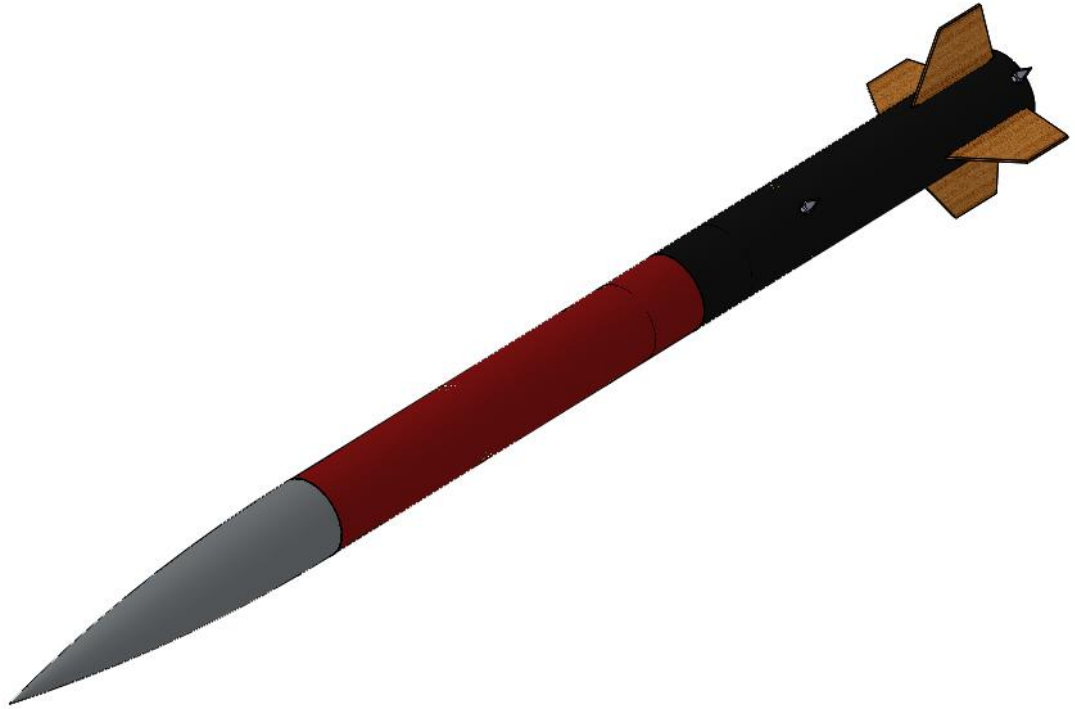
Tacho Lycos PDR Presentation

November 14, 2017

Outline

- Vehicle Design
- Structures
- Avionics
- Recovery
- Payload
  - Tube
  - Rover
- Subscale Design
- Compliance



Full-Scale Vehicle Design

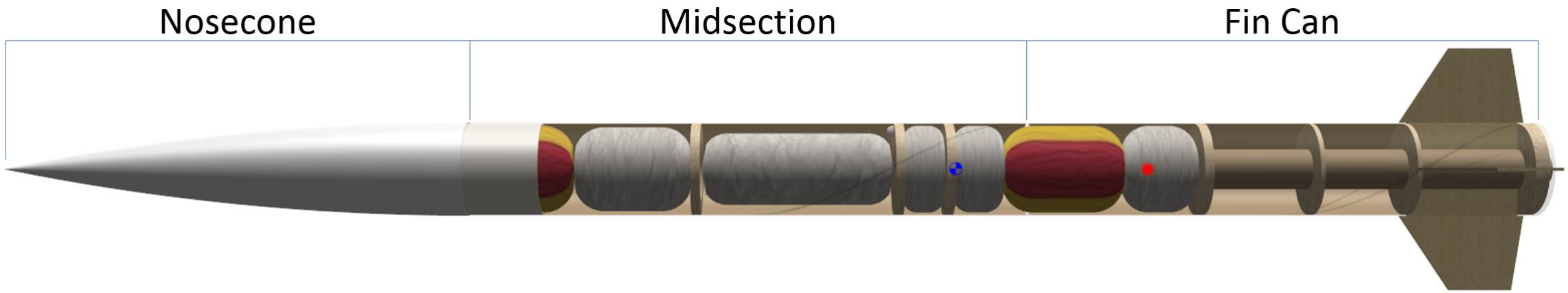
Dimensions

Aerodynamics

Flight Simulations

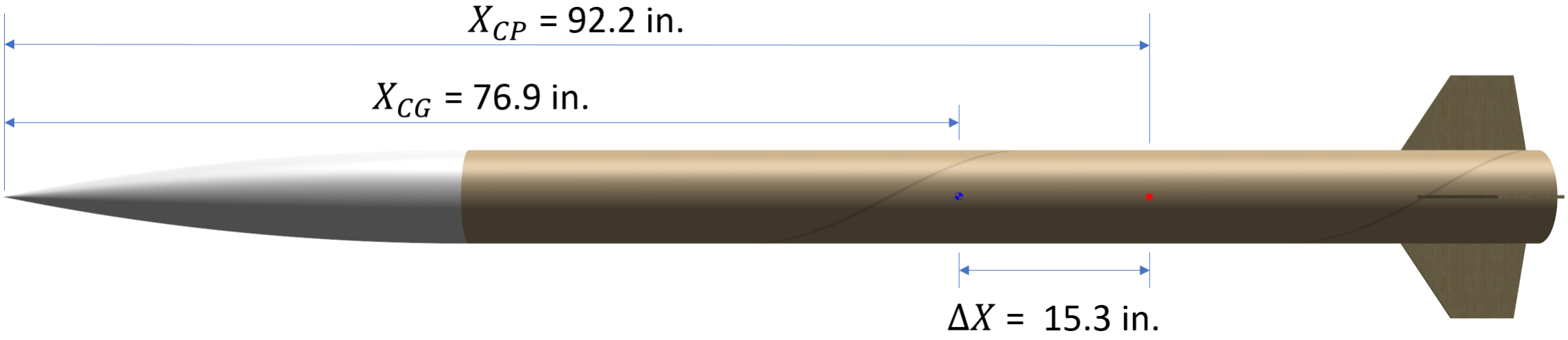
Dimensions

- Length: 125.0 in.
- Diameter: 7.5 in.
- Launch Weight: 46.2 lb
- Empty Weight: 40.6 lb
- Max Mach Speed: 0.64
- Max Acceleration: 466 ft/s^2
- Exit Rail Velocity: 59.5 ft/s
- Nose Ballast: 2.25 lb



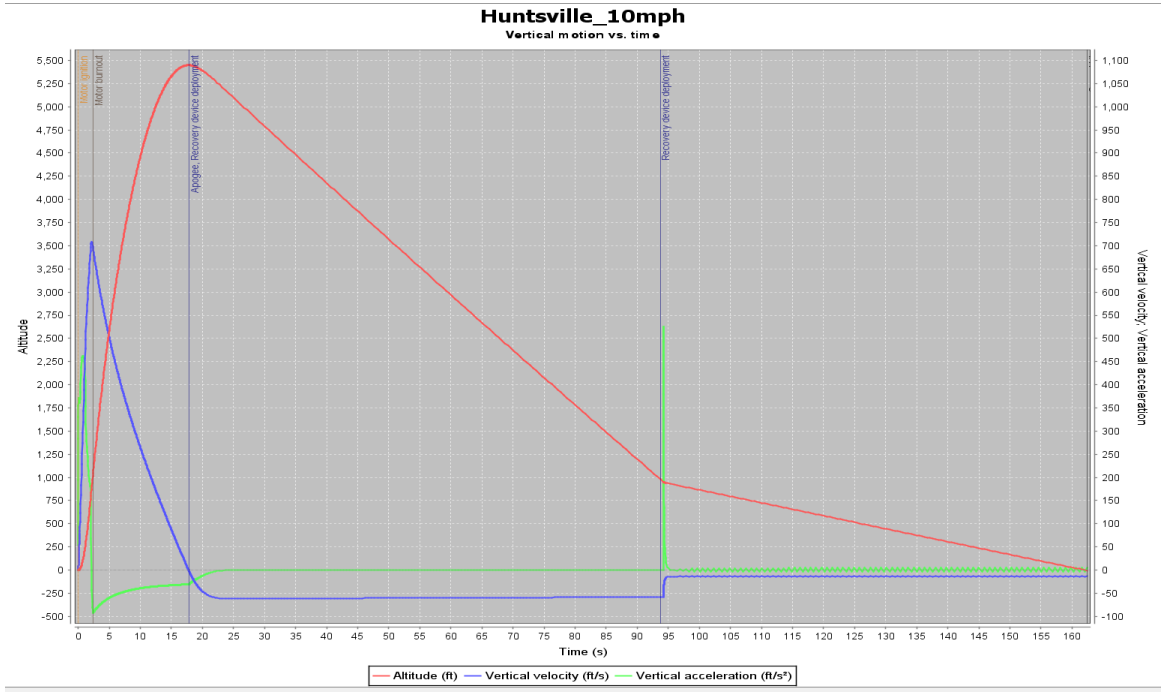
Aerodynamics

- Nosecone: 5:1 Ogive
- $C_D = 0.45$
- $TWR_{max} = 14.8$
- $X_{CP} = 92.2$ in.
- $X_{CG} = 76.9$ in.
- Stability Margin: 2.03



