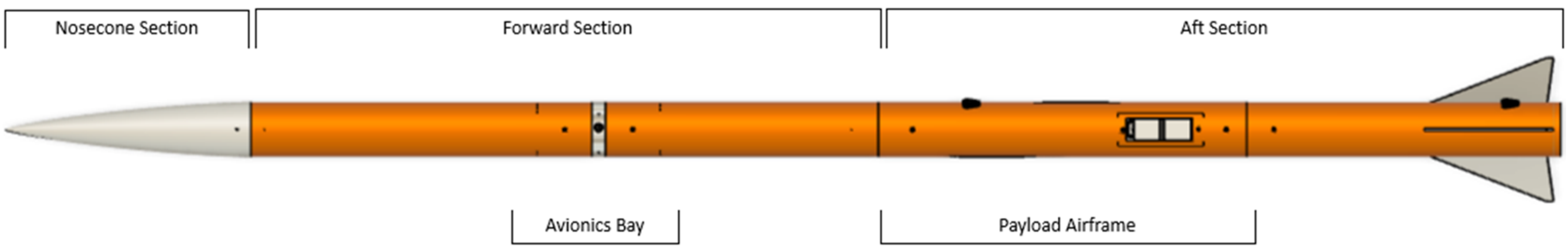
University of Florida

Swamp Launch Rocket Team

Flight Readiness Review Presentation

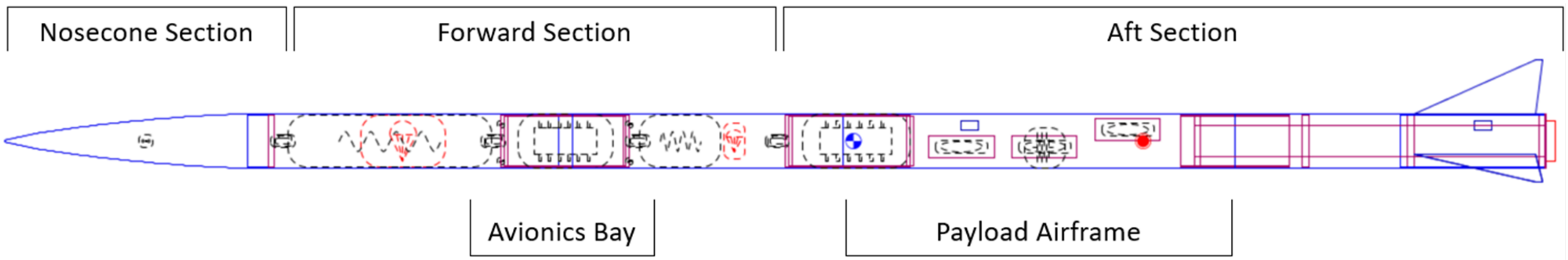
NASA University Student Launch 2022-2023

Vehicle Design and Dimensions



Section	Length (in)
Nosecone	18.0
Forward	44.0
Aft	53.0
Full Vehicle	115.0

Mass Statement

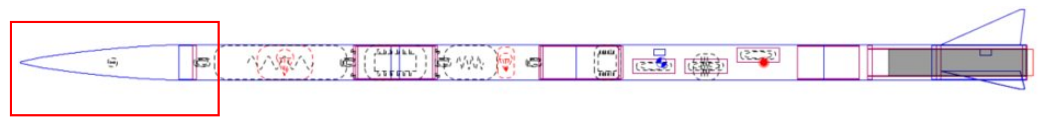


Section	Mass (oz)
Nosecone	27.8
Forward	117.0
Aft	266.4
Full Vehicle	411.0

Key Design Features

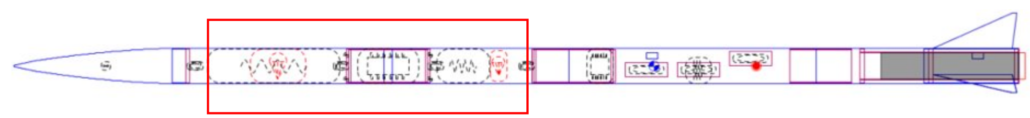
Nosecone Section

- Bulkhead in nosecone shoulder
- Eyebolt epoxied to bulkhead
- Recovery GPS



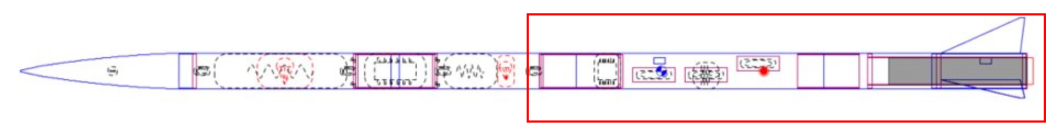
Forward Section

- Main Parachute and Main Recovery Harness in forward airframe
- Drogue Parachute and Drogue Recovery Harness in central airframe
- Avionics bay coupled to forward and central airframe
    - Recovery Electronics

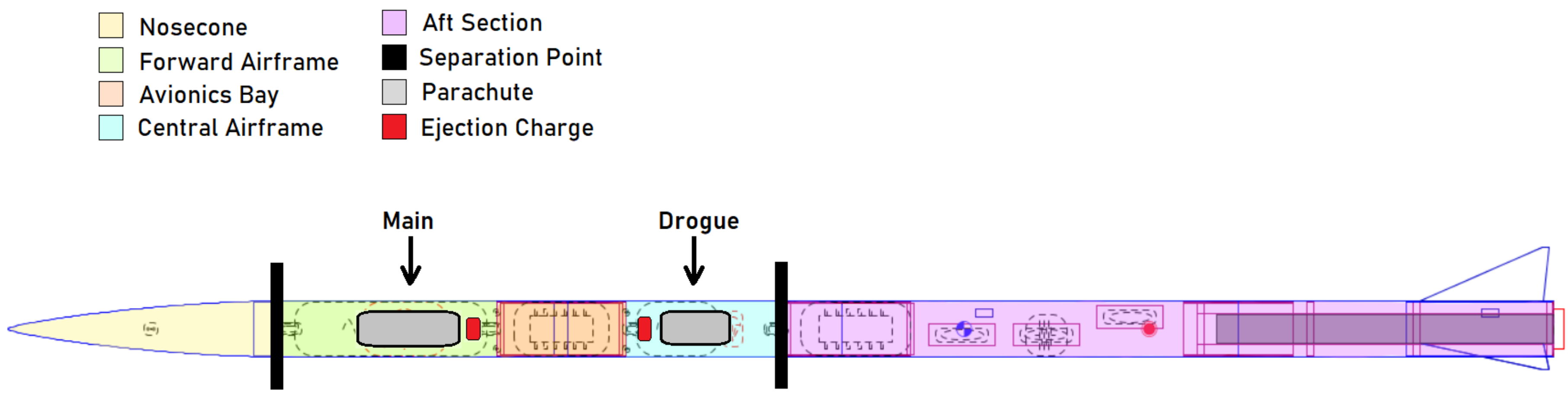


Aft Section

- Payload Bay connected to Payload Airframe
    - Payload Electronics
- Payload aft coupler epoxied into aft airframe
- Motor assembly in payload aft coupler and aft airframe
- Fins (x3)



