AIRPORTS AND THEIR INFRASTRUCTURE

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COMPARATIVE ANALYSIS OF CHECK-IN TECHNOLOGIES AT THE AIRPORT

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Abstract. *The problem of check-in technologies at the airport is studied. The research is based on the experimental data obtained by method of observation check-in process at Boryspil airport (Kyiv, Ukraine).Distribution laws of waiting time and passenger service time at the check-in area are described. The method of dynamic opening and closing of check-in counter, which based on a model of the queueing theory, is proposed.*

Keywords: check-in technologies; CUTE system; queueing theory; self-service; simulation.

1. Introduction

In 2012 the Government of Ukraine has approved the long-term state strategy targeted at airport development for the period until 2023 [2].

Among the basic principles that will be incorporated into the program are the increase of the airport capacities and aircraft traffic. Moreover, the reconstruction and modernization of the airports will be continued with the view to raising the classification of the airports in accordance with the recommendations of the International Civil Aviation Organization and providing coordination for air flights in difficult weather conditions. In addition, the program will be aimed to reduce the time required to service passengers and aircraft.

Public enterprise "Boryspil International Airport" (KBP) was modernized in 2012. According to [13] the area of the terminal D is 107 thousand square meters, it can serve up to 15 million passengers per year. There are 61 check-in counters, 18 control points of aviation security, 28 passport control points in the departure area of the new terminal. Throughput of baggage handling systems is more than 3 thousand units per hour. The terminal is equipped with 11 fixed air bridges for 6 wide-body and 5 medium-sized aircraft. It is planning to add 2 air bridges to long-term outlook. The maintenance and parking of aircraft is carried out on a new ramp with the area of 183 thousand square meters, which can take up to 25 aircraft.

The ramp is equipped with Centralized Aircraft Refuelling System, which allows fuelling up aircraft directly in the parking with a speed of 2 tons per minute.

The cost of the terminal with attraction of foreign investments amounted to 4.8 billion UAH.

Despite the significant investments in modernization of Boryspil airport, the problems of the airport operation were discussed at the Cabinet of Ministers in early June, 2013 [9].

In passengers' opinion problems of service technology are the same: long waiting time for check-in and dispensing baggage, lack of food services area, and small capacity of car parking.

Many passengers spend much queuing time for check-in or passport control.

2. Analysis of recent research and publications

Description of methods and technologies of departing from airports passengers' service can be found in many scientific papers.

Already in 1976 the classification of methods of technological operations for departing passengers' service (single flight and common flights services) were submitted in paper [11].

The check-in and baggage handling comprehensive automation was also reviewed in [11].

The study of departing passengers' service problem was also discussed in paper [5].

A.I. Kosov made a detailed study of the departing passengers processes at six Soviet Union airports in the period of the most intensive passengers traffic from June to August 1982 aimed to determine the distribution laws for the time of passengers arrival before check-in opening and passengers service time [8].

Extensive statistical data [8] (about 7,500) showed that this distribution is mainly log-normal. Then these data were used in the statistical optimization models for single flight and common flights check-in.

Over the last few years, e-commerce, online check-in and self-service kiosks have changed the

travel. Today these technologies deliver flexibility to passengers while reducing airport congestion. A new disruptive trend in passenger interaction is the mobile and social media revolution in travel.

Carried out at major international airports in key regions of the world, the Passenger Self-Service Survey [15] represents passenger opinions about technology used throughout the journey. Self-service continues to rise in popularity. Passengers are welcoming new self-service options for baggage, boarding and transfer. Airlines are actively introducing technologies of self-service check-in.

For example, passengers who have checked-in on the SWISS flight on the website swiss.com can order the delivery boarding pass in the form of SMS or email messages on a mobile with Internet access [3].

Bar code in the format 2D contains all the necessary information about the flight.

The mobile boarding pass is valid for check-in and baggage drop-off. However, the requirement of a paper boarding pass for verification by the security officers at Domodedovo airport (Moscow, Russia) causes the necessity to use special machines, which scan information and print the document.

