EXPLORER POST 1010
CRITICAL DESIGN REVIEW REPORT

January 2, 2021

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I) Summary of CDR 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

Primary Final Launch Location: Huntsville, Alabama
Backup Final Launch Locations: Higgs Farm in Price, MD, or 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 CDR.

Mentor

Jonathan Rains (L2 Certification)
jrains@comcast.net

Launch Vehicle Summary

Official Target Altitude
3600 ft

Final Motor Choice
Cesaroni J357-14

Size and Mass of Individual Sections

Upper Section: 4 in diameter, 23.62 in long, mass of 2.2 pounds.
Lower Section: 4 in diameter, 27.95 in long, mass of 1.46 pounds not including motor

Electronics Bay: 4 in diameter, 16.14 in long not including coupler, mass of 1.77 pounds.

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 PDR

Changes made to vehicle criteria

Some figures of the rocket have changed since the preliminary design review. The expected weight of the rocket is now 6.18 lbs, because as components for the full scale rocket arrived the team could get a more realistic estimation of the final weight. The actual weight for the electronics bay was more than initially predicted. The previous design also had a flaw where the parafoil could get stuck in the airframe upon deployment. The final design corrects that flaw by changing the length of the section of body tube between the electronics bay and upper section. The upper section electronics bay will now be retained inside a coupler, which is held into the nosecone by a set of screws. The team also changed the main parachute deployment to 725 feet so that the bottom section of the rocket can land within 90 seconds. Finally, due to a heavier mass estimate, we have decided to reduce our target altitude from 3750 feet to 3600 feet.

Changes made to payload criteria

The team decided to change the servo motor that would drive the parafoil to a stepper motor. It was determined that multiple rotations would be needed to actuate the brake line. Since a servo motor usually can only rotate 180 degrees, the servo motor had to be swapped for a stepper. Additionally, it was determined that the parafoil could still be fully controlled by actuating only one brake line instead of both. The other brake line will be attached to an eyebolt on the payload electronics bay, which reduces the overall complexity of the system.

Changes made to project plan

The team updated the budget figures (see Budget section).

III) Vehicle Criteria

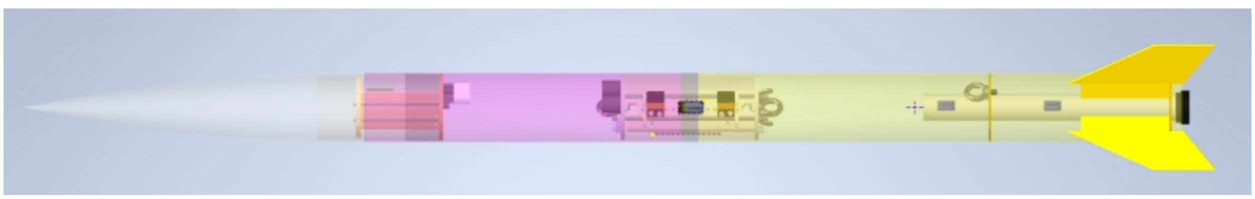
Design and Verification of Launch Vehicle

Mission Statement

The mission is to successfully launch the rocket to 3600 feet, carry and deploy the payload, and recover the rocket safely. After apogee, the payload will actively guide itself back to the launch site. This technical challenge supports our team mission to promote engineering careers in younger students.

Vehicle Overview

The launch vehicle will have a total length of 67.3 in and a diameter of 4 in. As outlined in the PDR, the vehicle will be constructed out of thick walled paper tubes and plywood due to their lower costs, mass, and difficulty compared to fiberglass. The vehicle will be recovered in two independent sections, the upper section containing the payload, which is a guided parafoil. The lower section will be recovered via conventional dual deployment. The drogue parachute will deploy at apogee and the main parachute will deploy at 725 ft.



Upper Section

The upper section has a length of 23.622 in and a weight of 2.2 lbs. It is made up of a body tube that contains the payload sled, the rocket nose cone, and the parafoil. The payload electronics bay itself is 6.9 in long with a switch through the airframe that toggles the payload flight computer on and off. The payload electronics bay will be held inside a coupler by two threaded rods through bulkheads on either side. The coupler will be held into the nosecone by a set of screws. This enables the payload electrical system to be easily accessible. On the aft bulkhead of the upper section is the parafoil brake line drum, and an eyebolt for controlling and retaining the parafoil.

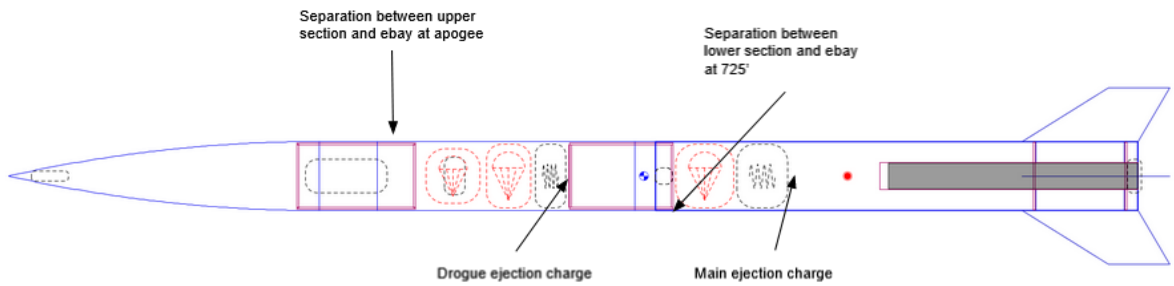
Upper Section CAD Model

Lower Section

The lower section has a length of 27.95 in and a weight of 1.46 lbs not including the motor. The lower section includes the fin can and the vehicle's airframe up to below the lower section's coupler. The fin can will be particularly strong because there are fillets on each joint between the centering rings, the fins and fin tabs, and the motor mount. The motor will be retained with a 38 mm threaded retainer and cap securely epoxied onto the aft centering ring and motor mount.

