Android Industries Rear Axle Load

By Chloe Wegener, Olivia Wright, and Wyatt Moser

Background

- The Rear Axle Line will be expanding from 9 to 17 different components
- We are looking for a semi-automated or fully automated solution to improve ergonomics and to work within the following constraints:
  - **Takt Time: 60 parts per hour**
  - **Overhead Space: 14ft**
  - **Weight of Axles: ~770lbs**
- Given these constraints Android Industries is looking for the following:
  - A delivery table or conveyor system
  - A defined system to fetch the parts or present the parts to the operator


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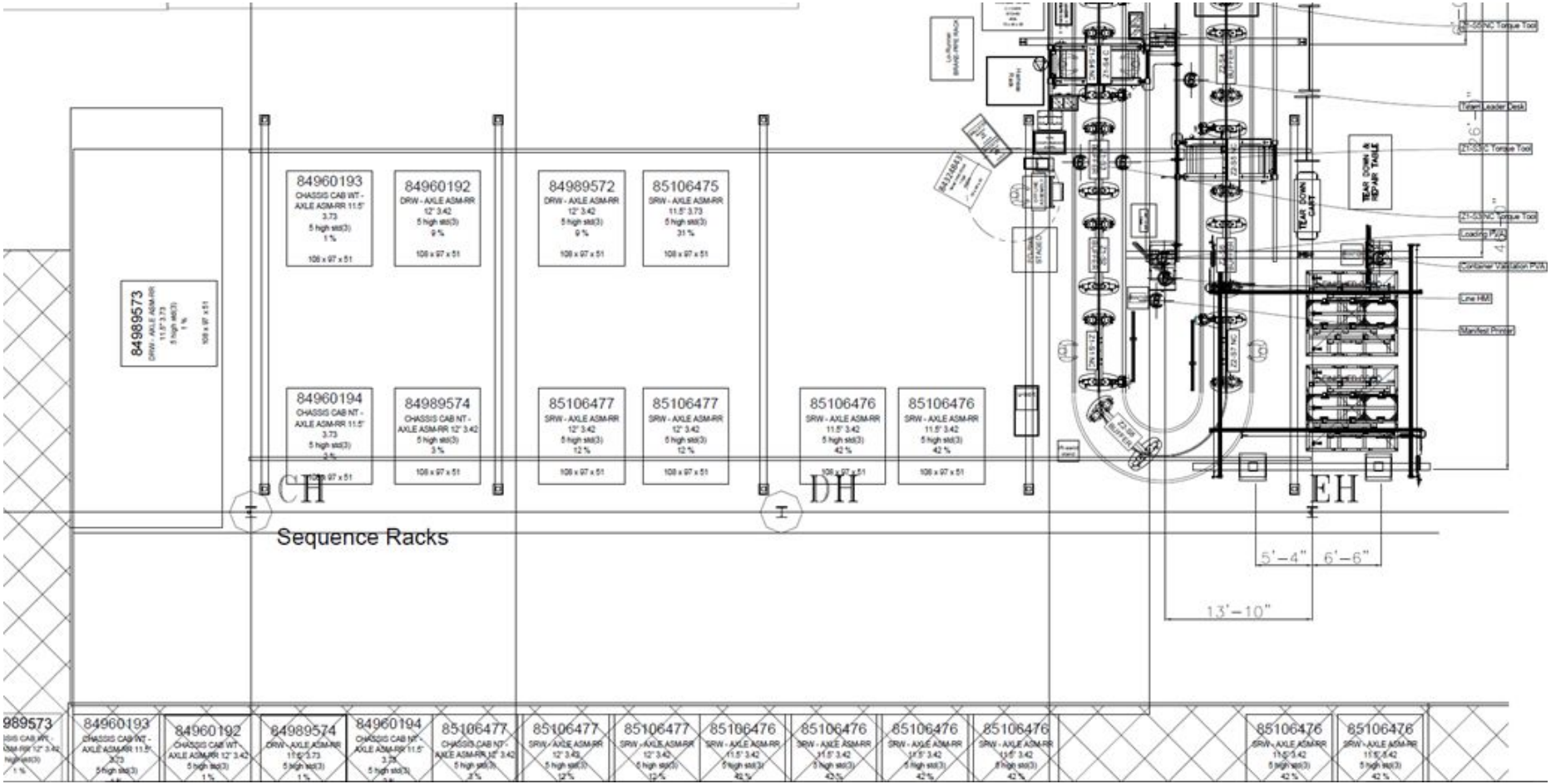
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DH
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Sequence Racks
TEAR DOWN & REPAIR TABLE
TEAR DOWN CART
Loading PVA
Container Validation PVA
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Manifest Printer
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Problem

