York College of Pennsylvania
NASA Student Launch 2017-2018
Post–Launch Assessment Review

The Aurora Project

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General Information

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

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Motor Used

The motor that was used for our full-scale launch was an Aerotech L1520T-PS Blue Thunder motor. This motor provided a total impulse of 3,716 N*s and propelled our rocket towards an eventual height of 4,476 feet. Additional information about the motor can be found in Figure 1.

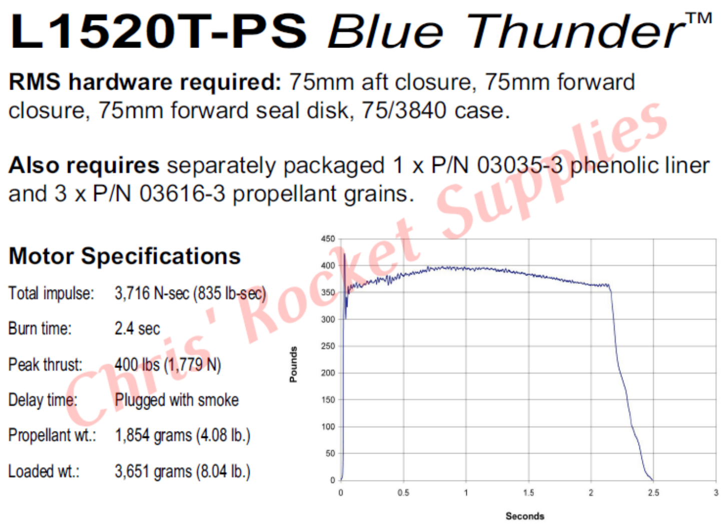

Figure 1: L1520 Motor Information
https://csrocketry.com/rocket-motors/aerotech-rocketry/motors/75mm/75/3840-reloads.html

Brief Payload Description

The Sparta Lander was an in-house design by York College of Pennsylvania students and advised by faculty members to complete the task of being deployed from the internal payload compartment within the rocket's airframe and displacing itself five or more feet from the launch vehicle. Once there it was tasked to then deploy a solar panel, all autonomously. The four wheeled, Arduino powered rover was 5.85 inches wide (front to back), 2.78 inches tall (height of the tires), and 8.75 inches long (side to side), and was housed inside the rocket between two semi-circle shaped trays. The rover was deployed sideways and would drive at 90 degrees to the long axis of the payload tube. The ultrasonic sensors would determine if the payload itself was still inside the tube or in open space by measuring the distance in front and behind the rover. The four independently operable motors were designed for high-torque use with very minimal current consumption and each had its own tire.

Vehicle Dimensions

The full-scale rocket was built to a final length of 136 inches and featured two carbon fiber airframe tubes, along with a fiberglass-wrapped phenolic payload airframe tube to allow for uninterrupted RX/TX communication with the receivers housed there for the payload deployment system. The full-scale rocket was made up of a 6” diameter airframe with an inner diameter of exactly 6.007 inches. The payload tube was exactly 26 inches in length, which housed our payload, “The Sparta Lander”. The middle body tube was 38” long and housed the main parachute which was ejected from the rocket at a height of 550 feet on its’ descent. The bottom tube was 48 inches in length and housed the drogue parachute, the motor, and securely held the fin can system.

