Stony Brook University
Mechanical Engineering

2019 STUDENT LAUNCH COMPETITION
Flight Readiness Review
March 04, 2019

Address:
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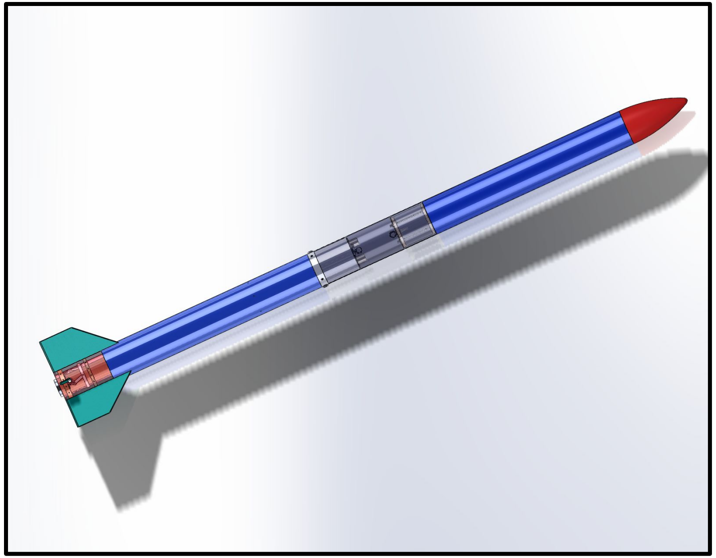
Stony Brook University
Stony Brook, New York 11794-2300

Shaping the Future of Aerospace

Structures, Aerodynamics, and Propulsion (SAP)

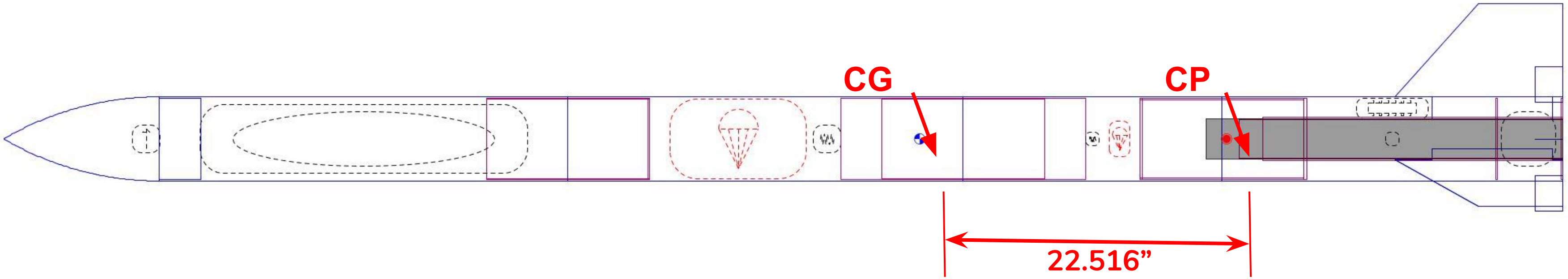
Launch Vehicle Overview

- Total Length: 114.42 in
- Outer Diameter: 6.160 in
- Gross Lift Off Weight: 52.92 lb
- Final Motor Choice: AeroTech L2200G
- Thrust/Weight Ratio: 9.35
- Rail Exit Velocity: 89.69 ft/s



Rocket Flight Stability

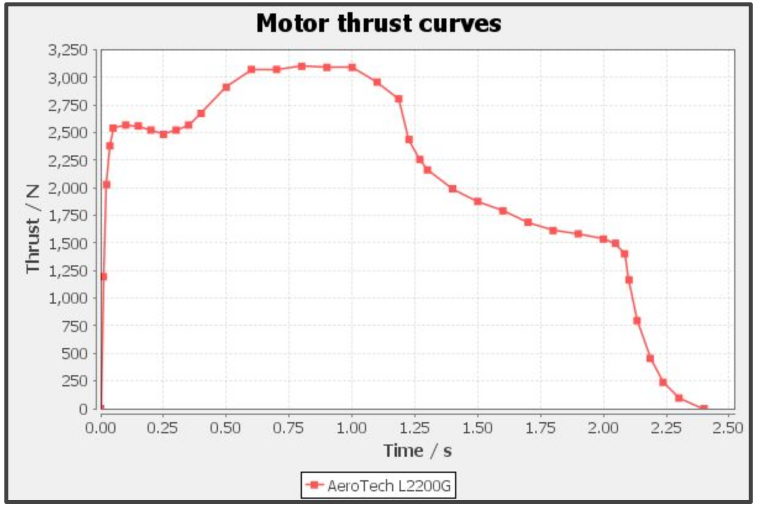
	Center of Pressure	Center of Gravity	Stability Margin
Calculated Result	92.34 inch	65.74 inch	4.32 (on pad)
Simulated Result	89.742 inch	67.226 inch	3.66 (on pad)



Motor Characteristics

- Motor selection based on estimated mass of rocket and target apogee
- Final selection: Aerotech L2200G

Diameter (mm)	75
Length (in)	26.81
Total Weight (lb)	10.46
Propellant Weight (lb)	5.54
Average Thrust (lb)	494.58
Max Thrust (lb)	700
Impulse (lb.s)	1147
Burn Time (s)	2.3



Mass Statement and Mass Margin

Mass Statement at Liftoff

	Wet Mass	Dry Mass
Forward Section	--	32.94 lb
Booster Bay	19.98 lb	14.44 lb
Overall Vehicle	52.92 lb	47.38 lb

Mass Ratio (Ratio of wet mass to dry mass): 1.12

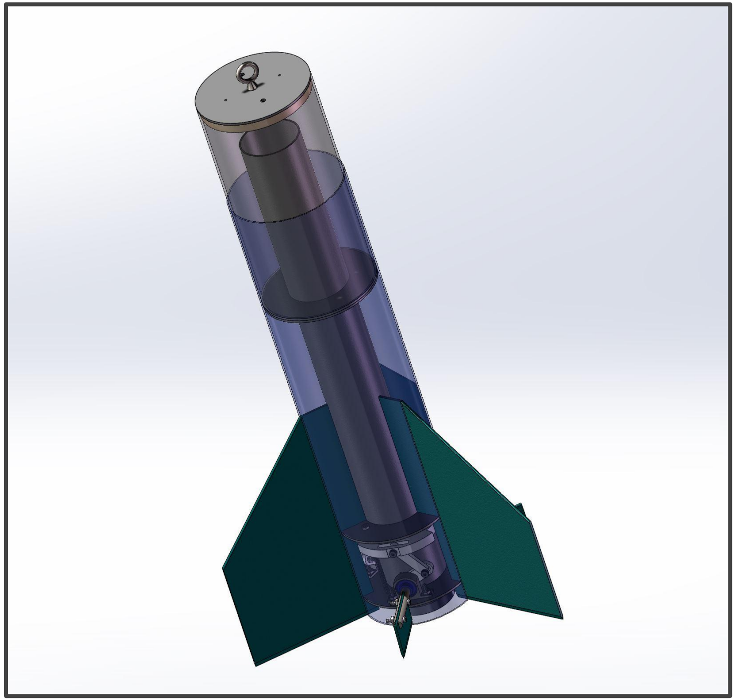
Flight Characteristics

Maximum Velocity (ft/s)	632
Maximum Acceleration (ft/s^2)	405
Predicted Apogee (Avg. of wind speeds) (ft)	5004.8
Center of Pressure (in. from nose)	89.742
Center of Gravity (in. from nose)	67.226
Static Stability Margin (on pad)	3.66
Static Stability Margin (at rail exit)	3.71
Rail Size/Type and Length (in)	1515/144 in
Rail Exit Velocity (ft/s)	89.7

Apogee Predictions

Wind Speed (mph)	**0**	**5**	**10**	**15**	**20**
Apogee (ft)	5141	5080	5022	4948	4839

Booster Bay



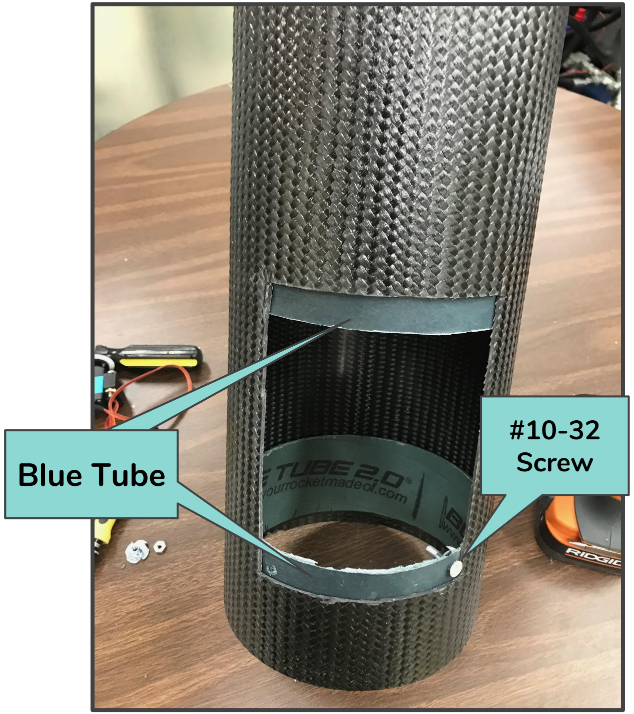
- Booster with coupler attached, the external length is 25 inches
- The upper portion of the motor mount tube was inserted into the coupler
- A double centering ring holds the upper portion of the motor mount tube and is placed against the bottom of the coupler
- Weight saved by reducing the length of the airframe

