UF Herbert Wertheim
College of Engineering
UNIVERSITY of FLORIDA

Impede Tech: The Millistriker

December 4th, 2024
EML4502: Mechanical Engineering Design 3

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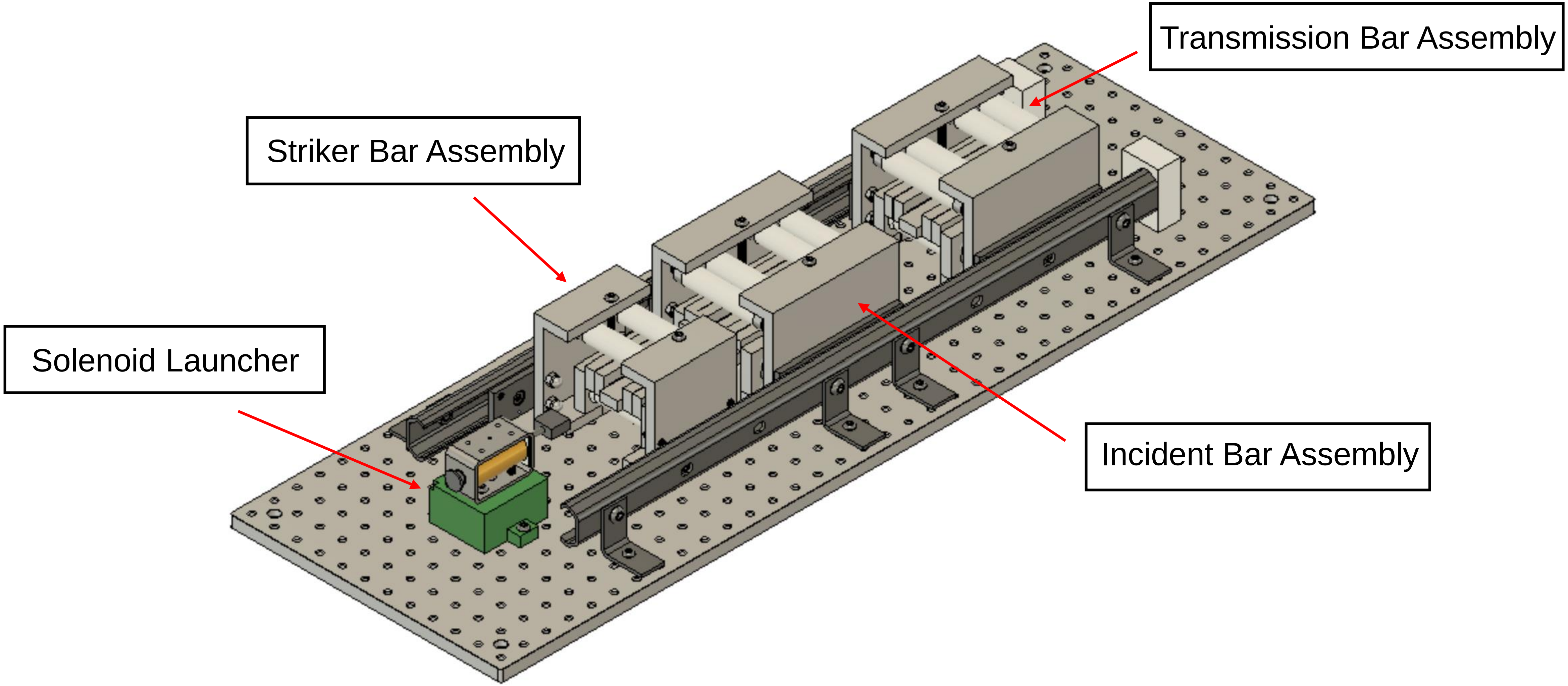
Presentation Outline

- Hedgehog Concept
- Product Specs & Features
- Design Performance and Modeling
- Manufacturing & Cost Analysis
- Design Summary & Improvements

Hedgehog Concept

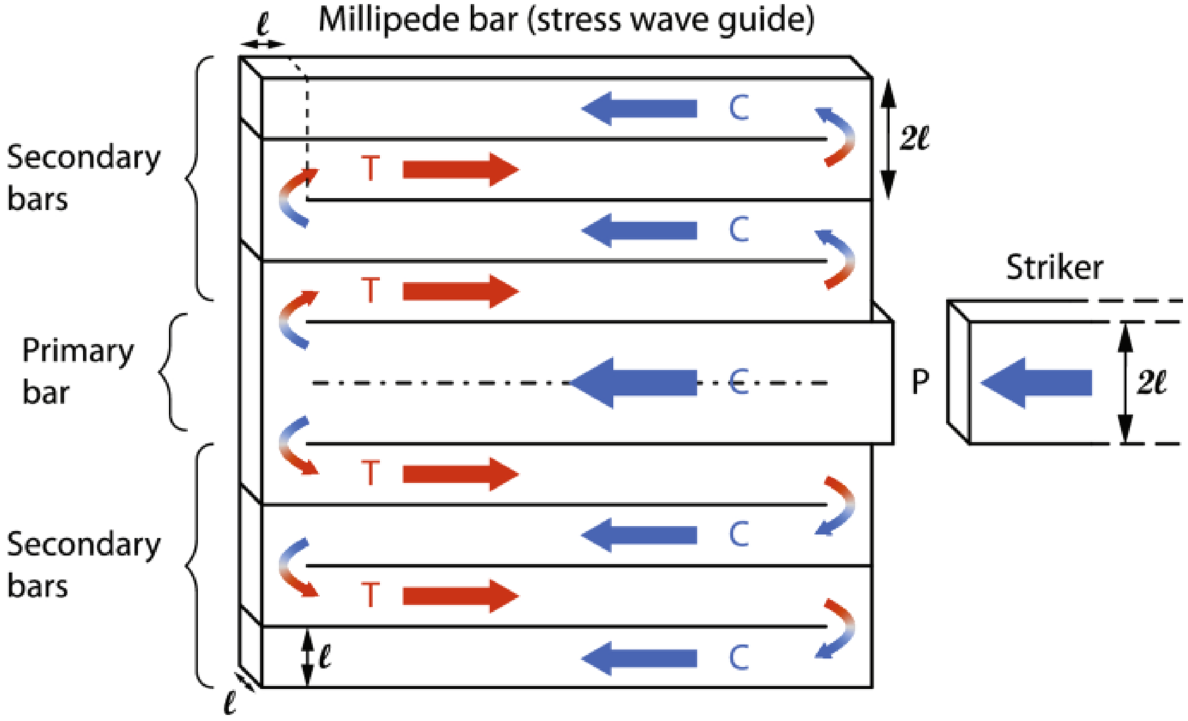
*By enabling **dynamic material testing** for **intermediate strain rate ranges** with a **precise**, **reliable**, and **robust** testing apparatus, our product sets the **global testing standard** sought by industries including manufacturing, aerospace, defense, and automotive.*

