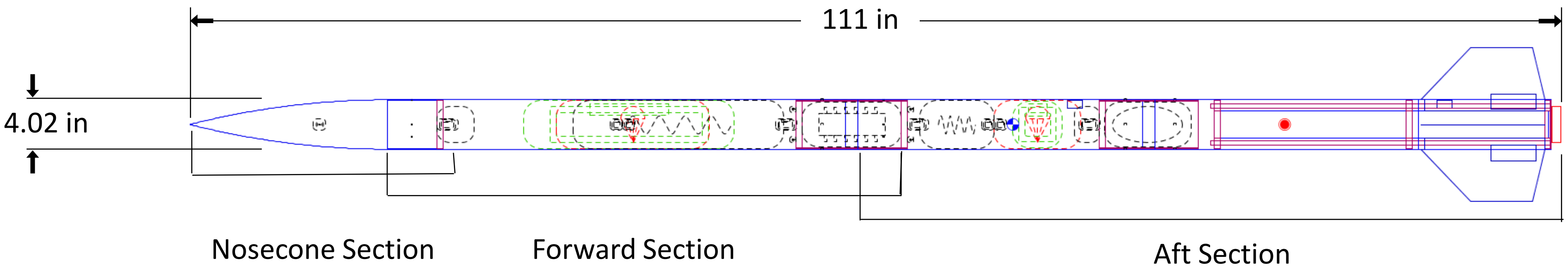
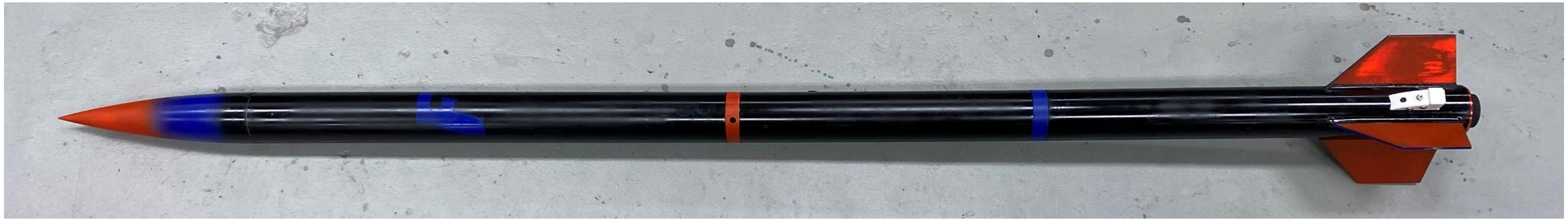
University of Florida
Swamp Launch Rocket Team

Flight Readiness Review Presentation

NASA University Student Launch 2021-2022

Vehicle Design and Dimensions

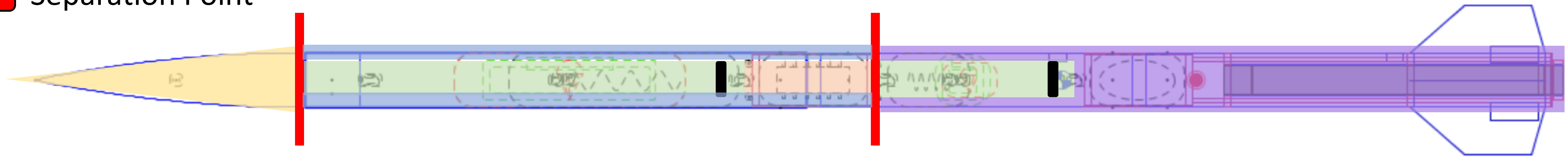




Section	Exterior Length (in.)
Nosecone	16
Forward	38
Aft	57
Launch Vehicle	111

Separation Points

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



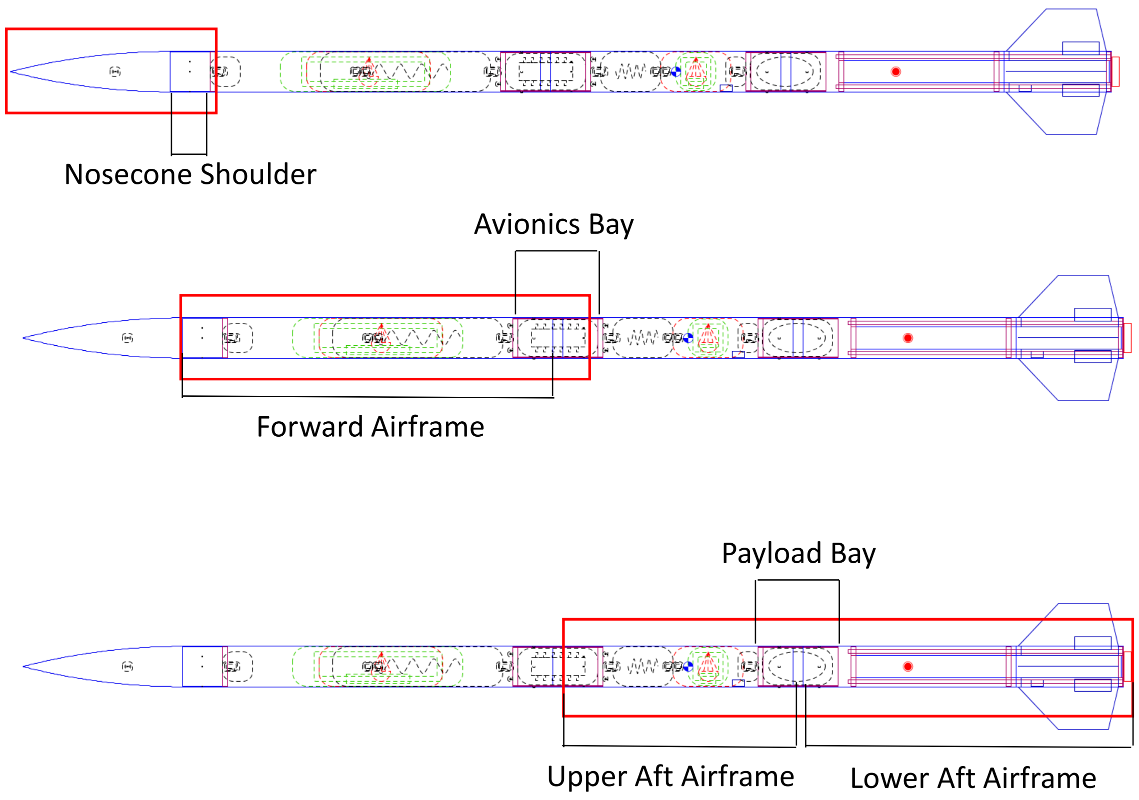
Ejection Charge Masses		
Ejection Charge	Primary (g)	Secondary (g)
First Separation	1.50	1.88
Second Separation	2.00	2.50

Key Design Features

Nosecone Section
- Bulkhead to the aft
- Nosecone shoulder
- Eyebolt for main recovery harness