The study of modern check-in technologies submitted in papers [6, 12]. In those papers self-service technology is defined as an object which allows customers to interact with self-service software. Such kiosks can be found in a variety of locations, and they typically include a computer loaded with the software and housed inside a protective case, although a Self-Service Kiosk (SSK) can also consist of a computer placed at a table or desk in an accessible area for customers to use.

The research [12] focused on the feedback from both Egypt Air agents and the passengers utilizing self-service.

The survey results reviewed that the passengers are responding positively to self-service deployment and generally understand the process.

However, the acceptance of this relatively new technology within Egypt Air's own workforce depends to a large extent on the type of station at which the employee works.

The purpose of this paper is to discuss service innovation to check-in technique at Boryspil airport.

The research is based on the experimental data, obtained by method of observation, and analysis the key parameters that affect the self-service and traditional check-in process and the factors that influence them.

3. Check-in techniques in Boryspil International Airport

Today CUTE and CUSS check-in techniques are used in Ukrainian airports.

As mentioned in [12], (Common User Terminal Equipment (CUTE) is the facilities at the airports are shared between the airlines to reduce the space and resources required. CUTE was first implemented in 1984 for the Los Angeles Summer Olympic Games.

IATA first created the recommended practice (RP) 1797 defining CUTE.

From 1984 until the present, approximately 400 airports worldwide have installed some level of CUTE. CUTE systems allow an airport to make gates and ticket counters common use.

These systems are known as "agent-facing" systems, because they are used by the airline agents to manage the passenger check-in and boarding process.

Whenever an airline agent logs onto the CUTE system, the terminal is reconfigured and connected to the airline's host system. From an agent's point of view, the agent is now working within his or her airline's information technology network.

CUSS – Common Use SSK were first introduced by Continental Airlines in 1995 at US airports [12]. Since then the CUSS has become an integral part of providing services for passengers.

Most schedule airlines now provide the option for CUSS kiosk check-in at major airports.

The cost of check-in through kiosks is just $0.16 as against $3.68 with normal check-in with an agent.

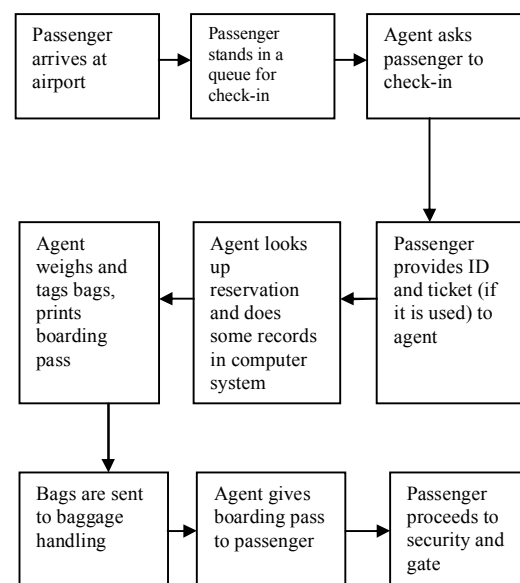At the Boryspil airport is used mainly single flight method of check-in (Fig.1).

Fig. 1. The Counter Check-in Process

One of the foreign airlines applies the common flights check-in method, however, only on a few (about 4) allocated for it counters.

It was found that check-in areas of terminal D has 61 check-in counters and 6 SSK, 18 aviation security points, 28 passport control desks. As it is declared in [4].

Terminal D can accommodate up to 10 million passengers annually or 3000 passengers per hour both for arrival and for departure.

For the purpose of identifying «queue» problems at the counters at the new terminal D of Boryspil airport, an analysis of the check-in process was performed by observation method with the subsequent processing of statistical data.

The check-in process was observed on the flights from Kyiv (IEV/ KBP) to Moscow (MOW), Warsaw (WAW), Almaty (ALA) and Tallinn (TLL). Check-in for flights to MOW, ALA and TLL started before 2 h of the flight departure and closed before 30 min of departure.

