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SIMULATION OF PASSENGER CHECK-IN AT A MEDIUM-SIZED US AIRPORT

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ABSTRACT

Delays in the check-in system at an airport vary with times of the day, day of the week, and types of check-in modes chosen by the passengers. Extensive data collection of the check-in system can be used to build a simulation that helps predict these delays. This paper explains the data collection process, simulation modeling, and scenario analysis for the check-in procedure at the Buffalo Niagara International Airport. Results from this study can be linked to other processes (security checkpoint and parking) in order to obtain information on a passenger's experience at the airport. The goal of this study is to identify delays and create scenarios that will improve the efficiency.

1. INTRODUCTION

The overall experience of a passenger at an airport can be demanding and time consuming. Delays occur with parking, checking in, security screening, and boarding. The less time the costumer spends in the system, the higher the satisfaction. However, at the same time, the airport is obliged to hold standards that the passengers must meet. These standards include proper identification, limited luggage weight, and safety procedures at the security checkpoint. The Buffalo Niagara International Airport is a medium-sized US airport offering approximately 110 flights daily to non-stop flights to 18 different cities (Buffalo Niagara International Airport homepage).

Researchers at the Industrial and Systems Engineering Department at the University at Buffalo have previously created a simulation created for the security checkpoint at the Buffalo airport (see Paul, Lin, Batta and Drury, 2007). This paper focuses on the passenger check-in procedure. The check-in procedure includes passengers who check-in online, curbside, or use the kiosk and counter inside. During peak hours, queuing can be a major problem for both passengers and ticket agents. Although it seems to be a very straight forward process, the fluctuations in demand throughout the day can cause delays (Joustra and Van Oijk, 2001). The time the customer spends waiting is directly related to their satisfaction: the more efficient the process, the happier the customer. Therefore, the overall objectives of this study are:

1. Collect data on peak hours for different days of the week for the curbside, kiosk, counter, and online check-in process.
2. Use this information to develop a simulation (using Arena software) that shows the passenger flow through the check-in process given the different types of check-in modes.
3. Analyze different scenarios on the basis of waiting time (time in queue) and total average time in the system.

2. AIRLINE CHECK-IN PROCEDURE

The passenger check-in process differs depending on the check-in mode chosen, the number of bags checked, and the airline the passenger has chosen to fly with. We chose a specific airline to study, Southwest Airlines. At Southwest Airlines, the check-in process is as shown in Figure 1. The flow of the check-in process begins with passenger arrival at the airport. The passenger then chooses to either utilize the curbside skycap check-in outside, or proceed inside to the ticket counter. If the passenger uses the curbside check-in, he/she must enter the queue and wait for an available ticket agent for assistance. The ticket agent then checks the customer in (if he/she hasn't done so online), and takes care of his/her luggage. If the passenger chooses to go inside, he/she must enter the queue inside for the Southwest ticket counter. If the passenger has already checked in online and does not have luggage to check, he/she may proceed directly to the security checkpoint. If the customer has checked in online but needs to check his/her luggage, he/she must wait in line and use the first available kiosk. If the passenger has not checked in online, he/she must also wait in the queue and use the first available kiosk or counter. All passengers that check-in, as well as online passengers checking in their luggage, must have their bags weighed and a tag applied to each bag that lists its destination.

3. DATA COLLECTION

The research team has spent many hours doing thorough data collection to use as inputs to the simulation. The importance of data collection is evident in order to present a model that accurately represents the check-in procedure at the airport.

3.1 Type of Data Collected

The data collection process was separated according to the different arrival modes stated above. Data collected for the curbside process includes inter arrival times, time in queue, service times, party size, number of bags, number of employees servicing a customer, and departure time. If the passengers chose to utilize the ticket counter inside, similar data was collected, but noted whether it was a passenger that already checked in online but needed to check bags, a kiosk check-in, or counter check-in. Other data collected included the delay between leaving the queue and starting the check-in process, and ending the check-in process and leaving the ticket counter area. The data collection was only done for peak hours on Friday, Saturday, Sunday, and Monday. Previous research for the security checkpoint proved that there is no significant difference between Monday-Thursday passenger volumes at the airport. In order to link the check-in procedure with the security checkpoint, only Friday afternoon (2:30pm-5:00pm), Saturday morning (5:30am-8:00am), Sunday afternoon (2:30pm-5:00pm), and Monday morning (2:30pm-5:00pm) data was collected (Paul et al., 2007).

