# Georgia Tech NASA Critical Design Review Teleconference

Presented By:

Georgia Tech Team ARES

# Agenda

1. Team Overview (1 Min)
2. Changes Since Proposal (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)

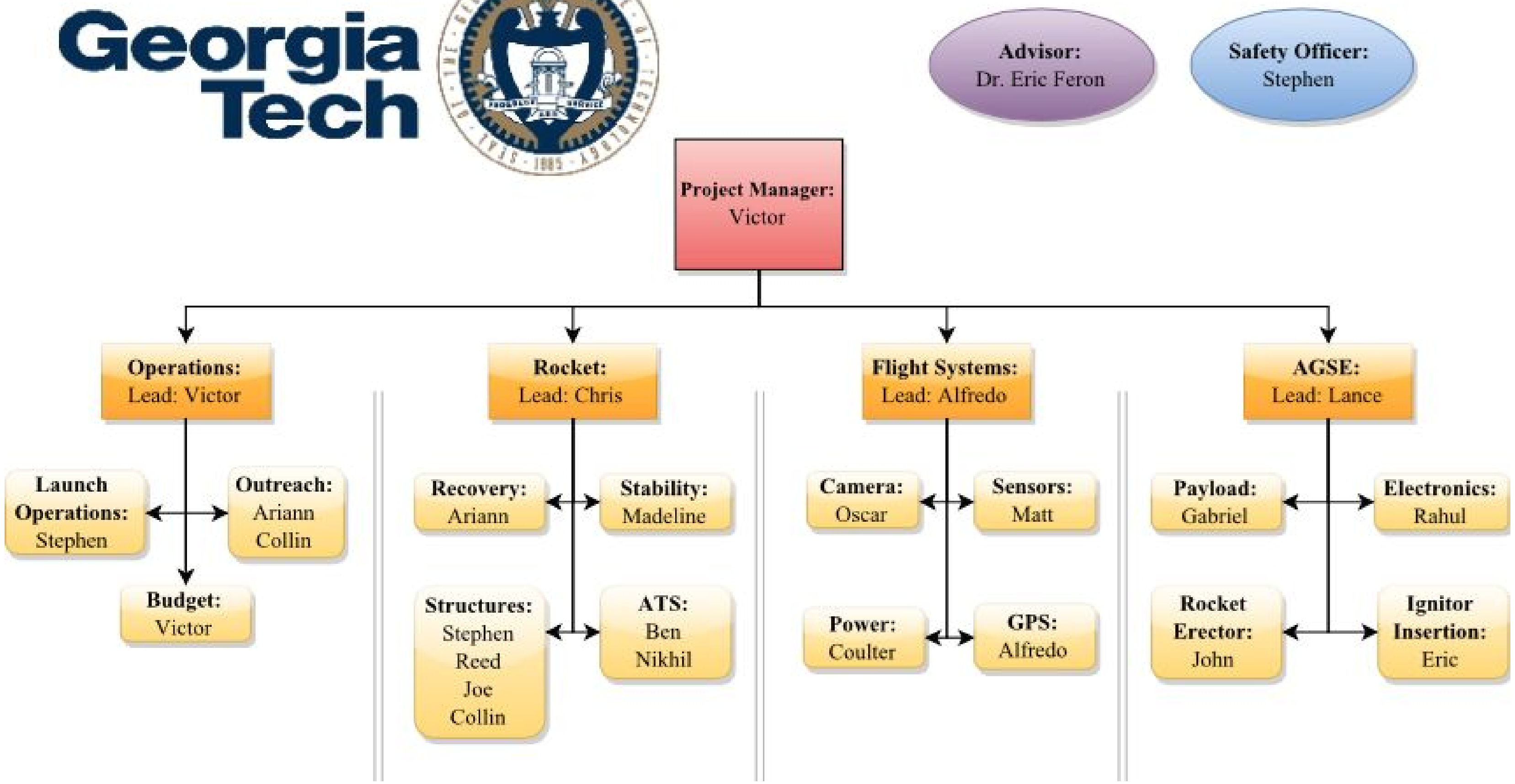
# Project Hermes - CDR

## TEAM OVERVIEW

# Georgia Tech Team Overview

- 19 person team composed of both undergraduate and graduate students
  - Graduate Students: 2
  - Undergraduates: 17
- Highly Integrated team across several disciplines

# Work Breakdown Structure



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# CHANGES SINCE PDR

# Changes since PDR

- Launch Vehicle
  - ATS now actuates with DC motors and a lead screw design.
  - Payload Bay, GPS, and ATS Power supply now relocated.
  - Slight overall dimensions changes to each segment.
  - L990 set as the new booster
- Autonomous Ground Support Equipment
  - Added servo motor to robotic arm (now 5)
  - Wider base
  - Added pulley to raising mechanism
  - Redesigned ignition system
- Flight Systems: No Changes
- Project Plan: No Changes

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# EDUCATIONAL OUTREACH

# Educational Outreach

- **Atlanta Maker's Faire**
- **FIRST Lego League**
- **CEISMC GT**

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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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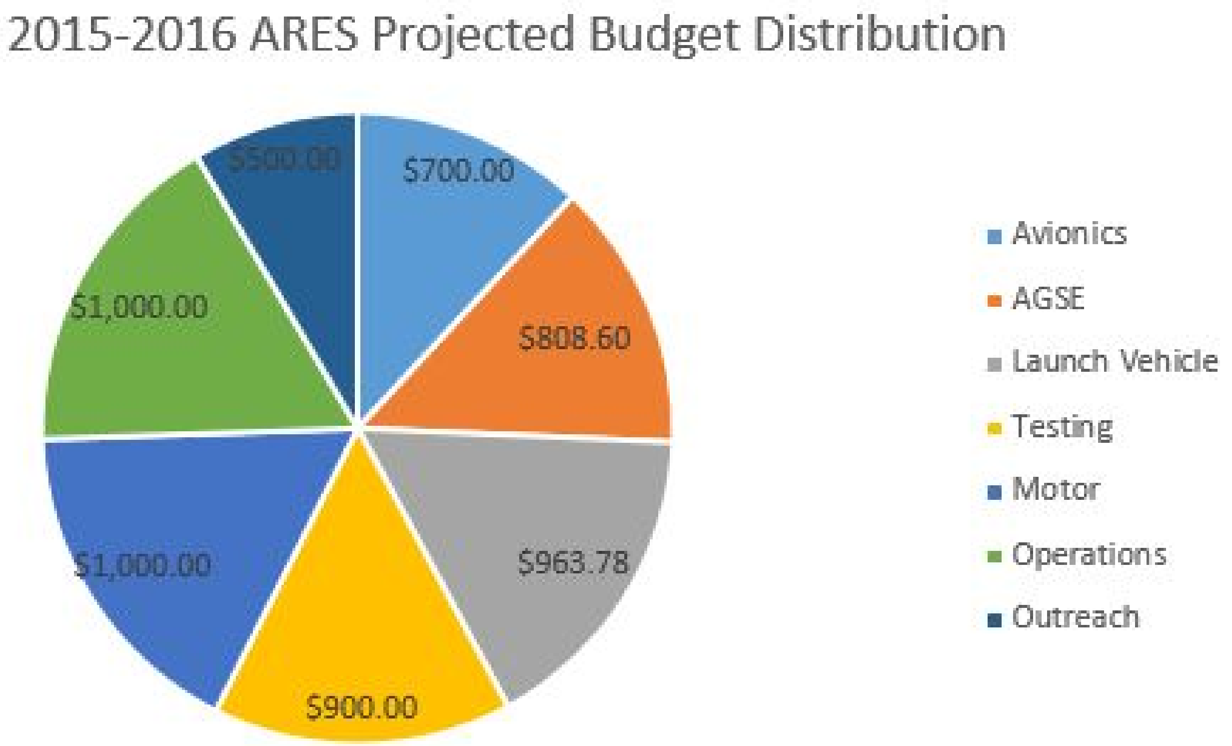
# PROJECT BUDGET

