Littlefield Technologies Assignment

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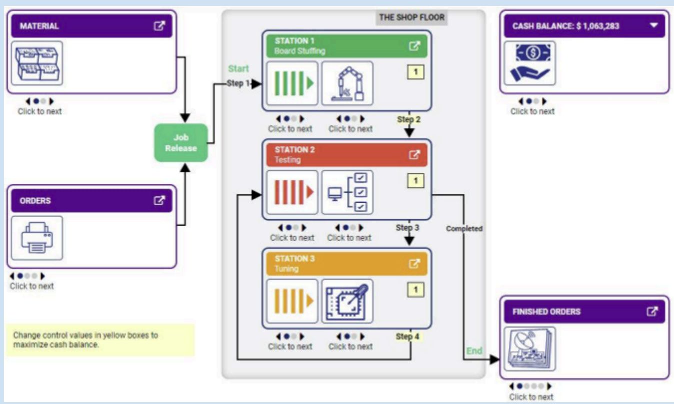
Background

Littlefield Technologies is a job shop that assembles Digital Satellite System receivers. This group's assignment is to take control of the factory to maximize the total "cash balance" by the end of the simulation.



This is the diagram for the job shop. There are three stations in the shop.

The **board stuffing station** involves mounting and soldering components onto PC Boards. Each additional board stuffing station costs $90,000.

The **testing station** tests the digital components. Each testing station costs $80,000.

The **tuning station** tunes the final components. Each tuning machine costs $100,000.

Orders arrive randomly at the factory. Each order is for 60 receivers. If an order arrives with fewer than 60 raw kits in the materials buffer, the order waits in the order queue. Raw kits are purchased from a single supplier and cost $10 per kit. There is also a fixed cost of $1,000 per shipment of raw kits, independent of shipment size. Orders are placed in multiples of 60 kits.

Customer contracts are listed below. Customers are willing to pay a premium for faster lead times:

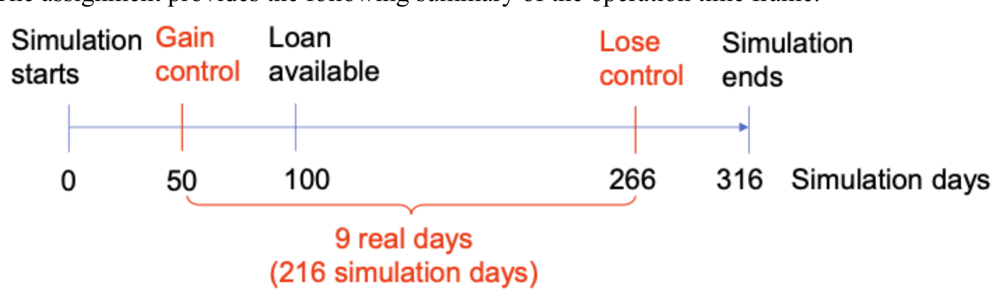
Contract	Price	Quoted Lead Time	Max Lead Time
Contact One	$750	7 days	14 days
Contract Two	$1,000	1 day	5 days
Contract Two	$1,250	0.5 day	1 day

The cash balance is depleted by buying machines and raw kit supplies. Revenue is earned from filling orders. The cash balance earns interest (compounded every simulated day) at 10% annually. There are no taxes, and all overhead is to be ignored. Additionally, on day 100, a bank loan may be taken with an annual interest rate of 20%, compounded daily, and a 5% loan processing fee incurred when the loan is made.

Therefore, the levers available to optimize these factory settings and maximize cash balance are:

Number of machines	Order Quantity	Reorder Point	Contract Type
The factory has three types of machines to buy.	The quantity in which orders are made.	The level of inventory that triggers an order.	There are three contract types to accept.

The assignment provides the following summary of the operation time frame.



Strategy

Our group strategy periodically evaluated EOQ for reorder quantity and R for reorder point and followed the following steps in cyclical form.

Once this is determined, we plan to determine the bottleneck by evaluating which station has the highest utilization.