Separation Points



Component		Description
Main Ejection Charge	Primary	2.8 g at 600 ft AGL
	Secondary	3.5 g at 550 ft AGL
Drogue Ejection Charge	Primary	1.7 g at apogee
	Secondary	2.1 g at 1s after apogee

All ejection charges are black powder

Parachutes and Decent Rates

Descent Rates	Drogue (ft/s)	Main (ft/s)
OpenRocket Simulation	80.7	17.4
MATLAB Simulation	81.4	17.44
Vehicle Demonstration Flight	79.8	19.5

Component Type	Component Name	CD	Location
Drogue Parachute	24" Rocketman Standard	0.97	Central Airframe
Main Parachute	72" Fruity Chutes Iris Ultra	N/A	Forward Airframe

Predicted Drift

$$drift = descent\ time * wind\ speed$$

$$drift = peak\ lateral\ distance\ near\ apogee + total\ lateral\ distance$$

Drift Calculation Results						
Wind Speed		0 mph	5 mph	10 mph	15 mph	20 mph
Excel Calculations	Drift under drogue	0 ft	385 ft	770 ft	1155 ft	1540 ft
	Drift under main	0 ft	243 ft	486 ft	729 ft	972 ft
	Drift	**0 ft**	**628 ft**	**1256 ft**	**1884 ft**	**2492 ft**
OpenRocket Simulation	Peak lateral distance	6 ft	133 ft	280 ft	370 ft	469 ft
	Total lateral distance	7 ft	451 ft	878 ft	1382 ft	1895 ft
	Drift	**13 ft**	**584 ft**	**1158 ft**	**1752 ft**	**2364 ft**
MATLAB Simulation	**Drift**	**0 ft**	**620 ft**	**1241 ft**	**1861 ft**	**2482 ft**

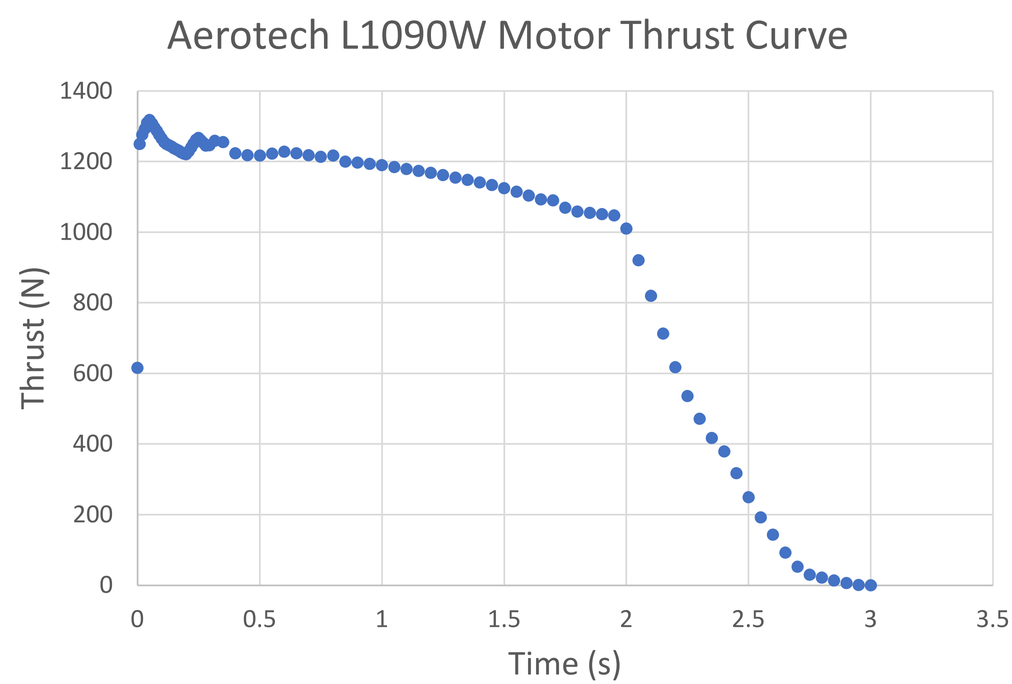
Predicted Kinetic Energy

$$kinetic\ energy = \frac{1}{2} * m_{section} * main\ descent\ rate^2$$

Kinetic Energy at Ground Hit Calculation Results			
Section	Nosecone	Forward	Aft
OpenRocket (ft-lbs)	8.1	34.0	62.9
MATLAB (ft-lbs)	8.2	34.2	63.4

Selected Motor: Aerotech L1090W

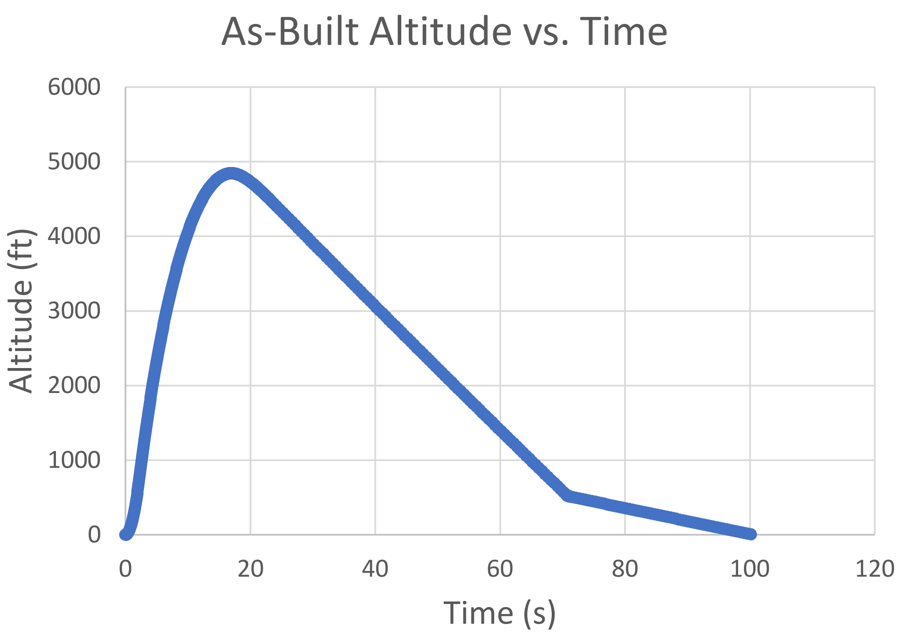
- Motor: L1090W
- Impulse: 2671 N-s
- Maximum Thrust: 1487 N
- Propellant Mass: 1400 g
- Burn Time: 2.5 s
- Thrust to Weight Ratio: 9.54:1



