Bearospace at UCLA

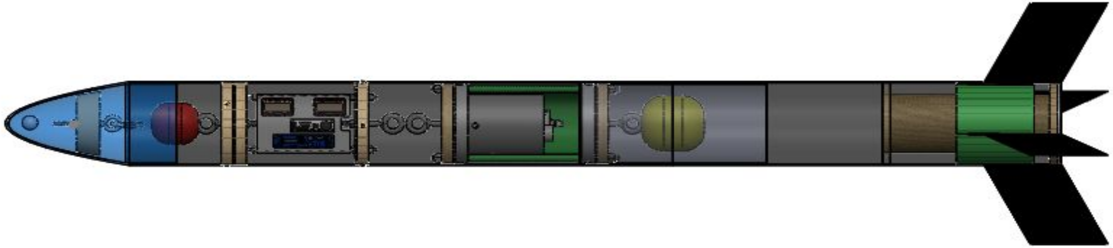
(LoL) Leveling on Land

2020-2021 USLI FRR

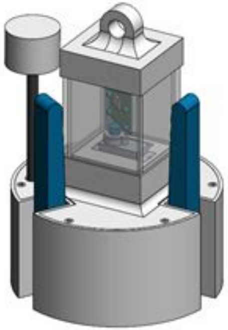
Bearospace @UCLA

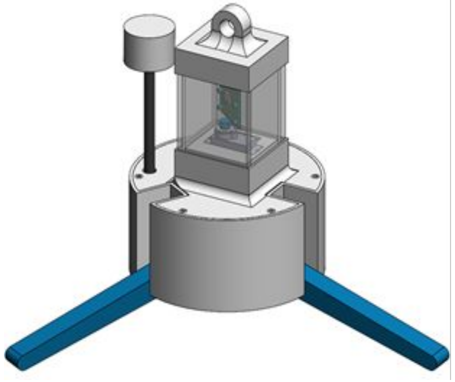
Vehicle Overview

Vehicle
Length: 71 in
Diameter: 6 in
Weight: 19.6 lb



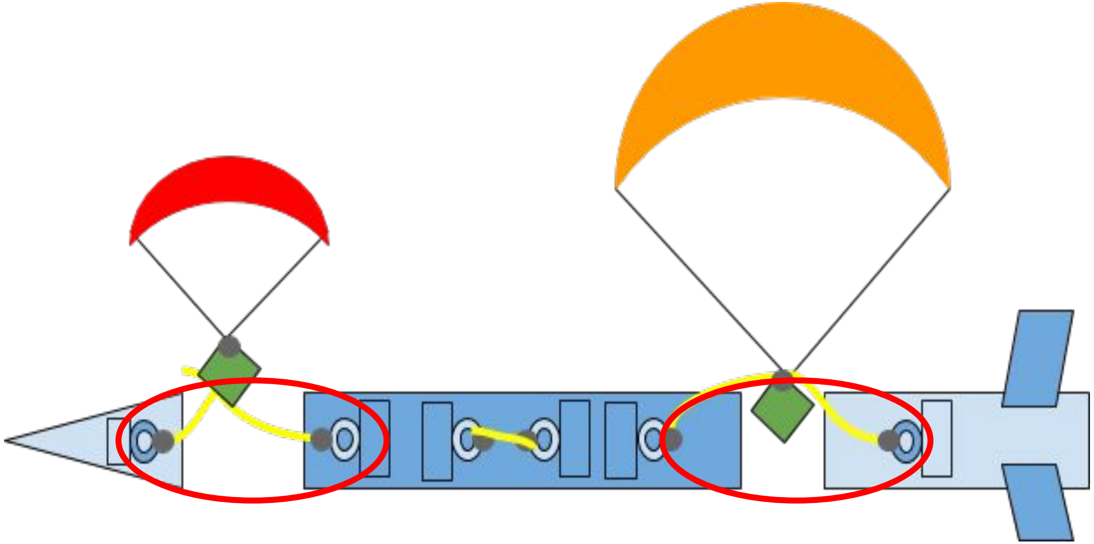
Payload
Height: 6.1 in
Diameter: 4.4 in
Weight: 0.905 lb

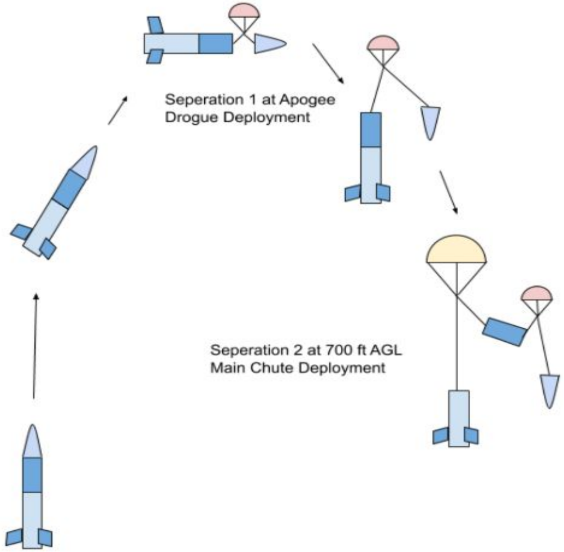




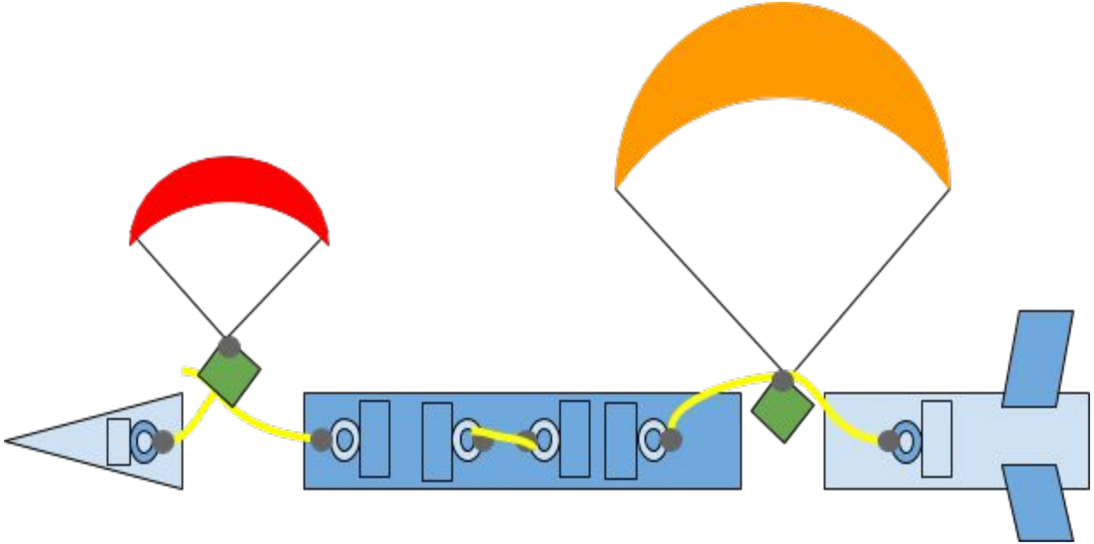
Launch Vehicle

Points of Separation and Energetic Materials





Interfaces

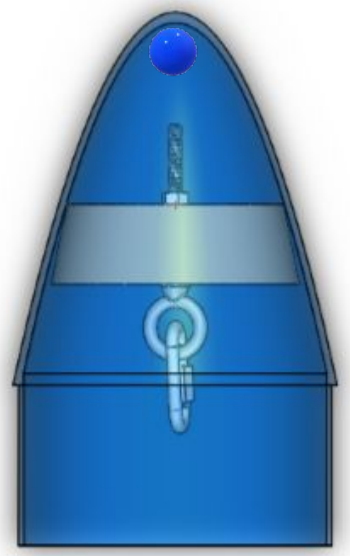


Key Design Features

<u>Nosecone</u>
Material: ABS Plastic
Length: 8 in
Thickness: 0.07 in
Total Weight: 2 lb

