2.008 Design and Manufacturing II
Spring 2025

Lean Manufacturing

April 9, 2025

Your Name and Lean Manufacturing Role:

_____

Team Number:

_____

Learning objectives
- Understand the interaction between quality, cost, systems, and supply chains
- Experience how practical improvements impact key system metrics

Do not do any optimization or practice before Game 1 begins.

Role: You will choose between the 4 painting roles (Yellow, Gray, Blue, Red) and 1 Quality & Rework role.

Length: 6 minutes. The goal is to make as many products as accurately as possible in that period of time.

Gameplay: On the left you will see your incoming work-in-progress for the cars and trucks. You will move this onto your work desk. On the right, you will see the units you have finished that are waiting to process. You'll need to process a full batch (4 units) to be able to move it to the next station.

Object of the game: The customers want faster deliveries, reduced costs and more quality. While those are your goals, the purpose for the challenge is to correctly analyze your data afterwards and that is what your grade will be based on, not your performance or choices in the game.

Settings:
Unit Sales Price: +$100
Late Penalty: -$30
Quality Penalty: -$50
Labor cost: -$50
WIP inventory cost: -$60
Rework operation cost: -$5

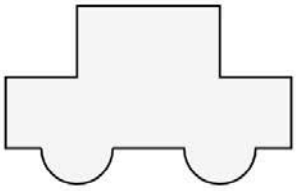
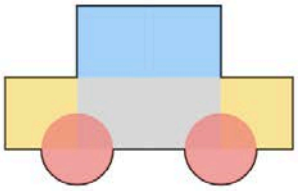
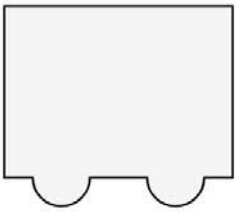
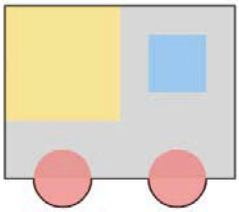
Statistics: Other than very simple math to assist your decision making, you need not do any calculations during or after the game. All of the statistics will be calculated automatically at the end for you to do analysis on.

1. Enter in the software game by following the link posted in the slides.

As you are playing **Round 1**, think about what caused your errors and limited your speed. This will help you decide what improvements to make later in the other game plays. You don't need to track any numbers since once **Round 1** has finished, you will be sent to the debrief summary page where it will assemble all of the data for you.

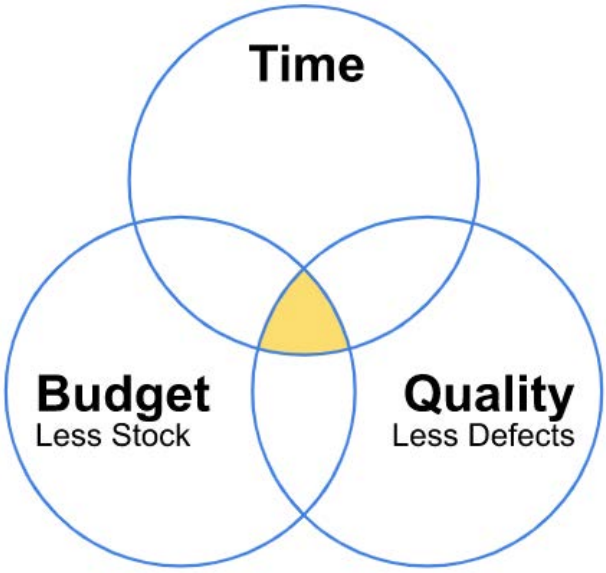
Products

Your workshop is painting and selling 2 types of products:

Product name:	Starting raw material:	After the full process:
City Car		
Truck		

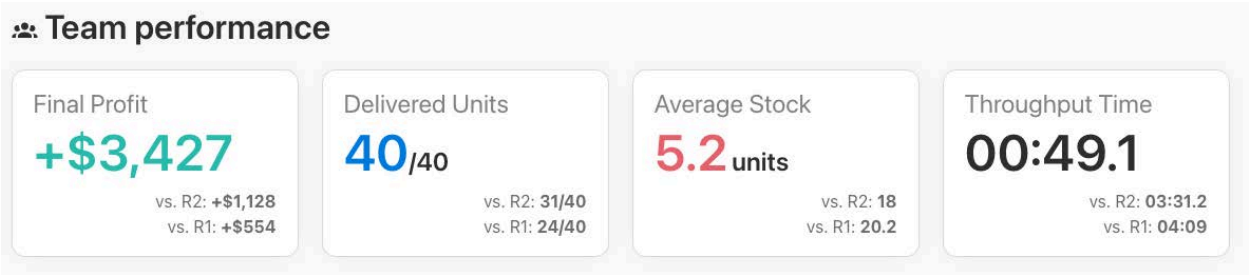
2. Look through the **"Team performance"** and **"Individual performance"** sections in the debrief area and use it to discuss the image below. Have each person describe their task and then as a team comment on if the units processed,

