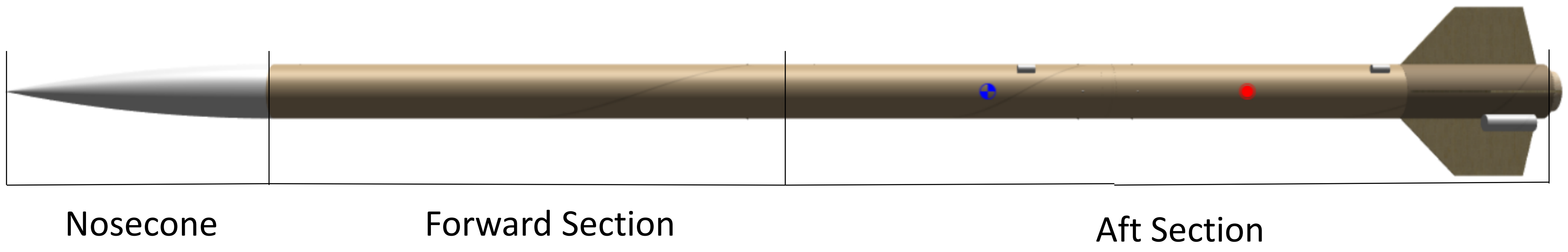
University of Florida
Swamp Launch Rocket Team

Critical Design Review Presentation

NASA University Student Launch 2022

Vehicle Dimensions

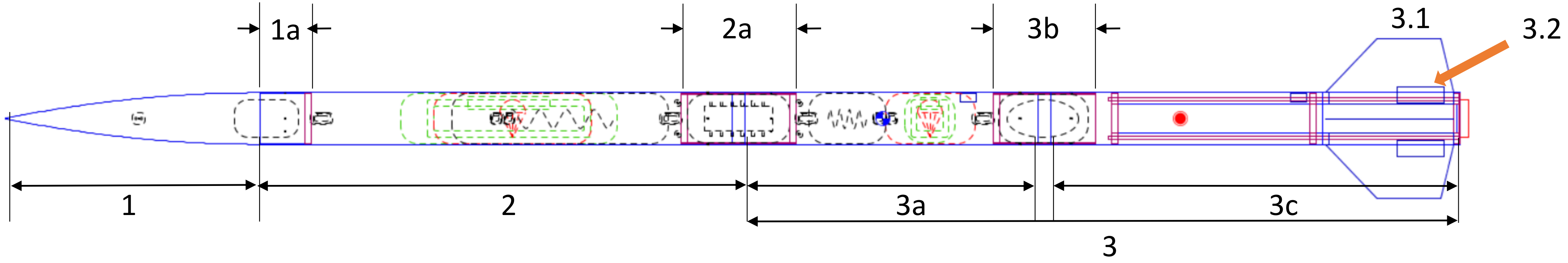


Section	Length (in.)	Component Mass (oz.)	Overall Length (in.)	Total Vehicle Mass (oz.)
Nosecone Section	20	27	115	414
Forward Section	38	112		
Aft Section	57	275		

Final Design

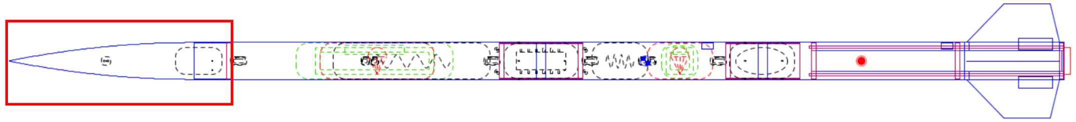
<u>Sections</u>

1. Nosecone section
   1a. Nosecone shoulder
2. Forward section
   2a. Avionics bay
3. Aft section
   3a. Upper aft airframe
   3b. Payload bay
   3c. Lower aft airframe
      3.1. Fins (x4)
      3.2. Camera mounts (x2)

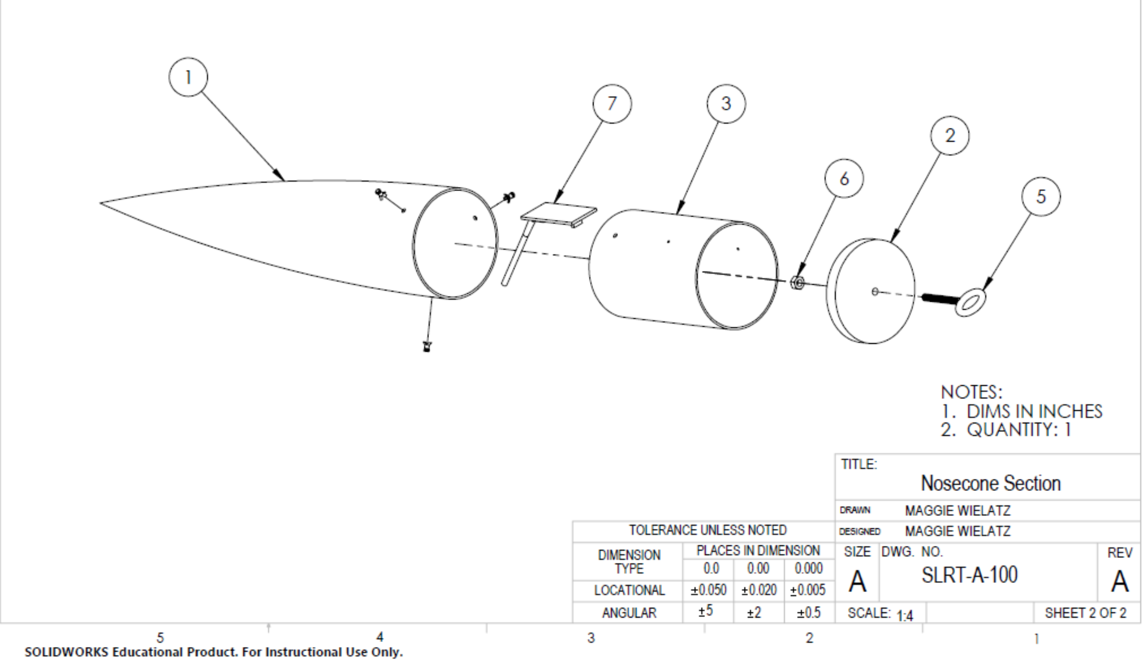


Nosecone Section

1. 5:1 Ogive nosecone
   (4.02 in base diameter G12 Fiberglass)
2. Nosecone bulkhead
   (3.90 in diameter Type II PVC)
3. Nosecone shoulder
   (3.90 in diameter G12 Fiberglass)
4. Rivets
   (0.154 in diameter ABS Plastic)
5. Eyebolt
   (¼-20 steel)
6. Hex nut
   (steel)
7. BIG RED BEE 900 GPS

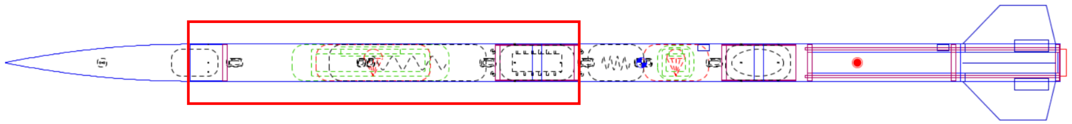


ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	SLRT-102	NOSECONE	1
2	SLRT-104	BULKHEAD	1
3	SLRT-103	NOSECONE COUPLER	1
4	SLRT-002	RIVET	3
5	SLRT-105	1/4-20 EYEBOLT	1
6	SLRT-207	1/4-20 HEX NUT	1
7	SLRT-104	BIG RED BEE 900 GPS	1

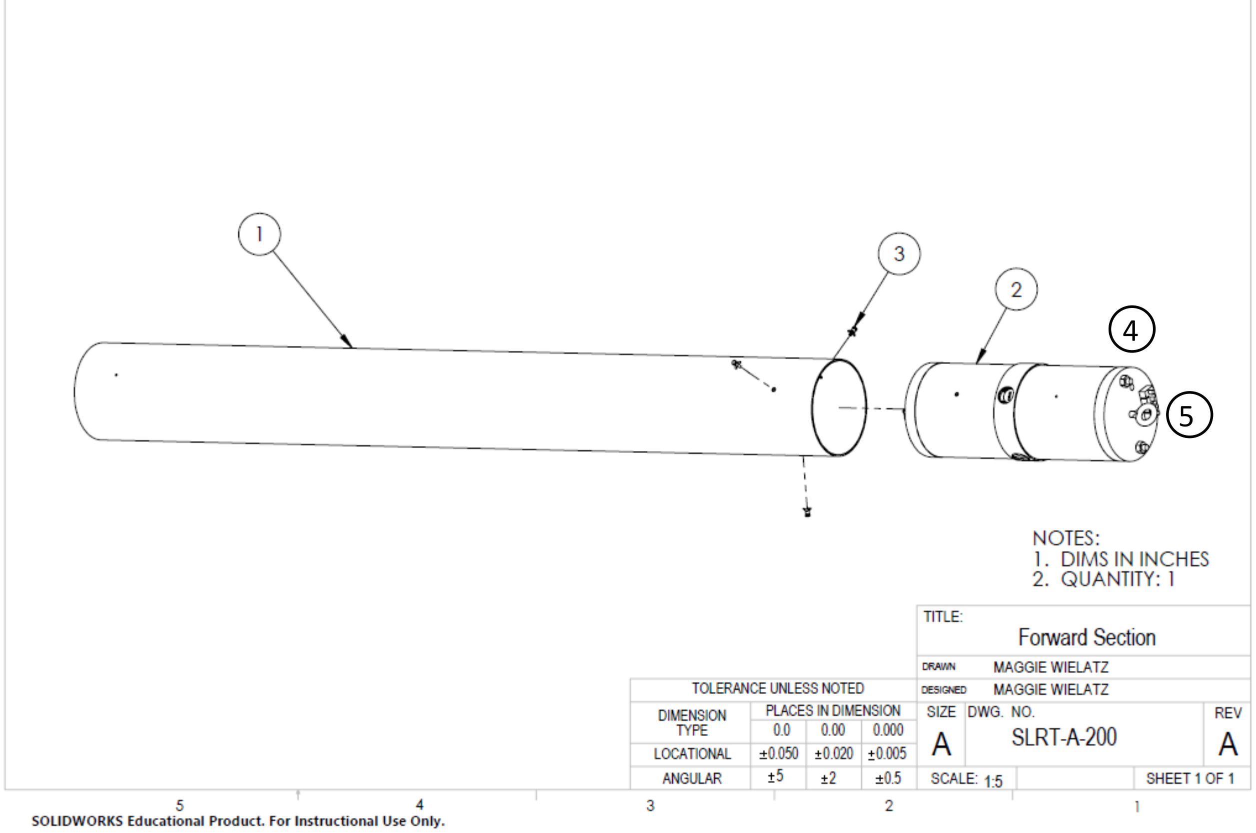


Forward Section

1. Forward airframe
   (4.02 in diameter G12 Fiberglass)
2. Avionics coupler
   (3.90 in diameter G12 Fiberglass)
3. Rivets
   (0.154 in diameter ABS plastic)
4. Avionics bay bulkheads
   (3.90 in diameter Type II PVC)
5. Eyebolts
   (¼-20 steel)



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	SLRT-201	FORWARD AIRFRAME	1
2	SLRT-202	AVIONICS BAY	1
3	SLRT-002	RIVET	3

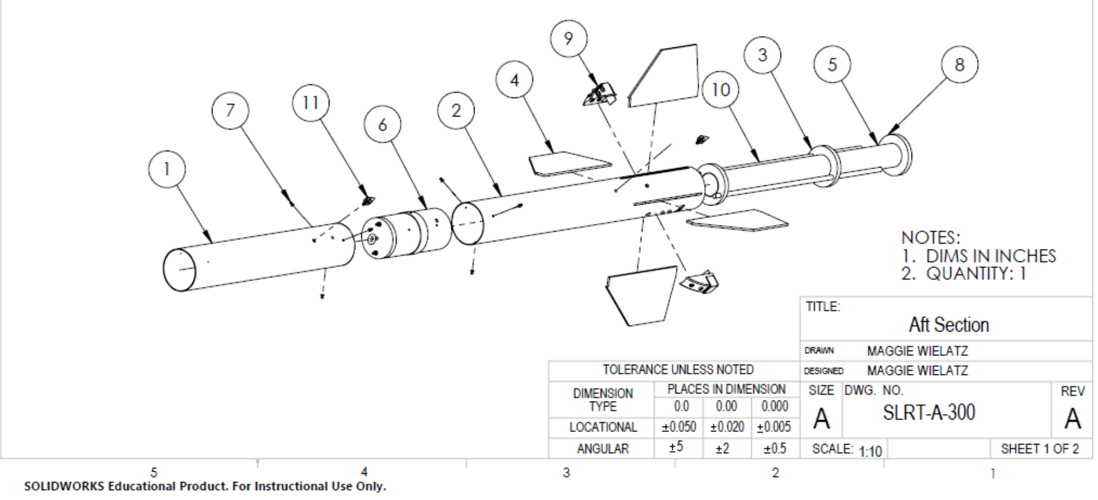


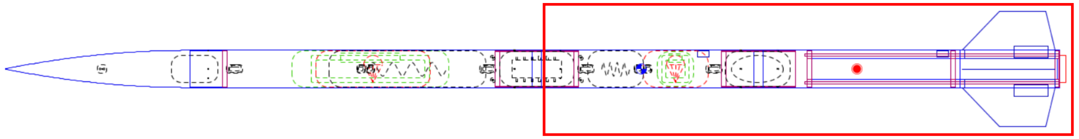
Aft Section

1. Upper aft airframe
- Rivets (0.154 in diameter ABS plastic, steel fastener)
- Forward rail button (1515 button ABS plastic, ¼-20 steel)

