AIRPORT RUNWAY CAPACITY

Miroslav Kiseľa – Ľubomír Fábry

This article describes the current state of airport capacity in Europe and the USA, the value of delays at these airports. It also contains a description of each runwayconfigurations and their hourly capacity and the possibility of increasing capacity by building tracks without additional airport infrastructure.

Keywords: capacity, delay, runway configuration, demand

1 INTRODUCTION

Airports play an important role in commercial aviation system, a place where they encounter the airlines and customers. Since 1970, growth in air traffic caused problems and concerns at airports around the world. Although airports are a very highly developed, many of them still face the problem of congestion and delays. Facilities at airports are not adequate to accommodate the demand generated at any time, in all weather conditions and visibility. The resulting delay leads to inefficiency and increased cost airlines, inconvenience and additional costs for passengers and the increased workload of staff and the entire aviation system. Lack of airport capacity has been predicted as one of the most serious limitation of the growth of commercial and private aviation. Table 1 shows the percentages of arriving on time arrivals at each airport in 2008 in USA.

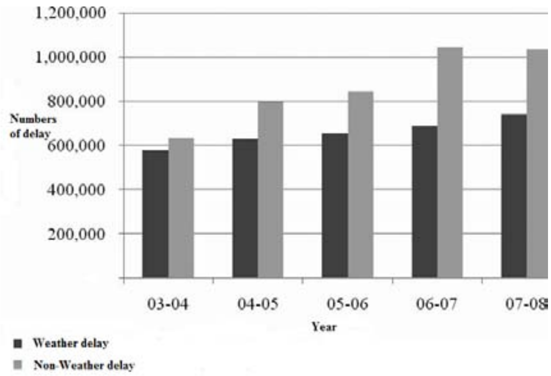
Tab. 1 Percentage of flights arriving on time on airports in 2008 in USA

Airport	On time arrivals
Hartsfield-Jackson Atlanta International	75,52%
Boston's Logan International Airport	73,36%
Baltimore Washington International Airport	80,31%
Denver International Airport	78,34%
Dallas Fort Worth International Airport	76,16%
McCarran International Airport	77,76%
Los Angeles International Airport	76,89%
LaGuardia Airport	62,80%
Orlando International Airport	77,81%

Source: Airline Operations and Scheduling, USA, 2010

According to the U.S. Department of Transportation in 2007 was more than 166 000 commercial flights with delay, which represents 100 million minutes of delay, in the aggregate cost amounts to $ 40 million, which were loaded with passengers and airlines.

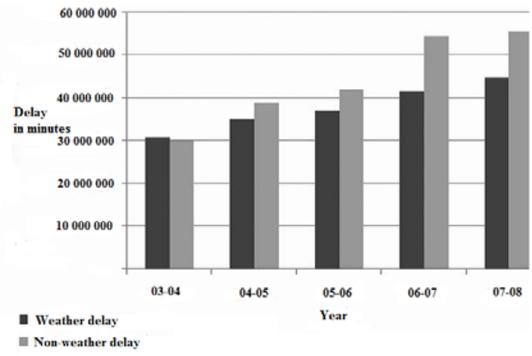
The delay arising from the operation of the airport is more than 54% of the total cost of delay. Figure 1 and 2 shows the number of missed flights and total minutes of delay for both conditions delay (delay due to weather and delays associated with the operation of the airport). These pictures show the trend in both delay conditions. The delay caused by the operation of the airport has a major presence in comparison to the delays caused by weather. As the pictures show, the delay caused by the operation of the airport is growing at an alarming rate and faster than the delays caused by weather. The average price per minute delays for commercial company represents $ 342 (see Tab. 2). [1]



Obr. 1 The number of delays for various conditions from 2003-2008
Source: Airline Operations and Scheduling, USA, 2010.

The main reason for the lack of capacity and delay are capital intensive development projects. For example, to build one runway at Lambert International Airport in Saint Louis was worth $ 1.1 billion, took the 6070 to 284.63 m^2.

