



Factory of the Future

Automation Roadmap & ROI Rankings

Final Report





AGENDA

NOTE: *this report has been modified for sample / informational purposes. Customer data has been masked as best as possible.*

- 01 Executive Summary
- 02 Scope Review
- 03 Workshop Data Collection
- 04 From Data to Recommendations



Factory of the Future

Executive Summary

01

Executive Summary

Significant opportunities to grow EBITDA via completion of projects #1, #2, and #4

- Eckhart and Customer A collaborated on a 6-week review of Manufacturing Site A to identify opportunities to grow company EBITDA
- Field data collected to inform recommendations included: headcount deployment by cell and process, square footage assignment, process takt times, contracted production volume, and OT incurred
- The data informed a roadmap of 18 projects for Customer A to consider that all have a likely payback period under 2 years.
 - Cell layout changes – 8 projects
 - Material staging improvements – 2 projects
 - Cell automation – 10 projects
- Many of the recommendations relate to addressing significant “hidden factory” expense that Customer A incurs by way of (1) uncontrolled WIP, (2) box handling & spend, (3) indirect labor dedicated to material flow, and (4) underutilized existing assets
- Eckhart believes a full-time Customer A champion is needed to pilot projects #1, #2, #4, and #9 (see next page)
- Eckhart will propose a semi-automated Pxxx process (project #3) that has the potential to reduce headcount from ten operators per shift down to three

Executive Summary

Project Roadmap Ranked by Payback Period

Priority	Description	Project Type	Est. Payback Period (Years)	Months to Implement	Investment	Page
1	Relocate high volume cells to the conveyor	Layout	0.9	18	\$490,000	23-27
2	Establish a flow rack standard for lineside delivery	Material Staging	0.9	6	\$250,000	28-29
3	Combined & Automated Pxxx YY Machine	Cell Automation	FAN	6	FAN	30
4	Migrate to intra-plant dunnage	Material Staging	1.1	12	\$381,000	31
5	Robotic letter placement	Cell Automation	FAN	6	FAN	32
6	Shared operator: xxF + xxA	Layout	1.2	8	\$215,000	33-35
7	Shared operator: xxB + xxC	Layout	1.2	8	\$215,000	33-35
8	Shared operator: xxD + xxE	Layout	1.2	8	\$215,000	33-35
9	Shared operator: xxJ + xxK	Layout	1.2	8	\$215,000	33-35
10	Shared operator: xxM + xxP	Layout	1.2	8	\$215,000	33-35
11	Cell xxx space reclaim	Layout	1.7	1	\$215,000	36
12	Modify cell xxx mold to eliminate cell xxx	Cell Automation	FAN	5	FAN	37
13	Intra-company logistics reduction	Layout	FAN	30	FAN	38
14	Cell xxR	Cell Automation	FAN	8	FAN	
15	Cell xxS	Cell Automation	FAN	8	FAN	
16	Cell xxT	Cell Automation	FAN	8	FAN	
17	Cell xxU	Cell Automation	FAN	8	FAN	
18	YY consolidation & automation	Cell Automation	FAN	16	FAN	

(FAN = Further Analysis Needed)



Factory of the Future

Scope Review

02

Guiding Principles for Our Engagement

Group dynamics for an efficient and constructive two days

- 1 Process improvement doesn't always mean robots and sophisticated equipment. We also seek improvements related to material staging and flow, visual indicators, and traditional lean practices.
- 2 "Don't boil the ocean" – Stay committed and focused on the agreed upon scope
- 3 Have a bias to contribute data and current state observations versus anecdotes and stories
- 4 Keep defense to a minimum; set aside existing norms related to superior/subordinate relationships and turf
- 5 Acknowledge that this is ultimately a subjective process and the pathway to consensus can take twists & turns
- 6 We seek a defensible methodology to prioritize our efforts, not a perfect one

Agenda

On-Site Workshop – Days 1 & 2

Day 1 – 2/8

- 10AM – Introductions, scope and methodology review
- 1030AM – First end-to-end tour of building #1
- Noon – Lunch and email catch-up
- 1230PM – Eckhart independent observation time
 - What machines/processes were staffed and by how many people?
 - How much material delivery labor exists?
 - Did work ever shut down or stop? Why?
 - Largely Eckhart alone time while we get our bearings
- 330PM – Report out

Day 2 – 2/9

- 8AM – Reconvene
- 805AM – Meet with Customer A stakeholders to:
 - Answer Eckhart generated questions from the prior day
 - Review the process scoring methodology
- 9AM – Head to floor to populate scoring spreadsheet – Customer A stakeholders requested
- Noon – Lunch and email catch-up
- 1230PM – Complete spreadsheet and determine focus area rank
- 330PM – Report out

Agenda

On-Site Workshop – Days 3 & 4

Day 3 – 2/10

- 8AM – Reconvene
- 8:05AM – Deploy to the **top** 5 focus areas with Customer A stakeholders
 - Connect with operators to understand process limitations and opportunities
 - Begin whiteboard concepts for an improved process
- Noon – Lunch and email catch-up
- 1230PM – Eckhart independent working time on top 5 focus areas re-design
- 330PM – Report out

Day 4 – 2/11

- 8AM – Reconvene
- 8:05AM – Deploy to the **next** 5 focus areas with Customer A stakeholders
 - Connect with operators to understand process limitations and opportunities
 - Begin whiteboard concepts for an improved process
- Noon – Lunch and email catch-up
- 1230PM – Eckhart independent working time on top 5 focus areas re-design
- 330PM – Report out

Agenda

On-Site Workshop – Day 5

Day 5 – 2/12

- 8AM – Reconvene
- 8:05AM – Deploy to the **remaining** focus areas with Customer A stakeholders
 - Connect with operators to understand process limitations and opportunities
 - Begin whiteboard concepts for an improved process
- Noon – Lunch and email catch-up
- 1230PM – Eckhart independent working time on top 5 focus areas re-design
- 330PM – Report out



Factory of the Future

Workshop Data Collection

03

Space Utilization

How is Customer A utilizing square footage in Building XX today?

Area	Value Add?	Square Footage
Process Cells (includes mezz)	Yes	9,280
Mold	Yes	19,856
Warehouse	No	29,556
Other (aisles, empty, office)	No	42,808
Total		101,500
Value add as a % of total		29%

Benchmarking to other Invio engagements:

- Automotive Tier 2 in Illinois: 45% of factory space is value add
- Home appliance tier 1 in Georgia: 47%
- Automotive Tier 1 in Michigan: 61%

Cell by Cell Data Collection

How are operators utilizing their allocated time?

Over 3 days, the team documented 53 production cells:

1. Operator staffing and standard work activities
2. Sequence of operations and process times
3. Square footage consumed

(raw data available as appendix #1)

Operation Coding		
1	Pre-Assembly	9 Laser weld
2	Heat Stake	10 Light test
3	Ad Pro	11 Air/Leak Decay
4	Wet Out	12 Glue
5	Inspection	13 Torque (non-camera)
6	Clip Install	14 Drill
7	Camera Install	15 Pierce
8	Camera Check	16 Hand Apply foam or tape

Cell	Headcount Per Shift	SQ Footage	Product Being Produced	OP1		OP2		OP3		OP4		OP5		OP6		OP7	
				Cycle	Time	Cycle	Time	Cycle	Time	Cycle	Time	Cycle	Time	Cycle	Time		
xxA	6	512	xxxxx	1	18	2	20	16	10	1	20	2	21	16	15	6	18
xxB	5	520	xxxxx	1	46	2	46	1	46	2	46	6	46	18			
xxC	5	493	xxxxx	1	46	2	46	1	46	2	46	6	46	18			
xxD	4	592	xxxxx	1		2		4		18							
xxE	6	756	xxxxx	12	80	14	80	6	80	7	16	2	80	4		18	80
xxF	3	240	xxxxx	1	31	2	46	4	24	18	45						
xxG	3	66	xxxxx	1	33	1	20	2	32	3	60	4	30	18	30		
xxH	4	336	xxxxx	1	43	2		6		4		18					
xxI	2	72	xxxxx	4	55	3											
xxJ	3	379.25	xxxxx	1	20	3	20	2	10	4	20	18	20				
xxK	2	208	xxxxx	3	15	1	15	4	45	18	15						
xxL	2	132	xxxxx	1	40	2	40	6	14	18	16						
xxM	2	277.5	xxxxx	4	18	6	18										
xxN	4	320	xxxxx	1	6	2	43	3	5	4	16	6	24	18	10		

Cell by Cell Data Collection

Cell data was linked with projected production volume and scrap dollars

A true cell-level annual operating cost emerges. Cells with the highest annual operating cost are where Customer A can most efficiently improve profitability and where scarce time and dollars should be deployed.

