The Great Midwestern Regional Rocket Competition Team Phlight Report

By:
Augustine Bageanis, Chris Bates, Austin Ruf, Clayton Summers

University of Illinois
Champaign Urbana, IL
Spring 2014

Table of Contents

1. Abstract

This paper describes the simulation, construction and testing of a rocket capable of reaching a 3000ft. apogee. In this paper we will also justify our decisions of the rocket kit, motor and payload instruments.

2. Executive Summary

Team Phlight from the University of Champaign Urbana consists of Christopher Bates, Augustine Bageanis, Austin Ruf and Clayton Summers. We, the team, decided to use a Torrent rocket for multiple reasons: the rocket complied with all the competition regulations, was able to be modified for dual-deployment and was not unnecessarily large as to compromise our thrust to weight ratio. In our payload we are using a Stratologger, Raven Altimeter and Arduino Uno to provide accurate measurements of position, velocity and acceleration with redundancy. In addition the Stratologger will be our dual deployment mechanism assuring the drogue parachute deploys at apogee and the main at 700ft. We suffered several setbacks during preparation in the form of shipping shipping damage to the main body and missing parts. This placed us a week behind schedule and allowed only one week to construct the rocket and the payload. We efficiently used this time to make certain we were ready for the competition.

3. Design Features

Our team decided to use the Madcow Torrent manufactured by Madcow Rocketry. We made several modifications to the rocket to optimize its flight. We modified the payload bay by extending it with a piece of balsa wood in order to fit all of our instruments. We also modified the upper body section of the rocket by lengthening it in order to fit the main parachute. With all of the modifications the rocket height is 44in including the motor mount. The final weight of the rocket is approximately 2.421 kg. We decided to use a Cesaroni J316 because the simulations showed it would get us closest to 3,000ft. The rocket is painted orange and white to make it highly visible in the air and on the ground to aid in retrieval. See Appendix Figure 2 for a diagram of the rocket showing the center of mass and the center of gravity.

4. Analysis using OpenRocket

To simulate the altitude, velocity and acceleration of the rocket Team Phlight used OpenRocket, which is open source software made to simulate model rockets. We were able to find an OpenRocket file on the Apogee website. We modified the OpenRocket file to fit the parameters of our rocket after we modified it (see Section 5). After adding the correct rocket we ran several simulations. The predicted maximum acceleration was 169m/s^2, while the apogee prediction is 1,047m(3,436ft). See Figure 1 for the acceleration versus time graph in the Appendix.

5. Construction

Construction of the rocket and payload included many steps and intricacies. These were accomplished by the team working mostly separately and communicating via email to discern which tasks needed completed at specific times. This worked well for our team to complete the rocket in the limited time and maximize our efficiency. Construction began with sanding of the fins and assembly of the payload bay bulkheads. The fins were smoothed on the edges that would be drag incurring surfaces to reduce drag and improve stability. The payload bay bulkheads (as shown in Pictures 1&2) were assembled and epoxied as to make them secure attachment points for the parachutes. They also served as the attachment points for the rails the payload bay was on.

After completion of this work, the motor mount was constructed and epoxied into place and the fins were epoxied to the motor mount. The motor mount would prevent the motor from moving in an unintentional direction after ignition and before burnout. On the end of the motor mount we attached a motor retention system to prevent the motor from being ejected from the rocket mid flight. This system was a simple base with threads epoxied to the motor mount and a screw on rim allowing with a slightly smaller diameter than the motor. This prevented the motor from moving once being attached. Fin installation allowed stable flight and after being epoxied was supplemented with fillets of wood glue.

The following construction consisted of assembly and painting of the rocket. Once assembled the rocket was given a coat of primer, allowed to dry and given a second coat of primer. It was then sanded to smooth out any rough patches before applying the paint. This led to overall improvement in aerodynamics.

Following the complete construction of the rocket, we assembled the payload sled with it's components. It included the Stratologger, Arduino Uno and Rave Altimeter. These provided measurements of altitude, acceleration, velocity, pressure and much more. These instruments were all controlled by a keyswitch, which would arm and disarm the rocket safely. Following this, we attached the ejection charges and parachutes to the payload bulkheads. With these securely in place, the rocket was flightworthy.

