Spring Grove Area High School

SL Rocketry Team PDR 2015

Project TreeTop

The Rocket Men of Spring Grove

General Information

1. School Information

Name: *Spring Grove Area High School*
Mailing Address: Spring Grove Area High School
1490 Roth's Church Road
Spring Grove, PA 17362
Name of Team: The Rocket Men (TRM)

2. Adult Educators:

- Rosemary Cugliari
  Spring Grove Area High School Principal
  Phone number: (717) 225-4731 ext. 7060
  Email: Cugliarr@sgasd.org

- Brian Hastings
  Physics teacher, Rocket Scientist Club Coach
  Phone number: (717) 225-4731 ext. 7220
  Email: Hastingsb@sgasd.org

- Renee Eaton
  Biology teacher, Rocket Scientist Club Coach
  Phone number: (717) 225-4731 ext. 7242
  Email: EatonR@sgasd.org

3. Safety Officer:

- Robert Dehate
  NAR Representative
  Phone number (cell):978-766-9271
  NAR L3CC 75198
  TRA TAP 9956

4. We are not part of a USLI team, we are a SL team.

5. Key Managers:

- Brian Hastings- Advisor and Supervisor of students
- Renee Eaton- Advisor and Supervisor of students
- Mr. Sengia- Instructional Technology Specialist
- Kyle Abrahims- Team Co-Captain (Electronics Bay Leader)
- Wyatt Nace- Team Co-Captain (Payload Leader)

6. For Launch Assistance, Mentoring, and Reviewing our team will be working with the local NRA representatives along with MDRA (Maryland-Delaware Rocketry Association) for all questions and launches.

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Team Members

Name: Brian Hastings

Position: Physics Instructor and Head Coach

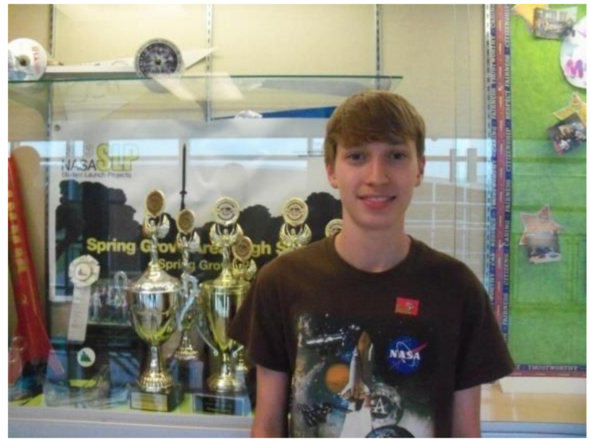
I have been a teacher at Spring Grove for 19 years, teaching Physics 1, Physics 1 Honors, and AP Physics 1 and 2. I have an Honors B.A. in secondary education Physics, a masters in science education and 60 graduate credits past my Masters Degree. I have taught graduate courses to teachers and for the past 15 years have taught fast - paced high school physics for Johns Hopkins University's Center for talented youth program. As a Rocket Scientists' coach, I have started a Science Olympiad team, a Vex Robotics Team, Physics Olympics Team, and a Team America Rocketry Challenge Team. The Science Olympiad team has advanced to the state level each of the last ten years. We have been participating in TARC for 9 years and have advanced to Nationals each of the past 6 years, placing fourth overall at Nationals in 2012, and eighth at the Nationals in 2013. I am a NAR member and have a level 1 certification. Currently I am building a rocket for level 2 NAR certification.

Name: Renee Eaton

Position: Biology Teacher and Assistant Coach

I have been a Biology teacher at Spring Grove High School since 2009. Since then, I have coached the Marching Band and Junior High Track and Field and have advised the Gay-Straight Alliance, Science Fair participants, and the Envirothon team. In addition, I have been a member of the York Jaycees, a local community service organization, since 2009. I finished my Master's degree in Classroom Technology in 2013. In my spare time, I enjoy spending time with my friends and family, hiking, biking, reading, and training for 5K races and half-marathons. I am a NAR member and have a level 1 certification. Currently I am building a rocket for level 2 NAR certification.

Name: Wyatt
Age: 17
Grade: 12
Position: Team Co-Captain and Payload Leader



In fourth grade, I participated in my first competition, Math 24, and became the champion for my school. I advanced through the county competition to the state competition, where I received a bronze medal. I became a “rocket scientist” at Spring Grove in eighth grade, when I joined Science Olympiad. I have been in Science Olympiad ever since, and we have advanced to the State competition every year since. My sophomore year was my first for both TARC and the SLP. In my first year with NASA I learned so much and being able to work with the top people in the field, I was able to prepare for becoming an Aerospace Engineer. These experiences taught me how to work with a team, working on a tight schedule, and leadership, among other things, and am ready for another year to work with NASA.

Name: Kyle
Age: 17
Grade: 12
Position: Team Co-Captain and Electronics Bay Leader

As a student I am involved in many activities throughout the school. I am a part of the Science Olympiad team that has made it to States' the past 5 years in a row including a 12th place finish in 2013. I am a part of TARC and am currently working with my team as a captain, and last year at my first nationals' was able to place a respectable 39th. This year I get to work with Wyatt and become a Co-Captain from our past experience with the SL Program in 2012 and good finishes in TARC. The Student Launch Program is a great experience for all of us and I plan to use the experience in my future clinical labs and use it to further my education in science. In the future I plan to get a bachelors' degree in Chemistry or Mechanical Engineering from either The University of Pittsburgh or Bucknell University.

Name: Josh (Budget and Funding plan)
Age: 16
Grade: 11

I became interested in science when I joined the Envirothon team in 7th grade. I began taking part in Science Olympiad the following year and have made it to the State competition each year since joining the team. I started learning about rockets in my freshmen year when I took part in Team America Rocket Challenge. I am also a member of the book club, German American Partnership Program, and I have played violin since 3rd grade. This year, I am looking forward to being a SL team member.

Name: David (Payload design and 3D modeling)
Age: 17
Grade: 11

SL is an excellent and great opportunity for me; I feel honored to be part of the program again it is truly a great opportunity to learn about the engineering field I would like to enter after high school. I will be able to contribute to projects like these in the future with great understanding of what I'm doing because this is after all our schools second year of working on such a project. I love this project and in the near future I hope it gets me where I want to go in life, thus launching me on my career path.

Name: Jake (Student Safety Officer)
Age: 18
Grade: 12
Position: Head Safety Officer and E-Bay Worker

I became a "Rocket Scientist" in 4th Grade by joining Envirothon. I have been doing Envirothon ever since then and was the captain of the team last year. Also last year I became a member of our Science Olympiad team, TARC team, and High powered rocketry team. In Science Olympiad we won the regional competition and advanced to the state competition. My TARC team qualified for Nationals and competed against 100 teams around the nation. Our high powered rocketry team launched a 38lb, 6in diameter rocket to an apogee of 5955 feet. All of these rocketry experiences have helped me develop my teamwork skills as well as learn many key concepts of engineering.