# 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 |

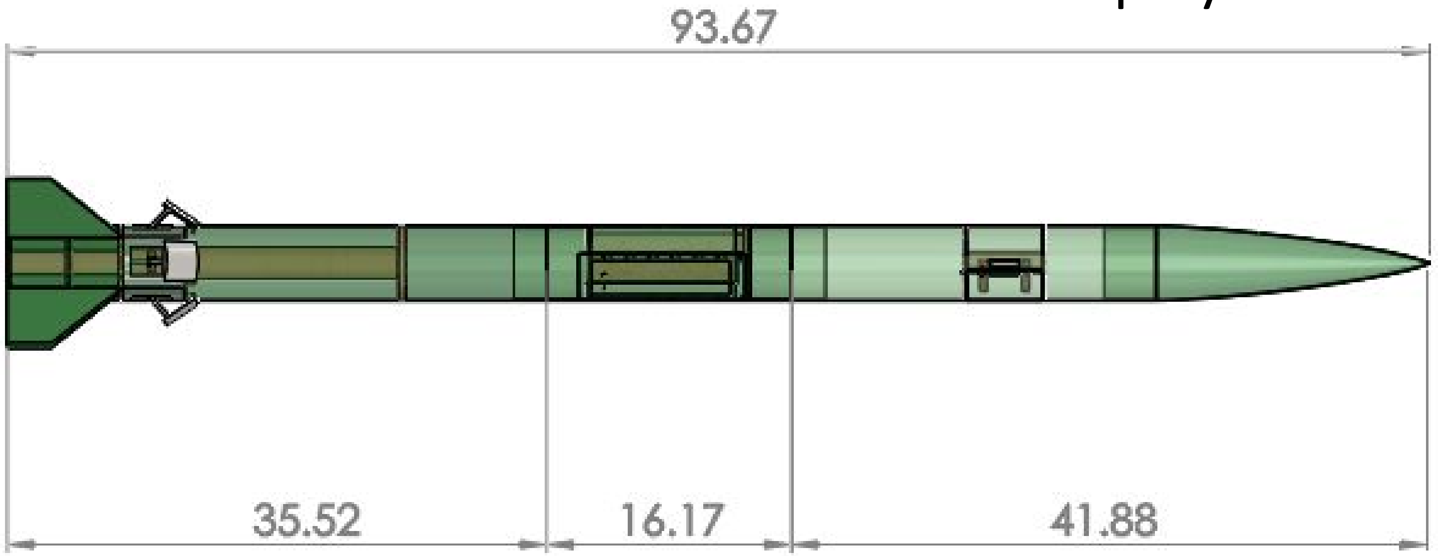


# Project Hermes - CDR

## LAUNCH VEHICLE

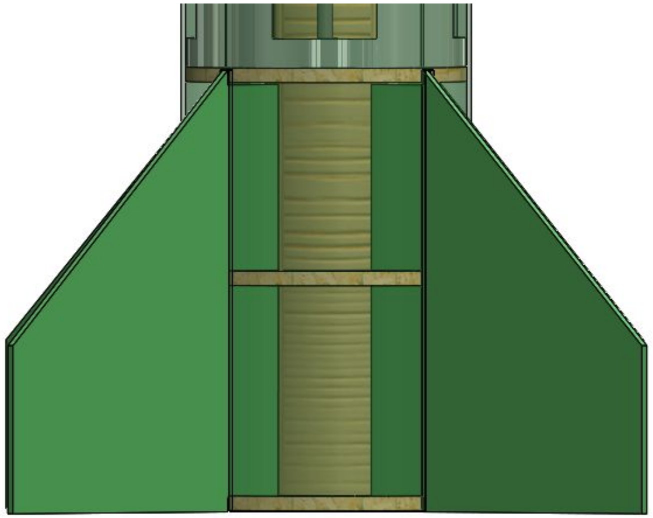
# Launch Vehicle Summary

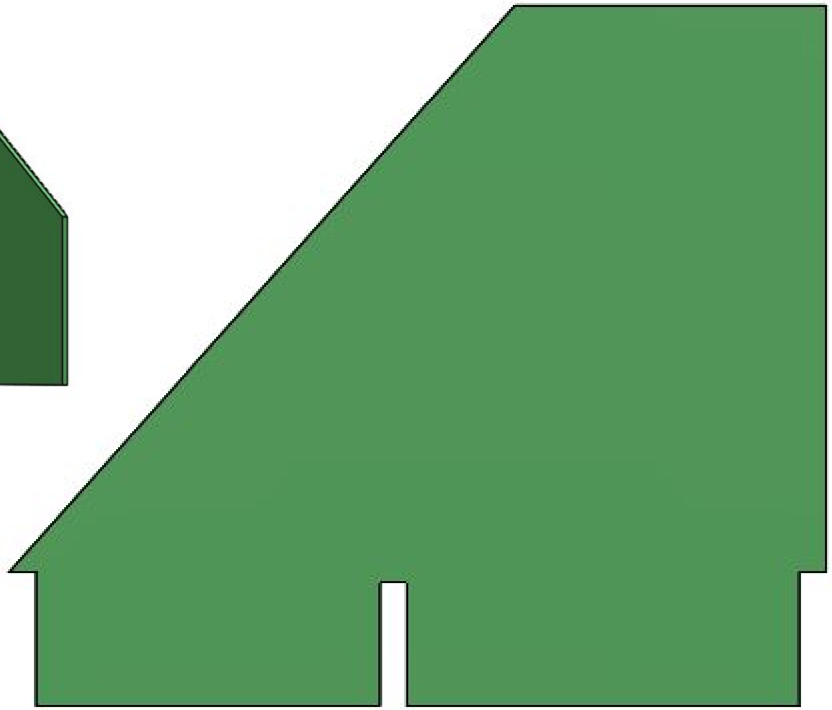
- Predicted apogee:  5803 ft
- Stability margin: 2.6 calibers
- Motor: Cesaroni L990
- Rail Exit Velocity: 53.9 ft/s
- Max Mach: 0.74
- Total weight: 20.25 lbs
- Dual deployment with 15” and 50 “




Georgia Tech ARES

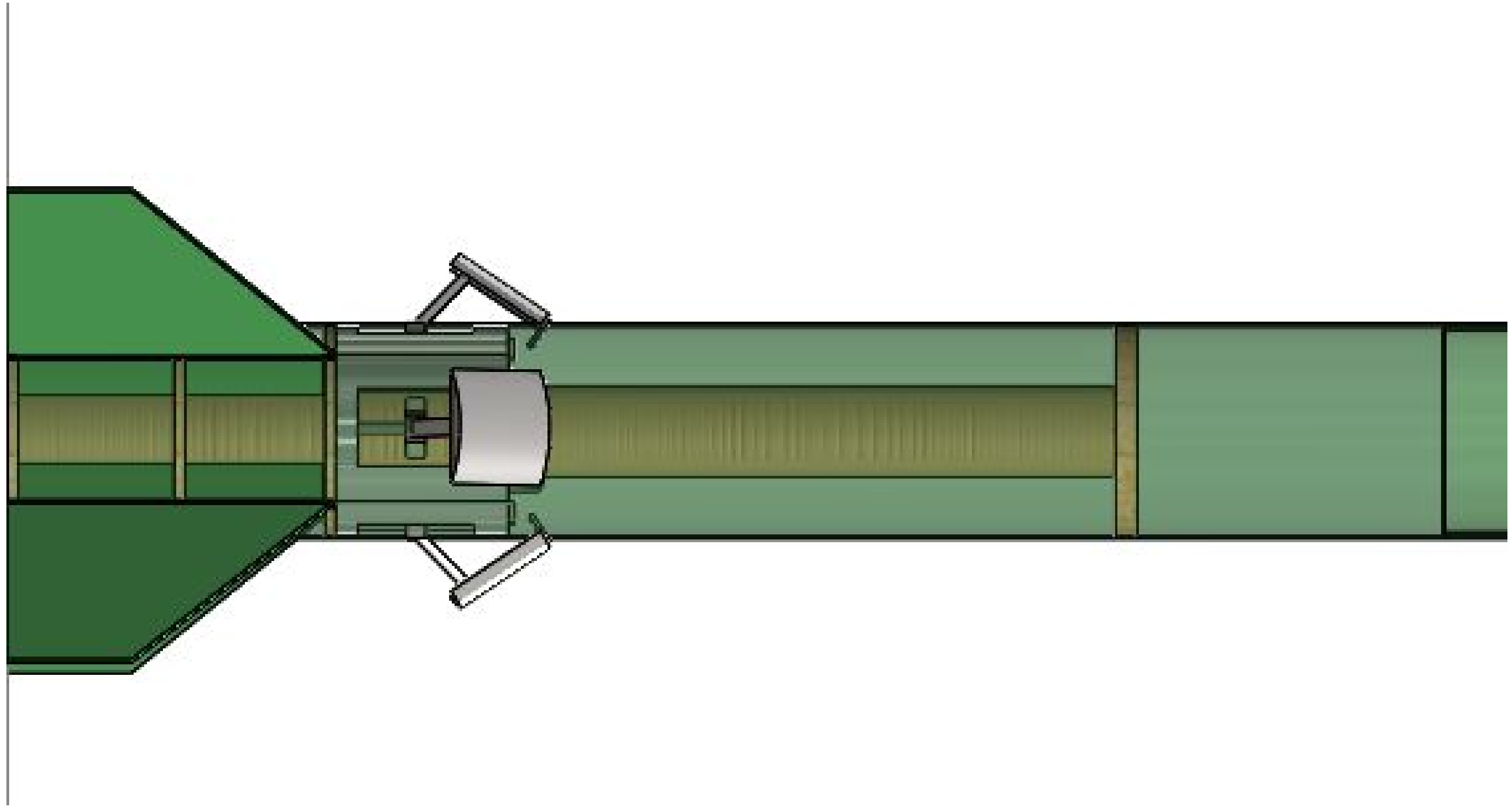
# Fins



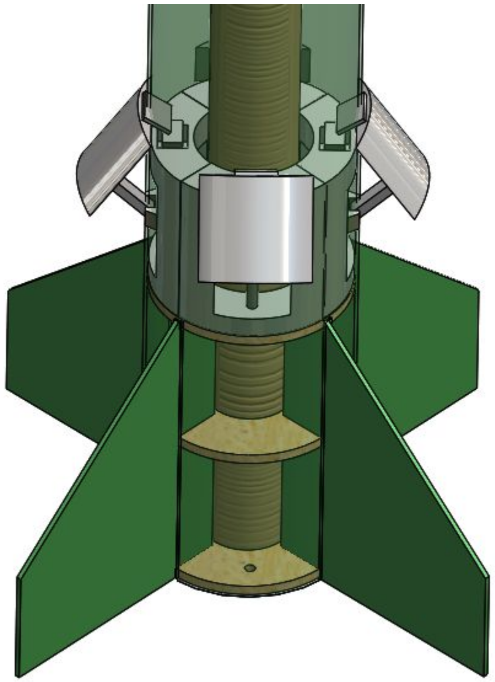


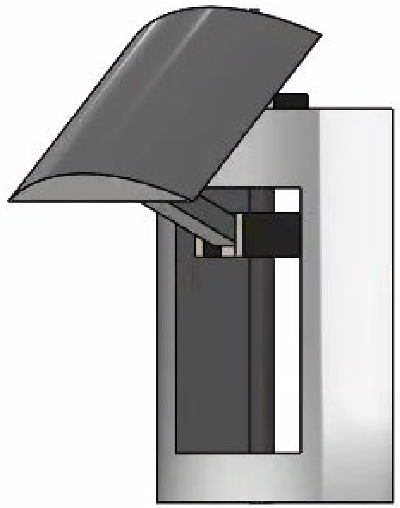
| | |
|---|---|
| Tip Chord | 7 cm or 2.75591 in |
| Root Chord | 19.3 cm or 7.598 in |
| Thickness | 0.318 cm or 0.1252 in |
| Fin Area | 55.23 in^2 |
| Span | 13.4 cm or 5.275591 in |
| Aspect Ratio | 0.50392 |

