

## Background



## Design Requirements

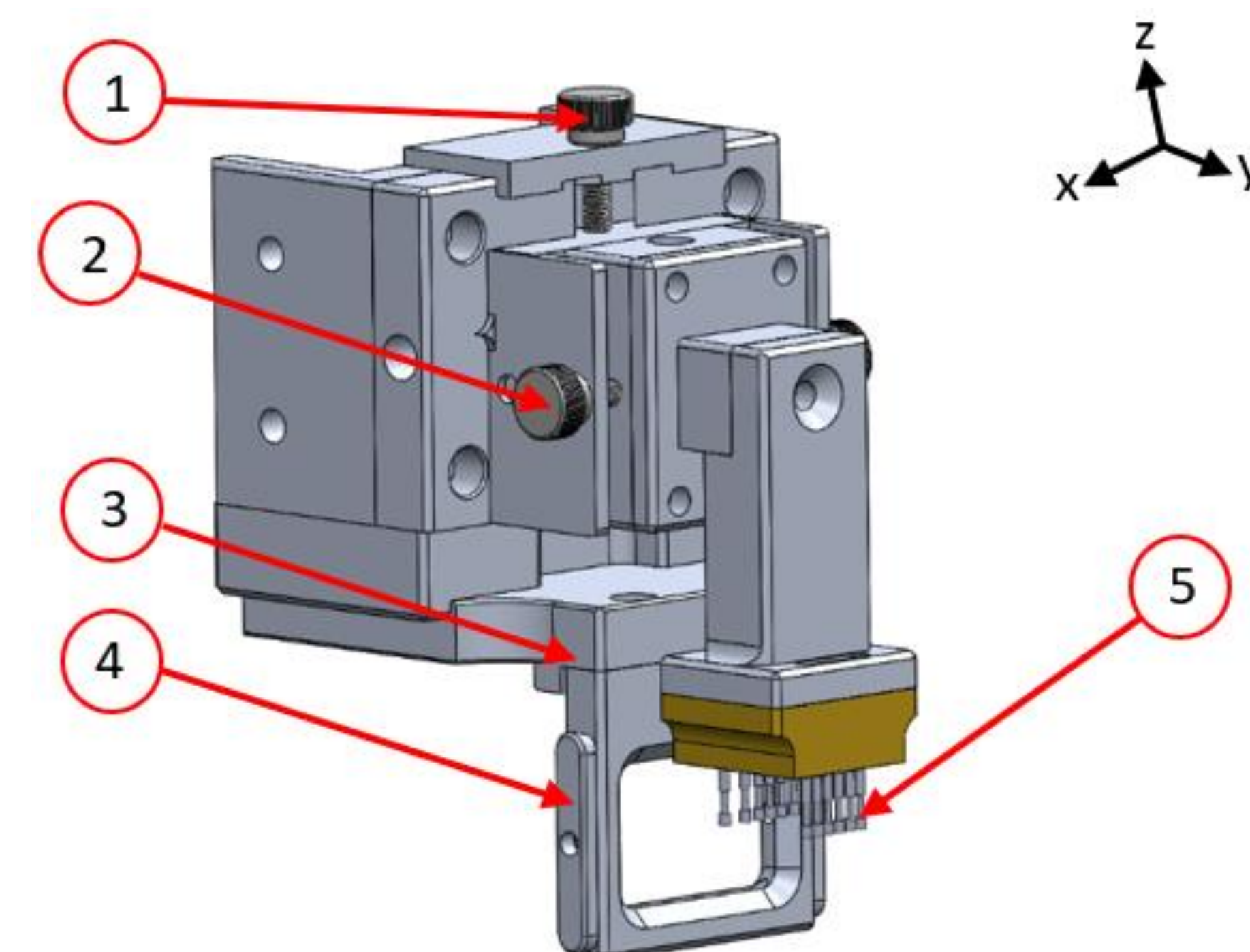
1. Perform each test in under 120 seconds
2. Operate safely without causing harm to the operator or the sensor
3. Maintain a footprint of less than 30 in by 36 in
4. Provide the operator with an accurate and clear Pass/Fail indication
5. Store and log resistance values for further investigation by the engineering department

## Evaluation Methods

1. An E-stop button was fitted to allow the operator to stop the apparatus at any time and pinch points of the apparatus were minimized by using rubber strips
2. The stepper motors on the linear slide actuators were tested at various speeds and accelerations to obtain optimal speed and ensure completion of the test in under 120 seconds
3. A wooden prototype with a footprint of 22 in by 26 in was constructed and taken to Walker Products to allow the operators to have input on the physical dimensions
4. The HMI panel on the front of the apparatus provides a clear indication to the operator using both fonts and colors chosen by Walker Products
5. A data logging shield is used on the Arduino to log and store resistance readings as well as which circuit failed for a failed sensor