Booster Bay

- Had 3 fin slots cut to fit the primary fins and 3 oval slots for the canard fins

Booster Bay

- Window cut into airframe to allow access to ASACU electronics
- Secured with blue tube, t-nuts, and #10-32 machine screws
- Blue tube epoxied to airframe



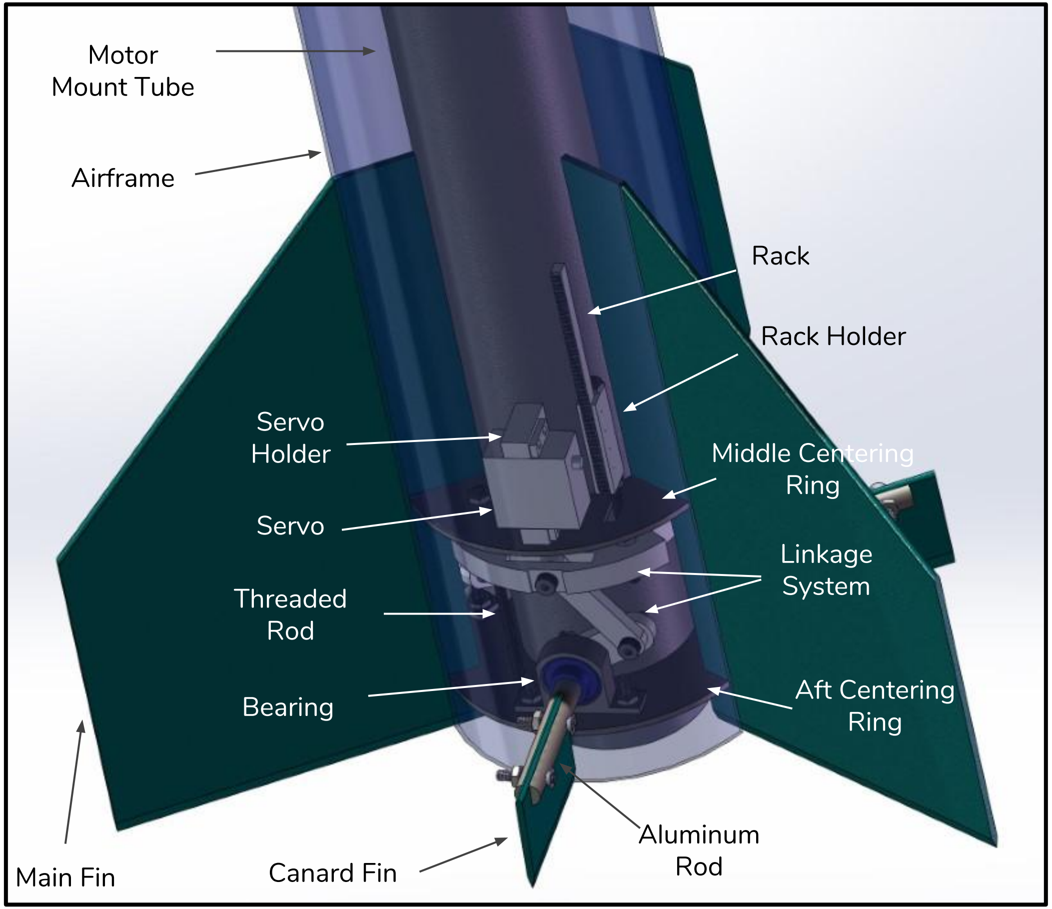
Electronics Housing

- Designed to hold the microcontroller and sensors used to drive the ASACU
- Provides a smooth fit inside the airframe
- Mount matches the contour of the airframe to facilitate mounting
- Will be epoxied to airframe

ASACU

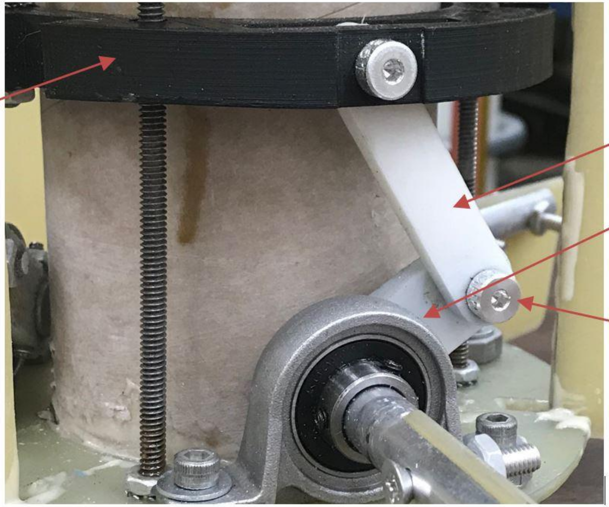
Active Stability and Altitude Control Unit (ASACU)

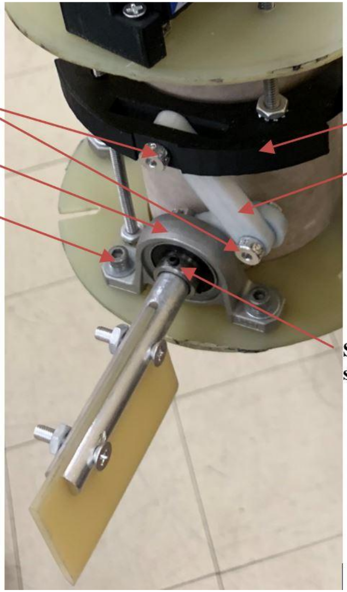
- Driven by a rack and pinion design rather than a lead screw, allowing for faster changes of the canard fins' angles
- Two screws and an Aluminum rod hold the canard fins in place to ensure their strength during flight



ASACU

- Canard fin design has been simplified in hopes that it will ease the aerodynamic complications that come with controlling the rocket’s roll in-flight





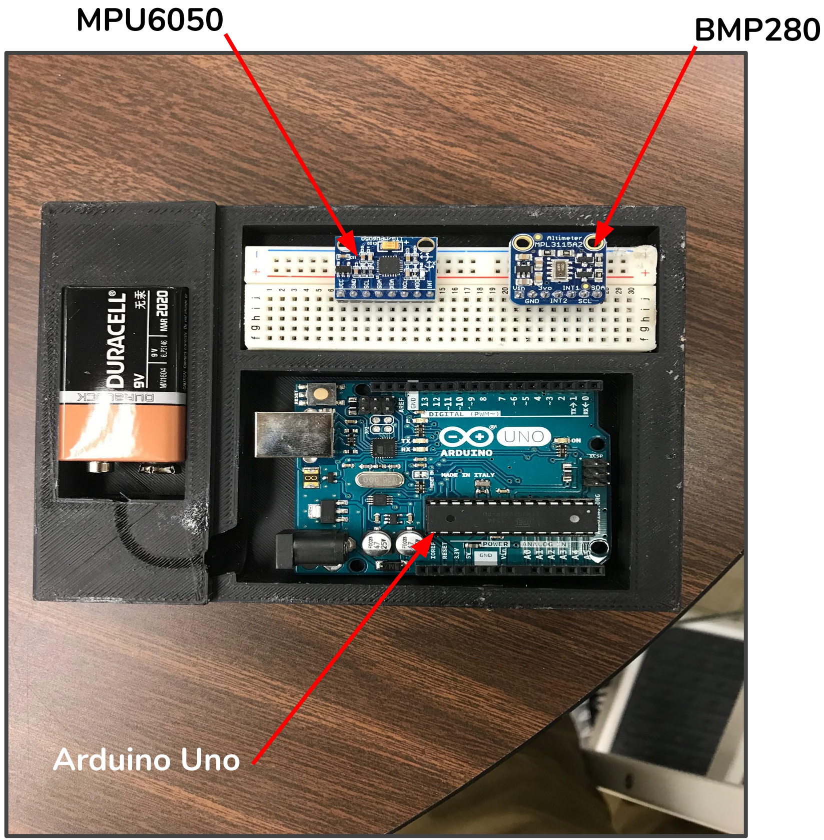
As-Built ASACU

- Mechanism is built and fits well within the airframe (picture taken before assembly of main fins)
- Only the electronics will be accessible via a “window” section cut from the airframe, located above the servo
- This window will have an electronics housing epoxied to it, housing the breadboard, microcontroller, and power supply
- The rack is attached by a threaded rod to the black disc that controls the canard fins. It will be held in place by lock nuts to ensure that it doesn’t rotate and displace from its mating gear during flight

