THE IMPACT OF A GENERIC TEMPORARY SEGREGATED AREA IN THE CROATIAN AIRSPACE WITHIN THE REGIONAL AIR TRAFFIC FLOW

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ABSTRACT

As a basic FUA principle, airspace should no longer be designated as military or civil airspace but should be used flexibly on a day-to-day basis. All users (military and civil) may have access and, based on actual needs, their requests should be managed to achieve the most efficient use of the airspace. Wherever possible, permanent airspace segregation should be avoided. In that regard, the introduction of Temporary Segregated Areas (TSAs) may seem as a necessity within a specific national system. However, during its activation period, TSAs will affect the air traffic flow within its sector in terms of capacity and flight economy for civil operators. In that regard, a case study on the generic TSA design in the Croatian Air Traffic system as presented in this paper analyzes the extent of its impact on the regional air traffic flow and consequently – the level of its acceptability.

Keywords: Flexible use of Airspace, Temporary Segregated Area, Conditional Route, Flight Efficiency, Military training, Re-routing procedures, Air Traffic Management

1 INTRODUCTION

Membership to NATO and EU organizations demands from national military aviation services to be increasingly engaged in many different multinational air exercises and joint training activities. These specific air sorties require segregated airspace structures and generally do not happen on a daily basis. By the virtue of the Flexible Use of Airspace Concept (FUA) it is no longer practical to designate airspace as either civil or military. Therefore, it should be considered as one continuum and used flexibly, while any segregation should be of temporary nature. Consequently, specific military air operations may be executed within temporary segregated airspace structures that would be active only within specified time period and necessary vertical limits.

In case of national airspace, it is postulated that there is a need for such airspace structure that would comply with a set of predetermined tactical requirements and would serve as temporary segregated area for military operations/training, regardless of mission type. Simultaneously to the activation of such area, it is up to Airspace Management services to ensure re-routing procedures for other airspace users in order to achieve regular and fluent traffic flow with required Operational Air Traffic/General Air Traffic (OAT/GAT) separation. In that particular arrangement, the introduction of new airway segments would inevitably cause negative effects on flight efficiency for airline operators, i.e. increase in flight time and distance, which would in turn cause further increases in fuel consumption.

While the application of the FUA Concept undoubtedly leads to a number of improvements related to flight efficiency of civil air traffic, which in this case may benefit from the increase in flight economy, it also brings an opposite impact in case a TSA is being activated. With this in mind, it is paramount that TSAs are designed in the most optimal way to mitigate the aforementioned effect.

In that regard, this paper elaborates impacts on certain aspects of flight efficiency that affect airline operators, in the case of establishment and activation of hypothetical new TSA within the Croatian airspace. The TSA itself will be designed in respect to a number of tactical requirements, mostly related to military missions and aircraft types.

For these purposes, a tool named the System for Traffic Assignment and Analysis at a Macroscopic level (SAAM), developed by EUROCONTROL, will be used for the given analysis.

2 OBSERVATIONS ON THE FLIGHT EFFICIENCY AND ITS RELATION TO THE FLEXIBLE USE OF AIRSPACE

The development of the airspace structure plays a major role in improving both flight efficiency and capacity, by providing alternative routeing options to accommodate diverse user requirements - both civil and military.

Flight efficiency is a key aspect of the operator's strategy how to use the airspace structures in the execution of commercial flight. Generally, airline operators will be interested to fly between two points of a route in the most direct fashion. Of course, this will not always be possible on the account of the airspace capacity within any given sector. Consequently, re-routing will take place and operators will suffer certain increase in overall flight time, which will directly affect their flight efficiency.

There are numerous interpretations of flight efficiency. The most common is that flight efficiency is defined as the difference between the actual flight path length and direct path length connecting the entry and exit points of the flights for the selected centre, presented as additional mileage, flight time, fuel burn and cost to operators [1]. In order to measure the flight efficiency, a set of indicators is established i.e. route efficiency indicator, flight duration indicator, fuel burn indicator and others, each of them being derived separately.

