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TRAFFIC VOLUMES AND MANOEUVRING AREA CAPACITIES AT EUROPEAN CAPITAL CITY AIRPORTS

ABSTRACT

Capital city airports in the European countries realise traffic volume of several thousands to several hundred thousand aircraft operations i. e. landings and takeoffs annually. In its Airport Planning Manual, the International Civil Aviation Organization recommends that the capital city airports have at least two runways in order to avoid complete closing down of the airport in cases of aircraft accidents on the runway or the runway strip, due to repair or maintenance of the runway, removal of snow, unlawful interference in civil aviation etc. The paper analyses the current situation in traffic and the capacities of the manoeuvring areas at the European capital city airports.

KEY WORDS

airport, capital city airport, maneouvring area capacity

1. INTRODUCTION

Airports with a single runway are extremely sensitive to possible disturbances that may result from the meteorological conditions, emergency situations during traffic operations, necessary maintenance of the runway, unlawful interference, etc.

Thus, e. g. in case of snow, the winter services start removing snow from the runway. During this procedure, the runway cannot be used for landings and takeoffs. After having removed the snow from the runway, the team continues to remove it from other surfaces so that the runway can be used for landings and takeoffs again. This procedure is repeated during the whole period of snow precipitations. The runway capacity during this time is substantially reduced. When there are two runways, and in case of snow, the snow can be removed on one runway while the other can continue to operate so that one runway is always open to traffic.

After years of exploitation the runway requires major maintenance. In case of a single runway maintenance is usually carried out during night. When large-scale reconstruction is necessary, the runway needs to be closed down for several weeks, even months. If the airport has only one runway, this means that the whole airport is closed down for traffic during the reconstruction.

Unlawful interference in civil aviation, several possible situations in which the aircraft is located on the runway, may be the reason for closing down the airport.

Emergency situations on the runway (situations related to incidents or accidents of aircraft at landing or takeoff leaving the disabled aircraft on the runway or on the runway strip) can close down the runway until the aircraft is removed from the runway strip. Lighter aircraft may be removed by means of a simple mobile crane within a very short period of time. Today, aircraft weigh as much as up to several hundred tonnes and the removal may take more than one day, requiring also very expensive and sophisticated equipment.

In all the abovementioned cases, when there is only one runway, the airport is closed down for traffic. The traffic has to be rerouted to another, alternative airport, thus causing dissatisfaction on the part of car-

riers, passengers and other traffic users. In order to avoid such situations, especially in case of airports that serve the capital cities of the states, a second runway is recommended

It should be emphasised that there are very few European capital city airports that serve at the same time as the airbases. The strategic defence aspects say that in such cases, from the viewpoint of the toughness of the air base in case of wartime operations, it is necessary to have several runways and taxiways of runway length, which are not to intersect. The double role of the manoeuvring area, civil and military, further increases the need for multiple capacity of the airside of the airport, since the military strategic and safety component is added to all the previously stated reasons for having two runways.

2. CAPACITIES OF MANOEUVRING AREA

A single runway with adequate system of taxiways, navigation instruments and a well coordinated team of air traffic controllers features capacity according to the International Civil Aviation Organization – ICAO of 195 to 240 thousand operations annually [1]. Two runways, depending on the fact whether they are parallel or not, on the space between them, whether they intersect or whether the extended runway centerlines intersect, which is the strategy of approach and takeoff phase, have the capacity of 200-370 thousand operations annually. The capacity of two parallel runways depends on the distance of their centerlines and amounts to 260 to 370 thousand operations annually. The runways that intersect at a certain angle or their extended runway centerlines intersect have the capacity depending on the runway usage of 200 to 270 thousand operations annually.

An example of an airport with a single runway and a large number of operations is Gatwick in London. In 2002 it registered 242,380 operations, which is even more than the given maximum capacity of a single runway and regarding the number of aircraft operations it was 13th in Europe. According to the Airport Characteristics Data Bank [2] Gatwick Airport has 2 runways. However, this is only theoretically so, since at one time only one runway can be used, whereas the other one is a parallel taxiway featuring all the physical characteristics and the necessary equipment of a runway. This taxiway is used as a runway in case the main one is closed down, which happens only at night due to the maintenance of the main runway. Because of the impossibility to use both runways at one time, this airport is considered to have only one single runway.

The capacity of 195,000 to 240,000 operations annually of one runway can be achieved only if there is adequate traffic demand, and if there are no restrictions in using the runway, with a sufficient number, location and type of taxiways and with adequate navigation equipment, well-coordinated team of air traffic controllers, etc.

