BULLETIN
OF "CAROL I" NATIONAL DEFENCE UNIVERSITY

https://buletinul.unap.ro/index.php/en/

Naval forces operational environment. Flexibility and strategic adaptability

Lt. Cdr. (N) Lavinia Elena TĂNASE (MĂXINEANU), Ph.D. Student*
Commander (r.) Prof. Ion CHIORCEA, Ph.D.**

*Romanian Naval Forces, 56th Frigate Flotilla / "Carol I" National Defence University
e-mail: laviniamaxineanu@gmail.ro
**"Mircea cel Bătrân" Naval Academy, Constanța

Abstract

In the dynamic scene of naval operations, constant adaptation and innovation are imperative to meeting the challenges and opportunities of technological advances, geopolitical changes and environmental considerations. This article aims to explore the multidimensional landscape of the naval operational environment, offering original insights and solutions to enhance naval capabilities and cooperation on a regional and global scale. From the forefront of technological innovation, onboard unmanned systems integration and artificial intelligence-based decision-making, to strategic adaptability in response to geopolitical dynamics, the study explores the complex interplay between naval strategy and emerging trends, with environmental considerations taking centre stage. The article argues for a collaborative global naval framework, highlighting the importance of international cooperation in addressing common maritime challenges. This framework envisages the creation of alliances, initiatives and partnerships to foster collective security, promote environmental protection and ensure the peaceful use of the world's oceans. The main objective is to highlight the intersections between technological advances, strategic flexibility, environmental factors and international cooperation in shaping the future of naval operations. Overall, the study aims to engage a diverse audience comprising policymakers, maritime military leaders, researchers, academics and stakeholders involved in maritime security, defence and environmental protection.

Keywords:

The operating environment of naval forces, characterized by the adjacency of the sea, rivers, and inland waters, constantly changes due to the fluctuating geopolitical situation, the impact of technological progress, the development of artificial intelligence, and the importance of environmental management. Naval forces around the world are being forced to adapt, innovate, and reconsider conventional frameworks for maritime strategies and naval operations.

In this article, we aim to examine and explore new and timely perspectives on the specifics of the naval force operating environment in general, with a particular focus on emerging technology, strategic flexibility, the consequences of climate change and the possibility of collaborative regional/global management of the world's seas and oceans.

The actions and operations of naval forces have been and continue to be the subject of extensive analysis, reflection and debate. From ancient Greece to the present day, operations, naval capabilities, battles and strategies have been instrumental in mapping the world and shaping global history. Thus, we will refer to present events as a perspective on the future of naval forces and the types of conflicts or engagements we will face.

We will explore the relationship between the environment, understood as civil society, and defence, focusing on conflict and cooperation. We will address the dual role of military structures in peacetime, highlighting both their conflicting aspect, which contributes to pollution and environmental degradation and their cooperative aspect, which engages in community activities such as emergency response, combating environmental degradation and managing climate change.

To this end, three research objectives have been set: following the status and trends of technological developments impacting naval operations, conducting an analysis of strategic adaptability and geopolitical factors, and identifying environmental factors and their impact on climate change.

In the first section of the article, we look at current tendencies and emerging technologies in naval operations, focusing on modular unmanned systems, artificial intelligence-based decision making and quantum cryptography to enhance flexibility and operational security. The second objective of this research is to highlight the importance of assessing alliances and military positions in the face of intense power rivalries, especially in regions such as the Black Sea. The paper proposes innovative strategies, such as dynamic force deployment plans to deter potential adversaries and create a secure environment for allies.

In addition to the first two proposed objectives, we considered it necessary to set an objective from the field of maritime security operations, in the area of non-combat operations, during which we will highlight the non-combat role of naval forces in contributing to the maintenance of maritime security, in the field of environmental protection. Thus, the study of the impact of naval activities on the environment and

the implications of climate change on maritime security is the focus of the final part, in which we have addressed the challenges and opportunities that climate change presents for naval forces, such as the opening of new shipping routes and the need for a strategic presence to secure maritime communications.

