Spring Grove Area High School

SL Rocketry Team CDR 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.

Table of Contents

Team Members

Name: Brian Hastings

Position: Physics Instructor and Head Coach

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

Name: Renee Eaton

Position: Biology Teacher and Assistant Coach

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

Name: Wyatt

Age: 17

Grade: 12

Position: Team Co-Captain and Payload Leader

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

Name: Kyle

Age: 17

Grade: 12

Position: Team Co-Captain and Electronics Bay Leader

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

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

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

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

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

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

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

Name(s): Sarah 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 CDR 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 373.66 ounces.
- Motor Choice: Cesaroni K510 Classic Burning 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. (Both Iris Ultra Fruity Chutes)
- We will utilize a 10-10 Size, 8 foot long launch pad, with both launch lugs on the back half of the rocket for stability, more time on the pad, and easier loading onto the pad.
- Milestone Review Flysheet - separate document that is on the website

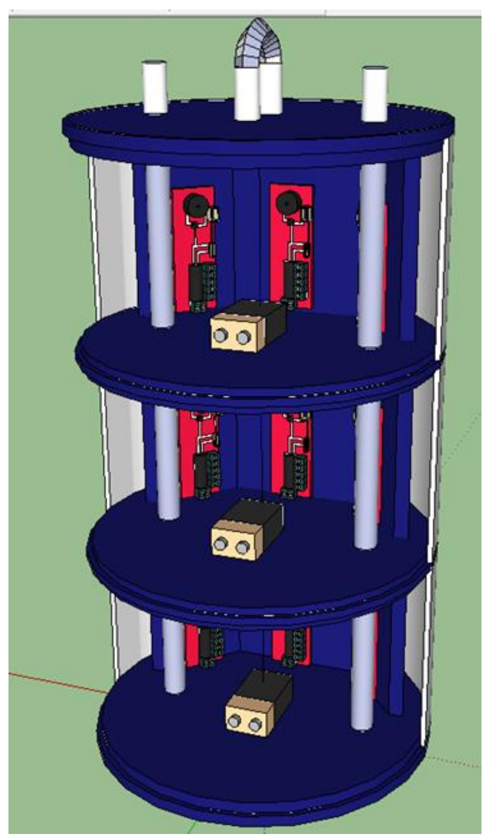
Part C) Payload

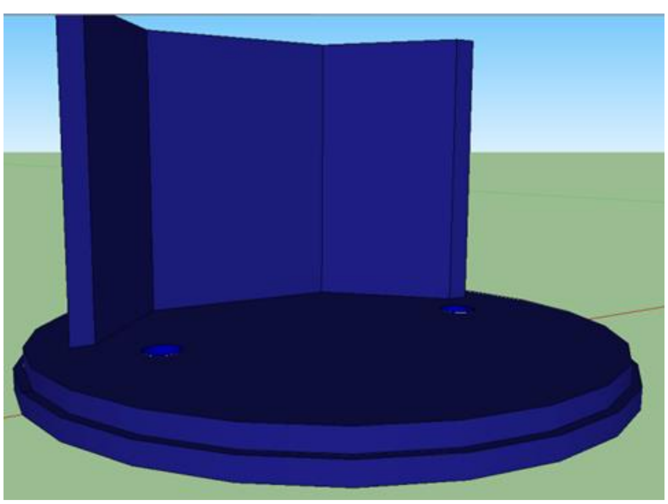
AGSE/Payload Title: Not needed because of being a middle/high school team

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 until it is ejected, at which point it will take data. The payload will have four half-inch bulkheads, which will be 3D printed with holes for the all thread precut. The bulkheads will have lips, so that the coupler tube will slide into the lips. The all thread will run through the entire payload, making the disassembly of the payload easier. The all thread will screw on both ends, tightening the fit and keeping all parts in place. This, along with the prefabrication of the lips, should create a sealed container for the altimeters to function correctly. The payload will be split into three separate sections, each of which will contain one 9 volt battery and three altimeters. These altimeters will be fastened onto “walls”, which are 3D printed onto the bulkheads. The altimeters in each section will be wired in parallel to one of three 9 volt batteries, one battery in each section. This arrangement will be ground tested to ensure that each altimeter receives the proper current from the battery. The 9 volt battery will be fastened to a bulkhead by a 3D printed “case”, which will secure it to the bulkhead while providing space for the altimeters to be wired to the battery.





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

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

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

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

II) Changes Made Since PDR

Changes made to Vehicle Criteria

To the main launch vehicle, there have been a few changes made to the design based off of data collected last month at the December MDRA launch in Maryland. First off, the main parachute has traded places with the drogue parachute as far as placement inside of the rocket. The main parachute will now be placed in the front half of the rocket, while the drogue parachute and payload will be placed in the back half of the rocket. These have been changed because after careful investigation, it was concluded that the main parachute would eject at apogee on certain occasions because the back half held too much weight with the motor and fins. The shear pins holding up the back half would then break because of the force that was put on them on the flight down. This meant that the electronics bay slid out of the back half of the rocket and the main parachute followed with the shock cord and eventually unfolded near apogee. If moved to the front half, the major decrease in weight should allow the shear pins to keep the electronics bay and front half together until deployment at 700 feet. This has been a past problem as two years ago our main parachute deployed at apogee for our launch in Huntsville for this same reason. Meanwhile, the drogue parachute and payload will be moved to the back half where the weight will not affect the deployment of both pieces because both are deployed at apogee. For this reason, our back half has also increased in length to accommodate the movement of these rocket parts. Along with the movement of these three pieces, the fin brackets have also changed in design from surface mounts to actually enclose the entire back surface of the body tube as will be shown later. All other vehicle components have not changed on the rocket. The only addition to the rocket is the addition of a surface mounted camera that will be attached to the side of the body tube by screwing the bottom case to the rocket. This will make sure that the camera is securely attached and nothing breaks off during launch. The aerodynamic case should allow for little to no difference in rocket stability and will be placed four body tube diameter lengths away from the fins so that stability and air flow will also not be compromised.

Changes made to Payload

There were no changes made to the payload as the systems have worked properly in pre-flight testing of component fit and function. No changes should need to be made until full-scale flight and payload testing is done in February.

Changes made to Project Plan

There was only one change made to the project plan from the PDR, which is a slight change to the planned timeline. On January 17th we now plan to launch the subscale rocket, and have a full-scale ejection charge test with no full-scale flight until February, and then another one in March. So far in our project we have raised nearly 11,000 dollars of our 18,000 budget with new sponsors helping us out including The Engineering Society of York and numerous others including personal donations for space on the rocket.

Preliminary Design Review Feedback Responses

1) The payload will consist of three altimeters and a battery in each independent section. The payload will be made up of these three sections. In each section, the battery will be placed inside a terminal where the wire will be sauntered to the terminal and wired in parallel to the three altimeters. Since no ejection charge is needed, the battery is only needed to supply a power supply, so wiring the three altimeters in a series with each altimeter connected should not be a problem.
2) Structural testing will be done in the near future. We plan on researching the tensile strength of the plastic and doing testing on the strength of the plastic.
3) In the electronics bay, there is two batteries, but each battery will be wired separately to the two altimeters in the electronics bay, not one. These two altimeters each need a power supply and will be independent of each other, one for the main charge and one for the redundant charges.

   In the payload, there is only one battery for the three altimeters in each independent section. The wiring was explained in question one as they will be wired in parallel.
4) No response needed
5) There will be three separate coupler tubes, one for each section of the payload. Each coupler section will be four and a half inches long.
6) We had the option of using either four holes or a single port based on equations given by Perfectflite. Based on our previous knowledge, we decided to go with one port hole because it is easier to measure, and we do not have to worry about evenly spacing the holes in alignment around the 3.9 inch coupler tube. This way, the variables will stay independent and we should keep the data consistent.
7) No response needed
8) No response needed
9) The heat from the motor was a major concern at the beginning of the project and we thought also that the heat could melt the plastic on the fin brackets. But after changes to the design and the fact that the fin brackets will now be on the outside of the body tube with air from the outside, the heat reaching the brackets should be minimal and no-where reach the maximum temperature to melt the plastic. The plastic is rated for far over the heat that will be transferred from the motor tube to the outside body-tube and then cooled by outside air.

III) Vehicle Criteria

Design and Verification of Launch Vehicle

Flight Reliability and Confidence

1) **Mission Statement, Requirements and Success Criteria:**

Our mission as a team is to effectively design, build, test, launch, and recover a rocket safely after reaching a height of 5,280 feet. We hope to do this while improving as a team both on our teamwork skills and on our own individual skills, while also educationally engaging students to get younger students involved in the STEM research fields.

The launch vehicle is designed to travel to an altitude of about 5280 feet, but cannot exceed this height. The rocket has three independent sections, which is less than the maximum of four independent sections as stated in the vehicle requirements section of the Statement of Work. The redundant recovery system will be capable of being set up within two hours of the time that the Federal Aviation Administration flight waiver opens. It will be able to remain in its launch-ready arrangement on the launch pad for at least one hour without it or any of its on-board components losing their capability to operate. The launch vehicle will be capable of being launched from either an 8 foot long 1 inch rail, or an 8 foot long 1.5 inch rail. The rocket will be able to be launched from a 12 volt DC firing system, which will be supplied by the Range Services Provider. It will not require any external circuitry or specialized equipment from the ground to initiate the launch, other than what will be provided by the range. The rocket will use an ammonium perchlorate composite propellant that is commercially available and has been approved by the National Association of Rocketry, Tripoli Rocketry Association, or the Canadian Association of Rocketry. The rocket and motor combination that we will use will not exceed an impulse of 2,560 Newton-seconds.