Optimizing the flight efficiency is a continuous process, faced with challenges of constant traffic growth and environmental requirements. In that regard, EUROCONTROL, IATA and CANSO have developed a Flight Efficiency Plan, with a goal of identifying operational actions that would lead to fuel and emissions savings in the short term [2]. Actions are derived through five different action points out of which 1) Enhancement of the European en-route airspace design and 2) Improving airspace utilization and route network availability are the most relevant ones in the narrow context of this paper.

Flight efficiency will be the primary aspect of OAT/GAT that will suffer from re-routing of trajectories in period when alternative usage of air structure is allocated within the dynamic airspace management process. The amount of impact will be relative to the efficiency in design of the alternative trajectories as well as the generic air structure itself. In other words, such an airspace design that brings lesser allocation in both lateral and vertical flight profile would entail more acceptable decrease in flight efficiency for civil operators.

It is further postulated that specific regional sectors are more saturated than others, and the impact of the activation of TSA to the civil air traffic would differ from case to case according to the specific airway layout, position of Terminal Airspace (TMAs) and average density of the air traffic in the given sector. However, relatively smaller states, such is Croatia, in case of establishing of the TSA have little room to negotiate either position of such area, or the impact that it would bring to the regional air traffic in time of its activation. This is where the national air traffic strategy comes into play, because this, or any other FUA based concept - may prove to be a necessity. It is worth noting that at this point of time it is that only Croatia, Slovenia, Cyprus and Turkey have not made any indication that those countries would adopt some sort of FUA based operational concept (TSAs, CDRs…)[3].

The planning and establishment of Permanent Air Traffic Services (ATS) Routes and Conditional Routes (CDRs), including OAT routing scenarios as well as of military training areas (TSA/TRA/CBA) is conducted nationally and internationally within the framework of a coordinated and cooperative European-wide ATS route structure [4].

Routing structures and scenarios are developed taking into account the following assumptions:

- The route architecture is planned to include adjustable elements in order to accommodate the variation in expected traffic demand, while
- The traffic distribution conforms to the recommended operational practices for the route utilisation in order to derive, from the structure, the best possible capacity.

3 DESIGNING OF THE TEMPORARY SEGREGATED AREA IN RESPECT TO PREDETERMINED TACTICAL REQUIREMENTS

Temporary Segregated Area (TSA) is an airspace temporarily segregated and allocated for the exclusive use of a particular user during a determined period of time and through which other traffic will not be allowed to transit [5].

Design of the TSA structure has to take into account several different operational parameters. In case of the Croatian national airspace strategy, TSA is needed for specific military training operations. In that regard, very stringent mission profile requirements should be derived in order to opt for the minimal footprint of the segregated structure.

For the purpose of this study, a specific profile is chosen to set the basis for TSA design. Aircraft type corresponds to the Lockheed Martin F-16 multirole jet fighter airplane. Aircraft type choice is made under few assumptions. Primarily, it is one of the most present multirole aircraft in the military inventories of most NATO/EU countries. Then, given the advertised strategy of long-term development of the Croatian Armed Forces, it is reasonably imaginable that aircraft of similar or same tactical characteristics enters into the inventory of its air force service [6].

After a reference aircraft type has been chosen, optimal dimensional parameters of the required airspace is derived on the basis of given mission profile. In that regard, two basic mission profiles may be used as a reference; Air-to-Ground and Air-to-Air training sorties, each requiring different amounts of airspace. Although there is a number of different requirements in existence for the same aircraft type and mission profile, the United States Air Force (USAF) requirements will be used for the purposes of this study henceforth. These state that for quality Air-to-Ground missions training a volume of 40 by 40 NM of airspace from the surface to FL 350 is required. When the mission changes to Air-to-Air events, this requirement expands to 80 by 40 NM, from surface to FL 500. However, only Air-to-Ground missions will be accounted for in this study, hence the requirement rests with a 40 by 40 NM perimeter, up to FL 350. Within this specified perimeter, also a sub-airspace volume has to be established with minimum of 26.1 by 30.3 NM for the purposes of SAT (Surface Attack Tactics) training sorties. All the safety buffers for segregation of the military and civil traffic should remain within this TSA.