# Booster Section



# Apogee Targeting System (ATS)



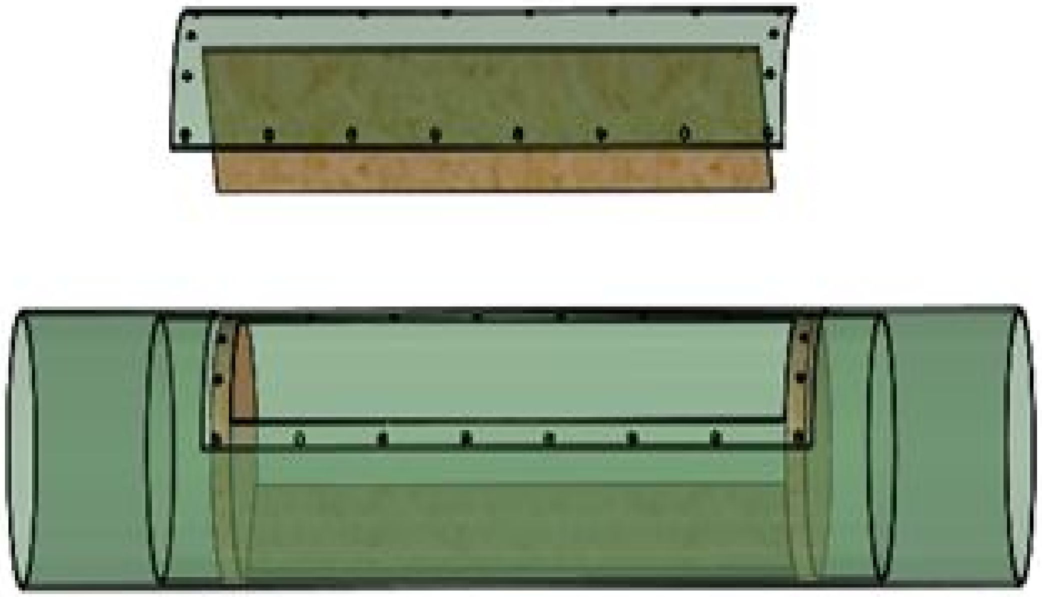


# Motor Selection

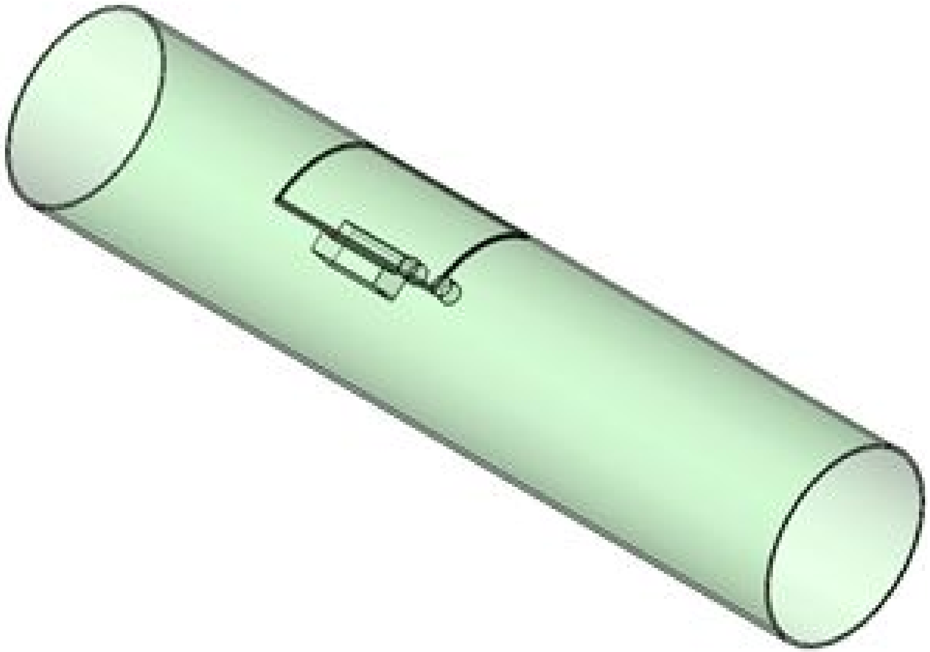
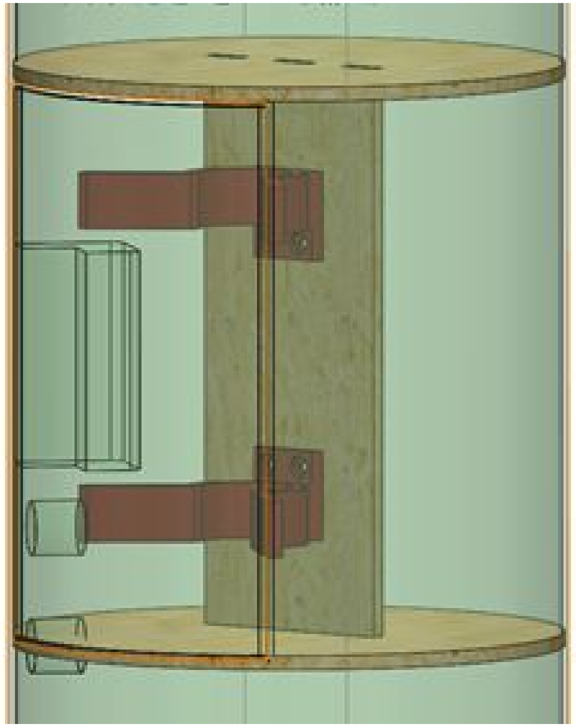
## Cesaroni L990

| | |
|---|---|
| MOTOR NAME | Cesaroni L990 |
| DIAMETER | 54mm |
| LENGTH | 64.9cm |
| PROP WEIGHT | 1.369kg |
| TOTAL WEIGHT | 2.236kg |
| AVG THRUST | 991.0N |
| MAX THRUST | 1702.7N |
| TOTAL IMPULSE | 2771.6 |
| BURN TIME | 2.8s |

