

DETERMINING AIR SOVEREIGNTY SYSTEM SUFFICIENCY

Svetoslav Slavov, Petrana Kokudeva

***Summary:** In order to understand the necessary potential of the air sovereignty system to cope with modern challenges, it is necessary to understand it as a complex system, including different but functionally related systems and the operational environment, whose role is reduced to the formation of requirements for these systems. For this objective, the components of the air sovereignty system and their associated criteria and benchmarks are considered. Analyzing the main components of the air sovereignty system, an attempt has been made to assess its sufficiency through the use of appropriate criteria and indicators.*

***Key words:** sufficiency, criterion, indicators, benchmarks. air sovereignty, system*

INTRODUCTION

Issues related to sovereignty over airspace have been a topic of international discussion since the beginning of the use of different types of aircraft (Slavov & Rusimov, 2021). The correct determination of the necessary capabilities to ensure air sovereignty allows the state to reach “the strategic goal of the defense policy of protection of territorial integrity and the defense of national interests by building, maintaining and using defense capabilities adequate to the security environment” (National defence strategy, 2023) and with sufficient potential to inflict unacceptable losses on the likely adversary in the event of aggression.

In order to justify the sufficient potential of the air sovereignty system regarding the capabilities to prevent unregulated use of the national airspace, it is necessary to understand it as a complex system that includes a number of functionally related systems and the environment that forms the requirements for this system.

Sufficiency characterizes the degree of conformity of tactical, technical, functional, economic, organizational and other characteristics of them to the level of requirements for this system and determines the part of this system in the general system of national security. Moreover sufficiency, it is a measure of conformity of resources, product or systems to pre-formulated and justified requirements when solving specific tasks in a specific environment. (Slavov & Rusimov, 2021, pp. 50-53).

Sufficiency creates an opportunity to optimize processes and costs in any organization and structure of a different type, especially in light of limited resources in the majority of cases.

In that perspective, this report is intended to indicate such criteria and indicators that could be used to assess the adequacy and sufficiency of the air sovereignty system.

1. COMPONENTS OF AIR SOVEREIGNTY SYSTEM

Before considering the sufficiency of the air sovereignty system, it is necessary to clarify when a state can be said to have sovereignty and how this sovereignty can be measured.

Sufficiency of sovereignty relates to the extent to which a state possesses and exercises control and authority over its territory, population and government.

Criteria such as:

➤ **Territorial control** – Could the state exercise effective control over airspace, territorial waters and land borders. Is it able to enforce legislation, provide security and regulate activities within its borders?

➤ **Independence** – from the point of view of the ability to make independent decisions without external interference in matters of internal affairs and foreign policy.

➤ **Protected territorial integrity** – related to the ability to defend its borders against external threats;

➤ **Monopoly on the use of force** on the territory of the state;

➤ **Participation in international organizations** – Is the state capable of maintaining diplomatic relations and participating in international organizations. Is the government recognized as a legitimate authority over a given territory by other countries and institutions?

Cooperation with neighboring countries and international organizations is important to address transnational threats to air sovereignty, such as terrorism and illegal trafficking. Airspace surveillance agreements, joint exercises and information sharing can improve collective security.

From a legal point of view, the environment for realizing air sovereignty – airspace can be divided into: sovereign and international (open).

The Convention on International Civil Aviation (Doc 7300, Chicago, 1944) states that the airspace is not included in the state territory of the specific countries, but only determines the effect of the full and exclusive sovereignty of the state over the airspace extending over the land and territorial waters.

Although there are some controversy regarding the upper limit of sovereign airspace, but a height no higher than 65 km is tacitly implied, since the movement of the aerodynamic devices requires a reaction of the air (Slavov & Rusimov, 2021, p.18).

According to the Airspace Control Ordinance (Ordinance on the control of aviation in the airspace of the Republic of Bulgaria in the protection of the airspace of the Republic of Bulgaria, 2010), „Air sovereignty is the internationally recognized right of the country to control and manage the use of the national airspace and, if necessary, to take actions for its protection and defense, ... including for impact on an aircraft that has made an unauthorized entry or flying through the airspace of the country or violated the rules of flights in the airspace of the Republic of Bulgaria.”

An air sovereignty system can be understood as the set of assets and management authorities, organized according to a single plan and designed to solve the tasks of ensuring air sovereignty in accordance with the concept of the protect and defence and taking into account the highly likely nature of action of air threats

An air sovereignty system encompasses a set of capabilities, procedures and infrastructure that a state uses to control its own airspace. It is intended to protect national sovereignty and ensure the safe and efficient movement of aircraft.

