

Conception of logistic support model for controlling passengers streams at the Wrocław Airport

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Abstract: The article presents a preliminary concept of a model of logistical support for the functioning of the Wrocław Airport in regards to controlling the passenger streams in the airport terminal. The model of logistical support for the functioning of the Wrocław Airport will be a dynamic model in which the original schedule of processes may change along with the duration of its execution. Dynamic reliability tools allow for a much better description of the surrounding reality by taking into account the changes in the time of input values for the calculations. Thereby the dynamic reliability breaks with the traditional approach to calculations, in which after the determination of states and relationships of a system, time-invariant input values for the calculations are introduced (results of calculations can show the dynamics through relationships of elements of the system). In the article we presented a developed preliminary concept of the functioning of a passenger terminal based on designated main characteristics of the random entries of passengers and random durations of individual activities. The article also presents the direction of the future development of the presented concept.

Keywords: simulation model, airport, reliability, passenger handling

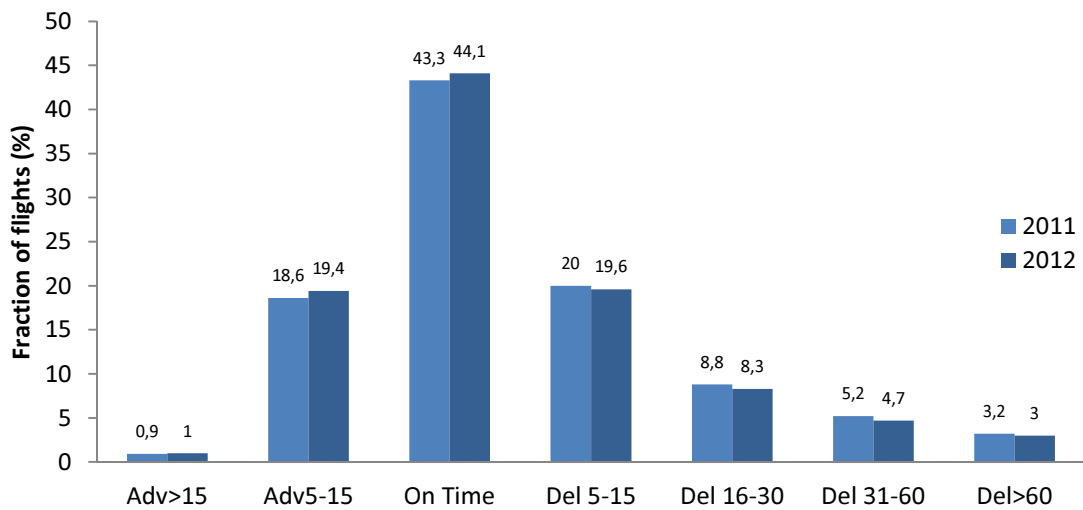
1. INTRODUCTION

According to data presented by CODA (Central Office of Delays Analysis) the greatest traffic delays occur in the summer months and the winter months. In the first case this is in relation with increased traffic and in the second case with worse weather conditions (higher probability of occurrence of bad weather). Some delays are therefore caused by air carriers (choice of airports with a greater risk of occurrence of disruption but with a greater commercial potential), others are independent of the carrier (weather, strikes, etc.). CODA in monthly reports presents the size of delays in the European airspace. The dependency chart of time interval on the percentage of delayed flights was presented in Figure 1.

It should be noted that only about 44% of all flights (for the year 2012) are performed without delay (in accordance with the adopted Eurocontrol directives, all flights that take place before the scheduled time and those with a maximum delay of 4 minutes, have the status of on-time flights). More than half of the delays in the European flight network in 2010 were caused by the airline (Fig. 2). This fact is very important and at the same time surprising because the airline bears the costs of the delays (for example the extension of the flight time), so it should seek to minimize delays.

