Spring Grove Area High School

SL Rocketry Team FRR 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. 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)

5. 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

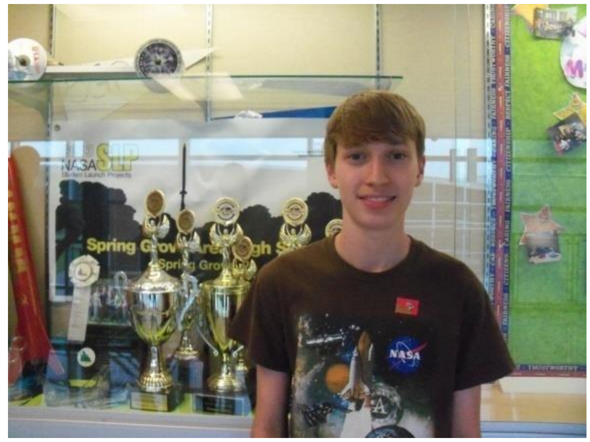
I have been a teacher at Spring Grove for 19 years, teaching Physics 1, Physics 1 Honors, and AP Physics 1 and 2. I have an Honors B.A. in secondary education Physics, a masters in science education and 60 graduate credits past my Masters Degree. I have taught graduate courses to teachers and for the 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: 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 H. and Sarah E. (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) <u>Summary of FRR report</u>

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 114.500 inches, and the mass is 373.9 ounces.
- Motor Choice: **Cesaroni K510 Classic** Motor (75.0 mm diameter, 2 Grain motor with 2,486 Newton*Seconds of Impulse)
- We have a dual Deployment Recovery System with a 24 inch drogue parachute and a 72 inch main parachute. The drogue is a Fruity Chutes Classic with high strength webbing and the main parachute is a Fruity Chutes Iris Ultra Parachute.
- We will utilize a 15-15 Size, 12 foot long launch pad, with two launch lugs on the back half of the rocket for stability, and one launch lug on the upper section of the rocket. This ensures the rocket more time on the pad, easier loading onto the pad, and is needed for the length of the rocket.
- Milestone Review Flysheet - separate document that is on the website

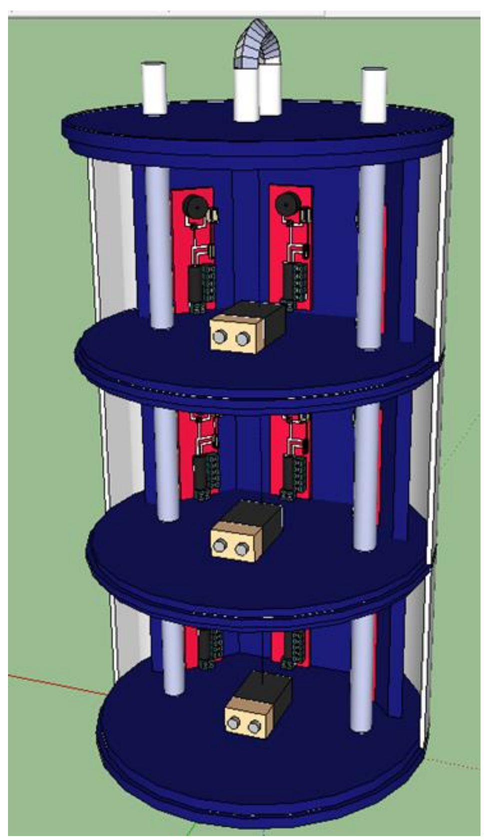
Part C) Payload

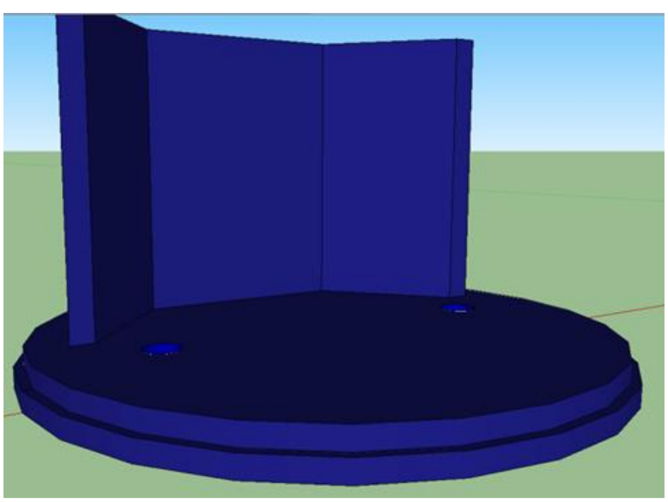
AGSE/Payload Title: Not needed because of being a middle/high school team

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 PerfectfliteStratologger 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, and now stay within the rocket during flight. 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.

$$\text{Single Port, hole size} = \text{Diameter} * \text{Diameter} * \text{Length} * 0.0016$$

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.

Response to CDR Feedback

1) Thank you for your concerns with the fin bracket design and we are making sure that after every launch we are ensuring no damage or melting to the fin bracket. We have designed the fin bracket to have a very high tensile strength through the rigid design and strong connections that it will stay together during flight and that was proved during the full-scale flight test.

2) The altimeters in the electronics bay do not have common wires coming together and that was a mistake on the diagram in the CDR presentation. Later in the FRR there are numerous schematics of the electronics bay wiring that were thoroughly checked and made sure to be correct.

3) The spikes in the altimeter data is due to the sudden break away from the rocket at the time of the ejection charge. From the charge, the altimeter will take a small upward reading and then spike downward due to a gap within the payload where air has leaked in. This spike is controlled and we have made sure that it will not drop far enough to reach the altitude where the main parachute deploys. We have taken measures to try and prevent these spikes from happening in and on the electronics bay. The holes where the wires come through the bulkhead have been closed off with epoxy to prevent air flow in. Secondly, the biggest area of potential air flow is the leakage around the bulkhead itself as it is attached to the electronics bay. We have sanded the tube just enough that electrical tape will fit around the seal of the bulkhead and the electronics bay to prevent air from coming home and hopefully make the electronics bay airtight.

4) The fin can of the rocket is attached via 8 screws that go through the fin can, the body tube of the rocket and into wood attatched to the motor mount. There are two screws on two sides of the fin can and then four screws that attach both the fin can and the launch lugs to the rocket. These screws go through the fin can that screw into wood strips that have been cut, epoxied, and screwed to the motor mount. These wood strips act as a strong holding piece for the screws to bite into and act as a strong connection to keep the fin can on the rocket.

5) At 20 mile per hour winds, the team has assessed the rockets drift and now concluded that the rocket will still be able to land safely if the main parachute is ejected at 600 feet rather than at 700 feet. This 100 feet of main parachute descent now puts the drift of the rocket under 2500 feet in all wind speed at and under 20 miles per hour. This change lowers drift and does not affect the descent rate of the rocket at all, so it will still prove to be a safe landing.

II) Changes Made Since CDR

Changes made to Vehicle Criteria

Since CDR, we have changed very few things about the rocket. A few changes that have occurred have come as a result of the full-scale test launch in Maryland. One change that has occurred is the addition of a third launch lug on the rocket in the top main body tube. Originally we had planned to have only two launch lugs on the rocket on the back body tube of the rocket. This would ensure a stable flight and enough time for the launch lugs to be on the rail for the rocket to maintain stable flight velocity. But with the length of our rocket, we have chosen to place a third launch lug on the front body tube to ensure stability and also not allow the rocket to lean off of the pad at the top section because of the weight in the upper sections. Another change to the rocket is the use of a slightly longer nose cone than was stated in the proposal. This nose cone now comes from public missiles limited and is 4 inches longer, but shaped into a smoother point. This nose cone with no mass increase from the precious one was chosen to reduce drag on the flight up and ensure a more stable flight. This decrease in drag is hoping to get us a few more feet on the height of the rockets flight. We have also went to stronger type 3 shear pins (6 of them) in the front half to make sure that the main parachute does not deploy early.

Changes made to Payload Criteria

Since CDR, we have changed nothing to the payload itself. The payload is still made up of 3 chambers with three altimeters each. What we have changed is the motion of the payload. In previous reports, we stated that the payload would slide out of the rocket at apogee. With recent non-successful pulls out of the rocket, we have decided to keep the payload secured inside of the rocket. This was chosen because the payload cannot be sanded any more or made smaller with the internal components that are needed to make up the payload. This stationary payload will now remain secured to the rocket through two bolts that will go through the rocket airframe, one on top and one on the bottom of the payload. These bolts will be capable of being taken out so that the payload can be taken out, but they will be strong enough to ensure that the payload will stay in the rocket and also have a strong enough attachment to the drogue parachute to keep the rocket all fully attached. Holes will now be drilled into the outside body tube to correspond with the holes in the body tubes of the payload. Each compartment will still be independently sealed, and make sure that each is getting the correct reading of air. These holes will take data on the way up and way down now just like the altimeters in the electronics bay which will be more accurate representations of the data. To ensure that the holes will stay lined up and that the payload cannot twist, two screws will go into the payload to make sure that it does not move inside of the rocket.

Changes to Project Plan

The project plan has changed slightly over the course of the past couple of weeks. The rocket building workshop is now scheduled to occur in the middle of March after our first full-scale test occurred. We plan to launch the full-scale rocket again on March 28th after a postponement by MDRA of the March 14 launch due to weather conditions. So far we have raised all money needed to make it to Huntsville in April!! We have to thank all of our generous donors and sponsors, and now we will be able to see you guys in a few weeks.

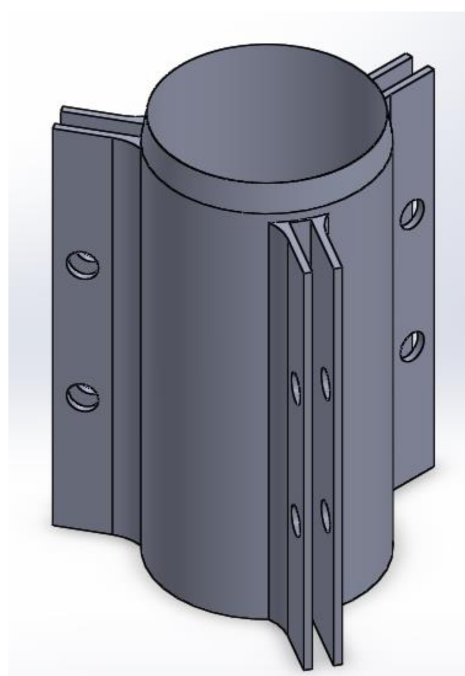
Vehicle Criteria

Design and Construction of Structural Elements

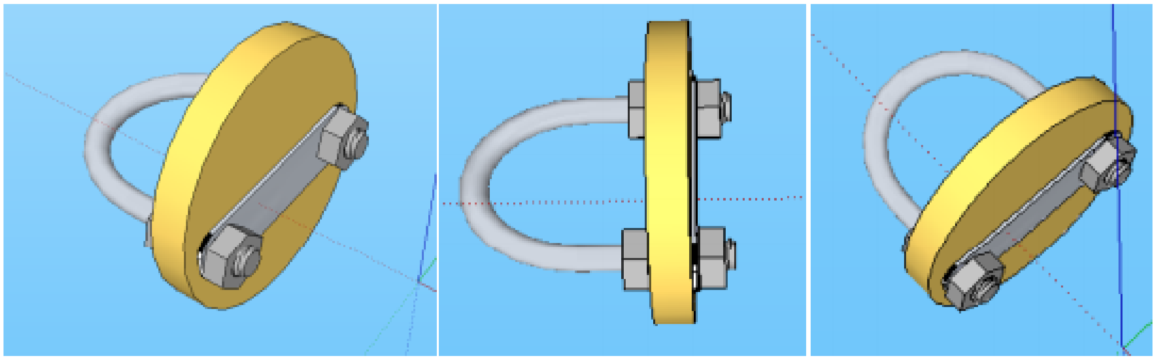
The airframe of the rocket is constructed from Public Missiles Limited Fiberglass wrapped phenolic tubing. The phenolic tubing is resin impregnated, spiral wrapped, and heat cured, which in itself is somewhat robust. With the addition of the fiberglass to the outside of the body, the rocket becomes a very resilient component to the rocket, capable of handling the normal stress encountered by the rocket on the flight to apogee. The tubing already comes prepared from the manufacturer, providing less of an inconvenience to the team and its preparation.

