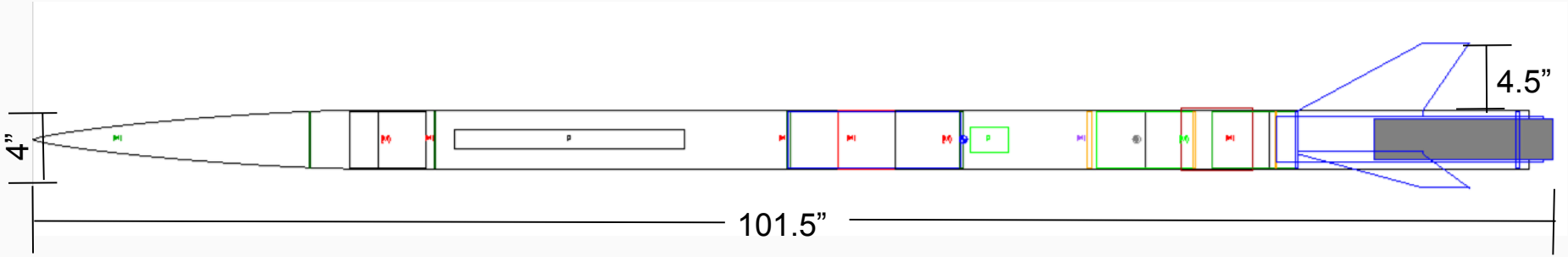
Critical Design Review (CDR) Presentation

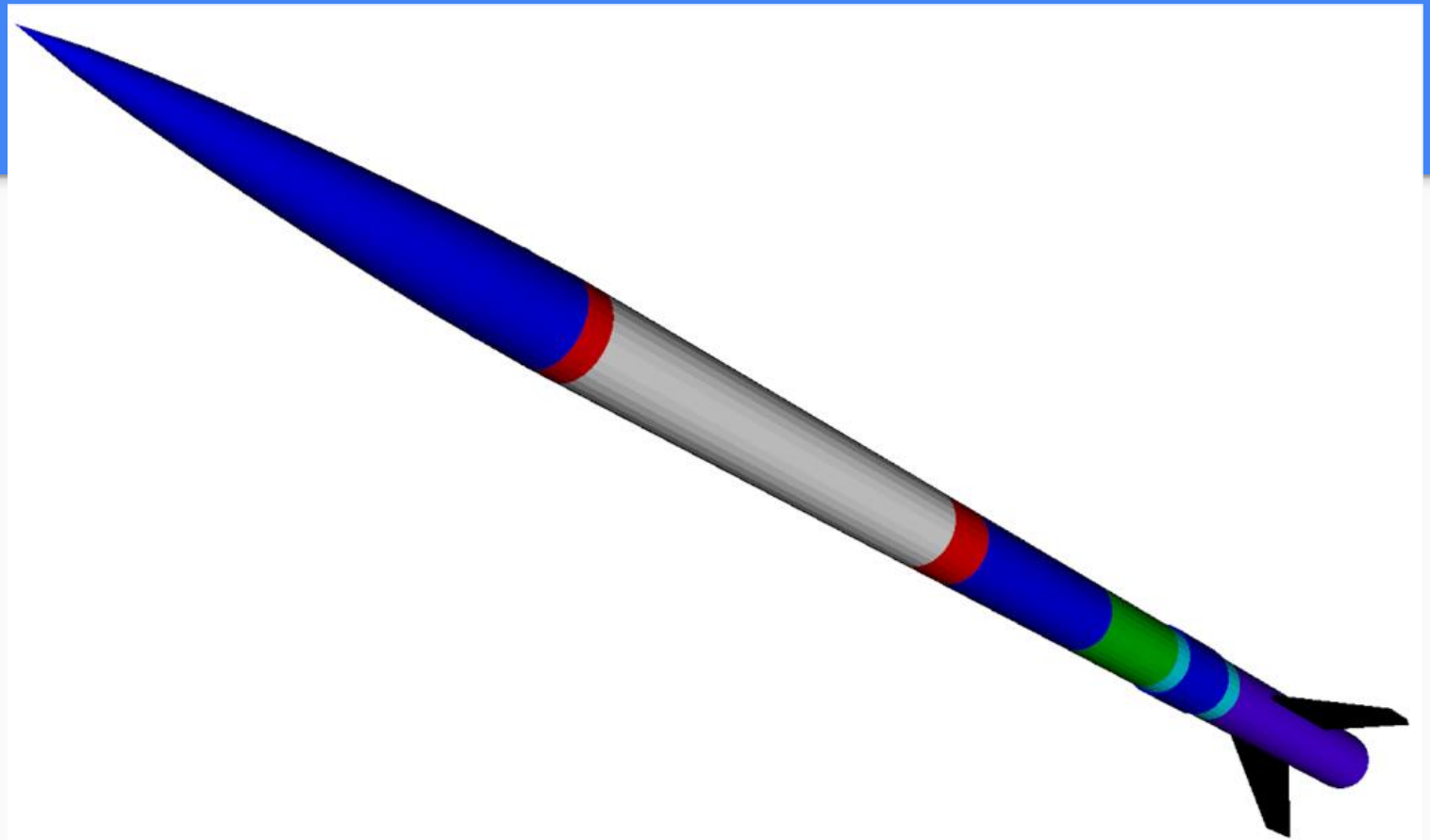
AIAA OC Section 2016-2017
January 30, 2017

Final Launch Vehicle Dimensions

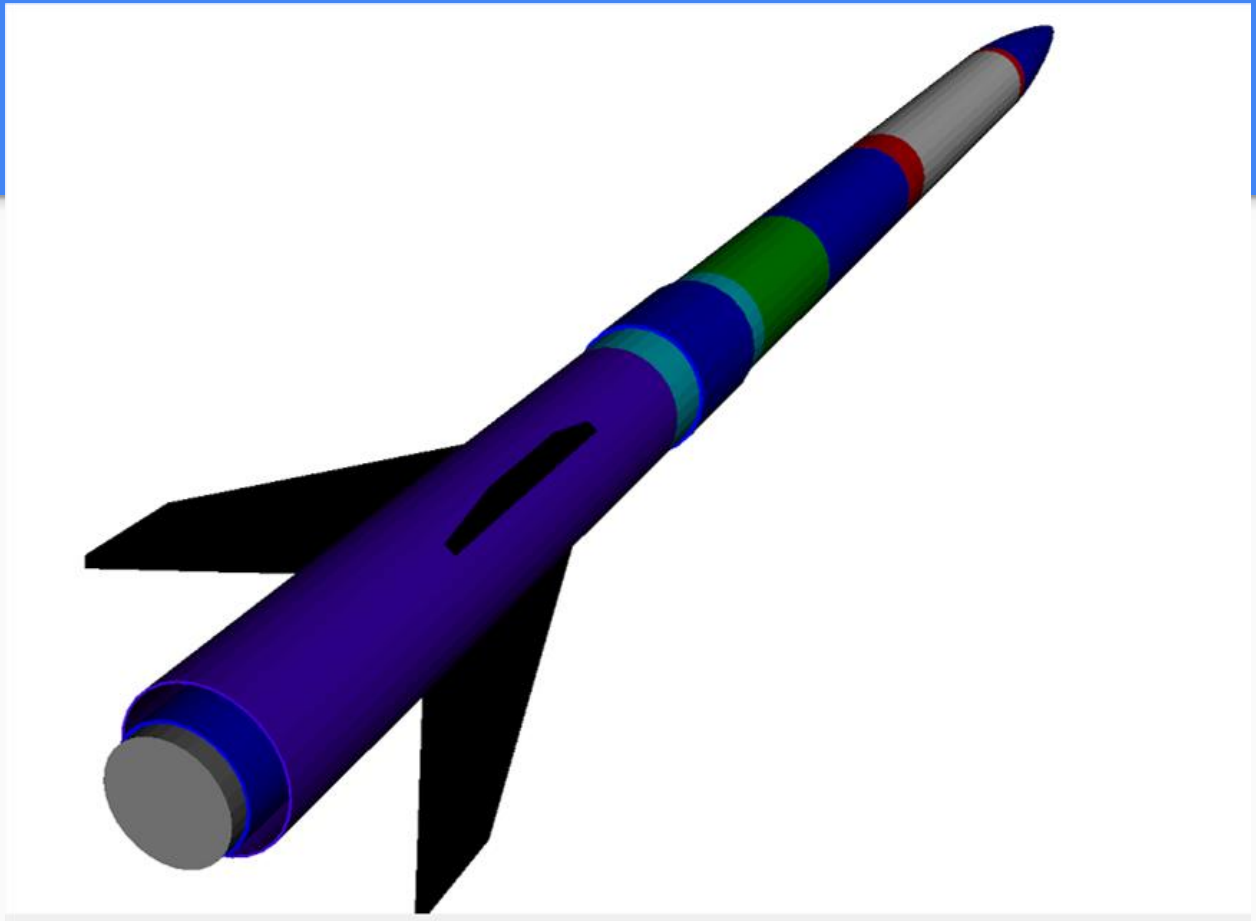
- Length: 101.5 in
- Diameter: 4 in
- Semi Span of Fins: 4.5 in
- Total mass: 9798.167 or 21.6 lbs



