STANISLAV PAVLIN, D.Sc.
stanislav.pavlin@fpz.hr
University of Zagreb,
Faculty of Transport and Traffic Sciences
Vukelićeva 4, HR-10000 Zagreb, Republic of Croatia
MARIO ŽUŽIĆ, student
zuzic@vip.hr
Zvonimira Rogoza 1, HR-10000 Zagreb,
Republic of Croatia
STIPE PAVIČIĆ, B.Eng.
stipe.paviciv@zg.t-com.hr
Kašinska 11, HR-10360 Sesvete, Republic of Croatia

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RUNWAY OCCUPANCY TIME AS ELEMENT OF RUNWAY CAPACITY

ABSTRACT

A great many factors determine airside capacity. In the first group are those factors correlated with characteristics of manoeuvring area such as number, layout and location of runways and taxiways. In the following group there are elements correlated with flight operations such as arrival, departure, touch and go operations and also the factors related to the aircraft such as weight, separation and wake vortex separation criteria. In the last group there are all other elements such as meteorological conditions and restrictions, ecological conditions, air traffic control skills and equipment, etc.

This paper presents a detailed description of runway occupancy time in arriving and departing flight operations and indications for possible improvements

KEYWORDS

airside, capacity, delay, runway occupancy time, arrival, departure, runway capacity enhancement

1. EFFECTIVENESS OF THE TRANSPORTATION SYSTEM

The effectiveness of the transportation system is commonly measured in terms of its ability to efficiently process the transported unit. Since the system performance is dependent upon the individual components of that system, it is usually necessary to evaluate these components to determine the overall system capabilities. In case in which the use of the system requires sequential utilization of a group of processors, the overall efficiency of the system is usually limited by the characteristics of the least efficient component.

Information on airport capacity and delay is important to the airport planner. There is a strong belief within the aviation community that significant gains in air transportation efficiency can be realized through an understanding of the factors causing delays and by the application of technological innovation to alleviate delay.

2. CAPACITY AND DELAY

The term capacity means the processing capability of a service facility over some period (this definition is known as practical capacity). For a service facility to realize maximum or ultimate capacity there must be a sufficiently big demand for service. In aviation it is virtually impossible to have a continuous demand and so the planner is faced with a problem of providing sufficient capacity to accommodate the fluctuating demand with an acceptable level or quality of service.

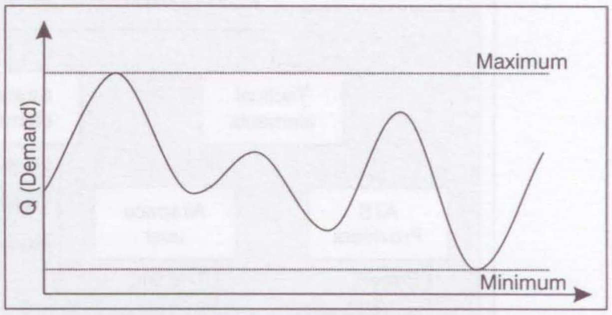

Figure 1 - Average demand during time period (day, week, month, etc)

The design specifications at an airport require that sufficient capacity is provided so that a relatively high percentage of the demand is subjected to some minimal amount of delay.

Airside capacity represents the maximal possible number of aircraft operations that an airfield can accommodate within a certain period of time with continuous demand for services (take-off/landing). Continuous demand for services means that there are one (or more) aircraft ready to take off or/and land. This definition has been referred to as the ultimate (maximum) capacity.

For determining the capacity and delay, the operations on the runways, taxiways, and gates at most airports can be considered independent of each other and may be analyzed separately. It is important to note

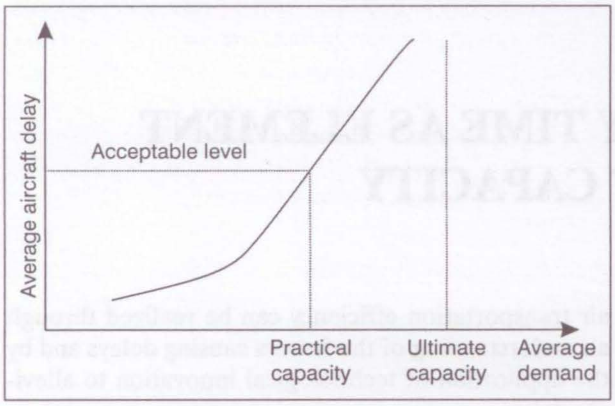

Figure 2 - Practical capacity and ultimate capacity [1]

that the capacity of each component on the airside does not affect each other, but rather the overall airside capacity is limited by the characteristics of the least efficient component.

