7. Jet Vane Thrust Vector Control (JVTVC) Test Vehicle

7.1 Rocket Design

Tech Dev's Mk I rocket is 0.903 meters tall with a diameter of 4 inches. Its wet mass is 4.378 kg and a dry mass of 4.020 kg. The body tubes are made of cardboard. The initial design proposal can be seen in the open rocket model below, however in the later iterations were developed to reduce overall mass.

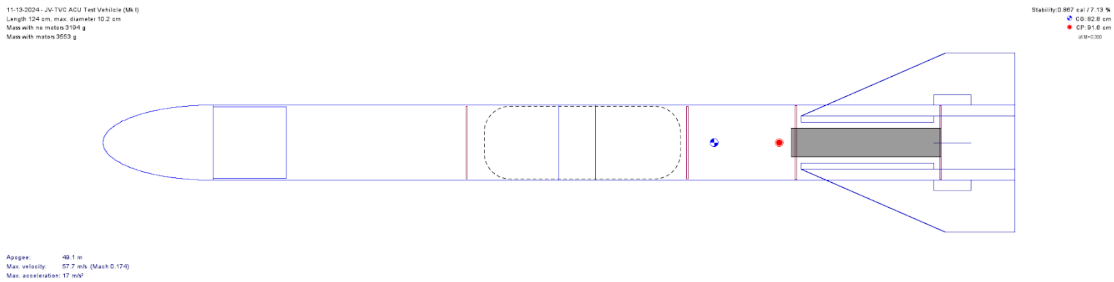

Figure 7.1.A - Initial Design of JVTVC Test Vehicle

In later iterations, the profile of the fins were greatly decreased due to the predicted weathercocking and overstabilization during low-speed jet vane testing. Since the rocket was designed for slow ascent or hover to evaluate jet vane performance, large fins were counterproductive, as they interfered with the inertial forces produced by the vanes. The final fins provide some stability to the rocket during its slow ascent and also to help steer the rocket .

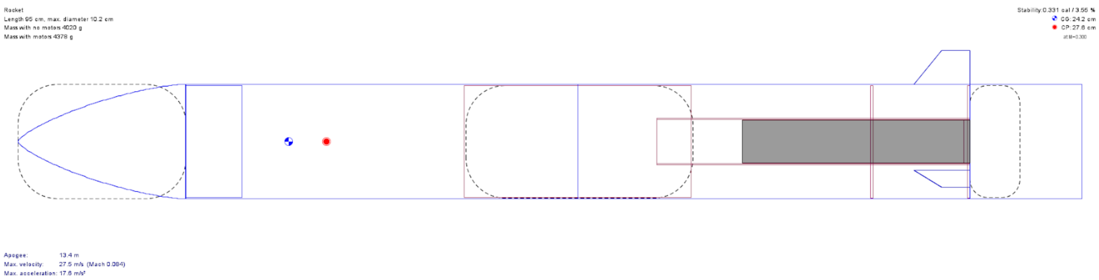

Figure 7.1.B - Final Design of JVTVC Test Vehicle

The center of gravity (CG) of the rocket was chosen to be higher than a standard CG. This is to allow the thrust from the jet vane mechanism to achieve a higher inertial force and control authority on the rocket, as the functionality of the vanes needs to be noticeable during the short flight time of the rocket.

The relationship between the center of gravity (CG) and center of pressure (CP) was carefully considered during the rocket's design. It is generally considered a rule of thumb to have the CP below the CG, with the CG being at about the midpoint of the rocket, but this is usually for a rocket flying straight up and at high speeds. For a slow ascent or hover, the effects of shifting the CP was researched. For the final rocket design, we opted to have the CP and CG at close to the same location so that the rocket would not weathercock but also not be so unstable that it tips over during the flight.

The length of the rocket was also a factor in the design. A long rocket tends to be stable but heavy. Since our selected motor for flight was the I-40, we had to reduce the rocket height which would affect stability but allow the rocket to take off and conduct the test effectively.

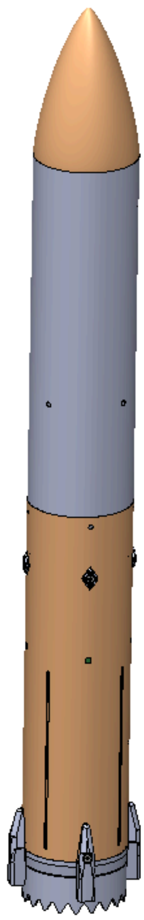

Figure 7.1.C - CAD Model of JVTVC Test Vehicle w/o Fins

Due to the rocket's low apogee and its primary function as a jet vane testbed, a parachute recovery system was intentionally omitted. Including a parachute would have introduced unnecessary mass without serving the experimental purpose. Due to this, the ground-hit velocity was a critical design parameter. The mass of the rocket was adjusted accordingly to achieve a ground-hit velocity <10 m/s so that the test vehicle could be recovered and reused.

3D printing played a significant role in the rocket's construction. Critical components such as the avionics bay lids, nosecone, and motor centering rings were all fabricated from PLA, enabling rapid prototyping, weight savings, and ease of customization throughout the design process.

The nosecone was designed using the Haack series (Von Kármán variant) with C=0, which was selected both for its aesthetic appeal and its low-drag profile. This design offers the minimum drag coefficient for a given length and diameter, optimizing performance during the slow ascent phase. The nosecone can be seen in the figure below.

Figure 7.1.D - 3D Printed Haack Nosecone

To maintain structural integrity, M4 fasteners were used to secure the avionics bay, which also served to rigidly connect the upper and lower body sections. These fasteners were chosen to ensure the rocket remained intact during the controlled crash at the end of flight. However, in hindsight, a less rigid fastening method such as plastic rivets may have been preferable, allowing the rocket body to separate more cleanly on impact rather than tear the cardboard airframe. To improve fastening reliability, heat-set threaded inserts were also installed where applicable. The avionics bay lid and avionics bay with lids installed can be seen in the figures below.

Figure 7.1.E - 3D Printed Avionics Bay Lid

Figure 7.1.F - Avionics Bay with Lids Attached