ASACU Integration & Movement

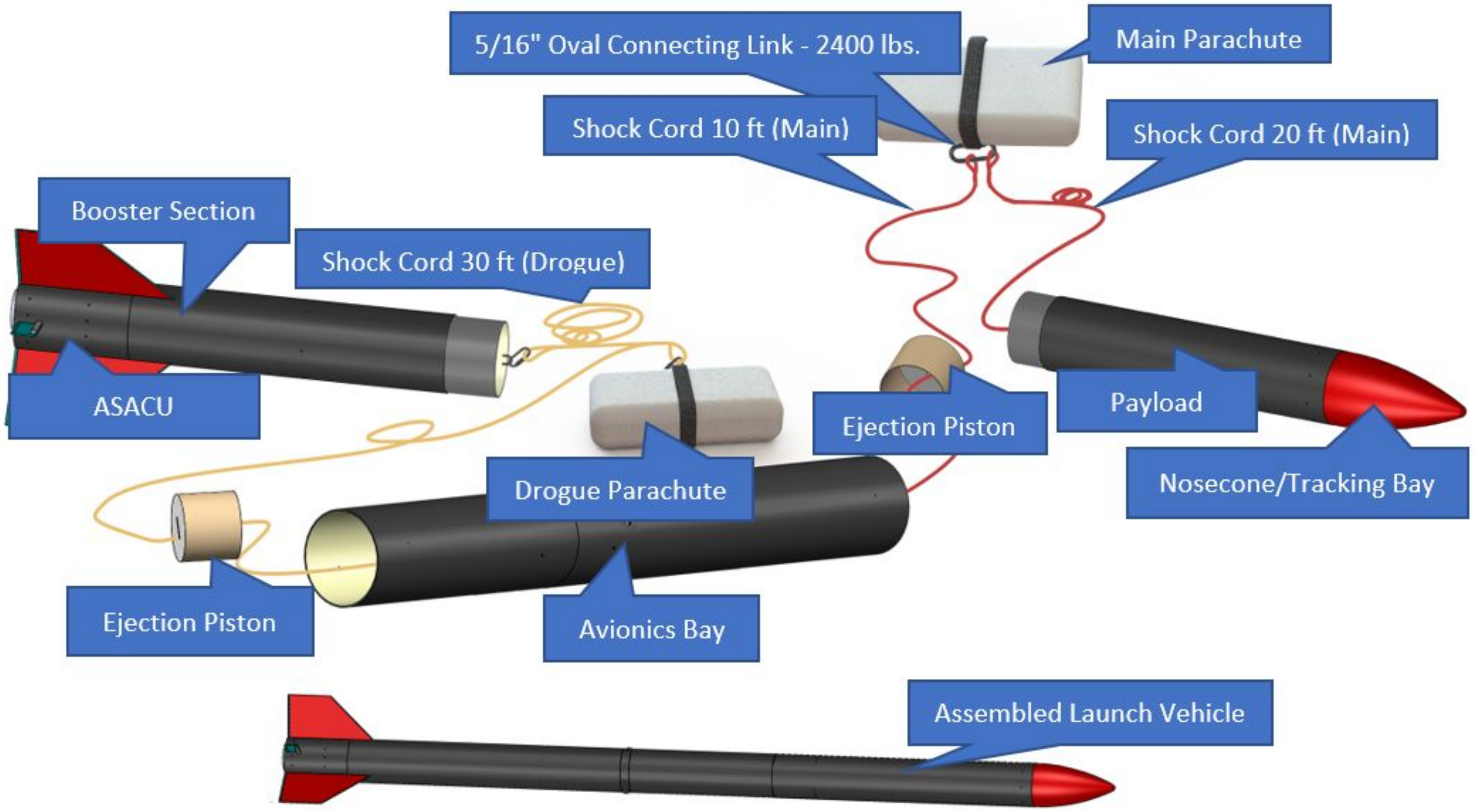
ASACU Code

- The ASACU will compare its current state to tabulated values of the ideal trajectory so that it may decide how much drag should be introduced to the system
- CFD simulations were recently ran to compile data on the drag/lift created by the canard fins at certain angles
- SAP is currently working to integrate this data into the code, allowing the unit to foresee the effects of certain angle changes and use that information to determine what maneuver should be made

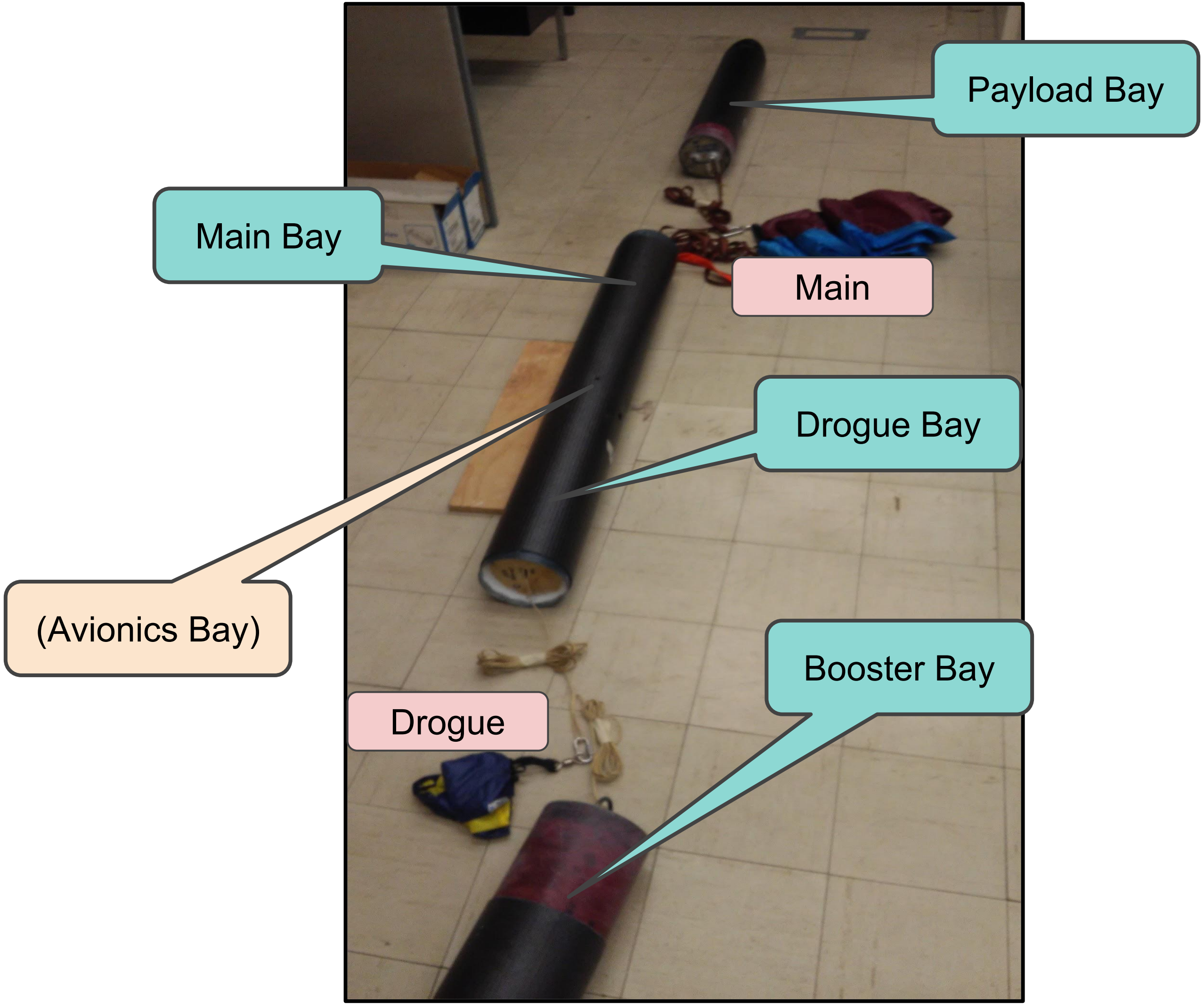


Recovery Subsystem (R&N)

