Pyxis

Jr L1 Attempt

Background

Pyxis was built to be my NAR Jr L1 certification rocket, and was my first high power rocket. It was designed, constructed, and flown on an extremely short timeline of just over a week. For readers who are unaware, the process to get a Junior Level 1 high power certification from both the National Association of Rocketry (NAR) and the Tripoli Association of Rocketry (TRA) is to first take a written test, then to successfully fly a rocket using an motor in the H or I impulse class. Pyxis was built to satisfy the second step of that process.

Design Requirements

- The Rocket shall be built of simple, cardboard construction.
- The Rocket shall be capable of flying on high power rocket motors of the H and I impulse class.
- The Rocket shall be able to recover safely using timed motor ejection and achieve a ground hit velocity less than 20ft/s.
- The Rocket shall house a data logging computer.
- The Rocket shall be flight ready before 11/4/2023

Design Overview

- 3” Outer diameter
- 1.5” Diameter motor mount
- 50” Tip to tail length
- 5.6lbs on the pad
- 3” Cardboard airframe from Balsa Machining Service (BMS)
- 1.5” Cardboard motor mount tube from BMS
- 3.7:1 Ogive plastic nose cone from BMS
- ¼” Plywood centering rings and bulkheads
- ¼” Plywood swept trapezoidal fins
- Through the wall fin construction
- JB Weld Original epoxy for all structural bonds

Simulation

The open source software OpenRocket was used to run simulations on the vehicle in order to evaluate the static stability margin and flight performance.

Airframe

The airframe, or body tube, was made from a 48” long 3” diameter cardboard tube from Balsa Machining Service (BMS) that was divided into three sections, the motor section, avionics switch band, and upper tube. The three sections were coupled together with one long coupler that ran through the length of the switch band and extended 1 caliber or 3” from each end. The coupler and switch band were glued together, and functioned as one single unit.

The nose cone was a commercial plastic 3.5:1 ogive cone from BMS with the base cut off and nose weight cast into the tip. The nose cone and upper tube were also glued together, and screws held the upper assembly onto the avionics coupler for all flights.

Fins and Motor Mount

The motor mount began with a 1.5” thick wall cardboard tube from BMS, to which forward and aft centering rings were attached. These rings held the motor mount concentric to the outer body tube and were cut from ¼” plywood. The fins were also cut from ¼” plywood and tacked onto the motor mount tube with CA glue. The fin shape was chosen by experimenting in Openrocket to find the shape that yielded the highest altitude while retaining a sufficient static margin. A section of motor mount tube was left hanging out the back to bond the 3d printed motor retainer/boattail onto.

Once the fins were tacked onto the motor mount, internal epoxy fillets were made with JB Weld. In hindsight this epoxy choice was incredibly overkill for this project, and wood glue or some lower strength and lower cost adhesive would have been preferable. The internal fillets also secured the centering rings in place. The shock cord was also adhered to the motor mount tube at this time with more JB Weld.

After all of the epoxy was cured, slots were cut in the motor section of the body tube and the entire motor mount assembly was slid into the aft of the airframe. The motor mount was glued in with 5 minute epoxy and external fillets were done on the outside to further secure the fins onto the body.

Avionics Bay

The avionics bay for this rocket was quite simple, only consisting of the two bulkheads, two sections of threaded rod, and the 3d printed sled to which the flight computer was attached. The bulkheads for the first flight were just flat disks of ¼” plywood with holes for the recovery attachment eye bolt and threaded rods. This proved troublesome for alignment, and later on stepped bulkheads were routed from thicker wood for the second flight . Eye bolts were attached in the center of each bulkhead to attach the shock cord to and threaded rods worked to transfer recovery loads through the avionics bay to the other bulkhead.

The avionics setup for this rocket was very simple and only consisted of my custom flight computer, Lyra. Lyra functioned to collect data such as altitude, acceleration, and velocity and log it to an onboard flash chip as well as to transmit limited telemetry down to a ground station. The telemetry was never able to be realized in flight due to range problems, but onboard data was recorded on all flights, which could then be accessed after the flight for analysis. Lyra was mounted to the 3d printed avionics sled that was supported by the threaded rods and held in place with hex nuts.

Recovery

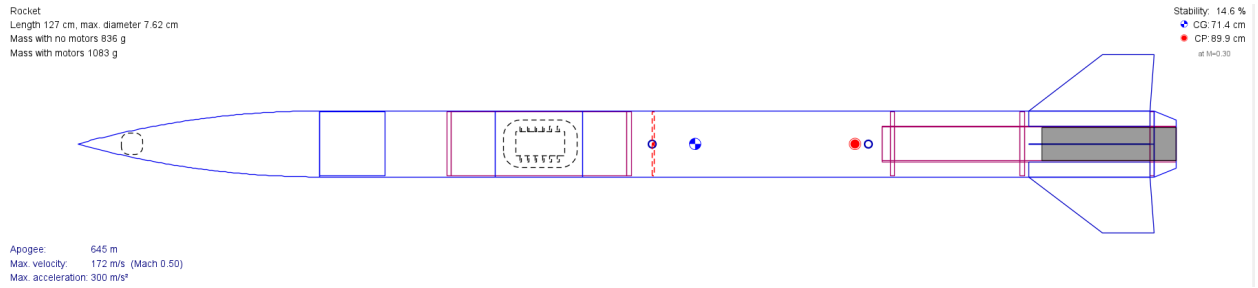
Recovery deployment was handled by the motor with a timed pyrotechnic ejection charge, which would separate the rocket at the motor section-avionics bay joint, deploying the parachute. The initial shock cord was made from three 550lb paracord lines which were braided together to survive the ejection and opening shocks. This was later replaced with a ½" kevlar cord. The parachutes for the first flight were two separate 24" plastic chutes, but these were also replaced by a single 36" chute for the second flight.