It was necessary reconfiguration of seven major roads and residential area resettlement. Therefore, to keep pace with rising demand is a challenge for airports and authorities. [1]



Obr. 2 The delay in minutes for various conditions from 2003-2008

Tab. 2 Price per minute delays for commercial airlines in 2007

Cost item	Cost/minute
Operating costs of airlines	$160.7
The value of passenger time	$101
Charges	$80.7
Sum	$342.4

Zdroj: Airline Operations and Scheduling, USA, 2010.

These data emphasize the importance of a thorough analysis of various options and their use in the planning stage. Analysis of demand and capacity are vital components of airport planning process and to define the ability of airport facilities. Airport facilities are Runways, Taxiways, gate, terminal buildings, parking. [1]

1.1 CAPACITY OF EUROPEAN AIRPORTS

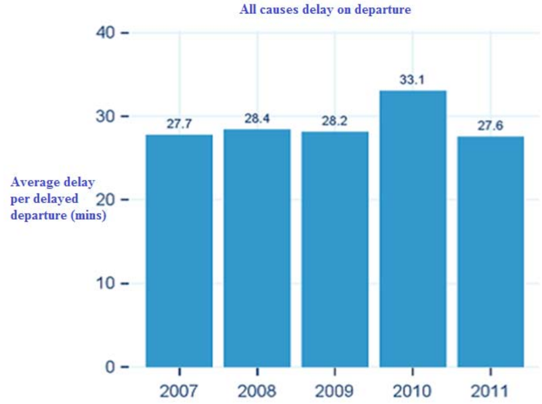
In Europe there is great concern in the aviation industry, because many airports are coming to fill their capacity. Particularly with respect to the runway, there are concerns about not being able to meet the demand for air travel without additional investment of about 2020.

Most critical is the situation at large hub airports, a Co. Airports such as London Heathrow and Frankfurt am Main operating at full capacity during peak hours from 6-23 hours. Growing demand causes congestion of airport facilities and long waiting times. When the demand for long-term pressure on airport capacity and further growth is limited, so chaotic conditions can occur in case of unexpected situations such as changes in weather like snow, rain, wind, temporary closure of airspace and more. In order to enable further growth in demand and provide the required level of service is necessary to build additional infrastructure, so the track itself, APRONS, terminals. In the case of capacity the runway, airport experienced times when on their investment in new infrastructure, attracted a large aircraft with a large number of seats, with higher fees or shifting operations to times outside of peak hours. Such airports can adjust their fees or invent other attractions for airlines. Because resistance to further construction of airport infrastructure, the expansion of the airport was a long process lasting ten years.

1.2 DELAYS OF EUROPEAN AIRPORTS

In 2010, achieved a high level of abstention, while the level of abstention in 2011 reached a value equal to that of 2009.

- The mean delay (departures) for all causes of delay is 28 minutes, down by 17 percent,
- The percentage of delay (5 minutes or more) fell by 8 percent at 37 percent compared to 2010,
- The percentage of delay (15 minutes or more) decreased from 20 to 18 percent,
- Mean residence (arrivals) for all causes of delay is 28 minutes a drop of 18 percent.
- The percentage of delay arrivals (5 minutes or more) fell by 7 percent to the value of 36 percent compared to the year 2010. [2]



Obr. 3 The mean delay departures in minutes

Obr. 4 The mean delay arrivals in minutes

2 AIRPORT CAPACITY

Airport capacity is defined as number of take-offs and / or landings may be made per unit of time, usually for an hour, without prejudice to the safety regulations. If the airport fails to meet the resulting demand with existing capacity, so there is a reduction in service levels, which ultimately leads to dissatisfaction airlines when traveling constantly changing schedules when delays of flights. The capacity of the airport, we can divide the capacity of the airside (airside) and landside capacity (Landside). Airside capacity is the capacity of the takeoff runway, taxiways and associated airspace. Landside capacity is the capacity of the terminal gate s and driveways. Table 3 shows the factors affecting the capacity of the airport.

