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MSE 603

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Developing Models and What if Scenarios with Tecnomatix

Abstracts

This report presents a comprehensive simulation project using Tecnomatix Plant Simulation, conducted over a 14-week period as part of the MSE 603 course. The project aimed to replicate a manual labor-intensive assembly line with sub-assemblies, resonating with the universal experience of manual labor to engage and connect with readers. The simulation model serves as a pedagogical tool, demonstrating how to interpret data from Tecnomatix and appreciate the nuanced capabilities of discrete event simulation in manufacturing. The findings underscore the potential for process optimization through simulation, particularly in line balancing and waste reduction, drawing on principles of Lean Manufacturing. The hope is that readers will emerge with a nuanced understanding of simulation as a predictive tool for manufacturing excellence.

Background

The years of being in the Manufacturing Industry, this project will be put together based on experiences of a what could be situation. What you see here is all made up; however, the process is relevant to any situation. Of course, in some situations, there are decisions that need to be made such as a deciding factor of understanding Efforts X Impacts. As always, the best choice would be making decisions based on the least effort for the biggest impact. This is where having a grasp in Lean Manufacturing comes into play, understanding and identifying what the waste is, and eliminating it from the process. In this project, there will be a scenario of what could be if process variation can be reduced.

Scope

With Technomatix, the plan is to create a model that can replicate an assembly line process. This model entails Subassemblies to make subcomponents, putting the sub-components in WIP, replenishing for the main assembly line to create a finished product. This project isn't intended to figure out a new layout, rather, to determine where in the process could there be a potential improvement. See figure 1, the objective is to replicate this model in Technomatix and simulate the assembly line.

