Bearospace at UCLA

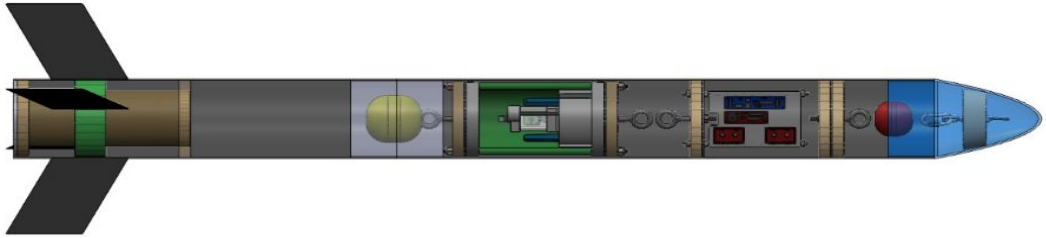
(LoL) Leveling on Land

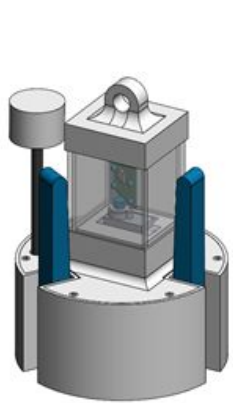
2020-2021 USLI CDR

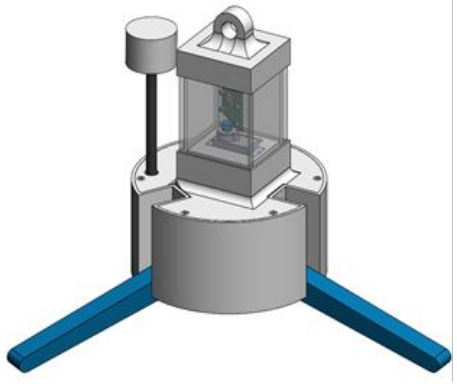
Vehicle Overview

Vehicle
Length: 68 in
Diameter: 6 in
Weight: 19.5 lb

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







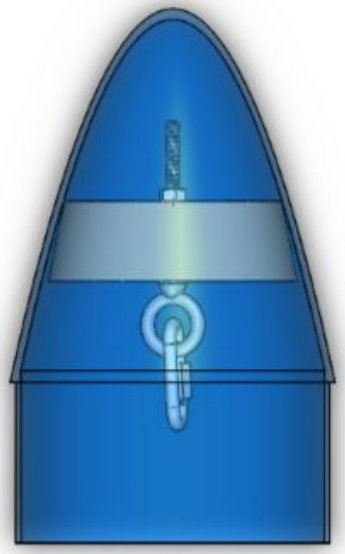
Launch Vehicle

Key Design Features

Nosecone
Material: ABS Plastic
Length: 7 in
Thickness: 0.07 in
Total Weight: 2 lb

Nosecone Shoulder
Length: 3 in
Thickness: 0.07 in

Key components: Bulkhead, eyebolt, quicklink



Key Design Features Pt. 2

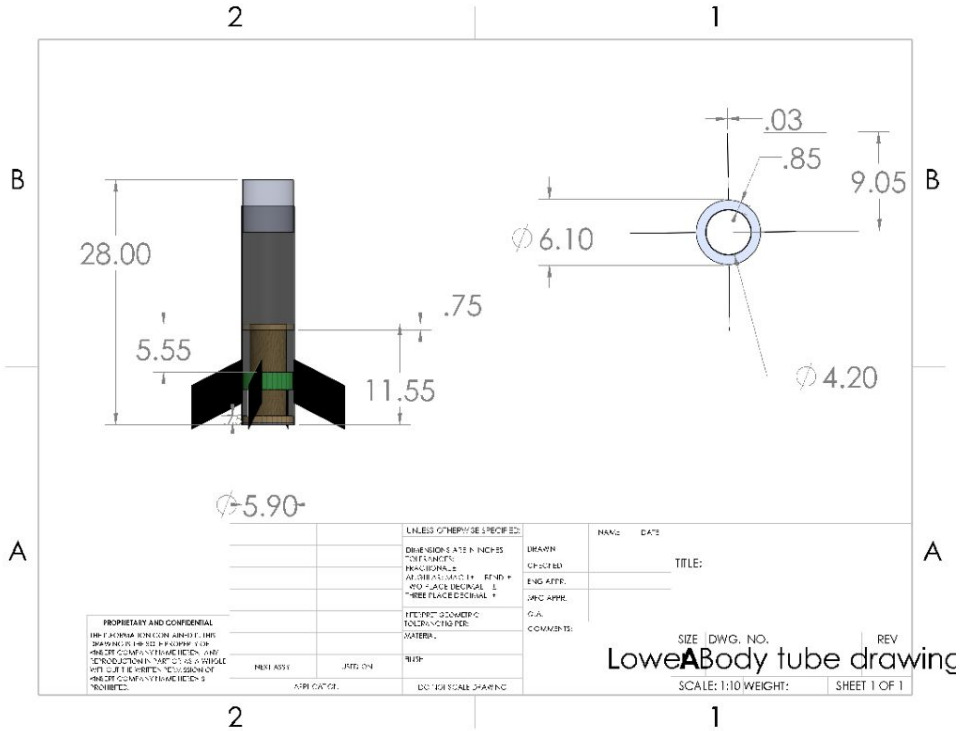
Upper Body Tube
Material: Carbon Fiber
Length: 35 in
Thickness: 0.07 in
Total Weight: 9.53 lb

