

Refined Hybrid Rocket Static Fire Testing with Increased Performance and Precision

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Background

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Hybrid Rocket Testing

- USU Battery Limits and Survivability Testing (BLAST) cell
- Locked into ground
- Cables passed through into safe room



Capabilities

- Thrust Levels: 0.5 – 900 N (0.1 – 200 lbf)
- On-demand start/stop
- Digital Throttling
- In-situ fiber optics for thermal and spectral measurements
- Fuel additive infusion methodology
- Low-cost entry to research

Propellants

Oxidizer

- GOX
- Nitrous Oxide
- Nytrox
- Hydrogen Peroxide (SDL collaboration)

Fuels

- ABS
- PA
- PMMA
- HDPE
- PP
- HTPB

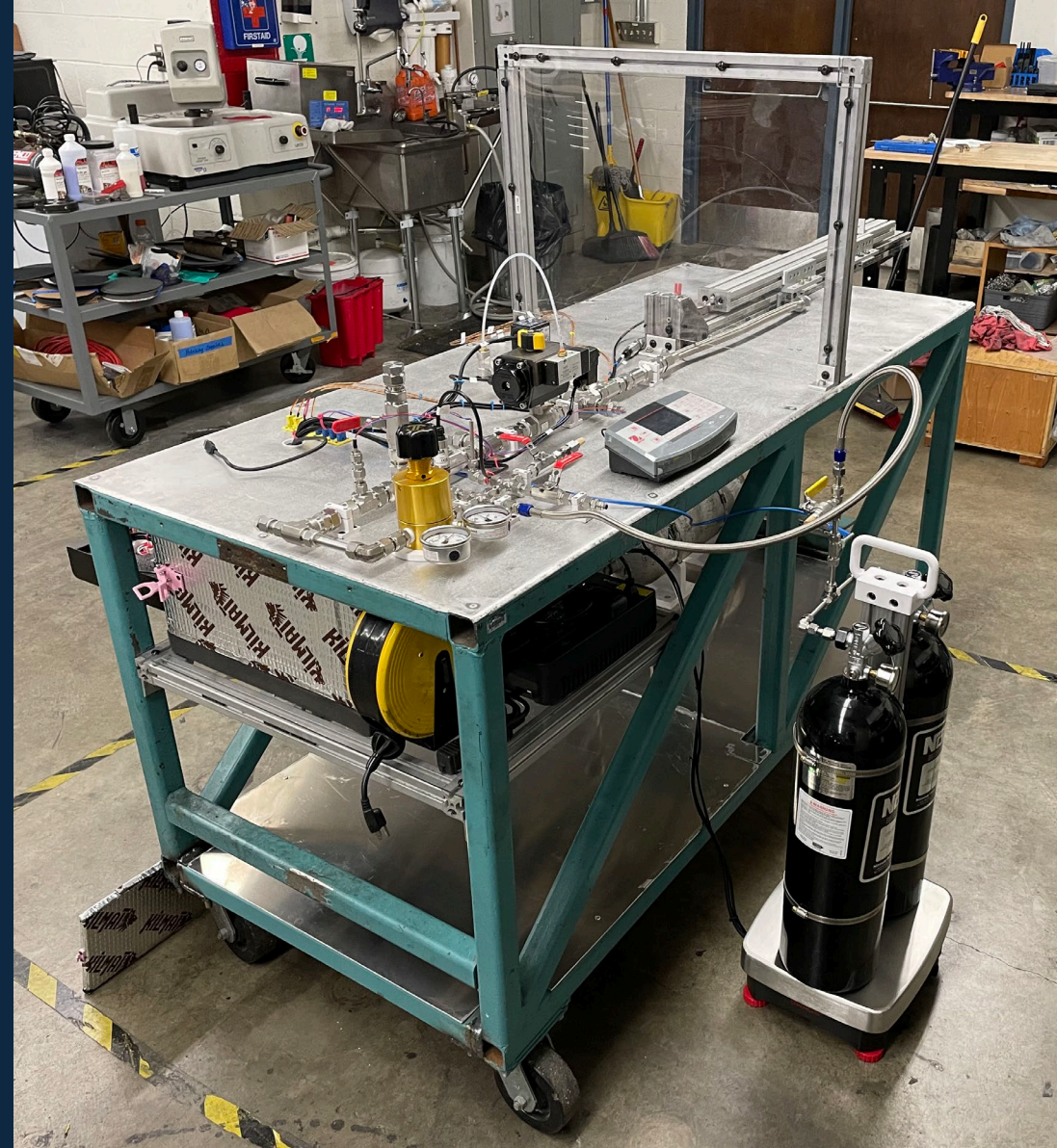


Problem

Need for increased thrust and enhanced data acquisition reliability

Cart Instruments

- 4 Type T Thermocouples
- 4 Type K Thermocouples
- 3 Pressure Transducers
- 1 Load Cell
- 1 Scale
- 2 Webcams
- 3 NI DAQ Cards



