Simulation Model of Check-in Management Regarding the IATA Level of Service Standards

Artur Kierzkowski, Tomasz Kisiel(✉), and Maria Pawlak

Transportation and Hydraulic Systems, Faculty of Mechanical Engineering, Wroclaw University of Science and Technology, W. Wyspianskiego 27, 50-370 Wroclaw, Poland
{artur.kierzkowski,tomasz.kisiel,maria.pawlak}@pwr.edu.pl

Abstract. The article presents a simulation model serving for the planning of resources (number of desks) that are necessary for the execution of the check-in process at the airport terminal. The elaborated model may be applied at any airport using conventional desks for the check-in process. We present a stochastic model that presents the degree of schedule adjustment for the fulfillment of the level of service assumptions according to the IATA standards as output data. A combination of quantitative and qualitative methods in the check-in process modeling, taking into consideration a stochastic character of the process, has not been fully considered yet. A simulation model uses the Monte-Carlo method, basing on the universal characteristics of passenger reports to the check-in with a division of the traditional, low-cost, and charter passengers. The simulation model obtains information on the degree of schedule adjustment for check-in desks 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 check-in process in order to avoid an overestimation or underestimation of the service work desks schedules.

Keywords: Airport · Check-in · Simulation model

1 Introduction

The airport as a punctual element of the critical infrastructure of the air transportation system fulfills a crucial role in terms of the reliable functioning of the air transportation process. The tasks related to the exploitation of critical infrastructure are mainly intended to prevent and minimize interferences in the functioning of the system. The airport is a place on the premises of which the main subsystems of ramp handling of the aircrafts are located as well as the check-ins of passengers arriving and departing from a given airport. There is a series of measures enabling the assessment of the functioning of logistics and transportation systems that are presented in each domain of transportation [1]. These measures mostly include operational indicators (e.g. performance of the system) [2–4]. Globally, the issues related to the reliability of transportation

I. Kabashkin et al. (Eds.): RelStat 2018, LNNS 68, pp. 150–158, 2019.
https://doi.org/10.1007/978-3-030-12450-2_14

systems have been addressed many times [5–8]. Models of evaluation of the functioning of complex exploitation transportation systems were presented in [9–13].

Taking into consideration the purpose of an airport, one of the most important measures is a timely execution of the aircraft handling processes. Therefore, it is crucial to ensure that the turnaround of the aircraft falls within the assumed time interval. An appropriate tactical management of flight timetables and execution of the resources of processes should also enable the minimization of results of the original delays of the aircrafts at a given airport.

The performance of the systems is currently very often related to information concerning the passengers' level of service. Assuming some time ranges, in which the passenger should be handled in order to minimize the delay, it is also possible to control the system in order to ensure the highest possible comfort for the passenger. This article presents a practical simulation model that enables the choice of resources for the execution of the check-in process at the airport terminal in order to ensure an appropriate level of service. We present a quantitative and qualitative approach that enables the classification of adjustment of the schedule to the optimal class of the level of service, and through quantitative indicators, to subsequently present the level of overestimation or underestimation of the system.

In Sect. 2, we present an overview of the methods applied in check-in modeling as well as the service quality indicators. In Sect. 3, we describe the structure of the model whose exemplary validation is presented in Sect. 4. At the end (in Sect. 5), we present the discussion and conclusion.

2 Modeling of the Check-in Process Regarding the Level of Service

The issues of the dynamic management of check-in processes at airports have been addressed many times. It was proposed in a study [14] to manage the check-in system in such a way as to balance the operating expenses and the waiting time in line.

A knowledge-based simulation system to predict resource requirements at an international airport used by a check-in desk allocation system was proposed in a study [15]. The authors take into consideration the minimization of the use of resources with the fulfillment of conditions determined by the level of service at the same time.

The same assumptions were also adopted in a study [16]. It takes into account the level of service with the minimization of the use of resources at the same time. The authors indicated that the process is easy to manage if the desk capacity is constant. The authors presented two exemplary alternative fixed plans with variable capacity.