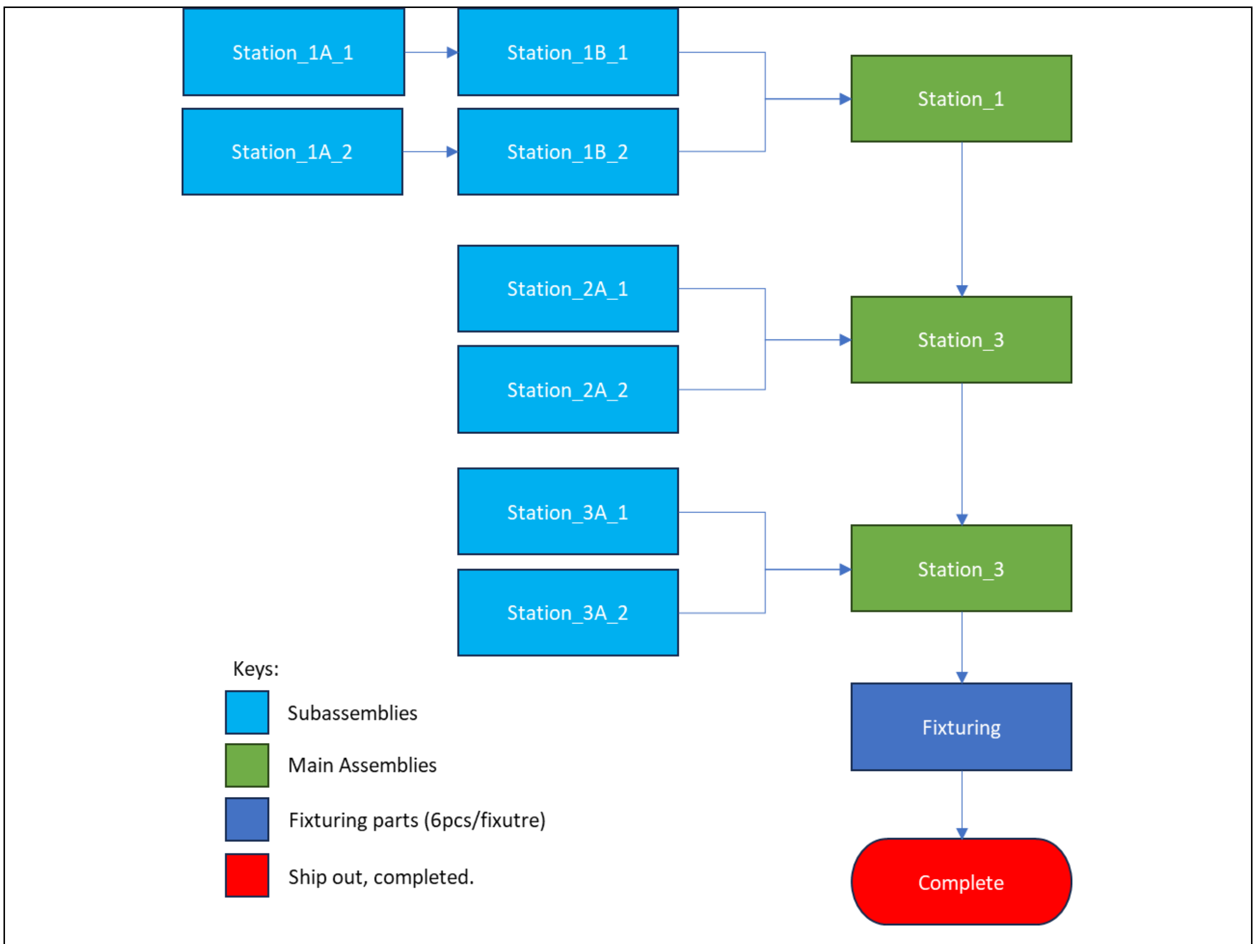

Figure 1: Simple Schematic of Assembly flow.

Developing Model

For simplistic understanding review the process flow created, see figure 2. This was put together to develop a model within Technomatix. By having a sketch/mock-up, tends to help on creating an official model. Now let's look at the actual model flow. The idea is to mimic real-world scenarios. In this model, we have resources picking-up and transporting materials to the next station. Additionally, each "MU objects" have been modified to have a visual on parts, as you can see each station, there are different looking parts. It was intended to be different so there is a better visual of watching the parts moving from one station to the next station.

