4- Axis SCARA Robot
For pick and place applications

California State University, Chico

MECA/MECH 440B

Project Members

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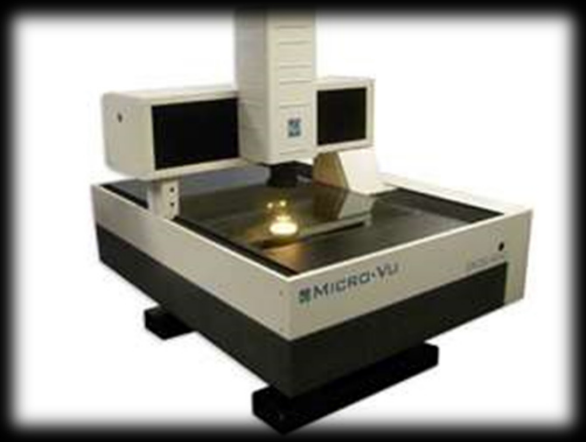
Project Sponsor / Customer:

MICRO·VU
Precision Measurement Equipment Since 1959

The Problem

Micro-Vu develops various high precision measuring devices, but they realize that there continues to be a demand for automation. If they can automate the process of loading and unloading of their measuring devices, it could increase the efficiency of their products.



The Need

Micro-Vu needs a reliable autonomous robot to be developed, capable of pick and place applications for their Excel Measuring Centers.

Excel Measuring Center

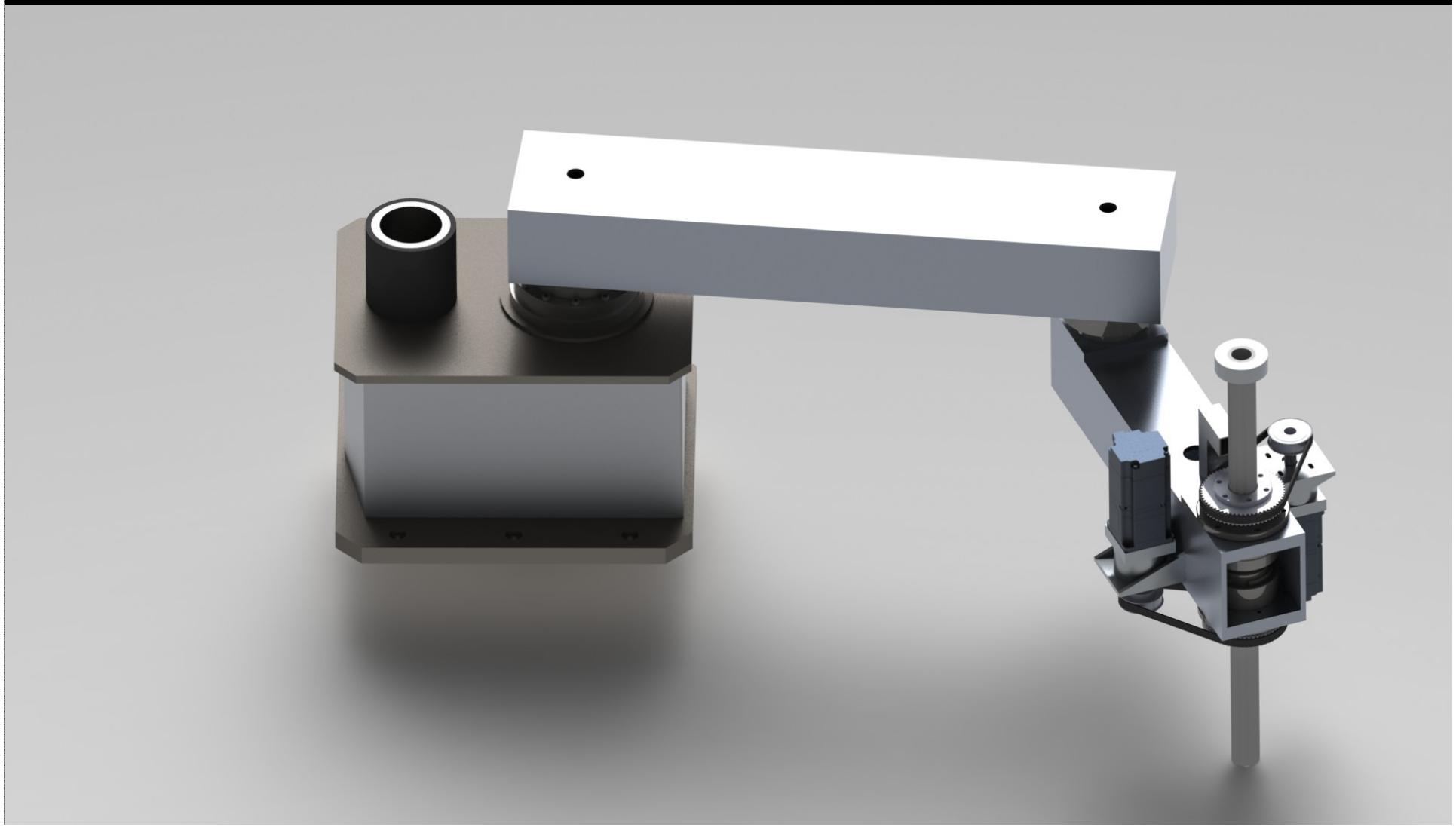
Function of the Device

The device to be built will be a competitive and reliable prototype of a 4-axis SCARA Robot for pick and place applications. It will meet all of the requirements provided by Micro-Vu.