Since the fins are mounted using a specially made fin bracket, no holes are needed to be made in the body tube itself. The fins on this rocket are made from 3/32" G10 FR4 fiberglass epoxy sheets. The sheet is a glass cloth reinforced with epoxy to make it much more robust. The fiberglass absorbs next to no moisture at all and has great dimensional solidity as it does not change much with temperature. With the makeup of the fin bracket and the makeup of the fins we are confident that the heat expelled from the motor shall not burn and/or damage the fins in the fin bracket itself. The fins are attached to the fin bracket using three bolts with three nuts securing the bolt on the other side.

The fin bracket is then screwed into the main body tube itself. There are wood slots on the outside of the motor mount (on the inside of the rocket body tube) that allow the screws to bite into the wood. This wood provides a sturdy enforcement for the screws and a reliable contact point. There are six screws that go through the fin bracket and to the wood slots securing the fin bracket to the main body tube, so the screw bites into both the body tube, but also the more reliable wooden strips. The fin bracket itself also has a fairly tight fit on the body tube for added friction between the tube and the mount to keep the fins and bracket secure.



The bulkheads that we are using inside the rocket are made from ½" plywood and were cut out on a CNC router for precision fit into the rocket. The bulkheads were then sanded around the outer edge and the inside of the rocket was sanded where the bulkheads were being placed, in order to ensure that the epoxy would create a better bond between the rocket and the bulkheads. The epoxy was placed as best as possible on both sides of the bulkheads and between the bulkheads and the inside wall of the rocket.



The U-bolts in the rocket are made from 5/16 inch stainless steel. They are attached through the bulkheads and secured on the other side with a reinforcement bar and two nuts that have been attached with epoxy to the threads. The metal bar on the back side helps to distribute the force on the U-bolt across the bulkhead to ensure that the U-bolt does not simply rip through the bulkhead.

The centering rings are a major component to our rocket, as they must be able to keep the strong force of the K510 Classic motor from pushing up through the rocket and play another role as a fin support. The centering rings are positioned 3/4 of an inch from the end of the motor tube and about 2 inches from the other end of the motor tube to ensure maximum support to the motor. There is epoxy both above and below the forward centering ring (the one just above the fin tab), and about ¼" of epoxy below the aft centering ring to ensure that it does not come out. These centering rings hold the motor tube and motor in place, but also keep the wood strips in place on top of the motor tube so that the screws from the fin bracket have a solid piece of wood to bite into too. This ensures a solid connection between the tube, the rocket and the fins and fin bracket.

The fin bracket is made with 100 percent fill 3D printed polylactic acid (PLA) material with extra supports made from the tube section to each of the three pieces holding the fins in place. We want to ensure that the brackets do not break off and were tested to withstand over 100 pounds of force. This is more than enough force that we are confident that our fin bracket system will hold during launch.

Design and Construction of Electrical Elements

The wiring in the electronics bay is set up in redundant fashion with each altimeter being connected to its own independent 9 Volt battery. For each altimeter, 16 gauge stranded wire is used to connect all switches and ejection impulses. Each altimeter is wired with a positive and negative wire to a battery terminal which houses the nine volt battery. These wires are sauntered onto the terminal and the stripped ends are plugged into the power points on the altimeter. In the switch outlets, two wires run directly to the switch that controls each altimeter with one end into the altimeter and one end soldered onto the battery terminal. The main and drogue ejection wires are put into the altimeter and ran to their respective sides of the electronics bay where the wire runs through the outer bulkhead of the electronics bay and into a terminal strip mounted on the bulkhead. This way, our mentor can place e-matches into the terminal strip and run them directly to the ejection wells.

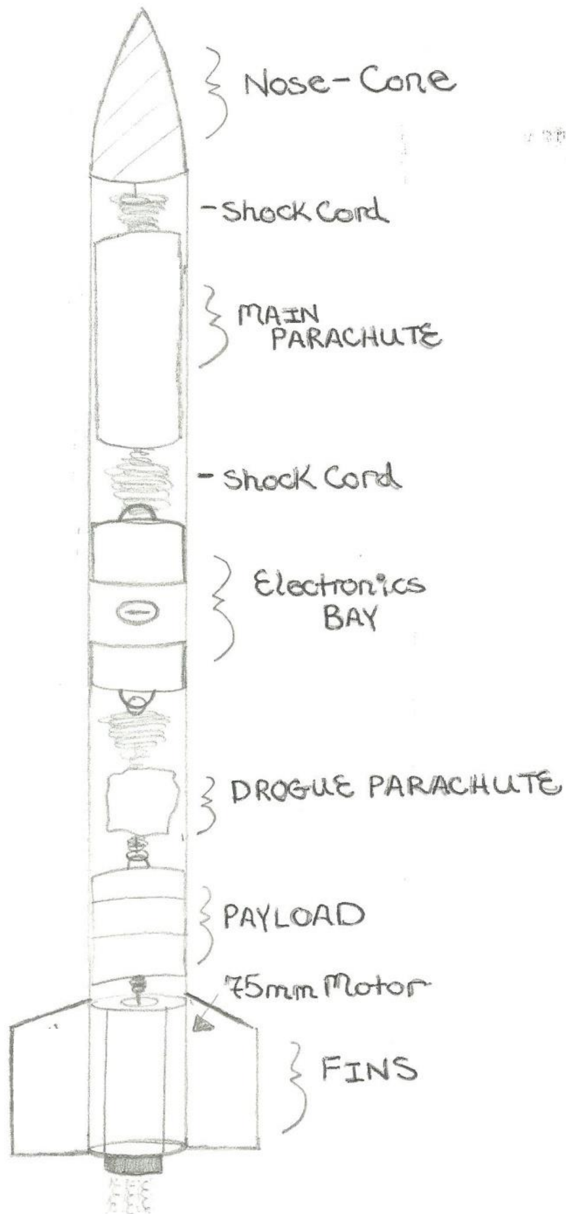
This setup is repeated for the redundant altimeter as well so that both altimeters are wired correctly.

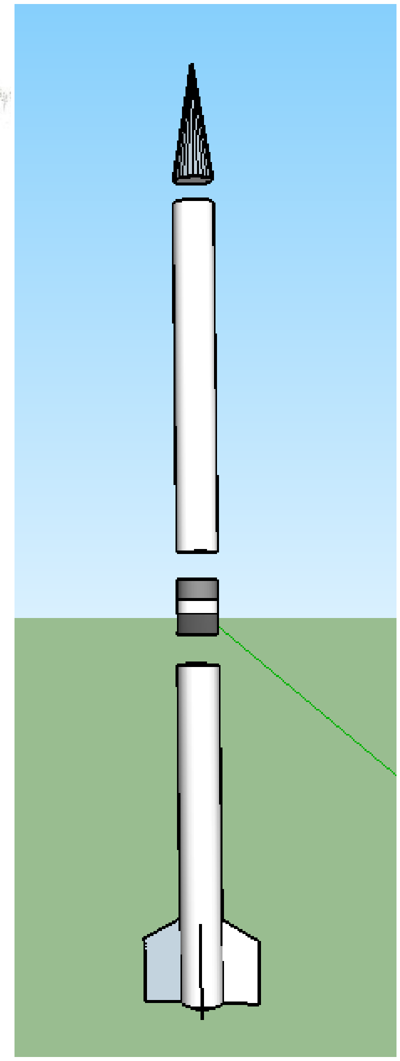
Each of the two batteries are placed into battery terminals on the sled of the electronics bay. These terminals are screwed and epoxyed onto the wood to ensure that the terminal stays attached to the wood during flight. To ensure that the battery stays in during flight, the terminals are mounted to ensure that the battery is pushed down and into the leads of the terminal during flight. We also have electrical taped the batteries into the terminals to ensure that the battery does not fall out.

Each altimeter itself is mounted using altimeter mounting hardware. A standoff is mounted through the wood and screwed like a bolt. The altimeter then is placed on top of the standoff where screws secure through the altimeter and into the standoff to ensure that the altimeter cannot move during flight.

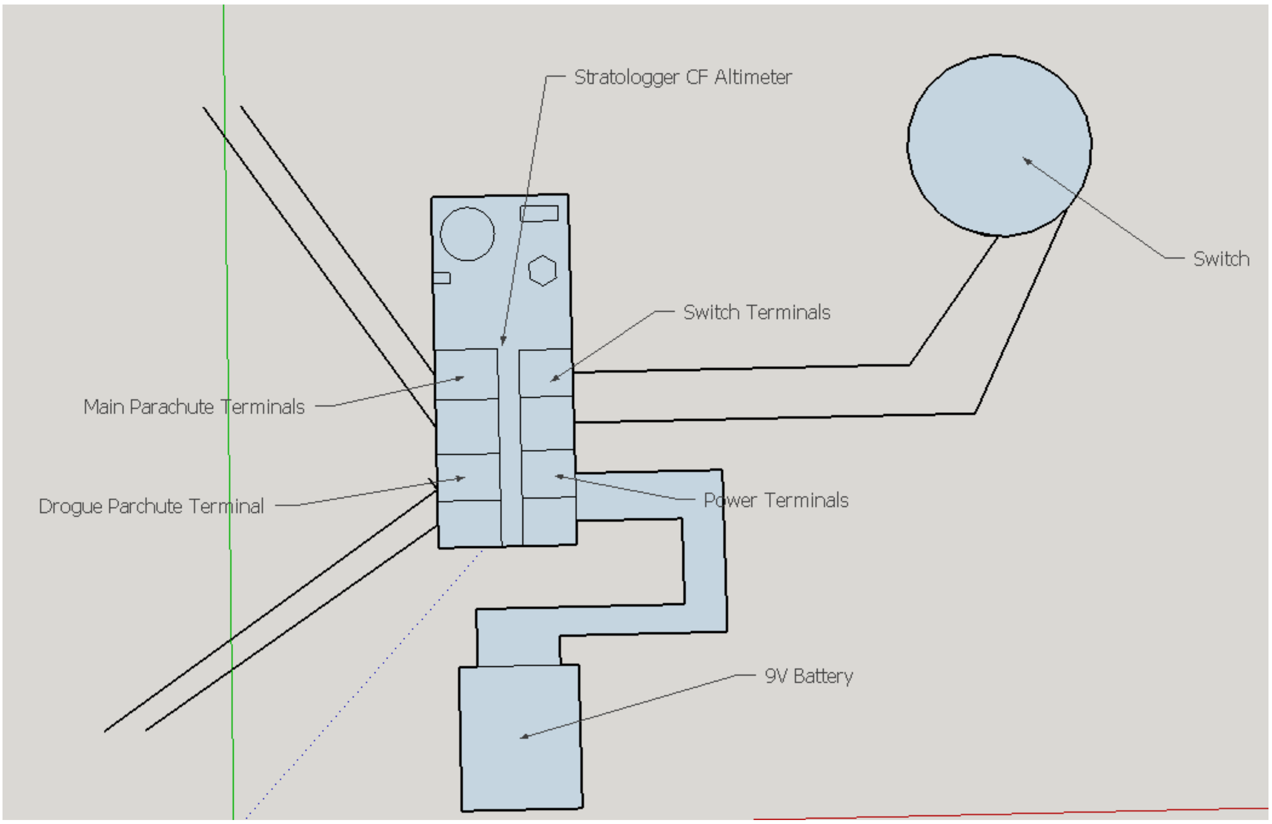
Finally, each key switch is mounted into the body tube on the middle of the electronics bay and mounted using a nut on the back side of the key switch, epoxy, and super glue to ensure that the key switch will not move during flight. The key switch is secured into position after wires are secured and are made sure to function properly before launch.

