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OVERVIEW ON SEA DRONES EVOLUTION AND THEIR USE IN MODERN WARFARE

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ABSTRACT

The unjustified invasion of Ukraine by the Russian Federation created the necessary conditions for the development and testing of technologies in the operational space of the traditional war theater. Considering that Ukraine has lost a large part of its naval forces in the first days of the conflict, there was an essential need to develop new technologies that would allow this state to defend itself. Moreover, given the innovative character of the surface and underwater technologies developed by the Ukrainians, they were able to be used for offensive actions, which surprised the naval forces of the Russian Federation repeatedly. Access to operational vehicles was made easier and more accessible with the introduction of smaller, lighter and less expensive equipment. The article proposes an analysis of the evolution of naval drones and how they were used in the most recent conflict in the Black Sea area. The main objective of the study is to identify and present the main types of underwater technologies that have enabled the development of naval drones, the analysis of how they have been used in a contemporary conflict and the recent evolution of their actions. The conclusions of the study are focused on the potential use of these technologies and how they can be used in combination with other combat technologies in armed conflicts of various types.

KEYWORDS: AUV, robotics, ROV, warfare, UUV

1. Introduction

Marine drones, or "Unmanned Underwater Vehicles" (UUVs) as well as "Unmanned Surface Vehicles" (USVs), are submersible or floating vehicles that can function underwater without on their own. Autonomous underwater vehicles (AUV) and remotely operated underwater vehicles (ROUV) are the two categories into which these technologies can be separated. A person controls ROVs remotely (Button, Kamp, Curtin & Dryden, 2009). Marine drones are amazing devices that have completely changed the way that marine data is gathered. They are autonomous and run without direct human involvement. Their significant discoveries came about as a result of the effective creation of complementing technologies to

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address the difficulties involved in autonomous operation in hostile situations.

The initial developments continued steadily and by the end of the last century, UUVs had gradually moved from the controlled academic environment into challenging operational scenarios, covering scientific, commercial and military applications. As the technology has matured, many technical solutions have been effectively demonstrated in various sizes and configurations, and several have evolved into established commercial products in both the military and commercial domains.

UUVs began to appear toward the end of the 20th century, having slowly advanced from controlled academic environments into demanding operational settings spanning commercial, military and scientific uses. Many technical solutions have been successfully proven in a range of sizes and configurations as the technology has developed and some of these have turned into well-known commercial products that are used in both the military and the commercial sector.

2. Research Methodology

The research methodology was centered on a structured and scientific approach that consisted in the collection, analysis and interpretation of quantitative or qualitative data related to naval drones starting from their early development and reaching the stage of their use in a recent armed conflict, the unfolding of which progress daily. The research methodology contributed to the realization of the research and contributed to maintaining the topicality of the studied theme, limiting the scope of the research. In this regard, aspects related to the limitations of the research, such as the availability of accurate information on this topic or the constant evolution of the situation in Ukraine, were taken into account.

The data collection and analysis methods consisted in consulting news sources that closely follow the evolution of military actions in the studied conflict zone, the pages on the social media sites of some users specialized in the analysis of events within the conflict. At the same time, the data necessary to carry out this study were collected from the official pages of some profile institutions in Ukraine, as well as from a very limited series of scientific articles, which analyze similar topics.

The main objective of the research is to present an accurate picture of how recent underwater technology can be used effectively, given that this equipment will be acquired, developed and used by many more navies, in addition to the states that already use these technologies.

3. Overview on the Evolution of Maritime Drones

Ocean research has been revolutionized by naval drones. Drones have changed dramatically over the last 20 years, from bulky, costly equipment used in scholarly ocean research to a versatile tool used in a variety of theoretical and applied domains, including the military and commercial. As a result, these devices now have higher demands for load capacity, processing capacity, autonomy and acoustics. For this reason, affordability and adaptability are crucial.

The “Applied Physics Laboratory” at the University of Washington in the United States created the first piece of equipment, which is essentially categorized as a maritime drone, in 1957. It was named SPURV (Special Purpose Underwater Research Vehicle; it is sometimes abbreviated to “SPURV”) and was intended to investigate arctic waters (Roberts & Sutton, 2022). The aluminum body of the SPURV was shaped like a torpedo. The SPURV was propelled by a screw-type propeller and featured a traditional hydrodynamic design. This underwater drone was controlled by audio communications. Up until 1979, SPURV was effectively employed in oceanographic research and it is now recognized as a

dependable and useful instrument for ocean exploration.