The analyses presented in the references indicate that an appropriate optimization level may be achieved by a choice of an appropriate time interval between subsequent changes in schedule. Thirty-minute long intervals applied in a study [17] enabled the authors to achieve higher profit than in the case of another study [16]. In a different study [16], one-hour long intervals were assumed. Another study [15] offers a possibility to adjust the time intervals between the subsequent ones, starting from 15-min long intervals.

The above-mentioned papers make reference to the level of the service concept and comprise analyses that have been conducted in such a manner as to meet the assumed requirements. However, there are no papers that make reference directly to standards for the level of service that have been standardized by the IATA. The simulation model presented in the further part of the present paper has been elaborated for this purpose.

3 Structure of the Simulation Model

Each passenger departing from a given airport must be subjected to a passenger check-in process. One of the sub-processes of a passenger check-in is the ticket and baggage check. The ticket and baggage check may be conducted with the use of an IT system (departure control system—DCS) or manually. The manual check-in is usually used as an alternative version in case of DCS system damage. The ticket and baggage check with the use of DCS is conducted in a traditional way at check-in desks or through alternative methods enabling the execution of the process by the passengers all by themselves (self service). The passengers using self-service methods may register their baggage at specially dedicated points (baggage drop off). In reality, we can also find mixed methods in which the passengers have a possibility to use self-service methods, but it is not obligatory and they can check-in at the airport terminal.

The ticket and baggage check-in, at check-in desks, is conducted with the use of different strategies. A common system for one’s own air transport operations means that, for a given carrier, there is an appropriate number of desks for the check-in carried out for all the flights of such carrier. Due to an unfavorable effect of mixing passenger streams with different time restraints (different departure time of the aircraft) in appropriate time intervals, dedicated desks for a flight in question may be appointed. Only the passengers of the indicated flight may be checked-in at a given desk. This strategy enables you to minimize the probability of a delay of the aircraft check-in or delays of passengers for a given flight. The dedicated method is primarily used for charter flights in which a high intensity of passengers’ reports with a large amount of baggage occurs.

The simulation model assumes a probability to carry out analyses in a dedicated or common system. For this purpose, the software user must enter the flight number, number of passengers, and desks’ numbers at which the passenger may be handled as input data. Through an indication of the same desks for different flight numbers, the check-in will be conducted in the common system for all flights indicated for them. For flights numbers to which exclusive desks have been assigned within a given time interval, the check-in is conducted in the dedicated system.

Based on the conducted analyses in the actual system, it has been observed that the reports stream varies considerably depending on the nature of transport that is carried out. The probability density functions (PDF) for the reports of passengers to the system have been indicated on this basis. It is possible to assign flight numbers to low-cost, traditional, and charter groups.

The moment of reporting the passenger for the low-cost carrier (t_{rep}^{lc}) is determined on this basis (1). The moment of reporting the passenger for the traditional carrier (t_{rep}^{tr})

is determined on this basis (2). The moment of reporting the passenger for the charter carrier (t_{rep}^{ch}) is determined on this basis (3). On a similar basis, the PDF for the times of passenger services at the desks have been determined. For the low-cost group, the service duration time at the check-in desk is compatible with (4). For the traditional group, the service duration time at the check-in desk is compatible with (5), whereas for the charter group, the service duration time is determined on this basis (6).

A simplification of the actual system has been adopted through an assumption that the passengers report themselves to the system individually and they are handled as a single item.