Lower section CAD Model

Separation Points and Energetics

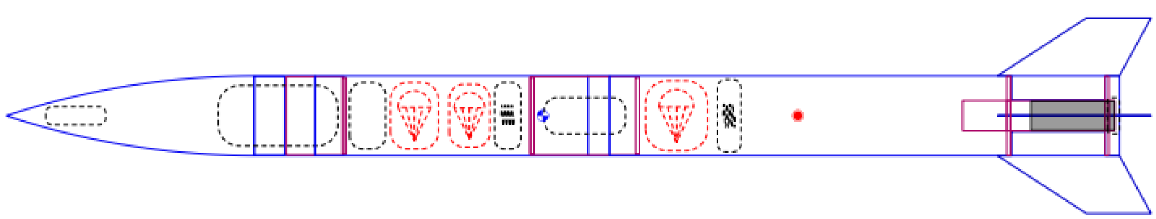


The vehicle will have two separation points. At apogee, the upper section will completely separate from the electronics bay. The electronics bay will separate from the lower section at 725 ft when the main parachute deploys. There will be redundant charge wells with the first having 1.5 grams of black powder and the second having 2.1 grams on the fore end of the electronics bay. Below the main parachute will be two redundant charges also with 1.5 and 2.1 grams to be fired when the main parachute is deployed.

Fin Design

We will be using trapezoidal clipped delta fins due to their aerodynamic properties and strength. In addition, we will be using internal fillets to increase fin strength.

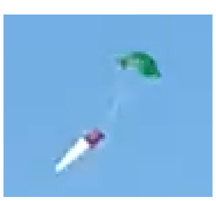
Subscale Flight Results



Subscale Rocket Design (OpenRocket)

Assembled subscale rocket

Descent of Lower & Electronics Bay Sections under main and drogue parachutes



Descent of "Payload" section–which is separate from the rest of the rocket on descent–under parachute that represents parafoil

Flight analysis

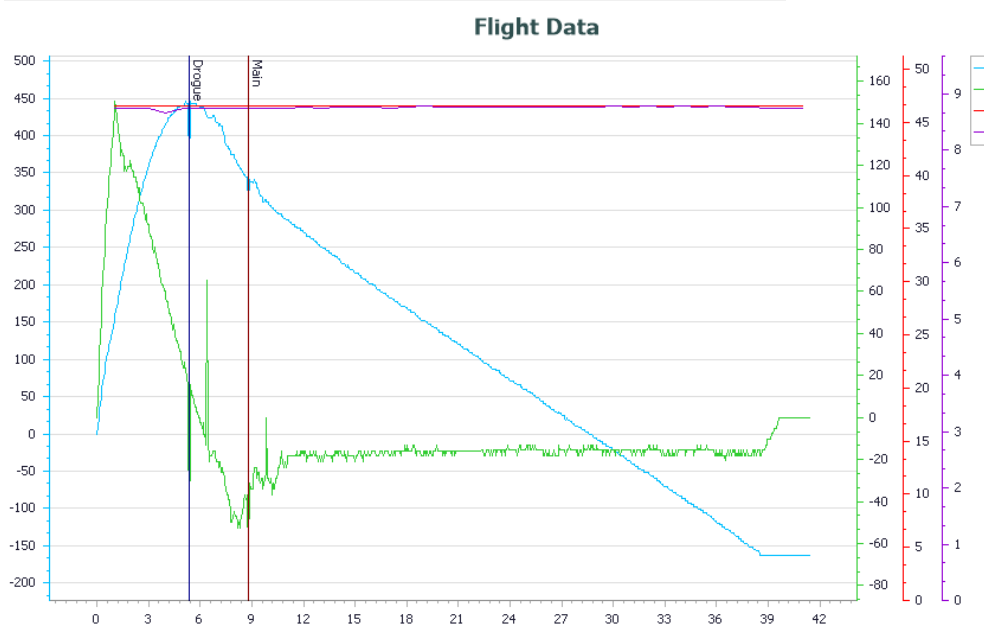
Flight Log Data

Flight Performance		Chute Performance	
Apogee (AGL)	600	Drogue Descent Rate	33
Peak Velocity	149	Main Descent Rate	16

Flight Times		Temperature Monitor	
Pad Time (min)	4.40	Power On Temp	44.6
Time to Apogee	5.35	Launch Temp	46.6
Total Descent Time	36.10	Flight Low Temp	46.4

Flight Log Statistics

Total Flights	1
Total Flight Minutes	0.6
Total Ascent Elevation	64



**Graph shows apogee of 440 feet but landing 160 feet below ground–real apogee is 600 feet.*

The rocket reached an apogee of 600 ft, which is lower than our target of 800 ft. The flight time was 41.45 seconds*. The rocket was 40 grams heavier than what was predicted in OpenRocket, due to some small differences including the use of metal swivels on the parachute shroud lines and a piston.