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

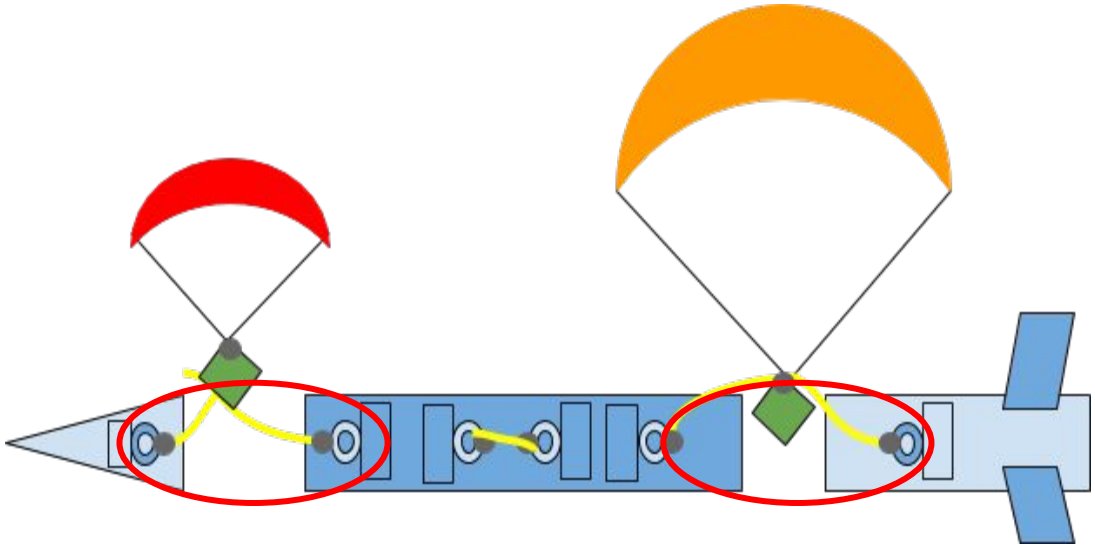
Key Design Features Pt. 3

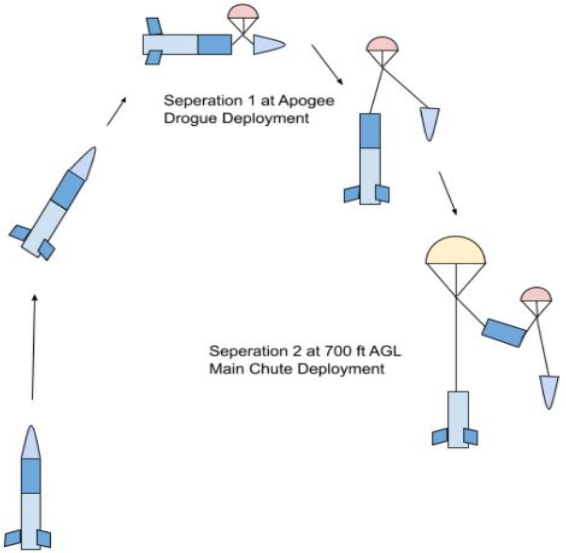
<u>Lower Body Tube</u>
Material: Carbon Fiber
Length: 25 in
Thickness: 0.07 in
Total weight: 4.76 lb