$$f\left(t_{rep}^{lc}\right) = \frac{4}{104.8} \cdot \left(\frac{t_{rep}^{lc}}{104.8}\right)^{3} \cdot exp\left(-\left(\frac{t_{rep}^{lc}}{104.8}\right)^{4}\right), \tag{1}$$

$$f\left(t_{rep}^{tr}\right) = \frac{3.8}{92.9} \cdot \left(\frac{t_{rep}^{tr}}{92.9}\right)^{2.8} \cdot exp\left(-\left(\frac{t_{rep}^{tr}}{92.9}\right)^{3.8}\right), \tag{2}$$

$$f\left(t_{rep}^{ch}\right) = \frac{8}{131.2} \cdot \left(\frac{t_{rep}^{ch}}{131.2}\right)^{7} \cdot exp\left(-\left(\frac{t_{rep}^{ch}}{131.2}\right)^{8}\right), \tag{3}$$

$$f\left(t_{ser}^{lc}\right) = \frac{1.57}{1.3} \cdot \left(\frac{t_{ser}^{lc}}{1.3}\right)^{0.57} \cdot exp\left(-\left(\frac{t_{ser}^{lc}}{1.3}\right)^{1.57}\right), \tag{4}$$

$$f\left(t_{ser}^{tr}\right) = \frac{exp\left(-\frac{1}{2} \cdot \left(\frac{ln\left(t_{ser}^{tr}\right) - 1.18}{0.68}\right)^{2}\right)}{t_{ser}^{tr} \cdot 0.68 \cdot \sqrt{2 \cdot \pi}}, \tag{5}$$

$$f\left(t_{ser}^{ch}\right) = \frac{exp\left(-\frac{1}{2} \cdot \left(\frac{ln\left(t_{ser}^{ch}\right) - 1.64}{0.39}\right)^{2}\right)}{t_{ser}^{ch} \cdot 0.39 \cdot \sqrt{2 \cdot \pi}}. \tag{6}$$

The simulation model functions on the basis of a basic queuing model in which any number (assumed by the user) of service channels occurs (see Fig. 1).

Each desk is equipped with its own queue, and the passengers choose the entry to the queue from a set of check-in desks dedicated to their flight number according to the lowest number of waiting passengers. The passengers are checked-in according to the FIFO (First In First Out) strategy. The execution of the process for a single passenger is presented in Fig. 2.

The simulation experiment is carried out many times on the basis of the Monte-Carlo method that enables you to obtain the value of the expected output data. It has been assumed in the simulation model that it is important to determine whether the assumed schedule allows for obtaining the C category in the aspect of the level of

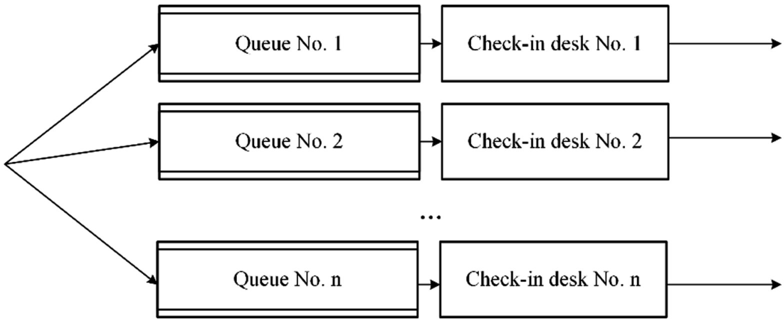

Fig. 1. Structure of the check-in system.

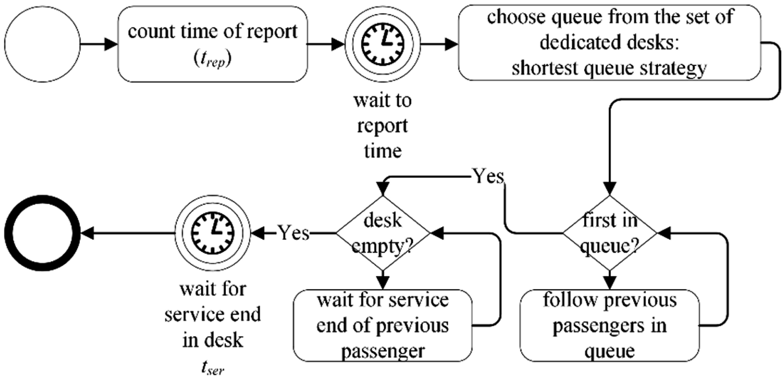

Fig. 2. Algorithm of the execution of a simulation for a single passenger.

