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SIMULATION MODEL OF CIVIL-MILITARY JOINT USE OF ZADAR AIRPORT MANOEUVRING AREA

ABSTRACT

This paper deals with the take-off and landing procedure of various aircraft types from the same runway. There are four-type queues, three different holding positions and one approach. The simulation model for these conditions has been created. The simulation analysis of the use of manoeuvring area by commercial and training aircraft indicates the necessity of the optimisation of the air traffic management and harmonisation of the participants' operational procedures.

KEY WORDS

civil-military coordination, air traffic management, simulation, take-off procedure, harmonisation, runway

1. INTRODUCTION

It used to be a sort of segregation throughout the history of aviation, that the military traffic and facilities were separated from the civilian ones. Due to the nature of the military tasks, it is not likely that the segregation of this kind might be completely terminated. Nevertheless, great efforts are made to minimise the need for the segregation, and to restrict it to the minimum size. The European Organisation for the Safety of Air Navigation, EUROCONTROL introduced the Flexible Use of Airspace concept, which made possible for civil and military users to use the required portion of airspace when they need it, in their own manner. This concept brought advantages such as: improved civil/military coordination, far better airspace management and efficient separation of operational and general air traffic. Generally speaking, the overall capacity improvement has been significant[4].

Both civil and military aviation seek to separate the training process from other traffic as much as possible. There are even special training airfields located in a peaceful, undisturbed corner of the airspace, away from the congested areas. [5] Furthermore, there are whole areas, thousands of square miles, reserved exclusively for military training flights. As the opposition to this approach, Zadar Airport represents a rare, perhaps unique example of an international airport that hosts civil fixed-wing aircraft flying school and is the home base for military both fixed and rotary wing flying school. Settled on the coast of the Adriatic Sea, 25 miles from the mountain line that blocks practically all influence of the continental climate, Zadar Airport features the Mediterranean climate with average of foggy days between 0.7 in July to 5.3 in December, and less than one day with stormy wind per month during winter. In addition, there are more than 100 sunny days per year and average temperatures practically never below 0°C. [3] Surrounded by a lot of islands, nature parks and national parks, Zadar marks a constant growth in the number of tourists. Consequently, there is an increasing number of commercial aircraft operations at Zadar Airport. During the first nine and a half months of 2007 there were 45 percent more than during the entire 2006. [10]

Having these facts as the starting point, and the innuendo of possible regional flying training centre, the question is how these different participants would interact, and whether their interdependence would be too great to provide harmonisation. In plain words, is it possible for these participants to operate at the same airport? The answer could be given by the analysis of the participants' function and by modelling and the simulation of their interaction system.

The EUROCONTROL Commonly Agreed Methodology for Airport Airside Capacity Assessment – CAMACA application has been developed (among other issues) in order to provide an objective and worthwhile decision-making assistance tool for strategic airport planning to members of the Airport community (airport authorities and operators, ATS providers and representatives of each major airport user). In order to assess the capacity of each airport airside component there are three CAMACA modules: RunSysCap, TaxiCap and ApronCap for the assessment of runway, taxiway and apron capacity, respectively. For the purposes of this paper, only RunSysCap has been considered. The concept of this user-oriented tool allows users to adjust the number of relevant parameters such as: traffic sample, aircraft classification, number of runways, runway operation modes, traffic mix, common approach path length of the runway, number of Standard Instrument Departures – SIDs for the runway, minimum distance of an arrival from the threshold to release departure, approach speed for different aircraft categories, wake vortex separation between different aircraft categories and minimum inter-departure time (same track and diverging tracks). The output information is represented in the following forms:

- chart of hourly capacity of the runway system (the percent of arrivals along x-axis, and the capacity of the runway system as aircraft movements per hour (arrivals and departures) along y-axis);
- arrivals/departures chart of the hourly capacity of the runway system (the arrival capacity along x-axis and the departure capacity along y-axis, both represented by aircraft movements per hour);
- absolute capacity table which presents hourly capacity of the runway system by percent of arrivals and correspondingly, the total capacity of the runway system (movements per hour), number of arrivals per hour, and number of departures per hour.

Although it is the state-of-the-art tool, CAMACA cannot represent the specific situation that appears at airports, such as Zadar Airport, regarding some internal regulations that rule the military flying school functioning. This paper describes the developed simulation model of the situation when the airport is used by training aircraft in a conventional manner, for take-off and landing operations. Other, non-conventional operations require a different approach and they are the subject of another research paper.

