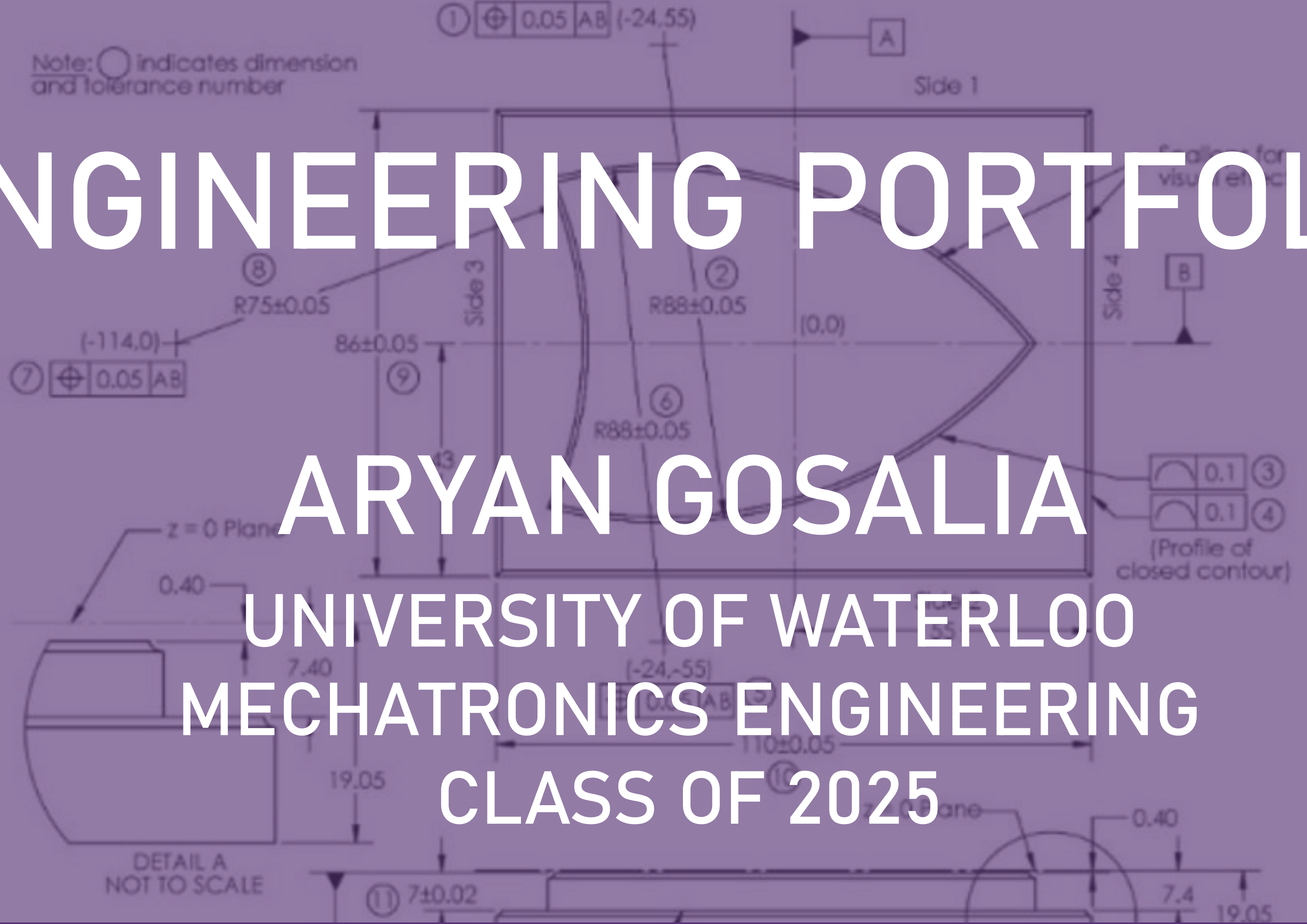

ENGINEERING PORTFOLIO

ARYAN GOSALIA

UNIVERSITY OF WATERLOO
MECHATRONICS ENGINEERING
CLASS OF 2025

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WORK PROJECT (ELECTRANS TECHNOLOGIES LTD.)

SHEET METAL COVER

Project Description:

Design a strong, lightweight metal cover to protect the unit underneath during operation. The cover must:

- Support the weight of 2 adult technicians
- Visually cover as much of the unit internals possible
- Weigh <5lbs total
- Attach to the unit with minimal modifications required
- Be easily assembled in-house, low volume production

WORK PROJECT (ELECTRANS TECHNOLOGIES LTD.)

SHEET METAL COVER

Solution Methods:

- SolidWorks CAD for sheet metal design, using DFMA principles such as bend reliefs and appropriate bend radii for sheet gauge
- 2-piece design to maximize strength to weight
  - 5052 Al top cover bonded to 304 SS subframe via a Polyurethane elastic adhesive
- Optimized design using SolidWorks FEA, including topology optimization to minimize subframe weight
- Attached to unit via 6 easily accessible screws
- Designed stainless steel subframe geometry for laser cutting, keeping Heat Affected Zones away from high stress regions to reduce risk of failure

FEA/CAD Image redacted for confidentiality

Results:

- Design can support 200kg
- Procured and assembled 70+ covers, currently being used in production units
- Cover is 36% lighter than the previous single piece design

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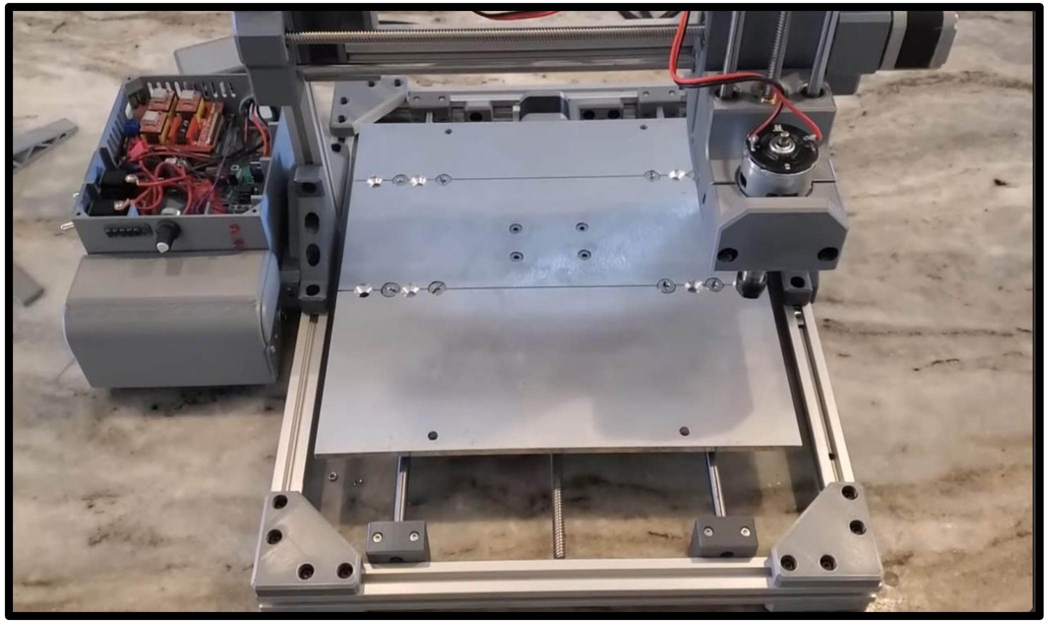
PERSONAL PROJECT

DIY MINI CNC MILL (V1)



Project Description:

Design a benchtop CNC mill for personal use. The CNC mill must:

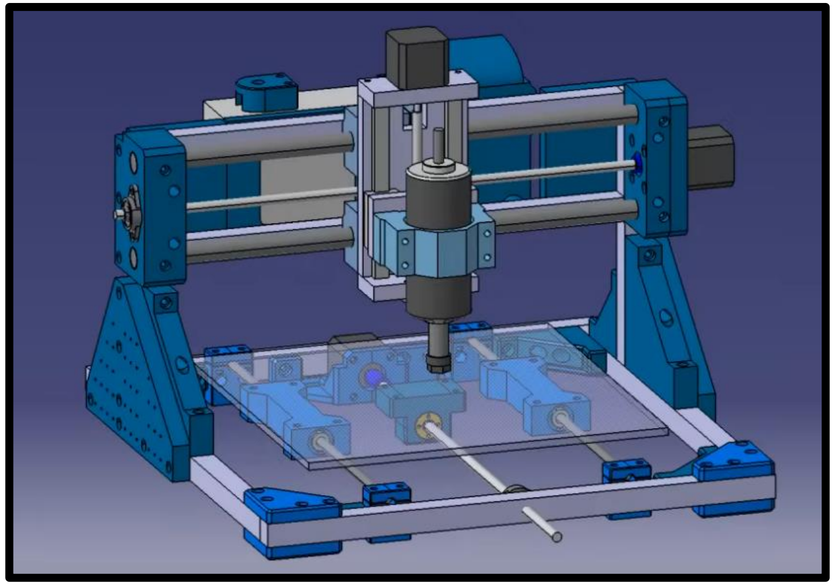
- Be able to translate G-Code to accurate positional movements
- Cut rough profiles from mild steel
- Cost as little as possible
- Require minimal machining
- Have robust electronics (should not be point of failure)

