Women in Aerospace

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1. Rocket Operation Assessment

1.1. Flight Anomalies Analysis

The first flight of the rocket (with active drag disabled) was a very stable flight on the J415 motor and there were no anomalies during launch. The parachute deployment events both occurred at their intended altitudes, but the landing damaged the rocket. The booster section of the rocket, which housed the external active drag, landed on the drag fin causing irreparable damage to the system. As a consequence, the entire active drag system had to be dismantled to ensure a safe next flight. The second flight happened with the K1103x motor- this flight was without the active drag system altogether. Due to the large forces experienced during launch, the up and down facing cameras separated from the rocket and were not recovered. As a result, no video has been obtained from the launches. There was an anomaly during descent, and the main parachute did not deploy. This will be further discussed in Section 1.5 Recovery Analysis, below.

1.2. Summary of Flight Characteristics

Two tables explaining the characteristics of each flight are provided below. Information on the weight of the rocket, the motor used, its peak altitude, and maximum velocity with respect to each flight is given in the tables below.

Table 1. Flight Characteristics of first flight, no active drag

Weight on pad	13.3 lbs
Motor	Aerotech J415-W
Apogee	2487 ft (Stratologger)
Maximum Velocity	610 ft/s

Table 2. Flight Characteristics of second flight, active drag system dismantled

Weight on pad	12.5 lbs
Motor	Aerotech K1103X
Apogee	5568 ft (Stratologger)
Maximum Velocity	~1000 ft/s

1.3. Flight Path Assessment

The flight paths for both were as expected, with the rocket going almost straight up with minimal deviation on each launch. A photo of the second launch can be seen in Figure 1.

Figure 1. Still from the second flight of the rocket.

1.4. Recovery Analysis

The recovery for the first flight went as planned: the drogue parachute was ejected at apogee and the main parachute was ejected at 500 ft AGL. Both ejection charges were set off by the Stratologger. For the first flight, the descent rate after the drogue parachute deployed was 55.1 ft/s and it landed at 23 ft/s after the main parachute deployed. During the second flight, the drogue parachute deployed at apogee; however, the main parachute did not deploy at all. Post flight inspection confirmed that the ejection charge went off, but the parachute failed to leave the upper airframe, likely due to tight packing. In the future, proper packing procedures will be more strictly followed to minimize the chance of this failure.

1.5. Rocket Location & (Ground) Recovery Analysis

After the first flight the rocket landed partially in a drainage ditch containing water, as seen in Figure 2. The booster section, which housed the active drag, was partially submerged. The other sections of the rocket remained dry. One of the active drag fins took the brunt of the landing and was consequently damaged- the rod was wobbling around where it should have only been allowed to rotate.

Figure 2. Booster section in drainage ditch.

The booster tube and active drag system were further inspected for damage. The section itself suffered no major damage and was safe to fly again. Unfortunately, the 3D printed donut holding the active drag was broken. The system was deemed irreparable with the tools available and hence unsafe to fly. The entire system was dismantled for the second flight. After the next flight, in which the main parachute did not deploy, the impact on landing was fortunately soft enough as to not damage any part of the rocket. Photos of the rocket on the ground after the second launch are shown in Figure 3.

Figure 3. Rocket after second flight landing.

Upon inspection of the rocket on the ground, it appeared the up and down facing cameras had become detached at some point during the flight. They did not appear to be in the local proximity of the landing site.

1.6. Pre- & Post-Launch Procedure Assessment

The team arrived at the launch site by 9:30 AM on the morning of the launches. This enabled all members to adequately prepare the rocket before the first launch. Working under the one-hour time constraint, each team member was assigned a role to re-assemble the rocket after each launch. The steps that had to be followed for pre-launch assembly and post-launch retrieval were clearly outlined in the team’s flight checklist. For instance, before the launches each team member had the unique role of either folding and packing the parachutes, folding the shock cords, preparing the recovery electronics, or cleaning the motor casing. Additionally, with the help of the team’s mentors, ejection charges were measured and the motor was prepared for each launch. All team members assisted in inserting the shear pins and screws to their respective places along the exterior of the body tube, as well as attaching the cameras, inserting the igniter, and turning on the necessary avionics for each flight on the launch pad. An image of some team members preparing the rocket for launch is depicted in Figure 4.