Check-in for WAW started 1 h 50 min before the scheduled departure time because of the flight from WAW had been delayed. Check-in for TLL and ALA has been opened on 3 check-in desks and for MOW and WAW – on 4 desks. The separate check-in was provided for passengers of business and economy class on all flights.

The used single flight check-in technology involves the opening of a number of desks depending on the aircraft load to a maximum of 50 passengers on one check-in counter, but not less than two.

4. Passenger arrival distribution pattern

Fig. 2 clearly shows the peakedness of the arrival pattern, because more than 60% of the passengers arrive more than 2.5 h before scheduled time of departure (STD) (excluding flight to TLL).
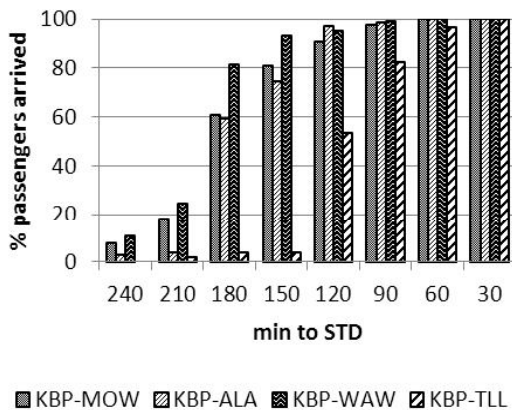

Fig. 2. Arrival pattern

The probability distribution of the passengers' arrival before STD (Fig. 3) depends on many factors, the main of which are: methods of service and the percentage of transfer passengers.
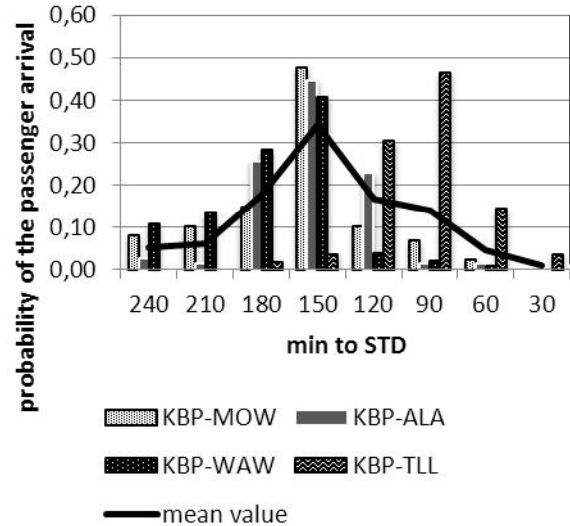

Fig. 3. Probability plot of passenger arrival time

Naturally at the check-in desks on flights to MOW, WAW, ALA before the opening of check-in were observed long queue, almost evenly distributed between the desks.

The queue length depended on aircraft load.

So, queue in front of the economy class check-in counter before 2 h of departure to MOW was about 35-40 passengers, to WAW and ALA – about 30 passengers.

For flight to TLL peak load started at approximately before 1 h 40 min of departure, the queue in front of one check-in counter was about 15 passengers.

CUSS technology for the MOW flight check-in has been used by 3 passengers (1.7% of the total), 13 passengers (7.4%) took advantage of web-check-in. 9 (8.74 %) passengers used check-in via CUSS kiosk to WAW, while 6 passengers (5.83%) embraced the opportunity to web-check-in.

The results of the check-in to ALA showed that self-checked-in up to 14 passengers, including 8 passengers (10.8%) that used CUSS kiosk.

5. Processing time

The processing time for each check-in process is shown in Table1.

The average processing time per passenger at the check-in counter was 3.51 min with a standard deviation of 4.77 min for MOW flight against the assumption that it takes less than 1.1 min (according to calculations, which are set out below).

