AE 166 - Rocketry Final Report
Glorified Lawn Dart A.K.A Cheese

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I. Mission

The mission of this project was to make a rocket capable of an L1 and L2 certification flight. The rocket must successfully launch without any failure and safely reach the ground through a recovery system. The rocket must be fully intact after recovery for the full flight to count as successful and for the flier to get certified. The steps in order to achieve this feat are first through simulating an initial design. Once the design is finalized the next step is to use CAD to model and print the parts needed for the rocket. The final step is to assemble the rocket and prepare it for flight.

II. Design Criteria

The design of my rocket was to accommodate both an L1 and L2 motor. With an L1 motor my rocket would go subsonic, but with an L2 motor it would reach supersonic speeds. I was only able to test my rocket with an L1 motor, but I catered my design more towards the L2 motor while still making sure my rocket would successfully fly at L1. The body tube of my rocket is made of fiberglass with the diameter being 38 mm and the length being 700 mm. Majority of the parts were 3D printed such as the motor retainer, nosecone, fin can, avionics bay, and recovery bulkhead.

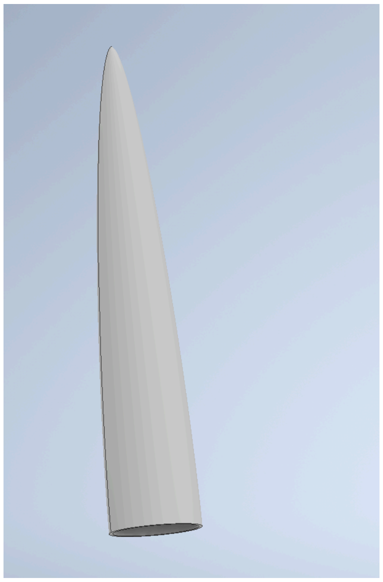

Fig.1 CAD model of nose cone

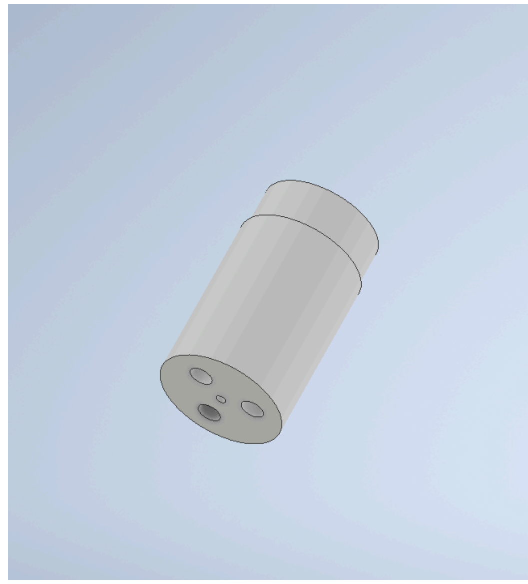

Fig.2 CAD model of avionics bay

The nose cone, shown in Fig.1, was designed to take the form of a Haak series with a slim and sharply curved tip designed for supersonic speeds. The length of the nose cone was 215 mm and a diameter of 40.5 mm. The nose cone was designed to have a shoulder that could be detachable for the avionics to sit in. The shoulder serves as an avionics bay, shown in Fig.2. The middle hole is where the eye screw for the shock cord to be tied to is attached. The avionics bay has a smaller diameter that sits inside of the nose cone while the larger diameter friction fits into the body tube. The avionics bay screws into the nose cone so it does not separate while deploying the recovery system.