- The job requires workers to use an overhead lift to move heavy axles from dunnage to the rear axle assembly line.
    - *While the vertical lifting/lowering of the axles are performed mechanically by the lift, workers must exert large forces to manipulate and move the lift/axle across the floor.*
- According to push/pull data collected from the site and analytics with Liberty Mutual, 99% of women cannot complete the task at hand proving it unsafe for the workplace.
    - *Not only the force, but the posture and position of the lift mechanism need to be altered to make this job more feasible.*
- Future expansions may require the worker to access dunnage that is farther away than the current layout.
    - *This could impact the ability to keep up.*

Ergonomics Study

Ergonomics: Tools Background

- **Methodology**
  - Mark-10 Series E Advanced Ergonomics Kit (200lbF)
- **Assessment of Repetitive Tasks (ART) Tool**
  - The ART tool is used to assess the risks associated with repetitive tasks specifically related to the upper body. This allows employers to assess the risk factor of employees developing upper limb disorders and meet any legal requirements associated with these disorders.
- **Liberty Mutual Snook Tables**
  - The Snook Tables are meant to assess a variety of material handling activities and define what percentage of the population could complete the task without overexertion.
- **3DSSPP**
  - A biomechanics tool that was designed by the University of Michigan to assess push/ pull strength capacities on heavy objects.

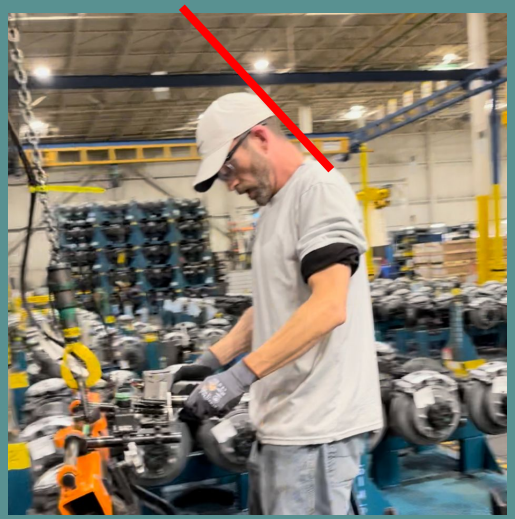
HSE Health and Safety Executive

Liberty Mutual. INSURANCE

3DSSPP

Ergonomic Reasoning

C1



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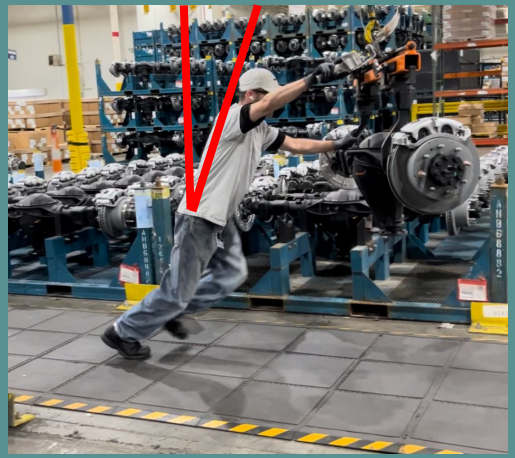