Table 1. Check-in time (in minutes per passenger) in terminal D

Check-in techn.	Ave-rage time	Min time	Max time	Standard devia-tion	No of pax
IEV - MOW					
CUTE	3.51	0.40	19.00	4.77	160
CUSS	1.15	0.92	1.55	0.34	3
IEV - ALA					
CUTE	1.92	0.60	4.50	1.30	60
CUSS	0.95	0.70	1.30	0.19	8
IEV - WAW					
CUTE	1.58	0.50	4.00	1.03	88
CUSS	0.93	0.70	1.10	0.13	9
IEV-TLL					
CUTE	3.24	0.60	13.00	3.26	56
CUSS	-	-	-	-	0

The following characteristics to MOW flight were observed:

– practically all passengers had a lot of baggage, which required additional time for handling;

– check-in of passengers for which the MOW was the transfer point required additional time to explain them the details of further travel;

– processing time could increase up to 19 min per passenger if check-in agents had to consider a problem of any immigration documents and visa.

For other observable flights the time of one passenger check-in also considerably increased when passenger had a lot of baggage or excess baggage or when agents demanded of additional documents regarding immigration procedures.

It was also established that the procedure of an Unaccompanied Minor (UM) check-in for the IEV-TLL flight took about 40 min.

In addition, for this flight the passengers could not use the registration by CUSS kiosk, because airline did not provide this service.

For all observed flights it is true that the processing time for the passenger who had some experience of using CUSS kiosk was significantly less than other.

Most of the passengers needed assistance in completing the process. The location of the CUSS kiosk must be very easily visible before the passenger could see the check-in counters.

Minimum processing time (24 s) was achieved when passengers without baggage were being checked-in. And it could be seen that the minimum processing time at check-in counters is smaller than at kiosks. This is a result of the efficiency of the check-in agent.

6. Queuing Time

The other important aspect that was observed in the process is the waiting times for each passenger.

Fig. 4 allows making of assumption that the number of arrived passengers for check-in is determined by Poisson distribution.
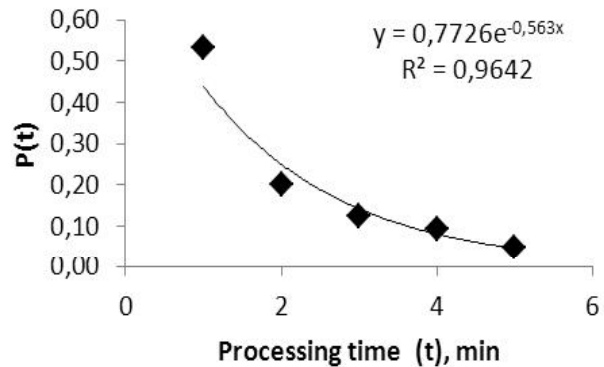
Fig. 4. Probability distribution of processing time on check-in counters

Obtained by observation data also confirms the hypothesis that the service time has exponential distribution (Fig. 4).

This means that for estimation of the average time of waiting in a queue and staying in the check-in area of passenger arrived before 2 h of STD is possible to use the M/M/s with finite source of jobs model of the queuing theory [10].

Presented in Table 2 results of calculations corroborate the obtained in monitoring of the flights check-in process factual data.

Table 2. Check-in queue characteristics (M/M/S with finite source of jobs)

Characteristic	Estimate
Input data	
Total number of passenger	90
Arrival intensity, passengers per minute	1,5
Service parameter, passengers per minute	0,4
The number of check-in counter	3
Output data	
Check-in counter use factor, %	100
Probability that the counter is empty P(0)	0,0000
Expected queue length L_q, passengers	86,2000
Expected number of passenger in system L	89,2000
Expected time in queue W_q, min	71,8333
Expected total time in system W, min	74,3333
Probability that passenger waits	1,0

So, if it is necessary to check-in 90 passengers using three counters, the waiting time in a queue may take up to 1 h 11 min.

Because of more than 90 % of passengers arrive before the check-in opening, it is clear that the probability of waiting in the queue equal to 1.

Note that maximum number of passengers waiting for the services was 0 for CUSS kiosks against 45 in the case of check-in counters.

But check-in observation revealed cases when the self-checked-in passengers had to stand in the general queue to check-in their baggage.

Probably there is a problem with informing passengers that Baggage Drop-Off desks are available.

