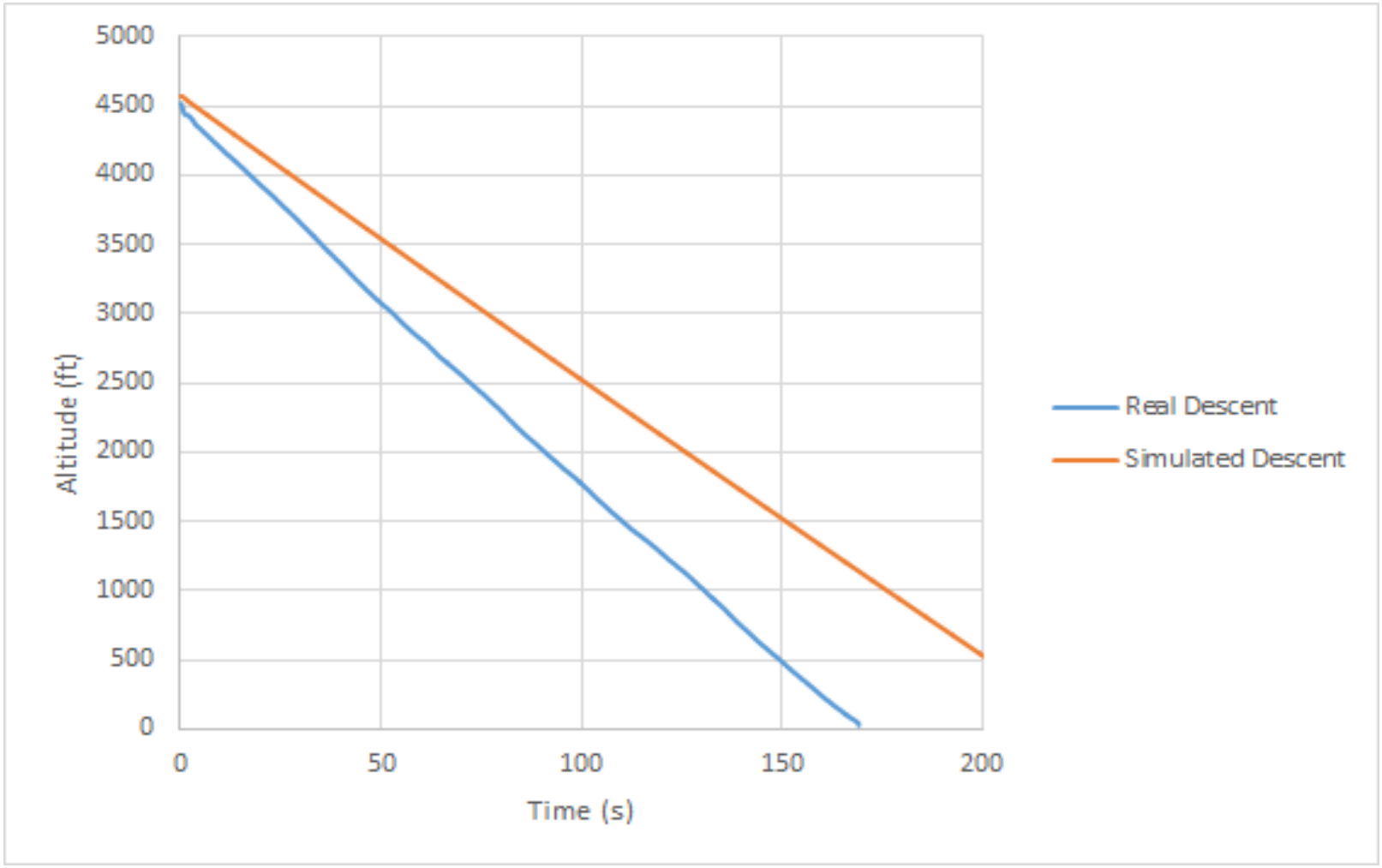
Status of Verification: Structures

- 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

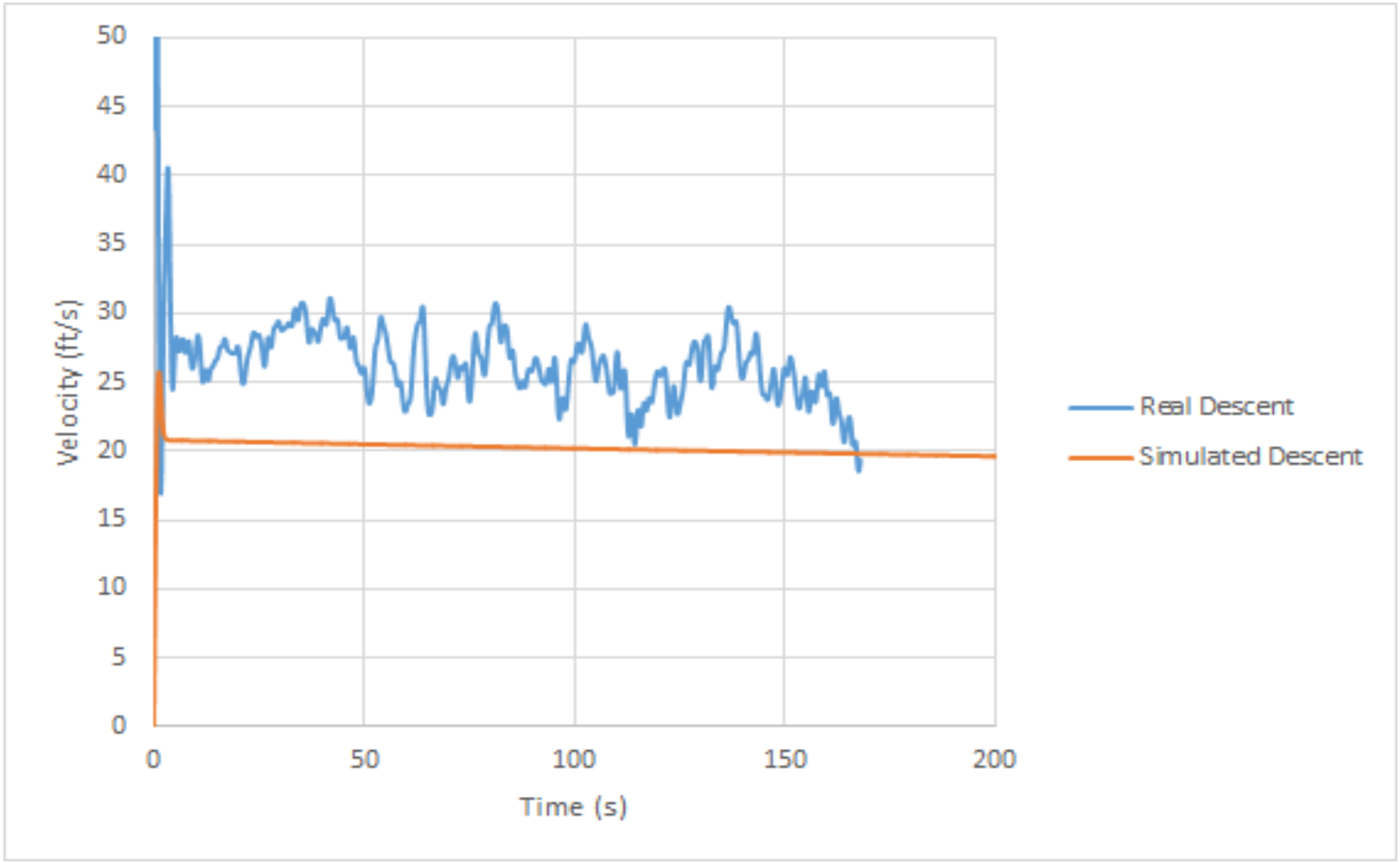
Full Scale Flight Results

- Apogee: 4518 ft
- Descent Time: 169 seconds
- Drift Distance: 1.03 miles
- Average Wind Speeds > 21 mph
- Coefficient of Drag: 0.6978
- Deployment: Anomaly at apogee
  - Main and drogue deployed
  - Too few or too small shear pins in the main coupler
  - Only one set of ejection charges deployed
- Zippering experienced in main body tube

