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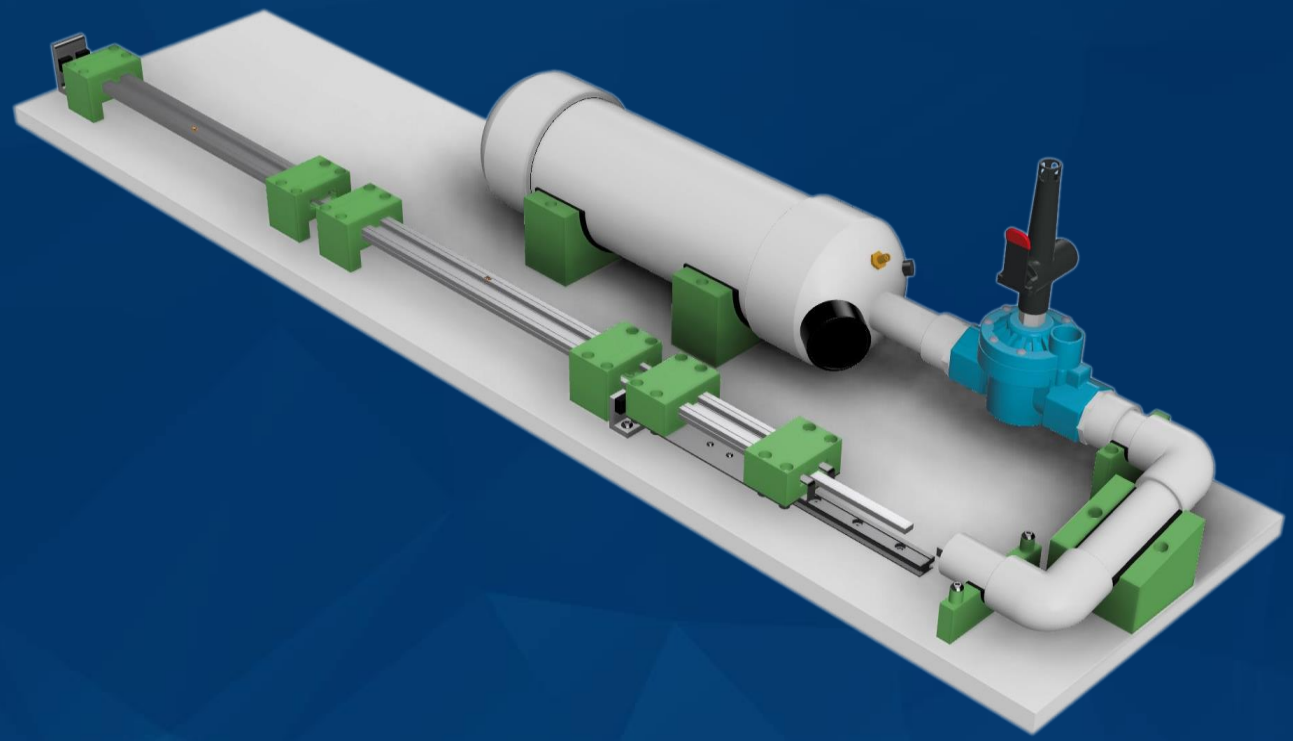
TWO TRAX™



Project MB

Two Trax™ - Millipede Group 1
December 04, 2024

Jonathan Acosta, Aaron Gettig, Karis Linnet, Donald Luchetti, Reece Navarro, Sean Ng, Connor Rodriguez, Cody Sackles, and David Woods

Agenda

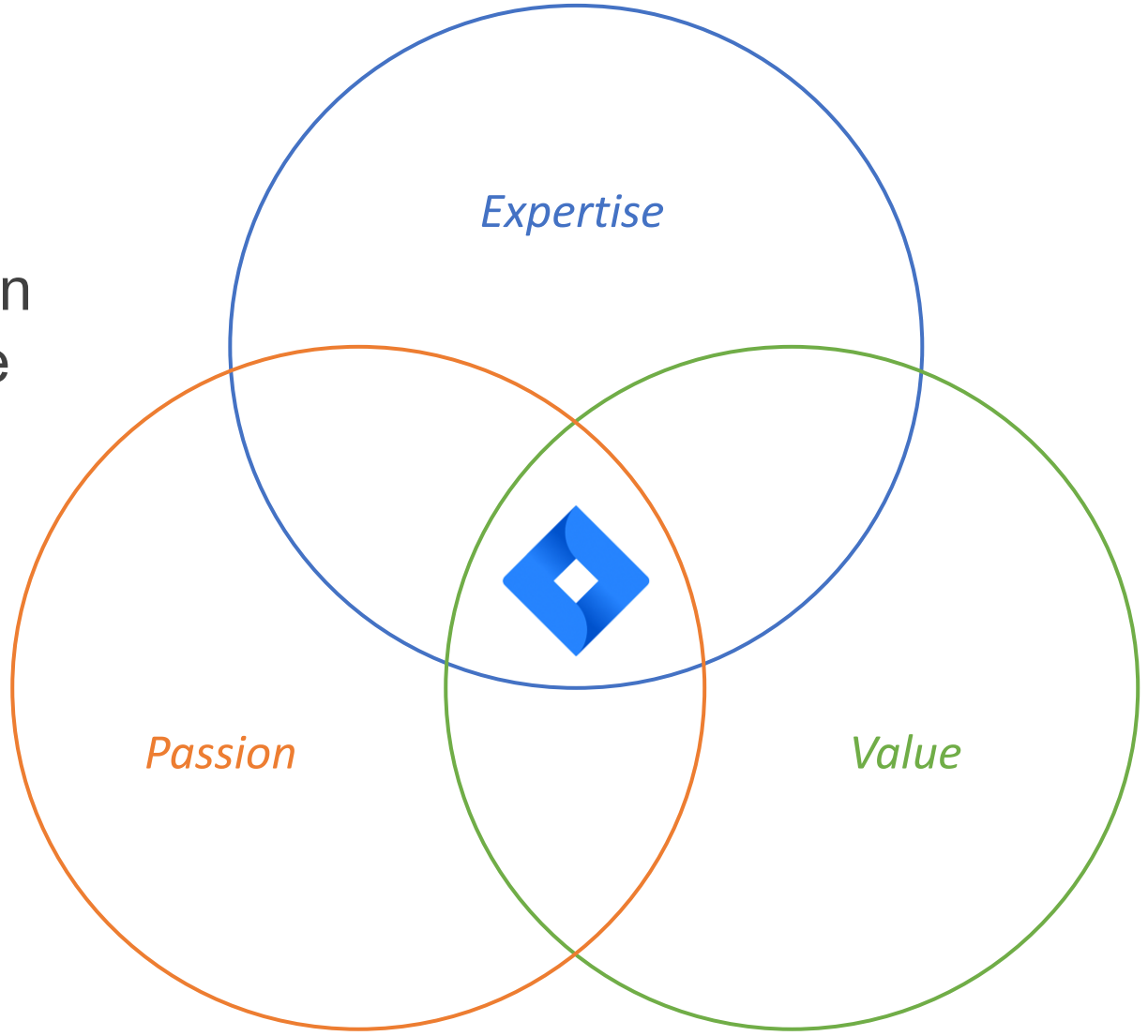
- Background & Hedgehog Concept
- Key Product Specifications
- Performance Evaluations
- Design Highlights & Key Features
- Design Evolution
- Costing
- Summary & Conclusion