The mass of the ballast in the final design to be flown in Huntsville will not be more than 10% of the rocket mass without the ballast. A full-scale version of our rocket will be launched prior to the Flight Readiness Review in its final configuration. The full-scale version of the rocket will be identical to the design that was made prior to the launch, and is the same design that was approved by our safety officer. This flight should include the testing of the payload within the vehicle, but if not, mass simulators will be placed at the same approximate location of the payload. Either a full-scale motor or a motor that will closely simulate the predicted velocity and acceleration of the full-scale motor will be used during this flight as well. The vehicle at this launch will also be in its completely-ballasted arrangement as that of what will be flown down in Huntsville. This flight's success will also be documented on the flight certification form by a Level 2 or Level 3 flight observer and will also be recorded in the Flight Readiness Review. The components of the rocket launched during the full-scale flight will not be modified unless approved by the NASA RangeSafety Officer. Lastly, the rocket will not use forward canards, forward firing motors, motors that eject titanium sponges, hybrid motors, or a cluster of motors or multiple stages.

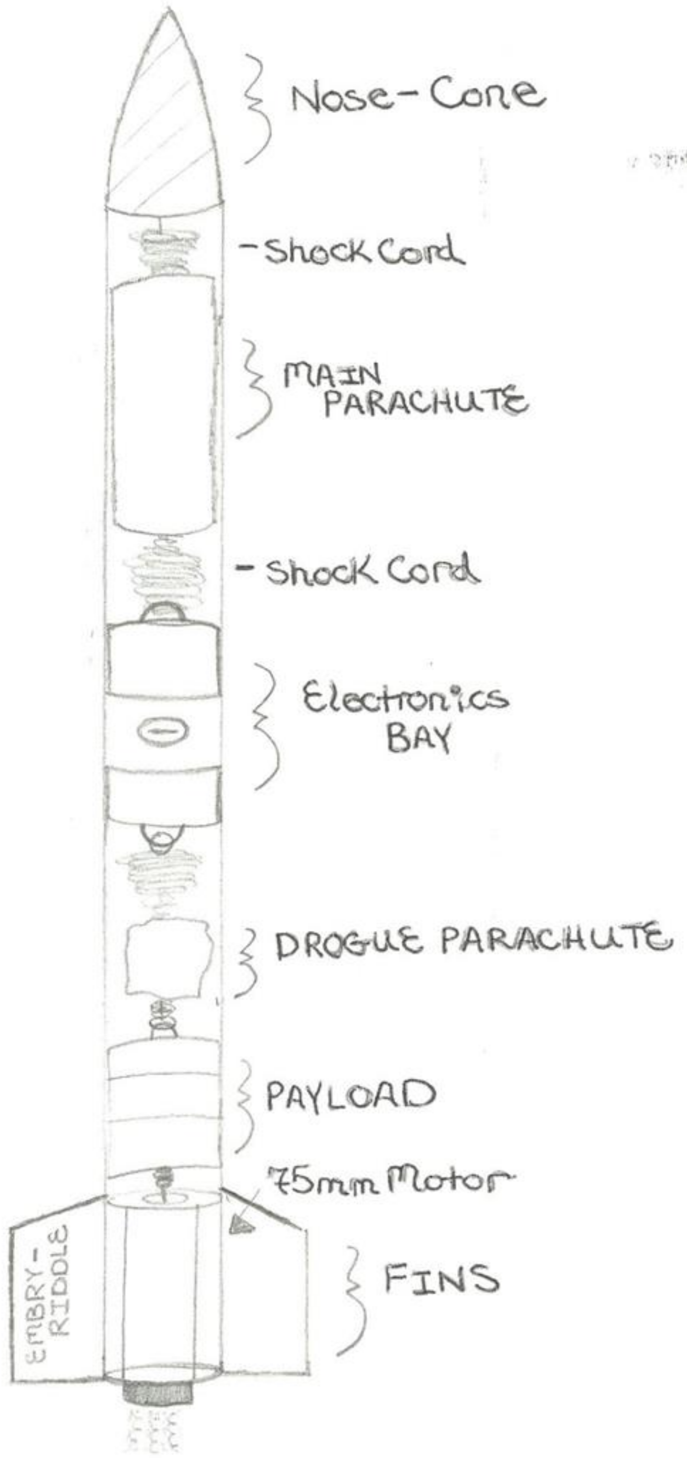
There are several factors needed for mission success. The mission would be considered a success if the rocket reaches an altitude of at least 4800 feet and no higher than 5280 feet, since the team recognizes that there are still uncontrollable sources of error involved with this project. The rocket must also be recoverable within a 2500 foot radius of the launch pad for mission success. The mission will also be successful if the payload collects useable data and the launch is conducted safely without catastrophic failure.

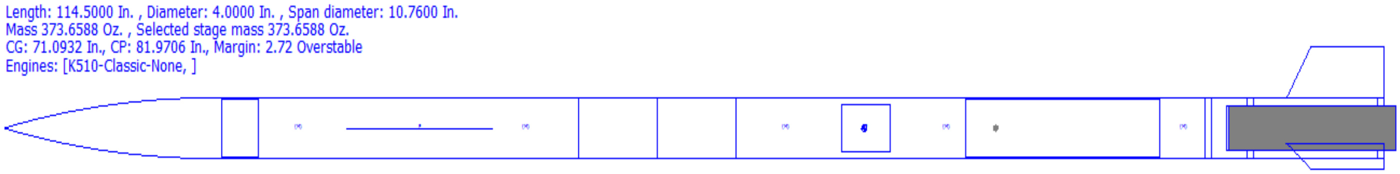
2) **Major Milestone Schedule:**

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

3) Final Design:

Final Drawings and Specifications





All systems on the rocket are designed that they will work together with each other in a safe and efficient manner as to gather data from the payload and record a safe and stable flight. The total length of the rocket is to be 114.50 inches in length made from fiberglass wrapped phenolic tubing for extra strength and with a total diameter of 4.09 inches because of the .09 inch thick fiberglass coating. The rocket is planned on weighing in at around 23.35 pounds when it liftoffs at our test launch next month in Maryland. With a center of pressure 81.97 inches from the front of the rocket and a center of gravity 71.09 inches from the front, the rocket is planned to have a static stability margin of 2.72, making it stable for flight. That is a difference of 10.88 inches between the center of pressure and the center of gravity, more than two and half body tube diameters in length. The thrust to weight ratio of the rocket is 4.949, making sure that the rocket has enough thrust to get off of the pad safely.

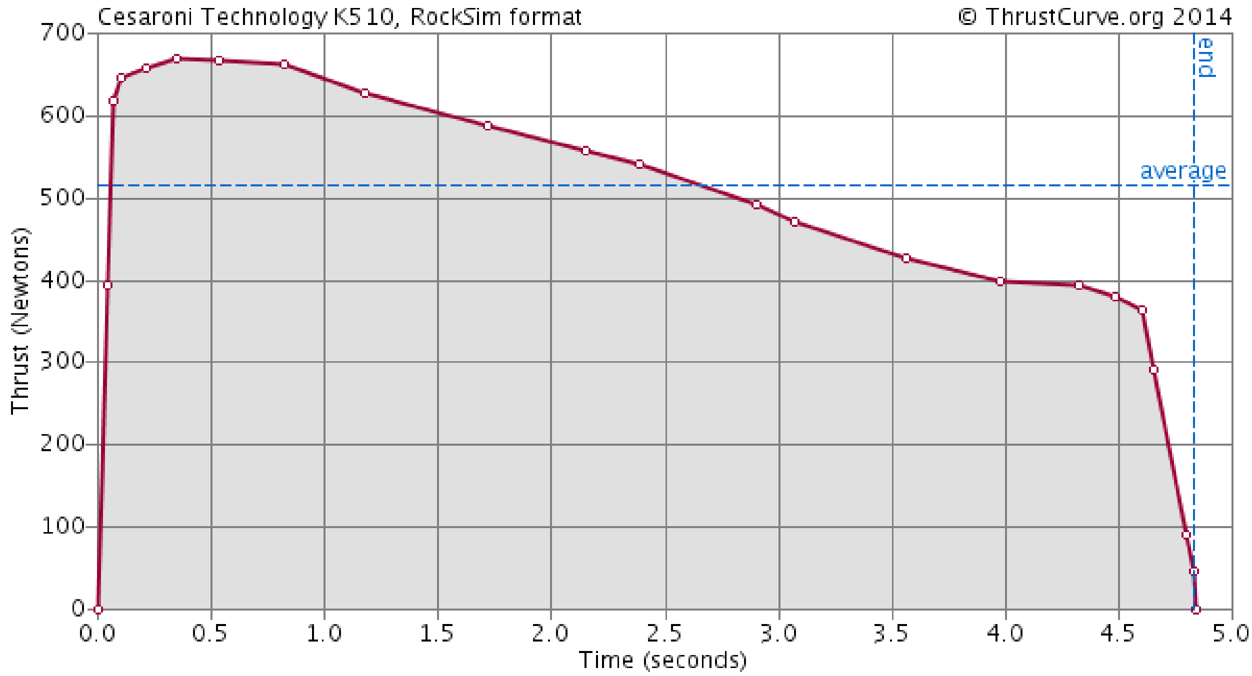
Systems

Motor and Motor Retention

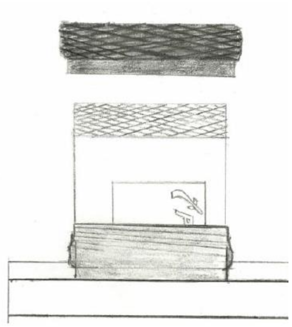
The motor that is planned on being used is a K-510 Classic Motor made by Cesaroni Technologies Incorporated. The motor has 2,486 Newton Seconds of Impulse that make up the rocket motor and is made from an ammonium perchlorate make-up.