The potential applications of drones have increased with the advancement of technology. In 1983, “ARCS” was created by “ISE Ltd.” with support from the Department of Defense and the Canadian Hydrographic Service. It went on its first mission in 1987. Using a 32-bit Motorola CPU, the device's feature allowed users to stay underwater for up to 35 hours, depending on the mission and watch and control marine drones in real time. New drone technologies, like algorithm-based missions, new navigation systems and new battery kinds, have all been successfully tested on ARCS.



Figure no. 1: *1960 SPURV launch in the ’60*
(Source: Gettinger, 2018)

The prospect of mounting solar panels on surface marine drones piqued the interest of specialists from the Russian Institute of Marine Technological Problems in the late 1990s. “SAUV” stands for “solar autonomous vehicle”, the name of this concept, developed in collaboration with “AUSI” (Autonomous Underwater System Institute). The SAUV was founded in 1998. Subsequently, AUSI researchers developed the SAUV II, a solar drone, based on their expertise constructing similar vehicles (Gettinger, 2018). The vehicle was able to finish its mission in a matter of weeks or months because to the solar panels mounted on it, which continuously recharged the batteries. The SAUV had a significant load capacity with sensors and equipment, could navigate using GPS and could drive for eight hours without needing to recharge its battery.

In 1994, MIT students were among the first to develop the “Tuna” project, an underwater robot that mimics a tuna fish. In addition, the “RoboPike” created by them featured a flexible body and functional features akin to those of a conventional marine drone. “Ariel II”, “RoboLobster” and other bionic marine drones of the “crawl” kind have been developed in addition to the scientific bionic (swimming) AUVs. They have pincers that resemble

those of crabs and lobsters, which allow them to travel through water.

Fin-equipped bionic marine drones have also been created recently ("AQUA2" project and others). AQUA2 is a functional robot that supports coral reef, sea floor and shallow environment monitoring. Its four robust polymer fins enable the system to travel on sand or snow in addition to underwater. AQUA2 has far more mobility than a traditional drone thanks to its four fins.

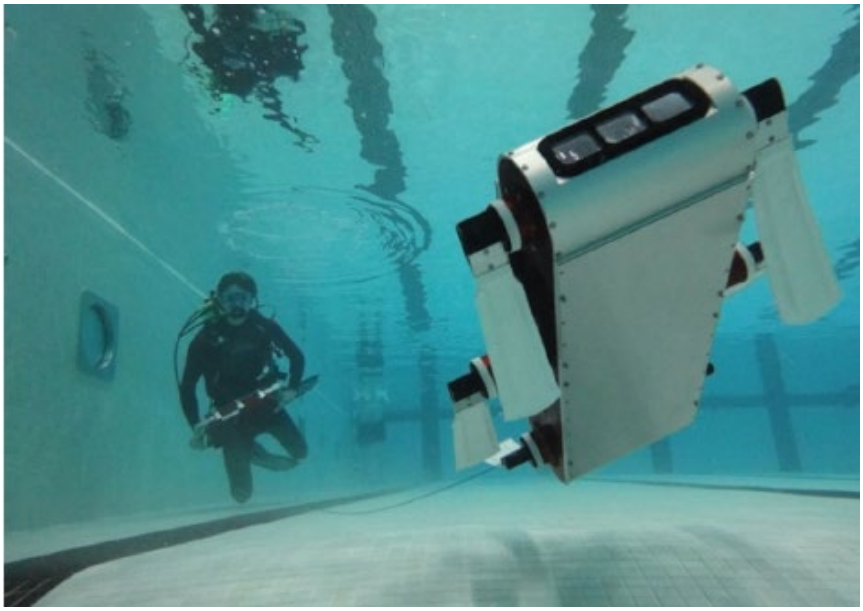


Figure no. 2: *AQUA2 drone testing*
(Source: Bocharov, 2019)

Thus, the creation of marine drones is not a relatively new endeavor. From the level of simulation study to commercialization and from a technological point of view, from the modelling of a single maritime drone to the cooperative control of numerous drones, a quick presentation of its conception, which dates back to the 1970s, is provided below:

– **Before 1970. Initial development of drones** – The first drones were developed as early as the 1960s, which were used for data collection and transfer.