Predicted As-Built Altitude

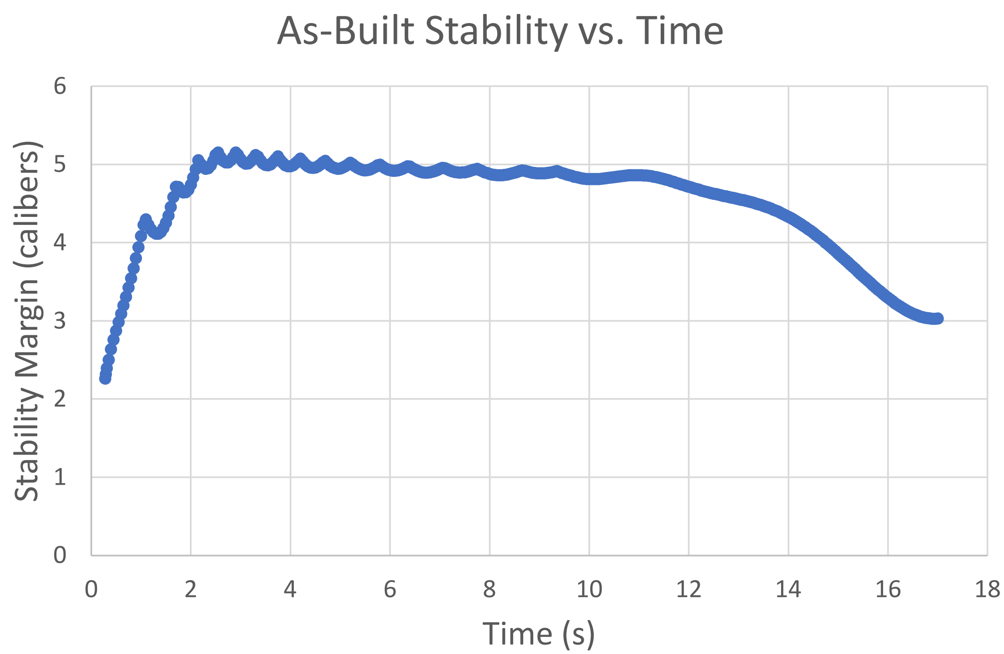
- OpenRocket Simulated Apogee: 4845 ft
- Monte Carlo Simulated Apogee: 4816 ft
- Target Apogee: 4600 ft

Monte Carlo: Average Altitude Prediction			
Launch Angle	Wind Condition	Probability Weight	Predicted Altitude
0˚	0 mph	5%	4868 ft
2.5˚	5 mph	10%	4801 ft
5˚	10 mph	70%	4812 ft
7.5˚	15 mph	10%	4831 ft
10˚	20 mph	5%	4828 ft
Average Altitude			**4816 ft**



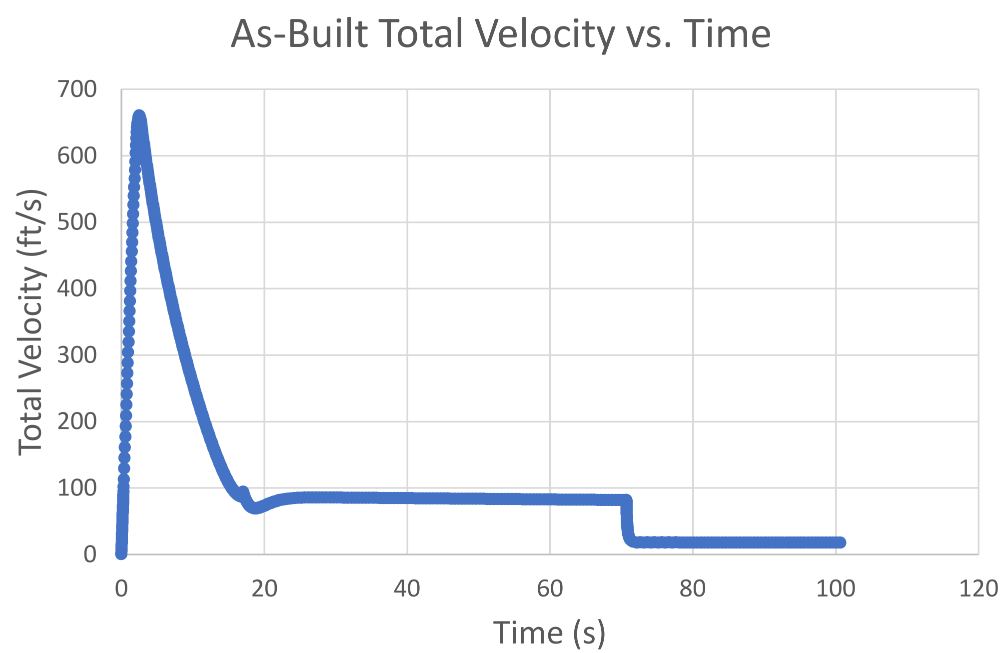
Predicted As-Built Stability

- Stability Margin on Rail: 2.26 calibers
- Stability Margin at Rail Exit: 2.40 calibers
- Maximum Stability Margin: 5.15 calibers



Predicted As-Built Velocity

- Velocity at Rail Exit: 89.3 ft/s
- Maximum Velocity: 660 ft/s
- Maximum Mach Number: 0.59



Test Plans and Procedures – Launch Vehicle

Title	Objective	Overview of Methods	Status
Airframe Material Compression Test	Measure compressive strength of airframe material.	Use Instron UTM to experimentally determine maximum compressive strength of a section of airframe.	Complete
Epoxy Strength Test	Measure shear strength of epoxy.	Use Instron UTM to experimentally determine maximum shear strength of epoxy through a lap shear test.	Complete
Airframe Material Zippering Resistance Test	Determine the resistance of the airframe material to zippering.	Apply brief force to airframe and recovery harness assembly to simulate ejection conditions.	Complete
Vehicle Vibration Test	Identify the resonant frequency of the launch vehicle.	Simulate vibrations vehicle is likely to experience during launch.	Complete
Vehicle Demonstration Launch	Verify successful function of launch vehicle.	Launch full-scale vehicle in final configuration.	Complete