3. FACTORS THAT AFFECT RUNWAY CAPACITY

Many factors influence the capacity of an airfield, and some are more significant than others. In general, the capacity depends on the configuration of the airfield, environment, availability and sophistication of aids to navigation and ATC.

The most important factors include:

- the configuration, number, spacing and orientation of the runway/taxiway;
- the arrangement, size, and number of gates in the apron area;
- the size and mix of aircraft using the facilities;
- weather conditions;
- noise regulations which may limit the type and timing of operations;
- ATC procedures;

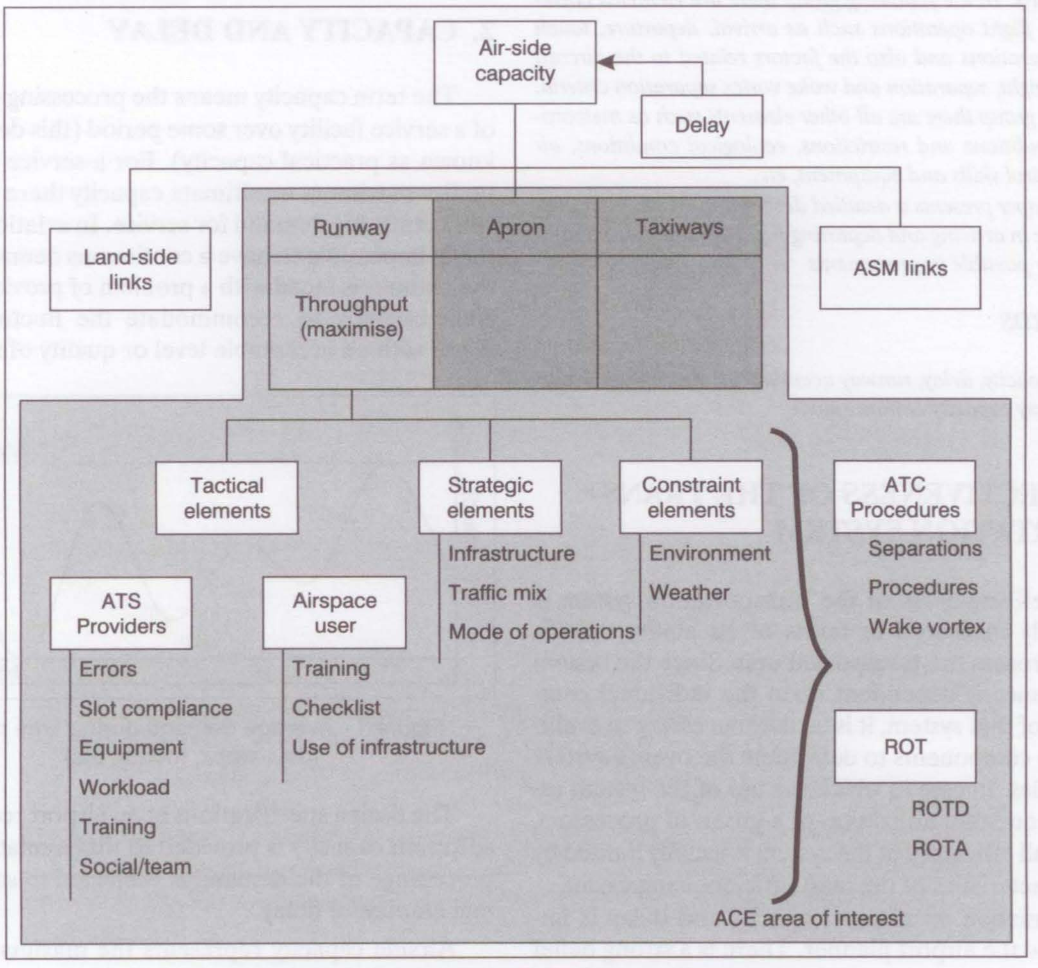

Figure 3 - Elements affecting airside & runway capacity [2]

- Runway Occupancy Time;
- etc.

