Midwestern Regional Rocket Competition Post-Flight Performance Report

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Team Firepower

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Pre-Flight

The preflight procedure that was created for the launch proved adequate for the safe launch of the rocket. The key improvement that could be made would be to move away from a sequential procedure -- which at times had group members waiting when certain tasks could have been performed simultaneously -- to a responsibility-based procedure which detailed the tasks to be performed by each individual member.

Flight and Drogue Deployment

When launched the rocket flew stably and relatively straight, very similarly to the expected flight profile. During the flight the recovery system performed as anticipated. Based on the data from the Arduino microprocessor, the drogue parachute was deployed at 3014 ft and the rocket glided to a maximum altitude of 3215 ft. Both the deployment altitude and stopping distance were higher than anticipated. This is likely due to the drag force on the drogue being overestimated and also to the parachute taking longer to unfurl than expected, as indicated by data from the Raven altimeter. The Arduino deployed the drogue parachute late due to an integration issue between the pressure sensor and the Arduino microprocessor; from the logged data, it was determined that the Arduino loop sampled the altitude from the pressure sensor faster than the pressure sensor refresh time. Thus, the measured altitude only changed every four Arduino loops which led to errors in measuring vertical velocity as change in altitude over time. Because the Arduino measured a velocity of either zero (because the altitude had not changed) or four times too large (because the time step used was too small), these velocities were outside the range of the decision table stored on the SD card and the Arduino never looked up the deployment decision in the table. This timing issue is easily fixed in the software and does not affect the post-flight data as all the velocity values can be divided by four to obtain correct values. The drogue was deployed during ascent by a failsafe case for situations outside our table. This case deployed the parachute if the current altitude was above 3000 ft and the velocity was less than 220 ft/s -- the allowable limit to keep the parachute load below 1200 N -- to avoid going any higher. This case was met three consecutive times -- the number required to avoid faulty data deploying the drogue -- and then the Arduino deployed the drogue. According to the velocity data determined after recovery, the rocket was traveling 150 ft/s at deployment then glided stably for 200 ft, validating the physical design. The motor used performed as expected; RockSim simulations predicted an apogee of 3500-3600 ft and based on the velocity recorded at 3000 ft, PebbleSim predicts an apogee of 3440 ft. Based on this, it can be assumed that the drogue parachute cut 200-300 feet off of the possible apogee.

Post-Flight

The rocket landed within view of the launchpad and the post-flight procedure was immediately followed. This procedure was of an appropriate length and expedited the completion of each member's individual tasks. The procedure used to calculate the rocket's landing location was accurate and the longitude coordinate was calculated correctly, however the latitude coordinate was calculated incorrectly due to a simple mathematical error. Upon recovery, it was found that the competition Raven and the Stratologger altimeter did not function correctly, yielding data that was indecipherable. These two systems were configured properly and gave valid audible signals on the launch pad and therefore the reason for their failure is unknown.

Data Analysis

A comparison between the predicted and actual values for altitude, velocity, and acceleration is shown in Figure 1. The actual apogee was over 200 ft higher than the predicted apogee due to the issues with the altitude look-up system. Otherwise, the recorded altitude and velocity closely follow the predicted results. The agreement between the predicted and actual data for the acceleration vs. time can be seen in the top right plot of Figure 1. The recorded acceleration follows the predicted shape however the values recorded by the Arduino do not peak as high as expected. The accelerations recorded by the Raven altimeter show accelerations higher than predicted were experienced; these errors are likely due to a configuration or calibration issue with the Razor IMU that was not detected during ground testing as it is difficult to safely achieve such high accelerations in ground testing. Furthermore, higher acceleration than predicted by PebbleSim on descent was recorded. This is likely due to the fact that PebbleSim does not account for wind gusts and that there were some complications fully opening the main parachute which would cause a less stable descent.

The primary Raven functioned properly and the data recovered from it is presented in Figure 2. The effect of the drogue deployment can be seen by the spike in acceleration data and accompanying rapid decrease in velocity. The secondary charge to deploy the drogue parachute was deployed as a failsafe at apogee, as it can be seen that the rocket had experienced the drogue deceleration well before this charge was deployed. In the top left plot of Figure 1 it can be seen that the actual measured velocity generally agreed well with the predicted velocity, the main difference being the time which the drogue parachute was deployed.

