Post Flight Performance Report

Team Rocket Power
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1. Team Summary:

"Team Rocket Power"

University of Illinois at Urbana Champaign

Team Leader: Stan Chan

Safety Officer: Stephanie Camello

Member: Ali El-Ashri

Member: Kento Kaneko

2. Approach to Complete Mission Requirements

The mission requirements for this project were to design, build and launch a rocket to reach as close to 3000 ft as possible with a CTI I-540 motor. The maximum dimensions specified for the rocket was 4 in diameter, 72in total length, and less than 7.5 lbs without the motor installed. The approach taken to meet mission requirements was to utilize altitude data collected during test flights and compare the data to that given by the simulations. Adjustable ballast was used to adjust the maximum altitude of the rocket to ensure that it reached mission requirements. The simulations given by OpenRocket are given in figures 1 and 2. The maximum altitude predicted by OpenRocket was 3089 ft using a ballast of 2.5 lb ballast. The margin of stability with the ballast installed was at 2.79 cal.

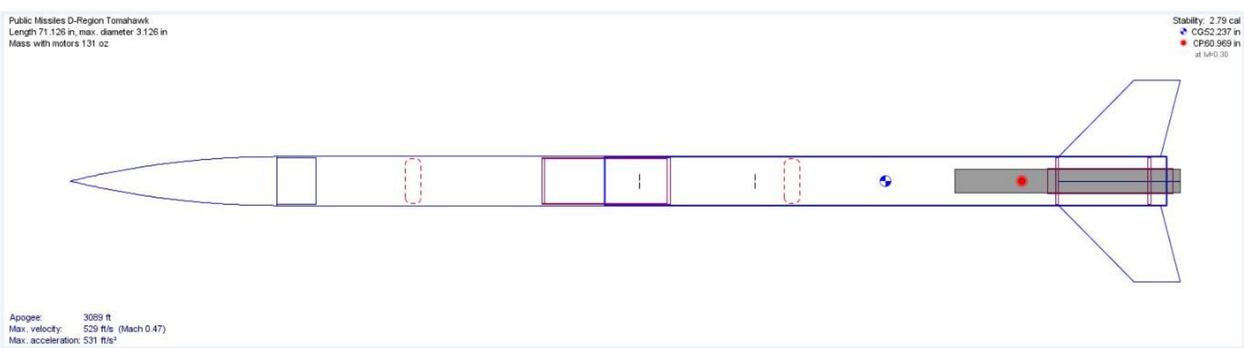

Figure 1: OpenRocket simulation of rocket

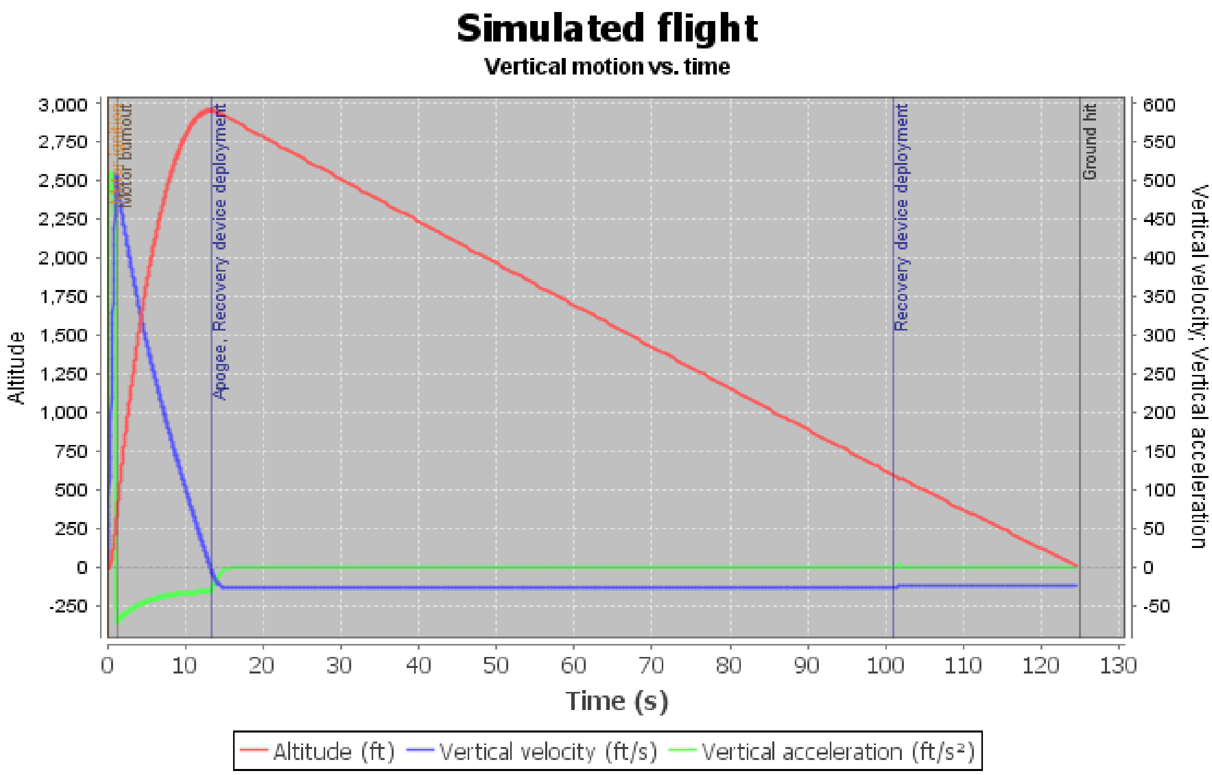

Figure 2: Open Rocket simulated flight results

A test launch was completed at the Thunderstruck event in Ash Grove, Indiana on April 7th, 2013. The altitude and velocity data collected by the onboard Stratologger SL-100 altimeter is shown in figure 3. The total rocket mass was 7.2 lbs with the CTI I540 motor installed. All safety precautions and proper launch procedures were taken for this flight to ensure safety of all team members and other bystanders in the launch area.

