Flight Readiness Review

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I) Summary of FRR report

Team Summary

-Team Name

- Team Tesla

-Address

- 1490 Roth's Church Road PA 17362

-Team Mentor

- Brian Hastings NAR #96571, Certification Level 2

-Launch Vehicle Summary

- Mass of Vehicle: 20.61lb
- Length of Vehicle: 85.25in
- Motor Choice: K740 C-Star
- Recovery System: Two PerfectFlite StratoLogger cf's igniting 2.0 grain charges
- Rail Size: 15x15

Payload summary

-Payload Title

- Assent Intake Generation System A.I.G.S

-Payload Summarization

- This year's payload, for Spring Grove's team TESLA is designed to test the rate at which airflow through a turbine will generate current on the accent of the launch vehicle.

II) Changes made since CDR

Motor selection

We have decided on using a 4 grain k740 c star after numerous experimental flights with differing motor selections we realized that other motors had too much power to keep us close to the one mile goal. We have launched with the K740 motor two time and so far both launches have been much closer to the one mile goal than other motors. The first launch with the K740 got us to the height of 5471 feet. The height is still high but with small mass adjustments we will be much closer to the goal. The second flight was on our backup rocket. This rocket weighed less than the first rocket by about one pound. This increased the height on the second launch by about 200 feet. The second height was 4675 feet, again this is well over a mile but by adding mass we will be able to dial in on the one mile goal.

III) Vehicle Criteria

Design and Construction of Vehicle

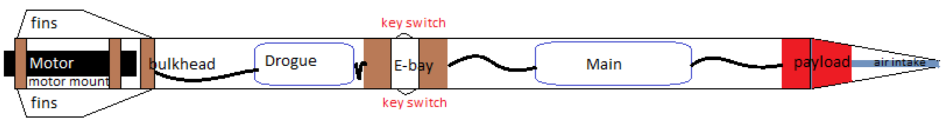
- Structural Elements
    - The airframe of the rocket is constructed from Fiberglass Tubing making it a very resilient component of the rocket, capable of handling the any stress encountered by the rocket on the flight to apogee. The tubing already comes prepared from the manufacturer, providing less of an inconvenience to the team and its preparation.
    - Since the fin bracket is mounted using 3 screws, no vertical slits are needed to be made in the body tube itself greatly increasing the strength of the rear body tube. With the makeup of the fin can being alltemp printer material we are confident that the heat expelled from the motor shall not burn and/or damage the fin can itself.
    - The fin can is then screwed into the main body tube itself. There are wood centering rings on the motor mount (on the inside of the rocket body tube) that allow us to screw into the wood. This wood provides a sturdy enforcement for the screws and a reliable contact point. The fin can itself has a fairly tight fit on the body tube for added friction between the tube and the mount to keep the fins secure.
    - The bulkheads that we are using inside the rocket are made from ½” plywood and were cut out on a CNC router for precision fit into the rocket. The bulkheads were then sanded around the outer edge and the inside of the rocket was sanded where the bulkheads were being placed, in order to ensure that the epoxy would create a better bond between the rocket and the bulkheads. The epoxy was placed on both sides of the bulkheads and between the bulkheads and the inside wall of the rocket.
    - The U-bolts in the rocket are made from 5/16 inch stainless steel. They are attached through the bulkheads and secured on the other side with a washers and two nuts that are then epoxied to the threads. The metal washers on the back helps to distribute the force on the U-bolt across the bulkhead to ensure that the U-bolt does not simply rip through the bulkhead.
    - The centering rings are a major component to our rocket, as they must be able to keep the strong force of the K740 motor attached securely to the body tube as well as act as a fin support. The centering rings are

positioned 3/4 of an inch from each end of the motor tube and a third ring 4 inches from the other rear end of the motor tube to ensure maximum support to the motor. There is epoxy both above and below the forward centering ring (the one just above the fin tab), and about ¼" of epoxy below the aft centering ring to ensure that it does not come out. These centering rings hold the motor tube and motor in place. This ensures a solid connection between the tubes, the rocket and fin can.

- The fin can is made with 100 percent fill 3D printed all-temp material with extra supports. We want to ensure that the fin cans do not break off and were tested to withstand over 100 pounds of force. This is more than enough force that we are confident that our fin bracket system will hold throughout the launch.

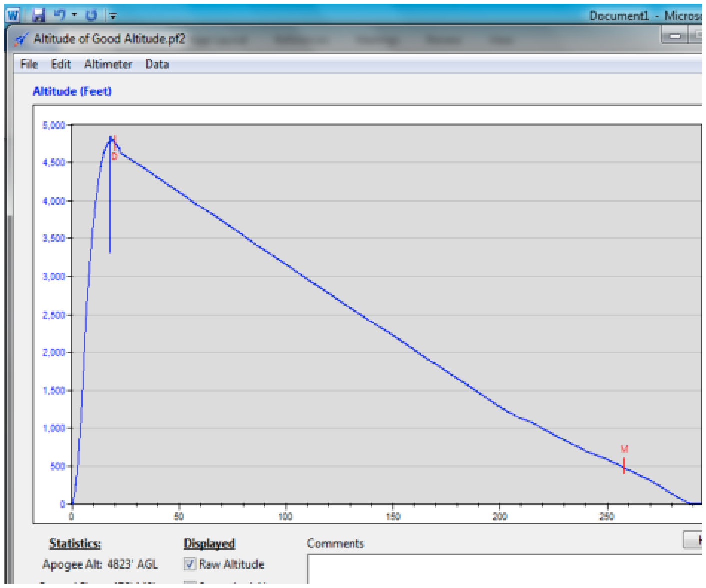
- Electrical Elements
    - The wiring in the electronics bay is set up in redundant fashion with each altimeter being connected to its own independent 9 Volt battery. For each altimeter, 16 gauge stranded wire is used to connect all switches and ejection impulses. Each altimeter is wired with a positive and negative wire to a battery terminal which houses the nine volt battery. These wires are then connected onto the terminal and the stripped ends are plugged into the power points on the altimeter. In the switch outlets, two wires run directly to a switch that controls each altimeter. The main and drogue ejection wires are put into the altimeter and ran to their respective sides of the electronics bay where the wire runs through the outer bulkhead of the electronics bay and into a terminal strip mounted on the bulkhead. This way, our mentor can place e-matches into the terminal strip and run them directly to the ejection wells.
    - This setup is repeated for the redundant altimeter as well so that both altimeters are wired correctly.
    - Each of the two batteries are placed into battery terminals on the sled of the electronics bay. To ensure that the battery stays in during flight, the terminals ensure that the battery is pushed down and into the leads of the terminal during flight. We also have electrical taped the batteries into the terminals to ensure that the battery does not fall out.

- Each altimeter itself is mounted using altimeter mounting hardware. A standoff is mounted through the wood and screwed like a bolt and then epoxied in place. The altimeter then is placed on top of the standoff where screws secure through the altimeter and into the standoff to ensure that the altimeter cannot move during flight.
- Finally, each key switch is mounted into the body tube on the middle of the electronics bay and mounted using a nut on the back side of the key switch, epoxy, and superglue to ensure that the key switch will not move during flight. The key switch is secured into position after wires are



secured and are made sure to function properly before launch.

- **Flight Reliability and Confidence:** We are confident in the design of our rocket and have been able to complete many test flights to ensure no major problems will occur. On our most recent test flight completed on March 12th and 13th. In our most recent flight we saw that our rockets took a very straight flight even in winds of 10-15 miles per hour. The rocket ensued a straight flight and was very successful. Our next full scale launch will be on March 28th, we are very confident that the rocket will have a successful flight. Overall, major aspects such as stability, ejection charges, fin attachment and the deployment of parachutes was met so confidence is at a high and no major rocket design changes are needed
- **Test Data:**



- As you can see in the graph above, we were able to have a successful full scale launch and received accurate data from the altimeters in reference to flight occurrences. In the above height graph, you can see that the drogue parachute was deployed at apogee and the main parachute did go off at 600 feet as planned. The spike at apogee is due to the altimeter undertaking an intense reading of air pressure which is very reasonable and shows us that our electronics bay is sealed. We will continue to work with the electrical tape and all open sections to lower this spike further.
- **Workmanship:** In order for Team Tesla to be successful and complete this project, all members of the team will collaborate with each other and meet the deadlines set by team captains and instructors. Team Tesla is comprised of hardworking and very dedicated individuals who are fully committed to completing the project correctly and on time. To ensure that professional workmanship is received from each member of the team, Team Tesla holds weekly meetings in which the team discusses its current progress on each of the projects sections of which they were assigned. If a team member is found to not be completing their parts of the project, the team member will have a conference with team captains and instructors and he or she will be asked to contribute more

to the project or face being removed from the team. Each Team Tesla member works hard to ensure that every component is made correctly and to the best of their ability. We consider all aspects of workmanship to ensure that all of our components are built correctly because we would not want anything to fail during the launch of our rocket.