4. RUNWAY OCCUPANCY TIME

4.1. General

Among the wide spectrum of runway capacity elements reducing the time spent by aircraft on the runway is one of the most important elements.

It should be stressed that increasing runway capacity by minimizing runway occupancy is a matter of seconds per operation. Indeed, aircraft that unnecessarily occupy the runway for additional seconds potentially provoke delays of at least one order of magnitude greater, i. e. minutes or worse. If this develops into a domino effect, then the overall system capacity will be reduced, causing losses of slots. On the other hand, the saving of a few seconds per movement can represent an important capacity increase. For example, saving 5 seconds per movement has the potential to increase capacity by 1 to 1.5 movements an hour [3].

Studies have shown that, depending on the traffic mix, runway capacity can be increased between 5% (in the case of single-runway airports) and 15 % (multiple-runway airports) by reducing ROTs. A more marked example is the 19% capacity increase achieved over a period of 3 years on the single runway at Manchester [2]. Therefore, reducing ROT becomes the primary mission for every airport.

Enhancing runway capacity is not necessarily a matter of seeking absolute minimum occupancy times but rather one of achieving consistent performance, thereby building up the confidence of pilots and controllers, which is necessary to optimize runway capacity. This striving for consistent average occupancy times might appear to contradict the objective of minimizing ROTs. However, this is not the case because a distinction should be made between the purely mathematical recording of data (relating to absolute ROT minima) and the operational environment in which air traffic is handled. Indeed, operational and/or safety requirements are the determining factors that influence the theoretical minima. Operational/safety actions taken by both pilots and controllers could therefore justify exceeding these minima, for reasons such as aircraft characteristics, traffic mix, pilot performance, runway system layout, meteorological conditions, etc. It should therefore be noted that when measuring ROTs and performance data, a clear distinction should be made between the operational context within which the traffic is handled and the recording of real-time runway occupancy data.

4.2. Reference elements

To be able to define ROT we will use the definitions according to ICAO

Threshold. The beginning of the portion of the runway usable for landing;

Separation for arriving aircraft. Separation is required because a landing aircraft will not normally be permitted to cross the beginning of the runway on its final approach until the preceding departing aircraft has crossed the end of the runway in use, or has started a turn, or until all preceding landing aircraft are clear of the runway in use.

Landing clearances. An arriving aircraft may be cleared to land if there is reasonable assurance that the prescribed separation will exist when the aircraft crosses the runway threshold, provided that a clearance to land is not issued until a preceding landing aircraft has crossed runway threshold.