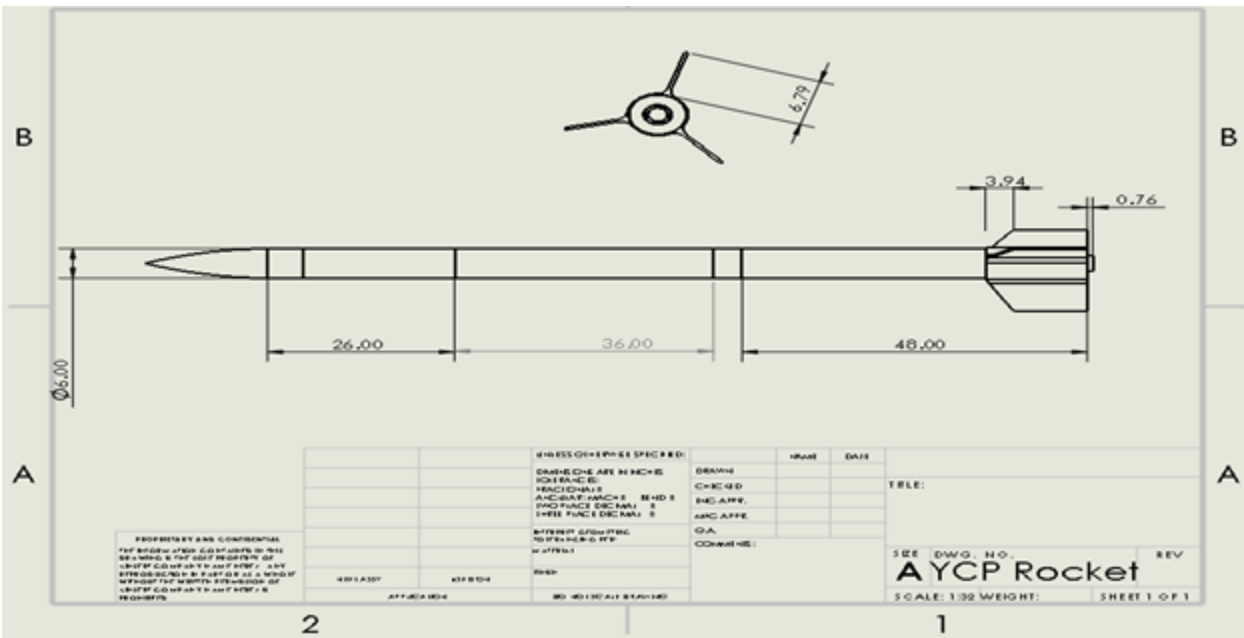

Figure 2: Dimensions of Full-Scale Rocket Created Using SolidWork’s

Altitude Reached

The official altitude reached during the National Championships held at Bragg Farm in Toney, Alabama was **4,476 feet.**

Vehicle Summary

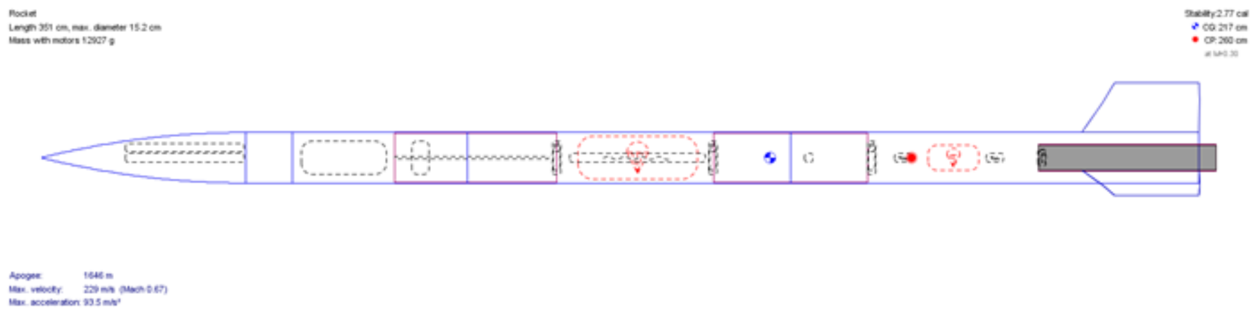

Figure 3: OpenRocket Full-Scale Rocket Design

“Artemis”, as the team named it, was the first full-scale rocket to be built on the campus of York College of Pennsylvania and will forever be a piece of the college’s history. Artemis was able to provide the 10 students who participated in this year’s project with a new outlook on engineering and provide them with new skills that will last them a lifetime. After 5 months of intense design and testing work, the rocket was constructed using carbon fiber composite tubes for the front and back halves of the rocket. The payload tube was then constructed using a fiberglass-wrapped phenolic tube, because after testing the RX/TX communication system inside the carbon fiber tubing, it was found that the carbon fiber acted like a Faraday cage, blocking the wireless signals to the payload integration system. Phenolic coupler tubes were used, each being at least twelve inches long to ensure structural stability and ensuring a straight flight profile upon launch.