Tab. 3 Factors affecting airport capacity

Factor	Description
Air traffic control	Navigation aids, air traffic control rules and procedures
Runway System	Layout and number of runways
Taxiways system	Configuration of taxiways
Apron/ Gate Facilities	Capability to accommodate aircraft in apron/gate area
Facilities of terminals	Landside facilities that passenger move through from curb to the loading bridge, like passenger waiting area, ticket counters, security screening points, customs and immigration etc.
Ground Transportation System	Landside access system for travelers such as access roads, parking facilities, and public transit.
Operating Restrictions	Regulations and rules to prevent the airport from operating at full capacity; such as curfews, special departure/arrival procedures, activities in the adjacent airspace
Meteorological Conditions	Winds, visibility, ceiling, and precipitation

The runways are usually the largest factor influencing the capacity of the airport. Table 4 shows the factors affecting the capacity of the runways. [3]

Tab. 4 Factors affecting the capacity of the runway

Factors	Description
Number of Runways and Configuration	The layout and number of runway(s)
Runway Operating Strategy	The way runways are used. For example, runway for arrival only/departure only or mix operations
Runway Occupancy Time (ROT)	The time an aircraft occupies the runway. For arrivals it starts when aircraft passes runway threshold and ends when aircraft exit the runway. For departure it starts when aircraft enters the runway and ends when the aircraft passes the departure end of the runway
Aircraft Mix and Operating Sequence	The percentage of operations among all aircraft weight classes and their arrival/departure sequence
Common Approach Path Length	The distance aircraft fly in-trail during the approach stage
Weather	Visibility and ceiling
Separation Requirements	The required minimum distance/time between leading and trailing aircraft
Approach Speed	The speed when aircraft passes through arrival end of runway
Air Traffic Control Related	Availability of tower, radar coverage

2.1 CONFIGURATION RUNWAY

The capacity of the runway is largely determined by their actual configuration. Configuration is the number of tracks and the orientation of one or more tracks. There are several basic types of configurations, but in practice it is used also their combination. The configurations of the basic types of orbits is a system with one runway, a system of parallel runways, intersecting runways system and the system - a combination of paths or different types of configurations.

2.1.1 Single runway system

This type of configuration is the simplest. Hourly runway capacity in VFR conditions, ranging from 50 to 100 movements in terms of IFR runway capacity ranges from 50 to 70 movements per hour. Number of movements depends mainly on the composition of traffic (mix) and the use of navigation devices. The one runway is shown in Fig. 5a).

2.1.2 The parallel runways system

Capacity at this configuration is affected by the number of tracks and spaced between tracks. There are cases where two, three and even four parallel tracks, but the distance between them may be different. The distance between tracks is divided into near, medium or large based on the distance between the two parallel runways. The close parallel runways have a distance from 700 ft to 2500 ft. In terms of IFR traffic to one lane operation is dependent on other tracks. Parallel paths are separated by a medium distance from each other in the range from 2500 ft to 4300 ft. The condition is IFR traffic pathway independent of one another in running track. Parallel tracks by far are spaced at least 4300 ft. The podmieka IFR can be operated independently to track arrivals and departures. As mentioned above, the distance between the axes of the orbits determined by the degree of operational independence to the railroads themselves. For this knowledge should be remembered, because in the future may lag significantly affect the simultaneous operation of parallel paths. In terms of VFR, parallel runways allowing simultaneous operation, that is one of the arrivals and departures runway, on the other. Simultaneous operations on parallel paths, where the distance between tracks is less than 700 ft may use aircraft with a maximum 171 ft wingspan. For aircraft which have a larger wingspan distance between parallel paths must be less than 1200 ft for simultaneous operation.

In any case, the observed spacing for wake turbulence with simultaneous operations on parallel paths with close spacing. On these tracks can not be operated simultaneous departures and arrivals. In IFR conditions, it is possible the simultaneous operation of these pathways.[4]

Co-operation arrivals can be done in orbits with a mean interval of tracks under VFR. Co-operation departures on parallel paths with a medium pitch tracks for IFR conditions in the environment without radar can be done if the distance between tracks is less than 3500 ft. The use of radar distance between tracks is less than 2500 ft.