Drawing/Schematics

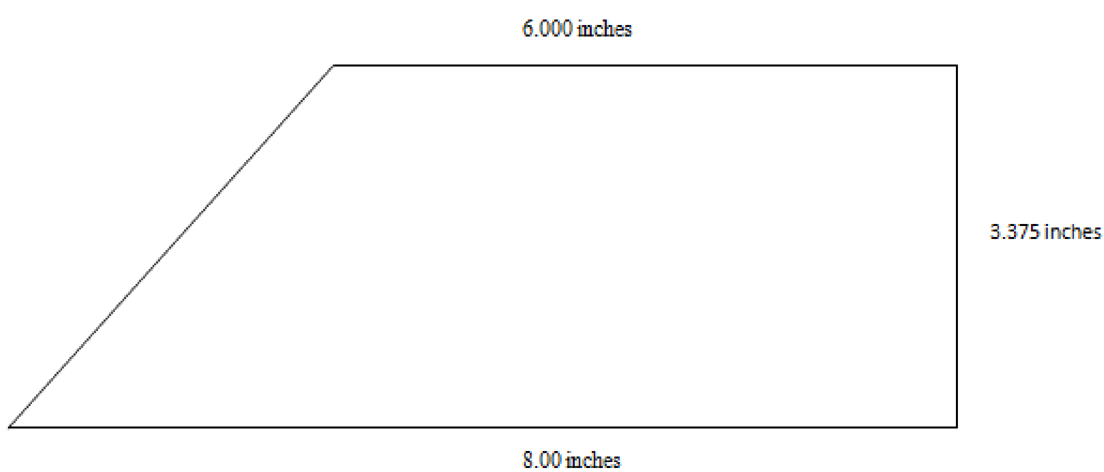




Electronics Bay Wiring



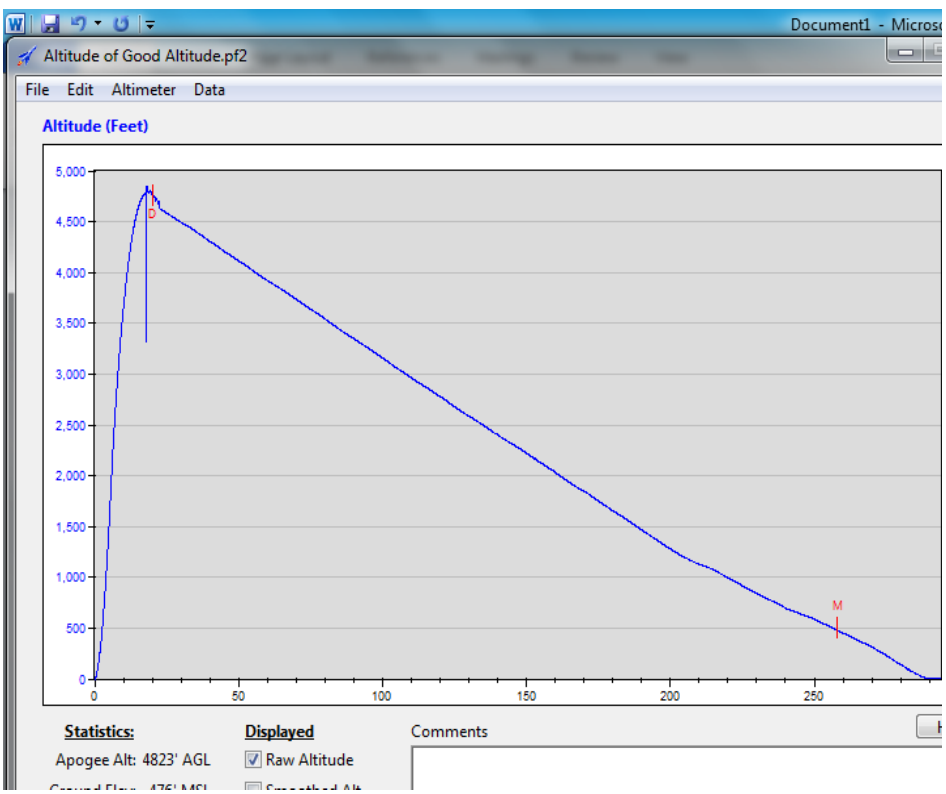
Fin Dimensions

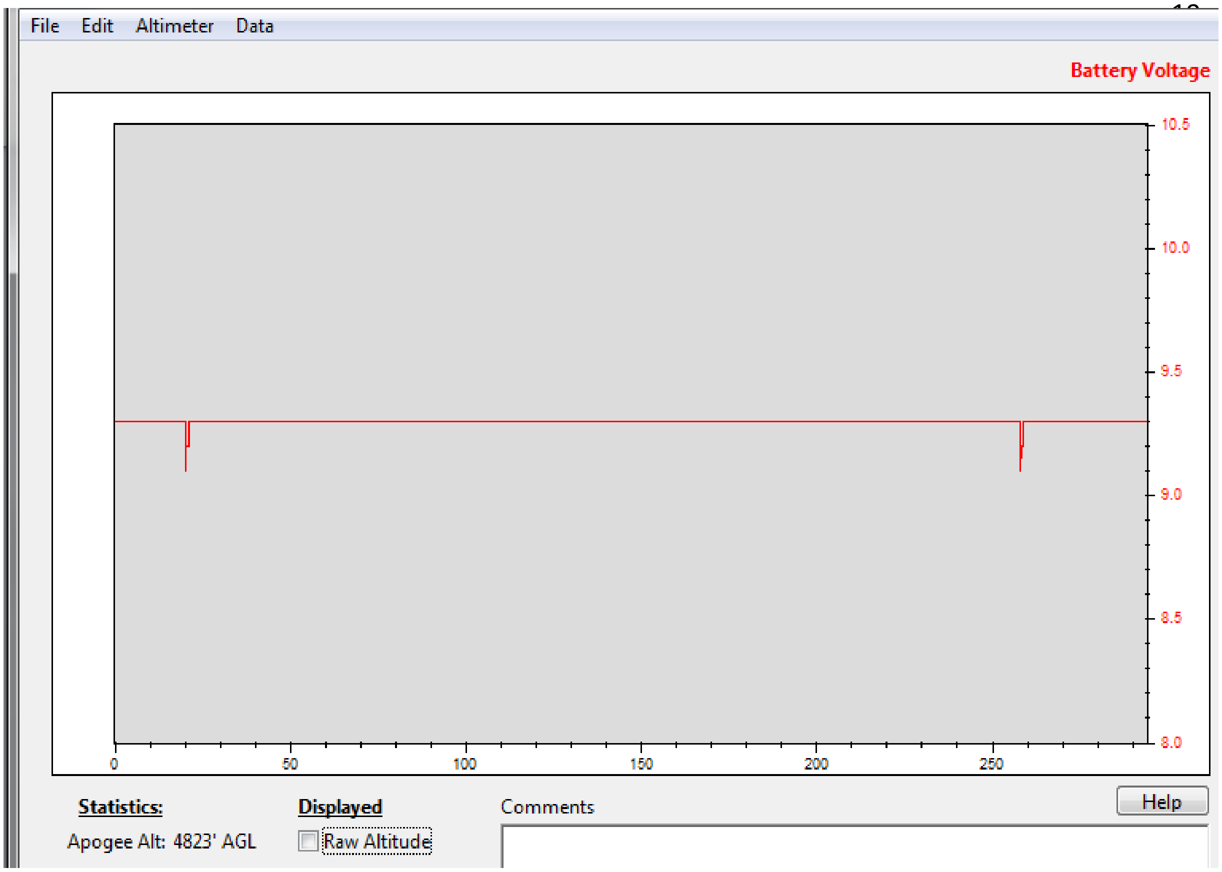


Flight Reliability

We are confident in the design of our rocket and have done both component and ejection testing to ensure that major portions of flight will occur without risk. On our only test flight launch that we were able to do before FRR on February 28th, we saw our rocket take a very straight flight even in winds of 10-15 miles per hour. The rocket ensued a straight flight and was on its way to be completely successful until the main parachute popped open at apogee. This we found later was a result of not having enough shear pins in the front end of the rocket and then the shear pins breaking too easily on flight. We have now decided to go to 6 shear pins to make sure that our flight is ensured to be successful and have the main deploy at 600 feet. This along with the other problem of the payload not ejecting are easy fixes that were though of by the team and at our next full scale launch on March 28th, we are very confident that the rocket will have a very successful flight. Overall, major aspects such as stability, ejection charges, fin attachment and the deployment of parachutes was met so confidence is at a high and no major rocket design changes are needed

Test Data





As you can see in the graphs of altitude vs. time above and voltage vs. time we were able to have a successful full scale launch and get accurate data from the altimeters as to flight occurrences. In the height graph, we can see that the drogue parachute was correctly deployed at apogee and the main parachute charge did go off at 600 feet like it was programmed to do. The spike at apogee due to the altimeter taking a intense reading of air pressure dropped to around 3300 feet which is very reasonable and shows us that our electronics bay is reasonably sealed. We are going to work with the electrical tape and all open sections to try and limit the spike even more, but there runs no risk of the altimeter telling the rocket that the charge for the main parachute will go off early. In the voltage graph, you can see that the battery and altimeter connection was constant and maintained a good connection with only small spikes in current when the ejection charges went off which will occur due to power being needed to blow out the ejection charges.

Workmanship

So far after full scale testing the team has built a total of 3 complete rockets, two electronics bays, and two payloads. I am proud of the workmanship of the team including the workmanship on reports that have been done on time and done with a lot of detail and time commitment. With the rocket, the team is able to build rocket parts in a small amount of time and build them correctly which allows us to launch the rocket more often. Three entire rockets were built as to always have a back up rocket. Since the first rocket had to be disassembled after its first launch as the payload became stuck, that made the need for the third rocket. So far, the team has been able to fix and major problems that have arisen and worked very well together as a team to get work done and spend major amounts of time together.

Safety and Failure Analysis

Failure Modes	Causes	Effects	Mitigations
The main parachute fails to deploy	-The parachute is too large for the diameter of the rocket -The parachute is not packaged in the most efficient method possible and gets stuck in the rocket	The rocket hits the ground with only the drogue chute to slow it down. The rocket is either damaged with minor fractures, or is damaged beyond repair.	Research methods for folding the main parachute, and what sizes fit which tubes. Practice folding several different ways to see which one works the best.
The rocket zippers	-Both altimeters deployed their ejection charges at around the same time. -The shock cord isn't long enough and isn't absorbing enough shock. -The structural integrity of the body tube is too weak.	The rocket part damaged by the shock cord must either be trashed and rebuilt, or fixed in a way that it doesn't not leave the rocket in a state of major structural vulnerability.	Try using a longer shock cord if you can, or spread out the delay on the one altimeter from the other, so that they do not interfere with each other.
The main chute deploys before it is supposed to.	-The shear pins were not strong enough. -Not enough shear pins were used. -The ejection charge for the drogue chute was too strong	The rocket drifts out of the 2500 ft radius of the launch pad. The rocket causes damage to property outside of the launch radius.	Make sure that the amount of black powder being used in the ejection charges is what was tested for that many shear pins.
The rocket assumes an unpredictable, unsafe flight path	-The rocket is unstable -Launch Lugs are not aligned properly	The rocket damages property, hurts someone, or becomes damaged itself.	Use a launch rail to align the launch lugs onto the rocket. Check them when their finished to make sure they're still straight.

Full-Scale Launch Data and Report

With the full scale motor of the Cesaroni K-510 Classic, the rocket traveled to a height of 4,823 feet in Price, Maryland on February 28th. The rocket weighed exactly 23.3 pounds which was very close to our predicted value that we had assigned. This smaller than 5,280 feet height is attributed to increased drag with the fin bracket design. It is also assumed that Rocksim flight data will overshoot the actual height of the rocket and in real life is decreased around 10 percent. With that decrease, our predicted height was 4,859 feet. This height was very close to the actual and we plan to try and cut around 1 pound of mass for the second full scale flight test to see if the height will increase. On this launch both ejection charges went off without flaw, the only problem was the payload occurrence and the fact that it got stuck in the body tube.