It is important to note the dependency of party size, number of bags, and check-in mode. A passenger traveling alone with only one bag using the kiosk check-in mode will most likely take less time than a family of five, with eight bags, utilizing the kiosk. It was important to note the party size and number of bags during our data collection procedure. Statistical analysis was preformed on the importance of this dependency in section 3.3.

3.2 Difficulties in Data Collection

In order to accurately model the check-in process, cooperation was needed from the airlines for the data collection process. Permission was obtained from Southwest Airlines for data collection. Due to time constraints in the schedules of the data collection team, the overall data collection processed spanned for almost two months. Since only four to five people were available to collect data at one time, it was sometimes necessary to collect only a random sample of data point (for example, the kiosk and counter check-in process). The peak times for passenger volumes for different days also led to constraints on when data collection had to take place.

3.3 Data Analysis

The data analysis was only performed for the Sunday data. In order to find accurate distributions, an ANOVA was conducted to find the significance of party size, number of bags, and check-in mode. The ANOVA General Linear Model was used instead of the Factorial Design (DOE) because party size, number of bags, and check-in mode have more than two levels. For the ticket counter inside, the results are shown in Table 1. Number of Bags and Check-in Mode are significant at $p < 0.05$. However, number of bags ranges from zero bags to six bags, with six bags only occurring once in the random sample. One sample is not enough to create a distribution. Therefore, the correlation between party size and number of bags was found to be 0.595 with a p-value < 0.001. The two factors show a relatively high correlation and can therefore be interchanged. This shows that grouping the data by party size in order to get more accurate distributions is acceptable. The same procedure was used to analyze the curbside check-in data, with the results shown in Table 2.

The check-in modes for curbside are passengers who already checked in online and only need to check bags versus those that still need boarding passes. Passengers are assumed to always check luggage at the curbside. However, the ANOVA test shows that there is no significant difference in the service times between passengers who checked in online, and those that still need boarding passes. Therefore, all the curbside data can be grouped together. Although party size and number of bags do not seem to show significant results at a 95% confidence level, curbside only represents 28% of all the data collected on Sundays. When analyzing the number of bags per person per party size, it was found that the numbers are very similar. A party size of 1 has 1.54 bags per person, a party size of 2 has 1.19 bags per person, a party size of 3 has 1.61 bags per person. Although the data in Table 2 does not show party size and number of bags to be significant, the results from the data collection show that it is safe to assume they are. The correlation between number of bags and party size is 0.653 at a p-value < 0.001. Therefore, the data was pooled using party size in order to get accurate distributions.

Party sizes of three, four, and five did not occur as often as party sizes of one or two. An ANOVA test was used to find if there is a significant difference between the service times of a party of three, four, or five. Table 3 shows the results for the ticket counter inside and the curbside process.

The results show that there is no significant difference between service times for a party of three, four, or five. The data was pooled for these party sizes in order to get an accurate distribution.

4. SIMULATION MODEL

Simulation is very useful tool in predicting the constant changes occurring at airports. All passengers behave differently, with experience being a key factor. Their actions are therefore difficult to predict. Simulation allows for the modeling of different passenger behaviors, as well as accounting for staffing schedules and changes in passenger volumes depending on time of day or day of the week (Verbraeck and Valentin, 2002.)

4.1 Model Development

Within the check-in process alone, passengers are faced with many decisions: whether to use the curbside skycap or go the inside ticket counter, whether to use the kiosk or counter, or whether to check-in online from their personal computers at home. The simulation model shown in Figures 2 and 3 considers all these possibilities. All passengers enter the system in the arrival node and are assigned an inter arrival distribution. The decide nodes uses n-way by chance to assign percentages to passengers that are use the express kiosk, kiosk with a party size 1, party size 2, or party size 3+, counter with a party size 1, party size 2, or party size 3+, and online with a party size 1, party size 2, party size 3+. Once the passenger has chosen a check-in mode, they are assigned a distribution for their service time. Since all the check-in modes share the same queue, they must first seize the first place spot in line (denoted "seize first place" and the check-in mode). At the end of the process, all passengers must proceed to the security checkpoint. The flow of the check-in modes is as follows:

Express Kiosk: The passenger using the express kiosk (not checking any bags) must seize the express kiosk, release the first place spot in the queue, delay the time it takes to leave the queue and start the service time. The passenger uses the express kiosk to check-in, and then releases the kiosk for the next customer.