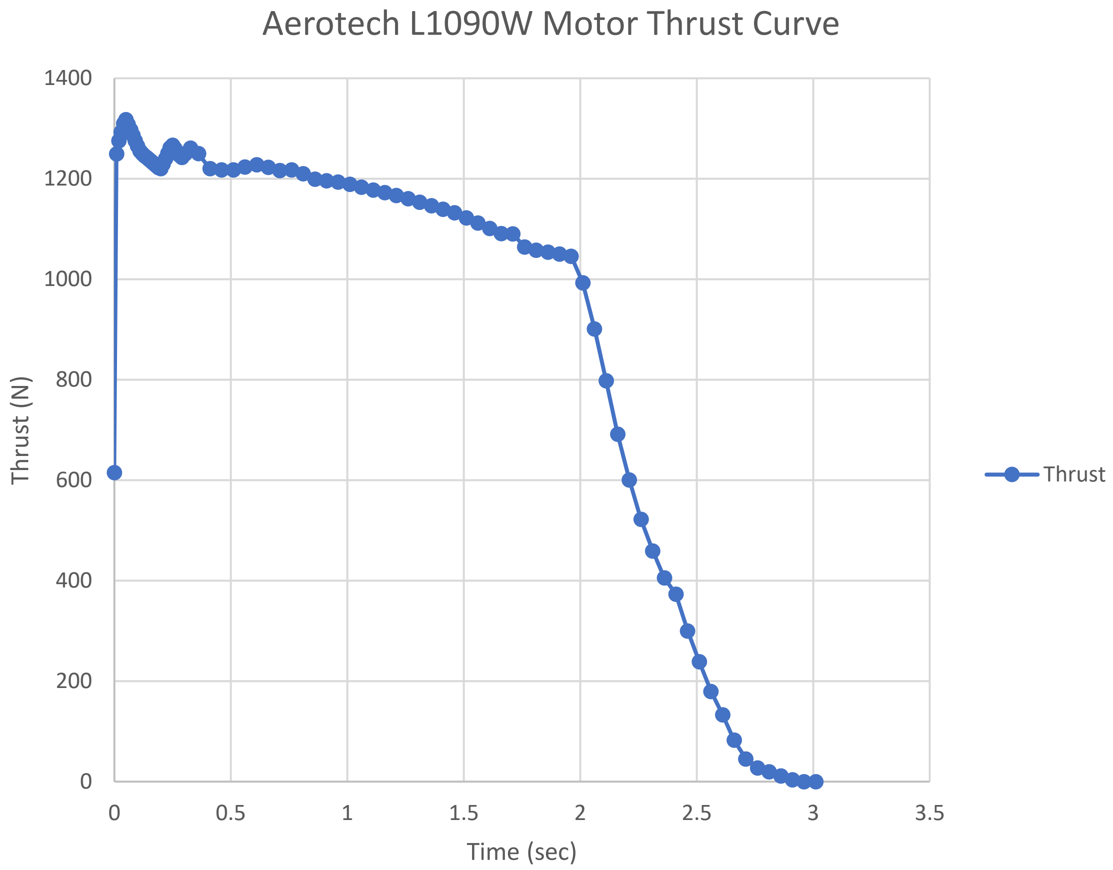
Forward Section
- Houses main parachute & main recovery harness
- Comprises forward airframe and avionics bay
- Avionics bay coupled to aft end of forward airframe

Aft Section
- Houses drogue parachute and drogue recovery harness in upper aft airframe
- Comprises upper aft airframe, payload bay, and lower aft airframe
- Houses motor assembly in lower aft airframe
- Houses payload structure and retention system, electronics tubes, payload cameras, recovery GPS and payload electronics
- Fins (x4)



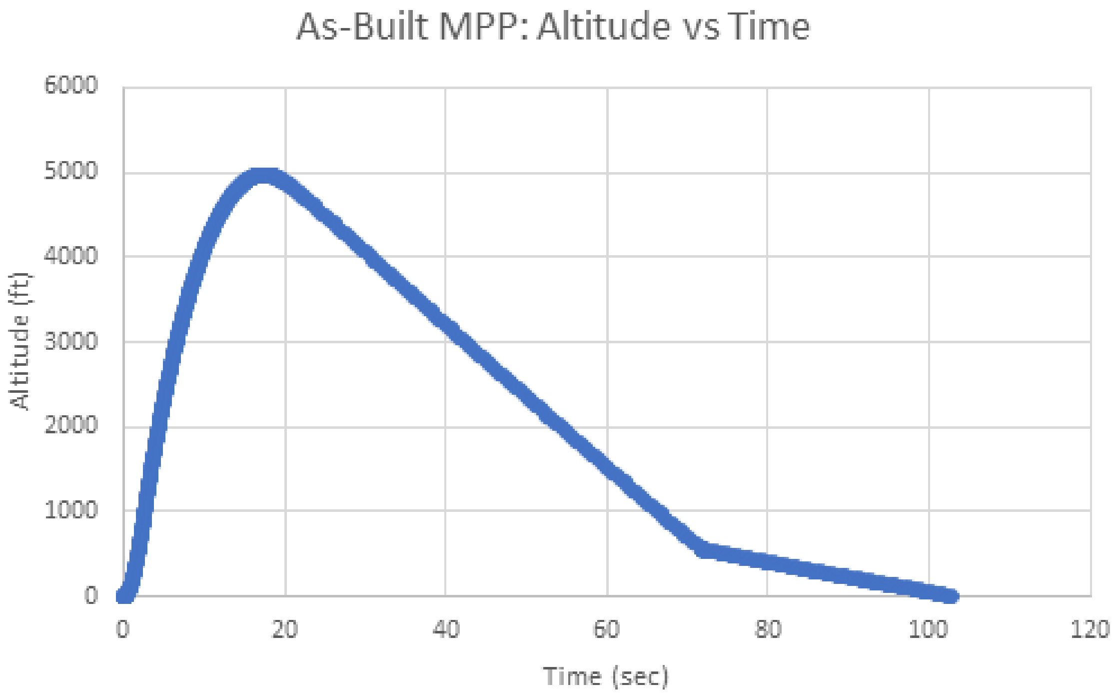
Selected Motor: Aerotech L1090W

- Motor: Aerotech L1090W
- Total Impulse: 2736 N-s
- Maximum Thrust: 1334 N
- Propellant Mass: 1400 g
- Burn Time: 3 sec
- Thrust to Weight: 9.27:1



