2023 Rocketville Blue Crabs Payload Post-Launch Assessment Review

Explorer Post 1010

5/16/2023

Payload description

Our payload for rockets for schools is a load cell placed below the nose cone that will record drag force. The load cell will be mounted between two bulkheads, with the upper bulkhead mounted to the base of the nose cone shoulder. The lower bulkhead will be attached to a centering ring that will allow it to be removed. Below the centering ring will be a small waterproof electronics bay that will hold an Arduino Nano, a load cell amplifier, and a SD card data logger.

We chose to use a 50kg rated load cell based on calculating the peak drag force with the drag equation Fd = 0.5*pv^2ca. Using this model, our drag force will peak at around 15 kilograms. The point of the experiment is to measure the drag force on the rocket throughout its flight and to determine how accurate the drag equation model is. After the flight, the SD card module will be recovered with the saved data.

Payload Theory and Supporting Calculations

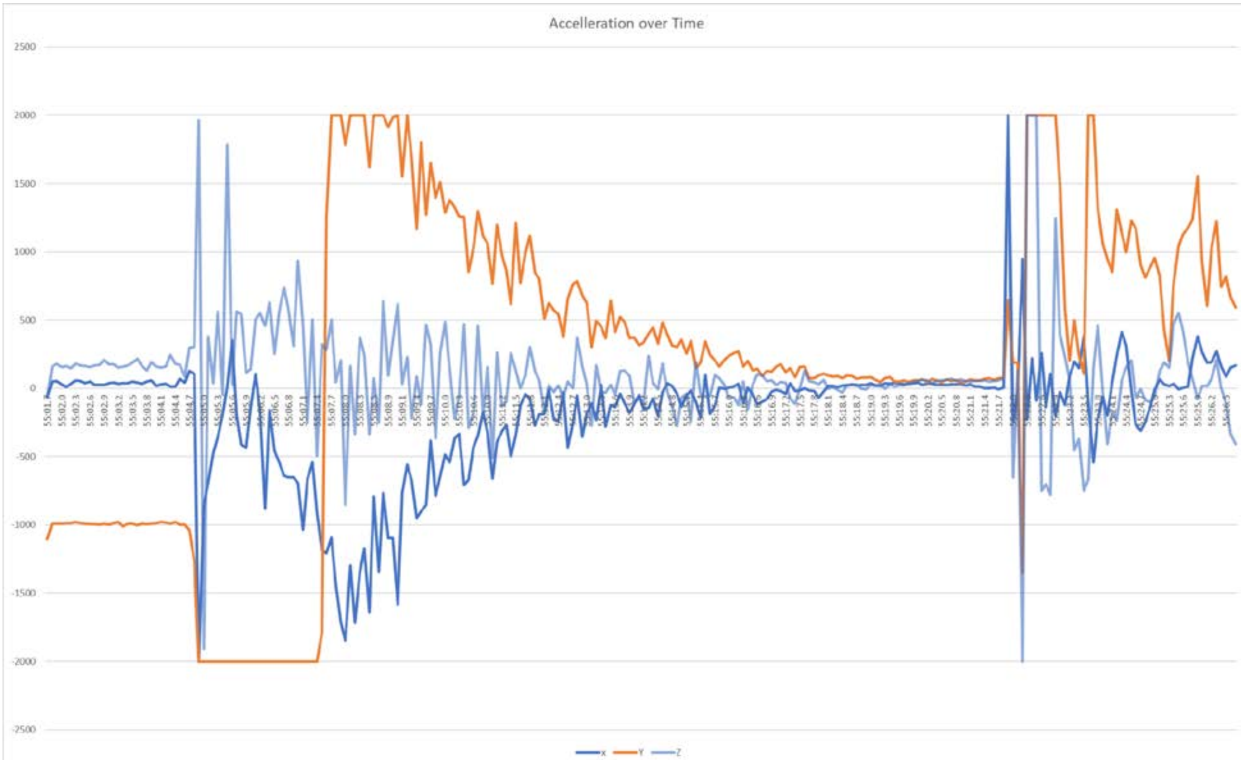
Our payload's goal was to measure the force of air resistance on the nose of our rocket using a load cell. Our theory for this load cell was that the rocket moving through the air would apply a force to the nose cone that we could measure. We developed a hypothesis for when the drag would be greatest, and believed it to be when its velocity was greatest. To calculate this value, and later compare to experimental results, we used the drag force equation, $F_d = C_d A \frac{\rho v^2}{2}$, where Cd is the coefficient of drag, A is the area of the shape, ρ is the air pressure, and v is the velocity of the rocket. Our variables were found to be Cd = .23127 (unitless), A = 58.166 cm, ρ = 1.293 kgm^3, and v = 238 m/s. Multiplying them gets $F_d = .0013452 * 36620.346$, so our theoretical maximum force of drag is equal to 49.2619 Newtons.

