MEMORANDUM

To: MN Space Grant 2015 Competition Board
From: Bulldog Rocketry
Date: 5/4/2015
Subject: Bulldog Rocketry 5-2-15 Test Launch Summary

Executive Summary:
On May 2nd, 2015, the Bulldog Rocketry team participated in a test launch event in of their Boosted Dart type rocket with the help of the Minnesota Tripoli Rocketry club. The rocket experienced a normal boost phase before a delayed separation, leading to instability at the beginning of the coast phase of flight. As a result the rocket veered off course, recovery components failed and both components fell to the ground. At booster impact all of its fins shattered to varying degrees and the booster body was bent, rendering the booster unusable for future launches. The dart fell but experienced no noticeable cosmetic damage, the Bulldog Rocketry club plans to re-use the dart in future launches.

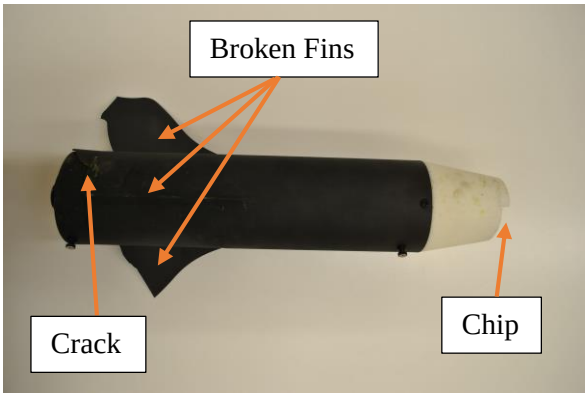

Figure 1: Post-flight booster with broken fins/reducer

Figure 2: Intact dart Post Flight

Rocket Detail:

After the preliminary design, the rocket needed further design work in order to achieve a stable rocket prior and after burnout. In order to accomplish a stable rocket, the booster fins became extremely large to assist in relocation of the center of pressure (CP). However, having the fins extremely large made them less rigid and became a concern. Bulldog Rocketry decided to move towards alternative materials in the booster, so the mass could be reduced, which resulted in making the fins smaller. The material of choice was PA 802-CF, which is a carbon fiber nylon 11 used in a laser sintered 3D printer. Using this material allowed for the booster's mass to be just one third that of the original booster design. This increased the stability of the overall rocket, along with allowing for the ability to give the dart more of the momentum.