Cell	Daily Headcount Staffing	Shifts	Annual Headcount Cost	Annual Sq. Footage SQ Footage	Annual Sq. Footage Cost	January Scrap \$ Annualized	Annual Operating Cost	Other Metrics			
								6 Year Volume	Annual Cost Per Piece	Volume Per Operator	Volume Per Square Foot
xxA	xx	3	\$1,xxx,xxx	512	\$xx,xxx	\$xx,xxx	\$1,xxx,xxx	1, xxx,xxx	5.0	xxx,xxx	xxx,xxxxxxx
xxB	xx	3	\$8xx,xxx	520	\$xx,xxx	\$xx,xxx	\$9xx,xxx	4,xxx,xxx	1.5	xxx,xxx	xxx,xxxxxxx
xxC	xx	3	\$8xx,xxx	493	\$xx,xxx	\$xx,xxx	\$958,xxx	4,xxx,xxx	1.3	xxx,xxx	xxx,xxxxxxx
xxD	xx	3	\$7xx,xxx	592	\$xx,xxx	\$xx,xxx	\$8xx,xxx	4,xxx,xxx	1.0	xxx,xxx	xxx,xxxxxxx
xxE	xx	2	\$7xx,xxx	756	\$xx,xxx	\$0	\$7xx,xxx	xxx,xxx	28.1	xxx,xxx	xxx,xxxxxxx
xxF	xx	3	\$5xx,xxx	240	\$x,xxx	\$xx,xxx	\$6xx,xxx	1,xxx,xxx	1.9	xxx,xxx	xxx,xxxxxxx
xxG	xx	3	\$5xx,xxx	66	\$x,xxx	\$xx,xxx	\$5xx,xxx	1,xxx,xxx	2.2	xxx,xxx	xxx,xxxxxxx
xxH	xx	2	\$4xx,xxx	336	\$x,xxx	\$xx,xxx	\$5xx,xxx	5,xxx,xxx	0.6	xxx,xxx	xxx,xxxxxxx
xxI	xx	3	\$3xx,xxx	72	\$x,xxx	\$xx,xxx	\$3xx,xxx	1,xxx,xxx	1.8	xxx,xxx	xxx,xxxxxxx
xxJ	xx	2	\$3xx,xxx	379	\$xx,xxx	\$xx,xxx	\$3xx,xxx	xxx,xxx	7.6	xxx,xxx	xxx,xxxxxxx
xxK	xx	3	\$3xx,xxx	208	\$x,xxx	\$xx,xxx	\$3xx,xxx	1,xxx,xxx	1.5	xxx,xxx	xxx,xxxxxxx
xxL	xx	3	\$3xx,xxx	132	\$x,xxx	\$xx,xxx	\$3xx,xxx	xxx,xxx	2.8	xxx,xxx	xxx,xxxxxxx
xxM	xx	3	\$3xx,xxx	278	\$x,xxx	\$xx,xxx	\$3xx,xxx	1,xxx,xxx	1.6	xxx,xxx	xxx,xxxxxxx

- 1) Within "Other Metrics", *Volume per Operator* is a key metric to guide the ease of automation. Higher volume per operator correlates to more simple standard work.
- 2) The operational challenge associated with a large quantity of unique SKUs was reinforced in nearly every conversation with Customer A stakeholders.
- 3) Certain cells have programs that end after 20XX. Investigation needed to determine if improvements made today have transferable value beyond current programs

Current State WIP Management

WIP is driving significant costs to the business today



38 boxes visible in cell 575

- On 2/9, the team counted approximately 975 boxes in the production area representing an estimated \$355,000 of WIP.
- Boxes with shipping labels dating back to 2016 were found on shelves directly off high traffic aisles
- Cells lack visual cues and structure to inform supervisors where and why WIP exists
- Any available space becomes box storage space
- Box expense in Jan 2021 was \$180k; Feb was \$220k
- These comments don't include the traditional inventory/warehouse areas which are out of scope of this contract and likely an even larger cost savings area

Conveyor system is a monument and under-utilized (near 0%)

Customer team should commit to utilizing system or remove it; Invio recommends it stays.



1:30 PM – 1 box



1:52 PM – 0 boxes



2:10 PM – 0 box



2:32 PM – 2 boxes

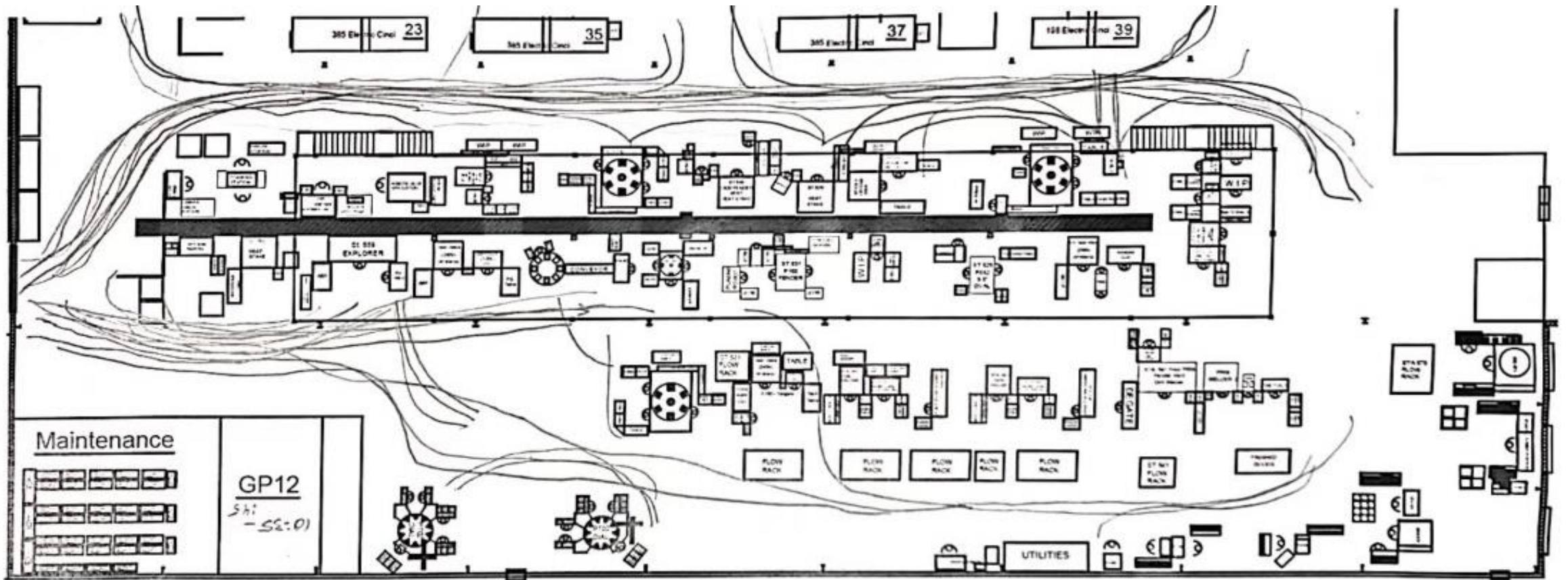
- The conveyor currently serves as trash conveyance for a small number of cells.
- Empty boxes are a poor assignment for the conveyor since they are the lightest and most compactable object to transport.
- There are many instances of cells located directly along the conveyor that do not even have access to the conveyor



“Hidden Factories”

Significant expense exists in the form of operators searching for and moving raw materials, WIP, and finished goods

This is a 15 minute snapshot during regular operation. While many people were logged in this illustration, in aggregate, the amount of travel aggregates to two dedicated operators in continuous walking and searching mode.



