Piedmont Student Launch Team

2018 NASA Student Launch

Post Launch Assessment Review

Piedmont Virginia Community College

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Glossary of Terms

ACS	-	Altitude Control System
Cd	-	Coefficient of Drag
CHEC	-	Community Homeschool Enrichment Center
FSEE	-	Family Space Exploration Event
PSLT	-	Piedmont Student Launch Team
PVCC	-	Piedmont Virginia Community College
STEM	-	Science, Technology, Engineering, and Mathematics

1 Summary

Piedmont Student Launch Team (PSLT) was honored for the chance to compete in NASA's University Student Launch Initiative. This year, the team chose to take on the rover payload for the greater challenge and the broader range of skills needed. In addition, the launch vehicle design included a cold gas thruster system for altitude control.

On the day of the launch, the rocket, *Stand Way Back*, reached an altitude of 3,938 ft; short of the target of 5,280 ft goal; however, it was within 20 ft of the apogee predicted as of the Flight Readiness Review. The rocket separated at apogee, as intended; although, the main parachute deployed early, causing the rocket to drift farther than anticipated. The rocket was ultimately recovered intact, albeit a bit muddy.

The design of the team’s rover incorporated six infinity wheels, that were to each be driven directly by stepper motors and controlled by a Raspberry PI. Due to a lack of thorough testing of the retention system, it was decided to not fly the rover on the final flight to increase the margin of safety, so at the time of the launch, the rover was replaced with the mass simulator that was used during the qualification flight.

Educational engagement and outreach were successful, exceeding their original goals and laying the ground work for many additional opportunities in the future.

2 Launch Vehicle Results

2.1 Summary of Launch Vehicle

The following table lists a few key features and dimensions of the launch vehicle along with some of the key results from the flight on launch day.

Feature / Result	Value
Diameter (in.)	6
Length (in.)	105.5
Motor	Aerotech L1420
Parachute diameter (ft)	16
Airframe material	Fiberglass
Fin material	Fiberglass
Apogee (ft)	3,938
Rail exit velocity (ft/s)	66.7
Maximum velocity (ft/s)	527
Drift (ft)	2,513
Maximum kinetic energy at landing (ft-lbf)	73

Table 2.1 - Key Launch Vehicle Features

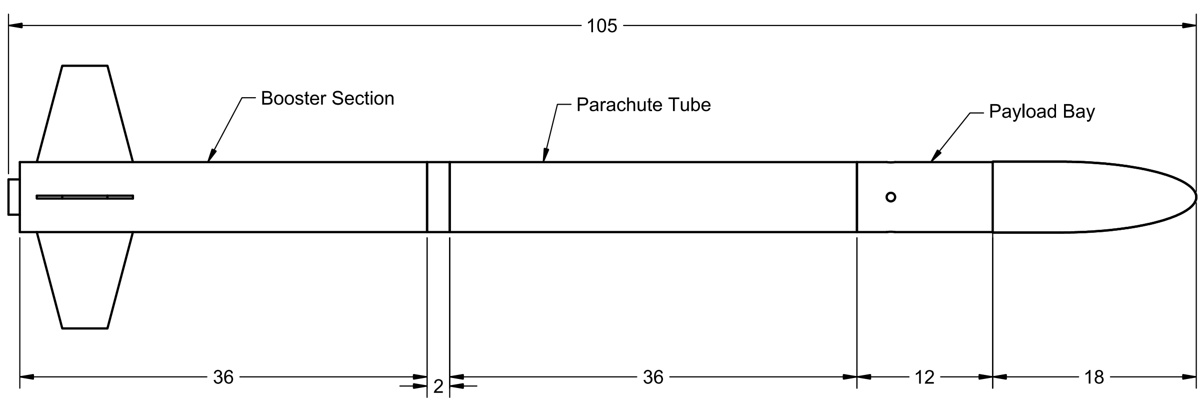

Figure 2.1 - Launch Vehicle Overview

The rocket performed nominally from ignition to apogee. The recovery system electronics functioned properly, and the rocket separated smoothly at its apogee of 3,938 ft; however, the main parachute, which was meant to be held closed by a pair of Jolly Logic Chute Releases until 500 ft, pulled free from the Chute Releases, allowing it to fully deploy at apogee, subsequently causing the rocket to drift significantly farther than it otherwise would have. Apart from that, the rocket landed successfully, and was recovered without any damage. Additionally, the tracker transmitted the rocket's position throughout the flight.