Kiosk: Passengers using the kiosk must seize the kiosk, release the first place spot in the queue, delay the time it takes to leave the queue and start the service time. The passenger at the kiosk then decides if they have a bag. If yes, they will continue using the kiosk to check-in their bags. They must then release the kiosk and seize the counter in order to weigh their bags and attach the bag tags that list the bag's final destination. If the passenger does not have to check bags, they will release the kiosk to the next passenger and go to the security checkpoint.

Online: An online passenger is only part of this system if they have bags. If they do not have bags, they can directly proceed to the security check since they already have their boarding pass. An online check-in passenger with bags still needs to utilize the kiosk. However, the kiosk has an option of "Check Bags Only," that an online passenger would choose. Their service time at the kiosk is therefore different than that of a passenger completing their entire check-in process at the kiosk. They must also release the kiosk and seize the counter in order to weigh their bags and attach the bag tags.

Counter: Passengers using the counter must seize the counter, release the first place spot in the queue, delay the time it takes to leave the queue and decide if they are checking bags. For this process, we did not distinguish between the exact times the passenger started checking bags. However, we did note if they were checking bags and the quantity of bags. Therefore, the service times for a passenger at the counter that does not have any bags to check differs from the service time at the counter of a passenger that does.

Curbside: Passengers that choose the curbside check-in have their own inter arrival times. The decide node tells the percentage of customers with a party size of 1, 2, 3 or more. The customers are then assigned a service time. The must seize the curbside counter and start the service time. The assumption is made that all curbside passengers check bags.

When running the simulation, 100 replications were made with a run time of 2.5 hours. A warm up time of 1.5 hours was chosen because there was one flight on Sundays that departs at 3:10pm. Passengers for this flight may still be checking in at 2:30pm (the start of the data collection), which does not make the system empty and idle.

4.2 Scenario Analysis and Results

Throughout the data collection process, observations were made that may be causing delays within the system. The express kiosk, which is used only for those customers that are not checking bags (mostly business travelers), limits the number of available kiosks for passengers with bags to only five. Therefore, scenario A looks at removing the express kiosk and making it a regular check-in kiosk.

Southwest is known for a different seat assignment procedure than most airlines. As noted in Figure 1, customers often choose to check-in online in order to obtain the zone A seating and be among the first passengers to board the plane. A passenger can utilize the online check-in procedure for their flight 24 hours in advance, giving them the opportunity to obtain a zone A boarding pass.

However, if Southwest Airlines chooses to remove this zone assignment procedure, the advantage to checking in online has decreased, unless you are passenger traveling without checked luggage. Even if you check-in online, you would still have to enter the queue, wait in line, use the kiosk to check-in, and use the counter to weigh your bags and obtain the bag tags. Therefore, if the zone assignment procedure is removed, the number of online passengers would most likely decrease. Scenario B looks at the possibility of a 10% decrease in online check-ins.
Customers that lack experience with the kiosks usually choose to use the counter to check-in. However, ticket agents are highly encouraging the use of kiosks and will even come around the ticket counter to show a passenger how the kiosk works. However, this takes time. The simulation shows that the counter is one of the slowest processes with the longest waiting time. Scenario C looks at removing the counter completely as a check-in option. The counter will only be used for weighing bags and printing bag tags, as well as special purposes (buying tickets, extra assistance, etc). Note that no changes were made to the curbside process, and therefore only results from the inside ticket counter process are shown. The scenarios and their results, along with the analysis of the combination of scenarios, are shown in Tables 4 and 5. Table 4 shows that scenario C (removing the counter as a check-in option) has the lowest waiting times and lowest average time in system. Table 5 shows that eliminating the seating zone assignments and the counter as a check-in option (scenario BC) decreases the waiting times and average time in system even more. However, there is only about a 7 second decrease in the total average time in system when also decreasing the percentage of online check-ins by 10%. Therefore, if only considering one scenario, removing the counter as a check-in option would be optimal according to the results. The simulation can be used to test other scenarios that may improve the delays occurring in the check-in procedure.

