

Collective Defense – a Means to Achieve a More Sustainable Future

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Abstract — The report analyzes the geopolitical situation in the world at the beginning of 2025. NATO is entering its eighth decade as a successful military-political alliance but faces new threats, which we will examine in this study. The conflict between Russia and Ukraine highlights the need for adaptation, deterrence, and innovation. NATO's Strategic Concept until 2022 reaffirms its commitment to unity and security. This study uses the Thomas L. Saatchi and Lotka-Volterra equations for security analysis, identifying key dependencies in the changing landscape. It outlines five main challenges: adapting NATO and the EU to new threats, modernizing military systems, prioritizing military security in Bulgaria, increasing the military budget by 2027, and emphasizing collective defense for European resilience. An interdisciplinary approach is crucial to address these challenges effectively.

Keywords – Geopolitics, Security, NATO, Adaptation, Military Resilience

I. INTRODUCTION

NATO is entering its eighth decade as a successful military-political alliance, covering a significant share of the world's GDP and population, but facing a growing range of threats and challenges. The changing geopolitical environment, including the rise of revisionist authoritarian states, hybrid threats, terrorism, and new technologies, requires the alliance to continue adapting while maintaining its cohesion and strengthening its military and political mechanisms.

The research aims to analyze the geopolitical situation in early 2025, focusing on the new threats and challenges facing NATO and the EU in the context of the changing international environment. The aim is to identify key dependencies and strategic directions for adaptation, deterrence, and innovation through an interdisciplinary

approach, including the equations of Thomas L. Saatchi and Lotka-Volterra. The study sets out to outline five main security challenges, including: the adaptation of NATO and the EU to new risks, the modernization of military systems, the prioritization of military security in Bulgaria, the increase in the military budget by 2027, and the strengthening of collective defense to strengthen European resilience.

II. MATERIALS AND METHODS

The study uses combined methods to analyze military security in the contemporary global context. It conducts a literature review of theoretical and empirical sources, examines documents and strategic reports of governmental and international organizations, and provides examples of emerging threats through case studies and comparative analyses of strategies of different countries and organizations.

III. RESULTS AND DISCUSSION

After the start of the military conflict (special military operation) between Russia and Ukraine in 2022, the need to rethink national and collective security has intensified. The environment in which the armed forces operate increases the number of its components as technology develops and new tactics are applied [1]. In response to these dynamics, NATO focuses on strategic adaptation, strengthening deterrence, technological innovation, and resilience to climate and pandemic threats. A key focus is on preserving collective defense, democratic principles, and the rules-based international order.

NATO's 2022 Strategic Concept reaffirms the commitment to unity, security, and cooperation. The changing security environment is increasingly bringing to

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the fore the risks of radicalization of large societal groups and related acts of violence motivated by extremism and terrorism [2].

This means that national security systems must face this risk and create the necessary regulatory, financial, informational, and human capacity for early warning, prevention, response, counteraction, and effective management of its consequences [3].

In parallel, the European Union defined its “Strategic Compass” for security, aiming to improve capabilities for joint response to threats, including through investments in technology and partnerships.

Military security is a key factor in a dynamic security environment that requires synchronization between military and political mechanisms to effectively address threats. According to the Marshall publication, “A dynamic security environment is constantly changing and evolving, requiring security measures to be constantly updated and adapted to keep pace with new threats and risks [4].

Significant and dynamic changes in the strategic security environment require adaptation and transformation of security and defense systems in the real global and regional environment [5]. It can be argued that the dynamic security environment requires organizations and individuals to be highly adaptable and operationally flexible. This adaptability must be supported by a strategic focus on continuous learning and improvement to anticipate and effectively manage emerging risks and threats. A key role in this process is played by broad expertise in the field of safety and security, which provides the basis for integrated and sustainable solutions. Some specialists pay particular attention to the determinants of internal and external influence on security [6]. The more dynamic the security environment, the more critical the ability to absorb and improve resilience becomes. In this context, the resilience aspects of management systems are considered comprehensive and also include elements of human resource management, organizational design, and crisis management [7]. The role of NATO and the European Union in the context of military security is crucial for stability and resilience in a context of increasing uncertainty. NATO is strengthening collective defense by investing in technology, strengthening strategic deterrence against revisionist states, and upholding democratic values. In parallel, the EU Strategic Compass complements these efforts with a focus on autonomous crisis response, partnerships to maintain international order, and the synchronization of military and civil security. The conflict in Ukraine highlights the importance of flexible mechanisms to address hybrid threats, modernizing military structures, and investing in technologies that provide an advantage on the battlefield and in cyberspace. Military security remains the basis for collective defense, integrating adaptation to new risks and the promotion of shared values and international cooperation.

