Critical Design Review Report

I) Summary of PDR report

Team Name: The Rocket Men

Mailing Address:

Spring Grove Area High School

1490 Roth's Church Road

Spring Grove, PA 17362

Mentor:

Tom Aument

NAR Number is 83791, Level 2 Certified

Launch Vehicle Summary

The length of the rocked is 81.95 inches, and the mass is 171.395 ounces.

Motor Choice: Cesaroni K2045 Vmax

We have a dual Deployment Recovery System with a 15 inch drogue parachute and a 72 inch main parachute.

Milestone Review Flysheet - separate document that is on the website

Payload Summary

Payload Name: Heliacal Sky

In the experiment we will have a solar panel array deployed from the rocket at apogee. The data logger will be measuring the current gathered by the solar panel while it is descending. It will continue to record data until it contacts the ground, where the change in current will stop. From the data we get, we will look for a correlation between energy and height. We hope to find a mathematical equation that compares height to solar efficiency.

II) Changes Made Since Proposal

Changes Made to Vehicle Criteria

There were little to no changes done to our Rocket. Our black powder mass was changed to about one gram per parachute. Our sub-scale launch was very successful, so no modifications were apparent that needed to be made. We will begin to build after the Critical Design Review when all of our parts are in.

Changes Made to Payload

There were many changes made to the Payload. We have simplified the payload into two systems. Of the two systems, one changed completely. Our electronics system has completely changed. This is due to our experiment needing more precise measurements. We plan on using an Arduino Uno. This device acts as a data logger once it is programmed and hooked up to an SD card. The advantage of starting the electronics from scratch is that the parts are interchangeable. So, if one part is faulty or broken, it would be able to be taken out and replaced in a timely matter.

Changes Made to Project Plan

Each aspect of the Project Plan advanced in one way or another. We met with a local business and got an official sponsor. They are paying for half of our budget, along with building kits for our educational engagement kits. They have helped us immensely and we appreciate their support and generosity.

Our presentations for our Educational Engagement have been scheduled, where team members will give presentations educating students about our project, and rocketry. We will then present them with the unique opportunity to build rockets with the SLI team.

III) Vehicle Criteria

Design and Verification of Launch Vehicle

Flight Reliability and Confidence

Mission Statement, Requirements, and Success Criteria:

Our mission as a team is to effectively design, build and then launch a rocket while improving as a team and educationally engaging students.

The rocket has been designed to travel to an altitude of 5280 feet, without exceeding that height. The rocket can be broken down into four independent sections after the deployment of the ejection charges, with all four sections tethered to each other. The rocket will not exceed the maximum number of sections allowed, as the rocket will only be capable of being broken down into the top half, the electronics bay, the payload, and the bottom half. These independent sections will all be attached to each other with shock cords. All components of the redundant recovery system (the electronics, the black powder ejection charges, the altimeter attachments to the sled, altimeter configurations, altimeter-sled mounts within the electronics bay, and altimeter arming) will be capable of being armed within two hours of the time that the Federal Aviation Administration Flight Waiver opens. The rocket can remain in its launch-ready array on the launch pad for more than one hour without any onboard components becoming inoperable. The rocket will be able to be launched from an eight-foot long 1 inch rail. The 12 volt DC firing system provided by the Range Services Provider will be the only thing needed to ignite the motors and launch the vehicle safely. This also means that the rocket will not require any external circuitry or specialized equipment from the ground other than what is provided by the Range Services Provider. The rocket motor will be comprised of an ammonium perchlorate composite propellant commercially available through the retailers of Cesaroni motors and has been approved by the National Association of Rocketry and the Canadian Association of Rocketry as fit for use in high-powered rockets. The motor that we will be using, a K2045 Cesaroni Technology motor, has an impulse of 1408 Newton-seconds, less than the maximum of 2,560 Newton-seconds as set forth by the Statement of Work. The amount of ballast flown in the rocket at Huntsville will not exceed 10% of the rocket mass without ballast. A full-scale version of the rocket to be flown at Huntsville will be launched prior to the Flight Readiness Review in its complete configuration. The full-scale version of the rocket will not differ from the rocket design approved by our safety officer and the NASA

Safety Officer. This full-scale flight should include payload testing and integration within the rocket, however, if those materials are not flown, mass simulators will be placed in the appropriate position on the rocket as to simulate the location of where the payload would be. A full-scale motor, or one that closely simulates the velocity and acceleration of the full-scale motor while inside of the vehicle, will be used in the full-scale launch. The full scale launch to be conducted before launch at Huntsville will be fully ballasted just the same as the rocket to be launched down in Alabama. A successful flight of this rocket will be documented on the Flight Certification Form by a Level 2 or Level 3 flight observer and will also be recorded in the Flight Readiness Review (FRR). The components of the rocket being launched during the full scale launch prior to Huntsville will not be modified for the launch at Huntsville, unless pre-approved by the NASA Range Safety Officer. The rocket will not make use of forward canards, forward firing motors, motors that eject titanium sponges, hybrid motors, or a cluster of motors/ multiple stages.

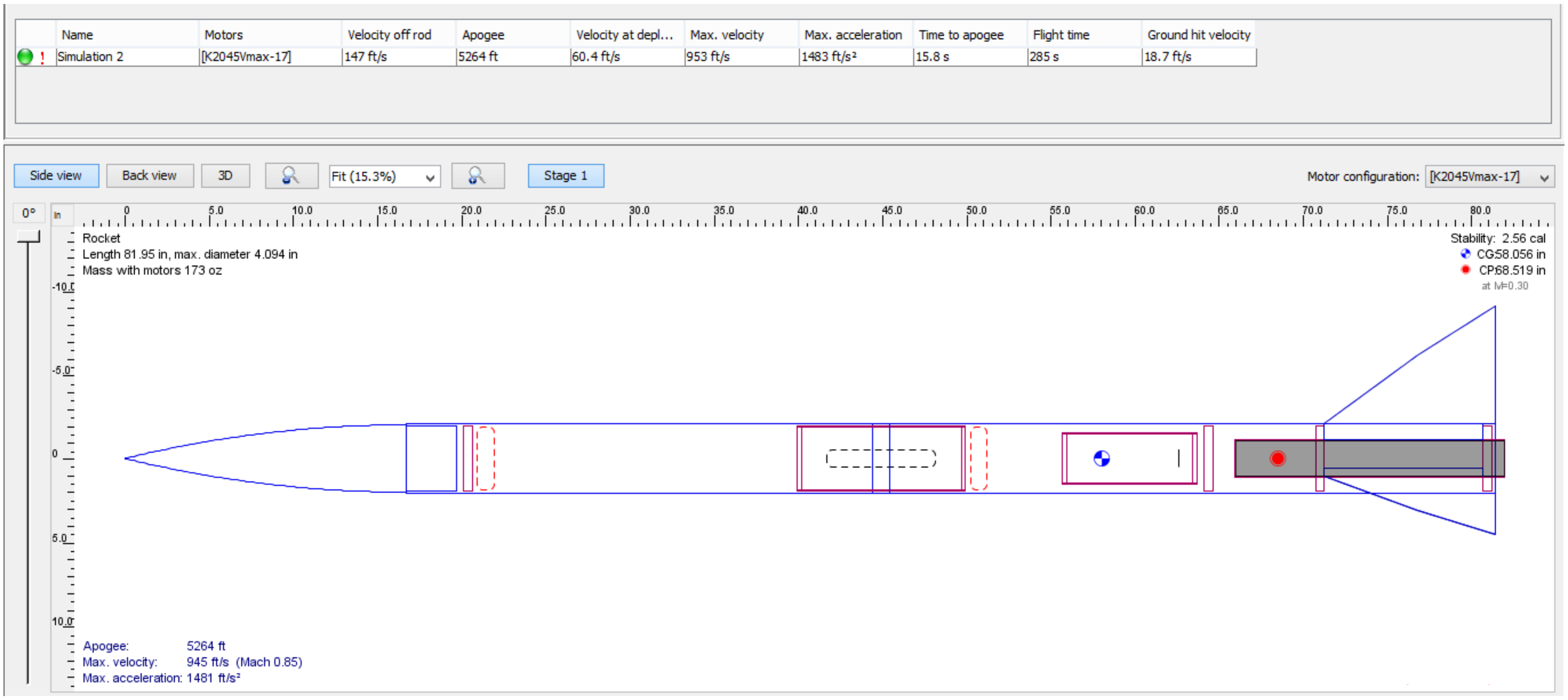
In order for the mission to be considered a success, the rocket needs to reach an altitude of at least 4800 feet, but travel no higher than 5280 feet, since we recognize that there are still uncontrollable sources of error involved with this project. The rocket must also be recoverable within a 2500 foot radius of the launch pad for mission success. The mission will also be successful if the payload collects useable data and the launch is conducted safely without catastrophic failures.

Major Milestone Schedule:

During the second and third weeks of December, supplies for the final rocket started being ordered. The design was finalized on January 5th with the approval of our team's NAR Representative; however, it is still able to be changed if NASA deems it necessary. Manufacturing has not been initiated, but will begin shortly, as components for the final rocket continue to arrive. The final rocket construction should begin no later than January 28th, with our NAR Safety Officer, Tom Aument, supervising construction. Manufacturing should begin with the construction of the electronics bay. The rest of the rocket construction will proceed with what Tom suggests should be built next. Before each step of the rocket is constructed, the team will collaborate on a plan of construction to make sure that each section of the rocket gets constructed correctly before we start using the precious supplies. This will cut down on the amount of materials being wasted and ensure that we have spare supplies, if needed. After a section has been completed, the team will assess if it was built effectively. This way, if a section of the rocket was not built in the most effective way the first time, it will be built in a more effective way if it needs to be built again.

Design Review at a System Level:

Final Vehicle Schematic/Drawings and Specifications

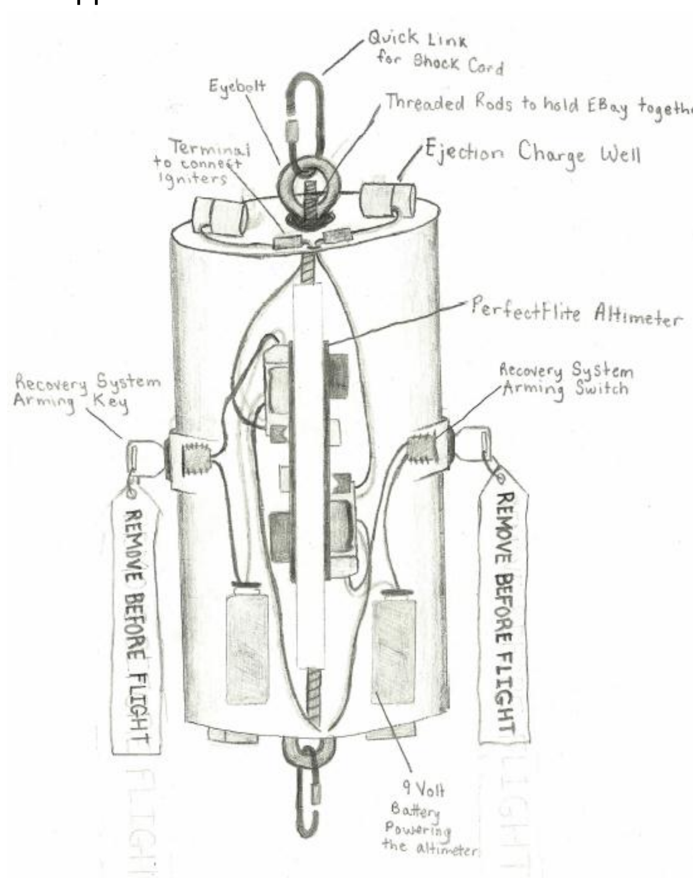


All of the systems within the rocket are designed to function well with each other to make an efficient, safe, and uniform rocket. The total length of the rocket is 81.95 in, with a body tube diameter of 4.094in on the outside, since the tube is wrapped in fiberglass for strength. The stability of the rocket is 2.56, with the Center of Gravity located 58.056 inches from the nose cone and the Center of Pressure located 68.519 inches from the nose cone. The separation between these points is 10.457 inches. The total mass of the rocket is 173 oz with the motor. The thrust to weight ratio of the rocket is 42.55, ensuring that the rocket is at a high enough velocity off the rail to not cause a problem.

Systems

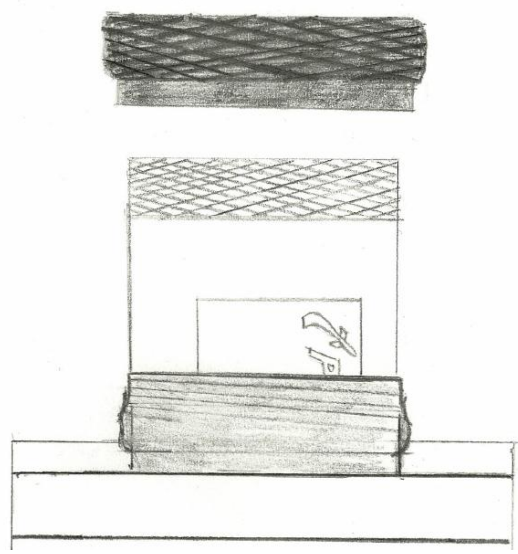
Recovery System

The recovery system is a crucial aspect of mission success. Its major components include a 72 inch main parachute, a 15 inch drogue parachute, a twenty foot section and a twenty-five foot section of 1 inch tubular nylon shock cord, two 5/16 inch thick U-bolts (with one attached to a bulkhead in the top body tube and one attached to a bulkhead positioned just above the motor mount tube), and a 3.9 inch diameter, 10 inch long LOC Precision Electronics Bay. This Electronics Bay will be the housing for our two PerfectFlite *StratoLogger* altimeters set up redundantly, and four batteries to power the altimeters and supply back-up batteries. The E-Bay will also contain a Communications Specialists Incorporated AT-2B radio transmitter which will output a signal of 222.470 MHz. This signal can be received by the two receivers that we have already purchased, which will allow us to triangulate the position of the rocket for faster recovery. On the outside of the Electronics Bay there will be a total of four ejection charges, one on either end of the Electronics Bay for each altimeter. This will ensure that the rocket can be recovered safely, by reducing our chances of complete E-Bay failure and allow for a back-up altimeter to take control of successful rocket separation if the first one fails. There will be two threaded rods that travel up through the E-Bay, which allow the Electronics Bay to be closed tightly and securely with wing nuts, so that ejection charges do not damage what's inside or provide false read-outs to the altimeter. The threaded rods double as supports for a sled that the altimeters and other electronics can be mounted to.



Propulsion and Motor Retention Systems

The propulsion system is comprised of a 2.152" Phenolic Airframe Tube acting as a motor mount tube. The motor mount tube is centered within the 3.9" rocket body tube with two ½ inch thick plywood centering rings. The back end of the centering ring is displaced ¼ of an inch from the base of the rocket body. This allows for more epoxy to secure the motor mount in position. There is half of a threaded motor retainer attached

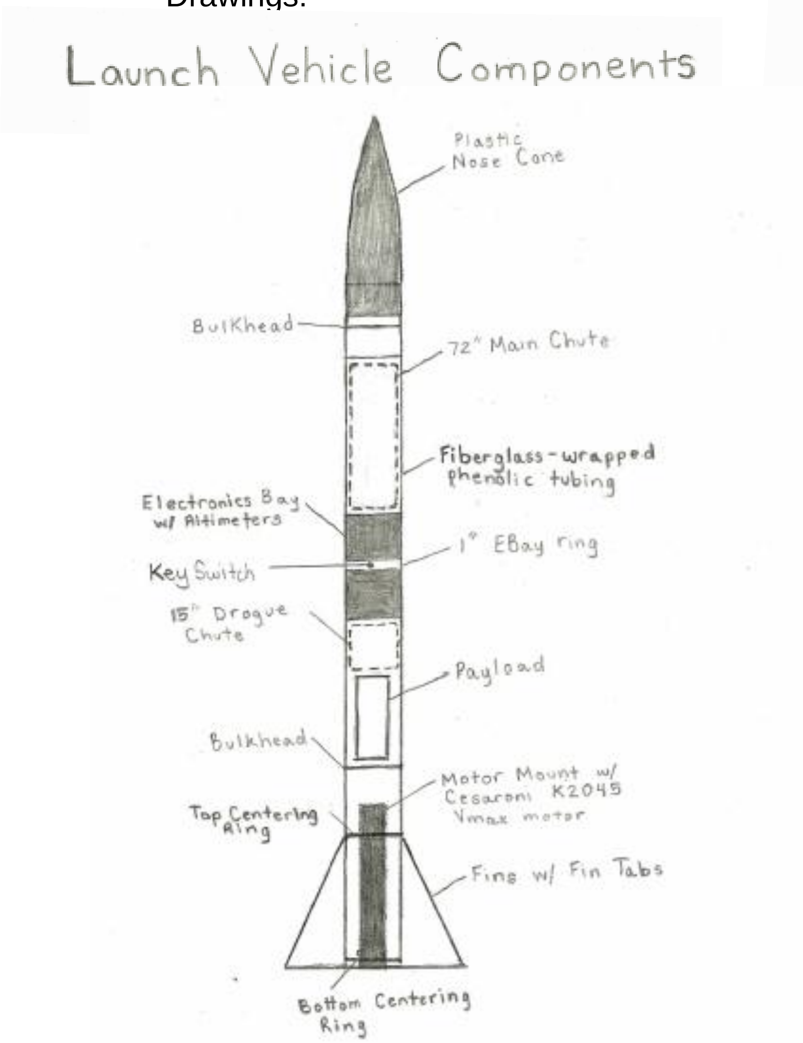


with epoxy to the motor mount tube. The motor retainer is made from aircraft-grade aluminum. One half of the motor retainer is attached to the motor mount, while the other half screws over the top of the motor retainer. The motor retainer will not interfere with what is being expelled from the motor (which ultimately makes the rocket fly), and will secure the motor into the motor mount of the rocket for the duration of the flight.

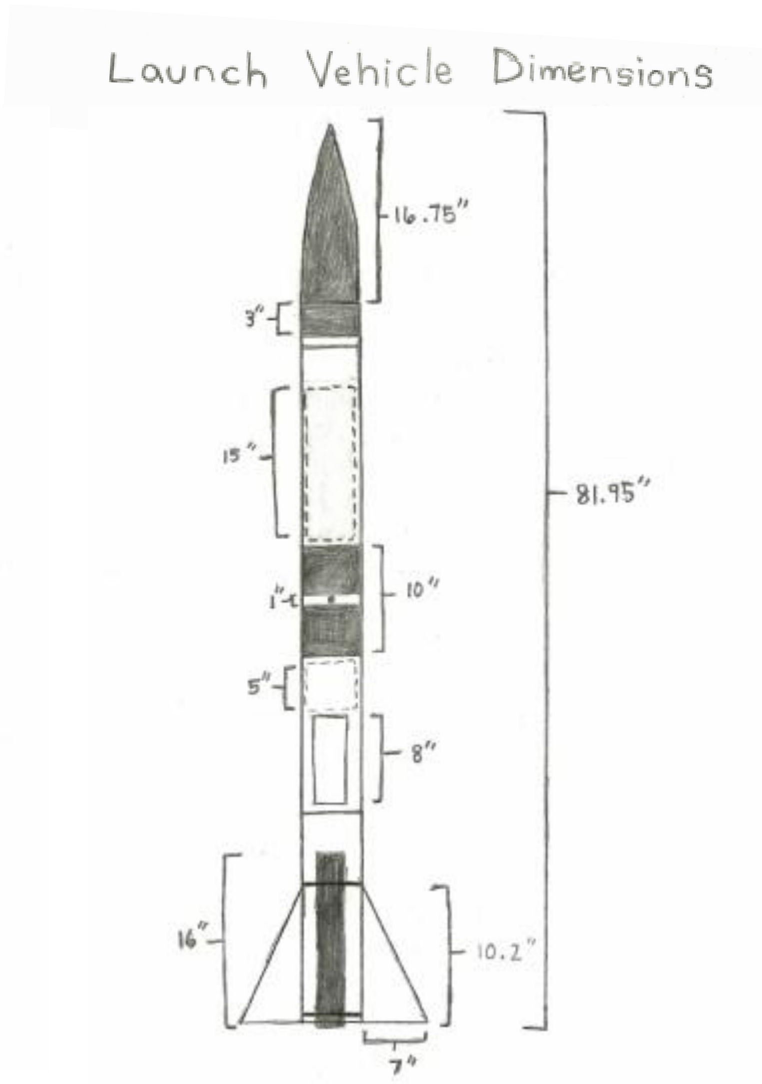
Rocket Airframe System

The rocket airframe system is another key component of the rocket. It is made up of an Ogive-shaped nose cone, Fiberglass-wrapped body tubing, and G10 FR4 fiberglass fins. The leading component of the rocket as it glides through the air is the plastic nose cone. It is smoothed to help reduce drag. The body tube is resin-impregnated spiral-wrapped phenolic airframe tubing which is sanded very smooth and covered with advertisement stickers which are fastened securely to the outside, and coated over with clear coat. This limits the amount of drag that the rocket produces as it travels through the air and should yield more accurate of results. The G10 FR4 fiberglass fins are fastened with six fill-its with four on the inside of the body tube and two on the outside. The 1/8 inch fiberglass is strong enough to resist the drag forces on it from its 953 feet/second flight or 1483 feet per second-squared acceleration off the pad. The fiberglass also provides a fire-retardant barrier so that the fins are not compromised with the burning of the motor. The fiberglass fins are very smooth as well, which reduces the drag produced by them.