2. EXPERIMENTAL SECTION

As the heritage from previous times there are some specific ways of organising the flying activities and grouping of aircraft. Hence, while performing missions via the same route for the same type of aircraft, a five-minute[2] separation between succeeding aircraft is prescribed. Once the mission is completed, aircraft are refuelled and manned, ready to perform the same route in the same manner. If there are two different types of aircraft flying at the same time, e. g. starting time 09.00 hours for both of them, there is an unwritten rule that the faster aircraft has the priority. Each flight has its declared take-off time in accordance with the five-minute separation and start time, and pilot in command is responsible not to be late at the holding point. [2,6,7,8,9]

On the other side, there is general air traffic acting in accordance with the prescribed regulations. In order not to create unnecessary delays, air traffic control unit gives the priority to departing commercial flights before other departing traffic. For the arrivals, the "first-come-first-served" rule is applied, and as such it is the subject of regular airport capacity study. Hence, the influence of the military training flights on their return to home base is not the subject of this paper.

The arriving aircraft have the priority to all other traffic. There is radar guidance with ten-mile separation between succeeding arrivals. If the arriving aircraft has passed the outer marker, the departing aircraft are not allowed to enter the runway. Once the arriving aircraft fly past the holding position, the waiting departing aircraft is allowed to commence the line-up. The departing aircraft can commence the take-off roll only after the preceding aircraft tail has vacated the runway.

The departing commercial aircraft have the priority to military training flights. The faster aircraft is given priority in case two or more commercial aircraft are at the departure at the same time. The succeeding aircraft is not allowed to commence take-off roll until the preceding aircraft has reached the minimum radar vectoring altitude.

Based on the pre-defined regulations, a simulation model of the use of the airport by training aircraft for take-off and landing operations is created. Count-down timers are used as a simultaneous multi-object tracking solution. The model functioning principle, as shown in Figure 1, is the activation of the count-down timers by the object passing through "gates" that are governed by appropriate count-down timers. The activation of the count-down timer makes it impossible to pass through the associated "gates". The created waiting times of military training aircraft at appropriate gates are recorded and are output model values. The model is realised in the "C" program language in K