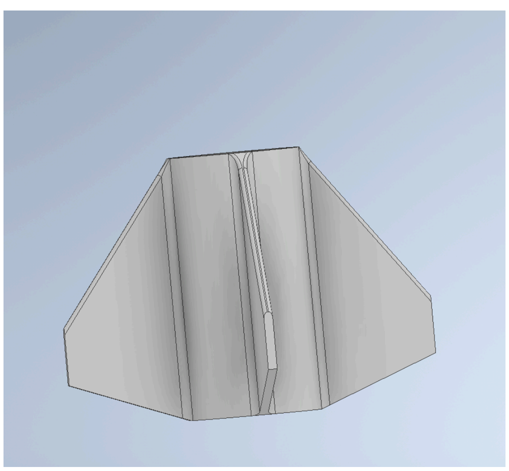

Fig.3 CAD model of fin can

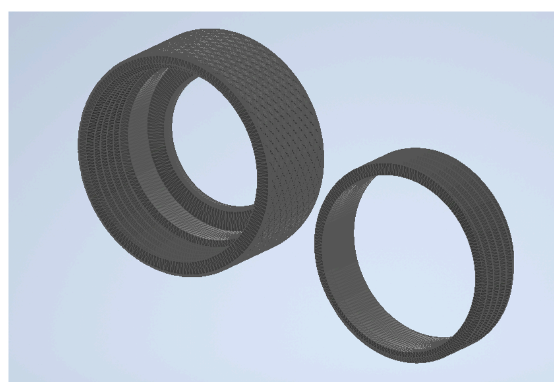

Fig.4 CAD model of motor retainer

The fin can, shown in Fig.3, was designed through an open rocket and was based on the stability of the rocket. The trapezoidal shape was to make the rocket more aerodynamic while still achieving the necessary stability. There are also four fins to improve stability as well. The fin can was epoxied above the motor retainer, shown in Fig.4. The motor retainer is sourced from Professor Biba specifically for a 38 mm diameter body tube. The smaller thinner part is epoxied onto the body tube while the larger part twists onto it after the motor is inserted.

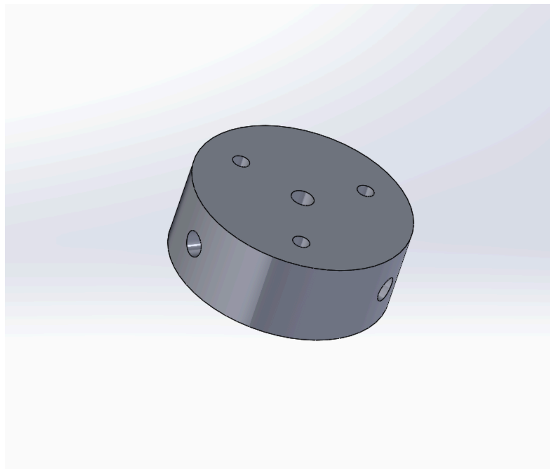

Fig.5 CAD model of the recovery bulkhead

The recovery bulkhead was designed by a classmate, Kyle Rivas, who ensured that the bulkhead was thick enough as to where it would not break when the recovery system was deployed. The hole in the middle is for the eye screw to be placed into where the other end of the shock cord would be tied to. The holes on the side are for the screws to attach the body tube to the bulkhead.

The non 3D printer parts consist of the avionics and the recovery system. The avionics used for this rocket was an Egtimmer Quark that hooked up to a battery. The recovery system included a shock cord made of kevlar that was tied to the recovery bulkhead and the avionics bay. The cord was around 2743.2 mm (9 ft) long. The parachute was then attached to the shock cord about ⅓ of the length of the cord from the nose.

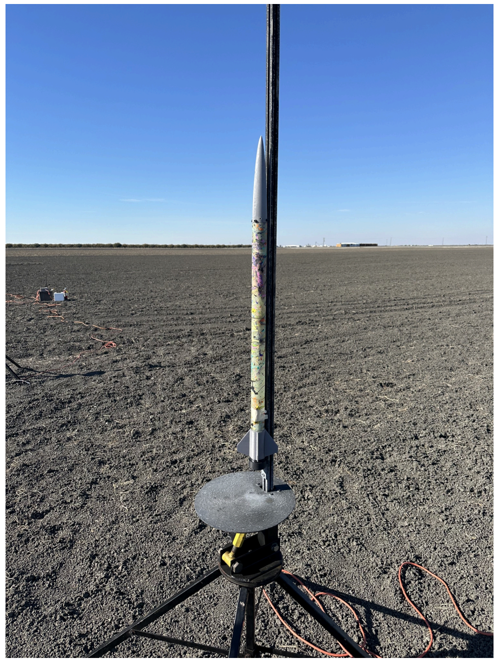

Fig.6 Glorified Lawn Dart A.K.A Cheese on the launch pad

The finished product fully assembled is shown in Fig.6. The final measurements concluded to be a center of gravity at 614.68 mm, a center of pressure at 711.2 mm, and a weight of 852.75 g. The entire length of the rocket from nosecone to motor retainer was 929.64 mm. I also decided to paint my rocket using a splatter technique that definitely adds to the design criteria.

