Preliminary Design Review Report

I) Summary of PDR report

Team Name: The Rocket Men

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Mentor:

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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

In order to make the vehicle more efficient during the mission, several changes have been made. To make the body tube stronger we have decided to cover the body tube in a fiberglass coating. Bulk heads have been added inside the top and bottom tube. The bulk heads will have a shock cord attached to them with an eyebolt. The shock cord will secure the payload, electronics bay, and main chute together. The length of the top tube has been shortened to 27.7 inches, and the bottom tube has been shortened to 36 inches. This change was made because the manufacture we have chosen sells fiberglass-wrapped tubes with a maximum length of 36 inches. The length of the electronics bay has been shortened to 10 inches to supply more room for other components in the rocket. With this changed length, there will still be enough room to put all of the recovery system electronics in the electronics bay. The total length of the rocket will now be 81.95 inches. The parachutes have changed sizes as well. The main chute is now 72 inches in diameter and the drogue chute is now 15 inches in diameter. These changes are due to the decrease in the size of the rocket. In order to facilitate the deployment of the payload, we have moved the payload from the top body tube to the bottom body tube. Since the initial rocket was overstable, we decreased the amount of fins from 4 to 3. We also changed their shape from a trapezoid to a triangle to reduce the amount of resistance and friction applied to the rocket. This changed the center of pressure from 71.8 inches from the tip of the nose cone to 68.5 inches, changing the stability from 4.83 cal to 2.54 cal. The motor was also changed from a J295 to a K2045 Vmax, increasing the size of the motor tube to 16 in long. The centering rings have also been changed from ¼ inch thick fiberglass to ½ inch thick to make them stronger. These changes will lead to a better vehicle for conducting our experiment efficiently, safely, and successfully.

Changes Made to Payload Criteria

Several changes were made to our payload design. The dimensions for the flexible solar panel are now 10 x 5.9 x .02 inches. Vertical wooden trusses will be adhered to the exterior of the body tube that will strengthen the payload structure and protect the wires. The wires will travel from the data logger, through the holes in the body tube, and connect to the solar panel. The centering rings will extend past the body tube, creating a lip for the trusses to be glued onto. The trusses will be glued to the inner lips of the centering rings. The solar panel will be wrapped around the trusses and glued onto them. Two small holes at the top and the bottom of the body tube will be made. The wires will extend from the data logger to each end of the solar panel. A positive wire will extend from the data logger and go through the hole at the top of the body tube. Similarly, a negative wire will extend from the data logger to go through the hole in the bottom of the body tube. The data logger inside the body tube will be protected by memory foam, securing the data logger and the wires that are attached to it. A bulkhead will be screwed into the centering ring on the top of the payload. The bulk head will act like a removable cap, and will ensure that the contents of the payload are secured within the body tube. The cap will be secured onto the centering ring with four wing nuts. The payload will be attached to the shock cord within the rocket. The shock cord will attach to the bottom bulkhead and connect to the bottom of the payload. The shock cord will then continue from the bottom of the payload and proceed to connect to the bottom of the electronics bay. The payload is attached to the top of the payload. This section was designed in series to prevent the payload from tangling, and to prevent the parachute from casting a shadow onto the solar panel.

Changes Made to Project Plan

Since the initial proposal, we have developed new ideas for educating our community and students. We will have until April to fundraise enough money for our trip to Huntsville, Alabama. To keep the team informed, we will have meetings with specific purposes and instructions. We plan on having meetings every Monday and Wednesday. Any other meetings that we will have will be scheduled ahead of time. The meetings will give the team structure and will help us all stay on the same page. We have done a lot of work on our budget. We have chosen manufacturers and materials that we plan on purchasing for the rocket. Our approximation for the budget for travel, food, and lodging has stayed relatively the same, while the new rocket budget has changed. We are currently in the planning stages of our fundraising, and are looking at many options to ensure that we can raise enough money for all aspects of our project. Meanwhile, we have already applied for a few grants. We have already received our first grant from MetEd. This grant was presented to us at our District Board Meeting on Monday, October, 15th and was worth $500. We also got a mini grant from the Education Foundation which was $1000. To gain our community's support, we presented our SLI project at a board meeting. We presented our proposal with the assistance of a blueprint and a prototype. The administration discussed our trip to Huntsville, Alabama, after our presentation. After all of our hard work, the School Board approved our trip to Huntsville, Alabama. In our community we will be giving presentations within our school district. We plan on having an informative assembly for all students from kindergarten to 9th grade. Parents will also be able to partake in these assemblies. The meetings will be purely informative. The meetings will be purely informative. Any students in grades 5-9 that are interested in rocketry will have a chance to partake in a rocketry workshop. In the workshop, they will be able to work with the SLI team to build a rocket. This will help our program become more successful and will help inform the community of our project.

III) Vehicle Criteria

Selection, Design, and Verification of Launch Vehicle

Section 1

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

The launch vehicle is designed to travel to an altitude of about 5280 feet, but cannot exceed this height. The rocket has three independent sections, which is less than the maximum of four independent sections as stated in the vehicle requirements section of the Statement of Work. The redundant recovery system will be capable of being set up within two hours of the time that the Federal Aviation Administration flight waiver opens. It will be able to remain in its launch-ready arrangement on the launch pad for at least one hour without it or any of its on-board components losing their capability to operate. The launch vehicle will be capable of being launched from either an 8 foot long 1 inch rail, or an 8 foot long 1.5 inch rail. The rocket will be able to be launched from a 12 volt DC firing system, which will be supplied by the Range Services Provider. It will not require any external circuitry or specialized equipment from the ground to initiate the launch, other than what will be provided by the range. The rocket will use an ammonium perchlorate composite propellant that is commercially available and has been approved by the National Association of Rocketry, Tripoli Rocketry Association, or the Canadian Association of Rocketry. The rocket and motor combination that we will use will not exceed an impulse of 2,560 Newton-seconds. The mass of the ballast in the final design to be flown in Huntsville will not be more than 10% of the rocket mass without the ballast. A full-scale version of our rocket will be launched prior to the Flight Readiness Review in its final configuration. The full-scale version of the rocket will be identical to the design that was made prior to the launch, and is the same design that was approved by our safety officer. This flight should include the testing of the payload within the vehicle, but if not, mass simulators will be placed at the same approximate location of the payload. Either a full-scale motor or a motor that will closely simulate the predicted velocity and acceleration of the full-scale motor will be used during this flight as well. The vehicle at this launch will also be in its completely-ballasted arrangement as that of what will be flown down in Huntsville. This flight’s success will also 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. The components of the rocket launched during the full-scale flight will not be modified unless approved by the NASA Range

Safety Officer. Lastly, the rocket will not use forward canards, forward firing motors, motors that eject titanium sponges, hybrid motors, or a cluster of motors or multiple stages.

There are several factors needed for mission success. The mission would be considered a success if the rocket reaches an altitude of at least 4800 feet and no higher than 5280 feet, since the team recognizes 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.

Section 2

The recovery system should be capable of deploying a 15 inch drogue parachute at apogee by initiating rocket body separation behind the electronics bay. It should be able to deploy a 72 inch main parachute at 600 feet during rocket descent by initiating rocket body separation in front of the electronics bay. It should also be able to set off a second ejection charge in case the first one does not fire, or does not completely separate the rocket body components. The recovery system shall be able to record the maximum altitude of the rocket and verbally output this reading. It should be capable of reading the voltage of batteries operating the electrical components and verbally outputting this reading to ensure its function. The recovery system shall be able to check for continuity within itself and its components, to ensure the correct operation of its electrical mechanisms. It is planned to be able to output a signal, perceptible by a tracking device, in order to foster rocket recovery. The system must be capable of separating parts of the rocket without damaging any of its parts. Most importantly, the system must make the rocket recoverable and reusable. The altimeters were selected for the recovery system (PerfectFlite *StratoLogger*) because they are capable of fulfilling all of these requirements.

The propulsion/ motor retention system should be able to boost the rocket and its components to an altitude of 5280 feet. At the same time, the systems intention is to facilitate ignition by being capable of being ignited by a simple ignition system. It should be able to retain the motor throughout the duration of the flight, and facilitate the removal/addition of a motor. The motor chosen to fulfill the task of propelling the rocket to one mile was selected because it is commercially available, and is capable of boosting the rocket to this exact height given the precise design specifications of the rocket. The rocket airframe is going to house all parts of the rocket needed for launch. It should also provide rigid stability to the rocket as a whole. The airframe will be smooth and aerodynamically sound with little air resistance. This system should also be able to provide the needed strength to survive the landing and make the rocket reusable, provided a functioning recovery system. The rocket airframe should also maintain the intended flight path with minimal deviation from its simulated path. Fiberglass-wrapped phenolic tubing from Public Missiles Limited was chosen to complete this task because of its rigid stability and strength. It also provides minimal air resistance during flight. The fins will be made from 1/8 inch G10 FR4 fiberglass sheets because they are capable of withstanding the higher velocities attained by the rocket, while remaining impervious to the high intensity of he being expelled from the rocket motor.

Section 3

Subsystems

Recovery Subsystem

The recovery system is required to achieve mission success. It is comprised of one 72 inch main parachute, one 15 inch drogue parachute, two 15 foot nylon shock cords surrounded by Kevlar shock cord protector sleeves, 2 closed eye bolts (one secured to a bulkhead in the top body tube and one secured to a bulkhead in the bottom body tube), and a 3.9" diameter, 10" long LOC Precision Electronics Bay. This Electronics Bay will contain two PerfectFlite *StratoLogger* altimeters and four batteries (two to power the altimeters and two as back-up batteries for the altimeters). It will also house the tracking device that will transmit a signal to be able to facilitate the quick, successful recovery of the rocket. 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 is to ensure that the rocket is recovered in the event of altimeter failure. The Electronics Bay will also contain two threaded metal rods with wing-nuts to secure the components of the Electronics Bay within it. The metal rods span the entire length of the Electronics Bay in order to keep it together while also supporting the altimeter and its components.

Propulsion and Motor Retention Subsystems

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 the expulsions from the motor, and will secure the motor into the motor mount of the rocket for the duration of the flight.

Rocket Airframe Subsystem

The rocket airframe design is comprised of a nose cone, body tubing, and fins. The plastic nose cone is conical in shape, and is smoothed to reduce drag. The body tube is a resin-impregnated spiral-wrapped phenolic airframe tube. This tube is then wrapped in fiberglass to strengthen the structure and prevent zippering. The fiberglass will be sanded by the manufacture, Public Missiles Limited, and will be painted by team members. The fins are to be made from $1/8$ inch G10 FR4 fiberglass. Fiber glass provides extra strength that is needed during the high velocities that the rocket will undergo. The fiberglass also adds a fire retardant barrier to ensure that the exhaust from the rocket motor does not melt the fins. This fiberglass is also very smooth, causing very little drag.

Section 4

Apogee, stability, maximum velocity, rail exit-velocity, and ground hit velocity were calculated for the design of the rocket by a rocket design program. Apogee was calculated as 5280 feet while utilizing a Cesaroni K2045 Vmax motor. With the same configuration, stability was calculated as 2.54. The maximum velocity reached by rocket was calculated as 963 ft/s, which is less than the maximum velocity requirement. The rocket left the 8 foot launch rail traveling at 148 ft/s. With the simulation that was done, a 72 inch main parachute was used. It safely delivered the rocket components to the ground while traveling at 18.6 ft/s upon landing. This leaves the rocket with a kinetic energy of 57.48 ft-lbf at the time of landing.

The recovery system we will be using consists of two PerfectFlite *StratoLogger* altimeters, a 72 inch main parachute, a 15 inch drogue parachute, ½ inch eye bolts, and shock cords. The altimeters contain two outputs to deploy a drogue chute at apogee and a main chute which can be programmed to deploy in between 100 feet and 9,999 feet. We will be programming the altimeters to deploy the main chute at 600 feet. The altimeters can record apogee, temperature, and battery voltage. This can be recorded at a rate of 20 samples per second. Later, this data can be downloaded to a computer after the conducted experiment. Data will not be lost, even if the power source is disconnected from the altimeter. The altimeters come equipped with special reverse polarity protection to prevent premature ejection charge firing if a battery is connected backwards. The altimeter can operate for three seconds after a battery is disconnected, adding security to the successful recovery of the rocket. A voltmeter connected to the altimeter will read battery at the startup of the device to ensure that batteries are functioning properly and all circuitry is connected. The device has been tested in a simulation, and has operated properly in 100+ mph winds. This ensures that a false triggering of the mechanism should not occur due to incorrect barometric readings. One altimeter can be programmed to delay firing at apogee, to prevent over pressurizing with concurrent ejection charge firing in the redundant altimeter setup. The altimeters also run on a low current, enabling them to function in their armed state for weeks on just a standard 9 volt battery. The 72 inch main parachute is made from Ripstop nylon. The shroud lines are tested to withstand 400lbs. of force and are made from braided nylon. There is a swivel attached to the parachute shroud lines which is capable of withstanding 1500 lbs. of force. The drogue chute is a 15 inch elliptical parachute. The parachute contains 330 lb. test braided nylon shroud lines, and a 1000 lb. test swivel. The parachute is rated to slow a 0.9 lb. rocket to a terminal velocity of 20 ft/s. The shock cord is a 1" tubular nylon shock cord capable of withstanding up to 4200 lbs. of force. There are also ½ inch closed eyebolts secured inside of the rocket airframe. The metal weld ensures that the eyebolt does not open and release the shock cord. The capability of these components to withstand large amounts of force should make them excellent components of the recovery system, as we expect a maximum force of 280 lbs. to be exerted on these components during separation, with the 4200 lb. test shock cord absorbing most of the force.

