

Garrett Pumps Inc. Report

by

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Introduction

In this report, a new layout for an existing production facility will be developed, as requested by the CEO of Garrett Pumps, Inc. The facility has evolved over the years, and it was initially organized by processes, which provided flexibility but resulted in an increase in cost. Now, the CEO seeks help from professionals who are knowledgeable in lean methods to redesign the facility into cells and reduce waste.

Currently, the company analyzed about 800 products and separated them into 22 different groups that have minor differences in the manufacturing process. The future scenario that will be considered for this analysis involves a 25% increase in demand for parts 4, 5, 9, and 13 in the next 5 years, as displayed in *Figure 5*.

Before starting the redesigning process, there are several factors that must be considered: space availability, flexibility to change some departments' locations, machine addition or removal, and any special requests made by the CEO.

Methods

2.1 Current Demand Scenario

For the current scenario, Garrett Pumps, Inc has provided a table with the total number of trips required for each part if the transportation equipment includes forklifts and pallets. In *Table 1*, the number of trips is calculated by dividing the weekly demand for each part by the number of units that can fit in one pallet, in this case 40 units.

Table 1: Current Demand with Number of Trips

Number of units per pallet		40
Part	Weekly Demand	Pallets' Trips
1	200	5
2	100	3
3	400	10
4	300	8
5	800	20
6	1000	25
7	400	10
8	300	8
9	1200	30
10	400	10
11	800	20
12	800	20
13	50	2
14	80	2
15	10	1
16	14	1
17	35	1
18	90	3
19	75	2
20	30	1
21	22	1
22	30	1

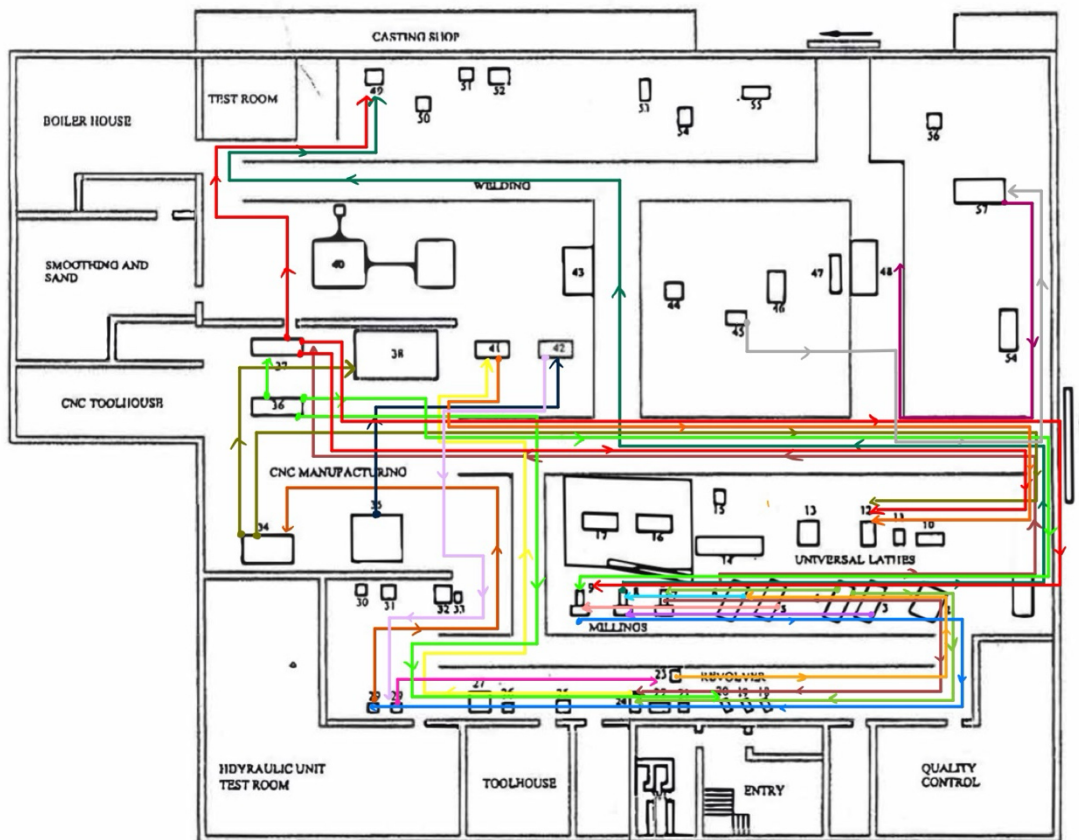
The first step taken to analyze the current facility layout was to create a table, *Table 2*, in order to assign different colors to each machine. This facilitates the process of drawing the facility flow of parts in the blueprint by relating each color to a specific machine.

Table 2: Legend for Facility Flow Design

From Machine	Color	From Machine	Color
3	Purple	34	Olive Green
4	Green	35	Dark Blue
5	Light Pink	36	Neon Green
6	Light Blue	37	Red
7	Brown	38	-
8	Christmas Green	41	Orange
9	Blue	42	Light Purple
12	-	45	Grey
20	-	46	-
23	Light Orange	48	-
24	Yellow	49	-
28	Pink	57	Dark Pink
29	Dark Orange		

More specifically, the facility flow design displayed in *Figure 1* simply demonstrates the current flow of parts. As seen by the numerous colors, several parts follow the same path but start and end in different locations. There are small dots that represent the starting point for a specific machine and arrows that show the direction of the flow until it reaches the ending location.

Figure 1: Facility Flow Design



After laying out the current facility flow in the figure above, the team created a between-trips matrix with the current demand, as depicted in *Figure 2*. This matrix shows that machines 7 and 37 have the greatest number of trips between them yet they are the farthest apart from one another, emphasizing one of the main goals of this analysis: to optimize the layout of the facility by reducing the distance between machines.