Motor Data

Brandname	Pro75 K510-P-U	**Manufacturer**	Cesaroni Technology
Man. Designation	2486 K510-P-U	**CAR Designation**	K510-P-U
Test Date	2003-12-16	**Certified Until**	2007-06-31
Single-Use/Reload/Hybrid	Reloadable	**Motor Dimensions mm**	75.00 x 350.00 mm (2.95 x 13.78 in)
Loaded Weight	2590.00 g (90.65 oz)	**Total Impulse**	2486.00 Ns (559.35 lb.s)
Propellant Weight	1197.00 g (41.90 oz)	**Maximum Thrust**	689.75 N (155.19 lb)
Burnout Weight	1322.00 g (46.27 oz)	**Avg Thrust**	514.00 N (115.65 lb)
Delays Tested	Plugged	**ISP**	211.80 s
Samples per second	1000	**Burntime**	4.84 s



The motor retention system that is planned to be used is made up of coated aluminum with two separate pieces. The first piece will slide over the 3/4 inch overhang on the rockets motor tube from the back centering ring and attach to the tube with epoxy. This solid connection will allow the motor to slide into the motor tube and reach the lip of tube. Then the second piece of aluminum will thread onto the first piece of aluminum covering the sides of the motor. This will ensure that the rocket motor will stay inside of the motor tube and connected to the rocket.



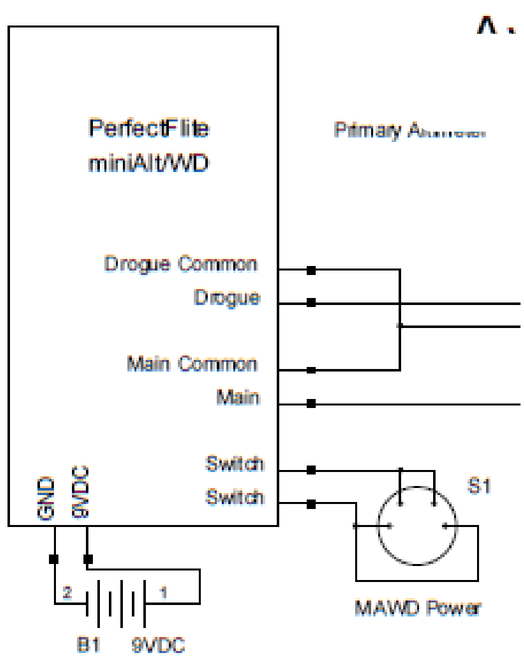
Recovery System

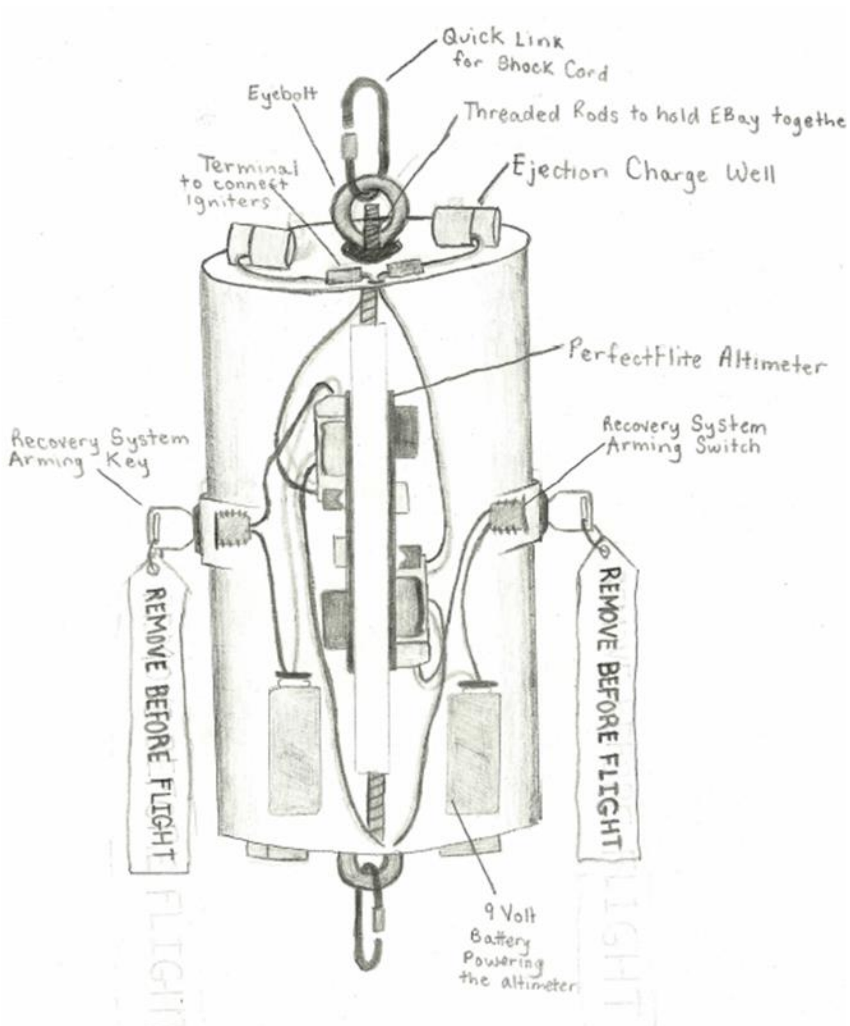
The recovery system is a crucial part of the missions success and will allow us to be able to recover the rocket and also reuse critical parts of the rockets parts for future launches. With the recovery system there is a 72 inch main parachute along with a 24 inch main parachute that will allow the rocket to safely reach the ground. Connecting the parachutes and all parts of the rocket that will eject from the rocket will be 1 inch tubular nylon shock cord. The shock cord will be hooked around a 1 inch eyebolt that will then thread over a 1 inch U-Bolt located on all the connection points within the rocket. The main parachute will be attached with shock cord to a

bulkhead near the nosecone in the top of the rocket and then connected to one side of the electronics bay. The other side of the electronics bay will have another u-bolt with a connection to the drogue parachute. The drogue parachute will be attached to the payload which will help slide it out of the body-tube. The payload will then be attached to the rocket to a bulkhead just on top of the motor mount. These strong connections of eye-bolts to U-bolts will allow for solid connection points that will not pull out or break away from the body tube.

Another vital part of the recovery system is the electronics bay which will house two altimeters which will be wired in series along with batteries. Each switch will be wired to have wires going from both the drogue and main parachutes ports to the outside of the bulkhead on the end of the electronics bay through a small hole in the bulkhead. These wires will be attached to a terminal strip so that e-matches put in by our mentor can occur easily and run directly to the ejection well with little to no problem. The power supply from the battery will come from a 9 Volt battery in a battery terminal so that the wires can be sauntered to the terminal strip and ran directly to the altimeter. Both key switches, one for the main altimeter and one for the redundant will run with wires from the switch port to the key switch. These connections will occur for both altimeters and allow for a strong and reliable connection.

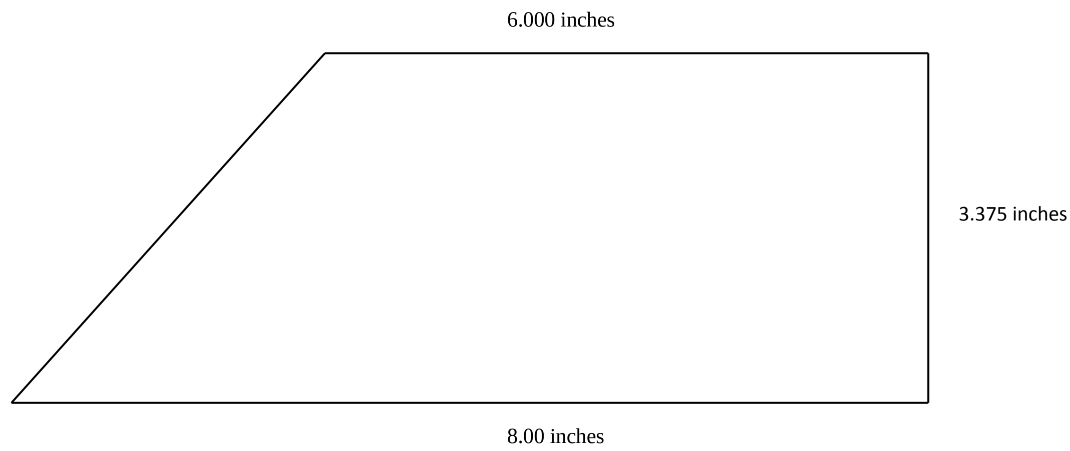
On the outside of the electronics bay tube will be four ejection charge wells that allow the black powder to be placed into and then fire when the altimeter is programmed to. The main altimeter will fire a drogue parachute ejection charge at apogee with the redundant firing two seconds later. The main parachute charge will occur at 700 feet and the redundant will occur at 550 feet. Also on the outside of the tube will run the all thread and wing nuts that will securely hold the electronics bay together and also act as supports for the sled that will hold the altimeters and batteries inside the rocket.





