ANALYSIS OF THE CHECK-IN PROCESS FUNCTIONING ON THE TYPOLOGY OF AIR CARRIERS

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Abstract

The article presents a developed simulation model of the check-in process of passengers using air transport. The model allows a detailed analysis of the process taking into account the typology of air carriers. The model was verified on a real system and sensitivity analysis shows that a different flight structure of the timetable in terms of the nature of the carrier offering a given connection may have a significant influence on the change of the passenger flow at the passenger terminal.

Keywords: Check-in, airport, simulation model

1. INTRODUCTION

The airport as the point element of the critical infrastructure of the air transport system plays the key role in the aspect of reliable operation of air transport of people. Tasks related to the operation of the critical infrastructure are mostly aimed at preventing and minimizing interferences in the operation of the system. The airport is a place, which contains main subsystems of the ramp service of aircraft as well as of the arrival and departure procedures for passengers. There are a range of measures for the assessment of system operation [1]. Such measures mostly include operational measures (e.g. system effectiveness). Taking into consideration the purpose of the airport operation, one of the most important measures includes timely performance of aircraft operation processes. Therefore, it is of key importance to have the full turnaround of the aircraft fit the assumed time window. Appropriate tactical management of the flight schedule and resources for process implementation should also allow minimization of the effects of original delays of aircraft at an airport.

The dynamic development of air transport for over 2 decades requires accurate analysis of the entire system to ensure the planned implementation of the connection network. It is necessary to continuously develop the infrastructure of the system, taking into account the research aimed at obtaining the maximum effectiveness of the operation of the system. It is rather important as, according to data presented by the Central Office for Delay Analysis [2] in Europe, as many as 37.4% of airport operations during the departure are delayed by more than 5 minutes. The average delay for delayed air operations is 26 minutes. The airline category is the main determinant causing aircraft delays during the operational day. In accordance with [2], delay determinants are included in this group:

- passenger and baggage service,
- ground handling of aircraft,
- unplanned technical service of aircraft under analysis,
- damage to aircraft,
- operational errors of airlines.

The fact that the percentage of delays occurring as a result of the propagation of the original delay keeps growing during the operational day. System management is not able to eliminate the effects of the original delay during subsequent airport operations performed by a given aircraft.

The aim of the article was to perform an analysis of the influence of the transport of passengers of low-cost carriers, passengers of traditional carriers and of charter carriers on the check-in process at the airport.

2. CURRENT STATUS OF KNOWLEDGE

In the global aspect, the issue of the reliability of transport systems were brought upon on numerous occasions [3-8]. Issues related to the modelling of the reliability of a railway transport network system are presented in [9]. Simulation models of the operation of complex operation systems are presented in [10-15]. An assessment of the functioning of an intermodal transport system was presented in [16,17]. The use of Markov processes for the purposes of the modelling of reliability of transport systems is described in [18,19].

The issue of congestion occurring in passenger streams was brought up on numerous occasions by [20,21]. The authors [22], apart from the need to ensure security, also indicate the appropriateness of minimization of inconveniences which may have a negative influence on passenger service quality. The problem of queuing time minimization with minimal use of resources has been brought up on numerous occasions [23,24].

3. THE MODEL OF HE CHECK-IN SYSTEM AT THE AIRPORT

Each passenger departing from a given airport must go through the passenger-handling process. The check-in process is one of subprocesses of the passenger check-in. The check-in process can be conducted using an IT system (departure control system - DCS) or manually. Manual check-in is usually used as an alternative version if a DCS system failure occurs. The check-in using DCS is performed in a traditional manner at check-in desks or using alternative methods allowing the passenger to perform the process on their own (self service). Passengers using self-service methods can check in their baggage at specially dedicated points (baggage drop off). In reality, also mixed methods can be used, in which passengers can use self-service methods; however, this is not obligatory and they can check in free of charge at the airport terminal.

The check-in at a check-in desk is conducted using various strategies. A common system for all airport operations means that an appropriate number of check-in desks are intended for a given carrier, at which the check-in is performed for all of the carrier's flights. Due to the disadvantageous effect of mixing passenger streams with various time limitations (different take-off times), dedicated desks can be designated in appropriate time intervals, where only passengers for a given flight are checked in. Only passengers for a specific flight can be checked in at such a desk. Such a strategy allows for minimizing the probability of aircraft delays or passengers being late for a given flight. The dedicated method is mostly used for charter fights with a high intensity of passenger reports with a large amount of baggage.