2. Lower aft airframe
- Payload coupler (3.90 in diameter G12 Fiberglass)
- Rivets (0.154 in diameter ABS plastic)
- Payload coupler bulkheads (3.90 in diameter PVC)
- Fins (0.187 in thick Structural FRP Fiberglass)
- Motor tube (2.24 in diameter G12 Fiberglass)
- Centering rings (0.5 in thick Plywood)
- Camera mounts (3D printed PETG filament)
- Aft rail button (1515 Button ABS plastic, ¼-20 steel)
- Electronics tubes (Kraft paper)

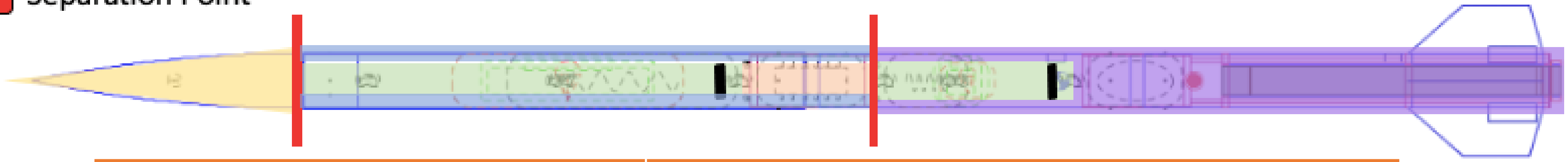
ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	SLRT-301	UPPER AFT AIRFRAME	1
2	SLRT-302	LOWER AFT AIRFRAME	1
3	SLRT-304	ELECTRONIC TUBE CENTERING RINGS	2
4	SLRT-307	FINS	4
5	SLRT-303	MOTOR TUBE	1
6	SLRT-314	PAYLOAD BAY	1
7	SLRT-002	RIVET	6
8	SLRT-305	AFT CENTERING RING	1
9	SLRT-312	CAMERA MOUNT	2
10	SLRT-306	ELECTRONICS TUBE	2
11	SLRT-318	RAIL BUTTON ASSEMBLY	2





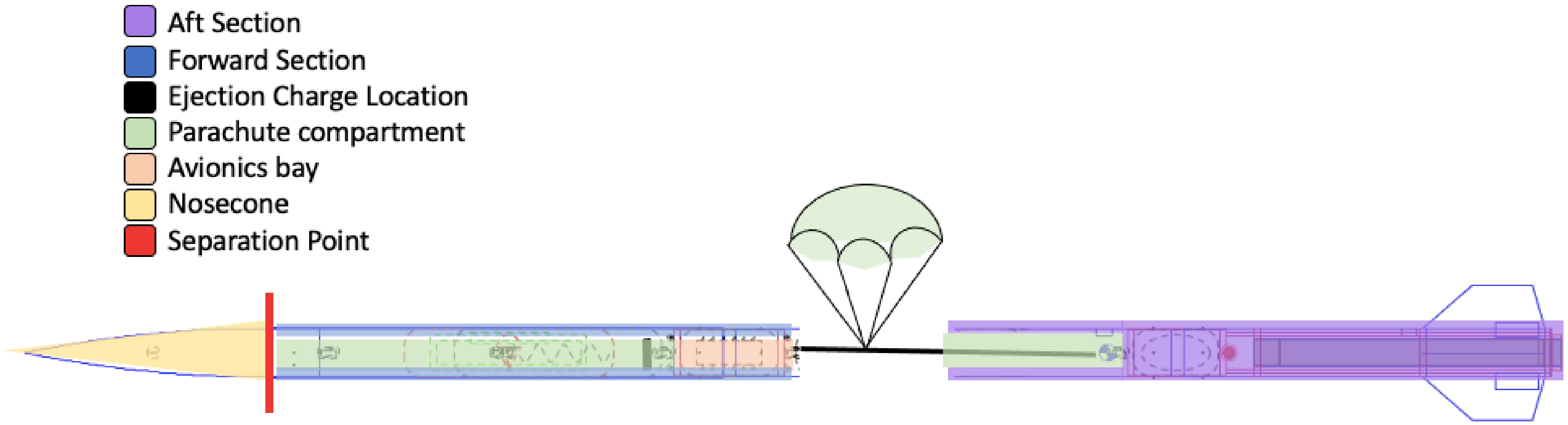
Separation Points

- Aft Section
- Forward Section
- Ejection Charge Location
- Parachute compartment
- Avionics bay
- Nosecone
- Separation Point



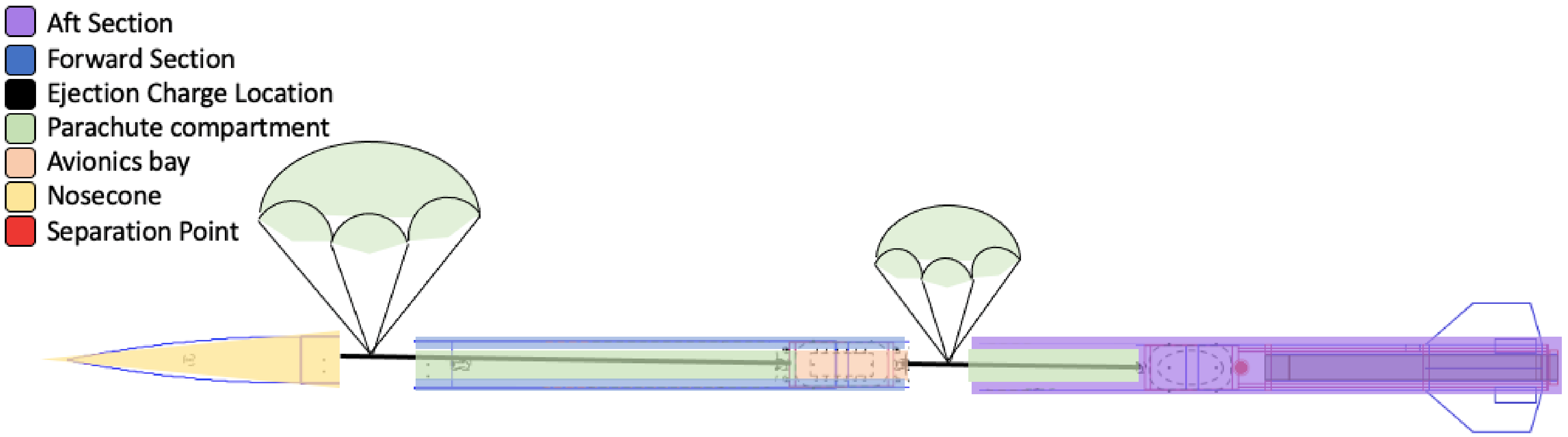
Object	Description
Primary aft ejection charge	2.5 g black powder at apogee
Secondary aft ejection charge	3.2 g black powder at 0.5 s after apogee
Primary forward ejection charge	1.5 g black powder at 600 ft AGL
Secondary forward ejection charge	2.0 g black powder 550 ft AGL

First Separation



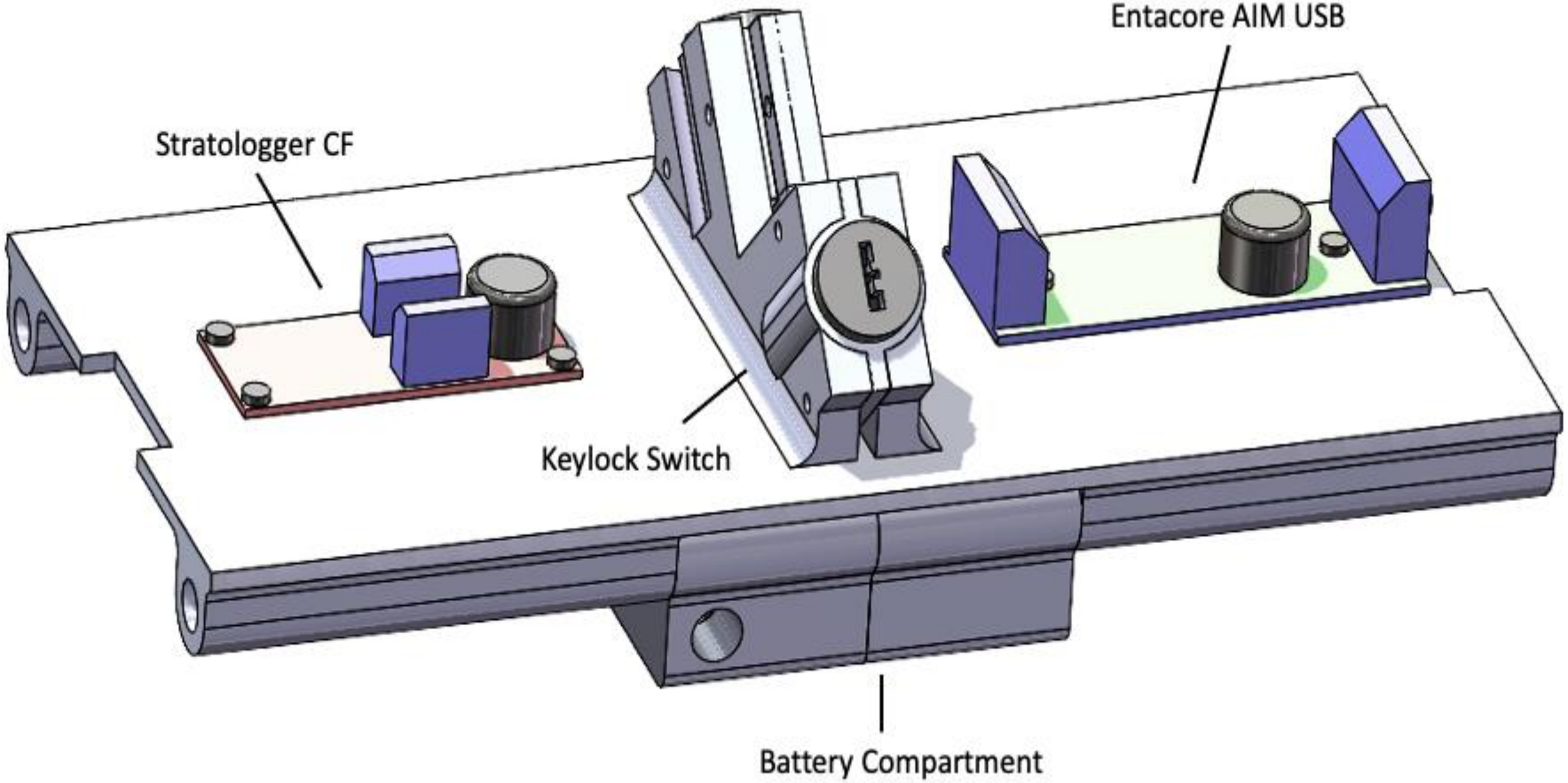
Object	Description
Recovery harness	Wildman Rocketry 7/16 in Kevlar 25 ft long
Drogue Parachute	24 in Rocketman Parachute CD of 0.97