Thus, the passenger with baggage needs to spend a lot of waiting time in the queues using both check-in counter and self-check-in kiosks techniques.

To maintain passenger comfort it will be necessary to reduce waiting time, implying the more resources during peak arrival.

7. Dynamic opening and closing of check-in counters

The availability of 61 check-in counters in terminal D can actually provide service of 3,000 passengers per hour (or 50 passengers per minute) if the time of one passenger check-in does not exceed 1.1 min.

This statement can be proved by the recommendations of the IATA [1] for the calculation of the terminal are a optimal characteristics.

If the maximum passenger traffic is known the optimal number of check-in counters N can be found by the formula according to [1]:

$$N = \lambda_{pas} t + 10 \ \%, \tag{1}$$

where λ_{pas} – the intensity of the arrival passenger, passengers per minute;

t – the average time of service, min.

However, the formula (1) seems to be more applicable in situations of only common check-in.

It means that a passenger will be able to check-in from any counter to any destination.

The queueing theory has a number of models for calculation of optimal number of check-in counters depending on the traffic flow. For example, in [4] formula is used

$$N = t \times \left(\lambda_{pax} + \frac{1}{t_w} \times \ln \frac{W}{P\left(t_f > t_w\right)} \right), \tag{2}$$

where t_w – the maximum waiting time in the queue estimated for passenger service, min;

W – the probability that all counters are busy;

$P \ (t_f > t_w)$ – the probability that the actual passenger waiting time in a queue may exceed the estimated waiting time.

It is also easy to determine the optimal characteristics of check-in system, including the required number of check-in counters and SSK, by applying the M/M/s basic model of the queueing theory [10].

Just note that the effectiveness of CUSS kiosk at the airport Boryspil could be significantly increased if passengers would be better informed about self-check-in technology and baggage handling at the Baggage Drop-Off desks with obligatory indication of their location in check-in area (this information must be on the airport website).

Formula (2) and the queueing theory models can be used in simulation either a single flight or a common check-in flights group.

If there is no possibility to implement the common check-in flights method, for optimization of the single flight check-in process at the Boryspil airport it is proposed to use a dynamic approach to identifying a number of check-in counters.

The point of such approach consists in determining the optimal check-in counters number for given time before SDT, depending on the number of arrived passengers for check-in.

So, having a flight check-in arrival statistical database it is possible to make an arrival pattern and then use it for simulate the check-in process.

The main thing of this approach is to fix the size of the queue at the counter according to the technology requirements and take into account the actual time of service.

If the number of passengers in the queue becomes longer than it is fixed than an additional counters must be opened.

The optimal number of counters can be calculated by using the appropriate model of the queueing theory.

If arrival passenger flow will decrease than number of counters which must be closed is calculated.

Dynamic approach has already been described in foreign papers [5, 7].

Let's consider the example of calculation of the check-in counters optimal number if the common check-in flights method is applied.

Suppose that the expected arrival intensity is 1000 passengers per hour (ten flights are checked-in practically at the same time) (Table 3).

Table 3. Modelling of common check-in queue characteristics (M/M/S)

Characteristic	Estimate
Input data	
Arrival intensity, passengers per minute	16,66
Service parameter, passengers per minute	0,4
The number of check-in counter	42
Total number of passenger per hour	1000
Output data	
Check-in counter use factor, %	99,21
Probability that the counter is empty $P(0)$	0
Expected queue length Lq, passengers	117,4060
Expected number of passenger in system L	159,0727
Expected time in queue Wq, min	7,0444
Expected total time in system W, min	9,5444
Probability that passenger waits	0,9392

Applying the M/M/s model we can determine that 42 check-in counters service in rush hour and the average service time equal 2.5 min per passenger could dramatically reduce the passenger waiting time. Arriving at the airport 2 h before departure, the passenger will spend no more 10 min in check-in area. It means that passengers will have enough time before the flight departure, and he or she becomes a potential customer for additional services (cafes, shopping, etc.). And that, in turn, is important for the development of airport' non-aviation activities (according to the Boryspil airport financial report [14], the revenues from non-aviation activities were only 18 % of the total income in 2011).