average processing time, average stock, and % of correct operations make sense based on the complexity and amount of work required. Which operation was the bottleneck?



The quality and rework stage required the least amount of processing time because many times you could immediately accept it. This also contributed to the lowest average stock. Whereas the yellow and gray paint stations had the most operations and also therefore had the most stock.

Related to the final team performance the first two processes contributed to over 50% of the average stock. The delivered units are also the minimum number of correct units that reached the end.

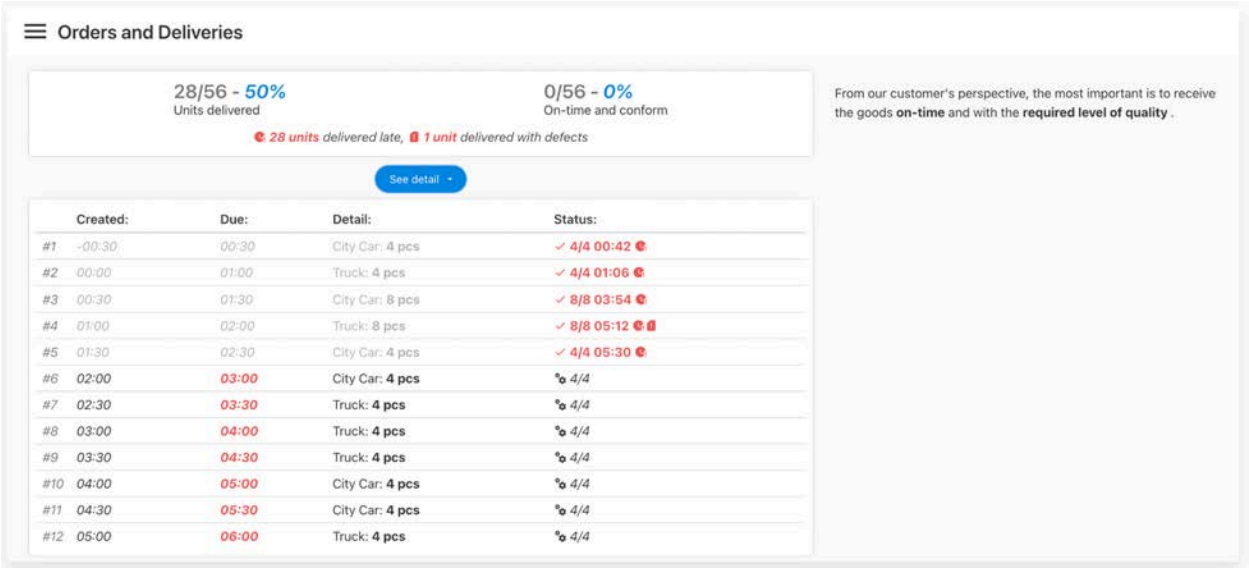


You should use the keyboard shortcuts for the space bar rather than clicking the mouse. You could also keep your mouse hovering over the next button. You could orient your laptop so that both of your hands don't get tired during gameplay.

The gray station had the slowest average processing time so it's no surprise that the station before it processed the most units since it slows everything down after it.

3. Expand the **"Orders and Deliveries"** dropdown to see the schedule of orders and their status. Do you think this schedule is even **feasible** as-is?

