Subject: Decision Analysis – Task 2

MEMORANDUM

TO: ALISTAR WU, U, Operating Director Of Shuzworld

FROM: Jon Horsman (operations consultant)

SUBJECT: Transportation, Maintenance & Reliability, Inventory Management, Waiting Lines

A. Distribution Pattern

The following is a distribution pattern that will contain sufficient detail that will help meet the availability and the demand constraints. As a result, this should minimize the total shipping costs for Shuzworld. We were able to accomplish this by utilizing the appropriate decision analysis tool.

It was important to us to use a transportation model to determine the lowest cost means of shipping shoes to several different facilities. In order to successfully utilize the transportation modeling tool, we needed to know the origin points and the capacity or supply per period at each origin point. The second piece of information was the destination points and the demand at each of the destination points. Thirdly, we need to know the cost to ship one unit from each of the origins to their destinations. In this case, Shuzworld has three factories. They were Shanghai (First Facility), Shuzworld H(Hangzhou) and Shuzworld F(Fuzhou).

After we received the information about the capacity, supply, factories and warehouse destinations, we were able to create a Transportation Matrix. A Transportation Matrix helps us summarize all of the relevant date and track the algorithm computations.

In order to create a distribution pattern, we needed to input the information to find what method would render the best results.

A1. Distribution Pattern Output

We had entered the following information into our POM program to find which method would render the best results. Below are the charts that we given to us by Mr Wu. It has been stated that they are at more capacity at all three factories in order to meet their current demand.

After reading about Shuzworld request to increase production from 1,300 to 2,800 for Shanghai, we had to take that demand increase into consideration. Mr. Wu had stated that there is no need for an increase now but anticipates the increase in demand in the near future. Below currently shows their information before the increase capacity from 1,300 to 2,800 in Shanghai.

Factory	Capacity	Warehouse	Requirements
Shanghai	1300	1	2500
Shuzworld H	2300	2	1500
Shuzworld F	2200	3	1800
Totals	5800		5800

To/From	Warehouse 1	Warehouse 2	Warehouse 3
Shanghai	$4	$3	$3
Shuzworld H	$3	$4	$2
Shuzworld F	$2	$4	$6

The most common models for developing a solution are:

The Northwest-Corner method Rule:

This method uses the upper left hand corner cell and allocates the shipping from top left to bottom right without exceed the supply or the demand. So when the supply exceeds the demand it goes to the next destination while all of the supply is reallocated. Eventually, all of the demand is fulfilled. If it is not, then the problem is not feasible.

The Intuitive Lowest-Cost method Rule:

This method assigns the most amount of low cost units to cells without exceeding the demand or supply. The process is then applied to until the lowest cost units are all fulfilled and then moves onto the next lowest cost unit. The next lowest cost unit is distributed when the lowest cost in mind until all of the units have been distributed.

The Stepping-stone method Rule:

This method attempts to find the most optimal solution. It takes a look at the unoccupied cells to see if there is the possibility of a better solution. This usually works by placing a unit into that open cell to see if it will lower the shipping costs. Usually this means the subtracting a unit from the supply in location and adding it to the empty cell. This also means it must take one unit away from the demand to so that the demand and supply are constant. By repeating this stepping-stone method for each unoccupied cell, we can come up with a Net Evaluation total. Since transportation is a minimization problem, The Net Evaluation for all of the cells must be equal or greater than zero to be optimal. If we find a negative number, we know this is the "entering" cell for our stepping stone. The "leaving" cell is the smaller of the two adjacent cells. So we subtract from the amount from the "leaving cell" and add it to the + cells and subtract from the – cells. This will create the new variables for the cells which would result in an improved solution.

Distribution Patterns

This is the optimal distribution pattern solution to be presented to the Shuzworld.

Optimal solution value = $13400	Warehouse 1	Warehouse 2	Warehouse 3	Dummy
Shanghai		1500		1300
Shuzworld H	300		1800	200
Shuzworld F	2200			

	Warehouse 1	Warehouse 2	Warehouse 3	Dummy
Shanghai		1500/$4500		1300/$0
Shuzworld H	300/$900		1800/$3600	200/$0
Shuzworld F	2200/$4400			

From	To	Shipment	Cost per unit	Shipment cost
Shanghai	Warehouse 2	1500	3	4500
Shanghai	Dummy	1300	0	0
Shuzworld H	Warehouse 1	300	3	900
Shuzworld H	Warehouse 3	1800	2	3600
Shuzworld H	Dummy	200	0	0
Shuzworld F	Warehouse 1	2200	2	4400

Total Shipment of **7300**

A1a. A Logical Explanation for the Selection of the Analysis tool of choice.