Second Separation

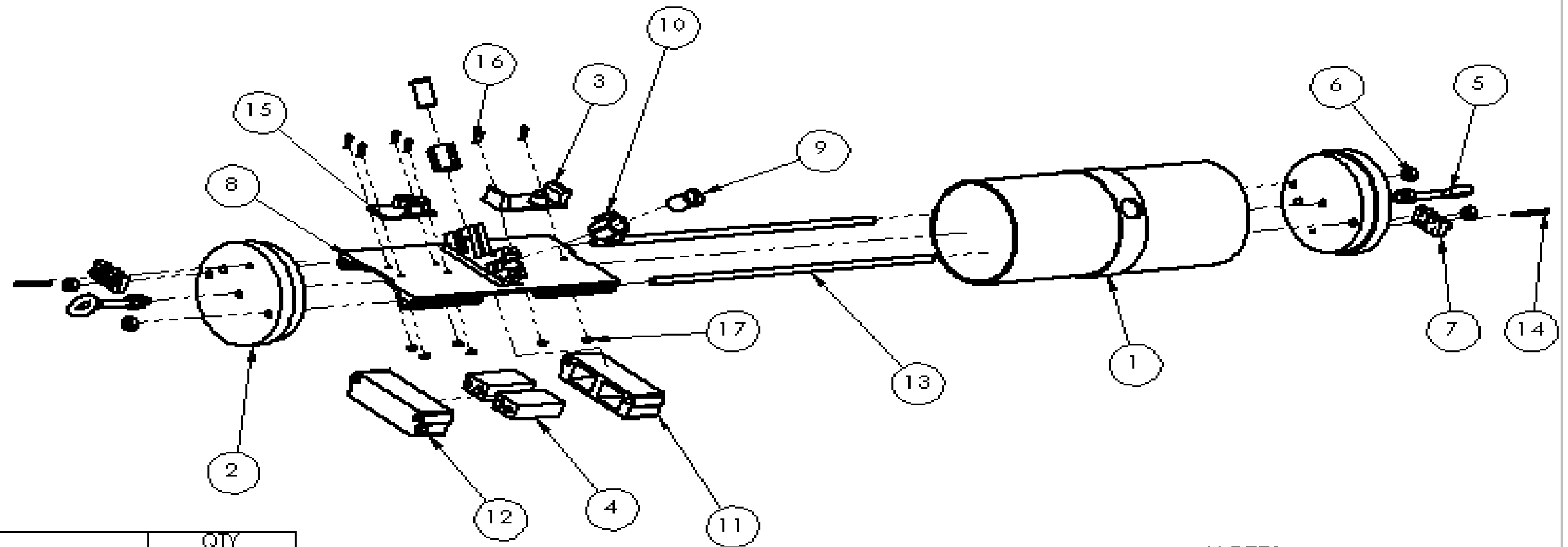


Object	Description
Recovery harness	Wildman Rocketry 7/16 in Kevlar 25 ft long
Main Parachute	72 in Fruity Chutes Iris Ultra CD of 2.2

Avionics Sled



Avionics Sled Integration



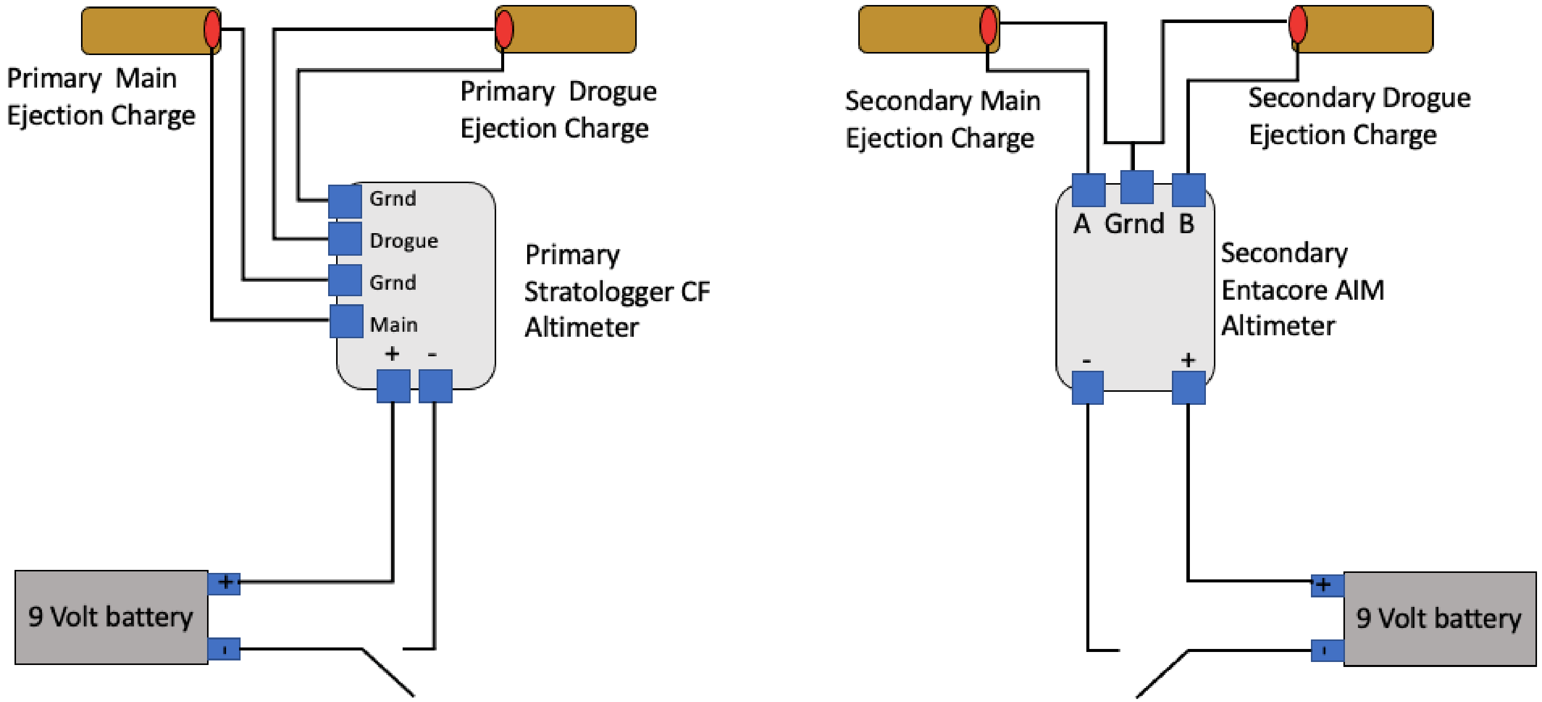
NOTES:
1. DIMS IN INCHES
2. QUANTITY: 1

TOLERANCE UNLESS NOTED				TITLE: Avionics bay assembly
OPERATION	PLACES IN DIMENSION			DRAWN Collin Larke
	0.0	0.00	0.000	DESIGNED Collin Larke
MACHINING	±0.050	±0.020	±0.005	SIZE A
CUTOFF (SAW, BURN, SHEAR)	±0.1	±0.060		DWG. NO. SLRT-202
WELDING	±0.1	±0.060		REV A
ANGULAR DIMS	±5	±2	±0.5	SCALE: 1:4 SHEET 2 OF 3

4 3 2 1

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	SLRT-203	Coupler and Switchband	1
2	SLRT-204	Avionics Bay Bulkhead	2
3	SLRT-212	Entacore AIM Altimeter	1
4	SLRT-213	9 Volt Battery	2
5	SLRT-205	Galvanized Steel Eyebolt without Shoulder	2
6	SLRT-207	1/4-20 hex nut	8
7	SLRT-215	Terminal block	2
8	SLRT-208	Avionics sled	1
9	SLRT-209	Key switch	2
10	SLRT-210	Key switch mount	2
11	SLRT-218	Battery holder	1
12	SLRT-219	Battery holder (terminal side)	1
13	SLRT-206	1/4-20 threaded rod	2
14	SLRT-214	4-40 X 1.25"	2
15	SLRT-211	StratologgerCF	1
16	SLRT-216	4-40 X 0.5"	6
17	SLRT-217	4-40 hex nut	6

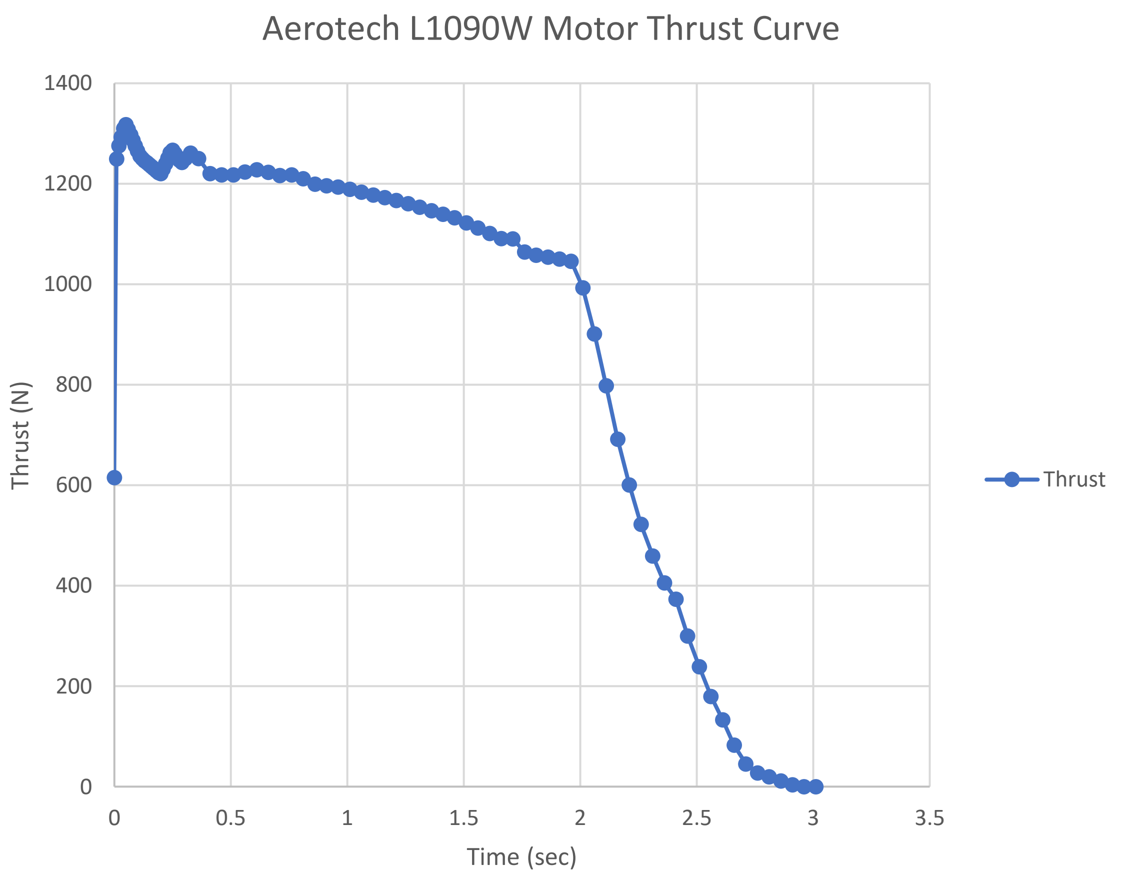
Altimeter Wiring and Redundancy



Object	Selected Component
Primary Altimeter	Perfectflite StratologgerCF
Secondary Altimeter	Entacore AIM USB

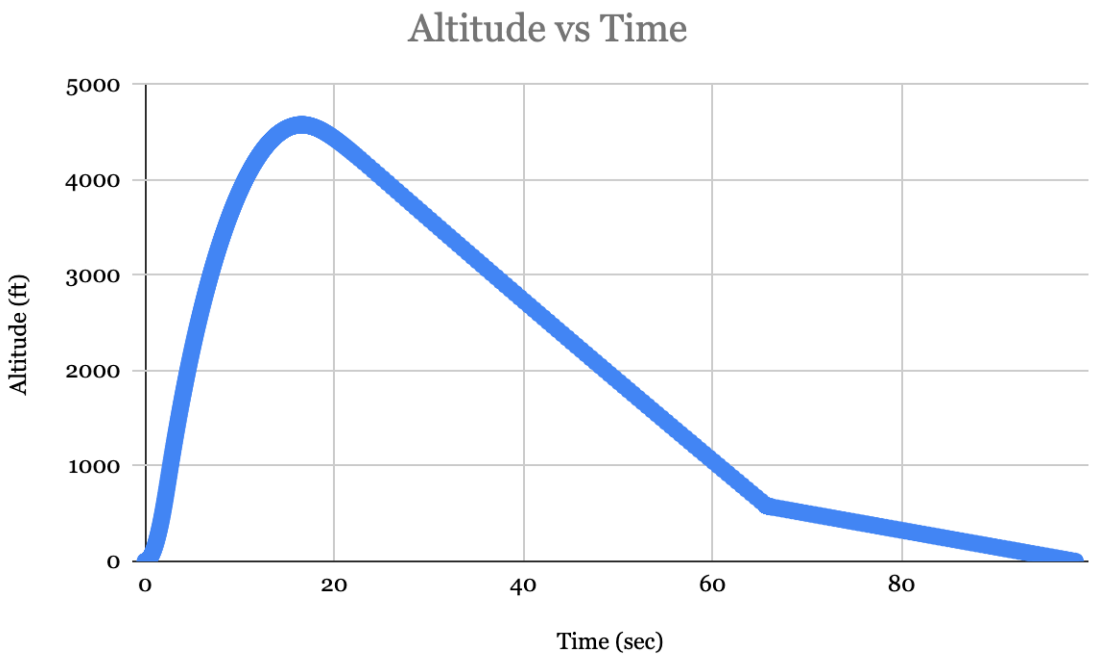
Motor Selection

- Motor: Aerotech L1090W
- Total Impulse: 2736 N-s
- Maximum Thrust: 1334 N
- Propellant Mass: 1400 g
- Burn Time: 3 sec
- Thrust to Weight: 9.2:1