Mass Report

Part	Mass (oz.)
Nose Cone	10.50
Top Bulkhead	2.01
Top Body Tube	30.00
Main Parachute	13.40
Electronics Bay Tube	1.50
Altimeters/Batteries/All-Thread/Exc.	36.50
Electronics Bay Upper Bulkhead	1.00
Electronics Bay Lower Bulkhead	1.00
Bottom Body Tube	50.00
Payload	48.00
Drogue Parachute	1.60
Bottom Bulkhead	2.18
Centering Rings	2.86
Fins	24.00
Motor	91.36
Shock Cords/U-Bolts/Eye-Bolts (5 each)	58.00
Total:	**373.9**

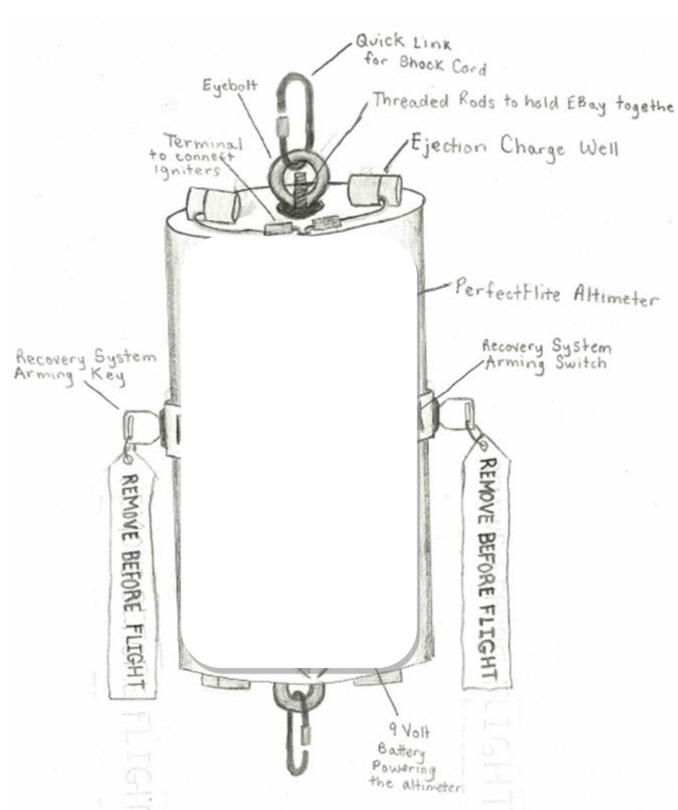
The predicted mass was to be around 23.35 pounds. When the rocket weighed in at 23.3 pounds we were happy to hear that it was very close to the predicted and this also shows up in the closeness of our flights height to 5,280 feet. Mass will try to be shaved from shock cord and also joints for our next launch to see how close to a mile we can get.

Recovery Subsystem

Our bulkheads are made out of half inch ply wood. These bulkheads are sanded to have a lip that fits inside the inner coupler tube of the electronics bay. The bulkhead then widens out and sits on top of the coupler tube. This fit allows for an air tight seal of the electronics bay, but also a small enough outside seam that it easily slides out of both the top and bottom portions of the rocket. A half inch of wood will not crack very easy. Attached to the bulkhead is a U-bolt for attachment to the quick links on the shock cord. Two holes were drilled into the bulkhead; the U-bolt was then attached with two nuts. Around the nuts and holes epoxy was applied to prevent the nuts from loosening. To attach the shock cord to the U-bolts we are using .23622 inch quick links. These quick links are rated for 880 pounds of force. With the U-bolt and quick link combination our recovery attachment system will be robust enough to withstand all the stress it will undergo in the ejection process. Also on top of the bulkhead are terminal strips for our ejection well wiring. These strips allow wires from the altimeters to come through the bulkhead and be able to provide a connection for the e-matches to fire the ejection charge for the separation of the rocket. These terminal strips are mounted using wood screws that make sure for a secure fit on the bulkhead. Also on the bulkhead are PVC round ejection wells with flat bottoms. These flat bottoms allow for a more secure epoxy surface as well as a surface to screw the ejection well to the bulkhead. With the screw and epoxy, we are confident that the ejection wells will stay in place and be able to fire off the ejection charge.

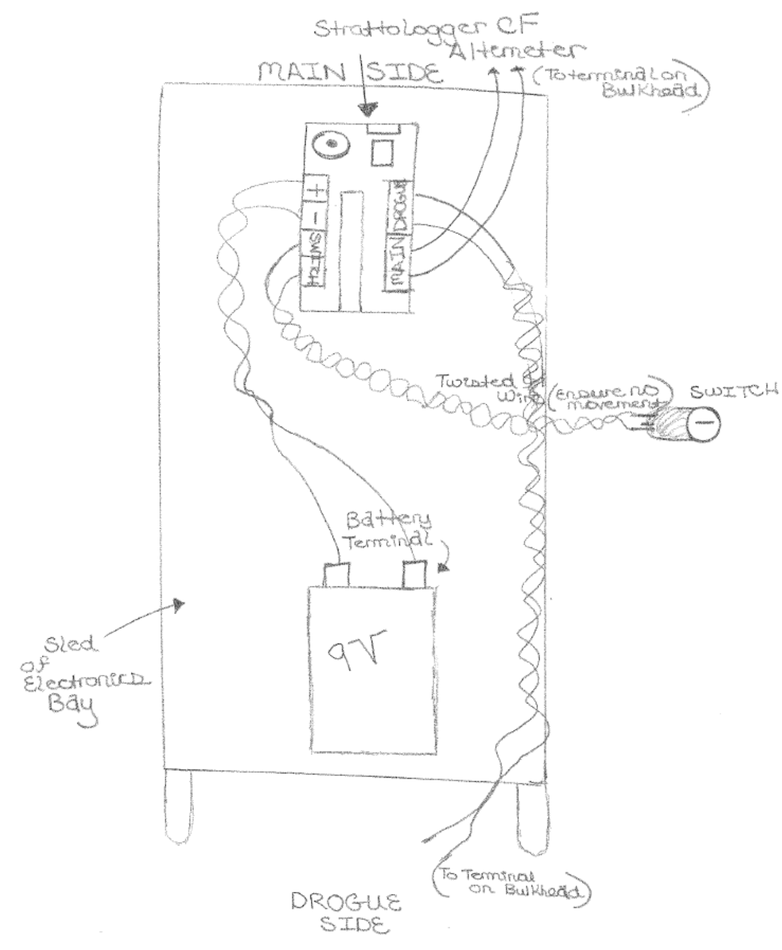
The PerfectFlite StratoLogger altimeters are produced by PerfectFlite. These altimeters are very well constructed. We have used PerfectFlite altimeters before and have had no problems. The key switches chosen are attached with custom made holes from the outside of the electronics bay to the inside. The switches are placed within the holes and a nut on the inside to secure the switch. This system will keep the switches in place during flight. The battery mount leads are attached to the wires with solder then covered with potting epoxy. This keeps the wires in place and continuity. The same is done to the battery terminals. These 9-volt terminals are epoxied and screwed to the sled inside of the electronics bay so that they will not move. They are also placed there so if they were to move they stay at the bottom of the electronics bay. With all of the precautions taken into consideration the electronics bay is robust enough to withstand the needed forces and be reusable. The electronics bay in this rocket were designed for redundancy. There are two PerfectFlite StratoLogger altimeters. Both altimeters are attached to a terminal strip where e-matches can be installed for the four ejection charges. There are four ejection charge wells on the electronics bay. There are two on the top, for the main parachute ejection and two on the bottom for drogue parachute ejection. Each altimeter will be wired to one charge for each side of the electronics bay. With this setup two ejection charges will be ignited for each parachute ensuring complete separation of the separate pieces of the rocket. The altimeters are programmed so that the charges are lit at different heights to avoid over pressurization of the rocket.

The recovery system is required to achieve mission success. It is comprised of one 72 inch main parachute, one 24 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 PerfectFliteStratoLoggeraltimeters and two batteries (one to power the main altimeter and one as the power source for the redundant altimeter). 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. The wiring of the electronics bay will ensure that the main ejection charges will occur at apogee for the drogue and at 600 feet for the main parachute. The back-up redundant altimeter will ensure that there will be an ejection charge with a backup 2 seconds after apogee for the drogue and at 500 feet for the main. **We will be using 3.0 grams of black powder for the ejection charge on the front half of the rocket. In the back half we will only be using 2.5 grams. We have lowered this amount from CDR after we realized that the power was too much for the rocket to handle as the payload was forced further into the rocket, making for the payload to become stuck and not slip out of the rocket.** We used the website Info-central.org to do the calculation for the mass of the black powder. We also did our own calculation using the equation C*D*D*L=Mass of black powder.The “C” in the equation is a given based on psi. The calculation gave us a mass of 3.5 grams of black powder but after ground testing we opted to use less. 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.



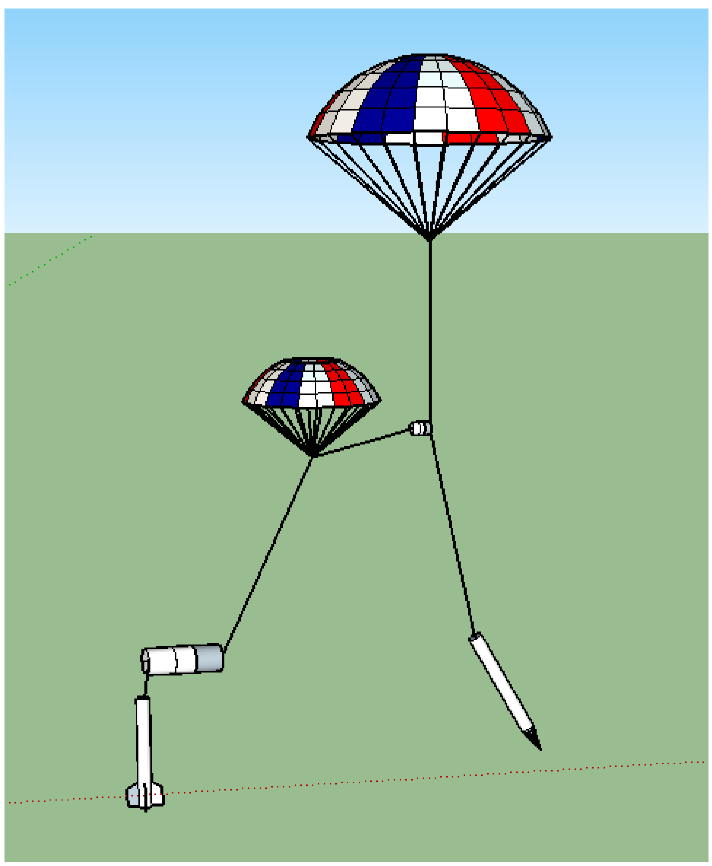
The 72 inch main parachute deployed at 700 feet is design to bring the rocket down to the ground the rest of the way under a safe velocity. This parachute is capable of delivering the rocket to the ground at a maximum of 17.1m/s which should be slow enough to prevent any damage to the rocket or anything that the rocket should land on.

Below is an example of one side of the sled in the electronics bay:



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 put onto the 1/2 inch thick bulkhead with a U-Bolt, 2 inches in front of the motor mount secured with a nut and epoxy. This is then attached to the bottom side of the payload as a precautionary measure in case that the bolts holding the payload in place fail. Another piece of shock cord will then be attached to the top side of the payload via a quick link and loop in the shock cord and then be firmly attached to the 24 inch drogue parachute in the bottom half of the rocket. Another shock cord will be attached to the drogue parachute and run to the bottom of the electronics bay. These six connection points will be deployed at apogee. The revised design of the rocket calls for the bottom half of the altimeter electronics bay to be fastened with no shear pins to the bottom body tube of the rocket. This allows for an easy opening of the drogue chute at apogee and no shear pins are needed because it opens as soon as it reaches a downward path of flight.

In the top tube of the rocket we will attach a shock cord to a 1 3/8" quick link which will then be attached to a U-Bolt that is fastened to a bulkhead in top portion of the rocket, directly underneath the nose cone of the rocket. At the other end of this connection the shock chord will be firmly fastened to the 72 inch main parachute. Another piece of shock cord will then run from the main parachute in the top half of the rocket to the top of the electronics bay. The top portion of the rocket will be secured using six shear pins to make sure that the top half does not deploy the main parachute before six hundred feet.