We had selected the Intuitive Lowest-Cost method over the methods of Northwest-corner rule and the stepping-stone method. The reason we went with the Intuitive lowest-cost method was because of the following. First it identifies the lowest cost cells and breaks any ties for the lowest cost arbitrarily. It also allocates the most number of units to the lowest cell without exceeding the supply or demand. The Intuitive Lowest-Cost method finds the lowest cost cells remaining that have not been crossed out. While we have noticed that the intuitive lowest-cost method provides the best initial solution over the northwest corner solution, neither present the optimal solution. The stepping-stone method does present the opportunity for optimization but only if it can further optimize the already successful Intuitive Lowest-Cost method.

B. A plausible analysis on the Reliability of the computer-driven shoe machine process.

Companies fight to maintain reliability in their equipment and operations. If a piece of equipment fails, this could potentially have devastating consequences. These consequences could become extremely disruptive, wasteful, inconvenient and expensive to the company.

The purpose of maintenance is to reduce and even remove the variability of the equipment. Maintenance is a key activity that keeping the equipment in continuous working order.

A maintenance tactic that could be used is to implement a program that focuses on the improving preventative maintenance. Another tactic is to find ways to increase speed and time it takes to repair the equipment. This also including designing equipment for reliability and creating a management program for interval maintenance. There are also three types of maintenance which include preventive maintenance, breakdown and even predictive maintenance. Preventive Maintenance includes inspections, servicing and components in good repair. The other Breakdown maintenance happens when the piece of equipment fails and requires urgent and repair on a priority basis. The Predictive Maintenance is able to impend failures by using technology that can detect imminent equipment failure. This process can forecast future failure and even schedule for automatic replacement or repair.

With Reliability, it is the measurement and probability that the piece of equipment will keep functioning properly for a specific period of time. Reliability can also be affected by the number of components that are placed in a series or row. The whole system's reliability decreases as we increase the number of components in that series or row. Even though an individual component could have a reliability rating if it was placed in a series of other equipment with less than 100% reliability, it could rapidly diminish the whole systems reliability. As a company, reliability analysis should closely examine the (MTFB) Mean Time Between Failures as this will help the company determine the expected times between the repair and the next failure of a machine.

Dieter Handel who is the lead quality manager at the Shanghai plant supplies us with the first problem. Dieter Handel's priority has been on improving the quality while maintaining production levels. The focus has been on the causal deck shoes. This process uses three machines in a sequence. Each of these machines performs a different function in the construction of the shoes. His problem is if one of the machines breaks down, the shoes can not be completed until the machine is either repaired or replaced. Reliability is of the highest importance.

B1. A Reliability Recommendation for ways to increase the reliability of the system by using the following appropriate decision analysis tool.

A great way to increase the reliability of a system is to add redundancy to the equipment. This is a process of backing up the equipment with additional equipment and components. Redundancy is commonly known as putting units in parallel. This process ensures that if one piece of equipment or component fails there will be another form of recourse to another piece of equipment.

Since the causal deck shoe uses three machines in sequence if any of these machines goes down, the shoe production will stop until the broken machine is replaced or repaired.

The decision analysis tool of choice was the Reliability tool with Mixed. The reason for this selection was to determine if the system was backed up or not. System Reliability is the reliability of the first component multiplied the reliability of the second component multiplied the third component until all components have been accounted for. We also analyze the percentage of the failure rate for a system FR(%). This can accomplished by dividing the number of failure by the number of units tested. Also, the product failure rate can be calculated for unit-hours by dividing the number of failures by the number of unit-hours of operating time FR(N). By having this number we can calculate the Mean Time Between Failures (MTBF). This can be done by dividing 1 into the Failure Rate FR(N).

B2. Reliability Output

The Chart below shows the results if the company does not implement a back-up system. This display of the current systems reliability without the backup gives only 75.68% reliability rating. Without a Backup system in place, this is what Shuzworld can expect if their one of their components goes down.