Figure 2: Between-Trips Matrix Prior to Increase in Demand

Machine	3	4	5	6	7	8	9	12	20	23	24	28	29	34	35	36	37	38	41	42	45	46	48	49	57	Total From Each Machine
3						3																				3
4					8						10															18
5							10																			10
6						3																				3
7											8						50									58
8																								3		3
9												10														10
12																										0
20																										0
23				3																						3
24																			8							8
28										3																3
29														10												10
34								1										10								11
35																				3						3
36							2		20												3					23
37							1	8									1							30		39
38																										0
41								2																		2
42												3														3
45																								1		1
46																										0
48																										0
49																										0
57																								1		1

In order to determine the current total distance traveled within the facility for the current demand, the team created a table with the number of trips taken between machines, the distance apart between machines in inches and feet, and the total distance traveled in feet, which results from multiplying the columns “Trips” and “Distance in Feet.” The total distance in feet for the current demand is shown below as 66,228 feet.

Table 3: Weekly Flow Distance Prior to Increase in Demand

From Machine	To Machine	Trips	Distance in Inches	Distance in Feet	Total Distance (feet)
3	8	3	1.25	100	300
4	7	8	0.85	68	544
4	24	10	2.6	208	2080
5	9	10	1	80	800
6	8	3	0.6	48	144
7	24	8	3.4	272	2176
7	37	50	6.7	536	26800
8	49	3	9.3	744	2232
9	29	10	4.3	344	3440
23	6	3	2.8	224	672
24	41	8	3.7	296	2368
28	23	3	1.4	112	336
29	34	10	2.9	232	2320
34	12	1	5.5	440	440
34	38	10	1.4	112	1120
35	42	3	1.6	128	384
36	9	2	7.1	568	1136
36	20	20	4.7	376	7520
36	37	1	0.2	16	16
37	9	1	7.3	584	584
37	12	8	5.3	424	3392
37	49	30	2.3	184	5520
41	12	2	4.7	376	752
42	28	3	2.8	224	672
45	57	1	3.3	264	264
57	48	1	2.7	216	216
Total Weekly Distance					66228

2.2 Future Demand with a 25% Increase

For the future scenario specific to our team, the original demand table provided in *Table 1* was adapted. Since the increase in demand for parts 4, 5, 9, and 13 – highlighted below – is 25% in 5 years, the current weekly demand for the corresponding parts was multiplied by 125% to get new demand. Following this calculation came the pallet's trips calculations which involved the division of the new demand by the number of units per pallet (40). The final calculations are displayed in *Table 4*.

Table 4: Future Demand (25% Increase) with Number of Trips

Number of units per pallet		40
Demand Increase (%)		25%
Demand Increase Multiplying Factor (%)		125%

Part	Weekly Demand	Pallets' Trips	Group 3	
			New Demand	New Pallet's Trips
1	200	5	200	5
2	100	3	100	3
3	400	10	400	10
4	300	8	375	10
5	800	20	1000	25
6	1000	25	1000	25
7	400	10	400	10
8	300	8	300	8
9	1200	30	1500	38
10	400	10	400	10
11	800	20	800	20
12	800	20	800	20
13	50	2	63	2
14	80	2	80	2
15	10	1	10	1
16	14	1	14	1
17	35	1	35	1
18	90	3	90	3
19	75	2	75	2
20	30	1	30	1
21	22	1	22	1
22	30	1	30	1

Due to the increase in demand, the between-trips matrix that was previously created has to be adapted to the new scenario. Once the pallet's trips were calculated, they were added to their respective locations in the matrix with an orange color to denote the difference, as can be seen in *Figure 5*.

Figure 3: Between-Trips Matrix of Future Demand (25% Increase)

Machine	3	4	5	6	7	8	9	12	20	23	24	28	29	34	35	36	37	38	41	42	45	46	48	49	57
3						3																			
4					10						10														
5							10																		
6						3																			
7											10						63								
8																								3	
9												10													
12																									
20																									
23					3																				
24																			10						
28										3															
29														10											
34								1										10							
35																				3					
36							2		20								1								
37							1	8																	
38																									38
41								2																	
42												3													
45																									1
46																									
48																									
49																									
57																								1	

The last step taken for this section was to calculate the total weekly distance in the facility for the new scenario with an 25% increase in demand. The table previously shown in the report was duplicated and edited with the new respective values in order to find the total weekly distance. As displayed in *Table 5*, the calculations result in 75,940 feet, which is about 5,000 extra feet in distance compared to the original scenario.

Table 5: Weekly Flow Distance for Future Demand (25% Increase)

From Machine	To Machine	Trips	Distance in Inches	Distance in Feet	Total Distance (feet)
3	8	3	1.25	100	300
4	7	10	0.85	68	680
4	24	10	2.6	208	2080
5	9	10	1	80	800
6	8	3	0.6	48	144
7	24	10	3.4	272	2720
7	37	63	6.7	536	33768
8	49	3	9.3	744	2232
9	29	10	4.3	344	3440
23	6	3	2.8	224	672
24	41	10	3.7	296	2960
28	23	3	1.4	112	336
29	34	10	2.9	232	2320
34	12	1	5.5	440	440
34	38	10	1.4	112	1120
35	42	3	1.6	128	384
36	9	2	7.1	568	1136
36	20	20	4.7	376	7520
36	37	1	0.2	16	16
37	9	1	7.3	584	584
37	12	8	5.3	424	3392
37	49	38	2.3	184	6992
41	12	2	4.7	376	752
42	28	3	2.8	224	672
45	57	1	3.3	264	264
57	48	1	2.7	216	216
Total Weekly Distance					75940

2.3 Creating Cells

Now, the team focused its efforts in creating the possible cells to redesign the layout of the facility. The first step was to reorganize the original part-to-machine matrix, *Figure 5*, by inverting the location of the parts and machines.