Data Analysis and Results

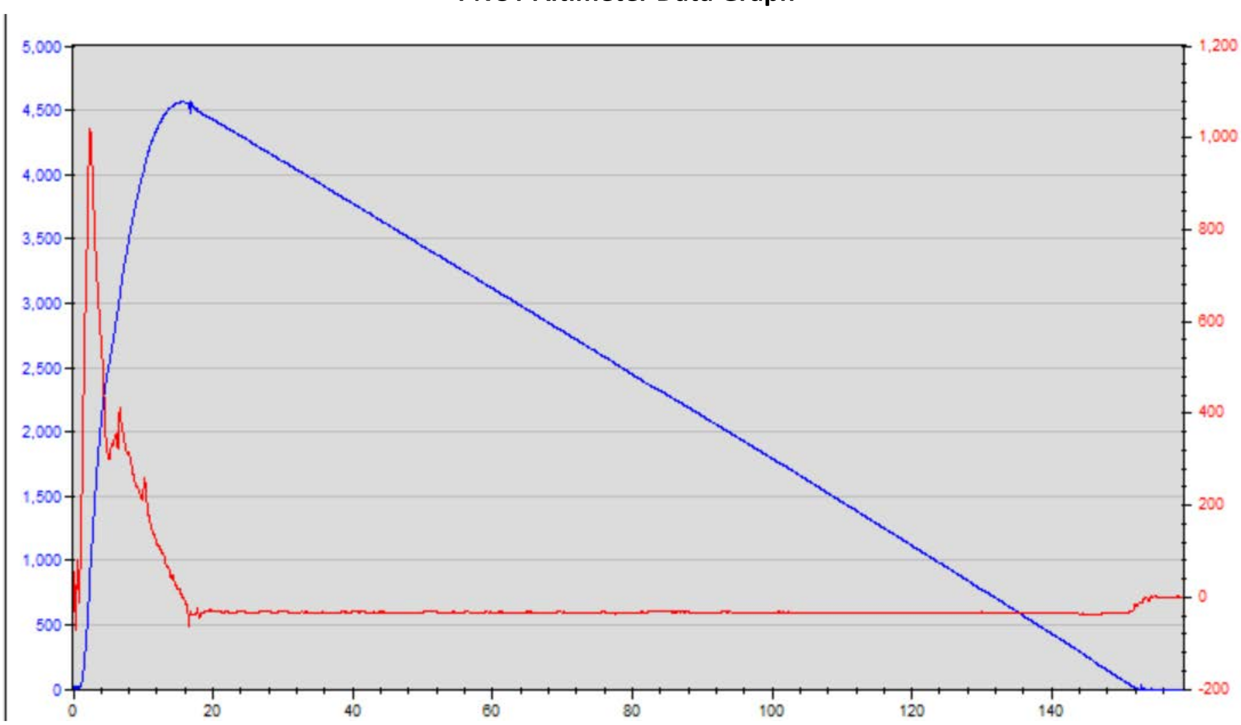
Pre-flight Weight of Payload
The pre-flight weight of the payload is .28lbs.

Raw Data Summary

Accelerometer Graph



PNUT Altimeter Data Graph



The rocket reached an apogee of 4562ft and a maximum velocity of 1040 Ft/s.