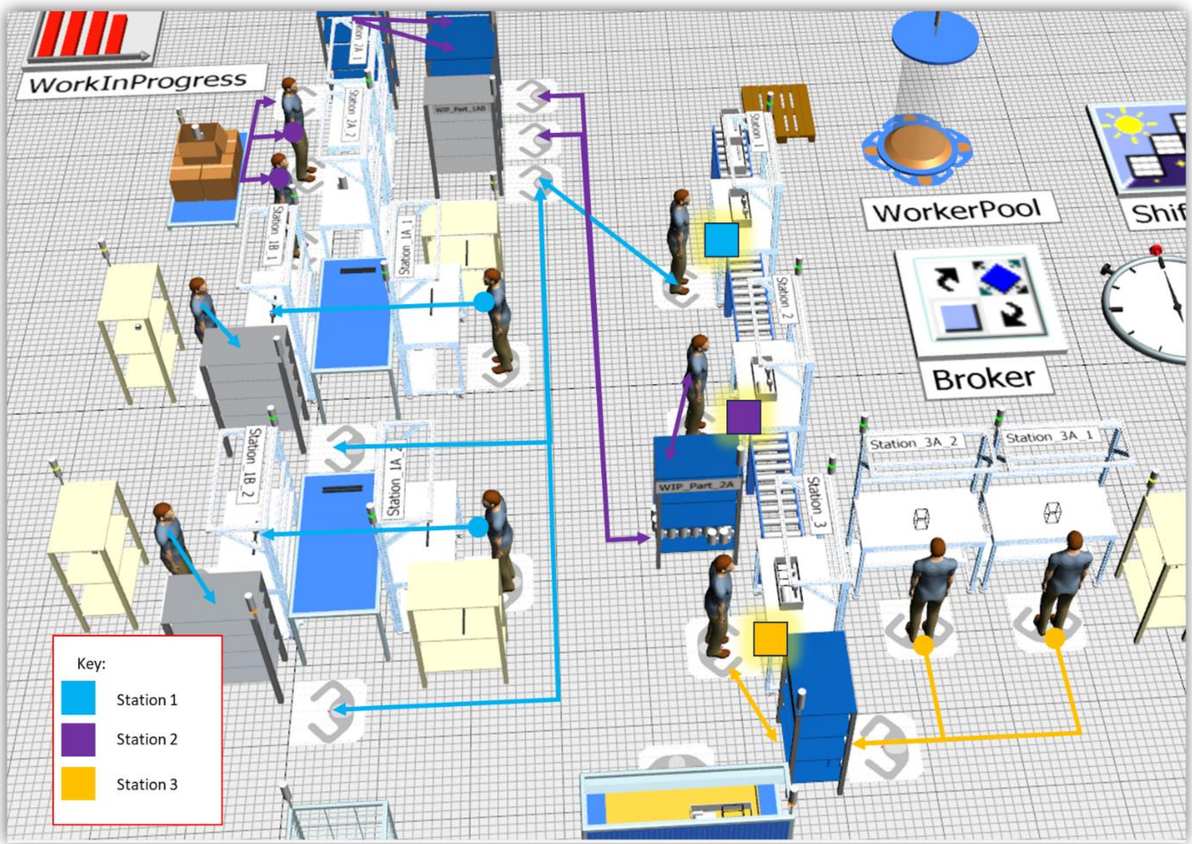

Figure 2: Completed 3D model in Technomatix

An attempt to make the model realistic, the process time established for each station has been determined based on made up numbers for the sake of getting something simulated and creating a baseline. See Figure 4, of the process time established for each station. The method Triangle is interesting, it takes the inputs of parameters (average, minimum, max). The power of using this is for someone who doesn't have time to collect data yet can use known variables. Interestingly, you can use normal distribution which would be an ideal method to go by, this way the population can properly be captured. For this project, Method Triangle has been used. The idea is to capture the variation which is the reality. There will always be variation.

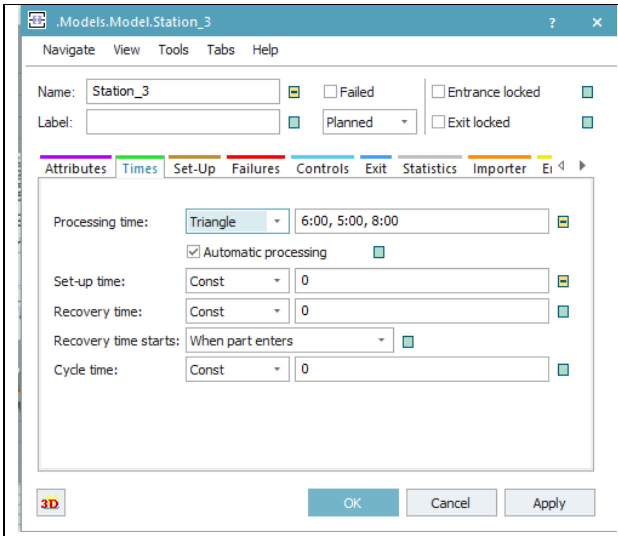

Figure 3: Double clicking on station and manipulating time via 'Time' tab. This is where to change the process time.

	Process Time:	Avg:	Min:	Max:
Station 1A_1	Triangle	14.75	14.5	15
Station 1A_2	Triangle	14.75	14.5	15
Station 1B_1	Triangle	16	12	24
Station 1B_2	Triangle	16	12	24
Station 1	Triangle	7	6	9
Station 2A_1	Triangle	11.41	11	12
Station 2A_2	Triangle	11.41	11	12
Station 2	Triangle	7	6	9
Station 3A_1	Triangle	17.5	16.75	18
Station 3A_2	Triangle	17.5	16.75	18
Station 3	Triangle	6	5	8

Figure 4: Process time set for each station.

Multi Scenario Attempted

Changed that were attempted:

- Take 1 person away from one of the 2 Subassembly stations that (2A_2) were building parts (2A) for Station 2 (Main assembly). The rationale behind this was due to the parts being overproduced.
    - Making 1 resource worker available for multiple services to alleviate other workers at different stations from fetching materials needed.
        - No change to throughput
    - Creating another Station, to help build parts (1AB) for Station 1. It appeared that Parts in WIP were empty. So, by supporting it, Station 1 shouldn't have to wait.
        - No change to throughput

After several more attempts of trouble shooting, it made sense. The true bottleneck was at station 3. It was evident that Station 3 was waiting the longest, it was waiting on subassemblies from stations that were building 3A.