To perform an analysis of the check-in process for low-cost, traditional and charter carriers, a simulation model was developed in the Flexsim simulator.

The simulation model of the process takes into account subsequent stages of the passenger-handling process in accordance with **Fig. 1**.

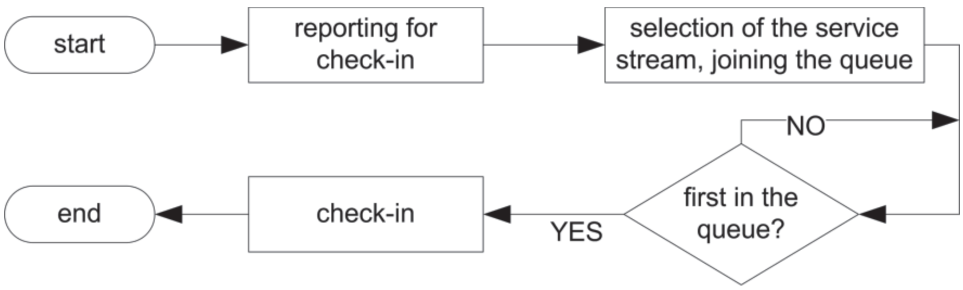

Fig. 1 Diagram of a check-in process simulation at an airport

The probability of the time of passenger reporting for the check-in, depending on the type of the aircraft carrier, has been described by the probability density function. The time of reporting by the low-cost airline passenger (t_{RS}^{LC}) is determined on the basis of (1). The time of reporting by the traditional airline passenger (t_{RS}^{TR}) is determined on the basis of (2). The time of reporting by the charter airline passenger (t_{RS}^{CZ}) is determined on the basis of (3). The passenger is placed in queue for a dedicated check-in for a given flight or the type of carrier, whose services the passenger is using. The analysis of measurements of the actual system allowed to adopt the assumption concerning the group quality of passenger reports. The simplification of the process was assumed, treating all reports of passengers for low cost and traditional flights as single and those for charter flights as double.

$$f(t_{RS}^{LC}) = \frac{4}{104,8} \cdot \left(\frac{t_{RS}^{LC}}{104,8}\right)^{3} \cdot exp\left(-\left(\frac{t_{RS}^{LC}}{104,8}\right)^{4}\right) \tag{1}$$

$$f(t_{RS}^{TR}) = \frac{3,8}{92,9} \cdot \left(\frac{t_{RS}^{TR}}{92,9}\right)^{2,8} \cdot exp\left(-\left(\frac{t_{RS}^{TR}}{92,9}\right)^{3,8}\right) \tag{2}$$

$$f(t_{ZG}^{CZ}) = \frac{8}{131,2} \cdot \left(\frac{t_{ZG}^{CZ}}{131,2}\right)^{7} \cdot exp\left(-\left(\frac{t_{ZG}^{CZ}}{131,2}\right)^{8}\right) \tag{3}$$

The queuing time depends on the number of passengers in the same stream before the passenger in questions. The moment a check-in desk is available and the passenger is first in the queue for the check-in, the passenger service time is determined, which depends on the type of the flight. For low-cost passengers, the check-in duration at the check-in desk is in accordance with (4). For traditional flight passengers, the check-in duration at the check-in desk is in accordance with (5). While for charter flight passengers, the check-in duration is determined on the basis of (6). The passenger leaves the system after the check-in.

$$\mathrm{f}\left(\mathrm{t}_{\mathrm{SER}}^{\mathrm{LC}}\right) = \frac{1,57}{1,3} \cdot \left(\frac{\mathrm{t}_{\mathrm{SER}}^{\mathrm{LC}}}{1,3}\right)^{0,57} \cdot \exp\left(-\left(\frac{\mathrm{t}_{\mathrm{SER}}^{\mathrm{LC}}}{1,3}\right)^{1,57}\right) \tag{4}$$

$$\mathrm{f}\left(\mathrm{t}_{\mathrm{SER}}^{\mathrm{TR}}\right) = \frac{\exp\left(-\frac{1}{2}\cdot\left(\frac{\ln\left(\mathrm{t}_{\mathrm{SER}}^{\mathrm{TR}}\right)-1,18}{0,68}\right)^{2}\right)}{\mathrm{t}_{\mathrm{SER}}^{\mathrm{TR}}\cdot 0,68\cdot\sqrt{2\cdot\pi}} \tag{5}$$

$$\mathrm{f}\left(\mathrm{t}_{\mathrm{SER}}^{\mathrm{CZ}}\right) = \frac{\exp\left(-\frac{1}{2}\cdot\left(\frac{\ln\left(\mathrm{t}_{\mathrm{SER}}^{\mathrm{CZ}}\right)-1,64}{0,39}\right)^{2}\right)}{\mathrm{t}_{\mathrm{SER}}^{\mathrm{CZ}}\cdot 0,39\cdot\sqrt{2\cdot\pi}} \tag{6}$$

