CAPACITY RESEARCH OF BRNO-TURANY AIRPORT WITH RESPECT TO NEW TRENDS IN AIR TRANSPORT

Milan Stefanik, Zoltan Bazso
Air Transport Department, University of Zilina, Slovakia
milan.stefanik@fpedas.uniza.sk; zoltan.bazso@fpedas.uniza.sk

Keywords: *airport capacity, simulation, passenger flows*

Abstract

The changes in air transport that have to be faced in Central Europe are mainly the steep growth of charter and low-cost traffic and new legislation requirements resulting from accession of several countries to the so-called Schengen area. International airports in this region, and especially those with regional character, are a part of European ATM system to which particular attention should be paid. The specific features include the fact that these airports are not constrained on the airside but a steep growth of charter and low-cost traffic in recent years in this region causes overloading of airport terminals. This is also underlined by new legislation requirements which have to be applied in operation and may lead to problems if not handled in time and in proper way. Another usual issue is that the link between reaching the annual capacity and the co-existence of hourly capacity is very weak. In other words, there are times of day when the traffic is very high and reaches critical hourly values for either the airside or landside (or both) - the peak hours. Nevertheless, looking at the annual operation, the airport is far from hitting the line. The peak hours simply reveal the bottlenecks of the airports.

The goal of our research was to perform a landside capacity study of the Brno-Turany Airport (Czech Republic) with respect to the possible future growth of traffic and number of passengers, and thus identify the potential constraints to passenger and baggage flows. The research was conducted using fast-time simulation of passenger and baggage flows within the terminal using an off-the-shelf tool which employs real passenger behaviour model. Another aim of our research was to show the managers of regional airports that such modelling can be useful for decision making support not only at busy airports. At regional airports, significant shifts in operation can be achieved through minor modifications of either terminal layout or operational procedures, or both.

1 Introduction

The air transport in Europe as well as worldwide has been undergoing a rapid and continuous growth in the recent years and it is anticipated that the volume of air transport in Europe will double by 2025 [1]. One of the most serious problems of air traffic system that will have to be solved in the following years is the capacity issue, and that applies to both airports and airspace. The airports are generally considered as principal constraint to traffic growth and increasing demand will definitely lead to congestion of airports and Terminal Manoeuvring Areas (TMAs) and consequently growing delays. With respect to major airports, the infrastructure, as it is now, is expected to be losing the ability to satisfy the growing demand gradually and the critical point is about to be reached in 2015 [2]. Therefore, one of the possible solutions to this could be transferring a certain part of traffic and thus passengers from hubs and other busy airports to regional airports offering point - to point - direct connections.

One particular chapter are the international airports in Central Europe with regional character. These used to be focused on general aviation and charter operation during the summer seasons. However, the recent years have brought about a huge 'boom' of low-cost carriers which changed the direction of development at these airports. As an example we can use the Brno-Turany airport which, thanks to Ryanair, in last two years doubled its number of passengers who passed through the airport. This trend was one of the factors which led this airport's managers to the conclusion that a new departures terminal was needed. The new terminal, which is fully compliant with the Schengen standards, was given to operation on 18th September 2006 and its annual capacity was estimated to be 3.2 million passengers.

Needless to say that another essential parameter exists, taking into account the operation and movements at the airport: the hourly capacity of the airport. The issue is that the link between reaching the annual capacity and the co-existence of hourly capacity is very weak. In other words, there are times of day when the traffic is very high and reaches critical hourly values for either the airside or landside (or both); we call these peak hours. Nevertheless, looking at the annual operation, the airport is far from hitting the line. The peak hours simply reveal the bottlenecks of the airports.

The goal of our study was to perform a landside capacity study of the Brno-Turany airport with respect to new trends and possible future growth of traffic, and thus identify the potential constraints to passenger and baggage flows. The study was conducted using fast-time simulation tool PaxSim, which is a sophisticated software application for simulating passenger and baggage flows within the airport terminal.

2 Brno-Turany airport

Brno-Turany Airport (ICAO code: LKTB) was picked for this study as it has a couple of interesting features. Combined together, they made Brno-Turany airport an attractive subject for investigation. This chapter describes the particular aspects for choosing this airport.