Avionics and Recovery – Full Scale Flight Results



Avionics and Recovery – Full Scale Flight Results



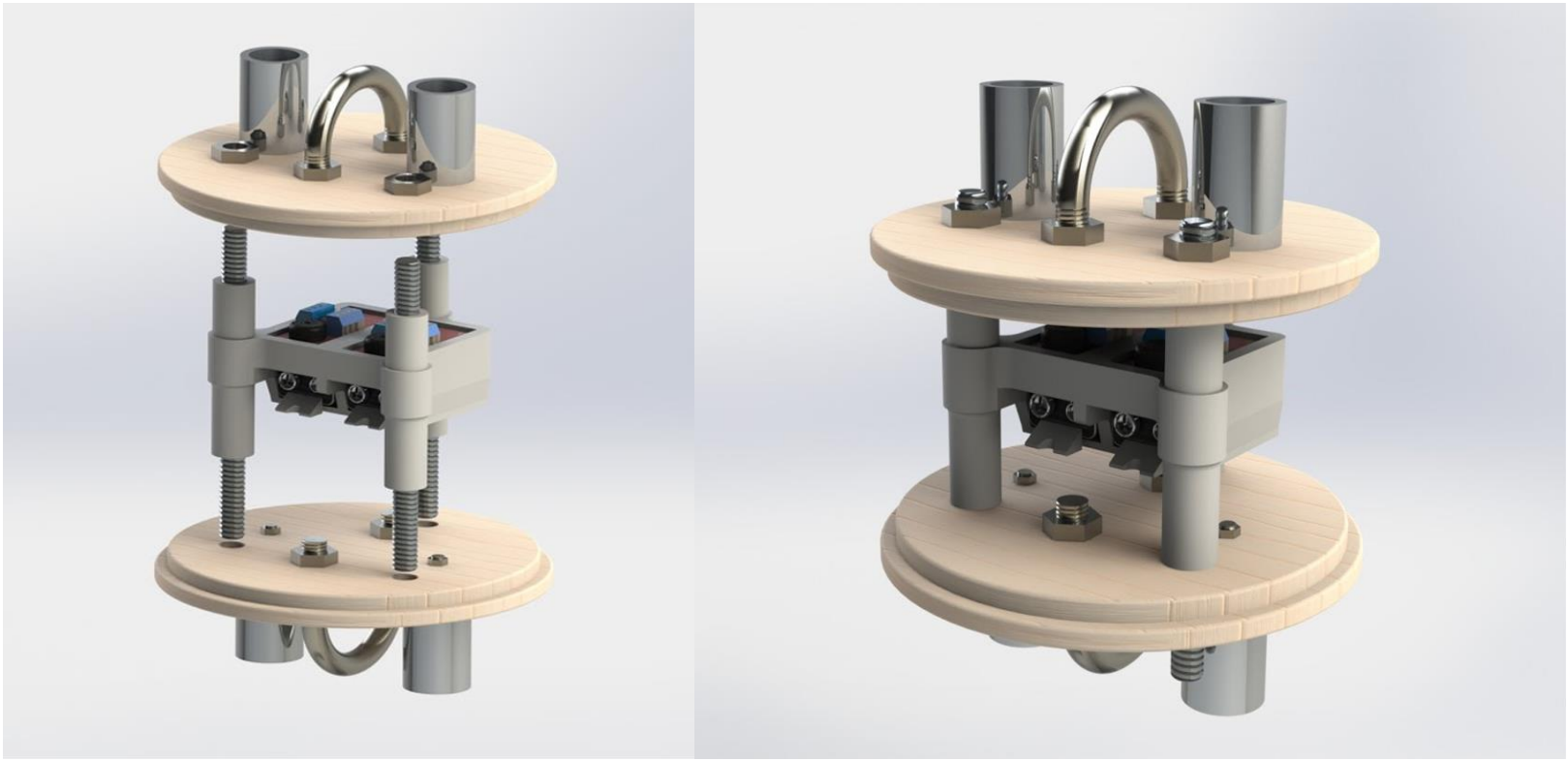
Avionics and Recovery – Full Scale Flight Results

Lessons Incorporated:

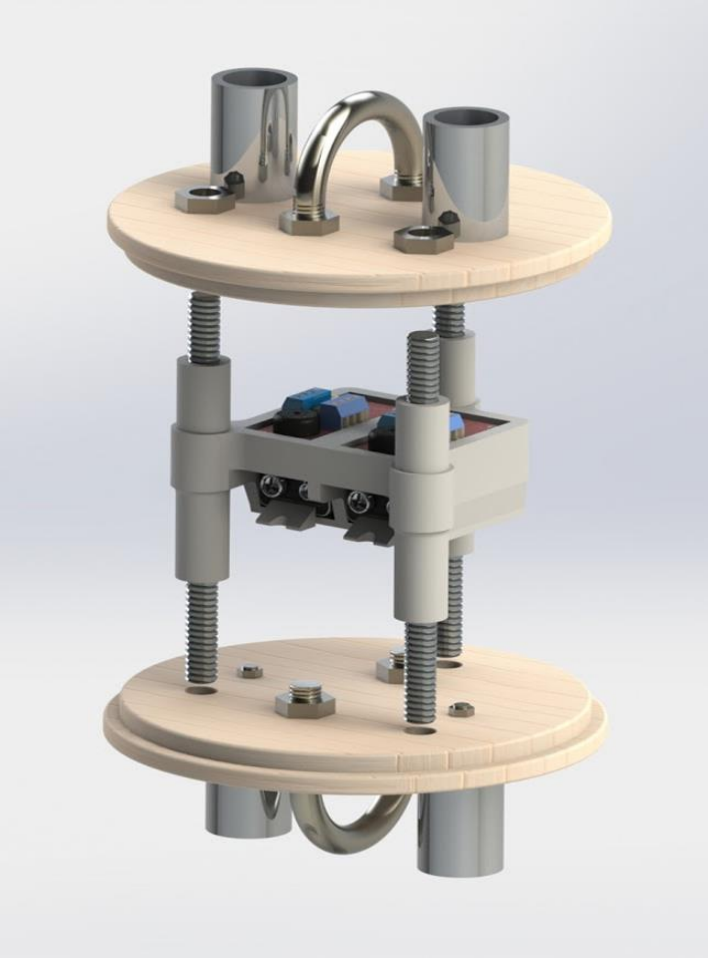
- Make sure to have sufficient supplies before launch
- Test the altimeters between launches
- Test all avionics wiring for security
- Use of a large “Fireball” to prevent zippering
- Duct tape can't fix parachutes: a new 72” Parachute will be purchased
- Ensure shroud lines have minimal tangling before launch

