# Final Presentation
# Team 24

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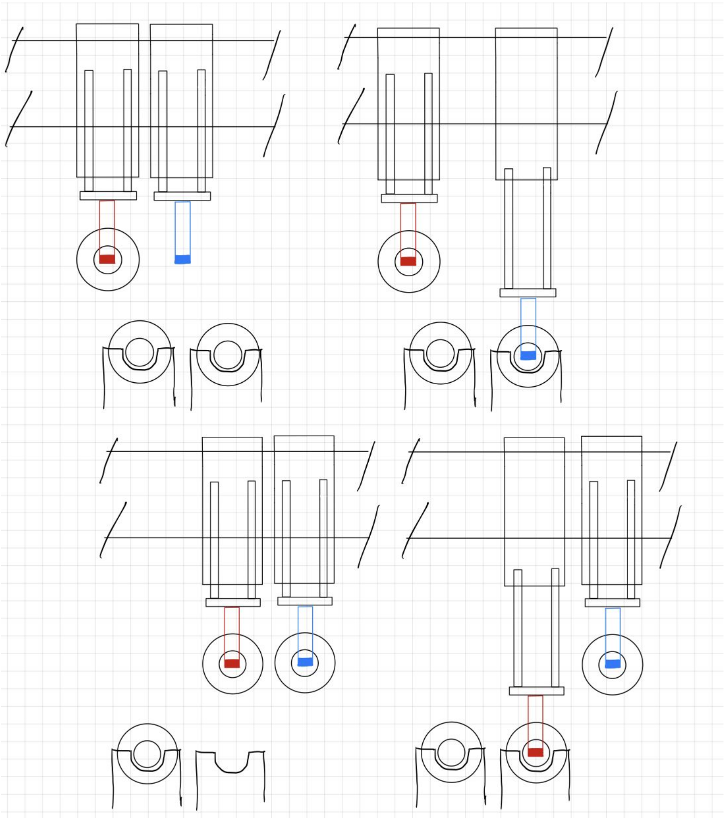
isola

ASU

# Problem Statement

Isola's current copper foil roll changeover solution is largely a manual process and takes 2 min which is far longer than it should, decreasing their ability to fill out next-day Printed Circuit Board (PCB) orders. Along with that it currently can only hold 2 rolls, because of this it has become a bottleneck in the PCB material production line.

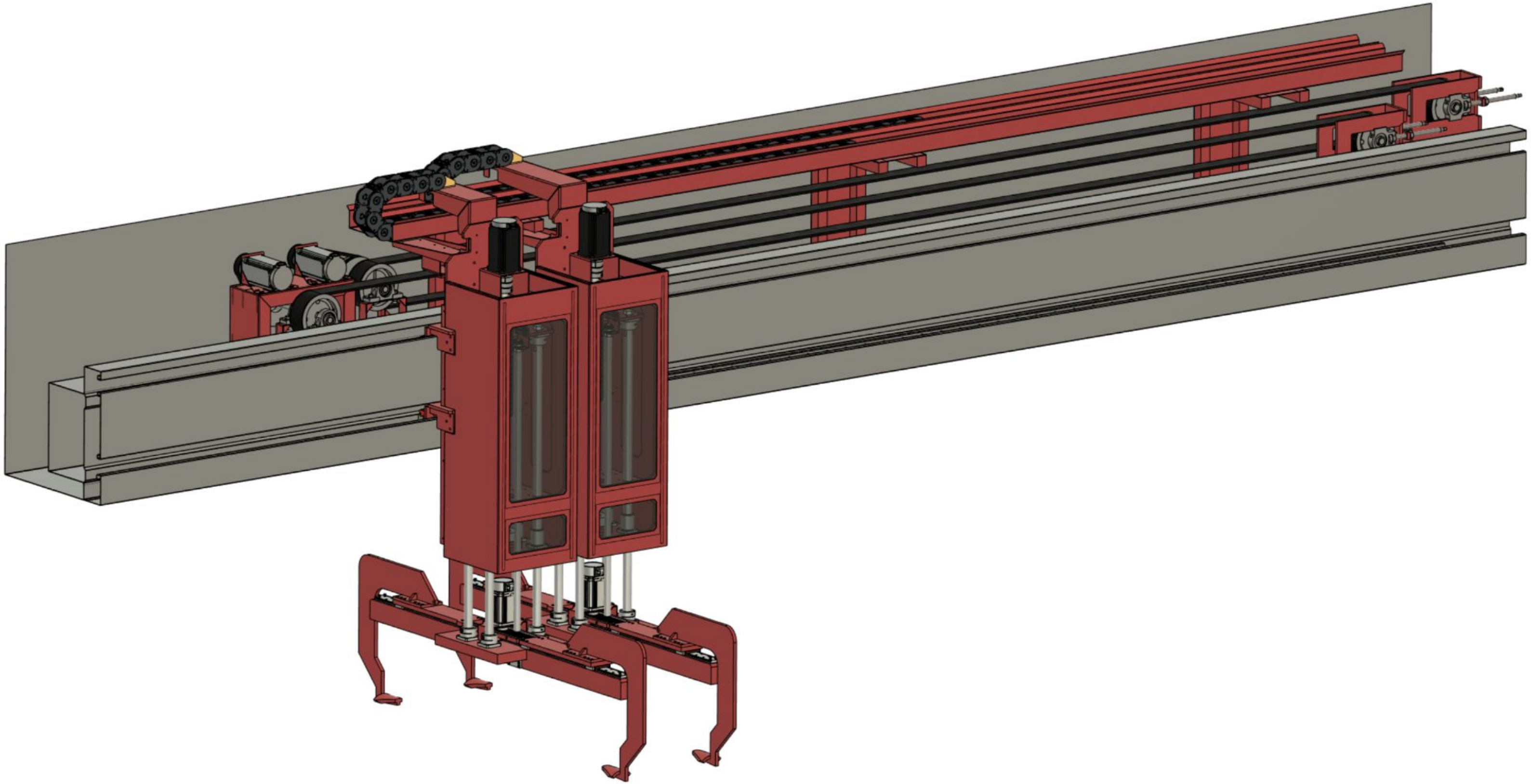
# Concept: Dual Head Lifter



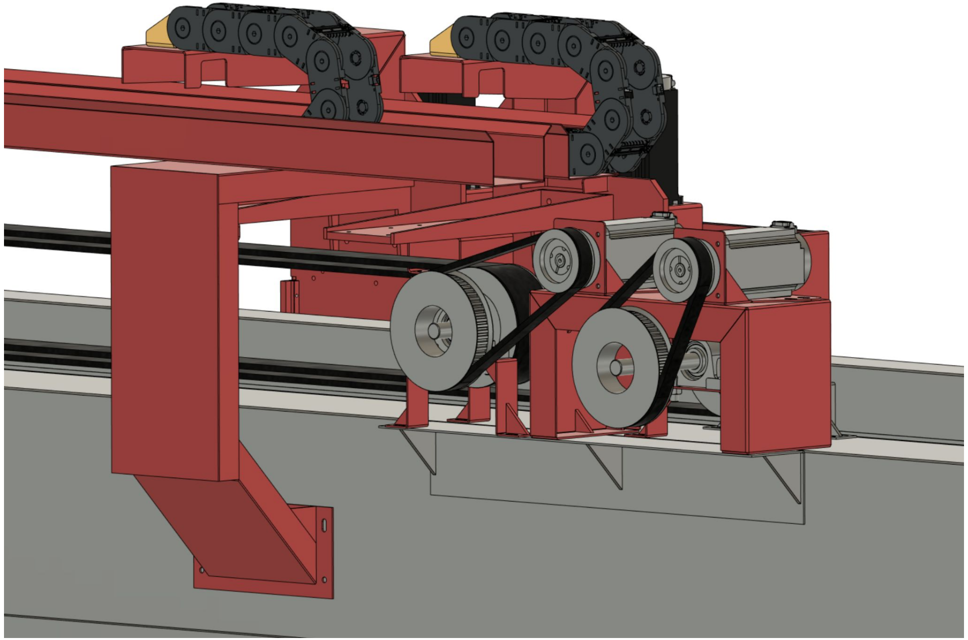
The automated hoist system features two independently driven cranes designed to efficiently replace copper rolls. The system utilizes two lifters, each capable of holding a roll, for quicker and smoother roll changes. With the ability to pick up and deposit rolls without damaging the copper, the machine reduces stress on the operator, making it a highly effective and reliable solution for automated or semi-automated roll replacement.