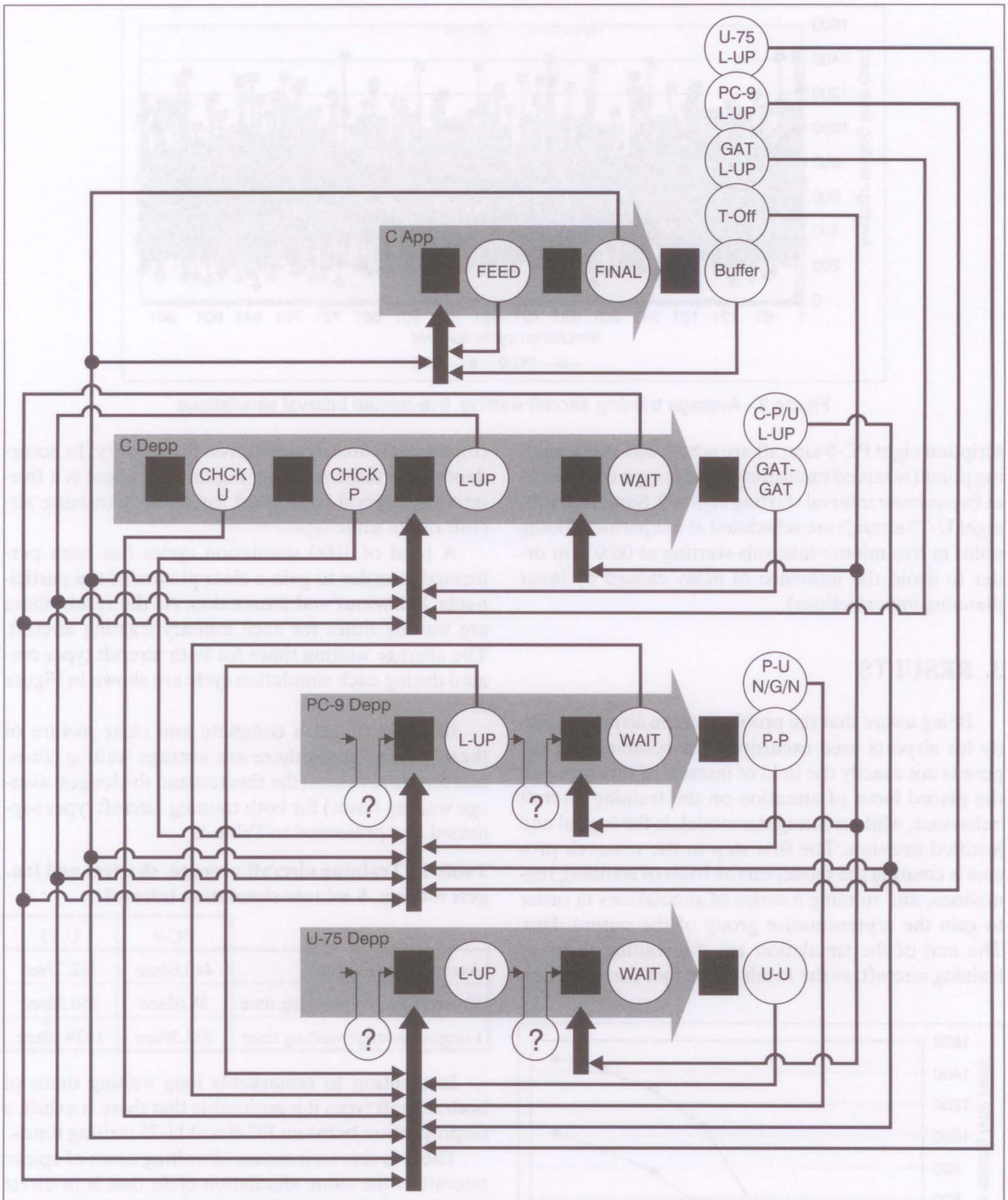

Figure 1 - Simulation model principal scheme

Develop (KDEV) environment at Linux SUSU 10.1 operating system.

The example of the simulation is represented by the situation when the commercial arrivals are divided into two identical groups and randomly distributed around 08:20 and 08:40 along interval of ± 20 minutes. Commercial departures are distributed randomly during one hour interval, from 08:00 to 09:00. There are two types of commercial aircraft, whose modelling is based on A320 and ATR 42 performance data. There are two aircraft of each type on arrival, and four aircraft of each type on departure. The training aircraft are represented by two types of aircraft: PC-9 and U-75. In accordance with the previous de-

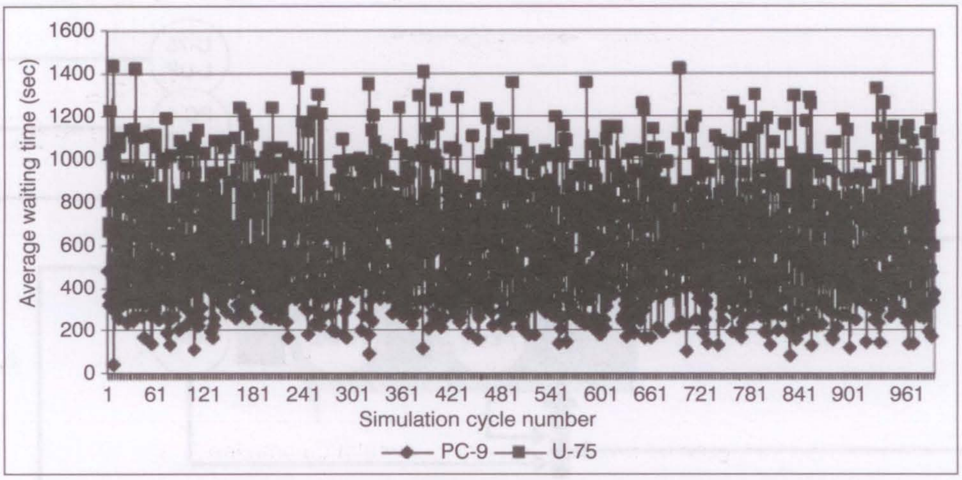

Figure 2 - Average training aircraft waiting, five-minute interval simulations

scription eight PC-9 aircraft are scheduled at the holding point (reserved exclusively for this type of aircraft) in five-minute interval starting at 08:00. Similar to this, eight U-75 aircraft are scheduled at a separate holding point in five-minute intervals starting at 08:01 (in order to avoid the influence of delay caused by inner planning imperfections).