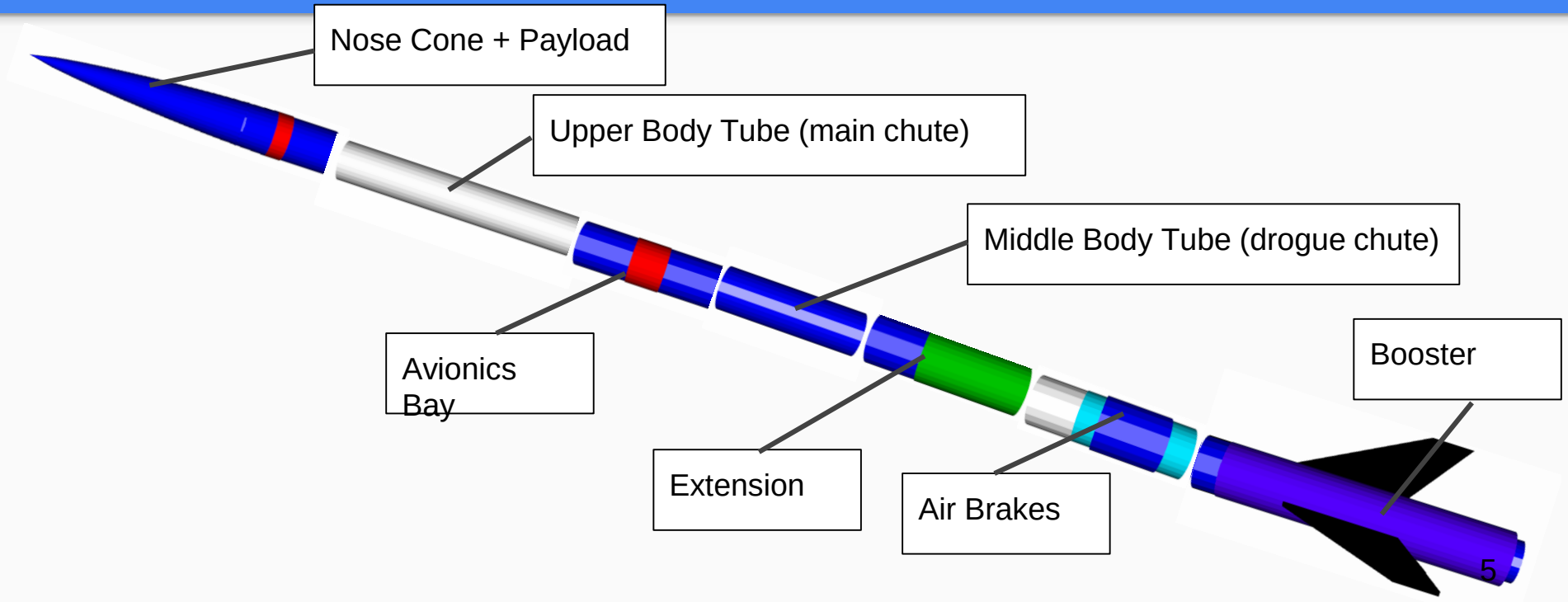
Front View



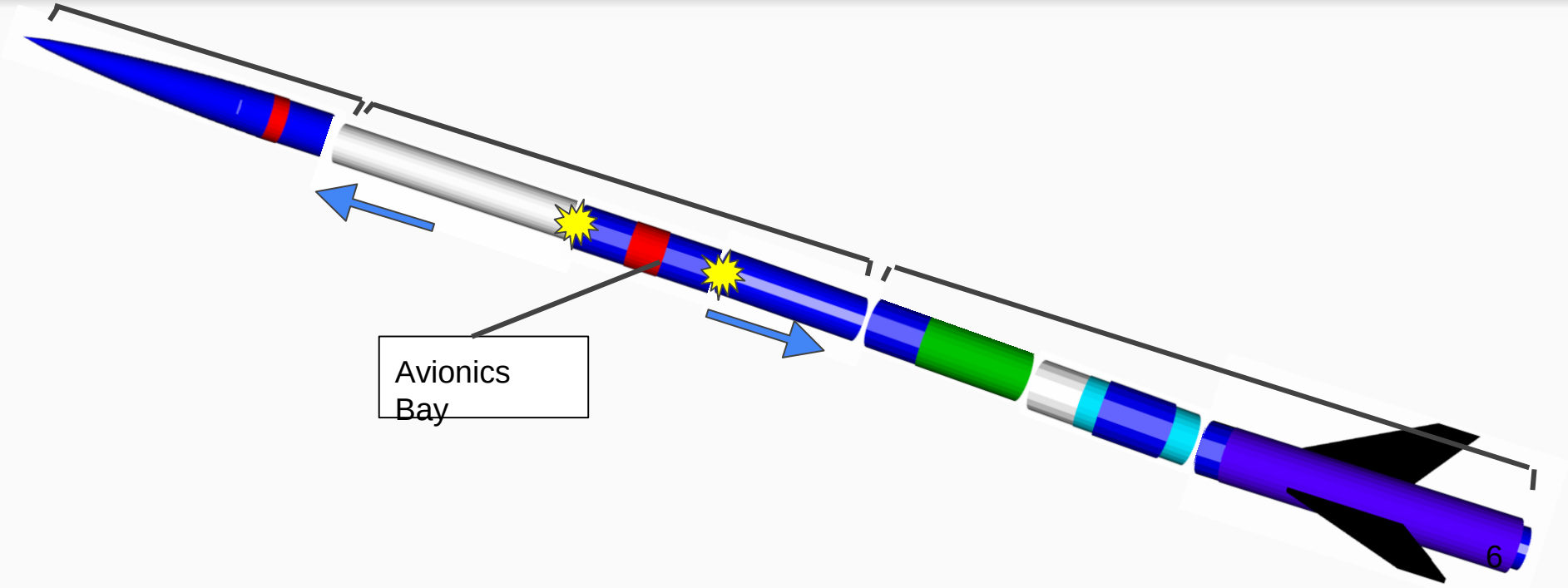
Rear View



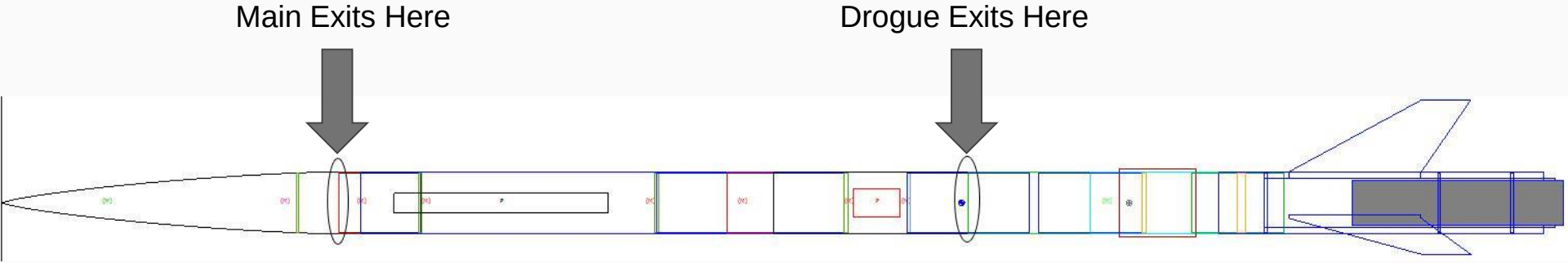
Exploded Model



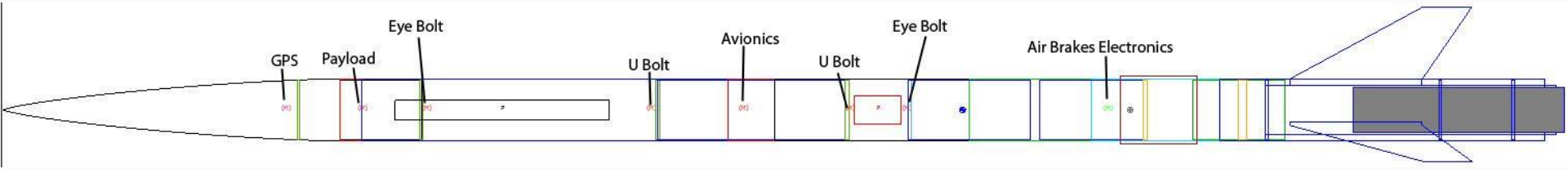
Exploded Model



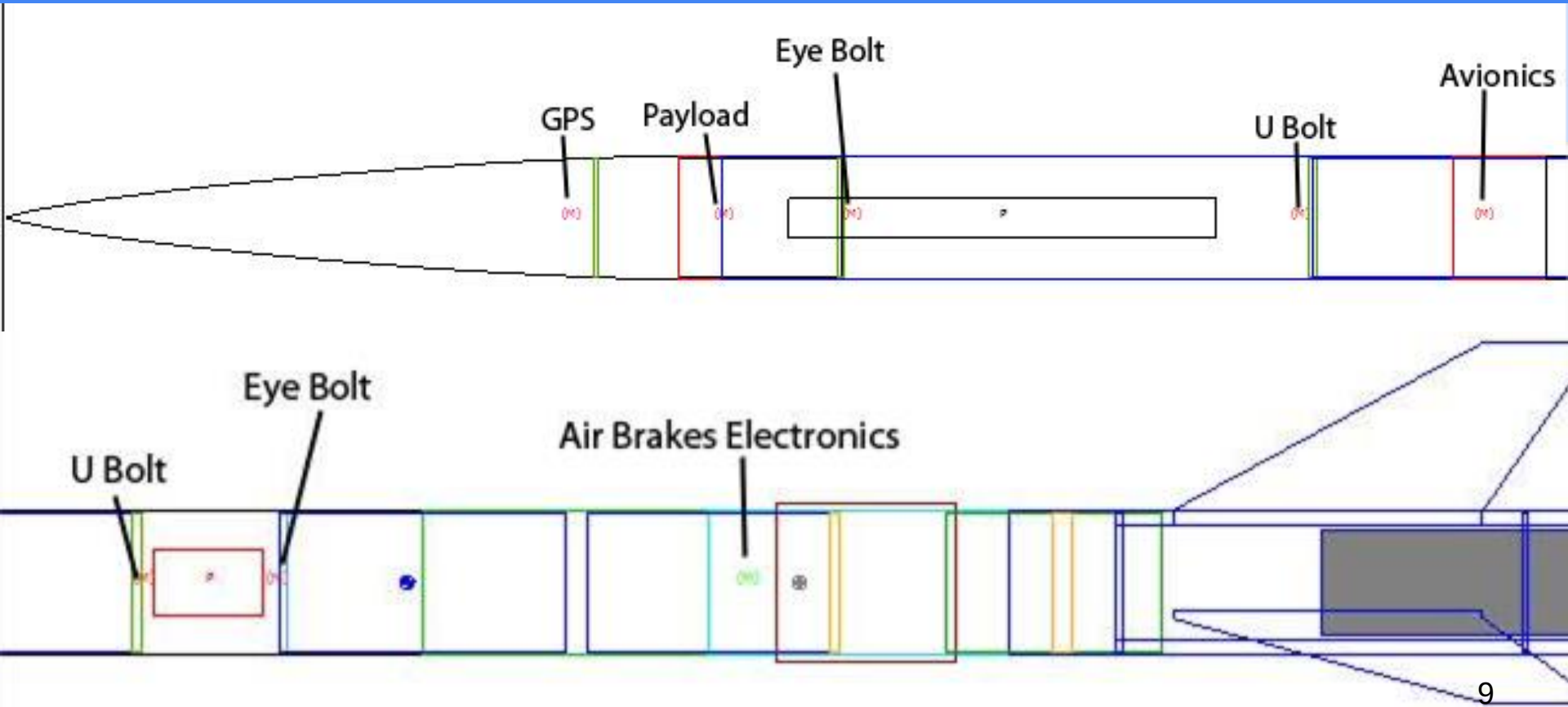
Separation Points