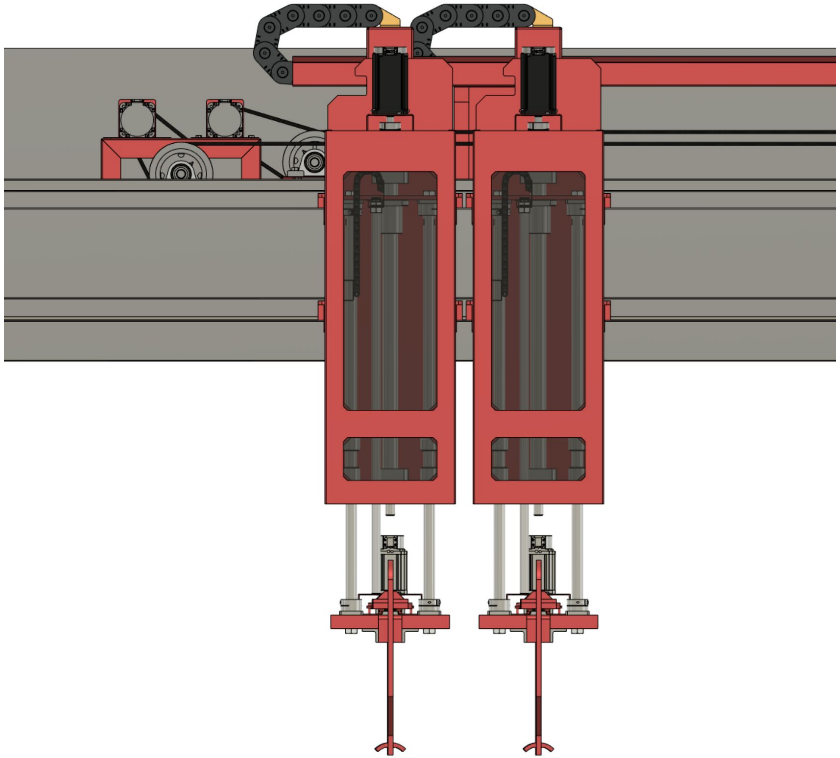
| Pros | Cons |
| --- | --- |
| • Holds 2 rolls<br>• Can be attached to existing gantry<br>• Allows rolls to be picked up and dropped simultaneously, speeding up changeover time<br>• All loads are vertical | • May not fit on the existing gantry<br>• Requires a second drive system<br>• May be expensive |

# Full Assembly



# Detailed View Full Assembly





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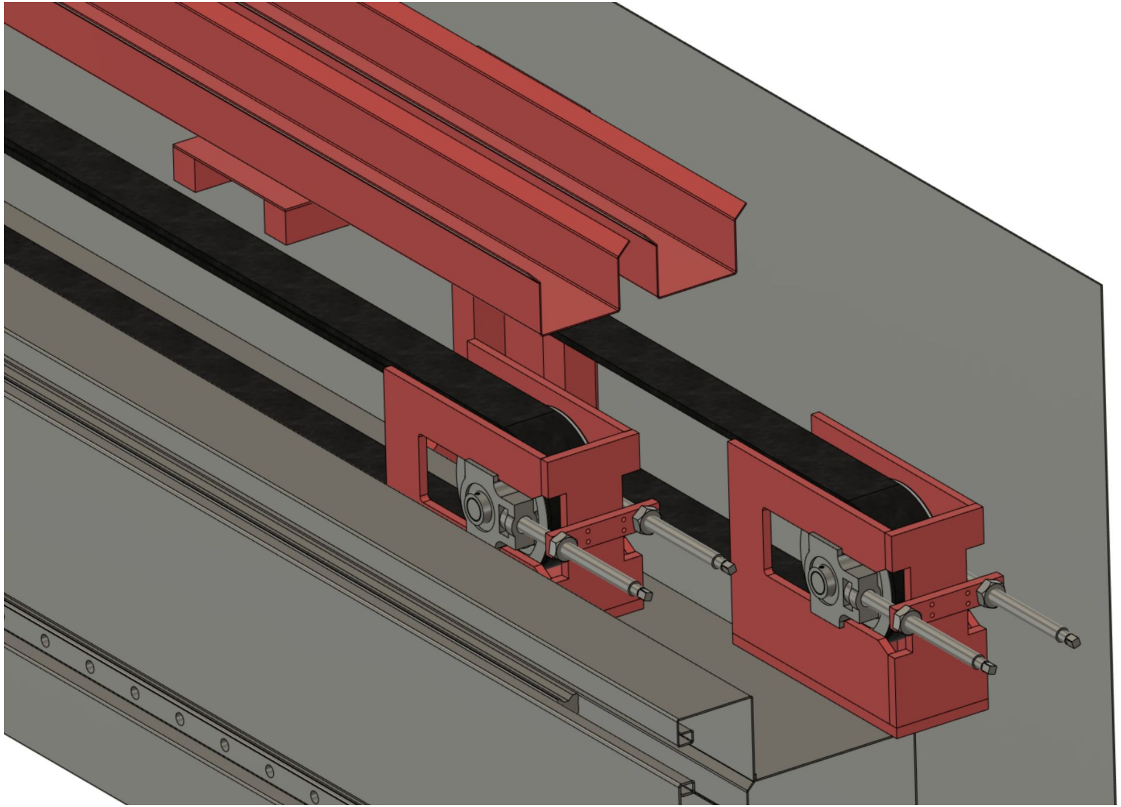

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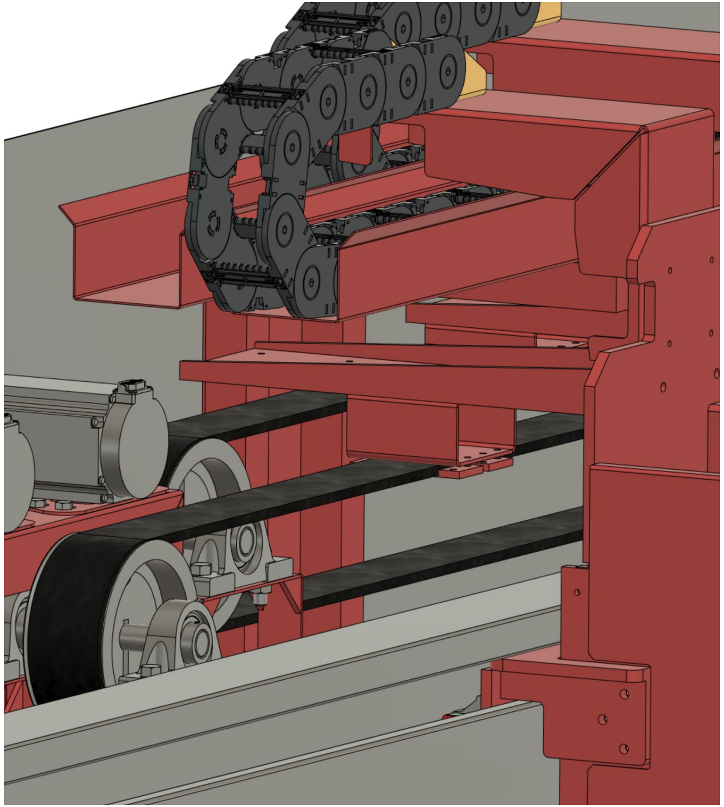
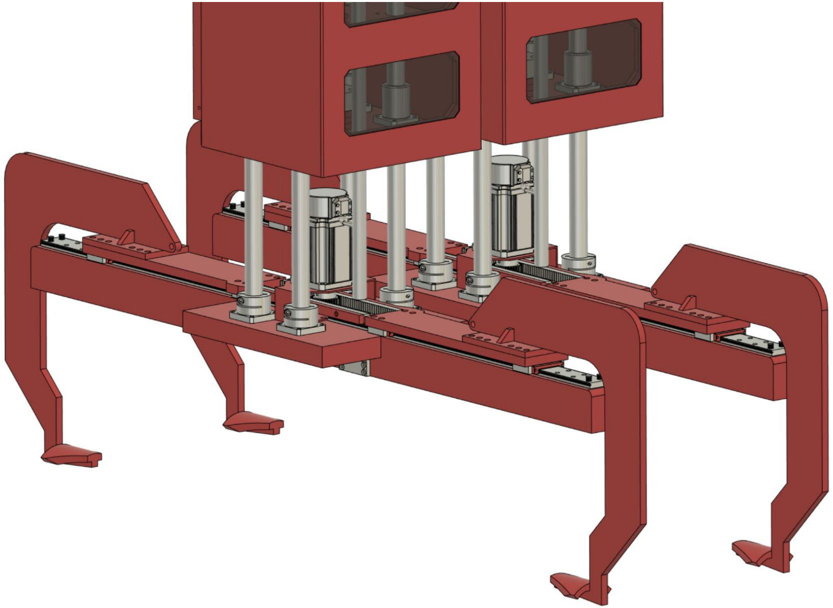
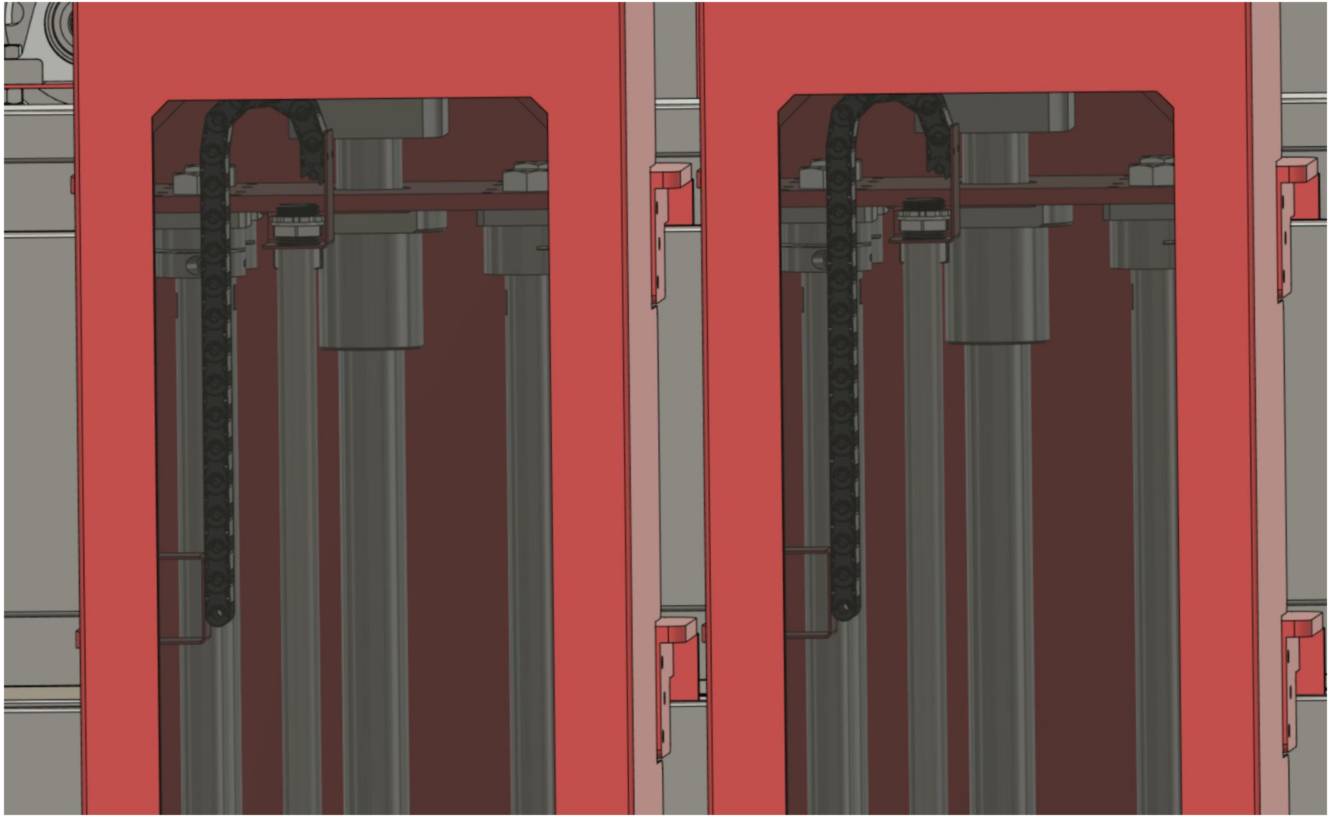
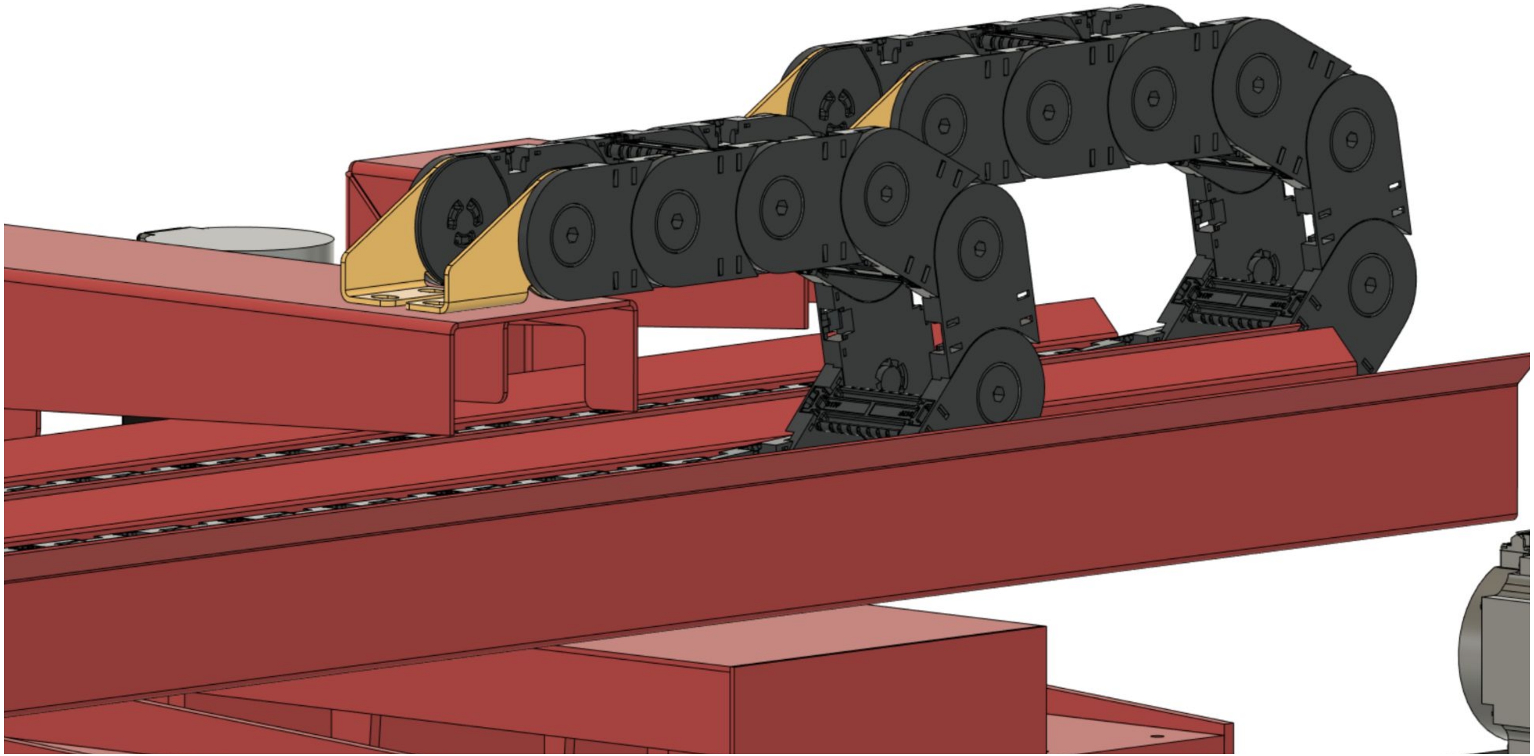