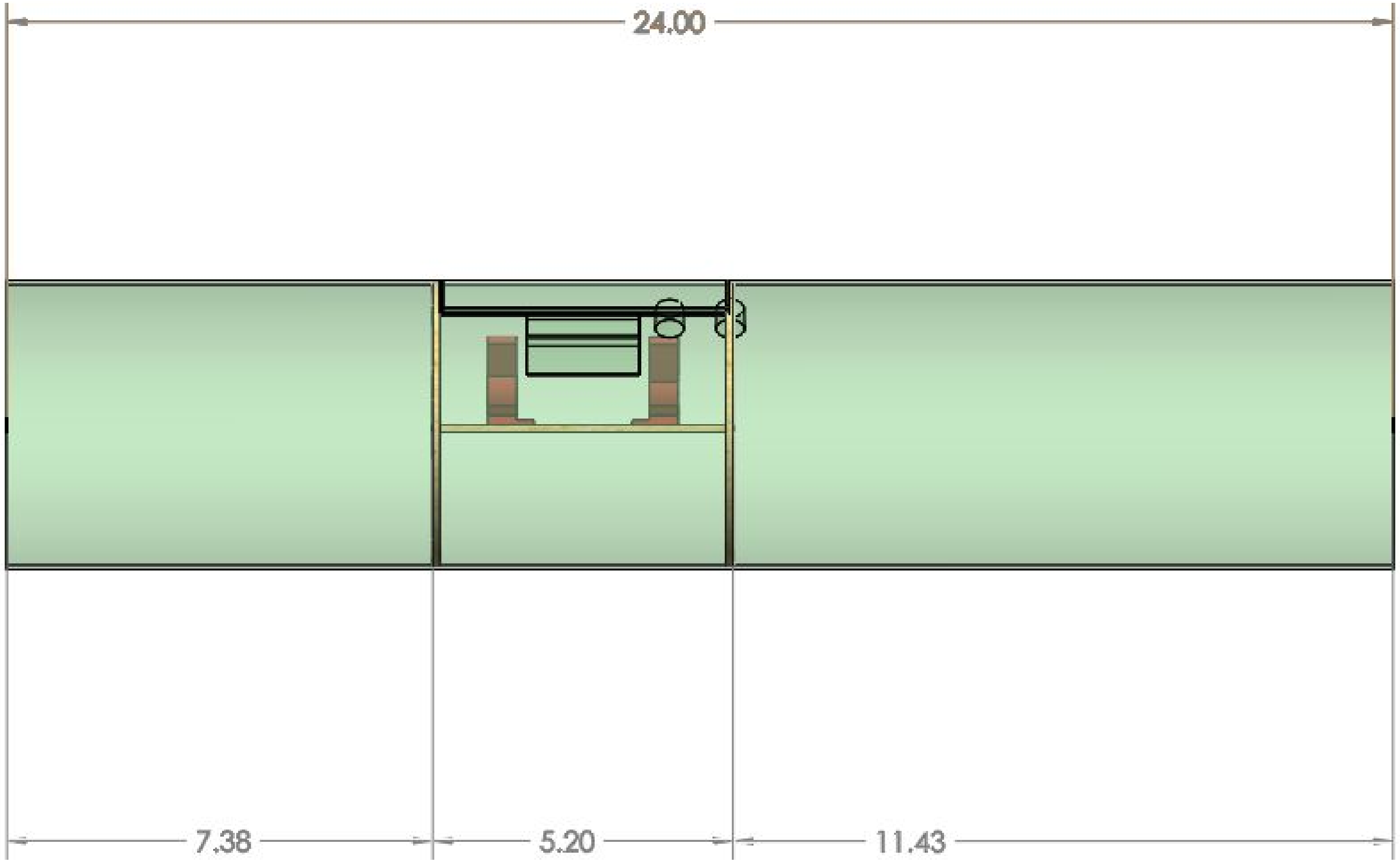
# Avionics Bay



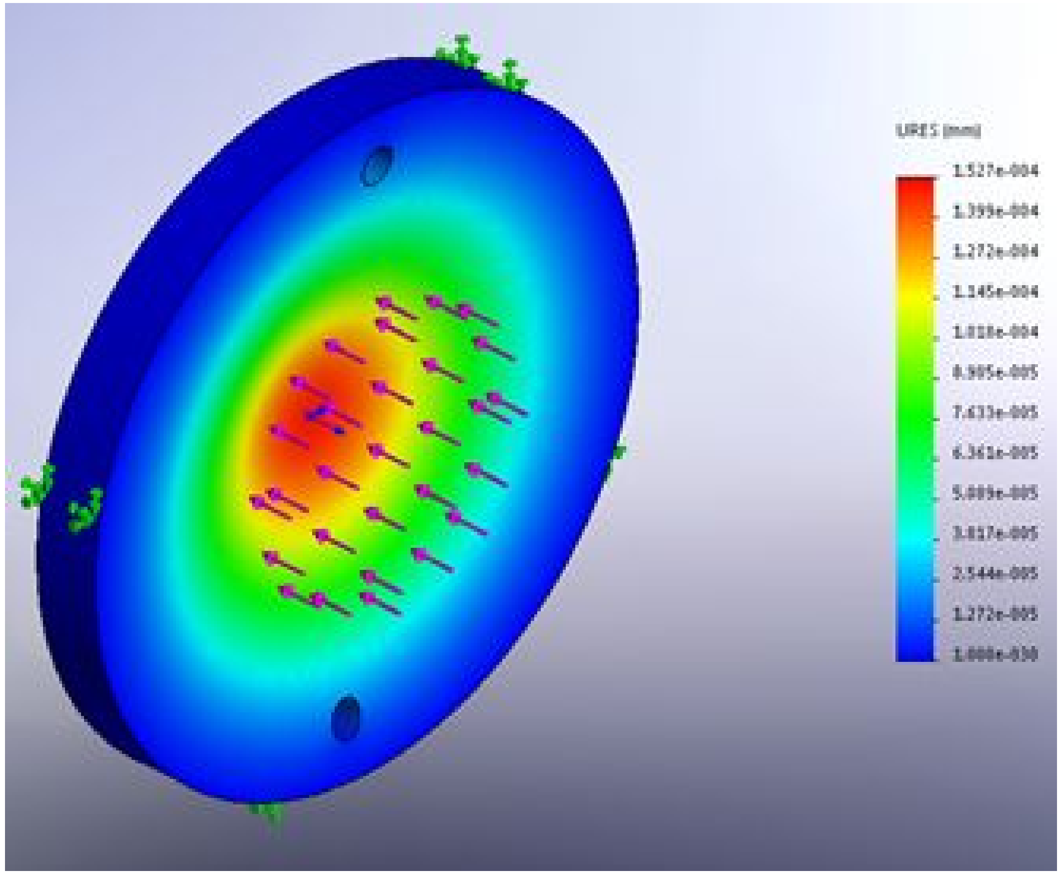
# Payload Bay

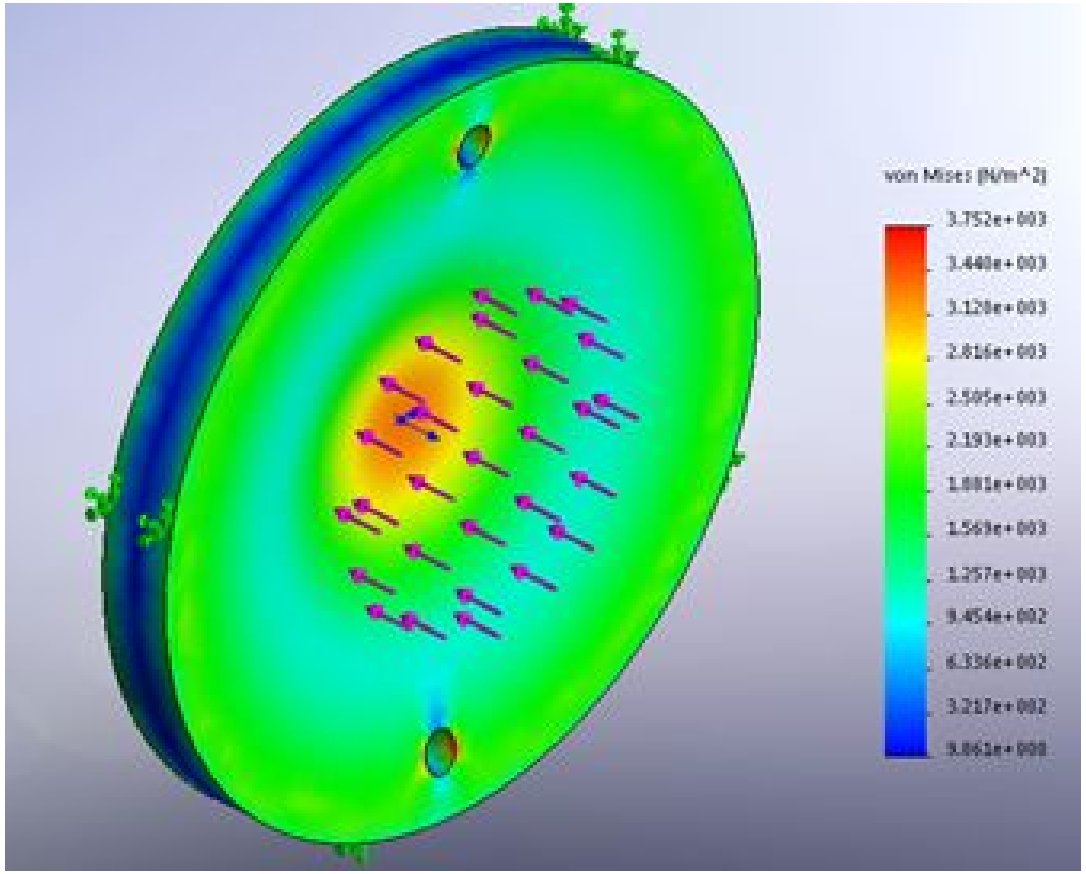




# Payload Bay – Dimension

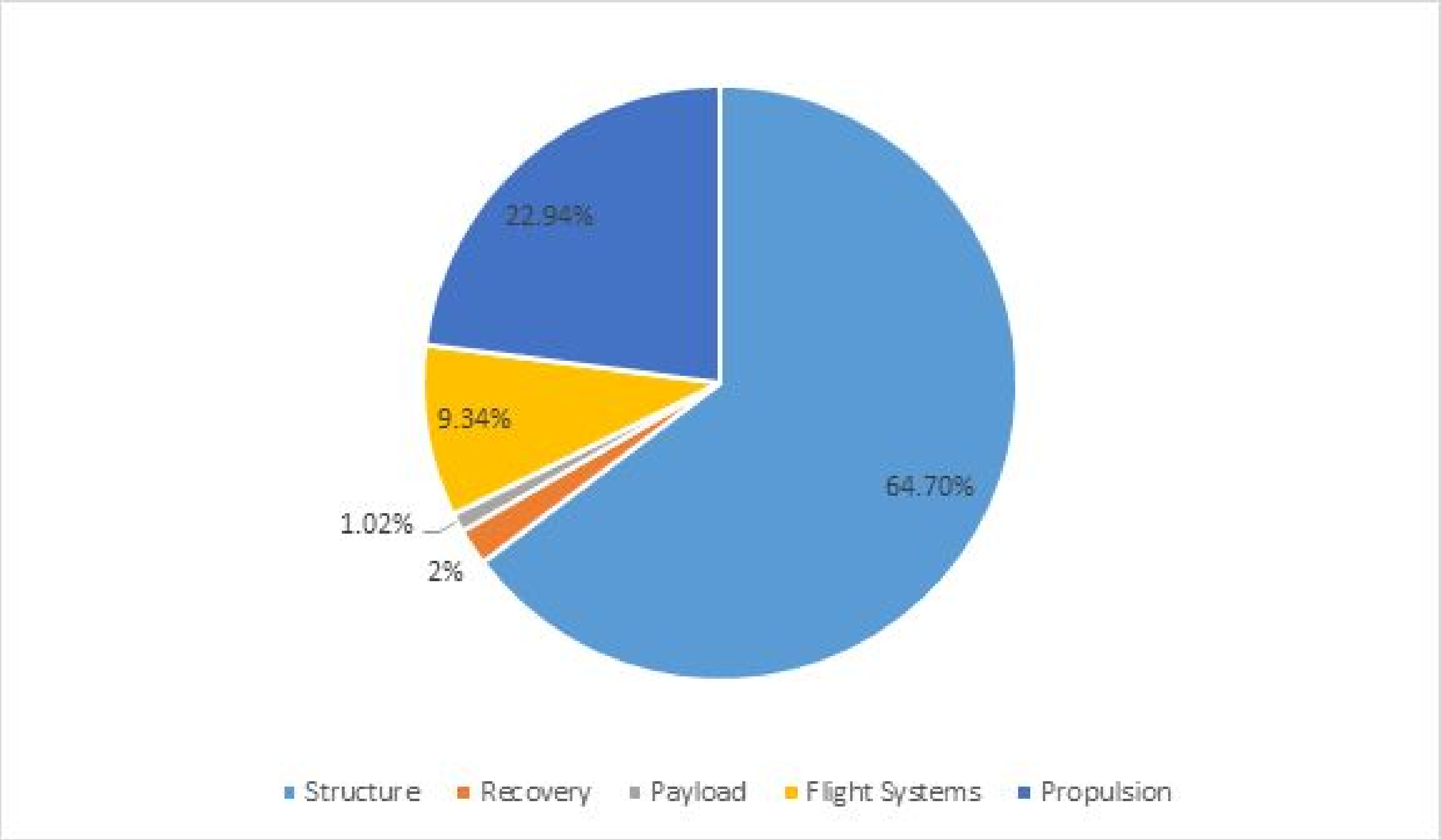


# FEA Thrust Plate



# Mass Breakdown



# Thrust-to-Weight Ratio *

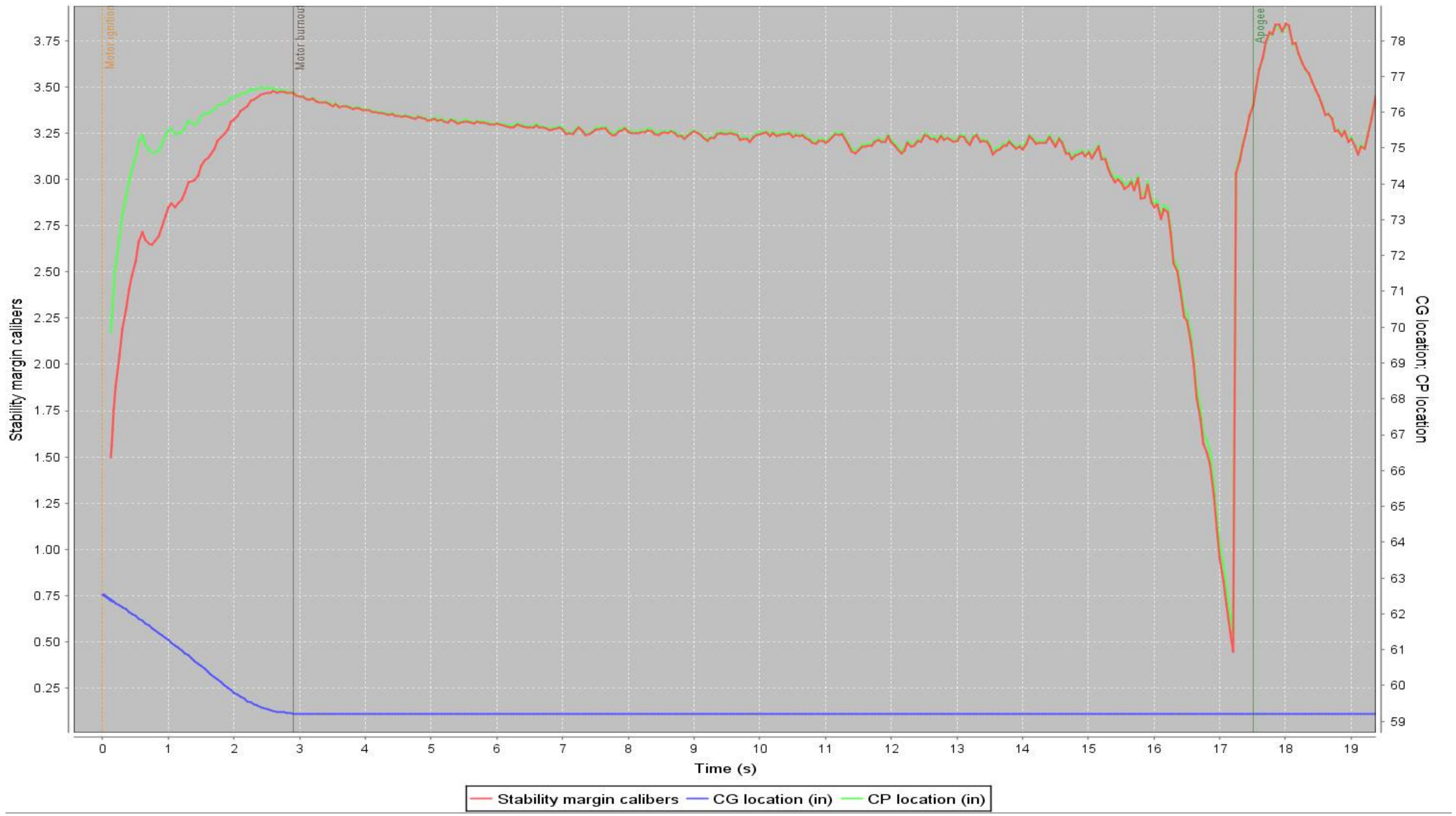
Thrust/Weight

Avg. Thrust = 991 N

Weight = 9.7 kg * 9.81 m/s2

Thrust-to-Weight Ratio = 10.414

# 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 |

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