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

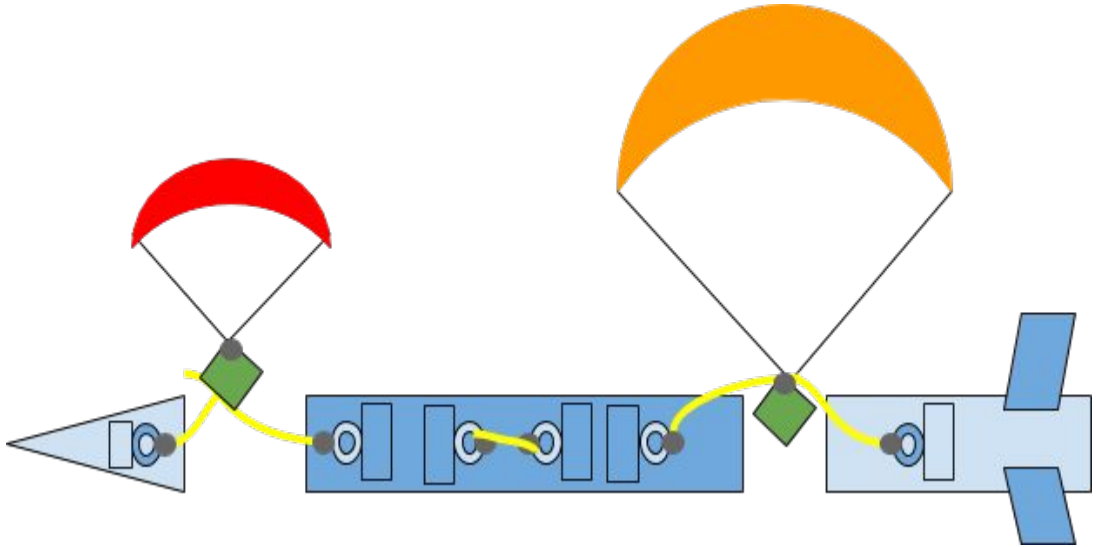


Points of Separation and Energetic Materials



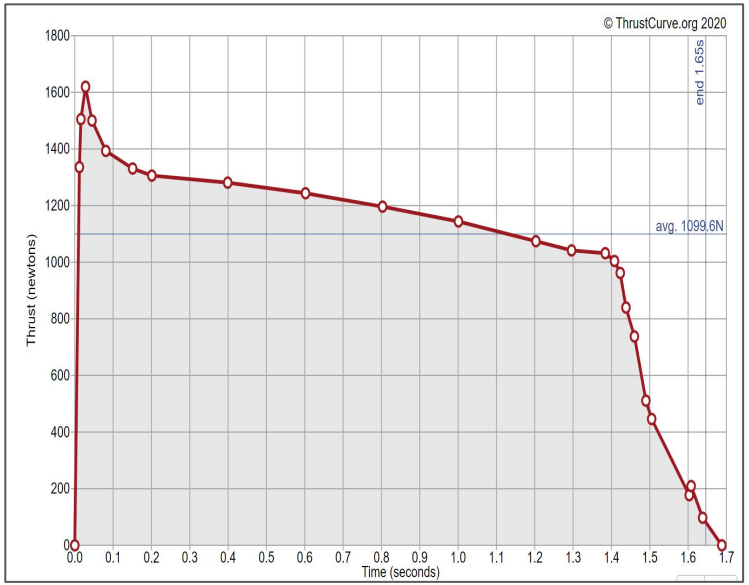


Interfaces

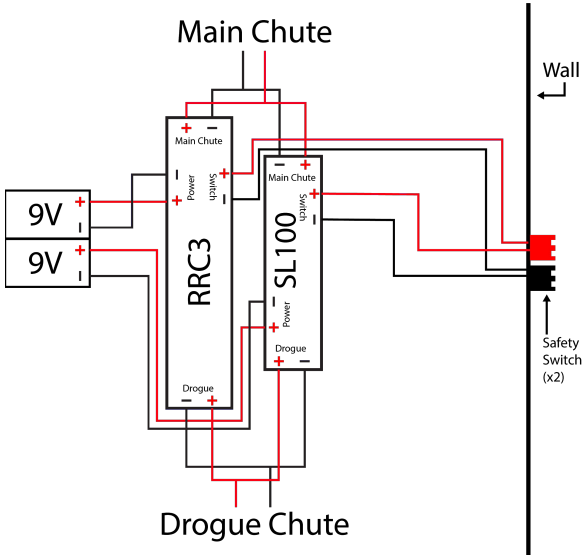


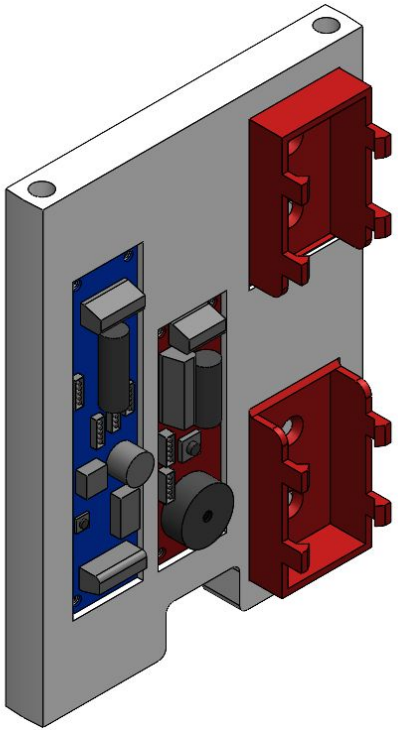
Final Motor Selection: AeroTech K1103X-14

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.