Although with the statute of international airport, LKTB is a typical regional European airport as long as traffic is concerned. The non-scheduled (or charter) flights represent a vast majority of movements, followed by general aviation (GA) movements; regular, or scheduled, flights add up to only a small percentage of all flights (movements) at the airport. However, the situation is changing. During the last few years, several new routes were established: Smart Wings in cooperation with Atlant-Soyuz Airlines flies from Brno to Moscow twice a week and Ryanair flies every day to London Stansted and four times a week to Barcelona/Gerona.

Brno-Turany, despite being officially an international airport, has been considered as a regional airport. There are several reasons for this: first is the fact that Prague is the only 'real' hub in the Czech Republic; secondly, there is Ostrava airport with its catchment area just in the neighbourhood of Brno-Turany's catchment area while both being of similar size and having similar traffic volumes. There is a population of more than 2.5 million people within a radius of 100 km from Brno that can be considered as the airport's catchment area.

The most important, but relatively unpredictable at the same time, is that significant traffic growth is expected at Brno-Turany airport. The actual rate of growth is hard to determine (although there are forecasts by Eurocontrol's STATFOR which present different scenarios for traffic growth in particular States). Nevertheless, looking at recent development in air transport in the Central European region, mainly in the area of low-cost operations, it can be expected that regular traffic will gradually increase its proportion within the traffic mix. The growth will also mean an increased landside load, whatever the traffic mix at the airport.

2.1 Airside

The airside aspects of the airport are generally satisfactory with respect to the movement areas capacity and current operations. The airport has one concrete runway 10/28 which is 2,650 m long and 60 m wide. The apron is connected to

the runway by a system of taxiways which consists of one main taxiway parallel to runway and six right-angle taxiways connecting main taxiway with the runway. This configuration is estimated to have the maximum theoretical hourly capacity of approx. 25 movements per hour [3] which highly exceeds current demand. Moreover, if demand at Brno-Turany airport reaches the current runway capacity, this could be increased by building rapid exit taxiways. New rapid exit taxiways could increase the runway capacity to as much as 35 movements per hour in good weather conditions.

There are two aprons at Brno-Turany airport. The first one has 6 stands for B737-size aircraft and is adjacent to both terminals. The other apron is located in a coach distance from terminals and is equipped with three B737-size aircraft stands. The third apron is being constructed for GA aircraft to relieve the main load during the summer peaks.

Brno-Turany airport is capable to accommodate B747 and An124-size aircraft.

2.2 Landside

The landside part of the airport has gone through major changes recently. On 18th September 2006, the new departure terminal building was put into operation. The old terminal building, formerly serving all traffic at the airport, now serves as the arrival and general aviation terminal only. The overall area is 5,500 sq m (out of which 3,000 sq m is in the departure terminal) and the maximum declared capacity is 1,000 departing passengers and 1,000 arriving passengers per hour.

The departure terminal was designed to meet the operational requirements resulting from recent accession of Czech Republic into Schengen area.

2.3 Current activity and traffic mix

Recently, the airport has been experiencing huge growth in operations. The reason, just like in other countries of Central Europe, is a boom of low-cost carriers that introduce new routes and attract a large portion of the population.

As can be seen in Tab. 1, the non-scheduled flights still add up to more than 60 % of total traffic at Brno-Turany airport. Therefore, it is very difficult to predict future traffic at this airport. Considering the STATFOR's optimistic scenario for the air traffic growth in Central Europe for the years 2006 – 2025 [4], the peak hour traffic at LKTB will reach declared hourly capacity of the terminal in the second half of the next decade. However, these are very rough estimations as a new low-cost carrier entering the market or established operators opening new route could cause the traffic boom similar to the one when Ryanair came to Brno-Turany airport in 2005.

Year	Passengers total	Passengers scheduled	Aircraft movements
1997	138,276	4,976	9,343
1998	110,948	4,748	8,246
1999	127,954	0	7,899
2000	112,950	4,816	7,406
2001	128,583	4,500	8,052
2002	156,519	4,600	13,506
2003	166,142	1,400	16,596
2004	171,888	0	17,823
2005	315,672	90,246	16,126
2006	393,686	151,864	20,081
2007	415,276	164,900	22,893

Tab. 1: Passenger and aircraft movement figures (Source: Brno-Turany airport [5])

3 Simulation setup

3.1 Simulation objectives

Setting the simulation objectives is an essential step towards a meaningful simulation. Our study was aimed at the analysis of passenger and baggage flow at Brno-Turany airport with a goal to assess the operational characteristics and determine potential bottlenecks of both arrival terminal and new departure terminal. In addition, we intended to examine the operation of the airport terminals at various levels of traffic taking into account various operational conditions. Considering these facts, we have set objectives as follows:

- Simulation model validation against actual operation;

- Impact analysis of a peak day traffic on terminal operations and passenger behaviour;
- Options analysis of terminal modifications with respect to accession of the Czech Republic to the Schengen agreement;
- Test of the declared maximum capacity of the new departure terminal.