## Design

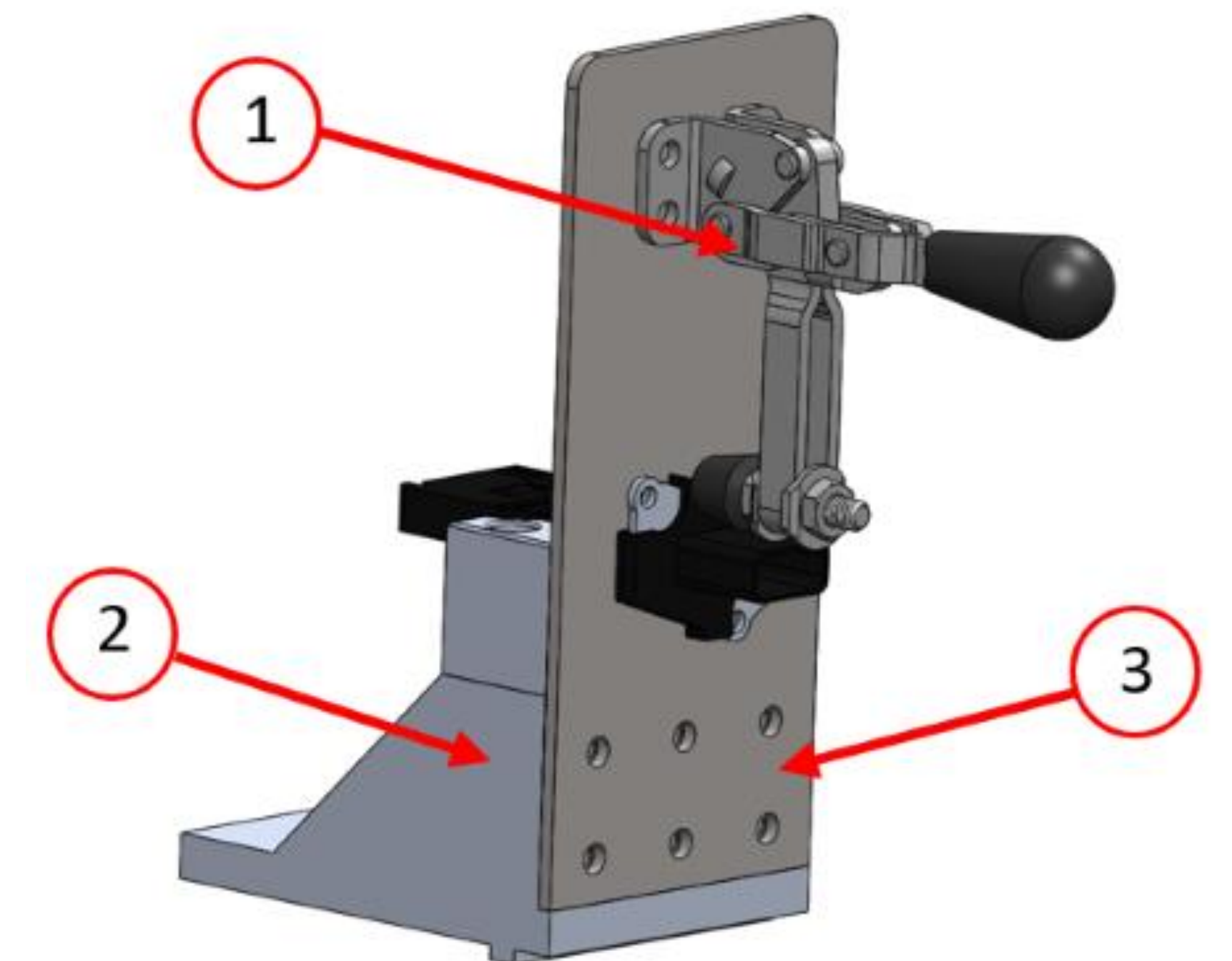
### Flex/Continuity Device



1. Z-axis adjustment
2. X-axis adjustment
3. Y-axis adjustment
4. Flex Apparatus
5. Pogo Pins

- Mounted to the vertical linear slide actuator slide plate
- The purpose of this device is to flex the sensor in both vertical directions while simultaneously testing the electrical continuity of the sensor's solder joints
- Allows for fine adjustments in the x, y, and z axes

