Georgia Tech NASA Flight Readiness Review Teleconference

Presented By:

Georgia Tech Team ARES

Agenda

1. Team Overview (1 Min)
2. Changes Since CDR (1 Min)
3. Educational Outreach (1 Min)
4. Safety (2 Min)
5. Project Budget (2 Min)
6. Launch Vehicle (10 min)
7. AGSE & Flight Systems (13 Min)
8. Questions (15 Min)

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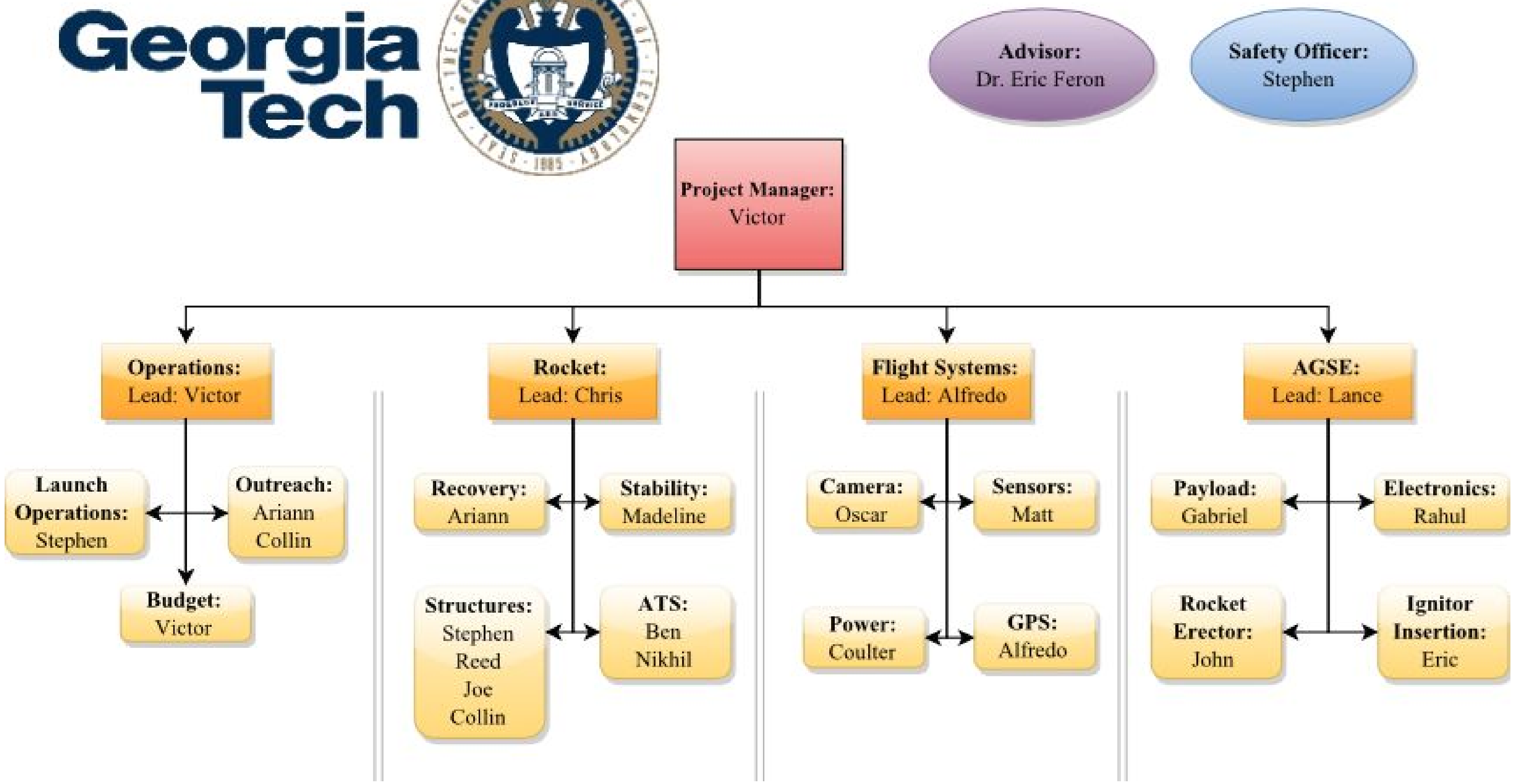
TEAM OVERVIEW

Georgia Tech Team Overview

- 29 person team composed of both undergraduate and graduate students
  - Graduate Students: 1
  - Undergraduates: 28
- Highly integrated team across several disciplines

Work Breakdown Structure



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CHANGES SINCE FRR

Changes since CDR

Subsystem	*Design Change*	*Justification*
GPS Bay	An independent section was created within the nosecone for the GPS, it will be insulated with aluminum foil to prevent signal interference.	The GPS transmit signals at 900MHz that pose a risk of signal interference with other subsystems.
Avionics Bay	New avionics bay configuration and fastening method.	Allows for better user interface and better accommodation of the electronics
ATS	Design was refined and finalized with high torque servo motors and 3D printed flaps	Allows for lower design complexity and eliminates possible points of failure.
Booster	Motor selection finalized as Cesaroni L910	Appropriate mission performance obtained with new selection
Recovery	Parachute resizing to reduce ground impact velocity	Total kinetic energy needed to be reduced due to the increased mass of the finalized design

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EDUCATIONAL OUTREACH

Educational Outreach

- **Atlanta Maker's Faire**
- **FIRST Lego League**
- **CEISMC GT**
- **Frederick Douglass High School**

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SAFETY

Risk Assessment & Launch Vehicle

- Hazard Identification
  - What has the potential to become a safety hazard?
- Risk and Hazard Assessment
  - What are the potential consequences of the hazard?
- Risk Control and Mitigation
  - What can be done to mitigate the risk?
- Reviewing Assessments
  - Are the mitigations working?

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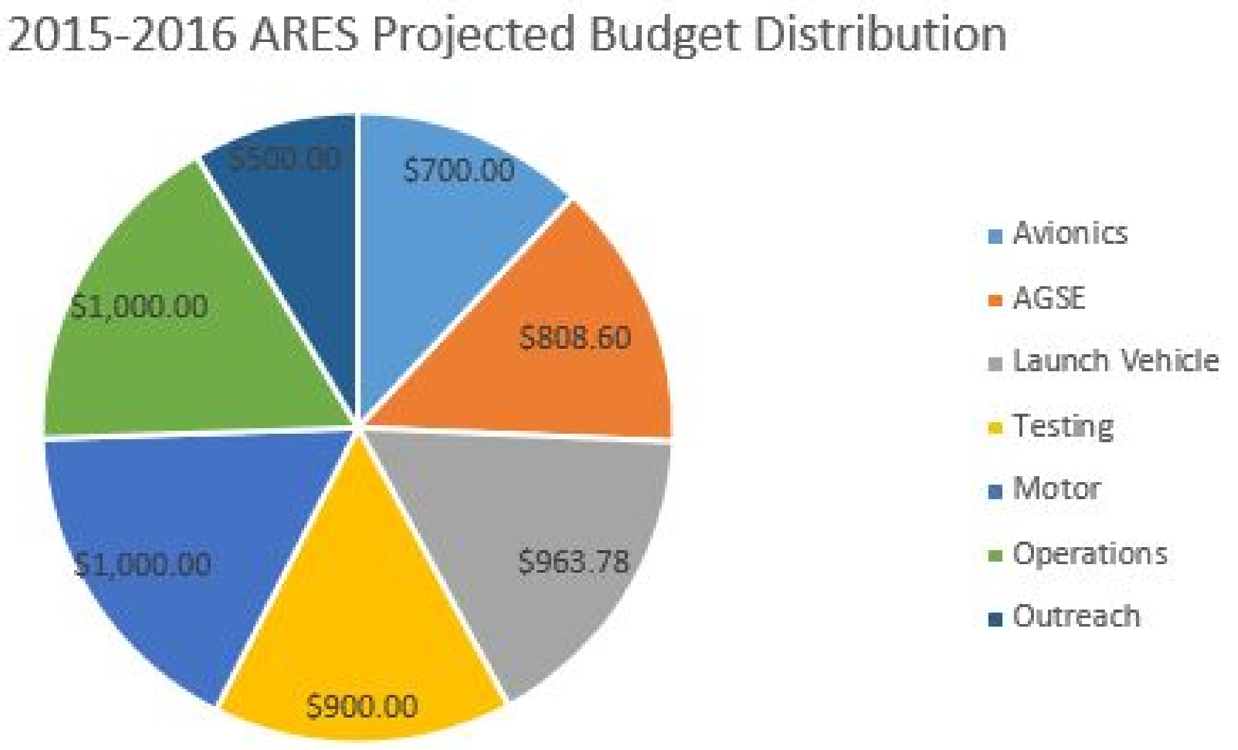
PROJECT BUDGET

Project Budget Summary

Section	*Cost*
Avionics	$700.00
AGSE	$808.60
Launch Vehicle	$963.78
Testing	$900.00
Motor	$1,000.00
Operations	$1,000.00
Outreach	$500.00
Total Budget	$5,872.38



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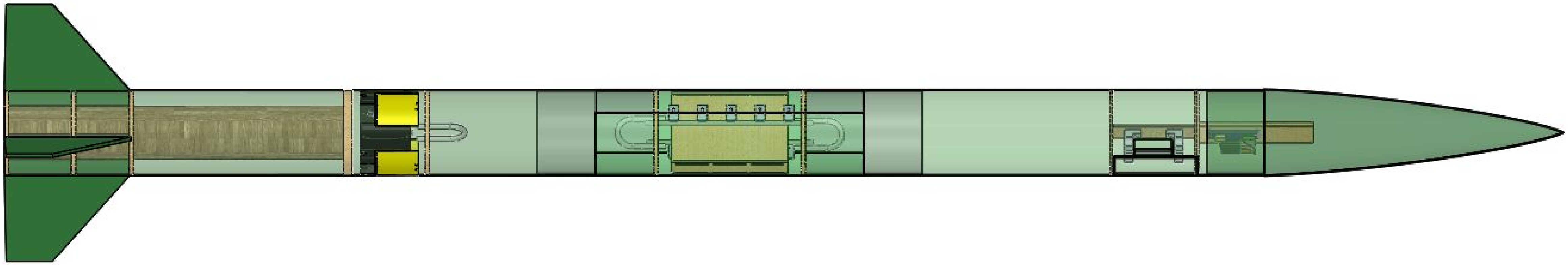
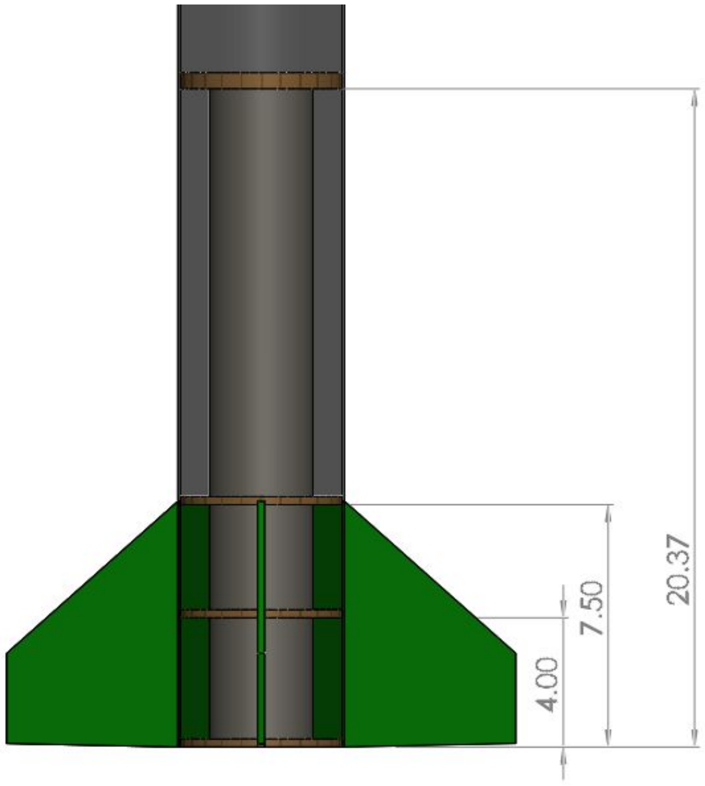
LAUNCH VEHICLE

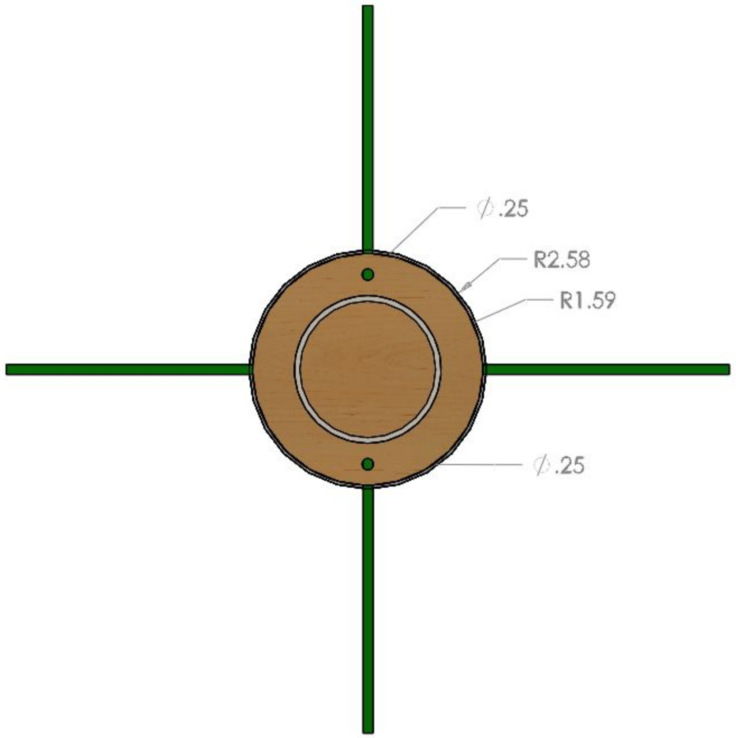
Launch Vehicle Summary

- Predicted apogee: 5464 ft
- Stability margin: 2.13 calibers
- Motor: Cesaroni L910
- Rail Exit Velocity: 52.5 ft/s
- Max Mach: 0.65
- Total weight: 24.56 lbs
- Dual deployment with 30” and 120 “