Avionics and Recovery – Avionics Bay Design

3D Printed board

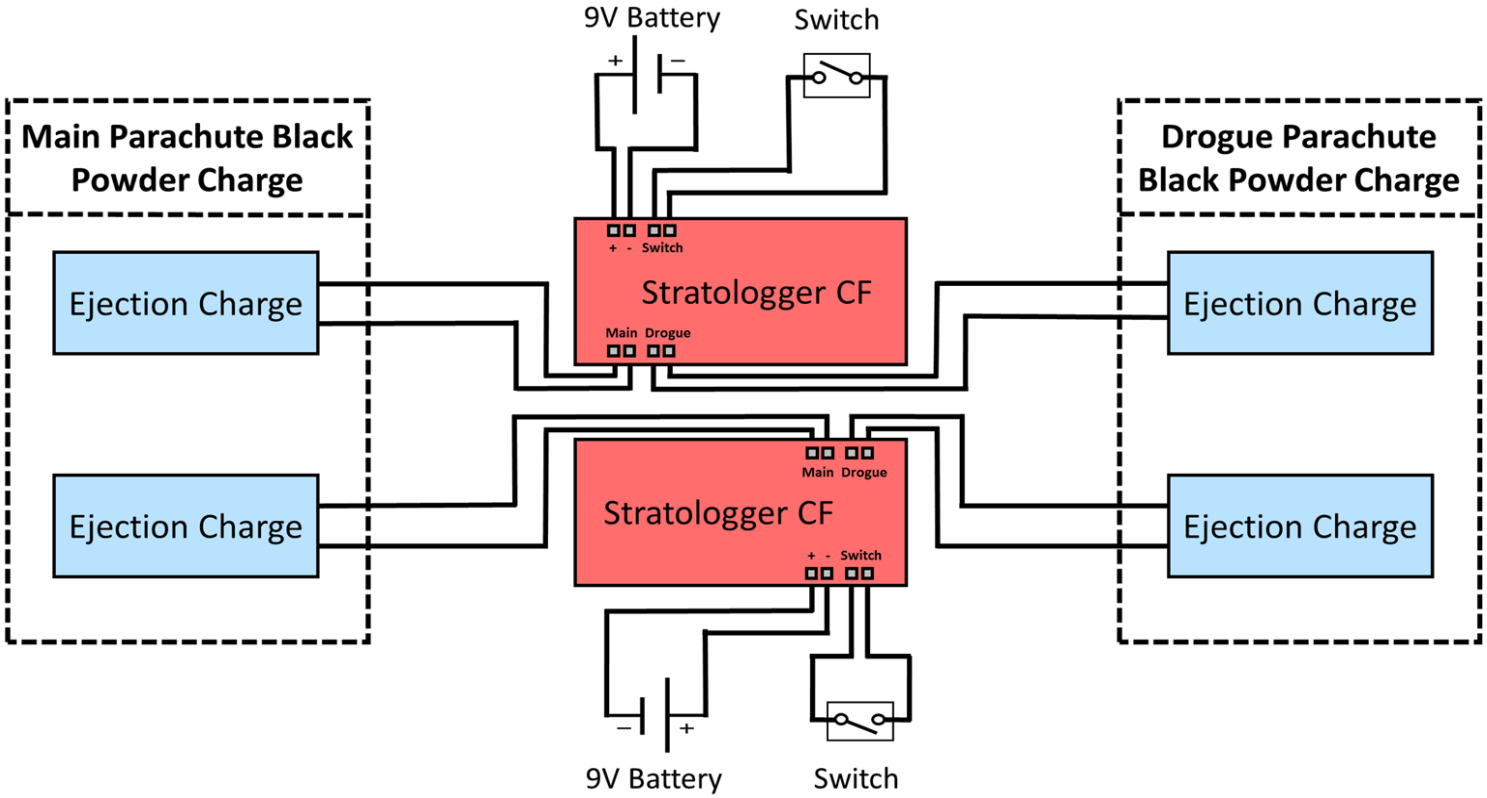


Avionics and Recovery – Avionics Bay Design



Avionics and Recovery – Wiring Diagram

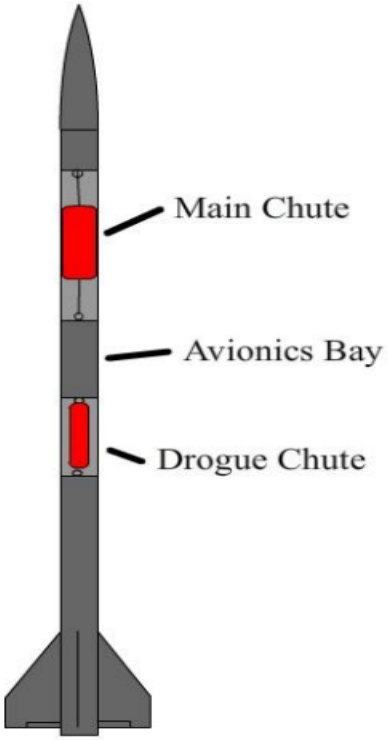
- Two independent altimeters
- Redundant Altimeter will be at a delay