– **1970-1980. Exploring the potential of drones** – The first true drones called "Torpedes" were developed in the 1970s by the US, which were used for testing purposes. Many successful (and failed) experiments were carried out during this period and, in addition to these, this decade also formed the basis for most of the theoretical and experimental work on sea drains.

– **1980-1990. Experimentation with prototypes** – This period was the golden age in the history of the chronological development of maritime drones due to the fact that most of the theoretical developments were implemented in practical areas (test benches were manufactured for this purpose). During this period, the DARPA laboratory developed most of the prototypes in the US (Wernli, 2022).

– **1990-2000. Development of technology to meet the objectives** – This decade saw the development of the first generation of maritime drones that were capable of performing tasks for the purpose of experiments. A number of organizations have been able to develop drones according to their goals and this decade has brought underwater-oceanic vehicles to commercialization.

– **2000-2010. Commercialization of Maritime Drones and Development of Cooperative Motion Control Technology** –

This is the decade of movement of maritime drone research and technology from academic to industrial level. During this period, many companies were able to develop the drones according to the market demand and this was the proper use of the drone technology in the practical field. Theoretical development of cooperative motion control of multiple drones has been accomplished in this decade.

4. Naval Drone Role in Modern Warfare

In order to identify the crucial elements of the future maritime battlespace, naval operations trends have been redefined as a result of the recent expansion of weapons and sensor technology.

The requirement to highly increase situational awareness through better information content, platform implementation and process development that facilitates more effective information gathering, processing, evaluation and exploitation was paramount to this project. This is partly because the quality of combat decisions made, especially those that would allow navies to more effectively coordinate observation, targeting and engagement actions against enemy forces, will define the future operating environment more so than the potency of the maritime force.

Although research on the future marine environment emphasizes diverse aspects of changing military capabilities, all of them acknowledge that maritime forces are increasingly likely to deploy networked systems and highly precision-guided weaponry in contested environments (Ura, 2021). There seems to be considerable cause to anticipate that in the future, even as the maritime battlespace really compresses and naval forces' surface freedom of maneuver is severely curtailed, the usage of long-range sensors and precision attack capabilities will grow dramatically.

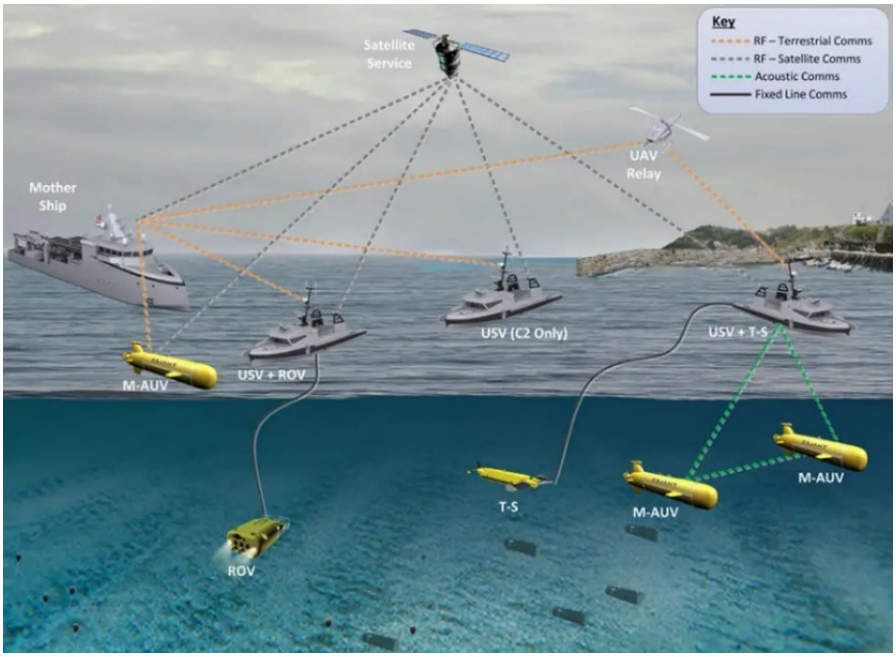


Figure no. 3: *Operating principle of an integrated system for naval drones* (Source: https://www.navyrecognition.com/index.php/naval-news/naval-news-archive/2019/february/6828-belgian-dutch-mcm-sea-naval-solutions-unveiled.html)