Booster Section





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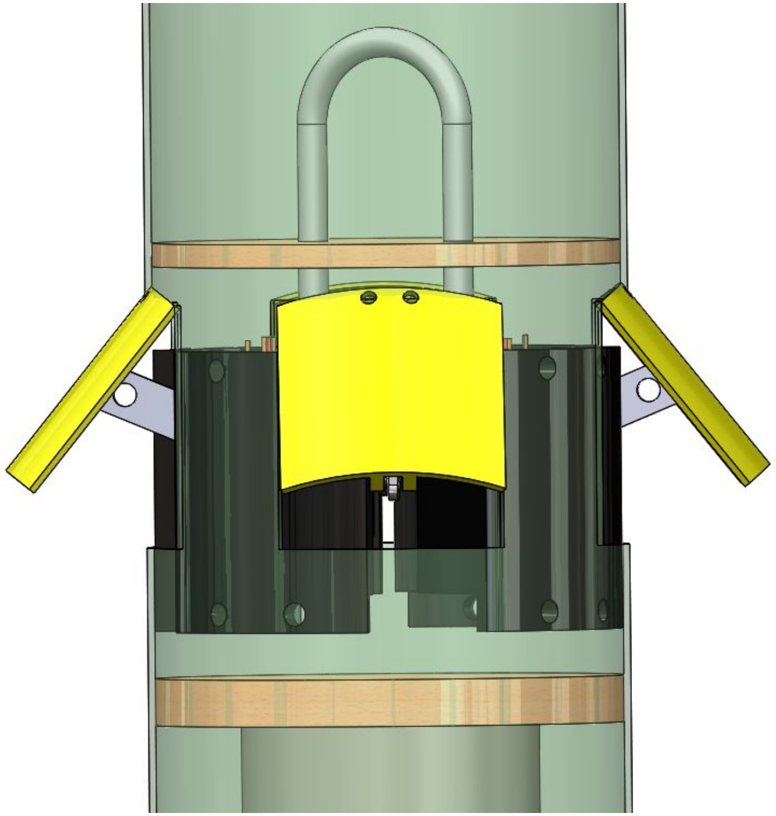
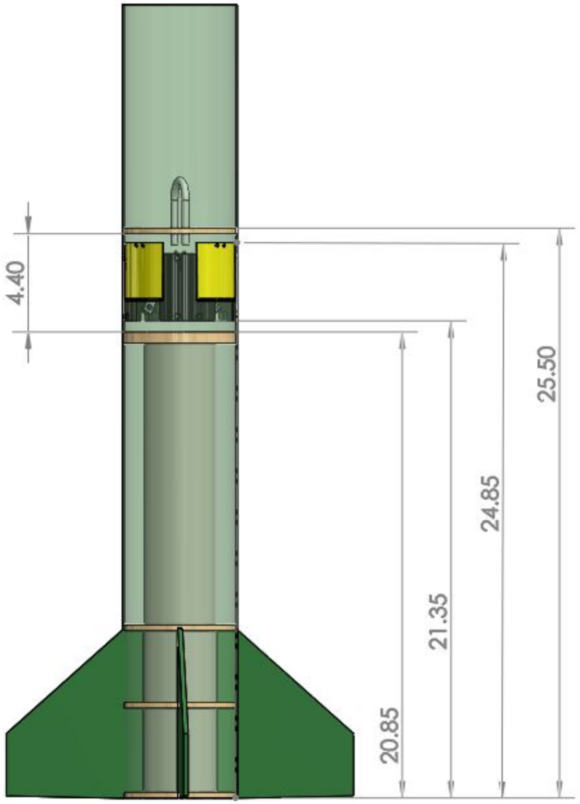
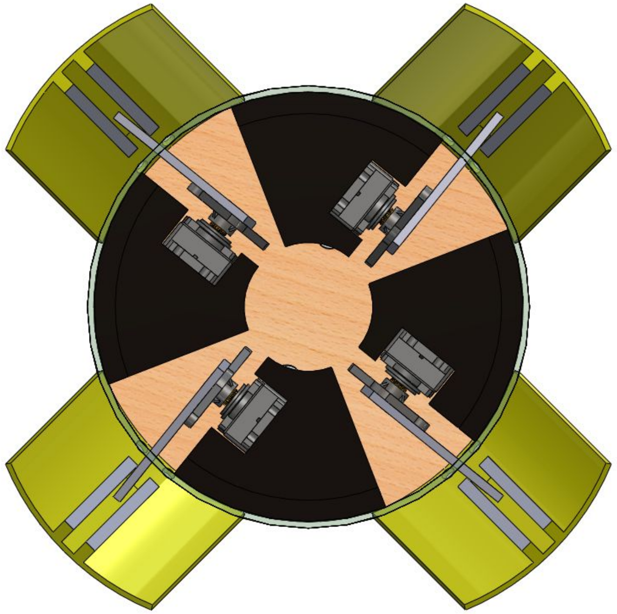
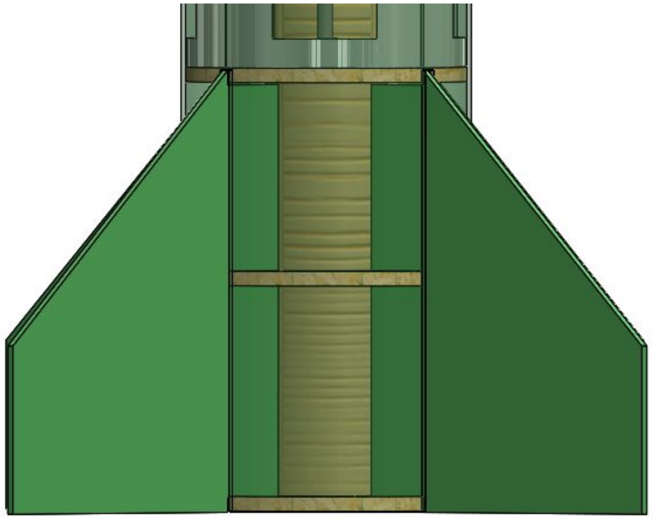
Apogee Targeting System (ATS)

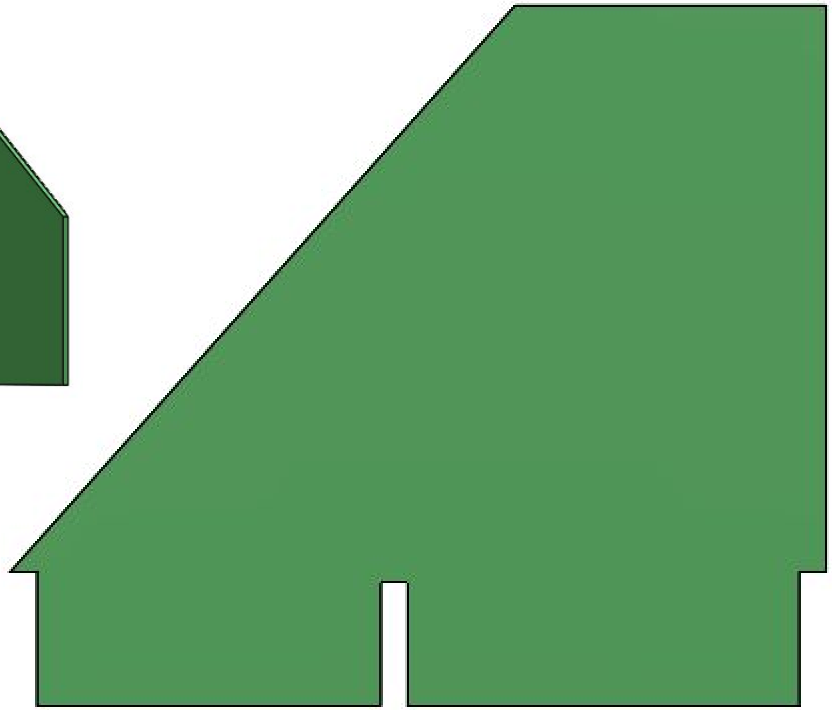






Fins



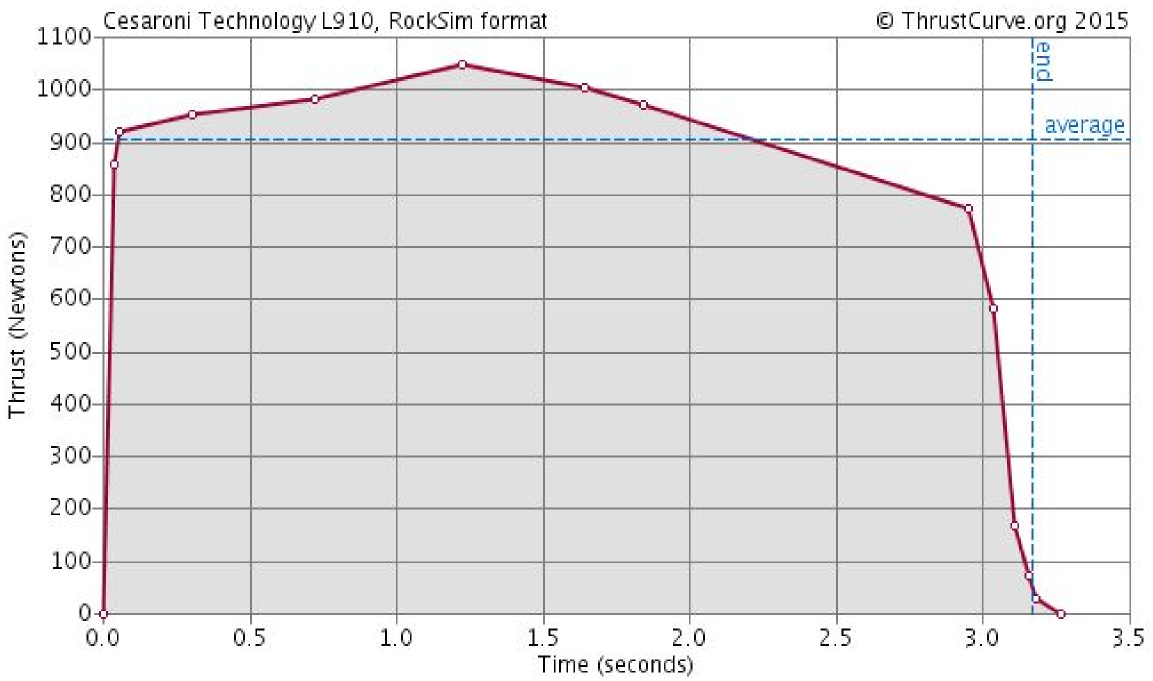


Tip Chord	7 cm or 2.75591 in
Root Chord	19.3 cm or 7.598 in
Thickness	0.318 cm or 0.1252 in
Fin Area	55.23 in^2
Span	13.4 cm or 5.275591 in
Aspect Ratio	0.50392