Predicted As-Built Altitude

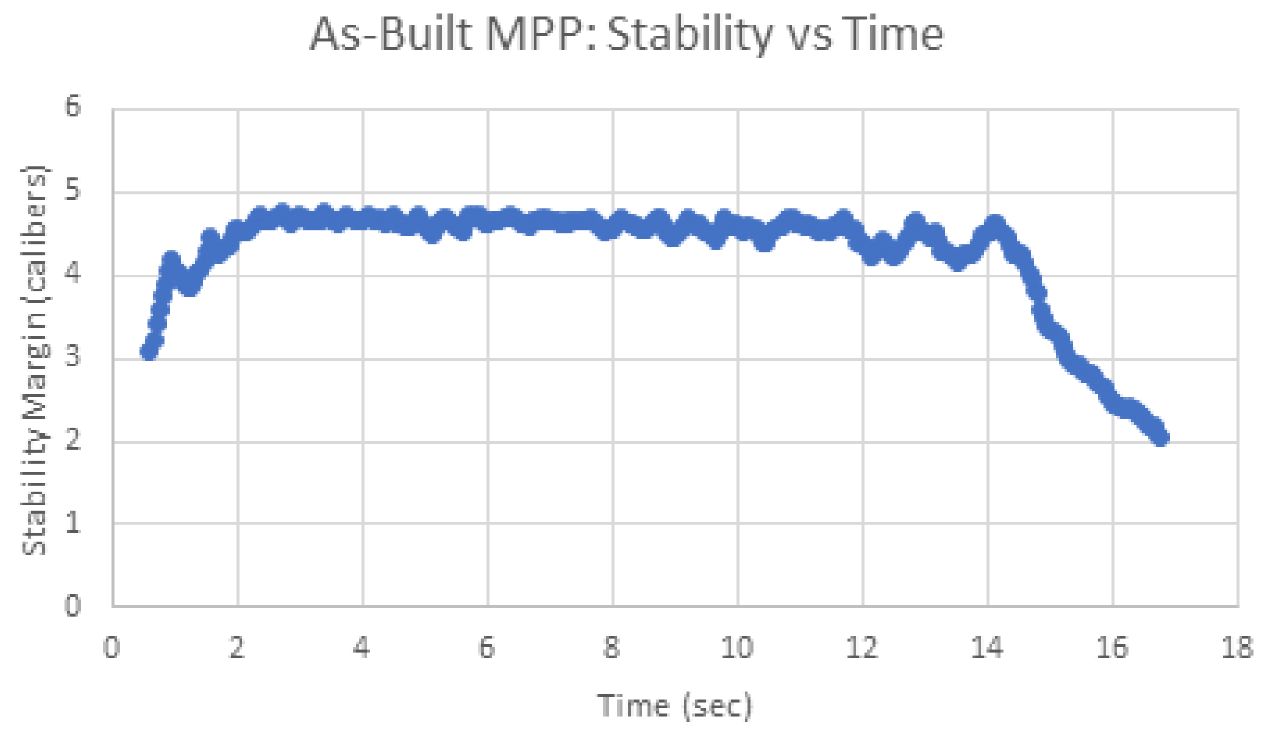
- Simulated Apogee: 4948 ft
- Target Apogee: 4578 ft



Average Altitude			
Launch Angle	Wind Condition	Probability Weight	Predicted Altitude
0	0 mph	5%	5111 ft
2.5 deg	5 mph	10%	5020 ft
5 deg	10 mph	70%	4964 ft
7.5 deg	15 mph	10%	4828 ft
10 deg	20 mph	5%	4674 ft
Average Altitude			**4948.9 ft**

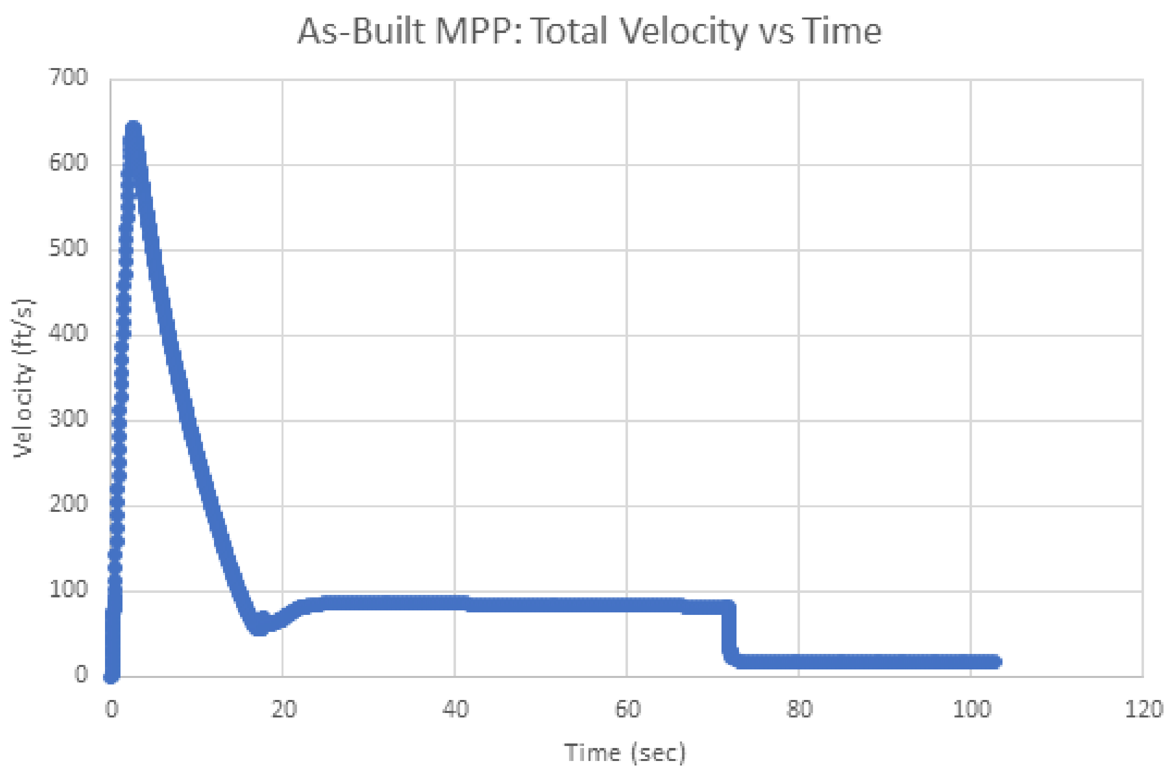
Predicted As-Built Stability

- Stability Margin at Rail (Loaded): 3.05
- Stability Margin at Rail Clearance: 3.2
- Maximum Stability Margin: 4.75

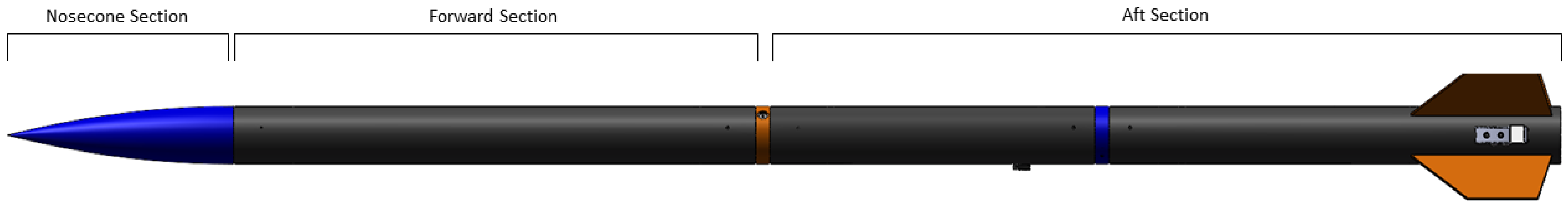


Predicted As-Built Velocity

- Velocity at Rail Exit: 89.5 ft/s
- Maximum Velocity: 643 ft/s
- Maximum Mach Number: 0.58



Mass Statement



Section	Mass (oz)
Nosecone	14.8
Forward	117.8
Aft	255.2
Full Vehicle	387.8

This table represents as-built figures of the launch vehicle in its full, launch-ready configuration

Parachutes and Decent Rates

Parachute Dimensions			
Parachute	Diameter (in)	Cd	Manufacturer
Drogue Parachute	24	0.97	Rocketman
Main Parachute	72	2.2	Fruity Chutes