We would then buy machines to decrease utilization, hoping to reduce overall lead time.

Once lead time was reduced beyond the point of the following most profitable contract's promised lead time, we would accept the next most profitable lead time contract.

Taking a loan may provide a strategic advantage with a cash infusion, allowing us to purchase more machines and decrease lead times more quickly. However, due to the high interest rate and a limited time frame for the simulation, there was a risk that the loan would burden our cash balance more than improve it.

"One Decision Cycle"

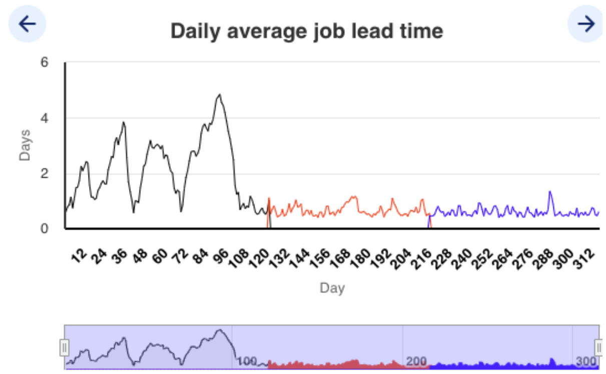
Important Formulas	
Profit	profit = operating profit + interest earned - debt cost - capital investment
Process Time	process time = lot setup time + unit time * lot size
AVG Daily Utilization	expected utilization = arrival rate * process time / number of machines
Lead Time	lead time = process times + wait time in queues
EOQ	$EOQ = \sqrt{(2 * D * K / h)}$
Reorder Point	$r = L\mu + z\sqrt{L}\sigma$

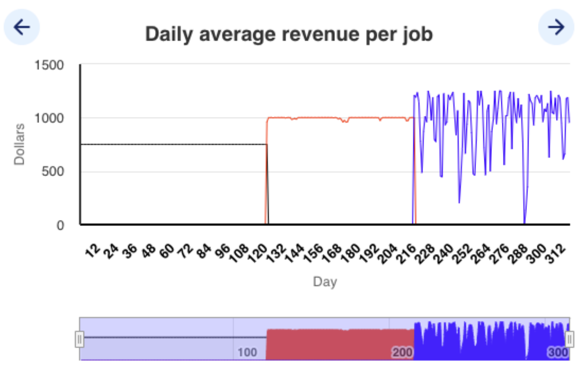
Results

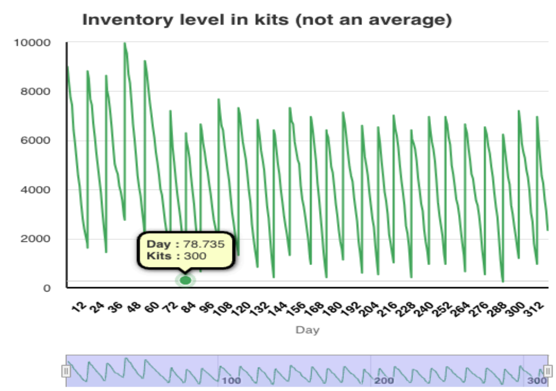
Simulation History:

Day	Parameters	Value	Decision Cycle
50.45	Reorder point (kits)	3,000	0
50.46	Reorder quantity (kits)	6,000	0
119.35	Station 2 machine count	2	1
119.36	Contract number	2	1
214.76	Station 1 machine count	4	2
214.76	Contract number	3	2

Simulation Summary:







Simulation Strategy:
On day 50, the first day of the simulation, we calculated the EOQ and R as follows:

Reorder Point (when to order) R:

$$r = L\mu + z\sqrt{L\sigma^2}$$

L = Average Lead Time = 4 days
μ = Average Demand = 8.5 jobs a day * 60 = 510 kits per day
z = z score, 99% availability = 2.33
σ = Demand Variability = 3.45 * 60 = 207 kits per day

$$r = L\mu + z\sqrt{L\sigma^2} = (4)(510) + 2.33\sqrt{(4)(207^2)}$$ = **3,004 kits**