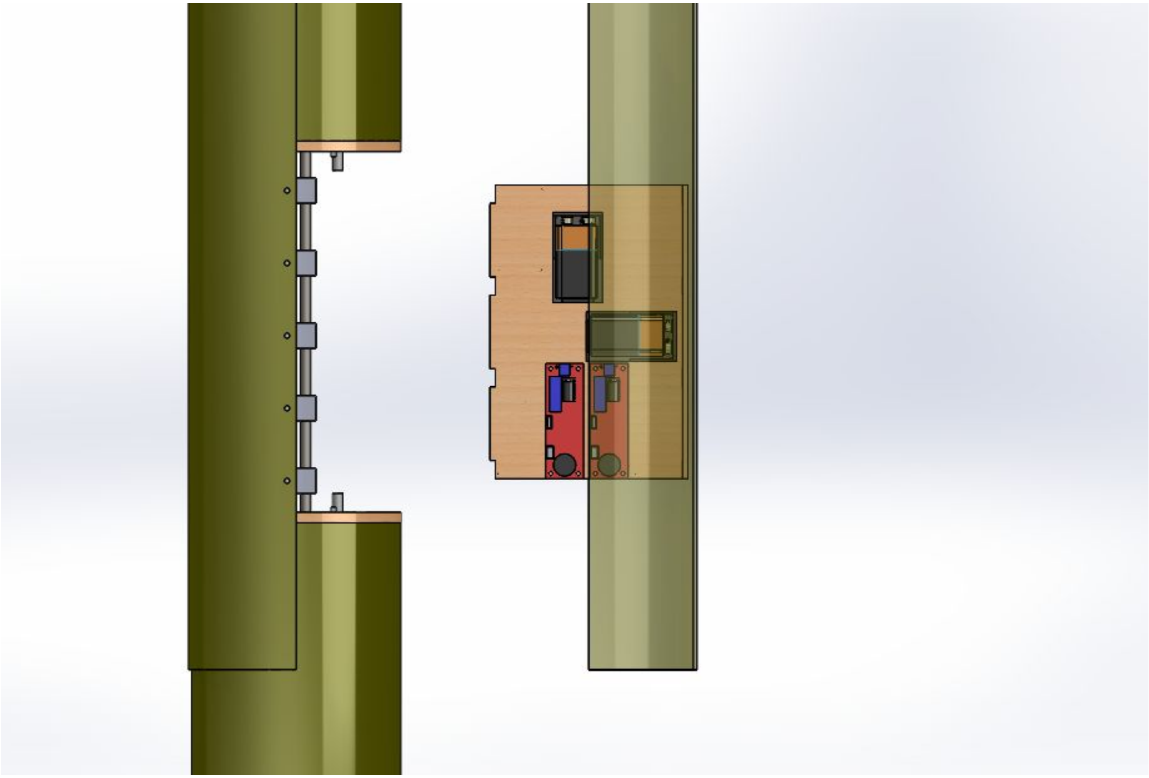
Motor Selection

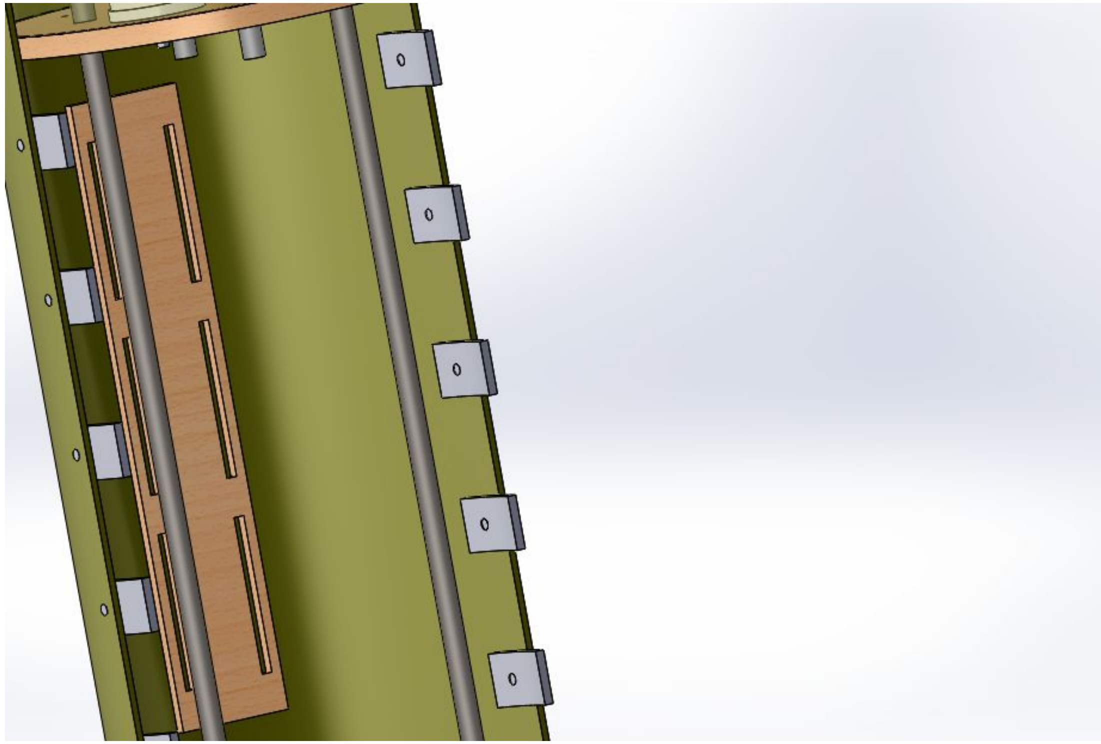
Cesaroni L910

Cesaroni L910	
Diameter	75.00 mm
Length	35.0 cm
Propellant Weight	2.616 kg
Overall Weight	1.270 kg
Average Thrust	907.1 N
Maximum Thrust	1086.1 N
Total Impulse	2,856.1 N-s
Specific Impulse	229 s
Burn Time	3.2 s