This the current back up system in place for Shuzworld at 75.68 Overall Reliability

	Parallel system 1	Parallel system 2	Parallel system 3
Component	.84	.91	.99
Backup 1			
Prll System Rel	.84	.91	.99
Overall Reliability	.7568		

By backing up Machine 1, it gives the result of a 87.78% reliability

	Parallel system 1	Parallel system 2	Parallel system 3
Component	.84	.91	.99
Backup 1	.84		
Prll System Rel	.9744	.91	.99
Overall Reliability	.8778		

By backing up Machine 2, it gives the result of a 82.49% reliability

	Parallel system 1	Parallel system 2	Parallel system 3
Component	.84	.91	.99
Backup 1		.91	
Prll System Rel	.84	.9919	.99
Overall Reliability	.8249		

By backing up Machine 3, it gives the result of a 76.43% reliability

	Parallel system 1	Parallel system 2	Parallel system 3
Component	.84	.91	.99
Backup 1			.99
Prll System Rel	.84	.91	.9999
Overall Reliability	.7643		

B2a. Reliability Output Explanation

We had selected the reliability tool with the mixed in order to obtain the best results. The objective for the reliability output is to obtain the highest overall reliability percentage. While investing in machines to back up other machines, it is a good practice to keep operations flowing. The important aspect is to back-up the machine that gives the greatest reliability boost to the overall percentage of reliability. To provide the redundancy rate to increase reliability would require the following. The probability of the first component working plus the probability of the second component working multiplied by the probability of needing second component.

In this case, Shuzworld should invest in backing up machine #1. Machine #1 would give the highest possible reliability of 87.78% in comparison to the other machines. The Pll System Rel also increases to a 97.44% reliability rate which translates to the lowest probability of failure throughout the whole system.

The objective of inventory management is to achieve a balance between inventory investment and the customer service. Integral to any good inventory system is a good annual physical count of inventory. To better any inventory system, a solid ABC Analysis system proves to be beneficial. An ABC analysis system divides the inventory into three classes based upon annual dollar volume. Class A deals with high annual dollar volume, Class B deals with medium annual dollar volume and Class C which deals with low annual dollar volume. This classification is used to establish policies that are mainly focused on the few critical items and not on the many trivial ones. It is known that about 15% or20% of the items are known to be 70% - 80% of the total cost. On the other hand, 50%-60% of the C Items only accumulate approximately less than 10% of the total inventory dollars.

We can also use other criteria for an ABC analysis other than the annual dollar volume. These other criteria methods could be anticipated engineering changes (retail might use it to move out older inventory which affects their annual sales), delivery problems, quality problems and even high unit cost.

Cycle Counting could be used in conjunction with ABC analysis. It is designed to provide a better overall control of the inventory system and utilization inventory systems. This provides the trained personnel an ability to audit inventory accurately on a more focused basis for better utilization of their time.

The important thing for Shuzworld is to determine when to place and how much should they order. There are three types of inventory models that could be used: The Basic Economic Order Quantity (EOQ), the Production Order Quantity (EPQ) and the Quantity Discount Model. Each of these models has three important costs that helped us determine which one to use for Shuzworld. They are the Holding "carrying" costs, the Ordering costs "cost of placing an order and the receiving of goods" and the Setup Costs "cost associated to the preparation of the machine or process for the manufacturing of the order".

C. Optimum Number of Shoelaces to order for the Shuzworld Factory after considering appropriate cost balancing and utilizing the appropriate decision analysis tool.

By using the appropriate cost balancing tool, we are able to provide the optimum number of shoelaces that Shuzworld should order. The recommended decision analysis tool would be the Inventory module with the Economic Order Quantity (EOQ) model. The EOQ model is specifically design for ordering where we have stable demand, stable availability and no quantity discount. After utilizing the appropriate decision analysis tool, we have determined the optimum order quantity (Q*) of shoelaces to order is 27386.13.

C1. How an economic order quantity amount relates to the problem.

The reason why we chose the EOQ Model was because we knew the demand rate was 300,000 pairs of shoelace each year. We also determined that the lead time was known and constant. Shuzworld said that every time an order is made to the supplier, it was an estimate that their cost was at $125. Shuzworld also mentioned that quantity discounts were not possible. The main concern was the variable costs that are associated with the Annual Setup Costs and Holding

Costs. They had informed us that the cost of keeping shoelaces in inventory is 100 cents per pair. Stock outs could be completely avoided.

