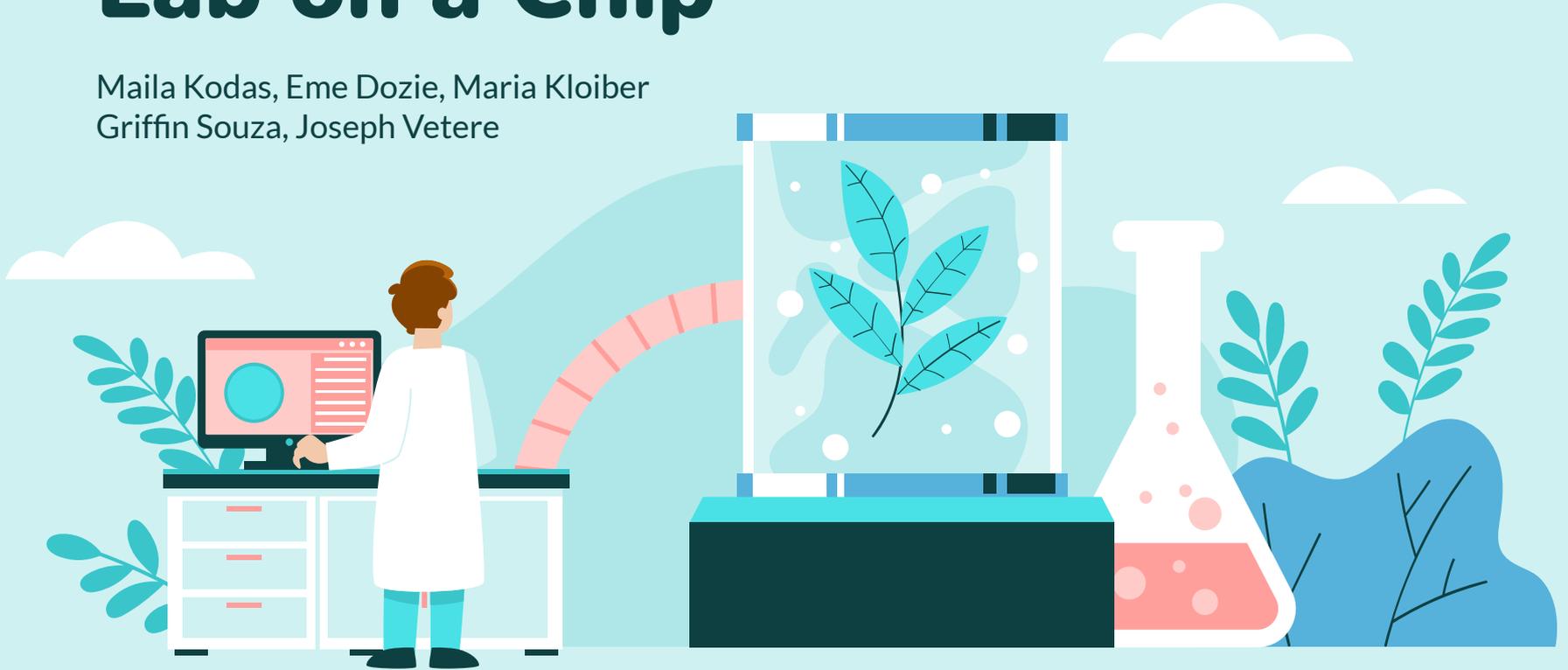


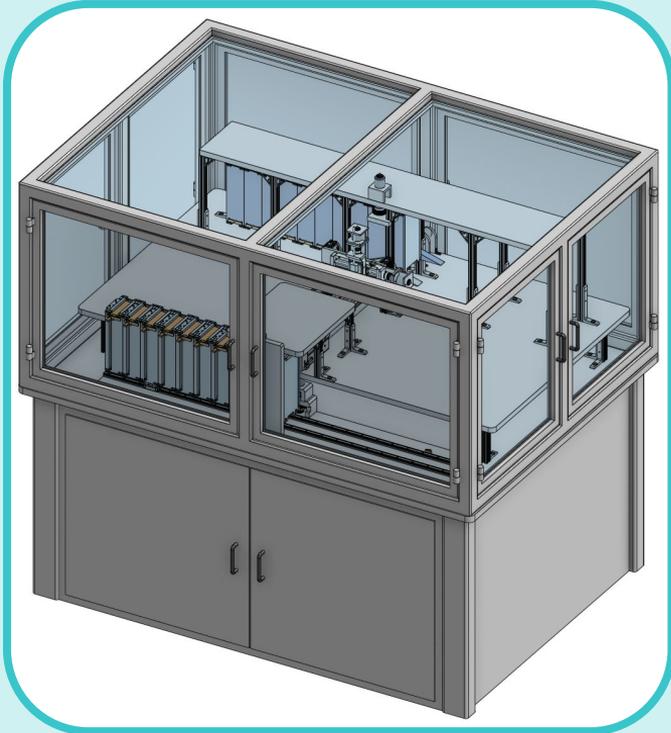
Final Design Review

Lab on a Chip

Maila Kodas, Eme Dozie, Maria Kloiber
Griffin Souza, Joseph Vetere



Presentation Overview



01 Final Project CAD

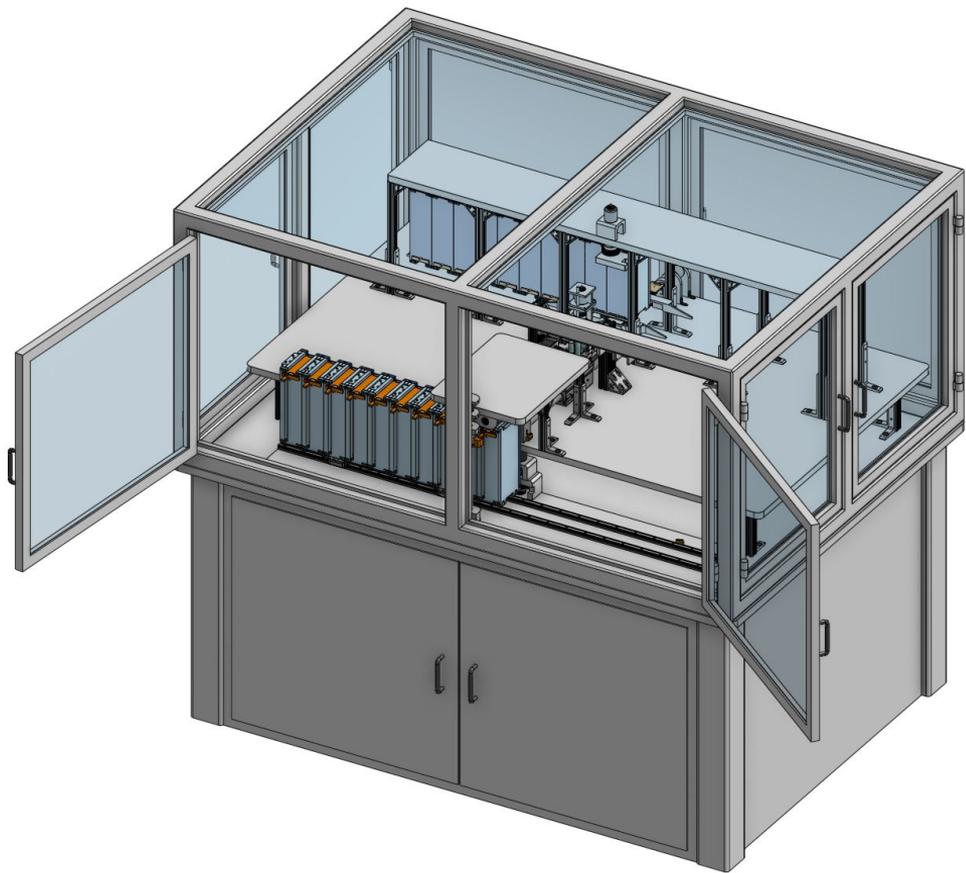
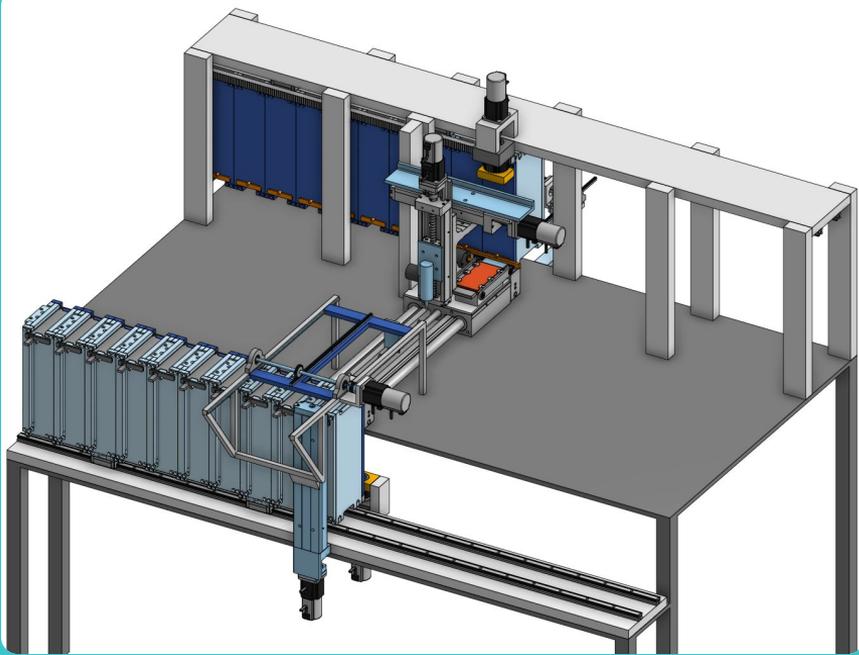
02 Machine Modules