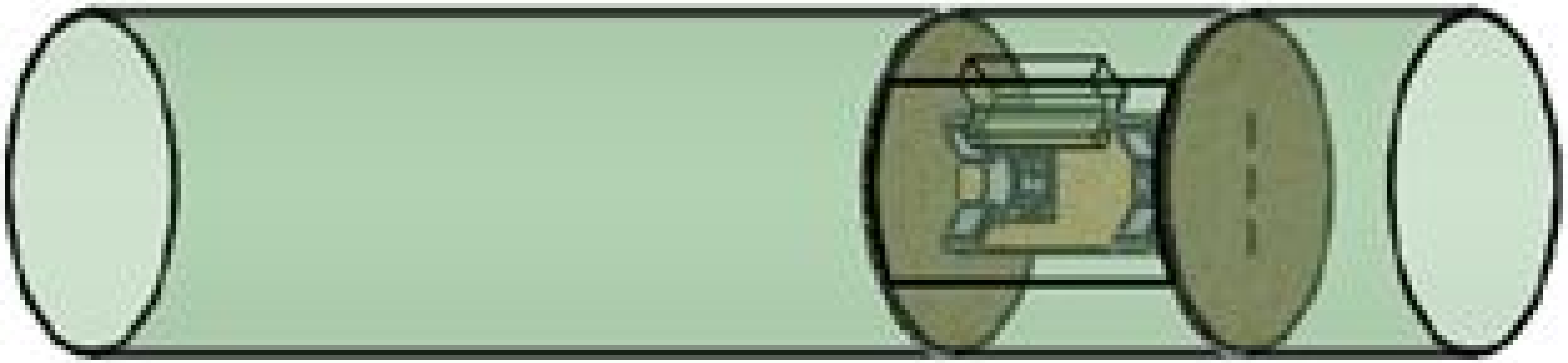


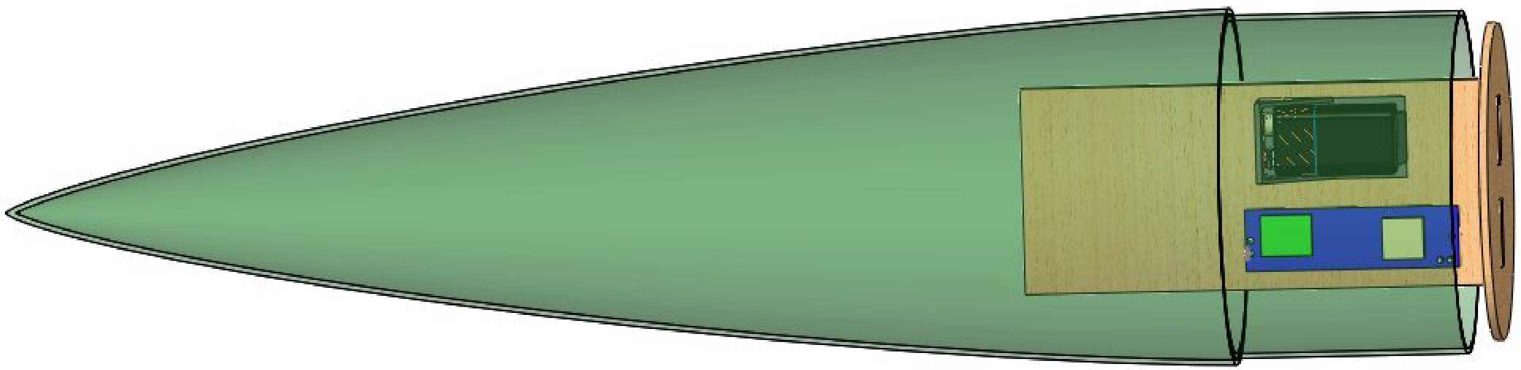
Avionics Bay



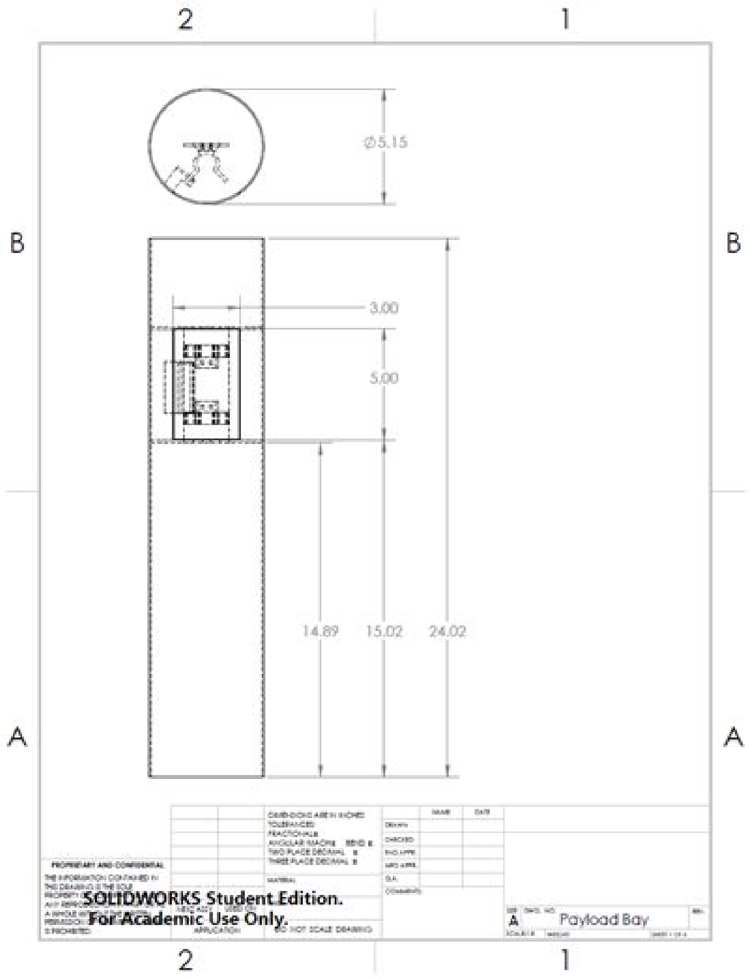


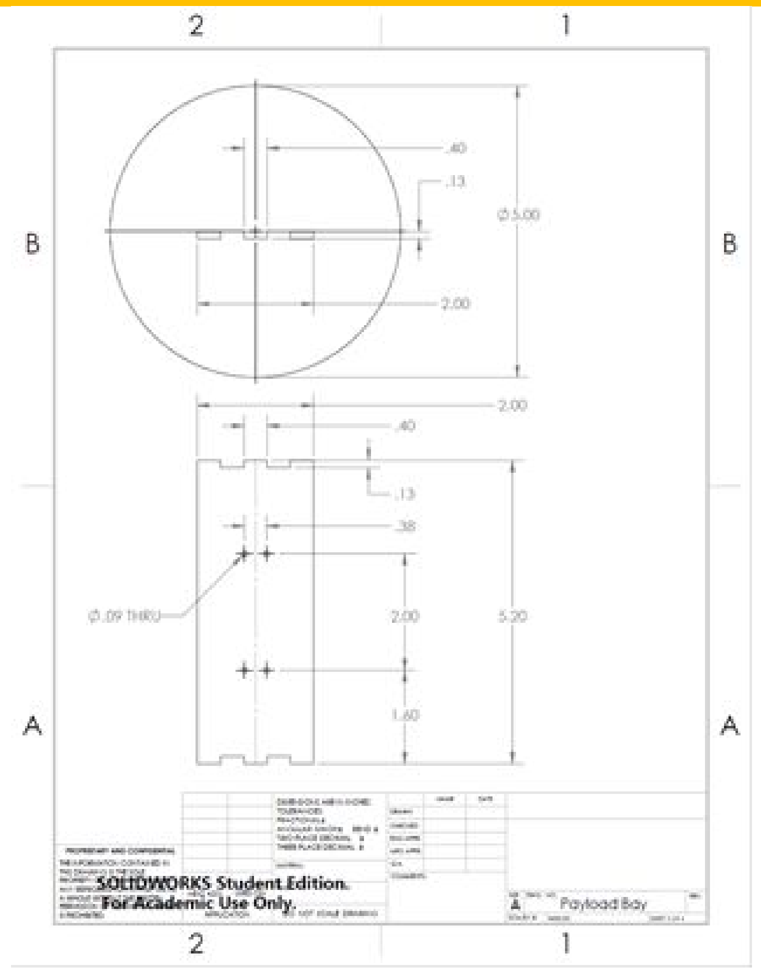
Payload Bay





Payload Bay – Dimension





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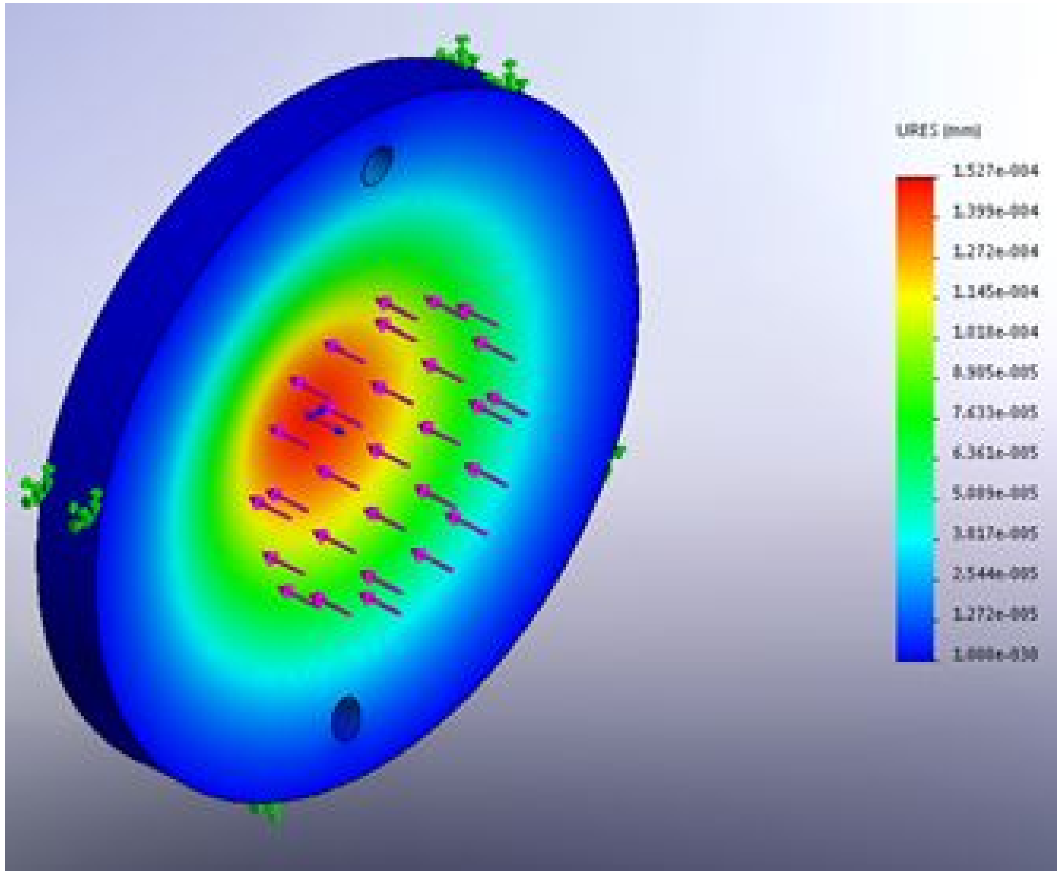
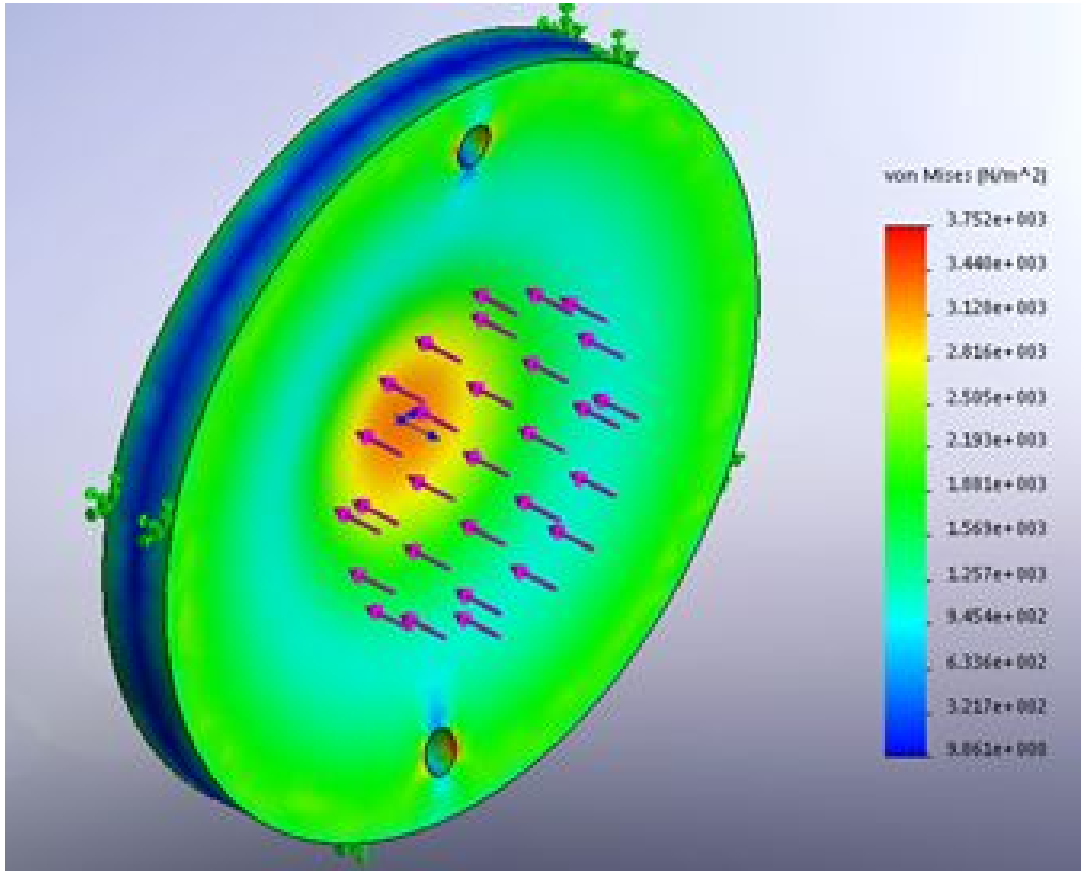
FEA Thrust Plate





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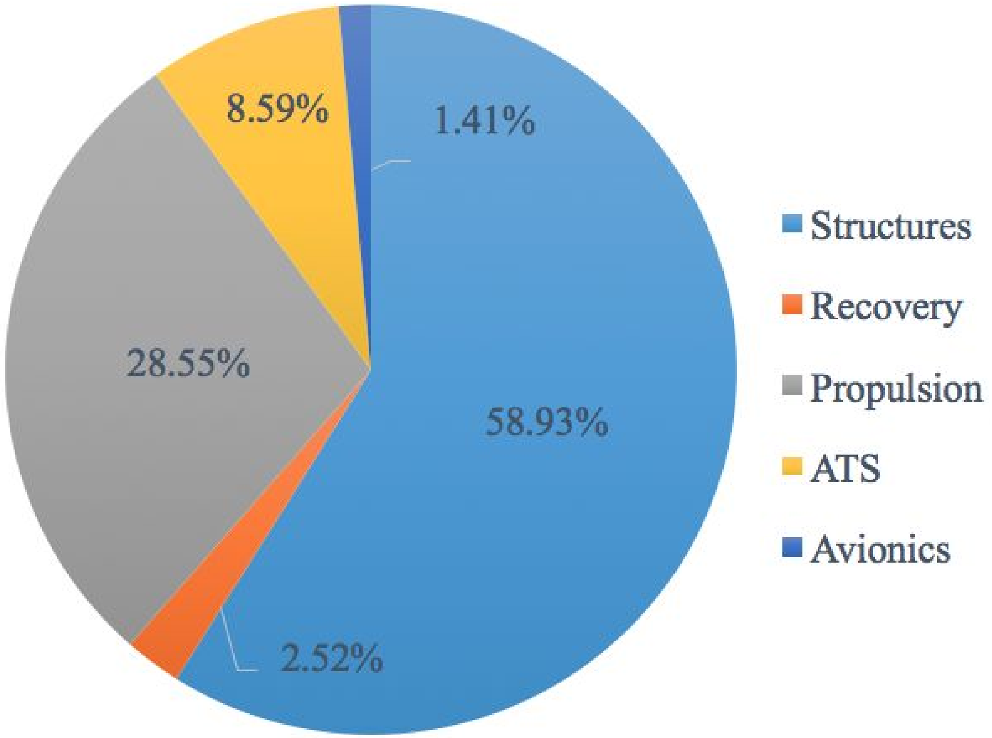
Mass Breakdown



Raw Total	9161.95
Total w/ Error Margin (25%)	11452.4375
Total w/o Propellant	10083.4375

Thrust-to-Weight Ratio *

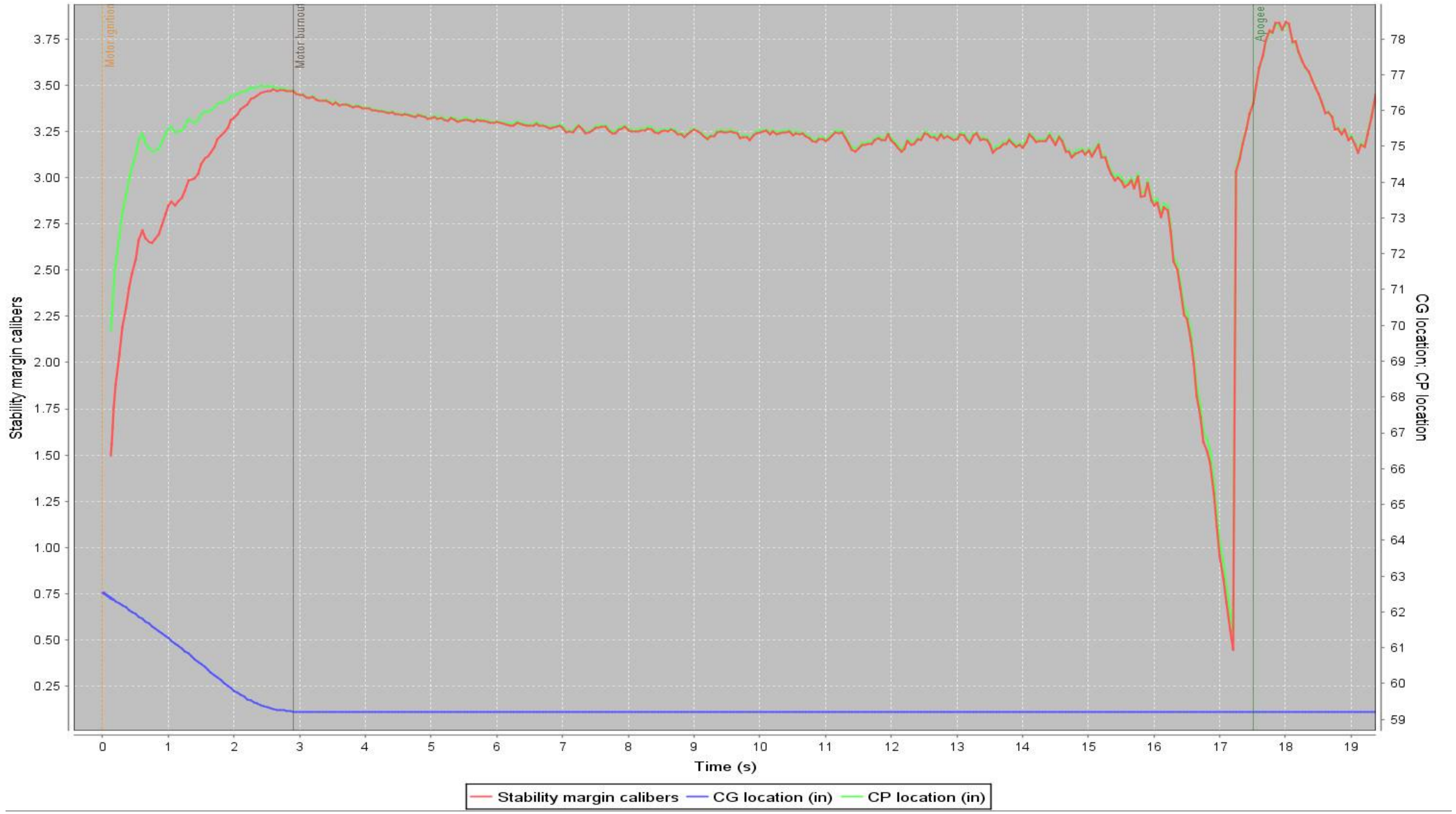
Thrust/Weight

Avg. Thrust = 907.1 N

Weight = 11.14 kg * 9.81 m/s2

Thrust-to-Weight Ratio = 8.26

Rocket Flight Stability



Stability Calculation

Table 13: Terms and their Respective Values

Term	Length (cm)
L_N	45.7
D	12.7
d_F	12.7
d_R	12.7
L_T	45.7
X_P	96.5
C_R	19.3

Term	Length (cm)
C_T	7.1
S	13.4
R	6.35
X_R	11.9
X_B	209.3
N	4 Fins

$$\bar{X} = \frac{(C_N)_N X_N + (C_N)_T X_T + (C_N)_F X_F}{(C_N)_R}$$

$$\bar{X} = 182.7957184cm$$

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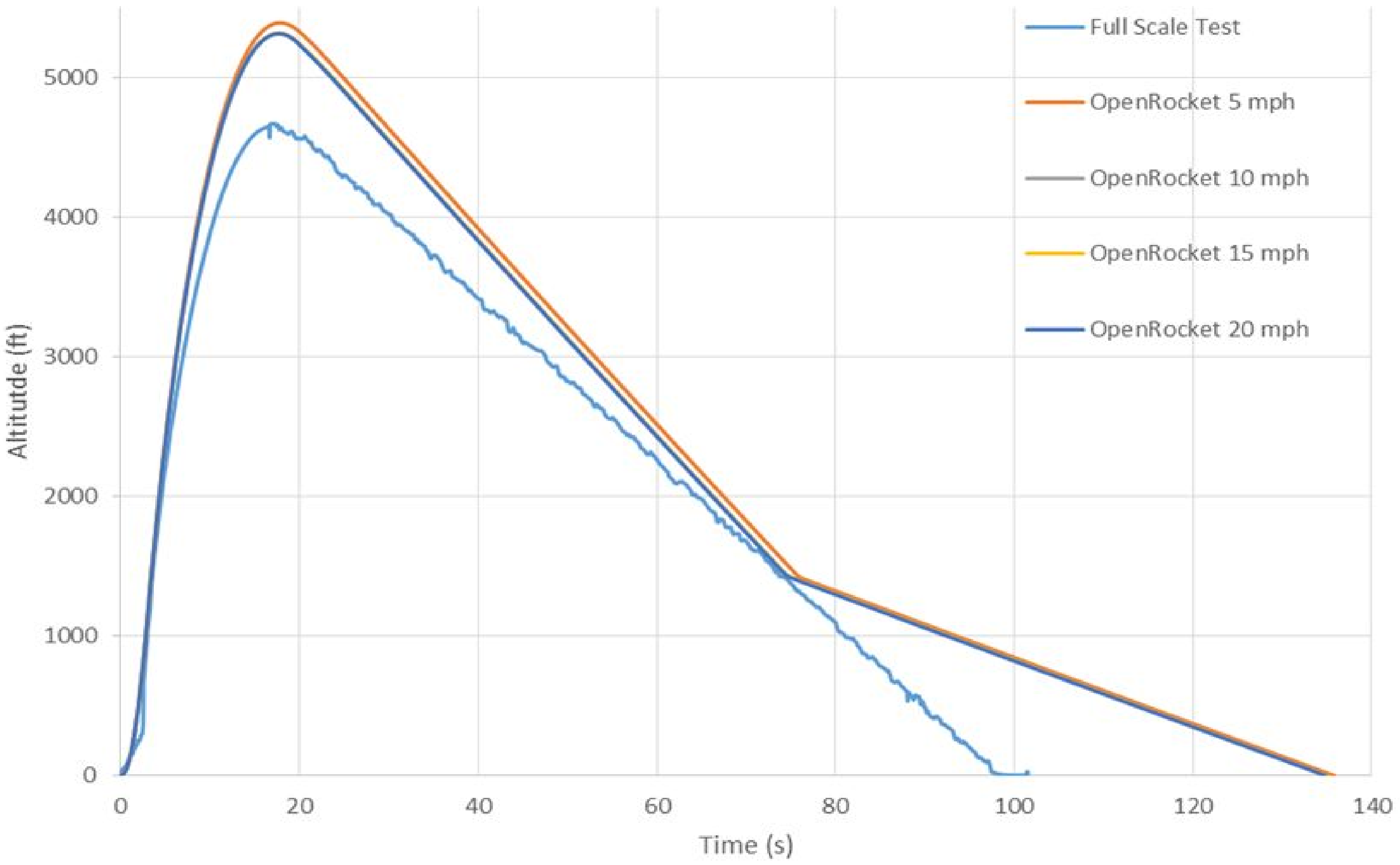
Parachutes - Specifications *