Name(s): Sarah and Sarah (Educational Engagement)

Age: 17

Grade: 12

(Right): This is my first year participating in both Student Launch (SL) and Team America Rocketry Challenge (TARC). I am involved in other school activities including National Honor Society, the German-American Partnership Program, Spring Grove Choral Ensembles, Expressions, and Globetrekkors. My out-of-school activities include Midstate Ballet, Greater York Dance, and National Honor Society for Dace Arts. I dance pre-professionally over 20 hours a week. I got involved with the rocketry program because I loved physics class and I wanted to explore the engineering field before deciding on a college major. Math was always my favorite subject in school because it is black and white. The answer is either right or wrong; it is simple and precise. I think my involvement in SL and TARC will allow me to utilize my math skills, apply them to my life, and have fun in the process.

(Left): As a student of Spring Grove Area High School, I have been involved in many extracurricular activities such as Student Launch Program, Team America Rocketry Challenge, Choir, Drama Club, International Thespian Society, National Honor Society, Administrative Technology Teaching, Symphonic Band, as well as dance outside of school. I had recently joined the SL program this year after joining TARC the previous year and making it to nationals with my team. In TARC, I am the team captain of an all girl team and I am the only girl involved in this year's Administrative technology Teaching. After school I plan on attending college majoring in Biology and following a pre-medical route.

Name: Gavin (Safety and Payload)

Age: 16

Grade: 11

Throughout my school career I was always interested in the sciences. It wasn't until 10th grade when my Physics teacher introduced the rocket programs at our school. I started my 10th grade year and I was quick to join again this year and take it to the next step by joining the SL team. My first year in TARC, Team America Rocketry Challenge, we made it to nationals and finished highest out of all the teams from our school. That year got me interested in all the science related clubs and activities and hope to expand my horizons even more this year.Other than SL and TARC, I'm on the soccer team which takes up a lot of my time in the fall season. I'm really looking forward to the opportunity to be on the Spring Grove SL team.

I) Summary of PDR report

Part A) Team Summary

Team Name: The Rocket Men

Mailing Address:

Spring Grove Area High School

1490 Roth's Church Road

Spring Grove, PA 17362

Mentor:

Robert Dehate

NAR Number is**75198 ,** Level 3 Certified

TRA TAP 9956

Part B) Launch Vehicle Summary

- The length of the rocked is 85.25 inches, and the mass is 377.99 ounces.
- Motor Choice: Cesaroni K510 Classic Burning Motor (75.0 mm diameter motor with 2,486 Newton*Seconds of Impulse)
- We have a dual Deployment Recovery System with a 36 inch drogue parachute and a 72 inch main parachute. (Both Iris Ultra Fruity Chutes)
- Milestone Review Flysheet - separate document that is on the website

Part C) Payload

AGSE/Payload Title: Not needed because of being a middle/high school team

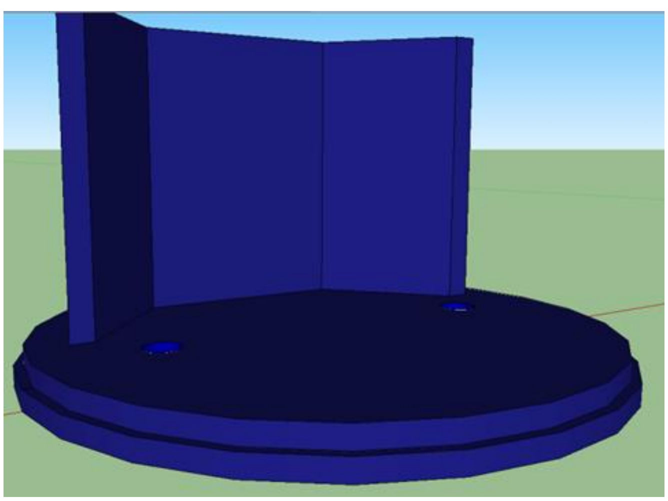
Autonomous Procedures Summary: Not needed because of being a middle/high school team

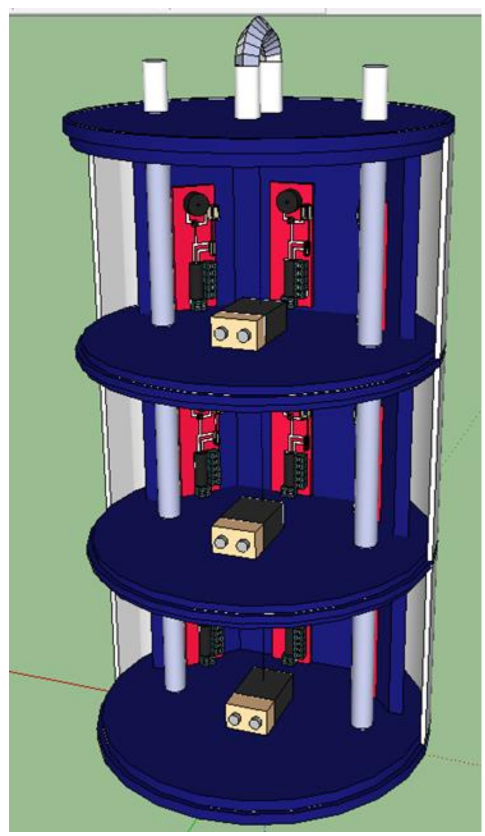
Payload Summary:

The payload will test the variance and effect of hole size on Perfectflite Stratologger altimeters. The payload will fit inside the body tube, directly below the nose cone. The payload will be 13 inches long, and the exterior will be a 3.78 inch phenolic coupler tube. The payload will be split into three sections, each divided by a bulkhead. Within each section will be three Stratologgers and one 9 volt battery. A U-bolt will be attached to the lowest bulkhead, which will be attached to the drogue parachute to be deployed at apogee. The payload will be completely sealed until it is ejected, at which point it will take data. The payload will have four half-inch bulkheads, which will be 3D printed with holes for the all thread precut. The bulkheads will have lips, so that the coupler tube will slide into the lips. The all thread will run through the entire payload, making the disassembly of the payload easier. The all thread will screw on both ends, tightening the fit and keeping all parts in place. This, along with the prefabrication of the lips, should create a sealed container for the altimeters to function correctly. The payload will be split into three separate sections, each of which will contain one 9 volt battery and three altimeters. These altimeters will be fastened onto "walls", which are 3D printed onto the bulkheads. The altimeters in each section will be wired in parallel to one of three 9 volt batteries, one battery in each section. This arrangement will be ground tested to ensure that each altimeter receives the proper current from the battery. The 9 volt battery will be fastened to a bulkhead by a 3D printed "case", which will secure it to the bulkhead while providing space for the altimeters to be wired to the battery.

Each section will be identical, except for the size of the port holes. Perfectflite recommends a single port hole size of .0914" for a coupler tube (diameter of 3.78") and a length of four inches. We will use a 3/32" (.0938") inch hole as our middle "standard" value. We will also test a 5/64" (.0781") and a 7/64" (.1094") hole to see how a larger and smaller hole affects both accuracy and variance among the altimeters. The recommended size was found in Perfectflite'sStratologger manual, which provided an equation for ideal single port size.