The vehicle’s recovery system was made up of 30-foot lengths of ⅜” twisted Kevlar shock cord manufactured by Giant Leap Rocketry. Connected to the shock-cord were an 18” drogue parachute in the back-half of the rocket, and a 120” main parachute in the front-half of the rocket both manufactured by Geoff Cooper of ParaMedichutes. For our electronic ejection system, we used two completely redundant PerfectFlite StratoLogger altimeters. Each altimeter had its own 9-volt battery. There were two black powder ejection charges for both the drogue and main parachute ejections. The second ejection charge was delayed by two seconds to ensure that the parachute would be deployed even if the first charge were to fail to separate the body tubes.

For being a first-year team, we spent a significant amount of time on innovation and how we could be more efficient and cost-effective in the building and launching of the model rockets that we were constructing. One design that was unique to our team was our fin-can design. For our fins, we used a custom-designed 3D-printed one-piece fin can. This fin-can was designed in Solidwork’s and gave us a few major advantages compared to normal “through the wall fins”. One major advantage is that it can be printed to have three exactly identical fins that are also exactly 120 degrees apart from one another and lined up parallel to the air-frame. This saves a significant amount of time in fabrication and labor. The other main advantage is the ease of use and the cost-efficiency that it brings. If a normal rocket were to break a fin, it would require a new back-half to be constructed. With our removable 3D fin-can we can replace a broken fin in a matter of 5 minutes without having to worry about rebuilding a substantial portion of the rocket.

Data Analysis and Results of the Vehicle

Figure 4: Altitude vs. Time Graph of the Full-Scale Flight

On April 8th, 2018 at approximately 11:30 AM, we launched our full-scale rocket at Bragg Farm in Toney, Alabama. The rocket left the launch rail and maintained a straight flight profile. There was no fin-flutter from the 3-D printed fin-can and the rocket was able to counteract the 10 mile per hour gusts that spread across the launch field. This was maintained by an accurate stability margin calculation along with center of pressure and center of gravity measurements that were within 4% of the simulation predicted values.