III. Simulation Results

The main simulation program that I used for my rocket was OpenRocket. I was able to design my rocket based on the results of the simulations.

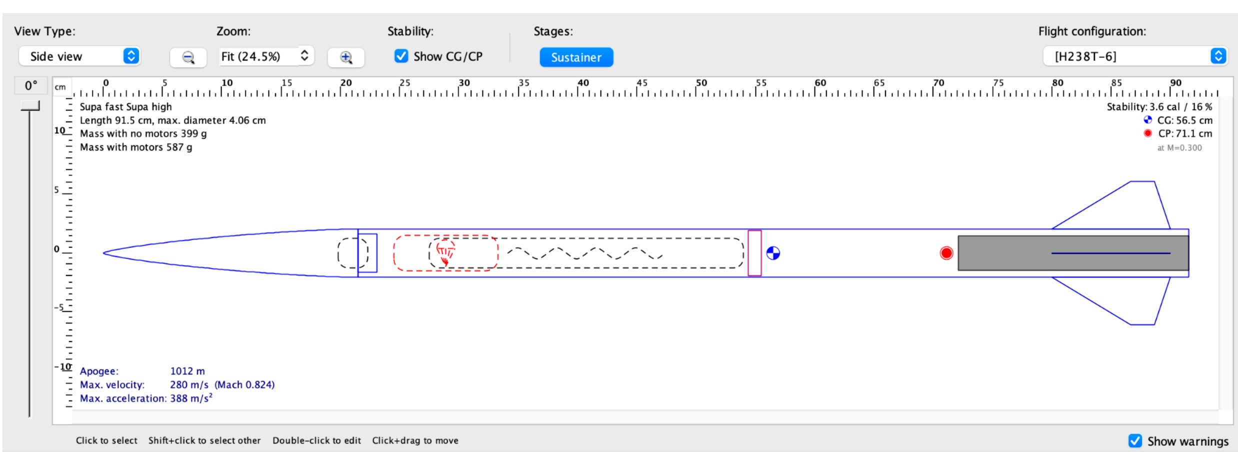

Fig.7 OpenRocket Simulation

Shown in Fig.7 is the original design of my rocket and what I based my rocket assembly on. The center of pressure is 717 mm and the center of gravity is 565 mm, which is extremely close to the actual measured CP and CG. It also shows the maximum weight of the rocket, which was off due to the extra weight of certain parts.