03 User Interface

04 Control Flowchart

05 Financial Justification

Final CAD - PDR to FDR



Primary updates from PDR to FDR include:

- Added enclosure & finalized fixturing
- Replaced rack & pinions with ball screws
- Addition of sensors and final motors

Financial Justification - Overview

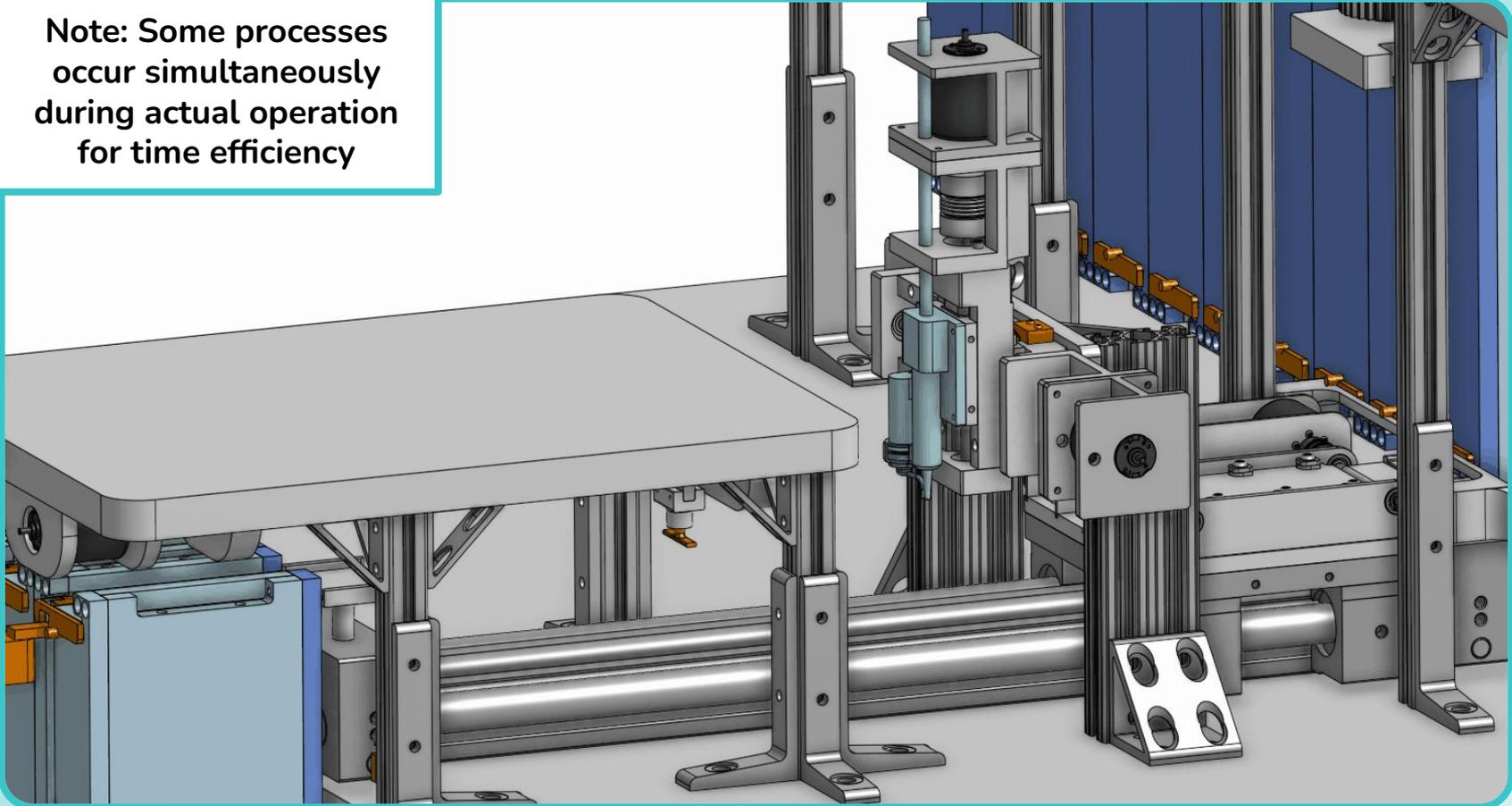
Net Present Value:
\$8,859,483

Payback Period:
0.28 Years*

*From Installation

Final CAD - In Operation

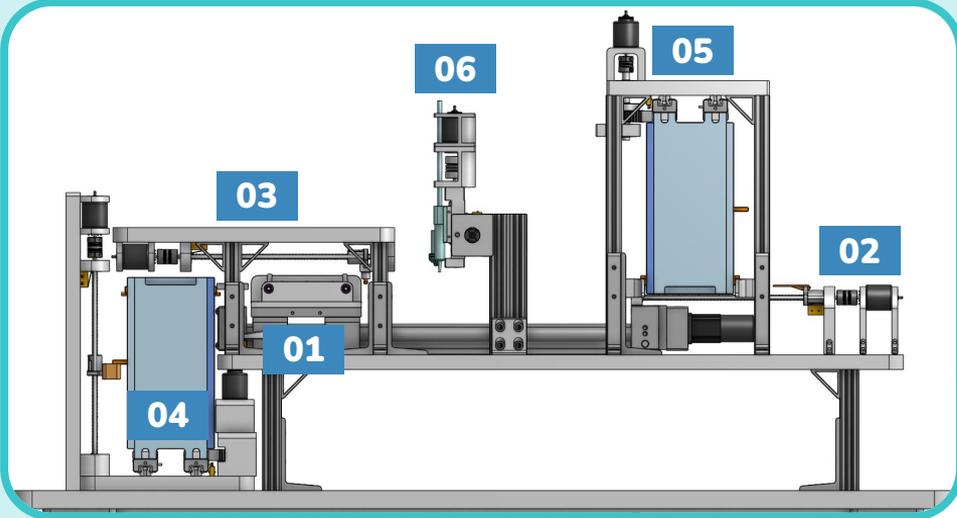
Note: Some processes occur simultaneously during actual operation for time efficiency



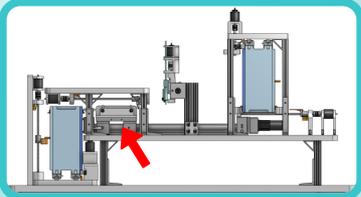
Bill of Materials

Part	Quantity	Manufacturer	Model Number
Ball Screw Linear Drive	1	Thomson Industries, Inc.	2DB12-200118
Ball Screw	1	Thomson Industries, Inc.	RM1605FDZ1-250.00RW-XX-XX
Horizontal Lead Screw	1	Thomson Industries, Inc.	MS25LAN0188-045N001A0A00
Vertical Lead Screw	1	Thomson Industries, Inc.	MS25LAN0098-045N001A0A07
Brushed DC Servo Motor	9	Parker Hannifin Corporation	RS110MR1000
Brushless DC Servo Motor	1	Aerotech, Inc.	BMS35
Force Sensor	1	Adafruit Industries	166
Limit Switch	10	Automation Direct	176111-1
Solenoid	1	Testco, Inc.	123421-031