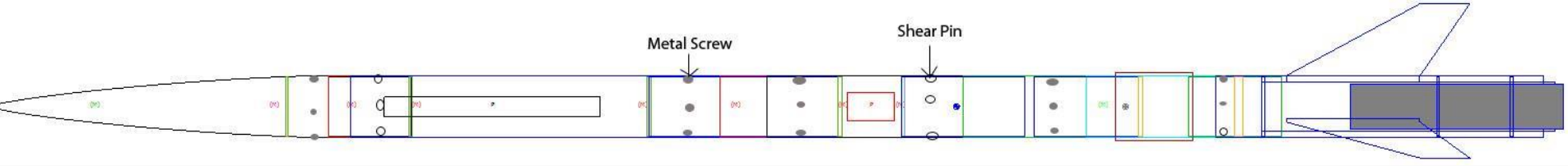
Mass Objects



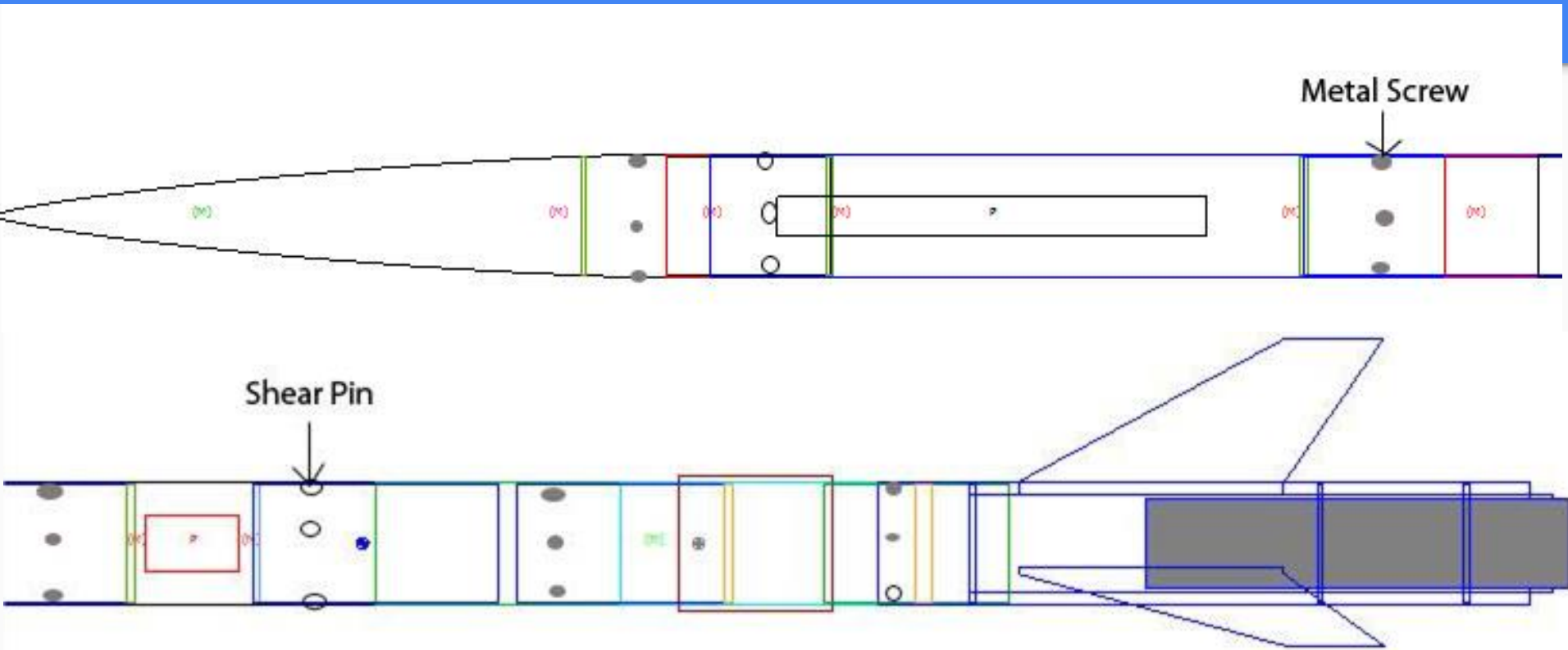
Mass Objects



Screws and Shear Pins

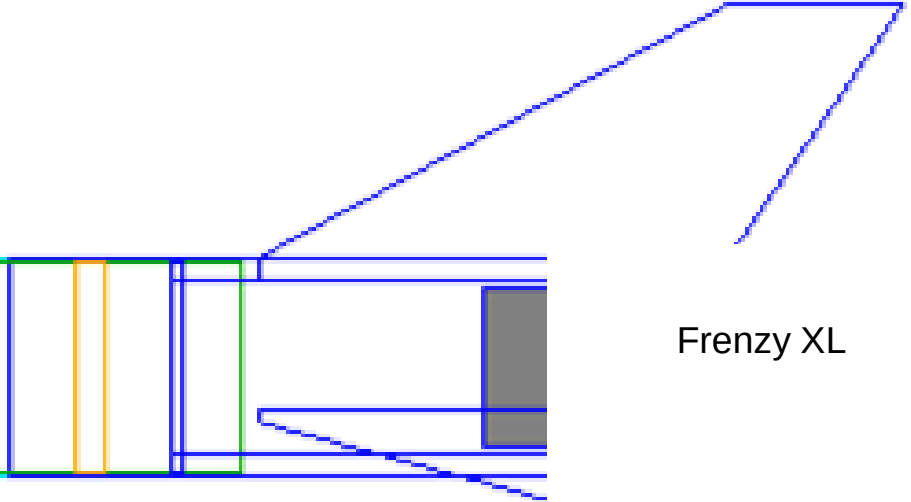


Screws and Shear Pins

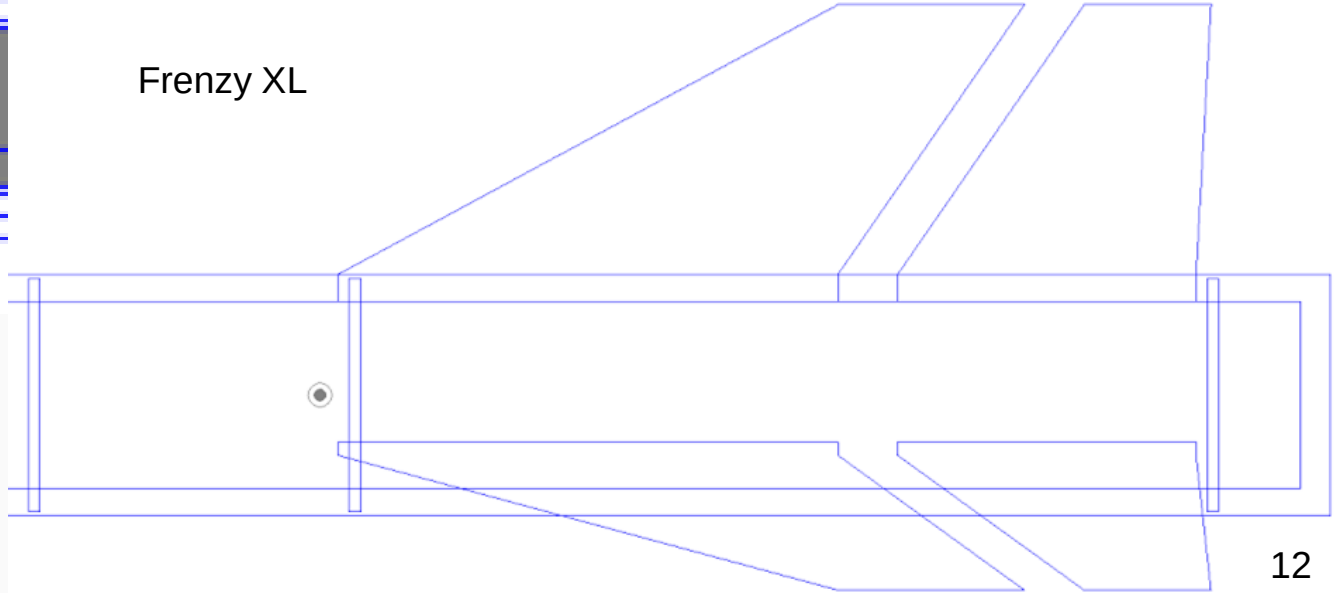


Why does the bottom look so funny?