Flight Simulation Results

- Location: Huntsville, AL
- Windspeed: 10 mph
- Launch Rail: 8 ft
- Angle: 5° from Vertical
- Apogee: 5,499 ft AGL
- Max Velocity: 717 ft/s
  - M = 0.64
- Max Acceleration: 468 ft/s^2



Structures

Materials

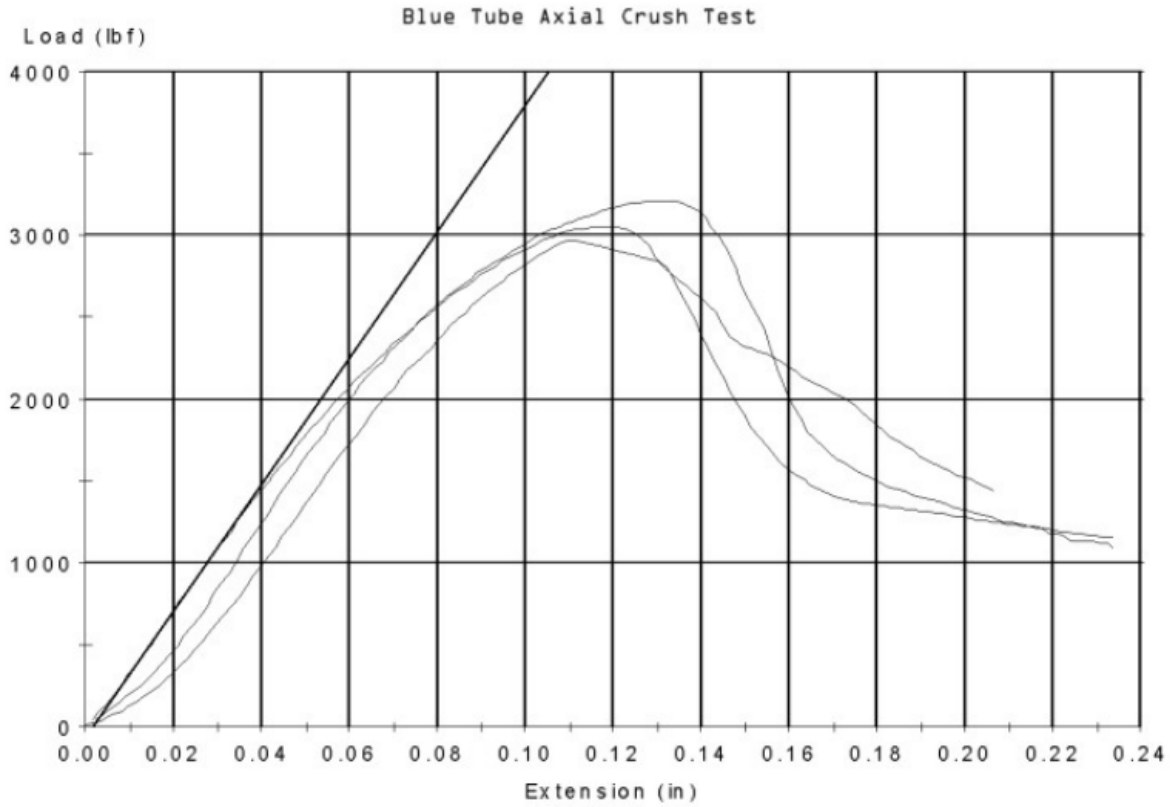
Bulkheads

Payload Bay

Fins

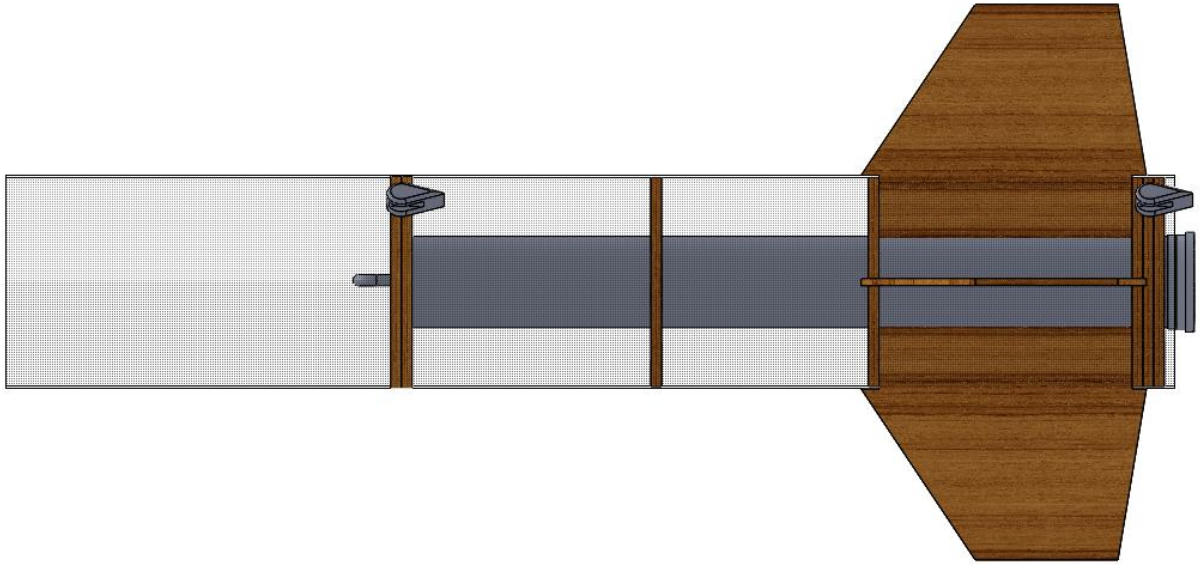
Body Tube Material

- Blue Tube 2.0
  - Buckling load: 3000 lb
  - Expected compression load during flight: 700 lb
  - Factor of Safety > 4
  - Weight savings compared to fiberglass body tubes: 4 lb



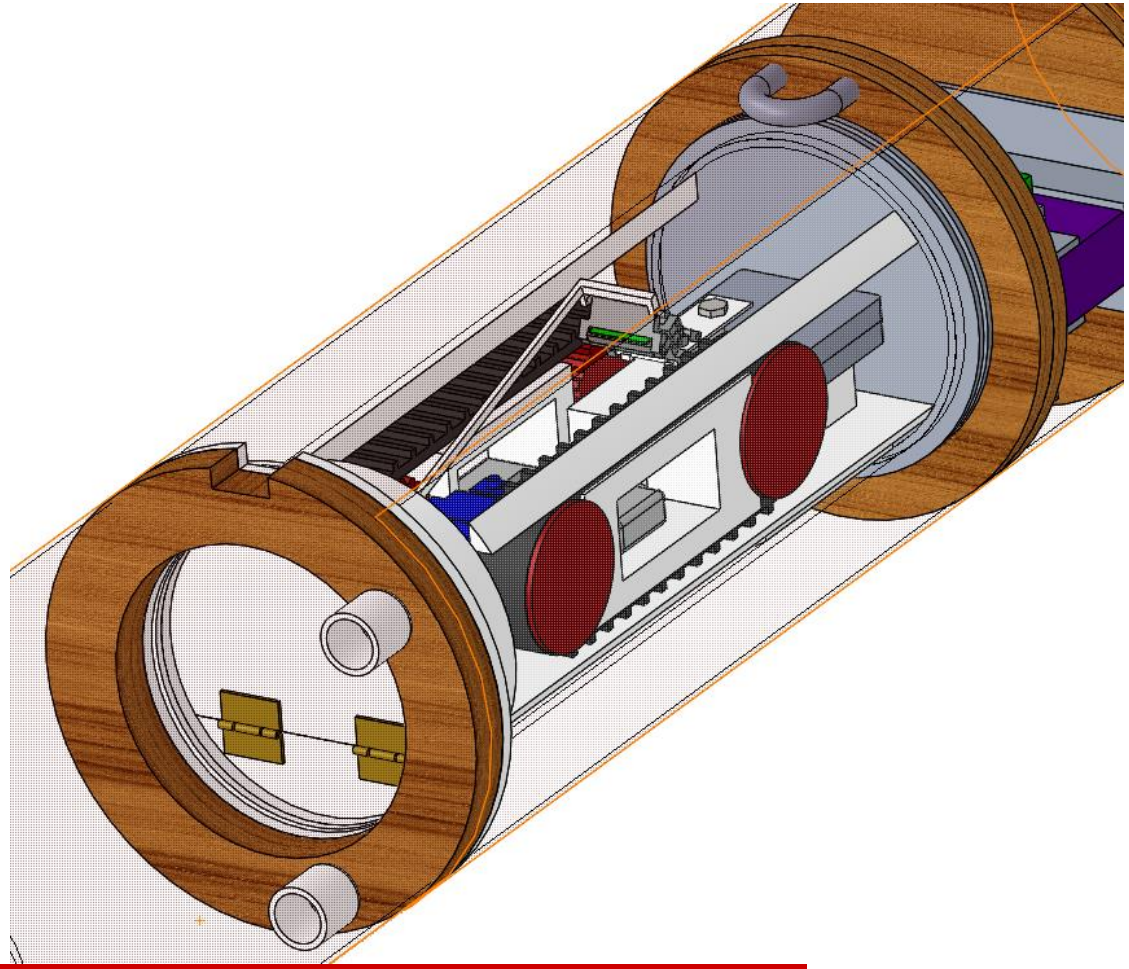
Bulkheads/Centering Rings

- Baltic Birch plywood
  - 3/8” plies epoxied together in areas of higher loading
- Motor Mount
  - 3 plies
- Payload/AV Bay bulkheads
  - 2 plies
- Centering Rings
  - 1 ply