The NATO-EU relationship has taken on even greater importance in light of the dramatic shift in the security environment since 24 February 2022, when the conflict between Russia and Ukraine has intensified the need for transformation in both national and international security strategies. The dynamics of “Military Security” have gained greater focus in response to this sharp shift in the security environment, especially in the context of the military conflict between Russia and Ukraine. This profound shift in the security context and emerging threats necessitates a reassessment of the relative importance of a country’s national security subsystems.

MILITARY SECURITY AS A BASIS FOR STABILITY	NATO'S ROLE	ROLE OF THE EUROPEAN UNION	IMPACT OF THE CONFLICT IN UKRAINE
<ul style="list-style-type: none"> •Basis for collective defense •Promoting shared values •International cooperation. 	<ul style="list-style-type: none"> •Investing in technology and innovation •Strengthening strategic deterrence •Upholding democratic values. 	<ul style="list-style-type: none"> •Independent Crisis Action •Partnerships for International Order •Synchronization of Military and Civil Security. 	<ul style="list-style-type: none"> •Flexible mechanisms to deal with hybrid threats •Modernization of military structures •Investment in technologies for advantage on the battlefield and in cyberspace.

Fig. 1 The key aspects of the role of NATO, the EU, and the impact of the conflict in Ukraine in the context of military security.

The study continues by applying Saati’s methodology, which provides a systematic approach to analyzing and prioritizing security subsystems adapted to the specific needs of a given situation. In addition, predictions made using the Lotka-Voltaire and Kolmogorov methods contribute to a more precise ranking of these subsystems in terms of importance, taking into account the interactions between different factors. This assessment reveals deeper dependencies within the dynamically changing military security, in which technological progress, geopolitical dynamics, emerging threats, and societal changes are asserting themselves as critical elements for adapting and strengthening national and collective security.

Based on the performed analysis [8] we can conclude that military security [9] takes a central place in the national security system of Bulgaria [10], and its importance is confirmed by using Saati’s method of hierarchy analysis. This approach reveals that military security, along with economic and demographic security, are priority subsystems necessary to ensure resilience and adaptation in a changing geopolitical environment. The study emphasizes the importance of clear hierarchies and interaction between subsystems for effective security management. Hierarchy of national security subsystems depending on the force majeure change in the security environment of the Balkan Peninsula, from 24.02.2022 to 01.06.2022 military conflict between Russia and Ukraine (variant). Their hierarchy is presented in Table 1 and Fig. 2.

Regression equation:

$$y = 0,0001x^4 - 0,0031x^3 + 0,0233x^2 - 0,0779x + 0,2137$$

Coefficient of determination: $R^2 = 0,5798$

In this case, which means that about 57.98% of the variation in *y* can be explained by this equation. This is considered a medium-strong relationship.

TABLE 1

security subsystems	coefficient	security subsystems	coefficient
A1- Military security	0,157	A7- Ethnic security	0,029
A2 - Economic security	0,115	A8- Energy security	0,027
A3 - Geostrategic security	0,134	A9- Migration security	0,097
A4 - Demographic security	0,132	A10- Cyber security	0,007
A5 - Information security	0,047	A11- Environmental security	0,001
A6 - Food security	0,133	A12- Health security	0,121
Total		1	

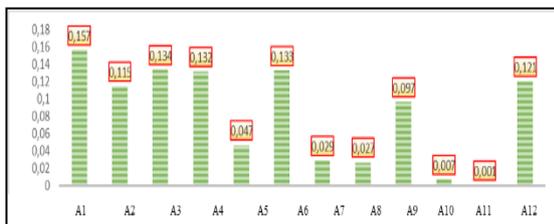


Fig. 2 Hierarchy of national security subsystems from 24.02.2022 to 01/06/2022 – military conflict between Russia and Ukraine

The data presented in Table 1 regarding the priority of the subsystems of national security in a force majeure situation show that at this particular moment “Military Security” – takes the first place with a relative weight of 0.157. This is thanks to the membership of the Republic of Bulgaria in the collective defense of NATO. Economic security takes second place due to the geographical location of the country and its membership in NATO. The remaining subsystems, such as Geostrategic Security and Demographic Security, necessarily follow the first two subsystems due to their close connection and mutual dependence, Fig. 2.