Section 5

Requirement	Design Feature to Satisfy the Requirement	Verification of Requirement
1.1 The vehicle shall deliver the science or engineering payload to, but not exceeding, an apogee altitude of 5,280 feet above ground level.	The mass of the vehicle, the air resistance on the vehicle during flight, and the stability of the rocket were designed with the impulse of the selected motor to keep the launch vehicle at one mile above ground level under perfect launch conditions.	This requirement has already been verified on a rocket design program, but it will also be tested and verified during the full scale rocket launch to take place prior to the FRR.
1.2 (USLI Only) The vehicle shall carry one commercially available, barometric altimeter for	N/A	N/A

recording of the official altitude used in the competition scoring		
1.3 The launch vehicle shall remain subsonic from launch until landing.	The mass of the vehicle, the air resistance on the vehicle during flight, and the stability of the rocket were designed with the impulse of the selected motor to keep the launch vehicle under one mach.	The speed of the vehicle has been verified to remain subsonic on a rocket design program and it will also be verified during the full scale launch to take place prior to the FRR.
1.4 The launch vehicle shall be designed to be recoverable and reusable.	The rocket has a recovery system designed to deploy a drogue chute at apogee and a larger chute at 600 feet that will provide the rocket with a ground-hit velocity of less than 20 ft/s, which should prevent any damage to the rocket.	The rocket recovery system has been verified to deliver the rocket safely to the ground by a rocket design program. This will also be verified during the tests with the scaled down model rocket. This shall accurately depict how the rocket will recover during a launch.
1.5 The launch vehicle shall have a maximum of four independent sections.	The rocket contains less than four independent sections as designed by a rocket design program. The shock cord shall be tested prior to the launch to determine how strong it is, and how much force it is able to withstand. All sections of the rocket not tethered with a shock cord will be secured by other means (such as epoxy).	The rocket design has been analyzed by a level 2-certified NAR representative, and will be inspected by a level 2-certified NAR representative after the rocket has been constructed in its final configuration to ensure that the rocket does not contain more than four independent sections.
1.6 The launch vehicle shall be capable of being prepared for flight at the launch site within 2 hours, from the time the Federal Aviation Administration flight waiver opens.	The rocket will be comprised of easy-assembly components, including body tubes that slide onto the electronics bay to hold them together, a recovery system that can be assembled and armed quickly, payload electronics that are preassembled, and a reloadable motor for quick	The design has been analyzed by a level 2 NAR representative to make sure that the rocket has a sound design that will require little assembly at the launch site. This will be tested during the scale test launch to make sure that all components can be prepared for launch within

	construction. The rocket will require little assembly at the time that flight waiver opens.	the 2 hour time restriction.
1.7 The launch vehicle shall be capable of remaining in launch-ready configuration at the pad for a minimum of 1 hour without losing the functionality of any critical on-board component.	The recovery system is designed to contain switches that can arm the recovery system, and nine volt batteries are attached to ensure that the recovery system can operate properly for over one hour.	The recovery system will be tested to see if the electronics can last longer than 1 hour in the on position. If not, a back-up battery will be wired into the recovery system electronics.
1.8 The vehicle shall be compatible with either an 8 foot long 1 in. rail or an 8 foot long 1.5 in. rail, provided by the range.	The launch buttons attached to the rocket will be compatible with either a 1010 or a 1515 rail that is eight feet in length.	The launch buttons on the rocket can be tested on a 1 inch rail available at the school. Also, the rocket will use launch buttons that are designed for a rail of one of these sizes.
1.9 The launch vehicle shall be capable of being launched by a standard 12 volt direct current firing system.	The rocket will use commercially available igniters which will be able to operate on a standard 12 volt DC current.	The igniters will be tested for their reliability when supplied with a 12 volt DC current from a standard firing system.
1.10 The launch vehicle shall require no external circuitry or special ground support equipment to initiate launch (other than what is provided by the range).	The launch vehicle will operate off of standard ignition systems, and will be self-containing all other components needed to initiate launch, including a motor.	The scale model rocket launch and full-scale rocket launch will be conducted using standard ignition and launch ground systems. The rocket design has been reviewed by a Level 2 NAR representative to confirm that the rocket design does not require specialized equipment on the ground or circuitry on the outside of the rocket airframe.
1.11 The launch vehicle shall use a commercially available solid motor propulsion system using ammonium perchlorate propellant which is approved and certified by the National Association of	The motor being used will be a Cesaroni K2045 Vmax, which is commercially available. This motor uses an ammonium perchlorate propellant.	The motor we are using has been tested and approved by the Canadian Association of Rocketry and the National Association of Rocketry. This motor will be used in our scaled rocket and will be launched prior

Rocketry, Tripoli Rocketry Association, and/or the Canadian Association of Rocketry.		our launch in Huntsville, Alabama.
1.12 (USLI Only) The total impulse provided by a USLI launch vehicle shall not exceed 5,120 Newton-seconds (L-class).	N/A	N/A
1.13 The total impulse provided by a SLI launch vehicle shall not exceed 2,560 Newton-seconds.	The maximum total impulse capable of being produced by the Cesaroni K2045 Vmax motor is 1417 Newton-seconds.	The impulse of the Cesaroni K2045 Vmax motor has been tested by the NAR and CAR.
1.14 The amount of ballast, in the vehicle's final configuration that will be flown in Huntsville, shall be no more than 10% of the unballasted vehicle mass.	The rocket design will not contain more mass than 10% of the total mass of the rocket without ballast.	The mass of the ballast and mass of the rocket (with all of its components) will be measured in order to ensure that the mass does not surpass 10% of the rocket mass without ballast. This process will be repeated whenever the mass of the ballast within the rocket is changed.
1.15 All teams shall successfully launch and recover their full scale rocket prior to FRR in its final flight configuration.	The full scale launch testing prior to launch at Huntsville will be responsible for fulfilling this requirement.	The successful launch and recovery will be verified and documented by an NAR Level 2 or 3 observer on the flight certification form and the FRR Package.
1.16 (USLI Only) The maximum amount teams may spend on the rocket and payload is $5000 total.	N/A	N/A
1.17.1 The vehicle shall not utilize forward canards.	N/A	The vehicle design will not include the usage of forward canards.

1.17.2 The vehicle shall not utilize forward firing motors.	N/A	The vehicle design will not include the usage of forward firing motors.
1.17.3 The vehicle shall not utilize motors which expel titanium sponges.	N/A	The vehicle design will not include the usage of motors which expel titanium sponges.
1.17.4 The vehicle shall not utilize hybrid motors.	N/A	The vehicle design will not include the usage of hybrid motors.
1.17.5 The vehicle shall not utilize a cluster of motors, either in a single stage or in multiple stages.	N/A	The vehicle design will not include the usage of a cluster of motors in a single or clusters in multiple stages.

The Team Mentor will be overseeing most of the rocket design and construction to ensure that the rocket is being built properly. At the same time, he will also be verifying the compliance of the rocket with the Statement of Work, along with the Team Advisors, Mr. Hastings and Ms. Eaton. The rocket design has already been verified. When construction on the rocket begins, most of the other requirements will be verified. The rest of the requirements will be verified before traveling to Huntsville. Requirements regarding the use of commercially available products and the materials used by the companies within these products have been verified. Also, the requirements of the vehicle ensuring the compatibility of the rocket with launch equipment supplied at Huntsville have already been verified.

Section 6

Risk Assessment

Risk	**Probability of Risk *(1-10)**	**Impact on Project Progress**	**Plans for Reducing Risks**
Parachute fails to deploy	2	We will lose a rocket and must build another one, losing work time and time to launch.	The team will carefully insert both parachutes before launch and make sure that there is enough heat shield material to prevent flame up.

Igniter failure	4	Delay of launch testing and rocket progress	The team will ensure that only commercially available igniters and motors are used. All members will follow the NAR High Power Safety Codes which outline what to do in event of ignition failure.
Parachutes become entangled with one another	3	Rocket may be lost or partially damaged. Another would have to be build, resulting in loss of work and launch time.	The team will carefully insert both parachutes before launch and be mindful of the location of both parachutes in relation to one another when editing the rocket design.
Payload is not ejected	4	No usable data would be collected. The team would have to redesign, rebuild, or reload the payload. Valuable launch and construction time would be lost and construction could be delayed.	Team members will ensure that the payload is properly installed before launch and also ensure that the payload doesn’t fit too tightly within the body tube of the rocket.

Rocket does not reach altitude of one mile	7	We will have to redesign or adjust the design of the rocket. The construction of the rocket would be delayed.	The team will use Rocksim to simulate the launch and determine an estimated apogee. Data from test launches will be used to determine what changes have to be made to get our goal altitude. After the data is collected, the team will make adjustments accordingly.
Motor not assembled correctly	1	Injury of team members, motor CATO, or loss of rocket could occur. The team would have to rebuild the rocket or part of it, delaying construction.	All motors will be assembled by our team's NAR representative, who is very experienced with the assembly of class 2 rocket motors.
Electronics bay failure	2	The team may have to rebuild the payload or make adjustments the payload. There will be a delay in the progress of test launching.	Team members will carefully inspect all parts of the electronics bay before launch to ensure that all parts are operating correctly.
Payload fails to collect usable data	3	Team members would have to redesign, rebuild, or retest the payload, losing launch and construction time.	Team members will ensure that the payload is inserted correctly within the rocket. They will also check the data logger and electronics within the payload to ensure that everything is operational before launching.

Drogue parachute ejects before apogee	2	Rocket may fail to reach intended apogee. Test launch would be delayed.	The team will use only commercially available ejection charges. Rocket motors will be handled only by our NAR representative
Second parachute ejects before 600ft	1.5	The rocket may drift significantly making the recovery of the rocket very difficult.	The team will use only commercially available ejection charges. Rocket motors will be handled only by our NAR representative.
Both altimeters malfunction	1	Altitude of rocket during launch would be unknown, delaying testing. New altimeters may need to be purchased. This will delay the construction and launching of the rocket. It will also cost money to replace them.	Team members will ensure that altimeters are functional before launch.
Shock cord damage or breakage	2	Rocket would split into two, payload data may be lost, and unsafe descend of either portion of the rocket could occur. In the event of an unsafe descent, the rocket may need to be rebuilt, therefore delaying the construction of the rocket and any also delaying any further launches.	Team members will ensure that shock cord is properly installed in the rocket during construction.

Motor CATO	1	A motor can be lost, along with potential damage caused to the rocket. Personal injuries could also occur.	All motors will be assembled and handled by our team's NAR representative.
Zippering	2	Loss of rocket airframe and damage to internal portions of rocket could occur. Damaged airframe and other parts would need to be rebuilt, costing valuable construction and testing time.	The rocket will be made out of fiberglass-wrapped phenolic tubing, which will make it more difficult to tear. Also, ejection charges will be tested to figure out the right amount of black powder to use in them.
Short circuiting of electronics	2	Lose of electronics or payload data could occur. The team would potentially have to purchase new electronics, delaying the construction of the rocket and adding an additional cost to the budget.	Team members will carefully install payload electronics, making sure that no bare wires are showing and that the power supply has a load onto which it is supplying current.
Rocket combustion	3	Major or minor injuries could occur to team members. The rocket could be lost due to the improper use of fire extinguishers.	The team will bring a fire extinguisher suitable for the needs of the fire and according to the MSDS of the motors being used.
Motor ignition delay	3	If in igniter fails to work, a rocket could be lost, a launch delay could occur, and injury may occur if someone approaches the rocket shortly after countdown.	The team will only use commercially available and Range Safety Officer-approved igniters.

Rocket fails to leave launch rail	1	Injury to team members, loss of rocket and/or motor could occur.	All motors will be handled and assembled by our NAR representative to ensure successful launch of rocket.
Damage of rocket materials in transport	3	Damaged materials would need to be rebuilt or replaced. Could result in cancellation of test launch.	All rocket materials susceptible to damage will be carefully packaged and stored for transport. Team members will take care to pack materials in a way so as to minimize jostling and other factors that may cause damage. Extra parts will also be brought.
Rocket materials being lost in transport	4	Loss of crucial materials may render rocket un-flyable. Cancellation or delay of test launch may result.	All rocket materials will be loaded in boxes whose contents will then be labeled. Materials will be loaded in an organized manner so that they are easy to find once we arrive at the launch site.
Rocket materials too large to transport	1	The team will be unable to travel to launch site if rocket materials are too large. Test launch may be canceled, delaying testing.	Team Advisors will reserve school vehicles large enough to accommodate all rocket parts to transport to the launch site.

Insufficient funds for transport	2	The team will be unable to travel to test launches or Huntsville until sufficient funds have been raised. Delays in testing may occur and the budget may need to be readjusted.	Within the budget, enough money will be allotted for transport to ensure that this does not occur. Fundraisers will be conducted throughout the project to continue to raise money.
Materials forgotten	6	Lack of crucial materials may render the rocket un-flyable. A cancellation or delay of a test launch may occur. If a flight is canceled, the money spent on transportation will have to be funded again to compensate for our already spent money.	Team members will keep a check list of all necessary materials for the launch. Before departure, the list will be consulted to ensure all materials are loaded.
Unforeseen complications in transport	4	May delay travel to launch site or result in cancellation of the practice launch.	The team will make sure that the launch date is known in advance and that all specifications are planned out well in advanced. The team will pack the rocket carefully and make sure it is secure during transportation. The team will also depart on time to be able to reach the launch site promptly and on time.

Coaches not available for after school meetings	2	The team will be unable to work on rocket construction or hold meetings. Construction progress may be delayed.	Coaches will coordinate their schedules in order to be available for the team as often as possible. Team members will plan mandatory meetings around days in which at least one of the coaches is available.
Team members unable to attend meeting due to prior commitments and schedule conflicts	5	The team will be unable to hold important meetings if too many members are unable to attend. Delay of progress and loss of team members if conflicts become too frequent may occur.	Team members will hold important meetings as first priority. They will be asked to adjust their schedules if possible to be able to attend team meetings and practices.
NAR representative not available for test Launches	2	Practice launch may be cancelled, delaying testing of rocket.	The team will work with our NAR representative's schedule to plan test flights. When choosing potential launch dates, we will do so in advance and be mindful of our NAR representative's prior commitments.