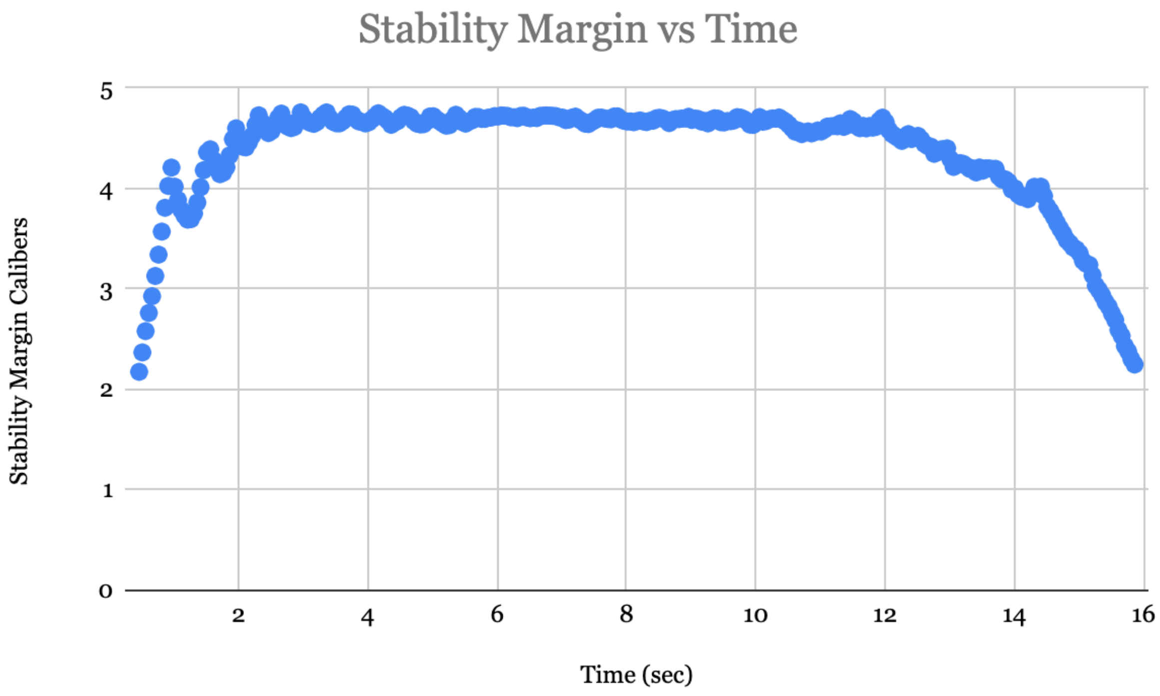
Mission Performance Parameters: Altitude

- Simulation Assumptions: 10 mph, 5-degree cant
- Simulated Apogee: 4579 ft
- Target Apogee: 4578 ft



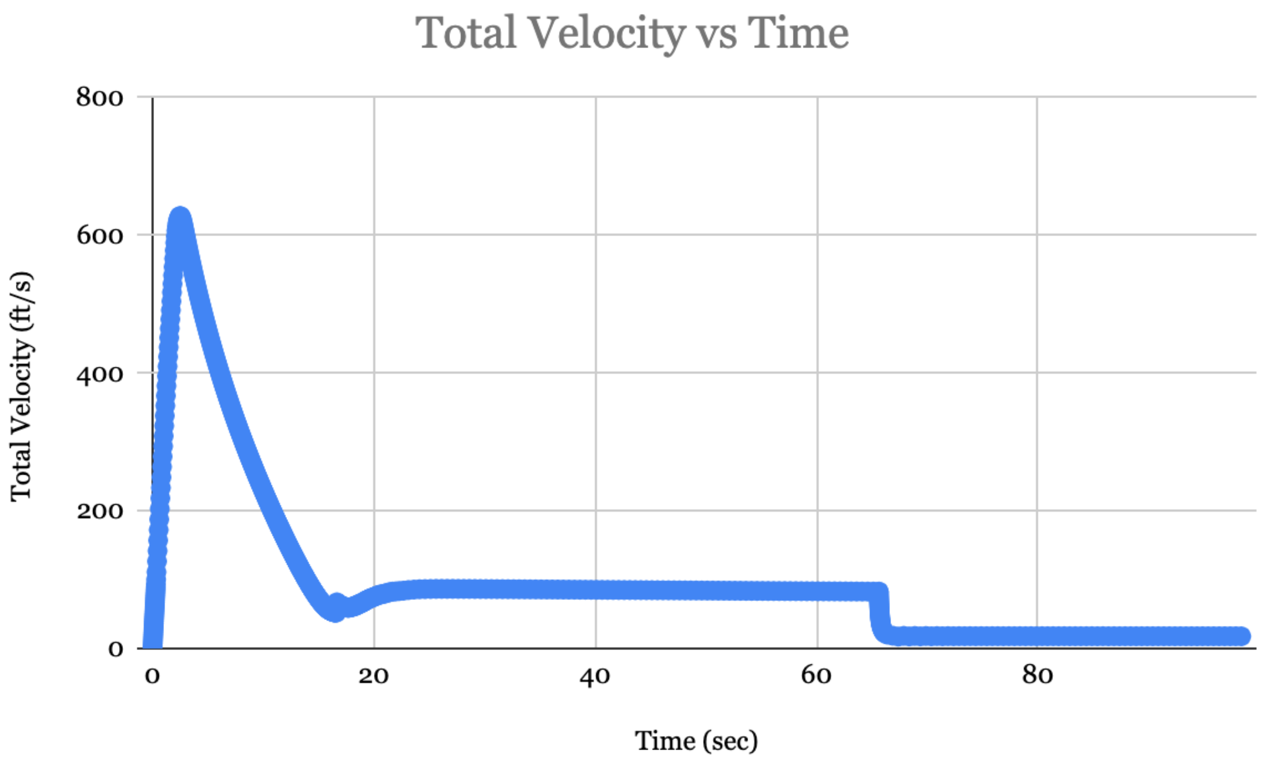
Mission Performance Parameters: Stability

- Stability Margin at Rail : 2.05
- Stability Margin at Rod Clearance: 2.2
- Maximum Stability Margin: 4.75



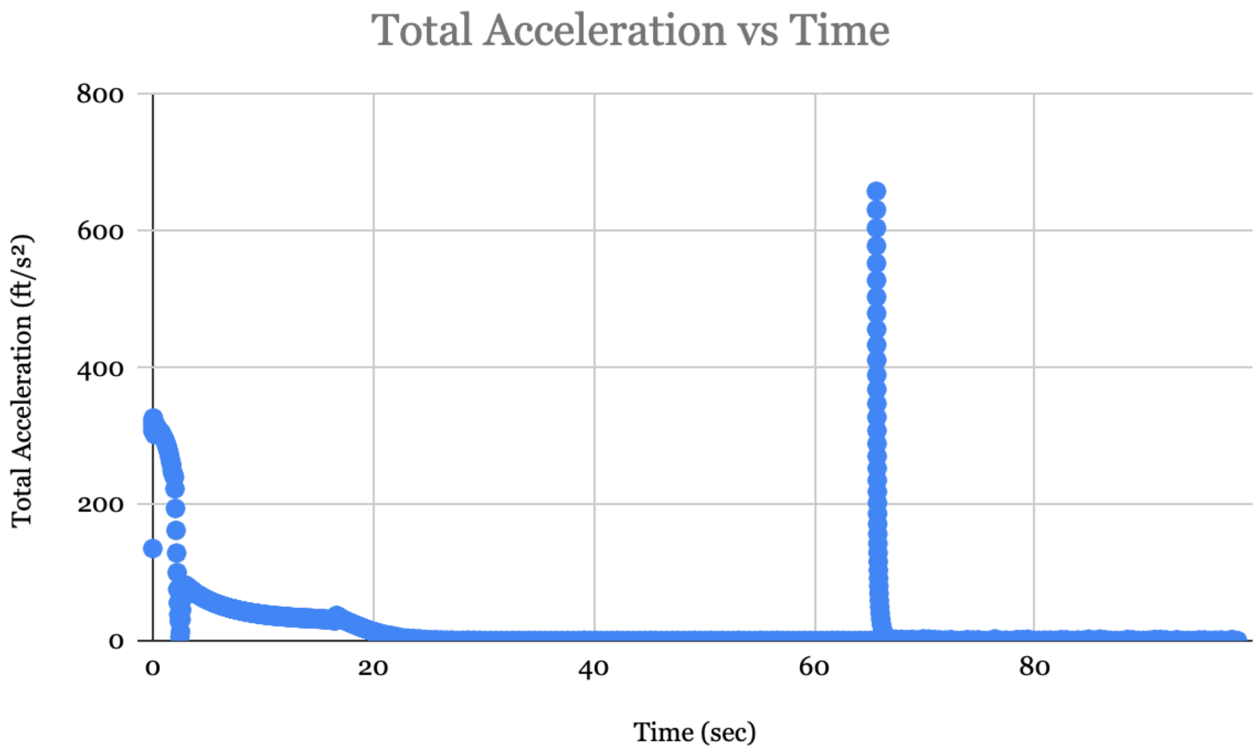
Mission Performance Parameters: Velocity

- Velocity at Rail Exit: 88.6 ft/s
- Maximum Velocity: 627 ft/s
- Max Mach Number: 0.56



Mission Performance Parameters: Acceleration

- Maximum Acceleration: 325 ft/s^2



Calculation Methods for Descent Predictions

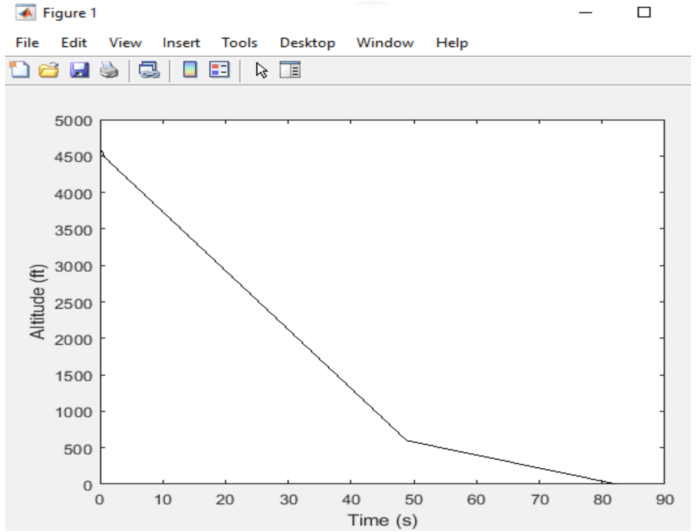
Launch vehicle recreated in Openrocket by Flight Dynamics Sub Team

Equations presented further in presentation

Uses ode23 function to solve the ordinary differential equation found by balancing the weight of the launch vehicle with forces produced by drag

$$0 = \begin{cases} -mg + \frac{1}{2}\rho v^2 s_{drogue} C_{drogue} & h_{main} < h \leq h_{apogee} \\ -mg + \frac{1}{2}\rho v^2 s_{main} C_{main} & 0 \leq h \leq h_{main} \end{cases}$$

