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A SIMULATION STUDY FOR OPTIMIZING STAFF NUMBERS OF SECURITY CHECK-POINT AT THE AIRPORT TERMINAL

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ABSTRACT

The security check-point area of airport terminals is one of the busiest places at airports at certain periods. The passengers are waited for queues and time delays during the check-point process. In fact, when passengers have to spend much time in that area, they will feel unsatisfied. These problems are due to constraints in the capacity of service facilities such as equipments, staff planning. This study presents a simulation model, which will help the airport operations managers develop an efficient planning for optimizing staff numbers required at terminal security areas with changes in passenger volumes depending on time of day on the week. The model is developed from SIMIO software with high flexibility through making the different experiments to achieve regularly basic conditions of the airport. Results from this study showed that the model will provide invaluable in-sight in operating of terminals to achieve minimum cost and improve the waiting time as well as higher customer satisfaction.

This work will start the research on model driven development of airport simulation model.

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1 INTRODUCTION

In recent years, due to the increase in aircraft and travelling demand of passengers, the forecasts predict an increase in air traffic of at least 3.6% until 2020 (Europe-ACI, 2004). With more demands and growth of passengers, there are always long queues of passengers because of the passengers' volume. As a result, customers spend long waiting time have created an environment of passenger dissatisfaction. This situation makes very important to come up with solutions to alleviate capacity congestions, improving the efficiency of airport operations and passenger's satisfaction in the airports. Customer satisfaction is a key performance indicator for the airlines throughout the world. However, an airport terminal is quite complex system, in that the process of security checking-points is stochastic and the amount of resources required is different with changes in passenger volumes depending on time of day on the week. Thus, the airport managers need to be made in the planning to identify the resources required on a daily basis. Deals with thus issue, the simulation is a technique that allows evaluating actual systems, the methodology is well-known and it has the capacity for solving operational problems in different fields where the stochasticity is a key component (Arias *et al.,* 2013). Therefore, the simulation tool is an effective method for airport analysis and in order to address these issues.

There are a number of different methods which have been used for airport simulation. Mumayiz *et al*. (1990) and Tosic *et al*. (1992) have presented exhaustive overviews on the development of terminal simulation technology and on their applications to airport terminals. Gatersleben *et al*. (1999)

presented a dynamic simulation model used in the redesign and analysis of passengers for Amsterdam Schiphol Airport to analyze passenger flows, identify spatial bottlenecks, and observe the interaction between consecutive processing facilities. Kiran *et al.* (2000) compiled a model of the Istanbul Ataturk Airport for the purpose of identifying bottlenecks through analysis of peak hour flight schedules. One of the outputs of this model is the utilization of duty-free shopping and restaurant areas in order to assist with estimating daily revenue. Guizzi *et al.* (2009) used simulation to improve the check-in and security checkpoint at the Naples International Airport. OptQuest function in Arena simulator was used to minimize the function of cost. Al-Sultan (2015) introduced a check-in allocation for airport terminal which decomposed to several check-in zones which have different counters capacity. The airport check-in scheduling problem requires both an integer programming and stochastic simulation approach.

Researchers recently used a higher frequency technology instead of the method to mathematical models. By building a discrete event simulation model using Arena or SIMIO, it has been possible to predict the impacts, benefits and possible constraints of a continuous high frequency drying system. Using airport simulation software can be found in Appelt *et al.* (2007) developed a simulation with Arena that shows the passenger flow through the check-in process given the different types of check-in modes at the Buffalo Niagara International Airport based on the waiting time and processing time in the system. Lazzaroni (2012) have built extensive simulation models of passenger flow, baggage systems, and aircraft movements, using Simio software. These models have been used to generate process and service level improvements, which have contributed at Vancouver International Airport in North America.

This paper aims to focus on the passenger checkpoint areas at a small airport terminal. Thus, the main objective of this study is to develop a simulation model for optimizing staff numbers required in the security check-point areas which considered regularly basis conditions of the airport by using Simio simulation program. Results from this study showed that the model will improve the efficiency in operating of terminals achieve minimum cost and customer satisfaction. The structure of this paper is organized as follows. Section 2 provides a problem formulation related to the check-point areas at the airport terminal and requirements must be considered. Section 3 presents methodology includes input data, modeling and simulation model and the experimentation to simulate models. Section 4 provides the critical results of simulation optimization, while section 5, finally, presents some concluding remarks.

