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Possible Measures to Estimate Military Airspace Capacity

Abstract

Controlled airspace have a capacity value to ensure safe and efficient management of air traffic. The capacity value represents the maximum number of aircraft that can safely operate within a given airspace over a certain period of time, while maintaining the required level of safety and efficiency. From a civilian air traffic control point of view, it is crucial to have a clear understanding of the capacity value of each airspace. This information helps controllers to effectively manage the traffic flow within the airspace and avoid overloading, which can lead to delays, increased fuel consumption and potential safety risks. Additionally, knowing the capacity value of an airspace can also help controllers to make valid decisions when it comes to scheduling flights, route planning and managing air traffic during peak periods. By understanding the importance of the capacity values of an airspace controlled by a civilian provider, it is essential to have capacity values in airspace under military control as well in order to complete the given military operations successfully. In my study, I would like to present the aspects of the possible determination of the capacity value of military airspace.

Keywords: airspace, air traffic management, air traffic control, capacity, traffic demand, value

Introduction

Russia's military aggression against Ukraine having significant impact on the airspace over Europe underlines the urgent need to secure our access and ability to operate in the air domain. Moreover, due to the rapid development of the aviation industry, civil and military airspace users are able to cover greater distances in a significantly shorter time than before. In this ever-changing environment, civilian air traffic and

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its technological systems and procedures have played a greater role, but military air traffic has also – thanks to the 4th and 5th generation combat aircraft and unmanned aerial vehicles – undergone significant changes. After the Covid-19 pandemic period, the civilian air traffic started to recover and similarly to the 2019 traffic period, air navigation service providers operate at the limit of their capacity with a certain degree of flexibility. In the months of May, June, July, August and September – which can be regarded as a special traffic period in aviation – ensuring a balanced and smooth air traffic flow is an extremely complicated task.

Thunderstorm activities, technical failures, lack of air traffic controllers and airport capacity, changes in the infrastructural condition of airports, possible strike situations, and many other negative factors individually or even together can negatively influence the flow of air traffic.² If we were able to theoretically reduce the impact of the above mentioned factors to an acceptable level, then there would still be the airspace itself, which the airlines and even the military parties would be unable by themselves to constantly maintain at the highest economic level (to get from the departure airport to the destination by the shortest route). One of the reasons for this is that from an aviation perspective, the airspace is not homogeneous, it is significantly fragmented, and the number of air navigation service providers – who provide air traffic control service – is extremely high. The other reason is the military side, as – from the point of view of the civilian actors – a potential source of danger, who from time to time request or require large segments of airspace in order to carry out training and other operational flights. In order to minimise the above mentioned negative impacts, and to ensure that the use of airspace is optimal for both military and civilian side at all times of the year, the coordination process between the parties must be well-defined, understandable and clear to all.

One of the main indicators of the smooth flow of civil and military air traffic is the capacity of the available airspace. In civil aviation, the number of aircraft provided with air traffic control service cannot be more than the air navigation service provider can handle safely, therefore, air navigation service providers must define air traffic control capacity values or control areas, control sectors and airports.³ In a civilian traffic environment, the capacity values for each control sector are well defined, the reason for this is that the intensity of civil traffic can be well predicted, and the flights carried out in each sector typically show the same picture (route flights).⁴ On the other hand, the military air traffic – managed by military air traffic services in reserved airspaces for military use – cannot be predicted in all cases (especially with regard to the current Russian–Ukrainian war situation) and the complexity of the traffic – both the manner of its task and the type of aircraft performing – is higher, which means that determining the military capacity values is also a complex task. In order to calculate the capacity value of military airspace, we have to analyse many factors, including the traffic needs, the characteristics of the available airspaces, the composition of air traffic services, as well as their technological possibilities.

² BIRDAL–ÜZÜMCÜ 2019.

³ COOK 2007.

⁴ ZHANG–CHEN 2018: 4609–4614.

