The paper presents the simulation model of passenger handling process being conducted at the Poznań-Lawica Airport. The first part is theoretical, containing an overall outline of the passenger handling processes and their meaning when concerning airports capacity. Second part of the paper is a presentation of a simulation model construction. The main goal of this paper was to model the departure process at Poznań-Lawica Airport using simulation tool. The lack of a satisfactory operational model of landside operations was a motivation to create a new flexible simulation model adaptable to various airport configurations for capacity and delays estimation in airport passenger terminals. The models, and simulation have been done by the author using ExtenSim simulation and modeling program.

Keywords: process optimisation, simulation model, airport capacity

1. INTRODUCTION

Air transport being the most modern and the quickest mode of transport has been gaining popularity. Central European countries are regions with the highest rates of traffic. Liberalization of air transportation opened the European market to low cost carriers. These processes influence some spatial changes. Development of airports requires more space for rebuilding terminals and enlarging service centers. The biggest congestion is observed in the terminal area. During just four years since 2004 to 2007 passenger traffic in Poland increased by nearly 116.61%. Thanks to that Poland was at the forefront of countries with the highest growth rate in passenger traffic numbers. The system of Polish civil airports used for international passenger and cargo traffic consists of eleven airports.

Poznań Lawica Airport is one of the oldest airports in Poland, currently sixth of the busiest Polish airports. It has been in regular operation since 1913, first as a Ger-
man military facility. Today Poznań-Lawica Airport is a dynamically expanding business. The airport struggled with the problem of exceeding the capacity and required expansion. The investment program for the years 2009-2013 included: runway modernization, passenger terminal extension in the arrivals section, building of a parallel taxiway to the rapid-exit taxiways, and further extension of the apron.

In 2013, the new and modernized departures area at the passenger terminal was opened. The total floor area of the passenger terminal building is 23,200 m². The work included the expansion and modernization of the passenger terminal building. Built in 2001, the passenger terminal was transformed into a zone of departure, 11 gates with a commercial and safety control zone. New six (including 3 additional) security control points are located at the former place of check-in. The newly built part is the check-in hall with 22 check-in, 6 self-service check-in desks, baggage arrivals hall and offices. The extension project allowed the airport capacity increase from 1.5 million to 3 million passengers annually. At present, the peak hour capacity is 1,900 arriving passengers and 1,100 departing passengers.

To provide safety of controlled aircrafts the airport capacity of passenger departures process is a key factor. In general capacity is defined as the practical maximum number of operations that a system can serve within a given period of time. The passenger traffic growth is hard to accommodate, especially when there are delays or when the terminal capacity is close to its limit. Solutions that can increase capacity while not increasing the infrastructure and land use are often considered the best. It makes airports an ideal application area for simulation [4].

One of the main processes carried out in air traffic is a process of passenger service. Modeling and simulation of processes with participation of humans is, according to M. Gatersleben and S. van der Weija [2], the most difficult task to perform in comparison with the processes without their participation, mainly due to unpredictability of human behavior. However, they point modeling and simulation as a valuable tool in the passenger logistics, determining bottlenecks and possible solutions in the field of passenger service at the airport. The presented method of modeling primarily relates to the departing passengers. As indicated by the authors [1, 5, 6] it is a process that requires much more time and is more complex compared to the processing of passengers arriving and transit. What is more the process is in a continuous state of change, is complex and stochastic and involves many moving objects.

2. PROBLEM DEFINITION

Planning of investments, especially in the airline industry, is a complex process and requires taking into account many factors and combination of different aspects. Decisions are preceded by planning – based on development strategy, needs assessment and growth forecast of passenger traffic. A large number of items that
need to be taken into account, lack of opportunities to experiment in real time, makes the airport a great facility to carry out the simulation process.

The overall objectives of the study were:

− construction and validation of a simulation model of the departure process at the airport,
− simulation assessment of the current departure process.

The departure is one of the core processes of an airline operation. That process is in a continuous state of change, involves many moving objects, it is also the most complex that an airline performs on a repeated basis. It requires a good performance that can be measured in several different performance indicators. In the departure process a lot of functions are performed by distinct group in a limited period of time between the arrival of a plane and its departure for the next flight. The less time the client spends in the system the higher the satisfaction. However, at the same time, an airport is obliged to hold standards that passengers must meet. These standards include proper identification, limited luggage weight, and safety procedures at the security checkpoints. Especially in the highly dynamic situations at airports the interaction between passengers and airport processes is extremely difficult to control and predict. Passengers have a free will and do not always behave as intended. Especially when there are delays or when the terminal capacity is near its limit, simulation studies can be a big help to support decision making about changes that will improve the airport processes. Repeated hundreds of times daily in dozens of locations, its success or failure can make or break an airport reputation for safety and reliability [4].