- **Safety and Failure Analysis:**

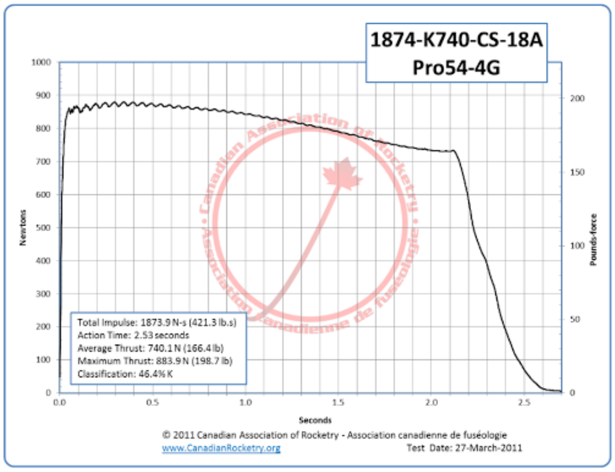
Failure Modes	Causes	Effects	Mitigations
The main parachute fails to deploy	-The parachute is too large for the diameter of the rocket -The parachute is not packaged in the most efficient method possible and gets stuck in the rocket	The rocket hits the ground with only the drogue chute to slow it down.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

- **Full-Scale Launch Data and Report:** With the full scale motor of the Cesarani K-470 C-Star, the rocket traveled to a height of 5,408 feet in Price, Maryland on March 13th and 14th. The rocket weighed 17.6 pounds which was very close to our predicted value that we had assigned. It is also assumed that Rocksim flight data will overshoot the actual height of the rocket and in real life is decreased around 10 percent.
- **Mass Report**:

Part	Mass (oz.)
Nosecone	20.53
Payload	23.56
Elecontrics Bay	33.86
Rear Body Tube	33.79
Front Body Tube	29.24
Fin Bracket	10.58
Quick Link (x3)	3.17
U-bolt (x3)	3.18
Main Parachute	13.05
Drogue Parachute	4.8
Shockcord	8.47
Electronics Bay Bulkhead (x2)	3.52
Motor Mount	14.99
Motor Casing	13.8
Motor	59.44
Epoxy	9.56
Total:	***265.01***

Mission Performance Predictions

- **Mission Performance Criteria:**
    - Our goal as Team Tesla is to build and test a rocket that will achieve an altitude of one mile, utilize a scientific payload, and return safely to the ground. To do this, we must first create a stable and reasonable rocket design on a simulation program (such as Rocksim). During flight, the rocket should take a straight and stable flight along with the proper ejection charges and parachute deployments, which will allow it to land safely and hopefully nearby. This will be accomplished by using computer software to program an altimeter which will eject the bottom half of the rocket at apogee and the top half of the rocket, which contains our payload, deploying the main parachute at 600 feet. To ensure safety and to maintain a reliable ejection system, there will be a second altimeter programmed to eject at the same flight events except with a slight delay.
- Provide Flight Profile Simulations, Altitude Predictions w/ Real Vehicle Data, Component Weights, and Actual Motor Thrust Curve, Real Values w/ Optimized Design for Altitude, Sensitivities



- Thoroughness and Validity of Analysis, Drag Assessment, and Scale Modeling Results, Compare Analyses and Simulation to Measured Values from Ground and/or Flight Tests, Discuss how the predictive analyses and simulation have been made more accurate by test and flight data

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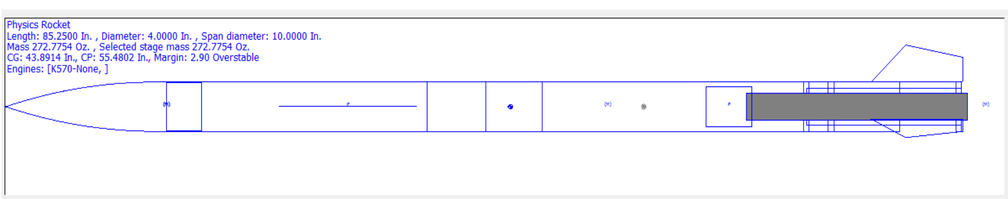
- **Stability Margin and CP and CG**:
  - Stability Margin : 2.90
  - Center of Gravity (CG): 43.89 in. from nose cone
  - Center of Pressure (CP) 55.48 in. from nose cone



- **Management of Kinetic Energy:**
  - With our 72 inch parachute, the rocket should have a slowed descent of 13.16 ft./s. With this velocity, the nosecone and payload are calculated to have 18.2 ft-lbf of Kinetic Energy at the moment that the rocket hits the ground. The front body tube which contains the electronics bay should hit the ground with 24.2 ft-lbf of Kinetic Energy. The last section of the rocket (the bottom half) should have 52.5 ft-lbf at the time it hits the ground. The total kinetic energy of the rocket is 94.9 ft-lbf when it hits the ground.

- **Wind Speed Calculations:**
  - With the rocket falling from a projected height of 5,408 feet after new test results and masses, the rocket shall reach wind drifts recorded below with the drogue and main parachute, with the main parachute coming out at 600 feet.

Wind Speed (mph)	Total Drift (ft)
0	0
5	512.072
10	1301.22
15	2236.28
20	2680.33

Major Milestone Schedule:

______Throughout the completion of the PDR and both subscale construction and launch, supplies were ordered and full-scale construction began. The design was proven stable by the subscale launch and construction of the full-scale vehicle, which began after these successful launches and the approval of our NAR representative. We have completed the construction of two full scale rockets and at this time have completed numerous successful flights on each. Review the design at a system level

- Nosecone and air intake
  - The nosecone is designed to act as a ram air intake while directing any excess air around the rocket in order to reduce as much drag as possible. At Its peak there will be a hole drilled in order for an air transfer shaft to direct air to the payload.
- payload
  - In relation to the airframe, the payload is designed to connect the nosecone to the front body tube for launch and to act as an anchor point for nylon shock cord to be run to the nose cone to keep it from being lost with the ejection of the main chute.

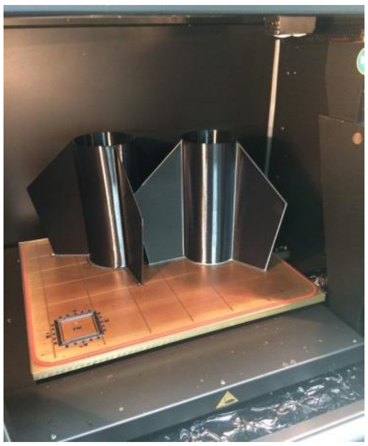
- Front Body Tube
  - The front body tube of the rocket will be made out of 4 inch fiberglass wrapped phenolic body tube. The front half of the rocket will house the payload and the main parachute. The payload will be in the nosecone of the rocket and a UBolt with be attached to the bottom of it to connect it to the recovery systems of the

rocket. A nylon shock cord will run from to payload to the main chute and then from the main chute to the ebay. The main chute will be ejected out of the nose cone of the rocket

- Ebay
    - The ebay acts at a body tube coupler for both the forward and rear body tubes as well as initiating separation and deployment of the main and drogue chutes. It also acts as an anchor point connecting both the nose cone and rear body tube with nylon shock cord.
- Rear Body Tube
    - Made of 4 inch fiberglass tube, the rear body tube will house the motor of the rocket along with the recovery system. The back half will house a Cesarani K740 motor. This motor will be in a motor mount made out of ½ inch thick wood centering rings and fiberglass body tube large enough for a 54mm motor casing with an I bolt at the end for shock cord attachment, for connection to the recovery system of the rocket. The drogue chute will be housed in the back half of the rocket, so a nylon shock cord will run from the motor mount to the drogue chute and then from the drogue chute to the ebay. The fins will be placed on the very end of the back half of the rocket. The rockets back half exterior will consist of 3 trapezoidal fins printed in all-temp material, which are then attached to the back half with screwed inserts through the PML body tube into the motor mount.
- Motor mount
    - Designed to adequately secure the motor to the launch vehicle's rear body tube and provide an anchor point for the 3D printed Fins.
- Motor selection
    - Cesarani K740
- Centering rings and motor mounts
    - mounts and rings will be made of ½ inch thick laminated plywood which will be cut to the proper size on our facilities CNC Router

- 3d printed Fins
    - The fins will be placed on the very end of the back half of the rocket. The rockets back half exterior will consist of 3 trapezoidal fins printed in all-temp material, which are then attached to the back half with screwed inserts through the PML

body tube into the motor mount. Our final motor selection is the K470. This motor is under the max impulse and it is also the motor that gives us the best chances of reaching the height of one mile.



