



# Project Avigator

University of Florida

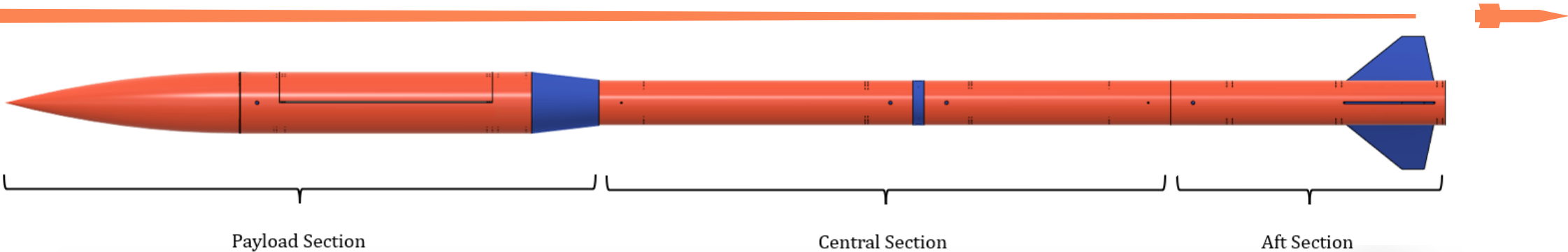
2024 Flight Readiness Review



# Launch Vehicle Design



# Launch Vehicle Dimensions



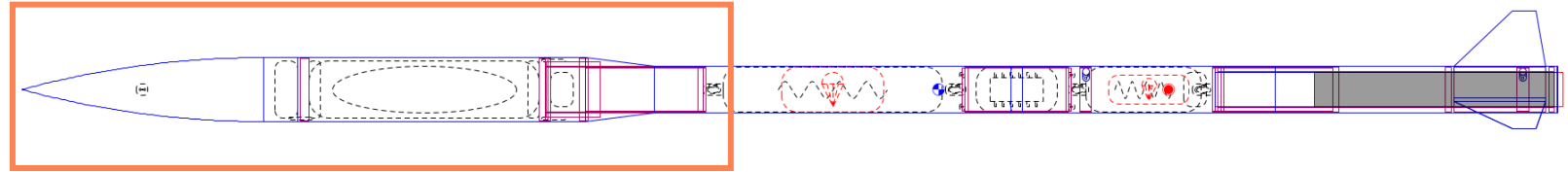
Section	Exterior Length (in)
Payload	55.0
Central	54.0
Aft	24.5
<b>Total</b>	<b>133.5</b>



# Key Design Features

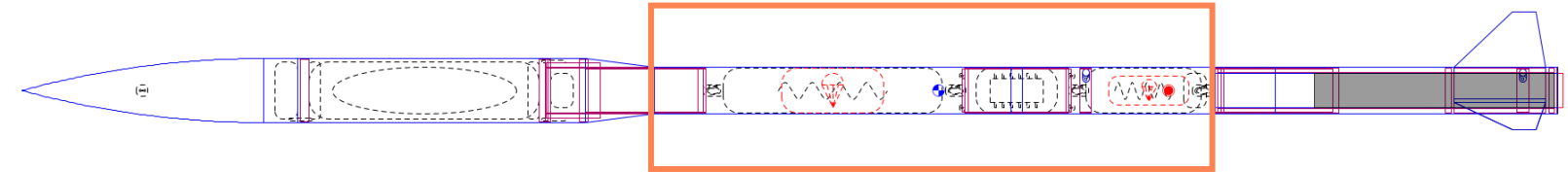
## Payload Section

- Nosecone with GPS mount
- Payload door assembly
- Payload retention mechanism
- Transition assembly
- Forward bulkhead with eyebolt



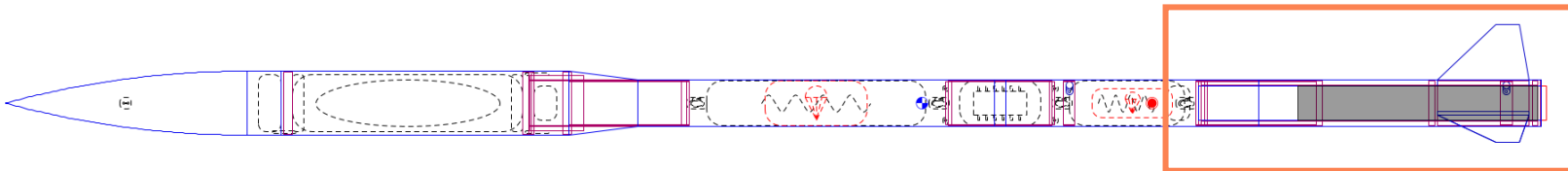
## Central Section

- Main parachute and recovery harness in forward airframe
- Drogue parachute and recovery harness in central airframe
- Avionics bay and electronics
- Avionics bulkheads with eyebolts

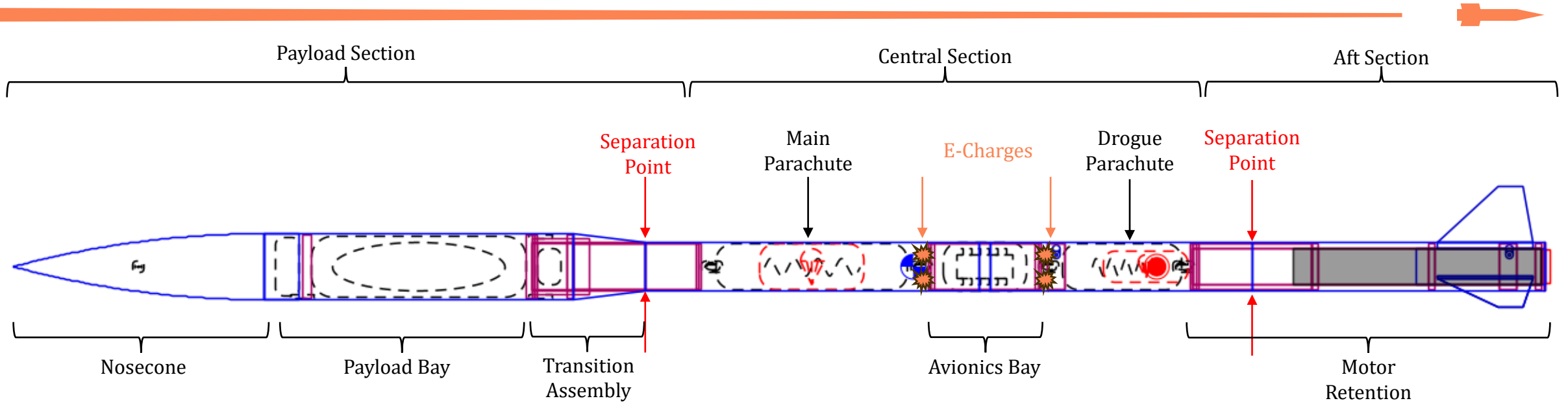


## Aft Section

- Motor retention assembly
- 3 trapezoidal shaped fins
- Aft coupler and aft bulkhead with eyebolt











# Mass Statement



Section	Mass (oz)	
	Non-Ballasted	Ballasted
Payload	254.7	254.7
Central	143.2	143.2
Aft	227.7	248.7
<b>Total</b>	<b>625.6</b>	<b>646.6</b>