This paper shows an approach for airport terminal modeling based on the assumption that simulation building blocks can provide a powerful airport modeling tool which is able to answer different questions about the airport. The simulation software Extend from ImagineThat Inc. was used as a tool for the model construction. Extend is a modern simulation system with the discrete-event simulation module. This software is widely used in the simulation community for research and analysis. Despite the wide range of applications Extend has features that can not be found in other simulation softwares. It is a flexible tool characterized by high simplicity. It allows the designer to focus on the most important element – the modeling process.

At Poznan-Lawica Airport any specific research on measuring the parameters of departure process has never been carried out. Comprehensive measurement of that parameter was made in 2003 for international Warszawa-Okecie Airport. The author of the study, Kraśnicki-Sokół notes that test results are representative of typical medium-sized airport [3]. Similar organizational pattern can be used for the other airports. Poznan-Lawica Airport has a typical passenger service system, thus the results of measurements carried out at Warszawa-Okecie Airport can be adopted. The first step of modeling consists of input data identification. The input pa-
Passengers flow intensity estimation was the main problem during model parameterization. It was successfully solved using realistic flight schedule developed for a 24-hours day design. Based on a flight schedule from 20th of August 2013. During experiments the following characteristics were estimated:

- operating rate of service points,
- passenger queue characteristics (average, maximum),
- delays on departure,
- process time distribution (average, maximum).

3. SIMULATION MODEL

The construction of a simulation model of the departure process at the airport of Poznan-Ławica began by establishing a global time scale. The Poznan airport operates 24 hours a day. The functioning of the airport during the 24-hour activity was examined. Minute was established as a unit of time. Flight schedule determines the time of passenger appearance at the airport. The first handling activities (check-in) begin 2 hours before take-off. The Poznań Airport operates according to the basic method in cruising technology which imposes that each flight has a separate one or more check-in counter.

The time of opening check-in desk was assumed as the time of passenger arrival at the airport. The stream of passengers can be divided into traveling with checked
Modeling of the departure process at Poznań–Ławica Airport 19

baggage and traveling with only hand luggage. The results of the simulation were as follows:

− 3662 passengers with baggage,
− 416 passengers only with hand luggage.

90% of passengers must enter the queue and wait for an available ticket agent for assistance. For each flight there is a separate one or more check-in counter. In total there are 22 check-in desks. The ticket agent checks the client and takes care of the luggage. The distribution of check-in process time has been assumed according to the Erlang distribution \((k = 4, \text{ mean 1.3 min [3]})\). Observed maximum value during the operation was 5.1 minutes, and minimum value 0.12 minutes. Total operating time was 148.75 hours. Meanwhile, the average capacity utilization rate was very low – about 12.6%. The low utilization rate is a result of current technology of passengers departure.

The parameters of check-in desks allows the smooth and uninterrupted operation. The maximum number of people waiting in the queue was 165 with the average queue size of 6 persons. Taking into account the type of cruises, the results were as follows:

− 2 people for flights of less than 50 passengers,
− 8 people for flights of between 50 to 100 passengers,
− 18 people for flights of more than 100 passengers.

The average waiting time was 17.8 minutes:
− 18 minutes for one check-in for the flight,
− 28 minutes for two separate desks,
− 30 minutes for flights of more than 100 passengers and three check-ins.

The scheduled model assumes the separation of cruises and a separate post for each trip. For flights with low passenger numbers expressions of support are not enough while the check-in must be active the entire 75 minutes. The low capacity utilization rate shows also the possibility of handling higher intensity traffic. A large number of active check-in allows handling of many clients at the same time. Security checks are the cause of the queue before the next stage of process.

After the check-in process a passenger goes toward security checkpoint covering a distance of about 95 meters. All passengers line up in a queue before the security check point. The procedure includes the following steps: identification, preparing to go through the gate and going through the security gate. The operation is carried out in accordance with the exponential distribution, the average processing time is about 0.53 minutes [3]. There are 6 security checks at Poznan–Ławica Airport. Simulation of the security checkpoint was conducted on the assumption of continuous activity of the six points. The maximum queue length was 22 people with the average of 1 passenger waiting for service. The maximum time spent in the queue was 2.2 minutes, the average was 0.87 minute. Utilization rate of one security checkpoint was 25%.
After passing through security control passengers have to cover a distance of about 75 meters. But before, the stream of passengers is split into two parts: traveling in the Schengen area and flying out of the zone.

Passengers who travel in the Schengen area wait in the waiting room for a briefing. In case of flying to countries outside the Schengen area there are more operations to do. Passengers intending to cross the border must present a passport. Operation is carried out according to the Erlang distribution ($k = 2$, average 0.42 minutes). There are 4 desks of passport control at Poznań–Ławica Airport. 1746 passengers travelled to non-Schengen countries on the 20th of August 2013 and the passport control point operated very smoothly. Maximum waiting time for service was 1 minute. Information about low utilization rate of service point (13%) should lead to reduction of the number of active desks.