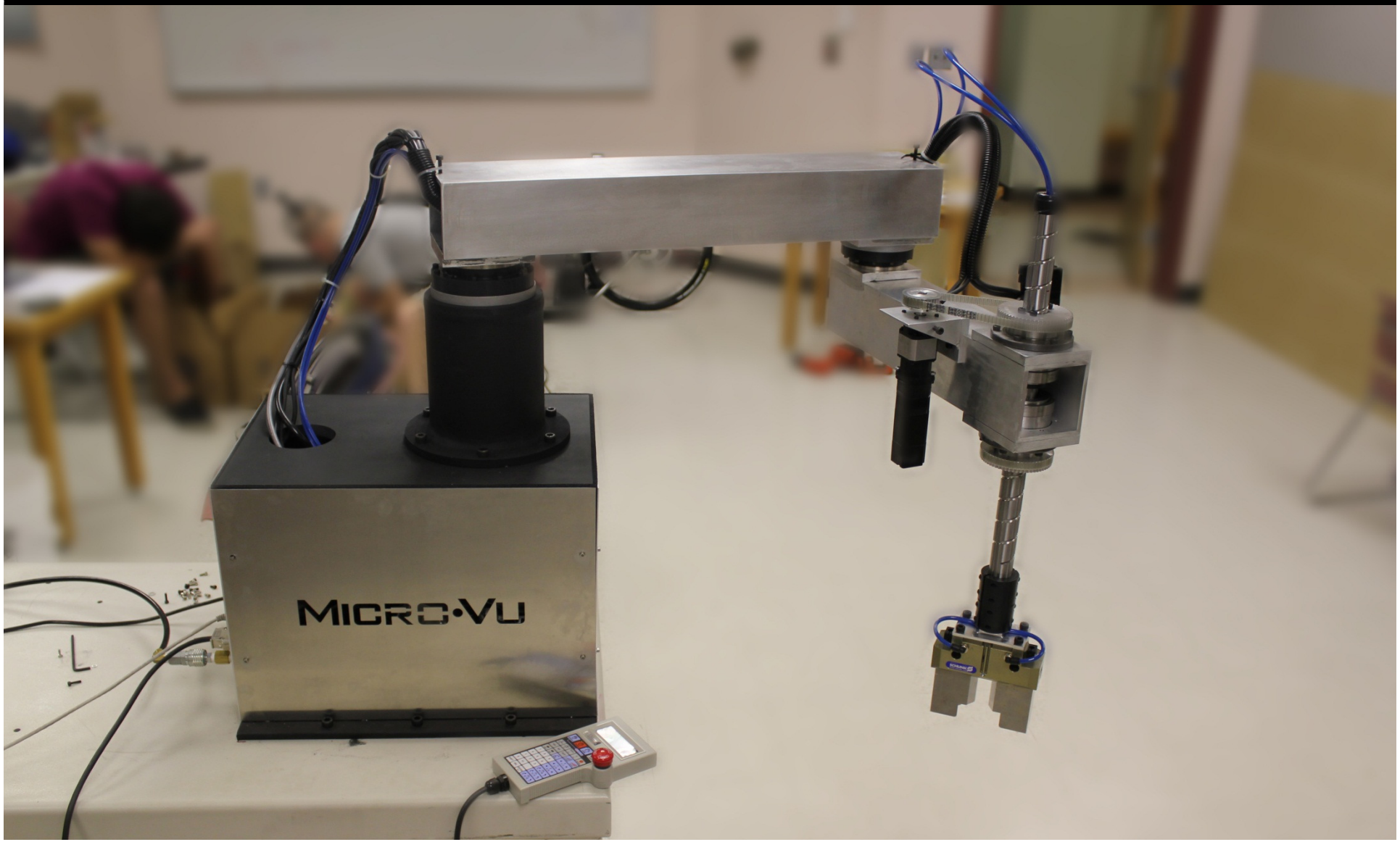
Problem Definition

Must Do	Should Do	Would be Nice
Be of a SCARA configuration	Have an accuracy of ±0.2 mm	Have an accuracy of ±0.1 mm
Operate in at least four axes of motion	Have a repeatability tolerance of ±0.1 mm	Have a repeatability tolerance of ±0.05 mm
Be able to lift a "sample piece" of 0.5 kg	Be able to lift at least 8 Kilograms	Upgrade to 6 axes of motion
Be capable of covering a workspace of multiple 650 mm Micro-Vu Excel measuring stages.	Operate for 10,000 hrs. without failure	Be aesthetically pleasing
Pick and place cycle a "sample part" in less than 1 hour	Pick and place cycle a "sample part" within 10 seconds	Pick and place cycle a "sample part" in less than 1 second
Be an independent unit, separate from Excel Measuring Center	Be designed for manufacturing 1,000 units per year	
Have an accuracy of ±1 mm		
Have a repeatability tolerance of ±0.5 mm		