Our rocket



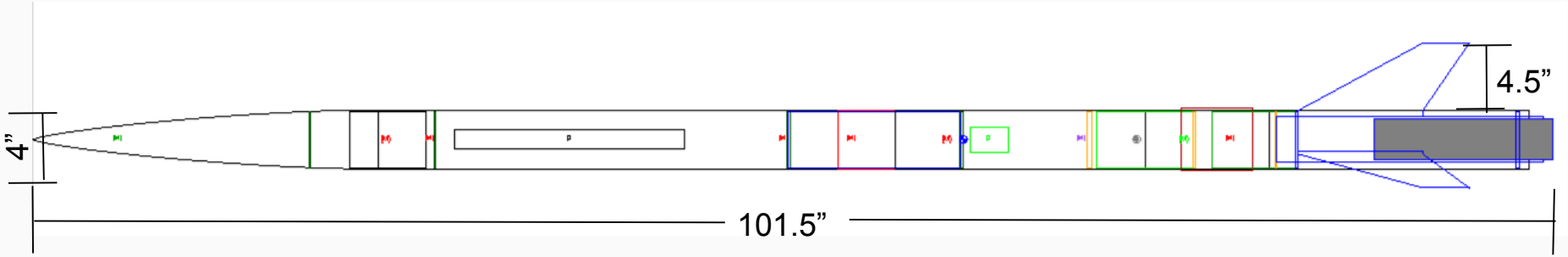
Frenzy XL



Key Design Features of Launch Vehicle

- Avionics
  - Redundant System
- Payload
- Airbrakes

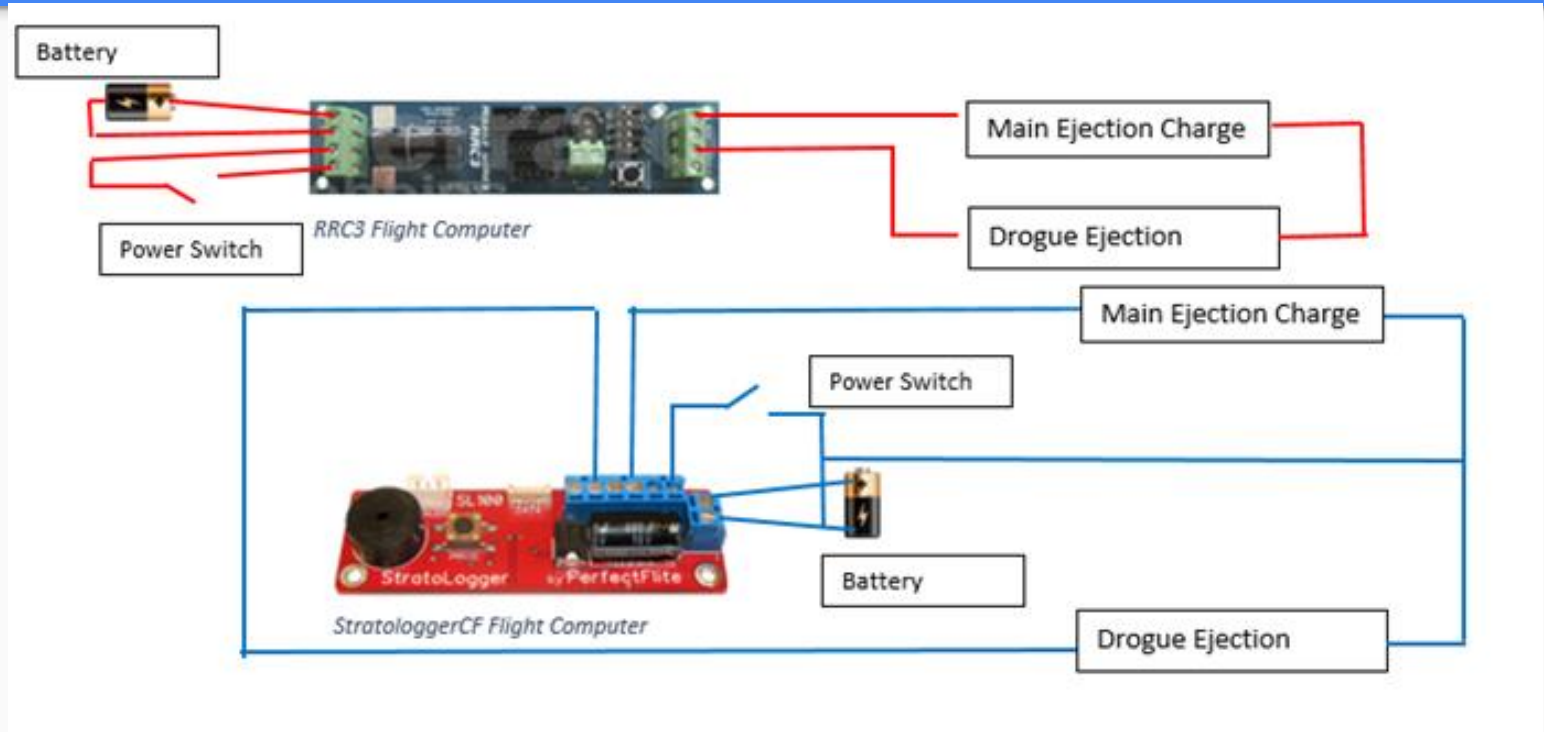
Rocket Dimensions:
- Length: 101.5”
- Diameter: 4”



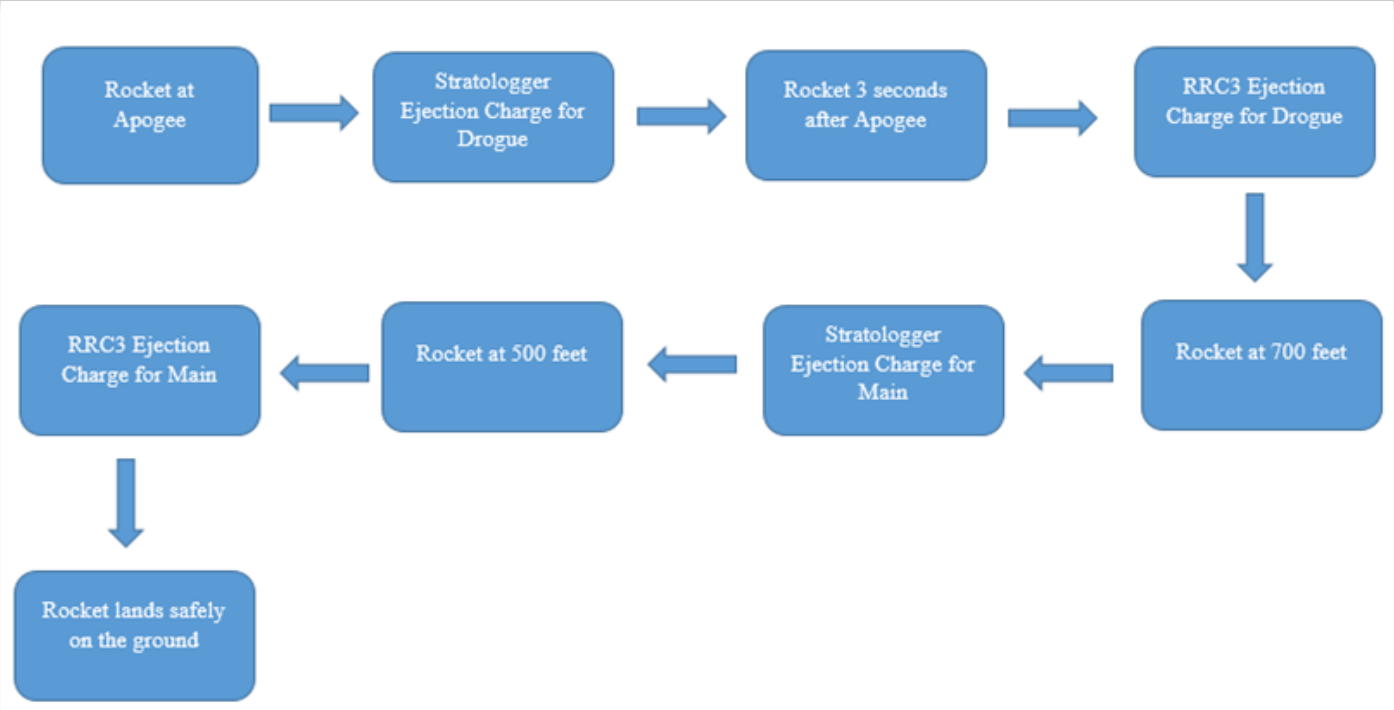
Key Design Features of Avionics

- Stratologger CF (primary)
- RRC3 (backup)
- 2 9V batteries
- 4 Terminals in the bulkheads
  - 2 for main Stratologger and main RRC3
  - 2 for drogue Stratologger and drogue RRC3