In order to position the new airspace structure, another key requirement has to be accounted for; for the purposes of Air-to-Ground missions, a designated ground range with dedicated facilities has to exist within this area. The Slunj range in northern Lika area (LD R-18), for which a navigational warning for restricted (R) areas issued by Croatian ATC exists - is best suited for this purpose and will serve as a basis for TSA design. The restriction warning is defined for the airspace from GND to 65650 ft MSL respectively. Additionally, if TSA is positioned around Slunj range, the requirement of 100 NM maximum flight distance to the airbase is automatically met, given the position of several existing or prospective Croatian military airbases (Zagreb, Zadar and Pula) as well as NATO airbase in Aviano, Italy.

In figure 1, a 40 by 40 NM zone is initially positioned with the respect to set of basic requirements (green). With given size and the Slunj area (violet) positioned within the boundaries of the zone, all of the previously set military requirements are successfully met. However, the existing airway layout clearly implies that a new TSA will bring implications on the civil air traffic during its activation. In that regard, the adaptation of new zone, as well of the existing route network, will have to be undertaken in order to conform to requirements of both civil and military flights.

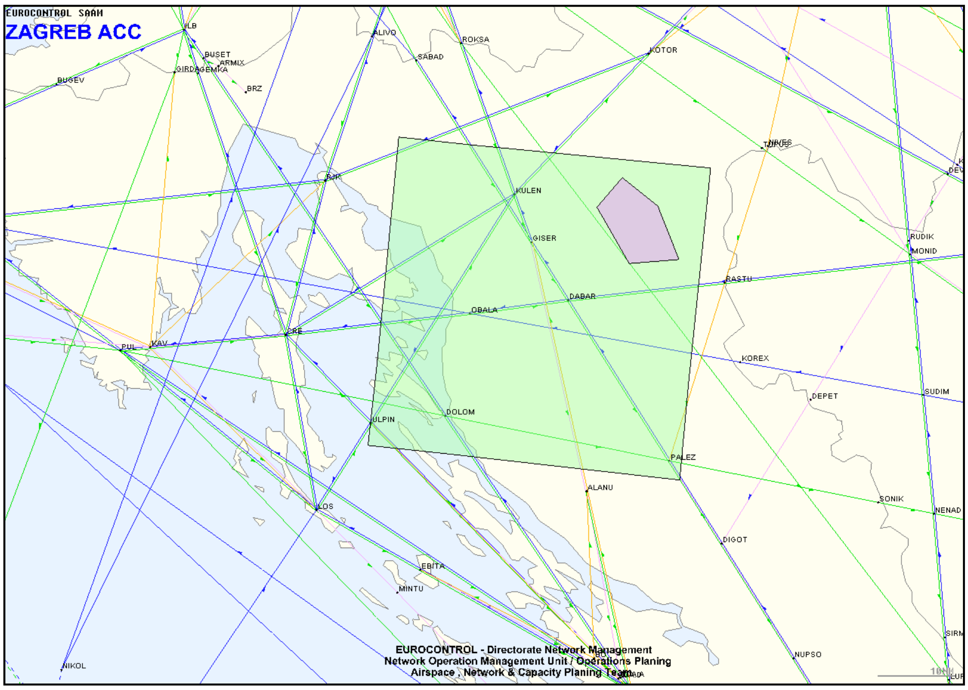

Figure 1: Initial zone layout with restricted airspace inside.
Source: Authors

After setting the initial zone layout, further adaptation has to be taken. In order to preserve as much of the civil traffic route segments as possible, the southwest corner of the zone may be trimmed in respect to the adjacent route segment. Additionally, the inner SAT module (26.1 by 30.3 NM) is also set considering the precondition of having the range positioned within its boundaries (yellow). Ultimately, the zone is designed as depicted in figure 2. It needs to be noted that minimal flight distance of 100 NM to respective airbases is positively achieved.

