EXPLORER POST 1010
FLIGHT READINESS REVIEW REPORT

March 6, 2022

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March 6, 2022

I) Summary of FRR report

Team Summary

Team Name: Flamingos
Institution: Explorer Post 1010
Mailing Address: Rockville Science Center, PO Box 1084, Rockville, MD 20849

Team Leaders: Jack Sherling, Samuel Troost
Safety Officer: Peter Camobreco
STEM Coordinator: Jayden Ku
Media Coordinator: Ethan Goldberg

Final Launch Location: BattlePark Rocket Launch site, in Culpeper, VA

Our team is sponsored by the Rockville Science Center. They help us find qualified adults to mentor our teams and work with the library to provide meeting space. We help the Center with staffing their outreach events which allows our student members to earn Student Service Learning hours. Post families financially support the Center and participate in other Center programs. 50 cumulative hours have been spent on the FRR.

Mentor

Jonathan Rains (L2 HPR Certification)
jrains@comcast.net

STEM Engagement Overview
5 engagement events were held, reaching 152 students. Topics covered include rocketry, programming, material science, astrophysics, and nanostructures.

Launch Vehicle Summary

Size and Mass of Individual Sections

Upper Section: 4 in diameter, 24 in long, mass of 1.9 pounds.
Lower Section: 4 in diameter, 28 in long, mass of 1.8 pounds not including motor
Middle Section: 4 in diameter, 20 in long not including coupler, mass of 2.5 pounds.

Launch Motor

Cesaroni J357-14

Official Target Altitude
3750 ft

Recovery system
The lower section will be recovered by a 12” drogue chute and a 36” main parachute. The upper section will be recovered by a guided parafoil.

Rail Size
1010, 96 in

Payload Summary

Payload Title
Autonomous Guided Recovery System

Experiment Summary
The upper section of the rocket will deploy a guided parafoil after apogee. A servo motor will actuate brake lines on the parafoil to autonomously guide it back to the launch site.

II) Changes made since CDR

Vehicle Criteria

1. We have added a piston in the middle section body tube to help push out the drogue chute and defend the parafoil from the heat of the ejection.
2. We increased the length of the middle section body tube by 4 inches to better fit the drogue parachute, parafoil, and the Jolly Logic Chute Releases around the parafoil. The total length of the section is now 19in and the total length of the rocket is now 70 in.

Payload Criteria

1. The payload bay used to be retained inside a stiffy tube which was held inside the nose cone by a screw. The bay is now held directly inside the nosecone by three screws with the bottom bulkhead being retained by two threaded rods.
2. The stepper motor from the CDR to a continuous-rotation servo.

Project Plan

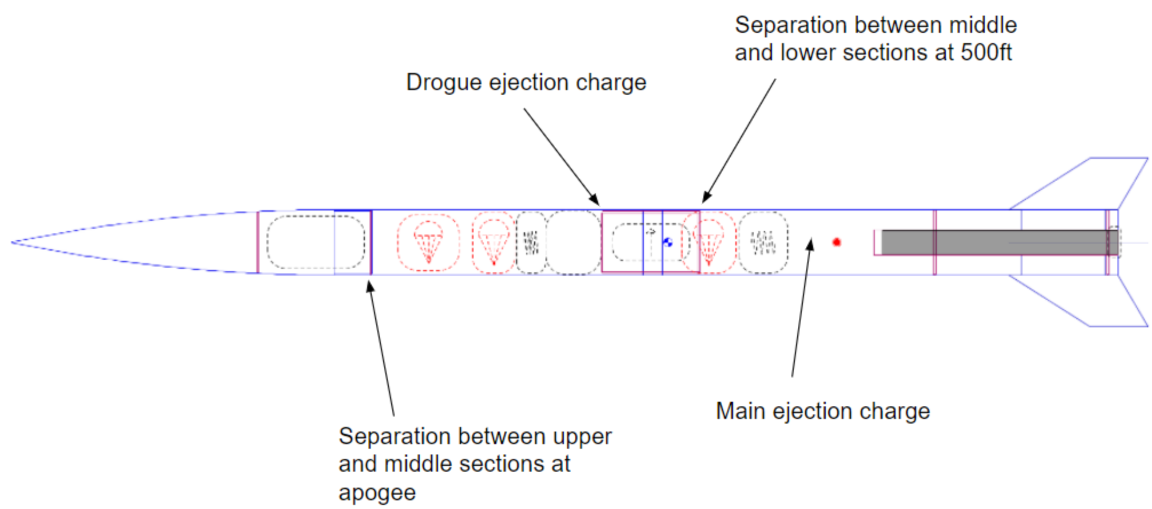
1. Dates: Payload Demonstration Flight is planned to be either March 12 or 13, weather permitting.
2. Budgeting: Ejection charges/black powder are being provided by existing supplies, so the cost will not be included here.

III) Vehicle Criteria

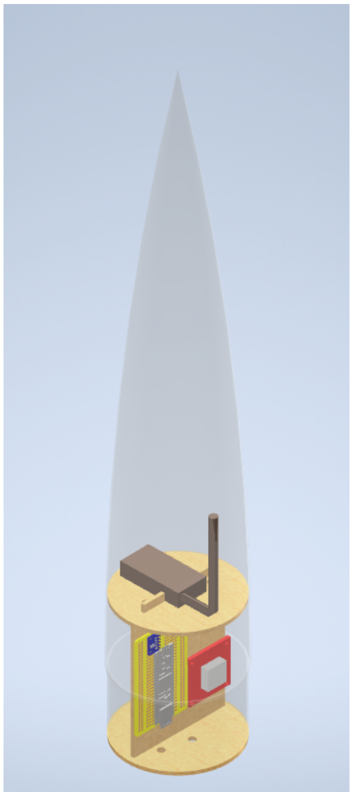
Design and Construction of Vehicle

The only change in the design of the launch vehicle is the electronics bay tube, which was increased by 4 inches to allow more space for the parafoil. The vehicle is composed of three sections: the upper section–including the nose cone–which contains the payload, the middle section/electronics bay, and the lower section/booster. All airframe portions are made from 4” diameter thick walled paper.