Drawings:



Launch Vehicle Components
Plastic Nose Cone
Bulkhead
72" Main Chute
Fiberglass-wrapped phenolic tubing
Electronics Bay w/ Altimeters
1" EBay ring
Key Switch
15" Drogue Chute
Payload
Bulkhead
Motor Mount w/ Cesaroni K2045 Vmax motor
Top Centering Ring
Fins w/ Fin Tabs
Bottom Centering Ring



Launch Vehicle Dimensions
16.75"
3"
15"
81.95"
1"
10"
5"
8"
16"
10.2"
7"

Analysis with model results

The Sub-scale flight was a 64% scale model of the full-scale rocket. We used a G64 Aerotech motor, which should have given us a height of 1105 feet, accounting for the measured wind speed at the launch site. However, the rocket only reached an altitude of 719 feet. Because only one of the G64 motors that we had with us would ignite, we had to switch to using a Roadrunner Rocketry G80R after the first flight with the G64. With a G80R, the simulated height of the rocket was 955 feet, given the measured wind speed of 4.1 mph at the time of the first launch of the G80. The actual height of the rocket at apogee, however, was 685 feet. At the time of the second launch of the G80R motor, the measured wind speed was 2.6 mph. This should have given us a height of 956 feet. Instead, the rocket reached a height of only 696 feet. This may have occurred because of slight burning of the motor which occurred on the pad for all launches. This may have been attributed to the cold weather, making it difficult for the igniter to ignite the motor. Also, there may have been stronger wind gusts at higher altitudes, which we could not measure and account for. Based on the sub-scale test data, the full-scale rocket will reach an altitude less than what is predicted. Researching the K2045 Vmax motor intended on being used in the full-scale rocket, it is not known to burn on the launch pad for too long of an amount of time. This should reduce the amount of error and keep the rocket close to the intended launch height for the full-scale launch. The simulated center of pressure of the rocket is 44.37 inches from the nose cone of the rocket, or about one inch in front of the fins. The simulation showed that the Center of Gravity of the rocket should be 35.46 inches from the nose cone, leaving a margin of 3.32. Because our sub-scale rocket only needed one parachute, and we did not have a location to attach ballasted mass to simulate where the main chute would be in the front of the rocket, the mass to simulate the parachute had to be placed in the nose cone. This created a Center of Gravity higher up on the rocket and a larger margin of about 5.2. Although this changes the stability of the rocket, we know that the rocket would have still been stable with the simulated mass of the main chute in the correct location, because we placed it in the correct location to measure where the center of gravity would have been. If the ballast had been in the correct location, the stability of the rocket would have been an estimated 3.5, higher than the simulated margin.

Test Description and Results

One test that has been conducted is the subscale rocket test flight. The purpose of the sub-scale test flight was to determine if the full-scale rocket’s stability would be great enough to complete a full-scale launch safely and effectively. Also, the subscale test could tell us what effect that the environment would have on the rocket versus the simulated data. The rocket was scaled down to a 64% model of the full-scale rocket and built with mass simulators located in regions of the rocket to simulate parts than can only be tested in the full-scale rocket. Mass simulators were used for the payload and for the main parachute. The rocket was launched three times at Penn Manor in Lancaster County, Pennsylvania. It was launched from a 1010 launch rod, which was eight foot long. The motor was ignited using a nine volt standard ignition system. The subscale rocket had a simulated mass of 1009 grams without a motor on OpenRocket. Once the rocket was finished being constructed, it had a mass of 1043.9 grams without the motor, larger than what had been simulated. The rocket was launched using a G64 Aerotech motor the first time. After the first launch, the other G64 motors refused to ignite, forcing the team to switch to G80R Roadrunner back-ups. The flight yielded great results with three flights that all were stable and landed safely.

Another test that has been conducted is the testing of black powder ejection charges to separate the rocket body. First, the ejection charge wells were filled with 1.5 grams of black powder, calculated to be the amount needed by a team member. Tom Aument, the team's Safety Officer and NAR Representative, conducted the tests out of concern for safety of the team. The first test with 1.5 grams of black powder successfully separated the rocket; however the rocket was separated with a large amount of force, too great for what is needed. After the first test results were observed, another test using 1.0 grams of black powder was conducted. Ejection charge wells on both sides of the EBay were filled with one gram of black powder and ignited. Both sides had separation with the right amount of force that we needed.

Final Motor Selection:

The final motor selection for the rocket to be launched down in Huntsville Alabama is a Cesaroni Technology K2045 Vmax Pro 54 4 grain motor. The backup motor selection is a Pro 54 4 grain Smokey Sam K530 motor, made by Cesaroni Technology Inc. The K2045 motor was selected on the basis that it could deliver the rocket to the desired altitude, while providing a large impulse, so the rocket is not as affected by the environment. The K530 Cesaroni motor was selected because it is the motor with the closest impulse to the K2045 and is also produced by Cesaroni, a company that our team puts much trust into.

Fulfillment of System Level Functional Requirements:

The recovery system will be capable of discharging the 15 inch drogue parachute at apogee by igniting the ejection charge which will cause the separation of the of the top and bottom body tube. It will also be capable of releasing the 72 inch main parachute at 600 feet above the ground during the rocket's descent. It will separate the top body tube from the electronics bay as well. There will be second ejection charges, in the event that the first charges do not fire or the tubes are not fully separated. The altimeter is capable of recording apogee and then audibly emitting the height. The recovery system will be able to check for continuity within the components and itself. It is planned to have a device that will produce a signal of 222.470 MHz, which will be received by a tracker to expedite rocket recovery. This tracking device was made by Communications Specialists Inc. The entire recovery system must be able to separate the three parts of the rocket without damaging any components. The altimeter, a PerfectFlite *StratoLogger*, was chosen because it is capable of achieving all requirements.

The motor retention and propulsion system should be capable of propelling the rocket and its components to a simulated maximum altitude of 5279 feet. The intention of our design is to enable ignition with a standard 12 volt igniting system. It shall be capable of retaining the motor during the entire flight and facilitate easy insertion and removal of the motor, while preventing its unwanted release. The motor was chosen to complete the task of getting the rocket to one mile. It was selected because it is commercially available and able to propel the rocket to the height given the dimensions and weight of the rocket. The rocket body will be the housing of all the parts necessary for launch, other than the ignition system and launch equipment. It will provide stability to the entire rocket. The airframe is smooth and aerodynamic. It has little air resistance, even though it contains key switches on the electronics bay. These key switches are designed specifically for rockets and are relatively so that they can be somewhat aerodynamic. The recovery system should deliver the rocket safely to the ground and ensure its reusability. The airframe should maintain the flight path with little deviation from it. The fiberglass-wrapped phenolic tubing, from Public Missiles Limited, was chosen because the rigidity and strength will allow it to complete the task at hand. The fins are being manufactured from 1/8 inch G10 FR4 fiberglass sheets due to its ability to withstand the high velocities the rocket will attain while not melting or breaking due to the high intensity heat that the motor will expel.

Approach to Workmanship:

In order for the team to be successful with the completion of this project, we must collaborate with each other and follow reasonable requests of supervisors/ advisors. Without this collaboration and cooperation, the project will not be completed. Hard working individuals are what the team seeks in order for the project to be completed correctly. Without these qualities within team members, the project will not be completed in an efficient and timely manner, leading to project failure. In order to ensure that good workmanship is being received from each member of the team towards the project, weekly meetings are held, where the team discusses progress on each section of the project which was delegated to them. If a team member is found to not be holding up to their part of the project, the team member will conference with team advisors and be asked to contribute more to the project or be relieved from the team. Only one team member has been relieved from the team for not contributing to the progress of the project. This serves as an example to other team members as to what may happen if they choose to not contribute to the success of the mission.

Additional Component Testing:

At this point, the team has completed the functional testing of the subscale rocket and therefore the rocket airframe. We plan on testing the bulkheads within a section of the body tubing using the West Systems Epoxy as a bonding agent. This test should confirm that a bulkhead secured in the tube with the same epoxy that we intend on using for the full scale rocket is strong enough to withstand ejection and descent. The proposed method of testing is attaching a bulkhead inside a small section of body tube with West Systems Epoxy. From there, a large mass would be placed inside of the body tube on top of bulkhead after the epoxy has finished drying. The body tube, bulkhead, and mass would then be dropped onto a force plate to measure the amount of force that is being stressed on the bulkhead. Larger heights and masses will be used until either the bulkhead breaks free of the inside of the rocket body tube, or the force exceeds an amount determined to be "reasonable," for its intended use inside the rocket. Testing will need to be conducted on both the recovery system electronics and payload electronics, once those components arrive and are assembled. Once the recovery system E-Bay is assembled, the team will test it to see if the E-Bay can be correctly powered up with the key switches. This will be tested using a voltmeter to check to see if an electrical charge is sent to ejection charges once the altimeter is programmed to do so at an extremely low test altitude.

Status and Plans of Additional Manufacturing and Assembly:

All parts of the final rocket have not yet been received. Once more parts arrive, the team will begin construction. Construction shall begin no later than January 28th. Most Rocket airframe supplies have been received, along with some recovery system components. As for the motor retention/ propulsion system, everything but the motors has been received. The manufacturing of the rocket will begin with the assembly of the recovery system Electronics Bay. Eyebolts for the recovery system have been received; however, they were too large of eyebolts, so the team is planning on picking up 5/16" U-bolts from a local hardware store in order to reduce the amount of time it takes to order and have new eyebolts shipped. The fins will be cut out with a router with a specialized bit on it made for trimming excess material off from around tables when surfaces are being placed on them. This will be easy to accomplish after a form for the fins has been made. The one half inch centering rings are being designed on a SolidWorks file so that they can be routed out on an automated router which accepts files from a computer to know where to cut. This will give us a more precise fit for the centering rings within the body tube. Also, the motor mount tube will fit better within the center hole in the centering ring. The 1 inch tubular nylon shock cord will be cut to length and the team will either put a hole in the center of one end with hole reinforcements, or a loop will be sewn onto one end of the shock cord so that the U-bolt can be placed through the loop and fastened shut.

Integrity of the Design:

Fin Shape and Style

The fins have been shaped on OpenRocket to match the needs of the rocket based on stability and height achieved. The fin style was selected for the same reason. The almost triangular shape of the fins allow them to reduce drag and propel the rocket higher, while forcing the Center of Pressure to the back of the rocket and increasing stability.

Material Usage in Fins, Bulkheads, and Structural Elements

The material being used for the fins is one eighth inch thick G10 FR4 Fiberglass, which was selected for its durability under large amounts of stress. It is also fire retardant, so it will not be affected by the high-intensity of heat that the Vmax motor emits. It will be used in a manner that will prevent malfunction of the fin system on the rocket, as the fins will contain tabs, which allow for more points of attachment onto the motor mount tube.

The bulkheads will be made from ½ inch plywood, and will have two holes drilled through it to allow for a U-bolt to be attached through them. Plywood bulkheads will be cut out on a CNC Router, which can deliver precise cuts into the plywood for very accurate fits within the rocket body tube. The bulkheads will be attached with epoxy within and as perpendicularly as possible to the inside of the rocket body tube.

The body tube is made from fiberglass-wrapped phenolic tubing. The body tubes have been purchased, with the factory (PML) having already cut them to the correct size with the correct size fin slots. This limits the amount of error that can be made while manufacturing the rocket. The rocket body tube without slots and is about 27.7 inches in length will be used as the top body tube for the rocket, and will contain components of the rocket which belong there. The body tube that is 36 inches in length and contains fin slots will be used as the bottom body tube. The motor mount, with fins attached through the body tube will be secured to this section of the body tube, with components placed in their correct locations. This section of body tube will also contain the payload and a bulkhead for the shock cord to be attached to.

Assembly procedures, attachments, and loading paths

The electronics bay must be assembled in a specific way, in order to limit any interference with other components of it. The key switches on the outside ring of the E-Bay have a long section protruding into the center of the E-Bay. In order to eliminate interference with these key switches, two precautions must be taken. First, the key switches must not be placed 90 degrees from each other. Instead, pairs of key switches will be placed next to each other, with the center of both pairs at 180 degrees to each other. This will allow for the protruding part of the key switches to not interfere with the sled or altimeters which must come down into the E-Bay by sliding it down the two allthread rods.

The motor mount must be assembled in a very specific method. Before fins are attached to the rocket, the top centering ring must be attached at its correct location on the motor mount tube just above where the top of the fin tab will end up. Once this is complete, the motor mount tube and centering ring will be slid up into the bottom of the rocket into its correct position. The centering ring should end up just above the top of the fin slots. After this has been completed, this centering ring will be attached with more epoxy to the inside of the body tube at this location. Following its drying, the fins will be inserted through the fin tab slots with the fin tabs resting against the motor mount tube. When this is completed, the fin tabs will be attached with epoxy fill-its on either side of the motor mount tube up against the motor mount tube and on the inside of the rocket body tube. As soon as this is completed for every fin, the aft centering ring will be slid up into position, and followed up by a large amount of epoxy to keep this centering ring in. On the outside of the rocket, two more fill-its for each fin will be placed on either side of each fin along its base to secure the fin in even more.

For the recovery system, shock cords will be attached to the U-bolts and eyebolts before being sewn in order to form a secure connection to the U-bolts. Once the U-bolts are attached to the bulkheads and secured into the body tube, it will be more difficult to attach the shock cord to these components as they are more difficult to access.

In order to ensure correct attachments, epoxy will be applied to all cracks and crevices in component junctions to ensure that those components junctions will not fail. A final inspection of the rocket by our NAR Representative will yield whether or not all junctions are connected correctly with little room for failure.

When loading the rocket, after all parts have been manufactured and attached, there is a procedure that must be followed. The shock cord below the payload will be forced down into the bottom of the rocket, followed by the payload. The remaining shock cord will be placed on top of the payload along with the folded drogue chute and wadding to ensure that payload components, the parachute, and shock cording is not compromised. After those components are in the bottom, and the ejection charge wells have been loaded, the recovery system E-Bay will be loaded into the bottom tube. In the top half of the rocket, the main chute will be folded and inserted, followed by all shock cording and wadding to prevent the parachute and shock cords from being damaged.

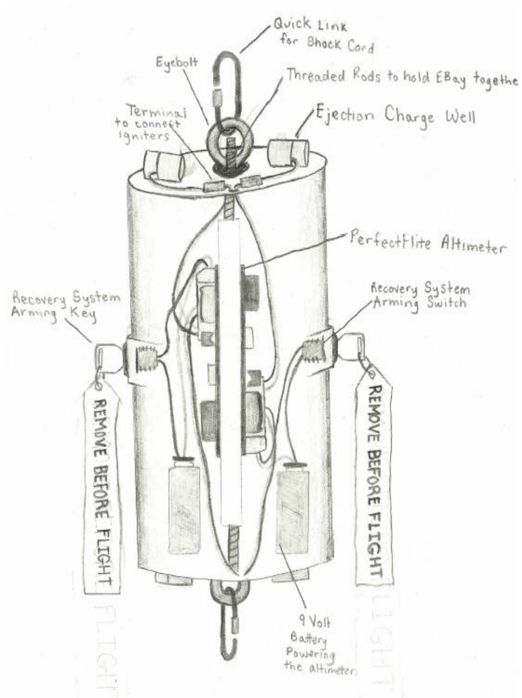
Sufficient Motor Mounting and Retention

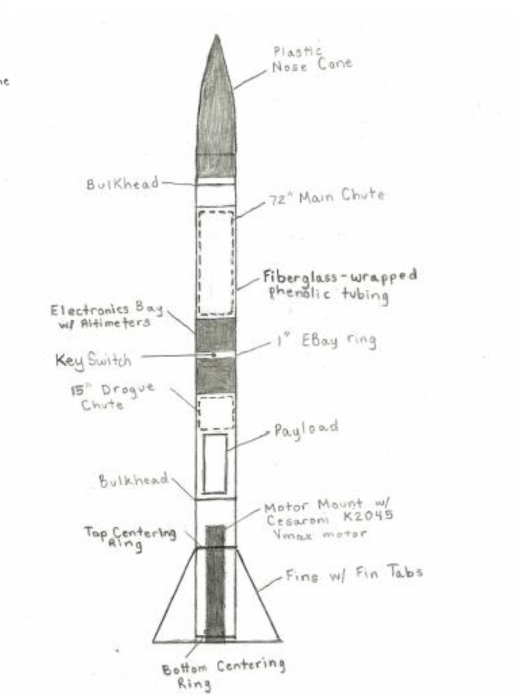
In order to ensure that the motor stays in during flight, there must be methods of preventing the motor from going up into the rocket, or coming out of the back end of the rocket. In order to stop the motor from going up into the rocket, a correctly sized motor mount tubing was chosen so that the lip of the motor will not pass a certain point. The motor mount tubing will be secured to centering rings, which will have epoxy on both sides where the motor mount has a junction with the centering rings. The fin tabs also interfere with the free movement of the centering rings and motor mount tube. This prevents the motor mount from moving up or down within the rocket. The aft centering ring is displaced ¼ inch in from the back end of the rocket in order to allow for more epoxy to be placed in here. This will reinforce that centering ring, decreasing the chances of motor mount failure by even more. To prevent the motor from coming out the other direction, a 54 mm motor retainer will be used. This motor retainer comes in two parts. One part contains male threads and is attached with epoxy to the end of the motor mount tube, with the threads facing away from the rocket. This will allow for the other part of the motor retainer to be screwed down over top of this part, once the motor has been inserted.

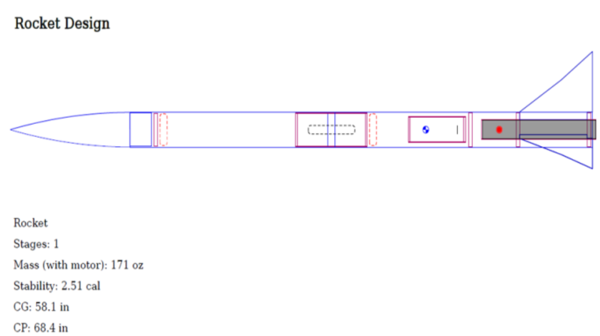
Status of Verification

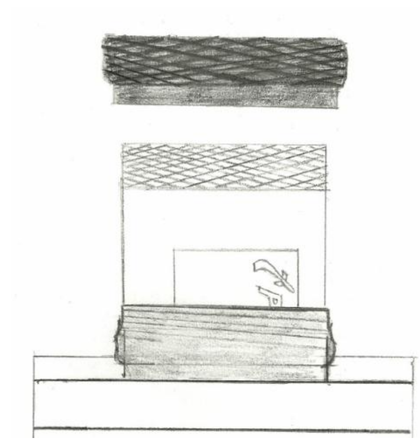
The requirement stating that rocket must deliver a payload to, but not exceeding 5,280 feet has not yet been verified other than by OpenRocket, a rocket simulation program. This requirement will be verified later, during the full-scale rocket launch prior to the FRR. The speed of the vehicle has also been verified to not become supersonic, as it is far from supersonic on OpenRocket at .84 Mach. This will later be confirmed by the full-scale launch. The recovery system has been verified to deliver the rocket safely to the ground, as the rocket was scaled down to 64% of the full-scale size and mass, and the parachute was scaled down accordingly. The parachute used during the subscale launch was even less than that of the scaled down main parachute size, yet it delivered the rocket safely to the ground. This requirement will be verified further during the full-scale rocket launch. The rocket has been verified to separate into no more than four independent sections, as the subscale rocket contained only two independent sections, and the full-scale will contain four. It will not have any more independent sections than the top half, the E-Bay, the Payload Bay, and the bottom half. The rocket has not yet been completely verified to be capable of being prepared for flight within two hours of the Flight Waiver opening, but it has been designed to be easily constructed, with key switches to easily power up the E-Bay and a Payload Bay that can be powered up and easily inserted into the rocket. The launch vehicle has also not been verified to be able to stay on the launch pad for one hour, although values have been calculated for pad stay time to be an estimated one hour and thirty minutes. The pad stay time will be confirmed further once the supplies for the altimeter, tracking device, and payload electronics are received and assembled. The rocket has been verified to be compatible with a 1010 rail, with the testing of the intended launch lugs on a 1010 rail. The rocket has been tested to be compatible with a standard 12 volt firing system with the testing of our subscale rocket. The same igniters that will be used on the full-scale rocket were used on one of the subscale rocket launches. The igniter lighted successfully with a 9 volt power supply, thus a 12 volt power supply should yield the same results, if not better results. The rocket has also been confirmed to require no external circuitry, with the analyzing of electrical components of the rocket. The altimeters, tracking devices, and payload electronics all are self-contained with the rocket airframe and do not need external circuitry to function. The motor choice for the rocket will also use a commercially available rocket, confirmed to be certified and approved by the National Association of Rocketry and the Canadian Association of Rocketry. Both organizations certify that maximum impulse of the rocket motor is 1417 Newton-seconds, less than the maximum of 2,560 Newton-seconds. The amount of ballast needed in the final rocket at this point is zero, which means that the amount of ballast in the final rocket shall not surpass the maximum of 10% of the unballasted rocket mass. The full-scale rocket has not yet been tested and recovered, but will be once it has been assembled. Rocket launch dates and locations have already been selected. The rocket has been verified to not use forward canards, forward firing motors, titanium sponges, hybrid motors, and multiple stages or clusters as these were not used in the subscale launch or incorporated into the design of the rocket.