# Separation Points

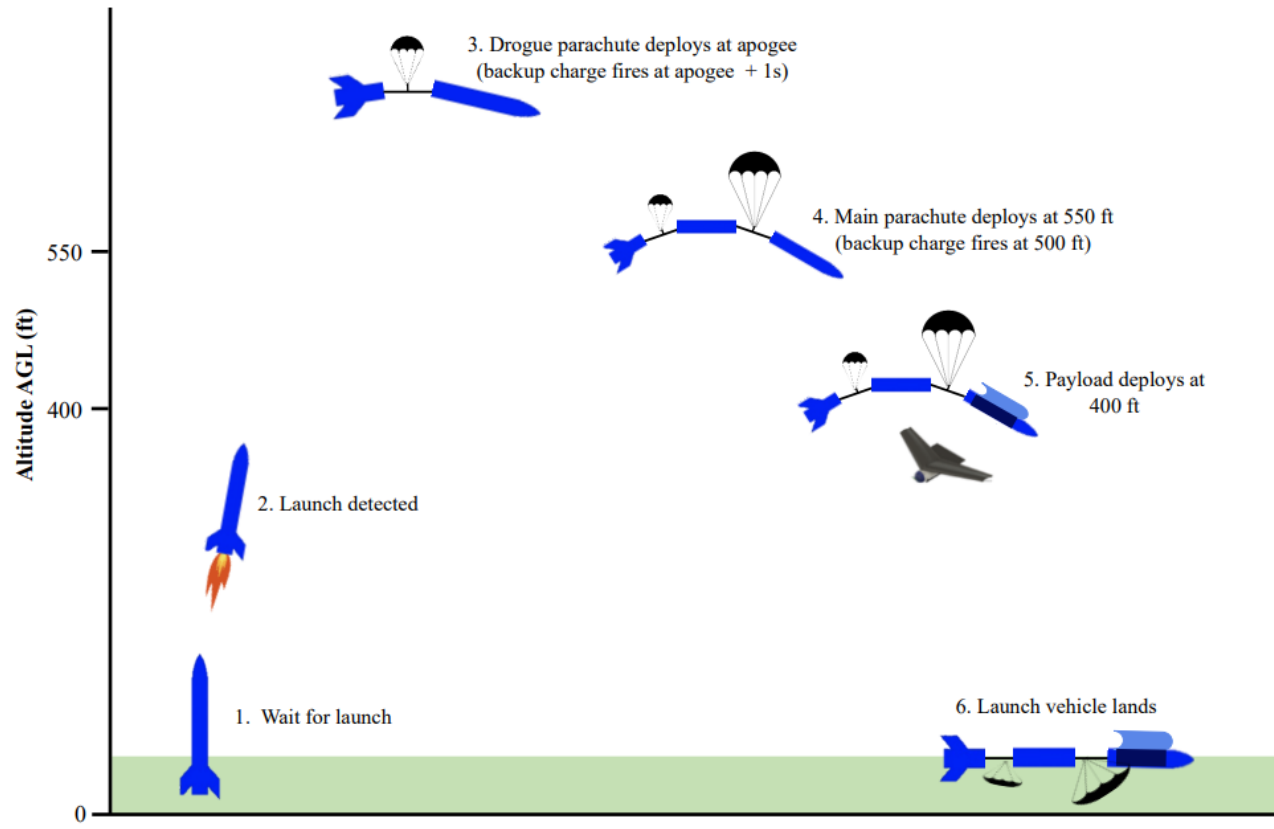
- Nosecone 
- Payload Airframe 
- Forward Airframe 
- Avionics Bay 
- Central Airframe 
- Aft Section 
- Parachutes 
- Ejection Charges 

Component	Main Parachute	Drogue Parachute
Main Deployment Altitude	550 ft	Apogee
Backup Deployment Altitude	500 ft	Apogee + 1 s
Main Ejection Charge	2.90 g	3.10 g
Backup Ejection Charge	3.63 g	3.88 g

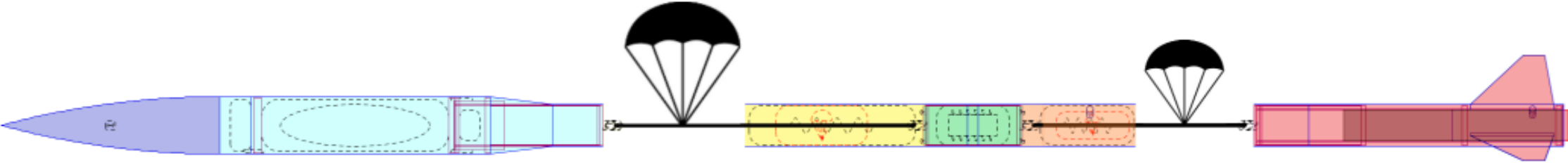
\*All ejection charges are black powder



# Recovery Concept of Operations



- Nosecone
- Payload Airframe
- Forward Airframe
- Avionics Bay
- Central Airframe
- Aft Section
- Recovery Harness



# Recovery Components

Component Type	Component Name	Size/Length	Component Location
Drogue Parachute	SkyAngle CERT-3 Drogue	24 in	Central Airframe
Main Parachute	Iris Ultra Standard Parachute	96 in	Forward Airframe
Recovery Harnesses	Flat Kevlar Strap	1-in, 32 ft long	Central & Forward Airframe
Main Altimeter	Stratologger CF	N/A	Avionics Bay
Backup Altimeter	MissileWorks RRC3	N/A	Avionics Bay
GPS	EggFinder Mini Transmitter	N/A	Nosecone

Scenario	Descent Rate
Under Drogue	93.7 ft/s
Under Main With Payload	16.6 ft/s
Under Main Without Payload	15.1 ft/s



# Kinetic Energy Predictions



Maximum Kinetic Energy (OpenRocket Simulations)		
Launch Vehicle Section	Payload does deploy (ft-lbf)	Payload does not deploy (ft-lbf)
Payload section with payload	N/A	68.18
Payload section without payload	38.52	N/A
Central section	21.11	25.51
Aft section	35.57	43.00

Maximum Kinetic Energy (ODE Solver MATLAB)		
Launch Vehicle Section	Payload does deploy (ft-lbf)	Payload does not deploy (ft-lbf)
Payload section with payload	N/A	65.89
Payload section without payload	38.27	N/A
Central section	20.98	24.65
Aft section	35.36	41.54



# Descent Time & Drift Predictions

Descent Time		
Calculation Method	Payload does deploy (s)	Payload does not deploy (s)
Descent Time Calculations	79.2	76.7
OpenRocket Simulations	N/A	75.8
ODE Solver MATLAB	79.5	77.5

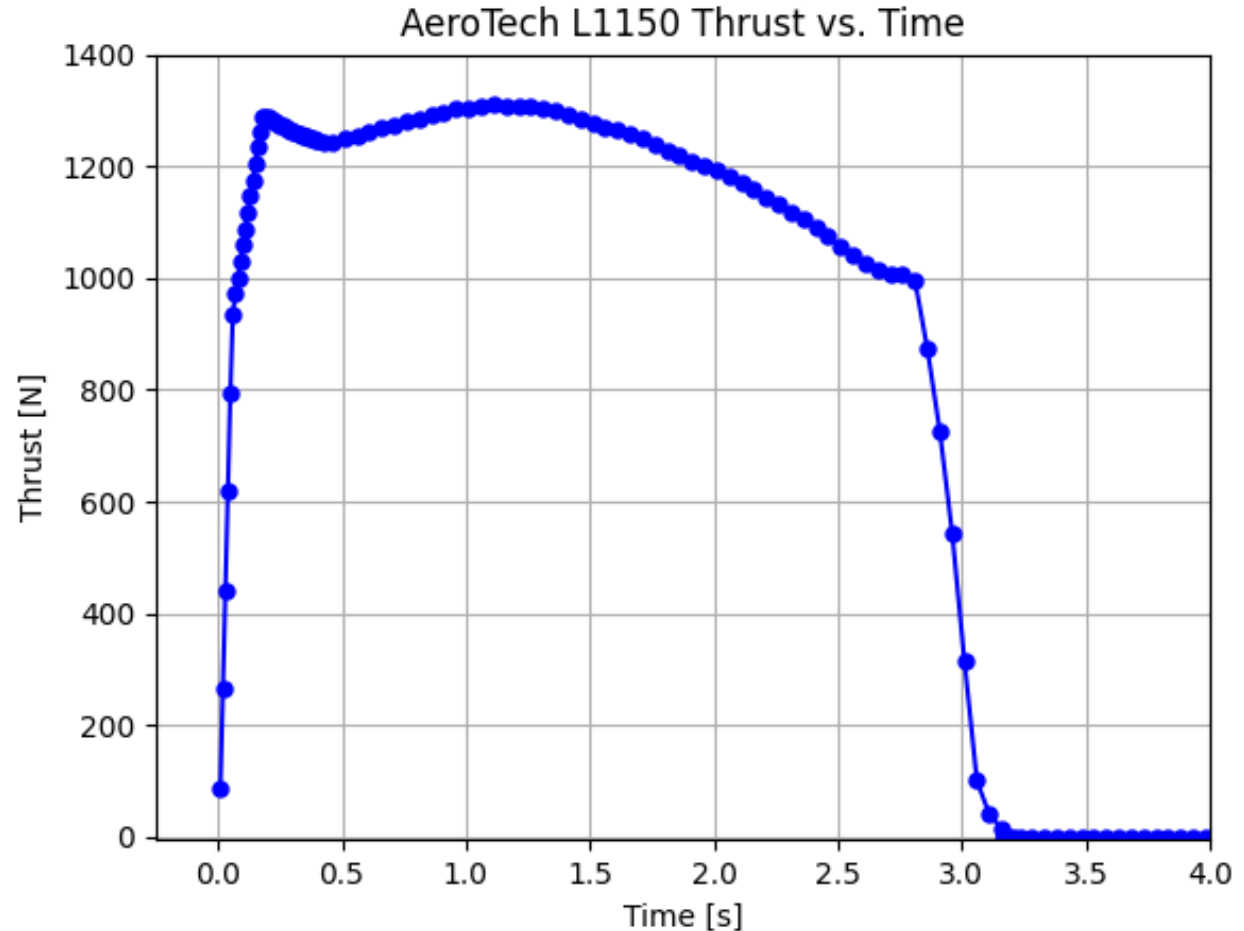
Total Drift (Descent Time Calculation)		
Wind Speed	Payload does deploy (ft)	Payload does not deploy (ft)
5 mph	581	563
10 mph	1161	1126
15 mph	1742	1689
20 mph	2323	2252