Single Port, hole size = Diameter * Diameter * Length * 0.0016





These holes will be drilled around the payload on the outer walls, with the payload housed inside of the upper rocket body tube. These holes will not be drilled onto the actual rocket main frame. This will allow no change in atmospheric pressure until the payload deploys at apogee where we will get a reading of the altimeters. Since it will not read on the way up, the relative approximated closeness to the nose-cone will not affect the readings put off by the altimeter.

With a 3.78” diameter coupler tube and four inch segments, the calculated diameter is .0914”. The nearest drill bit is 3/32”, the most ideal bit size available to us. Each altimeter will be connected to a 9 volt battery because the stratologgers do not contain their own power supply, and after the launch each altimeter will be individually read. This step will be easy, since the payload is easy to break apart.

II) <u>Changes Made Since Proposal</u>

Changes made to Vehicle Criteria

In order to make the vehicle more efficient during the mission, several changes have been made. The length of the electronics bay has been lengthened to 13 inches from 11 inches to supply more room inside of the electronics bay for the batteries, altimeters, and wires. With this changed length, there will still be enough room to put all of the inner components such as the parachutes inside of the rocket. The total length of the rocket will now be 85.25 inches. The mass of the payload has been increased in the design along with the mass of the fins. Because of the newly found mass of the altimeters, the payload mass has increased by about 5 ounces, and the fins with a slightly thicker G-10 Fiberglass, the fins have increased by about 3 ounces. In the new design, the stability margin has decreased to 2.84 from 2.98, because we have made the fins .1 inches smaller on height. This small lowering in stability will help increase that the rocket stays on a straight path to apogee. The motor was also changed from a K661 Blue Streak to a K510 Classic because of the increased burn time with the classic. This decreases thrust on the internal components of the rocket and allows for a safer and more stable flight. The addition of a camera to the outside of the rocket has been approved and will be added to the mainframe of the rocket, away from the fins to affect any airflow that could mess up the flight. The final design for this will be given by CDR. 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 payload will remain intact on the inside, but on the outside, 3-D printed bulkheads will be printed to cover the upper and lower openings in the payload. Along the outside, we will have our coupler tube that will be drilled with our holes for the altimeter readings. The main change is that no holes will be drilled through the front main rocket frame to the outside. The readings of the altimeters will occur when the payload is ejected at apogee, so we should not have to worry about leaving sufficient space between the payload and the nose-cone to affect data. The data should be very accurate and the altimeters will be sealed within that coupler and the first change in air will just occur at apogee.

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. Thanks to our generous educational fund, we have recieved a 5,000 dollar grant along with a generous 500 dollar donation fromAdvanced Application Design Inc. to help fund our project. 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. This will help our program become more successful and will help inform the community of our project.

Response to Feedback from The Proposal

1. The student safety officer is a team member, Jacob Guinn
2. Student's last names have been removed from documents
3. The payload's holes are too close to the nosecone, causing anomalous data to be collected. This was a mis-understanding on our part as the hole sizes will only go through the payload wall, which will be inside the exterior body tube. It will be ejected with the drogue parachute, so it will then be a completely separate component during the interval it is collecting data. Because the inside will be sealed, no readings will take on the way to apogee from inside the rocket tube and the airflow off of the nosecone will not affect the readings. Since the altimeters will take a reading on the ground, the height will be accurately measured as the payload slides out at apogee when the ejection charge went off. Also, the actual height gathered by the altimeters doesn't matter; the only part that matters is the reading's relation to each other.
4. Why does each Stratologger in payload not have its own battery?
    - It will take up space
    - We will reduce mass with only 1 battery in each section
    - With parallel wiring there will be sufficient current to each stratologger and the most current is drawn during ejection, so these altimeters should function correctly with only one battery per three altimeters

III) Vehicle Criteria

Part A) Selection, Design, and Verification of Launch Vehicle

Section 1

Our mission is to efficiently design, build, and launch a rocket to reach a height of 5,280 feet while improving as a team with improved skills and the opportunity to educationally engage 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 4500 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 maintain a straight stable path and 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 36 inch drogue parachute at apogee by initiating rocket body separation in front of 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 the back 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 smoothaerodynamically 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 36 inch drogue parachute, five nylon shock cords varying in length surrounded by Kevlar shock cord protector sleeves, 6 closed eye bolts (Secured to a bulkhead in the top nose-cone, on both sides of the Payload/Electronics Bay, and on a bulkhead in the bottom body tube), and a 3.9" diameter, 13" 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 2.952" 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 1/2 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 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

The recovery system we will be using consists of two PerfectFlite*StratoLogger* altimeters, a 72 inch main parachute, a 36 inch drogue parachute, 3/8 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 36 inch elliptical parachute. The parachute contains 750 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 3/8 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.

The rocket airframe meanwhile, shall perform based on the stability of the rocket and its ability to maintain rigidity, shape, and strength during flight. The rocket tube itself is made to withstand supersonic flights and is formed from composites. Our body tubes will have added fiberglass on the outside for added support and should be able to withstand speeds of up to 1000 miles per hour. Because our rocket will reach the threshold of speed at around 500 miles per hour, the rocket airframe should easily be able to sustain itself and maintain a straight flight. On the end of the airframe, the fins plan on being attached with screws and 3-D printed brackets to the airframe. With both the strength and support of the screws, fin material, and brackets, the fins will not come off of the rocket.

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 K510 Classic, 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 K510 Classic motor is 2486 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

Risks	**Probability of Risk *(1-5)**	**Impact on Project Progress**	**Mitigations**
The payload may get lodged in rocket such that it comes down with the rocket and yields no usable data.	2	We will need to redesign, rebuild, or reload the payload. This would delay the progress of construction.	The team shall ensure that the payload is properly installed.
The rocket parachute does not deploy and rocket returns unsafely to the ground.	3	We lose a rocket and must build another one, losing work time and time to launch.	The team will carefully insert the parachute and make sure there is enough heat shields the

			ground material to prevent flame up.
Injury could occur while using coping saw.	2	A leave of absence of a team member could occur due to minor or severe injury and possibly delay the rocket-building progress.	The team will be aware of limbs and fingers when using this tool.
Injury could occur during Exacto knife usage.	5	A small injury could occur, possibly delaying the rocket-building progress.	The team will carry the knife in cautious matter, cut away from oneself, and be aware fingers when using this tool.
Accidental combustion of rocket materials	3	In addition, possible injury and a delay of rocket-building progress could occur.	The team will keep 25 feet away from electrical outlets, open flame, and the indoor magazine.
Allergic reactions to chemicals involved in rocket production	2	Minor or severe chemical burns of team members and possible delay of rocket progress could occur.	The team will make all students aware of each other's allergies and stay away from possible allergens.
Electrocution during electrical outlet usage	1	Minor or severe injury could occur.	The team will only use electrical outlets if hands are dry and static free. The team will keep fingers away from prongs.
Adhesion to materials or self	4	Minor injury and very minor delay of rocket progress could occur.	The team will exercise proper caution when handling adhesive material and will not use too much of the material.
Injury during laser engraver usage	2	Possible combustion of rocket materials could lead to reordering of materials and delay progress.	The team will make sure the laser is on the proper power, speed, and focus settings, and ensure that the exhaust fan is on.