TWO TRAX™

Hedgehog Concept

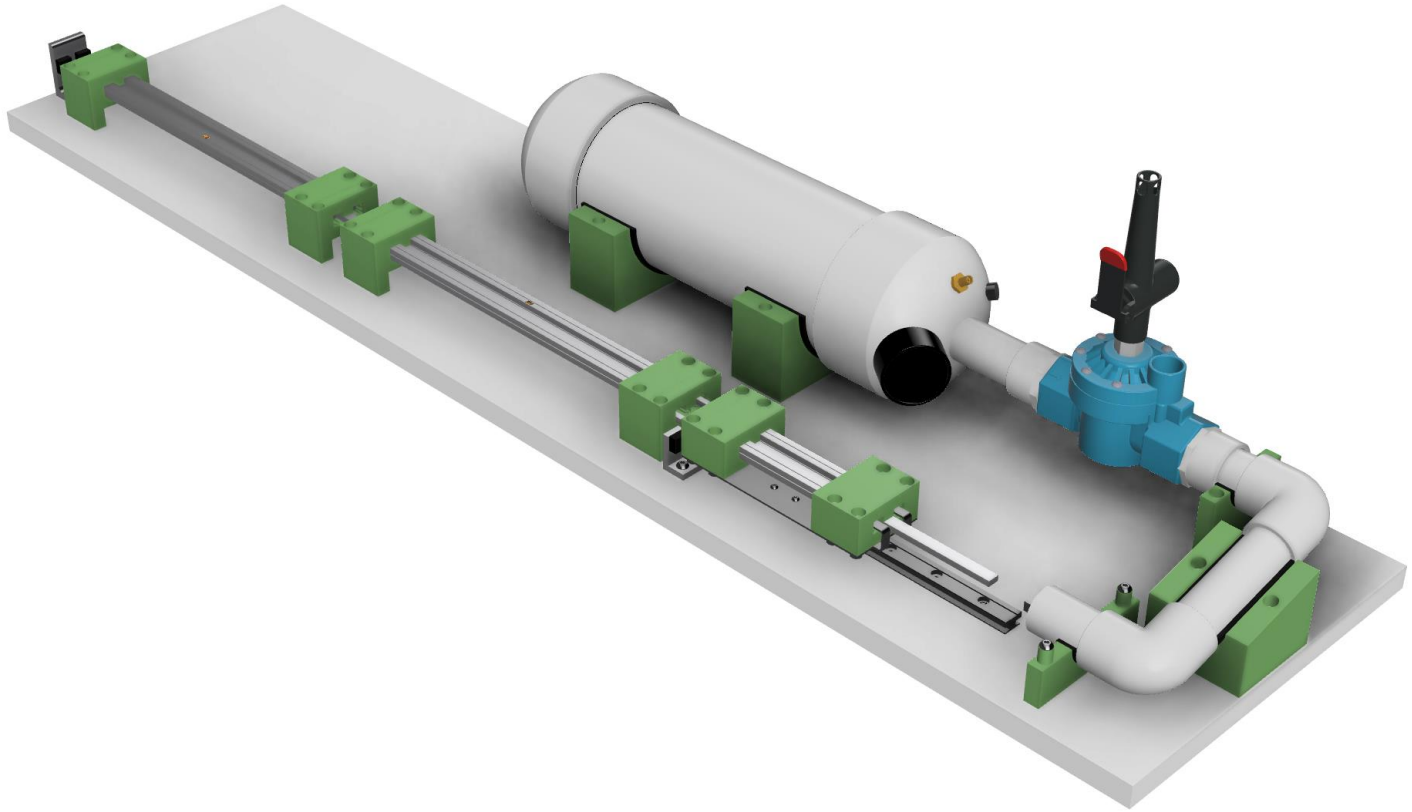
Two Trax™

- We lead the world in manufacturing small-scale serpentine Split-Hopkinson Pressure Bars (SPHB's) to interrogate intermediate strain rates using a fraction of the space and budget.
  - *Passion*
  - *Expertise*
  - *Value*



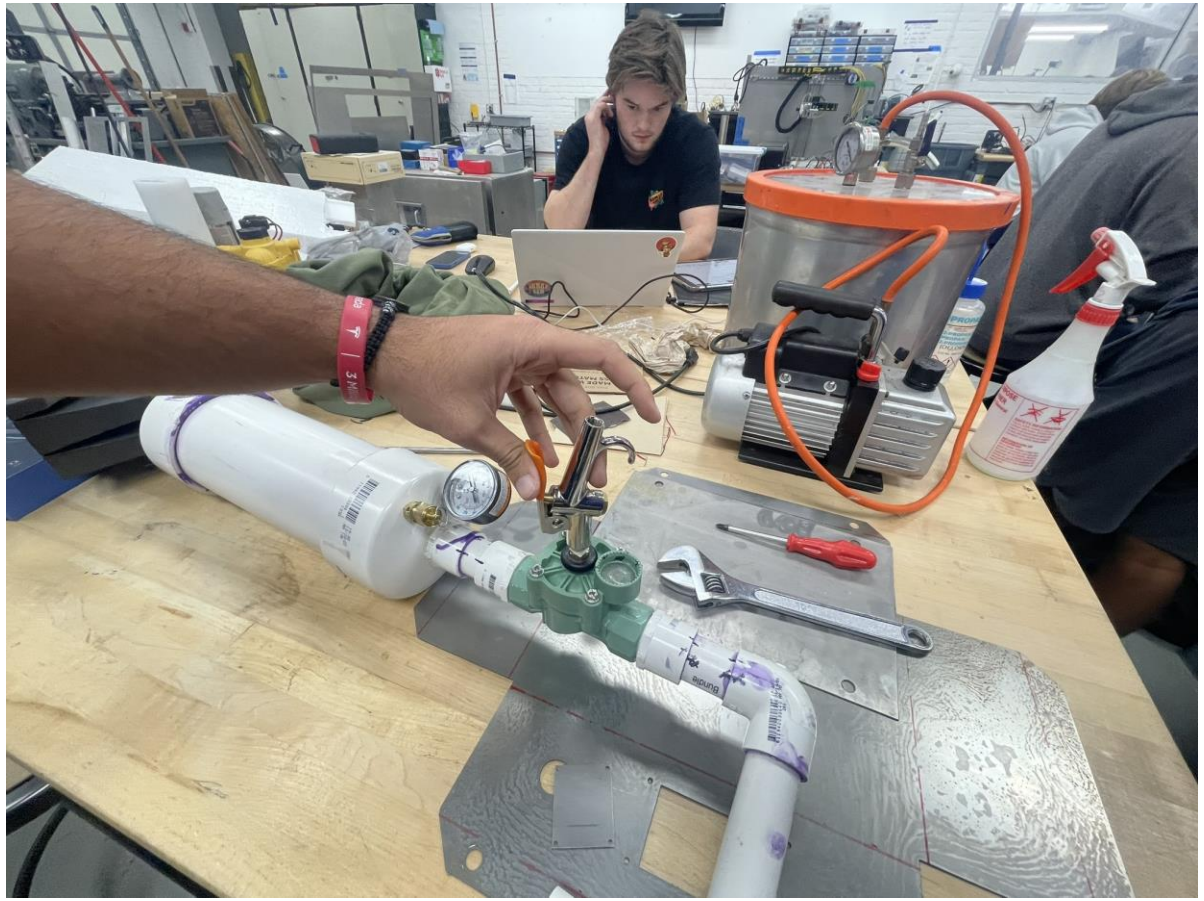
Key Product Specifications

- Footprint:
  - 48 in × 12 in × 10.5in
- Pressure:
  - Max. 150 psi
- Velocity
  - Max. 13.7 m/s
- Tank Volume
  - 163 in^3



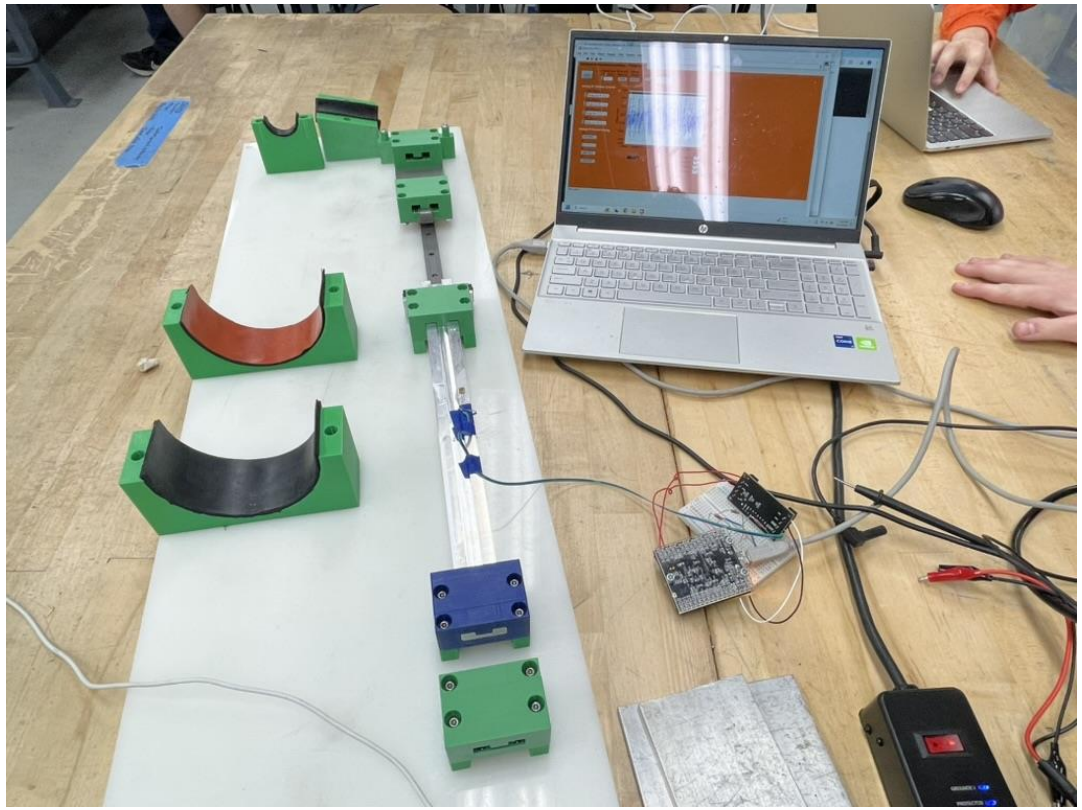
Performance Evaluation 1 (Modified)