Test Plans and Procedures – Payload

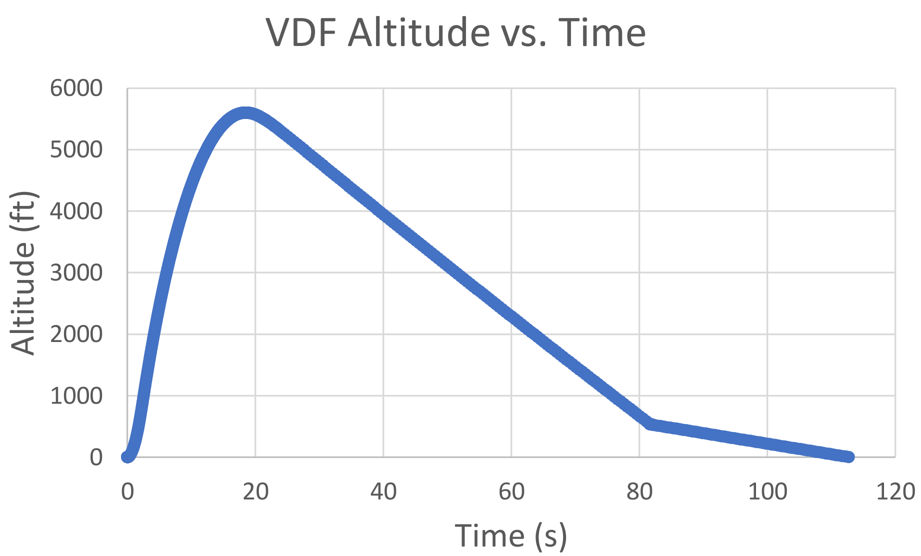
Title	Objective	Overview of Methods	Status
Radio Reception Demonstration	Receive and record an APRS transmission with the SDR dongle.	Transmit radio instructions to payload receiver and determine if instructions were received.	Complete
Stepper Motor Rotation Demonstration	Rotate stepper motor through 360 degrees.	Instruct motor to rotate camera around z-axis through software.	Complete
Payload Housing Compressive Strength Test	Measure compressive strength of payload housing.	Use Instron UTM to experimentally determine maximum compressive strength of payload housing.	Complete
Landing Detection Demonstration	Determine whether payload is capable of detecting landing.	Simulate landing conditions and determine whether payload detected landing.	Complete
Payload Demonstration Launch	Demonstrate successful function of all payload objectives.	Launch payload in final configuration in full-scale launch vehicle.	Incomplete

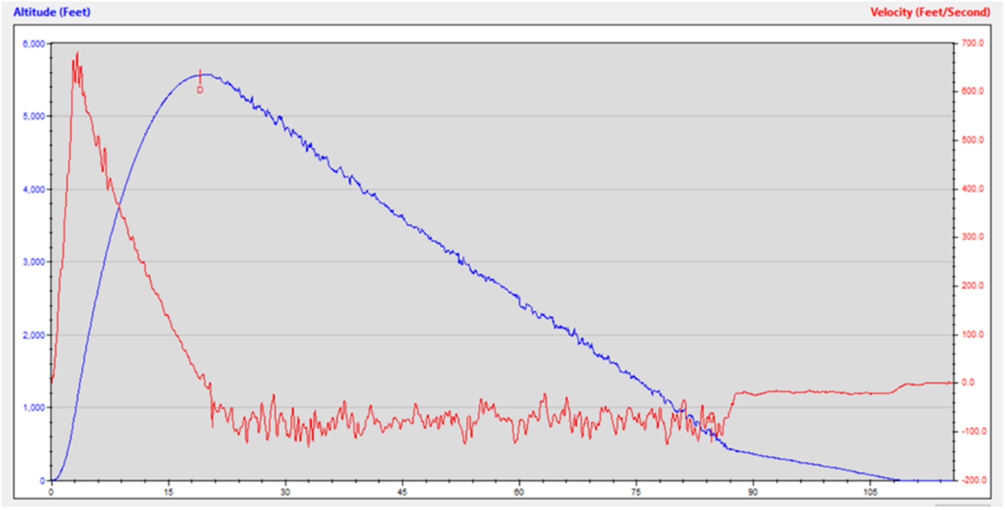
Vehicle Demonstration Flight

- Performed on February 18th at Tampa Bay Rocketry Association (Prefecture #17)
- Successful on first attempt
- Payload IMU flown, PET-G ballast for camera systems
- No additional ballast
- Successful parachute deployments
- No damage to launch vehicle



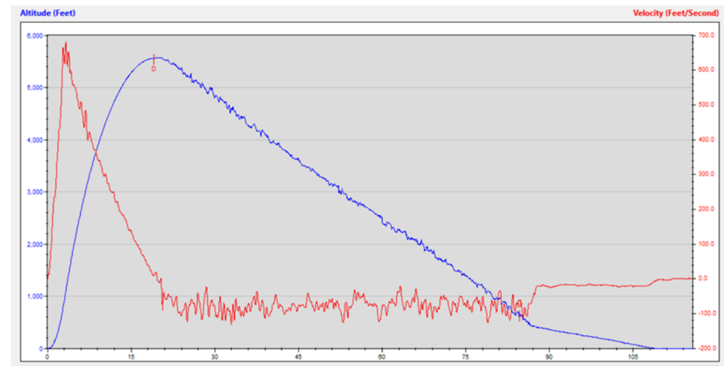
Vehicle Demonstration Flight Results





Vehicle Demonstration Flight Data

Vehicle Demonstration Flight Data			
Data Type	Predicted	Experimental	Percent Error
Apogee Altitude	5603 ft	5590	0.232%
Center of Gravity	70.04 in	68.75 in	1.842%
Maximum Velocity	672 ft/s	695 ft/s	3.42%
Descent Time	86.8 s / 85.3 s / 84.6 s	88.8 s	2.20% / 3.89% / 4.68%
Drift	628 ft / 584 ft / 620 ft	367 ft	71.12%/59.13%/ 68.94%
Kinetic Energy of Aft	62.9 ft-lbs / 63.4 ft-lbs	79.0 ft-lbs	20.34% / 19.75%
Drag Coefficient	0.820	0.800	2.44%



Recovery System Tests - Ejection

Drogue Parachute Ejection Demonstration
- Performed in advance of vehicle demonstration flight
- Successful on first trial
- Primary charge: 1.7 g
- Secondary charge: 2.1 g

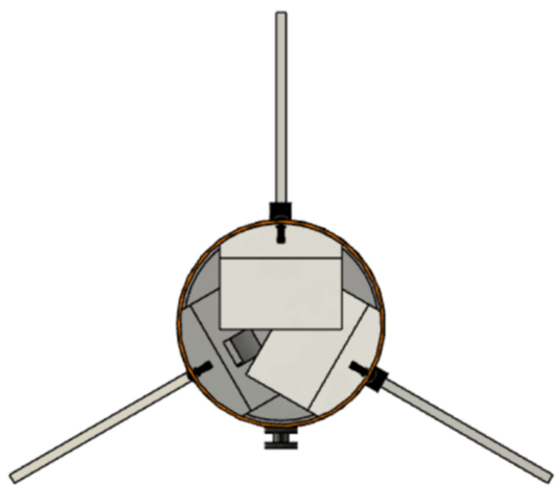
Main Parachute Ejection Demonstration
- Performed in advance of vehicle demonstration flight
- Successful on first trial
- Primary charge: 2.8 g
- Secondary charge: 3.5 g

