Team Jarts
Post Flight Analysis

May 20, 2013

"THE RIPPER II"

Brett Foster, Joe Hintz, Eric Logisz, Cameron Schulz

Post Flight Analysis

Overall Performance

The overall flights of the rocket were successful. The rocket was designed to meet the requirements of the competition and this occurred. The rocket reached an apogee of 3149 feet and 2748 feet in its two flights, fitting in the window. Along with reaching a suitable apogee, the rocket was recovered safely and in flyable condition for both flights. By design, using electronics to deploy parachutes, using a Cesaroni I540 motor for one flight and a Cesaroni I216 for the second flight, using the Raven III altimeter as the competition altimeter, and the parameters on the rocket size and mass were met. The main design component of our rocket was simulation to reach an apogee of 3000 feet. Along with simulation, the only active means to make the rocket reach exactly an apogee of 3000 feet was the deployment of a drogue parachute on the ascent of the rocket. In order for this design to work, the rocket needs to have a projected apogee higher than 3000 feet. As mentioned, the apogee of 3000 feet was overshot by 149 feet. The reason the second flight flew to an apogee lower than 3000 feet was due to a different motor being used. Test flying was a key aspect to our design and without flying on the new motor before, it was difficult to predict the flight. Ideally, we would have flown again on an I540 and increased the mass to reduce the altitude achieved. With the additional design component, the apogee reached was sufficient, but the deployment of the drogue parachute did not occur allowing the rocket to reach this altitude. The rocket was designed such that this component failure did not result in the rocket failing. A big aspect of the rocket was its durability. This was shown on launch day by launching the rocket successfully, twice. After both flights, the rocket had no damage occurred to it and is in flyable condition.

Recovery

The initial flight design was to deploy a parachute during the ascent phase of the flight. The design was done to predict the stopping distance of the rocket using a 24 inch drogue parachute. During the competition flight the MARSA4 altimeter malfunctioned and did not have any pyro events. As a result, the rocket flew to an altitude 149 feet higher than predicted the first flight. Due to the redundancy built into the design there was still a successful dual deployment. The PerfectFlite StrattoLogger deployed the drogue at apogee as designed and also fired the 48 inch main parachute 700 feet above the ground. With the good weather, the parachutes were sized correctly and both flights landed the rocket within a half of a mile from the launch pad.

Structural

The rocket had been extensively tested structurally in one of the previous test flights when all of the parachutes deployed prematurely at maximum acceleration. During this flight the rocket sustained no damage due to a successful zipper less design. This premature event occurred due to a low voltage in one of the altimeters. This was corrected and moving forward the team had great confidence in the structural design. As expected the rocket sustained no structural damages during the competition flight. The rocket did have some of the cosmetic fillets on the exterior of the fins crack off but the fins are still securely attached by the structural fillets in the interior of the rocket.

Altitude – Open Rocket

When comparing the results of the predicted data to the actual data, one can confirm the analysis method used. There was a relatively small disparity between the predicted altitude and the recorded value for the OpenRocket prediction. The predicted value was lower than the actual value due to the fact that OpenRocket estimated the coefficient of drag to be .54. In reality the coefficient of drag was roughly 0.41. This value was obtained by backing out the value using the MATLAB code.