Total Drift (ODE Solver MATLAB)		
Wind Speed	Payload does deploy (ft)	Payload does not deploy (ft)
5 mph	583	568
10 mph	1166	1137
15 mph	1749	1705
20 mph	2332	2273



# Motor: AeroTech L1150R

- Liftoff Thrust: 971 N
- Maximum Thrust: 1346 N
- Average Thrust: 1148 N
- Total Impulse: 3517 N-s
- Burn Time: 3.04 s
- Thrust-to-Weight Ratio:
  - Fully Ballasted: 6.40:1
  - Non-Ballasted: 6.61:1



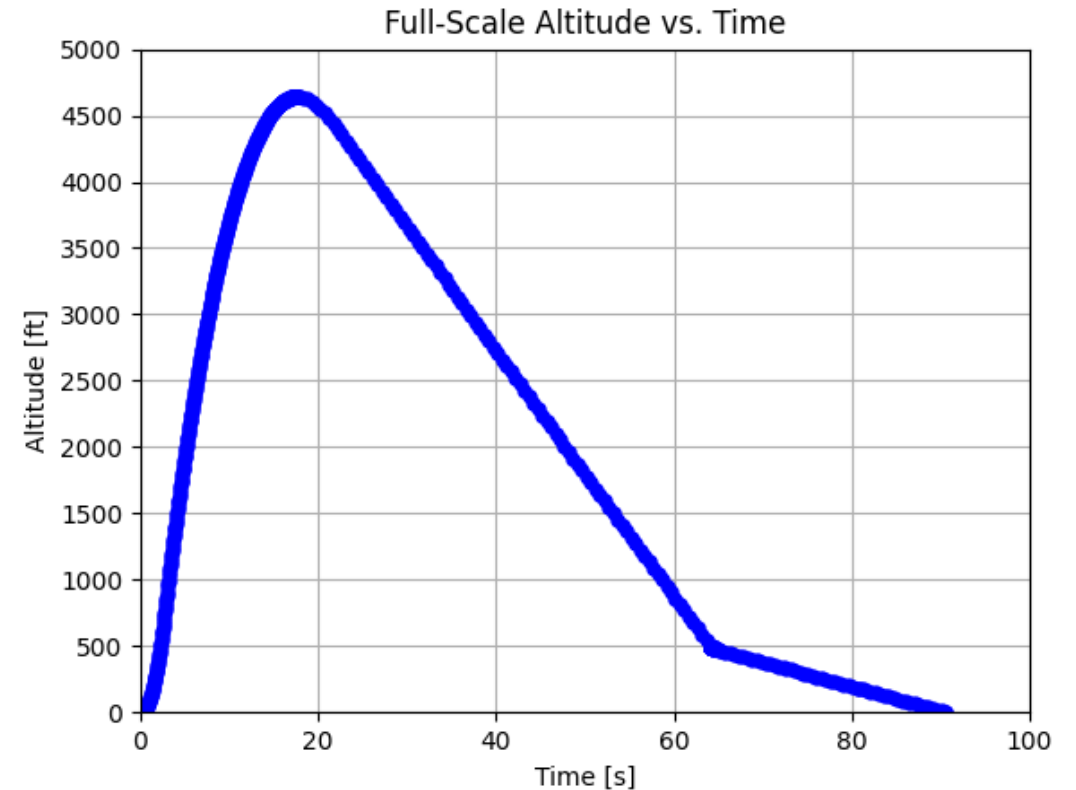
# Altitude Predictions

Monte Carlo Simulations Apogee: **4616 ft**

OpenRocket Apogee: **4640 ft**

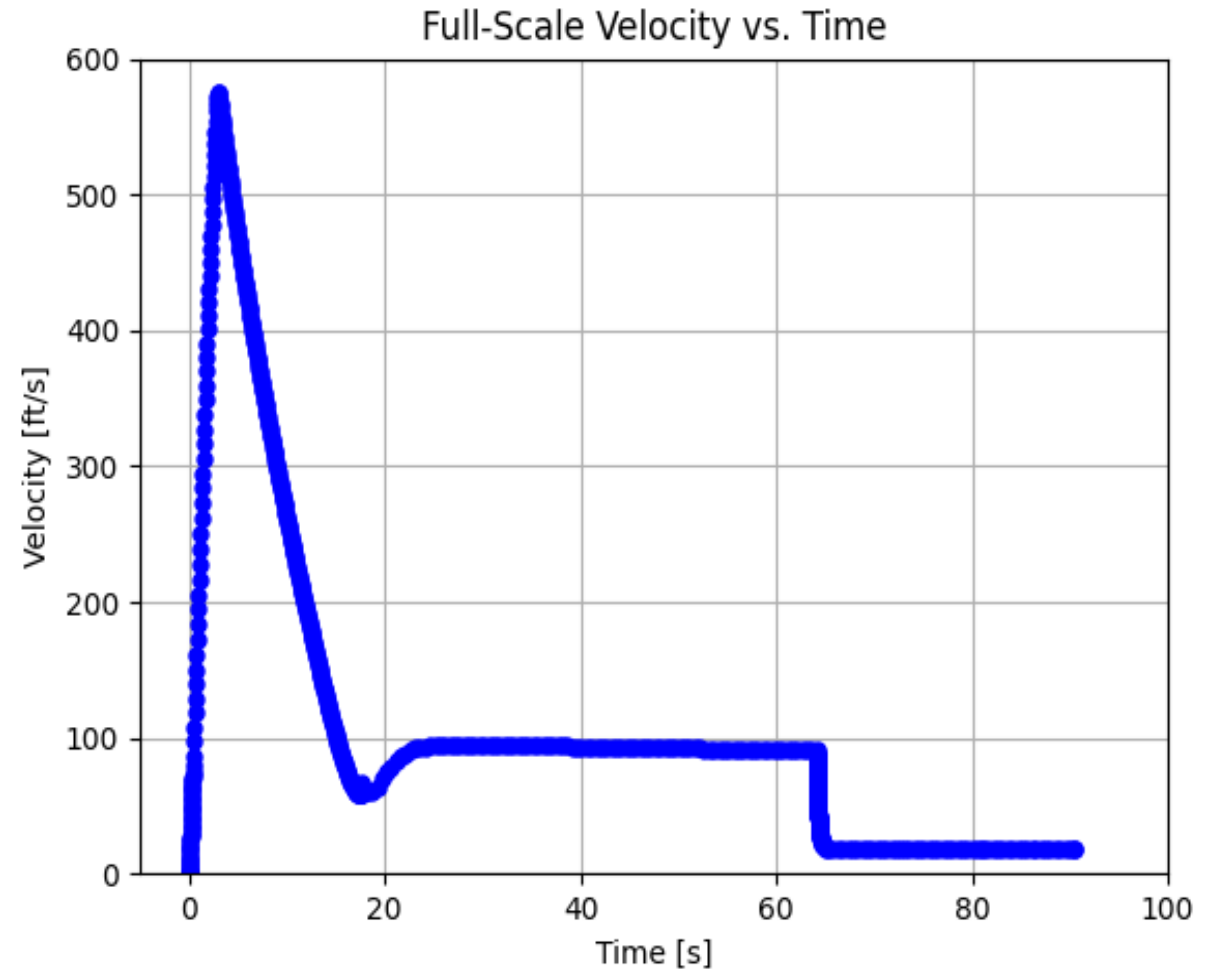
MATLAB Monte Carlo Simulations Apogee Altitude Verification			
Launch Angle	Average Wind Condition	Probability Weight	Predicted Average Apogee Altitude (ft)
5 deg	0 mph	5%	4757
5 deg	5 mph	20%	4697
5 deg	10 mph	60%	4636
10 deg	15 mph	10%	4401
10 deg	20 mph	5%	4347
Most Probable Altitude:			<b>4616</b>