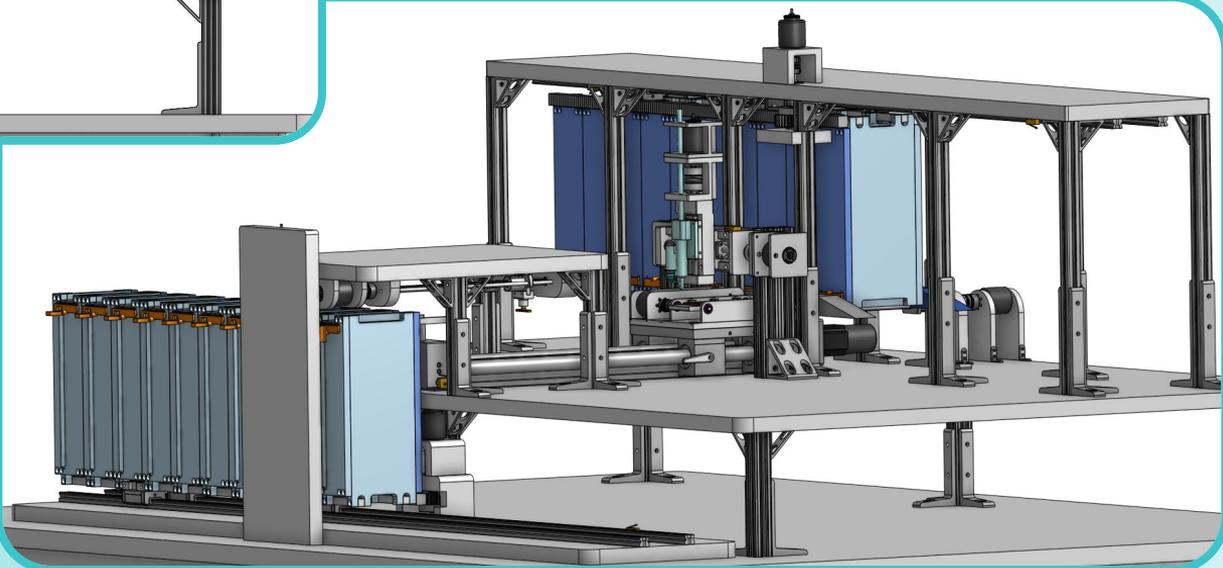
Final CAD - Modules



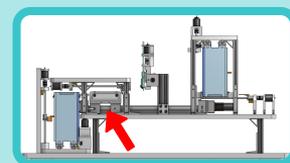
- 01 Chip Fixturing
- 02 Chip Push
- 03 Chip Pull
- 04 Cassette Load
- 05 Cassette Unload
- 06 Pump



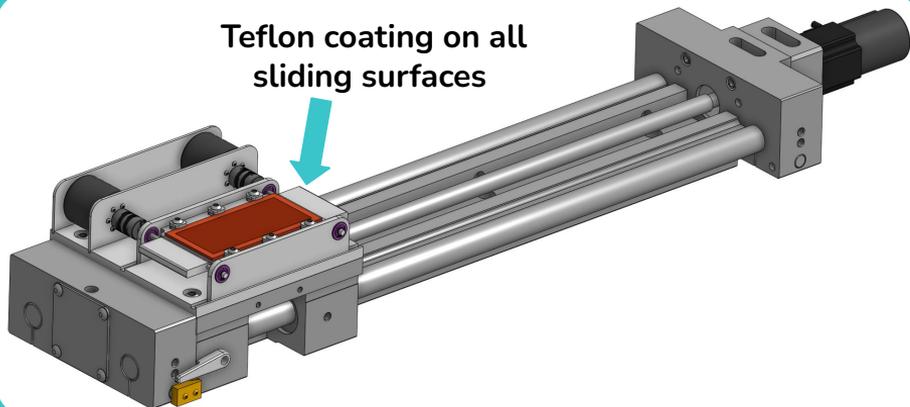
Visual guide provided on subsequent slides



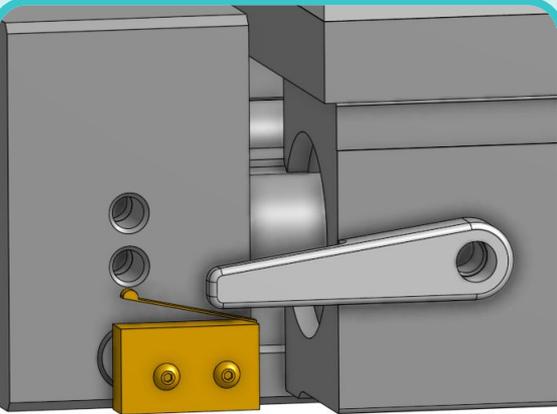
Module - Chip Fixturing Assembly



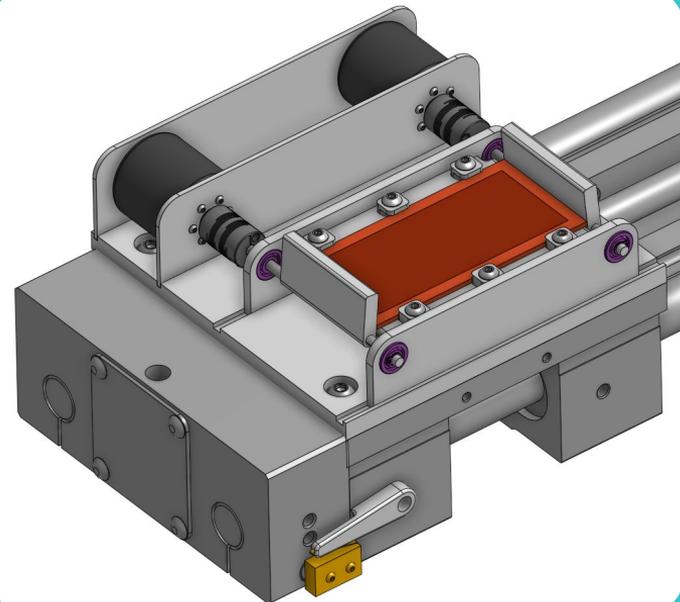
Teflon coating on all sliding surfaces



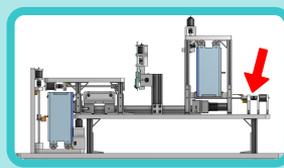
Each fixturing flap is controlled by Parker Servo Motor + Flexible Coupling + Bearing Pair secured by retaining rings on shafts



Linear Drive features Aerotech Brushless Servo Motor with Limit switch for homing

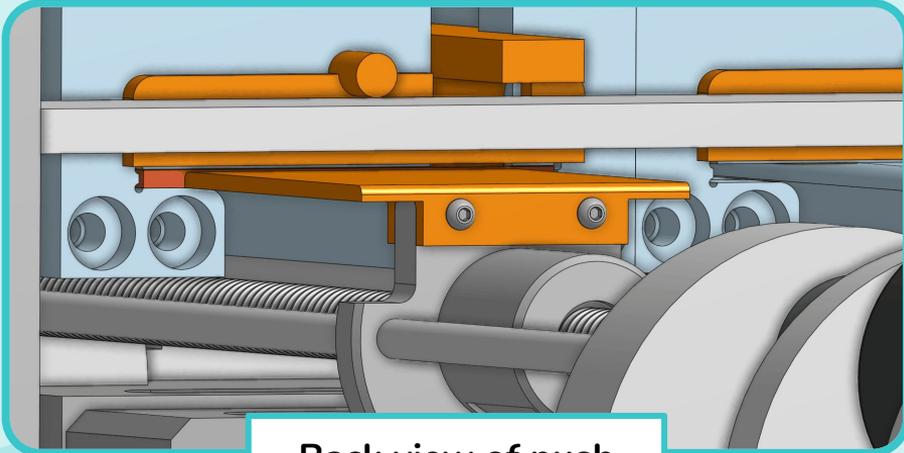
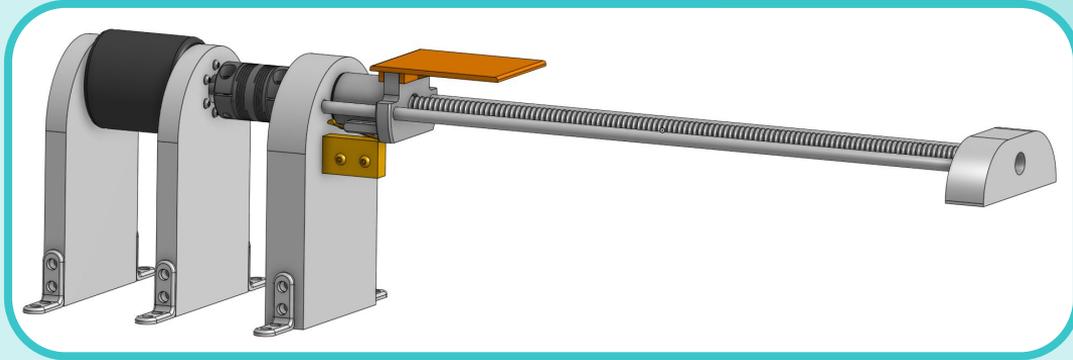


