Owala Facility Design Proposal

Prepared By: Rae Ehrbar

Prepared For: Laine Schrewe

Production Systems I

4/30/25

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Introduction

Owala is a child company of Trove Brands. They have recently seen a surge in tumbler sales, having increased by 300% since 2020. This growth is expected to continue if not increase due to the addition of the Owala Pet Sip Duo. The Owala Pet Sip Duo is a new design which features a silicone bowl seamlessly integrated into the standard lid. This feature is designed to fold outward and provide a convenient water source for pets on the go. Market demand for this innovative model is projected to align with the brand's existing customer base. Due to the popularity of the Free Sip and the New Owala Pet Sip Duo model Owala requires a new facility to keep up with the demand. The empty facility that has been chosen to be assessed is Autotool Incorporated in Plain City, Ohio.

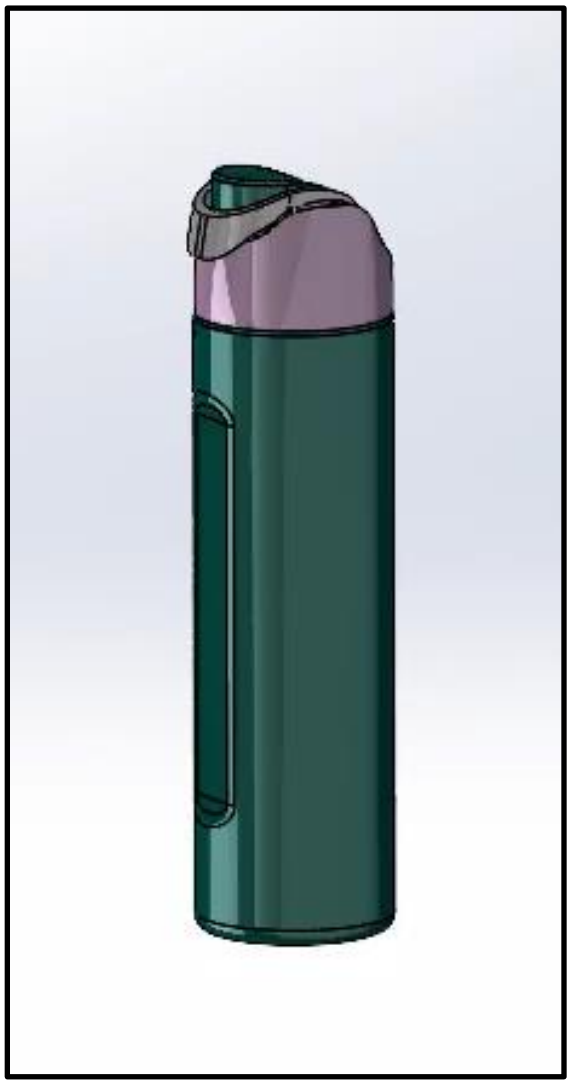


Figure 1: Owala FreeSip Model

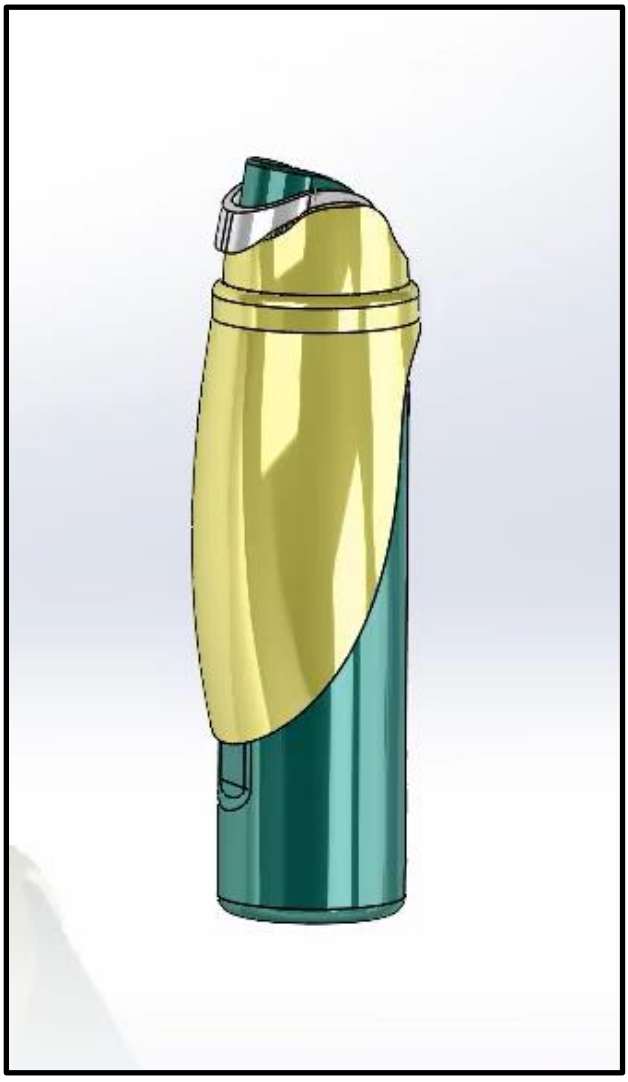


Figure 2: Owala PetSip Duo Model

Designing models of the two products intended for production provided a deeper understanding of how each part is made as well as material type. Their volume and sizes were measured with the Evaluate tab in SolidWorks to create the Assembly Chart for the products.

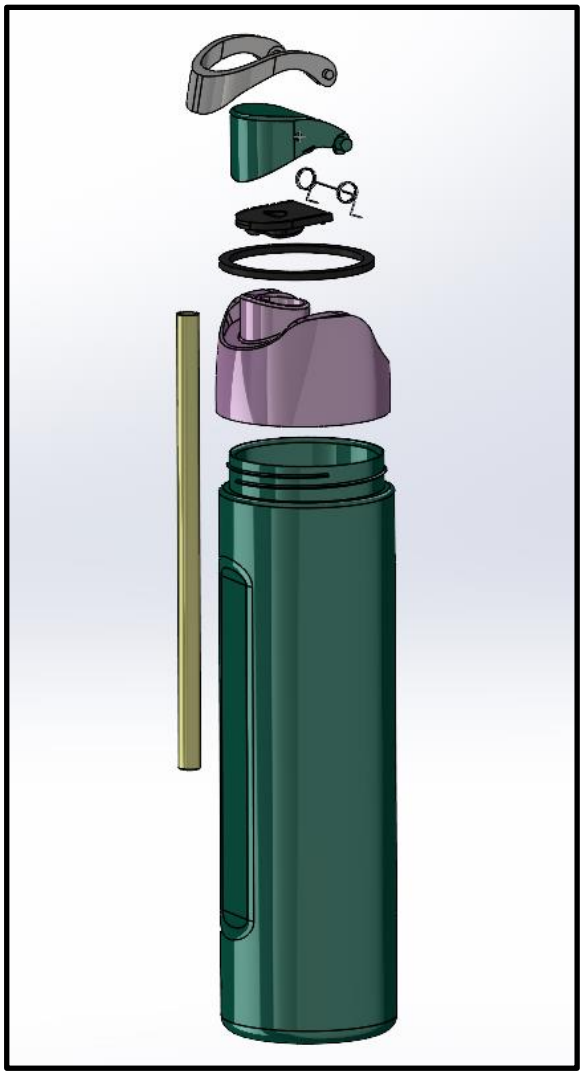


Figure 3: Exploded View - Owala FreeSip

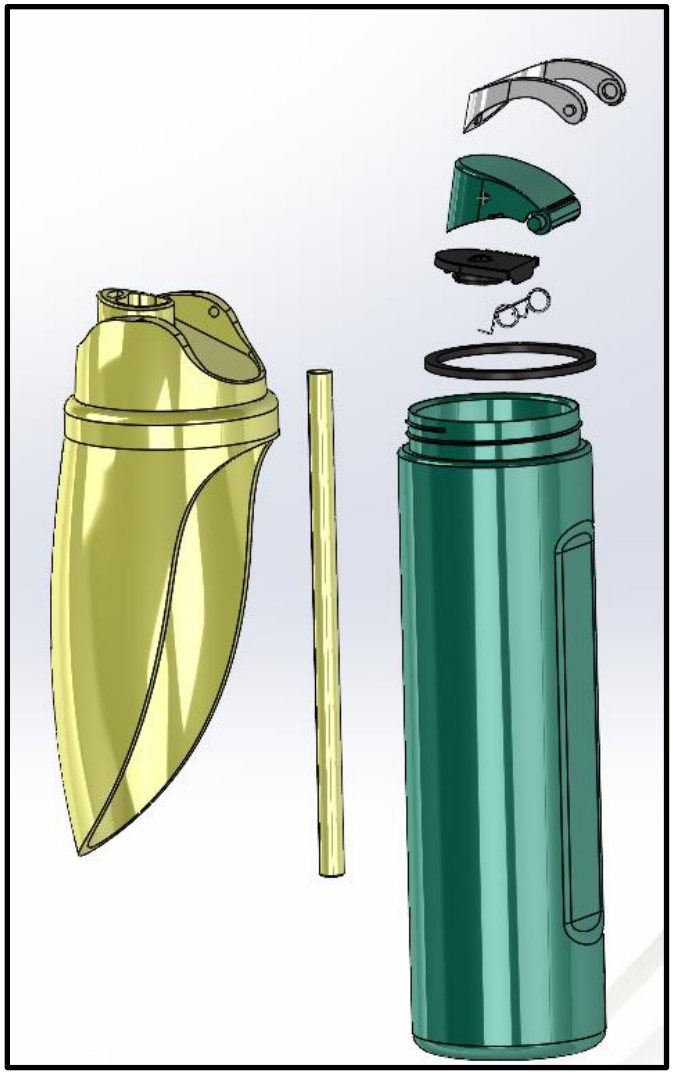


Figure 4: Exploded View - Owala PetSip Duo

This facility is anticipated to require the following departments: manufacturing, management, quality control, shipping & receiving, engineering, HR, sales, accounting, maintenance, legal, marketing, and health. 83 total employees are required once they are divided proportionally between departments based off required workload.

A unique element of this process was the deliberation between teammates, all passionate about delivering Owala a solution that adequately meets both production and employee needs.

Through this proposal I will introduce an optimized layout as shown below in Figures 5 and 6 below that focuses on enhancing workflow capability while minimizing operational costs. The following sections of this report detail our team's findings and recommendations regarding moving forward in the adaptation of Autotool Incorporated.

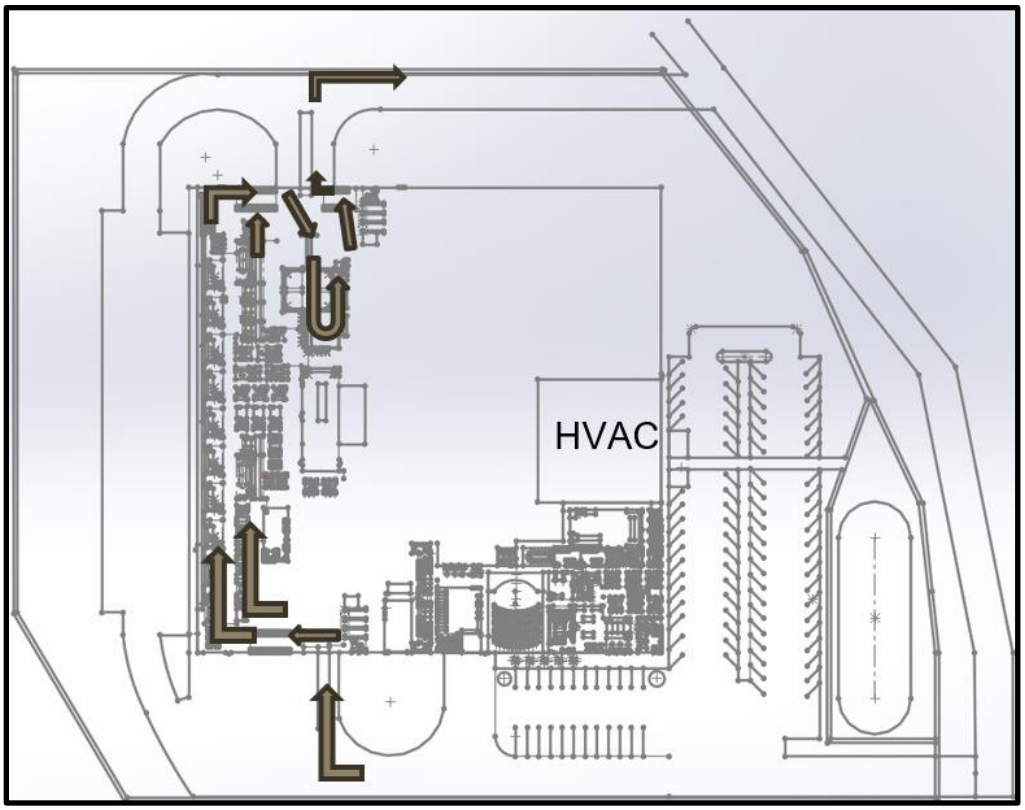


Figure 5: 2D Layout of Owala Expansion Proposal

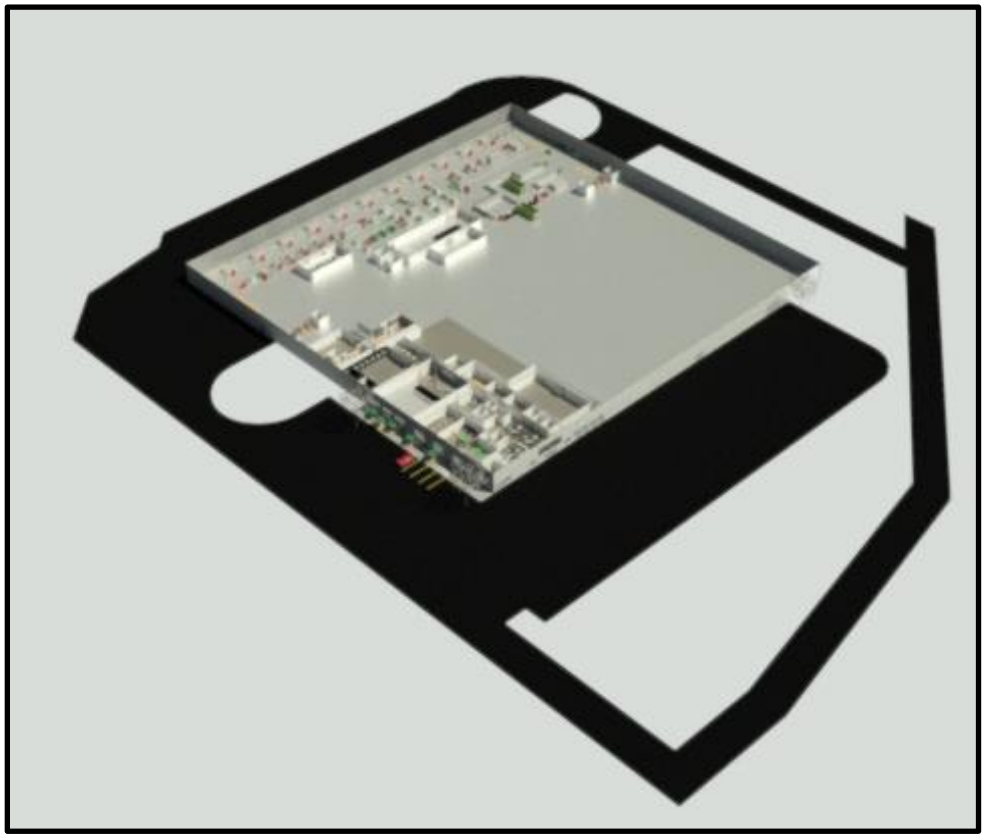


Figure 6: 3D Layout of Owala Expansion Proposal

Planning Logic Documentation

Project Schedule

Below is an overall schedule for the Owala Facility Design in the form of a Gantt Chart. The purpose of this chart is to detail the work required this semester toward creating the facility plan. This schedule was overall adhered to over the course of the semester.

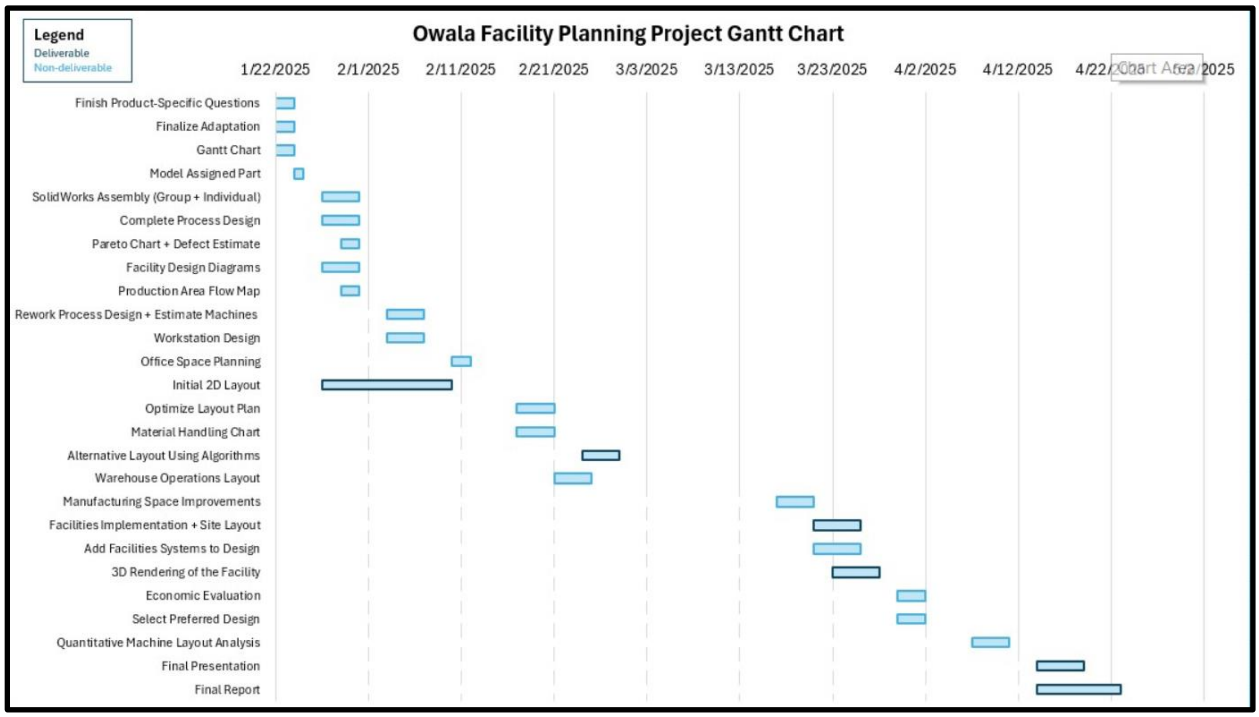


Figure 7: Gantt Chart

Production Volume Predictions

Given that Owala and the parent company Trove Brands do not have much information available to the public regarding sales, we chose to base our production volume logic on Stanley, a competitor company. Stanley had over $750 million in sales revenue in 2024, with $180.6 million of that coming from Amazon sales alone. Comparing this to Owala, who made $46.2 million in sales on Amazon, we concluded that Owala is making roughly 1/5 of the amount of revenue as Stanley. This would suggest they made roughly $153 million last year all-in-all. Assuming an average water bottle cost of $34 dollars (average of most bottles currently sold on their website assuming FreeSip has a heavy weight), that gives us an estimate of the amount of water bottles produced to be about 4.5 million bottles. As for calculating the expected production volume of our facility, we must make a lot of assumptions because Owala's manufacturing is likely done entirely overseas. We are assuming our facility will produce at least 12,000 special edition bottles annually (adhering to Owala's standard bimonthly special color edition drops of 500), filling the rest of our production room with standard free-sip bottles. The remaining volume of bottles will need to fall in the range of 150-500k to be a worthy investment for Owala, increasing

production by up to 10%. We believe that a facility of this size will be able to handle this large of a task if optimized properly.

Assembly Chart

Owala Assembly Parts List						
Part #	Part Name	Quantity	Material	Size	Mass (g)	Make or Buy
203	Springs	2	302 Steel	L: 1.59" Inner Dia: .31" Outer Dia: .36"	0.61	Make
105	O-ring	1	Silicone Rubber	Inner Dia: 2.4" Outer Dia: 2.75"	3.85	Make
201	Cap seal	1	Silicone Rubber	L: 1.65" W: 1.43" H: .37"	5.23	Make
103	Handle	1	Polypropylene Plastic	L: 2.2" W: 2.18" H: 1.35"	5.99	Make
108	Straw	1	Polypropylene Plastic	L: 8.25" Inner Dia: .32" Outer Dia: .40"	5.56	Make
101	Cap	1	Polypropylene Plastic	L: 2.03" W: 1.82" H: 1.19"	7.88	Make
202	Button	1	Polypropylene Plastic	L: .75" W: .67" H: .3"	1.95	Make
107	Inner Wall	1	Stainless Steel	Inner dia: 3.11" Outer dia: 3.20"	156.04	Make
204	Outer wall	1	Stainless Steel	Inner Dia: 3.11" Outer Dia: 3.29"	176.3252	Make
301	Plastic Lid	1	Polypropylene Plastic	Diameter: 3.12" Height: 2.25"	58.816	Make
402	Rubber Lid	1	Silicone Rubber	Diameter: 3.12" Height: 1.64"	36.72	Make
302	Inner Bottom	1	Stainless Steel	Diameter: 3.12" Thickness: .125"	47.17	Make
401	Outer Bottom	1	Stainless Steel	Diameter: 3.29" Thickness: .125"	47.17	Make
501	Dog Bowl Attachment	1	Silicone Rubber	L: 3.7" W: 4.0" H: 7.0"	185.97	Make

Figure 8: Assembly Chart

The Assembly Chart in Figure 8 above provides an organized depiction of each part's characteristics including material, size, mass, quantity per product, and whether it will be bought or made. This confirmed the facility needs to be designed to accommodate the production of every part of the product. The dimensions and materials determined the weights of each part. The weights and dimensions determined the most suitable method of material handling which is discussed in depth in Material Handling.