Increasing military budget vs. airspace characteristics

Access to airspace is a primary concern for both the civilian and military parties; however, the motivation is different. Despite the fact that the civilian air traffic is growing, increasing defence budget in many countries has also significant effect on the airspace usage. The measures taken at the 2016 NATO Summit in Warsaw to increase the defence budget – reaching 2% of GDP – also increased the military procurement, research and development projects. A newly introduced military equipment – regardless of whether it is used within the air force or the ground forces – can easily affect significant changes in the airspace structure, which I would like to illustrate with an example:

Recently, several NATO member states announced that they are planning to acquire 5th generation F-35 II combat aircraft as part of their military development. In terms of airspace utilisation, the difference between the most modern 5th generation aircraft compared to previous generations is the larger airspace required in order to use all the capabilities of the aircraft. The United States Air Force has defined the parameters of the airspace necessary to provide training flights for the 4th and 5th generation combat aircraft, which can be summarised in the table below:

Table 1: Airspace requirements of 5th generation combat aircraft

Parameter/Mission	Minimum requirement	Desired requirement
Altitude	10K to 50K feet MSL	Surface to Unlimited
Large Force Exercise	120 NM × 80 NM	160 NM × 100 NM
Strategic SEAD/DEAD	120 NM × 80 NM	160 NM × 100 NM
Tactical SEAD/DEAD	80 NM × 80 NM	120 NM × 80 NM
Offensive Counter Air	90 NM × 60 NM	160 NM × 100 NM
Defensive Counter Air	90 NM × 60 NM	120 NM × 80 NM
Close Air Support	40 NM × 40 NM	120 NM × 80 NM

Source: Compiled by the author based on the data presented by the NATO Joint Air Power Competence Center at the spring meeting of the NATO Aviation Committee 2019.

By comparing the values in the above table with the parameters of the separated airspaces of the European member states of NATO, it can be seen that the vertical and horizontal airspace requirements of 5th generation combat aircraft training flights are significantly greater than the parameters of the currently available airspace. Due to the main European air traffic routes and the increased number of aircraft, it is currently a big challenge to designate 160 NM × 100 NM airspace in Europe for 5th generation aircraft training flights. Allies must be able to exploit 5th generation aircraft to the maximum extent and be able to exercise current and future technological capabilities of such platforms, in order to be able to operate in highly contested and degraded environments. A mix of permissive and contested scenarios are necessary to fully explore, normalise and optimise the ability of these aircraft. Exercises and training activity to produce deterrence and defence effects may vary greatly in size, frequency and locations. Different types of missions entail specific airspace requirements, which will in turn have specificities for aircrew proficiency, mission qualification, upgrade

training or deployment and tactics development. These scenarios may include GPS jamming, supersonic flights, Electromagnetic Warfare, as well as the use of ground emitters simulating radars on a common datalink.⁵ Based on the above mentioned reasons, we can say that the current airspace in Europe is not yet fit for this purpose. The need for larger volumes of airspace has been recognised but we have not yet determined exactly how many military aircraft can be in a larger volume of airspace.

Issues of the military airspace capacity estimation

According to the Joint Decree 26/2007 (III.1.) of the Ministry of Economy and Transport, the Ministry of Defence, the Ministry of Environment and Water on the designation of the Hungarian airspace for aviation, MCTR⁶ and MTMA⁷ areas are designated for military operations. These areas are considered as controlled airspace, so the Hungarian Armed Forces provide air traffic control services there. In addition, the military side typically uses other airspace too in order to perform various tasks (Temporary Reserved Area, Danger Area, ad-hoc airspace, etc.), however, I plan to illustrate the aspects related to capacity values through the MCTR and MTMA given that these military areas usually have the highest traffic load in Hungary.

Thanks to the military development projects, military air traffic is significantly growing in Hungary. Parallel to these processes, the workload of the military air traffic services and the traffic load of the available airspace are also growing. The capacity of the airports is basically determined by material factors. The parameters of the runway, aprons, taxiways and other infrastructural elements (terminal building, navigation, communication and surveillance equipment, etc.) make it easy to calculate the capacity of a given airport. Nevertheless, determining the capacity of an airspace (MCTR, MTMA) which belongs to a given airport is a much more complicated task which requires a different approach.

Since military air traffic in Hungary will reach a higher level compared to the last period, it is essential to maximise the capacity of the airspace designated to the airports. In order to achieve this, it is essential to understand the traffic demand. Without an accurate forecast of traffic demand we cannot use the available airport resources (air traffic control services, ground handling, navigational personnel, etc.) in a proper way. The level of traffic demand in MCTR and MTMA depends on several variables such as weather, number of training flights, international exercises, calibration flights as well as all tasks which occupy the available frequency for providing air traffic services. Forecasting these variables is a complex task, regardless of whether we want to plan the traffic demand for a month, a day, or even an hour in advance.

During the pre-tactical air traffic flow management phase (one day before the mission day) the availability of (mostly) exact traffic forecast data will most likely mean a balanced load during the mission day in our airspace or sector. In addition, with the help of the transmission of relevant air traffic data via a predefined protocol,

⁵ NATO 2023: 1-1.

⁶ Military Control Zone.