Module - Chip Push Assembly

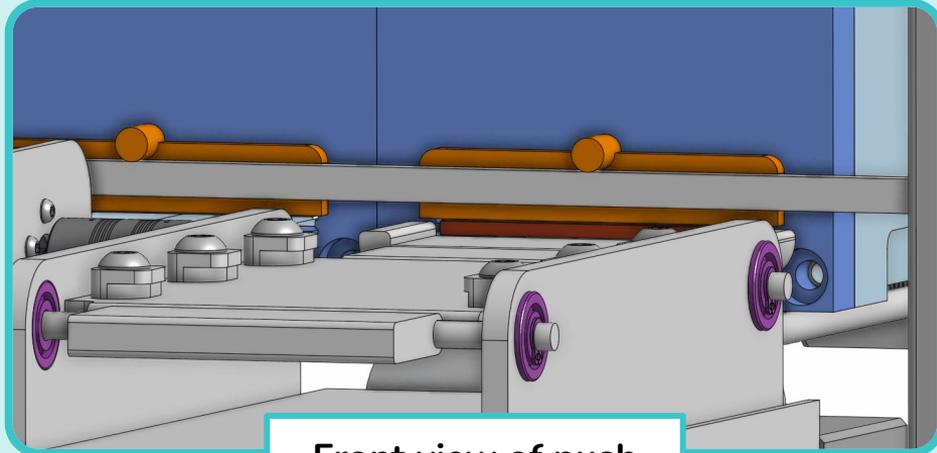


Chip push mechanism previously consisted of a rack and pinion actuator

- Rack & Pinion required too much space
- Ball Screw reduced required torque and reduced footprint of mechanism
- Servo motor + limit switch for control

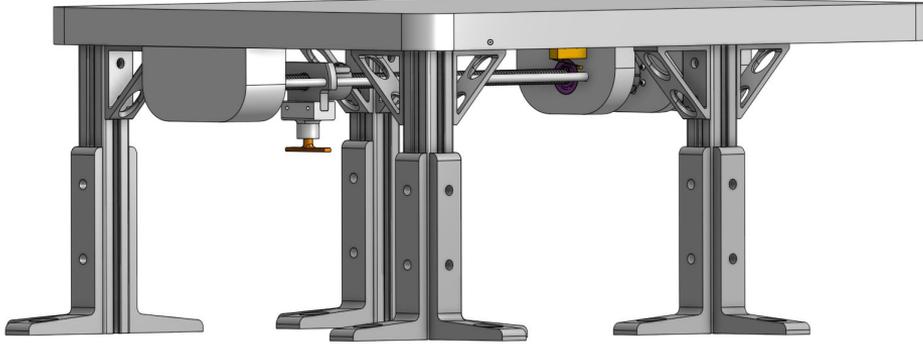
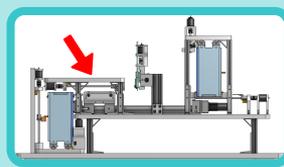


Back view of push



Front view of push

Module - Chip Pull Assembly

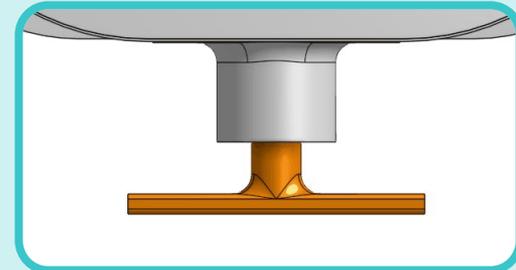
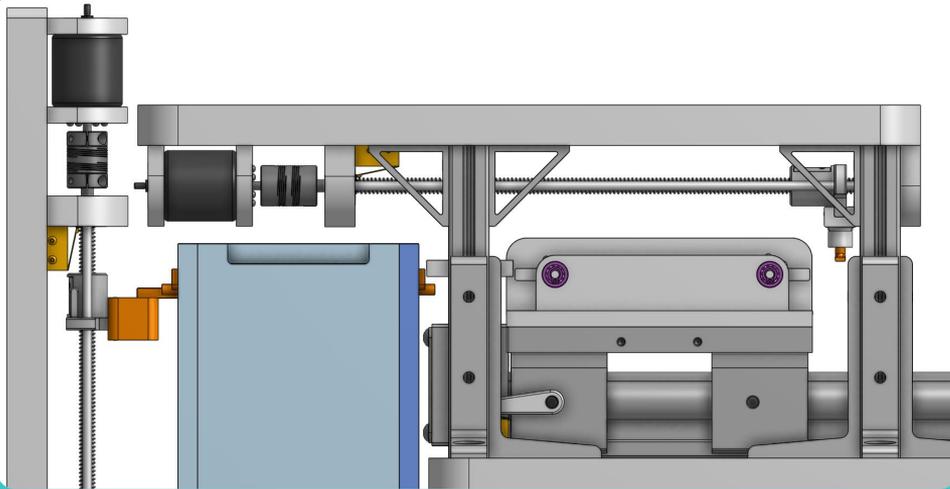


Chip pull mechanism was also changed from Rack & Pinion to Ball Screw actuator

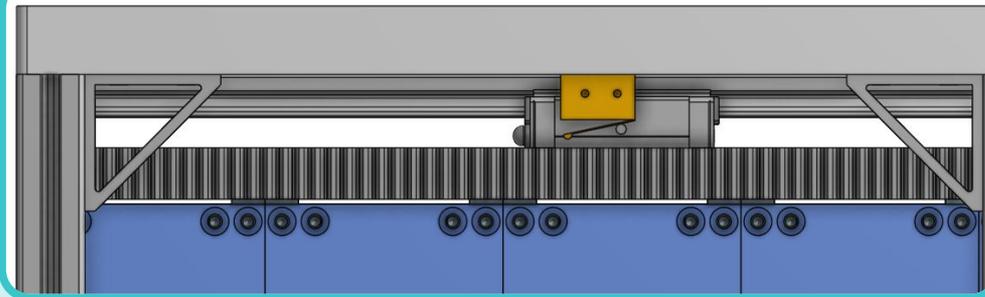
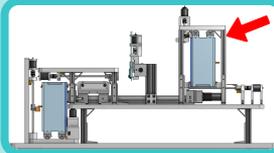
- Ball Screw is more expensive, but reducing footprint of machine reduces cost of materials

Features:

- Carefully integrated to prevent collision with other modules
- Servo motor + limit switch for control
- Solenoid engages to drag chip