Demonstrate Design Can Meet System Level Functional Requirements:

- 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 7 feet and 2 inches constructed from 2 sections of full-fiberglass 4 inch diameter body tube for extra strength to ensure a safe return flight of the rocket. The total weight of the rocket is 16.29 pounds. The center of gravity is located at 43.89 inches behind the tip of the nose cone and the center of pressure is located at 55.48 inches behind the tip of the nose cone, giving us a stability margin of 2.90.

- The motor retention system we plan to use consists of corresponding threaded aluminum tubing with two individual parts. The first section of aluminum tubing attaches via an epoxy bond over rear external overhang of the rocket's motor tube from the furthermost 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. A second larger diameter piece of aluminum will inner threads will screw onto the first piece of aluminum tubing via corresponding outer threads. This retention system is to ensure that the rocket motor and casing will be secured inside of the motor tube and thus connected to the rocket.

Planned Additional Component, Functional, or Static Testing:

- Static testing was completed in Price, Maryland prior to the launch of the full-scale rocket.
- Finally, testing will not be done on the 3D printed plastic parts because the team has already done extensive testing on such components in previous years and is at this point confident that the material chosen has shown it is strong enough to withstand the pressure of flight. This plastic was tested on a strength tester in which the amount of force needed to break the plastic is higher than the expected forces that will be placed on the fins during flight.

Status and plans of remaining manufacturing and assembly.

Integrity of Design:

Fins:

- The dimensions of our fins were first drawn in Rocksim and used in computer projected launches. After these fins were tested, a 3D drawing was made which incorporated the fin dimensions into a fin canister designed by our team. This means the fins can be easily replaced if broken upon landing because they are constructed from both an ABS and AllTemp filament. Our 3D model was then printed by one of our sponsor companies (T.E.). The fins' trapezoidal shape reduces drag while bringing the center of pressure towards the rear of the rocket thus increasing overall stability.
- Bulkheads and Structural Elements:

  The rocket airframe has and will continue to perform well, based on the calculated and subscale tested stability of the rocket and its rigidity, shape, and strength during flight. The rocket tube itself is made to withstand supersonic flights. Our body tubes are full fiberglass 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 and the fin canisters will be attached with screws through the 3D printed brackets into the airframe. The screws, fin material, and brackets will insure that the fin canister does not come loose or fly off the rocket. Our bulkheads are made from ½ inch laminated plywood and will have two holes drilled through any bulkhead that requires it, allowing for a U-bolt to be attached securely to the subframe of the rocket. Our plywood bulkheads were cut using our facility's CNC Router for an accurate fit within the rocket body tube. The bulkheads will then be attached via epoxy. This connection will be strong enough to keep the shock cord attached to the rocket and prevent it from detaching from the rocket. Additionally, the motor mount will also be secured to the body tubes this way by utilizing three centering rings.

- **Assembly Procedures**

The electronics bay is assembled so that there will be no interference with other components within both the front and rear body tubes. 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 the switches were placed at 180 degrees to each other so that they do not interfere with the placement of sled which will be inserted into the E-Bay by sliding it down the two all thread rods that firmly hold the ebay together. 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 can will end on the outside of the body tube. 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 below the top of the fin can. After this has been completed, this centering ring will be attached with more epoxy to the inside of the body tube at this location and a screw will go through the fin can into this ring securing the fin can to the rocket. For the recovery system, shock cords will be attached to the U-bolts in order to form a secure connection. 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 drogue in the rear body tube will be forced down, followed by the drogue. The remaining shock cord will be placed on top of the drogue along with fire retardant to insure 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 fire retardant to prevent the parachute and shock cords from being damaged this front body tube will then be attached and remaining shock cord will come out the front end or the forward body tube so as to attach to the payload and nose cone via a U-bolt and quick link this entire section will then insert into the front body tube and complete the assembly of our launch vehicle.

- 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 cans securing system also interferes 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 even more. To prevent the motor from coming out the other direction, a 54 mm motor retainer will be used. This motor retainer comes in two parts. One part contains male threads and is attached with epoxy to the end of the motor mount tube, with the threads facing away from the rocket. This will allow for the other part of the motor retainer to be screwed down over top of this part, once the motor has been inserted.

- **Verification Status**

  The full scale rocket will be using 3D printed fin canister in place of the more traditional filets. Because we are using a 54mm 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 can will be one piece, and will slide onto the exterior of the body tube. There we can bolt the can to the body tube 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.

  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 15x15 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. We will use two 15x15 lugs, and both will be attached to the back half of the rocket. Lugs will be spaced far apart enough that they are not ripped off the rocket during launch.

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. 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” thick 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 already traveled to Maryland to launch the subscale rocket. The flight went well, these values for mass were gathered using values posted on the manufacturer's website.

To account for any failures that may occur at launches, we have built 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 protocols will be followed, and our student safety officer constantly ensures that all members are working safely and efficiently.

- Mass Statement and Expected Growth
  Full scale versions of our rocket were launched multiple times and the vehicles at this launch were completely- ballasted arrangement as that of what will be flown down in Huntsville. This flight's success was also documented on the flight certification form by a 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 6 Range Safety Officer. Lastly, the rocket does not use forward canards, forward firing motors, motors that eject titanium sponges, hybrid motors, or a cluster of motors or multiple stages.

Safety and Failure Analysis:

- To account for any failures that may occur at our launches, we have built two subscale and will build two full-scale rockets to take with us to our launches. Additionally, we will build any replacement parts that will be needed to ensure availability. Because our team has built two rockets, we can repair rockets on the field or even swap out a rocket entirety to maximize efficiency at launches. During construction and launches, all safety protocols will be followed and our student safety officers will ensure all team members are working safely and efficiently.

Full Scale Flight Results

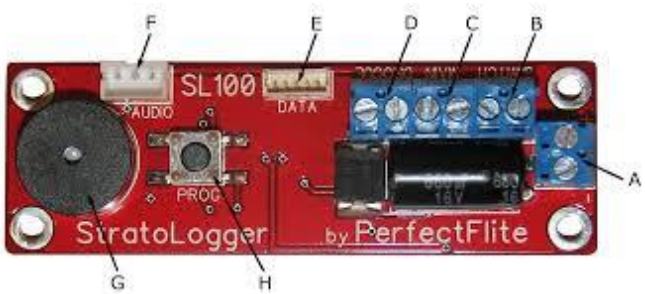
- We have built two full scale Rockets for testing before Huntsville. We have launched both of the rockets combined a total of seven times. We have launched the one full scale rocket four times. This rocket was very consistent with its flights, all of the flights were stable and the recovery systems deployed perfectly on all of the launches. This rocket was launched most recently the weekend of March 12th to 13th. It was launched one time this weekend. The height was relatively close to a mile reaching a height of 5471 ft. The height was slightly over the one mile goal but with adjustments we will be able to dial in to the height. Rocket two has been slightly more troublesome but only recently. This Rocket has been launched a total of three times. At the most recent launch the rocket proved the stability of its design by showing a stable flight path. Unfortunately this rocket's flight wasn't quite as smooth. We had a failure in our sheer pins in the nosecone and the main parachute came out at apogee. The rocket drifted for about five miles and it took about 2 hours to find and recover it. The height on this rocket was 5675 ft., this height was even farther away from the goal but adjustments are being made. We plan to add mass to the rocket to bring down the max height. We plan on launching each rocket at least five more times before we head down to Huntsville. Each launch will give us another data point that will allow us to dial in on the goal of one mile.

Recovery Subsystem

- Deploys a 36 inch drogue parachute at apogee, and a 72 inch main parachute at 600 feet
- The altimeter will record maximum altitude of rocket
- Checks for continuity within itself and its components
- Ready to set off second ejection charge if first one fails
- Outputs signal to simplify tracking
- Is capable of separating parts of the rocket without damaging any of them
- Makes the rocket recoverable and reusable!
- PerfectFlite StratoLogger altimeters can fulfill all these requirements
- We will be using an I-Bolt attached to the bottom of the payload to run the 1 inch tubular nylon shock cord to the ebay. The main end of the E-bay that is in the front half of the rocket has a U-Bolt on the end of it. We used a U-bolt instead of an I-Bolt because the U-Bolt allowed the sled to fit inside of the E-bay the easiest. The drogue end of the E-bay has an I-Bolt. This I-Bolt connects the shock cord the motor casing of the rocket. Attaching the recovery system of the rocket to the motor casing is easier than installing a separate bulkhead and it is also safer in the event of a motor failure. If there is a failure and for some reason the motor casing is ejected from the rocket it will still be secured to the recovery system ensuring as safe a landing as possible.