As for post-flight inspection, the team waited for the range to be clear, then retrieved the rocket and checked for undetonated charges. After returning to the safe area, the Stratologger data was collected and all avionics were turned off and prepared for the next flight. Some of the team members can be seen retrieving the rocket after landing in Figure 5.

Figure 4. Preparing rocket for first launch

Figure 5. Retrieving the rocket after inspection.

2. Actual vs. Predicted Performance

2.1 Peak Altitude and Velocity Comparison

For both of the rocket’s flights, data collection was done from the Stratologger and Arduino. The stratologger recorded velocity and altitude versus time, and the Arduino collected custom velocity data and wrote to an SD card. Altitude and velocity versus time for both flights can be seen below in figures 6 and 7.

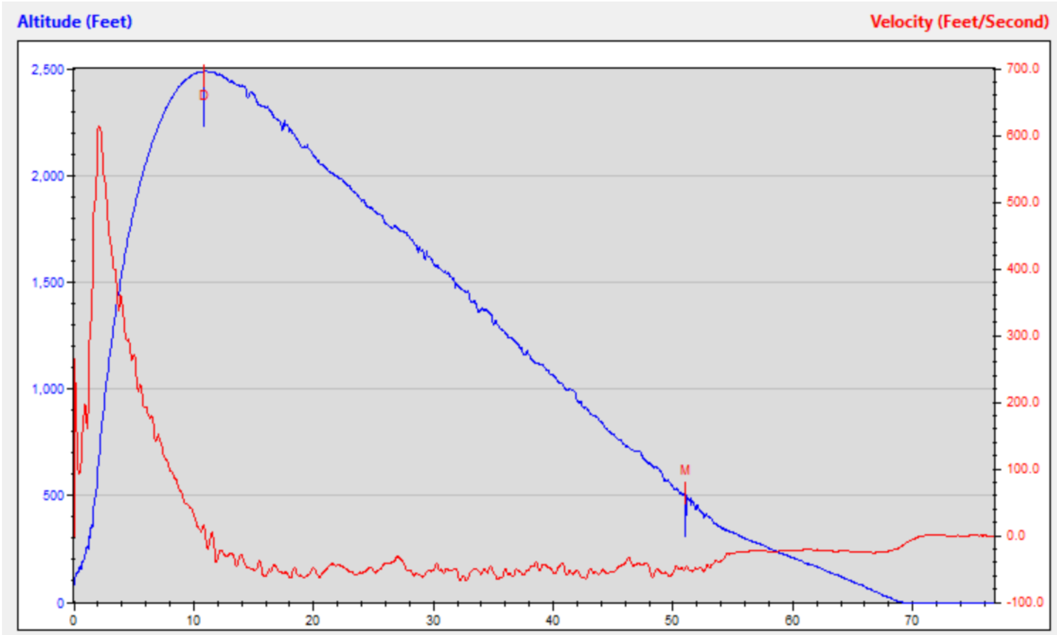

Figure 6. Altitude and velocity data collected from the Stratologger for the first flight.

