Pioneer Rocketry 2022 WSGC Collegiate Rocket Launch Competition

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Abstract

The Wisconsin Space Grant Consortium hosts the annual Collegiate Rocket Launch Competition every year. The goal of the competition this year was to design and build a rocket that can achieve an apogee below 3500 ft, has a system that can stabilize the roll-rate after motor burnout, has a system that logs the acceleration and roll of the flight, and utilizes a dual-deploy recovery system. The rocket, Sialia, used a I435 motor to lift off to an apogee of 1970 ft and successfully recovered using a dual-deploy system. Unfortunately, neither the control system nor the flight recording systems were confirmed to function due to the camera system and Sialia landing in water. Pioneer Rocketry is very proud to have placed second in this competition.

Introduction: The Collegiate Rocket Launch (CRL) competition is hosted every year by the Wisconsin Space Grant Consortium (WSGC), where colleges throughout the state are tasked with a rocket design challenge. The 2022 CRL competition objective was to develop a high-powered rocket that can stabilize its roll-rate during the cruise phase of ascent, log the roll and acceleration data, and utilize a dual-deploy recovery system. The maximum apogee for the rocket was 3500 ft and the only motor allowed was an I435.

Rocket Design

Airframe Design: The design of the rocket, as seen in Figure 1, utilized a 4-inch fiberglass tube as the airframe, consisting of two sections connected using a coupler along with shear pins to transmit the torque of the canards. The top section of the rocket contained both the rocket payload and camera system, separated by a bulkhead to protect the electronics. The bottom section contained the recovery system's parachutes and ejection charges. Both the canards and main fins were made of ¼-inch plywood, laser cut and sanded to shape.

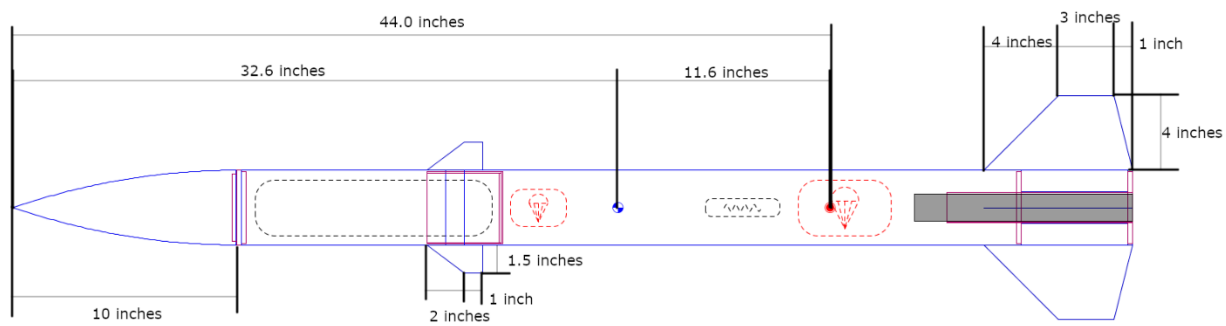
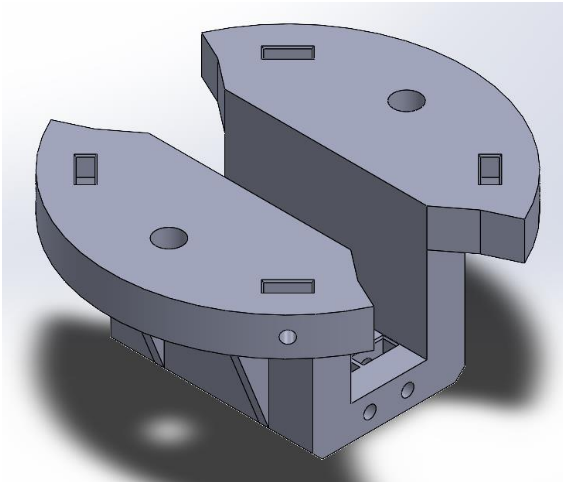


Figure 1: Final OpenRocket design of Sialia

Figure 2: Drogue and Main Parachute recovery setup

Recovery System Design: The recovery system utilized two parachutes, a 12-inch drogue chute and a 40-inch main parachute, as seen in Figure 2. A StratoLoggerCF altimeter mounted in the upper section of the rocket was used to deploy both the main and drogue chutes at apogee by electronic ejection, however the main was constricted at the base by a Jolly Logic Chute Release. Once the rocket descended to 500 ft, the main chute was then allowed to open. In case the electronic ejection does not work, the motor has an ejection charge set to separate the rocket a second after apogee. The shock cord for the rocket was made of nylon, permanently secured to the forward centering ring of the motor mount. The cord was then connected using quick links and other mechanical fasteners, to the bottom of the upper section's bulkhead. To aid in the recovery after landing, a radio tracker was attached along the shock cord.

Payload Design: The method used to actively minimize the roll-rate of the rocket was two canards placed on opposite sides of the rocket. Using a mount seen in Figure 3, two S1213 analog feedback servo motors were used as actuators for the canards, utilizing brass couplers to mount directly to the ends of the servos. An Arduino Nano ran the primary PID loop that controls the canards, where it was activated based on the acceleration data of a L3GD20H gyroscope/accelerometer. To log the data collected, a microSD card reader/writer was utilized to record the roll-control system. A FUVISION Micro Camera was mounted above one of the canards and was set to record before flight. The system was powered using a PowerBoost 1000 and a LiPo battery.



