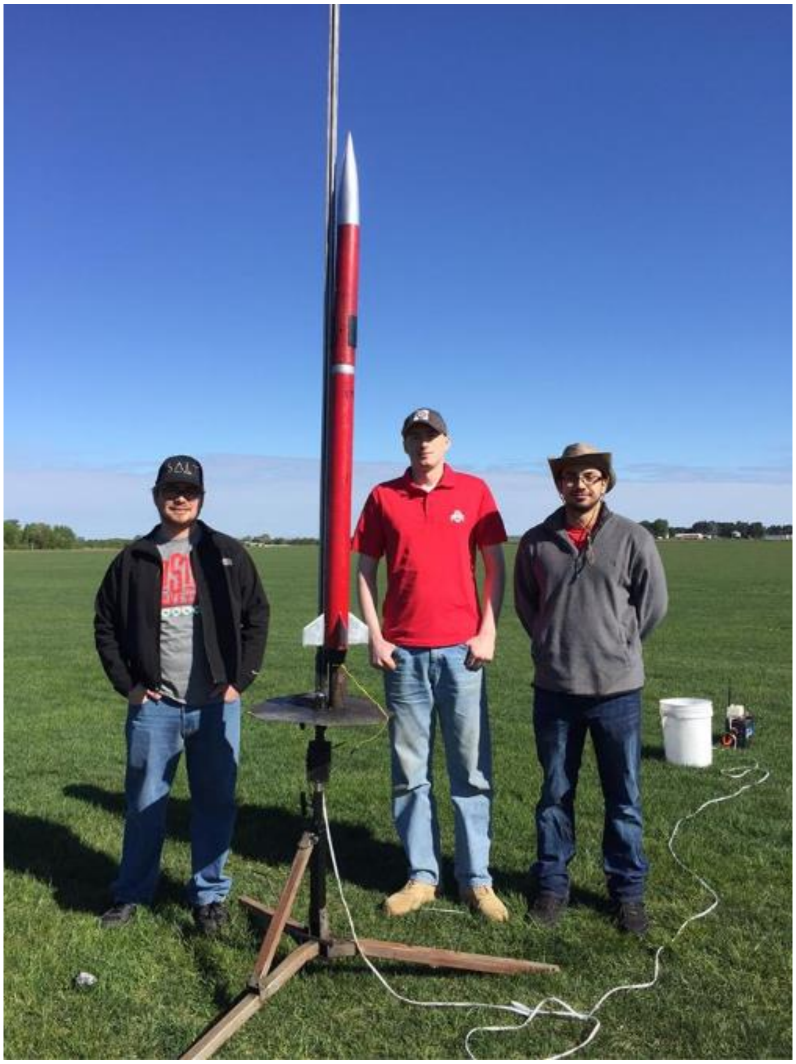

The Ohio State University High Power Rocketry Team

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Contents

I. Rocket Operation Assessment

a Flight Anomalies Analysis

The rocket was set to fail since January and was completely unknown at the time. The retainer mount was attached using regular epoxy. The mount should have been attached using high temperature epoxy. During the second flight of the competition, the epoxy yielded to the high temperature of the motor during the boost stage. The rear enclosure fell off and the nozzle was ejected. The enclosure and nozzle were found 200 yards from the launch site, while the rocket continued to fly a half mile away. As the flight continued, stills from the video shows grains falling out of the motor tube. (Figure 1) The motor casing lodged itself up into the rocket when it crashed to the ground. The stratalogger ejection charge never fired due to cruising at such a low altitude. The motor ejection occurred after landing and destroyed the remaining parts of the rocket.

Figure 1: Still from video of Grain loss during second Flight

b Propulsion System Assessment

On the first launch, the boost phase lasted 1.55 seconds with a max speed of 193.6 m/s occurring at burnout. The rocket flew true and stabile pulling a max acceleration of 14.5 G's. The second launch had the main failure occur. The data was destroyed on impact. According to previous launches it can be assumed the phase lasted 1.6 seconds, but without the nozzle to direct flow the max acceleration would be significantly lower. Another factor that would limit max acceleration is the loss of grains during flight. It is impossible to estimate the actual velocity and acceleration without any of the data.

c Flight Path Assessment

The first launch had a flight path similar to the simulated launch, as well as the test launch. The additional weight of the electronics cause the rocket to have a significantly lower apogee. The difference in apogee from the test launch was 229.21 m. The resulting coast to apogee was only 14.3 seconds as opposed to the previous time of 15.4 seconds. Ejection occurred right after apogee.