Headcount and Labor

Cost Assumptions utilized in ROI Assessment

Headcount Cost Assumptions & Inputs		
Straight Time: (Wage Rate + Fringe) / Hour	\$	21
Overtime Multiplier		1.5
Straight Time Hours Per Week		40
Avg OT Hours Per Week in 2020		10
Headcount Cost Per Week	\$	1,155
Annual Headcount Cost Per Week (assumes 51 work weeks)	\$	58,905



Factory of the Future

From Data to Recommendations

04

Recommendations

Customer A's Project Roadmap, Ranked by Payback Period

Priority	Description	Project Type	Est. Payback Period (Years)	Months to Implement	Investment	Page
1	Relocate high volume cells to the conveyor	Layout	0.9	18	\$490,000	23-27
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(FAN = Further Analysis Needed)

Recommendations

Overtime reduction activities should precede more ambitious headcount reduction initiatives

- Headcount reduction is an obvious and desired goal.
- Smaller and easier projects to improve station layouts and shave seconds from operator standard work have the potential to eliminate the estimated 10 hours per week per operator in overtime
- Overtime hours are Customer A's most expensive production mode and profit is likely zero or negative for units produced at 1.5x wage rates.
- Third parties like automation integrators are ill-suited for these types of projects as they require deep process intimacy and day-to-day reinforcement of behavior modification
- Prior to more ambitious headcount reduction activities, narrow continuous improvement activities for overtime reduction should happen first.

HEAD COUNT BY MONTH												
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1ST SHIFT	91	93	91	92	93	87	81	86	92	94	94	91
2ND SHIFT	56	66	59	54	56	56	43	49	53	57	55	46
3RD SHIFT	28	35	31	30	33	34	22	28	31	30	32	18
TOTAL	175	194	181	175	182	176	146	164	176	182	181	155
HEAD COUNT NEEDED FOR OT	81	97	55	35	75	71	33	37	68	103	67	27

Priority #XX

A new assembly area layout optimized for the highest production cells is the fastest payback activity that Customer A can undertake. Minimal CapEx expected.

Customer A has significant ***hidden factory expense*** in the form of WIP and people walking throughout the assembly area. An improved layout:

- Places high volume cells adjacent to the conveyor and establish the conveyor as the artery for finished goods transport
- As an organization standard, every cell has a gravity flow rack directly off the aisle (see pages 24-25 for further discussion)
- Move lower volume cells to the periphery (e.g., along the walls) of the assembly area
- Designate paths as either fork truck or operator walkways; create a loop for fork trucks to service high volume cells
- Move the service and lowest volume cells to building 2
- Redefine the mezzanine for non-assembly process
 - Significant work place improvement in summer temperatures
 - Fewer spaces for inventory to “hide”
 - Maintenance, and hold & rework areas
 - Cost prohibitive to remove mezzanine; a true monument

Priority #XX

Where do the savings come from?

- Customer A currently staffs 4 delivery people per shift to service the production area. The responsibilities of the fork truck drivers are to deliver raw material and pick-up finished goods.
- An estimated 95% of all the finished goods-related fork truck traffic is eliminated by way of the conveyor and a simple AMR to shuttle product to the warehouse
- This analysis conservatively assumes only two of the four fork truck drivers are eliminated leaving 2 fork truck drivers to deliver raw material to all cells and do pick-ups at certain low volume cells.
- We estimate at least one of the two full-time operators from the “walking and searching” observation is eliminated as well

Annual Savings Associated with Project Implementation

- (2) Material handlers per shift x 3 shifts x \$58,905 = \$353,430 annually
- (1) Walking/Searching operator x 3 shifts x \$58,905 = \$180,180
- Total Annual Savings = \$540,540

Project Implementation Investment

- Time and electrical work to relocate 30 cells along the conveyor @ an estimated \$10,000 per cell = \$300,000
- AMR to receive FGs at the end of the conveyor and transport to the warehouse = \$190,000
- Total est. investment = \$490,000

Payback Period: 11 months

Priority #XX

Autonomous Mobile Robot (AMR) to receive finished goods at the end of the conveyor and transport to the warehouse

AMR material delivery from the end of the line to the warehouse is expected to reduce to reduce at least 1 indirect headcount per shift and greatly reduce fork truck traffic in crowded areas.

Representative system can be [viewed here](#) with an expected investment of \$190,000:

- (2) AMRs capable of transporting 4 boxes per trip (box dimension understanding is still needed)
- Modifications to existing conveyor to facilitate hand-off to the AMR
- (1) Charge station
- A process in the warehouse to offload finished goods is required

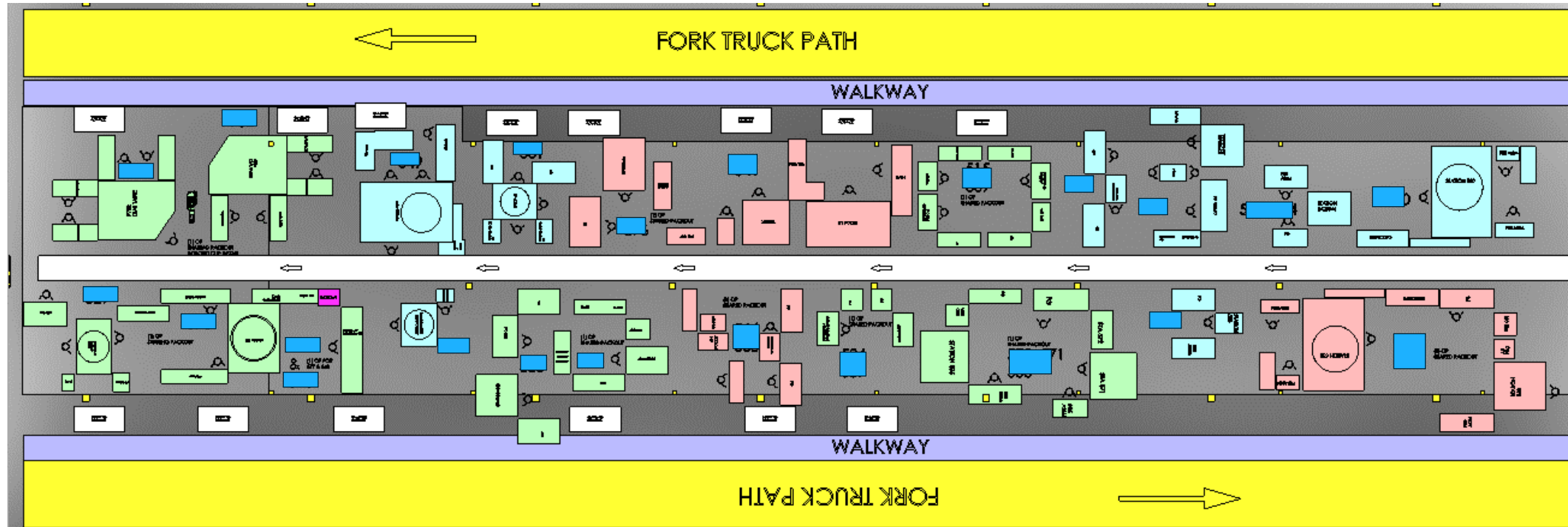
ROI calculation:

- Annual fork truck operator expense: \$58,905
- Expense for three shifts: \$176,715
- AMR system investment: \$190,000
- **Payback period is estimated at 1.1 years**
- **Headcount reduction of 1 person per shift**