In conclusion, we will advocate for a holistic approach that balances operational efficiency, environmental responsibility and international cooperation in naval operations.

Advancements in technology for naval operations

We share the opinion that advances in technology have altered the way naval tactics are addressed (Scipanov and Totir 2023, 46), so we build on this premise to highlight the role of unmanned systems on board, predictive engagement based on artificial intelligence, and quantum cryptography in addressing future naval force strategies.

The vanguard of innovation in naval operations is marked by impressive developments in unmanned systems, artificial intelligence (AI) and cyber security. Unmanned systems, such as aerial vehicles (UAVs), underwater vehicles (UUVs) and surface vehicles (USVs), offer enhanced surveillance capabilities, mine countermeasures, anti-submarine warfare, targeting, and the list could continue, depending on the ingenuity and technical knowledge of the users (Boulanin and Verbruggen 2017). By incorporating artificial intelligence into these systems, we can improve autonomous decision-making processes, increase operational efficiency, and increase the pace at which risks are addressed. In addition, the cyber domain has emerged as a crucial conflict arena for naval forces. The need for cyber security measures has become paramount, given the increasing reliance on digital systems and networks. Advances in quantum computing and encryption technologies have the potential to provide naval forces with unprecedented protection against cyber threats, ensuring the reliability of command-and-control systems (Venegas-Andraca, Lanzagorta și Uhlmann 2015, 1-8).

According to Mekdeci et al. (2012), maritime unmanned systems have become essential assets in contemporary naval operations, offering exceptional capabilities for enhancing Maritime Domain Awareness and force multiplication. In order to optimize the use of these technical advancements, it is possible to create modular unmanned systems (Barbier, Bensana and Pucel 2018) that may be readily tailored to different tasks. These platforms could have interchangeable modules for surveillance, electronic warfare, or striking vector delivery, allowing rapid reconfiguration to align with specific mission demands. According to Boulanin and Verbruggen (2017), the use of modularity would enhance operational flexibility and minimize the logistical strain by enabling a single platform to carry out various functions.

Artificial intelligence (AI) and machine learning (ML), which are rapidly expanding fields within contemporary technology, have the potential to significantly transform

naval operations via enhancements in decision-making processes, predictive equipment maintenance, and threat detection. Integration of artificial intelligence in analytics enables efficient and precise identification of threats and abnormalities by processing extensive quantities of data derived from satellite images, sensor networks, and ISR systems. The implementation of AI-driven predictive engagement systems, which leverage current operational models and historical data (feedback) to forecast potential threats and suggest preventive measures, has the capacity to streamline decision-making processes and effectively mitigate the impact of diverse risks. Simultaneously, machine learning algorithms could be implemented in these systems to enhance their precision progressively, enabling naval forces to maintain a strategic advantage over adversaries through predictive manoeuvring and preemptive countermeasures (Mukherjee 2018, 9).

Securing the digital infrastructure of naval operations is imperative as naval forces increasingly rely on networked systems, therefore cybersecurity becomes essential to protect these assets from espionage, sabotage and cyber threats. Concurrently, the complexity and sophistication of cyber threats require constant innovation and ingenuity in cybersecurity measures to protect communications, navigation and operational command systems.

Quantum cryptography for naval communications has been proposed as a potential way to address the challenges posed by cyber-attacks (Papathanasaki, et al. 2021). Quantum cryptography leverages the fundamental laws of quantum physics to provide encryption that is nearly impervious to decryption, therefore guaranteeing the preservation of communication integrity and confidentiality, even when confronted with sophisticated cyber threats. The use of quantum encryption technology in naval communications networks will greatly augment the security of confidential data and operational guidelines. Simultaneously, the establishment of alliances, the facilitation of information exchange, and the cultivation of situational awareness are critical components of a holistic strategy towards maritime cybersecurity, aiming to attain worldwide maritime cyber supremacy (Greiman 2019).