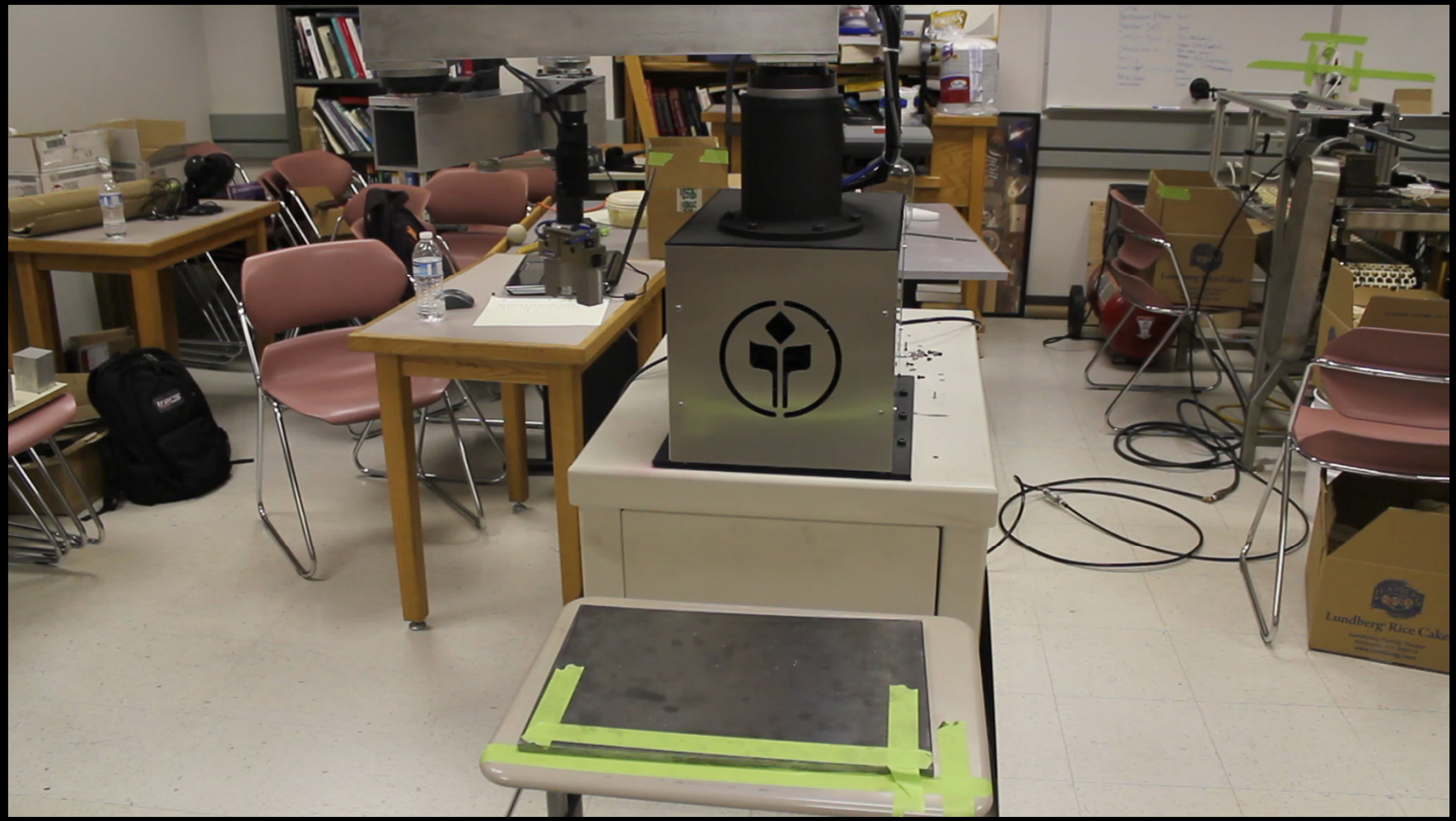
Design Solution



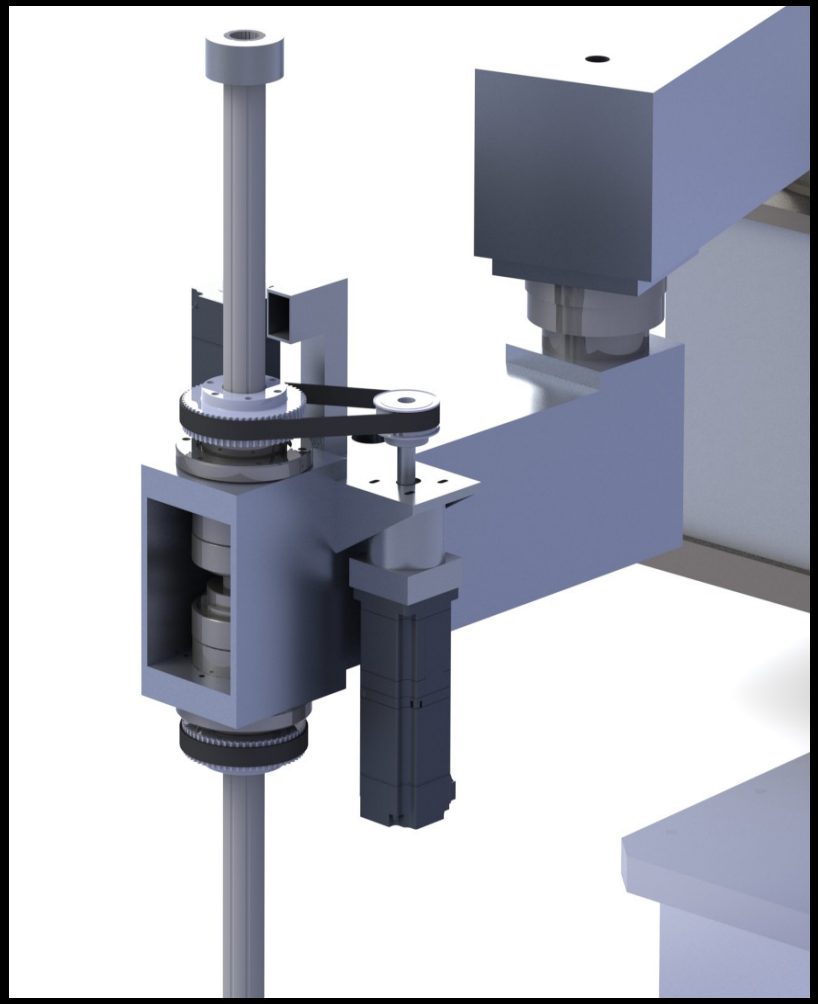
Design Solution



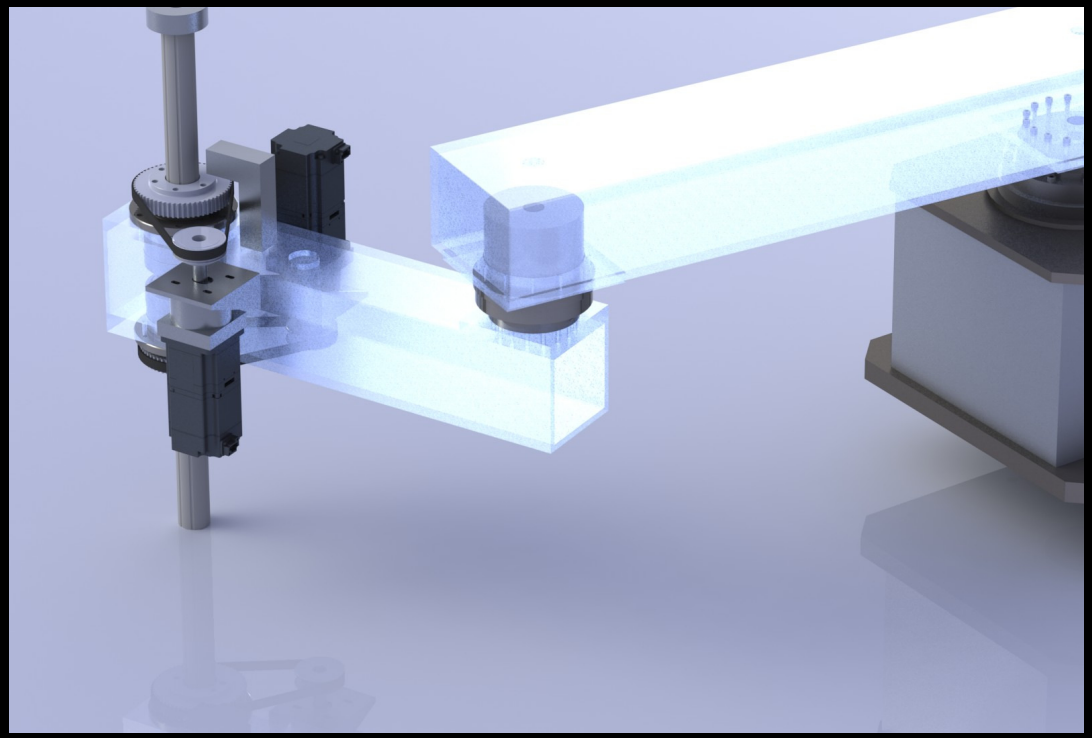
Work Envelope Video