Mistakes

Mistakes were learned. While reviewing the Statistic report, it was apparent that the 2 workstations weren't included and were important. After multiple scenarios, the throughputs weren't impacted. The 2 neglected workstations were treated as a source, when it should've been treated like a workstation. There are long build times attached to them which caused one of the stations to wait. This was the true bottleneck. Lesson learned, to include all the workstations regardless. The idea is to see the whole system. It was a small thing that was overlooked that caused unnecessary scenario changes that weren't making an impact. Now that those 2 stations have been considered, the throughput has increased. The following will begin discussing the New Baseline and Scenario A

Baseline Model

Per figure 7, Parts AB for station1, and Part A for station3 have been empty almost 100% of time. This indicates that parts aren't being picked up to be placed in WIP. The most logical approach to this would be that if there are no parts 1AB, then stations responsible for building parts 1A & 1B would further need to be investigated. When looking at the Statistics for Workstations, Figure 6, it is evident that station 1A is always working, and 1B is waiting sometimes. Perhaps, Stations 1 is starving and waiting for parts 1AB, which is what happening, Station 1 is evidently faster than Station 1A & 1B.

Object	Name	Mean Life Time	Throughput	TPH	Production	Transport	Storage	Value added	Portion
Drain	Fixture	1:47:39.0982	8	1	100.00%	0.00%	0.00%	0.94%	

Figure 5: For 8 hours shift, this resulted throughput of 8 cases, 48 pcs (6pcs/case)