If the threshold is not defined, parallel operation of arrivals and departures are permissible distance between the runways at least 2,500 feet. There are instances when it is necessary to offset threshold for shorter distances such as scrolling vzlietajúcich or landing aircraft. Reduction in rolling distance is done assuming that a track will be used purely as a takeoff and one landing aircraft only. When the threshold then the offset to the following modifications distance between the tracks is made possible simultaneous operation of arrivals and departures.

Hourly capacity of parallel runways in VFR conditions, ranging from 60 to 200 movements per hour, depending on the composition of traffic (aircraft mix) and how they are arriving or departing controlled on those tracks. Pri IFR conditions on parallel paths with a small offset hourly capacity is 50 to 60 movements, hourly capacity will increase to 60 to 75 movements in parallel paths to the middle interval and in parallel paths by far the pohybuje hourly capacity from 100 to 125 movements.

The (dual lane) parallel paths is expected to handle about 70% more traffic than systems with a single runway VFR conditions and 60% more in IFR conditions. The main benefit (dual lane) parallel runways is to increase traffic capacity in IFR conditions without additional built-up areas. The parallel tracks are shown in Fig. 5 b).

2.1.3 Intersecting Runways

Many airports have two or more runways oriented in multiple directions and often intersecting each other. The intersecting runways are built mainly in areas where wind is strong in many ways, what would the existence of only one pathway caused a significant reduction of air traffic cross winds. If the strong side wind, so the use is only one of the intersecting paths which significantly reduces the capacity. If wind power is not so much the track can be used simultaneously. The capacity of both intersecting tracks depends on the position of their crossing point (the center of the track or near the end of the track) and the method of operation of the track (one track for takeoff and landing on the second) and the composition operation (Aircraft mix).

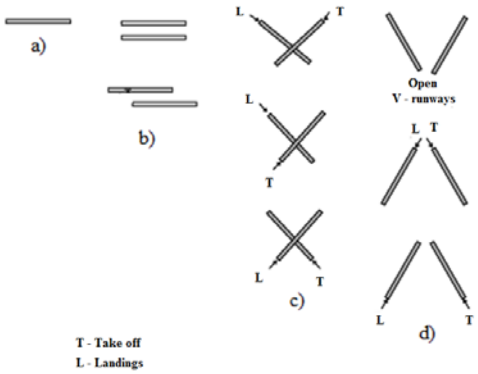
Capacity is lower when the position of crossing paths away from the end of the runway for take-off and threshold. Increased capacity is achieved when the position of crossing orbits closer to the end of the runway for takeoff if runway threshold. The crossing of tracks is shown in Fig. 5 c).

2.1.4 Open V – runways

Tracks oriented in different directions, which intersect each other are known as System V - Railways (Open-V runways). Thus, as the system of intersecting runways, and in this type of track leads to the use of only one of the tracks, if the air traffic operating strong crosswind. Both runways are used simultaneously in case the wind effect is not significant. Highest Memory Capacity is reached when the operation being conducted as a strategy divergent pattern (Diverging pattern) away from V. Hourly capacity in this strategy is 60 to 180 movements in VFR conditions. In IFR conditions, the capacity ranges from 50 to 80 movements per hour. If a convergent strategy applied to the model (Converging pattern), this means that the direction of operation is in, so capacity reaches values of 50 to 100 movements in VFR conditions and 50 to 60 Movements in IFR conditions for an hour. The system - tracks shown in Fig. 5 d).