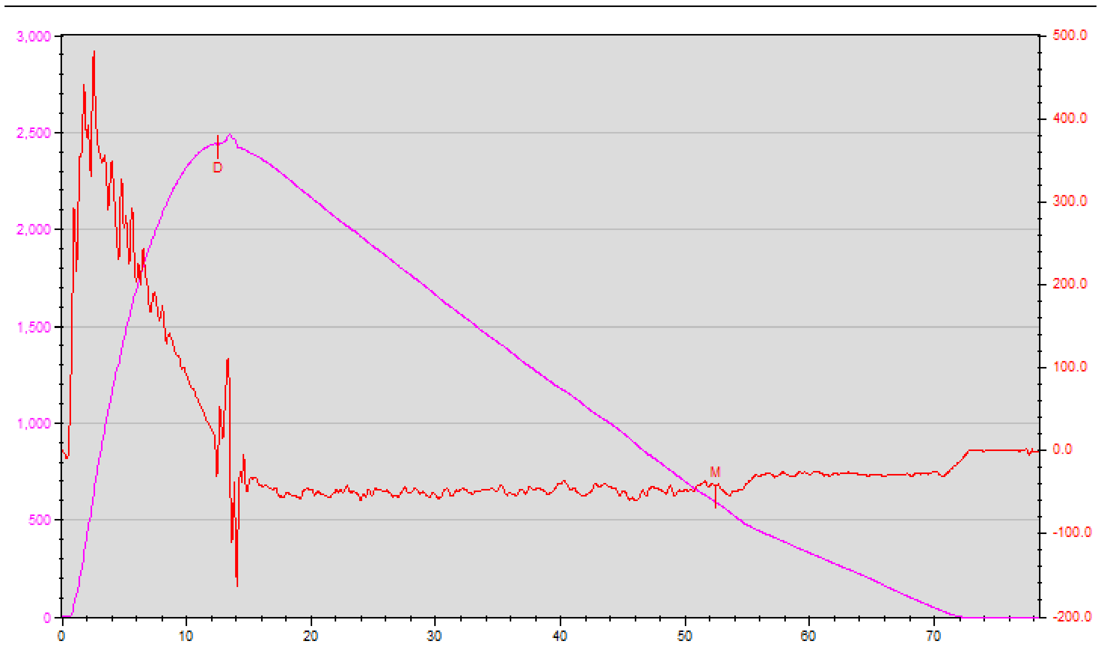

Figure 3: Actual test flight results

The predicted altitude for the test flight was 3089 ft while the maximum altitude obtained was 2486 ft AGL. The difference in altitude was attributed to the extra surface drag on the exterior of the rocket due to sanding and the presence of bolt heads on the surface.

3. Launch Vehicle Summary

The kit chosen for this project was the PML D-Region Tomahawk kit with a 4 in diameter airframe and 71in length. The two section body tube was formed from the Quantum Tube material by the manufacturer with four fin slots for the G-10 fiberglass fins. The nose cone used was a 7 in plastic O-give von Karman nose cone supplied with the kit. To convert the kit to a dual deploy rocket, a 1.5 in section of the airframe was used in conjunction with the Phenolic coupler as the switch band and avionics bay. Aeropoxy was used as the structured adhesive during the construction of the rocket. Two standard rail buttons were secured to the side of the rocket and an AeroPack motor retainer was used for positive motor retention. For recovery, a 20 in drogue and a 60 in main chute was used. A Stratologger SL-100 and an Altus Metrum

TeleMetrum was housed in the avionics bay. The ballast was constructed from several bulkheads and a small section of phenolic tubing. Four bolts were used to hold the ballast near the natural CG of the rocket to maintain the desired margin of stability. An extensive analysis of each component of the rocket can be found in the Flight Readiness Report.

Functional testing was completed on the rocket to ensure proper function of the recovery system. Charge testing was completed and the final amounts of black power charges required to separate the sections was determined to be 1.5g for the drogue and 2.5 for the main chute.

Several pictures of the components can be seen in figures 4, 5, and 6. A picture of the test flight can be seen in figure 7.