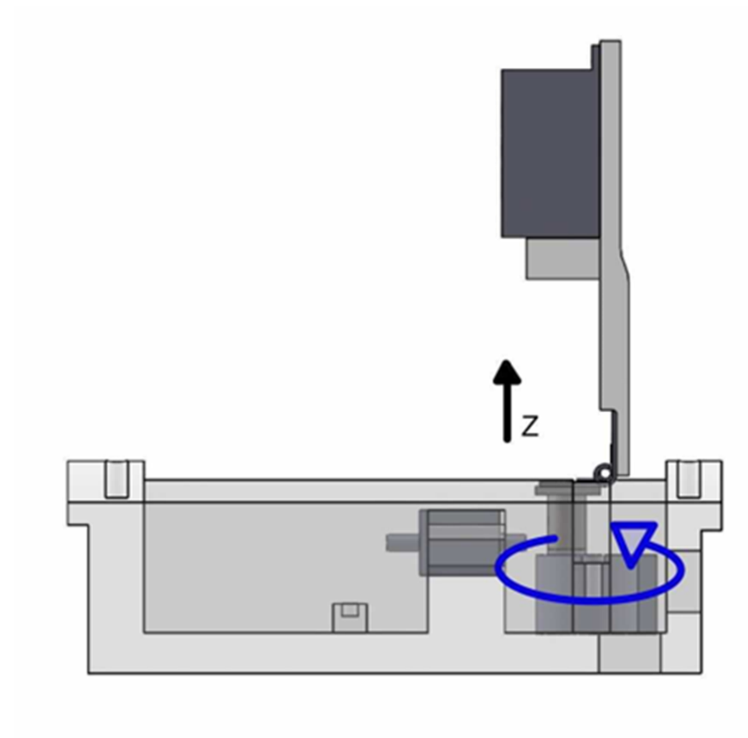
Launch Vehicle Requirements Verification

Requirement	Method of Verification	Status
NASA 2.6. The launch vehicle and payload will be capable of remaining in launch-ready configuration on the pad for a minimum of 2 hours without losing the functionality of any critical on-board components, although the capability to withstand longer delays is highly encouraged.	Test	Verified; test LV-A-3, Avionics Battery Life Test, has been successfully completed.
NASA 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 LV-L-3, Vehicle Demonstration Launch, has been successfully completed.
Team 1.1 The airframe section containing the payload will retain sufficient structural strength to endure forces of flight and recovery.	Test	Verified; test P-D-3, Payload Housing Compressive Strength Test, has been completed.
Team 1.4 Vehicle will land in the correct orientation for proper payload operations.	Test	Verified; both the subscale and full-scale vehicles landed in the correct orientation after their respective flights.

Payload Design Overview

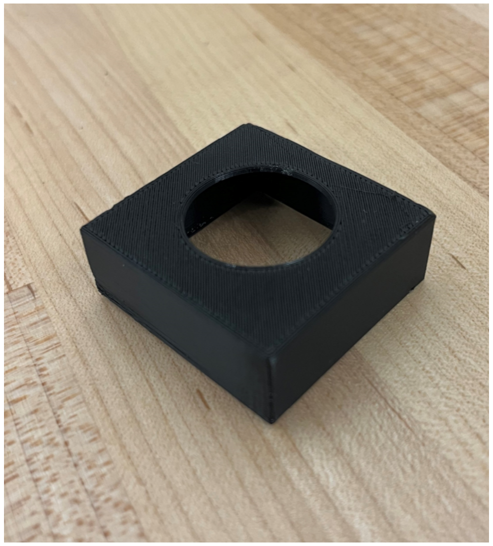
- Each of the payload systems are aligned with the three fins
- The camera system rotates on a stepper about the z-axis after it rotates out of the airframe