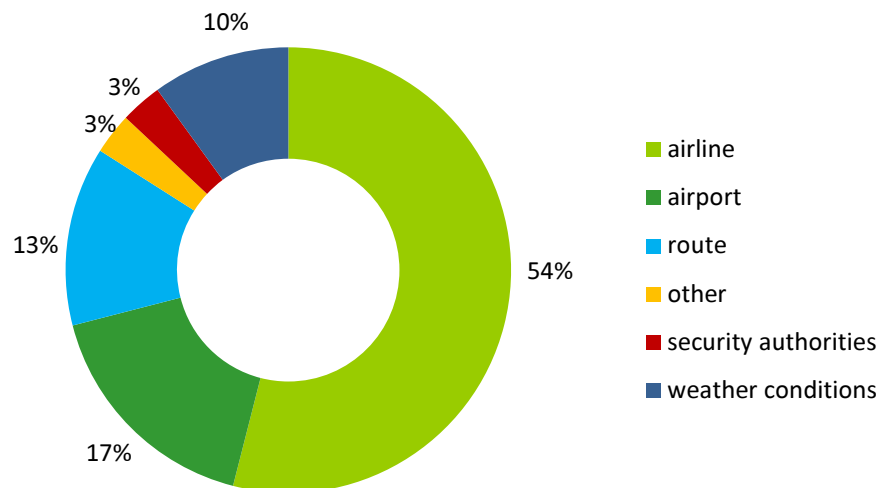
Also surprising is the 17% share in the primary delays of the airport, which at the time of the inquiry by the carrier about the possibility of flight operations, agrees to them, undertaking their timely servicing. Therefore it is crucial to designate a model of logistical support of the functioning of the air carrier and the development of a model of logistical support of the functioning of the airport, which will evaluate in an objective manner the actions of the carrier and of the airport. They will have the goal of reducing the occurrence of disruptions.

Fig. 1. The chart of dependency of time interval on the percentage of delayed flights.
[www.eurocontrol.int/CODA]



The structure of the equipment of the airport infrastructure is dependent on the size of traffic flows. Providing aviation infrastructure to air carriers while limiting costs is extremely important from the point of view of the airport. Passenger handling costs can be reduced in various ways. The most important issue is the appropriate scheduling (in cooperation with air carriers) of the time of arrival and departure of the aircraft. The opening and closing hours of the check-in desks and time intervals of the appearance of the passenger at the security checkpoint are directly linked with the scheduled time of departure and arrival. Incorrect distribution of arrivals and departures of aircrafts in time may result in the need for the temporary opening of a bigger number of passenger check-in desks (which in turn increases the costs).

Fig. 2. The determinants of primary delays in European airspace
[www.eurocontrol.int / CODA]



It is also crucial to ensure adequate liquidity in the flows of passengers, goods and the minimization of the probability of the occurrence of delay of the aircraft.

One of the first publications in which analysis was performed on the impact of disruptions on the functioning of the airport was [6]. The authors employed a fairly significant simplification by analyzing the individual elements of the infrastructure and not the airport as a whole. There are many

models which treat the problem of modeling traffic at the airport macroscopically (generally) [1], [2], [6].

For the purpose of evaluation of the functioning of the airport in Athens, a model presented in [4], [5] was developed, which is based on the dynamic system. In the process of modeling of the functioning of an airport is crucial to assume the adequate flow of entries. In paper [5] the relationship between different types of carriers and the flow of entries to the check-in and security check was presented. A broader analysis of models of support for the functioning of passenger terminals presented in world literature was presented in [8].

An important aspect in the functioning of real processes is the necessity to respect all of the rules concerning the method of execution of air transport. It is also an important aspect in simulation modeling, which often has an optimizing character. The simulation model should function and optimize the processes within the extent permitted by by law and possible for implementation in a real system. The main legal act determining the management of civil air transport within the Republic of Polish is the Aviation Law Act of 3 July 2002 [14] implementing the directives of the European Communities. These are binding rules unless ratified international agreements do not provide otherwise. The international rules contained in the Chicago Convention [3], which replaced the Paris Convention and is still the basic act regulating the international air traffic also apply within the Polish Republic.