*The payload section, which did not have an altimeter, landed a few seconds after the lower section, which included the altimeter. The total flight time (ending when the payload section hit the ground) was 46 seconds.

Recovery Tests

We performed two ground tests of the ejection system, with 0.36 grams of black powder forward and 0.45 g aft. Both separations were successful, though we determined that less black powder should be used.

Scaling Factors

We scaled the 4” body tubes of our full-scale design down to 2.56” BT-80 tubes. Therefore, the scale factor of our components was 0.64. We had to alter some mass locations and values, because the motor used by our full-scale rocket will not easily scale down to a motor that can be used by our subscale. We will be flying with a F35W motor.

We decided not to use redundant altimeters or batteries because we were testing the design, so in case of failure we did not want to lose expensive electronics. In addition, having two altimeters would be difficult to fit in a BT-80 sled.

Launch Day Conditions

We launched the subscale rocket on January 8th, 2022 (we had delays due to COVID-19 complications). The temperature was 30 degrees Fahrenheit, wind was 2mph, and pressure was 1036 mb or 1.02 atm.

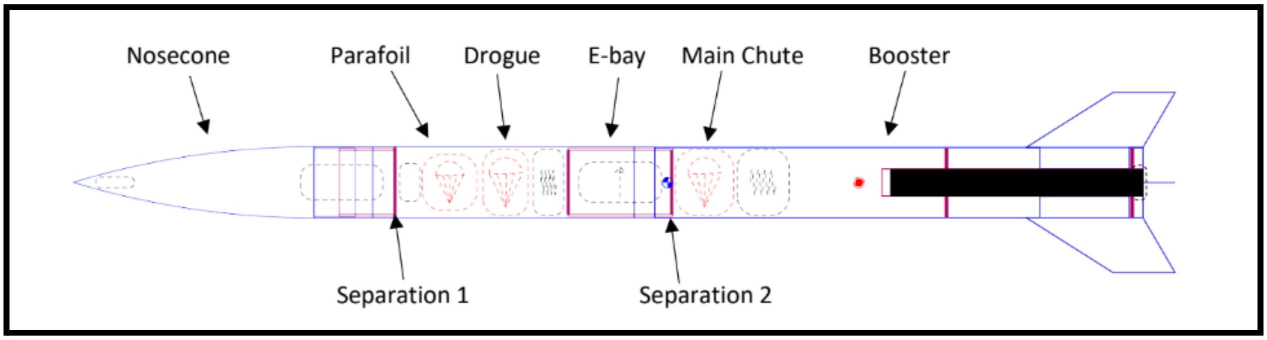
Impacts on Main Design

1. To ensure that the drogue parachute deploys, we added a piston located below the drogue parachute. This way, when the forward ejection charge activates, the pressure pushes the piston, and therefore the drogue parachute, out.
2. We learned that we need to reinforce the body tube–likely with brass shims–where the shear pins are so that the shear pins do not tear through the rocket.

Recovery Subsystem

Overview

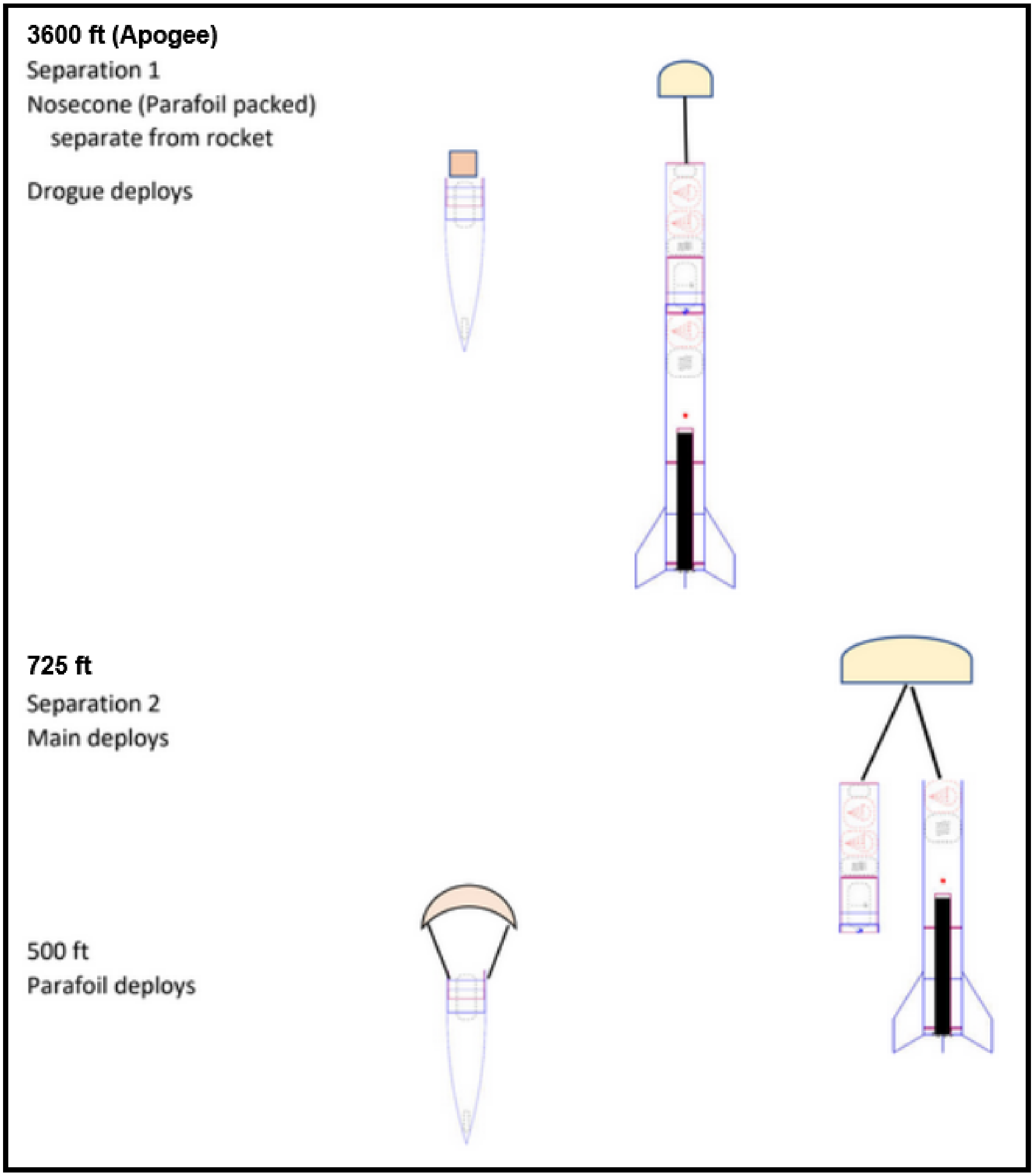
Unchanged from the PDR design, a charge on top of the electronics bay is activated at apogee that deploys the drogue parachute for the lower section and the parafoil on the upper section. The payload section is not attached to the lower section during descent. The parafoil is attached to the aft end of the upper section with no surrounding airframe, so it will easily deploy at apogee with no risk of becoming stuck.



