# Post-Flight Report

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**Midwest High Power Rocketry Competition Team**

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**Rocket Operation Assessment**

*Flight Anomalies*
No anomalies occurred during the flight. After recovery of the dart, it was found that the rotational data was not recorded. This is discussed in more detail in the *Data Collection* section. All components of the rocket were recovered successfully and assessed to determine if any damage occurred during the flight. No damage was found, and the rocket could have been flown again without needing to make any modifications or repairs.

*Propulsion System*
The given competition motor was a Cesaroni I445-16A Vmax motor. The delay was adjusted to be 9 seconds. This was placed into a Cesaroni Pro54 motor casing and secured with the corresponding closure ring. An Aeropack retainer ring was used to hold the motor in place during the rocket's flight. At the launch pad, the igniter was inserted into the rocket and the leads were connected.

*Flight Path Assessment*
The rocket followed the expected flight path. The launch was vertical until burnout, and the dart and booster separated as expected. Each component followed the expected arc to apogee, and the descent phase went as expected with minimal traveling occurring for both components. Further analysis of the flight path can be found in the *Actual vs. Predicted Performance* section.

*Recovery System Assessment*
The booster recovery system was a 52'' LOC Angel parachute. This was deployed using the ejection charge from the Cesaroni motor. The booster parachute deployed properly. The dart contained a dual deployment system to prevent the dart from travelling too far during descent. The dual deployment system was filled with 0.7 grams of FFFG black powder on both sides. Two 6x60'' nylon streamers were set to deploy 0.2 seconds after apogee. The main parachute was set to deploy at 900 feet above ground level. The main chute used was a 30'' Fruity Chute.

*Rocket Location and Recovery Analysis*
The dart was safely recovered roughly 500 – 1000ft from the launch pad. Upon recovery, the electronics payload indicated successful video recording and rotational data collection. Further analysis of the recorded data showed that rotational data was not properly collected. This is discussed in the *Data Collection* section. Both sections of the dual deployment system separated cleanly and no black powder remained allowing for safe recovery of the dart immediately after landing. The rocket was taken to the post-flight assessment area and checked for damage. No damage was found. The recorded video was saved for later comparison with video from other flights.

*Pre- and Post-launch Procedure*
The rocket was assembled and prepared for launch according to the prepared checklist. The booster was assembled first. The motor was set up by one person while another packed the booster parachute and inserted the shear pins. The motor was then placed in the booster and the retaining ring was screwed on to secure the motor. Another team assembled the dart. A battery was placed in the dual deployment system. 0.7 grams of black powder was placed in each blast

cap, and wadding was secured over the caps using rubber bands. The streamers and parachute were tied to their respective ends of the dual deployment system, and then placed into the dart. Shear pins were used to secure the dual deployment system. A battery was placed into the electronics package, and the package was then secured to the aluminum coupler.

At the launch pad, the final aspects of setup were completed. The booster was slid onto the launch rail. The dart was then placed on top of the booster. The pin was pulled from the dual deployment system to activate it. Finally, the igniter was placed into the motor. The connection was checked, and the leads were attached.

After launch, two team members were sent to retrieve the booster and two were sent to retrieve the dart. Care was taken to ensure that shock cords were not tangled and that the parachutes were picked up carefully. The dual deployment system was deactivated by inserting the pin. The entire rocket was taken to the post-flight assessment area to check for damage and to provide the flight video for later comparison.

## Actual vs. Predicted Performance

Figure 1 shows the altitude data collected by the dual deployment altimeter in the dart. The maximum altitude was 1730 feet for the dart and 1476 feet for the booster giving a separation distance of 256 feet. The separation distance and maximum altitude were both higher than the simulations and the test launch. This could be due to lower wind speed conditions than simulated. Tables 1 and 2 give various values from the rocket's flight for the dart and booster respectively. Certain values are discussed in more detail below.

Table 1: Dart Data

| | |
|---|---|
| Apogee | 1730 ft |
| Maximum Velocity | 271 MPH |
| Thrust Time | 1.6 s |
| Peak Acceleration | 13.5 G |
| Average Acceleration | 11.7 G |
| Coast to Apogee | 9.6 s |
| Apogee to Ejection | 9.5 s |
| Ejection | 122 ft |
| Descent | 0 MPH |
| Duration | 94.5 s |

Table 2: Booster Data

| | |
|---|---|
| Apogee | 1476 ft |
| Maximum Velocity | 269 MPH |
| Thrust Time | 1.6 s |
| Peak Acceleration | 13.5 G |
| Average Acceleration | 11.6 G |
| Coast to Apogee | 8.6 s |
| Apogee to Ejection | 8.5 s |
| Ejection | 113 ft |
| Descent | 0 MPH |
| Duration | 94.5 s |

The maximum velocity was 271mph and 269mph. The maximum acceleration for both the booster and dart was 13.5G. This was comparable to the simulated value of 15G. The difference in acceleration could be due to a better surface finish on the simulated rocket than the actual one. The actual rocket did not have an incredibly smooth finish along the body, and also had shear pin heads sticking out of the body which caused extra drag on the rocket. The simulation, however, assumes a smooth finish as an ideal condition.