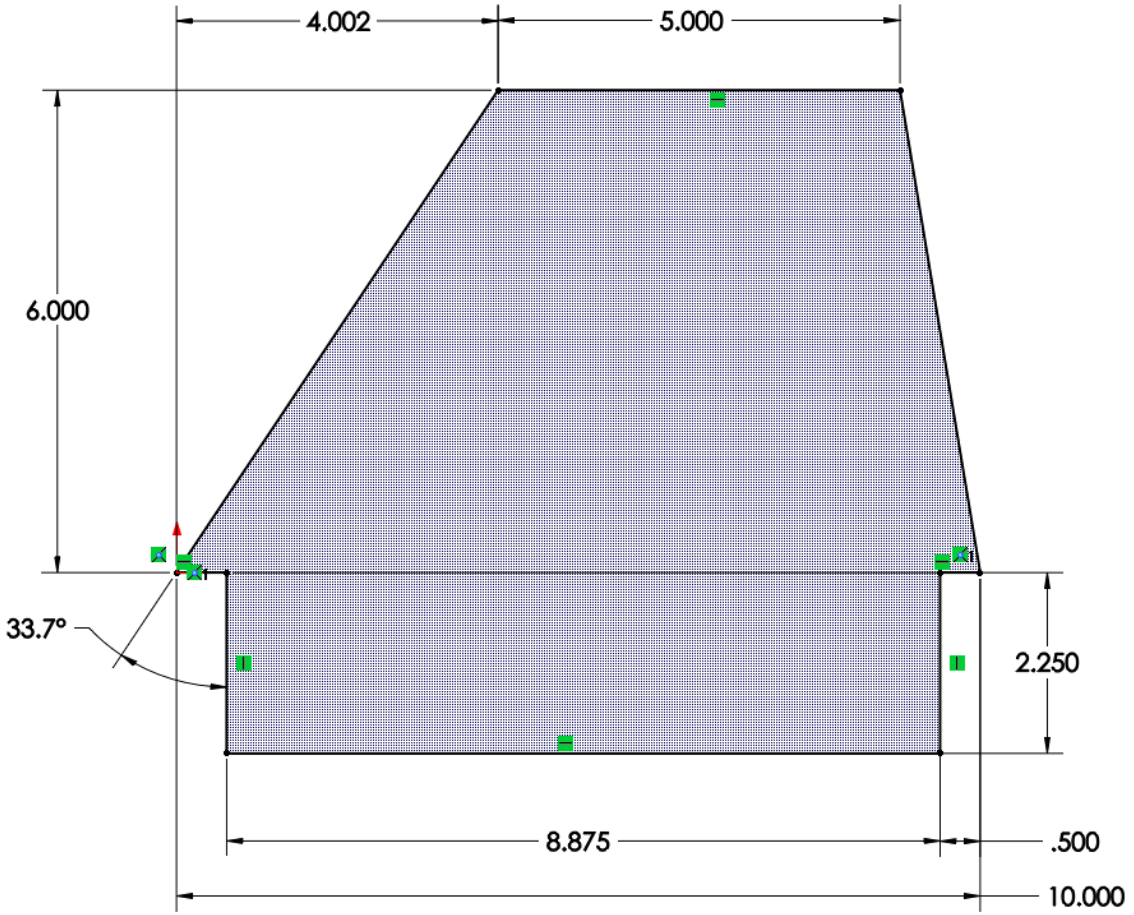
Payload Bay

- FWD Bulkhead
  - black powder charges
  - Ring-shaped
  - Payload bearing mounts on aft side
  - Slot cut to for main parachute shock cord
- AFT Bulkhead
  - U-bolt for main parachute shock cord
  - Payload bearing



Fins

- Four trapezoidal fins
  - Modified clipped delta
  - Forward-swept trailing edge to increase durability
  - Rear of root chord offset
- Size determined by design iterations described in PDR
- Baltic Birch plywood
  - Two 1/8” sandwiched plies
- Using jig for assembly