The objectives are reflected in the simulation scenarios which are described further in this article.

3.2 Simulation process

The simulation development process is shown in Fig. 1.

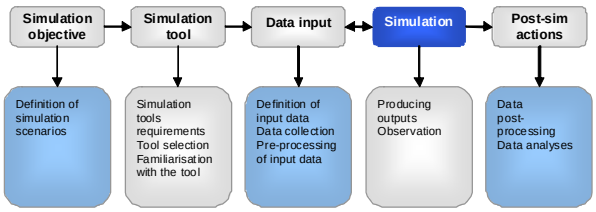

Fig. 1: Simulation development process

3.3 Selection of simulation tool

We have done an exhaustive research on simulation tools related to traffic flows. Based on the results, we have made a conclusion to perform a fast-time simulation by using a tool which includes real passenger behaviour model.

Passenger movement Simulation System (PaxSim) is a set of software tools that enable simulation of passenger and baggage movements within an airport terminal and on the apron. PaxSim was developed by Preston Aviation Solutions, which is a leader in the development of advanced airspace and airport simulation, decision support and scheduling systems for the global aviation industry.

PaxSim is a graphics-based computer program used for the fast-time simulation of airport landside operation. It processes information from flight schedules to determine number of arriving and departing passengers and daily distribution of traffic at the airport. Unlike competitive simulation tools, PaxSim employs sophisticated algorithms of real passenger behaviour. The simulation outcomes therefore reach a high level of conformity with real terminal operation. Statistical reports that are the results of the simulation provide airport designers or airport operators with valuable data concerning utilisation of various facilities and dwell areas within the terminal. PaxSim is a valuable tool supporting complex decision-making processes of airport stakeholders [6].

Based on above listed features, we found PaxSim to be the most suitable tool for our study.

3.4 Data collection

Data collection was performed in co-operation with management of Brno-Turany airport. Service times at check-ins, security checks and passport controls, earliness arrival distribution profile, baggage profile, party size profile and some other operational parameters were determined on the basis of measurements and observations undertaken directly in the airport terminal during one weekend in May 2007. Parameters that could not be measured were either estimated or determined by airport operational staff.

The passenger flow simulation process itself has many inputs which might have considerable effect on the results of the simulation. We are aware of the fact that there are certain inputs which are specific for the particular airport, e.g. the ones depending on type of operations. The most important inputs are the service times, arrival earliness distribution and group/baggage profiles. Taking this into account, we performed measuring and observing exercises directly in the terminal of Brno-Turany airport. The values obtained have been statistically processed to reflect reality. Subsequently, we adjusted the PaxSim default values according to the results of the exercises and observations to reach as high precision as possible.

4 Simulation scenarios

4.1 Baseline (validation) scenario

The first step towards the simulation was a validation of gathered information and setup of simulation inputs. For this purpose, we proposed a validation scenario which modelled the passenger flows at Brno-Turany airport during the last three months of 2006, which also represents the first three months of real operation of the new departure terminal. The results of the simulation were compared against the actual data in the respective period. This analysis was supposed to show the meaningfulness and reliability of PaxSim algorithms and simulation in general, considering the regional character of Brno-Turany airport with unbalanced, high volatility character of terminal operation.

For the baseline scenario simulation, we chose the 26th September 2006, as it was the busiest day during the first three months of new departure terminal operation. 1,261 arriving and 841 departing passengers passed through the terminal at Brno-Turany airport on that particular day. Although 14 check-in counters and 3 security checks are planned to be installed in the departure terminal, on the 26th September 2006, there were only 8 check-in counters and 2 security checks installed and in operation.

Transit passengers were not taken into account for the simulation as the only transit passengers are on charter flights. These either stay in the aircraft while on the stand or are taken directly to the departure lounge if refuelling is required. Therefore, the transit passengers at LKTB do not have any significant impact on passenger and baggage flow within the terminal.

4.2 Peak day traffic scenario

The main objective of this scenario was to determine if current configuration of terminal at Brno-Turany airport (with 8 check-in counters and 2 security checks) is sufficient for accommodating peak season traffic volume.