C2. Output from our Decision Analysis Tool

Parameter	Value		Parameter	Value
Demand rate(D)	300000		Optimal order quantity (Q*)	27386.13
Setup/Ordering cost(S)	125		Maximum Inventory Level (Imax)	27386.13
Holding cost(H)	.1		Average inventory	13693.06
Unit cost	0		Orders per period(year)	10.95
			Annual Setup cost	1369.31
			Annual Holding cost	1369.31
			Unit costs (PD)	0
			Total Cost	2738.61

C2a. The reason why we chose the decision analysis that we used

The EOQ was the perfect decision analysis tool to determine the Orders per period (year) needed, what the setup and holding costs were and finding the Optimal order quantity Q* for Shuzworld to obtain the minimum total costs. To determine the Total Cost is to take the Setup Cost plus the Holding Cost. We discovered the optimal order quantity can be found by determining when the annual setup cost equals the annual holding cost.

EOQ is An inventory-related equation that determines the optimum order quantity that a company should hold in its inventory given a set cost of production, demand rate and other variables. This is done to minimize variable inventory costs. (Economic Order Quantity - EOQ)

Shuzworld also needed to determine their reorder points (ROP). To determine Reorder Point (ROP) is the demand per day multipled by lead time for a new order in days. In this case, Shuzworld needs to reorder 10.95 (11) times a year at the Q* of 27386.13.

The reason we did not select the Production Order Quantity Model was because this places the order to our own operations which set-ups the machines and run off that inventory for us. Which ships back to us as it produces. This means it will come over at some period of time but not all at one time. This is the primary difference between EPQ and the EOQ. The Quantity Discount Model takes advantage of quantity discounts which were not offered to Shuzword.

A consideration for Shuzworld is to think about applying a Safety Stock to their ROP reorder points. Since there is talking about possible expansion in the future, the creation of safety stock might prevent the probability of stockout situation.

D. Waiting-Line Systems and the characteristics of the one-cashier and two-cashier waiting-line systems.

To determine which waiting-line system to use, we need to understand Queuing Theory. Queuing theory is the study of waiting lines which are helpful in both manufacturing and service industries.

Waiting Lines are composed of three components. These three components can help determine which type of cashier waiting line system the company wants to use.

The first component is the Arrivals in the System. The Arrival characteristics are defined by the size of the population, arrival rate (lambda) and arrival patterns, behavior of those arrivals and the statistical distribution of those arrivals. The patterns of arrivals are often a Poisson type of distribution. This can help determine the arrival rates and the distribution rates.

The second component is the “in the system” Queue (waiting line), service queue (number of tellers) to determine if it is limited or unlimited. There are many types of queue disciplines, one of the most common is the (FIFO) First-in, First-out. However, the priority rules could be different based upon certain circumstances.

The Queuing system can have different service characteristics. These queuing systems can be single-channel or multiple channel which could have single-phase or multiphase systems. On top of that, the service time distribution whether it is a constant service time or random service times.

The third component is the "Exit from the system".

The differences between the one-cashier and two-cashier waiting line systems. The one-cashier system design is with a single channel. This one-cashier design is fine if the wait times are not too long. In order to prevent the extra cost of having more resources allocated to a two-cashier system, the company could create single-channel, multiphase system. This creates multiple steps in the service process so that waiting does not have behavioral disruptions. The advantage of the two-cashier system would be able utilize a multi-channel approach. The Multi-channel system would expedite the service but would also increase the overhead and operating costs. If there is a long lag in wait time, the first suggestion would be to go with the single channel, multiphase. However, the single channel could bottleneck production so a Multi-channel system could bypass the slower channel and increase throughput.

The biggest difference between Single channel and Multi-channel model (M/M/s) is the one more variable to the arrival rate and service rate. Multi-channel increases the number of servers in its system. The calculations have the same factors as the single channel.

The biggest benefits of the two channels are the increase of servers will increase speed of getting people through the queue. It also decreases the time spent in the system. Average time spent in queue radically improves the service that Shuzworld is providing. However, adding the additional server comes at a cost.

D1. Recommendation with support of using a one-cashier or two-cashier waiting-line system.

The recommendation for Shuzworld is to utilize a one-cashier system. The following information shows that one cashier should be able to complete their transactions with the specified time. The average customer will only have five minute wait time. If the company feels that the wait time is too long, I would look into creating a single-channel, multiphase system but would hesitant to expand into the two-cashier channel system at this time. Shuzworld may want to go to a two-cashier channel system, but it should only happen when they consider the following queue performance measurements. The Measurement of Queue Performance includes Average time the customers spends in the queue, average queue length, average time a customer spends in the entire system, average number of customers in the system, probability of an idle service facility, utilization factor and the probability of the specific number of customers in the system.