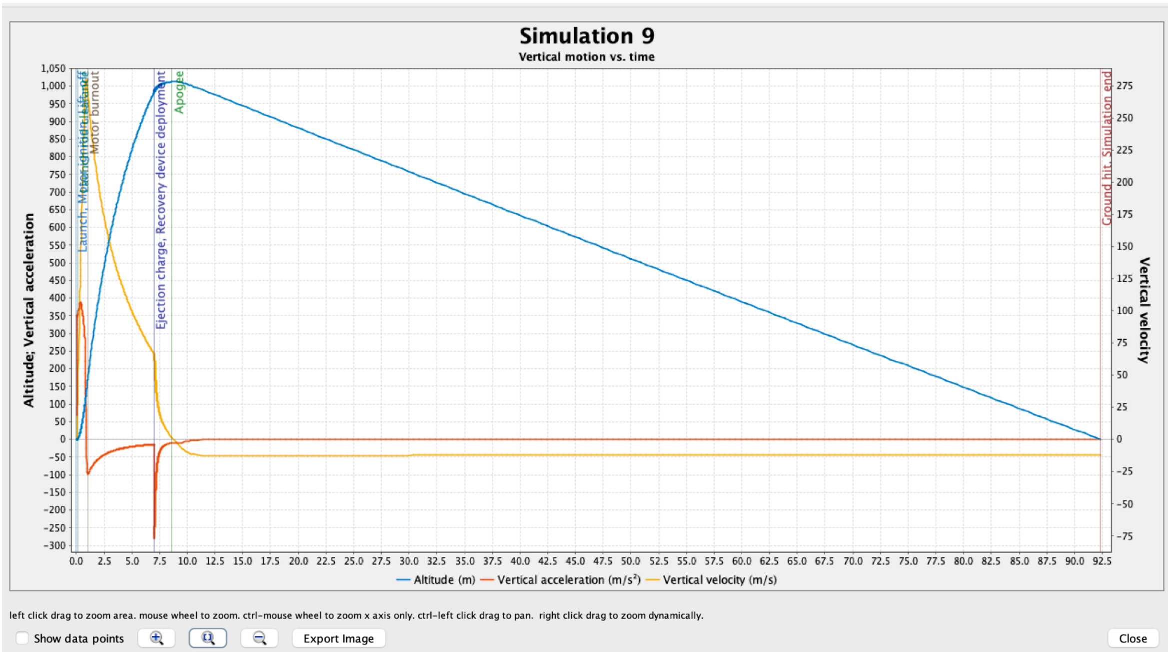

Fig.8 OpenRocket Simulation

Fig.8 shows the specifics that will occur during launch. The simulation suggests that apogee will reach 1012 m, the max velocity will be 280 m/s (Mach 0.824), and the max acceleration will be 388 m/s^2.

IV. Flight Results

The moments leading up to the flight results were stressful because there were some last minute adjustments that needed to be made. The first major adjustments were caused by the recovery bulkhead's holes not being large enough to let the gas from the ejection charge through. Therefore, I was only able to rely on the avionics in my rocket. Once that was figured out the second adjustment that needed to be made was to short my avionics. Right before I was about to launch I double checked my avionics and a classmate, Rae Chauvaux, listened in on the beeps, but said it was giving the wrong reading. So I needed to take my rocket off of the launch pad and bring it back to short circuit the avionics, but one of the screws to feed the wire into was broken. Thankfully, I was able to borrow a gas soldering iron and used some extra solder to short it. Once I successfully did that I was finally able to launch.

Utilizing a H283ST-15A Aerotech motor my rocket was able to successfully launch and fly vertically at the altitude expected of the design. A couple of seconds after reaching apogee the ejection charge deployed the recovery system. The nosecone came off of the body tube, still tethered to the recovery bulkhead, and deployed the parachute. My rocket safely landed a couple of hundred of feet away from the launch site and I was able to fully recover it. After showing my rocket to Mr. Rouse he marked me down for a successful launch and L1 test. I now have my L1 certification!

V. Lessons Learned

I have had a great experience while building my rocket. The main thing I learned during my experience was the specifics of how a rocket operated. I went into this class without any knowledge of how a rocket worked, but now I am able to understand the physics behind every part and know how each part works together. Throughout the course I have done several new things and expanded upon my skill set. I have never 3D printed anything before, nor have I made anything with the expectation of it being 3D printed. I unfortunately do not own a 3D printer so I had to outsource some of my work. I also had to redesign some parts because they did not work with my rocket. I have also never soldered before which is an amazing skill to have. I was able to solder something for the first time and have it work successfully. Throughout this experience I was able to actually apply what I have learned and build something. One of the things that I have been lacking throughout my aerospace engineering experience is being able to actually build something based on information learned during class. A lot of what I have done has only been theoretical, which makes sense because building certain things in aerospace takes lots of time and money, but I was actually able to build something this time. This experience will help me in the future because I now understand the process of building something from scratch and how it all works. I now have experience translating my theoretical data then analyzing it in order to build something that will have the best results. I also understand the process of testing and remaking parts if issues arise. Overall this has been an amazing experience and I would love to work towards my L2 certification. I am definitely including this experience in my resume!