Electro-Mechanical Nose Cone Separation Mechanism

Miles Atherly, Benjamin Butler, Andrew Eads, Jason Hamilton, Brian Happ, Alin Resiga

Mechanical Engineering

Maseeh College of Engineering and Computer Science

PORTLAND STATE UNIVERSITY

Problem Statement:

Most nose cone separation rings (NSR) use epoxy to secure the nosecone to the body of the rocket. Gunpowder deposited throughout the separation ring is ignited at apogee, separating the sections and deploying the parachute. Using epoxy to bind the rings is labor intensive, uses consumables, and is not easily testable. A more reliable method of binding and separating the rings is necessary on larger, more expensive rockets to ensure safe landing. The device needs to actuate quickly, be easily testable, and be able to withstand the forces experienced during rocket flight.

Design Challenges:

The NSR is to be designed for use in Portland State Aerospace Societies LV3 launch vehicle. The LV3 is composed of modular sections that have an outer diameter of 6.6 inches and an inner diameter of 6 inches. The entire NSR device must fit within the nominal inner diameter of the LV3 rocket. The device needs to incorporate a kick-off mechanism, be able to withstand axial loadings of up to 250 lb_f, and have a verifiable failure rate of less than 1%.

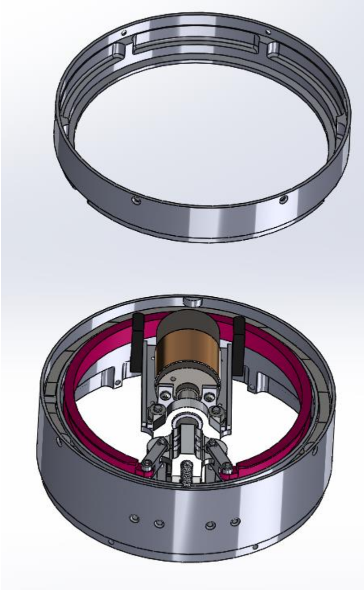

Figure 1: Solid model of the NSR

Detailed Design:

The electromechanical NSR design uses a Banebots RS-550 brushed DC motor to rotate a ¼-16 ACME power screw. The rotation of the power screw drives a rail guided sled assembly which interfaces with a V-band clamp through a set of relative motion arms. The motion of the arms are constrained by a set of pins which ride in a channel situated under the front of the sled. As the sled drives forward, tabs of the V-band are forced outward, increasing the diameter of the band. At the sleds maximum displacement, the V-band mates with a clamping surface on the rockets coupling rings. By reversing the current to the DC motor, the actuation is reversed. A wave spring incorporated in the larger coupling ring provides kick-off force, separating the two rings.

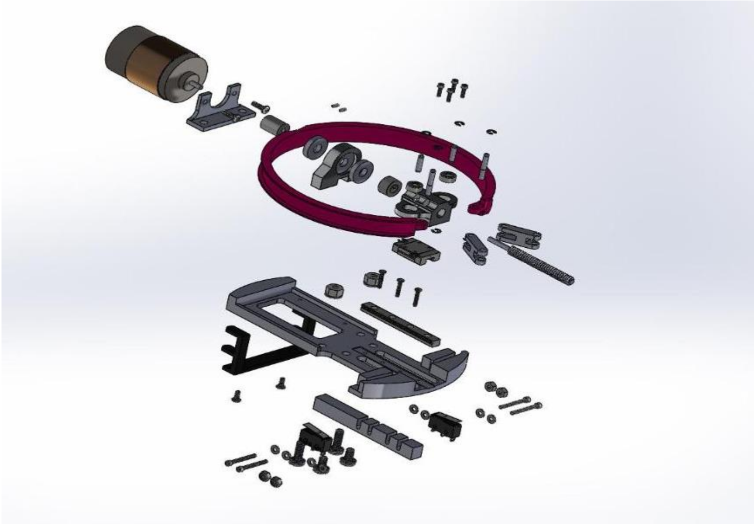

Figure 2: An exploded view of the NSR actuator

Key Observations / Lessons Learned:

Finite Element Analysis (FEA) of the V-band showed that the maximum stress incurred by the band during actuation is 23.9 ksi. The yield strength for aluminum 6061-T6 is 40 ksi, yielding a factor of safety of 1.67. Fatigue analysis of the band suggests that the band will last through 44,000 actuation cycles. This exceeds the design requirements for mechanical failure 440 fold. Due to the tight spatial constraints, aligning all of the mechanical components in the actuator proved to be extremely challenging. Custom dowel pins, shaft couplers, motor mounts and journals had to be made due to spatial constraints.