Rocket Airframe System

The rocket airframe system is another important part of the rocket that makes up a majority of the length of the rocket. The rocket airframe is made up of an ogive shaped nose-cone made from plastic. It is smooth to reduce drag and allow for a smooth cut through the air on flight. The body tube that will make up 98 inches of rocket length will be made from fiber glassed phenolic tubing made to withstand the high pressures that it will endure during flight. The body tube is impregnated and formed using high strength adhesives to try and keep the tube from feathering and damage when the rocket hits the ground or when the parachutes are deployed and the shock cord rubs against the body tube. The fins on the rear of the rocket will be made from G10 Fiberglass that is 3/16 th of an inch thick to prevent the fins from breaking on flight. To secure the fins, we have come up with a 3-D printed bracket using a MakerBot Replicator 2 that allow the fins to be secured on the outside of the tube. First here is our current fin design and current dimensions:



The fin bracket that is being manufactured has a tight lip that comes up 1 inch from the base on each side to wrap around each independent fin and securely keep it held in place. Through each of these risers will be two bolt holes that we can run two 3/16 inch bolts through and securely fasten each fin. There will be six of these holes, two for each fin. The bracket is a complete piece that slides over the tube of the rocket, with an exact 4.09 inch fit. The bracket will be secured to the tube using bolts that come out from the inside of the tube. These bolts will come up through the tube and through holes in the plastic that will be again bolted in place. The fin bracket has been tested enough to secure that it will not break on flight and will be able to stay in place on flight. The nuts and bolts will all be cut down as much as possible to reduce drag running through the fins and keep their aerodynamic benefits. The front of the mount is curved to allow air flow to go directly over the fins and onto the rocket. The nice part of this fin bracket design is that if one breaks it can be replaced in a matter of seconds.

Analysis with Model Results:

Last month we launched our subscale rocket test in Maryland at a MDRA launch. This launch of the rocket was recorded using high speed camera footage; using the footage revealed that the rocket was on a stable path towards apogee. But due to high wind speed that it was launched in, the rocket drifted into a tree on the far side of the field. From the data gathered by launching on an I-566 Motor, we were shown that all internal components of the rocket functioned and all parts worked as drogue chute came out at apogee and our main chute came out at 600 feet. This means that the altimeter was built using the correct wiring methods and our amounts of black powder are correct. The rocket that was flown, was flown with a stability margin of 3.27, slightly higher than the full-scale rocket at 2.72. This is accounted for because the motors' mass that was used is smaller than a third weight of the full-scale rocket. Since we used a third weight for everything but the motor, the motors lighter mass made the rocket over stable by allowing more weight to be towards the front of the rocket. The rockets predicted altitude on this motor was 1,266 feet. Because the rocket was un-recoverable, we cannot tell much more about the rocket than the data recovered from its stability and high speed camera footage.

Testing:

Testing Requirement	**Achievement Plan**
Altimeter Testing	The altimeters and redundant electronics bay setup will be tested on a school Lenovo Laptop using a USB data transfer kit for the Perfectflite Altimeters. This data kit allows us not only to set up the altimeters settings such as the main deployment height, but also test ejection charges with igniters to make sure that the wiring is functioning properly. This testing will ensure that both altimeters will function in reading and also that the ejection charges will deploy and at the correct times.
Black Powder Testing	At the launch coming up on January 17th, we will be testing our masses of black powder for both sides of the electronics bay by testing on a mock up full scale rocket that will be ground tested on two rocket stands. When the ejection charges go off we are looking for a clear separation of the two tubes and that they fall into the correct pieces without breaking or cracking.
Strength of the 3-D printed plastic	***We did a force test on the plastic uprights that will make up the walls of the payload. It held a force of 50 ft-lbs before breaking.*** In the coming weeks, we will launch a mock up of the full scale fin design on the remade subscale rocket and make sure that the components will stay together and not break on liftoff. This test should ensure that the plastic is strong enough to last during flight on the full scale rocket, but we will also do strength testing on the plastic using the strength tester in the labs at the high school to see how much the brackets can hold up.

Final Motor Selection:

Our final motor selection for the full-scale rocket will be the K-510 Classic motor made by Cesaroni Technologies Incorporated. This motor has an impulse of 2,486 Newton*Seconds and has sufficient thrust to be able to get our rocket to apogee on its flight up. It is a 75 mm, two grain motor that is 13.78 inches long. This motor is reliable and is easy to access from our supplier: Animal Motor Works. For Back-up, we will have a K-661 Blue Streak Motor from Cesaroni also on hand in case something with the other motor is malfunctioning or we designate that another motor must be used. This motor has an impulse of 2,430 Newton*Seconds.

Fulfillment of System Level Functional Requirements:

The recovery system will be capable of discharging the 24 inch drogue parachute at apogee by igniting the ejection charge which will cause the separation of the of the top and bottom body tube. It will also be capable of releasing the 72 inch main parachute at 700 feet above the ground during the rocket's descent. It will separate the top body tube from the electronics bay as well. There will be second ejection charges, in the event that the first charges do not fire or the tubes are not fully separated. The altimeter is capable of recording apogee and then audibly emitting the height. The recovery system will be able to check for continuity within the components and itself. It is planned to have a device that will produce a signal of 222.470 MHz, which will be received by a tracker to expedite rocket recovery. This tracking device was made by Communications Specialists Inc. The entire recovery system must be able to separate the three parts of the rocket without damaging any components. The altimeter, a PerfectFlite *StratoLogger*, was chosen because it is capable of achieving all requirements.

The motor retention and propulsion system should be capable of propelling the rocket and its components to a simulated maximum altitude of 5481 feet. The intention of our design is to enable ignition with a standard 12 volt igniting system. It shall be capable of retaining the motor during the entire flight and facilitate easy insertion and removal of the motor, while preventing its unwanted release. The motor was chosen to complete the task of getting the rocket to one mile. It was selected because it is commercially available and able to propel the rocket to the height given the dimensions and weight of the rocket. The rocket body will be the housing of all the parts necessary for launch, other than the ignition system and launch equipment. It will provides stability to the entire rocket. The airframe is smooth and aerodynamic. It has little air resistance, even though it contains key switches on the electronics bay. These key switches are designed specifically for rockets and are relatively so that they can be somewhat aerodynamic. The recovery system should deliver the rocket safely to the ground and ensure its reusability. The airframe should maintain the flight path with little deviation from it. The fiberglass-wrapped phenolic tubing, from Public Missiles Limited, was chosen because the rigidity and strength will allow it to complete the task at hand. The fins are being manufactured from 1/8 inch G10 FR4 fiberglass sheets due to its ability to withstand the high velocities the rocket will attain while not melting or breaking due to the high intensity heat that the motor will expel.

Approach to Workmanship:

In order for the team to be successful with the completion of this project, we must collaborate with each other and follow reasonable requests of supervisors/ advisors. Without this collaboration and cooperation, the project will not be completed. Hard working individuals are what the team seeks in order for the project to be completed correctly. Without these qualities within team members, the project will not be completed in an efficient and timely manner, leading to project failure. In order to ensure that good workmanship is being received from each member of the team towards the project, weekly meetings are held, where the team discusses progress on each section of the project which was delegated to them. If a team member is found to not be holding up to their part of the project, the team member will conference with team advisors and be asked to contribute more to the project or be relieved from the team. We all work hard to ensure that every component is made correctly and to the best of our ability. We take our time to ensure that things are correct and do not want anything to ever fall apart on the rocket.

Additional Component Testing:

At this point, the team has completed the functional testing of the subscale rocket and therefore the rocket airframe. We plan on testing the bulkheads within a section of the body tubing using the West Systems Epoxy as a bonding agent. This test should confirm that a bulkhead secured in the tube with the same epoxy that we intend on using for the full scale rocket is strong enough to withstand ejection and descent. The proposed method of testing is attaching a bulkhead inside a small section of body tube with West Systems Epoxy. From there, a large mass would be placed inside of the body tube on top of bulkhead after the epoxy has finished drying. The body tube, bulkhead, and mass would then be dropped onto a force plate to measure the amount of force that is being stressed on the bulkhead. Larger heights and masses will be used until either the bulkhead breaks free of the inside of the rocket body tube, or the force exceeds an amount determined to be "reasonable," for its intended use inside the rocket.

Testing will need to be conducted on both the recovery system electronics and payload electronics, once those components arrive and are assembled. Once the recovery system E-Bay is assembled, the team will test it to see if the E-Bay can be correctly powered up with the key switches. This will be tested using a voltmeter to check to see if an electrical charge is sent to ejection charges once the altimeter is programmed to do so at an extremely low test altitude.