After all other final preparations have been made for the rocket launch and the altimeter connections have been checked for continuity, two rotary switches (one for each altimeter) will be turned on by turning a key inserted into an access hole located on the outside of the rocket. This will arm the altimeters so that they may deploy ejection charges.

The 24 inch drogue chute is robust enough to withstand at least 330 lbs. of force, as this is what has been tested by the company from which the parachutes are being purchased (Fruity Chutes). The swivel mounted to the 330 lb. test shroud lines is capable of withstanding 1000 lbs. of force. With the shock cord absorbing most of the force of ejection, these threshold parameters of the drogue parachute components will be large enough to withstand ejection and descent. The main chute that we will be using for the recovery system is a 72 inch Iris Ultra Parachute. The shroud lines on the parachute are capable of withstanding 400 lbs. of force. The swivel attached to the shroud lines is rated for 1500 lbs. making the main chute strong enough to withstand its ejection and descent. For a shock cord, we’re using 4200 lb. test, 1” wide tubular nylon shock cording. Therefore, the shock cord will be robust enough to absorb the energy encountered during ejection and descent. The shock cord will be attached to U-Bolts secured into bulkheads in the bottom and top half of the rocket and also to U-Bolts secured to the bottom and top of the electronics bay. These U-Bolts are made from forged carbon steel, that have been welded closed. These U-Bolts 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.

In the event that our rocket drifts out of our line of site we will be using a tracker attached to the inside of the electronics bay. The frequency of the tracker is set at 245 hertz. The Tracker we are using is has a tested range of 2.43 miles and three different distance settings, long range, medium range and short range.

The recovery system is not very sensitive to transmitting devices that would create an electromagnetic field. The only electronics in the electronics bay are the two altimeters. They are not sensitive to the field for they use a pressure difference when detecting things such as apogee and height for drogue shoot deployment.

Safety/Failure Risk	Cause	Effect	Risk Mitigation
Parachute does not deploy	Ejection charge not fired, parachute not properly packed	Rocket will come down too fast, mild to serious damage to rocket	Follow proper folding and packing techniques and ensure altimeters work properly
Rocket not fully separated	Ejection charges not lit, not powerful enough	Rocket will come down too fast, mild to serious damage to rocket	Test black power charges before launches, test for continuity in altimeters to ensure charges will be set off
Ejections charges do not fire	Current not sent through ematches	Parachutes do not deploy, rocket does not separate, minor to serve damage to rocket	Test for continuity in the altimeters before filling charges, test the altimeters with the packaged computer program
Wires in electronics bay break	Too much use, bending wire in unnatural directions	Wires must be replaced and time is lost	Use stranded wire, keep wires tidy
Rocket over pressurized by the ejection charges	Both ejection charges set off at the same time, too much black powder	Serious airframe damage, damage to electronics bay and recovery aspects	Stagger the fire height of the redundant charges, test black powder charges before hand

Mission Performance Predictions

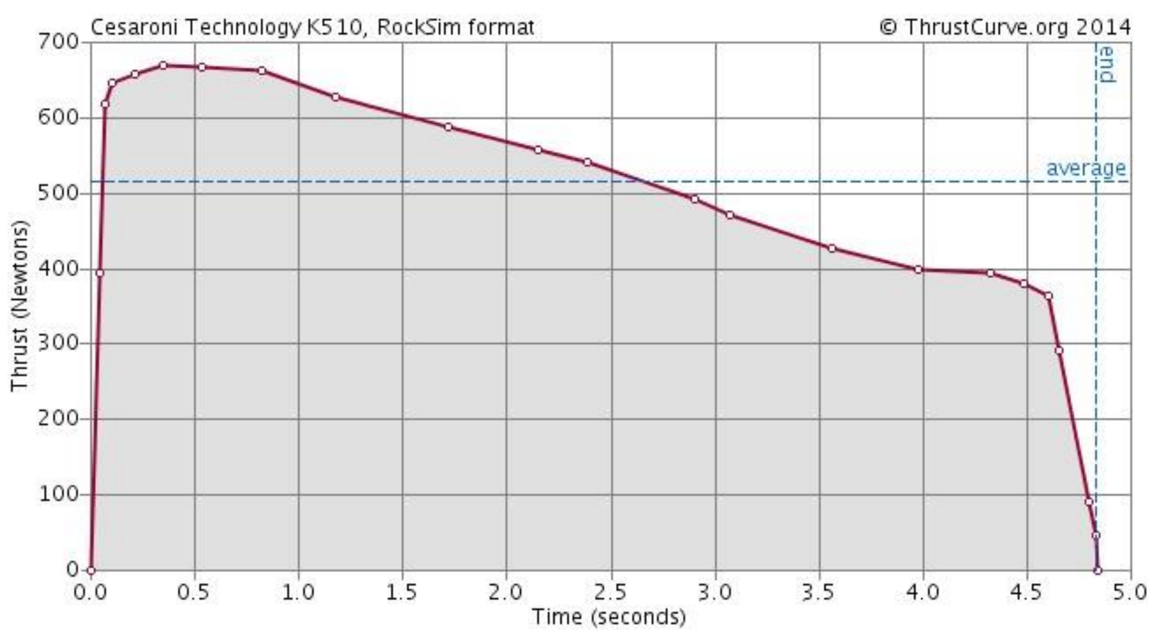
Section 1: Mission Performance Criteria

Our goal is to build and test a rocket that will achieve an altitude of one mile, eject a scientific payload, and return safely to the ground. In order to do this, we must first create a stable and reasonable rocket design on a simulation program such as Rocksim. Then during flight, we hope the rocket takes a straight and stable flight along with the proper ejection charges and parachute deployments, allowing it to land safely and nearby. This will be accomplished by using computer software to program an altimeter to eject the bottom half of the rocket containing the payload at apogee and the top half of the rocket deploying the main parachute at 600 feet. To ensure safety and to maintain a reliable ejection system, there will be a second altimeter programmed to eject at the same flight events, except with a slight delay.

Rocket Analysis:

Currently our 114.5 inch rocket is projected to reach a height of 5,441 feet. This value is a value based off of acceleration and rail exit velocity that is calculated from the computer data program Rocksim. This value is slightly over the value of 5,280 feet because Rocksim overshoots all height results around 10 percent because of drag and other characteristics. With this in mind, the height of the rocket is meant to be 4,859 feet.

When the rocket leaves the pad, it will stay on its flight path upwards for around 19 seconds, then at apogee the 24 inch drogue parachute will deploy and then the main parachute at 600 feet. Taking this into consideration, the rocket is expected to be in the air for roughly 100 seconds based off of descent velocity values and other drag calculations. This was then computed and found to have the following values of drift from the launch pad in 0 to 20 miles per hour winds.

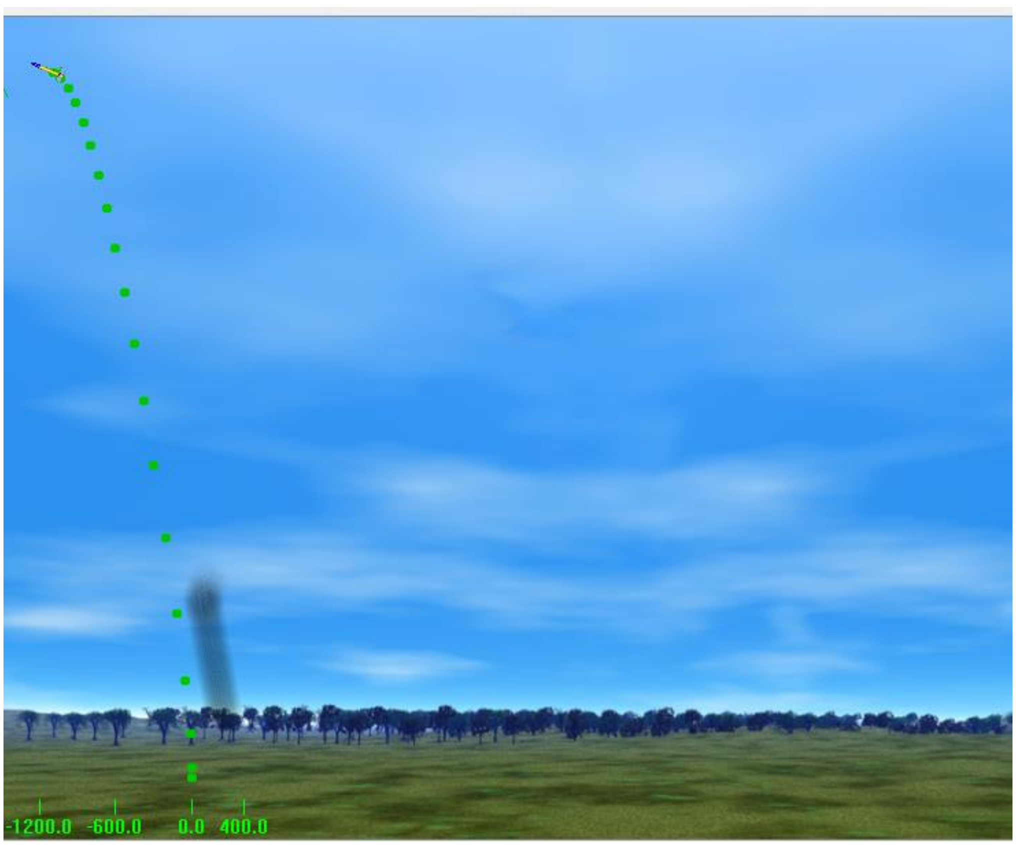


71	[K510-Classic-None]	5481.63	597.64	645.25	19.27	4.55	5481.64
72	[K510-Classic-None]	5458.07	597.56	[illegible]	[illegible]	30.40	5458.08
73	[K510-Classic-None]	5441.08	597.51	645.86	19.19	39.71	5441.09
74	[K510-Classic-None]	5228.15	597.06	645.86	18.80	98.06	5228.15
75	[K510-Classic-None]	5172.15	596.96	625.23	18.70	108.08	5172.15

Simulation summary results.

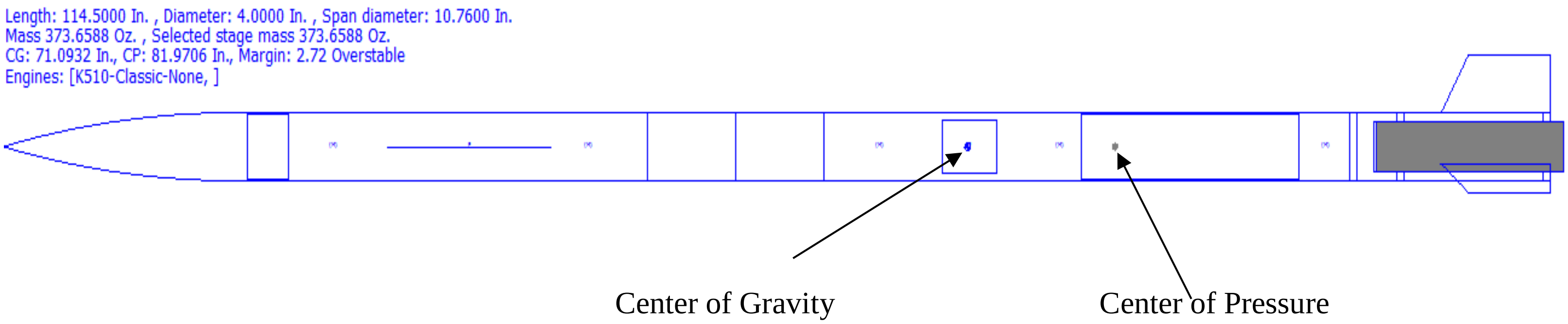
Motor: Cesaroni K510 Classic, 2486 Ns of Impulse When solving for the theoretical impulse needed to launch this rocket to an altitude of 5280 ft, the impulse calculated is 1,900 Ns, as the rocket weighs 23.35 pounds. This is assuming a frictionless environment. The impulse of the K510 Classic motor is 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.
The drag of this rocket is near 1.2 verified by calculations, so multiplying that by the 1900 N/S gives us a Newton second impulse range for the actual motor launched to be between 2,020 N/S and 2,480 N/S. Our motor currently falls on the far edge of that range.