Final Separation Locations

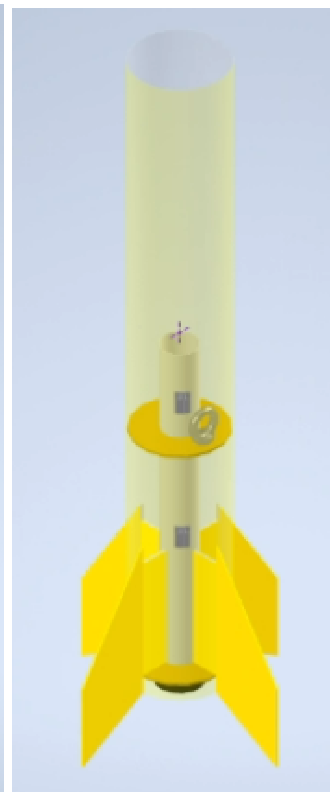


The forward (drogue) ejection uses 0.4g of black powder, with a backup of 0.5g, and the aft (main) ejection uses 1g of black powder.



Upper Section CAD

Middle Section CAD



Lower Section CAD

Upper Section

The upper section of the rocket is 19.8 in long with a weight of 1.5lbs. At apogee, it separates completely (i.e. without any shock cord connection) from the rest of the rocket under a guided parafoil.

We shifted from our CDR with our payload electronics retention system. We have now attached two threaded rods into the nose cone, which will allow a sled to be slipped on and sealed with a bulkhead.

At the forward of the middle section, in the connection between the main electronics bay and booster, and on the main electronics bay stiffy and tube, we have placed brass shims to better hold the shear pins to prevent them from zippering the tube during ejection charges.

Middle Section/Electronics Bay

The middle section of the rocket starts from the aft of the upper section and ends at the aft of the electronics bay. The length of the middle section is 20 in with a weight of .5lbs, while the electronics bay itself has a length of 8 in with a weight of 2.5 lbs.

Forward of the electronics bay but still in the middle section is the airframe that houses our drogue parachute, parafoil, and the Jolly Logic Chute Releases that are attached to the parafoil. We also added a piston to help push the drogue parachute out and to defend the parafoil from the high temperatures of the ejection charge. Deviating from the CDR, we decided to increase the length of this subsection by 4 inches to better fit the parafoil.

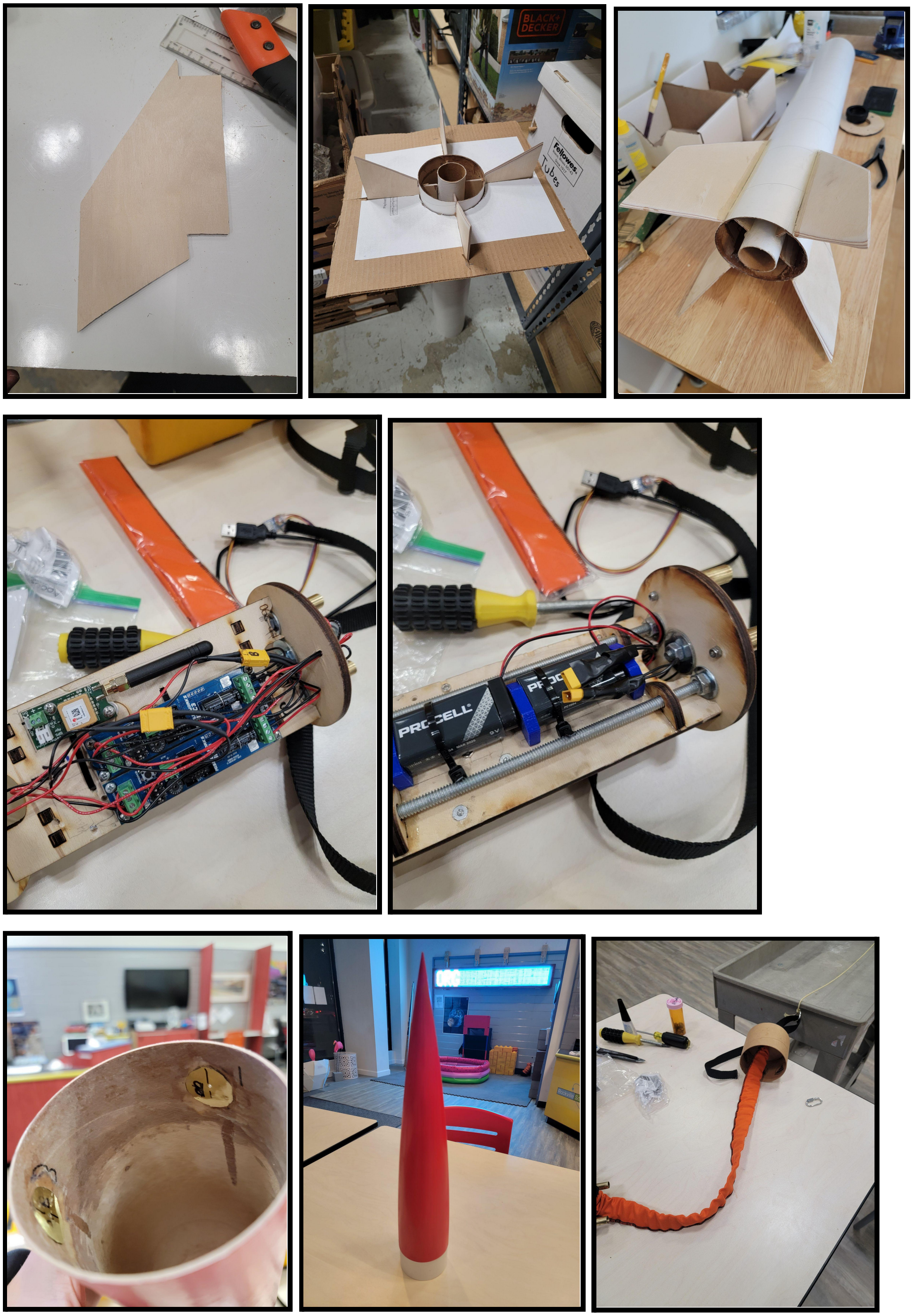
The electronics bay is well sealed to ensure that no extreme pressures damage the electronics. There is an external switch that allows us to easily turn on the electronics.