The objective of the Queuing analysis is to balance the cost of providing service with the cost of service. The cost waiting in line and the cost of providing service vs the losing the customer along the way. Finding the point at the lowest possible total cost which is at our optimal service level is the ultimate goal.

After reviewing the results below, It would be in the best interests of Shuzworld to run with a single-cashier system at this time.

The first reason is the server utilization rate is only at 50% of operation capacity. The second reason is a low number of individuals in the queue is only 1 person. The third reason is the time spent in the queue is only 5 minutes. The fourth reason is the whole system for a customer is only 10 minutes. It would be a waste of resources if Shuzworld was to add a second cashier to the system. If the server utilization rates rises closer to the 100 % utilization, then a second cashier system should be considered.

D2. Waiting Line System Output from the decision analysis tool of choice.

Shuzworld had mentioned that their pilot team tests showed they can expect a sale every ten minutes on average and that each transaction at the register takes an average of 5 minutes.

<u>One Cashier System</u>

Average Server Utilization: .5 (Probability of no one being in line or served (server busy 50% of the time)

Average number in the queue (inline): .5 people

Average number of people in the system (inline or being waited on): 1 person

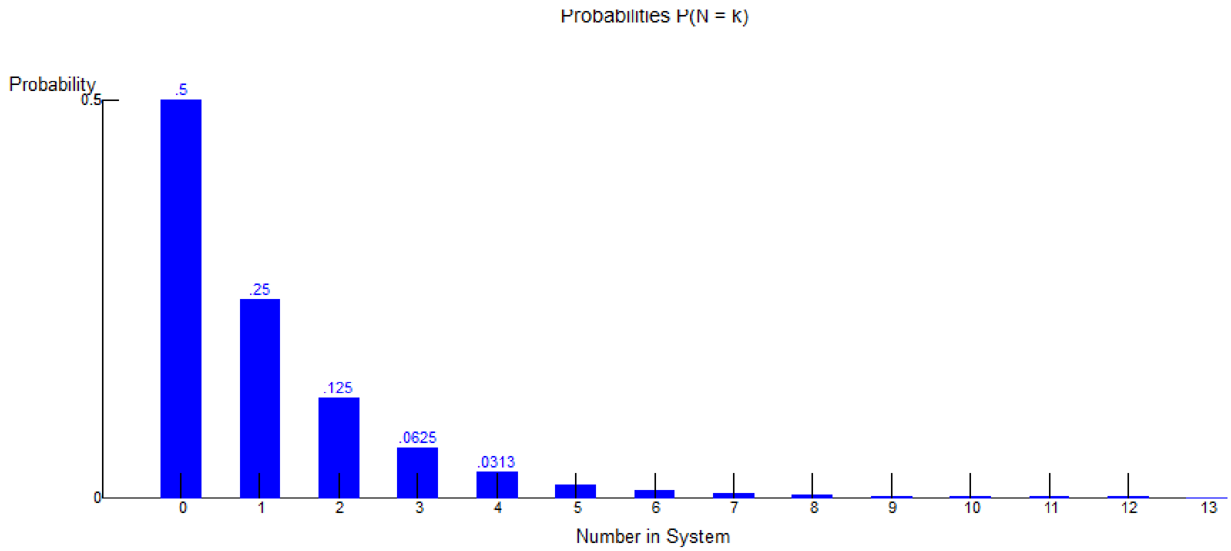
Average time in the queue: .08 or 5 minutes

Average time in the (whole system) queue: .17 or 10 minutes

Parameter	Value	Parameter	Value	Minutes	Seconds
M/M/s		Average server utilization	.5		
Arrival rate(lambda)	6	Average number in the queue(Lq)	.5		
Service rate(mu)	12	Average number in the system(Ls)	1		
Number of servers	1	Average time in the queue(Wq)	.08	5	300
		Average time in the system(Ws)	.17	10	600

k	Prob (num in sys = k)	Prob (num in sys <= k)	Prob (num in sys >k)
0	.5	.5	.5
1	.25	.75	.25
2	.13	.88	.13
3	.06	.94	.06
4	.03	.97	.03
5	.02	.98	.02
6	.01	1	.01
7	.0	1	.0
8	.0	1	.0
9	0	1	0
10	0	1	0
11	0	1	0
12	0	1	0
13	0	1	0

	1	2	3	4	5
Average server utilization	.5	.25	.17	.13	.1
Average number in the queue(Lq)	.5	.03	.0	0	0
Average number in the system(Ls)	1	.53	.5	.5	.5
Average time in the queue(Wq)	.08	.01	0	0	0
Average time in the system(Ws)	.17	.09	.08	.08	.08



Two Cashiers System

With the Two Cashier System, we entered the same inputs for the sales every ten minutes and the five minutes taken for each transaction at the register.