<u>Nosecone Shoulder</u>
Length: 3 in
Thickness: 0.07 in

Key components: Bulkhead, eyebolt, quicklink, ballast



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Key Design Features Pt. 2

<u>Upper Body Tube</u>

Material: Carbon Fiber

Length: 35 in

Thickness: 0.07 in

Total Weight: 9.53 lb

Key components: locking mechanism, avionics bay, payload and retention assembly, eyebolts, quicklinks

Key Design Features Pt. 3

<u>Lower Body Tube</u>

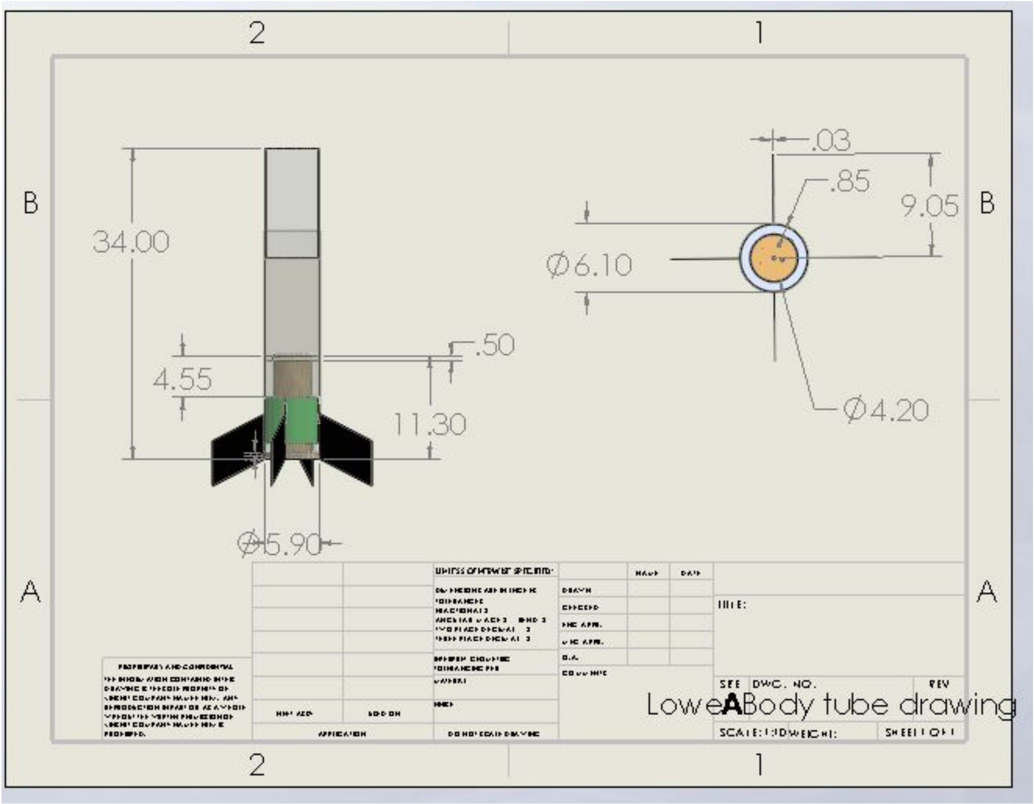
Material: Carbon Fiber

Length: 25 in

Thickness: 0.07 in

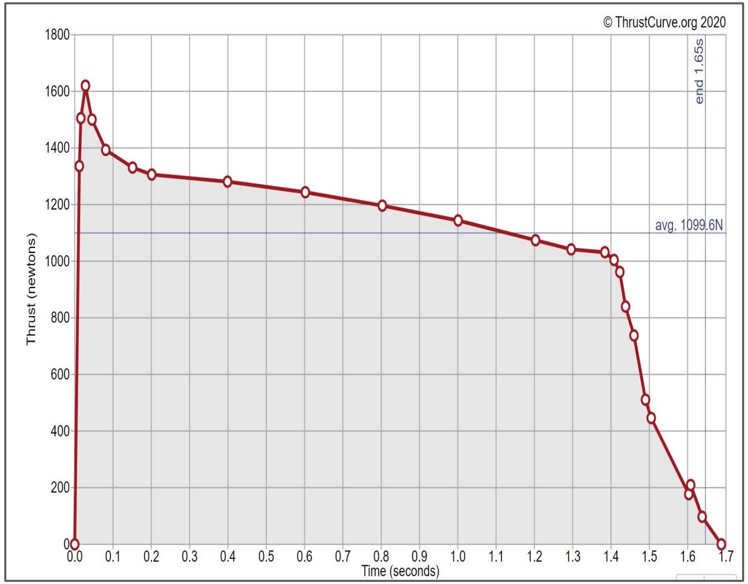
Total weight: 4.76 lb

Key components: centering rings, eyebolts, quicklinks, phenolic tube, trapezoidal fins, FSM, aluminum rings



Final Motor Selection: AeroTech K1103X-14

Motor Diameter	2.13in	**Motor Length**	15.8in
Average Thrust	1099 N	**Max Thrust**	1620 N
Burn Time	1.65s	**Total Motor Mass**	3.2 lbs.
Total Impulse	1810Ns	**Propellant Mass**	1.8 lbs.
Thrust to Weight	13.17	**Post-burn Mass**	1.4 lbs.



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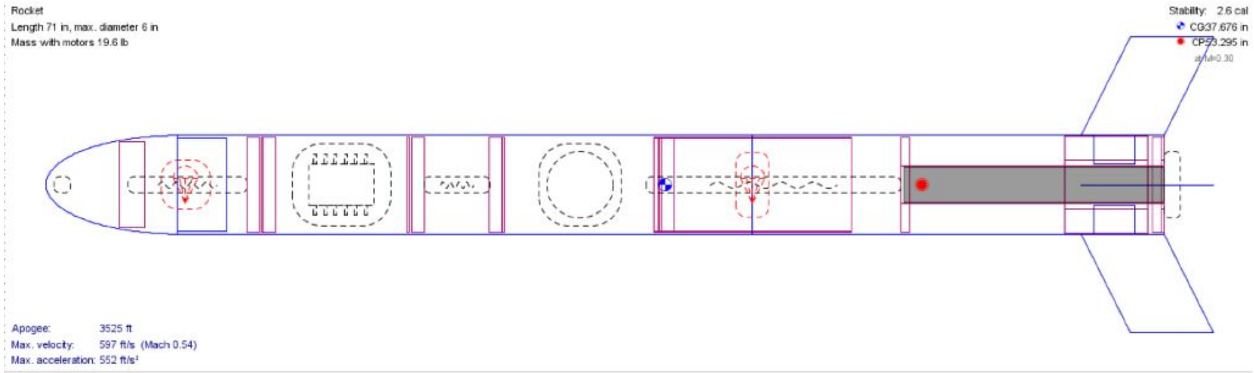
Rocket Flight Stability

CG: 37.684 in. from the tip of the nose cone

CP: 53.295 in. from the tip of the nose cone.