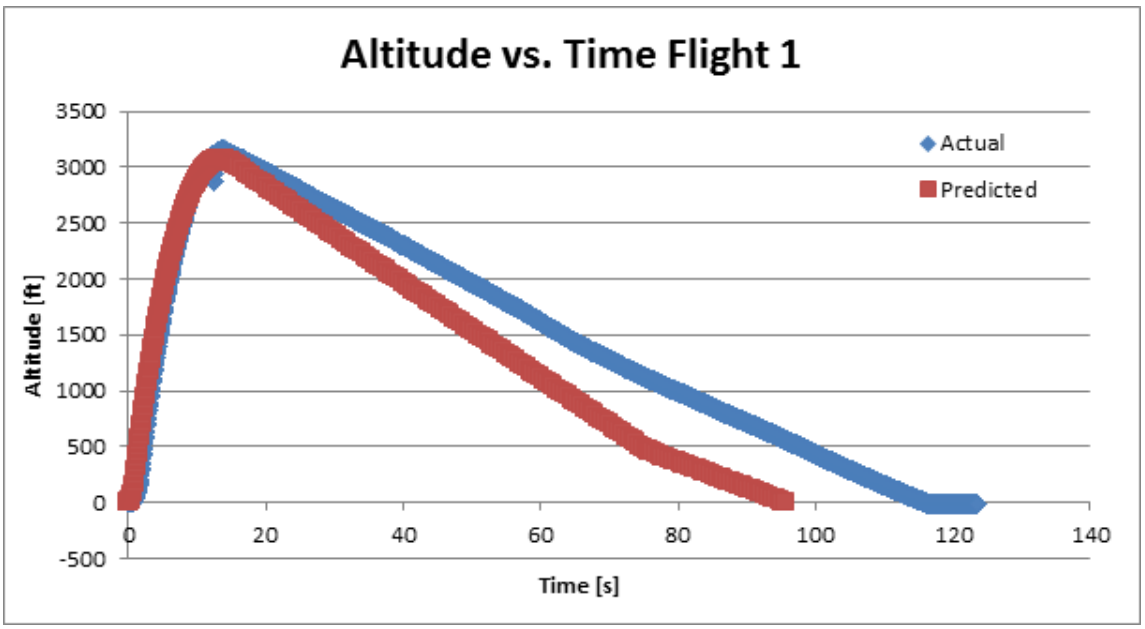

Figure 1: Actual and Simulation Comparison of Altitude, Flight 1

The OpenRocket prediction of the second flight with the new motor was 2976 feet. With the rocket exceeding the predicted altitude on the first flight, an assumption that the rocket would also exceed the predicted altitude was made. After flight, it was clear this assumption was not valid. With a test flight on this motor, a better prediction could have been made.