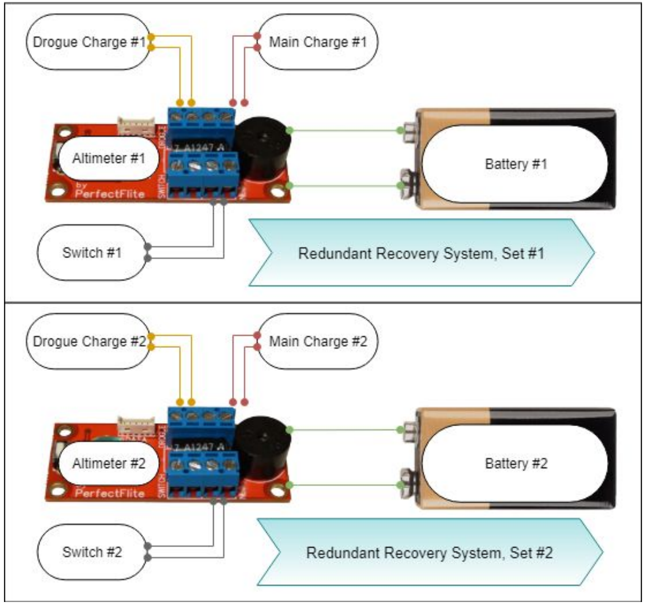
Recovery Subsystem - Overview



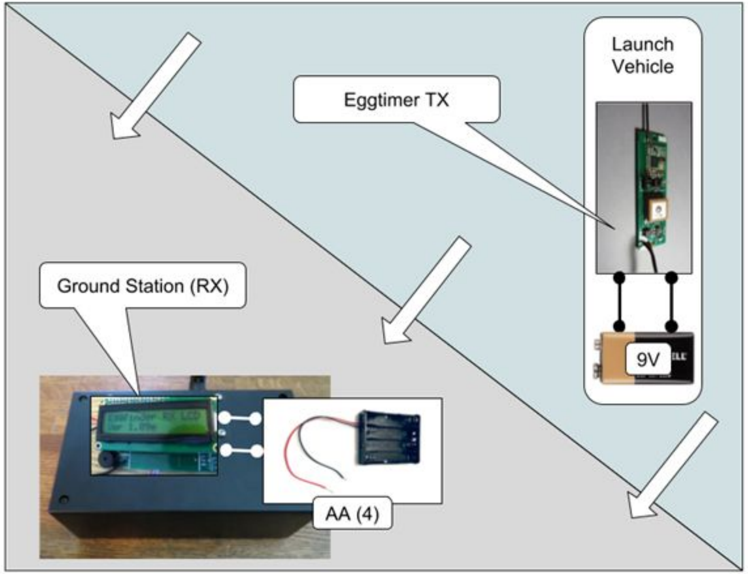
Recovery Subsystem - Overview



Recovery Subsystem - Avionics

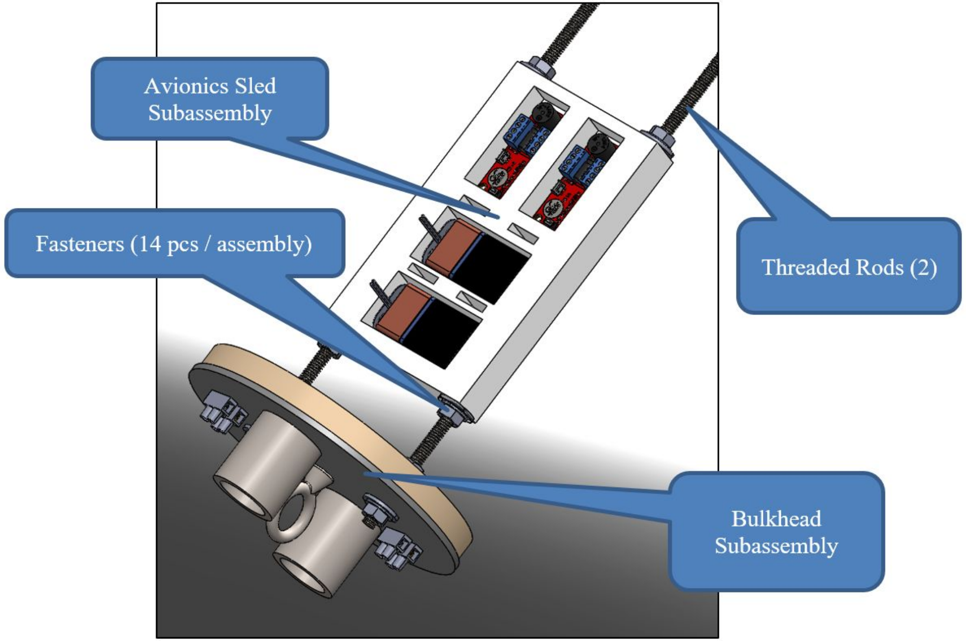


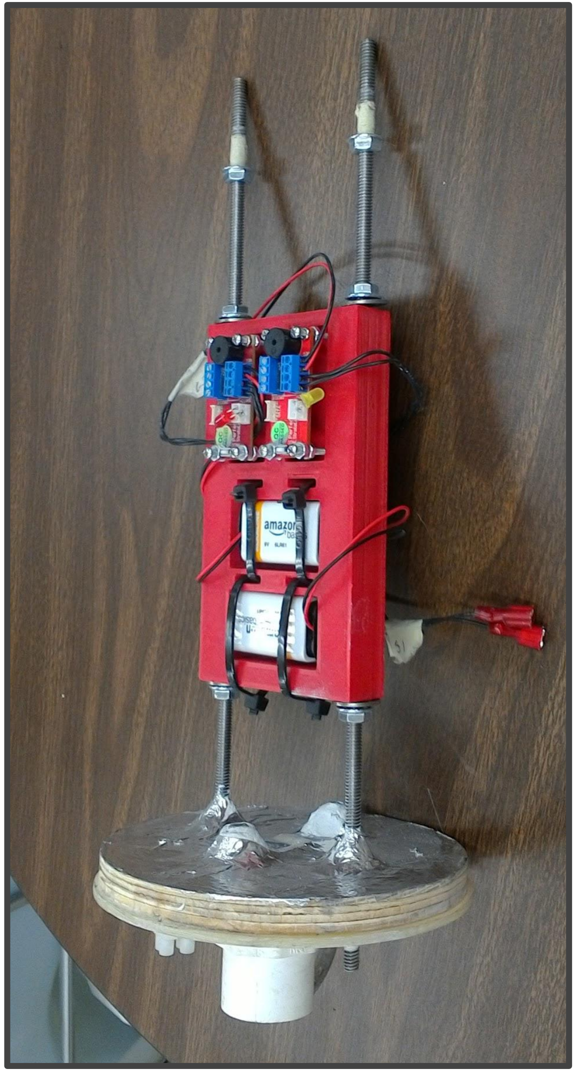
Electronic Redundancy in Altimeter Bay



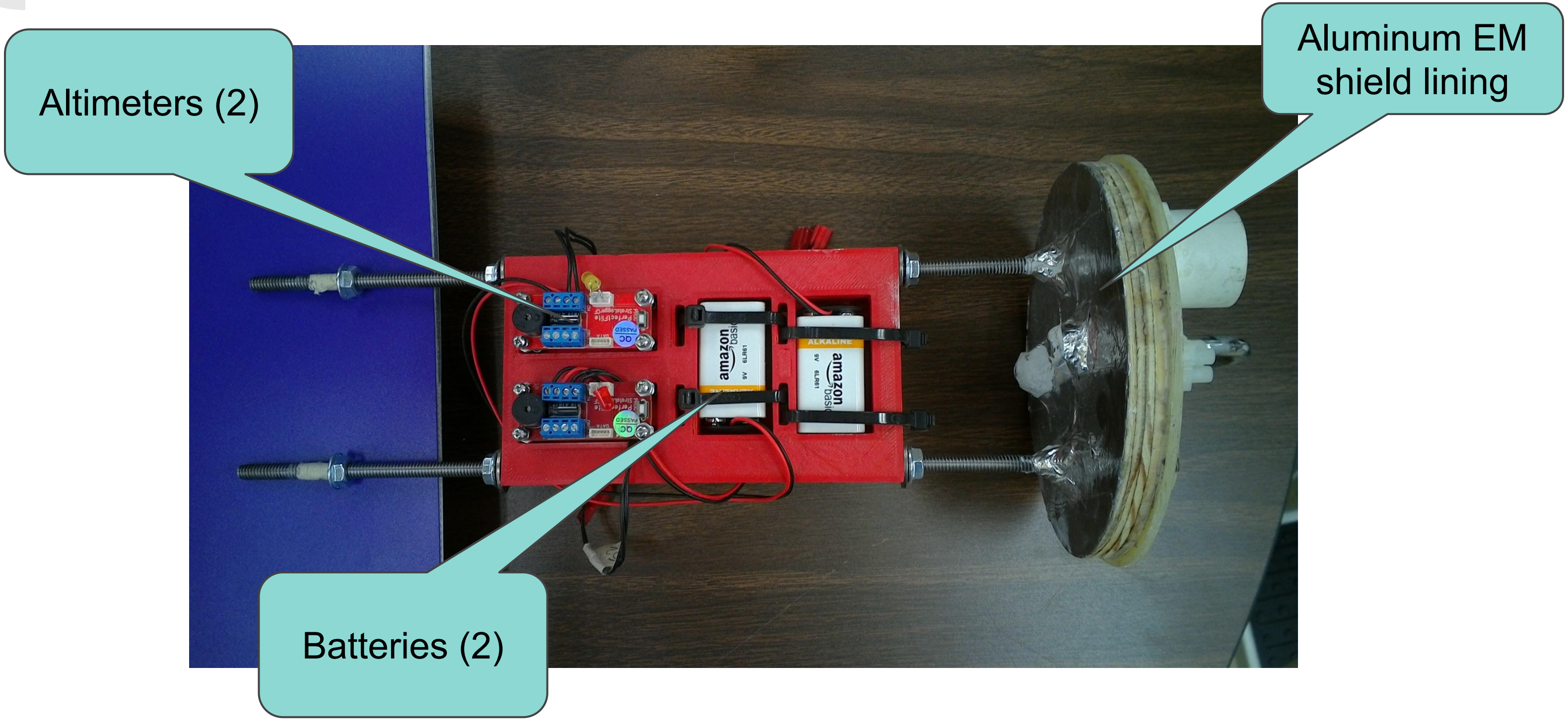
Tracking Bay Function

Recovery Subsystem