Ebay

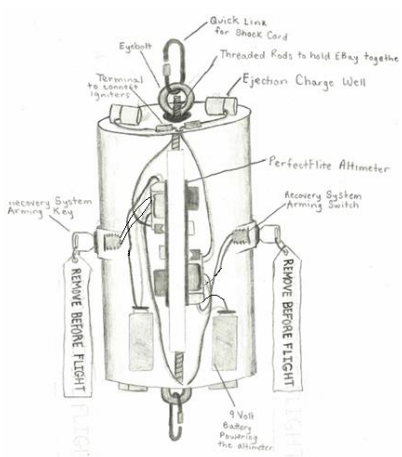
- The ebay was made of 4 inch fiberglass coupler tube with ¼ inch bulkheads on each side of the tube. All of this is held together by 2 ¼ inch all--thread rods with one wing nut on each side per rod. A ⅛ inch thick wooden sled will ride on the inside of the ebay held in place by the all--thread rods. On that wooden sled 2 altimeters will ride on either side to give redundancy to the ejection system. Each altimeter with be attached to its own key switch. The key switches will be mounted on the outside of the coupler tube. Each fiberglass bulkhead will have two ejection charge caps made out of the same material as PVC pipe. The two ejection caps are required to achieve redundancy. The blast from these two ejection charges will provide the force needed to separate the rocket and eject the drogue and main chute. One charge on each end of the ebay will be wired to one altimeter. The other two charges will be wired to the other altimeter. Each ¼ inch bulkhead will also be fitted with a ¼ inch U- bolt allowing for nylon shock cord to be

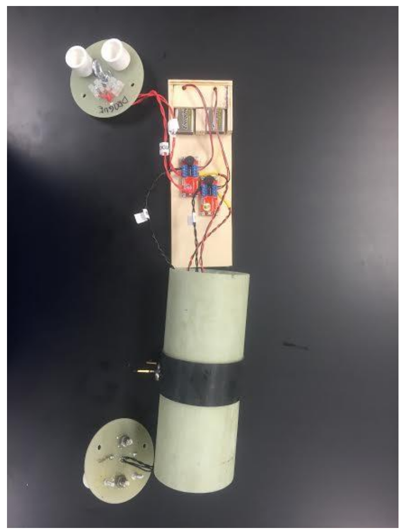


connected to it.

- A) Power in terminals.
- B) Switch.
- C) Main.
- D) Drogue.
- E) PC Data Transfer port.
- F) Audio add-on port.
- G)Speaker
- H) Program switch 8 the above picture is the schematic for the recovery systems altimeter.

- The below picture shows a 9-volt battery connected to a StratoLogger Altimeter. Bellow you can see that each altimeter will then be connected to two separate igniters that will be placed above and below the electronics bay housing. Ejection charges will be placed





onto these igniters. The entire system then will be grounded to the chassis of the electronics bay.

- For redundancy, there will an additional altimeter and two additional igniters and ejection charges to ensure the separation of the rocket. These altimeters will be armed from the outside of the rocket before launch using an electric key- switch that will be wired up to the altimeter to allow for arming of the altimeters and accurate deployment of the payload and parachutes.
- At our most recent full scale launch, February 20th, it was the last launch for our rocket and when we recovered it, the back half of the rocket had landed in a small stream. This resulted in wet recovery equipment but after cleaning the rocket we found that the wooden sled in our ebay had gotten wet from the launch too and there was mold growing on it as well as it being a little damp. As well as corrupted altimeters. We had to build another altimeter sled but the design schematics haven't changed so it will be the exact same as it was before. Also one of the two key switches that connect to the

altimeters was not functioning properly due to the same water damage so that was replaced with a new, functioning one.

- The recovery system is capable of deploying a 36 inch drogue parachute at apogee by initiating rocket body separation in front of the electronics bay. It will deploy a 72 inch main parachute at 600 feet during rocket descent by initiating rocket body separation in the back of the electronics bay. It will also set off a second ejection charge in case the first one does not fire, or does not completely separate the rocket body components. The recovery system will be able to record the maximum altitude of the rocket and verbally output this reading. It will be capable of reading the voltage of batteries operating the electrical components and verbally outputting this reading to ensure its function. The recovery system will be able to check for continuity within itself and its components, to ensure the correct operation of its electrical mechanisms. It is planned to be able to output a signal, perceptible by a tracking device, in order to foster rocket recovery. The system must be capable of separating parts of the rocket without damaging any of its parts. Most importantly, the system must make the rocket recoverable and reusable. The altimeters were selected for the recovery system (PerfectFlite StratoLogger) because they are capable of fulfilling all of these requirements as demonstrated in previous years use. The motor retention system should be able to take the launch vehicle and its components to an altitude of 5280 feet. At the same time, the system's intention is to be able to be ignited by a simple electronic ignition system. The rocket airframe is going to house all parts of the rocket needed for launch. It should also provide rigid stability to the rocket as a whole. The airframe will be smooth and aerodynamically sound with little air resistance other than that from the payloads air intake system. This rockets overall frame should also be able to provide the needed strength to survive the landing and make the rocket reusable, provided a functioning recovery system. The rocket airframe should also be able to maintain the intended Flight path with minimal deviation from its simulated path. Fiberglass was chosen to complete this task because of its rigid stability and strength. It also provides minimal air resistance during flight. The fins will be made from 3D printed ABS and Ultem which will be capable of withstanding the higher velocities attained by the rocket, while remaining impervious to the high intensity of he being expelled from the rocket motor, as shown in previous years.

Kinetic energy at key phases (landing)

Main

- Section 1 235.9
- Section 2 314.5
- Section 3 681.4

Drogue

- Section 1 18.2
- Section 2 24.2
- Section 3 52.5

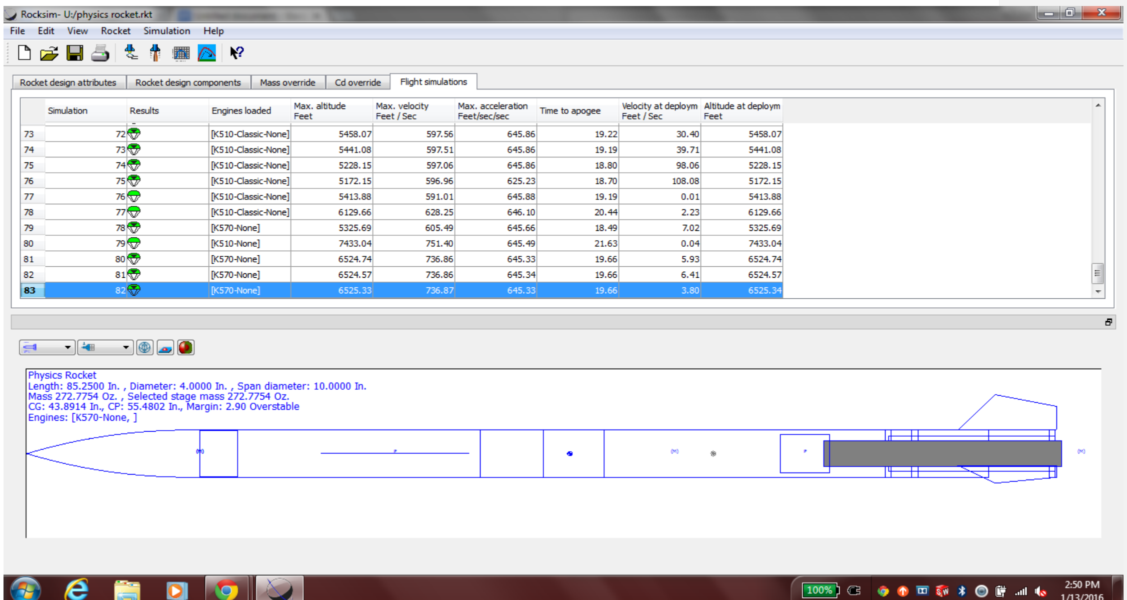
Safety is one of our main concerns when it comes to the recovery of the rocket. We have multiple failsafes in the event of a malfunction. In our electronics bay we have two altimeters that work as our main safety mechanism. The one altimeter is our main altimeter and it is the first altimeter to initiate detonation of the ejection charges. The second altimeter is our way of adding redundancy to the recovery system. The second altimeter detonates slightly after the first one to ensue the rocket separates completely. This redundancy makes the rocket much safer than it would be without it. The redundancy ensures safe and complete separation of the rocket. The chutes inside of the rocket also need to be folded in a very specific way to ensure that they open once ejected from the rocket. The SSO (Student Safety Officer) has been studying up on parachute folding by watching online videos. He's practiced folding both the main and the drogue chutes and he has it down to a science.