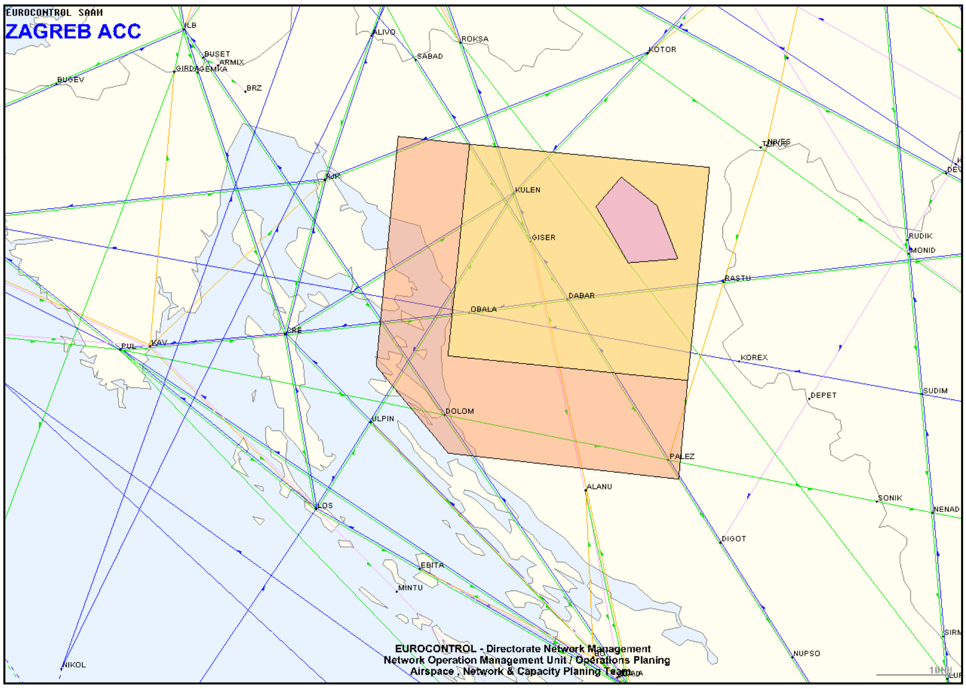

Figure 2: Final layout of possible future TSA.
Source: Authors

4 ADAPTATION OF ROUTE SEGMENTS IN ACCORDANCE WITH TSA LAYOUT

The intersection of the TSA geographical footprint and the existing route network conditions some adaptation of a number of affected route segments. The goal of this adaptation is re-routing of the air traffic in respect to regular air traffic flow requirements. These include landing and departure procedures to/from Split, Pula, Zadar, Zagreb, Lošinj, Brač, Rijeka and Ljubljana airports, as well as the provision of optimized alternative route network for overflights during TSA activation. Considering the fact that the introduction of a new zone will comply with the FUA Concept, the existing route segments that cross through the new airspace structure should be defined as Conditional Routes (CDRs).

CDRs are non-permanent Air Traffic Services (ATS) route or portion thereof which can be planned and used under specified conditions. According to their foreseen availability, flight planning possibilities and the expected level of activity of the possible associated TSAs, CDRs can be divided into few categories. However, route segments in the particular case should be defined as Category 1 (CDR1) which stands for permanently plannable CDR. For CDR1 route segments, Airspace Use Plans (AUP) and Updated AUPs (UUP) should be issued accordingly and in respect to Airspace Management (ASM) and the FUA Concept.