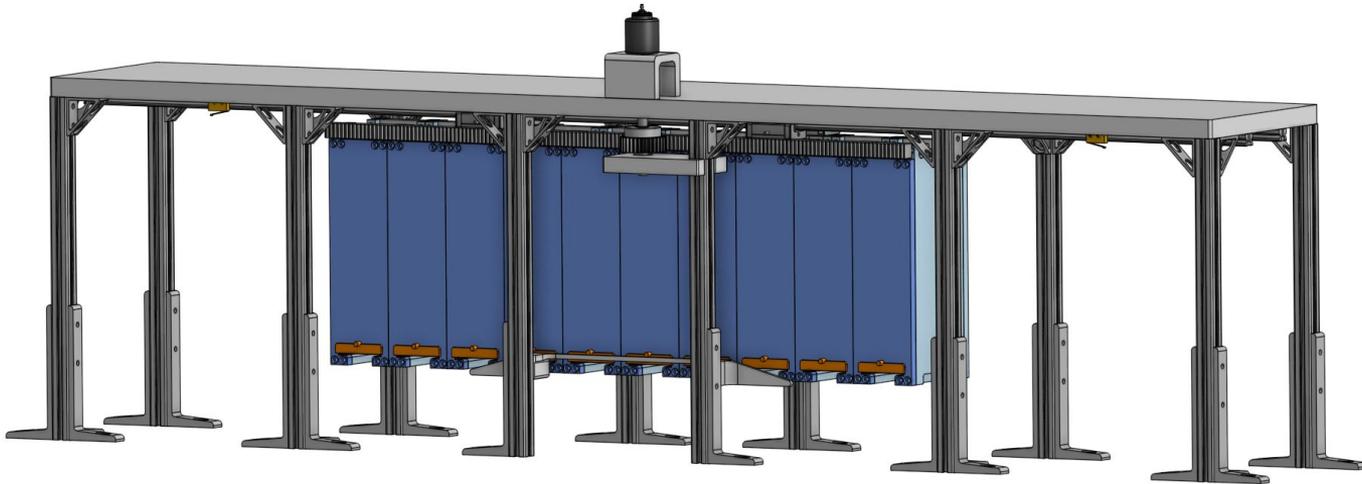


Module - Unload Assembly

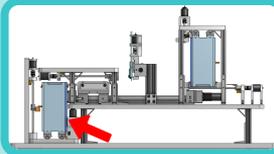


Cassettes remain unchanged from initial design, overall assembly has been updated:

- Added limit switches on either end
- Selected motor: Parker RS110MR1000
- Changed supports to 80/20 framing

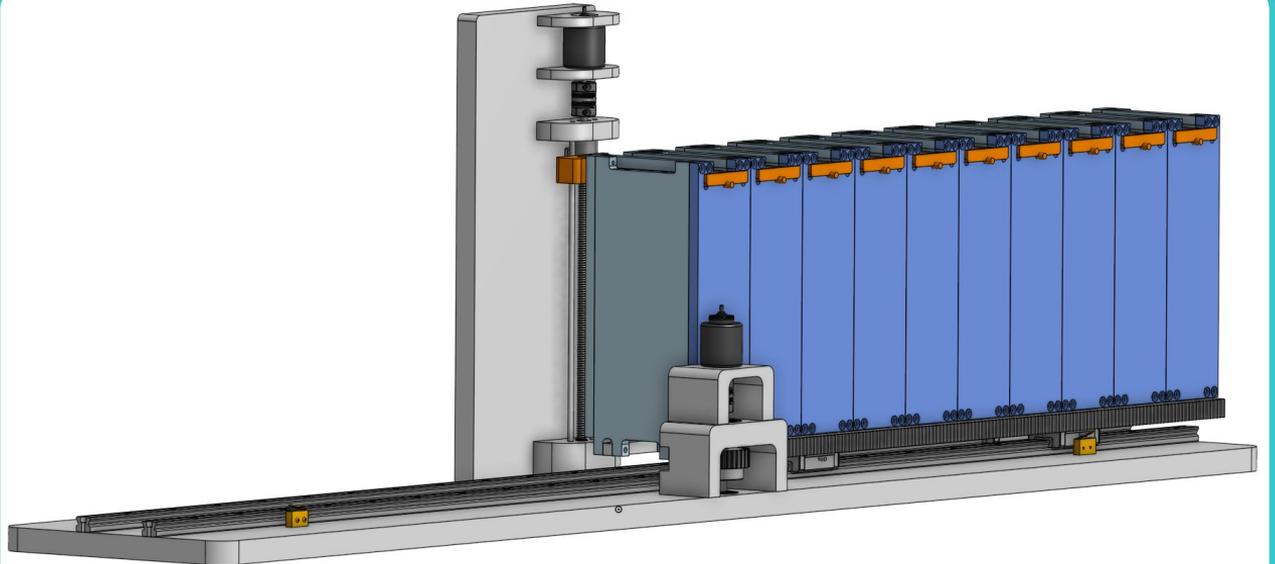
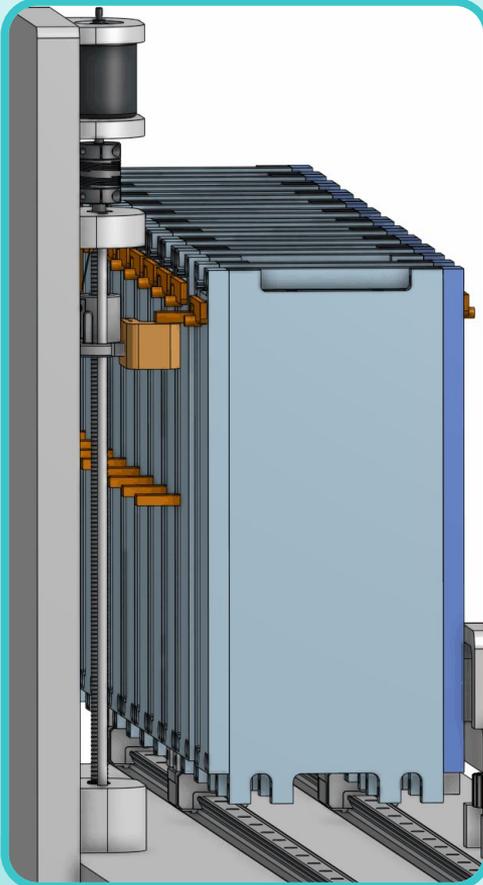


Module - Load Assembly

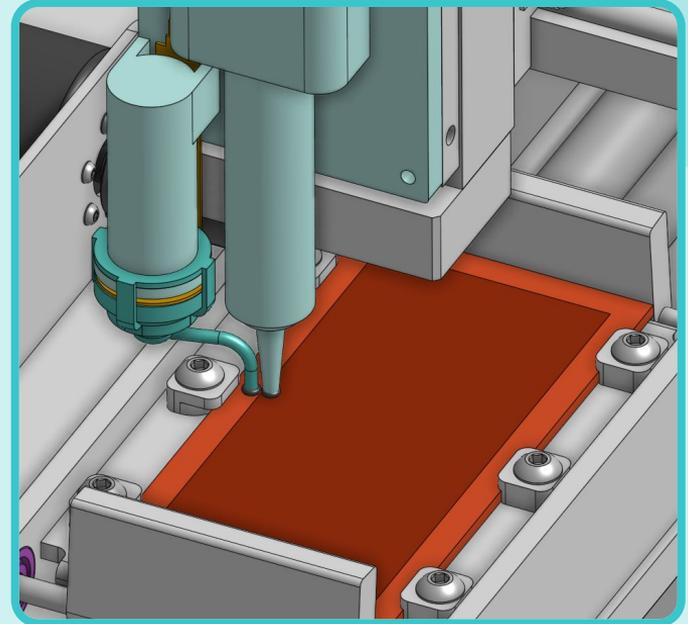
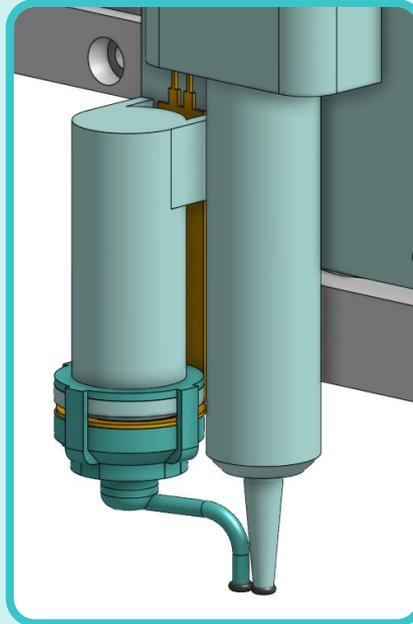
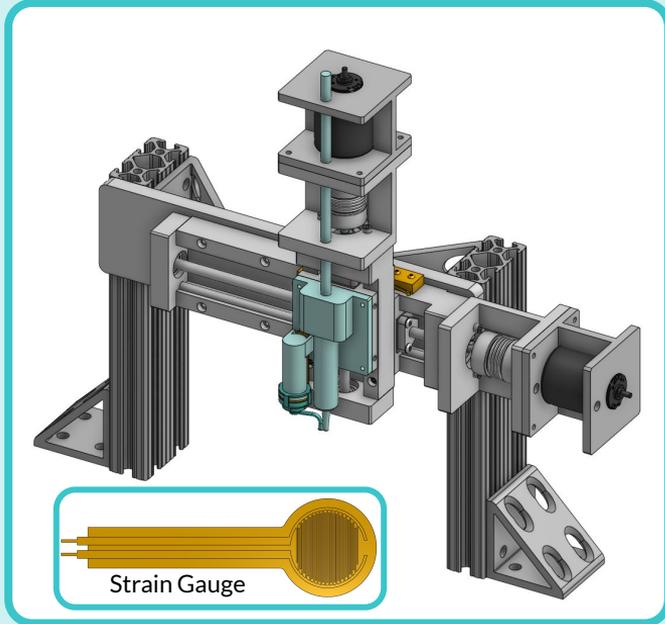
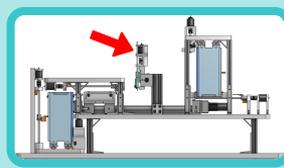


Load Assembly allows chips to be added one at a time by the machine

- Added limit switches for safety and homing
- Selected motor: Parker RS110MR1000
- Modified Follower Ball Screw



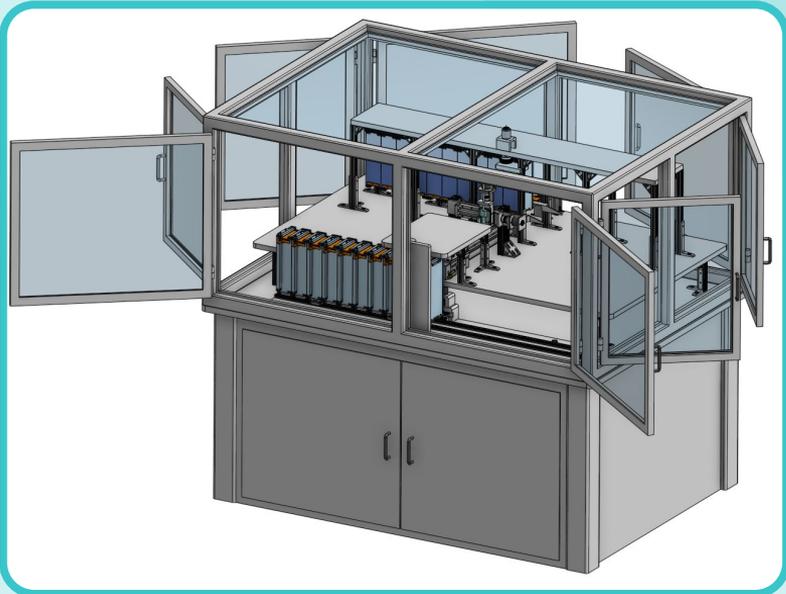
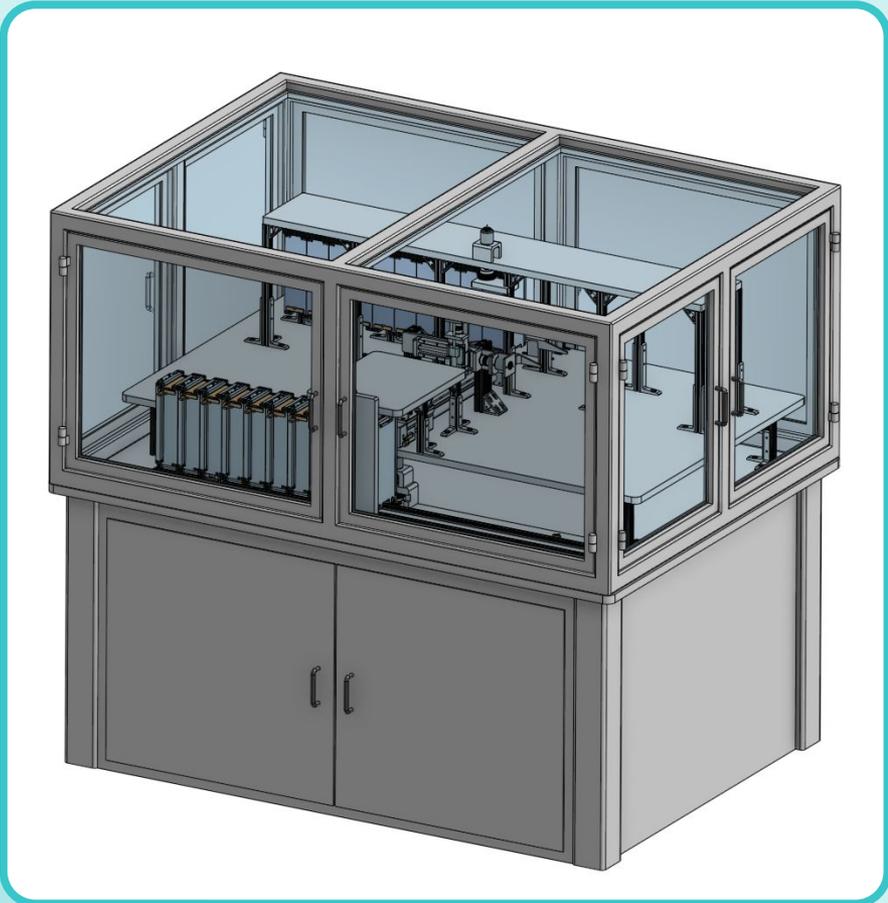
Module - Pump Assembly



Force Sensor consists of flexible Strain Gauge to measure 0.5 pound force on chip

- Placed as close to nozzle as possible, matching O rings allow for accurate measurement
- Designed to avoid collision even when pumping at extremes of chip exclusion zone

Machine Enclosure



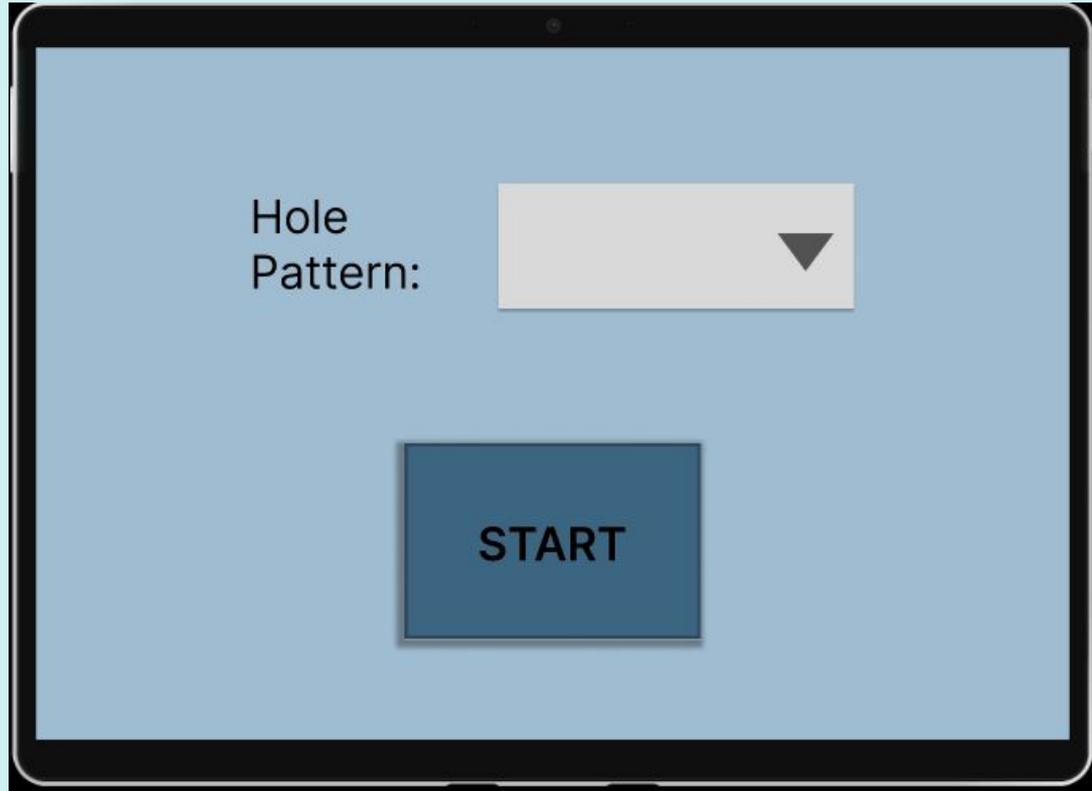
Enclosure features doors on every side for easy loading, repairs, & ergonomics