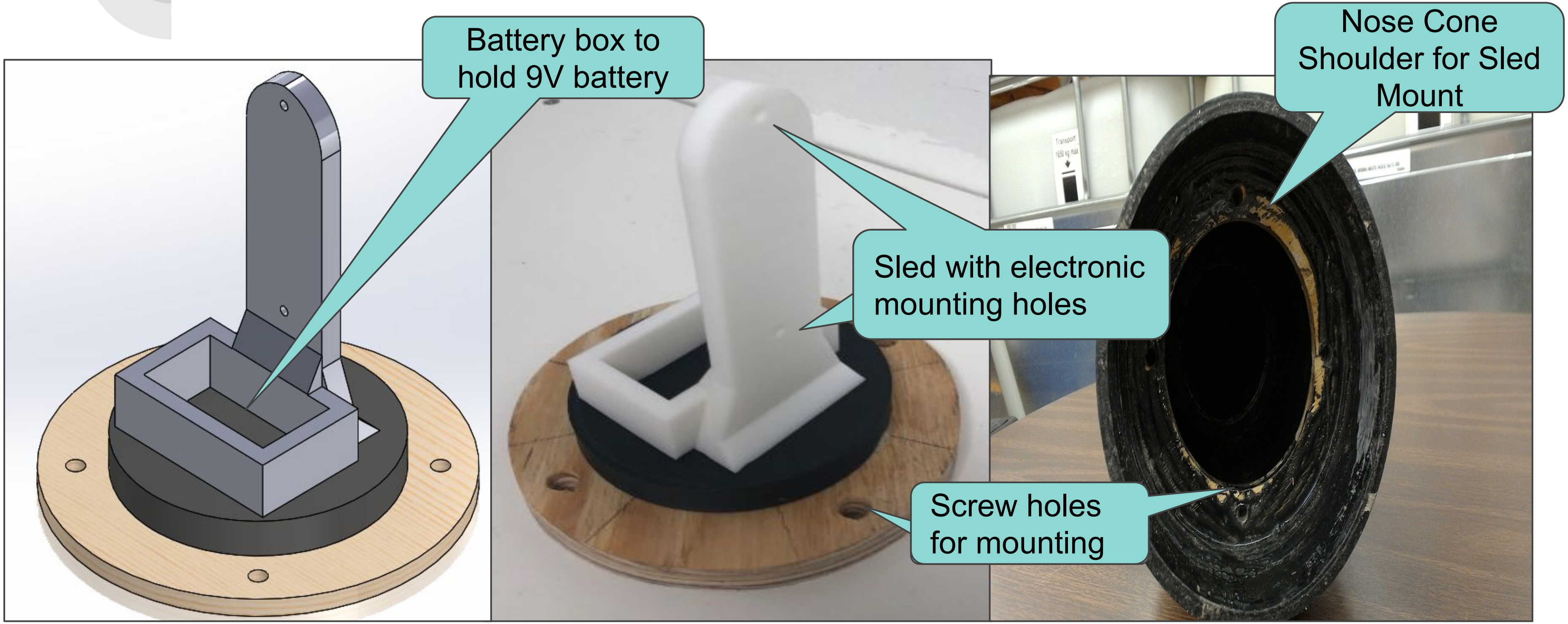




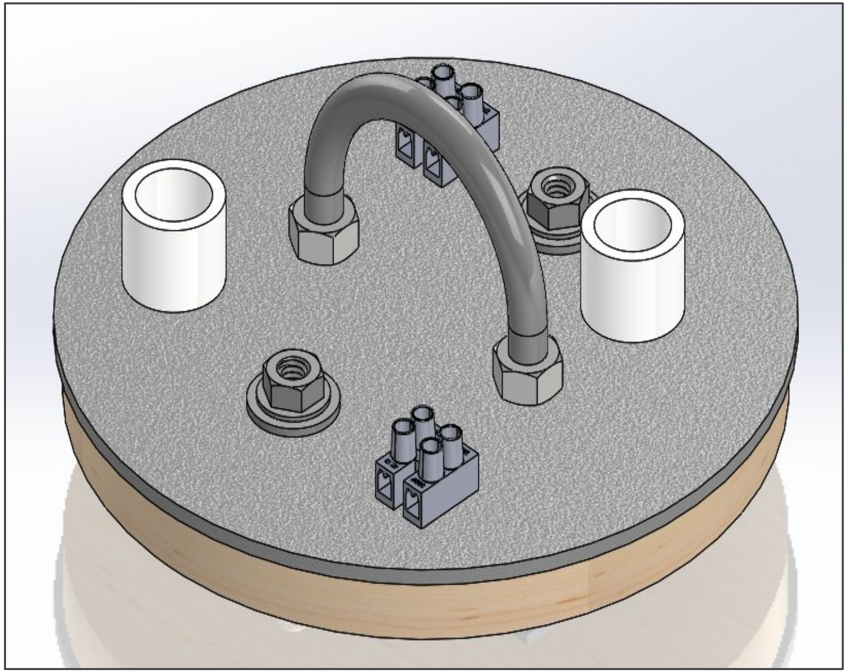
Recovery Subsystem - Avionics

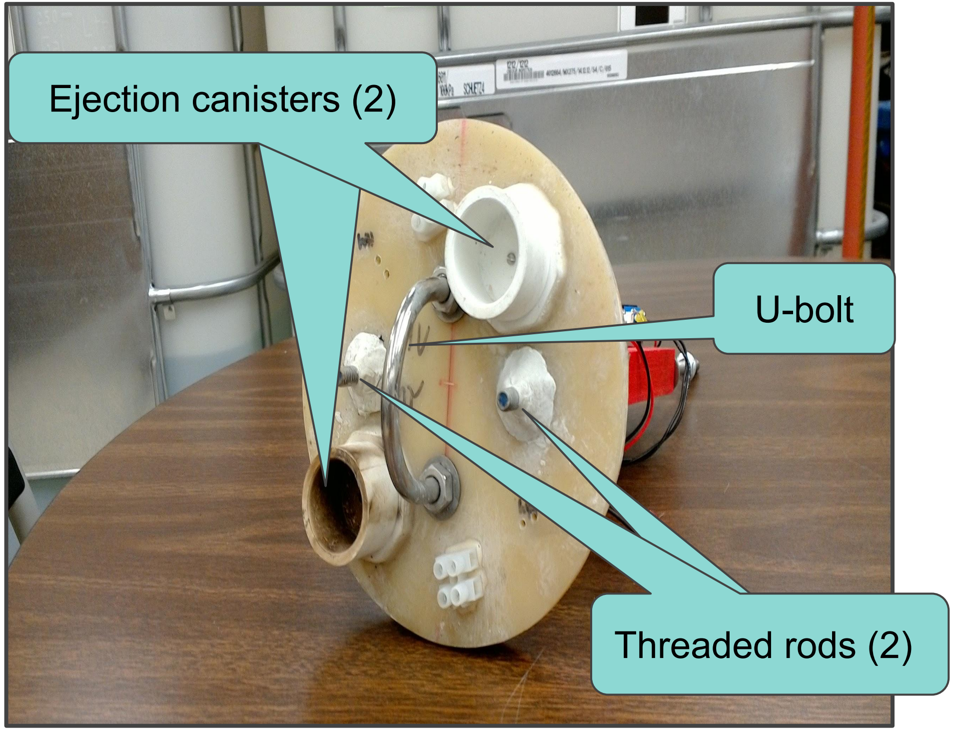


Recovery Subsystem - Tracking Bay



Recovery Subsystem - Bulkheads





Recovery Subsystem - Equipment

Main Parachute

Diameter:	Shape:	Material:	Drag Coefficient:	Terminal Velocity:
8 [ft]	Toroidal	Ripstop Nylon	2.20	18.4 [ft/s]