In summary, the use of technical advancements in naval operations offers a range of prospects and obstacles, alongside the introduction of new vulnerabilities. To solve these problems and enhance their operational capabilities, naval forces might use novel technologies such as modular maritime unmanned systems, predictive engagement based on artificial intelligence, and quantum cryptography. These technological advancements will empower naval forces to sustain strategic advantage in a progressively intricate and disputed maritime domain, guaranteeing their position as leaders in contemporary military technology and strategy. Simultaneously, we will witness a revolution in the way naval forces operate and a redefinition of maritime warfare and security. The future trajectory of naval warfare will be primarily influenced by the interplay between humans and machines, including both tangible realms such as water, space, air, and land, as well as intangible realms like cyberspace, electromagnetic networks, brain waves, and human consciousness.

Strategic adaptability and geopolitical factors

The purpose of this section is to evaluate the geopolitical processes that impact maritime security, especially in regions of strategic significance, such as the Black Sea. Additionally, this section aims to provide solutions for enhancing strategic adaptability in order to effectively respond to emerging threats and alliances.

Simultaneously, within the framework of evolving geopolitical circumstances, naval forces must exhibit strategic adaptability to maintain maritime security and exert significant influence within their designated area of responsibility and interest. The resurgence of intense competition among the dominant nations, particularly in the Black Sea, Baltic Sea, or Indo-Pacific region, necessitates a comprehensive evaluation of alliances and military stances. A novel and distinctive approach would include the development of a dynamic force deployment strategy, enabling adaptable and unpredictable naval operations. The regional military program BLACKSEAFOR, which operated from 2001 to 2008, has effectively deterred illicit activities in the Black Sea area. Exercises executed jointly by the littoral states, through the activation of a multinational naval group at least once a year (being also an 'on-call' force), in which naval forces of all littoral states participated, increased the stability of the Black Sea area (Sanchez 2012).

The advent and development of maritime hybrid warfare, which combines traditional naval capabilities with asymmetric tactics and cyber operations, has the potential to reinvent the fundamental concepts of naval warfare. By prioritizing non-kinetic warfare and information superiority, we can gain a significant advantage in contested maritime areas.

An effective approach to address these rapid transformations is the establishment of adaptable regional alliance frameworks. These include dynamic alliances between nations with similar interests, with a specific emphasis on swift deployment capabilities, combined maritime patrols, and also the establishment of a common database. In contrast to conventional alliances, which may get entangled in bureaucratic processes, the use of agile frameworks would provide prompt and synchronized reactions to new threats and occurrences, therefore enhancing collective security and deterrence.

Apart from rivalry between major powers or military threats, global maritime security is threatened by non-state actors, including piracy, maritime terrorism, illegal weapons and human trafficking, and environmental degradation. These challenges require multinational cooperation and innovative approaches to ensure the security of the seas for all nations. By implementing an integrated maritime surveillance and response initiative we could leverage satellite technology, unmanned autonomous systems, and artificial intelligence-based data analytics to monitor maritime traffic and threats regionally and globally. As hybrid threats originate from both state and non-state actors, targeting either a state's citizens, critical infrastructure or

even armed forces we can include naval forces, border police and even the civilian population in the surveillance system by developing national maritime awareness and vigilance to threats originating from the sea, so that every yacht or recreational vessel present at sea can be a sensor/warning system.

Participating nations could contribute with resources, and capabilities and also facilitate the exchange of information, enabling rapid response units to address piracy, trafficking, environmental crises, etc. The initiative would also promote adherence or facilitate compliance with international maritime laws and regulations, strengthening global maritime governance.

To enhance strategic adaptability, a term that signifies the ability to rapidly adapt strategy and course of action in response to circumstances, opportunities and trends based on past experience and available resources (McKee, Varadarajan and Pride 1989) the concept of hybrid naval force development can be introduced. This approach involves training and equipping naval forces with a combination of conventional, unconventional and cyber warfare capabilities. By integrating cyber units with traditional naval forces, they can conduct a diverse array of operations, from naval operations to asymmetric warfare and cyber defence. This multi-dimensional force structure would significantly complicate the calculations of potential adversaries, enhancing deterrence and operational flexibility.