Hierarchy Chart

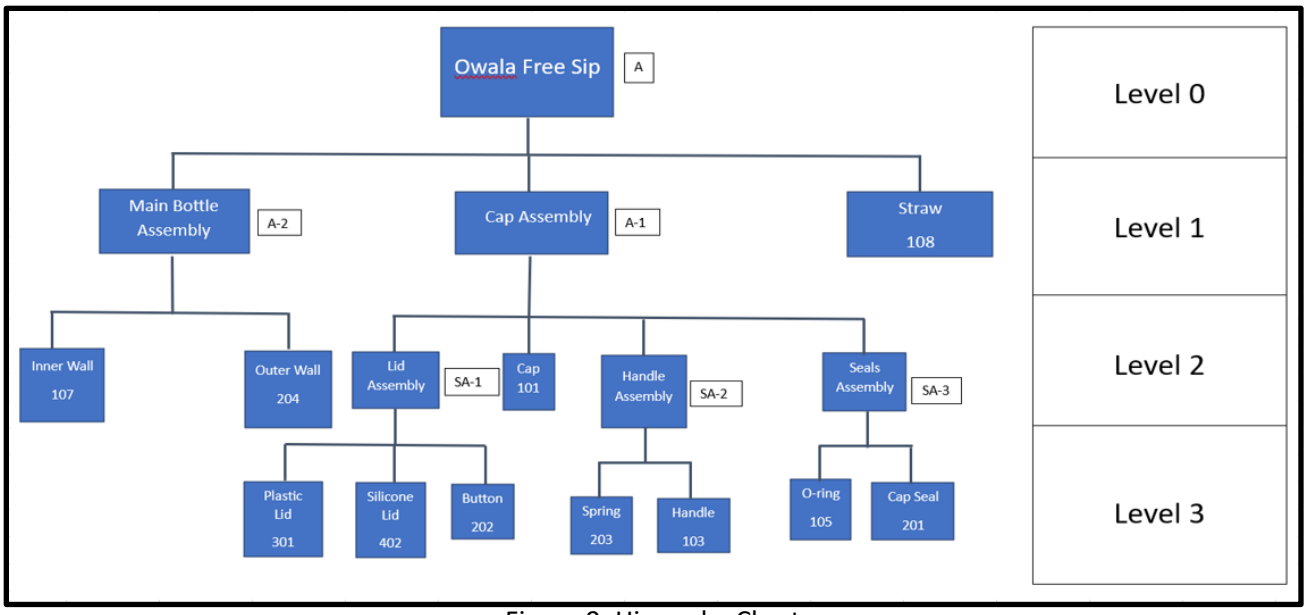


Figure 9: Hierarchy Chart

The Hierarchy Chart provides a clear understanding of how the product is created and assembled. A specific takeaway from this chart is that assembly can be one department in one area but it will require sections and structure.

Operations Chart

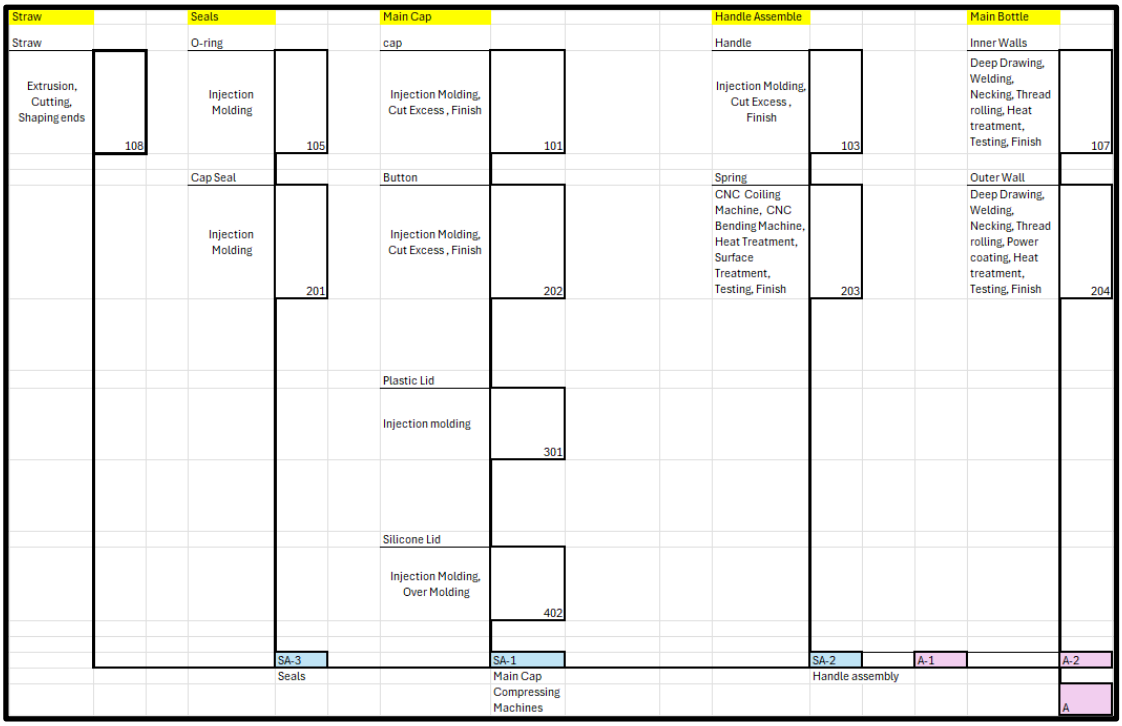


Figure 10: Operations Chart

Product Flow Map

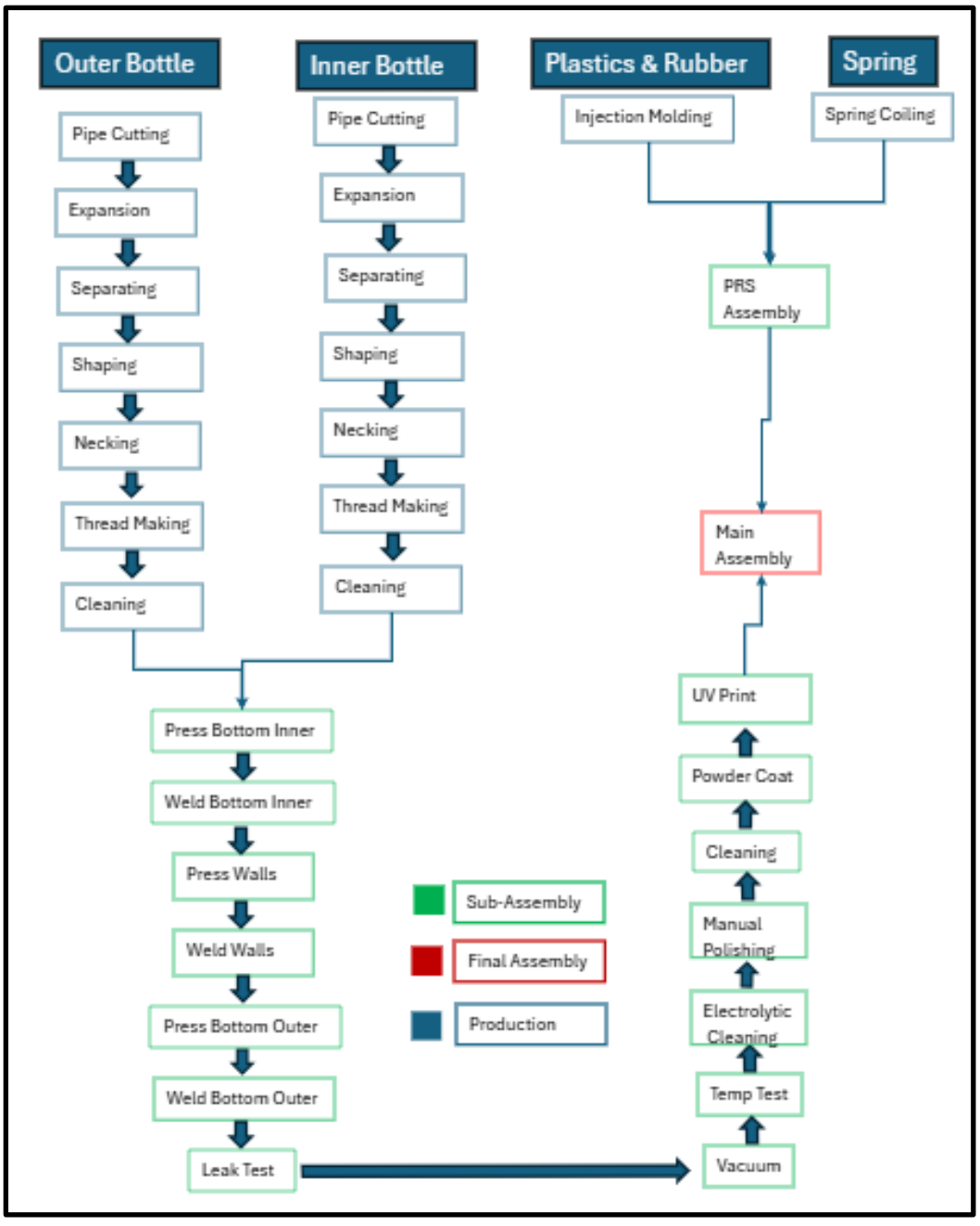


Figure 11: Product Flow Map

The Operations Chart and Product Flow Map have similar purposes. They walk through the processes required to produce each part. The Operations Chart groups these processes. These groups are used to consider placement of machines. The Product Flow Map is easily digestible and was also considered when producing the production lines as I modeled the lines off the order depicted. With this information we determined machines that perform these processes to include in the machine calculations of Figure 12.

Machine Calculations

Machine Name	Calculated	Decided Number	Variaton Baseline	Total Normal+ Variation	Reason
Injection Molding - Cap	1.2392	8	3	**11**	These are the machines required for plastic part production. Molds can be changed to create different parts using the same machine.
Rubber Cap Seal Machine	1.7893				
Rubber O-Ring Seal Machine	0.5964				
Injection Molding - Handle	0.7457				
Injection Over Molding - Rubber Lid	1.4911				
Injection Molding - Plastic Lid	1.3420				
Extrusion Molder	0.2982	1	0	**1**	One machine will have plenty of capability to handle number of bottles produced.
12 Axis Spring Coiler	0.0780	1	0	**1**	
Cutter	0.1548	1	0	**1**	These are the machines for the first part of the metal production process. The inner/outer production of the metal bottle was condensed into one line to cut down on cost by reducing required machines and downtime.
Water Expander	0.3096	1	0	**1**	
Separator	0.1239	1	0	**1**	
Shaper	0.1548	1	0	**1**	
Necking Machine	0.4025	1	0	**1**	
Press for Bottom	0.1790	1	0	**1**	
Welder for Bottom	0.3096	1	0	**1**	
Lathe	0.1491	1	0	**1**	Only one machine because the process is either used to press a bottom on the inner or outer cylinder or connect the two.
Press for In/Out	0.1790	1	0	**1**	
Welder for Mouth	0.2685	1	0	**1**	
Leak Tester	0.5965	1	0	**1**	
Vacuum Machine	0.5965	1	0	**1**	
Temperature Tester	2.3861	3	1	**4**	These are all the cleaning/finishing machines.
Electrolytic Polisher	2.3224	3	1	**4**	
Hand Polishing Workstation	0.2386	1	0	**1**	
Cleaning Workstation	0.3580	3	0	**3**	
Powder Coater	0.1548	1	0	**1**	
UV Printer	1.1931	2	0	**2**	
LSR Injection Molding Machine	0.9592	N/A	1	**1**	Accounts for the silicone bowl attachment.

Figure 12: Machine Calculations

Machine calculations are the backbone for the implementation of the production floor into the design. A sample machine calculation can be found under Equation 2 of the Appendix.

Tree Diagram

The Tree Diagram combines acquired information from the Product Flow charts and the Machine Calculations.
No new information is provided by this chart however, this set of charts has continued to group plastic machines, rubber machines, and metal machines together.

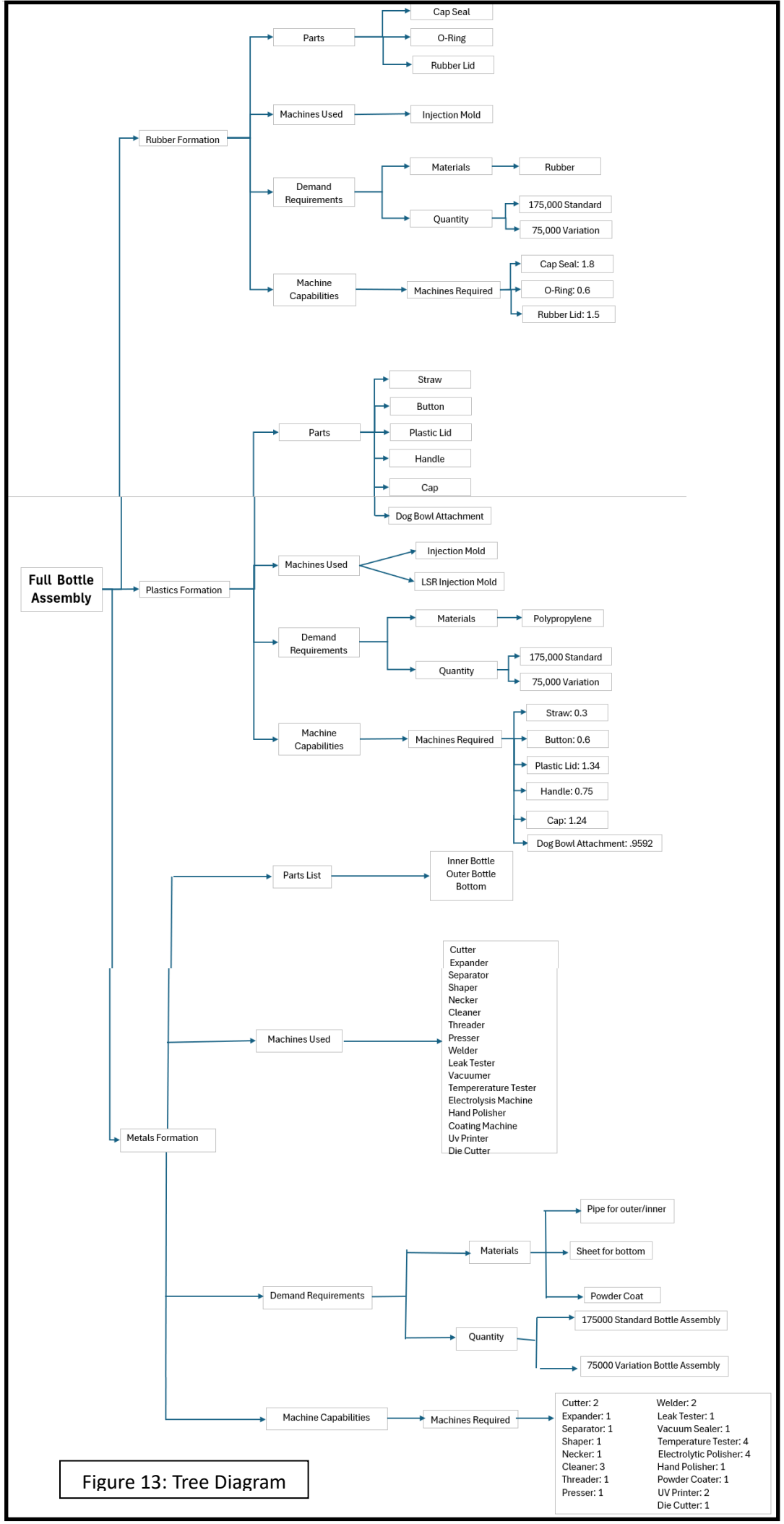


Figure 13: Tree Diagram

Interrelationship Graph

The Interrelationship Digraph maps logical links among related items. Ideas to prioritize when planning include quality control, efficiency, process flow, resource optimization, open communication, safety training and employee welfare.

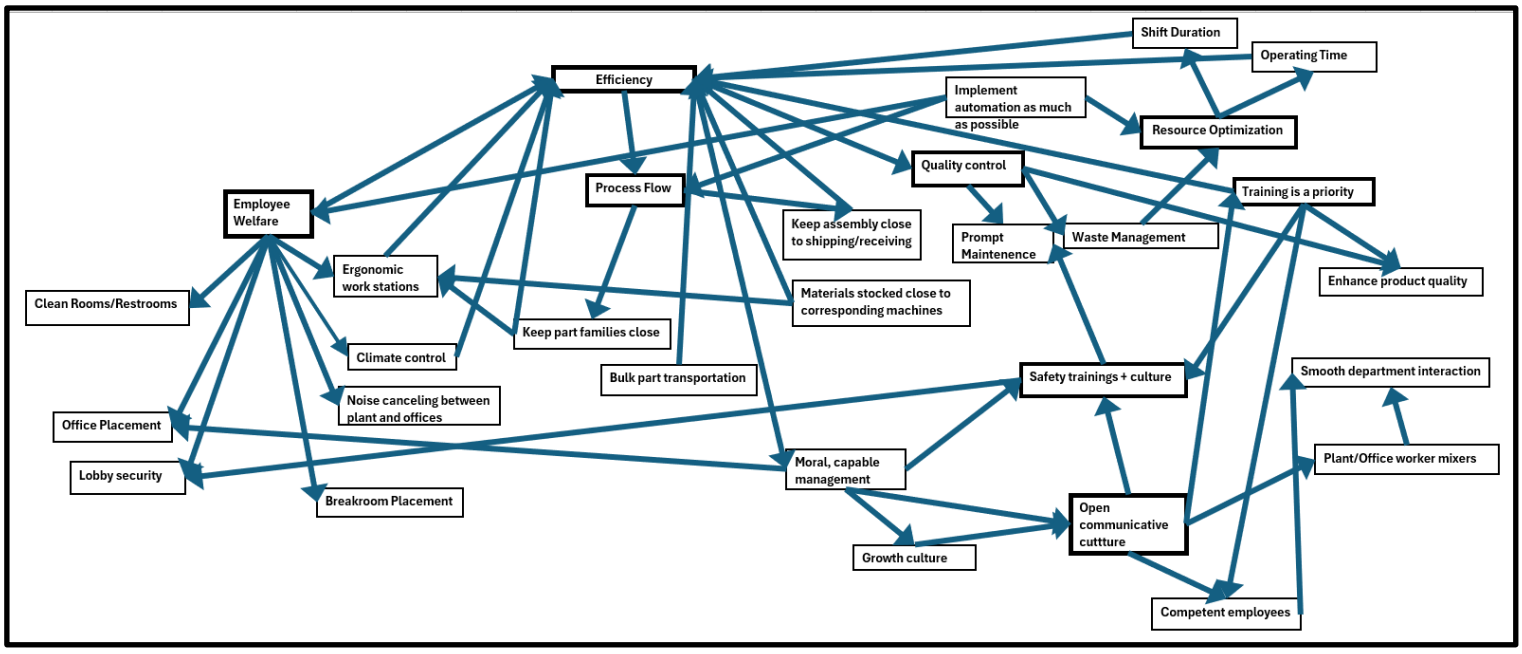


Figure 14: Interrelationship Digraph

Prioritization Matrix

The Prioritization Matrix below is used to evaluate the relative importance of the criteria in the Key below in the facility design. This will be used throughout to analyze alternatives and make decisions that prioritize the top scoring criteria. Workflow capability, operational costs, and safety risks scored the highest leading our team to prioritize these concepts in each design of the design.

Key	
A	Safety risks
B	People requirements
C	Storage Capacity
D	Space Utilization
E	Workflow Capability
F	Operational Cost
G	Waste Management
H	Carbon Footprint
I	Community Impact
J	Maintenance/ improvement Ease
K	Supplier Proximity
L	Layout Aesthetics
Weights	
1	equally important
5	significantly more important
10	extremely more important
1/5	significantly less important
1/10	extremely less important

Prioritization Matrix for the Evaluation of Facilities Design Alternatives

	A	B	C	D	E	F	G	H	I	J	K	L	Row Totals (%)
A	1	5	5	5	1	1	5	10	10	5	5	10	63
B	1/5	1	1	1	1/5	1/5	5	5	5	1	1/5	5	24.8
C	1/5	1	1	1	1	1/5	5	5	5	1	5	10	35.4
D	1/5	1	1	1	1/5	1/5	1	5	5	1	5	10	30.6
E	1	5	1	5	1	1	10	10	10	5	5	10	64
F	1	5	5	5	1	1	5	10	10	5	5	10	63
G	1/5	1/5	1/5	1	1/10	1/5	1	5	5	1	1	5	19.9
H	1/10	1/5	1/5	1/5	1/10	1/10	1/5	1	1	1/5	1/5	1	4.5
I	1/10	1/5	1/5	1/5	1/10	1/10	1/5	1	1	1/5	1/5	1	4.5
J	1/5	1	1	1	1/5	1/5	1	5	5	1	5	10	30.6
K	1/5	5	1/5	1/5	1/5	1/5	1	5	5	1/5	1	5	23.2
L	1/10	1/5	1/10	1/10	1/10	1/10	1/5	1	1	1/10	1/5	1	4.2
Column Totals	4.5	24.8	15.9	20.7	5.2	4.5	34.6	63	63	20.7	32.8	78	367.7

Figure 15: Prioritization Matrix

Cellular Manufacturing Analysis

A cellular manufacturing analysis was performed by grouping machines / processes based on their relationships and dependence to form cells that act as families in the manufacturing system. This analysis provided a clear three cells: a plastics production cell, metals production cell, and a main assembly cell.

