Executive Summary

This month marked the third launch of the MkI Viper. The liftoff mass was ~ 1.4 kg which includes a propellant mass of ~ 94 gm. Ignition occurred in less than one second. I had active control using a transmitter and receiver. The Viper yawed to port and pitched up (as opposed to pitching down on the last launch) as it cleared the rail guide. On comparing the two launches, it is clear that the center-of-mass was below the thrust vector (pitch down) on the last launch and above (pitch up) the thrust vector on this launch. I feel I'm getting a handle on CM calculations with predictable results.

Technical Stuff

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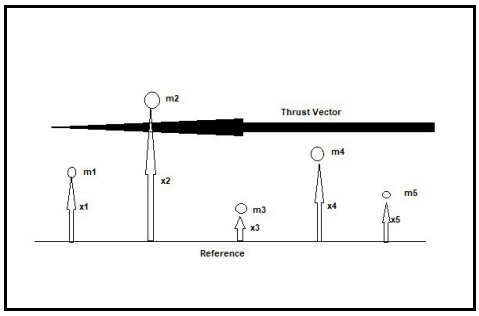
To calculate the CM, I chose a reference line along the bottom of the Viper (first picture). The CM is a summation of the mass of each component multiplied by it's center-of-mass distance from the reference line (i.e., $m_1x_1 + m_2x_2 + ...$) divided by the total mass of each component (i.e., $m_1 + m_2 + ...$). The picture only shows five masses as an example. The Mark I Viper has over 20 masses (lets pay homage to the SpaceX Starship engineers). Each mass has it's own CM and distance from the reference line. On the second launch, the calculated CM was ~ 6 cm which was slightly above the thrust vector (~ 5.5 cm). But, the Viper pitched down which indicates the CM to be below the thrust vector. I'll admit that I had to estimate a lot of the masses and distances as the Viper was already assembled.



For the third launch, I rearranged some of the masses and lowered the thrust vector to ~ 3.5 cm. The CM was calculated to be ~ 4.4 cm. On this third launch, the calculated CM is above the thrust vector which would indicate a pitch up. As seen in the video, the Viper does indeed pitch up. So, I feel I'm getting a better handle on CM calculations. I need to be more diligent on massing and determining the center-of-mass of each component. It is a tedious job, but necessary. Especially, as I go to bigger (and more expensive) systems.

For this third launch, I used 50 ml of HTP and 2 ml of ethanol for the oxidizer. Ignition took less than 1.0 second and burn time was about six seconds. The HTP was concentrated to ~ 91% and the PLA/$KmNO_4$ fuel core had been stored in a dry bag (zip lock bag with desiccant) for a about 45 days.

When the MkI Viper cleared the rail guide, it began to yaw to port and pitch up. I had active control but did not try to correct. Since it pitched up instead of pitching down I decided not to interact. It flipped a few times as it came toward me and crashed into the ground. Again, the damage wasn't as bad as it looked. The major components survived the crash. The aft strut, vertical stabilizer, equipment bay, and solenoid valve were damaged and will be replaced.

Next month, I plan on replacing the canopy with fiberglass. The PLA canopy has a mass of 114 gm and is ~ 14 cm from the reference line. As such, it contributes a large mass*distance when calculating the CM. A lighter canopy would contribute less to the overall CM calculation and hopefully lower the CM, bringing the CM more in line with the thrust vector.