Lower Section

The lower section of the rocket is from the aft of the electronics bay to the aft of the entire rocket. It has a length of 28in and a weight of 3.1 lbs.

Proof of fully constructed rocket:

We began construction of the full-scale rocket immediately after submitting the CDR documents. We started with the fins, then the booster with its centering rings and motor retention, and moved onto the upper section. Lastly, we configured all of the electronics. Below are pictures of our construction process and the fully completed vehicle.



Rocket Construction

Final Launch Vehicle

Recovery Subsystem

Overview

At apogee, we separate the upper section from the rest of the rocket. The upper section descends under our payload, a guided parafoil. The rest of the rocket descends under drogue until 600 feet, when another ejection charge separates the middle from the lower section, deploying the main parachute.

Structural Elements

The recovery harness is attached to eye bolts. We used ⅛ inch quick links and a swivel on each parachute. The recovery harness uses 1000 pound rated kevlar. The piston is made by PML.

Electrical Elements

We have two terminals on either side of the electronics bay bulkheads with wires feeding from the main and drogue altimeter's ejection ports. These terminals connect to black powder charge wells with electric matches.

Both altimeters run on 9V batteries, which are zip tied in with stoppers both above and below to ensure that the connection remains intact under the forces the rocket endures during flight.

Redundancy Features

We are using two redundant RRC3-"Sport" Altimeters. Both have separate battery and wiring systems. Additionally, we have backup ejection charges attached to one of the altimeters in case the first charge does not cause separation or b. the first charge does not activate.

Parachutes

The drogue parachute is 12" nylon with a descent rate of 48 ft/s made by Fruity Chutes, the main parachute is 36" nylon elliptical parachute with a descent rate of 18 ft/s made by Fruity Chutes, and the parafoil is 0.6 square meters, nylon, with a descent rate of 23 ft/s.

Transmitters

To locate the middle and lower sections, we are using a FeatherWeight GPS, which runs on 921 mHz and 250 mW. It worked very well in our Vehicle test flight.

Our payload uses a NRF24L01+ transmitter, running on 2450 mHz and 80 mW.

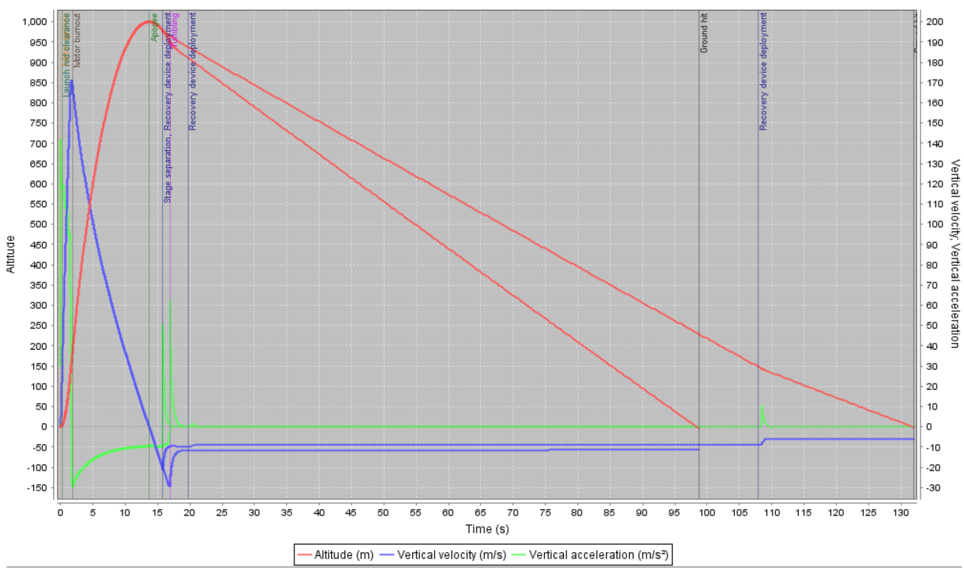
Resilience to Electromagnetic Fields

None of the critical systems of the rocket will be impacted by electromagnetic fields. The recovery system involving separation and parachute deployment operates independent of electromagnetic radiation.

Additionally, to reduce interference, our transmitters run on different frequencies and are separated by plywood bulkheads.