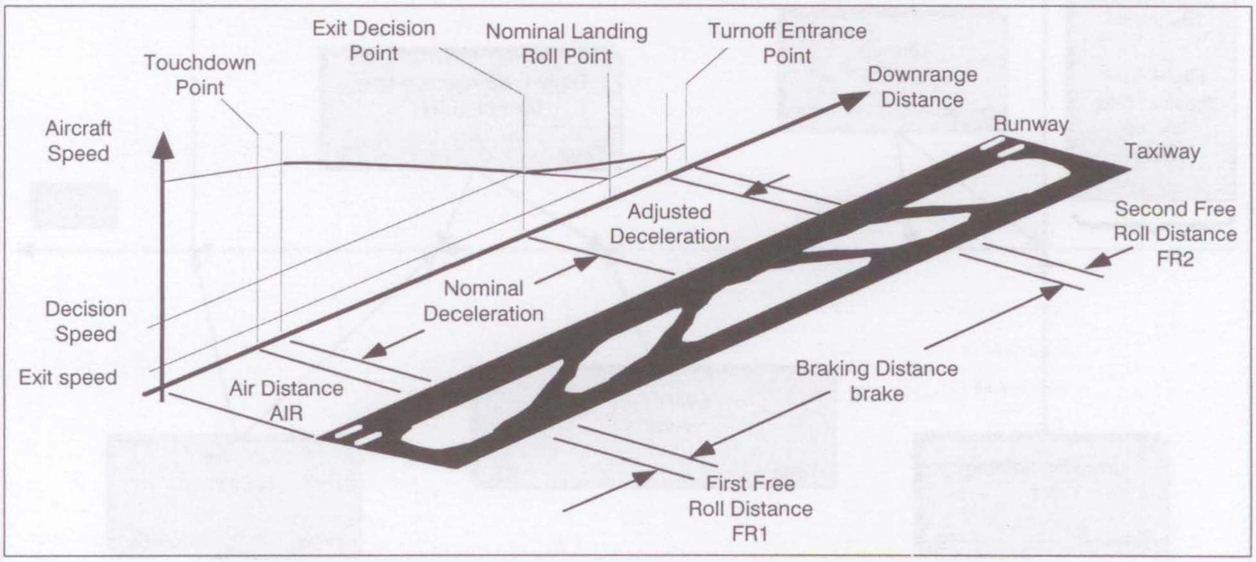

Figure 4 - Elements of the runway occupancy during the landing procedure [4]

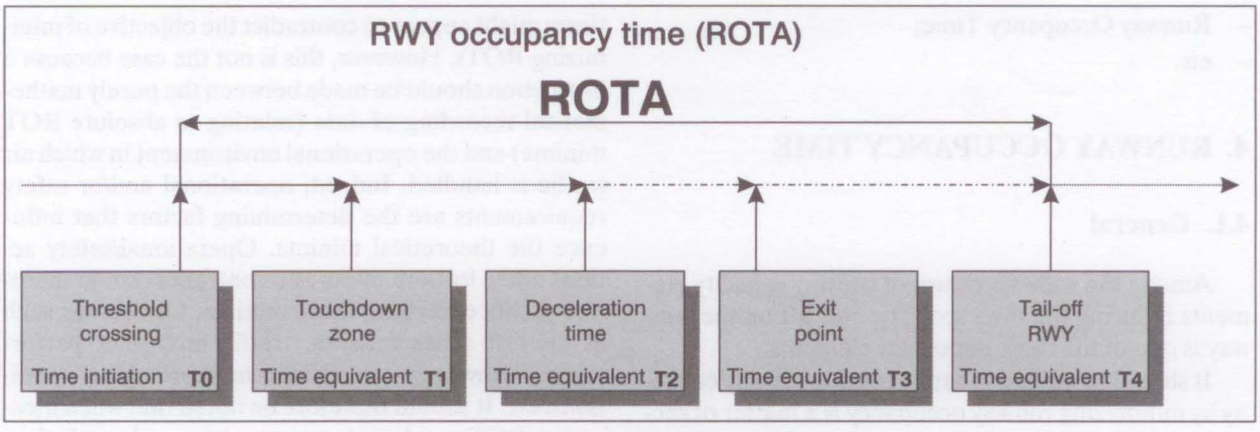

Figure 5 - Elements that affect ROTA [2]

Runway-holding position. A designated position intended to protect a runway, an obstacle limitation surface, or an ILS/MLS critical/sensitive area at which taxiing aircraft and vehicles shall stop and hold, unless otherwise authorized by the aerodrome control tower.

Furthermore, the real occupancy of the runway for both arriving and departing aircraft has to be determined. A distinction should therefore be made between arrival and departure runway occupancy times, ROTA and ROTD respectively.

4.3. Runway occupancy time of arrival (ROTA)

ROTA is defined as the time interval between crossing the threshold and the aircraft tail vacating the runway.

The key elements of runway occupancy time for arriving aircraft are pilots briefing and landing techniques:

- Pilots should ensure that they have completed an early review and through briefing of airport and runway layout before starting the approach;
- The runway exit point that will allow minimum runway occupancy should be nominated during the approach briefing;
- Upon landing, pilots should use appropriate retardation to exit the runway without delay;
- The aim should be to achieve a normal touchdown with progressive smooth deceleration to exit at a safe speed at the nominated exit point;
- Target the earliest suitable exit and exit the runway expeditiously.