Drawings of Launch Vehicle, Subsystems, and Major Components









Mass Statement

The total mass of the rocket is estimated to be 173 oz. To make the rocket unable to launch due to how heavy the vehicle is, you would have to add 195 oz. This will give you a margin of 1.10. The estimated mass of the airframe system is 76.64 oz., while the propulsion system is estimated to be about 52.37 oz., and the recovery system is estimated to be an additional 24.959 oz. The last system, the payload, is estimated to be about 14.836 oz. These masses have been determined based on manufacture mass data, density estimates and volume, and additional mass has been added to the rocket based on the estimated amount of epoxy that will be used to secure components of the rocket together. The mass estimate is about 75% accurate, because many of the rocket components have had masses based on manufacture-supplied data. However, exact mass growth because of epoxy application has not been tested and the estimated mass of the epoxy may not be as large as it should be for a 25-33% mass growth. We are expecting that the mass of the rocket will change, and even grow. As we begin more strength tests and epoxy mass testing for the size of this rocket. We expect the mass of the rocket to grow at least 35 oz, however we could see a growth in the mass of the rocket of as much as 42.75 to 56.56 oz. To make the rocket unable to launch due to how heavy the vehicle is, you would have to add 195 oz. This will give you a margin of 1.10. We are not expecting a decrease in the mass of the rocket as the design matures into a final product, because mass estimates were calculated as close as possible to their expected values, and the mass of the rocket is expected to increase as a direct result of underestimating the mass of epoxy, the payload and recovery system bay electronics, and smaller, yet functional, components within the rocket such as washers for eyebolts. The mass growth between the simulated subscale rocket and the actual subscale rocket was 39 grams. If the full-scale rocket increases by the same percentage mass as the subscale, it would increase by 60.9 grams from the simulated rocket mass.

Safety and Failure Analysis:

There is not much room for failure with the rocket. Potential methods of failure with the rocket would be if either parachute fails to deploy, components of tracking devices, altimeters, or payload electronics are sheared off under the large acceleration of the rocket, igniters fail, parachutes entangle with one another, the payload fails to eject, the rocket fails to reach one mile or travels over one mile, the motor is not assembled correctly, the Electronics Bay fails to prevent pressure from entering, so electronics are damaged, the payload doesn't collect usable data, the drogue parachute ejects before apogee, the main chute ejects at apogee, the main chute ejects before 600 feet, both altimeters malfunction, the shock cord becomes damaged or weakened by the ejection charges, a motor has a catastrophic failure, the rocket body tube zippers under the stress of the shock cord against the wall of the body tube, the electronics short-circuit, the rocket body tube combusts from the motor or ejection charges, or the rocket doesn't leave the launch rail. The team has worked to resolve all of these issues, under the direction of the NAR Safety Officer, Tom Aument. Most problems were resolved with specific design features, such as a redundant recovery system, strengthened body tubing, or integrating the payload neatly with the rocket. Preventing these problems from arising will also prevent any safety hazards. Additional Safety concerns could be attributed to, but are not limited to: injury from a coping saw, exacto knife, or power tools, allergic reactions to chemicals being used in manufacturing, electrocution during electrical outlet usage, accidentally adhering materials to one's self while using adhesives, tripping or falling, burns from soldering iron, or premature motor ignition. These safety concerns are being addressed with warnings of caution before tools, adhesives, or electrical outlets are used. Students are advised to be extremely cautious when working on the rocket, and are instructed to follow safety guidelines for all tools or chemicals being used.

Subscale Flight Results

Flight Data:

The primary subscale motor was a G64 Aerotech, and the secondary a G-80 Roadrunner. Both were set at a seven second delay. The parachute was a 36 in hemispherical rip-stop nylon chute. The margin of stability was estimated at 5.2, with the center of gravity 38 cm. All of our launches were overstable, because the simulated mass for the main chute had to be placed in the nose cone.

Launch #1

On the first launch we used a G-64 Aerotech motor with an impulse of 115 Newton-seconds. The propellant weight was 60 g. The average thrust of the motor is 64 N. The subscale reached apogee at 719 feet, safely returning in 40.20 s. The wind speed was 2.7 mph during launch, causing the rocket to drift about 100 yards from the launch pad.

Launch #2

The second launch was with a G-80R Roadrunner motor. The rocket reached apogee at 685 feet, and returned to the ground in 41.44 seconds. The wind speed was

4.1 mph at the time of the launch, causing the rocket to drift about 120 yards from the launch pad.

Launch #3

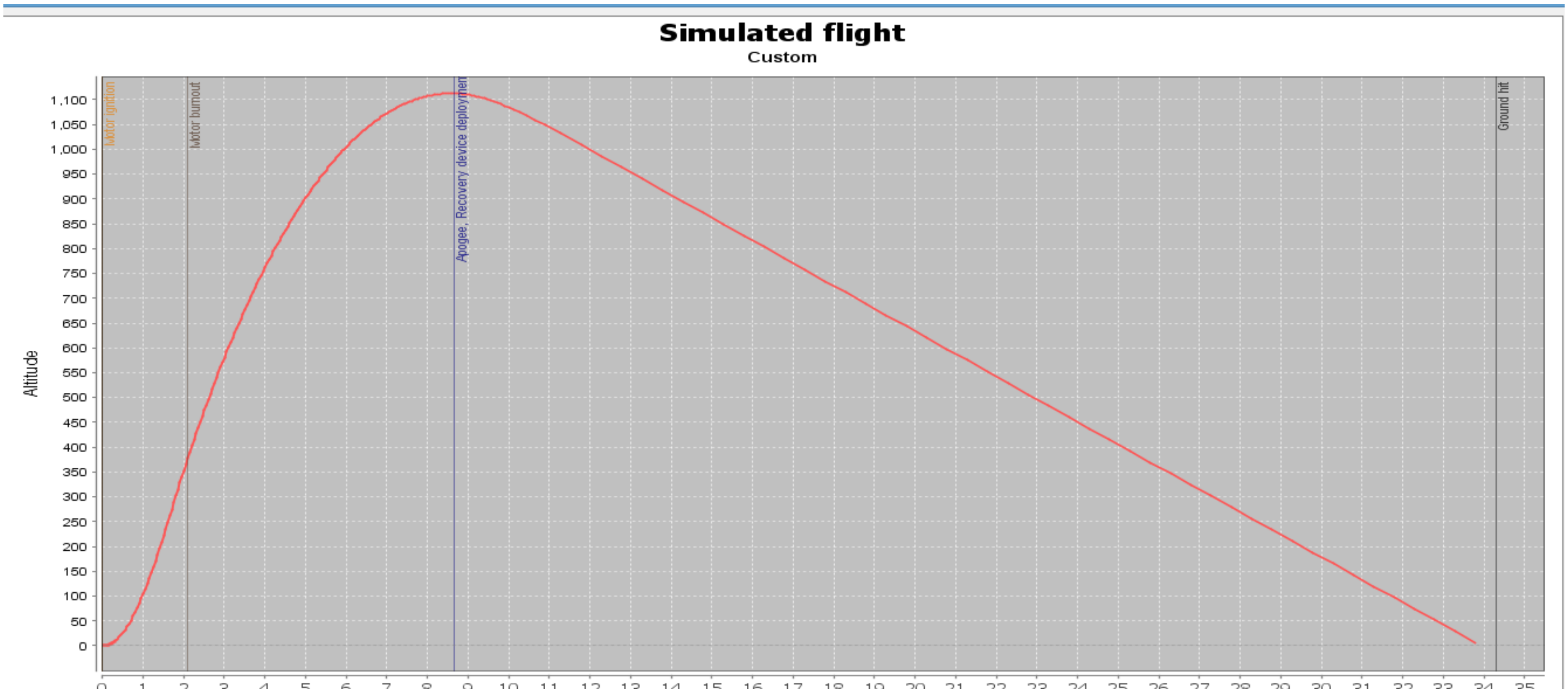
In the third launch, the team again used a G-80R Roadrunner. It reached an altitude of 696 feet returning to the ground in 37.82 seconds. The wind speed was 2.6 mph, and the rocket drifted about 30 yards from the launch pad.

Section 2:

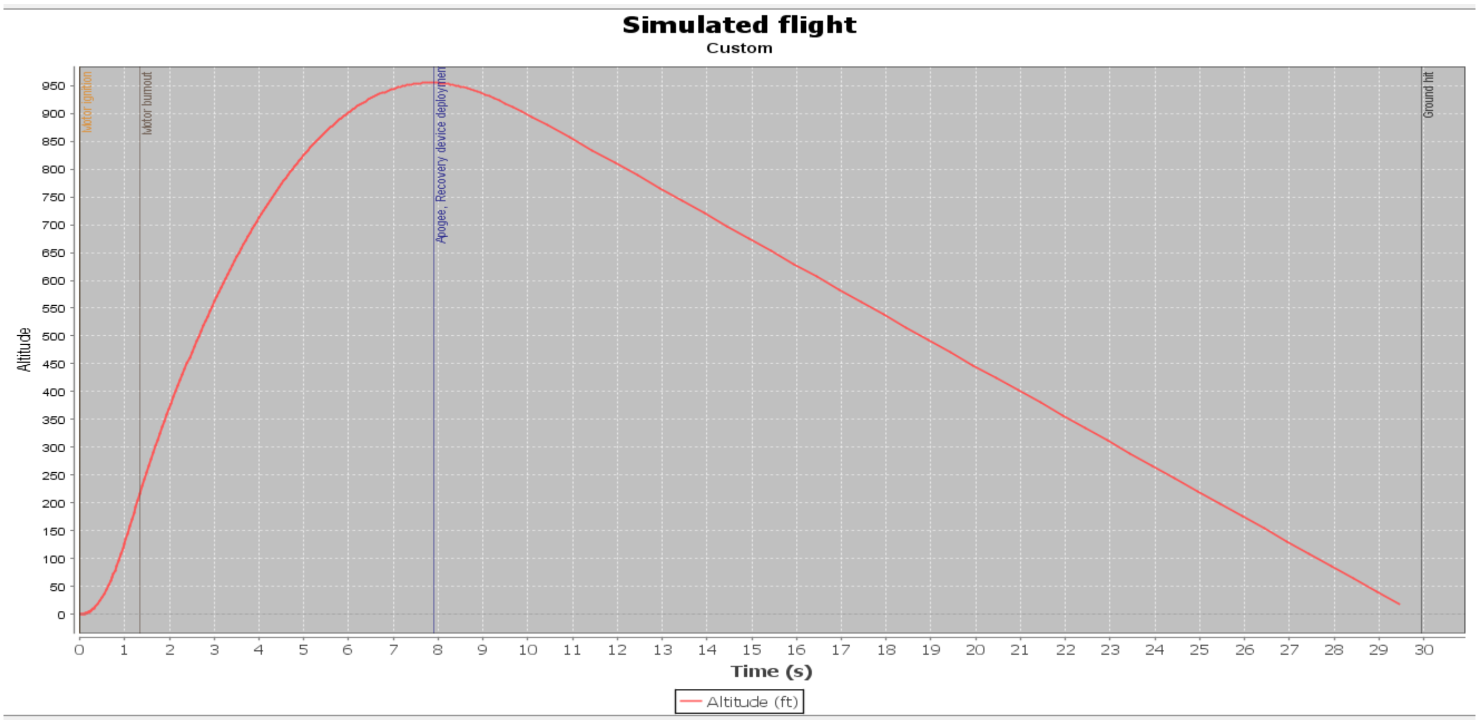
Subscale Comparison

The subscale was designed and simulated on OpenRocket. The simulated mass of the subscale without a motor was 1009 grams, while the actual was 1043.9 grams. The predicted apogee was 1113 ft, while the actual was 719 ft. The predicted drift was 99 ft, while the actual was 300 ft. The predicted ascent velocity and descent velocities were 265 ft/s and 45.2 ft/s, respectively. The actual descent velocity of the rocket with the spent G64 Aerotech motor was 23.1 feet/ second. The actual descent velocity of the first rocket containing the G80 Roadrunner motor was 18.9 feet/ second. The actual descent velocity of the second launch with the G80 Roadrunner was 19.2 feet per second.

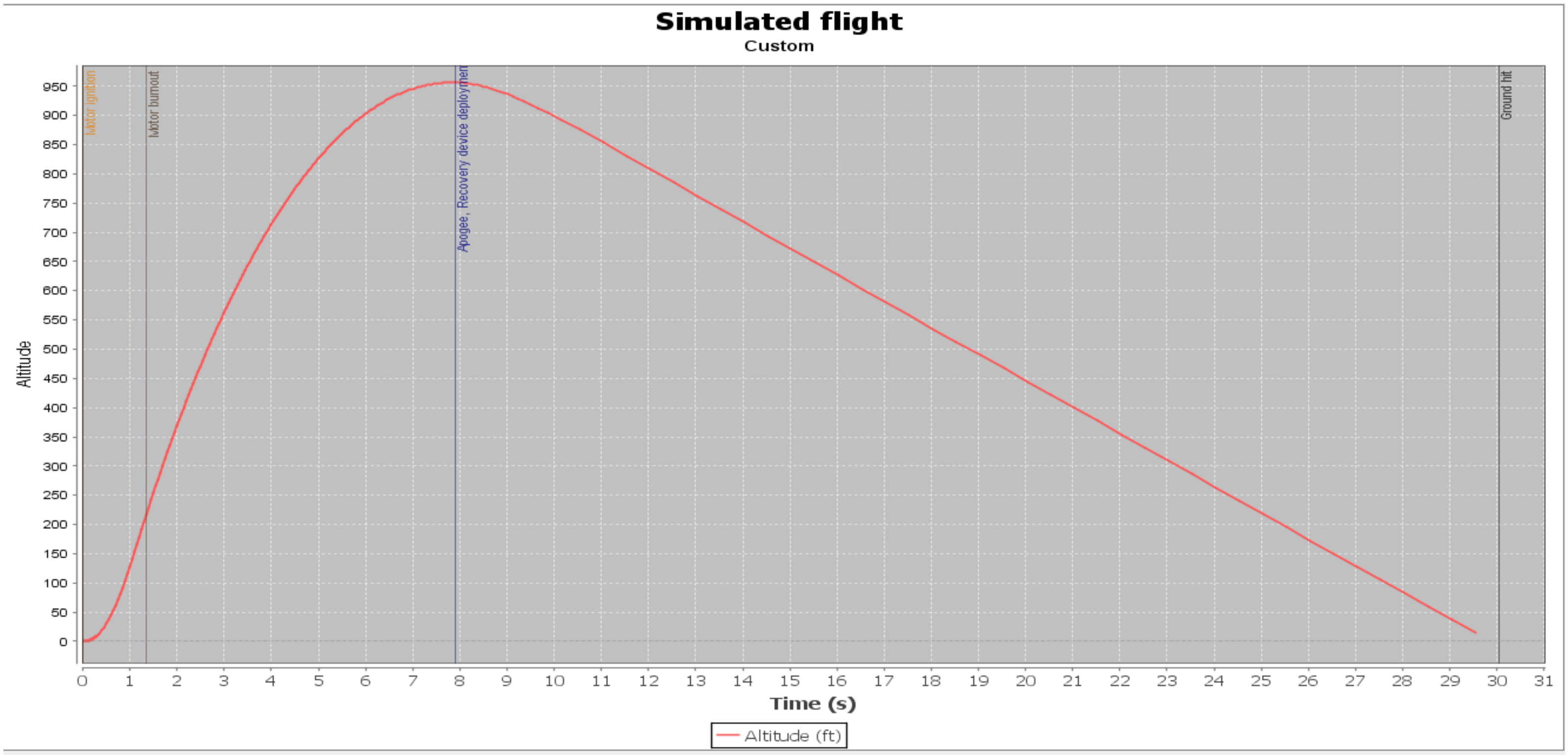
Predicted Altitude vs. Time Graph for the G64 Aerotech motor with 2.7 mph Wind



Predicted Altitude vs. Time Graph for the G80 Roadrunner motor with 4.1 mph wind

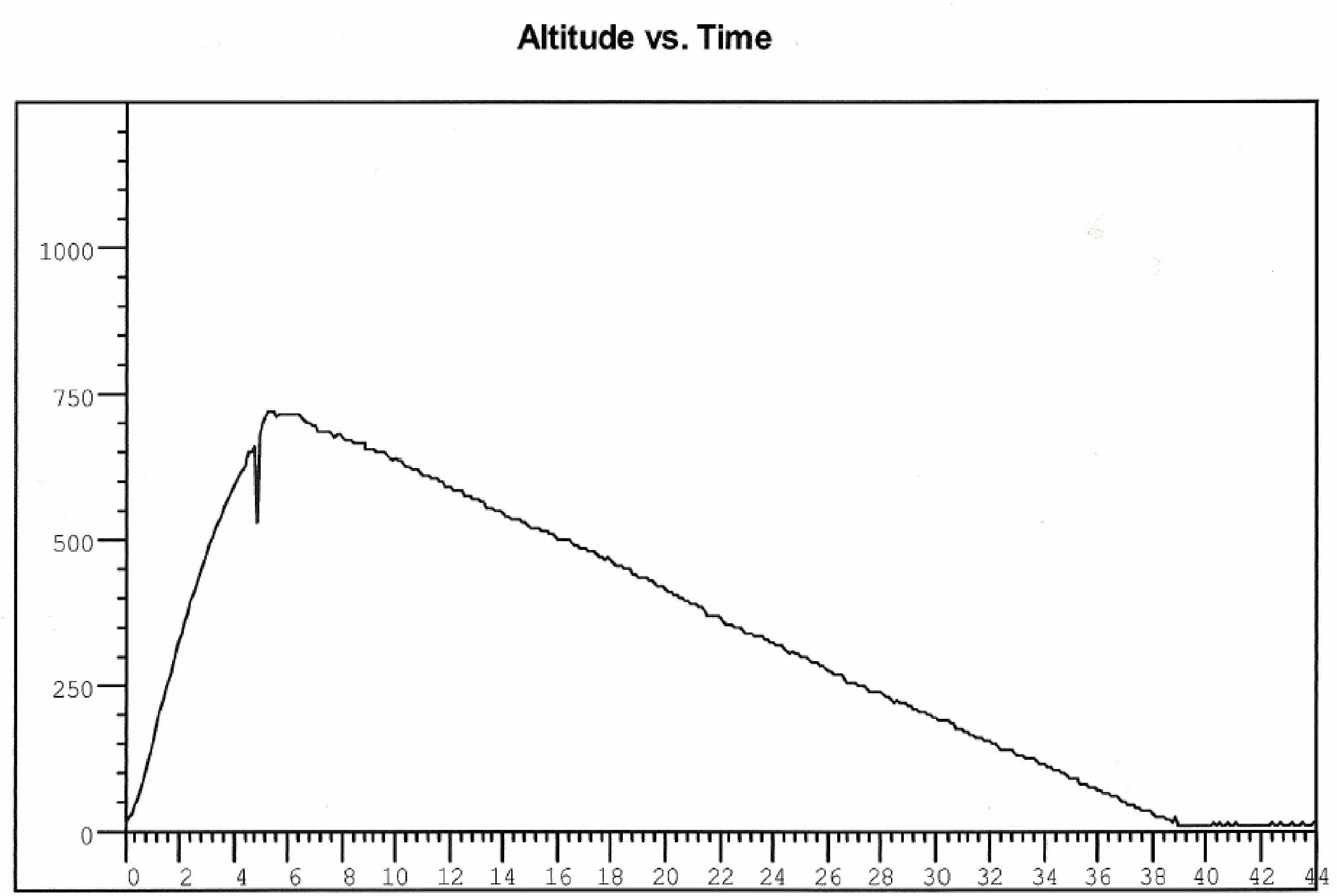


Predicted Altitude vs. Time Graph for the G80 Roadrunner motor with 2.6 mph wind

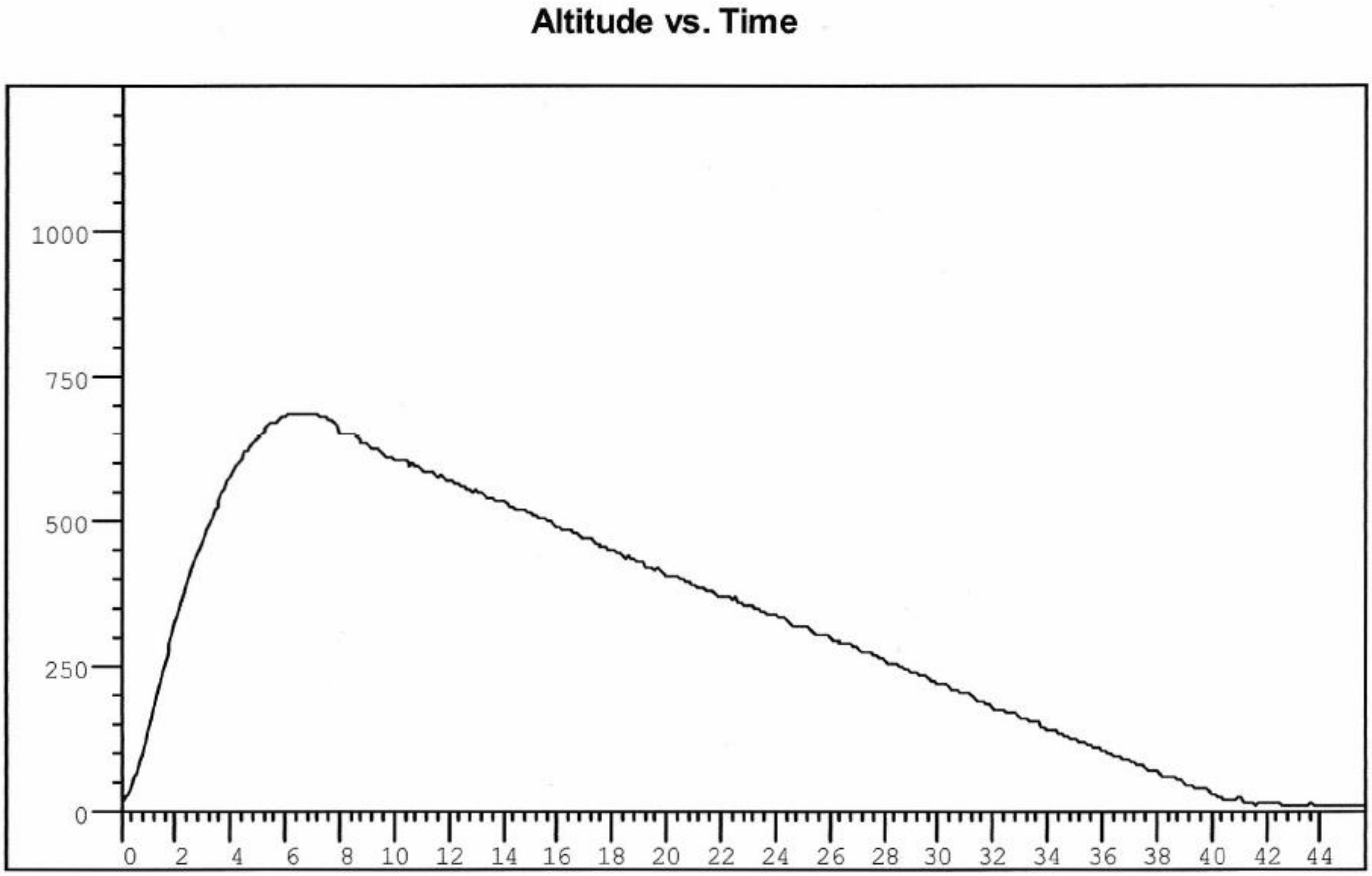


Actual Altitude Time Graphs:

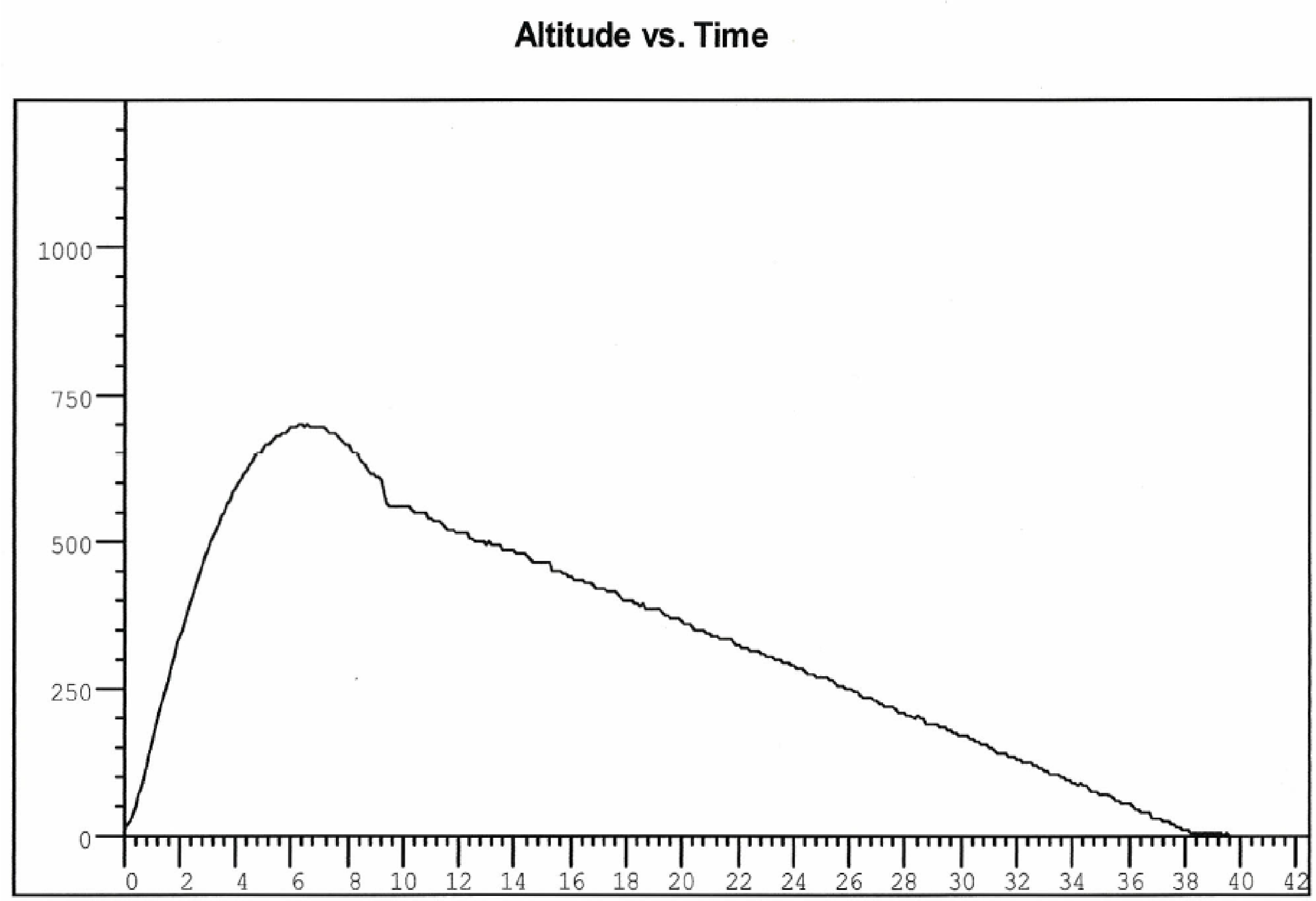
Actual Altitude vs. Time Graph for the G64 Aerotech motor with 2.7 mph wind



Actual Altitude vs. Time Graph for the G80 Roadrunner motor with 4.1 mph wind



Actual Altitude vs. Time Graph for the G80 Roadrunner motor with 2.6 mph wind



Subscale Flight Results Impact on Full-Scale Rocket:

Based on the subscale test results, the rocket should be stable without having to add ballast to it. The rocket was launched in moderate wind conditions, which may have played a role in its height loss. The rocket returned to the ground safely with a parachute that was less than the scaled down main parachute size, meaning that the main parachute for the full-scale rocket should be sufficient enough to bring down the rocket safely from 600 feet after the drogue chute has brought it down from 5280 feet down to 600 feet.

Recovery Subsystem

Parachutes, harnesses, bulkheads, and attachment hardware:

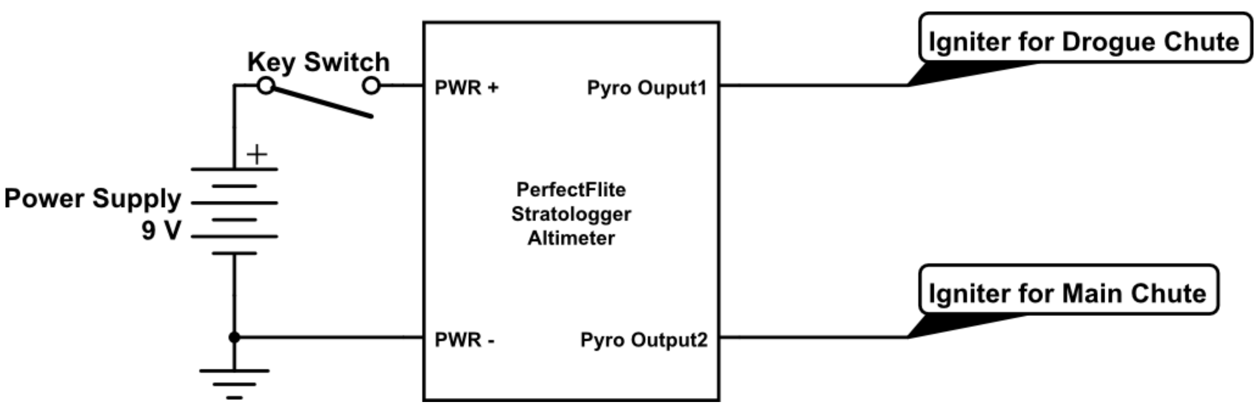
Our design has two parachutes, a drogue chute and a main chute. The drogue chute is 15 inches and will be deployed at apogee. The 15 inch drogue chute is strong enough to withstand at least 330 lbs. of force, as given by Fruity Chutes, our chosen manufacturer. The swivel mounted to the 330 lb. test shroud lines is capable of withstanding 1000 lbs. of force. The shock cord will be absorbing most of the force when the ejection charge is set off, these parameters will be satisfied by the drogue parachute and attachments. The 72 inch Iris Ultra Parachute that will be used as our main parachute, which will be deployed at 600 feet, is designed to bring the rocket down way under a safe velocity for the duration of the fall. This parachute will be delivering the rocket to the ground at a maximum of 19.1 ft/s, which should be slow enough to prevent any damage to the rocket or anything that the rocket may land on. The shroud lines on this parachute are capable of withstanding 400 lbs. of force. The swivel attached to the shroud lines is rated for 1500 lbs, making the main chute and harnesses satisfactory for the ejection and descent. For a shock cord, we’re using 4200 lb. test, 1" wide tubular nylon shock cord. This type of shock cord was chosen because it is strong enough to absorb the energy encountered during ejection and descent.

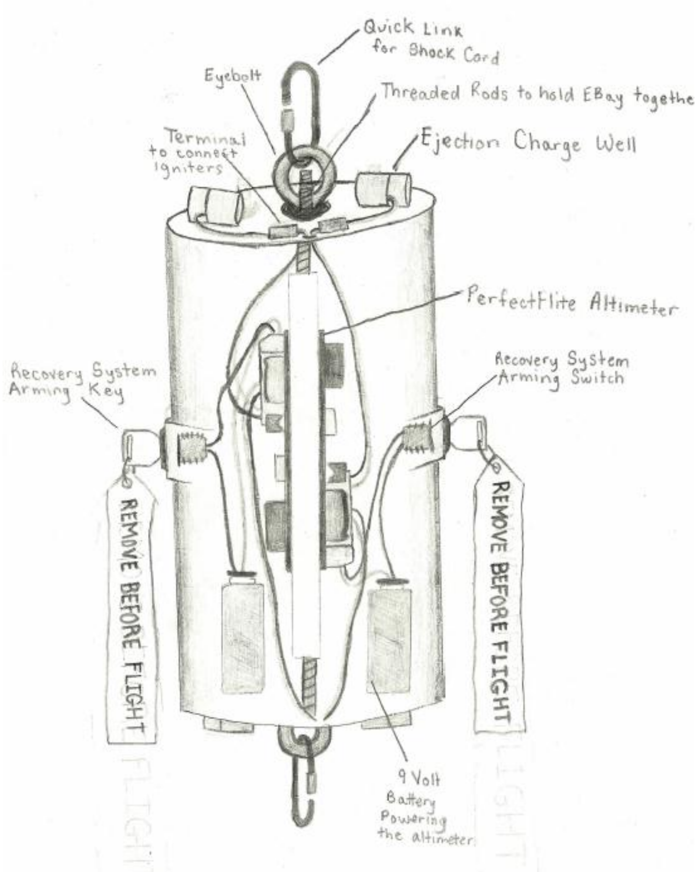
The shock cords for the recovery system will have the following attachments within the rocket: the bottom shock cord will be fastened to a 1 3/16" closed eyebolt. That is inserted into the 1/2 inch thick forward centering ring of the motor mount secured with a nut and epoxy on both sides. The other end of this shock cord will be attached to an eyebolt that is fixed firmly to the bottom of the altimeter electronics bay with epoxy, a nut, and a washer. This eyebolt will fit through a hole drilled into the electronics bay. The other shock cord will be fixed to another eyebolt that is screwed into the top of the altimeter’s electronics bay and reinforced in the same fashion. The other end of this shock cord will be fastened to a ½ inch bulkhead just below the nose cone. The revised design of the rocket calls for the bottom half of the altimeter electronics bay to be fastened with epoxy to the middle body tube of the rocket. This way, the bottom and middle body tubes of the rocket split during the ejection at apogee instead of the electronics bay splitting from the middle tube. If the electronics bay were not fastened to the middle tube, we would run a greater risk of having the top body tube (housing the main chute) split away from the electronics bay at apogee. This may happen because the acceleration that the electronics bay will undergo when it reaches the end of the shock cord would oppose the direction that inertia is carrying the top tube.

Electrical Components:

After all other final preparations have been made for the rocket launch and the altimeter connections have been checked for continuity, four rotary switches (two for each altimeter) will be turned on by turning a key switch inserted into access holes located on the outside of the rocket. This will arm the altimeters so that they may deploy ejection charges. Both altimeters contain two igniters; one for each ejection charge. Both altimeters will also include two batteries, one to run the computer for the altimeter, and one to deploy ejection charges. Both altimeters will be wired to deploy the different ejection charges, with one firing at apogee, and one firing at six hundred feet during descent. The PerfectFlite *StratoLogger* altimeters have preprogrammed settings that will send a current to the bottom ejection charges when the accelerometer within detects apogee. The forward ejection charges will be fired at 600 feet, because the altimeter is able to be programmed on a computer, which will allow us to change the altitude at which the ejection charge is fired based on a barometric reading. The amount of black powder that will be used in the ejection charges for the recovery system will be calculated and then tested with the components of the rocket to ensure complete separation of the rocket without over pressurization.

Drawings/ Sketches:





Kinetic Energies:

At the rocket's apogee a 15 inch drogue chute will be deployed and the rocket will be split into three separate pieces. The pieces will be the top body tube with the electronics bay inside, the payload, and the bottom body tube. These parts will reach a terminal velocity of 92.1 ft/s. The top half will have a kinetic energy of 486 ft-lb. The payload will have a kinetic energy of 100 ft-lb. Finally, the bottom tube will have 607 ft-lb of kinetic energy. At 600 feet a second ejection charge will be set off and separate the top body tube and the electronics bay deploying the 72 inch main parachute. At this point, there will be four pieces that will have a landing velocity of 19.1 ft/s. The top body tube will have a kinetic energy of 15.8 ft-lb when it touches down. The electronics bay will have a final kinetic energy of 5.5 ft-lb. The bottom tube will land with 25.8 ft-lb of kinetic energy. Finally the payload will land with 6.2 ft-lb of kinetic energy. All of the final total kinetic energies are low enough that they should not damage parts of the rocket.

Test Results:

Our subscale test of the recovery system was a success. The parachute that we used was less than the scaled down size of the parachute, yet it safely deployed and brought the rocket down to a safe velocity for landing. The difference was that instead of having a main parachute we had a mass of clay in the nose cone to simulate the weight of the main parachute. We will take our modified rocket specifications and put them into OpenRocket and simulate the launch to see if we get similar results in our simulations. The only complication we had was the rocket landing in a tree once. The chute deployed near apogee every time, which made our subscale testing of the recovery system a success.

Another test was conducted to see how much black powder is needed in the ejection charge wells. First, the ejection charge wells were filled with 1.5 grams of black powder, which ended up being too much black powder for what we desired. Instead, 1 gram of black powder was placed in the well, and it yielded great results for separation of rocket components.

Safety and Failure Analysis:

The recovery system is stable due to our design. Safety precautions will be taken when experimenting and launching the rocket. Failure to do this will lead to penalties, such as not being able to attend launches. If our recovery system fails, then it will be considered a safety hazard. We will prevent this with simulations, proper construction, further testing, and launches.

<u>Mission Performance Predictions</u>

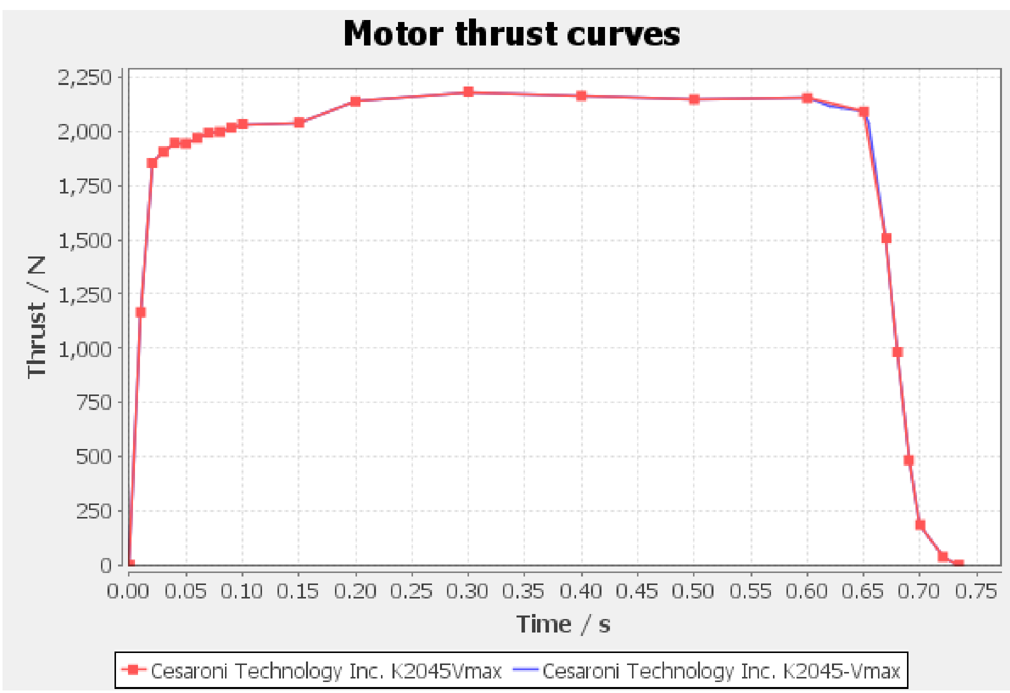
Mission Performance Criteria:

Our goal is to build and test a rocket that will achieve an altitude of one mile, eject a scientific payload, and return safely to the ground. In order to do this, we must first create a stable and reasonable rocket design on a simulation program such as RockSim. Our scientific payload will be equipped with solar panels and will be deployed at apogee along with the drogue parachute. The solar panels will be connected to a data logger that will record the voltage gathered from the panels. Using these measurements, we can then determine whether or not higher altitudes have an effect on the amount of current produced. At 600 feet, the main parachute will be ejected from the rocket, allowing it to land safely and nearby. This will be accomplished by using computer software to program an altimeter to eject the bottom half of the rocket containing the payload at apogee and the top half of the rocket deploying the main parachute at 600 feet. To ensure safety and to maintain a reliable ejection system, there will be a second altimeter programmed to eject at the same flight events, except with a slight delay.

Simulated Vehicle Data:

	Name	Motors	Velocity off rod	Apogee	Velocity at depl...	Max. velocity	Max. acceleration	Time to apogee	Flight time	Ground hit velocity
!	No wind	[K2045Vmax-P]	148 ft/s	5279 ft	N/A	965 ft/s	1504 ft/s²	15.8 s	129 s	86.8 ft/s
!	5-mph	[K2045Vmax-P]	148 ft/s	5278 ft	N/A	967 ft/s	1506 ft/s²	15.8 s	129 s	93.4 ft/s
!	10-mph	[K2045Vmax-P]	148 ft/s	5274 ft	N/A	967 ft/s	1510 ft/s²	15.8 s	129 s	98.2 ft/s
!	15-mph	[K2045Vmax-P]	148 ft/s	5260 ft	N/A	967 ft/s	1513 ft/s²	15.8 s	125 s	99.6 ft/s
!	20-mph	[K2045Vmax-P]	148 ft/s	5247 ft	N/A	966 ft/s	1513 ft/s²	15.8 s	105 s	92.5 ft/s

The altitude predictions for the final vehicle design indicate that in ideal wind conditions, the rocket will reach an altitude of 5279 ft, just a foot shy of the one mile goal. Increasing in increments of 5 mph wind speed, the next prediction is 5278 ft. At 10 mph wind speeds, the predicted altitude is 5274 ft. The prediction at 15 mph wind speeds is 5260. Finally, at the wind speed of 20 mph, the rocket should still manage to come near to the one mile mark at 5247 ft.



Motor: Cesaroni K2045Vmax, 1417 Ns

When solving for the theoretical impulse needed to launch this rocket to an altitude of 5280 ft, the impulse calculated is 861 Ns. This is assuming a frictionless environment.

The impulse of the K2045Vmax motor is 1417 Ns. This is larger than the calculated impulse, so it verifies that the motor is indeed robust enough to carry the designed rocket to the targeted one mile mark. We will be using this motor for our final design of the rocket.