### Sensor Mount

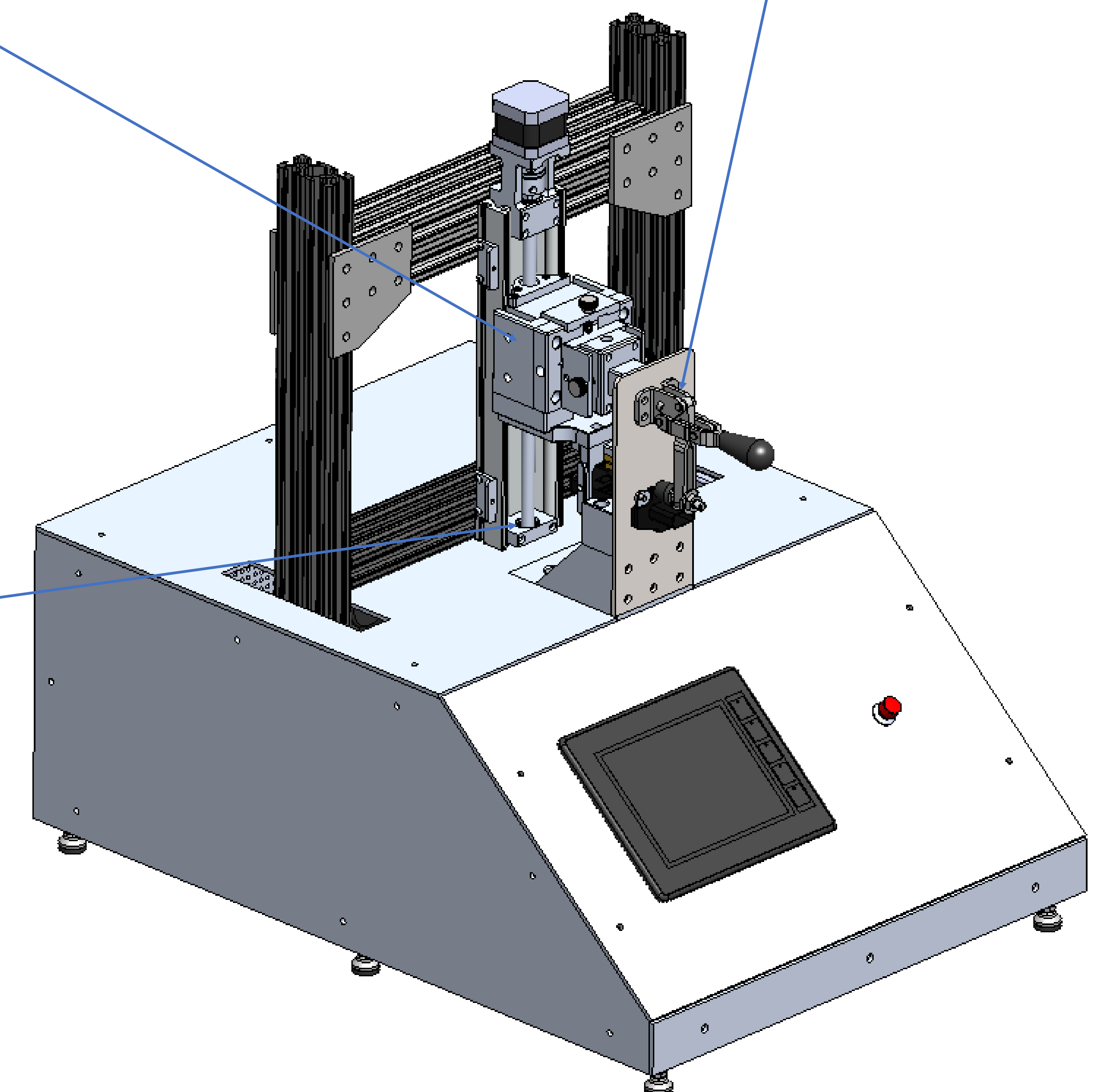


1. Destaco Holding Clamp
2. Bottom Support Plate
3. Vertical Bracket

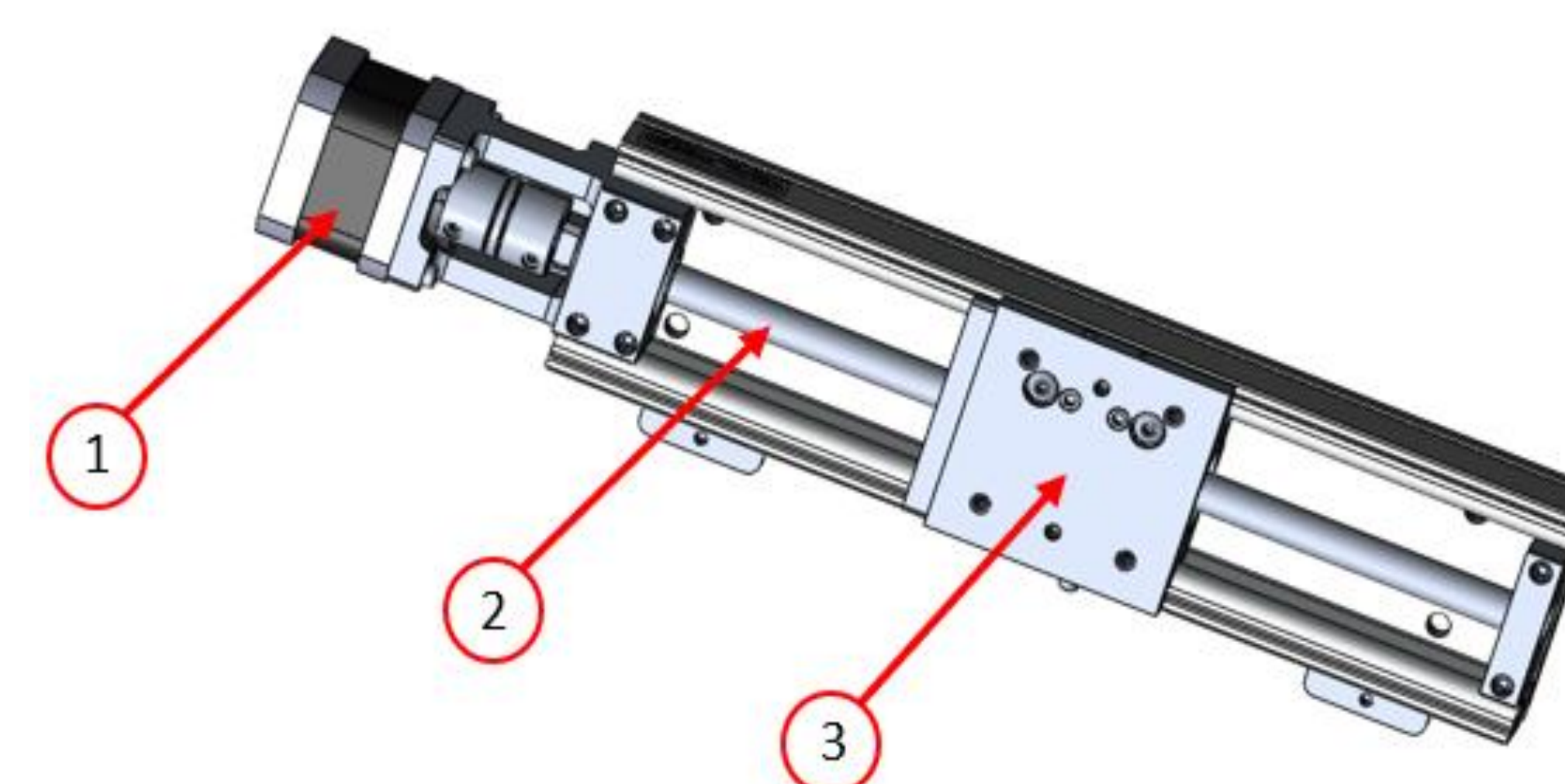
The sensor mount consists of:

- Two separate machined aluminum pieces
- A Destaco holding clamp to latch the sensor into the apparatus

### Our Final Product



### Linear Slide Actuators



1. Stepper Motor
2. Lead Screw
3. Carriage

Two identical linear slide actuators are used within the design:

- The horizontal actuator adjusts the depth of the apparatus to accommodate various sensor sizes
- The vertical actuator is used to perform the flexing operation on the sensor

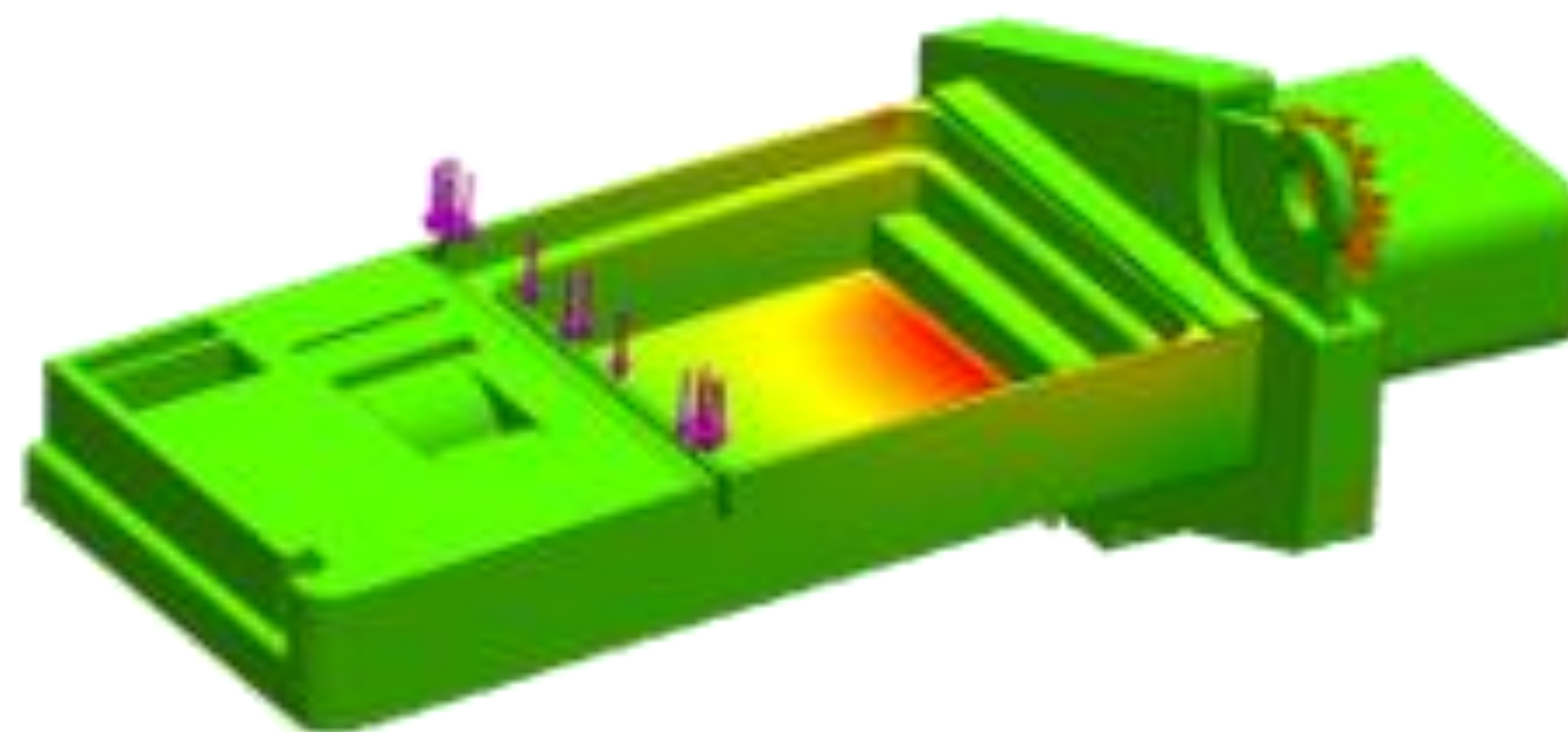
## Acknowledgements

Chris Penick (Professor) · Nathan McNeill (Professor) · Aric Harper (Project Sponsor)



## Evaluation Methods

- Operator Safety  
Pinch/amputation points and ergonomics