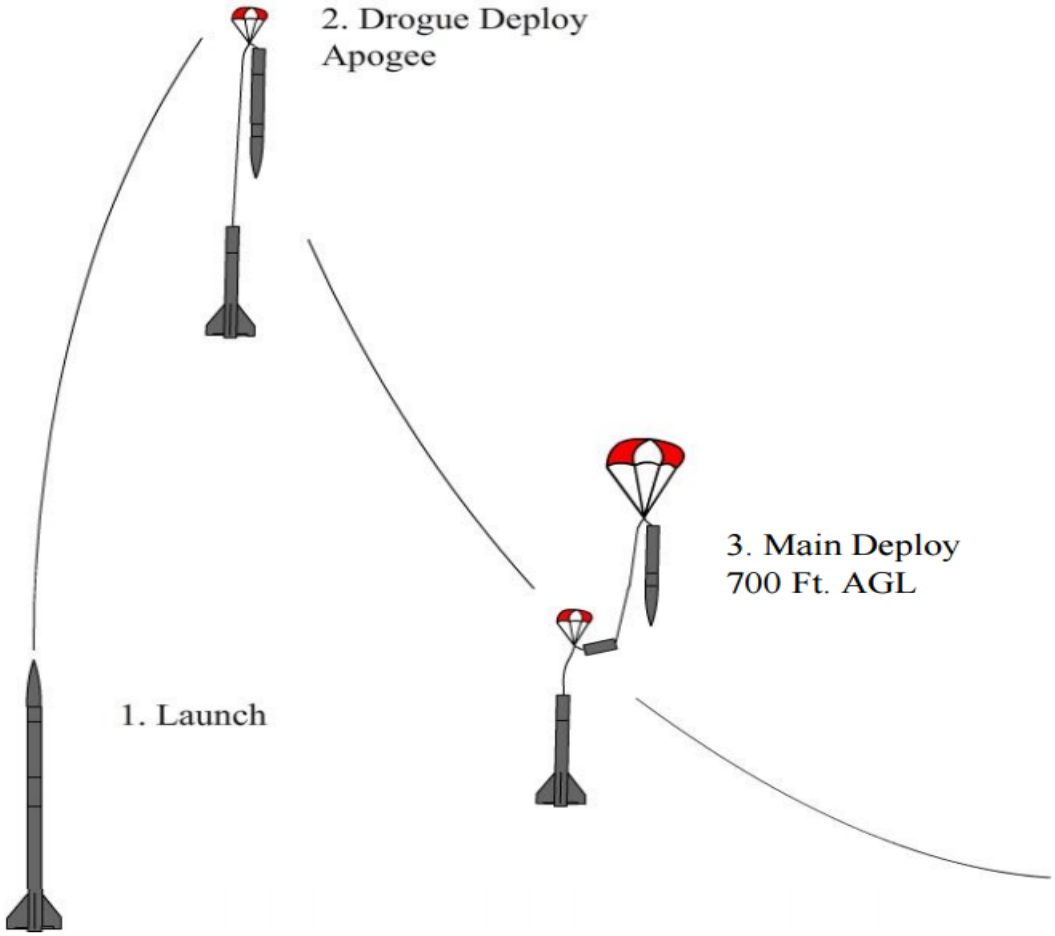


Avionics and Recovery – Parachute selection

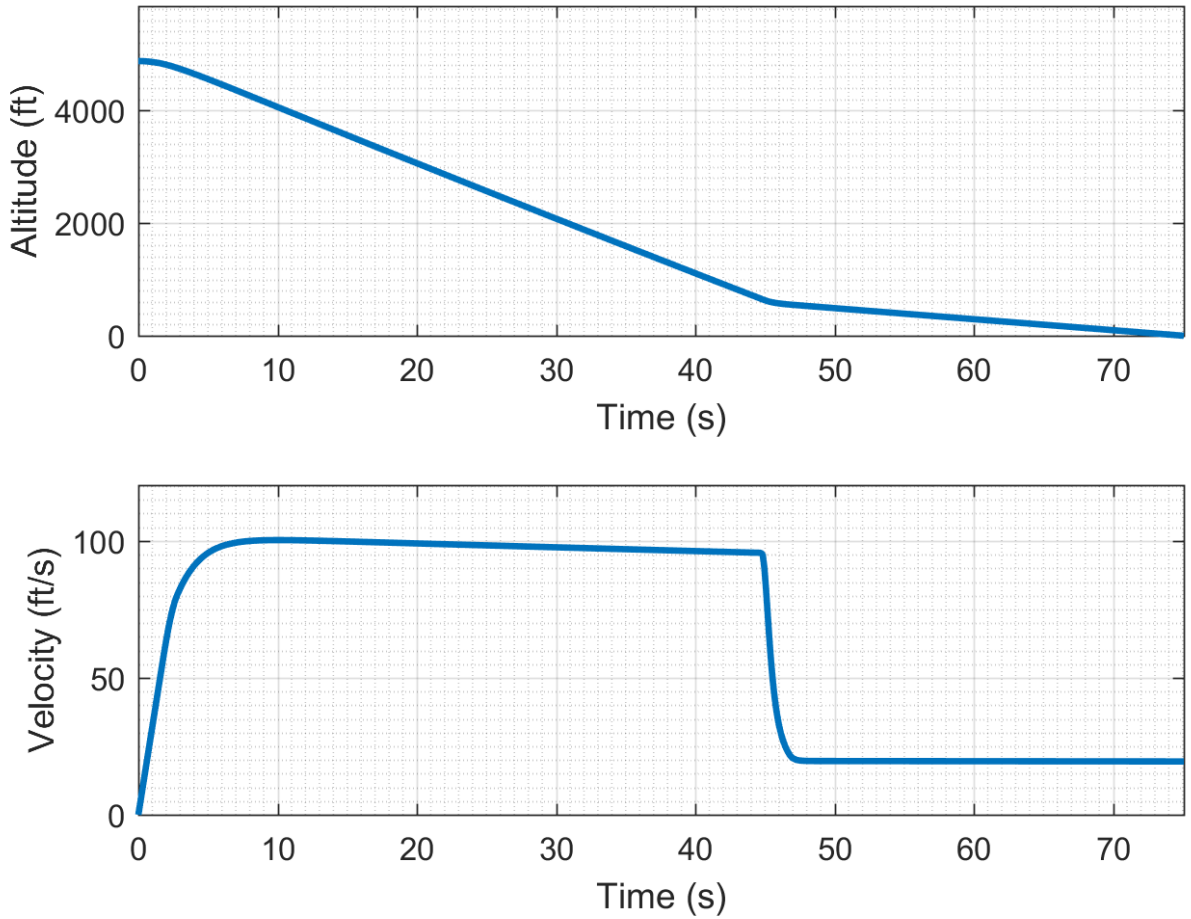
Drogue Parachute	Main Parachute
18” Classic Elliptical	72” Iris Ultra Standard

Avionics and Recovery – Deployment Method

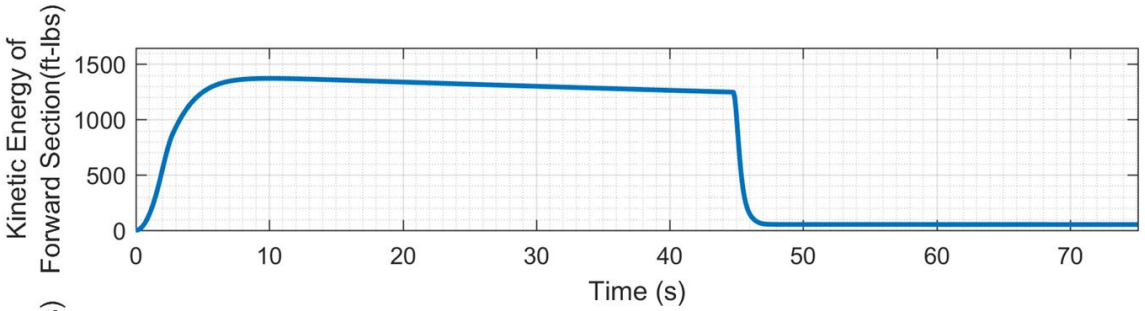


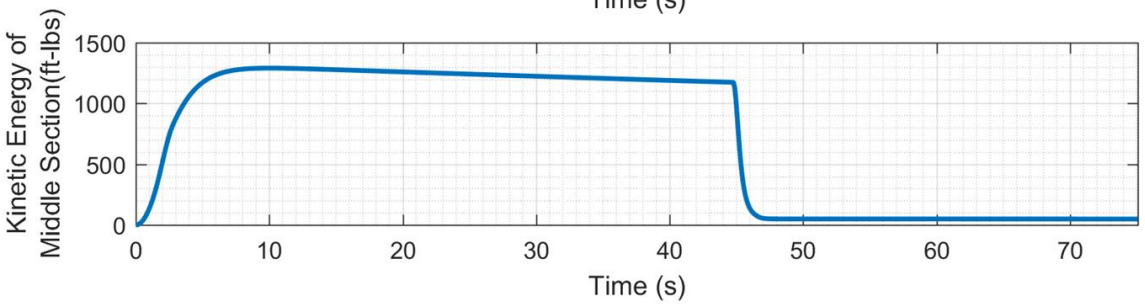


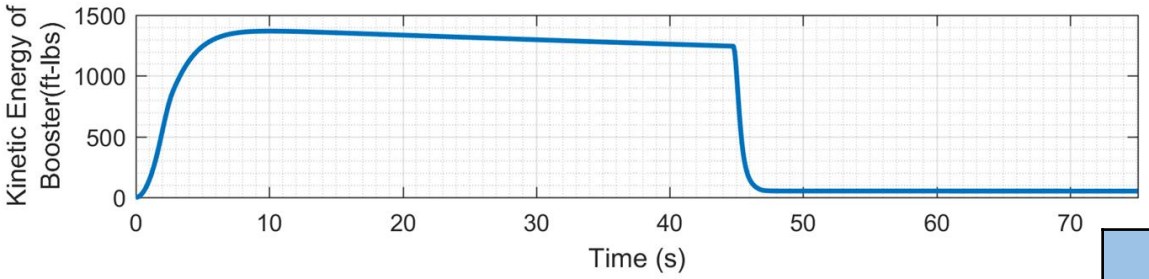
Avionics and Recovery – Velocity and Altitude Models



Avionics and Recovery – Kinetic Energy







Stage	Terminal Velocity (ft/s)
Drogue	**95.7**
Main	**19.5**

Wind Velocity (mph)	Drift Distance (ft)
0	**0**
5	**551**
10	**1101**
15	**1652**
20	**2203**

Section	Weight (lbm)	Kinetic Energy at Landing (ft*lbs.)
Nosecone	8.768	51.68
Central Body	8.254	48.65
Booster Section	8.750	51.58

Payload Changes since CDR

FOPS:

- The FOPS materials bag dimensions are now 5.5” x 7”
- The FOPS bag is being lined with cotton and open cell foam

Kiwi:

- By default Kiwi will deploy the parachute at 500 ft.
- Kiwi’s body length was increased to 7.1” and the parachute bay was increased to a 1.3” wide by 3” long cylinder
- Kiwi has a retainment system to keep the vehicle in the rocket in case of emergency
- Kiwi’s propeller will be folded up while in the rocket and open when Kiwi exits the rocket.

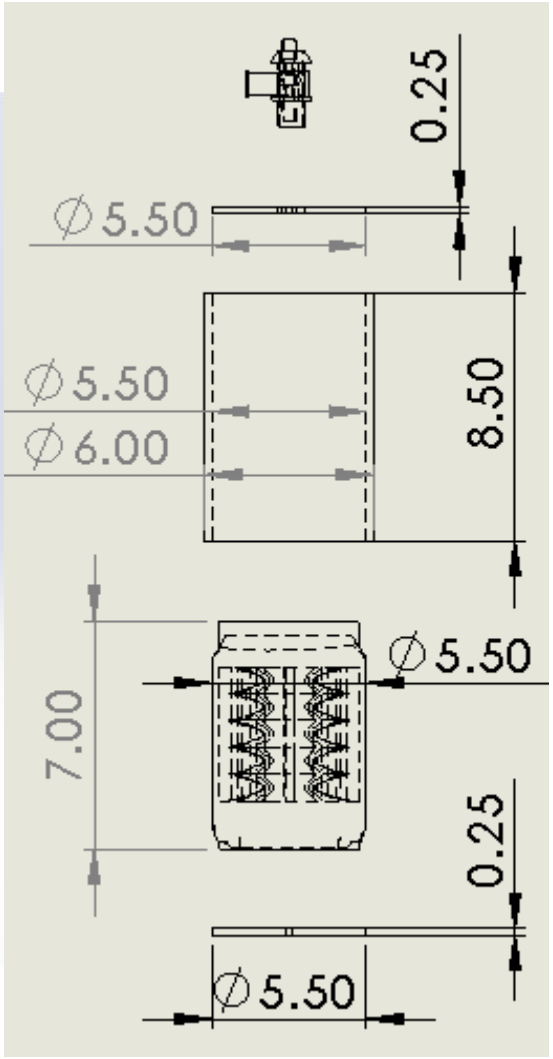
Payload Full Scale Launch Results

- FOPS successfully protected the sample payloads, an egg and a chip
- Kiwi successfully exited the rocket, however, the team could not recover Kiwi due to communication failure
    - Possible Reason: The code got stuck in the initialization phase
        - Mitigation: Initialize XBees first
    - Possible Reason: The electronics were damaged because Kiwi was forced closed
        - Mitigations: Make the circuit more concise, make Kiwi longer

FOPS

-Balloon (not shown in image) will hold excess dilatant until the fragile specimens have been inserted

- Balloon is supported by open-ended two-liter bottle to enable complete drainage

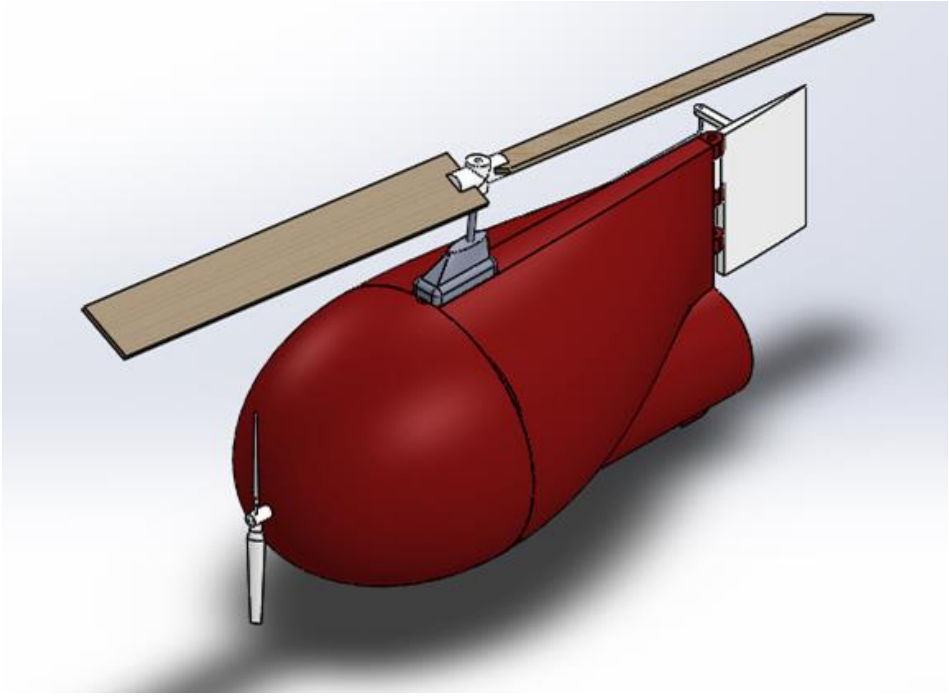


FOPS Testing

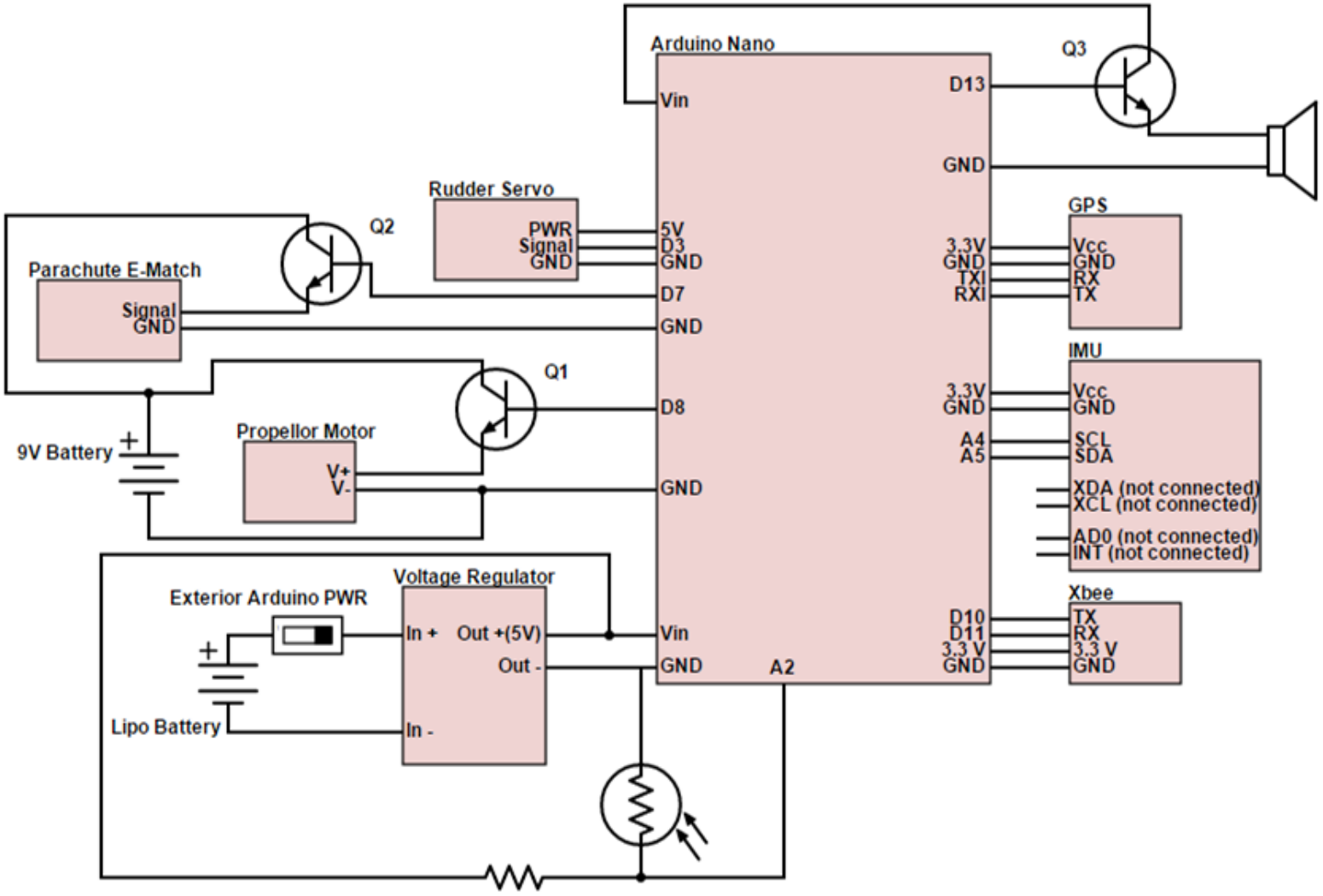
- 30 ft drop tests using pringles cans as bays for proof of concept
- Full scale launch test: Success
  - Sample payloads: Egg, chip

Kiwi Vehicle

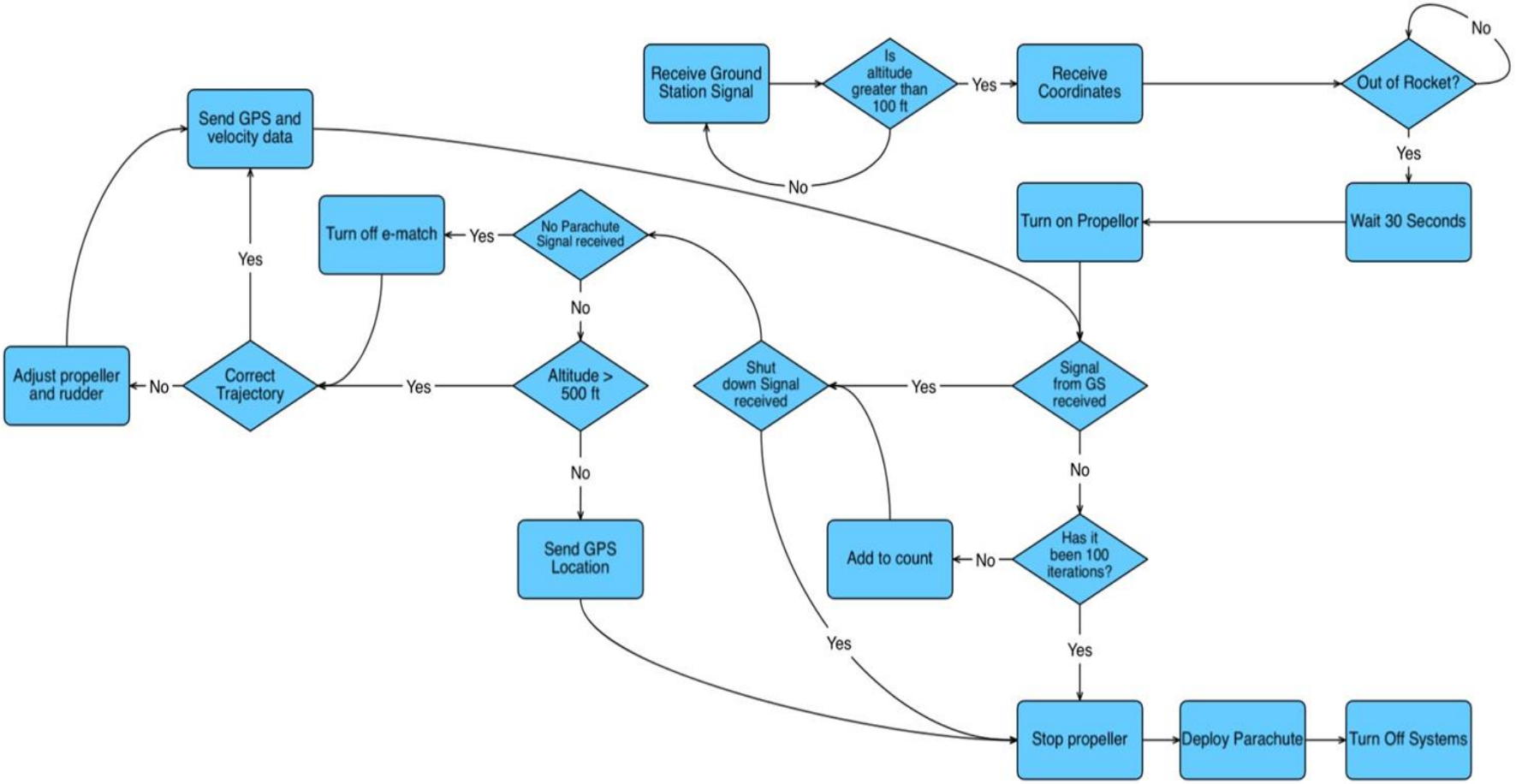
- Body is 3.5” in diameter, 7.1” tip to rudder mount
- Independent Altimeter System
- In constant communication with the ground station
- Equipped with a kill sequence that can be activated by the ground station



Kiwi Vehicle Electronics

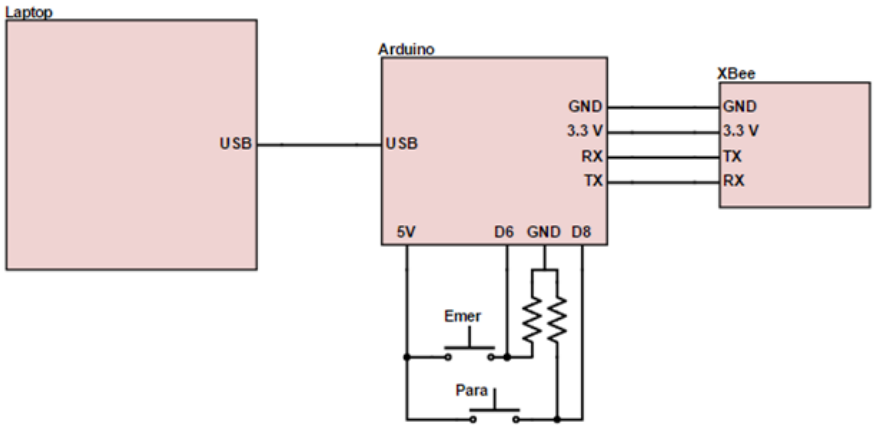


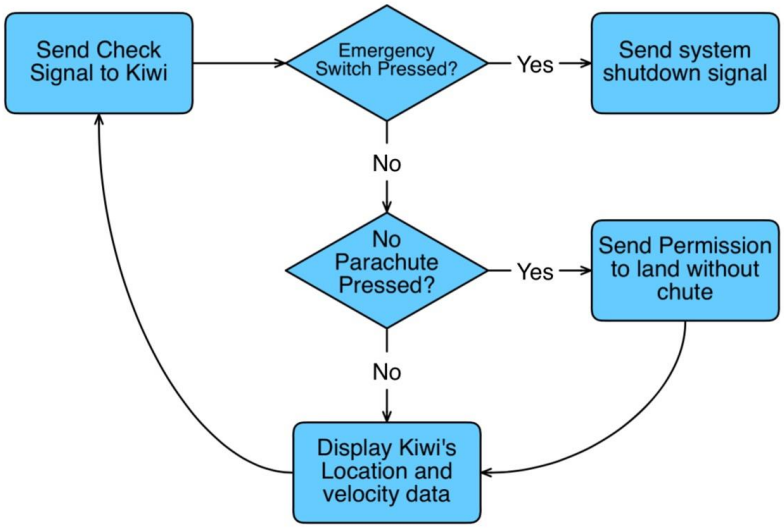
Kiwi Vehicle Software



Kiwi Ground Station Electronics and Software

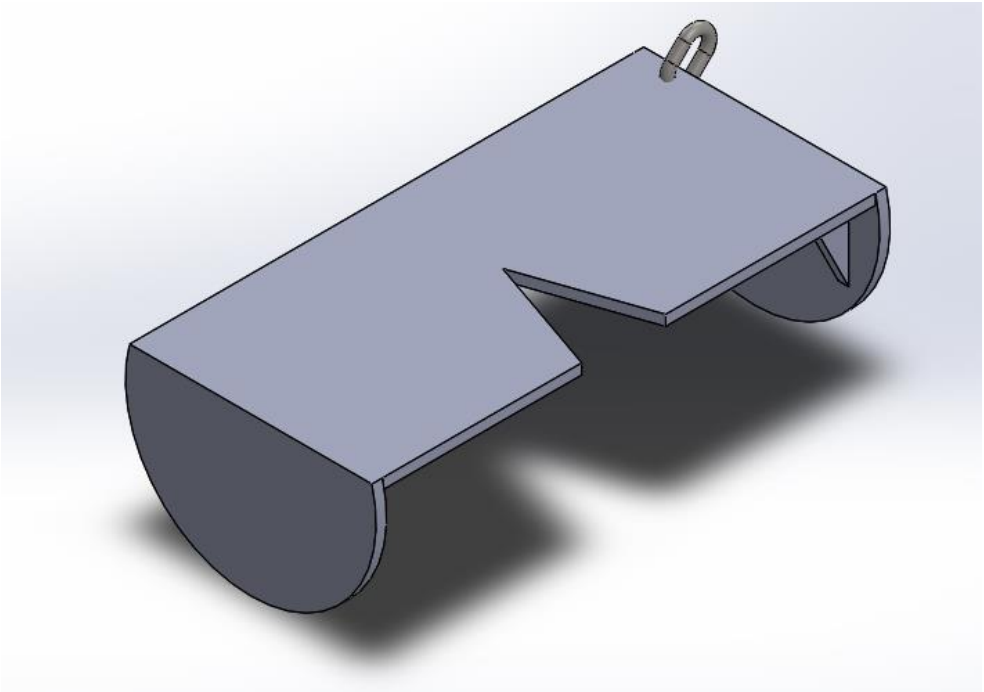
- Emergency Switch will be pressed to deploy chute and keep Kiwi in the rocket





Kiwi Retainment System

- Quicklink will attach to shock cord via tender descender
- Bottom flap of sabot will attach to the bottom bulkhead via shear pins
- If Kiwi must stay in the rocket, Kiwi blows tender descender, and shear pins hold sabot inside



Kiwi Testing

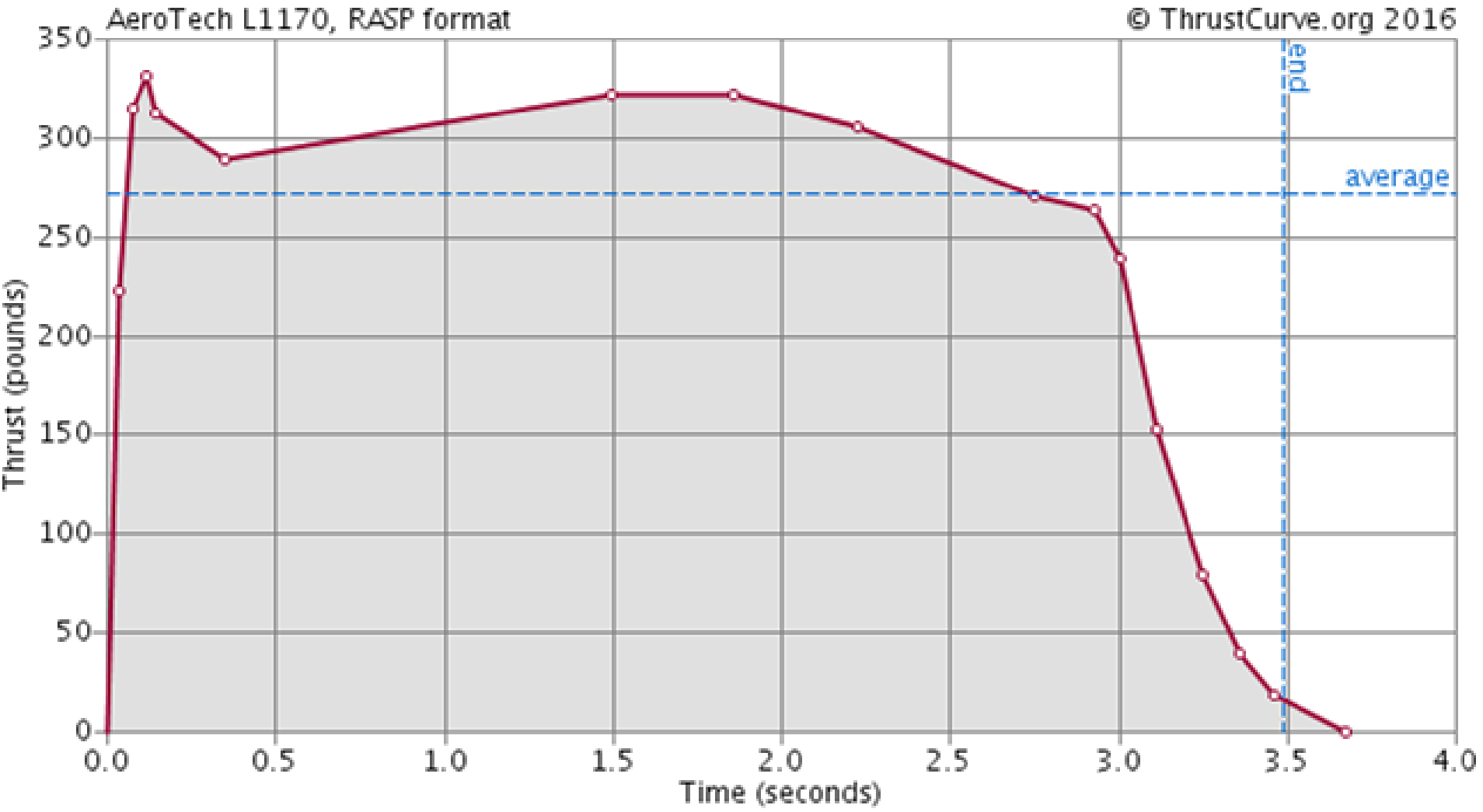
- XBee communication range: 1.2 miles
  - Two teams walked away from each other until connection was lost.
- GPS and IMU accuracy: to 3 ft
  - Compared the GPS and IMU readings at places on campus and in buildings to the actual GPS coordinates and Altitude
- Maneuvering Code: works
  - Drove Kiwi around in a car, and observed how it reacted
- Parachute Deployment Circuitry: works
  - Put Kiwi in the pressure chamber and simulated 500 ft
- Propellor Start-up Code: works

Propulsion – Preliminary Motor Selection

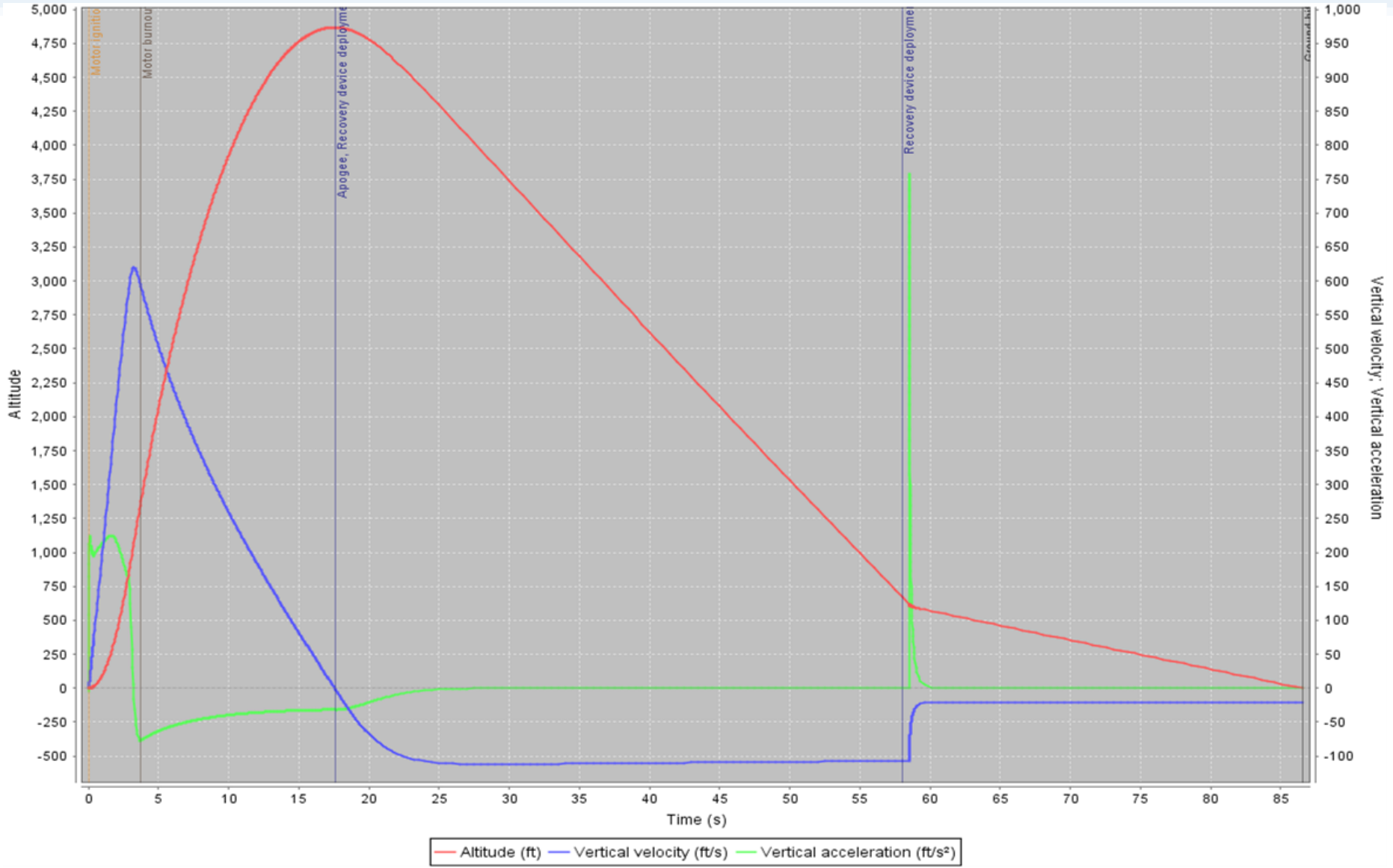
Designation	Apogee (ft.)	Velocity off rail (ft./s)	Impulse (lbf-s)	Weight (oz.)	Thrust/Weight Ratio
AeroTech L1170 (4 Gr.)	4876	70.5	951.39	176.02	6.39

The L1170 is the AeroTech motor that most closely matched the characteristics of the Cesaroni L1350. The L1350 was not available due to shortages of Cesaroni's 75 mm motors.

Propulsion – Primary Motor Thrust Curve



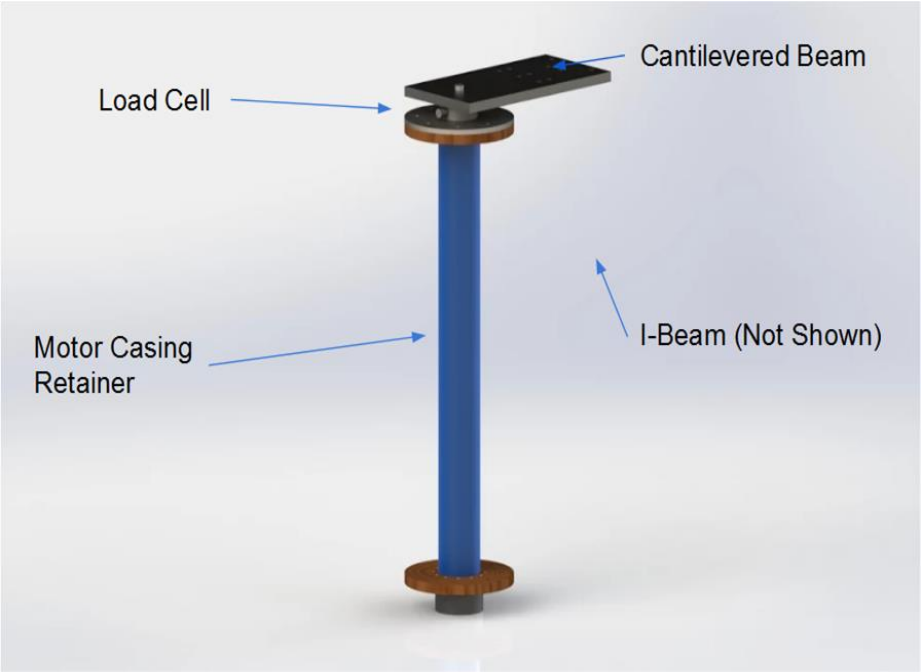
Propulsion – Full Scale Flight Simulation



Propulsion – Static Motor Testing

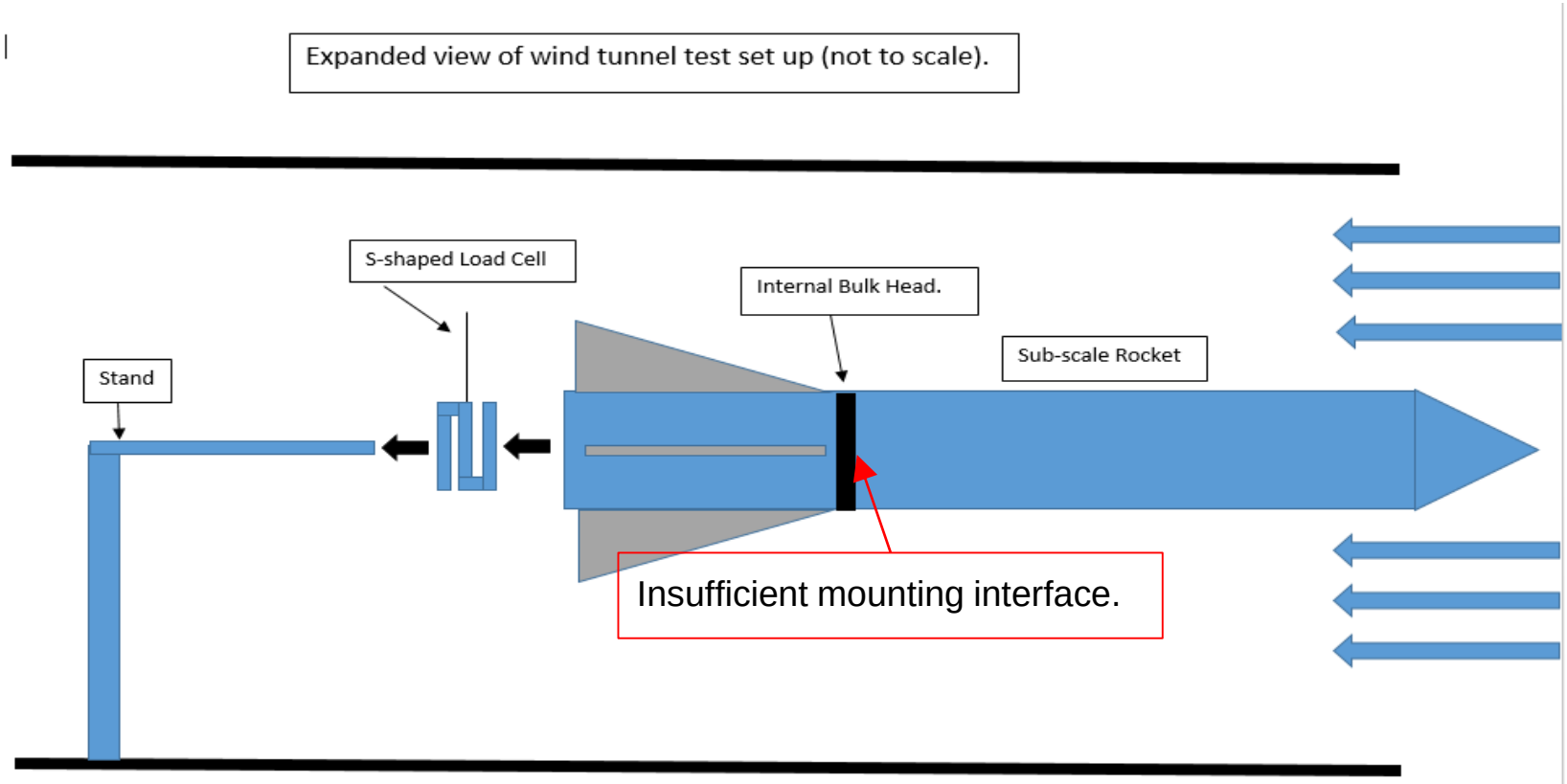
Static Motor Testing will be conducted before the USLI launch if proficient funding is available.

Static Motor Testing



Propulsion – Wind Tunnel Testing

Wind tunnel testing was conducted on a subscale model, however the data was invalid. It is believed that this was due to the mounting of the load cell to the bulkhead caused erroneous forces that corrupted the results. If the tunnel can be scheduled before the USLI launch, the testing will be repeated. Additionally, the mounting mechanism will be redesigned.



Mission Overview - Budget

Expected Costs 2016-2017	
Full Scale	$1,926.33
Subscale	$277.65
Propulsion	$1,283.92
Travel	$7,440.55
Outreach	$300.00
Tools and Fabrication Supplies	$870.62
Outsourced Services	$500.00
Total	**$12,599.07**

2016-2017 Funding	
Aerospace Engineering Department	$5,000.00
Mechanical and Nuclear 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?