The peak day traffic scenario was based on flight schedule from 4th June 2006. With 1,354 arriving and 1,783 departing passengers, this day was the busiest day of the year 2006. We assumed that during summer seasons in a few following years, the Brno-Turany airport would deal with traffic intensity comparable to the one noted on 4th June 2006.

For the simulation of this scenario we considered 8 check-in counters to be installed and in operation. Concerning the security checks, we considered two options, either with 2 or with 3 security checks in operation. The objective was to determine the impact of additional security check on the passenger flow rate.

4.3 Schengen/non-Schengen operation scenario

Aim of this scenario was to simulate Schengen/non-Schengen operation at Brno-Turany airport. Although new departure terminal was designed in accordance with operational requirements resulting from accession of the Czech Republic to the Schengen area, at the time of simulation it was serving both domestic and international operation. Czech Republic signed the Schengen Agreement on 1st May 2004 and the free movement of persons and cargo became reality on 31st December 2007 for overland borders and on 29th March 2008 for airports. As soon as the Czech Republic joined the Schengen area, all Czech international airports had to switch the operation from domestic/international to Schengen/non-Schengen.

Unlike domestic/international operation, which does not require any separation of domestic and international passengers on departure (i.e. departure lounge is common to all passengers), the Schengen/non-Schengen operation requires strict separation of passengers flying to Schengen countries and passengers flying to non-Schengen countries. It means that there must be a special departure lounge for Schengen flights separated from the departure lounge for non-Schengen flights. Concerning arrivals, the passengers flying from Schengen countries are considered as domestic and do not pass a passport control while passengers from non-Schengen countries do.

New departure terminal at Brno-Turany airport has two departure lounges; departure lounge A with 4 gates and departure lounge B