Injury during drill press usage	2	Severe injury and delay of progress could occur.	The team will keep clothing, hair, and body parts away from the drill bit and use safety glasses.
Tripping and falling hazards	3	Minor or severe injury, delay of rocket progress could occur.	The team will make sure the walking path is clear and keep clutter off of floor.
Abrasions and bruises caused by belt sander	2	Minor injury and delay of progress.	The team will keep hands and clothing away from the sandpaper.
Burning caused by soldering iron usage	2	Minor injury and delay of progress.	The team will use soldering iron in a proper manner and use safety gear.
Premature ignition of rocket motors	2	Possible minor or severe injury, the need to reorder rocket motors, and delay of rocket progress.	Ensure that only the proper level certified personal handle the rocket motors and installations as well as reloads.
Team estrangement because of lack of cooperation	1	Delay of rocket progress.	The team will talk calmly and will not fight with one another. The team will respect each other and themselves.
Going over-budget	5	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.
Misuse or mishandling of hazardous materials	2	Minor or severe injury, leave of absence for team member affected, and delay of progress	The team will follow all safety code regulations, laws, and instructions.

Unforeseen rocket design complications	4	Delay of rocket design and rocket building progress	The team will design a stable rocket based on the locations of the center of pressure and center of gravity. The team will also have a NAR representative check rocket design.
Unforeseen payload design complications	3	Delay of payload design and production.	The team will design a payload that will be effective for the size body tube that is used and double-check that the components of the payload are properly wired and attached.
Complications during transportation of participants and materials to SL or practice launch sites	3	Delay of rocket progress due to rocket repairs or cancellation of practice flights because of extensive damage.	The team will make sure that the launch date is known in advanced and that all specifications are planned out well in advanced. The team will pack the rocket well and make sure it is secure during transportation.
Accidental partial or complete destruction of building site	2	Damage to work environment, additional expenditures for repairs, possible progress delay.	The team will ensure that safety guidelines from NAR and the MSDS are being followed.
Team communication failure	3	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.
Shortage of rocket building materials	2	Major delay due to the need to order new material and wait for it to ship.	The team will double-check all materials before ordering and enforce a checklist while parts are being used.

Commitment complications among team members	2	Loss of time or team member if the complication is too great.	The team will make sure all team members make this their first priority and plan accordingly.
Inhalation of dangerous fumes	2	Minor to severe injury, time lost taking student to ER, delay of progress.	The team will wear proper safety gear, exercise proper use of fume hoods, and be aware of surroundings.
Accidental ingestion of rocket materials	1	Minor to severe injury, delay of progress, possible loss of material.	Only experienced students should work with dangerous materials under proper supervision.
Motor ignition delay	3	Launch delay, loss of motor if it does not ignite, minor to severe injury if motor ignites while personnel are approaching rocket.	The team will only use commercially available and Range Safety Officer-approved igniters.
Rocket catches fire on the launch pad	2	Possible loss of rocket, minor to severe injuries if fire is not properly extinguished.	The team will bring a fire extinguisher suitable for the needs of the fire and according to the MSDS of the motors being used.
Cancellation of launch due to poor conditions	4	Delay of testing.	The team will plan multiple days to launch, be flexible in scheduling practice launches, and practice patience.
Motor ignition failure	3	Delay of launch testing and rocket progress.	The team will ensure that commercially available igniters and motors are used and follow the NAR High Power Safety Code, which outlines what to do during motor ignition failure.

Premature Detonation of Black Powder Charges	2	Partial destruction of rocket and/or premature parachute deployment.	All black powder will be handled by professionals and the team will check that the charges are set for the correct time.
Team members becoming sick before or during the trip to Huntsville.	3	Loss of manpower and possible loss of team leaders and/or safety officer	Team members will be well informed and be able to cover multiple rules in the project if needed.
Pieces of the rocket falling off of the rocket during launch	2	Damage to the rocket and danger of injury to the people and processions on the ground.	Check all aspects of the rocket before launch and delay launch if repairs are needed.
Cancellation of Huntsville due to unforeseen causes	1	Ending of the program for this year or the event being held at a later date.	Follow through with the current program and launch separately.

Section 7

We are confident that we have all of the parts needed to finish and mature the design to the finished state before FRR. Because we have built many rockets in years' past, many small parts and tools needed to build a rocket of this scale are already here. These components include, but are not limited to epoxy, hardener, drills, saws, couplers, duct-tape, wooden rods, nose-cones, some altimeters, and more. Delays on shipment orders could have a delay on how fast the rocket could be built, but we have already planned on ordering the parts directly after the PDR is turned in, so any delays should not be long enough to impact any rocket progress significantly. Other major components will be ordered that are needed for the rocket design. We have selected our manufacturers' from past experience on reliability and ability to ship parts out efficiently and with little to no damage. Altimeters for the payload, exact length body tube, fin material, fiberglass, a new nose-cone, new quick-links, new eye-bolts, and new shock cord material will be shipped in or made in the near future to begin work on the subscale and then full-scale rocket. We are confident that we have all of the parts and materials here to finish the rocket and work hard on the design and progress.

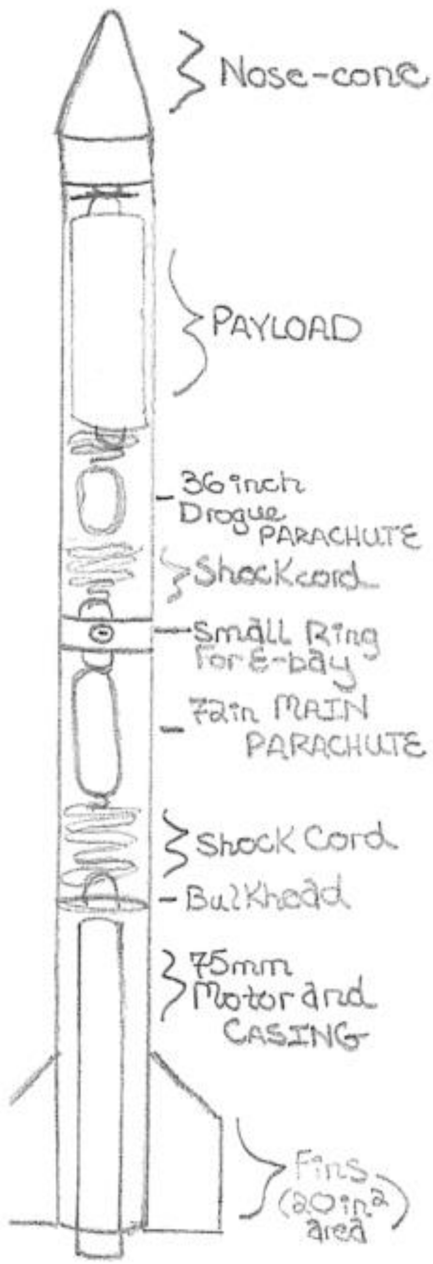
Section 8

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. Static testing will also occur to make sure that the black powder charges are sufficient to launch and that when the black powder ignites, it is enough to knock the rocket parts off of each other.