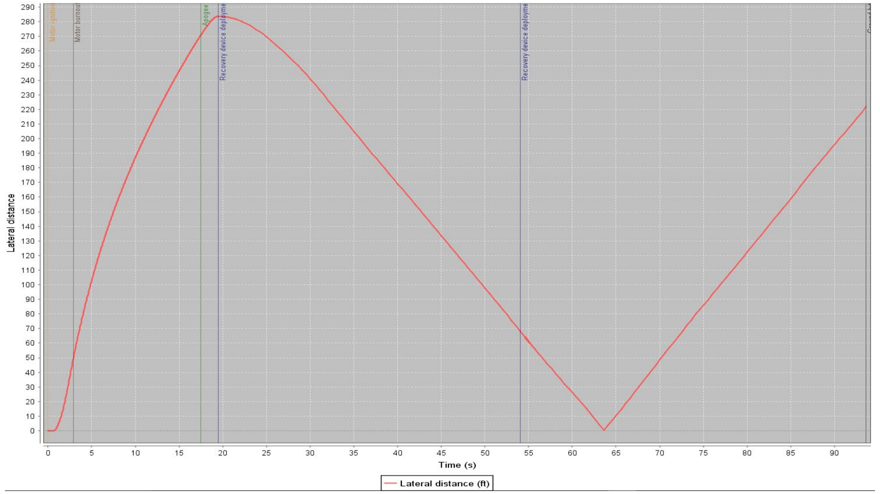
Sizes	Main: 120” Drogue: 30”, composed of tubular nylon
Recovery Harness Type	Main: Angel Parachute, Drogue: Eliptical Costuem
Length	Main: 40’, Drogue 30’
Descent Rates	68.56ft/s, 15.54ft/s

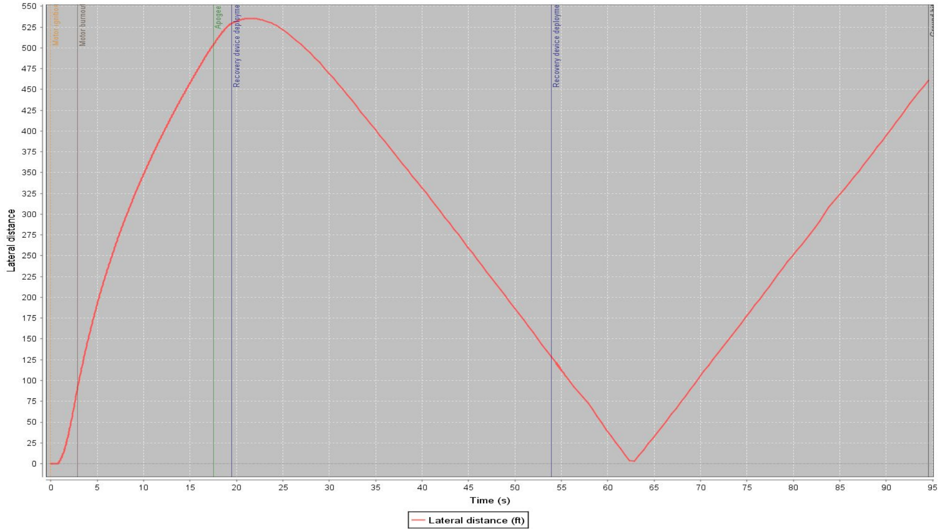
Explain sizes, recovery harness type, size, length,
And descent rates *

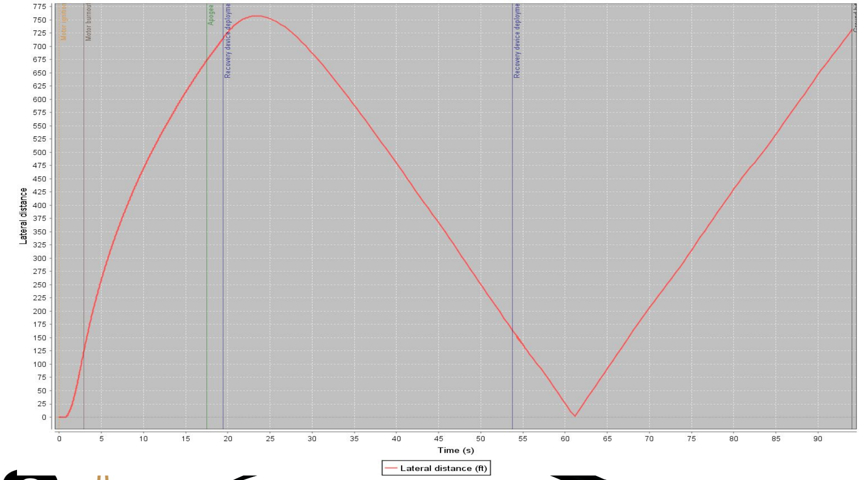
Mission Performance – Flight Profile

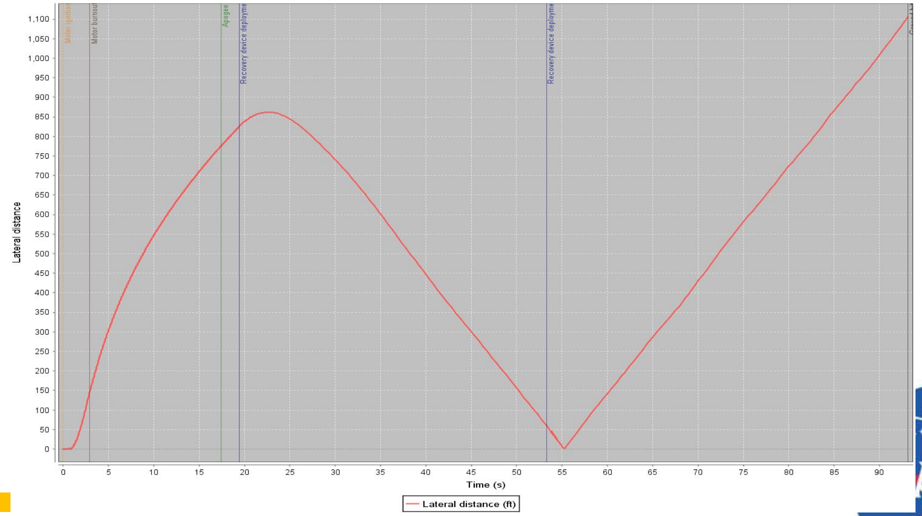


Mission Performance - Drift Profile









Launch Vehicle Kinetic Energy

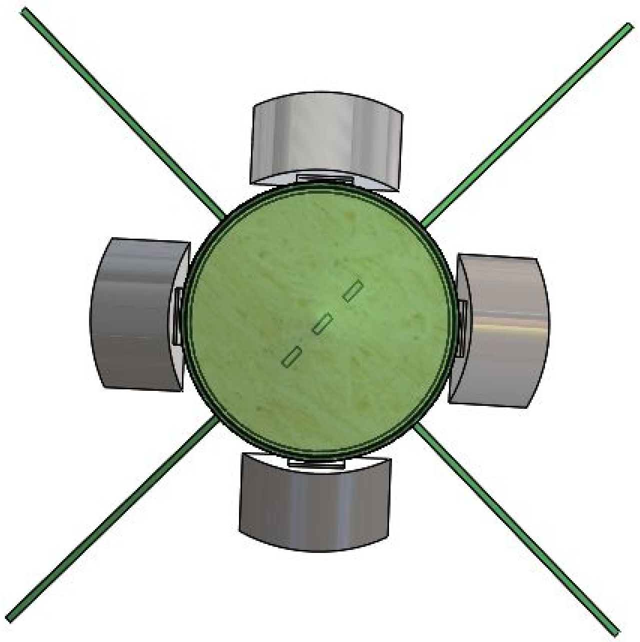
Launch Vehicle Section	Weight (lb)	Velocity (ft/s)	Kinetic Energy (ft-lbf)
Upper Section	6.52	15.54	24.45
Avionics Bay	3.62	15.54	13.57
Booster Section	8.65	15.54	32.44

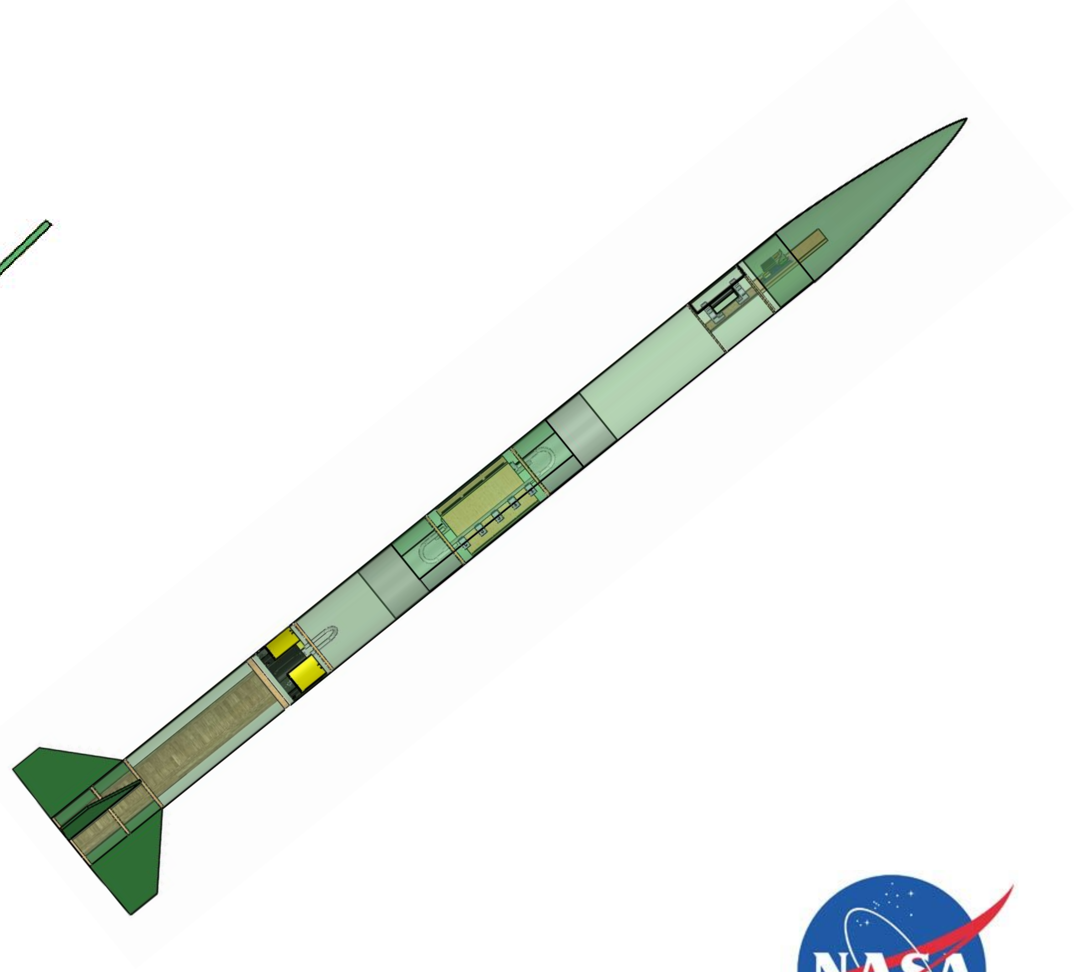
Our total Kinetic Energy at landing is approximately 70.46 ft lbf.