Figures 5-7: Artemis Coming off the Rail
Courtesy: Tahoma Photography

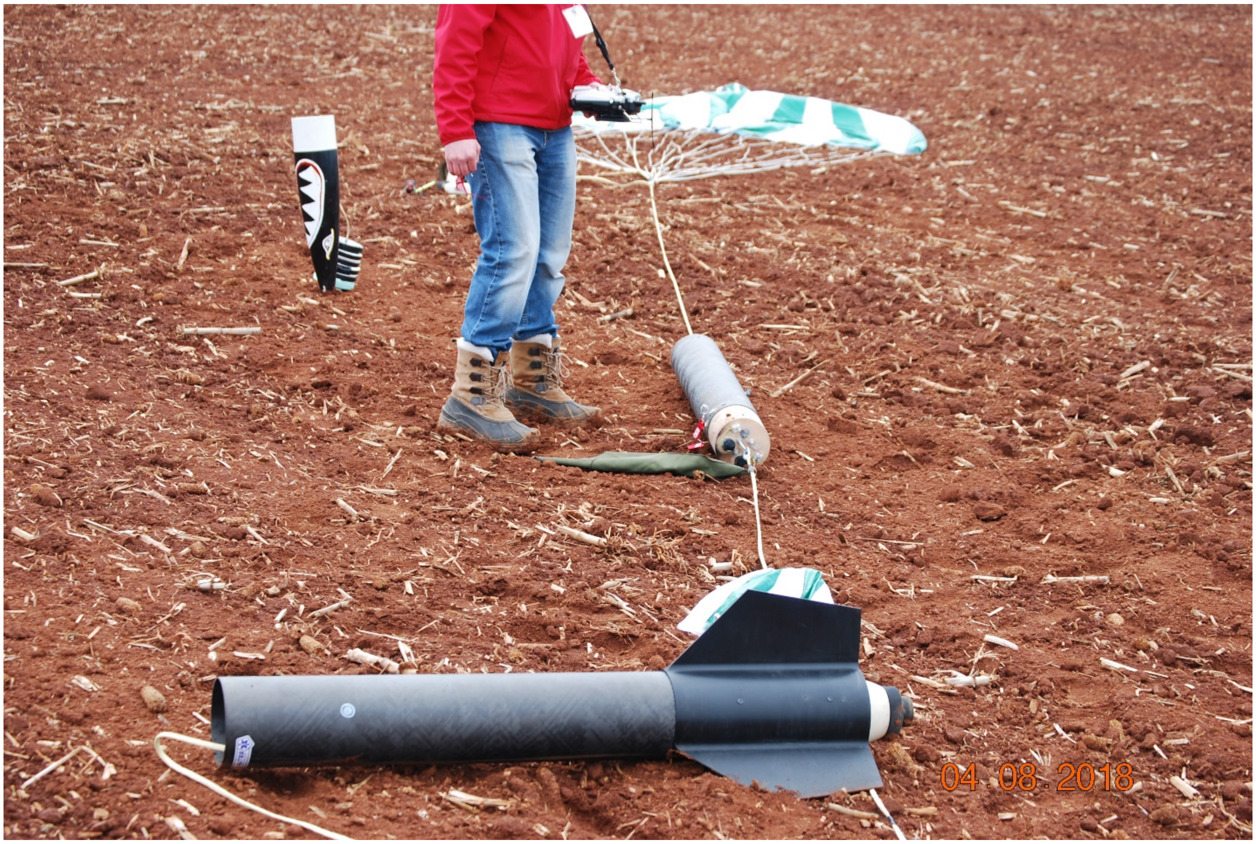

Figure 8: Successful Rocket Recovery

Once it reached its' apex or apogee of flight, the drogue parachute was successfully deployed from the back-half of the rocket and slowed the rocket down to a speed of 103 ft/s as measured post-launch from the altitude versus time graph. At a height of 600 feet above the Earth, the full-sized 120 inch main parachute was also successfully ejected from the front-half of the rocket and slowed the descent rate down to 13.9 ft/s. After post-launch inspection, the recovery system of the rocket performed flawlessly and met the standards that we had set for the system pre-launch.

After a final post-launch inspection the vehicle performed as well as we had hoped and we considered the launch a full-success. This was met because we had a straight flight, a successful drogue ejection, and a successful main parachute ejection.

The final section of the flight was the post-landing sequence of ejections that occurred on the ground to pop the nose-cone off the rocket and open the airframe for the rover to be able to climb out. Using our Fr-Sky/Crossfire transmitter module and a Fr-Sky receiver, we were successfully able to gain communication between the launch vehicle and the team after launch. The nose-cone then was also successfully ejected off about 32 minutes post-launch once we received the all-clear signal.

Overall, we considered our rocket's flight a complete success and we were very happy with the results. The only part of the flight that was not close to the initial guidelines was the rocket's height. The rocket was able to reach a final apogee of 4,476 feet, about 4% percent off from our simulation predicted height of 4,652 feet. This was well off the 5,280 feet goal and target height. This was due to a mass increase of around 3 pounds post CDR which meant that we launched a heavier rocket than was expected. This is something that we plan to work on it the future.