Target Apogee: **5000 ft**

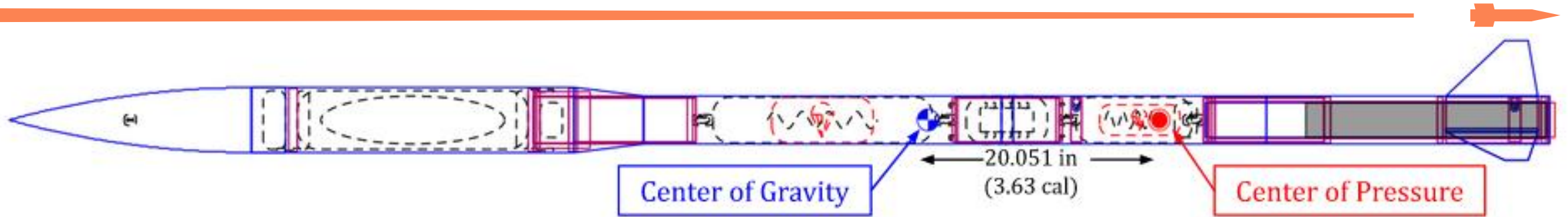


# Velocity Predictions

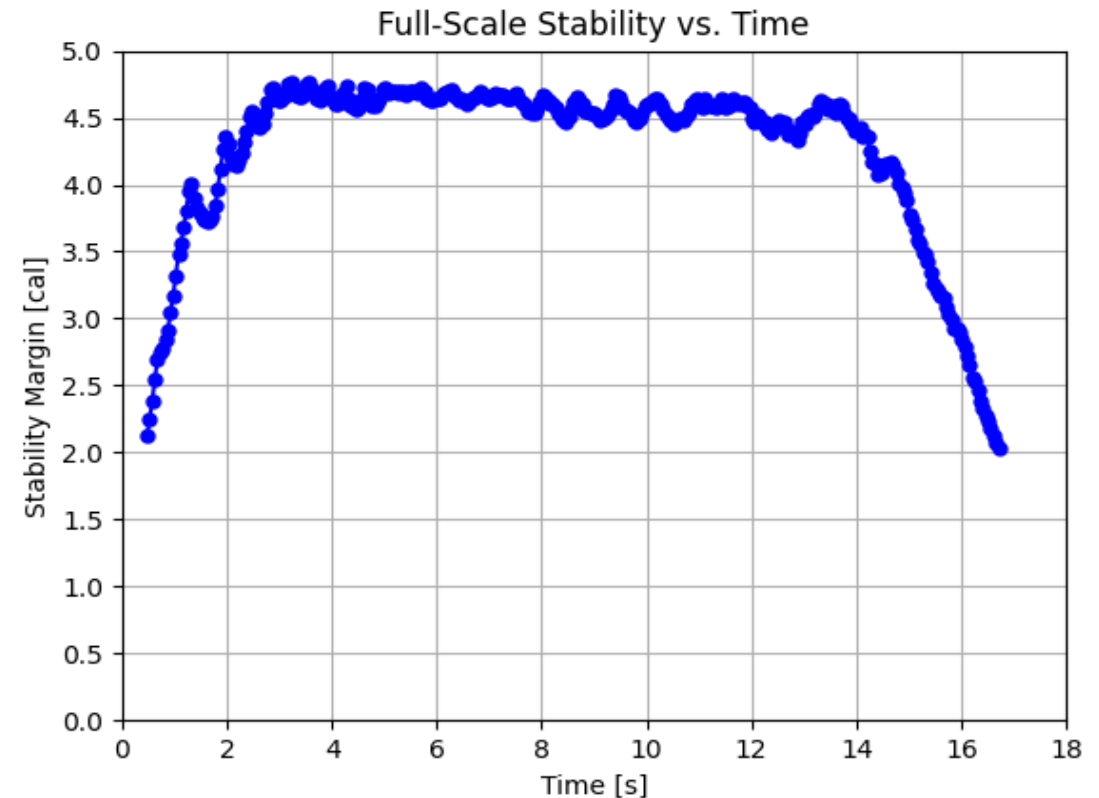
- Velocity at Rail Exit:
  - Fully Ballasted: **69.3 ft/s**
  - Non-Ballasted: **72.1 ft/s**
- Maximum Velocity:  
**574 ft/s**
- Maximum Mach Number:  
**Mach 0.51**



# Stability



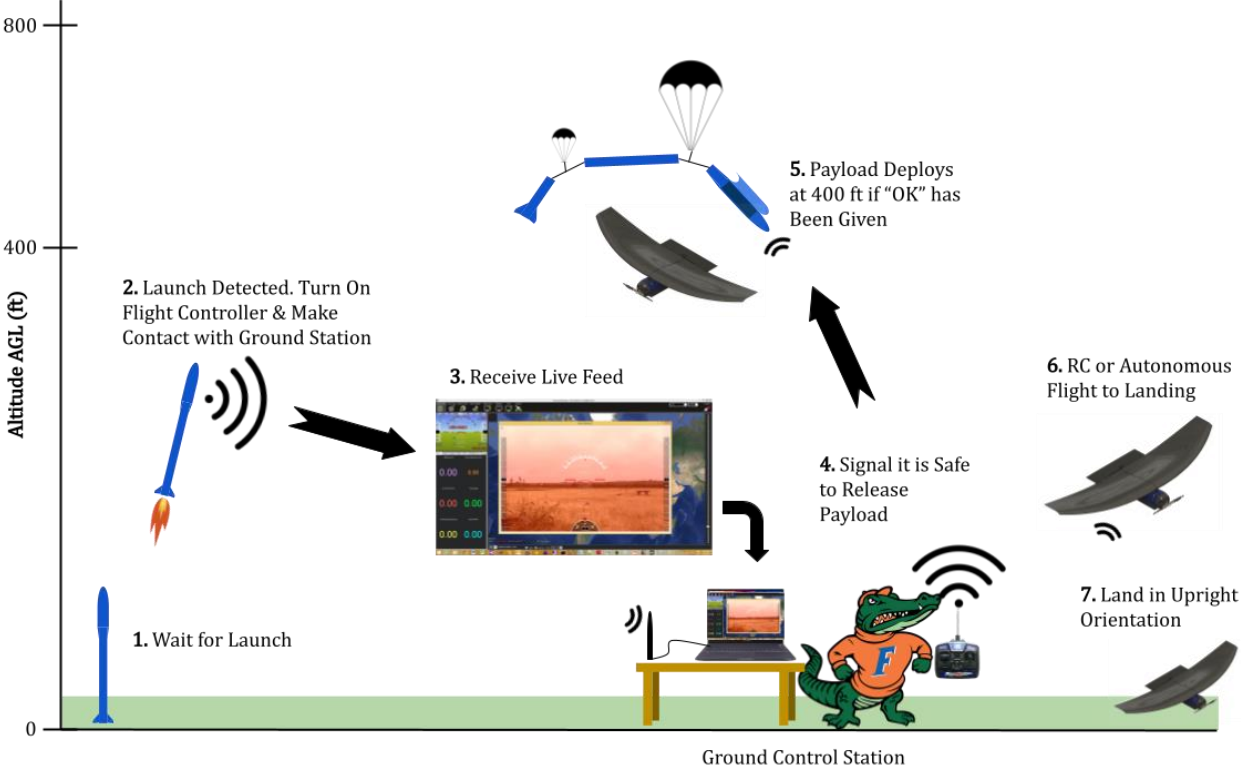
Parameter	Value
$x_{Cp}$	99.70 in
$x_{Cg}$	79.65 in
Static Stability <i>Launch Pad</i>	3.63 cal
Static Stability <i>Rail Exit</i>	3.75 cal
Maximum Stability Margin	4.78 cal