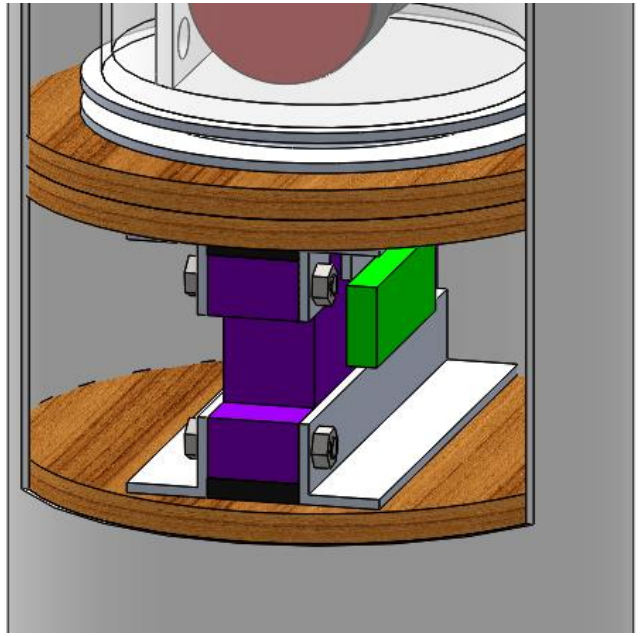


Avionics

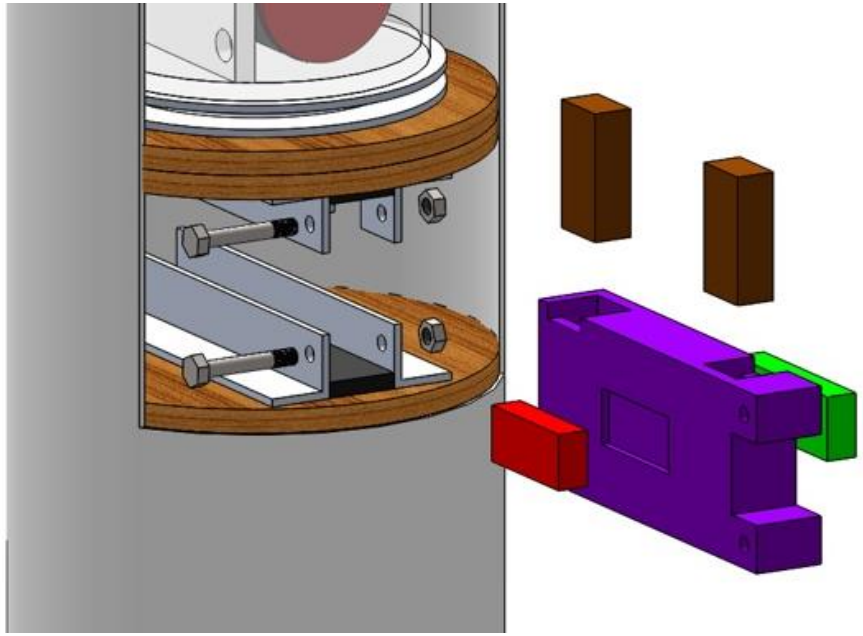
Components

Electrical Diagram

Avionics Sled Design



Assembled view



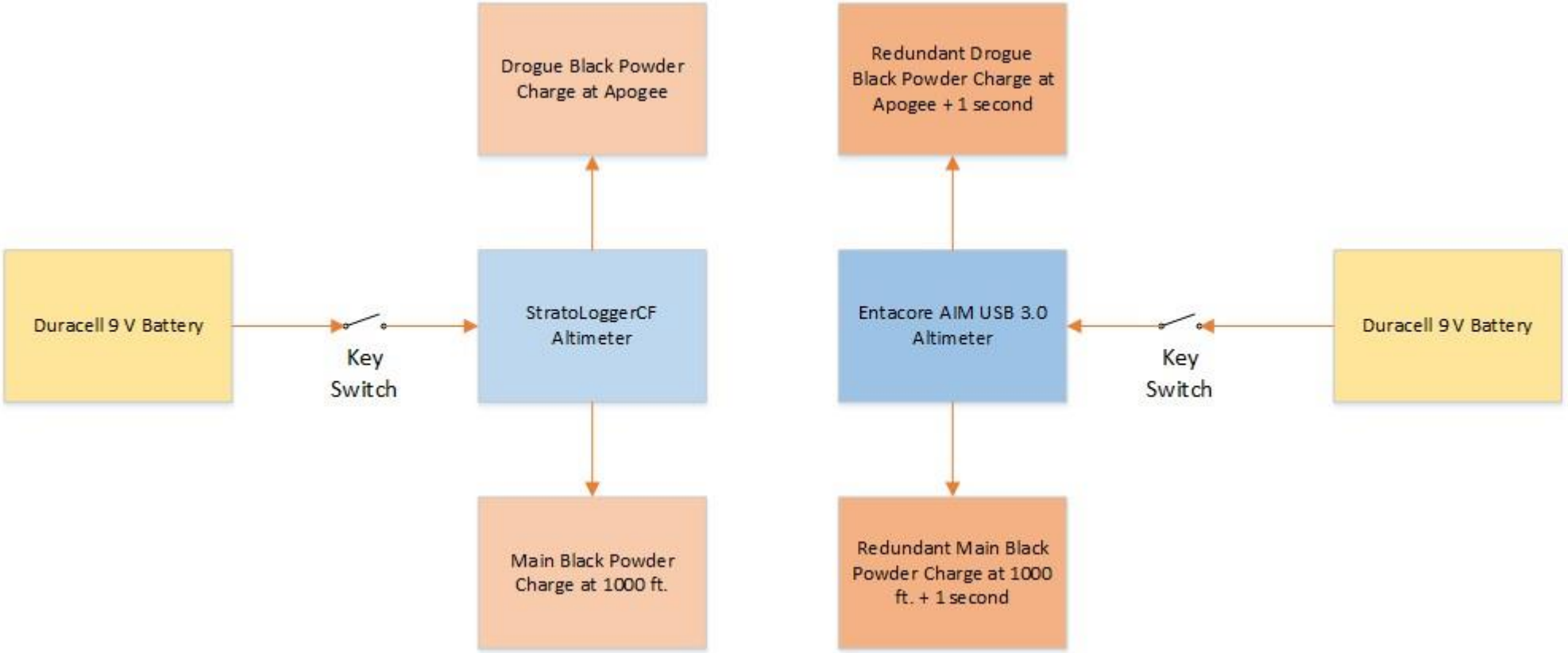
Unassembled view

- Altimeters shown in red and green
- Batteries shown in brown

<u>Components:</u>

- 3D printed sled: 6.50 in. long, 2.75 in. tall, 1.13 in. thick.
- Four 1 in. by 1 in. aluminum L brackets
- Two 0.25 in. steel bolts
- Two 0.25 in. thick hard foam inserts

Avionics Electrical Components



Propulsion

Motor Comparison

Motor Selection

Thrust-to-Weight

Propulsion: Motor Comparison

AeroTech L2200G

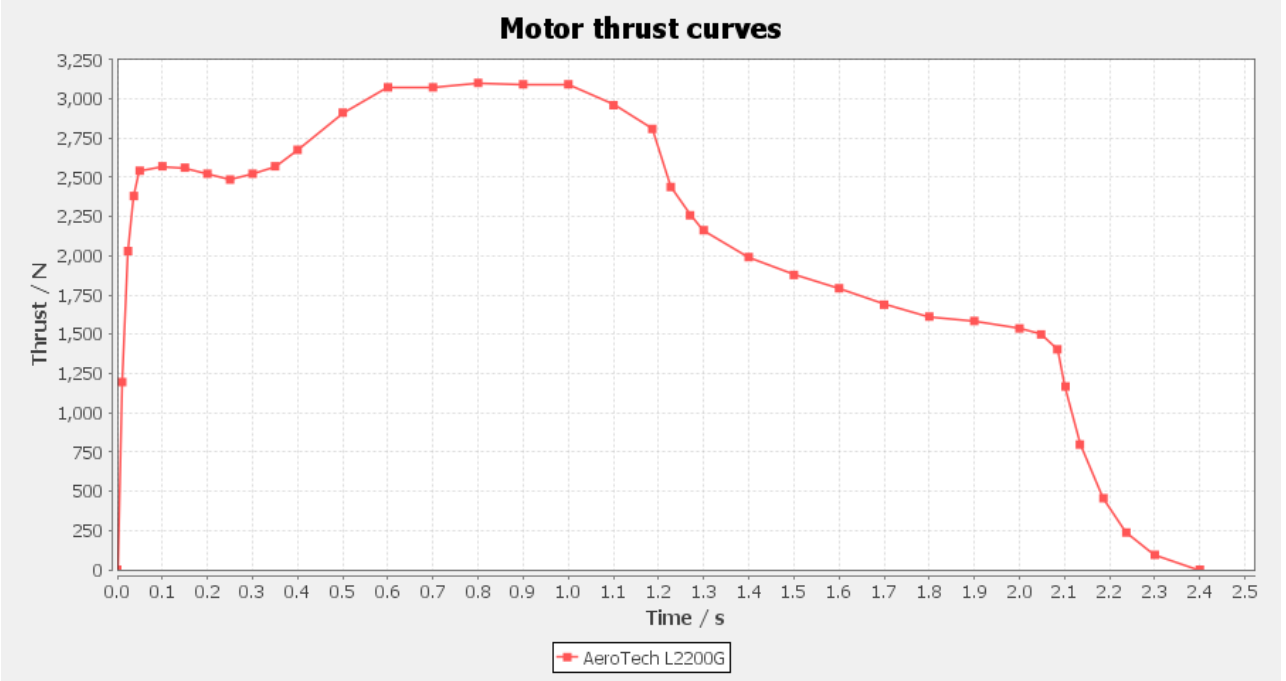
- Specific Impulse: 5,104 N-s
- Average Thrust: 2,243 N
- Max Thrust: 3,102 N
- Apogee: 5,573 ft AGL
- Weight: 10.59 lb
- Length: 26.18 in.
- Mojave Green

Cesaroni L1685-SS

- Specific Impulse: 5,104 N-s
- Average Thrust: 1,669 N
- Max Thrust: 2,300 N
- Apogee: 5,573 ft AGL
- Weight: 13.3 lb
- Length: 29.8 in.
- Smokey Sam

Propulsion: Motor Selection

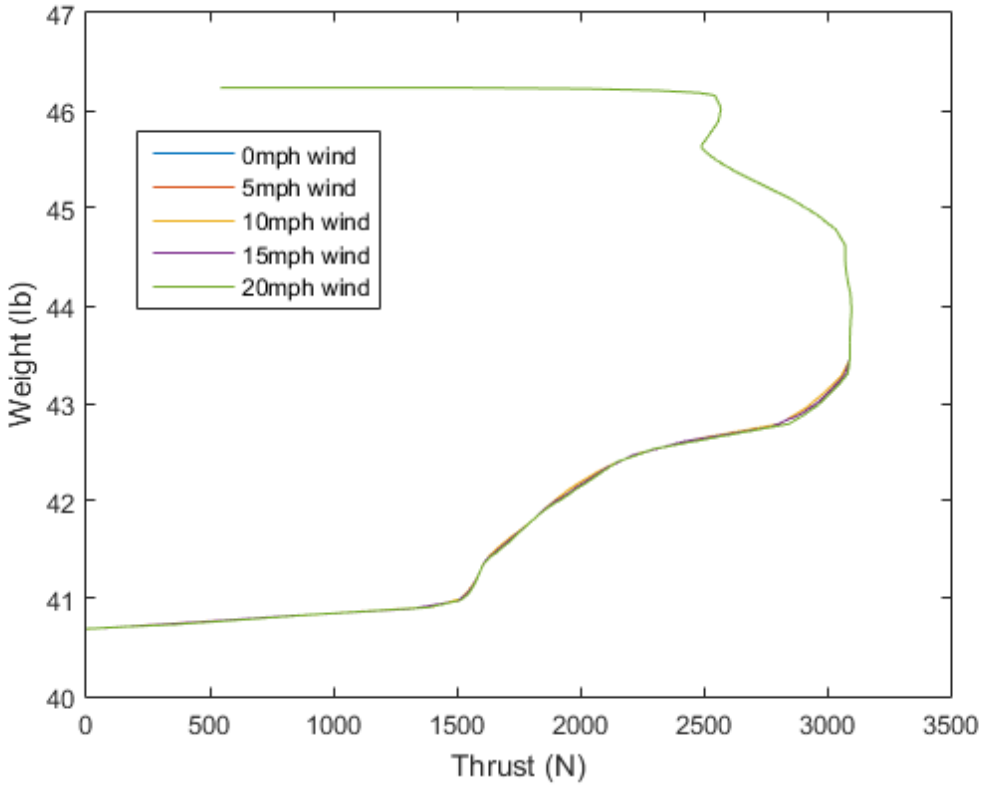
- AeroTech L2200G
  - Motor Casing AeroTech RMS 75/5120 (already own)
  - Experience in Use



