Automatic Spool Tension and Retraction Optimizer

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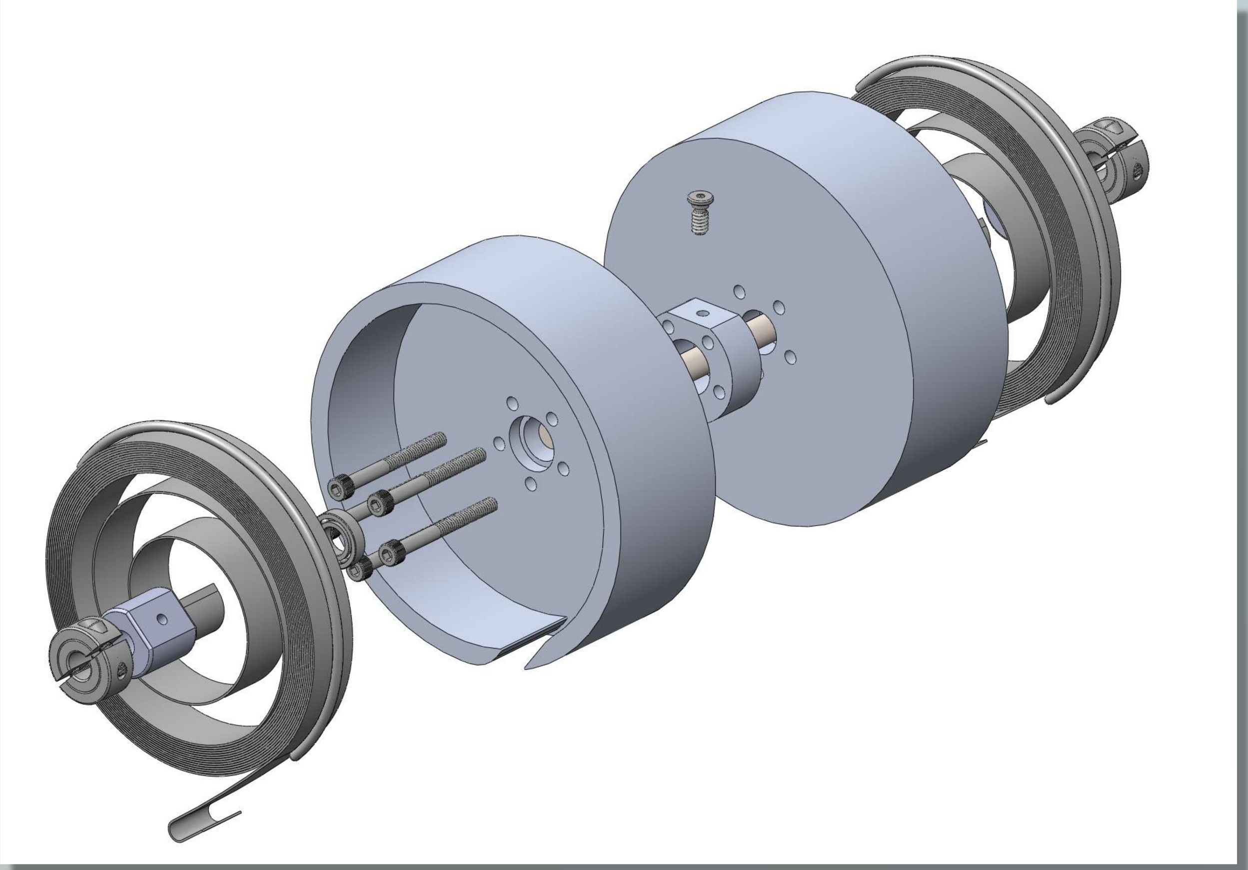
Background

One of the most important words in aerospace is redundancy, which safeguards against unforeseen damage. Damage can occur if lanyard drive systems, which are designed to pull satellite arrays open, derail or tangle. This is caused by slack accumulating in the lanyard as it deploys. Our team seeks to decrease risk in satellite deployment by adding a tensioning device, preventing potential tangling and millions of dollars in damage.