In subscale testing, the rocket achieved a height of 2,075 feet and the rocket was very stable and maintained a nice straight path on flight. The rocket with its' dual deployment payload deployed the payload and drogue chute at apogee correctly and the main at 600 feet. The payload had one altimeter in it to make sure that data could be recorded. That altimeter read 2,071 feet and functioned correctly allowing us with confidence building the full-scale rocket. **Compared to subscale, the rocket did the same things as the subscale and worked correctly the entire launch. The subscale provided a very good comparison to the full scale and allowed us to get a baseline before full scale testing.**



Section 4

- Stability Margin : 2.72
- Center of Gravity (CG): 71.09 in. from nose cone
- Center of Pressure (CP) 81.97 in. from nose cone



Section 5

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.

Wind Speed Calculations

With the rocket falling from a projected height of 4,859 feet after new test results and masses, the rocket shall reach wind drifts recorded below with the drogue and main parachute, with the main parachute coming out at 600 feet.

Wind Speed (mph)	Wind Speed (Ft/s)	Time in Air (s)	Time to Landing From Apogee (s)	Descent Velocity Main (ft/s)	Total Drift (ft)
0	0	101.6	82.6	16.8	0
5	7	101.6	82.6	16.8	508
10	15	101.6	82.6	16.8	1,016.00
15	22	101.6	82.6	16.8	1,524.00
20	29	101.6	82.6	16.8	2,032.00

Verification of Vehicle

Our goal is to build and test a rocket that will achieve an altitude of one mile, eject a scientific payload, gain meaningful data and return safely to the ground with no malfunctions. In order to do this, we must first create a stable and reasonable rocket design on a simulation program such as Rocksim. Our scientific payload will be equipped with 9 stratologger altimeters that will be put in three separate airtight compartments and will test the effect of the hole diameter on the altitude reading that is recorded. This will deploy with the drogue parachute. This will be done with a black powder charge that is controlled by a redundant altimeter. At 600 feet, the main parachute will be ejected from the rocket, allowing it to land safely and nearby. This will be accomplished by using computer software to program an altimeter to eject the bottom half of the rocket containing the payload at apogee and the top half of the rocket deploying the main parachute at 600 feet. To ensure safety and to maintain a reliable ejection system, there will be a second altimeter programmed to eject at the same flight events, except with a slight delay. All safety guidelines, rules and the directions of our club supervisor, captains, and range masters will be complied with and respected.

Our rockets have met all safety regulations and satisfied all pre-flight checklists made. The rocket has integrated its payload and made it work safely and accurately. The rocket reaches a height close to one mile, but not over it, and all work papers have been completed to their maximum points and made sure that everything is covered/

This satisfies all statements in the SOW and proves that are rocket is capable of flying in Huntsville in April.

Safety and Environment (Vehicle)

Failure Modes	Probability of Risk *(1-5)	Mitigations
The rocket parachute does not deploy and rocket returns unsafely to the ground.	2	The team will carefully insert the parachute and fold it properly. We will make sure there is enough heat shield and shock cord protector to prevent any chance of an injection charge putting holes in the parachutes
Unforeseen payload design complications	3	The team will double -check that the components of the payload are properly wired and attached.
Premature Detonation of Black Powder Charges	3	The ebay workers will check that the charges are set for the correct time and do injection testing to make sure the charges will go off.
Pieces of the rocket falling off of the rocket during launch	2	Check all aspects of the rocket before launch and delay launch if repairs are needed.
Rocket drifts too far and cannot be found	1	Team will make sure the tracker is properly placed and is working so the rocket will be recovered
Motor Failure	1	Mentor will follow all instructions in building motor. Team will check and make sure the motor mount and casing is properly in place

Personnel hazards

Personnel hazards will be minimal after the FRR is completed, however the team will account for all hazards we are faced with. Possible hazards include transportation of materials and tools from vehicles to launch sites. The team will always be cautious when carrying any kind of tool or piece of the rocket. Hazards that exist at the launch site include the use of any tools required for preparation of rocket. The team will follow safety protocol on all tools while at the launch site.

Materials that are hazardous to personal using include the power tools in our wood lab and epoxy. Included in this section are material safety data sheets for the Z-Poxy hardener and resin. There are also the safety procedures for all of the power tools. We do plan on having the rocket painted by a professional so we will not have to deal with the painting of the rocket.

Updated MSDS

West Systems Hardener-http://www.westsystem.com/ss/assets/MSDS/MSDS205.pdf

West Systems Resin-http://www.westsystem.com/ss/assets/MSDS/MSDS105.pdf

Operator's Safety Protocol in the Wood Lab

Framar Band Saw

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

Router

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

Delta Radial Arm Saw

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

Planer-Surface Sander

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

Dewalt Compound Miter Saw

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

Jointer

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

Hand Sanders

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

Electric Drills

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

Powermatic Drill Press

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

CNC Router

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

Oliver Table Saw

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

Powermatic Belt Sander

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

Powermatic Disc Sander

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

Powermatic Drum Sander

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

Craftsman Reciprocating Saw

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

Craftsman Circular Saw

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

CNC Lathe (EMCO Concept Mill 55, Lab Volt 5400 CNC Mill, a Lab volt Automation 5500-B0)

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

Victor metal lathes

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

Miller Spot Welder

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

Baldor grinder/buffers

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

Tennsmith Sheet metal cutter

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

Gravograph LS100 30 watt laser/engraver/cutter

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

Maker Bot Replicator 2-

The 3D printer we will be using to make the payload and fin brackets has dimensions of 11.2in wide, 6in deep, 6in tall. For safety using the 3D printer, it is placed in a ventilated area so no toxic fumes are given off from the plastic. There is a heat guard on the printer so students can not touch the hot end of the plastic.

Operation Hazards for Above Equipment

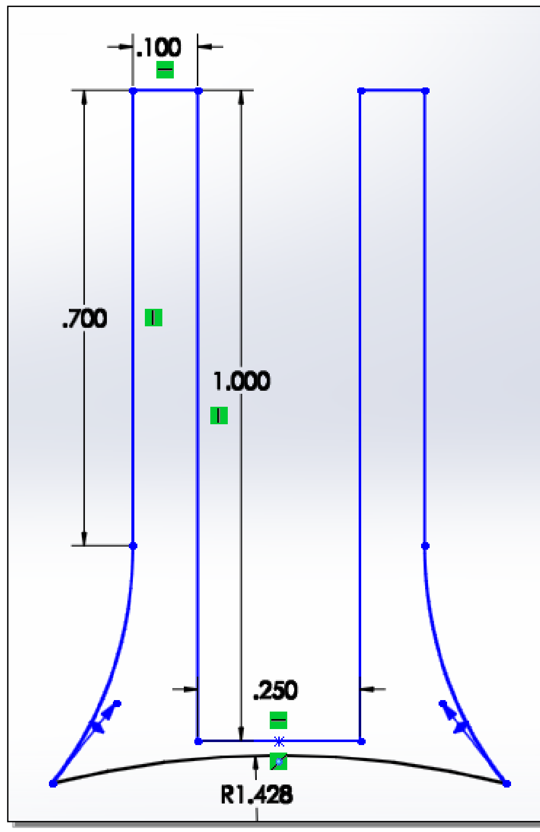
Hazards that could occur include but are not limited to hair or clothing being caught in machinery or tools which could result in major injury of the user. Limbs may be cut partially or completely off if the user becomes distracted or does not know how to use the machine correctly. Misuse of tools and machine could result in bodily damage to the user or other team mates. Abrasions while using tools or machinery may take place and cause minor to severe bodily damage. The supervisor will mitigate the chances of these hazards arising by having the students sit in on safety briefings that will cover how to operate all tools and machinery. We will also identify as many hazards as possible and mitigations. A briefing on proper use and safety procedures while operating tools and machines will also take place.

- Environmental concerns include the temperature being very cold, thunderstorms, and high wind. If the temperature becomes very cold certain parts of the rocket may condense or shrink so it will be hard to fit all rocket parts inside the airframe properly. Thunderstorms prevent dangerous fly conditions and this may delay the launching of our rocket. High wind could cause unnecessary damage to the airframe as it flies through the air. Also the high wind speeds could cause a delay in launching if it is unsafe for the drift of our rocket.

AGSE-(Payload)

This experiment is the first of its kind, as far as we are aware. Perfectflite, the manufacturer of our Stratologger CF altimeters, gives an equation to determine the optimal single port hole size and also the four port hole size. We were curious as to the accuracy of this equation, and also how a different hole size can affect the actual readings of these altimeters.

The outcome of this experiment will affect every rocket we make afterwards, since every rocket must use holes in the body for the altimeter to gather the height at apogee. Thus, the outcome of this experiment can be applied in future experiments, and pertains to every rocket.



The payload will determine the effect of the size of a single port hole on a Stratologger CF altimeter. Each altimeter will be completely sealed in its four inch section except for a single hole, which it can take measurements through. We expect the altimeters to take data throughout the entire flight, taking similar measurements as the electronics bay altimeters. Each section will house three altimeters, and these three altimeters will take measurements through the same hole. Three sections allow for testing of various hole sizes, so a smaller and larger hole will be used. The Stratologger user manual provides an equation for finding optimal single port hole size. This suggested size will be used as the control, and a slightly larger and smaller hole will be used for the other two sections. The altimeters in identical sections are expected to yield nearly identical results, since no variables are different for these altimeters. Any variance in measurements of altimeters in the same section are due to the manufacturing of the altimeter, which we will take into account while comparing measurements taken between the three sections.

This experiment will determine the precision of these altimeters, because each section's altimeters will be operating under identical circumstances. With this data, we can find the typical variance of these altimeters. Also, we will determine the effect of various port hole sizes on the measurements taken by the altimeters, potentially allowing the relationship to formulated by an equation. This experiment is very repeatable, so that we can take as many data points as possible. This experiment is important to our team because all of our team members participate in Team America Rocketry Challenge, where an variance of a few feet in an altimeter reading can mean the difference between winning or losing. At the beginning of this project, we were all curious how the measurements taken by altimeters can vary upon identical flights.

The first variable, which is our controllable variable, is the size of the single port hole. Other factors which could affect the ideal size of the port hole are constant, such as bay length and bay diameter. The actual height of the rocket at apogee will vary with different launches, but this will not affect our experiment, because the variance between the altimeters is what is being tested, not the difference in height between launches.