MilliStriker™ by Impede Tech



Project Background

- New method of stress-strain response material testing
- “Serpentine” bar
- With the right input pulse duration, long duration stress pulses can be propagated undistorted



[Subhash, G., Bavdekar, S., Leonard, R. et al. Concept Article: A Novel Compact Millipede Bar Waveguide for Propagation of Longitudinal Stress Waves. J. dynamic behavior mater. (2023).]

Market Relevance

Current material testing devices

- *Large footprint*
- *Expensive*
- *Complex assembly and transport*

Why is this device viable?

- *Small scale*
- *Lower cost*
- *Diverse applications*

Form

- 6061 T6 Aluminum
- 900 x 300 mm footprint
- User friendly design

Function

Tests material samples at a range of strain rate waves

Benefit

Material testing that is more affordable, compact, and lightweight than products on the market

Product Specifications

- **Launcher Velocity:**
  - Reaches 12 m/s
- **Total Weight:**
  - ~ 50 pounds
- **Manual Assembly Time:**
  - ~ 30 minutes
- **Wave Propagation**
  - Bend junction length: 5.6 mm
  - T* ratio: 100
- **# of Systems/Components**
  - Systems: 3
  - Total manufactured components: 15

Key Design Features

- Fixed Alignment **Guide Rails** and **Carriages**
  - Zinc-plated for low friction
- **Precision** manufactured **Clamping** & Lower jaw components
  - Provides adjustability
- Boundary conditions with **Rollers** implemented
  - Allows for free movement of bend junctions while maintaining stability
- **Compact** and **Portable** design
  - (900mm x 300mm)

Performance Evaluation 1- Incremental Launch Velocity

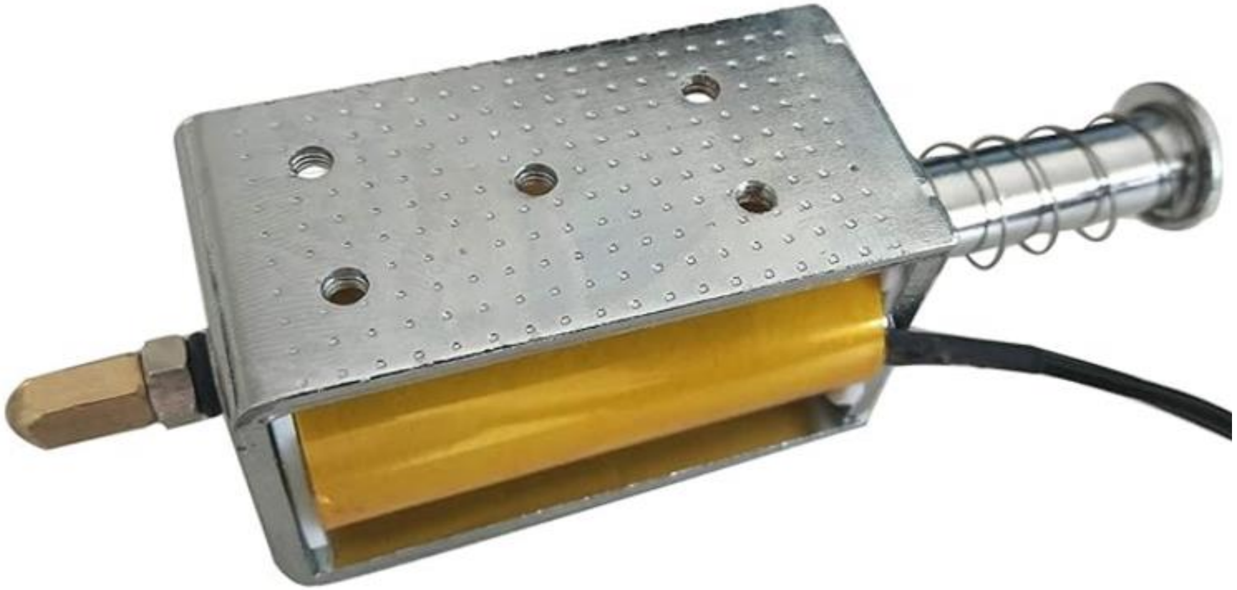
Primary Testing Factor:
1 m/s Increments