⁷ Military Terminal Control Area.

the traffic situation will be more predictable not only in MCTR and MTMA, but it can contribute to a more accurate determination of the traffic indicators of the European air traffic network, which can also contribute to a safer and continuous flow of air traffic. Sharing data between neighbouring civilian or military air traffic control services allows us to take into account the different priorities of stakeholders in flight missions, which we can later use in the decision-making process. This mutual attention can ensure a more predictable operation for all stakeholders, with a much more efficient and effective use of resources. For both civil and military airspace users, such improvements mean that they can optimise each flight tasks while trying to take into account the priorities of other users.⁸ For the Hungarian Air Force all of this means that they are able to make the best use of the available resources at a time when civil air traffic is operating with the highest level.

After clarifying the philosophy of traffic demand, it is necessary to review the determination of the capacity of the airspace belonging to the military airports. Decree 57/2016 (XII. 22.) of the Ministry of National Development on the Rules and Procedures of the Air Traffic Control Services provides directives for the capacity planning in Hungary. According to this legislation, air traffic services must define air traffic control capacity values for control areas and airports. In accordance with this, the decree regulates in detail the process of the determination of the capacity values, as well as the procedures related to the review and reduction of the already determined values.

We can use several models to calculate the capacity of the airspace (e.g. neural network modelling, geometric modelling). The specifications of each model are well presented in the study of Bence Számel and Géza Szabó about *Airspace Capacity Estimation Based on Theoretical Models*. Regardless of which model is used, it is always necessary to provide the given method with data input, which can be grouped as follows:

- static data of the airspace characteristics (e.g. sector boundaries, route network)
- radar data
- subjective data from controllers regarding the complexity of traffic situations and the importance of complexity factors⁹

From the list above, the static data can be obtained from the AIP¹⁰ and MILAIP¹¹ documents, and the traffic-related radar data can be obtained from the applied air traffic management system. In order to find the proper way to calculate the capacity value, the production of traffic complexity related data is the biggest challenge. One of the biggest differences between the characteristics of the flight tasks performed at military and civilian airports is that while civil airports are mostly used by fixed-wing aircraft with scheduled departure and arrival procedures, the military operational tasks in MCTR and MTMA could be much more complex and difficult (e.g. fix and rotary wing aircraft movements at the same time, parachute exercise, special flight procedures). According to this, when we assess the complexity factors during the

⁸ SCHEFERS et al. 2017: 321–328.

⁹ SZÁMEL–SZABÓ 2014: 301.

¹⁰ Aeronautical Information Publication.

¹¹ Military Aeronautical Information Publication.

determination of the capacity values, the above-mentioned circumstances must be taken into account in all cases. In my opinion, the typical complexity factors of civil and military airports can provide together the necessary amount of data which can be used in a calculation model.

Based on the above mentioned study, I have summarised the military complexity factors¹² in MCTR and MTMA (military control area means MCTR and MTMA):

Table 2: MCTR and MTMA complexity factors

	Complexity factors
1.	The number of aircraft in the military control area
2.	The number of aircraft climbing and descending in the military control area
3.	The proportion of climbing and descending aircraft in the military control area in relation to all aircraft
4.	Average density of aircraft in the military control area
5.	The dispersion of the speeds of aircraft in the military control area
6.	Average divergence of aircraft in military control area and its relative insensitivity
7.	Average convergence and insensitivity of aircraft in military control area
8.	The volume of the military control area
9.	The amount of potential conflicts between aircraft in the military control area
10.	The standard deviation of aircraft category in the military control area
11.	Proportion of aircraft on precision approach in the military control area compared to all other aircraft
12.	The complexity of typically used training scenarios
13.	The number of climbing and descending aircraft in the neighbouring sectors

Source: compiled by the author

If it is possible to calculate the capacity of the MCTR and MTMA values with the help of the data provided by the above mentioned complexity factors, it is not necessary to use the result as a static data. This statement is important because during the flight tasks, expected or unexpected events (e.g. navigation failure, thunderstorm activity, shortage of air traffic control personnel, etc.) can reduce the capacity values. When calculating the capacity of a specific airspace, the workload of the air traffic controllers must also be taken into account.