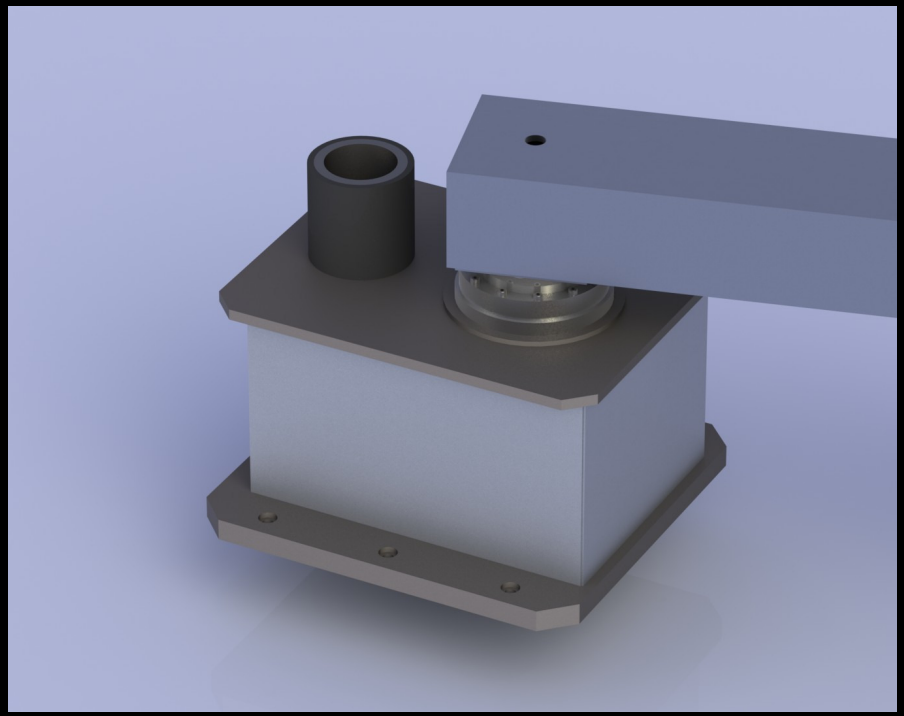
End Mechanism



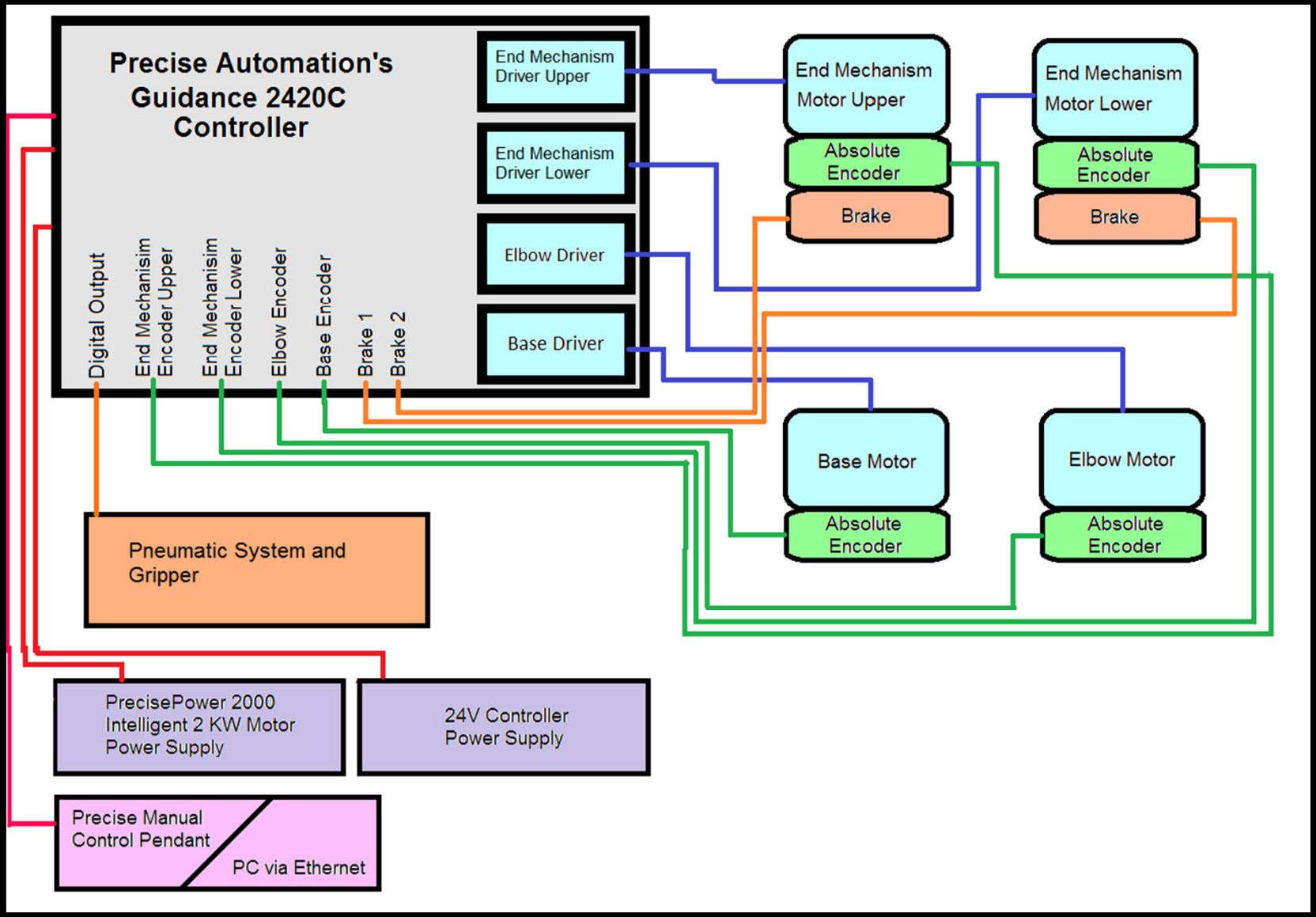
Elbow Joint



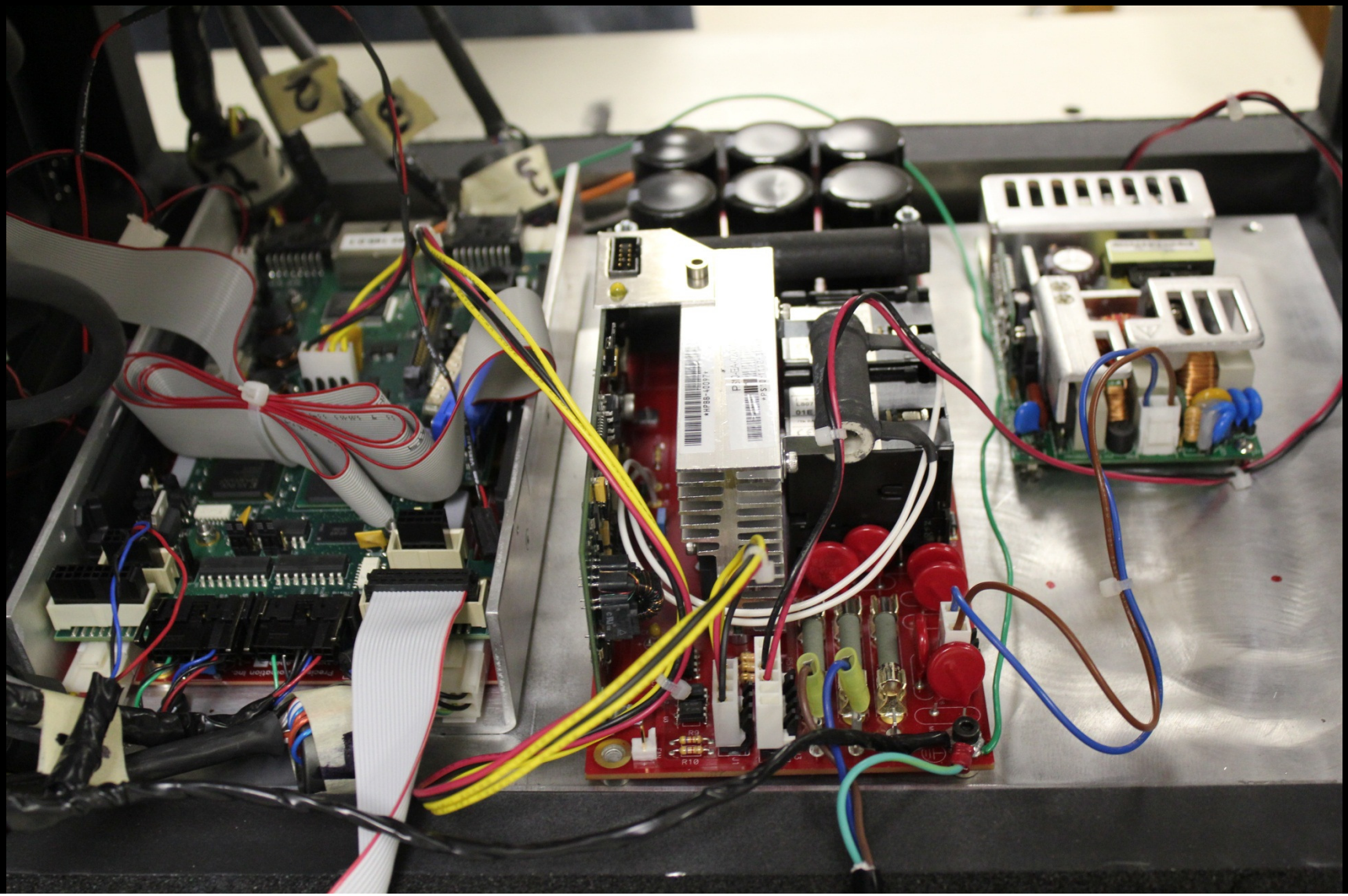
Base Joint



Control Systems



Controller Actual Picture



Fabrication

Purchased Parts

- SHA 25 & 32 motors
- 2x Yaskawa SGMAV motors
- Controller and power supplies
- Gripper module
- Pneumatic solenoid & regulator
- THK ball spline/screw
- Raw machining materials
- Miscellaneous electrical components
- Miscellaneous mechanical fasteners

Fabricated parts

- Base and riser
- Base side panels
- Link 1 & 2
- Motor mounts
- Gripper Fingers
- Gripper Mounting Apparatus