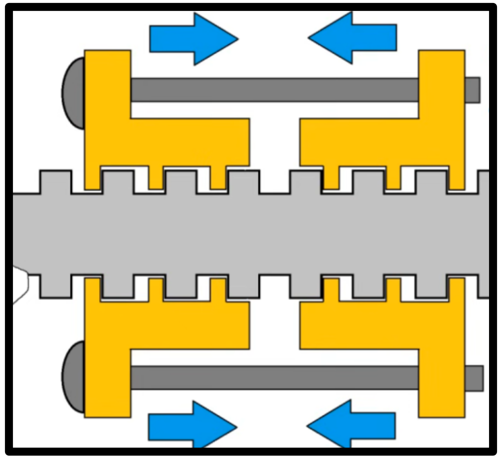
PERSONAL PROJECT

DIY MINI CNC MILL (V1)

Solution Methods (Mechanical):

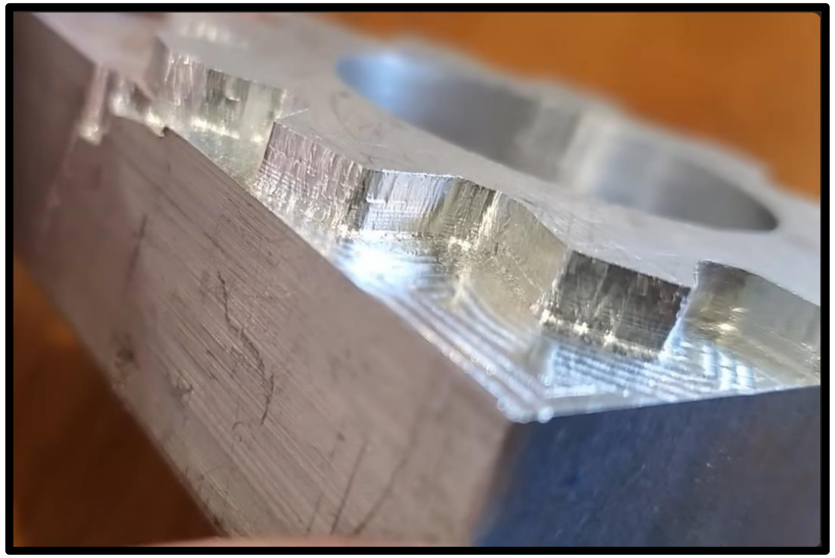
- Designed to be assembled with 3D printed and mass market parts, modifications made with power tools
- Implemented dual lead screw nut system to minimize lead screw backlash





Results:

- Built full system for under $150
- Able to cut aluminum, ok surface quality
- Lots of chatter, needs improvements:
  - Stronger spindle
  - Linear rail > Linear shaft
  - More mass, hollow printed parts filled with concrete
  - Backlash compensation controller

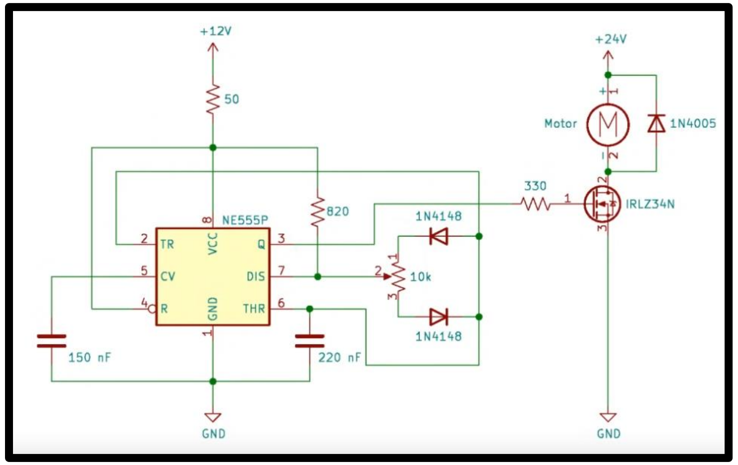


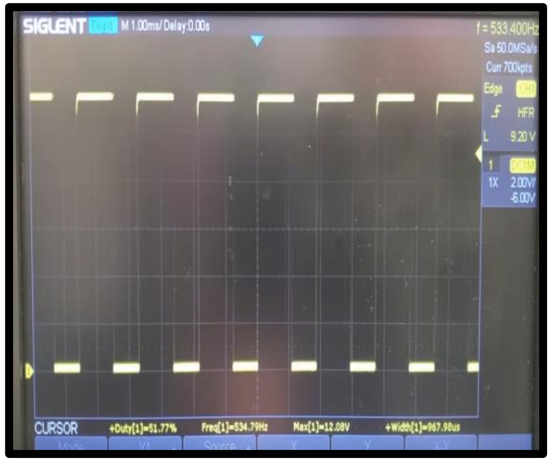
PERSONAL PROJECT

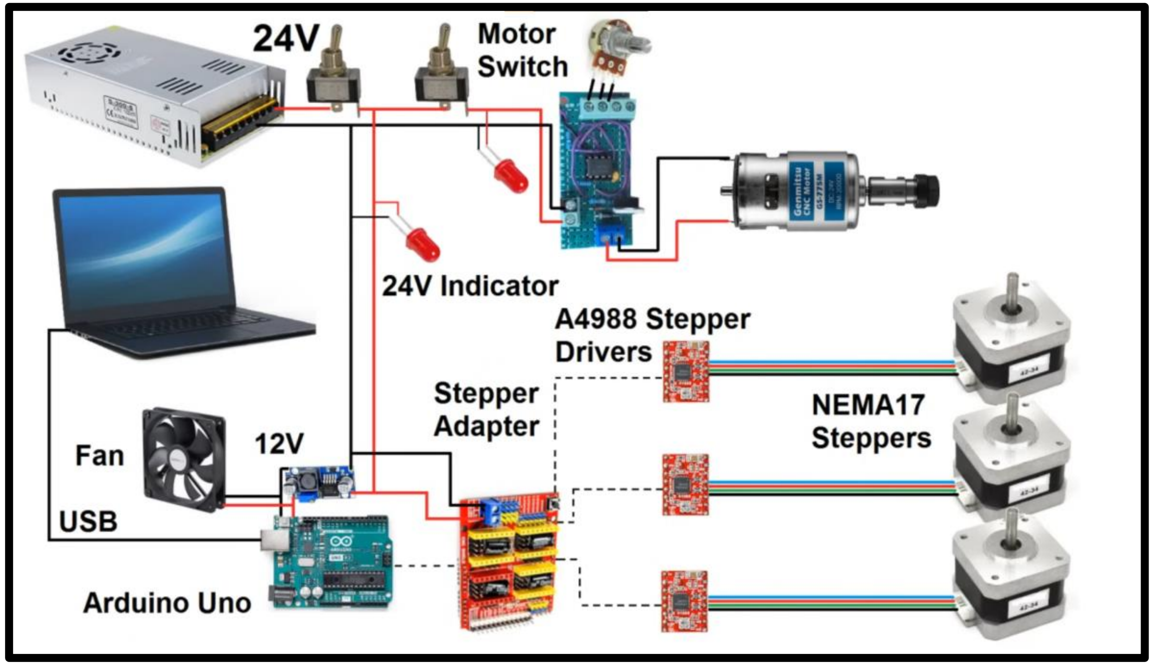
DIY MINI CNC MILL (V1)

Solution Methods (Electrical):

- Arduino Uno running GRBL software
- Custom brushed DC speed controller using 555 timer and MOSFET to control spindle speed, designed with KiCAD
- Tested duty cycle operation with oscilloscope







Results:

- ~7%-99% duty cycle range
- Electronics adequately cooled and protected
- Would like to control spindle speed digitally
- Stepper motors struggle with higher torque requirements