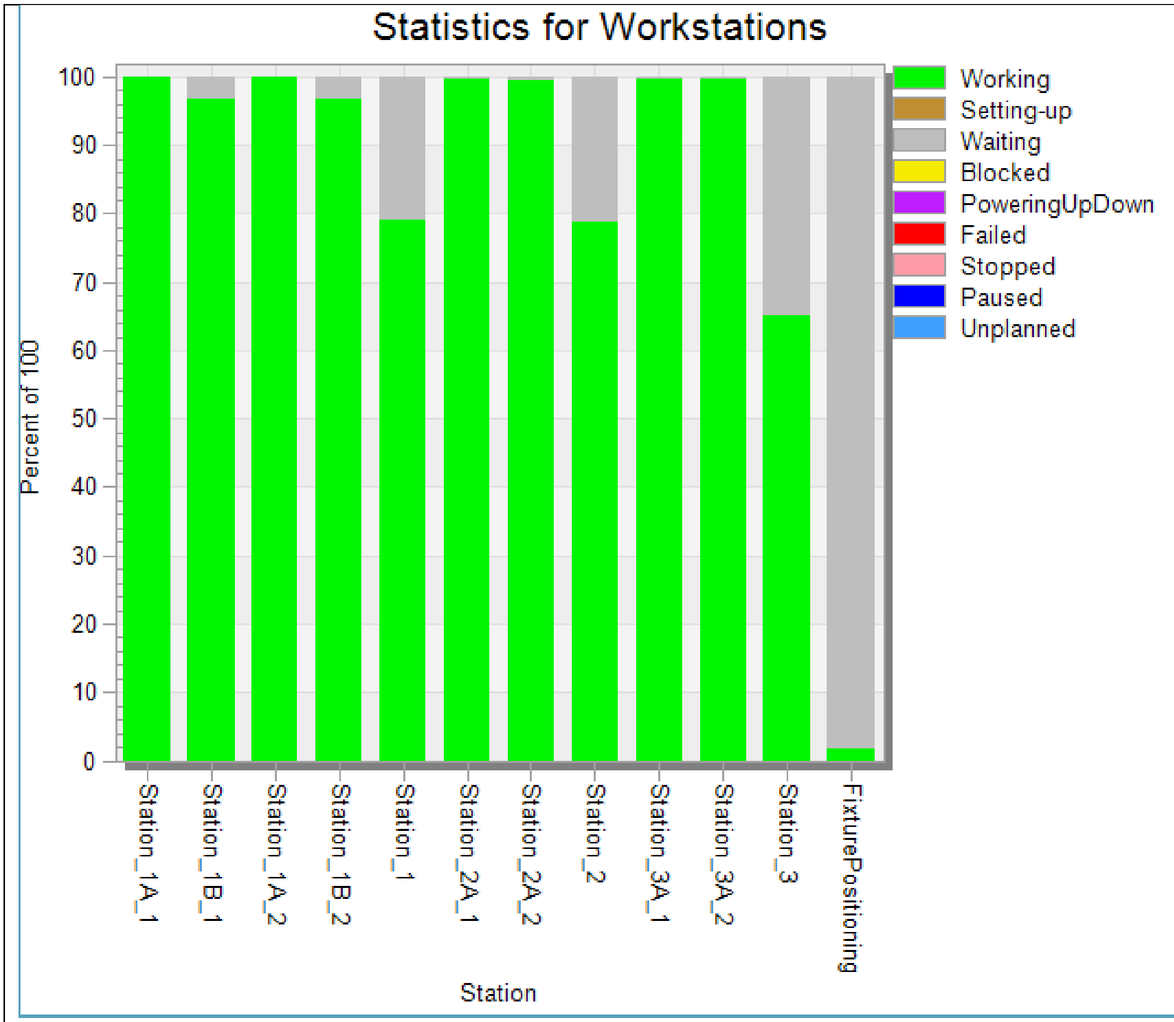

Figure 6: Visual indicator of what is happening at each station. To understand the intention of the naming convention:

- _1 is the main Assembly Station
- _1A is essentially Subassembly Station making Part A for Station 1
- _1A_1 which is the primary Subassembly Station making Part A for Station 1.