Ground handling at an airport includes a number activities in the scope of eleven categories, including also the category no. 2 concerning the passenger flows [13]:

1. Ground Administration And Supervision,
2. Passenger Handling,
3. Baggage Handling,
4. Cargo And Mail Handling,
5. Ramp Handling,
6. Aircraft Cleaning And Servicing,
7. Fuel And Oil Handling Services,
8. Aircraft Maintenance Services,
9. Flight Operations And Crew Administration Services,
10. Ground Transport Services,
11. Aircraft Catering Services.

An additional role is played by the high standards of maintaining security as a result of which the passengers are moving through zones with varying levels of access. Procedures for movements between the individual zones are determined by law. The main law responsible for maintaining the level of security of air transport in Poland is the Regulation of the Minister of Transport, Construction and Maritime Economy of 31 July 2012 on the National Civil Aviation Security Program [11], referring to regulations ([9], [10], [12]), setting out detailed procedures, the enforcement of which is the duty of the manager of the airport. Airports designate appropriate zones designed for the movements of passengers, baggage and the performance of the necessary ground handling processes:

- landside,
- airside,
- security restricted area,
- critical part of the restricted area,
- separated areas.

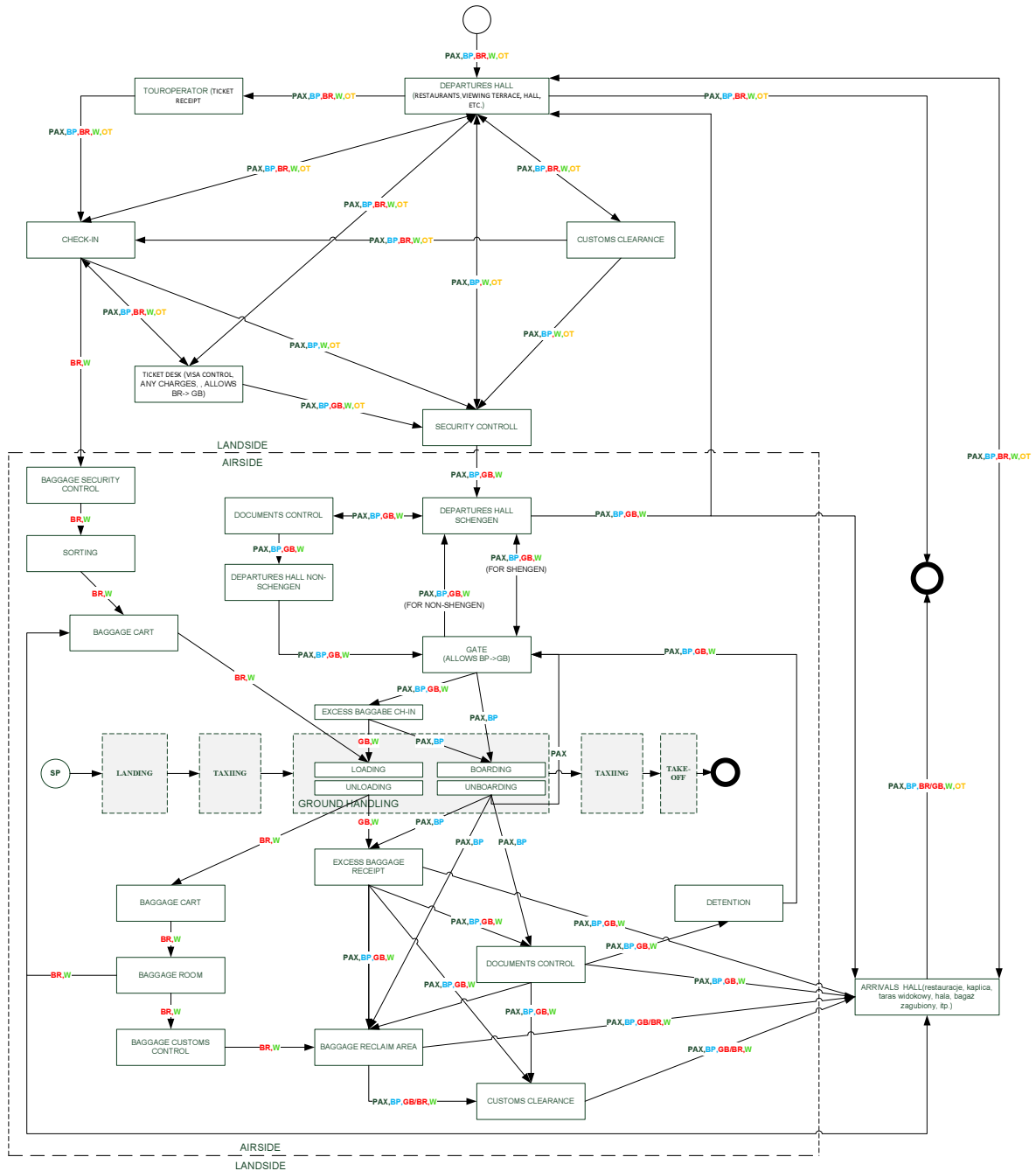
This aspect can play an important role in limiting the effectiveness of control passenger flows