Electronics





Altimeters

- Stratologger SL100 Altimeter
- RRC3 Sports Altimeter

Power

- 2X 9V Battery

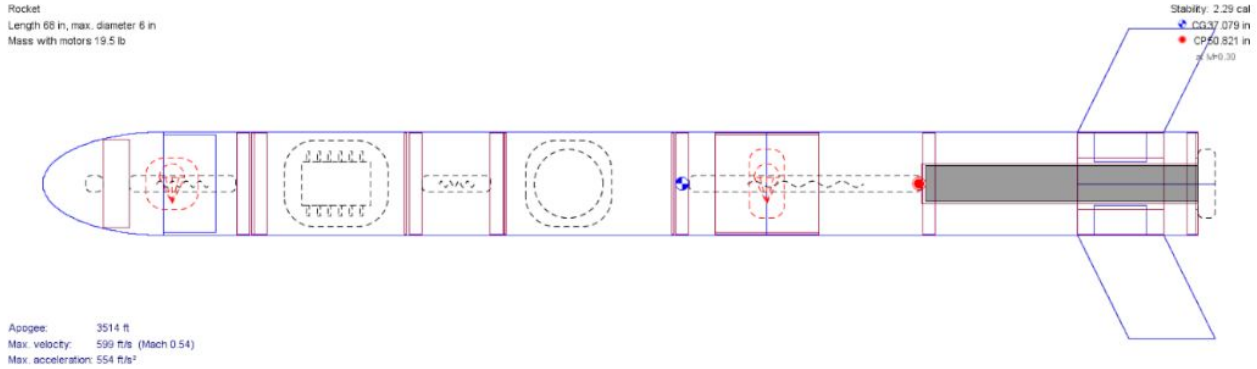
Flight Predictions

Rocket Flight Stability

CG: 37.08 in. from the tip of the nose cone

CP: 50.82 in. from the tip of the nose cone.

Together, with a 6 in. diameter body tube, the resulting static stability is anticipated to be 2.29.

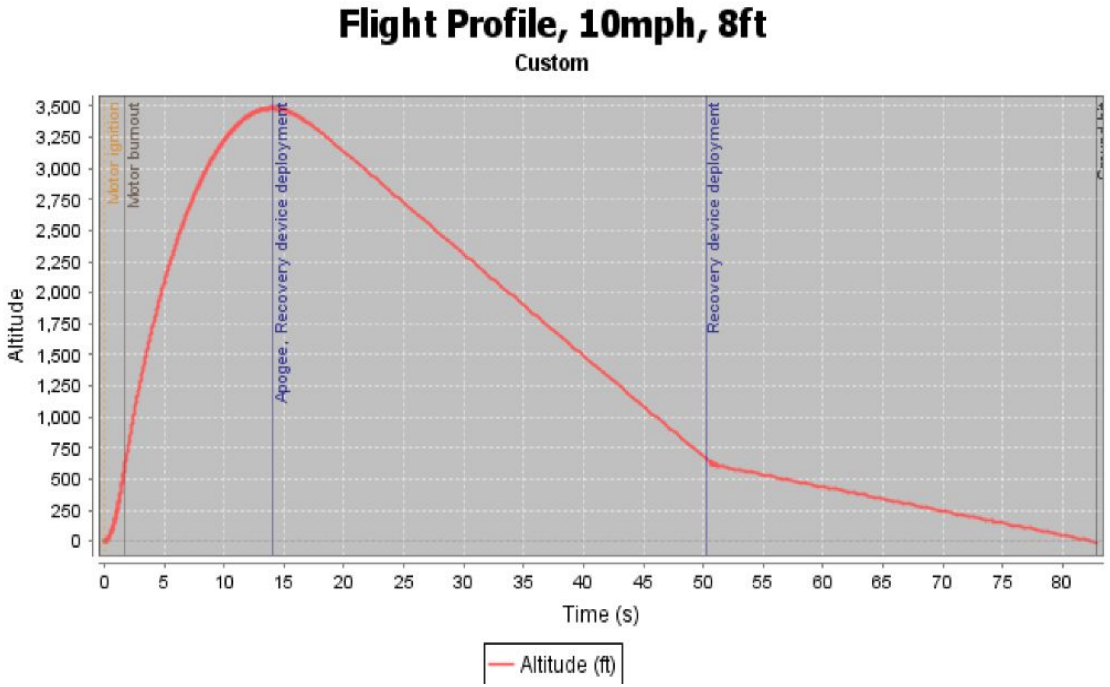


Liftoff Figures

Thrust to Weight Ratio: 12.7

Rail Exit Velocity: 89.7 ft/s

Rail Size: 8 ft



Parachutes

Drogue Chute Size: 2 ft diameter

Drogue Deployment Time: Apogee

Main Chute Size: 7 ft diameter

Main Deployment Time: 700 ft

Recovery Hardware

Drogue Chute

Recovery Harness: Kevlar

Size: ½”

Length: 23 ft

Main Chute

Recovery Harness: Kevlar

Size: ½”

