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NEW AERODROME OPERATING PROCEDURES FOR OPERATIONAL AIR TRAFFIC IN THE VICINITY OF ZADAR AIRPORT

SUMMARY

The implementation of the new military training areas and aerodrome operating procedures is based on several researches of the airspace characteristics, flight safety, traffic flow, evaluation of legislative, traffic demand and air traffic control and surveillance. This paper contains an analysis of airspace characteristics in the vicinity of Zadar airport, present military training areas and proposal for the implementation of new military training areas for operational air traffic (OAT). The factors which affect flying operations and complexity of creating new military training areas and aerodrome operating procedures are defined and analysed. Conducted research is based on the aerodrome operating procedures for Pilatus PC-9M aircraft and parameters of various regimes. The efficiency analysis is done using flight time and fuel consumption.

KEY WORDS

military training areas; aerodrome operating procedures, operational air traffic, general air traffic, Zadar Airport, Pilatus PC-9

1. INTRODUCTION

Civil-military cooperation has more and more effect on flight efficiency and effective use of airspace in scope of air traffic due to continuous growth of air operations. According to the flexible use of airspace (FUA) concept, which has recently been fully implemented in the Republic of Croatia, civil-military coordination is taking place at all provided levels of airspace management (ASM). Research for this paper was conducted in 2014 due to favourable conditions for that kind of research. This paper is still up-to-date because the similar research has not been repeated yet and neither the reconstruction of the military flying organization has taken place. The proposal of a part of airspace reservation shown in this paper, is suitable to FUA concept requirements [1]. That kind of implementation of military training area allows the inner structural setup of reserved airspace at tactical level which optimizes the entire air traffic. This kind of airspace can be reserved as temporary reserved area (TRA) or temporary segregated area (TSA), entirely or partially. Reservation criteria of the same airspace can be changed within a day if needed. The presented aerodrome operating procedures positively affect airspace capacity and air traffic flow within the controlled airspace, decrease the air traffic controllers' workload and impact on the environment. Reconstruction of the Croatian Air Force military training areas, according to the new organization and airspace usage models should contribute to the optimization of the Croatian airspace. Presented characteristics of Zadar airport surrounding airspace and statistical traffic data discovere a huge potential for airpace reconstruction. Presented proposals of aerodrome

operating procedures and military training areas meet all factors defined in this paper to prove economic benefits.

2. CHARACTERISTICS OF ZADAR AIRPORT AND THE SURROUNDING AIRSPACE

Zadar Airport characteristics refer to the geographical position and characteristics of manoeuvring areas. The most important elements are number and direction of runways and their equipment. Characteristics of the surrounding airspace are described in detail the organization of the surrounding airspace by the Croatia Control Ltd. and the Ministry of Defence of the Republic of Croatia. They also describe the meteorological conditions of the mentioned airspace. Those data are important for flight planning which affects other users of the airspace and flight safety as well.

2.1 BASIC INFORMATION

Zadar Airport is one of nine airports in the Republic of Croatia. It is situated near Donji Zemunik village which is seven kilometers away from Zadar city after which it was named. It has two perpendicularly positioned runways, which allows different flying operations to be performed in almost all meteorological conditions. Zadar airport is a home base of 93rd Air Force base of Croatian Air Force, i.e. for Pilatus PC-9M, Zlin Z242L, Bell 206B Jet Ranger 3, Kiowa Warrior OH-58D, Canadair CL-415, Airtractor AT-802 and AT-802F aircraft. Zadar airport meets 4E category of equipment and firefighting equipment meets the category CAT5 (CAT6 for summer flight schedule). Zadar Airport is equipped with approach lights CAT1 (A) on runway 14 and SALS (E) system on runway 32, 04 and 22. Precision approach path indicator (PAPI) is situated on runways 14, 32 and 04 and runway 22 does not have any. Geographical position of Zadar airport is presented further in this paper in Figure 1.

