UMass Amherst
Daniel J. Riccio Jr. College of Engineering

Yearlong Senior Capstone Design

Mid-Year Progress Report

Project #1402 - UMass MIE FMS 1

Liam Wasser | Tiernan O'Kane | Andri Mahegan
Aman Patel | Ethan Wlodyka

Motivation

The UMass Industrial Automation class requires a learning aid to practice Industry 4.0 concepts.

Objective

Design stations 1 & 5 to be reliable and repeatable, integrating 5 smart sensors as part of a larger assembly line serving as a learning aid for MIE 690: *Industry 4.0*.

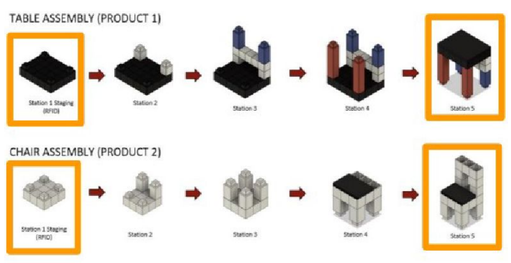
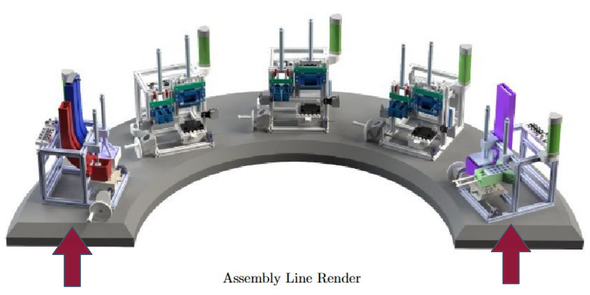


Table and Chair Assembly Diagram



Assembly Line Render

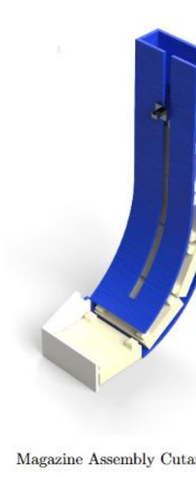
Specifications

Customer Requirements	Target Specifications/Engineering Standards
Repeatability	99% build success rate
Flexible Assembly	Adaptable to table and chair assembly
Magazine Size	5 block capacity
Smart Sensors	5 smart sensors routed through IO link
Portability	< 50 Lb (NIOSH Lifting Equation)
Safety	<5 mm pinch points (ISO 12100:2010)

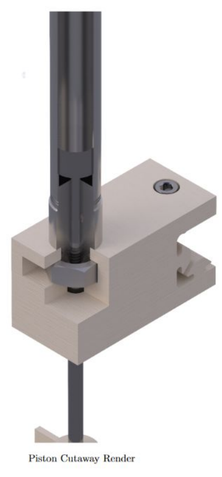
Selected Design

	Designs Considered and Selected			
Feeder Type	Gravity Fed	Vibratory Table	Rotational Magazine	Linear Spring Fed
Block Connection	Magnetic	Press Fit	Compliant Mechanism	
Base Plate	Universal Connection	Vacuum	Mechanical Ejection	
Stage Fixture	Detents	TPU Wings		
Piston Mount	Captive Nut	Bracket with Threaded Insert		

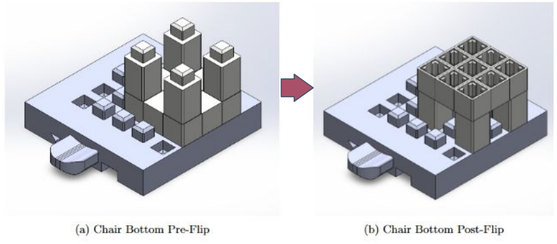
- Gravity fed magazine for plate-shaped components
- Spring fed magazine for specialty components
- Compliant, self-seating stage fixture to align components before placement
- Captive-nut hybrid design mounting block, integrating standard hardware while leveraging flexibility of 3D printing
- Universal baseplate accommodating table assembly and chair



Magazine Assembly Cutaway



Piston Cutaway Render



(a) Chair Bottom Pre-Flip (b) Chair Bottom Post-Flip

Chair on Baseplate Positions

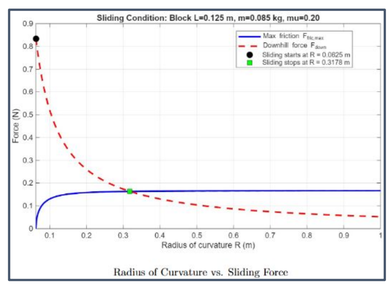
Supporting Engineering Analysis

Comprehensive Analysis of All Components

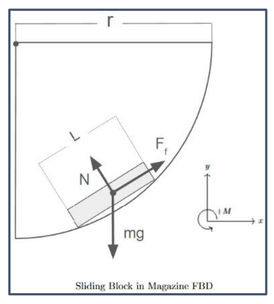
- Justification of all FOS used
- Calculated minimum magazine curvature to ensure sliding
- Calculated internal block dimensions to ensure sufficient holding force and ensure stress FOS met
- Calculations of required piston size and forces applied