Priority #YY

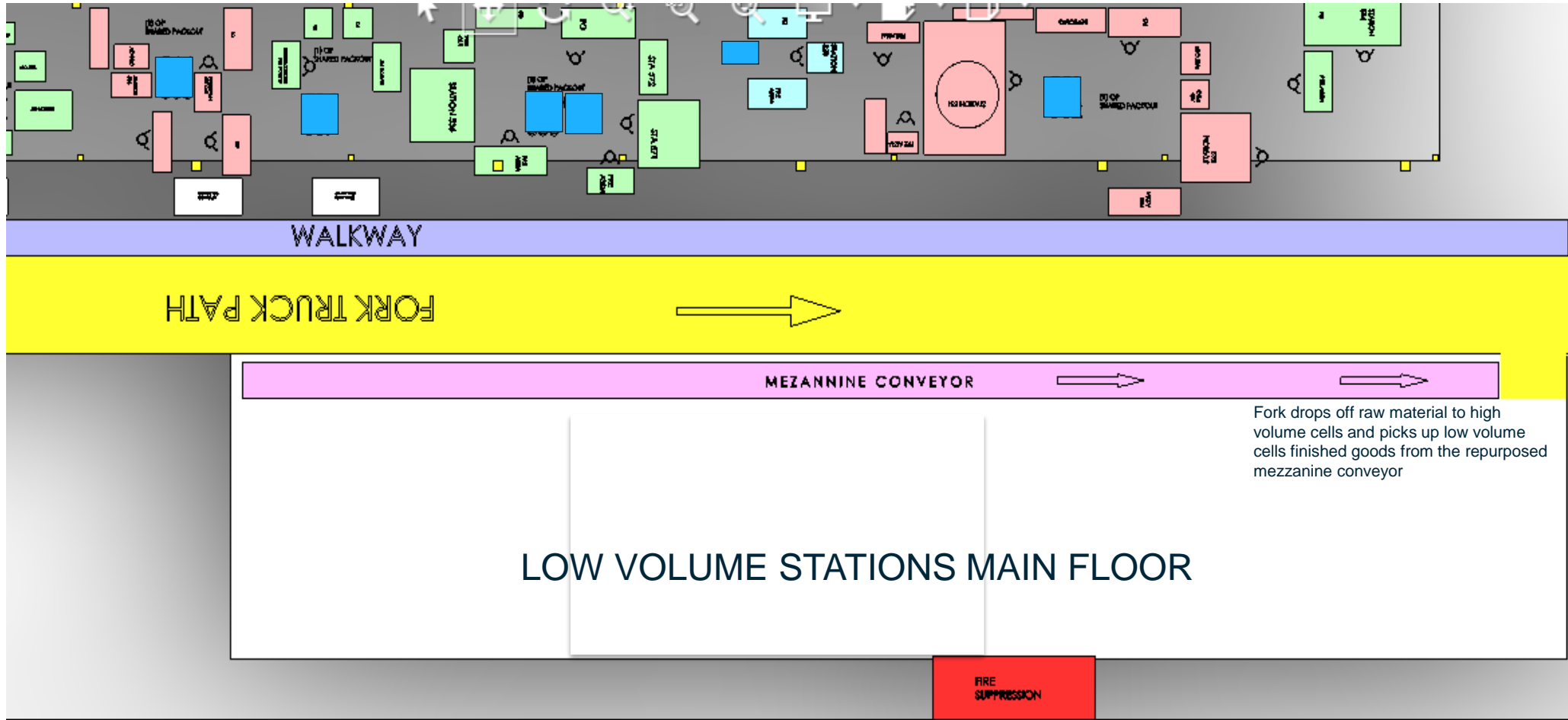
New layout that's "high production-centric", leverages the conveyor, & clusters "like" cells



- High volume cells located closer to the molds and the warehouse
- Grow the utilization of the existing conveyor from nearly zero to dozens of boxes per hour
- Create a one-way loop for fork trucks to improve safety and flow (current state: fork trucks have one lane that weaves through production)

Priority #YY

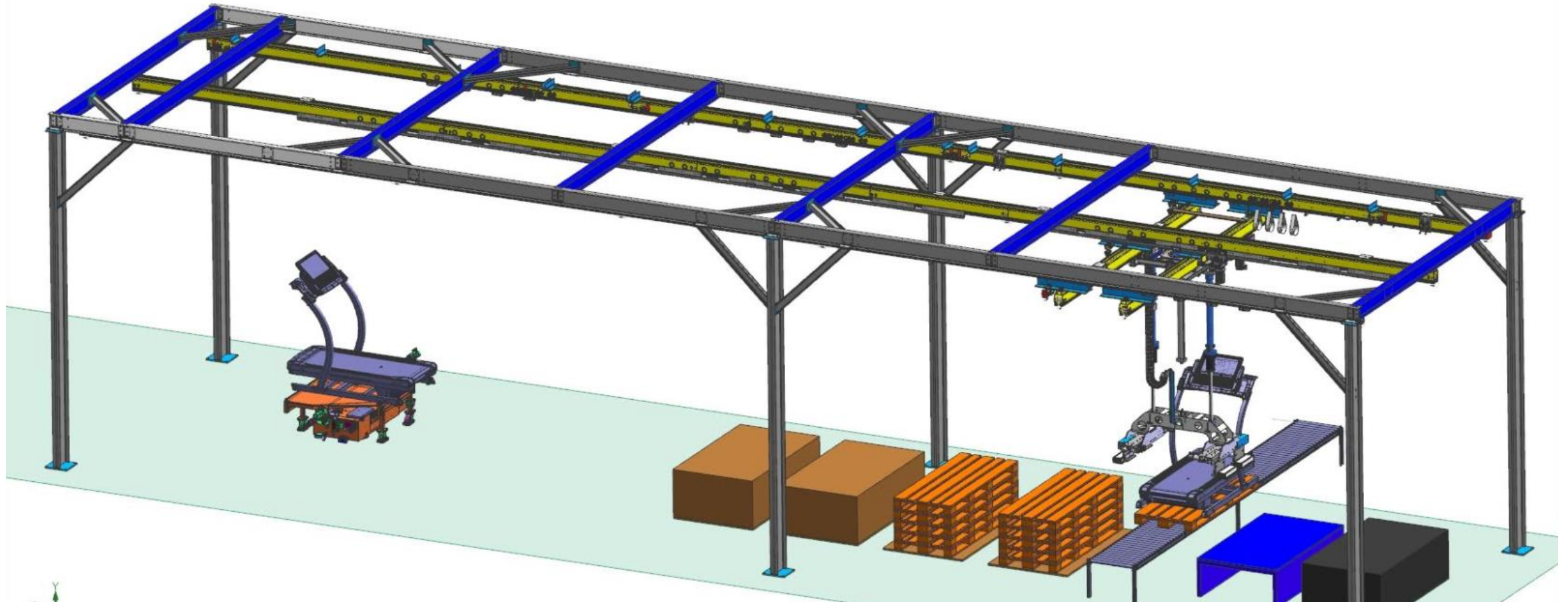
Segregate lower volume cells from high production cells. Repurpose the mezzanine conveyor to the first floor. Labor in this area needs to be flexible and reprioritized often.



Priority #YY

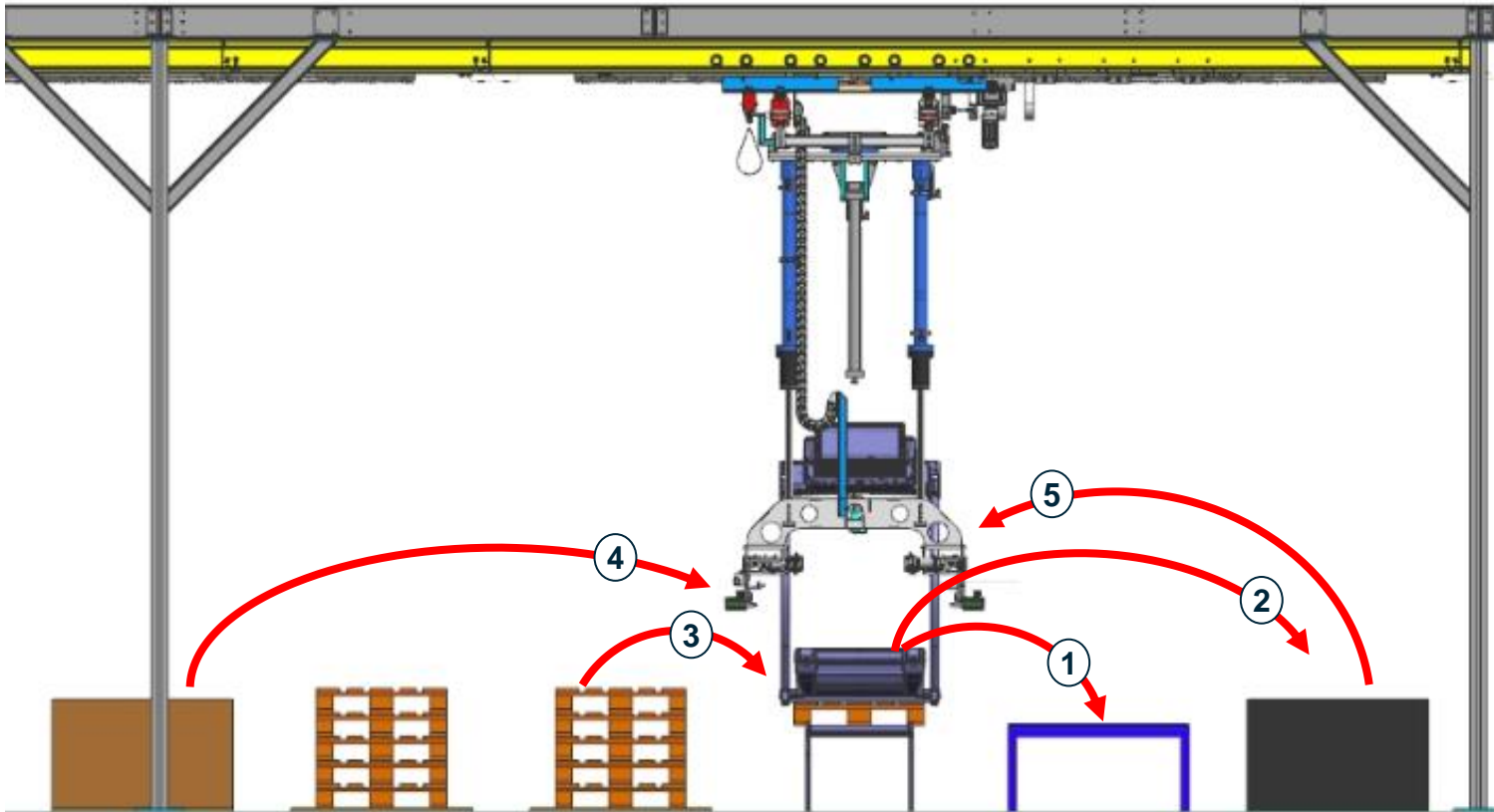
Automated material handling & end of line packaging