Figure 1 – Geographical position of Zadar airport
Source: [2]

2.2 METEOROLOGICAL CHARACTERISTICS

Meteorological characteristics consist of data on suitable and unsuitable meteorological conditions, cloudiness, number of sunny and rainy days, possibility of fog, value and type of rainfalls and winds. According to these parameters, Zadar Airport is one of the most suitable airports in the Republic of Croatia which provides future pilots huge opportunity for conducting training flights. Meteorological characteristics of Zadar Airport are presented in Table 1.

Table 1 – Meteorological conditions of Zadar Airport, Source [3]

Description		Value		
Average annual days with unsuitable conditions for jet flying		19		
Average annual cloud coverage		4 / 8		
Average annual sunny days		98		
Average annual cloudy days		55		
Average annual rainy days		129		
Average annual foggy days		26		
Average annual precipitation		966 mm		
Average annual snowy days		5	The earliest 23rd Nov.1965	
			The latest 22nd March,1958	
Fog appearance	Mostly	Autumn / Winter		
	Rarely	Summer		
Average annual thunder days		42		
Characteristic winds			Mostly directions	Highest speed
		Bura	030°- 060°	34 m/s 1958. g.
		Jugo	None	None

2.3 AIRSPACE – CTR, TMA, OAT TRAINING AREAS

Zadar Airport controlled airspace consists of control zone (CTR) and terminal area (TMA). CTR is limited by geographical coordinates and vertical limit. Zadar Airport CTR is categorized as Class D and flight rules specific to that class are applied. Transition altitude is set at 9500 ft above ground level (AGL) above which it is necessary to set the adequate pressure of 1013 hPa. Lower limit of TMA is 1000 ft AGL and upper limit is flight level 155 (FL155). CTR and TMA limits are presented in Figure 2.

Figure 2 – Cartographic display of Zadar CTR and TMA limits
Source: [4]

OAT means all flights, which do not comply with the provisions stated for GAT and for which rules and procedures have been specified by appropriate national authorities [5]. OAT training areas are situated in the vicinity of Zadar Airport and are defined in a document *''Naputak o načinima, postupcima i drugim uvjetima za sigurno uslijetanje i slijetanje vojnih zrakoplova na Aerodrom Zadar''* [3]. Visual flight rules (VFR) military training areas are presented in Figure 3.

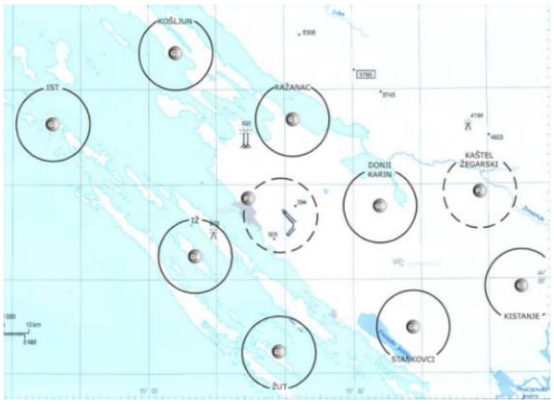

Figure 3 – VFR training areas for PC-9M aircraft
Source: [3]

As it can be seen in Figure 3, there are ten VFR military training areas for Pilatus PC-9M. Eight of them are set as main and two of them are set as auxiliary. Main VFR military training areas are Ražanac, Košljun, Ist, Iž, Žut, Stankovci, Kistanje and Donji Karin. Auxiliary VFR military training areas are Aerodrome and Kaštel Žegarski. By joining the already mentioned military training areas: Ražanac-Povljana, Molat-Premuda, Iž-Žut, Stankovci-Kistanje and Donji Karin-Kaštel Žegarski VFR military training areas for formation flying of two or more aircraft are created. Reserved Aerodrome is auxiliary VFR military training area for formation flying. They are presented in Figure 4.