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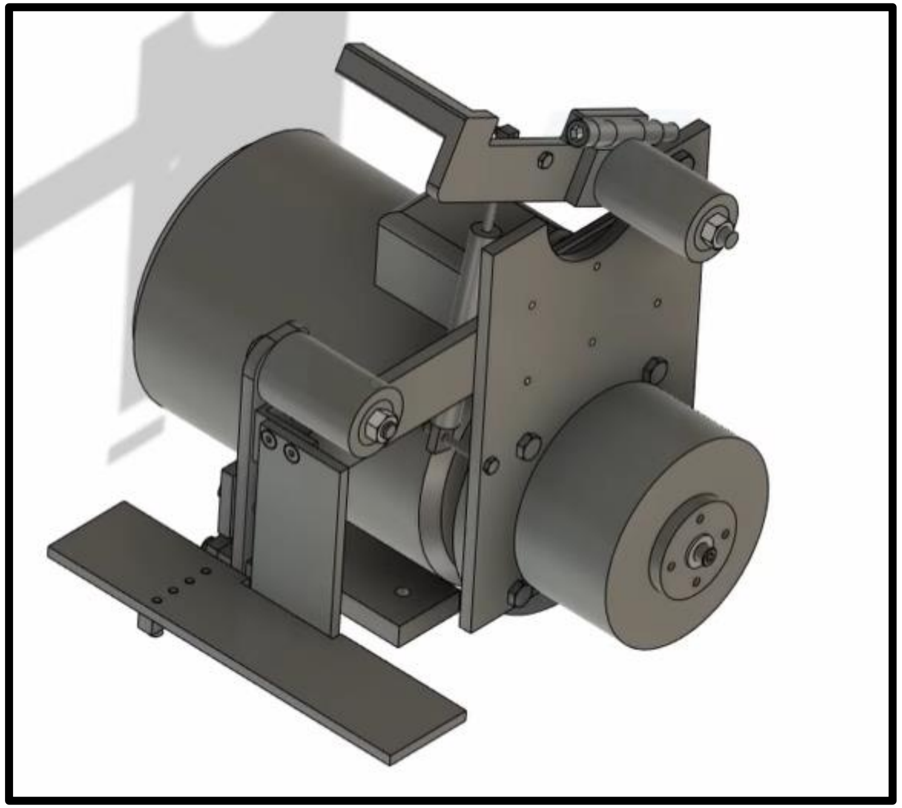
PERSONAL PROJECT
DIY BELT GRINDER



Project Description:

Design a 2x72 belt grinder for personal use. The grinder must:

- Have a flat grinding face
- Hold a 2x72 sanding belt in place during operation
- Allow for easy belt swapping
- Have rough and fine belt tensioning capability
- Maintain a constant rotation speed
- Be cost-effective

PERSONAL PROJECT

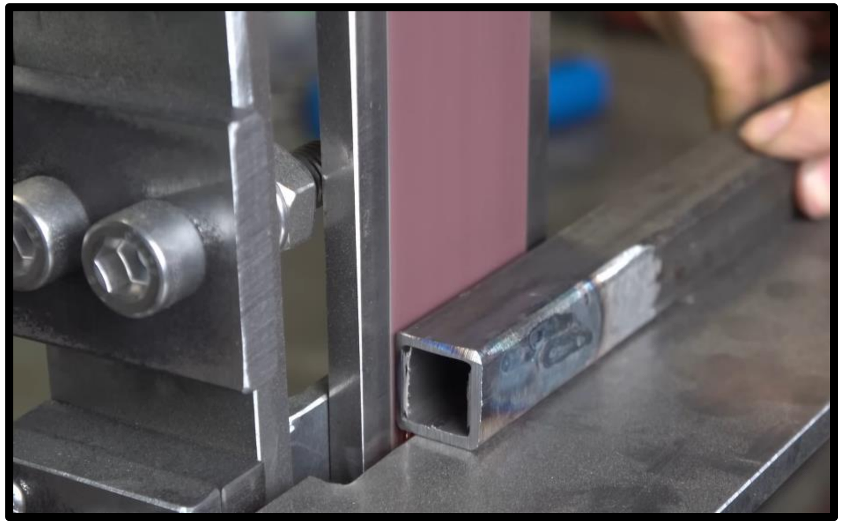
DIY BELT GRINDER

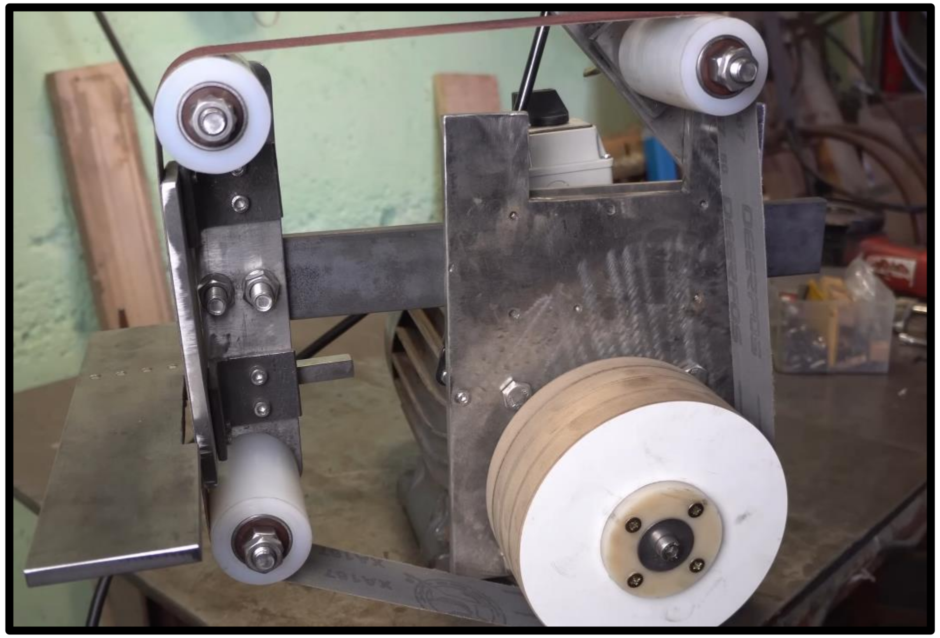
Solution Methods:

- Manufactured parts with power tools, manual machining (lathe, mill, drill press), and stick welding
- Barrel-shaped tracking wheel mounted on hinge, angle adjusted via UNF screw
- 150N Gas spring to keep belt in tension, can be retracted to easily swap belt
- Sliding grinding face for rough tensioning

Results:

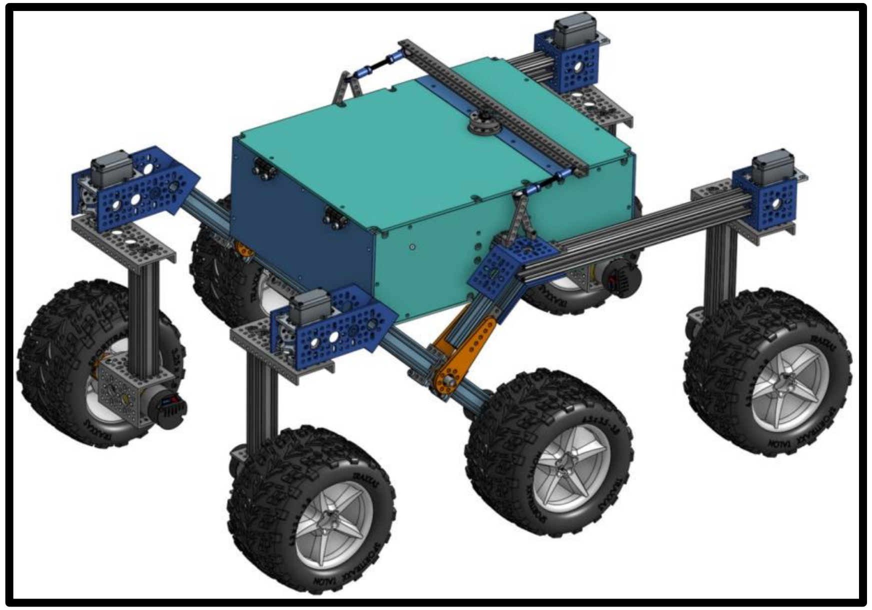
- Built full system under $250
- Able to grind high carbon steel
- Belt tracks correctly, does not deviate excessively





CAPSTONE PROJECT

SEARCH & RESCUE ROVER



Project Description:

Design an autonomous rover for nonprofit organizations to use in search and rescue operations. The rover must:

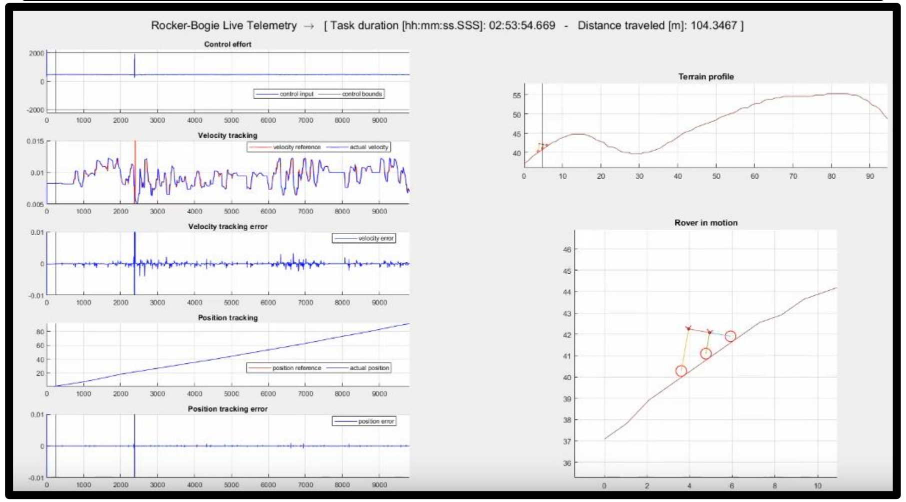
- Be capable of traversing uneven terrain
- Cost as little as possible
- Be modular and adaptable to the organizations' needs
- Have autonomous capabilities
- Keep its payload (battery + sensors) gyroscopically stabilized (for pathfinding system)
- Weigh as little as possible, to optimize battery life

CAPSTONE PROJECT

SEARCH & RESCUE ROVER

Solution Methods

- SolidWorks CAD and Excel calculations for design
- Used Mars Curiosity Rover for bogie-rocker suspension design reference; passive payload stabilization minimizes the number of required actuators
- Made entirely from off-the-shelf DIY robotics/automotive parts, runs on ROS2
- MATLAB used for kinematics, dynamics, and controls system simulation



Results:

- Entire robot costs under $1100 (including LiDAR & Nvidia onboard computer), compared to $8000+ for competition
- Can traverse large debris and climb stairs

WORK PROJECT (ELECTRANS TECHNOLOGIES LTD.)

HMI ENCLOSURE

Project Description:

Design a custom enclosure to house HMI board, control buttons, and display for system integration and field testing. The enclosure must:

- Protect against ingress of dust and splashing water (NEMA 12)
- Be as compact as possible
- Be as cost-effective as possible
- Allow for easy in-house assembly
- Prevent the display from moving during truck operation (ribbon connector is delicate, prone to breakage)

WORK PROJECT (ELECTRANS TECHNOLOGIES LTD.)

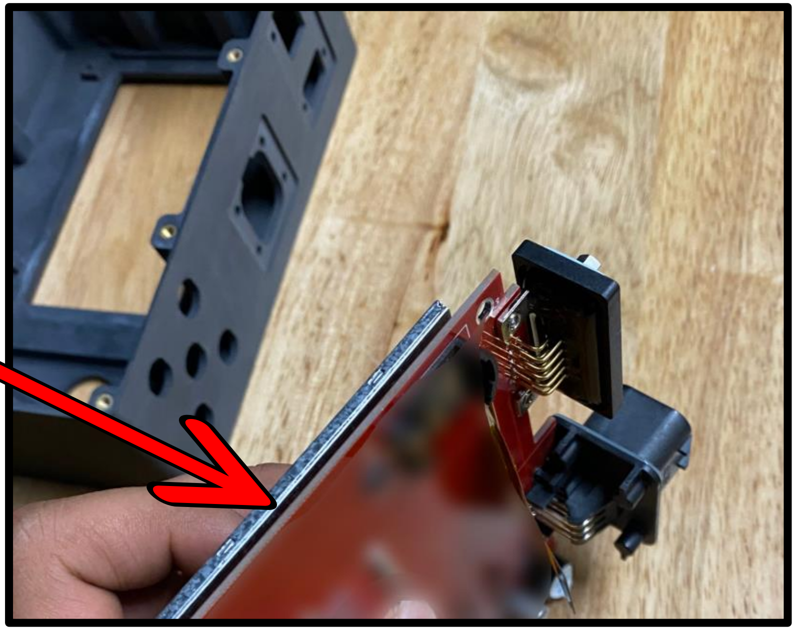
HMI ENCLOSURE

Solution Methods:

- SolidWorks CAD for design
- Prototyped using SLA 3D Printing
- Sourced IP67+ components and o-rings, designing cutouts/grooves per component sealing specifications
- Designed for CNC machining, using rounded internal corners, dogbone fillets, etc.
- Machined from ABS plastic due to impact resistance and low cost

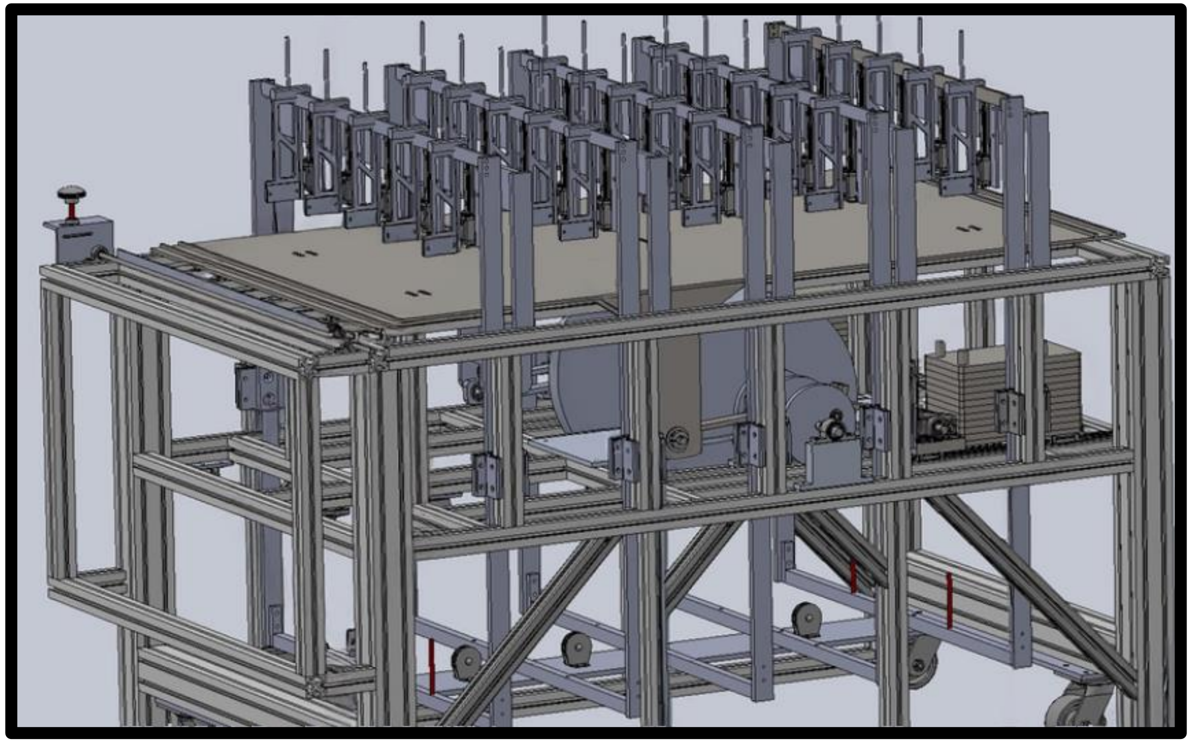
Results:

- Passed basic dust and water ingress testing
- Corresponded with 5+ international vendors to find lowest cost of production
- Cut overall costs by 46% from previous version



WORK PROJECT (GBIE INC.)

ABRASION TESTER



Project Description:

Design a custom test fixture to cycle test abrasion of glass samples against rubber coatings. The test fixture must

- Run for days at a time, and complete 1 million+ cycles consistently and without failure
- Have minimal power draw
- Operate quietly
- Be robust, allowing for immediate startup after power loss
- Have modularity, allowing for future expansion

WORK PROJECT (GBIE INC.)