To determine the criteria for assessing the sufficiency of the air sovereignty system, it is necessary to specify its main components with the integration of which the protection, management and control of the national airspace is guaranteed.

The effectiveness of the air sovereignty system depends on the relationships of its constituent elements. Due to the fact that different structures from different departments build the system, difficulties related to the system's operability may arise (Hristov, 2019).

The main components of the air sovereignty system (Figure 1) could include:



Figure 1. Air Sovereignty System Components (*Source:* Developed by the authors)

By effectively integrating these components, the air sovereignty system can ensure the protection and management of national airspace, protecting territorial integrity and sovereignty.

2. SUFFICIENCY EVALUATION OF AIR SOVEREIGNTY

Determining the sufficiency of the air sovereignty system from the point of view of the country's defense capabilities comes down to the selection of criteria and indicators that must be set in order to achieve the desired degree of control of one's own airspace.

These criteria and indicators allow the Air Sovereignty System to build a set of capabilities, procedures and infrastructure to detect, monitor and respond in a timely manner to potential threats, ensure aviation safety and security and protect national sovereignty.

The main criteria enabling the assessment of the adequacy of the air sovereignty system include the required capabilities of the specified components of the system.

Indicators provide quantifiable data or information that can be used to track trends, monitor performance, and make informed decisions to improve the organization and processes in the air sovereignty system.

Air and Missile Defense System

Effective air defense is paramount to ensuring air sovereignty. After our accession to the Alliance, the air defense of the Republic of Bulgaria became part of the NATO Integrated Air Defense and Missile Defense System (NATINAMDS). The role of the integrated military structure is expressed in providing organizational frameworks and necessary capabilities for air defense on the territory of the member countries against air threats, according to Article 5 of the North Atlantic Treaty, on the basis of shared responsibilities.

This is a serious challenge, because by being included in this system, our national air defense system is responsible for the protection of the country's airspace, as part of NATO's European airspace.

The capabilities of the **Air and Missile Defense System** related to detection, interception and response to threats in its own airspace are of crucial importance for air sovereignty. This includes radar systems, fighter aircraft, air defense systems and established command and control infrastructure.

Air and Missile Defense (AMD) is built through a combination of aviation and surface-based air defense and missile defense assets, providing protection against air and missile threats.

An essential requirement for Air and Missile Defense is **integration** expressed by coordinating and synchronizing all available capabilities.

A necessary condition for the integration of Air and Missile Defense capabilities is **interoperability** (procedural, technical, interpersonal and organizational compatibility), including the ability of the various elements to communicate, coordinate and work effectively with each other and with allied systems.

At the technical level, the systems must be interconnected correctly, and using common protocols and system-level messaging standards, they will be able to exchange information. moreover, each system must be able to process the information of the other subsystems and correlate this data with its own information (Paraskov, 2022).

Air and Missile Defense is implemented through the integrated air and missile defense system including the systems indicated in figure 2.