Figure 4: Original Part-to-Machine Matrix

Part	Machine																									Score	Rank
1																										1,024.00	17
2																										2,665,456.00	5
3																										4,462,720.00	4
4																										9,453,632.00	2
5																										1,048,832.00	4
6																										2,048.00	10
7																										2,048.00	10
8																										131,328.00	7
9																										1,048,832.00	3
10																										8,484,992.00	2
11																										66,048.00	8
12																										8.00	13
13																										262,656.00	6
14																										1,024.00	11
15																										1,024.00	12
16																										262,912.00	5
17																										21.00	13
18																										17,301,506.00	1
19																										131,136.00	6
20																										133,120.00	5
21																										8.00	14
22																										2,048.00	11
Weight	16777216	8388608	4194304	2097152	1048576	524288	262144	131072	65536	32768	16384	8192	4096	2048	1024	512	256	128	64	32	16	8	4	2	1		

After completing this step, we implemented Rank Order Clustering. The weight of each column was calculated by calculating 2^n from right to left starting at $n = 1$ until all the columns were filled. Now the score for each part could be determined depending on the machines, and their corresponding weights, they traveled to. Once all the values were added up, the team ranked the parts from highest to lowest. In the case of an equal value, the ranking would go from top to bottom for those numbers. There were multiple iterations, that are not entirely displayed in this report, in order to reorganize the rows and columns of this original matrix, which resulted in *Figure 6*, the initial draft for the cells' layout.

Figure 5: Initial Cell Layout

Part	Machine																									Weight
18	1	1	1																							2097152
2	1	1																								1048576
9		1																								524288
1																										262144
14																										131072
15																										65536
5																										32768
4																										16384
8																										8192
16																										4096
10																										2048
19																										1024
20																										512
3																										256
13																										128
11																										64
6																										32
7																										16
22																										8
17																										4
12																										2
21																										1
Score	3,145,728.00	2,621,440.00	2,097,152.00	1,507,328.00	1,048,576.00	1,048,576.00	1,048,576.00	1,048,576.00	573,440.00	569,344.00	18,432.00	18,432.00	17,408.00	9,728.00	4,800.00	4,288.00	824.00	256.00	256.00	256.00	256.00	64.00	4.00	4.00	4.00	3.00
Rank	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	

After creating the red border to identify the three cells, the team noticed that there were some parts that would have to travel to at least two cells. The other option was to duplicate the machines in one cell to the other in order to avoid multiple parts traveling to various cells. However, it was determined that the most optimal solution would be to evaluate which machines within the respective cells could be used to finish a specific part's process instead of spending money on transportation between cells. *Table 6* shows the machines that are currently available at the facility. It is important to note that machines are interchangeable, meaning that parts that use the Lathe machines can use any of the four available, no matter their location.

Table 6: Machines Available

Machine	#
Lathe	3
Lathe	4
Lathe	5
Lathe	6
Mill	7
Mill	8
Mill	9
Plane	12
Rovolver	20
Press	23
Drill	24
Drill	28
Drill	29
CNC	34
Machining Center	35
CNC	36
CNC	37
Machining Center	38
CNC	41
CNC	42
Eccentric Press	45
Eccentric Press	46
Press	48
Saw	49
Guillotine	57

Now that all the machines and cells are identified, the team can make some rearrangements, so the company does not have to spend more money on transportation within cells or on duplicating machines if it is not necessary. *Figure 6* displays the original cell layout with the machines and parts pertaining to each cell and the updated version of it.

Figure 6: Original vs. Updated Cell Layout

Original Cell Layout			Updated Cell Layout		
Cells	Machines	Parts	Cells	Machines	Parts
1	8	18	1	8	18
	49	2		49	2
	3	9		3	9
	35	1		35	1
	6	14		6	14
	23	15		23	15
	28			28	
	42			42	
2	7	9	2	7	5
	37	5		37	4
	4	4		4	8
	24	8		24	16
	41	16		41	10
	12	10		12	19
	9	19		9	20
	36	20		36	13
		3	3	9	3
		13		34	11
3		11		5	6
	34	20		29	7
	5	3		38	22
	29	11		20	17
	38	6		45	12
	20	7		48	21
	45	22		57	
	48	17		46	
	57	12			
	46	21			

As can be seen above, parts 3, 9, 11, and 20 are the only ones who require a machine in a different cell from where they are originally placed. In order to keep each part within one cell, the team decided to interchange some machines so the parts would remain within their cell, *Table 7*. The only part that remains in two cells is part 3 since there was no other efficient alternative. In this case, the team determined that the best course of action would be to duplicate machine 9 in Cell 3 so the process for part 3 could be more easily fulfilled.

Table 7: Machine Replacement for Better Cell Layout

Part	Current Machine Used	Current Cell	New Machine Used	New Cell
9	7	1 & 2	8	1
9	37	1 & 2	42	1
11	36	2 & 3	34	3
20	34	2 & 3	36	2

Additionally, two important pieces of information that were also taken into consideration before finalizing the design for the cell layout is machine utilization and routing. *Figure 7* displays the original utilization provided by the company.