2. MODEL OF LOGISTICAL SUPPORT OF THE FUNCTIONING OF THE WROCLAW AIRPORT

The model presented in the article was developed in the FlexSim simulation software. In the model the relationships between the individual transport processes were taken into account and

the reliability of airport infrastructure and equipment for terminal operations and ground handling was also taken into account. A model of the movement of passengers, baggage, etc. was developed, along with designated probability density functions of the times of execution of individual tasks. Later in the paper we present the most important assumptions of the model without focusing on certain specific cases, which were included in the model (Fig. 3).

Figure 3. Model of execution of transport processes at an airport.



LEGEND:
PAX - PASSENGER
SP - AIRCRAFT
BP - CABIN BAGGAGE
BR - CHECKED BAGGAGE
GB - GATEBAG
W - TROLLEY
OT - ACCOMPANYING PERSONS

The execution of passenger movements is dependent on the tariff options. If a passenger has a possibly complete tariff option (traveling with checked baggage) the first point in the implementation of the process is the ticket and baggage check-in. A two-point distribution was defined for any air carrier:

- the passenger has checked baggage and is cleared through the ticket and luggage check-in;
- the passenger does not have checked baggage and does not pass through the baggage check-in (the necessity of passenger on-line check-in was assumed);

For the model of logistical support of the functioning of the Wrocław Airport the following characteristics have been developed (broken down into individual carriers such as LOT, Lufthansa, Wizzair, Ryanair):

- the distribution function of the time of arrival of the passenger to the queue at the ticket and baggage check-in in relation to the planned time of departure;
- the execution time of the ticket and baggage check-in procedure - distribution functions of the queue waiting time were developed as well as distribution functions of the time of the check-in activities (weighing and wrapping baggage, checking identity documents, issuing tickets, etc.)

Visualization of the model of check-in is presented in figure 4.

Fig. 4. Visualization of the model of check-in.



Check-in desks for individual flights were defined as follows:

- for traditional airlines (Lot, Lufthansa, SAS) one desk was opened for check-in for the economy class and one for the business class,
- for the low-cost carriers, depending on the arrangements with the airline: the carrier Ryanair opened two check-in desks for a flight, however, at a given desk passengers from any flight can check-in;
- for other carriers two desks for a selected flight were assumed.
- If a passenger does not have checked baggage he goes directly to the security check (similarly as a passenger who completed the ticket and baggage check-in).

In the developed model the following characteristics have been developed:

- the distribution function of the time of joining the queue (depending on the time of the scheduled departure of the aircraft) of a passenger who did not go through the ticket and baggage check-in (characteristics developed for each carrier)

- the distribution function of the time of joining the queue (depending on the time of the planned departure of the aircraft) of a passenger who went through the ticket and baggage check-in (characteristics developed for each carrier)
- the distribution function of time between the passenger leaving the check-in and joining the queue at the security check;
- the distribution functions of the time waiting in queue.