5. FUTURE WORK

Since data was collected for Monday, Friday and Saturday as well, the same kind of analysis can be performed for those days. The airline can use the results to change the check-in procedure specific to the day. For example, the express kiosk may be an optimal check-in mode for Monday travelers, since business travelers usually do not check-in luggage. Friday and Saturday passengers may consist more of leisure travelers that have more luggage to check-in. The simulation results can be used to analyze how the days of the week differ.

Another scenario option is controlling the arrival rate. If an airline decided only to let their passengers' check-in 1.5 or 2 hours in advance, the simulation could be used to show the results for such an analysis.

Staffing schedules can also be taken into consideration. The check-in times, especially bag weighing and tag printing times, are often dependent on the number of employees working. Curbside is especially affected by the number of people servicing the customer.

Our goal is to expand the airport research to include the parking and initial arrival of the passenger before the check-in process. Combining this information with the check-in process and security checkpoint can give an overview of a passenger's entire experience at the airport. A time window analysis can be performed by collecting data on the departure time of a passenger's flight, along with their service times and waiting times for these processes. This can give an estimate of the percent chance of making a flight when arriving X minutes in advance of flight departure.

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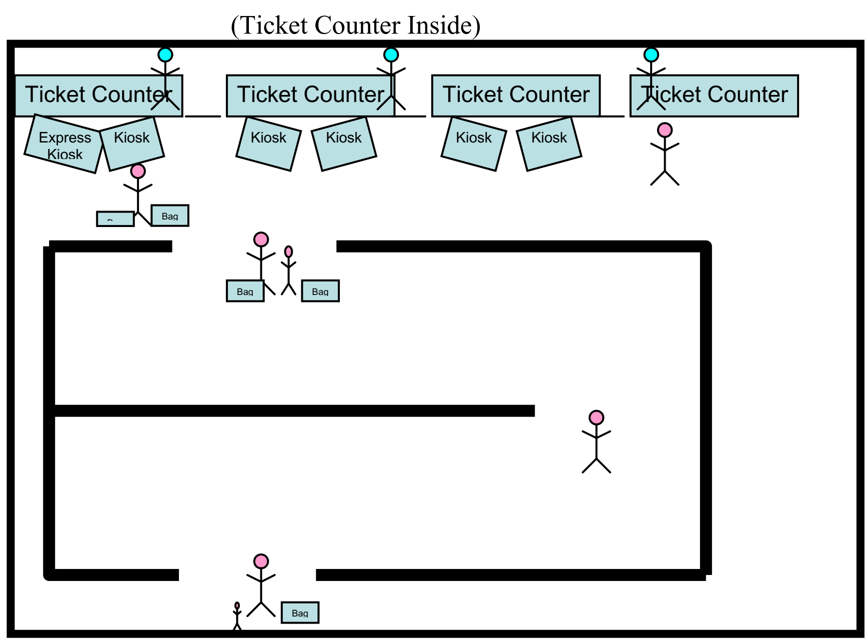
Note that Southwest Airlines does not have a separate line for business/elite travelers due to its zone assignment procedure. Customers are given a zone (A-C) depending on when they checked-in prior to their departure times, with zone A assignment boarding first, B second, and C last. Once a passenger boards, he/she then choses any available seat and is therefore not given seat assignment upon check-in.