Figure 7: Original Utilization

Machine	#	Parts																						Current Utilization
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
Lathe	3																		80					80%
Lathe	4				20						20													40%
Lathe	5			35																				35%
Lathe	6		60																					60%
Mill	7				40	30					20													90%
Mill	8		40																30					70%
Mill	9			30										15			15							60%
Plane	12								15											55	10			80%
Revolver	20											65												65%
Press	23		90																					90%
Drill	24				45						35													80%
Drill	28		70																					70%
Drill	29			90																				90%
CNC	34			10			20	25				30											10	95%
Machining Center	35	30	20												10	5								65%
CNC	36													20			40				10			100%
CNC	37					25			20								30							75%
Machining Center	38			70																				70%
CNC	41				50															30				80%
CNC	42		40							10														50%
Eccentric Press	45																50							50%
Eccentric Press	46												30									30		60%
Press	48																70							70%
Saw	49									15									50					65%
Guillotine	57																	90						90%

However, since this matrix represents the original demand scenario, it was necessary to include the new increased demand and adapt the matrix to it. Before finalizing our cell layout design, the available utilization for each machine must be considered. For this reason, the team evaluated the parts that were swapping machines to ensure that there was still room for more utilization for those machines while still leaving room for some buffer. The updated demand and utilization are shown below in *Figure 8*.

Figure 8: Updated Utilization (25% Increase)

Machine	#	Parts																						Current Utilization (%)
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
Lathe	3																		80					80
Lathe	4				25						20													45
Lathe	5			35																				35
Lathe	6		60																					60
Mill	7				50	37.5																		88
Mill	8		40							25									30					95
Mill	9			30									18.8			15								64
Plane	12							15												55	10			80
Revolver	20											65												65
Press	23		90																					90
Drill	24				56.3						35													91
Drill	28		70																					70
Drill	29			90																				90
CNC	34			10			20	25				30											10	95
Machining Center	35	30	20											25		10	5							65
CNC	36																40				10			75
CNC	37					31.3			20								30							81
Machining Center	38			70																				70
CNC	41				62.5															30				93
CNC	42		40							13														53
Eccentric Press	45																	50						50
Eccentric Press	46												30									30		60
Press	48																	70						70
Saw	49									15									50					65
Guillotine	57																	90						90

Both the utilization and routing matrices were affected by the rearrangement of machines in order to optimize the cell layout. *Figure 9* displays the original routing matrix while *Figure 10* exhibits the updated routing matrix in order to ensure accurate data collection amongst the entire team and the CEO himself.

Figure 9: Original Routing

Machine	#	Parts																						Current Utilization
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
Lathe	3																		1					80%
Lathe	4				1						1													40%
Lathe	5			1																				35%
Lathe	6		5																					60%
Mill	7				2	1				1														90%
Mill	8		6																2					70%
Mill	9			2										2			3							60%
Plane	12								2											2	2			80%
Revolver	20											2												65%
Press	23		4																					90%
Drill	24				3						2													80%
Drill	28		3																					70%
Drill	29			3																				90%
CNC	34			4			1	1													1		1	75%
Machining Center	35	1	1												1	1								65%
CNC	36											1		1			1							90%
CNC	37					2			1	2							2							85%
Machining Center	38			5																				70%
CNC	41				4															1				80%
CNC	42		2																					40%
Eccentric Press	45																	1						50%
Eccentric Press	46												1									1		60%
Press	48																	3						70%
Saw	49									3										3				65%
Guillotine	57																	2						90%

Figure 10: Updated Routing

Machine	#	Parts																						Current Utilization
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
Lathe	3																		1					80%
Lathe	4				1						1													40%
Lathe	5			1																				35%
Lathe	6		5																					60%
Mill	7				2	1																		90%
Mill	8		6							1									2					70%
Mill	9			2									2				3							60%
Plane	12								2					2						2	2			80%
Revolver	20											2												65%
Press	23		4																					90%
Drill	24				3						2													80%
Drill	28		3																					70%
Drill	29			3																				90%
CNC	34			4			1	1				1											1	75%
Machining Center	35	1	1												1	1								65%
CNC	36												1					1			1			90%
CNC	37					2			1									2						85%
Machining Center	38			5																				70%
CNC	41				4															1				80%
CNC	42		2							2														40%
Eccentric Press	45																	1						50%
Eccentric Press	46											1									1			60%
Press	48																	3						70%
Saw	49									3									3					65%
Guillotine	57																	2						90%

At last, the cell layout has been updated with the new changes and is displayed in *Figure 11*, where there are no overlaps between cells and the duplicate for machine 9 can be seen.

Figure 11: Updated Cell Layout (Sequentially Ordered)

Part	Machine																											
	8	49	3	35	6	23	28	42	7	37	4	24	41	12	9	36	9	34	5	29	38	20	45	48	57	46		
18	2	3	1																									
2	6			1	5	4	3	2																				
9	1	3						2																				
1				1																								
14				1																								
15				1																								
5									1	2																		
4									2																			
8										1		3	4															
16										2					2													
10											1	2				3	1											
19													1		2													
20														2			1											
3															2			2										
13															2													
11																												
6																												
7																												
22																												
17																												
12																												
21																												

The cell layout has been determined by the steps described above, but now the team needs to decide where to strategically place the machines within the department so there are no bottlenecks. In order to do so, the greedy-2-opt technique was implemented as displayed in the following images.

For Cell 1, shown in *Figure 12*, the total distance decreased from 296 to 103 feet by swapping machines 28 and 35 with one another.