In conclusion, the complexity of today's geopolitical landscape and the broad nature of maritime security challenges require a prospective approach to naval strategy. Hybrid warfare and its cyber dimension also force us to reassess traditional naval strategies. Naval forces must adapt to these changes to protect their interests and maintain their strategic advantage, and by adopting flexible alliance frameworks, launching a Maritime Surveillance and Response Initiative and developing hybrid naval forces, we could achieve a high degree of strategic adaptability. These solutions support building resilience, promoting international cooperation and securing maritime interests in an uncertain and unpredictable regional/global environment.

Environmental factors and the impact of climate change

This section aims to examine the impact of naval activities on the environment and the implications of climate change on maritime security. The goal is to identify sustainable practices and measures that enhance the resilience of naval forces. This will be achieved by demonstrating the non-coercive benefits of projecting naval power at sea.

The interplay between the environment, sometimes referred to as a civil society, and defence is marked by both divergent components and collaborative efforts. During times of war, it is undeniable that the armed forces have a purpose of causing violence and destruction. However, in times of peace, military formations have a dual responsibility in relation to the environment. The initial role is characterized

by conflict, as the armed forces, tasked with preparing for missions mandated by the Constitution and the government, inadvertently contribute to extensive pollution (including acoustic, atmospheric, and chemical pollution) and the degradation of the territory. This occurs through the execution of training exercises and operations, as well as the frequent establishment of industrial enterprises, military airports, barracks, and arms and munitions depots. The second function is collaboration, whereby the armed forces position themselves as entities capable of executing actions that are often dual in character, including both preventive and intervention in emergency scenarios, for the benefit of the community.

As mentioned above, the naval operational environment is inextricably linked to the natural environment, and the phenomenon of climate change presents both challenges and opportunities for naval forces. The ongoing phenomenon of polar ice cap melting is creating new shipping routes that require a strategic presence to ensure safe maritime navigation. Furthermore, naval forces have the potential to assume a pioneering role in environmental preservation via the use of sustainable technology, including alternative fuels and energy-efficient propulsion systems, in order to mitigate their ecological footprint.

The need for naval forces to reduce their environmental footprint has led to the exploration of sustainable technologies and practices, and we can include the adoption of alternative fuels, energy efficiency measures and advanced propulsion systems. One solution is the widespread adoption of advanced biofuels and hybrid-electric propulsion systems in fleets. Sustainably sourced biofuels can significantly reduce greenhouse gas emissions compared to conventional fuels. Hybrid-electric systems, which combine electric propulsion with traditional engines, offer improved fuel efficiency and lower emissions (Council of the European Union 2023). In addition, the development of solar-powered charging stations at sea or in port for these hybrid vessels could reduce pollution.

Regarding the climate change issue, to enhance resilience we can adapt infrastructure and naval operations. Climate change poses significant challenges to naval operations, including rising sea levels affecting naval bases and increasing frequency of severe weather events impacting force deployment and even training. One potential strategy is the establishment of naval bases that are resilient to climate change. This necessitates the construction of bases that can endure the impacts of rising sea levels and severe weather events which be achieved by integrating floating docks, flood defence systems, and stormwater management systems. Furthermore, equipping bases with weather radars, marine beacons, waste collection infrastructure, and the integration of renewable energy sources like solar and wind power into base infrastructures has the potential to enhance sustainability and diminish reliance on external energy sources (Ministerul Transporturilor și Infrastructurii 2023).
Due to their distinctive capabilities and extensive worldwide presence, naval forces are in a favourable position to make significant contributions to environmental

conservation initiatives and advancements in meteorology and oceanographic research. The involvement of naval forces in environmental monitoring and catastrophe response may significantly contribute to the advancement of innovation in these domains. The use of sophisticated satellite imagery and data analysis techniques has the potential to enhance comprehension of climatic patterns, hence making valuable contributions to humanitarian aid operations and disaster relief endeavours.