Route segments that are affected will be defined as CDR1 (closed for civil air traffic during TSA activation period) and these are as follows:

a) NIVES – RASTU – PALEZ (Y137)

This segment is used for Arival procedures (ARR) to Split (LDSP) over VOR ZAG from North or Zagreb (LDZA). As an alternative, a new segment is added; NIVES – DEPET which joins with the ARR segment DEPET – DIGOT.

b) KOTOR- RJK and RJK – KOTOR (T/UT742)

This segment is used for ARR/DEP procedures to/from Pula (LDPL) as well as for overflights. It does not enter the TSA, but it is not possible to define area's boundaries beyond the minimal distance from the segment, which is 5 NM. Therefore, alternative route should be added for this segment as well. The alternative is KOTOR – LDLDL – RJK and RJK – LDLDL –RJK where LDLDL is a new point. However, with the introduction of LDLDL, the minimum distance of 5 NM to TSA is still not achieved and further adaptation of north-west corner is needed. New segment and TSA layout are depicted in figure 3.

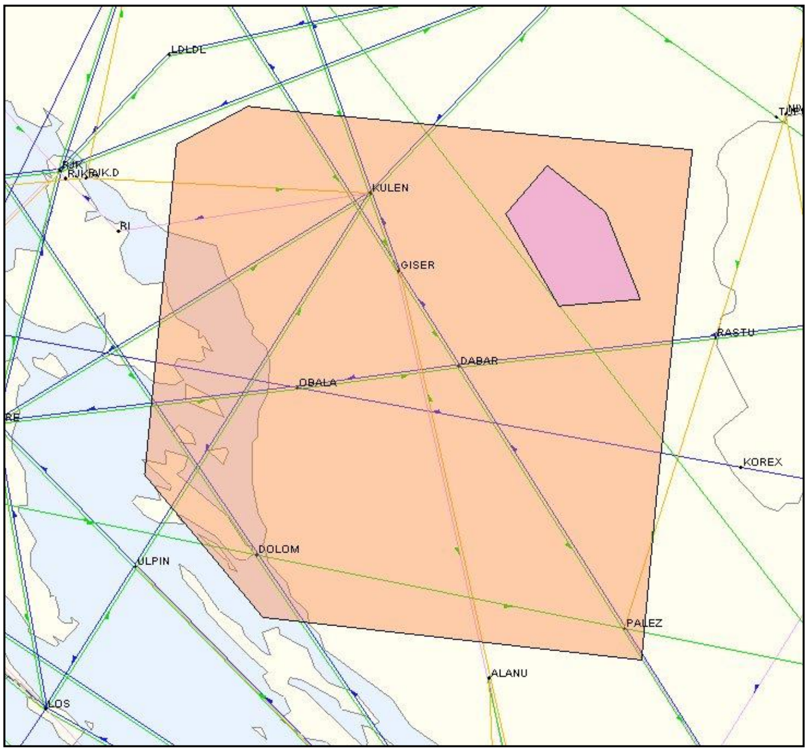

Figure 3: New segment and further adaptation of TSA
Source: Authors

c) KOTOR – MULEN (M/UM986)
This important segment is used for ARR procedures to LDZD, LDPL, LDRI and LDLO. A number of modifications have been undertaken in terms of alternative routing. As an alternative for LDPL there is a possibility of using LDLDL (new point) for ARR/SEP procedures and then through RJK. As an alternative for LDRI, a new segment DEP LDRI is added (SID) through LDLDL and for ARR segment (STAR) - new segment is LDLDL – FAFAF – RJK, where FAFAF is a new point. For LDZD there is a possibility of routing through KOTOR – LDLDL – RJK – CRE or by development of a new STAR procedure over DIGOT point. For LDLO a number of procedures exist over CRE and in that regard new segments are not needed. Additionaly, for overflights there is an alternative over CRE and RJK.

d) PUL – DOLMO – PALEZ (UL614)
For this segment a new alternative route has been defined. The alternative segment is SPSPS – NENAD, where SPSPS is a new point and lies on UN606 between PUL and ZDA VORs.

e) KOREX – OBALA – NAKIT (L/UL615)
This segment has also been given a new alternative routing. New segment is BOSNA – NENAD – SPSPS.

f) RASTU – DABAR – OBALA – CRE (P11)
This segment is Lower airspace only and is used mostly for departures from LQBK (Banja Luka). This segment is already covered with a number of alternatives so no new segments will be added.

g) ROKSA – LUPAR (UY450)
There is an alternative over TUPUS.