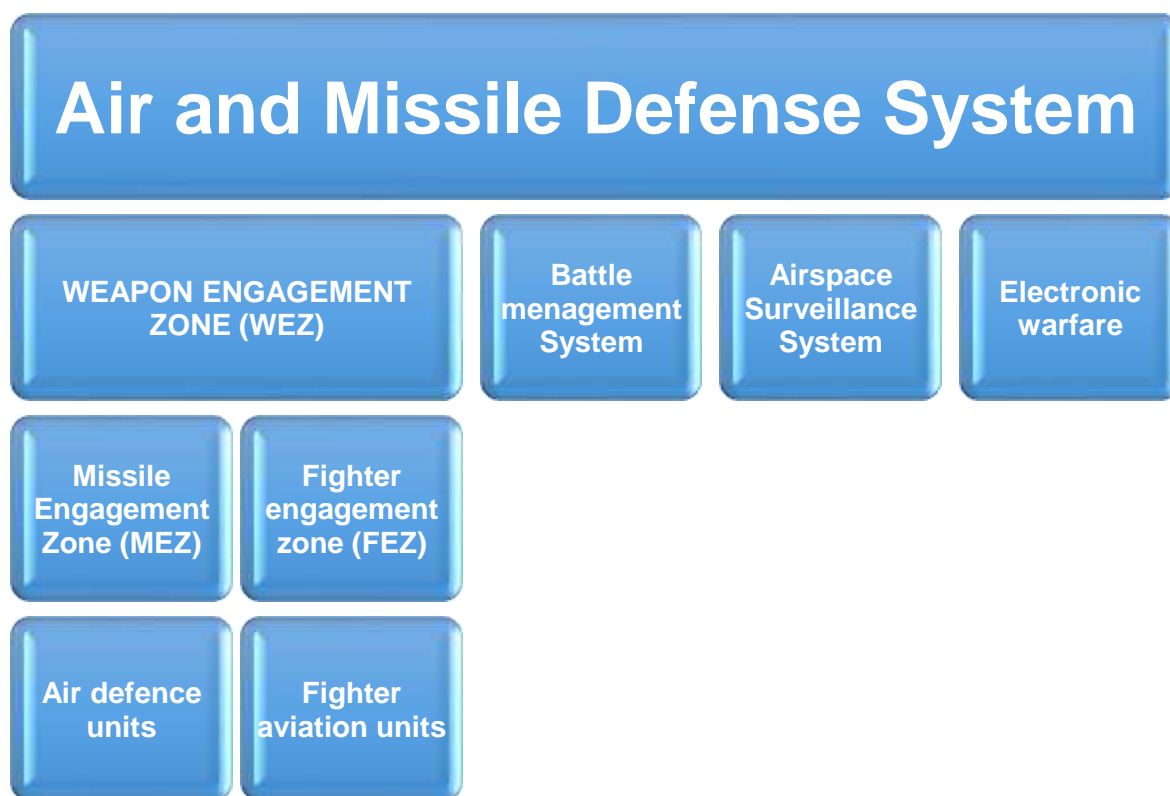


Figure 2. Integrated Air and Missile Defense System (*Source:* Developed by the authors)

Analysis and assessment of the air and missile defense system in terms of sufficiency faced difficulties by the high uncertainty of the initial data and the conditions for planning the air sovereignty protection operations. Defense, as the main strategy of the air and missile defense, requires adapting the parameters of the air defense system in accordance with the parameters of the air threat. The limited potential to protect all assets and the dispersion of the potential to cover large spatial areas, imposed by the capabilities of the air adversary to strike and change its variant in a short time, necessitates the search for high quality of planned and conducted operations.

The Integrated Air and Missile Defense system is created to implement the management of missile defence compounds, echeloning available resources, reserve, command posts and control centers and last but not least, support assets.

The operational capabilities of the air and missile defense system are variable quantities. Depending on the situation, they can increase or decrease— depending on topographical conditions, electronic interference, etc.

When choosing indicators of operational capabilities, it is necessary to proceed from the fact that they most fully characterize the capabilities of the air defense system for airspace protection.

The requirements for selecting indicators are:

- be sensitive to changes in input parameters;
- correspond to the task being solved;
- have a clear physical meaning;
- be computable.

As measurable indicators related to the capabilities of the air defense and anti-missile defense system to ensure air sovereignty, the following can be used:

- Number and characteristics of radars providing airspace surveillance;
- Quantity and capabilities of Fighter aviation;
- Missile engagement zone and effectiveness of air defense and missile defense systems;
- Reaction time for search, detection, recognition and impact on air targets detected in the national airspace, etc.

Airspace Utilization System

The capabilities of the **airspace utilization system** are essential to air sovereignty and the establishment of air traffic management and control rules and procedures ensuring the safe and efficient use of airspace.

Effective airspace management policies and regulations are essential to ensure air sovereignty. This includes defining restricted airspace, establishing flight corridors and deploying air traffic control systems to monitor and regulate air traffic.

The airspace utilization system includes various elements related to the provision of safe and efficient air traffic:

- Air traffic control centers;
- Air traffic tracking and monitoring radar systems;
- Navigation systems providing accurate navigation of aircraft;
- Communication systems;
- Route planning systems;
- Automated traffic management systems.

The system's ability to use airspace can be determined by indicators such as:

- Degree of compliance with international airspace regulations and standards;
- Number of air traffic control facilities and their efficiency;
- Frequency of airspace violations and incidents related to unauthorized entry of aircraft;
- Capacity and reliability of the communication and navigation infrastructure.

A clear legal framework defining the boundaries of national airspace and the rights and responsibilities of airspace users is important for asserting and protecting air sovereignty. International law, including conventions such as the Chicago Convention, provides the basis for regulating airspace sovereignty.

Border Surveillance System Capabilities

Border surveillance and patrolling to detect and deter entry into national airspace is critical to ensuring air sovereignty. This includes air patrols, surveillance systems and border control measures.