Secondary Testing Factor:
Capable of 10 m/s

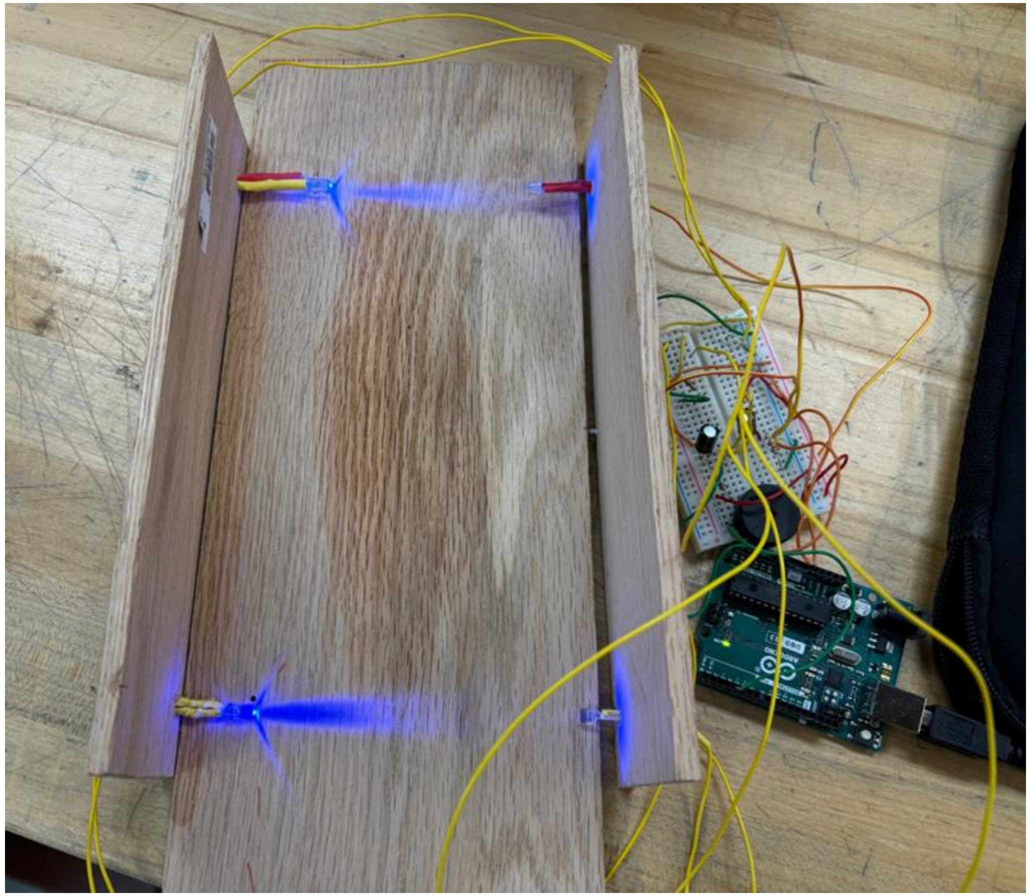
Methods:
Experimental relationship between voltage and launch velocity

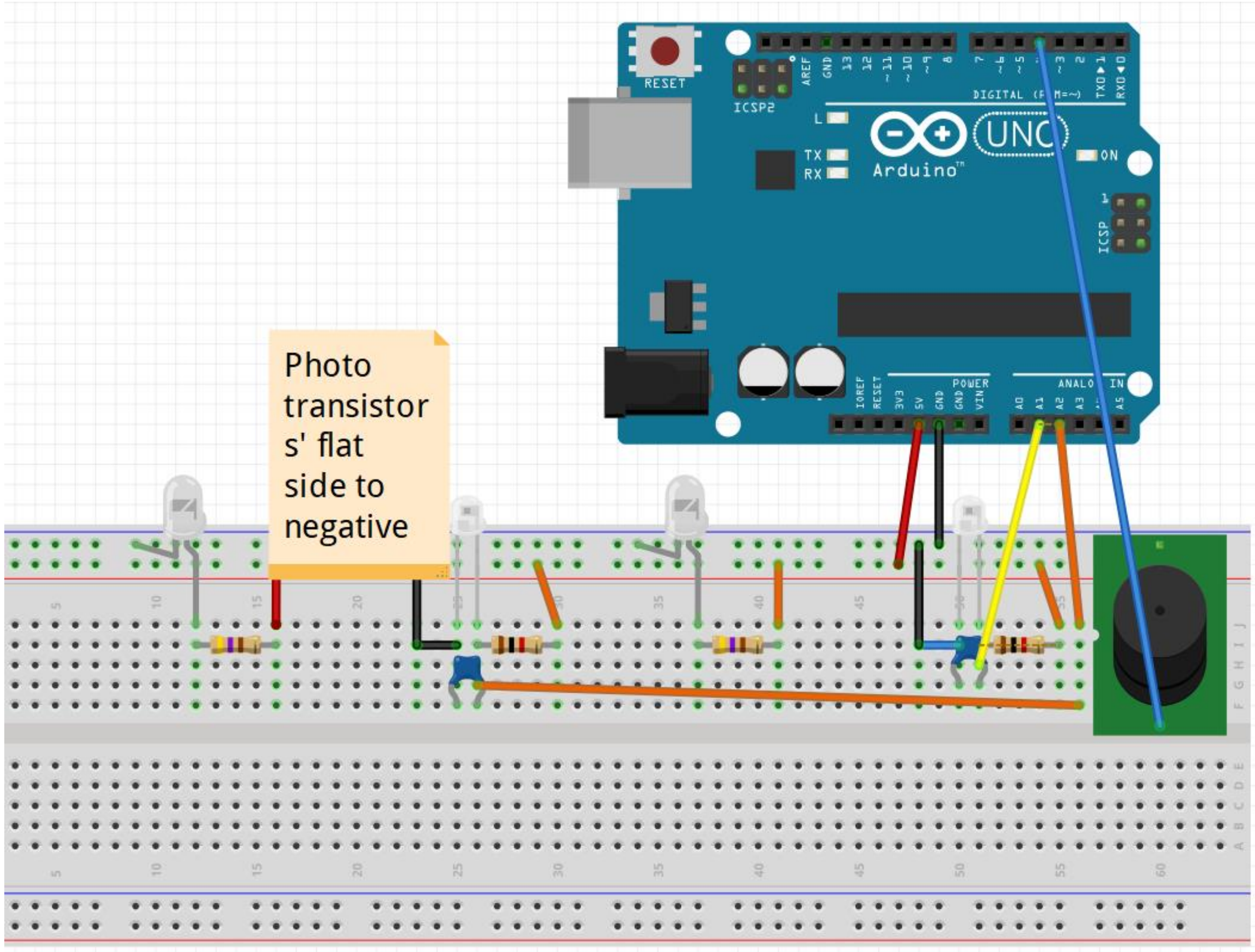
Performance Evaluation 1: Theory

$$E = \frac{1}{2}LI^2 = \frac{1}{2}mv^2$$



Performance Evaluation 1: Arduino Circuit





Performance Evaluation 1: Incremental Launch Velocity

- The experimental relationship developed between applied voltage (*V*) to launch velocity (*S*): $S = 0.8281e^{0.0147V} \longrightarrow V = 68.0272 * \ln(1.2076S)$