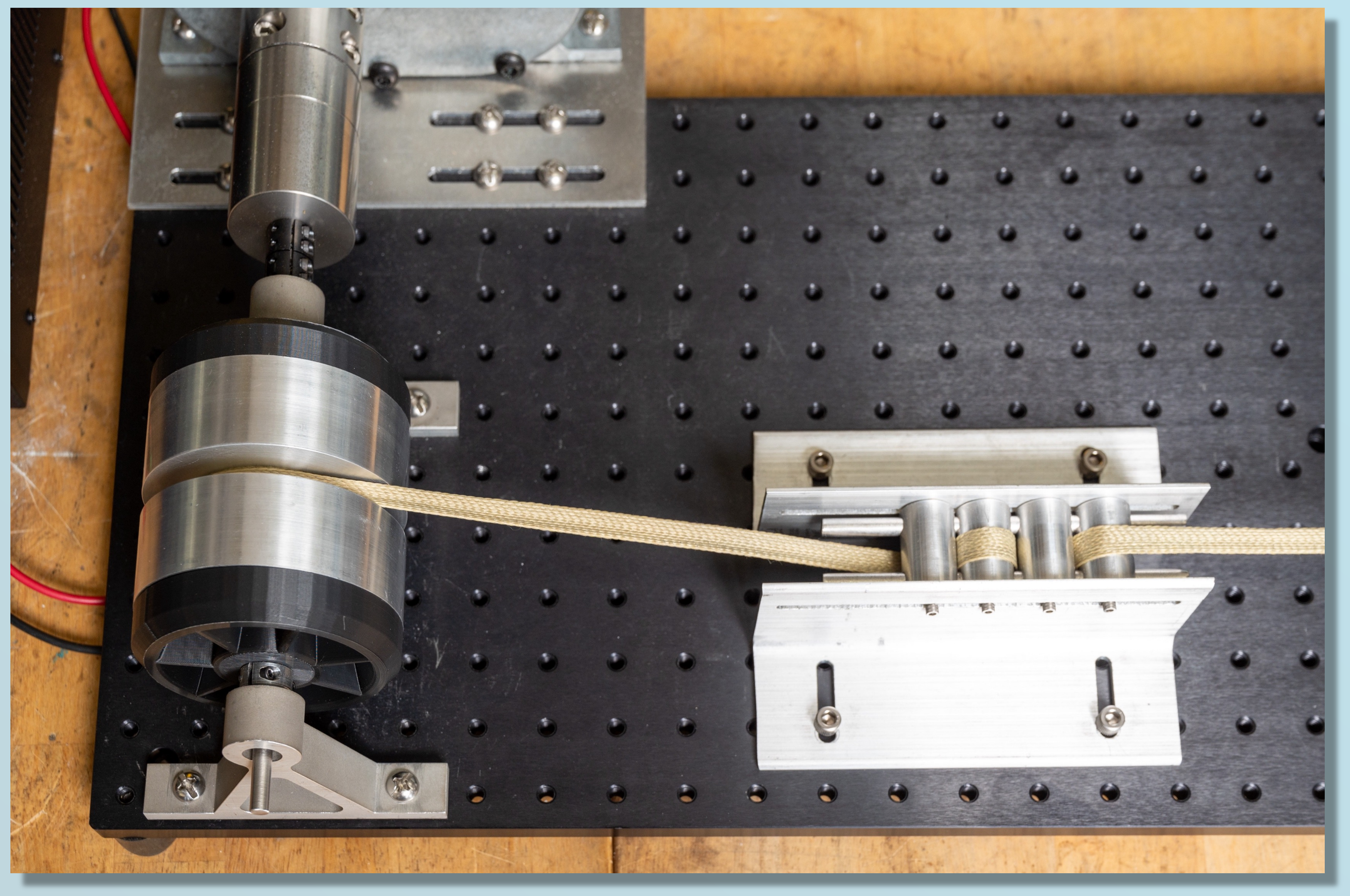
Overview / Design Specs

The Automatic Spool Tension and Retraction Optimizer (ASTRO) eliminates slack, providing an extra layer of protection against tangling. ASTRO operates using a capstan resistive system and a clock spring spool. Capstans create tension in the lanyard before it enters the spool, and the clock springs inside the spool take up any further slack that may develop between the subsystems. This ensures that retraction can be performed regardless of slack, while adding layers of passive redundancy to safeguard operation.