Parachute Descent Rates		
Parachute	Drogue (ft/s)	Main (ft/s)
OpenRocket Prediction	78.9	17.3
MATLAB Prediction	80.6	17.8
Vehicle Demonstration Flight	70	17

Predicted Kinetic Energy

$$KE_i = \frac{m_i V^2}{2}$$

$$KE_{aft} = \frac{(173.2\ oz)\left(0.00194256\ {}^{slugs}/_{oz}\right)\left(17.3\ {}^{ft}/_{s}\right)^2}{2}$$

$$KE_{aft} = 50.3 \text{ ft-lbs}$$

Kinetic Energy Predictions			
Section	Nosecone	Forward	Aft
Excel (ft-lbs)	5.9	31.4	50.3
MATLAB (ft-lbs)	6.3	33.3	53.5

Predicted Drift

$$X = X_{apogee} \pm X_{final}$$

$$X_{10\ mph} = 1300\ \text{ft} - 67\ \text{ft}$$

$$X_{10\ mph} = 1233\ \text{ft}$$

$$X = V * t$$

$$X_{10\ mph} = (10\ \text{mph} * 1.46667\ \text{ft/s/mph}) * 85.1\text{s}$$

$$X_{10\ mph} = 1248\ \text{ft}$$

Drift Predictions					
Wind Speed	0 mph	5 mph	10 mph	15 mph	20 mph
Drift at apogee (ft)	852	1165	1300	1392	1595
Final drift (ft)	1015	545	67	489	902
Openrocket total (ft)	163	620	1233	1881	2497
Spreadsheet (ft)	0	624	1248	1872	2496
MATLAB (ft)	0	607	1214	1820	2427

Test Plans and Procedures

Test Name	Objective	Procedure	Status
Airframe Bending and Compression Analysis	Measure bending and compressive strength of airframe material	Place material in Instron Universal Testing Machine and simulate compressive forces. Analyze data to determine the compressive strength point. Perform four-point test and analyze data to determine bending strength point.	Complete
Parachute Drag Analysis	Determine if the parachutes provide the appropriate drag to slow the launch vehicle during descent	Using the descent velocity data from the vehicle demonstration flight, calculate the coefficient of drag using the drag equation.	Complete
Ejection Demonstrations	Determine the amount of black powder required to completely separate the appropriate sections of the launch vehicle	Prepare black powder ejection charge and assemble the launch vehicle. Place launch vehicle on test stand and ignite charge.	Complete
Zippering Demonstration	Ensure the launch vehicle structure will not zipper	Apply a force to the airframe using the recovery harness that would simulate the deployment of parachutes.	Complete

Test Plans and Procedures

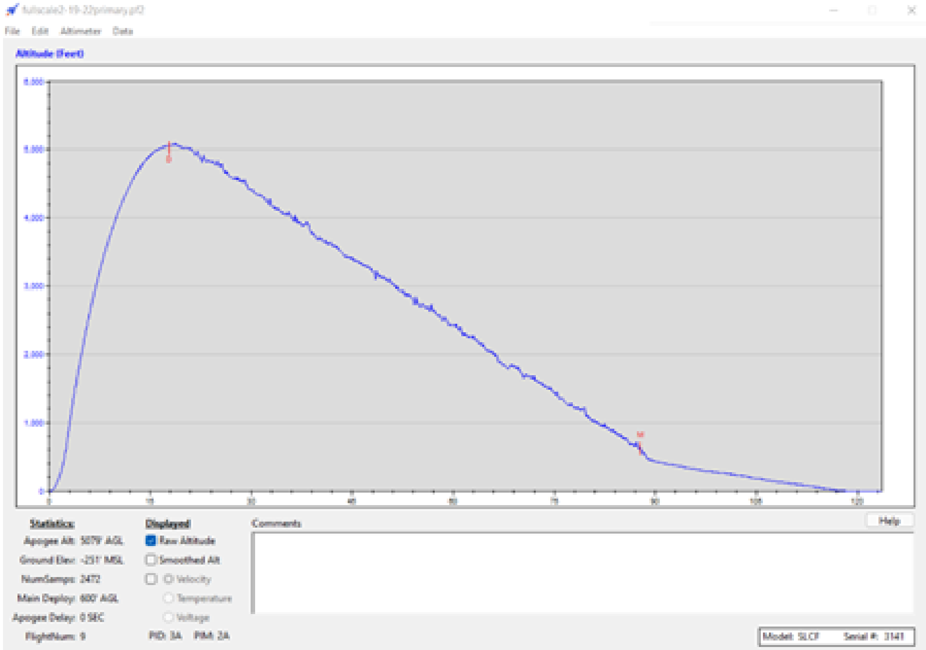
Test Name	Objective	Procedure	Status
Camera Mount Strength Test	Ensure the camera mount will not detach from the launch vehicle during flight	Attach camera mounts to airframe for launch. Assess if mount is sufficiently attached to the airframe after flight.	Complete
Wire Heat Resistance Test	Ensure that the motor firing does not cause the electronic wiring of the payload to overheat	Place the wires inside the wire tubes and configure within airframe for launch. Assess if damage to the wires occurred after flight.	Complete
Wire Tube Inspection	Ensure that wire tube is wide enough to protect wires without compromising motor position	Configure wire tube set-up and observe if tube interferes with centering rings and if tube fits within airframe.	Complete
Vehicle Demonstration Flight	Demonstrate the functionality of all components of the fullscale launch vehicle	Design and manufacture a fullscale model and conduct a launch.	Complete
Payload Demonstration Flight	Demonstration the complete functionality of the payload	Design and manufacture the payload and conduct a fullscale launch that includes the payload	Incomplete

Vehicle Demonstration Flight Results

- Performed on February 19th, 2022, at Tripoli Tampa Rocketry Association
- Successful on first attempt
- 1 kg ballast (maximum)
- Payload electronics substituted with clay ballast
- Camera mounts flown; payload sled flown
- Vehicle separated successfully and parachutes deployed
- No damage to vehicle; determined to be recoverable and reusable

Vehicle Demonstration Flight Data

- Apogee:
  - Target: 4,578 ft
  - Actual: 5,079 ft
- Descent Time:
  - Estimated: 85.6 s
  - Actual: 95 s
- Descent Rates:
  - Main: 70 ft/s
  - Drogue: 17 ft/s
- Landing Kinetic Energy:
  - Nosecone: 5.7 ft-lbs
  - Forward: 30.4 ft-lbs
  - Aft: 49.6 ft-lbs
- Drift of 1500 ft
- Coefficient of Drag
  - Simulated: 0.97
  - Post-flight analysis: 0.78



Recovery System Tests

- Fullscale Main Parachute Ejection Demonstration
  - Performed prior to the vehicle demonstration flight
  - Successful on first attempt
  - Primary charge – 2.00 g of black powder
  - Backup charge – 2.50 g of black powder