Drogue Parachute

Diameter:	Shape:	Material:	Drag Coefficient:	Terminal Velocity:
2 [ft]	Elliptical	Low-Porosity 1.1 Ripstop Nylon	1.6	86.3 [ft/s]

Parachute sizes, and descent rates

Recovery Subsystem - Equipment

Main Parachute Shock Cords

Thickness:	Length:	Material:	Load Rating:	Safety Factor:
0.5 in	10 ft	Tubular Nylon	2,200 lbf	4
	20 ft			

Drogue Parachute Shock Cord

Thickness:	Length:	Material:	Load Rating:	Safety Factor:
7/16 in	30 ft	Tubular Kevlar	5300 lbf	17.5

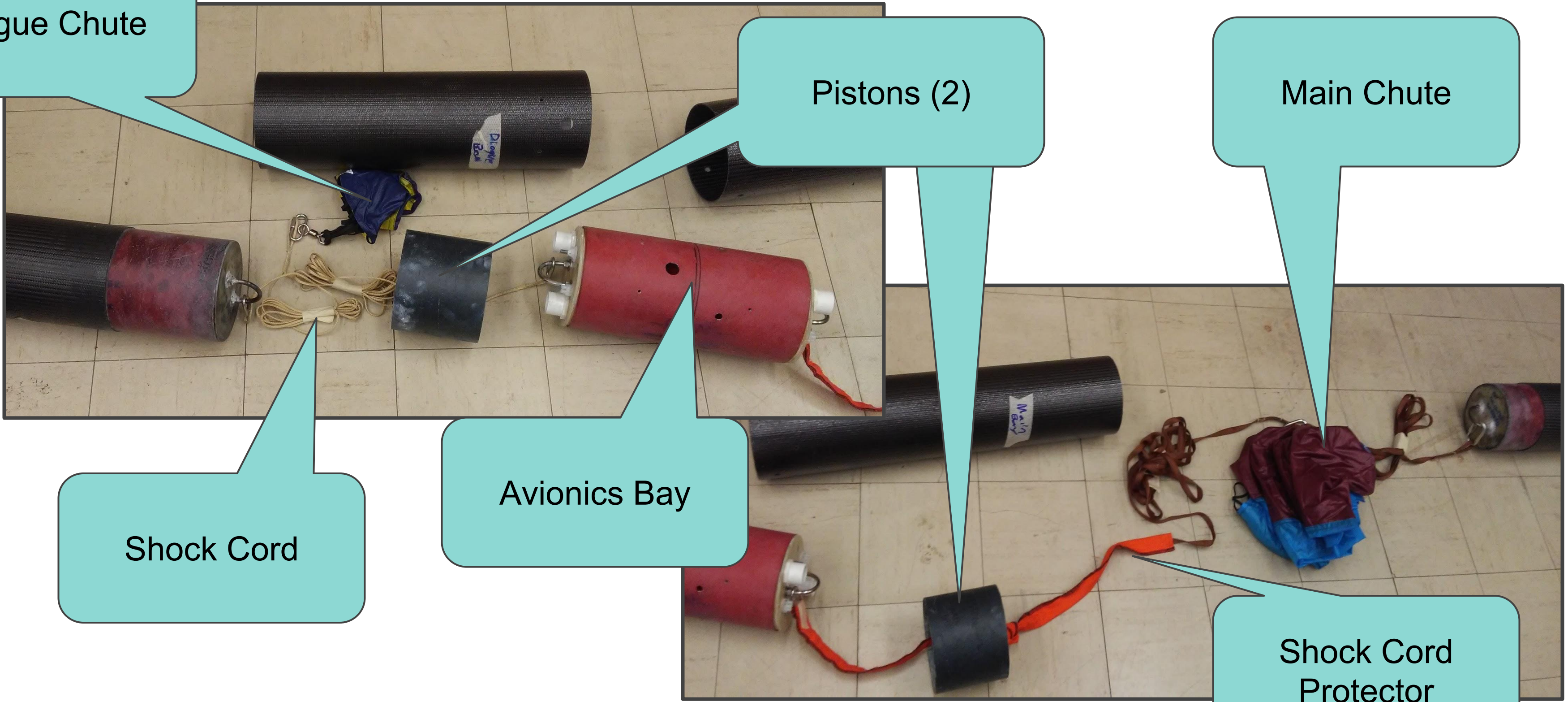
Recovery harness type, size, and length
the-rocketman.com/kevlar-nylon-shock-cords/

Recovery Subsystem - Equipment

Main Parachute
the-rocketman.com/iris-parachutes/

Drogue Parachute
the-rocketman.com/chutes.html

Recovery Subsystem - Equipment



Recovery Subsystem - Kinetic Energy

Main Parachute Deployment Kinetic Energy

Section:	Joined Booster and Avionics Bay	Forward (Payload)
Kinetic Energy [lb-ft]:	2466	1755

Launch Vehicle - Deployment Kinetic Energy

Section:	Booster	Avionics Bay	Forward (Payload)
Kinetic Energy [lb-ft]:	74.5	45.7	57.7

Recovery Subsystem - Descent & Drift

The Launch Vehicle has a calculated descent time of: 81.8 seconds

OpenRocket Predictions

Wind Speed [mph]:	0	5	10	15	20
Drift [ft]:	6.5648	543.5	1086.4	1605.3	2116.9

Analytical Predictions

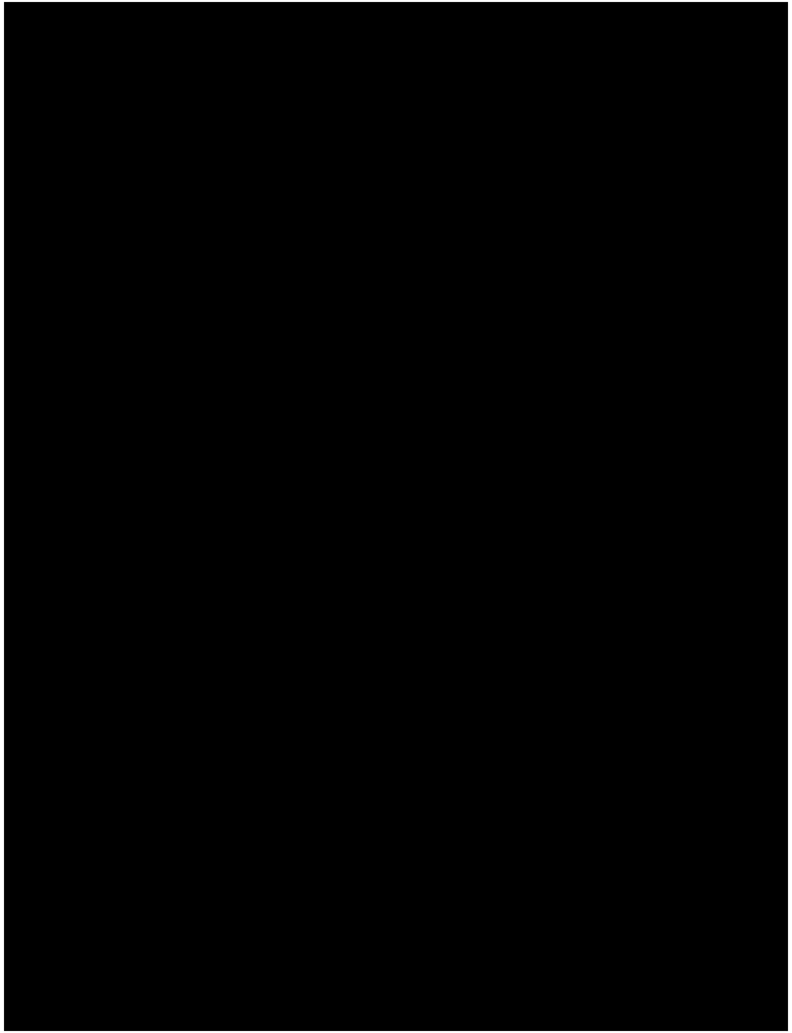
Wind Speed [mph]:	0	5	10	15	20
Drift [ft]:	0	596	1192	1787	2383

Ground Ejection Test

- Ground ejection tests were performed to verify the amount of black powder in ejection canisters for parachute deployment.
- The tests were very successful, as the initial estimates of black powder were sufficient in separating the rocket segments

Ground Ejection Test

Recovery System Properties - Energetics		
Ejection System Energetics (ex. Black Powder)		Black Powder [g]
Energetics Mass - Drogue Chute (grams)	Primary	1.25
	Backup	1.38
Energetics Mass - Main Chute (grams)	Primary	2.83
	Backup	3.11



Recovery Subsystem - Procedures

Procedure document ensures:

- All necessary components are present
- All electrical connections are verified
- Avionics are armed properly
- Black powder has been measured
  - Ground ejection test
- Vehicle is tethered