Payload Summary

Payload Title: **Sparta Lander**

Payload Summary: Our payload featured a four-wheeled rover that had wheels larger than the base plate, which held our servos, motors, and sensors. The base plate held the necessary components to allow the rover to move forward and clear any obstacles. The rocket design was analyzed and documented to include a 26-inch payload tube that was attached to the nosecone via 4 shear pins. The payload tube and attached nose-cone were ejected from the front body-tube when the main parachute was deployed. This payload tube and nose-cone attachment was held to the main body of the rocket via shock cord and a U-bolt on its back edge. After landing, the nose-cone was ejected from the payload tube via a CO_2 ejection system, allowing one-side of the body-tube to be open to the environment. After the nose-cone ejection, a gear system was utilized. This gear system was located behind the payload and housed within a tubing coupler. This gear system threaded a piece of all-thread out through a bulkhead and pushed the rover out the top of the payload tube, where the nose-cone was once attached. The rover then exited the payload tube and once fully emerged, began its attempt at autonomous movement to a distance of at least five feet from the rocket's body tube. The rover was equipped with Arduino programmable boards which had two sensors wired into them. This allowed for wheel movement as well as the rover to steer around any very large objects that may have been in the way of its travel path.

Data Analysis and Results of the Payload

After arriving at the launch field, one modification was made based on observations of the landing field conditions. Originally, the sensors would remain in use to maneuver around corn stalks, rocks, or other obstacles. Once the observation was made that there was no corn stalks in the field, the decision was made by the payload team in conjunction with the team mentor that the rover's sensors should be powered off after the movement began. This was to avoid the rover "dancing" in place on the clumpy soil and not completing the task in a reasonable amount of time. No other modifications were made to the rover physically, only that programming change.

The nosecone ejection system was crucial to the rover deployment. Housed within the nosecone, a dual canister CO_2 ejection charge paired to a FR-Sky receiver and electronic speed controller was tasked with blowing the nosecone off and clearing the way for the integration system to push out the rover. The system had been tested several times to evaluate the correct balance of shear pins to ejection charge size. The final system flown had four shear pins and 24g of CO_2, which was successful on launch day.

The integration system consisted of multiple 3-D printed pieces, a high-torque R/C engine, and an 18-inch-long all-thread rod. This system used a long-range Team Black Sheep Vr2 Micro Receiver that was paired to the same Fr-Sky transmitter set to imitate the ram action of the all-thread being spun out via a worm gear system. The system had been tested and was successful very consistently and was also successful on launch day.

Initially, a team member was sent to the rockets touchdown location to set up a camera. The camera was used to stream video via Facebook to see the deployment. After returning to the pre-determined rover deployment location, the team captain, faculty advisor, and other team members loaded the video. Once the videos had loaded the captain turned on the transmitter, once the transmitter was connected to the receiver a signal was sent to the rocket. Following the signal transmission, the nose cone was ejected from the rocket and landed 8 ft away from. After visual confirmation of the nose cone leaving, the captain transmitted a motor signal for the integration system to deploy the rover. The rover took one minute and ten seconds to fully exit the payload tube.

The rover was successfully pushed out of the rocket on the launch field. However, it immediately became stuck in the clumpy soil before moving the required distance. We deemed the rover to be a failure due to either a malfunction or damage and called it dead. After traveling out to the rover, it was not photographed right away because the main parachute started to drag the rocket after a large gust of wind. The payload rover was bumped and was moved slightly and began to move several inches before becoming stuck again. Seconds later, the solar panel deployed. The team then photographed that final position, which will be displayed below. Due to the faculty advisor being informed of this, he advised that we clearly state that the team members did not touch the rover or initiate movement but recognize that we gave up on it prior to this movement. As of now, we are unclear which result will be our final result but it is one of the following:

1) The rover was a failure in both the distance challenge and solar panel deployment due to the rover becoming stuck immediately after being deployed.

2) The rover was a partial failure: the distance was not reached, however the solar panel was fully deployed.

Overall, two of the three systems were total successes. The nosecone was blown off enough that the rover had a clear exit path and the ram system pushed the rover clear of the launch vehicle. The rover was recovered undamaged and was tested back in-house and performed the tasks on gravel, concrete, and grass surfaces.