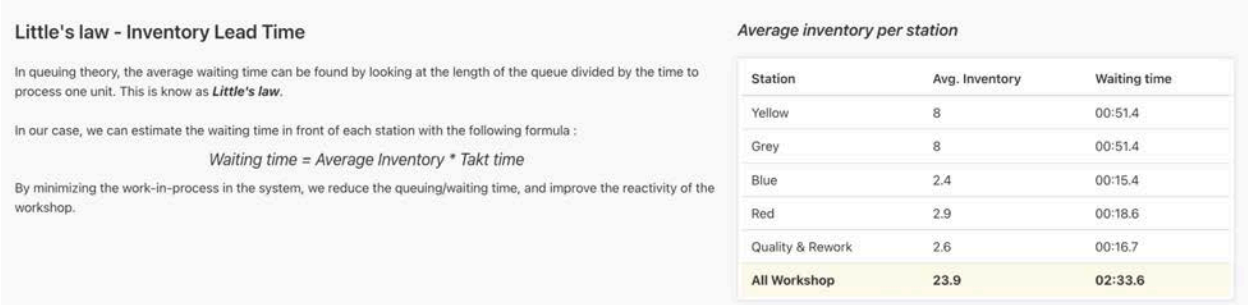
This does not seem feasible since the game ends at 6 minutes and basically every batch needs to be finished within 60 seconds otherwise it is late to the customer.



4. Look at the **“Work in Progress Evolution”** tab. Adjust the time precision as needed in order to evaluate which station contributed most to the stock piling up, and when that seemed to occur. Explain what the **waiting time is and why it is problematic.**

Generally, our average stock rose over time both in the system and within most stations. However, the yellow and gray paint stations seemed to contribute the most in the middle of the operation, which is not surprising since they are the bottleneck.

Waiting time is bad because it means that there are unfinished parts in the system waiting to be worked on. If demand changes or designs need fixed, this is a sunk cost.



Little's law - Inventory Lead Time

In queuing theory, the average waiting time can be found by looking at the length of the queue divided by the time to process one unit. This is know as ***Little's law***.

In our case, we can estimate the waiting time in front of each station with the following formula :

*Waiting time = Average Inventory * Takt time*

By minimizing the work-in-process in the system, we reduce the queuing/waiting time, and improve the reactivity of the workshop.

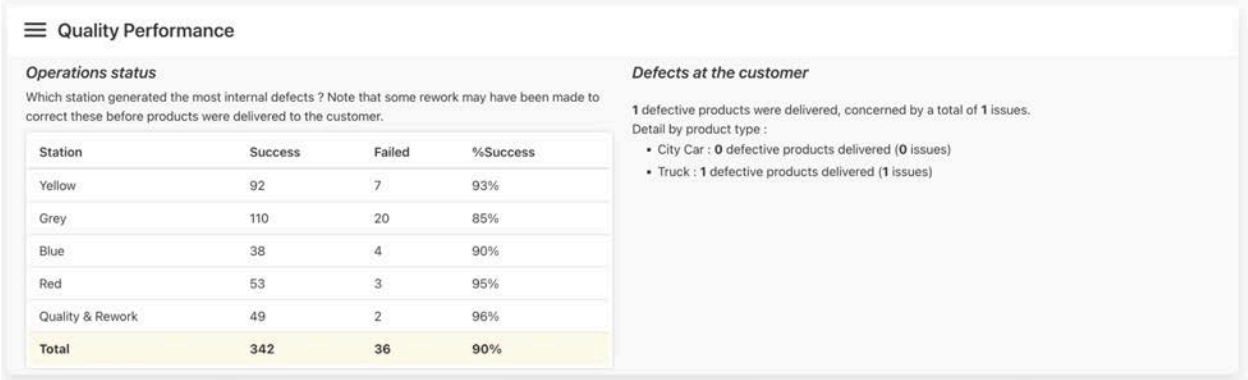
Average inventory per station

Station	Avg. Inventory	Waiting time
Yellow	8	00:51.4
Grey	8	00:51.4
Blue	2.4	00:15.4
Red	2.9	00:18.6
Quality & Rework	2.6	00:16.7
All Workshop	**23.9**	**02:33.6**

Note that we learned a slightly different version of Little's Law which was L = lambda*w. Rearranging gives the equation for waiting time, w = L/lambda. The difference here is that the Takt time is equal to the inverse of the production rate (lambda) when the production rate is what is required to meet demand.

5. Look at the **"Quality Performance"** tab. The "% Success" column represents that station's **yield**, or the proportion of parts correctly produced. How critical was the "Quality & Rework" station to your team? What does the yield of the "Quality & Rework" station represent?

If we didn't have a Quality & Rework station, then our total yield would likely be the product of each of the success rates which would generally be very bad. Having this station allows us to recapture most of the yield that was lost across the earlier steps. However, in order to have this station there needs to be an automated system that marks the check and X on each of the cars and paint spots, otherwise it's likely that station would be a lot slower and less helpful.