Order Quantity (how much to order), EOQ:

$$\sqrt{\frac{2DK}{H}}$$

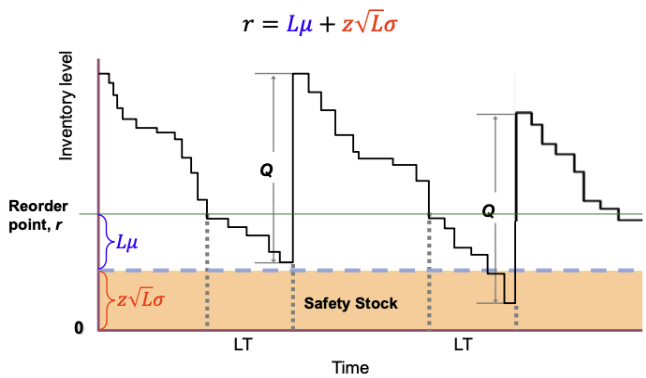
D = the annual demand
D = **8.5 jobs per day** (from daily job analysis tool) × **60 kits** = **510 kits a day**
D = **510 kits a day** × **365 days a year** = **186,150 kits a year**

K = the ordering cost per order, and

K = it is stated that the ordering cost is **$1,000**

H = the holding cost per unit per year.
H = No holding costs were explicitly provided by the simulation, and no average turnover rate is determined (such that H = $\frac{Cost\ per\ Kit}{Inventory\ Turnover\ Rate}$), so we decided to use the opportunity cost (ROI of alternative investments) of capital (20%) to calculate H. Therefore, $H\ =\ ROI\ \times\ Cost\ per\ Kit =$ $0.20\ \times\ \$10\ =$ **$2.00**

$EOQ\ =\ \sqrt{\frac{2DK}{H}} = \sqrt{\frac{2(186{,}150)(1{,}000)}{(2)}} =$ **13,643.67 kits**



$L\mu$ = Lead Time Demand

$z\sqrt{L\sigma^2}$ = Safety Stock

This requires us to make a number of more decisions. Due to extremely low potential holding costs, the EOQ model formula would recommend the ordering of 13,643 kits. This however, would be impractical for two reasons. Firstly, the initial investment cost of 13,643.67 kits would be prohibitive, especially were were interested in decreasing lead time by purchasing more machines as quickly as possible. Secondly, purchasing such a large amount of inventory upfront would prohibit flexible strategies given any changes in conditions. Therefore, a careful decision needs to be made about which fraction of the EOQ result should be ordered.

Order Quantity	Cost	Rationale
13,643 (EOQ)	$136,430	Optimal order quantity, but pricey upfront
6,821 (½ EOQ)	$68,210	A balanced approach between balancing upfront costs and frequent ordering costs
3,410 (¼ EOQ)	$34,100	Very tight cash flow, but more frequent order costs

We decided on a more balanced approach, erring on the side of more frequent orders upfront to keep a tiger cash balance in the beginning (with the intention to invest in machines as quickly as possible). Therefore, we chose an initial EOQ of 6,000 kits with the option to increase in the future, and we chose an initial R of 3,000 (as calculated above).

Once EOQ and R are determined, the next step in our decision cycle is to determine the bottleneck in the system by identifying which station has the most utilization.

The next step in our decision cycle is to wait for the lead time to be less than or equal to the quoted lead time of the next most profitable contract.
Discussion
Day 50.45-50.46 Narrative:

Due to our experience in the test run, we were comfortable moving to our target EOQ and R on the first day of the simulation. Therefore, we changed our EOQ volume to 6,000 and R to 3,000. We do not yet have the capital to purchase any machines at this time.