Gaskets on doors seal from dust

Electronics may be safely housed below

User Interface

User begins by selecting the correct hole pattern from pre-programmed drop down list

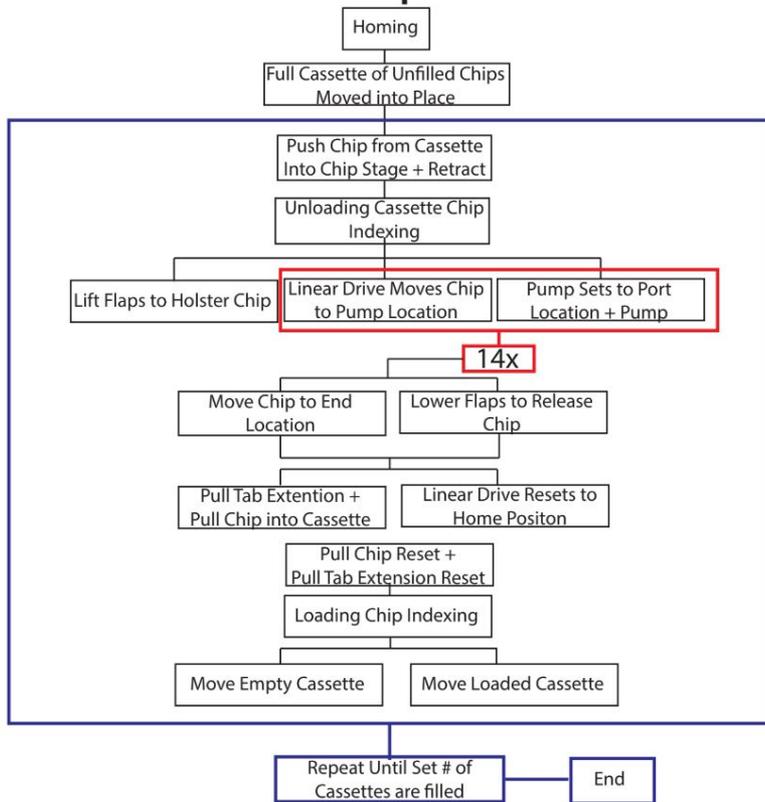


Status bar will report any errors or display current process

“Pumping”
“Unloading”
“Loading”
“Error! Jam”

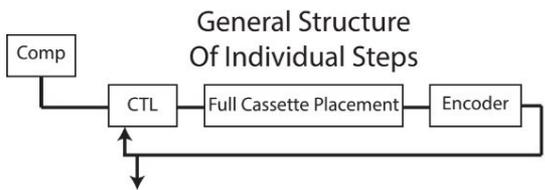
Control Flowchart Order of Operations

Order of Operations

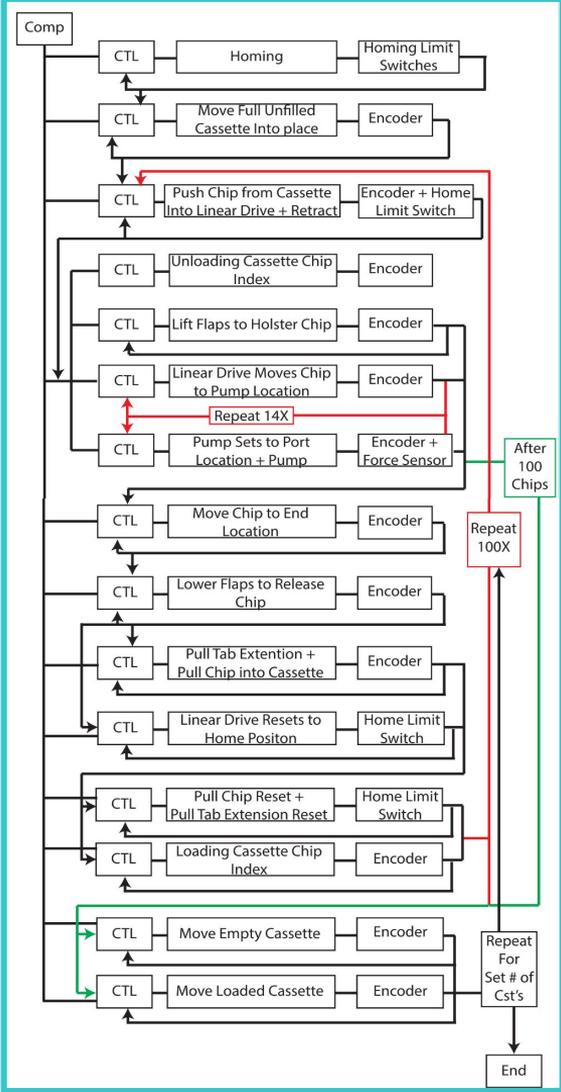


Parallel boxes indicates parallel processes.

This allows for more time for individual processes by “overlapping” some of chip processing.



Control Flowchart



10 total encoders are present within the motors, paired with a force sensor and 10 limit switches.

Financial Justification - Overview

Net Present Value:
\$8,859,483

Payback Period:
0.28 Years*



*From Installation



Financial Justification - Manual Production

Number of Operators	1
Number of Shifts	1
Time per Chip	10 minutes
Total Yearly Manual Production	12,480 Chips
Operator Hourly Wage	\$50
Total Operator Cost per Year	\$104,000



Financial Justification - Automated Production

Number of Operators Eliminated	1
Number of Shifts	1
Time per Chip	1.5 minutes
Total Yearly Automated Production	83,200 Chips
Yearly Maintenance Cost Estimate	\$10,000



Financial Justification - Automated VS Manual

Automated / Manual Production Rate	6.67
Profit per Chip	\$25
Manual Production Inventory Value	\$312,000
Automated Production Inventory Value	\$2,080,000
C _n	\$2,174,000
R	0.1

Profit per chip estimated from Fivephoton Biochemicals selling price of \$50 per chip with an estimated 50% margin

Financial Justification - Initial Investment Cost

Engineering Time cost:	\$564,000
Materials Cost:	\$15,994.92
Purchased Parts Cost:	\$11,459.73
Sensors Cost	\$117.00
PID Controllers Cost	\$4,000
Motors Cost	\$3,282.80
Pump Cost	\$10,000
Total Initial Cost (Co)	\$608,854



Financial Justification - Pro Forma Analysis

Year		0	1	2	3	4	5	6
Development Cost		-608,854						
Profit			2,080,000	2,080,000	2,080,000	2,080,000	2,080,000	2,080,000
Labor Savings			104,000	104,000	104,000	104,000	104,000	104,000
Maintenance			-10,000	-10,000	-10,000	-10,000	-10,000	-10,000
Annual Cash Flow		-608,854	2,174,000	2,174,000	2,174,000	2,174,000	2,174,000	2,174,000
Cumulative Cash Flow		-608,854	1,565,146	3,739,146	5,913,146	8,087,146	10,261,146	12,435,146
NPV of Cash Flow			1976364	1796694	1633358	1484871	1349883	1227166
R	0.1							
Net Present Value	8,859,483	\$						
Payback Period	0.28	years						