Separation Points and Parts

At 725ft, the charge located at the bottom of the booster section is activated, separating the electronics bay from the booster and deploying the main parachute. The charge is located below the main parachute, to avoid forcing the parachute into the airframe. The impact velocity of the lower section with the main parachute deployed is 6.47 m/s, which is acceptable.

At 500ft, our two redundant Jolly Logic chute releases are released from the parafoil. We will not be making adjustments to the parafoils lines until 400 ft to abide regulation. The parafoil needs time to open and to decelerate before making adjustments; therefore, the parafoil opens at 500ft instead of the 400ft minimum for adjustments. We will discuss the parafoil more in the Payload Section.



Recovery Diagram

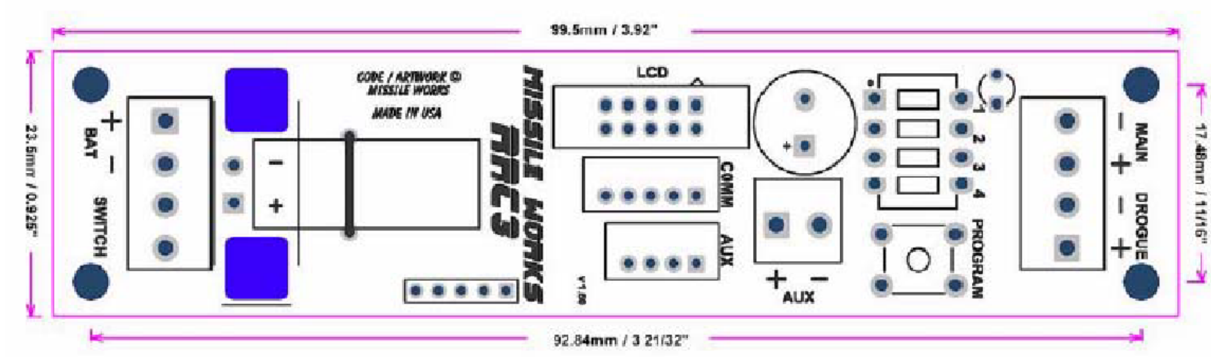
Recovery Hardware

The drogue parachute is 12” nylon made by Fruity Chutes, the main parachute is 36” nylon elliptical parachute made by Fruity Chutes, and the parafoil is 55x22” nylon.

The drogue chute is attached to a shock cord knotted to an eyebolt on top of the electronics bay. The main parachute is attached to an eye bolt on the aft bulkhead of the electronics bay. The electronics bay is connected to the launch vehicle by a 1000lb rated kevlar line shock cord. The shock cord is knotted to an eye bolt on the top centering ring. The payload is recovered by the guided parafoil, which is attached to an eyebolt and a winch on the upper section.

Electrical System

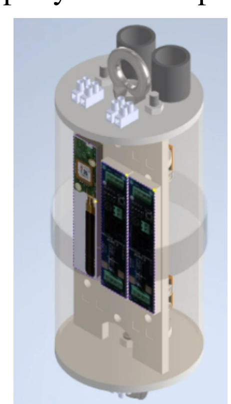
The launch vehicle uses two redundant RRC3 “Sport” Altimeters in the Electronics bay, which will activate the pyro charges. The altimeters have separate 9 volt batteries to keep the systems as separate and redundant as possible.

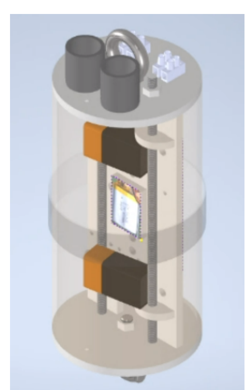


RRC3 Pinout Diagram

A switch located outside of the electronics bay turns on and off the altimeters. Wires attached to the altimeter’s pyro channels lead through the fore and aft bulkheads of the electronics bay into terminals that connect the electronic matches that activate the charges. If one altimeter or e-match fails, the other will safely ignite the charge well.