3. RESULTS

Being aware that the problem of the airport capacity for airports used exclusively for commercial purpose is not exactly the field of interest of this research the placed focus of attention on the training aircraft behaviour, while creating the model, is the logical and justified decision. The first step in the research process is creating the model on the basis of standing regulations, and running a series of simulations in order to gain the representative group of the output data. The aim of the simulation are the waiting times of training aircraft, as the result of the fact that all other, commercial aircraft were given the priority. In accordance with these standing regulations, there is a five-minute interval prescribed for military training aircraft of the same type. [2,6,7,8,9]

A total of 1000 simulation cycles has been performed in order to gain a clear picture of the participants' behaviour and interaction. As the result, there are waiting times for each military training aircraft. The average waiting times for both aircraft types created during each simulation cycle are shown in Figure 2.

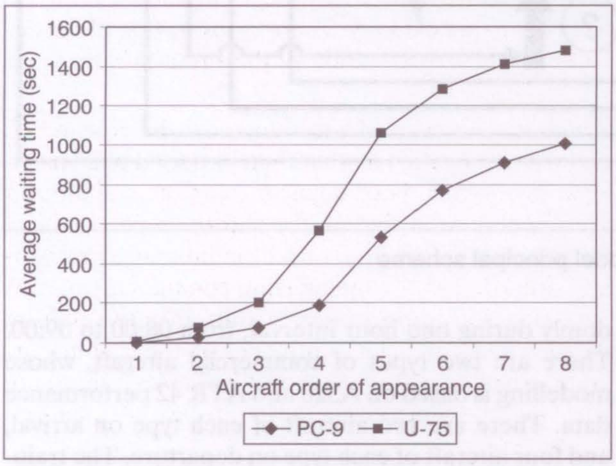

Figure 3 - Average apiece aircraft waiting time, five-minute interval simulations

In order to get a complete and clear picture of these waiting times there are average waiting times, and terminal values (the shortest and the longest average waiting times) for both training aircraft types separated and presented in Table 1.

Table 1 - Training aircraft average, shortest and longest waiting, 5-minute simulation interval

	PC-9	U-75
Average waiting time	440.64sec	762.77sec
Shortest average waiting time	38.63sec	250.38sec
Longest average waiting time	933.38sec	1428.88sec

In addition to remarkably long waiting times of both aircraft types it is noticeable that there is a shift, a disproportion between PC-9 and U-75 waiting times.

There is also an increase of waiting times of apiece aircraft in the same simulation cycle that is in direct correlation with the order of appearance, as shown in Figure 3.

These peculiarities of the simulation results require a thorough analysis. For this purpose, a case study is required, of the ideal situation where no interaction of different user's aircraft is obtained. Just for the purposes of clarification of the effect of the minimum separation between succeeding training aircraft of the same type the system is defined at the basis of fixed times of departure for training aircraft.