Figure 9: Rover Movement

Scientific Value

Scientific values that we can relate to our group's experience is to that of interplanetary space exploration. Different planets have unknown terrain and designing a rover that will be able to drive across anything or figure a way around will be crucial.

Different worlds first and foremost have different weather conditions, so designing a case for the electronics to go so that they don't get damaged, broken, or ripped apart will increase the odds of your rover lasting longer. Another important conclusion we came across was covering the electronics so that they wouldn't get damaged during flight. This is extremely important so that bugs, water, sand, or other foreign objects cannot reach the electronic instruments carried on-board and possibly cause internal harm.

While constructing our payload, a large amount of focus revolved around its durability. The vehicle experiences large forces and the payload is relatively small. The rover itself had to be able to survive the remaining forces acting upon it during flight. The forces are even larger than the ones the rover experienced and a considerably larger amount of resources go into designing it. It should be assumed that just as much thought also goes into designing it to be resilient against the forces during flight.

The solar panel being able to deploy autonomously from the rover allows it to sustain itself without human intervention. While exploring other regions that humans are unable to, the rover requires an extended lifetime to complete the designated tasks. Our rover was able to successfully deploy the solar panel after traveling using inner mechanisms. In larger scale projects, the ability to recharge using solar energy cannot be understated.

In designing a rover to cover unknown terrain, all possibilities must be considered. Our rover was designed to cover any and all terrain that we tried, but not any possible terrain. The wheels allowed for excellent torque but fell short in climbing over clumpier soils such as the terrain at the Huntsville launch. Due to this, the rover failed to complete the full movement. If this were to occur on a larger project, the results could be more disastrous. Some rover tasks are to survey the region and without proper equipment to navigate the region, it would fail in that task. This highlights the importance of testing and making sure that you cover all variables before flight to ensure the utmost level of success.

Visual Data Observed

Arriving at the field on Sunday morning, several environmental observations were made. The temperature varied between 41 and 52 degrees throughout the day, as observed by the team's mentor. The wind was between 5 and 15 miles per hour with gusts of 20 miles per hour. The slight fog burned off before the first volley and was not an issue in our launch. The field itself was observed to be much rougher and uneven than planned for by the payload team, requiring us to make changes to the programming. Also, due to the rain from the previous day, the soil was clumpy and very sticky, observed by many teams when trying to talk through the field during their recovery stages.

The overcrowded launch viewing area made the transportation of the rocket to the final checks and pad much more tedious. An observation made by another team was that our rocket did not fit on the tables provided for the checks and therefore we were required to hold the rocket for almost an hour in a slightly angled horizontal position to keep the nose above the crowd, an unnatural position for the electronics and payload vehicle.

After receiving the clearance to bring the rocket to the assigned pad, the rail assigned was slightly angled against the wind. This was a preferable misalignment as we had already seen a few teams fly with the wind and drift towards the property line once the main deployed. The team then returned to a very crowded viewing area populated by mostly students but some parents and children were among the crowd.

As our volley was fired, multiple delays were observed as aircraft violated the airspace. This extended our pad-stay time to nearly double that of the first volley. By the time our rocket launched, the electronics in the nosecone ejection system, integration system, and payload rover had been on for more than two hours (9:30 am until 11:45 am). This was due to a late start as teams spent nearly 45 minutes in the field recovering their rockets.

At launch, our rocket fired instantly due to the ignitor being placed farther inside the motor than usual to ensure ignition. A 6-11 degree lean was overserved after the rocket left the rail due to the motor being underpowered, however after about 75 feet above the pad, it straightened and flew straight for the remainder of the sub-three-second burn. The rocket maintained stability throughout the remainder of the flight and no shaking or fin flutter was observed. At apogee, the drogue parachute deployed and began controlling the descent, and it was observed that the entire length of the shock cord snapped straight during ejection. The rocket fell nearly straight down due to a correctly sized drogue and the main deployed at exactly 550 feet above the ground. The rocket then drifted about 500 feet under main and laid itself down piece by piece and the main fell into a flat and stable position.