Technology advisors not available when needed	7	Will result in inability of the school's shop tools to be used, potentially delaying progress.	When shop tools need to be used, team members will make sure to check when the technology advisors are available prior to when the tools are needed. They will schedule a time to use the tools accordingly.
Team mentor unavailable to aid in rocket design/construction	3	When unavailable, team members may be unable to continue progress until necessary help/advice is received. Progress may be briefly delayed.	Team members will try to ask our NAR representative design/construction questions at least several days before important deadlines to ensure enough time for him to respond.
NAR representative unavailable for official launch	1	The Team will be unable to partake in the official launch in Huntsville.	The team has given our NAR representative all important dates for the official launch in advance so that he can make sure he is available those days.
Inability to get group members together over school breaks	7	Delay in rocket progress and construction.	The team will plan out several meetings over Thanksgiving and Christmas break to ensure that progress is continuing to be made. Team members will be given meeting dates prior to break so that they can adjust their schedules accordingly

Lack of communication during school breaks	8	Delay in rocket progress and construction.	Team members will remain connected through email updates and though team meetings during break.
Team estrangement because of lack of cooperation	3	Delay of rocket progress.	The team will talk calmly and will not fight with one another. The team will respect each other and themselves
Lack of communication	5	Rocket/payload may be built incorrectly or too many of one part may be made, causing a slight to major delay of progress or loss of material.	Every team member will have access to other members' email addresses and have the ability to talk during the school day. Emails will be sent out by the project managers, detailing project updates, important deadlines, and upcoming meetings.
Cancellation of launch due to poor conditions	4	Delay in testing of rocket.	The team will plan multiple days to launch to be flexible in scheduling practice launches, and practice patience.

Going over budget	4	Delay of rocket progress due to the need for more time to fundraise.	The team will carefully use all materials, order only the parts needed, keep track of materials, and use the budget wisely. The team will be diligent in fundraising endeavors.
Budget miscalculation	6	Budget miscalculation may result in the delay of rocket construction due to having to check and adjust the budget before more parts can be ordered. If the budget is miscalculated to be lower than it actually is, purchase of materials may be delayed until sufficient funds are raised.	The team will carefully review each part of the project to determine the total cost of each. They will double check their calculations and hold a small amount of money in reserve in the event that a miscalculation or complication occurs.

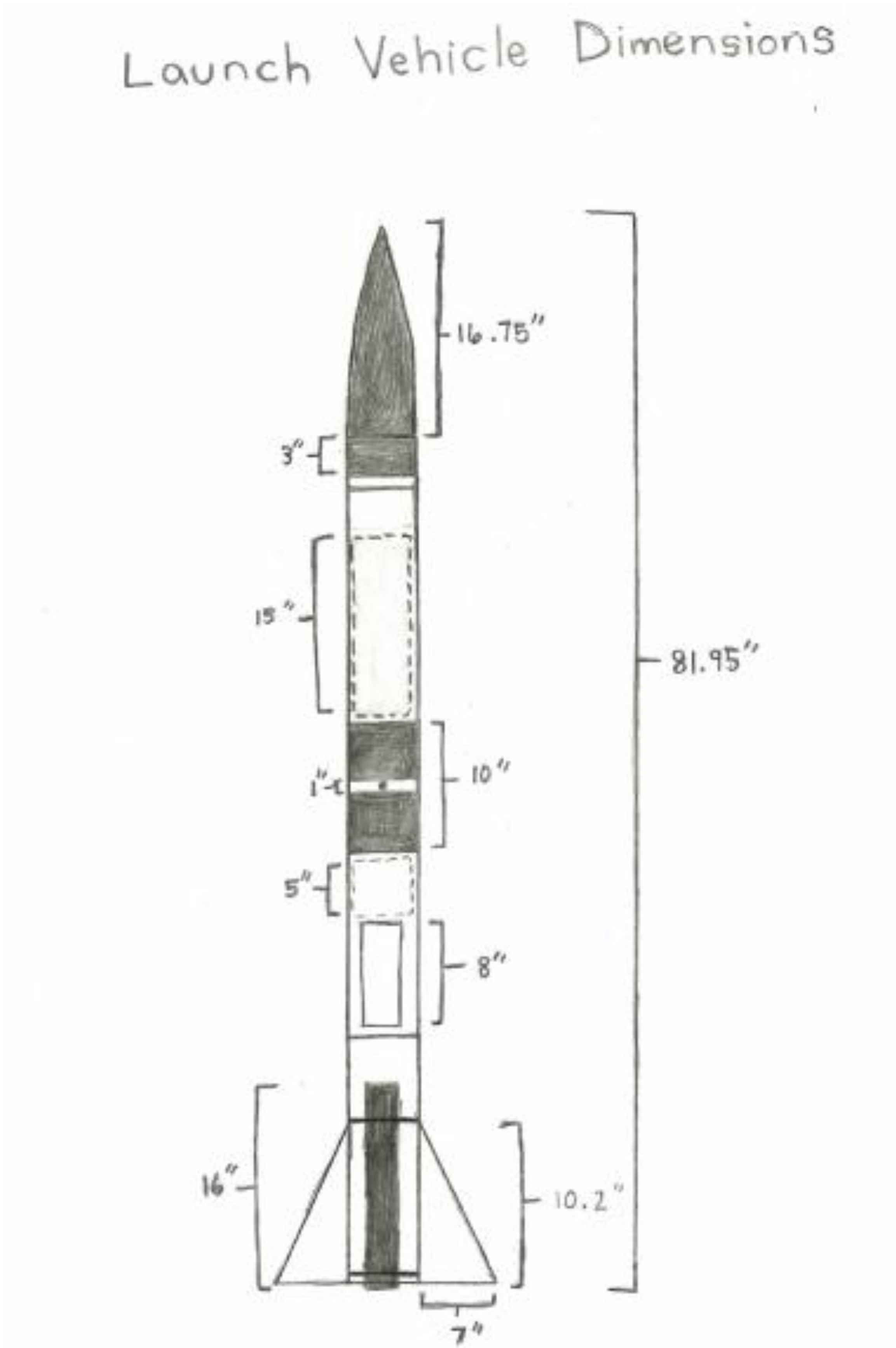
Section 7

We plan on manufacturing our rocket, payload, and other non-ordered parts during or after school. Students will be staying after school and building these pieces on a regular basis to ensure we can complete it by the launch dates. We will use check lists to ensure that the rocket is being built properly and efficiently. If a check list is posted, then students will know what pieces are due by what date. Then, we will have our project manager and mentors look over the work that was done to ensure that all that was done is up to the standards that it needs to reach, and that everything is in the correct place. We have access to a structural analyzing machine that can test up to 1000lbs. With this, we will test the structural strength of the bulkhead, fins, and the centering rings. The bulkheads and centering rings will be manufactured from half inch plywood and the fins will be built from G-10 fiberglass. We chose these materials because we believe that they will perform the best under the stress they will undergo. To test the electronics in the payload as well as the ejection charges attached to the altimeter, we will be holding scale launches. This will show us if everything is working properly and if not we will know what is wrong with it. When the rocket is complete we will disassemble the rocket, mass all the parts again, and update the simulation. We will run the simulation again with the corrected mass to see the results. We will keep our results and checklists hanging in a spot so that every member of the team will be able to see the progress.

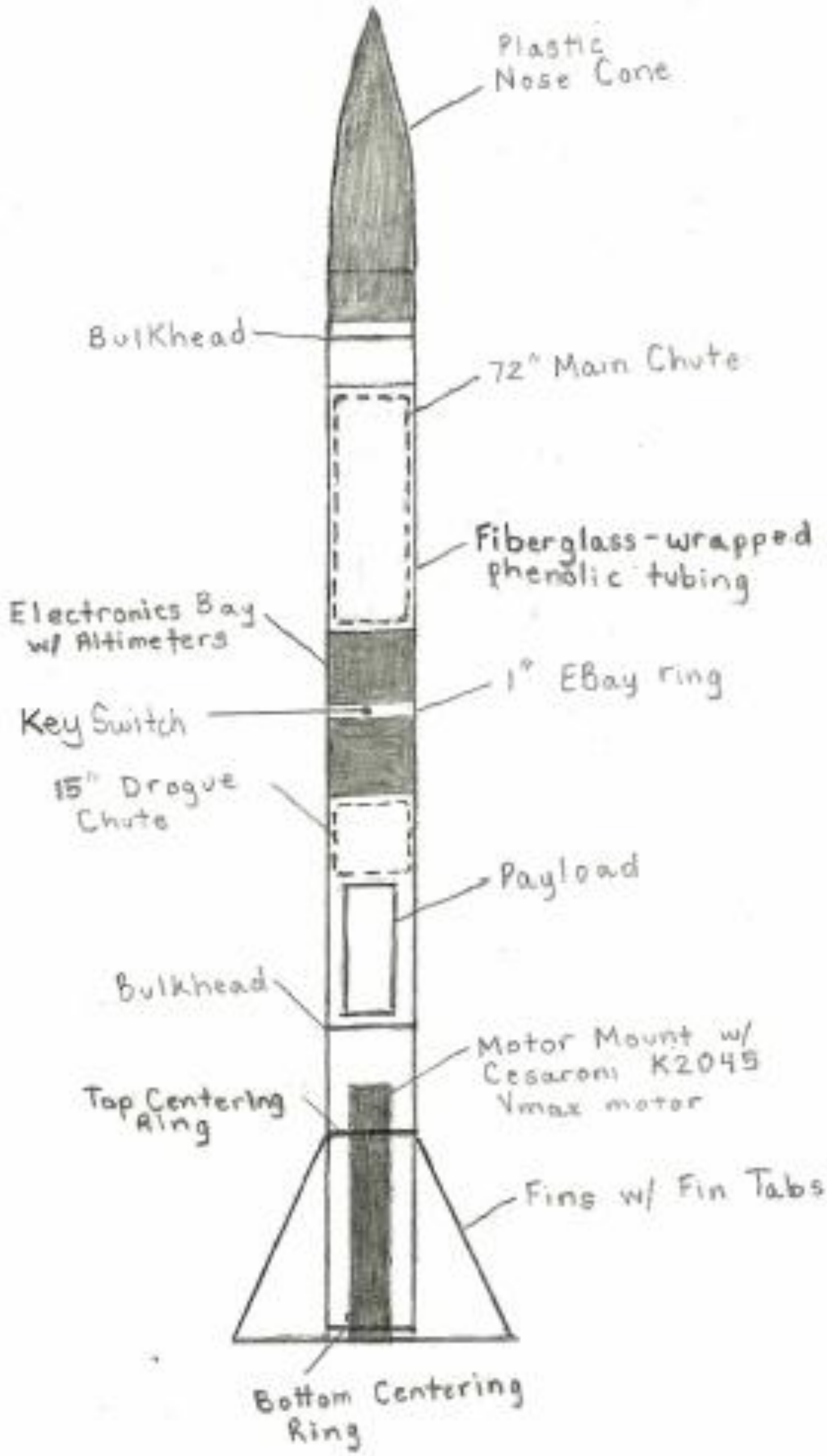
Section 8

The design for our rocket has been revised multiple times in order to comply with the suggested changes of our NAR mentor, Tom Aument. The suggested changes were intended to improve the overall safety, stability, and reliability of the rocket. We have also conducted many simulations on Rocksim 9, achieving the one mile mark in simulations. The recovery system has been modified to reduce the Kinetic Energy of the rocket components at landing. The first separation of the rocket will occur at apogee, where the payload and the 15 inch drogue parachute will be deployed. The drogue parachute will reduce the speed of the rocket to a lower rate. This will ultimately make the secondary deployment more reliable by reducing the strain on the shock cord, shroud lines, and main parachute during ejection. The reduction of the force on these components will lessen the chances of main chute deployment failure. The second separation will occur when the rocket reaches 600 ft, at which the main parachute will deploy. This will keep the rocket's descent controlled and reduce the rate of decent to 18.6 ft/s. The rocket will then have a kinetic energy of 60.7 ft-lbf when it hits the ground, well under the maximum of 75 ft-lbf. This, along with the redundancy of the recovery system, ensures us that the flight will have a safe recovery, and will stay within the 2500 foot radius. The design also uses fiberglass-wrapped phenolic tubing.. The phenolic tubing is strong, but the fiberglass will supplement this strength, providing the rocket with durability during flight and recovery. The extra strength will also guarantee that the rocket remains reusable. We have also chosen to use a Cesaroni K2045 Vmax motor in order to attain the one mile altitude mark. The quicker burn time of the Vmax motor will provide the rocket with a larger rail exit-velocity, reducing possible error in the flight of the rocket once it leaves the launch rail. Any changes that we have made to the original rocket design will improve the overall efficiency and safety of the rocket, allowing us to be more successful with upcoming launches.

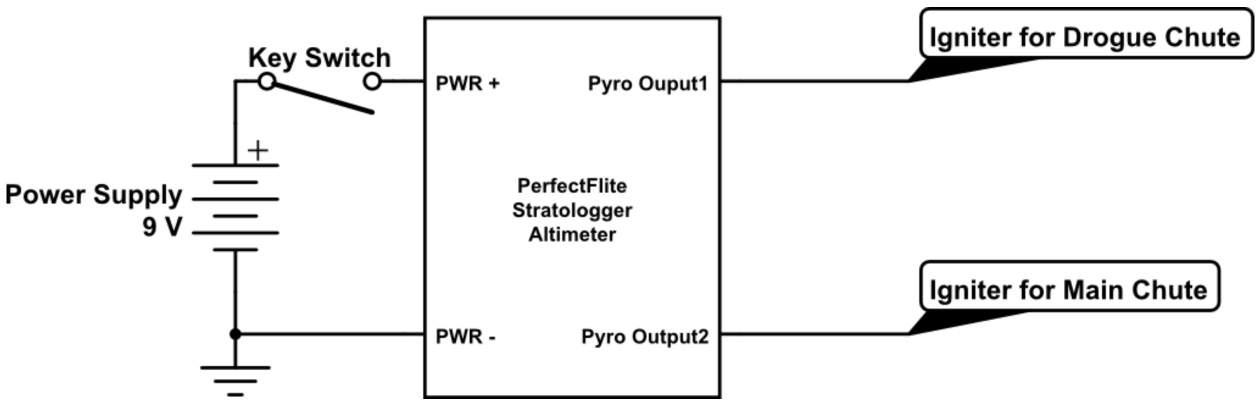
Section 9



Launch Vehicle Components



Section 10



Here is the schematic for the recovery system. There will be a 9-volt battery connected to a *StratoLogger* Altimeter. The altimeter will then be connected to two separate igniters that will be placed above and below the electronics bay housing. Ejection charges will be placed onto these igniters. The entire system then will be grounded to the chassis of the electronics bay. For redundancy, there will an additional altimeter and two additional igniters and ejection charges to ensure the separation of the rocket.

