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War at sea in 2022–2023: lessons learned, perspectives and features of maritime unmanned vehicles employment

In the Russo-Ukrainian war, events at sea and their consequences play an important role. Therefore, it is a very important task to investigate the factors affecting changes and trends in the use of forces at sea. In addition, this article deals with issues related to the strategies of actions of the parties at sea and the presence of capabilities as well as the ratio of forces at sea. The main attention is paid to the consideration of the issue of disruption of command of the sea for the Russian forces and its consequences at the tactical, operational and strategic levels. A key aspect of superiority over Russian forces at sea is defined as intellectual superiority and anticipating the enemy through better awareness. Also, the article considers strengths and weaknesses of maritime robotic (unmanned) systems in the Russo-Ukrainian war. Based on the results of the analysis conducted during the study, the main lessons learned from the war at sea were determined.

Key words: Russo-Ukrainian war, experience of war at sea, naval strategy, warfare at sea, command of the sea, maritime robotic systems, unmanned vehicles, lessons learned.

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The analysis of the experience of ensuring the national security and defence of Ukraine in the conditions of the full-scale military invasion of the Russian Federation testifies the importance of actions conducted at sea and their significant contribution to success in the fight against the enemy. During the war at sea in 2022–2023 the defence of Ukraine from maritime directions was built, which is functioning now taking into account the actions of the Russian Federation and is constantly being improved. In order to ensure successful defence against Russian aggression, it is necessary to constantly study the lessons learned from the experience of warfare at sea, summarize it and formulate the stages of the war at sea, determine the prospects for the development of the situation and ways of responding to changes in the situation. In addition, an important task of scientific research is to study the experience of using maritime robotic systems in 2022–2023, to determine the factors that most influenced the effectiveness of their actions, to determine the tactical properties of these modern means and their role and prospects in the war at sea. All of the above determines the relevance of this study.

Recently, the experience of warfare at sea in the Russo-Ukrainian war and the experience of employment of maritime robotic systems were considered in the works [1–5]. The analysis of these works proves that they did not comprehensively and fully investigate the course of the warfare at sea in the Russo-Ukrainian war and the role of maritime robotic systems there.

Therefore, the aim of this work is to highlight the content of the main stages and identify lessons from the experience of the war at sea in 2022–2023, the main tactical, operational and strategic consequences of the disruption of Russia's command of the sea, the role of maritime robotic systems and the prospects for conducting warfare at sea in the future.

To achieve the aim of the work we need to find answers to such questions: what factors influenced the course of the war at sea at its beginning, above all the strategies of actions of the parties at sea and the presence of capabilities as well as the ratio of forces at sea; what led to the disruption of command of the sea for the Russian forces; what are the strengths and weaknesses of maritime robotic (unmanned) systems; and what are the main lessons learned from the war at sea?

First of all, let's consider the Russian naval strategy before the war. As is known, in 2017 «Fundamentals of the Russian Federation state policy in the field of naval activities» it was said that [6]:

- the main naval fleet task is «...to destruct of the military and economic potential of the enemy by destroying his vital facilities from the sea»;
- in wartime fleet must «...successfully confront an enemy in near and far sea zones ...»;
- after 2025 fleet will be armed of «...robotic vehicles, including unmanned underwater vehicles...».

Thus, the Russian naval strategy before the start of the war provided for the suppression of the economic potential and the destruction of the enemy's forces from the sea.

On the other hand, before Russo-Ukrainian war Ukraine developed new state strategic documents on maritime and naval fields – Maritime Doctrine of Ukraine [7], Doctrine of the Naval Forces of Armed Forces of Ukraine [8], Strategy of the Naval Forces of the Armed Forces of Ukraine 2035 [9] and innovative draft Concept for development and employment of maritime robotic (unmanned) systems [10]. All of these strategic documents were accorded with NATO approaches (standards), primarily with the main provisions of AJP-3.1, Allied Joint Doctrine for Maritime Operations.

But the goals and objectives of Ukraine's naval strategy had to take into account the insufficient level of naval capabilities, because as of January 2022, not everything had been done. UAV «Bayraktar TB2» [11], patrol boats [12], awareness system Delta [13] were accepted and started to be used. However, the division of the «Neptune» missile system was not put into service [14], the agreement with Great Britain on missile boats did not yet delivered the envisioned results [15]. On 24th February 2022, Russian Task Force at sea has significant advantage: general ratio was 1 to 12 [16]. These limitations largely determined the nature of the actions of the Navy in the first days of the war.

