ISE 580 Performance Analysis with Simulation

Instructor: Dr. Saeideh Fallah-Fini

AIRPORT SECURITY WITH ARENA

Final Project Report

Group 8: Fangjie Qi Tianxiao Yu Shaoqian Chen Junxuan Fu

Contents

Figures and Tables

1. Introduction

1.1Background

A new terminal is being added to the existing airport design. There is just enough space to develop the new terminal adjacent to Terminal 3 (T3). The diagram below depicts the proposed Terminal 4 (T4). A major concern for the airport operations team is the design of the security check-point(s). The security check-points have become major bottlenecks in the system due to increased mandatory security procedures. Currently, each terminal in the airport has its own security check-point. Travelers frequently complain of long lines and congestion in this area. A primary question that RA must answer is whether the new terminal should have an independent security check-point, or a single shared security check-point for T4 and T3. Currently, T3 caters to three major airlines; Fabulous Flights, Premium Planes and Jolly Jets. T4 will service two additional airlines; Wild Wings and Airborne Airlines.

1.2Problem description

The aim of this project is to simulate the flow of travelers through airport check and security process to provide a solution that reduces the time travelers spend in the airport from the point of entrance to the time of boarding. Rather than providing a single solution, we have discussed various models under different criterions like the entry and exit time of arrival and exit of devotees respectively and total number of queue lines. Out of all those simulation models, the best and viable solution can be considered.

1.3Basic assumptions

- Assuming customer left each courter at its midpoint, which is 25 meters away from the counter's edge;
- Assuming the right side of Moving Sidewalks 1 is at the same position as the right of Counter 3;
- Assuming people from all counters have to walk/transport to the right side of Moving Sidewalks 1 in order to enter Security 3(Distance between Security 3 and Moving Sidewalks Right = 50 meters);
- Assuming Security 3 has no width;

- Assuming the process time of recheck people's ID is TRIA(1,2,5);
- Assuming the length of scanner conveyor is 10 meters; Assuming the speed of baggage scanner conveyor is 0.22m/s (https://www.foodgrademetaldetector.com/sale-10417060-conveyor-belt-security-x-ray-luggage-scanner-screening-machine-for-airport.html)
- Assuming customers in both People Scanner lines are included in Scanner Waiting Area.