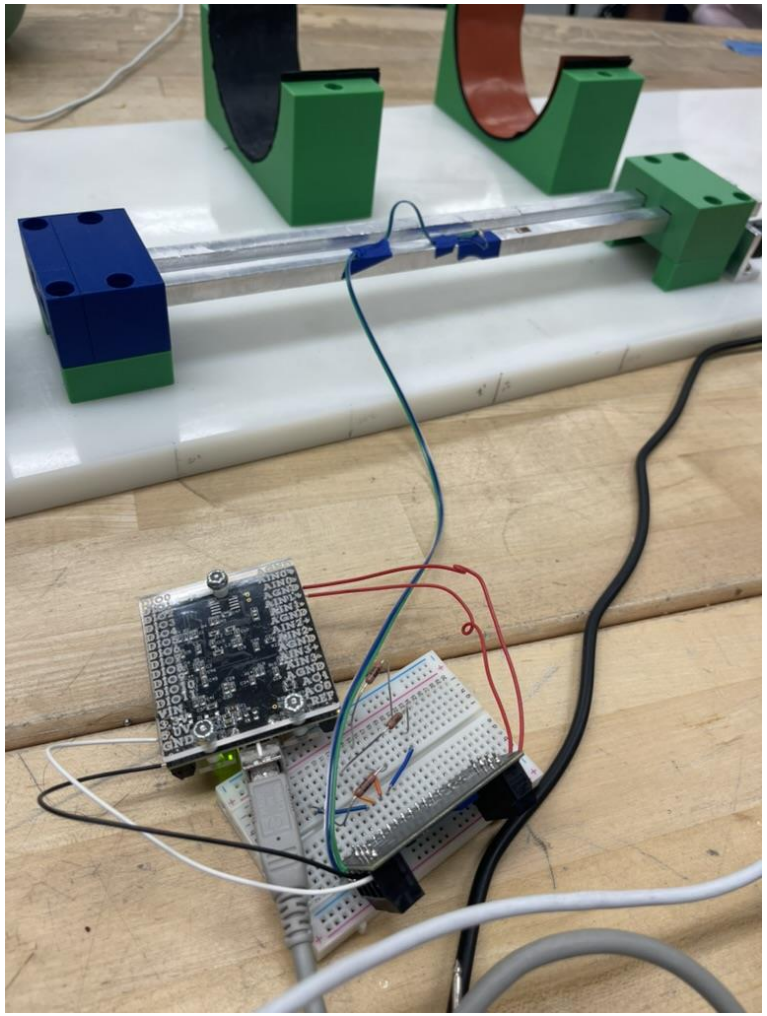
- Tank Pressure Test



Performance Evaluation 2 (Modified)

- Strain gauge testing





Final Performance Evaluation

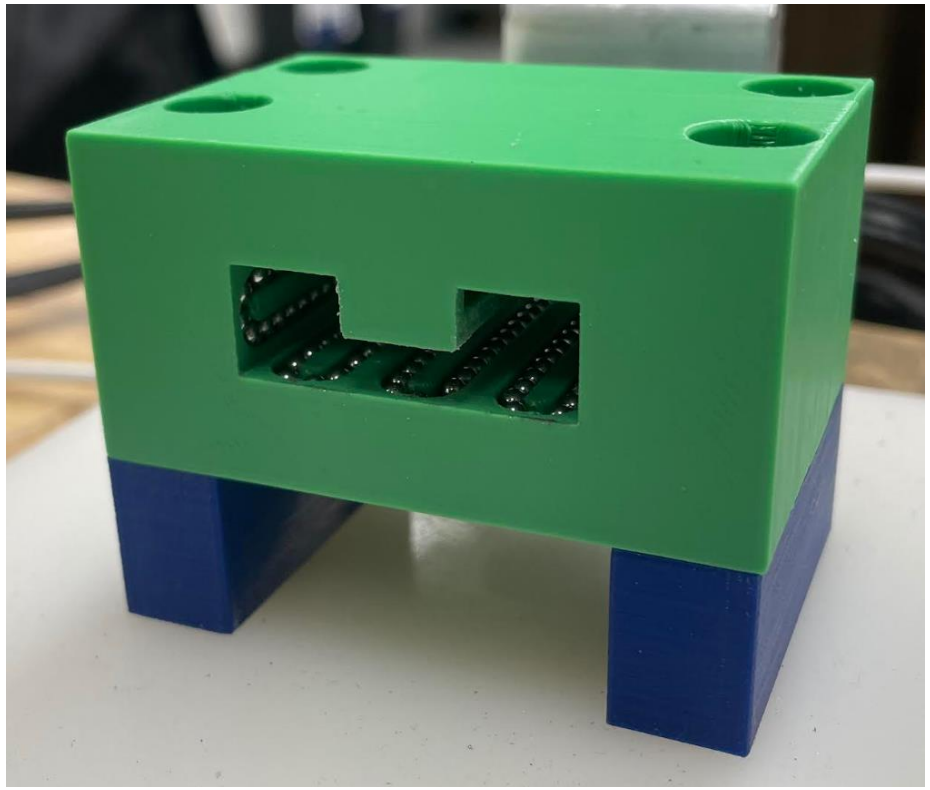
- What we can test right now:
  - 6.1 Aesthetics, Finish: **2**
  - 6.2 Aesthetics, Components: **3**
  - 6.3 Aesthetics, Wiring: **1**
  - 17.1 Launcher Anchoring, Drag Test: **3**
  - 19* Wave Propogation: **1***
  - 20 SG Adhesion Fidelity: **3**
  - 22* Smooth Bar Motion: **1***
  - 26 Safety: **2**

Final Performance Evaluation

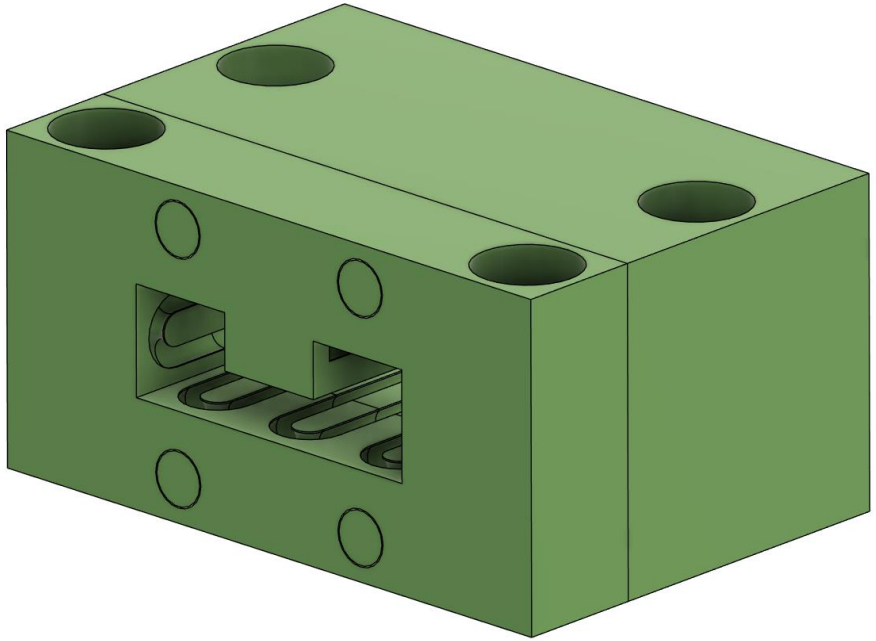
- What we cannot test right now:
  - 10.1 Impacting Surface Finish
  - 10.2 Non-Impacting Surface Finish
  - 16.1 Striker Velocity Adjustability: **Expected 3**
  - 16.2 Striker Velocity Range: **Expected 3**
  - 17.2 Launcher Anchoring, Operational Test: **Expected 3**
  - 19 Pulse Shape Propagation
  - 22 Smooth Bar Motion
  - 27 Speed of Use **Expected 3**
  - 28 Connectivity

