

Preferred Customer Service at U.S. Airways

CASE STUDY QUESTIONS

You are required to write a report addressing the following points. Guidelines for the length of each question is provided. However, you can provide additional tables and graphs in an appendix. You are required to submit a hard copy on the last day of class along with soft copies of the report and of the supporting Excel files. This is a comprehensive case study that considers various aspects of decisions related to management of variability and service systems (queueing). You will have dedicated times to work on this case and you will receive ample support from the instructors who will guide you through the questions.

1. Considering that the competitive importance of perceived service quality was well understood by the company and its employees, do you think that establishment of a preferred customer desk in the Winston-Salem center is an effective strategy to improve both the quality and the speed of service to the small but highly valued preferred customers of the company? What are the pros and cons of using specialized agents? Please support your answer. [$\approx\frac{1}{2}$ a page]
2. Assess the appropriateness of the short-cut that Kostelic and Saunders are considering.¹ Is it appropriate to analyze the personnel implications of the proposed new preferred customer desk as well as the impact of 30-second average hold time based on an *average day*, ignoring the significant day-to-day call volume changes? [$\approx\frac{1}{2}$ a page]
3. McHenry suggests that the bids that the Centers implement are based on the application of queuing theory, which assumes exponential service times. Look at the call handle times in case **Exhibit 5**. Does the data appear to satisfy this assumption? If not, can we conclude that McHenry was using the queuing models unjustifiably? [≈ 1 page including a graph]

- Note: you are required to plot the distribution from Exhibit 5, which is provided below:

From	To	Frequency
0	25	1
25.01	50	1
50.01	75	6
75.01	100	10
100.01	125	11
125.01	150	13
150.01	175	14
175.01	200	27
200.01	225	34
225.01	250	43
250.01	275	61
275.01	300	86
300.01	325	127
325.01	350	130
350.01	375	166
375.01	400	161
400.01	425	122
425.01	450	99
450.01	475	79
475.01	500	54

From	To	Frequency
500.01	525	51
525.01	550	20
550.01	575	14
575.01	600	14
600.01	625	15
625.01	650	11
650.01	675	10
675.01	700	5
700.01	725	14
725.01	750	2
750.01	775	2
775.01	800	2
800.01	825	3
825.01	850	1
850.01	875	0
875.01	900	4
900.01	925	1
925.01	950	2
950.01	975	2
975.01	1000	0
1000.01	More	13

4. Given the average handle times and the pattern of average call volumes, compute the minimum number of agents that must be available during each hour of a typical 24-hour period to maintain the average hold times to the current 45 or proposed 30 seconds. Compare the overall (weighted average) agent utilization factors, assuming the required number of agents are made available at each hour. [2-3 pages including graphs/tables]

¹ The short-cut we are referring to is the averaging of the information provided in Exhibit 6. Namely, rather than carrying out the analysis for each day, the values are averaged to yield the average call volume each hour.

How to calculate the number of agents during each one hour block?

- Since we are using the shortcut, find the average number of calls during each of the hours. The data from Exhibit 6 is provided below:

5.

Hour	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
0:00	7.3	7.3	8.5	7.2	8.2	14.3	7.8
1:00	9.8	18.3	11.5	10.8	10	12.3	9.6
2:00	14.8	26.5	17.5	27.4	21.4	28	12
3:00	20.5	46.5	31.5	40.8	32.6	45.5	24
4:00	42	68.8	58	78.8	65.8	78	47
5:00	76.8	115	91.8	102.4	107.6	110.5	66
6:00	66.8	154.5	125.5	121.8	128	161.3	89.8
7:00	85.3	148	133.3	138.4	152.8	163.3	96
8:00	129	146.5	134.8	134.4	159.4	171.3	103
9:00	117.3	141.5	122	119.2	151.8	150	97.5
10:00	109.5	131.3	127	121.8	143.2	168	91.3
11:00	119.3	134.5	129.8	130	151	167.8	88.8
12:00	117.3	127.8	121.5	139	150.4	154.3	87.3
13:00	111.8	123.8	127.3	145	151.6	167.8	79.5
14:00	119	130.8	108.8	139.6	157.8	148	69.3
15:00	106	85	95.8	110.6	139.8	122.8	67.8
16:00	133.8	85	79.5	90.4	150.2	95.5	56.3
17:00	112.5	67.3	84.8	79.6	122.8	81.3	51
18:00	82.8	81	94.8	76.2	102.8	63.8	55
19:00	60.3	59.3	84	66.6	82.6	58.8	46
20:00	48	40.3	45.5	46.6	56.6	42.3	35.8
21:00	33.8	30.3	29.8	33.2	32	27	20.5
22:00	18.5	20	18.3	17.2	24.2	17	23.3
23:00	8	9	6.3	10.4	15.2	9.5	11.8