Together, with a 6 in. diameter body tube, the resulting static stability is anticipated to be 2.6.

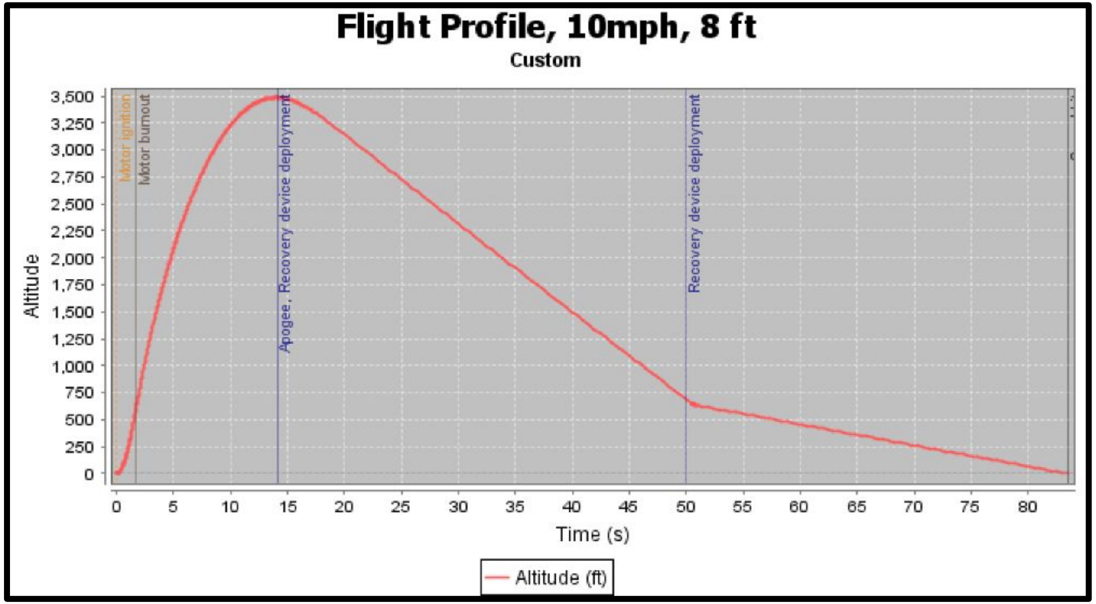


Liftoff Figures

Thrust to Weight Ratio: 12.6

Rail Exit Velocity: 89.4 ft/s

Rail Size: 8 ft



Parachutes

Drogue Descent Rate: 81 ft/s

Drogue Chute Size: 2 ft diameter

Drogue Deployment Time: Apogee

Main Descent Rate: 19.4 ft/s

Main Chute Size: 7 ft diameter

Main Deployment Time: 700 ft

Kinetic Energy

After Drogue Chute Deployment

Kinetic Energy for Nosecone: 231.5 ft-lbf

Kinetic Energy for Upper Body Tube: 971.9 ft-lbf

Kinetic Energy for Lower Body Tube: 462.9 ft-lbf

After Main Chute Deployment

Kinetic Energy at Landing for Nosecone: 13.278 ft-lbf

Kinetic Energy at Landing for Upper Body Tube: 55.75 ft-lbf

Kinetic Energy at Landing for Lower Body Tube: 26.53 ft-lbf

Predicted Altitude

Averaging the results from OpenRocket and RockSim:

5 mph winds: 3825.5 ft

10 mph winds: 3799.5 ft

15 mph winds: 3765.4 ft

20 mph winds: 3705.1 ft

Predicted Drift

5 mph winds: 505.2 ft

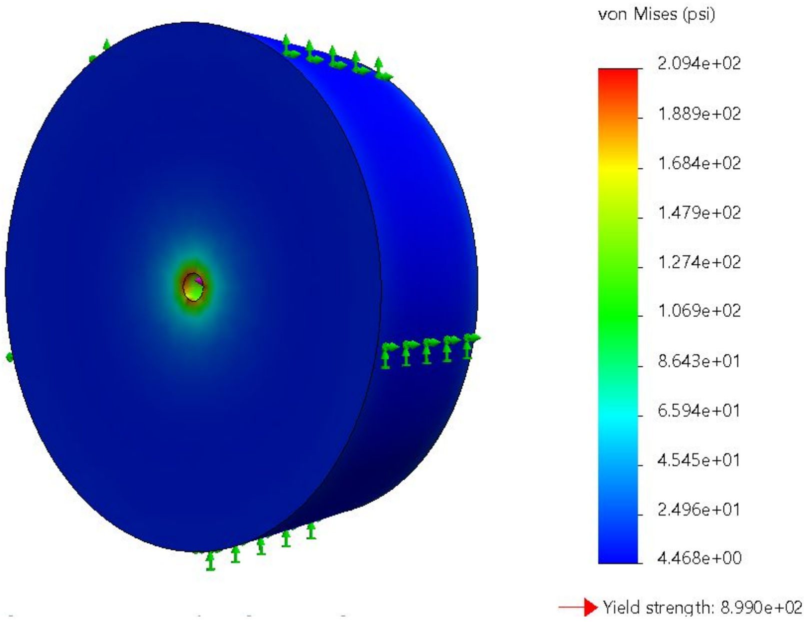
10 mph winds: 1007.6 ft

15 mph winds: 1504.8 ft

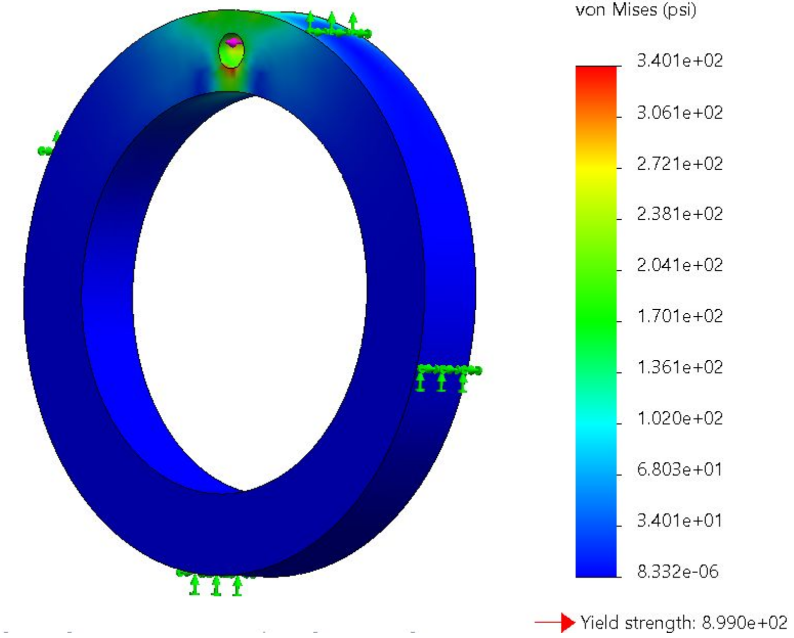
20 mph winds: 2009.3 ft

Test Plans and Procedures

Nosecone Bulkhead

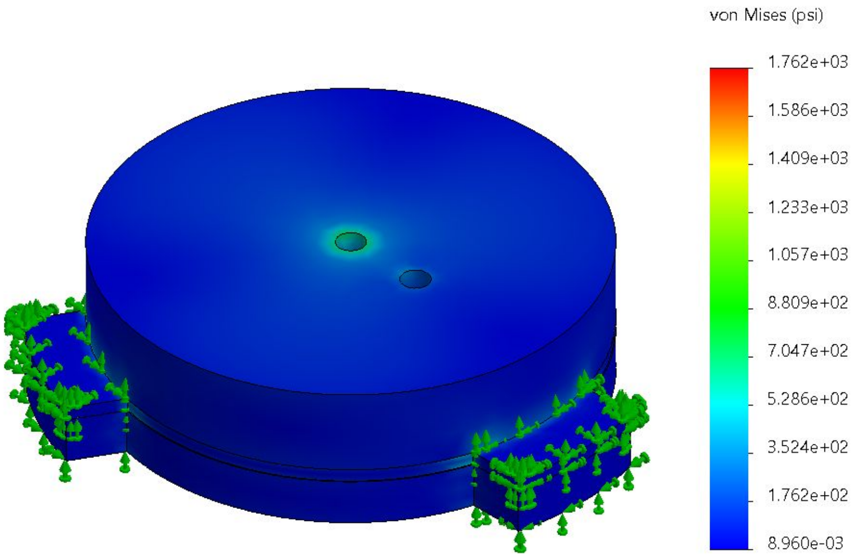


Centering Ring

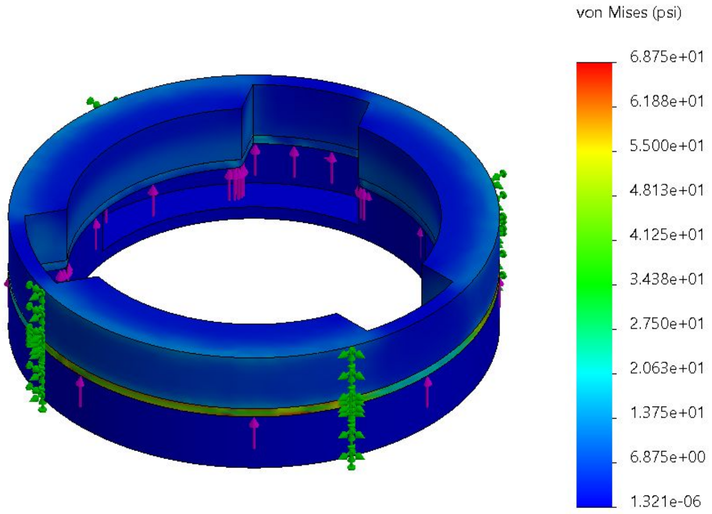


Test Plans and Procedures Pt. 2

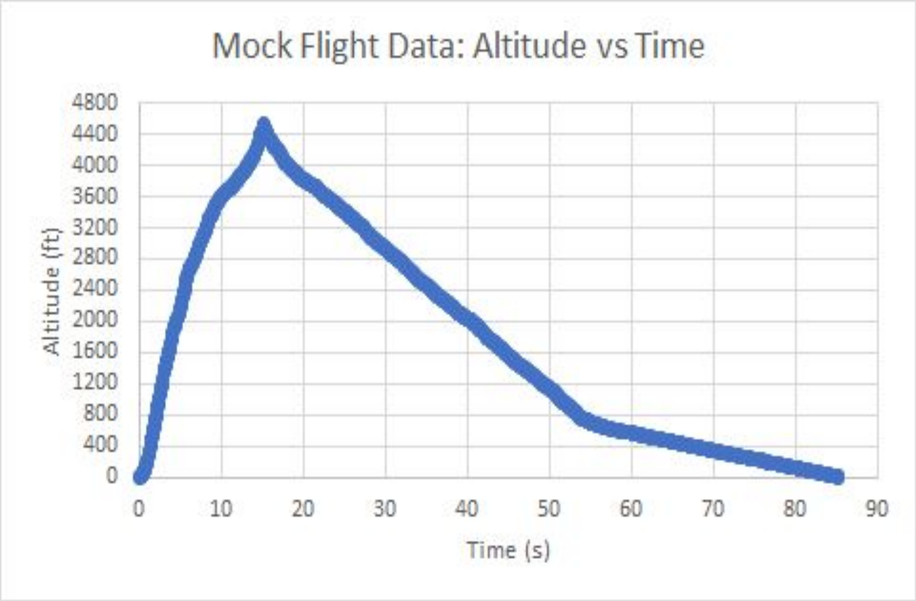
Inner Locking Mechanism

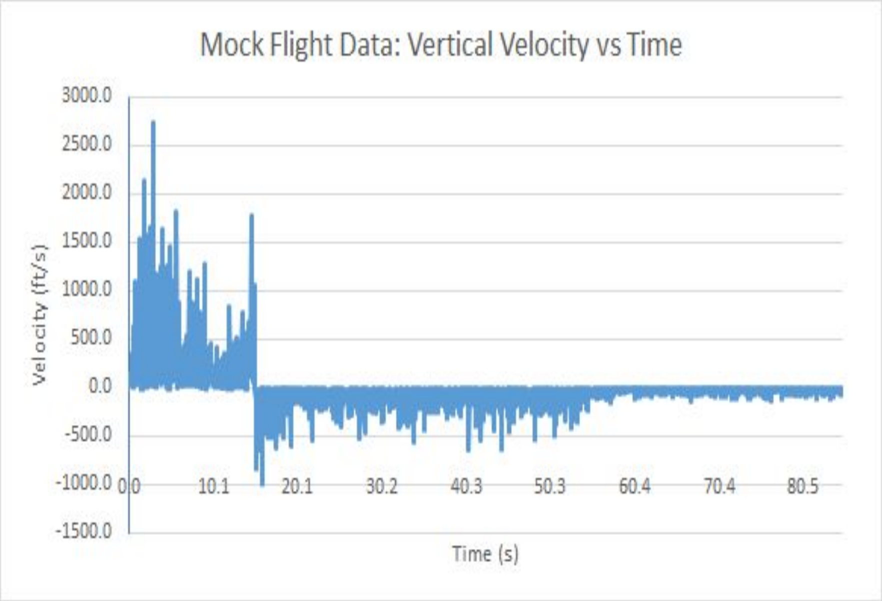


Outer Locking Mechanism

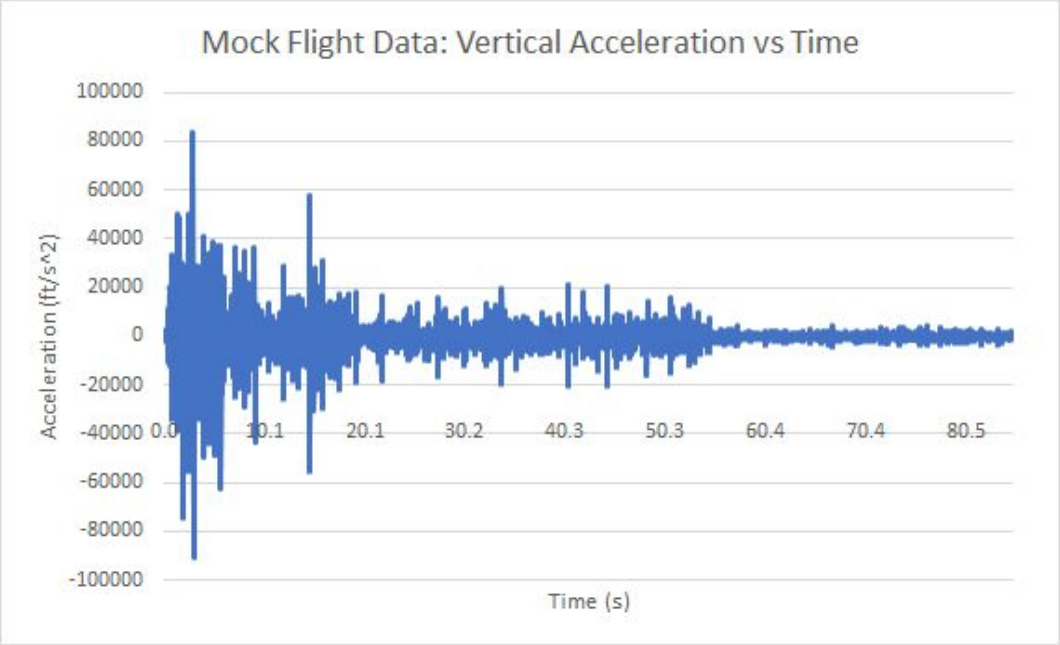


Mock-Demonstration Flight Results