- Compliance with international agreements and contracts;
- Investment potential in technology infrastructure: Investments in air defense systems and aviation platforms, in air traffic control systems, communication networks and navigation aids, improve the state's ability to exercise control over airspace;
- Quality of the training system – training personnel, including air defense and military pilots and air traffic controllers is essential to ensure the adequacy of the air sovereignty system;
- Cyber Defense Capabilities: Protecting airspace management and air defense systems from cyber threats is increasingly important to ensuring air sovereignty in today's digital space.

Evaluating these criteria and by correctly selecting the relevant indicators for each of them and the standards that need to be reached, the adequacy of the air sovereignty system can be assessed. Problem areas can be identified and ways and means to solve them can be sought while ensuring effective airspace protection and “management.

As an important component of the air sovereignty system, **Border surveillance** the following indicators can be used to determine its sufficiency:

- Scope and effectiveness of aerial border surveillance patrols;
 - Number of targets detected and intercepted in the airspace;
 - Response time for unauthorized entry into the airspace;
 - Investments in border security infrastructure and technology.
- Capabilities to enforce sovereignty are associated with control of territory and could be measured by the following indicators:
- Number of interceptions of aircraft violating the airspace;
 - Amount of airspace violations successfully resolved through diplomatic or military means;
 - Legislative measures and penalties applied to violators of airspace sovereignty;
 - Public perception of the government's ability to protect national airspace.

Cybersecurity

As airspace control increasingly relies on interconnected systems, **cybersecurity** becomes critical. “It is a form of warfare that involves the use of digital technologies, such as malware, hacking, and phishing, to disrupt, damage, or destroy computer systems, steal information, or gain unauthorized access to sensitive data” (Mahmudov, 2023). Protecting against cyber threats ensures the integrity and reliability of airspace surveillance and control systems. “Cyber warfare can be carried out by individuals, organizations, or nation-states, and can have serious consequences for national security, economic stability, and individual privacy” (Mahmudov, 2023).

Indicators in a **cybersecurity system** are essential to monitor, assess, and respond to potential security threats, vulnerabilities, and incidents. These indicators reveal the effectiveness of cybersecurity measures and enable the detection, analysis and mitigation of risks.

Such indicators are:

- Average time to detect a breach in the system;
- Detection of anomalies in the system;
- Duration of removal of system vulnerabilities - period of time

between the detection of a vulnerability and its removal.

Cyber-attacks on critical infrastructure, such as power grids or transportation systems, can have significant consequences for public safety and the economy. Cyber security measures help protect against these attacks and minimize their impact (Viganò, Loi, & Yaghmaei, 2020)

After evaluation of those cyber security indicators and using benchmarks to compare with, the aviation authorities could prepare to protect of air sovereignty

The foundation of the management of the air sovereignty system is the **Total command and control system**.

This system is laid on the purposeful activity of all structures involved in ensuring air sovereignty and a correctly constructed command line, line of communication, coordination and interaction. It gives an answer to the questions of who, with whom, on the basis of what, for what purpose and with what methods the system created in this way should be managed.

Essentially, the management process is an information process that involves receiving, transforming, storing and transmitting information. All information about the air and surface situation, the condition and readiness of the units interacting, and as a result of the processing of this information, the management impact on the subordinates is formed, i.e. the task of protecting air sovereignty is set and the ability to adapt to changing threat scenarios.

Personnel education and training system

Education and training are essential to the functioning of the air sovereignty system. The human factor is a key and has a significant impact on the functioning of each subsystem. How people think about their responsibilities regarding the protection of sovereignty, their qualities and morals and responsibilities, and not least how they interact with others in the performance of tasks, greatly affects the effectiveness of the system

The human factor contributes, both positively and negatively, to organizational effectiveness. Human factors is about understanding how people interact with each other including the interaction between air traffic controllers, radar operators, aviation and air defense and other related to the management of systems ensuring air sovereignty for timely response to potential threats.

Their capabilities and limitations influence the activities of others. As a result, consideration of the human factor is an integral part of the system's operation and investment in education, training and training has a high added value.

CONCLUSION

Sovereign airspace is a complex set of elements that must be managed, used and protected. Therefore, issues related to the protection of air sovereignty must be clearly outlined, defined and analyzed.

During the process of building the total system of air sovereignty, it can be assumed that the whole set of elements that make it up is one system, and all participants with their systems for ensuring sovereignty are subsystems. Therefore, the main task of the state is how best to manage the interaction between different actors

This necessitates the implementation of systematic activities, both in the legislative and executive spheres, with the aim of the normal functioning of the state.

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