Mission Performance Predictions

Flight Profile Simulations



OpenRocket Simulation

Stability, CP, CG

Stability on pad: 2.58
Stability on rail-exit: 2.69
Center of Pressure: 50.79 in from tip of nose cone
Center of Gravity: 40.16 in from tip of nose cone

Kinetic Energy Analysis

OpenRocket simulations estimate the ground hit velocity is predicted to be approximately 18 ft/s. The spent mass of the rocket is about 6 lbs. Using the formula $KE = ½ * mv^2$ (with conversion to Ft-lbs), the kinetic energy at impact with the ground can be calculated to the following values:

Kinetic Energy (Main)

Kinetic Energy of Each Section (Ft-lbs)	Section 1 (Payload)	Section 2 (Ebay)	Section 3 (Lower section)	Section 4
	20.11	12.4	11.9	N/A

Kinetic Energy (Drogue)

Kinetic Energy of Each Section (Ft-lbs)	Section (Ebay)	Section 2 (Lower section)	Section 3	Section 4
	88.4	84.7	N/A	N/A

Descent Time

The rocket separates at apogee into two separable parts–the upper/payload section and the rest of the rocket (middle section and lower/booster section). The middle and lower section's descent time is 88 seconds, and the upper/payload section's descent time is 70 seconds.

Wind Drift

The following table lists the drift distances in winds of 0 mph, 5 mph, 10 mph, 15 mph, and 20 mph. The drift distance in the second column of the following was derived by multiplying descent time (88 seconds) by wind speed. The third column shows the estimated drift distance based on OpenRocket simulation.

Wind speed (mph)	Manually Calculated Drift Distance (ft)	OpenRocket Drift Distance (ft)
0	0	0
5	645.3	517.4
10	1290.7	1000.7
15	1936	1480.9
20	2581.3	1974.25

The distances calculated by hand were increasingly more than those derived from OpenRocket, because they showed the absolute worst case scenario when the rocket's drift matches the wind speed. OpenRocket shows a more realistic scenario.

IV) Payload Criteria

Overview

Our payload is a parafoil that is intended to guide the payload/upper section to a designated location. Instead of the stepper motor discussed in the CDR, we decided to use a continuous rotation servo because they offer higher torque and speed. Additionally, we moved the payload bay directly into the nosecone without the need of a stiffy tube or coupler, which saves weight.

The microcontroller calculates a vector between the payload's current position and the target position with a GPS. It finds the current velocity vector using a compass. Then, we calculate the angle between the vectors and thus know how much to turn the parafoil.

Structural

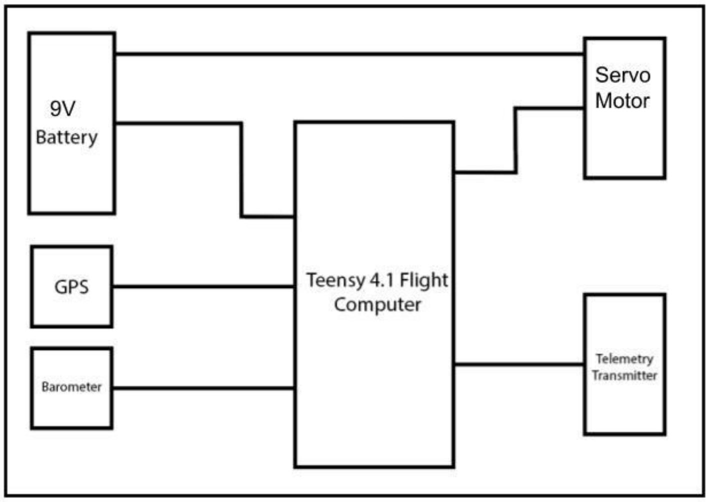
On the aft side of the upper section bulkhead (on nosecone), there is a servo motor that turns a spool connected to one of the parafoil lines. When this spool allows for more slack, this parafoil line becomes relatively longer than the other line, causing the payload to turn in that direction. When the spool is pulled in, creating less slack, this parafoil line becomes relatively shorter than the other line, causing the payload to turn in the other direction.

Electrical

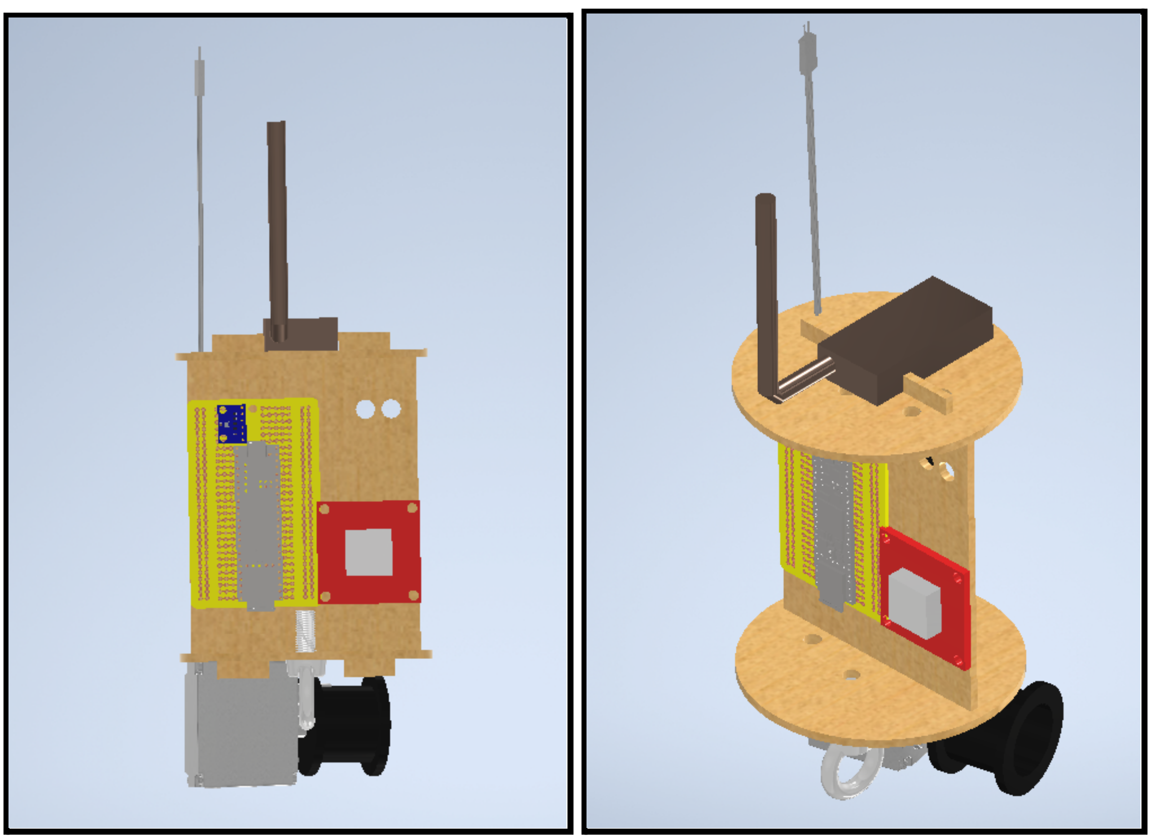
We are using a Teensy 4.1 Flight Computer to operate the payload. It is connected to a 9V battery, powering the entire payload. To ensure we make no parafoil adjustments above 400ft, abiding by regulation, we include a barometer in the payload.