Finally testing will be done on the 3-D printed plastic and the other parts to ensure that the plastic is strong enough to withstand the pressure of flight while carrying the fins. This plastic will be tested on a strength tester down-stairs to measure the amount of force needed to break the plastic and make sure that the pressure needed to break it is higher than the expected value calculated by the team on the fins.

Status and Plans of Additional Manufacturing and Assembly:

All parts of the final rocket have not yet been received. Enough parts have been received though that we are building a mock up full scale rocket so that we can test the correct amount of ejection charges needed for the full-scale launch. Construction shall begin no later than January 28, on the rest of the components of the rocket with the plan to launch the rocket at the MDRA launch in February. Most Rocket airframe supplies have been received, along with some recovery system components. All motor and motor retention systems have arrived. The major components left to build are four inch diameter centering rings and bulkheads that we can cut out after we launch the sub-scale rocket on January 17th. The manufacturing of the rocket will begin with the assembly of the recovery system Electronics Bay. The fins will be cut out with a router with a specialized bit on it made for trimming excess material off from around tables when surfaces are being placed on them. This will be easy to accomplish after a form for the fins has been made. The one half inch centering rings are being designed on a SolidWorks file so that they can be routed out on an automated router which accepts files from a computer to know where to cut. This will give us a more precise fit for the centering rings within the body tube. Also, the motor mount tube will fit better within the center hole in the centering ring. The 1 inch tubular nylon shock cord will be cut to length and the team will either put a hole in the center of one end with hole reinforcements, or a loop will be sewn onto one end of the shock cord so that the U-bolt can be placed through the loop and fastened shut.

Integrity of Design:

Fin Shape and Style:

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

Material Usage in Fins, Bulkheads, and Structural Elements:

The material being used for the fins is one eighth inch thick G10 FR4 Fiberglass, which was selected for its durability under large amounts of stress. It is also fire retardant, so it will not be affected by the high-intensity of heat that the motor emits. It will be used in a manner that will prevent malfunction of the fin system on the rocket, as the fins will contain tabs, which allow for more points of attachment onto the motor mount tube. The rocket airframe meanwhile, shall perform based on the stability of the rocket and its ability to maintain rigidity, shape, and strength during flight. The rocket tube itself is made to withstand supersonic flights and is formed from composites. Our body tubes will have added fiberglass on the outside for added support and should be able to withstand speeds of up to 1000 miles per hour. Because our rocket will reach the threshold of speed at around 500 miles per hour, the rocket airframe should easily be able to sustain itself and maintain a straight flight

On the end of the airframe, the fins plan on being attached with screws and 3-D printed brackets to the airframe. With both the strength and support of the screws, fin material, and brackets, the fins will not come off of the rocket.

The bulkheads will be made from ½ inch plywood, and will have two holes drilled through it to allow for a U-bolt to be attached through them. Plywood bulkheads will be cut out on a CNC Router, which can deliver precise cuts into the plywood for very accurate fits within the rocket body tube. The bulkheads will be attached with epoxy within and as perpendicularly as possible to the inside of the rocket body tube. This connection will be strong enough to keep the shock cord attached to the rocket and not detach away from the rocket.

The body tube is made from fiberglass-wrapped phenolic tubing. The body tubes have been purchased, with the factory (PML) having already cut them to the correct size with the correct size fin slots. This limits the amount of error that can be made while manufacturing the rocket. The motor mount, with fins attached through the body tube will be secured to this section of the body tube, with components placed in their correct locations. This section of body tube will also contain the payload and a bulkhead for the shock cord to be attached to.

Assembly procedures, attachments, and loading paths:

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

The motor mount must be assembled in a very specific method. Before fins are attached to the rocket, the top centering ring must be attached at its correct location on the motor mount tube just above where the top of the fin tab will end up. Once this is complete, the motor mount tube and centering ring will be slid up into the bottom of the rocket into its correct position. The centering ring should end up just above the top of the fin slots. After this has been completed, this centering ring will be attached with more epoxy to the inside of the body tube at this location.

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

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

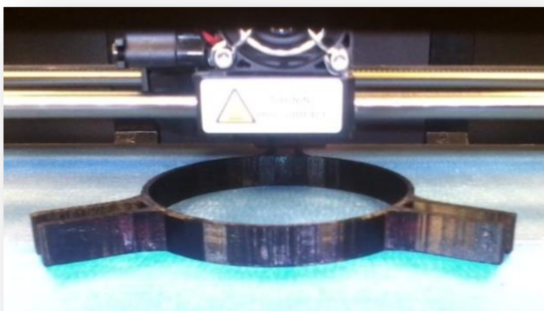
When loading the rocket, after all parts have been manufactured and attached, there is a procedure that must be followed. The shock cord below the payload will be forced down into the bottom of the rocket, followed by the payload. The remaining shock cord will be placed on top of the payload along with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

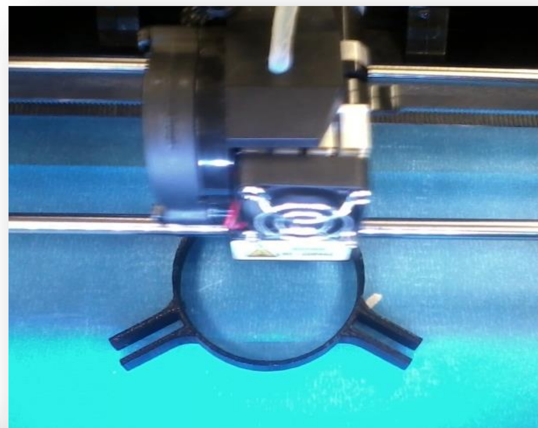
Sufficient Motor Mounting and Retention:

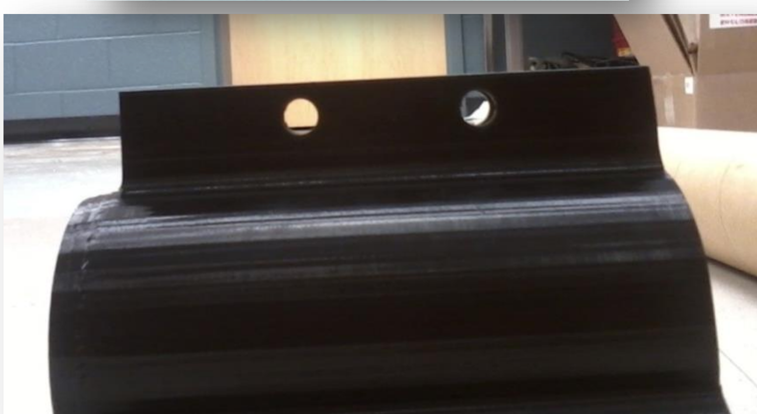
In order to ensure that the motor stays in during flight, there must be methods of preventing the motor from going up into the rocket, or coming out of the back end of the rocket. In order to stop the motor from going up into the rocket, a correctly sized motor mount tubing was chosen so that the lip of the motor will not pass a certain point. The motor mount tubing will be secured to centering rings, which will have epoxy on both sides where the motor mount has a junction with the centering rings. The fin tabs also interfere with the free movement of the centering rings and motor mount tube. This prevents the motor mount from moving up or down within the rocket. The aft centering ring is displaced 3/4 inch in from the back end of the rocket in order to allow for more epoxy to be placed in here. This will reinforce that centering ring, decreasing the chances of motor mount failure by even more. To prevent the motor from coming out the other direction, a 75 mm motor retainer will be used. This motor retainer comes in two parts. One part contains male threads and is attached with epoxy to the end of the motor mount tube, with the threads facing away from the rocket. This will allow for the other part of the motor retainer to be screwed down over top of this part, once the motor has been inserted.

Design and Verification of Launch Vehicle

The full scale rocket will be using 3D printed fin brackets in place of the more traditional filets. Because we are using a 75mm motor on a four-inch diameter body tube, it will be difficult to properly attach fins that attach directly to the motor mount with through-the-wall filets. The 3D printed bracket will be one piece, and will slide onto the exterior of the body tube. There we can bolt the bracket to the body tube and also attach the fins to the bracket. This way, the entire system is replaceable if any piece were to break. We have done some strength testing on the plastic material, and we are confident it will be strong enough to withstand the force of the launch. A bracket will be printed for the subscale rocket, so we can test the design before applying it to the full scale rocket. If the brackets cannot be used, due to some failure in design, we will use either surface mounted fins or through-the-wall fins.







We will be using G-10 fiberglass for the fins of the full scale rocket. We have used 1/8" fiberglass in the past for even larger rockets, and have had no issues whatsoever with this material. G-10 fiberglass can maintain mechanical and physical properties up to 130 degrees Celsius, and it is a non-flame retardant. Eighth inch G-10 fiberglass has a tensile strength of about 40,000 pounds per square inch, a much higher value than we expect to reach during a launch.

All bulkheads will be made from 1/2" wood. Once again, we have used 1/2" bulkheads in the past with larger rockets, and have had no issues or malfunctions due to the bulkheads. We will be using launch lugs for a 1515 rail, since the rocket will be very long. We want the rocket to have sufficient time on the rail for its speed to increase, allowing for a much more stable flight.

Every component of the rocket will be attached to a shock cord. U-bolts and Quick Links will be used to ensure that every component is secured to the shock cord. With this method, none of the shock cord will be attached to the components using epoxy or any other adhesive, but with bolts, ensuring that none of the components will break during the launch and ejection of the payload and main parachute.