As an analysis showed, from the first day of the war one of important strategic directions of Russians was offensive actions from the south with the following goals:

- use of the Crimean Peninsula for a strategic blitzkrieg from the south;
- cutting off Ukraine from the Sea of Azov;
- capturing Odesa, Mykolaiv, Kherson regions from the sea and cutting off Ukraine from the Black Sea.

So, what were Russia's operation goals at sea? In accordance with the general strategy in the war, they were in the Black Sea as follows:

- gaining command of the sea in the north-western part of the Black Sea,
- blocking Ukrainian naval forces and ports;
- creation of favourable conditions for attack on Ukraine from sea directions (by amphibious operations);
- using the sea areas and air zones above them for «Kalibre» missiles and air drones launches on important objects on the territory of all regions of Ukraine.

In the Sea of Azov Russia's operation goals were:

- assistance to the troops during the capture of Berdiansk and Mariupol;
- carrying out a transportation and ensuring sea line of communications for the interests of military operations on land and export operations.

For the defence of Ukraine from sea directions, the Ukrainian Naval Task Force had to oppose the enemy at sea, first of all: to prevent the enemy landing operations from the sea and the deployment of a new front of Russian troops in the south of Ukraine; to support the troops defending the

coastal areas, in particular to take part in the defence of ports from the sea; create conditions for disrupting the enemy's blocking actions against Ukrainian forces and seizing the initiative in actions at sea. One of the important tasks at sea, which consisted in inflicting damage on enemy ships – carriers of long-range cruise missiles, could not be performed due to the lack of capabilities to strike such ships in their combat manoeuvring areas.

However, it should be said that the issue of damaging such ships was considered by Ukrainian military scientists in the previous period, and certain ways and methods of neutralizing the actions of such enemy forces were proposed [17].

In order to realize the aims in the warfare at sea, the enemy from the first days carried out a forward presence with warships at a distance of 25–30 km from Ukrainian coast, tried every night to land sabotage groups from small boats, and struck from the sea. There were cases when the enemy involved up to 7 landing ships at the same time! But Ukrainians determined that it was a deception. Later, the general situation in the war at sea changed significantly. Events took place that led to significant changes in the nature of the warfare at sea.

Now, as a result of an analysis of the combat experience in 2022–2023 we can identify the following stages of the war at sea:

- stage 1 (24th February – 1st April 2022), the Russian forces created and used command of the sea;
- stage 2 (2nd April – 21st July 2022), the successful Ukrainian missile strikes on the Russian's large warships (the frigate «Essen», on 2nd April, and the cruiser «Moskva», on 13th April), which disrupted enemy's command of the sea;
- stage 3 (22nd July – 28th October 2022), the restricted employment of forces at sea after concluding of agreements on the grain initiative between Ukraine, Turkey and UN, and the same Russian agreements;
- stage 4 (29th October 2022 – 4th August 2023), the transition to robotic warfare at sea, which began on 29th October 2022 with a complex strike against Russian forces in Sevastopol by unmanned surface and aerial vehicles;
- stage 5 (5th August 2023 – to present time), the interception of the initiative by Ukrainian forces at sea by strikes of unmanned surface vehicles on Russian ships near Novorossiysk and Kerch strait, partial blocking of sea communications and enforcement of Russian naval forces to relocate to the eastern part of the Black Sea.

In order to draw correct and useful conclusions from the warfare at sea during the Russo-Ukrainian war, let's consider the most revealing combat episodes.

The first episode demonstrates anti-amphibious defence of the sea coast, which was created by Ukrainian forces before Russian invasion. On 25th February 2022, Ukraine officially declared 7 areas off limits to navigation in the Black Sea. On 23rd March, the small diving vessel «Pochaiv»

was returning to Odesa after completing its tasks. In this moment missile frigate «Makarov» tried to intercept the ship. It began to strike with artillery. «Pochaiv» approached the shore at maximum speed in an anti-artillery zigzag. When the frigate had approached the shore, it was hit by coastal artillery. The frigate disengaged and launched 2 anti-aircraft missiles, but they hit the shore. This combat example confirmed the effectiveness of creating mine-missile-artillery positions.

The second combat episode illustrates the decision-making process on the command post of the Ukrainian Naval Task Force and the success of strikes by a coastal missile system. At the end of March 2022, the enemy announced a false «humanitarian corridor» for the exit of civilian ships from Ukrainian ports. Every day in the morning, one of the frigates entered the «area of the formation of the convoy» and then demonstrated movement through this «corridor».