Empirical studies have shown that postmodern marine operations may incorporate operational ideas requiring the use of remote sensing and ranging capabilities. Analysts predict that unmanned and autonomous systems will be crucial in shaping events

during both peace and war in several of these domains, including reconnaissance campaigns, network-centric warfare, special operations and littoral combat.

Autonomous systems are seen by many observers as the most significant aspect of the maritime environment of the future. Integrated decision-making and artificial intelligence (AI) systems are a revolutionary and potentially disruptive capacity that can push the bounds of invasive maritime missions to create a new normal in the maritime community. Their capacity to carry out combat operations into an enemy's anti-access/area denial zone without jeopardizing own forces or onboard system integrity is what sets them apart. But what likely sets these systems apart from other platforms is their capacity to overwhelm target systems and sensors with sheer numbers, which drastically reduces the enemy's combat effectiveness.

Modern fleets employ advanced underwater drones for anti-submarine warfare (ASW), mine countermeasures (MCM), naval intelligence, surveillance and reconnaissance (ISR) missions. Although unmanned underwater vehicles (UUVs) are still relatively new, their employment is expanding quickly, particularly in regions like the South China Sea and the Strait of Hormuz and this is altering the way fleets see littoral operations (Button, Kamp, Curtin & Dryden, 2009).

Today's UUVs can be broadly categorized as either remotely operated underwater vehicles (ROVs) or autonomous underwater vehicles (AUVs). An AUV differs from a ROV in that it retains some autonomy from human control, despite the fact that many distinctions between the two platforms have become less clear because to the rapid advancements in technology. The primary capability of the maritime drone is its ability to carry out ASW operations that are typically handled by nuclear-powered attack submarines, which are better equipped to handle more crucial duties. To enable continuous submarine tracking, these platforms are outfitted with a passive sonar-style device.

The ability of these platforms to carry out standard underwater operations may ultimately determine the direction that unmanned and autonomous underwater technologies go. It's true that there has been significant conjecture in recent years regarding autonomous vehicles' purported capacity to conduct full-spectrum submarine operations. Indeed, even if this estimate is still purely theoretical, its conceptualization nonetheless presents some intriguing possibilities. Modern submarines require significant financial and technological commitment to maintain secret, which reduces a commander's willingness to take on forward operations in hostile waters. The Navy might become far more adventurous in hostile waters if underwater platforms could take the role of submarines.

Therefore, it should come as no surprise that the world's leading navies – the US, Russia, UK and China – are aggressively creating undersea platforms for cutting-edge operations. Moscow declared in 2022 that it was creating a family of unmanned surface and undersea vehicles that would be able to hunt out US submarines in Russian territorial seas. It is also said that the Russian Navy is developing tethered drones to do intricate missions at very deep depths. According to reports, the US Navy is developing comparable tools to counter Russian submarine operations in the Atlantic. The Pentagon detailed plans to create a network of underwater platforms, sensors and charging stations in a report to the US Congress in January 2021.

Surveillance and Research – The maritime domain has highlighted a requirement for a persistent ISR action. It is significant not just for the conventional reason of obtaining intelligence, but also as a forerunner and facilitator of more drone missions and uses. When it comes to drones, the goal of ISR missions is to gather intelligence while staying under the radar.

This includes gathering data on electromagnetic, optical and aerial samples, weather, acoustic signals, water sampling, monitoring equipment on the ocean floor and object location (Ahmed, 2023). Littoral area ISR, port monitoring, chemical, biological, nuclear, and radiological (CBRN) detection and localization, placement of surveillance sensors, battle damage assessment, active target identification and other specific UUV ISR capabilities are among the many capabilities available.