Physical Measurements
Nose cone length: 65 cm
Payload length: 61 cm
Booster length: 85 cm
Total length: 211 cm
Payload length: 28 ½ cm
Fin Width: 14 cm
Fin Length: 38 ½ cm
Rocket Diameter: 14 cm

Visual Observations:
After the rocket was ignited, it almost immediately shot up into the sky. A thick cloud was left behind along with a dark gray trail of smoke. As for the rocket's tilt, it was mostly stable and perpendicular to the ground. When it first took off, it had a slight tilt but as it gained altitude, the rocket straightened out. Eventually, the rocket went so high that the clouds thickly covered its path and it could not be seen. About 30 seconds later, the rocket was visible again. By this time, it had drifted a considerable amount. Around a minute later the rocket seemed to have landed beyond the launching area.

Payload Scientific Value

Our payload was a load cell that's goal was to determine the force of air resistance on our rocket's nose. We used a scientific formula to determine a theoretical result, and through the use and testing of our payload, developed an experimental result. Unfortunately, this did not happen as our load cell failed to record the force on the nose cone. However, this payload did act as proof for the scientific method, we developed a theory and hypothesis, came up with a procedure, made theoretical calculations, and potentially obtained experimental results and determined our sources of error. Further, if this payload worked, it could have been used to calculate the coefficient of drag of the nose cone.

Lessons Learned

Throughout this project we learned a multitude of lessons in construction, electrical engineering, programming, and testing. While building the rocket we learned to plan out build phases and milestones such as installing the fins and motor mount, as well as the filets. With electrical engineering we discovered that we lack sufficient skill in soldering and circuit construction, additionally, the programming of the Arduino was an arduous task as we needed to learn to incorporate multiple libraries to transcribe the load cell to the SD card. Finally, during our testing, we did not bring a control load cell to test our payload, so during the flight we did not receive meaningful data. In conclusion, although our payload did not function to our expectation, we gained valuable experience for rocket construction and testing, as well as experience for competitions, and we will absolutely apply these lessons when working on any other competition, whether that be TARC, R4S, or SLI.

Summary of Overall Experience:

The payload attempted to sense the force on the nose cone and compare that to the altitude and acceleration of the rocket. Unfortunately our payload was not entirely successful. The altimeter was successful and was able to measure the altitude, but the load cell was faulty. Weeks before the competition took place, we performed multiple tests and the load cell seemed to be functioning properly. Days before the launch, issues arised. Instead of the load cell giving us a numerical value it would present us with the value “h?” or a numerical value that was provably incorrect. Through multiple hours of work the load cell became functional again only a night before the launch. Disappointingly the data collected by the load cell read all zero’s when it was uploaded. This data is clearly incorrect and tells us that there is more work to be done if we wish to go through with this idea. Despite the failure of the load cell we still collected significant data from the other functions of the payload. The Pnut altimeter collected altitude and velocity data while the open log artemis collected 9 axis accelerometer data. The experience of going somewhere far from home for the competition was interesting. We had to figure out issues that arose, for example the transportation of the rocket. We had to build a crate to go on the plane with us to bring the rocket and the trifold board. On top of that we needed to bring a lot of tools with us in case the payload broke(which ended up happening so the tools did come to use.) Actually going to Wisconsin was a stressful experience, we arrived at 2 AM the night before presentations and were very tired throughout the rest of the competition. It was still a fun experience that we learned a lot from despite the stress and other shenanigans.

Damage and Post Launch team photos:

Here's our rocket before being launched. You can see all the paint and the rocket itself is is in great shape.

The damage to the nose cone can be seen here. Most of this is just paint damage but a bit of the plastic also got crushed when landing.

Here is the post-launch damage to the outer bottom tube of the rocket. This damage tells us the rocket had a rough landing and must have hit a hard surface.

After we evaluated our rocket for damage, we spotted this. The fin must have been hit and the plywood split. This would take a bit of work to fix, but it is repairable.

This picture displays the damage done to the upper bottom section to the rocket. This damage corroborates the theory that the rocket had a rough landing on a hard surface.

This is our team photo. It was taken before leaving for the competition. It was taken in the Rockville Science Center Makerspace. It shows our shirt and mission patch design.