One potential unique project could be the implementation of regional or global naval environmental patrols, which would consist of dedicated naval forces responsible for monitoring environmental well-being, enforcing rules pertaining to illegal fishing and pollution, as well as performing climate research. These entities have the potential to engage in partnerships with global scientific institutions, facilitating the exchange of data and resources in order to enhance comprehension of oceanic climatic phenomena, marine biodiversity, and the ramifications of climate change on marine ecological systems. Utilizing technology for environmental monitoring and disaster response has exceptional prospects to enhance the involvement of naval forces in environmental monitoring and emergency response to climate change-induced natural catastrophes.

The utilization of artificial intelligence (AI) in the advancement of environmental monitoring and catastrophe prediction systems is a novel strategy for leveraging naval technology capabilities. These systems could use satellite imagery, drone surveillance and sensor data to monitor environmental conditions, predict natural disasters and coordinate rapid response efforts. By integrating artificial intelligence algorithms, these systems could analyze vast data sets to identify patterns and predict events such as tsunamis, hurricanes and oil spills, enabling proactive response and mitigation efforts.

To summarize, the convergence of naval operations, environmental factors, and climate change poses a range of obstacles and prospects. Naval forces can effectively address global environmental and climate challenges by implementing sustainable naval operations, enhancing resilience to climate change, actively participating in environmental protection and climate research, and utilizing technology for environmental monitoring and disaster response. The proposed solutions have the dual objective of reducing the environmental consequences associated with naval operations and using naval assets to foster a sustainable and resilient marine environment.

The pressing need for naval forces to embrace a more sustainable and responsible strategy is underscored by the environmental consequences of naval operations and the broader ramifications of climate change on maritime security. Comprehensive strategies to incorporate environmental responsibility into navy activities include several initiatives, including the deployment of biofuel-powered and hybrid-electric

ships, the creation of climate-resilient naval facilities, and the organization of naval environmental patrols. These endeavours not only provide a significant contribution to the worldwide battle against climate change but also guarantee the long-term viability of naval operations for future generations.

An alliance to address environmental challenges could promote the adoption of green technologies in naval fleets, encourage joint research missions to study the impact of climate change on the seas and oceans and initiate global naval operations dedicated to reducing pollution and supporting the conservation of marine biodiversity. International seminars and conferences would provide a platform for naval forces to exchange best practices and innovative approaches in the field of environmental management.

The promotion of technical cooperation and innovation among naval forces worldwide should not be disregarded. This hub would function as a centralized platform for the exchange of information, resources, and optimal methods in the advancement of naval technology, with a specific emphasis on unmanned systems, cyber security, and artificial intelligence.

Establishing a global maritime governance and legal framework is essential to ensure consistent and equitable application of international maritime law, addressing emerging challenges such as cyber warfare at sea and the militarization of maritime zones. This framework would work towards harmonizing maritime law enforcement and conflict resolution processes, ensuring that all actions are grounded in international law. Additionally, it would assist with continuous communication and bargaining on the revision of global maritime legislation, guaranteeing its continued applicability in light of evolving maritime security dynamics and technology advancements.

Conclusion

By achieving the objectives listed in each section, the study aims to contribute to advancing knowledge and understanding of the naval operational environment from a different perspective, while providing applicable recommendations for policymakers, military leaders, and stakeholders to skillfully manoeuvre through the complexities of the contemporary maritime sphere.

The 21st-century naval operational environment presents a panorama of challenges and opportunities, so by embracing technological innovation, adapting to geopolitical changes, addressing environmental impacts and pursuing collaborative frameworks, naval forces can navigate the uncertain waters ahead with confidence and strategic foresight. The future of naval operations will be characterized by agility, innovation and an unwavering commitment to maintaining regional/global maritime security.

However, in an era marked by rapid technological advances, changing geopolitical landscapes and pressing environmental challenges, the role of naval forces extends far beyond traditional notions of maritime security and power projection.

Throughout this study, we have explored the multifaceted dimensions of the naval operational environment, offering original solutions aimed at improving technological innovation, strategic adaptability, environmental management and regional/global collaboration. Collaboration must operate on the principles of mutual respect, shared responsibility and collective action, encouraging the participation of regional and/or global naval forces, irrespective of their size or capabilities.