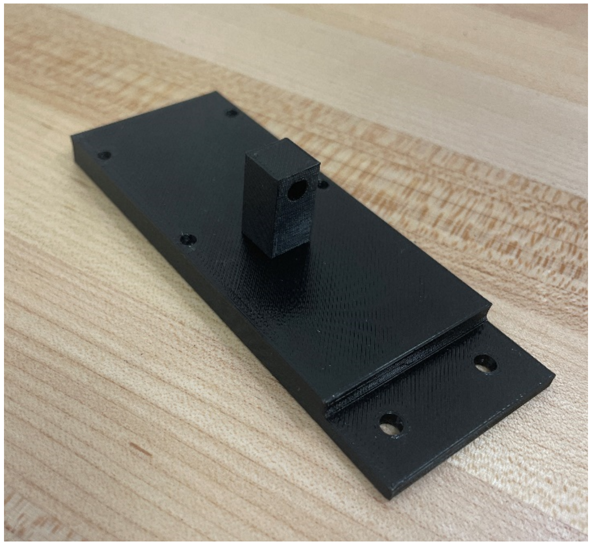


Payload Design

- 3D printed components PET-G



Camera Case

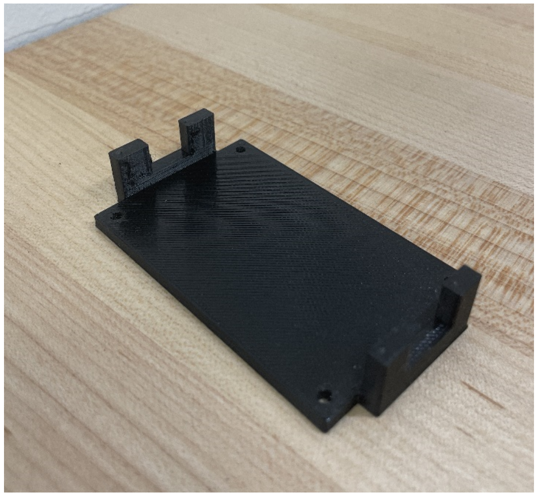


Camera Mount

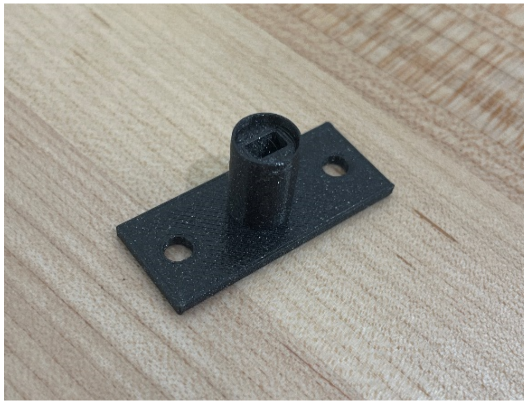
Payload Design

- 3D printed components PET-G

Payload Housing



Radio Cover



Motor Mount

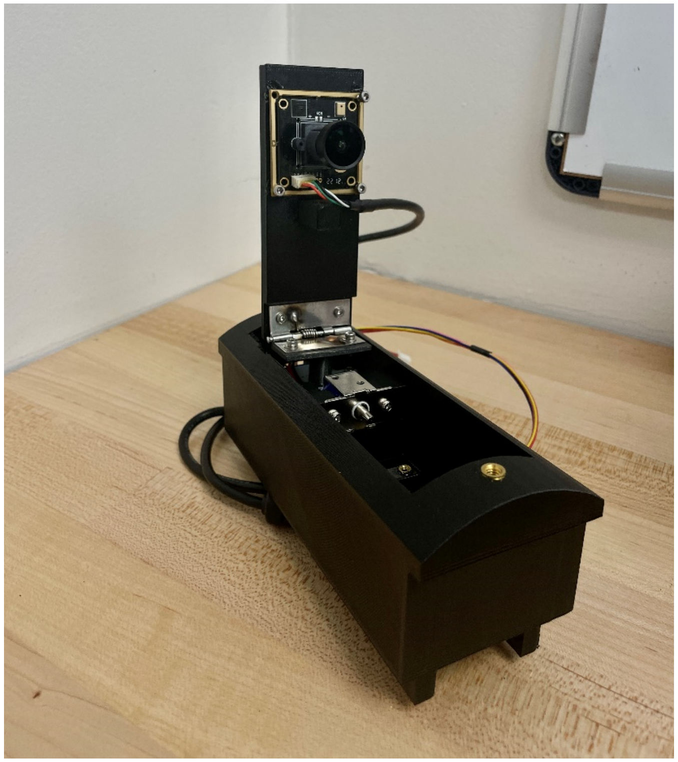
As-Built Payload Assembly Dimensions

- The loops of the hinge were cut off with a Dremel and the pin was pulled out
- Spring coil was wound around the pin
- The spring was inserted in the section of the hinge where the loops were cut, and the pin was put back
- Spring coil was TIG welded to the hinge faces

Spring-Loaded Hinge

As-Built Payload Assembly

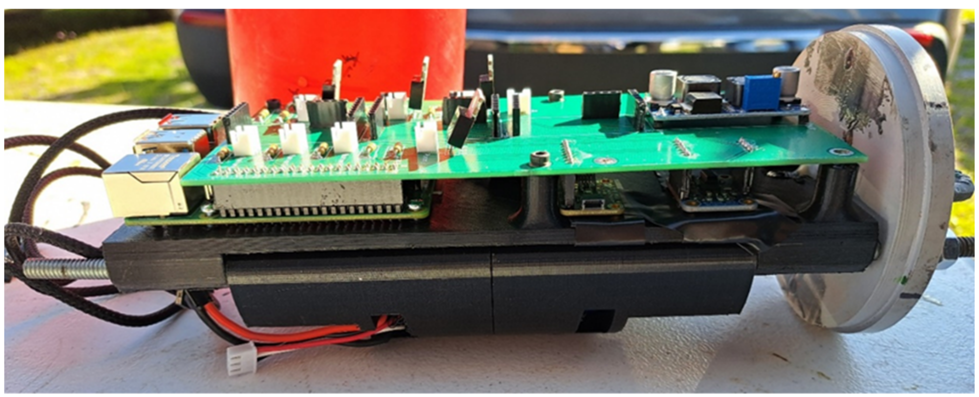
- Payload System with components fastened with threaded heat-set inserts and screws
- The motors and internal components are secured with M2.5 6mm fasteners
- The camera is fastened to the motor mount with M3 4mm fasteners
- The housing is fastened to the airframe with 8-32 fasteners