All of the new segments as proposed by authors, are depicted in figure 4.

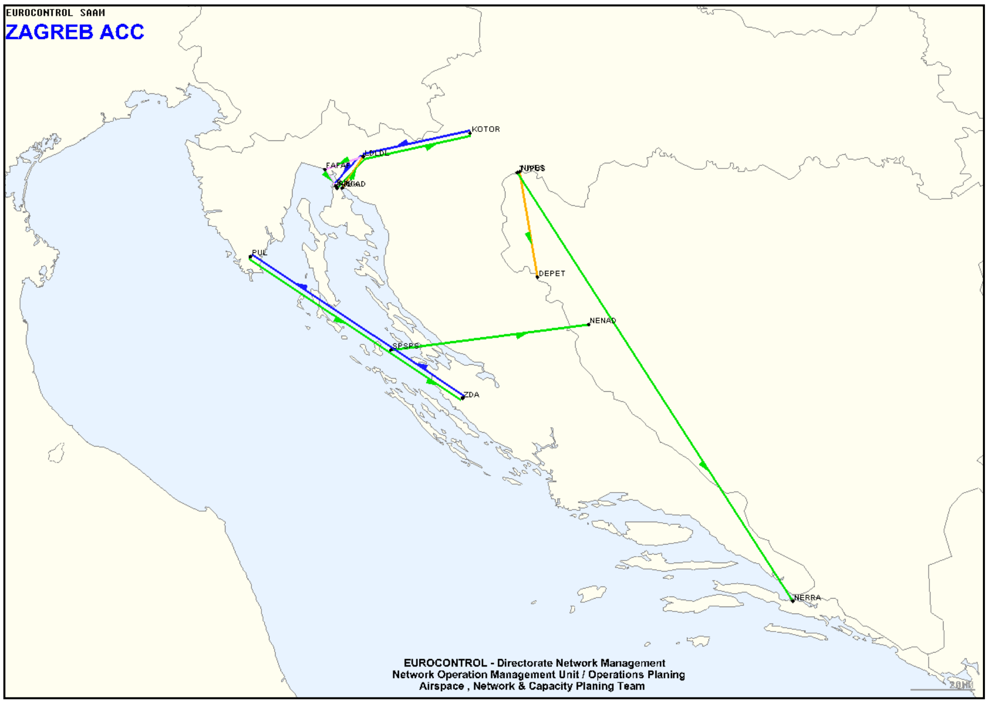

Figure 4: New segments for alternative routing.
Source: Authors

5 EVALUATION STUDY ON THE IMPACT OF TSA ACTIVATION ON THE FLIGHT EFFICIENCY OF THE CIVIL AIR TRAFFIC

The study is intended to evaluate the potential impact of a hypothetical TSA, as proposed in this paper, on the civil air traffic during its activation period. The impact will be addressed in terms of flight distance and time increase, fuel combustion difference and environmental influence (CO2 and NOx emissions). Considering the dynamic nature of the traffic flow and the fact that the impact could be mitigated with an adequate choice of activation period in relation to the given density over time criteria, that period will also be subject of analysis.

The analysis will be made on the basis of real traffic data for the given sector, as recorded in CFMU (Central Flow Management Unit – Eurocontrol) on July 30, 2011, within 24 hours timeframe. The data corresponds to flights on CDRs only. Same matrix will serve as a baseline for obtaining the optimal activation time slot in respect to some other military requirements that will be explained further in this paper.

The collected data indicate that the average flight distance in segments is 35.4 NM with the average flight time of 5.3 minutes. The maximum number of aircraft within the zone in the same time is 5. Maximum number of flights (origin – destination; city pair) is between ESSA (Stockholm) and LDSP (Split) and equals 5 flights. Most number of departures is from Ljubljana (10 flights) and the most arrivals is to LDSP (54). The most present aircraft type is A320 with 22 flights in total, while the most present operators are Adria Airways with 17 flights and Croatia Airlines with 13 flights. Total number of flights within 24 hour period is 143. Load within inactive TSA for H24 is shown in figure 5.