Wind gusts became a concern after another team's main chute did not fall closed and began to drag their rocket. Our rocket experienced about 50 feet of dragging before being recovered, a few inches of that coming after the payload had ejected. We were told not to fold up the main during the placement of the camera before the payload ejection. After a full recovery, a distance of just over 1,400 feet was paced back to the pad, confirming our drift was under the 2,500-foot limit.

Lesson's Learned

First and for most there are always learning opportunities with any project. That said for this project many exist with our team being rookies. The main learning experience with this year's rocket is weight estimation and experimentation. During the design phase a discrepancy was noticed in the rockets weight estimation and actual weight. The team worked toward a solution and was able to cut down the weight by removing unnecessary components and minimizing important ones. Based on prior knowledge tube weights and main components were estimated, but with a 6-inch body tube verse 4-inch body tube significant mass came into account. The lesson associated with this is that more research should go into initial estimations while also consider an unavoidable mass increase.

Another learning experience comes from motor selection. During the project multiple times our motor was based on the mass of the rocket. Instead the team should have overestimated the mass, expecting a mass increase, and selected a motor accordingly. It is easier to add mass than remove it. In addition to sudden mass increases if a design change occurs a full motor change could possibly be avoided. Finally, the motor selection process should start early, by doing so any discrepancies can be accounted for quickly.

The final major lesson is in the design process itself. All throughout the project it seemed that problems occurred after testing. Our team can learn a few things from this situation. First, initial designing phases should account for multiple variations of the same design such as varied materials and configurations. Secondly, several testing procedures should be designed for a final configuration. This hopefully will cover situations during flight and landing. Thirdly, building the rocket and payload should be done in the earlier stages of the competition. By prototyping the rocket design, it allows for changes to be made while not compromising flight data for the reports. Lastly, fully identifying the problem is important. A lot of the time brainstorming even prototyping occurred before the problem was identified. The team has learned to investigate the problem fully and brainstorm solutions that comprehensively solves the problem instead of partial fixes that cause problems later.

Overall, the project was somewhat successful for a new team. While the flight was successful, and landing was successful many improvements can be made. Through lessons of design, testing, and selection the team is more prepared to fully solve next year's problem with an innovative and effective solution.

Summary of Overall Experience

After participating in the NASA Student Launch competition for the first time, the YCP team hopes to excel by utilizing the key skills and knowledge the team gained throughout the project. The team understands the importance of continuous improvement in the quality of design as well as manufacturing the rocket.

YCP's goal this year was to create a rocket design that efficiently houses the payload and all the systems that are required for the integration of the payload. The team designed a rocket that was expected to reach the apogee of a mile but due to unforeseen weight increases in the rocket design, the rocket fell short of the goal in the actual competition. The team also worked diligently on the payload and had several designs to choose from before they began constructing the rocket. The team finally decided to design a rover with a 3D printed body with enough space in the inside cavity for the batteries, motors, wiring, and the solar panel. The rover was programmed to read the data from the UV sensors attached to the front and the back face of the body. The team also designed two integration systems, one in the nose cone and the second in the payload tube. The nose cone integration system's purpose was to separate the nose-cone from the payload tube after landing. The payload tube integration system's purpose was to push the rover out upon landing using a motor.

The results of the launch were less than satisfactory in some areas, but also very satisfactory in others. The rocket did not fly to the planned apogee and fell short by several hundred feet. The payload integration systems worked very well while the payload itself failed to perform as the sensors were buried in the ground. But our rocket did maintain a straight flight, successfully eject both parachutes at the desired heights, eject the nose-cone after flight, and also successfully deploy the rover from inside the rocket. These successes make us even hungrier for next-year to improve on our results. Even after some unsatisfactory results from the payload, the team prides themselves in the fact that each system is unique and can be manufactured completely by team members. The team will continue to strive for excellence in design efficiency, documentation, educational engagement, and safety awareness. The team has learned a lot about the design process throughout the project and we hope to strive for the best that we can be.