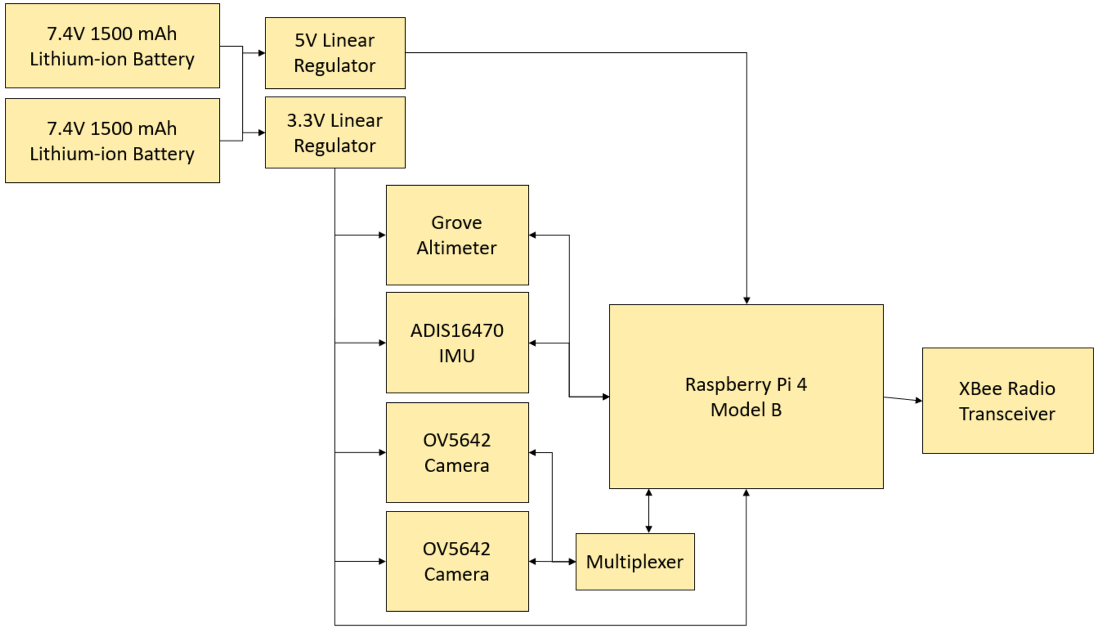
- Fullscale Drogue Parachute Ejection Demonstration
  - Performed prior to the vehicle demonstration flight
  - Successful on first attempt
  - Primary charge – 1.50 g of black powder
  - Backup charge – 1.88 g of black powder

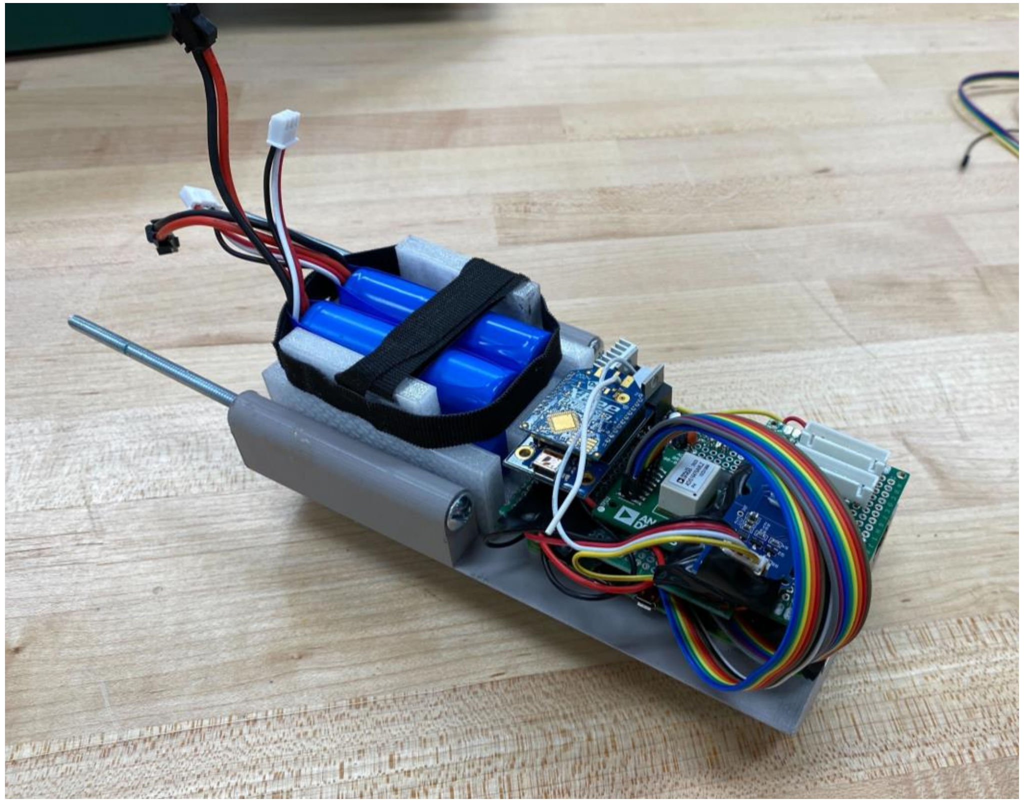
Launch Vehicle Requirements Verification

Requirement	Method of Verification	Team's Design and Status
2.19.1. Vehicle Demonstration Flight - All teams will successfully launch and recover their full-scale rocket prior to FRR in its final flight configuration.	Demonstration	Verified: Test #24 was deemed successful.
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 #11 and #12 Parachute Ejection Demonstration	Verified for subscale: Tests #11 and #12 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 2,427 ft.

Payload Design and Dimensions

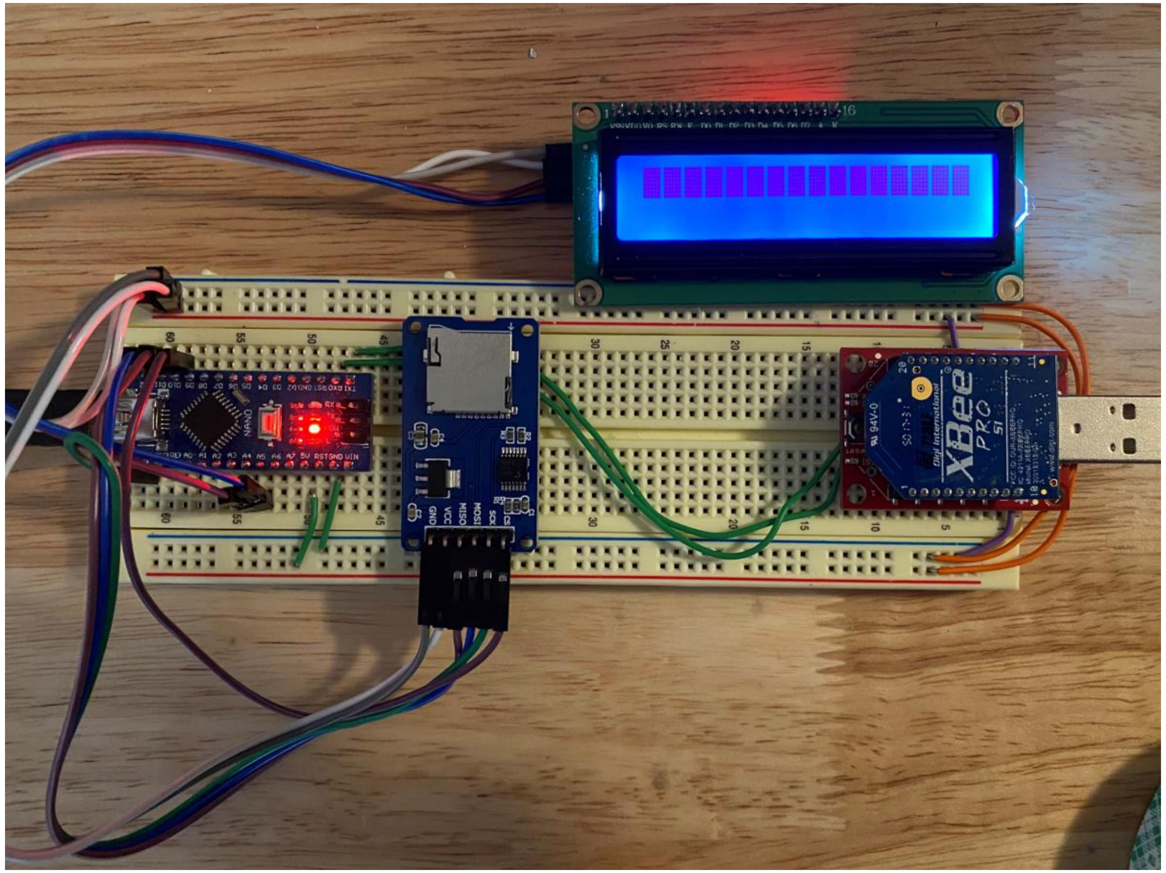
- Raspberry Pi 4 Processor
- Two OV5642 cameras
- ADIS16470 IMU
- Grove altimeter
- 2x 1500 mAh 7.4V Lithion Batteries
- XBee Radio Transceiver (905.6 MHz)