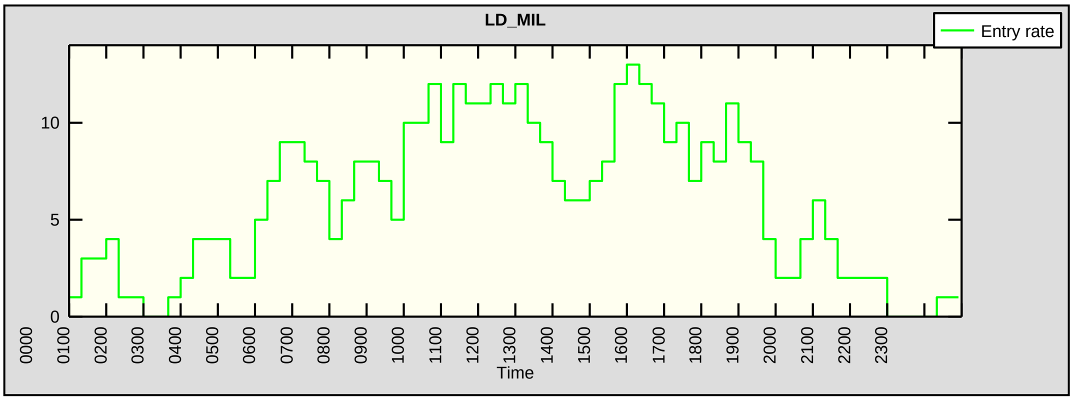

Figure 5: Load for H24 with inactive TSA
Source: Authors

Considering the traffic flow within the H24 time slot, and military requirements in terms of "working hours" (which is usually set between 08:00 to 17:00 hours for routine activities), we can derive a time slot when activation of TSA is most acceptable from the civil point of view. This will correspond to a lesser traffic density at given time. Taking both requirements into consideration, the period between 12:30 and 14:30 seems to be the most adequate in terms of possible activation period. If circumstances permit, this period could be further refined to a more narrow time slot of 1 hour (training sorties of that duration). In that case the optimal period would be set between 13:00 and 14:00. The most adequate period of TSA activation is shown in figure 6.

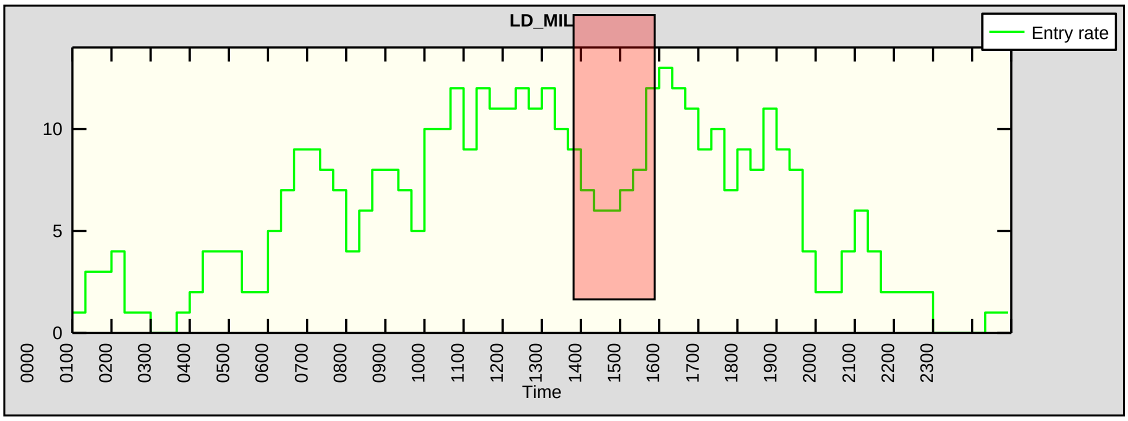

Figure 6: The most adequate period for TSA activation.
Source: Authors

The analysis of the traffic flow in the chosen two hours period shows the following: It is necessary to re-route the total of 28 flights, all of which are to be re-routed laterally. There is no practicality in re-routing by altitude, given the abundant height of the TSA (up to FL350). Those 28 flights will be affected in the following manner:

- Flight distance is increased by **261.59 NM**,
- Flight duration is increased by **38.36 min**,
- Fuel combustion is increased by **1225.85 kg**,
- Additional **3848.89 kg** of **CO2** and **14.49 kg** of **NOx** is produced.