2. Simulation Modelling

2.1 Scenario 0 (Terminal 3 with 3 airlines)

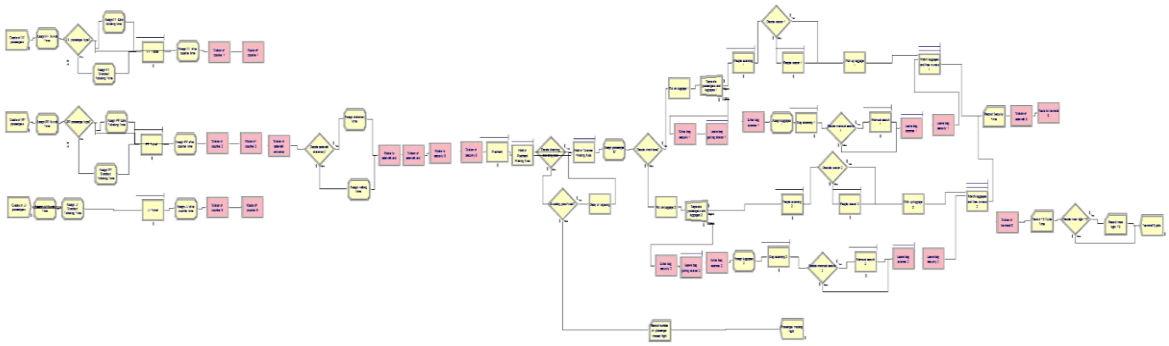

Figure 2.1: Scenario 0 Model

2.2 Scenario 1 (Terminal 3 and Terminal 4 with only security 3)

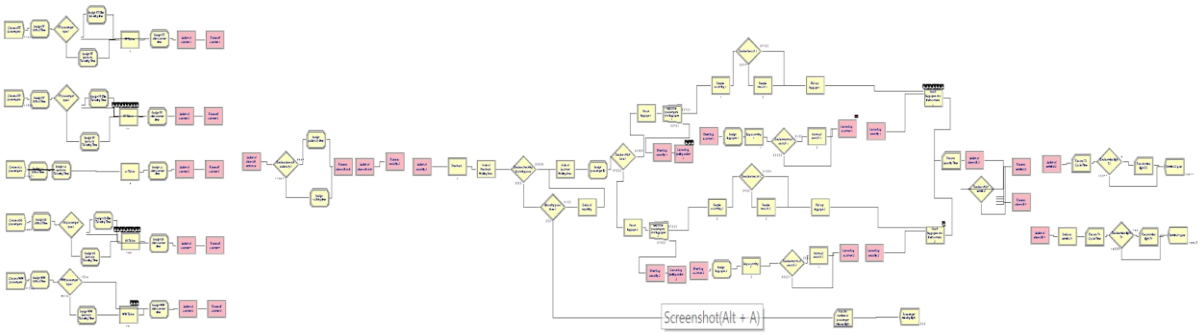

Figure 2.2: Scenario 1 Model

2.3 Scenario 2 (Terminal 3 and Terminal 4 with security 3 and security 4)

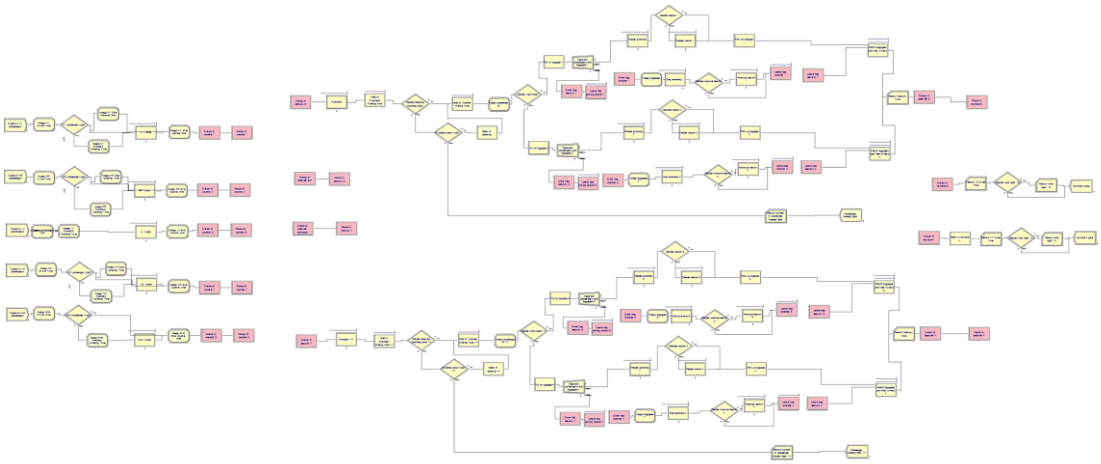

Figure 2.3: Scenario 2 Model

3 Simulation Results and Analysis

3.1 Scenario 0

Scenario 0 shows the present layout of the airport. Terminal 3 services the existing three airlines, FF, PP and JJ (short for Fabulous Flights, Premium Planes and Jolly Jets). We have three counters and one security checkpoint in Terminal 3. To start off the evaluation of Scenario 0, we have fixed the capacity of each check in counter in schedule of 2, 3 or 4 hours range. The capacity matches the flow of passengers that reduces congestion in the process.

In addition, by trial and error process, we fixed capacity of bag scanners, people scanners and manual bag search to 3 each. That reflects the lowest capacity we can do to meet the satisfactory security waiting time. Precheck officer is fixed at 5 as well. We will fix all these capacities in the whole simulation. The simulation runs for 7 days and 4 replications for a conclusive result.