Length: 20 ft

Descent

Descent Rate with Drogue Chute: 82 ft/s

Descent Rate with Main Chute: 19.4 ft/s

Kinetic Energy at Landing for Nosecone: 11.69 ft-lbf

Kinetic Energy at Landing for Upper Body Tube: 55.69 ft-lbf

Kinetic Energy at Landing for Lower Body Tube: 27.8 ft-lbf

Predicted Drift

5 mph winds: 520.6 ft

10 mph winds: 1041.3 ft

15 mph winds: 1561.9 ft

20 mph winds: 2032.8 ft

Vehicle Testing

Fin Flutter

Step-by-Step Execution:

- Using equation found on apogee rockets, calculate the maximum fin flutter velocity
- Using OpenRocket, find altitude and value of greatest velocity of rocket
- Computer fin flutter velocity at given altitude and compare to max rocket velocity
- If fin flutter is greater, fin design will not fail

$$V_f = 1.223\, C_{s0} \exp\left(0.4\frac{h}{H}\right) \sqrt{\frac{G}{P_0}} \sqrt{\frac{(2+B)}{(1+\lambda)}} \left(\frac{T}{B}\right)^{3/2}$$

symbol	SI	imperial	other
H	8077 m	26500 ft	—
P_0	101352 Pa	14.7 psi	—
C_{s0}	335 m/s	1100 ft/s	750 mph

fin parameters

c_r = root chord, L
c_t = tip chord, L
b = fin height, L
t = fin thickness, L
G = fin material shear modulus, R

atmospheric parameters

$P(h)$ = pressure (function of altitude), R
$C_s(h)$ = sound speed (function of altitude), V

derived parameters

$S = \frac{h}{2}(c_r + c_t)$ fin area, L^2
$\lambda = \frac{c_t}{c_r}$ fin taper ratio
$B = \frac{b^2}{S}$ aspect ratio
$T = \frac{t}{c_r}$ normalized thickness

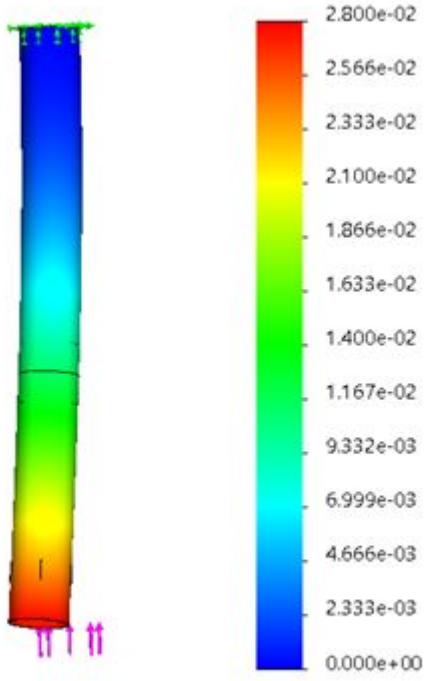
Airframe Bending

Objective:
Determine if the body tube may be subject to buckling under peak loading of the motor.

Step-by-Step Execution:

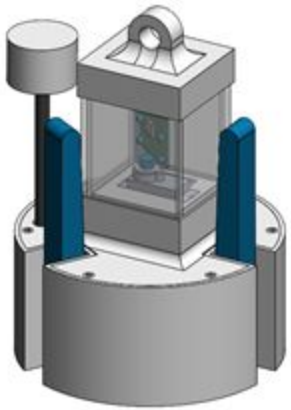
1. Fix upper face of upper body tube facing the nose cone
2. Place total force over the bottom face of the lower body tube
3. Mesh components
4. Examine results

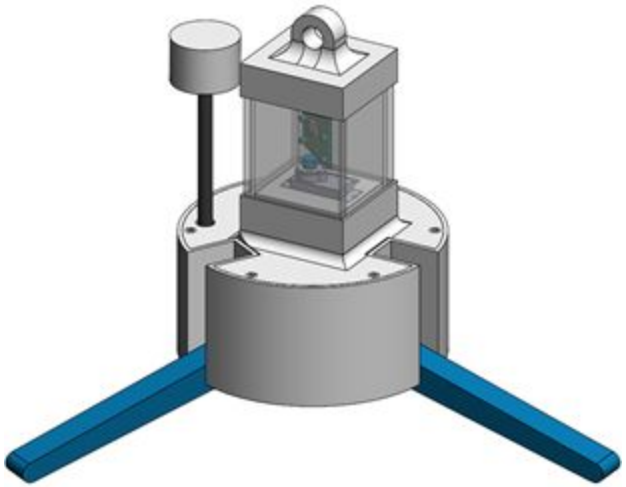
Justification:
Since selected motor has a very high initial force, the body tube may be subject to buckling which can highly jeopardize the structure of the vehicle. By examining behavior we can make necessary changes to vehicle design as necessary.