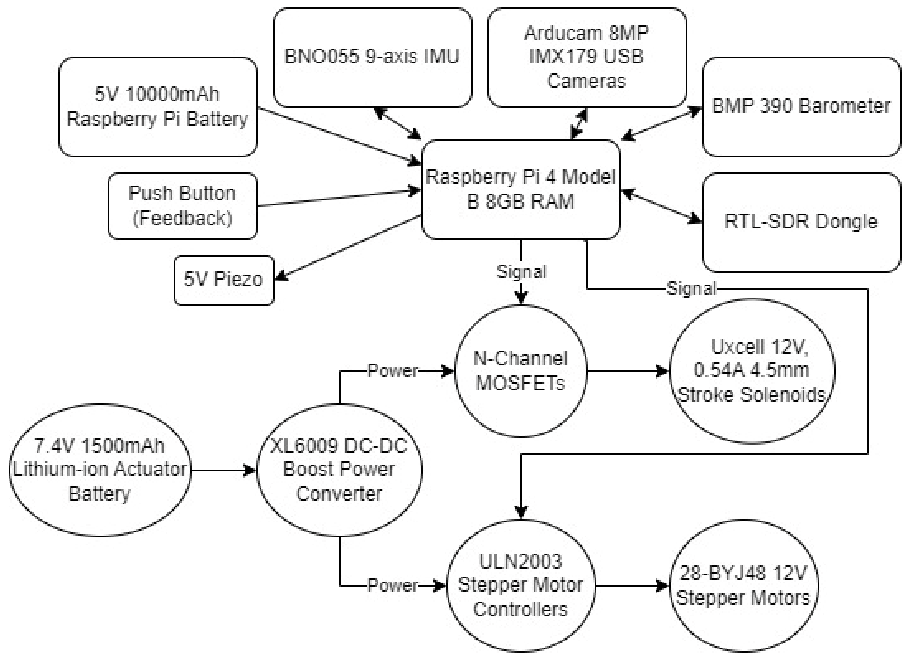


As-built Payload System

Payload Sled Assembly

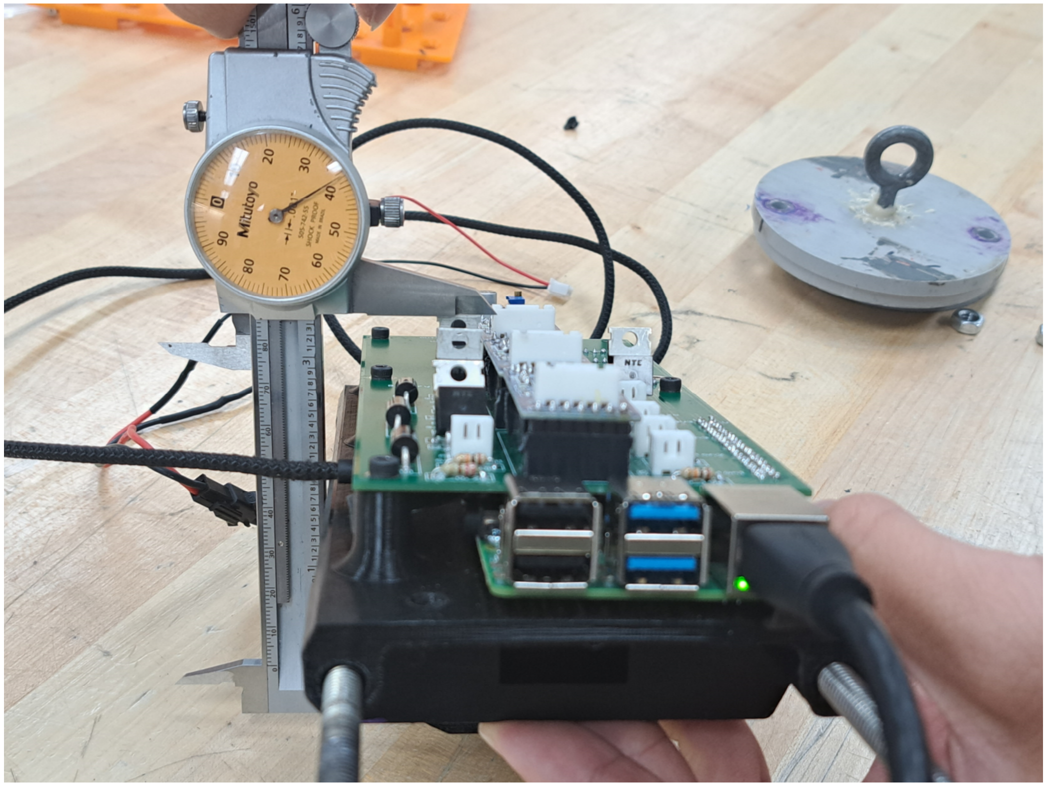
- Raspberry Pi 4 Processor
- BNO055 IMU and BMP390 Barometer
- DC-DC Boost Power Converter
- Control circuit for solenoid and stepper motors
- 2 separate power supplies





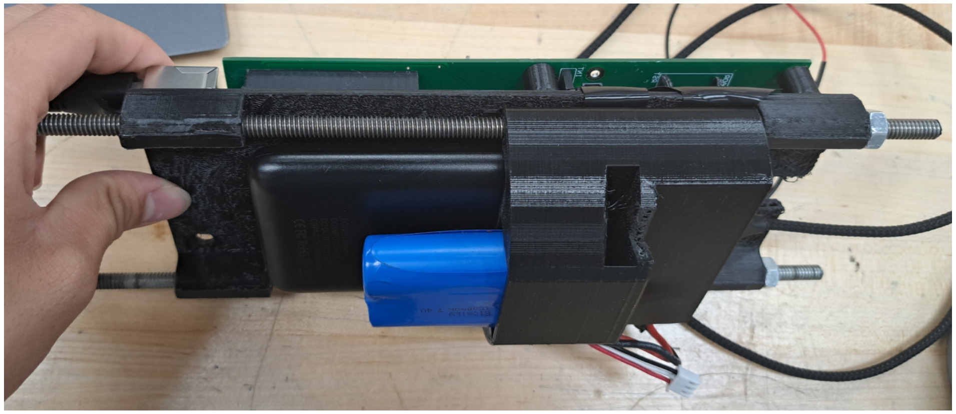
Payload Sled Assembly Dimensions

- Length: 8.35 inch
- Width: 3.65 inch
- Height: 3.34 inch



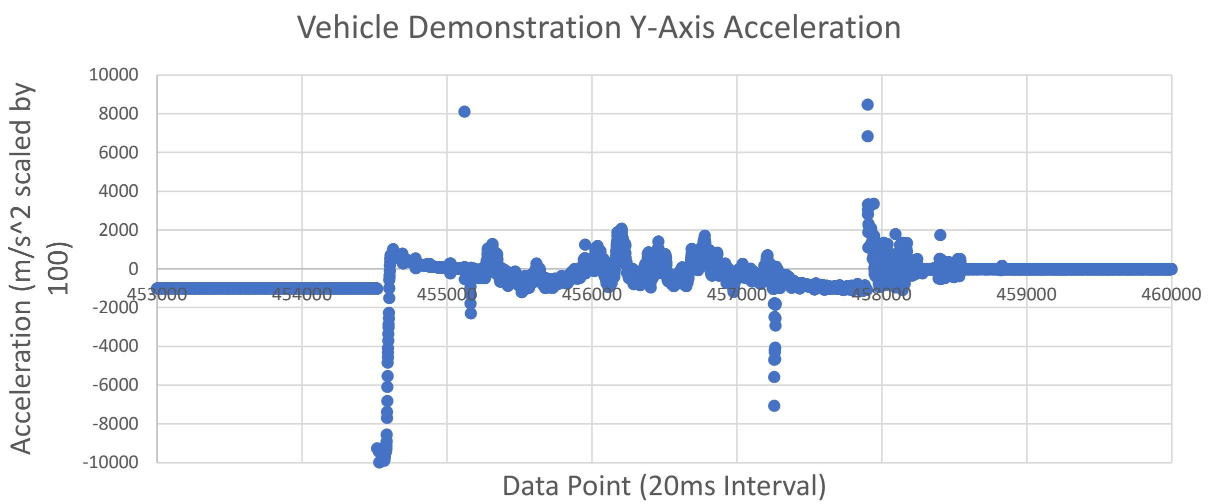
Payload Sled Design

- Sled is assembled with electronics (Raspberry Pi and PCB) and battery housing
- M2.5 fasteners and threaded inserts for fastener connections of Raspberry Pi and PCB
- Battery Housing secured by threaded rod and the sled
- Flown in vehicle demonstration and retrieved IMU data