2.1.5 Combinations of Runway Configurations

In terms of capacity and air traffic control operation is performed in one direction on the track most sought. This configuration provides the highest capacity compared with other configurations. Managing traffic in one direction is less demanding activities such as managing air traffic in several directions. When comparing different configurations in the system - tracks are more desirable than a system of paths crossing. When the system - tracks where traffic is controlled by the strategy to reach a higher capacity than the reverse strategy. The system tracks the crossing should make every effort to accommodate crossing two lanes closest to the threshold and drive traffic away from the crossing as the crossing towards the tracks. [4]



Obr. 53 Runway configurations

3 INCREASING RUNWAY CAPACITY WITHOUT INCREASING AIRPORT SIZE

Many airports are currently operating at full capacity or capacities have long been inadequate. Capacity problems rarely occur on the side, land-side ". Airport are often financially independent and able to fully finance its own expansion. Capacity problems of the earlier occurs in conjunction with the capacity and landing and the additional increases. Without sufficient capacity, these airports are facing an increasing problem of delays and other consequences resulting from the delays incurred. Most airports have capacity problems are surrounded by built-up area. Building another runway requires a significant amount of land which they do not have airports. This often leads to lengthy and often contentious fight between airports and landowners. If such disputes to build a new runway and may be delayed for several years and it obviously increases the delay due to lack of capacity and also if there is eventually to build the track, so construction costs are much higher due to inflation. What are the options for increasing airport capacity without additional construction impacts? Such solutions, respectively. technology would mean an increase of profits from increasing demand for air transport and would save time that would be spent long litigation in an attempt to airport expansion.

These technologies, most of them already exist, are planned for inclusion in the new concept of air traffic management system and to replace the current system over the next 20 years. The whole concept was developed for group scheduling (The Joint Planning & Development Office) in collaboration other major teams. The final result is called the NextGen system.

NextGen system is designed to address these limitations:

- Use of existing, but not fully implemented aircraft communications equipment to safely reduce separation between aircraft,
- Use of special procedures for approach and departure, as the introduction of standards for all approaches and departures
- Improve the management of aircraft wake turbulence near the airport,
- Using the same technology central computer system to control movement around the airport.

The introduction of NextGen technology is increasing the capacity of the tracks without further airport expansion. Airport managers, planners, and also people who are concerned by the possible expansion of the airport should be aware of these options increase capacity. The overall implementation of the NextGen system requires a time period of 10-20 years, but with the growing resistance to the expansion of airports will become increasingly desirable.

Time the introduction of this technology is equal to the time of the planned projects of building additional runways. Airports that are close to exceeding its capacity must address this issue because of growing demand for air travel will grow them undesirable congestion and delays.

Simpler solution to the problem of capacity is the problem of land-side of the airport (size and availability of terminals etc.), because the available space for further expansion of the airport and available financial resources. Far more difficult problem is related to increasing the capacity of "air-side" - tracks that are able to accommodate the growing demand for air travel.

The capacity of the runway has several implications, most passengers are not affected and the economy. For example, limits the capacity of paths can lead to increased charges by reducing flights and competition between carriers, which may have significant benefits to the airport and around the airport. Delays due to lack of capacity paths also lead to dissatisfaction of passengers, which may involve only one airport, but further follow-up airport. [5]

NextGen system not only helps to increase the capacity of the tracks, but allow greater use of parallel pathways in close proximity without any compromise on safety. They also allow the construction of another runway at a lesser distance from the existing ones. And nearly all circumstances, NextGen provides increased security and an hourly capacity of each individual track. This technology does not build new runways and this requires expanding the frontiers of the airport, but attempts to reduce the number of cases where this expensive and complicated process is needed, where the completion time of a new runway could be deferred.

NextGen represents a significant step in the automation of air traffic control. To safely reduce separation between aircraft and allows more efficient use of.

3.1 NextGen Concept

The use of NextGen is to increase the capacity of the runways and adjacent airspace. Aircraft equipped with new communications technologies comply trace transfer via GPS and their precise location, the estimated flight path is determined in real time. This information is displayed air traffic controller at the screen similar to what is in the aircraft cabin. The screens in the cabin but the pilot can see the position of cloud, but no further air operations. The information about the next operation can be used to create accurate flight routes for approach and landing, which are programmed into the computer's Flight Management System (FMS). This aircraft can be sorted automatically many miles from the airport, observing the separation minima necessary to ensure flight safety.