(Curbside Check-in Outside)

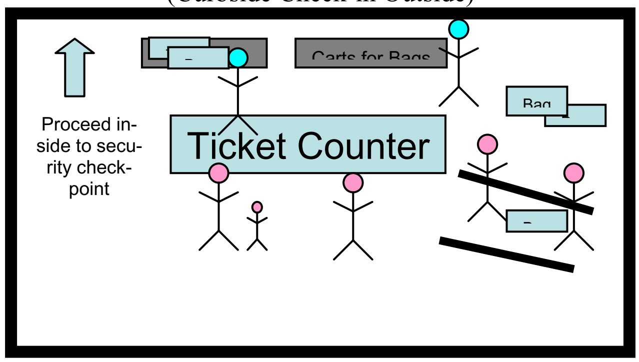


Figure 1: Southwest Airline Layout at Buffalo Niagara International Airport

Table 1: ANOVA General Linear Model: Service Time versus Num Bags, Party Size, Mode

Factor	Type	Levels	Values
Num Bags	fixed	7	0, 1, 2, 3, 4, 5, 6
Party Size	fixed	5	1, 2, 3, 4, 5
Mode	fixed	4	1, 2, 3, 4

Analysis of Variance for Service Time, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Num Bags	**6**	**219921**	**65830**	**10972**	**3.23**	**0.005**
Party Size	4	12806	455	114	0.03	0.998
Mode	3	256657	256657	85552	25.22	0.000
Error	129	437521	437521	3392		
Total	142	926905				

S = 58.2378 R-Sq = 52.80% R-Sq(adj) = 48.04%

Table 2: General Linear Model: Service Time versus Party Size, Number of Bags, Mode

Factor	Type	Levels	Values
Party Size	fixed	4	1, 2, 3, 4
Number of Bags	fixed	8	1, 2, 3, 4, 6, 8, 9, 12
Mode	fixed	2	1, 2

Analysis of Variance for Service Time, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Party Size	3	88173	29100	9700	2.21	0.091
Number of Bags	7	57805	57029	8147	1.86	0.084
Mode	1	1401	1401	1401	0.32	0.573
Error	106	464389	464389	4381		
Total	117	611768				

S = 66.1893 R-Sq = 24.09% R-Sq(adj) = 16.21%

Table 3: ANOVA General Linear Model Service time vs. Party Size

Ticket Counter Inside:

Factor	Type	Levels	Values
Party Size	fixed	3	3, 4, 5

Analysis of Variance for Service Time 2, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Party Size	**2**	**506.3**	**506.3**	**253.2**	**1.18**	**0.458**
Error	2	428.5	428.5	214.3		
Total	4	934.8				

S = 14.6373   R-Sq = 54.16%   R-Sq(adj) = 8.32%

Curbside:

Factor	Type	Levels	Values
Party Size	fixed	3	3, 4, 5

Analysis of Variance for Service Time, using Adjusted SS for Tests

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Party Size	2	66406	66406	33203	19.74	0.157
Error	1	1682	1682	1682		
Total	3	68088				

