Interactive Dynamic Modeling for the Passenger Flow Bottleneck and Security Checkpoint Management at an Airport

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Abstract

In this paper, the current structure of the passenger flows in Atatürk Airport is examined, aiming an improvement in the management of passenger flows. It is observed that security checkpoints are the main causes of the bottlenecks in the passenger flows. In this regard, passenger flows and their relations with security checkpoints/personnel are modeled dynamically. The model is set up based on two main flows through the domestic and the international terminals. After analyzing real hourly flow data of both international and domestic terminals and estimating their statistical properties, results are used in the model as input data. Validity of the model is tested under various extreme conditions, against real data and under different scenarios. In initial simulations, number of active x-rays devices and personnel needed are formulated as dynamic inputs. After obtaining these initial simulation results, an algorithm is developed to distribute necessary number of active x-rays/personnel to each security checkpoint. Finally, for the airport managers to test their own strategies, a game version of the model is built. It is expected that by using the model and the simulation game, decision-making structure of security personnel allocation at the airport will be improved.

Key Words: dynamic system modeling, queue management, airport security checkpoints.

Acknowledgments

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INTRODUCTION

Atatürk Airport in Istanbul is the largest airport with the densest air traffic in Turkey. In comparison with the last year, this year's five-month-growth is increased by nineteen percent. Actually, this increase represents the density and also warns about potential problems in terminals. In addition, the airport has already several critical bottlenecks. As the number of passengers using this airport increases, these bottlenecks may create some problems. By this project, we expect to find these possible problems out before the airport management faces them. Key factors of the problem can be listed as:

- Arrival rates of the entrance points of the airport
- Queue lengths of five checkpoints.
- Total number of x-ray devices available
- Number of desired and active x-rays at these checkpoints.

This project aims to increase the efficiency of the resources of the airport such as x-ray devices and security personnel, so that there can be less people waiting with the same number of x-rays. There is a tradeoff between queue lengths and the number of x-rays. The more x-rays are used, the more security personnel are hired that creates an increase in security expenses. If the company keeps the number of x-rays low, queue lengths would be longer, people would wait and the chance of missing their flights would increase, resulting in customer dissatisfaction.

There are five main checkpoints at the airport and in the model. The goal is to allocate x-ray devices to these checkpoints in balance, in order to keep queues in acceptable boundaries. Total number of x-ray devices, i.e. the x-ray capacity of the airport is another key factor at this point because the active x-rays cannot exceed the physical limits of the airport.

It should be stated that this project is only concerned with departure sections of terminals because passengers landed do not pass through security checkpoints. Before starting to explain the model, we should picture the airport structure (departments, gates, security checkpoints, etc.). There are two main terminals, domestic and international. International terminal constitutes most portion of the airport with its high passenger flow and huge number of flights. Thus it is better to begin with international terminal structure.

International Terminal

Atatürk Airport international terminal departure entrance consists of three different floors. After people enter the terminal from these entrances, they have to pass through international departure security checkpoints (primary security). Then, they continue with check-in areas, to passport desks. Those coming from domestic flights (domestic-to-international transfer) have to go to passport desks too. With the completion of passport control process, they all have to pass through airside security checkpoints (secondary security) and passengers make their way to boarding gates. On the other hand, those coming from international flights (international-to-international transfer) do not have to pass through passport control. Atatürk airport has separate security checkpoint for these passengers. After they are checked in these security checkpoints, they directly go to their planes to depart.

Domestic Terminal

This terminal entrance consists of two different floors. After people enter the terminal from these entrances, they have to pass through domestic departure security checkpoints (primary security). Then, they continue with check-in areas to gates. Since the transfer rates of international-to-domestic and domestic-to-domestic are relatively small, they are negligible. Before entering the gate areas, all passengers have to pass through airside security checkpoints (secondary security) and passengers make their way to boarding gates. After they are checked in these security checkpoints, they directly go to their planes to depart.

RESEARCH OBJECTIVES AND OVERVIEW OF THE MODEL

The purpose of this project is: modeling and analysis of the main passenger flows of the Atatürk Airport, by investigating the passenger accumulations at the main security checkpoints, and eventually developing an algorithmic model to obtain a more efficient way of distributing the security personnel in the airport, and finally developing a web based game to allow managers test different decision making policies. Through these objectives, it is possible to minimize the number of passengers waiting in the security checkpoint queues and lower the budget planned to be spent for security related costs.

As a research methodology, system dynamics modeling is chosen to represent the general security structure and passenger flows. Although the input data of the model are deterministic, in the real world the process is highly stochastic. It is certain that the number of incoming passengers to the airport can be interpreted more or less accurately through the planned departure times of scheduled flights, however the expected and actual departure times of the scheduled flights differ in many cases. Another probabilistic factor is the transfer passengers. Again due to the same problematic delay structure of arriving flights to the airport, it is hard to guess the exact time of entrance of transfer passengers to the terminal. For these reasons, it is not suitable to use a deterministic optimization approach in this case. Furthermore if a discrete event simulation was used, it would be obligatory to model every entering passenger to the airport and keep the personal statistics. This process is time consuming, tedious and creates unnecessary personnel statistics, rather than the general behavior of the working system. In short, system dynamics method is chosen as the most suitable research method.

The aim of this study is to construct a model that first describes the distribution structure of the security personnel and then optimizes it with the help of an algorithm. Time unit is selected as a minute in order to observe meaningfully the dynamic behaviors of the passenger flows and accumulation processes in the airport. Time horizon, on the other hand, is selected as a day (in some runs it is selected as three or four days as needed). This time horizon is sufficient and appropriate to analyze the periodic changes in the system.

The model consists of three main sectors: passenger flows, security personnel distribution and the algorithmic sector. In the passenger flows sector, the entrance of passengers to the system, accumulation processes at different areas and exiting from the security related parts of the airport are modeled. The second sector of the model is security personnel distribution in which the movement of the security personnel between the security checkpoints is modeled. The final algorithmic part interrelates the other two parts. In other words, how many security personnel are required is decided dynamically according to passenger flows and accumulations at each security checkpoints. In the model, the security checkpoints are modeled as five nodes: these are domestic terminal departure entrance security checkpoint, domestic terminal airside security checkpoint, international terminal entrance security checkpoint, international terminal airside security checkpoint and international terminal transfer line security checkpoint. All of these nodes have the same structure and variables. The nodes consist of some sections of three main parts of the model.

DESCRIPTION OF THE MODEL

As it is stated before the model consists of three main parts: passenger flows, security personnel distribution and algorithmic parts. In this section, how they are constructed, which assumptions are made and how they interact together are explained.

Passenger Flows Segment

This part includes entrance of the passengers, their accumulation in certain stocks and the time they spend and finally their exit from the system. Boundary of the system is determined as between the terminal entrance and the secondary (airside) security checkpoint because after that point passengers are not checked again and there is no need to model that part of the airport. However this procedure varies in different terminals. The airport consists of two terminals: domestic and international. Their departure sections are modeled in this project. There are also domestic-to-domestic and international-to-international transfer lines in the corresponding terminals, but they are located in different sections of the terminal and also their inputs are completely different. Thus these transfer lines should be modeled separately. In addition to that domestic-to-domestic transfer line passenger flow density is negligible so it is not included in the model.

Domestic Departure Terminal

Passenger inflow to the Domestic departure terminal is input as a graphical function. In this function, reliable data from Atatürk Airport is used. Incoming passenger firstly accumulate in a stock called "Domestic Departure Entrance Security Checkpoint". Their outflow rate from this stock is depend on number of passengers in this stock and the number of active x-rays that are used at that moment in the security checkpoint. In this process the average processing time of an x-ray assumed constant and calculations are made by this value always. The rate is named as "Domestic Departure Terminal Entrance Rate".

After passing the security checkpoint, passengers spend some time in a common are at the terminal before they continue to boarding gates. In order to represent the time they spend in this common area, a third order material delay is used. A third order material delay consists of three stocks, three outflows and three average times values to calculate the outflow rates. Names of these three stocks are stated as "Pre Check-In Period", "Check-In Period" and " After Check-In Period", and the corresponding average times to be spent in these stocks are assumed 5, 20 and 5 minutes respectively.

Finally passengers reach to the airside security checkpoint after this third order material delay. In this stock, the principle is the same as in the entrance security checkpoint. Passenger outflow rate is calculated by average processing time of an x-ray, number of active x-rays and the number of passengers in the security checkpoint.

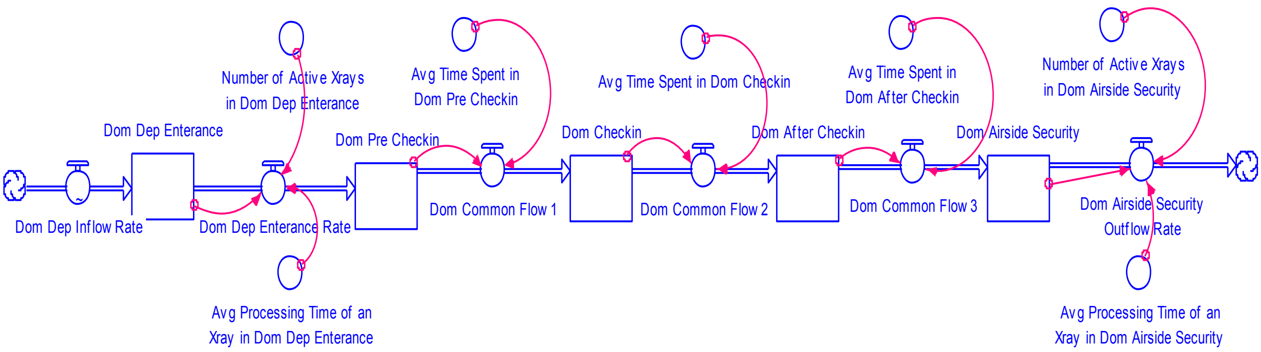

Figure 1: Structure of the Domestic Departure Terminal in the Model

International Departure Terminal

The structure of the international terminal is almost the same as the domestic. The main difference is the passport control stock. In the domestic terminal, passengers proceed to the airside security checkpoint after they spend some time in the common area. In the international terminal, however they have to go first to passport control, then to airside security checkpoint. In addition to the inflow from the common area, passport control stock has another inflow from the domestic terminal; it is called as "Domestic-to-International Transfer Flow". The meaning of this flow is that some passengers came from another airport from Turkey, but they are going to continue their journey to abroad. Hence they first come to the domestic arrival terminal and then they have to be transferred to international departure terminal, and their joining point is modeled as passport control stock. The outflow from the stock is dependent on the average passport control time per person and it is also assumed constant.

The other only difference from the domestic terminal is that, average passing time of the after Check-In period is assumed 15 rather than 5 because passengers spend more time in the international terminal in order to buy a duty stamp for abroad trips.

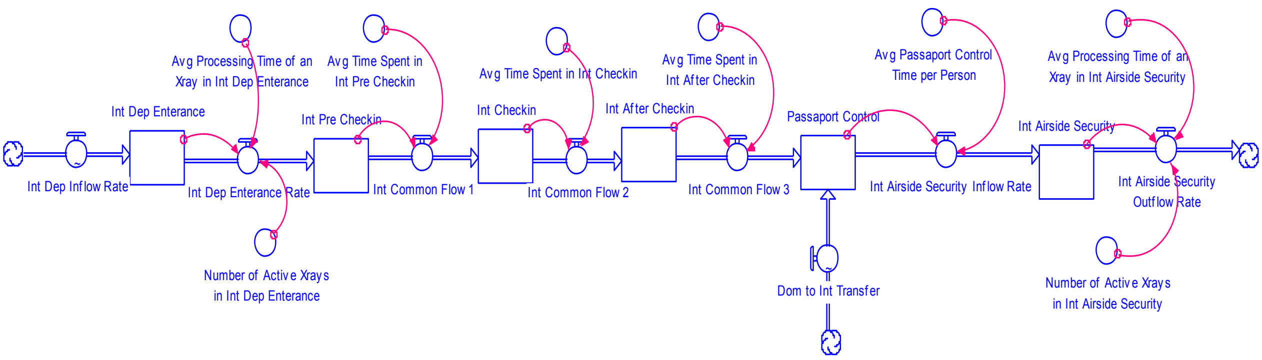

Figure 2: Structure of the International Departure Terminal in the Model

Another necessary part to be modeled is the international transfer line security. In this line there are passengers come from abroad and going to leave the country again. They are not mixed in the common area of the terminal with the other passengers; alternatively their security check is done in this checkpoint. The stock and flow principles are again the same as before. The inflow of this stock is another graphical input; the required data is also from the airport statistics.

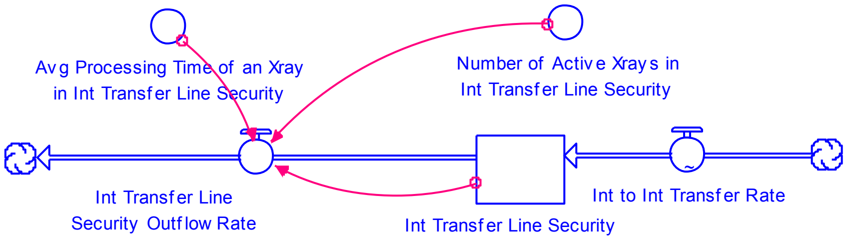

Figure 3: Structure of the International Transfer Line Security Checkpoint in the Model

Security Personnel Distribution Segment

In this part the distribution process is represented. As it is stated before, the model consists of five main security checkpoints. Number of security personnel at each checkpoint and the remaining unallocated personnel is modeled as stocks. The number of security personnel in the stock at a security checkpoint determines directly the number of active x-rays at that checkpoint. The distribution process works as follows. First the algorithm determines the difference between the desired and the actual number of personnel at each security checkpoint. If the difference is positive, in other words there is a need for more personnel in a checkpoint, required number of personnel come to that stock from unallocated stock in a determined time called security personnel inflow time. In this model all of these inflow times are assumed seven minutes.

On the other hand, if the difference is negative meaning that more than enough number of security personnel is present at the checkpoint. In that case, undesired number of personnel is immediately sent to the unallocated stock. Hence if a personnel goes to a security checkpoint, s/he may come from any of other checkpoints and the inflow time is like an average time to spend between any two checkpoints.

Finally it is also possible to change the total number of personnel during the run. It is possible by making the total number of security personnel variable as a graphical function. When total number is changed, necessary adjustment is made by a bi-flow between cloud (outside of the system) and unallocated number of personnel stock. Hence the new entering personnel can reach a security checkpoint again in seven minutes.

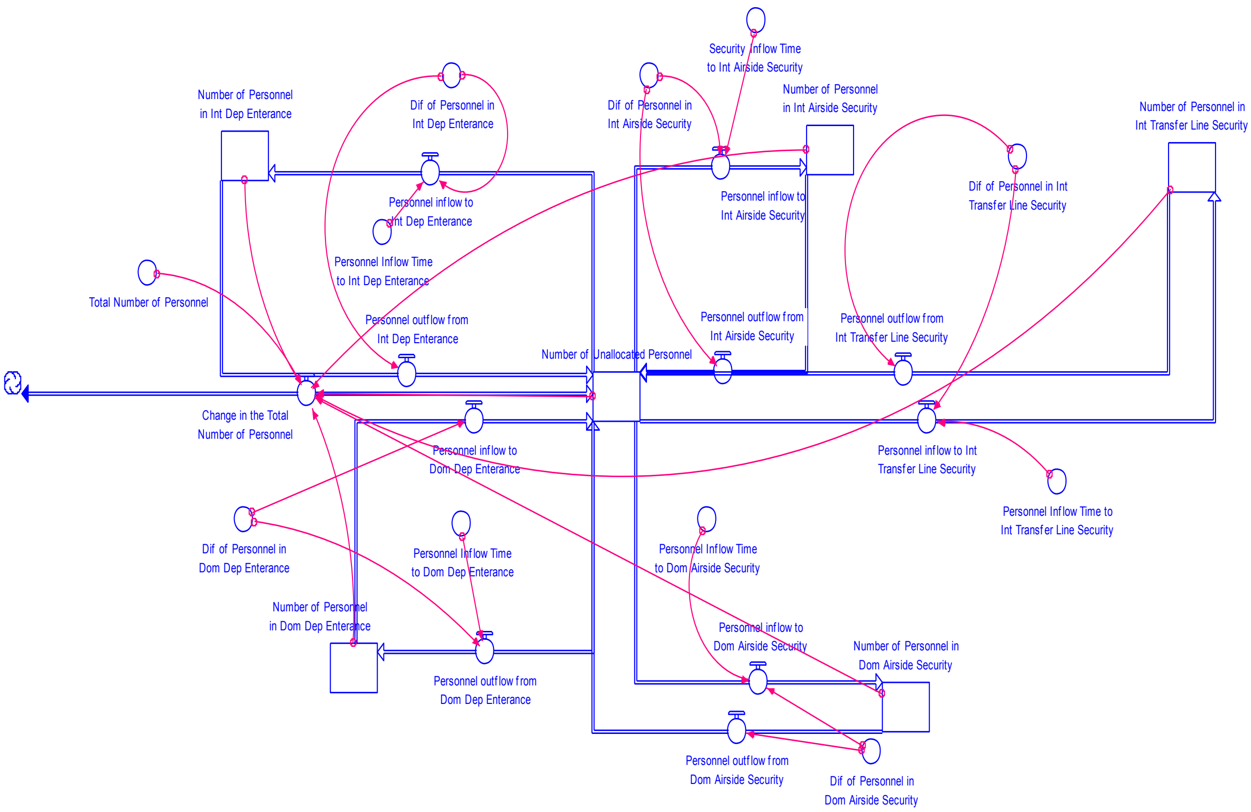

Figure 4: Structure of the security personnel distribution part in the mode

Algorithmic Segment

This part describes how the model decides the number of active x-rays and also number of security personnel at each node (i.e. security checkpoint). The algorithm needs total number of x-rays and goal queue length per x-ray as inputs at each node. For instance, in International transfer line security checkpoint there are eight x-ray devices can be used at maximum. These values are varying between each node. As a secondary input, a goal queue length should be entered. The algorithm tries to keep the number of passengers per x-ray at that particular value. In other words, it should activate more x-rays if the actual queue length is more than the goal. By multiplying the goal queue length of an x-ray and the number of x-rays at that node, the base queue length of that security checkpoint is obtained. Then, average queue lengths are calculated. The need coefficients are the ratio of average queue lengths and the base queue lengths at each node. After that desired number of x-rays at each node is calculated by multiplying the need coefficients with the total number of x-rays at each node. This process is done at each node individually, and then total desired number of active x-rays is calculated, if the number of security personnel is enough for that value available percentage of desired number of active x-rays stays as one, on the other hand if they are not enough available percentage is calculated as dividing total available number of x-rays (which is calculated according to total number of personnel and needed number of personnel to activate an x-ray) by total desired number of x-rays. How many more (or less) x-ray device is needed can be calculated, by using this percentage, desired number of active x-rays and the actual value of active x-rays. After that the difference of working personnel in each node is calculated via these values and personnel distribution can be done.

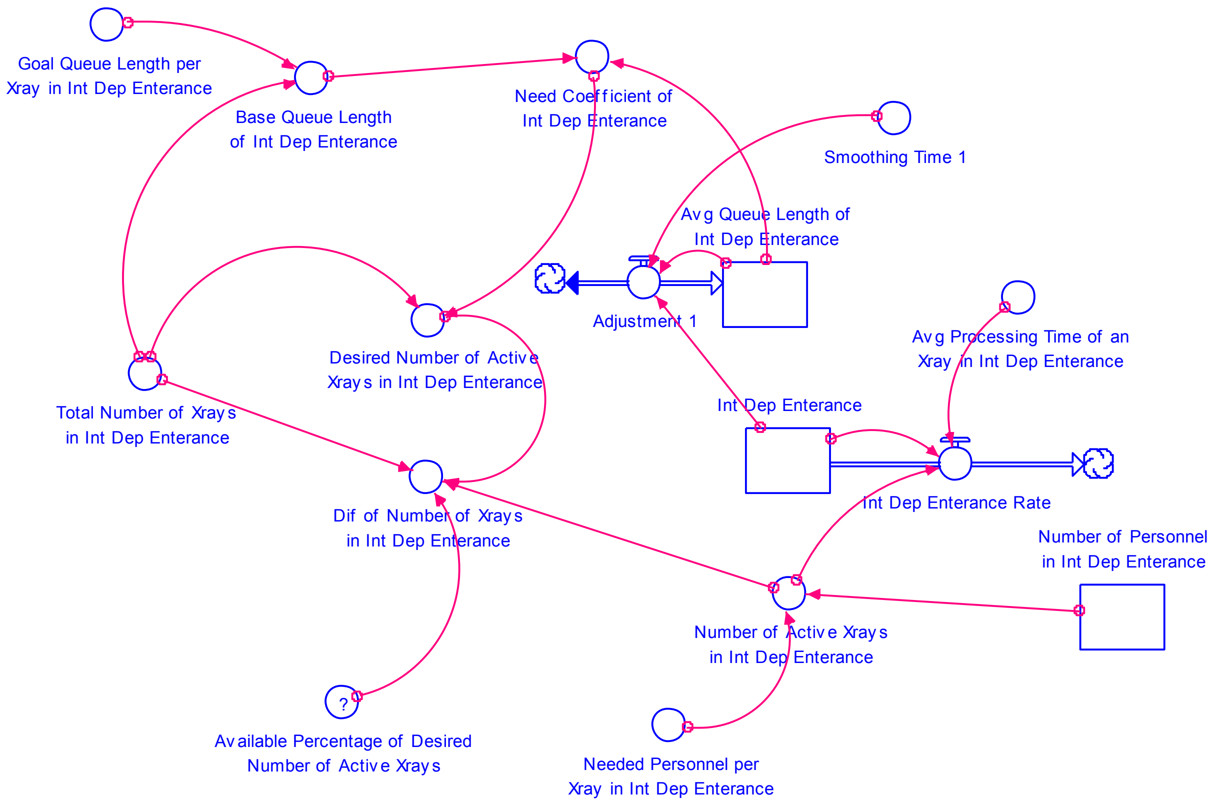

Figure 5: Structure of the algorithmic part in one of the five nodes in the model

MODEL VALIDATION AND OUTPUT ANALYSIS

In order to validate the model, first a steady state analysis and extreme condition tests are made. Model behaves as expected under both conditions; stocks stay at equilibrium levels in the steady state analysis and increase gradually in the extreme condition cases such as very high arrival rates or very low available number of personnel.

Furthermore sensitivity and scenario analysis are made to observe that how the parameter value changes affect the behavior of the model output. In conclusion of the investigation critical values for the model parameters are found.

Comparison of the Base Model and Algorithmic Model Outputs

In this section the results of two models, the base model and the model with the distribution algorithm are compared in terms of the number of people waiting in the queues and the number of active x-rays at any time. The reason for comparing the number of x-rays is to show that the model with algorithm uses fewer x-rays than the base model under same input data.

There are two different simulation runs made for both models in terms of weekdays. First one is the simulation for Friday, Saturday, Sunday and Monday. On these days air traffic is more intense than other weekdays. Second simulation is for Tuesday, Wednesday and Thursday.

Friday, Saturday, Sunday and Monday Run

This run has 5760 minutes in total and each 1440 minutes stands for a day consecutively starting from Friday. Friday is the most crowded day of the week at Atatürk Airport.

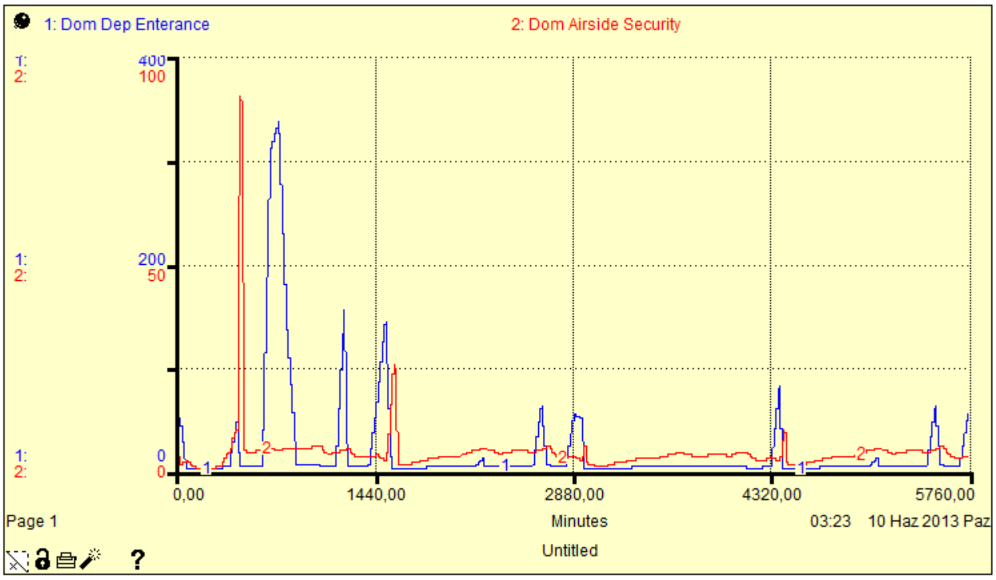

Figure 6: Domestic Terminal Queues in Base Model

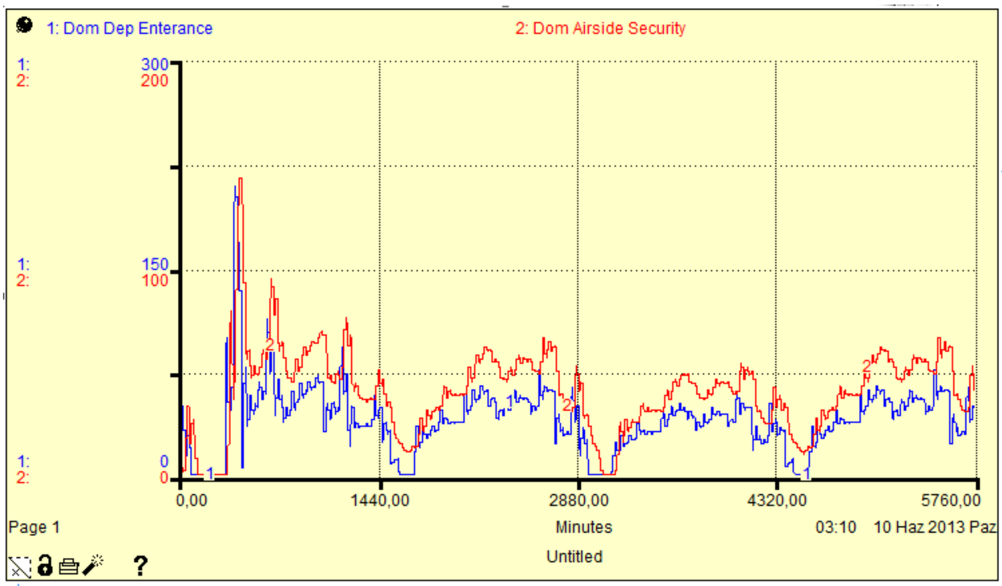

Figure 7: Domestic Terminal Queues in Algorithmic Model

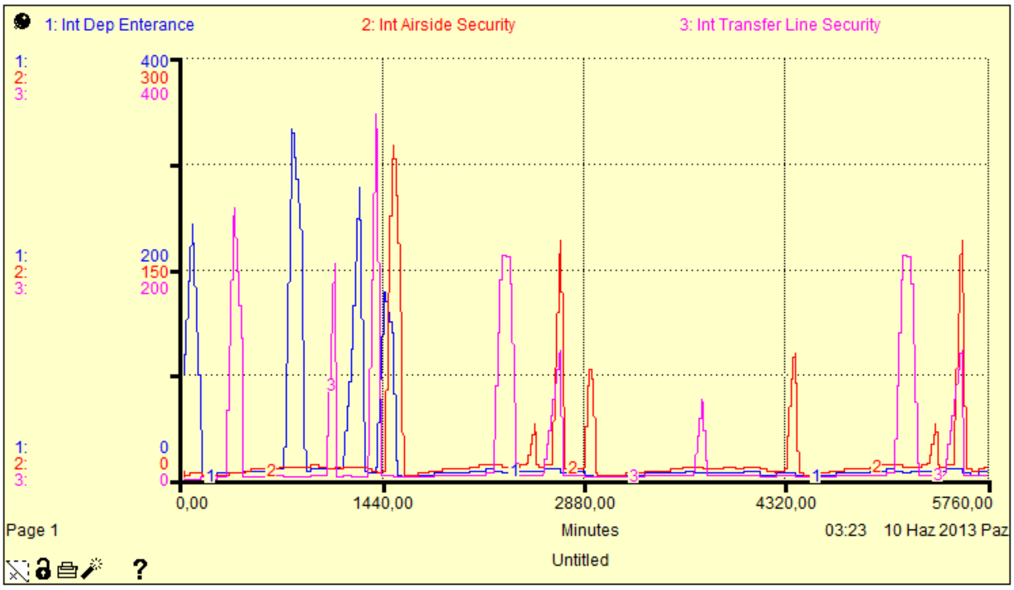

Figure 8: International Terminal Queues in Base Model

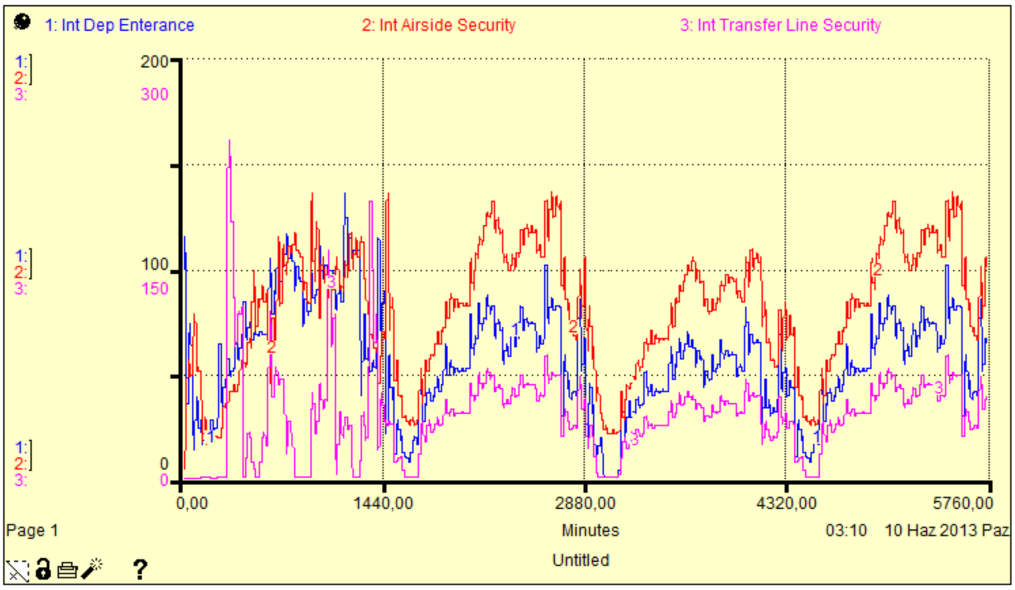

Figure 9: International Terminal Queues in Algorithmic Model

Observations show that the algorithmic model distributes queues smoother over time horizon. Algorithmic model avoids sharp jumps where the base model has very dramatic changes. It can be observed that there are more people in the domestic airside queue of the algorithmic model. The base model is deterministic and has no feedback structure thus it creates a strange behavior. However the algorithmic model tries to keep all queues under boundaries.

The total number x-ray comparison was also conducted:

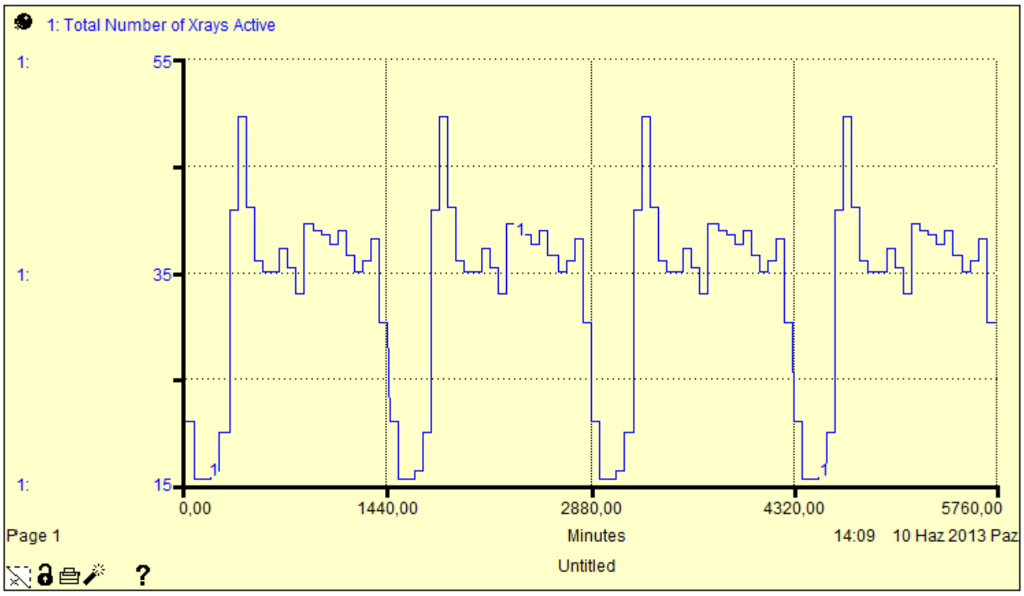

Figure 10: Total Number of Active X-rays in Base Model

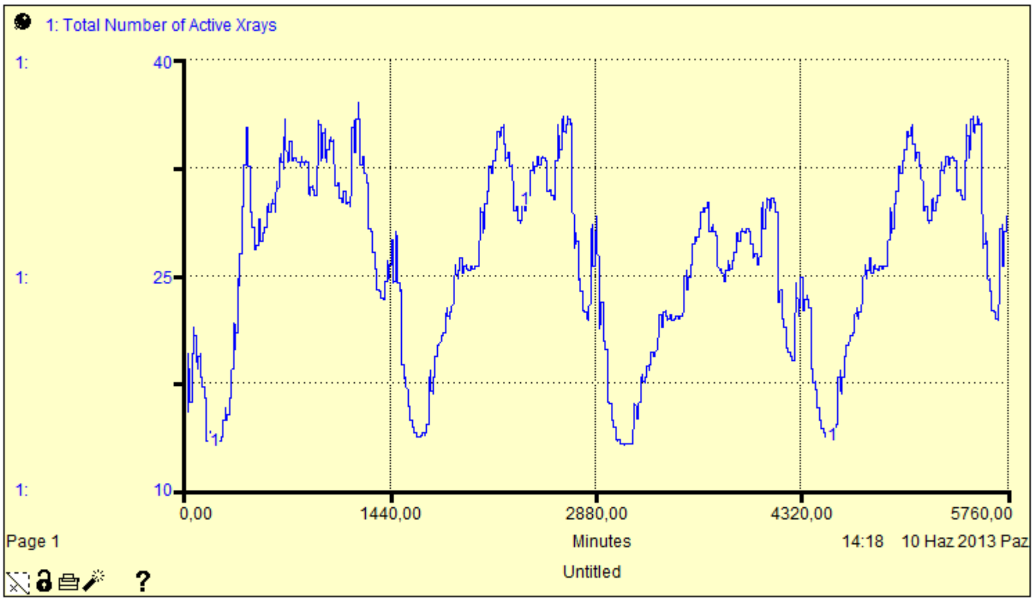

Figure 11: Total Number of Active X-rays in Algorithmic Model

Tuesday, Wednesday and Thursday Run

This simulation made in order to observe the behavior of the model under less crowded days. Same results obtained from previous simulation are also valid for these runs. Peaks occur in the morning at the domestic terminal and these peaks are quite small in the algorithmic model comparing to the base model.

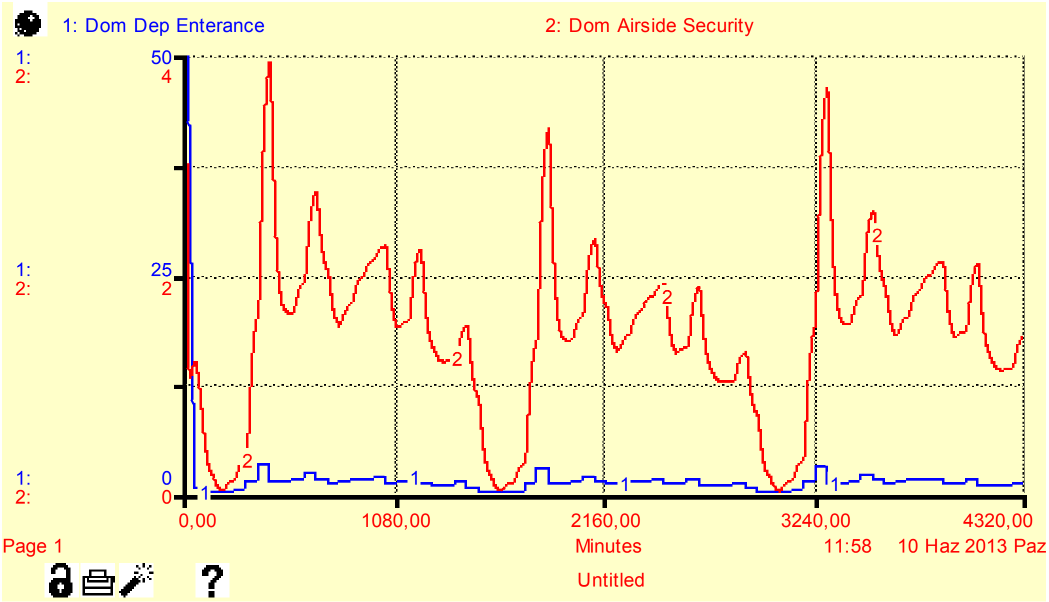

Figure 12: Domestic Terminal Queues in Base Model

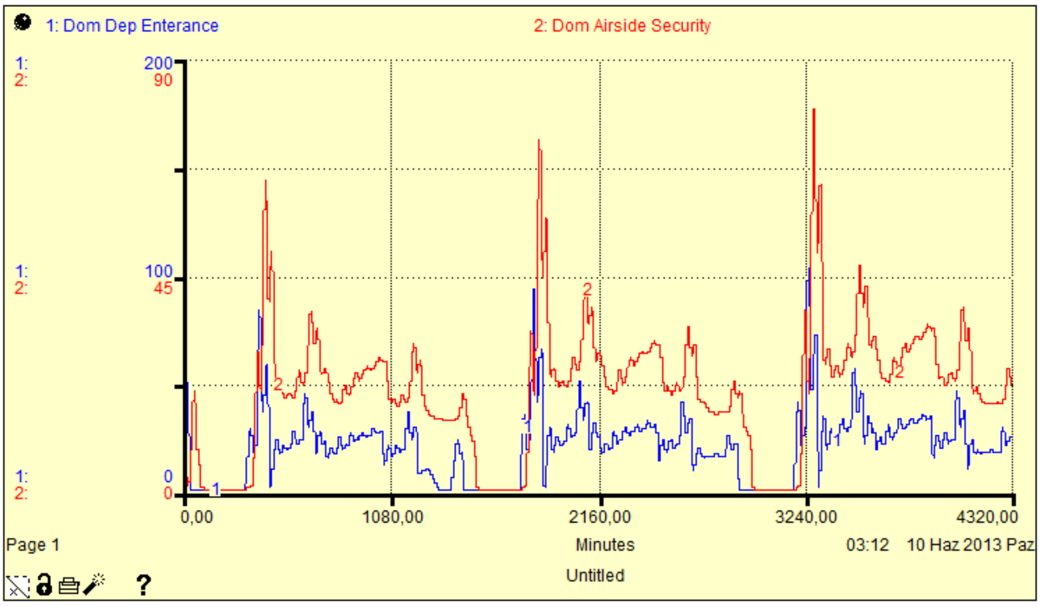

Figure 13: Domestic Terminal Queues in Algorithmic Model

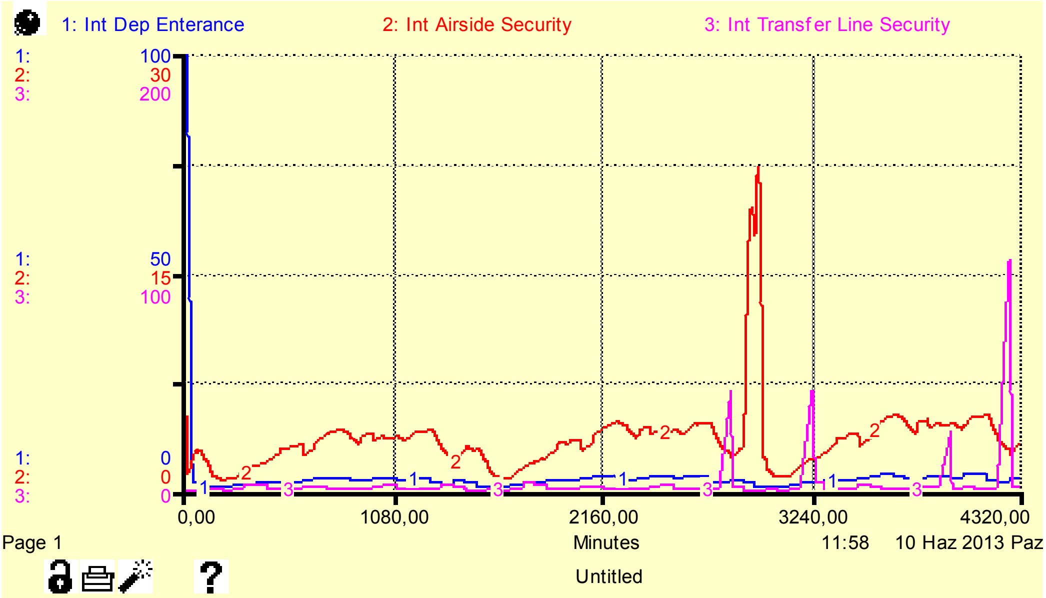

Figure 14: International Terminal Queues in Base Model

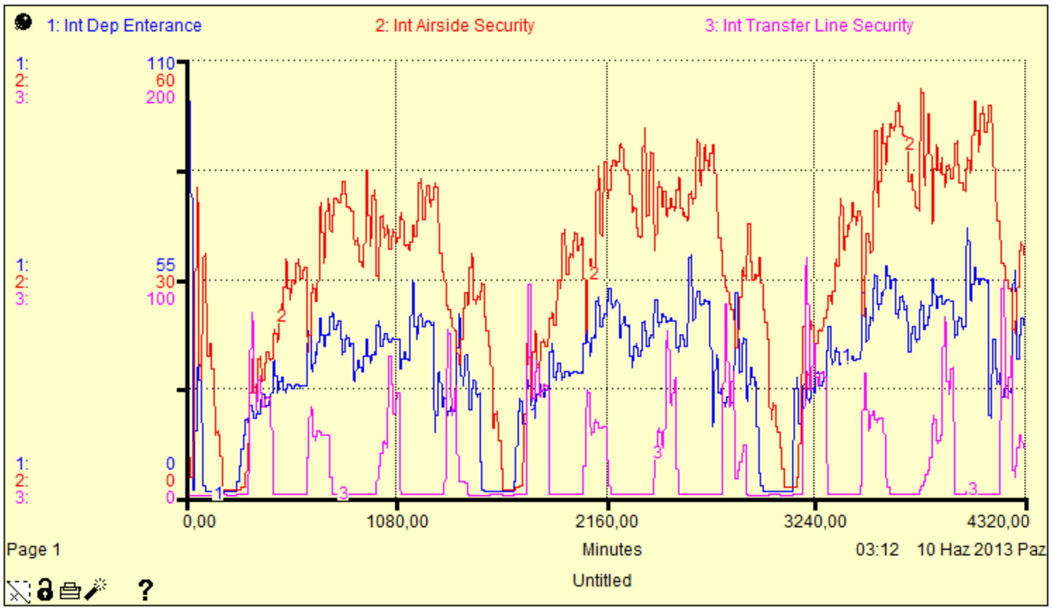

Figure 15: International Terminal Queues in Algorithmic Model

At international airside security checkpoint queue never exceeds 60 people where it reaches 90 people in the base model. A daily cycle can be observed in the graphical result. It is quite smooth and balanced in contrast to the base model.

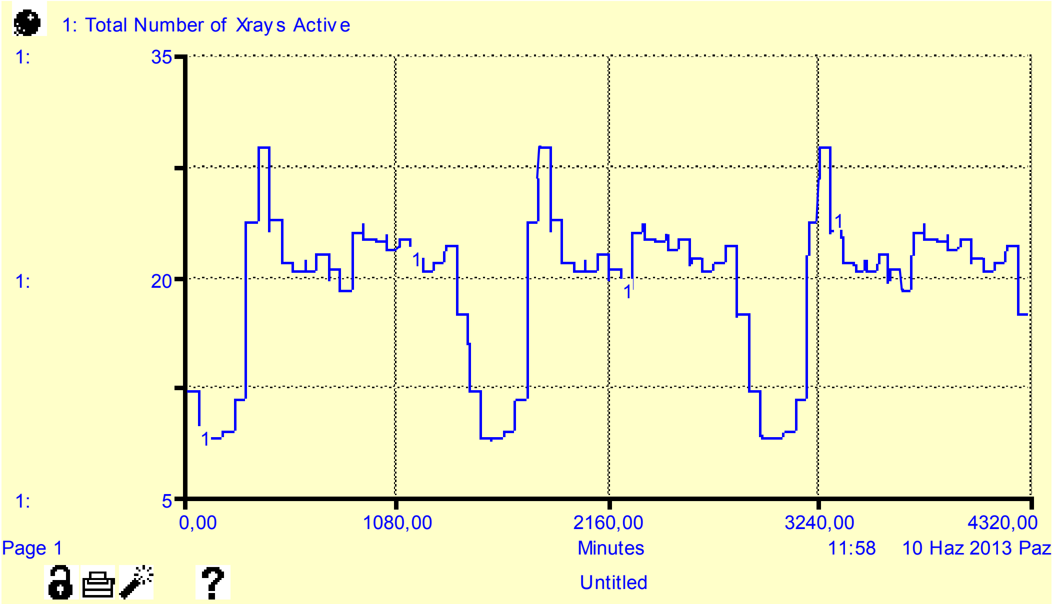

Figure 16: Total Number of Active X-rays in Base Model

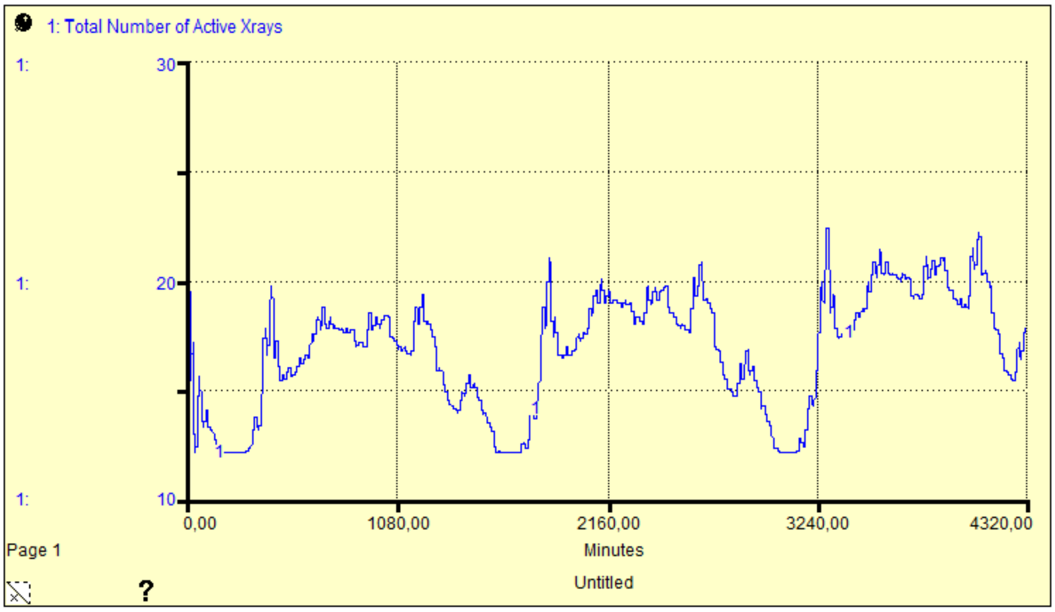

Figure 17: Total Number of Active X-rays in Algorithmic Model

The trends between two outcomes have a substantial difference. In the base model the number of x-rays is set as 29 at 8 am. However the algorithmic model uses only 20-23 x-ray devices. Behaviors of the active x-ray usages are very similar for both, which is another indicator of the algorithmic model is sensible and better in practice.

The results of the algorithmic model are promising. With the same input data, one can observe that the active x-ray trend in algorithmic model is much lower than the base model.

GAME DESIGN

By constructing a game, a platform is provided to the authorized people in Ataturk Airport to carry out interactive experiments about the necessary security personnel numbers and allocation strategy of these security personnel. The game is constructed in FORIO SIMULATE programming by converting the STELLA model equations to a web based form.

The game is designed to provide some experience about security personnel allocation to different checkpoints at airports. Number of security personnel at each checkpoint is important; it should be enough to avoid long queues at checkpoints, but should not be more than necessary to minimize unnecessary personnel budget. To this end, a cost score is defined as a joint function of the average queue length and the number of security personnel used. The objective of the player is to keep the cost score as low as possible.

In the game, the player simultaneously decides on the total number of personnel and also the desired number of x-rays at each security checkpoint. Simulation is run for one day; the decisions are taken once in every two hours. Relevant information about security personnel allocation problem is given to the player at the beginning. The game interface and outputs of an example game are shown in Figure 18.

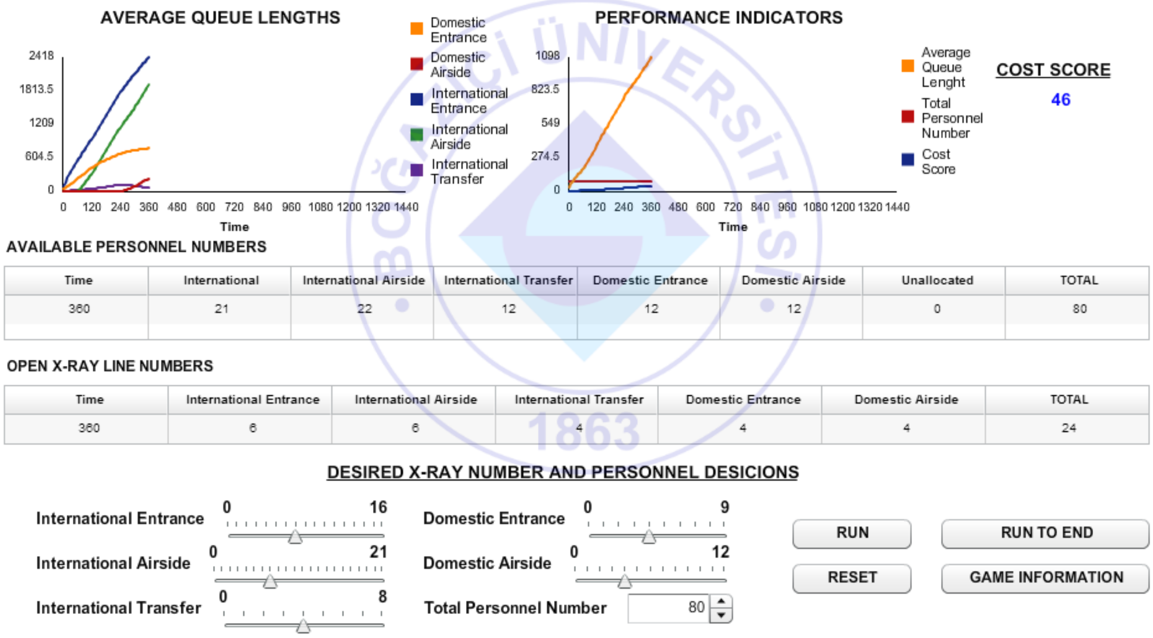

Figure 18: The Game Interface

CONCLUSION

In this paper, with the purpose of analyzing passenger flow and security check-point behaviors of Atatürk Airport, a dynamic model is constructed. After constructing the model, validation is done with extreme condition and sensitivity analyses in order to proceed to scenario analysis. In scenario analysis part, several different cases are simulated to predict alternative solutions, in case of possible changes in passenger behaviors and security system structure. Next, simulations and output analysis are completed with real data inputs. Finally, the model is turned into a web based simulation game.

Following extreme condition and sensitivity analyses, it is concluded that the model shows realistic and meaningful behaviors and results. This indicates that the model is well structured. By comparing with the behaviors of real data, validity of the model is confirmed. Key factors of the model are five queue lengths, number of active x-ray devices in these queue locations, and number of security personnel working at these queues. Inputs and construction of the model is designed to focus on these three key factors. In order to simplify the construction, the model is separated into two parts, domestic and international terminals, by taking into account inter-relations with each other.

In domestic departure entrance, domestic-to-international and international-to-international transfers and international departure entrance points, graphical real data inputs are entered to the model. Since domestic-to-domestic and international-to-domestic transfer rates are too small compered with the other two transfer rates, these two transfers are not reflected in the model. Effects of changes in total number of security personnel, graphical inputs, smoothing time and personnel inflow time to security checkpoints are investigated in the scenario analysis part.

An algorithm that dynamically finds the number of active x-ray machines and allocated personnel is next designed. The algorithm decides about these two decision variables optimally, by keeping the queue lengths at the checkpoints as close to their desired levels as possible. Results are shown to be promising, using real input data.

Finally, an interactive game version of the model is constructed via FORIO Online Simulations Software. Thus, a web based interactive platform is offered to managers of the Airport to carry out their own policy experiments about the security personnel numbers and allocation strategy of these security personnel.

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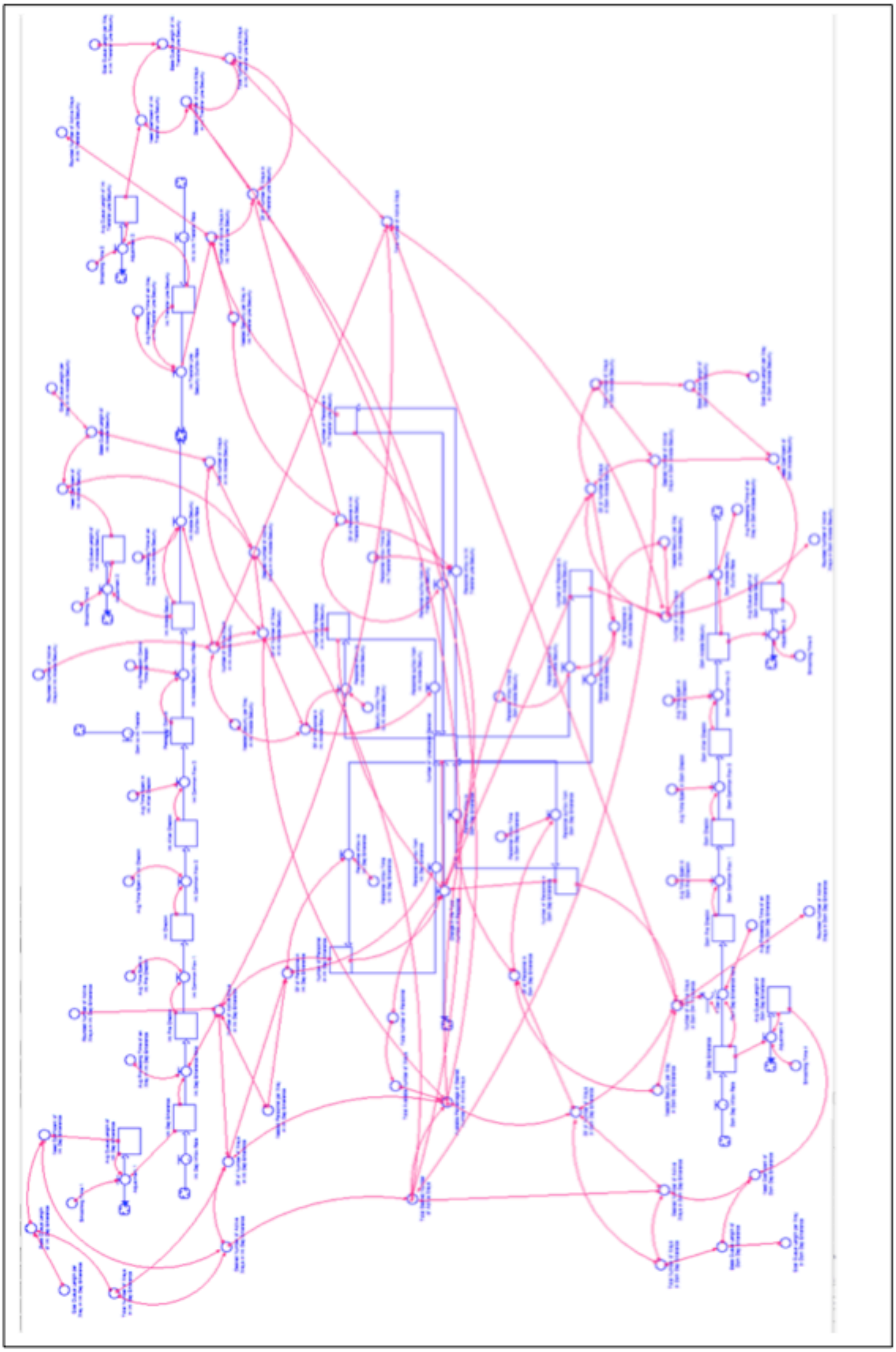
APPENDIX A: COMPLETE DIAGRAM OF THE MODEL



APPENDIX B: COMPLETE LIST OF MODEL EQUATIONS

Avg_Queue_Length_of_Dom_Airside_Security(t) = Avg_Queue_Length_of_Dom_Airside_Security(t - dt) + (Adjustment_5) * dt

INIT Avg_Queue_Length_of_Dom_Airside_Security = 3

INFLOWS:

Adjustment_5 = (Dom_Airside_Security-Avg_Queue_Length_of_Dom_Airside_Security)/Smoothing_Time_5

Avg_Queue_Length_of_Dom_Dep_Entrance(t) = Avg_Queue_Length_of_Dom_Dep_Entrance(t - dt) + (Adjustment_4) * dt

INIT Avg_Queue_Length_of_Dom_Dep_Entrance = 50

INFLOWS:

Adjustment_4 = (Dom_Dep_Entrance-Avg_Queue_Length_of_Dom_Dep_Entrance)/Smoothing_Time_4

Avg_Queue_Length_of_Int_Airside_Security(t) = Avg_Queue_Length_of_Int_Airside_Security(t - dt) + (Adjustment_2) * dt

INIT Avg_Queue_Length_of_Int_Airside_Security = 5

INFLOWS:

Adjustment_2 = (Int_Airside_Security-Avg_Queue_Length_of_Int_Airside_Security)/Smoothing_Time_2

Avg_Queue_Length_of_Int_Dep_Entrance(t) = Avg_Queue_Length_of_Int_Dep_Entrance(t - dt) + (Adjustment_1) * dt

INIT Avg_Queue_Length_of_Int_Dep_Entrance = 100

INFLOWS:

Adjustment_1 = (Int_Dep_Entrance-Avg_Queue_Length_of_Int_Dep_Entrance)/Smoothing_Time_1

Avg_Queue_Length_of_Int_Transfer_Line_Security(t) = Avg_Queue_Length_of_Int_Transfer_Line_Security(t - dt) + (Adjustment_3) * dt

INIT Avg_Queue_Length_of_Int_Transfer_Line_Security = 0

INFLOWS:

Adjustment_3 = (Int_Transfer_Line_Security-Avg_Queue_Length_of_Int_Transfer_Line_Security)/Smoothing_Time_3

Dom_After_Check-In(t) = Dom_After_Check-In(t - dt) + (Dom_Common_Flow_2 - Dom_Common_Flow_3) * dt

INIT Dom_After_Check-In = 20

INFLOWS:

Dom_Common_Flow_2 = Dom_Check-In/Avg_Time_Spent_in_Dom_Check-In

OUTFLOWS:

Dom_Common_Flow_3 = Dom_After_Check-In/Avg_Time_Spent_in_Dom_After_Check-In

Dom_Airside_Security(t) = Dom_Airside_Security(t - dt) + (Dom_Common_Flow_3 - Dom_Airside_Security_Outflow_Rate) * dt

INIT Dom_Airside_Security = 3

INFLOWS:

Dom_Common_Flow_3 = Dom_After_Check-In/Avg_Time_Spent_in_Dom_After_Check-In

OUTFLOWS:

Dom_Airside_Security_Outflow_Rate = MIN(Dom_Airside_Security,Number_of_Active_Xrays_in_Dom_Airside_Security)/Avg_Processing_Time_of_an_Xray_in_Dom_Airside_Security

Dom_Check-In(t) = Dom_Check-In(t - dt) + (Dom_Common_Flow_1 - Dom_Common_Flow_2) * dt

INIT Dom_Check-In = 40

INFLOWS:

Dom_Common_Flow_1 = Dom_Pre_Check-In/Avg_Time_Spent_in_Dom_Pre_Check-In

OUTFLOWS:

Dom_Common_Flow_2 = Dom_Check-In/Avg_Time_Spent_in_Dom_Check-In

Dom_Dep_Entrance(t) = Dom_Dep_Entrance(t - dt) + (Dom_Dep_Inflow_Rate - Dom_Dep_Entrance_Rate) * dt

INIT Dom_Dep_Entrance = 50

INFLOWS:

Dom_Dep_Inflow_Rate = GRAPH(TIME)

(0.00, 4.49), (60.0, 0.779), (120, 0.0462), (180, 0.766), (240, 2.08), (300, 11.0), (360, 26.2), (420, 9.97), (480, 10.3), (540, 12.3), (600, 17.9), (660, 12.4), (720, 9.46), (780, 11.0), (840, 12.6), (900, 13.5), (960, 14.4), (1020, 9.25), (1080, 10.0), (1140, 14.5), (1200, 8.10), (1260, 7.54), (1320, 7.72), (1380, 9.84), (1440, 6.89), (1500, 3.29), (1560, 2.32), (1620, 2.74), (1680, 5.00), (1740, 6.07), (1800, 6.88), (1860, 8.45), (1920, 8.14), (1980, 8.23), (2040, 10.2), (2100, 11.8), (2160, 12.9), (2220, 11.5), (2280, 9.55), (2340, 10.5), (2400, 11.8), (2460, 11.8), (2520, 10.3), (2580, 12.9), (2640, 13.0), (2700, 7.42), (2760, 6.36), (2820, 9.64), (2880, 5.51), (2940, 2.63), (3000, 1.86), (3060, 2.19), (3120, 4.00), (3180, 4.86), (3240, 5.51), (3300, 6.76), (3360, 6.51), (3420, 6.58), (3480, 8.14), (3540, 9.46), (3600, 10.3), (3660, 9.18), (3720, 7.64), (3780, 8.38), (3840, 9.46), (3900, 9.41), (3960, 8.24), (4020, 10.3), (4080, 10.4), (4140, 5.94), (4200, 5.09), (4260, 7.71), (4320, 6.89), (4380, 3.29), (4440, 2.32), (4500, 2.74), (4560, 5.00), (4620, 6.07), (4680, 6.88), (4740, 8.45), (4800, 8.14), (4860, 8.23), (4920, 10.2), (4980, 11.8), (5040, 12.9), (5100, 11.5), (5160, 9.55), (5220, 10.5), (5280, 11.8), (5340, 11.8), (5400, 10.3), (5460, 12.9), (5520, 13.0), (5580, 7.42), (5640, 6.36), (5700, 9.64), (5760, 9.64)

OUTFLOWS:

Dom_Dep_Entrance_Rate = MIN(Number_of_Active_Xrays_in_Dom_Dep_Entrance,Dom_Dep_Entrance)/Avg_Processing_Time_of_an_Xray_in_Dom_Dep_Entrance

Dom_Pre_Check-In(t) = Dom_Pre_Check-In(t - dt) + (Dom_Dep_Entrance_Rate - Dom_Common_Flow_1) * dt

INIT Dom_Pre_Check-In = 20

INFLOWS:

Dom_Dep_Entrance_Rate = MIN(Number_of_Active_Xrays_in_Dom_Dep_Entrance,Dom_Dep_Entrance)/Avg_Processing_Time_of_an_Xray_in_Dom_Dep_Entrance

OUTFLOWS:

Dom_Common_Flow_1 = Dom_Pre_Check-In/Avg_Time_Spent_in_Dom_Pre_Check-In

Int_After_Check-In(t) = Int_After_Check-In(t - dt) + (Int_Common_Flow_2 - Int_Common_Flow_3) * dt

INIT Int_After_Check-In = 20

INFLOWS:

Int_Common_Flow_2 = Int_Check-In/Avg_Time_Spent_in_Int_Check-In

OUTFLOWS:

Int_Common_Flow_3 = Int_After_Check-In/Avg_Time_Spent_in_Int_After_Check-In

Int_Airside_Security(t) = Int_Airside_Security(t - dt) + (Int_Airside_Security_Inflow_Rate - Int_Airside_Security_Outflow_Rate) * dt

INIT Int_Airside_Security = 5

INFLOWS:

Int_Airside_Security_Inflow_Rate = MIN(Passport_Control/(5*Avg_Passport_Control_Time_per_Person) , 28/Avg_Passport_Control_Time_per_Person)

OUTFLOWS:

Int_Airside_Security_Outflow_Rate = MIN(Int_Airside_Security,Number_of_Active_Xrays_in_Int_Airside_Security)/Avg_Processing_Time_of_an_Xray_in_Int_Airside_Security

Int_Check-In(t) = Int_Check-In(t - dt) + (Int_Common_Flow_1 - Int_Common_Flow_2) * dt

INIT Int_Check-In = 50

INFLOWS:

Int_Common_Flow_1 = Int_Pre_Check-In/Avg_Time_Spent_in_Int_Pre_Check-In

OUTFLOWS:

Int_Common_Flow_2 = Int_Check-In/Avg_Time_Spent_in_Int_Check-In

Int_Dep_Entrance(t) = Int_Dep_Entrance(t - dt) + (Int_Dep_Inflow_Rate - Int_Dep_Entrance_Rate) * dt

INIT Int_Dep_Entrance = 100

INFLOWS:

Int_Dep_Inflow_Rate = GRAPH(TIME)

(0.00, 12.2), (60.0, 5.85), (120, 4.13), (180, 4.87), (240, 8.90), (300, 10.8), (360, 12.2), (420, 15.0), (480, 14.5), (540, 14.6), (600, 18.1), (660, 21.0), (720, 22.9), (780, 20.4), (840, 17.0), (900, 18.6), (960, 21.0), (1020, 20.9), (1080, 18.3), (1140, 23.0), (1200, 23.1), (1260, 13.2), (1320, 11.3), (1380, 17.1), (1440, 9.19), (1500, 4.39), (1560, 3.09), (1620, 3.65), (1680, 6.67), (1740, 8.09), (1800, 9.18), (1860, 11.3), (1920, 10.9), (1980, 11.0), (2040, 13.6), (2100, 15.8), (2160, 17.2), (2220, 15.3), (2280, 12.7), (2340, 14.0), (2400, 15.8), (2460, 15.7), (2520, 13.7), (2580, 17.2), (2640, 17.3), (2700, 9.90), (2760, 8.48), (2820, 12.9), (2880, 7.35), (2940, 3.51), (3000, 2.48), (3060, 2.92), (3120, 5.34), (3180, 6.47), (3240, 7.34), (3300, 9.01), (3360, 8.68), (3420, 8.78), (3480, 10.9), (3540, 12.6), (3600, 13.8), (3660, 12.2), (3720, 10.2), (3780, 11.2), (3840, 12.6), (3900, 12.5), (3960, 11.0), (4020, 13.8), (4080, 13.9), (4140, 7.92), (4200, 6.78), (4260, 10.3), (4320, 9.19), (4380, 4.39), (4440, 3.09), (4500, 3.65), (4560, 6.67), (4620, 8.09), (4680, 9.18), (4740, 11.3), (4800, 10.9), (4860, 11.0), (4920, 13.6), (4980, 15.8), (5040, 17.2), (5100, 15.3), (5160, 12.7), (5220, 14.0), (5280, 15.8), (5340, 15.7), (5400, 13.7), (5460, 17.2), (5520, 17.3), (5580, 9.90), (5640, 8.48), (5700, 12.9), (5760, 12.9)

OUTFLOWS:

Int_Dep_Entrance_Rate = MIN(Int_Dep_Entrance,Number_of_Active_Xrays_in_Int_Dep_Entrance)/Avg_Processing_Time_of_an_Xray_in_Int_Dep_Entrance

Int_Pre_Check-In(t) = Int_Pre_Check-In(t - dt) + (Int_Dep_Entrance_Rate - Int_Common_Flow_1) * dt

INIT Int_Pre_Check-In = 20

INFLOWS:

Int_Dep_Entrance_Rate = MIN(Int_Dep_Entrance,Number_of_Active_Xrays_in_Int_Dep_Entrance)/Avg_Processing_Time_of_an_Xray_in_Int_Dep_Entrance

OUTFLOWS:

Int_Common_Flow_1 = Int_Pre_Check-In/Avg_Time_Spent_in_Int_Pre_Check-In

Int_Transfer_Line_Security(t) = Int_Transfer_Line_Security(t - dt) + (Int_to_Int_Transfer_Rate - Int_Transfer_Line_Security_Outflow_Rate) * dt

INIT Int_Transfer_Line_Security = 0

INFLOWS:

Int_to_Int_Transfer_Rate = GRAPH(TIME)

(0.00, 0.00), (60.0, 0.00), (120, 0.132), (180, 0.00), (240, 0.647), (300, 21.8), (360, 19.4), (420, 4.42), (480, 2.84), (540, 4.44), (600, 12.6), (660, 12.4), (720, 5.54), (780, 1.60), (840, 2.81), (900, 6.78), (960, 9.39), (1020, 19.3), (1080, 5.69), (1140, 6.49), (1200, 1.12), (1260, 5.62), (1320, 20.1), (1380, 7.93), (1440, 6.89), (1500, 3.29), (1560, 2.32), (1620, 2.74), (1680, 5.00), (1740, 6.07), (1800, 6.88), (1860, 8.45), (1920, 8.14), (1980, 8.23), (2040, 10.2), (2100, 11.8), (2160, 12.9), (2220, 11.5), (2280, 9.55), (2340, 10.5), (2400, 11.8), (2460, 11.8), (2520, 10.3), (2580, 12.9), (2640, 13.0), (2700, 7.42), (2760, 6.36), (2820, 9.64), (2880, 5.51), (2940, 2.63), (3000, 1.86), (3060, 2.19), (3120, 4.00), (3180, 4.86), (3240, 5.51), (3300, 6.76), (3360, 6.51), (3420, 6.58), (3480, 8.14), (3540, 9.46), (3600, 10.3), (3660, 9.18), (3720, 7.64), (3780, 8.38), (3840, 9.46), (3900, 9.41), (3960, 8.24), (4020, 10.3), (4080, 10.4), (4140, 5.94), (4200, 5.09), (4260, 7.71), (4320, 6.89), (4380, 3.29), (4440, 2.32), (4500, 2.74), (4560, 5.00), (4620, 6.07), (4680, 6.88), (4740, 8.45), (4800, 8.14), (4860, 8.23), (4920, 10.2), (4980, 11.8), (5040, 12.9), (5100, 11.5), (5160, 9.55), (5220, 10.5), (5280, 11.8), (5340, 11.8), (5400, 10.3), (5460, 12.9), (5520, 13.0), (5580, 7.42), (5640, 6.36), (5700, 9.64), (5760, 9.64)

OUTFLOWS:

Int_Transfer_Line_Security_Outflow_Rate = MIN(Int_Transfer_Line_Security,Number_of_Active_Xrays_in_Int_Transfer_Line_Security)/Avg_Processing_Time_of_an_Xray_in_Int_Transfer_Line_Security

Number_of_Personnel_in_Dom_Airside_Security(t) = Number_of_Personnel_in_Dom_Airside_Security(t - dt) + (Personnel_inflow_to_Dom_Airside_Security - Personnel_outflow_from_Dom_Airside_Security) * dt

INIT Number_of_Personnel_in_Dom_Airside_Security = 25

INFLOWS:

Personnel_inflow_to_Dom_Airside_Security = Dif_of_Personnel_in_Dom_Airside_Security/Personnel_Inflow_Time_to_Dom_Airside_Security

OUTFLOWS:

Personnel_outflow_from_Dom_Airside_Security = -Dif_of_Personnel_in_Dom_Airside_Security

Number_of_Personnel_in_Dom_Dep_Entrance(t) = Number_of_Personnel_in_Dom_Dep_Entrance(t - dt) + (Personnel_outflow_from_Dom_Dep_Entrance - Personnel_inflow_to_Dom_Dep_Entrance) * dt

INIT Number_of_Personnel_in_Dom_Dep_Entrance = 5

INFLOWS:

Personnel_outflow_from_Dom_Dep_Entrance = Dif_of_Personnel_in_Dom_Dep_Entrance/Personnel_Inflow_Time_to_Dom_Dep_Entrance

OUTFLOWS:

Personnel_inflow_to_Dom_Dep_Entrance = -Dif_of_Personnel_in_Dom_Dep_Entrance

Number_of_Personnel_in_Int_Airside_Security(t) = Number_of_Personnel_in_Int_Airside_Security(t - dt) + (Personnel_inflow_to_Int_Airside_Security - Personnel_outflow_from_Int_Airside_Security) * dt

INIT Number_of_Personnel_in_Int_Airside_Security = 5

INFLOWS:

Personnel_inflow_to_Int_Airside_Security = Dif_of_Personnel_in_Int_Airside_Security/Security_Inflow_Time_to_Int_Airside_Security

OUTFLOWS:

Personnel_outflow_from_Int_Airside_Security = -Dif_of_Personnel_in_Int_Airside_Security

Number_of_Personnel_in_Int_Dep_Entrance(t) = Number_of_Personnel_in_Int_Dep_Entrance(t - dt) + (Personnel_inflow_to_Int_Dep_Entrance - Personnel_outflow_from_Int_Dep_Entrance) * dt

INIT Number_of_Personnel_in_Int_Dep_Entrance = 5

INFLOWS:

Personnel_inflow_to_Int_Dep_Entrance = Dif_of_Personnel_in_Int_Dep_Entrance/Personnel_Inflow_Time_to_Int_Dep_Entrance

OUTFLOWS:

Personnel_outflow_from_Int_Dep_Entrance = -Dif_of_Personnel_in_Int_Dep_Entrance

Number_of_Personnel_in_Int_Transfer_Line_Security(t) = Number_of_Personnel_in_Int_Transfer_Line_Security(t - dt) + (Personnel_inflow_to_Int_Transfer_Line_Security - Personnel_outflow_from_Int_Transfer_Line_Security) * dt

INIT Number_of_Personnel_in_Int_Transfer_Line_Security = 20

INFLOWS:

Personnel_inflow_to_Int_Transfer_Line_Security = Dif_of_Personnel_in_Int_Transfer_Line_Security/Personnel_Inflow_Time_to_Int_Transfer_Line_Security

OUTFLOWS:

Personnel_outflow_from_Int_Transfer_Line_Security = -Dif_of_Personnel_in_Int_Transfer_Line_Security

Number_of_Unallocated_Personnel(t) = Number_of_Unallocated_Personnel(t - dt) + (Personnel_outflow_from_Int_Dep_Entrance + Personnel_outflow_from_Int_Airside_Security + Personnel_outflow_from_Int_Transfer_Line_Security + Personnel_inflow_to_Dom_Dep_Entrance + Personnel_outflow_from_Dom_Airside_Security + Change_in_the_Total_Number_of_Personnel - Personnel_inflow_to_Int_Dep_Entrance - Personnel_inflow_to_Int_Airside_Security - Personnel_inflow_to_Int_Transfer_Line_Security - Personnel_outflow_from_Dom_Dep_Entrance - Personnel_inflow_to_Dom_Airside_Security) * dt

INIT Number_of_Unallocated_Personnel = 30

INFLOWS:

Personnel_outflow_from_Int_Dep_Entrance = -Dif_of_Personnel_in_Int_Dep_Entrance

Personnel_outflow_from_Int_Airside_Security = -Dif_of_Personnel_in_Int_Airside_Security

Personnel_outflow_from_Int_Transfer_Line_Security = -Dif_of_Personnel_in_Int_Transfer_Line_Security

Personnel_inflow_to_Dom_Dep_Entrance = -Dif_of_Personnel_in_Dom_Dep_Entrance

Personnel_outflow_from_Dom_Airside_Security = -Dif_of_Personnel_in_Dom_Airside_Security

Change_in_the_Total_Number_of_Personnel = Total_Number_of_Personnel-(Number_of_Personnel_in_Dom_Airside_Security+Number_of_Personnel_in_Dom_Dep_Entrance+Number_of_Personnel_in_Int_Airside_Security+Number_of_Personnel_in_Int_Dep_Entrance+Number_of_Personnel_in_Int_Transfer_Line_Security+Number_of_Unallocated_Personnel)

OUTFLOWS:

Personnel_inflow_to_Int_Dep_Entrance = Dif_of_Personnel_in_Int_Dep_Entrance/Personnel_Inflow_Time_to_Int_Dep_Entrance

Personnel_inflow_to_Int_Airside_Security = Dif_of_Personnel_in_Int_Airside_Security/Security_Inflow_Time_to_Int_Airside_Security

Personnel_inflow_to_Int_Transfer_Line_Security = Dif_of_Personnel_in_Int_Transfer_Line_Security/Personnel_Inflow_Time_to_Int_Transfer_Line_Security

Personnel_outflow_from_Dom_Dep_Entrance =
Dif_of_Personnel_in_Dom_Dep_Entrance/Personnel_Inflow_Time_to_Dom_Dep_Entrance

Personnel_inflow_to_Dom_Airside_Security =
Dif_of_Personnel_in_Dom_Airside_Security/Personnel_Inflow_Time_to_Dom_Airside_Security

Passport_Control(t) = Passport_Control(t - dt) + (Int_Common_Flow_3 + Dom_to_Int_Transfer - Int_Airside_Security_Inflow_Rate) * dt

INIT Passport_Control = 7

INFLOWS:

Int_Common_Flow_3 = Int_After_Check-In/Avg_Time_Spent_in_Int_After_Check-In

Dom_to_Int_Transfer = GRAPH(TIME)

(0.00, 3.20), (60.0, 4.78), (120, 0.00), (180, 0.15), (240, 0.05), (300, 0.57), (360, 0.17), (420, 1.42), (480, 5.23), (540, 7.32), (600, 0.4), (660, 4.87), (720, 5.22), (780, 5.82), (840, 3.20), (900, 9.33), (960, 4.42), (1020, 2.27), (1080, 3.68), (1140, 5.50), (1200, 4.37), (1260, 5.03), (1320, 3.58), (1380, 0.88), (1440, 8.35), (1500, 3.99), (1560, 2.81), (1620, 3.32), (1680, 6.07), (1740, 7.36), (1800, 8.34), (1860, 10.2), (1920, 9.87), (1980, 9.98), (2040, 12.3), (2100, 14.3), (2160, 15.6), (2220, 13.9), (2280, 11.6), (2340, 12.7), (2400, 14.3), (2460, 14.3), (2520, 12.5), (2580, 15.7), (2640, 15.8), (2700, 9.00), (2760, 7.71), (2820, 11.7), (2880, 6.68), (2940, 3.19), (3000, 2.25), (3060, 2.66), (3120, 4.85), (3180, 5.89), (3240, 6.67), (3300, 8.19), (3360, 7.89), (3420, 7.98), (3480, 9.87), (3540, 11.5), (3600, 12.5), (3660, 11.1), (3720, 9.26), (3780, 10.2), (3840, 11.5), (3900, 11.4), (3960, 9.99), (4020, 12.5), (4080, 12.6), (4140, 7.20), (4200, 6.17), (4260, 9.35), (4320, 8.35), (4380, 3.99), (4440, 2.81), (4500, 3.32), (4560, 6.07), (4620, 7.36), (4680, 8.34), (4740, 10.2), (4800, 9.87), (4860, 9.98), (4920, 12.3), (4980, 14.3), (5040, 15.6), (5100, 13.9), (5160, 11.6), (5220, 12.7), (5280, 14.3), (5340, 14.3), (5400, 12.5), (5460, 15.7), (5520, 15.8), (5580, 9.00), (5640, 7.71), (5700, 11.7), (5760, 11.7)

OUTFLOWS:

Int_Airside_Security_Inflow_Rate = MIN(Passport_Control/(5*Avg_Passport_Control_Time_per_Person) , 28/Avg_Passport_Control_Time_per_Person)

Available_Percentage_of_Desired_Number_of_Active_Xrays =
IF(Total_Desired_Number_of_Active_Xrays<Total_Available_Number_of_Xrays) THEN 1 ELSE Total_Available_Number_of_Xrays/Total_Desired_Number_of_Active_Xrays

Avg_Passport_Control_Time_per_Person = 0.636

Avg_Processing_Time_of_an_Xray_in_Dom_Airside_Security = 0.395

Avg_Processing_Time_of_an_Xray_in_Dom_Dep_Entrance = 0.313

Avg_Processing_Time_of_an_Xray_in_Int_Airside_Security = 0.395

Avg_Processing_Time_of_an_Xray_in_Int_Dep_Entrance = 0.313

Avg_Processing_Time_of_an_Xray_in_Int_Transfer_Line_Security = 0.313

Avg_Time_Spent_in_Dom_After_Check-In = 5

Avg_Time_Spent_in_Dom_Check-In = 20

Avg_Time_Spent_in_Dom_Pre_Check-In = 5

Avg_Time_Spent_in_Int_After_Check-In = 15

Avg_Time_Spent_in_Int_Check-In = 20

Avg_Time_Spent_in_Int_Pre_Check-In = 5

Base_Queue_Length_of_Dom_Airside_Security = Goal_Queue_Length_per_Xray_in_Dom_Airside_Security*Total_Number_of_Xrays_in_Dom_Airside_Security

Base_Queue_Length_of_Dom_Dep_Entrance = Goal_Queue_Length_per_Xray_in_Dom_Dep_Entrance*Total_Number_of_Xrays_in_Dom_Dep_Entrance

Base_Queue_Length_of_Int_Airside_Security = Goal_Queue_Length_per_Xray_in_Int_Airside_Security*Total_Number_of_Xrays_in_Int_Airside_Security

Base_Queue_Length_of_Int_Dep_Entrance = Total_Number_of_Xrays_in_Int_Dep_Entrance*Goal_Queue_Length_per_Xray_in_Int_Dep_Entrance

Base_Queue_Length_of_Int_Transfer_Line_Security = Goal_Queue_Length_per_Xray_in_Int_Transfer_Line_Security*Total_Number_of_Active_Xrays_in_Int_Transfer_Line_Security

Desired_Number_of_Active_Xrays_in_Dom_Airside_Security = Total_Number_of_Xrays_in_Dom_Airside_Security*Need_Coefficient_of_Dom_Airside_Security

Desired_Number_of_Active_Xrays_in_Dom_Dep_Entrance = Need_Coefficient_of_Dom_Dep_Entrance*Total_Number_of_Xrays_in_Dom_Dep_Entrance

Desired_Number_of_Active_Xrays_in_Int_Airside_Security = Need_Coefficient_of_Int_Airside_Security*Total_Number_of_Xrays_in_Int_Airside_Security

Desired_Number_of_Active_Xrays_in_Int_Dep_Entrance = Need_Coefficient_of_Int_Dep_Entrance*Total_Number_of_Xrays_in_Int_Dep_Entrance

Desired_Number_of_Active_Xrays_in_Int_Transfer_Line_Security = Need_Coefficient_of_Int_Transfer_Line_Security*Total_Number_of_Active_Xrays_in_Int_Transfer_Line_Security

Dif_of_Number_of_Xrays_in_Dom_Airside_Security = MAX(1,MIN(Total_Number_of_Xrays_in_Dom_Airside_Security,Available_Percentage_of_Desired_Number_of_Active_Xrays*Desired_Number_of_Active_Xrays_in_Dom_Airside_Security))-Number_of_Active_Xrays_in_Dom_Airside_Security

Dif_of_Number_of_Xrays_in_Dom_Dep_Entrance = MAX(1,MIN(Total_Number_of_Xrays_in_Dom_Dep_Entrance,Available_Percentage_of_Desired_Number_of_Active_Xrays*Desired_Number_of_Active_Xrays_in_Dom_Dep_Entrance))-Number_of_Active_Xrays_in_Dom_Dep_Entrance

Dif_of_Number_of_Xrays_in_Int_Airside_Security = MAX(MIN(Available_Percentage_of_Desired_Number_of_Active_Xrays*Desired_Number_of_Active_Xrays_in_Int_Airside_Security,Total_Number_of_Xrays_in_Int_Airside_Security),1)-Number_of_Active_Xrays_in_Int_Airside_Security

Dif_of_Number_of_Xrays_in_Int_Dep_Entrance = MAX(MIN(Total_Number_of_Xrays_in_Int_Dep_Entrance,Available_Percentage_of_Desired_Number_of_Act

ive_Xrays*Desired_Number_of_Active_Xrays_in_Int_Dep_Entrance),1)-
Number_of_Active_Xrays_in_Int_Dep_Entrance

Dif_of_Number_of_Xrays_in_Int_Transfer_Line_Security =
MAX(1,MIN(Total_Number_of_Active_Xrays_in_Int_Transfer_Line_Security,Available_Percentage_of_Desired_Number_of_Active_Xrays*Desired_Number_of_Active_Xrays_in_Int_Transfer_Line_Security))-
Number_of_Active_Xrays_in_Int_Transfer_Line_Security

Dif_of_Personnel_in_Dom_Airside_Security =
Dif_of_Number_of_Xrays_in_Dom_Airside_Security*Needed_Security_per_Xray_in_Dom_Airside_Security

Dif_of_Personnel_in_Dom_Dep_Entrance =
Dif_of_Number_of_Xrays_in_Dom_Dep_Entrance*Needed_Security_per_Xray_in_Dom_Dep_Entrance

Dif_of_Personnel_in_Int_Airside_Security =
Dif_of_Number_of_Xrays_in_Int_Airside_Security*Needed_Security_per_Xray_in_Int_Airside_Security

Dif_of_Personnel_in_Int_Dep_Entrance =
Dif_of_Number_of_Xrays_in_Int_Dep_Entrance*Needed_Personnel_per_Xray_in_Int_Dep_Entrance

Dif_of_Personnel_in_Int_Transfer_Line_Security =
Dif_of_Number_of_Xrays_in_Int_Transfer_Line_Security*Needed_Security_per_Xray_in_Int_Transfer_Line_Security

Goal_Queue_Length_per_Xray_in_Dom_Airside_Security = 12

Goal_Queue_Length_per_Xray_in_Dom_Dep_Entrance = 15

Goal_Queue_Length_per_Xray_in_Int_Airside_Security = 10

Goal_Queue_Length_per_Xray_in_Int_Dep_Entrance = 15

Goal_Queue_Length_per_Xray_in_Int_Transfer_Line_Security = 18

Needed_Personnel_per_Xray_in_Int_Dep_Entrance = 3.5

Needed_Security_per_Xray_in_Dom_Airside_Security = 3.5

Needed_Security_per_Xray_in_Dom_Dep_Entrance = 3.5

Needed_Security_per_Xray_in_Int_Airside_Security = 3.5

Needed_Security_per_Xray_in_Int_Transfer_Line_Security = 3.5

Need_Coefficient_of_Dom_Airside_Security =
Avg_Queue_Length_of_Dom_Airside_Security/Base_Queue_Length_of_Dom_Airside_Security

Need_Coefficient_of_Dom_Dep_Entrance =
Avg_Queue_Length_of_Dom_Dep_Entrance/Base_Queue_Length_of_Dom_Dep_Entrance

Need_Coefficient_of_Int_Airside_Security =
Avg_Queue_Length_of_Int_Airside_Security/Base_Queue_Length_of_Int_Airside_Security

Need_Coefficient_of_Int_Dep_Entrance =
Avg_Queue_Length_of_Int_Dep_Entrance/Base_Queue_Length_of_Int_Dep_Entrance

Need_Coefficient_of_Int_Transfer_Line_Security =
Avg_Queue_Length_of_Int_Transfer_Line_Security/Base_Queue_Length_of_Int_Transfer_Line_Security

Number_of_Active_Xrays_in_Dom_Airside_Security =
Number_of_Personnel_in_Dom_Airside_Security/Needed_Security_per_Xray_in_Dom_Airside_Security

Number_of_Active_Xrays_in_Dom_Dep_Entrance =
Number_of_Personnel_in_Dom_Dep_Entrance/Needed_Security_per_Xray_in_Dom_Dep_Entrance

Number_of_Active_Xrays_in_Int_Airside_Security =
Number_of_Personnel_in_Int_Airside_Security/Needed_Security_per_Xray_in_Int_Airside_Security

Number_of_Active_Xrays_in_Int_Dep_Entrance =
Number_of_Personnel_in_Int_Dep_Entrance/Needed_Personnel_per_Xray_in_Int_Dep_Entrance

Number_of_Active_Xrays_in_Int_Transfer_Line_Security =
Number_of_Personnel_in_Int_Transfer_Line_Security/Needed_Security_per_Xray_in_Int_Transfer_Line_Security

Personnel_Inflow_Time_to_Dom_Airside_Security = 7

Personnel_Inflow_Time_to_Dom_Dep_Entrance = 7

Personnel_Inflow_Time_to_Int_Dep_Entrance = 7

Personnel_Inflow_Time_to_Int_Transfer_Line_Security = 7

Rounded_Number_of_Active_Xrays_in_Dom_Airside_Security =
ROUND(Number_of_Active_Xrays_in_Dom_Airside_Security+0.5)

Rounded_Number_of_Active_Xrays_in_Dom_Dep_Entrance =
ROUND(Number_of_Active_Xrays_in_Dom_Dep_Entrance+0.5)

Rounded_Number_of_Active_Xrays_in_Int_Airside_Security =
ROUND(Number_of_Active_Xrays_in_Int_Airside_Security+0.5)

Rounded_Number_of_Active_Xrays_in_Int_Dep_Entrance =
ROUND(Number_of_Active_Xrays_in_Int_Dep_Entrance+0.5)

Rounded_Number_of_Active_Xrays_in_Int_Transfer_Line_Security =
ROUND(Number_of_Active_Xrays_in_Int_Transfer_Line_Security+0.5)

Security_Inflow_Time_to_Int_Airside_Security = 7

Smoothing_Time_1 = 5

Smoothing_Time_2 = 5

Smoothing_Time_3 = 5

Smoothing_Time_4 = 5

Smoothing_Time_5 = 5

Total_Available_Number_of_Xrays = Total_Number_of_Personnel/3.5

Total_Desired_Number_of_Active_Xrays =
Desired_Number_of_Active_Xrays_in_Dom_Airside_Security+Desired_Number_of_Active_Xrays_in_Dom_Dep_Entrance+Desired_Number_of_Active_Xrays_in_Int_Airside_Security+Desired_Number_of_Active_Xrays_in_Int_Dep_Entrance+Desired_Number_of_Active_Xrays_in_Int_Transfer_Line_Security

Total_Number_of_Active_Xrays = Number_of_Active_Xrays_in_Dom_Airside_Security+Number_of_Active_Xrays_in_Dom_Dep_Entrance+Number_of_Active_Xrays_in_Int_Airside_Security+Number_of_Active_Xrays_in_Int_Dep_Entrance+Total_Number_of_Active_Xrays_in_Int_Transfer_Line_Security

Total_Number_of_Active_Xrays_in_Int_Transfer_Line_Security = 8

Total_Number_of_Personnel = 120

Total_Number_of_Xrays_in_Dom_Airside_Security = 12

Total_Number_of_Xrays_in_Dom_Dep_Entrance = 9

Total_Number_of_Xrays_in_Int_Airside_Security = 21

Total_Number_of_Xrays_in_Int_Dep_Entrance = 16