Simulation Project Report

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EXECUTIVE SUMMARY

In this project, I mainly researched a small airport check-in and security process. As an international student, I have a lot of travel experience in the airport. Since I am quite familiar with the airport check-in and security process, I made up my mind to set this airport project as my simulation report.

The check-in and security process usually take much time for passengers which can cause congestion in the airport and more severely, even make the passengers delayed. At the airport, except for the traditional manual check-in system, a variety of systems are available to provide convenience for passengers, like the automated check-in machine which can assist travelers with relatively rapid procedures.

A simulation model based on ARENA is built for this airport check-in and security mimics. Numerous types of modules in Basic Process, Advanced Transfer and Advances Process are used in the model design. I aim to change each process resource capacity to make each queue smoothly which means each queue could have a shorter waiting time. Process Analyzer is used to compare the different resource number results. I change the resource number for each process to make the airport passenger towards to gate as soon as possible.

I. INTRODUCTION

At the airport, the queue waiting time is essential. Passengers must wait in the check-in and security station. When passengers continue to be in the waiting situation, the airport becomes increasingly crowded and at the same time, passengers become increasingly uncomfortable. Due to the increase in the number of tourists, it is expected that the problem of the adequate capacity of airport facilities and various difficulties in the operation of airport facilities is expected [1]. In order to solve this common problem, the airports are preparing various measures. For example, increase the resource number of security stations or change the resources from other stations to security to make the balance. In this research, I change each station resource number to get less waiting time for travelers.

In this system, passengers arrive at the airport at a time. Within these arriving passengers, they are divided into three parts: manual check-in station, automated check-in station and directly from the front door to security station. After the passengers go to the manual or automated check-in station, they will eventually get to the security area. Once through the security check, they all head to the gates. The details about the model will be illustrated in the next chapter.

II. Simulation Configuration

Here I introduce all the details about ARENA model. Now, I will first give an overall view of all the module's logic.

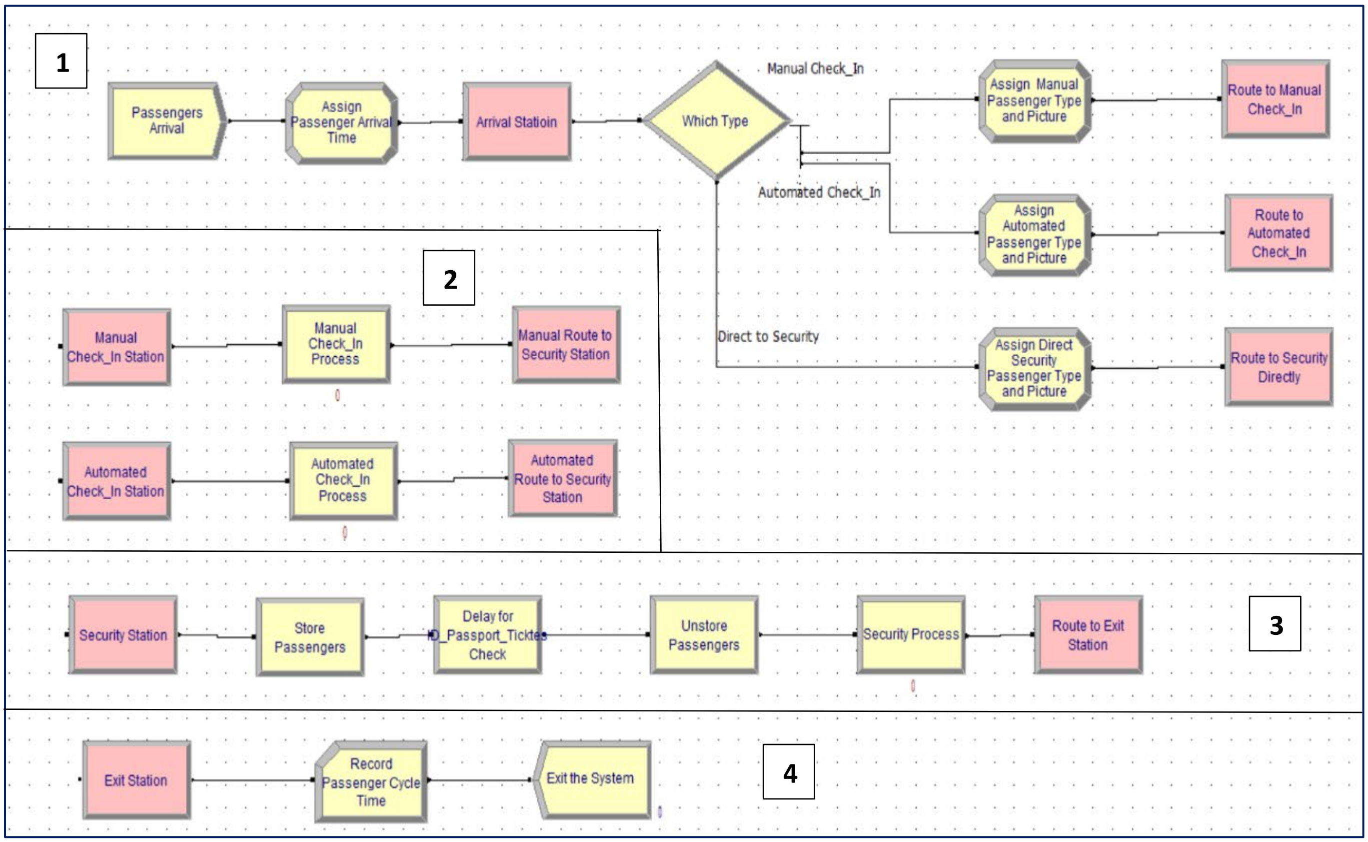

Figure 1. Overall Picture for the Model

Figure 1 is a simulation diagram. 1 is an Arrival Station that creates a passenger and enters the system. Also, it includes the decide module for the different types of passengers. 2 is the part for the check-in station (including manual check-in and automated check-in). 3 is the Security

Station where passengers get into the security process. 4 is the Exit Station where passengers leave the system.

I build 5 Station for Arrival Station, Manual Check-In Station, Automated Check-In Station, Security Station and Exit Station. For each Route Module to the next Station, they all have the traveling time. Since each part belongs to the separate station/area, I use the Station-Route combination instead of Seize -Delay-Release combination. [2]

The process I made is 3: Manual Check-In Process, Automated Check-In Process and Security Process. In the original model I set the Resources number for the above process as 2,2,3. And at each process queue, the passengers are fed by a single FIFO queue.

In the security Station part, there is a Store-Delay-Unstore Module which represents the passport, ID and ticket checking. This double-check is in the Security Station, so I use the Delay module to convey the time rather than the Station-Route combination.

2.1 Arena Simulation Module

2.1.1 Part 1 Arrival Station

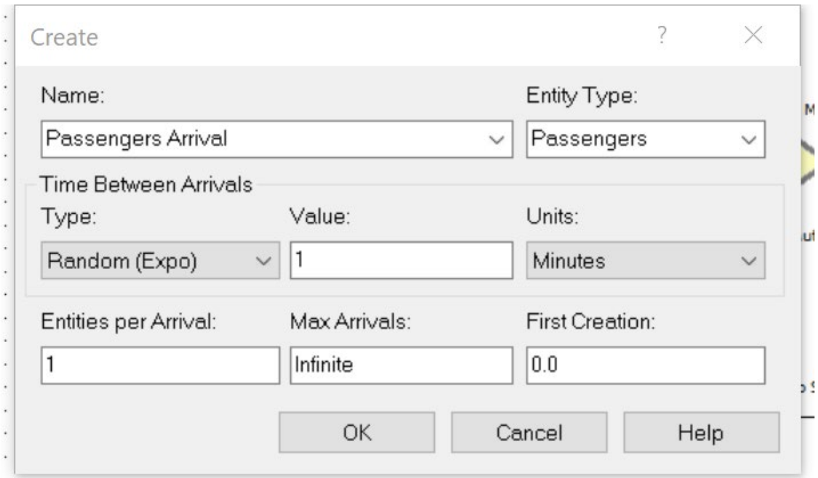

Figure 2. Passenger Creation Module

In the type of Time Between Arrivals area, Random (Expo) is selected which means that the arrival time interval will be generated according to the extraction of the random variable value, specifically the exponential distribution. Since the Arena version we use now is the student version, I set the time value as Expo (1) minutes to avoid the system entities too much. Enter 10 in the value field and Minutes in the Units field, which means 10 minutes. For the rest dialog box, I put the default.

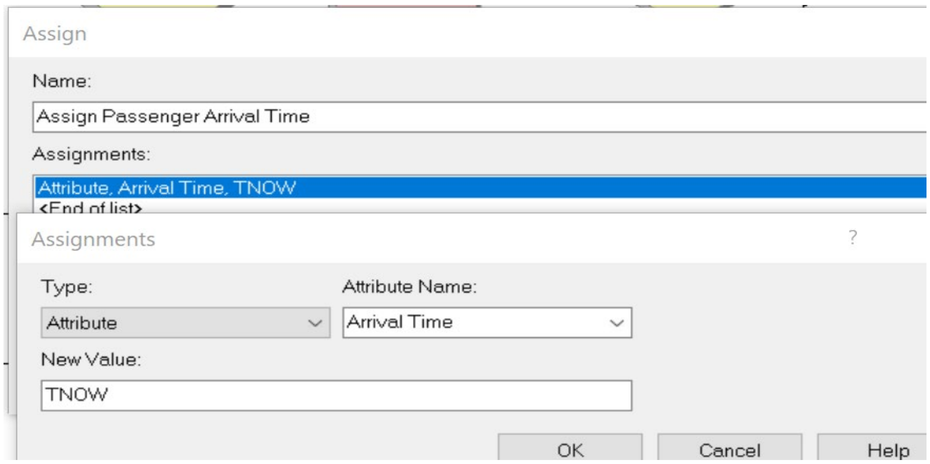

Figure 3. Assign Arrival Time

In the Assign Module, I assign the Attribute Arrival Time for the value of the current time which is TNOW in the dialog box. This Assign module is coordinated with the Record module at the end of this whole system.

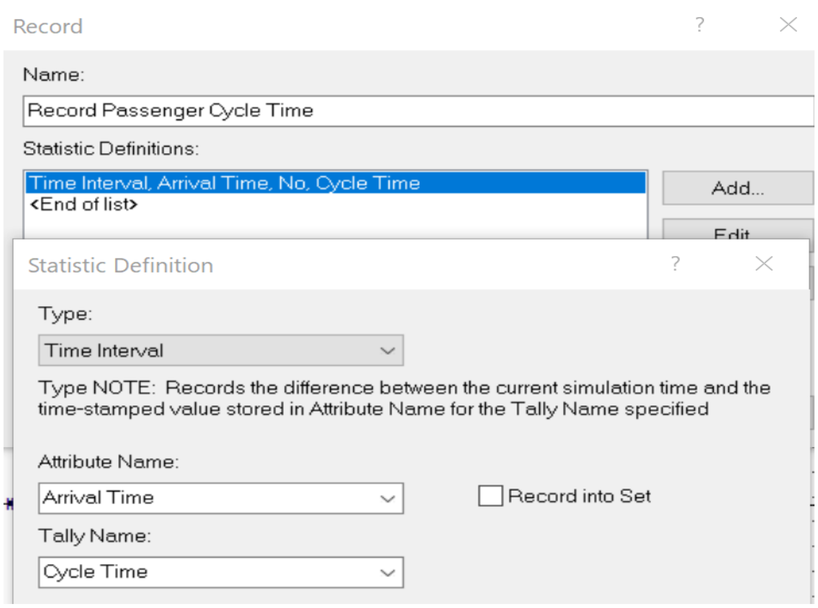

Figure 4. Record Cycle Time Module

In this Record Module, I choose the Type for Time Interval and choose the Attribute name for Arrival Time to calculate the passengers average time in the simulation system.

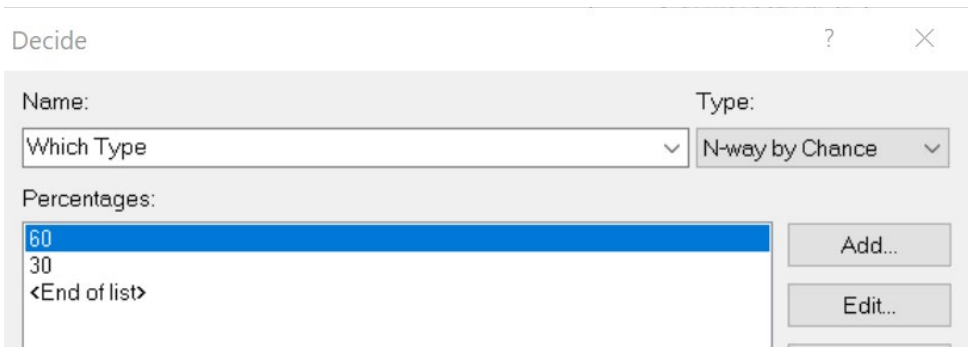

Figure 5. Decide Which Type Passengers Module

Among these passengers, 60% go to the old-fashioned manual check-in counter, 30% go right to the new automated check-in counter, and the remaining 10% do not need to check-in at all and they proceed directly from the arrival door to the security station.

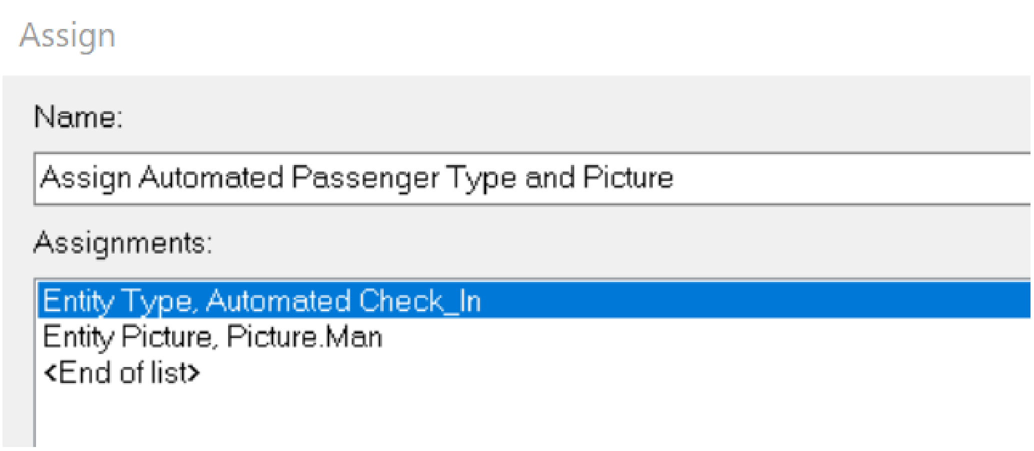

Figure 6. Assign Different Types of Passengers Entity Type and Entity Picture.

After the decide module, I assign each of the 3 types of passenger Entity Type and Entity Picture. The Entity type is for the future comparison and Entity Picture is used to show different animation pictures for each type. These three Assign modules are all the same except for the different names, types and pictures. I put the first Assign module Figure 6 as an example.

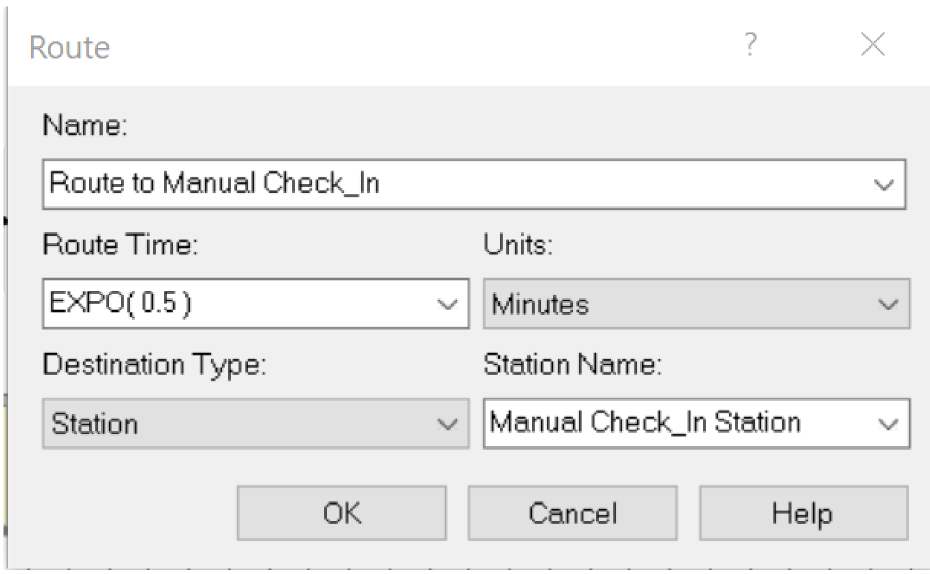

Figure 7. Route to the next Station Module.

In this part I put three Routes for the different types of passengers to the next Station. For passenger routes to the Manual Check-In Station, Automated Check-in Station and Security Station, the travel time for the passengers is all EXPO (0.5) Minutes.

2.1.2 Manual and Automated Check-In Station

Here I will introduce the details about the Manual and Automated process and Route Module.

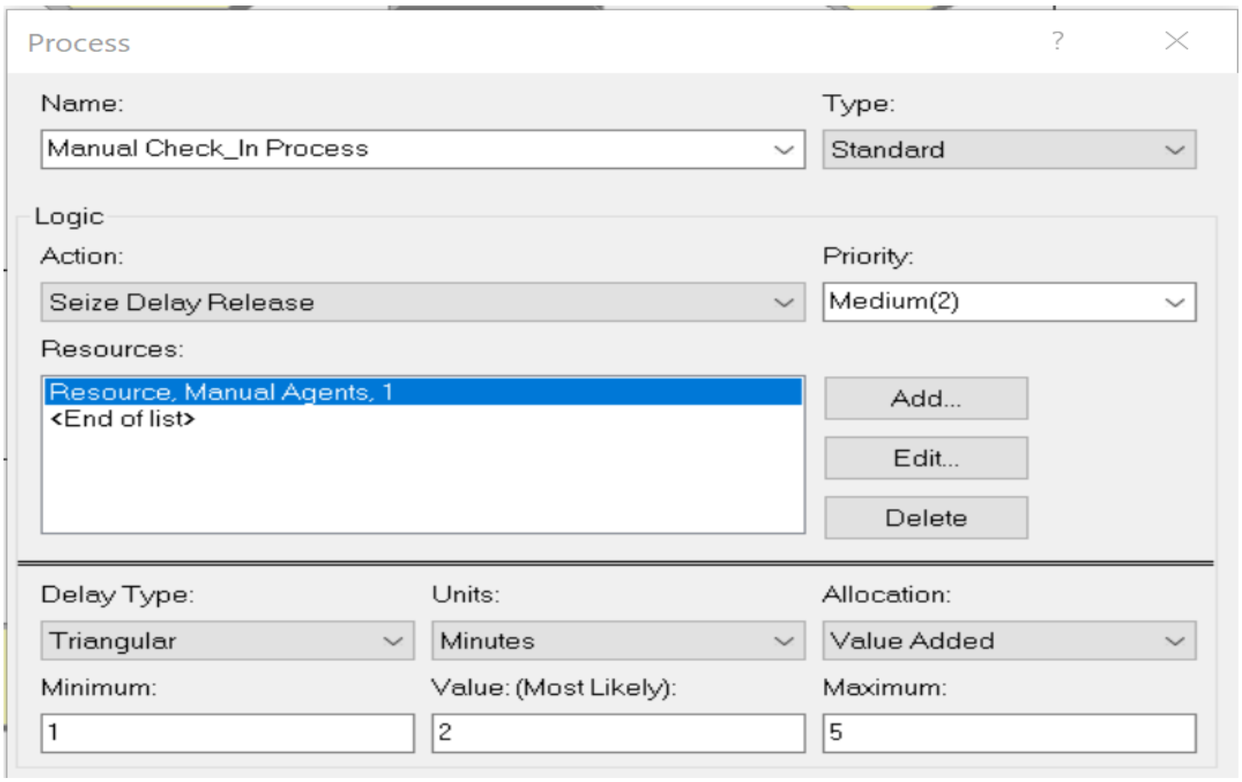

Figure 8. Manual Check-In process.

As I mentioned in 2.1, there are 2 agents at the manual check-in Station in Figure 9, fed by a single FIFO queue, manual check-in times follow a triangular distribution between 1 and 5 minutes with a mode of 2 minutes.

	Name	Type	Capacity
1	Manual Agents	Fixed Capacity	2
2	Security Check Machine	Fixed Capacity	3
3	Machine Employee	Fixed Capacity	2

Figure 9. Resource original capacity.

After manual check-in, passengers walk to the security area, a stroll that takes them between 2 and 5.8 minutes, uniformly distributed, as shown in Figure 10.

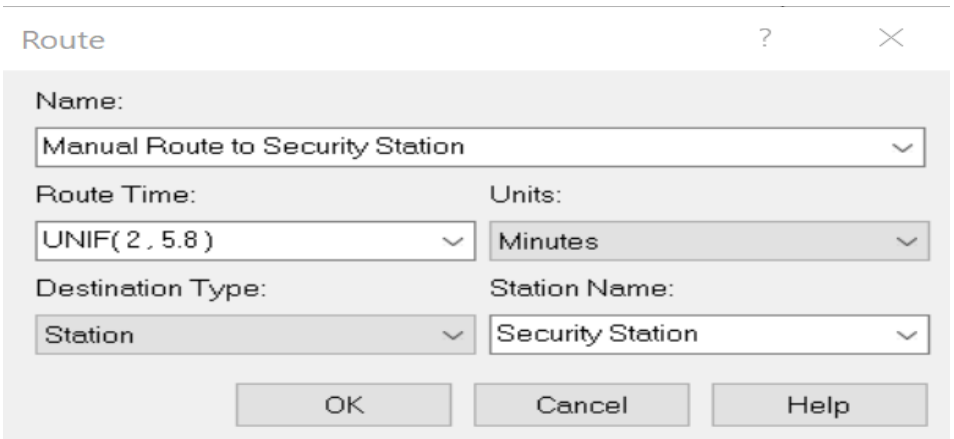

Figure 10. Manual Route to Security Station.

In fact, the automated check-in has 2 stations (a station consists of a touch-screen kiosk and an employee to take checked bags; view a kiosk-employee pair as a single unified unit, that is, the kiosk and its employee cannot be separated), fed by a single FIFO queue, and check-in times are triangularly distributed between 0.5 and 1.5 with a mode of 1. After automated check-in, passengers walk to the security area, taking between 1 and 3 minutes, uniformly distributed, to get there (automated check-in passengers are just quicker than manual check-in passengers at everything). The automated station part is similar to the manual station, so I would not attach the related figure here.

2.1.3 Security Station

All passengers eventually get to the security area, where there are originally 3 stations fed by a single FIFO queue which is shown in figure 9; security-check times are triangularly distributed between 1 and 6 with a mode of 2 (this distribution captures all the possibilities there, like x-ray of carry-ons, walking through the metal detector, bag search, body wanding, shoes off, laptop checking, etc.). Once through the security check (everybody passes, though it takes some longer than others to do so), passengers head to Exit Station.

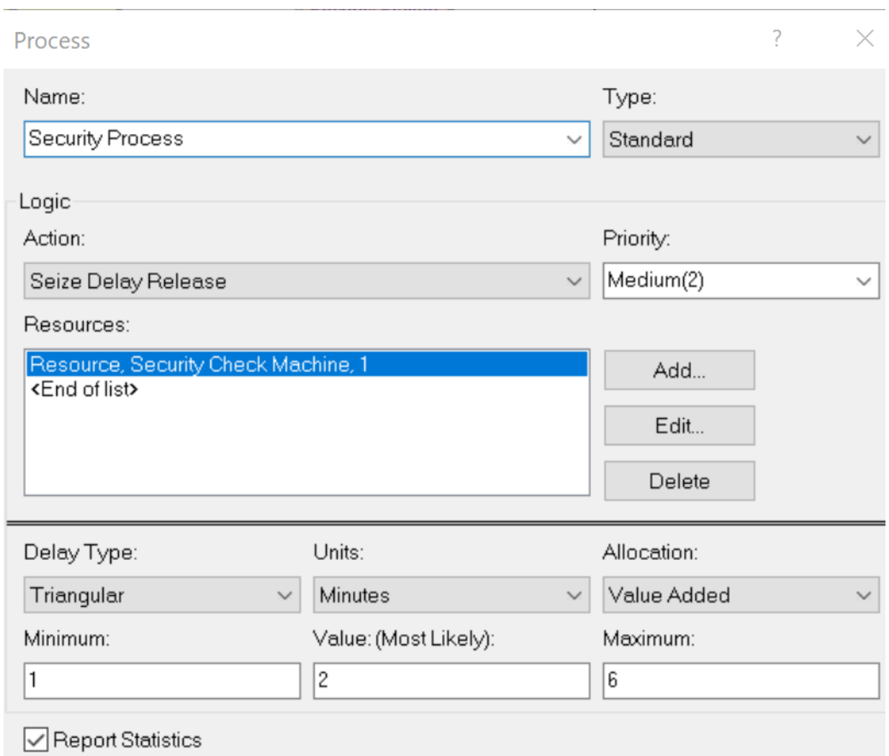

Figure11. Security Process.

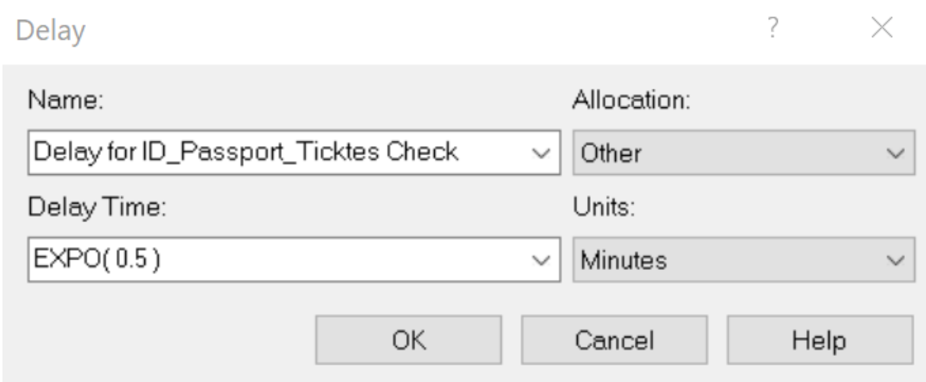

Figure 12. ID/Passport checking Delay.

Before the security process, you might notice there is a Store-Delay-Unstore module. I design this part for the ID or passport and tickets checking before the security process which checking delay time is Expo (0.5) minutes.

2.1.4 Exit Station

The last station is Exit Station which is the easiest one. The Record module which is shown in figure 4 to records the passengers average cycle time in the whole model.

After the Dispose module named Exit the system, the passengers head to their gates and are no longer in the model.

2.2 Simulation Animation and Setup

2.2.1 Animation

I also animate the whole model with the main three stations which is in blue, red and green frame, respectively. In the animation figure, Storage to animate the Delay module is also included.

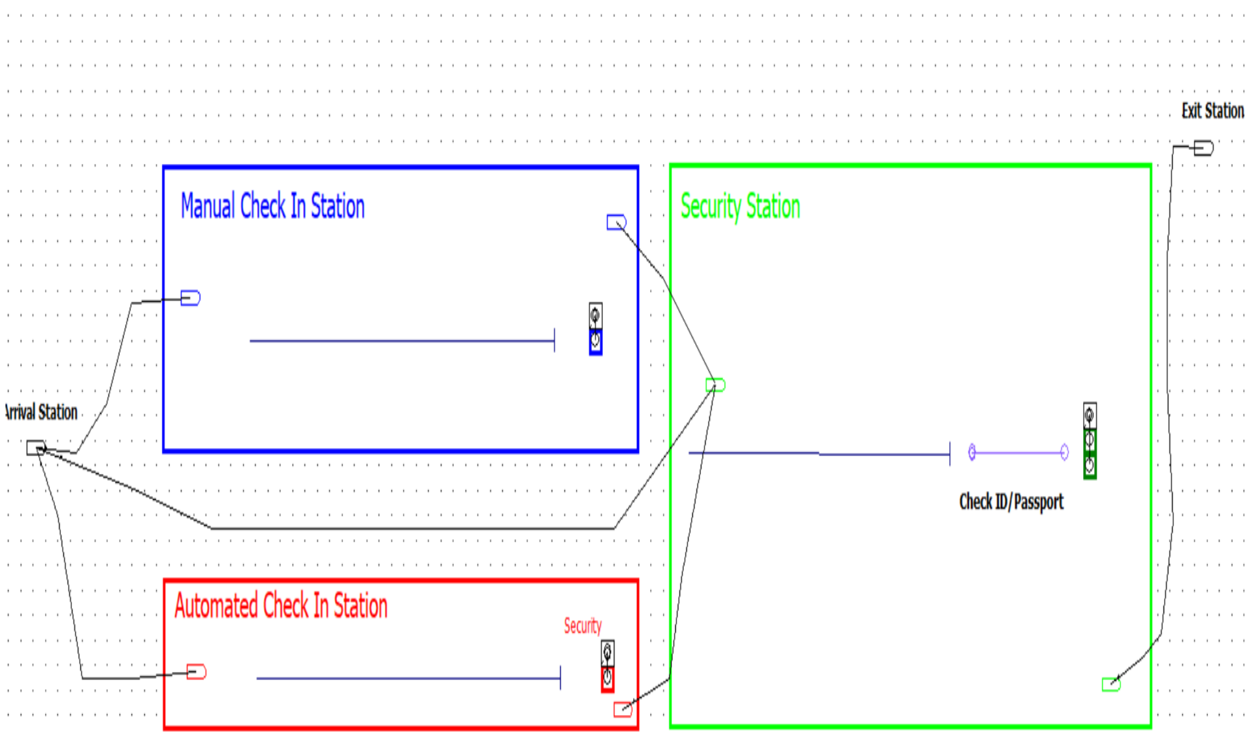

Figure 13. Animation of the model

2.2.2 Simulation Setup

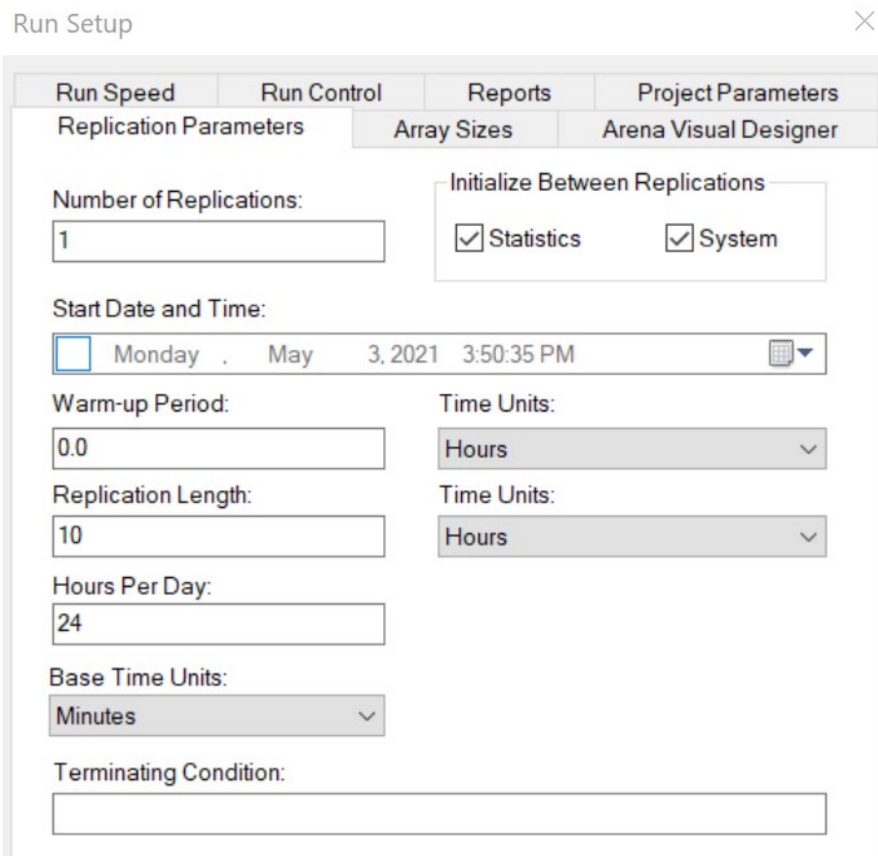

Figure 14. Simulation Setup.

For the original result, I will put the Number of Replication for 1 and run the system for 10 hours which is the time in the daytime.

III. Simulation Results

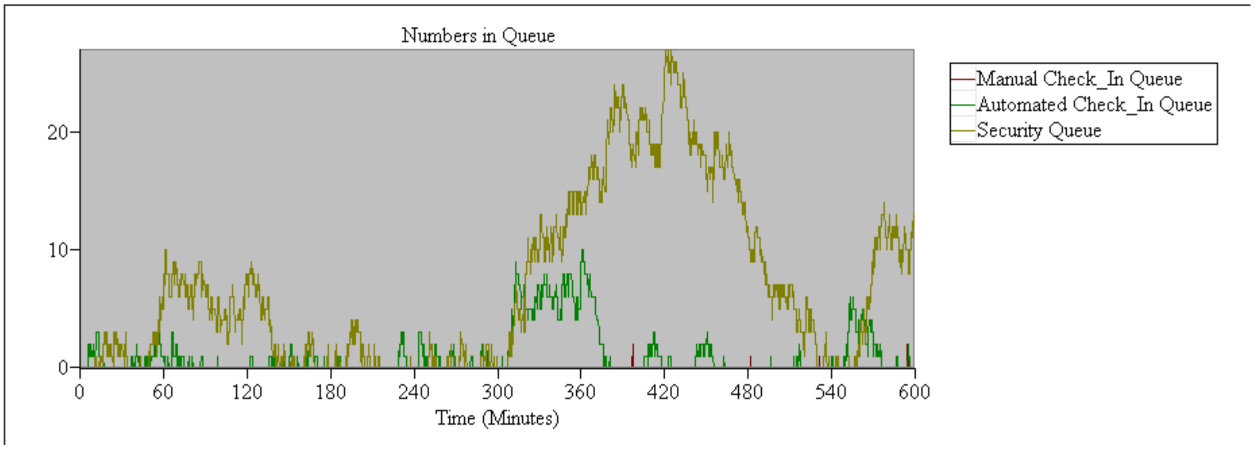

Figure 15(a). Current Number in Different Queue.

Queue

Time

Waiting Time	Average	Half Width	Minimum Value	Maximum Value
Automated Check_In Process.Queue	0.01773225	(Insufficient)	0.00	0.7612
Manual Check_In Process.Queue	1.9859	(Correlated)	0.00	13.4640
Security Process.Queue	7.1094	(Correlated)	0.00	23.0635

Other

Number Waiting	Average	Half Width	Minimum Value	Maximum Value
Automated Check_In Process.Queue	0.00582209	(Insufficient)	0.00	2.0000
Manual Check_In Process.Queue	1.0592	(Correlated)	0.00	10.0000
Security Process.Queue	6.8585	(Correlated)	0.00	27.0000

Figure 15(b). Average waiting time and number waiting in report.

According to the simulation result for 3 queues in figure 15(a), with the time increasing, Security Queue is a little bit exploding from 300 minutes which means that the 3 resources number for security station is not enough. we can also notice in figure 15(b), compared to

Automated check-in queue and Manual check-in queue, Security process queue average waiting time and the average number waiting is much larger.

Scheduled Utilization

	Value
Machine Employee	0.1633
Manual Agents	0.7048
Security Check Machine	0.9228

Figure 16. Resources Utilization.

User Specified

Tally

Interval

	Average
Cycle Time	18.7237

Figure 17. Average Cycle Time.

For each process resources utilization, we can see from figure 16, Security check machine (resource for Security process) utilization is 0.9228 and Machine Employee (resource for Automated process) is only 0.1633. Figure 17 shows the average cycle time for the whole system is 18.7237.

IV. Model improvement

As we already noticed that the resource number for each station maybe is not appropriate in this airport. I would like to change the number of resources in a different process. Here I use the Process Analyzer to execute the results and to find the best number of resources.

	Scenario Properties				Controls			Responses			
	S	Name	Program File	Reps	Manual Agents	Machine Employee	Security Check Machine	Automated Check_In Process.Queue.WaitingTime	Manual Check_In Process.Queue.WaitingTime	Security Process.Queue.WaitingTime	Cycle Time
1		Base	1 : Project_Model.p	50	2	2	3	0.013	2.610	19.436	31.890
2		Change 1	1 : Project_Model.p	50	2	2	4	0.013	2.695	0.583	13.150
3		Change 2	1 : Project_Model.p	50	3	1	4	0.224	0.307	0.783	11.971
4		Change 3	1 : Project_Model.p	50	2	1	5	0.222	2.554	0.118	12.671
5		Change 4	9 : Project_Model.p	50	2	1	4	0.220	2.443	0.571	13.041

Figure 18. Process Analyzer changing scenarios.

I change the Run Setup replication to be 50, and I use the Process Analyzer to compare the different queue waiting time. We can see the Base in Table means the original version which has 2_2_3 resources in the three processes. The security queue waiting time is 19.436 and the cycle time is 31.89 which is too much larger compared to Manual check-in and Automated check-in queue.

I made several changes to the model scenario. Change 1 resource number is 2_2_4, change 2 number is 3_1_4, change 3 number is 2_1_5 and the last one change 4 is 2_1_4.

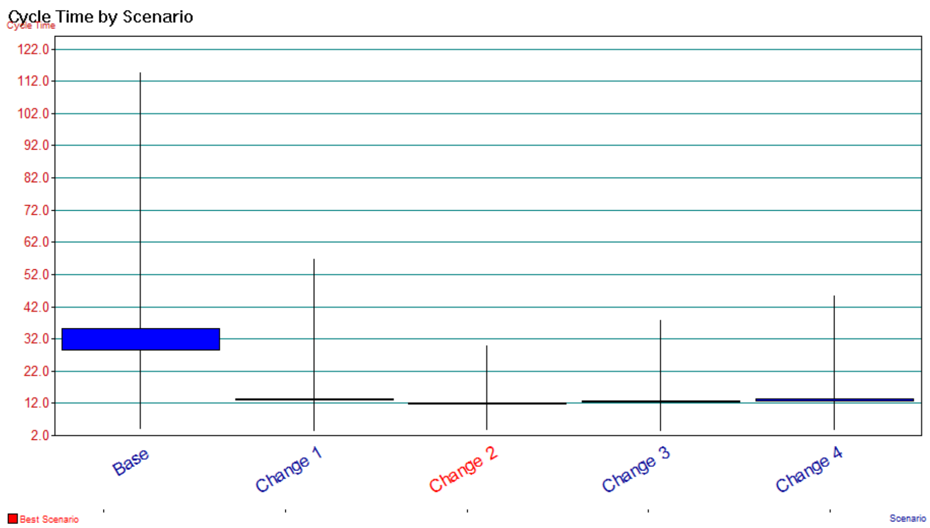

Figure 19(a). Average Cycle Time comparison.

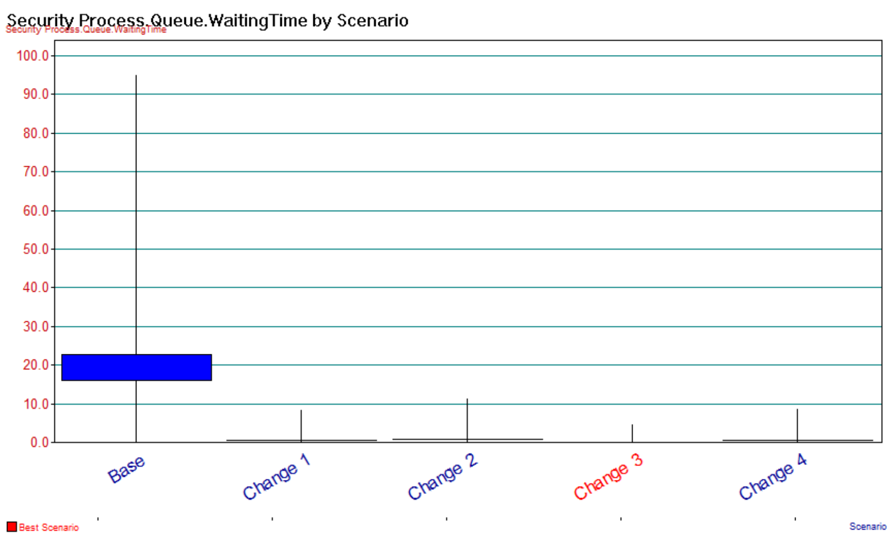

Figure 19(b). Security queue wanting time comparison.

Figure 19(a) shows the comparison for cycle time and Figure 19(b) shows the comparison for Security process queue. We can get that change 2 and 3 is the best way for less waiting time in this system. But at the same time, I notice that although the change 4 is not the smallest value in both the scenario, its waiting time is still low. For change 2 &3, the total numbers of resources are 8 which is 3+1+4 or 2+1+5, but for change 4, it only has 2+1+4 which is 7 Resources!

In this way, the airport can employ fewer people but still relieve the congestion pressure. Finally, I plan to select Change 4 for the model improvement methods which number is 2 in Manual check-in, 1 in Automated check-in and 4 in Security check-in. The airport does not need to employ the new staff, they can just move one staff from Automated check-in Station to Security Station.

Queue

Time

Waiting Time	Average	Half Width	Minimum Value	Maximum Value
Automated Check_In Process.Queue	0.2447	(Insufficient)	0.00	2.2152
Manual Check_In Process.Queue	2.3114	0.763806927	0.00	10.8623
Security Process.Queue	0.7018	0.234520405	0.00	4.6188

Other

Number Waiting	Average	Half Width	Minimum Value	Maximum Value
Automated Check_In Process.Queue	0.07502625	(Insufficient)	0.00	3.0000
Manual Check_In Process.Queue	1.5024	(Correlated)	0.00	9.0000
Security Process.Queue	0.7455	(Correlated)	0.00	7.0000

Figure 20. New Model queue waiting time.

Figure 20 is the improvement result for the model. We can easily draw the conclusion that the waiting time for the security queue is much lower than the previous version.

And for the Runtime, I set them for all 10 hours. At the beginning of the report, it shows the numbers out in the system, now is 632 and the original one is 589 approximately. That means the airport can go through more passengers for the daytime after the resource number changing.

We can also double-check the Security waiting time in Output Analyzer which result is shown in Figure 21.

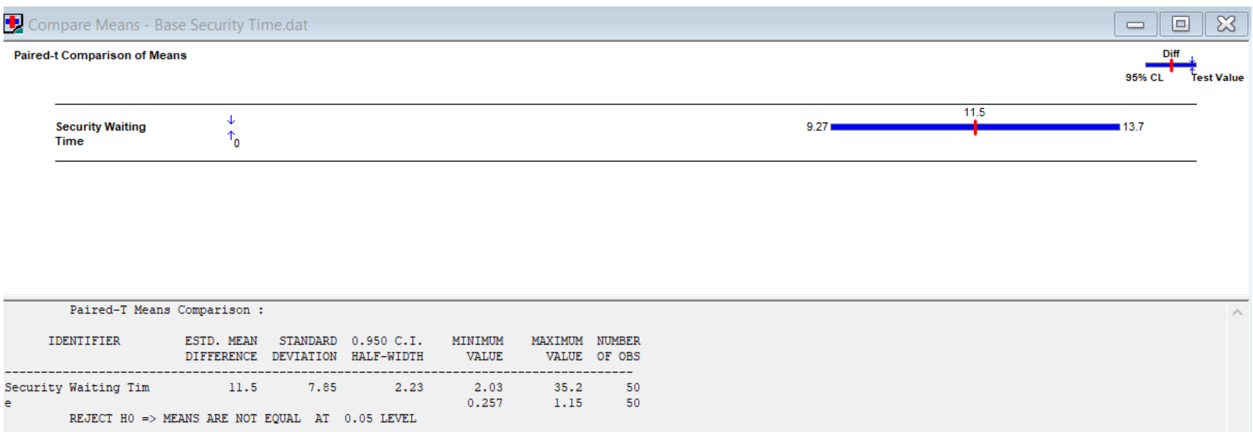

Figure 21. Output Analyzer for Security Waiting Time.

V. Model Discussion

As we know in the textbook the simulation model can be classified as either terminating or steady state. A terminating simulation is one in which the model dictates specific starting and stopping conditions as a natural reflection of how the target system actually operates. According to the definition of the terminating state, the model I build now is a terminating state because it runs for 10 hours which has a specific ending point.

In fact, the airport never really stops or restarts especially for the international airport, so the steady state might be appropriate. A steady-state simulation, on the other hand, is one in which the quantities to be estimated are defined in the long run; that is, over a theoretically infinite time frame.

In principle (though usually not in practice), the initial conditions for the simulation do not matter. We just need to do something to make sure that we are running it long enough. So I reset the Run Setup for 5 days and set the replication time for 5, the Base Time Units is still minutes. We can see it in Figure 22.

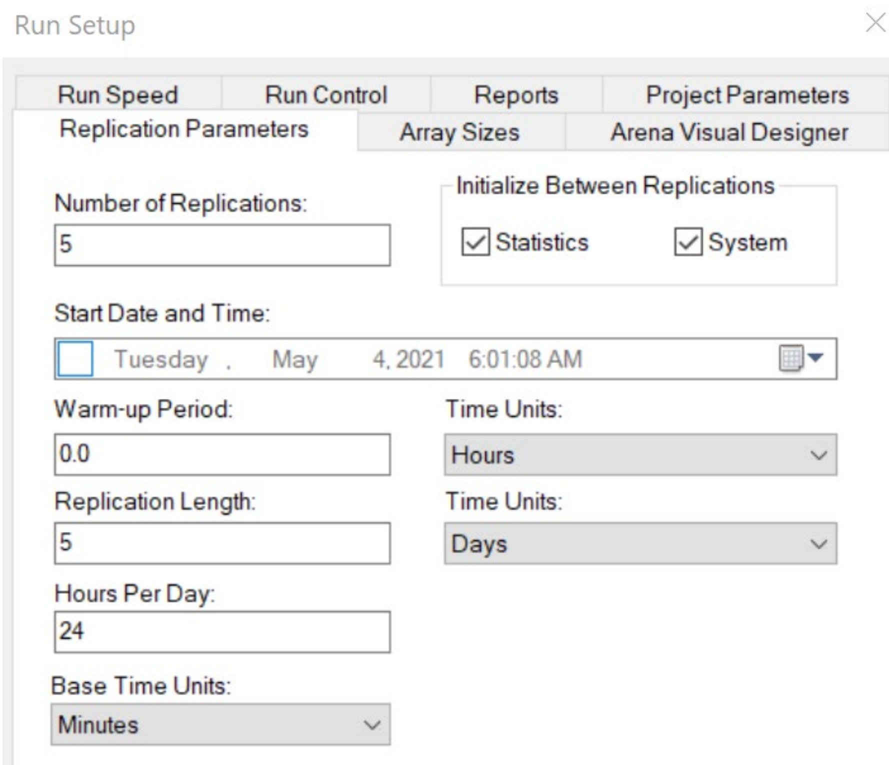

Figure 22. Reset Run Setup.

I use the Output Analyzer again to plot the picture for the 5 replications results. And before that, in Figure 23, I attach the set for statistics. In Figure 24, I use the red line to truncate the warm period.

For further investigation about this airport model, we need to consider the warm period.

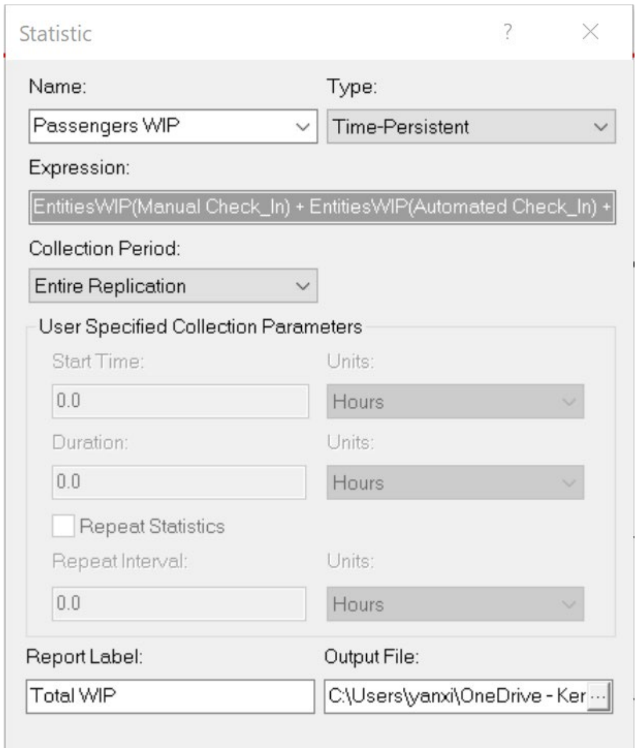

Figure 23. Statistics Set.

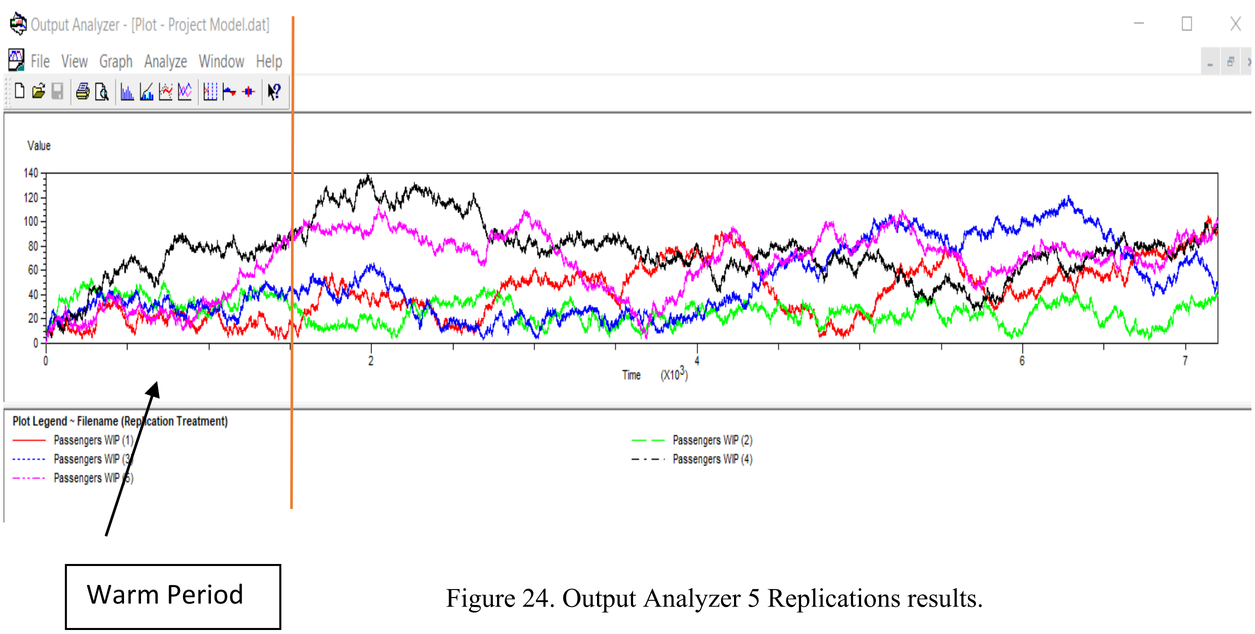

Figure 24. Output Analyzer 5 Replications results.

VI. Conclusion

In order to reduce the waiting time and discomfort index of passengers using the airport, changing each station resources number to get less waiting time for travelers is essential.

In this research, I improved the original model by changing the one Resource from Automated check-in Station to Security Station which is an efficient method to reduce the Security average waiting time, and also the total passengers cycle time in the system. By reducing the waiting time, the discomfort of the passengers can be reduced, and as a result of the simulation, the airport can efficiently operate the whole system.

However, the data I use here is mostly virtual and the model is simplified. In the real system, the model can be much more complicated than this model, if we want to simulate a real, huge international airport, additional effort will also be included like considering the warm period.

References

[1] G. U. Ryu, Editor, “Airport Operation and Management”, BAEKSANS PUBLISHING, Korea, (2004).

[2] Kelton, Sadowski and Sturrock, Simulation with Arena*, 6th Edition, 2015*. McGraw-Hill, Inc. ISBN10: 0073401315, ISBN13: 9780073401317. SWA hereafter.