service according to the IATA [18] standards. It has been assumed on this basis that the system may be in three states during the execution of the service process. The state in which the system finds itself is determined on the basis of the actual time t_q [min] of waiting of the passengers in queue according to (7).

$$S = \begin{cases} S_{overestimated} \ for t_q < 10 \\ S_{optimal} \ for t_q \in \langle 10.20 \rangle \\ S_{suboptimal} \ for t_q > 20 \end{cases}. \tag{7}$$

On the basis of formula (7), it is possible to elaborate the output data in the form of:

- percentage of occurrence of particular states,
- occurrence of particular states in the function of time (with an indication of the amount of assigned resources, the time of process execution).

The model enables you to carry out the analysis on three different scales:

- Macroscopic—indicators presented for the entire stream of handled passengers,

- Mesoscopic—indicators presented with a division of the nature of the transportation or of the chosen carrier,
- Microscopic—indicators presented with a division according to the flight number.

4 Validation and Verification of the Model

A validation and verification of the proposed method have been carried out on an actual system. Below, we present an exemplary analysis for a given day executed at the Wrocław Airport. The analysis is presented in mesoscopic scale for a given carrier. The performed simulation gave the results shown in Figs. 3 and 4.

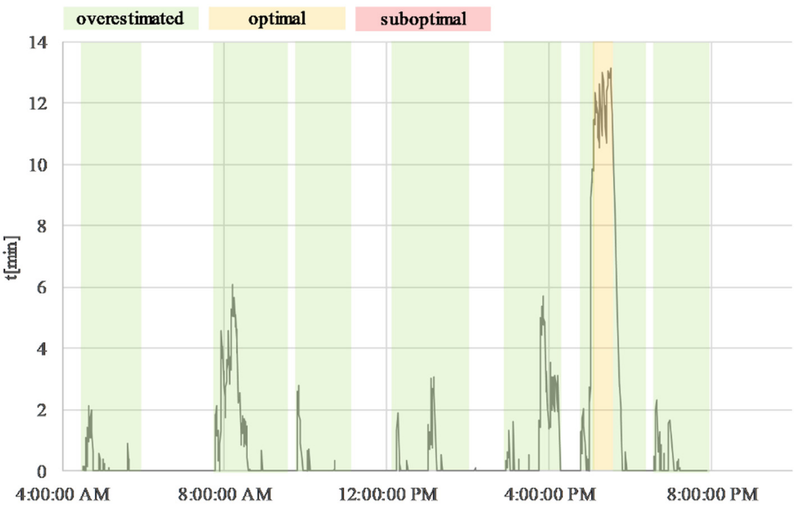

Fig. 3. Expected time in queue with an indication of service states.

Figure 3 shows an expected value of the time in queue to the check-in desks of a chosen carrier from the low-cost group. The areas of the system remaining in a given state are also indicated on the chart. A similar comparison is presented in Fig. 4, but the areas of the system remaining in a given state was compared to the number of desks dedicated for service provided by the chosen carrier. The simulation model also determined the number values of probability of remaining in particular states. For the obtained simulation, they are in accordance with (8)

$$P_S = \begin{cases} P_{S_{overestimated}} = 0.94 \\ P_{S_{optimal}} = 0.06 \\ P_{S_{suboptimal}} = 0.00 \end{cases}. \quad (8)$$

It can be concluded on the basis of the obtained results that the airport correctly adjusted the desks functioning schedule. The Wrocław Airport implements the