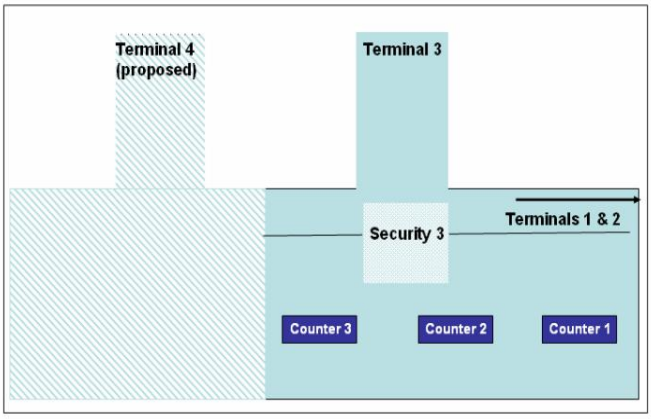

Figure 3.1: Layout of Scenario 0

	Counter 1	Counter 2	Counter 3	Security Time	95% CI Security	Cycle Time	Miss Rate
	FF	PP	JJ	0.2167	+/-0.00	0.5161	0.44%
	PP	FF	JJ	0.2132	+/-0.01	0.5044	0.48%
	PP	JJ	FF	0.2169	+/-0.01	0.5137	0.45%
	FF	JJ	PP	0.2191	+/-0.01	0.5123	0.47%
√	JJ	FF	PP	0.2152	+/-0.01	0.5020	0.44%
	JJ	FF	FF	0.2208	+/-0.00	0.5138	0.49%

Table 3.1: Time Varicosity of Different Counters Order of Scenario 0

Layout Redesign: The above table shows the variation of counter placement with security/Cycle time and miss flight rate. Per simulation, it is more efficient to place JJ at counter 1, FF at counter 2 and PP at counter 3. Average cycle time and miss flight rate drops to the lowest among 6, and average security time drops to the second lowest. The placement satisfies the passengers with security time of 0.2152 hour and 0.44% missed flight rate. Per observation, we have no more than 160 passengers waiting in line at each check in counter at a time. As a result, a waiting area is sufficient for 200 people shall be provided in front of each counter. That would avoid chaos most of the time near the check in areas, even in peak season.

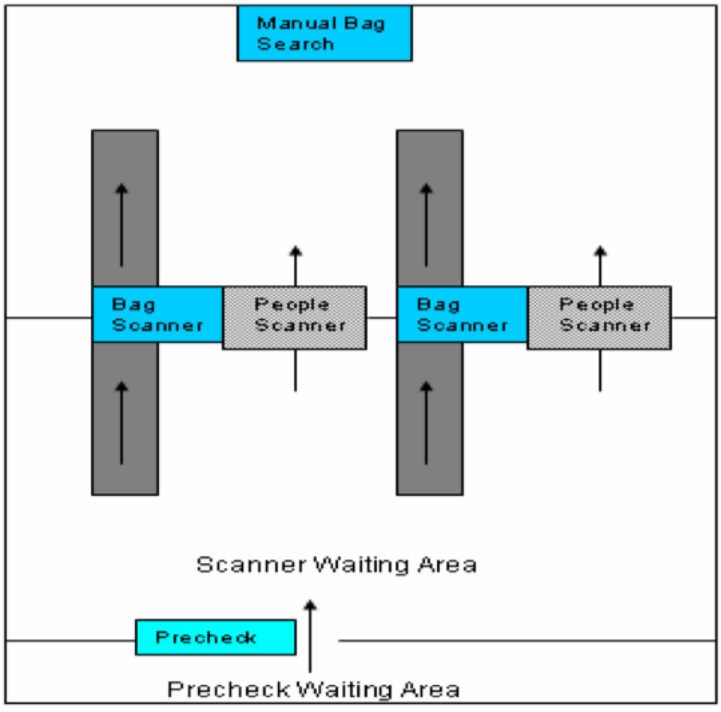

Figure 3.2: Layout of Waiting Area

The next major process in simulation is the security check. This is an area including precheck, bag scanner and people scanner. We have fixed the scanner waiting area to 60 in order to match the capacity of bag scanners, people scanners and manual bag search. Precheck waiting area was observed up to 500 passengers waiting in line. We shall provide a space for 700 passengers in order to avoid chaos.