# Payload Design

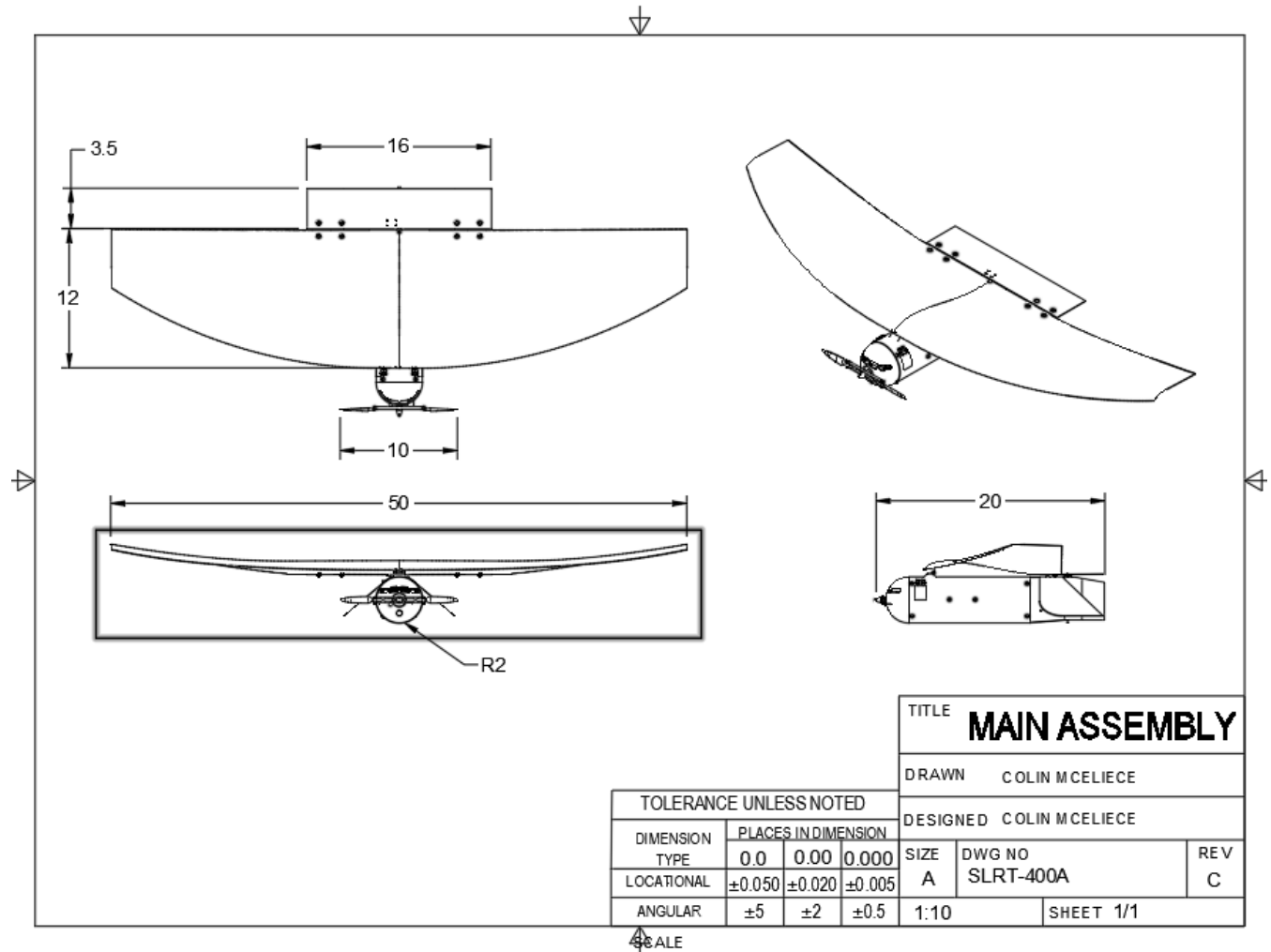


# Payload Design Overview



# Payload Dimensions

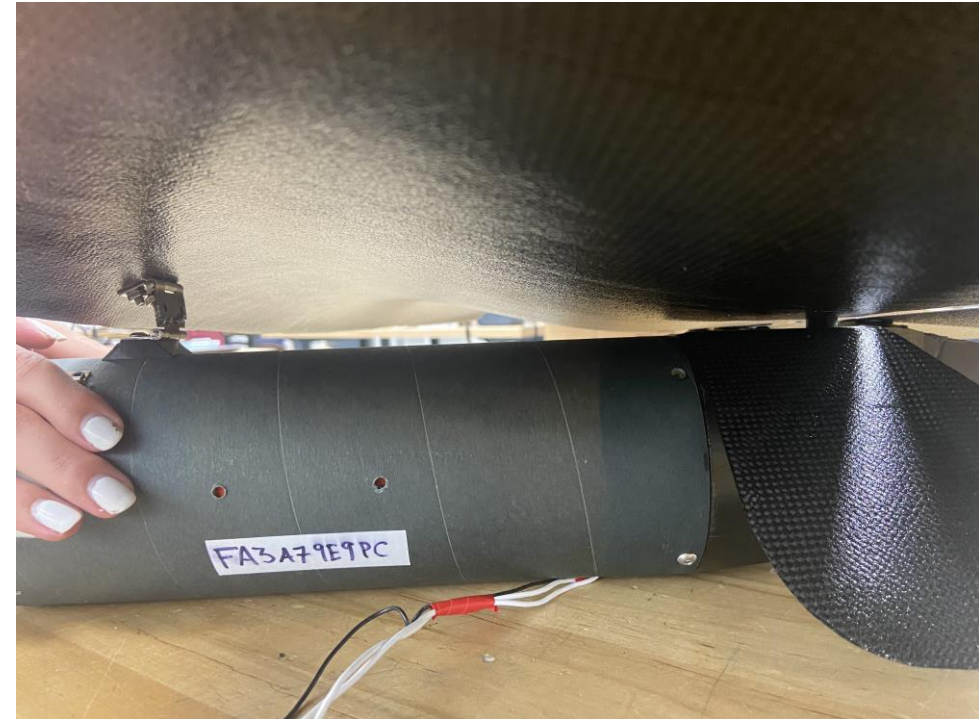
- 50" Wingspan
- 12" Cord Length
- 20" Long Fuselage
- 4" Diameter Fuselage
- 80 oz