Flight Attempts

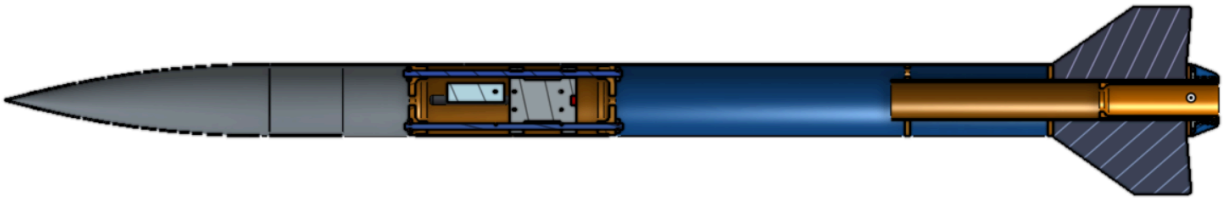
Two flight attempts were made for the vehicle, the first at the Sierra Rocketry Association's November launch on 11/4/2023. This flight attempt was on a CTI H225 rocket motor with the delay shortened to nine seconds. Unfortunately, the motor did not function properly and approximately 1.25 seconds into the flight the CTI H225 fired its ejection charge, separating the two sections and snapping the shock cord. As a result of the breakup and the hard landing on the lakebed, one fin sustained a crack, the shock cord snapped completely, and the forward end of the motor section was slightly frayed.

The second flight attempt was made at the Friends Of Amatuer Rocketry Launch Site in the Mojave desert, and also suffered a motor related failure. This attempt was made on 1/20/2024, and upon launch the motor blew by its ejection charge, effectively creating a second nozzle pointing up into the rocket, completely roasting the inside of the motor section. After this failure the vehicle was retired.

Media

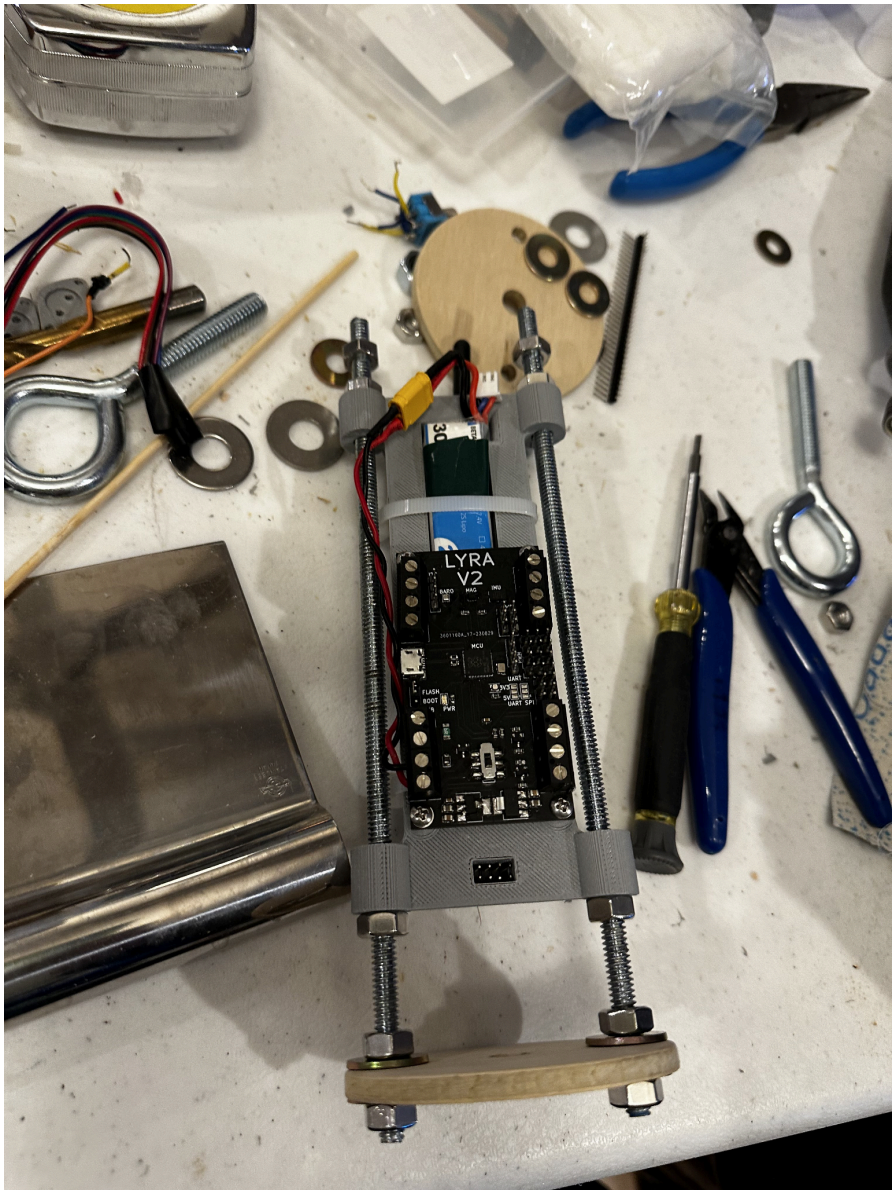


OpenRocket simulation



CAD cross section from OnShape

Completed motor mount assembly, with shock cord mounting and internal fillets visible.



Partially integrated avionics bay

Painted and ready to go.

https://www.youtube.com/watch?v=qc96OAqmqmc Video with more pictures and videos of flight 1