Adding priority line for elite passengers makes no difference in security time and cycle time in Scenario 0. We have picked the best simulation model in Layout Redesign to test for difference with or without priority lines for elite passengers.

Arrived time before the flights: The recommended arrival time before the flights is 45 minutes in advance. That represents the average cycle time of passengers spend in airport plus 15 minutes pre boarding time.

3.1 Scenario 1

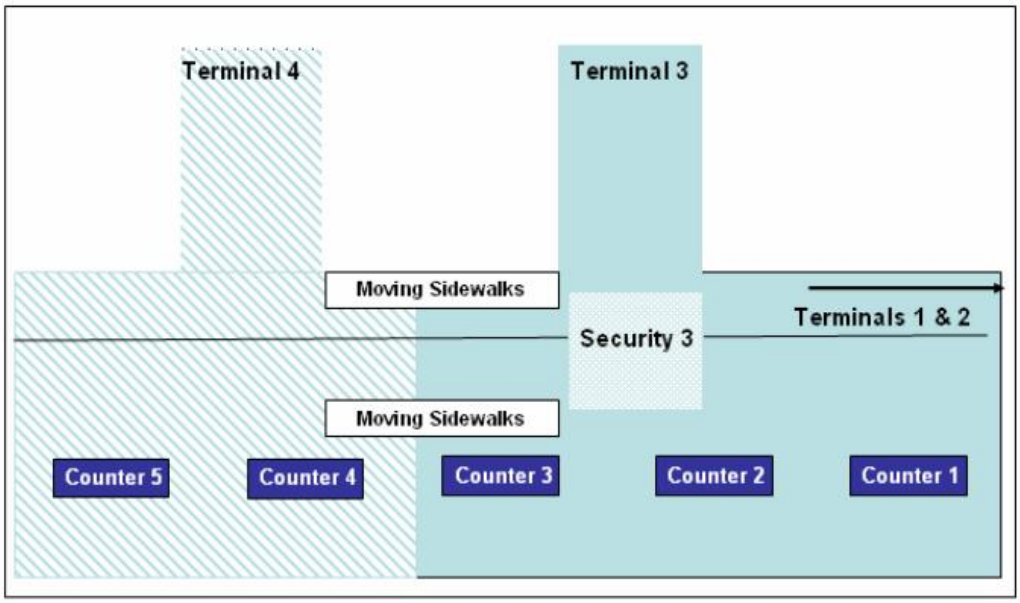

Figure 3.3: Layout of Scenario 1

Layout Redesign

Part A

We start testing our system by setting up only one security area which includes 20 spaces in Precheck Waiting Area and 16 spaces in Scanner Waiting Area. The results of running this model for 7 days showing that the security cycle took

passengers more than 5 hours to complete. Then we fix the Capacity at Precheck into 10, and increase the number of Bag/People Scanner system (includes 2 Bag Scanner and 2 People Scanner) by one at a time. When we reach 4 Scanner system, the result rapidly drop into the designated zone, which is on average, passengers spend less than 24 mins in security system and 90% CI of average security cycle time is less than 45 mins. Later on we test the precheck capacity at 9 and decrease by 1 at a time. As the capacity hit 7, the system fit the standard of Security Time the most. Thus, we decided to choose 4 Walking Area with a capacity of 80 each and 4 Scanner Walking Area with a capacity of 64 each.