Test Plan Overview

Component	*Test*	*Verification Method*
Lead Screw with DC motor actuation	Extension force of flaps test.	Quantitative Analysis
ATS	Wind tunnel testing to confirm Cd simulations.	Quantitative Analysis
Thrust Plate	Bend test and pressure test to verify rigidity until breaking point.	Quantitative Analysis
Payload Bay	Payload retention force measurement test.	Quantitative Analysis
Avionics Bay	Altimeter accuracy and accelerometer performance test.	Quantitative Analysis
Recovery System	Recovery system ground test fire.	Inspection
Fins	Fin attachment robustness test along two axis.	Quantitative Analysis
Launch Vehicle Assembly	Vehicle will be completely assembled under a time constraint to verify efficiency and effectiveness.	Inspection

Final Launch Vehicle Product





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FLIGHT SYSTEMS

Flight System Responsibilities

Requirement	Design Feature to Satisfy Requirement	Requirement Verification	Success Criteria
The vehicle shall not exceed an apogee of 5,280 feet	Drag from the ATS system	Full-scale flight test	Apogee within 1% of target
The vehicle will be tracked in real-time to locate and recover it	GPS module will be used in the vehicle and base station	Full-scale flight test	The vehicle will be located on a map after it lands for recovery
The data of the vehicle's flight will be recorded	Sensors will save data	Full-scale flight test	The data will be recovered and readable after flight

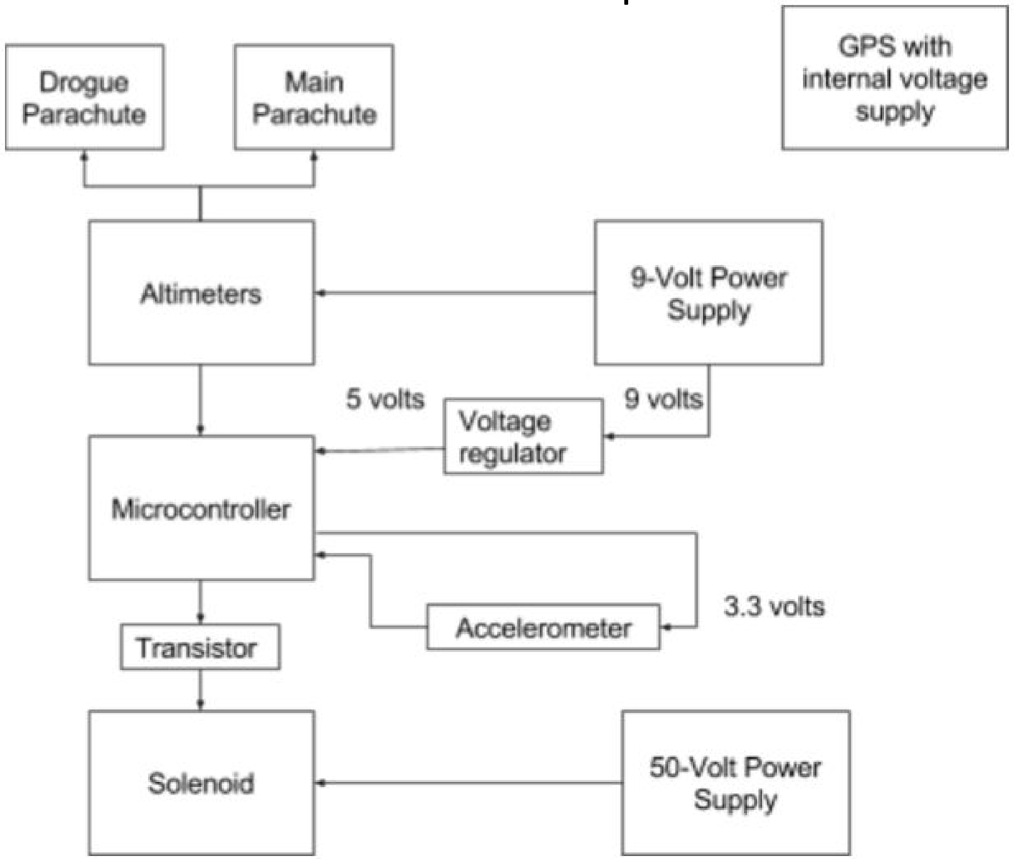
Flight Systems: Avionics

Avionics Components

Part	***Function***
Stratologger SL100	Altimeter - used to receive and record altitude
MMA8452Q	Accelerometer - used to receive and record acceleration
mbed LPC 1768	Microcontroller - used to receive sensor data to compute and control the ATS
Eggfinder TX/RX Module	GPS module - used to track the rocket in real time
9V Alkaline Batteries	Used to power all Avionics components and ATS

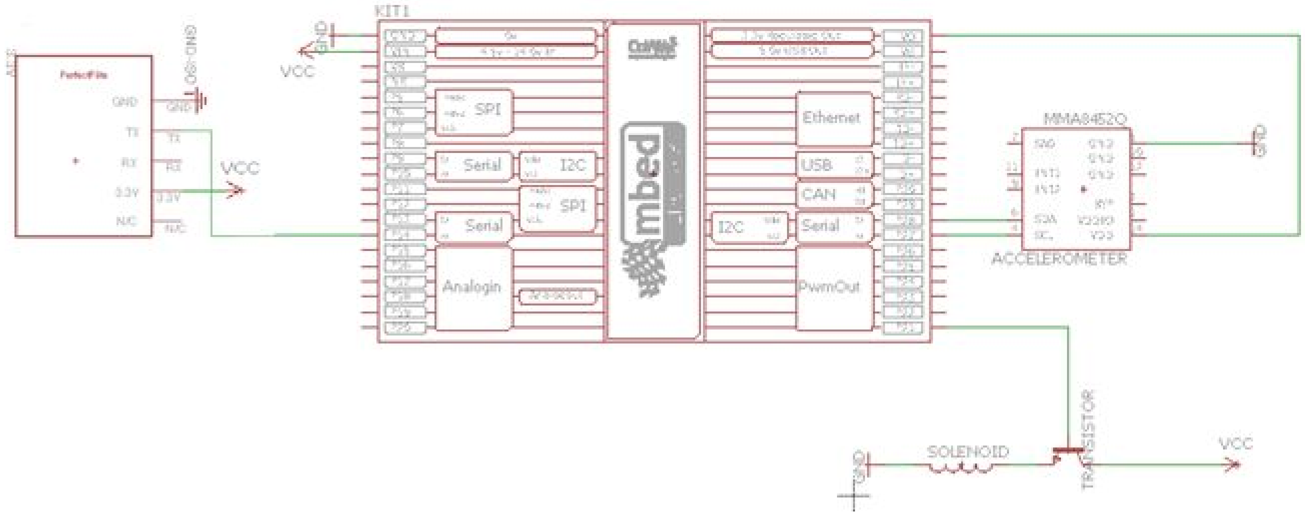
Flight Systems: Avionics

General connection of main components

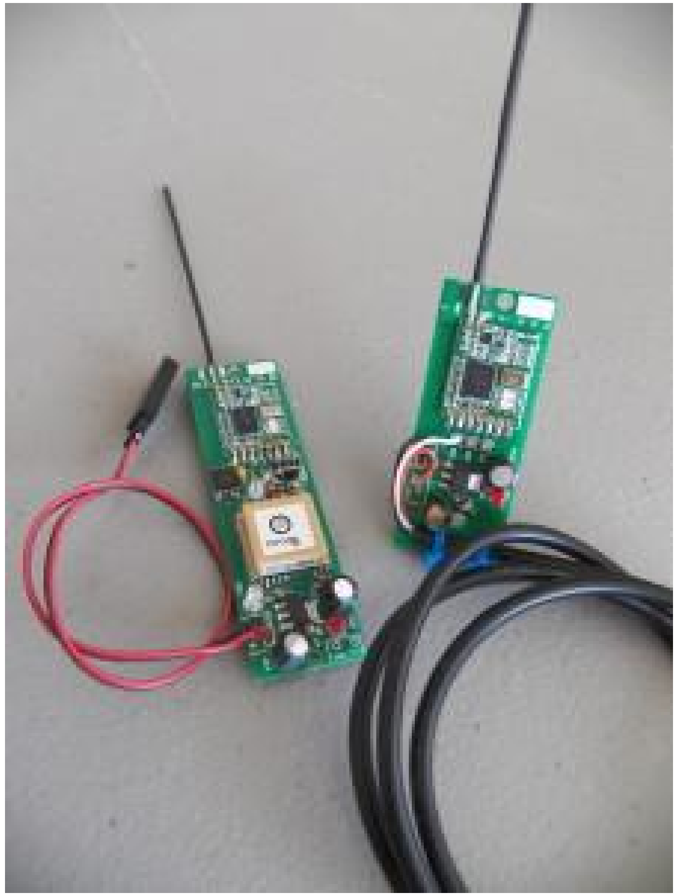


Flight Systems: Avionics

Eagle CAD schematic of main components



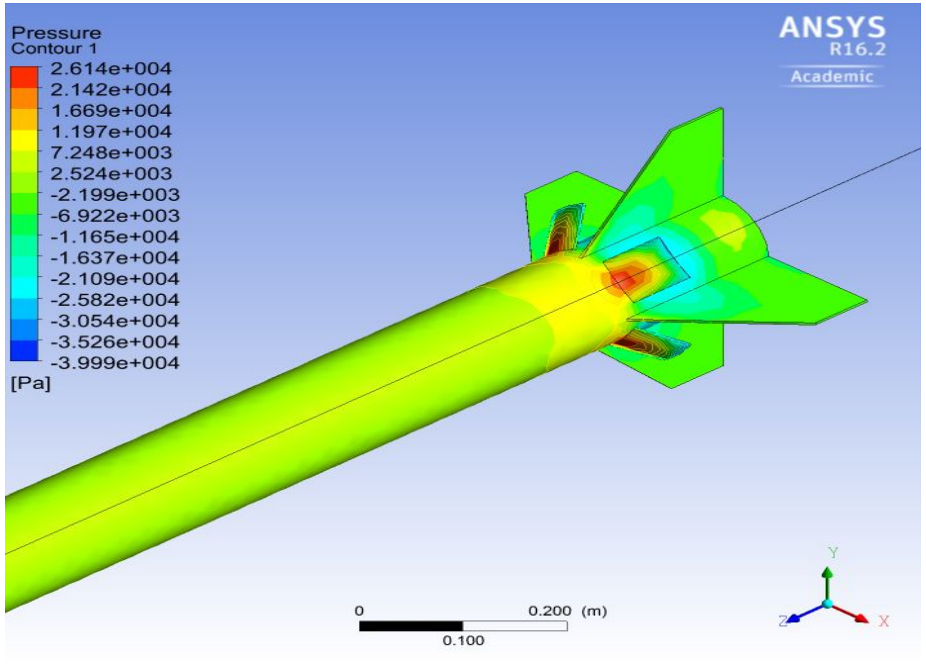
Flight Systems: Ground Station

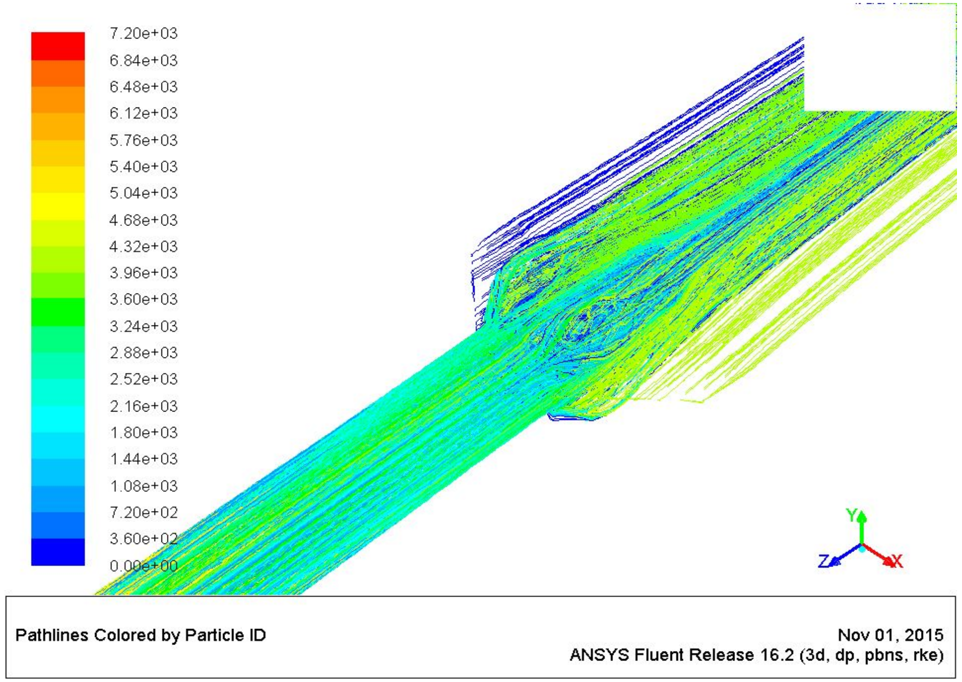


Equipment:

- ❖ Eggfinder TX (Transmitter)
- ❖ Eggfinder RX (Receiver)

Flight Systems: ATS Science

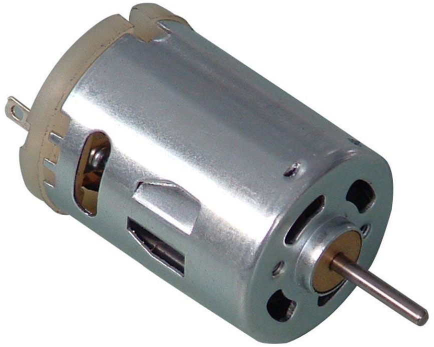




Dynamic drag adjustment by changing the geometry exposed to the flow to increase the vehicle's aerodynamic properties.

Flight Systems: ATS Power

- 9-volt alkaline batteries will be used to power the ATS
- DC motors will be used to create torque on the air-brake flaps



Flight Systems: Testing Overview

Wind Tunnel: Test Cd of flaps against simulation, and ability for solenoids to withstand the given pressures

Flight Simulation: Forged flight data will be fed to the sensors and the response efficacy will be analyzed.

Power Consumption: Full charged power supply will be connected to flight systems to see its maximum lifespan.