Payload Sensor Software

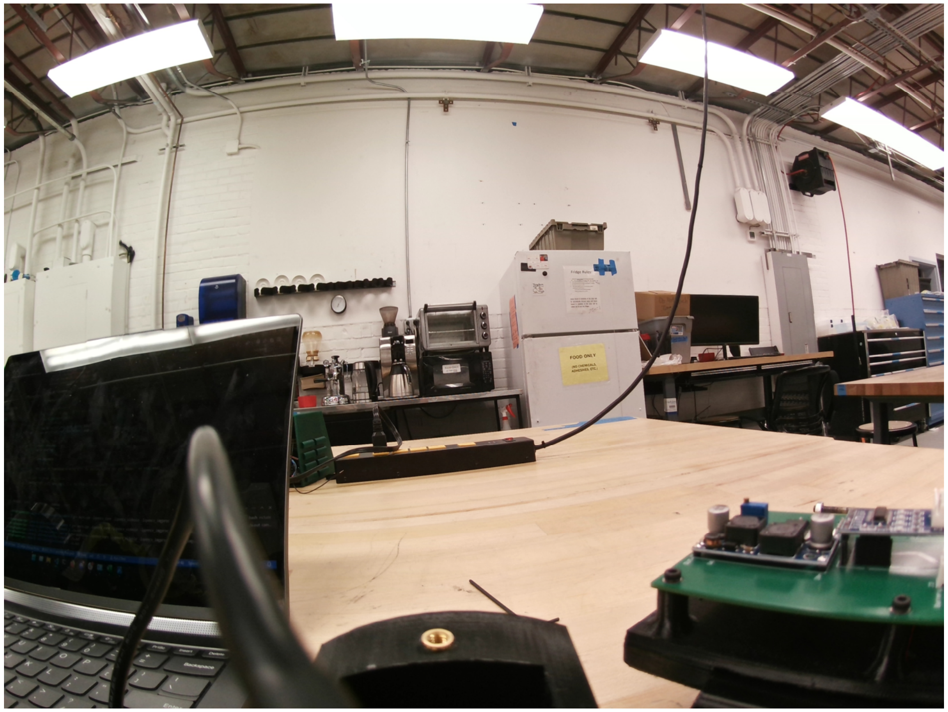
- Communicate with external IMU and Barometer sensors via the I2C Serial Communication Protocol
- Filter out extraneous data and capable of detecting launch and landing conditions
- Extensive logging and redundancy



Payload Camera Software

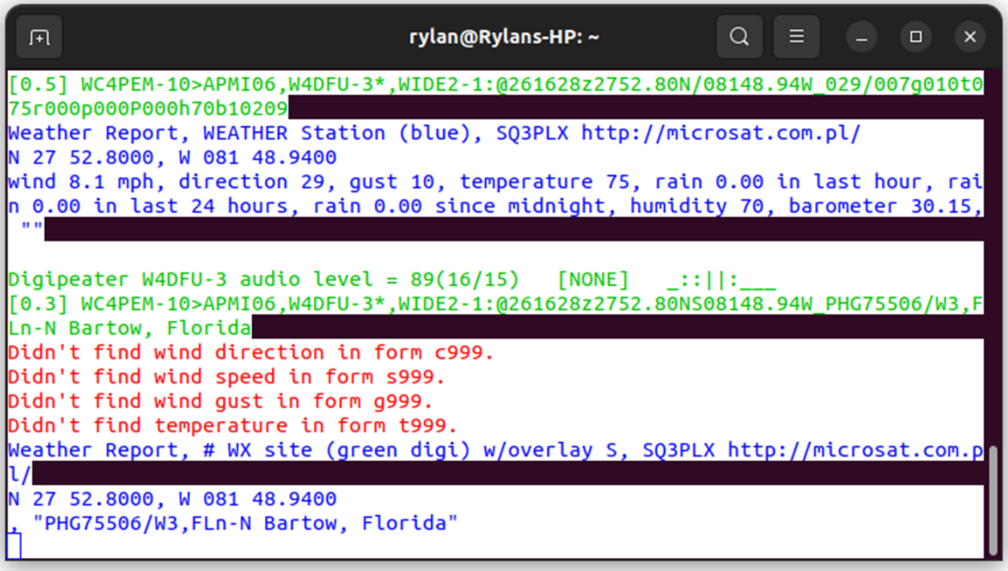
- Take photo based on camera index using OpenCV software library
- Save photo to onboard SD card
- Filter and apply C3-H8 payload operations with OpenCV tools

- Maximum resolution: 3264 x 2448
- FOV: 150°

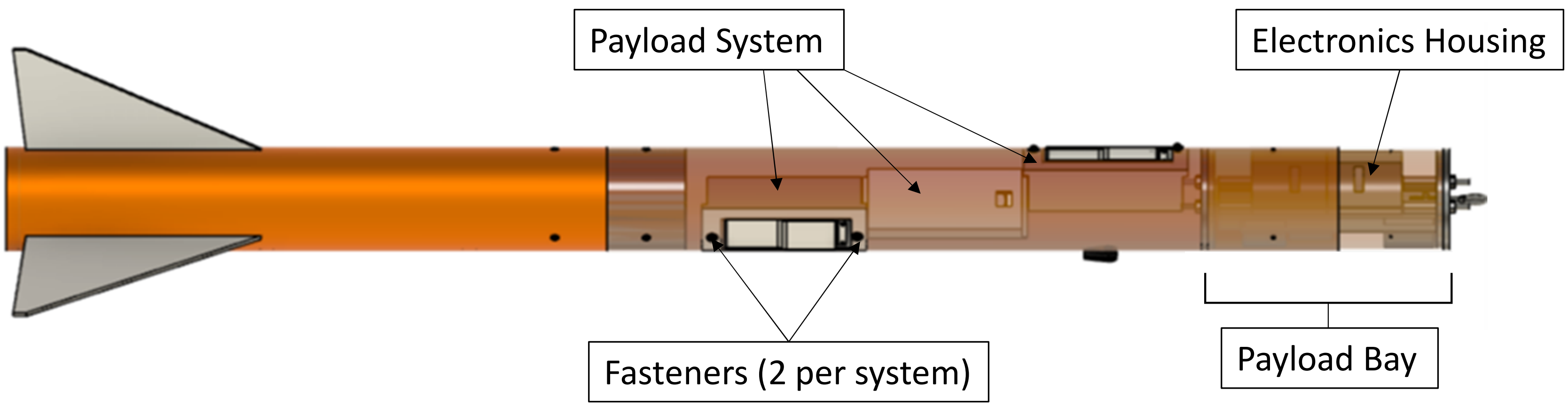


Payload Radio Software

- Receive radio data from RTL-SDR radio dongle
- Send audio via *rtl_fm* to *Dire Wolf* for decoding
- Successful parsing of APRS messages



Payload Integration



Payload Demonstration Flight Plans

The team plans to launch on March 18th at the Tampa Bay Rocketry Association (Prefecture #17)

Payload Requirements Verification

Requirement	Method of Verification	Status
NASA 4.1. College/University Division—Teams shall design a payload capable upon landing of autonomously receiving RF commands and performing a series of tasks with an on-board camera system.	Test	Partially verified; the payload has been designed to accomplish the outlined objectives. However, test P-SI-4, Radio Integration Demonstration, has not been completed.
Team 3.5 Payload electronics will be able to resist acceleration forces during launch.	Demonstration	Unverified; test P-D-4, Payload Acceleration Resilience Demonstration, has not been completed.
Team 3.6 Payload must be able to detect landing.	Demonstration	Verified; test P-SF-6, Landing Detection Demonstration, has been completed.
Team 3.8 Payload must be able to complete received commands in less than two minutes after reception of commands.	Inspection	Unverified; test P-CF-3, Payload Performance Inspection, has not been completed.

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