The second launch had a completely unpredictable flight path. When the nozzle was ejected, the rocket lost all stability. This caused an erratic flight pattern. The rocket traveled roughly 27 meters vertically before taking a 90 degree turn and travelling an additional 800 meters before impact.

d Rocket Location & Recovery Analysis

The first launch performed as predicted. The main chute deployed close to apogee and allowed for the rocket to coast a significant distance before landing in the top of a pine tree. (Figure 2) The rocket was successfully recovered by team member Sloane Le and brought to the launch site for data collection. The Altimeter Two, stratalogger, and Pi data was collected. Unfortunately, the stratalogger and Pi data was lost due to a Windows 10 upgrade. The

Altimeter Two was luckily saved on a second device. The rocket was prepped for a second launch and relaunched.

The second launch landed without chute deployment due to the low altitude and short time of flight. The rocket landed about 800 meters from the launch site and all data collection devices were destroyed on impact. (Figure 3) The stratalogger was sent in to the company to see if the data could be extracted from the broken board. The company has not yet responded.

Figure 2: First Launch Recovery

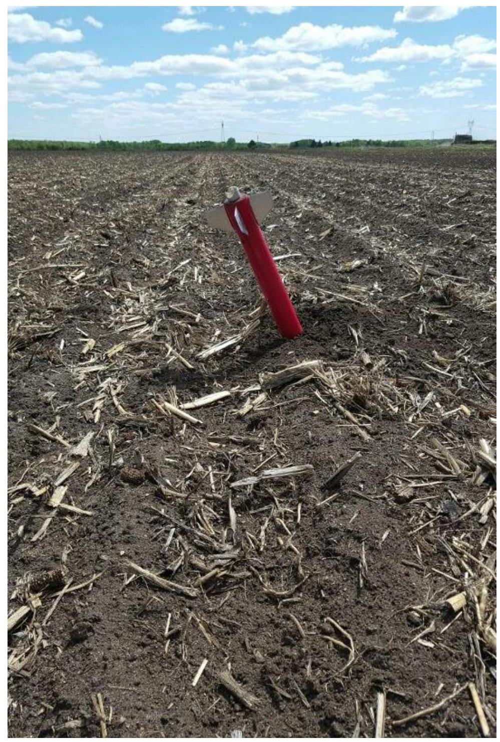

Figure 3: Second Launch Recovery

e Pre- & Post-Launch Procedure Assessment

The following checklists were followed to ensure proper safety and recovery. (Figure 4 & 5)

Pre-flight check list

Initial	Procedure
____	1) Fill the ejection cap with 2.0g of black powder
____	2) Check the electrical wiring
____	3) Fold the parachute properly
____	4) Insert 3 diameters worth of Dog barf
____	5) Plug in the battery in the electronics bay
____	6) Hook up the ejection charges to the Stratologger and Raspberry Pi
____	7) Set up the camera
____	8) Slide in the electronics bay
____	9) Screw on the nose cone
____	10) Insert the J410 motor
____	11) Screw on the retainer
____	12) Insert the igniter and cap
____	13) Place rocket on launch pad
____	14) Turn on the electronics with the off/on switch (bottom switch)
____	15) During drag flight, turn on the drag system with the drag off/on switch (top switch)
____	16) Check that Stratologger produces the correct sequence of beeps
	(drag off -1- 4-5-10-10-> means at preset 1 main deploys at 4500ft, drag on – 2-3-5-10-10-> means at preset 2 main deploys at 3500ft) (the rest
____	17) Check for the light conformation when the switches are turned on
	(red for the electronics and green for the drag)
____	18) Go back to Range Control and start stop watch at launch

Figure 4: Pre-Flight Checklist

Post-flight check list

Initial	Procedure
____	1) Visually track rocket trajectory and landing
____	2) Return to launch site
____	3) Power off electronics
____	4) Inspect the rocket for damage
____	5) Go back to range control, remove and inspect electronics
____	6) Remove mini SD card to recover data and video
____	7) Record altimeter 2 data
____	8) Take data and rocket to judges

Figure 5: Post-Flight Checklist

II. Actual Vs. Predicted Performance

a Peak Altitude Comparison

The peak altitude was found to be 1351.8 m which was over the expected

1160.5 m, (Figure 6) but under the 1581 m/s test flight altitude due to the added weight to the rocket. The true value for the 2nd Competition flight altitude was unknown due to the rocket having a catastrophic failure and crashing into the ground, damaging all flight electronics. The estimated altitude for the 2nd Competition flight was 27 m.