Part B

After we determined the optimized capacity of each resource in the security area, we swapped each airline's counter in both terminal and run all 12 possible cases 7 days per replications for 4 replications in order to simulate the operation of Airport within a month. The results are shown in the following chart:

	A	B	C	D	E	F	G	H	I	J	K	L	M
1		Flight Counter											
2	FF	PP	JJ	AA	WW		Total Time	Half Width	Security Time	Half Width	Missing Flight	Number Out	Missing Rate
3	1	2	3	4	5		0.6066	0.04	0.281	0.03	941.5	135579	0.6944290782
4	1	3	2	4	5		0.6188	0.05	0.2845	0.02	1062.75	135779	0.7827057203
5	2	1	3	4	5		0.5897	0.04	0.2681	0.03	828.25	135490	0.6112997269
6	2	3	1	4	5		0.6018	0.02	0.2808	0.02	931.25	135832	0.6855895518
7	3	1	2	4	5		0.6013	0.05	0.2694	0.02	1029.25	135509	0.7595436465
8	3	2	1	4	5		0.5998	0.04	0.2788	0.02	935.5	135637	0.6897085603
9													
10													
11	1	2	3	5	4		0.5946	0.04	0.2682	0.02	905.5	135708	0.6672414301
12	1	3	2	5	4		0.6109	0.04	0.2845	0.03	1115	135715	0.8215746233
13	**2**	**1**	**3**	**5**	**4**		**0.5892**	**0.03**	**0.2777**	**0.03**	**876**	**135720**	**0.6454465075**
14	2	3	1	5	4		0.5985	0.03	0.2798	0.02	842.25	135387	0.6221055197
15	3	1	2	5	4		0.5893	0.03	0.2665	0.03	938	135520	0.6921487603
16	3	2	1	5	4		0.5951	0.03	0.2638	0.01	935	135654	0.6892535421
17													

Table 3.2: Time Varicosity of Different Counters Order of Scenario 1

From the chart above, we found that the winning case is:

Counter 1: Premium Planes

Counter 2: Fabulous Flights

Counter 3: Jolly Jets

Counter 4: Wild Wings

Counter 5: Airborne Airlines

In this case, passengers will spend 0.5892 hour in the whole airport system on average; passengers will spend 0.2777 hour in the whole security check system on average. Furthermore, only 0.64544% of passengers who enter our airport miss their flight.

These numbers are the lowest in all 12 cases. Therefore, our chosen case is the most efficient set up of the airport in scenario 1.

Arrival Priority Line for Elite Passengers

We choose the optimal situation we get to analyze the impact of priority. when a priority line gets created through security precheck for elite passengers, the cycle time, security time, and missing rate become as following:

Total Time	Half Width	Security Time	Half Width	Missing Flight	Number Out	Missing Rate
0.5937	0.02	0.2723	0.03	864.5	135770	0.636738602

Table 3.3: Total time of all airlines under elite passengers' settings

The security time and missing rate are still in the preferred range, while the total time increases. Although elite passengers have shorter cycle time due to priority, overall, the model without priority performs better.

Arrival Time Before the Flights

Interval	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
Cycle Time	0.5897	0.04	0.5615	0.6106	0.1431	9.7944

The recommended arrival time before the flight is cycle time plus 15 minutes before flights departs, which is 0.8397 hour. It varies between each airline, since total time is different.

Total Time	Average	Half Width	Minimum Average	Maximum Average	Minimum Value	Maximum Value
AA passenger	0.8659	0.07	0.8097	0.9147	0.03593268	9.7944
FF Passenger	0.6128	0.07	0.5750	0.6679	0.02304550	3.5042
JJ passenger	0.4472	0.02	0.4362	0.4567	0.05641261	1.5231
PP passenger	0.5876	0.04	0.5586	0.6126	0.03703615	2.8821
WW passenger	0.5264	0.02	0.5094	0.5391	0.05006609	1.6146

Therefore, the recommended arrival time before the flight is 1.1159 hour, 0.8628 hour, 0.6972 hour, 0.8376 hour, and 0.7764 hour for AA passenger, FF passenger, JJ passenger, PP passenger, and WW passenger, respectively.