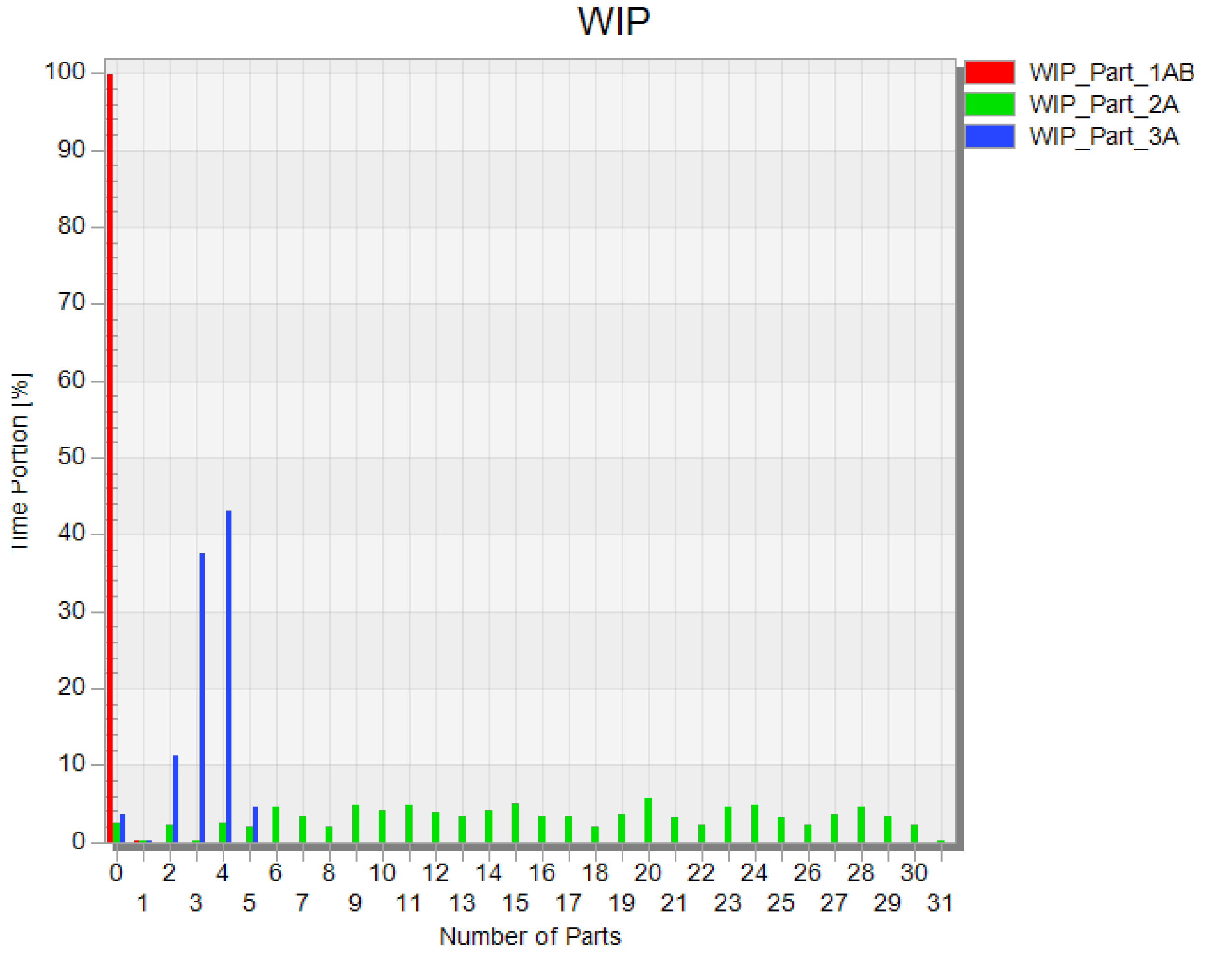

Figure 7: Visual indicator of how long Number of Parts been in the WIP. The naming nomenclature:

- Part_1AB, Parts A & B for Station 1

Scenario A

In this scenario, let's discuss the hypothetical improvements that were made. In line balancing, the product is only as fast as the slowest station in the line. This was where time changes were made, see figure 8 for the time changed. Here are the reasonable assumptions made:

1.) Identified parts that had bad designs. This can be communicated with Design Engineer to ensure proper Design for Assembly to be re-evaluated. Therefore, in theory, a process can be improved. Perhaps, Manufacturing Engineer may need to do it to kick-off the change and devise a plan to ensure it is sustainable.

2.) Re-evaluate Cellular Layout, are the tooling and materials close to the Operators? Perhaps proper tooling or improved tooling can enhance the process. By giving proper tooling and defining processes, this can reduce process variation, improve repeatability.

3.) Re-evaluate Methods of assembly, can the sequence of assembly be changed around, can the subcomponents be outsourced? If so, this can drastically improve the time to assemble parts.

	Avg:	Min:	Max:
Station 1A_1	14	12	15
Station 1A_2	14	12	15
Station 1B_1	14	12	18
Station 1B_2	14	12	18
Station 1	7	6	9
Station 2A_1	11.41	11	12
Station 2A_2	11.41	11	12
Station 2	7	6	9
Station 3A_1	14	12	18
Station 3A_2	14	12	18
Station 3	6	5	8

Figure 8: Time changed due to hypothetical improvements. See orange highlighted sections to get an idea what has been changed.

The changes made are in theory, more balanced. Let's look at the Avg time to build station 1, which is 7 minutes. Compared to Station 1A, note there are 2 stations, the average time to build is 14 minutes. We know that there are 2 stations in parallel, so technically it is 7 minutes per part. This is now in balance with station 1. Same thing with Station 3A.

Object	Name	Mean Life Time	Throughput	TPH	Production	Transport	Storage	Value added	Portion
Drain	Fixture	1:36:07.9969	9	1	100.00%	0.00%	0.00%	1.02%	

Figure 9: For 8 hours shift, this resulted throughput of 9 cases, 54 pcs (6pcs/case)