3. AIRCRAFT TRAFFIC AND THE CAPACITIES OF MANOEUVRING AREA AT AIRPORTS IN THE EUROPEAN CAPITALS

3.1. Airports with two or more runways

Table 1 shows the data about the traffic volume at the European capital city airports or possibly the major airports in the countries where the capitals are minor towns without an airport or with traffic levels which are negligible (the Netherlands, Switzerland, etc.) and the number and configuration of runways (number of parallel runways, total number of runways) for airports with two and more runways. The order is given respecting the aircraft traffic, i. e. the number of operations.

The examples of relations between aircraft traffic and the runway capacities in the capital cities in Europe show that the airports with large number of operations have several runways and a somewhat higher capacity than the traffic volume, and airports with smaller and much smaller traffic volume than a single runway capacity have two or more runways. At some airports the second and further runway are wind runways which are constructed in order to achieve high level of openness regarding wind i. e. the prevailing and intensive winds from several directions that are present at certain locations. According to ICAO the usability factor regarding winds should be greater than 95% [4]. In case one runway is closed down the secondary runway can take over the major part of aircraft traffic at the respective airport, unless the reason for closing down of one of the two runways is at the intersection of two runways or in the close vicinity. Certain, significant number of European capital city airports with smaller number of aircraft operations than the maximum for one runway, have parallel or non-parallel runways for safety reasons, so that in case one runway is closed down the airport may continue to operate.

The data in Table 1 show that nine European capital city airports (two out of these represent the biggest ones in the state: Amsterdam and Zurich) feature more than 240 thousand operations annually. One airport, Paris – Charles de Gaulle, has more than 500 thousand operations with 4 runways (parallel) and two airports with 400-500 thousand operations, London – Heathrow with 3 runways out of which 2 are parallel

Table 1 – Realised aircraft operations in 2002 at the European capital city airports with two or more runways [3]

Ord. No.	Country	City	Operations total	Commercial operations	Passengers	Cargo in t	Parallel/total RWY
1.	France	Paris CDG	510,098	501,547	38,350,172	1,399,000	4/4
2.	G. Britain	London LHR	466,554	460,303	63,338,641	1,234,973	2/3
		Gatwick LGW	242,380	234,700	29,628,423	242,633	0/1
3.	Netherlands	Amsterdam	417,120	401,385	40,736,009	1,239,900	2/5
4.	Spain	Madrid	368,029	367,184	33,913,456	297,511	2/3
5.	Italy	Rome	282,787	282,787	25,340,383	130,755	2/3
6.	Switzerland	Zurich	282,154	247,720	17,902,073	309,724	0/3
7.	Denmark	Copenhagen	266,894	263,247	18,197,606	373,694	2/3
8.	Belgium	Brussels	256,867	237,461	14,413,795	509,673	2/3
9.	Sweden	Stockholm	245,694	236,196	16,537,332	123,200	2/3
10.	Austria	Vienna	206,279	184,919	11,973,805	113,612	0/2
11.	Ireland	Dublin	181,873	163,884	15,084,667	108,385	2/2
12.	Norway	Oslo	180,872	172,925	13,441,885	50,069	2/2
13.	Greece	Athens	159,464	143,982	11,827,493	106,813	2/2
14.	Finland	Helsinki	157,690	150,638	9,605,589	72,403	2/3
15.	Germany	Berlin	127,470	121,370	9,879,888	14,790	2/2
16.	Russia	Moscow SVO	124,630	124,630	10,895,225	171,155	2/2
17.	Portugal	Lisboa	115,746	110,437	9,369,090	81,028	0/2
18.	Poland	Warsaw	108,885	92,403	4,936,835	32,194	0/2
19.	Czech Rep.	Prague	103,904	101,347	6,306,222	34,829	0/3
20.	Hungary	Budapest	77,941	71,523	4,468,821	42,386	2/2
21.	Turkey	Ankara	37,421	30,860	2,865,505	14,075	2/2
22.	Ukraine	Kiev	35,859	35,859	1,806,604	11,750	2/2
23.	Romania	Bucuresti	34,108	33,401	2,118,712	11,864	2/2
24.	Malta	Malta	31,028	29,285	2,667,776	13,351	0/2
25.	Island	Reykjavik	17,680	-	1.219.705	43.749	0/3
26.	Slovakia	Bratislava	17,472	10,097	366,907	4,628	0/2
27.	Georgia	Tbilisi	5,808	5,808	270,505	4,101	2/2
28.	Azerbaijan	Baku	–	–	–	–	2/2
29.	Cyprus	Larnaca	–	–	–	–	0/2

and Amsterdam with 5 runways out of which 2 are parallel. The Madrid Airport has 300 - 400 thousand operations and 3 runways out of which 2 are parallel. The remaining five airports have traffic volume of 240-300 thousand operations. All five of them have three runways, but only four of them have two parallel runways: Rome, Copenhagen, Brussels, Stockholm. Zurich has three non-parallel runways.