***Below is a summary of the specifications for the PLA plastic that is used for the fin bracket and payload parts.*

Mechanical	**Nominal Value Unit**	**Test Method**
Tensile Modulus		
73°F	293000 to 514000 psi	ASTM D638
73°F	45000 to 815000 psi	ISO 527-2
Tensile Strength		
Yield, 73°F	8840 to 9500 psi	ASTM D638
Yield, 73°F	2250 to 10400 psi	ISO 527-2
Break, 73°F	7080 to 8150 psi	ASTM D638
Break, 73°F	2000 to 10200 psi	ISO 527-2
73°F	6930 to 10000 psi	ASTM D638
Tensile Elongation		
Yield, 73°F	9.8 to 10 %	ASTM D638
Yield, 73°F	1.0 to 8.5 %	ISO 527-2
Break, 73°F	0.50 to 9.2 %	ASTM D638
Break, 73°F	1.0 to 12 %	ISO 527-2
Flexural Modulus		
73°F	347000 to 715000 psi	ASTM D790
73°F	44200 to 1.38E+6 psi	ISO 178
Flexural Strength		
73°F	6950 to 16000 psi	ASTM D790
73°F	1310 to 16100 psi	ISO 178
Impact	**Nominal Value Unit**	**Test Method**
Charpy Notched Impact Strength (73°F)	0.67 to 2.6 ft·lb/in²	ISO 179
Charpy Unnotched Impact Strength (73°F)	4.0 to 11 ft·lb/in²	ISO 179
Notched Izod Impact		

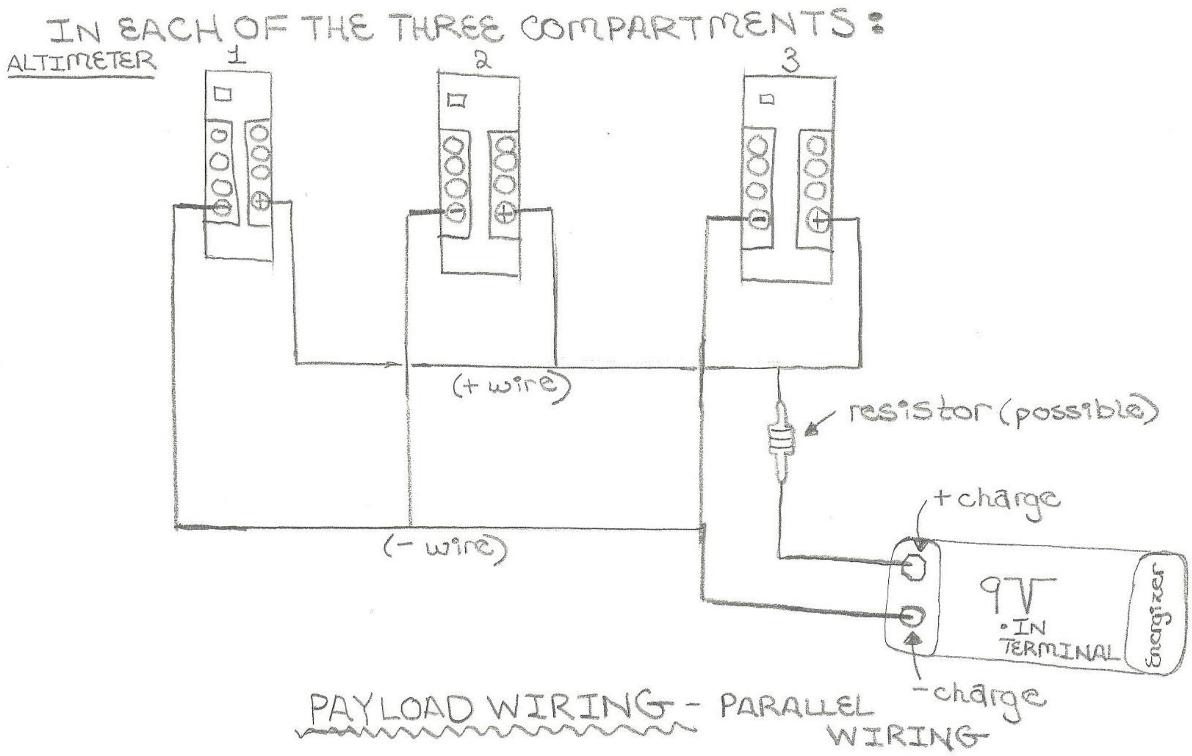
The setup of the payload before a launch will be simple. Each of the nine altimeters must simply be turned on by adding the 9V battery, and they will take data throughout the entire launch. After testing, we have determined that the batteries last slightly over an hour while providing power to each of the altimeters, which is a sufficient amount of time to launch the rocket. Using a computer program, each altimeter will be individually examined, and a graph of height vs. time will be collected for each altimeter. The height at apogee read by each altimeter will be used to find the variance caused by port size.

The payload is comprised of three sections, with a 1/2" bulkhead separating each section. The bulkheads are 3D printed, and the walls which the altimeters are mounted on is printed with the bulkhead as one solid piece. This prevents these walls from breaking during the flight. Both end bulkheads are printed at 100 percent fill, so they are even stronger to prevent the U-bolts from ripping through the plastic. A 1/2" carriage bolt will go through the outside of the main body tube and through the U-bolts on each end to prevent the payload from moving in any way.

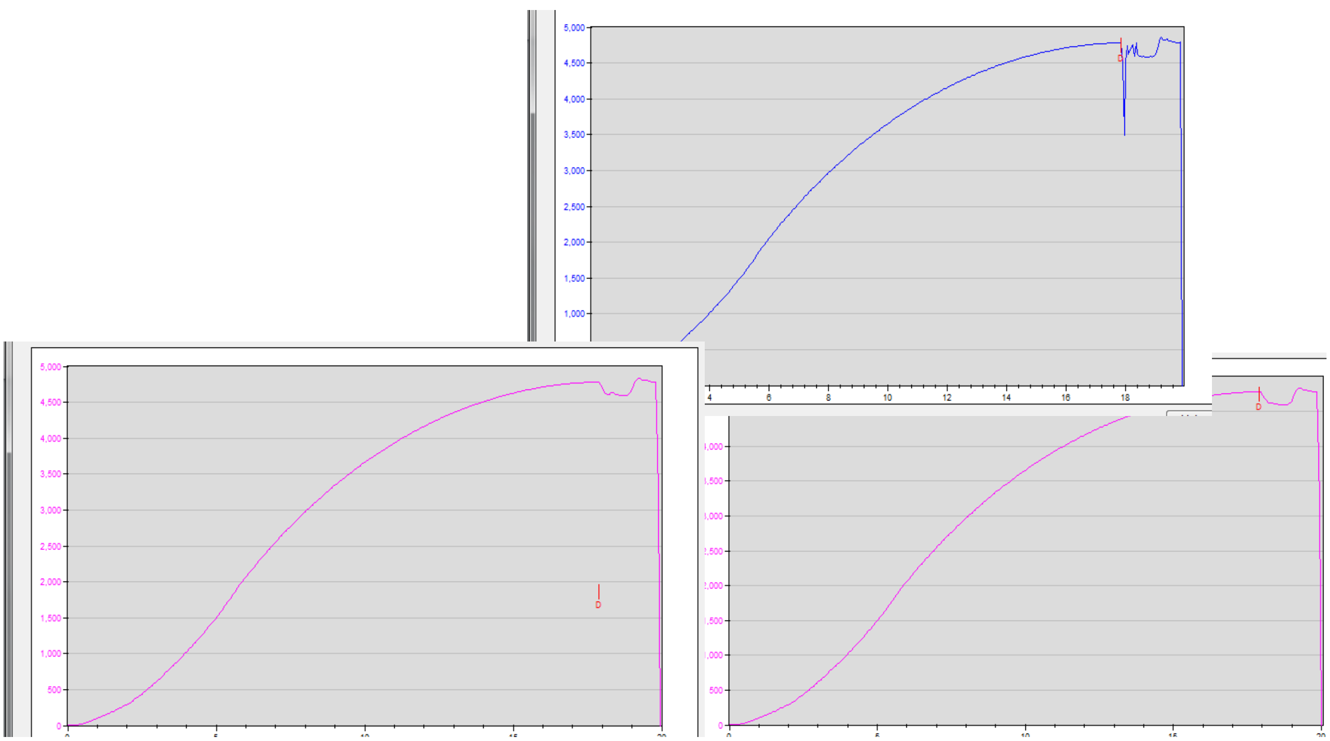
The payload will no longer eject, and it will take measurements directly through the exterior body tube. Large holes will be placed on the main body tube directly over the port holes of the coupler tube which the altimeters are housed in. These holes will be larger to ensure that they do not obstruct the port holes on the coupler tubes underneath. This will account for any rotation of the payload which could occur during the flight. The bolts and the all thread will prevent the payload from rotating, but it could still shift a few degrees in each direction. The bottom U-bolt will attach to the bulkhead directly above the motor mount with only about a foot of shock cord. This is because the payload will not eject during either the drogue or main parachute deployment. The top U-bolt will attach to the drogue parachute, which will be attached to the electronics bay through a series of quick links.

- Each section of the payload will house three altimeters and one 9V battery. The 9V battery will be placed in a terminal. The terminal will be bolted to the bulkhead. The 9V will be taped to the terminal to ensure it does not slip out during the launch, causing power to be lost to the entire section. The terminal will be wired in parallel to each of the three altimeters. Every connection will be soldered and heat shrink will be placed over these connections to ensure that the wiring withstands the force of the launch.
- The payload must carry three independent sections, each containing three Stratologger CF altimeters. The payload will deploy at apogee, and height readings will be collected. The compartments will be completely sealed except for the ports, so that data is based purely off of the size of the ports. The connection between the altimeters and the 9V battery must be strong enough that the force of the launch does not disconnect any wires. To prevent this we will use soldering and terminals to make the connection points as strong as possible. If we can collect data from each altimeter during the launch, the payload will be deemed successful.

  ***Below is a accurate diagram displaying the wiring that will be used for the payload system. This wiring will be done by the lead of the electronics bay to ensure that all wiring is correct and that the altimeters will function correctly. The altimeters will be wired in parallel as shown below. They were tested and the battery lasted for 1 hour and 34 minutes. This time should be sufficient to be able to get a launch off and record data.*
  **The resistor in the drawing below was found to not be needed in ground and flight tests.*



<u>Data from Payload</u>



The payload received data from all three sections and resulted in heights in each section of.....

5/64 Average (4781.6)

- 4787
- 4779
- 4779

3/32 Average (4780)

- 4779
- 4780
- 4781

7/64 Average(4779.5)

- 4783
- 4775
- 4781

The preliminary data shows no real correlation between hole size and altitude. Since the payload was still in the back half of the rocket for this flight, the data may be unreliable however. Modifications to the design have been made to prevent this error from occurring during future launches.

Safety Of Payload

Part A

A	B	C
Payload Requirement	***Satisfied***	***Verified***
The launch vehicle shall carry a science or engineering payload. The payload may be of the team's discretion, but shall be approved by NASA. NASA reserves the authority to require a team to modify or change a payload, as deemed necessary by the Review Panel, even after a proposal has been awarded.	The science payload will determine the effect of single port hole size on the measurements taken by multiple Perfectflite CF altimeters. The payload will take data from within the back half of the rocket throughout the entire duration of the flight. Data can be recorded for each altimeter through the use of computer software.	The payload has been accepted by NASA and no major changes to the experiment have been made. The payload has been built and test flown during a full scale flight.
Data from the science or engineering payload shall be collected, analyzed, and reported by the team following the scientific method.	Data will be collected by nine Perfectflite CF altimeters for each launch. The altimeters can store data for up to fifteen flights. After every flight the data will be saved onto a computer, where it can be compared and	The payload has flown in the full scale rocket once, and data was taken by eight of the nine altimeters. The data will be analyzed, and will also be kept to compare with future flights.
Unmanned aerial vehicle (UAV) payloads of any type shall be tethered to the vehicle with a remotely controlled release mechanism until the RSO has given the authority to release the UAV.	N/A	N/A
Any payload element that is jettisoned during the recovery phase, or after the launch vehicle lands, shall receive real-time RSO permission prior to initiating the jettison event.	N/A	N/A
The payload shall be designed to be recoverable and reusable. Reusable is defined as being able to be launched again on the same day without repairs or modifications.	The payload is designed to be both reusable and recoverable. All parts of the payload, barring any damages to the electronics, can be used repeatedly. To prepare the payload for another launch, each of the three 9V batteries must be replaced.	The payload was involved in one full scale flight, and all pieces remained intact and reusable. No complications arose, and the payload encountered no issues except for the malfunctioning of one of the nine altimeters.

<u>Part B</u>

Failure Mode	Cause and Effect	Mitigation	Likelihood
The 3D printed pieces fail to withstand the force of the launch.	If the 3D printed sections were to fail, the altimeters and electronics could become damaged. Because one payload, which consists of nine altimeters, is expensive, such an event could cause a major loss of money.	The 3D printed bulkheads were designed to be able to withstand the force of a launch. The pieces are 1/2” thick, and the pieces on either end are printed with 100% fill. This protects the payload's electronics from any outside object or any type of collision. All electronics are fastened to the 3D printed piece, so they will not move in any way during the launch.	Low
The 3D pieces cannot hold the U-bolts during the course of the launch.	The U-bolts could shear through the 3D piece, causing the rocket's two halves to separate compete completely. The back half, with encompasses the bottom body tube, motor casing, and fin bracket, would free-fall to the ground, most likely resulting in the loss of all parts.	The 3D printed pieces that hold U-bolts are printed with 100% fill, making them as strong, if not stronger, than a traditional wooden bulkhead. This piece will be sufficient in preventing the U-bolt from detaching with the payload.	Low
The payload twists during the launch, obstructing the port holes.	If the port holes are partially or completely blocked, the data gathered the altimeters will be inaccurate and the data should be discarded..	Carriage bolts will be placed through both of the U-bolts on either end of the payload, prevented any rotation or twisting.	Low

Possible Injuries to Payload Workers

• Lacerations while cutting with modeling knives and other sharp instruments.	Team members will alert their peers and mentors when they are operating sharp objects, so that others can be cautious while moving around the team member while he or she is cutting. Proper cutting techniques will be used, mitigating the possibility of an accidental laceration.
• Abrasions caused by a belt sander or other sanding equipment.	Team members will be cautious while operating sanding equipment. The member should be constantly aware of his or her fingers and should ensure that they do not touch the belt.