Exploded View

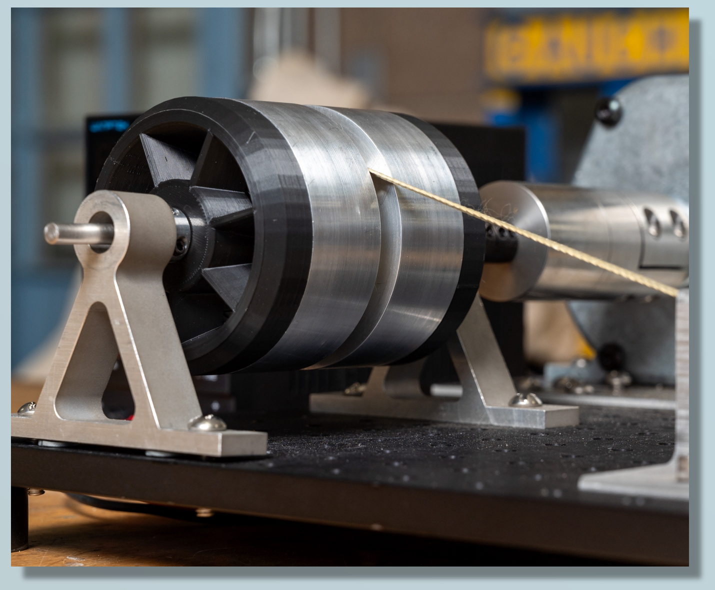


Final ASTRO Design



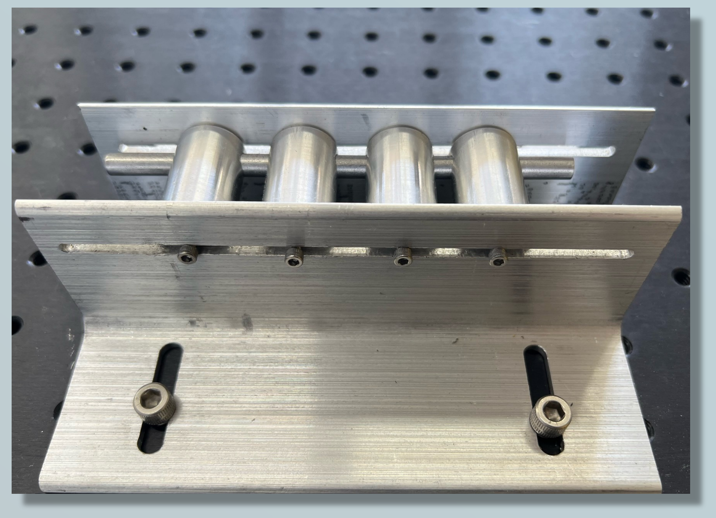
- Collection of subsystems to enhance redundancy
- Passive operation and resets after removing slack

Hardware / Key Components



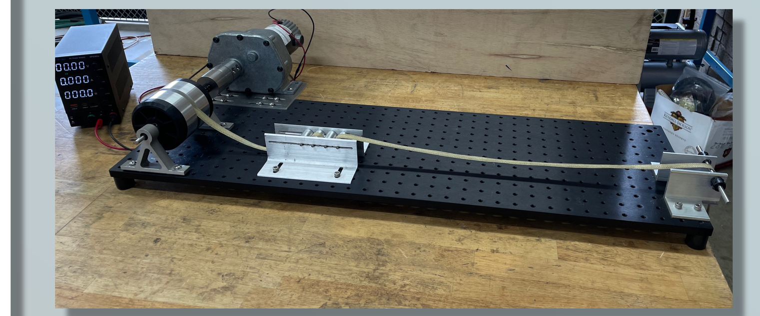
Clock Spring Spool

- Spool with two integrated clock springs
- Clock springs pre-tensioned to allow spool rotation in unison with motor shaft
- Pulls in slack as tension drops
- Constant torque of 16.6 lb·in