An airport with the traffic volume of 195-240 thousand operations annually is also the Vienna Airport with two non-parallel runways.

Nine airports have traffic volume of 100-195 thousand operations annually. All of them have at least two runways, and two of these have three runways.

Budapest Airport realises annually a traffic volume of 50 to 100 thousand operations and it has had two parallel runways for decades already.

Four capital city airports realise traffic volume of 30 to 50 thousand operations annually, and three of these have two parallel runways (Ankara, Kiev and Bucharest), and Malta has two non-parallel runways.

The data for the capital city airports in Azerbaijan and Cyprus have not been obtained, but they probably belong to the group of airports with several thousand operations annually.

A total of 20 out of 29 European capital city airports that have two or more runways, realise the annual number of operations below 220 thousand. Out of this number 12 airports have two parallel runways. At two out of 21 airports with two or more runways the traffic is probably lower than 10 thousand operations annually, and at one airport it is lower than 10 thousand operations. At nine of these airports there are fewer than 40 thousand operations annually. This means that they realised a traffic volume of up to 17% of the maximum capacity of one runway, and these airports have two or more runways.

3.2. Airports with one runway

Table 2 shows the airports of the capital cities of the European countries with one runway according to the realised aircraft traffic volume in 2002.

It is obvious from Table 2 that 14 European capital city airports have only one runway or that about 32,5% of the total number of capital cities have airports for conventional aviation (runway lengths greater than 1,800 m). These are the airports with the realised traffic volume of up to approx. 30 thousand operations annually, except Luxemburg. All except four of them (Luxemburg, Belgrade, Sofia and Tirana) became European capital city airports after the disintegration of the USSR and Yugoslavia. Excluding Luxemburg, which in 2002 realised 83,597 aircraft operations annually i. e. 48,413 commercial operations (this means that almost half of the operations were small-size aircraft unlike the big and middle-size airports where the average number of small aircraft is lower than 10%), it may be concluded that only the transition countries, those less developed (the more developed are the Czech Republic, Hungary and Poland which joined the European Union and NATO in the first cycle in May 2004 and have capital city airports with two or more runways) have capital city airports with one runway. Here, Slovenia represents an exception, since Slovenia, the most developed country in transition is joining the EU and NATO, and the Ljubljana Airport does not have two runways.

Part of the airports with one runway are in the process of constructing the second runway, such as Sophia, announced the construction as Belgrade or have a long-term development plan which foresees the construction of the second runway (Tirana, Ljubljana) like a certain number of the remaining airports.

3.3. Other capitals

There are 48 countries in Europe. Twenty nine capital city airports have two or more runways. Out of the remaining 19 countries, 14 capital city airports have one runway each, and the remaining 5 are small states (Andorra, San Marino, Monaco, Lichtenstein and Vatican) without airports or not having airports with runways longer than 1800 m which could accommodate bigger aircraft. They are served by the airports in the neighbouring countries.

If small European states are not considered, then 67,5% of countries, that is, European capital city airports have at least two runways (taking into account

Table 2 – Realised aircraft operations in 2002 at the European capital city airports with one runway

Ord. No.	Country	City	Operations total	Commercial operations
1.	Luxemburg	Luxemburg	83,597	48,413
2.	Serbia and Montenegro	Belgrade	30,866	24,264
3.	Slovenia	Ljubljana	28,571	18,135
4.	Croatia	Zagreb	28,082	23,100
5.	Estonia	Tallinn	26,226	19,779
6.	Bulgaria	Sofia	24,212	21,112
7.	Latvia	Riga	18,676	16,095
8.	Lithuania	Vilnius	17,124	14,884
9.	Macedonia	Skopje	13,725	8,002
10.	Armenia	Yerevan	11,620	11,454
11.	Moldova	Chisinau	10,416	10,184
12.	Belarus	Minsk	4,106	4,011
13.	Bosnia and Herzegovina	Sarajevo	3,618	3,432
14.	Albania	Tirana	-	-

only the runways with code symbol 4E, 1800m and more in length), and 32,5% have only one runway.