Propulsion: Thrust-to-Weight

- Thrust-to-Weight Ratio
  - Max Thrust to Max Weight

$$\frac{T_{max}}{Weight_{max}} = \frac{3100\ N}{209.04\ kg} = 14.83$$



Thrust vs Weight for the full-scale rocket

Recovery

Recovery Avionics

Parachute Sizing

Recovery Events

Wind Drift

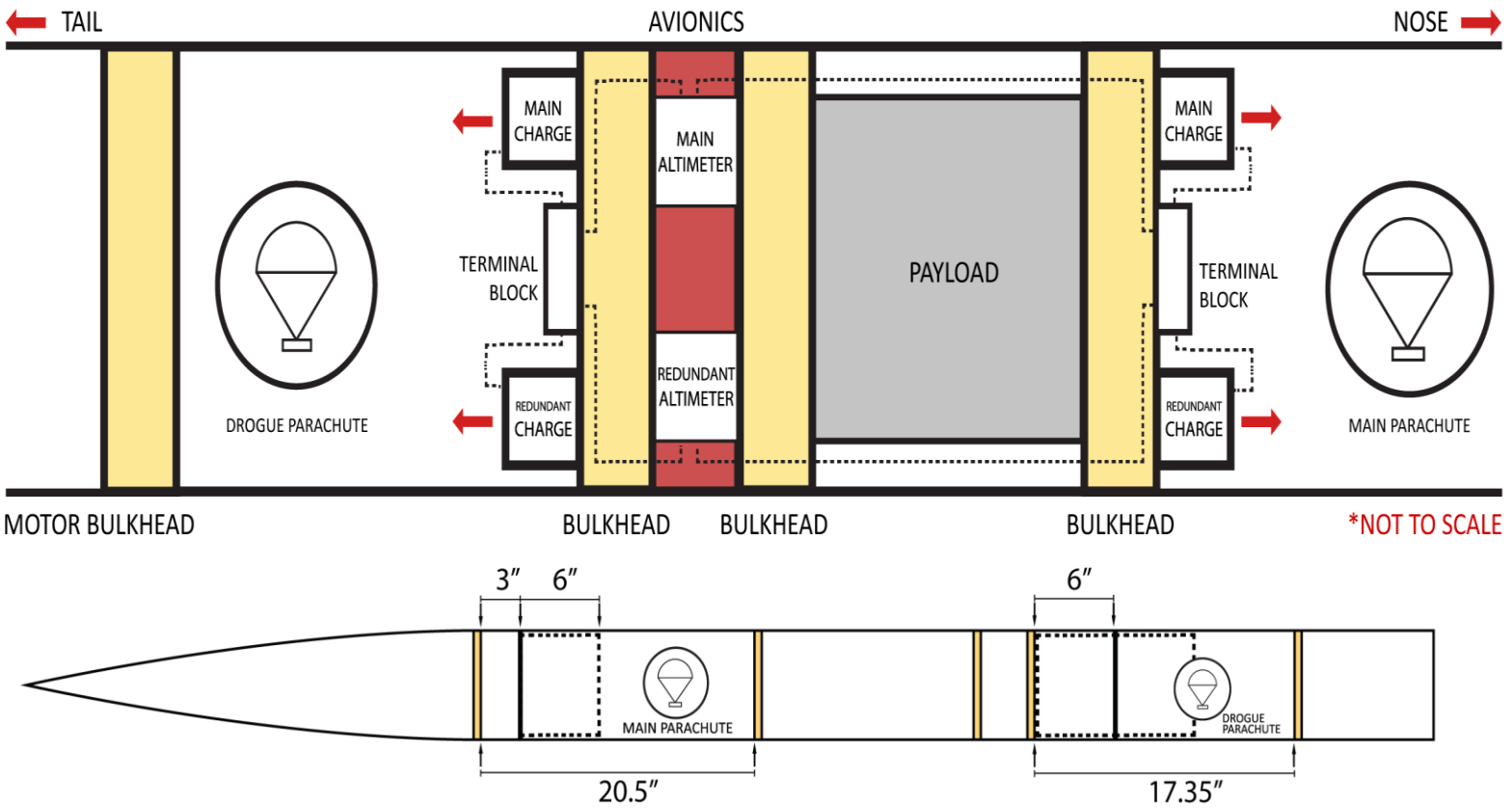
Recovery: Avionics

Apogee - Drogue

- 5.6 g Black Powder Charge
- 1 second redundancy
- Ejection Force: 635 lbf

1000 ft AGL - Main

- 6.6 g Black Powder Charge
- 1 second redundancy
- Ejection Force: 735 lbf



Recovery: Parachute Sizing

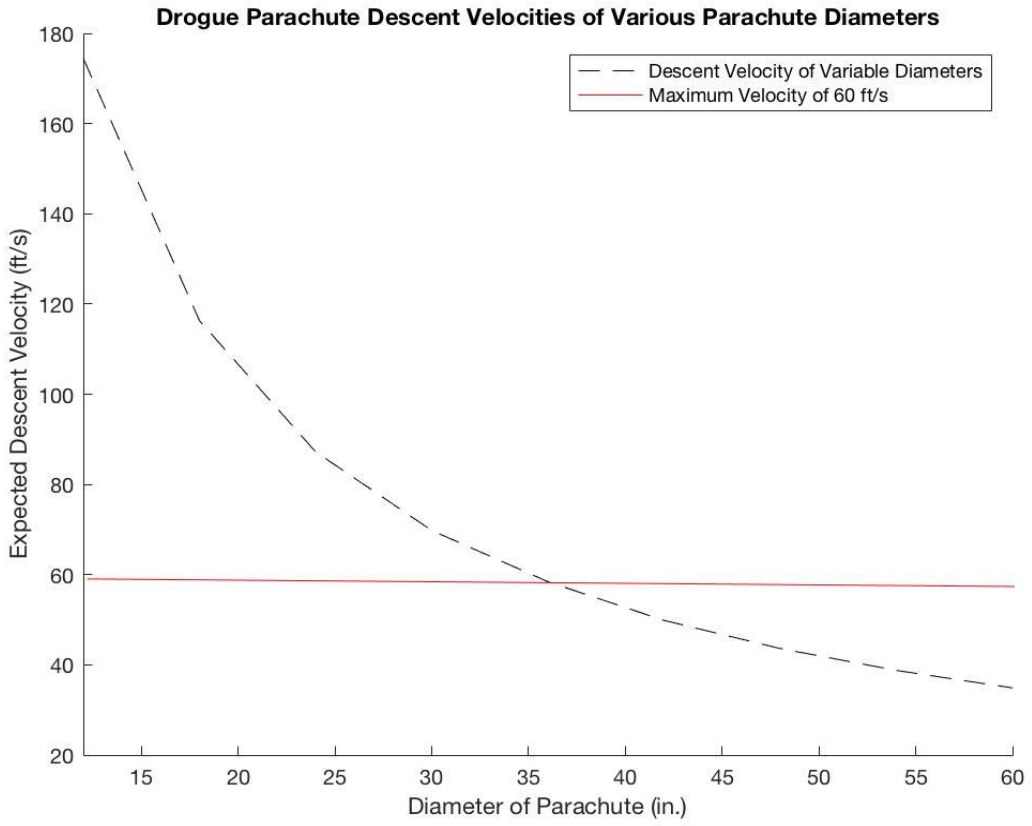
- Reefing Advantages
  - Utilize available resources
  - Decrease deployment force during ejection and inflation of main parachute
- Elliptical (Non-Reefed) vs. Iris Ultra (Reefed)
  - $C_d = 1.5$ vs. $C_d = 2.2$
- Elliptical for Drogue
- Iris Ultra for Main

Diameter of Parachute (in.)	Iris Ultra Compact - Reefed Descent Rate (ft/s)	Standard Elliptical – Non-reefed Descent Rate (ft/s)
18	N/A	81.27
24	N/A	60.67
30	40.08	48.76
36	33.40	40.63
48	25.05	30.33
60	20.04	24.47
72	16.70	N/A
96	12.52	N/A

Recovery: Drogue Event

- Set maximum $V_{terminal}$ = 60 ft/s

- 36 in. Drogue
  - Fruity Chute Standard Elliptical
  - C_d =1.5
  - Predicted $V_{terminal}$ = 58.43 ft/s



Recovery: Main Event

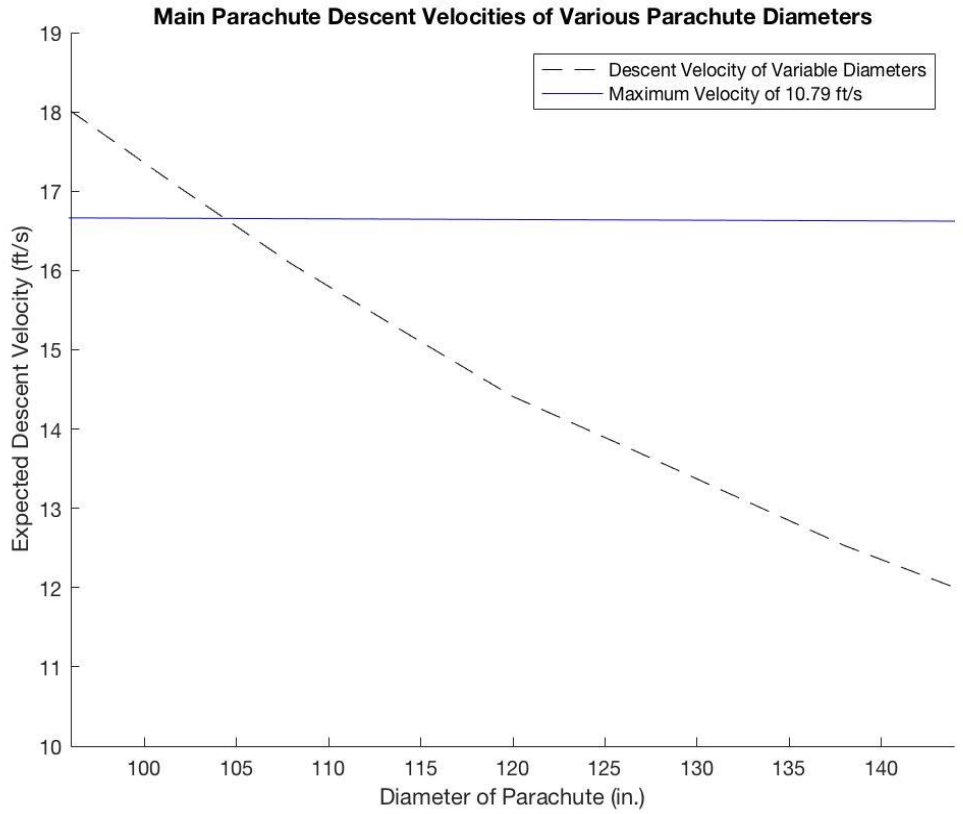
Use max KE to determine max $V_{terminal}$/V_{impact}