Boarding is the next step. Passengers must show their identification card and boarding card. The duration of a single operation is 0.2 minutes. At Poznań–Ławica Airport, there are 7 exits to the taxiway for Schengen area. Non Schengen departure lounge has 4 exits. The capacity of boarding does not depend on the number of exits but on the number of staff. The number of staff depends on the intensity of traffic, there are usually two/three employees.

The airport coped with traffic growth which took place on the 20th of August 2013 without any problems. It is worth emphasizing that the flight schedules were taken from a sample of the summer season. Summer season means increased traffic at the airport due to the large number of holiday travels – charter flights. Table 1 contains a summary of simulation results obtained at each service counter.

Table 1.

<table>
<thead>
<tr>
<th>Step of departure process</th>
<th>Queue</th>
<th>Service point</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average length [number of person]</td>
<td>Max length [number of person]</td>
</tr>
<tr>
<td>Check-in</td>
<td>6</td>
<td>165</td>
</tr>
<tr>
<td>Security control – 6 service point</td>
<td>1</td>
<td>22</td>
</tr>
<tr>
<td>Passport control – 4 service point</td>
<td>0.02</td>
<td>10</td>
</tr>
<tr>
<td>Average and maximum waiting time</td>
<td>19.07</td>
<td>54.9</td>
</tr>
</tbody>
</table>
During the simulation process described above it was noted that:
- 2332 passengers were traveling to the Schengen Area, and 1746 passengers were traveling to countries outside the Schengen Area – in fact 4078 passengers were served,
- maximum waiting times for service before the next service point has not been exceeded,
- average time to pass through the system was about 19 minutes, maximum process took 55 minutes,
- utilization rate of service point suggested the possibility of handling higher intensity traffic,
- efficiency of check-in desk was low – within 24 hours of activity, the working time of check-in desks was 148.75 hours while the average utilization rate was 12.6%.

The results of the study indicate that the system is working properly and is able to handle all the passengers while maintaining the timing.

4. CONCLUSIONS

During last years the air transport has become in Poland more and more popular as a mean of traveling. At the same time forecasts predict that growing trend will continue, albeit at varying rates across world regions.

Air traffic is carried out in selected air zones that are controlled by Air Traffic Services. The biggest congestion is observed in the Terminal Area. To provide safety of controlled aircrafts airport capacity must be evaluated. The problem of capacity of airport passenger departures process is one of the key factors that determine the capacity of the whole airport. Airports now cater for the millions of people who flow in, out and within countries each year. This growth is hard to accommodate, especially when there are delays or when the terminal capacity reaches its limit.

The main goal of this paper was to estimate and systematize passenger handling system at the airport of Poznań-Lawica based on simulation model. For the model development the simulation software Extend was used that is a modern simulation system, which has the discrete-event simulation module. The overall objectives of this study were:
- analysis of parameters of passenger service points at the airport,
- using this information to develop a simulation tool that shows the passenger flow through the departure process.

The implementation of the simulation process showed the relations between time of arrival, time of waiting for service and closing time of each flight. This correlation validated the model. According to the results the average time of passage through the system was about 19 minutes, with the highest time of 55 minutes.
There was a periodic congestion on the road of passengers stream. Simulation also showed the large amount of work at check-in desks (149 hours) and small utilization rate of individual service points. Taking into account schedule to arrive at the airport, flight schedule on 20th of August 2013 (served 4078 persons), the results of simulation should be positively assessed and the system operated smoothly and without delay.

Simulation results, despite many adopted simplifications in the model, showed a good compliance with real measurements. As a result, the model is characterized by a sufficient compatibility with the described system, and is simple enough to be applied in a wide range. It offers realistic modeling and evolution of passenger operation in terminals providing information on passenger flow capacities, arrival flows, check-ins and security check points operations, passport check points and boarding gates flows.

REFERENCES


MODELOWANIE ODPRAWY PASAŻERÓW W PORCIE LOTNICZYM POZNAŃ-LAWICA

Streszczenie

Przedmiotem publikacji jest model symulacyjny odprawy pasażerów w Porcie Lotniczym Poznań-Lawica. W pierwszej części omówiono podstawowe założenia odprawy, sformułowano problem i scharakteryzowano poznańskie lotnisko. W drugiej części zaprezentowano model symulacyjny. Celem działań było odwzorowanie odprawy na podstawie rzeczywistego rozkładu lotów w wybranym dniu. Model sporządzono za pomocą oprogramowania Extend. Jest to pro-
gram obiektowy służący do modelowania, symulacji i wizualizacji zdarzeń ciągłych i dyskretnych. W rezultacie otrzymano model dostatecznie zgodny z opisywanym systemem, i wystarczająco prosty, aby móc go stosować w szerokim zakresie.