Pre-launch Procedures

Note: This document assumes that you have all required items to prepare the R&N system. If you haven't yet, make sure to check the items you have against the Item Checklist

#	✓	Step	Completed by	Verified by
RN1	☐	Before beginning to prepare the R&N system, ensure that all nearby devices capable of producing an electromagnetic field are not powered. No interference should be present for the safety of those present at the launch site.		
RN2	☐	Mount electronics to avionics sled (batteries, cables for external connections, transmitters, etc.).		
RN3	☐	Slide the avionics bay into the coupler and fasten it with washers and nuts from CBS.		
RN4	Use **ONLY** Quick-Disconnect links that have been tested to connect the altimeters to the switches.			
RN4.1	☐	Switch 1 - Positive		
RN4.2	☐	Switch 1 - Negative		
RN4.3	☐	Switch 2 - Positive		
RN4.4	☐	Switch 2 - Negative		
RN4.5		Main Chute - Charge 1, E-Match		
		Main Chute - Charge 2, E-Match		
		Drogue Chute - Charge 1, E-Match		
		Drogue Chute - Charge 2, E-Match		
		Main Altimeter - Battery		
		Backup Altimeter - Battery		
RN5	☐	Make sure the altimeter can be turned on using the switch in the installed position. Ensure that the altimeters are programmed correctly (e.g. one with apogee delay, both at the same main deploy altitude, etc.)		
RN6	☐	Fasten the bulkheads to the coupler to close the avionics bay.		
RN7	☐	Add black powder charges and e-match tips to canisters.		
RN7.1	Main Charge 1 Mass:	______________________ grams		
RN7.2	Main Charge 2 Mass:	______________________ grams		
RN7.3	Drogue Charge 1 Mass:	______________________ grams		
RN7.4	Drogue Charge 2 Mass:	______________________ grams		
RN8	☐	Attach the shock cords to the parachutes and eyebolts.		
RN9	☐	Fold the parachutes and insert them into their respective bays with the pistons, as necessary.		
RN10	☐	Install shear pins into the vehicle		
RN11	☐	Turn on the tracking electronics (connect to power, ensure a connection with ground station)		
RN12	☐	Secure tracking sled to nosecone.		

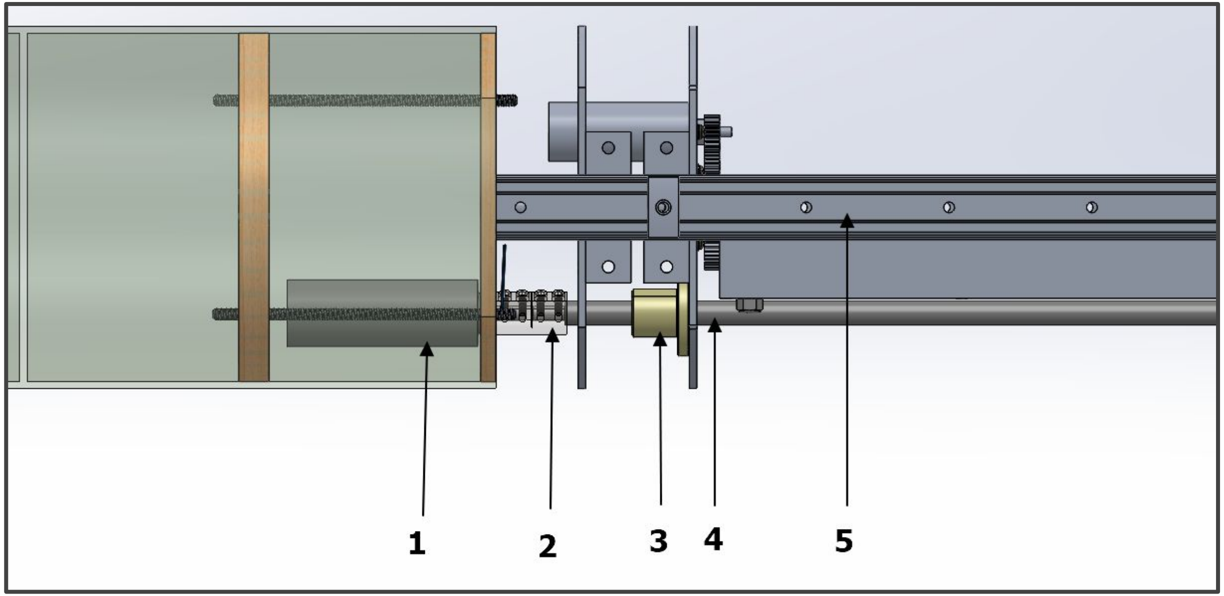
Payload Subsystem (PAY)

Key Changes Since CDR

- Redesigned orientation mechanism for increased reliability.
- Drone size optimized and payload bay airframe shortened to 30 in.

DRES Exit Mechanism

- Drone Re-orientation and Exit Mechanism system (DRES) exits the drone platform using a lead screw connected to a DC motor.
- Linear rails ensure smooth exit.