We will ensure that the bulkheads separating the electronics bay and the payload avionics are properly sealed to prevent the extreme pressures damaging our electronics.

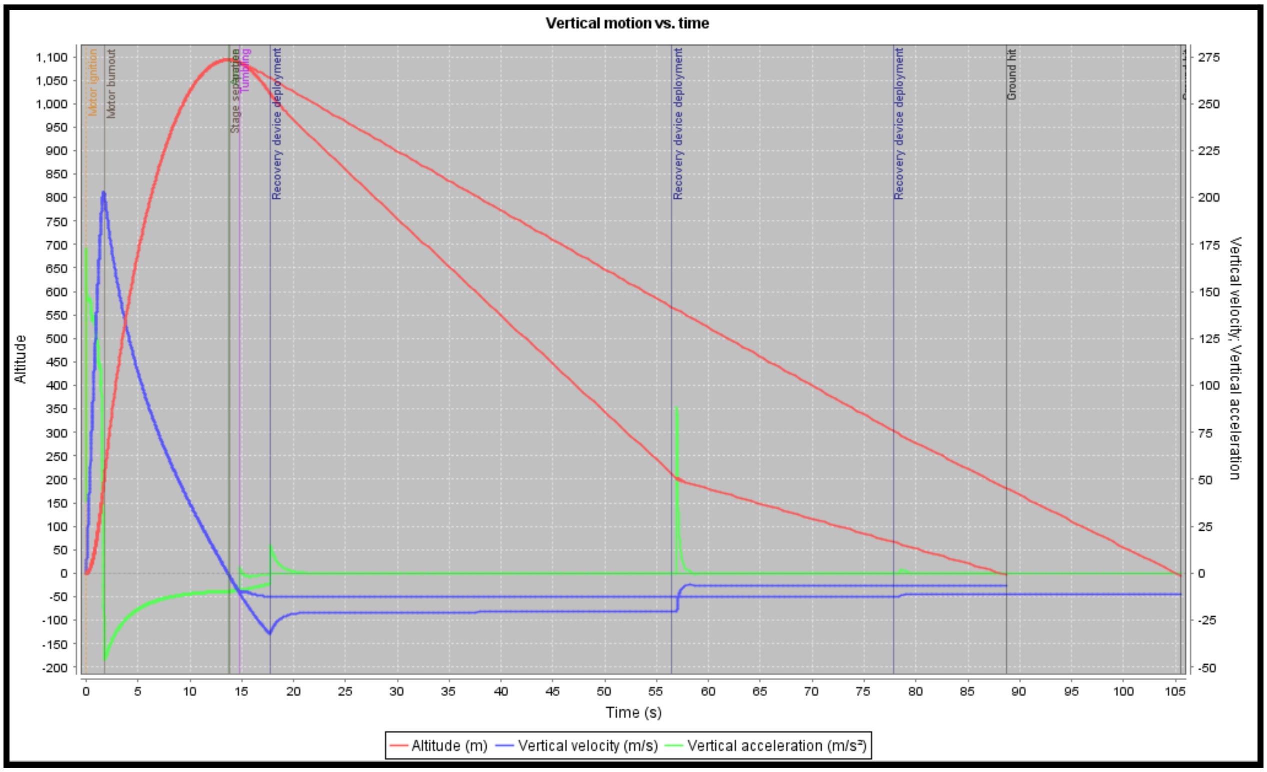




Mission Performance Predictions

The goal of the flight is to exactly reach an apogee of 3600 feet and meet all of the earlier outlined mission success criteria.

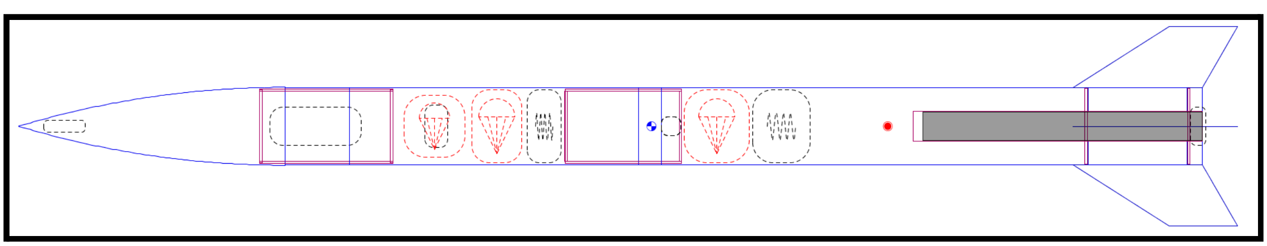
Flight profile simulations



Flight simulation of altitude (red), vertical acceleration (blue), and vertical velocity (green) over time on a Cesaroni J357-14. The lower red line represents the launch vehicle, and the upper is the payload descending under a placeholder parachute. Simulated by OpenRocket.