	Inner/Outer
	Bottle Assembly
	Plastic Parts

	Machine #																									
Part #	11	12	13	14	15	16	17	18	19	20	21	10	5	6	7	8	9	24	1	2	3	4	22	23	25	26	**# of 1's**
12	1	1	1	1	1	1	1	1	1	1	1	1															12
9												1	1	1	1	1	1	1									7
8												1						1	1	1	1	1					6
11																							1				1
10																							1				1
7																							1				1
6																							1				1
5																								1			1
4																							1				1
3																							1				1
2																							1				1
1																									1		1
13																										1	1
# of 1's	1	1	1	1	1	1	1	1	1	1	1	3	1	1	1	1	1	2	1	1	1	1	7	1	1	1	

Parts	
Springs	1
O-ring	2
Cap seal	3
Handle	4
Straw	5
Cap	6
Button	7
Inner Wall	8
Outer wall	9
Plastic Lid	10
Rubber Lid	11
Main Bottle Assembly	12
Bottom Plastic Lid + Silicone Attachment	13

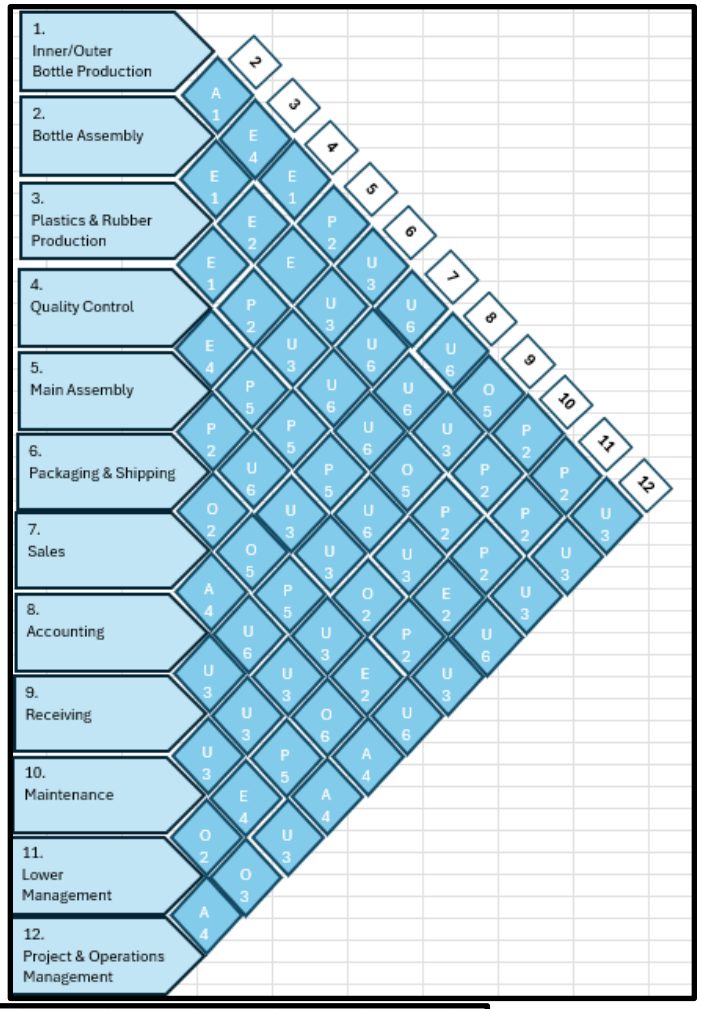
The cell manufacturing analysis began with classification of Owala parts, and the machines required to produce them. The strength of the relationships between these two variables were measured. They were then manipulated which determined the most efficient and cohesive groupings of machines. This revealed 3 groups as depicted above: plastic part production, inner/outer wall production and the assembly of the bottle. My variation added a machine, 26, and a part, 13, to this analysis with a low overall impact.

Machines			
Inner Water Expansion	1	Mouth Welder	14
Inner Separating	2	Leak Tester	15
Inner Shaping	3	Vacuuming Machine	16
Inner Necking	4	Temp Tester	17
Outer Water Expansion	5	Electroylsis	18
Outer Separating	6	Hand Polishing machine	19
Outer Shaper	7	Coating	20
Outer Necking	8	UV Printer	21
Outer Threads	9	Injection Molder	22
Cleaning	10	Plastic Extrusion	23
Press In/Out	11	Cutter	24
Press Bottom	12	12-axis spring coiler	25
Bottom Welder	13	LSR Injection Molder	26

Figure 16: Cellular Manufacturing Analysis

Qualitative Flow Analysis

This chart began by defining departments and the need for closeness and interaction between them. Entering these values into the chart's format shows us which departments are most dependent on each other. For example, the most important relationship is between departments 1 and 2. This chart did not change with my variation as no new departments are necessary. Defining these relationships allowed us to perform a block optimization of our layout later on.



Value	Closeness	Reasoning
A	Absolutely necessary	This relationship is critical for the facility's operations. Constant communication is necessary and any disruption could halt essential processes.
E	Especially important	This relationship is very important for maintaining efficiency and quality. Disruption would lead to significant negative impacts.
P	Pretty Important	This relationship is important for smooth operation and convenience. Disruption would cause inconvenience.
O	Ordinary closeness / Okay	This relationship is standard and functional. Disruption would have minimal impact on overall operations.
U	Unimportant	This relationship is not crucial and can be easily altered or removed without consequence.
X	Undesirable	This relationship is not wanted and should be avoided. Maintaining it could lead to negative outcomes.

Code	Reasoning
1	Frequency of use high
2	Frequency of use medium
3	Frequency of use low
4	Information flow high
5	Information flow medium
6	Information flow low

Figure 17: Qualitative Flow Analysis

Quantitative Flow Analysis

From\To	A	B	C	D	E	F
A		8-2000 9-2000				
	0	4000	0	0	0	0
B				13-2000		
	0	0	0	2000	0	0
C				1-1000 2-1000 3-1000 4-1000 5-1000 6-1000 7-1000 11-1000		
	0	0	10-1000 1000	12-1000 9000	0	0
D					1-1000 2-1000 3-1000 4-1000 5-1000 6-1000 7-1000 11-1000 12-1000 13-2000	
	0	0	0	0	11000	0
E						14-3000
	0	0	0	0	0	3000
F						
	0	0	0	0	0	0

	Components	Production quantities	Movement Factor	Equivalent Flows	Routing
1	Springs	1000	1	1000	C-D-E
2	O-ring	1000	1	1000	C-D-E
3	Cap seal	1000	1	1000	C-D-E
4	Handle	1000	1	1000	C-D-E
5	Straw	1000	1	1000	C-D-E
6	Cap	1000	1	1000	C-D-E
7	Button	1000	1	1000	C-D-E
8	Inner Wall	1000	2	2000	A-B
9	Outer wall	1000	2	2000	A-B
10	Plastic Lid	1000	1	1000	C-C
11	Plastic + Rubber Lid	1000	1	1000	C-D-E
12	Bottom Plastic Lid + Silicone Attachment	1000	1	1000	C-D-E
13	Main Bottle Assembly	1000	2	2000	B-D-E
14	Main Assembly	1000	3	3000	E-F

	Department
A	Inner Outer
B	Metal Bottle Assembly
C	Plastic Rubber Spring
D	Quality Control
E	Final Assembly
F	Shipping/Handling

Figure 18: Quantitative Flow Analysis

This chart helps identify high traffic areas by incorporating ideas of size of parts, production quantities, and flow of parts. What stands out to me is parts in departments A and E have higher movement factors, and parts in departments C and F have straightforward sequences. My adaptation again had a low impact and fit into the flow of others in department C. This was a major factor in our decision to prioritize hand carts over forklifts because we realized we would be moving lower volumes, but more frequently.

Production Space Flow Map

The Production Floor Flow Map in the space below is the culmination of the figures above. Figures 9, 10, 11, 13, and 16 recommended separate lines for plastic and metal which is implemented below in the Production Flow Map. A separate area for assembly was also both recommended and implemented. Material enters at the south end of the plant and flows unilaterally which works to minimize the overall distance materials are traveling. The only time material will travel backwards is for assembly which is a loop, giving it purpose as the final product ends at shipping. Every part of the metal bottle process is dependent on the previous machine/process as shown in Figure 11: The Product Flow Map and Figure 13: The Tree Diagram. Since they are directly dependent on one another they are placed close to one another unilaterally.

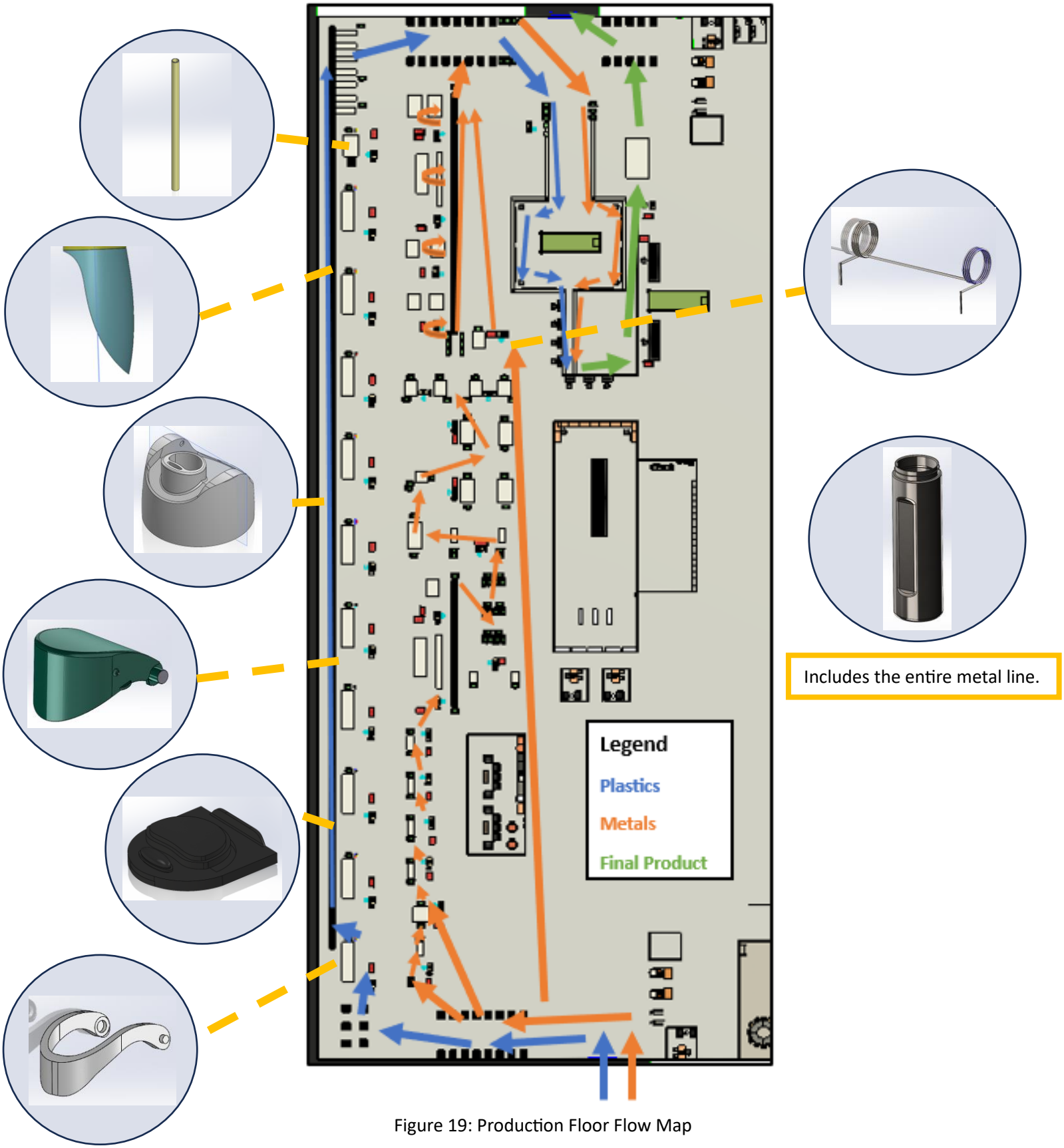


Figure 19: Production Floor Flow Map

Individual Workstation Space Analysis

Many of the workstations are similar as the machines and processes have similar requirements and storage solutions. Four unique cases that summarize the types of workstations needed have been included below. Constants in each workstation are the red storage bins to hold maintenance tools and supplies necessary to run the machines. The green bins represent standard storage totes that hold the finished parts. A chair, desk and computer are included for the employee operating the machine at the time, to assist them in controlling the process. Trash bins are also included for convenience. The injection molding workstations include a scale at the product output of the machine. This counts parts and notifies the worker to transfer the tote onto the conveyor when it is full. The straw extruder workstation has space for a pallet of incoming material as it will need its own material source because it is a different type of plastic than most of the lid parts. The powder coating and copper coating workstation utilizes a conveyor due to the machine's involved dependence on each other in terms of timing. The electrolytic cleaning workstation is an example of minimizing workers required. If two processes can be run by one worker, that is what will happen.

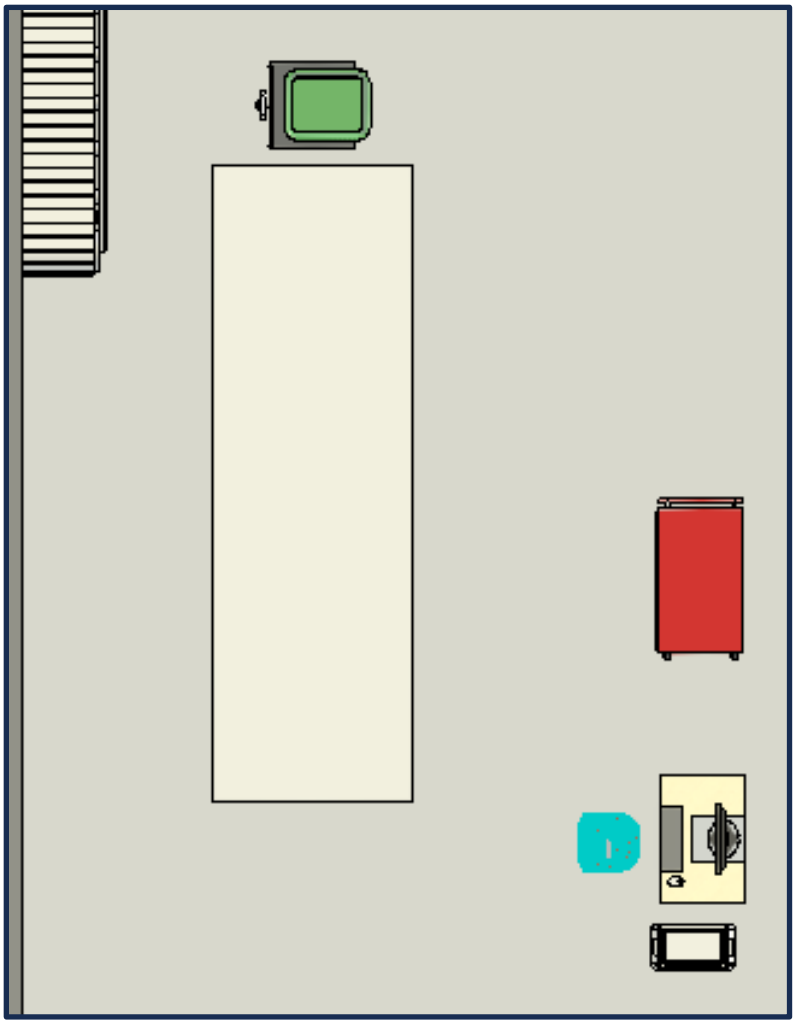


Figure 20: Injection Molding Workstation

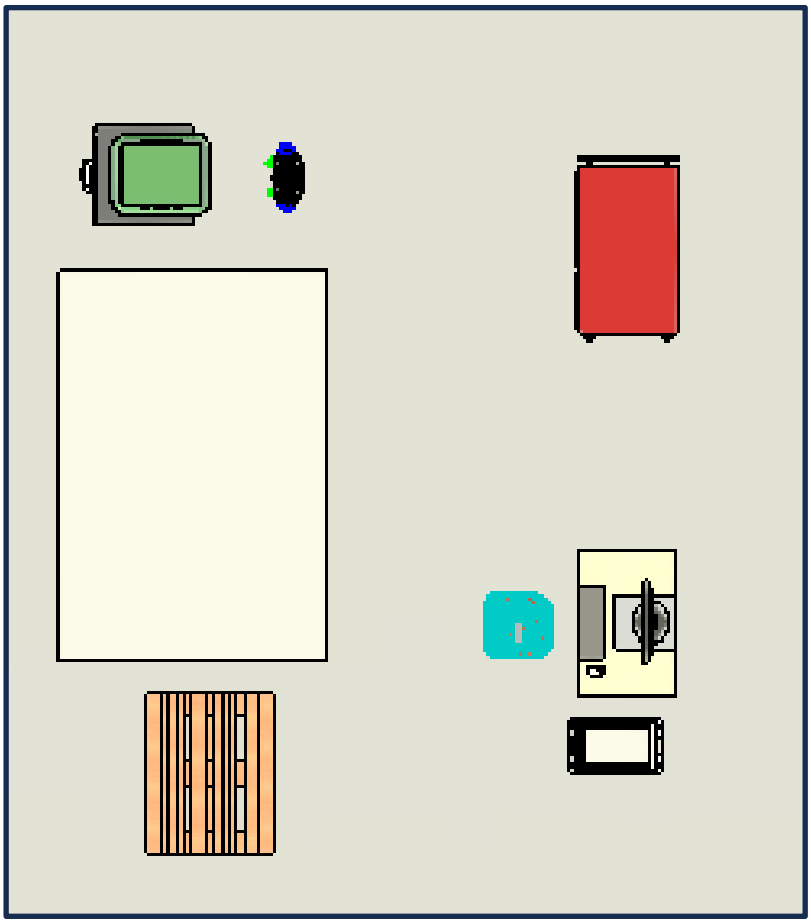


Figure 21: Straw Extruder Workstation

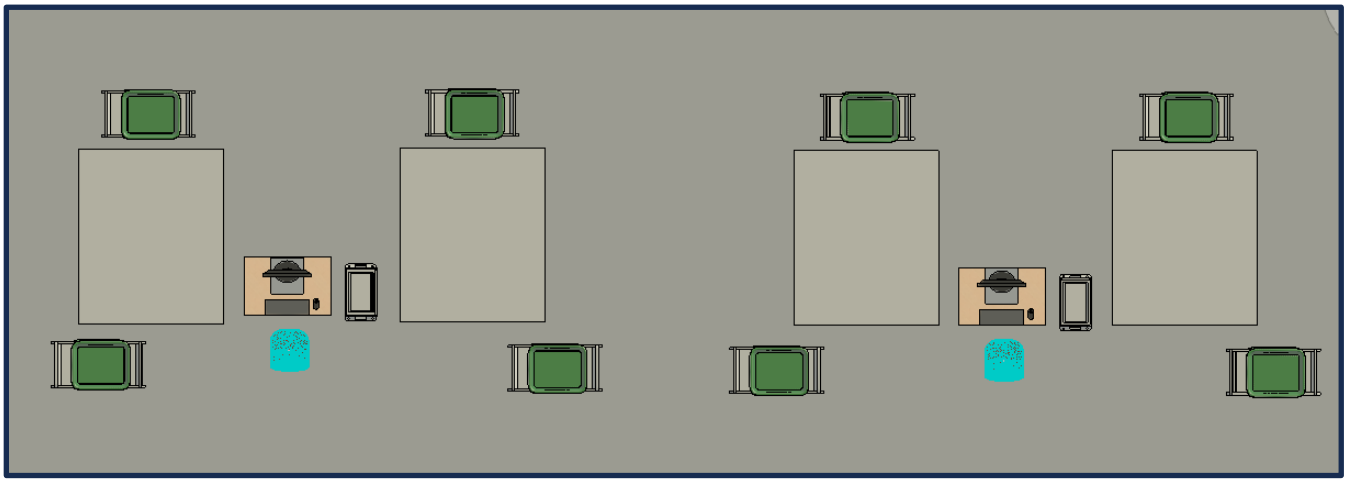


Figure 22: Electrolytic Cleaning Workstation

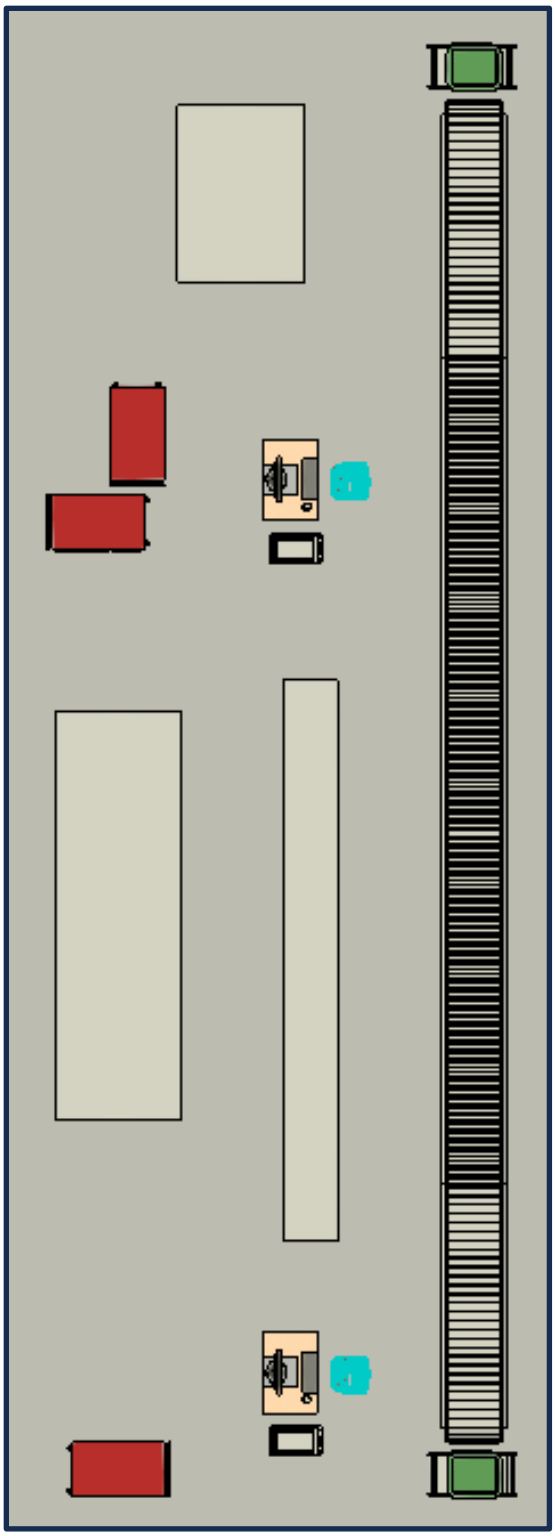


Figure 23: Powder Coating and Copper Coating Workstations

Material Handling Planning Charts

Material Handling Planning Chart

Company: Owala | Prepared By: Abby, Halen, Rae | Layout Alternative: 1
Product: Cap | Date: 2/24/2025 | Sheet 1 of