3.2 Scenario 2

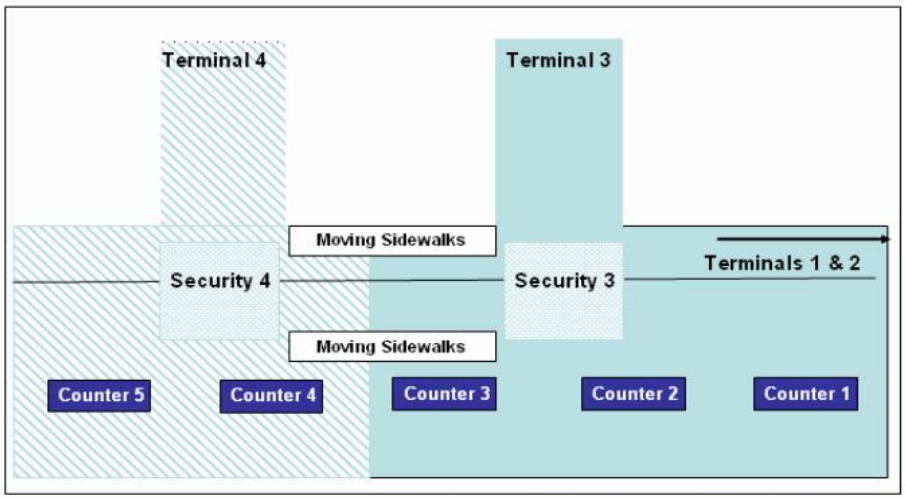

Figure 3.4: Layout of Scenario 2

Layout redesign

Part A:

For this case, we assume that one scanning area has room for 10 people and contains a pair of bag scanner and people scanner and one manual bag search. Our aim is to reduce security time of 95% of all passengers to be less than 45 minutes (and 45+24=69 minutes at worst). Besides, less than 1% of all passengers who would miss the flight will be another important condition we observe.

By duplicating one single scanning area (precheck process is not included), more waiting area is allocated. To achieve this, we decided to change the capacity of each resources, e.g. bag scanner, people scanner and manual bag search.

Resource - Basic Process			
	Name	Type	Capacity
1	Bag Scanner 1	Fixed Capacity	3
2	People Scanner 1	Fixed Capacity	3
3	Mannual bag search	Fixed Capacity	3
4	Bag Scanner 2	Fixed Capacity	3
5	People Scanner 2	Fixed Capacity	3

Figure 3.4 Resources Capacity of Each Resources

Because in scenario 2, there exist 2 terminals, for terminal 3 with 3 airlines, adding 8 more resources for each type of resources (except precheck staff) will significantly

change the number of people in the queues. Also, if adding 9 more people is applied, there is only a slight improvement for this case. Thus, we changed the number of all resources in security check into 3 and precheck staff into 9. As regard to terminal 4, we need 2 pairs of scanners and 5 precheck officers.

Part B.

Counter No.	1	2	3	4	5	Total Time (h)	Security Time (h)	Missing Flight Rate (%)
Airline	Fabulous Flight	Premium Planes	Jolly Jets	Airborne Airlines	Wild Wings	0.4274±0.04	0.1136±0.01	0.52±0.09
	Fabulous Flight	Jolly Jets	Premium Planes	Airborne Airlines	Wild Wings	0.4353±0.04	0.1212±0.02	0.50±0.07
	Premium Planes	Fabulous Flight	Jolly Jets	Airborne Airlines	Wild Wings	0.4194±0.02	0.1139±0.02	0.54±0.03
	Premium Planes	Jolly Jets	Fabulous Flight	Airborne Airlines	Wild Wings	0.4324±0.04	0.1237±0.02	0.53±0.05
	Jolly Jets	Fabulous Flight	Premium Planes	Airborne Airlines	Wild Wings	0.4422±0.06	0.1259±0.02	0.51±0.07
	Jolly Jets	Premium Planes	Fabulous Flight	Airborne Airlines	Wild Wings	0.4436±0.05	0.1336±0.04	0.49±0.10
	Fabulous Flight	Premium Planes	Jolly Jets	Wild Wings	Airborne Airlines	0.4434±0.05	0.1174±0.02	0.48±0.08
	Fabulous Flight	Jolly Jets	Premium Planes	Wild Wings	Airborne Airlines	0.4320±0.02	0.1220±0.01	0.53±0.07
	Premium Planes	Fabulous Flight	Jolly Jets	Wild Wings	Airborne Airlines	0.4316±0.02	0.1116±0.01	0.50±0.09
	Premium Planes	Jolly Jets	Fabulous Flight	Wild Wings	Airborne Airlines	0.4216±0.04	0.1136±0.01	0.52±0.09
	Jolly Jets	Fabulous Flight	Premium Planes	Wild Wings	Airborne Airlines	0.4324±0.03	0.1173±0.02	0.54±0.04
	Jolly Jets	Premium Planes	Fabulous Flight	Wild Wings	Airborne Airlines	0.4324±0.03	0.1173±0.02	0.54±0.04

Table 3.4: Time Varicosity of Different Counters Order of Scenario 2

After referring to table 3.4, it is safe to conclude that the best counter arrangement is following the order of Premium Planes, Fabulous Flight, Jolly Jets, Airborne Airlines and Wild Wings from counter 1 to counter 5. Although no obvious diversities of total time and security time can be observed between all different orders above, we can still find a slight advantage of this order over other cases.

Arrival Priority Line for Elite Passengers

Will adding priority lines for elite passengers do the change? Assigning a priority number to the attribute of different queues will let us observe the change. Only three airlines have elite passengers and we change the settings (Figure 3.5) of their check-in queues.

10	FF Ticket.Queue	Highest Attribute Value	priority number
11	JJ Ticket.Queue	First In First Out	Attribute 1
12	PP Ticket.Queue	Highest Attribute Value	priority number
13	AA Ticket.Queue	Highest Attribute Value	priority number
14	WW Ticket.Queue	First In First Out	Attribute 1

Figure 3.5: Assigning priority number attribute

Total Time (h)	Security Time (h)	Missing Flight Rate (%)
0.4250±0.04	0.1159±0.0	0.42±0.09

Table 3.5: Total time of all airlines under elite passengers' settings

We reached the conclusion that there is no need to arrange for an extra line especially for elite passengers, due to the consequences that no obvious improvement is recorded when compared with cases without elite priority assigned. There is also no need to test an extra elite line under other counters order conditions because whatever order the counters is, the change takes place only within a certain area but has no link to other routes and sidewalks.

Arrival Time Before the Flights

Total Time (h)				
Premium Planes	Fabulous Flight	Jolly Jets	Airborne Airlines	Wild Wings
0.4167±0.01	0.4585±0.06	0.3586±0.00	0.5614±0.04	0.3143±0.00

Table 3.6: Cycle Time of Different Airlines Under Scenario 2

We collected data under scenario 2 from different types of airlines and discovered that the recommended time ahead of schedule varies from airline to airline.

4 Conclusion and Lessons Learned

Performance Analysis with Simulation is the course the aim of which is to build the appropriate model with Arena under specific scenarios, and then by judging the simulation results, give suggestions to decide with what parameters does the model performs best.

As regard to this project, we analyzed 3 different scenarios, the original one and other two with 2 additional airlines. It is necessary to add one security area into terminal 4, based on the simulation results of both scenario 1 and scenario 2. Passenger satisfaction reaches its best under scenario 2, for both cycle time (time in total) and security time. Detailed information, layout design and testing results have been covered in previous chapter.

There is still space for the improvements of this project, after all, all concerns regarding to cost are ignored intentionally. However, budget plan is of great significance when it comes to decision making. The project almost covers all learning materials of this course and we believe it is well selected as the final project. Arena is a powerful tool to simulate sophisticate systems with plenty of modules and functions. Though we don't have enough time to go through all of them in class, we learned basic principles and logic behind this software and we can find the best module or function we need. For example, the "hold" module is a simple one we haven't discussed in class, but we found it is the best one to set a limit on the maximum number of a queue.

How to use Arena is simple, we just transform our demands into settings in Arena and make a run to observe the results. The hardest part is, however, best describing the scenario we want to simulate, and throughout the whole project, we now have an excellent example of a complete process from input to output and then the analysis.