For functions (1-6), the λ-Kolmogorov consistency test was used to verify the consistency of empirical distribuants (obtained as a result of research conducted at the Wroclaw Airport) and theoretical ones (obtained from the simulation model). The correctness of the match between distributions was shown at the significance level of $\alpha = 0,05$.

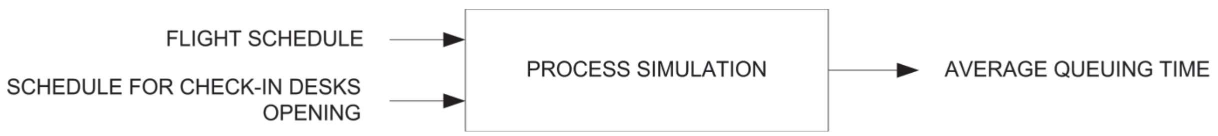

Fig. 2 Diagram of the functioning of the model

The user of the simulation model enters input data including the flight schedule with the specification of the number of passengers, the departure time of the aircraft and the type of the carrier. Also, the operation plan of check-in desks is entered. In the simulation process, an index characterizing the process in time. The forecast average time of the passenger queuing for the check-in is determined, depending on the time the passenger reported to the system. The simulation is carried out using the Monte Carlo method. A diagram of the functioning of the simulation model is presented in **Fig. 2**.

4. VERIFICATION OF THE MODEL

To verify the model, actual input data were entered into the system. The flight schedule was entered in accordance with **Table 1**. The plan of the day of the check-in operation was entered in accordance with **Fig. 3**. The plan for the day of the check-in operation is determined in accordance with the policy of a given carrier who, in the Ground Handling Manual, defines the time framework, within which passengers can check in. Also, the strategy and resources, which should be used for the performance of this process, are also defined. In reality, the operational plan of the check-in is entered with a detailed division for carriers and even for individual flights. Due to the large number of data, the plan for the day of the check-in operation as presented in **Fig. 3** was simplified for the type of the carrier.

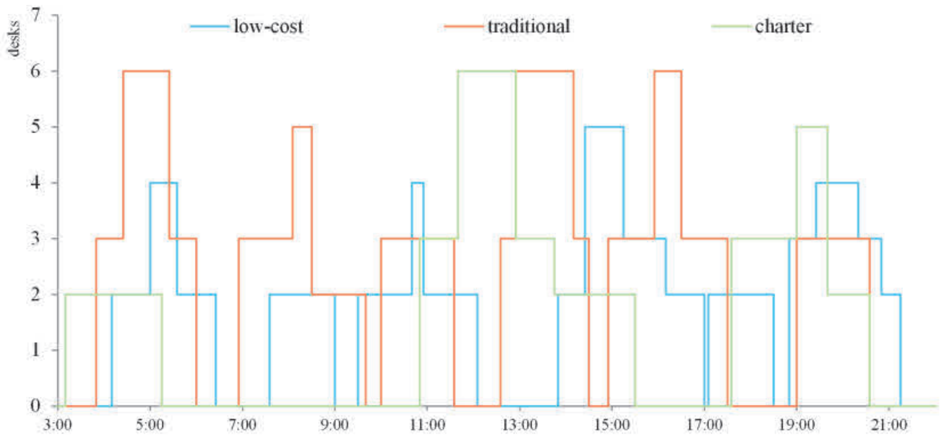

Fig. 3 The plan of the day for check-in desks with the division into the type of the carrier

The time spent by passengers queuing for the check-in was verified according to the type of the carrier. The results in the form of distribuants are presented in **Fig. 4**.

The λ-Kolmogorov consistency test was used to verify the consistency of empirical and theoretical distributions. Consistency between distributions was revealed at the significance level of $\alpha=0.05$. The obtained statistical value is lower than $\lambda=1.36$.