On 2nd April, after analysing the daily nature of the enemy's frigate manoeuvring on the «corridor», the advisor of the commander of the Ukrainian Naval Task Force calculated its expected location at a certain time, and the commander made a decision to attack the Russian frigate «Essen». During the attack the frigate fired a false electronic target, but the «Neptune» anti-ship missile continued toward the frigate. After the attack the frigate left the area of the combat mission and at 9 o'clock in the evening arrived at Sevastopol. It did not go to sea for the next 10 days.

The next combat episode is about the first hunt for the cruiser «Moskva» on 4th April. The first problem was substantiating the priority of targets in the conditions with a limited number of missiles. Secondly, at that time, the main targets were landing ships. But they didn't approach the shore for a long time. The commander and staff were faced with questions: the expediency and possibility of hitting the cruiser.

On 4th April 2022, the weather was excellent, and thanks to UAV «Bayraktar TB2», the manoeuvre of the cruiser in front of gas platforms was clearly visible. But while preparing to fire, the cruiser quickly changed position and hid behind the gas platform. The staff of Ukrainian Naval Task Force analysed the behaviour of the cruiser for several days and made some recommendations to the Task Force commander.

On 13th April, the weather was bad and UAV «Bayraktar TB2» was not used. Analysis of cruiser movements over the preceding days provided a good estimate of position of cruiser «Moskva». The commander was allowed to use only 2 missiles. It was initially unknown whether the «Neptune» missiles hit cruiser «Moskva». The result was not known for some time – about 40 minutes, then the radars noticed the rapid approach of other enemy ships to the location of the cruiser. The cruiser's radar stopped working. The fight against the fire on the board of the cruiser was unsuccessful. Explosive ammunition finished off. On the

morning of 14th April, UAV «Bayraktar TB2» confirmed that the cruiser was already lying on its side and burning.

The main factors which was evaluated before attack on cruiser [16]:

- technical readiness of weapons and ship systems, including the ship's survivability combat system;
- degree of modernization of radar and anti-aircraft missile weapons, including the ability of complexes to timely detect and destroy air targets at extremely low altitudes;
- level of combat training of the crew, including the professional skills of young sailors and training results of the ship's combat exercises;
- combat experience of the crew in military operations in Georgia, Syria;
- the fact that the ship was a flagship of the fleet and had the name of the capital of the state, as an element of moral and psychological influence.

The main conclusions are as follows: the need for a constant and deep analysis of the nature of the enemy's actions, and on the other hand – not allowing for stereotyped actions, and, of course, – a reasonable prioritization of goals for defeating the enemy.

What were the results of the strikes on the frigate «Essen» and the cruiser «Moskva»? After the strike on the frigate «Essen», the enemy took the ships on a distance more than 80 km from the Ukrainian coasts, and after the sinking of the cruiser «Moskva» – more than 240 km from the Ukrainian coasts, that is at a distance of no more than 10–12 km from the western coast of Crimea (*Fig. 1*, [16]).

These strikes of the Ukrainian Naval Task Force at sea with guided missiles «Neptune» caused the following consequences at the tactical, operational and strategic levels. Main tactical consequences were [16]:

- the destruction of the cruiser required its replacement with another warship to perform the tasks of isolating the area, covering the garrison of Snake Island, and ensuring the control of forces at sea;
- a significant reduction in the overall combat capabilities of the enemy forces operating at sea;
- negative impact on the morale and psychological state of the crews of warships and other forces which performed tasks in the War Risk Area.

At the operational level the main consequences were [16]:

- the emergence of the need to make changes in the distribution of tasks by forces in operations, in the organization of the operational order of battle as well as enemy's command and control of the sea;
- shifting the areas of action of the forces to the east, in fact to the coastal areas of Crimea, primarily with the aim of securing ships of the main classes from entering the zone of damage of the «Neptune» missile system.