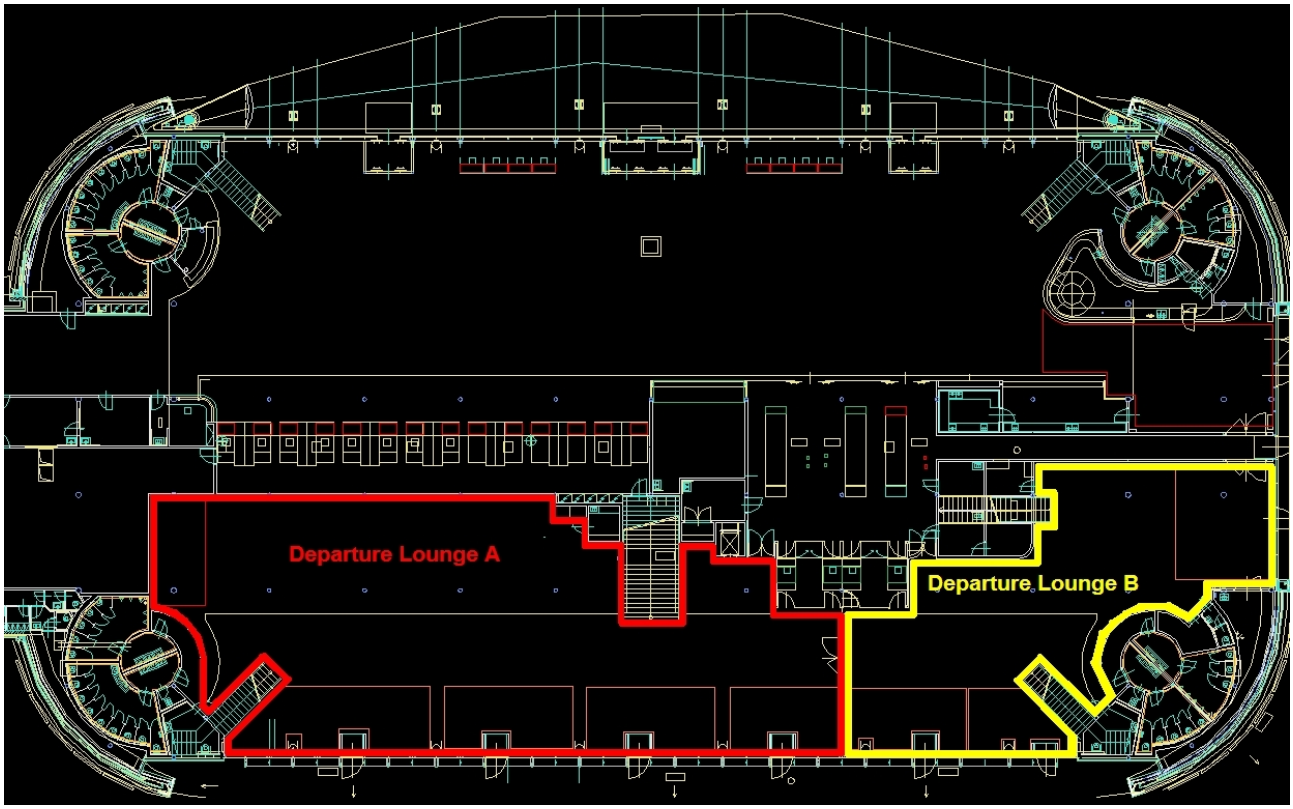

Fig. 2: Departure lounges (ground floor)

with 3 gates (see Fig. 2). In simulation, we considered two possible options:

a) Departure lounge A for Schengen flights and departure lounge B for non-Schengen flights;
b) Departure lounge A for non-Schengen flights and departure lounge B for Schengen flights.

Both departure lounges have a waiting area on the first floor. Unlike departure lounge B, there are retailers in departure lounge A (newsagent on the ground floor; shop and bar on the first floor).

This scenario is based on the same flight schedule as peak day traffic scenario. Taking this into account there were:

- 9 Schengen arrivals with total of 365 passengers,
- 9 non-Schengen arrivals with total of 989 passengers,
- 12 Schengen departures with total of 958 passengers,
- 6 non-Schengen departures with total of 825 passengers.

In this scenario we considered 8 check-in counters and 3 security checks to be in operation.

4.4 Maximum landside capacity test scenario

The Brno-Turany airport terminal has declared maximum hourly capacity for 1,000 arriving and 1,000 departing passengers. The objective of this scenario was to determine major bottlenecks of airport terminal and to examine if airport terminal is capable of accommodating the traffic volume corresponding to the declared maximum capacity.

For this purposes, we have created a flight schedule consisting of one arrival and one departure peak hour. Although it is difficult to forecast when the demand will reach Brno-Turany airport's landside hourly capacity ceiling, we assume that this will not happen earlier than in 2015. Therefore, we considered Schengen/non-Schengen operation in this scenario assuming that departure lounge A serves for Schengen flights and departure lounge B serves for non-Schengen flights.

In this scenario, following traffic was simulated:

- 4 Schengen arrivals with total of 580 passengers,
- 3 non-Schengen arrivals with total of 563 passengers,
- 4 Schengen departures with total of 510 passengers,
- 3 non-Schengen departures with total of 523 passengers.

For the simulation of this scenario, we considered 14 check-in counters and 3 security checks to be in operation which represents all check-in and security check resources available at Brno-Turany airport.

5 Simulation results and conclusions

In order to achieve results reflecting actual operation, we ran each scenario three times, each time with different randomisation factor setting. Average values of the particular outputs of these three iterations were then calculated and consequently used for further analyses.

5.1 Baseline (validation) scenario

The main purpose of the baseline scenario was a validation of simulation model and verification if simulation results reflect a real operation at Brno-Turany airport. Therefore, the baseline scenario was based on actual day that was selected as the busiest day from the first three months of new departure terminal operation. As the terminal was put into operation in the second half of September 2006, which is already out of peak season, the traffic volume on that particular day conforms to annual average. This allowed for an easy and meaningful comparison of achieved results with actual traffic.

The model development process was continuously discussed with operational staff from Brno-Turany airport and we also took an advantage from our experience gained during our measurements and observations in the airport terminal. Whole process of baseline scenario model settings took almost three months. We have conducted several basic trial simulations in order to detect irregularities in passenger and baggage movements, inaccurate situations and bugs that were removed before performing the actual simulation. Valuable comments and suggestions were provided by airport operational experts from Department of Air Transport at University of Zilina.

5.2 Peak day traffic scenario

The objective of this scenario is to examine if current terminal configuration with 8 check-in counters and 2 security checks is capable of accommodating the traffic volume that is expected during peak days of summer season 2007. By means of this scenario, we also tested the impact of additional security check on a passenger flow and delay.

This scenario is based on flight schedule of the busiest day of 2006. We expected that the maximum daily level of traffic during peak seasons in a few following years would be similar to the one encountered during summer 2006.