Section 11

The total mass of the rocket is estimated to be 171.395 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.

Parts	**Mass (oz)**
Total System Mass	**171.395**
Nose Cone	10.3
Bulkhead for Top Half	2.01
Top Body Tube	20.4
Main Chute	9.0
EBay Body Tube	0.74
LOC Electronics Bay with Altimeter	3.74
EBay Upper Bulkhead	1.02
Altimeter and Electronics	10.8
EBay Lower Bulkhead	1.02
Bottom Body Tube	23.8
Electronics Bay w/ Payload	2.970
Top Bulkhead for Payload EBay	0.633
Electronics for Payload	10.6
Lower Bulkhead for Payload EBay	0.633
15" Drogue Parachute	0.379
Bulkhead for Bottom half	2.18
Motor Mount Tube	4.01
Lower Centering Ring	1.43
Upper Centering Ring	1.43
Fins	18.8
Motor	45.5
Airframe Mass	**76.64**
Nose cone	12.9
Top Body Tube	20.4

Bottom Body Tube	23.8
Fins	18.8
1in Ring for EBay	0.74
Propulsion	**52.37**
Motor Mount Tube	4.01
Lower Centering Ring	1.43
Upper Centering Ring	1.43
Motor	45.5
Recovery System	**24.959**
Main Chute	8.0
Drogue Parachute	0.379
LOC Electronics Bay with Altimeter	3.74
Altimeter and Electronics	10.8
EBay Upper Bulkhead	1.02
EBay Lower Bulkhead	1.02
Payload	**14.836**
Reinforcement Coupler for Payload Electronics Bay	2.97
Top Bulkhead for Payload	0.633
Electronics for Payload	10.6
Lower Bulkhead for Payload EBay	0.633
Additional Parts	**2.19**
Bulkhead for Top Half	2.01
Bulkhead for Bottom Half	2.18

Recovery Subsystem

Section 1

The 72 inch main parachute deployed at 600 feet is design to bring the rocket down to the ground the rest of the way under a safe velocity. This parachute is capable of 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 should land on.

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" eyebolt that is inserted into the 1/2 inch thick forward centering ring of the motor mount secured with a nut and epoxy. 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. The other shock cord will be fixed to another eyebolt that is screwed into the top of the altimeter's electronics bay and reinforced with epoxy at one end. 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) also split away from the electronics bay at apogee, because the acceleration that the electronics bay would undergo when it reaches the end of the shock cord would oppose the direction that inertia is carrying the top tube. 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 screwdriver inserted into an access hole 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 two 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 installed within detects apogee. The forward ejection charges will be fired at 600 feet, because the team will program the altimeters with a PerfectFlite altimeter *StratoLogger* Software 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 should 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 pressurizing the chambers of the rocket.

<u>Section 2</u>

The 15 inch drogue chute is robust enough to withstand at least 330 lbs. of force, as this is what has been tested by the company from which the parachutes are being purchased (Fruity Chutes). The swivel mounted to the 330 lb. test shroud lines is capable of withstanding 1000 lbs. of force. With the shock cord absorbing most of the force of ejection, these threshold parameters of the drogue parachute components will be large enough to withstand ejection and descent. The main chute that we will be using for the recovery system is a 72 inch Iris Ultra Parachute. The shroud lines on the 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 strong enough to withstand its ejection and descent. For a shock cord, we're using 4200 lb. test, 1" wide tubular nylon shock cording. Therefore, the shock cord will be robust enough to absorb the energy encountered during ejection and descent. The shock cord will be attached to eyebolts on secured into bulkheads in the bottom and top half of the rocket and also to eyebolts secured to the bottom and top of the electronics bay. These eyebolts are made from forged carbon steel, that have been welded closed. These eyebolts are capable of withstanding up to 2600 lbs. of force. This will be enough to withstand ejection and keep all of the components tethered during ejection and descent. The bulkhead that we will be using will be constructed from ½ inch thick plywood. The bulkheads will be tested by securing them within a body tube using the West System's Epoxy that we will use on the actual rocket. The amount of force required to break the bulk head or break it free from the inside of the body tube will be measured with a stress-tester, unless the system does not fail even under a large amount of stress. This will ensure that the bulkheads will be able to handle the pressurization of that chamber of the rocket and will not allow depressurization which could cause recovery system deployment failure.

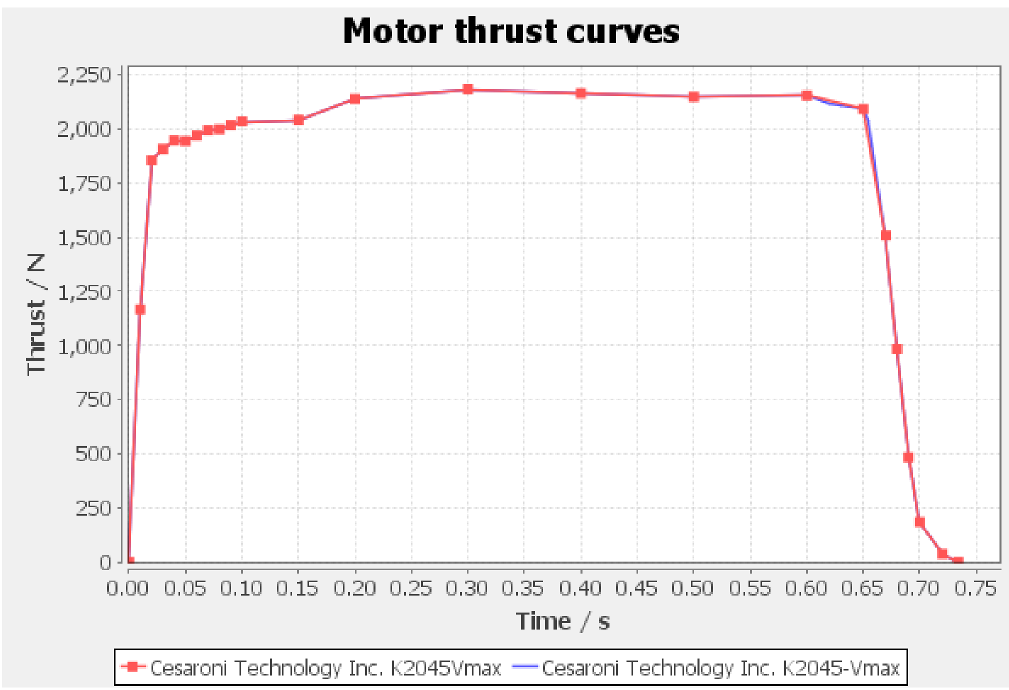
Mission Performance Prediction

Section 1: Mission Performance Criteria

We will build and test a rocket that will achieve an altitude of one mile and eject a scientific payload. In order to do this, we must first create a stable and reasonable design on a rocket simulation program such as Rocksim. The 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, which we can use to determine if 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. This will be accomplished by using computer software to program one altimeter to eject one side at apogee and one 600 feet and the other altimeter to eject at the same flight events, except with a slight delay.

Section 2: 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



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.

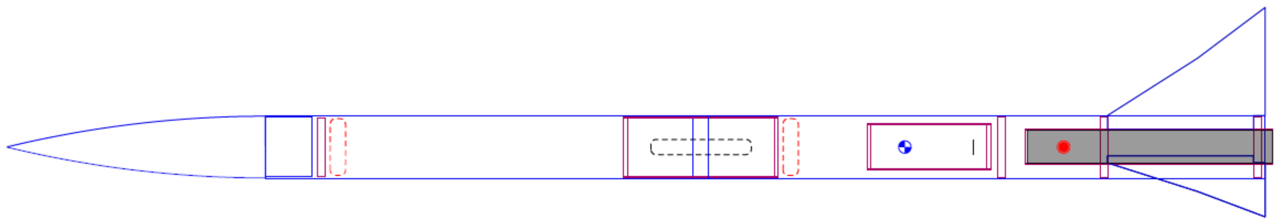
Parts Detail

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)	Diaout 3.75 in	Len: 0.5 in	Mass: 2.01 oz
Top Body Tube	Quantum tubing (1.05 g/cm³)	Diain 3.9 in Diaout 4.09 in	Len: 27.7 in	Mass: 20.4 oz
Main Chute	Rip stop nylon (66.8 g/m²)	Diaout 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)	Diain 3.9 in Diaout 4.09 in	Len: 1 in	Mass: 0.74 oz
LOC Electronics Bay with Altimeter	Cardboard (0.68 g/cm³)	Diain 3.78 in Diaout 3.94 in	Len: 10 in	Mass: 3.74 oz
Ebay Upper Bulkhead	Plywood (birch) (0.63 g/cm³)	Diaout 3.78 in	Len: 0.25 in	Mass: 1.02 oz
Altimeter and Electronics		Diaout 0.98 in		Mass: 10.8 oz
Ebay Lower Bulkhead	Plywood (birch) (0.63 g/cm³)	Diaout 3.78 in	Len: 0.25 in	Mass: 1.02 oz
Bottom Body Tube	Kraft phenolic (0.96 g/cm³)	Diain 3.9 in Diaout 4.09 in	Len: 36 in	Mass: 23.8 oz
Electronics Bay w/ Payload	Paper-BT (1.12 g/cm³)	Diain 2.88 in Diaout 3 in	Len: 8 in	Mass: 2.97 oz
Top Bulkhead for Payload Ebay	Plywood (birch) (0.63 g/cm³)	Diaout 2.97 in	Len: 0.25 in	Mass: 0.63 oz
Electronics for Solar Panel Stuff		Diaout 0.98 in		Mass: 10.6 oz
Lower Bulkhead for Payload Ebay	Plywood (birch) (0.63 g/cm³)	Diaout 2.97 in	Len: 0.25 in	Mass: 0.63 oz
Drogue Parachute	Rip stop nylon (66.8 g/m²)	Diaout 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)	Diaout 3.9 in	Len: 0.5 in	Mass: 2.18 oz
Motor Mount Tube	Kraft phenolic (0.96 g/cm³)	Diain 2.15 in Diaout 2.28 in	Len: 16 in	Mass: 4.01 oz
Lower Centering ring	Plywood (birch) (0.63 g/cm³)	Diain 2.28 in Diaout 3.9 in	Len: 0.5 in	Mass: 1.43 oz
Upper Centering ring	Plywood (birch) (0.63 g/cm³)	Diain 2.28 in Diaout 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

Section 3: Rocket 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.

Interfaces and Integration

Section 1

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.

Section 2

Directly under the nose cone there will be a ¼ inch bulkhead. This bulkhead will have a closed eyebolt through it that will have a nut fastened on the opposite side of the bulkhead as the eye of the bolt. The eyebolt will also be reinforced with some epoxy placed around the base of the bolt on either side of the bulkhead. This eyebolt will hold one end of a shock cord. The shock cord will lead to the main parachute and from there it will lead to the top of the electronics bay holding the recovery system. On the other end of the electronics bay, there will be another shock cord that will be connected to a drogue parachute. The other end of this shock cord will be secured to the scientific payload through an eyebolt on the bottom of the electronics bay. The shock cord will continue on past the payload until it reaches one last bulk head. This bulkhead will also have an eyebolt attached to it using the same process as what we used to attach the bulkhead in the top of the rocket. Underneath of this bulkhead will be a gap above the motor mount. The motor itself will not have an ejection charge. Ejection charges will be placed on the top and bottom of the electronics bay. They will be connected to two altimeters inside the bay that will be programmed to set off the charges at their appropriate altitudes. There is also a one inch wide ring with the same diameter as the rocket airframe which will provide a surface on which the recovery system arming switches will be attached.

Section 3

The rocket will be mechanically attached to an eight foot 1515 launch rail with 1515 linear rail lugs. It will have an electronic attachment to the ground with an igniter for the rocket motor having to leads that will connect to a standard 12 volt DC firing system. The firing system will be used to spark the igniter and light the motor. The rocket will not require any other specialized ground support equipment other than these pieces of equipment supplied by the range or the Range Services Provider. The only transmitting device within the rocket will be the tracking device, which will operate off of a frequency that will not interfere with equipment on the ground, the payload, or the recovery system.

Section 4

The rocket will be mounted onto an eight foot 1515 launch rail with 1515 linear rail lugs that will be attached, with screws and epoxy to the outside of the rocket. The igniter will be placed through a motor retainer and into the motor of the rocket as far as it needs to be to ignite the motor correctly. The launch rail will have a stopping mechanism along it to ensure that the rocket is not too close to the blast deflection plate at the time it is being launched. The igniter will be attached to a standard launch system operating off of a 12 volt DC power supply.

Safety and Environment (Vehicle)

Section 1

Our team safety officer is our NAR Representative Tom Aument.

Section 2

Conceivable failures in our proposed rocket design include but are not limited to adhesion failure, breaking of bulkheads or centering rings, and using a motor the is unable to carry the rocket and payload to the proposed height. Also, the rocket may be instable or the structural integrity of the body tube is not great enough to handle the high forces and pressure that it will undergo. Ways to mitigate these happenings are using an adhesive, such as epoxy with a long curing time, which will be strong enough to adhere the components without the bond breaking. We will choose a material thick enough to suit the needs of these components by testing them under high-stress situations. The stability will be checked on the rocket program and the fins will be substantial enough to keep the rocket stable without over-stability occurring. The tubing we are planning to use is wrapped in a fiberglass exterior so the structural integrity should not be an issue.

Problems that may arise in payload integration include the payload being too large for the selected tube, not being able to properly attach to the shock cord, and insufficient space due to other interior parts. To lower the risk of coming across these errors or other unforeseen errors we will check that the exterior diameter of the payload and the interior diameter of the body tube and see that they will fit together. We will design the payload so that it will easily attach to the shock cord and it will be safely attached. When designing the rocket the size of the payload and other apparatuses will be taken into account and then verify there is enough room for all the parts inside the rocket to avoid complications.

Failures that may arise in the launch operations are a motor delay, the ejection charge not being set off, and having an ejection charge that is not powerful enough to break apart the rocket to provide a safe decent. To help prevent these we will ensure that our NAR representative properly build or rebuilds the motor as well as using the proper launch mechanisms. To mitigate ejection charges not being set off we will redundantly wire the system so that there are two wires that will ensure that the ejection charge does go off or possibly even having multiple ejection charges. We will use the proper amount of black powder in our ejection charge so that it will break apart the rocket to provide a safe decent.