Quality Performance

Operations status

Which station generated the most internal defects ? Note that some rework may have been made to correct these before products were delivered to the customer.

Station	Success	Failed	%Success
Yellow	92	7	93%
Grey	110	20	85%
Blue	38	4	90%
Red	53	3	95%
Quality & Rework	49	2	96%
Total	**342**	**36**	**90%**

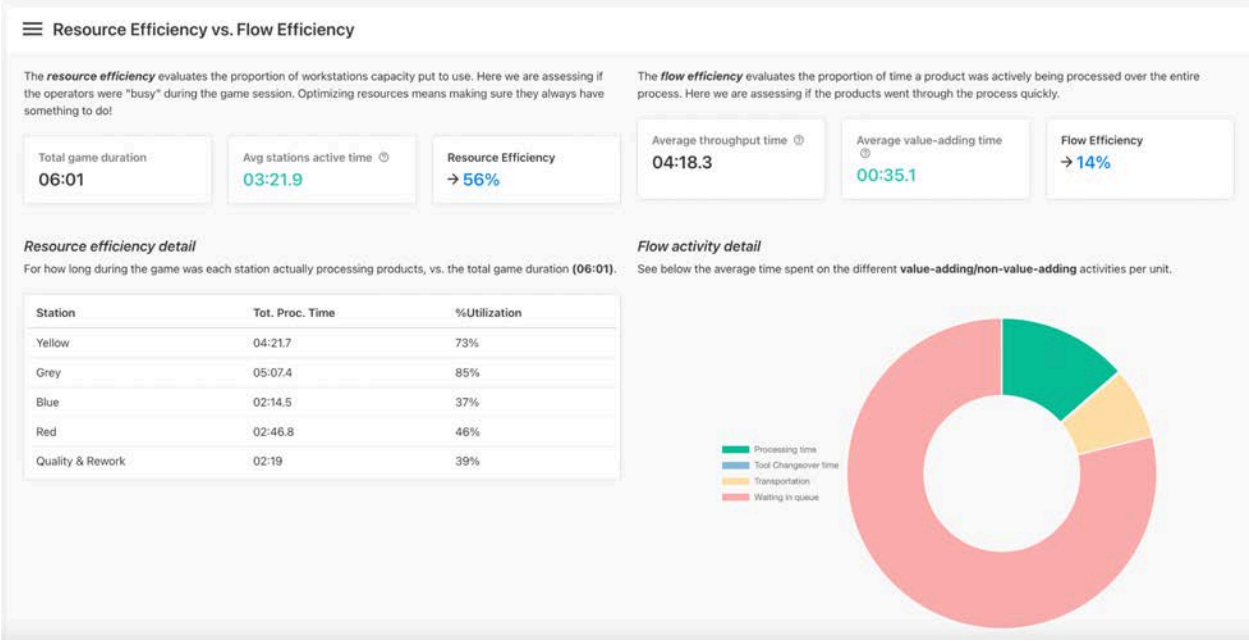
Defects at the customer

1 defective products were delivered, concerned by a total of **1** issues.
Detail by product type :

- City Car : **0** defective products delivered (**0** issues)
- Truck : **1** defective products delivered (**1** issues)

6. Inspect the **“Value Adding/Non Value Adding Activities”** and **“Capacity Utilization”** sections. What does it tell you about the layout of the manufacturing system as designed?

We did not have good efficiency which was probably why we didn’t meet our demand, were constantly behind schedule, and didn’t make any profit. The stations were only active a little over half of the time (59%) and the part spent way more time waiting than being worked on (14%).



7. Now you will play Rounds 2 and 3. There will be a series of improvements added during each round, and we’ll discuss these improvements together. Take notes for each Round on what you think is making the largest difference in terms of improving the performance of your team.

Does the layout of the workstations impact rate much? Two seconds in between stations could add up but doesn't seem like a contributing factor due to the waiting time dominating.

Does the tool-changeover time impact rate much? This only accounted for 1-2 seconds whenever a tool needs changed so it should not be chosen.

The kanban system also doesn't seem like it would influence much here since this is a relatively short and tedious operation, so it doesn't require much visualization.

Most likely teams will be choosing between reducing batch size, auto-inspect work, balance workload, level production plan, and adding click-guides for the next three games.

Through the first runs, it seems like the click-guides (poka-yoke / error-proofing) had the most amount of success creating profit because it allows for stations (especially the bottleneck) to fly through the painting and also reduces the amount and cost of the rework later on.

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