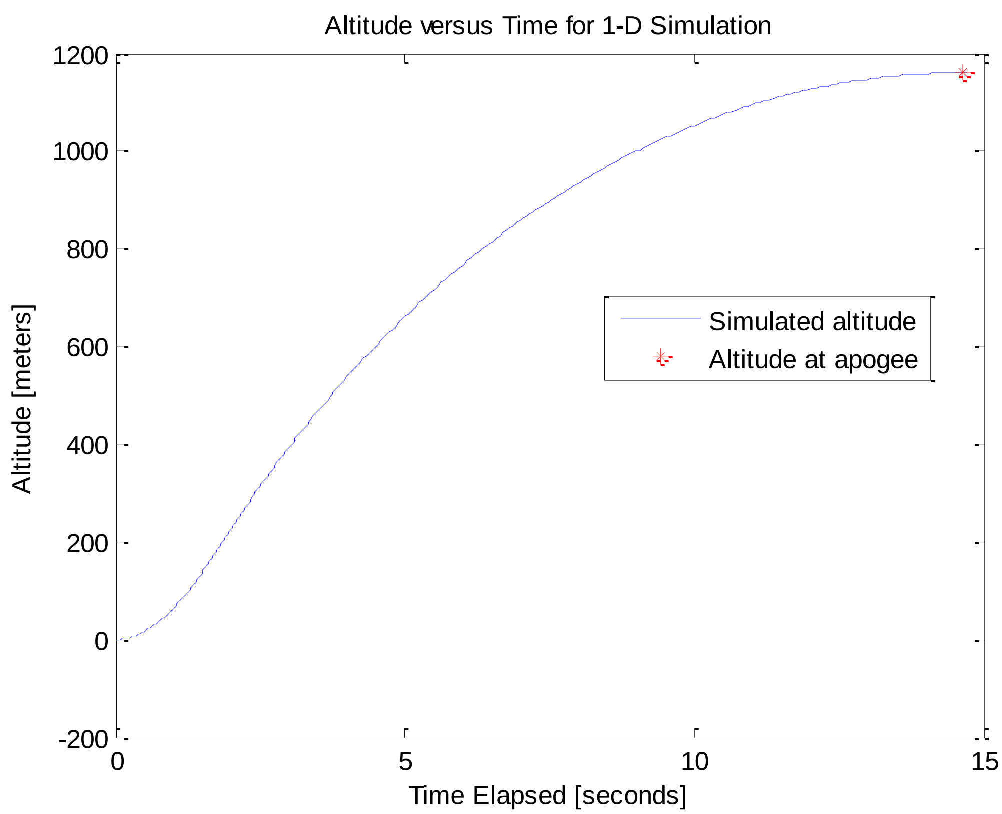

Figure 6: Peak Altitude Simulation

b Coefficient of Drag Comparison

The rocket, with the drag system off, had the coefficient of drag of .61. The predicted coefficient of drag with the drag system on was 1.21. (Figure 7)