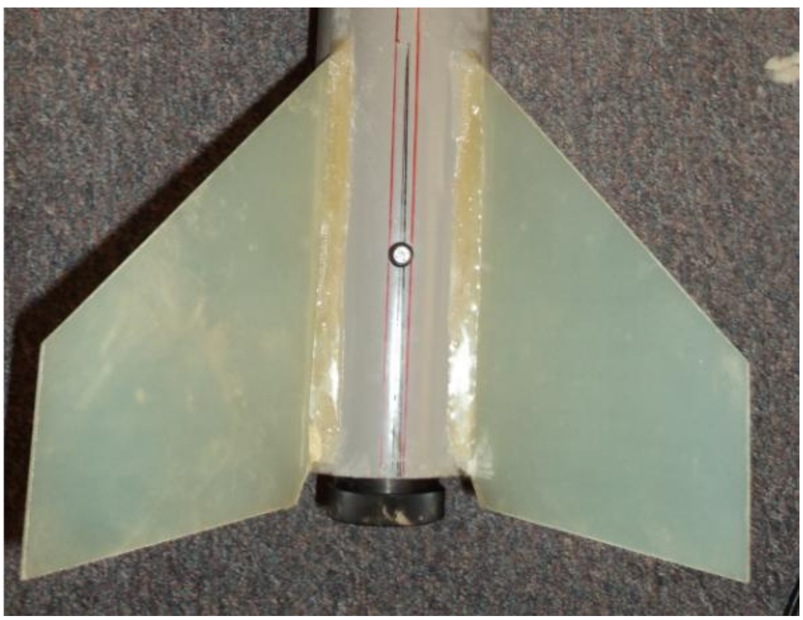

Figure 4: Fin and rail button assembly

Figure 5: Variable ballast system

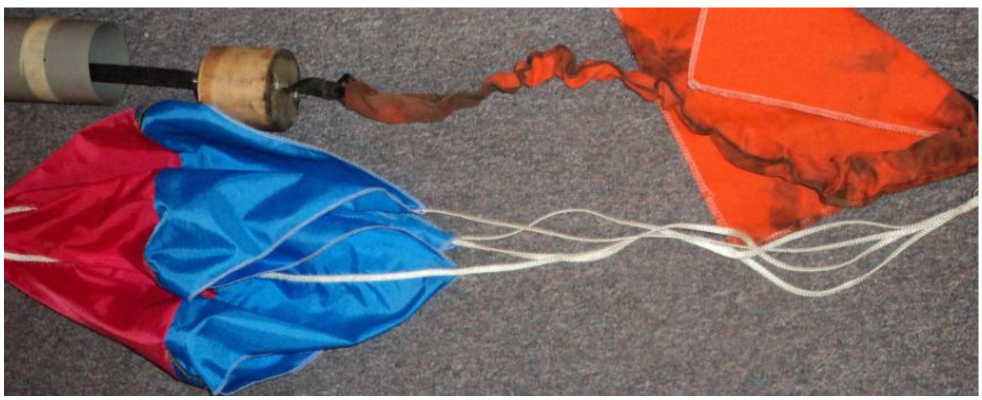

Figure 6: Drogue parachute system

Figure 7: Test flight recovery

4. Flight Performance Overview and Data Collected

The competition flight was completed on April 27th, 2013 at the Bong recreation area in Wisconsin. All safety checks were completed to ensure the safety of all persons and equipment. The Altus Metrum was chosen as the backup altimeter because it had not been tested as such in functional testing. The SL-100 on the other hand, had been used as the primary altimeter during the test flight. The ballast used was 1.0 lb to increase the altitude of the rocket. The flight characteristics as recorded by the competition Raven altimeter is shown in figure 8. The maximum altitude achieved was 2644 ft AGL. The predicted altitude for the flight was 3200 ft by OpenRocket. The rocket was recovered successfully and in a flyable condition. No damaged was observed to compromise the structural integrity of the rocket. The SL-100 was set to deploy the drogue chute at apogee and 600 ft for the main. The Altus Metrum was used for the backup altimeter and was set with a 2 second apogee delay for the drogue chute and 500 ft main chute.

Due to the nature of the ballast system, a motor back up was not used. The redundant recovery system ensured deployment of the parachutes. During the competition flight, it is apparent that the drogue parachute opened near the apogee of the flight and the main chute opened near the 600 ft setting. A picture of the recovery is shown in figure 9.