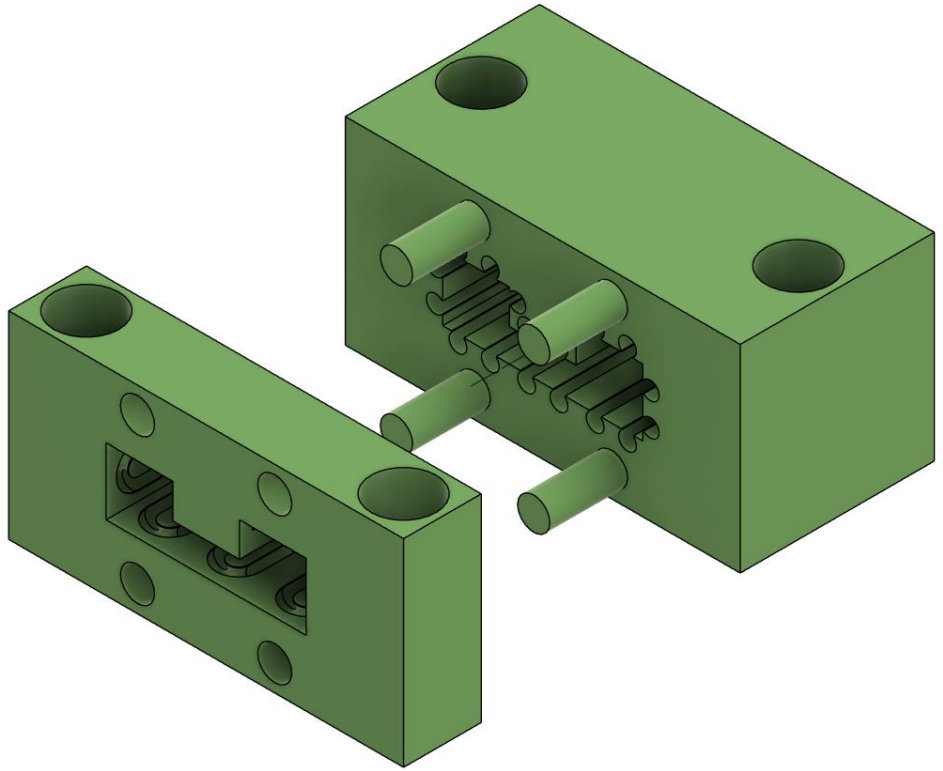
Design Highlights– Boundary Conditions

- 3D Printed (PETG) Base
- 2.5 mm Stainless Steel Ball Bearings
- Six in total
- Pockets within casing hold ball bearings in place
- 360-degree encasement of millipede bars using 10 bearing tracks
- Prevent unnecessary lateral & vertical motion
- Allow for millipede bars to slide translationally to initiate contact with next bar



Design Highlights– Boundary Conditions





Key Features – Rail System

- 16 Gauge Steel Sheet Metal Mounting Plate
- Zinc Sleeve Bearing Carriage
- Aluminum Guide Rail
- Allows for Striker Bar to make smooth contact with incident bar.
- Load Capacity: 310 lbs
- Assumed no friction
- Rail Velocity Calculations:

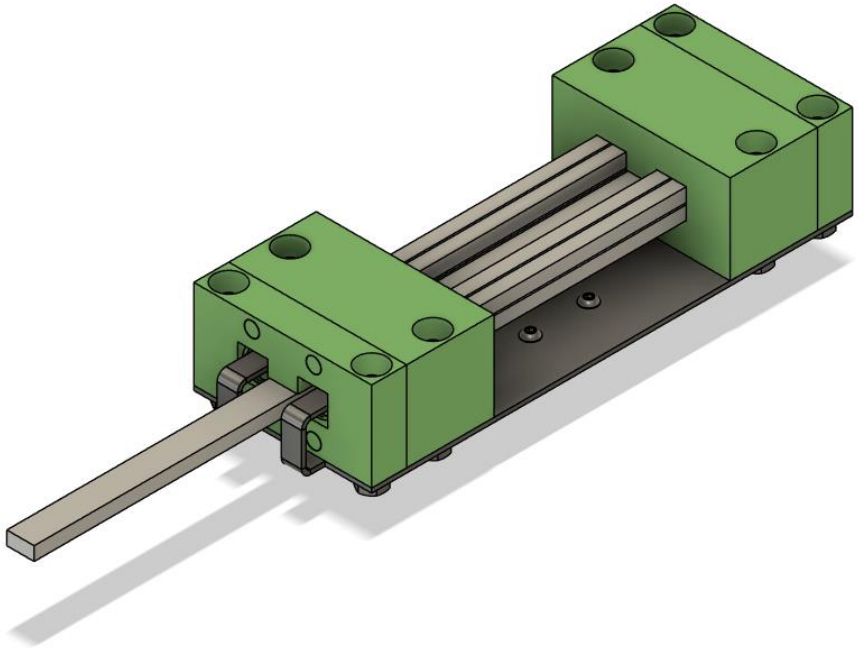
$$a = \frac{F}{m} = \frac{444.7\ N}{0.426\ kg} = 1043.92\ \frac{m}{s^2}$$

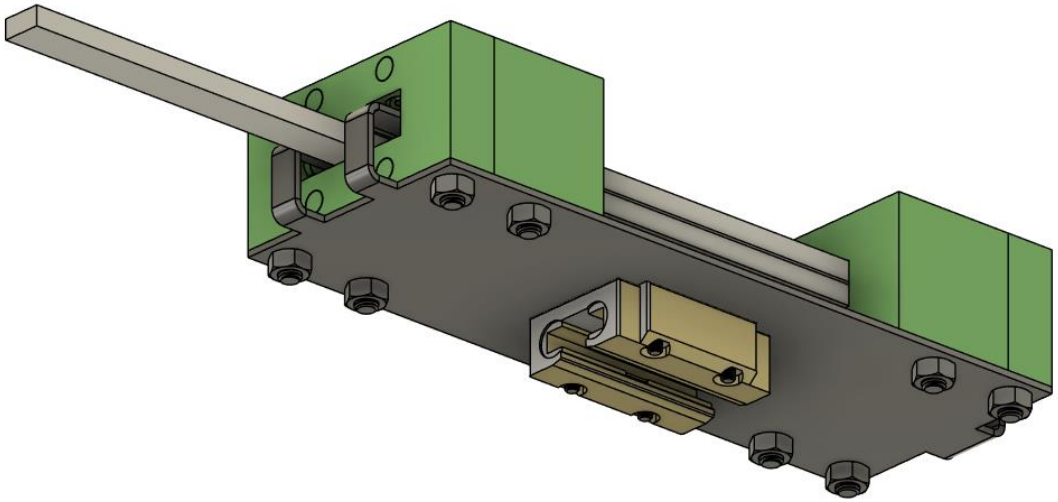
$$t = \sqrt{\frac{2l}{a}} = \sqrt{\frac{2 * 0.09\ \cancel{m}}{1043.92\ \frac{\cancel{m}}{\cancel{s^2}}}} = 0.0131\ s$$