Step No.	O	T	S	I	Description	Operation No.	Dept.	Cont. Type	Size	Wt.	Qty. Per Cont.	Freq	Dist.	Method of Handling
1			X		Storage of plastic/rubber pellets		Receiving & Shipping							
2		X			Transportation of plastic pellets to Injection Press storage		Receiving & Shipping	Boxes on Pallets	4' x 4' x 4'	3000 lb		1	400 ft	Forklift
		X			Transportation of rubber pellets to Overmolding Storage		Receiving & Shipping	Boxes on Pallets	4' x 4' x 4'	2500 lb		1	400 ft	Forklift
3	X				Injection Press Plastic	101A	PRS Prod.							
4	X				Injection Press (Overmold) Rubber	102A	PRS Prod.							
5		X			Transportation to PRS Storage			TOTE Bin	15" x 24" x 24"	20 lb	320	3	170 ft	Conveyor
6			X		Visual Inspection	103A	QC							
7		X			Transportation to PRS Assembly		PRS Assem.	TOTE Bin	15" x 24" x 24"	20 lb	320	3	10 ft	Carrying

Material Handling Planning Chart

Company: Owala | Prepared By: Abby, Halen, Rae | Layout Alternative: 1
Product: Lid | Date: 2/24/2025 | Sheet 1 of

Step No.	O	T	S	I	Description	Operation No.	Dept.	Cont. Type	Size	Wt.	Qty. Per Cont.	Freq	Dist.	Method of Handling
1			X		Storage of plastic pellets		Receiving & Shipping							
2		X			Transportation to machine storage		Receiving & Shipping	Boxes on Pallets	4' x 4' x 4'	3000 lb			400 ft	Forklift
3	X				Injection Press Part	101B	PRS Prod.							
4		X			Transportation to PRS Storage			TOTE Bin	15" x 24" x 24"	30 lb	500	2	170 ft	Conveyor
5			X		Visual Inspection	103B	QC							
6		X			Transportation to PRS Assembly		PRS Assem.	TOTE Bin	15" x 24" x 24"	30 lb	500	2	10 ft	Carrying

Material Handling Planning Chart

Company: Owala | Prepared By: Abby, Halen, Rae | Layout Alternative: 1
Product: Handle | Date: 2/24/2025 | Sheet 1 of

Step No.	O	T	S	I	Description	Operation No.	Dept.	Cont. Type	Size	Wt.	Qty. Per Cont.	Freq	Dist.	Method of Handling
1			X		Storage of plastic		Receiving & Shipping							
2		X			Transportation to machine storage		Receiving & Shipping	Boxes on Pallets	4' x 4' x 4'	3000 lb			400 ft	Forklift
3	X				Injection Press Part	101C	PRS Prod.							
4		X			Transportation to PRS Storage			TOTE Bin	15" x 24" x 24"	30 lb	500	2	170 ft	Conveyor
5			X		Visual Inspection	103C	QC							
6		X			Transportation to assembly station		PRS Assem.	TOTE Bin	15" x 24" x 24"	30 lb	500	2	10 ft	Carrying

Material Handling Planning Chart

Company: Owala | Prepared By: Abby, Halen, Rae | Layout Alternative: 1
Product: Straw | Date: 2/24/2025 | Sheet 1 of

Step No.	O	T	S	I	Description	Operation No.	Dept.	Cont. Type	Size	Wt.	Qty. Per Cont.	Freq	Dist.	Method of Handling
1			X		Storage of plastic		Receiving & Shipping							
2		X			Transportation to machine storage		Receiving & Shipping	Boxes on Pallets	4' x 4' x 4'	3000 lb			400 ft	Forklift
3	X				Plastic Extruding	104D	PRS Prod.							
4	X				Cutting to Size	105D	PRS Prod.							
5		X			Transportation to PRS Storage			TOTE Bin	15" x 24" x 24"	35 lb	600	2	170 ft	Conveyor
6			X		Visual Inspection	103D	QC							
7		X			Transportation to assembly station		PRS Assem.	TOTE Bin	15" x 24" x 24"	35 lb	600	2	10 ft	Carrying

Material Handling Planning Chart

Company: Owala | Prepared By: Abby, Halen, Rae | Layout Alternative: 1
Product: Button | Date: 2/24/2025 | Sheet 1 of

Step No.	O	T	S	I	Description	Operation No.	Dept.	Cont. Type	Size	Wt.	Qty. Per Cont.	Freq	Dist.	Method of Handling
1			X		Storage of plastic		Receiving & Shipping							
2		X			Transportation to machine storage		Receiving & Shipping	Boxes on Pallets	4' x 4' x 4'	3000 lb			400 ft	Forklift
3	X				Injection Press Part	101E	PRS Prod.							
4		X			Transportation to PRS Storage			TOTE Bin	15" x 24" x 24"	40 lb	700	2	170 ft	Conveyor
5			X		Visual Inspection	103E	QC							
6		X			Transportation to assembly station		PRS Assem.	TOTE Bin	15" x 24" x 24"	40 lb	700	2	10 ft	Carryinh

Material Handling Planning Chart

Company: Owala | Prepared By: Abby, Halen, Rae | Layout Alternative: 1
Product: Dog Bowl Attachment | Date: 2/24/2025 | Sheet 1 of

Step No.	O	T	S	I	Description	Operation No.	Dept.	Cont. Type	Size	Wt.	Qty. Per Cont.	Freq	Dist.	Method of Handling
1			X		Storage of silicone		Receiving & Shipping							
2		X			Transportation to LRS storage		Receiving & Shipping	Boxes on Pallets	4' x 4' x 4'	4500 lb		1	360 ft	Forklift
3	X				Injection Mold Part	101F	PRS Prod.							
4		X			Transportation to IPP Storage			TOTE Bin	15" x 24" x 24"	56 lb	150	2	170 ft	Conveyor
5		X			Transportation to Quality Control			TOTE Bin						Cart
6			X		Visual Inspection	103F	QC	TOTE Bin						Conveyor
7		X			Transportation to Assembly		PRS Assem.	TOTE Bin	15" x 24" x 24"	56 lb	150	2	10 ft	Conveyor

Material Handling Planning Chart

Company: Owala | Prepared By: Connor, Dom, Jordan | Layout Alternative: 1
Part: Outer Bottle | Date: 2/24/2025 | Sheet 6 of 10

Step No.	O	T	S	I	Description	Operation No.	Dept.	Cont. Type	Size	Wt.	Qty. Per Cont.	Freq.	Dist.	Method of Handling
1		X			Pipe stock from truck to storage			Pallet	48x40	825	200	2-3 pallets per week	50-100ft	Pallet Jack
2			X		Store stock in facility storage		Facility Storage							
3		X			Transport stock to cutting workstation			Pallet	48x40	825	200	every 2 day	100-150ft	Pallet Jack
4			X		Store stock in cutting workstation		Out. Cutting							
5	X				Cut stock to length	101	Out. Cutting							
6		X			Transport to expansion workstation			Plastic Tote	15x30x12	34.4	50	2 totes per, 5 times a day	10ft	Hand Truck
7			X		Store in expansion workstation		Out. Expansion							
8	X				Expansion	102	Out. Expansion							
9		X			Transport to separating workstation			Plastic Tote	15x30x12	34.4	50	2 totes per, 5 times a day	10ft	Hand Truck
10			X		Store in separating workstation		Out. Seperating							
11	X				Seperate	103	Out. Seperating							
12		X			Transport to shaping workstation			Plastic Tote	15x30x12	17.2	50	4 totes per, 5 times a day	10ft	Hand Truck
13			X		Store in shaping workstation		Out. Shaping							
14	X				Shape	104	Out. Shaping							
15		X			Transport to necking workstation			Plastic Tote	15x30x12	17.2	50	4 totes per, 5 times a day	10ft	Hand Truck
16			X		Store in necking workstation		Out. Necking							
17	X				Neck	105	Out. Necking							
18		X			Transport to Threading workstation			Plastic Tote	15x30x12	17.2	50	4 totes per, 5 times a day	10ft	Hand Truck
19			X		Store in Threading workstation		Out. Threading							
20	X				Thread	106	Out. Threading							
21		X			Transport to Cleaning workstation			Plastic Tote	15x30x12	17.2	50	4 totes per, 5 times a day	10ft	Hand Truck
22			X		Store in Cleaning workstation		Cleaning							
23	X				Clean	107								
24				X	Inspect									
25		X			Transport to metal bottle parts storage			Plastic Tote	15x30x12	17.2	50	4 totes per, 5 times a day	50ft	Hand Truck
26			X		Store in metal bottle parts storage		Temp Metal Storage							

Material Handling Planning Chart

Company: Owala | Prepared By: Connor, Dom, Jordan | Layout Alternative: 1
Part: Outer Bottom | Date: 2/24/2025 | Sheet 7 of 10

Step No.	O	T	S	I	Description	Operation No.	Dept.	Cont. Type	Size	Wt.	Qty per cont.	Freq.	Dist.	Method of Handling
1		X			Steel Sheet from truck to storage			Pallet	4'x 4'	130	4 sheets	once a day	50-100ft	Pallet Jack
2			X		Steel Sheet stored in facility storage		Facility Storage							
3		X			Transport sheet to Die Cutting workstation			Pallet	4' x 4'	130	4 sheets	once a day	200ft	Pallet Jack
4			X		Stored at Die Cut Workstation		O Bottom Cutting							
5	X				Die Cutting the sheet	301	O Bottom Cutting							
6		X			Transport to metal parts storage			Plastic Tote	15x30x12	26	250	4 times a day	15-30ft	Hand Truck
7			X		Store in metal parts storage		Temp Metal Storage							

Material Handling Planning Chart

Company: Owala | Prepared By: Connor, Dom, Jordan | Layout Alternative: 1
Part: Metal Assembly | Date: 2/24/2025 | Sheet 8 of 10

Step No.	O	T	S	I	Description	Operation No.	Dept.	Cont. Type	Size	Wt.	Qty per cont.	Freq.	Dist.	Method of Handling
1		X			Transport inner bottom to inner bottom press			Plastic Tote	15x30x12	17.2	50	4 totes per, 5 times a day	10ft	Hand Truck
2		X			Transport inner wall to inner bottom press			Plastic Tote	15x30x12	17.2	50	4 totes per, 5 times a day	10ft	Hand Truck
3			X		Store Inner bottom in inner bottom press storage		Temp Metal Storage							
4			X		Store Inner wall in inner bottom press storage		Temp Metal Storage							
5	X				Press inner wall and inner bottom together	501	Metals Production							
6		X			Transport Inner bottle to inner bottle welding			Plastic Tote	15x30x12	17.4	50	4 totes per, 5 times a day	10ft	Hand Truck
7			X		Store Inner bottle in inner bottle welding		Temp Metal Storage							
8	X				Weld inner wall and inner bottom	502	Metals Production							
9		X			Transport Inner bottle to Inner/Outer Press			Plastic Tote	15x30x12	17.4	50	4 totes per, 5 times a day	8-10ft	Hand Truck
10			X		Store Inner bottle in Inner/Outer Press workstation		Temp Metal Storage							
11		X			Transport Outer wall to Inner/Outter Press			Plastic Tote	15x30x12	17.2	50	4 totes per, 5 times a day	8-10ft	Hand Truck
12			X		Store Outer wall in Inner/Outer Press workstation		Temp Metal Storage							
13	X				Press Inner bottle and outer wall	503								
14		X			Transport part to outer bottom welding			Plastic Tote	15x30x12	34.6	50	4 totes per, 5 times a day	8-10ft	Hand Truck
15			X		Store part in outer bottom press storage		Temp Metal Storage							
16		X			Transport outer bottom to outer bottom press			Plastic Tote	15x30x12	34.6	50	4 totes per, 5 times a day	8-10ft	Hand Truck
17			X		Store outer bottom in outer bottom press storage									
18	X				Press outer wall and outer bottom	504								
19		X			Transport bottle to outer bottom welding			Plastic Tote	15x30x12	34.8	50	4 totes per, 5 times a day	8-10ft	Hand Truck
20			X		Store bottle in outer bottom welding storage		Temp Metal Storage							
21	X				Weld outer bottom and outer wall	505								
22		X			Transport bottle to mouth welding			Plastic Tote	15x30x12	34.8	50	4 totes per, 5 times a day	8-10ft	Hand Truck
23			X		Store bottle in mouth welding storage		Temp Metal Storage							
24	X				Weld bottle mouth	506								
25		X			Transport bottle to leak testing			Plastic Tote	15x30x12	34.8	50	4 totes per, 5 times a day	8-10ft	Hand Truck
26			X		Store bottle in leak testing storage		Temp Metal Storage							
27	X				Leak test	507								
28		X			Transport bottle to vacuuming			Plastic Tote	15x30x12	34.8	50	4 totes per, 5 times a day	8-10ft	Hand Truck
29			X		Store bottle in vacuuming storage		Temp Metal Storage							
30	X				Vacuum	508								
31		X			Transport bottle to temp testing			Plastic Tote	15x30x12	34.8	50	4 totes per, 5 times a day	8-10ft	Hand Truck
31			X		Store bottle in temp testing storage		Temp Metal Storage							
31	X				temp test	509								
31		X			Transport bottle to electrolysis polishing			Plastic Tote	15x30x12	34.8	50	4 totes per, 5 times a day	8-10ft	Hand Truck
31			X		Store bottle in electrolysis polishing storage		Temp Metal Storage							
31	X				electrolysis polishing	510								
31		X			Transport bottle to manual polishing			Plastic Tote	15x30x12	34.8	50	4 totes per, 5 times a day	8-10ft	Hand Truck
31			X		Store bottle in manual polishing storage		Temp Metal Storage							
31	X				Manual Polishing	511								
31		X			Transport bottle to cleaning			Plastic Tote	15x30x12	34.8	50	4 totes per, 5 times a day	8-10ft	Hand Truck
31			X		Store bottle in cleaning storage		Temp Metal Storage							
31	X				Clean	512								
31		X			Transport bottle to powder coating			Plastic Tote	15x30x12	34.8	50	4 totes per, 5 times a day	8-10ft	Hand Truck
31			X		Store bottle in powder coating storage		Temp Metal Storage							
31	X				Powder coat	513								
31		X			Transport bottle to UV printing			Plastic Tote	15x30x12	34.8	50	4 totes per, 5 times a day	8-10ft	Hand Truck
31			X		Store bottle in UV printing		Temp Metal Storage							
31	X				Uv print	514								
32		X			Transport bottle to assembly station		Final Assembly	Plastic Tote	15x30x12	34.8	50	4 totes per, 5 times a day	50-80ft	Hand Truck

Material Handling Planning Chart

Company: Owala | Prepared By: Connor, Dom, Jordan | Layout Alternative: 1
Part: Inner Bottle | Date: 2/24/2025 | Sheet 9 of 10

Step No.	O	T	S	I	Description	Operation No.	Dept.	Cont. Type	Size	Wt.	Qty. Per Cont.	Freq.	Dist.	Method of Handling
1	T	X			Pipe stock from truck to storage			Pallet	48x40	825	200	2-3 pallets per week	50-100ft	Pallet Jack
2	S		X		Store stock in facility storage		Facility Storage							
3	T	X			Transport stock to cutting workstation			Pallet	48x40	825	200	every 2 day	100-150ft	Pallet Jack
4	S		X		Store stock in cutting workstation	201	In. Cutting							
5	X				Cut stock to length		In. Cutting							
6	T	X			Transport to expansion workstation			Plastic Tote	15x30x12	34.4	50	2 totes per, 5 times a day	10ft	Hand Truck
7	S		X		Store in expansion workstation		In. Expansion							
8	X				Expansion	202	In. Expansion							
9	T	X			Transport to seperating workstation			Plastic Tote	15x30x12	34.4	50	2 totes per, 5 times a day	10ft	Hand Truck
10	S		X		Store in seperating workstation		In. Seperating							
11	X				Seperate	203	In. Seperating							
12	T	X			Transport to shaping workstation			Plastic Tote	15x30x12	17.2	50	4 totes per, 5 times a day	10ft	Hand Truck
13	S		X		Store in shaping workstation		In. Shaping							
14	X				Shape	204	In. Shaping							
15	T	X			Transport to necking workstation			Plastic Tote	15x30x12	17.2	50	4 totes per, 5 times a day	10ft	Hand Truck
16	S		X		Store in necking workstation		In. Necking							
17	X				Neck	205	In. Necking							
21	T	X			Transport to Cleaining workstation			Plastic Tote	15x30x12	17.2	50	4 totes per, 5 times a day	10ft	Hand Truck
22	S		X		Store in Cleaning workstation		Cleaning							
23	X				Clean	206	Clean							
24	X				Inspect		Clean							
25	T	X			Transport to metal bottle parts storage			Plastic Tote	15x30x12	17.2	50	4 totes per, 5 times a day	50ft	Hand Truck
26	S		X		Store in metal bottle parts storage									

Material Handling Planning Chart

Company: Owala | Prepared By: Connor, Dom, Jordan | Layout Alternative: 1
Part: Inner Bottom | Date: 2/24/2025 | Sheet 10 of 10

Step No.	O	T	S	I	Description	Operation No.	Dept.	Cont. Type	Size	Wt.	Qty. Per Cont.	Freq.	Dist.	Method of Handling
1	T	X			Steel Sheet from truck to storage			Pallet	4'x 4'	130	4 sheets	once a day	50-100ft	Pallet Jack
2	S		X		Steel Sheet stored in facility storage		Facility Storage							
3	T	X			Transport sheet to Die Cutting workstation			Pallet	4' x 4'	130	4 sheets	once a day	200ft	Pallet Jack
4	S		X		Stored at Die Cut Workstation		In Bottom Cutting							
5	X				Die Cutting the sheet	401	In Bottom Cutting							
6	T	X			Transport to metal parts storage			Plastic Tote	15x30x12	26	250	4 times a day	15-30ft	Hand Truck
7	S		X		Store in metal parts storage		Temp Metal Storage							

Figure 24: Material Handling Charts

Material Handling Strategies

Before developing the flowing material handling strategies, our team came up with three principles to prioritize in the process design. Space utilization, planning and the unit load principle are the three material management principles we chose to focus on.

Plastic & Silicone Components:

Plastic pellets and silicone rubber pellets come in on pallets which are moved via forklift to raw material storage. Same for silicone rubber pellets. One pallet is transported to rubber machines and one to base of plastic injection machines. When empty, the pallet gets transported to waste storage via forklift. Parts are produced and collected into tote bins. When the weight sensor detects the tote bin is full, a message notifies the employee and the tote bin is placed on the conveyor belt with an RFID sticker. The RFID stickers on the totes will be connected to a computer system for which the employee will have handheld scanners and or automated scanners. The stickers, when scanned, can identify what is in each tote to improve trackability. It allows everyone to know what's in the tote and interchange the totes. At the end of the plastic conveyor belt, a push diverter pushes the tote onto a roller directing it towards the correct storage. It will be transferred on a cart to the official in part storage until a tote is needed at assembly.

Metal Components:

All materials for the metal production line come in on pallets. They will be moved to raw material storage by forklift. One pallet of pipe is transferred to the pipe cutting station for outer bottle production. One pallet of sheet metal is transferred to the die cutting station to start the bottom production. The calculated required number of the following machines: pipe cutter, water expansion, separating, shaping, necking, cleaning and threading was cut in half. Since the usage of the metal inner/outer wall machines are extremely low, we will be using one machine for both the inner and outer

processes and switching the setup in the middle of each day. For the first day, no assembly will be done, and 1036 inner and outer walls will be made to be used at the start of the next day. We added storage at the end of the section of production line (threading) and before assembly for the bottles stored for the next day. This storage will be split in half with new parts on one half and the old on the other which will switch day by day. 21 totes are anticipated for inner and 21 totes for outer (6 wide 3-4 tall). Storage is 15 feet wide (12 totes side by side) and 9 foot long (one tote each side 4 foot walkway). The parts are to be counted by weight for plastic as mentioned above and by number (50) for metal. As for the rest of production; next a copper coating is sprayed on the inner wall. The bottom and the wall are pressed and welded together for inner and outer wall. This new part now undergoes mechanical polishing, leak testing, temperature testing and then vacuuming. Electrolytic cleaning, powder coating and UV printing are the last steps before assembly.

Variation Accommodations:

My variation will require one injection molding machine for the plastic part of the lids and one LSR injection molding machine for the silicone part. These machines are the two furthest from raw material storage as they will require less frequent delivery. The attachment of the silicone part to the plastic lid will require a food safe adhesive to bond the two. Given the needed production volume this assembly can be worked into the assembly area for normal lids. Once these parts are assembled, they will need 24 hours to cure and will be stored inside the assembly area before reentering the assembly process. Metal machines workstations have incoming and outgoing part storage for carted totes to transfer product between machines.

Assembly Process:

One of each of the parts involved in the lid (cap, handle, spring, button, straw and lid base, (dog bowl attachment when the Owala PetSip Duo is in production)) will be placed in a tote bin on the left conveyor. This conveyor passes 2 QC personnel, one to inspect qualitatively and one to inspect quantitatively at a frequency and level determined by the quality department. The tote bin then heads to assembly where 4 employees will each be assigned on of the four assembly steps. The right side will use a chain conveyor that will be loaded with the metal bottles from in process part storage. An employee is located where the conveyors join to make sure the assembled caps get loaded on the chain conveyor smoothly. The next employee will finish the assembly by screwing the cap on the bottle and the next employee will add the label to the bottle. The bottles must make it through another qualitative and quantitative assessment by two QC employees before being packaged and palletized to be sent to final product storage.