And at the strategic level of war at sea the main consequences were [16]:

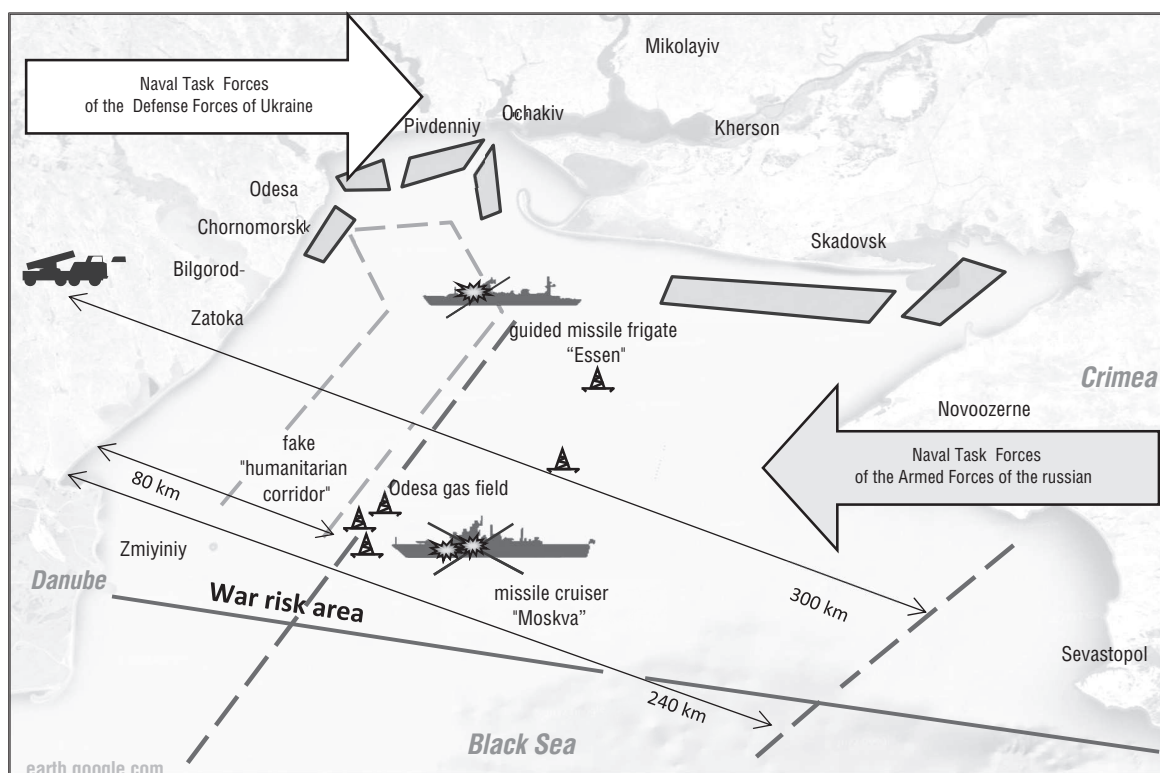


Fig. 1. The disruption of the Russian forces command of the sea [16]

- the enemy's refusal to use most of the area of military operations and, in fact, the disruption of the enemy's sea control;
- significant decrease in the probability of sea landing and, accordingly, a threat to Ukraine regarding the emergence of a new dangerous strategic direction in the war;
- a significant negative impact on the moral and psychological state of the population and the military and political leadership of Russia.

As a result of the destruction of the cruiser, the Russian's strike capabilities at sea were reduced by more than 30 percent (Fig. 2).

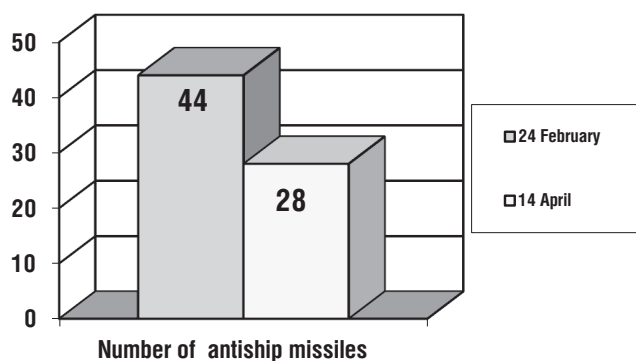


Fig. 2. Reduction of the anti-ship strike capabilities of the Russian forces at sea

The dynamics of reduction of the areas controlled by the Russian forces within the declared war risk area in the Black Sea (Fig. 1) is shown in Figure 3.

Let's consider the experience of the employment of maritime robotic systems by the Naval Forces of Ukraine and other components of the Defence forces of Ukraine during the war. Unmanned surface, undersea and aerial vehicles have played a very important role in warfare at sea. Currently, the active development of tactics for the employment of maritime robotic systems continues [18].

In present time the Ukrainian Naval Forces and other components of the Defence forces of Ukraine use a number of devices both received from foreign countries and of their own production. These are including: unmanned undersea vehicle REMUS-100, unmanned aerial vehicle «Bayraktar TB2», unmanned surface vehicles (USV), etc.