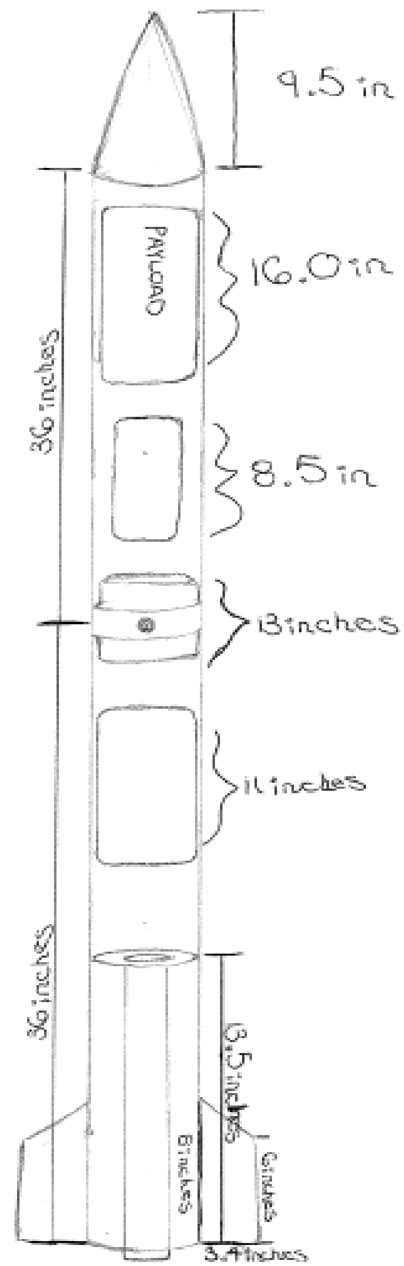
Section 9

We are very confident in our design and the design is very mature along in the process. With past experience in the rocket field, we understand what works and what can result in a tragic failure. With a good solid design, sound structural components, a good stability margin of 2.84, and a good array and size of fins on the rocket, we feel that if we built our rocket tomorrow, that it would fly on a nice straight path, and reach our target altitude of a mile. As far as maturity, there is not many changes left to do to the rocket. The largest obstacle left is to discuss an accurate way to incorporate a camera into the outside of the rocket. Our length is accurate and other than the covering for the camera, our design is close to being final.

Section 10

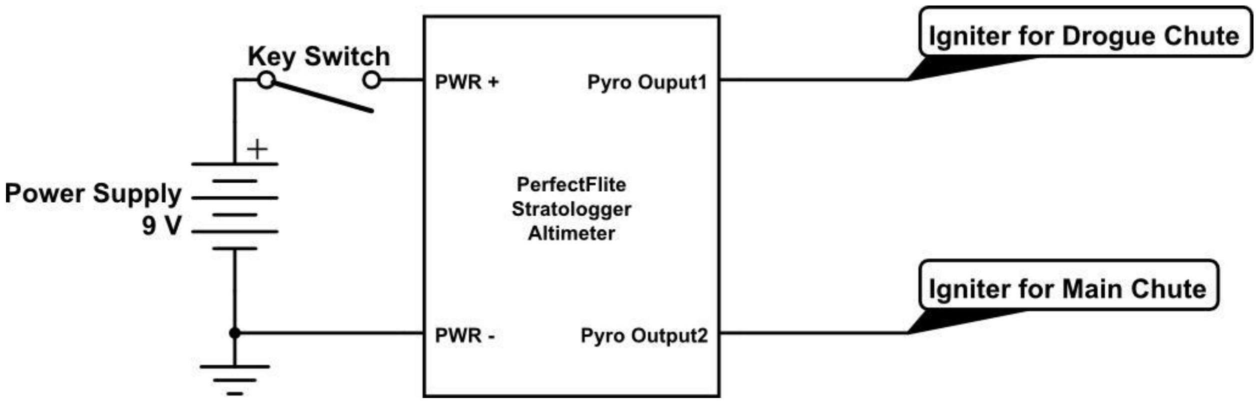


Nose-cone
PAYLOAD
36inch Drogue PARACHUTE
ShockCord
Small Ring for E-bay
72in MAIN PARACHUTE
Shock Cord
Bulkhead
75mm Motor and CASING
Fins (20in² area)



9.5 in
PAYLOAD
16.0 in
36 inches
8.5 in
13inches
11 inches
36 inches
13.5 inches
8 inches
6 inches
3.4 inches

Section 11



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. These altimeters will be armed on the outside of the rocket before launch using a electric key-switch that will be wired up to the altimeter to allow for arming of the altimeters and accurate deployment of the payload and parachutes.

Section 12

Mass Estimate

The total mass of the rocket is estimated to be 377.996 oz. To make the rocket unable to launch due to how heavy the vehicle is, you would have to add 431.04 oz. This will give you a margin of 1.30. 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 epoxy application has not been tested and the estimated massof 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 75.5oz, however we could see a growth in the mass of the rocket of as much as 94.5 oz. to 124.74 oz. 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	**377.99**
Nose Cone	14.40
Bulkhead for Top Half	2.01
Top Body Tube	30.5
Main Chute	10.00
E-Bay Body Tube	0.74
Electronics Bay with Altimeters and Battery Terminals	32.00
EBay Upper Bulkhead	1.02
EBay Lower Bulkhead	1.02
Bottom Body Tube	30.5
Top Bulkhead for Payload EBay	0.633
Payload and Electronics	46.73
Lower Bulkhead for Payload EBay	0.633
36” Drogue Parachute	5.000
Bulkhead for Bottom half	2.18
Motor Mount Tube	6.70
Lower Centering Ring	1.43
Upper Centering Ring	1.43
Fins	24.00
Motor	91.36
Total Shock-Cord Mass with U-Bolts	75.70
Electronics Bay	**32.00**
2 Altimeters	12.6
Lower Bulkhead	1.43
Upper Bulhead	1.43
Battery Terminals, Batteries, and Wires	16.54

IV) Recovery Subsystem

Part I)

The 72 inch main parachute deployed at 600 feet is designed 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 17.4m/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 3/8" eyebolt that is inserted into the 1/2 inch thick bulkhead, 2 inches in front of the motor mount secured with a nut and epoxy. The other end of this shock cord will be firmly attached to the 72 inch main parachute in the bottom half of the rocket. The other end of this shock cord will be attached to the bottom of the electronics bay. These four connection points will be deployed at 600 feet on the decent of the rocket. The revised design of the rocket calls for the bottom half of the altimeter electronics bay to be fastened with four shear pins to the bottom body tube of the rocket. This way, the bottom and top body tubes of the rocket split during the ejection at apogee instead of the electronics bay splitting from the bottom tube. If the electronics bay were not fastened to the bottom tube, we would run a greater risk of having the bottom 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. In the top tube of the rocket we will attach a shock cord to a 1 3/8" eyebolt that is fastened to a bulkhead in the nose cone at the other end of this connection the shock chord will be firmly fastened to the payload. At the bottom end of the payload there will be another eyebolt also 1 3/8", from that eyebolt we will attach a shock cord to the 36 inch drogue chute. At the other end of that shock cord we will firmly connect it to the electronics bay. These six connections will be deployed at apogee.