Body Section	Mass (slugs)	Maximum Descent Velocity (ft/s)
Nose Cone	.24	25.00
Mid Section	.47	17.86
Fin Can	.53	16.82

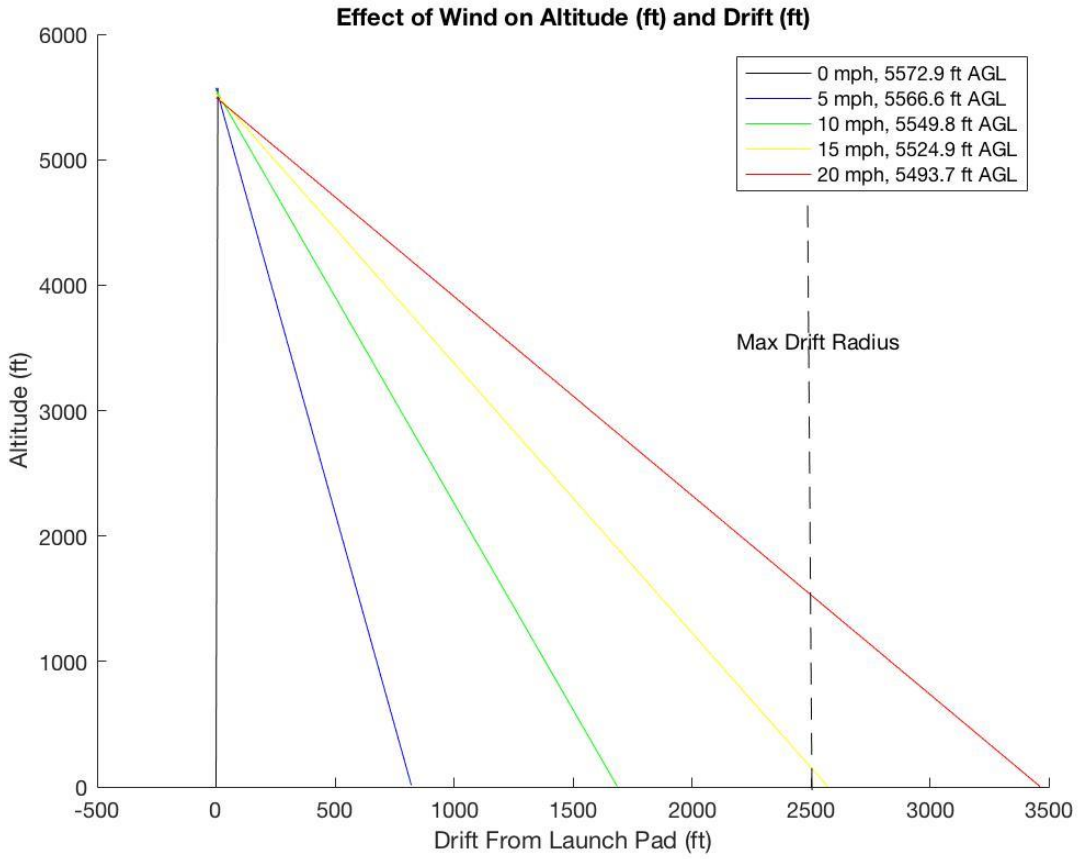
- Max $V_{terminal}$ = 16.82 ft/s
- At least 108 in. diameter required

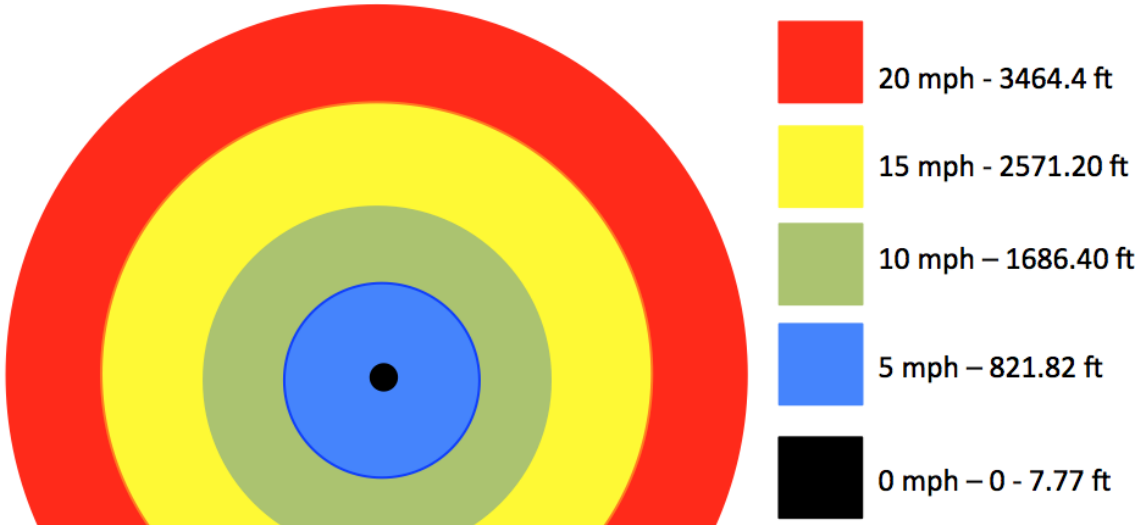
120 in. Iris Ultra Compact Main Parachute

Body Section	Mass (slugs)	Maximum Descent Velocity (ft/s)	Kinetic Energy at Landing (ft-lbf)
Nose Cone	.24	14.41	24.92
Mid Section	.47	14.41	48.79
Fin Can	.53	14.41	55.03



Recovery: Wind Drift





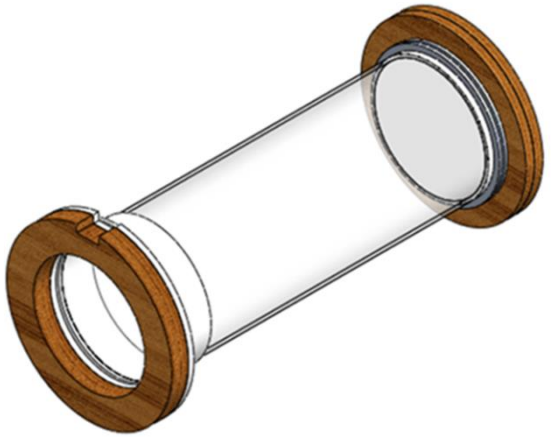
Payload

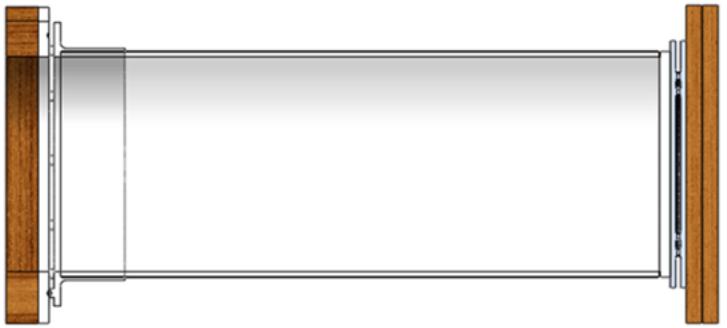
Housing

Rover

Payload Housing Structure

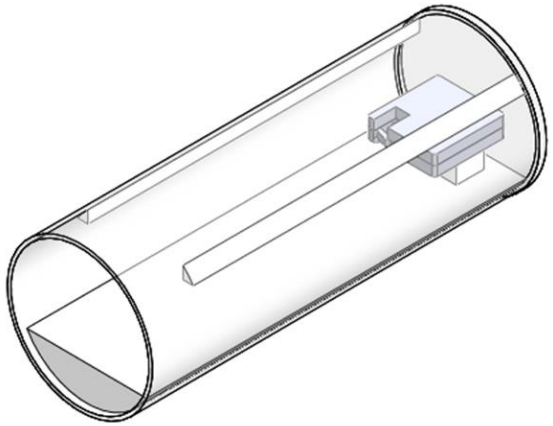
- Acrylic Tube that houses the payload – 5.25” with 0.125” walls
- Two Lazy Susan bearing systems on the forward and aft ends
  - Allows the payload to spin freely during flight
  - Payload will stabilize once landed
  - Attached to the bulkheads