We will make sure to attach the launch lugs so that they do not interfere with the fin brackets. If necessary, we will also create a small ring for the launch lugs to attach to if the ring is too thick for the rail to slide on. We will use two 1515 lugs, and both will be attached to the back half of the rocket. The back half will be five feet long, so the lugs will be spaced far apart enough that they are not ripped off the rocket during launch. Also, placing both lugs on the back half will make it easier to line up the lugs during attachment.

Shear pins will be attached to both the back half and the front half through the body tube and electronics bay. These are used to prevent premature ejection during the launch and the ejection of the payload. We have had issues with our main parachute ejecting at apogee during the ejection of the payload. To fix this we have moved the payload to the back half, so the black powder charge will eject downward, not affecting the front half in any way. We will use about five or six shear pins in both half, enough to hold the components together while allowing for the ejection to be accomplished easily.

The payload will be placed in the bottom half of the rocket to be ejected at apogee. The drogue parachute will be placed above the payload, so that it will eject first. The opening of the drogue parachute will pull out the payload, ensuring that all components of the back half fully eject. The front half contains only the main parachute, so we expect no problems with the ejection of the front half.

The motor mount system will be comprised of a 3.002" diameter body tube, attached to the interior of the body tube with two 1/2" centering rings. The back end of the motor mount tube will extrude about half an inch from the base of the body tube. A threaded motor retainer will be attached to the back centering ring, and the motor retainer will be screwed over the top of the motor. This motor retention system will not interfere with the burning of the motor, and the entire system will ensure that the motor remains centered and stationary throughout the launch process.

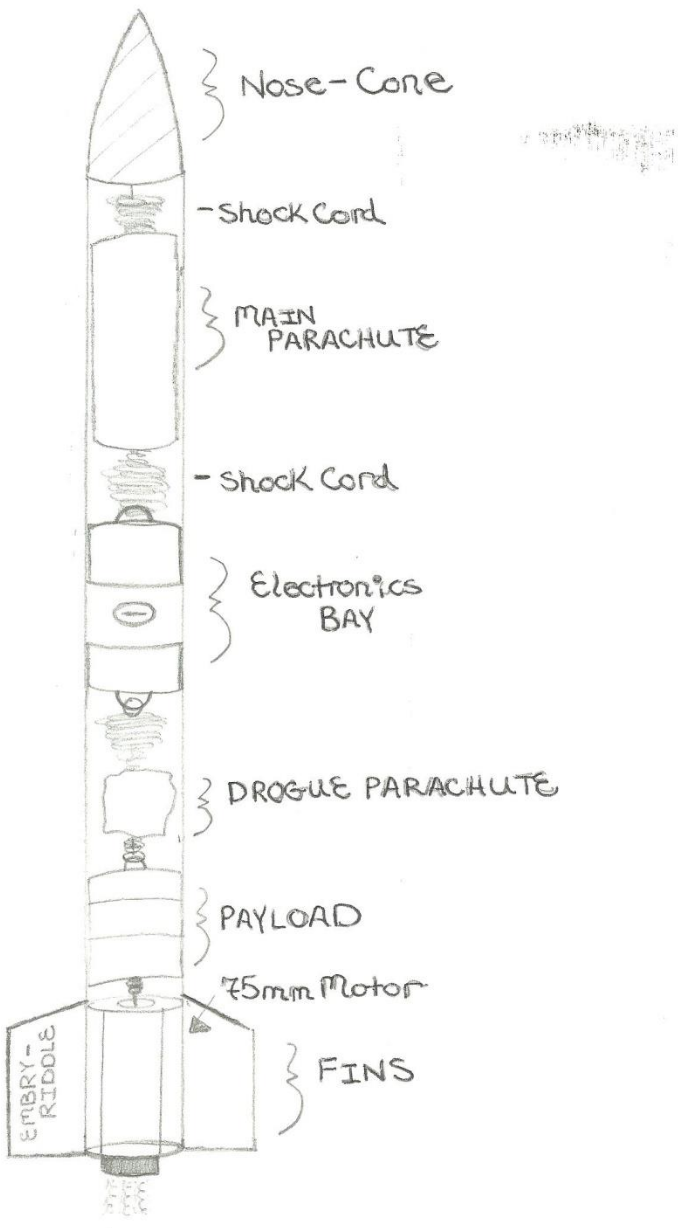
Our team has traveled to Maryland to launch the subscale rocket. The flight went well, except the front half of the rocket went into a tree, causing a loss of all data. We are in the process of rebuilding the subscale to launch on January 17. The subscale will have the proposed fin bracket for the full-scale, scaled as accurately as possible. Once recovering the subscale, we can fully verify the full scale vehicle. However, the subscale launch that we did complete did show stable flight and complete ejection of both halves.

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**

These values for mass were gathered using values posted on the manufacturer's website. Based off of our experience with previous rockets, we expect an increase of mass between 10-25% of the total mass of the rocket. This is due to the addition of epoxy and also the difference between the posted mass on the manufacturer's website and the actual mass of the components we receive. We will continuously update our mass statement as we receive parts and build the full-scale rocket. Since we expect an increase in mass, we have also chosen a motor that puts our proposed height at around 6,000 feet. If necessary, mass can be added to the rocket to alter the height to as close to a mile as possible.

To account for any failures that may occur at launches, we plan to build two subscale and two full scale rockets to take to any launch, as well as replacement parts that are needed. With two rockets, we can repair rockets on the field, or even swap out a rocket in its entirety, in order to maximize efficiency at launches. During construction and launching all safety protocol will be followed, and our student safety officer constantly ensures that all members are working safely and efficiently.

DRAWINGS:


Nose-Cone
-Shock Cord
MAIN PARACHUTE
- Shock Cord
Electronics BAY
DROGUE PARACHUTE
PAYLOAD
75mm Motor
FINS
EMBRY-RIDDLE

Subscale Flight Results:

As previously stated, our launch of the subscale rocket was successful, however the front half, including the electronics by, was unrecoverable. The rocket's flight was very stable, and both ejection charges fully deployed the main and the drogue parachute. The subscale rocket is being rebuilt, and the newly designed fin bracket will be 3D printed to test on the subscale.

As a result of the subscale launch, we have decided to move the payload and drogue parachute to the back half, while moving the main parachute to the front half. This way the downward ejection of the payload will not stress the shear pins on the front half, preventing the main parachute from deploying at apogee.

We will be launching the subscale again on January 17th to obtain information that was lost when the rocket landed in a tree at the last launch. This data will be presented in the CDR presentation following the deadline of the CDR.

Recovery Subsytem:

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 PerfectFlite *StratoLogger* altimeters 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 700 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 600 feet for the main.* We will be using 3.5 grams of black powder for each the ejection charges. 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. 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.

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

After all other final preparations have been made for the rocket launch and the altimeter connections have been checked for continuity, 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.

II)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 eyebolts on secured into bulkheads in the bottom and top half of the rocket and also to eyebolts secured to the bottom and top of the electronics bay. These eyebolts are made from forged carbon steel, that have been welded closed. These eyebolts are capable of withstanding up to 2600 lbs. of force. This will be enough to withstand ejection and keep all of the components tethered during ejection and descent. The bulkhead that we will be using will be constructed from ½ inch thick plywood. The bulkheads will be tested by securing them within a body tube using the West System’s Epoxy that we will use on the actual rocket. The amount of force required to break the bulk head or break it free from the inside of the body tube will be measured with a stress-tester, unless the system does not fail even under a large amount of stress. This will ensure that the bulkheads will be able to handle the pressurization of that chamber of the rocket and will not allow depressurization which could cause recovery system deployment failure.

Mission Performance Predictions

Rocket Analysis:

Currently our 114.5 inch rocket is projected to reach a height of 5,481 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 we are fully expecting a mass increase from the predicted and expect the height to drop 10 percent with the 10 percent mass increase.

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.

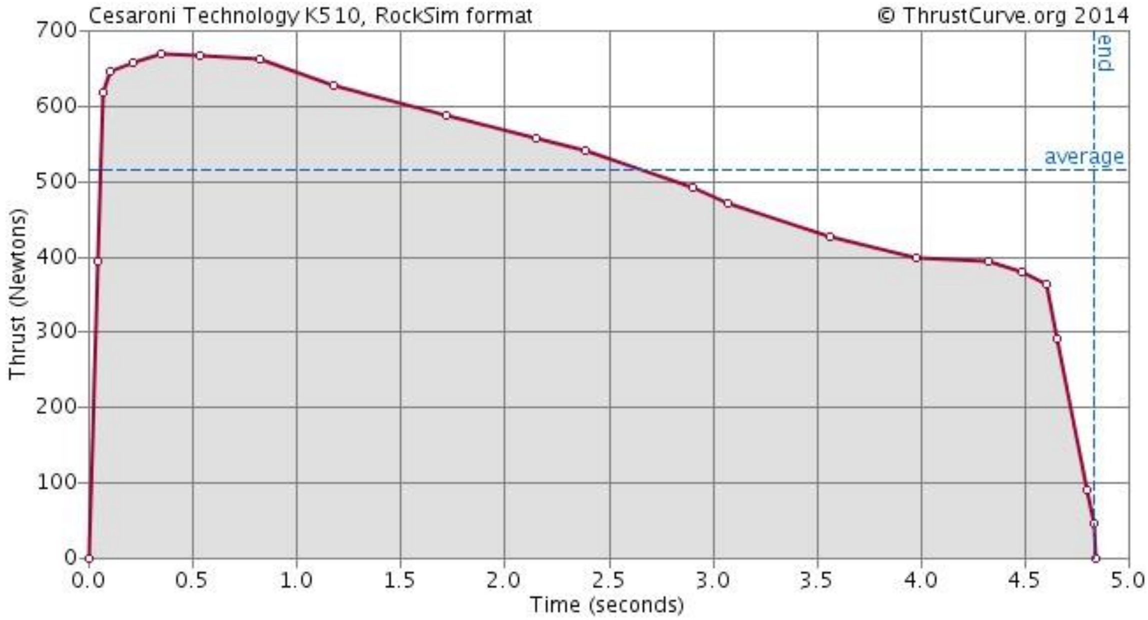
When the rocket leaves the pad, it will stay on its flight path upwards for around 19 seconds, then at apogee the 24 inch drogue parachute will deploy and then the main parachute at 700 feet. Taking this into consideration, the rocket is expected to be in the air for roughly 105 seconds based off of 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.