Mission Performance Predictions

Mission Performance Criteria

Currently our 85.25 inch rocket is projected to reach a height of 6,525 feet. This value is a based off of the acceleration of the rocket and rail exit velocity that is calculated with the program Rocksim. This height value is over 5,280 feet because we are expecting a large drag increase caused by the payload which is supported by data from our subscale flight. We can expect a loss in overall height of about 20%.

When the rocket leaves the pad, it will stay on its flight path upwards for around 19.66 seconds, than at apogee the 24 inch drogue parachute will deploy and then the



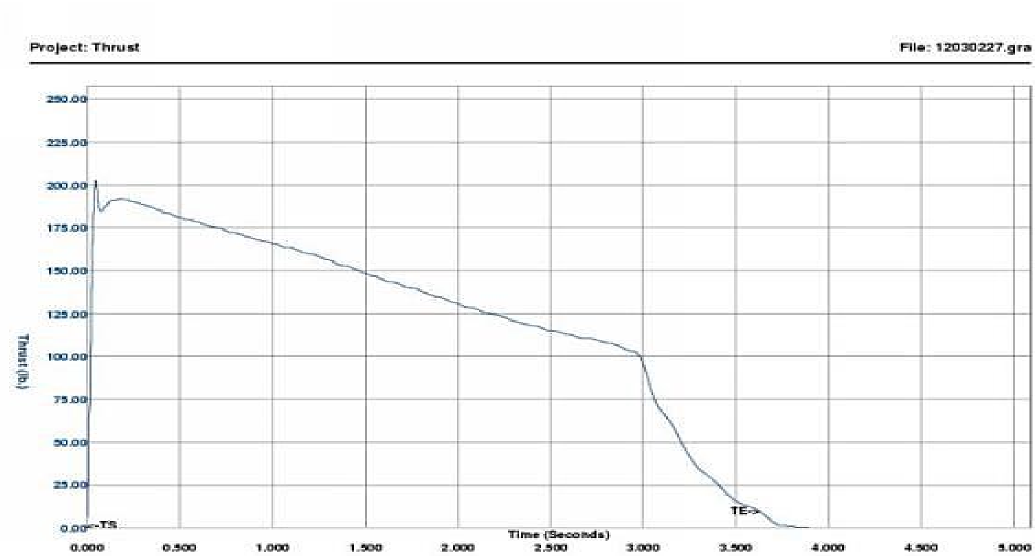
	Simulation	Results	Engines loaded	Max. altitude Feet	Max. velocity Feet / Sec	Max. acceleration Feet/sec/sec	Time to apogee	Velocity at deploym Feet / Sec	Altitude at deploym Feet
73	72		[K510-Classic-None]	5458.07	597.56	645.86	19.22	30.40	5458.07
74	73		[K510-Classic-None]	5441.08	597.51	645.86	19.19	39.71	5441.08
75	74		[K510-Classic-None]	5228.15	597.06	645.86	18.80	98.06	5228.15
76	75		[K510-Classic-None]	5172.15	596.96	625.23	18.70	108.08	5172.15
77	76		[K510-Classic-None]	5413.88	591.01	645.88	19.19	0.01	5413.88
78	77		[K510-Classic-None]	6129.66	628.25	646.10	20.44	2.23	6129.66
79	78		[K570-None]	5325.69	605.49	645.66	18.49	7.02	5325.69
80	79		[K510-None]	7433.04	751.40	645.49	21.63	0.04	7433.04
81	80		[K570-None]	6524.74	736.86	645.33	19.66	5.93	6524.74
82	81		[K570-None]	6524.57	736.86	645.34	19.66	6.41	6524.57
83	82		[K570-None]	6525.33	736.87	645.33	19.66	3.80	6525.34

1	Wind Speed (mph)	Total Drift (ft)
2	0	0
3	5	512.072
4	10	1301.22
5	15	2236.28
6	20	2680.33

main parachute at 700 feet with redundancy at 600 feet. Taking this into consideration, the rocket is expected to be in the air for roughly 20 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.

This is an accurate measure of the thrust over time graph for the K570 motor made by Cesarani Technology Incorporated.

Representative CMT Thrust Curve



Section 3:

Payload Integration

Internal Integration of Launch Vehicle

- The payload structure will consist of a 3d printed chamber designed to have the intake plate and top half of the air chamber inserted firmly into the nosecone leaving the lower half of the air chamber and the baseplate to be inserted into the front body tube section. These components will be held together securely with pop rivets to allow for easy disassembly while safely joining these components. Our vehicles nose cone will have an intake hole at its peak which will be connected to the top of the payloads' intake plate via a cylindrical tube that will transfer airflow into the payload through its intake plate and thus into the air chambers' past the turbine and thanks to the 3d printed exhaust cone, that will mount onto the payloads base plate, air will be directed out of the sides of our vehicle. The air will escape from corresponding exhaust ports at both, the base of the air chamber and the front body tube. This exhaust method is key to our rockets design as it will drastically decrease drag created by the air intake, allow continuous flow of air through the payload, and keep our vehicle from building up unwanted and possibly catastrophic pressure in the forward section of our vehicle on its accent.

- Team Tesla's rocket is designed to be comprised of three separate sections, each attached together with nylon shock cord. These sections of shock cord are attached to the rocket compartments as follows. Firstly starting from the base of the payload which will have a ¼in ubolt secured through the base plate. Both the nose cone and front body tube section will be firmly connected onto the payload via rivets thus connecting the front half and nosecone too the Ebay section at the center of the launch vehicle with nylon shock cord. In the front body tube between the ebay and payload the main chute will be attached to the nylon shock cord via quick links. On both sides of the ebay there will be a ¼in ubolt which nylon cord will be able to attach too. Between the rear of the ebay and the back half of the rocket's body tube where a Ibolt or U bolt will to the motor mount. A section of shock cord will attach to our main chute via quick links such as used on the drogue chute.

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 of 100 feet.

Motor Preparation

- The motor is being built by our Level III NAR representative, Brian Hastings. 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 Cesarani Motor. It will be inserted into the motor so that it can ignite the motor causing the rocket to lift off.

Preflight procedures

- Test data logger in payload
- payload intake needs unblocked
- Insert rivets into payload, nose cone, and front body tube
- 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 and holding rocket together
- test key switches
- take rocket to pad with igniter
- place rocket on pad and arm altimeters, then remove key switches
- insert igniter into motor
- walk away to a safe viewing distance

Post Flight Procedures

- Recover rocket
- Check for damages
- check for zippering of body tube
- check shock cords
- make sure parachutes don’t have holes

Safety and Environment (Vehicle and Payload)

Conceivable failures in our proposed rocket design

- These include but are not limited to adhesion failure, breaking of bulkheads or centering rings, and using a motor that is unable to carry the rocket and payload to the proposed height. Also, the rocket may be unstable or the structural integrity of the body tube is not great enough to handle the high forces and pressure that it will undergo.

- Ways to mitigate these happenings are using an adhesive, such as epoxy with a long curing time, which will be strong enough to adhere the components without the bond breaking. We will choose a material thick enough to suit the needs of these components by testing them under high stress situations. The stability will be checked on rocket programs and the fins will be substantial enough to keep the rocket stable without over stability occurring. The tubing we are planning to use is fiberglass so the structural integrity should not be an issue. Problems that may arise in payload integration include the payload being too large for the selected tube, not being able to properly attach to the shock cord, and insufficient space due to other interior parts. To lower the risk of coming across these errors or other unforeseen errors we will check that the exterior diameter of the payload and the interior diameter of the body tube and see that they will fit together and leave adequate room on said components for any printing errors on the 3d printer. We will design the payload so that it will easily attach to the shock cord and it will be safely attached. When designing the rocket the size of the payload and other apparatuses will be taken into account and then verify there is enough room for all the parts inside the rocket to avoid complications.

- Failures that may arise in the launch operations are a motor delay, the ejection charge not being set off, and having an ejection charge that is not powerful enough to break apart the rocket to provide a safe decent. To help prevent these we will ensure that our NAR representative properly build or rebuilds the motor as well as using the proper launch mechanisms. To mitigate ejection charges not being set off we will redundantly wire the system so that there are two wires that will ensure that the ejection charge does go off or possibly even having multiple ejection charges. We will use the proper amount of black powder in our ejection charge so that it will break apart the rocket to provide a safe decent. Update the listing of personnel hazards and data demonstrating that safety hazards have been researched, such as material safety data sheets, operator's manuals, and NAR regulations, and that hazard mitigations have been addressed and enacted.

Environmental Factors

- As the Spring Grove SLI team, being environmentally friendly is one of our major concerns. Our project is very environmentally safe and has little environmental concerns. The only way our rocket would affect the environment would be if the rocket got lost after launch and became unrecoverable. The burning of the black powder and motor can produce potentially irritating, corrosive, or toxic gases. However, the amount of toxic gases released should be very minimal with the amount of black powder that we are using, making the launch still environmentally friendly. If the rocket was to be unrecoverable the environment would be slightly affected. Animals who consuming the potentially hazardous parts could be affected. We make sure most of our rockets are recoverable by making them land in a 2500 foot radius.