# Payload Mechanical Design Features



- Carbon Fiber Wing, elevator, and diagonal stabilizers
- Foam rudder



- Bluetube Fuselage
- 3D Printed Cockpit and aft
- Hinging Mechanism



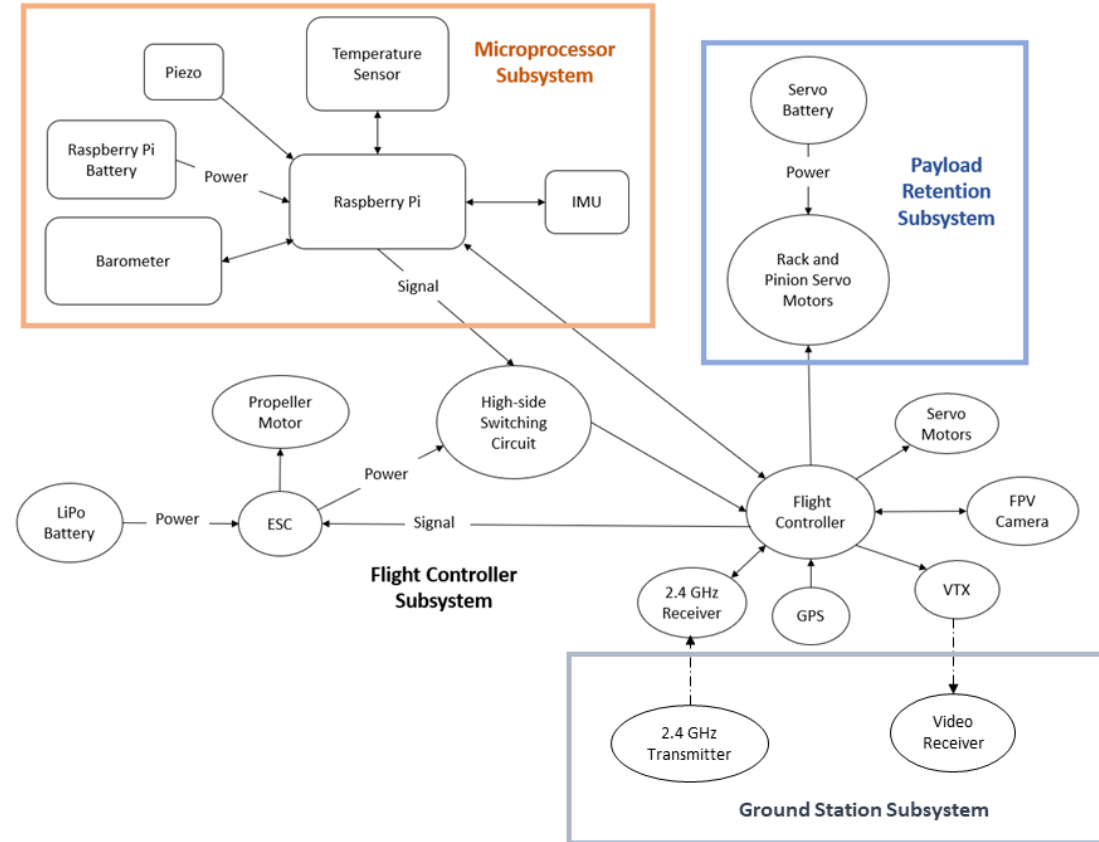
# Payload Mechanical Design Features



# Payload Electrical Design Features

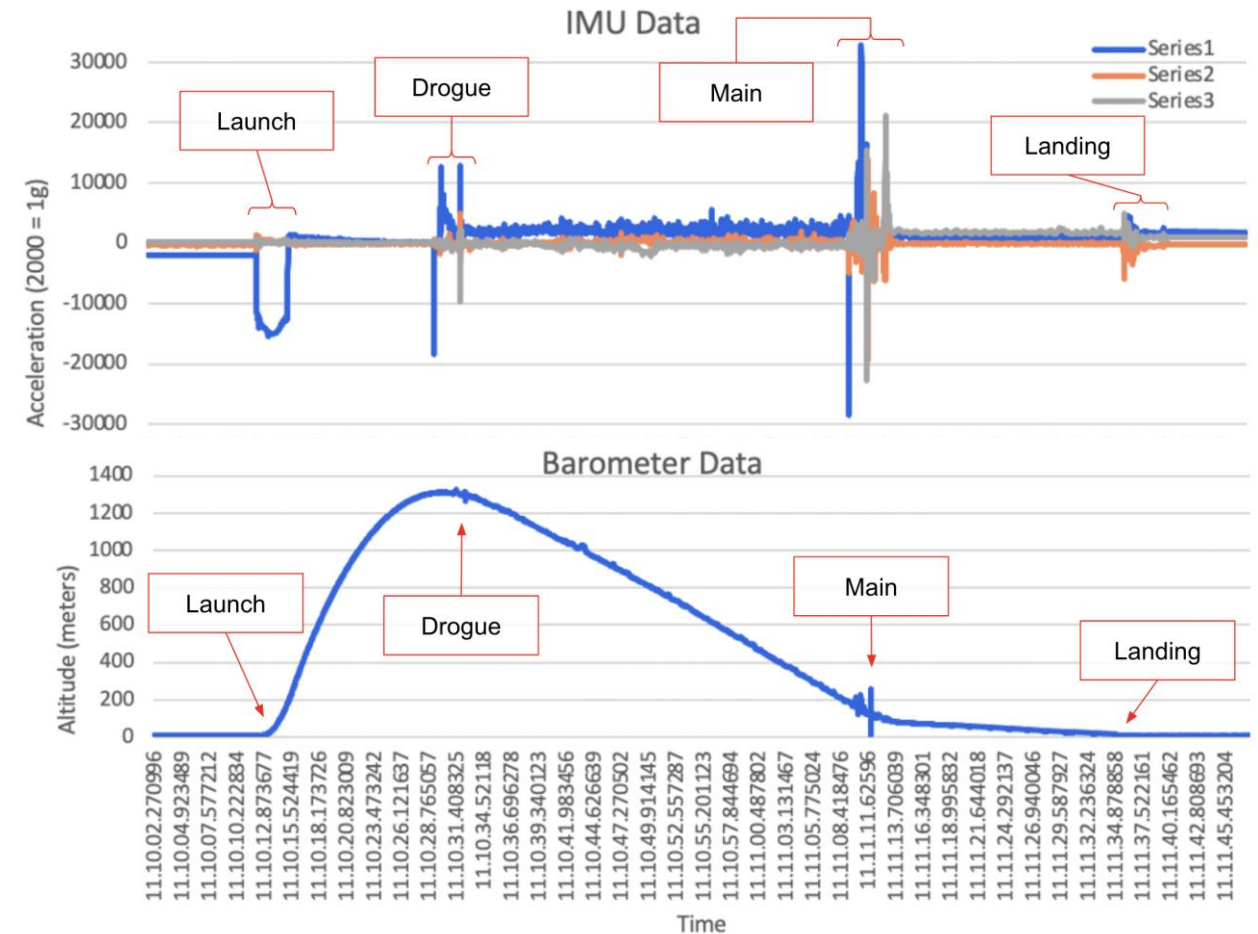
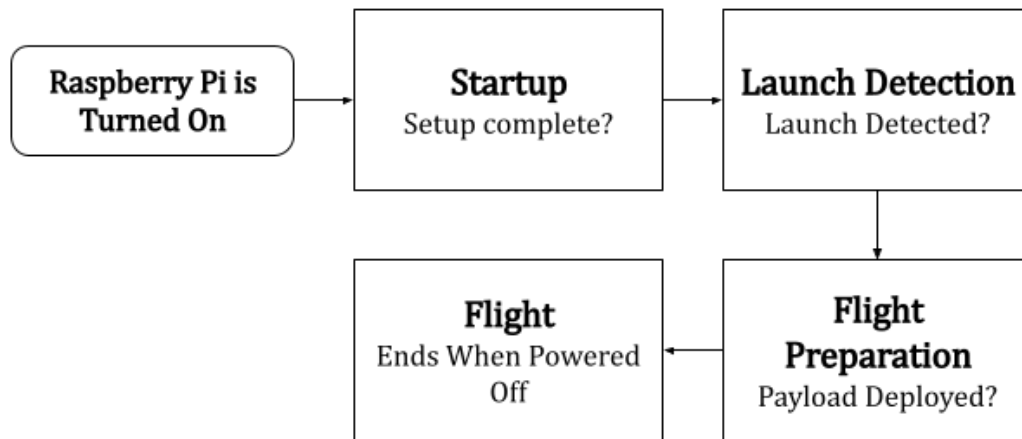
## 4 Subsystems:

1. Microprocessor Subsystem
  - Sensor Suite
    - Launch Detection
    - Temperature Safety
    - Software State Notification
    - STEMnaut survivability
  - Communication with Flight Controller
2. Flight Controller Subsystem
  - Video Transmitter (5.733 GHz)
  - Radio Control Receiver (2.4 GHz)
3. Payload Retention Subsystem
  - Hold and Deploys Payload
4. Ground Station
  - Video Receiver (5.773 GHz)
  - Radio Control Transmitter (2.4 GHz)



# Payload Software Design Features

- Raspberry Pi: python code that
  - logs sensor data
  - detects launch
  - communicates with the flight controller
- Flight Controller: Ardupilot firmware for plane control

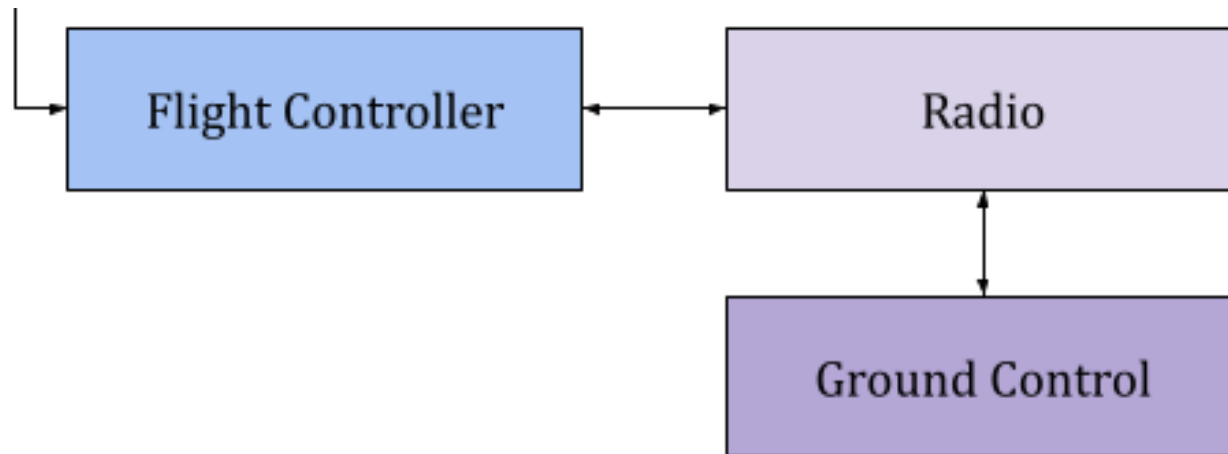


Data from February 24 Launch



# Interfaces with Ground Systems

- Ground to Payload: 2.4 GHz, FlySky FS-i6, 100 mW
  - Controls Payload
- Payload to Ground: 5.733 GHz, Eachine TX805, 200 mW
  - Sends Telemetry Data & FPV Video