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.

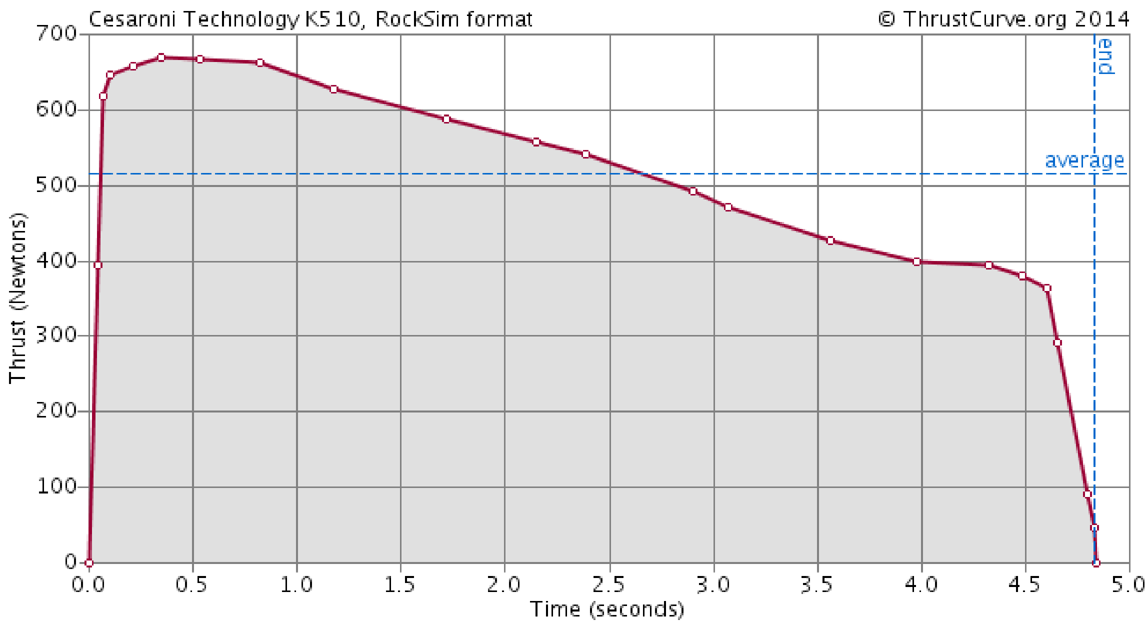
Il)The 36 inch drogue chute is robust enough to withstand at least 330 lbs. of force, as this is what has been tested by the company from which the parachutes are being purchased (Fruity Chutes). The swivel mounted to the 330 lb. test shroud lines iscapable of withstanding 1000 lbs. of force. With the 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 Predictions

Section 1

In order for this project to be successful the following criteria must be met. It must successfully launch and deploy both parachutes. The rocket must be within 10% of our target altitude of 1 mile or 5280 feet. The payload must deploy and gather relevant data for our experiment. We must be able to use that data to draw a meaningful conclusion to our experiment. Lastly no onboard systems or parts must break or malfunction during the course of the launch.

Section 2



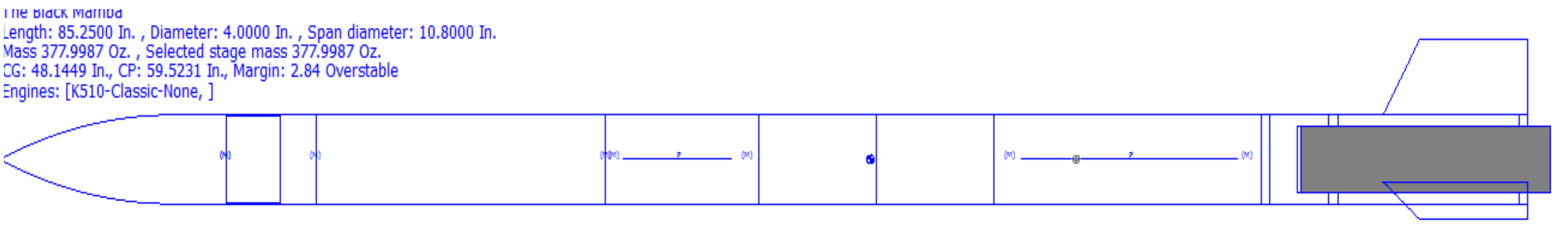
- This is an accurate measure of the thrust over time graph for the K-510 Classis motor made by Cesaroni Technology Incorporated.

67	66		[K510-Classic-None]	5651.21	594.27	175.01	19.77	10.71	5651.22
68	67		[K510-Classic-None]	5606.63	594.15	177.04	19.69	43.83	5606.62
69	68		[K510-Classic-None]	5559.35	594.03	175.23	19.61	61.87	5559.35
70	69		[K510-Classic-None]	5470.67	593.83	177.25	19.45	85.81	5470.66
71	70		[K510-Classic-None]	5111.71	593.16	174.48	18.81	145.81	5111.71

- In the above model from Rocksim, in even intervals of 5 miles per hour of wind, the heights are shown along with the max velocity and max height. The interval starts with the top value at 0 miles per hour of wind, increasing until it hits the bottom and 20 miles per hour of wind. At each interval, we are assuming a 10 percent over-shoot based off of Rock-sim values. So at 0 miles per hour, the calculated height of the rocket is 5, 651 feet, but multiplying by .9 percent with the mass increase and you end up with the rocket reaching 5,086 feet, under the target altitude, but very close to the actual.

- Motor: Cesaroni K510 Classic, 2486 Ns of Impulse

When solving for the theoretical impulse needed to launch this rocket to an altitude of 5280 ft, the impulse calculated is 1,920 Ns, as the rocket weighs 23.62 pounds. This is assuming a frictionless environment. The impulse of the K510 Classic motor is 2486 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, even with friction and other factors.



Section 3

- Stability Margin : 2.84
- Center of Gravity (CG): 48.14 in from nose cone
- Center of Pressure (CP): 58.52 in from nose cone

Section 4

With the 72 inch parachute, the rocket should have a slowed descent of 17. 1 ft/s. With this velocity, the top half of the rocket is calculated to have 52.66 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 7.54 ft-lbf of Kinetic Energy. The payload, which is also tethered to the rocket, should hit the ground with around 9.07 ft-lbf of Kinetic Energy. The last section of the rocket (the bottom half) should have 45.44 ft-lbf at the time it hits the ground. The total kinetic energy of the rocket is 114.71 ft-lbf when it hits the ground.