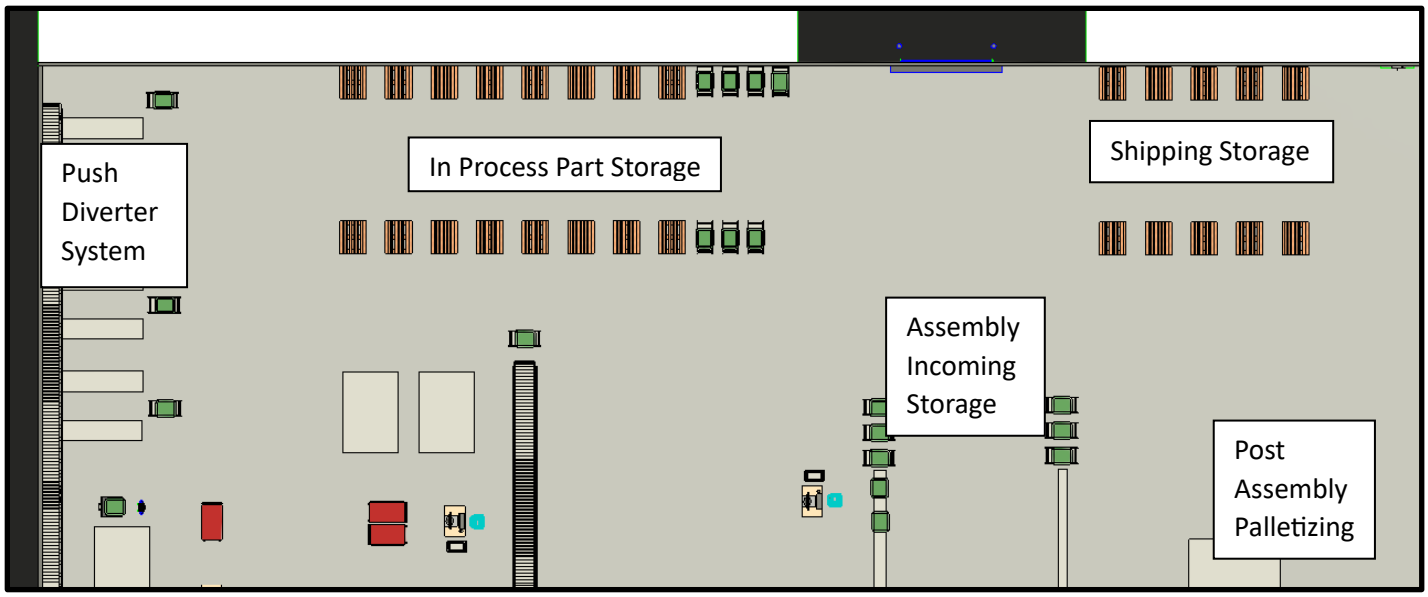


Figure 25: 2D View of Material Handling

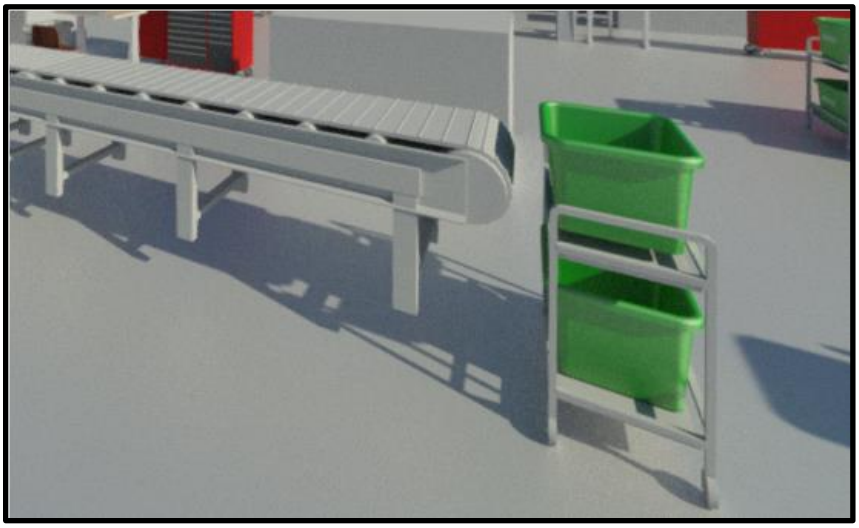


Figure 25: Conveyor and Tote Carts Model

Figure 25: Intended Tote

Logically Developed Parking Lot

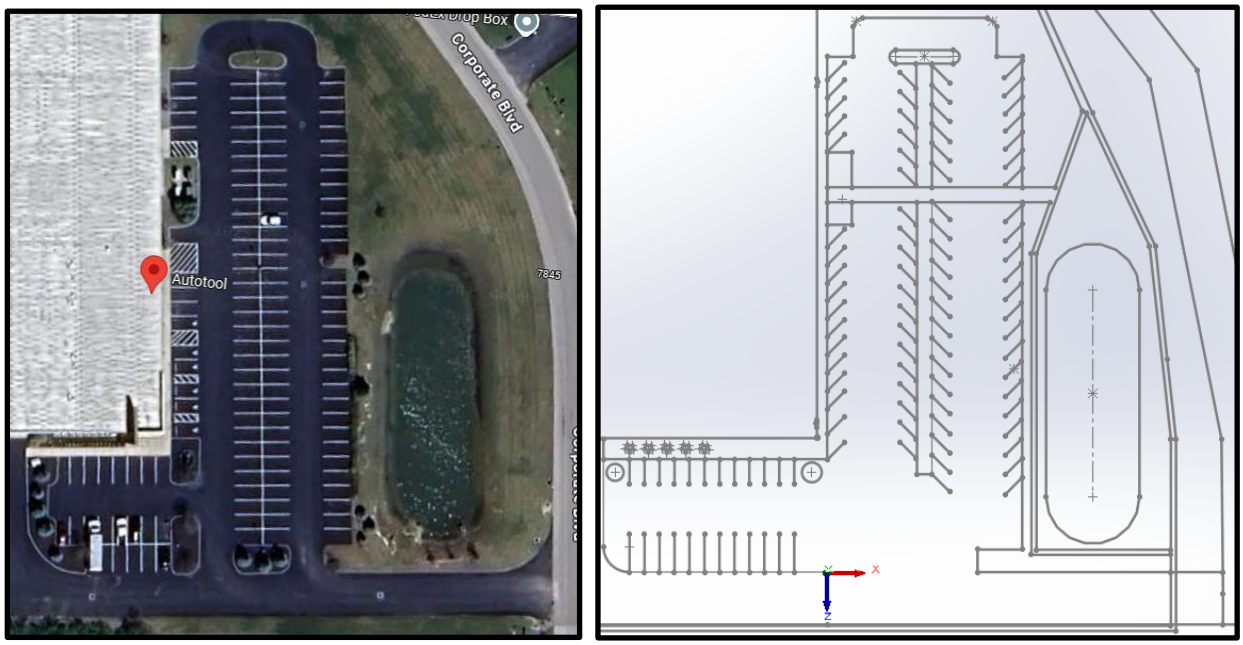


Figure 25: Parking Lot

Table 1: Parking Lot Dimensions

Spot Type	Width	Length	Quantity
Compact	13’	16’	19
Standard	12’	16’	51
Handicap	17’	16’	2
Visitor spots	10’	16’	11
Service Vehicle / Semi Pull Through	10’	25’	11
Total			**94**

45° angled spots were chosen to increase employee satisfaction and allow for quicker ingress/egress. A crosswalk was added down the vertical center and horizontal center to the employee lot to offer a safe walkway between cars and provide access to the walking path. 2 Handicap spots are included closest to the facility entrance. The visitor lot is separate from the employee lot but still adjacent to the main entrance. Pull-through spots for delivery semi-trucks are available in the visitor lot. This site is not serviced by public transportation, so a parking space is needed for every 1.25 employees. We anticipate 83 employees working at this facility to start, so right now the spot: employee ratio is adequate at 70:83, a parking space for every 1.19 employees. However, if growth is ever required, there is an adaptable lot on the west end of the facility. The minimum requirement is 2 handicap spots per 100 spaces. Adding 2 handicap spots, 11 visitor spots, and 11 service/pull through spots brings the total to 93 spots. 1/3 of vehicles can be expected to be compact automobiles, 27% of the employee spots are compact in this

design. These considerations from *Facilities Planning* lead us to the following number and dimensions of spots.

Locker Rooms

The locker rooms transition the office spaces to the production floor. This is intentional to preserve comfort and cleanliness of employees when in the office spaces as well as act as a natural noise barrier. 39 lockers are included, enough to accommodate all 29 anticipated plant workers and leave some extra for other employees using the gym or other health spaces. 3 showers are included, 2 handicap stalls, 4 regular, and urinals in the men's locker room.

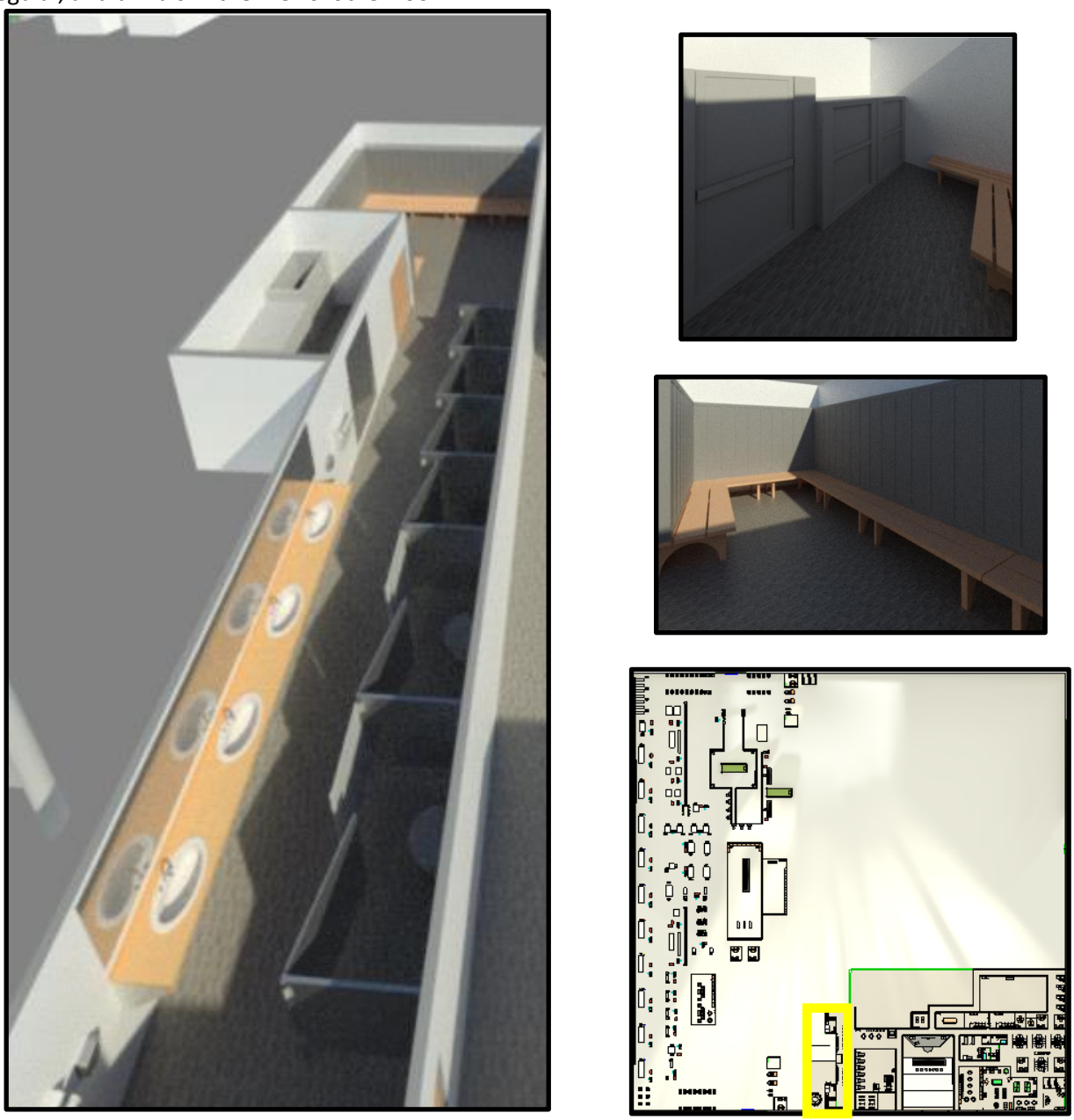


Figure 26: Locker Room Visuals

Food Services

A full-service cafeteria was deemed unnecessary for the anticipated staff which is less than 200, especially when prioritizing operational costs from the Prioritization Matrix. These spaces will include vending machines, prepackaged refrigerated option for purchase, a fridge, freezer, microwave and coffee machine. The first of these spaces will double as a soundproof breakroom for plant workers and the latter is the office break space / cafeteria. The office food services room has an open door to the game room and seating right outside of it. The cafeteria can accommodate 53 people, offering 15 ft^2, per Table 14.

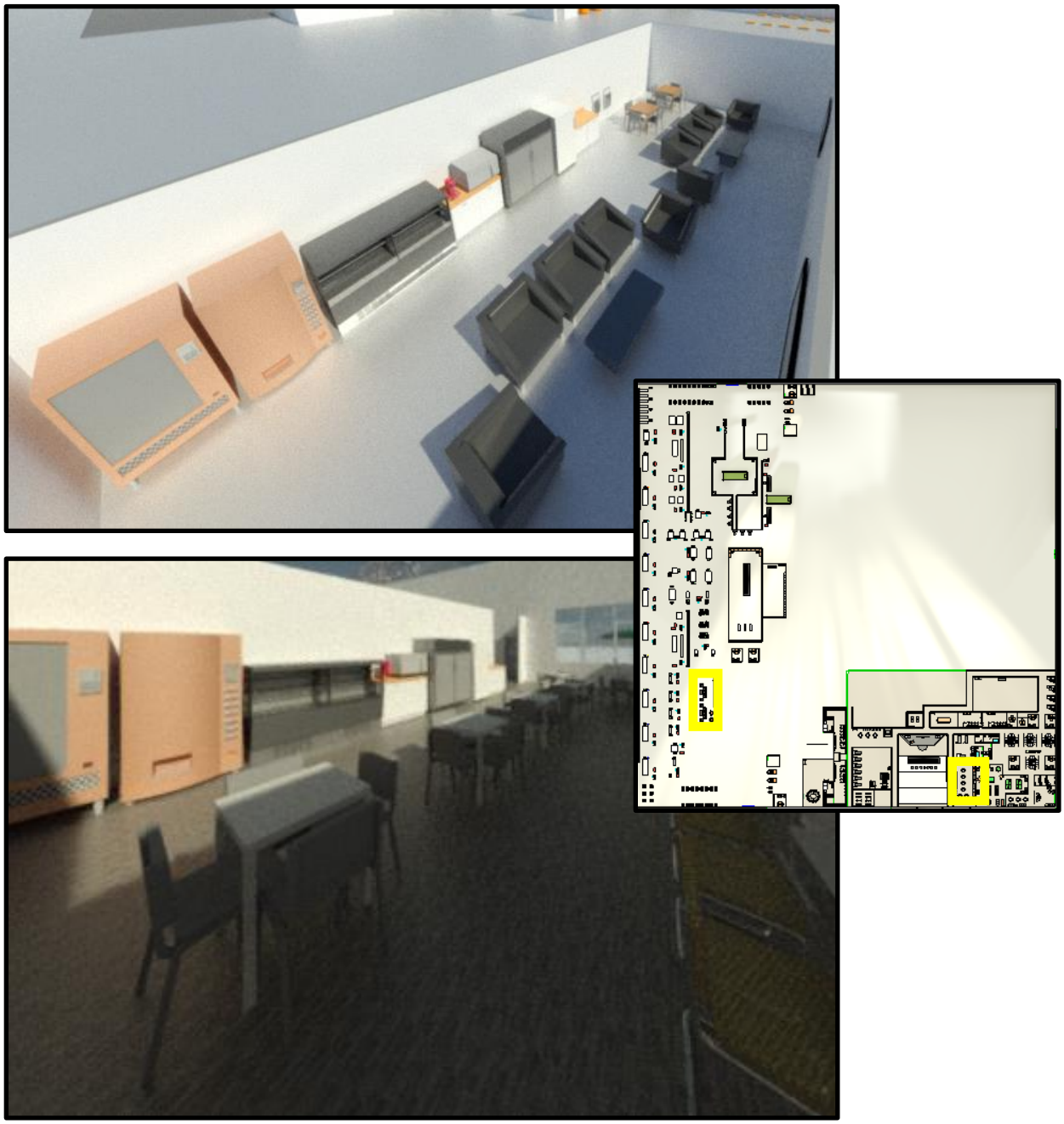
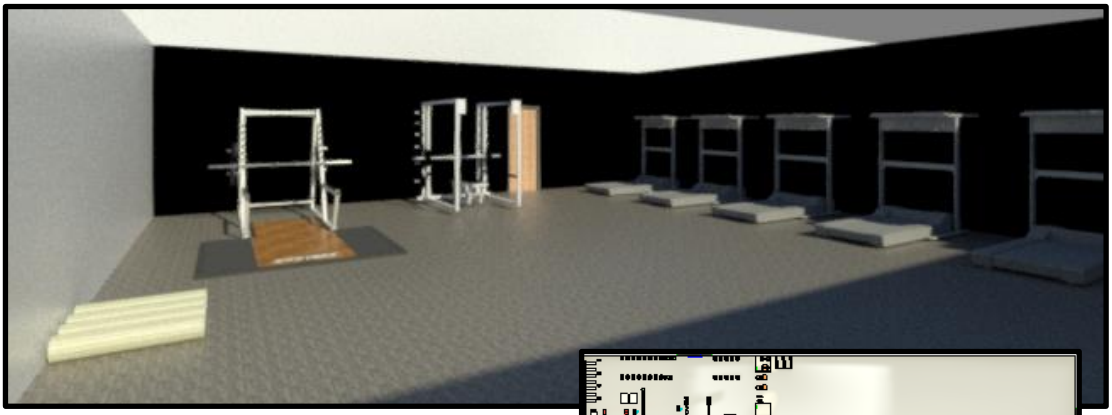
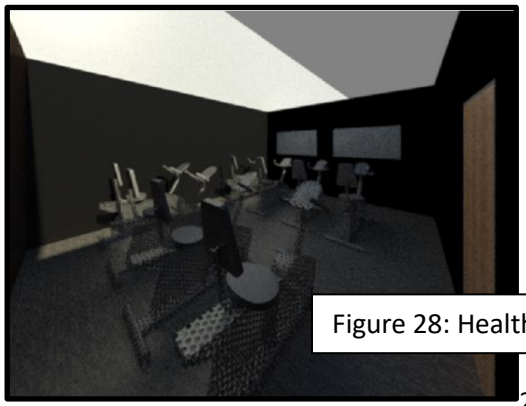


Figure 27: Food Services Visuals

Health Services

Unfortunately, facilities that include a plant prone need to prepare for and attempt to prevent both misuse and overuse injuries. We included a gym with a cycle room attached to promote overall employee health and camaraderie. We also included a nursing complex complete with 2 beds, over 250ft^2, a 75 ft^2 waiting room, 3 lavatories, 2 water closets per Figure 40 and a physical therapy center to focus on reducing the impact of repetitive strain injuries on both our production and employee welfare.





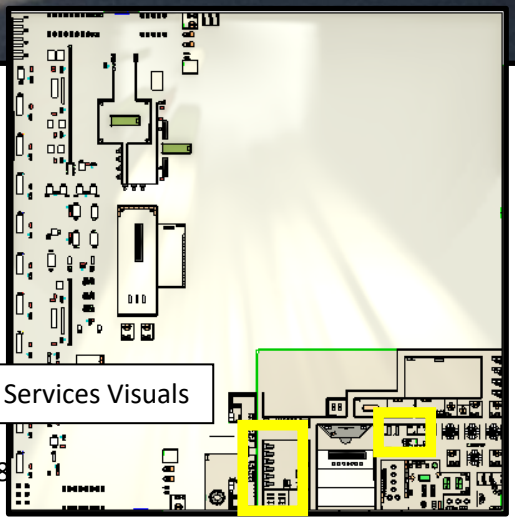
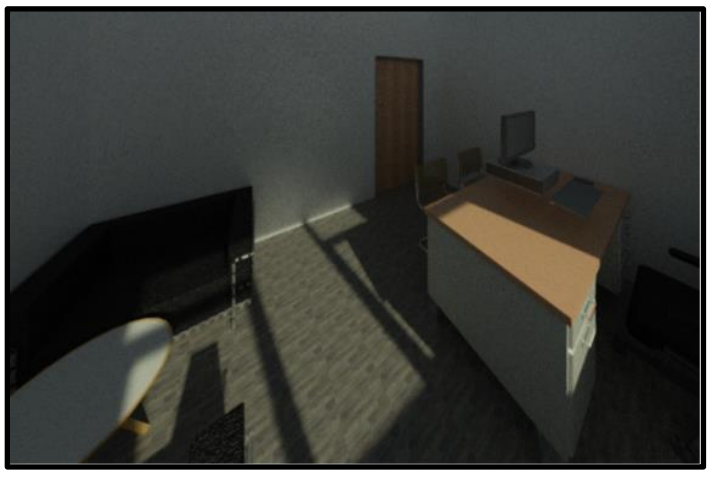


Figure 28: Health Services Visuals

Office Spaces

Our employee department breakdown includes accounting, sales, marketing, HR, legal, management, and engineering. Accounting, sales marketing, and HR were assigned the most popular cubicle size of 6’ x 6’. Legal and shipping and receiving managers were allotted 13’ x 9’ and the engineering cubicle were allotted 8’ x 9’ because this size fit well in the space across the engineering lab, and they were anticipated to need more storage space. This space was designed with an open concept focusing on lots of light and general closeness to encourage interdepartmental communication.