The force majeure situation led to a significant change in the security environment on the Balkan Peninsula. This development is due to the interaction of at least two different factors, which subsequently led to a reconfiguration of the hierarchy between the security subsystems, an integral part of the national security of the Republic of Bulgaria.

Changing the level of threat on the Balkan Peninsula, due to the simultaneous actions of two or more reasons, implies the complex accounting, arrangement, and influence of the subsystems that are part of the country's national security. A similar situation was observed in the second half of 2022, where the state of national security will be determined both by the increased probability of an escalating military conflict between Russia and Ukraine, as

well as by the existing health pandemic, increased migration coming from the Republic of Turkey, and of course by growing inflation. In the security environment so formally described, using the well-known Saati methodology, a hierarchy of importance in the specific situation of the security subsystems is obtained. Their complex influence in sequence is presented in Table 2 and Fig. 3

The hierarchy of national security subsystems depends on the complex change in the security environment on the Balkan Peninsula and the world from 01.06.2022 to the end of 2022 in combination with a projected escalating military conflict between Russia and Ukraine and a subsiding health pandemic, economic reasons, and migration (variant).

TABLE 2

security subsystems	coefficient	security subsystems	coefficient
A1- Military security	0,187	A7- Ethnic security	0,029
A2 - Economic security	0,116	A8- Energy security	0,034
A3 - Geostrategic security	0,154	A9- Migration security	0,11
A4 - Demographic security	0,112	A10- Cyber security	0,007
A5 - Information security	0,048	A11- Environmental security	0,001
A6 - Food security	0,113	A12- Health security	0,089
Total		1	

Regression equation:

$$y = 4E - 0,5x^5 - 0,0011x^4 + 0,0123x^3 - 0,0555x^2 + 0,0777x + 0,1415$$

Coefficient of determination: $R^2 = 0,6552$

In this case, which means that about 65.52% of the variation in *y* can be explained by this equation. This is considered a medium-strong relationship.

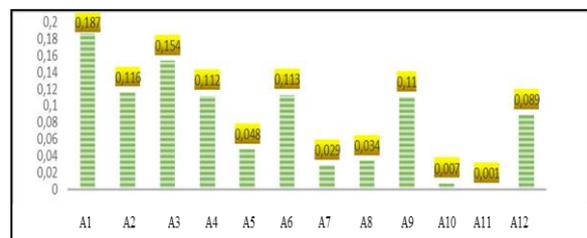


Fig. 3 Hierarchy of national security subsystems in the second half of 2022 - from 01.06.2022 to the end of 2022 - the military conflict between Russia and Ukraine, migration, and economic reasons

The results presented in Fig. 3 are obtained according to the criteria taking into account the importance of both reasons for the change in the state of the security environment. In this case, the resulting hierarchy for the first reason, for example, an escalating military conflict between Russia and Ukraine and a subsiding health

pandemic, economic reasons, and migration, “Military Security” dominates over the others with a relative weight of 0.187 or 18.7%. The remaining “Economic Security” and “Geostrategic Security” in terms of importance, as well as the minimum values of “Health Security” fully correspond to the logic. The philosophy of the response of the national security system to reduce the consequences of the threat to the country, Fig. 3.

The hierarchy of the national security subsystems in the security environment of the Balkan Peninsula and the world (variant) for the period from 01.01.2023 to 01.06.2023 is presented in Fig. 4.

TABLE 3

security subsystems	coefficient	security subsystems	coefficient
A1- Military security	0,229	A7- Ethnic security	0,039
A2 - Economic security	0,128	A8- Energy security	0,032
A3 - Geostrategic security	0,154	A9- Migration security	0,121
A4 - Demographic security	0,108	A10- Cyber security	0,006
A5 - Information security	0,046	A11- Environmental security	0,012
A6 - Food security	0,103	A12- Health security	0,022
Total		1	

Regression equation: $y = 4E - 0,5x^4 - 0,0015x^3 + 0,0185x^2 - 0,1066x + 0,3104$

Coefficient of determination: $R^2 = 0,7593$

In this case, which means that about 75.93% of the variation in y can be explained by this equation. This is considered a strong relationship.