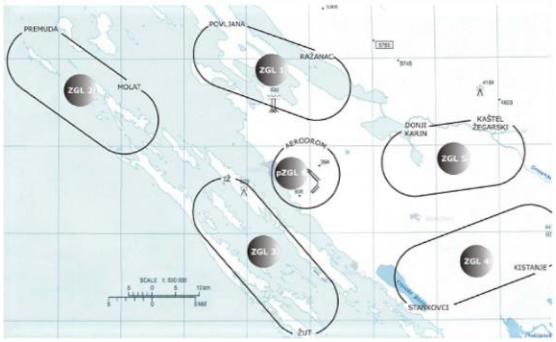

Figure 4 – Military training areas forPC-9M aircraft formation flying
Source: [3]

Five instrument flight rules (IFR) military training areas (SIERRA 1A/B, TANGO 1A/B, HOTEL 3B, FOXTROT 4A/B and INDIA 5A) are defined in document *''Naputak o načinima, postupcima i drugim uvjetima za sigurno uzlijetanje i slijetanje vojnih zrakoplova na Aerodrom Zadar''*. In the mentioned IFR military training areas, letters A and B refer to the flight levels in certain areas. In this paper, IFR military training areas are described for better perception of airspace in which flight operations are performed. They did not affect the formation of new VFR military training areas and aerodrome operating procedures.

3. STATISTICAL TRAFFIC DATA

3.1 OAT AND GAT TRAFFIC

Statistical data of OAT and general air traffic (GAT) are unavoidable elements of usage and congestion analysis of a certain airspace. GAT traffic means all movements of civil aircraft, as well as all movements of State aircraft (including military, customs and police aircraft) when these movements are carried out in conformity with the procedures of the ICAO [5]. Analysis of the mentioned data provides a real condition of the airspace within the observed area and reveals areas of different

situations. While analysing these data, it is important to mention and present numbers of flight operation at a certain airport during the whole year presenting the variable traffic according to months. Certain destinations are more loaded in winter period, depending on the type of tourism, so the number of flight operations are different according the time of the year. Also, data depend on the flight rules that aircraft use: visual flight rules (VFR) and instrument flight rules (IFR). VFR are rules conducted in accordance with visual meteorological conditions. IFR are rules conducted in accordance with instrument meteorological conditions. Statistical data of OAT and GAT and relation between VFR OAT, IFR OAT, VFR GAT and IFR GAT within the same period are presented in Chart 1.