4. CONCLUSION

The analysis of the traffic volume and the number of runways at European capital city airports shows that only the big airports, that is, large regarding traffic volume, the first ten, have the capacities of manoeuvring areas that slightly exceed the traffic requirements. All airports are located in the countries of the once so-called Western Europe.

At middle-size airports, ten in all, at which the number of operations varies from 75-200 thousand, a single runway should be satisfactory regarding capacity, but they all have two runways except for one, which has three. All airports in this group with over 120,000 operations have parallel runways. Apart from the traditional countries of western orientation the second part of this group includes also four representatives of the transition countries: Moscow, Warsaw, Prague and Budapest.

Minor airports with traffic volume of 30-40,000 operations annually, four of them, have two runways each, out of which three airports with parallel runways and one airport with two non-parallel runways. They realised traffic volume of 14-18% of the highest capacity of one runway, and all four have two runways out of which three parallel, with a capacity that should exceed 300 thousand aircraft operations annually.

Small-size airports accommodating traffic volume of up to 30,000 operations annually have one to three runways. This group consists of 18 airports among which, out of five, four have two runways (Bratislava, Tbilisi, Baku, Cyprus), and one airport has three runways (Reykjavik). Regarding aircraft traffic volume, the majority of small airports has only one runway. These are the capital city airports of the countries that originated after the disintegration of Yugoslavia (none of the five airports has two runways) and the USSR (Estonia, Lithuania, Latvia, Moldova, Belarus, Armenia) and Bulgaria and Albania.

To summarise, the majority of the European capital city airports have two or more runways regardless of the level of aircraft traffic. The least developed are the capital city airports located in the transition countries becoming independent with disintegration of USSR and Yugoslavia, from the Baltic countries across Belarus, Moldova to the Balkan Peninsula. On the Balkan Peninsula there are seven countries with capital city airports, which have only one runway. Thus, almost half of the capital city airports with one runway are in the Balkans. The only exceptions are Luxembourg, representing an extremely well developed Western country, but probably because the airport accommodates lower volumes of commercial traffic and because of the relative vicinity of the airports in the neighbouring countries, it does not have two runways, and Slovenia, i. e. Ljubljana, which, although the best developed transition country, because of the fact that it had not been the capital before the disintegration of Yugoslavia, the airport does not have two runways.

The plans for the development of airports with a single runway in the near future indicate solutions with two mainly parallel runways (Sofia, Belgrade). Even Albania, Tirana, with one of the lowest realised aircraft traffic volume among the capital cities is planning to construct a second, parallel runway.

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SAŽETAK

PROMET I KAPACITETI MANEVARSKIH POVRŠINA ZRAČNIH LUKA GLAVNIH GRADOVA EUROPSKIH DRŽAVA

Zračne luke glavnih gradova europskih država ostvaruju promet od nekoliko tisuća operacija zrakoplova odnosno slijetanja i uzlijetanja do nekoliko stotina tisuća operacija godišnje. Međunarodna organizacija za civilno zrakoplovstvo preporučuje u Priručniku za planiranje aerodroma da zračne luke glavnih gradova imaju najmanje dvije uzletno-sletne staze da se izbjegne potpuno zatvaranje zračne luke u slučajevima: nesreće zrakoplova na uzletno-sletnoj stazi ili njezinoj osnovnoj stazi, popravljanju odnosno održavanju uzletno-sletne staze, uklanjanju snijega, nezakonitog ometanja zračnog prometa itd. U radu je analizirano postojeće stanje prometa i kapaciteta manevarske površine zračnih luka glavnih gradova europskih država.

KLJUČNE RIJEČI

zračna luka, zračna luka glavnog grada, kapacitet manevarske površine

LITERATURE

[1] Airport Planning Manual, Part 1, Master planning, Second Edition, Doc 9184-AN/902 Part 1, International Civil Aviation Organization, Montreal, Canada, 1987.

[2] Airport Characteristics Data Bank, International Civil Aviation Organization, Montreal, Canada, 2002

[3] Data on airports have been obtained from the following web pages:
http://www.aci-europe.org/index.html
http://www.worldaerodata.com

[4] Aerodromes, Annex 14 to the Convention on International Civil Aviation, International Civil Aviation Organization, Montreal, Canada, 1999.