Section 5

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 201.35 feet from the launch pad. With a 5 mph horizontal wind, the rocket is estimated to drift 582.13 feet from the launch pad. With a 10 mph horizontal wind, it is calculated that the rocket will drift 953.98 feet from the launch pad. With a 15 mph wind, the rocket is calculated to drift 1300.28 feet from the launch pad. With a 20 mph wind, the rocket should only drift 2900.71 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 3000 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 payload to the drogue chute, 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 the main parachute. The shock cord will continue on past the parachute 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)

Preliminary checklist of final assembly and launches procedures:

- ☐ Test altimeters in Payload
- ☐ Payload sections need to be airtight
- ☐ Check wiring in ebay section
- ☐ Check altimeters in ebay
- ☐ Fold drogue parachute properly
- ☐ Fold main parachute properly
- ☐ Observe and monitor the building of motor by our mentor
- ☐ Put payload in top body tube then pack drogue parachute
- ☐ Pack main chute in bottom section of body tube
- ☐ Connect both body tubes with ebay section
- ☐ Put shear pins in ebay holding rocket together
- ☐ Test key switches
- ☐ Take rocket to pad with igniter
- ☐ Place rocket on pad and arm altimeter, then remove key switches
- ☐ Place igniter in motor
- ☐ BOOM

Section 1

Our team safety officer is our NAR Representative Robert DeHale.

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 that isunable 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, thenhave 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, thenhave 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 therest 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

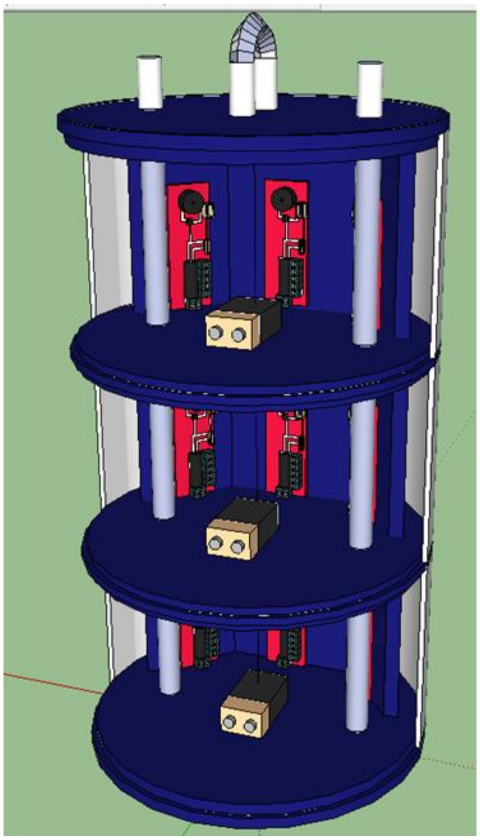
Environmental concerns should be relatively miniscule with this project. One environmental concern is if the rocket should get lost after launch and become unrecoverable. Animals and plants could be harmed from the potentially hazardous chemical components of the rocket and payload. The burning of the 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.

The environment may affect our vehicle in many different ways. Humidity may cause the rocket not to travel as high. Gusts of wind will cause rocket to travel far away from launch pad when parachutes are deployed. Rain will hurt electronics if they get wet. Any type of wet landing surface like a creek, pond, or lake may damge electronics or payload data.

Payload Criteria

Design

- The payload is designed to test the variance and effect of hole size on Perfectflite Stratologger altimeters.
    a. The payload fits inside the body tube, directly below the nose cone. and is 13 inches long, with an exterior 3.78 inch diameter phenolic coupler tube.
    b. The payload is made of three compartments, each separated by a sealed bulkhead. Within each section there are three Stratologgers and a single 9 volt battery that provides power to the 3 Stratologgers in its own section. A U-bolt will be attached to both the lowest and highest bulkheads at each end of the payload, which on one end will attached to the drogue parachute to be deployed at apogee. and to the rest of the rocket
    c. The payloads compartments will be completely sealed until it is ejected, at which point it will take data.
    d. The payload has four 3D printed half - inch thick bulkheads with holes for the all thread preprinted for a clean fit. The bulkheads will have lips, so that the coupler tube will slide into the lips cleanly. The all thread will run through the entire payload, making the disassembly of the payload easier. The all thread will screw on both ends, tightening the fit and keeping all parts in place. This, along with the prefabrication of the lips, should create a sealed container for the altimeters to function correctly.
    e. The altimeters are fastened onto “walls”, which are 3D printed as one piece with the bulkhead.
    f. The altimeters in each section will be wired in parallel to one of three 9 volt batteries, one battery in each section. This arrangement will be ground tested to ensure that each altimeter receives the proper current from the battery. The 9 volt battery will be fastened to a bulkhead by a 3D printed “case”, which will secure it to the bulkhead while providing space for the altimeters to be wired to the battery. 32 Each section will be identical, except for the size of the port holes. Perfectflite recommends a single port hole size of .0914” for a coupler tube (diameter of 3.78”) and a length of four inches. We will use a 3/32” (.0938”) inch hole as our middle “standard” value. We will also test a 5/64” (.0781”) and a 7/64” (.1094”) hole to see how a larger and smaller hole affects both accuracy and variance among the altimeters. The recommended size was found in Perfect flite’s Stratologger manual, which provided an equation for ideal single port size. Single Port, hole size = Diameter * Diameter * Length * 0.0016 With a 3.78” diameter coupler tube and four inch segments, the calculated diameter is .0914”. The nearest drill bit is 3/32”, the most ideal bit size available to us. Each altimeter will be connected to a 9 volt battery, and after the launch each altimeter will be individually read. This step will be easy, since the payload is easy to break apart.



Mock-Up of this years' payload

Project Plan

Part 1: Budget and Funding Plan

As of right now we have already obtained a few sources of funding. The school district, the Spring Grove Educational Fund, has generously donated $5,000 towards the Student Launch project. This initial money will help pay for the parts and transportation required for the subscale flight. Any funds left over will continue to help pay for the full-scale rockets and the trip to Huntsville.

We also will be continuing fundraisers, many of which we have already begun. A Nuts About Granola sale already took place, collecting $150 for the Student Launch project. Each bag of granola sold raised $2.00 for the club. We plan on holding a few more granola sales throughout the year, since the sale was an overall success.

Bonus book sales are underway, providing a profit of **$**12.50 per book sold. The fundraiser will continue through until mid-January. We expect to raise approximately $1,200 from the Bonus book sales. We also are selling bonus books at some local businesses in the area, which will also spread awareness for the project.

We have also rented a cotton candy maker from Harvey's Rental and have sold cotton candy at our school's events, including football games, wrestling matches, and any other event where concessions can be sold. Each event has netted approximately $350 per event.

We have just recently been given permission to sell Avon products. 20% of the sales will go towards the Student Launch project. Online info will be provided, and all products will be shipped directly to the customer's houses. The team will also have books and can sell items directly. Christmas books will be coming out within a matter of weeks.

We plan on selling rocket space once again for our full-scale rocket to be launched in Huntsville. We have not made this official however, but it will most likely occur.

We will also sell Christmas wreaths and poinsettias in the future. This will be sold through the Christmas season, possibly raising around $300 dollars for our project.

Further efforts will be made to fundraise for the complete projects. More fundraisers will be occurring until the completion of the project. We are actively searching for and applying to grants, and we have contacted dozens of local businesses with hopes of a donation, sponsorships, or any type of monetary donation. We have already received a donation of $500 from one of these local businesses: Advanced Application Design Inc. With all of these fundraisers, grants, and donations, we will be able to raise enough to pay for the completion of the 2015 SL project. Any funds left over will go towards next year's Spring Grove rocketry clubs.