Figure 2 shows the simulated altitude and velocity. The differing graphs help support the above conclusions as to why the values differed. The fin placement can also be named as a cause for deviations from the simulation. In the simulation, the fins were assumed to be perfectly spaced. During the manufacturing process, the fins on the dart were not spaced out perfectly, and the fillets were not sanded down as much as was necessary.

Figure 3 gives the simulated altitude and velocity. A graph was unable to be created for the actual flight of the booster, so a direct comparison of graphed data over time cannot be performed.

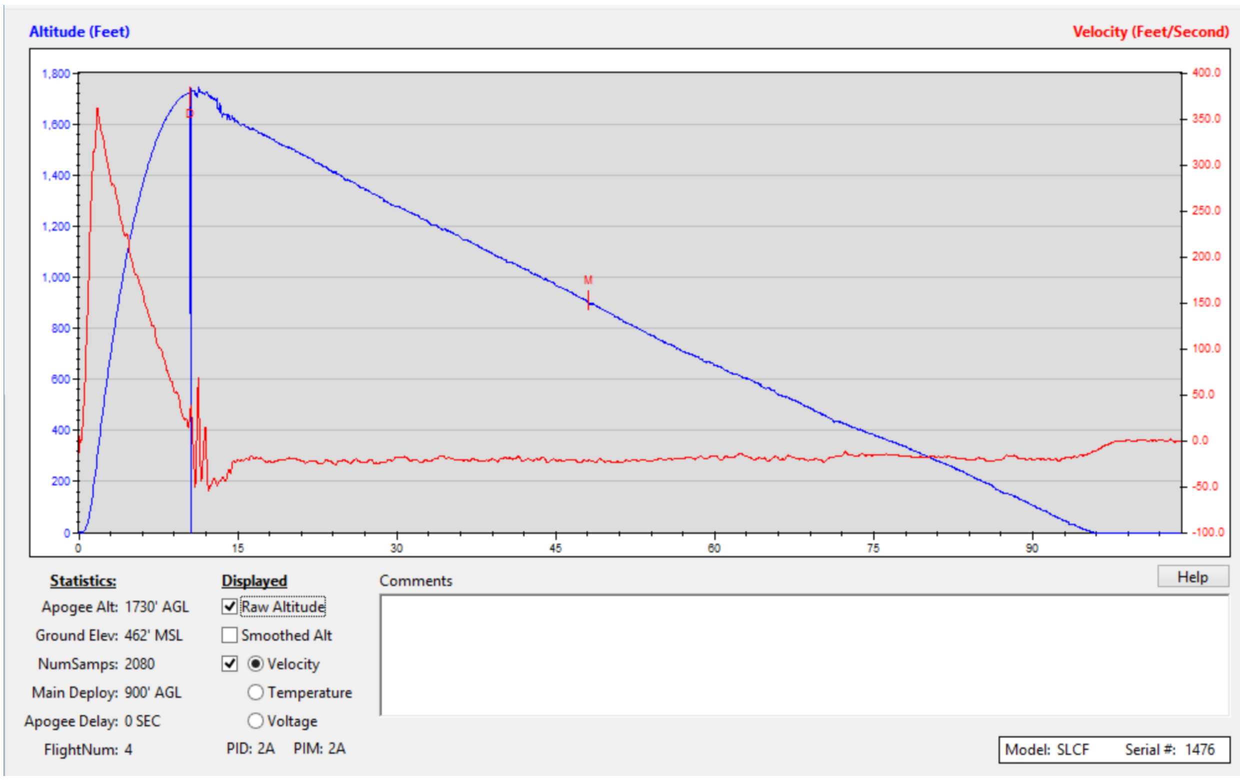

Figure 1: Dart altitude and velocity data from final launch

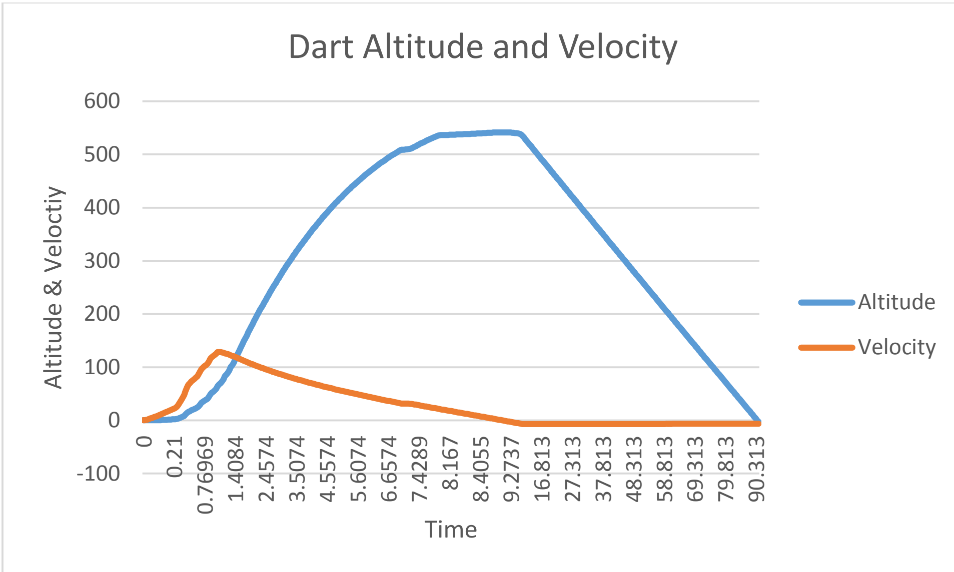


Figure 2: Dart altitude and velocity data from simulation

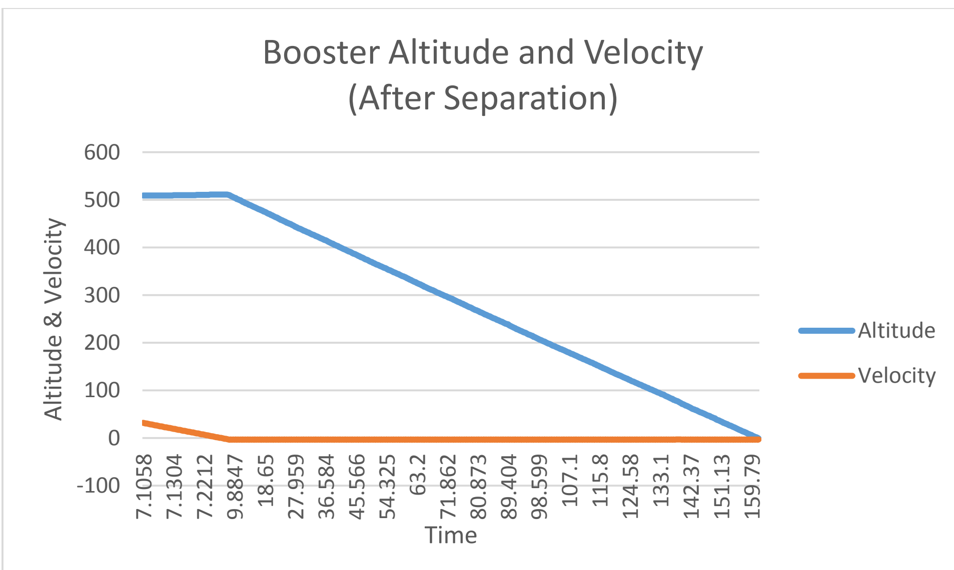


Figure 3: Booster altitude and velocity data from simulation

**Data Collection**

The SD card was unable to record the rotational data from the flight. The likely cause of this was corruption of the SD card prior to launch, though the exact cause is unknown without testing of the full electronics payload.

The recorded video was of high quality and captured the entirety of the flight. During descent, the booster was able to be seen in the video as both the booster and dart descended toward the ground. A rough analysis of rotation was done using the video recorded during the flight. This helped to both verify the video quality and obtain some level of rotational analysis. 21 rotations were noted from launch to the dart’s apogee. This is roughly 7560 degrees of rotation. The rotational velocity of the dart increased greatly after separation from the booster. This increase in rotational velocity suggests that the fins were not placed perfectly on the dart and booster. It is likely that during flight, the placement of the fins on the booster and dart cancelled out some of the rotation. Although an actual comparison of recorded rotational data and video could not be done, this video-only analysis allowed for a chance to study the rocket’s flight characteristics and analyze the overall performance.