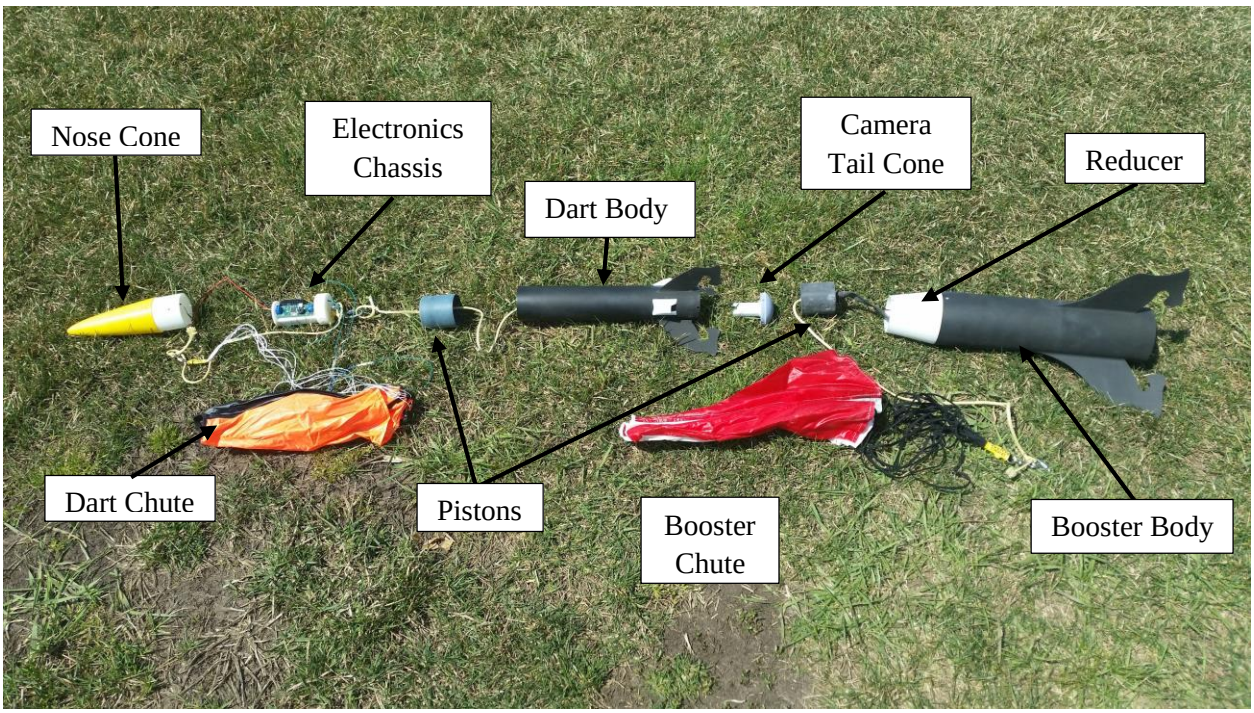

Figure 3: Major component layout of the rocket

Failure analysis:

Video of the launch was taken both from the launch pad using a Go-Pro and from a downward facing camera on-board the dart during takeoff. The on-board camera footage was flawed as the images were completely blacked out. The UMD High Powered Rocketry class utilized an identical camera for on board footage capture in a prior launch and recorded acceptable images. The cause of camera malfunction is currently under investigation.

Using the footage captured it was seen that the rocket did not travel in a clean upward trajectory, almost immediately the rocket veered off course. Pre-flight observation of the booster fins

brought about speculation of an insufficiently stiff fin. The thickness of the PA 802-CF fin material used (1/16") was less than needed and all the fins could be easily deformed by hand. The atypical shape of the fin design did not help this but it can be seen in Figure 2 that the dart fins of the same design survived impact well. The minimal thickness and exaggerated booster fin size resulted in an unstable flight path as each fin flexed in the crosswinds, creating unpredictable pressure differentials rather than stabilizing the rocket.

The booster chute came undone from the booster body upon deployment due to a faulty knot. The booster then fell from an estimated 670 feet before impacting the ground. It fell on its side with considerable force shattering the booster and reducer upon impact.

Figure 4: Detail View of Booster Body (PA-802-CF) fracture due to impact

The dart separated as planned but both shock cords for the parachute and dart body were tied in the wrong configuration, putting more stress on the I-bolt located in the nose cone than intended. Figure 5 below shows the deformed I-bolt with the chute cord for the nose cone still attached.

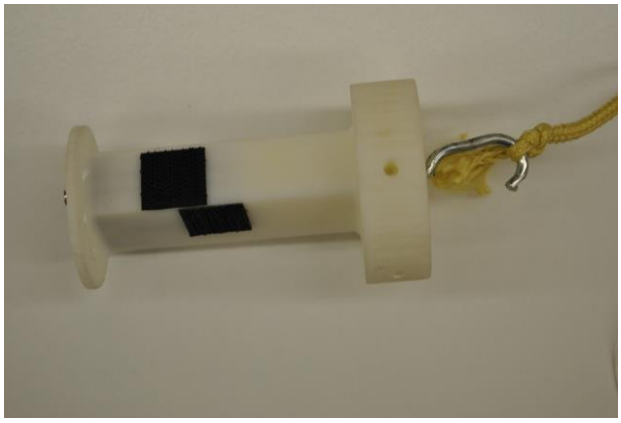

Figure 5: Deformed I-bolt holding nose cone to dart/parachute

Data Analysis:

During the test launch, Bulldog Rocketry used an Altimeter Two in both the booster and dart, along with an AIM USB 3.0 in the dart. The AIM USB 3.0 was used to collect maximum altitude and ignited the ejection capsules. Comparing the data collected from the two Altimeter Twos showed that they are not capable of handling such high g-forces, both of which reported just under 24Gs, which the maximum g-force the Altimeter Two's are capable of is G's. This would

explain why the Altimeter Two in the dart reported a lower altitude of 1,555 feet than that of the AIM USB 3.0, which was 1,740.8 feet. The AIM USB 3.0 is capable of much higher g-forces than the Altimeter Two's. Additional support that there was something happening to the Altimeter Two's is that the booster's parachute was deployed at 53 feet and the dart's at 29 feet, which was visually confirmed during the launch to not be correct. It is also confirmed looking at the graph from the AIM USB 3.0 (Figure 6), which shows the nose cone coasting down at a steady descent rate. The AIM USB 3.0 only indicates the maximum flight velocity and altitude in terms of actual data points, the remaining information is represented by a graph.