Invio envisions a fully autonomous cartesian palletizing cell will serve as the confluence point for the High Runner and Low Runner assembly lines; a unit leaving this cell will be riding on its dedicated cardboard+pallet and ready for final boxing



Priority #YY

Automated material handling & end of line packaging



The automated palletizing cell will conduct all work content required to transfer the treadmill unit onto its pallet for shipment

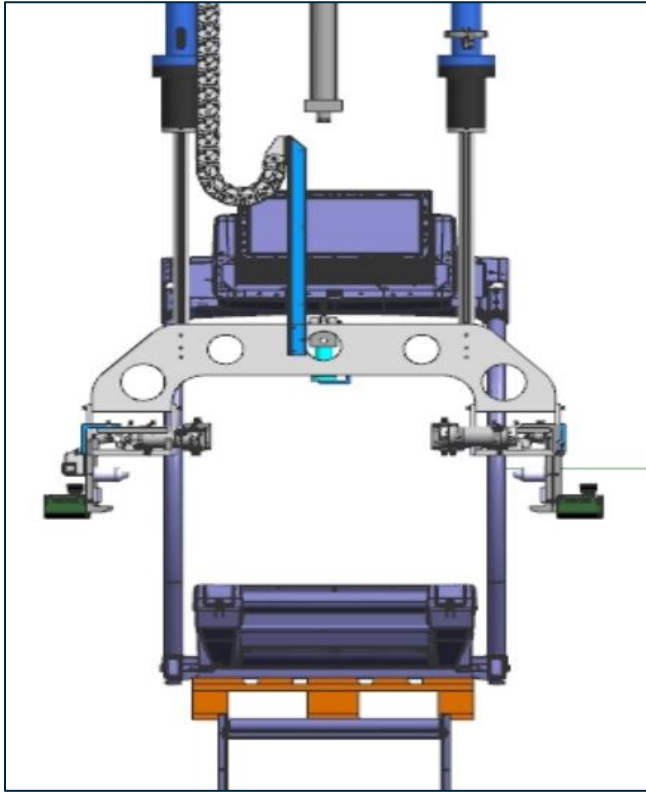
Sequence of operations for HIGH RUNNER

1. Unit is lifted off the travel board and placed onto the hold platform
2. Travel board is removed from line and placed onto the stack for return
3. Pallet is moved from stack to line
4. Cardboard liner is placed on top of pallet
5. Unit is placed back onto the pallet assembly
6. Unit is automatically indexed out of cell

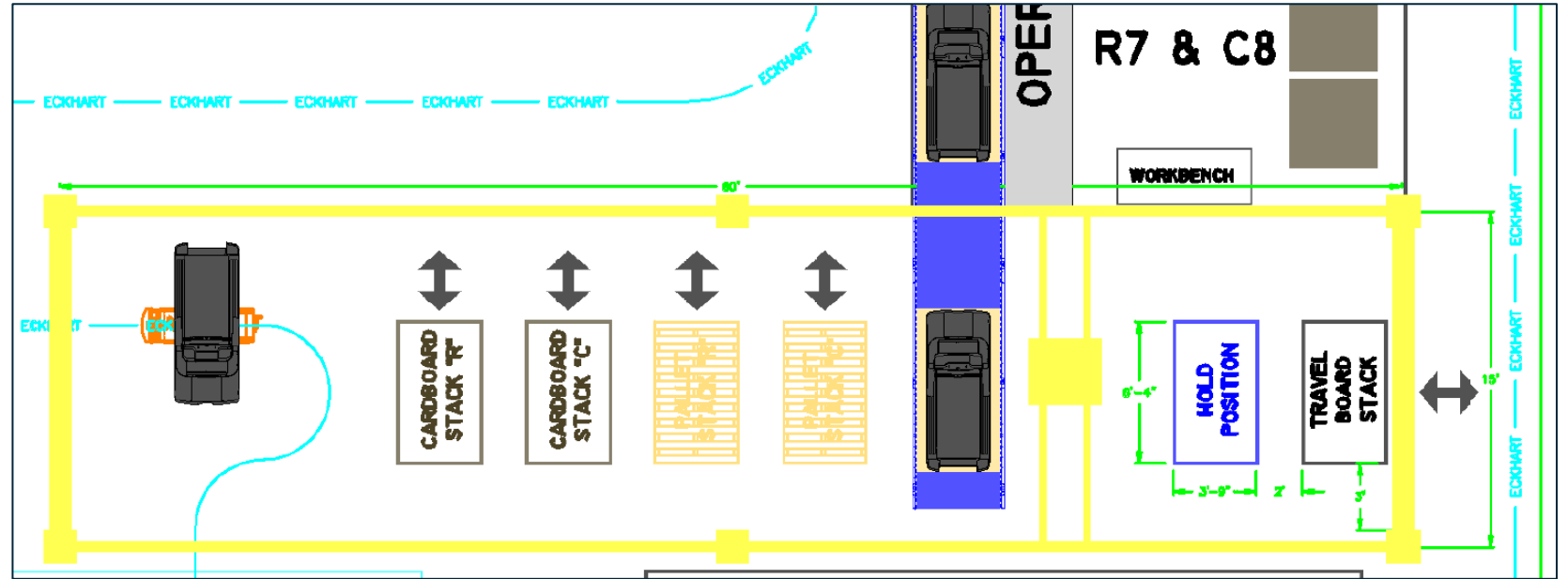
The sequence of operations for the Mid-Runner line is highly similar, however the hold position table will not be utilized as the unit can be picked up directly from its AMR and brought to the pallet

Priority #YY

Automated material handling & end of line packaging



The end-of-arm-tooling on the palletizer will be designed with gripper fingers to accommodate both types of cardboard liners, pallets, and treadmills



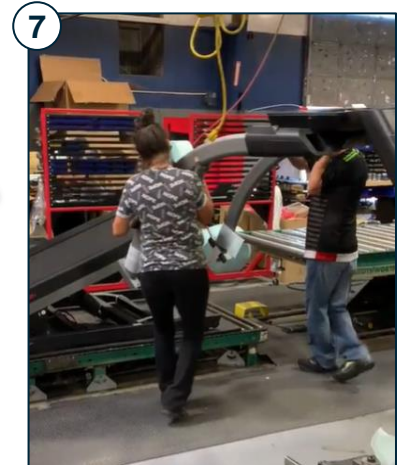
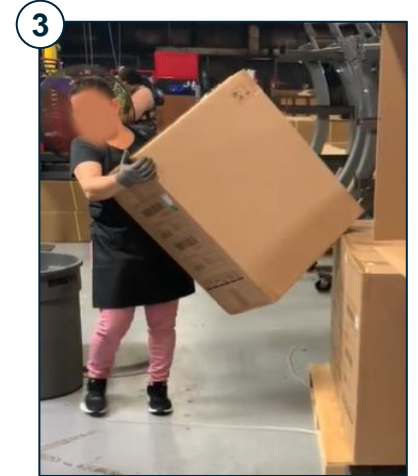
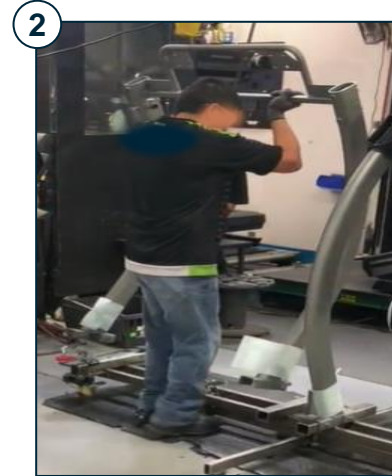
- (1) operator will be required to tend the cell to supply full stacks of cardboard liners, pallets, and to remove the travel boards
 - Travel board return to the start of the High-runner line can be automated by the AMR trolley
- Operator safety is accounted for by light curtains and fencing surrounding the cell to prohibit access into the palletizing area while the tooling is in motion