Taking into account the flight schedule that was used in this scenario, there were 1,354 arriving and 1,780 departing passengers passing through the terminal on that day. Like in the baseline scenario, the daily distribution of traffic in this scenario had two significant departure peaks. The departing traffic in the afternoon peak hour reached as much as 60 % of declared departure terminal capacity. With respect to arriving traffic, there were several peaks during the day but none of them was significant in terms of declared capacity of arrival terminal. Utilisation of arrival terminal attained 30 %. The following chart depicts daily distribution of arriving and departing traffic during simulated busy day.

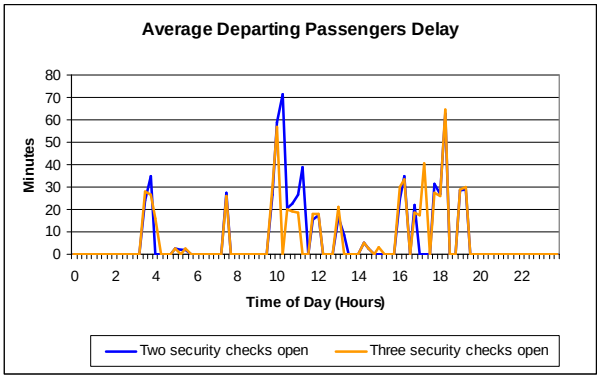

Fig. 3: Departing passenger delay

Regardless the number of opened security checks, departing passengers spent 127 minutes on average in the terminal. However, concerning the passenger delay caused by queues on paths, opening an additional security check reduced average delay of departing passengers by 2 minutes and delay reduction during morning peak hour is even more significant. Fig. 3 shows the difference between daily delay distributions of departing passengers when 2 security checks, respectively 3 security checks are open.

One of the objectives of the peak day traffic scenario was to examine whether the current terminal configuration with 8 check-in counters is sufficient for accommodating summer season traffic. Fig 4 clearly shows that during peak hours, there were 7 to 8 check-in counters open and utilisation of these reached 95 %. Although, taking into account the traffic volume simulated in this scenario there are still some small capacity margins in current check-in resources. However, as soon as Brno-Turany airport attains this level of traffic regularly, the airport management should consider installation of additional check-in counter(s) to avoid check-ins forming a bottleneck during departure peak.

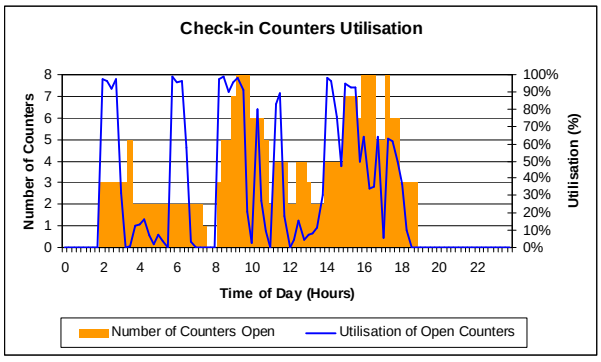

Fig. 4: Check-in counters utilisation

5.3 Schengen/non-Schengen operation

The main objective of this scenario was to assess the impact of Schengen/non-Schengen operation on passengers and baggage flow at Brno-Turany airport. In this scenario, we assumed 8 check-in counters and 3 security checks to be in operation.

In this scenario, we analysed two possible options (both described in Chapter 4.3) of Brno-Turany airport terminal configurations after accession of the Czech Republic to Schengen area. For this purposes we set two sub-scenarios:

Sub-scenario 1: Departure lounge A for Schengen flights and departure lounge B for non-Schengen flights;

Sub-scenario 2: Departure lounge A for non-Schengen flights and departure lounge B for Schengen flights.

We analysed both sub-scenarios from operational point of view and compared them with current international/domestic operation.

Our simulations showed that there are no differences either in passenger flow steadiness or terminal facilities utilisation between Sub-scenario 1 and Sub-scenario 2. However, from the operational and economical point of view, the departure lounge A should be assigned to the bigger of the two groups of passengers.