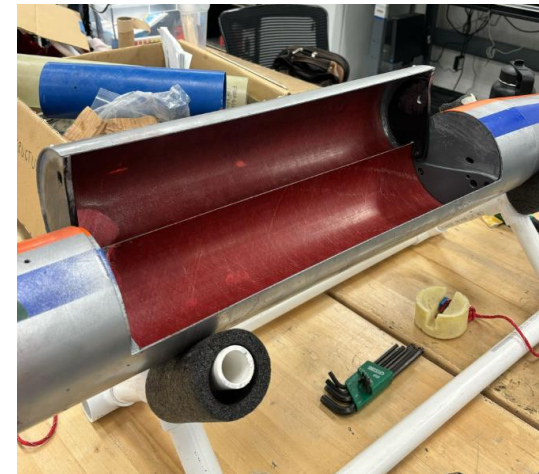
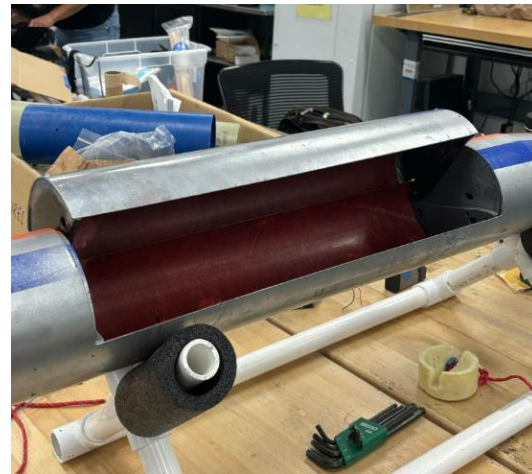
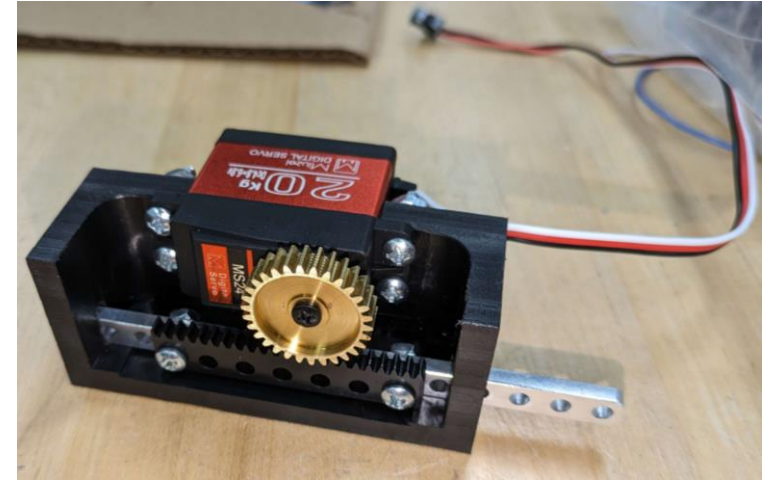
# Payload Integration

- Payload is secured into sabots
  - Sabots made from expanding foam
- Wing is rolled
- Payload is loaded into launch vehicle
- Door is closed and locked with payload retention system.
- Door is unlocked during deployment of payload
  - Force by payload wings will push the door open



# Payload Retention

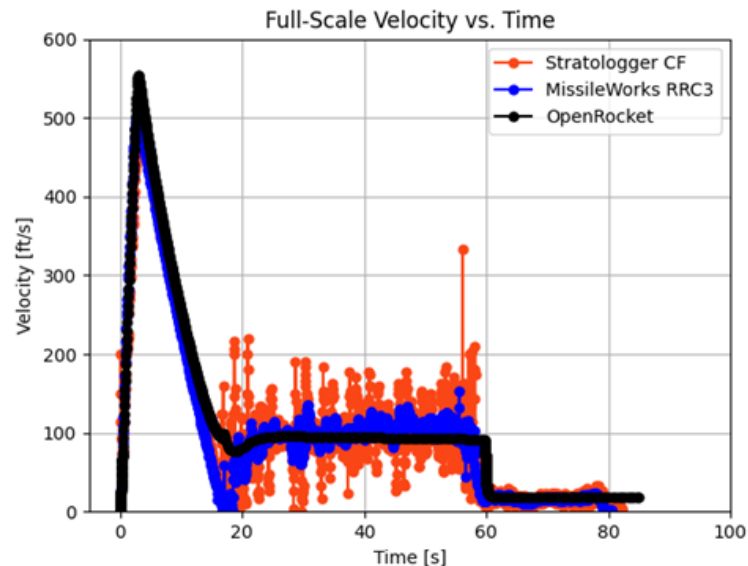
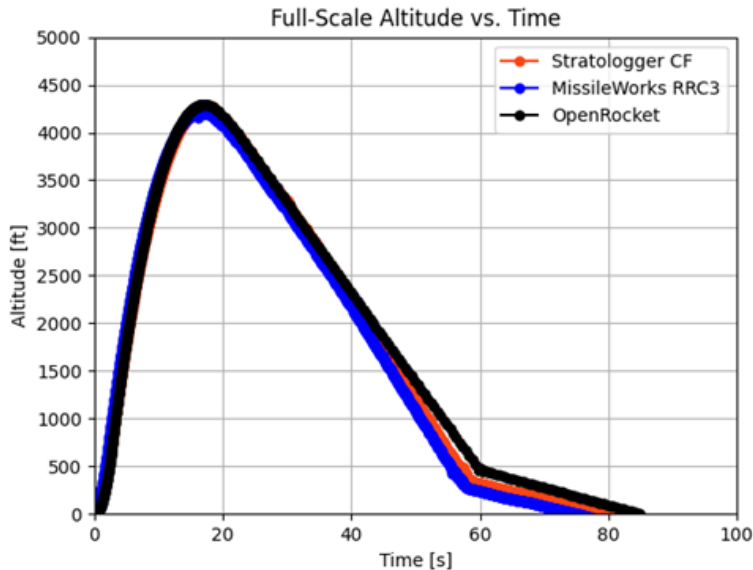
- Two rack and pinion mechanisms
  - Powered by single 2000mAh battery
  - Extends and retracts beam
- Payload door assembly pivots opened
  - Shoulder head screw fastened into payload bulkheads



# Vehicle Demonstration Flights



# Vehicle Demonstration Flight – Attempt 1



- Performed on **February 24th, 2024** in Palm Bay, FL
- Recovery malfunction and damage to launch vehicle
- 21 oz ballasted launch vehicle

Vehicle Demonstration Flight Data			
Parameter	Predicted	Actual	Percent Error
Apogee	4292 ft	4270 ft	0.52%
Drogue Descent Rate	91.7 ft/s	100.4 ft/s	9.48%
Main Descent Rate	18.5 ft/s	15.5 ft/s	16.22%