- Convert the number of calls each hour to arrival rate in calls/min (simply divide by 60).
- What is the minimum number of agents required each hour? Note, the condition to guarantee minimum service is $\rho_s < 1$. (see end of this document for math)
- Consider the exact formulation provided at the end of this document (i.e., not the approximation from the slides). You may realize that it is hard to code these expressions in excel. Without advanced Excel skills it is hard to find the minimum value of c that yields $T_q \leq 45$ using the exact formulation. Since it is hard to code multi-server equation in to excel, we will make use of an existing package. Install the queuing toolpack qtp.exe. It can also be found at <http://queueingtoolpak.org/download.shtml#Downloading%20and%20Installing%20QTP%204.0> Follow installation instruction (which are also provided at end of this document). Once the toolpack is installed, we can use the function QTPMMS_Wq (ArrivalRate, ServiceRate, Servers, QueueCapacity) to find the waiting time in queue,
- For each of the hour blocks, find the value of c that gives $T_q \leq 45$ and yields $T_q \leq 30$. To do that, you will need to create another column for the number of agents in each hour and adjust

c manually till conditions are satisfied. **Summarize the number of required agents during the day for each of the service targets.**

- **Bonus: Is the approximation valid?** Consider the P-K approximation,

$$I_q \approx \frac{\rho^{\sqrt{2(c+1)}}}{1-\rho} \times \frac{C_a^2 + C_s^2}{2}$$

Using Excel, find the number of agents needed for the 45 seconds target. Do you obtain the same results as before?

- **Is the shortcut valid?** How far off the number of agents could be if we use the average across the week rather than precise daily values? You are not required to calculate for each day, just demonstrate.
- **Construct a decision table showing waiting times as a function of the number of agents for each hour of the day.**
- The table will have the following structure:

Hour	0:00	1:00	2:00	3:00	4:00	5:00	6:00
λ	0.144	0.196	0.351	0.575	1.044	1.595	2.018
1	4790						
2	105	251					
3	13.9	34.8	294				

- The top rows show the hour of the day and the corresponding arrival rates, the left column is the number of agents, and the cells in the table are the average waiting times. For example, in this demonstration, between 0:00 and 1:00, if we have a single agent then the expected waiting time is 4790 seconds. By increasing the number of agents from 1 to 2, the expected waiting time drops to 105 seconds.

5. Supposing only full-time agents who work the standard shifts of four-hours-on/one hour-off/four-hours-on are to be used, how many more agents should be trained and employed for a 30- second average hold time target as compared to 45 seconds? Compute the additional annual cost of lowering the average wait time for the preferred customers to 30 seconds. [½-1 a page]

- Now we need to construct an optimization problem that can be solved using Excel’s solver.
- Define the decision variables as the number of agents that start the shift during each hour of the day.
- The objective is to minimize the total working hours during a week, while satisfying the waiting time targets.
- It is recommended to create a table in the following structure:

hour	λ	X_0	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	...	X_{23}	Sum	Tq	s (45)
		1	3	2	1	3	1	1	1	5	3		1			
0	0.144286	1											1	3	13.93589	3
1	0.195952	1	3										1	5	34.79319	3
2		1	3	2												
3		1	3	2	1											
4			3	2	1	3										
5		1		2	1	3	1									

- The shaded cells are your decision variables. Note how the decision variables correspond to the number of agents available during each hour of the day. Summing across gives the total number of agents which than can used to derive waiting time (using QTPMMS_Wq).
- **Calculate the number of employees required to be hired under each of the scenarios. What is the additional cost due to the shorter target waiting time?**

- **How many employees do you need to train under each of the targets, assuming 10% excess personnel?**
6. Compute agent utilization based on the suggested schedules obtained for Question 5. Compare with the utilization factors from Question 4 and explain the difference. [½-1 a page]
 7. Suggest a shift schedule that allows part-time agents (four-hour shifts) in addition to fulltime eight-hour shifts. How do these compare with the schedules obtained for Question 6? [½-1 a page]
 - This is very similar to question 6. Only that now you will increase the number of decision variables to include part timers as well.