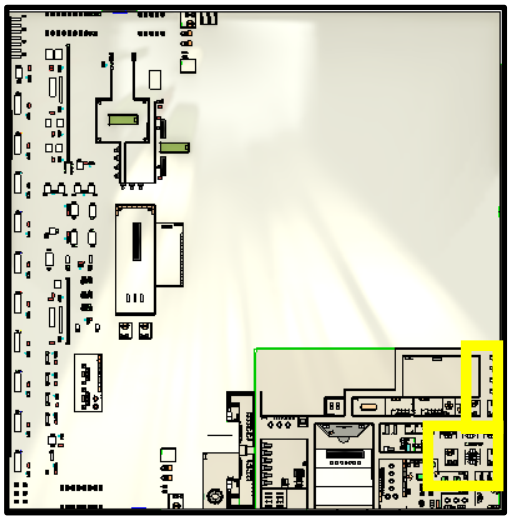
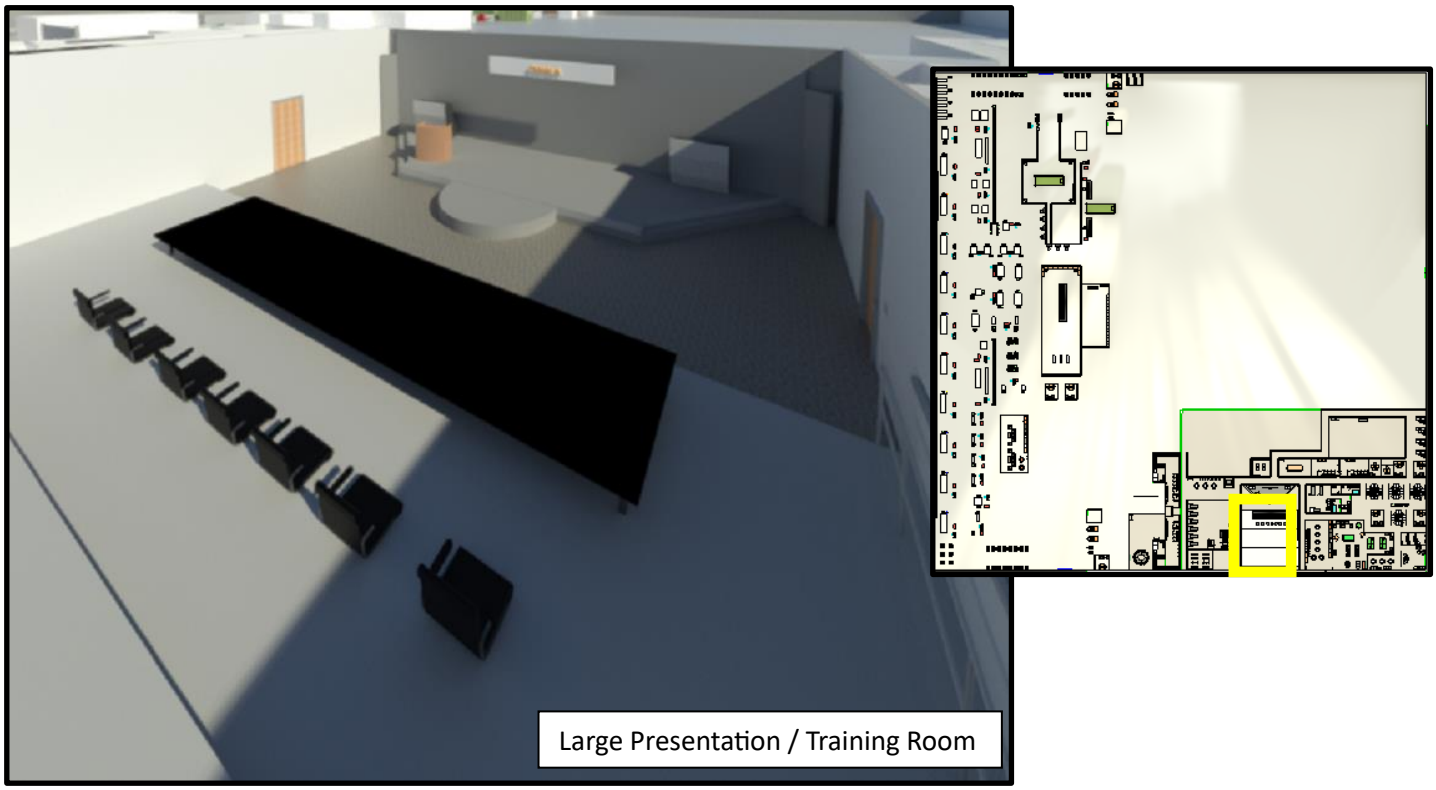


Table 2: Office Department Division

Department	Personnel Required
Manufacturing	39
Management	4
Quality Control	8
Shipping & Receiving	6
Engineering	5
HR	2
Sales	3
Accounting	6
Maintenance	5
Legal	1
Marketing	3
Health	1
Total	83
Parking Needed	67

Figure 29: Office Spaces Visuals

Additional Public Spaces



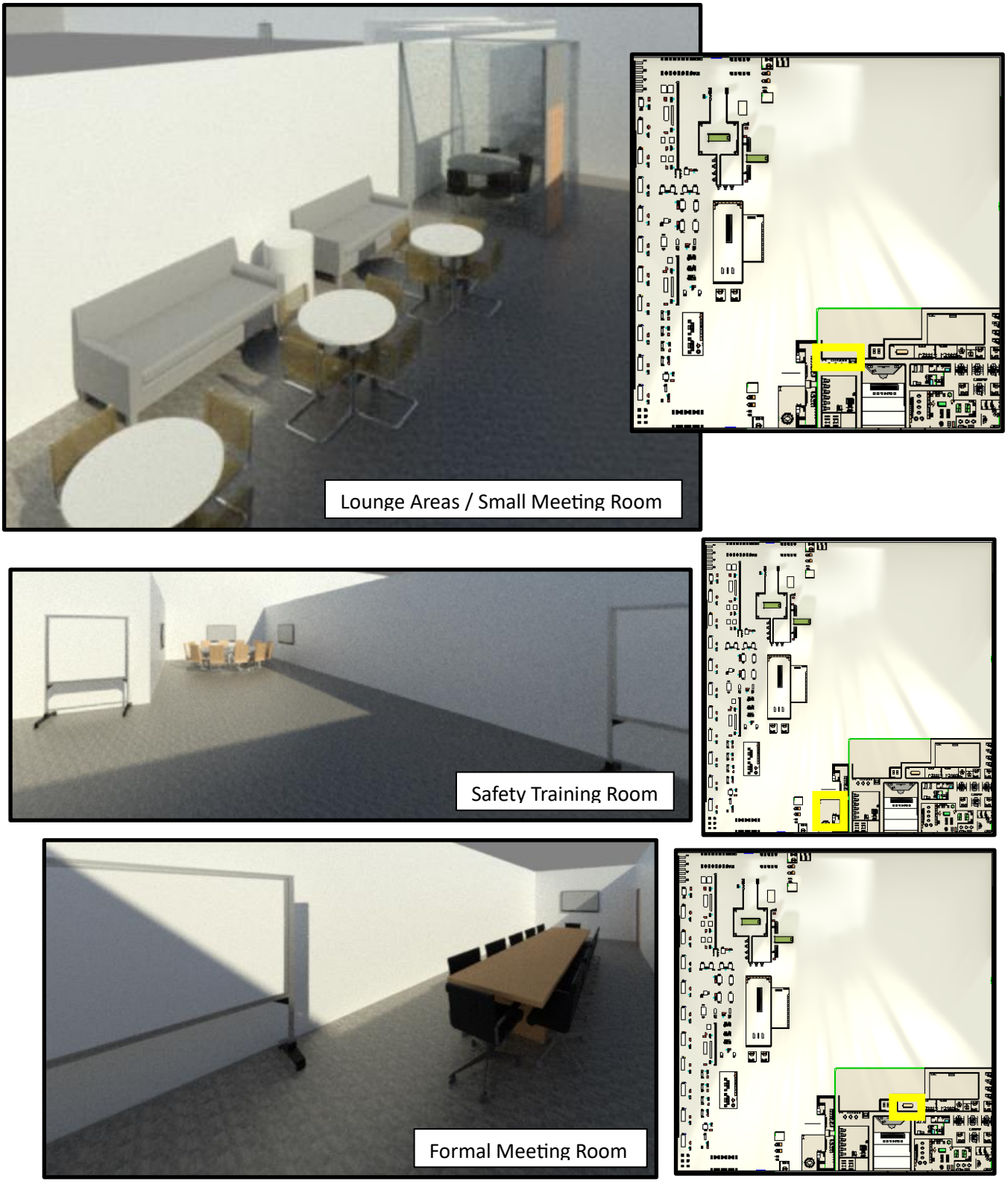


Figure 30: Additional Public Spaces Visuals

Another way we encouraged workflow capability and safety risks is through the inclusion of various meeting room types. Two standouts here are the presentation room and the safety training space as they are a good symbol of the capabilities and priorities of this facility. The design and development aspect of this facility and the nature of the relationship between the plant floor team and the business team will lead to visiting teams, design meetings, and overall, an increase in collaboration which we wanted to prepare for. Another important component this facility is capable of offering is a safety training space and goals board upon entering the plant. This is training room is located on the left after entering the plant and the goals board is on the right. Both will help employees start the day with their priorities straight regarding both production goals and safety goals.

Employee Welfare

The main purpose of these inclusions is to encourage open flow between these spaces and therefore employee interaction in these time periods. The game room has a door opening to an outdoor break space with picnic tables and a large chess set. The game room has a variety of games and is also attached to the lobby through a door. Another notable inclusion is this property's ability to offer a walking path which is a unique draw. This doesn't have to be a budget consideration either as it can be paved or unpaved.

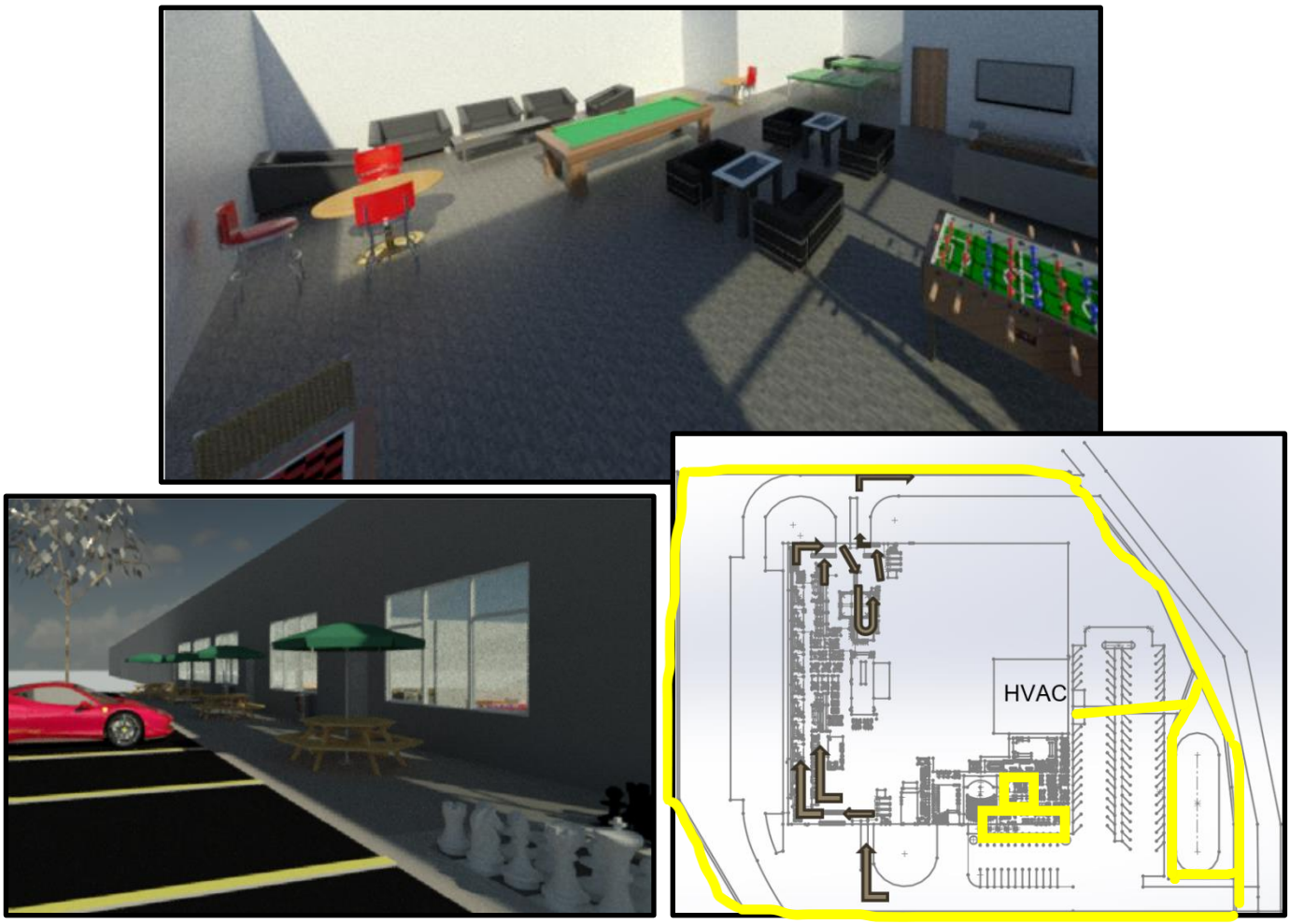


Figure 31: Employee Welfare Visuals

ADA Compliance Considerations

Two main ADA considerations are implemented into this layout. First, a wheelchair counter has been included in the office break room. Second, all doorknobs, soap dispensers, air dryers, sinks, etc. are mounted between 34 and 48 inches above the finished floor per ADA Guidelines found in Standard 1.

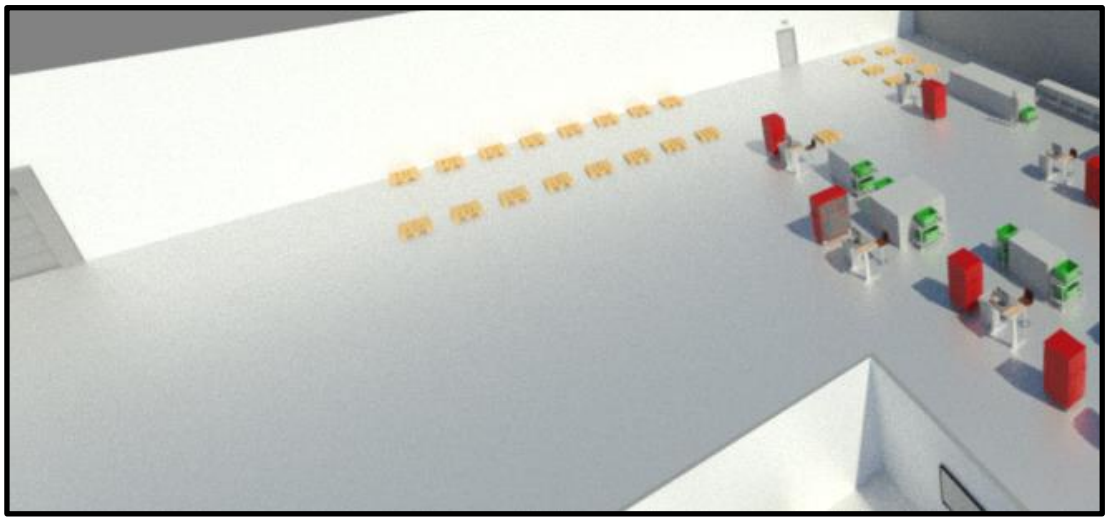
Figure 32: ADA Wheelchair Counter

Shipping and Receiving Areas

Receiving will be located on the south side of the plant. This area is equipped with two forklifts, two pallet jacks, a receiving manager's office, 144 ft^2 per x and a storage room. The shipments will be scheduled to be one per week to support Just In Time manufacturing. They will be one shipment ahead to provide room for errors of delays. The plastic Polypropylene pellet pallets will go straight to plastic line storage at the base of the line. The silicone pellets pallets will go to receiving and the current pallet in receiving will go to the designated area in the workstation for the LSR injection molding machine. The pipe stock is the largest incoming raw material which is why the first machine that requires this material is at the south end of the metal line. This will follow the same storage and replacement method as the plastic pallets. The bottom sheet material has a greater distance to travel because proximity to storage was prioritized for the heavier material. The hand deliveries for office supplies will be delivered to the lobby for the receptionist to handle and the hand delivery for the adhesive and spring steel coil will be delivered to smaller receiving door for the receiving manager to handle. We are expecting 15 pallets weekly as shown in figure x below which is why 16 pallet areas have been allotted to receiving storage. All incoming material will be dropped off via Dock 1. Dock 1 has a calculated apron length of 65', width of 10', and 12 square feet of receiving area dedicated inside the plant. Flush docking was chosen for simplicity, and it requires the least amount of adaptation while still performing as needed. We anticipate

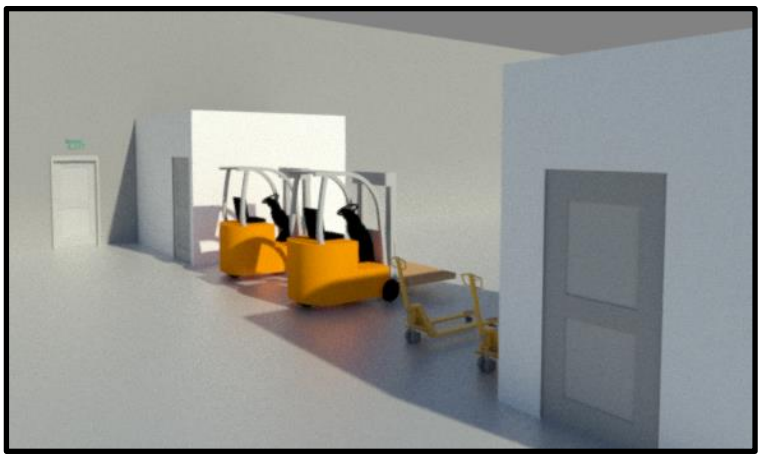
55’ long trucks with 40’ trailers that can hold 80,000 lbs. The incoming road is 27’ wide; wide enough for a two way. Incoming trucks can either exit the way they entered or leave via the back exit depending on traffic which would be the call of the receiving manager. If there is ever a waiting period for multiple deliveries, there is space on both sides of the dock for trucks to wait. However, this isn’t anticipated with the volume of shipments currently anticipated weekly. Forklift and pallet jack storage is included to the right of the dock neighboring additional equipment storage and an office space for the receiving manager. The pallets will be stored on the left of the dock as two rows of pallets (34’ x 40’) with a 12’ aisle for the forklift and a front area of 12’ for unloading. These standards have been sourced from the figures x-x below. The receiving manager will perform visual checks to implement quality control in this area of the facility. This employee will also handle the operation of the forklifts and pallet jacks in distributing material. This information was sourced from Figure 36, Tables 5 and 6 and Standard 1.

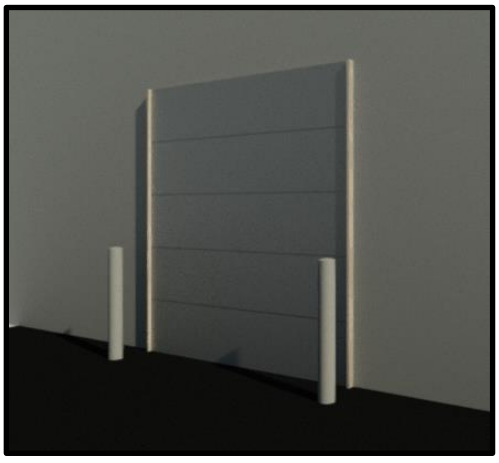
Shipping out will be located on the north side of the plant. The shipping out dock is designed to be the same dimensions as the receiving dock and is equipped with the same storage and equipment. The only difference is that 9 pallets are expected to leave weekly as seen in figure x below and 10 pallet areas have been allotted to shipping storage accordingly. This facility will not include a picking station. There will be a shipping station but it will be generic. It is assumed that there will be an outsource warehouse for sorting/picking and we will be outsourcing to a distribution center.



Description	Unit Loads				Size of Shipment (Unit Loads)	Frequency of Shipment	TRANSPORTATION		MATERIAL HANDLING	
	Type	Capacity	Size	Weight (kg)			Mode	Specifications	Method	Time
Pipe stock inner (SS)	Pallet	208 Pipes/Pallet	48"x40"x60"	161.66	5	Weekly	Semi	Truck #1 (55 ft)	Forklift	10 m
Pipe stock outer (SS)	Pallet	208 Pipes/Pallet	48"x40"x60"	161.66	5	Weekly	Semi	Truck #1 (55 ft)	Forklift	10 m
Bottom Sheet (SS)	Pallet	41 Sheets/Pallet	48"x40"x5"	1230	1	Weekly	Semi	Truck #1 (55 ft)	Forklift	5 m
Spring steel coil (SS)	Hand	1 Box Pallet	1'x1'x6"	6.8	2	Monthly	Semi	Truck #1 (55 ft)	By Hand	2 m
Plastic Injection Material (PP)	Pallet	1 Box Pallet	48"x40"	415.415	1	Weekly	Semi	Truck #1 (55 ft)	Forklift	8 m
Rubber Injection Material (SR)	Pallet	1 Box Pallet	48"x40"	476.33	1	Weekly	Semi	Truck #1 (55 ft)	Forklift	4 m
Powder Coating	Pallet	1 Box	48"x40"	80	1	Weekly	Semi	Truck #1 (55 ft)	Forklift	4m
Packaging Boxes	Pallet	5200 Boxes	48"x40"	1000	1	Weekly	Semi	Truck #1 (55 ft)	Forklift	10 m
Office Supplies	Package	As needed	Varies	Varies	1	Bi-Weekly	Order/Shipping	Fedex	By hand	3 m
Sil-Poxy Adhesive	Package	1 Box / As needed	5"x5"x5"	1	1	Weekly	Order/Shipping	Fedex	By hand	3 m

Figure 33: Receiving Visuals and Receiving Analysis Chart





Description	Unit Loads				Size of Shipment (Unit Loads)	Frequency of Shipment	TRANSPORTATION		MATERIAL HANDLING	
	Type	Capacity	Size	Weight (Kg)			Mode	Specifications	Method	Time
Standard	Pallet	660	48"x40"x60"	1,935.97	6	Weekly	Semi	Truck #2 (40 ft)	Forklift	10 m
Variation	Pallet	660	48"x40"x60"	2,058.72	3	Weekly	Semi	Truck #2 (40 ft)	Forklift	10 m

Figure 34: Shipping Visuals and Shipping Analysis Chart

Facilities Mapping

Structure and Enclosure Systems:

The ideal structural system for this facility will be made of steel, heavy wall round tubular columns spaced in a 36' x 24' grid spacing configuration. These types of columns are ideal for this facility because they prevent nesting, are easy to clean, and will take up less space. These columns will be hidden in walls as much as possible, but material flow will take priority.

Windows will be purchased in standard sizes only to reduce costs. Windows will be heavily placed at ground level on the office side of the facility and towards the ceiling on the production side of the facility. The plant floor will be concrete with synthetic fibers mixed in to prevent cracking with rebar support and epoxy sealant on top. Carpet will be used for the office spaces. Ventilation is necessary near the metal machines and moderate insulation should be included to account for Ohio's temperature fluctuations. The maximum amount of people this facility can accommodate is 1,600 per Calculation 2.