- Sensor Safety  
Find the force required to break the sensor  
Error of the system in the linear slide actuators
- Time Requirement  
Must perform the test quickly as all sensors produced will be tested
- Size Restriction  
Must fit within the allotted space
- Accurate and Clear Pass/Fail Indication  
Must be able to distinguish between good and bad sensors and clearly communicate the results to the operator
- Data Logging Capabilities  
Must store the location of failure on failed sensors



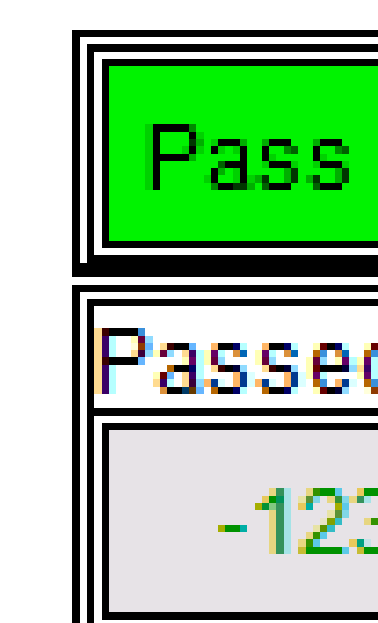
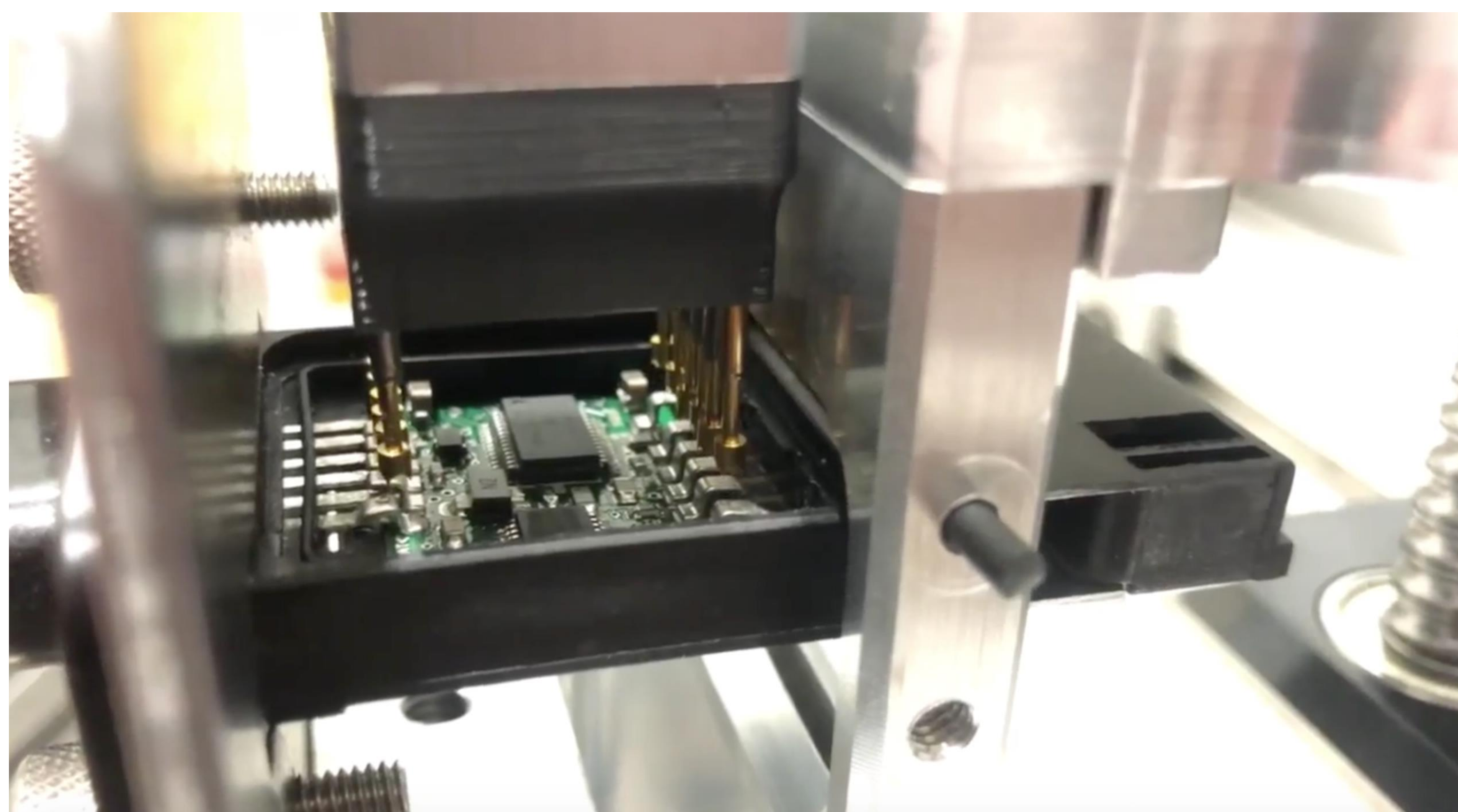
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## Results