Payload

Design Overview





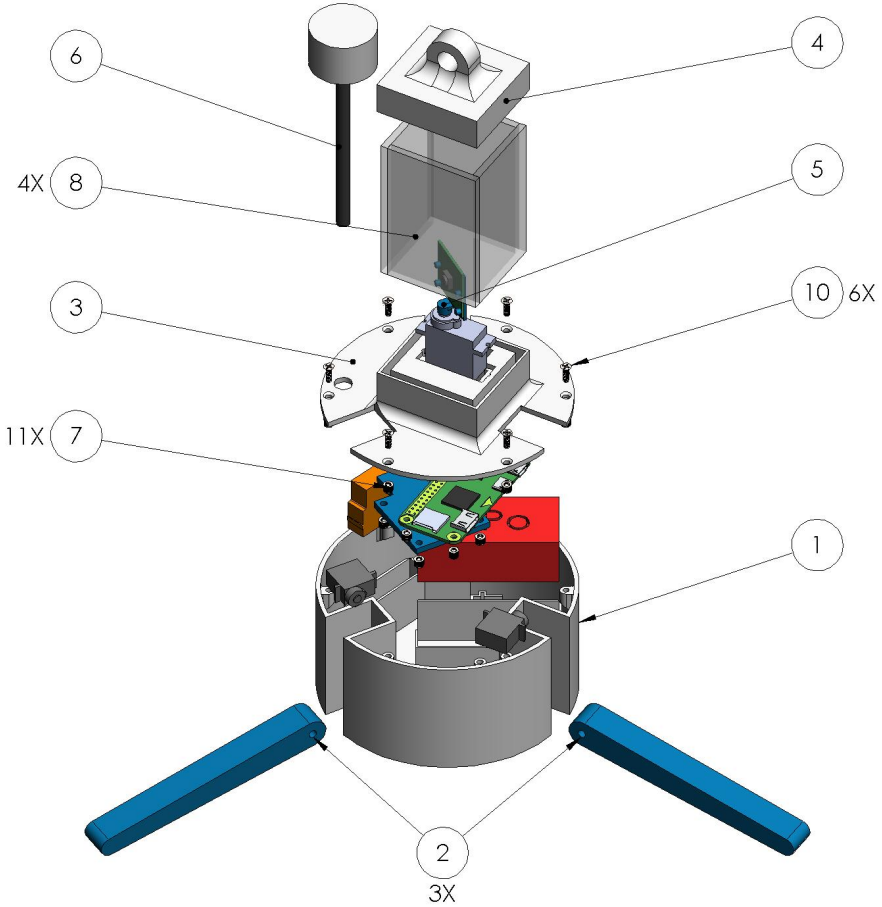
Simple 3-legged lander

4.4” diam x 6.1” tall

14.48 oz

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

Exploded View of Payload



Epoxy is used to attach top cap and main cover with acrylic sheets

Legs are attached to servo motors using screw

M2.5 threaded heat set inserts and M2.5 screws are used to fasten electronics and the main cover