Atmospheric and Safety Systems:

The commercial office spaces and the warehouse spaces need to remain between 68°F and 76°F. The commercial office spaces will require .6 $ft^3/min\text{-}ft^2$ of supply air, .3 $ft^3/min\text{-}ft^2$ of exhaust air, and 4 air changes/hour per Table 8. Approximately 11,200 ft^2 is allocated to HVAC central equipment storage per Table 9. Table 9 states that 5-7% of the total facility will be dedicated to HVAC and because this is a production facility we chose to go on the safer side of this requirement by selecting 7%, anticipating greater requirements to ventilate the production floor.

Life Safety Systems:

Class ABC fire extinguishers are recommended for this facility due to the concern of freely burning combustibles, specifically paper and plastic for this situation, burning liquid or gas, specifically oils and solvents used in the manufacturing process, and electrical fires, which are common in facilities with extensive machinery. One fire extinguisher per 3,000 ft^2 is recommended to ensure fire protection and safety. This results in 54 total for the facility. Table 11 determines the minimum number of fire exits to be 4. I recommend 5 be included to soundly satisfy 1014.2.1: Two exits or exit access doorways. This standard dictates the minimum required distance between fire exits to be 283 ft as shown in Calculation x. An extra exit was needed to satisfy this distance requirement without resulting in an exit that is not easily accessible by a large flow of employees.

Electrical and Lighting Systems:

There are a few considerations necessary in planning the electrical and lighting systems of this facility. First, areas such as workstations, maintenance, quality control and accounting will require higher levels of illumination than other areas of the facility such as general offices, large meeting rooms, amenity rooms and storage rooms. I recommend white walled rooms for the office side of the plant to give the illusion of an open space, fluorescent amps in prismatic lens fixtures for office space areas, and fluorescent lamps in uncovered fixtures for plant floor spaces. Covered fixtures are not needed for the plant floor because they are more expensive and it is not worth the extra expense because aesthetics matter less on the plant floor. I would expect medium dirt buildup on luminaries and 12 months between cleaning. I recommend fluorescent lamp types at a medium wattage. The spacing of

luminaries will depend on the combination of these factors for each room. Table 3 below provides detail regarding number of lamps and luminaries recommended for this facility that were calculated using Equation 1.

Table 3: Luminary Calculation

		Reasoning
Illumination level	100	Medium bench and machine work, regular office work
RCR	0.375	15 foot elevation of lamps
WR	80	Wall reflectivity - white walls
ECR	80	Ceiling reflectivity - white ceilings
CU	0.88	From RCR WR and ECR
LLF	0.9	Light machining, 12 months between cleaning
# of lamps	2693.602694	110 watt florescent bulbs, 7500 lumens @ 75% life
# of luminaries	1346.801347	2 lamps per luminary

Sanitation and Plumbing Systems:

Water fountains will always be paired with restrooms to reduce costs associated with plumbing/water transport within a building and minimize opportunities for leaks. Grouping plumbed facilities can also reduce operational costs associated with plumbing/water transport. There are two sets of single bathrooms, one adjacent to the lobby and one on the other side of the plant to satisfy the requirement that there must be a bathroom within every 200 ft of a permanent workstation. A larger set of bathrooms is included off the office spaces and the larger locker rooms are included off the plant spaces. Restrooms were designed to adhere to Figure 39.

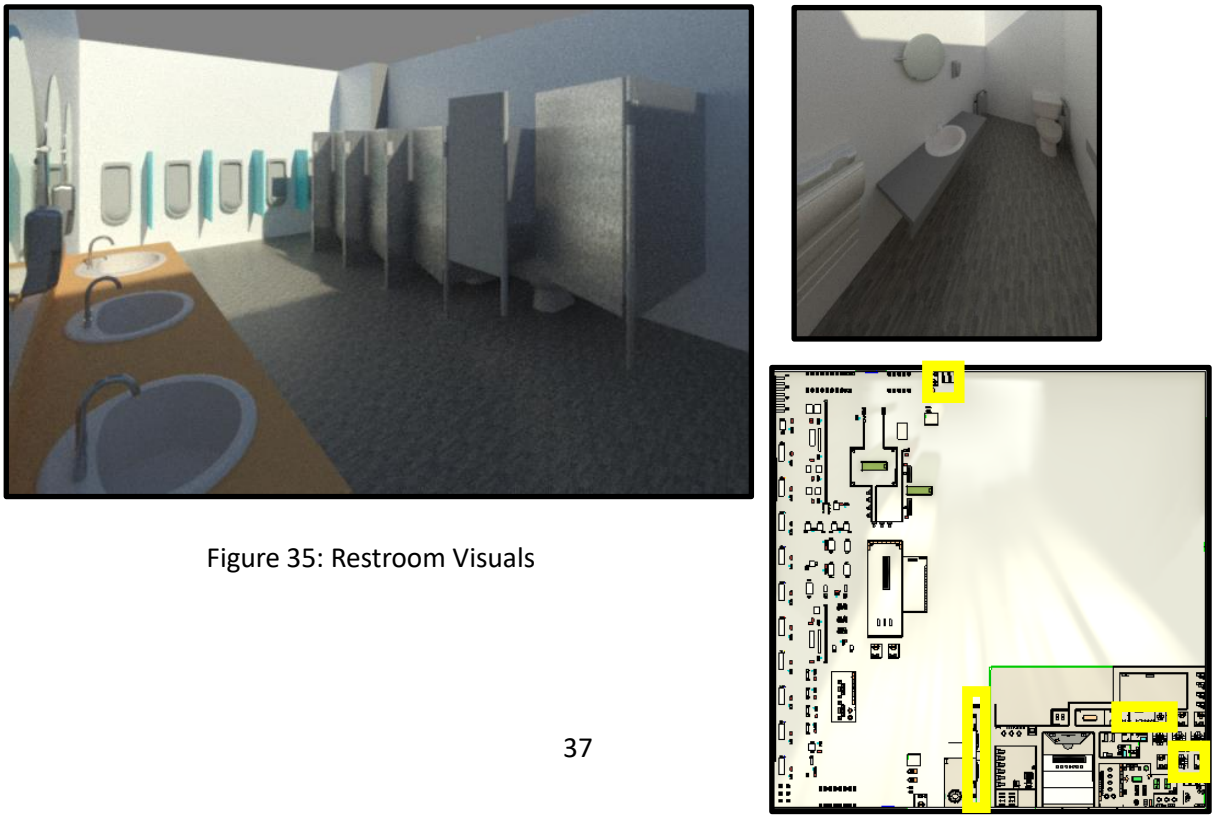


Figure 35: Restroom Visuals

Design Proposal

Table 4: Layout Decision Matrix

Decision Matrix						
	Weight	Initial	Optimized	Layout V.3	Connor's	Dom's
Employee Satisfaction	3	3	3	4	2	4
Safety	4	3	2	4	3	4
Cost	3	2	2	3	4	4
Optimized Dept. Location	3	2	5	4	3	4
Space Utilization	4	3	4	3	3	4
Planning	5	2	3	5	3	4
Unit Load Principle	4	3	4	4	4	2
Working Conditions	3	3	2	4	2	3
Minimal Flow	5	2	1	4	4	4
Total		86	96	134	108	125

Initial: This is the first version of the 2D layout fully produced. It focuses less on minimizing flow and more on finding ways to use the space.

Optimized: This design utilized the output of the optimized block design. Figure x in the appendix depicts the result of the graph-based algorithm that was applied with the goal of maximizing adjacency by connecting the departments that are most heavily dependent on each other. The adjacency score of the original block layout improved by 45 points using this optimization method. The feasible conclusions I drew from this process were to add lower plant floor management offices to the plant floor, centralize quality control by integrating it into production, and centralize maintenance and assembly departments as well because they had the most significant connections with the most other departments.

Connor's: Teammate member Connor's design was selected for the design matrix due to its similar flow to my initial layout. Comparing Layout V.3 to this design solidifies the success of the adaptations that were made because Connor's design had a higher adjacency score than Initial layout.

Dom's: Teammate member Dom's design was selected for the design matric because of its differences to my initial layout. Dom's layout used the absolute minimum necessary space which is something my Initial layout could improve on. His layout also received a high adjacency score. Both of these factors made Dom's layout a good measure of how my Initial layout improved in terms of minimization as well as adjacency.

Layout V.3: This is the finalized layout that takes into consideration the following:

Employee Satisfaction: The walking path, gym, health centers, indoor and outdoor working spaces, convenient parking, lots of amenities, and the minimal plant floor manual product carrying due to the minimal flow category below all contribute to a safe and sociable work environment.

Safety: There is less cross traffic on the plant floor due to the changes discussed in minimal flow below. There are less material flow paths which go shorter distances resulting in less room for error.

Cost: The cost is greater than other designs due to the necessary pavement additions for the back access route and parking lot. However, there is plenty of room to rent the space out which could offset these costs.

Optimized Dept. Location: This design is a happy medium between the department locations of the initial and optimized layout. I added lower plant floor management offices to the plant floor, centralized QC, maintenance and assembly departments as an adjustment from the initial layout because they had the most significant connections shown in the optimized design.

Space Utilization: There is still some awkward gapping in the bridge area between the production floor and office spaces which explains the score of a 3. This design overall still does a good job of only using the space it needs and leaving a prime area to be developed for other purposes.

Planning: There is defined flow in the production lines with raw materials entering at the south end of the plant, following a unilateral flow towards the north end where the finished products will be sent out.

Unit Load Principle: There are not many opportunities to increase the unit load principle more than we already have for the production of a product this size. The storage totes, conveyors, and pallets we are using for transportation and storage ensure that product is moving in groups.

Working Conditions: The minimized flow describes below improves safety and prevents fatigue for employees. Employees also have indoor and outdoor access to amenities for health and socializing.

Minimal Flow: I flipped the plastic production line so that plastic and metal raw material enter at the same side of the plant. The finished products will end close to each other and be placed in in-process part storage which is near assembly which loops back around to final storage located right next to shipping.

Conclusion

To conclude, this facility in Plain City Ohio is recommended to be selected for the Owala expansion because of the design's achievements in the following categories. It accommodates an office space that fosters interdepartmental communication. It has the potential for a simple and effective shipping and receiving system, being the only unique and notable budget consideration. And the unidirectional flow of the plant floor sets up minimal distances for moving material which results in cost and time savings over time.

There is plenty of room for future growth which is to be anticipated and could be in the form of taking on distribution in the future, which would be ideal considering its central Midwest location. In the meantime, the space is divided where it could be rented out as a form of passive income to offset the cost of having a space larger than necessary.

Appendix A

Basic Considerations

Opening Doors to Everyone, Large Print

- Door should have 32’ clearance

Here's How Much Space You Need Between Your Desk and a Wall

- 30 inches between desk and wall

OSHA Regulations for Ramps

- 20 inch width minimum aisle width to exits

7 Standard Interior Door Size Options Explained

- 32” x 80” doors

How much space should I leave between door's casing and a wall corner?

- 4” between door and wall

Wall height:

- https://definecivil.com/standard-height-of-1-2-3-4-5-and-multi-storey-building/

Wall thickness:

- How Thick Are Walls? – Here’s Everything You Need To know – Homeeon

ADA

Standard 1: Wheelchair Accessible Height:
https://www.bing.com/ck/a?!&&p=627a38f5d3120909035265082e5db0370034828be3c45296818dddbff88084b6JmltdHM9MTc0NjA1NzYwMA&ptn=3&ver=2&hsh=4&fclid=2bfbe17f-a451-63c3-0c27-f4a4a50d6231&u=a1aHR0cHM6Ly93d3cuc2lnbnN0ZWsuY29tL2Jsb2dzL25ld3Mvd2hhdC1pcy1hZGEtaGVpZ2h0LWZvci1kb29yLWhhbmRsZXM&ntb=1

ADA (Americans with Disabilities Act) **Compliance**

While ADA compliance considers a range of different disabilities, barrier-free compliance is generally the main consideration.

Barriers include:

- Physical barriers
  (Any physical object that impedes access to the use of a facility)
  - Example:
    - Narrow doorways
    - Steps without a ramp
- Communication barriers
  - Visibility of signage

Standard wheelchair dimensions and turning radius

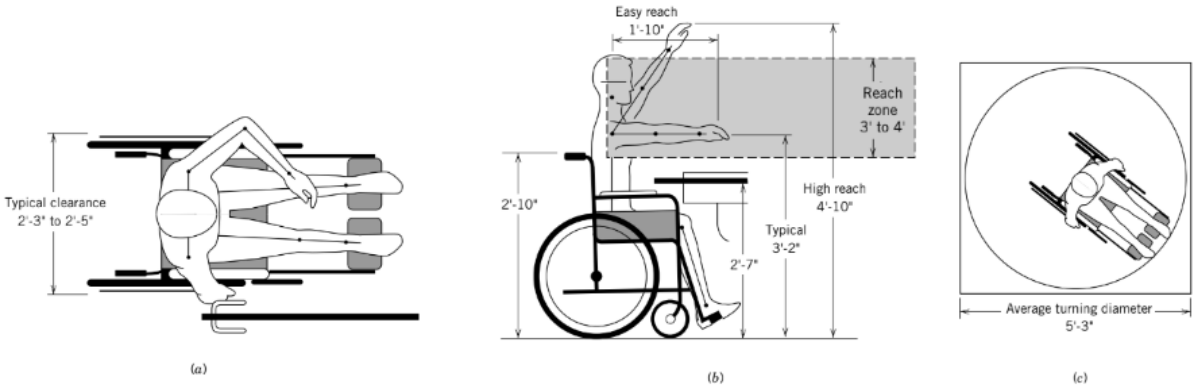


Figure 35: ADA Considerations

Dock Transportation Access Guidelines

1. Two-directional service roads should be at least 24 feet wide.
2. One-way service roads should be at least 12 feet wide.
3. If pedestrian travel is to be along service roads, a 4-foot-wide walk physically separated from the service road should be included.
4. Gate openings for two-directional travel should be at least 28 feet wide.
5. Gate openings for one-way travel should be at least 16 feet wide.
6. Gate openings should be 6 feet wider if pedestrians will also use the gate.
7. All right-angle intersections must have a minimum of a 50-foot radius.
8. If possible, all traffic should circulate counterclockwise because left turns are easier and safer to make than right turns (given that steering is on the left of the vehicle).
9. Truck waiting areas should be allocated adjacent to the dock apron and need to be big enough to hold the maximum expected number of trucks waiting at any given time.

Figure 36: Dock Transportation Access Guidelines

Table 5: Space Requirements for 90° Docks

Table 7.1 *Space Requirements for 90° Docks*

Truck Length (feet)	Dock Width (feet)	Apron Depth (feet)
40	10	46
	12	43
	14	39
45	10	52
	12	49
	14	46
50	10	60
	12	57
	14	54
55	10	65
	12	63
	14	58
60	10	72
	12	63
	14	60

Table 6: Minimum Maneuvering Allowances for Receiving and Shipping Areas

Table 7.3 *Minimum Maneuvering Allowances for Receiving and Shipping Areas*

Material Handling Equipment Utilized	Minimum Maneuvering Allowance (feet)
Tractor	14
Platform truck	12
Forklift	12
Narrow-aisle truck	10
Handlift (jack)	8
Four-wheel hand truck	8
Two-wheel hand truck	6
Manual	5

Standard 1: Shipping/Receiving Office Size

- *Personnel convenience/offices.* These must be provided for receiving and shipping supervision and for clerical activities. Approximately 125 ft^2 of office space should be provided for each dock employee who will regularly work in the office. The supervisor's office space will often be located within the dock area, and many of the receiving and shipping, clerical, and data-processing activities will be combined with similar activities in the remainder of the warehouse.

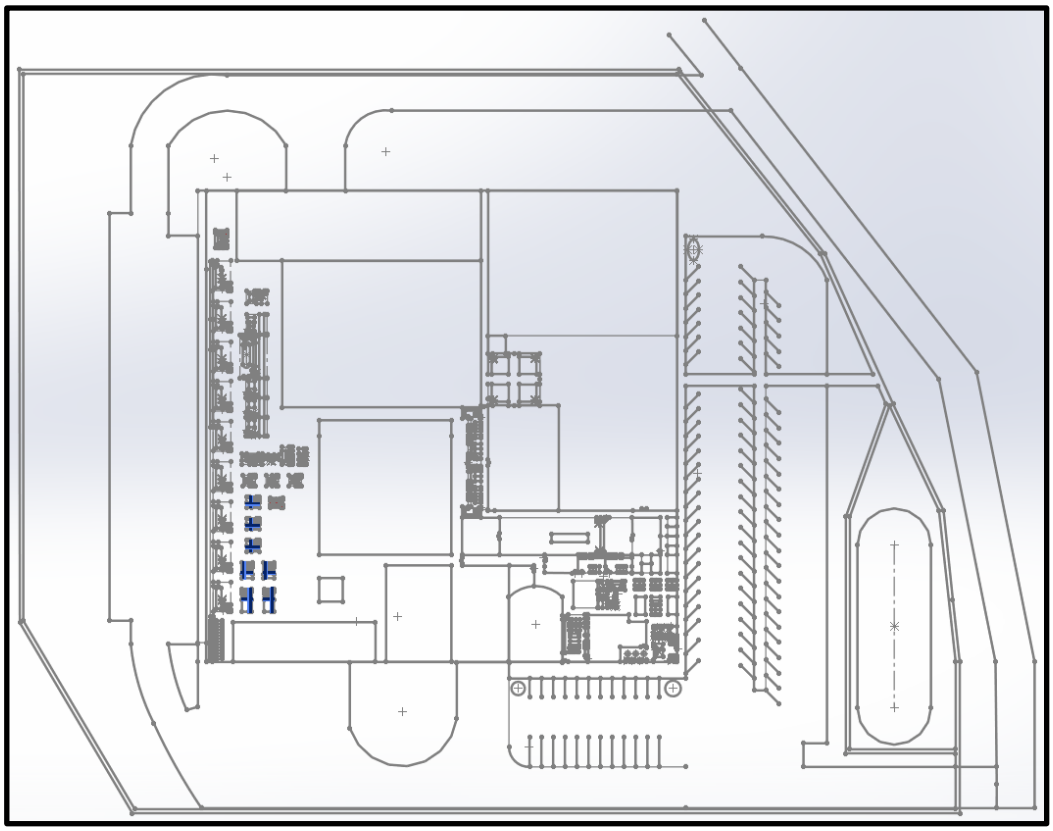


Figure 37: Initial 2D Layout

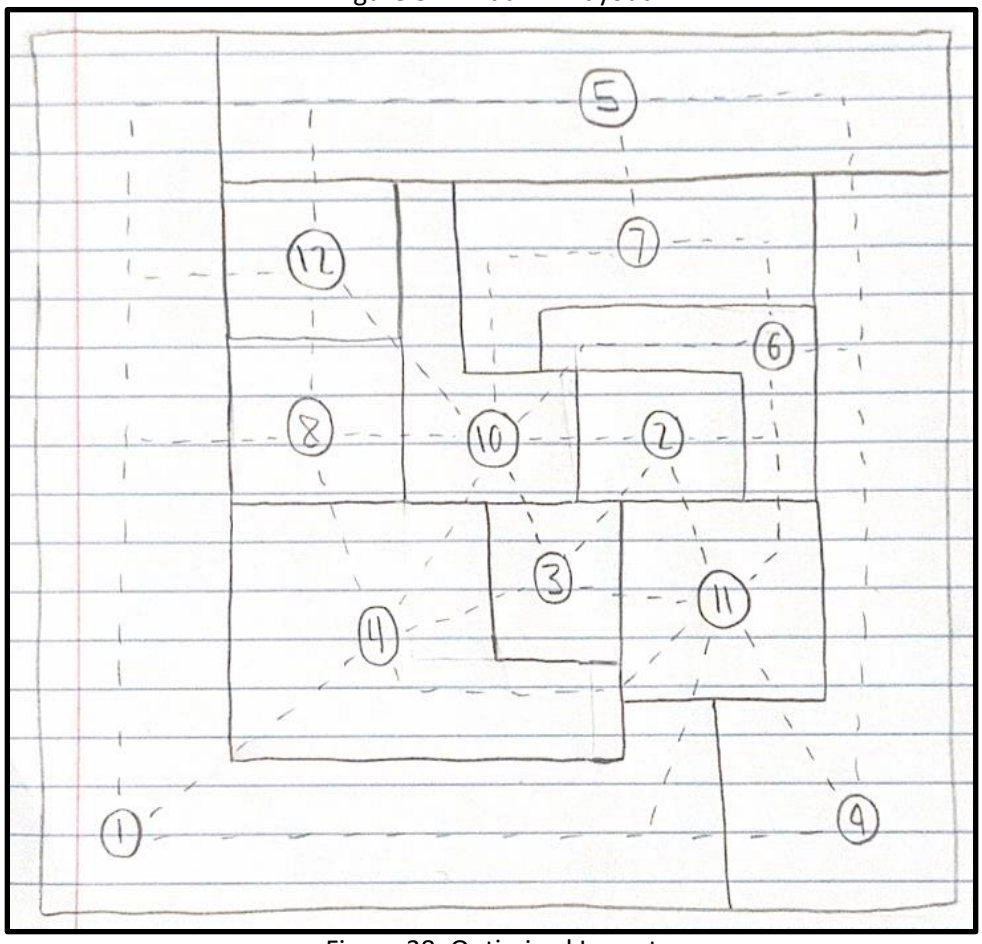


Figure 38: Optimized Layout

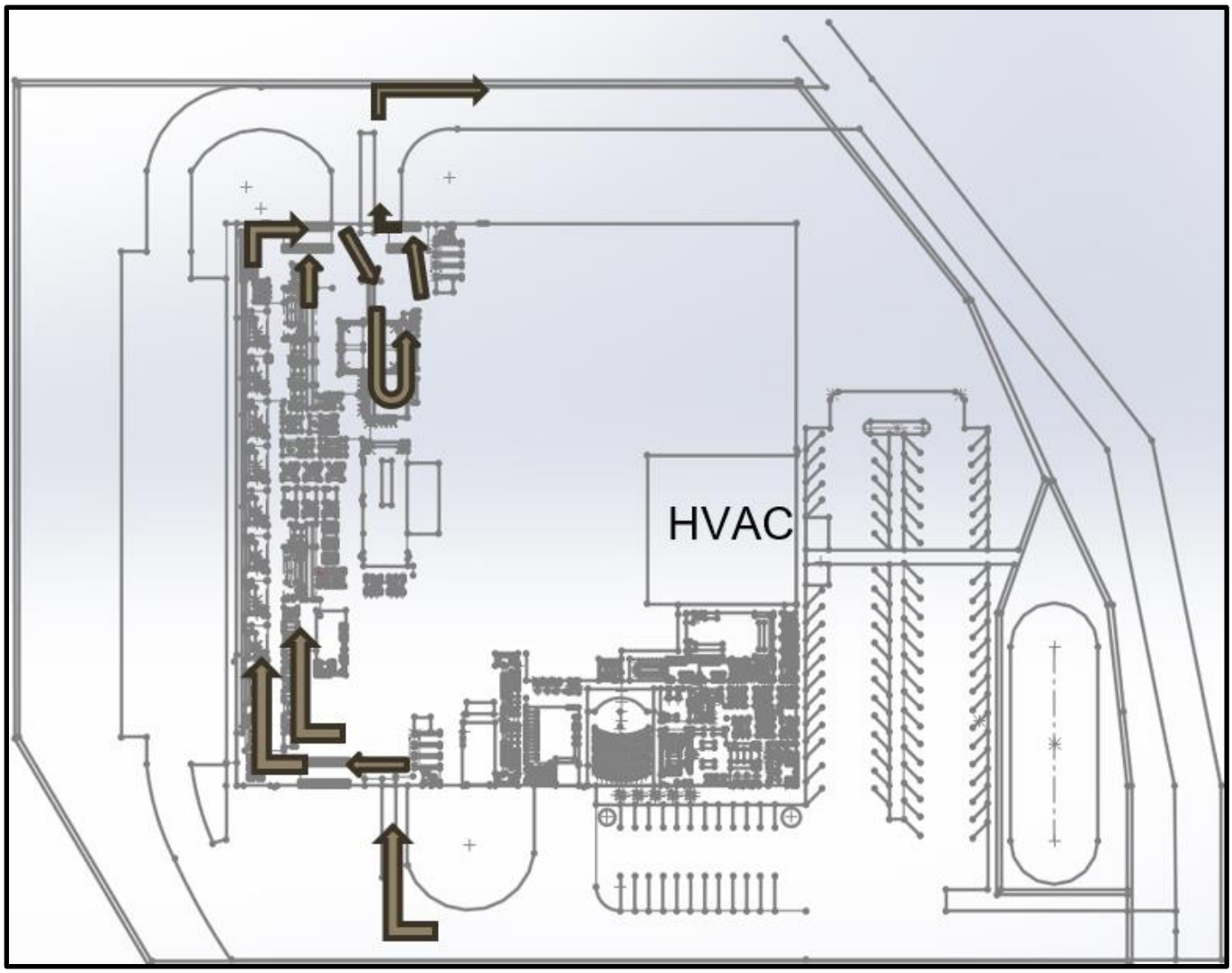


Figure 39: Layout V.3 (Current)