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	116.5	97.23	16.8114	0
5	7.33	116.5	97.23	16.8114	712.7
10	14.67	118.1	98.83	16.8114	1,449.84
15	21.99	118.1	98.83	16.8114	2,173.27
20	29.33	122.3	103.03	16.8114	3,021.87

Section 1

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

Section 2



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

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.**

<u>Section 3</u>

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

<u>Section 4</u>

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.

Interfaces and Integration

<u>Section 1</u>

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

<u>Section 2</u>

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

Section 3

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

Safety and Environment

Launch Concerns and Operation Procedures

Final Assembly and Launch Procedure

To ensure that the rocket was completed properly, the team captains and our safety officer will check over the project. They will be looking to make sure all the parts are secure and where they need to be. They will check for any errors or problems that may endanger our project to be a success. For launch, the motor will be placed in the rocket at the launch site. The rocket will be looked over once again and then will be placed on the launch pad. After this, everyone will clear to a safe distance and the rocket will be launched.

Recovery Preparation

The shock cord will be cut to the proper length, at least one rocket length long or longer, and then attached to each side of the electronics bay and their respective bulkheads. We will place a heat shield on the shock cord to prevent the drogue parachute from melting. Then the parachutes will be connected onto the shock cord and folded so that the fit into the tube. In the electronics bay we will check over the wiring to make sure none are touching so they don't short. We will be using a USB data transfer kit to set the altimeters to send ejection charges at apogee with the drogue chute and at 650 feet with the main chute. The redundant altimeter will be set for ejection of drogue at apogee with a 2 second apogee delay and a main chute deployment at 550 feet.

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 to activate the altimeters that will control when ejection charges deploy.

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.

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

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

We will locate the rocket's final resting place. We will then inspect that all aspects of the rocket are still attached and in the place they should be. We will check that the shock cord is still attached to either side of the electronics bay and has not been compromised, and that the parachutes are still attached. We will then carry the rocket back to our home base where we can use a USB data transfer kit to get readings from all of the altimeters in the ebay and payload.

Safety and Environment (Vehicle and AGSE/Payload)

Failure Modes

New failures that may arise in this stage of the project are the rocket being too massive for the motor. The rocket may also be unstable or it may be over stable. To reduce the odds of the rocket being too massive we will carefully choose the materials being used and ensure that they are not too heavy when compared to their mass on RockSim. Though we have checked the stability margin in RockSim, the actual rocket may not be stable. The fins may be off or the edges do not match up at the coupler and causes the body to not be straight. To mitigate these odds, construction will be carefully monitored. Construction will never be rushed and will be done with detail. Where the tube is cut will be sanded until it is flat and the couplers will fit snuggly.

With our design of the payload, the only conceivable failure is with the attachment. The payload will be attached to the shock cord by a U-Bolts on both ends. The payload may exert too great of a force on the shock cord at ejection and could possibly snap. To decrease these odds we chose a shock cord tested for 2000 pounds. This should be more than enough to stand up to the forces involved in our launch. We will be testing this in the full scale test. Also the inner electronic wiring may pull out of altimeters from injection. To mitigate this problem we will check over wiring make sure each is snug and tight in the correct place on the altimeter and battery terminals.

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

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

Electrical Circuitry within the payload loses its functionality as a result of wires becoming detached.	The payload circuitry will be tested after its completion to ensure that it functions properly. Once this is confirmed, any components that can be soldered will be, and a specialized epoxy will coat over components and junctions that must not be tampered with.
The payload was not constructed properly, and as a result poses a major problem that could affect the system's functionality.	All parts of the payload will be assembled only while at least two well-versed persons in its construction are present. The two people will come to an agreement as to where components are to be attached, or what line of code needs to be used in operation, before it is executed. Both people who are working on its construction will ensure that
The switch which enables data to be recorded fails and no data is recorded.	A pre-launch testing of the payload operation will be conducted to ensure that the switch functions as it is supposed to. Once this has been ensured, the switch will be activated and secured in the correct position to continue recording data.
The payload is not attached properly to the shock cord within the rocket, and it becomes an independent section of the rocket that is falling	Methods will be researched to find out the most effective way of attaching the shock cord to the eye bolt. This will ensure that the payload section will not become independent from the rest of the rocket.

Personnel hazards

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.

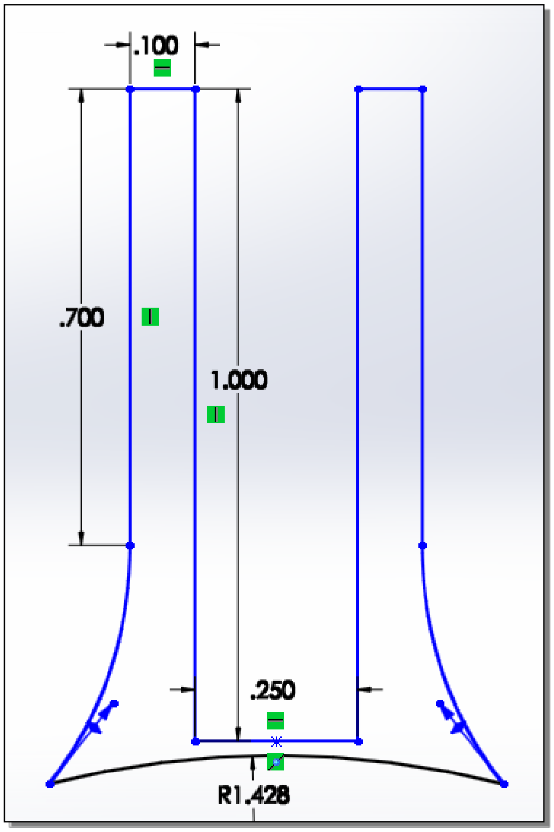
Operation Hazards for Above Equipment

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

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

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



Payload Design and Integrity

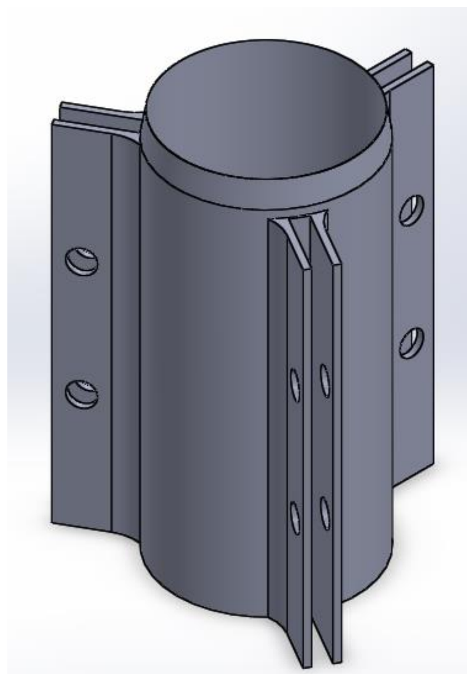
The payload will consist of four 3-D printed plastic bulkheads, each of which will have lips on the edges so that the external coupler tube sections will be capable of sealing each section from the others. The bulkheads will each be 1/2” thick, which should be strong enough to easily withstand any stress placed on them. The lips will be 1/6” high. Three of the four bulkheads will also have “walls” printed directly onto the bulkheads. The bulkhead and wall will be printed together, so that the strength of the payload is maintained. These walls, which will be four inches tall will each accommodate three altimeters, which will be wired to a 9 Volt battery in parallel. Two lines of 1/4” all thread will run through the entire payload. A U-Bolt will be attached to each end bulkhead. These holes will not be drilled: they will be printed on each corresponding bulkhead. The entire payload will be approximately 13” in length, not including the length of the U-Bolts extruding from both sides.

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		

Upon initial analysis, the bulkheads will be sturdy enough that, barring catastrophic malfunctions, they will be able to withstand the force of the vehicle's liftoff and flight. We will make replacement parts for each section, so if any piece were to break, it can simply be replaced.

The plastic used during 3D printing is polylactic acid plastic, a starch-based plastic. It has a melting temperature between 315 and 338 degrees Fahrenheit, which will not be an issue for the payload.