The largest increase in flight distance and flight time would be recorded for the flight LJILJ – LGIR (operated by Adria Airways) and it would be 28.26 NM or 3.77 minutes respectively. Fuel combustion in this case would be increased by 148.03 kg. The largest amount of re-routed flights would be from EDDM (Munich) – 4 flights, and to LDSP (Split) – 8 flights. All 28 respective flights are shown in figure 7.

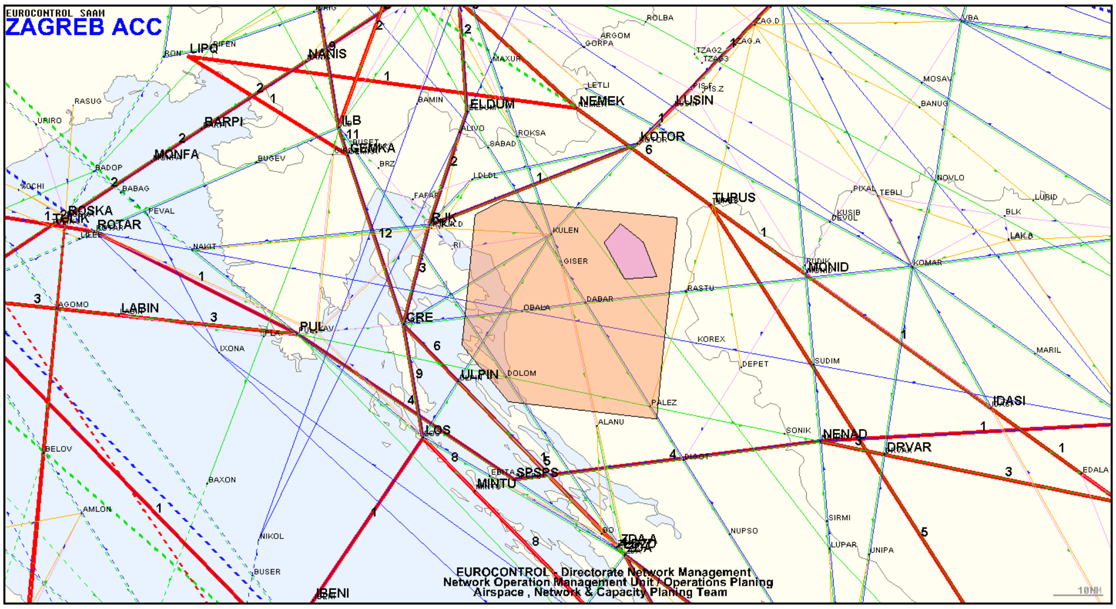

Figure 7: Re-routed flights during TSA activation
Source: Authors

6 CONCLUSION

The study has shown that the impact of the hypothetical TSA design activation for the purposes of specific military operations would not present significant challenges for the respective Air Traffic Management (ATM) cells in terms of the sector capacity management. It should be noted that any changes in terms of re-routing would take place within the same sector (West – Lower/Upper) hence no changes in load would be expected for adjacent sectors. In parallel, no need for capacity changes for those sectors would be expected either. Any hypothetical changes of the capacity would be the consequence of some unexpected eventualities related to changes of the traffic flow complexity. These eventualities are too specific to be part of this study and further research is needed in that regard.

From the operator's standpoint, any negative changes to flight efficiency indicators would present an unwanted event. However, although this study has shown that there would be a number of changes; these would be in no way critical for the routine operations of the civil air traffic and in that regard these would be deemed as operationally acceptable.

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