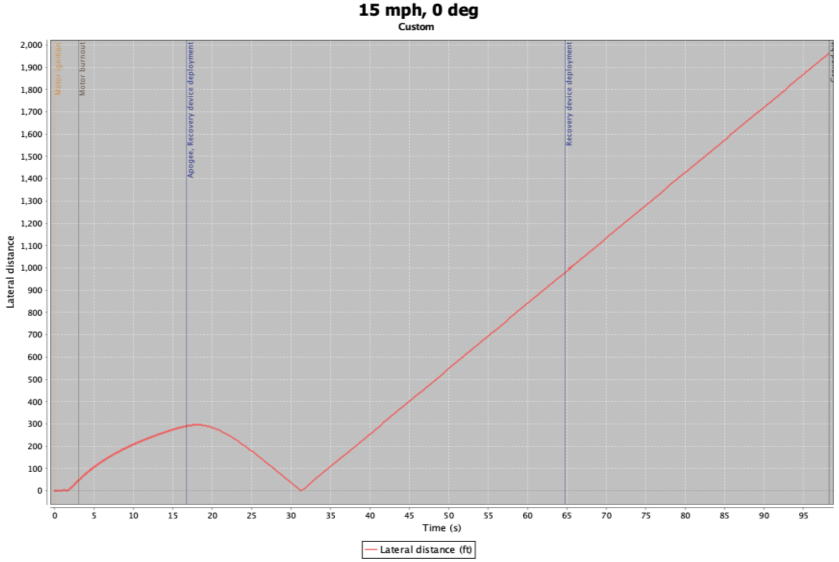
Descent Time

	Openrocket	Spreadsheet	MATLAB
	$t = t_{total} - t_{apogee}$	$t_{main} = \frac{h_{main}}{v_{main}}$ $t_{drogue} = \frac{h_{apogee} - h_{main}}{v_{drogue}}$ $t = t_{drogue} + t_{main}$	
Results:	82.9	82.3	82.5

Object	Description	Predicted Descent Rate (Openrocket)
Drogue Parachute	24 in Rocketman Parachute CD of 0.97	82.5 ft/s
Main Parachute	72 in Fruity Chutes Iris Ultra CD of 2.2	17.6 ft/s

Max Drift Radius

Openrocket	Spreadsheet	MATLAB
	$X = V * t$	$X = V * t$



Drift Calculation Results					
Wind Speed	0 mph	5 mph	10 mph	15 mph	20 mph
Drift at apogee (ft)	7	200	360	465	550
Final drift (ft)	No change	360	775	1225	1655
Openrocket total (ft)	7	560	1135	1700	2205
Spreadsheet (ft)	0	604	1207	1811	2414
MATLAB (ft)	0	607	1214	1820	2427

Max Kinetic Energy

$$KE_i = \frac{v_{main}^2 * m_i}{2}$$

Kinetic Energy Calculation Results			
Section	Nosecone	Forward	Aft
Spreadsheet (ft-lbs)	10.1	34.0	68.2
MATLAB (ft-lbs)	10.3	34.8	70.0

Deployment Force of Main Parachute

$$\text{Load} = \frac{\Delta KE}{d}$$

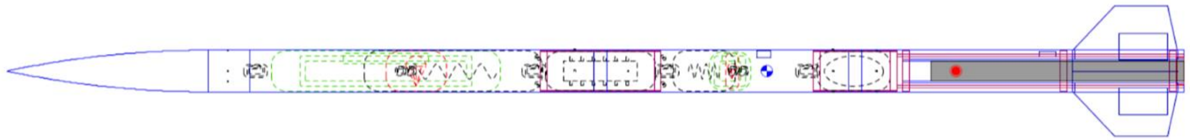
Predicted Deployment Load	
$KE_{Drogue\ aft}$ (ft-lbs)	1457.8
KE_{aft} (ft-lbs)	68.2
ΔKE (ft-lbs)	1389.6
d (ft)	50
Load (oz)	**444.7** (27.8 lbs)

Test Plans and Procedures

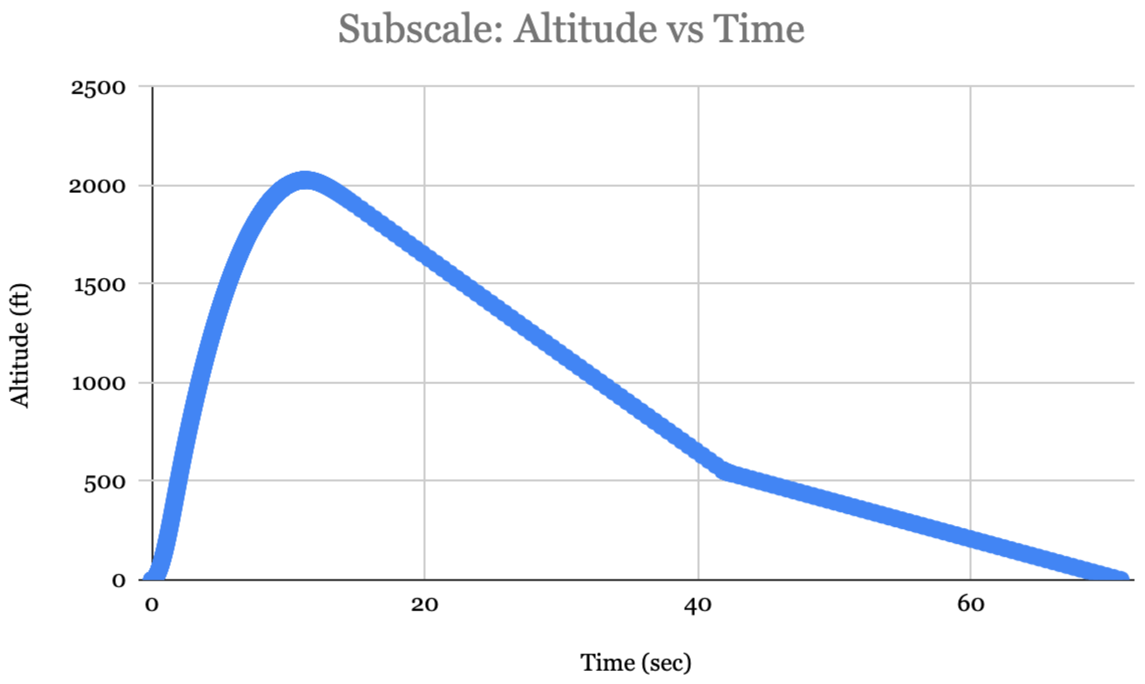
Test Name	Objective	Procedure
Recovery Altimeter Resolution Test	Ensure both the primary and secondary altimeters are detecting the correct altitude	Place the Entacore AIM altimeter at multiple heights and record readings. Repeat for the Stratologger altimeter.
Ejection Demonstration	Determine the amount of Pyrodex required to completely separate the appropriate sections of the launch vehicle	Prepare Pyrodex ejection charge and assemble the launch vehicle. Place launch vehicle on test stand and ignite charge.
Parachute Packing Test	Ensure that parachute fits in airframe and will deploy smoothly	Fold parachute in an appropriate manner and simulate deployment. Fold in the same manner and place in the airframe.
Drone Camera Landmark Analysis	Determine how many keypoints can be captured during launch time by OV5642 cameras	Place payload camera on a testing drone and fly it to predicted altitude, then fly back to the ground. Allow camera to take photos during ascent and descent. Perform test for both the cameras.

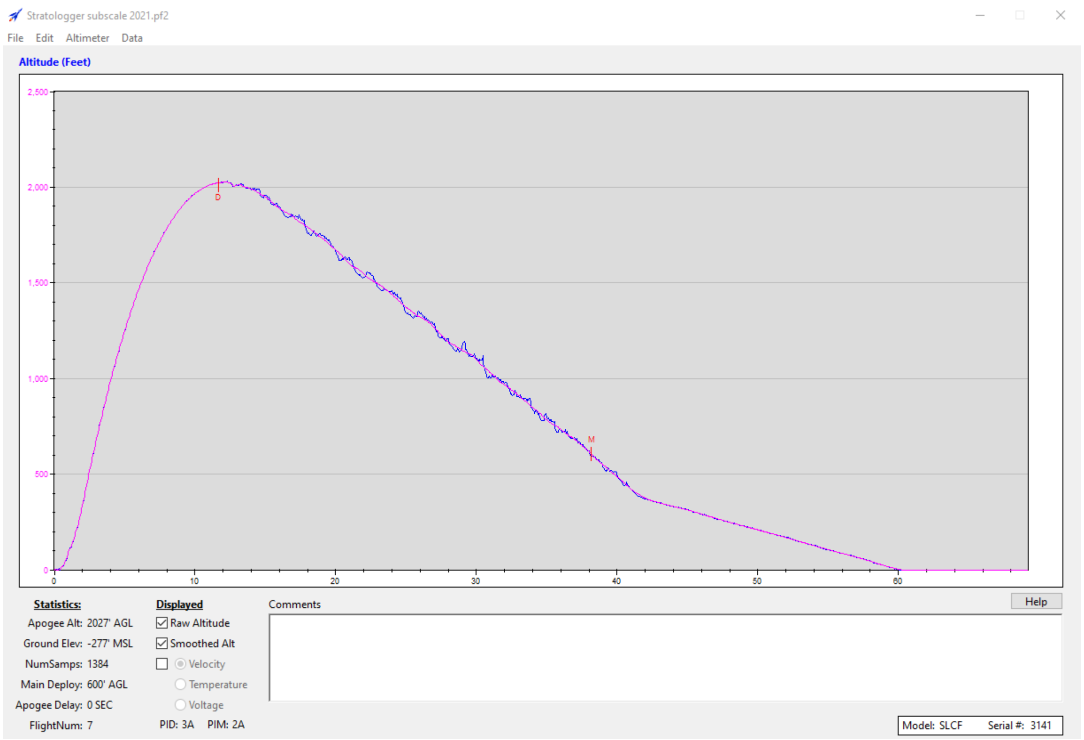
Subscale Flight Test

- Subscale Demonstration Flight
  - Performed on December 4th, 2021, in Tripoli Fort Myers
  - Successful on first attempt
  - Payload electronics and camera mounts were flown
  - Reached an apogee of 2,025 ft
  - Vehicle separated successfully and parachutes deployed
  - No damage to vehicle; determined to be recoverable and reusable

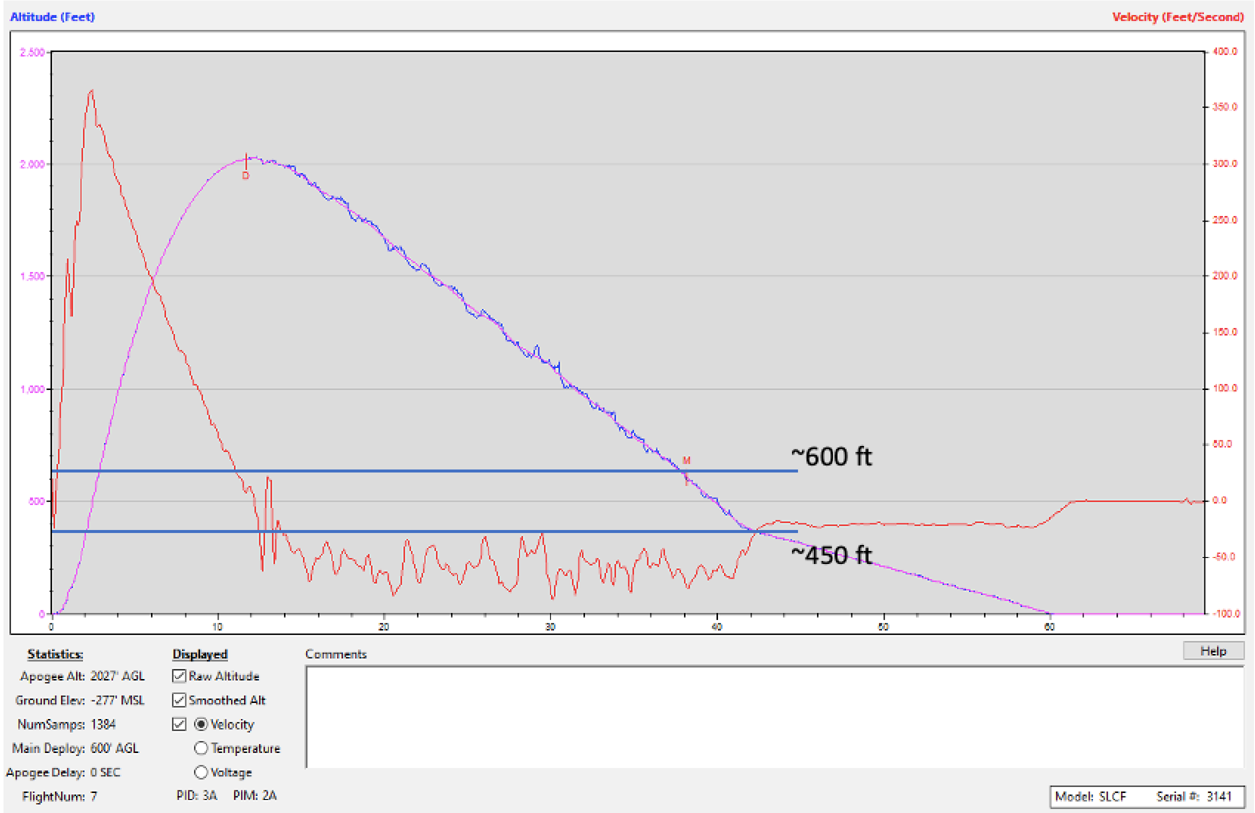


Subscale Flight Test Data





Subscale Flight Test Descent Data



Average Descent Rates	
Main Parachute	25 ft/s
Drogue Parachute	70 ft/s

Subscale Payload Prototype

- Scaled down for subscale requirements
- Testing of mechanical structures with electronics models
- Utilized new retention system and camera mount design
- Successful for all mechanical components