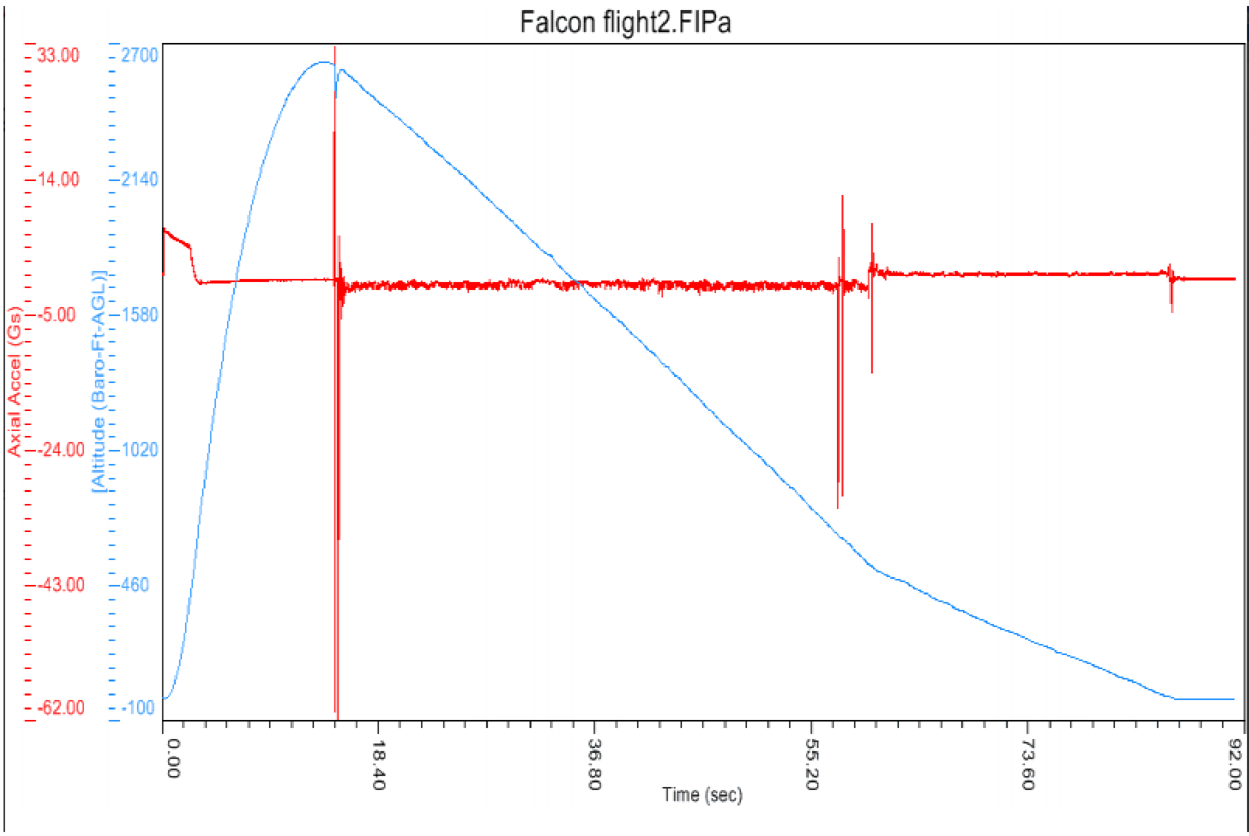

Figure 8: Competition flight data

Figure 9: Successful parachute deployment and recovery

5. Comparison of Actual to Predicted Performance and Discussion of Differences

As shown in the flight data collected by the competition Raven altimeter, there was still a large difference in the predicted flight altitude and the actual flight altitude. The difference between the actual flight and predicted flight was 556 ft with a percent error of 21%. For OpenRocket, an error ~20% is not uncommon depending on the geometry of the rocket. For this project, the surface finish was not extremely fine due to the pre-sanding and the paint chosen. The required bolts for the standoffs to hold up the ballast added extra skin drag to the rocket. In addition to the bolts, the bezel on the keyed switches also added extra skin drag. Without access to a wind tunnel, the actual coefficient of drag could not be reliably calculated for the rocket. Also, wind speed was not taken into account in the simulation and thus weather-cocking was ignored in the simulation. With a large margin of stability, weather-cocking could have had a large effect on the rocket depending on the wind speed during launch.

6. Conclusion

While the rocket did not perform as well as predicted by the simulations produced from OpenRocket, much was still learned from the construction, team building, and technical writing for this project. The approached used to solve the engineering problem was that of a simple guess and check method. Using simulations to determine the expected altitude and using test flights to refine the simulations. Using a simplified model of the rocket did not provide a high fidelity model of the behavior of the rocket. Much was not taken into account, such as the high coefficient of drag discussed above in section five, and the weather-cocking effect. Since a majority of the team was not fully experienced with high powered rocketry and technical writing, this project provided a great opportunity for exposure to the core competencies of engineering.