The overall experience was extremely valuable to each team member. One of the most important experiences for each team member was the educational outreach. We have visited many schools with each team member taking lead and providing these amazing students with unique experiences. The outreach has been designed to spread passion for rocketry throughout the community while educating students of the importance of math and science in STEM fields.

The team continues to strive to be the best they can be and hopes to bring something unique to the competition in the upcoming years.

Educational Engagement Summary

Educational engagement has been an important part of this project because it allows community involvement and interaction. We have continued our educational engagement activities, even after the deadline, and hope to remain in contact with the community during future projects. We also hope that in hosting these activities, students will experience design processes, gain a better understanding of rocketry, and pursue STEM careers in the future.

Based of feedback from previous events, we would like to integrate more engaging activities to go along with our presentations. We have not done any launches of our rockets at the schools visited but having smaller model rockets might be a good idea to allow more hands-on learning. Hopefully our community involvement will not cease as the year goes on, and we will get a chance to recruit new team members in the fall.

Below are the schools and events we attended with a short description of our activities.

Number of students to date: 425

York County School of Technology (1/25/18, 2/1/18)

York Tech was the first school we partnered with, and we talked with 77 students. We presented our project, and most of the high schoolers seemed interested and asked us questions. Our feedback was moderately positive, as we did not have many opportunities for them to become involved, but many answered that they would look forward to attending a similar event. After this presentation, we added a few trivia questions, and encouraged students we were presenting to to ask questions in attempt for them to become more involved.

Dallastown High School (2/21/18)

We went to Dallastown and only presented to 3 students. Our contact with them was a bit last minute, and we believe that not many had the opportunity to come. Here we decided that we needed to try getting the word out about our group more in hopes that we can have a greater attendance. However, the students seemed to enjoy our presentation, and because it was a small group, they were able to be more involved.

Hereford High School (2/28/18)

We presented to 17 students at Hereford in Maryland, most who were in the engineering program there. Their feedback was mostly positive, although, again, many felt that there could be more involvement. We wanted to perform a small launch for them, but unfortunately conditions would not permit. Hereford actually had a small rocketry club a couple years ago, and hopefully we helped gain more interest for them to start it back up again.

York County Involvement Fair (3/2/18)

We held a table at York County's involvement fair, where we spoke with over 200 people about our project. Many people had the opportunity to ask us questions and to see all our rocket's components. We hope that students will be interested in joining our team for future projects.

Spring Grove Area High School (4/20/18)

Spring Grove was hosting its first STEM event with model rocketry kits. We volunteered to help Mr. Brian Hastings, physics teacher at the school, and is also a mentor to both the Spring Grove rocketry team, and our student launch team. It was a very successful event, with a turnout over 100 parents/ students there to build a rocket. Most of the kids were elementary to middle schoolers, and really enjoyed learning how all the rocket parts came together.

York College STEM activity (4/28/18)

We hosted our own event at Kinsley Engineering Center with about 20 students. We showed both our subscale and full scale systems, and taught them how all the parts worked together. They then built their own model rockets, which were launched in a field off property, along with our full scale from the competition.

Budget Summary

Total Cost of Hardware / Tools	$1,496.13
Total Cost of Rocket Supplies:	$8,597.39
Food for all Trips (To Be Updated)	$184.23
Gas Money to Huntsville, AL and Home (TBU)	$600.00
Plane Ticket to Huntsville, AL for Student	$200.00
Lodging in Huntsville, AL (TBU)	$1,700.00
Team Polo Shirts	$322.00
Total Cost of 2017-2018	$13,099.75

During the 2017-2018 project, we spent roughly 13,000 dollars, with about 15% of that going towards tools and set-up costs that will not have to be repaid each year. Thankfully with the generous support of Hoosier Pattern Inc., The PA Space Grant Consortium, The Walmart Foundation, Mr. Kansagra, The Matthews Family, and many others we were able to fundraise around $15,000 dollars. We look forward to continuing the program next year.

Sincerely,

2017-2018 York College of PA Student Launch Team