Financial Justification - Overview

Net Present Value:
\$8,859,483

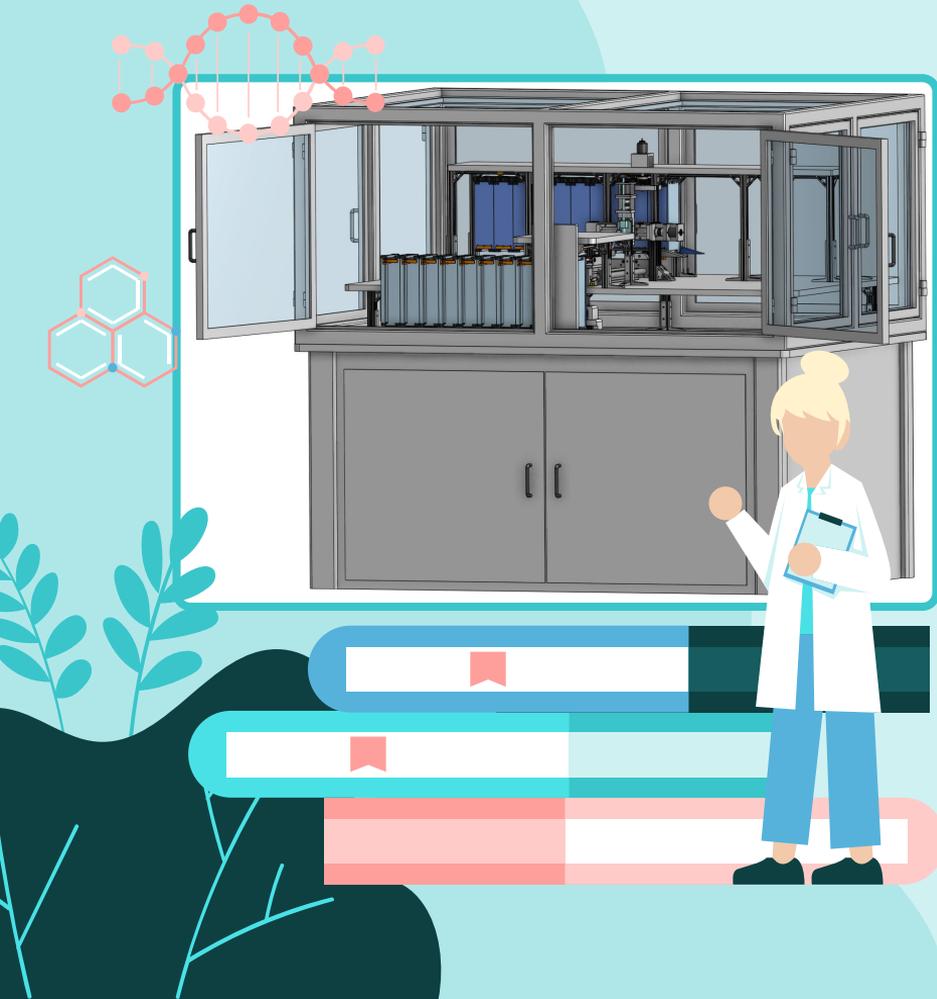
Payback Period:
0.28 Years*

*From Installation

THANK YOU

QUESTIONS?

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Appendix A: Financial Justification

Automated					Manual:	
Year	Cost	Increased Profit	Cn	Cost of Money	# of Operators	1
0	\$608,854	0	0		# of Shifts	1
1	\$10,000	\$2,184,000	\$2,174,000	\$1,976,364	Cost per operator per hour	\$50.00
2	\$10,000	\$2,184,000	\$2,174,000	\$1,796,694	Total Cost per year	\$104,000.00
3	\$10,000	\$2,184,000	\$2,174,000	\$1,633,358	Production per year	12480
4	\$10,000	\$2,184,000	\$2,174,000	\$1,484,871		
5	\$10,000	\$2,184,000	\$2,174,000	\$1,349,883	Profit per Chip	25
6	\$10,000	\$2,184,000	\$2,174,000	\$1,227,166	Manual Production Inventory Value	312000
Auto/Manual Production Rate	6.666666667				R	0.1
Engineering Time cost:	\$564,000					
Materials Cost:	\$15,994.92				NPV	\$8,859,483
Purchased Parts Cost:	\$11,459.73					
Sensors Cost	\$117.00				Payback Period	0.28
PID Controllers Cost	\$4,000					
Motors Cost	\$3,282.80					
Pump Cost	\$10,000					
Total Initial Cost (Co)	\$608,854					

Number of Engineers	Cost per Hour	# of weeks working part time	# of weeks working full time	Total hours	Total cost
5	\$120	14	20	4700	\$564,000

Sensor Type	Module	Single Cost	Quantity	Total Cost	Link
Force Sensor	Pump	\$7.00	1	\$7.00	https://www.adafruit.com/product/166
Limit Switch	Multiple	\$11.00	10	\$110.00	https://www.automationdirect.com/adc/shopping/catalog/sensors -z- encoders/limit switches/lever with roller actuator/176111-1?gclid=Cj0KCOiAyracBhDoARIsACGFcS4IHgTO3eMH5NKZ-TVLn6Zlazce-JFXgobrNWbse6lsdv_p1VDd47IaAlurEALw_wcB
				Total Cost	\$117.00

Motors	Description	Single Cost	Quantity	Total Cost	Link
Aerotech BMS35	Brushless DC Servo Motor	\$1,580	1	\$1,580	https://buy.motionplusmore.com/ccrz_ProductDetails?sku=BMS35&cclcl=en_US
Parker RS110MR1000	Brushed DC Servo Motor	\$189.20	9	\$1,702.80	https://ph.parker.com/us/en/high-performance-dc-servo-motor-rs-series/rs110mr1000
				Total Cost	\$3,282.80

Part	Module	Single Cost	Quantity	Total Cost	Link
Ball Screw Linear Drive	Chip Movement	\$3,887.03	1	\$3,887.03	https://www.tho
Ball Screw	Chip Push	\$242.24	1	\$242.24	https://www.tho
Lead Screw (Horizontal)	Pump	\$980.62	1	\$980.62	https://drive.goo
Lead Screw (Vertical)	Pump	\$955.09	1	\$955.09	https://drive.goo
10mm Shaft Angular Bearing	Cassette	\$31.70	2	\$63.40	https://us.misum
10mm Shaft Ball Bearing	Load/Unload	\$10.29	2	\$20.58	https://us.misum
Ball Bearing Carriage	Cassette	\$130.36	8	\$1,042.88	https://www.mcr
10mm Flexible Coupling	Load/Unload	\$143.64	2	\$287.28	https://us.misum
6mm Flexible Shaft Coupling	Push/Pull/Load	\$59.97	5	\$299.85	https://us.misum
10mm Retaining Ring	Load/Unload	\$0.88	7	\$6.16	https://us.misum
Gear Rack	Load/Unload	\$178.54	2	\$357.08	https://us.misum
Spring loaded pin	Cassette	\$4.37	20	\$87.40	https://www.mcr
Solenoid	Pull	\$39.90	1	\$39.90	https://www.test
Guide Rail	Cassette	\$464	4	\$1,856	https://www.mcr
Gear	Load/Unload	\$31.85	2	\$63.70	https://us.misum
Gusset	Unload	\$10.54	53	\$558.62	https://www.mcr
Long Foot	Unload	\$12.98	36	\$467.28	https://www.mcr
Short Foot	Table/Pull	\$12.98	14	\$181.72	https://www.mcr
Double Gusset	Pump	\$25.63	2	\$51.26	https://www.mcr
Handle	Enclosure	\$0.97	12	\$11.64	https://www.mcr
				Total Cost	\$11,459.73

Material	Cost per Unit	Quantity	Total Cost	Link
80/20 Aluminum 20mm	0.011167979	5905.604	72.54902762	https://www.mcmaster.com/5537T101-5537T504/
Aluminum Sheet	0.002021644017	4767181.702	10601.2988	https://www.mcmaster.com/5865T79-5865T84/
80/20 Aluminum Double	\$12.98	2	\$28.56	https://www.mcmaster.com/47065T107-47065T418/
HDPE	0.00008365912999	905042.0274	83.28653148	https://www.mcmaster.com/8619K117/
Acrylic	0.00005466478972	5046800	303.4704868	https://www.plasticsheets.com/5mm-clear-acrylic-sheet-2040x3040/
4" x 4" Steel Tubing	0.08458005249	3200	297.7217848	https://www.mcmaster.com/6527K444-6527K44/
1.5" x 2.5" Steel Tubing	0.05710301837	5067.2	318.2876562	Used Like: https://www.mcmaster.com/6527K434-6527K43/
2" x 2" Steel Tubing	0.02853783902	18800	590.1625109	Used Like: https://www.mcmaster.com/6527K89-6527K893/
5mm Aluminum Sheet	0.000436351706	6113896	2934.589845	https://www.mcmaster.com/9146T44-9146T446/
1" x 1" Aluminum tubing	0.02777230971	22000	672.089895	https://www.mcmaster.com/88875K54-88875K33/
4" x 4" Aluminum Block	0.3748797025	225.3	92.90643668	https://www.mcmaster.com/9008K68-9008K42/
			Total Cost	\$15,994.92

Material cost calculated by unit length or unit area depending on which applied best to application