Wired through the bulkhead from the flight computer is the servo, which operates the mechanical side of our payload as discussed in the previous section.

For autonomous movement of the payload, we include a GPS, and for manual and/or overriding movement, we have a transmitter that connects back to our ground station.



Payload Electronics Block Diagram



Payload CAD Diagram

Proof of Payload Construction

Payload Demonstration Flight Information

Overview

At the time of the submission of this document, we have yet to perform our Payload Demonstration Flight. We intend on flying on March 12 or 13 before presenting to the NASA team regarding the FRR on March 23.

Success Criteria

There are three degrees to the success of the Payload Demonstration Flight.

1. The parafoil deploys at 400 feet
2. The parafoil turns the rocket in the direction of the target
3. The parafoil guides the section to within 20 meters of the target

The flight will be considered successful if part three of these degrees is met.

V) Demonstration Flights

Vehicle Demonstration Flight

Date
02/12/2022

Location
Culpeper, VA

Launch Conditions
55 degrees Fahrenheit
Low wind

Motor
Cesaroni J357-14

Ballast
500 grams

Final Payload Flown
No

Altitude

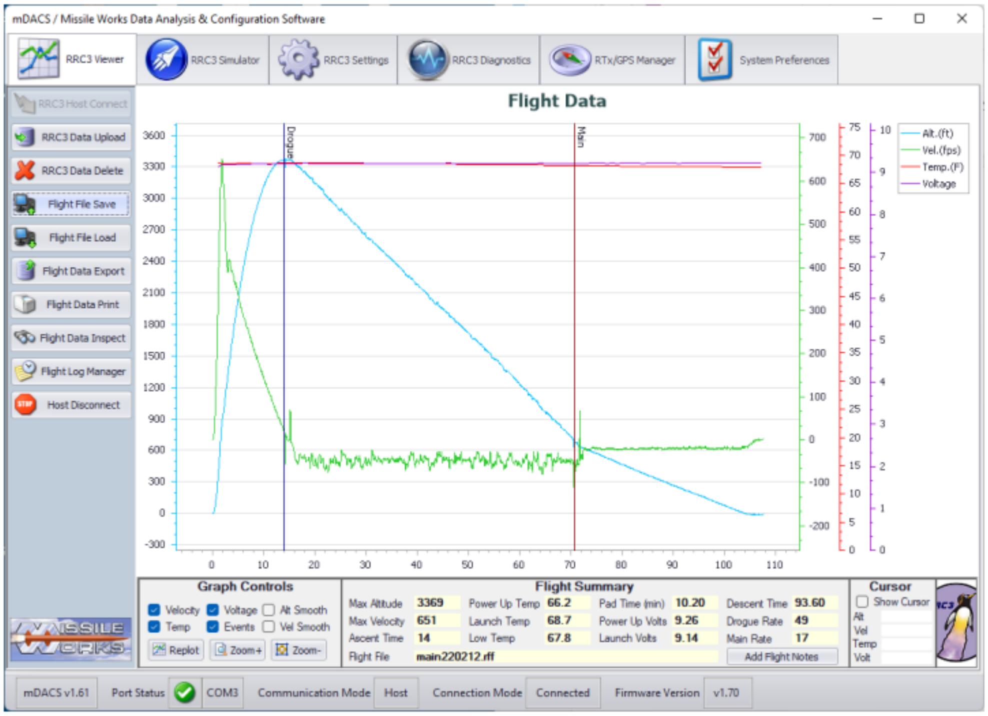
Official Target
3750ft

Predicted
3557ft

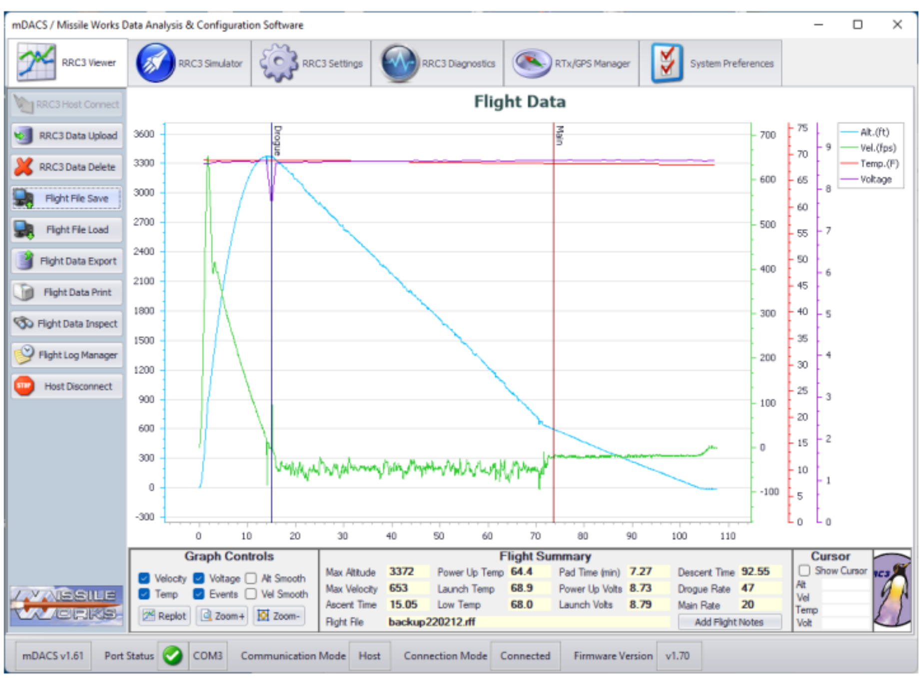
Measured
Featherweight GPS - 3472ft
RRC3 Main - 3369ft
RRC3 Backup - 3372ft

Altimeter Data

Main Altimeter



Backup Altimeter



Components that Functioned As/Not As Intended

All components functioned as intended. The recovery system was successful in separating the rocket and safely bringing it to the ground, and the Featherweight GPS allowed us to locate the rocket well.

Payload Simulation

We simulated the weight of our payload as a 0.5 kg mass.

Estimated Drag Coefficient

Calculated

0.375

Simulated

0.45

Similarities and differences Between Full-scale & Subscale Flights

Both designs flew straight and without wobbles, indicating fair stability. The ejection charges on both flights successfully separated the sections. However, the shock cord of the subscale re-launch malfunctioned during the test flight and ripped off of the fuselage of the rocket, resulting in a crash landing of the fuselage, while we encountered no such issues with the full scale flight

Lessons Learned

1. We learned that we need to clear the shear pin holes before preparing the vehicle.
2. To reduce descent times, we decided to make our main deployment at 600feet.
3. To reach our altitude goal, we need to reduce weight. The ballast for our payload weighed more than the payload, so this is an item which we can reduce weight.

VI) Safety and Procedures

All members of the Post undergo safety training from qualified makerspace personnel prior to using any of the equipment. All construction machinery used will be supervised by at least one other person. A fire extinguisher will be accessible during any construction activity. There will be adult support when using any construction machinery. Motors will be handled and transported by Jonathan Rains, a NAR member with a L2 certification.

Launch Concerns and Operation Procedures

Failure to comply with these rules could cause either a failure in the launch, injury to the rocket, or injury to other people. If all these rules are followed, however, it should lead to a safe and successful launch.

- Recovery preparation