Parts Detail

Stage

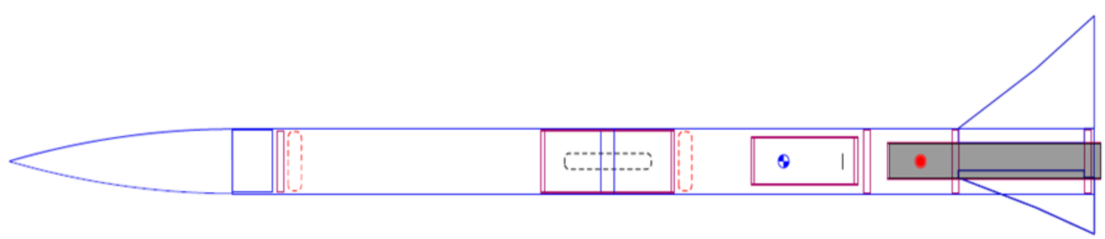
Nose cone	Polystyrene PS (1.05 g/cm³)	Ogive	Len: 16.8 in	Mass: 10.3 oz
Bulkhead	Plywood (birch) (0.63 g/cm³)	Dia_{out} 3.75 in	Len: 0.5 in	Mass: 2.01 oz
Top Body Tube	Quantum tubing (1.05 g/cm³)	Dia_{in} 3.9 in Dia_{out} 4.09 in	Len: 27.7 in	Mass: 20.4 oz
Main Chute	Rip stop nylon (66.8 g/m²)	Dia_{out} 70 in	Len: 0.98 in	Mass: 9 oz
Shroud Lines	Braided nylon (3 mm, 1/8 in) (3.5 g/m)	Lines: 8	Len: 72 in	
Ebay Body Tube	Quantum tubing (1.05 g/cm³)	Dia_{in} 3.9 in Dia_{out} 4.09 in	Len: 1 in	Mass: 0.74 oz
LOC Electronics Bay with Altimeter	Cardboard (0.68 g/cm³)	Dia_{in} 3.78 in Dia_{out} 3.94 in	Len: 10 in	Mass: 3.74 oz
Ebay Upper Bulkhead	Plywood (birch) (0.63 g/cm³)	Dia_{out} 3.78 in	Len: 0.25 in	Mass: 1.02 oz
Altimeter and Electronics		Dia_{out} 0.98 in		Mass: 10.8 oz
Ebay Lower Bulkhead	Plywood (birch) (0.63 g/cm³)	Dia_{out} 3.78 in	Len: 0.25 in	Mass: 1.02 oz
Bottom Body Tube	Kraft phenolic (0.96 g/cm³)	Dia_{in} 3.9 in Dia_{out} 4.09 in	Len: 36 in	Mass: 23.8 oz
Electronics Bay w/ Payload	Paper-BT (1.12 g/cm³)	Dia_{in} 2.88 in Dia_{out} 3 in	Len: 8 in	Mass: 2.97 oz
Top Bulkhead for Payload Ebay	Plywood (birch) (0.63 g/cm³)	Dia_{out} 2.97 in	Len: 0.25 in	Mass: 0.63 oz
Electronics for Solar Panel Stuff		Dia_{out} 0.98 in		Mass: 10.6 oz
Lower Bulkhead for Payload Ebay	Plywood (birch) (0.63 g/cm³)	Dia_{out} 2.97 in	Len: 0.25 in	Mass: 0.63 oz
Drogue Parachute	Rip stop nylon (66.8 g/m²)	Dia_{out} 15 in	Len: 0.98 in	Mass: 0.38 oz
Shroud Lines	1/16 In. braided nylon (1.02 g/m)	Lines: 8	Len: 15 in	
Bulkhead for Bottom half	Plywood (birch) (0.63 g/cm³)	Dia_{out} 3.9 in	Len: 0.5 in	Mass: 2.18 oz
Motor Mount Tube	Kraft phenolic (0.96 g/cm³)	Dia_{in} 2.15 in Dia_{out} 2.28 in	Len: 16 in	Mass: 4.01 oz
Lower Centering ring	Plywood (birch) (0.63 g/cm³)	Dia_{in} 2.28 in Dia_{out} 3.9 in	Len: 0.5 in	Mass: 1.43 oz
Upper Centering ring	Plywood (birch) (0.63 g/cm³)	Dia_{in} 2.28 in Dia_{out} 3.9 in	Len: 0.5 in	Mass: 1.43 oz
Fins (3)	G10 fiberglass (LOC) (1.91 g/cm³)	Thick: 0.13 in		Mass: 18.4 oz

Validity of Analysis:

The scale rocket is 64% of the actual rocket. The predicted mass from Open Rocket was 41 oz and the actual mass of the subscale rocket was 42.4 oz. The stability margin was about 5.2. This means that the subscale was stable enough to be launched safely. The launch later on supported this because we noticed that the rocket flew up straight and steady. The motor used for the subscale was an Aerotech G64 motor. The predicted altitude of the subscale rocket was 1113 ft. Unfortunately, the actual altitude of the subscale was only 719 ft. under wind speeds of 2.7 mph at launch. This could have occurred because the wind speeds might have been much higher as the rocket climbed in altitude. This would have put more fluid resistance on the rocket, causing it to lose altitude. The weather on launch was very cold and windy, so the higher density of air could have affected the rocket as well. Overall, the results were successful and this shows that the full scale rocket should be stable and should be relatively close to the projected mass and altitude.

Stability:

Rocket Design



Rocket

Stages: 1

Mass (with motor): 171 oz

Stability: 2.51 cal

CG: 58.1 in

CP: 68.4 in

Center of Gravity (CG): 58.1 in from nose cone

Center of Pressure (CP): 68.4 in from nose cone

The top half of the rocket is calculated to have 14.79 ft-lbf of Kinetic Energy at the moment that the rocket hits the ground. The electronics bay housing the altimeter and tracking device should hit the ground with 6.15 ft-lbf of Kinetic Energy. The payload, which is also tethered to the rocket, should hit the ground with around 5.26 ft-lbf of Kinetic Energy. The last section of the rocket (the bottom half) should have 25.39 ft-lbf at the time it hits the ground. The total kinetic energy of the rocket is 60.71 ft-lbf when it hits the ground. This is well under the maximum of 75 ft-lbf of Kinetic Energy at the time of touchdown set by the Statement of Work. Because all components of the rocket are being tethered to each other, the drift distance for all components is relatively the same. With no wind, the rocket drifts 4.35 feet from the launch pad. With a 5 mph horizontal wind, the rocket is estimated to drift 474.32 feet from the launch pad. With a 10 mph horizontal wind, it is calculated that the rocket will drift 939.08 feet from the launch pad. With a 15 mph wind, the rocket is calculated to drift 1401.2 feet from the launch pad. With a 20 mph wind, the rocket should only drift 2037.9 feet from the launch pad, ensuring that even under the most extreme launching conditions allowed by the NAR (in reference to wind speed), the rocket will stay within the 2500 foot radius of the launch pad.

Payload Integration:

The plan for integrating the design of the scientific payload into the design of the rocket is to create an ideal product that will be able to fit well inside the body tube of the rocket and will be able to perform its required tasks when it is deployed from the rocket at apogee. The payload will be designed and constructed to be durable enough to withstand the stresses produced on the rocket from liftoff, ejection, and landing. The payload will be attached to a shock cord that has enough length to effectively absorb forces delivered to the payload by ejection charges and prevent the components from entangling.

Launch Concerns and Operation Procedures

Final Assembly and Launch Procedures:

All of the body tube that is has been ordered and received has been cut to proper size by the manufacturer with slots for the fins. We are ordering the electronics bay from LOC Precision. They do not manufacture an electronics bay long enough so we purchased a 6 inch and an 8 inch long electronics bay. We will attach them together in a manner that their seams do not overlap. We will join them together and the length will then be 14 inches long. We will cut the extra three inches off so that our final electronics bay is 11 inches long. We will then be cutting our fins, centering rings, and bulkheads out with an automatic router. The shock cord will be cut, parachutes will be attached, and all components will be secured to one another. To ensure that the rocket was completed properly, the project manager and our safety officer will check over the project. They will be looking to make sure all the parts are secure and where they need to be. They will check for any blatant errors or problems that may endanger our project to be a success. For launch, the motor will be placed in the rocket at the launch site. The rocket will be looked over once again and then will be placed on the launch pad. After this, everyone will clear to a safe distance and the rocket will be launched.

Recovery Preparation

The shock cord will be cut to the proper length, at least one rocket length long or longer, and then attached to either side of the electronics bay and their respective bulkheads. We will place a heat shield on the shock cord to prevent the drogue parachute from melting. Then the parachutes will be connected onto the shock cord and folded so that the fit into the tube. The ejection charges will also be loaded to deploy the parachutes at apogee and 600 feet.

Motor Preparation

The motor is being built by our NAR representative. He will assemble the motor with caution. He will follow all instructions so that the motor is built and will perform properly.

Igniter Installation

For an igniter we are using Ematches. These Ematches are hand dipped by our NAR rep. It will be inserted into the motor so that it can ignite the motor causing the rocket to lift off.

Setup on Launcher

The rocket will be set up on the launch pad. The keys in the electronics bay will be turned and removed to activate the altimeters that will dictate when ejection charges deploy. The data logger will also be checked to ensure that it is in the on position.

Post-Flight Inspection

We will locate the rocket's final resting place. We will then inspect that all aspects of the rocket are still attached and in the place they should be. We will check that the shock cord is still attached to either side of the electronics bay and has not been compromised, and that the parachutes are still attached. We will then get a reading from the altimeter and remove the data logger so that our data can be put on a computer and analyzed.

Troubleshooting

If problems occur on the launch pad then our safety officer /NAR representative will wait the necessary time before approaching the rocket. He will check the fuse and the clips to check for any problems. If the altimeters do not set off the ejection charges then they were not properly triggered and there is an internal electronics error that will have to be worked out at a later time

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Safety and Environment (Vehicle)

Safety Officer:

Our team safety officer is our NAR Representative Tom Aument.

Failure Modes:

New failures that may arise in this stage of the project include the rocket being too massive for the motor or adhesion failure. The rocket may also be unstable or it may be overstable. To reduce the odds of the rocket being too massive we will carefully choose the materials being used and ensure that they are not too heavy when compared to their mass on OpenRocket. To mitigate epoxy failure, the mixture will be carefully monitored to ensure the resin and the hardener are mixed in equal parts. Epoxy will be applied so that there is enough to safely secure the parts. The ballasted mass will be carefully added to confirm that the mass added will not be too great. Though we have checked the stability margin in OpenRocket and RockSim, the actual rocket may not be stable. The fins may be off-kilter or the edges do not match up at the coupler and causes the body to not be straight. To mitigate these odds, construction will be carefully monitored. Construction will never be rushed and will be done with an eye for details. Where the tube is cut will be sanded until it is flat and couplers will fit snuggly.

The payload integration has been subject to much thought. With our design the only conceivable failure is with the attachment. The payload will be attached to the shock cord by a closed eye bolt. The payload may exert too great of a force on the shock cord at ejection and could possibly snap. To decrease these odds we chose a shock cord tested for 1000 pounds. This should be more than robust enough to stand up to the forces involved in our launch. We will also be testing this in the subscale launch and the full scale test.

Conceivable failures that could occur during the launch operations are motor ignition delay or failure. Also, the altimeter may not set off the ejections charges. To mitigate these failures are having our experienced NAR representative building our motors. This should eliminate all building errors. We will use the proper launch mechanisms so that there are no operating faults. To help lower the chance of a motor failure we are buying from trusted manufactures and retailers that we have bought from in the past. We're going to redundantly wire the altimeter and ejection charges. The two charges will be set off a few feet after each other. This will guarantee the rocket will break apart without over pressuring the rocket.

Personnel Hazards:

Materials that are hazardous to personal using include the power tools in our wood lab, epoxy, and spray paint. Included in this section are material safety data sheets for the Z-Poxy hardener and resin as well as the Krylon Spray Paint. There are also the safety procedures for all of the power tools. However, if the rocket is unrecoverable some parts will decompose. If decomposition occurs then it would be harmful to the plants and earth that it is being decomposed into.

Updated MSDS:

West Systems Hardener

http://www.westsystem.com/ss/assets/MSDS/MSDS205.pdf

West Systems Resin

http://www.westsystem.com/ss/assets/MSDS/MSDS105.pdf

Krylon Spray Paint

http://www.paintdocs.com/webmsds/webPDF.jsp?SITEID=DBS&UPC=724504021162

Goex Black Powder

http://usli.byu.edu/sites/usli.byu.edu/files/msds-Black%20Powder.pdf

Operator's Safety Protocol in the Wood Lab

Framar Band Saw

Before operating the band saw, remove all jewelry, confine long hair, and remove or roll up long sleeves or any article of clothing that could become caught in the blade or the band saw. Also, obtain an instructor's permission to use the machine and ensure that safety glasses are covering your eyes. When cutting, make sure adjustment knobs are tight; the upper blade guard should be around one eighth of an inch above the material being cut. Do not force any material through the blade, attempt to cut a radius smaller than the blade will allow, and do not back out of long cuts. Keep fingers on either side of the cut line, never on the line. If necessary, use a push stick or scrap block to guide the material through. Do not allow bystanders to stand at the right of the machine, because if the blade breaks, it may hit them. Never leave the machine until the blade has come to a complete stop. If an injury should occur during the usage of the band saw, stop the machine, step on the break to stop the blade quickly, inform an instructor of the injury, and then have the rest of the students in the classroom sit outside in the hallway to avoid being in the way of instructors and medical personnel helping the student.

Router

Before operating the router, remove all jewelry, confine long hair, and remove or roll up long sleeves or any article of clothing that could become caught in the router or router bit. Also, obtain an instructor's permission to use the machine and ensure that safety glasses are covering your eyes. Ensure that the power switch is in the off position before plugging in the router. Then, check to make sure that the bit is firmly secured in the chuck and that the piece being worked on is firmly secured and that the intended path of the router is free of obstructions. Hold the router with both hands and apply constant pressure. Never force the router or bit into the work. When changing bits or making adjustments turn off the router and unplug it from its power source. If an injury should occur during usage of the router, turn off the machine, inform an instructor of the injury, and then have the rest of the students in the classroom sit outside in the hallway to avoid being in the way of instructors and medical personnel helping the student.

Delta Radial Arm Saw

Before operating the saw, remove all jewelry, confine long hair, and remove or roll up long sleeves or any article of clothing that could become caught in the blade. Also, obtain an instructor's permission to use the radial arm saw and ensure that safety glasses are covering your eyes. Make all needed adjustments, such as adjusting the blade guard and kickback fingers, while the power is off. Test to see if leaf guards are properly working and that the blade does not extend past the edge of the table. Always firmly hold materials against the fence and pull the blade completely through the material and return blade behind the fence before removing the material and starting another cut. If too much of the table is cut away then the instructor must be notified for the table to be replaced**.** Wait for the blade to stop before leaving the machine. If injury occurs during usage of the saw, turn off the machine, inform an instructor of the injury, and then have the rest of the students in the classroom sit outside in the hallway to avoid being in the way of instructors and medical personnel helping the student.

Planer-Surface Sander

Before operating the sander, remove all jewelry, confine long hair, and remove or roll up long sleeves or any article of clothing that could become caught in the machine. Also, obtain an instructor's permission to use the sander and ensure that safety glasses are covering your eyes. Turn on the saw dust collection system. Check all material for loose knots, nails, staples, or any other loose, foreign objects. Never force a material through the planer; after insertion the machine will automatically feed it through. The operator should wait on the other side of the machine to receive the material. Select a proper machine depth and speed for the material being used. Never attempt to plane more than an eighth of an inch of material in one pass. Do not look into the machine at surface level or try to clean debris while the machine is turned on. Always stand to the side, because the possibility of kick back always exists. If injury occurs during usage of the sander, turn off the machine, inform an instructor of the injury, and then have the rest of the students in the classroom sit outside in the hallway to avoid being in the way of instructors and medical personnel helping the student.

Dewalt Compound Miter Saw

Before operating the saw, remove all jewelry, confine long hair, and remove or roll up long sleeves or any article of clothing that could become caught in the blade. Also, obtain an instructor's permission to use the saw and ensure that safety glasses are covering your eyes. Make all changes to the saw and saw blade while the power is off and the plug is disconnected from its power supply. Hold the material firmly against the fence and the table. Allow the motor to reach its full speed before attempting to cut through the material. Make sure that all guards are functioning properly. If injury occurs during usage of the Miter Saw, turn off the machine, inform an instructor of the injury, and then have the rest of the students in the classroom sit outside in the hallway to avoid being in the way of instructors and medical personnel helping the student.

Jointer

Before operating the jointer, remove all jewelry, confine long hair, and remove or roll up long sleeves or any article of clothing that may become caught in the blade. Also, obtain an instructor's permission to use the jointer and ensure that safety glasses are covering your eyes. Turn on the saw just collection system. Make all changes or adjustments to the jointer while the power is off. Use a push stick or scrap block if your hands could come within two inches of the blade. Do not attempt to take off more than one eighth of an inch at a time. The minimum length of material that can be cut with the jointer is double the size of the blades. If injury occurs during usage of the jointer, turn off the machine, inform an instructor of the injury, and then have the rest of the students in the classroom sit outside in the hallway to avoid being in the way of instructors and medical personnel helping the student.

Hand Sanders

Before operating the hand sanders, remove all jewelry, confine long hair, and remove or roll up long sleeves or any article of clothing that could become caught in the machine. Also, obtain an instructor's permission to use the hand sanders and ensure that safety glasses are covering your eyes. Replace the sand paper while the sander is off and unplugged. Only use sand paper that is in good condition and properly installed. Place the material that you intend on sanding on a flat surface and sand slowly over a large area. Wait for the sander to stop oscillating before placing it on a secure resting surface. Never carry any corded tool by the power cord. If injury occurs during usage of the hand sanders, turn off the machine, inform an instructor of the injury, and then have the rest of the students in the classroom sit outside in the hallway to avoid being in the way of instructors and medical personnel helping the student.

Electric Drills

Before operating the drill, remove all jewelry, confine long hair, and remove or roll up long sleeves or any article of clothing that may become caught in bit. Also, obtain instructor permission and ensure that safety glasses are covering your eyes. Replace the bit while the power is off, install the bit properly and make sure the chuck is tightened and the chuck key is taken out. Never drill without first marking the hole with an awl. Ensure the material is clamp securely and drill with even pressure. Never carry any corded tool by the power cord. If injury occurs during usage turn off machine, inform instructor of injury, then have the rest of the students in the room go into the hallway to avoid being in the way of instructors helping the student.

Powermatic Drill Press

Before operation remove all jewelry, confine long hair, and remove or roll long sleeves or any article of clothing that may become caught in bit. Also, obtain instructor permission and ensure that safety glasses are covering your eyes. Replace the bit while the power is off, install the bit properly and make sure the chuck is tightened and the chuck key is taken out. Firmly secure material with vices or clamps. Adjust the table to avoid drilling into the table and pick the correct bit and properly sharpened. If drill becomes stuck turn of machine and inform instructor. Select proper speed for the material. If injury occurs during usage turn off machine, inform instructor of injury, then have the rest of the students in the room go into the hallway to avoid being in the way of instructors helping the student.

CNC Router

Before operation remove all jewelry, confine long hair, and remove or roll long sleeves or any article of clothing that may become caught in bit. Also, obtain instructor permission and ensure that safety glasses are covering your eyes. Turn on the saw dust collection system. Make all adjustments while machine is off. Material must be firmly secured before the project is run. A person needs to be with the machine during the entire operation. Check the spindle rotation, speed, and depth of cut are all correct before starting the machine. Only clean machine while it is off and make sure all set up tools are cleared from the table. If injury occurs during usage turn off machine, inform instructor of injury, then have the rest of the students in the room go into the hallway to avoid being in the way of instructors helping the student..

Oliver Table Saw

Before operation remove all jewelry, confine long hair, and remove or roll long sleeves or any article of clothing that may become caught in blade. Also, obtain instructor permission and ensure that safety glasses are covering your eyes. Turn on the saw dust collection system. Make all adjustments while machine is off. Gullets of the blade must clear the top of the material. Never use the miter gauge and the fence at the same time, miter gauge for cross cutting and fence for ripping. Use extra caution while using a dado cutting head. Always use a push stick when your hand may come close to the blade and have another person to catch the material that was just cut. Do not leave the table until the blade stops. If injury occurs during usage turn off machine, inform instructor of injury, then have the rest of the students in the room go into the hallway to avoid being in the way of instructors helping the student.

Powermatic Belt Sander

Before operation remove all jewelry, confine long hair, and remove or roll long sleeves or any article of clothing that may become caught in machine. Also, obtain instructor permission and ensure that safety glasses are covering your eyes. Make all adjustments while machine is off. Check that there is adequate tension in the belt and that it is not torn. Keep material on the table at all times. Keep fingers away from sand paper. If injury occurs during usage turn off machine, inform instructor of injury, then have the rest of the students in the room go into the hallway to avoid being in the way of instructors helping the student.