# Detailed View Full Assembly

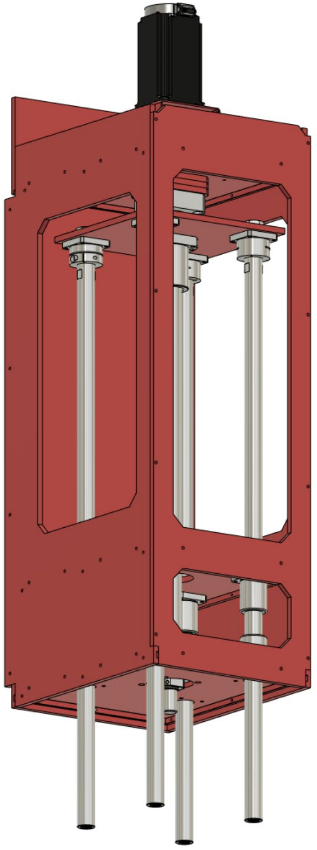


# Detailed View Full Assembly



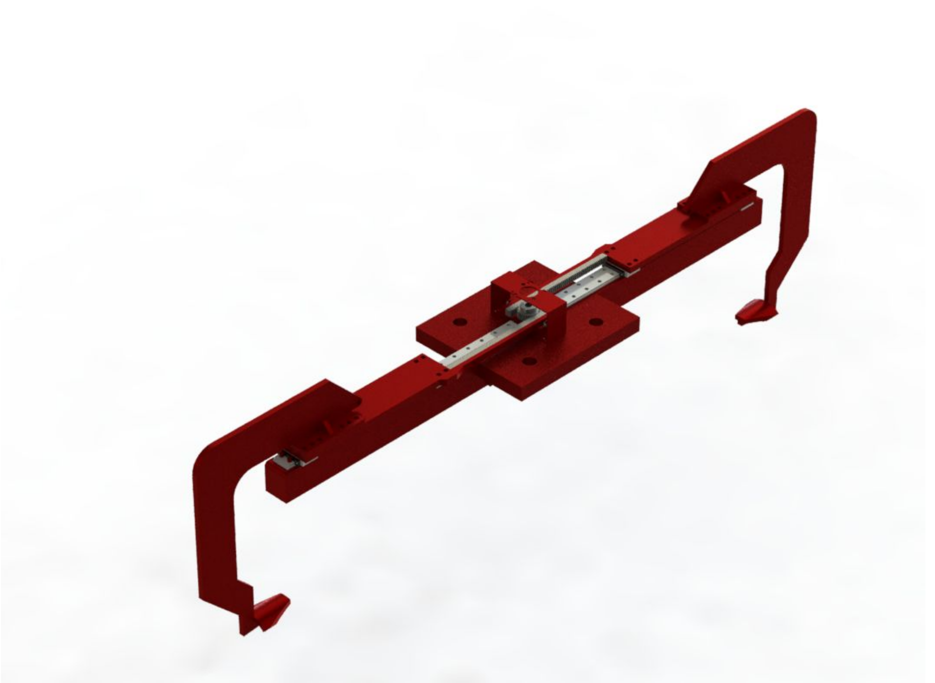
# CAD Model of Z-Axis

- System uses a ball screw driven by a Mitsubishi servo motor
- Uses four 30mm hollow stainless steel linear shafts to connect to the Y-axis
- Frame is made of welded 10mm stainless steel plate. Laser cut with machined straight grooves for alignment.



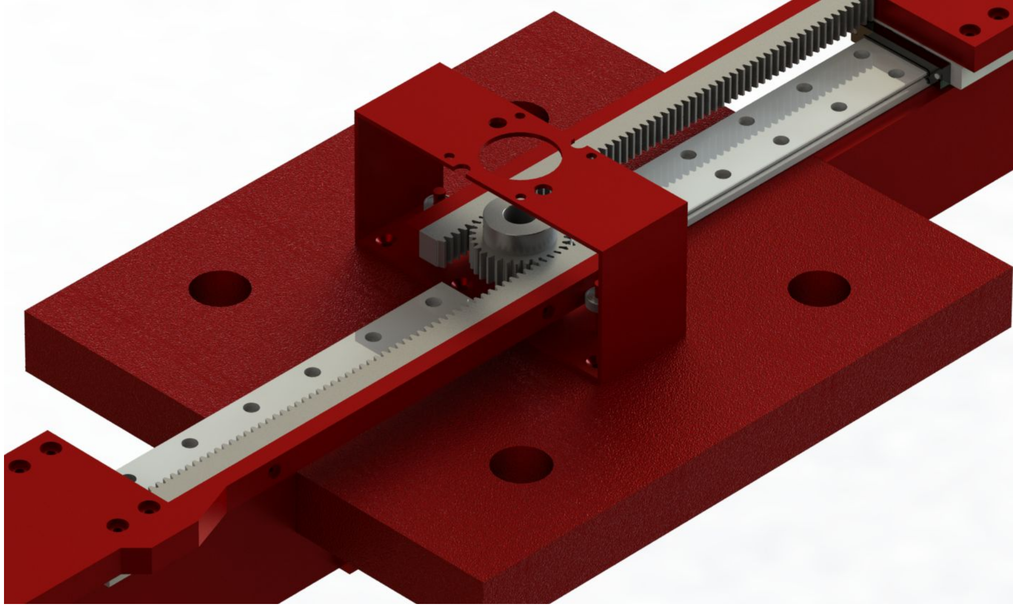
# CAD Model of Y-Axis

- System uses a rack and pinion along with linear rails to move the end effector
- The Y axis is moved up and down by the Z axis design
- Weight: ~230 lbs
- Whole design is made out of stainless steel