We will use a dual deployment recovery system so that all parts of the rocket return safely and undamaged and can be flown again, and we will use flame-resistant or fireproof recovery system wadding in the rocket to avoid lines from burning. We will not attempt to recover the rocket from dangerous places such as trees or powerlines. We will fly it under conditions where it is likely to recover in spectator areas or outside the launch site, and we will not attempt to catch it as it approaches the ground.

- Payload preparation

Our payload will have a parafoil in the nose cone meaning we will include a Jolly Logic Chute Release that ensures it will not deploy until 500 feet. The parafoil will also have a manual override in case the autonomous does not work. It will deploy in a spiral so that we can control the rocket and make sure we do not land in any hazardous material.

- Electronics preparation

Everything will be tested before the launch to make sure it will work for the real rocket, this includes ejection tests in a controlled environment. We will have a fresh battery everytime we launch and not turn on the electronics until the rocket is on the launch rail. We are using a backup altimeter in case our altimeter fails.

- Rocket preparation

PPE: Safety glasses for debris and gloves for black powder or sharp objects
Official over 18 to handle black powder
Assemble the rocket and all its different sections making sure that they will remain together until they need to be broken apart. We will put baby powder and wadding on and around the parachute to ensure it does not burn before releasing from the rocket.

- Motor preparation

PPE: Safety glasses for debris and gloves for black powder or sharp objects
Official over 18 to handle black powder
We will use only certified, commercially made rocket motors, and will not tamper with these motors or use them for any purposes except those recommended by the manufacturer. We will not allow smoking, open flames, nor heat sources within 25 feet of these motors.

- Setup on the launch pad

We will launch our rocket from a stable device that provides rigid guidance until the rocket has attained a speed that ensures a stable flight, and that is pointed to within 20 degrees of vertical. If the wind speed exceeds 5 miles per hour we will use a launcher length that permits the rocket to attain a safe velocity before separation from the launcher. We will use a blast deflector to prevent the motor's exhaust from hitting the ground. We will ensure that dry grass is cleared around each launch pad to stop fires from starting when we launch and that the launch rail itself is clean.

- Igniter installation

PPE: Safety glasses for debris and gloves for black powder or sharp objects
Official over 18 to handle black powder
We will launch our rockets with an electrical launch system, and with electrical motor igniters that are installed in the motor only after the rocket is at the launch pad or in a designated prepping area. The launch system will have a safety interlock that is in series with the launch switch that is not installed until the rocket is ready for launch.

- Launch procedure

We will use a 5-second countdown before launch and ensure that a means is available to warn participants and spectators in the event of a problem. No person should be closer to the launch pad than allowed. When arming onboard energetics and firing circuits, we will ensure that no person is at the pad except safety personnel and those required for arming and disarming operations. We will check the stability of my rocket before flight and will not fly it if it cannot be determined to be stable.