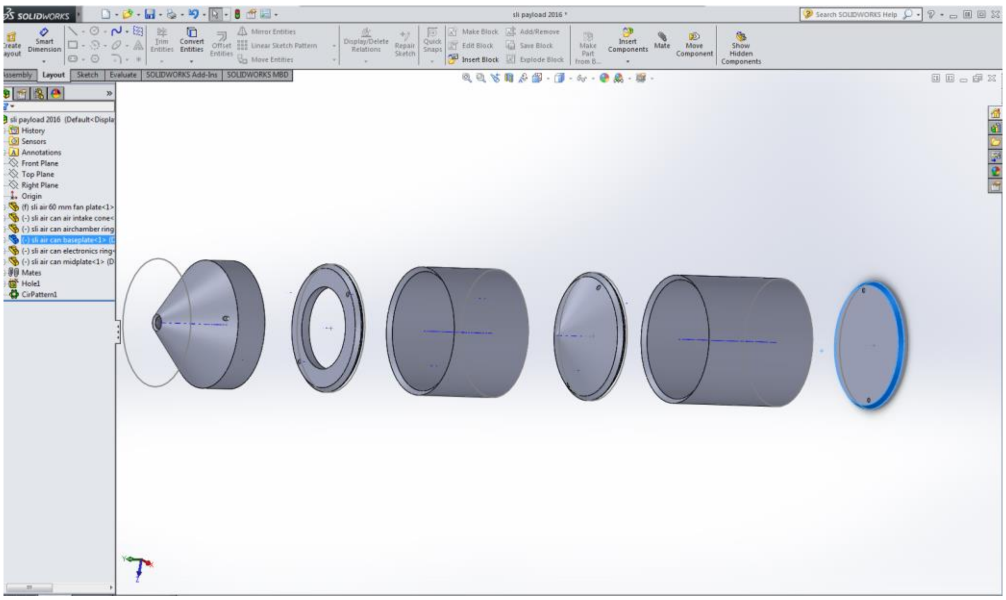
- The environment may affect our vehicle in many different ways. Humidity may cause the rocket not to travel as high. Gusts of wind will cause rocket to travel far away from launch pad when parachutes are deployed. Rain will hurt electronics if they get wet.

- Any type of wet landing surface like a creek, pond, or lake may damage electronics or payload data.

IV) Payload Criteria

Testing and Design of Payload Equipment

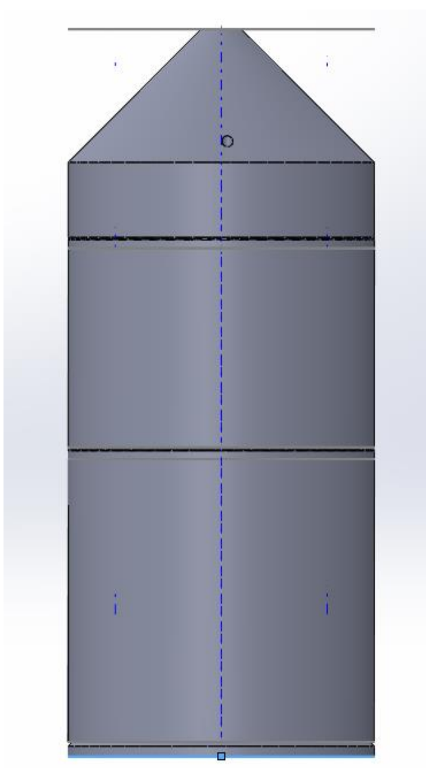
Review of Payload Design and Systems



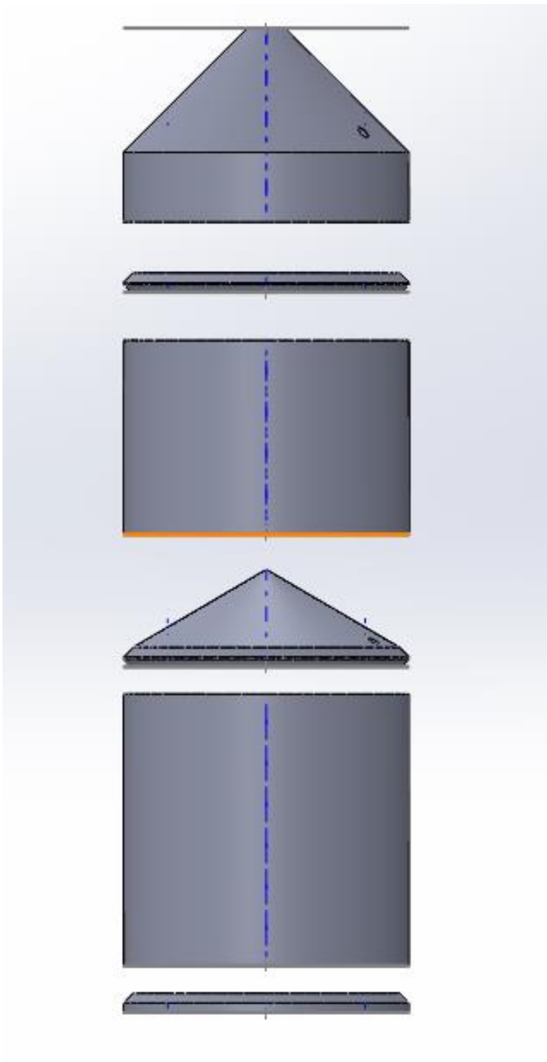
- This year’s payload for the Spring Grove SL team will test how airflow through a turbine will generate a current. The payload will have a small computer fan placed into a bulkhead and then wired to an ammeter lower in the payload. The airflow for the turbine will be generated by the rocket on its way up to apogee. The turbine we will be using will be a small computer fan because it already has a small motor attached to it. A small tube will be placed directly above the turbine in the nose cone and will run directly to the tip of the nose cone so air can flow to the turbine. The tube running from the tip of the nose cone towards the fan will have a funnel inverted over the turbine to maximize airflow. Approximately 3 inches below the bulkhead holding the turbine we will place another bulkhead to seal of the payload. Small spill holes will be drilled between these two bulkheads so the air has somewhere to escape to after it runs through the turbine. The complete payload should be no longer than a foot when it’s completed, the smaller size of this payload will make it easier for the nosecone to eject off the rocket when the parachute deploys. It will be built out of fiberglass coupler tube built for a 4 inch diameter rocket so the fit should be nice and smooth. The payload will be half in the nose cone and half in the body tube, it will be inserted in the nose cone and pop riveted in place before each launch. The placement of this payload is vital to the experiment, without easy access to the nosecone there would be no way for us to get airflow to the turbine in the payload. The placement is also important when it comes to deploying the parachutes, last year the placement of the payload made it very difficult for the main chute to come out. This year the payload is smaller and won't be held into place so tightly allowing for easier deployment.

- This shot shows a side view of the nosecone and payload air chamber. You can see two pieces of all thread running from the bottom bulkhead the whole way to the top, these pieces of all thread will be responsible for holding the payload together. The cone shaped pieces on the two bulkheads serve to direct the airflow. The cone on the bottom bulkhead directs the airflow out of the spill holes at the bottom of the payload.

- In this screenshot you can see the way that the payload will fit together and the



way it fits in the nose cone. If all goes smoothly the payload should word as an extension of the nose cone. In this picture you can more clearly see the spill holes cut into the bottom of the payload. The main objective of the payload is to find the relationship between wind speed and current produced. The payload to be considered a success it will need to collect data the duration of the whole flight. We're hoping that once we recover the rocket we'll have a smooth curve graph of our data charting the correlation between speed and current. We expect that as the rocket accelerates upward the wind speed through the payload will increase, in turn increasing the speed on the impeller. As the impeller speed increases the current produced will increase. The graph should look somewhat like the normal curve after the flight. The current will increase as long as the motor is burning and then start to decrease once the motor is fully burned. On launch day payload preparation should be relatively easy. The computer fan and ammeter will slide completely out of the payload so they can be checked before each launch. The payload won’t require any external power sources which will make the wiring easy. The only wiring in the payload will be the ammeter and the computer fan. The ammeter will be wired in series with the computer fan so it can collect data from the fan. Safety with this payload should not be an issue. As long as the payload is securely connected to the nosecone there won't be any issues. Before each launch the team will check over the payload to make sure everything



is secure and structurally sound. The main payload compartment will be attached to our nosecone with pop rivets before each launch. A bulkhead on the bottom of the payload will have a UBolt on it connecting it to the recovery systems of the rocket.