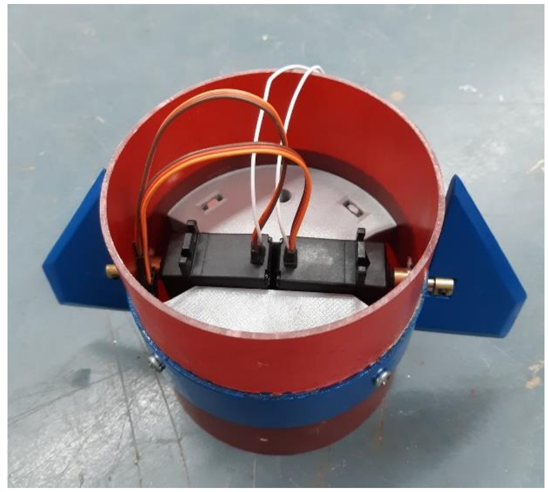


Figure 3: (Left) SOLIDWORKS model of the mount used to secure the S1213 servo motors; (Right) Assembled canard section of the payload.

Rocket Operations Assessment

Flight Anomalies Analysis: The rocket, Sialia, made one successful flight. Before the launch, an anomaly in the code was found, leaving the rocket's data logging unable to operate. These complications in the payload will be discussed further in the report. Another anomaly in flight was found upon landing, where the rocket sustained damage. Upon landing, the rocket hit a road, breaking the tip of the nosecone, causing the rocket to bounce into a pool of water. The StratoLoggerCF was still able to report the achieved apogee. However, the competition altimeter was damaged.

Flight Performance Assessment: The rocket was able to perform a launch safely and successfully on the competition day. The propulsion system was able to launch the rocket up to an apogee of 1970 ft, making a stable ascent along the way. The rocket had to fly at a slight angle to account for the wind conditions, which reduced the actual apogee from its predicted value. The motor ignited perfectly with no notable anomalies.

Recovery System Analysis: The rocket's StratoLoggerCF performed nominally, successfully detonating an ejection charge at apogee. Both the drogue and main were able to successfully eject out of the rocket, where the drogue fully deployed. The Jolly Logic Chute Release then successfully released the main chute once the rocket reached 500 ft, taking the rocket safely to the ground. The radio tracker allowed the team to quickly find the rocket after touchdown.

Rocket Location and Recovery Analysis: Locating the rocket posed no difficulty, as the radio tracker functioned as intended and the rocket was located by the side of a road. Recovering the rocket from the water posed no difficulty, as seen in Figure 4. The water was shallow, and the rocket was located close to the shore. The rocket suffered no structural damage from the water.

Figure 4: Sialia after landing before recovery.

Payload System Performance:

System Performance: Analyzing the performance of the rocket, the avionics system was deemed successful. Unfortunately, the payload performance was inconclusive, as confirmation of the canards successfully activating was unable to be accomplished. Neither the microSD card reader nor the camera system functioned as intended. For the microSD card reader, the component was found to be incompatible with the accelerometer when both were set up for two different communication protocols. Despite the Arduino Nano being capable of both SPI and I2C communication simultaneously, the use of both devices led the Arduino to crash if both component's code was allowed to run. Unable to be fixed at the launch, the decision was made to use the accelerometer without the microSD card reader. For the camera system, the FUVISION micro camera encountered an issue not found in testing, where the camera went out of focus after more than 15 minutes. As the camera never went back into focus, the resulting video of the rocket launch only appeared gray, which can be seen in Figure 5.

Figure 5: Sample image of the video produced by the FUVISION camera

Possible Design Improvements: The performance of the roll-control system was affected by bugged code and a faulty camera system. The program could have had more time writing and debugging before the launch day. If the FUVISION micro camera were to be used again, better positioning of the camera controls would be needed. Since the first few minutes of recording work as intended, the camera should work if enabled on the launchpad. One last issue that could be improved upon was the accessibility and ease of working on the rocket components. The canards were difficult to get mounted to the servos as they required hard to access set screws. For future designs, additional time during planning should be used in ensuring that rocket assembly could be done quickly on the competition day.

Actual vs. Predicted Flight Performance: Comparing predicted and actual apogees of the rocket, a large discrepancy in performance was found. The predicted apogee was 2540 ft, far higher than the 1970 ft achieved in the competition flight. Two primary reasons for this were identified. The first was the wind speed used in simulating the predicted performance, as the wind on the day of the competition was much higher than expected. Increasing the simulated wind speeds from 0 mph to 20 mph, a noticeable drop in apogee was found, going from 2540 ft to 2450 ft. The second was the unaccounted for drag in the simulation. The camera mount found outside the rocket was not accounted into the total drag of the airframe, which if it was accounted for, would have led to simulated apogee lower and more in line with what the actual performance shows.

Photographic Documentation of Flight:

Figure 6: (Left) Sialia launching off launchpad 4; (Right) Sialia descending with both parachutes successfully deployed.

Conclusion: This year's CRL competition provided a unique and difficult challenge of actively stabilizing the rocket's roll rate during the cruise phase of ascent. The team was able to build and fly a rocket to 1970 ft that had the potential to overcome this challenge. However, a few problems caused by the camera system and payload electronics led to the rocket falling short of completing its goal. Despite these shortcomings, the team learned a lot about rocketry, from better rocket design considerations to flight electronics and programming. Overall, the team learned a lot of valuable lessons from this experience and was excited to have had this opportunity to compete in this year's competition.

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