LAKE MICHIGAN LAUNCHERS

CARTHAGE COLLEGE

Lake Michigan Launchers Black Brant II

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Abstract
The objective of the 2015-2016 Collegiate Rocket Launch aimed to model and scale a historical rocket no longer in use. The Lake Michigan Launchers chose to model the Black Brant II and used a J class motor in order for the rocket to propel between 2500' and 3500'. The construction of the rocket itself and the prediction of apogee depending on wind speed and temperature were the two most vital parts of the research. We aimed to have a successful flight along with an accurate prediction on the day of the launch using precise construction techniques and accurate predictions of the highest altitude the Black Brant II will fly.

Propulsion System Assessment

The propulsion system used for the Black Brant II was the Aerotech J350. This was the most powerful propulsion option available in the competition, and due to the size and weight of the Black Brant II model, in order to be able to reach the minimum altitude, it was decided that the most powerful system should be used. The 38mm J350 has a burn time of 1.8s and makes a maximum thrust of 890.4 Newtons. It weighs a total of 665g, and provides a total impulse of 697.4 Ns. In terms of recovery deployment, the motor has a 14 second delay before the backup charge is set off. Ultimately, the propulsion system selection was the best possible, given the options.

Flight Path Assessment & Recovery System Analysis

The Black Brant II model had a beautiful flight. It launched in a straight ascent just as planned and continued until apogee where it deployed the main parachute. The rocket drifted down to the ground and landed Northeast from where it launched. The electronics were more than sufficient. They blew the parachute at apogee as programmed using four grams of black powder charge. As a result, the backup electronic deployment nor motor deployment were needed. The main parachute opened as it should and guided the rocket safely back to the ground.

Rocket Location & Recovery Analysis

The rocket was located approximately 1,300 feet away from the launch pad (approximated using Google Earth). This distance was much less than expected due to the deployment of the main parachute at apogee. It was found behind a group of trees and bushes laying on its side as shown. The rocket was thoroughly inspected by a Tripoli member as well as the team. Two of the three fins are slightly pliable and that was the only part of the rocket that was minorly damaged during flight. Our electronics were periodically beeping, not as expected, so there were initial concerns. Later, there were not any issues pertaining to a failure of the electronics.

Fig. 1: Shows the Black Brant II post-launch position

Pre & Post Launch Procedure Assessment

Our pre-launch procedure was by far the most in depth part of launch day. Once we were able to find our table, there were a myriad of subtle changes we had to make to the rocket. Firstly, we installed our Raven3 altimeter, as well as the WSGC supplied

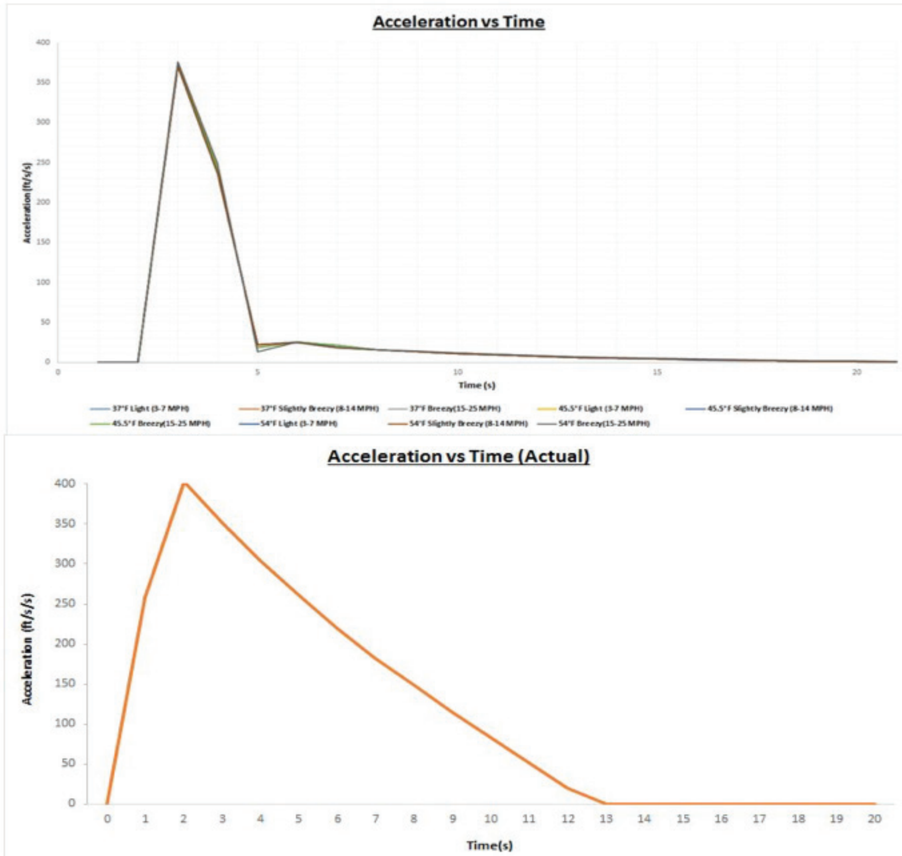
Raven3. Once those were harnessed in our electronics sled, the first obstacle we had overcome was the best way to wire the altimeters and how to connect the batteries. We had originally placed a whole power perch on our altimeter with a battery that could be turned on via a magnet. After we had realized the magnet had been left in our lab at school, we had to get a little creative on how to activate our altimeter. After some deliberation, we had settled that we would do a “twist and tuck” method of connecting a separate 9V battery. This approach, which we also used for the WSGC altimeter, involved two wires from the positive end of the battery, in which a pseudo-switch was created to connect our circuit. The process was to drill small holes in our rocket, feed the wires through the hole and then twist the wires together on the launch pad in order to complete our circuit and power both altimeters. After those small issues had been figured out, and with the electronics sled removed from the coupler, we drilled our pressure holes slightly larger to ensure both altimeters would accurately record our data and would ignite the ejection charge at apogee. Once we drilled the holes, we then had to attach our ejection charge which was supplied by Frank Nobile. For our rocket, we used a 4g black powder charge with an electric match connected to our own Raven3 altimeter. Continuing our pre-flight procedure, we inspected our rocket visually and made sure the shock cord was connected to the parachute, and each end of the shock cord was connected to the centering ring and nose cone, respectively. We had used a motor casing supplied by Chris Duffy, our Carthage alumni mentor. We greased the motor casing and the motor itself to ensure that the fit was tight with everything. After the motor, casing, and motor backup deployment were set to go, we inserted the motor casing into our quick switch motor mount tube, and headed to the inspection table. Once given the all clear, we attached our rocket to the launch rail using the rail buttons on our rocket, where we also used the “twist and tuck” method to arm our electronics. We attached the igniter wires to the supplied alligator clips, and inserted the igniter, checked to see our rail was at a perfect 90 degree angle with the ground, and then wished our rocket farewell.