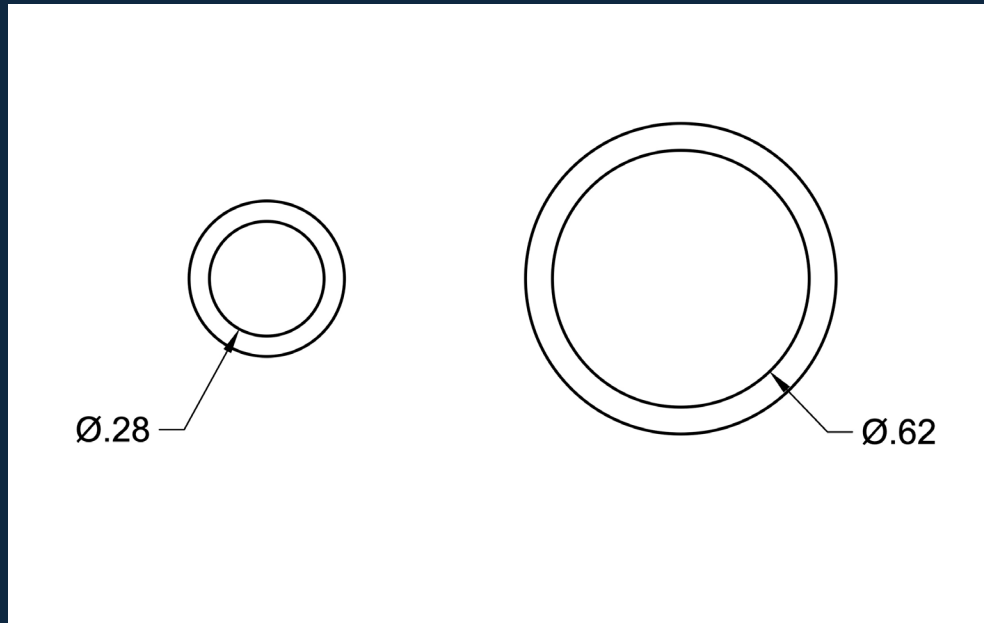
Issues with Current Setup

- Thrust capabilities were not large enough
- Instrument noise complicated data analysis
- Too many devices and not enough bandwidth to collect data
- Load cell hysteresis caused errors in thrust data

What did we change?

1. Piping inner diameter increased from 0.277" to 0.620"
2. Wiring simplified to reduce noise
3. Cable passthroughs upgraded for higher transfer bandwidth
4. Load cell stand modified to create a "frictionless" stand with no hysteresis

1. Piping Diameter Increase



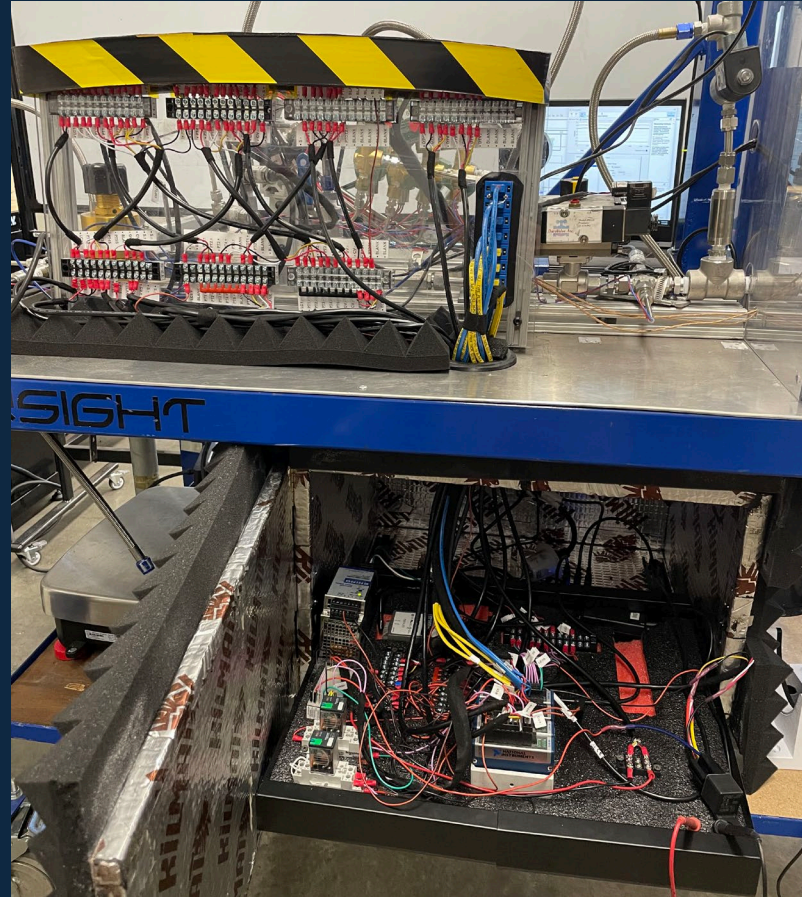
- Ratio given by Darcy-Weisbach-derived turbulent flow equation