Day 119.35-119.36 Narrative:
Upon revisiting the simulation, we:

1) Revisit EOQ and R values.
    a. We found our EOQ and R values to be adequate, and we were unwilling to change them because on Day 78 (as shown in Chart 4 above), we reached a minimum stock level of 300 kits. We did not want to risk a stockout, so we kept our EOQ and R values the same.
2) Revisit our bottlenecks.
    a. We had the capital to relieve our bottleneck at Station 2, so we purchased one machine at Station 2.
3) Revisit our contract.
    a. We learned from the trial run that relieving our bottleneck at Station 2 was sufficient in consistently meeting the promised lead time of 1 day. Therefore, we changed from Contract 1 to Contract 2 with success, as evidenced by the sustained lead time of less than 1 day (red line of Chart 2) and a sustained rise in income (red line of Chart 3).

Our next move was to recover capital and reevaluate our position to repeat this cycle.

Day 214.76 Narrative:
Upon revisiting the simulation, we:

1) Revisit EOQ and R values.
    b. By day 214.76, there were more instances where the minimum stock neared only a few hundred, so we decided against changing our EOQ and R values.
2) Revisit our bottlenecks.
    b. When reviewing our new bottlenecks, we saw that Station 1 and Station 3 had the highest utilization but that the utilization of Station 1 was higher than that of Station 3. Therefore, we purchased a machine for Station 1.
3) Revisit our contract.
    b. We were hovering around 0.5 day lead time, so we assumed that by relieving this bottleneck, we would more consistently have a lead time of under 0.5 days, satisfying the promised lead time of Contract 3. Based on this assumption, we changed our contract to Contract 3.

Once these changes were made, we realized that our mistake had not been made until it was too late.

Missteps:

1. We could have chosen a more reasonable z-value than 99%, like 95%. This would have lowered our Reorder point to 2,700 kits.

    $r = L\mu + z\sqrt{L\sigma^2} = (4)(510) + 1.645\sqrt{(4)(207^2)}$ = 2,721.03 kits

    Given our concerns about minimum stock levels nearing 300 kits, lowering our reorder value by 300 should not cause excessive stockouts.

2. We could purchase a new machine at Station 2 and subsequently change our contract to Contract 2 much sooner in the simulation. We, therefore, should have checked the simulation more regularly and gathered consensus more quickly to make these changes.

3. Similarly, we had the ability to purchase a new machine to relieve our bottlenecks sooner and should have purchased this new machine as soon as possible.

4. Rather than making the assumption that relieving this new bottleneck would automatically place our lead time under 0.5 days, we should have watched the simulation more closely to verify this. Furthermore, we should have only accepted Contract 3 once our lead time was verified to be consistently under 0.5 days.

5. If we had monitored the simulation more closely, we would have noticed that our lead time was not as we were expecting it to be and that we would have needed to purchase a machine at Station 3 in order to keep lead times under 0.5 days, as required by this new contract.

6. We did recheck the simulation around Day 240 and noticed this mistake (Mistake 5), but we didn't feel that a purchase of a new machine so late in the simulation would pay off, so we decided not to purchase any. Given this belief, we should have moved back to Contract 2 and sold any unnecessary machines, knowing that the simulation would end soon. This ultimate mistake led to the punishing daily average revenues from Day 240 onward in Chart 3.

Conclusion:

We ended up in fourth place in class, near the podium. Given the opportunity to run the simulation again we would correct our mistakes listed in the section above and would implement a better system for staying on top of the simulation. While we did make assumptions early on and a few mathematical errors we could have corrected them sooner if we had calendared out a plan for following up on the factory at least once or twice a day. This highlights an important lesson in the reality of managing operations. In real life when managing operations be it services or a factory, operations do not only exist between the hours of 9-5. In a multilateral globalized world with globally sourced parts and customers it is important to have human eyes on the operation 24/7 to respond to problems as they manifest. The inability to respond to problems in the production line can lead to delays, backorders, and lost customers. Furthermore the simulation highlighted that reality does not always fit into a formula, even with all the data at your disposal it is nearly impossible to accurately estimate demand to prevent high inventory costs and stockouts. Manufacturing presents a risk even with the most up to date data.