Priority #YY

Ergonomic Lifting Devices

- The workshop participants observed multiple opportunities to implement tooling to improve ergonomics and increase safety in daily operations
- Top priority identified for an immediate quick win is a re-imagined Station 6: Console+Uprights
- Standard work content in Station 6 involves multiple ergonomically-challenged motions such as:

- ① Lifting of Upright off of the staging rack
- ② Placement onto build-rack on floor
- ③ Lifting console box off the staging rack
- ④ Lifting console out of box and on to build table
- ⑤ Picking up console from staging area and mounting to Upright
- ⑥ Assembly of back panel on Console
- ⑦ Lifting of Console+Upright and installation on Treadmill base frame



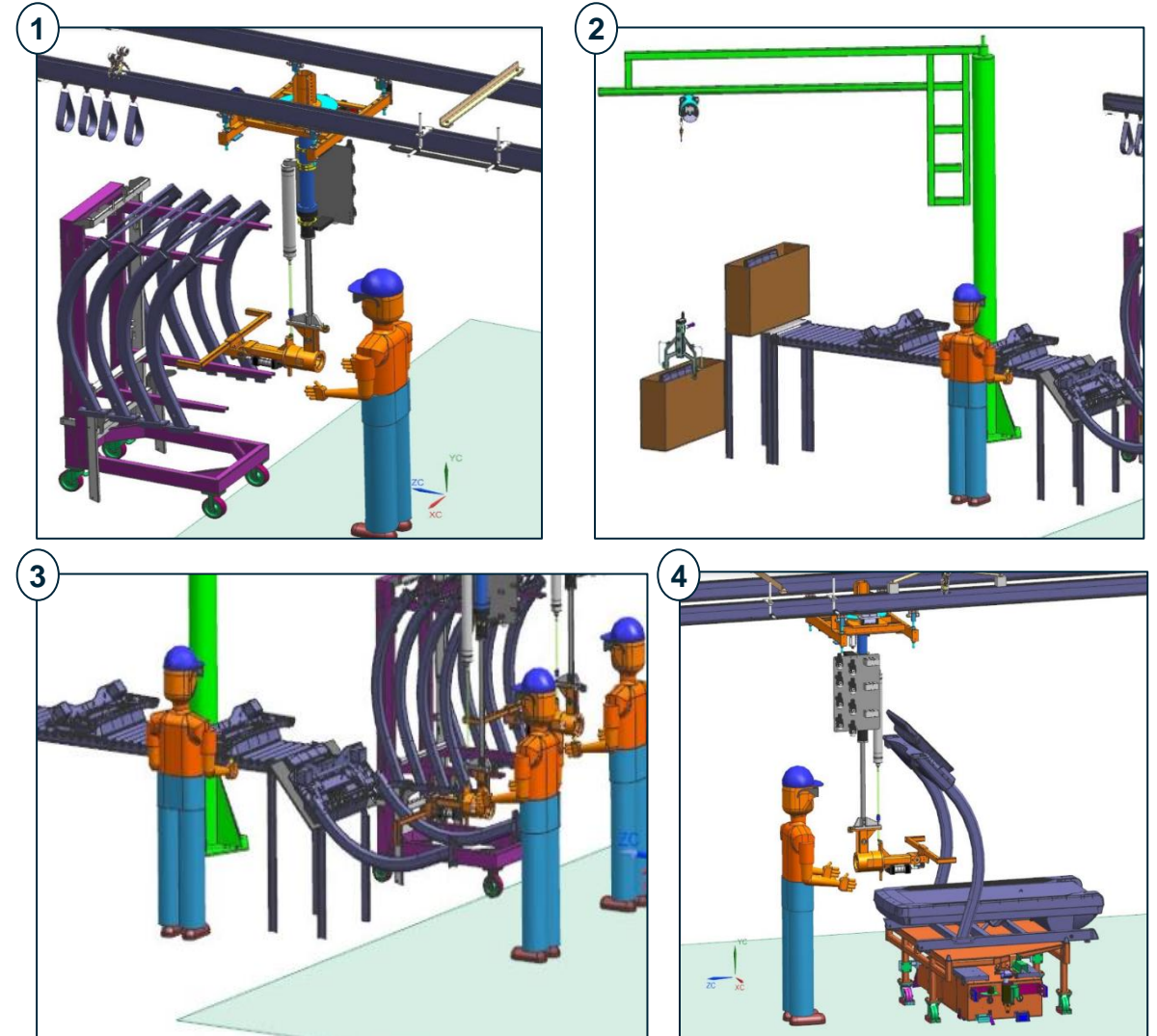
Story-board of current Station 6 process today

Priority #YY

Ergonomic Lifting Devices

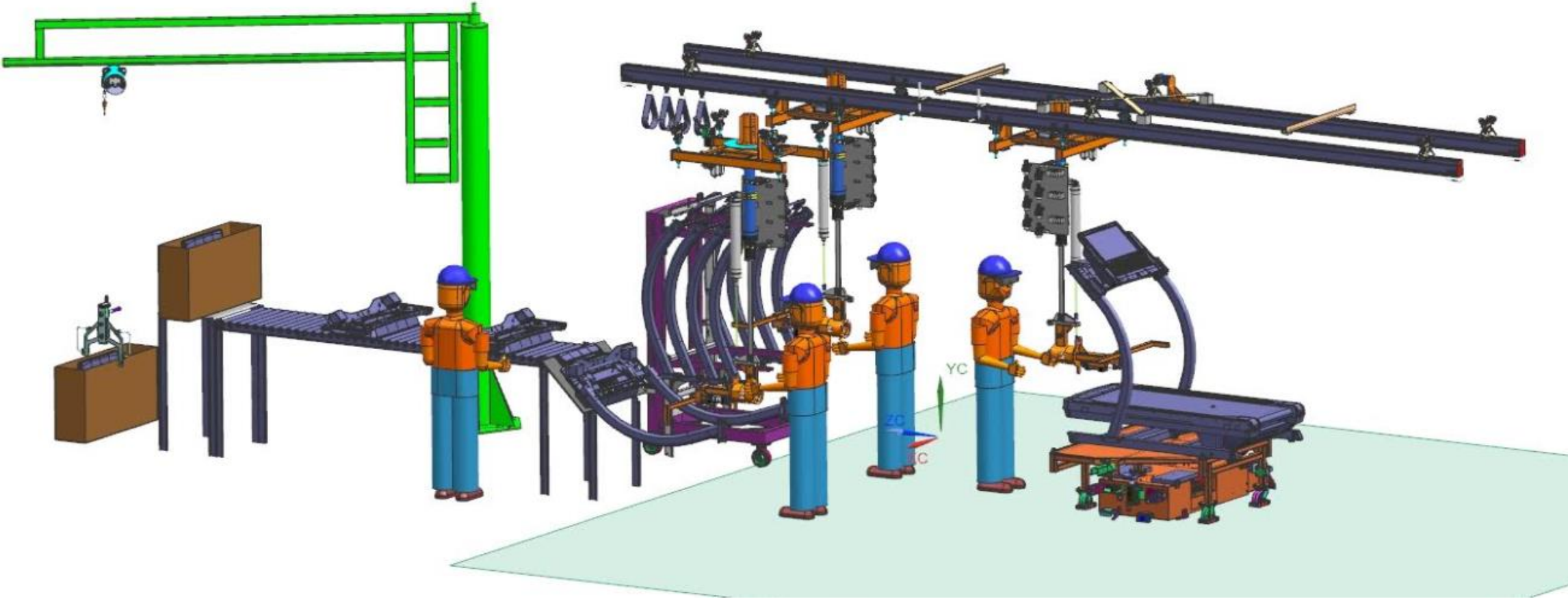
- A new cell consist of a lifting device capable of 5-axes of motion
 - ① Operators will be able engage an Upright in the tool directly from the Universal Rack
 - ② A smaller, secondary jib boom with an 'ice-tongs' tool can facilitate pick-up of the console from floor and loading onto the build table
 - ③ The lifting device will enable operators to lower the Upright to the appropriate Console mate-up angle
 - ④ An assembled Upright+Console will then be seamlessly transferred to its installation location
- Lifting device eliminates the need for (1) operator
 - No more tandem lifts
 - Grip part only once, positions part in a predictable place for easier bolt-hold alignment
- Estimated investment for implementation of concept is ~\$70k* for the Uprights device, and ~\$17k* for the jib-mounted box lifting tool