$$\frac{Q_{new}}{Q_{old}} = \left(\frac{D_{new}}{D_{old}} \right)^{5/2} = \left(\frac{0.620}{0.277} \right)^{2.5} = 11.2$$

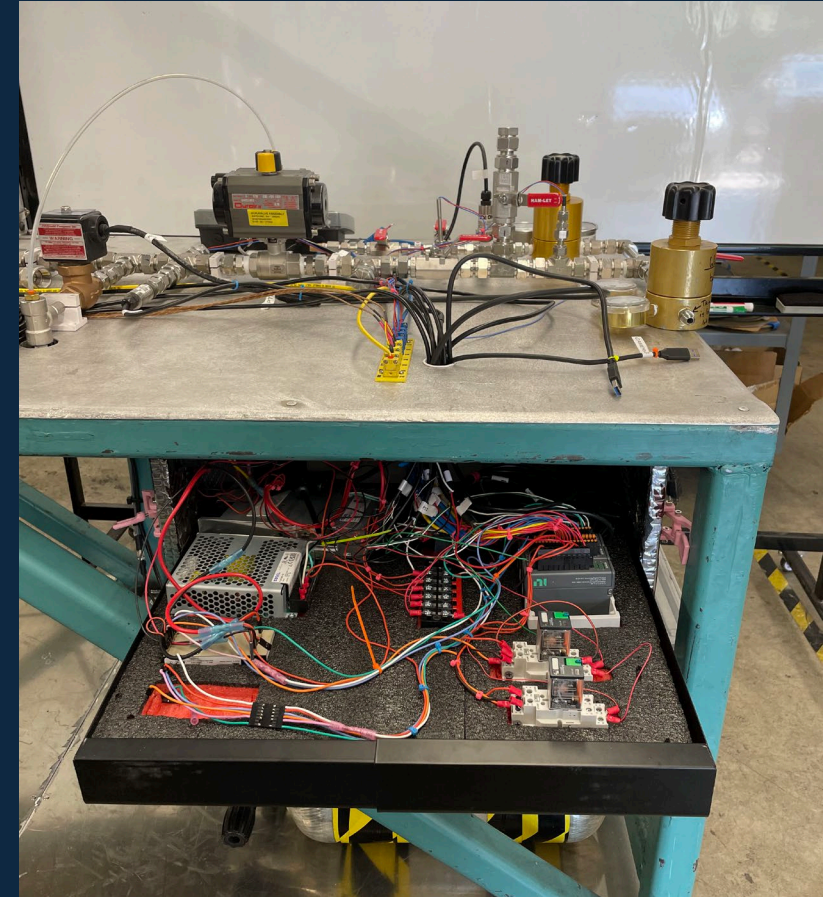
- 11.2x higher oxidizer mass flow rate
 - Higher thrust during testing