6. Budget

The budget for our rocket had four main components: rocket kit, electronics, motor and finishing materials. The rocket kit we purchased cost $133. The stratologger cost $80 while the arduino uno and other various electronics for the payload cost a total of $35. For our motor we used the Cesaroni J316, which cost appx. $60. Our total cost for the finishing materials was roughly $20. Finishing materials included paint, sandpaper, wood glue, epoxy, etc. The total cost of our product then came out to almost $330. This was reasonable price for a rocket capable of a 3000ft. ceiling and taking measurements of all portions of the flight. This cost analysis does not take into account the cost of labor for assembly and launch preparation or transportation. If labor and transportation had been estimated in at $10/man-hour, the cost would exceed $700 for the total procedure, doubling the original estimate.

7. Conclusion

Our simulations show that our rocket will attain the apogee of 3,436ft and return safely at a rate of descent of roughly 20ft/s after deployment of the main parachute. The materials and components used on the rocket ensure that we will have a successful flight and will recover the rocket intact with meaningful data to be used in our post-report. Even though we have had setbacks with our rocket we are sure that our work is sufficient to complete the task.

8. Appendix

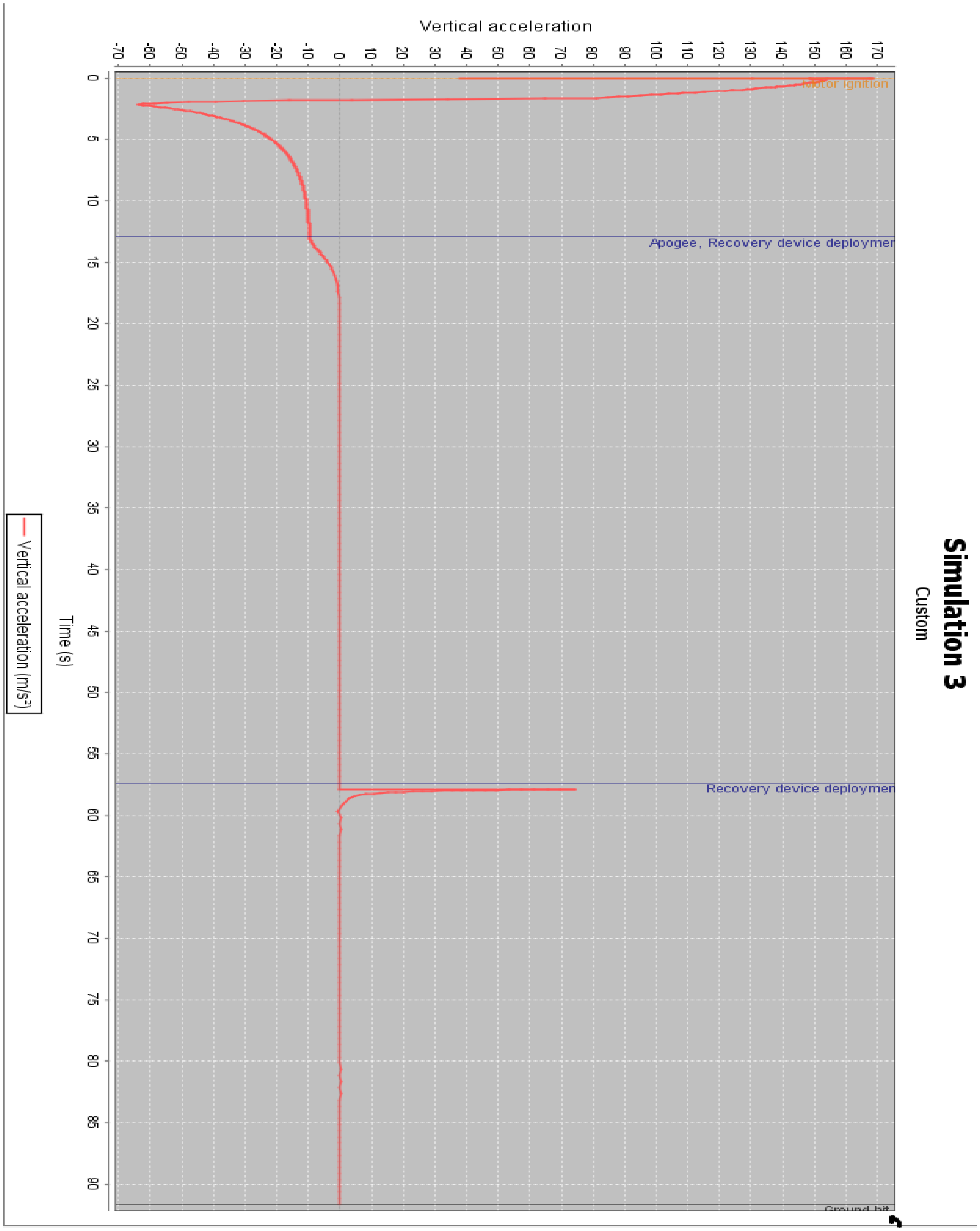

Figure 1

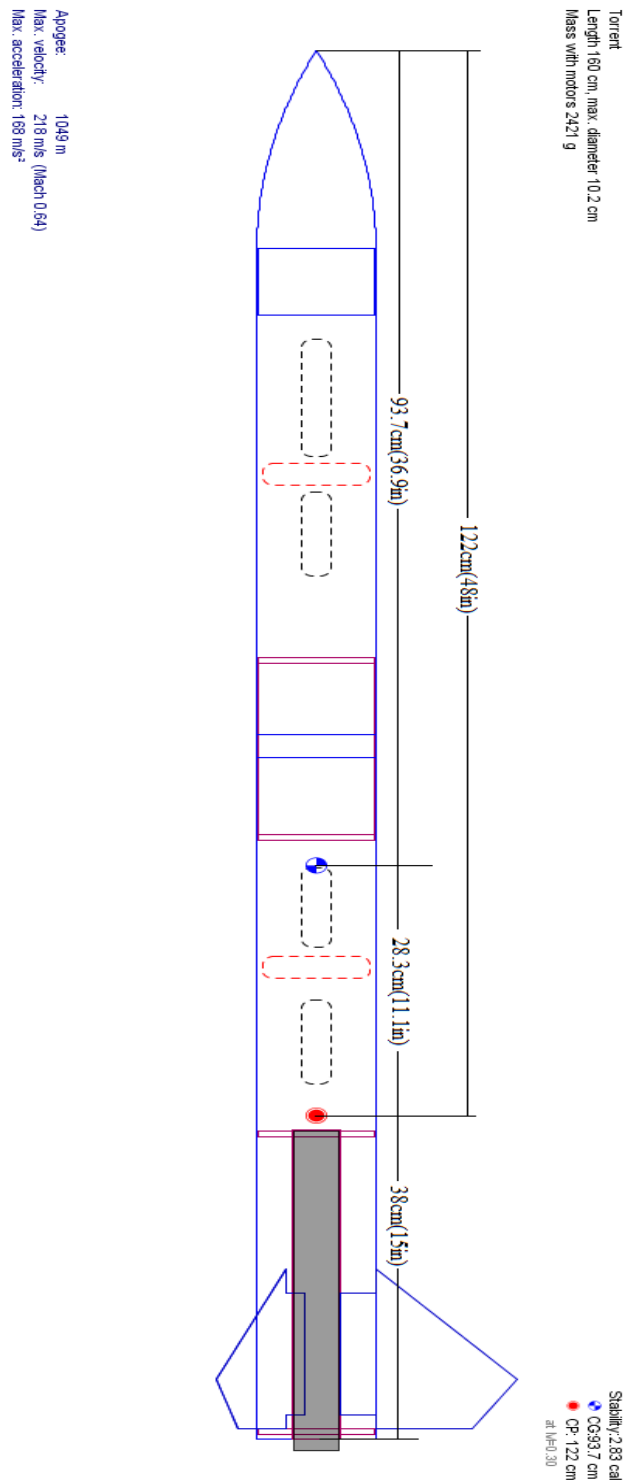
Torrent
Length 160 cm, max. diameter 10.2 cm
Mass with motors 2421 g
Apogee: 1049 m
Max. velocity: 218 m/s (Mach 0.64)
Max. acceleration: 168 m/s²
93.7cm(36.9in)
122cm(48in)
28.3cm(11.1in)
38cm(15in)
Stability: 2.83 cal
CG: 93.7 cm
CP: 122 cm
at M=0.30

Figure 2

Picture 1

Picture 2