Figure 5 presents a visualization of a model of security check-in.

Fig. 5. Visualization of a model of security check-in.



A two-point distribution of possible implementations of the transport process was developed:

- the passenger passed through the security gate without setting it off - a probability density distribution was developed of the time from the moment a passenger approaches the x-ray machine conveyor until the departure of the passenger from the control position
- the passenger has not passed security control positively (security gate was set off) - two scenarios were developed together with two-point distributions for the selection of one of them (and similar probability distributions as for the passenger who passed through the security gate without setting it off):
 - the passenger was subjected to manual inspection
 - the passenger was subjected once again to control through the security gate.

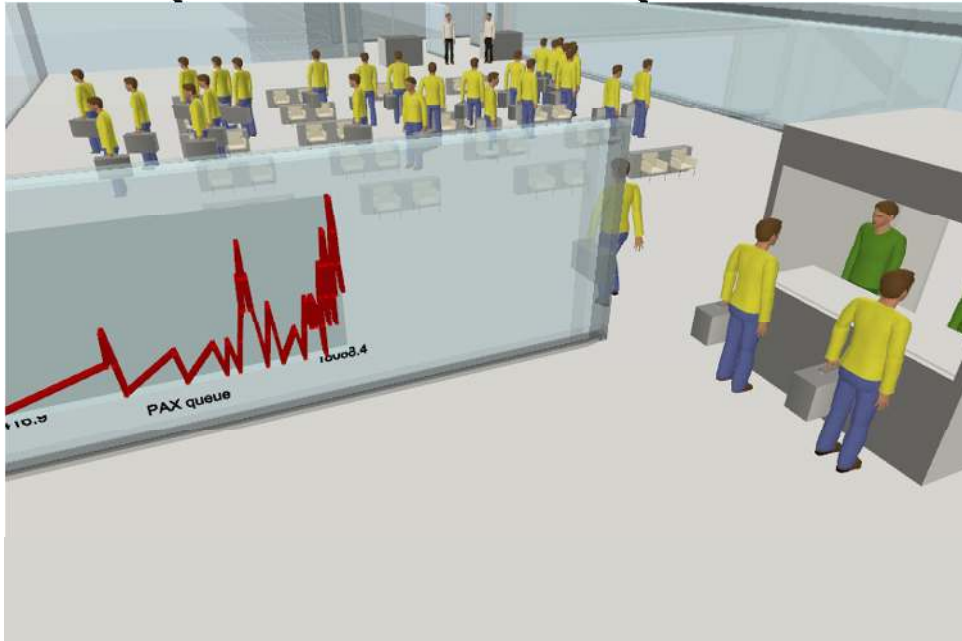
Similarly, a two-point distribution analogous to the previous situation was used (the passenger passed without setting the gate off or the gate was triggered), but it was assumed that if the gate is set off, the manual control follows.

On the basis of the observations made, the function of transition from the security check point to the departure hall was determined. A passenger passport control zone was also designated (Fig. 6).

Probability density functions were developed for the time of performance of passport handling as well as probability density functions of time between successive entries. Probability density functions were also designated for the opening of gates for particular flights, which are directly dependent on the probability density function of the timely arrival of a given flight. Probability density functions were developed of the number of passengers served at the gate in 30-second cycles, as well as similar functions of the time of transition of passengers to the aircraft. For the purposes of the model

probability density functions were developed of the time of each of ground handling operations and the relationship between the individual implementations of processes. For each type of aircraft a set of ground handling equipment required for the implementation of the process was assigned and a set of possible equipment available to the handling agent was described.

Fig. 6. Visualization of a model of immigration control.



The reliability of the infrastructure was described, among others, by the probability density function of the time between damages of the ground handling equipment and the probability density function of time for the restoration of its operating capability. The check-in desks, security check posts and the ticket control prior to boarding the aircraft were described with similar functions. For the purposes of the model on the basis of historical data, probability density functions were developed of the execution times of individual tasks during ground handling of aircraft, as well as logical functions, which are responsible for the exclusion of individual ground handling operations (the ones that do not have to be performed during each ground handling).