Average Server Utilization: .25 (Probability of no one being in line or served is 75% of the time)

Average number in the queue (inline): .3 people

Average number of people in the system (inline or being waited on): .53 people

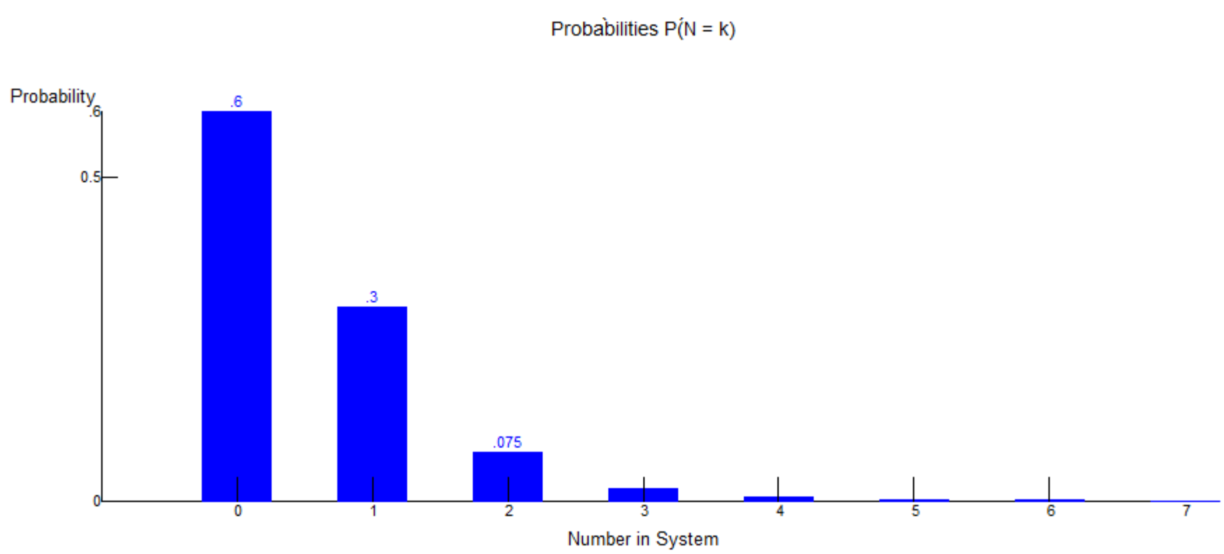
Average time in the queue: .01 or .33 minutes

Average time in the (whole system) queue: .09 or 5.33 minutes

Parameter	Value	Parameter	Value	Minutes	Seconds
M/M/s		Average server utilization	.25		
Arrival rate(lambda)	6	Average number in the queue(Lq)	.03		
Service rate(mu)	12	Average number in the system(Ls)	.53		
Number of servers	2	Average time in the queue(Wq)	.01	.33	20
		Average time in the system(Ws)	.09	5.33	320

k	Prob (num in sys = k)	Prob (num in sys <= k)	Prob (num in sys >k)
0	.6	.6	.4
1	.3	.9	.1
2	.08	.98	.02
3	.02	1	.01
4	.0	1	.0
5	.0	1	0
6	0	1	0
7	0	1	0

	1	2	3	4	5
Average server utilization	.5	.25	.17	.13	.1
Average number in the queue(Lq)	.5	.03	.0	0	0
Average number in the system(Ls)	1	.53	.5	.5	.5
Average time in the queue(Wq)	.08	.01	0	0	0
Average time in the system(Ws)	.17	.09	.08	.08	.08



D2a. Waiting Line System Explanation and why chose the decision analysis tool we used.

The decision analysis tool selected was the Waiting Line analysis with no costs. I used the multichannel system M/M/S. The reason I had chosen that tool was because I wanted to compare both of the effects of having a single channel and multi-channel to find the optimum results.

References

Economic Order Quantity - EOQ. (n.d.). Retrieved from investopedia.com: http://www.investopedia.com/terms/e/economicorderquantity.asp