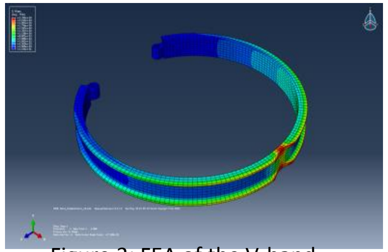

Figure 3: FEA of the V-band

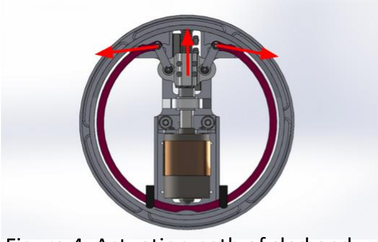

Figure 4: Actuation path of sled and tabs

Results and Conclusions:

A working prototype of the separation mechanism was completed on time and under budget. A prototype control system was developed using an Arduino Uno R3, a 30 A H bridge, and a pair of limit switches. The device is capable of actuating in less than 63 milliseconds, can be easily reset, and is robust in design. The mechanical components of the NSR are rocket ready. However, a better control system should be developed and implemented prior to use on the LV3 launch vehicle.

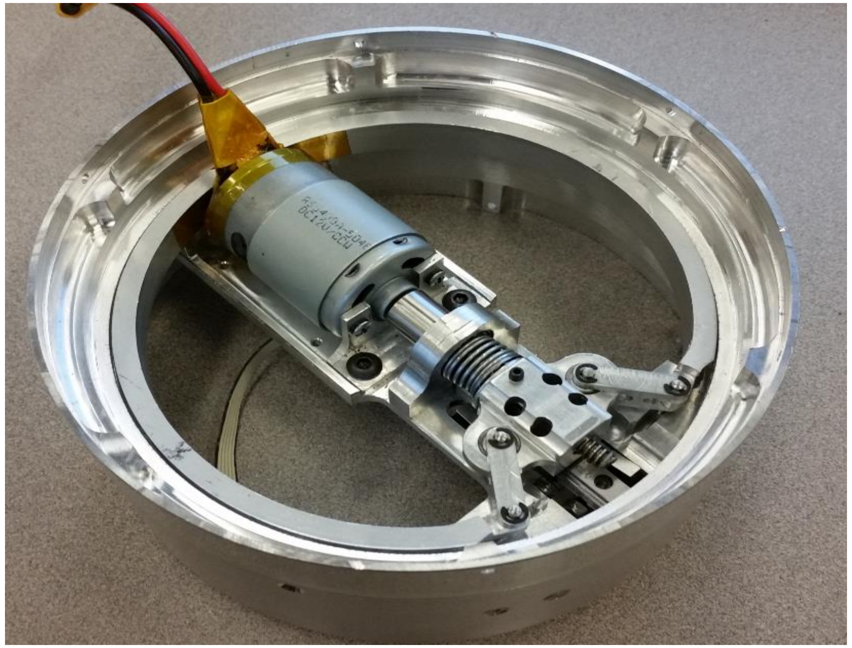

Figure 5: Completed electro-mechanical NSR

Future Work:

The stall current of the selected motor is 85 A. The prototype control system currently in use limits the output current to 30 A. This does not allow the motor to be run at full power, and can cause the system to bind after repeated actuations or when the battery is low. The motor also spins up so quickly that the system exhibits measurable overshoot after crossing the limit switches. Both of these issues could be mitigated by developing a faster and more robust control system.