# CAD Model of Y-Axis

Closer look at the linear rails



Closer look at the rack and pinion

# CAD Model of X-Axis

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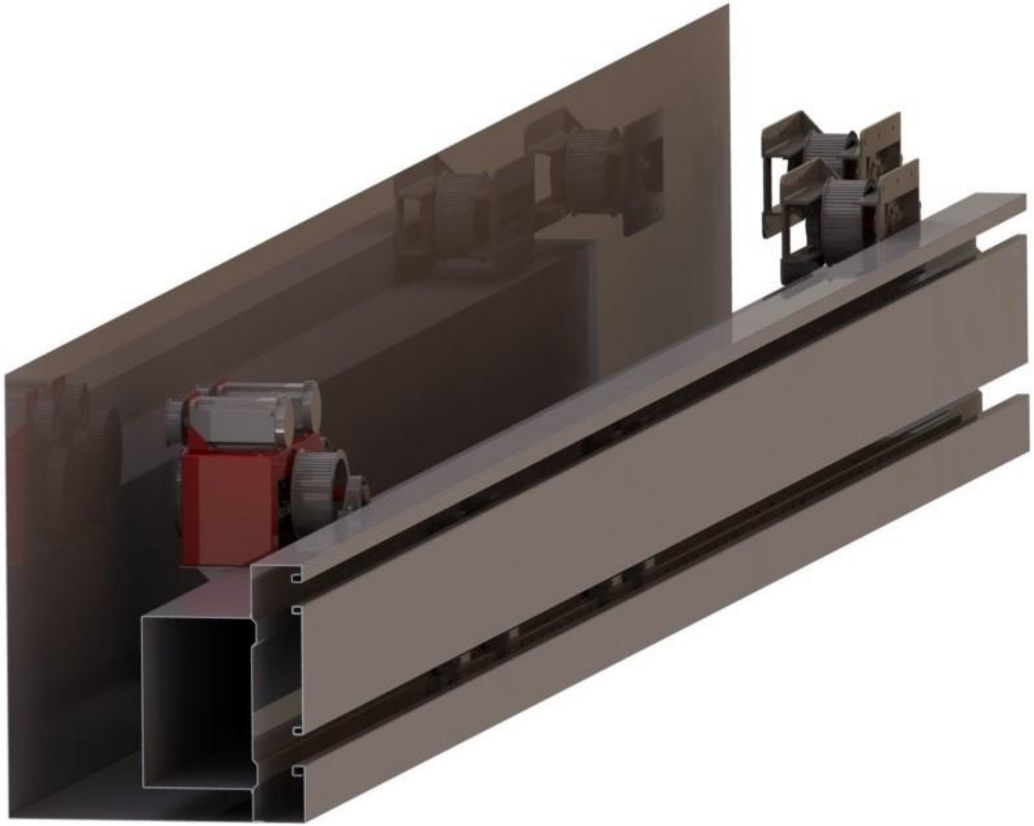
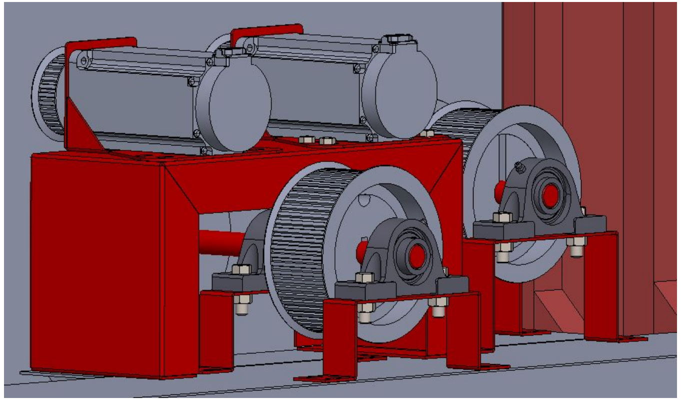
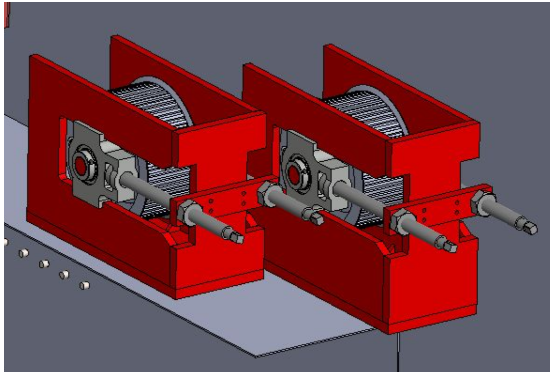
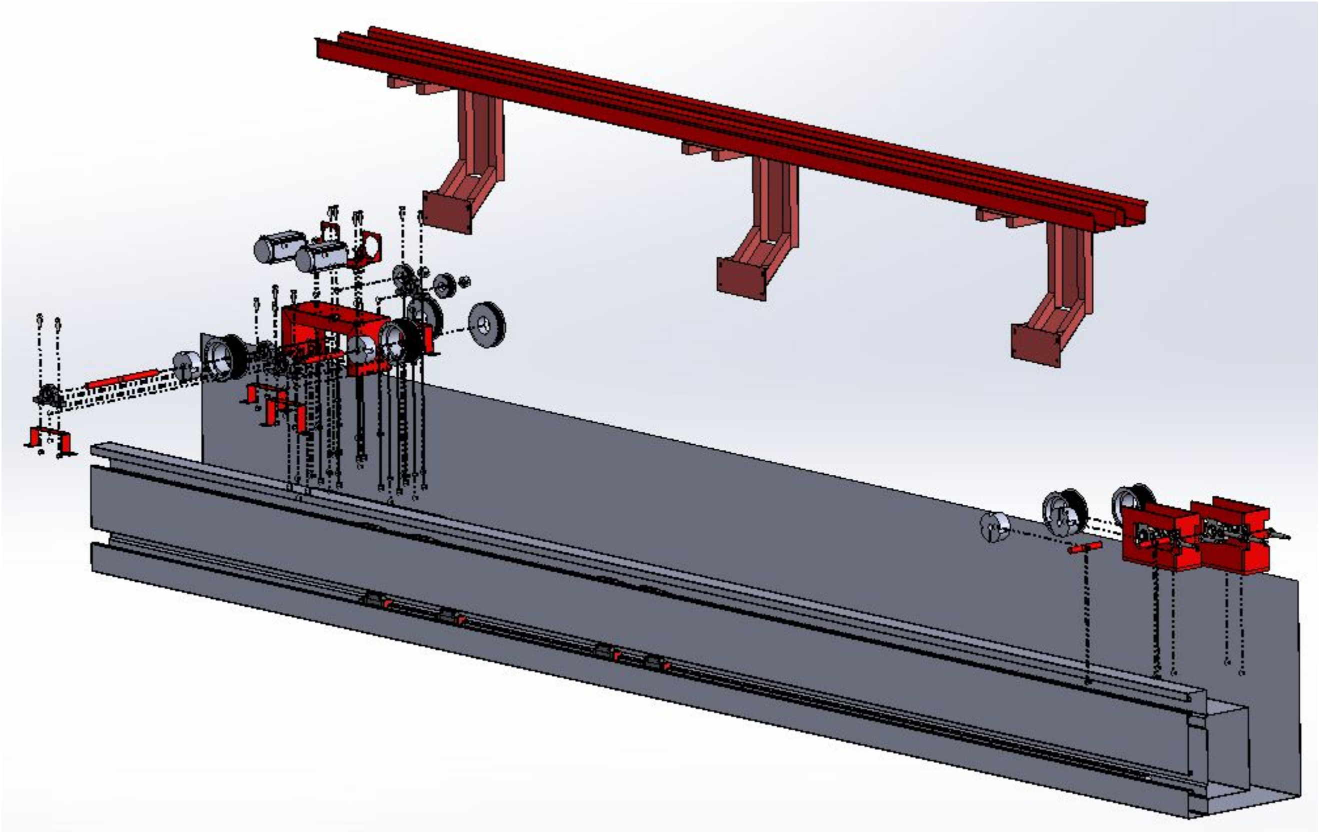