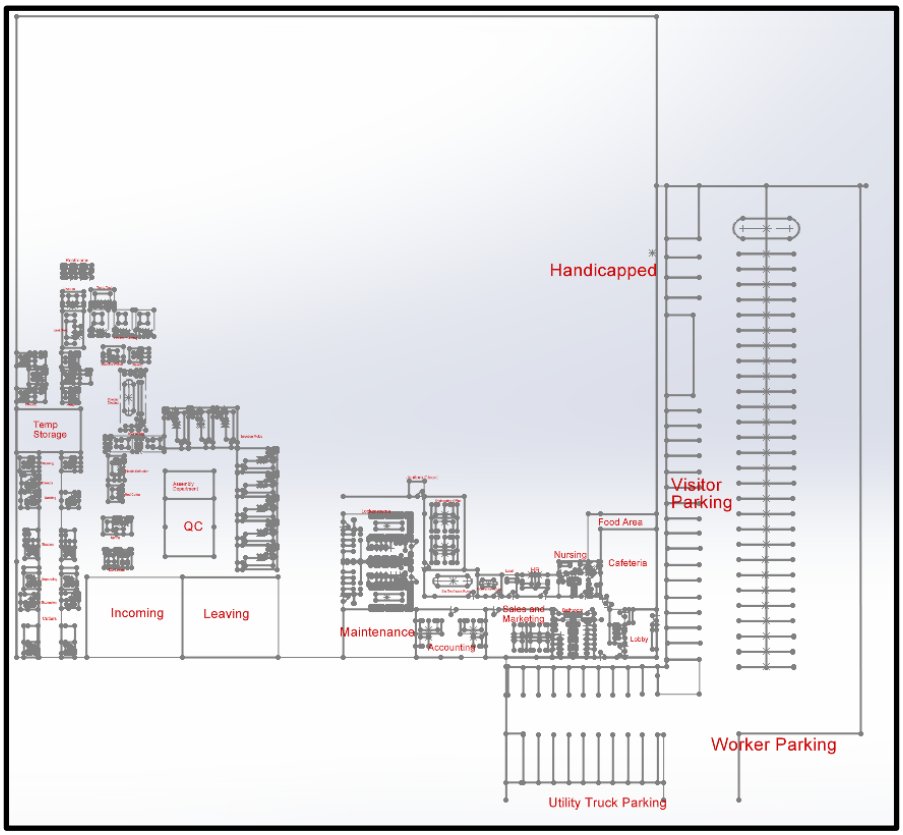


Figure 40: Team Member Connor's Layout

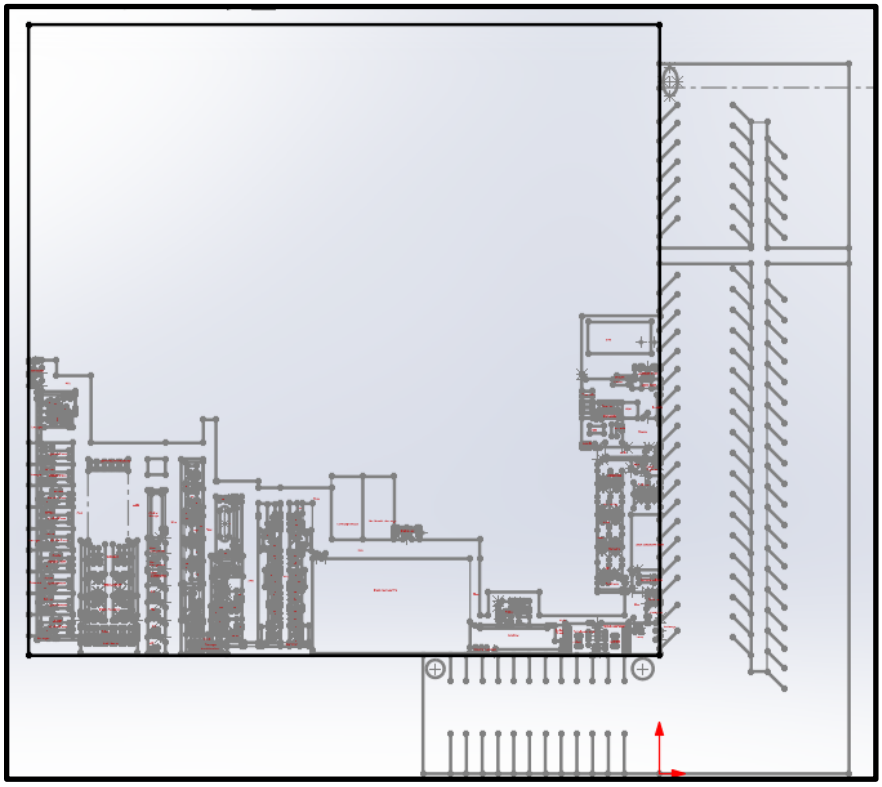
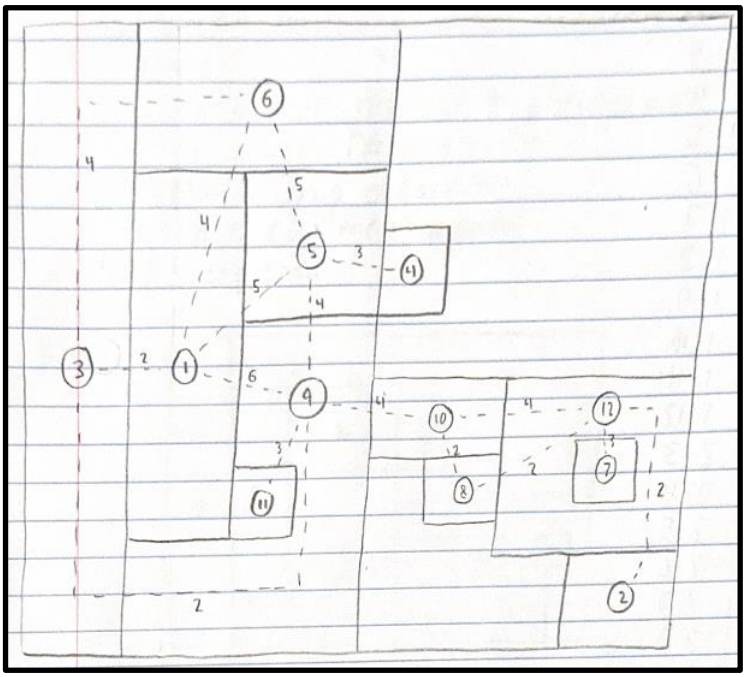


Figure 41: Team Member Dom's Layout

Arc	Weight
2-12	2
7-12	3
12-8	2
12-10	4
8-10	2
10-9	4
9-11	3
9-5	6
9-3	2
9-1	6
4-5	3
5-6	5
5-1	5
1-6	4
1-3	2
3-6	4
Total	**57**



Key	
1 Metal Assembly	7 Sales/Accounting
2 Reception	8 Health
3 Plastics & Rubber Production	9 Receiving
4 Quality Control	10 Maintenance
5 Main Assembly	11 Lower Management
6 Packaging & Shipping	12 Project & Operations Management

Arc	Weight
1-4	6
1-5	5
1-8	3
1-9	6
1-11	5
1-12	4
6-9	2
9-11	3
6-7	5
2-6	2
2-10	2
2-3	1
2-11	1
6-11	5
3-11	5

Arc	Weight
3-4	6
8-10	2
4-10	4
8-4	2
8-12	2
10-12	4
7-10	6
5-7	1
5-9	4
6-10	4
3-10	5
5-12	4
4-11	5
Total	**102**

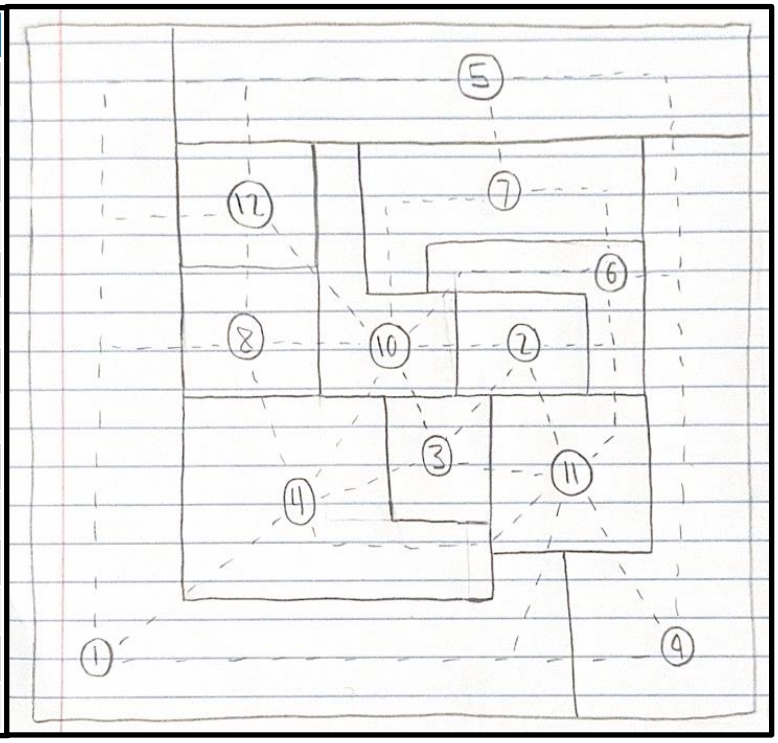


Figure 38: Initial Block Layout vs. Optimized Block Layout

Calculation 1: Volume Calculation Sample, Material Handling

Dog Bowl Attachment Volume From SolidWorks = 8.03 in^3

Standardized Tote Volume = 8640 in^3

Weight of a 4' x 4' x 4' Pallet of Material With a Density of 1.2 g/cm^3

1 foot = 30.48 cm,

4 ft = 121.92 cm

- The pallet volume is 121.92 cm × 121.92 cm × 121.92 cm

(121.92 * 121.92 * 121.92) = 1,813,000 cm^3

1,813,000 * 1.2 = 2,175,600 grams

2,175,600 g ÷ 1,000 = 2,175.6 kg

1 kg ≈ 2.205 lbs

(2,175.6 * 2.205) = 4,796.1 lbs

Table 7: Recommended Aisle Widths for Various Types of Flow

Table 3.5 *Recommended Aisle Widths for Various Types of Flow*

Type of Flow	Aisle Width (feet)
Tractors	12
3-ton forklift	11
2-ton forklift	10
1-ton forklift	9
Narrow aisle truck	6
Manual platform truck	5
Personnel	3
Personnel with doors opening into the aisle from one side	6
Personnel with doors opening into the aisle from two sides	8

Table 8: Central Equipment Room Area by Use

Table 9.1 ***Typical Air Change Rates***

Use	Supply Air $ft^3/min\text{-}ft^2$	Exhaust Air $ft^3/ min\text{-}ft^2$	Air Changes/hr
Residence			
Toilet room	—	1.5	10
Kitchen	—	1.5	10
Other rooms	Natural ventilation—5% of floor area		—
Office/commercial	0.6	0.3	4
School	1.5	0.75	9
Public assembly	3.0	1.5	—
Hospital	2.0	1.0	13
Labs	1.2	1.2	8
Animal laboratory	—	3.0	20

Table 9: Central Equipment Room Area by Use

Table 9.2 ***Central Equipment Room Area by Use***

Use	Area of Equipment Rooms
Residential	2%
Office/industrial	5–7%
Public assembly	10–15%
Hospital	25%
Laboratory	25–50%
Animal laboratory	50%

Table 10: Fire Suppression System Requirements

Fire Class	Fuel Type	How to Suppress	Fire Extinguisher Type
Class A	Freely burning combustibles	Water, Smothering	ABC/powder, water, water mist, foam
Class B	Burning liquid or gas	Smothering	ABC/powder, CO2, water mist, clean agent
Class C	Electrical fire	Non-conductive chemicals	ABC/powder, CO2, water mist, clean agent
Class D	Metallic fire	Dry powder agent	Powder
Class K	Cooking or grease fire	Smothering, wet chemical	Wet chemical, water mist

Table 11: Maximum Floor Area Allowances per Occupant

Table 9.11 *(2003 IBC Table 1004.1.2) Maximum Floor Area Allowances per Occupant*

Use	Floor Area per Occupant (ft^2)
Agricultural building	300 gross
Aircraft hangers	500 gross
Airport terminal	
Baggage claim	20 gross
Baggage handling	300 gross
Concourse	100 gross
Waiting areas	15 gross
Assembly	
Gaming floors (keno, slots, etc.)	11 gross
Assembly with fixed seats	See Section 1003.2.2.9
Assembly without fixed seats	
Concentrated (chairs only—not fixed)	7 net
Standing space	3 net
Unconcentrated (tables and chairs)	15 net
Bowling alleys allow five persons for each alley, including 15′ of runway, and for additional areas	7 net
Business areas	100 gross
Court rooms—other than fixed seating areas	40 net
Dormitories	50 gross
Educational	
Classroom area	20 net
Shops and other vocational room areas	50 net
Exercise rooms	50 gross
H-5 fabrication and manufacturing areas	200 gross
Industrial areas	100 gross
Institutional areas	
Inpatient treatment areas	240 gross
Outpatient areas	100 gross
Sleeping areas	120 gross
Kitchen, commercial	200 gross
Library	
Reading rooms	50 net
Stack areas	100 gross
Mercantile	
Basement and grade floor areas	30 gross
Areas on other floors	60 gross
Storage, stock, shipping areas	300 gross
Parking garages	200 gross
Residential	200 gross
Skating rinks, swimming pools	
Rink and pool	50 gross
Decks	15 gross
Stages and platforms	15 net
Accessory storage areas, mechanical equipment room	300 gross
Warehouses	500 gross

Calculation 2: $\frac{160{,}000\ ft^2}{100\ \frac{ft^2}{person}} = 1{,}600\ people$

Table 12: Minimum Number of Exits / Occupant Load

Occupant Load	Minimum Number of Exits
500 or less	2
501–1000	3
Over 1000	4

Calculation 3: Fire extinguisher – ABC – 1 for every 3,000 ft^2

- (400 ft * 400 ft) / 3,000 ft^2 = 53.33 = **54 total**

Table 12: Plumbing Fixture Requirements for Number of Employees

Table 4.2 *Plumbing Fixture Requirements for Number of Employees*

Business, Mercantile, Industrial Other Than Foundry and Storage

Water Closets	Employees	Lavatories	Employees
1	1–15	1	1–20
2	16–35	2	21–40
3	36–55	3	41–60
4	56–80	4	61–80
5	81–110	5	81–100
6	111–150	6	101–125
7	151–190	7	126–150
		8	151–175
One additional water closet for each 40 employees in excess of 190.		One additional lavatory for each 30 employees in excess of 175.	

Industrial, Foundries, and Storage

Water Closets	Employees	Lavatories	Employees
1	1–10	1	1–8
2	11–25	2	9–16
3	26–50	3	17–30
4	51–80	4	31–45
5	81–125	5	46–65
One additional water closet for each 45 employees in excess of 125.		One additional lavatory for each 25 employees in excess of 65.	

Assembly, Other Than Religious, and Schools

Water Closets	Occupants	Urinal	Male Occupants	Lavatories	Occupants
1	1–100	1	1–100	1	1–100
2	101–200	2	101–200	2	101–200
3	201–400	3	201–400	3	201–400
4	401–700	4	401–700	4	401–700
5	701–1100	5	701–1100	5	701–1100
One additional water closet for each 600 occupants in excess of 1100.		One additional urinal for each 300 occupants in excess of 1100.		One additional lavatory for each 1500 occupants in excess of 1100. Such lavatories need not be supplied with hot water.	

Restrooms

Additional Space Requirements:

- Sinks
  - For single use sinks, 6 ft^2 should be allocated for each sink
- Entrance doorways
  - Doorways should be designed such that the interior of the restroom is not visible from the outside when the door is opened.
  - 15 ft^2 should be allocated for the entrance
- Aisles
  - For aisles up to 16' long, 3.5-4' aisle width is recommended.
  - For aisles above 16' long, 4-6' aisle width is recommended.
  - Aisles between rows of fixtures should be slightly larger than those prescribed above.
  - When toilet doors open outward, the aisle width between rows should be a minimum of 6.6'

A restroom should be located within 200 feet of every *permanent* workstation
Decentralized restrooms often provide greater employee conveniences than large centralized restrooms.
Mezzanine restrooms are common in production facilities
- Access to restrooms must be possible for all employees, however.

Currently, the convention is to have restrooms designed for single occupancy or to have separate facilities for each sex.
For planning purposes, from 12.5 ft^2 (2.5' x 5') to 15 ft^2 (3' x 5') should be allocated for each toilet and 6 ft^2 should be allocated for each urinal.

Figure 39: Restroom Requirements

A small first aid room should include:

- Approved first aid kit
- Bed
- Two chairs
- >100 ft^2

When a nurse is employed, this should be expanded (as shown in the diagram):

- 2 beds
- > 250 ft^2
- 75 ft^2 waiting room

(If a physician is employed, these numbers would increase again.)

All health service spaces should include restroom facilities and be located in a quiet, non-hazardous area of the facility.

Figure 40: Health Center Requirements

Table 13: Recommended Aisle Widths for Various Types of Flow

Table 3.5 ***Recommended Aisle Widths for Various Types of Flow***

Type of Flow	Aisle Width (feet)
Tractors	12
3-ton forklift	11
2-ton forklift	10
1-ton forklift	9
Narrow aisle truck	6
Manual platform truck	5
Personnel	3
Personnel with doors opening into the aisle from one side	6
Personnel with doors opening into the aisle from two sides	8

Table 14: Space Requirements for Cafeterias

Table 4.4 *Space Requirements for Cafeterias*

Classification	Square Footage Allowance per Person
Commercial	16–18
Industrial	12–15
Banquet	10–11

Equation 1: # of Lamps and # of Luminaries

$$\text{Number of lamps} = \frac{\left(\begin{matrix}\text{Required level}\\ \text{of illumination}\end{matrix}\right)\left(\begin{matrix}\text{Area to}\\ \text{be lit}\end{matrix}\right)}{(\text{CU})(\text{LIF})\left(\begin{matrix}\text{Lamp output at}\\ \text{70\% of rated life}\end{matrix}\right)} \qquad \text{Number of luminaries} = \frac{\left(\begin{matrix}\text{Number}\\ \text{of}\\ \text{lamps}\end{matrix}\right)}{\left(\begin{matrix}\text{Lamps}\\ \text{per}\\ \text{luminary}\end{matrix}\right)}$$

Equation 2: Machines Required Sample Calculation

Estimating Machines Required via Eq. 1:

Equation 1

$$F = \frac{SQ}{EHR}$$

where

F = number of machines required per shift
S = standard time (minutes) per unit produced
Q = number of units to be produced per shift
E = actual performance, expressed as a percentage of standard time
H = amount of time (minutes) available per machine
R = reliability of machine, expressed as percent uptime

Cap Injection Molding Machine Calculation - Rae

Variable	Value	Reasoning
S	0.667	Researched injection molding takes about 30 seconds - 2 min, this is a smaller part
Q	1036	We chose to produce 181,300 units annually of the core free sip on a five day / week, fifty week, eight hour shift production schedule.
E	0.875	Assuming the machine is operable 7 / 8 hours of each day. => .875
H	480	8 hr work day => minutes
R	0.965	We chose to calculate based off a 3.5% defect rate which is mid tier.
F	1.239208	