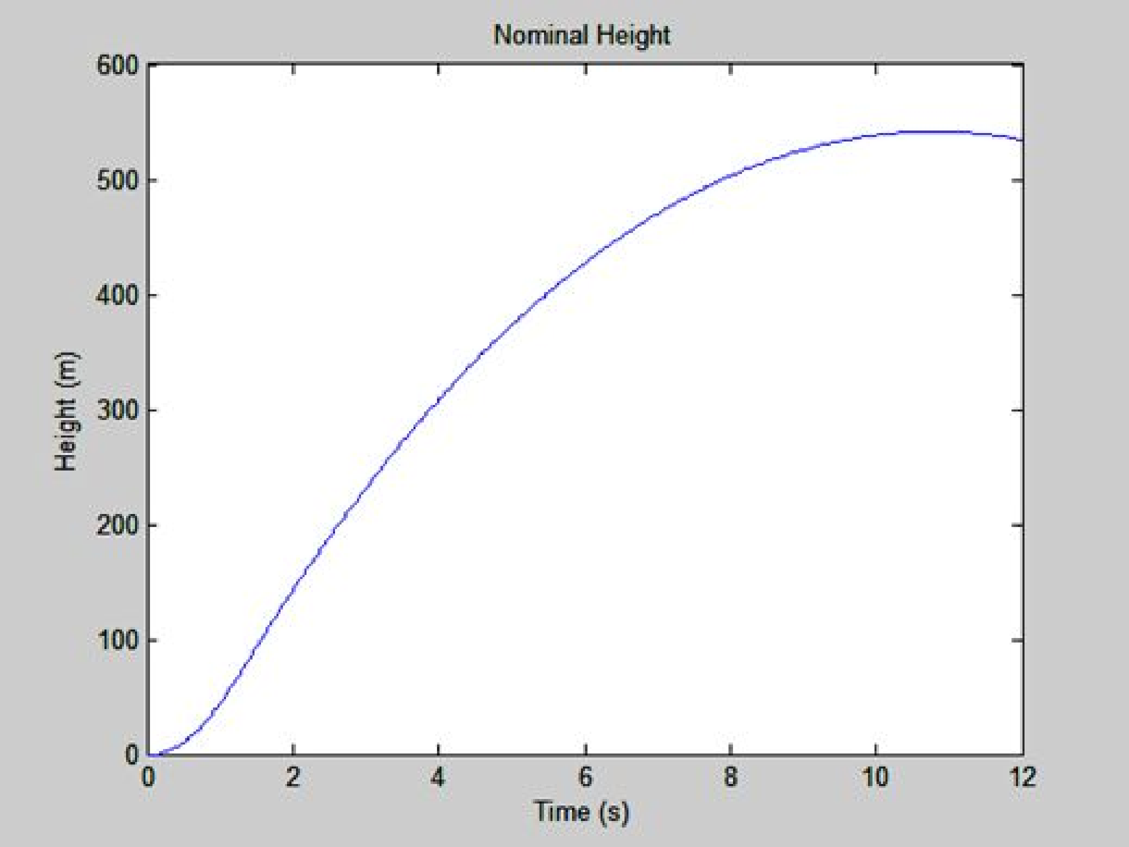
$$\bar{X} = 182.7957184cm$$

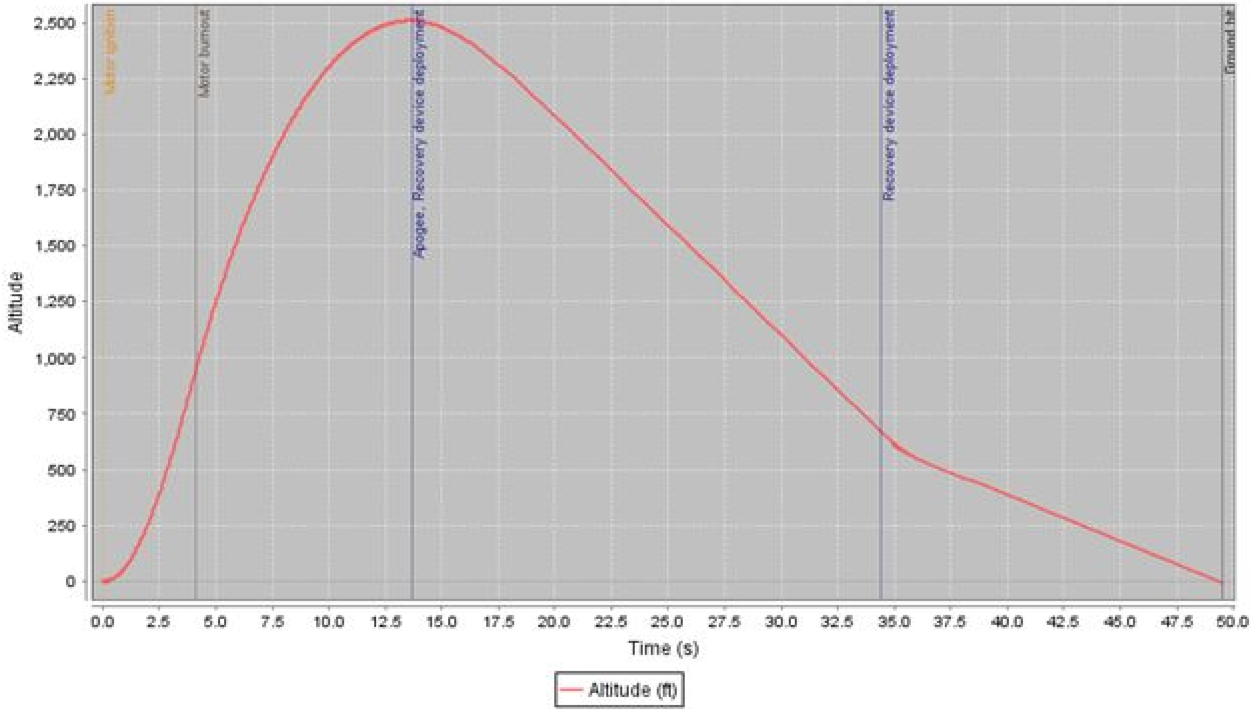
# Parachutes - Specifications *

| | |
|---|---|
| ***Sizes*** | Main: 50” Drogue: 15”, composed of tubular nylon |
| ***Recovery Harness Type*** | Main: Angel Parachute, Drogue: Eliptical Costuem |
| ***Length*** | Main: 30’, Drogue 15’ |
| ***Descent Rates*** | |

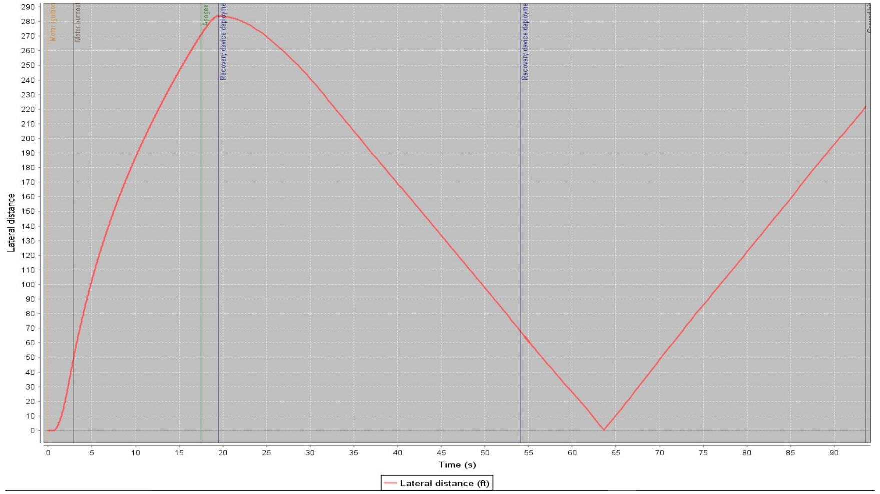
Explain sizes, recovery harness type, size, length,
And descent rates *