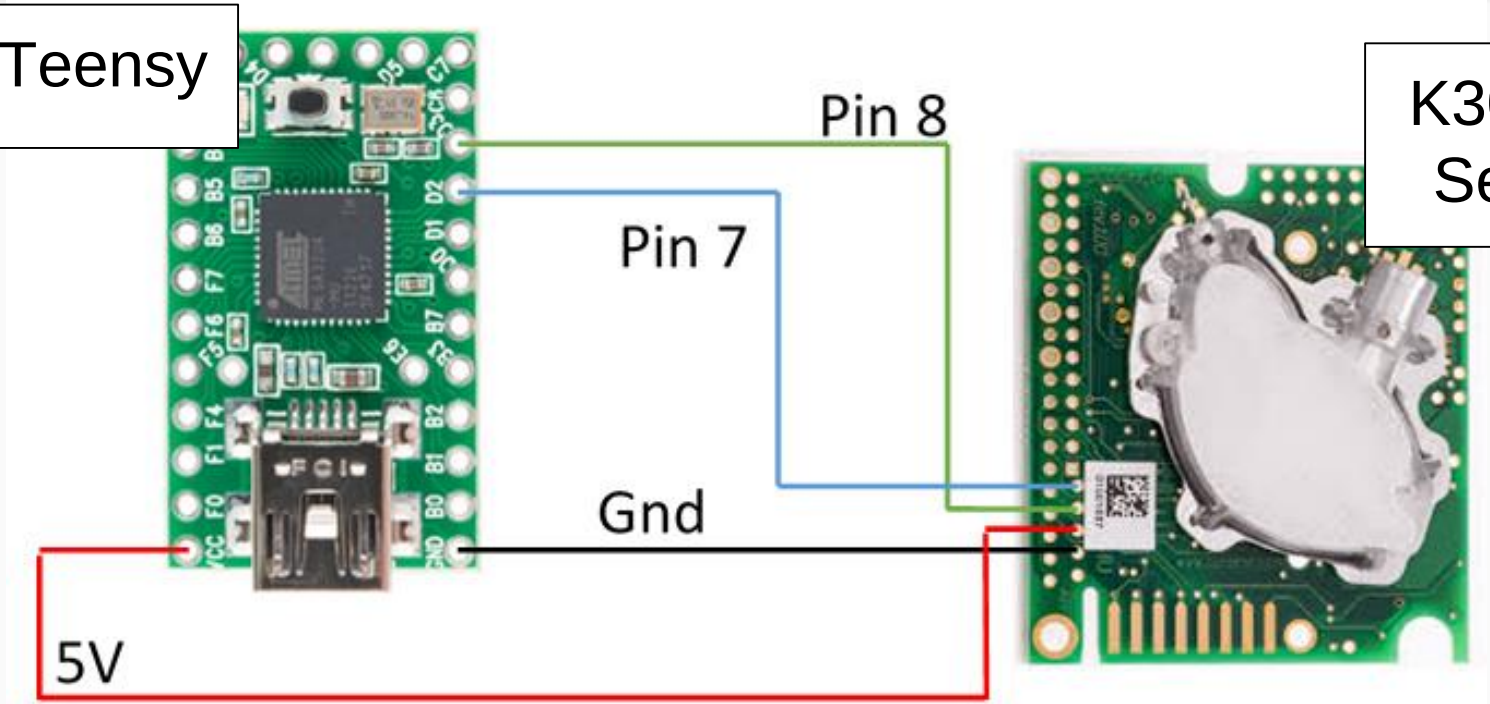
Proof of Redundancy



Recovery Algorithm Flowchart



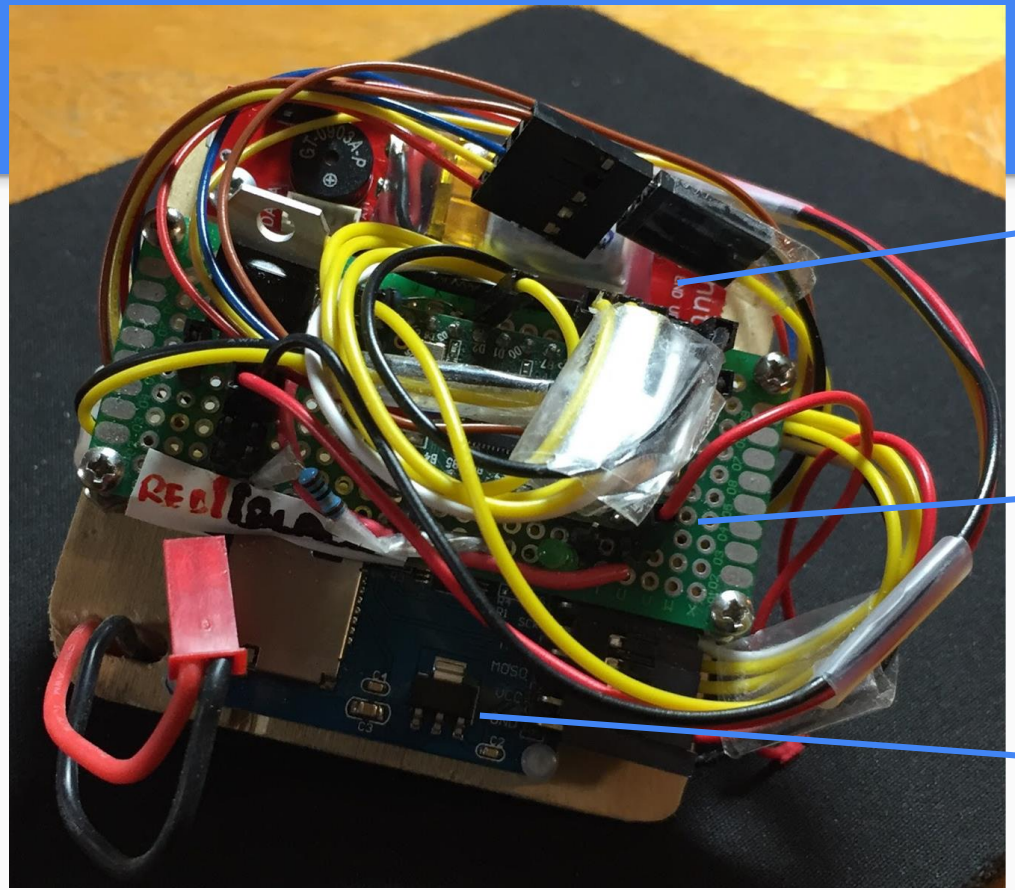
Key Design Features of Payload



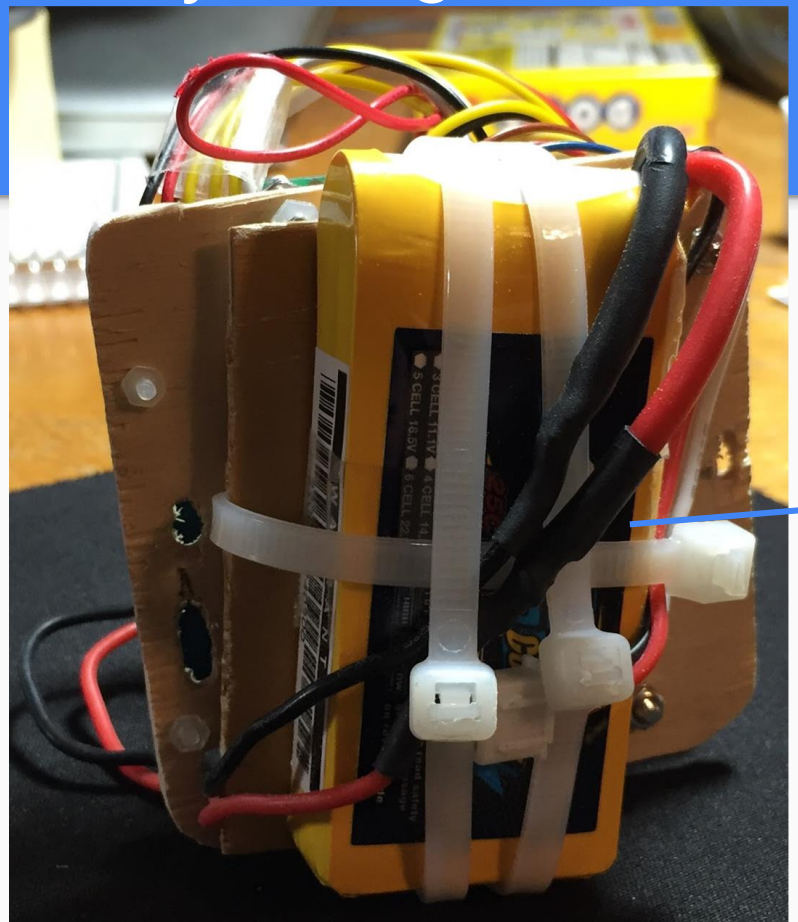
Key Design Features of Air Brakes

- Air Brakes (mechanism)
- Electronics Board
  - Algorithm

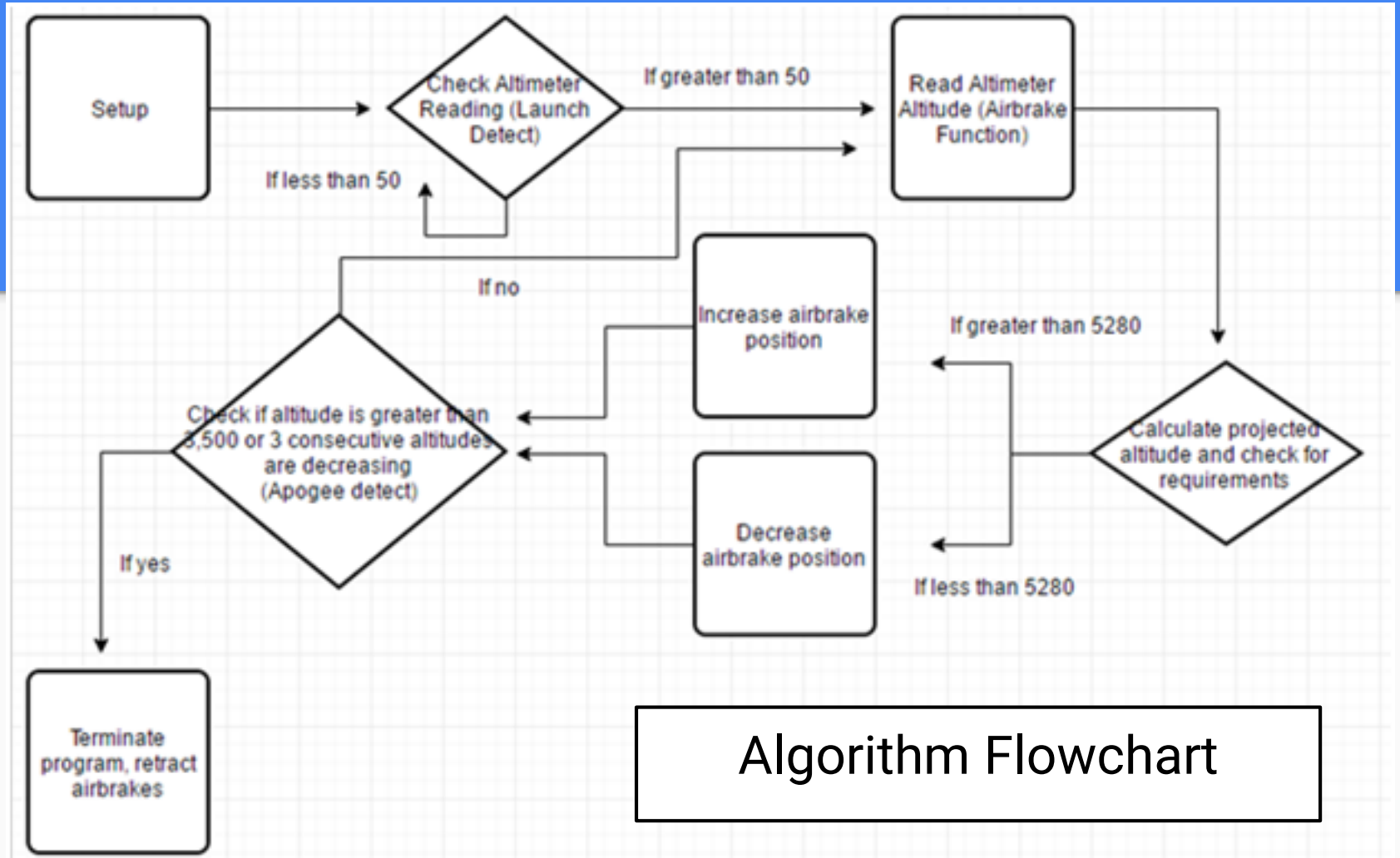
Key Design Features of Air Brakes



Key Design Features of Air Brakes



Lipo Battery



Algorithm Flowchart

Algorithm's Predicting and Actions

Conservation of Energy

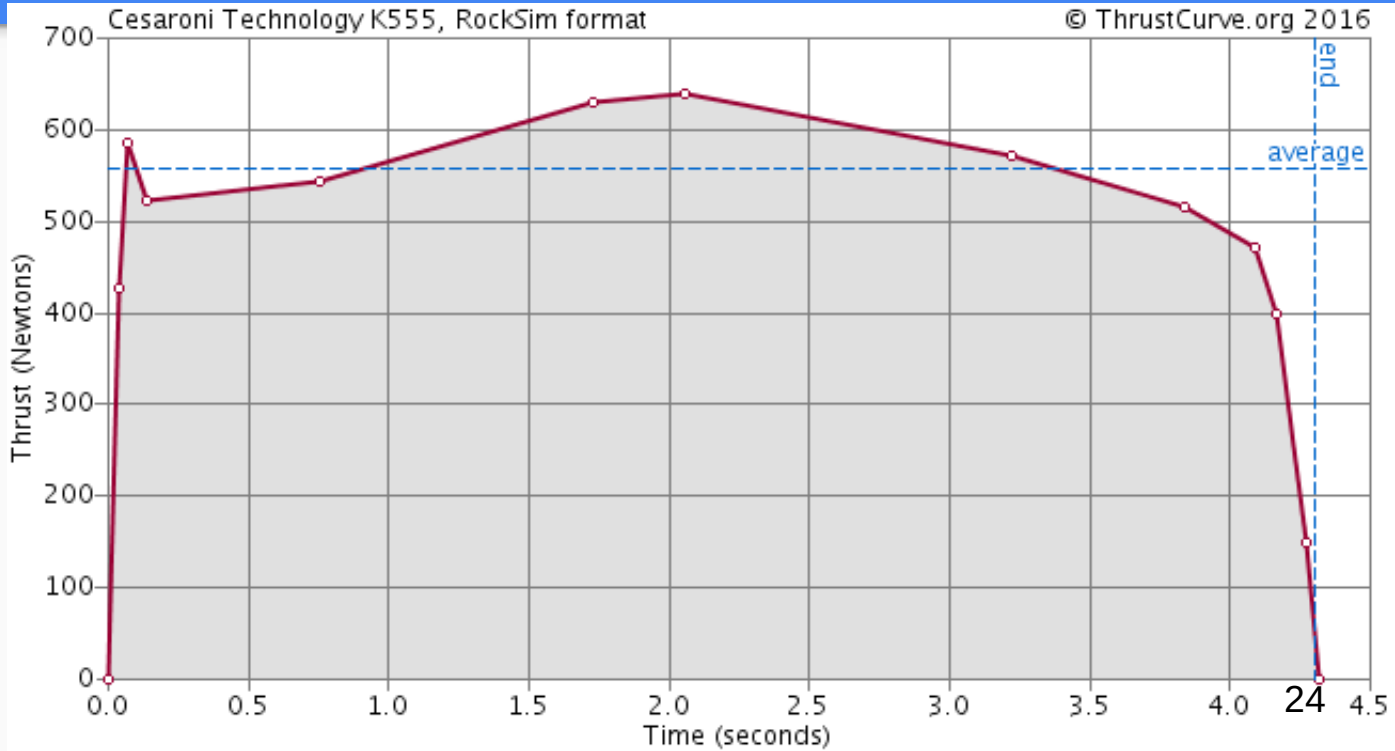
- $U_0 + K_0 = U_f + K_f$
- $mgh_0 + \frac{1}{2}mv_0^2 = mgh_f + \cancel{\frac{1}{2}mv_f^2}$
  - $v_f = 0$ mph at apogee
  - $v_0, h_0 > 0$
- $mgh_0 + \frac{1}{2}mv_0^2 = mgh_f$
- $h_f = h_0 + v_0^2/(2g)$