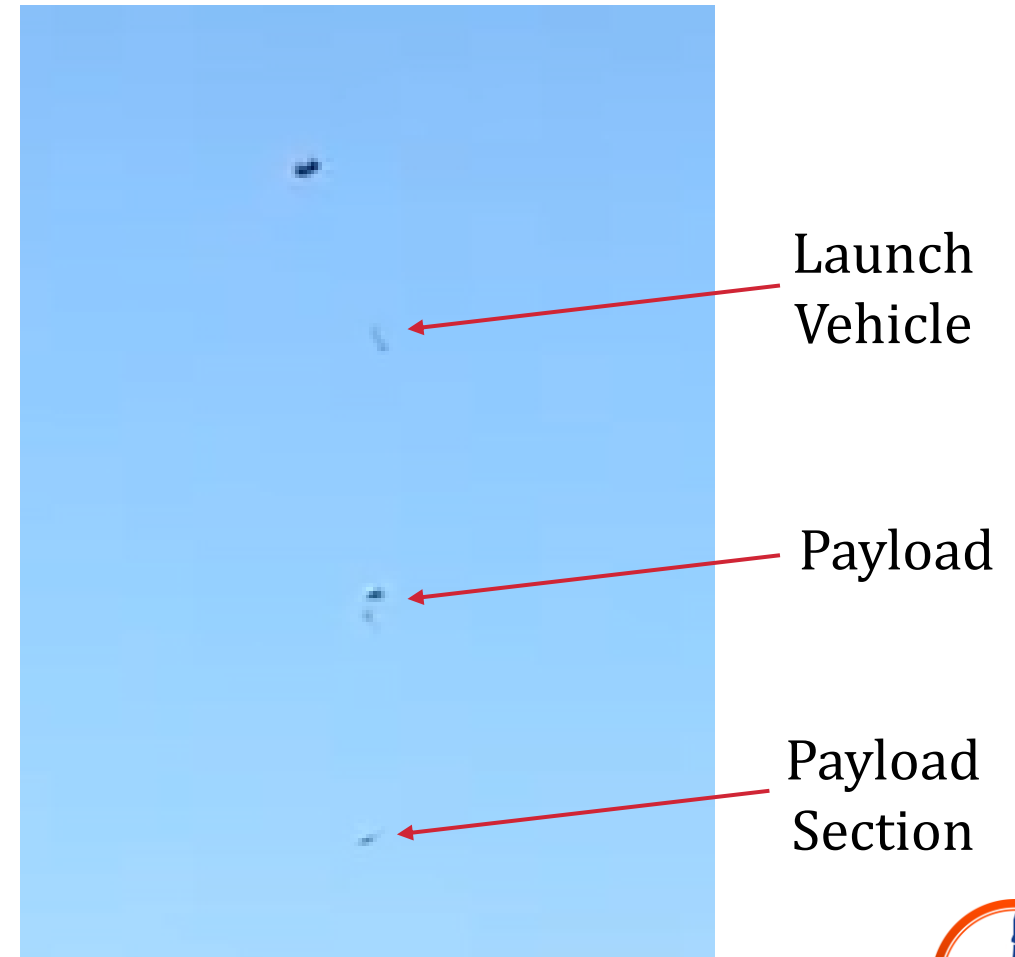


# Vehicle Demonstration Flight – Attempt 1

- Drift of main and central section: 1911 ft
- Drift of payload section: 2467 ft

Section	Stratologger CF Kinetic Energies (ft-lbf)	MissileWorks RRC3 Kinetic Energies (ft-lbf)
Payload	N/A	N/A
Central	22.85	24.05
Aft	36.64	38.56

Descent Time		
Predicted	Actual	Error
85.0 s	80.4 s	5.72%



# Vehicle Demonstration Flight – Attempt 1



Launch Vehicle

Payload

Payload Section



# Vehicle Demonstration Flight – Attempt 1



# Vehicle Demonstration Flight – Attempt 1

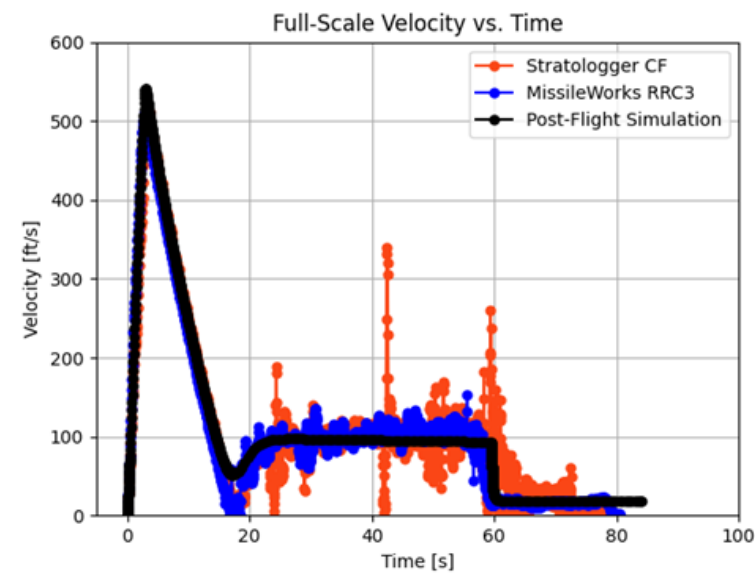
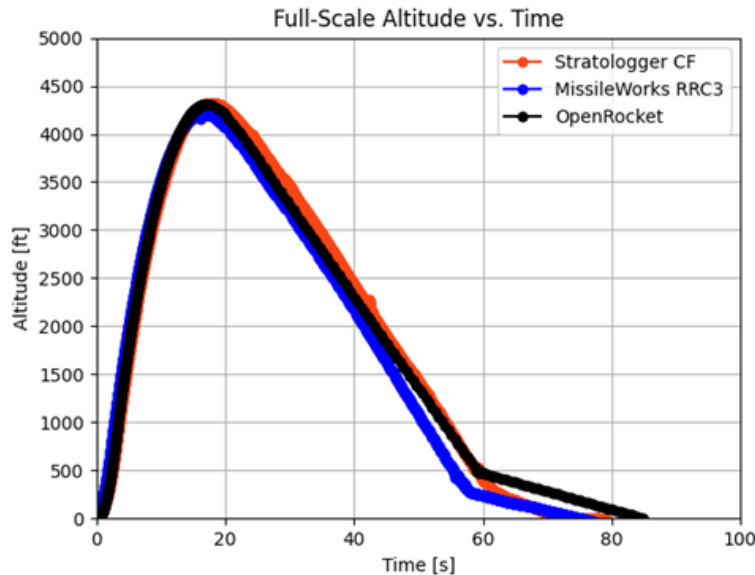
Damages:



Repairs:



# Vehicle Demonstration Flight – Attempt 2



- Performed on **March 3rd, 2024** in Samson, AL
- Successful attempt
- 21 oz ballasted launch vehicle

Vehicle Demonstration Flight Data			
Parameter	Predicted	Actual	Percent Error
Apogee	4310 ft	4324 ft	0.32%
Drogue Descent Rate	93.3 ft/s	100.7 ft/s	7.93%
Main Descent Rate	16.5 ft/s	16.2 ft/s	1.82%



# Vehicle Demonstration Flight – Attempt 2

- Drift: 946 ft

Section	Stratologger CF Kinetic Energies (ft-lbf)	MissileWorks RRC3 Kinetic Energies (ft-lbf)
Payload	64.93	66.55
Central	24.98	25.60
Aft	46.30	47.45

Descent Time		
Predicted	Actual	Error
71.3 s	61.5 s	13.74%



# Vehicle Demonstration Flight – Attempt 2



# Recovery System Tests

- GPS Verifications:
  - Functionality/Connectivity Demonstrations
  - Accuracy Test
    - GPS has an average positional error of 22.121 yards.
  - Interference Test
    - Losing line of site caused connection to drop between transmitter and receiver. Since the launch site will allow for continuous line of site with the launch vehicle, this issue was deemed inconsequential.
- Parachute Verifications:
  - Parachute drag tests
    - Drag coefficients of each parachute were calculated.
- Ejection Charge Demonstrations:
  - Black powder amounts were calculated.



# Tests and Procedures



# Testing Plan

- Total tests:
- Completed tests:
  - Material Strength (MS):
    - All materials will be able to withstand forces experienced during flight and landing.
  - Material Property (MP):
    - The necessary material properties of all materials have been calculated and analyzed.
  - Recovery (R):
    - All recovery subsystems have been tested to ensure the safe landing and collecting of the launch vehicle and payload.
  - Avionics (A):
    - All avionics subsystems will function as intended.
  - System Property (SP):
    - All necessary launch vehicle and payload system properties have been analyzed and the correct design changes have been made.
  - System Integration (SI):
    - All subsystem interactions have been run to ensure that they can communicate and function with each other.
  - System Functionality (SF):
    - All subsystems are functional.
  - Component Functionality (CF):
    - All hardware and software components are functional.
  - Durability (D):
    - All components that experience forces via the launch vehicle or payload will survive.
  - Launch (L):
    - All preliminary launches have been complete, verifying that the launch vehicle and payload will deploy successfully.



# Requirements Verification



# Requirements Verification: Launch Vehicle

---

- Launch Vehicle Requirements:
  - Total launch vehicle requirements: 76
  - Completed launch vehicle requirements: 70
  - In progress launch vehicle requirements: 0
  - Incomplete launch vehicle requirements: 6
- Recovery Requirements: All recovery requirements are complete.
- Payload Requirements:
  - Total payload requirements: 50
  - Completed payload requirements: 36
  - In progress payload requirements: 3
  - Incomplete payload requirements: 11



# Requirements Verification: Launch Vehicle

---

- General Requirements:
  - Total general requirements: 14
  - Completed general requirements: 8
  - In progress general requirements: 6
  - Incomplete general requirements: 0
- Safety Requirements:
  - Total payload requirements: 8
  - Completed payload requirements: 1
  - In progress payload requirements: 7
  - Incomplete payload requirements: 0





# Project Avigator

University of Florida

Thank you!