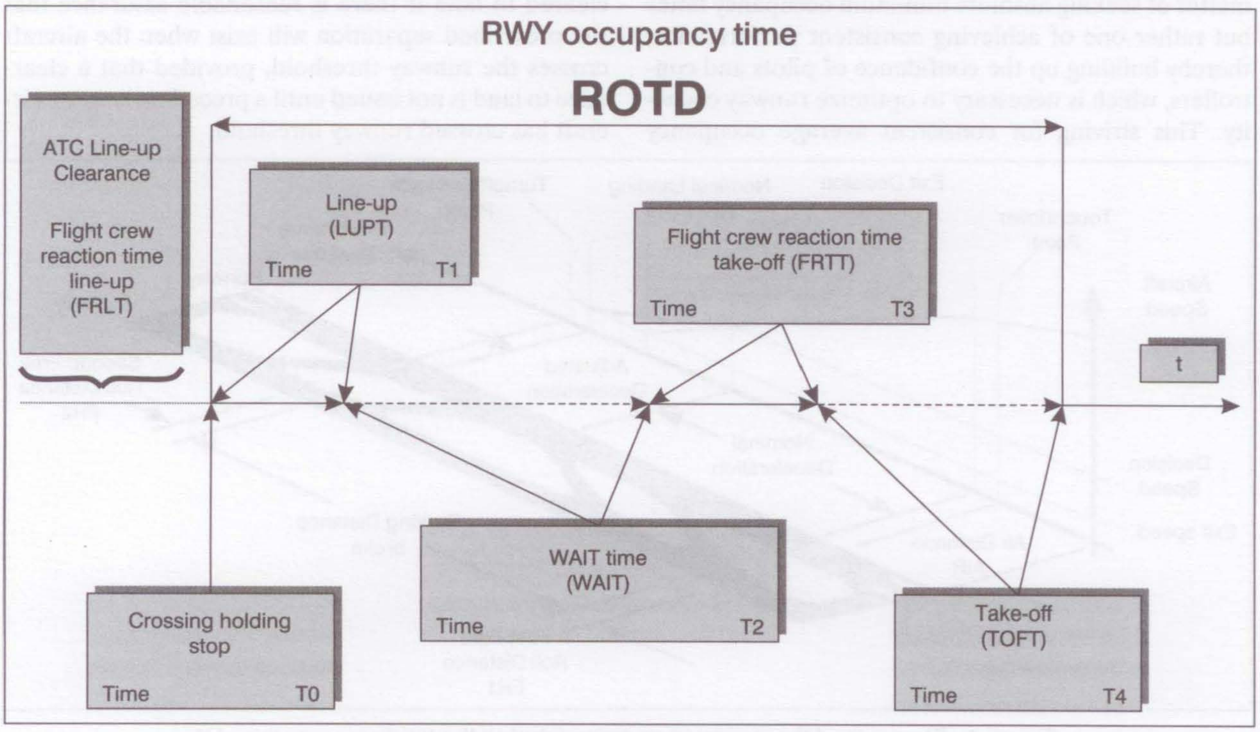

Figure 6 - Elements that affect ROTD [2]

4.4. Runway occupancy time of departure (ROTD)

Departure runway occupancy time is the time interval between crossing the holding stop bar and the main gear lifting off the runway.

The ROTD is further broken down into the following measurable variables:

- *Line-up time (LUPT):* the time interval between crossing the stop bar and the moment the aircraft is fully lined up.
- *Wait time (WAIT):* the time interval measured between the completed line-up and the ATC clearance for take-off.
- *Flight crew reaction time to ATC take-off clearance (FRTT):* the time interval between the ATC clearance and commencement of take-off (roll).
- *Take-off roll time (TOFT):* the time interval between the moment the take-off roll has been initiated and the moment the main gear is off the runway.

4.4.1. Take-off reaction

In Figure 7, each bar represents the measured reaction times of different airlines operation at Heathrow airport. The green bar is the shortest reaction time. The linked bar is the longest reaction time by pilots of the same fleet.