1 - DC Motor

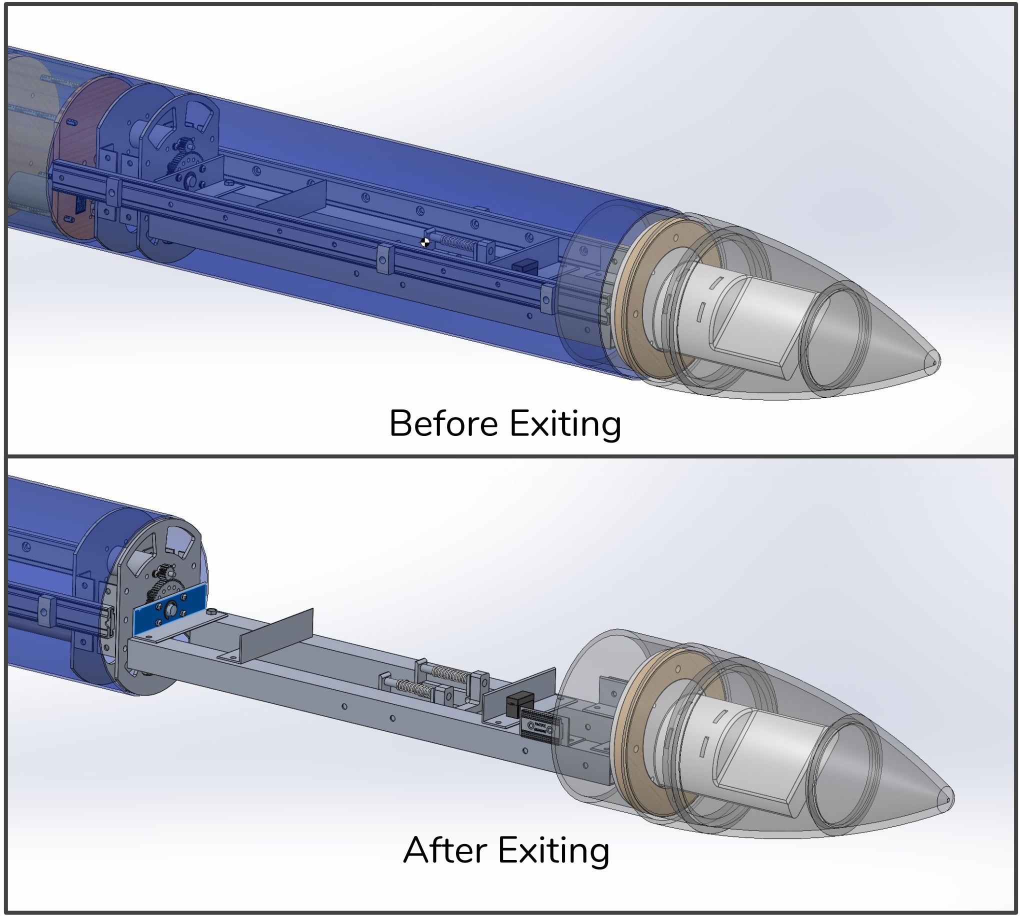
2 - Lead Screw Coupler

3 - Lead Screw Nut

4 - Lead Screw

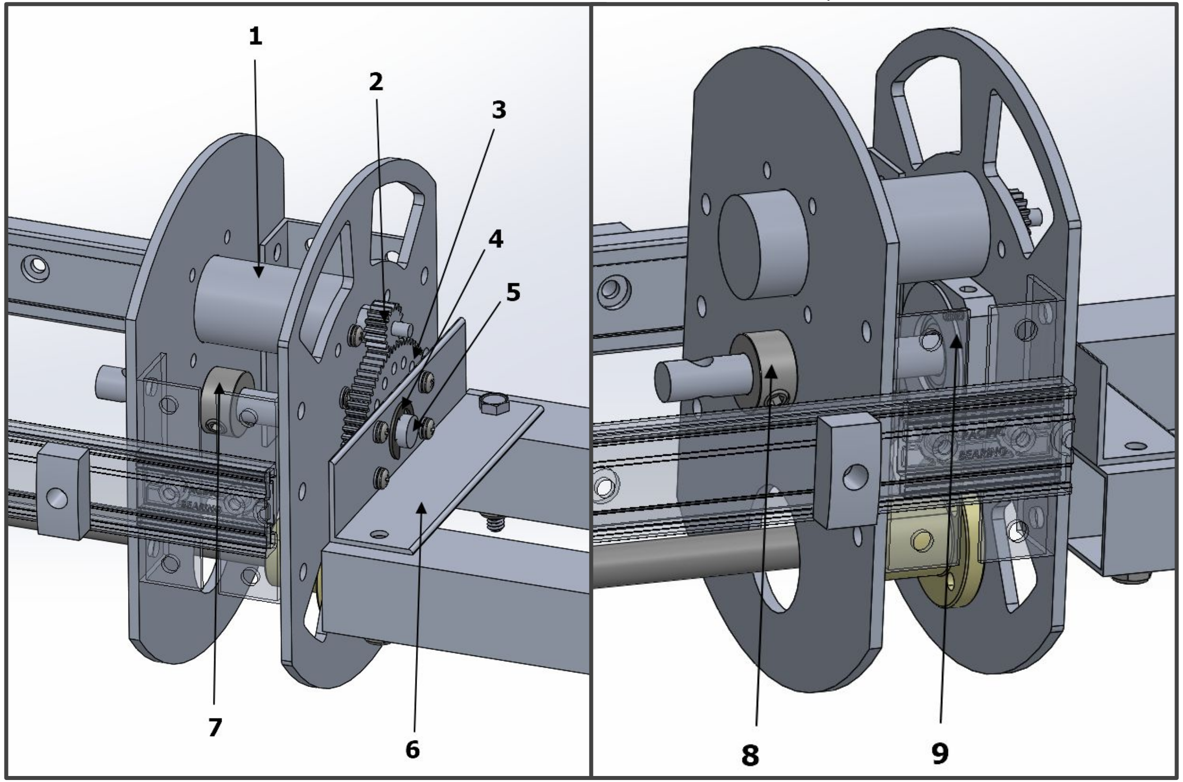
5 - Linear Rail

DRES Exit Mechanism



DRES Orientation Mechanism

- DC motor rotates the drone platform until the drone is upright for take-off.



1 - DC Gear Motor

2 - Driving Gear

3 - Driven Gear

4 - Retaining Ring

5 - Shaft

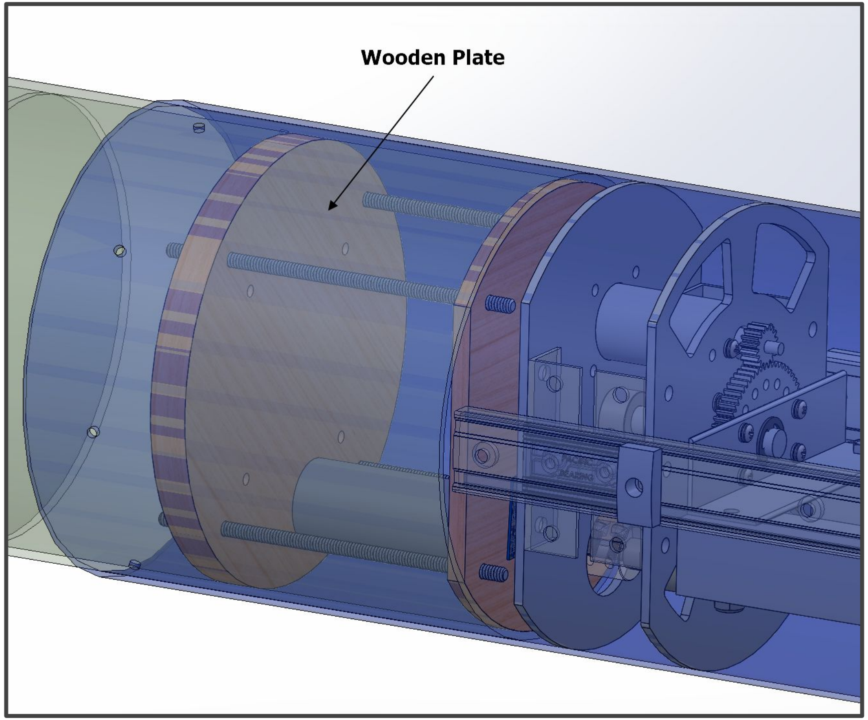
6 - L piece connected to drone platform

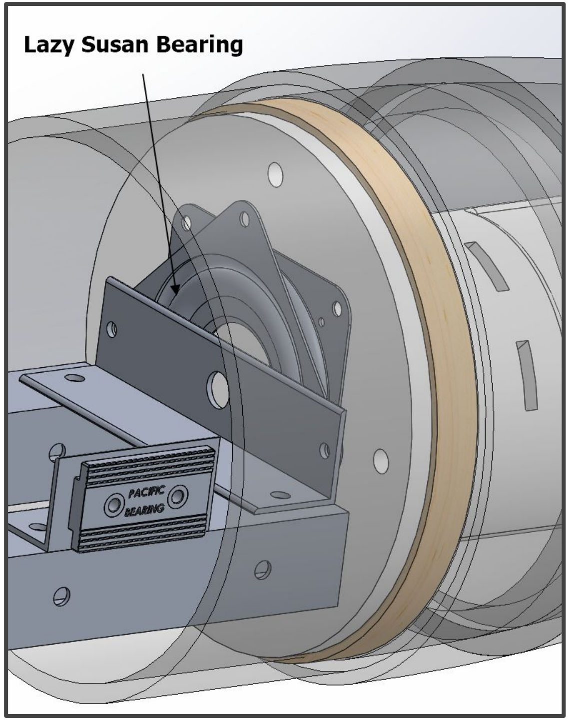
7, 8 - Shaft Collar

9 - Bearing Block

Integration with Vehicle

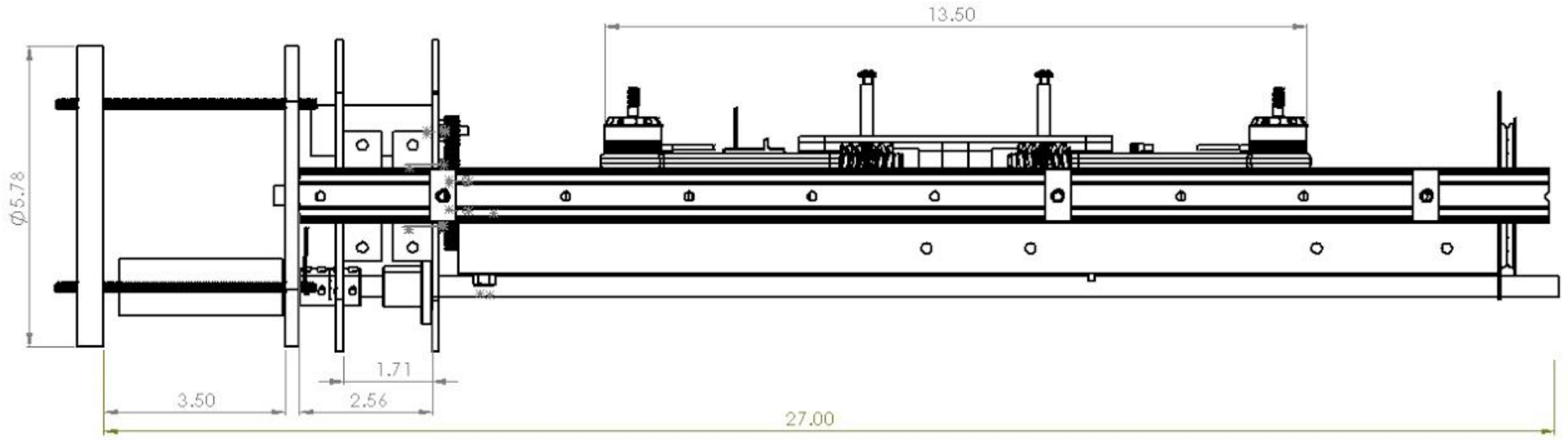
- Bottom of the payload system is a wooden plate that is fixed to the payload coupler using epoxy.
- The top of the payload system is attached to the nose cone via a lazy susan bearing.





Payload Subsystem Dimensions

- Drone is approximately 13.5 in long.
- The payload airframe is approximately 27 in long.



Payload Ground Station Setup

- Drone Transmitter: RadioLink AT9S
  - 2.4 GHz
  - Less than 100 mW
- DRES Transmitter: HC12 module connected to Arduino
  - 433 MHz
  - 100 mW
  - 10 dBi high gain antenna
- FPV Receiver: Eachine RT01 connected to laptop
  - 5.8 GHz
  - 14 dBi high gain panel antenna

Launch Date

- Full scale launch date March 16
- A date late enough to ensure build and verify correct functionality will be selected.