The most telling combat example is the episode of the destruction of combat boats near island Zmiyniy (Snake Island). The drone «Bayraktar TB2» was able to approach the target several times and, in that case, destroyed several boats at once. He struck them in the most critical place – the command post of the boat. The situation changed after the enemy began installing anti-aircraft missile systems on the decks of landing crafts and auxiliary ships. UAVs «Bayraktar TB2» could not freely strike at such targets.

The main lessons learned of UAVs «Bayraktar TB2» employment are:

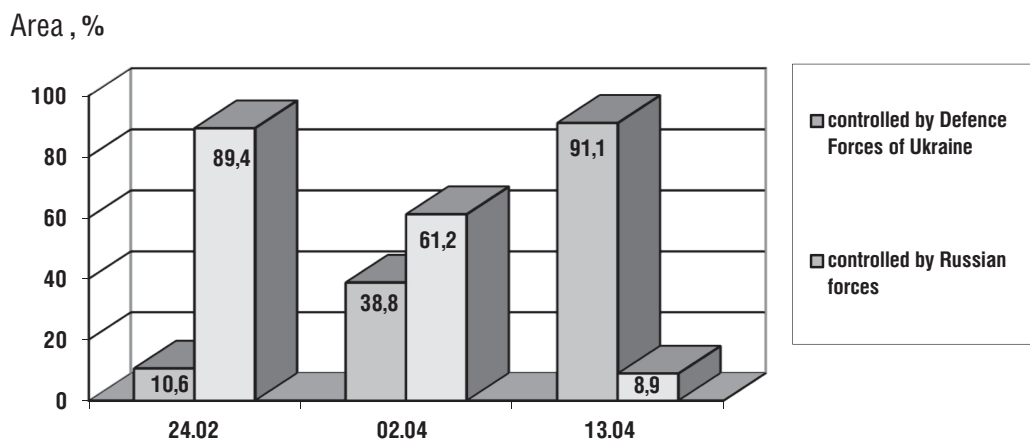


Fig. 3. The reduction of the areas controlled by the Russian forces within the declared war risk area in the Black Sea

- ensured the detection of surface targets at a long distance (several hundred km);
- ensured the advance of the enemy and superiority over him;
- bad weather conditions (cloudiness, low temperatures) and insufficient combat resilience limit UAV capabilities.

In the next period of the war at sea, the employment of unmanned surface vehicles (USV) gained significant importance. A lot of combat episodes of the USV employment are known. The main ones are:

- 21st September 2022, Sevastopol;
- 29th October 2022, Sevastopol;
- 18th November 2022, Novorossiysk;
- 22nd March 2023, Sevastopol;
- 24th April 2023, Sevastopol;
- 24th May 2023, south-west area of the Black Sea;
- 17th July 2023, Kerch Strait (the bridge);
- 1st August 2023, south-west area of the Black Sea;
- 4th August 2023, Novorossiysk;
- 5th August 2023, Kerch Strait;
- 18th August, south-west area of the Black Sea.

One of the largest combat episodes of the USV employment of maritime robotic systems is the complex strike of unmanned aerial and unmanned surface vehicles in Sevastopol on 29th October 2022. According to open data, about 9 aerial and 7 surface vehicles were used. As a result of the UAV and USV employment, several ships were damaged.

The most effective was the USV employment on 4th and 5th August 2023, there were damaged the large landing ship «Olenegorsky Gorniyak» near the naval base Novorossiysk and the Russian oil tanker «Sig» in the Kerch Strait.

The main conclusions and lessons from USV employment:

- for the first time in the history of warfare at sea it was a complex and large-scale employment of maritime robotic systems, in particular aerial and surface systems;

- the results of the strike in Sevastopol indicated the enemy's loss of control over its own waters at the base points and on the approaches to them;

- navies of the world need to be prepared to effectively counter the USV;

- dynamic development of maritime robotic systems requires the development of the counter weapons and special theory regarding the new tasks and ways of employment of such systems.

It is very important that the main positive and negative tactical properties of such systems are determined based on combat experience. The main positive (favourable) tactical properties of the USV should include, first of all, the following:

- a significant advantage in the speed of combat manoeuvring, usually over objects of influence and surface ships;
- low level of visibility due to the small size during detection by traditional (non-specialized) technical means (radar, hydro-acoustic, optical-electronic, thermal imaging, etc.);
- a relatively high level of communication and control stability in the case of using satellite communication and information transmission systems;
- the ability to quickly and completely transmit information to the control point about the situation in the area of operations.