Next, using the same M/M/s model, we can calculate the suitable characteristics of the check-in area by simulating the process on the basis of statistical data or taking into account the factual data of passengers' arrival (it requires a sensor for counting the number of arrived passengers to the check-in counters) and factual time of service.

So, 13 check-in counters can provide quick service (less than 10 min) for 300 passengers per hour (if the average service time is 2.5 min per passenger).

As noted above, the M/M/s model can be used for simulating single flight check-in process.

Fig. 5 presents the results of simulation to determine the optimal number of check-in counters on the flight IEV-MOW for a given time before departure with step of 30 min.
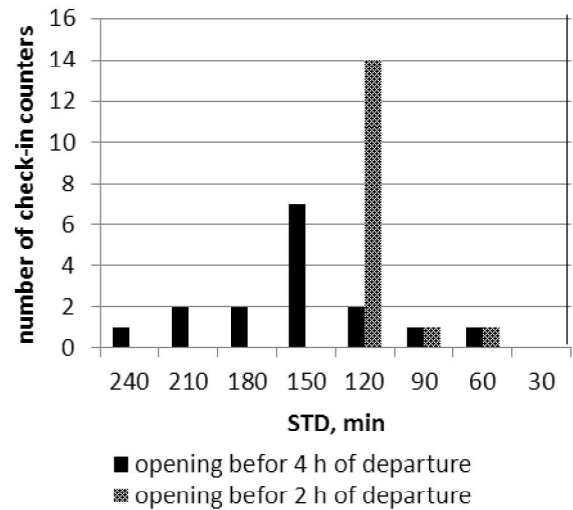

Fig. 5. Simulation of dynamic opening and closing of check-in counters for IEV-MOW flight

Assumptions were made in calculations about the possibility of opening check-in counters 4 h before the departure.

Dynamic approach in this example gives 7 min of expected waiting time of passenger at check-in area.

8. Conclusions

1. Development of self-check-in technology at Boryspil airport requires more informative and initial assistance to passengers for self-printing of boarding passes.

2. Clear instructions concerning the location and baggage handling technology on the Baggage Drop-Off desk allow improving the quality and usability of the CUSS kiosk.

3. The factual time of service at the check-in counters may differ significantly from the estimated one, depending on the pieces of baggage, the presence of transfer points and the need to verify the immigration papers.

4. Introduction a dynamic approach to the opening and closing of check-in counters allows reducing the maximum passengers' waiting time at the check-in area from 1 h 11 min to 10 min.

5. Reducing the waiting time for the airport formalities hypothetically may affect growth of revenues from non-aviation activities at Boryspil airport.

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К.В. Марінцева. Порівняльний аналіз технологій реєстрації в аеропорту
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Вивчено проблеми технологій реєстрації в аеропорту. Наведено результаті дослідження, які базуються на експериментальних даних, отриманих методом спостереження реєстрації в аеропорту Бориспіль (Київ, Україна). Розглянуто закони розподілу часу очікування та обслуговування пасажирів у зоні реєстрації. Запропоновано метод динамічного відкриття і закриття реєстрації, в якому використовується модель теорії масового обслуговування.
Ключові слова: імітаційне моделювання; самообслуговування; теорія масового обслуговування; технології реєстрації; CUTE системи.

К.В. Маринцева. Сравнительный анализ технологий регистрации в аэропорту
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Изучены проблемы технологий регистрации в аэропорту. Приведены результаты исследования, основанные на экспериментальных данных, полученных методом наблюдения регистрации в аэропорту Борисполь (Киев, Украина). Рассмотрены законы распределения времени ожидания и обслуживания пассажиров в зоне регистрации. Предложен метод динамического открытия и закрытия стоек регистрации, в котором используется модель теории массового обслуживания.
Ключевые слова: имитационное моделирование; самообслуживание; теория массового обслуживания; технологии регистрации; CUTE системы.

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