Coarse tuning and fine tuning

- High velocity affects altitude predictions

Final Motor Choice

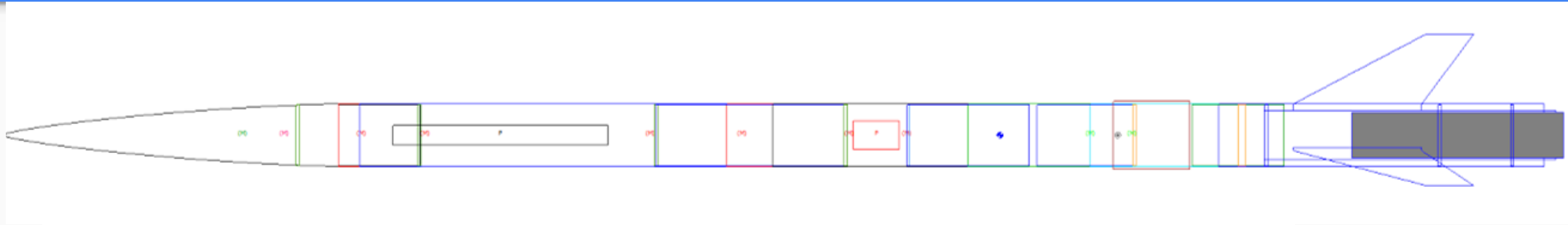
Cesaroni K555

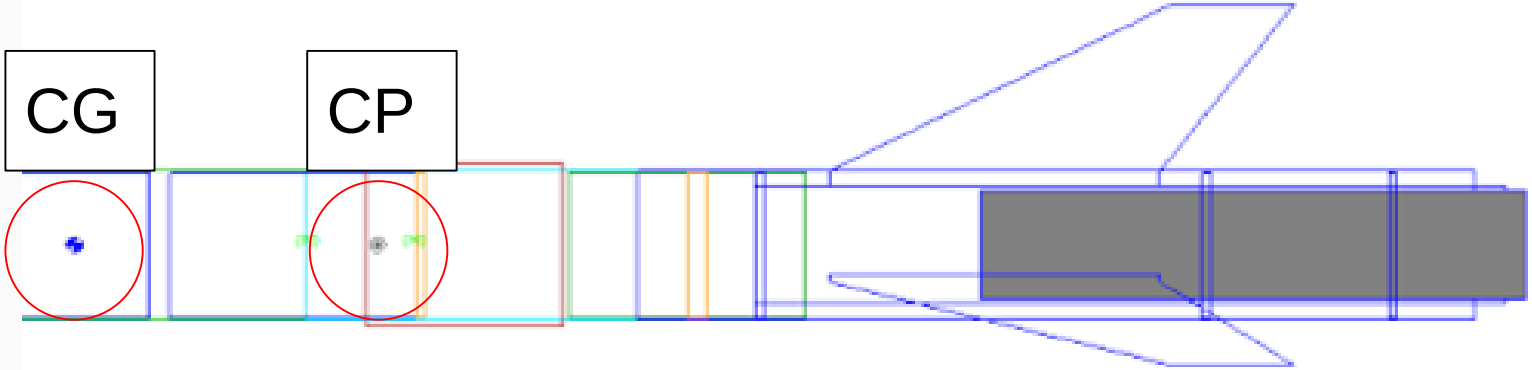


Final Motor Choice Stats

Name	Total impulse (Ns)	Total Mass (g)	Max Altitude (ft), no air brake function	Max velocity (ft/s)	Max acceleration (ft/s^2)
K555	2400.688	2759.0	5724.77	661.14	615.88

Rocket Stability margin in Static Margin Diagram





Stability Margin

- CG: 63.9729 in
- CP: 72.8941 in
- Static Stability Margin: 2.22 calibers
- Launch Stability Margin: 3.47 calibers
- Stability Margin at Rail Exit: 3.55882 calibers

Thrust-to-Weight Ratio, Rail Exit Velocity

- Full Scale
  - 6:1
  - 48.28 ft/s (predicted)
- Subscale
  - 6:1
  - 41.73 ft/s (predicted)
  - 55.5 ft/s (actual)

Mass Statement and Mass Margin of Full Scale

Mass of Subsystems:

- Payload: 611 g
- Avionics: 930 g
- Airbrakes: 857 g

Predicted Total Mass of Rocket: 9798.167 g

Mass Margin: 48.53 g or 0.107 lbs

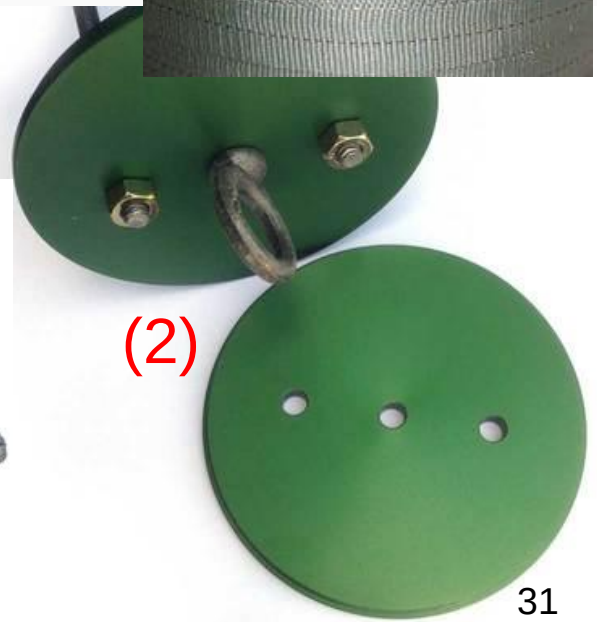
Calculated using the Fruity Chutes Descent Rate Calculator

Parachute Sizes

- Full Scale
  - Main: 84”
  - Drogue: 18”
- Subscale
  - Main: 60”
  - Drogue: 16”

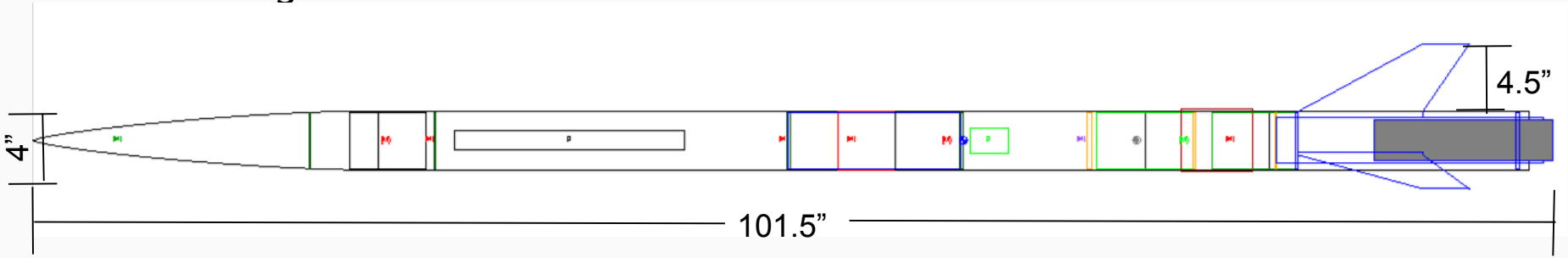
Recovery Harness Type

- Mad Cow Rocketry 1” Flat Nylon Shock Cord (1)
- Mad Cow Rocketry 4” Aluminum Bulkhead (2)
- U Bolt (3)
- Machine Closed Eye Bolts (4)



Shock Cord Length

- 1” Shock Cord
- 21 ft each
- Strength: 4000 lb break



Descent Rates

- Full Scale
  - Velocity with drogue chute out: 87.86 ft/s
  - Velocity with main chute out: 14.87 ft/s
- Subscale
  - Velocity with drogue chute out: 76 ft/s
  - Velocity with main chute out: 56 ft/s
  - Velocity at landing: 6 ft/s

Kinetic Energy Calculations

KE Calculation for landing is on the next slide

	Drogue Chute			Drogue Chute and Main Chute		
Sub Scale	Section 1 KE = 1/2mv^2 1/2(2.75 lbs)(76 ft/s)^2(1 lbf s^2/32.2 lbm ft) =246.65 lbf	Section 2 KE = 1/2mv^2 1/2(3.42 lbs)(76 ft/s)^2(1 lbf s^2/32.2 lbm ft) =306.74 lbf	Section 3 KE = 1/2mv^2 1/2(6.24 lbs)(76 ft/s)^2(1 lbf s^2/32.2 lbm ft) =559.66 lbf	Section 1 KE = 1/2mv^2 1/2(2.75 lbs)(56 ft/s)^2(1 lbf s^2/32.2 lbm ft) =133.91 lbf	Section 2 KE = 1/2mv^2 1/2(3.42 lbs)(56 ft/s)^2(1 lbf s^2/32.2 lbm ft) =166.54 lbf	Section 3 KE = 1/2mv^2 1/2(6.24 lbs)(56 ft/s)^2(1 lbf s^2/32.2 lbm ft) =303.86 lbf
Full Scale	Section 1 KE = 1/2mv^2 1/2(3.06 lbs)(84.46 ft/s)^2(1 lbf s^2/32.2 lbm ft) =338.95 lbf	Section 2 KE = 1/2mv^2 1/2(6.60 lbs)(84.46 ft/s)^2(1 lbf s^2/32.2 lbm ft) =731.07 lbf	Section 3 KE = 1/2mv^2 1/2(11.94 lbs)(84.46 ft/s)^2(1 lbf s^2/32.2 lbm ft) =1322.57 lbf	Section 1 KE = 1/2mv^2 1/2(3.06 lbs)(14.87 ft/s)^2(1 lbf s^2/32.2 lbm ft) = 10.51 lbf	Section 2 KE = 1/2mv^2 1/2(6.60 lbs)(14.87 ft/s)^2(1 lbf s^2/32.2 lbm ft) =22.66 lbf	Section 3 KE = 1/2mv^2 1/2(11.94 lbs)(14.87 ft/s)^2(1 lbf s^2/32.2 lbm ft) =41.00 lbf

Kinetic Energy Calculations (Cont.)