The main negative tactical properties of the USV should include, first of all, the following:

- relatively low level of combat resilience against conventional (traditional) naval, aerial and other means;
- lack of armaments to repel enemy strikes;
- lack of redundant control systems and movement support.

Thus, it can be argued that robotic systems are changing the nature of warfare on land, in the air, at sea, and becoming significant means of superiority and success.

The analysis of the experience of the war at sea testified the emergence of a number of innovations that must be taken into account in the future. The main innovations from the experience of the war at sea are:

- new tactics of joint employment of the maritime robotic complexes (surface, subsurface, aerial);
- new requirements to the defence system of the forces at sea and in the naval bases (in the conditions of strikes of maritime robotic complexes);
- new requirements to the defence of maritime states (taking into account the latest means of warfare at sea, their capabilities and the consequences of their employment).

The consequences of actions at sea clearly demonstrate the losses of the Russian naval forces:

- destroyed missile cruiser of the project 1164 «Moskva», the flagship of the fleet (13th April 2022, the Black Sea, displacement – 11,280 tons);
- destroyed large amphibious ship of the project 1171 «Saratov» (24th March 2022, the Azov Sea, displacement – 4,650 tons);
- destroyed support vessel of the project 22870 «Spasatel Vasily Bekh» with air defence systems (17th June 2022, the Black Sea, displacement – 1,670 tons);
- destroyed 5 combat boats with weapons and assault units (2nd–7th May 2022, the Black Sea, total displacement – 200 tons);
- damaged frigate of the project 11356R «Essen» (4th February 2022, the Black Sea, 10 days absence);
- damaged large landing ship «Novocherkassk» (24th March 2022, the Azov Sea);
- damaged large landing ship «Caesar Kunikov» (24th March 2022, the Azov Sea);
- damaged minesweeper «Ivan Golubets» (29th October 2022, the Black Sea, 5 months absence);
- damaged medium intelligence ship «Ivan Hurs» (24th May 2023, the Black Sea);
- damaged large landing ship «Olenegorsky Gorniyak» (4th August 2023, the Black Sea);
- damaged Russian oil tanker «Sig» (5th August 2023, the Black Sea).

Also, an important success in the warfare at sea was the damage to the Kerch bridge on 17th July 2023, with the employment of unmanned surface vehicles.

As **general conclusions**, it should be first of all emphasized the importance of disrupting the enemy's command of the sea, reducing the probability of amphibious operations and an enemy attack from the south. However, at present, the task of destroying the Kalibr missile carriers remains unresolved. The main conclusions and lessons learned from the war at sea in 2022–2023 are:

1. The successful conduct of combat actions by the Ukrainian Naval Task Forces in the north-western part of the Black Sea disrupted the enemy's command of the sea and limited the areas of combat manoeuvring of his strike forces near the coast of Crimea [16].

2. The effective organization of the defence of the sea coast, in particular with the creation and use of mine-missile-artillery positions, disrupted the enemy's amphibious operations and his strategic attack on Ukraine from the sea [16].

3. The lack of long-range weapons in the Ukrainian forces does not allow to preventively destroy the enemy's cruise missile carriers and significantly reduce its negative impact on the general military-strategic and operational situation, avoid damage to important military, defence-industrial, energy infrastructure and other objects within the entire depth of the territory of the state and victims among the civilian population [16].

4. The joint employment of maritime robotic systems (surface, subsurface, aerial) has ensured the capture of the initiative in the war at sea and creates the prerequisites for command of the sea, and in the long run – for a full-scale transition to robotic warfare at sea.

5. There are also new requirements for the complex defence of maritime states:

- must be built on the principles of joint forces and have a unified C2 system before wartime;
- can be ensured by the use of asymmetric methods and means (mine weapons, coastal missile systems, reconnaissance and strike maritime robotic systems, etc.);
- requires an advantage in awareness of the situation at sea, constant complex analysis (retrospective and prospective) of the enemy forces;
- in order to prevent or disrupt the enemy's command of the sea it is necessary to ensure an intellectual advantage and combination of kinds of defence, in particular coastal defence by the creation of mine-missile-artillery positions.

The features of Russo-Ukrainian war at sea defined above, as well as the conclusions and lessons learned, in the opinion of the author, must be used when analysing and forecasting future actions at sea and ensuring the security and defence of maritime states.

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