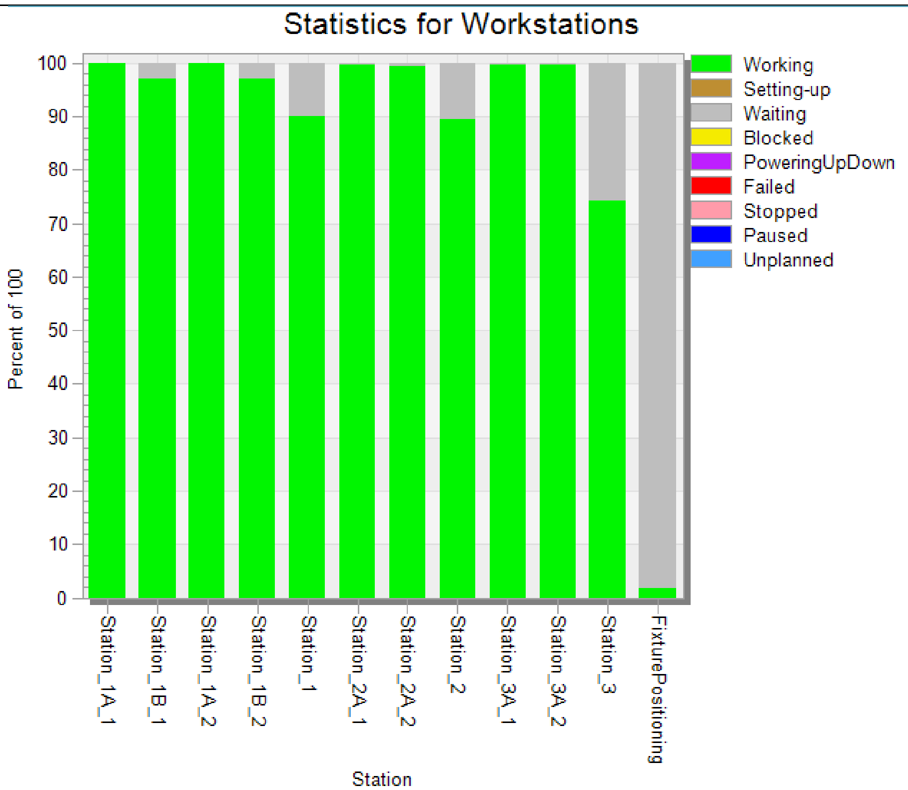

Figure 10: Visual indicator of what is happening at each station in Scenario A

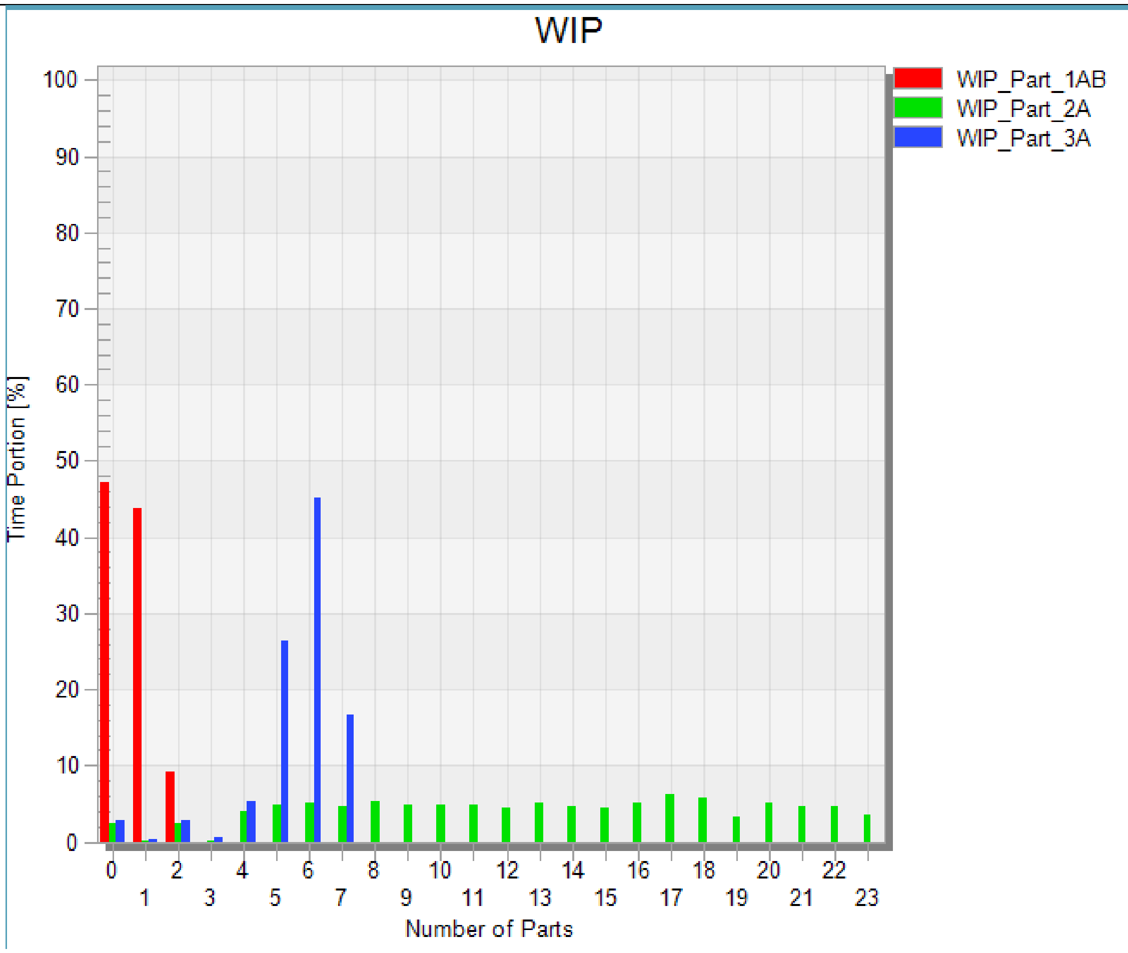

Figure 11: For Scenario A, this shows that Part 1AB is no longer empty in WIP. In fact, 45% of time, there is at least 1 in WIP.

Analyze

After reviewing Scenario A, there is a significant improvement made. As a result, it increased the throughput of 8 cases to 9 cases, this yielded to about 13% improvements made regarding throughputs.

	Original (Minutes)				Scenario A (Minutes)			Improvements (Reduction):		
	Process Time:	Avg:	Min:	Max:	Avg:	Min:	Max:	Avg:	Min:	Max:
Station 1A_1	Triangle	14.75	14.5	15	14	12	15	-5.1%	-17.2%	0.0%
Station 1A_2	Triangle	14.75	14.5	15	14	12	15	-5.1%	-17.2%	0.0%
Station 1B_1	Triangle	16	12	24	14	12	18	-12.5%	0.0%	-25.0%
Station 1B_2	Triangle	16	12	24	14	12	18	-12.5%	0.0%	-25.0%
Station 1	Triangle	7	6	9	7	6	9	0.0%	0.0%	0.0%
Station 2A_1	Triangle	11.41	11	12	11.41	11	12	0.0%	0.0%	0.0%
Station 2A_2	Triangle	11.41	11	12	11.41	11	12	0.0%	0.0%	0.0%
Station 2	Triangle	7	6	9	7	6	9	0.0%	0.0%	0.0%
Station 3A_1	Triangle	17.5	16.75	18	14	12	18	-20.0%	-28.4%	0.0%
Station 3A_2	Triangle	17.5	16.75	18	14	12	18	-20.0%	-28.4%	0.0%
Station 3	Triangle	6	5	8	6	5	8	0.0%	0.0%	0.0%

Figure 12: Visual Matrix put together with Excel. This is to summarize the changes made on all the stations and comparing Scenario A to Baseline.

	Throughput (Cases)	Throughput (PCS)	Improvement
Original	8	48	Baseline
Scenario A	9	54	13%

Figure 13: Visual Matrix via Excel, this is a simple chart to display the obvious improvement with Scenario A

Scenario A have noticeably improved about 10 percent, see figure 6 & 10. It is displaying that Station 1 & 2 improved from ~80% to ~90% utilization. And Station 3 improved from ~65% to ~75% utilization. So, this improvement has been verified by seeing the increase in throughput, see figure 13. This goes to show that for line balancing to be effective, the priority should be focused on the longest Process time.

Looking at Figure 11, there is a way to further improve the process, perhaps utilizing resources effectively. It suggests that Subassemblies for 2A and 3A are being overproduced. There is a potential to eliminate 1 resource worker by making 1 build both subassemblies 2A and 3A. This is something that can be investigated for future improvements.

Conclusion

The project successfully leveraged Tecnomatix Plant Simulation to model an assembly line, enabling the identification and analysis of bottlenecks and inefficiencies. By simulating various scenarios, key insights were gained into the assembly process, highlighting the importance of line balancing and resource allocation. The implemented changes, based on hypothetical improvements, resulted in a significant increase in throughput, validating the model's utility in process optimization. Future directions include exploring the consolidation of subassembly resources to optimize labor utilization further and revisiting layout designs for enhanced operational efficiency.