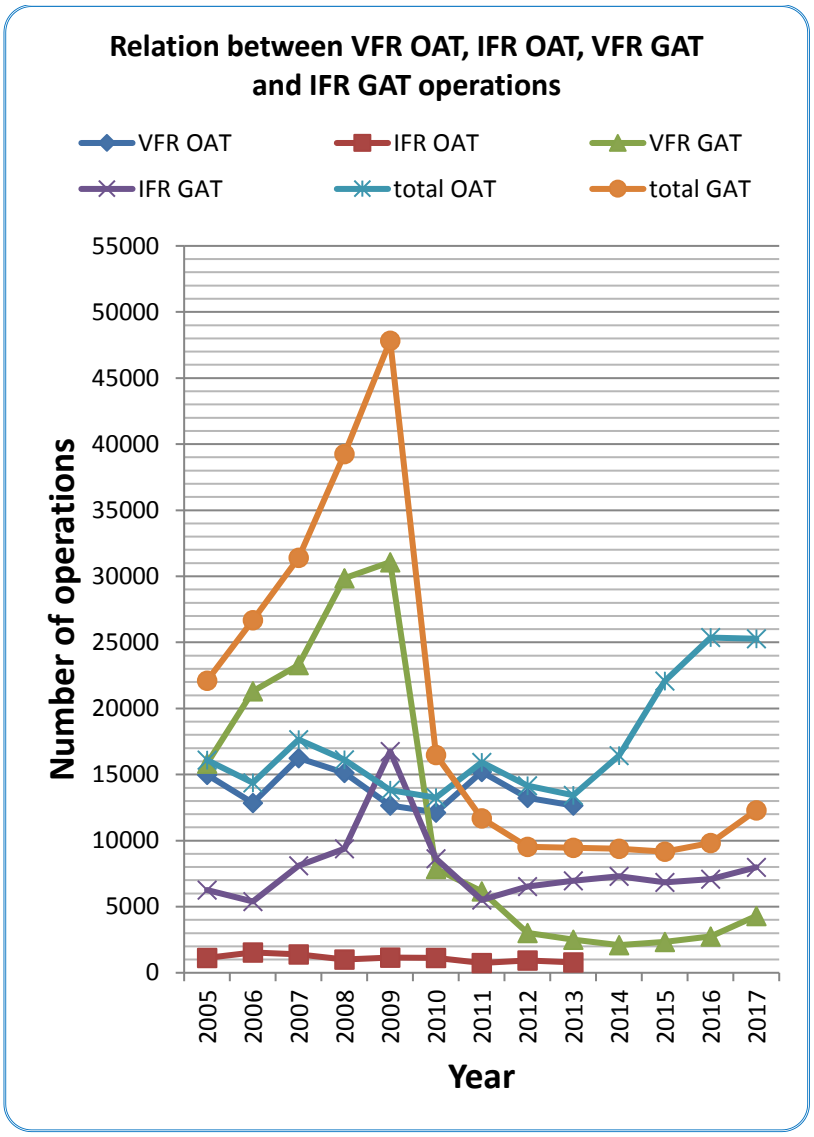

Chart 1 – Relation between VFR OAT, IFR OAT, VFR GAT and IFR GAT operations
Source: [6]

According to Chart 1, it can be concluded that years 2009 and 2010 were the milestones in the total number of OAT and GAT operations and, the aftermath of economic crisis can be seen. In the following years, the number GAT operations continued to fall due to the crisis. Since military traffic does not depend so much on the financial situation, OAT operations drop stopped. In 2011 the increase in the number of OAT operation is recorded, but just temporary. Until 2014, the number of OAT and GAT operations continued to decrease with the tendency to stabilize. In 2014, the number of total OAT operations rapidly increased until 2017 due to RAFO pilots training. Traffic data for OAT traffic are given just for the total amount of operations between 2014 and 2017. These years don't show individual data for VFR OAT and IFR OAT operations. In the same period, number of GAT operations

slowly increased. The effect of the economic crisis in the Republic of Croatia and the surrounding states that have established continuous airline connections with the Zadar Airport needs to be emphasized.

3.2 VFR AND IFR TRAFFIC

Relation of the number of VFR and IFR flight operations is important for determining the most common type of flight operation. During the mentioned years, the share relation of VFR and IFR operations of OAT and GAT, according to statistical data, was changing. Major changes happened with IFR GAT which has, unlike in the early years, made serious advance in the number of operations. The reason is, as mentioned, economic crisis which financially influenced the numerous private airspace users disabling them in using air traffic services (ATS). Airlines which provide commercial flight service succeed to sustain their own share of air traffic operations. After 2014, share relation between IFR GAT and VFR GAT operations started to equate and merge during 2017. Share relation, especially for VFR OAT and IFR OAT operations, between 2014 and 2017 is unknown. The relation of VFR and IFR, OAT and GAT operations from 2005 to 2017 is presented in Chart 2.