Section 3

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.

Materials Safety Data Sheets

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

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.

To 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.

Section 4

Environmental concerns should be relatively miniscule with this project. One environmental concern is if the rocket should get lost after launch and become unrecoverable. Animals and plans could be harmed from the potentially hazardous chemical components of the rocket and payload. The burning of the black powder and motor can produce potentially irritating, corrosive, or toxic gases. However, the amount of toxic gases released should be very minimal with the amount of black powder that we are using, making the launch still environmentally friendly. If the rocket landed without being recoverable, many components of the rocket will not decompose easily, making it somewhat unsafe for plants and animals. This problem has been solved by making a redundant recovery system and having the rocket land within 2500 feet of the launch pad.

IV) Payload Criteria

Selection, Design, and Verification of Payload Experiment

a) There are three systems within the payload. The three systems of the payload are the airframe system, the electronics system, and the recovery system. The recovery system is part of the rocket systems. Part of the recovery system for the rocket, is used for the recovery of the payload. This part of the recovery system is crucial for the deployment and safe landing of the payload.

The purpose of the airframe is to stabilize the electronics system, and also support it. Every system of the payload is directly attached to the airframe system. This system is necessary to construct the payload. Without it, there would be no framework for the components to fit in. It serves as the base of the entire payload.

The electronics system's purpose is to record the data for the experiment. This data is vital to the results and success of our project. The components of the electronics system are intertwined with the airframe system. This is because the components of the electronics system are both on the inside and on the outside of the payload.

The third system for the payload is the recovery system. The purpose of the recovery system is to ensure that the payload has a successful and safe flight. This will ensure that the payload descends gracefully from apogee. This is essential to both the rocket and the payload. For the purpose of the payload, we will only be focusing on the first ejection of the drogue parachute, and disregard the second ejection with the main parachute.

b) Within each system, there are two subsystems.

The airframe system consists of the inner subsystem and the outer subsystem. The inner subsystem consists of the body tube, and trusses. This subsystem serves as a base for the entire payload. In the experiment, we will start with the body tube and add the trusses for extra support.

The electronics system has two specific subsystems. These subsystems are the panel subsystem and the data logger subsystem. The panel subsystem consists of the solar panels, and the wires. The wires are included in this subsystem because they are connecting the data logger to the solar panel and the ends of the wires are on the outside of the airframe system. The other subsystem is the data logger subsystem. This subsystem consists of the data logger and the switches that will be used to arm the data logger.

Within the recovery system contains the attachment subsystem and the parachute subsystem. The attachment subsystem consists of both the eyebolts drilled into the payload, and the shock cord that connects the payload to the rest of the rocket. The bottom eyebolt is the only part of the payload that connected to the actual rocket. The shock cord attaches the bottom of the payload to both the electronics bay and the bulk head that is in the bottom half of the rocket. The payload is parallel to the shock cord. The parachute subsystem includes the parachute and its shroud lines. The parachute is in series with the payload. Therefore the parachute is attached to the top of the payload. This orientation is more practical and is safer than the alternatives. This lay out shall prevent the payload from interfering with the parachute. The parachute will come out first, and then the payload will follow it out of the bottom body tube of the rocket.

c) The payload’s structure must be able to withstand the forces of the ejection charges. It must be able to descend properly and withstand impact of its descent. The main features consist of the body tube, the Lucite cylinder, the bulkheads, and the eyebolts. The eyebolts keep the payload attached to the rest of the rocket. The drogue parachute is connected to the top of the payload. The payload is in series with the drogue parachute, and then the payload is in parallel with the shock cord. The eyebolt is capable of handling a load of 2600 lbs.

The body tube, supported by a centering ring and a bulkhead placed on the inside of the tube should easily be able to withstand ejection and descent. The shock cord placed on the bottom of the payload and connected to both halves of the separating rocket should absorb most of the energy supplied to these components by the ejection charge during the ejection at apogee. The Lucite cylinder is a clear cast acrylic tube that will be able to slide down over top of the solar panels to prevent the pressure wave from the ejection charges from damaging the experiment. It will be capable of withstanding the force from this pressure wave because acrylic has a high tensile strength and is capable of withstanding this same strength in heated environments for short periods of time. The bulkheads will be able to withstand all of these forces, as there will be two layers of bulkheads fastened together for extra strength. There is a low probability that these components of the payload will not be able to withstand these launch events. However, to confirm not only the capability of these bulkheads to withstand the forces that they will be undergoing during ejection and descent, but the other components included in the exoskeleton, we will be doing tests to ensure that there is little to no failure once it’s time to launch.

d)

Verification Plan

Requirement	Design feature that satisfies the requirement	Verification: including inspection, analysis and tests
3.1.1 The engineering or science payload may be of the team's discretion, but shall be approved by NASA. NASA reserves the authority to require a team to modify or change a payload, as deemed necessary by the Review Panel, even after a proposal has been awarded.	Our revised payload will be presented to NASA through the PDR. Any changes that need to be made will be done by the CDR.	Our payload will be thoroughly researched throughout the designing process. After we build the payload, we will be testing the payload at ground level, to ensure that all of the electronics work harmoniously. Our NAR Representative will test our ejection charges, with the payload inside of the tube. This test will be conducted to ensure that the payload was successfully designed to withstand the ejection charges and therefore be able to withstand the entire launch safely.
3.2 Data from the science or engineering payload shall be collected, analyzed, and reported by the team following the scientific method.	The components of the electrical system need to be protected from the ejection charges to be able to accurately collect data. The payload's solar panel is covered in Lucite to protect the solar panel from the ejection charges. Between the trusses, there will be a	Our first tests will be conducted at ground level, before the rocket is even launched. This will show us how reliable, and how well the payload can perform under this amount of stress. The payload must also withstand the ejection charges, to be able to collect data

	space where the wires can be withheld. This will ensure that they are safe from the ejection charges and prevent any damage that could occur during the launch. Our data logger will be collecting the data, and we will be able to analyze it after our launches. All team members know the scientific method, and will know how to use it to effectively portray our results of the experiment with the scientific method.	during its descent. This test will be done by our NAR Representative prior to our launches. Next, we will be testing our experiment with test launches to ensure that the payload can still handle the stress of the ejection charges and deployment. Upon retrieval of the payload, we will be able to observe the data collected during the experiment and also analyze the data.
3.3 Unmanned aerial vehicle (UAV) payloads of any type shall be tethered to the vehicle with a remotely controlled release mechanism until the RSO has given the authority to release the UAV.	The payload is planned to be attached to the rocket's shock cord, and should not detach from the shock cord at any time during flight.	Practice Launches will confirm that the payload will stay attached to the shock cord.
3.4 Any payload element which is jettisoned during the recovery phase, or after the launch vehicle lands, shall receive real-time RSO permission prior to initiation the jettison event.	The payload will be attached to the shock cord for the duration of the flight.	Practice launches will ensure that the payload does not become detached from the rocket after the payload is ejected from the rocket.
3.5 The science or engineering payload	Design features have been added to ensure	All electronics will be tested for functionality

shall be designed to be recoverable and reusable. Reusable is defined as being able to be launched again on the same day without repairs or modifications.	the security of each component of the rocket. The electronics have been specifically accounted for in the payload's design. A protective layer of Lucite has been added. Memory foam has been added to the interior of the payload to protect the wires and data logger. Trusses have been added to ensure that the wires can be safely within the payload and also connected to the solar panel.	and continuity. The electronics will be tested before they are even assembled within the payload structure. Once the electronics are in working order, they will be adhered into the payload structure to be tested again. Once the payload is built, it will undergo tests to ensure that the payload will not be destroyed or damaged during deployment or while it descends. Test launches will be the final verification that our tests have been accurate. If any part of the payload is damaged at the test launch, we will be able Any modifications that need to be made will be made, documented, and thoroughly tested.

e) The preliminary integration plan purpose is to make an ideal payload that it has a detailed preliminary design, is cost efficient, and is quickly and effectively produced.

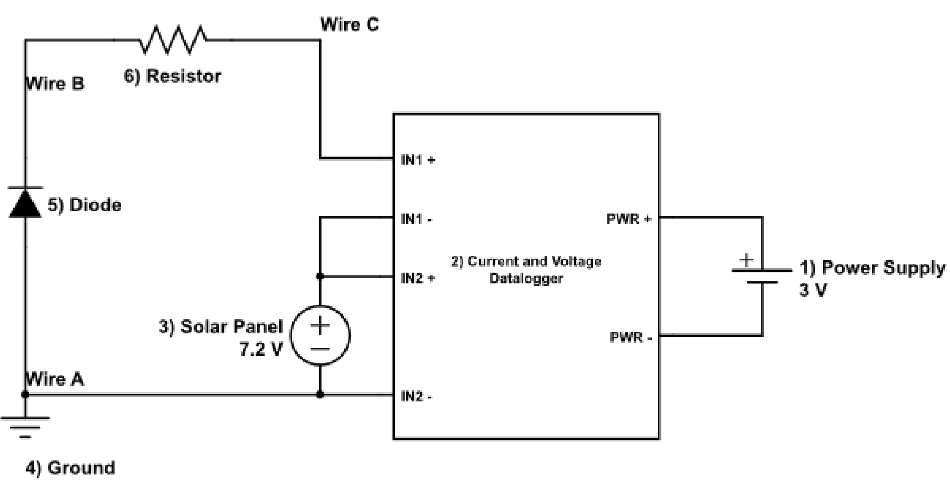
We have already done multiple sketches, and design elements to determine the dimensions, and schematics of the payload. These sketches will become more and more detailed with each exact detail that is incorporated within the payload. We plan on using an advanced program to portray these details visually to clarify any possible misinterpretations.

We have spent a lot of time finding the correct devices and materials that we plan to use on the payload. We have looked at multiple companies, and have looked at three factors when buying them. The first would be cost, followed up by the company's reliability and most importantly the quality and specifications of them. These three factors must all be satisfied for the best product for the money you spend on it. This relationship is very important for this project, because we have a finite budget and a lot of parts to buy. We also have to factor in the parts of the rocket, that will take up a majority of the budget we are given. We may look into finding better prices before we buy any parts. Fundraising will help us cover any extra cost that we will need.

With the time frame we are given we must work efficiently and quickly. We will be working frequently to do quality work, instead of doing a large quantity of work at one time. This will ensure that students are taking their time to think, problem solve, analyze the situation, and ultimately build all of the parts correctly. As a team we will work like a company. Focusing on the payload primarily, we will have a few specialized students working on the project, and watching after each other's construction of the payload. This will include having an assigned partner to work with, who will verify and observe everything the other partner does to ensure that everything is done accurately and efficiently. This will prevent any mistakes and build team work. This will also help us effectively produce the payload.

f) With successful research, planning, design, and construction of our payload, we will be able to be tested it many times. Although the construction of the payload may be a little more complex, the repeatability of the experiment should not be. All variables will be accounted for during our experiments. Some of these would include, wind speed, temperature, and weather. The variable data will be considered when putting it together with the collected results. With both the variable data and collected data put together, a trend should result corresponding to all factors of the experiment.

g) Below are the Electrical Schematics of the Payload, including the payload's key elements. It contains a description of each key element of the circuit. Each part is labeled and corresponds to a number in the circuit. The numbering system is set up so that, going in order; you will follow which way the current and voltage are going. Each step will tell you what the functions and details of each component are. Some sections include what is happening to the current and voltage at their step in the circuit. This will give a clear understanding of what is going on in the circuit and electrical subsystem as a whole.



1) A 3 Volt Lithium battery is powering the datalogger.

2) The data logger is being powered by the 3 volt battery. It is measuring the current in the circuit with the solar panel across the positive and negative terminals of input 1. It is also measuring the voltage created by the solar panel through the positive and negative terminal of input 2. The datalogger does not change the voltage or current of the circuit.

3) The Solar Panel produces a maximum voltage of 7.2 Volts and a maximum current of 200mA.

Wire A) This wire directs the current from the solar panel into the diode. It allows for the ground to hook up within the circuit.

4) The ground prevents static charge from building up in the circuit by letting it flow out of the wires. It does not have an effect on the current or voltage in the circuit.

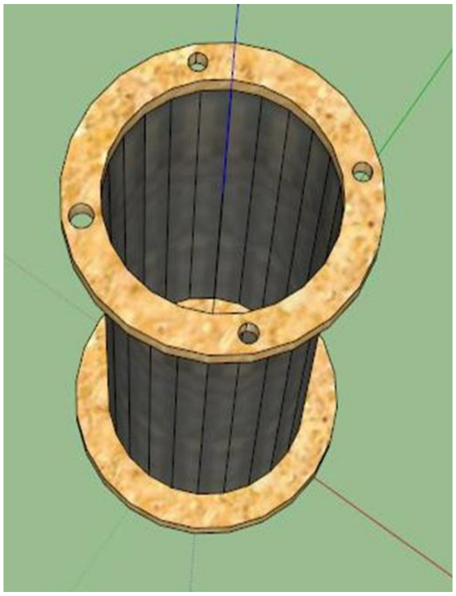
5) The diode prevents the current from flowing from positive to negative, when the solar panel stops creating current. It does not change the voltage or current in the circuit.