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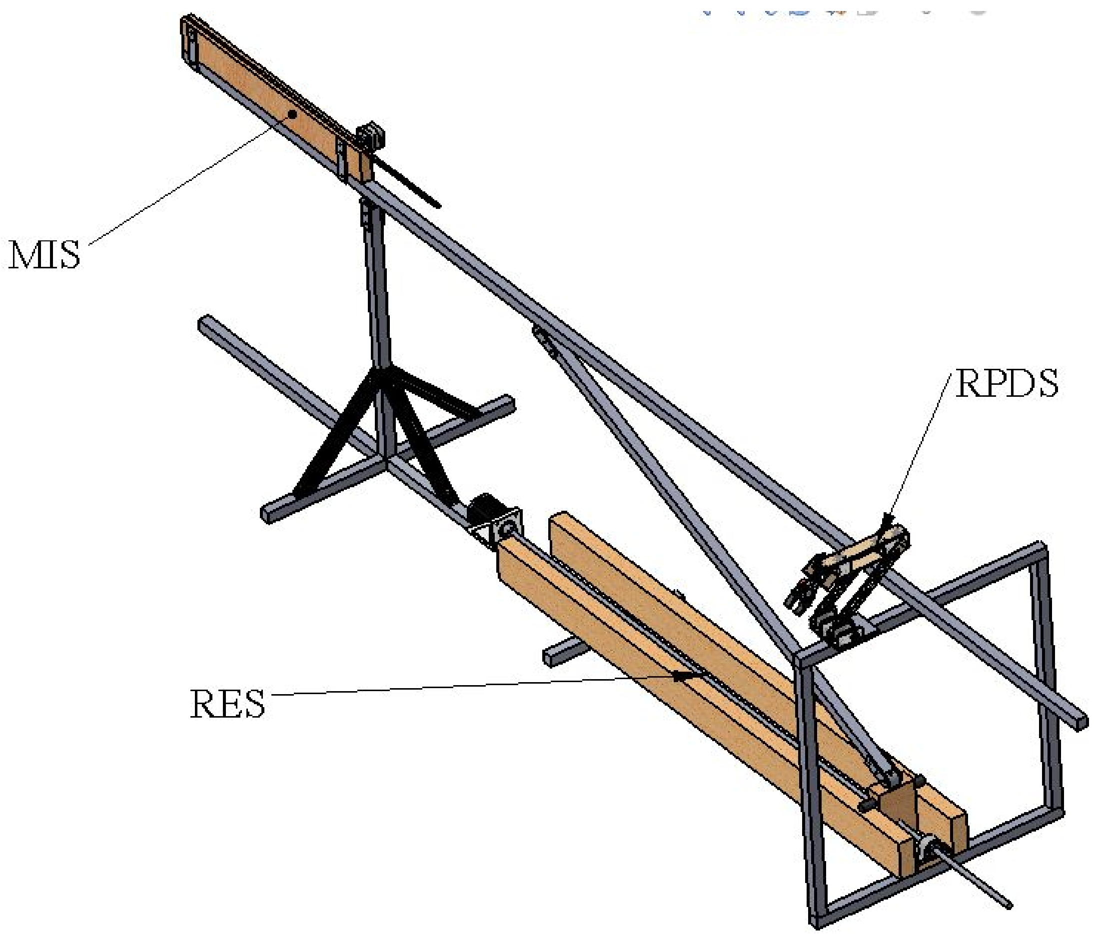
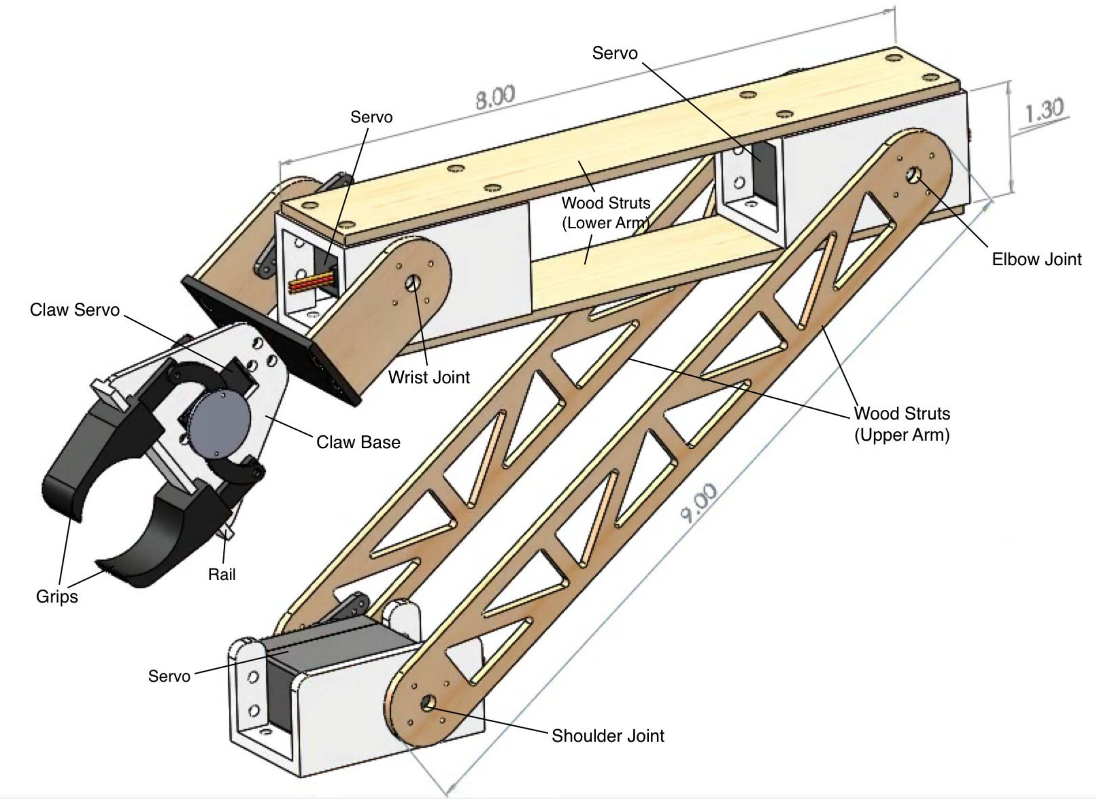
AUTONOMOUS GROUND SUPPORT EQUIPMENT

AGSE: Initial Design



- 10 ft. by 2 ft. base
- 2 ft height
- Weight ≈ 35 lbs.
- 3 subsystems
- RPDS: Robotic Payload Delivery System
- RES: Rocket Erection System
- MIS: Motor Ignition System

AGSE: RPDS

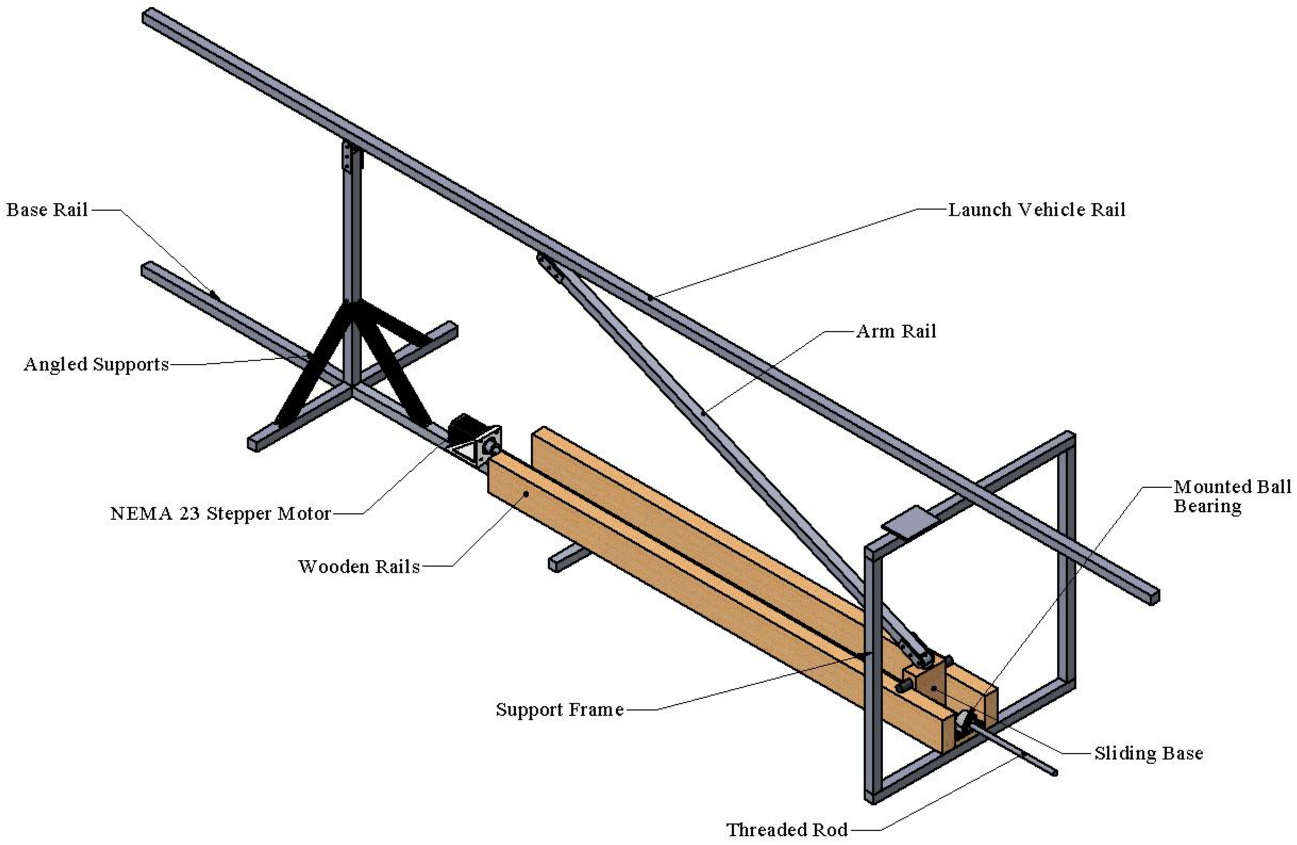


- Grab payload using gripping claw
- Arms constructed from plywood
- Motor mounts 3D printed (ABS plastic)
- 4 servo motors

AGSE: RPDS

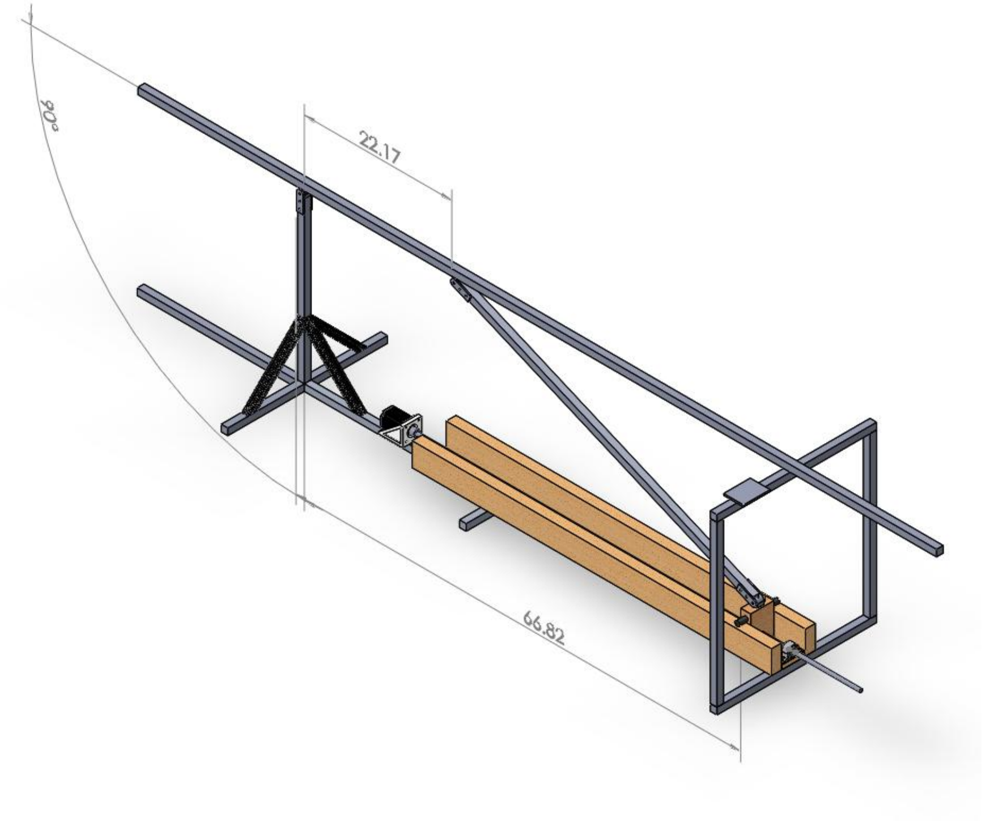
- Arm will move payload into payload bay
- Payload secured by plastic clips
- Arm will close the magnetically locking hatch

AGSE: RES



- Launch vehicle will be raised by a cable and spool system
- Spool will pull in steel cable that runs through the pulley and eye hook
- 1 unipolar Stepper motor

AGSE: RES (continued)