- Operator Safety  
Sharp edges were minimized in the design and rubber stripping will be adhered to necessary edges
- Sensor Safety  
A range of safe displacements were determined and will be provided to Walker Products
- Time Requirement  
Optimal speed was determined and was within the allotted 120 seconds
- Size Restriction  
The final dimensions were well within the allowable footprint
- Accurate and Clear Pass/Fail Indication  
The apparatus has not yet been tested through a blind study
- Data Logging Capabilities  
The apparatus data logging capabilities has not yet been tested



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## Budget

### Walker Products MAFS B. O. M

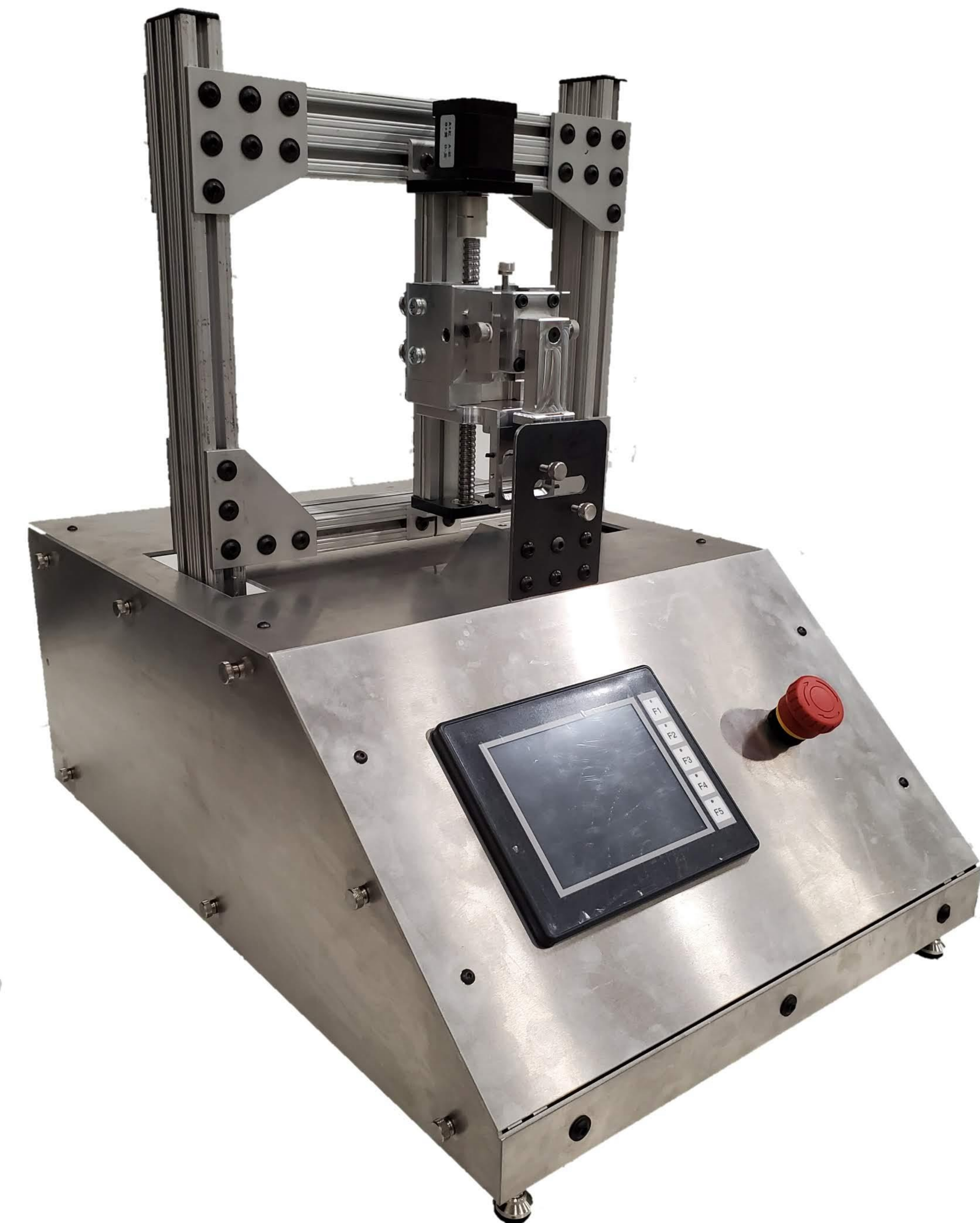
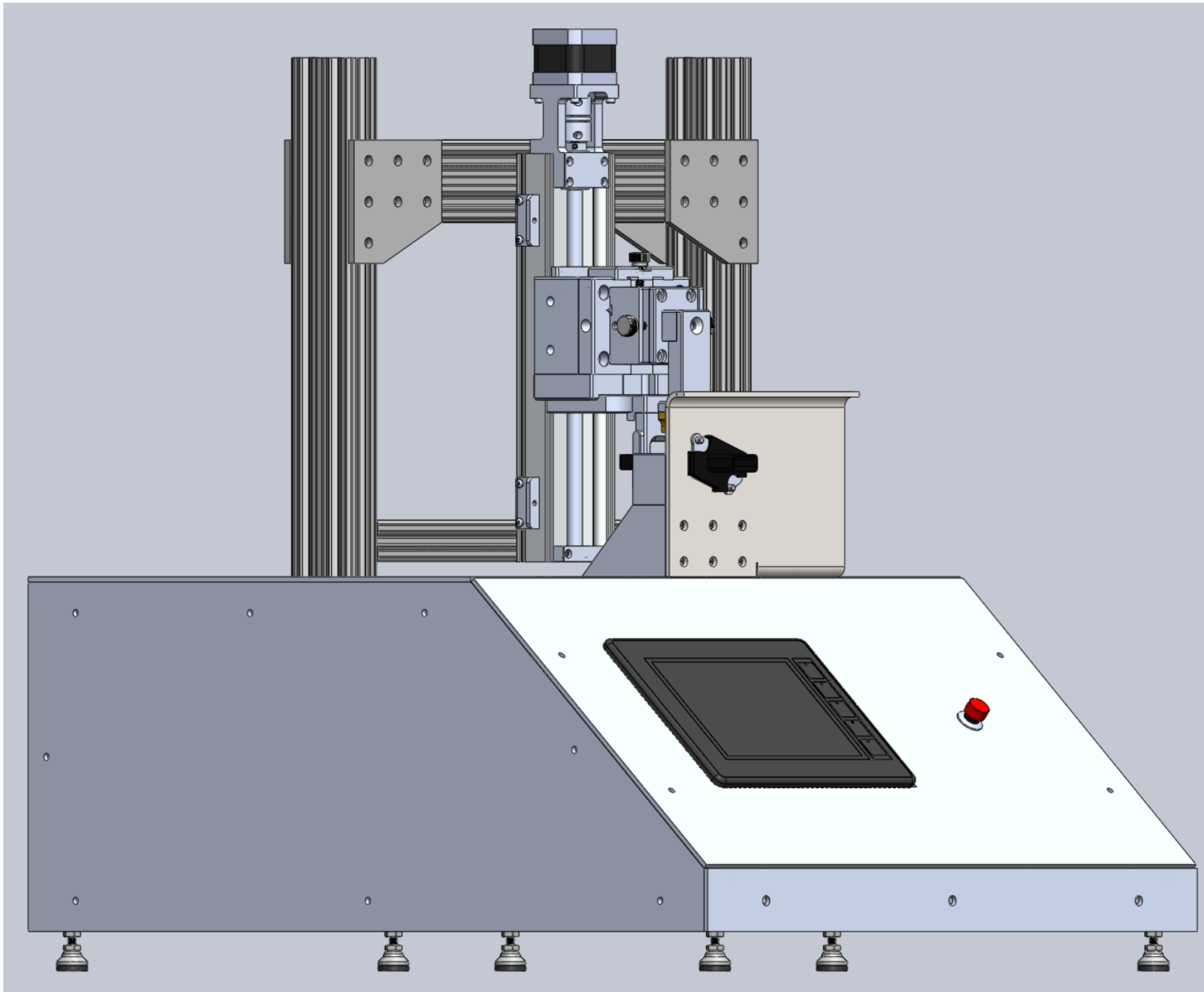
Description	Product	Part Number	Quantity	Price \$	Source
To create frame	80/20 Material	N/A	-	-	J-Catalog
To run the Arduino/actuator	PLC	CO-01DD2-D	1	\$ 101.00	automationdirect.com
To communicate with the PLC	6 in. HMI	EA3-T6CL	1	\$ 312.00	automationdirect.com
To Power the PLC and HMI	24 V Power Supply	PSE24-115	1	-	J-Catalog
Colors follow wire code	Wire	N/A	-	-	J-Catalog
To probe MAF sensor	Linear Guide Actuator W/ Stepper Motor	200192-100mm	2	\$ 158.96	ebay.com
To run the Actuator	Motor Driver	N/A	1	-	J-Catalog
To test resistance	Arduino Mega 2560	2560R3	1	-	J-Catalog
To log arduino data	Adafruit Data Logging Shield	N/A	1	-	J-Catalog
To contact pins	Spring Test Probes	5949T63	3 (Packs of 5)	\$ 31.14	mcmaster.com
To contact pins	Spring Test Probe Receptacles	5949T64	3 (Packs of 5)	\$ 20.64	mcmaster.com
To Power the Arduino	Arduino Power Supply	B018OLREG4	1	-	J-Catalog