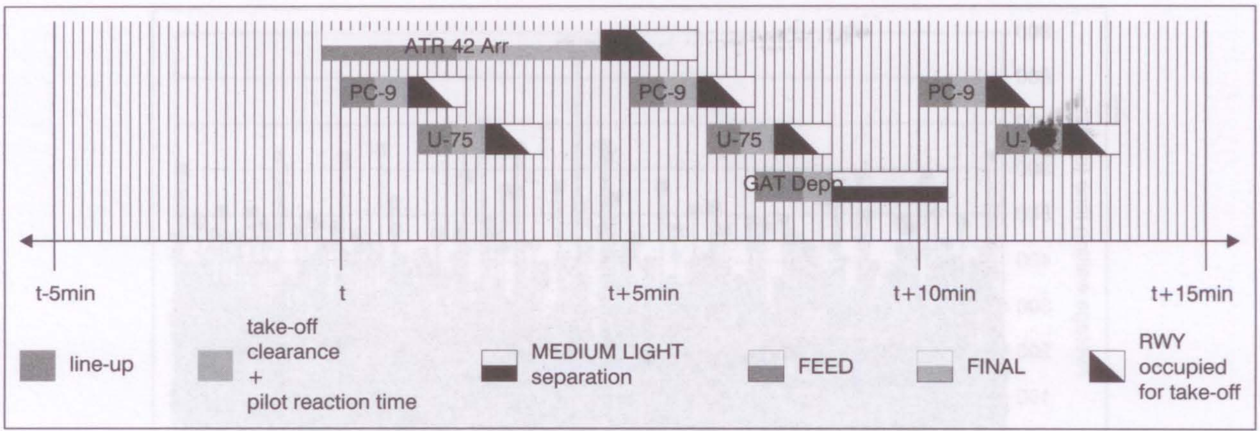

Figure 4 - Five-minute interval simulation timeline

The structure of particular timeline is shown in Figure 4. Starting at time "t" there is one PC-9 take-off operation followed by one U-75 take-off operation. Seconds after the U-75 started her take-off roll a commercial aircraft passes the outer marker position on her landing procedure and manages to pass the holding position of second PC-9 just in time to ensure that the No. 2 PC-9 is allowed to line-up without delay. Furthermore, the tail of the commercial aircraft on the landing manages to vacate the runway just in time to ensure that No 2. PC-9 is allowed to commence the take-off roll without delay. A similar ideal case is presented for the departing commercial aircraft.

Although sequencing of commercial arrival and departure is theoretically possible, it is not likely to be manifested in practice. It is obvious that every intrusion of a commercial flight into the chain structure of training flights produces delay that is transmitted to all succeeding flights in a domino effect. Additionally, there is a projection of delay from PC-9 chain to U-75 chain due to the given priority. This effect is shown in Figure 2 as the enormous average waiting times, those for U-75 being of greater value than those for PC-9.

The shape of the curve in Figure 3 shows increased build-up of aircraft delays in the middle part of chains, both U-75 and PC-9. The reason for this lies in the fact that there is a concentration of arriving aircraft in the corresponding portion of timeline.

It is interesting to spot that there is practically no solution to reduce the queue time once it is created.

The intervention into the structure of training flights operations timeline by increasing the separation interval between two aircraft to the value twice longer than the minimum separation opens the buffer space for delay absorption. In addition, the phase shift of five minutes between two training aircraft type chains aims to reduce interdependence of these aircraft types and hence the difference between waiting times of these aircraft types.

Another 1000 simulation cycles with previously described adjustment of settings were performed. What can be spotted in Figure 5 at a glance is that the results array descended down to values several times lower than these created in the previous set of simulation cycles.

Table 2 – Training aircraft average, shortest and longest waiting, 10-minute simulation interval

	PC-9	U-75
Average waiting time	129.41 sec	208.73 sec
Shortest average waiting time	4.25 sec	2.5 sec
pdefaultLongest average waiting time	525.75 sec	843.73 sec

Although the absolute difference between PC-9 and U-75 waiting times was considerably diminished, as shown in Table 2, PC-9 and U-75 average waiting times relative difference has changed just slightly. As a matter of fact it has increased from 0.577684 in the first simulation cycles to 0.619988 in the actual simulation cycles. The cause for this practically permanent ratio lies in model prerequisite that gives PC-9 aircraft the right of way in front of U-75 aircraft.

Another evidence of improvement of the model, besides greatly reduced waiting time, shown in Figure 6, is the chain flexibility. There is absorption of the delay generated in the middle of the aircraft chains, both PC-9 and U-75.

The complexity of the subject of the research is emphasized by the fact that there is a total of 28 participating aircraft. Four departing commercial aircraft are distributed in the middle and the second half of the simulation timeline, with little influence on training aircraft. Two of the arriving commercial aircraft have predicted appearance within an interval from 08.20 to 09.00, with little influence on the training aircraft as well. And yet, as shown in Table 2, there are great waiting times created even in case of enhanced model setup.

If the hourly runway capacity for mixed operations of commercial aircraft operations, that varies between