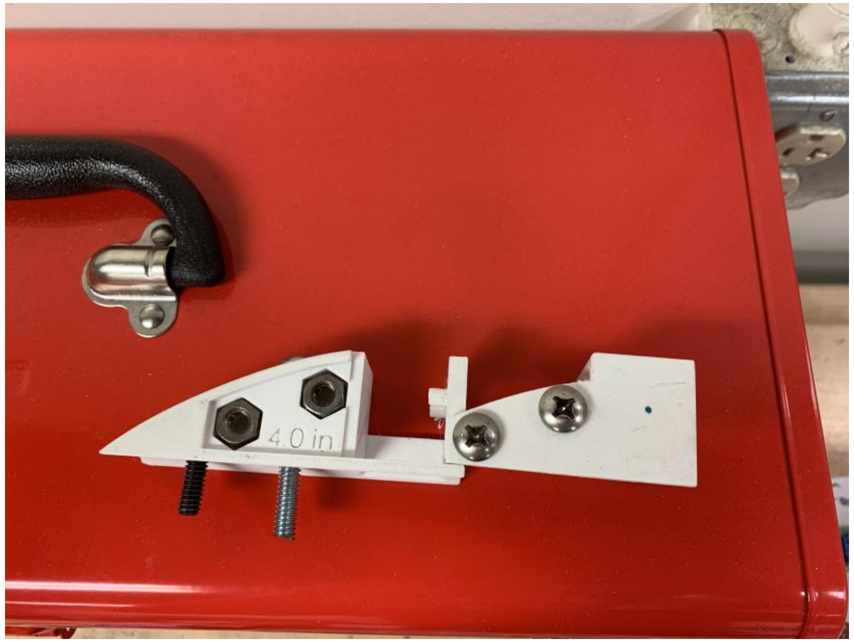
Ground System Interfaces

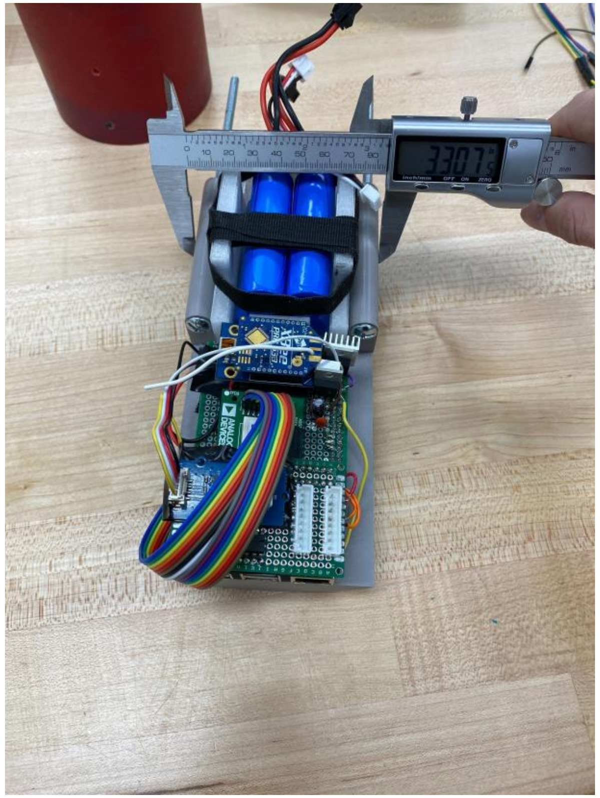
- XBee Radio Transceiver allows communication between the ground station and payload
- Received data is parsed by the microcontroller and displayed on a 16x2 LCD screen
- All received transmissions are recorded to an SD card using an SD reader adapter



As-Built Payload Assembly Dimensions

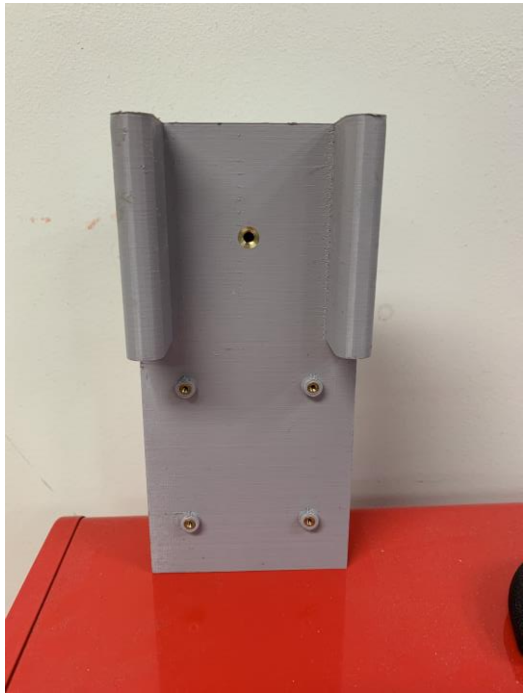
- Payload sled assembly and camera mount assembly
- Payload sled assembly:
  - Width: 3.31 in
  - Height: 2.86 in
  - Length: 7.25 in
- Camera mount assembly:
  - Width: 1.31 in
  - Height: 1.25 in
  - Length: 3.71 in