Figure 12: Cell 1 Iteration 1

8	3	6	28
49	35	23	42

Swap 28+35

3	8	6	23
49	42	35	28

Machines		Distance	Trips	Total Distance
From	To			
3	8	1	3	3
6	8	2	3	6
8	42	4	38	152
8	49	1	3	3
23	6	1	3	3
28	23	2	3	6
35	42	2	3	6
42	28	1	3	3
42	49	3	38	114
Total Distance				296

Machines		Distance	Trips	Total Distance
From	To			
3	8	1	3	3
6	8	1	3	3
8	42	1	38	38
8	49	2	3	6
23	6	1	3	3
28	23	1	3	3
35	42	1	3	3
42	28	2	3	6
42	49	1	38	38
Total Distance				103

Similarly, for Cell 2, exhibited in Figure 13, the total distance decreased from 113 to 103 feet with only one iteration when machines 4 and 24 were swapped.

Figure 13: Cell 2 Iteration 1

7	4	41	9
37	24	12	36

Swap 4+24

7	24	41	9
37	4	12	36

Machines		Distance	Trips	Total Distance
From	To			
4	7	1	10	10
4	24	1	10	10
7	24	2	10	20
7	37	1	25	25
24	41	2	10	20
36	9	1	2	2
36	12	1	1	1
36	37	3	1	3
37	9	4	1	4
37	12	2	8	16
41	12	1	2	2
Total Distance				113

Machines		Distance	Trips	Total Distance
From	To			
4	7	2	10	20
4	24	1	10	10
7	24	1	10	10
7	37	1	25	25
24	41	1	10	10
36	9	1	2	2
36	12	1	1	1
36	37	3	1	3
37	9	4	1	4
37	12	2	8	16
41	12	1	2	2
Total Distance				103

However, for Cell 3 there was a total of two iterations where the total distance decreased twice, once from 113 to 73 feet and then from 73 to 72 feet. In this case, machines 28 and 34 were swapped first and then came machines 48 and 46 in order to achieve such a small total distance value.

Figure 14: Cell 3 Iteration 1 and 2

Iteration 1				
9	5	38	45	57
34	29	20	48	46

Machines		Distance	Trips	Total Distance
From	To			
5	9	1	10	10
9	29	2	10	20
29	34	1	10	10
34	20	2	20	40
34	38	3	10	30
45	57	1	1	1
57	48	2	1	2
Total Distance				113

Swap 29+34

9	5	38	45	57
29	34	20	48	46

Machines		Distance	Trips	Total Distance
From	To			
5	9	1	10	10
9	29	1	10	10
29	34	1	10	10
34	20	1	20	20
34	38	2	10	20
45	57	1	1	1
57	48	2	1	2
Total Distance				73

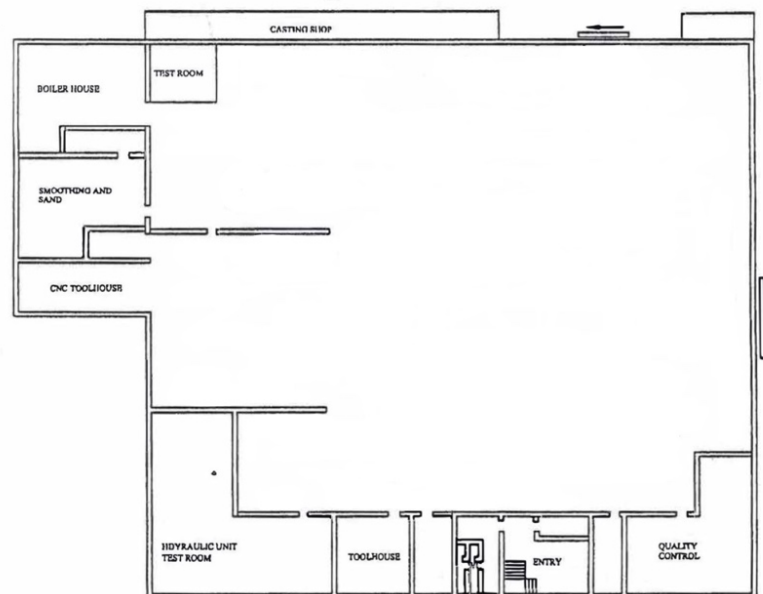
Swap 48+46

9	5	38	45	57
29	34	20	46	48

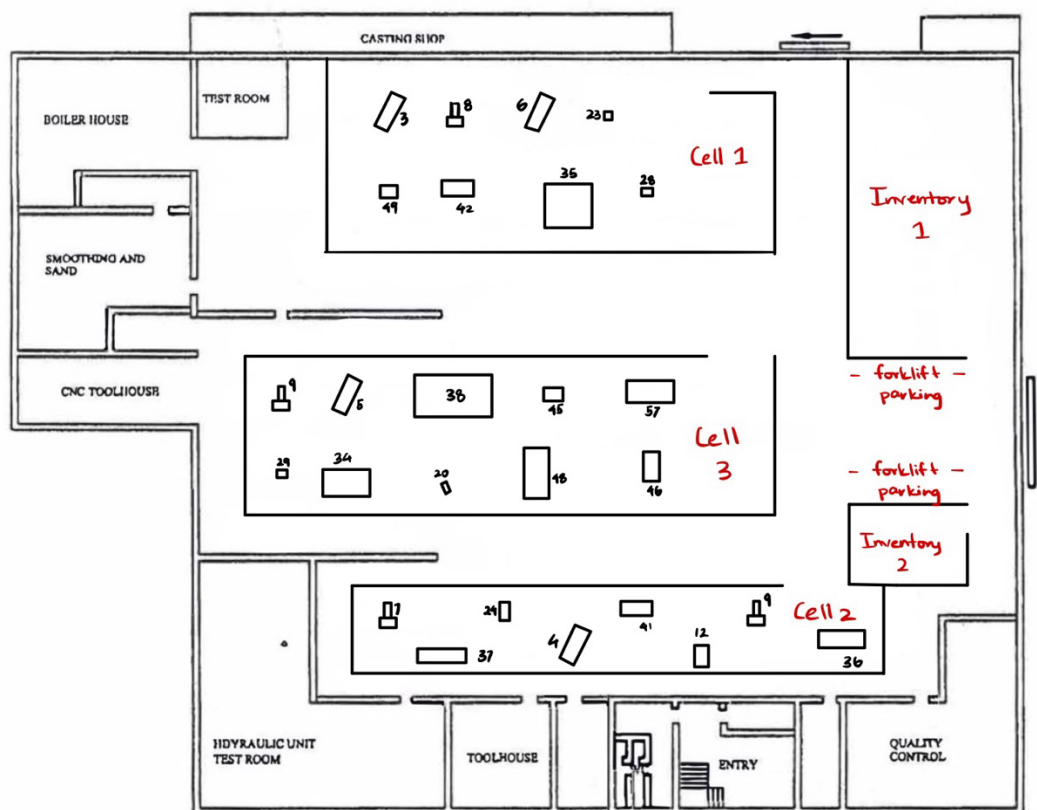
Machines		Distance	Trips	Total Distance
From	To			
5	9	1	10	10
9	29	1	10	10
29	34	1	10	10
34	20	1	20	20
34	38	2	10	20
45	57	1	1	1
57	48	1	1	1
Total Distance				72