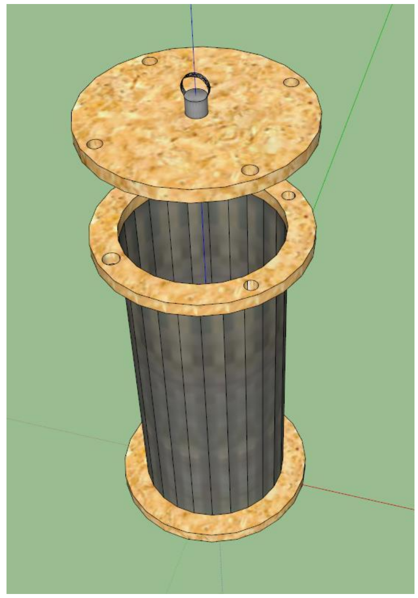
Wire B) The voltage and current have remained the same through the diode. This wire directs the current through the resistor

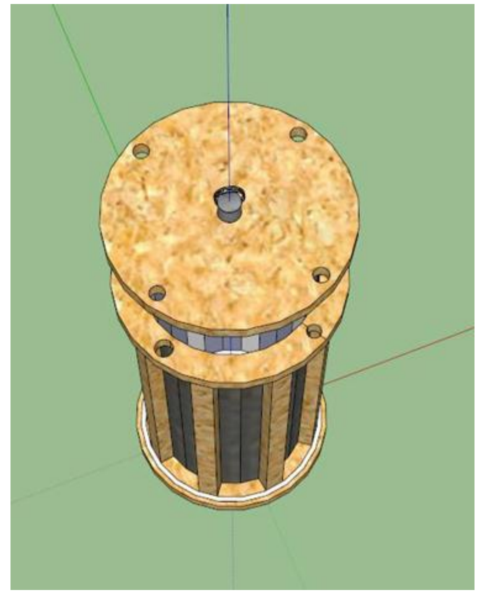
6) The resistor acts as a load for the circuit, so that it isn't short-circuited. The resistor decreases the voltage running through the circuit, but keeps the current the same.

Wire C) The voltage has dropped from Wire B due to the resistor, but the current remained the same. This wire returns the current to the datalogger

h) Below are the key components of the payload. The write up serves as the basic instructions for the payload. They are laid out in a way that you would build the payload. They start from the inside of the payload, and work their way out, just like the procedure we will be conducted when constructing the payload.



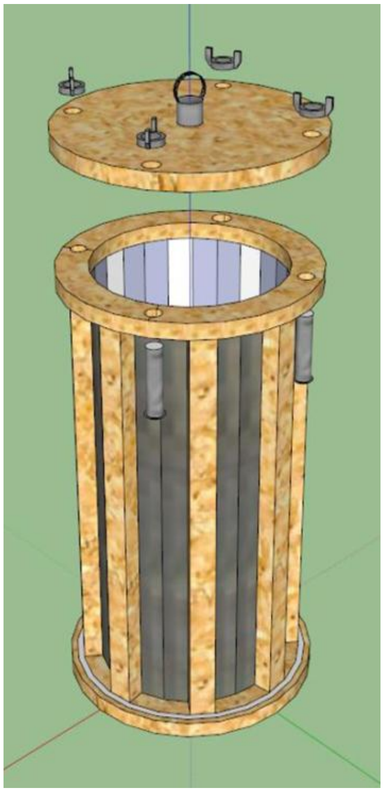




The core of our planned payload starts with a BT-300 Tube that is three inches in diameter, and 8 inches long. This tube is the base of the payload. Next we need to make a strong outer structure, so that anything within the body tube won't be damaged. To start off, two centering rings will be epoxied to each end of the BT-300 tube. These centering rings will be epoxied on the top and bottom of the body tube. They will be flush with the edges of the top and the bottom of the body tube.

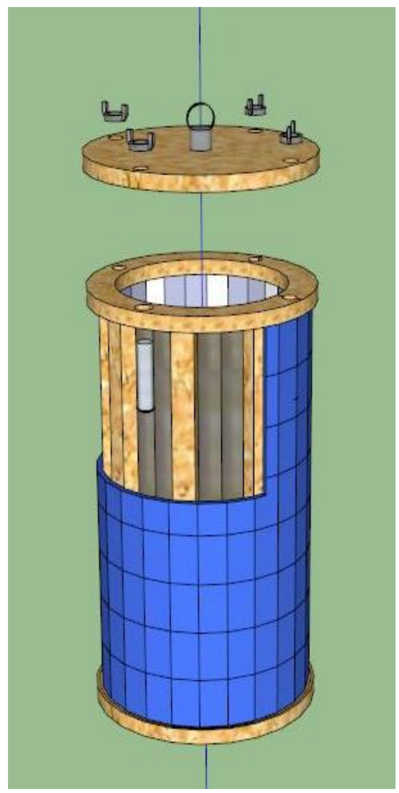
We will have to epoxy a small bulkhead inside the bottom of the BT-300 tube, to close off the bottom of the body tube. This will ensure that when the data logger is within the tube, it won't come out from the bottom of the body tube. To get the data logger in, we will have to leave the top of the tube open. We also need a secure way to cover the open top of the body tube. A simple solution to this requirement would be to put a bulk head on top of the top centering ring. To do this, we plan to make about four holes in the top centering ring. We must also put the same amount of holes in the bulk head to ensure that they will fit together. To connect the two, we plan on using bolts and securing them with glue on the bottom and wing nuts on the top. This system will be removable, so that we can put the data logger in before a launch, and take it out after a launch.

Within the body tube, something needs to secure the data logger in place. The plan is to have it held in place by memory foam. It will need to be form fitted to the altimeter, and also the wires that will be hooked up from the altimeter to the solar panels. The purpose of the foam is to absorb any impact from the launch. Its other purpose is to keep the altimeter and wires connected but also to prevent them from moving within the body tube. This foam will ensure that all of the data recorded is safe, and won't be harmed.



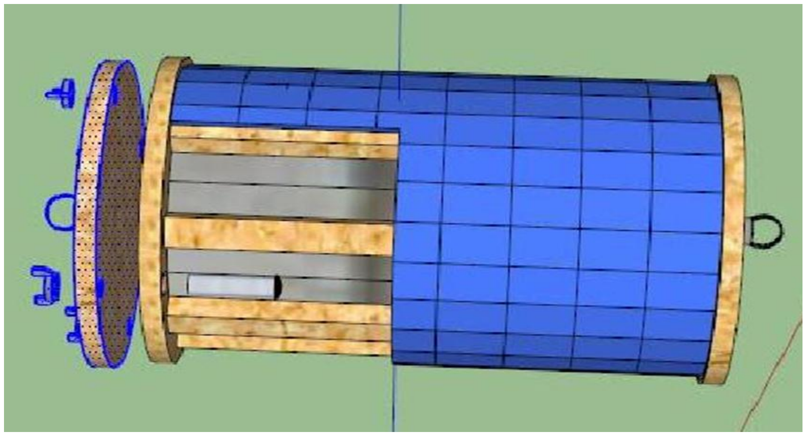
On the outside of the BT-300 body tube we plan on placing vertical wooden trusses to strengthen the payload structure. They will be glued on the outside of the BT-300 body tube. The centering rings overhang the BT-300 body tube, creating a lip where the top and bottom of the wooden trusses can be glued on. This addition to the original structure will give the body tube extra support and prevent any compression of the body tube.

This wooden structure creates channels between the BT-300 body tube and the solar panel. The channels will allow the wires to be run between the BT-300 tube and the solar panel, so that they aren't completely outside of the payload. These wires will run along the channels between the wooden trusses so that they can safely connect the solar panel to the data logger insuring that there is no damage to the wires.



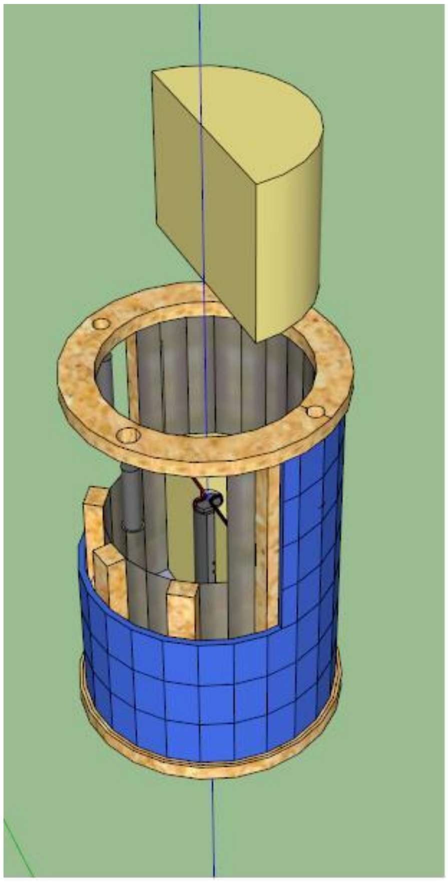
The positive and negative wires will fit through two small holes in the side of the BT-300 body tube. This way, the wires aren't exposed on the outside of the payload, and are safely within it. The wires will be connected to the altimeter, protected in foam, fed through the holes that were made in the body tube, and connected to the solar panel.

The solar panel will be wrapped around the wooden trusses. We plan on using a flexible solar panel that can be wrapped around the outer structure, and epoxied onto it precisely. The solar panel will be wrapped around the entire cylinder, so that none of the solar panel is wasted. This also creates a 360 degree solar panel for maximum coverage. The panel will also be covered with a Lucite tube to protect it from the ejection charge.



This is the entire model, with each item of the payload included. There are two eye bolts on each side of the payload. These eyebolts are necessary to connect the payload to the rest of the rocket. The whole rocket is grouped together. This is so that the components within the rocket are connected; ensuring that no parts will become disconnected and free fall during the flight. The right eye bolt will be connected to the drogue parachute. The parachute will deploy with the payload at apogee. The drogue parachute is directly connected to the payload and the parachute should not cast a shadow on the payload.

When the payload is safely in the rocket, the outer centering rings will keep the payload secured in the rocket's body tube. When the payload is deployed from the rocket at apogee, the payload will be able to gather data. The solar energy will be collected as the rocket descends. The solar panels will collect the solar energy and record the data, with the data logger that is inside of the payload.

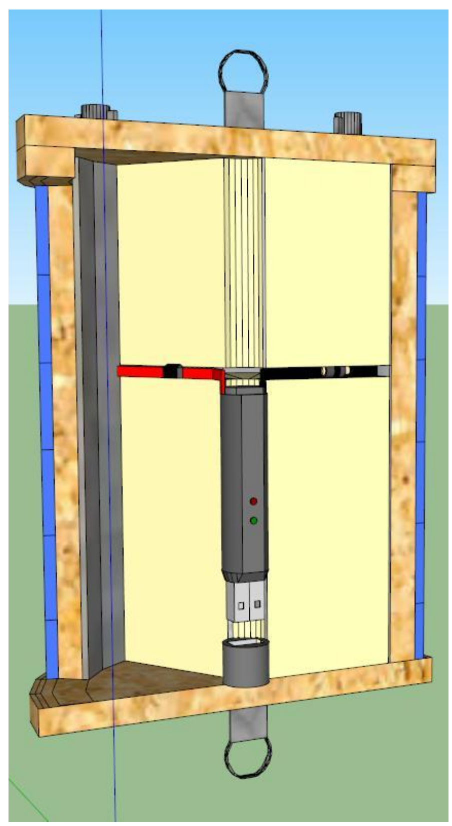


On the inside of the payload, the data logger and wires are held securely inside. There will be a top and bottom section of memory foam. The top part of the memory foam will be a solid piece of foam, while the bottom piece will be customized to fit around the data logger.

There may also be a small channel cut on the top of the bottom piece of memory foam, where the wires will sit snuggly between the two pieces of foam without compressing them. The reason there is a split between the two sections is because we will have our wires running from the inside of the payload's body tube, where the wires will exit the body tube and run along the wooden trusses until they link up with the solar panel on the outside of the payload.

There will also be a diode and resistor in the circuit. This was incorporated into the electrical schematics to show how the parts of the payload would fit in the circuit. These two components will be on the positive wire, while the ground will be on the negative wire.

The memory foam serves as insulation within the payload. The wires need to be secured within the payload to ensure its safety and security. This will also help the data logger, diode, resistor, and ground to stay in place. It will prevent any of the electronics or wires from having tension or getting damaged.



Payload Concept Features and Definition

i) We have chosen a solar paneled array for our payload. This started out as a simple idea, and with brainstorming turned into the payload we have now. When we started off the payload it was just a data logger in a tube with centering rings to hold it in place within the rocket. It is now a complex system of trusses, wire placement, padding and detailed construction. The payload is being built completely from scratch. We have added an extra skeleton to the payload, to hide and protect the wires within the payload.

j) This was a creative way to solve the problem of having loose wires, and also create a stronger core for the payload. It is a unique idea as opposed to having extra pieces on the outside of the payload, and therefore wasting space within the rocket. This array is complex and must be done correctly to work. If the trusses are not put in place correctly, and the holes are not wide enough or are put in the wrong place, our payload will not work the way we intend it to.

k) The difficulty level of this project is suitable for our team. It is our first year in SLI, and we have been learning about the electronics involved in the payload. We have been doing a lot of research on what needs to be done to make our experiment successful. Each step of the way we learn something new and learn how to improve our design.

Science Value

l) The goal of the solar panel payload is to determine if a mile of atmosphere will affect the current generated by the solar panel array. We will have one solar panel array that deploys at apogee, gathering data as it descends, and the current change should stop once it hits the ground. Next, we will compare the two currents at apogee and the ground, thus giving us our rate of solar energy collected in the amount of time it took for the solar panel to descend.
We can also see if the current generated is greater at a higher altitude with the data that will be collected by the data logger. The change in

current will be logged over time; therefore we can see how current changes with time as it descends. We should then be able to determine the mathematical relationship between altitude and current generated. The hypothesis of the experiment is that the system will see very little difference between the current generated at altitude compared to the current generated at ground level. We expect that the difference in the current generated between apogee and ground level will be clearly evident because the amount of water vapor in a mile of air will affect the collection of the solar energy. The reasoning behind this is due to the limited effect of the extra mile of atmosphere on the energy of the light striking the panel. However, we still expect to see a very small, but gradual change in the amount of current at apogee compared to the ground.

m) For the payload to succeed there are a few objectives that need to be fulfilled. First and foremost, the payload must eject at apogee to be able to record the data. Second, the payload must not get tangled in the parachute or the shock cord. Third, the solar panels can't be blocked from the sun or be covered by a shadow. Fourth, the data logger must record the data accurately and effectively. If the data is not readable or not efficient enough we may have to change our data logger to something more complex or better suited for our experiment. This will be an easy fix, and shouldn't prolong our project for very long. Fifth, the data logger must be able to have readable and be able to be retested with similar results.

n) In our experiment we plan on seeing a very minute amount of change in current in the launched payload. With this minute amount of change we hope to correlate a mathematical relationship between height and current generated. The current generated will start at apogee. This will also give us the height at deployment. With these two variables, we will be able to see the correlation between the two when we interpret our data.

o) With each experiment we plan on testing all of the equipment beforehand. We plan on remeasuring each part of the payload after building. The data logger will also be checked to ensure that it is measuring its data correctly.