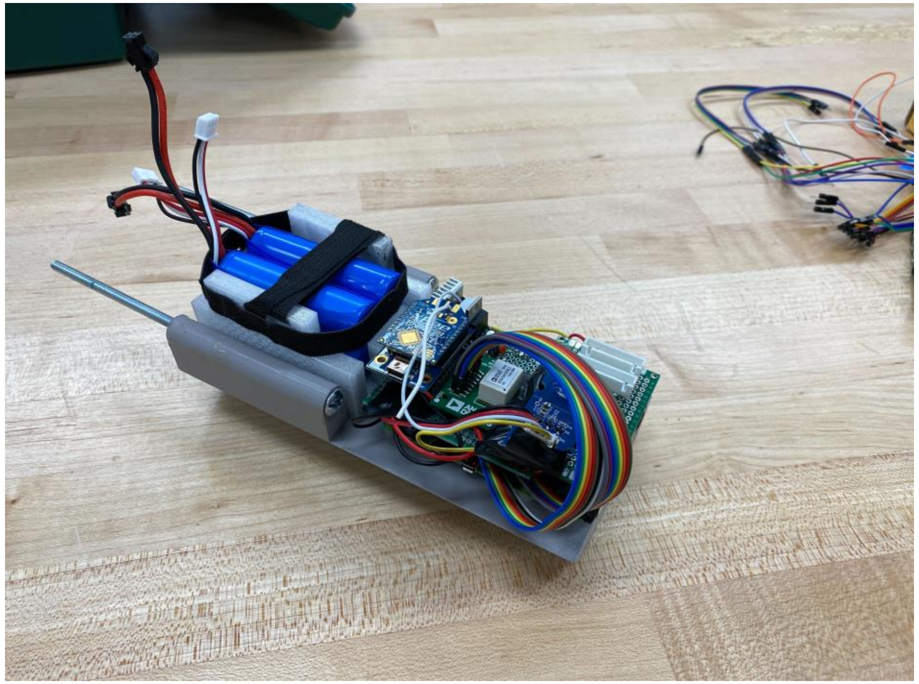




Payload Sled Assembly

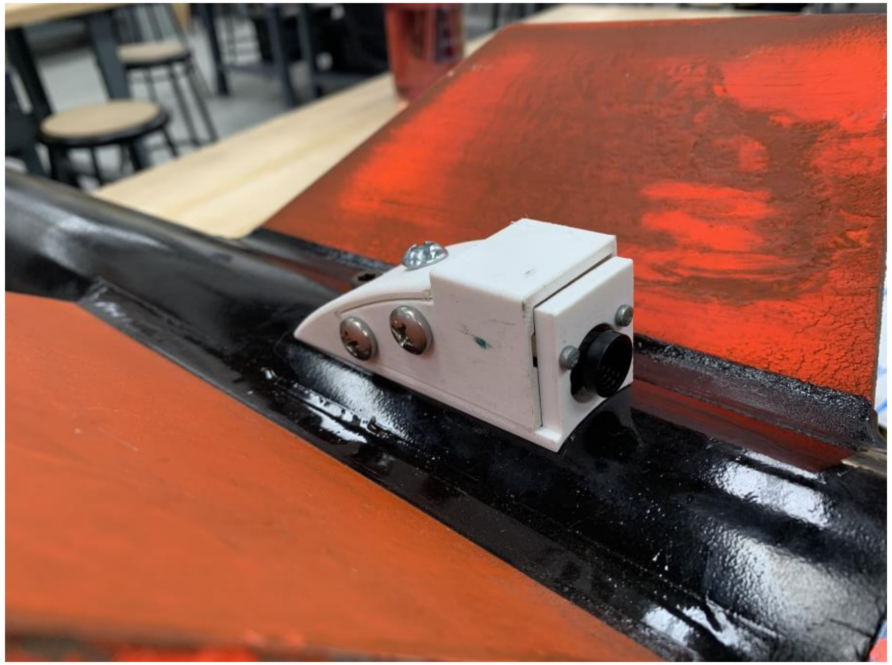
- Consists of payload sled, battery compartment, electronics and batteries
- M2.5 and 10-24 style threaded inserts for fastener connections
- Velcro for securing batteries vertical translation
- Similar design of structure tested with success on subscale and vehicle demonstration flights





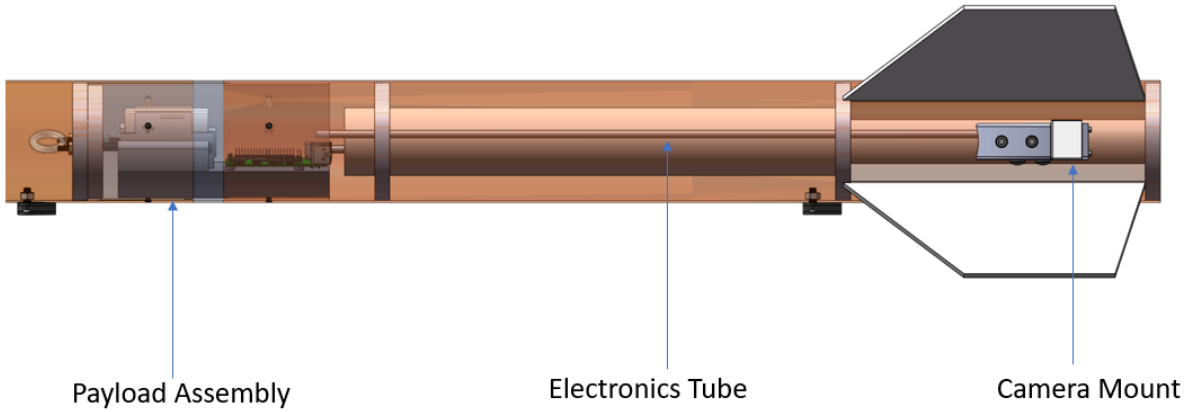
Camera Mount Assembly

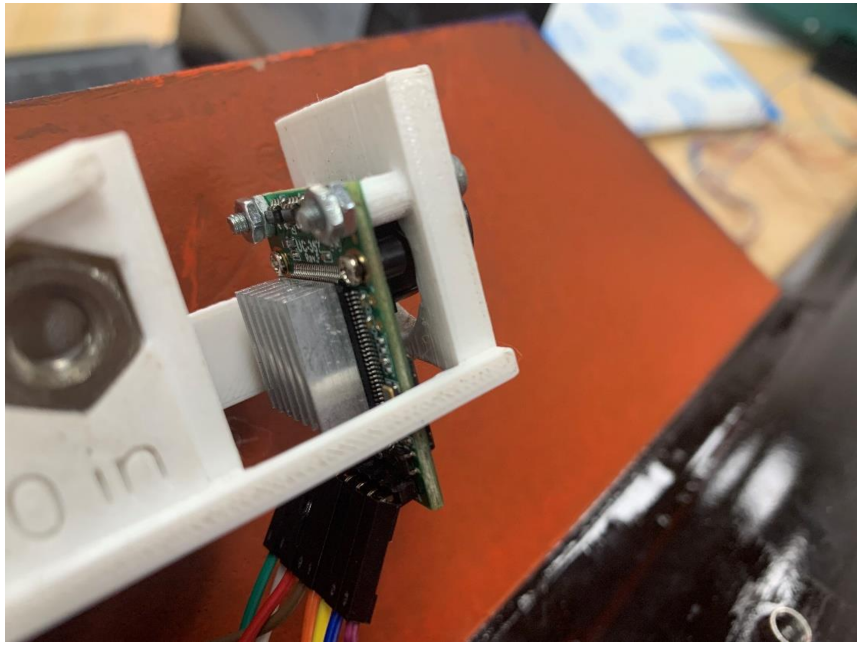
- Consists of camera cover and camera housings
- Standard fasteners and hex-nuts for fastening
- Camera mates to camera housing, which mates to the aft airframe
- Camera cover seals the camera mount
- Similar design of structure tested with success on subscale and vehicle demonstration flights