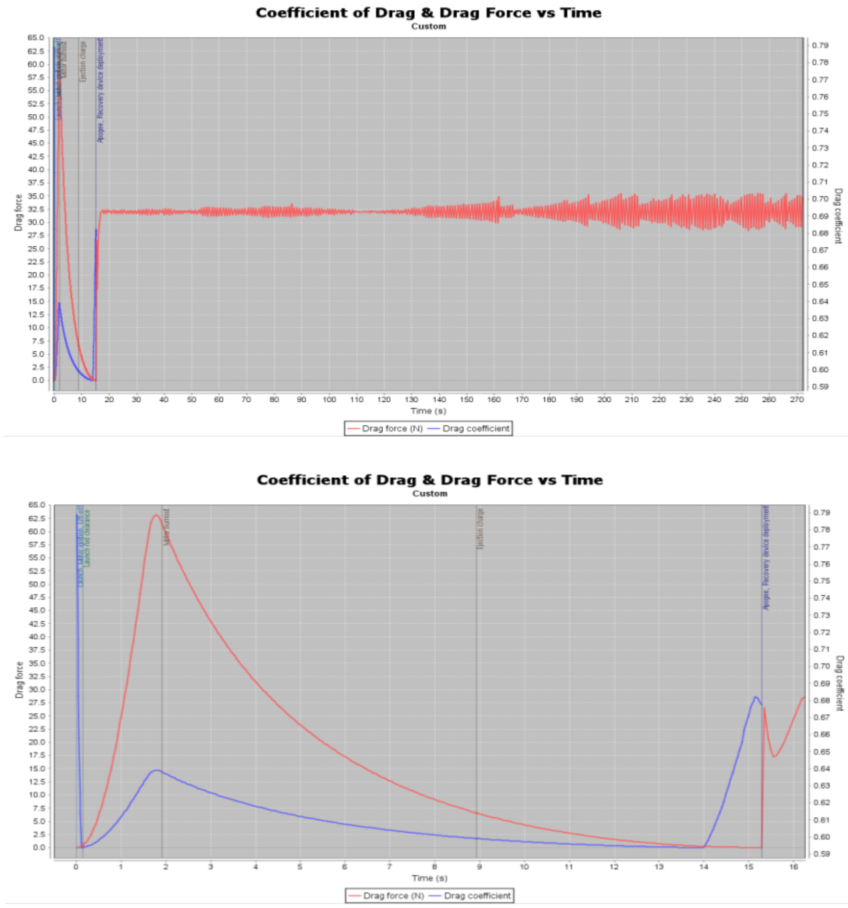

Figure 7: Coefficient of Drag Simulations

c Peak Velocity Comparison

The Altimiter Two read a peak velocity of 193.6 m/s while our simulation gave a max velocity of 184.8 m/s. These two values are in near agreement. Thus supporting the approximate accuracy of our simulations. (Figure 8 & 9)