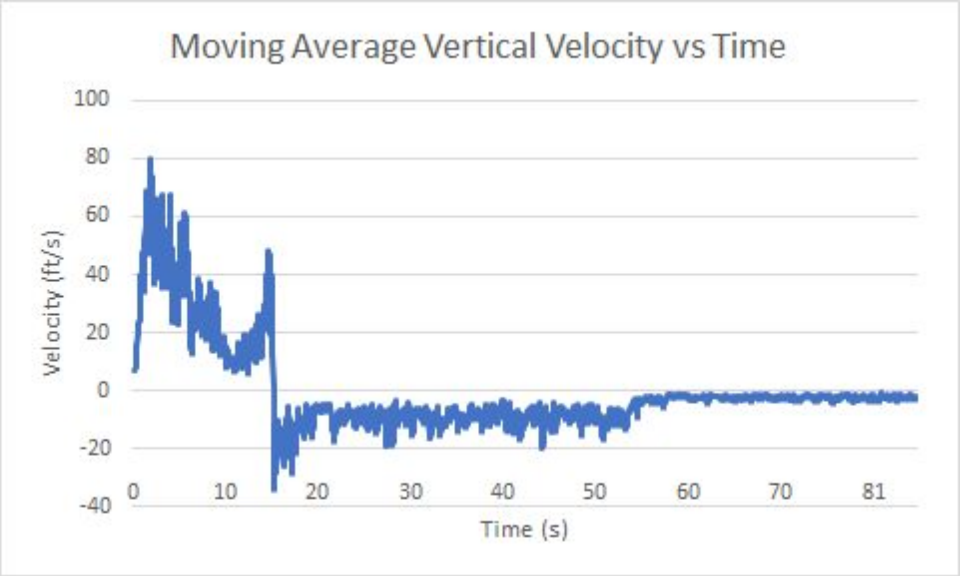


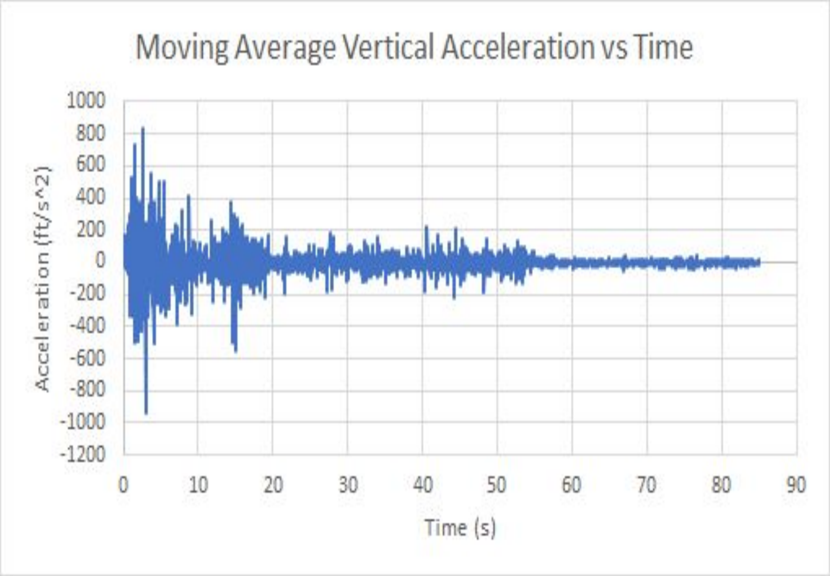


Mock-Demonstration Flight Results Pt. 2



Mock-Demonstration Flight Results Pt. 3





Mock-Demonstration Flight Results Pt. 4

Analysis of Mock Flight Data	
Maximum Altitude (ft)	4525.25
Maximum Velocity (ft/s)	79.9 (from moving average)
Maximum Acceleration (ft/s^2)	8 (from moving average)
Total Flight Time (s)	85.24
Time to Apogee (s)	15.1
Descent Time (s)	70.14
Descent Rate Under Drogue Parachute (ft/s)	96.2 (average)
Descent Rate Under Main Parachute (ft/s)	22.4 (average)

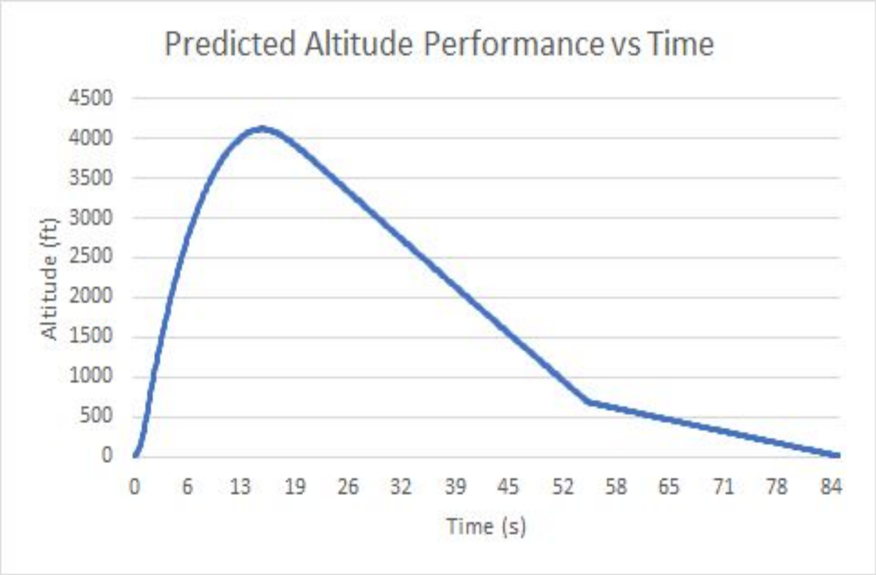
	Nose Cone	Upper Body Tube	Lower Body Tube
Landing Kinetic Energy	17.69 ft-lbf	74.3 ft-lbf	35.37 ft-lb