3. APPLICATION OF THE MODEL OF LOGISTICAL SUPPORT OF THE FUNCTIONING OF THE WROCLAW AIRPORT

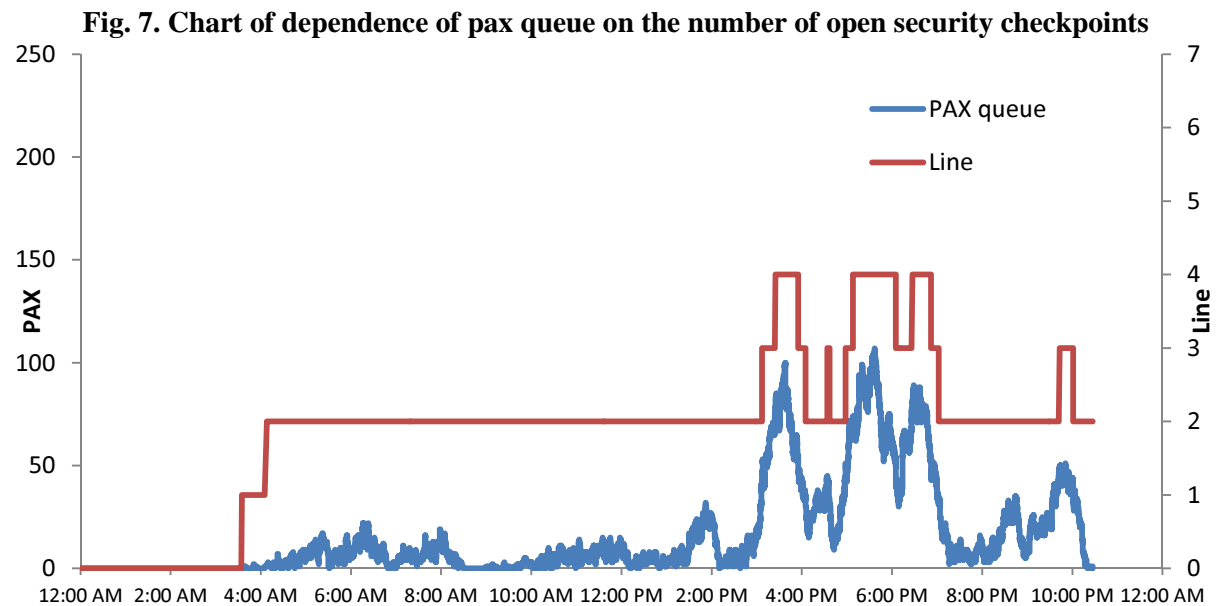
The model of logistical support of the functioning of the Wrocław Airport enables forecasting the execution of the following processes:

- on the basis of the declared flight grid and the designated characteristics of the flow of passenger entries it is possible to designate dynamic changes in the allocation of the ticket and baggage check-in desks to a given flight, depending on the length of the queue.
- on the basis of the declared flight grid and the designated characteristics of the flow of entries it is possible to determine the time intervals for opening the individual security check points depending on the number of passengers in the queuing system. Simulations of the process of opening subsequent security check points were presented in Figure 7.

The advantage of the model is the possibility of introducing the maximum acceptable number of people to the queuing system of security check points in order to obtain the minimum number of open check points. This minimization will reduce:

- costs,
- the number of passengers traveling within the terminal at any time interval.

It is also possible to examine the impact of aircraft delay on the execution of the ground handling of the aircraft.



4. CONCLUSION

In this work a preliminary model of logistical support for the functioning of the Wrocław Airport was presented. This model has some limitations, which will be removed in subsequent works, such as:

- lack of accurate data enabling the modeling of passenger movement within the public area,
- independence of the number of passengers on competing routes,
- lack of utilization of time series models for the descriptions of the execution of processes,
- lack of consideration of the constraints arising from the departure hall zones (Schengen, Non-Schengen)

The models of implementation of individual transport processes will also be extended in further works.

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