Table 1 Flight schedule

Type of carrier	Planned departure time	Number of check-in reports	Type of carrier	Planned departure time	Number of check-in reports	Type of carrier	Planned departure time	Number of check-in reports
charter	05:40	65	low-cost	12:40	107	traditional	17:55	142
traditional	05:50	144	charter	13:20	94	charter	18:25	30
low-cost	06:10	80	charter	14:10	95	low-cost	19:05	113
traditional	06:25	138	low-cost	14:35	41	charter	20:05	86
low-cost	07:00	113	low-cost	14:55	80	charter	20:45	87
traditional	08:55	26	low-cost	15:50	106	low-cost	20:50	106
low-cost	09:35	34	charter	15:55	34	low-cost	20:55	31
charter	10:05	21	low-cost	16:25	112	traditional	21:00	66
low-cost	11:30	103	low-cost	16:45	50	traditional	21:00	65
traditional	12:00	54	traditional	16:55	131	low-cost	21:25	110
charter	12:10	95	low-cost	17:35	113	low-cost	21:50	112

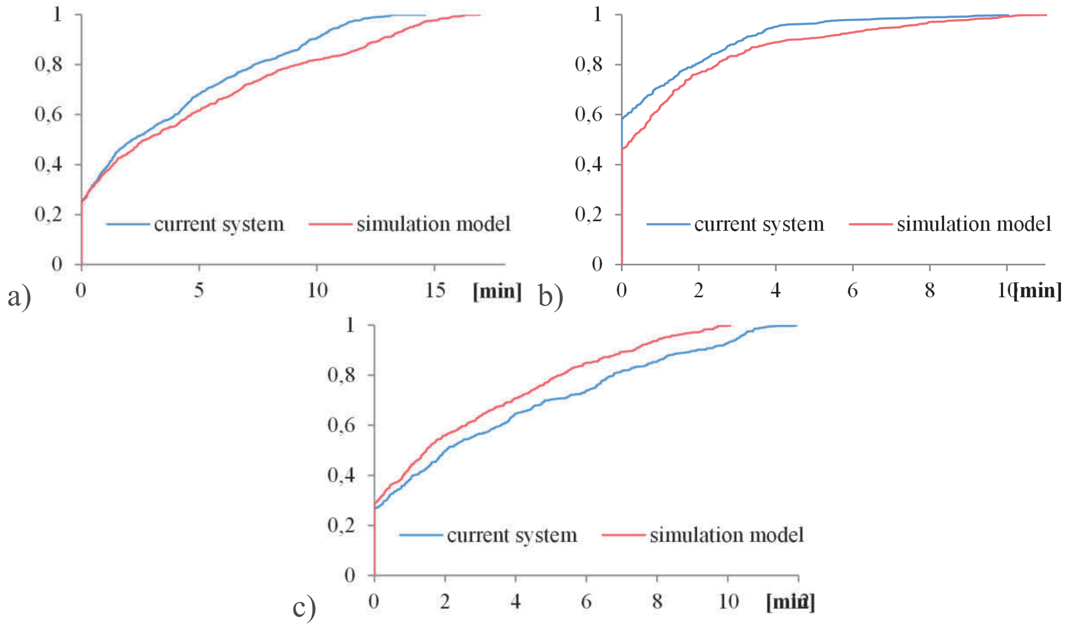

Fig. 4 Distribution functions of passenger waiting times for the check-in for a) low-cost carriers, b) traditional carriers, c) charter carriers

5. SENSITIVITY ANALYSIS

The performed analysis was aimed at verifying how the passenger waiting time for the system is influenced by the flight structure as regards the typology of air carriers. A simulation of four scenarios was performed for this purpose. Scenario 1 was the scenario consistent with Chapter 4. It was assumed that the passenger structure is mixed. Average times of passengers waiting for the check-in in the entire stream of reports were determined. Next, it was adopted that, in the next scenarios, the passengers would represent just one type of the carrier for each air operations in accordance with the flight schedule (**Table 1**). For all of these scenarios, the check-in desk operation time was adopted as the total number of all open desks at a given time in accordance with **Fig. 3**. A new schedule of check-in desk operation for scenarios 2, 3, 4 is presented in **Fig. 5**. Average times of passengers waiting for the check-in were determined for scenarios 2, 3, 4. The results of the analysis are presented in **Fig. 6**.