Departure lounge A is larger, has more departure gates compared to departure lounge B and last but not least, unlike in departure lounge B, there are retailers in departure lounge A. It is clear that more passengers need more space, more departure gates and that more passengers will bring more benefit to retailers. However, considering current traffic mix at Brno-Turany airport, it is not possible to define which one of the two groups is bigger (see the numbers of passengers on Schengen and non-Schengen flights in Chapter 3.3). Moreover, it is very hard to predict further development of traffic mix at Brno-Turany airport because of several reasons. For example:

- Accession of Bulgaria and Romania to the European Union can make these countries more attractive for Czech tourists, which would increase the number of non-Schengen flights.
- United Kingdom and Ireland are favourite destinations for Czechs due to open labour markets, which could make air carriers open new regular air connections with these non-Schengen countries.

- Many Czech people favour seaside resorts in non-Schengen countries in North Africa/Near East.
- On the other hand, accession of the Czech Republic to Schengen area will likely increase tourism between Czech Republic and other Schengen countries.
- In July 2007, new regular service to Moscow (i.e. non-Schengen destination) was opened, and more such routes may be opened in the near future.

As departure processes in international/domestic and Schengen/non-Schengen operation are absolutely identical and the only difference is the strict separation of the departure lounge for Schengen flights from the departure lounge for non-Schengen flights, introduction of Schengen rules into Brno-Turany airport operation will influence only flows of arriving passenger.

Taking into account Schengen/non-Schengen operation, only passengers from non-Schengen flights have to pass through inbound passport control. According to our simulations, this leads to delay reduction of arriving Schengen flights passengers and to the reduction of inbound passport control load. Fig. 5 depicts the delay reduction resulting from replacement current domestic/international operation by Schengen/non-Schengen operation.

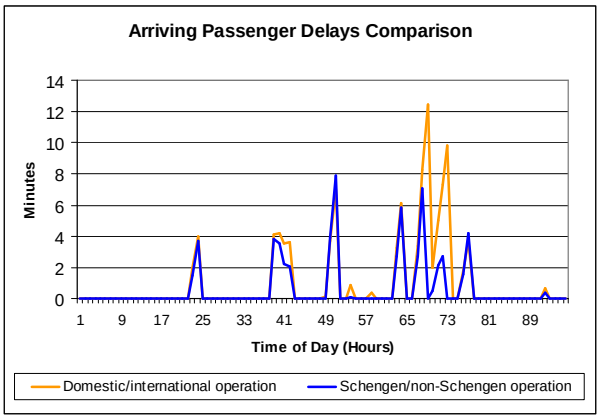

Fig. 5: Arriving passenger delay

As the Schengen/non-Schengen operation scenario was based on the same flight schedule as peak day traffic scenario, in Schengen/non-Schengen operation scenario, there were no significant differences in passenger throughput and daily utilisation of departure terminal facilities (e.g. travel agent counters, check-in counters, security checks and outbound passport control) compared to peak day traffic scenario. Therefore, any further analysis of these operational characteristics was not necessary.

5.4 Maximum landside capacity test

The simulation of this scenario was aimed at determining maximum capacity of the airport terminal at Brno-Turany. For this purposes, we compiled simplified flight schedule consisting of one arrival and one departure peak hour (arrival peak hour between 8:00 – 9:00; departure peak hour between 9:00 – 10:00). Number of arriving and departing passengers in this scenario slightly exceeded declared hourly capacity of the terminal.

In this scenario we considered Schengen/non-Schengen operation and assumed all available check-in and security check resources to be in operation (14 check-in counters and 3 security checkpoints). The level of traffic simulated in this scenario was as follows:

- 4 Schengen arrivals with total of 580 passengers,
- 3 non-Schengen arrivals with total of 563 passengers,
- 4 Schengen departures with total of 510 passengers,
- 3 non-Schengen departures with total of 523 passengers.

Our simulation unveiled that security checks are going to be a major bottleneck of the LKTB airport terminal. In order to provide security checkpoints with sufficient time horizon for handling the heavy traffic, we had to modify the service times of check-ins and travel agents. Therefore in this scenario, the travel agent counters opened 180 minutes and check-in counters 150 minutes before relevant departure flight. Figure 6 depicts the simulation screenshot that clearly shows overloading of security checks during departure peak hour.