$$v = a * t = 1043.92\ \frac{m}{\cancel{s^2}} * 0.0131\ s = 13.7\ \frac{m}{s}$$

*Customer Requires $10\ \frac{m}{s}$

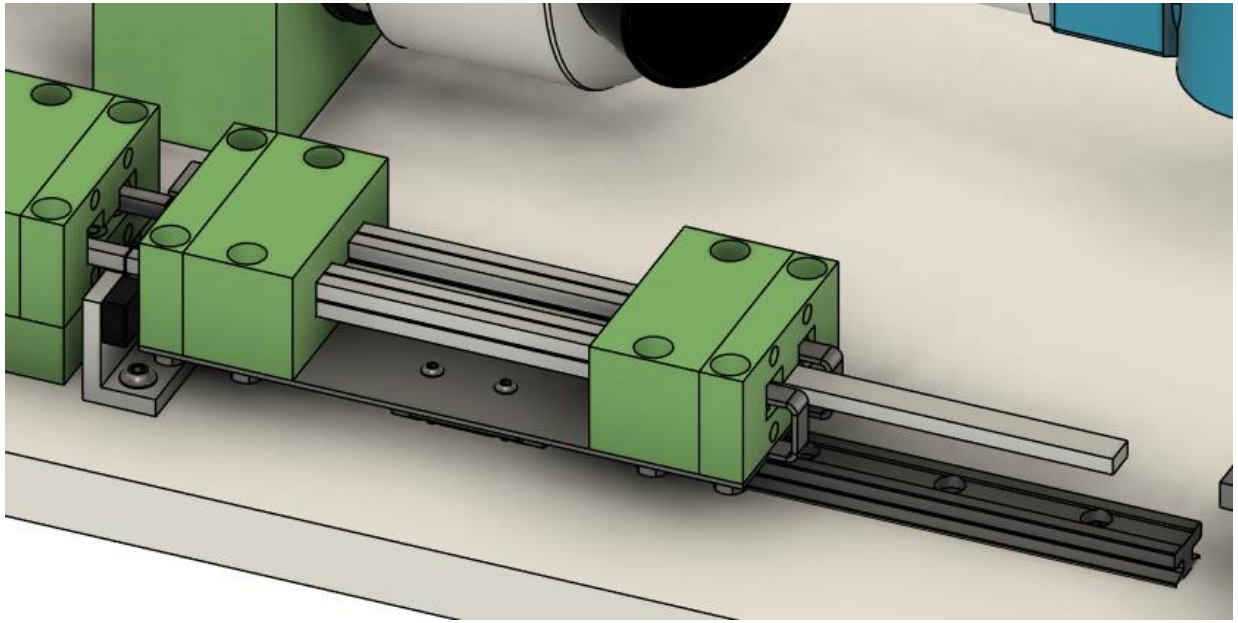
Key Features – Rail System

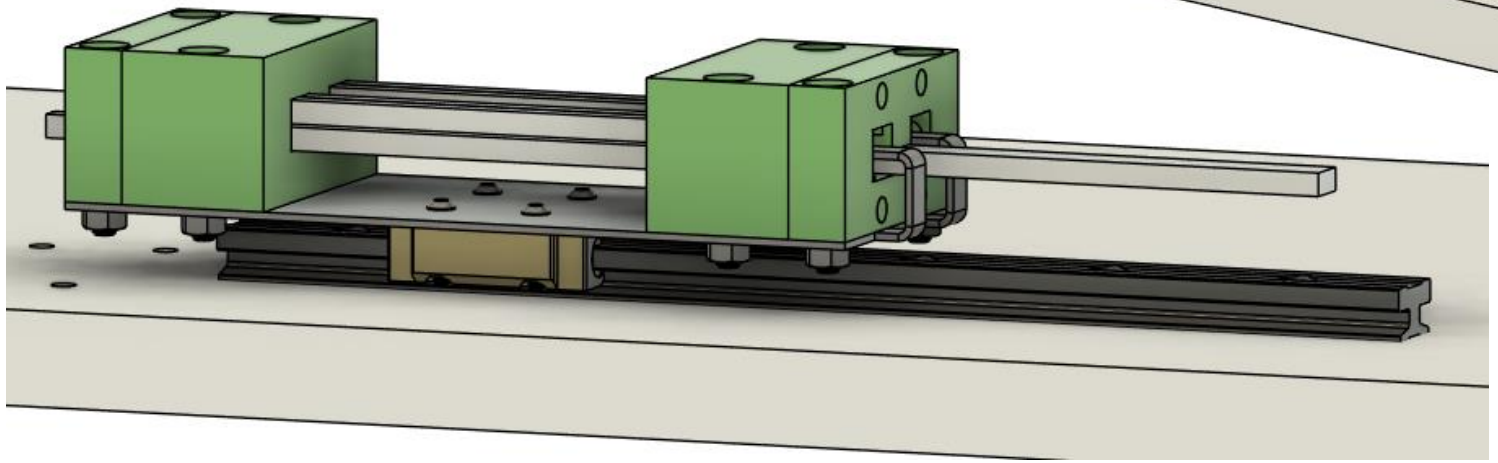




Striker Bar, Mounting Plate, &
Carriage

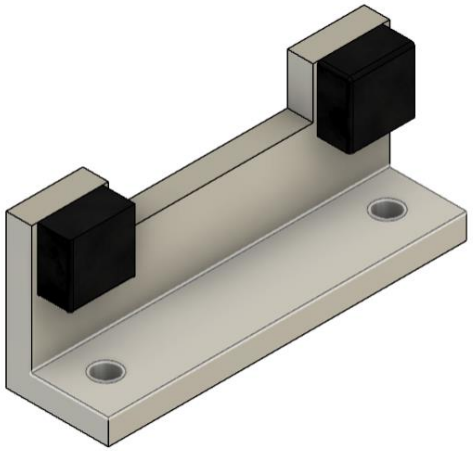
Key Features – Rail System



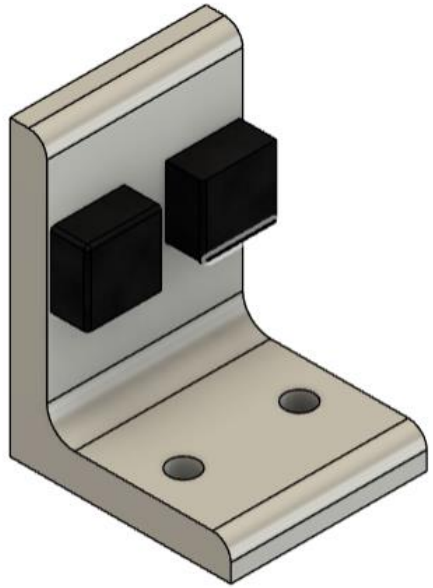


Key Features - Stoppers

- Stoppers for carriage and transmission bar
- Rubber stock cut and glued to stopper bases



Carriage Stopper



Transmission Bar Stopper

Key Features – Cannon

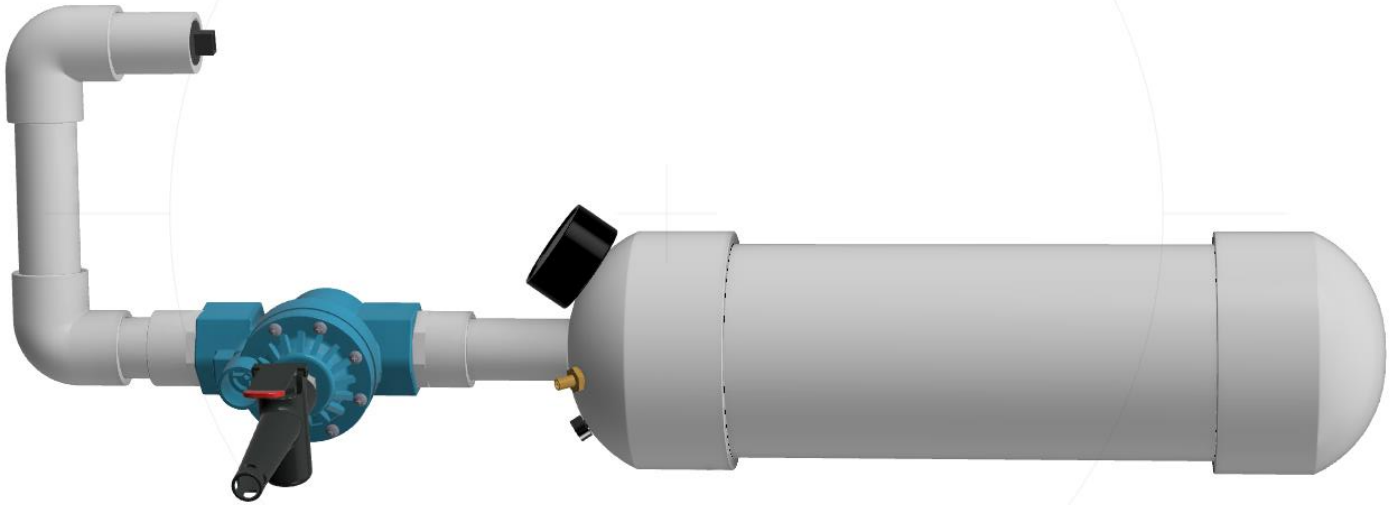
- PVC Pressure Vessel Gas Gun
- Sprinkler valve & air nozzle trigger
- Factor of Safety (FOS) Calculations
  - 100 psi required pressure
  - Vessel radius: 2.55 in
  - Wall thickness: 0.266 in

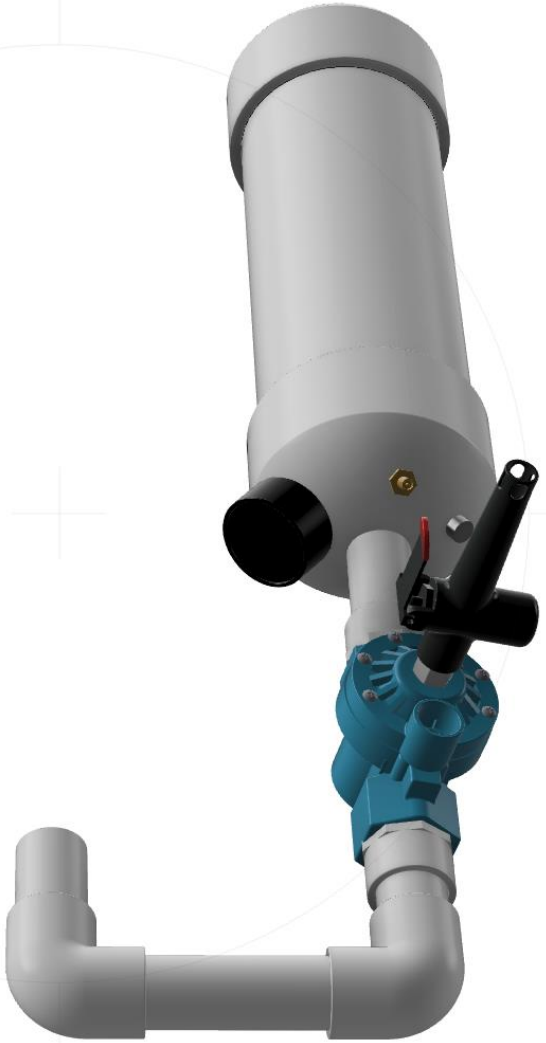
$$f_{hoop} = \frac{Pr}{t} = \frac{(100\ PSI)(2.55\ in)}{(0.266\ in)} = 958\ psi$$