Note:

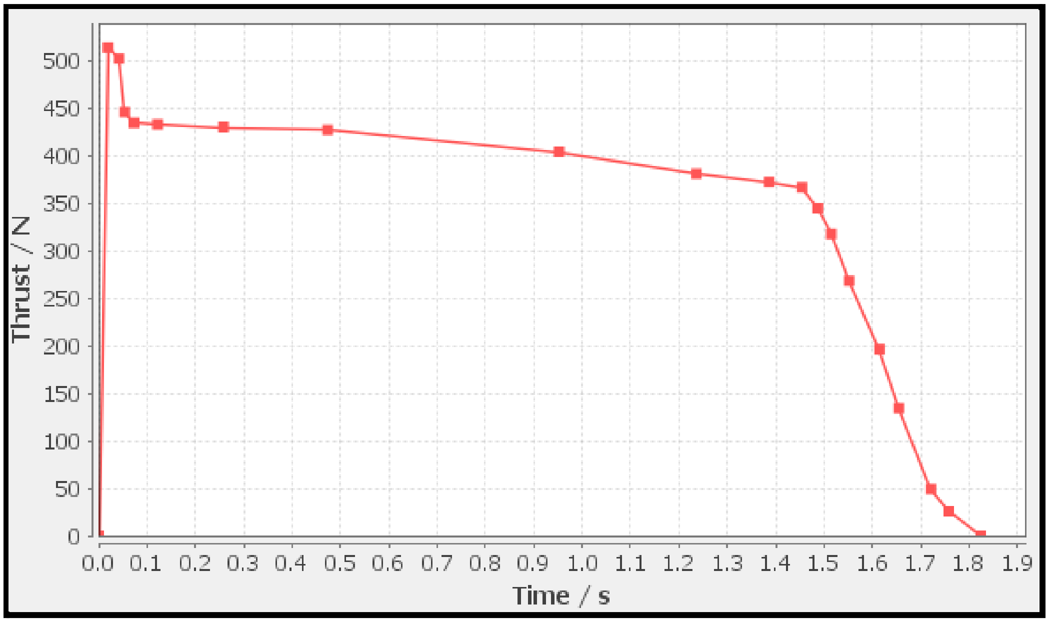
- *Figures on graph are in meters, not feet*
- *Payload (red line on far right) is under a placeholder parachute in OpenRocket, actual descent time will be less than 90 seconds using a chute release system*



Model of the launch vehicle in ready to fly configuration.

Stability, Center of Mass, and Center Of Pressure

Before ignition, the center of pressure of the rocket is located 48.43 inches from the tip. The center of mass is approximately 36.8 inches from the tip. The rocket has a stability margin of 2.94 calibers upon liftoff. The total mass with the unburned motor is 6.17 pounds.



Simulated thrust curve of the Cesaroni J357-14 motor.

Kinetic Energy Analysis

Based on openrocket simulations, the ground hit velocity is predicted to be approximately 20.8 ft/s. The spent mass of the rocket is about 5.43 lbs. Using the formula $KE = ½ * mv^2$, the kinetic energy at impact with the ground can be determined.

Subsection	Kinetic Energy (Ft-lbs)
Electronics Bay	16.21
Lower Section	9.87
Upper Section (Payload)	23.48

Kinetic energy at impact of each subsection

Wind Drift Analysis

The following table lists the drift distances in winds of 0 mph, 5 mph, 10 mph, 15 mph, and 20 mph. The drift distance was derived by multiplying descent time (89.65 seconds) by wind speed.

Drift distance using descent time multiplied by wind speed

Wind speed (mph)	Drift distance (ft)
0	0
5	650.32
10	1300.64
15	1950.96
20	2600.98

Drift distance found using OpenRocket's predictions

Wind speed (mph)	Drift distance (ft)
0	0
5	286.52
10	586.15
15	886.15
20	1181.1

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.