2. Wiring Changes

- Simplification of design
- Usage of high voltage shielded wires



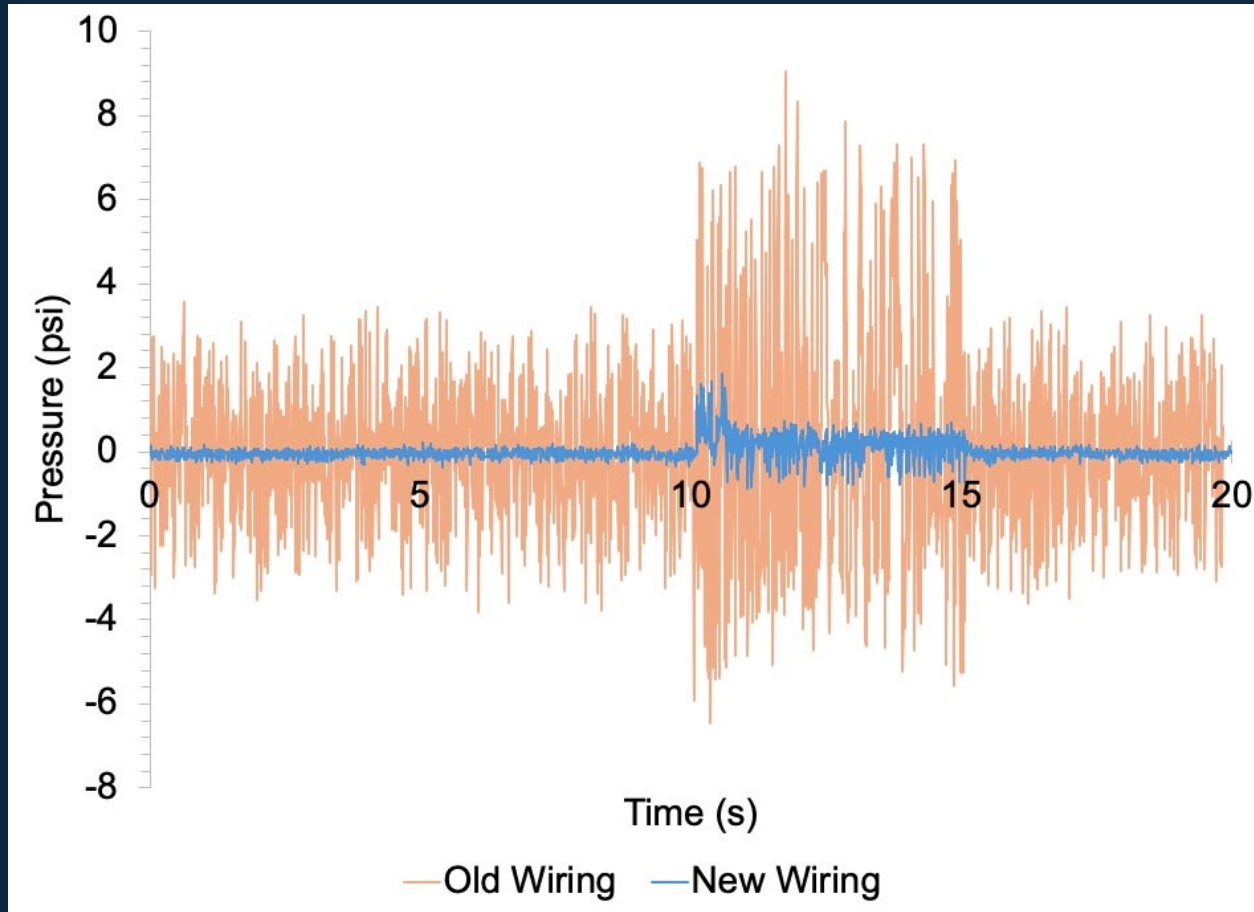
Previous Setup



Updated Setup

Noise Comparison

Old Wiring
Std Dev: 3.29 psi