Fig.2: Shows the damage done to one of the fins post-flight

Once we had seen the parachute deploy, we tracked the rocket with our radio receiver in case the rocket had drifted far away. Luckily, the winds were calm at the time of the launch, so the rocket was easily located with our eyes. After walking to get our rocket, we first noticed the position the rocket had been in after landing. The nose cone, and bottom part of the rocket were all still attached, and the parachute had no tears or rips in it. We checked the fins, and noticed that two were slightly loose, but could easily be flown again if we used 5 minute epoxy to re-attach the loose part of the fin. The airframe suffered no punctures or major damage and the nose cone had no breaks or broken parts. Overall, our rocket was in extremely good shape after landing. We had noticed the black powder charge had blown, meaning our Raven3 had successfully electronically deployed our parachute. After putting everything back together, we carried the rocket back to the inspection table, where the judge had declared we had a successful flight, electronic parachute deployment, and was still in flyable condition after landing, despite the loose fins.

Actual vs. Predicted Performance

The top chart displays our predicted acceleration curve while the bottom chart demonstrates the actual acceleration curve. The actual acceleration curve was greater than our predicted curve.



Graph 2 demonstrates the acceleration of flight over time. The top graph shows the predicted acceleration at different wind speeds. The bottom graph shows the actual acceleration taken by the altimeter.

	Predicted	**Actual**
Altitude (ft)	2726	2279
Max Acceleration (ft/s/s)	479.35	400

Our predicted altitude differed from our actual by 447 ft and the max acceleration differed by 79.35 ft/s^2.

Future Improvements
We consider our model of the Black Brant II a success. As a first year team, our main goal was to have a successful flight absent any major catastrophes, and we accomplished this goal.

Although our rocket launched and landed successfully, we were disappointed that it failed to reach the minimum 2500 ft. altitude. We attribute this failure to too much weight. Since the kit we constructed was designed for a 54 mm motor, it was the largest and heaviest rocket in the competition. Even the most powerful motor was not powerful enough to propel the rocket to the required altitude. Therefore, given the calm and ideal conditions of the launch day, we deduced that the main issue was indeed the weight of the rocket. In the future, a lighter rocket will need to be built to reduce or eliminate this issue (given the same competition requirements).

If the rocket is made to be lighter, it will also allow us to improve our recovery system to a dual-deployment setup. Although the single-deployment worked well this year, the rocket drifted a few hundred yards upon landing. A dual-deployment system would reduce the amount of drift, making it easier to retrieve.

Lastly, modifications could be made to the quality of the assembly, specifically application of the epoxy. Our rocket stayed in one piece throughout the entire flight, however, the looseness of the fins can most likely be attributed to inadequately applied epoxy. In the future, potentially more care and more planning can be put into the assembly process to ensure the rocket is as sturdy as possible.