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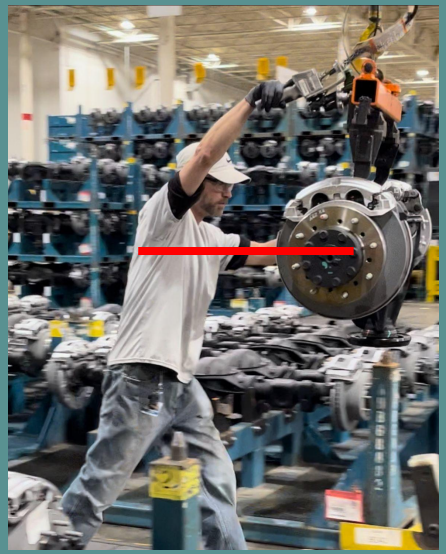
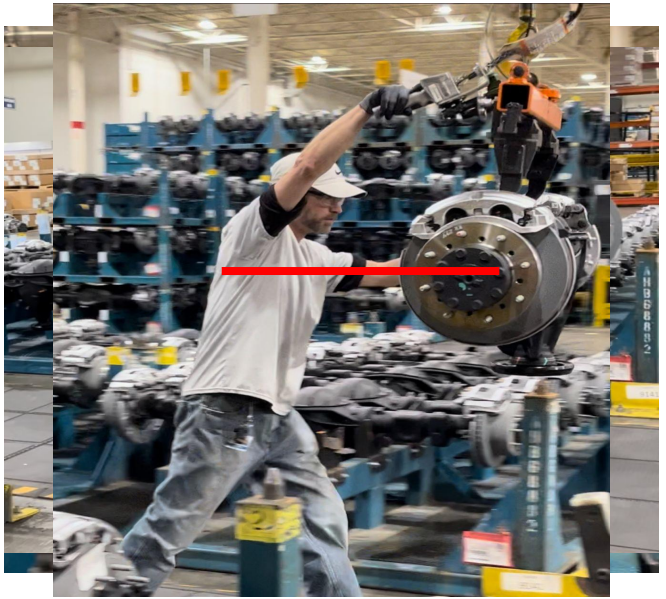


Ergonomics Study: ART Tool Scorecard

Risk Factors	Left / Right Arm	
	Color	***Score***
A1 Arm Movements		**0**
A2 Repetition		**0**
B Force		**12**
C1 Head/neck posture		**1**
C2 Back posture		**2**
C3 Arm Posture		**4**
C4 Wrist posture		**0**
C5 Hand/finger grip		**0**



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C3 Arm Posture		**4**
C4 Wrist posture		**0**
C5 Hand/finger grip		**0**

Ergonomics Study: ART Tool Scorecard

Risk Factors	Left / Right Arms	
	Color	***Score***
D1 Breaks		**4**
D2 Work pace		**1**
D3 Other Factors		**1**
Task Score		**25**
D4 Duration Multiplier		**X 0.75**
Exposure Score		**18.75**
D5 Psychosocial factors: **N/A**		

Ergonomics: ART Tool - Analysis

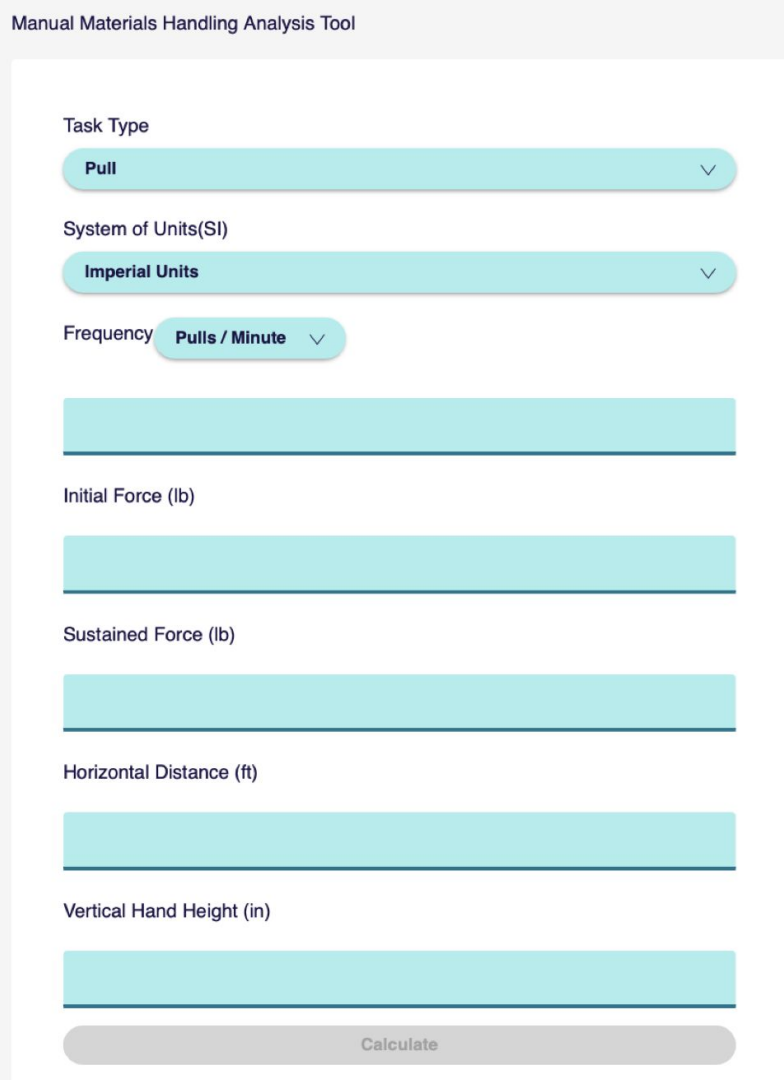
Final Exposure Score: **18.75**

Exposure Score	Proposed Exposure Level	
0-11	**Low**	*Consider individual circumstances*
12-21	**Medium**	*Further investigation required*
22 or more	**High**	*Further investigation required urgently*