- Troubleshooting

We will ensure all team members keep detailed notes on their respective subsystems and that they approach problems with a composed and organized approach. If we are encountering problems on the pad, then we will take the rocket off and test what could be wrong.

- Post-flight inspection

After the flight we will check parachutes and shock cords for damages and properly dispose of any live black powder charges. We will then turn off electronics if necessary to ensure that we save battery. We will also check the rocket itself for any damages and prepare for another launch if necessary.

SAFETY KEY

Severity	**Likelihood Scale**
1 - Low	1 - Not Likely
2 - Medium	5 - Very Likely
3 - High	

Personnel Hazard Analysis

Hazard	**Cause of Hazard**	**Effect of Hazard**	**Severity**	**Likelihood**	**Mitigation**
Sharp objects	Misuse of cutting tools during rocket construction	Personal injury to user and damage to hardware	2	3	Proper tool training from makerspace professionals
Toxic Fumes	Use of adhesive and glue without proper safety precautions	Exposure to carcinogens	2	2	Wear proper safety equipment and take necessary precautions
Glue in eyes and hands	Improper use of glue	Bonding of glue to skin and eyes	1	1	Use of proper PPE while working with

					adhesives
Burns	Laser cutters, hot glue, soldering	Need for medical attention, burns	2	3	Limit exposure to hot materials and use insulation
Electrical shock	Tools grounded incorrectly, battery malfunctions	Burns	3	2	Insure a proper ground and use electric safe equipment
Exposure to loud noises	Heavy machinery, rocket motors	Partly or severe hearing loss	1	1	Ear plugs and other forms of hearing protection
Splinters	Working with wood	Infection	1	1	Gloves
Lasers getting in eyes	Working with laser cutter	Blindness	3	2	Proper PPE
Falling Debris	Rocket recovery failure, falling boxes	Concussion, Bruising	3	2	Head protection and awareness of your surroundings
Tripping hazards	Loose cords and debris on floor	Concussion, broken wrist and bones	2	4	Awareness of surroundings and cleaning up working environments
Black powder explosion	Misuse of black powder	Burns, blindness	3	2	Have professionals handle black powder

Environmental Concerns

Hazard	**Cause of Hazard**	**Effect of Hazard**	**Severity**	**Likelihood**	**Mitigation**
Wind	High wind speeds	Launch rail falling over Rocket going off course	3	2	Test wind speeds before launching rocket
Rain	Rainy weather	Damage to electronics, deterioration of rocket, and causing the rocket to go off course	3	1	Check weather before launch and plan accordingly
Snow/Cold Weather	Low temperature outside	Damage to rocket, altimeters not reading	3	1	Check weather before launch and do not launch when weather is to cold
Litter caused by rocket	Wadding materials escaping the rocket	Damage to the local environment	2	3	Use proper amounts of wadding and pack it correctly
Burning the ground under the rocket	Flames from motor sets dry objects on fire	Damage to ground and possibility of forest fire	1	4	Clear the ground under the rocket of dry grass and leaves

Before every launch we will test our rocket and make sure every part works before launching. We will also continuously look at the checklist to make sure we are not skipping or failing any steps. Last, we will obey the High Power Rocket Safety Code provided by NASA.

All launch activities will be monitored by NAR officials and we will not launch the rocket without an official. These officials will be in charge of motor installation and pyrotechnics. All launches are conducted by a range safety officer in compliance with the Safety Code of the National Association of Rocketry as well as NFPA 1127: Code for High Power Rocketry. For launch sites, we have access to locations previously used for the Tripoli LDRS National event and the National Battle of the Rockets competition to ensure the sites we launch at are safe to use.

Only team members, mentors, and NAR officials will be present on the launch pad. We will ensure that no power is on the igniter leads before loading. We will ensure that the rocket is stable on the launch rail after placing it on to avoid launching at an angle. We will activate the electronics and drone and ensure that they are working properly by using the radio signals and LED displays that signify statuses. We will then load up igniters and prepare for launch.

The team will exercise extreme caution before launching any rocket, making sure to abide by rules set by NASA, NAR, and the officials on site.
The team will not launch:

1. At any altitude where clouds or obscuring phenomena of more than five tenths coverage prevails;
2. At any altitude where the horizontal visibility is less than five miles;
3. Into any cloud;
4. Between sunset and sunrise without prior authorization from the FAA;
5. Located within 9.26 kilometers (5 nautical miles) of any airport boundary without prior authorization from the
6. In controlled airspace without prior authorization from the FAA;
7. Unless you observe the greater of the following separation distances from any person or property that is not associated with the operations applies:
   (1) Not less than one quarter the maximum expected altitude;
   (2) 457 meters (1,500 ft.);
8. Unless a person at least eighteen years old is present, is charged with ensuring the safety of the operation, and has final approval authority for initiating high-power rocket flight; and

9. Unless reasonable precautions are provided to report and control a fire caused by rocket activities.

Vehicle Pre-flight Checklist

Bolded items are performed by Jonathan Rains, a NAR HPR Level 2

- Ensure all shear pin holes are clear
- ElectronicsPrepare Featherweight
        - Connect battery
        - Turn on
        - Ensure connection to base station
    - Prepare RRC3 #1
        - Be sure all arming switches are off
        - Install battery and zip tie
        - Altimeter properly programmed and verified
    - Prepare RRC3 #2
        - Be sure all arming switches are off
        - Install battery and zip tie
        - Altimeter properly programmed and verified
- Recovery System Preparation
    - Pyrotechnics, Drogue
        - **Prepare drogue deployment pyrotechnic devices**
        - Connect aft pyrotechnic leads to the terminal's devices drogue chute connections
    - Drogue
        - Check shock cords, shroud line, and drogue chute to ensure there are no cuts, burns, or tangles.
    - Verify that all connections and devices are secured and in good condition.
        - Avionics bay shock cord to piston
        - Piston to drogue
    - Pack drogue chute, keep lines even and straight
        - Fold drogue chute
        - Ensure shroud lines are free from tangles
        - Ensure all quick links are secure
        - Insert piston