Formulas and notation for multi-server queues

λ = average calls coming/minute

μ = average number of calls processed/minute

c = number of agents (servers)

μc = mean effective service rate

$\rho = \lambda / \mu$ = utilization for a single server

$\rho_s = \lambda / c\mu$ = utilization factor for the system

P_n = probability of n customers in the system

P_w = probability that an arriving customer will wait

T = average time in the system = waiting + service time

T_q = average time in the queue

I = average number of callers in the system

I_q = average number waiting in the queue

P_n = probability of n callers in the system

Provided that $\rho_s < 1$, equivalently mean effective service rate, μc , exceeds the arrival rate (for otherwise, the queue would grow indefinitely without reaching a steady state), the following formulae can be used to obtain steady state queue results to be used in making pertinent decisions. The condition also places a lower limit on the required number of servers for any λ and μ . I.e., $c > \lambda / \mu$.

$$P_0 = \left[\sum_{n=0}^{c-1} \frac{1}{n!} \left(\frac{\lambda}{\mu}\right)^n + \frac{1}{c!} \left(\frac{\lambda}{\mu}\right)^c \left(\frac{c\mu}{c\mu - \lambda}\right) \right]^{-1}$$

$$P_n = \frac{1}{c! c^{n-c}} \left(\frac{\lambda}{\mu}\right)^n P_0$$

$$I = \frac{\lambda \mu \left(\frac{\lambda}{\mu}\right)^c}{(c-1)! (c\mu - \lambda)^2} P_0 + \frac{\lambda}{\mu}$$

$$T = \frac{I}{\lambda}$$

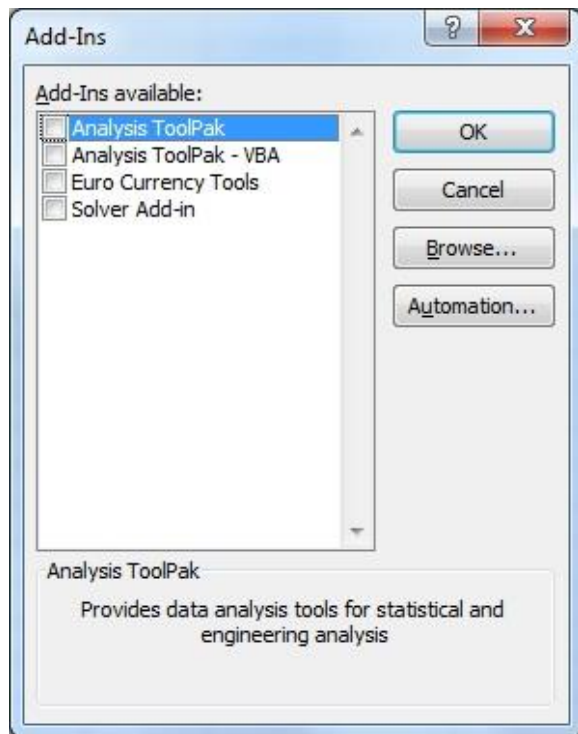
$$I_q = I - \frac{\lambda}{\mu}$$

$$T_q = T - \frac{1}{\mu} = \frac{I_q}{\lambda}$$

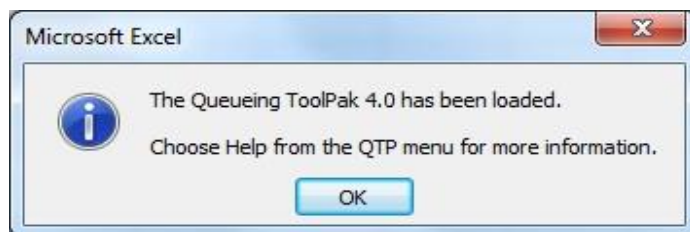
$$P_w = \frac{1}{c!} \left(\frac{\lambda}{\mu}\right)^c \left(\frac{c\mu}{c\mu - \lambda}\right) P_0$$

Installing Queueing ToolPak 4.0

1. Double-click qtp.exe . Click "OK" and then "Unzip." This will "unzip" the files necessary for the Queueing ToolPak to work and copy them to your hard disk. By default, the files are copied to C:\QTP\ but you can change the folder if you wish. Click "Close."
2. To load QTP 4.0, open Excel and click the File ribbon, then "Options," "Add-Ins," and then click "Go ..." next to "Excel add-ins." You should see the following window:



3. Click the browse button, browse to the folder that you unzipped the QTP files to (C:\QTP\ by default), select qtp.xll and click "OK." Click "OK" again. The message below should appear indicating that the Queueing ToolPak has been loaded. Click "OK."



4. To verify that the Queueing ToolPak has been loaded correctly, look for an "Add-Ins" ribbon with a new QTP menu and choose help from that menu. As well, open the function wizard and look for a new function category for "Queueing ToolPak."
5. You are now ready to use the Queueing ToolPak. The help file (also available [here](#)) contains a tutorial that can help get you started.