The system must be able to keep nine Stratologger CF altimeters activated for a long enough time that if complications were to arise while the vehicle is on the launch pad, the payload will remain fully functional for over an hour after the components are activated. One 9V battery will power three altmeters. Each altimeter will have sufficient power to remain activated, and the 9V battery should last for multiple hours. The battery will be wired to the altimeters in such a way that the force of the launch will not affect the wiring in any way, so that the payload remains activated throughout the duration of the flight. The altimeters will be removed one at a time after the launch, and they will be individually read to take data. We have downloaded a program on a laptop, which we can take to the launch field and use to read the altimeters. Extra altimeters, wires, and every other component of the payload will be brought, so that they may be replaced at any time.

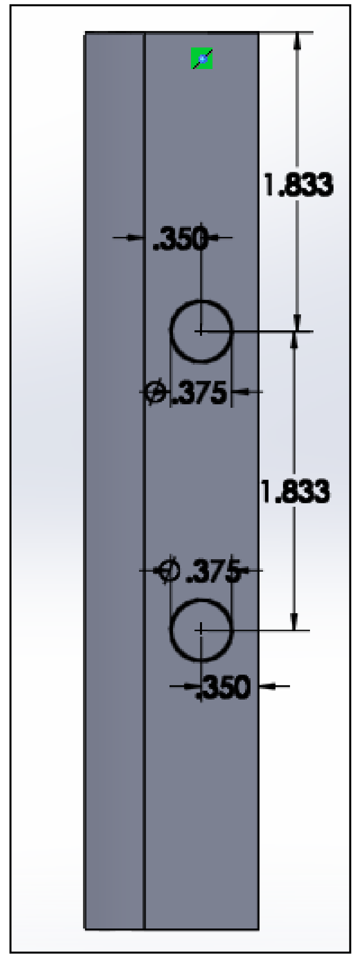


Further testing will be conducted on both the electronics within the payload and the half inch bulkhead. We have researched the type of plastic and its strength indicated in this research, but we will also follow up with testing of our own. While we may not be able to perform as much testing of our own as we would like, we are already confident that all structures will be able to withstand the entirety of the launch. We are testing the fin components during subscale launch, and if any complications arise we can redesign the fin brackets in a sturdier way.

Multiple fin brackets will be printed prior to any launch, so that every part is replaceable. We plan to print at least three brackets for our first test launch, and a copy of each payload piece will be printed prior to any launch as well.

The entire payload will be the dimensions of a coupler tube, so the entire piece will slide easily out of the back half at apogee. Both ends will have a U-Bolt attached directly to the bulkheads, which will attach the payload to the drogue parachute and the rest of the rocket components. The payload will eject at apogee during the first stage of ejection, at which point the drogue parachute will also deploy.

The purpose of the payload is to measure the precision of the altimeters within the payload, so all variation is a part of the experiment. Since the wiring of the altimeters is fairly simple, the experiment can be repeated in future launch by reconnecting the 9 Volt battery to the altimeter.



Any failure of the payload will most likely occur due to the failure of the connection from the 9 Volt battery to the altimeters. This failure will not pose a significant threat to the integrity of the design, as it will not affect the performance of the remainder of the rocket's systems. Since the payload is close to the motor, motor failure can cause major damage or loss of the payload. Even a complete loss of the payload will not pose a serious threat to the project, as every part is replaceable, and the payload can be rebuilt.

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.

We are confident that this payload suits the level of challenge that we can meet. Our team has had different experiences in the past, from electronics to computer design. Our rocket now has two payloads, the altimeter experiment and the fin bracket, and every member of the team has specialized experience that is needed to complete the project.

Science Value

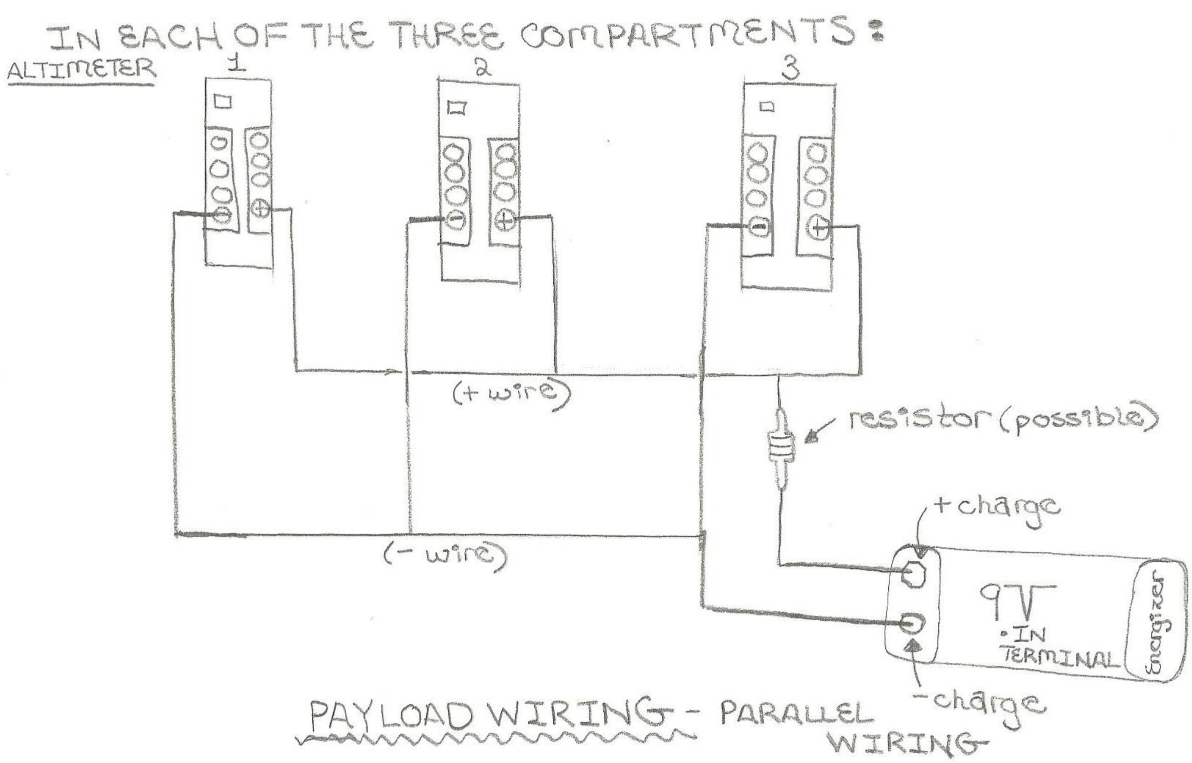
The fin bracket system must remain intact during the entirety of the launch, in a way that the stability of the flight is not affected. The fins must remain intact and attached to the fin bracket, so that no major pieces fall off of the main rocket.

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.*

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

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

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

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

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

We plan on selling rocket space once again for our full-scale rocket to be launched in Huntsville. We have not made this official however, but it will most likely occur. We will also sell Christmas wreaths and poinsettias in the future. This will be sold through the Christmas season, possibly raising around $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. We have already received a donation of $500 from one of these local businesses: Advanced Application Design Inc. With all of these fundraisers, grants, and donations, we will be able to raise enough to pay for the completion of the 2015 SL project. Any funds left over will go towards next year's Spring Grove rocketry clubs.

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

7. Full Scale Launch in Price MD

8-15. Work on FRR documents and presentation.

16. Flight Readiness Review (FRR) report, presentation slides, and flysheet posted on the team. Website by 8:00 a.m. Central Time

17. Practice FRR presentation.

18-27. FRR video teleconferences

April 2015

3. Pack rocket, tools and all parts for Huntsville trip

6. Teams Travel to Huntsville, AL

7. Launch Readiness Review (LRR)

8. LRR and safety briefing

9. Rocket Fair and Tours of MSFC

10. Mini/Maxi MAV Launch day, Banquet

11. Middle/High School Launch Day

12. Backup launch day

29. Post-Launch Assessment Review (PLAR) posted on the Team. Website by 8:00 a.m. Central Time

Part 4: Educational Engagement

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

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

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

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

A Team America Rocketry Challenge group will be formed in the middle school, spreading more awareness to the younger generation. They will then hopefully continue to participate throughout high school and then involve the generation after them. This system of getting teenagers involved has worked very well and will continue to be the best way of involving students through their peers. Along with this we will contact local television stations and newspapers. They would then make short segments on our project, further spreading awareness of our rocketry programs. We also plan on going to home football games to set up a table and spread awareness about our project. This idea allows us to go in many different directions including going to many different school events to spread our ideas and lessons. (Not limited to home sports games, museum visits, back-to-school nights, and many others) Through these ways, we should be able to spread our word to a younger generation and bring STEM ot the forefront in our local community.

Poem that will be taught to the elementary students:

I'm building a rocket,

As soon as I'm done,

I'm taking my friends,
On a trip to the sun.
But what do you mean,
That the sun is too hot?
Oh well, I suppose,
I'll just pick a new spot.
I'm building a rocket,
I'm finishing soon,
And taking my friends,
On a trip to the moon!
But what do you mean,
That the moon has no air?
Well dang, then I guess,
That we can't go up there.
I'm building a rocket,
It's going to fly,
I'm taking my friends,
Way up high in the sky!
--Kenn Nesbitt