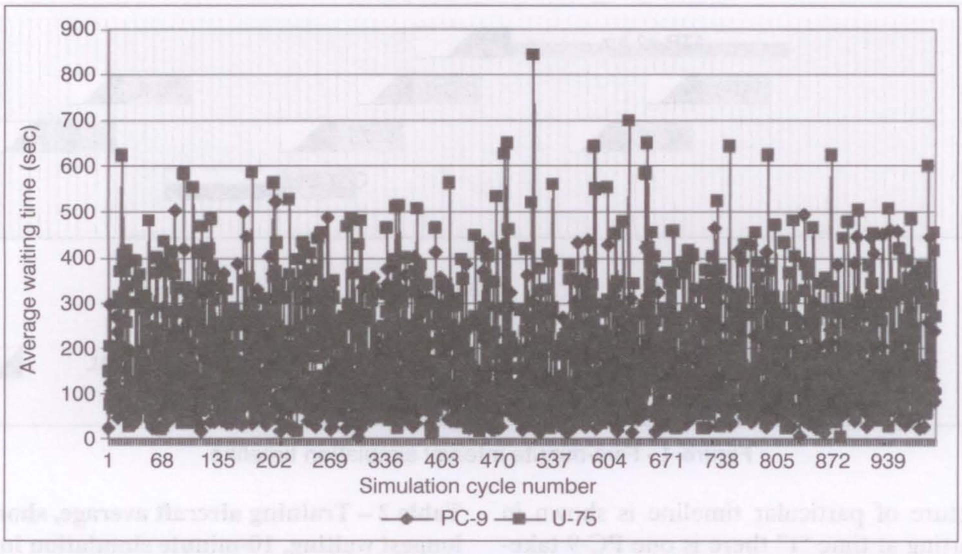

Figure 5 - Average training aircraft waiting times, ten-minute interval simulations

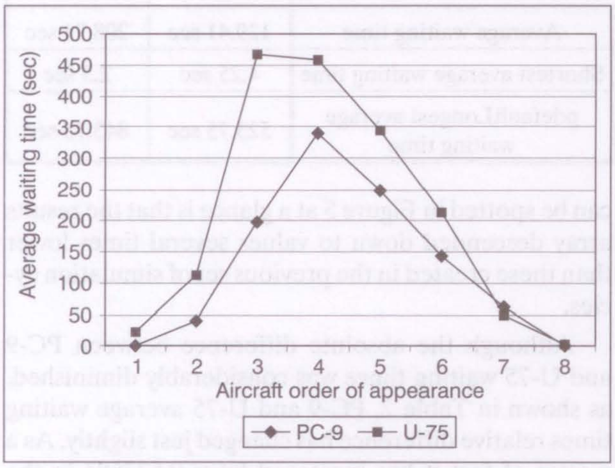

Figure 6 - Apiece aircraft waiting time, ten-minute interval simulations

28 and 42 operations per hour, depending on traffic mix, is taken into consideration, it is not likely that the excuse for the delays will be found. [1]

Further model enhancements are likely to be directed toward termination of strictly pre-defined training aircraft take-off time.

4. CONCLUSION

For a long period of time the military flying school performed their flying activities in a protected environment separated from other military and civil traffic. As a result of the growing air traffic, the undisturbed environment is not reserved for training flights any more. Different users were brought into the same airspace.

Among other peculiarities of military training flying, there is a variety of unconventional operations performed at the airport. Even these, at first sight conventional, take-off and landing operations, at the beginning and the end of route flying, have some organisational regulations that impose potential deterioration of the fluent performance of airport operations.

The simulation of possible traffic in case of further development of both commercial and training traffic in a volume that is below maximum runway capacity indicates that delays are unacceptably high.

Improvements of radar system precision that would improve runway capacity require more than sustainable investments. Simple re-structure of military training flight restrictions produce the reduction of delays to the acceptable level.

This relatively simple intervention into the mode of operations of only one of airport users by redefinition of inner regulations confirms the EUROCONTROL Airport Operations Programme. One of its four interdependent projects is Airport Collaborative Decision Making (CDM), information sharing and facilitating decision-making processes that ensure that airport users are provided with timely and accurate information essential for the planning of their operations.

Should the planning of the flying activities be altered to the level of collaboration of airport users instead of separate processes, one of the benefits would be better use of the existing resources and efficiency in operations.

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SAŽETAK

SIMULACIJSKI MODEL ZAJEDNIČKE CIVILNO-VOJNE UPORABE MANEVARSKE POVRŠINE AERODROMA ZADAR

Rad se bavi procedurama polijetanja i slijetanja raznovrsnih tipova zrakoplova sa iste uzletno sletne staze. Predočena su četiri različita reda čekanja, tri različite pozicije čekanja pokraj uzletno sletne staze i jedan prilaz na slijetanje. Izgrađen je simulacijski model tih uvjeta. Simulacijska analiza uporabe manevarske površine od strane komercijalnih i školskih letova pokazuje potrebu za optimizacijom menadžmenta zračnog prometa i harmonizacijom operativnih procedura sudionika.

KLJUČNE RIJEČI

civilno-vojna koordinacija, menadžment zračnog prometa, simulacija, procedura polijetanja, harmonizacija, uzletno-sletna staza

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