Payload Concept Features and Definition

- We on team tesla believe that this a unique form of energy generation that is quite unheard of and thus have decided to pursue its research and development. It is significant because the energy collected via this method could be used to power onboard systems for future small scale missions or vehicles propelled by fuel and thus convert such energy into electrical energy.
- The complexity of creating proper airflow through the payload as to create as little drag as possible as well as get the greatest current collection rates possible without reaching tolerances of parts such as max RPMs of the turbine, makes this experiment suitably challenging for this level of team.

Payload Data

- We have tested the payload live in two separate launches. We launched the payload two times the weekend of March 12-13 but unfortunately both times no data was collected. We know the fan in the payload creates current because it we tested it with a multimeter before launching. We believe that the issue is with the data logger we are using to collect the data. We are going back to the drawing board to look for a new way to collect the data from our payload. Even though we came back from our launch without the data we were looking for we found a critical issue and now that it’s found we can work on fixing it.

Science Value

Payload objectives.

State the payload success criteria.

- The objective is to collect energy on assent and calculated the rate at which it is collected vs the assent speed of the rocket.

Experimental logic, approach, and method of investigation.

- The payload will be considered a success as long as data is recovered and a collection rate vs speed is extrapolated from the data.
- The experiment will collect data on the vehicles assent then record that data for later viewing, at which point a rate of generation can be calculated. Rather than

trying to calculate data from changing air density and intake rates with a changing acceleration.

Describe test and measurement, variables, and controls.

- Measurement of current, will occur over the assent of the rocket variables are wind speed during the course of the launch and given the assent speed throughout the launch.

Show relevance of expected data and accuracy/error analysis.

- Accuracy will mainly be affected by the friction created from the bearings within the turbines generator itself and the airflow through the turbine.

Describe the experiment process procedures.

- On the rocket's ascent, data will be recorded for future analysis and said data will recovered on retrieval of the launch vehicle

V) Launch Operations Procedures

Checklist

Launch Operations Procedure

A. Recovery preparation

1.Zeb Shroud Lines of all parachutes untangled. Drogue Parachute, Main Parachute folded properly using z-fold technique following the fruity chute guidelines.

Signature ______________________

Verification ____________________

2.Zeb Fireproofing ready to place covering both sides electronics bay for the protection of parachutes from charges.

Signature______________________

Verification_____________________

3.Josh & Zeb Attach tracker to drogue shock cord about 6 feet from electronics bay. Use electrical tape around tracker with transmitter tail sticking out.

Signature___________________________

Verification__________________________

B. Electronics Bay Preparation Gavin & Zeb

1. Batteries secured tightly to battery holder using zip ties crossed on each side.

2. Use flat head screwdriver to check each wire connection to each port on altimeter and use Phillips head screwdriver to check wire connection to terminal strip.

3. Turn on Drogue key switch and listen for correct series of beeps. Turn on main key switch and listen for correct series of beeps.

4. Use USB Data transfer kit to check deployment of parachutes at proper heights for drogue parachute at apogee and main parachute at 600 feet.

5. Use E-matches to test fire ejection charges for each altimeter including redundant to make sure wiring is done properly.

6. Put sled into Electronics Bay carefully and close bulkheads on each side tightening nuts on all thread using crescent wrench.

7. Oversee mentor using the proper amount of black powder in each ejection well. 2.5 grams in both wells on bulkhead labeled drogue- 2.5 grams in both wells on bulkhead labeled main. Use wadding in well with electrical tape overtop.

Signature for all Electronics Bay Work _______________________________
Verification for all Work ____

C. Payload Preparation David

After setting data logger

1. Attach data logger to wires leading to the turbine
2. Place data logger into cradle on payload baseplate
3. Attach payload to baseplate by sliding it onto all thread rail
4. Close payload by tightening wing nuts on baseplate.
5. Attach shock cord to u bolt on baseplate and tighten securing nut on quick link
6. Insert payload into nose cone base
7. Secure payload in nosecone with three screws through nose cone wall after insuring vent ports are aligned.

Signature for all Payload Preparation_________________
Verification for all Payload Preparation________________

D. Rocket Preparation Zeb

1. After placing payload in rocket, attach safely shock cord with quick link on back side of payload.
2. Place 36-inch Drogue into back body tube below electronics bay
3. Attach shock cord from Payload to Electronics Bay with quick link
4. Place Main parachute into front body tube
5. Attach 25 foot shock cord from main parachute to front side of electronics bay using a quick link

Signature for Rocket Prep____________________
Verification for Rocket Prep____________________

E. Motor Preparation

- Brian Hastings: The motor is being built by our Level III NAR Representative, Brian Hastings. He will assemble the motor with caution. He will follow all instructions so that the motor is built and will perform properly.

Signature_______________________
Verification______________________

F. Setup on Launcher

- The rocket will be set up on the launch pad and we'll make sure the launch lugs are smooth moving up the rail. If not smooth we will use sandpaper and file to make sure rocket slides easily. The keys in the electronics be turned and removed. We will listen to make sure beeps are correct and altimeters are functioning properly.

Signature_______________________________
Verification______________________________

G. Igniter Installation

We will be using the igniter provided with the Cesarani Motor. It will be inserted into the motor so that it can ignite the motor causing the rocket to lift off.

We will close off the motor with the igniter inside with the end cap provided with the Cesarani Motor.

Then the igniters will be securely attached to the alligator clips that will send a current to the rocket that launches it off the pad.

Signature___________________________

Verification___________________________

H. Launch Procedure (Pre-Flight Checklist of all parts)

1. Follow instructions on Recovery Preparation for electronics bay and parachutes. See A and B
2. Parachutes are in proper position in rocket. See A-4
3. Observe building of motor by NAR mentor. See E
4. Connect the body tubes together with the electronic bay, place the bulkhead labeled drogue in the back body tube and the bulkhead labeled main in the front body tube.
5. Place 4 number 4 shear pins into electronics bay on the front body tube to hold rocket together.
6. Take rocket to pad with igniter.
7. Place the rocket on pad and arm the altimeter. Then remove the key switches and listen for the correct series of beeps from each altimeter. See F
8. Place the igniter properly in the motor. See G

Signature for all Pre-Flight Checklists ___________________________

Verification for All Pre-Flight Checklists ____________________________

I. 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.

If troubleshooting was needed:

Troubleshooting reason______________________

Signature__________________________________

Verification________________________________

Solution for problem________________________

J. Post-Flight Inspection David

1. Verify rocket is not hazardous to retrieve.
2. Verify all ejection charges have gone off.
3. Inspect all parts are in the right place and where they should be.
4. Check that shock cord is still on both sides of electronics bay and has not been compromised.
5. Parachutes are still attached.
6. Carry rocket carefully back to home base
7. Use USB Data transfer kit to get altimeter readings from electronics bay and each altimeter in each separate section of payload

Signature of Post-Flight inspection ________________________________

Verification for Post-Flight inspection ______________________________

VI) Project Plan

Timeline:

- August 7, 2015: Request for Proposal (RFP) goes out to all terms

- September 11, 2015: Electronic copy of completed proposal due to project office by 5pm
- September 20, 2015: Launch to help give new team members experience.
- October 2, 2015: Awarded proposals announced
- October 7, 2015: Kickoff and PDR Q&A; work after school from 2:50 to 5:00
- October 23, 2015: Team web presence established
- November 6, 2015: Preliminary Design Review (PDR) reports, presentation slides, and flysheet posted on the team website
- November 9-20, 2015: PDR video teleconferences
- December 4, 2015: CDR Q&A
- January 15, 2016: Critical design review (CDR) reports, presentation slides, and flysheet posted on the team website
- January 19-29, 2016: CDR video teleconferences
- February 3, 2016: FRR Q&A
- March 14, 2016: Flight Readiness Review (FRR) reports, presentation slides, and flysheet posted to team website.
- March 17-30, 2016: FRR video teleconferences
- April 13, 2016: Teams travel to Huntsville, AL; Launch Readiness Reviews (LRR)
- April 14, 2016: LRR's and safety briefing
- April 15, 2016: Rocket Fair and Tours of MSFC
- April 16, 2016: Banquet; launch day
- April 17, 2016: Backup launch day
- April 29, 2016: Post-Launch Assessment Review (PLAR) posted on the team website
- May 11, 2016: Winning team announced

Team Schedule:

As far as team members collaborating all at once, there will be two types: Meetings, and Sessions. The Meetings will be conducted by the Co-Captains. Sessions however, will be only for team members with an advisor only supervising, to let them work as a team. This will help with communication and team building. Our schedule will include both general and formal meetings, briefings during homeroom, sessions included for work, bonding, and construction

Meetings:

At our general meetings, tasks will be assigned to team members and information will be given to them as to what they need to do, when works need to be completed to, and who to turn them in to. These meetings are very informal and are short because they will be held before the work sessions begin during that day.