The diagram clearly illustrates the variation in response times to take-off clearance. *Inconsistent performance continues to have adverse effect on departure delays.*

4.4.2. Variation in departure readiness

Departure Readiness is time between the first aircraft commencing its take-off roll and the next aircraft being lined up ready on the runway centre line. Each red and green bar represents a sample operator showing the longest and the shortest departure readiness times at Heathrow airport.

Whilst there is consistently good performance amongst those pilots with the shortest time, the disparity between these pilots and those with the largest intervals in the same fleet continues to have significant adverse effect on delays.

The key elements for minimising reaction time and hence runway occupancy on departure are:

- Aircraft should enter the runway at a suitable angle to quickly line up on the centre line and if necessary continue into a rolling take-off when cleared;
- Pilots who for whatever reason are not able to take off immediately when cleared must inform ATC before they enter the runway;
- Cockpit checks should be completed prior to line-up and any checks requiring completion on the runway should be kept to a minimum;
- Line-up promptly and start the take-off roll immediately when cleared

5. WHERE CAN IMPROVEMENTS BE MADE?

Runway occupancy time is primarily the function of aircraft type, landing weight, threshold speed, weather and runway conditions, although the point at which the aircraft exits the runway is largely dependent upon pilot operation techniques. The pilot's ob-

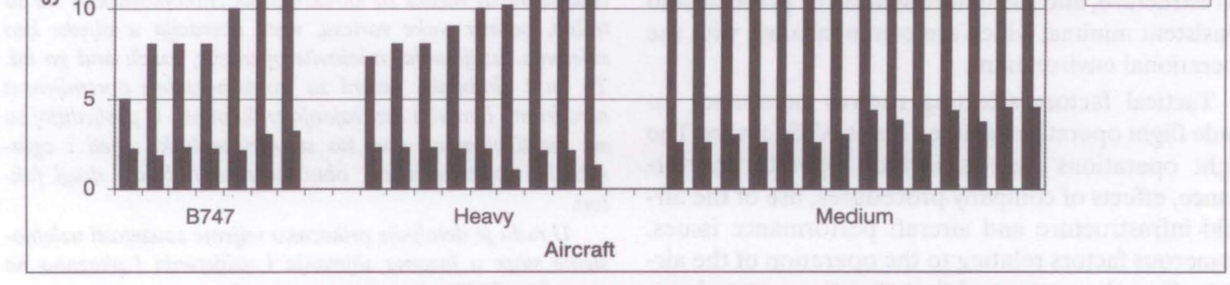

Figure 7 - Variation in reaction to take-off clearance at Heathrow airport [5]