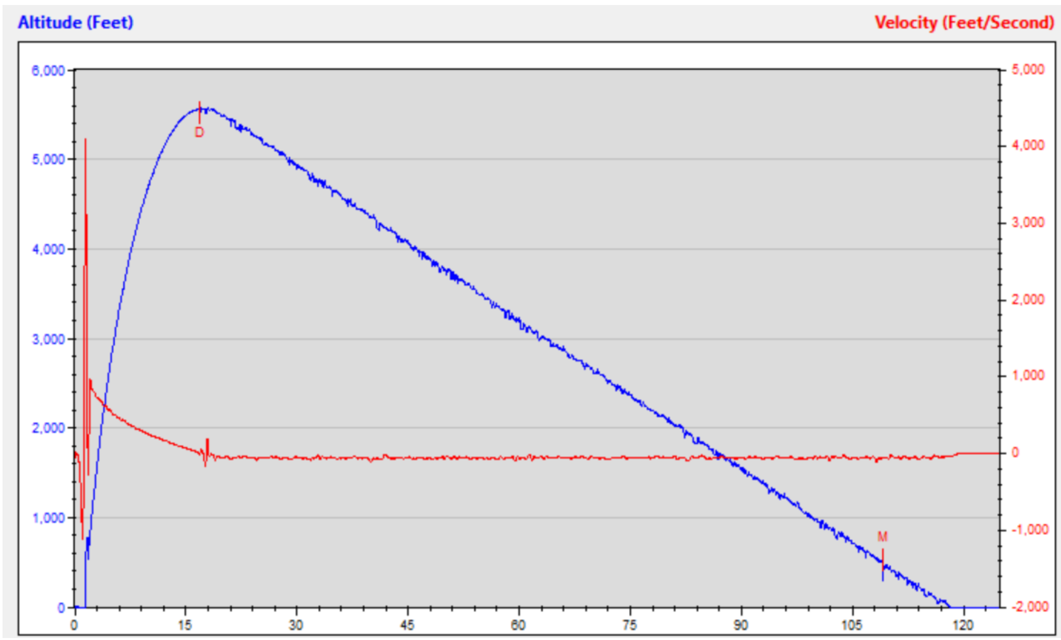

Figure 7. Altitude and velocity data collected from the Stratologger for the second flight.

The predicted altitude and velocity versus time is shown below in figure 8.

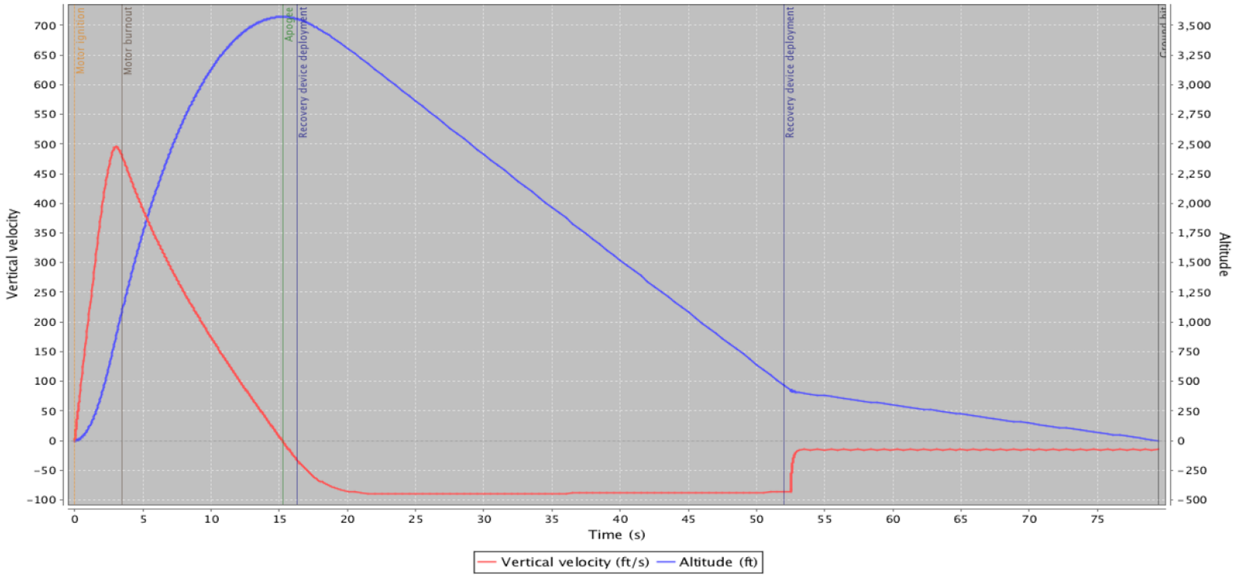

Figure 8. Predicted altitude and velocity.