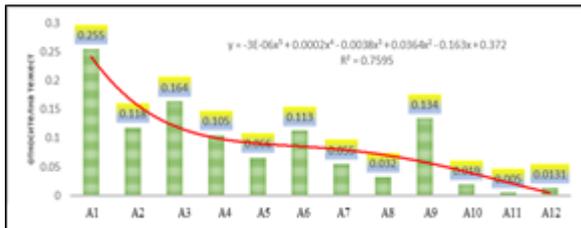


Fig. 4 Hierarchy of national security subsystems from 01.01.2023 to 01.06.2023 - the military conflict between Russia and Ukraine remains

In the specified period, the subsystem “Military Security” is again in a priority position with a relative weight of 0.209, which constitutes almost 21% of the value of the national security system of the country taken as 100%. In the general trend of development of the security environment, mainly expanding military conflicts - Russia Ukraine, Syria, Israel in the Gaza enclave and the tension between Kosovo and Serbia, it is quite normal for “Economic Security” and “Geostrategic Security” to occupy second and third place in the security system in the country, Fig.4.

The hierarchy of national security subsystems in the security environment of the Balkan Peninsula and the world (option) for the period from 01.06.2023 to 31.12.2023 remains.

TABLE 4

security subsystems	coefficient	security subsystems	coefficient
A1- Military security	0,229	A7- Ethnic security	0,039
A2 - Economic security	0,128	A8- Energy security	0,032
A3 - Geostrategic security	0,154	A9- Migration security	0,121
A4 - Demographic security	0,108	A10- Cyber security	0,006
A5 - Information security	0,046	A11- Environmental security	0,012
A6 - Food security	0,103	A12- Health security	0,022
Total		1	

Regression equation: $y = 1E - 0,5x^5 - 0,0004x^4 + 0,0035x^3 - 0,0073x^2 - 0,0502x + 0,2724$

Coefficient of determination: $R^2 = 0,7616$

In this case, which means that about 76.16% of the variation in y can be explained by this equation. This is considered a strong relationship.

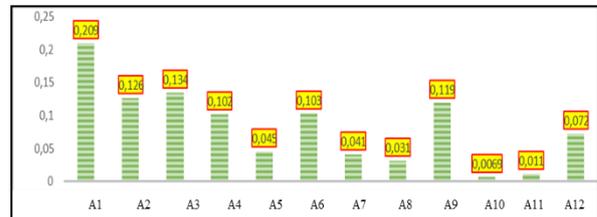


Fig. 5 Hierarchy of national security subsystems for the period from 01.06.2023 to 31.12.2023 - military conflict between Russia and Ukraine

TABLE 5

security subsystems	coefficient	security subsystems	coefficient
A1- Military security	0.241	A7- Ethnic security	0.055
A2 - Economic security	0.138	A8- Energy security	0.032
A3 - Geostrategic security	0.164	A9- Migration security	0.134
A4 - Demographic security	0.108	A10- Cyber security	0.019
A5 - Information security	0.066	A11- Environmental security	0.012
A6 - Food security	0.118	A12- Health security	0.021
Total		1	

The changes in the hierarchy of security subsystems are presented in Fig. 6:

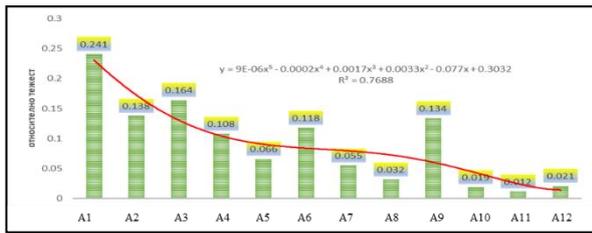


Fig. 6. Hierarchy of national security subsystems for the period from 01.01.2024 to 01.06.2024 - military conflict between Russia and Ukraine

TABLE 6

security subsystems	coefficient	security subsystems	coefficient
A1- Military security	0.255	A7- Ethnic security	0.055
A2 - Economic security	0.118	A8- Energy security	0.032
A3 - Geostrategic security	0.164	A9- Migration security	0.134
A4 - Demographic security	0.105	A10- Cyber security	0.019
A5 - Information security	0.066	A11- Environmental security	0.005
A6 - Food security	0.113	A12- Health security	0.0131
Total		1	

Regression equation: $y = -0,0157x^4 + 0,2268x^3 - 0,2664x^2 - 4.609x + 23.528$

Coefficient of determination: $R^2 = 0,9605$

In this case, which means that about 96.05% of the variation in y can be explained by this equation. This is considered a strong relationship.