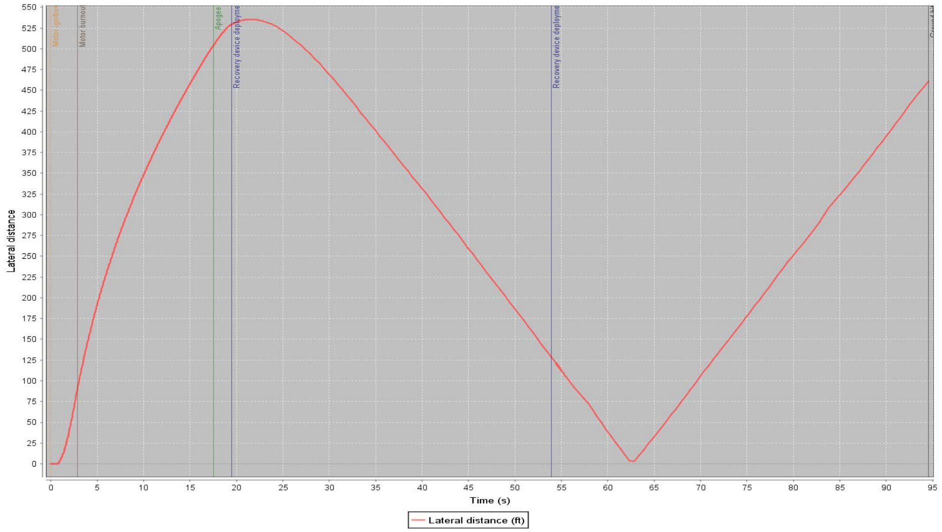
# Mission Performance – Flight Profile

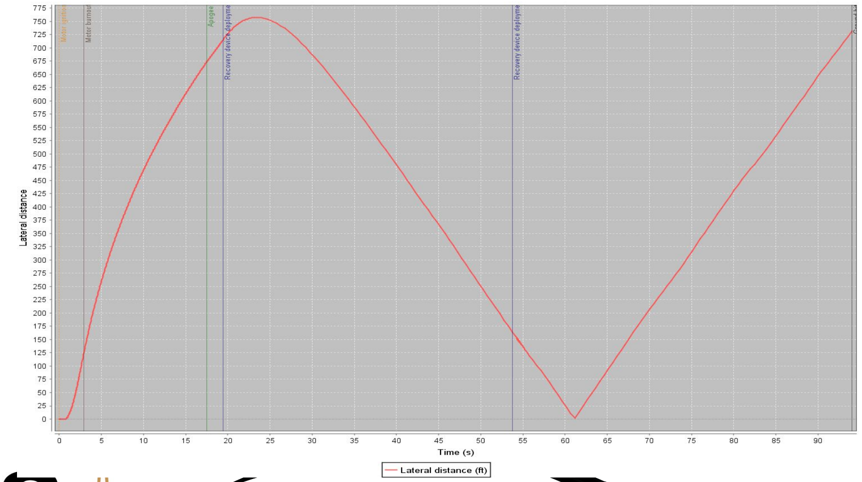


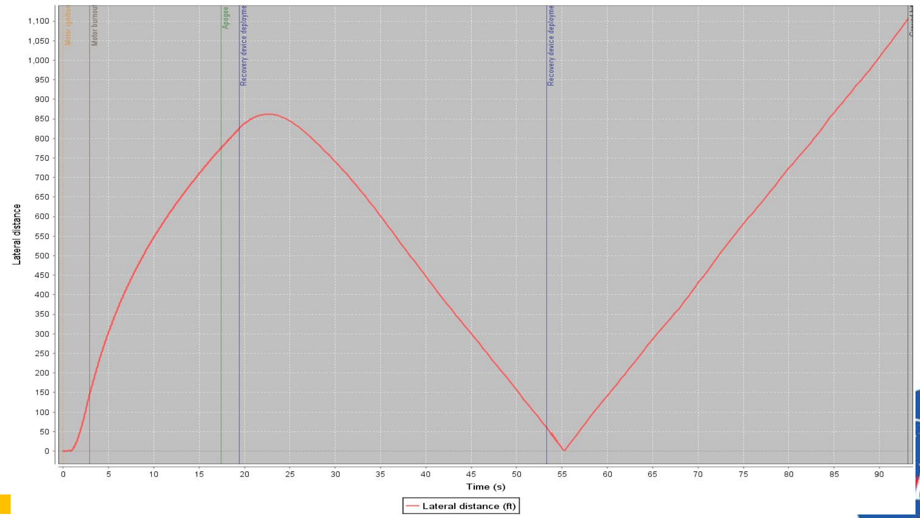



# Mission Performance - Drift Profile



# Launch Vehicle Kinetic Energy

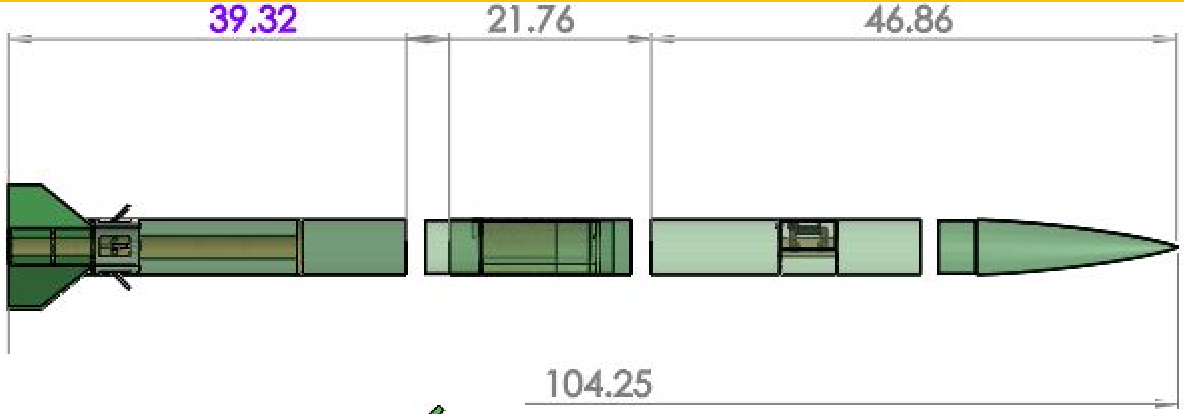
| *Sections* | *Mass (lbs)* | *KE ( ft-lbf)* |
|---|---|---|
| Nosecone | 0.47 | 8.83 |
| Avionics Bay | 2.2 | 35.437 |
| Booster Section | 1.5 | 28.18 |

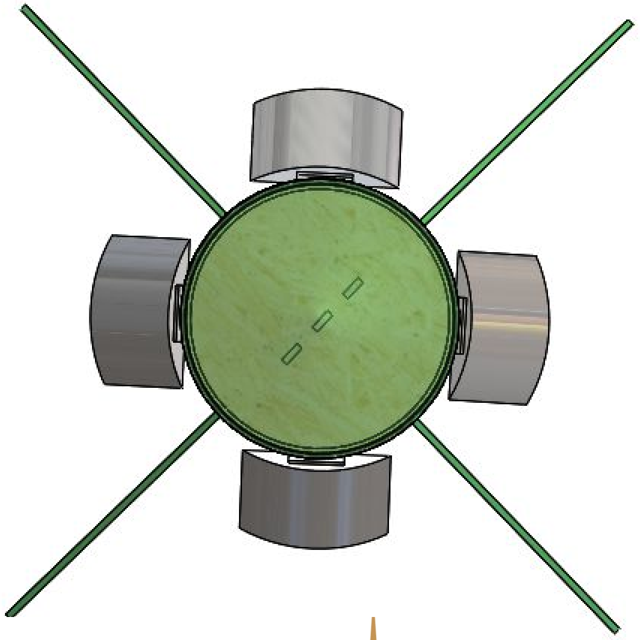
Our total Kinetic Energy at landing is approximately 72.447 ft lbf.

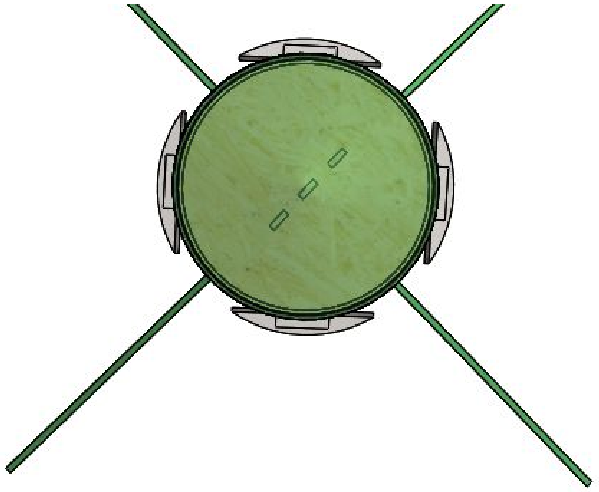
# Test Plan Overview

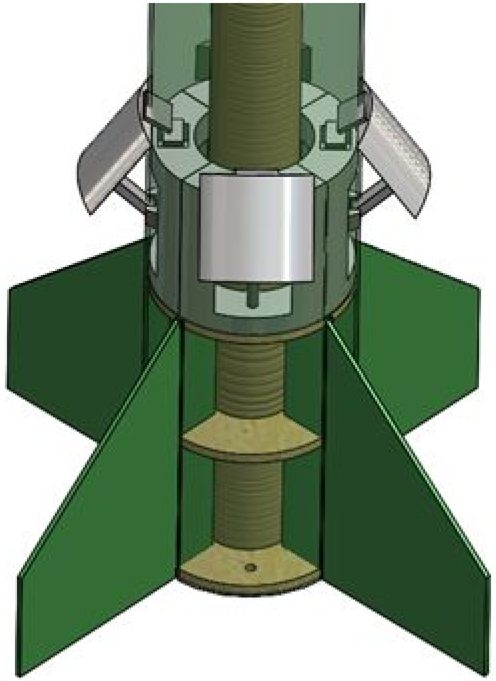
| *Component* | *Test* | *Verification Method* |
| --- | --- | --- |
| Lead Screw with DC motor actuation | Extension force of flaps test. | Quantitative Analysis |
| ATS | Wind tunnel testing to confirm Cd simulations. | Quantitative Analysis |
| Thrust Plate | Bend test and pressure test to verify 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