CNC Production

High Speed Machining

Repeatability Results

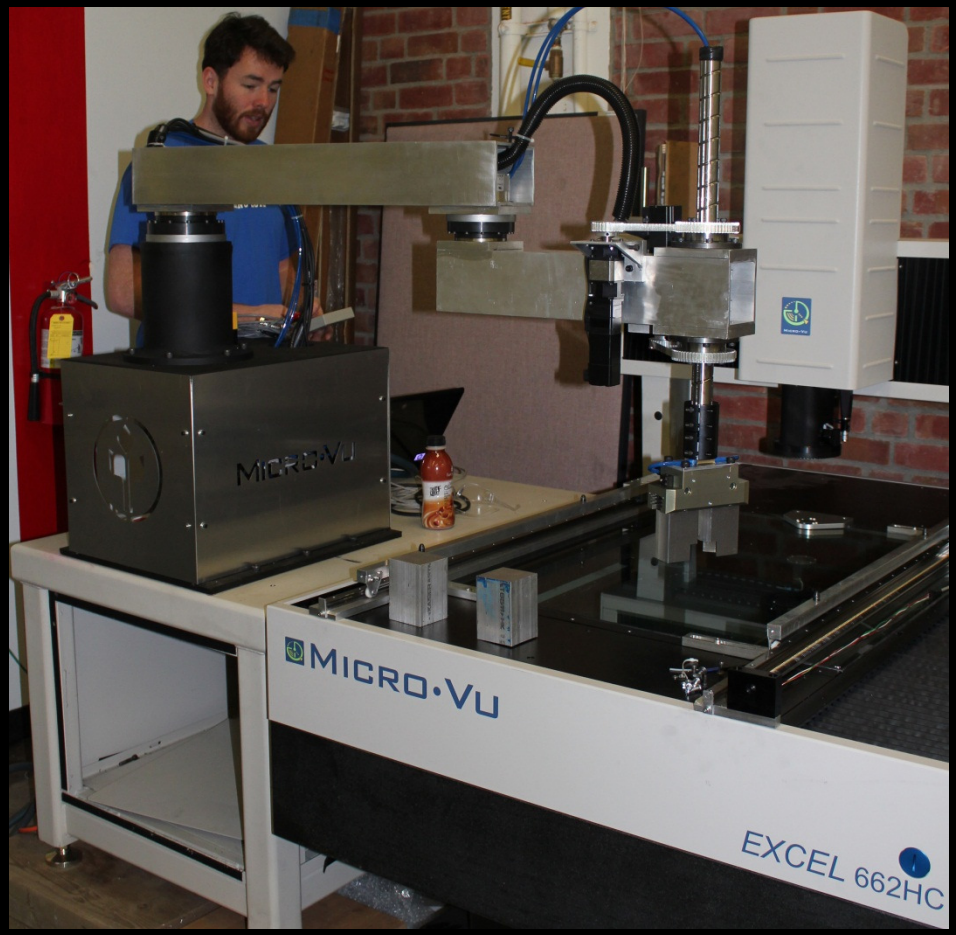
Repeatability Requirements — Met = ✔ Not met = **X**

- Must do: ± 0.5 mm ✔
- Should do: ± 0.1 mm ✔
- Would be nice: ± 0.05 mm ✔
- Test Results: **± 12 µm**

Accuracy Results

Accuracy Requirements

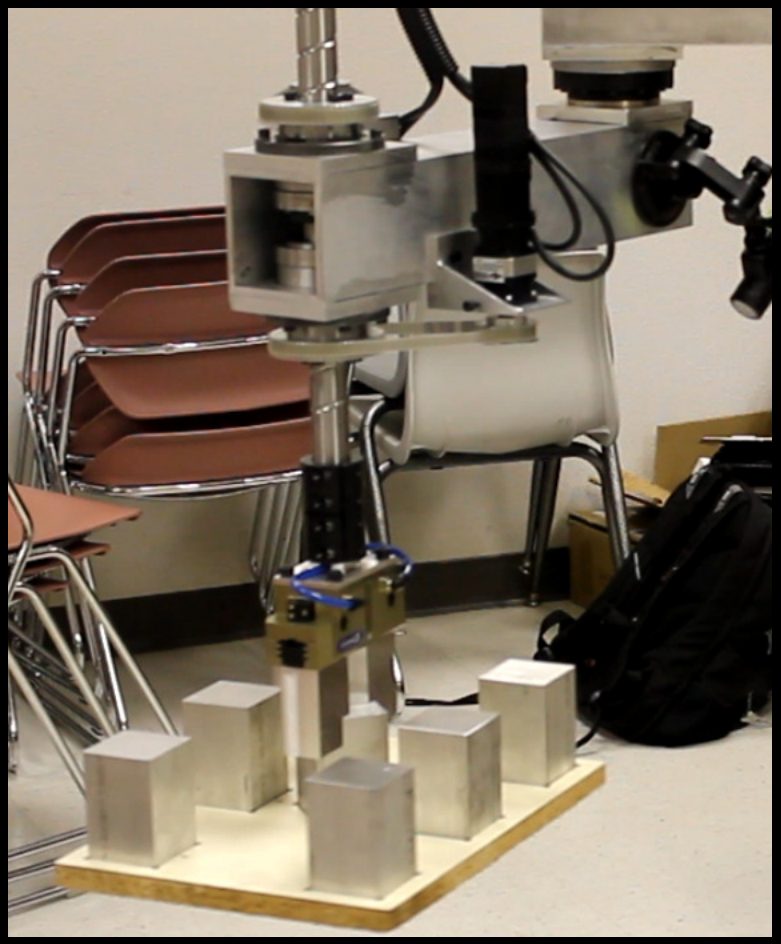
- Must do: ± 1 mm X
- Should do: ± 0.2 mm X
- Would be nice: ± 0.1 mm X
- Test Results: **± 1.3 mm**