Note: *See Invio quote in Appendix for detailed pricing and assumptions



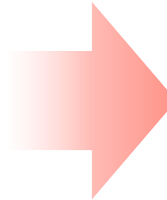
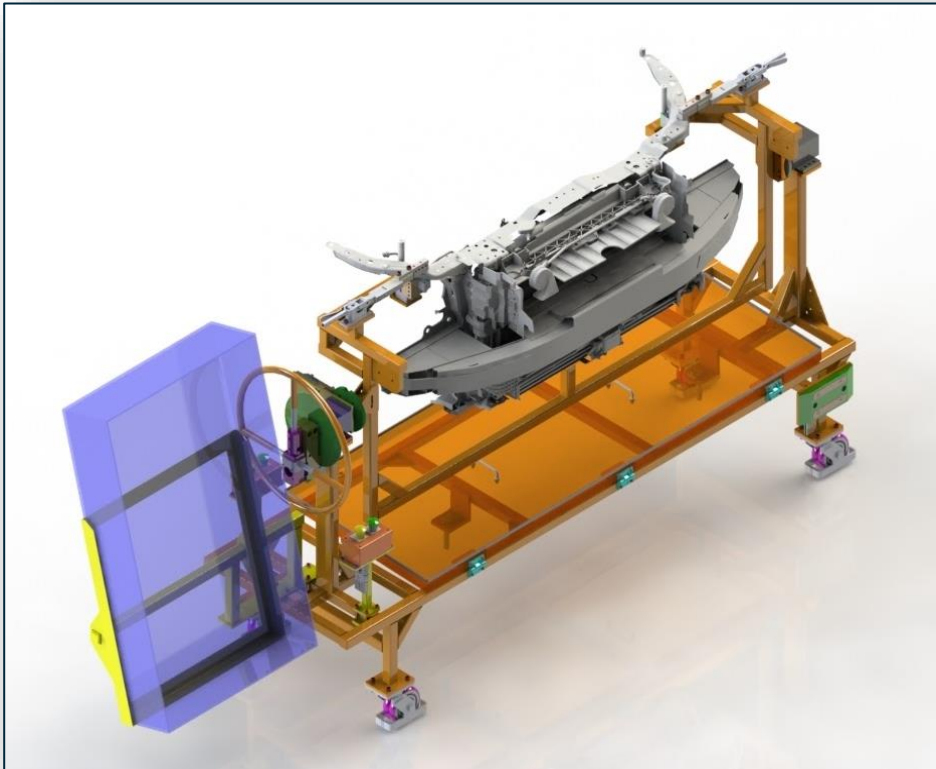
Priority #YY