        - Insert drogue chute into recovery compartment
        - Install shear pins
    - Pyrotechnics, Main
        - **Prepare main deployment pyrotechnic device and ready for installation into the rocket**
        - Make the break away wires
        - Connect forward pyrotechnic leads to the terminal's main chute connections
    - Recovery System, Main Chute:
        - Check shock cords, shroud line, and main chute, to ensure there are no cuts, burns, or tangles.
    - Verify that all connections and devices are secured and in good condition.
        - Avionics bay shock cord to booster
    - Pack main chute, keep lines even and straight.
        - Fold main chute per manufacturer's instructions
        - Ensure shroud lines are free from tangles
        - Ensure all quick links are secure
        - Insert ejection charge protection
        - Insert main chute into forward recovery compartment
    - Install shear pins
- Motor Installation
    - **Install motor**
    - Install motor retaining device
- Final Launch Preparations
    - Load Rocket on Pad
        - Prepare launch pad.
        - Load rocket on launch rod
        - Arm RRC3's for launch
    - Prepare Igniter
        - Insert igniter. Be sure it is completely forward and touching fuel grain.
        - Secure igniter in position
        - Assure that launcher is not hot
        - Attach leads to ignition device
        - Be sure all connectors are clean
        - Be sure they don't touch each other or that circuit is not grounded by contact with metal parts.
        - Check tower's position and be sure it is locked into place and ready for

launch

- Misfire Procedures
  - Remove failed igniter.
  - Return to “Prepare Igniter” step under “Final Launch Preparations”

Payload Pre-flight Checklist

- Input target GPS coordinates into code
- Check code for compiler errors
- Upload code to Teensy 4.1 flight computer
- Replace battery for Teensy
- Power Teensy
- Power Ground Station
- Verify that transmitters can send and receive data to each other
- Insert sled into nose cone
- Wire servo motor with spool
- Verify that spool has a little slack by default
- Pack parafoil
- Seal nose cone

VII) Project Plan

Testing

Test	Date	Success
Forward Ejection	02/12/2022	Yes; the rocket separated in the intended location
Aft Ejection	02/12/2022	Yes; the rocket separated in the intended location.
Vehicle Flight	02/12/2022	Somewhat; the rocket was recovered safely but did not reach our 3750ft target altitude
Payload Override Control	3/5/22	Yes; the ground station sent commands to the onboard receiver which controlled the parafoil winch
Payload Test Flight	03/12/2022	Pending

Requirements Compliance

Vehicle

To confirm that our rocket's flights observe NASA's regulations of an apogee between 3,500 and 5,500 feet as well as no more than 2,500 feet of drift, we will perform test launches of the rocket via simulation and physically prior to the final launch. After launches we will observe data and make changes accordingly.

Our rocket will have couplers that are at least 1 body in diameter and the rocket will have no more than 4 separation points to abbadie to NASA's regulations.

We will record all flight data to determine changes we can make to the design, such as small weight differences, to improve future flights.

Recovery

The lower section of the rocket will be recovered via drogue and main parachute, observing NASA's regulation. The upper (payload) section of the rocket will be recovered using its own recovery system, the autonomous parafoil, abiding by NASA's regulation.

We have redundant altimeters with separate batteries that we replace before every launch.

We have redundant Jolly Logic Chute Releases on the parafoil that are chained together such that if only one activates, they will both release.

We will perform ground tests for our energetics and ejections to verify that the rocket can separate at its designated locations.

Each section of the rocket's descent is less than 90 seconds.

Payload

We will only adjust parafoil lines below 400 feet, complying with FAA regulation. We will also have override control from the ground so that we can switch to manual controls.

We have override functionality from the ground to adjust the parafoil's movements if necessary.

The requirement for our payload is to autonomously return to the launch site within a reasonable distance. This will be verified by measuring the distance of the payload section to the target after launch. This distance should be less than 20 meters.

Budgeting and Funding

Item	**Description** (If applicable)	**Quantity**	**Cost**
Cesaroni J357-14 Motor	Rocket motors	3	250
Rocket Body Tubes	4 inch diameter paper body tubes	2	50

Coupler	4 inch coupler	1	8
Subscale Rocket Body Tubes	2.6 inch diameter paper body tubes	2	25
Main Parachute	36 inches	1	107
Drogue Parachute	15 inches	1	40
Parafoil	Ram-Air System	1	60
Payload GPS Unit		1	10
Featherweight GPS		1	375
PCB Fabrication		N/A	60
Jumper Wires	Male to Male and Male to Female Package	1	10
Teensy 4.1	Microcontroller	1	30
Stepper Motor	Pulls Parafoil Lines	1	15
Batteries	9 Volt; Powers Electronics	2	40
Electronic Bay Sleds	For Main &Sub-scale Rockets	2	60
Altimeter	RRC3 “Sport”	2	150
Nose Cones	For Main & Sub-scale Rockets	2	50
Plywood	For fins & bulkheads	N/A	19
Epoxy	15 minute, 30 minute	2	35
Maintenance Expenses	General Repairs and Replacements	N/A	200
TOTAL			1594

Source	**Amount**
Organization Earnings from The American Rocketry Challenge 2nd Place Finish	1000
Membership Fees	1600
Total	2600