We will also check to see that it is fulfilling its roll while following the expectations that we have predicted the product will have.

There are a few variables and controlled variables in our experiment. Within the experiment there is one independent variable. It is height. The dependent variable is current change and voltage change. There are other dependent variables that will be measured by the data logger such as the temperature, amount of light gathered, humidity and the amount of Carbon Monoxide in the air. We won't be focusing on these dependent variables, but if we see a relationship between them and the current or voltage, we will be able to observe and record that relationship. There are many controlled variables in this experiment. All of the materials are considered controlled variables because they do not change during, before, or after the flight. These control variables are the data logger, solar panel, wires, Lucite, body tube, trusses, centering rings, bulk heads, wing nuts, bolt, and memory foam. There are two other major controlled variables, which are time and weather conditions. The weather will be consistent for both of the solar panel payloads.

p) With our expected data, we will be recording all of it in a log. With each experiment we plan on saving our data, and interpreting it. After the first one, we plan on comparing each test with the others to see how consistent our data logger is. With our data we will also keep in account whether and wind conditions. This will be noted in our log. Our data logger logs both voltage and current so we could also record and see the relationship between them. Our data logger accurately measures data for one second. Although this is a short span of time, it should suffice for the amount of data that is being collected. We may get a data logger with an even smaller recorded time than one second, to be able to see the change at a smaller and more incremented rate. It has 23,000 data points so that all of our data can be stored or converted to be recorded, logged, and observed. The data logger also hooks up to a USB, for convenient and transferrable data. It also measures temperature, so we could find a relationship between the temperature and the current generated also. All of its parameters include temperature, humidity, voltage, current, and carbon monoxide. The temperature and humidity may help us see why the data has changed according to the weather.

With our data, there will be some error, such as reaction time. This includes the time it takes for the solar energy to transfer into energy to be transferred through the wires and recorded by the data logger. This process happens in a very small amount of time, so it will be a very finite detail in the error analysis. The accuracy of the instruments will be tested and compared to other types of devices to see the differences or preciseness or our data logger. Through these experiments, and possible calibrations, we will be able to analyze the accuracy and possible error that comes along with our data logger, wires, and solar panel.

q) Before our launch, the data logger, wires, and solar panel will be check for connections. We may do a test, to ensure that each part is connected, and that the data logger is reading effectively. We will test both payloads at the same time to ensure that the results are accurate and identical at ground level. This will prove that the when the first payload that is in the rocket, will be comparatively accurate compared to the second payload on the ground. Here are the steps of our preliminary experiment process procedures:

1) Check to make sure all parts are still connected, and that no parts are loose.
2) Activate the switch to initiate the start the logging of the data.
3) Put the payload in direct sunlight to get optimal results.
4) Let it sit in the sun for an extended amount of period.
5) Deactivate the data logger, and look at the data that was recorded
6) If there was no data logged, check all connections.
7) Fix any problems, and repeat the experiment until the data is identical and all parts are in working order to use it for the launch.

r) Tom Aument is our safety officer, who will be watching over and advising us during our project. We appreciate his verification in our plans, and appreciate the advising that he has given us already and look forward to more in the future.

s)

Failure Modes with Proposed and Completed Mitigations

Failure Modes	Proposed and Completed Mitigations
Motor failure of rocket	We propose to have our safety officer test, and practice using K motors to ensure that the experiment is able to happen. This will also prevent any explosions that could ruin the rocket and possibly terminate the payload.
Failure of parachute deployment	We plan on our safety officer testing how much black powder we will need for our ejections charges, to ensure that the payload will come out of the bottom half of the rocket.
Unplanned path of rocket	Test rocket on flight simulators, along with checking each component of the rocket while building the rocket and also multiple times before a flight, to ensure that the experiment will proceed.
Failure to deploy payload	With practice launches, and special testing, we will try to prevent any problems that would happen with the payloads deployment.
Hook up to solar panel is detached from wires	Read the operator’s manual and be well versed in its rules and construction. Have the partners in charge of this aspect of the payload; know each part of the manual.
Construction of payload is inconsistent and uneven or flawed	Have two people work together on each part of construction. Have one partner do the building, while the other watches, and mentions any changes, or precautions that need to be taken. Also, have them remeasure any parts multiple times before gluing any materials together.

Failure of switch that will initiate the data logger to collect data at apogee	Ensure before a launch that the switch works and that the data logger is initiated by the switch instead of just starting on its own. Also, test that the data logger is actually recording any data before the launch.
Solar panel damage	We plan on protecting the solar panel with a cover. This cover will be a Lucite tube, therefore we won't have to worry about it breaking, and it will be clear so that the solar panel can still collect solar energy.

t) Personnel Hazards:

All personnel hazards will be addressed before any construction is to begin. The payload has very specific hazards. There are a many hazards included with the electronics. One hazard with the electronics is static discharge or electrocution from a circuit. Another hazard would be the leaking of battery acid. 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

Materials Safety Data Sheets

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

The payload will be comprised of lightweight materials. The payload is made with a PML body tube, wooden supports, Lucite, and ductile 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 attempt to recover the payload if it is irretrievable due to a hazardous environment surrounding the payload. The team will not attempt to catch the payload while it descends.

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.

u) 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

We have already chosen companies that we plan on buying our supplies from. These companies were chosen based on four criteria, reliability, funding, pricing, and recommendations. We have gotten many recommendations from our safety officer about products that he has used in the past, and value his experience greatly.

Rocket Component	**Details**	**Item #**	**Company**	**Individual Cost**	**Amount**	**Cost**
Nose Cone	Plastic Nose Cone 16.75" Long w/ a 3" shoulder	PNC-3.9	PML	$21.95	2	$43.90
Body Tube	FGPT-3.9 Fiberglass-wrapped Phenolic Airframe Tubing with pre-cut fin slots	FGPT-3.9	PML	$102.20	4	$408.80
Motor Mount Tube	2.152" ID Phenolic Airframe Tubing	MMT-2.1-18	PML	$6.99	2	$13.98
Drogue Parachute	15" Elliptical Parachute	CFC-15	Fruity Chutes	$35.00	2	$70.00
Main Parachute	Iris Ultra 72" Parachute	IFC-72	Fruity Chutes	$165.00	2	$330.00
Altimeters	Perfectflite *Stratologger*® Altimeters	SL 100	Perfectflite	$79.95	5	$399.75
Altimeter Data Transfer Kit	USB Data Transfer Kit	DT3U	Perfectflite	$29.95	1	$29.95
9 Volt Batteries for Altimeters	9V NiMH Batteries	NM9V	Perfectflite	$10.95	4	$43.80
Fiberglass for Fins	1/8" G10 FR4 Fiberglass (2'x2')	8667K273	McMaster-Carr	$46.68	1	$46.68
Epoxy	1 quart (105 Resin) and .44 pints (205 Hardener)	Epoxy Kit D	Soller Composites	$47.00	1	$47.00
Nylon Shock Cord	1"x25' Tubular Nylon Shock Cord 4200lb. Test	TUNSC-1"X25'	What's Up Hobbies	$19.95	4	$79.80
Shock Cord Protector Sleeve	30" of Kevlar® tubing to slide over the Nylon Shock Cord ($6.95 Shipping)	N/A	Giant Leap Rocketry	$9.44	2	$18.88
Electronics Arming Switch	Key Switches- Type 3	KSW3	Aerocon Systems	$6.00	8	$48.00
Terminal Strip for Ejection Charge	RadioShack® 8-Position European-Style Terminal Strip	274-678	RadioShack	$0.97	2	$1.94
3.9" Electronics Bay	3.9" Electronics Bay Long version + 15" payload tube	EXL-3.9	LOC Precision	$37.95	2	$75.90
Quick Link	1/4" Quick Link	29621	Apogee Components	$3.75	8	$30.00
1/2" Eye Bolts	Armstrong® Forged Carbon Steel Eye Bolt, 1/2-13 UNC, 1 1/2 in Shank (L)	701987	Staples	$5.99	8	$47.92
Centering Rings and Bulkheads	1/2 x 2 x 4 Pine Sheathing Plywood	35663	Lowe's	$8.97	1	$8.97
Motor	Cesaroni - P54-4G Vmax (K2045)	71448	Apogee Components	$113.94	6	$683.64
Motor Casing	Cesaroni 54mm 4-Grain Case	71033	Apogee Components	$84.69	2	$169.38
Motor Retainer	54 mm Aeropack Retainer- P	24067	Apogee Components	$34.00	2	$68.00
Ematches and Ignitors				$5.00	2	$10.00
Spray Paint	Rustoleum		Rustoleum	$5.00	5	$25.00
Parachute Protectors	NOMEX Flame Resistant Wadding Chute Protectors for Rockets - 12"x12"	N/A	Sunward Aerospace Group Limited	$5.69	4	$22.76
Total						**$2,724.05**
Scale Rocket Component	**Details**	**Item #**	**Company**	**Individual Cost**	**Amount**	**Cost**
Body Tube	36" long Pre-glassed Phenolic Airframe Tubing	FGPT-2.1	Public Missiles Limited	$79.45	3	$238.35
Nose Cone	9.50" Plastic Nose Cone	PNC-2.1	Public Missiles Limited	$13.95	2	$27.90
Tube Coupler	36" Phenolic Coupler Tube	CTF-2.1-36	Public Missiles Limited	$12.50	1	$12.50
Motor Mount Tube	1.525" ID Phenolic Airframe Tubing	MMT-1.5-18	Public Missiles Limited	$5.78	2	$11.56
Main Chute	42" Classical Elliptical Parachute	CFC-42	Fruity Chutes	$80.00	2	$160.00
Drogue Chute	12" Classical Elliptical Chute	CFC-12	Fruity Chutes	$33.00	2	$66.00
Motor	Cesaroni P38-3G Blue Streak (I236)	71333	Apogee Components	$41.35	4	$165.40
Motor Casing	Cesaroni 38mm 3-Grain Case	71022	Apogee Components	$40.93	2	$81.86
Fiberglass for Fins	G10 FR4 Fiberglass Sheeting	8667K241	McMaster Carr	$14.13	1	$14.13
Wood for CR and BH	1/4x12x16 5 ply Poplar Lite-Ply	PLY14L-16	Balsa Machining Services	$3.90	1	$3.90
Shock Cord	Tubular Nylon Shock Cord1/2"x10' 1000lb test	TUNSC-1/2"x10'	What's Up Hobbies	$10.95	4	$43.80
Shock Cord Protector	Kevlar Shock Cord Protector- 30" Long	N/A	Giant Leap Rocketry	$9.44	2	$18.88
1/2" Eye Bolts	Armstrong® Forged Carbon Steel Eye Bolt, 1/2-13 UNC, 1 1/2 in Shank (L)	701987	Staples	$5.99	8	$47.92
Motor Retainer	38mm AeroPack Retainer-P	24063	Apogee Components	$29.00	2	$58.00
Ematches and Igniters				$5.00	2	$10.00
Terminal Strip for Ejection Charge	RadioShack® 8-Position European-Style Terminal Strip	274-678	RadioShack	$0.97	2	$1.94
Epoxy	1 quart (105 Resin) and .44 pints (205 Hardener)	Epoxy Kit D	Soller Composites	$47.00	1	$47.00
Electronics Arming Switch	Key Switches- Type 3	KSW3	Aerocon Systems	$6.00	8	$48.00
Quick Link	1/4" Quick Link	29621	Apogee Components	$3.75	4	$15.00
Parachute Protector	NOMEX Flame Resistant Wadding Chute Protectors for Rockets - 9"x9"	N/A	Sunward Aerospace Group Limited	$4.89	4	$19.56
Spray Paint	Rustoleum		Rustoleum	$5.00	4	$20.00
Total						**$1,111.70**
Payload Component	**Details**	**Item #**	**Company**	**Individual Cost**	**Amount**	**Cost**
Datalogger	USB Current Datalogger	WO-23039-56	Davis Instruments	$75.25	2	$150.50
Wood for Bulkheads	1/4" x12" x16" 5 ply poplar Lite-Ply	PLY14L-16	Balsa Machining Services	$3.90	1	$3.90
BT300	BT300 Phenolic Tubing (36")	PT-3.0	PML	$16.50	1	$16.50
Memory Foam	TRAVEL SIZE Memory Foam Molded Contour Neck Pillow	N/A	Z by Malouf	$13.99	1	$13.99
Lucite Cylinders	Plexiglass - Clear Cast Acrylic Tube	ACRCAT3.875ODX.125	Eplastics	$36.01	2	$72.02
Solar Panels	7.2V, 200mA 10.0"x5.9"x0.02" Rollable Solar Panel	S-MP7.2-150	PowerFilm	$35.95	2	$71.90
Total						**$328.81**
Travel Expenses						**Cost**
Travel to Huntsville	School Vans					$1,640.00
Lodging	Hotel					$4,165.00
Food						$2,730.00
Travel to practice launches						$0.00
Total						**$8,535.00**
				Overall Total		**$12,699.56**

We will need extra funds outside of our budget that NASA is giving us. We need a lot of supplies and have a limited amount of funding from outside sources that we can get. We have worked very hard on making an accurate budget, based on the prices given by our chosen suppliers. Our approximated budget for the rocket is $1839.29, while our payload is an approximate $328.81. These prices are subject to change based on supplies needed and suppliers. Compared to our travel expenses, the rocket is a mere fraction of the cost in our budget. Our travel expenses are approximated at $8535.00. This is about ¾ of the whole budget.

There are a few manufacturers that have products that we believe would be advantageous and appropriate for our project and budget.

We plan on using two PerfectFlite altimeters in our rocket. We have used PerfectFlite altimeters in the past. They have been accurate and effectively reusable in the past. These altimeters had good reviews online, and PerfectFlite is a reliable company. We plan on purchasing the PerfectFlite *StratoLogger* to use in our rocket and throughout our project.

We plan on purchasing our body tubes from Public Missiles Limited. They carry the FGPT-3.9 Fiber-glass wrapped Phenolic Airframe Tubing. This tubing was chosen for its sturdy tube base, with a smooth fiberglass wrap. This fiberglass will help strengthen the body tube and prevent zippering. At Public Missiles Limited, they also offer to pre-cut fin slots. This will prevent any mistakes in cutting the body tube, and also save us time when constructing the rocket. Since it is our first year, it seems appropriate that we would choose this option.