2 PROBLEM FORMULATION

An airport terminal layout will service five airline companies: Airborne Airlines (AA) and Wild Wings (WW), Fabulous Flights (FF), Premium Planes (PP), and Jolly Jets (JJ) (Morgado and Walker, 2010; Star Alliance Member Airlines, 2015). The airport manager concerns about the design of the security check-point areas which includes a precheck area, bag scanners, people scanners, and manual bag search tables. A flow chart shows key processes that each passenger enters the system.

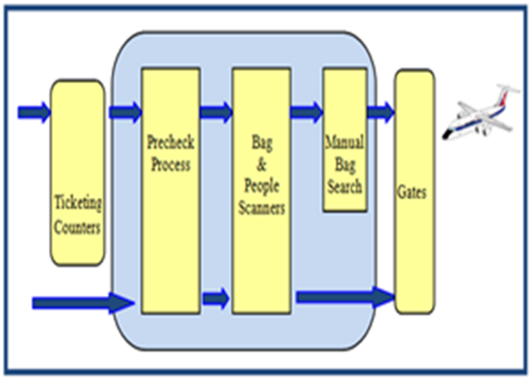

Fig. 1: The terminal layout

The staff at the check-point areas work in 3 shifts (7 hour/shift): (4:00 AM - 11:00 AM) (11:00 AM - 6:00 PM) (6:00 PM - 1:00 AM).

Assumptions are as follows:

– The capacity of the bag unloading is 3, the bag scanner is 3, and the bag loading is 2.

– Passengers can be sent back to ticket system one time maximum.

– Passengers can be rescanned at the people scanner one time maximum.

– Each passenger has belongings that have to go through the bag scanner (bag, wallet, keys, laptop and etc.).

– The belt conveyor of the bag scanners has a speed of 1.5 m/sec.

– Two bag scanners can be coupled with one people scanner.

The airport management always needs a proper staffing level for the areas. Therefore, studying the solutions for this problem, three metrics must be considered, due to the airport policy (Lindsey and Charles, 2010; United.com, 2015).

1. Each passenger will arrive to the airport 120 minutes before the departure time.

2. Precheck area needs minimum number of staff in each shift for each day.

Conditions: Average time in queue is less than 6 mintues, and the cost should be the least

3. Scanning area make maximum number of people scanners and bag scanners needed in the system.

Conditions: 90% of passengers spend less than 45 minutes in the security check-points, 99% of passengers reach their flights before at least 15 minutes and cost effectiveness.

3 METHODS

Simio^{TM} modeling software was used to develop the model followed by input data, modeling, simulation model, ending with experimentation.

3.1 Input Data

To analyze this problem, a set of data is collected and used as inputs of the model. The data provided for this model are:

Ticketing processing time for each of the six airline companies for both standard and elite passengers.

The percentage of each type of passengers (i.e. standard, elite, or express) for each airline company.

The arrival rate of passengers for each airline company depending on the day of the week.

Processing time for each of the following processes:

- Precheck.
- Placing items on the bag conveyer.
- Processing time of the bag scanner.
- Processing time of the people scanner.
- Time to pick-up bags from the bag conveyer.
- Manual baggage search.

3.2 Modeled Processes

Flow processes were modeled for all arriving and departing flights as shown in Figure 2, and it will be transformed to a simulation model.