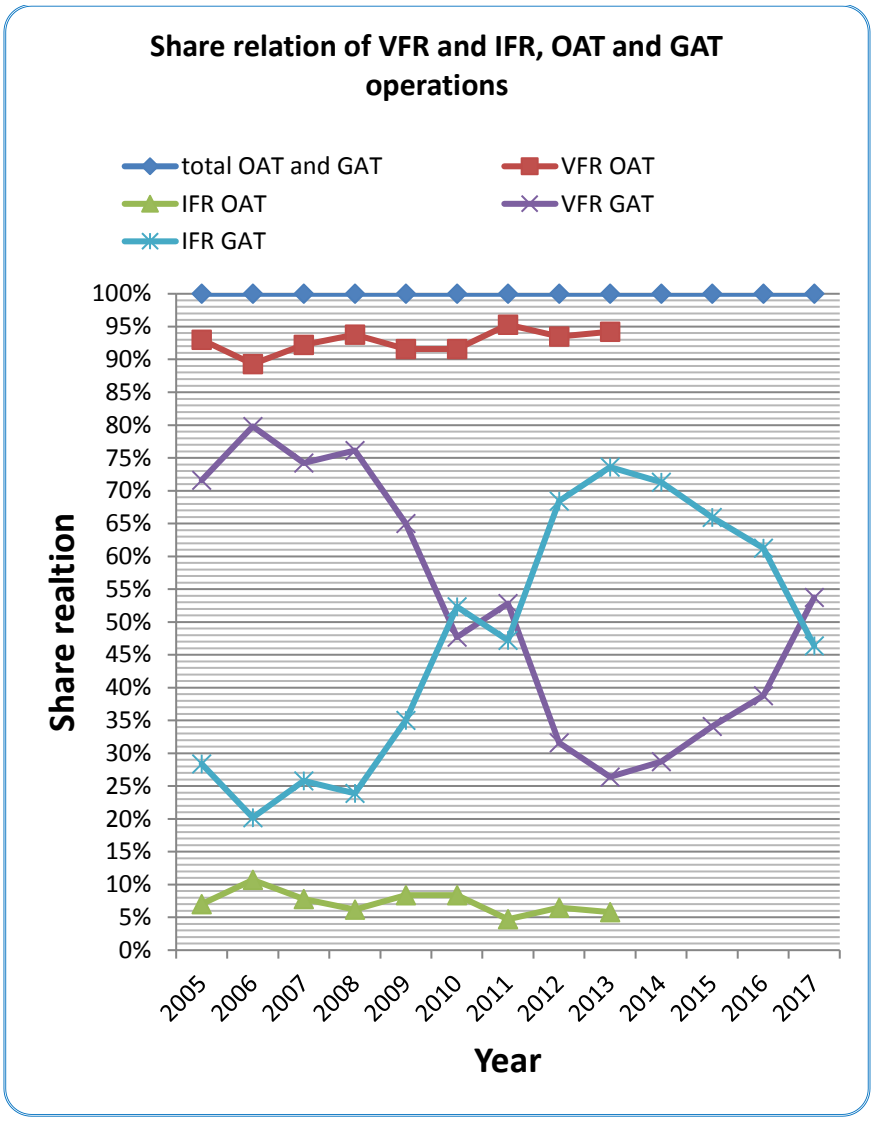

Chart 2 – relation of VFR and IFR, OAT and GAT operations
Source: [6]

3.3 ANALYSIS OF THE PRESENT OAT AERODROME OPERATING PROCEDURES

For a high-quality analysis of the present OAT aerodrome operating procedures it is necessary to conduct an analysis of the impact on factors that affect OAT aerodrome operating procedures. The mentioned factors contain components of airspace organization, general air traffic, meteorological conditions, flight safety and economics. These factors allow selection of the suitable airspace to construct the proposal of new military training areas and OAT aerodrome operating procedures and they are listed and shortly explained in the continuation of this paper.

3.4 FACTORS WITCH AFFECT OAT AERODROME OPERATING PROCEDURES

3.4.1 TRAJECTORY OF GAT

During the military flight planning it is necessary to take into calculation GAT flights and foreseen times of GAT flight operations to avoid collision of the two or more aircraft and to decrease congestion in certain parts of the given airspace. Also, by avoiding trajectory of GAT, the possibility of endangering the flight safety decreases. Analysing the standard GAT flight routes and trajectories, the free airspace suitable for Croatian military aircraft missions is discovered.

3.4.2 DISTANCE FROM THE AIRPORT

Distance from the airport is related to flight safety and emergency procedures. During the conduction of Croatian military aircraft flight operations, the possibility of the emergencies is increased in relation to the civil flights. The reason for this is higher intensity of aircraft and pilot/crew load caused by demanding way of flying and demanding manoeuvres. During the flight operations with two or more aircraft, the possibility of emergencies exponentially grows.

3.4.3 VERTICAL LIMITS OF MILITARY TRAINING AREAS

Military training area is set by geographical coordinates as lateral limits, and by vertical limits. There are lower and upper vertical limits. Lower vertical limit is defined according to flight safety and the upper vertical limit is defined according to the operational abilities and legal regulations of the airspace. Higher altitude of military training area is more adequate during the emergencies because a pilot/crew has greater possibility to reach distant points or airports from the present position, using the aircraft glide ration. That gives the pilot/crew additional safety and greater range of possibilities for emergencies which directly contributes to the higher level of flight safety.