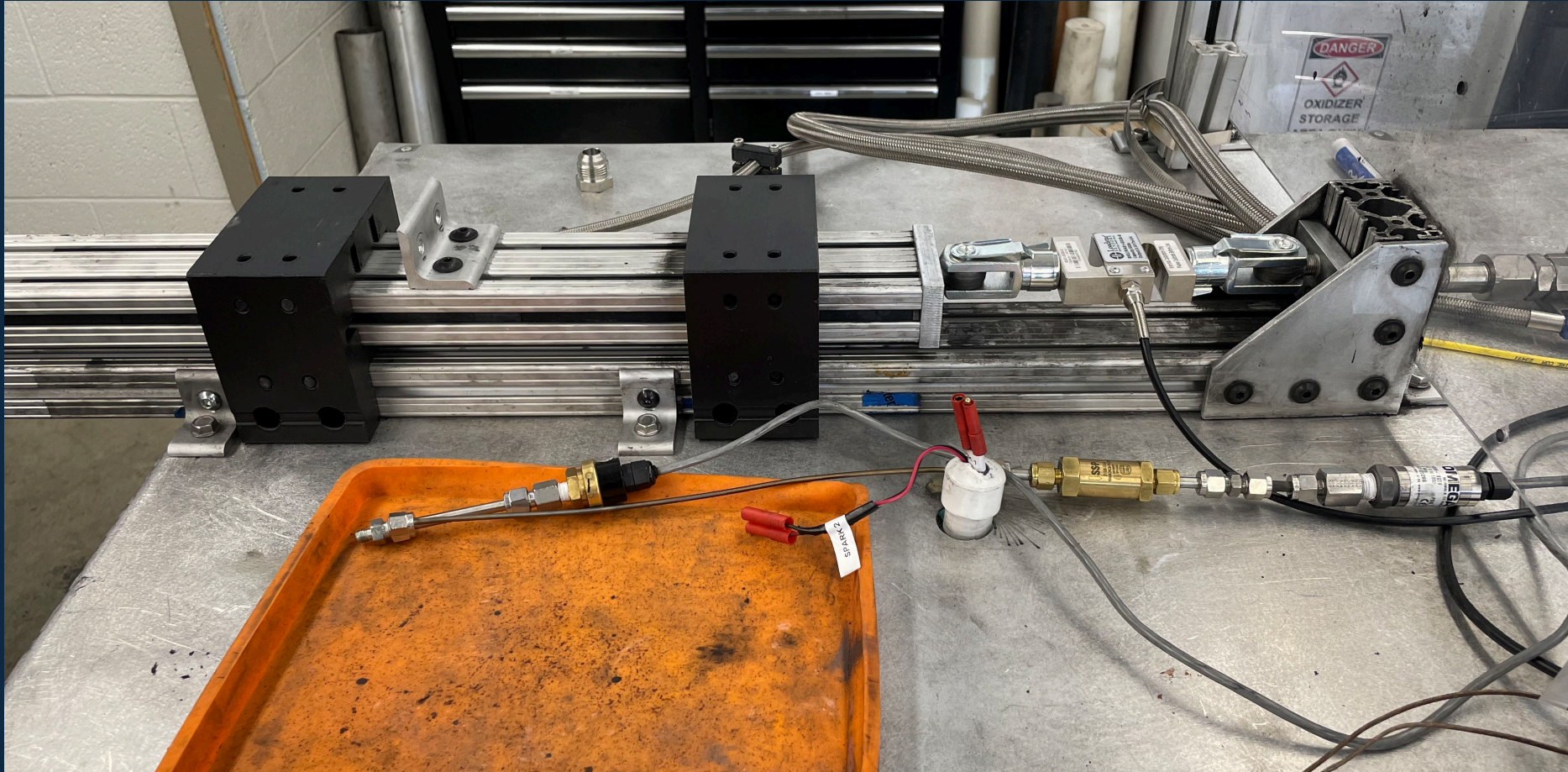
New Wiring
Std Dev: 0.39 psi

3. USB Passthroughs

- Previous
 - 2 USB 2.0 (~60 MB/s)
 - 1 USB 3.0 (<5 GB/s)
- New
 - 4 USB 3.1 (~5 GB/s)
- More passthroughs
- Higher bandwidth