	Landing		
Sub Scale	Section 1 KE = 1/2mv^2 1/2(2.75 lbs)(6 ft/s)^2(1 lbf s^2/32.2 lbm ft) =3.07 lbf	Section 2 KE = 1/2mv^2 1/2(3.42 lbs)(6 ft/s)^2(1 lbf s^2/32.2 lbm ft) =1.91 lbf	Section 3 KE = 1/2mv^2 1/2(6.24 lbs)(6 ft/s)^2(1 lbf s^2/32.2 lbm ft) =3.49 lbf
Full Scale	Section 1 KE = 1/2mv^2 1/2(3.06 lbs)(14.87 ft/s)^2(1 lbf s^2/32.2 lbm ft) =10.51 lbf	Section 2 KE = 1/2mv^2 1/2(6.60 lbs)(14,87 ft/s)^2(1 lbf s^2/32.2 lbm ft) =22.66 lbf	Section 3 KE = 1/2mv^2 1/2(11.94 lbs)(14.87 ft/s)^2(1 lbf s^2/32.2 lbm ft) =41.00 lbf

Total vehicle KE at landing:
8.47 lbf

Total vehicle KE at landing:
74.17 lbf

Drift Calculations

	0mph	5mph	10mph	15mph	20mph
Sub Scale	0 miles 0 ft	0.0974 miles 514 ft	0.1948 miles 1029 ft	0.2922 miles 1543 ft	0.3896 miles 2057 ft
Full Scale	0 miles 0 ft	0.170 miles 898 ft	0.339 miles 1790 ft	0.509 miles 2688 ft	0.679 miles 3585 ft

Test Plans and Procedures

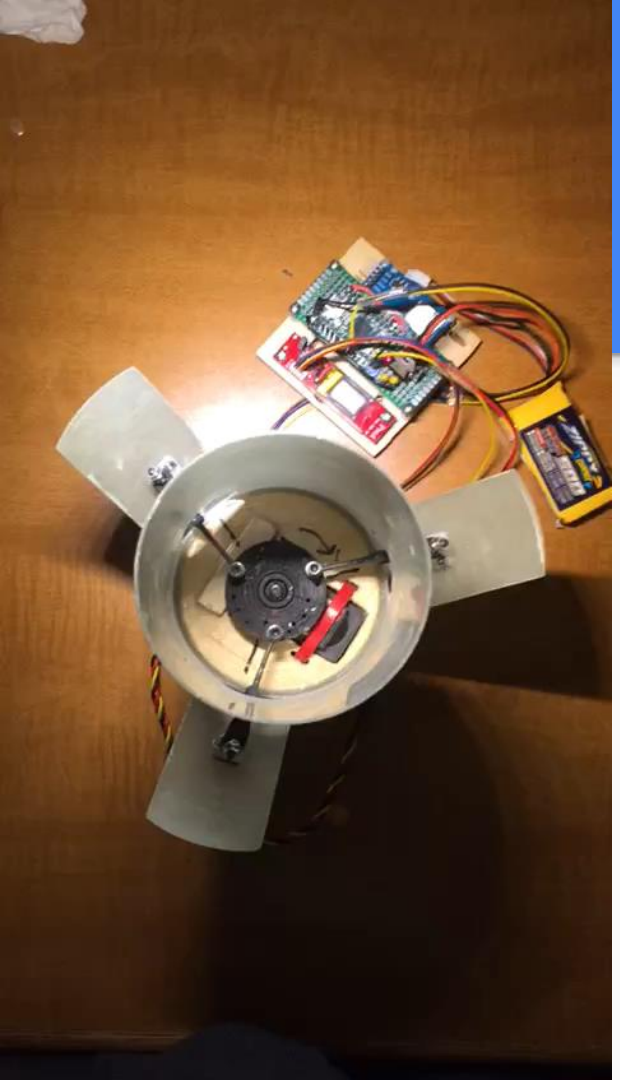
- Vehicle Test Plan
- Recovery Test Plan
- Air Brakes Test Plan
- GPS Test Plan
- Payload Test Plan

Vehicle Test Plan

Full plan in section 7.11

Recovery Test Plan

- Light Bulb test in Vacuum Chamber
  - To test functionality of flight computers
- Black Powder test
  - 2.5 g main
  - 1.3 g drogue
- Continuity Checks
  - Key Cards at Launch Site



Air Brakes Test Plan

We have video of us testing the air brakes.

GPS Test Plan

- Use the official Whistle GPS app
- Requires Data
- Full procedures in section 7.1.5

Payload Test plan

- Plug in battery
- Plug in jumper to Pnut
  - Activate Teensy, CO_2 sensor and altimeter
- Place Pnut in vacuum chamber, use tape
- Check SD card for changes
- Full procedures in section 7.1.6

Scale Model Flight Test

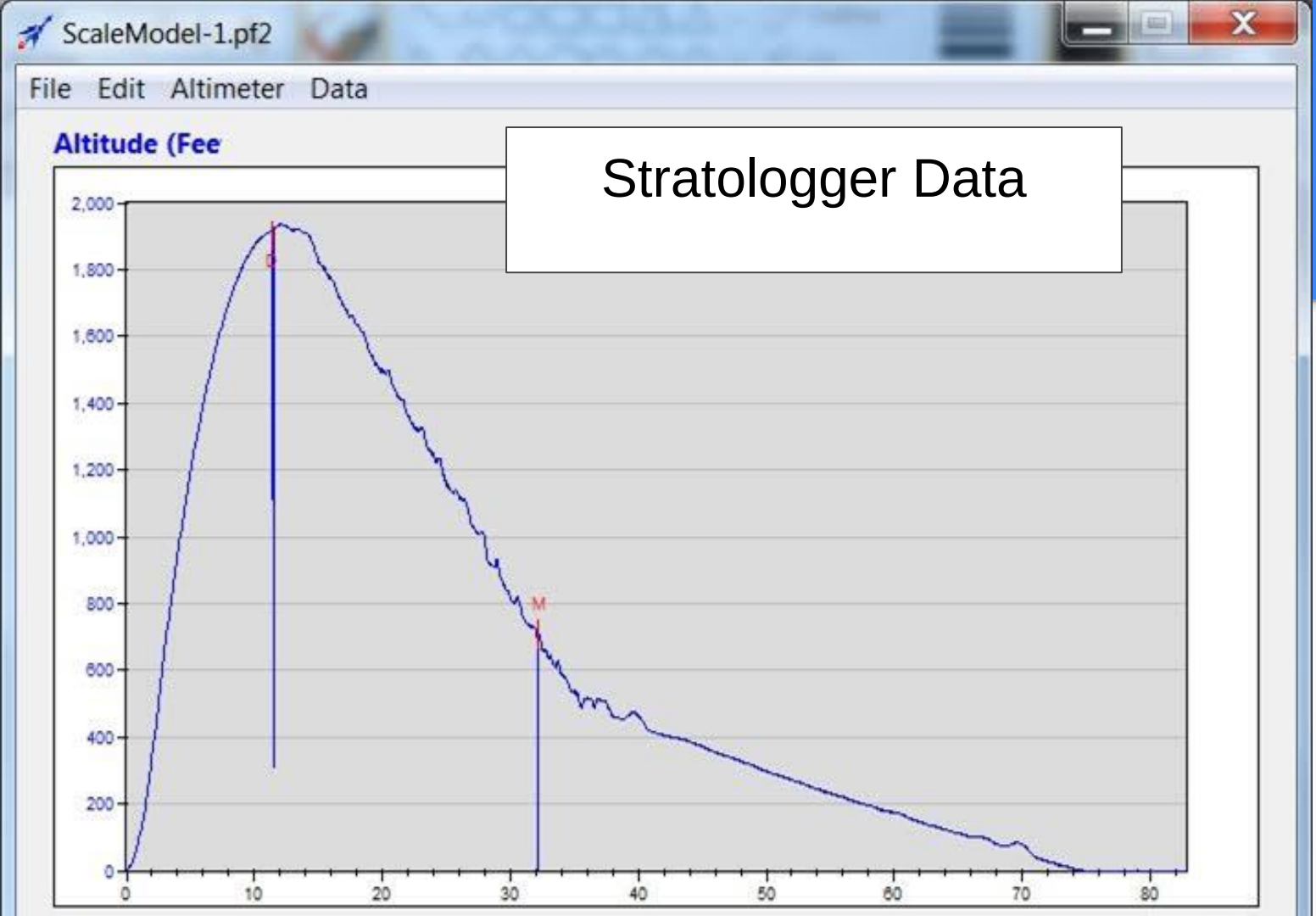
Target Altitude: 1900 ft

Altitude: 1934 ft

Flight time: 70.12 s

Dual deployment was successful

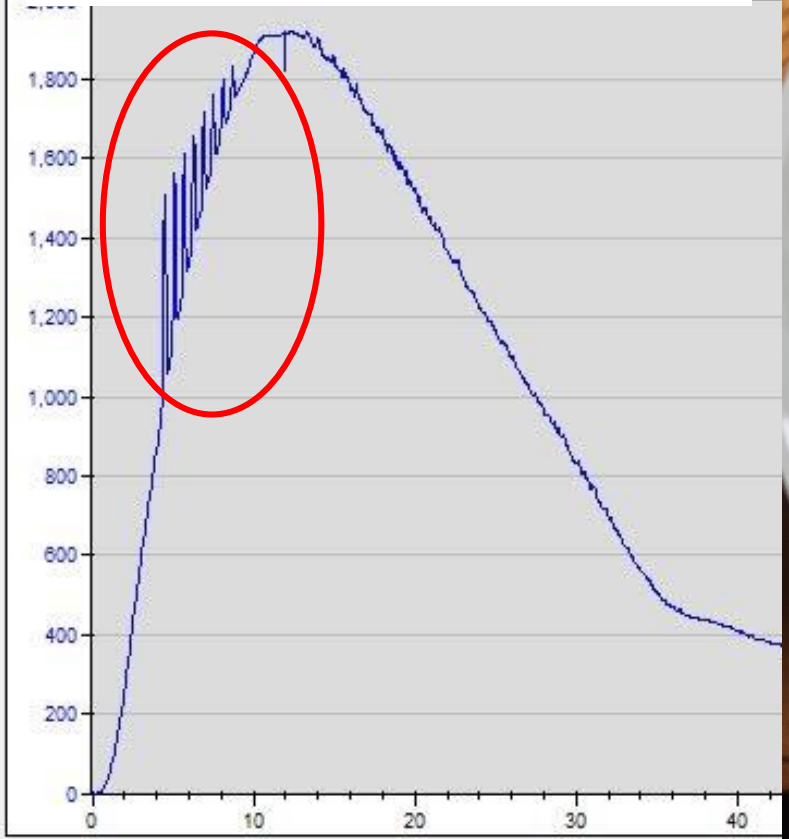
Air brakes operated successfully


ScaleModel-1.pf2
File Edit Altimeter Data
Altitude (Fee
Stratologger Data
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
0 10 20 30 40 50 60 70 80
M