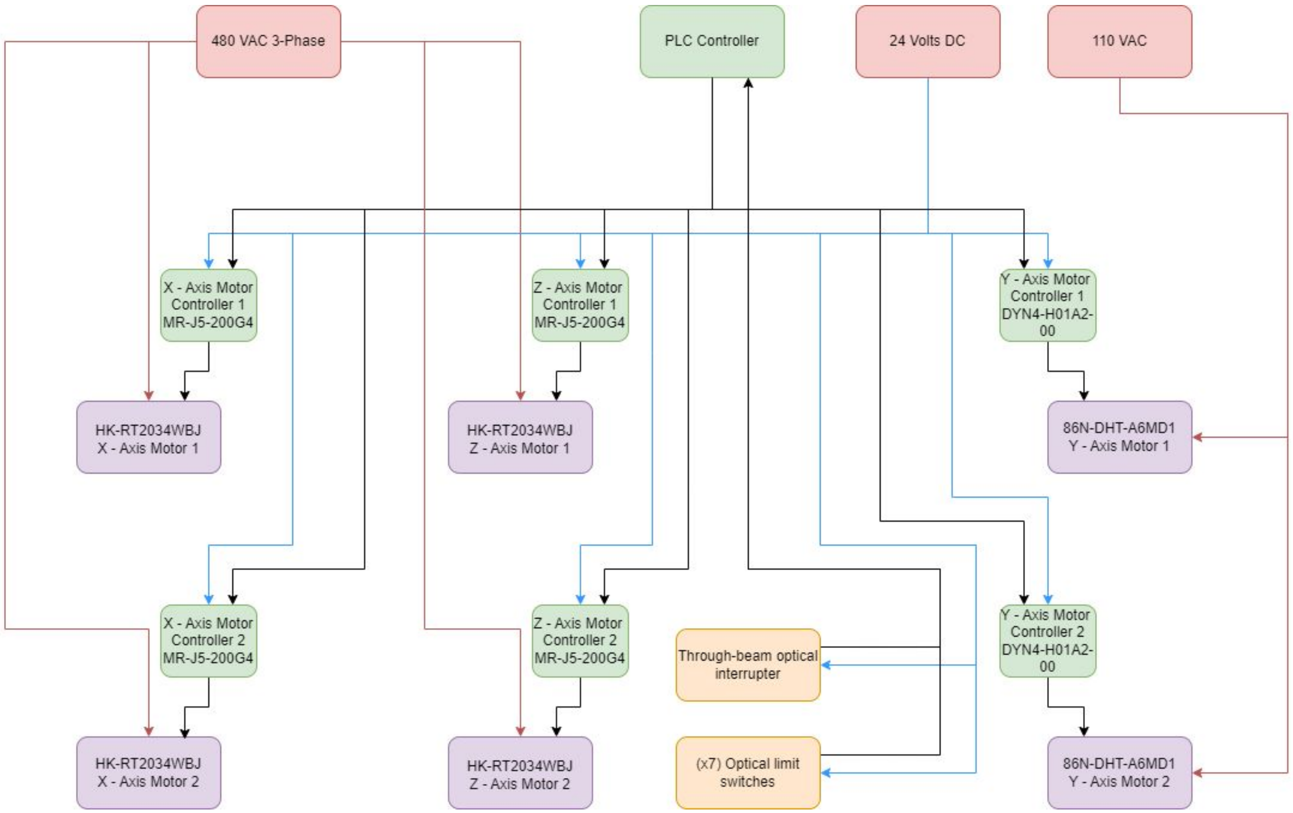




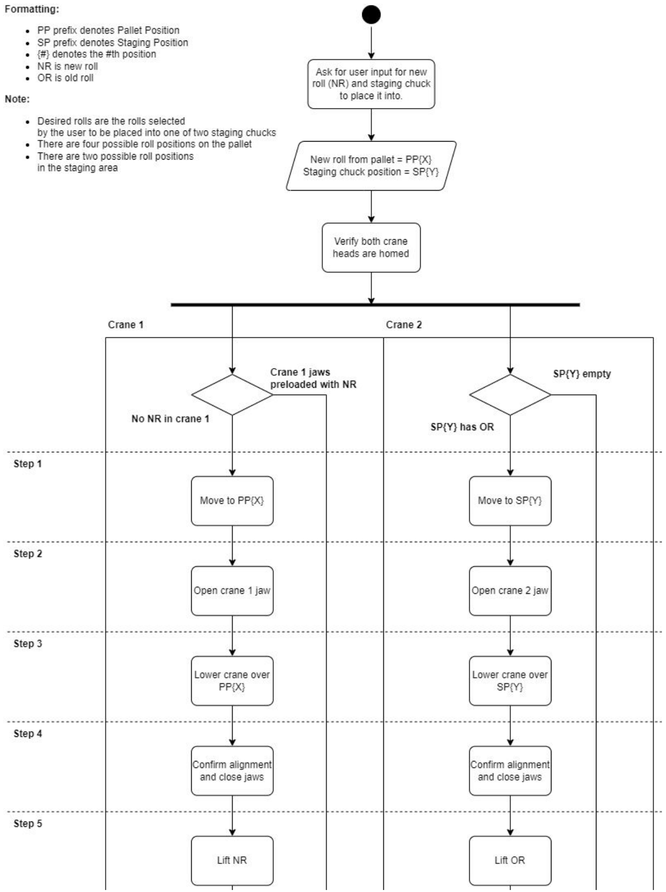
# CAD Model of X-Axis

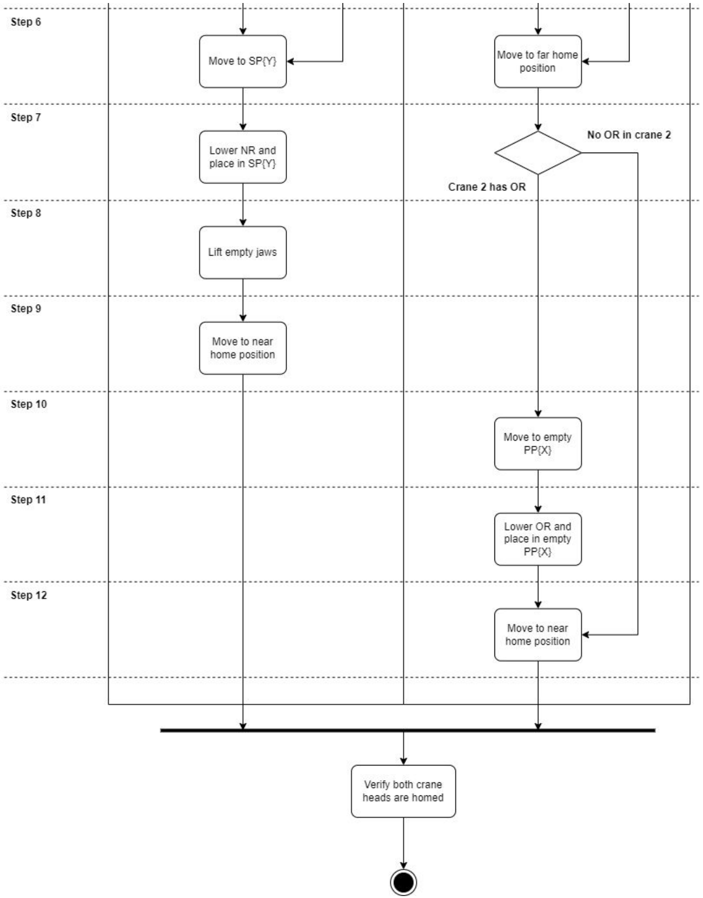


# Electrical schematic



# Control flow schematic



# Control flow example

| | Crane 1 | Crane 2 |
|---|---|---|
| 1 | Move from home to pallet position 1 | Move from home to staged position 2 |
| 2 | Open crane 1 jaws | Open crane 2 jaws |
| 3 | Lower crane 1 over pallet roll 1 | Lower crane 2 over staged roll 2 |
| 4 | Confirm alignment and close jaws | Confirm alignment and close jaws |
| 5 | Lift pallet roll 1 | Lift staged roll 2 |
| 6 | Move from pallet position 1 to staged position 2 | Move from staged position 2 to far home position |
| 7 | Lower pallet roll 1 and place in staging chuck 2 | Wait for crane 1 step 7 to complete |
| 8 | Lift empty crane 1 head | Wait for crane 1 step 8 to complete |
| 9 | Move to near home position | Move to empty pallet roll 1 position. |
| 10 | Wait at near home position | Lower staged roll 2 and place in empty pallet roll 1 position |
| 11 | Wait at near home position | Lift empty crane 2 head |
| 12 | Wait at near home position | Move to near home position |

# Success Criteria that were tested

## Changeover Time

1. Generate simplified CAD design
2. Create analytical model of system in MATLAB
3. Simulate a set of roll changeover scenarios with Simulink
4. Determine the changeover time with the CAD specifications
5. Evaluate results, determine if success criteria are met, and decide how to iterate on initial design

## Weight Capacity

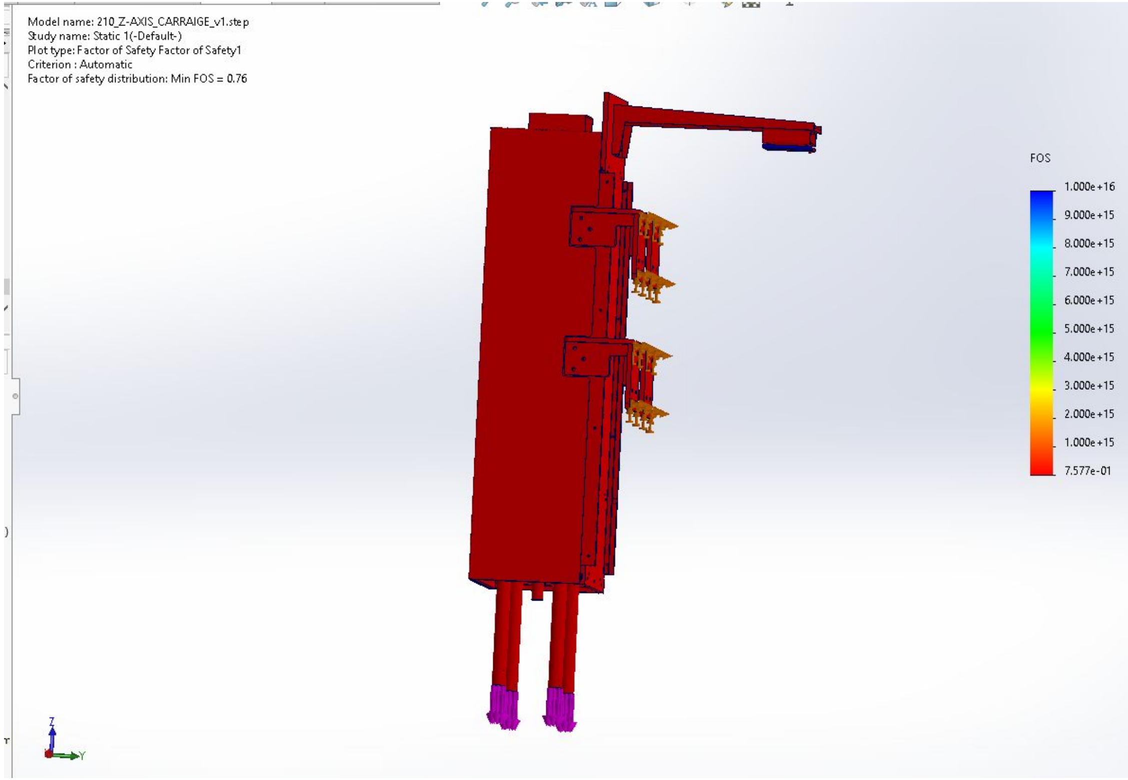
1. Isolate the affected parts of assembly
2. Run static FEA
   a. Define Fixture and load locations
3. If passed, run dynamic FEA
4. Evaluate results
   a. Determine if success criteria are met
   b. Decide how to iterate on initial design