Through regular technology exchanges, workshops and joint development programs, cooperation between naval forces, defence industries and academic institutions is achieved, and by pooling resources and expertise, the development and deployment of state-of-the-art technologies in global naval operations would be accelerated, enhancing overall maritime security and operational effectiveness.

The proposed solutions provide a roadmap for the transformation of naval operations, highlighting the need for a holistic approach that balances operational efficiency with environmental responsibility and international cooperation. In the context of the 21st century, the establishment of a peaceful, safe, and sustainable maritime domain for present and future generations necessitates the collaborative efforts of international naval forces.

References

Barbier, Magali, Eric Bensana, and Xavier Pucel. 2018. "A generic and modular architecture for maritime autonomous vehicles." Porto, Portugal. 2018 IEEE OES Autonomous Underwater Vehicle Symposium (AUV).

Boulanin, Vincent, and Maaike Verbruggen. 2017. *Mapping the Development of Autonomy in Weapon Systems.* Stockholm International Peace Research Institute. https://www.sipri.org/publications/2017/policy-reports/mapping-development-autonomy-weapon-systems.

Council of the European Union. 2023. *FuelEU maritime initiative: Council adopts new law to decarbonise the maritime sector.* https://www.consilium.europa.eu/en/press/press-releases/2023/07/25/fueleu-maritime-initiative-council-adopts-new-law-to-decarbonise-the-maritime-sector/.

Greiman, Virginia. 2019. "Navigating the cyber sea: Dangerous atolls ahead." International Conference on Cyber Warfare and Security: 87-93,XI. https://www.proquest.com/conference-papers-proceedings/navigating-cyber-sea-dangerous-atolls-ahead/docview/2198531195/se-2.

McKee, Daryl O., P. Rajan Varadarajan, and William M. Pride. 1989. "Strategic Adaptability and Firm Performance: A Market-Contingent Perspective." *Journal of Marketing* 53 (3): 21-35. https://doi.org/10.2307/1251340.

Mekdeci, Brian, Adam M. Ross, Donna H. Rhodes, și Daniel E. Hastings. 2012. „Investigating Alternative Concepts of Operations for a Maritime Security System of Systems." *INCOSE International Symposium* 22 (1): 1986-1998. https://doi.org/10.1002/j.2334-5837.2012.tb01451.x.

Ministerul Transporturilor și Infrastructurii. 2023. "Ordinul nr. 1848/2023 privind aprobarea Schemei de ajutor de stat pentru realizarea de investiții în infrastructura de transport naval aferentă Programului Transport (PT 2021-2027)." Publicat în Monitorul Oficial nr. 954 din 23 octombrie 2023. https://legislatie.just.ro/Public/DetaliiDocument/275550.

Mukherjee, Tuneer. 2018. *Securing the Maritime Commons: The Role of Artificial Intelligence in Naval Operations.* ORF Occasional Paper. https://www.orfonline.org/research/securing-the-maritime-commons-the-role-of-artificial-intelligence-in-naval-operations.

Papathanasaki, Maria, Panagiotis Fountas, Leandros Maglaras, Christos Douligeris, and Mohamed Amine Ferrag. 2021. "Quantum Cryptography in Maritime Telecommunications." *2021 IEEE International Conference on Cyber Security and Resilience (CSR).* Rhodes, Greece. doi:10.1109/CSR51186.2021.9527973.

Sanchez, W. Alejandro. 2012. *Did BLACKSEAFOR Ever Have a Chance?* https://www.e-ir.info/2012/11/18/did-blackseafor-ever-have-a-chance/.

Scipanov, Lucian Valeriu, and Valentin Costinel Totir. 2023. "Nevoia de adaptare a tacticilor navale la evoluția tehnologică – drone și platforme port-drone", *Gândirea Militară Românească* (nr. 3). doi:10.55535/GMR.2023.3.

Venegas-Andraca, Salvador E., Marco Lanzagorta, and Jeffrey Uhlmann. 2015. "Maritime applications of quantum computation." *OCEANS 2015 - MTS/IEEE Washington.* doi:10.23919/OCEANS.2015.7404356.