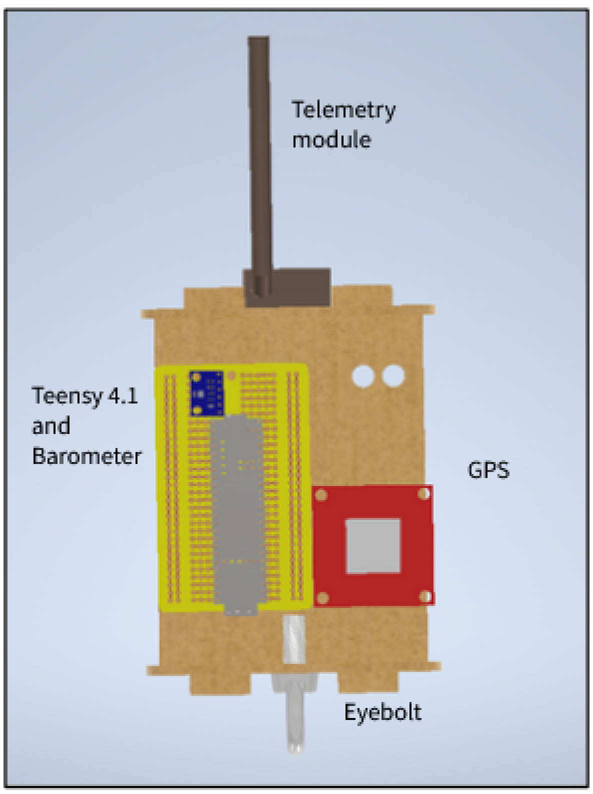
IV) Payload Criteria

Design of Payload Equipment

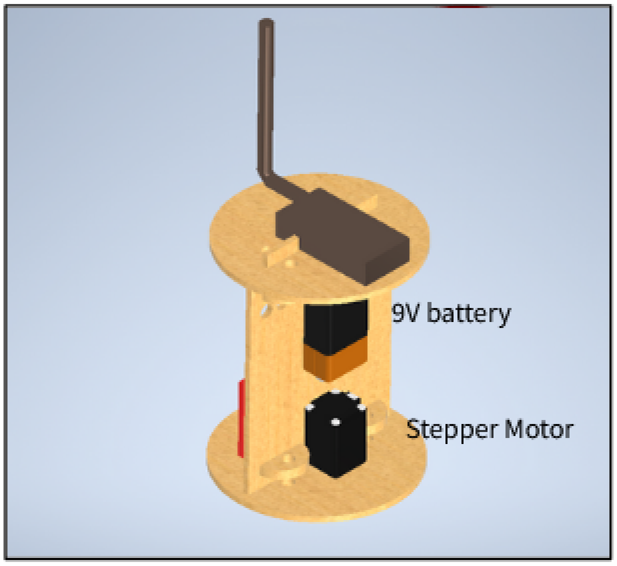
Our payload is a guided parafoil that will allow the payload section to return to a designated location within a reasonable distance.

Parafoil Design

One line of the parafoil is actuated by a winch on the aft bulkhead of the upper section. The winch is driven by a stepper motor and is contained inside a drum. If it is pulled in, air resistance will impact the opposite side of the parafoil more, causing the parafoil to turn that direction and vice versa if the parafoil line is put out. Since the PDR, two actuating brake lines were considered for guiding the parafoil. The team decided that only one actuating line would be necessary while the other line would remain fixed. This reduces the complexity of the payload while still allowing for sufficient angle change for guidance.



Payload Front View

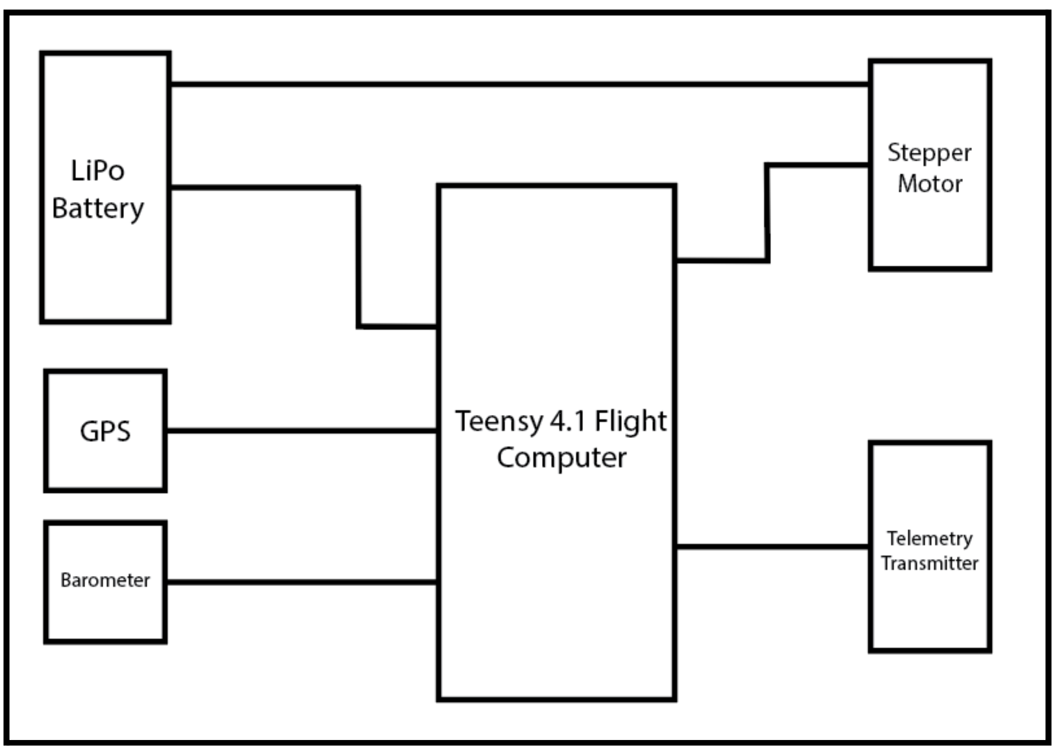


Payload ISO View

The Avionics are held on a sled pushed into the nose cone and upper section of the rocket. There is a bulkhead on the bottom of the upper section that separates the upper section from the rest of the rocket.

Payload Avionics

The parafoil and electronics are controlled by a Teensy 4.1 flight computer.

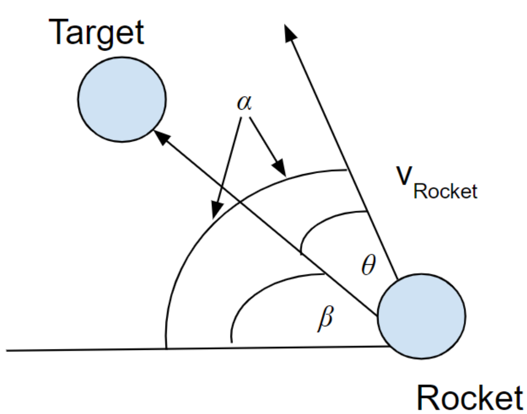


The avionics include:

- A stepper motor to control the parafoil line
- A GPS to determine our location relative to our target location
- A transmitter for override functionality and recovery data transmission (location)
- An altimeter so we know if we will fall short or overshoot our target
- A 9 volt battery to power the electronics

Parafoil algorithm:

First, we find the angle α that is the payload's (payload section) current course. Then, we find the angle β between the rocket's location and the target's location using $tan^{-1}(\Delta y / \Delta x)$. The angle θ that the payload needs to turn is $\alpha - \beta$. Once the parafoil turns θ we set the parafoil to a neutral position so it goes straight. Depending on the parity and magnitude of if θ, we will pull the parafoil line in or release it more. If we are above our target but too high we will pull the parafoil line as far in as safe so the rocket circles the target prior to landing.