Two aircraft can be controlled to zoom in on a close parallel runways in bad weather (which in many cases it is not possible today). Maintaining security is achieved by each aircraft equipped with new technology, he knows the position of other aircraft, making it capable of responding promptly in case of breach of separation, or deviation from the track. The aircraft can also be programmed to descend to the lowest of the engine running at cruising level and landing without changing settings in the engine running and in the shortest possible path. This reduces fuel consumption while reducing the noise that occurs during acceleration or deceleration, in carrying out the instructions of air traffic controller. These technologies are not only a source of capacity benefits, but also environmental. The runway system consisting of a single runway separation minima in bad weather increasing, leading to a reduction in the hourly runway capacity.

Similarly, reducing the number of takeoffs and landings on runways with crossing in adverse weather conditions. When running on parallel paths are parallel arrivals are allowed only if the track apart 4300 ft or 3000 ft, but in this case only for use with the precise tracing (Precision Runway Monitoring equipment). With NextGen aircraft technology sequence can be created by hundreds of miles from the airport and from many different directions so that the aircraft will arrive at the right time and order. In addition, this technology allows for precision approach runway parallel to each other at a distance of 750 ft in bad weather, and also allows for landing on a runway with cruising.

These activities are possible because the aircraft crew will know their relative positions.

These procedures can significantly increase the capacity of the runway system. Exact departure methods can merge together to form a reduced space for landings and departures. Where is the way to approach or departure of experienced, there may be delays and capacity requirements to modify or cancel the whole. Accurate systems to maintain constant flow can be established to ensure separation of aircraft arrival and departure routes between various airports so that the aircraft will not pass or cross assigned level, so any airport can reach a maximum flow of traffic or to track system. This flow control can be extended to the actual gate-y. Arriving aircraft lands and then while he releases the gate for him, thus avoiding unnecessary waiting to leave the gate, with the previous plane. Departing aircraft will be moved to the end of the tracks in the order for take-off, which implies a minimum separation and problems with turbulence.

Using these technologies eliminate the impact of bad weather delays, and thereby the capacity of the bad weather is approaching, or equal to the capacity for good weather. These technologies can not of course eliminate delays caused by the occurrence of snow and ice at airports, and occasional storms. [5]

The full integration of NextGen technology, the capacity of all types of channels are increased, while its value for bad weather will be similar to the favorable weather, which is invaluable in planning the operation.
On the following pages describes the components necessary to achieve these skills and potentially increase the runway capacity systems.
The primary technology for increasing the capacity of the runway system, which are part of NextGen technologies are:
- Required Navigation Performance (Required Navigation Performance, RNP),
- Automatic dependent surveillance system - Transmission (Automatic Dependent Surveillance-Broadcast, ADS-B)
- The system covers a large area (Wide Area Augmentation System, WAAS)
- The principle of gradual decline (Continuous Descent Approach, CDA)
- Motion control of operational areas (Surface Area Movement Management (SAMM).
Another important component to which the work is still needed and the technological improvements in flight control wake turbulence.
Strong research and development in conjunction with the NextGen technology is imperative nature. NextGen technology significantly improves the flow of traffic and adding management of wake turbulence will also increase the capacity of the runways and ultimately the capacity of the airport itself. [5]

3 CONCLUSION

Capacity of the runways should be given most attention, because this is a key element in managing the growing demand for air travel and further development of the airport. It also represents a significant factor in achieving the expected profit and match the expectations of the passengers and the maintenance and continuous improvement of services quality.

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AUTHOR(S)´ ADDRESS(ES)

Miroslav Kiseľa Bc.
Faculty of Aeronautics, Technical University Košice
Rampová 7, 041 21, Košice
Email: miroslav.kisela@gmail.com

Ľubomír Fábry Ing., PhD.
Faculty of Aeronautics, Technical University of Košice,
Rampová 7, 041 21 Košice.,
email: lubomir.fabry@tuke.sk

Reviewer: Ing. Juraj Vagner