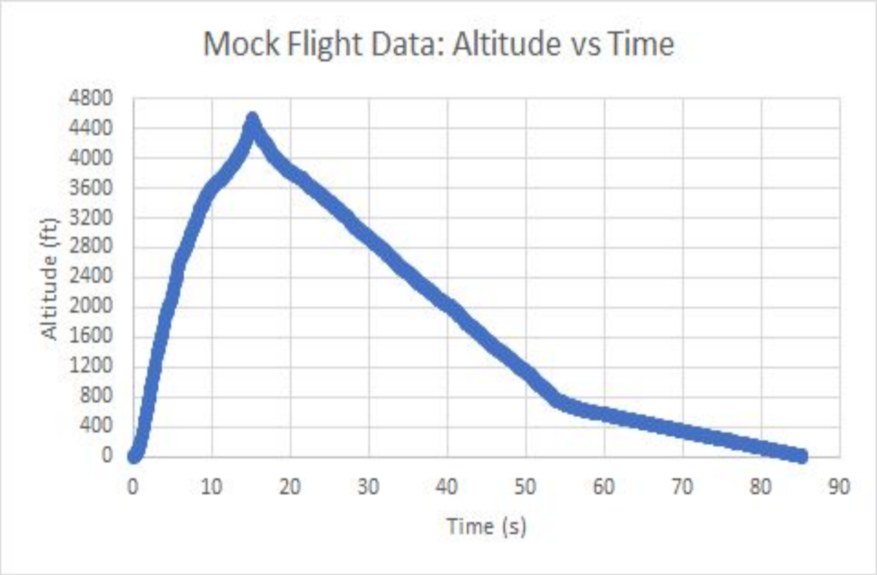
Kinetic Energy after Main Chute Deployment

Wind Speed	0 mph	5 mph	10 mph	15 mph	20 mph
Horizontal Drift	0 ft.	512 ft.	1031 ft.	1543 ft.	2055 ft.