Capstan Serpentine

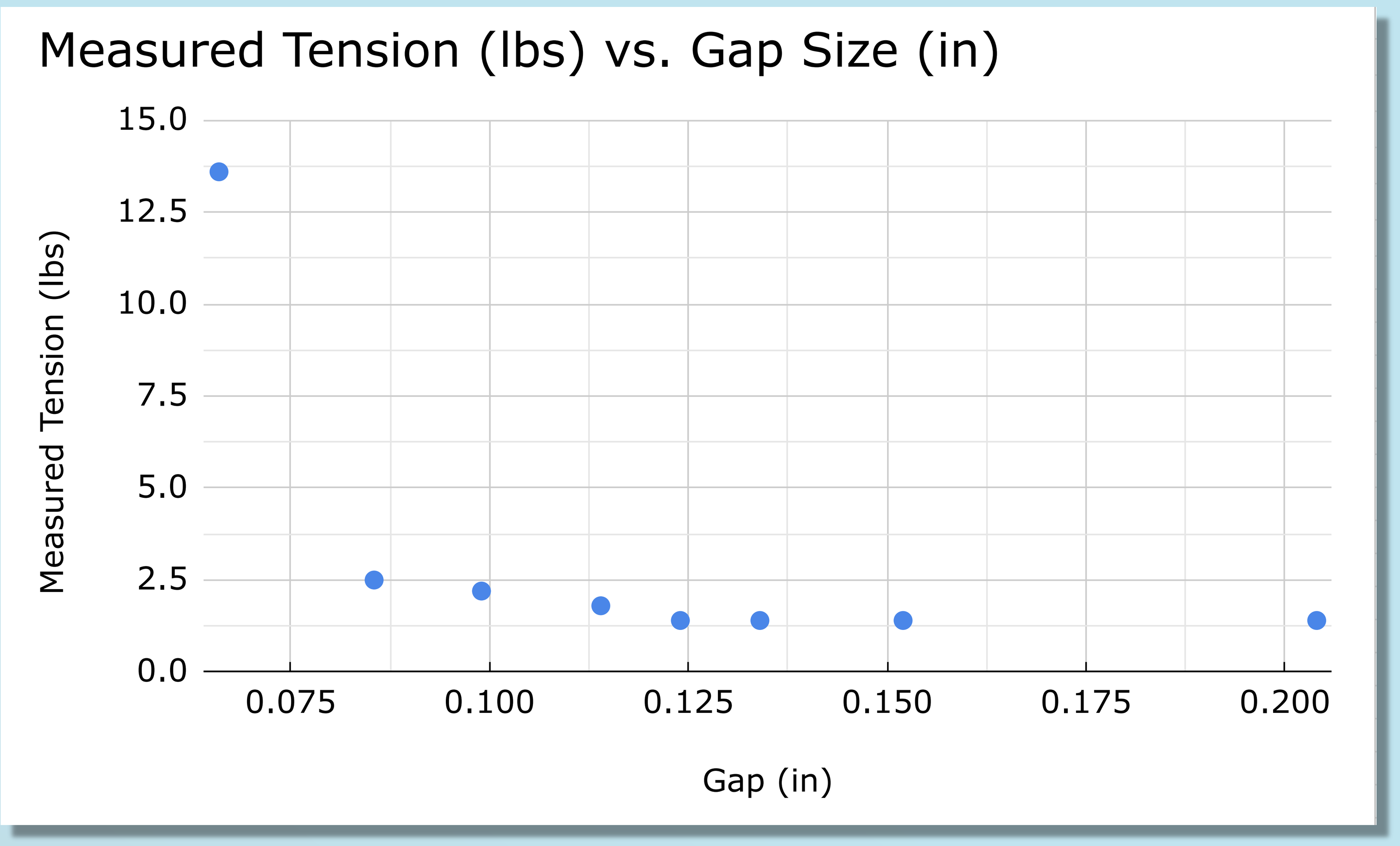
- Adjustable capstan cylinders allow for fine tuning of resistance
- Capstans farthest from the spool have the greatest impact
  - Due to entry angle and contact area with the lanyard
- About 6 lbs of tension typically generated



Test Rig

- 75 lb·in 12V DC motor
- Adjustable spacing optical board for testing specifications

Key Results



- Resistance generated by serpentine is directly influenced by spacing between capstans
- Performance greatly reduced by increasing gap size above thickness of the lanyard

Conclusions

Need	Engineering Characteristic	Target Specification	
		Minimum	Ideal
Repeatability	Number of Consecutive Successes in Multiple Trials	10	15
Must be Close to Spool Motor	Distance to Spool	12in	6in
Accept Varying Loads	Variance of Load Capacity	0 to 15lbs	0 to 50lbs
Slack Can Be Varied	Length of Slack That Can Be Introduced Before Device	4in	10in
Low-Profile	Maximum Distance Orthogonal to Mount Surface	3.45in	1in
Test Rig Can Vary Loads	Number of Discrete Intervals of Tension in Test Rig	3	5
Normalize Lanyard Tilt Into Spool	Angle of Lanyard That Is Possible to Be Corrected before Device	0°	±90°
Must Survive Launch Conditions	Maximum Vibration Acceleration Device Can Survive	15g	60g
Must Be Temperature-Resistant	Maximum Deviation of Temperatures Tolerated	0°C	±60°C
Must Move at Reasonable Speed	Maximum Rate of Lanyard Retraction	0.1in/s	0.2in/s

- Met all major requirements except vibration resistance and temperature tolerance
  - Unable to test with available resources
- Particularly reliable in total slack length that can be eliminated

NORTHROP GRUMMAN

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