We are aware that simulation of two isolated peak hours does not reflect actual operation but we underestimated the PaxSim's hardware requirements, which disallowed us to do a maximum declared hourly capacity test in a

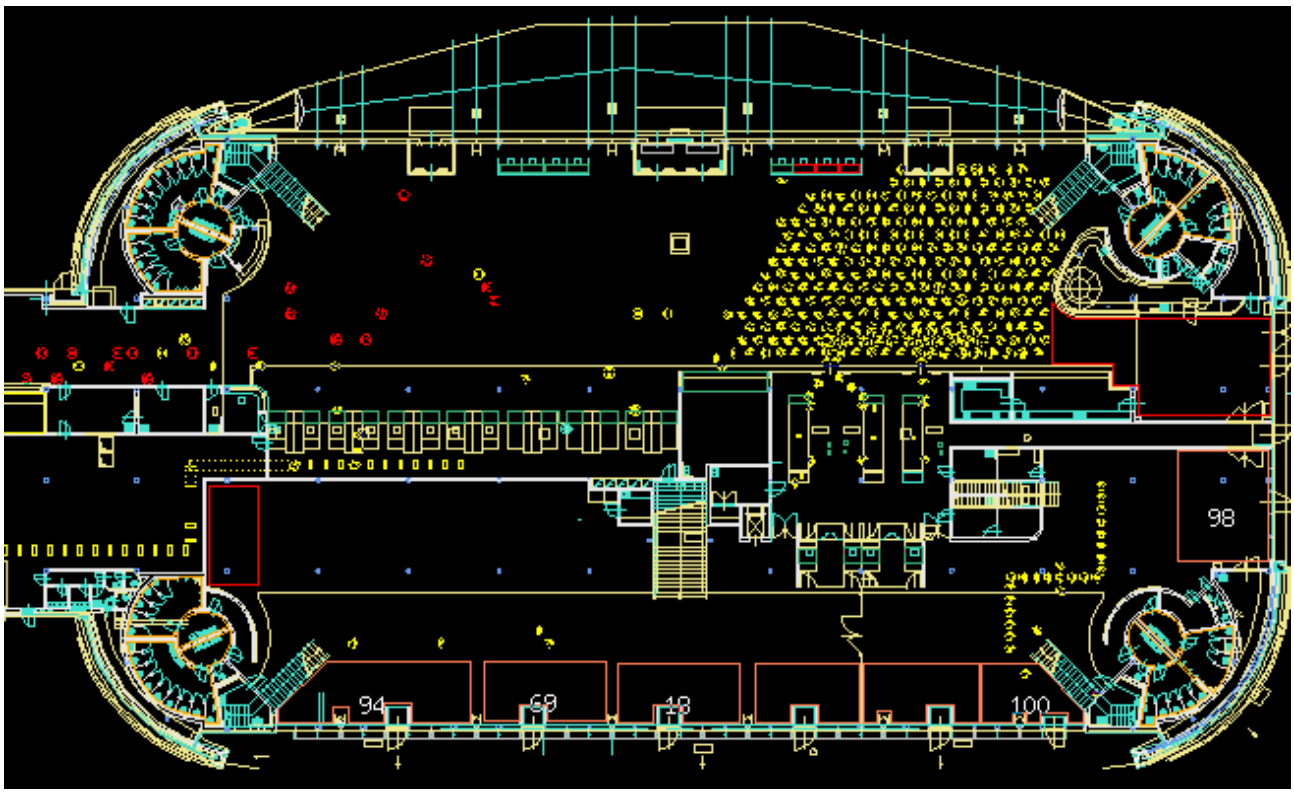

Fig. 6: Maximum capacity test scenario: Overloaded security checks

context of whole day operation (it would have been time consuming).

Apart from above mentioned fact, the results of our simulation showed that terminal at Brno-Turany airport is able to accommodate traffic volume corresponding to its declared hourly capacity. Moreover, the simulation of this scenario allowed us to detect one major bottleneck and several weak points of the airport terminal.

While detected weak points will presumably not have any significant impact on the airport operation, the lack of capacity of security checks will likely result in significant operational staff workload increase.

6 Future work

This study allowed us to understand the process of airport landside assessment using the fast-time simulation methods. Our current research is aimed at the problems of air and ground transport coordination with a view to design a concept of transport to/from the airport that would allow an efficient utilisation of existing terminal facilities. In our further research, the passenger flow simulations will allow us to assess the impact of various airport access concepts on the airport landside capacity. Unlike our trial study, our current research is focused on mapping the passenger flows within the airport catchment area as the process of transportation to/from the airport significantly influences the time spent by passengers in the airport terminal and consequently the terminal load. We assume that more efficient transport to/from the airport can increase the airport terminal throughput.

We would hereby like to thank Preston Aviation for providing us with PaxSim simulation tool for this pilot study.

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