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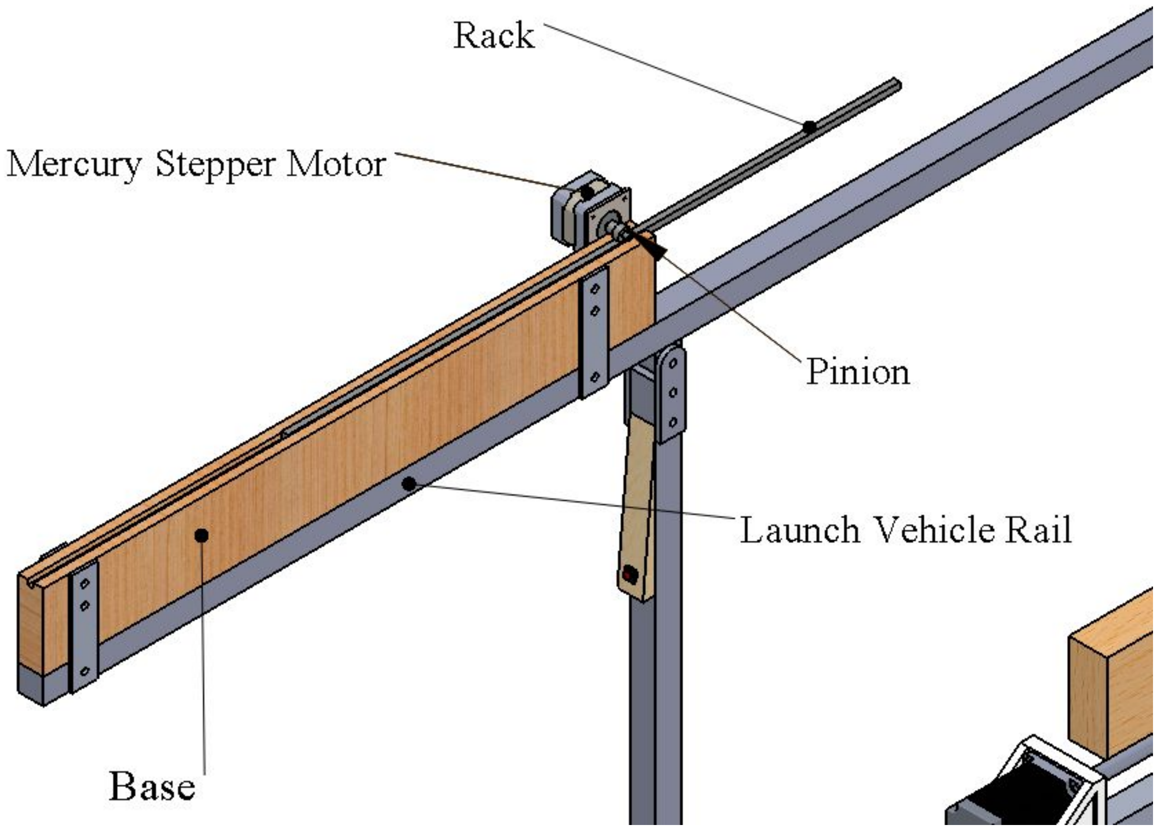
AGSE: MIS



- Rack and pinion system inserts electronic match 12 inches into the motor cavity
- Fixed to the bottom of the guide rail
- Constructed from MDF
- 1 bipolar stepper motor

AGSE: Safety

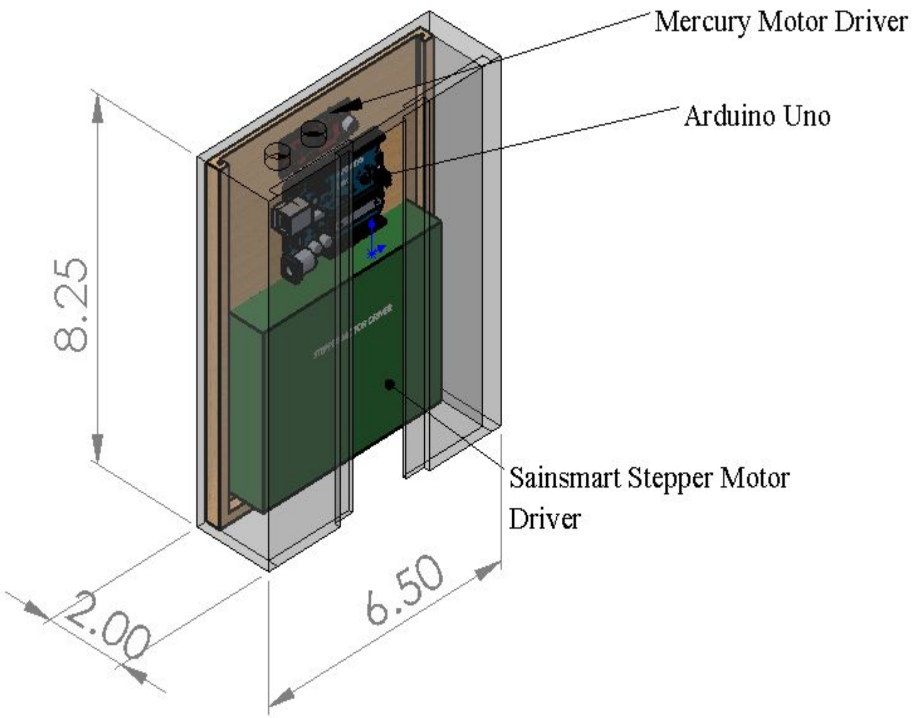
Potential Failure	Effects of Failure	Failure Prevention
Payload is not secured in bay.	Payload will bounce inside the payload bay, disrupting flight.	Test various plastic clip dimensions to find best fit.
RPDS is stuck inside the payload bay.	Payload bay will not close and RPDS will be destroyed by raising the launch vehicle.	RES will be started by a signal from the RPDS after it has completed its task.
Launch Vehicle moves uncontrollably on the rail.	Could disrupt the performance of other subsystems.	More support along the launch rail to keep the disruptive movement of the launch vehicle at a minimum.
RES is not stable while raising.	Rocket will not be raised, and motors may potentially be broken.	Test subsystem, add counterweights to reduce necessary force from motor and add more framing to increase stability.

AGSE: Safety

RES is not stable at full extension.	Launch vehicle could tip over.	Increase the weight to lower the center of gravity. Increase the base width. Add more supports to the launch rail.
RES does not stay upright.	Launch vehicle will fall unpredictably.	Lead screw prevents slipping backwards
RES stepper motor does not stop.	Tension will continue to increase in the cable leading to failure.	Emergency stop button in place that activates when rail is at maximum angle.
MIS stepper motor does not stop.	Rack will move further into motor cavity, possibly damaging rotor.	Emergency roller switch in place that activates when rack passes a certain distance.
Electronics short circuit or are overloaded.	System will lose control.	Fuses will protect electronics, subscale testing will prevent short circuits and overload.

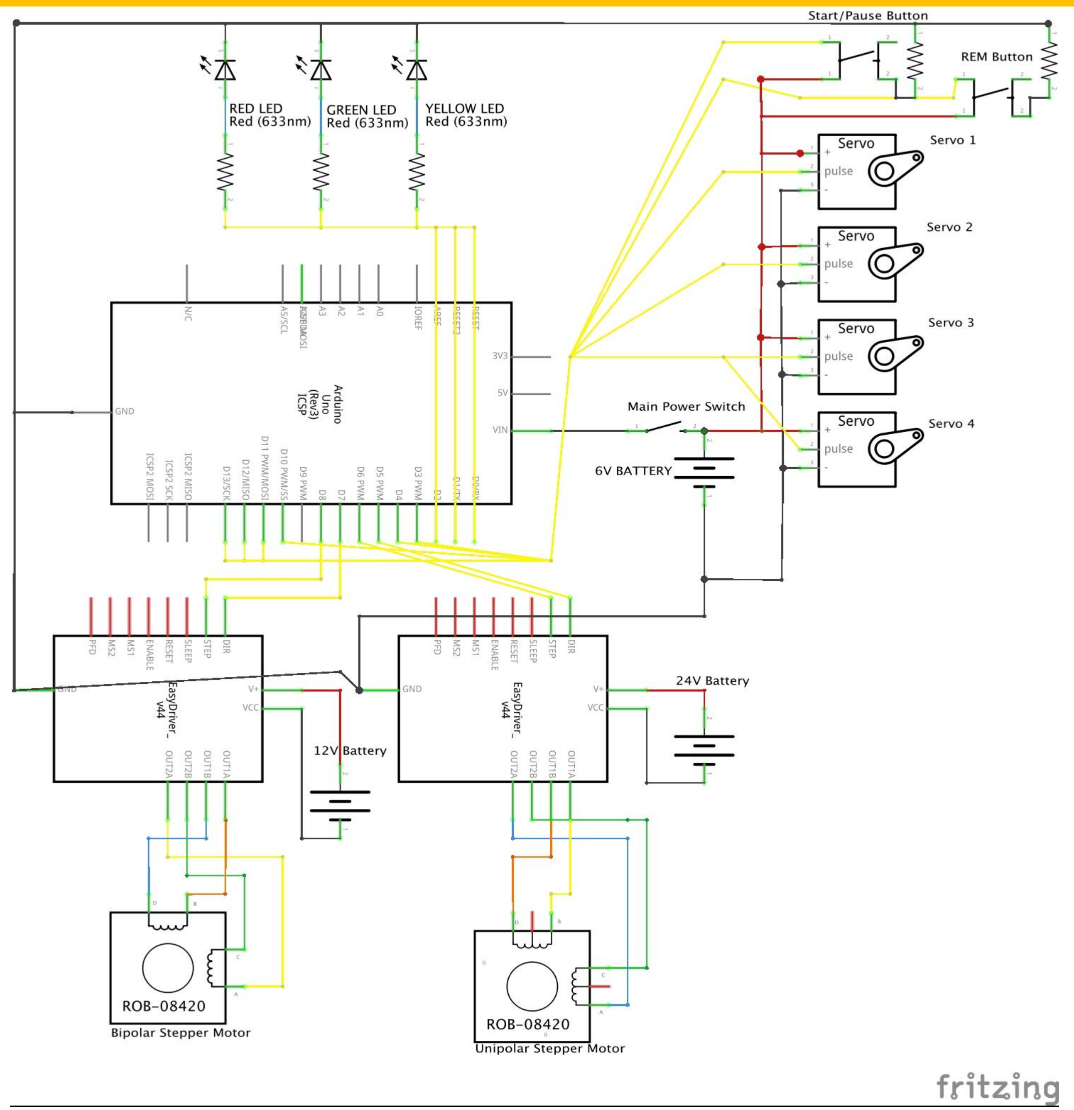
AGSE: Electronics

- 4 servo motors for RPDS
- 1 unipolar stepper motor for RES
- 1 bipolar stepper motor for MIS
- 2 LEDS as indicators
- 1 button to start and stop the program
- 1 button to stop RES
- Controlled by Arduino Uno-R3



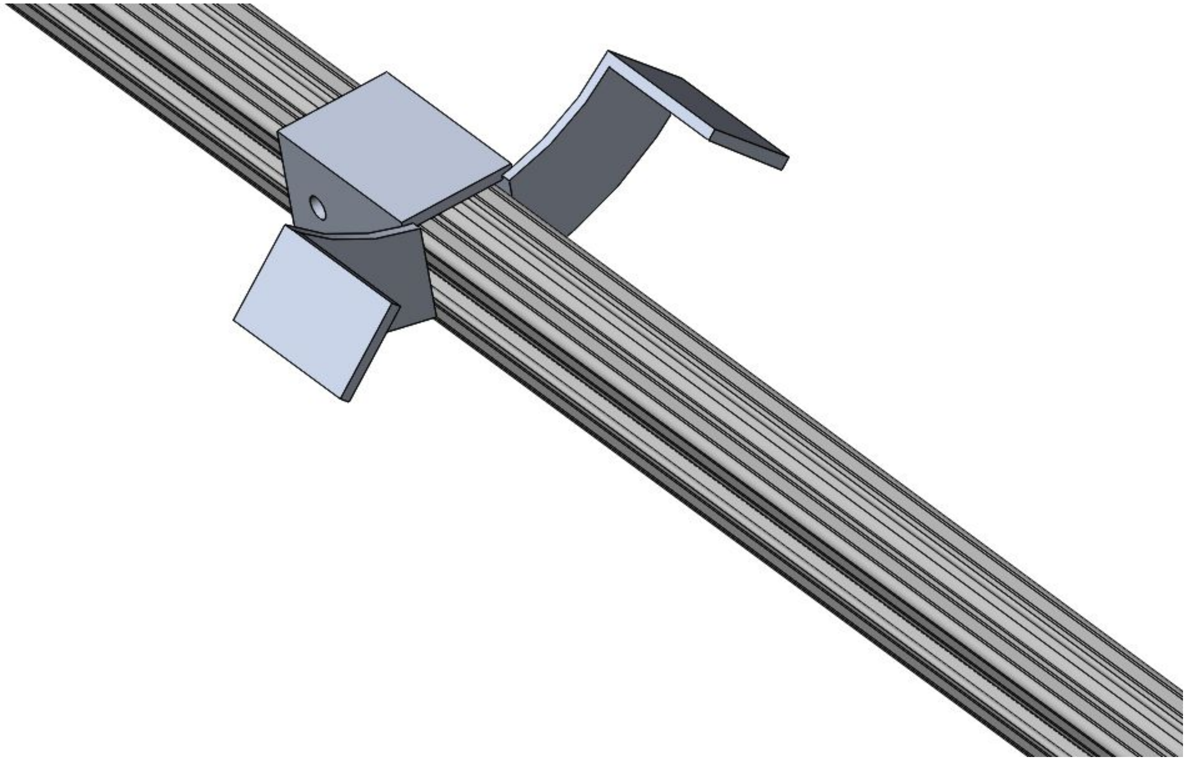
AGSE: Power

- System will be powered by 12V, 6V, and 24 V batteries
- System can run continuously for 8 full runs before 6V must be changed



AGSE: Launch Vehicle Interface

- Launch Vehicle will rest on launch vehicle rail via rail buttons
- Launch vehicle will not slide down rail because of stopper placed at on rail
- The payload bay is wide enough to accommodate the RPDS's movements



AGSE: Test Results

- RES lifting test
  - Can lift easily with no weight applied
  - Weights exceed 10 lbs cause bending moment in threaded rod, inhibiting movement
  - Past 30 degrees, weights up to 30 lbs can be moved with stability
- Electronics test
  - Pause button works properly
  - All functions of various motors have been coded properly

Questions

Questions?