Recovery System Testing

- Subscale Main Parachute Ejection Demonstration
  - Performed prior to the subscale launch
  - Successful on fourth attempt
  - Utilized 2.5 g of Pyrodex
  - Backup charges tested, successful at 3.125 g of Pyrodex

- Subscale Drogue Parachute Ejection Demonstration
  - Performed prior to the subscale launch
  - Successful on second attempt
  - Utilized 2.0 g of Pyrodex
  - Backup charges tested, successful at 2.5 g of Pyrodex

Recovery System Testing

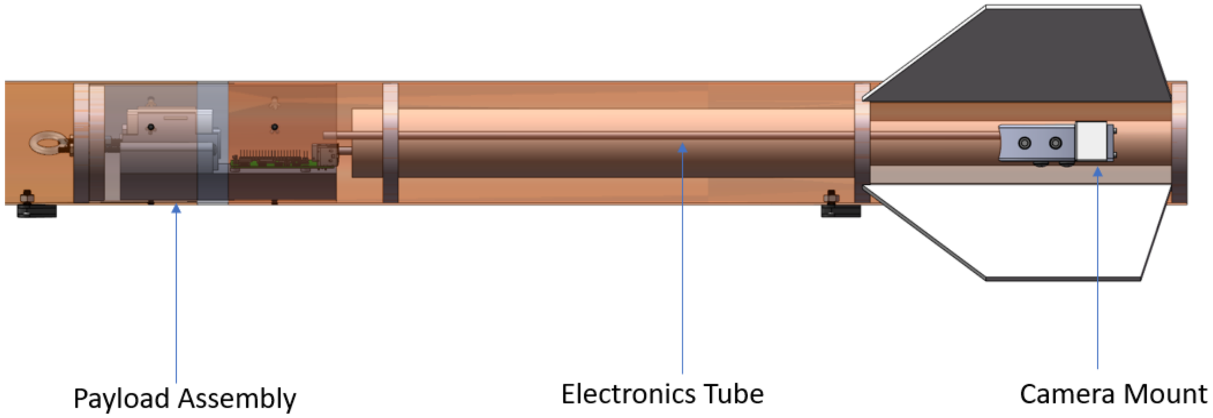
- Parachute Packing Demonstration
  - Performed on site of the launch
  - Successful on first attempt
  - Packing manner deemed appropriate

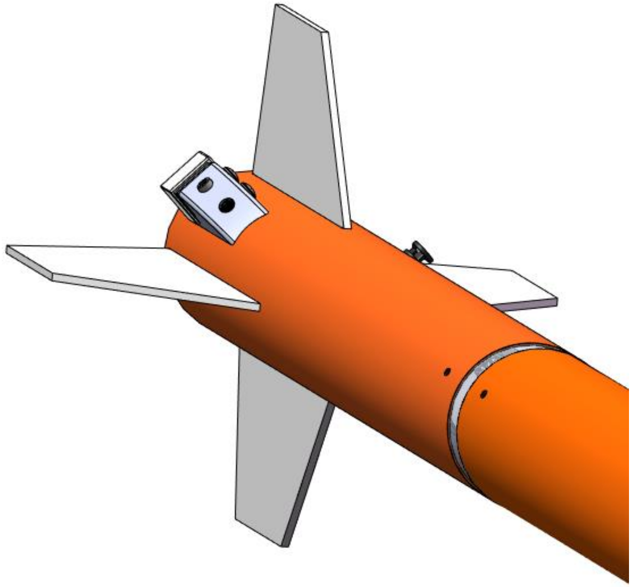
- Center of Gravity Inspection
  - Performed on site of the launch
  - Center of gravity identified before launch
  - True COG was at same point as OpenRocket calculations

- Recovery Altimeter Resolution Test
  - Performed prior to the subscale launch
  - Successful on first attempt
  - Both altimeters deemed functional
- Barometer Functionality Test
  - Performed prior to the subscale launch
  - Successful on first attempt
  - Barometer deemed functional

Payload Design Overview

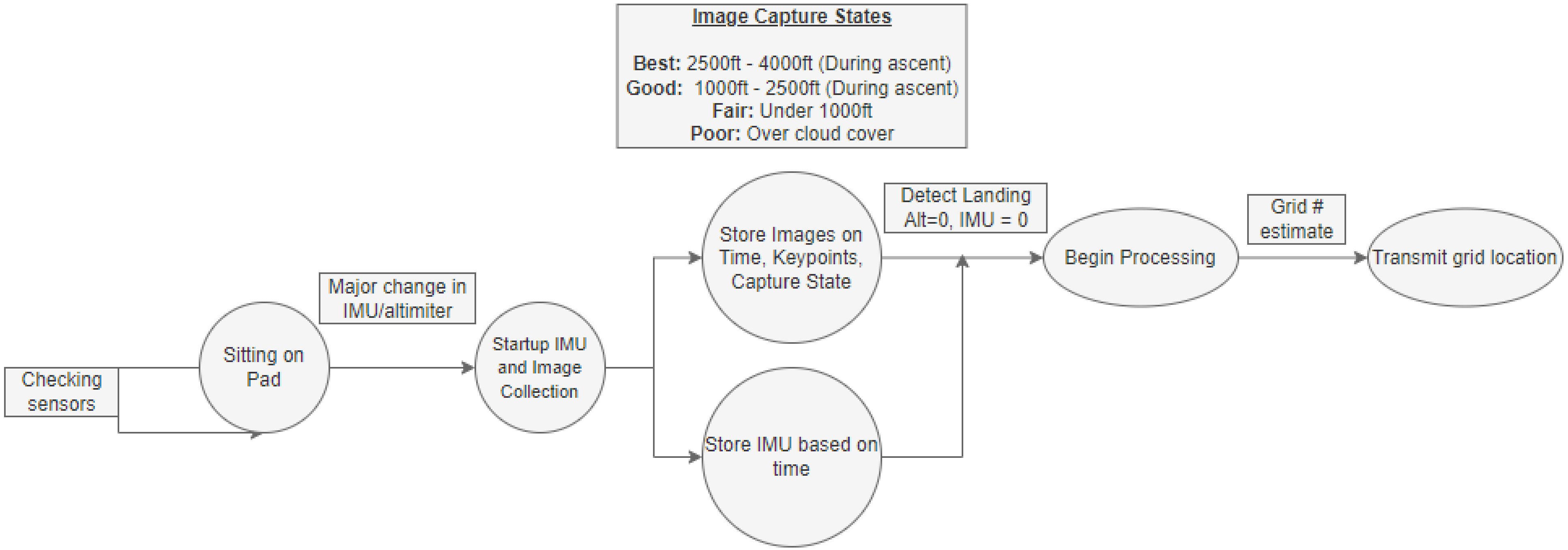
- Utilizes image processing and IMU data to locate launch vehicle
- Downward facing cameras to capture images on ascent
- Comprised of payload assembly, electronics tubes and camera mounts





Payload Software Overview

- The software controls all aspects of the payload including the cameras, the IMU and the processing.
- Images from the camera are used to find a reference location, by utilizing the SIFT algorithm
- IMU data from reference location till the landing location is utilized to find the displacement
- The displacement and the reference location helps us calculate and identify the grid location

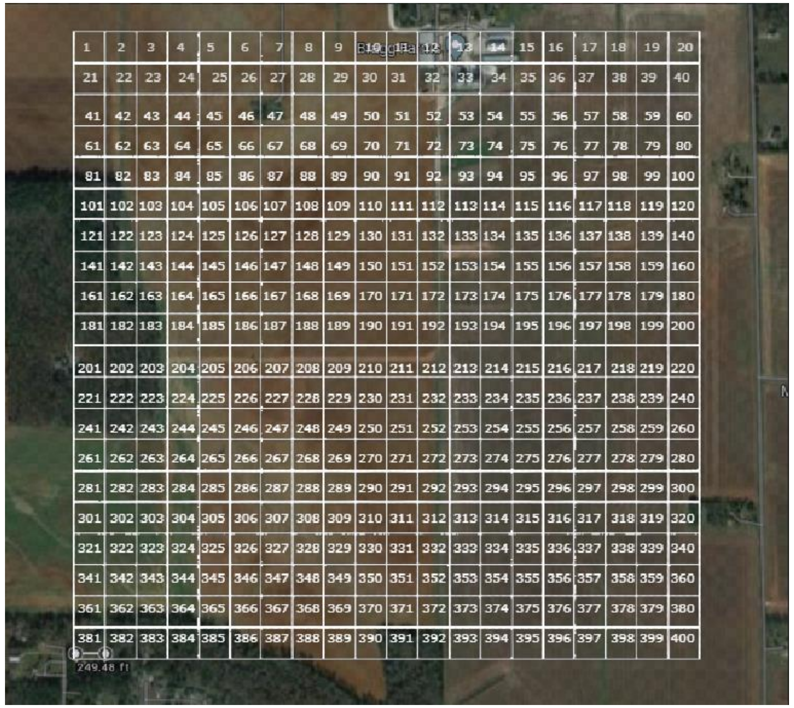


Payload Software – Image Comparison

- The images taken by the rocket are compared against the pre-uploaded image
- The comparison is done by generating SIFT objects and matching the SIFT objects
- This helps use identify a constant location, which then serves as our reference location.

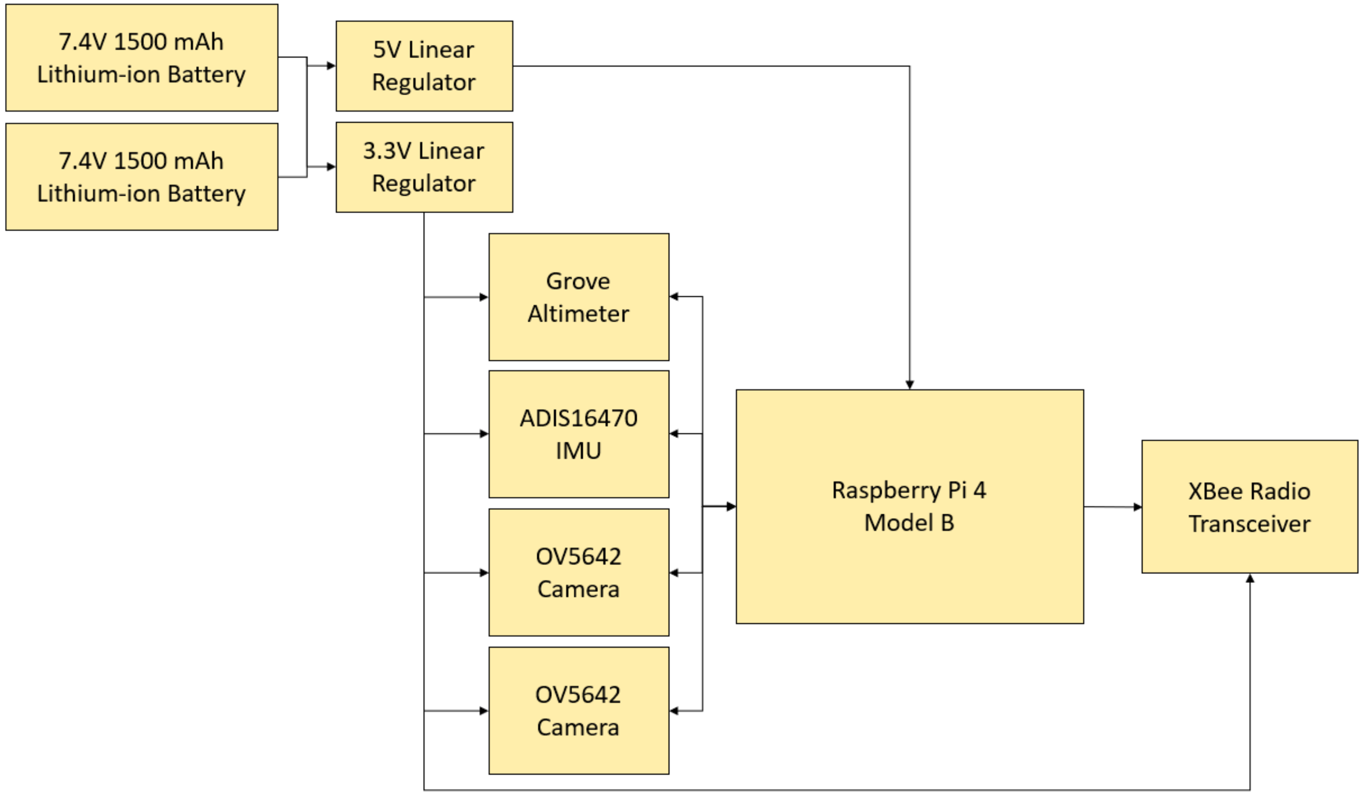
Payload Software – IMU Usage

- Once the reference location is acquired, the IMU data from that location, till the landing location will be used
- The IMU data from the reference location is retrieved by timestamp
- The accelerometer data is used to calculate the displacement which also helps us identify the final grid location