S = 41.0122   R-Sq = 97.53%   R-Sq(adj) = 92.59%

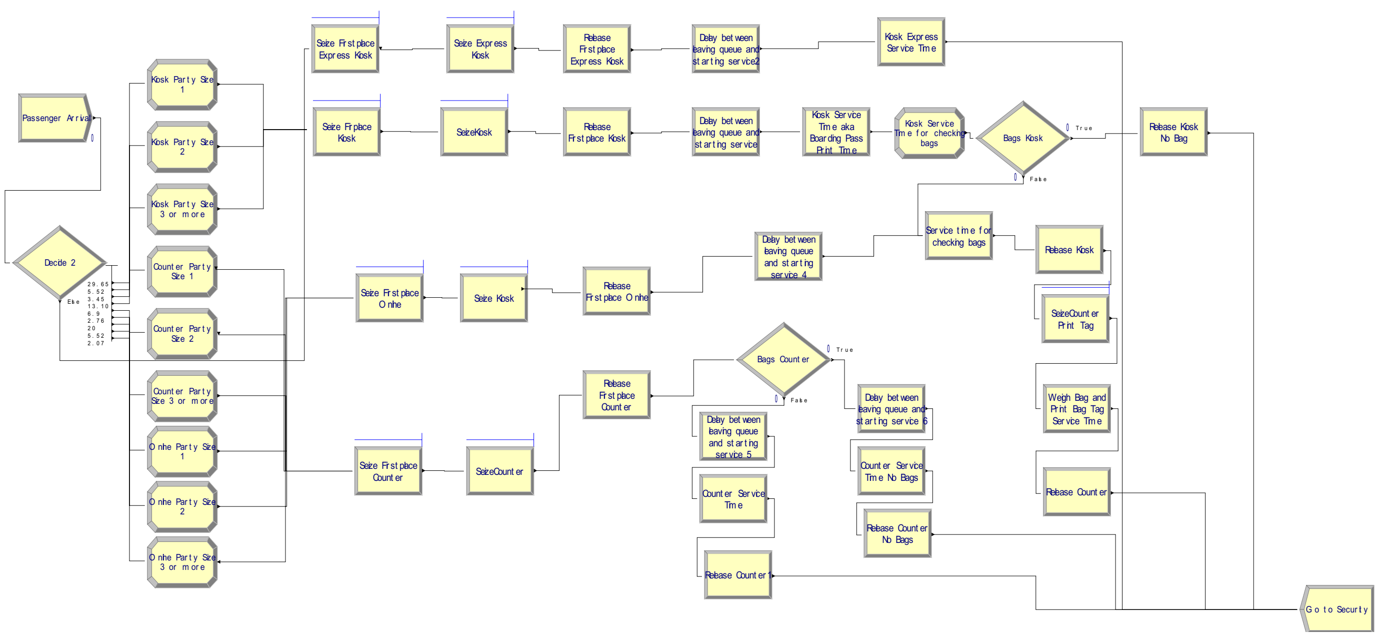


Figure 2: Simulation Model Layout using Arena (Inside Ticket Counter)

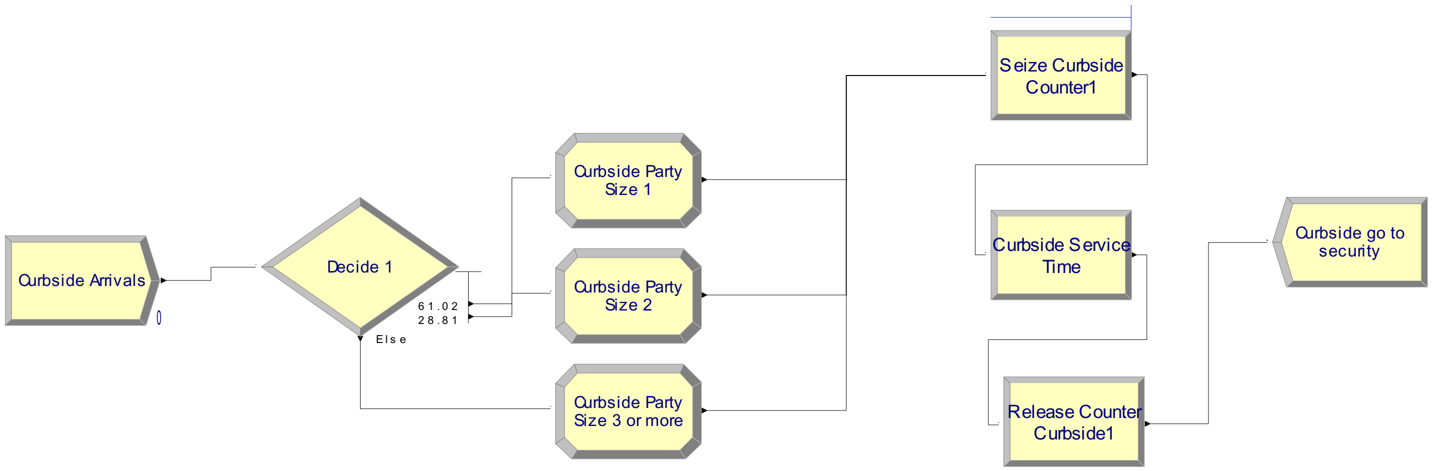


Figure 3: Simulation Model Layout using Arena (Curbside)