Testing Results Continued

Weight/Payload Requirements

- Must do: 0.5 kg ✔
- Should do: 8 kg ✔
- Test Results:
  - 0.5 kg ✔
  - 1.0 kg ✔
  - 2.0 kg ✔
  - 4.0 kg ✔
  - 8.0 kg ✔
  - **11.6 kg** ✔



Cycle Time Results

Requirements

- Must Do: < one hour ✔
- Should Do: < 10 seconds ✔
- Would Be Nice: < one second X
- Test Results: **1.2 seconds**

Final Budget Overview

Description	Price
Controller	$ 5,750.39
Base	$ 1,095.77
Links	$ 3,567.77
Pneumatics	$ 1,701.21
Motors and Gearheads	$ 10,882.00
Misc.	$ 488.88
Shipping Costs	$ 300.00
Total Component Cost	$ **23,786.02**
Labor Cost	$ 121,470.00
Machining Costs	$ 900.00
Total Project Cost	$ **146,156.02**

Reflection

Unique Problems Encountered

1. Extra time needed when using Beta systems (i.e. our controller)
2. Keep in constant contact with suppliers
3. Monitor lead times closely

Solutions Achieved (for above problems)

- Communication
  - Teammates
  - Supervisors
  - Suppliers
- Plan ahead for troubleshooting time

Suggestions for Future

- Regulate the air exhaust valve to slow open/close of the gripper
- Evaluation of hard stops for all axes
- Electrical gripper instead of pneumatic
- Proper sized ball spline/screw
- Cast aluminum arms – lighter & stronger

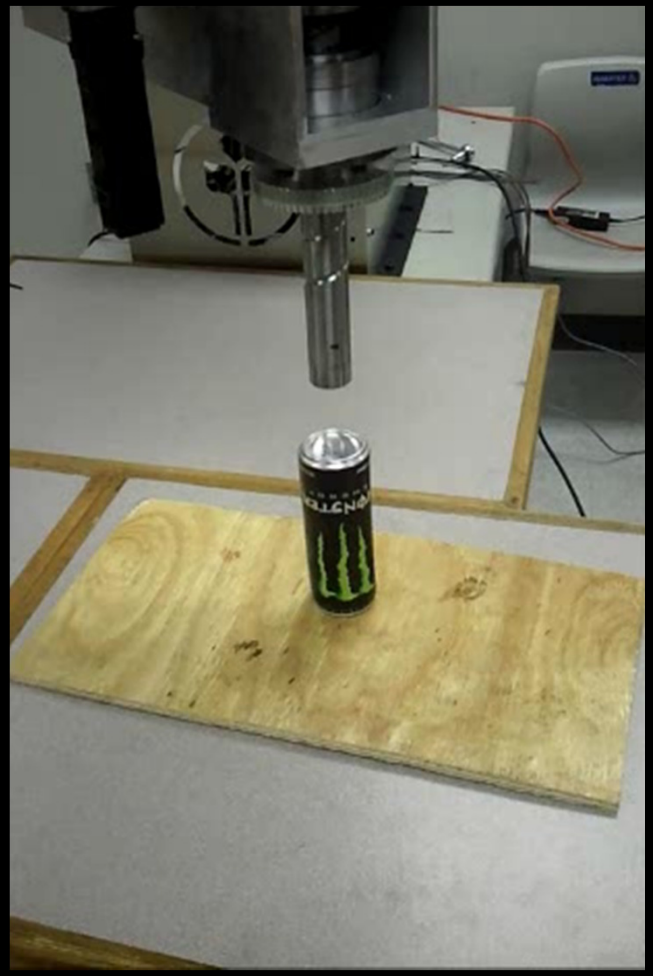
Conclusion

- Product met all but one of the required must do and should do specifications
  - Accuracy requirements not met
  - Error is due to the gripper release mechanism
- Several would be nice specifications were also met
- Is product ready for market?
- A special thanks to:
  - Micro Vu
    - Jeremy Bardell
    - Chuck Howard
  - Nick Repanich

  Tony Arena

  Louk Hendricks

  Support staff at Precise Automation

  CSU, Chico Tech Shop

Questions?