Payload Parachute Selection & Analysis

Apogee Components 18” nylon parachute with a hexagonal parachute shape

For 20 MPH Wind Speeds

-Drift of rocket at 700 ft AGL = 704 ft

-Descent rate = 23.95 ft/s

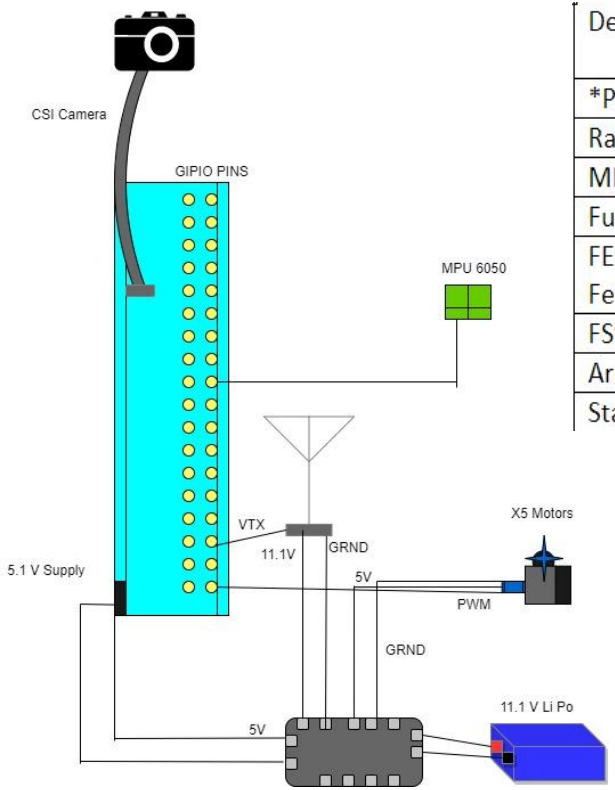
-Payload KE = 9.22 ft-lbf

-Descent time = 29.23 s

-Payload Drift = 857 ft

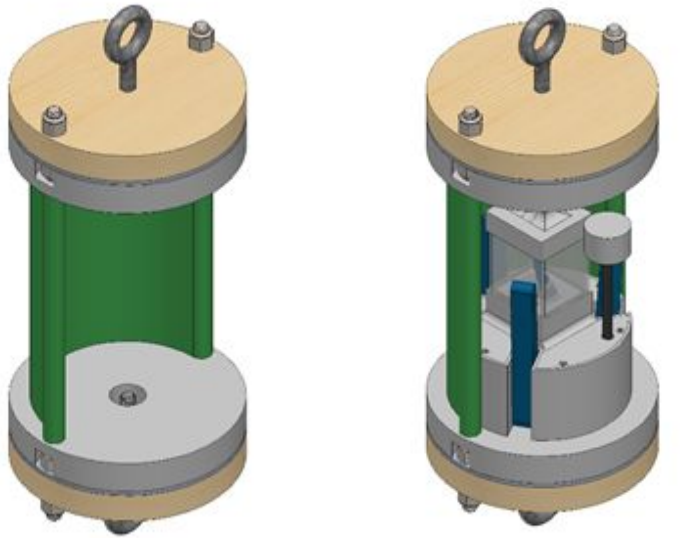
-Total Drift = 1561 ft

Payload Electronics



Device	Current Draw (Max)	Voltage	Power
*Powered by GPIO on PI ZERO			
Raspberry Pi Zero WH	1.2 A	5 V	6 W
MPU 6050 (Gyroscope + Accelerometer) *	100 mA	3.3 V	330 mW
Furious FPV Transmitter 2.4 GHz	20 mA	11.1V	200 mW
FEETECH Micro Servo Motor w/ Position Feedback	500 mA	5 V	2.5 W
FS90n Continuous Rotation Micro Servo	500 mA	5 V	2.5 W
ArduCAM for Raspberry PI *	250 mA	5 V	1.25 W
Standby Time: 4 hrs			

Payload Retention System

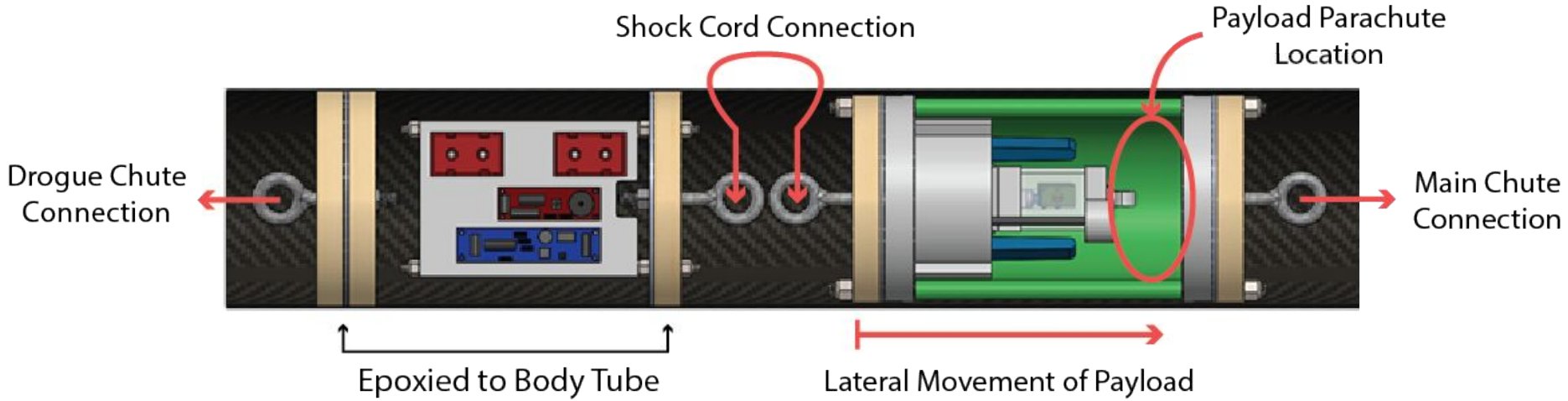


Composed of pine bulkhead blocks and aluminum reinforcement, 3/8" threaded rods, locknuts, and eyebolts.