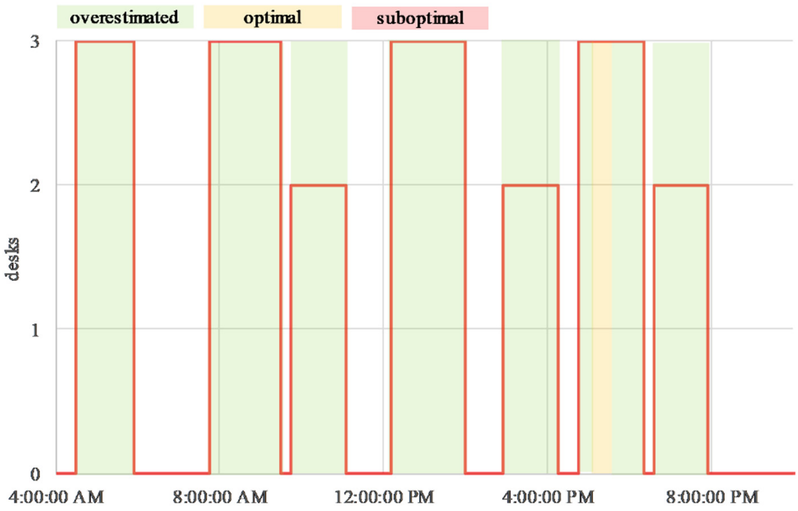

Fig. 4. Assumed resources schedule with an identification of the service states.

assumed strategy of "No queues" and, therefore, it assumes the necessity to ensure a higher class than the C standard according to the IATA. The analysis carried out for the chosen carrier shows that these assumptions are met at the level of 0.94 which is an acceptable value for the airport.

However, before accepting these results as correct, it was necessary to carry out a verification of the simulation model. Studies on the actual system have also been conducted for the analyzed day. The distribution functions of waiting times in the passenger queue system within the whole day have been compared. The comparison is shown in Fig. 5. A Kolmogorov-Smirnov test has been conducted at the significance level of 0.05. The obtained statistic value was lower than the critical value and, therefore, it could be concluded that the model generates correct results.

5 Summary

The present paper presents a model whose purpose is to support the scheduling processes of the technical resources for the execution of the check-in processes at an airport terminal. The main purpose of the model is to enable the management of the process in order to ensure the required level of service class according to the IATA standards.

The model may be applied for systems using conventional check-in desks. This method is applied in most European airports as the main method or as an auxiliary method for persons who do not want to use the self-service methods.

The proposed simulation model assumed the starting of the ticket and baggage check-in within a time frame of 40–120 min before the planned departure. The further development stage will consist of enabling the execution of any configuration of the

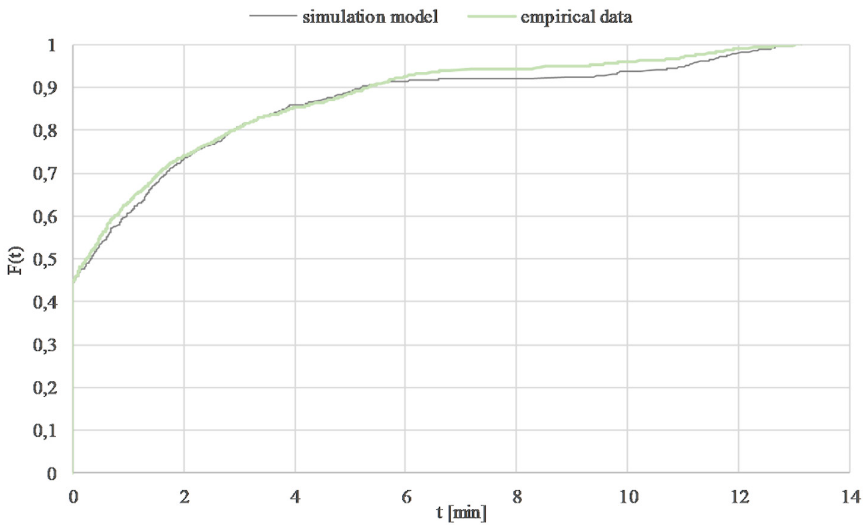

Fig. 5. CDF functions for the queue waiting times obtained from the actual system and the simulation model.

system by the user, thanks to which the model will be more universal and will be more suitable for a larger group of recipients. Another application may be a verification of the service quality class of the airport according to the IATA standards.

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