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Simulation model of security control system functioning: A case study of the Wroclaw Airport terminal

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ABSTRACT

A security control system is the key element at an airport because each passenger must undergo security check before boarding. Security control must be performed efficiently while maintaining a high level of safety. This article presents a security control model that is applied at a given airport. A set of variable input data describing the model and data received by the user as a result of its use is presented. The security control model is developed using the FlexSim software and based on security control model implementation, for which algorithm for managing the security checkpoint operation schedule are used. The algorithm allows a capacity lack margin to be established in the security control system in order to lower the system operation cost and maintain an acceptable passenger service quality. We describe two basic patterns of implementing the security control process: single- and double-lane counters. The security control counter has been divided into specific areas (queues). The developed model was implemented into the management system of the security checkpoint at Wroclaw Airport. Measures of the system's capacity are determined for the following sample input data (system characteristics and the stream of passenger reports): the average duration of a passenger's stay in the security control system and the number of operator work hours depending on the adopted management strategy. The developed model can be used in existing security control systems and also to evaluate the operation of a system at its design stage.

1. Introduction

1.1. Problem background

Timely execution of the passenger handling process is possible through dynamic management, which is desirable from an economical point of view, or the use of a redundant system structure. Dynamic management of the security control process is justified in the case of a uniform stream of passengers. On the basis of generally available flight schedules, we analysed the number of operations carried out per day at 50 airports of various annual operation intensity. Figs. 1 and 2 show the percentage of takeoff operations carried out during particular hours at four chosen regional airports and four airport hubs. The examples are shown for airports of various numbers of passengers serviced in 2015: WRO (around 2 million), KRK (around 4 million), BGY (around 10 million), LIS (around 20 million), SIN (around 55 million), FRA (around 61 million), HKG (around 69 million) and DXB (around 78 million). It can be seen that the percentage of takeoff operations during different parts of the day varies at each of the airports presented. The percentage of takeoff operations varies in time and does not take the form of a uniform distribution. The only exception is HKG, where the difference between two extreme values obtained between 8:00 a.m. and 8:00 p.m. was only 0.01. For the remaining airports, those differences were much higher: 0.06 for FRA and 0.04 for DXB. HKG was designed to handle 87 million passengers annually (HKIA, 2015). The annual capacity for DXB is 90 million passengers (DAS, 2015).

None of the regional airports had a uniform volume of takeoffs during the day. It was noticed that traffic at the airports occurs mainly between 5:00 a.m. and 11:00 p.m. Here, the differences between the extreme values of the percentage of takeoff operations were greatly higher than in the case of hub airports: 0.18 for WRO, 0.11 for KRK, 0.10 for BGY and 0.08 for LIS. At these airports, carriers provide hub and spoke connections during the morning peak by

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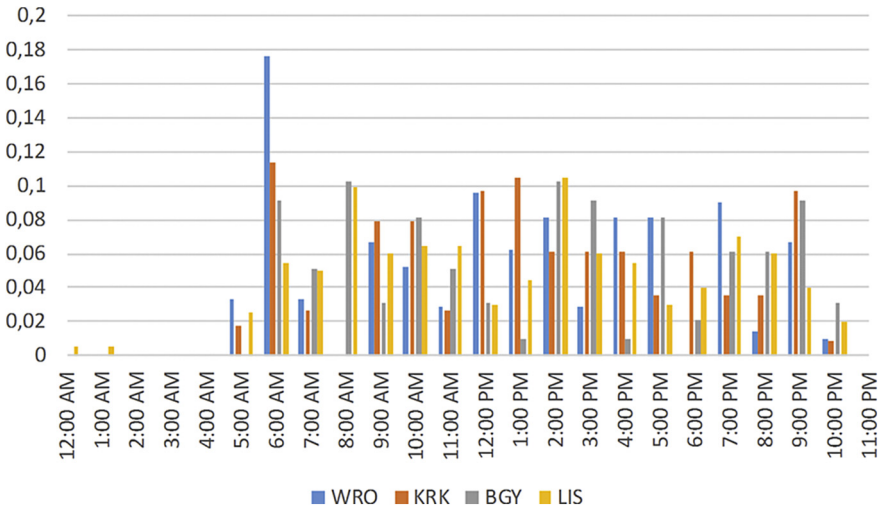

Fig. 1. Percentage of takeoff operations carried out during particular hours at four chosen regional airports.