3.4.4 METEOROLOGICAL CONDITIONS

Meteorological conditions are important factor for flight planning. To decrease the number of cancelled flights due to unsuitable meteorological conditions it is necessary, if possible, to plan flight over the areas with more favourable meteorological conditions. Areas over the open sea or lowlands have steadier atmosphere in relation to mountainous areas. Surrounding area of Zadar Airport is specific with a great surface variety. Impact of the Velebit mountain, its downwashes and turbulences, are highly recommended to be avoided and the western area from Zadar Airport, mostly unused, is presented as a possible solution for planning and conducting flight missions.

3.4.5 AIR TRAFFIC CONTROL

Air traffic control (ATC) provides service in the controlled airspace with the special emphasis on the vicinity of Zadar Airport where great number of military and civil flight operations are being performed. Zadar Airport is recording a large number of flight operations, especially during the summer. To reduce the air traffic controller workload, it is necessary to move the traffic outside the CTR and leave it under radar supervision. In case of Croatian military aircraft flights, there are pre-arranged aerodrome operating instructions for home base so the radio-communication between pilot/crew and air traffic controller is minimized. Additional decrease of radio-communication load can be achieved by

shortening or simplifying aerodrome operating procedures in the vicinity of the airport. It is mostly achieved by direct routing to specific points in the airspace after departure.

3.4.6 DIRECTION OF THE RUNWAY-IN-USE

Direction of the runway-in-use affects the flight time of aerodrome operating procedure. It is ideal to plan military training areas which are perpendicular to the extended runway centreline. In that way, the time of departure and recovery does not depend on runway-in-use which decreases the possibility of flight time extension in case of active runway changing. As it was mentioned before, there is a huge unused airspace west of Zadar Airport. That airspace can easily be used for more intensive conducting of flights than it is used nowadays and, thus, it can contribute to flight mission economics of the Croatian military aircraft.

3.4.7 CIVILIAN POPULATION AND ENVIRONMENTAL IMPACT

Civilian population safety and preservation of infrastructure necessary for living and business represent the basic mission within the safety scope. To decrease the possibility of threats to human life it is necessary to plan flights over the less populated areas. The area west of Zadar Airport meets that requirement. Islands and sea area contain significantly lower percentage of population than mainland areas. It should be taken into consideration that military flights are more often exposed to higher mechanical loads on the aircraft construction, so the possibility of emergencies is increased. The impact of noise and exhaust gases pollution on the civilian population and agricultural goods, should be minimized to the lowest possible level. Today, modern aircraft power-plant systems are constantly being tested and meet the highest standards of ecological protection. The awareness of nature conservation and people's health should be constantly developed and sustained at the highest level.

3.5 RESTRICTED AREAS

Restricted areas in the vicinity of Zadar Airport do not affect greatly the entire air traffic. Restricted area LD(R) 22 is located west of Zadar Airport and west of Dugi otok island. Airspace between the mentioned restricted area and Zadar Airport CTR is mostly free. At present it is being used for Croatian military flights but not entirely. The rest of the Zadar Airport surrounding airspace does not contain restricted areas except for certain parts of airspace that are sometimes temporarily closed as military training areas.

4. METHODOLOGY OF DETERMINING NEW AERODROME OPERATING PROCEDURES FOR OAT

Methodology of determining new military training areas and aerodrome operating procedures contains four parts: statistical data processing of the present airspace status, discovering free and suitable airspace, defining lateral and vertical limits of the military training areas and production of aerodrome operating procedures for the particular military training area. Tendency of air traffic within a certain airspace is revealed through statistical data processing. These data are used for detection of free i.e. unused airspace. The same airspace is tested according to the parameters explained in the previous chapter. A military training area, or more than one, is constructed within the suitable airspace by defining lateral and vertical limits. During this phase of construction, it is necessary to consider the flight characteristics of the aircraft for which they are intended. Flight characteristics of Pilatus PC-9M aircraft are published in Aircraft Flight Manual (AFM). They are important in this phase so that military training area can be adjusted to all possible flight elements. First and foremost, there are acrobatic elements being the most demanding flight elements. After the construction of military training areas, aerodrome operating procedures are made for every military training area with the adjusted flight

characteristics for PC-9M aircraft to assure conduction within the aircraft performance limits and flight safety.