Mine Countermeasures (MCM) – The necessity to swiftly build expansive and secure operating areas, routes and transportation lanes drives the requirements of the MCM mission. It is stated that all MCM operations in designated regions must be finished in seven to 10 days, but obviously, the sooner the better. This MCM capability aims to reduce MCM delays while simultaneously identifying or creating operating areas free of sea mines without requiring human platforms to access suspected mined regions.

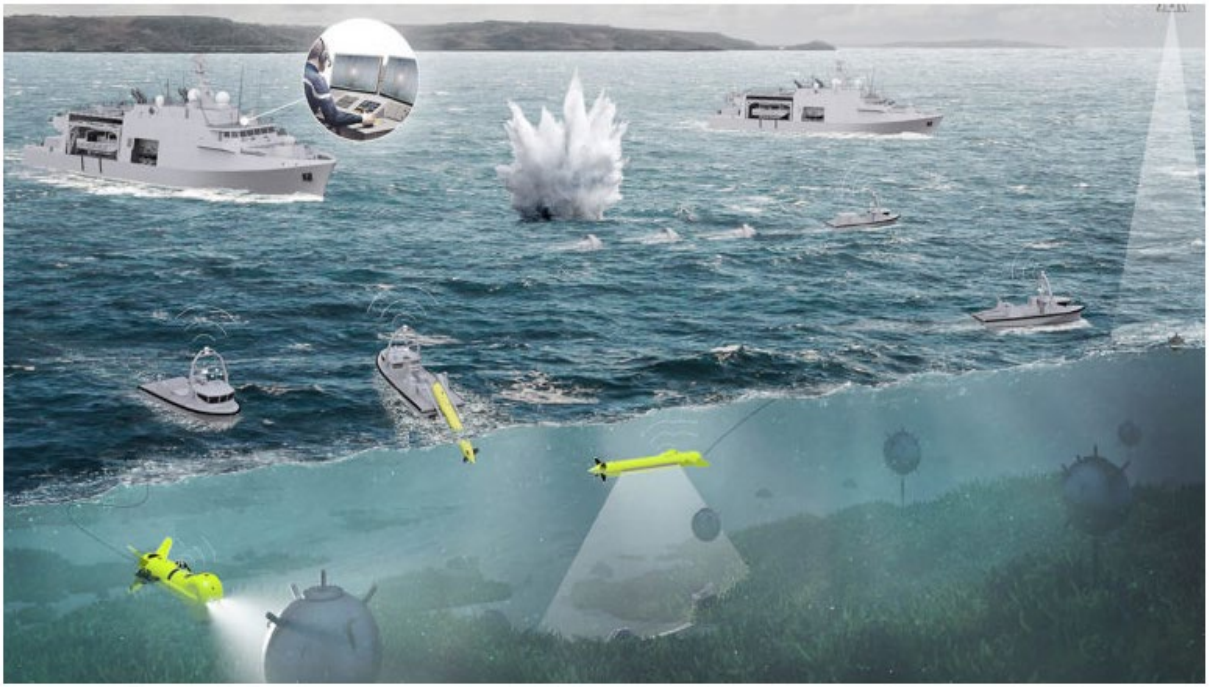


Figure no. 4: *Customization of the maritime drone system for MCM missions*
(Source: https://www.navalnews.com/naval-news/2020/09/eca-groups-belgian-subsidiary-to-manufacture-mine-warfare-drones-for-mcm-program/)

Among the tasks that maritime drones must complete, MCM is arguably the most difficult. The MCM mission is regarded as such due to the variety of mine types, their accessibility to possible enemies, their simplicity of use at a wide range of depths and the zero tolerance nature of MCM operations. These requirements can be met by MCM mission types in operational contexts due to the variety of mine-related risks they face. Among them are:

– Reconnaissance – Detection, Classification, Identification and Location;
– "Clearance" – Neutralization;
– Activation – Mechanics and Influence;
– Protection – Tampering and Blocking (Mondal, Banerjee & Panja, 2021).

In the immediate term, mine hunting and neutralization-specific MCM functions are those that lend themselves to drone-specific solutions. The phases of detection,

categorization, identification and neutralization can be separated out of them.