The actual and predicted flight path trajectories were not identical. The simulation predicted that the rocket would go several hundred feet higher than what the rocket actually achieved. The prediction did not account for the area of the solenoids, cameras, and external wires. It is likely that the increased drag from these objects drove down the peak altitude.

2.2 Velocity Comparison

In both flights, the actual peak velocity was higher than the predicted velocity. The predicted J motor peak velocity was 495 ft/s, while the peak velocity of the first flight was 610 ft/s. This may have been due to assuming a higher coefficient of drag for the rocket during the flights without active drag than the actual value. The predicted K motor peak velocity was 695 ft/s, while the peak velocity of the second flight was about 950 ft/s. As can be seen in figure 7, the Stratologger did not record very good data during motor burn, as evidenced by a reading of 4000 ft/s.

3. Data Collection

3.1 Drag System Report

The active drag fins were intended to be deployed based on an Arduino code which read altitude and time. At an altitude of 100 ft a timer started which waited until shortly after motor burnout and then began fin deployment. This delay was calculated to ensure the active drag did not deploy before motor burnout. Once fin deployment was triggered, solenoids would be released to allow fins to rotate to horizontal position. Unfortunately due to damage sustained during the first flight, the functionality of the active drag system was never realized in practice.

3.2 Velocity Measurement System Report

The custom built velocity measuring package worked with minimal faults. The first flight yielded very accurate velocity readings and a peak velocity of 600 ft/s compared to the actual 610 ft/s. The second flight did however present some faulty data. There are two peaks in the velocity curve. A possible source of this error is viscous effects and turbulent flow as the rocket approached mach 1. Despite this, the resulting velocity curve is overall nicer than that of the Stratologger which gave velocity readings up to 4000 ft/s during motor burn. The custom velocity reading curves are plotted in figure 8.

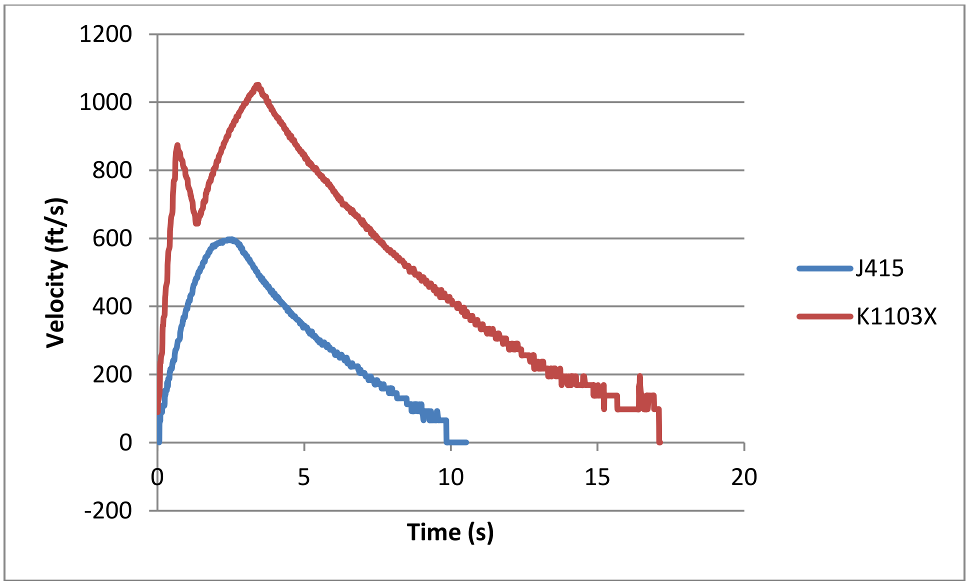

Figure 8. Velocity versus time on custom built package until apogee