Item	Manufacturer	Item Cost	Item Quantity	Total Cost
Pre-Glassed Phenolic Airframe Tubing	Public Missiles Limited	$99.95	4	$399.80
Plastic Nosecone	Public Missiles Limited	$21.95	2	$43.90
Phenolic Coupler Tube	Public Missiles Limited	$18.50	1	$18.50
Iris Ultra 72" Parachute	Fruity Chutes	$188.00	2	$376.00
Classical Elliptical 36" Parachute	Fruity Chutes	$78.00	2	$156.00
1/8" G10 Fiberglass (1 square foot)	Wildman Rocketry	$18.00	3	$54.00
75mm Motor Mount Tube	LOC Precision	$14.95	1	$14.95
75mm Cesaroni Motor Casing	Apogee Rockets	$288.85	2	$577.70
Centering Ring (1/2")	Public Missiles Limited	$4.80	6	$28.80
Bulkhead (1/2")	Public Missiles Limited	$6.00	4	$24.00
0.25" All Thread (36")	Lowes	$1.88	2	$3.76
Perfectflite Stratologger	Perfectflite	$63.96	15	$959.40
50-Count 0.25" Wingnuts	Lowes	$6.88	1	$6.88
Rubber Washers	McMaster Carr	$3.88	2	$7.76
Energizer 4-Pack 9 Volt Batteries	Lowes	$11.97	2	$23.94
1" Shock Cord (42')	Fruity Chutes	$32.60	2	$65.20
Square U-Bolts (2" Width)	McMaster Carr	$2.46	15	$36.90
Quick Links (3/16")	McMaster Carr	$3.75	20	$75.00
			Total:	$2,872.49

Full Scale Transportation	$2,412.00
Full Scale	$2,872.49
Sub Scale Transportation	$1,206.00
Sub-Scale	$250.00
Lodging	$4,270.70
Food	$2,544.00
Transportation	$6,000.00
Total:	$17,143.19

Timeline and Team Schedule

- September 2014
  - 11 Request for Proposal (RFP) is successfully received from NASA
- October 2014
  - 6 Electronic copy of completed proposal is delivered to NASA officials
  - 17 Confirmation of acceptance of completed proposal
  - 18 – 31 The team will have meetings twice a week to work on PDR documents and presentation.
  - 31 Team has a working website and meetings are occurring frequently
- November 2014
  - 3 Safety Briefing for our team
  - 4 Review completed PDR prior to posting on website
  - 5 Preliminary Design Report (PDR) report, presentation slides, and flysheet posted on the team. Website by 8:00 a.m. Central Time
  - 6 Practice PDR presentation
  - 7-21 PDR video teleconferences
- January 2015
  - 3 Subscale Launch for our team in Price, Maryland
  - 4-16 Team meetings to work on CDR documents and presentation.
  - 16 Critical Design Report (CDR) report, presentation slides, and flysheet posted on the team. Website by 8:00 a.m. Central Time
  - 20 Practice CDR Presentation.
  - 21-31 CDR video teleconferences
- February 2015
  - 1-4 CDR video teleconferences
  - 5-27 Built full scale rocket including payload. Test ejection charges at ground level.38
  - 28 Full Scale Launch in Price MD.
- March 2015
  - 7 Full Scale Launch in Price MD
  - 8-15 Work on FRR documents and presentation.
  - 16 Flight Readiness Review (FRR) report, presentation slides, and flysheet posted on the team. Website by 8:00 a.m. Central Time
  - 17 Practice FRR presentation.
  - 18-27 FRR video teleconferences
- April 2015
  - 3 Pack rocket, tools and all parts for Huntsville trip
  - 6 Teams Travel to Huntsville, AL
  - 7 Launch Readiness Review (LRR)
  - 8 LRR and safety briefing
  - 9 Rocket Fair and Tours of MSFC
  - 10 Mini/Maxi MAV Launch day, Banquet
  - 11 Middle/High School Launch Day
  - 12 Backup launch day
  - 29 Post-Launch Assessment Review (PLAR) posted on the Team. Website by 8:00 a.m. Central Time

Educational Engagement

In order to spread awareness of all science programs at Spring Grove, we first plan to hold presentations to both our intermediate and middle schools from grades 5 to 8 to inform them of our project, the basics of a rocket, and how to get involved in them when they reach the high school. If we presented to both schools, over 1,000 children would be involved.

Another idea is to use kits of small rocket parts donated by our sponsor, AquaPhoenix, where upon, we will hold a workshop for children to get involved in rocketry. The rocket kits include body tubes, nose cones, 2 oz. bottles of super glue, bulk heads, motor centering rings, wings, air resistance tubes, sandpaper, motors, ruler, shock cord, twine, solar igniters, bags, and scissors. Every team member of the Student Launch program would lead a small group, where the member will guide the children through the basics of rocket-building. The groups would then launch their small rockets, further spreading rocketry awareness.

To obtain feedback, we will give small surveys to all children who were involved in our presentations and workshops. These surveys will ask how well the presentation was given, how interested the student is in joining a rocket club, and if they are interested in participation in our rocketry workshop.

Some additional ideas are holding an assembly at Spring Grove's Elementary Schools, to invite any interested kids to a rocket awareness camp, and the camp itself. During the assembly, we will teach them a rocket related poem and dance that will be performed at the rocket camp, if attended. We also will show them videos of our previous launches to stimulate their interest in STEM related fields. At the camp, we will launch our TARC rockets to give the children an example of what they would be dealing with when they enter high school. Afterwards, the kids will be designing, building, and eating their own rocket snack made out of small sweets. Any kid who signed up to make a t-shirt will then be giving the chance to dye their shirt in their preference. The shirts will have some sort of rocket related quote or saying on the front of them. Wearing these shirts will promote our program and encourage them to explore the field of rocketry.

A Team America Rocketry Challenge group will be formed in the middle school, spreading more awareness to the younger generation. They will then hopefully continue to participate throughout high school and then involve the generation after them. This system of getting teenagers involved has worked very well and will continue to be the best way of involving students through their peers.

Along with this we will contact local television stations and newspapers. They would then make short segments on our project, further spreading awareness of our rocketry programs. We also plan on going to home football games to set up a table and spread awareness about our project. This idea allows us to go in many different directions including going to many different school events to spread our ideas and lessons. (Not limited to home sports games, museum visits, back-to-school nights, and many others) Through these ways, we should be able to spread our word to a younger generation and bring STEM ot the forefront in our local community.

T-shirts

- Design
    - saying
- for…
    - prizes for middle school

Elementary

- After school Song, dance, coloring, drawing, snack

Assembly

- Hand out field trip permission slip, field trip……permission slip to visit a local launch $10

Song and dance Sample Idea

I'm building a rocket.
As soon as I'm done
I'm taking my friends
on a trip to the sun.

But what to you mean
that the sun is too hot?
Oh well, I suppose
I'll just pick a new spot.

I'm building a rocket.
I'm finishing soon
and taking my friends
on a trip to the moon!

But what do you mean
that the moon has no air?
Well dang, then I guess
that we can't go up there.

I'm building a rocket.
It's going to fly.
I'm taking my friends
way up high in the sky.

--Kenn Nesbitt