Launch Operations Procedure

- Recovery preparation
  - Drogue Parachute and Main Parachute folded properly using z-fold technique following the fruity chute guidelines.
  - Fireproofing cut to right size for the protection of parachutes from injection charges.
  - Electronics Bay Preparation
    - Batteries are secured tightly into the battery holders. Electric Tape around the battery for extra security
    - Use screw driver to check each wire connection to the actual altimeter and the terminal strip.
    - Turn on each key switch and make sure the correct beeps come from each altimeter.
    - Use USB Data transfer kit to check the deployment of parachutes are at the proper heights for drogue parachute at apogee and main parachute at 600 feet.
    - Use E-Matches to test fire injection charges of each altimeter to make sure wiring was down properly
    - Place tracker on electronics bay sled and make sure it is tightly secured to sled
    - Oversee the mentor using the proper amount of black powder in each well, and make sure mentor places wadding in the injection wells with electrical tape overtop of wells
    - Tighten nuts on all-thread
- Motor preparation
  - The motor is being built by our Level III NAR representative, Robert DeHate. He will assemble the motor with caution. He will follow all instructions so that the motor is built and will perform properly.
- Setup on launcher
  - The rocket will be set up on the launch pad and we will make sure the launch lugs are smooth moving up the rail. The keys in the electronics bay will be turned and removed. We will listen to make sure beeps are correct and altimeters are functioning properly.
- Igniter installation

    - We will be using the igniter provided with the Cesaroni Motor. It will be inserted into the motor so that it can ignite the motor causing the rocket to lift off.
- Launch Procedure(Pre-Flight Checklist of all parts)
    - Payload Procedure
        - Place batteries in holder and make sure they are secure in place
        - Test Altimeters in each section and make sure each wire is properly attached to the altimeters.
        - Make sure payload is completely sealed and airtight with proper experimental hole in each section of payload
        - When placing payload into rocket, make sure it is placed inside the airframe in the proper direction
        - Place bolts into airframe on each side of payload to make sure the payload cannot move
        - Tighten nuts on each side of bolt to secure them in place
    - Follow instructions on Recovery Preparation for electronics bay and parachutes.
    - Parachutes are in proper position in rocket
    - Observe building of motor by NAR mentor
    - Connect body tubes together with electronic bay
    - Place 6 shear pins into electronics bay 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 properly in motor
- Troubleshooting
    - If problems occur on the launch pad then our safety officer will wait the necessary time before approaching the rocket. He will check the fuse and the clips to check for any problems. If the altimeters do not set off the first ejection charges on the first altimeter, there was an internal electronic error and hopefully the redundant altimeter will set off the second ejection charges deploying the chutes properly.
- Post-flight inspection
    - Verify rocket is not hazardous to retrieve
    - Verify all injection charges have went off
    - Inspect all parts are in right place and where they should be
    - Check shock cord is still on both sides of electronics bay and has not been compromised

- Parachutes are still attached
- Carry Rocket carefully back to home base
- Use USB Data transfer kit to get altimeter readings from electronics bay and each altimeter in each separate section of payload

Safety and Quality Assurance

Failure Modes	Proposed/Completed Mitigations
The rocket motor does not function properly.	Our NAR Representative has loaded and tested Cesaroni motors before; therefore, he has experience with the type of motor that we are using. This will prevent catastrophic failure of motor.
The parachute fails to deploy and causes the rocket to fall unsafely to the ground.	We have completed static ground tests of injection charges and know how much black powder is needed for a successful injection. Also the parachutes will be folded properly since we have researched proper folding techniques so the parachutes will not get lodged inside the rocket.
Electrical Current within the payload fails as a result of wires becoming detached.	Our co-captain in charge of the payload design will make sure all wires are connected properly and soldered together using proper techniques. We will check all wiring prior to launch
Electric Current within payload fails as a result of batteries falling out of terminals	We will make sure batteries are secured properly and the payload is place inside the rocket facing the right direction so that the forces on the air frame will not cause the batteries to fall out.

Environmental Concerns

All members of the team understand the consequences of improper use of materials and the damage it could have on the environment. We believe that we will have a minimal effect on wildlife or on the ecosystem. The smoke from the motor ignition, will be absorbed by the atmosphere and not harm the wildlife. If the rocket ends up in a tree it will not affect the entire tree or damage the tree. We will be careful when using West system Epoxy and Hardener and Industrial batteries as they could harm the environment if not used properly. We will use caution when around black powder and the Ammonium Perchlorate propellant.

Project Plan

Part 1: Budget Plan

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	$0.00 because we already have 2 from 2012 project
Classical Elliptical 24" 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
Steel U-Bolts Packages (3/4" Width; 5 each)	McMaster Carr	$5.48	3	$16.44
Quick Links (3/16")	McMaster Carr	$3.75	20	$75.00
			Total	$2,852.03

Full Scale Transportation	$2,412.00
Full Scale	$2,852.03
Sub-Scale Transportation	$1,206.00
Sub-Scale	$250.00
Lodging	$4,270.70
Food	$2,544.00
Transportation	$6,000.00
Total	$19,158.73

Part 2: Funding Plan

As of March 5th, 2015 we have obtained all funding necessary to reach Huntsville, Alabama in April. Through many grant applications and generous donations we have reached our goal. Near the conclusion of our project, we have found funding from TE Connectivity (4800), The Spring Grove Educational Fund (5000), Aquaphoenix Scientific (2000), The Engineering Society of York (1000), Advanced Application and Design (500), McClaren Plastics (500), Penn Waste (250), and numerous other small sponsors and donators that have helped us achieve the ultimate goal and be able to reach Huntsville, Alabama

We also will be continuing fundraisers, many of which we have already begun to prepare for next year and try to not have as much money to raise as this year. 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.

We also sold Bonus Books from a local company around the area with a profit of $12.50 per book. That sale netted over 1000 dollars in profit for the club and helped chip away at the goal of 18,000 dollars total.

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 $1000 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. With all of these fundraisers, grants, and donations, we will be able to raise enough to pay for any extra buys for the 2015 SL project and to start and help with funding for the 2016 NASA SL program. Any funds left over will go towards next year's Spring Grove rocketry clubs.

Part 3: 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

17. Practice Flight in Maryland for the Sub-Scale Rocket

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.

28. Full Scale Launch in Price MD.

March 2015

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.

20. FRR video teleconferences

28-29. Full Scale Launch in Price, MD

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 held presentations for both 7th and 8th graders at our middle school to inform them of our project, the basics of a rocket, and how to get involved in them when they reach the high school. We introduced to them about creating a TARC team at the middle school, which was of popular interest when they were allowed to ask us questions at the end of the presentation. This presentation reached over 500 students at the middle school and we plan to involve even more students.

To obtain feedback, we gave small surveys to all the students who were involved in our presentations. These surveys asked how well the presentation was given, how interested the student is in joining a rocketry club, what the mission of the Student Launch Program is, and additional information. These are some of the interesting results we received. 74% of the student had absolutely no prior knowledge of rocketry and 90% of the students said they learned something. By the end 63% were even able to identify where the motor casing was on the rocket, which is very impressive for a presentation that was only around 25 minutes long. Students also received permission slips to attend a unique rocketry workshop at the high school. The experience was very positive and we had 18 students who signed up to participate in the rocketry workshop in result of the presentation.

We just recently held a rocketry workshop for students that heard the presentation and were interested in learning more about rocketry. ---- students attended and the outcome was very positive. This idea was created when we received kits of small rocket parts donated by our sponsor, AquaPhoenix, where upon, we wanted to hold a workshop for children to build these kits and 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 led a small group and guided the children through the basics of rocket-building. The groups then launched their small rockets, further spreading rocketry awareness and teaching the fundamentals of rocketry. Photos of the event can be found on our website and some here. Students who attended the workshop were then given the following survey at the conclusion of the event. Feedback will be useful for planning purposes and contacting interested students about TARC. After the event, participants were able to view TARC launches from current high school teams and some were even qualifying score attempts.

After the first workshop, we took a survey from the 6 students who attended and found out that:

- All 6 enjoyed the workshop
- 5 of 6 learned something new
- 6 of 6 understood the basics of building rockets by the time they left
- 6 of 6 are interested in joining TARC next year

NASA Student Launch

Rocketry Workshop Survey Choose Yes or No

1. Did you enjoy the workshop?

   Yes or No

2. Did you learn something new?

   Yes or No

3. Do you understand the basics of building a rocket?

   Yes or No

4. Would you be interested in joining TARC (Team America Rocketry Challenge) or the NASA Student Launch program?

   Yes or No

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. Of the 18 students who attended the workshop, 16 are currently seventh graders and next year they will be still in the middle school for eighth grade and can form the core group of students for one or two TARC teams. The eighth graders that signed up, as a ninth grader next year, will be able to join one of the 5 teams at the high school.

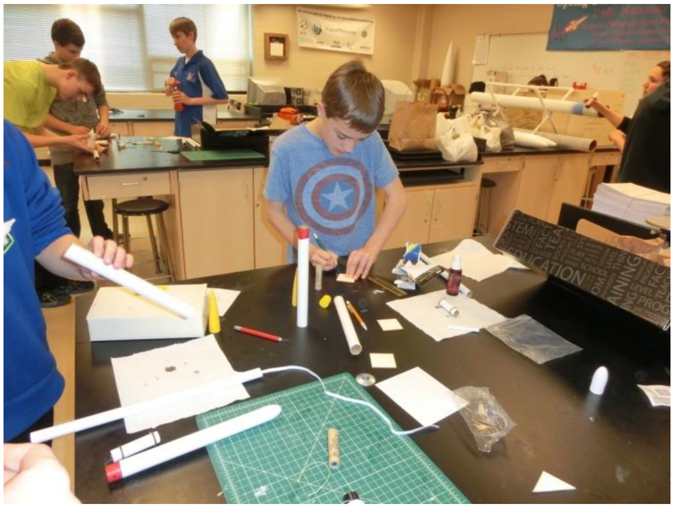
Some additional ideas are holding an assembly at Spring Grove's Elementary Schools, to invite any interested kids to a rocket awareness camp. During the assembly, we will teach them a rocket related poem and dance that will be performed at the rocket camp, if attended. We also will show them videos of 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.

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. To date, we have had two full news stories on our local NBC and CBS stations (links to the programs are on our website). We have recently been contacted by the assistant editor of the magazine Product and Design, and they intend to do a feature article about our team in one of their weekly newsletters about our work with the 3D printed parts of the rocket. They interviewed the mentor and the two team captains. 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) In December, we held an informational session at the high school inviting members of the press, and representatives from the state and federal governments. representatives and aides attended the event, where the team provided a roughly 15 minute long presentation about the project followed by a question and answer session. The event was very well received and we received many compliments from the attendees about the team's work, presentation, knowledge and thoroughness. Through these ways, we should be able to spread our word to a younger generation and bring STEM to the forefront in our local community.

Update-

- On Wednesday March 11, we were notified that Spring Grove's Student Launch Program was selected as an exemplary program by the Shippensburg University School Study Council. We will be honored on May 6th at a banquet showcasing our efforts and we are very proud to receive the prestigious award. We will also be able to set up a display at that time, where administration and representatives of nearly 100 school districts will be able to see what the Student Launch program is all about.

Rocket Building Workshop Pictures



The Conclusion of Spring Groves' 2015 FRR!!!!!!!