Conclusion

Airspace is a strategic domain shared by civilian and military actors: civilian aviation is a strong driver of economic growth, ensuring jobs, trade and mobility; military aviation is an essential component of the Armed Forces that complements and protects the civilian dimension. In recent years, the traffic demand exceeds the available airspace capacity on both civilian and military side. The constantly growing traffic demand requires a completely new innovative approach from the military side in the field of airspace management. The adaptation of some civilian procedures related to the use

¹² Cook et al. 2015: 149–158.

of airspace is necessary for military actors, given that a significant part of the flight tasks performed by military aircraft are under general air traffic rules. Based on this, it is necessary to determine military capacity values in MCTR and MTMA, which will provide a reference point to the calculation of the acceptable workload of military air traffic controllers as well. Determining the capacity values for each airspace requires a comprehensive analysis of various factors that can impact air traffic operations. These factors can include the size and shape of the airspace, the types of aircraft and operations that will take place within the airspace, the available air traffic control resources, and the weather and other environmental conditions.

The complexity of military air traffic in terms of capacity values can vary significantly depending on the type and location of the military airspace and the nature of the military operations being conducted. Military airspace can range from small to large training areas, and the capacity values can vary based on the airspace type, location and operational requirements. It is important to note that capacity values are not fixed and can vary based on the mentioned factors. Therefore, it is essential to stay up-to-date with the latest information and guidance provided by the relevant authorities to ensure safe and efficient operations within the airspace. Military air traffic can be more complex than civilian air traffic due to several factors. For example, military aircraft can operate at different altitudes and speeds than civilian aircraft, and they may have different navigation and communication equipment. Military aircraft may also operate in formation or conduct tactical manoeuvres, which require additional coordination and communication with air traffic control. Furthermore, military airspace may have different capacity values because of the different types of aircraft and they also are affected by specific military assets in the airspace. In my opinion, using the complexity factors presented in my study the missing capacity values in MCTR and MTMA segments in Hungary may become possible to determine. As soon as the capacity values have been determined, military air traffic flow management procedures can be introduced into Hungarian Military Air Navigation Services.

References

- BIRDAL, Emre O. – ÜZÜMCÜ, Serdar (2019): *Usage of Machine Learning Algorithms in Flexible Use of Airspace Concept*. 2019 IEEE/AIAA 38th Digital Avionics Systems Conference (DASC), San Diego, USA. Online: <https://doi.org/10.1109/DASC43569.2019.9081654>
- COOK, Andrew ed. (2007): *European Air Traffic Management. Principles, Practice and Research*. London: Routledge. Online: <https://doi.org/10.4324/9781315256030>
- COOK, Andrew – BLOM, Henk A. P. – LILLO, Fabrizio – MANTEGNA, Rosario Nunzio – MICCICHÈ, Salvatore – RIVAS, Damián – VÁZQUEZ, Rafael – ZANIN, Massimiliano (2015): Applying Complexity Science to Air Traffic Management. *Journal of Air Transport Management*, 42, 149–158. Online: <https://doi.org/10.1016/j.jairtraman.2014.09.011>

- NATO (2023): AVC Tasks to Investigate Possible Measures to Mitigate Crossborder Limitations for Modern Air Combat Aircraft, AC92-WP(2023)0011 (INV), 20 April 2023, 1-1. Online: <https://diweb.hq.nato.int>
- REMUS, Lacatus (2016): Preparing for a 'Single European Sky'. Military Prompted to Adapt to Future Air Traffic Management. *JAPCC Journal*, 23.
- SCHEFERS, Nina – PIERA, Miquel Angel – RAMOS, Juan José – NOSEDA, Jenaro (2017): Causal Analysis of Airline Trajectory Preferences to Improve Airspace Capacity. *Procedia Computer Science*, 104, 321–328. Online: <https://doi.org/10.1016/j.procs.2017.01.141>
- SZÁMEL, Bence D. – SZABÓ, Géza (2014): Légtérkapacitás-számítás elméleti modellek alapján [Airspace Capacity Estimation Based on Theoretical Models]. *Repüléstudományi Közlemények*, 26(2), 296–318. Online: <https://folyoirat.ludovika.hu/index.php/reptudkoz/article/view/4623>
- ZHANG, Defu – CHEN, Yangzhou (2018): *Airspace Sectorization Method for Flexible Airspace Management*. 37th Chinese Control Conference (CCC), Wuhan, China. 4609–4614. Online: <https://doi.org/10.23919/ChiCC.2018.8482807>

Legal references

- Commission Regulation (EC) No. 2150/2005 of 23 December 2005 Laying Down Common Rules for the Flexible Use of Airspace
- Decree 3/2006 (II. 2.) of the Ministry of Defence on Rules of the Air Applicable within the Airspace Designated for the Purpose of State Flights
- Decree 57/2016 (XII. 22.) of the Ministry of National Development on the Rules and Procedures of the Air Traffic Control Services