Figure 2.2 - Full-Scale at Landing

The reason for the lower altitude was a change in components used in the Altitude Control System. Several parts were replaced with equivalent parts with higher pressure ratings for safety purposes at CDR, but these parts were significantly heavier, reducing the final altitude.

2.2 Altitude Control System

2.2.1 Altitude Control System Overview

The Altitude Control System (ACS) design featured a nitrogen tank filled to 2,100 psi. Once a controller determined that the launch vehicle needed to be slowed down, a solenoid would open, allowing propellant to travel to the four thrusters on the airframe. This would have slowed the launch vehicle down, reducing its apogee to reach the target of 5,280 ft. However, because the qualification flight of the rocket was done using a motor smaller than the full-scale motor flown in Huntsville, the ACS was not active during that flight, and so, for purposes of safety, was not active on the final flight. Additionally, because the system is only able to reduce the rocket's velocity, and not increase it, it is only able lower apogee, which was not necessary, as the predicted altitude was already below the target.

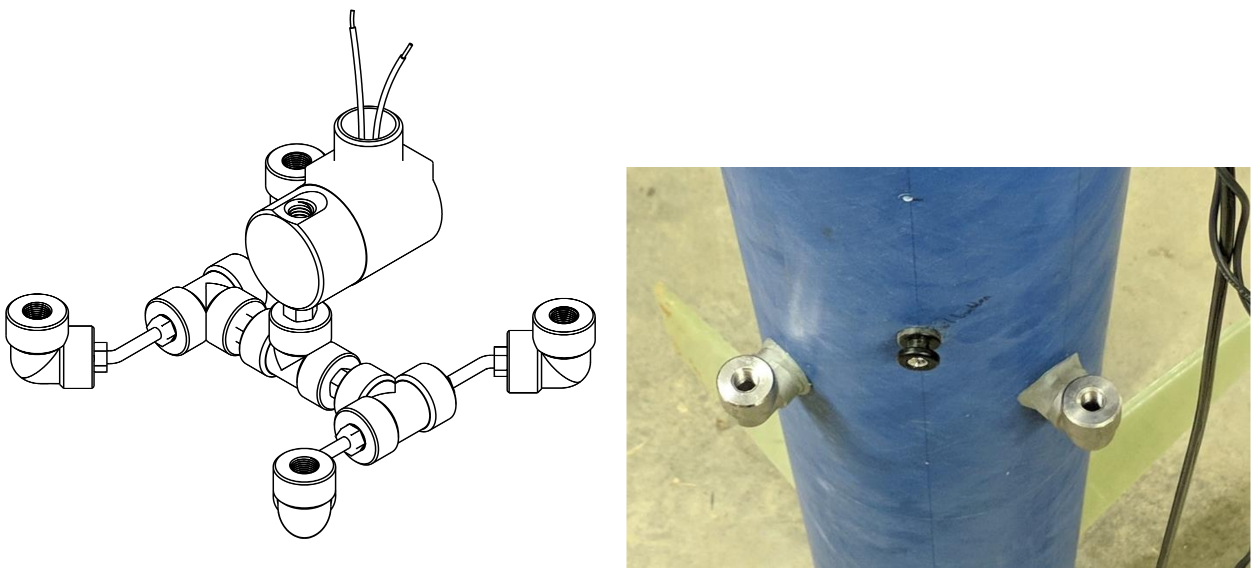

Figure 2.3 - ACS

2.2.2 Altitude Control System Lessons Learned

The ACS, while novel and technically intriguing, did not prove to be as viable an option for adjusting the altitude as was originally thought; however, with further refinements, particularly including nozzles for the thrusters and a higher pressure for the propellant, the system may well provide a useful amount of control.