Powermatic Disc Sander

Before operation remove all jewelry, confine long hair, and remove or roll long sleeves or any article of clothing that may become caught in machine. Also, obtain instructor permission and ensure that safety glasses are covering your eyes. Make all adjustments while machine is off. Check that the disc was properly installed and that it is not torn. Keep material on the table at all times. Keep fingers away from sand paper. If injury occurs during usage turn off machine, inform instructor of injury, then have the rest of the students in the room go into the hallway to avoid being in the way of instructors helping the student.

Powermatic Drum Sander

Before operation remove all jewelry, confine long hair, and remove or roll long sleeves or any article of clothing that may become caught in machine. Also, obtain instructor permission and ensure that safety glasses are covering your eyes. Make all adjustments while machine is off. Use proper drum for the radius that is being sanded. Keep material on the table at all times. Keep fingers away from sand paper. If injury occurs during usage turn off machine, inform instructor of injury, then have the rest of the students in the room go into the hallway to avoid being in the way of instructors helping the student.

Craftsman Reciprocating Saw

Before operation remove all jewelry, confine long hair, and remove or roll long sleeves or any article of clothing that may become caught in blade. Also, obtain instructor permission and ensure that safety glasses are covering your eyes. Make all changes with the power off and plug disconnected from the power supply. Firmly secure all material to a work bench or table. Allow the motor to reach its full speed before cutting through the material. Hold saw with both hands while using. If injury occurs during usage turn off machine, inform instructor of injury, then have the rest of the students in the room go into the hallway to avoid being in the way of instructors helping the student.

Craftsman Circular Saw

Before operation remove all jewelry, confine long hair, and remove or roll long sleeves or any article of clothing that may become caught in blade. Also, obtain instructor permission and ensure that safety glasses are covering your eyes. Make all changes with the power off and plug disconnected from the power supply. Firmly secure all material to a work bench or table. Before cutting; check that the cut line is not above the table. At least one person must be holding the material being cut off. Allow the motor to reach its full speed before cutting through the material. Hold saw with both hands while using. If injury occurs during usage turn off machine, inform instructor of injury, then have the rest of the students in the room go into the hallway to avoid being in the way of instructors helping the student.

CNC Lathe (EMCO Concept Mill 55, Lab Volt 5400 CNC Mill, a Lab volt

Automation 5500-B0)

Before operation remove all jewelry, confine long hair, and remove or roll long sleeves or any article of clothing that may become caught in bit. Also, obtain instructor permission and ensure that safety glasses are covering your eyes. Make all adjustments while machine is off. Material must be firmly secured before the project is run. A person needs to be with the machine during the entire operation. Check the spindle rotation, speed, and depth of cut are all correct before starting the machine. Only clean machine while it is off .If injury occurs during usage turn off machine, inform instructor of injury, then have the rest of the students in the room go into the hallway to avoid being in the way of instructors helping the student.

Victor metal lathes

Before operation remove all jewelry, confine long hair, and remove or roll long sleeves or any article of clothing that may become caught in work. Also, obtain instructor permission and ensure that safety glasses are covering your eyes. Make all changes with the power off. Center the material so that it will not spin off center. Firmly secure all material to a machine. Use proper speed for the task at hand. Use the correct and sharpened tools. If injury occurs during usage turn off machine, inform instructor of injury, then have the rest of the students in the room go into the hallway to avoid being in the way of instructors helping the student.

Paasche FABSF-6 spray booth

Before use turn on ventilation system and wear proper protection. Use the correct spray for the material and do not inhale. If injury occurs during usage turn off machine, inform instructor of injury, then have the rest of the students in the room go into the hallway to avoid being in the way of instructors helping the student.

Miller Spot Welder

Before operation put on proper clothing, welding mask, gloves, and apron. Obtain instructor permission. Do not look at the welding torch unless wearing a welding mask. Ensure the proper solder is being used and materials are secured. If injury occurs during usage turn off machine, inform instructor of injury, then have the rest of the students in the room go into the hallway to avoid being in the way of instructors helping the student.

Baldor grinder/buffers

Before use put on safety glasses, check the spark shield is intact, and obtain instructor permission. Keep hands away from spinning wheel. Adjust the tool rest to the proper height and always use it. If injury occurs during usage turn off machine, inform instructor of injury, then have the rest of the students in the room go into the hallway to avoid being in the way of instructors helping the student.

Tennsmith Sheet metal cutter

Before operation remove all jewelry, confine long hair, and remove or roll long sleeves or any article of clothing that may become caught in work. Also, obtain instructor permission and ensure that safety glasses are covering your eyes. Do not attempt to cut material thicker than the machine is rated for. Make sure the material and blade are free from debris. If injury occurs during usage turn off machine, inform instructor of injury, then have the rest of the students in the room go into the hallway to avoid being in the way of instructors helping the student.

Gravograph LS100 30 watt laser/engraver/cutter

Before operation; ensure that the laser is focused, the vent fan is on, and the right speed and power are selected for the material. Obtain instructor permission before use. Never look directly into the laser. Stay at the laser throughout the entire process. If machine cuts unwanted area or malfunctions turn off and alert instructor immediately. If injury occurs during usage turn off machine, inform instructor of injury, then have the rest of the students in the room go into the hallway to avoid being in the way of instructors helping the student.

Operation Hazards for Above Equipment

Hazards that could occur include but are not limited to hair or clothing being caught in machinery or tools which could result in major injury of the user. Limbs may be cut partially or completely off if the user becomes distracted or does not know how to use the machine correctly. Misuse of tools and machine could result in bodily damage to the user or other team mates. If spray painting in too small of an area the user or bystanders may inhale fumes for too long and bodily damage may occur. Abrasions while using tools or machinery may take place and cause minor to severe bodily damage.

The supervisor will mitigate the chances of these hazards arising by having the students sit in on safety briefings that will cover how to operate all tools and machinery. We will also identify as many hazards as possible and mitigations. A briefing on proper use and safety procedures while operating tools and machines will also take place. All students will have another student as well as mentor supervision with them while operating tools and machinery.

Environmental Concerns:

Environmental concerns with our project are very small. All parts of our rocket stay connected to each other. The only problems would stem from motor ashes or residue being blown away and then eaten by an animal. Also, a piece of the rocket may break off and become lost and would also be harmful if eaten by an animal. If any of the paint chips on the rocket than it may cover pants and cause them to wilt. Our payload is designed to possibly help the environment so our environmental impact is miniscule.

IV) Payload Criteria

Testing and Design of Payload Experiment

Review the design at a system level

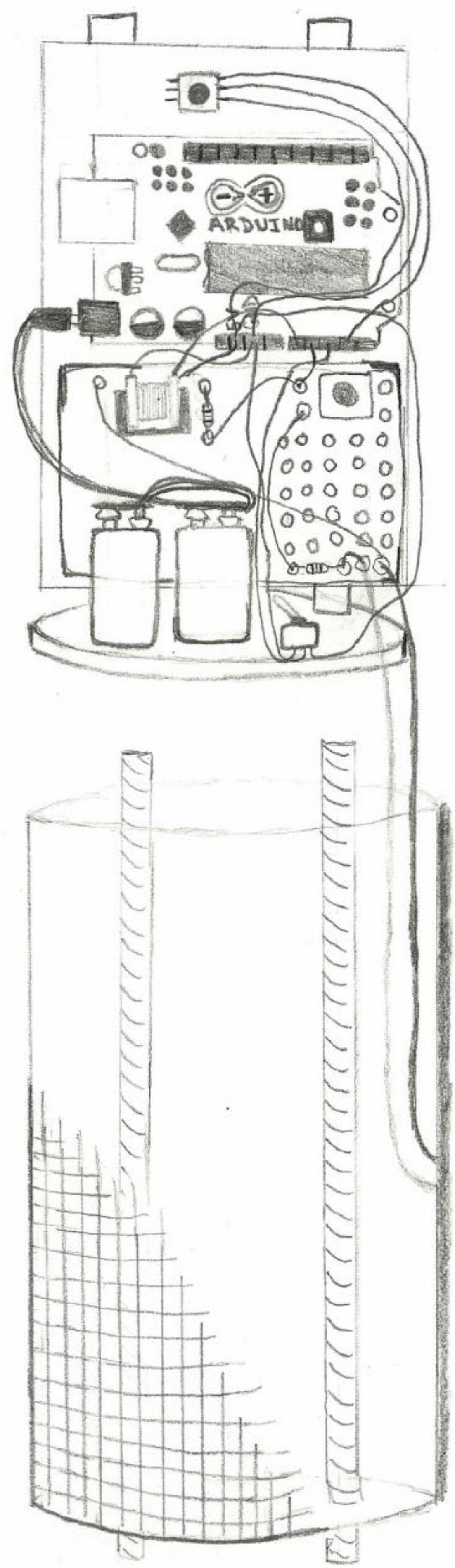
Design:

We have simplified our design and split the payload up into two sections. The first is the frame system, and the second is the electronics system. The electronics system is secured within the structure system. The frame system consists of a BT-300, two centering rings, two bulk heads, two threated rods, wing nuts, a sled for the electronics to sit on, and memory foam. This system is meant to completely surround the electronics system.

The frame system consists of a BT-300, a Lucite tube, two centering rings, two bulkheads, wing nuts, wooden trusses, threaded rods, and launch lugs. This structure is sturdy and will be able to protect all of the inner components of the payload.

The electronics system is made up of an Arduino, solar panel, pressure sensor, two nine volt batteries, a potentiometer, a an ammeter, two resistors, and electric wires. We have devised a method of securing all of the electronics on a sled, just like the electronics bay is in the recovery system. The main focus of our electronics system is the Arduino, which must be programmed. This Arduino acts as a data logger, and will record data for our experiment.

Drawings and Specifications:



There are a few major new changes for our payload. One of the biggest changes in our payload design is the new electronics system.

In our new electronics system we have many separate parts, despite the fact that there is little room for the electronics in the payload space. We do not need to worry about this, because the elements of our payload are small enough to fit snuggly together.

All of the electronics will be assembled on a sled. This design resembles the electronics bay system. Since our motor is so strong, we need to ensure that the electronics will not more during flight. We also need to ensure that all of the wires are connected throughout the entire flight, both before and after the flight.

This sled will consist of launch lug tubs that are slid over the threaded rods. These rods will help close the payload, and also hold the sled in place during flight.

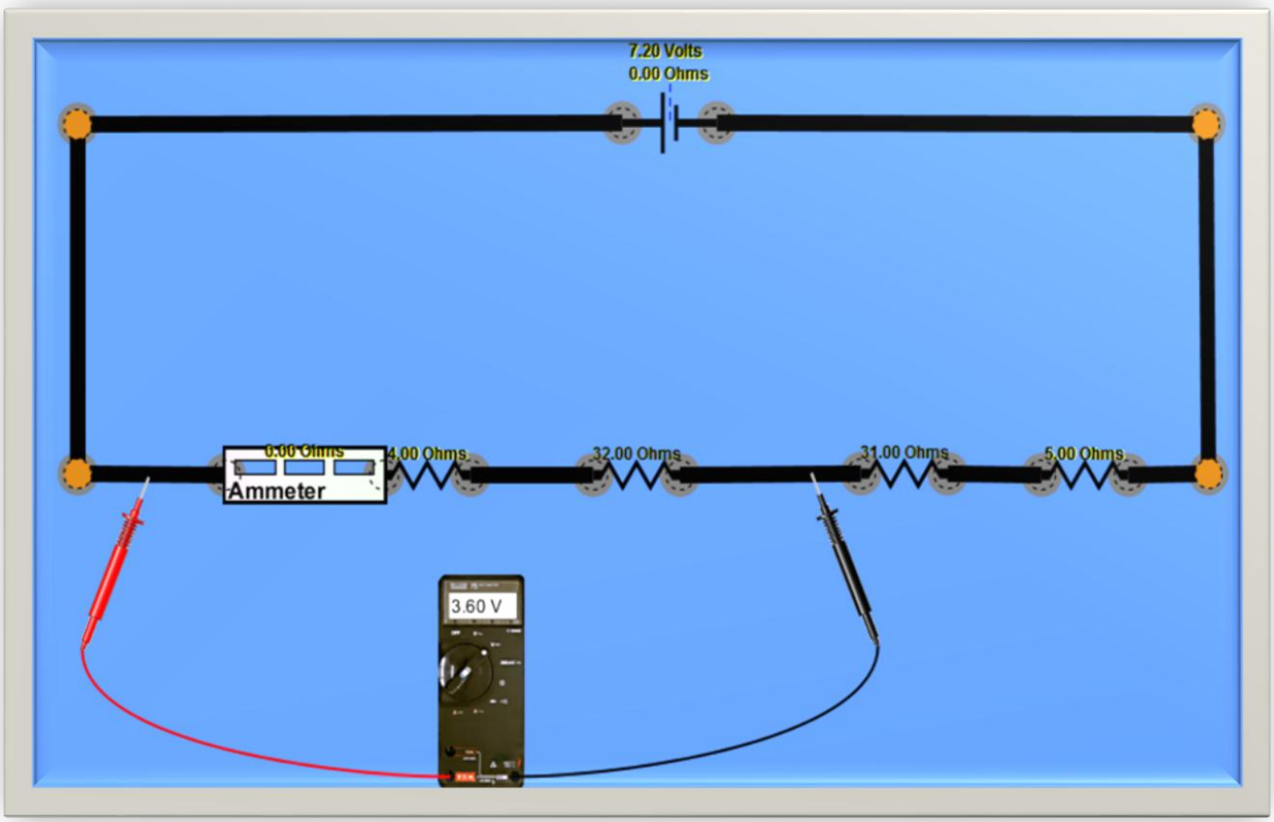
The payload will be slightly bottom heavy, which will not affect the experiment, but will help when the payload is in the rocket. This is because heavier objects tend to stay in one place when accelerated from a velocity of zero.

Overall the new design will help the payload more effective and secure for flight. Due to this enhanced design, the payload will be safer and more efficient.

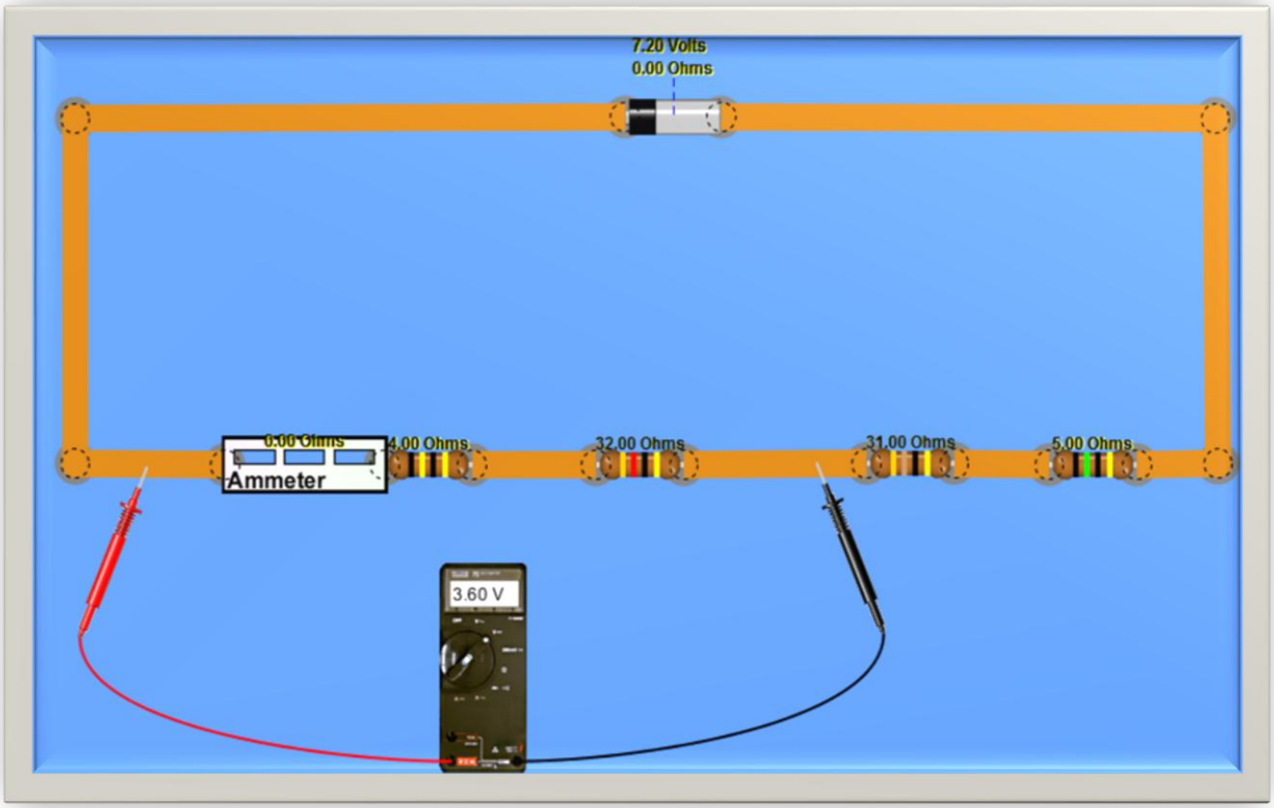
Test Results:

We have tested our electronics system with simulations. This will prepare us to start constructing the electronics for ourselves. A few members, who have had experience with electronics, are researching and simulating alternative options to ensure that we are successful, and that the project continues with ease. There are a few simulations that have been done. There are a few different simulations presented here with the same objective, which is to prove that our circuitry will be able to function.

In the simulation below, the circuit is set up with specific numbers. This simulation proved that the circuit will be suitable for the Arduino. These series of resistors are necessary to reduce the amount of voltage going through the circuit.



In the simulation below, the resistors are more accurately drawn. The bands on the resistors represent the level of resistance that will be needed at each one in the circuit. It is also clear that there is a power source with a positive and negative end. From that information we know which way the flow of electrons is going. We can also infer the direction of positive charge, or current.



Integrity of Design:

Both systems have been thoroughly designed and adjusted to fit the specifications of the other aspects of the rocket. This includes the rocket's body tube diameter, the space within the rocket available in the back end of the rocket. In our frame system we have worked to secure the electronics system within it. All of the basic electronics would be able to fit within the BT-300. Then the wires will be able to feed through both sides of the payload, and continue through the space between the trusses to finally connect to the solar panel. This solar panel is securely adhered to the outside of the BT-300 tube. However, the powerful ejection charge would damage the solar panel if it was not protected. So, we incorporated a Lucite tube to cover the solar panel. The modifications done to our design will optimize its ability to be reused, and easily modified in the future if it is needed. The payload must also be able to withstand the impact upon hitting the ground. To keep it attached to the rest of the rocket, it is secured to the shock cord and drogue parachute with sturdy eyebolts on each end of the payload.

There are interchangeable parts in case any damage is done or in case any piece is faulty. This is why when we start to test out our new electronics; we may have a few modifications to further secure our electronics.

Design meets all system-level functional Requirements

Within the payload is the electronics system. There are many components within the payload, which need to work together and need to work independently to ensure success. The advantage of our design, is that if one part breaks or is damaged, we can easily replace it, instead of needing to buy an entire pre-programmed, new data logger.

The Arduino must read three different sensors for our collection of data needed to prove or disprove our hypothesis. The three sensors are the ammeter, the pressure sensor, and the voltmeter. Both the ammeter and pressure sensor are in the outer circuit, while the voltmeter is already programmed into the Arduino. This gives the Arduino the ability to read voltages, so that they can be read and written on the SD Card. Data collection is necessary, and is the most important for our results.

The solar panel must also be able to collect solar energy, so that we can measure the amount of current generated by that solar energy. To make sure the solar panel can function, it must be protected from the ejection charge that could easily damage it. This could block solar cells with the black powder residue, or even exert so much pressure on the solar panel, or even worse, damage them so that solar energy can’t even enter the cells.

Workmanship and Mission Success

Our mission for our experiment is to determine if more solar energy can be captured at a higher altitude due to its proximity to the sun. To prove our hypothesis, we must work together to program, build, and test our payload. To achieve this, we will create a schedule to ensure the completion of our payload. Students will distribute work so that the large project of the rocket is completed, and the smaller project, of the payload will be done in as much detail as possibly by other students. This will give students a chance to be more specialized in one subject, along with learning how to write in words what they are doing, and need to do for the successful completion of our entire project.

For the payload, we have selected students with experience in electronics, and the eagerness to learn and create such an advanced system. These students were also chosen because they can work well together, and spend an excess amount of time working on this intricate design. Our electronics system will need very precise measurements for such a special experiment. The application of programming is very advanced, and it will take many hours to complete this program. This will take a lot of patience, and a lot of workmanship to write. Electrical circuit construction will also take a lot of patience, and a steady hand. This specialized group will need to spend many hours outside of team meetings.

Planned Component Testing, Functional Testing, and Static Testing

The circuit can easily be tested once we have all of the components of the payload. Once the circuit is constructed, we can hook up external voltmeters to see the changes throughout the circuit. This will give us an idea of how each component of the circuit is working. For example, it will be able to measure the voltage at a certain point in the circuit. From that information we would be able to calculate the amount of resistance the potentiometer, resistors, or ammeter are causing. After that is done, your results will tell you what needs to be notified. Another option is to test the circuit by recording data through the Arduino, before it is integrated into the payload frame system. This will prevent any flaws in the design and further construction of the payload. This step is crucial mile stone for the project, because it proves that the second step can be taken in the payload construction.