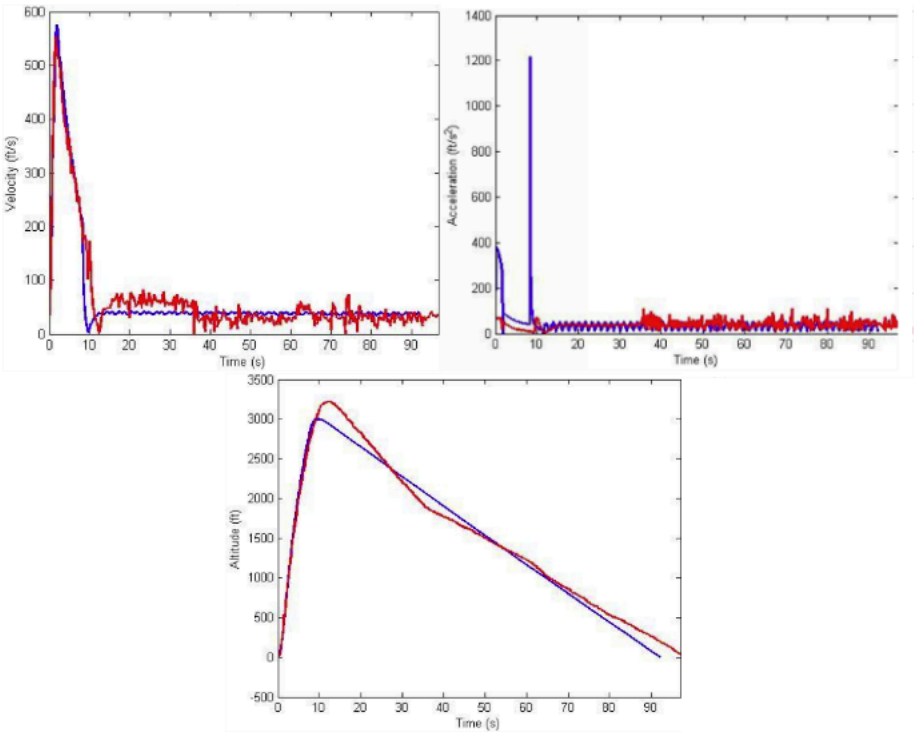

Figure 1: This figure shows the comparison plots for altitude, velocity, and acceleration of the rocket during flight, with the expected values in blue and the measured values in red. Overall, there is excellent agreement between the two data sets.

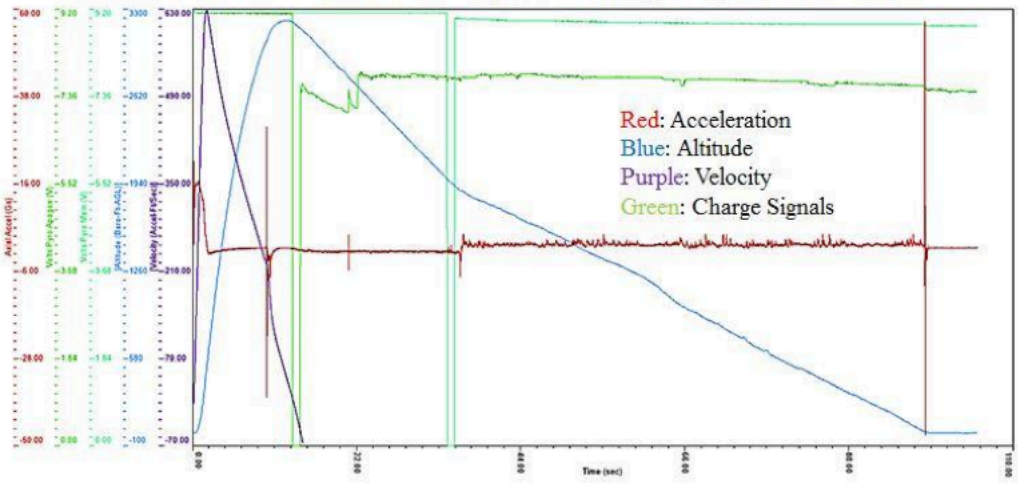

Figure 2: The data acquired from the Raven altimeter during flight is shown. The altitude is in blue, the acceleration in red, the velocity in purple, and the points in time that the raven deployed its charges in green. The charges deployed were first for the backup drogue charge at apogee and second for the main parachute charge on descent.