2.4 Estimating the space needed for each cell.

To estimate the space needed for each cell, the existing layout was duplicated and the changeable parts – including machines, aisles, and alignments – were removed.



Then the machines from the original layout were traced and placed together in the new layout diagram in terms of the redefined cells. Through this method, the team was able to get a better idea of the most optimal location for each cell and the space that would be required, keeping in mind space considerations for movement and transportation. Two cell spaces for inventory were added to the layout since there was empty space not being utilized. Additionally, the team left enough space for the forklifts to park and unload.



Space Estimates (1 inch = 80 feet):

- Cell 1: 1.0 inch * 2.3 inch = 80 feet * 184 feet
- Cell 2: 0.5 inch * 2.8 inch = 40 feet * 224 feet
- Cell 3: 0.8 inch * 2.8 inch = 64 feet * 224 feet

Recommended Layout

3.1 VIP Plan Opt

As the team updated the cell layout, it was determined that the better solution would be to have no flow between cells in order to decrease the total distance. This leads to having each part start and finish their operation within the same cell, respectively. For this reason, there was no need to utilize VIP Plan Opt to optimize the locations of each cell in the facility, as there is no flow between cells.

But, for the purpose of this report, the original layout was implemented for the VIP Plan Opt to work since it had flow between departments, or in this case cells.

Original Cell Layout		
Cells	Machines	Parts
1	8	18
	49	2
	3	9
	35	1
	6	14
	23	15
	28	
	42	
2	7	9
	37	5
	4	4
	24	8
	41	16
	12	10
	9	19
	36	20
		3
		13
3		11
	34	20
	5	3
	29	11
	38	6
	20	7
	45	22
	48	17
	57	12
	46	21

First, the flow Between Cell 1 and Cell 2 was determined by Part 9 (Trips = 38) being routed to complete its operations, as shown in *Figure 15*.

Figure 15: Cell 1 Flow

From	To	Flow	Unit Cost	Cost of Flow
1	1	0	1	0
1	2	38	1	38
1	3	0	1	0

Moving on, the flow between Cell 2 and Cell 3 was determined by Part 11 (Trips = 20), Part 3 (Trips = 10) and Part 20 (Trips = 1) being routed to complete its operations, as can be seen from *Figure 16* and *17*.

Figure 16: Cell 2 Flow

From	To	Flow	Unit Cost	Cost of Flow
2	1	38	1	38
2	2	0	1	0
2	3	31	1	31

Figure 17: Cell 3 Flow

From	To	Flow	Unit Cost	Cost of Flow
3	1	0	1	0
3	2	31	1	31
3	3	0	1	0

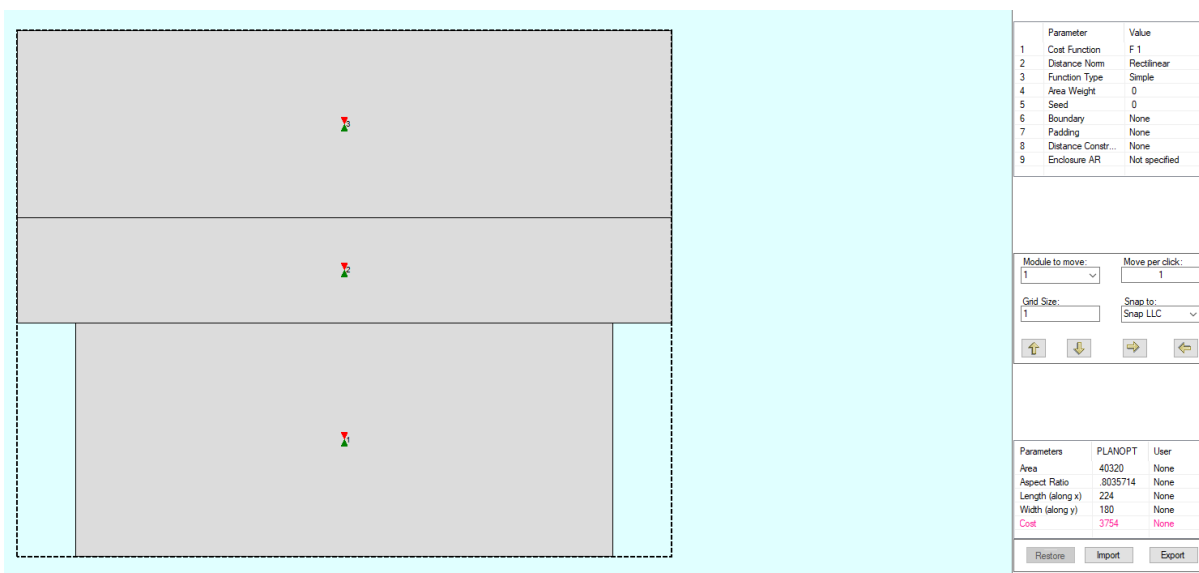
Another significant factor before optimizing the layout in VIP Plan Opt is the cell dimensions for each cell. These were determined by space estimates calculated in Section 2.4.