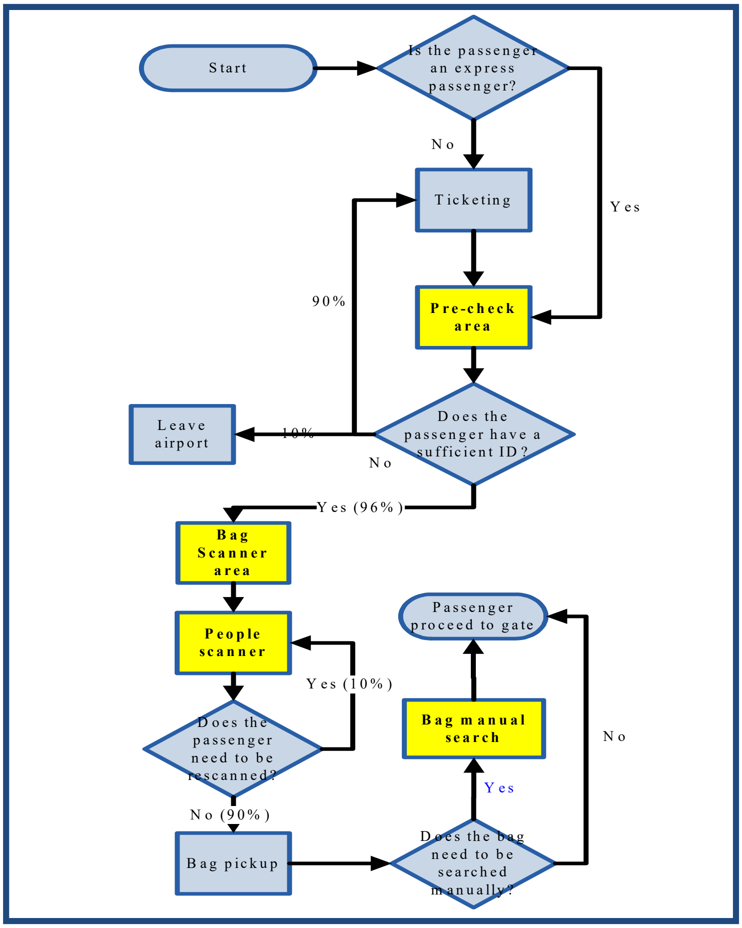

Fig. 2: Flow chart

3.3 Simulation Model

After the modeling step, the simulation has been developed in a simulation Simio software allowing to obtain all advantages inherent to a modular system representation.

Object from standard library: Sources, servers, combiners, separators, sinks, entities, paths, conveyors, time paths

Built objects: Small/big scanning area.

Tables: Passengers sequences, passengers processing times, arrival rates, precheck schedules, scanning machines schedules.

Definitions: Timers, output/tally statistics, cost centers, batch logic, lists.

Processes: Compute costs, batch bags, assign states, decide.

This model was started by creating the arrival passengers and moving through the passenger's exit to the terminal security checkpoint, finally going to the airport gate.

Figure 3 is logical model, and Figure 4 is animation model which is developed with dynamic 3D animated for checking areas.

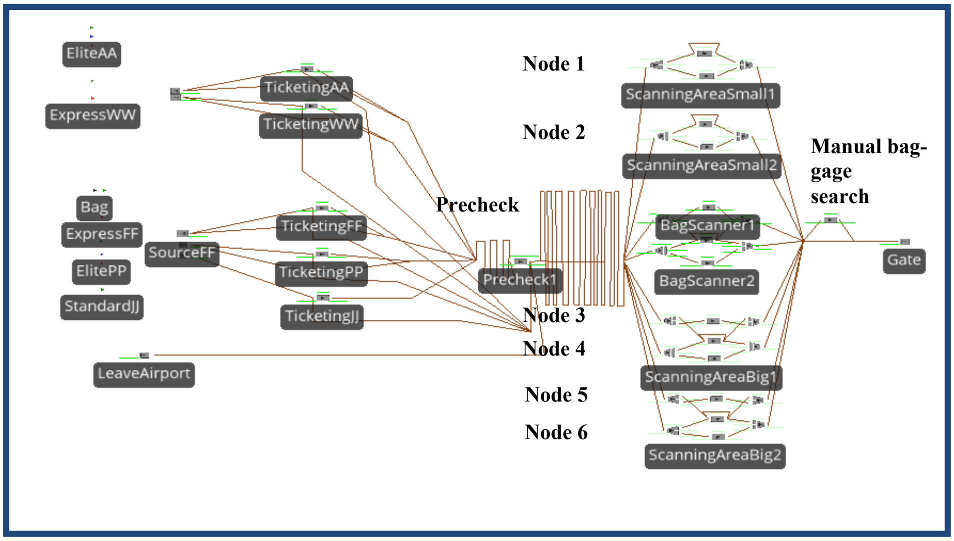

Fig. 3: Logic model

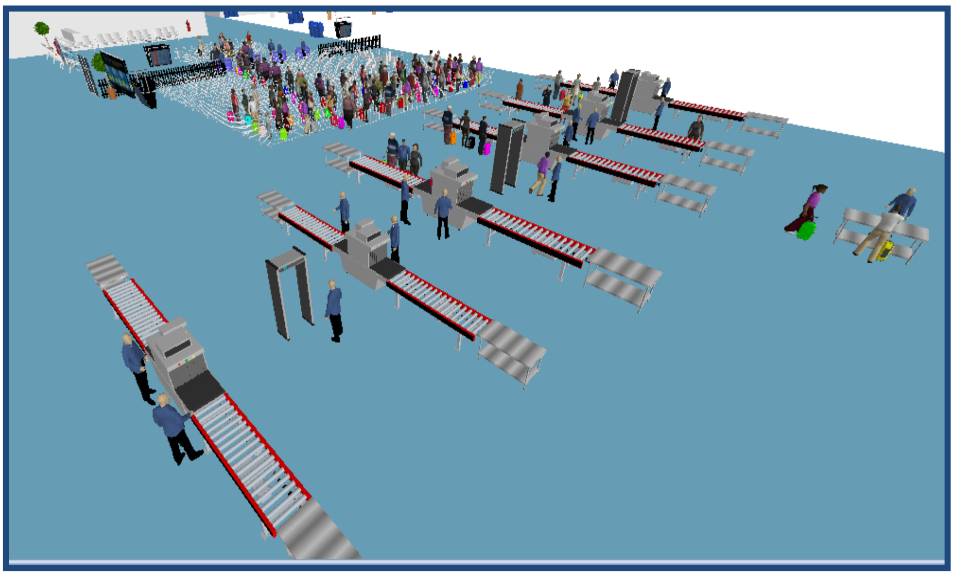

Fig. 4: 3D animation model

This model has two small scanning areas that consists of one bag scanner and one people scanner. Using two bag scanners in parallel with one people scanner is more efficient, since the processing time of the bag scanner is higher the processing time of people scanner and two big scanning areas that consists of two bag scanners and one people scanner.

The following formulas in model related conditions of the system are considered.

At first, 90% of passengers spend less than 45 minutes in the security check-point areas, this rate is calculated as follows.

On Time Percentage In Security check-points = Number OnTime At Security/

(Number On Time At Security + Number Late At Security)

Secondly, 99% of passengers reach the flights before at least 15 minutes, and this rate is calculated.

On Time Percentage In System= Number On Time/ (Number Late + Number On Time)

Finally, cost effectiveness is calculated based on the total cost of each area. Cost of each capacity for people scanner or manual bag scanning = $18 USD/hour. Cost of 2 capacities for bag scanner = $28 USD/hour.

PreCheck Cost = Sum [Current Capacity for Precheck== Scheduling *18]

Scanning Cost= Sum [(Node1: Capacity of ScanningAreaSmall1== Infinity)* (18 + 28 *2) +

(Node2: Capacity for PeopleScanner == Infinity)* (18 + 28 *2) +

(Node3: Capacity for ScanningAreaBig1==Infinity)* (28 *2 +

(Node4: Capacity for ScanningAreaBig1== Infinity)* (28 *2) +

(Capacity for PeopleScanner== Infinity))*18+

(Node5: Capacity for ScanningAreaBig2== Infinity)* (28 *2) +

(Node6: Capacity for ScanningAreaBig2 ==Infinity)* (28 *2) +

(Capacity for PeopleScanner== Infinity))*18]

Manual Scanning Cost = (18*1*21*7)

Thus, lead to following Weekly Cost:

Weekly Cost= PreCheck Cost + Scanning Cost + Manual Scanning Cost

3.4 Experimentation

To make sure our basic standard conditions, we made "Experiments" to determine the best staffing level. We carried out three phases. In the phase one, we focused on the staffing level at the precheck area. The second and third phases focused on the people and bag scanners area. For the last area in the system, manual bag search, it was obvious that having more than one manual bag search table will not improve the system significantly. In fact, it takes only 120 seconds (maximum) to manually scan each bag and only 8% of bags that go through the bag scanner require a manual search.

Phase 1: Precheck

In order to determine the proper staffing level for the precheck area, we created three experiments for each arrival rate pattern which are on Mondays & Fridays, Tuesdays, Wednesdays & Thursdays and Saturdays & Sundays (MF, TWT, and SS). In each experiment, we studied all the possible combinations for 3 shifts per day (7 hour/shift). These combinations can be seen in Table 1, where each number inside the parentheses represents the number of staff required for that shift and the first shift starts at 4:00 AM.

Table 1: Phase one combinations for staffing level

(1st shift, 2nd shift, and 3rd shift)		
(4,3,4)	(3,2,2)	(2,2,2)
(4,2,3)	(3,3,2)	(2,3,2)
(4,3,3)	(3,4,2)	(2,4,2)
(4,4,3)	(3,2,3)	(2,2,3)
(4,2,2)	(3,3,3)	(2,3,3)
(4,3,2)	(3,4,3)	(2,4,3)
(4,4,2)	(3,2,4)	(2,2,4)
(4,2,4)	(3,3,4)	(2,3,4)
(4,4,4)	(3,4,4)	(2,4,4)

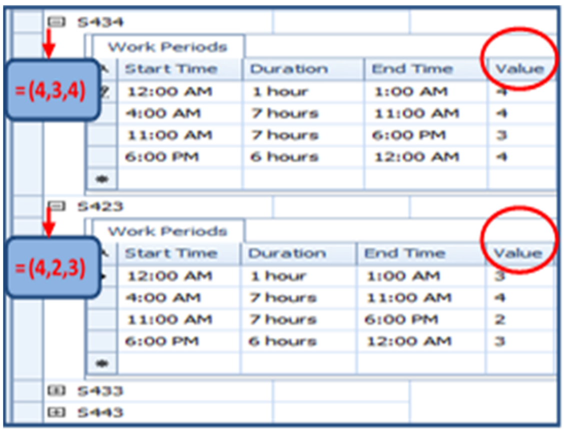

Fig. 5: A snapshot of model shows a number of combinations using the Work Schedule

Figure 5 shows all the combinations and the Value is the capacity of the resource using the Work Schedule for 3 shifts per day (7 hour/shift).

After that, we ran the model in one week to know what combinations for the results and each combination is a row in the following Figure 6.

Scenario		Controls	Responses				
Name	Status	Schedules	OnTimePercentageInSecurity	OnTimePercentageInSystem	WeeklyCost (USD)	Average time in queue (Minutes)	max (Minutes)
W434	Idle	W434	1	1	4314.36	2.03246	3.9343
W423	Idle	W423	0.99931	0.996929	4047.39	9.5222	37.7748
W433	Idle	W433	1	1	4183.19	2.08419	4.08597
W443	Idle	W443	1	1	4297.17	1.99394	3.59949
W422	Idle	W422	0.994283	0.908293	3905.94	15.9576	39.6752
W432	Idle	W432	0.999902	0.999722	4030.1	5.62038	33.2486
W442	Idle	W442	0.999784	0.999887	4146.28	5.17558	31.9138
W424	Idle	W424	0.999381	0.99815	4187.45	7.8105	37.7665
W444	Idle	W444	1	1	4438.03	1.94646	3.11089
W222	Idle	W222	0.981312	0.489488	3520.89	35.3525	40.2314
W232	Idle	W232	0.99492	0.87644	3773.56	19.8395	39.6814
W242	Idle	W242	0.994762	0.889607	3890.17	17.0131	39.6814
W223	Idle	W223	0.988677	0.558387	3792.72	30.0192	40.0437
W233	Idle	W233	0.995043	0.876623	3917.04	16.4032	39.6814
W243	Idle	W243	0.995	0.889972	4036.09	13.8358	39.6814
W224	Idle	W224	0.987397	0.650686	3936.59	27.0706	40.0437
W234	Idle	W234	0.995045	0.876706	4062.33	16.3548	39.6814

Fig. 6: A snapshot of model shows the outputs of these combinations

From the results, the best staffing level was built on two main outputs factors: average time in queue and weekly cost. Firstly, we only considered the combinations that have an average time of 6 minutes or less in the precheck queue. Secondly, among combinations that satisfy this condition, we chose the one with the least weekly cost. After studying all combinations in Figure 6, we were able to determine the optimum staffing level at the precheck area for each day. The following table summarizes the best staff scheduling for the pre-check area.

Table 2: Number of staff required at Precheck area

Day	Time	Number of staff
Mondays & Fridays	4:00AM-11:00AM	4
	11:00AM-6:00PM	3
	6:00PM-1:00AM	3
Tuesdays, Wednesdays & Thursdays	4:00AM-11:00AM	3
	11:00AM-6:00PM	3
	6:00PM-1:00AM	2
Saturdays & Sundays	4:00AM-11:00AM	3
	11:00AM-6:00PM	2
	6:00PM-1:00AM	2

Phase 2: Scanning Area

In order to determine the maximum number of people scanners and bag scanners needed in the system, the peak of the arrival rate was considered. We studied the arrival rate for each day and found that the peak happens on MF (Fig. 7). Different reasonable combinations of bag and people scanners and two on MF. These combinations can be seen in Tables 3.

Table 3: Phase two combinations (No. of bag scanners, No. of people scanners)

(8,5)	(8,4)
(7,5)	(7,4)
(6,4)	(6,3)
(5,4)	(5,3)
(4,3)	(4,2)
(3,3)	(3,2)

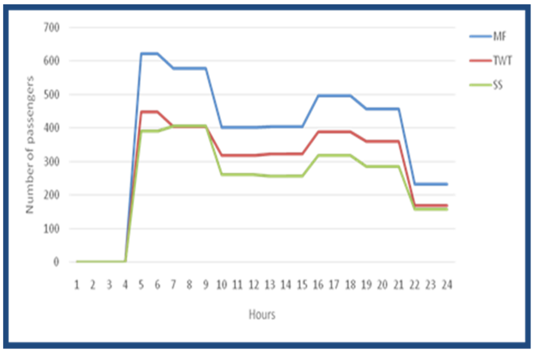

Fig. 7: Arrival numbers of passengers

In order to determine the the maximum number of people scanners and bag scanners needed in the system, we considered three main objectives of the problem. Firstly, we only considered the combinations that satisfy these two conditions: 90% of passengers spend less than 45 minutes at the security check-point area and 99% of passengers reach their flights before at least 15 minutes. Among combinations satisfied these two conditions, we chose the one with the least cost.

The system needs 6 bag scanners and 3 people scanners in order to handle the arriving passengers properly.

Phase 3: Set Phase 1 and 2 to determine the best one

The same model is used, but we set Phase 1 and 2 to their best combinations. After that, we tested all combinations for Phase 3 in order to determine the best one. In order to reduce the amount of effort for Phase 3, we used the add-in tool "OptQuest" that comes with Simio to run some random combinations. After using OptQuest, it was obvious that it would take Simio weeks to examine all the available combinations. To find an easier approach, we decided to check the outputs of the combinations that OptQuest has generated after one day of running and use one of these combinations as a starting point. From all the combinations that OptQuest has generated, after one day of running, we chose the combination that satisfies the goals, and determnining the minimum cost. The outputs of this phase can be seen in Table 4 as following.

Table 4: Number of people and bag scanners needed for scanning area

Day	Time	Bag scanner	People scanner
Mondays & Fridays	4:00AM-11:00AM	6	3
	11:00AM-6:00PM	5	3
	6:00PM-1:00AM	4	2
Tuesdays, Wednesdays & Thursdays	4:00AM-11:00AM	4	2
	11:00AM-6:00PM	4	2
	6:00PM-1:00AM	3	2
Saturdays & Sundays	4:00AM-11:00AM	4	2
	11:00AM-6:00PM	3	2
	6:00PM-1:00AM	3	2

For each phase, we used the same basic model, but the only thing that we changed is some settings (properties, schedules). After testing all the possible combinations for this phase, we determined the best one.

4 RESULTS

The optimum staffing level and determining people and bag scanners for each area was defined. The following table shows the main outputs of the model run in one week.

As we mentioned in the introduction, in order to determine the best solution, there are three metrics which should be considered.

As can be seen from Table 5, results satisfy the first and second metrics, but for the third metric, cost effectiveness, it is about $60,712.49 per week. If airport managers are interested in applying this solution for the staffing plan on the week, the following table summarizes the required staffing level for each area.

Table 5: Main outputs of model

Name	Outputs
Percentage of passengers spend less than 45 minutes in the security check-point area	95.11% ± 0.89
Percentage of passengers spend less than 105 minutes in the system	99.86% ± 0.06
Weekly cost	$60,712.49 ± 42.68

Table 6: Staffing level for each area

Day	Time	Precheck	Bag scanner	People scanner	Manual bag search
Mondays & Fridays	4:00AM-11:00AM	4	6	3	1
	11:00AM-6:00PM	3	5	3	1
	6:00PM-1:00AM	3	4	2	1
Tuesdays, Wednesdays& Thursdays	4:00AM-11:00AM	3	4	2	1
	11:00AM-6:00PM	3	4	2	1
	6:00PM-1:00AM	2	3	2	1
Saturdays & Sundays	4:00AM-11:00AM	3	4	2	1
	11:00AM-6:00PM	2	3	2	1
	6:00PM-1:00AM	2	3	2	1

Assuming that this simulation will be chosen, the following table shows the average and maximum time of each passenger type spending in the system.

Table 7: Time spent in the system for each passenger type

Airline company	Passenger type	Average (min.)	Maximum (min.)
AA	Standard	46.47 ± 0.99	128.84 ± 9.96
	Express	29.28 ± 1.13	78.39 ± 4.17
	Elite	45.15 ± 0.77	120.99 ± 8.58
FF	Standard	47.74 ± 0.90	130.89 ± 10.35
	Express	26.59 ± 0.96	77.06 ± 3.90
	Elite	37.43 ± 0.96	112.26 ± 8.77
PP	Standard	42.93 ± 0.89	130.09 ± 12.70
	Express	28.55 ± 0.94	82.56 ± 6.90
	Elite	38.02 ± 0.92	119.25 ± 11.14
WW	Standard	41.38 ± 0.74	123.70 ± 7.76
	Express	26.19 ± 0.89	78.60 ± 0.89
JJ	Standard	34.25 ± 0.85	113.96 ± 6.64

Regarding to design and space considerations, the following table shows the maximum number of passengers in each queue.

Table 8: The maximum number of passengers in each queue

Name	Maximum number in queue
Precheck area	191.94 ± 3.7
Scanning area	298.62 ± 7.8
Manual bag area	20.14 ± 2.3

5 SUMMARY AND CONCLUSIONS

This study has developed the simulation model for the processes of security check-point at the airport terminal, with high flexibility. Different experiments were considered in order to determine optimizing staff numbers for each area. The results show that simulation model will help airport managers to make a better decision-making for the optimum waiting number of passengers as well as waiting times and the cost per week of the airport.

REFERENCES

Al-Sultan, A.T., 2015. Airport Check-In Optimization by IP and Simulation in Combination. World Academy of Science, Engineering and Technology International Journal of Social, Behavioral, Educational, Economic and Management Engineering. 403-406.

Appelt, S., Batta, R., Lin, L., Drury, C., 2007, Simulation of Passengers Check-in at a Medium-sized US Airport. In: Simulation Conference, 2007 Winter. IEEE, pp. 1252-1260.

Arias, P., Guimarans, D., Mujica, M., Boosten G., 2013. A methodology combining optimization and simulation for real applications of the Stochastic Aircraft Recovery Problem. In: Modelling and Simulation (EUROSIM), 2013 8th EUROSIM Congress on. IEEE, pp. 265-270.

Europe- ACI., 2004. Study on the use of airport capacity. Airports ACI EUROPE. Brussels, Belgium, pp. 1-15.

Gatersleben, M., van der Weij, S., 1999. Analysis and simulation of passenger flows in an airport terminal. In: Simulation Conference Proceedings, 1999 Winter. IEEE, pp. 1226-1231.

Guizzi, G., Murino, T., Romano, E., 2009. A discrete event simulation to model passenger flow in the airport terminal. In: Proceedings of the Applied Computing, Conference 2009 (ACC '09). Mathematical Methods and Applied Computing, pp. 427-434.

Kiran, A., Cetinkaya, T., Og, S., 2000. Simulation modeling and analysis of a new international terminal. In: Proceedings of the 32nd conference on Winter simulation. Society for Computer Simulation International, pp. 1168-1172.

Lazzaroni, M., 2012. Modeling Passenger and Baggage Flow at Vancouver Airport, accessed on 04 June 2015. Available from http://www.simio.com/case-studies/Modeling-Passenger-and-Baggage-Flow-at-Vancouver-Airport/Modeling-Passenger-and-Baggage-Flow-at-Vancouver-Airport.pdf

Morgado, L., Walker, C., 2010. School of Business Administration university Report 2010, accessed on 15 September 2015. Available from https://www.bus.miami.edu/_assets/files/undergradu ate programs/research/2010/Lindsey%20Morgado-Charles%20Walker.pdf

Mumayiz, S.A., 1990. Overview of airport terminal simulation models. Journal of the Transportation Reseach Board. 1273: 11-20.

Simio® simulation software., 2015, accessed on 11 June 2015. Available from http://www.simio.com

Star Alliance Member Airlines. 2015, accessed on 15 September 2015. Available from https://www.united.com/web/en US/content/travel/airport/process/

Tosic, V., 1992. A review of airport passenger terminal operations analysis and modeling. Transportation Research Part A: Policy and Practice 26(1): 3-26.