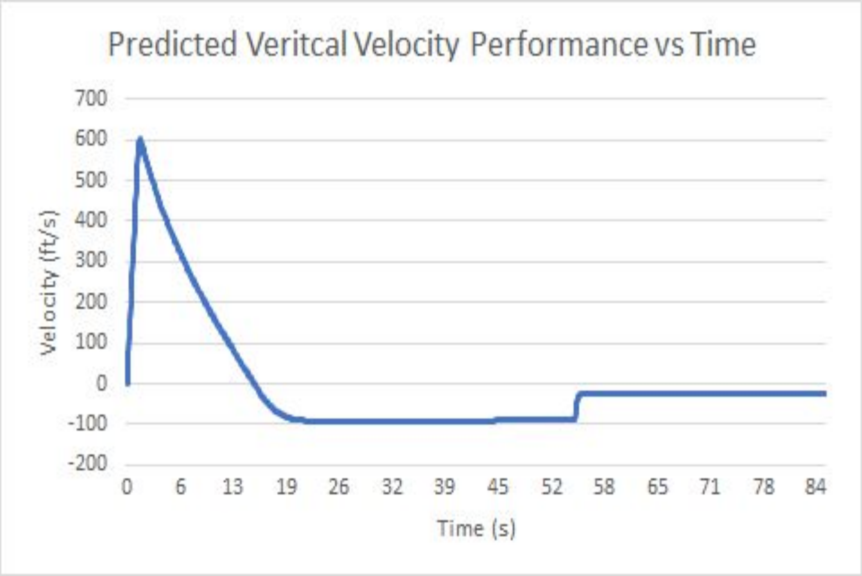
Drift Values

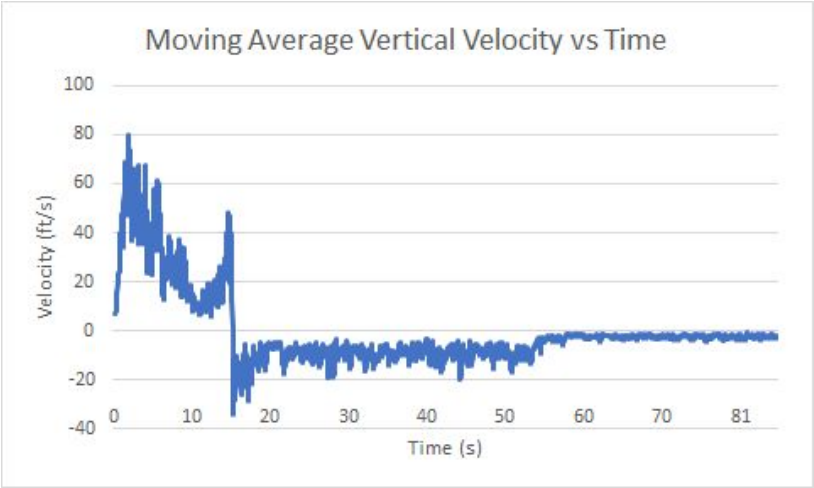
Mock-Flight Analysis

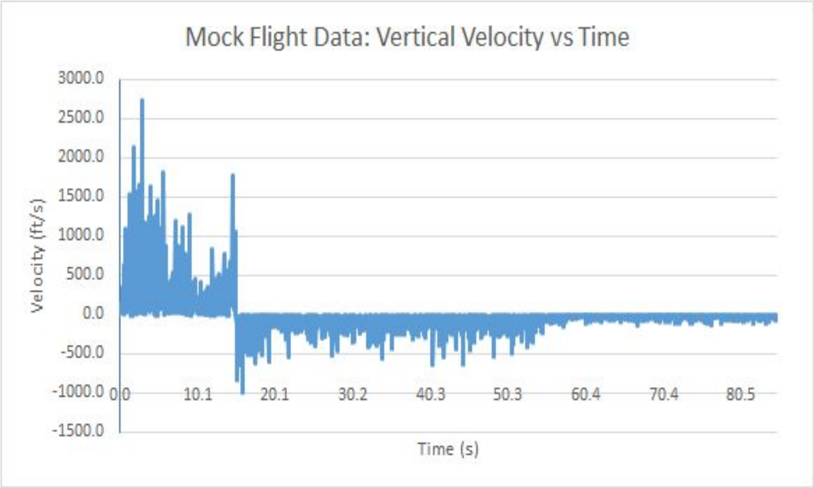




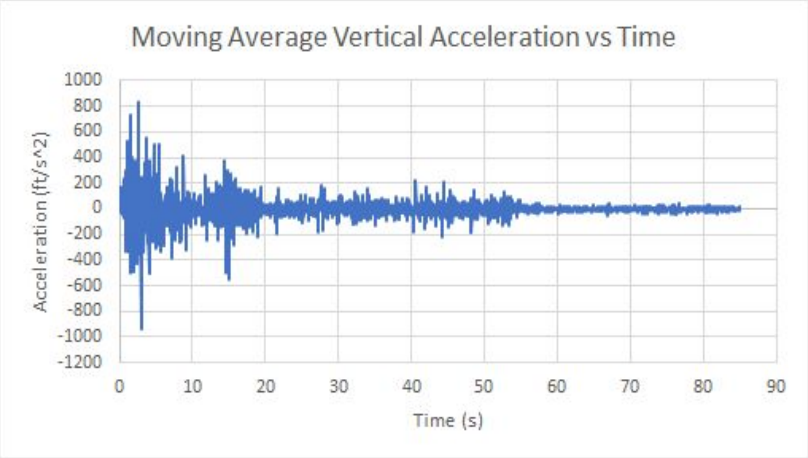
Mock-Flight Analysis Pt. 2

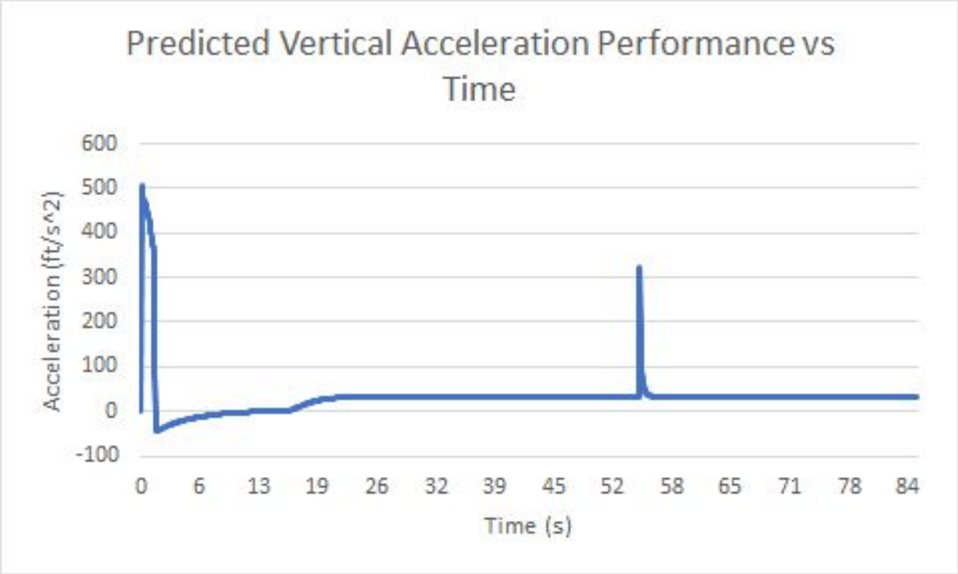


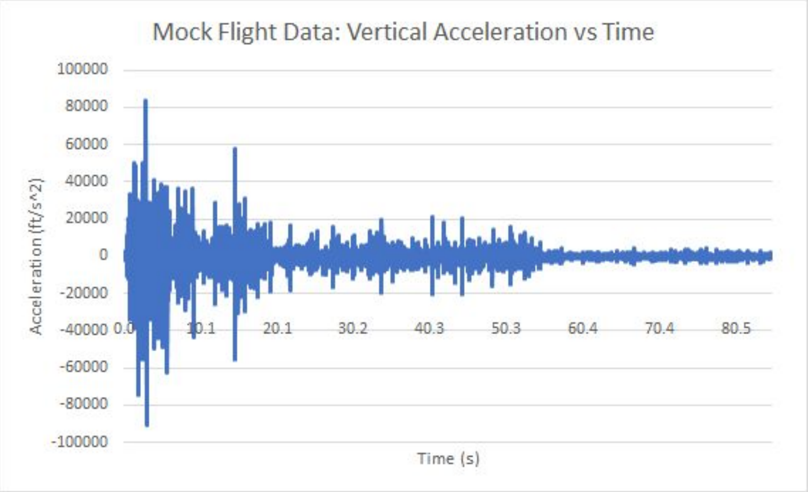




Mock-Flight Analysis Pt. 3







Requirements Verification: Launch Vehicle

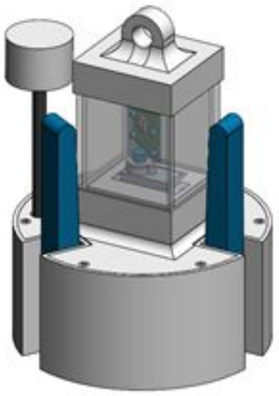
Requirement Summary	Method/Verification
2.1. The vehicle will deliver the payload to an apogee altitude between 3,500 and 5,500 feet above ground level (AGL). Teams flying below 3,000 feet or above 6,000 feet on Launch Day will receive zero altitude points towards their overall project score and will not be eligible for the Altitude Award.	OpenRocket will be utilized to design a launch vehicle that can comply with this requirement. Test launch will be utilized to confirm simulation expectations. Both these actions should prepare the vehicle to meet this requirement on launch day.
2.10-2.10.1. The launch vehicle will use a commercially available solid motor propulsion system using ammonium perchlorate composite propellant (APCP) which is approved and certified by the National Association of Rocketry (NAR), Tripoli Rocketry Association (TRA), and/or the Canadian Association of Rocketry (CAR). Final motor choices will be declared by the Critical Design Review (CDR) milestone.	Vehicle will be designed to utilize a motor within these specifications and motor will be declared at CDR. Valid motor choice will be confirmed with the NAR/TRA mentor. Motor has been declared at CDR.
2.14. The launch vehicle will have a minimum static stability margin of 2.0 at the point of rail exit. Rail exit is defined at the point where the forward rail button loses contact with the rail.	Vehicle has been designed to have a static stability margin above 2.0 at rail exit point. This has been confirmed using simulation software at many different conditions.s

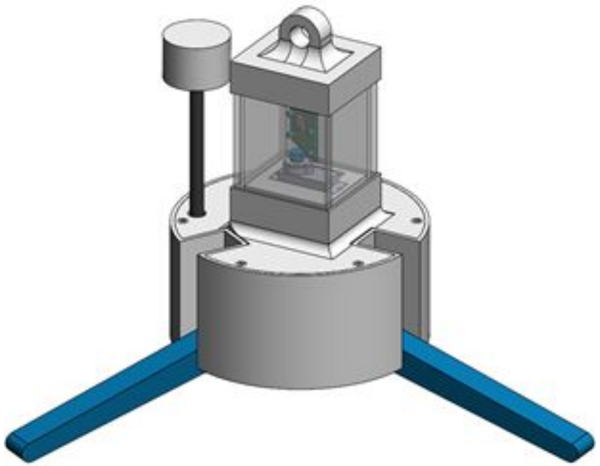
Requirements Verification: Recovery System

Requirement Summary	Method/Verification
3.1. The full-scale launch vehicle will stage the deployment of its recovery devices, where a drogue parachute is deployed at apogee, and a main parachute is deployed at a lower altitude. Tumble or streamer recovery from apogee to main parachute deployment is also permissible, provided that kinetic energy during drogue stage descent is reasonable, as deemed by the RSO.	Vehicle will be designed to utilize dual deployment, with drogue deployment occurring at apogee and main deployment occurring at 700 feet as determined by deployment speed and descension time. This will be demonstrated at launch and full-scale verification flight.
3.3. Each independent section of the launch vehicle will have a maximum kinetic energy of 75 ft-lbf at landing.	OpenRocket will be utilized to analyze weights of individual tethered sections as well as landing speed to ensure completion of this. Main parachute sizing can be altered to alter speed and kinetic energy at landing.
3.10.-3.11. The recovery area will be limited to a 2,500 ft. radius from the launch pads. Descent time will be limited to 90 seconds (apogee to touch down). The jettisoned payload (planetary lander) is not subject to this constraint.	Simulation software will be utilized with varying wind conditions to ensure recovery area complies with this restriction. Full scale demonstration will verify simulation. Simulation software will be utilized to ensure this. Main parachute deployment time can be altered to comply if needed.