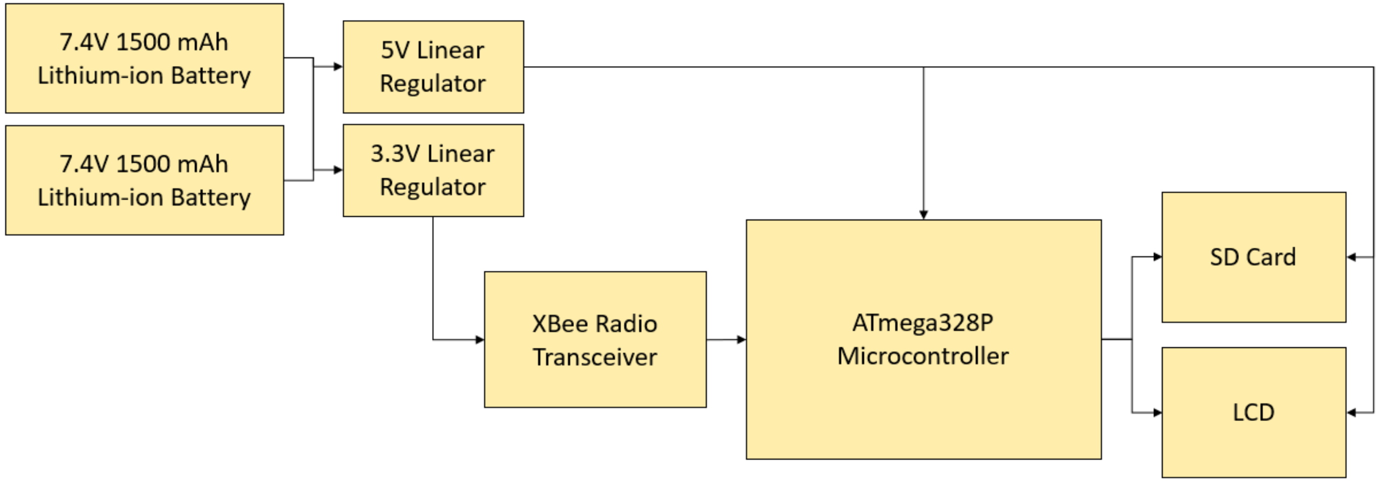
Payload Electronics

- Two Arducam OV5642 cameras
  - 65° FoV, 90° FoV
- ADIS16470 Inertial Measurement Unit
  - 6-axis
- Raspberry Pi 4 Processor, 8GB RAM
- Grove Altimeter
- Xbee Radio
  - 250 mW power output
  - 9 mile range
  - 905.6 MHz
- 2x 1500 mAh, 7.4V Lithium-ion batteries



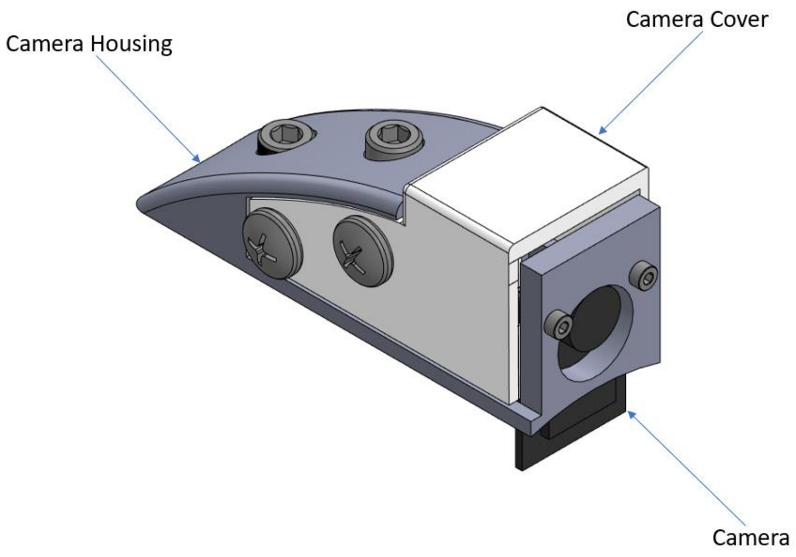
Payload Ground Station Electronics

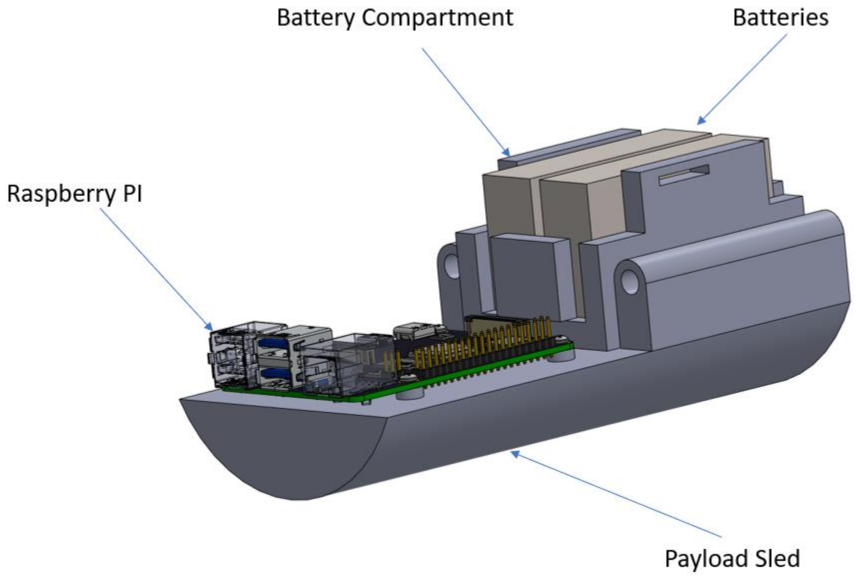
- ATmega328P microcontroller
- LCD output for radio connection status and grid number display
- SD card for storage of landing grid number
- Xbee Radio
    - 250 mW power output
    - 9 mile range
    - 905.6 MHz
- 1500 mAh, 7.4V Lithium-ion battery



Payload Mechanical Design

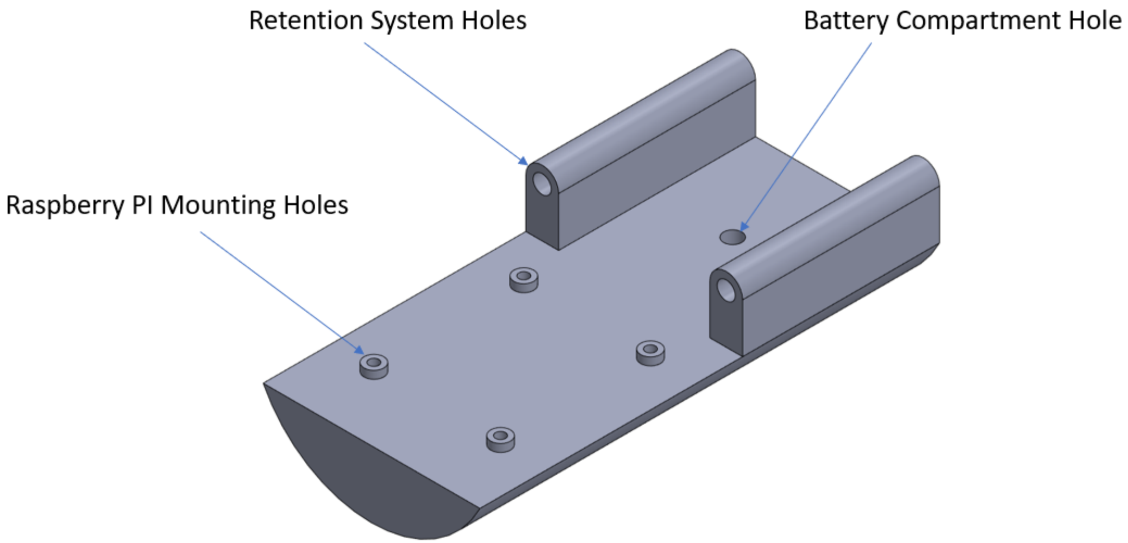
- Utilizes a payload sled assembly and camera mounts
- All components are 3D printed using PETG filament
- Provides structural support to payload hardware
- Designed for modularity and strength
- All component mating utilizes threaded inserts for plastic





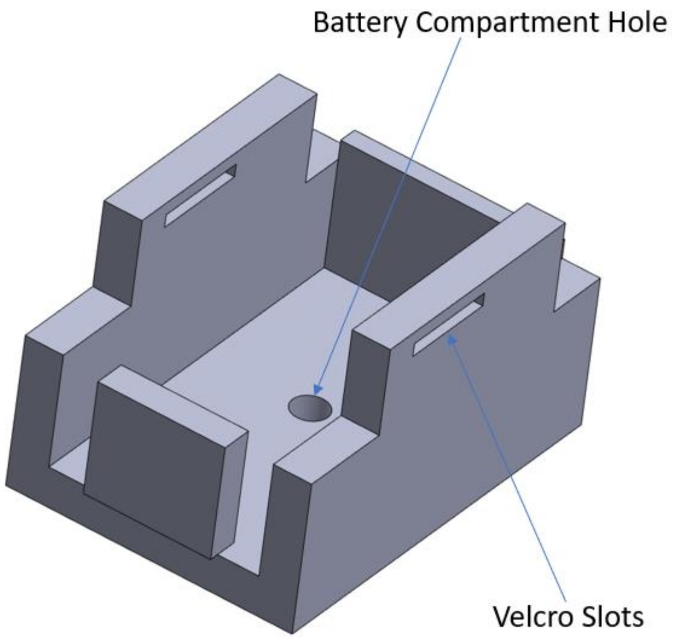
Payload Sled Design

- 3D printed using PETG filament
- Provides support and housing for Raspberry Pi and electronics
- Utilizes threaded inserts for plastic to attach electronics and battery compartment
- Includes new retention system mounting holes
- Successful design during subscale launch



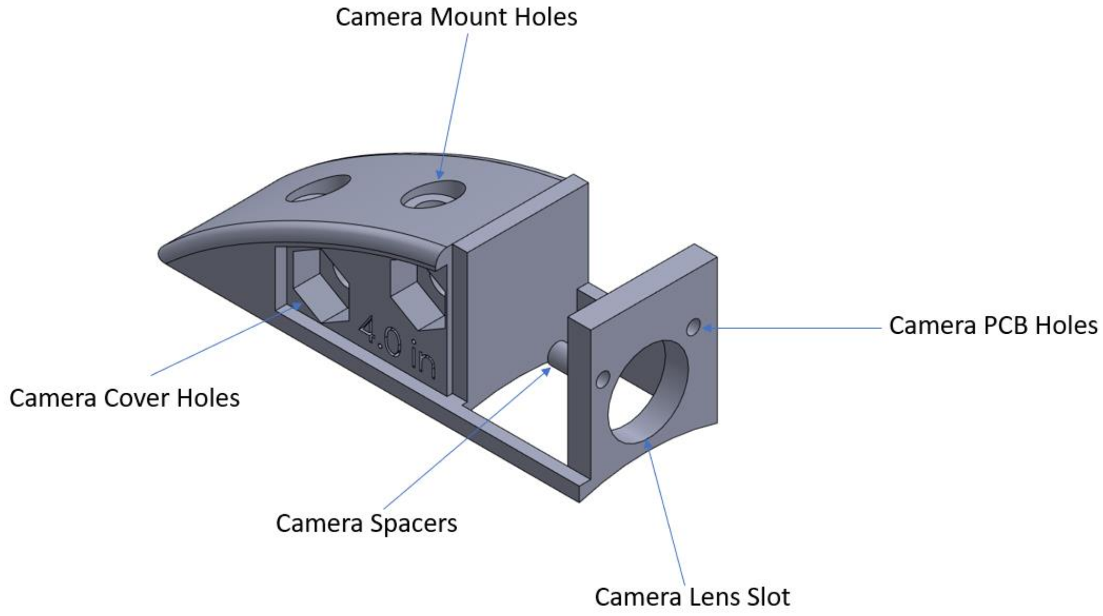
Payload Battery Compartment Design

- 3D printed using PETG filament
- Provides support and housing for the two Lithium-Ion batteries
- Utilizes slots for Velcro to secure battery translation in the vertical direction
- Similar design successful during subscale launch