  - PVC yield stress: 8000 psi

$$FOS = \frac{Yield}{Required} - 1 = \frac{8000\ psi}{958\ psi} - 1 = 7.4$$

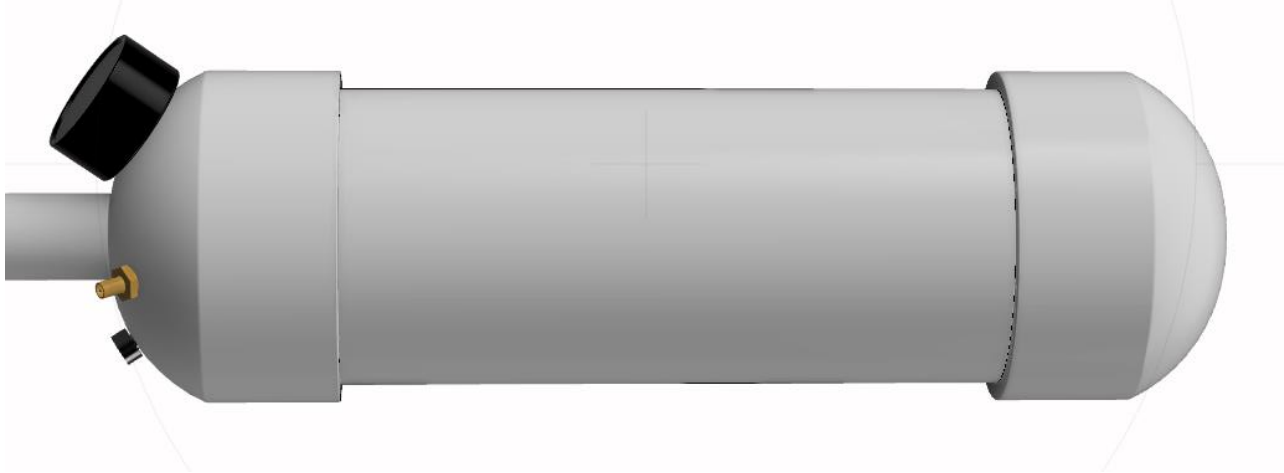
Key Features – Cannon





Key Features – Cannon

- Pressure Vessel

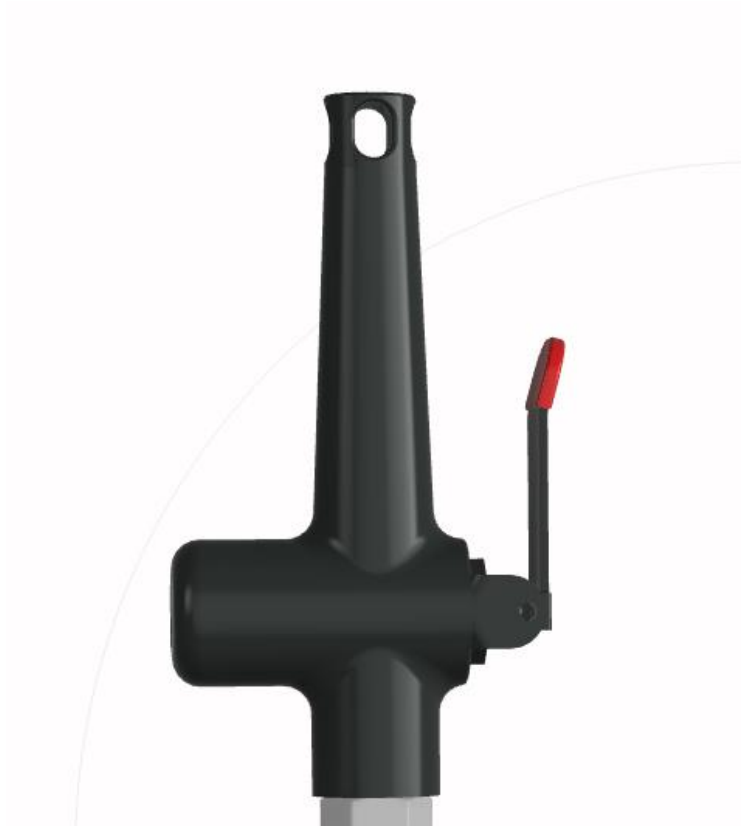


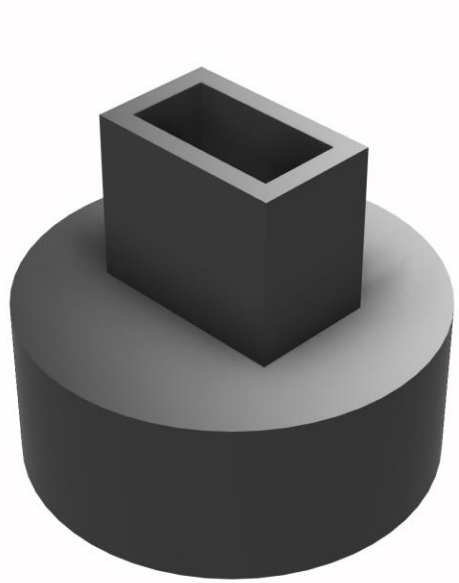
Key Features – Cannon

- Relief valve / Schrader Valve / pressure gauge

Key Features – Cannon

- Trigger system/ Cannon Nozzle

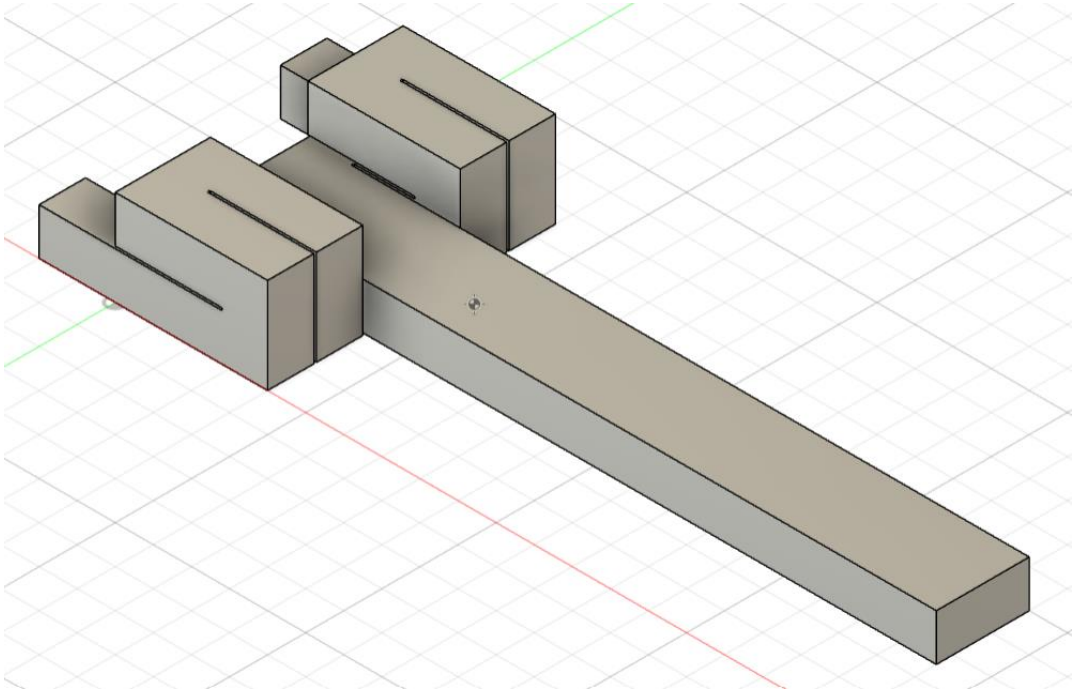