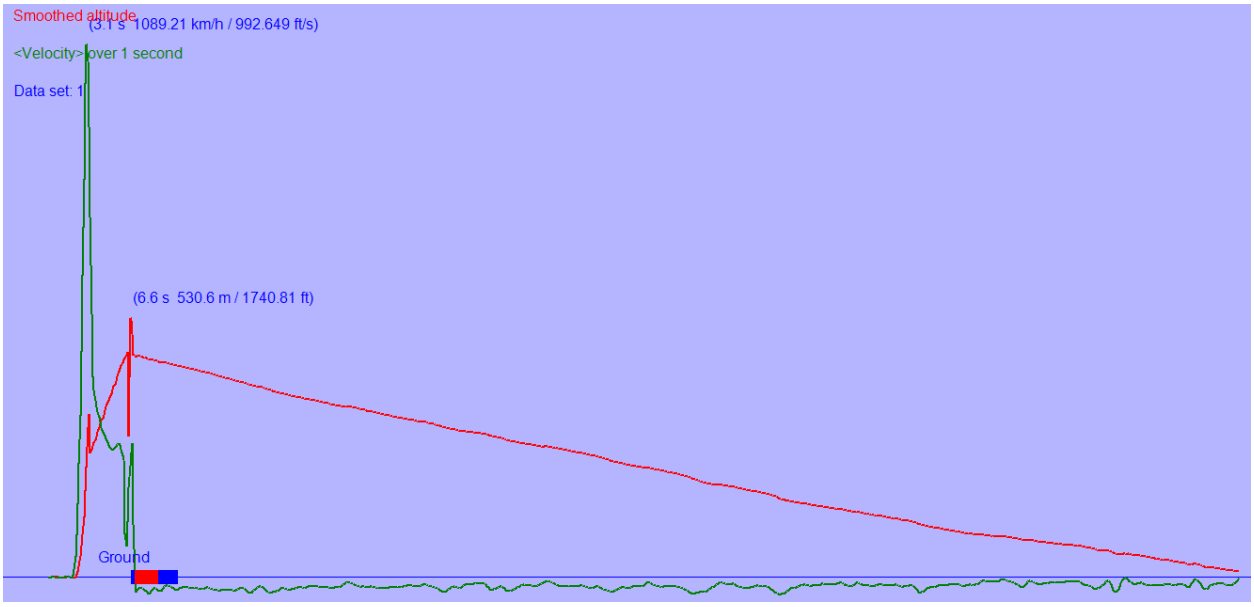

Figure 6: Dart velocity profile (green line) & altitude profile (red line)

Design Improvements/Rebuild:

The booster is going to be redesigned and built using the Blue Tube. Redesign will require accommodations needed in order to keep the rocket stable since Blue Tube has a greater mass per unit length than the PA 802-FC. Additionally, since the booster will increase in mass and change the center of gravity (CG) location, the fins will be required to increase in size in order to move the CP and make the rocket stable. For this reason, the booster fins are going to be a traditional fin design, since it will be possible to get a greater surface area with slightly smaller fins than those of the bulldog legs. This will also assist in keeping the fins rigid and thus reduce any chances of fin flutter.

Conclusion:

With the events that occurred at the test launch, Bulldog Rocketry is going to continue to work on redesigning the booster, so that a successful test launch can be completed and thus be able to

continue in the competition. Do to this being the last week of the semester, Bulldog Rocketry is limited on available time and students since projects are due and final exams are coming up. But most materials are already purchased or left over from previous years so there is considerably less lead time for the fabrication. Stability will be reevaluated once the booster is redesigned and any necessary alterations will be made in order to make this next launch successful.