Aesthetics	End Caps for Top 80/20	3136N22 (Black)	2	-	J-Catalog
Accommodates various MAFS	Rollers for Adjustability	2281	8	-	J-Catalog
To assemble apparatus	Hardware & Brackets	N/A	-	-	J-Catalog
Feet for the apparatus	Adjustable Feet for 80/20	6111K121	6	\$ 34.86	mcmaster.com
To bend the MAF sensor	Rubber Cord Stock	1430K53	3 ft	\$ 1.83	mcmaster.com
To cool the internal components	24 V fans	1939K49	2	\$ 53.18	mcmaster.com
Safety	E-Stop Plate	6741K55	1	\$ 8.35	mcmaster.com
Safety	E-Stop Button	8382K44	1	\$ 39.48	mcmaster.com
Support	80/20 Bracket (7-hole adapter)	4129	4	\$ 28.80	8020.net
Safety	Perforated Aluminum Sheet (24 in x 24 in)	9232T335	1	\$ 39.59	mcmaster.com
Support	80/20 Bracket (3-hole straight)	4118	5	\$ 21.50	8020.net
Support	80/20 Bracket (4-hole corner)	4136	4	\$ 22.60	8020.net
Holds linear actuator	80/20 Material	2020	300 mm	\$ 8.78	8020.net
To test resistance	5V Relays to Isolate Resistance Tests	B00VRUAHLE	9	\$ 49.50	Amazon.com
Accommodates Relays & Wiring	Breadboard	EL-CP-003	1	\$ 8.99	Amazon.com
To machine sensor holder & flexor	Aluminum Bar Stock 3.5"x3.5"x12"	9008K66	1	\$ 77.03	mcmaster.com
Holds Linear Slides	Flat Washers SAE 10	58123	2	\$ 2.78	Lowe's
Holds Linear Slides	Bolts 10-32 X 1-1/2 (6 per)	63458	4	\$ 5.12	Lowe's
Fastener	T Slot Nuts 1/4-20 (25 per)	47065t905	3	\$ 16.86	mcmaster.com
Fastener	Button Head Bolts 1/4 x 3/8-20 (50 per)	91255a537	2	\$ 14.16	mcmaster.com
Fastener	Flanged Button Head Bolts 1/4 x 3/8-20 (25 per)	91355a081	1	\$ 8.81	mcmaster.com
Side Panels	1/8 5052 Water Jetted Aluminum Sheet (5 parts)	N/A	1	\$ 147.42	All Metals Welding
Bottom Panel	1/4 5052 Aluminum	N/A	1	\$ 52.43	All Metals Welding