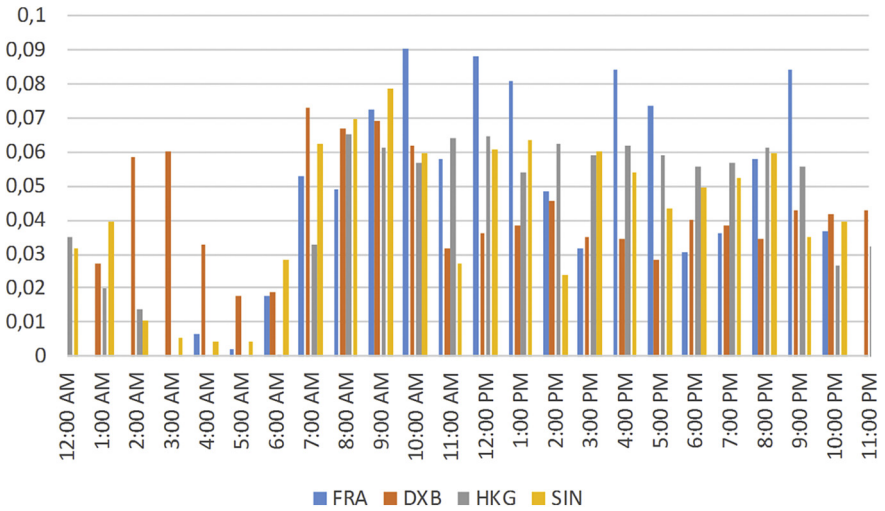

Fig. 2. Percentage of takeoff operations carried out during particular hours at four chosen airport hubs.

providing means of transport to hubs in order to deliver passengers to their long-distance flights.

It can be therefore concluded that the problem of the dynamic nature of takeoff operations concerns both regional and hub airports. On the basis of the studies conducted at Wroclaw Airport (WRO), it can be concluded that the dynamic takeoff operation intensity means that the volume of passengers undergoing security control during the day varies. Fig. 3 shows an exemplary volume of passengers reporting to the security checkpoint per hour on a chosen day.

The data presented in Fig. 3 reveal that the demand for the system capacity differs during the day. It is important to take into account the passenger service level. The system should be configured in a way that ensures an appropriate capacity, especially during rush hour. This makes static management of the system (a constant number of open security checkpoints) redundant at other times, resulting in higher costs. However, several methods can be used to avoid this. One involves increasing the capacity of the system by reconfiguring the checkpoints. Another solution is the use of dynamic management. The parallel use of both methods mentioned above is the most advantageous.

In our previous studies (Kierzkowski and Kisiel, 2014, 2015), we developed a security control counter simulation model on a microscopic scale. Those studies were aimed at showing that the capacity of the system can be increased by factors such as the size of the security control preparation area and luggage collection area, the number of manual control operators, and the checkpoint arrangement (single- or double-lane counters). Such activities allow for a significant increase in process capacity.

Models for the dynamic management of security checkpoints have already been presented in scientific studies (Section 2). Generally, it can be concluded that they are aimed at scheduling the checkpoint operation to achieve the required capacity. This means that there should be no queues in the system. In our article, however, we made an attempt to achieve even higher economic benefits. We allowed the possibility of queue formation while retaining an appropriate level of service (Section 4). Because of this, the authors decided to expand their studies on the model with an algorithm for security checkpoint management. The algorithm was verified on the basis of a real system implemented at Wroclaw Airport.

1.2. Profile of Wrocław Airport

Wrocław Airport (WRO) is a regional airport situated in southwestern Poland in Europe. At present, it serves approximately 2.3

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