Applied Voltage (*V*)	Launch Velocity (*m/s*)
50	1.08
70	1.55
90	2.33
110	2.80
130	3.50
150	4.67
170	7.00

Performance Evaluation 1: Incremental Launch Velocity

- Using the experimental relationship between *V* and *S*, velocities were calculated in 1 m/s steps to test for incremental velocity capability

Theoretical Velocity (m/s)	Measured Velocity (m/s)	Velocity Increment (m/s)	Voltage (V)
13	6.9	-	187.3
14	7.0	0.1	192.6
15	7.4	0.4	197.1
16	7.5	0.1	201.4
17	8.3	0.8	205.6
18	9.7	1.4	209.5
19	**11.8**	2.1	**213.1**

Performance Evaluation 1: Incremental Launch Velocity

- For our primary test factor, our launching system ranks in the “Fair” category. For our secondary test factor, our launching system ranks in the “Good” category.

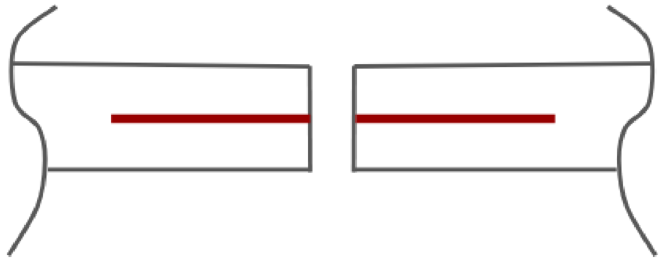
Primary Test Factor				
	Excellent (100%)	**Good (75%)**	**Fair (50%)**	**Poor (25%)**
Incremental Velocities (30)	$\Delta n < 0.1$ m/s or better	$\Delta n < 1$ m/s or better	1 m/s $< \Delta n < 2$ m/s	$\Delta n >$ +- 2 m/s
Secondary Test Factors				
	Excellent (100%)	**Good (75%)**	**Fair (50%)**	**Poor (25%)**
S_{max} (10)	$S_{max} > 16$ m/s	$11 < S_{max} < 15$ m/s	$S_{max} = 10$ m/s	$S_{max} < 10$ m/s

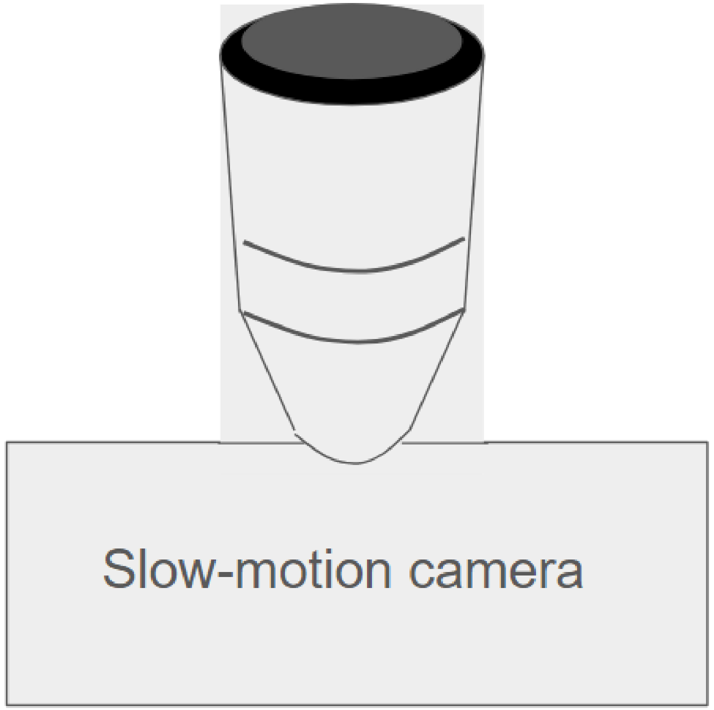
Performance Evaluation 2: Alignment Check