Figure 18: Cell Dimensions

Module ID	Type	Mobility	Orientation	Area	Length	Width
1	Hard	Movable	Fixed	14720	184	80
2	Hard	Movable	Fixed	8064	224	36
3	Hard	Movable	Fixed	14336	224	64

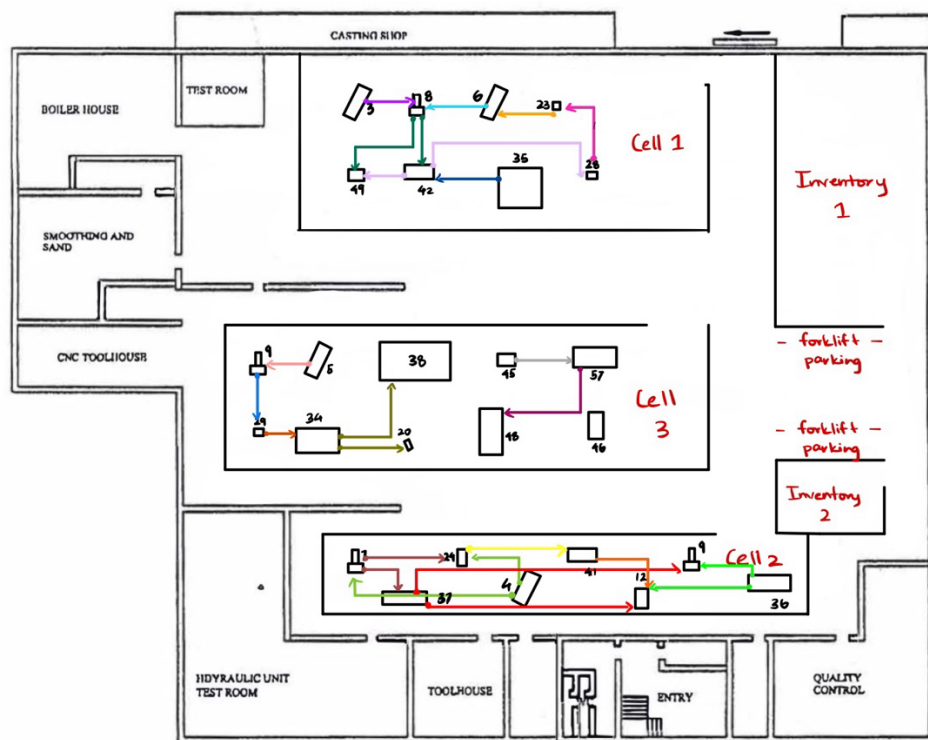
Lastly, the VIP Plan Opt Layout from the original cell layout, where there is flow between departments, is displayed in *Figure 19*. As one can see from the small box at the bottom right of the image below, there is a total cost of \$3,754 resulting from the flow between the cells.

Figure 19: VIP Plan Opt Layout



However, the team found that by not having any flow between cells, there would be no cost associated with movement between cells as each part is being finished within the individual cells. No parts are being routed to a different cell, as depicted by *Figure 20*.

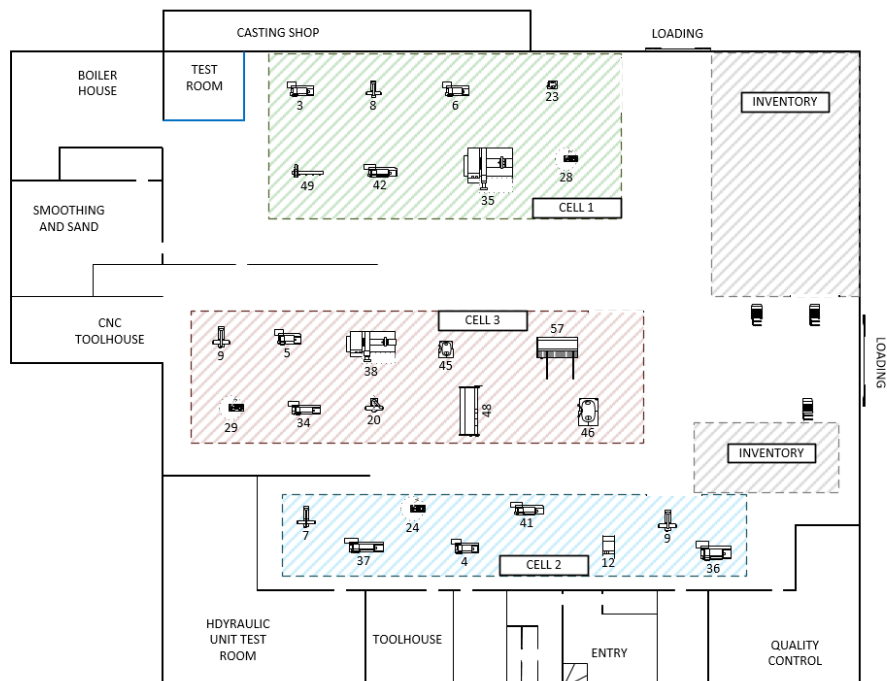
Figure 20: New Cell Layout with no flow between Cells