Static testing will be done for the programming done for the Arduino. All of the code that is needed for the program is written on the computer, and then downloaded onto the Arduino. Therefore, the code must be reviewed, and can be modified also. This will be convenient since the entire code does not need to be rewritten. Programming can take days to finish writing the code completely and accurately.

Remaining Manufacturing and Assembly

Since we changed our electronics, we are still waiting for our parts to come in from our manufacturer. We ordered a majority of our parts from the website digikey.com. This website made it very easy to find parts and it is just a matter of time until we get our parts to start construction. We have already tested our simplified main circuit on simulations to prove that our circuit will work well when applied. Team members are also already working on the programming necessary for the Arduino. A lot of research has gone into the construction, and programming that needs to be done for the electronics system. The assembly of the electronics system and payload will be easily constructed once the parts are in. Shipping has been slow over the holiday break, but a lot of the rocket parts have already been shipped to us, and received too. We have already ordered extra parts, but if any other extra parts are needed, they can be ordered immediately. Parts of the payload can be found at RadioShack and we have a few of their stores in the area. Overall we have a good start on the payload, and when our parts get in, we will be able to start right away on construction.

Integration Plan

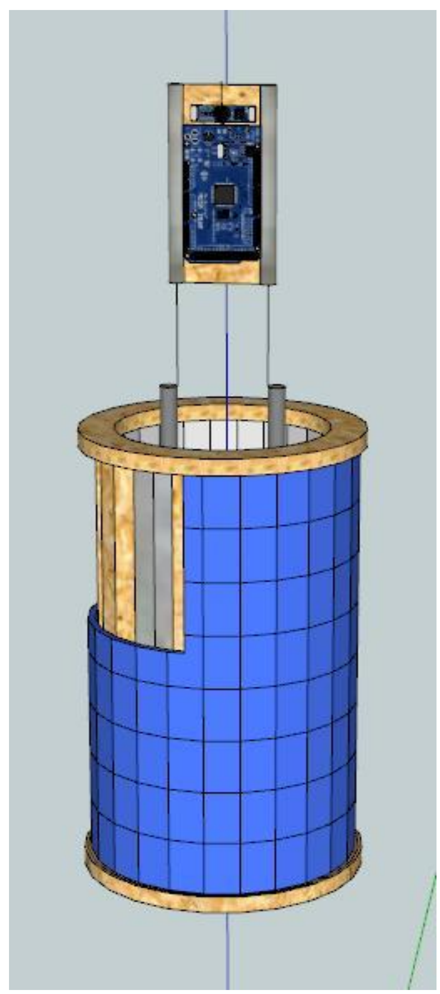
We have designed the payload frame system to fit within the rocket in a precise manner that will also make it able to be ejected from the rocket at apogee. When designing the payload, we needed to consider not only the ejection charge, but also the parachute placed in front of it. When considering the design, we needed to place the payload within the body tube, but we also needed to keep in mind that the payload should not exceedingly move. This is why we chose to create a complete cylinder that will maximize our amount of space in the rocket, without hindering or compressing the parachute. This is also why the payload has a lighter mass. The ejection charge should be able to deploy the payload with the parachute. Another decision that was made already, was that the payload would be in series with the drogue parachute, but in parallel with the shock cord. Therefore, the bottom of the payload is attached to the length of shock cord and the drogue parachute is connected to the top of the payload, but not the rest of the rocket. The reason for this, is so that the payload will get full coverage, and there will be access space between the drogue parachute and the rocket, so there is a less likely chance of the rest of the rocket tangling in the shroud lines. It is apparent that this is essential to the flight of the rocket, and also that is it essential for the entire experiment.

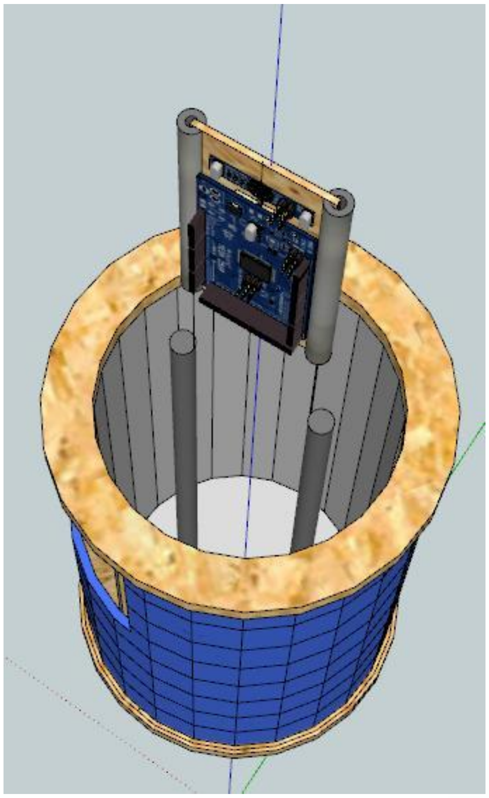
Precision of Instrumentations and Repeatability of Measurements

Since our experiment it is controlled, it is apparent that our results will differentiate between the two solar panel arrays. With the right conditions, our data will be repeatable. If each experiment is conclusive, we will be able to calculate a mathematical relationship for the effects of solar energy collected, or current, compared to the height of the flight.

Payload Electronics

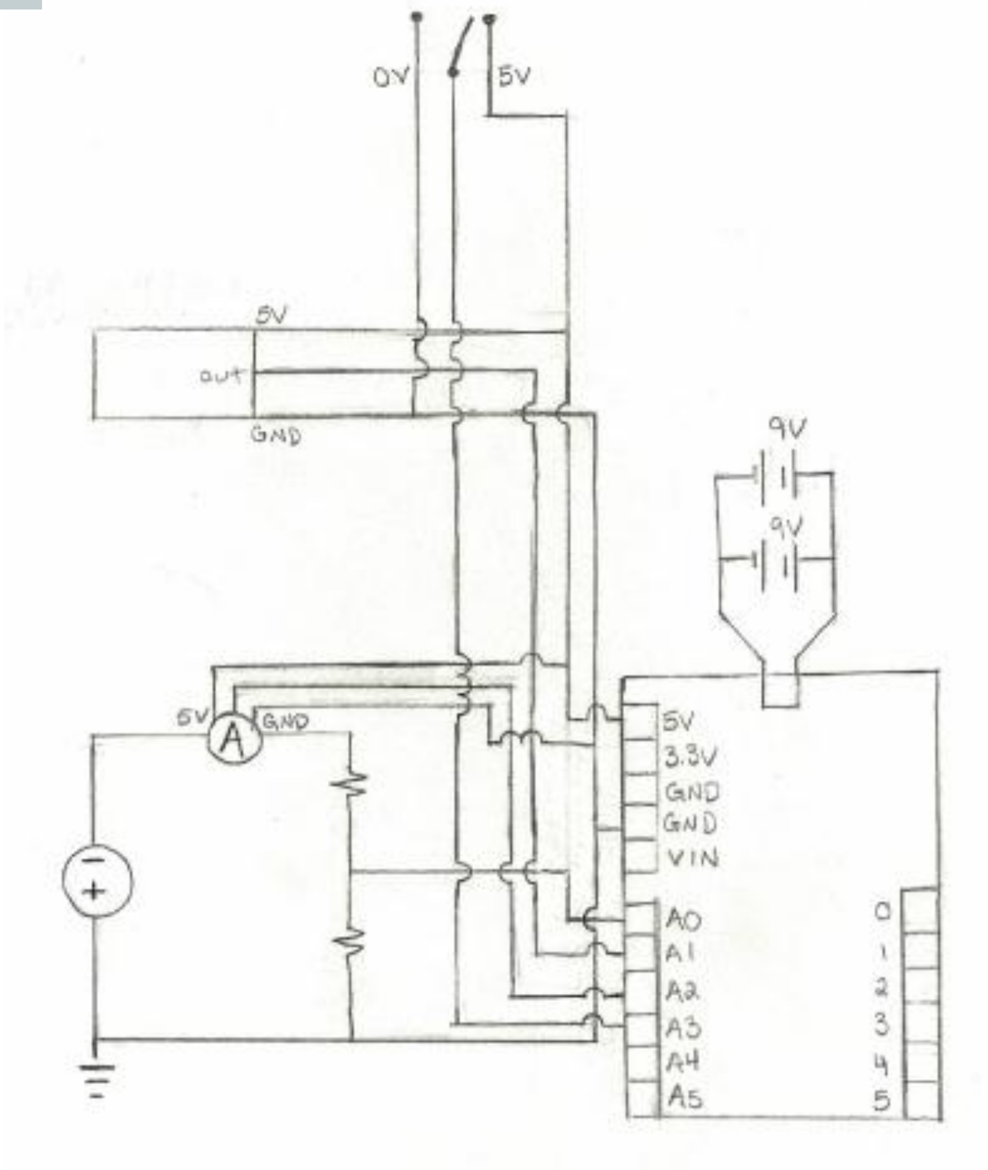
The payload's electronics will easily be fit into the payload's frame system. These diagrams represent the method in which we plan to insert the electronics into the payload's frame. This method is very easy and will help keep all of the contents in line and safe, especially during the overwhelming lift off.



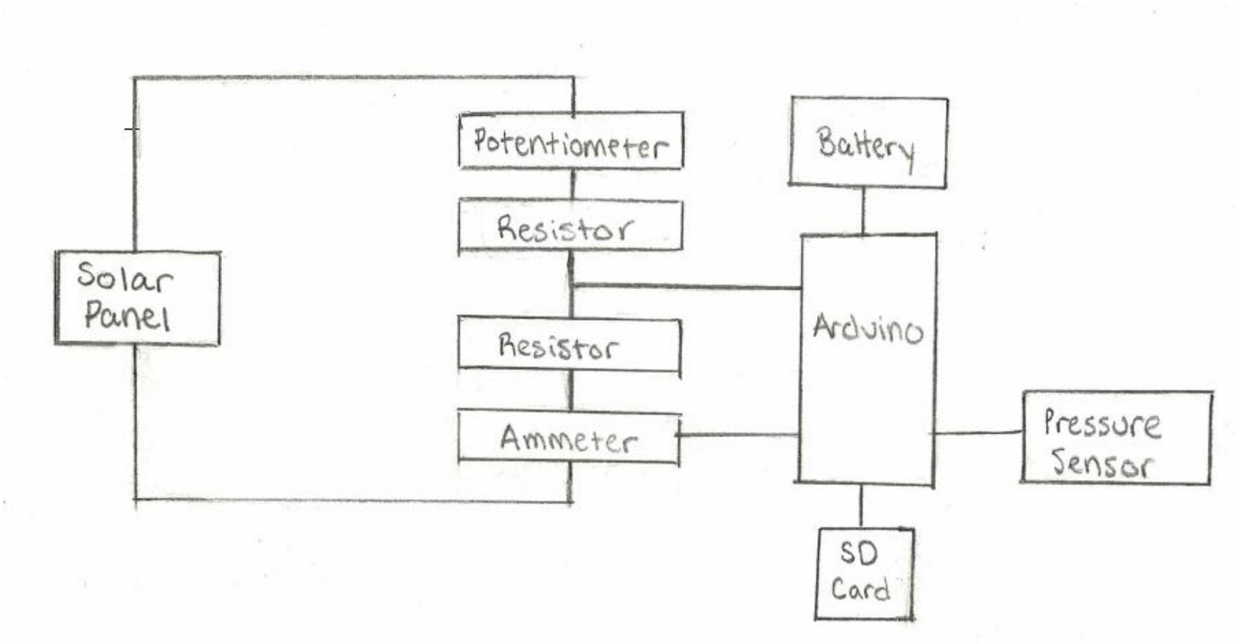


To the right is a diagram of the of the set-up of the payload, including the electronics system. This is a 3D model, that portrays the importance of each specification of the design.

To the left is the electrical schematic of the electrical system of the payload. This includes all of the sensors, and inputs.



Below is the Block Diagram. This diagram is a basic flow chart of what elements are connected within the circuit, and their relationship to each other. It is a simplistic, but brief blueprint that was helpful in the beginning stages of the project, and helpful when trying to present the circuit to others.



Safety and Failure Analysis

One of the most important aspects of this project is safety. To make sure that our experiment is successful, it will need to also be safe. If a part of the electrical circuit fails, we will be able to find out where the problem is before the circuit has the chance to overload or short circuit. We will check the circuit regularly to prevent any safety hazards.

Payload Concept Features and Definitions

Creativity and originality

As our team brainstormed of ideas for our payload, we all came to the conclusion that renewable energy is important to all of us. It is obvious that it is necessary for all of our future, and we wanted to prove that we could find a more efficient way to make energy. As we began our project we started out with a preprogrammed data logger, but now we will truly be starting from scratch. Each aspect we will need to assemble and create as our own. This project will require lots of learning and patience. With all of our hard work and determination we will be working until we make this experiment the best it can possibly be. Ever since we started this project, we have been changing our payload to perform in a way that will give us conclusive results that may have never been tested before.

Uniqueness or significance

This design is very unique. There are many aspects that have been carefully considered and will be carefully constructed to make our results conclusive. There are factors that had to be included in safety also, making certain aspects of the design more challenging and specialized. We have started over our electronics for the payload from scratch. In fact, we will be making our own circuit with all separate parts. This will not only save us money, but will help us get the exact specifications we need for a successful experiment. The significance of this experiment is to discover if there is more current, or power generated at a higher altitude. If our hypothesis is proven, it could help with the renewable resource revolution.

Suitable level of challenge

Our project is advanced for our age group, and could easily be considered a collegiate level project. This consideration could be verified for many reasons. These examples may include the varying different aspects of our payload, such as programming, circuit design, circuit analysis, circuit construction, physics application, and renewable energy efficiency. Team members are researching the specific programming for our Arduino, since we will have to program it ourselves. Some of these team members have already had computer programming, which is very similar to the programming we will need to do for the Arduino. This programming will take many hours to program, and then transferred onto the Arduino. If this program is through, little to no changes will need to be made to it. Once the program is written, it is possible to go back and edit it. As a result, once the program is written, any changes can be done immediately, and be able to be fixed in a timely matter.

Science Value

Payload Objective

The objective of our payload is to determine if the proximity to the sun will affect the amount of solar power generated. To determine if the amount of power generated is greater, we will have to look at the relationship between voltage, current, and power. The change in current will change over time, along with voltage. For the purposes of this experiment we will focus mostly on current since it will vary the most. By knowing this we should be able to also observe the relationship between altitude and current generated. In another mathematical equation, power is equivalent to the amount of voltage multiplied by the amount of current. In our experiment, the amount of current should increase if it collects more solar energy than it does on the ground. This is why we will need two solar panel arrays. One will be in the rocket, and the other will be on the ground. The solar panel array that is at ground level will be the control in our experiment, meaning that it will be a consistent log of data that can be compared to the ejected solar panel array, since there should be a difference between the two. The solar panel array that is within the rocket will deploy at apogee. As it descends it will be collecting data, until the battery runs out or the SD card is full of data. The battery is more likely to run out before the SD card is filled. This is due to the limited amount of space, and the mass limit of the payload. Since the SD card is so lightweight, we can get one with more space, and still get about the same mass. This will make our objective possible, because the launch is so quick, there will be plenty of time for data to be read so that we can interpret our data. After the launch we will be able to see if our hypothesis was true. We predicted that there would be a change in current, which means there would be more power generated, at a higher altitude. The differences in current should be very apparent. There are a few variables, such as the amount of water vapor or the amount of atmosphere, which will affect the results. Even though we expect a change, we also predict that it will be very minute. With our results, our hypothesis will either be disproven or proved by our data. This will fulfill the purpose of our experiment, and define if there will be a difference in the amount of power generated a mile closer to the sun. This will also prove if it will create more power that could possibly be harnessed for renewable energy.

Payload Success Criteria

One of the most important aspects that are necessary for our experiment to work is that the solar panel array must be deployed at apogee. However, possibly the equivalently important factor for a successful experiment would be functioning electronics. Both problems must be tested and checked before launching. With each launch and test, parts and modifications will be monitored and recorded to keep track of parts and possible flaws in the design. Our safety officer would be able to do ground tests to see how much black powder will push the payload and the drogue parachute out at the same time. Although this is not a perfect science, in most cases there will be left over residue from overuse. Another problem that could occur would be if the payload was somehow infringed upon by the rocket or the parachutes. This could also damage the rocket, or even cause the rocket to free fall. In another detrimental situation, the data logger could fail to record, despite a successful launch. This could also include corrupted data, or a damaged Arduino, which is also considered a data logger. The advantage to having building our rocket from scratch is that many of the parts are interchangeable. As a result, if any parts are damaged, we should have back up parts to replace them, so that our flights are not prolonged. A minor but important aspect of the success criteria is to have enough room for data on the SD card, which should be easily achievable due to the availability and low cost of an SD card. The solar panel will need to be protected when being launched so that the ejection charge does not damage it. If the solar panel is damaged it will make our data askew and it will hinder our progress in the project.

Experimental Logic, Approach, and Method of Investigation

The start of our experiment began with the concept of a solar energy. Logically, we started out with a solar panel, and a data logger to measure the amount of solar energy captured at different heights. When approaching this idea, we came to the conclusion that having one solar panel array go up in the rocket to descend down would not be a controlled experiment. Therefore, it was obvious that we needed a solar panel array at ground level, to see if there was any difference at ground level.

Test, Measurement, Variables and Controls

To test our payload we plan on first testing at ground level. Before we integrate our electronics system within the payload frame, we could test it outside of the payload with synthetic lights and an appropriate voltmeter. These individual tests on the entire circuit will help us configure and adjust the circuit so that it will perform at its best. After a thorough analysis of the circuit, we can then integrate it into the payload's frame and begin to do trials of testing in an outside environment. Once we get, and record, conclusive results we will be able to take the next step. Before we even conduct the actual experiment, we will need to inspect the entire payload for possible disconnections, breaks, or cracks. If any changes need to be done, we will be able to repair the flaw accordingly. Likewise, we will also bring tools to our launches that could be used for immediate repairs or replacements. This would ensure that we do not fall behind in our project. Before departure for a launch, we will test the electronics of both solar panel arrays before leaving to double check that they will be able to perform when we launch one or the other. After these tests, we will review the data recorded, to see if it is following the previous, and newly expected results. Every measurement made in the payload will be checked, and rechecked to ensure little percent error.

With every experiment there are different variables and controls that will result in repeatable results when maintained. In our experiment the independent variable would be the height. In our experiment, this will be coupled along with the dependent variables. These two dependent variables are current and voltage. Although voltage will only fluctuate in small amounts, it will also affect the amount of solar energy, or power, being generated. However, this will only affect the experiment in micro measurements. In this experiment, we will be focusing on the dependent variable, current. This dependent variable will change with the independent variable. Therefore, upon descent, the height will be constantly changing, but the current generated will depend on height. Although there are other uncontrollable variables such as wind speed or weather, we will consider it when interpreting data. There are other variables that make the experiment consistent. These variables are controls, so they do not change throughout the experiment. These controls include the entire payload frame system, and the electronics system. This means that the Arduino, solar panel, wires, Lucite, body tube, trusses, centering rings, bulk heads, wing nuts, threated wires, sled, and memory foam will remain consistent. Therefore, we must keep those variables consistent. This aspect is very important so that both of the solar panel arrays needed for the experiment are identical.

e) Expected Data, Accuracy, and Error Analysis

We expect that the solar panel array that was deployed at apogee will have a larger amount of current produced compared to the solar panel array at ground level. Therefore, the amount of current produced will directly correlate to the amount of power produced due to its linear relationship between current and power.

With the Arduino as our data logger, we will be able to program our data into very tiny increments. Since the Arduino is a computer, it has its own language that can measure standard increments into even smaller increments due to its ability to sense small amounts of change. However, the accuracy of the measurement should also be recorded with little percent error.

f) Experimental Process Procedures

First the payload must be turned on. We have included a switch in our circuit, so that we can easily turn the circuit on or off. Second, the solar panel should take in solar energy, tht is transferred through the potentiometer, then the resistor. This process will already cut the voltage in half so that it can be measured by the Arduino. The Arduino is started by the switch, causing energy to flow from the nine volt batteries into the Arduino. This will trigger it to start writing data points when the solar energy transfers through the wires as voltage. After that first data point is recorded, the solar energy will still be simultaneously be flowing through the circuit. This is where it will go through another resistor, and then through an ammeter. Some current is transferred down t hat wire to the Arduino to write another point. The current that is still traveling around the circuit is completely reduced, or exhausted. Then the process starts all over again.

To keep this process going after you have turned on the switch, you must keep it in a sunny place with no shadows. When placing the payload into the rocket, it should be placed in carefully and not tightly. Then, the parachute is lightly placed on top of the payload, for the electronics bay to be placed half way in the back end of the body tube. Once the rocket is put together, at apogee it will deploy and descend until it hits the ground. Once you retrieve it, you will be able to take out the SD card and interpret the data.

Safety and Environment Payload

Safety Officer:

The team Safety Officer is Tom Aument, a Level 2 NAR Representative, who be overseeing the progress and analyzing the safety of the design. He will verify components of the payload, to make sure that they do not interfere with the functionality of the rocket.