Table 4: Scenario Analysis and Results

Letter	Scenario	Programming Effort	Performance Measures	Simulation Execution	Decision Analysis	Confidence Intervals
0	Baseline	Original	Total Average Wait Time Average Time in Queue Total Average Time in System	Run baseline	Total Average Wait Time: 24.3 seconds Average Time in Queue: -Kiosk: 5.49 seconds -Counter: 27.74 seconds -Express Kiosk: 8.70 seconds Total Average Time in System: 158.85 seconds	Total Average Wait Time: Average Time in Queue: -Kiosk: -Counter: -Express Kiosk: Total Average Time in System:
A	Eliminate Express Kiosk, replace as regular kiosk	System Change, Data Change	Total Average Wait Time Average Time in Queue Total Average Time in System	Add 11.03% express kiosk check-in to kiosk check-ins party size 1 Change kiosk capacity to 6	Total Average Wait Time: 47.47 seconds Average Time in Queue: -Kiosk: 15.283 seconds -Counter: 49.30 seconds -Express Kiosk: N/A (removed) Total Average Time in System: 191.02 seconds	Total Average Wait Time: Average Time in Queue: -Kiosk: -Counter: -Express Kiosk: Total Average Time in System:
B	Discard Seating Zone assignment, decrease % of online check-ins	Data Change	Total Average Wait Time Average Time in Queue Total Average Time in System	Decrease the % online check-ins by 10% and add to kiosk check-ins	Total Average Wait Time: 27.45 seconds Average Time in Queue: -Kiosk: 6.51 seconds -Counter: 30.76 seconds -Express Kiosk: 9.98 seconds Total Average Time in System: 159.65 seconds	Total Average Wait Time: Average Time in Queue: -Kiosk: -Counter: -Express Kiosk: Total Average Time in System:

C	Remove Counter as a check-in Option (Counter only used to weigh bags, print bag tags, and special needs)	System Change, Data Change	Total Average Wait Time Average Time in Queue Total Average Time in System	Remove the counter as a check-in option and add the counter % to the kiosk check-ins.	Total Average Wait Time: 7.53 seconds Average Time in Queue: -Kiosk: 0.28 seconds -Counter: 8.76 seconds -Express Kiosk: 3.72 seconds Total Average Time in System: 129.96 seconds	Total Average Wait Time: Average Time in Queue: -Kiosk: -Counter: -Express Kiosk: Total Average Time in System:

Table 5: Scenario Analysis and Results of Combinations

AB	Eliminate Express Kiosk and discard Seating Zone assignment	System Change, Data Change	Total Average Wait Time Average Time in Queue Total Average Time in System	Eliminate the express kiosk and add % to kiosk party size 1. Descrease % online check-ins by 10% and add to kiosk check-ins.	Total Average Wait Time: 41.08 seconds Average Time in Queue: -Kiosk: 11.91 seconds -Counter: 43.69 seconds -Express Kiosk: N/A (removed) Total Average Time in System: 180.28 seconds	Total Average Wait Time: Average Time in Queue: -Kiosk: -Counter: -Express Kiosk: Total Average Time in System:
AC	Eliminate Express Kiosk and remove Counter as check-in option	System Change, Data Change	Total Average Wait Time Average Time in Queue Total Average Time in System	Eliminate the express kiosk and add % to kiosk party size 1. Change kiosk capacity. Remove counter as check-in option and add % to kiosk check-ins.	Total Average Wait Time: 10.82 seconds Average Time in Queue: -Kiosk: 0.00 seconds -Counter: 11.89 seconds -Express Kiosk: N/A (removed) Total Average Time in System: 137.31 seconds	Total Average Wait Time: Average Time in Queue: -Kiosk: -Counter: -Express Kiosk: Total Average Time in System:
BC	Discard Seating Zone assignment and remove Counter as check-in option	System Change, Data Change	Total Average Wait Time Average Time in Queue Total Average Time in System	Decrease the % online check-ins by 10% and add to kiosk check-ins. Remove counter as check-in option and add % to kiosk check-ins.	Total Average Wait Time: 7.0159 seconds Average Time in Queue: -Kiosk: 0.33 seconds -Counter: 8.376 seconds -Express Kiosk: 3.956 seconds Total Average Time in System: 122.8 seconds	Total Average Wait Time: Average Time in Queue: -Kiosk: -Counter: -Express Kiosk: Total Average Time in System: