SIMULATION MODEL OF SECURITY CHECKPOINT MANAGEMENT REGARDING THE IATA LEVEL OF SERVICE STANDARDS

Tomasz KISIEL

Wroclaw University of Science and Technology, Faculty of Mechanical Engineering, Department of Maintenance and Operation of Logistics, Transportation and Hydraulic Systems, Poland, EU,
tomasz.kisiel@pwr.edu.pl

Abstract

This paper presents a simulation model dedicated to resources planning in the security control process at the airport terminal. The developed model may be applied at any airport using centralised security checkpoint. This article presents a stochastic model that allow for measurment the degree of schedule adjustment for the fulfillment of the level of service assumptions according to the IATA standards as output data. This model has been developed as user-friendly, which automatically takes into account IATA standards. It has not been combined yet. In the models, only the waiting time was determined without reference to the required standards. A simulation model uses the Monte-Carlo method, basing on the universal characteristics of passenger reports to the security checkpoint. The simulation model obtains information on the degree of schedule adjustment for security lanes to the C level of the service category according to the IATA standards. The application of the simulation model may be applied in the management of the security control process in order to avoid an overestimation or underestimation of the service work lanes schedules.

Keywords: Airport, security checkpoint, simulation model

1. INTRODUCTION

The airport is a point element of air transport infrastructure. Ground handling plays a key role in the reliability of this type of transportation system. Reliability of transportation systems is extremely important to carry out tasks on time. This is evidenced by the number of scientific papers dedicated to these issues. The reliability of air transport systems has been mentioned, inter alia, in [1-4]. The significance of this issue is also mentioned in the work that concerns the remaining means of transport [5-13].

However, with regard to air transport, it is important to consider the implementation of processes on time. Air transport delays have twofold consequences. The first of them concern air carriers. They must pay compensation to passengers in accordance with the EU regulation [14]. Air carriers are exposed to financial losses in this case. The second consequences concern airports and business entities who run their services at the terminal. The research, which was presented in [15], shows that passengers who are not satisfied with the quality of the transport service spend less money in commercial areas at the airport. While airport earnings are up to 40 % [16] revenues from non-aeronautical activity.

This article considers the process management due to passenger satisfaction, because the happier passengers are, they spend more money. The airport generates greater profits then. The largest profits from non-aeronautical activities are generated in duty-free zones. To increase them, special attention should be paid to passenger service processes.

In the scientific literature it is in vain to look for articles that show models for passenger handling management in the aspect of level of service (LoS). LoS is often considered [17,18], but mainly to evaluate a system functioning. LoS is not used for future process management and decision making.

There is already a huge knowledge base in the scientific literature on the efficiency of passenger service processes. State of art for applied models can be found in [19,20]. These articles usually focus on the waiting time in queues, process times, etc. There is no link between these indicators and the requirements that apply to LoS. Especially no one refers to the requirements of the International Air Transport Association (IATA).

This article will present a simulation model that enables the user to plan technical resources to implement the airport security screening process. This simulation model allows to evaluate the fulfillment of IATA requirements with given input data.

2. STRUCTURE OF THE SIMULATION MODEL

The security screening process can be carried out in various areas of the air terminal: at the entrance to the terminal, at the access point to the restricted area, at the departure gate. This simulation model is directly dedicated to the centralized structure (security checkpoint at the access point to the restricted area). However, it can always be modified and used for other security checkpoints. A centralized structure means that the passenger waits in queue for the access point. The boarding card is checked at the access point. Then the passenger enters directly into the security control lane. Security checkpoint is composed of several parallel security control lanes and access points and one queue system. The example structure of the system is shown in **Figure 1**.

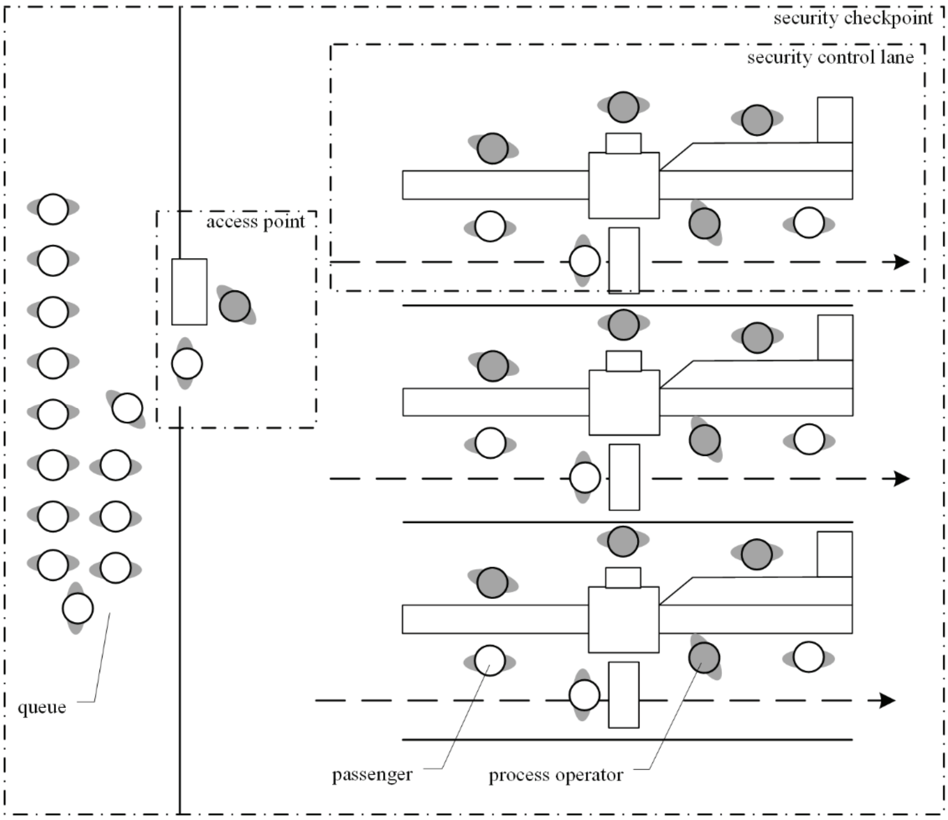

Figure 1 Security checkpoint structure with 1 access point and 3 security control lanes

2.1 Input data

The passenger arrives at the security checkpoint at the time of his choice. However, the reporting time is within a certain time frame. It will be referenced to the departure time. A probability density function (pdf) f(t_{rep}) should therefore be determined for the time of report prior to departure.

The passenger enters the queuing system in front of the access point and follows the passengers in the queue ahead of him. If the passenger is first in queue and the service desk at the access point is empty, the passenger is served. This is a random process because there is a human factor both from the passenger side and the process operator. It is therefore necessary to set a pdf f(t_{aps}) of service time in the access point as an input variable.

Then if one of the security lanes has an available place, the passenger passes to that lane and the service begins. The passenger handling process in security control lane is complex. There are a number of subsequent activities such as: preparation of items for X-ray control, examination of items by X-ray device, control of the passenger by metal detector, manual control of baggage and passenger, detection of trace amounts of explosives, etc. These activities are modeled in detail when the performance of the security checkpoint is analyzed and the process is to be optimized. This model is used for management, so in this case the pdf f(t_{scls}) of service time on the security control lane will be designated as the input variable. This will facilitate the collection of input data and speed up the implementation of simulation experiments. After service, the passenger leaves the system. There is the possibility of servicing several passengers at the same time. It is therefore necessary to define the security control lane capacity l_c.

2.2 Output data

IATA [21] directly defines that the structure of the service system can be over designed, optimal and suboptimal. These categories were compiled directly to the waiting time in the queue t_q. IATA has defined separate standards for each of the passenger service subsystems. For security checkpoint, the conditions for belonging to these states S are presented in formula (1).

$$S = \begin{cases} S_{over\ designed}\ for\ t_q < 5 \\ S_{optimal}\ for\ 5 \le t_q \le 10 \\ S_{suboptimal}\ for\ t_q > 10 \end{cases} \quad (1)$$

This article proposes an assessment of the system by determining the probability P_s of a system being in a given state (2). For this purpose, the simulation model will check the waiting time in the queue for each passenger and determine the probability of the system being in a given state.

$$\mathrm{P_S} = \begin{cases} \mathrm{P_{S_{over\ designed}}} \\ \mathrm{P_{S_{optimal}}} \\ \mathrm{P_{S_{suboptimal}}} \end{cases} \quad (2)$$

For practical purposes, this model also allows you to develop a graphical summary of results (occurrence of a given state as a function of time). Examples will be presented in Chapter 3.

2.3 Simulation model structure

To sum up the assumptions presented in chapters 2.1 and 2.2, the basic structure of the model is shown in **Figure 2**. There are 2 types of input variables in the computer program. The first type data is entered once to configure the simulation model. The first type is the passengers flow characteristics. The first type is also the system structure (number of parallel access points, security lanes, capacity for each areas). During everyday work with the simulation model, the user introduces flight schedule and schedule for security lanes. This is the second type of input variables that must be entered into the experiment each time.

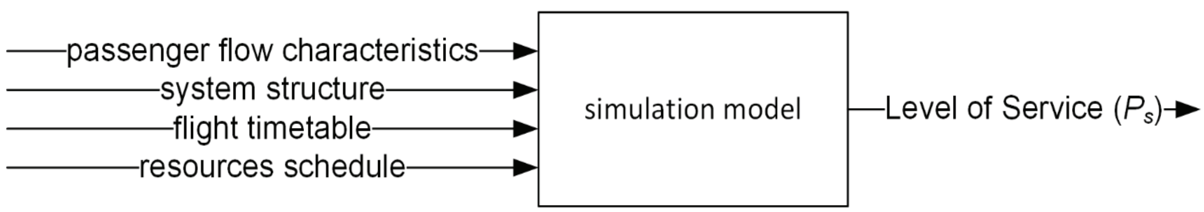

Figure 2 Model structure

Movement of the passenger through the system is described by the algorithm shown in **Figure 3**. At the beginning, the random time is calculated when the passenger (pax) enters the queue. The moment is stored in the variable tr_i, where i denotes the index of the next passenger. The passenger is placed at the end of the queue and stands there until he is first and one of the positions in the access point is free. Then the boarding card with random time from f(t_{aps}) is checked. Then, if the security checkpoint is free, the waiting time for the security check ends. Then the waiting time tw_i is calculated as the difference between the current time tc and the tr_i time. The assessment indicators Ps are updated. The passenger moves to the lane. The process is carried out in accordance with the time f(t_{scls}). The passenger leaves the system.

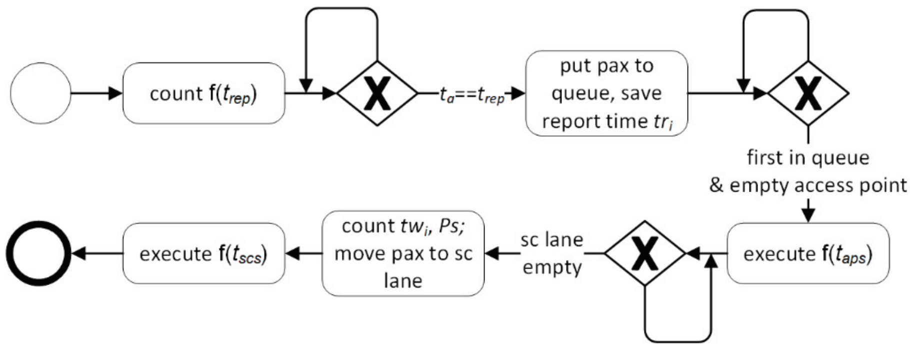

Figure 3 Operating algorithm for one passenger

3. MODEL VALIDATION

The model has been validated on the example of a security control checkpoint at the Wrocław Airport. The system is equipped with 2 parallel access points with capacity of 1 and 5 parallel security control lanes with capacity of 11. The tests were performed on the real system and input data (3-5) was determined. These functions have been tested by the Kolmogorov-Smirnov test at the significance level of α = 0.05.

$$\mathrm{f}(t_{rep}) = \frac{3.4}{105.9}\left(\frac{t_{rep}}{105.9}\right)^{2.4} exp\left(-\left(\frac{t_{rep}}{105.9}\right)^{3.4}\right) [min] \quad (3)$$

$$\mathrm{f}(t_{aps}) = \frac{2.3}{0.12}\left(\frac{t_{aps}-0.1}{0.12}\right)^{1,3}\left(1+\left(\frac{t_{aps}-0.1}{0.12}\right)^{2.3}\right)^{-2} [min] \quad (4)$$

$$\mathrm{f}(t_{scs}) = \frac{(t_{scs}-0.78)^8}{0.36^9\Gamma(9)} exp(-(t_{scs}-0.78)/0.36) [min] \quad (5)$$

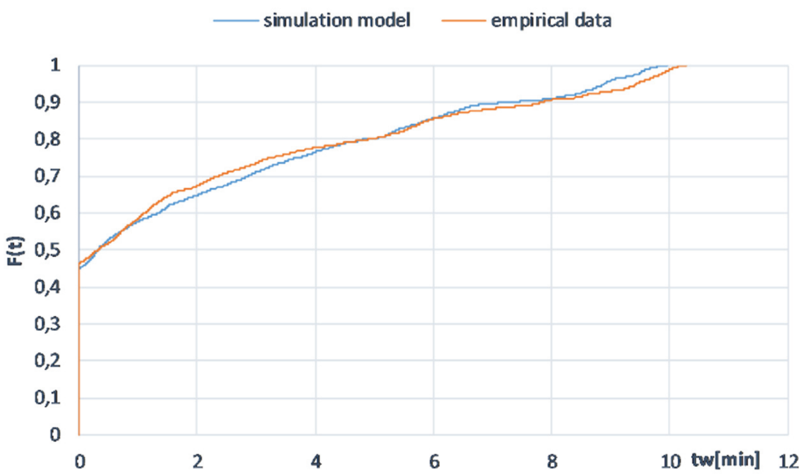

Figure 4 CDF functions for the queue waiting times obtained from the actual system and the simulation model

Waiting times in the queue were checked in the real system. Then they were compared with those shown in the simulation model (**Figure 4**). Here too, the compliance Kolmogorov-Smirnov test was carried out on a significance level of α = 0.05. The obtained test result allows to assume that the model works properly.

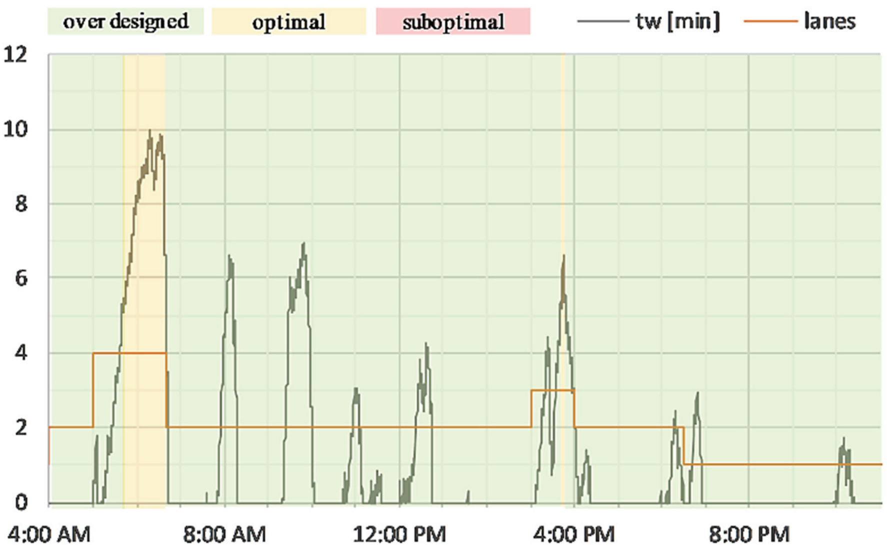

Figure 5 Share of system states along the day

Figure 5 shows the sample results obtained from the simulation model. This data presentation is useful. It is possible to check in what states the system was located along the day for a given schedule of security control lanes. The probabilities of passengers waiting times in the queue in this case were:

$$P_S = \begin{cases} P_{S_{over\ designed}} = 0.80 \\ P_{S_{optimal}} = 0.20 \\ P_{S_{suboptimal}} = 0 \end{cases} \quad (6)$$

The illustrated example is a reflection of a properly selected schedule in terms of service quality because waiting times of less than 10 minutes have been achieved. The suboptimal state did not occur in the case of this analysis.

4. CONCLUSION

This article presents a user friendly simulation model that is dedicated to managing the security checkpoint at the airport. The model focuses on the assessment of the system in terms of service quality. The model takes into account the quality standards set by IATA. The use of the model allows to check whether the IATA standards will be met for the assumed schedule of security control lanes. Numerous configurations can be checked. These options will allow to choose the most optimal option for the process manager. The model has been developed on a macroscopic scale. It does not require the collection of detailed data that pertains to subsequent inspection activities. This makes it easy to implement it at any airport with a centralized structure. This model will be further developed to search for the best schedule autonomously.

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