Liberty Mutual: Material Handling Population Percentiles

What was Needed:

- # of Push/Pulls per trial
- Amount of Force Used per Pull
- Sustained Force throughout Pull
- $\frac{Total\ Distance}{\#\ of\ Pulls} = Distance\ Between\ Pulls$
- Vertical Hand Height



Liberty Mutual:
Material Handling Population Percentiles

Ideal:

- “The goal is to design jobs that are acceptable to at least 90% of the female population.”
  - Typically safer
  - Women, due to weight/force, will be able to discern pain faster than men

Example: Canary in Coal Mine

- Canary’s are more sensitive to dangerous gases
- Canary died = Cave was not safe

Liberty Mutual:
Material Handling Population Percentiles

Application Limitation: Cannot Distinguish Between

- Pulls vs. Pushes
- Forces for each pull/push
- Vertical Height
- Distances between push/pulls
- Hours worked

Liberty Mutual:
Material Handling Population Percentiles

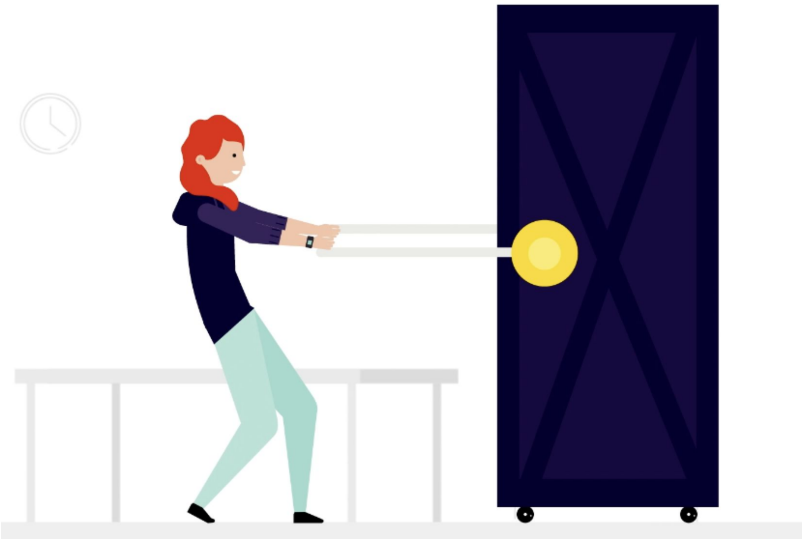
Frequency of Stops: 4

1st: Pull Lift Assist from WorkStation

2nd: Move Lift Assist to pick up Axle

3rd: Remove Axle from Rack

4th: Push Axle down Aisle



Liberty Mutual:
Material Handling Population Percentiles

Maximum Forces/Longest Distance Case

Initial: 69 lbs

Sustained: 20 lbs

Distance: 83 ft/4 = 20.75 ft

Vertical Hand Height (in): 70 inches

Minimum Forces/Shortest Distance Case:

Initial: 51 lbs

Sustained: 20 lbs

Distance: 14.9 ft/ 4 = 3.729 ft

Vertical Hand Height (in): 70 inches

Ergonomics: Liberty Mutual Snook Tables - Analysis - Maximum Forces Used

Gender	Initial Force %	Sustained Force %
Males	4%	90%
Females	1%	1%

Ergonomics: Liberty Mutual Snook Tables - Analysis - Minimum Forces Used

Gender	Initial Force %	Sustained Force %
Males	63%	90%
Females	1%	1%

Ergonomics: Liberty Mutual Snook Tables - Analysis - Vertical Height Decrease to 40in & Initial force under 38 lbs