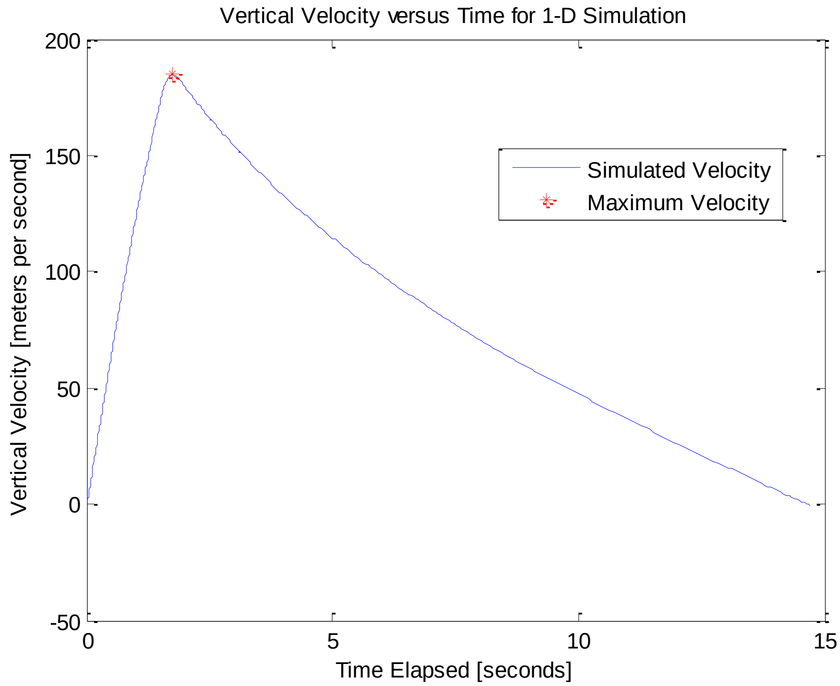

Figure 8: Peak Velocity Simulation

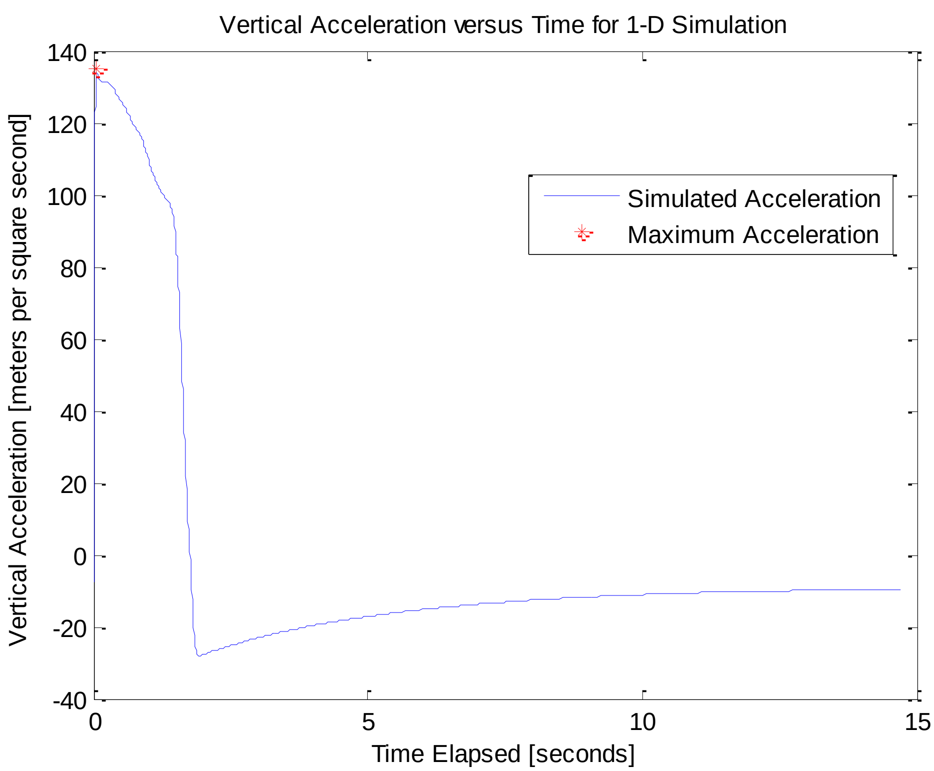

Figure 9: Peak Acceleration Simulation

III. Data Collection

a Drag System Report

The designed drag system, due to structural failure of the motor retainer, was not successfully deployed during the second launch. This was a result of improper epoxy being used to secure the motor retainer. If it were the case that the drag system successfully activated then it was expected that the coefficient of drag would increase by about a factor of two. This can be attributed to the associated increase in drag force resultant of the near doubling in reference area exposed to the freestream. During the first launch, without the drag system deployed, the reference area was taken to be S_(inactive drag system)=0.0182414692 m^2 whereas the reference area for the deployed drag system was taken to be S_(active drag system)=0.0291898342 m^2. Supposing that coefficient of drag varies as an approximately linear function of the reference area leads to the expectation that the drag coefficient would nearly double for twice the reference area. This supposition is extremely limited and is based on intuition since no usable flight data was actually recovered.

b Coefficient of Drag Data Analysis

Analysis of the measured drag coefficient over time was sadly impossible due to the lacking of experimental data. Had the drag system successfully deployed then the experimental measurements would have been compared with the simulated values of drag coefficient obtained from OpenRocket. This comparison would have allowed for computation of the deviations between actual and expected values of drag coefficient. Ideally, the sets of data for drag coefficient would be in near agreement, but due to the limitations of a computer simulation, and its underlying assumptions, it was expected that there would be some significant deviations between the two data sets. Regardless, both data sets would be expected to show an increase in drag coefficient upon flap deployment and a decrease in the velocity as the rocket slows near apogee and the drag flaps are stowed.

c Data Interpretation & Comparison

Interpretation of the drag data would allow for computation of the maximum force to which the drag system was subjected. Knowledge of these forces would enable improved structural design of the drag system to decrease the possibility of failure. Additionally, having experimental data would allow for validation and verification of the simulated rocket motion both in MATLAB and OpenRocket. This ultimately would allow for development of an improved model to simulate the rocket flight. Without experimental data for analysis and comparison not many conclusions can be drawn. Overall, the structural design of the rocket is of paramount importance and must be accounted for much more thoroughly in future rocket designs. Due to team miscommunication and improper usage of materials it was learned that a more strategic and ordered procedure must be implemented in the future when designing and building any rocket. This served as a learning experience because had the structure of the rocket not failed, the experimental data would not all have been lost.