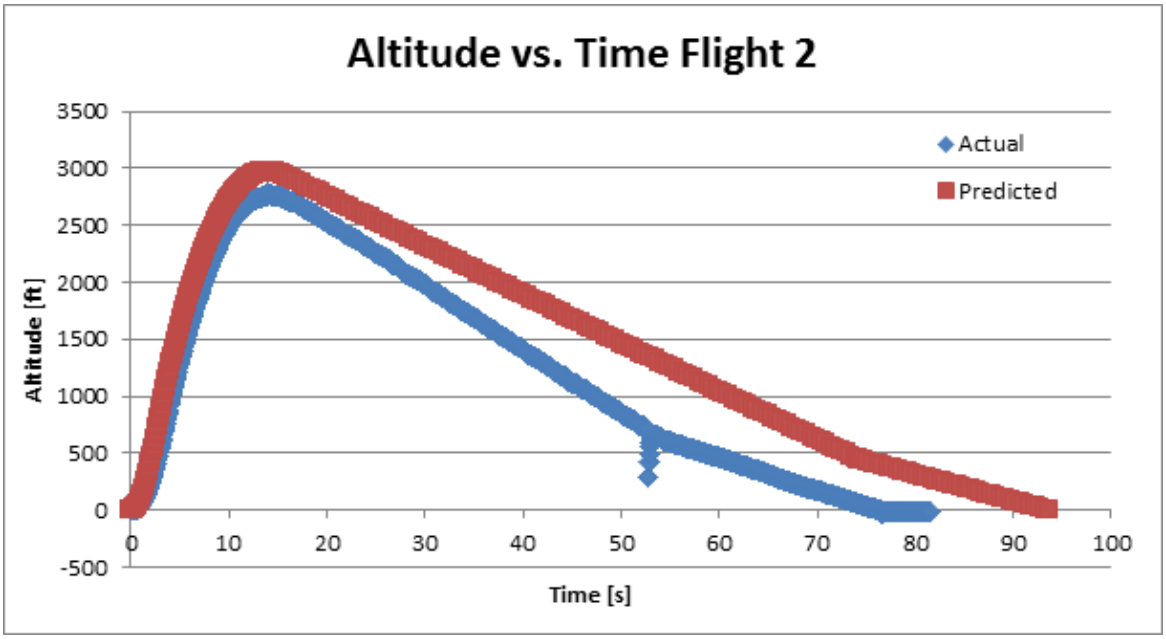

Figure 2: Actual and Simulation Comparison of Altitude, Flight 2

Altitude - MATLAB

With test flights conducted prior to launch day, the MATLAB simulation was an iterative process to increase the accuracy of the model. With the second test flight successful, a coefficient of drag was backed out to more accurately model the rocket. This coefficient as well as the coefficient from OpenRocket was used to determine a coefficient of drag for the rocket. The exact coefficient of drag backed out was not used because of error in the model coming from the assumptions. The final model predicted the rocket to reach an apogee of 3092 feet without the deployment of a drogue parachute. The coefficient of drag backed out from the test flight was used. The model then predicted an apogee of 3090 feet. The mass of the rocket was lighter than predicted in this simulation. Therefore, this explains the higher altitude reached compared to the prediction. No simulation was done in MATLAB for the second flight.

Acceleration

The following figure illustrates the comparison of the actual acceleration to the predicted acceleration. The spikes in the actual acceleration come from the blast charges for parachute deployment. The peak acceleration was 685 ft/s^2 compared to the predicted $515ft/s^2$. This can be due to the inconsistency in the motors as well as the error in the coefficient of drag. With a lower coefficient of drag, the acceleration was higher.