ISR and oceanographic missions benefit MCM. Drones can gather oceanographic data on wind, bathymetry, water visibility, currents, waves, geophysical parameters, concentrations of algae, sand dams and other factors that could alter mine contacts well in advance of hostile operations.

Payload Delivery – Although it is not a mission in and of itself, payload delivery is necessary to supply power, autonomy, navigational capabilities and payload deployment systems for several other mission areas. Big drones can help with logistics by providing covert support and supply without disclosing critical platforms. Possible payloads consist of:

– Sensors or vehicles deployed in support of ISR, ASW, MCM;

– Oceanography, CN3 or TCS;

– Weapons to deploy;

– Supply for Special Forces or EOD missions;

– MCM neutralization devices;

– Loading as a result of divers delivery platforms (Galushko, 2023).

Force Protection – Using maritime drones, ASW seeks to patrol, identify, track and destroy enemy submarines. The ASW mission has historically been labor-intensive, requiring individuals with various degrees of sensor expertise to collect vast volumes of data, such as from buoys or towed sonar. From this data, pertinent information can be created, allowing for a potential assessment of the target or risk. Recently, other strategies for ASW have been proposed, involving dispersed mobile and fixed sensors like drones. Broadly speaking, there are three types of ASW operations, which are as follows:

– "Hold at Risk" – monitoring of all submarines leaving a port or transiting a narrowing point;

– Maritime shield – checking and maintaining the area of operation of a large maritime force without threatened submarines;

– Protected passage – verifying and maintaining a route for a maritime force from one area of operation to another without threatened submarines (Mondal, Banerjee & Panja, 2021).

5. The Successful Use of Maritime Drones in the Ukrainian Conflict

The armed confrontation between the Russia and Ukraine serves as an example of how quickly the political-military landscape and global objectives can shift. Given the contradicting and erroneous information coming from many sources, predictions on the conflict's potential result are hazy. The strategic psychological and informational operations played a prominent part in this fight. It is evident that the economic fallout for the Union will likely be more than expected, even in a local conflict that does not occur on EU territory.

When Russia took Crimea in 2014, Ukraine lost almost 75% of its navy. Early in the Russian Federation attack, the last Ukrainian naval stations were destroyed. It looked like the Russian navy was taking over the Black Sea at that time, but the Ukrainians were able to defeat their more powerful opponent by using some sort of "unorthodox weaponry" and asymmetric warfare strategies. There was widespread employment of unmanned systems throughout wartime. This is the first significant battle in which unmanned aerial vehicles (UAVs) and USVs have been so crucial to the outcome. These systems are used by both sides for many different tasks, such as electronic warfare, defense, logistics, intelligence collection, reconnaissance and strikes (Yonchev, 2023).

When the Ukrainian military launched an attack on the Sevastopol Naval Base on October 29, 2022, marine drones took part in the naval conflict. With the use of USVs

and UAVs, that raid demonstrated the military potential of surface drones by launching a “swarm” attack on Sevastopol. The first-ever naval combat operation using the coordinated deployment of airborne and marine drones to engage a stationary enemy naval fleet was successfully completed. Eight UAVs and seven USVs were employed in the raid, according to information from accessible sources. The unmanned vehicles traveled 300 km undetected and reached the port of Sevastopol and attacked the naval base (Dimitrov, 2024). Coordination was performed by the “Starlink” satellite communication system.

It was reported that the two Russian warships – a frigate and a navy mine hunter – that were struck by the comparatively tiny naval drones only suffered minimal damage. The attack's USVs measured 5.5 meters in length, had a 400-kilometer range, 60 hours of autonomy, weighed 1,000 kg, could carry a 200-kg warhead and could reach a top speed of 80 km/h. The Russian Navy's shift to defense mode came after the raid, which had a military consequence beyond simple defeat (Satam, 2023). Novel approaches to force protection and defense were promptly implemented, along with the addition of additional protocols. Consequently, Russian vessel activity in the ensuing months was significantly reduced. The Russian Navy's ease of retreat from the sea to its naval bases, along with its heightened fortifications and fewer active operations for ships operating outside of ports, have been attributed to the fleet's perceived vulnerability within its bases.