Failure Modes with Proposed and Completed Mitigations:

Failure Modes	Proposed and Completed Mitigations
The rocket motor does not function properly.	Our Safety Officer has loaded and tested Cesaroni motors before; therefore, he has experience with the type of motor that we are using. We plan on having him practice using the specific motor that we will use during the full-scale launch: a K2045. This will prevent major catastrophic failure of the motor, along with recognition of common motor or igniter complications, if any.
The parachute fails to deploy and causes the rocket to plummet unsafely to the ground.	Our Safety Officer has tested how much black powder needs to be placed in the ejection charge wells, and has finalized how much we will be using based on test results. Also, methods for packaging recovery system components have been researched in order to prevent the payload or other components from getting lodged in the rocket.
The rocket travels along a path that is unplanned and is either unsafe or will prevent the rocket from reaching one mile.	The rocket design has been tested on OpenRocket to make sure that it is stable for launch. Also, the rocket will be inspected after assembly to ensure that nothing can break loose during flight. The

	full-scale flight will also yield data on whether or not the rocket contains any major flaws, and those can be addressed before another test is conducted.
Electrical Circuitry within the payload loses its functionality as a result of wires becoming detached.	The payload circuitry will be tested after its completion to ensure that it functions properly. Once this is confirmed, any components that can be soldered will be, and a specialized epoxy will coat over components and junctions that must not be tampered with.
The payload was not constructed properly, and as a result poses a major problem that could affect the system's functionality.	All parts of the payload will be assembled only while at least two well-versed persons in its construction are present. The two people will come to an agreement as to where components are to be attached, or what line of code needs to be used in operation, before it is executed. Both people who are working on its construction will ensure that precautions are being taken to prevent injury or improper material usage.
The switch which enables data to be recorded fails and no data is recorded.	A pre-launch testing of the payload operation will be conducted to ensure that the switch functions as it is supposed to. Once this has been ensured, the switch will be activated and secured in the correct position to continue recording data.
The solar panel is damaged by either the pressure from the ejection charges, or by other means.	We plan on using a Lucite cylinder around the flexible solar panel, which will allow the solar array to gather solar energy; however the solar panels will not be subject to the direct pressure of the ejection charges. The solar panels will be handled carefully when not covered in the Lucite cylinder, and will be stored in the proper environment to prevent its malfunction.
The code for the Arduino is not written correctly, and the proper data is not recorded.	The Arduino and its components will be tested after assembly to check for functionality with the code that has been written for it. All sensors will be checked to see if they are producing accurate and usable data, before the payload setup is considered completed. In order to surpass complications in code writing, a series of

	Youtube tutorials will be referenced, or a teacher well versed in computer programming will be referenced for help.
The payload is not attached properly to the shock cord within the rocket, and it becomes an independent section of the rocket that is falling	Methods will be researched to find out the most effective way of attaching the shock cord to the eye bolt. This will ensure that the payload section will not become independent from the rest of the rocket.

Personal Hazards:

Before construction, safety procedures will be discussed along with proper techniques to prevent any accidents. There are hazards when using the electronics in the payload. It is important to know that these hazards include bodily damage. As previously stated, electronics is static discharge or electrocution from a circuit. Batter acid is toxic, and any mess of it should be cleaned up immediately. Burns could result from the combustion of the electrical components that was caused by short-circuiting. If the solar panel would combust, hazardous chemicals could be inhaled. The misuse or overuse of solder could result in first or second degree burns. Solder creates the byproduct Lead Oxide; any excessive exposer to this gas could have damaging effects on the body. Other injuries could occur due to materials used and human error. An injury could occur from improper or carless use of cutting tools. Any accidental indigestion of epoxy or hazardous materials could be extremely hazardous or deadly. Personal hazards could occur if the safety guidelines are not followed. A lack of knowledge pertaining to the electronics or proper operation of construction tools could lead to minor or severe bodily damage. Any excessive exposure to Lead Oxide fumes.

Safety Data and Regulations:

There are a few Safety Data Sheets that need to be read and followed for safe use. These sheets include:

- Z-Poxy Resin http://web.mit.edu/rocketteam/www/documents/MSDS/Z-Poxy%20Resin.pdf
- Z-Poxy Hardener http://web.mit.edu/rocketteam/www/documents/MSDS/Z-Poxy%20Resin.pdf
- Operator's Manuals: PowerFilm Rollable Solar Panel http://www.solarmade.com/PowerFilmInstruct.htm

NAR Regulations

All of the NAR Regulations have not changed. The materials we have chosen will be safe and lightweight. These materials include PML body tube, wooden supports, Lucite, and electrical wires. A parachute will be used to ensure that the payload returns to the ground safely and undamaged so that it can be flown again. The team will not, in an circumstance, attempt to catch, infringe, or effect the flight of the rocket. This safety precaution will be discussed with the team before a launch, to make sure that all members are safe.

Mitigations:

In order to prevent injury when working with payload electronics, the team will not solder, change, or touch electronic connections while power is being supplied to them. The payload will also use a ground wire to prevent any static charge from damaging the components of the payload or from injuring anyone working on the payload. A 1N5817 or similar diode connected in series with the circuitry will prevent the current from reversing the direction of its flow and causing major malfunction of the payload, as solar panels tend to withdraw stored energy when they are not collecting sunlight. A 24 gauge wire or larger will be used on the solar panel hook-up to prevent overloading the circuit and potentially causing payload combustion. In order to prevent accidental battery polarity reversal, which could cause the battery to explode and destroy the solar panel, a specialized battery holder will be used and connected with the positive end connected to the positive end of the solar panel. This will prevent the battery from being hooked up correctly, as long as the battery holder is connected correctly from the start. This will be verified by several people with an excellent understanding of electronics before a battery is installed. A multimeter will be used on connections of the solar panel to ensure that voltage, current, and, therefore, power outputs do not exceed what the solar panels are expected to generate. The same will be done for the lithium battery to ensure that it will not cause the malfunction of other payload components. The flexible solar panel will not be rolled too tightly to ensure that the solar cell, encapsulant, substrate, seal, and gasket within the solar panel are not damaged. When soldering, the team must unplug the soldering iron when it is not in use and will be advised of the caution that they should take when using it. Also, lead-based solder will not be used to prevent indigestion, nausea, vomiting, constipation, headache, abdominal cramps, nervousness, or insomnia caused by excessive exposure to lead oxide fumes.

Environmental Concerns:

There are a limited amount of environmental concerns with the launching of this rocket. Since there are a lot of controlled variables in this experiment, the probability of these problems are very slim. One environmental concern would be a small effect on the ecosystem. This could include an unexpected motor ejection, a rocket's recovery system unpredictably faults, or the rocket coincidently getting stuck in a tree. The smoke that comes from the motor may be potentially harmful to the environment and the organisms within it, including humans. If the rocket disappears into a wooded area, it may endanger an animal's life if it gets hit, or if it tries to digest a part or parts of the rocket. With the specified launch site, these problems should not arise, and have a very small chance of happening.

V) Project Plan

Budget and Funding Plan

For our funding, we currently have received a total of $1500 dollars from NASA for award of contract, verification of web presence, and PDR completion. Another $1600 total will be awarded after completion of both the CDR and FRR.

We were presented with a MetEd First Energy grant of $500 on October 15, 2012 at a school board meeting for our solar energy payload. Our school provided a mini grant of $1000 on December 7, 2012. We were awarded the $250 AIAA Foundation Classroom Fund the same day. We also sold Bonus Books with a profit of $12.50 each, numbering 134 books for a profit of $1, 675.00 concluding the fundraiser. We sold advertising space on the rocket at $5 per square inch. We sold 85 in^2 to individuals, gaining $425. We then acquired a sponsor: Aqua Phoenix, who bought 1,089 in^2 for a profit of $5,400 dollars, filling the surface. Aqua Phoenix has promised to help us along our process and has decided to help us, for one to get them out into the community and also help some hard-working local students. Aqua Phoenix has committed to half the budget, and making free rocketry kits for educational seminars.

We are applying for STEM/education grants from STEM-related companies and local businesses. We have applied for a Lockheed Martin grant, reviewed quarterly and submitted year round. We qualify for the grant as SLI is a STEM related extracurricular activity. We have applied for the Lowe's Toolbox for Kids grant as well, providing up to $5000, but as of 1/10/11 we were denied because of our travel budget compromising of ¾ of our total budget. We failed to secure the grant because Lowe's does not fund "field trips". We have gone to school athletic events, holiday bazaars, and school plays to raise community awareness. With these events we have increased community awareness and support, receiving donations to the project. We will continue to use public events to gain funding.

In November, we 2012 sent out forms asking for donations from local businesses, with the hope to add additional sponsors to our group. After receiving a few replies, we sent out letters in December, 2012 to engineering firms and past alumni informing them of our project, and asking for their support. We are still waiting to find out from several firms and have had much more success directly speaking to these establishments and receiving generous donations.

With materials purchases we are following recommendations from our safety officer. We chose our materials based on four criteria: reliability, funding, pricing, and recommendations. Our budget was made based on the current prices of these materials. The estimated cost of the rocket is $2, 724.05, and the payload is approximately $328.81. These prices are subject to change due to price changes and unexpected needs. Our travel expenses to Huntsville and launches are estimated at $8535.00.

We have opened an account in a local bank to keep our finances separate from other science clubs. As of January 7, 2013, we currently have $3,044.49 in our bank account and have spent $2,108.57 on supplies.

After we raise half of our proposed budget, we will receive half of our funding from our official sponsor, AquaPhoenix Scientific. If they were to give us half of the proposed budget currently, it would bring our deposited amount to $10,553.06.

Timeline:

August 2012

1: Request for proposal goes out to all teams
2: Start of Initial Proposal
31: One electronic copy of complete proposal along with web presence due to NASA Marshall Space Flight Center

September 2012

27: Schools notified of selection
28: Start of PDR and Edited Proposal

October 2012

4: Team teleconference
11: PDR question and answer session
22: Web presence establishment for each team
29: PDR reports, presentation slides, and flysheet posted on the team Web site by 8:00 a.m. Central

November 2012
7-16: PDR presentations

December 2012
3: CDR question and answer session
31: CDR rough draft due to team captain

January 2013
7: CDR final draft due to team captain
14: CDR reports, presentation slides, and flysheet posted on the team web site by 8:00 a.m. Central
22-23: 7th-8th grade presentations
23-Feb 1: CDR presentations
31: 9th grade presentation

February 2013
11: FRR question and answer session

March 2013
4: FRR rough draft due to team captain
11: Final Draft of FRR due to team captain
18: FRR reports, presentation slides, and flysheet posted on the team web site by 8:00 a.m. Central
25-Apr 3: FRR presentations

April 2013
17: 5:00 p.m.: All teams arrive in Huntsville, AL
5:30 p.m.: Team lead meeting
6:30 p.m.: Launch Readiness Reviews begin
18-19: Welcome to MSFC/LRRs continue
20: Launch Day
21: Launch Day Rain Day
23: PLAR rough draft due to team captain
29: PLAR final draft due to team captain

May 2013
6: Post Launch Assessment Review posted on team web site by 8:00 a.m. Central
17: Winning USLI team announced

Educational Engagement

We plan on educating the seventh, eighth, and ninth graders at Spring Grove Area School district, community members and continuing to work with companies to make our project possible. Gaining the support and help of our community will ensure the success of our project.

So far we have met with the Spring Grove's school board to inform them of our progress and details involved in our project. Along with blueprints of the rocket's final design, we also brought along a model of the full scale rocket to give them a better idea of what the design would entail. We also briefly discussed with them our plan for educating our district's middle school and high school students.

Towards the end of January, team members will present to the seventh, eighth and ninth graders. So far the principals in our school district have welcomed us to work with their students and our chosen dates have been approved by the administration of the middle school and high school. On January 22nd and 23rd, the team will present to the entire middle school. Each day a different grade will attend our presentation (the middle school consists of the seventh and eighth; one day the seventh graders will attend and the next the eighth graders will). On January 31st, the team will present to the freshman.

The presentation will be a means to inform the student body about our project and gain support for SLI and our TARC program at the high school. Gaining support among these students will provide strengthen these project and increase involvement and interest for both. Support for and participation in TARC is especially important as success in TARC is the reason we were even able to be involved in SLI this year and next.

The presentation will consist of power point slide. Team members will explain to students what SLI is and what the project entails. They will explain how we were selected and briefly go over our rocket design. Team members will also explain the fundamental design aspects of model rockets and go over rocket terminology as a basic introduction to the topic. Visual aids will be provided to help students understand the components that make up a rocket as well. This introduction to rocketry will help spark the interest of student's and allow them to further explore this interest through our rocketry workshop.

Our workshop's purpose is to give students a real life application of what rocketry is. We have already designed two rockets for our workshop. In the workshop, students will be working with three to four other students to build a rocket. We will also have a seminar on how to design rockets, and some of the general rules on how to build a rocket. At this seminar they will learn how to build a rocket and for the workshop, we plan on giving them a choice between two rockets that were already designed by our team members. This will ensure that all rockets are safely designed, and that the correct supplies are given to the students for their rocketry project.

This project will actively engage students and give hands on experience to students interested in aerospace and rocketry. The SLI Team will be there help students, show them how to use tools, and instruct them with the safety precautions needed for each part of their project. These students will get a chance to ask the SLI Team personal questions about their experience with rocketry and the SLI Program. Students are encouraged to suggest extra ideas of what else they would like to learn, so that the SLI Team can educate them further. They will also be able to ask questions about the proposal that we submitted, or any other reports that we will hand in. We will encourage them to ask questions about our rocket design, and even our payload design.

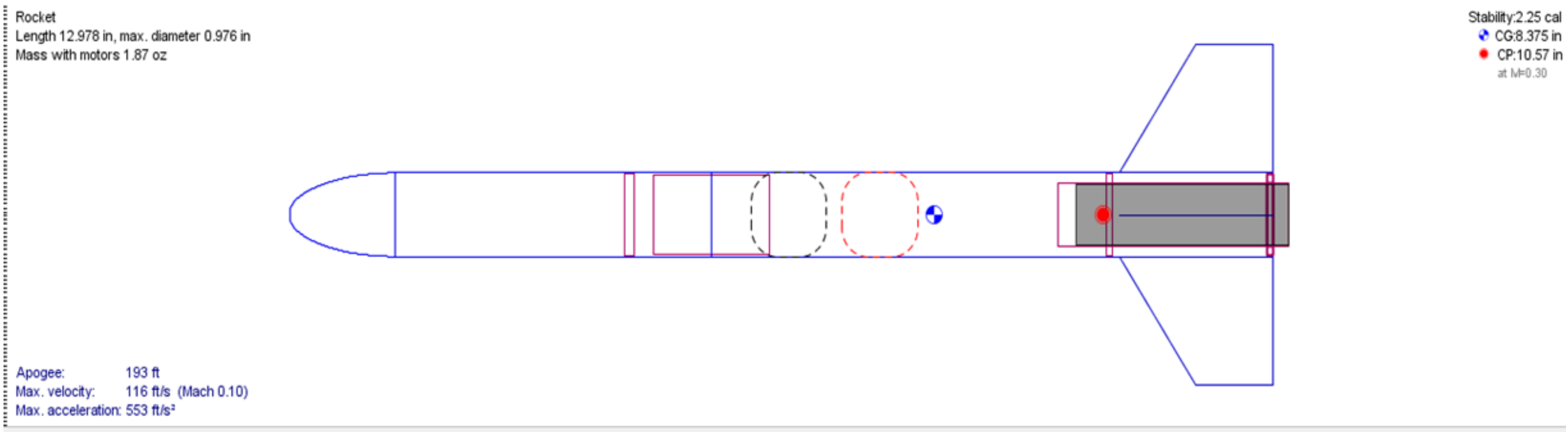
We plan on having students enroll for the workshop. Enrollment will include a meeting for parents and students on the details of the project, and also a consent form for the student and parent to fill out and sign.

Below is the pricing of both rockets offered in the rocketry workshop. These two rockets are relatively the same price, and groups will be able to choose between the two. The only relative difference in pricing is the price of the nose cone, the shape of the fins, and the amount of fins. These are the two rocket designs that students can pick from. This includes their design and also their pricing of each rocket.

Rocketry Workshop Rocket Designs

The first rocket consists of a shorter body tube, rounded nose and three trapezoidal fins. All other components of the rocket are the same as Rocket B.

Rocket Design A

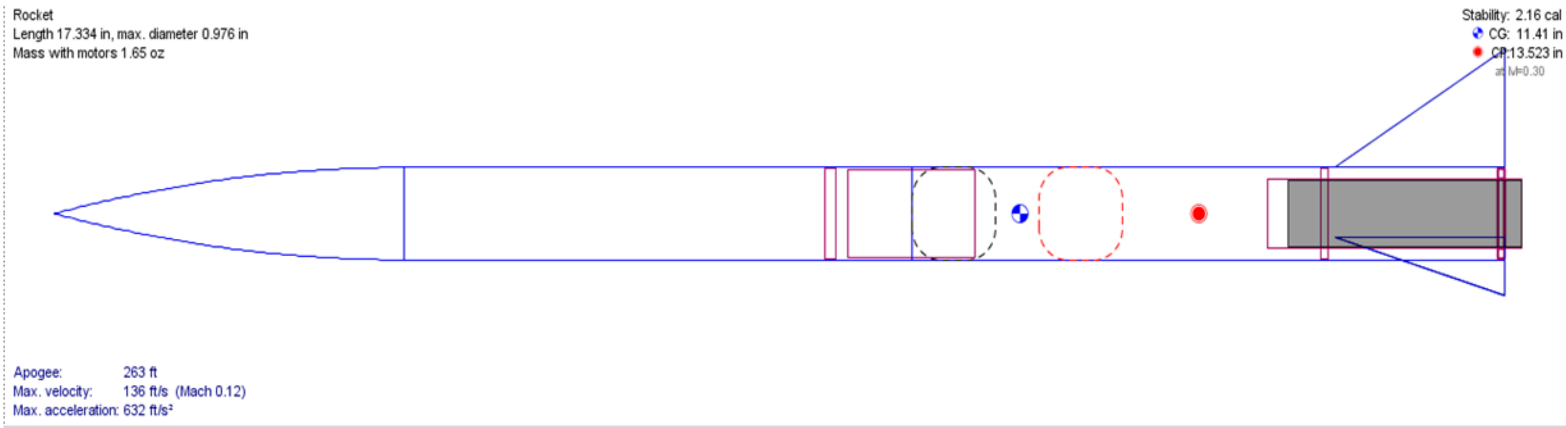


Budget for Rocket A

Details	Item #	Company	Indivual Cost
A 6-pack of BT-50 18" long	10100	Apogee	$8.62
A 3-pack of AC-24 B 1.5" long	13009	Apogee	$1.77
1/8 x12 x16 3 ply poplar Lite-Ply	PLY18L-16	Balsa Machining Service	$3.50
PNC 24C	19999	Apogee	$6.00
A 3-pack of Estes A8-3 Motors	5747	Estes	$11.01
A 6-pack of BT-20 18" long	10086	Apogee	$8.35
An 80-pack of 13 gallon Great Value Garbage Bags Walmart #000441368	441368	Great Value	$6.57
1/4" x 10 ft. Elastic Shock Cord	ESC 14-10	Balsa Machining Service	$2.00
25 foot Heavy Cotton String	30320	Apogee	$0.07
2oz. Bottle of Zap-a-Gap CA+ super glue	ZAPPTO1	AC Supply Company	$9.99
6-pack of Sunward Aerospace 1/4" Tubular Launch Lugs	13057	Apogee	$2.31

Rocket B has a longer body tube, conical nose cone, and three triangular fins. All other components of the rocket are the same as Rocket A.

Rocket Design B



Budget Rocket B

Rocket Component	Details	Item #	Company	Indivual Cost
Body Tube	A 6-pack of BT-50 18" long	10100	Apogee	$8.62
Tube Coupler	A 3-pack of AC-24 B 1.5" long	13009	Apogee	$1.77
Wood for Fins, CR, and BH	1/8 x12 x16 3 ply poplar Lite-Ply	PLY18L-16	Balsa Machining Service	$3.50
Nose Cone B	PNC 24C	19999	Apogee	$6.00
Motors	A 3-pack of Estes A8-3 Motors	5747	Estes	$11.01
Motor Mount Tubing	A 6-pack of BT-20 18" long	10086	Apogee	$8.35
Parachutes	An 80-pack of 13 gallon Great Value Garbage Bags Walmart #000441368	441368	Great Value	$6.57
Shock Cords	1/4" x 10 ft. Elastic Shock Cord	ESC 14-10	Balsa Machining Service	$2.00
Shroud Lines	25 foot Heavy Cotton String	30320	Apogee	$0.07
Super Glue	2oz. Bottle of Zap-a-Gap CA+ super glue	ZAPPTO1	AC Supply Company	$9.99
Launch Lugs	6-pack of Sunward Aerospace 1/4" Tubular Launch Lugs	13057	Apogee	$2.31

VI) Conclusion

Overall our project has just started up. We will be beginning our Educational Engagement Presentations, and following that we will start our Rocketry Workshop. After our successful sub-scale launch we are ready to start building our full scale launch as soon as all of the parts are in. Once our payload parts get in, we will be able to apply our research and programming knowledge and delve into its application. Our team looks forward to working with the students in our Rocketry Workshop, and presenting to older students that will be entering high school in only a few years. We look forward to visiting AquaPhoenix, our official sponsor, and their facilities. In our trip there we will be putting together the rocketry kits, learning how to work as a team and showing AquaPhoenix that we deserve their support, and can work together on our own.