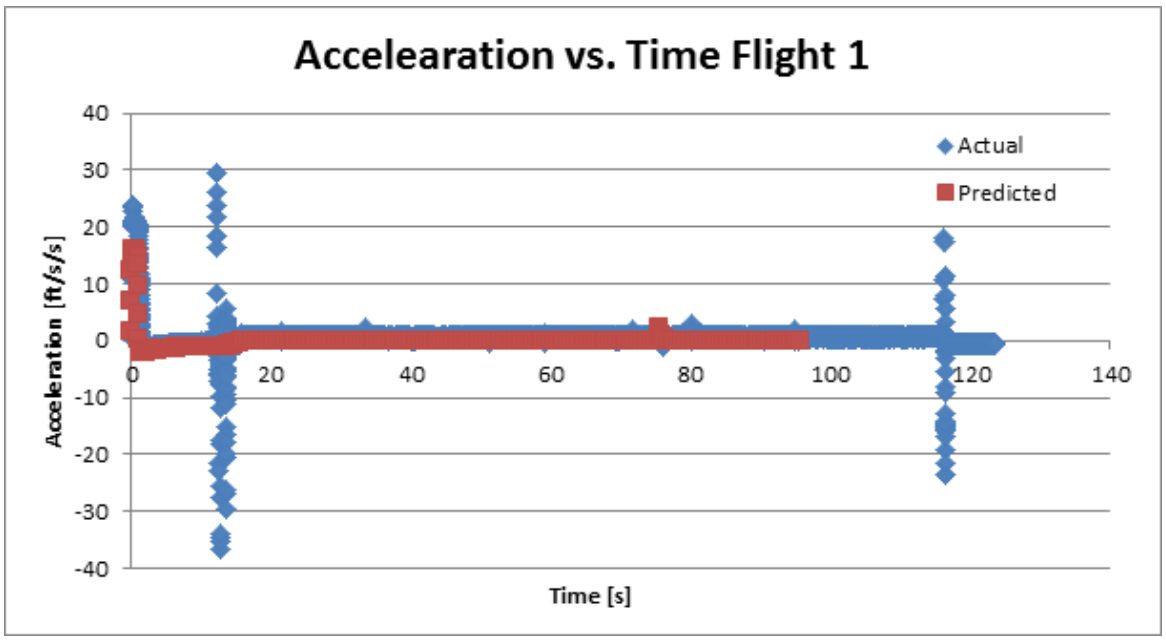

Figure 3: Actual and Simulation Comparison of Acceleration, Flight 1

The second flight's maximum acceleration was 253 ft/s^2. This acceleration was much lower because the burntime of the motor was much longer. This resulted in a similar total impulse as the I540.

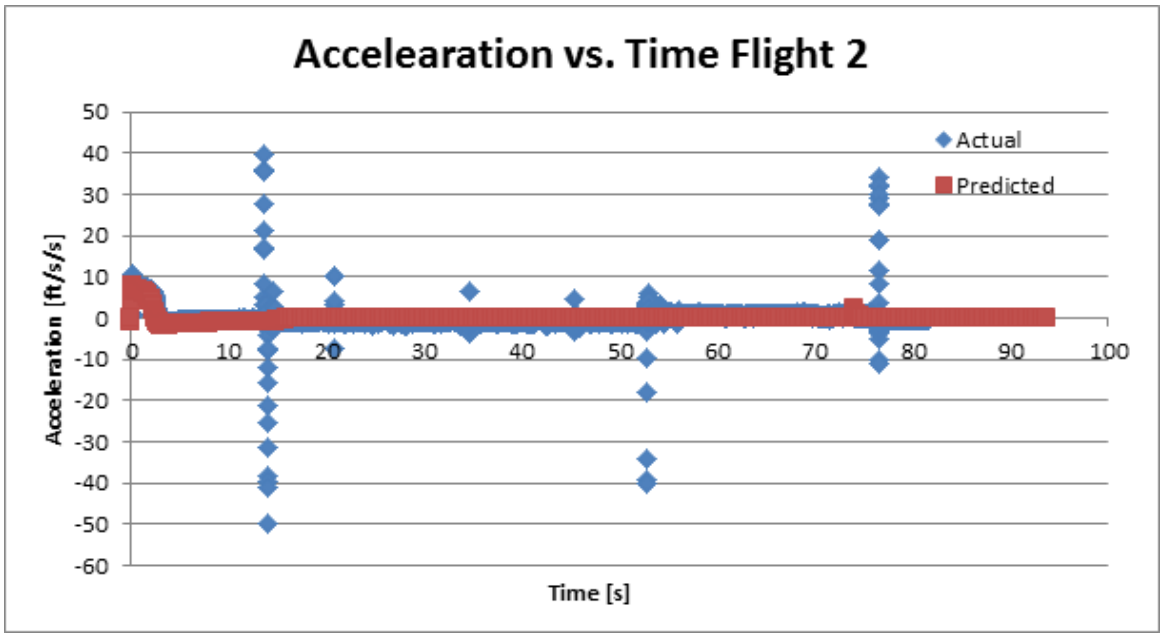

Figure 4: Actual and Simulation Comparison of Acceleration, Flight 2

Conclusion

The rocket design was confirmed on launch day with the successful flights. The rocket performed very closely to its prediction. Even with the failure of the electronics to deploy the drogue parachute, the design still led to the rocket reaching an apogee near 3000 feet. The rocket reached a higher apogee than predicted in both models for the first flight. A reason for this can be explained through the coefficient of drag. In OpenRocket, the coefficient of drag was higher than the actual resulting in a loss of altitude. In MATLAB, the mass of the rocket was greater in the prediction than the mass on launch day. Overall, this rocket was launched 5 times, all resulting in apogees in the window minus an electronic failure. All of the flights resulted in the rocket being in flyable condition and confirmed the structural design of the vehicle.