4.1 AN EXAMPLE OF THE PROPOSED NEW MILITARY TRAINING AREA

Military training area ''X'' is shown in this paper as the main airspace suitable for military fight organization. There are four proposals of the organization of military flights situated within that area in terms of new military training areas and new aerodrome operating procedures. The mentioned proposals are based on the previously listed factors that affect OAT aerodrome operating procedures. One proposal of the airspace organization within the military training area 'X'' is presented in Figure 5.

Figure 5 – Organisation of military training area ''X'' (proposal 1)
Source: [7]

According to Figure 5, training areas ''X1'', ''X2'' and ''X3'' are approximately of the same size which has been proved by mathematical calculation. Each of the presented areas in their size and volume is suitable for the conduction of all types of single aircraft flight missions.

The size of the military training area was chosen according to the present size of the military training areas intended for PC-9M aircraft. Vertical limits in this proposal are from 5000 ft to FL150. The mentioned military training areas can be divided in half with safety buffers which enables implementation of two military training areas. Each proposal is elaborated in detail in this paper.

4.2 FLIGHT PARAMETERS

During the determination of new military training areas and aerodrome operating procedures, PC-9M aircraft flight parameters were considered for climb, steady level flight and descent phase and took during flight. Listed parameters are necessary for economic analysis and they are presented in Table 2.

Table 2 – Parameters for economic analysis of new aerodrome operating procedures, Source: [7]

Flight regime	Airspeed (IAS) (kt)	Vertical speed (ft/min)	Fuel consumption (lb/min)
Climb	180	3000	9 (8000')
	140	3500	9 (9000')
			8,8 (FL 130)
Steady Level Flight	210	-	6 (5000')
			5,9 (6000')
			5,8 (7000')
			5,7 (8000')
			5,6 (9000')
			5,5 (FL 110)
			5,3 (FL 130)
Descent	210	3500	4 (5000')
			3,9 (6000')
		4500 (airbrake)	3,8 (7000')
			3,6 (FL 110)

The presented Table 2 consists of data which shows flight regimes of PC-9M aircraft. Airspeed is defined according to the flight regime, vertical speed is read from the instrument during the flight, and the fuel consumption is expressed as the average fuel consumption during level change or during steady level flight. Climb is a regime where altitude is increased. There are two climb regimes with different airspeeds. The first regime requires indicated airspeed (IAS) of 210 kt and the rate of climb (ROC) 3000 ft/min. The same data are presented for the regime at IAS of 140 kt. In that regime ROC is 3500 ft/min and fuel consumption, as during the first regime, depends on the altitude. Steady level flight is a regime at IAS of 210 kt and fuel consumption depends on air density. Fuel consumption is presented in (Table 2) and detailed data can be checked in fuel consumption chart within the AFM for PC-9M. Descent is a regime during which altitude is decreased. There are two descent regimes. The difference is in airbrakes usage. IAS 210 kt is the same during both regimes. Without airbrakes, the rate of descent (ROD) is 3500 ft/min and with airbrakes ROD is 4500 ft/min, while IAS stays fixed. Fuel consumption depends on the altitude and it is presented in Table 2.

5. RESULT – ECONOMIC ANALYSIS

Economic analysis presented in this paper verifies the well conducted analysis of the current airspace state and research into new organization solutions of Zadar Airport surrounding airspace. Comparative analysis of the current military training area ''Iž'' and the new military training area ''X2L'' is presented in Table 3.