# Timing analysis results - Simulation in Simulink

| Steps for Worst Case scenario | **Time** |
| --- | --- |
| 1: Move Z - Axis Down no roll14 in (0.3556m) - | 1: 1.5 s |
| 2: Move Y - Axis in - | 2: 2 s |
| 3: Move Z - Axis Up with roll 14in (0.3556m) - | 3: 5 s |
| 4: Move X - Axis 3.7m - | 4: 20 s |
| 5: Move Z - Axis down with roll - | 5: 4.5 s |
| 6: Move Y - Axis out - | 6: 2 s |
| 7: Move Z - Axis up no roll - | 7: 1.5 s |
| | Total = 36 s |

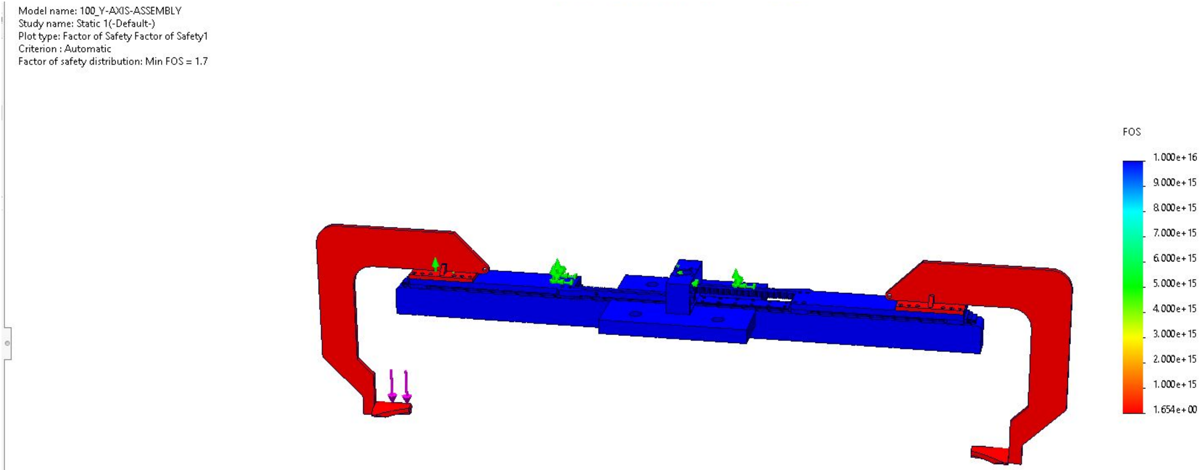
# Z-axis Weight Capacity Analysis - Solidworks Simulations

- FOS of .76 with 1300 lbf
  - 1000lbs for copper roll
  - 300lbs for y-axis
- CAD software
  - Fusion 360
- Stress Report
  - https://docs.google.com/document/d/1KZtIbDuP4CQBt1wj39I0JRIAjMUCrfVk/edit?usp=sharing&ouid=117687347861756154722&rtpof=true&sd=true



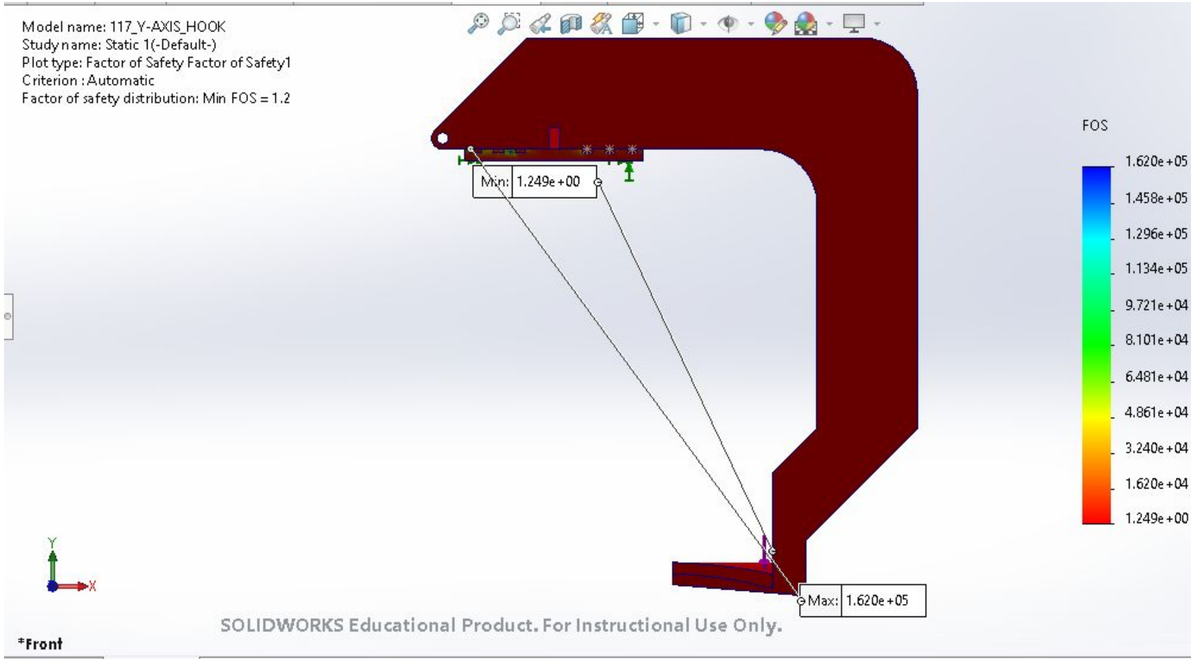
# Y-axis Weight Capacity Analysis - Solidworks Simulations

- FOS of 1.7 with 1000 lbf
- CAD software
  - Solidworks
- Stress Report
  - https://docs.google.com/document/d/1jZ49amwHMNin8M4D6h1QPXJ2rFmE6KR2/edit?usp=sharing&ouid=117687347861756154722&rtpof=true&sd=true