Ergonomic Lifting Devices



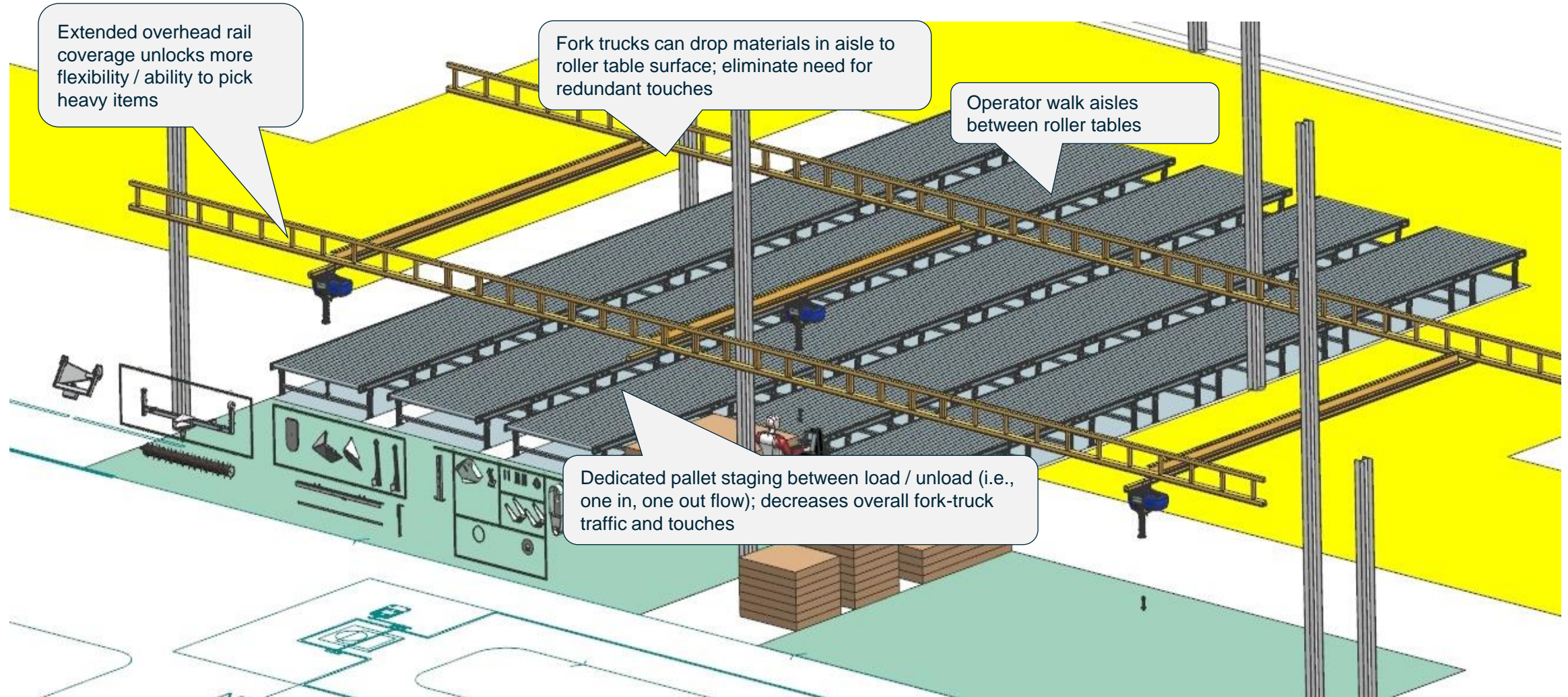
Priority #YY

Utilize AMRs to pair kits w/ carts directly on the line



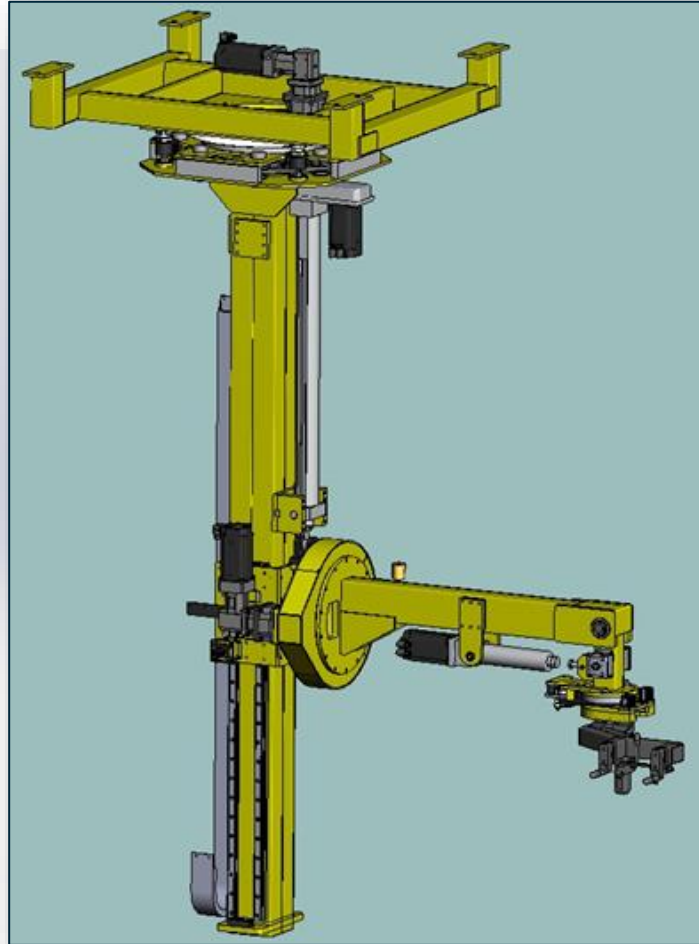
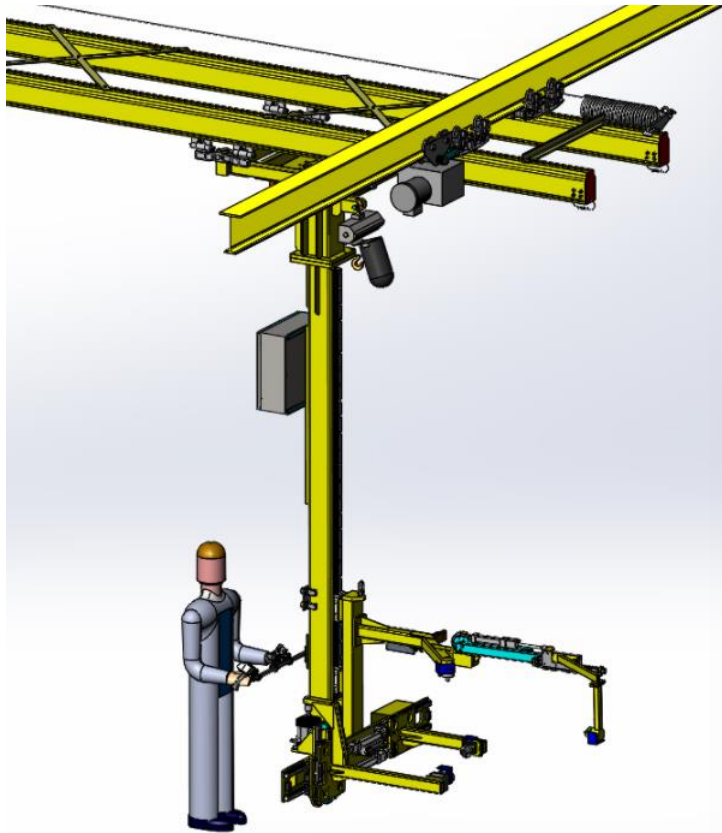
Priority #YY

Re-configure Loading Zone Layout to Accelerate Throughput



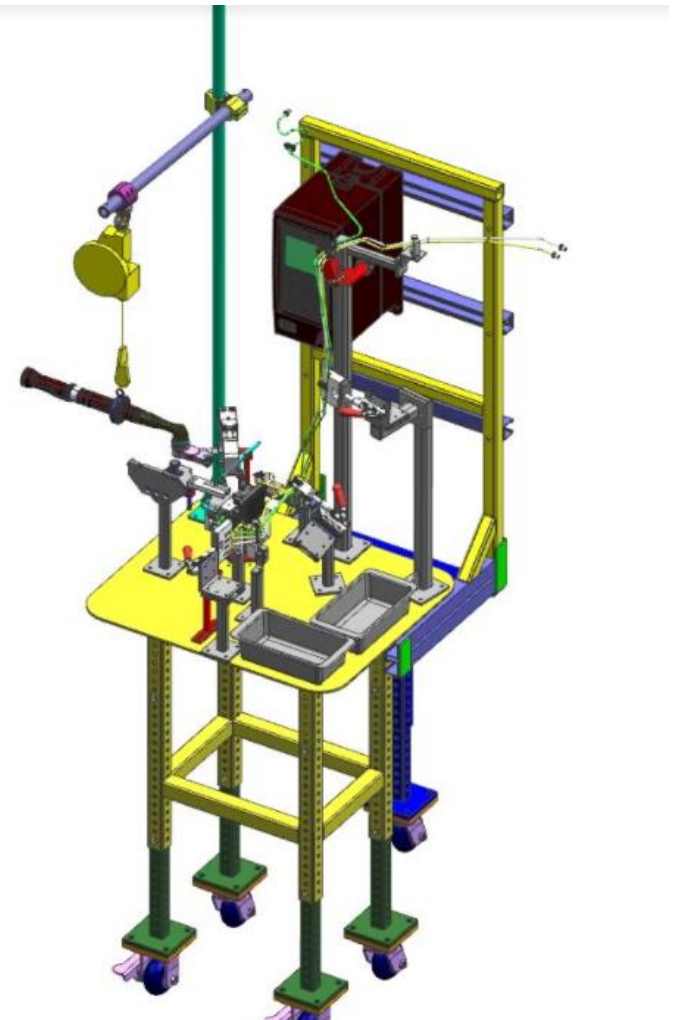
Priority #YY

Lift tooling for bulky-item transfers



Priority #YY

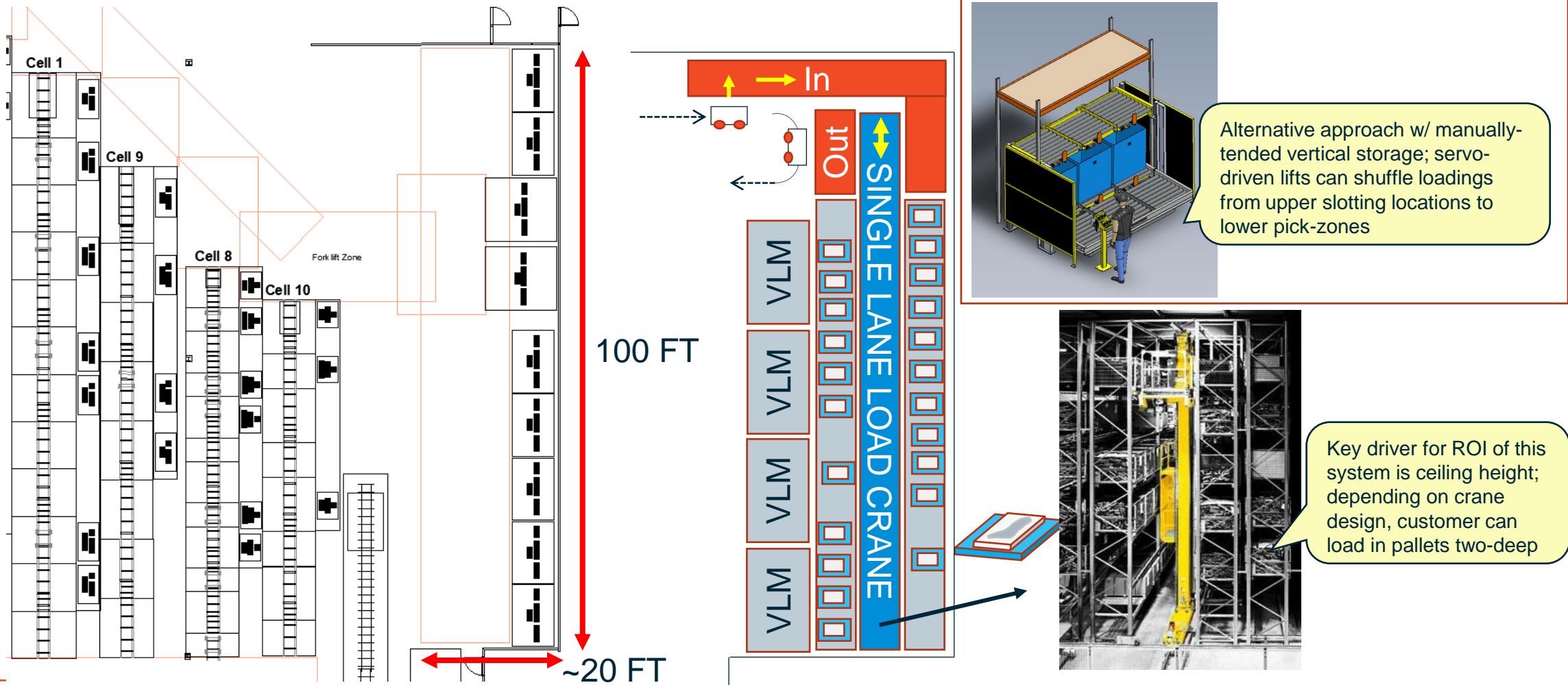
Ergonomic workstations



Priority #YY

Utilize vertical storage to reclaim high-value square footage; ASRS or Vertical Lift Modules / Buffers

Anticipate civil modifications due to limitations in existing facility's concrete loading capacity



INVIO

AUTOMATION



Factory of the Future Consulting
connect@invioautomation.com



570 Lake Cook Road
Deerfield IL • 60015



Invioautomation.com



YOUTUBE.COM/Invioautomation