- **Primary testing factors**:
  - Deflection
  - Level bars

- **Secondary testing factors**:
  - Consistent Velocities

- **Methods**:
  - Slow-motion camera
  - Digital Leveler





Design Evolution

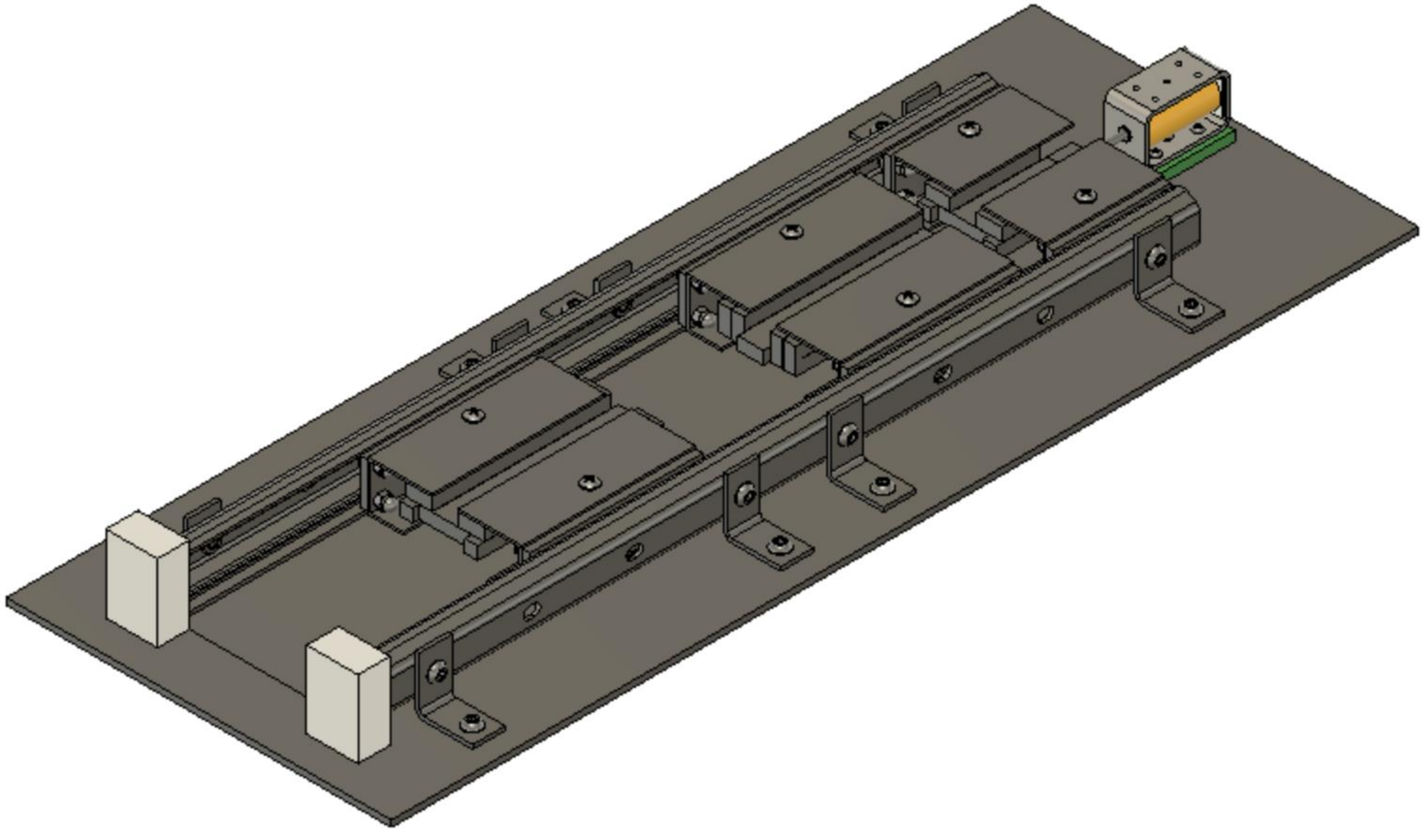
Concept Generation

Design Review 1

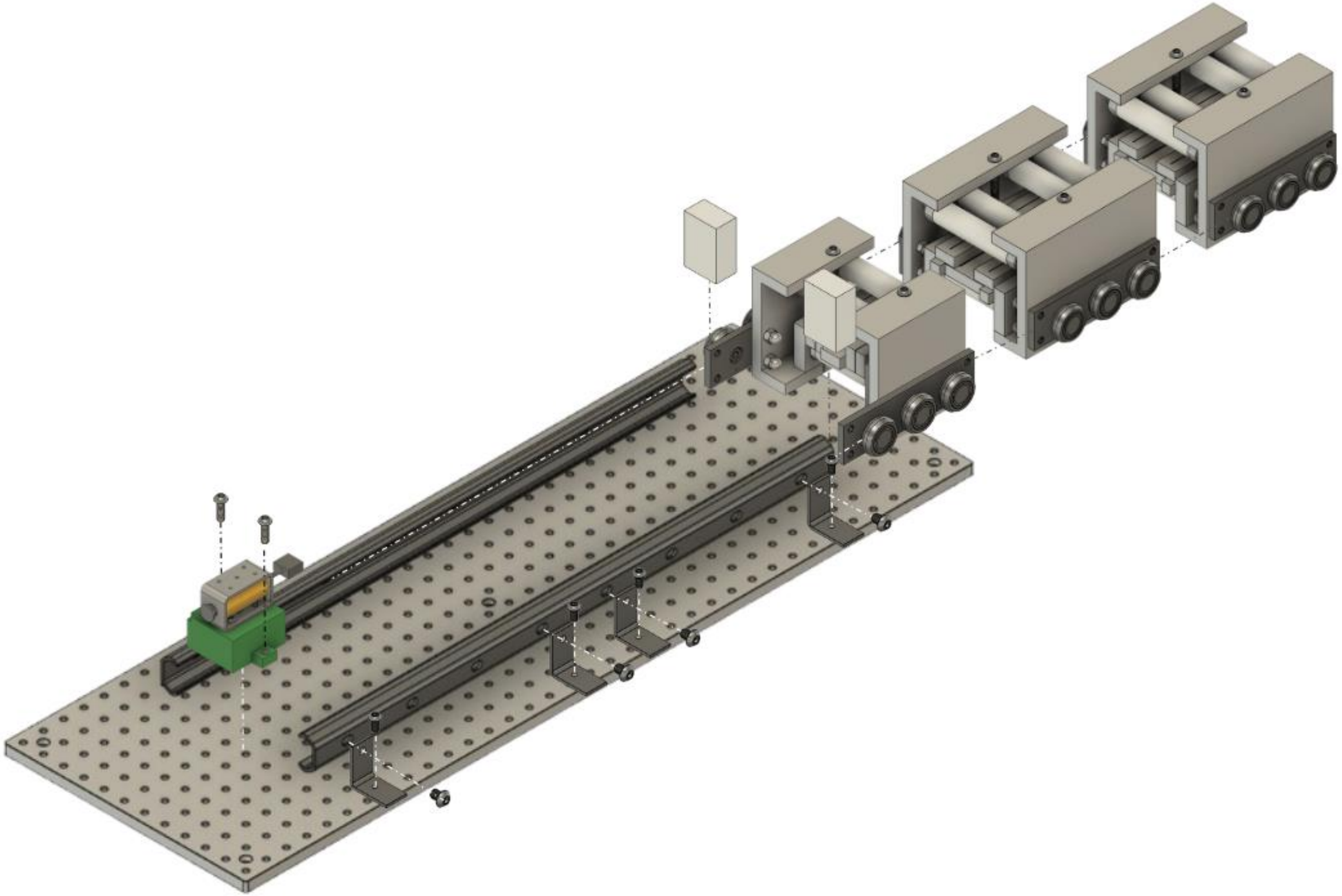
Design Review 2

Design Iteration 1

- Main concern: obstructed particle movement through the bend junctions



Exploded CAD Views