We have also chosen to order our body tube with fin slots precut into it. This is because we are a first year team, and feel that it is appropriate to take this advantage in our project. It will take us more time to get acquainted with the safety rules including MSDS. We will also need to be concerned about chosen materials and how to construct them in a timely matter. This is why we feel it’s appropriate and helpful to get these precut fin slots.

Funding Plan

We have a few ideas for fundraising. We plan on doing formal fundraising, writing grants, and hope to get donations from our supporters. We have already started selling Bonus Books. Bonus Books are full of coupons to use at local businesses. Everyone on the team will be selling these Bonus Books. We have already sold a few dozen, and plan to continue selling them. We have also decided to sell advertising space on our rocket. Anyone can buy a section and put something they would like to put on their section for the rocket. This will give the community a chance to contribute to our project and congratulate the team or put a message on it.

We have applied for a few grants, and will continue to apply for them also. The first grant we received was from MedEd 500 dollars. We have also gotten a grant from FirstEnergy that was worth 1000 dollars. These grants will be used wisely, just like all of the other grants will be. We plan on crediting these companies for their support in the near future.

In the future we plan to do different types of fundraisers to help raise money for our trip to our practice launches and also our trip to Huntsville, Alabama.

We hope to have parent support throughout our school so that we can raise money quicker and raise the money we need for our entire project to succeed. We will continue to fundraise throughout our entire project.

We have gone to a football game, and had people donate money to us, and buy space on our rocket to put a message of their choice. Our community can feel involved and supportive of us directly by helping us with our fundraising. We hope to go to many other events in our school, to inform as many people as possible about our SLI Project.

Educational Engagement

We plan to educate our community about our SLI project. We plan on doing this by educating our community, educating the students in our district, and working with companies to make our project possible. Without our communities support and help our project would be close to impossible.

Our community has always been supportive of our science programs and clubs in the past. We have always worked very hard to earn their respect and support and plan on continuing to get their support by working even harder.

We have presented our project to the Board Meeting informed them that we would like to educate the students in our district about SLI.

We have already talked to the principals in our school district, and they have welcomed us to work with the students in their school. We hope to have an assembly for all of the students in the schools, to inform all students of what we are doing, and what they could possibly do in the future. Inspiring these students is important to our SLI Team. These students will be representing our school in the future, and they are part of our upcoming generation.

NASA would like us to educate kids from 5^{th} to 9^{th} grade specifically. This is an appropriate age group for our workshop. Our workshop's purpose is to give kids a real life application of what rocketry is really like. We have already designed two rockets for our workshop. In the workshop, they will be working with 3-4 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. For the workshop though, 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 kids 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 teach them more. 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.

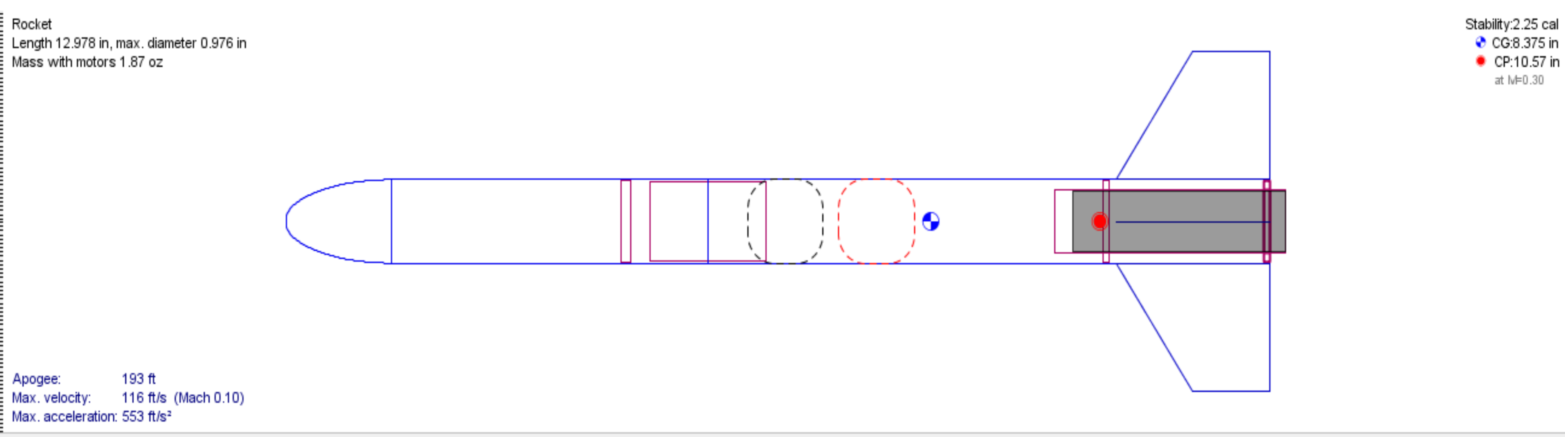
We plan on having students enroll for the workshop. Enrollment will include a meeting for parents and students on the details of the project, and also a consent form for the student and parent to fill out and sign.

Below is the pricing of both rockets offered in the rocketry workshop. These two rockets are relatively the same price, and students 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

The first rocket is characterized by a shorter body tube. The nose cone is rounded at the top, and there are three fins that are in the shaped like trapezoids. All of the other components of the rocket are the same as Rocket.

Rocket Design A

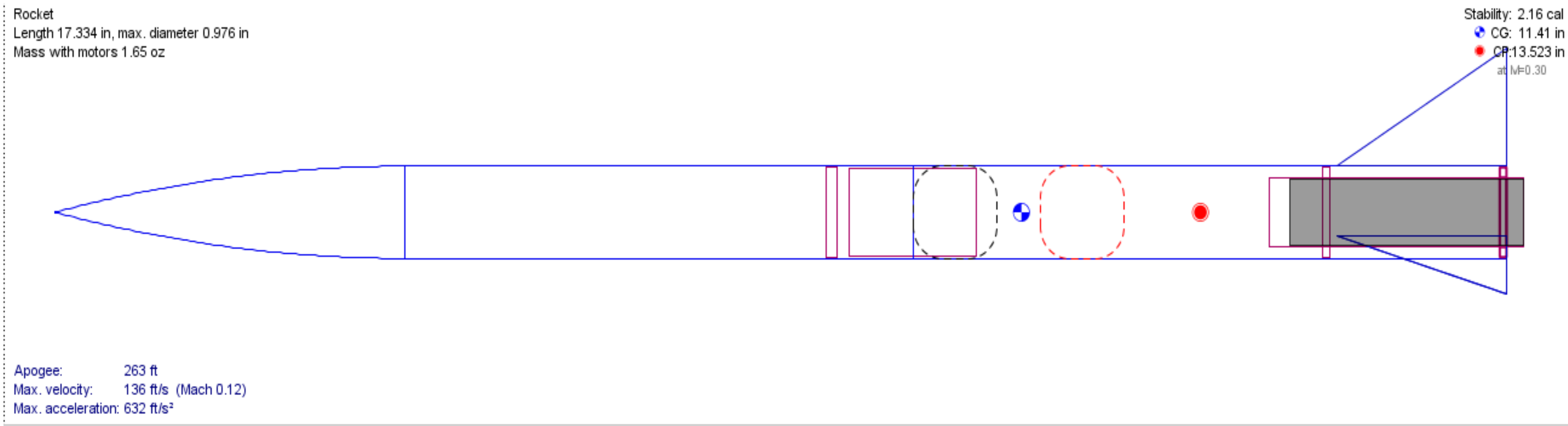


Budget for Rocket

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 is characterized by a longer tube. Its nose cone is in the shape of a cone and has three triangular fins. All of the other components of the rocket are the same as Rocket A.

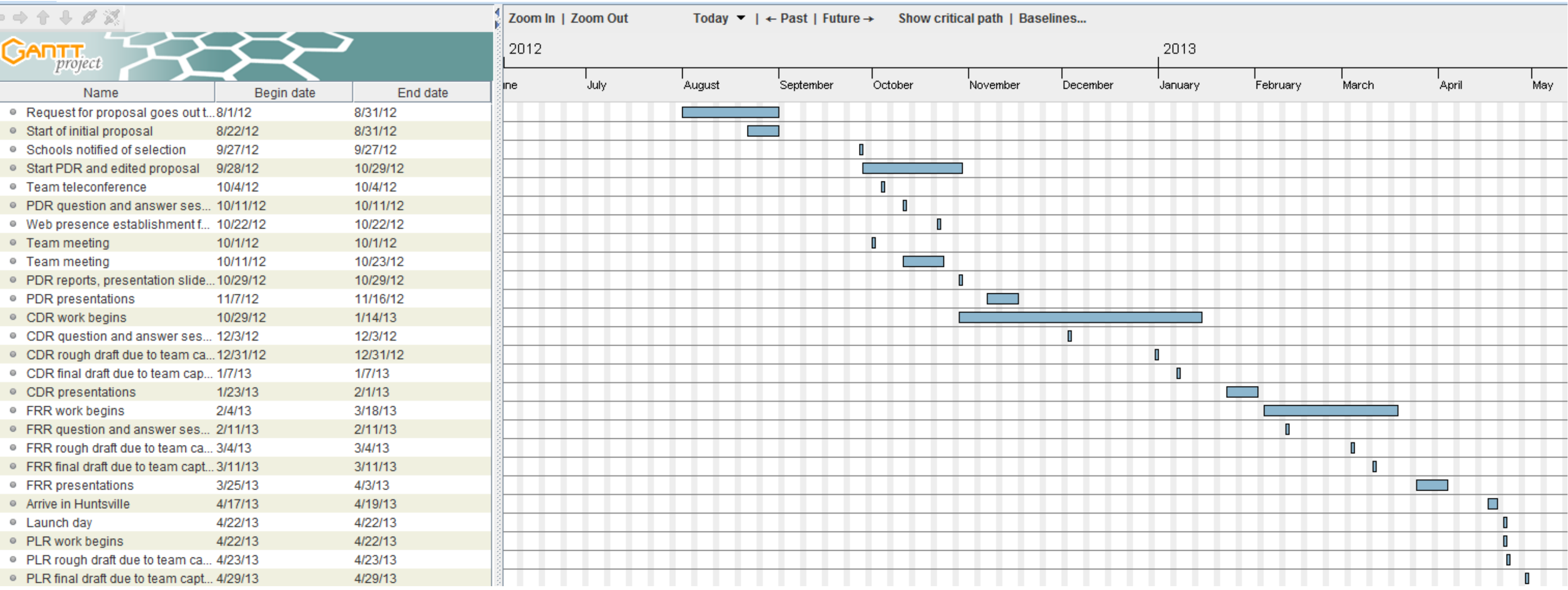
Rocket Design B



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

Schedule:



Name	Begin date	End date
Request for proposal goes out t...	8/1/12	8/31/12
Start of initial proposal	8/22/12	8/31/12
Schools notified of selection	9/27/12	9/27/12
Start PDR and edited proposal	9/28/12	10/29/12
Team teleconference	10/4/12	10/4/12
PDR question and answer ses...	10/11/12	10/11/12
Web presence establishment f...	10/22/12	10/22/12
Team meeting	10/1/12	10/1/12
Team meeting	10/11/12	10/23/12
PDR reports, presentation slide...	10/29/12	10/29/12
PDR presentations	11/7/12	11/16/12
CDR work begins	10/29/12	1/14/13
CDR question and answer ses...	12/3/12	12/3/12
CDR rough draft due to team ca...	12/31/12	12/31/12
CDR final draft due to team cap...	1/7/13	1/7/13
CDR presentations	1/23/13	2/1/13
FRR work begins	2/4/13	3/18/13
FRR question and answer ses...	2/11/13	2/11/13
FRR rough draft due to team ca...	3/4/13	3/4/13
FRR final draft due to team capt...	3/11/13	3/11/13
FRR presentations	3/25/13	4/3/13
Arrive in Huntsville	4/17/13	4/19/13
Launch day	4/22/13	4/22/13
PLR work begins	4/22/13	4/22/13
PLR rough draft due to team ca...	4/23/13	4/23/13
PLR final draft due to team capt...	4/29/13	4/29/13

Our schedule is becoming more consistent as time goes on. We will be spending a lot of time on our reports. We only had a week and a half to work on our proposal, because school started in late August, which is when we were notified of the program. This time we have had more time to prepare, research, and will continue to work harder and harder. We plan on formally meeting to discuss what is going on during the week. We plan on doing this at least twice a week, unless a report or presentation is coming up. We plan on meeting on Mondays from 3:30 to 4:30. We also plan on formally meeting from 3:00 to 5:00 on Wednesdays. Throughout the week, students will meet up after school, during study halls, or at the library to continue work on the reports. This time is crucial and essential to finishing the reports both on time and with quality work. After each report we plan on having a day off, completely dedicated to spending time as a team and relaxing after our hard work is done. This will give incentive to work hard, to earn and enjoy a reward for everything that we have done.

VI) Conclusion

After the initial proposal, we have made a lot of progress on our project. We plan to improve our write up and designs for our next report. We look forward to getting feedback, and will be open to any suggestions or ideas. We plan on working better as a team, and scheduling more time to work together as a team. With our changes, we plan on doing more research on each part of the rocket. This will ensure that we can verify the use of the right materials and as a result create a better design.

In our community we will work hard to get everyone's support. We will also pride ourselves in educating the kids in our community about the potential they could have as a rocket scientist or as an engineer. We will encourage all students to get involved and ask for things they would like to do with the SLI team, such as seminars and watching a small model rocket being launched. We will also encourage the students, in the appropriate age group, to come and work with the SLI team and learn how to build a rocket.

We plan to do research on our rocket parts, materials and the safety rules and directions that are included with each. We plan to practice safe procedures, and will try our hardest to prevent any injuries. Our test launches will be expensive, but manageable with the right amount of fundraising. We have already started a few fundraisers and have gotten 2 grants and applied for a few more. We will need the communities support to be able to raise the money for our coming up test launches. These test launches will be very important to ensure that our experiment is successful and reusable. We can't wait to come down to Huntsville, Alabama to launch our rocket, and see the results of our experiment.