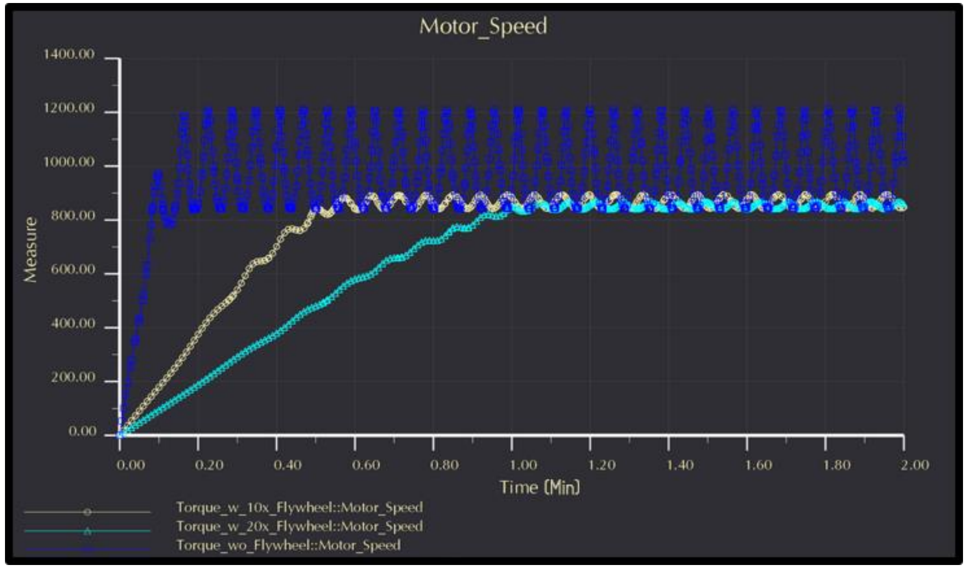
ABRASION TESTER

Solution Methods:

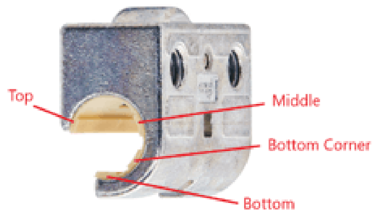
- Designed crank-slider system, constraining system to linear motion for consistent testing
- Developed mechanical cycle counter, constraining electrical points of failure to motor
- Used GD&T to specify bearing-shaft fits
- Designed flywheels using hand-calculations to minimize motor power fluctuations due to periodic motion
- Prototyped crank-slider system on wooden frame, made entirely with power tools

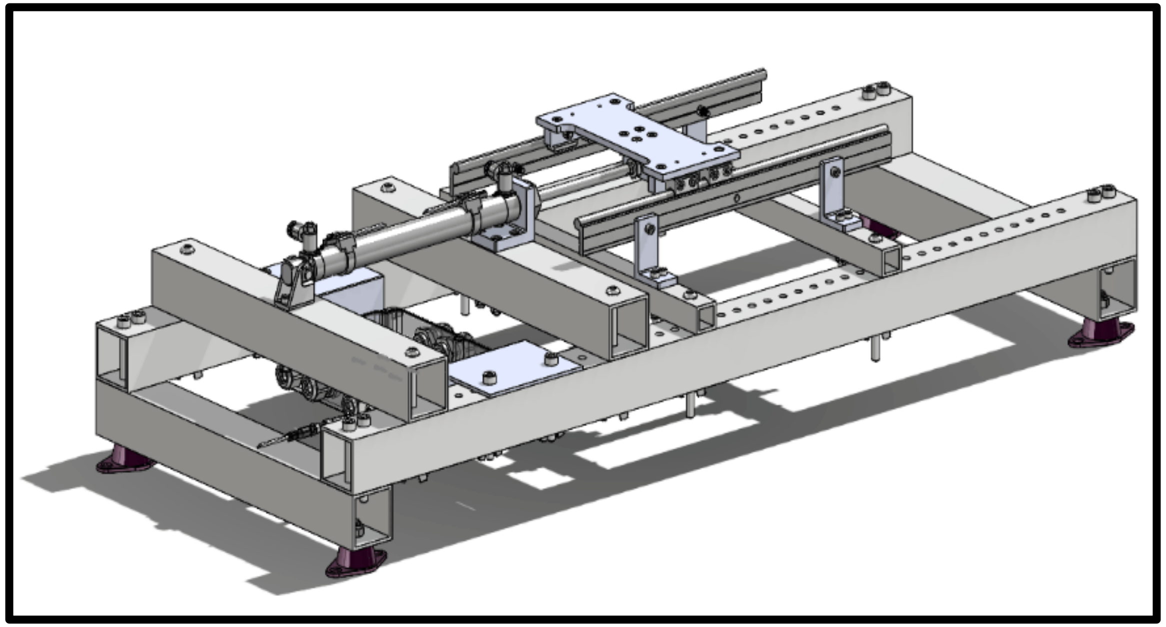
Results:

- Operated for 3x 5mil cycles consistently
- Motor speed smoothed out by flywheels



Linear Bearing Tester





Project Description:

Design a custom test fixture to test linear bearings against loading conditions seen on unit. The test fixture must:

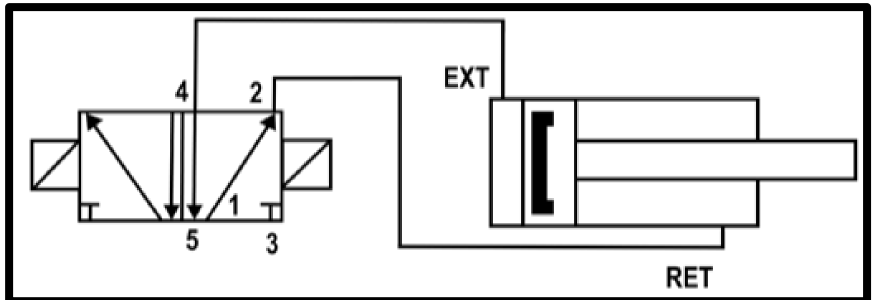
- Be able to test the linear bearings against eccentric offsets and varying loads
- Entirely fit within an environmental test chamber
- Protect electronics and logging equipment from environmental effects

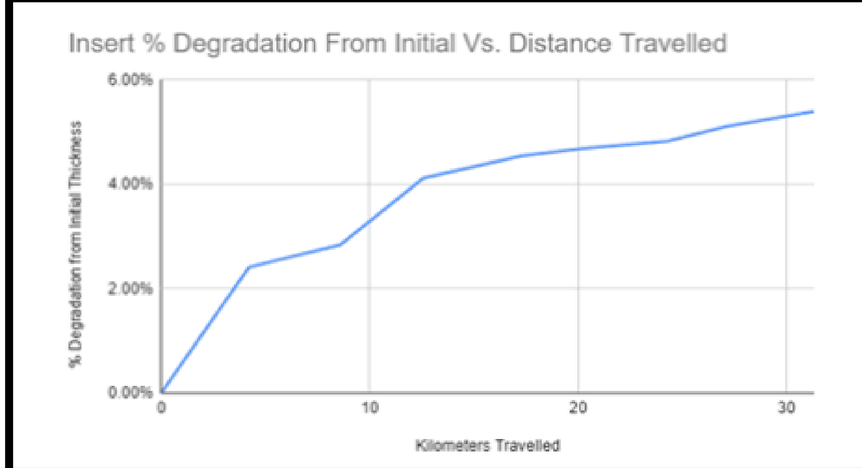
WORK PROJECT (ELECTRANS TECHNOLOGIES LTD.)

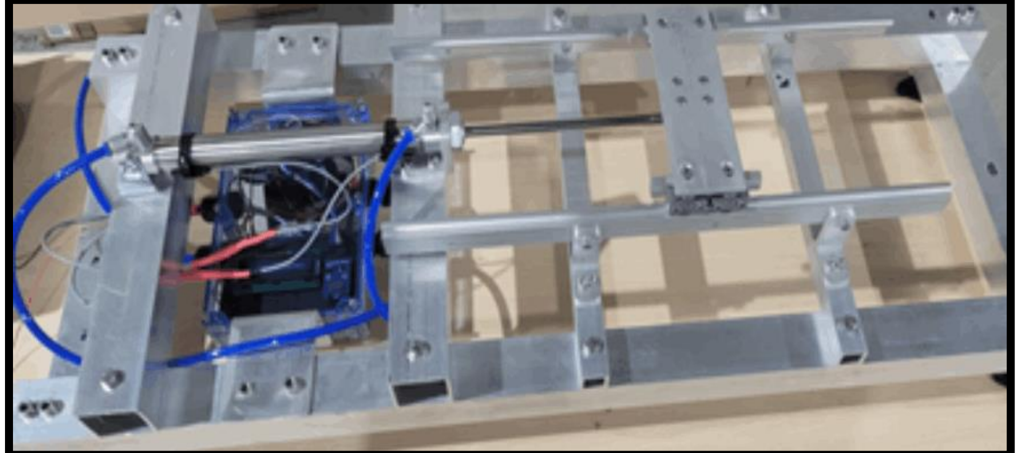
LINEAR BEARING TESTER

Solution Methods:

- Simple mechanical design for future modularity
- Dual-action pneumatic manifold to power cylinder extension and retraction
- Arduino Uno powered by L298N dual H-bridge motor controller for control board, programmed with C++
- Inductive proximity sensors to detect cylinder position
- Time, cycle data, and distance travelled output to I2C LCD screen and logged to Micro SD card







Results:

- Allowed for measuring of wear on bearing pads after 10k+ cycles
- Tester successfully logged the conditions in which the bearings would consistently bind

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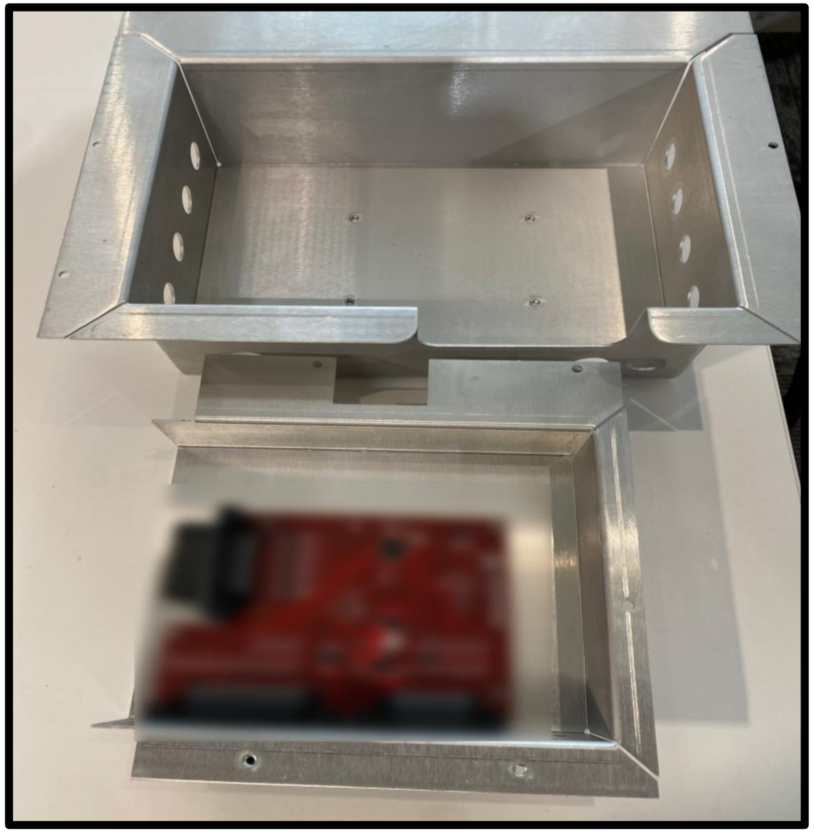
WORK PROJECT (ELECTRANS TECHNOLOGIES LTD.)

PNEUMATIC MANIFOLD HOUSING



Project Description:

Design a sheet metal housing to protect the unit's pneumatic manifold and EC. The housing must:

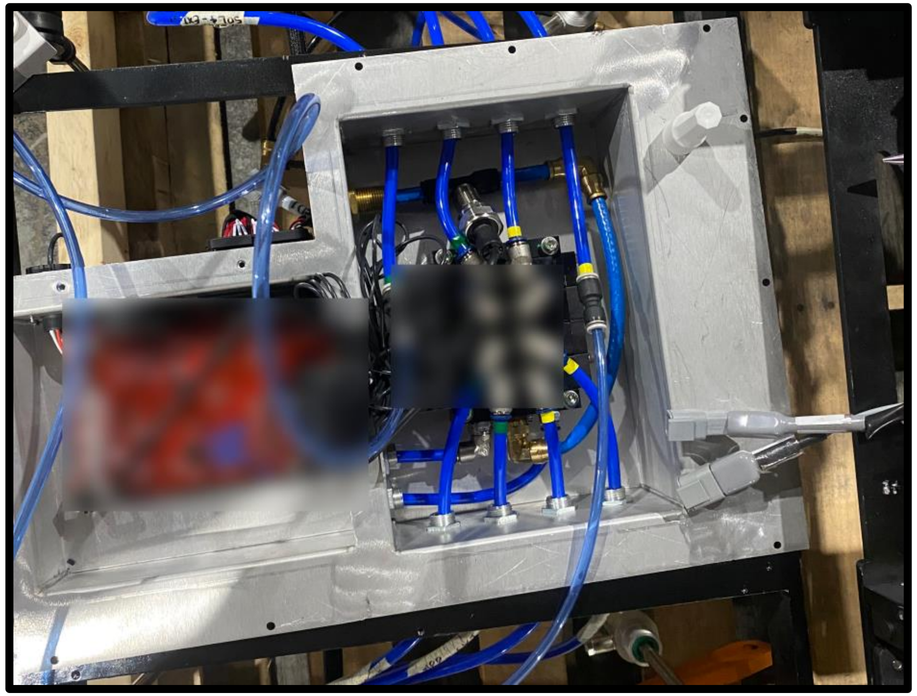
- Be corrosion resistant
- Securely hold the PCB and pneumatic manifold in place during system operation
- Resist wear from truck grease and grime
- Resist ingress of water in outdoors environment
- Resist ingress of cleaning solvents in automotive washdown environment

WORK PROJECT (ELECTRANS TECHNOLOGIES LTD.)

PNEUMATIC MANIFOLD HOUSING

Solution Methods:

- SolidWorks CAD for sheet metal design
- Secured components to housing by fastening to PEM nuts & using threadlock sealant
- Used appropriate GD&T callouts to ensure welds are sealing, and ground flat on top surface
  - Chose automotive liquid gasket to seal top surface against cover plate
- Housing made of 6061 Al
  - Aluminum pneumatic bulkheads chosen to prevent galvanic cell formation, DOT approved
  - Insulating washers used where necessary



Results:

- Passed IP66 testing
- Procured and assembled 40+ housings, currently being used in production units
- No recorded instances of failure since field deployment

COURSE PROJECT (ME 548)

CNC SHIELD CAM & CMM

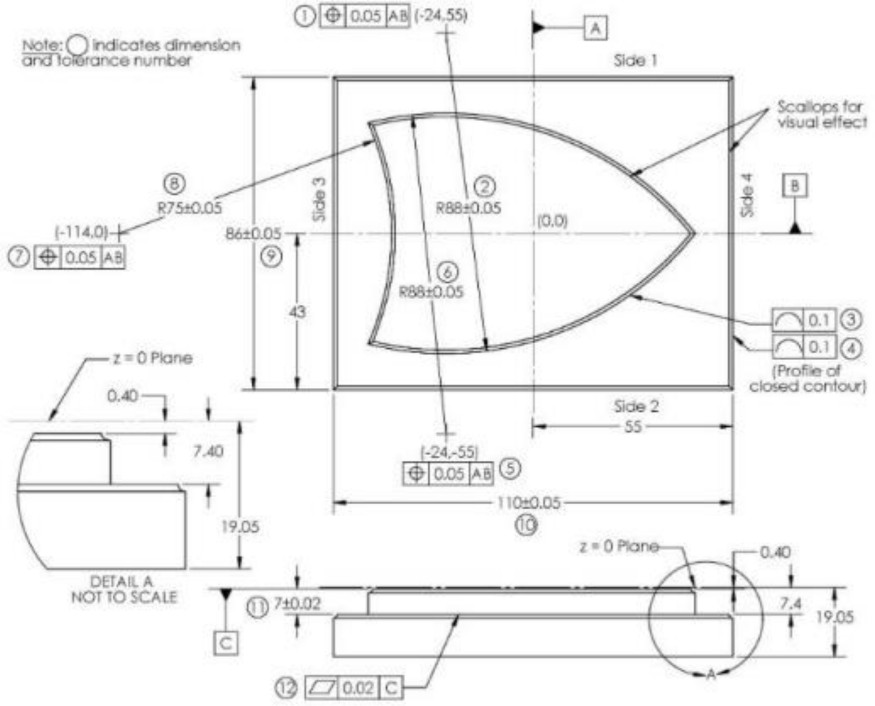


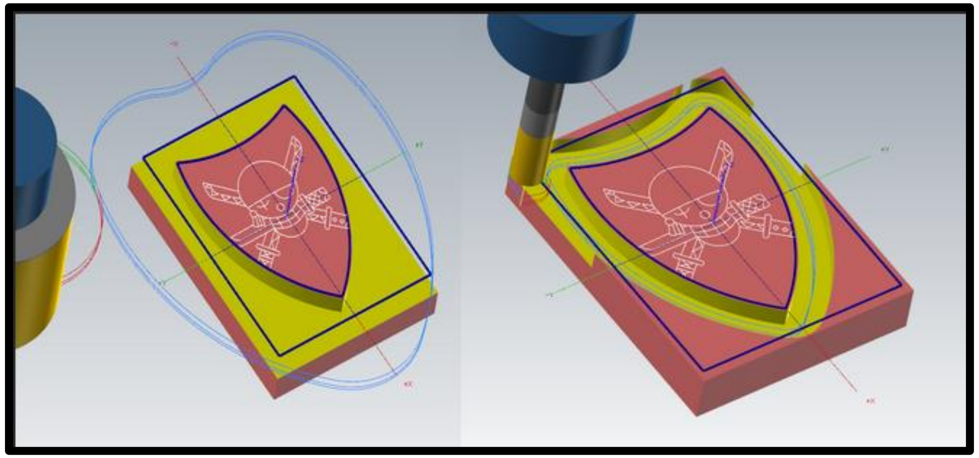
Figure 1: Shield drawing

Project Description:

Design a CAM program to machine a shield out of an aluminum blank, with the dimensions shown in Figure 1. Use a CMM program to verify the actual dimensions match the drawing.

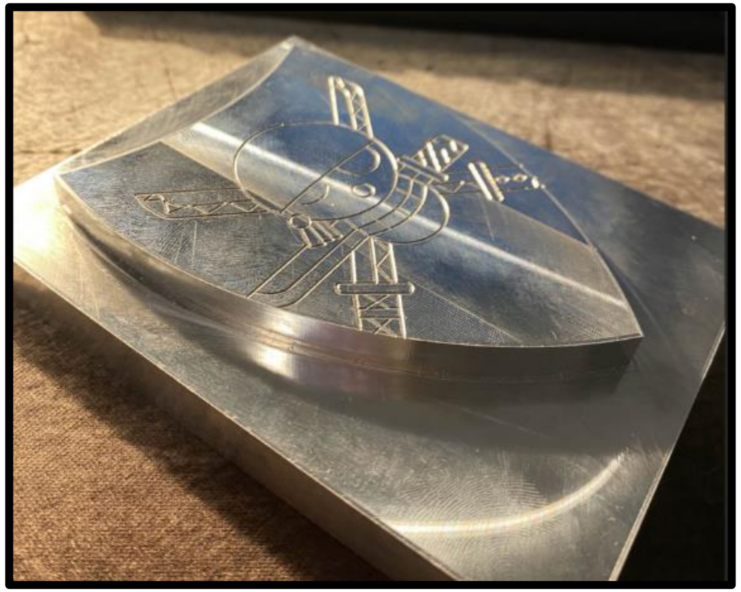
COURSE PROJECT (ME 548)

CNC SHIELD CAM & CMM



Solution Methods

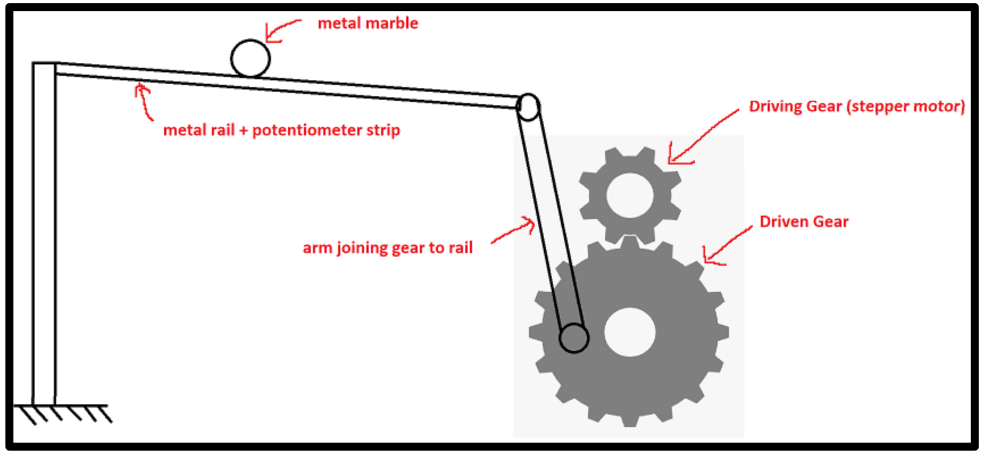
- SolidWorks CAD to make the shield model, MasterCAM to generate the CAM and CMM programs
- Optimized tooling selection and toolpaths to minimize machining time and cutting forces



Results:

- Passed 11/13 dimensions, flatness dimension failed due to endmill radius, profile dimension failed due to tool leaving contact with piece => larger cutting forces on entry
- Learned how to create CAM program from scratch
- Learned how to design for CNC, and what factors affect machining time and cost

COURSE PROJECT (MTE 484)
BALL BALANCING CONTROLLER



Project Description:

Design a discrete complex controller to balance a metal marble on a metal rail via motor voltage modulation. The controller must:

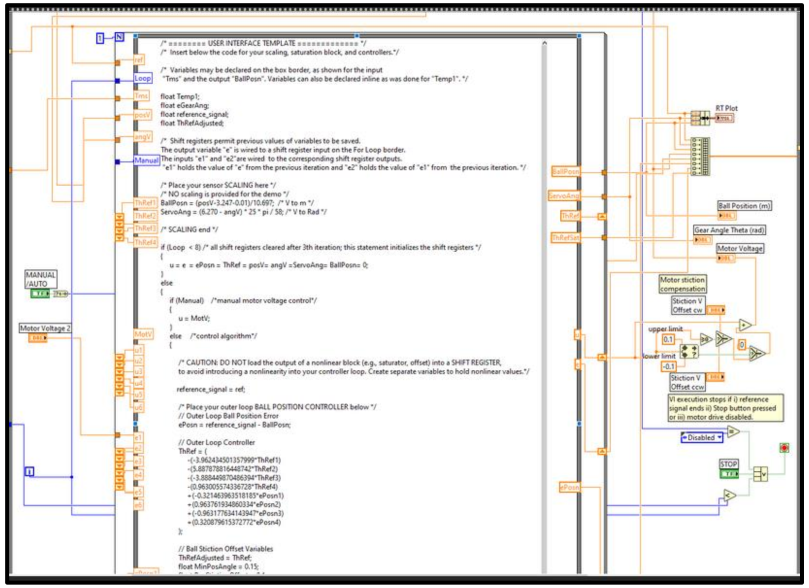
- Take an input waveform (square wave) to dictate desired marble position
- Move the marble such that it tracks the input waveform within given overshoot, steady state error, and settling time specifications

COURSE PROJECT (MTE 484)

BALL BALANCING CONTROLLER

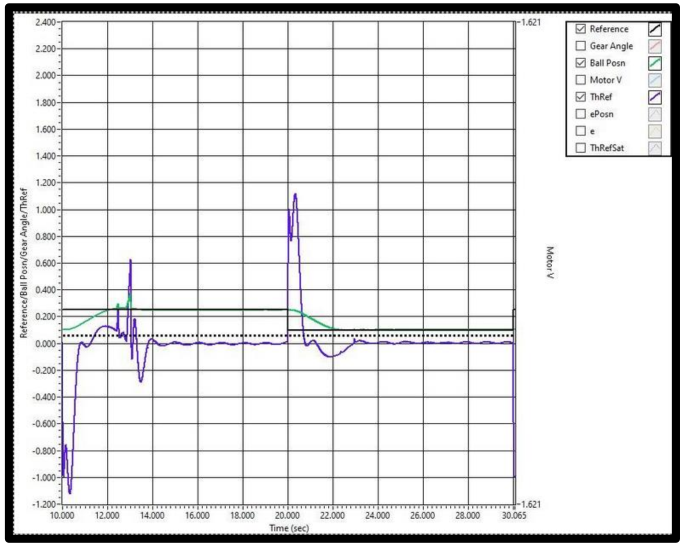
Solution Methods

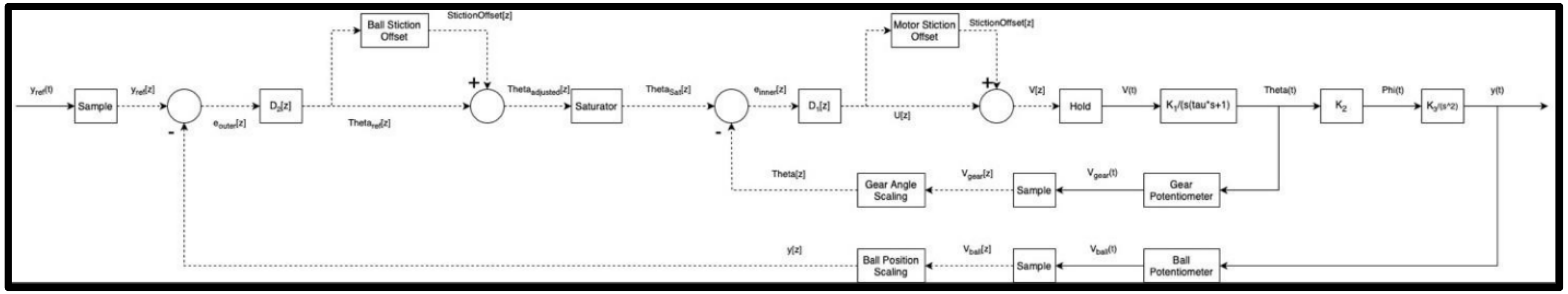
- LabView for testing and programming
- MATLAB and Simulink for controller polynomial solving, n^{th} degree pole finding, and block diagram simulation