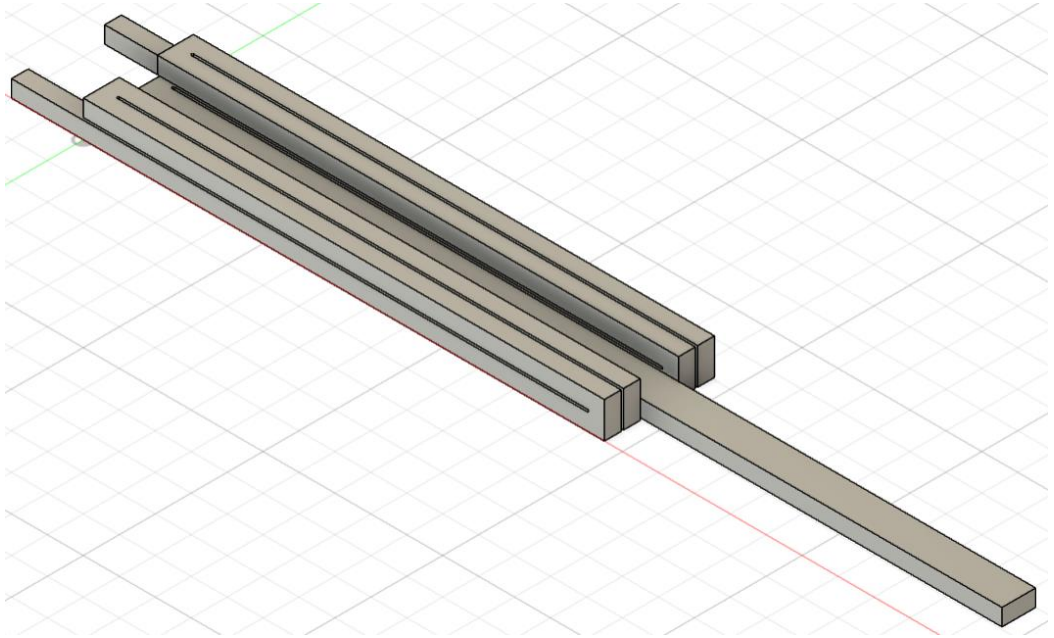


Design Evolution – Millipede Bars

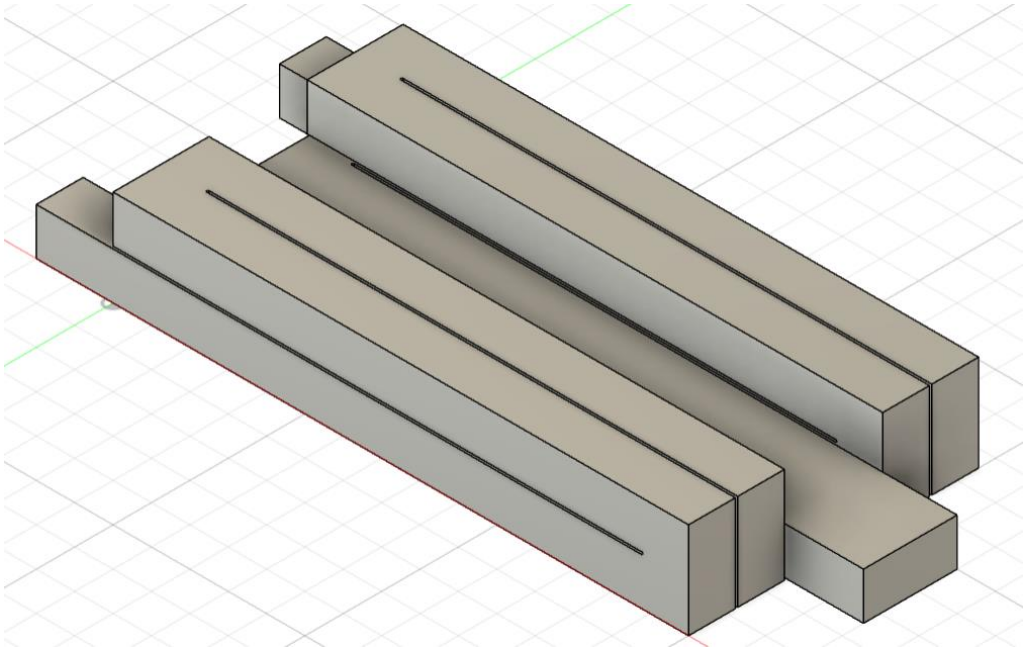
- Bars were redesigned to increase time ratio, T^*:
  - Increased overall length
  - Decreased cut width
- $T^*_{new,\,striker} = 31.0$
- $T^*_{new,\,transmission/incident} = 71.5$

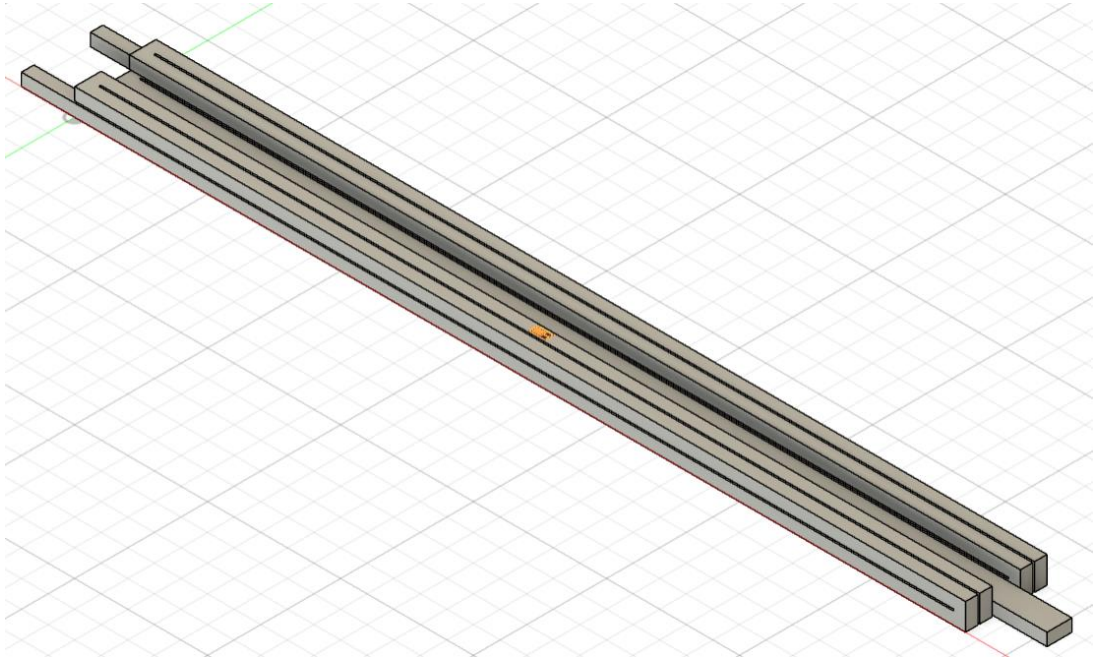
Design Evolution – Millipede Bars (Striker)





Design Evolution – Millipede Bars (Transmission/Incident)