More formal meetings will have a strict agenda to them as we need time to discuss imperative information and goals/deadlines that are approaching. Teams will also include progress reports on certain and specified tasks that have been assigned, and will discuss problems that they have seen throughout the course of the week. Team members and our Mentor will be able to share their thoughts and comments and will discuss the aforementioned topics as a respectable team.

Briefings will be short, informative meetings during homeroom that consists of a collective report of any and all work that has been completed, and progress on any unfinished tasks. These meetings will be used to inform team members of any changes to any part of the group as a whole.

Sessions:

- Sessions are a type of counseling meeting, meaning that we will use this time to discuss personal problems and challenges that have seemed to arise within the course of the completion of the project. Team members may share personal problems that are affecting their ability to complete their set task. This will allow the team to help each other and pick up each other’s slack. Since these are only held with team members, the members can be honest about how they feel, allowing the Team as a whole to resolve the problem(s) at hand. Our goal is to have as much fun as we can while completing SLI this year with the least stress as possible. These sessions will help with bonding and working cooperatively.

- Part of these sessions are to make an effort to grow as a team and cooperate well, thus they will be labeled bonding sessions. These will be held to help improve the bond between team members and mentor. They’re designated to help team members build relationships outside of SLI, so we will be doing various activities like watching movies about science and aerodynamics.

- Work sessions will be held to work on reports that are needed through the project, these will present the opportunity for team members to clarify any confusion about certain parts and allow for easy communication. There will be updated progress reports to see what needs to be completed and what has been completed. It will give the chance for our two teams to work together and assist each other as needed.

- Constructions sessions will be used for when the teams need to work on the physical aspect of the project, including the sub-scale rocket and the final rocket we will take to Huntsville. Team members will be paired to work on specified parts of the rocket or payload so that we prevent as many mistakes and accidents as possible. Partners are available in case something does happen, so that in case an accident does occur, they are able to get help. Construction sessions will always have adult supervision in case a serious accident occurs. Both team members will be required to read and abide by all safety rules regarding the operation of tools, for everyone's safety.

Meeting Times, Session Times, and Proposed Schedule:

- Meetings and sessions will be held on several different dates; general meetings will be held every day when the team is capable of meeting together, typically before work sessions and before/after school hours. Formal meetings will be mandatory meetings that will be ideally held once a week from about 3:00pm to 5:00pm. Briefings will also be mandatory, as they are ideally held every Friday from 3:30pm to 4:30pm. Group sessions will be held every other week on the day that is more convenient for the team at the time. Work sessions will be held during any of the available times after school, allowing for convenience for each team member and mentor. Construction sessions, once the teams have met that point in the year, will be held once or twice a week with Friday being our official construction day. Extra days will be assigned as needed later on in the project to assure that we stay on schedule. Partners must be present during the construction sessions for a team member to be able to do any work on their designated task. These construction sessions will also be under close supervision by a mentor so in case any of the issues stated above arise.

I. Budget:

Item:	*Cost (In Dollars):*
Travel to Huntsville	6,000.00
Food for All Trips:	4,354.00
Practice Trips to Maryland	8400.00
Lodging in Huntsville	3,600.00
Nose Cone	19.95
Body Tubes	399.80
Rocket Mount	4.99
Fast-Hardener	43.94
Resin	84.96
Shock Cords	47.80
Large Parachute	188.00
Small Parachute	113.00
Centering Rings	55.88
Bulkheads	70.54
Motor Casings	149.95
Reloads	1531.80
Reload for subscale	650.90
tube Couplers	74.00
Motor Mount Tube	9.95
Engine Retainers	72.76
U-Bolts	15.84
Quick-Links	14.88
Altimeters	1,119.03

Batteries for E-BAY	25.46
Wire	30.78
All-Thread rods	6.40
Key-Switches	106.68
Subscale Rocket	500.00
Alkaline Batteries	29.98
Nylon Webbing	25.49
9 Volt Batteries	14.55
Sanding Paper	5.81
Coping Saw	17.97
3 Volt Batteries	6.44
3D Printer Filament	21.22
Camera	99.99
Battery Holder	5.60
Other Necessary Items for building sessions	3,344

I. Funding Plan:

In order to receive the necessary funds and in order to successfully complete this project our team intends to cover the costs through a combination of fundraisers, donations and sponsors/grants. All of which will be completed and then sent to our financial advisor for approval. Our club will be taking part in fundraisers throughout the year to help finance our endeavor. Current fundraisers include "Nuts About Granola" (information is located at (www.nutsaboutgranola.com), selling cotton candy at locale sporting events, Bonus Books (information is located at www.bonusbook.com), Yankee Candle (information located at yankeecandlefundraising.com), Paint nights, and we are currently trying to approve other fundraising options that are not yet official. Our clubs are currently accepting all donations and bring donation jars to all the events that we are planning to take part in to reach our goal of $25,000.

I. educational outreach:

To publicize our project, our team will be contacting local television stations like FOX 43 of the FOX Corporation and WGAL 8 in the Susquehanna Valley, just as we have done in previous years. We will also be contacting local radio stations like 107.7 and 105.7 to broadcast news of Spring Grove's SLI team. Lastly we will contact local newspapers to spread the word of the Spring Grove Rockets. We will be sending each of these kinds of organizations information about us and asking if they were willing to spread awareness about our club. We will also be using our own SL website to notify the public about the project and to post updates. We plan on making presentations to both our middle school and intermediate school about our project and the clubs offered at our high school to help get the kids more into and aware of the great possibilities that SLI provides. We also intend to create posters to put around our school and local businesses to promote and encourage sponsorship and donations.

I. Sustainability Plan:

We intend to keep our SL club together now and into the future through a combination of many plans and elements. We intend to maintain all of our current relationships by send them regular reports, maintain an active dialogue with them and taking their feedback into account. Our current relationships are with several certified NAR members, Advanced Application Design and the Engineering Society of York. Now, in keeping a steady stream of new members coming into the club, we will primarily recruit new members from our TARC teams who have had past experience in rocketry but we are willing to accept anyone who wants to join and is willing to put in the work. We will be using a combination of announcements, posters, and our website to get the word to potential club members. We intend to engage the students of Spring Grove Area School District in our club and mission through a series of assemblies and workshops. Lastly we intend to keep a steady stream of funding coming in through fundraisers, donations and sponsors and grants. This will all ensure that our club is maintained well into the future. We also plan to:

a. Avoid safety hazards is to have team members and supervisors read the all operation manuals for the tools and products that will be handled during the completion of our project before proceeding with any of such devices or products, while following the enclosed safety plan.

b. Address if a team member is comfortable with using a tool at any time or not. ·
c. Raise enough funds for our project we will be holding public outreach programs for funding and support we will be contacting local businesses for grants such as our local power company's (Met Ed's)
d. Stay on budget, we will keep track of all funds being used and track whether the prices of materials are within the projected coast by researching for the best pricing of the materials. If going over budget is inevitable, due to rising prices of materials, we will raise more funds from companies using our progress on the project to incite sponsorship from more companies and businesses.
e. In order to make it to Huntsville, we want to work with people, local businesses, and corporate sponsors in and around the Spring Grove area. We plan on spreading awareness of our rocketry programs at Spring Grove to every adult and student in the area, to accomplish this we would like to create hands-on learning experiences for kids in our community to explore and learn more about the rocketry field.
f. We will also be holding public out-reach and funding programs at school and local events to help with awareness of our project to get the attention of adults of our community.
g. We hope to have small groups work together and build small scale rockets, each group will have an SL member directing the group to help teach the students to build the small rocket. If feasible, we may launch the said rockets (if they are deemed safe to fly). We want to provide fun hands on experience for our students so more students will be interested in joining TARC and potentially even SL in the future.
h. In order to spread public awareness, we are planning to contact television stations, such as FOX and our local news channels, to see if they are interested in making a short segment on the SL program of Spring Grove High School. We will also contact local radio stations such as 107.7 and 105.7 to see if they are interested in speaking on behalf of our program here.

VII) Conclusion

We have made progress on the project following our CDR presentation. Improvement in write ups and designs are our main goals for the future reports.

Support from the community is still a huge factor in the success of this program. Without them, our SLI project would be almost impossible to complete. Education to the community about the project is key in gaining this support. We encourage all students to get involved with the SLI team in STEM programs. Presentations, seminars, rocket launches, and a variety of workshops will allow students to experience rocketry first hand. We want all students to know that they have the potential to succeed at whatever they so desire, such as being a rocket scientist or an engineer in their future. Our support for the students will help gain us the respect and support of the community.

We are currently tweaking the overall height of our rocket and working on presenting our team’s education presentation this coming Wednesday.