Results:

- Controller tracked input waveforms within desired specifications





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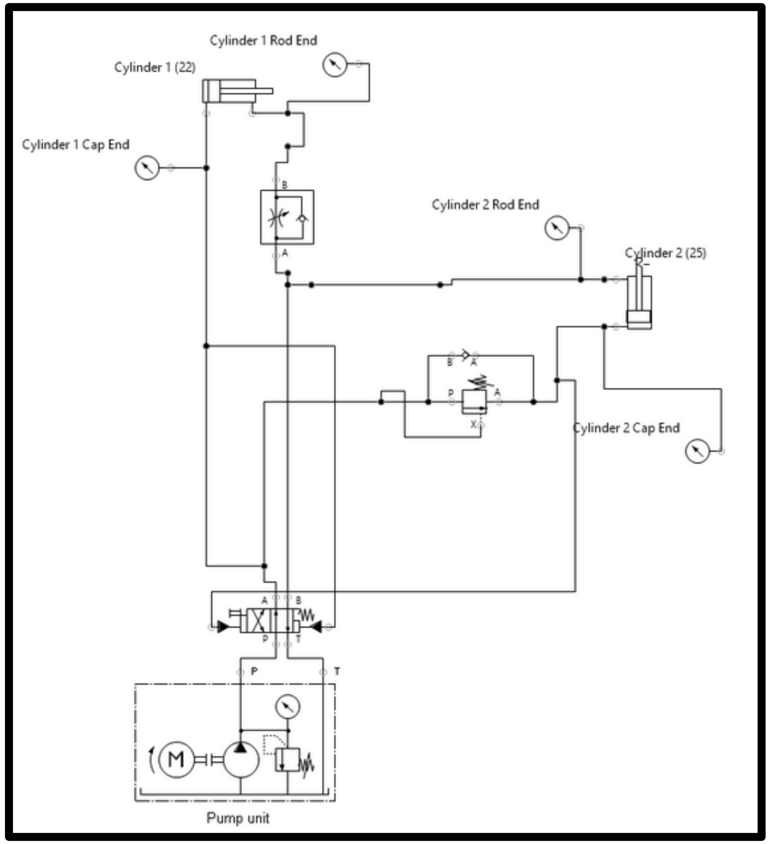
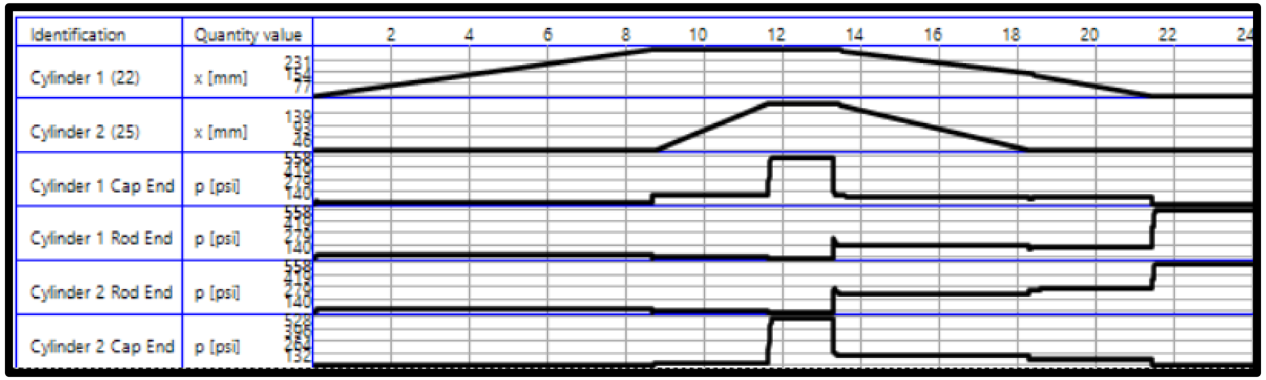
COURSE PROJECT (ME 561)

HYDRAULIC CIRCUIT DESIGN (FluidSIM)



- The larger cylinder (Cylinder 22) extends fully before the smaller cylinder (Cylinder 25) extends
- Cylinder 22 and Cylinder 25 retract at the same time
- The retraction speed of Cylinder 22 is adjustable



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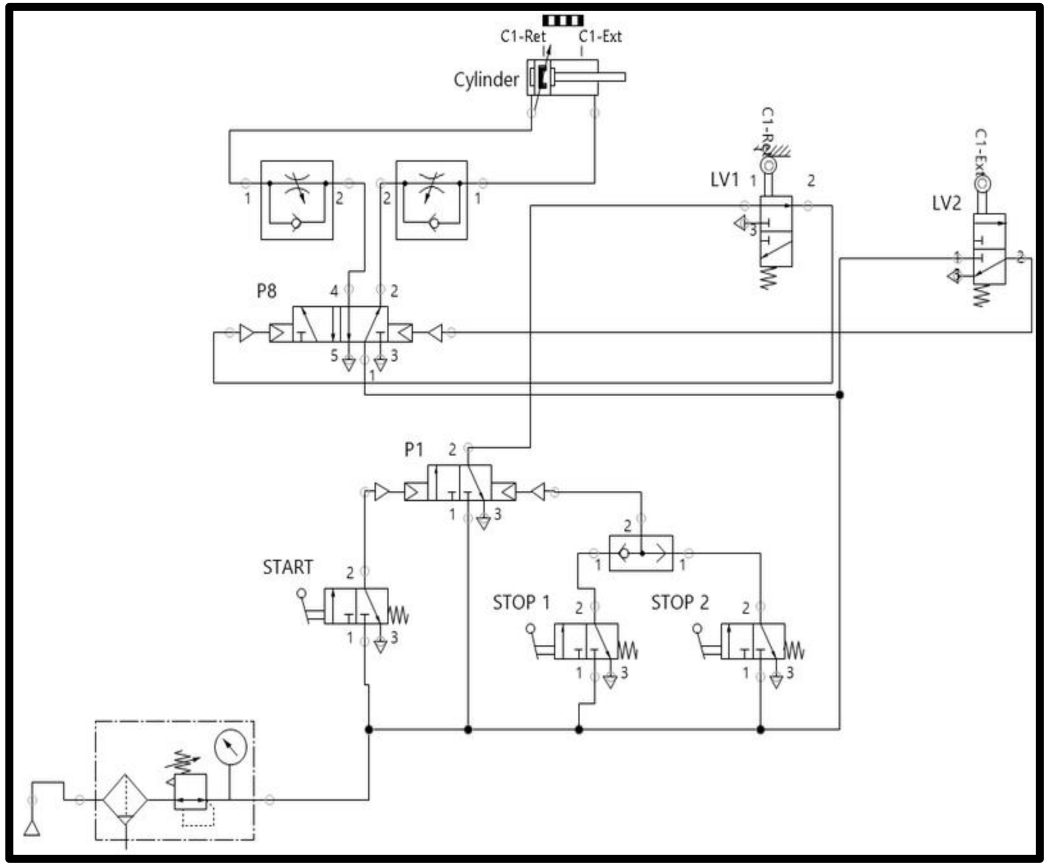
COURSE PROJECT (ME 561)
PNEUMATIC CIRCUIT DESIGN



- Automatically reciprocating cylinder
- Reciprocating motion starts from retracted state once start valve is actuated
- Ends in retracted state once both stop valves actuated