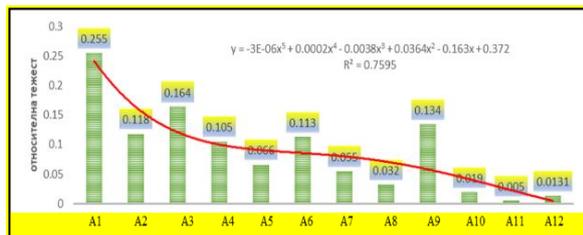


Fig. 7 Hierarchy of national security subsystems for the period from 01.06.2024 to 01.12.2024 – military conflict between Russia and Ukraine

The analysis shows that the simultaneous consideration of two or more reasons that shape the change in the state of the security environment in a given region implies a dynamic and adequate change (relative weight of influence) specifically for “Military Security” in the composition of the country’s national security. Furthermore, when considering the place of this security subsystem, its dynamics must always be considered no less than the simultaneous action of at least two or more reasons that shape the state of the Security Environment. Research shows that with these and other changes in the security environment, the “Military Security” subsystem is always

in the top three places in terms of importance for the functioning of the country’s national security system, Table 6 and Fig. 7.

The relative weight of influence of the “Military Security” subsystem in relation to the National Security system depends on the complex change in the security environment on the Balkan Peninsula and in the world, from March 13, 2020, to December 31, 2024, in the Security Environment formed for the period mainly: the Covid 19 pandemic, escalating military conflict between Russia and Ukraine, military actions between Israel and Hamas in the Gaza Strip, refugee migration, inflation, etc. The indicated military-political situation in the world and the Balkan Peninsula, the relative weight of influence of the “Military Security” subsystem in relation to the National Security system is presented in Table 7.

The relative weight of influence of the Military Security subsystem relative to the National Security system

TABLE 7

Periods for analysis of national security - military security	Relative weight of military security by periods – percentages
until March 13, 2020	19.1
after March 13th until July 2020	13.8
from July 15 to the end of December 2020	13.5
beginning of 2021 until July 1, 2021	11.3
from July 1 to February 24, 2022	11
from 24.02.2022 to 01.06.2022	15.7
from 01.06.2022 until the end of 2022	18.7
from 01.01.2023 to 01.06.2023	20,9
from 01.06.2023 to 31.12.2023	22,9
from 01.01.2024 TO 01.06.2024	24.1
from 01.06.2024 TO 31.12.2024	25.5

The indicated values of the relative weight of influence of the “Military Security” subsystem in relation to the National Security system are presented in Fig.8.

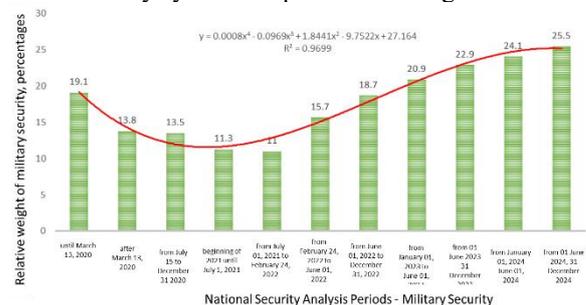


Fig. 8. Relative weight of the “Military Security” subsystem to National Security in the country in percentages for the periods from March 13, 2020, to December 31, 2024.

The interdependence by periods of national security analysis and their respective relative weights (Fig. 8.) form a regression equation as shown:

$$y = 0.008x^4 - 0.0969x^3 + 1.8441x^2 - 9.7522x + 27.164$$

Coefficient of determination: $R^2 = 0.9699$

The equation shows how the importance of different time periods for national security changes with very high accuracy. Such analysis is useful for strategic planning, as it highlights which periods were most important and can help predict future trends.