Hold down for top panel and HMI panel	8-32 button head screw, 5/16" long	91255A191	1	\$ 7.26	mcmaster.com
Bottom "t-slot" in actuator carriage to hold "bottom bracket"	Square nut 10-32 thread,	94855A283	1	\$ 3.39	mcmaster.com
Holds "Bottom Bracket" to linear carage	Flat head screw 10-32, 5/8" long	91253A006	1	\$ 11.77	mcmaster.com
Holds z axis dovetail, pogo pin extension, pogo pin holder	10-32 socket head screw, 1/2" long	91251A342	1	\$ 10.07	mcmaster.com
Bronze rod will be cut to 45 angle and used as locking pin for dovetail	Bronze rod, 3/16 diam, machinable	2575T2	1	\$ 15.43	mcmaster.com
Bronze rod to act as washer inside hole for set screw to distribute lock	Bronze rod, 5/16 diam, machinable	8947K23	1	\$ 8.80	mcmaster.com
Set screw to lock against bronze rod washer and angled rod to lock dovetails	Set screw, hollow, 3/8"-16, 3/16 long	91301A031	1	\$ 13.50	mcmaster.com
Thumb screw to adjust the dovetail to desired height/width while unlocked	Stainless Knurled thumb screw	91830A407	3	\$ 17.10	mcmaster.com
Holds "bender bracket" to "bottom bracket"	Flanged socket head screw, 10-32, 3/4" long	92235A514	4	\$ 16.76	mcmaster.com
For better sliding connection on bender	PTFE plastic washer 7/16" wide	95630A438	1	\$ 4.64	mcmaster.com
Dovetail Cutter (MSC) 3/4" diam, 5/16"diam cutting shank, 3/8" diam shank	3/4" diameter Dovetail cutter	1827484	1	\$ 35.30	mcmaster.com
Graphite lube			1	\$ 5.42	True Value
Bolts			1	\$ 1.30	True Value
Screws, washers, sharpie, solder, clear paint			1	\$ 17.22	True Value

Total:	Remaining
\$ 1,409.83	\$ 290.17



## Conclusion & Next Steps

- Current Progress
- Next Steps



## Acknowledgements

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