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

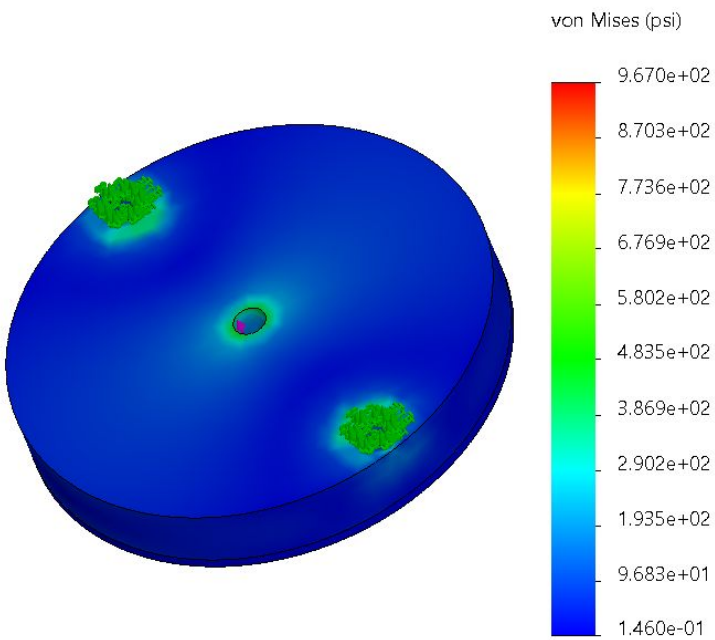
Green cover limits payload motion in one direction

Payload Integration Plans



Payload Testing

Retention System Bulkhead Virtual Testing

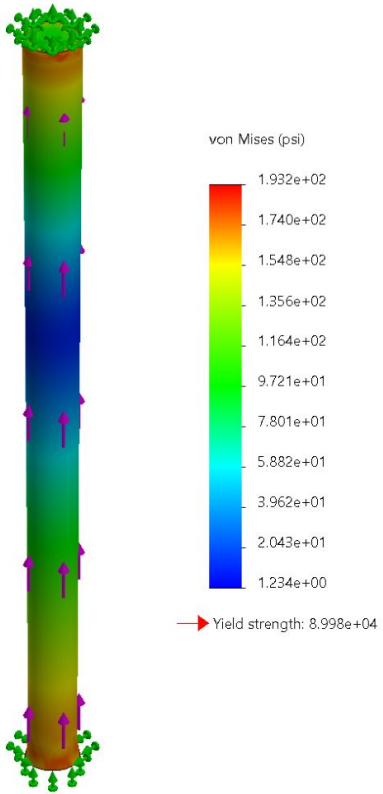


Force: 81.20 lbf total of axial force; 40.6 lbf on each of the two rods (safety factor of 4)

Max Stress: 967 psi

Yield Strength (Pine) (shear): 899 psi

Retention System Threaded Rod Virtual Testing



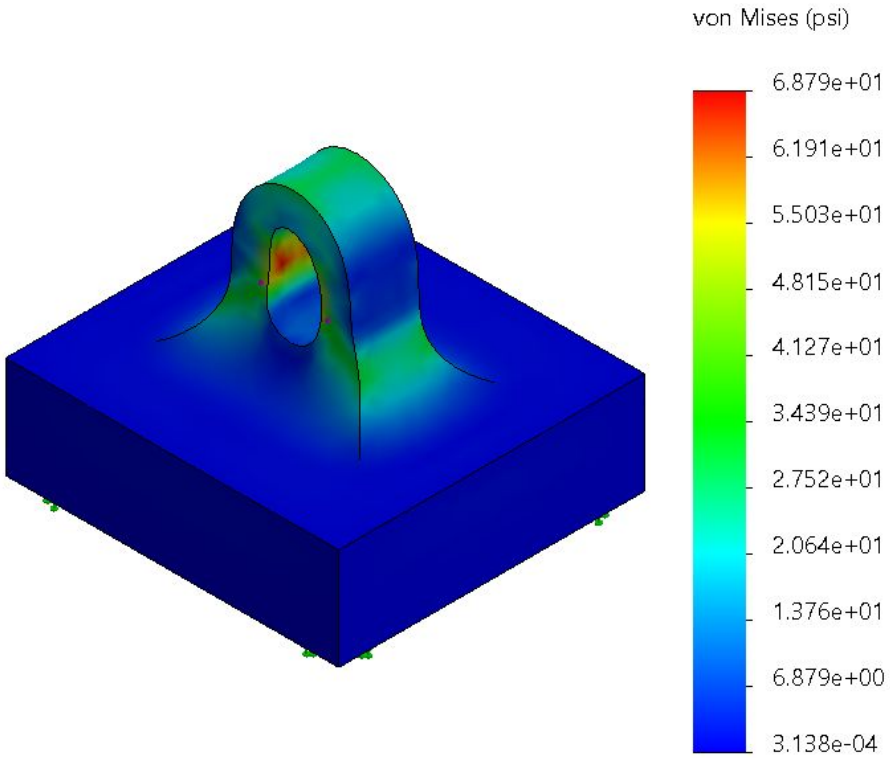
Approximation of a ⅜” steel threaded rod

Force: 81.20 lbf total of axial force; 40.6 lbf on each of the two rods (safety factor of 4)

Max Stress: 193 psi

Yield Strength (Steel): 9000 psi

Payload Top Virtual Testing



Force: 3.62 lbf of axial force (safety factor of 4)

Max Stress: 6.879 psi

Yield Strength (ABS): 7000 psi

Questions?