V) Safety

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. 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. 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

We will test everything before the launch to make sure it will work for the real rocket. We will have a fresh battery everytime we launch and not turn on the electronics until we are ready to launch. We are also using two altimeters in case one fails.

- Rocket preparation

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

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.

- Igniter installation

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

1 - Low

2 - Medium

3 - High

Likelihood Scale

1 - Not Likely

5 - Very Likely

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 for all team members
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	Eye protection
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
Black powder explosion	Misuse of black powder	Burns, blindness	3	2	Limit exposure to 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	3	1	Make sure we are launching on a clear day with no rain

		off course			
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

Before every launch we will check our rocket to make sure everything is working correctly and we have no broken parts. We will also obey the High Power Rocket Safety Code provided by NASA.

All launch activities will be monitored by NAR officials. 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.

On the launch pad, only team members, mentors, and NAR officials will be present. 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. We will activate the electronics and drone and ensure that they are working properly with radio signals and LED displays that signify statuses. We will then load up igniters.

The team will exercise extreme caution before launching any rocket. 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.

Project Risks FMEA

Hazard	**Cause of Hazard**	**Effect of Hazard**	**Severity**	**Likelihood**	**Mitigation**
Damage during transportation	Mishandling the rocket before flight	Broken parts	3	2	Proper handling and protective case for the rocket
Broken launch lugs	Improper placement on launch rail	Unable to launch rocket	3	1	Proper installation on launch rail
Misfire	Bad ignitor	Rocket would not launch	1	3	Check ignitors before launch
Ejection charge not deploying	Problems with coding in the ejection charge, black powder, or ignitor	Parachutes would not deploy, rocket landing speed substantially increases	3	2	Check the black powder and ignitor before launching
Premature ejection	A problem with the	Damage to the	3	2	Review coding before

charge	coding	landscape, launch rail, and rocket			flight, ensure altimeters read accurate data
Parachute not inflating	Tangling of Parachute,	Increased landing velocity of Rocket, damage to hardware	3	2	Ensure parachute lines are not tangled

All team members understand and will abide to the following safety regulations:

1. Range safety inspections will be conducted on each rocket before it is flown. Each team shall comply with the determination of the safety inspection or may be removed from the program.
2. The Range Safety Officer has the final say on all rocket safety issues. Therefore, the Range Safety Officer has the right to deny the launch of any rocket for safety reasons.
3. The team mentor is ultimately responsible for the safe flight and recovery of the team's rocket. Therefore, a team will not fly a rocket until the mentor has reviewed the design, examined the build and is satisfied the rocket meets established amateur rocketry design and safety guidelines.
4. Any team that does not comply with the safety requirements will not be allowed to launch their rocket.

VI) Project Plan

Requirements Verification

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 and perform post-launch analysis. We have also ensured that our design observes NASA's design requirements, such as couplers being at least 1 body in diameter and the rocket having no more than 4 separation points.

We will record all flight data, not only as evidence of flight for NASA's regulation, but 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 via its own recovery system, the parafoil, abiding NASA's regulation.

We have redundant altimeters with separate batteries.

We will perform ground tests for our energetics 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 NASA's regulation. We will also have override control from the ground.

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.

Budgeting and Timeline

Purchased items are in bold

Item	**Description** (If applicable)	**Quantity**	**Cost**
Cesaroni J357-14 Motor	Rocket motors	3	240
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	45
GPS Unit		1	40
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
Ejection Charges/Black Powder		12	60
Altimeter	RRC3 “Sport”	2	150

Nose Cones	For Main & Sub-scale Rockets	2	50
Plywood	For fins & bulkheads	N/A	19
Maintenance Expenses	General Repairs and Replacements	N/A	200
TOTAL			1249

Funding Plan

Source	**Amount**
Organization Earnings from The American Rocketry Challenge 2nd Place Finish	1000
Membership Fees	1600
Donations and Contributions	600
Total	3200

Project Timeline

Completed events in bold

Date(s)	**Description**
Late Oct.	Submit Preliminary Design Review
Nov.	STEM Engagement Events 1 and 2
Nov.-Dec.	Build Sub-scale Rocket
Dec.	STEM Engagement Events 3 and 4
Jan 8 (DELAYED DUE TO COVID-19 COMPLICATIONS)	Launch Sub-scale Rocket
Dec. 2021-Jan. 2022	Complete and Submit Critical Design Review

(Update sent Jan 9 due to COVID-19 Complications)	
Jan.	STEM Engagement Events 5 and 6
Feb.	Finish Build Final Rocket
Feb.	Flight Test 1 (Vehicle Demonstration)
Feb.	STEM Engagement Event 7
Feb.-Mar.	Finish Build Final Payload
Mar.	Flight Test 2 (Payload Demonstration)
Mar.	STEM Engagement Event 8
Apr. 20	Huntsville Launch Week
May	Post-Launch Assessment