Payload

Payload Design and Dimensions





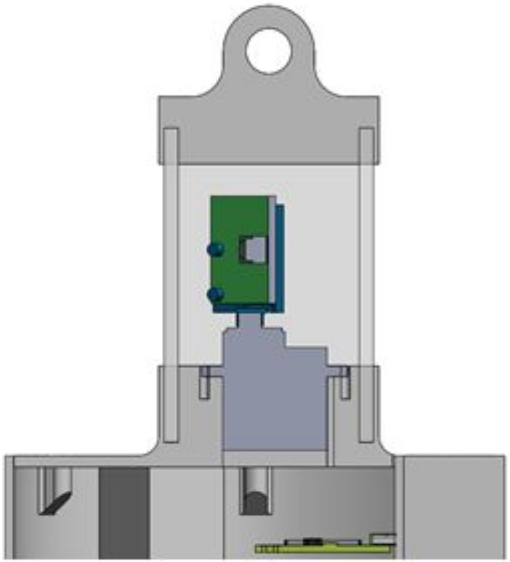
Simple 3-legged lander

4.4” diam x 6.1” tall

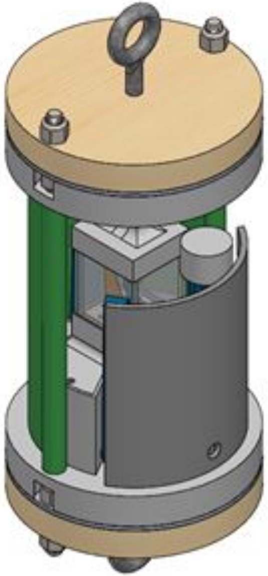
14.48 oz

Camera mounted on continuous servo motor for 360° view of landing site

Key Design Features

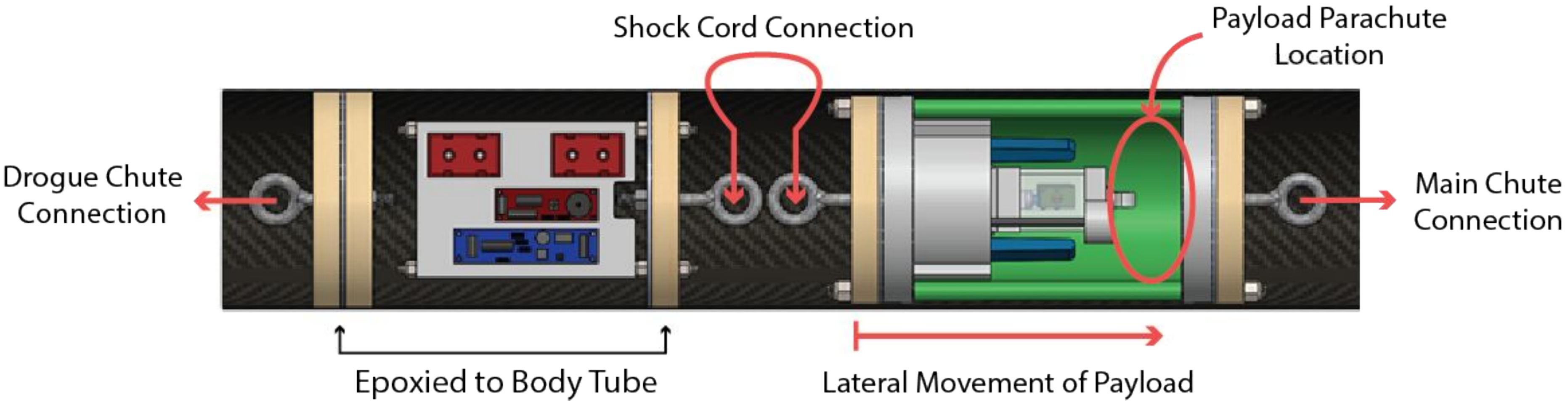


Payload Central Column

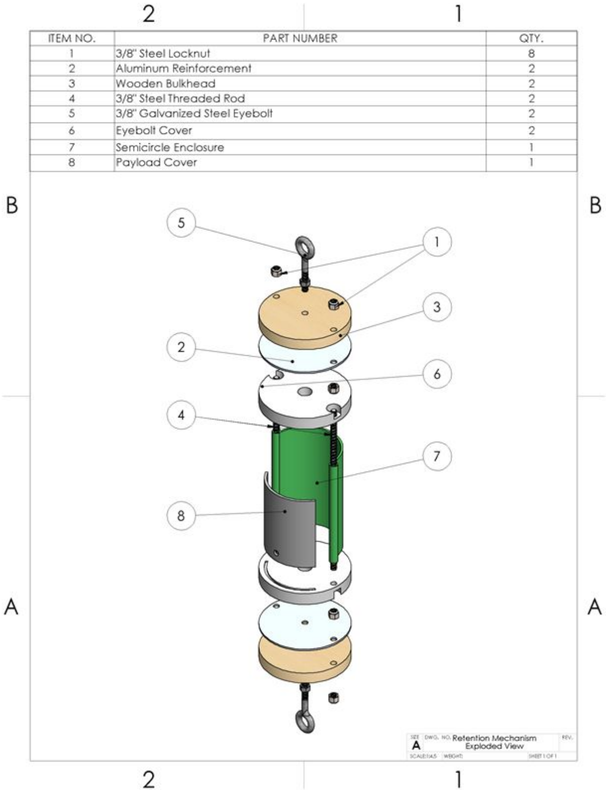


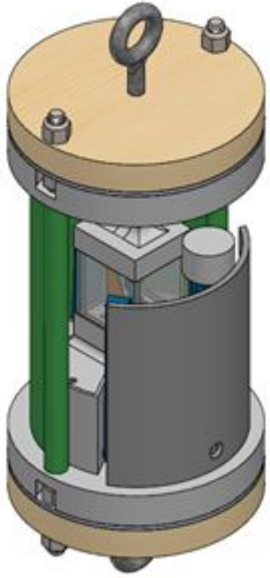
Payload Retention System

Payload Integration



Payload Retention System





Composed of pine bulkhead blocks and aluminum reinforcement, 3/8" threaded rods, locknuts, and eyebolts.

Deploys at 700 ft AGL during main chute deployment phase

Bottom & top grey components provide a flat surface for the payload

Green cover limits payload motion in one direction

Front grey cover prevents payload from scratching inner surface of body tube during deployment

Inner Volume:

5.7” diameter

10.74” tall

Requirements Verification

Requirement Summary	Method/Verification
4.3.1. The landing system will be completely jettisoned from the rocket at an altitude between 500 and 1,000 ft. AGL. The landing system...must land within the external borders of the launch field. The landing system will not be tethered to the launch vehicle upon landing.	Deployment at 700 ft AGL during main chute phase 20 mph wind drift worst case is 1561 ft
4.3.2. - 4.3.4 Autonomous upright landing, self-levelling, recording angles, panoramic pictures, and transmitter limitations	Use of actuated legs, gyroscope/accelerometer, camera mounted on 360 servo, and 200mW transmitter
4.4.1. Black Powder and/or similar energetics are only permitted for deployment of in-flight recovery systems. Energetics will not be permitted for any surface operations.	Payload deployment is a ***result*** of energetics used for parachute deployment of the main chute. Payload does not directly interact with energetics

Interfaces With Ground Systems

Launch vehicle and payload provide feedback to team's ground systems.

Launch Vehicle:

- Tiny Telematics Tracker (T3) GPS provides positional feedback to the team for recovery of launch vehicle
- Operates at 900MHz at a selected fixed frequency

Payload:

- Furious FPV Transmitter provides image data for local ground stitching for a cohesive panoramic picture
- Operates at 2.4 GHz at a selected fixed frequency

Questions?