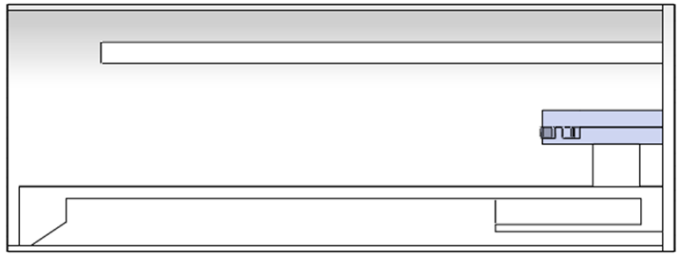




Payload Security

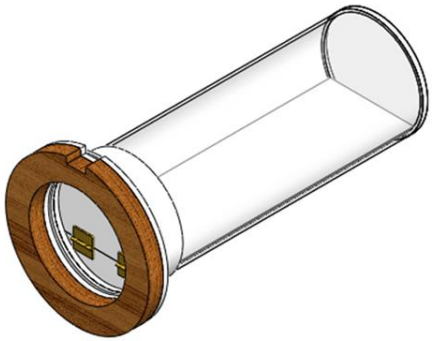
- Rover platform
  - Rests below the horizontal axis and is concentric with the tube
  - Houses the electronics for latch and door
  - Front face fills the bottom of the tube then tapers to 0.25”
- Southco R4-EM 4&6 Series Electronic Rotary Latch
  - Secures the rover from moving in the longitudinal direction
  - Powered by the servo housed under the platform
- Rover braces
  - 3D printed braces that are attached to the interior face of the tube
  - Secures the rover from moving in the vertical direction

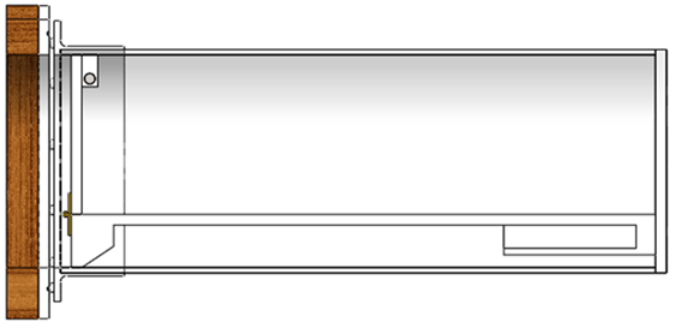


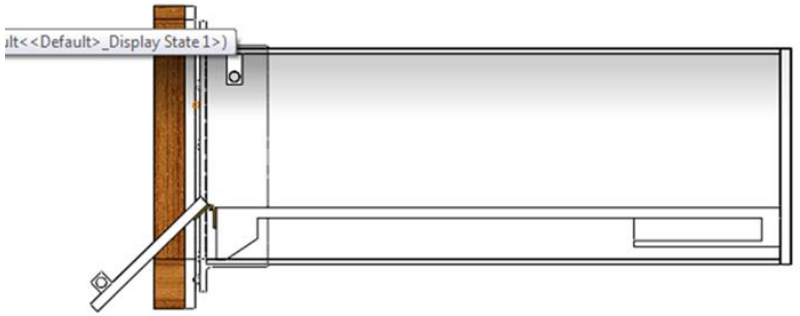


Payload Deployment

- Southco R4-EM 4&6 Series Electronic Rotary Latch
  - Once rocket lands, servo will be remotely triggered to release the latch
- Door
  - The door is on the forward end of the payload
  - Rests and hinged to the platform
  - The shape is concentric with the tube
  - Secured with a pin attached to the servo – pulled when servo is triggered

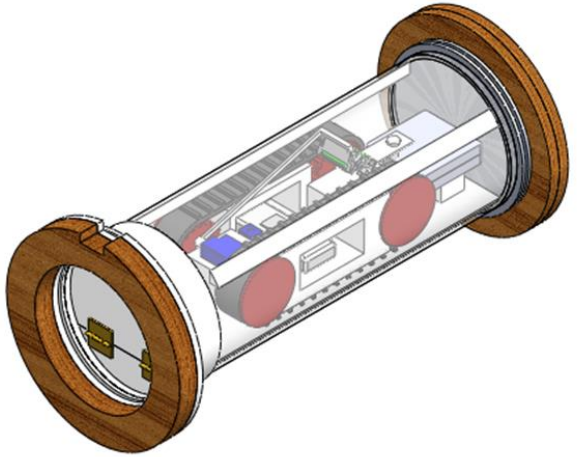


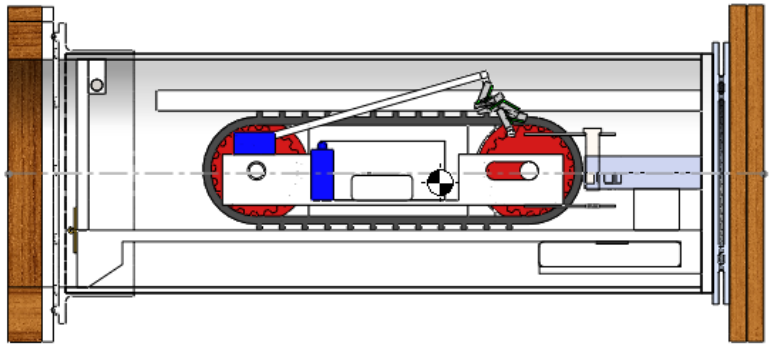




Payload Completed

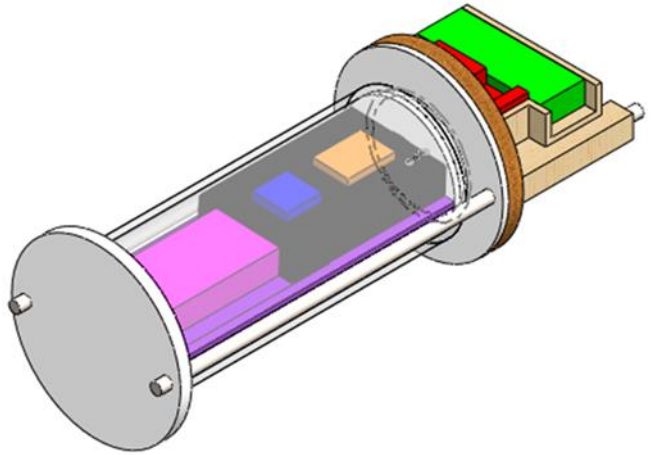
- The complete payload weighs:
  - Without bulkheads – 5.585 lb
  - With bulkheads – 6.730 lb
  - Below the desired 7 lb limit
- The center of gravity is below the longitudinal axis
  - The payload will be self-righting
  - Not a large enough offset to promote flight instability

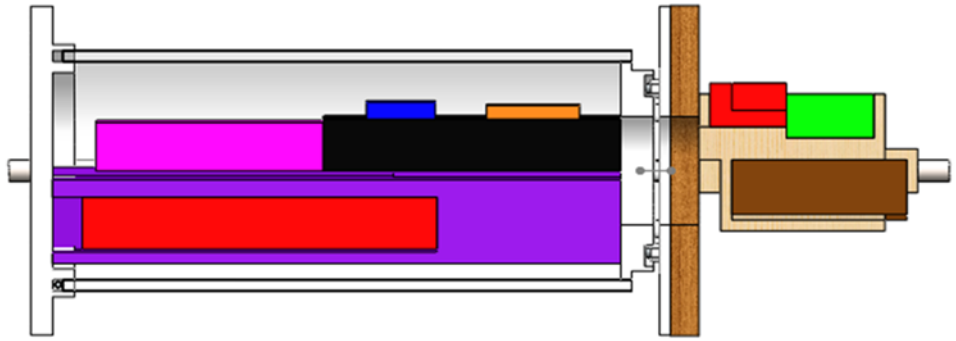




Subscale Payload

- The subscale payload is designed to mimic the full scale design
  - 2.75” acrylic tube that houses the payload
  - Lazy Susan to allow spin
- Testing will provide measurements the spin during flight