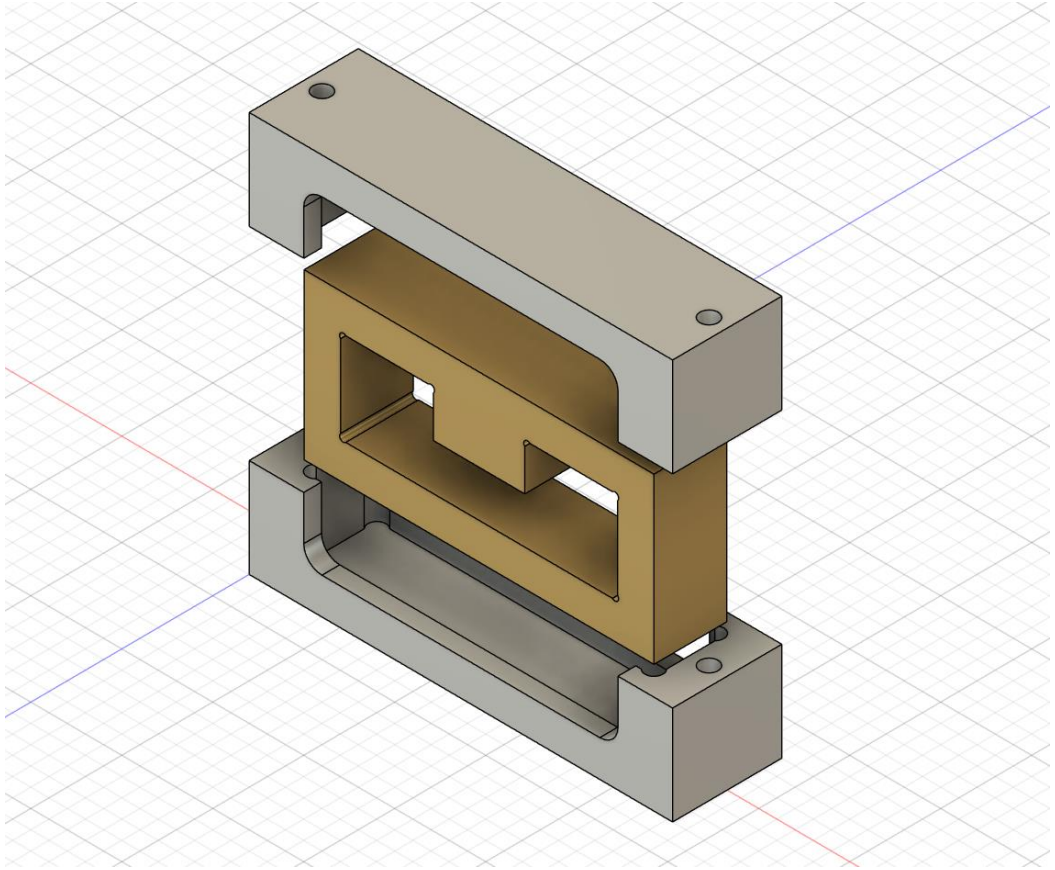




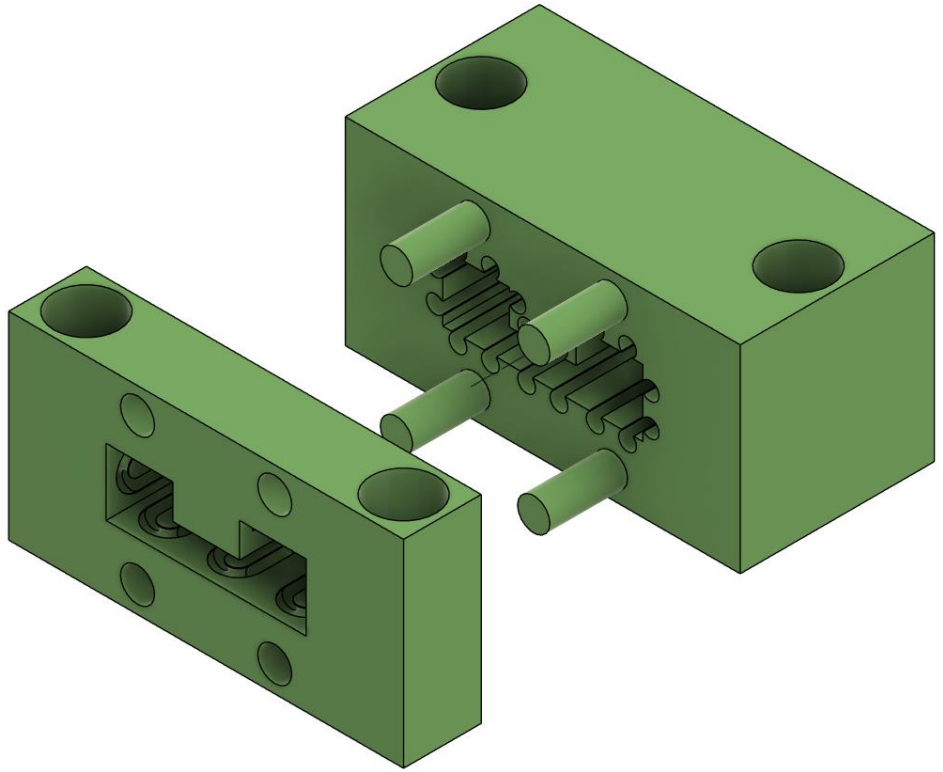
Design Evolution – Boundary Conditions

- Our original boundary condition designed consisted of a solid brass bushing that was held in place by a 3D printed housing. This housing would have been able to open up to replace the brass bushings in order to perform maintenance.
  - This boundary condition system was abandoned because in order to achieve the tolerances required to restrict all unwanted motion, the friction between the bar and the bushings would have restricted axial motion and introduced losses into the data.
- The new boundary condition system we implemented involved ball bearing tracks that would allow the bars to move freely while only having a low contact surface area, reducing friction.

Design Evolution – Boundary Conditions



Old



New

Cost Table Summary

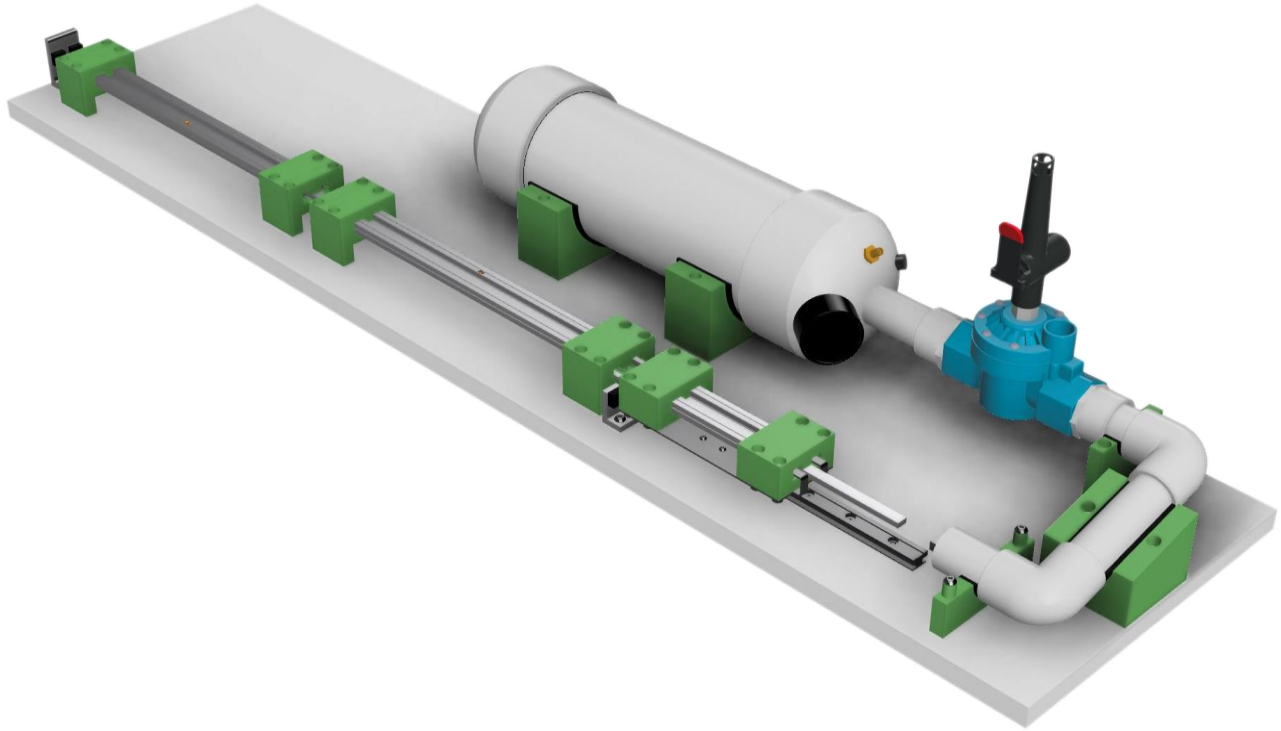
- *Cost to build one prototype:* ***408.47$***
  - **Student Assistant manufacturer labor:**
    - Based on price of total operations performed: 46.84$
    - *This price total is a fairly conservative estimate, with the actual price of outside labor more likely being higher than this value.*
  - *Our labor:*
    - Based on all operations performed by team members: 58.79$
  - **Material price total:**
    - Total price to buy required units of all materials: 552.14$
    - Price of materials needed for one prototype unit: 302.84$
- *Cost for a production-scale run of units*
  - *Based on the price of one prototype, including all labor and material costs, a large scale run of producing 100 units would cost 40,847$.*
    - *This cost would likely be reduced by buying materials in bulk and refining manufacturing processes over time.*

Summary

- Performance Evaluations
  - Tank succeeded in holding air with no observable leaks and firing
  - Strain gauges are capable of measuring strain
- Key Features
  - Boundary conditions that restrict any unwanted bar rotation
  - Rail system launching velocity of 13.7 m/s
  - Millipede bar geometry that sufficiently allows wave propagation
  - Cannon tank factor of safety of 7.4
  - Production cost of prototype- 408.47$
    - Cost of large scale run of 100 units- 40,847$

Conclusion

- Project MB
  - A small-scale serpentine Split-Hopkinson Pressure Bar (SPHB) used to test intermediate strain rates from 10^{-1}/s to 10^{2}/s using a fraction of the space and budget



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