3.2 Visio Illustration

In order to depict a more accurate rendition of the recommended optimized layout, the team used the Visio diagramming software to plan out the space. Visio provides a wide selection of factory and shop machine outlines, which were used in place of the labeled boxes from the given old factory layout. The drawing scale was set to match that of the original copy, at 0.25 inches = 20 feet. The outline of the facility and that of the fixed departments were constructed by selecting the options in the *Walls, Shell and Structure* shapes section then inputting measurements manually. The equipment outlines were selected from the *Shop Floor - Machines and Equipment* shapes section and the *Shop Floor – Storage and Distribution* section. The space estimates for each cell are illustrated by the shaded areas: green for Cell 1, blue for Cell 2, and red for Cell 3. Inventory space is also shown by the gray shaded spaces. The dimensioning tools allowed for precise sizing of the cells and remaining areas to ensure consistency between the layout and the actual facility. The outcome from all these tools is displayed in *Figure 21*.

Figure 21: Optimized Final Recommended Layout



Conclusion and Recommended Next Steps

In summary, the steps the team recommends to the CEO of Garrett Pumps Inc. in order to improve their facility layout are the following:

1. Reorganize the Cells/Departments

While *Table 8* displays the parts that should be within each cell, *Table 9* exhibits the machines that pertain to each cell.

Table 8: Parts within each Cell

Cell 1	Cell 2	Cell 3
1	4	3
2	5	6
9	8	7
14	10	11
15	13	12
18	16	17
	19	21
	20	22

Table 9: Machines within each Cell

Cell 1	Cell 2	Cell 3
3	4	5
6	7	9
8	9	20
23	12	29
28	24	34
35	36	38
42	37	45
49	41	46
		48
		57

2. Remove Unused Machines

Table 10: Machines that do not have Utilization within the Facility

Unused Machines	
Machine Name	Machine #
Cylindrical Grinder	1
Column Grinder	2
Special Link Rod Machine	10
Plane	11
Radial Drill	13
Lathe	14
Saw	15
CNC	16
CNC	17
Rovolver	18
Rovolver	19
Lathe	21
Drill	22
Special Mill	25
Special Drill 1	26
Special Drill 2	27
Drill	30
Drill	31
Special Drill 3	32
Special Drill 4	33
Special Machine	39
Punch Press	40
Hydraulic Press	43
Eccentric Press 1	44
Bending Machine 1	47
Pipe Bending Machine	50
Welding Machine (Oksiasetilen)	51
Welding Machine (MAG)	52
Drill	53
Welding Machine (MAG)	54
Welding Machine (ARK)	55
Saw	56
Saw	58

3. Interchange Machines regarding the parts that use them

a. Part 9

- i. From Machine 7 to 8
- ii. From Machine 37 to 42

- b. Part 11
 - i. From Machine 36 to 34
- c. Part 20
 - i. From Machine 34 to 36
- 4. Duplicate the necessary Machines
 - a. Part 3
 - i. Duplicate Machine 9 into Cell 3 (*it will go through Cell 2 and Cell 3 to complete the process*)

If this course of action is implemented within the company, the total distance traveled between machines in the facility will decrease by 90%, from 75,940 to 7,672 feet, as depicted in *Figure 20*.

Figure 22: Old vs. New Layout Weekly Flow

Weekly Flow Distance with a 25% in Demand						Weekly Flow Distance with New Layout					
From Machine	To Machine	Trips	Distance in Inches	Distance in Feet	Total Distance (feet)	From Machine	To Machine	Trips	Distance in Inches	Distance in Feet	Total Distance (feet)
3	8	3	1.25	100	300	3	8	3	0.3	24	72
4	7	10	0.85	68	680	4	7	10	1	80	800
4	24	10	2.6	208	2080	4	24	10	0.4	32	320
5	9	10	1	80	800	5	9	10	0.2	16	160
6	8	3	0.6	48	144	6	8	3	0.3	24	72
7	24	10	3.4	272	2720	7	24	10	0.4	32	320
7	37	63	6.7	536	33768	7	37	25	0.3	24	600
8	49	3	9.3	744	2232	8	42	38	0.4	32	1216
9	29	10	4.3	344	3440	8	49	3	0.6	48	144
23	6	3	2.8	224	672	9	29	10	0.2	16	160
24	41	10	3.7	296	2960	23	6	3	0.3	24	72
28	23	3	1.4	112	336	24	41	10	0.5	40	400
29	34	10	2.9	232	2320	28	23	3	0.4	32	96
34	12	1	5.5	440	440	29	34	10	0.2	16	160
34	38	10	1.4	112	1120	34	20	20	0.3	24	480
35	42	3	1.6	128	384	34	38	10	0.6	48	480
36	9	2	7.1	568	1136	35	42	3	0.3	24	72
36	20	20	4.7	376	7520	36	9	2	0.4	32	64
36	37	1	0.2	16	16	36	12	1	0.6	48	48
37	9	1	7.3	584	584	36	37	1	0.2	16	16
37	12	8	5.3	424	3392	37	9	1	1.6	128	128
37	49	38	2.3	184	6992	37	12	8	1.2	96	768
41	12	2	4.7	376	752	41	12	2	0.5	40	80
42	28	3	2.8	224	672	42	28	3	1.1	88	264
45	57	1	3.3	264	264	42	49	38	0.2	16	608
57	48	1	2.7	216	216	45	57	1	0.3	24	24
Total Weekly Distance					75940	Total Weekly Distance					7672

Figure 23: Old vs. New Layout Facility Flow Diagram