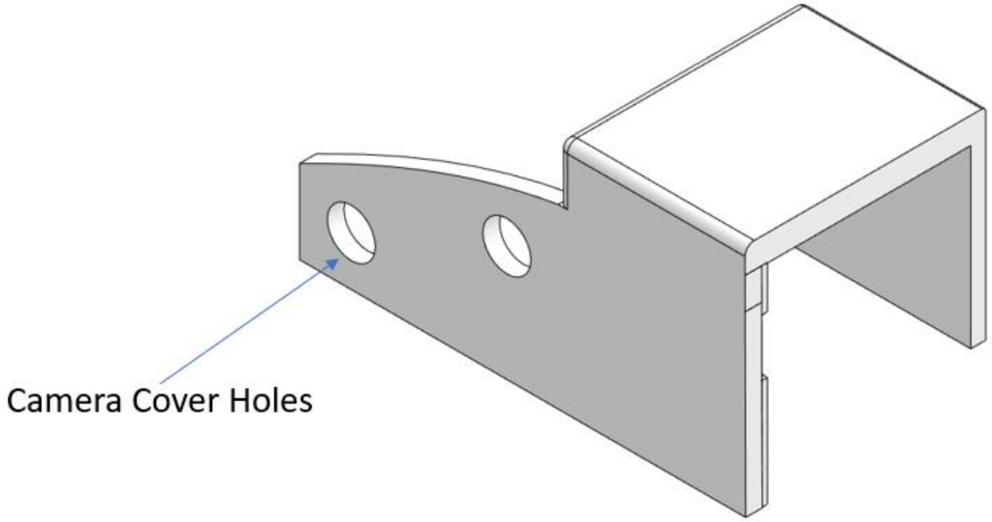
Camera Housing Design

- 3D printed using PETG filament
- Provides support and housing for the camera
- New open design allows for easier assembly of camera to housing
- Shorter design due to camera slot in airframe
- Decreased protrusion from launch vehicle
- Similar design successful during subscale launch



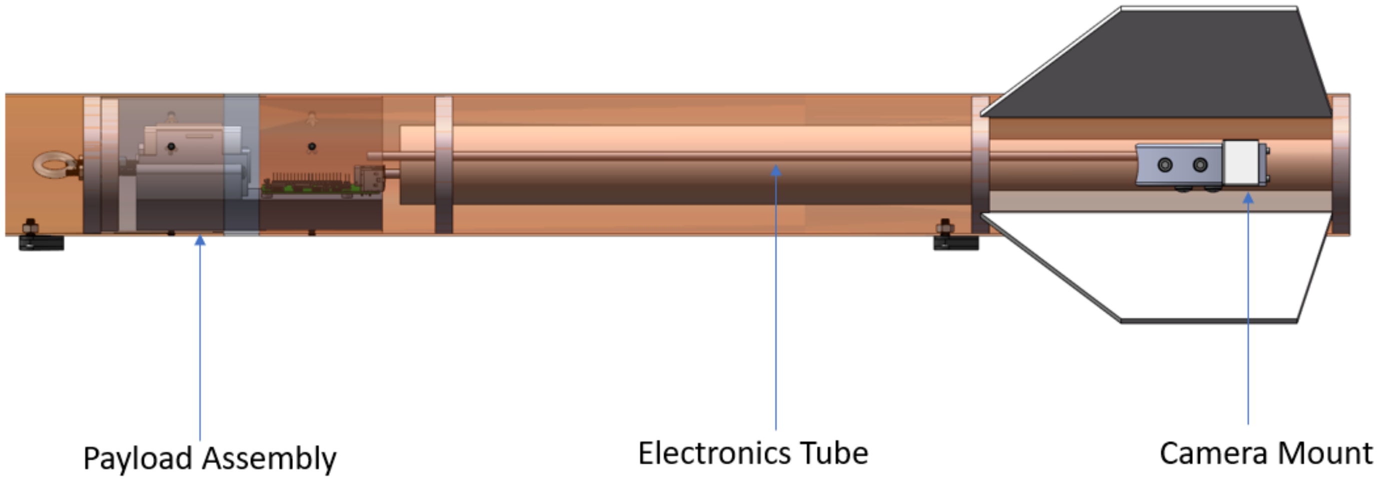
Camera Cover Design

- 3D printed using PETG filament
- Protects camera from aerodynamic forces
- Design altered to fit new camera housing dimensions
- Shorter design due to camera slot in airframe
- Similar design successful during subscale launch



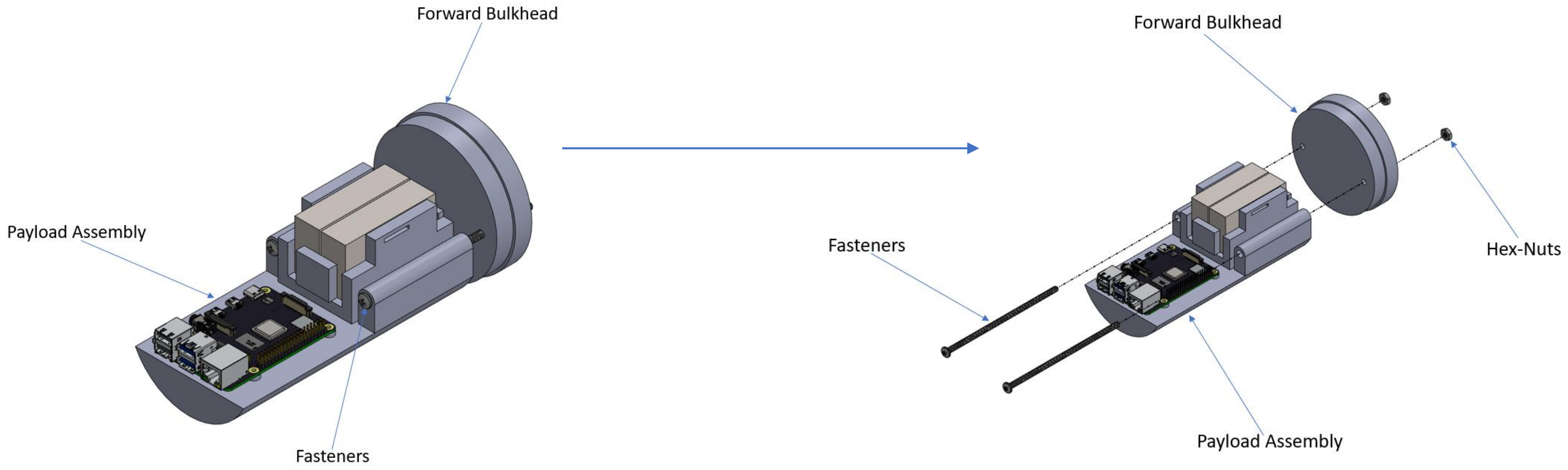
Payload Integration Plans

- Consists of payload assembly, electronics tubes, and camera mounts
- Payload assembly is attached to the aft airframe
- Wires travel from payload assembly to camera mounts via electronics tubes
- Camera mounts attached to airframe via T-nuts and camera housing
- Similar integration design utilized on subscale successfully



Payload Retention System

- Consists of the payload assembly, forward bulkhead, and fasteners
- Previous system required epoxy, more fasteners, and more components
- Current design is extremely modular and requires less precision during assembly
- Forward bulkhead epoxied to payload coupler, payload attached to bulkhead
- Design was tested and was successful during subscale launch



Competition Requirements Verification Status

General:

Requirement	Method of Verification	Team’s Design and Status
1.5. The team will engage a minimum of 250 participants in direct educational, hands-on science, technology, engineering, and mathematics (STEM) activities.	Inspection	Unverified: the team has engaged with 12 out of 250 participants thus far.

Events for next semester have been planned in advance to meet the requirement.

Competition Requirements Verification Status

Vehicle:

Requirement	Method of Verification	Team's Design and Status
2.1. The vehicle will deliver the payload to an apogee altitude between 4,000 and 6,000 feet above ground level (AGL).	Analysis – OpenRocket simulations	Verified: target altitude of 4578 ft
2.5. The launch vehicle will have a maximum of four (4) independent sections.	Analysis – determine locations of separation	Verified: 3 independent sections
2.7. The launch vehicle and payload will be capable of remaining in launch-ready configuration on the pad for a minimum of 2 hours[.]	Testing – Test #30 Battery Life Test	Verified: Test #30 deemed successful
2.12. The total impulse provided by a College or University launch vehicle will not exceed 5,120 Newton-seconds (L-class).	Inspection – chosen motor does not exceed L-class	Verified: chosen motor is AeroTech L1090W
2.14. The launch vehicle will have a minimum static stability margin of 2.0 at the point of rail exit.	Analysis – OpenRocket simulations	Verified: stability margin is 2.2 calibers
2.15. The launch vehicle will have a minimum thrust to weight ratio of 5.0:1.0.	Analysis – OpenRocket simulations	Verified: thrust-to-weight ratio is 9.2:1.0
2.17. The launch vehicle will accelerate to a minimum velocity of 52 fps at rail exit.	Analysis – OpenRocket simulations	Verified: rail exit velocity is 89 fps

Competition Requirements Verification Status

Vehicle (continued):

Requirement	Method of Verification	Team's Design and Status
2.18. All teams will successfully launch and recover a subscale model of their rocket prior to CDR.	Demonstration – Test #23 Subscale Demonstration Flight	Verified: subscale launch was successful
2.23.6. The launch vehicle will not exceed Mach 1 at any point during flight.	Analysis – OpenRocket simulations	Verified: expected Mach number is 0.56

Competition Requirements Verification Status

Recovery System:

Requirement	Method of Verification	Team's Design and Status
3.1. The full-scale launch vehicle will stage the deployment of its recovery devices, where a drogue parachute is deployed at apogee, and a main parachute is deployed at a lower altitude.	Analysis – OpenRocket simulations	Verified: drogue parachute will deploy at apogee and main parachute will deploy at 600 ft
3.2. Each team will perform a successful ground ejection test for all electronically initiated recovery events prior to the initial flights of the subscale and full-scale vehicles.	Demonstration – Tests #9 and #10 Parachute Ejection Demonstration	Verified for subscale: Tests #9 and #10 deemed successful prior to launch
3.3. Each independent section of the launch vehicle will have a maximum kinetic energy of 75 ft-lbf at landing.	Analysis – OpenRocket simulations	Verified: kinetic energy of 70.0 ft-lbf at landing
3.10. The recovery area will be limited to a 2,500 ft. radius from the launch pads.	Analysis – OpenRocket and spreadsheet simulations	Verified: expected drift of 2427 ft
3.11. Descent time of the launch vehicle will be limited to 90 seconds (apogee to touch down).	Analysis – OpenRocket and spreadsheet simulations	Verified: expected descent time of 82.5 s

Competition Requirements Verification Status

Payload:

Requirement	Method of Verification	Team's Design and Status
4.1. College/University Division – Teams shall design a payload capable of autonomously locating the launch vehicle upon landing by identifying the launch vehicle's grid position on an aerial image of the launch site without the use of a global positioning system (GPS).	Analysis	Verified: image recognition
4.2.1. The dimensions of the gridded launch field shall not extend beyond 2,500 feet in any direction[.]	Inspection	Verified: gridded launch field dimensions are 5,000 ft by 5,000 ft
4.2.1.1. Your launch vehicle and any jettisoned components must land within the external borders of the launch field.	Analysis – OpenRocket simulations	Verified: expected drift within borders and payload will not jettison

Team-Derived Requirements Verification Status

Vehicle:

Requirement	Method of Verification	Team's Design and Status
1.1 The launch vehicle must not have a coefficient of drag that exceeds 2.5 due to the external camera mounts.	Analysis	Verified: The launch vehicle's coefficient of drag is 2.5, determined through OpenRocket analyses.

Safety

- Final assembly and launch procedures
    - Avionics and recovery procedure
    - Camera preparation procedure
    - Payload bay preparation procedure
    - Ejection charge preparation procedure
    - Rocket assembly procedure
    - Motor preparation
    - Launch pad procedure
    - Igniter installation procedure
    - Launch procedure
    - Troubleshooting
    - Post-flight inspection
- Safety Officers continue to oversee manufacturing and testing

University of Florida

Swamp Launch Rocket Team