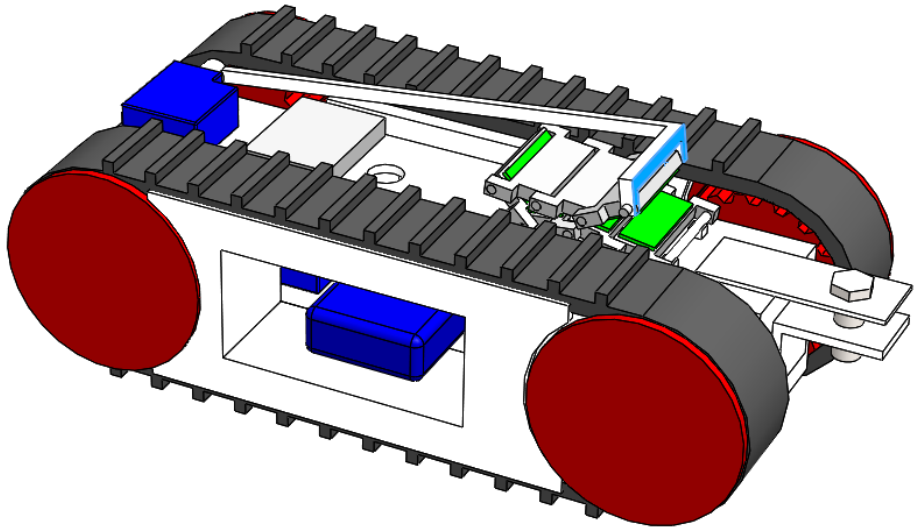




Rover: Requirements

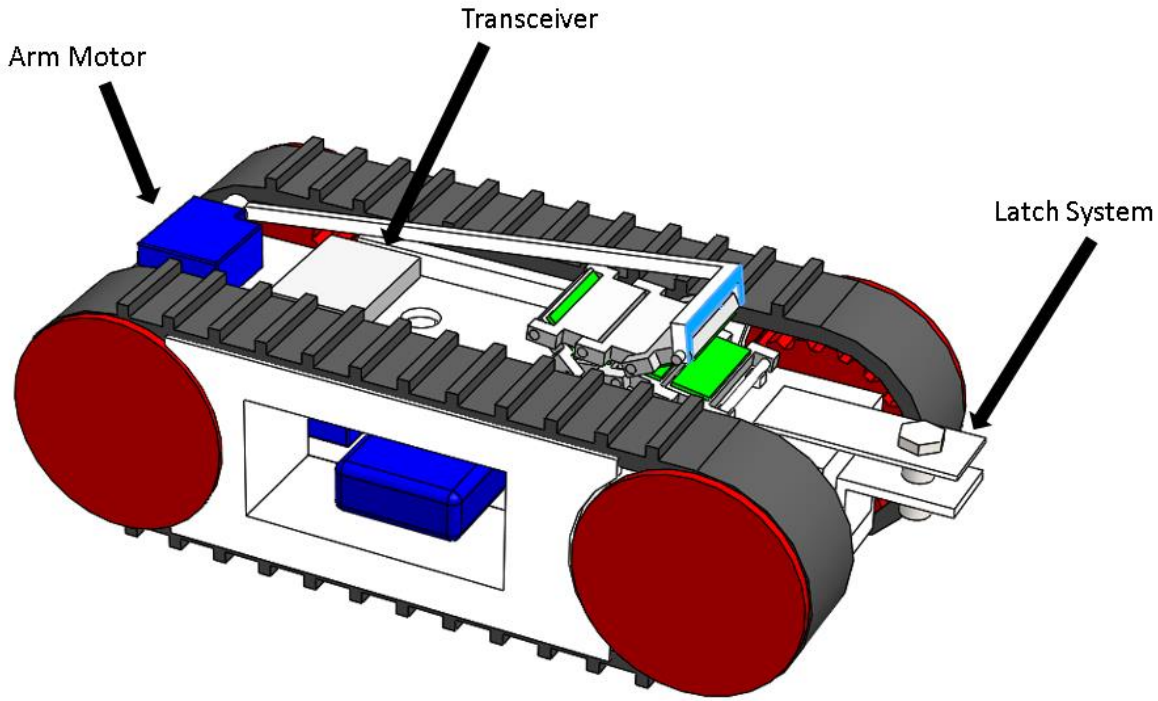
Section 4.5 in the NASA Student Launch Handbook

- Custom rover deployed from internal structure
- Remote activation
- Autonomously move 5 ft laterally in any direction
- Deploy a set of foldable solar panels after reaching its final destination



Rover

- Length: 9.08”
- Width: 4.10”
- Height (stowed): 2.20”
- Height (deployed): 5.44”
- Total Weight: 1.856 lb

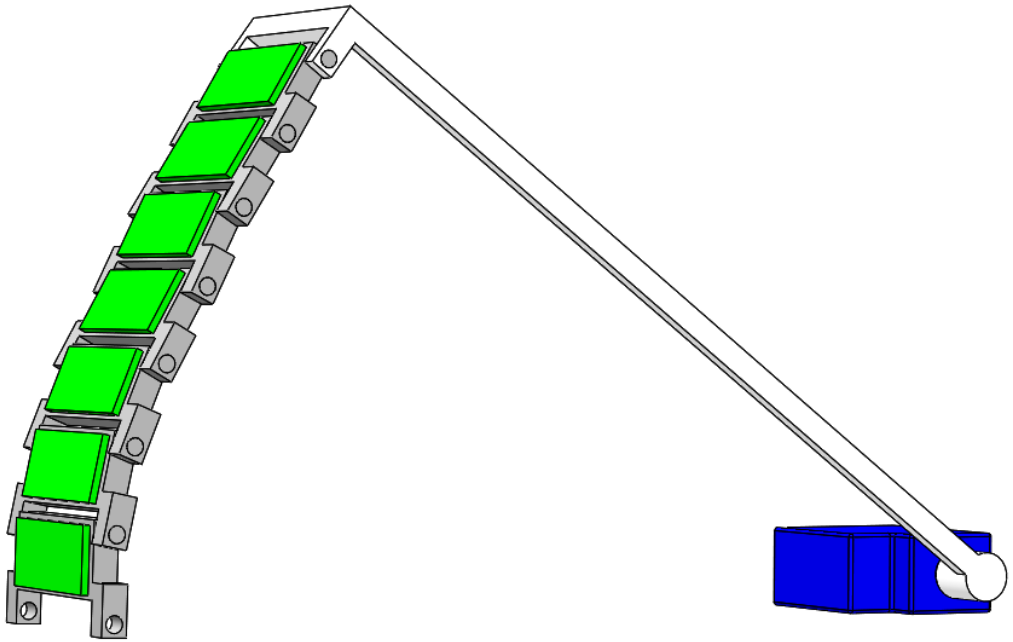


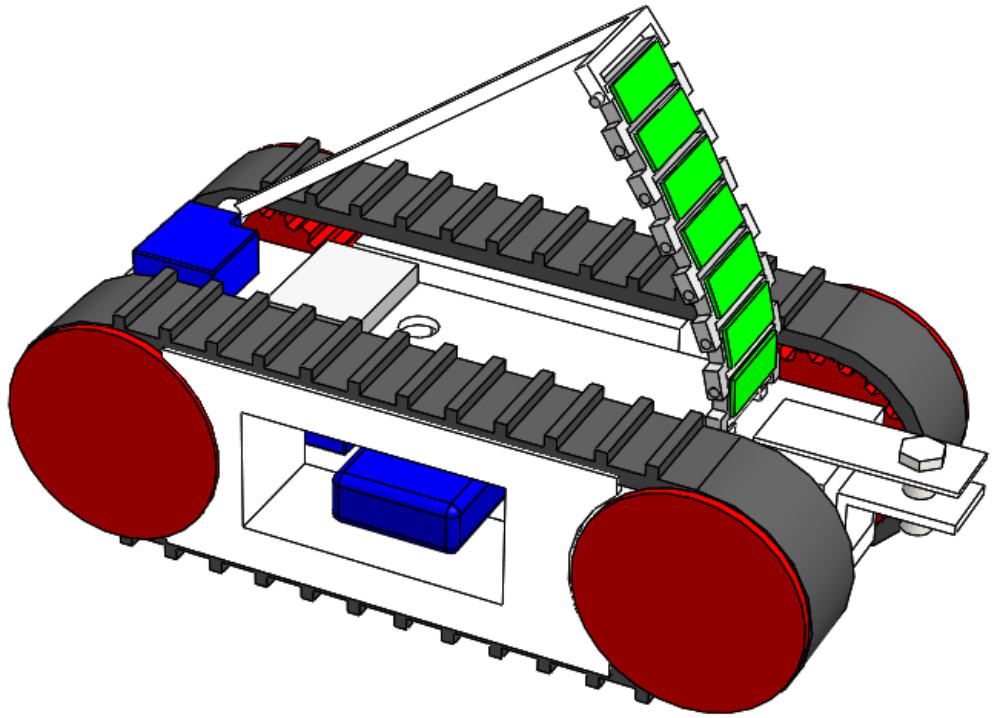
Rover Weight

Part	Material	Weight (lb)	Quantity	Total Weight (lb)
Body	ABS	0.360	1	0.360
Opening	ABS	0.160	2	0.320
Wheel	ABS	0.120	4	0.480
Tread	Rubber	0.170	2	0.340
Arm	ABS	0.010	1	0.010
Front Axle	ABS	0.020	1	0.020
Rear Axle	ABS	0.020	1	0.020
Latch Screw	Steel	0.020	1	0.020
Screw Guide Bottom	ABS	0.010	1	0.010
Screw Guide Top	ABS	0.010	1	0.010
Panasonic - BSG AM-1456CA Solar Panels	n/a	0.002	7	0.011
Accordion	Paper/Plastic	0.010	1	0.010
FEETECH FS90R	n/a	0.020	2	0.040
Turnigy 1000mAh 2S 20C LiPoly Pack	n/a	0.181	1	0.181
Arduino Pro Mini 328	n/a	0.004	1	0.004
Misc. Wires (estimate)	n/a	0.020	1	0.020
			TOTAL (lb)	**1.856**

Part	Material	Weight (lb)	Quantity	Total Weight (lb)
Arm	ABS	0.010	1	0.010
Panasonic - BSG AM-1456CA Solar Panels	n/a	0.002	7	0.011
Accordion	Paper/Plastic	0.010	1	0.010
FEETECH FS90R	n/a	0.020	1	0.020
			TOTAL	0.051

Sail System





Compliance

Experiments

Subscale Payload

Compliance Plan

- Launch Vehicle Testing
  - Material Strength
  - Ejection Charges
  - Altimeter Testing
- Payload Testing
  - 3D Printing Experiment
  - Free Spinning Inner Tube Testing

Questions?