2.3 Recovery System

2.3.1 Recovery System Overview

The recovery system design consisted of two Missile Works RRC3 altimeters connected to a total of four ejection cups, which were mounted to a bulkhead at the fore end of the parachute tube. After separation, a pair Jolly Logic Chute Releases was used to deploy the main parachute at 500 ft.

2.3.2 Recovery System Lessons Learned

The primary lesson learned for the recovery system was to locate the parachute such that it is pushed to the separating end of its bay by flight forces. This can prevent an issue that occurred during the first subscale flight where the parachute was caught on threaded rods protruding from the bulkhead at the end of the parachute bay opposite where it was designed to separate, preventing the pressure from the ejection charges firing from reaching the appropriate bulkhead, in turn preventing the rocket from separating, and resulting in a ballistic return.

3 Payload Results

3.1 Overview

The payload design consisted of a rover stowed within a 3D printed nosecone. The rover had six "infinity" wheels, designed to improve the rover's ability to navigate difficult terrain, as well as a hinged arm that served as both the solar panel deployment mechanism and a righting mechanism.

Figure 3.1 - Rover Body

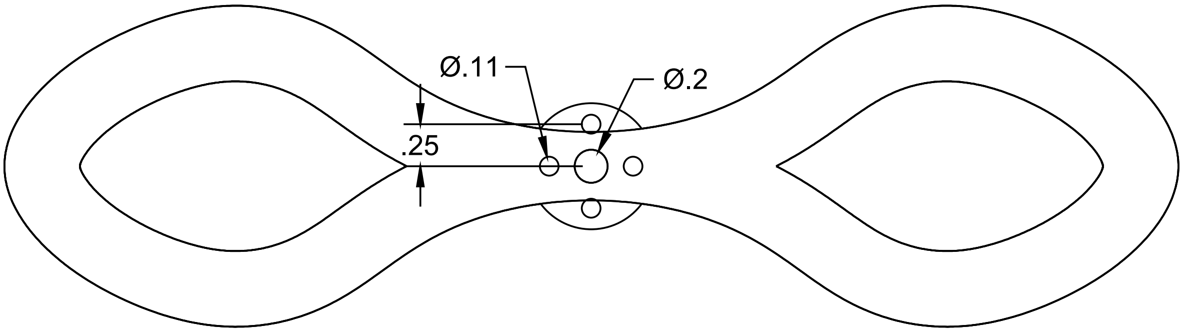

Figure 3.2 - Rover Wheel Drawing

3.2 Results

Due to the potential hazards that could result from the rover not being well enough secured in the rocket, and because delays prevented the mounting system from being thoroughly tested, the rover was not flown on launch day. Instead, a mass simulator was flown, as was done on the qualification flight.

While the rover was not flown, in testing, the components were successful. The wheels moved correctly, and the righting mechanism could deploy and had enough power to lever the rover into the correct orientation, albeit very slowly. Thus, a system that can help a disabled rover as well as this drivetrain design is feasible and can be successful.

3.3 Lessons Learned

One of the key things that could have been improved upon was more rigorous and thorough component and integration testing. By testing each component and then adding components together one at a time with testing occurring between each addition, errors and problems can be caught early and can be more easily addressed.

Another lesson learned from this project is to do more manufacturing tests and prototyping. For example, creating the nosecone took a lot of time since it had to be 3D printed in parts and then assembled to form a singul piece. Had small sized testing been done earlier, fewer problems would have occurred later on. Overall a detailed plan for when and where each part was going to be made. This could have expedited the construction and testing.

4 Project Results

4.1 General Lessons Learned

The following list includes many of the project level lessons learned throughout the course of the past eight months along with the reasons behind them.

Lesson Learned	Reason
Streamline the part procurement process	Due to the disparate ways that parts were requested, it was frequently unclear what had been purchased, what still needed to be purchased, or what was no longer required. This led to many delays in construction and testing
Have earlier design deadlines and spend more time prototyping and testing	The amount of time spent iterating theoretical designs did not leave enough time to do the prototyping and thorough testing that would have caught areas where the practicality and simplicity of designs could have been improved
Have a dedicated project manager	The team has grown to a size where there is enough work for the team leader to do that they cannot also do the job of project manager as well as it should be done
Make more use of the team wiki	Because the team wiki was not set up until fairly late into the project, it was not used as well as it could have been to provide a single, clear source of the most current designs and analyses

Table 4.1 - General Lessons Learned

4.2 Summary of Experience

All members of the team agreed that the project as a whole, although not completely successful in all areas, and to some extent because of that, was an invaluable opportunity. Among the things that team members learned were how to and how not to go about doing engineering design; how to work as part of a team, in particular a large team; how to write large, technical documents; how to teach STEM subjects, especially to a younger audience; and recover from failures.