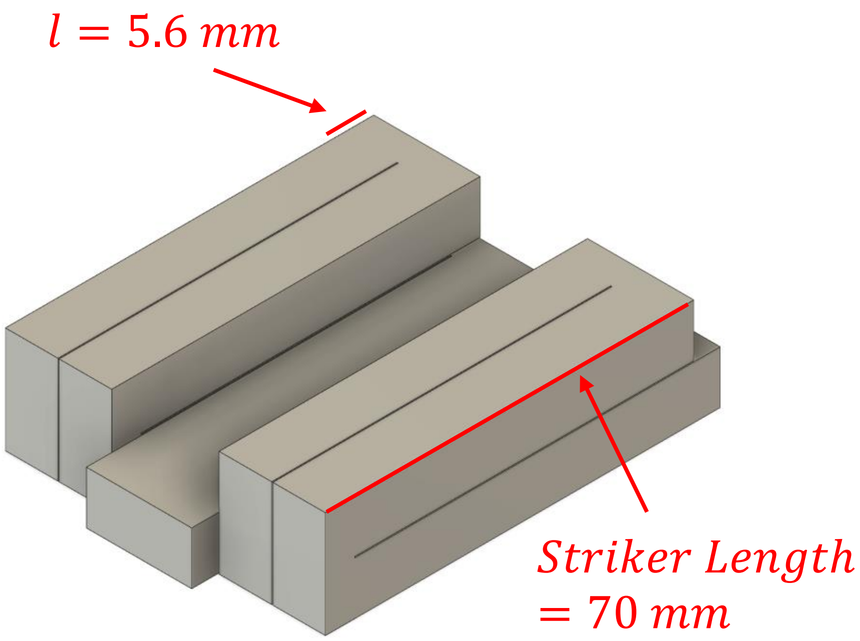
Millipede Bar Specifications

$$T^* = \frac{T_P}{T_J} = \frac{\left(\frac{2L}{c}\right)}{\left(\frac{l}{c}\right)} = \frac{2L}{l}$$

Assume bend junction $l = 5.6mm$

$$100 = \frac{\frac{2L}{5000\frac{m}{s}}}{\frac{0.0056\,m}{5000\frac{m}{s}}} \Rightarrow L = 280mm = 0.280m$$

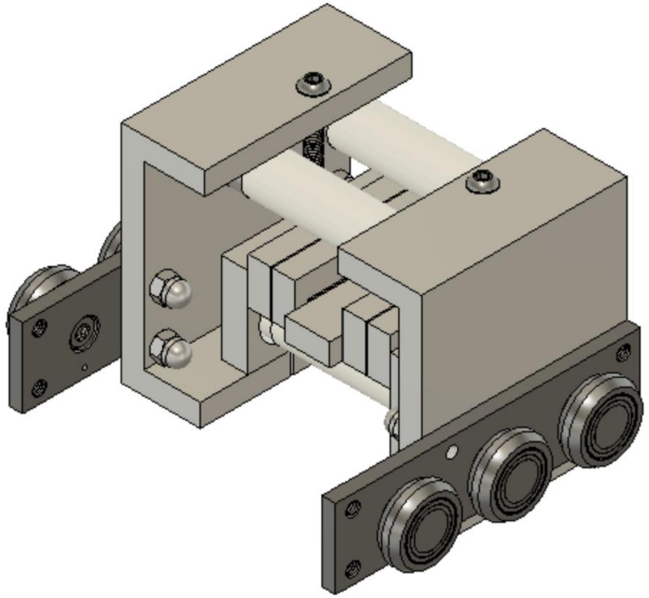
$$Length\ of\ each\ striker\ leg = \frac{0.28\,m}{4\ bend\ junctions} = 0.070\,m$$