Gender	Initial Force %	Sustained Force %
Males	83%	84%
Females	77%	71%

Ergonomics: 3DSSPP - Pull Analysis

Android Industries Worker

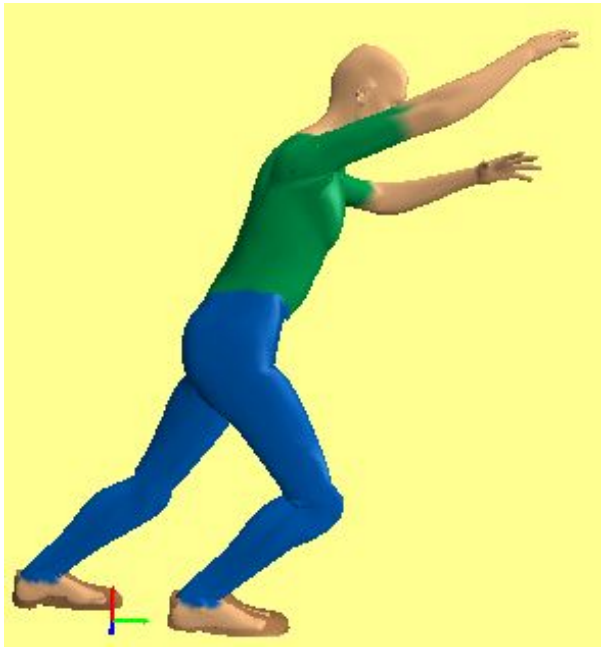
3DSSPP Model

3DSSPP - Pull Force Results

Force	Gender	Lower Back Compression (lb)	Wrist	Elbow	Shoulder	Torso	Hip
Average **(59.94lbs)**	*Male*	190	99	100	98	100	100
	Female	230	98	99	81	96	99
Minimum **(51.75lbs)**	*Male*	152	99	100	99	100	100
	Female	189	99	99	88	98	99
Maximum **(69.35lbs)**	*Male*	234	98	100	97	100	100
	Female	279	98	99	71	94	98

Ergonomics: 3DSSPP - Push Analysis

Android Industries Worker



3DSSPP Model

Ergonomics: Push Force Results

Force	Gender	Lower Back Compression (lb)	Wrist	Elbow	Shoulder	Torso	Hip
Average **(39.5lbs)**	*Male*	586	96	100	99	72	70
	Female	533	94	97	95	50	28
Minimum **(20.85lbs)**	*Male*	495	99	100	100	87	86
	Female	428	99	100	99	77	68
Maximum **(63.8lbs)**	*Male*	692	82	98	98	44	42
	Female	663	74	79	79	17	3

Why Ergonomics Should Improve

- Turnover Rate
- Initial Resistance for Gantry System
- Long-Term Repetitive Movement
- Low-Percentile of Women are Able to Complete the Task (**LM**)

Results

Cycle Time Sheet of Second Shift

Operator 2	Column1	Column2	Column3	Column4	Column5	Column6	Column7	Column8	Column9	Column10	Average
Tasks	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8	Trial 9	Trial 10	
Walk to SB	0	0	0	0	4	0	0	0	0	0	0.4
Place on Stand	0	0	0	0	4	0	0	0	0	0	0.4
Prep-Stabilization Bar	0	0	0	0	3	0	0	0	0	0	0.3
Walking Distance	14	11	7	5	3	13	7	9	10	5	8.4
Rotating LA	0	0	0	0	2	0	0	1	2	0	0.5
Walk to Axle	1	2	2	3	3	0	0	0	0	3	1.4
Pick Up Rear Axle	2	4	3	3	4	4	5	3	3	3	3.4
Back-UP	3	5	3	4	5	1	3	6	3	5	3.8
Walk to Station	13	12	11	9	7	15	11	13	13	6	11
Waiting Time (Not Normal Process)	0	0	0	0	48	0	15	0	0	0	6.3
Set Axle on Station	5	9	5	4	3	9	6	6	5	12	6.4
Scan Part	2	2	2	3	2	3	3	12	2	3	3.4
Remove Caps *(Occasional Process)*	0	0	0	0	2	0	4	0	0	2	0.8
Place Sticker	0	8	5	6	6	6	2	6	8	3	5
Remove Lift Assist	0	1	0	1	1	2	1	1	1	1	0.9
Stabilizer Installation	0	0	0	0	0	0	0	0	0	0	0
Cap & Screw Install	0	0	0	0	0	0	0	0	0	0	0
Walk to Stab-Bar	2	0	0	0	0	0	0	0	0	0	0.2
Walk Back to Station	2		0	0	0	0	0	0	0	0	0.222
Install Stabilizer Bar											
Total Time	**44**	**54**	**38**	**38**	**97**	**53**	**57**	**57**	**47**	**43**	**52.8**
Total Time w/out Waiting Time	**44**	**54**	**38**	**38**	**49**	**53**	**42**	**57**	**47**	**43**	**46.5**
Time in Video Start			2:01	2:39	3:17		1:55 end	2:55	3:42		