4.3 Summary of Educational Engagement & Future Plans

This year, PSLT has committed even more time and attention to building sustainable educational partnerships and programs. The team created an educational engagement sub-team this year, unlike last year, and they directly engaged with over 800 students, educators, parents, and the community at large. The team has taught classes, run educational sessions, hosted events, given talks at schools, and put on demonstrations. They have partnered with local schools, STEM based groups, local businesses, other educational groups, and even formed connections in the offices of local legislators. This year, PSLT has laid the ground work for years of community engagement and STEM education.

This summer, the team will be teaching a week-long course in partnership with PVCC. The college has a summer camp for K-12 students called Kids College, and the team will be teaching one of the sessions.

The Piedmont Student Launch Team will be spending their summer continuing to engage with the community and forming sustainable STEM enthusiasm and programs in Charlottesville and throughout the area.

4.4 Summary of Project Budget

The income for this project year came from three primary sources: PVCC, corporate sponsors, and individual donors. The expenses are broken into four main categories: travel, educational engagement, rocket & payload, and other. The distributions among these categories is shown below. The totals for both income and expenses is $8,530.

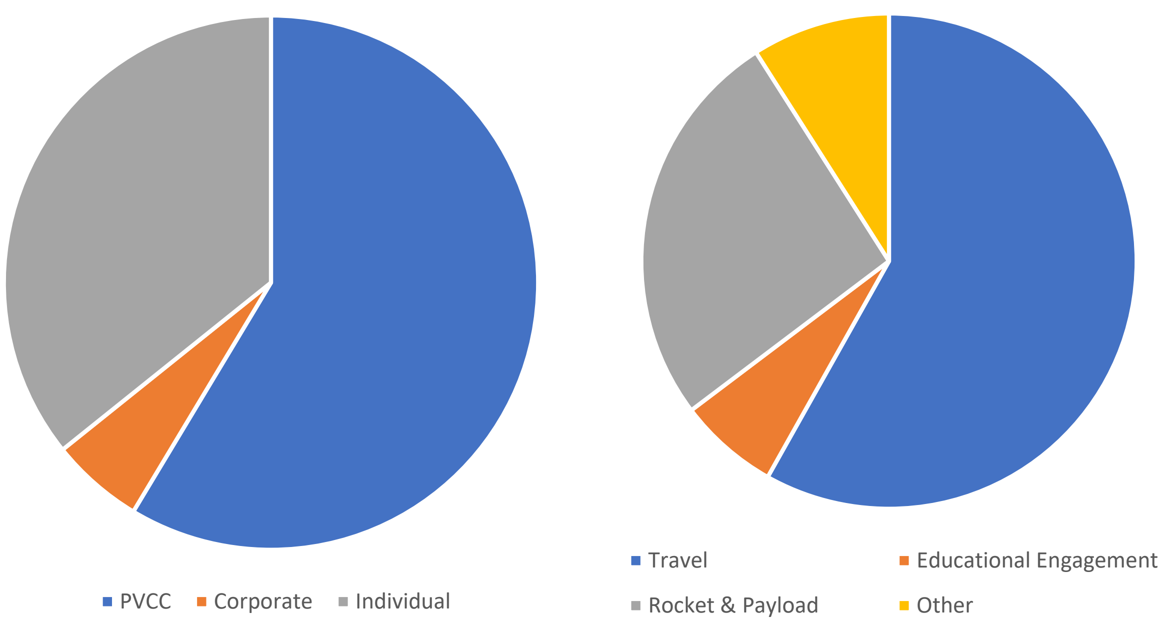

Figure 4.1 - Income (left) & Expenses (right)