The changes in the values of the relative weights of the subsystem “Military Security”, are presented in Table 7. The period from March 13, 2020, to 31.12.2023, demonstrates that the minimum value of 0.11 or 11% is observed in the segment from July 1 to February 24, 2022, Fig. 8. Minimum values of the subsystem “Military Security” are observed in the period - after March 13, 2020. to July 2020. and from June 1, 2022. to the end of 2022. This is mainly due to the priority relative values of the subsystem “Health Security” - due to the “Covid 19” pandemic in values from 13.8 to 18.7 percent, Fig. 8. The increase in the relative values of the “Military Security” subsystem is observed throughout 2023, where it increases in relative values, respectively - in the first part of the year 20.9 to 22.9 percent in the second. The derived regression dependence based on the relative values of the “Military Security” subsystem for the specified period from March 13, 2020, to December 31, 2024, is characterized by a concordance coefficient $R^2=0.9699$ or almost 97% of the changes during the period can be expressed, described with this regression equation presented in Fig. 8.

Important for the study is the dynamics of the subsystem “Military Security” in the changing security environment, which is the possibility of predicting the nature of its change in a close, immediate period of time, for example, 6 months. For this purpose, a forecast was made by the relative weight of the subsystem “Military Security” based on the latest data for 2023. A forecast in relative weight of the influence of the subsystem “Military Security” depending on the complex change in the security environment on the Balkan Peninsula and in the world for the period from 01.01.2024 to 01.06.2024 in a situation of escalating military conflict between Russia and Ukraine, events in the Middle East - Israel, Palestine, Syria refugees and emerging inflation (variant), is presented in Fig. 9.

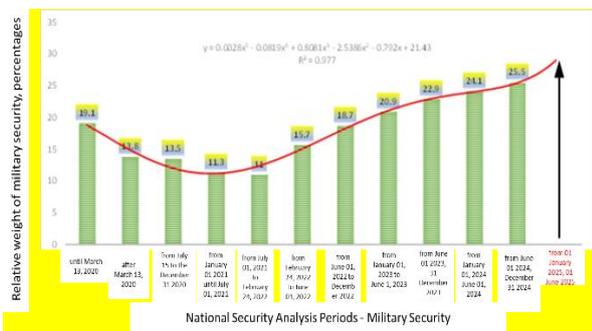


Fig. 9. Forecast of the relative weight of the Military Security subsystem relative to National Security in the country in percentages for the first half of 2025

The results of the forecast demonstrate that by 01.06.2025 the relative weight of “Military Security” will increase to 24.9% or almost 25%. This value requires significant funding through an increase in the military budget for this and next year. Of particular scientific interest are the reaction time, the reflection of the “Military Security” subsystem in relation to the dynamics of development, and changes in the security environment for the period from 24.02.2022 to 31.12.2024.

Using the modified Lotka-Volterra model for military security analysis for the period from 24 February 2022 to 31 December 2024.

The Lotka-Volterra model is a mathematical framework used to describe the population dynamics of predators and prey. The model assumes that the growth of the predator population depends on the availability of prey, while the growth of the prey population depends on the number of predators. This relationship leads to complex dynamics characterized by cyclical fluctuations in the size of both populations.

Applying this model to military security, we can consider the predator population as a country's military forces and the prey population as the civilian population. In this context, the growth of military forces depends on the availability of resources (civilian population), while the growth of the civilian population depends on the size of the military forces.

The modified Lotka-Volterra model can be represented by the following differential equations, where:

$$\frac{dN}{dt} = rN - aNP \quad (1)$$

$$\frac{dP}{dt} = bNP - cP \quad (2)$$

- “N” represents the population of the “predator” (military forces, changing security environment);
- “P” represents the “prey” population (Military Security);
- “r” and c are natural growth rates respectively for N and P;
- “a” and b are interaction coefficients between “N” and “P”.

By solving these equations, we can obtain the dynamics of the populations of “predators” (“External Security Environment”) and “prey” (“Military Security”). This allows us to analyze the impact of various factors on the “Military Security” of the country, such as changes in resources, technological progress of the entities forming the “External Security Environment” or their external change.

When taking into account the average values of the changes in the “Security Environment”, the reaction of the “Military Security” subsystem according to the Lotka-Volterra method. Especially in the method, it represents the reaction time, the dynamics of change, of the “Military Security” subsystem to changes in the “Security Environment”. For example, for the period from February

24, 2022, to December 31, 2024, the reaction time to changes in the "Military Security" subsystem is presented in Fig. 10.