Case	Minimum FOS
Magazine Bending	2.5
Block Holding	3.0
Piston Force	3.5
Frictional Sliding	1.5
80/20 Deflection	4.5
Lead Screw Deflection	5.0

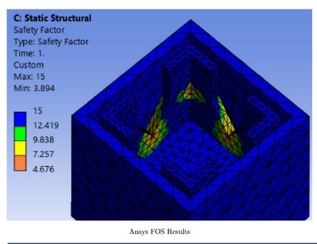
Summary of Recommended Factors of Safety



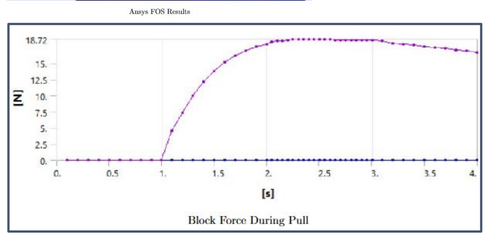
Radius of Curvature vs. Sliding Force



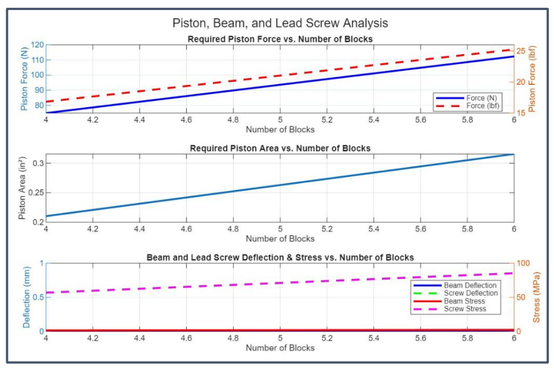
Sliding Block in Magazine FBD



Ansys FOS Results



Block Force During Pull



Proof of Concept Implementation

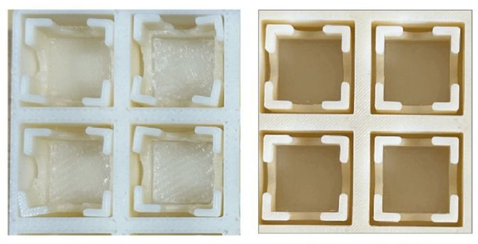
- Station 1 prototype developed, designed, manufactured
- Machined brackets to reduce imprecision in crank
- Enforced 3D print reliability with optimal orientation

A

(a) Old Bracket Design (b) New Bracket Design

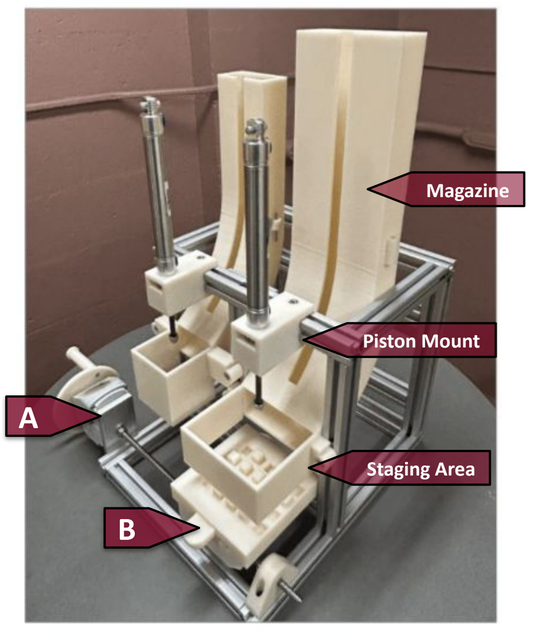
Bracket Design Comparison

B



(a) Wrong Print Orientation (b) Correct Print Orientation

Block Print Results Comparison

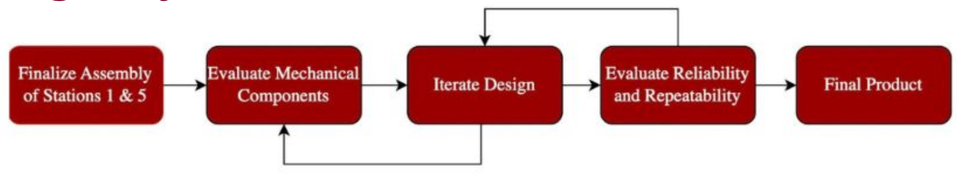


Station 1 Assembly

Performance Evaluation

Customer Requirement	Preliminary Evaluation Method
Flexible Assembly	Assemble 5 chairs, switch to 5 tables, repeat 10 times
Repeatability/Reliability	Measure jam rate (%) on each station in 250 cycles and measure deformation of internal components
Build Cycle Time	Time station builds for 100 cycles per product
Portability	Measure each station weight
Block Durability	Find average & standard dev. block forces over 100 cycles

Spring Project Plan



Project Plan Flowchart

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