Outline of Success Criteria

| **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 |

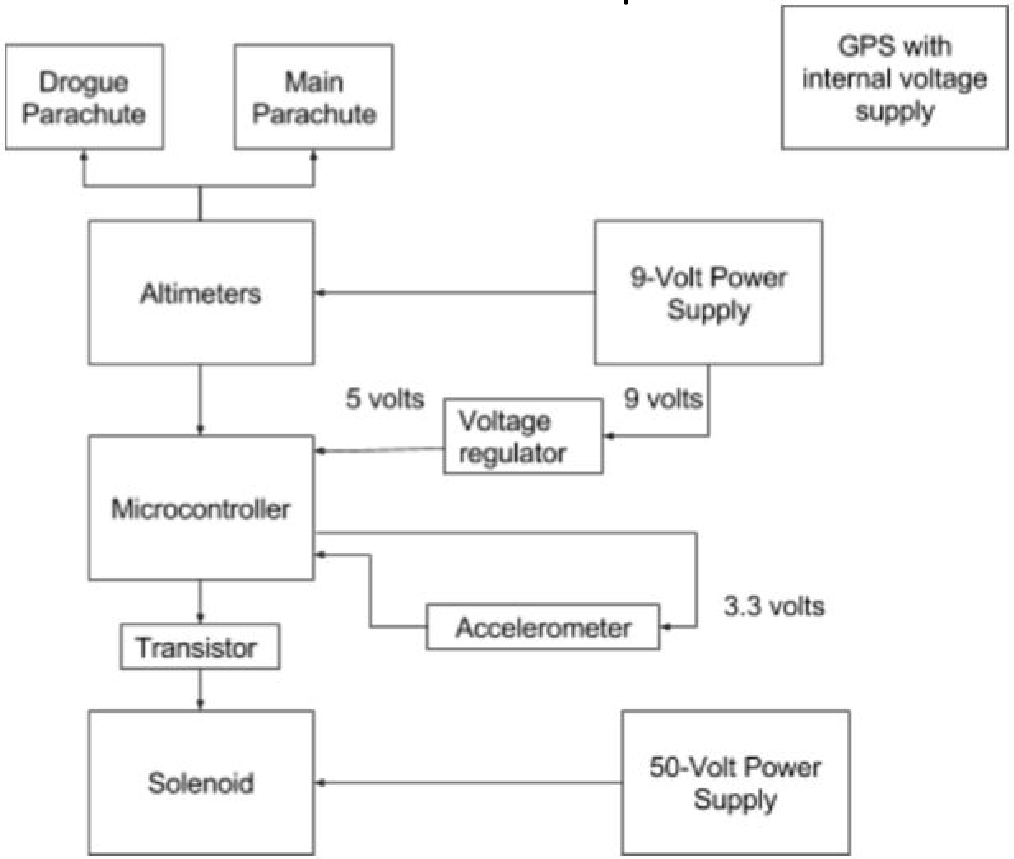
# Flight Systems: Avionics

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 |

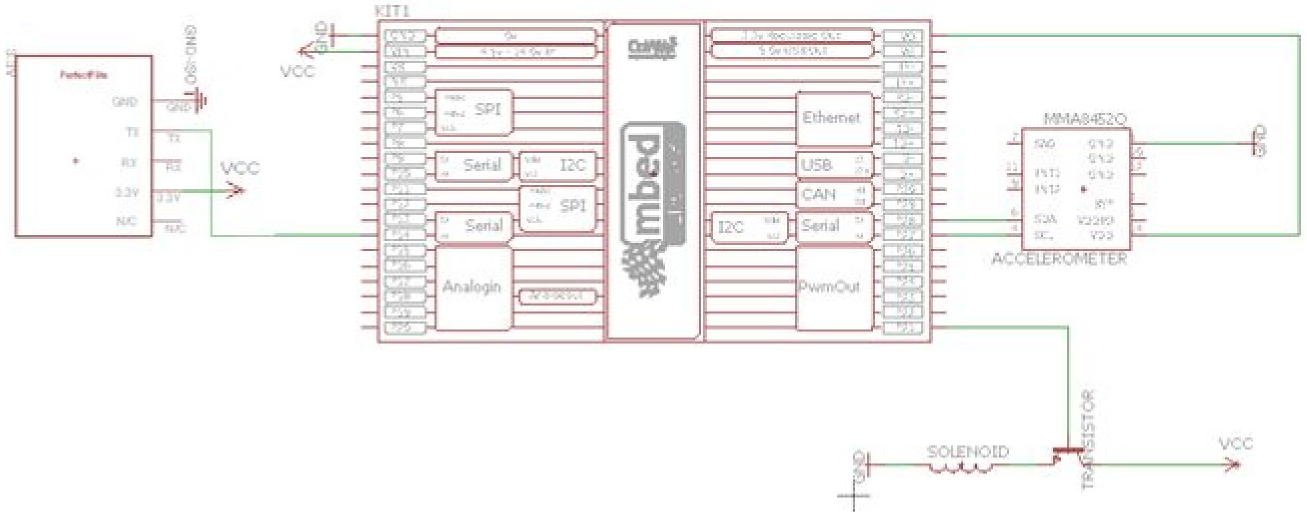
# Flight Systems: Avionics

General connection of main components

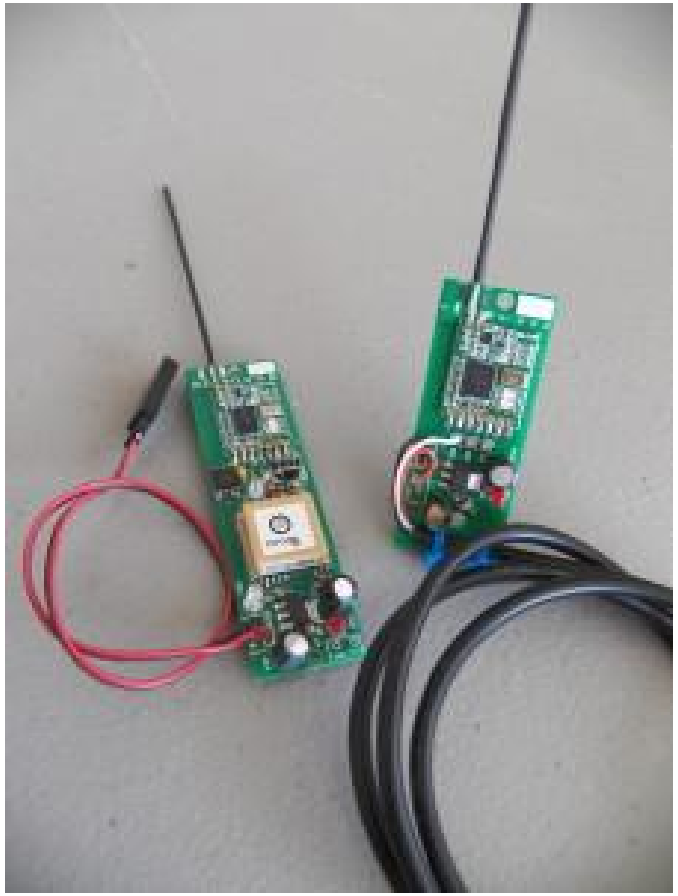


# Flight Systems: Avionics

Eagle CAD schematic of main components



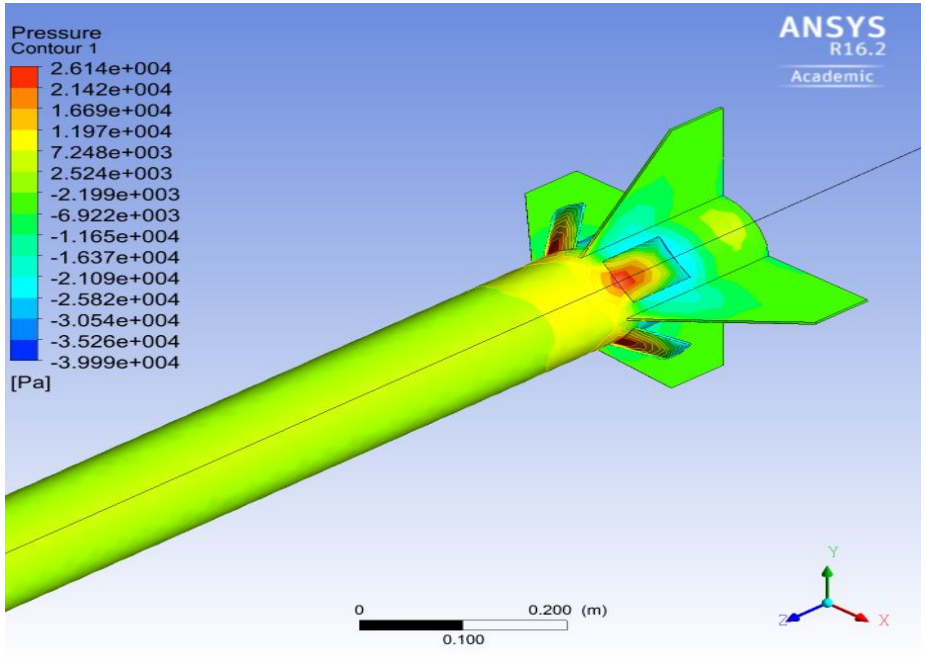
# Flight Systems: Ground Station

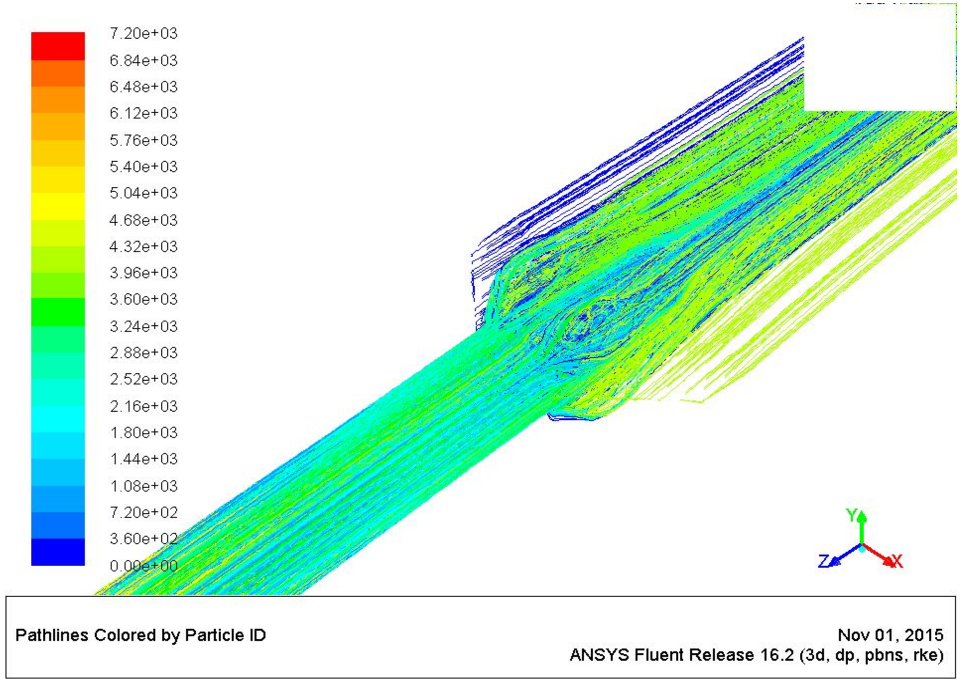


**Equipment:**

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

# Flight Systems: ATS Science

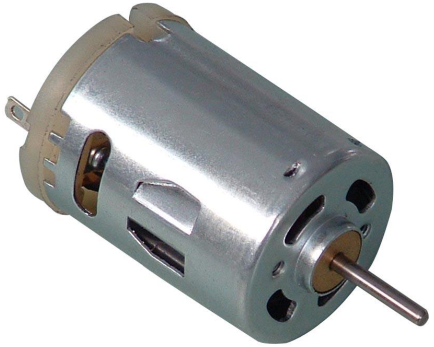



Dynamic drag adjustment by changing the geometry exposed to the flow to increase the vehicle's aerodynamic properties.

# 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

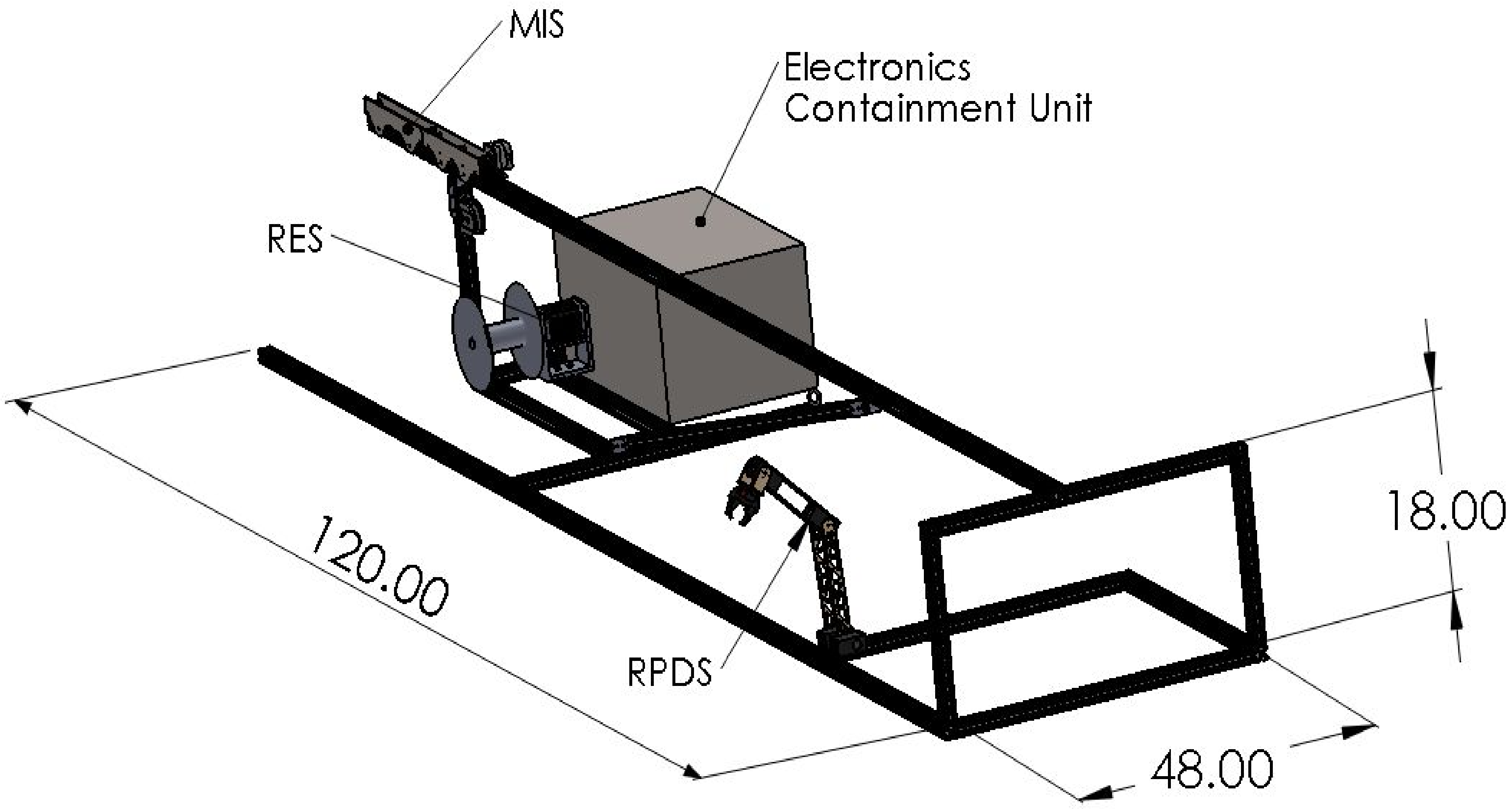
**Flight Simulation:** Forged flight data will be fed to the sensors and the response efficacy will be analyzed.