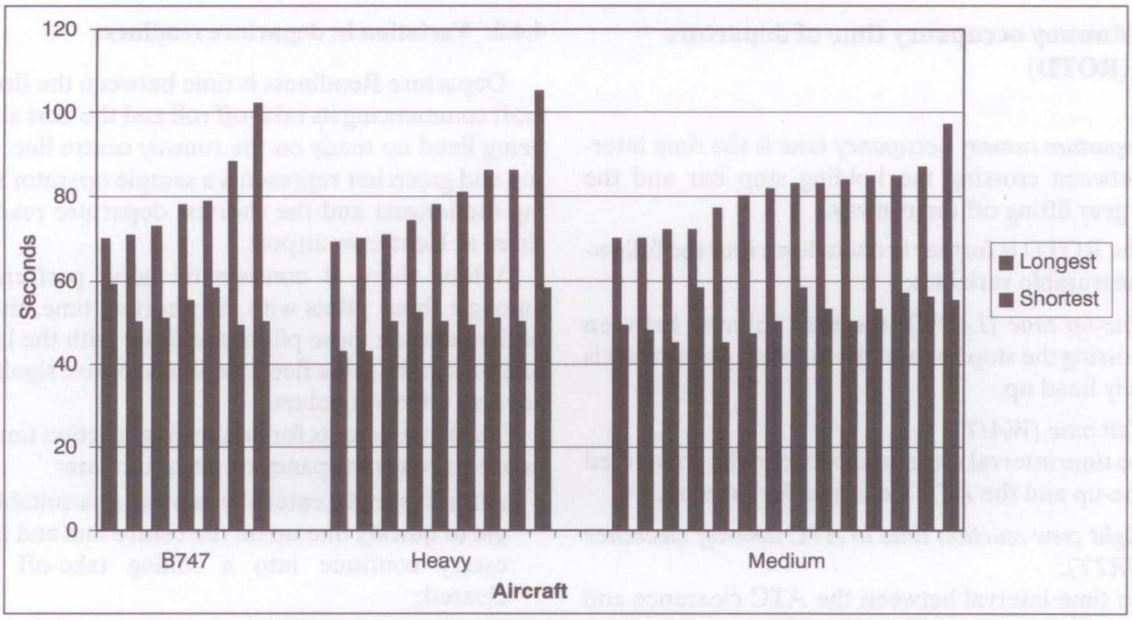

Figure 8 - Variation in Departure Readiness at Heathrow airport [5]

jective should be to consistently achieve minimum runway occupancy - within the normally accepted landing and braking performance of the aircraft - by targeting the earliest suitable exit point and applying the right deceleration rate so that the aircraft leaves the runway as expeditiously as possible at the nominated exit. *It is better, in terms of runway occupancy times to aim for an exit which can be made rather than to aim for an earlier one, to just miss it and then to have to roll slowly to the next.* It is essential that the aircraft do not roll down the runway to vacate an exit more convenient for their parking gate without prior authorisation from ATC.

. CONCLUSION

Achieving the optimum capacity from each runway is a complex task involving many factors, both tactical and strategic. In order to effectively manage that task it is essential to measure the effects of changes and to monitor performance of the users. It is important to make a distinction between the determination of the mathematical absolute minima for ROT, which will have an application in the planning of procedures and infrastructure, and the determination of practical and consistent minima, which are commensurate with the operational environment.

Tactical factors affecting runway occupancy include flight operations related items ATS factors. The flight operations aspects include operator performance, effects of company procedures, use of the airfield infrastructure and aircraft performance issues. Numerous factors relating to the operation of the aircraft affect the amount of time that the runway is occupied and it must therefore be possible for the pilot community to make a significant contribution to the reduction of ROT. Care should be taken to ensure that this is not simply a drive to complete tasks and actions more quickly, as this may erode margins of safety.

Dr. sc. STANISLAV PAVLIN
stanislav.pavlin@fpz.hr
Sveu ilište u Zagrebu, Fakultet prometnih znanosti
Vukelićeva 4, 10000 Zagreb, Republika Hrvatska
MARIO ŽUŽIĆ, student
zuzic@vip.hr
Zvonimira Rogoza 1, 10000 Zagreb, Republika Hrvatska
STIPE PAVIČIĆ, dipl. ing.
stipe.paviciv@zg.t-com.hr
Kašinska 11, 10360 Sesvete, Republika Hrvatska

SAŽETAK

RIJE E AU ETOSTI KAO ELE ENT KA ACI TETA U LETNO SLETNE STA E

apacitet uzletno-sletne staze ovisi o nizu čimbenika. U prvoj grupi su oni koji su vezani za karakteristike manevarske površine kao što je broj, tip, lokacije i prostorni odnosi uzletno-sletnih staza i voznih staza. Slijedeću skupinu čine elementi vezani za karakteristike zrakoplova kao što su težina, pojava wake vortexa, vrsta operacija u slijedu kao slijetanja, uzlijetanja, mješovite operacije, touch and go itd. Tu su i čimbenici vezani za instrumentalnu opremljenost aerodroma i pravila razdvajanja zrakoplova. U posljednjoj su svi ostali elementi kao što su meteorološki uvjeti i ograničenja, ekološke uvjete, obučenost kontrolora i drugi faktori.

U radu je detaljnije prikazano vrijeme zauzetosti uzletno-sletne staze u fazama slijetanja i uzlijetanja i ukazano na moguća poboljšanja.

KLJUČNE RIJEČI

zračna strana, kapacitet, kašnjenje, vrijeme zauzetosti uzletno-sletne staze, dolazak, odlazak, povećanje kapaciteta uzletno-sletne staze

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