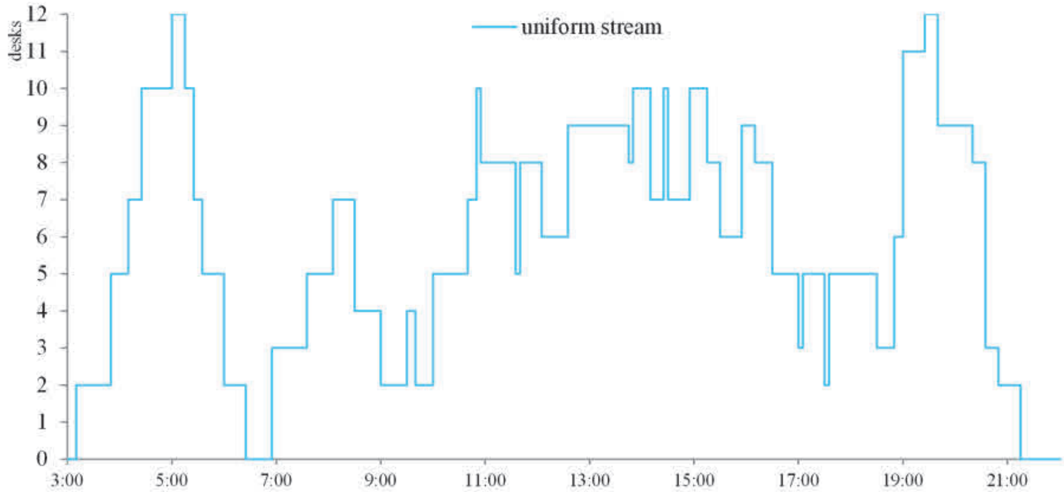

Fig. 5 Plan of the day for check-in desks for scenarios 2, 3, 4

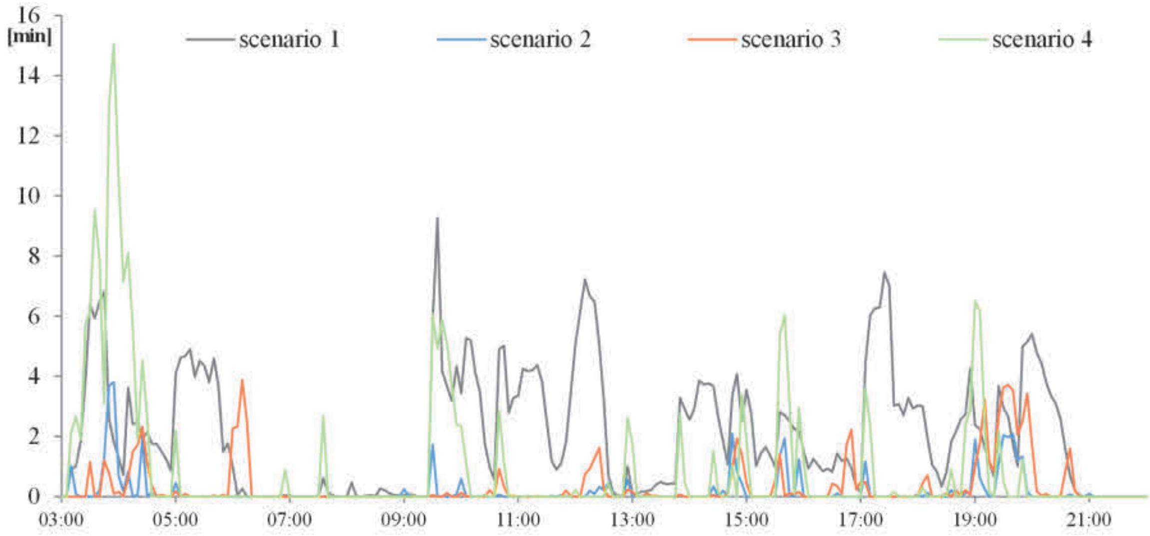

Fig. 6 Results of the process sensitivity analysis

6. CONCLUSION

The analysis of the check-in process presented in the article, which takes into account the typology of air carriers, proves, in accordance with **Fig. 6**, that the check-in process differs significantly depending on the type of the flight. Various characteristics of reports as well as various passenger report handling times for low-cost, traditional and charter carriers are significantly reflected in the results obtained for average passenger queuing times. The presented analysis provides significant knowledge, which should be taken into account during negotiations concerning the planning of the connection network for subsequent scheduling periods by airports and air carriers. Cooperation between these entities in the flight schedule planning process aided by computer simulation can have a significant influence on limiting delays caused by interferences in the check-in process at the airport terminal.

Future research on the development of the simulation model will focus on analysis of the influence of the check-in process on the stream of passengers reporting for security control.

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