VT ThickSat: A Passive Deployer Mechanism for a Carbon Fiber Tape Spring in the ThinSat Program

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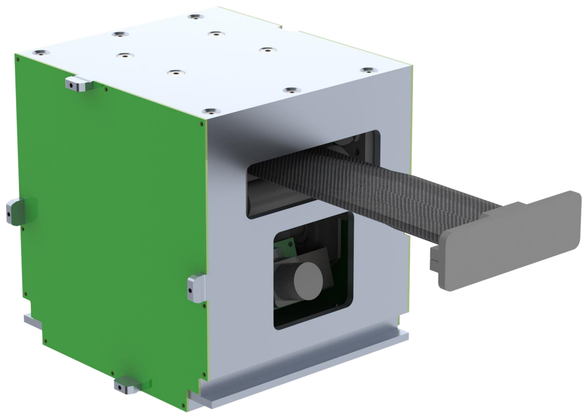
Introduction

The passive deployer mechanism will fly on Virginia Tech's ThinSat mission, VT ThickSat, scheduled to launch along with the resupply mission to the ISS, NG-15. This mission is a proof-of-concept that could lead to similar deployable structures in future missions, e.g., solar sails and solar panel deployments. The mission-critical objective is to demonstrate a passive deployment mechanism in space. The boom is required to release itself from the coiled state using only its stored elastic energy. Furthermore, the mechanism takes advantage of a scalable chassis, built for the same mission, restricting it to fit within the space of a 5 x 1T ThinSat form factor. This poster showcases the design progression of the deployer.

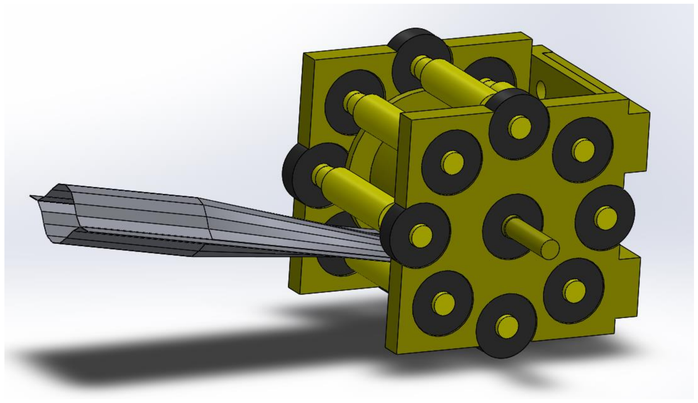


Tape Spring Boom

The tape spring used is a collapsible tubular mast (CTM) with a cross section height of 18 mm and a width of 39 mm. When flattened the boom reaches 45 mm in width. It is made of carbon fiber and was provided by the NASA Langley Research Center.

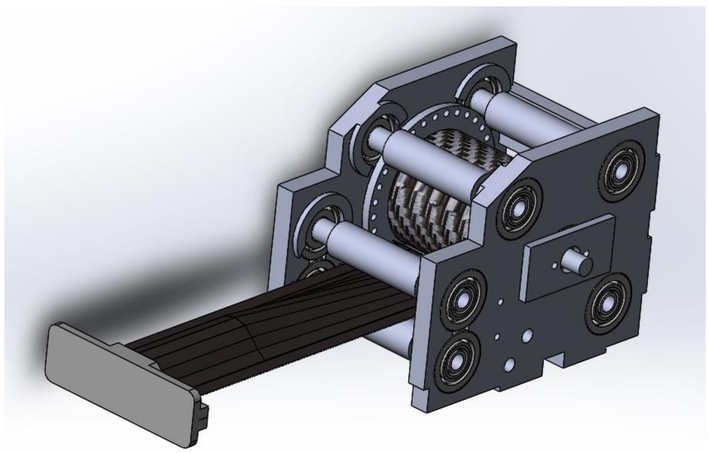
Design 1

The first design was a demonstration of the deployment mechanism. There were initial design issues such as a lack of direction for the deployment. However, it was also discovered that only 4 rollers attached to ball bearings were necessary for deployment. Based on the performance of this design, a tape spring length of 80 cm was chosen.



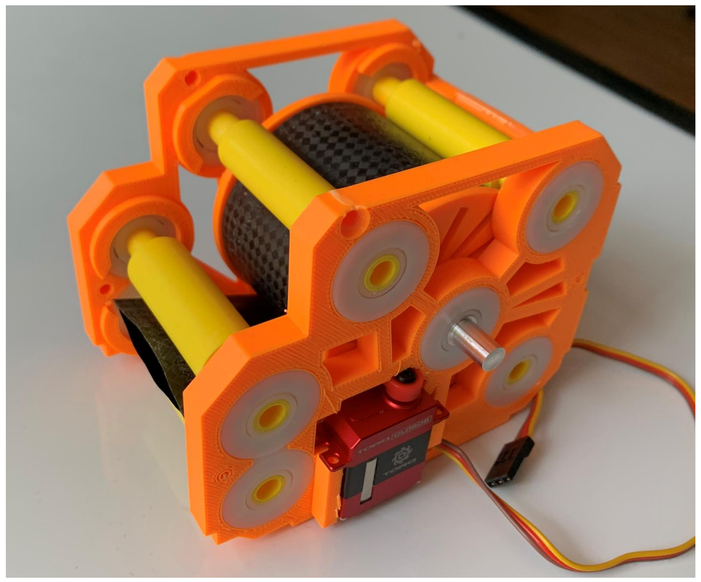
Design 2

An improvement of Design 1 and intended to be the design implemented on the satellite. Used a fishing line to hold the spool from turning that was broken by a burn wire to allow deployment. Attachment points were added and the overall geometry was adjusted to fit into the satellite. The Ball Bearings were updated to perform better at cold temperatures and rust less. The spool had an aluminum shaft through it for strength and for attaching an encoder.



Design 3

The final design used a servo as the deployment method allowing for increased reliability. The servo arm would block the deployment by inserting itself into a grove in the main spool and then turning to allow it to rotate and release. Under regular testing conditions, the deployer never failed.



Conclusions

- The tape spring loses considerable elasticity in temperatures under -10 degrees Celsius and thus the deployer does not function in those temperatures
- The tape spring was vulnerable to fractures after repeated launch attempts due to the undamped release
- The size constraints prevented the deployer from using a longer tape spring
- Need temperature cycling and vacuum testing to test its viability in orbit before launch
- Need better quantification of the stresses acting on the tape spring during deployment
- Overall, the final deployer proved to be a reliable design that will be developed further in the future