Table 3 – Comparison of the military training area ''Iž'' and military training area ''X2L'', Source: [7]

Military training area	Iž				X2L			
RUNWAY DIRECTION	14		32		14		32	
AERODROME OPERATING PROCEDURES	DEPARTURE	RECOVERY	DEPARTURE	RECOVERY	DEPARTURE	RECOVERY	DEPARTURE	RECOVERY
Flight time (min)	5	8	4	9	3,7	3,5	3,1	3,7
Fuel consumption (lb)	36,5	54,1	30,7	51,1	30,4	16,9	26,9	18,1
Total fuel used (lb)	90,6		81,8		47,3		45	
Fuel saved (lb)	-		-		43,3 (47,8 %)		36,8 (45 %)	

Comparison of the mentioned training areas has been considered because they have almost identical positions but different aerodrome operating procedures. The shape of the area and its lateral limits have been changed which provides larger military training area. Even though the vertical limit has been decreased, it is still suitable for all flight missions for PC-9M aircraft.

Fuel consumption data in the specific military areas during the aerodrome operating procedures can be read from the Table 3. Fuel used depends on the direction of runway-in- use. Total fuel used necessary for aerodrome operating procedures shows the difference between military training areas. The most important is percentage of fuel saved. According to fuel savings based on single flight of single aircraft, the difference is not great. However, when the number of PC-9M aircraft flight operations is considered, according to percentage of fuel saving, a major amount of saved fuel can be calculated annually.

6. CONCLUSION

During the last decade, the number of flight operations at Zadar Airport constantly changed. OAT statistical data show that economic crisis left consequences even on the strongest user – air force. Trend of changing the number of flight operations and types of flights in a specific airspace leads to increased frequency of flight operations in certain parts of airspace and leaves the other parts unused. To eliminate this negative phenomenon, it is necessary to reroute air traffic, if possible, to less used airspace. Croatian Air Force flights are independent in relation to civil commercial flights so they can be adjusted in time and space.

Zadar Airport surrounding airspace is specific due to its diversity of Earth's surface. The best suitable airspace is west of Zadar Airport. That airspace is unused by the civil air traffic. Commercial flights do not have implemented routes in that area and GAT is trying to avoid flights above the sea. As it can be concluded from the mentioned data, airspace above the sea stays free. By reviewing the restricted areas and published routes of civil air traffic, there is a huge empty airspace ideal for Croatian military flights.

Military training areas intended for PC-9M aircraft are scattered in almost all directions from the Zadar Airport. Some of them are unsuitable due to several reasons if factors for improvement of military flights are being considered. As mentioned, the best suitable position for military training areas is the one perpendicular to the runway. Implemented military training area ''X'', explained in this paper, is placed in such a way. The same military training area would allow decreased impact of military flights to civil flights and vice versa, decreased flight time for aerodrome operating procedures which directly affect the fuel consumption and pilot/crew and air traffic controller workload.

Further research is conditioned by practical checks during flights and measuring of the parameters in real situations for obtaining more precise results. Will it happen depends on the will and persistence of the leading individuals in the Croatian Air Force. The undertaken effort will result in the reduction of the Croatian Air Force flights costs, system improvement and the awareness of the Croatian military pilots to constantly monitor the supply and demand balance in the Croatian airspace.

REFERENCES

[1] Eurocontrol. European Route Network Improvement Plan – PART 3: Airspace Management (ASM) Handbook. Eurocontrol; 2017

[2] URL: http://www.zadar-airport.hr/ (cited: 04.06.2014.)

[3] Republika Hrvatska. Naputak o načinima, postupcima i drugim uvjetima za sigurno uzlijetanje i slijetanje vojnih zrakoplova na Aerodrom Zadar. Zagreb: Ministarstvo obrane RH; 2005

[4] Hrvatska kontrola zračne plovidbe. eAIP Republic of Croatia. Zagreb: Hrvatska kontrola zračne plovidbe; 2014

[5] Eurocontrol. Specifications for harmonized Rules for Operational Air Traffic (OAT) under Instrument Flight Rules (IFR) inside controlled Airspace of the ECAC Area (EUROAT). Erocontrol; 2016

[6] Zračna luka Zadar. Statistički podaci o prometu. Ured operativnih usluga u zračnom prometu. Zračna luka Zadar; 2018

[7] Jerinić D. Novi postupci letenja OAT prometa u okolnom prostoru Zračne luke Zadar [diplomski rad]. Zagreb, Sveučilište u Zagrebu; 2015.