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

# Project Hermes - CDR

## AUTONOMOUS GROUND SUPPORT EQUIPMENT

# AGSE: Initial Design




- 10 ft. by 4 ft. base
- 1.5 ft. height
- Weight ≈ 60 lbs.
- 3 subsystems
- RPDS: Robotic Payload Delivery System
- RES: Rocket Erection System
- MIS: Motor Ignition System

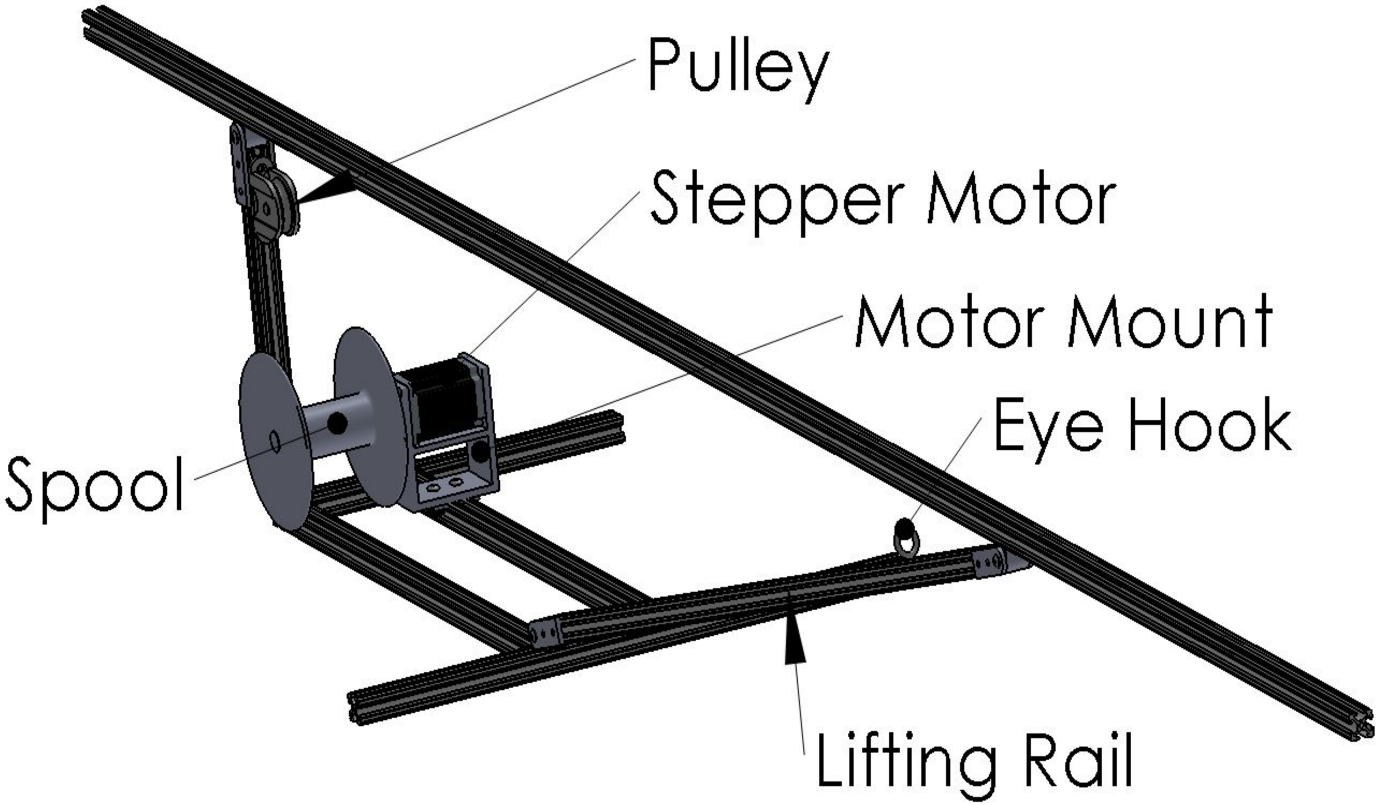
# AGSE: RPDS

- Will locate payload using IR sensors
- Grab payload using gripping claw
- Arms constructed from plywood
- Motor mounts 3-D printed (ABS plastic)
- 5 servo motors

# AGSE: RPDS

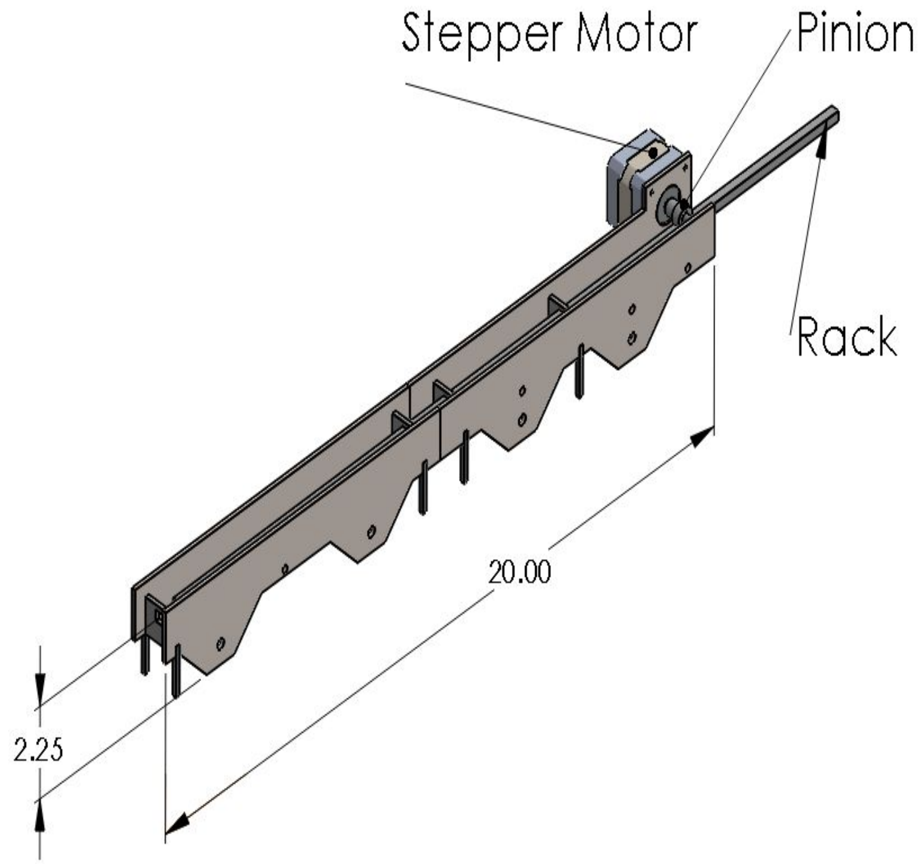
- Arm will move payload into payload bay
- Payload secured by plastic clips
- Arm will close the magnetically locking hatch

# 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: MIS




- Rack and pinion system inserts electronic match 12 inches into the motor cavity
- Fixed to the bottom of the guide rail
- Constructed from 1/8 in steel
- 1 bipolar stepper motor

# AGSE: Safety

| *Potential Failure* | *Effects of Failure* | *Failure Prevention* |
|---|---|---|
| Payload is not secured in bay | Payload will bounce inside payload bay, disrupting flight | Test various plastic clip dimensions to find best fit |
| RPDS stuck inside payload bay | Payload bay will not close and RPDS will be destroyed by raising of 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 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 potentially the motors will be broken | Test subsystem, add counterweights to reduce necessary force from motor, and add more framing to increase stability |

# AGSE: Safety

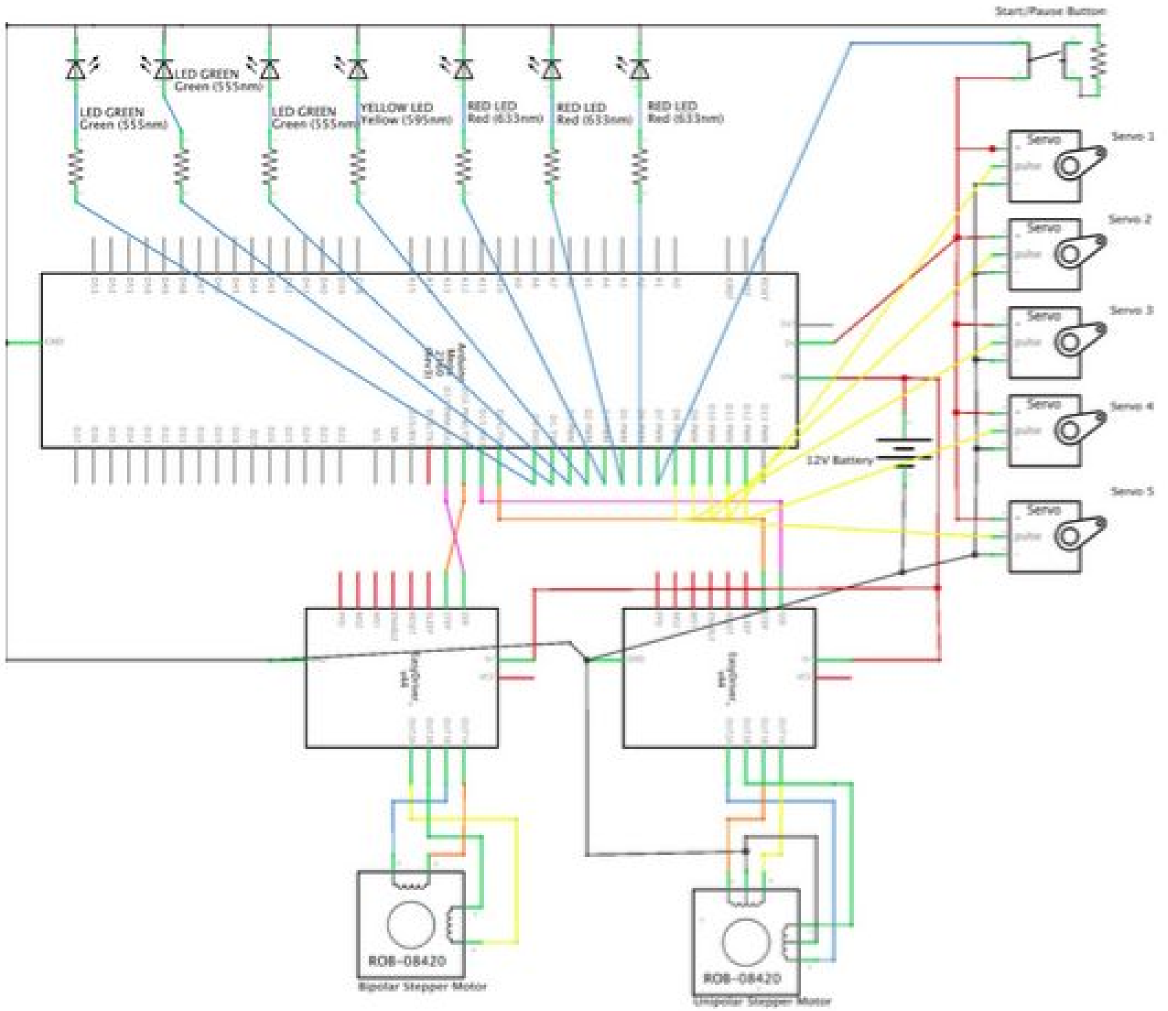
| | | |
|---|---|---|
| RES is not stable at full extension | Launch vehicle could tip over | Increase the weight to lower the center of gravity. Increase the base width. Add more supports to the launch rail. |
| RES does not stay upright | Launch vehicle will fall unpredictably | Perfect ratchet system, ensure tension in steel cable |
| 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 motor | 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 overloads |

# AGSE: Electronics

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

# AGSE: Power

- System will be powered by 12V- 10.5 Ah lead acid battery
- System can run continuously for 6.37 hours
- Batter can power 47 runs



# AGSE: Test Plan Overview

- RES lifting test
  - Ensure that individual components are durable enough to withstand various forces during operation
  - Hold at various positions to simulate pausing
- RPDS payload insertion test
  - Determine the strength of the robotic arm
  - Determine the precision

# Questions

Questions?