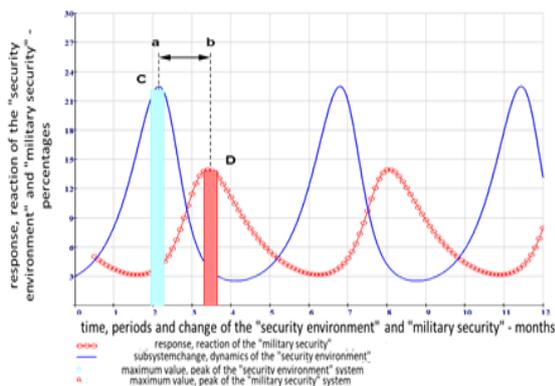


Fig. 10. Dynamics of the security environment according to the Lotka-Volterra method for the period from February 24, 2022, to December 31, 2024

The response time of the security environment, especially in the current military conflicts near our country - the escalation of the war in Ukraine, the events in the Middle East - Israel, Palestine, Syria, inflation, impoverishment, etc. presented in Fig. 10. demonstrates a peak in the changes of the "Security Environment". For example, point "C" reaches the maximum of the changes of the "Security Environment", with an average value of 22% (from 3 to 22 percent) And the maximum of the response, the reaction of the subsystem "Military Security", the maximum - point "D" has an average value of 14%. On this occasion, the response time of the subsystem "Military Security" for the period 24.02.2022 - 31.12.2024 is from 30 to 45 days shown between points "a-b", Fig. 10. This period includes only the reaction of the country's management units for managing the values of the security subsystems when the "Security Environment" changes.

In the rapidly evolving global and regional security environment, military security faces complex and multifaceted challenges. To address them, it is necessary to develop and implement an integrated and proactive strategy. Its main components include the implementation of technological innovations, adaptation to hybrid and multi-domain threats, strengthening strategic partnerships, and compliance with ethical and legal standards. The entire European community aspires to promote partnership and unity among all EU member states. [11]

The systematic approach to military security management provides the opportunity for long-term forecasting (within 3-7 years), while identifying investment priorities and ensuring effective resource allocation. The analysis and assessment methodology is aimed at a smooth transition to higher levels of security through an in-depth consideration of the factors affecting military stability. This is especially important in the context of increasing geopolitical instability in the Balkan region, where a synergistic approach is crucial to strengthening resilience. These management challenges increase significantly in the

context of finding effective solutions in the balanced role of human capital in organizations. [12]

The strategies and payment matrix for ensuring Bulgaria's national and military security focus primarily on the acquisition of high-tech weapons systems and the increase in the military budget. This strategic direction emphasizes Bulgaria's commitment to building a stable military force capable of maintaining security and stability on the Balkan Peninsula.

The continuous implementation of the strategies and payment matrix for ensuring the national and military security of the country by the leadership contributes to establishing a sustainable dynamic in the growth of military security and the protection of national interests, which is of crucial importance for the field of regional and collective security. The development of technologies will be one of the few positive long-term consequences of the crisis. [13] Digital transformation requires significant investments, technological innovations, and targeted measures to stimulate digital competence and digital culture.[14]

IV. CONCLUSIONS

This study offers new perspectives on collective defense and highlights the need for an interdisciplinary approach to more effectively address the related challenges. These challenges can be categorized into five key areas. The first key area, NATO and the EU are adapting to emerging threats, focusing on strategic deterrence and enhanced cooperation between allies in light of the Russia-Ukraine conflict. The second, the changing global security landscape requires the modernization of military systems and an emphasis on strengthening cybersecurity, especially in response to the ongoing conflict in Ukraine and rising regional tensions in the Balkans. The security environment is influenced by the risks and challenges of the conflicts in the country and in the countries close to the Republic of Bulgaria [15].

The third key area, Bulgaria faces an imperative to prioritize military security in the post-2022 security environment, which requires increased investment in defense capabilities, even as a NATO member. Fourth, by 2027, military security is expected to comprise 25.5% of Bulgaria's national security framework, which highlights the need for a larger military budget and innovative strategies to counter hybrid threats and cyberattacks. Finally, the fifth key area, the principle of collective defense, is crucial for the resilience of both Bulgaria and Europe, which requires coordinated strategies and investments in modern defense technologies by both NATO and the EU.

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