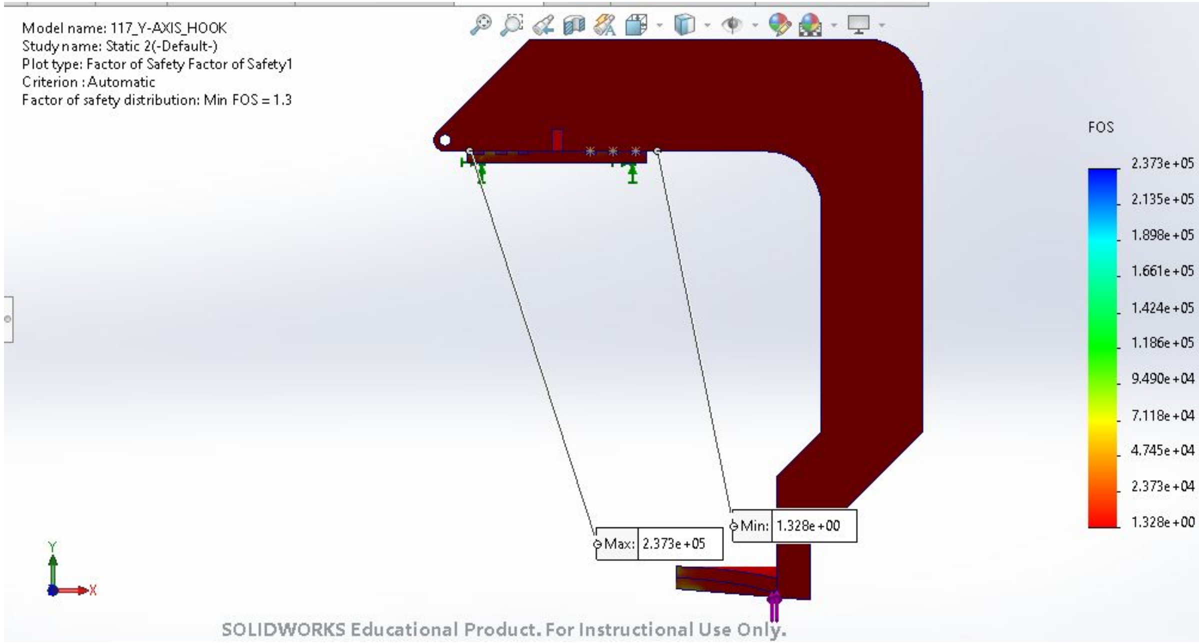
# CAD Model of End Effector

- 1000 lbf downwards on where the copper roll would be place
- Safety factor of 1.2
  - Can hold max of 1200 lbf



# CAD Model of End Effector

- 626 N + 100 N applied sideways to simulate fast acceleration
- Safety factor of 1.3
    - Can withstand acceleration up to 943 N



# Engineering Standards

- Device should follow the following OSHA standards: 1910, 1926, 1809
- Device should follow Class 6 clean room standards
- Device should interface with Mitsubishi PLC control systems by following IEC 61131-3
- Device should be built using ISO 724 Metric threaded hardware.

# Project Success Criteria

| *Criterion (Requirement)* | *Threshold (Halt & Review)* | *Team's concept* | *POR Risk (H, M, L)* | *Comments* |
|---|---|---|---|---|
| Number of rolls staged on machine | 4 | 5 | L | The dual hoist system adds extra roll space |
| Changeover time | 40 sec | 36 sec (worse case scenario) | M | Even at worst case scenario team is able to keep the change over time under 40 sec. |
| Per roll weight capacity | 500 lb | 750 lbs | L | Controllable by design |
| Clean room standard | Class 6 | Class 6 | L | The components used in the design rated to maintain air cleanliness levels of a maximum of 1,000 particles per cubic meter |

# Video demonstration of Project

# BOM

| X axis (horizontal) | | | | |
|---|---|---|---|---|
| x drive motor | HK-RT2034WBJ | Mitsubishi | | Link |
| x drive motor driver | MR-J5-200G4 | Mitsubishi | | |
| x drive main pulley | 8MX-60S-62 | Gates Corp | $ 500.00 | Link |
| x drive main pulley bushing | 3020 24MM 7859-6524 | Gates Corp | $ 50.50 | Link |
| x drive Idler pulley bushing | Gates 3020 25MM Bushing | Gates Corp | | Link |
| x drive Idler pulley tensioner | TUUFLN25 | Misumi | $ 100.00 | Link |
| x drive motor pulley | 8MX-30S-21 | Gates Corp | $ 200.00 | Link |
| x drive motor pulley bushing | 1108/19mm 7858-0119 | Gates Corp | $ 30.00 | Link |
| x drive drive pulley | 8MX-60S-21 | Gates Corp | $ 200.00 | Link |
| x drive drive pulley bushing | 2012 24MM 7858-2524 | Gates Corp | $ 30.00 | Link |
| x axis pillow block bearing | Ultra Class Series UCP - Pillow Block - Wide Inner Ring, Set Screw (UCP-7/8) | Misumi | $ 80.00 | Link |
| x drive belt | LL8MGT-036 (inquire abt 62) | Gates Corp | $ 100.00 | Link |
| x reducer belt | 8MGT-1120 P.L. 44.09 140 Teeth | Gates Corp | $ 100.00 | Link |
| x axis linear rail | HGW35CA2R3700ZBCII | HIWIN | - | Link |
| x optical limit switches | PR-F51CP | Keyence | $ 150.00 | Link |

# BOM

| | | | | |
|---|---|---|---|---|
| **Z axis (lift)** | | | | |
| z drive motor | HK-RT2034W | Mitsubishi | $ 2,000.00 | Link |
| z ball screw | RBS-R40-10T4-FSI-600-822-0.05-M | Hiwin | - | Link |
| z linear shaft | SSPJ30-1000 | Misumi | $ 894.80 | Link |
| z linear shaft bearings | LMK30MUU | Misumi | $ 227.00 | Link |
| z linear shaft mounts | SSTHWS30b | Misumi | $ 150.00 | Link |
| z drive coupling | SCXW55-19-25 | Misumi | $ 50.00 | Link |
| z limit switches | PR-M51CP | Keyence | $ 150.00 | Link |
| z ball screw supports | FK-30B | Hiwin | $ 300.00 | Link |
| z locating pins | AJPNGB5-P6-B8-G5-RAC | Misumi | $ 5.48 | Link |

# BOM

| | | | | |
|---|---|---|---|---|
| **Y axis (end effector)** | | | | |
| y actuation motor | 86N-DHT-A6MD1 | Dynamic Motor Motion | $ 292.00 | Link |
| y motor driver | DYN4-H01A2-00 | Dynamic Motor Motion | $ 235.00 | |
| y Pinion | GEAS1.5-30-15-B-13 | Misumi | $ 45.00 | Link |
| y Rack | RGEAS1.5-300-Z | Misumi | $ 186.00 | Link |
| y linear rail | SSE2BWML16G-669 | Misumi | $ 543.00 | Link |
| y through beam | PR-G51CP | Keyence | $ 150.00 | Link |
| y limit switches | KSK6-AP-4H | Automation Direct | $ 35.00 | Link |
| y limit switch bracket | ST18C7W | Automation Direct | $ 7.25 | Link |
| Total | | | $6,779 | |

# Management: Risks

| Risk Number | Triggered (Y/N) | Description of Risk | Owner/ Responsible | Type | Severity (H/M/L) | Mitigation Strategy | Actions to Mitigate |
|---|---|---|---|---|---|---|---|
| R2 | N | Our industrial partner may not be able to meet on a regular schedule since he is the Plant Engineering Manager | Team | Commun ication | M | Address | We will talk to our industry partner about meeting at different times |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| R3 | N | The team may not be able to properly model the full-scale system with a smaller scale prototype, leading to uncertainties in the design. | Team | Technical | L | Address | We will ask for assistance from our IP or from our mentors |
| R4 | N | The team cannot test if the solution will have a 20 year lifespan, only make estimates and design in safety factors, so it is possible that the final solution may not last that long. | Team | Technical | M | Address | We will ask for assistance from our IP or from our mentors |
| R5 | N | The Return on Investment (ROI) of the project may not be under 2 years if the final solution is too expensive | Team | Financial | H | Address | We will talk to the IP and see if there is anything we can do |

# Evaluation of Planned vs Actual schedule

- The only time we fell behind schedule was completing the BOM
  - This happened because we had to change parts out a few times (mainly the Y axis motor and sensors)
- Overall we met our schedule for every big milestone

| Color Key | |
|---|---|
| Completed on/before time | |
| Was late less than one week | |
| Was late more than one week | |

| ***Milestone*** | ***Due Date*** |
|---|---|
| Design Review | Oct 31st |
| Preliminary Prototype Plan | Nov 2nd |
| Sourcing Parts both electrical and mechanical | Feb 5th |
| Initial Prototype Complete (CAD model and Analysis) & Design Review | Jan 23st |
| Second Design Review | Mar 5th |
| Final project delivery date | Apr 28th |

# Conclusion

- Our team fully designed a twin hoist system to accelerate the copper roll changeover process
- Our team hit all of our success criteria and deliverable

# Suggestions for future work

- The control of the axis (the PID’s) can be further optimized using Mitsubishi’s built in PID tuning.
  - This could further improve the timing of the system
- Modify model to increase the FOS of the Z-axis to at least 1
  - May have to modify the bracket
- We made the assumption that the X-axis rails could hold the weight of the hoists (as we do not know the inside structure of the rails)
  - New rails may have to be made to support the new weight

# Questions?