4. Load Cell Stand



Load Cell Stand Upgrade

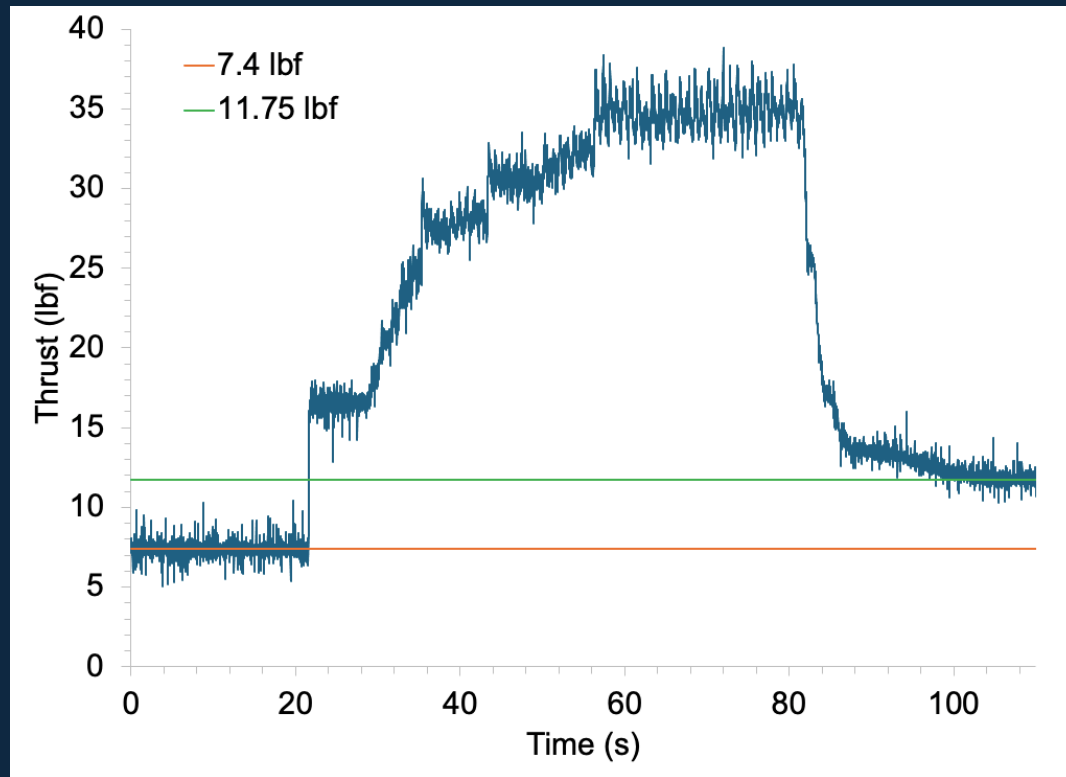


Previous sliders

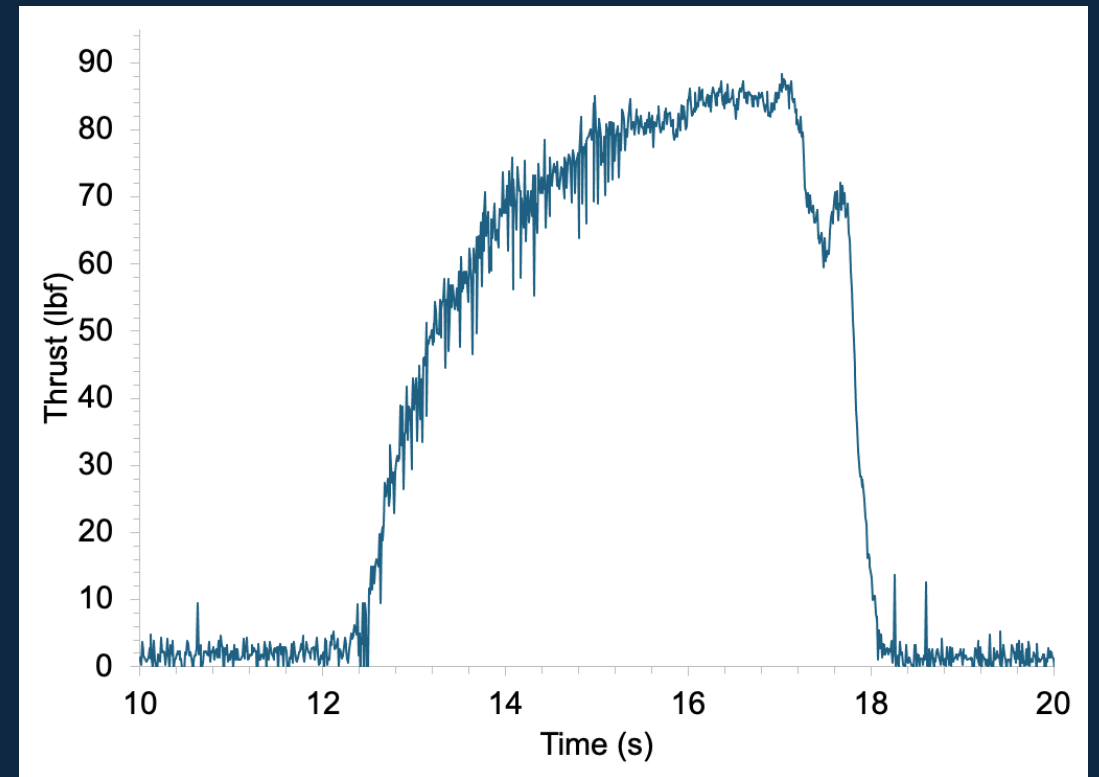


Updated mounts with 608 ball bearings

Hysteresis Comparison



“Frictionless” Sliders



Ball Bearings Mount

Recap

1. Larger diameter tubing
2. Simplified Wiring
3. Upgraded USB cables
4. Modified load cell stand



Questions?