Cycle Time Analysis

1st Shift Operator:

- Average Task Time: **46s**
- Average Total Time: **103s***

**Wait time training*

2nd Shift Operator:

- Average Task Time: **46.5s**
- Average Total Time: **52s**

Factors affecting Cycle Time:

- Variables: *Distance, Prep & Install Stable Bar, Other Operators (training, assisting, etc.), Maintenance Issues, Etc.*

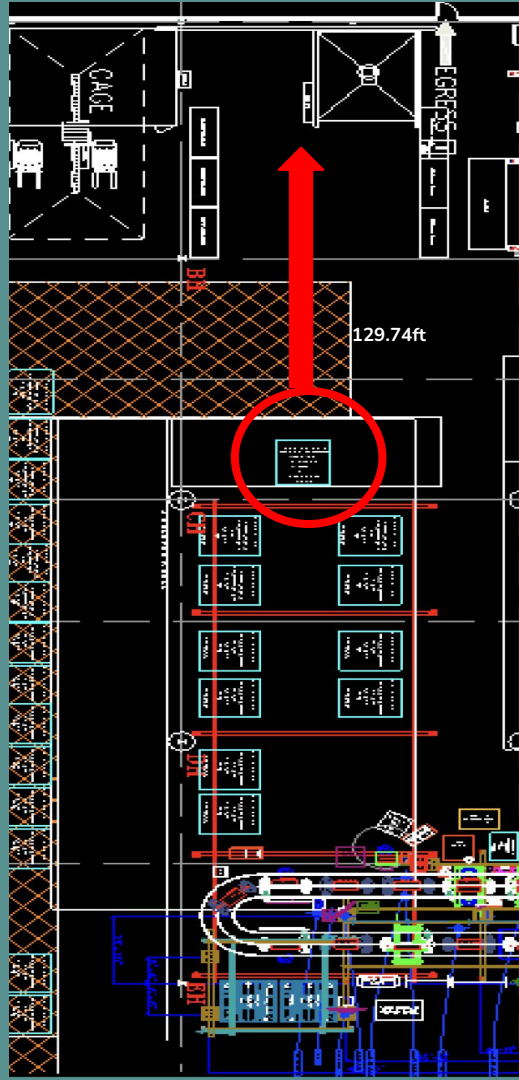
Distance/Time Analysis for Walking:

Distance Axel Station to farthest Tote: 996.105in or 83 ft

- **Max Walking Time w/out Weight:** 14s (28s there & back)
- **Velocity W/out Weight:** 5.92 ft/s
- **Walking Time w/ Weight:** 13s

Future Distance to Furthest Box:

- **83ft + (Box Set Dist.) x 2** = 129.74 ft
- **Farthest Walking Time** = 21.9 s x2
- Cycle Time - Original Walking Time = 18s
- **Total Estimated Cycle Time = 18 s + (21.9 x 2)= 61.8s**



Vendor Contact

FLT

- Visited the Android plant, awaiting proposal/response.

AMC

- Received proposal for rotating conveyor.

Tri-State Overhead Crane

- Sending building and operation specs in order to draft up crane solution.

4D Systems

- Did not respond to email communication for project.

Current Proposal from AMC:

<u>Details:</u>

- Clockwise Rotating Conveyor
- Pull-Out & Sequence w/ Overhead Manipulator

The conveyor proposal from AMC doesn't solve a lot of the ergonomic lift issues such as the vertical height and the gantry resistance forces in the gantry system.

Recommendations

- The best opportunity for improvement in regards to reaching the goal of *75% percentile* of female population being able to complete this task is to acquire an Intelligent G-Force Lift Assist Device which can add power to move the rear axles with slight pressure from an operator.
    - This can help the operator not use as much force and likely lower the vertical wrist height of the pulls and pushes, increasing the percentile of females who are able to complete the task.
- **<u>Final Recommended Solution:</u> Crane Powered X-Axis**
    - Less than 40lbs Force, Elbow Height, Usable for Men & Women

Thank you!

Any Questions?