Payload Integration

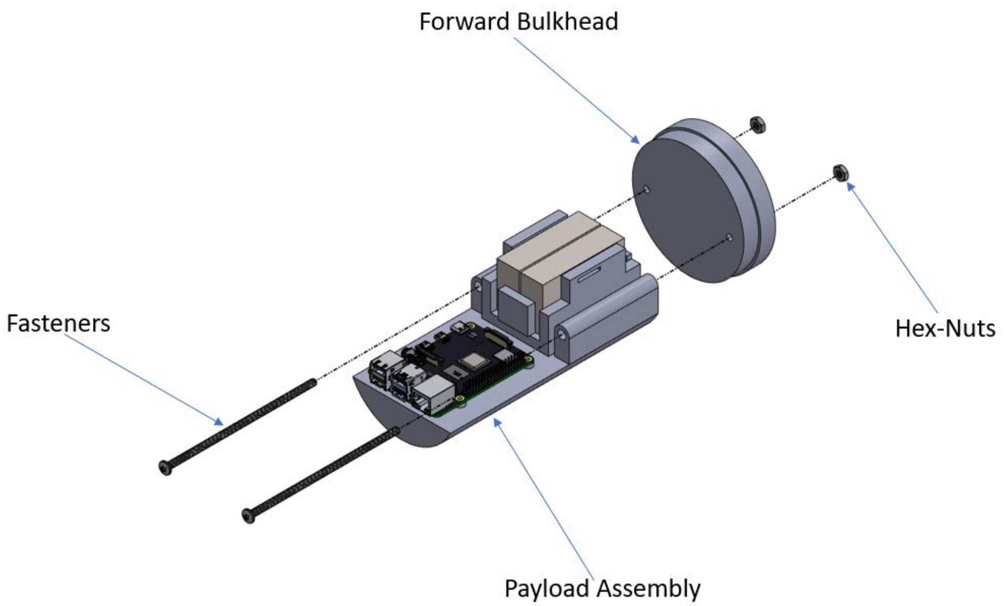
- Consists of the payload sled assembly, electronics tubes and camera mounts
- Payload located in aft section
- Connects the electronic hardware from sled to camera mounts
- Design tested successfully during subscale and vehicle demonstration flight





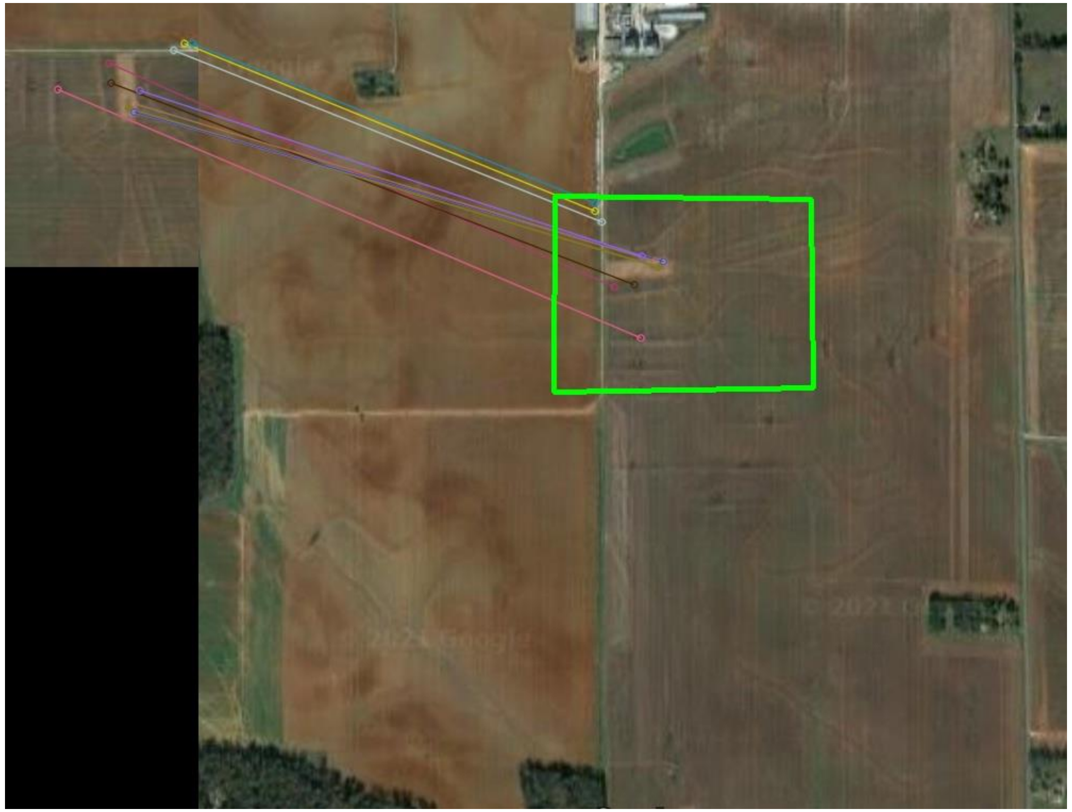
Payload Retention System

- Consists of four components
- Modular design with simple removal
- Forward bulkhead epoxied to payload coupler
- Payload Sled Assembly secured using fasteners
- Design tested successfully during vehicle demonstration flight



Payload Software Design

- Images used for reference location detection gathered from cameras with OpenCV
- SIFT points generated and mapped between image and Google Maps reference image
- IMU used to calculate displacement from reference location



Payload Software Design

Software Step	Code written and working	Code finished and tested
1. Generate SIFT points	**Yes**. Multiple images with SIFT points generated.	**Yes**. Parameters for generating SIFT points fine-tuned.
2. Mapped SIFT points to compare images	**Yes**. FLAN used instead of Brute Force for matching	**Yes**. Different matchers tested and FLAN fine tuned
3. Created bounding box after mapping	**Yes**. Bounding box created for images	**No**. Bounding box sometimes exceeds screen.
4. Calculate the location data by using the bounding box created	In progress	Incomplete
5. Retrieve and format IMU data	In progress	Incomplete
6. Calculate final location by using location data from images and IMU data	In progress	Incomplete
7. Create BASH scripts for running the program automatically	In progress	Incomplete

Payload Demonstration Flight Plans

Payload Demonstration Flight

- To be performed on March 19th, 2022, at Tripoli Tampa (Prefecture #17)
- Payload and payload retention system will be fully functional

TRIPOLI TAMPA

ROCKETRY ASSOCIATION

Payload Requirements Verification

Requirement	Method of Verification	Team's Design and Status
4.1 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: the team’s payload design adheres to the requirements.
4.2.1.1. Your launch vehicle and any jettisoned components must land within the external borders of the launch field.	Analysis	Verified: OpenRocket and spreadsheet simulations ensure that the launch vehicle will not drift outside the field borders.
4.2.2. A legible gridded image with a scale shall be provided to the NASA management panel for approval at the CDR milestone.	Inspection	Verified: the created gridded launch field adheres to the requirements and was included in CDR.
4.2.3. GPS shall not be used to aid in any part of the payload mission.	Inspection	Verified: the payload’s design does not implement a GPS.

University of Florida
Swamp Launch Rocket Team