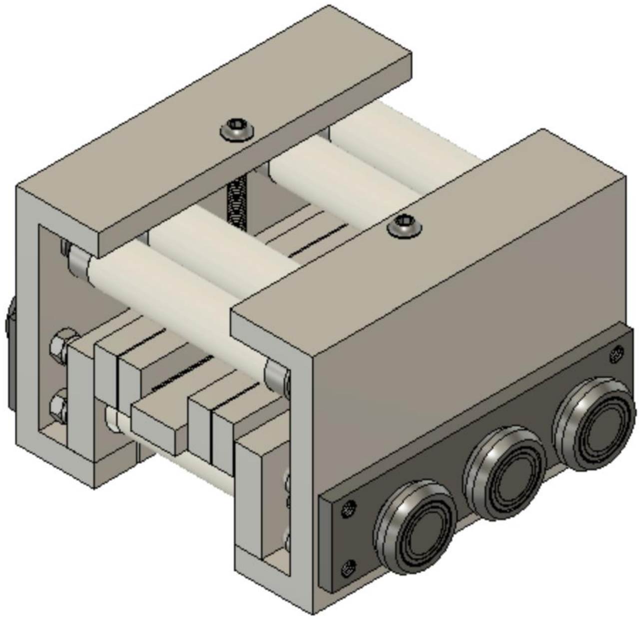
6061 Aluminum – T6

- High Elastic Modulus (69 GPa)
- Density (2,700 kg/m^3)
- Cost-Effective

Roller Cage Assembly Subsystems



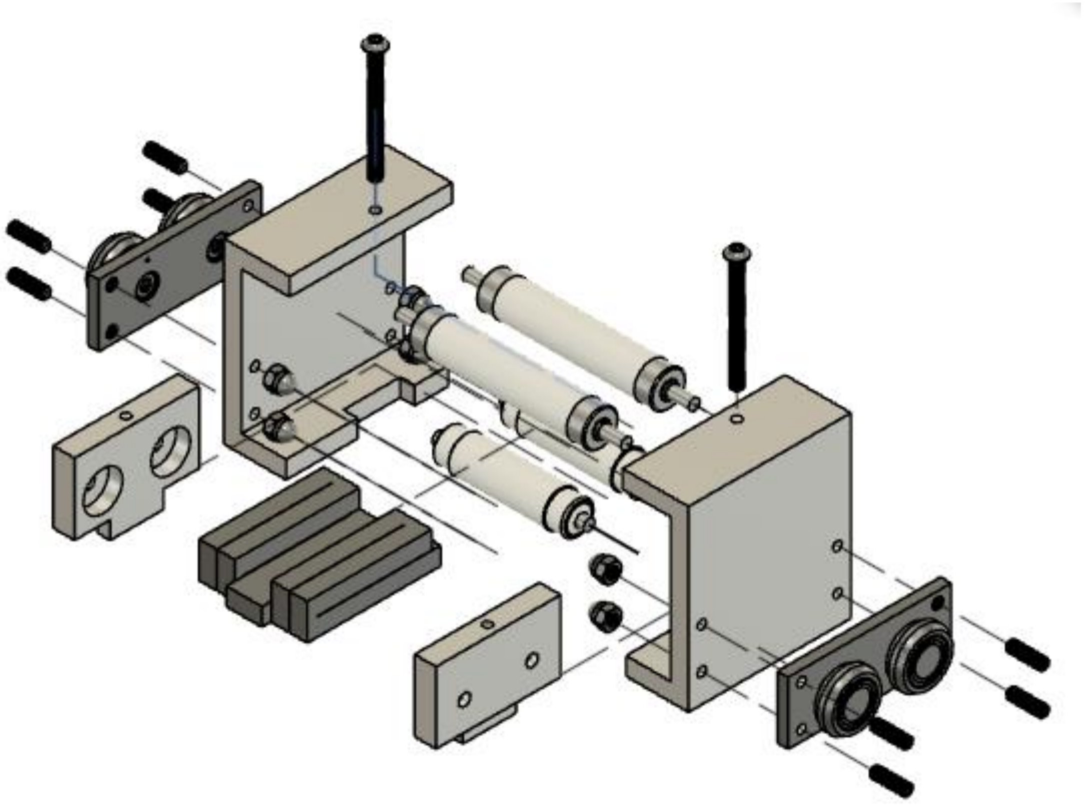
Striker Roller Cage



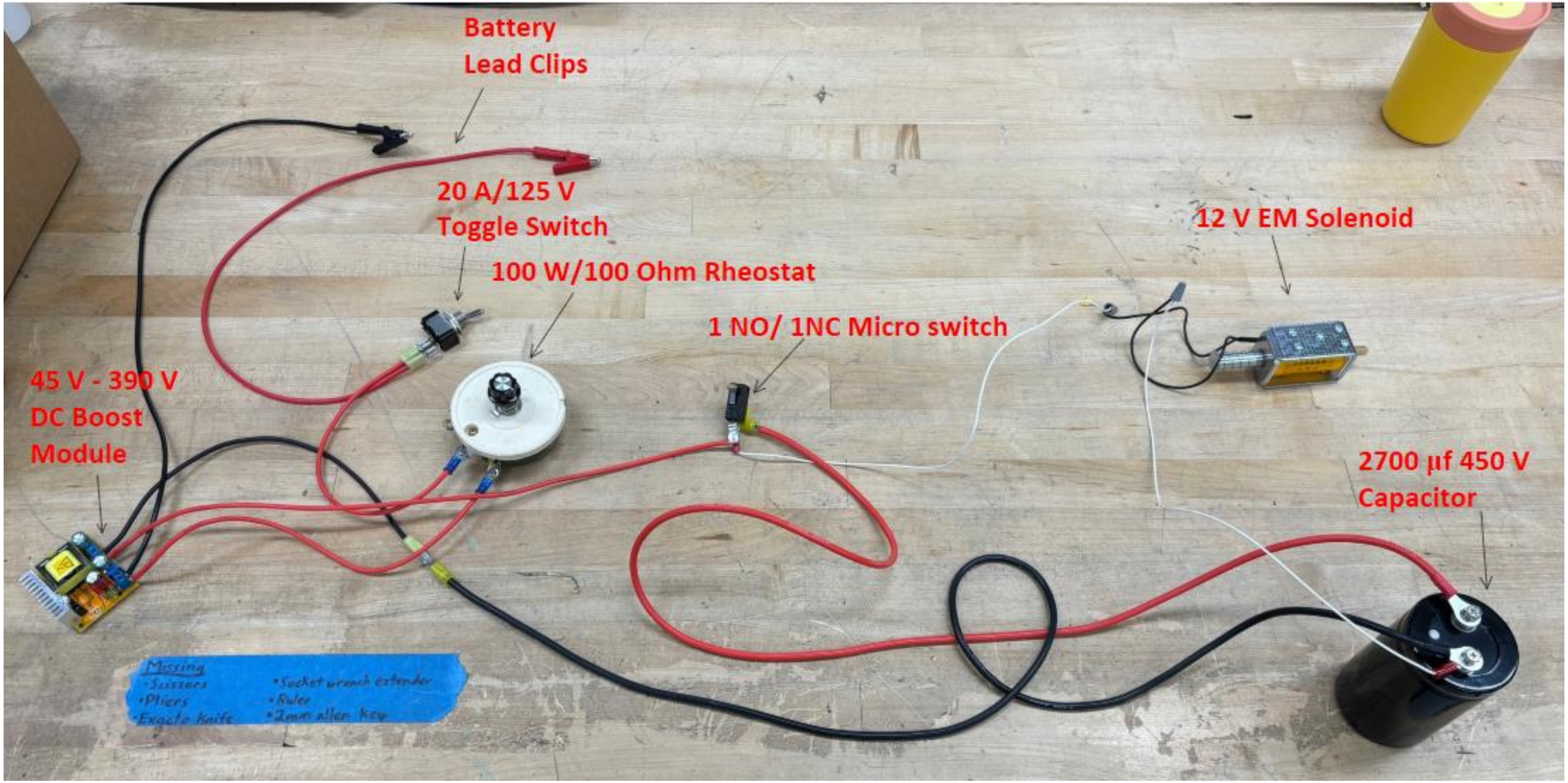
Incident/Transmission Roller Cage

Roller Cage Assembly Subsystems: Exploded View

- **Key Design Aspects**
  - **Ensuring Alignment**
    - Self-Aligning Roller Carriage
  - **Balancing Wave Propagation and Clamping**
    - Roller Set-Screw Clamping mechanism
    - Narrow fit side clamping
  - **Minimizing Friction**
    - Anti-abrasion rollers
    - Finished aluminum interior



Solenoid Launcher Circuitry



Main Factors in Cost Analysis

- **Millipede Bar**
  - Striker Millipede Bar
  - Incident Millipede Bar
  - Transmission Millipede Bar
- **Housing**
  - Alignment Rail
- **Millipede Support**
  - Roller Carriages
  - Guide Rails
- **Launcher**
  - Capacitor
  - Batteries

Full Cost Breakdown

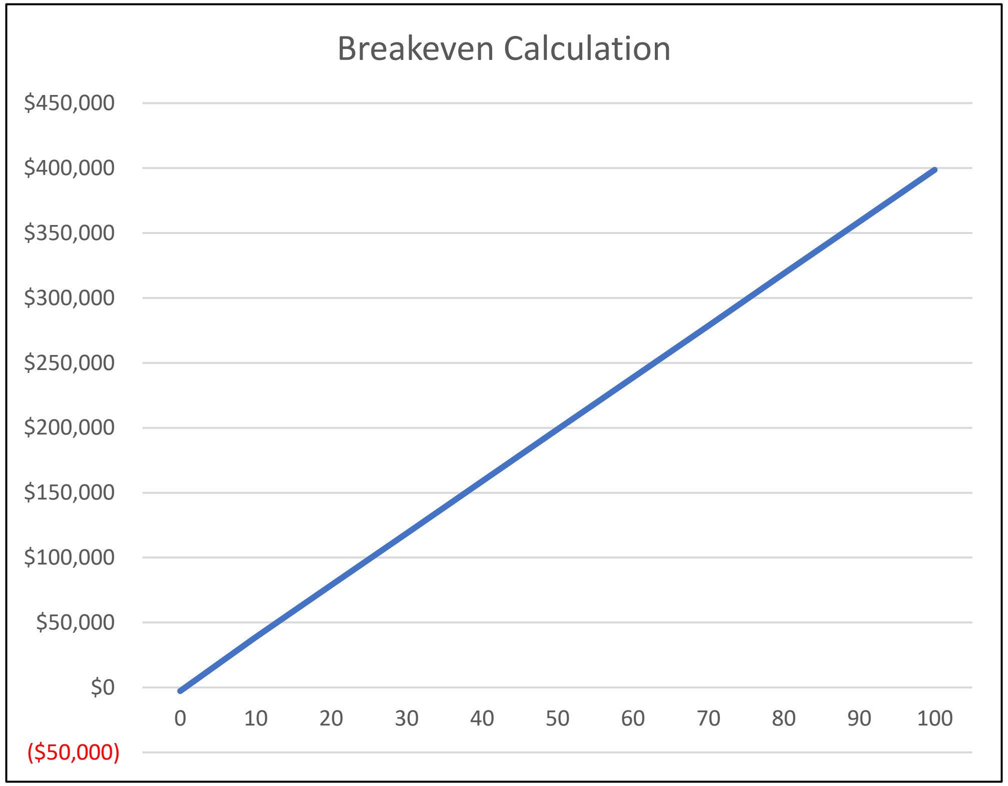
- **Costs**
  - **Millipede Bars: ~$700**
  - **Millipede Support: ~$1,100**
  - **Launcher: ~$250**
  - **Housing: ~$250**
  - **Labor: ~450$**
  - **TOTAL: ~$2,750**

Cost Analysis

- Majority of our cost comes from OTS parts : **~$2,000**
  - Striker Millipede Bar: **~$240**
  - Transmission/Incident Millipede Bar: **~$225 x2**
  - Side-Mount Track Roller Carriage: **~$100 x6**
  - Fixed Alignment Rail: **~$64 x2**

Cost Analysis

- Price of Unit: **$4,000**
  - 150% Profit Margin
  - Typical Split Hopkinson Pressure Bar ~$50,000-$200,000
  - Estimated 50% Reduction of cost with manufacturing development



Design Constraints

- Timeline
  - 15-week semester
  - Loss of time due to natural disasters
  - Pace of the design course
- Millipede bar manufacturing difficulty
  - Expensive
  - Had to be made Internationally
- In-house manufacturing delays
  - Project build-up

Future Improvements

Improved Design for Manufacturing: Reduction of Components

Improve Millipede Bar Motion: Brass Inserts between Bars and Clamp wall

Improve Modularity for Variable Millipede Bar Shapes

Improve Solenoid Precision and Max Obtainable Velocity

Improve Alignment: Positioning sensors and redesign for simultaneous clamp movement

Improve the Clamping Mechanism: Have the bars raise with the turn of the screw

Future Steps

- **Funding** to continue project research and development
- **Move our product** to the market
- Reach our goal of **filling the market gap** for affordable, small footprint, and easy to use impact testing equipment

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