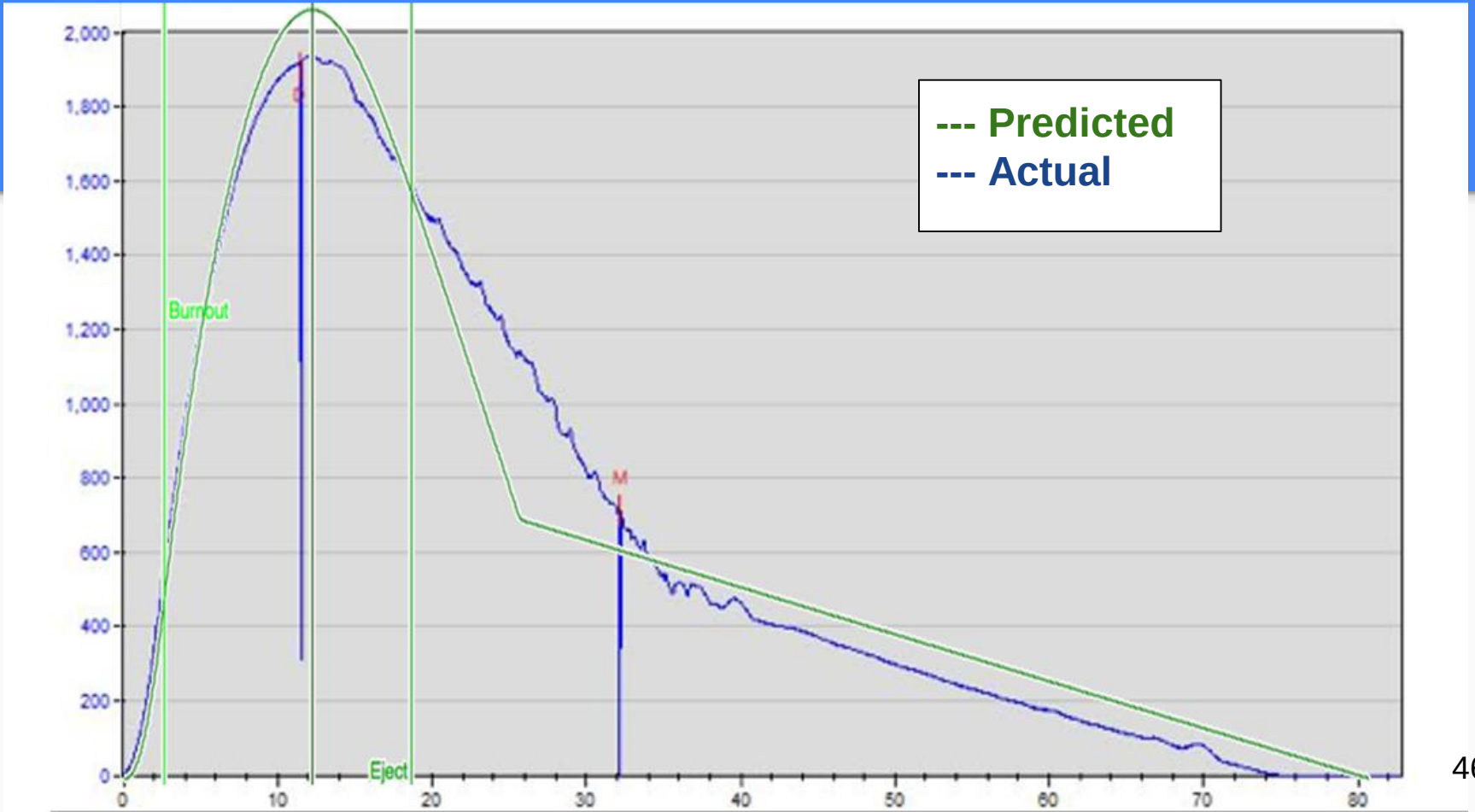
ScaleModel-2-AirBrakeModule.pf2

File

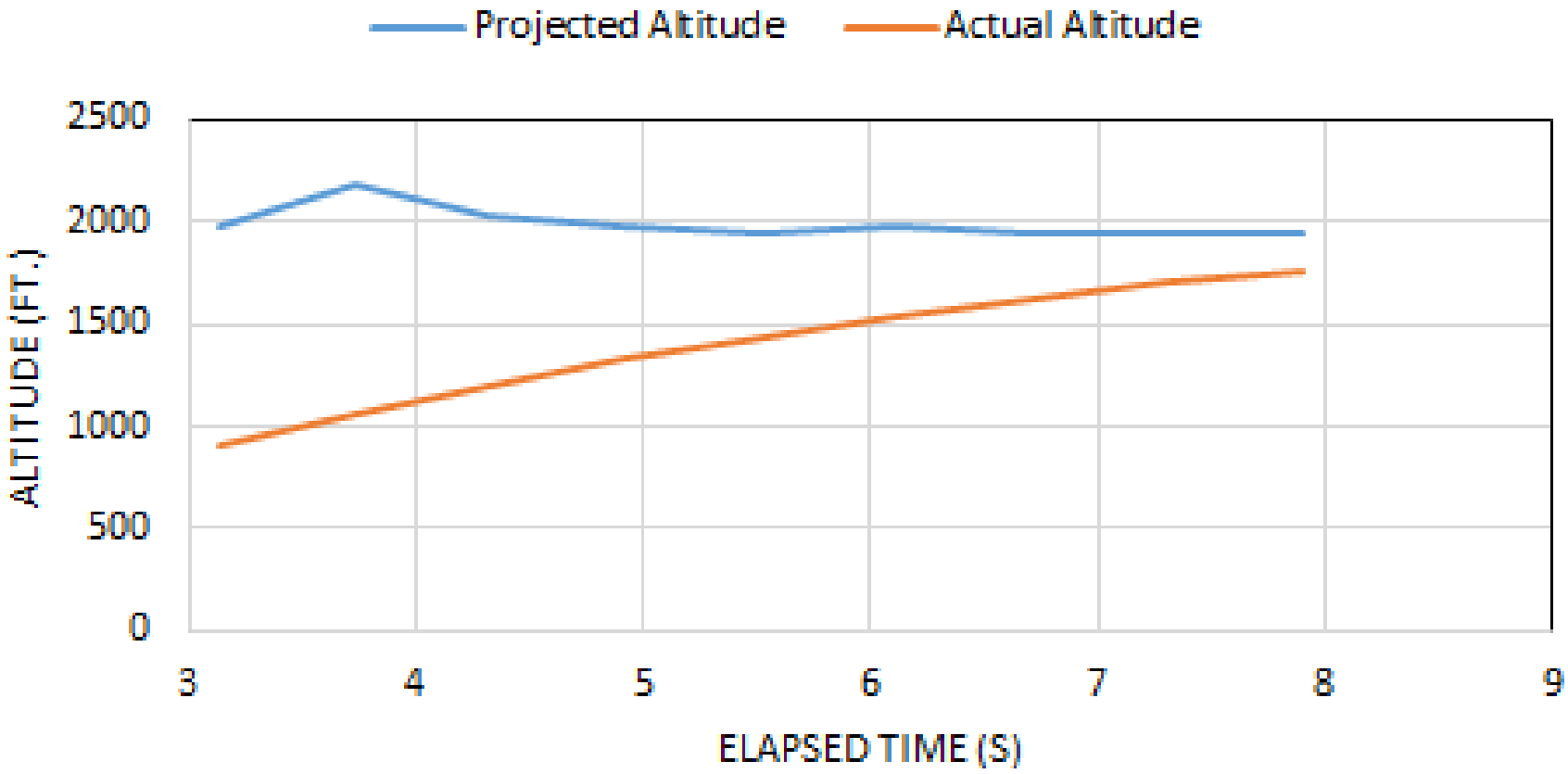
Pnut Data



Predicted and Actual Flight Data



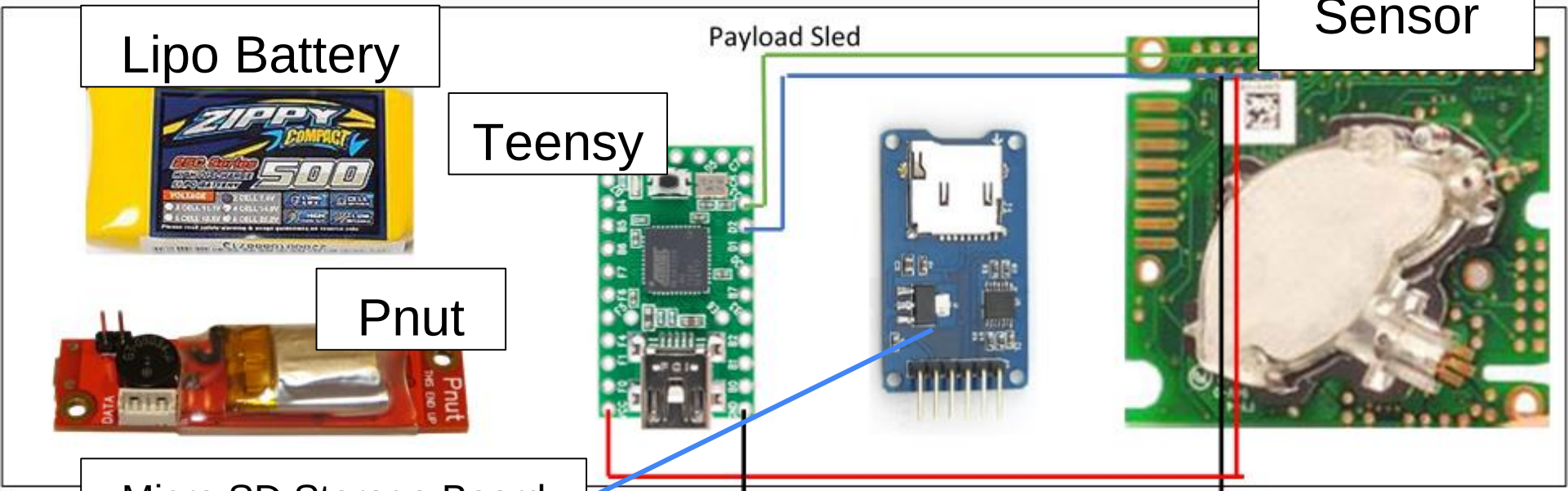
SUBSCALE FLIGHT SD CARD REPORT



Simulation Flight Error

- Errors
  - Maximum Altitude
  - Rail Exit Velocity
- Factors
  - Coefficient of Drag
  - Total Mass – heavier than it looks

Final Payload Design Overview



Payload Integration

Interfaces

- Internal
  - Air Brakes
  - Avionics
  - Payload
- External
  - GPS and smartphone
  - Igniter

Systems Diagram