On November 11, 2022, Ukraine announced its intention to use funds from the “United24” fundraising campaign to construct the first drone-based navy fleet in history. Soon after, in mid-November, at night, there was another drone raid in Novorossiysk, which was much farther away from Sevastopol but still on the Black Sea. Experts have taken notice of these novel instances of contemporary naval warfare, even though certain Russian media outlets have contradicted reports and denied the attack. Major naval base and oil terminal Novorossiysk is situated 420 miles from Odessa and quite a distance from Sevastopol. It was thought to be outside the purview of Ukrainian strikes up until that point.

Rejecting direct military implications, the American business “SpaceX” prohibited the usage of their satellite communications equipment after January 2023. Drone operations in Ukrainian waters were restricted. In the meantime, the Russian Navy has developed its small-ship drone capabilities and on February 10, 2023, it successfully executed an operation to strike a bridge. The Zatoka road-rail bridge over the Dniester estuary in the Odesa area, a vital bridge between Ukraine and Moldova, was struck by a Russian drone carrying explosives. At that time, the prospect of more extensive use of maritime drones to influence the outcome of the war remained up for debate. It was felt that both the physical limitations of current equipment and evolving anti-drone capabilities could make these vehicles vulnerable.

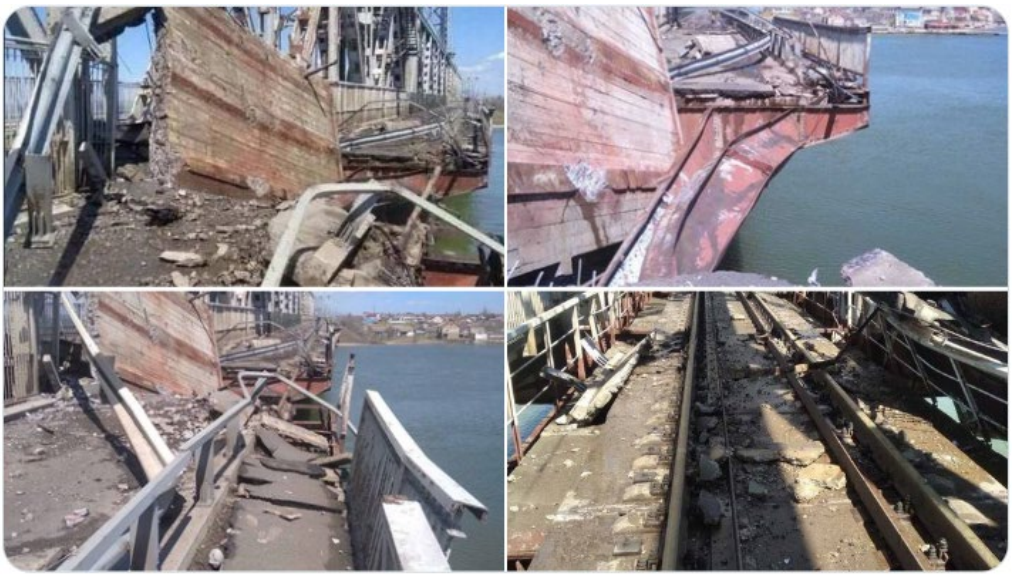


Figure no. 5: *The aftermath of the Russian attack on the Zatoka bridge*
(Source: https://twitter.com/Archer83Able/status/1518935759310438402)

On April 24, 2023, a third attack of this kind was carried out, but only two surface drones were used. The first was destroyed and the second detonated naturally with no harm done. The attacks on April 23 occurred at night, suggesting that the Ukrainians have increased their skills, in contrast to the attacks in 2022, which occurred during the day with good visibility (Satam, 2023).

Drones operating in maritime domains assaulted the reconnaissance ship "Ivan Khurs" on May 24, 2023, some 70 nautical miles north of the Bosphorus Strait. At the time of the attack, the ship was guarding the "Blue Stream" and "TurkStream" gas pipelines. Video evidence of the incident shows the drone was shot down, despite Russia's claims that it was able to destroy all three of them before they reached the ship.



Figure no. 6: *Image from the attack on the ship "Olenegorsky Gornyak"*
(Source: https://www.theguardian.com/world/2023/aug/04/ukraine-russian-warship-sea-drone-attack)

Tens of thousands of tons of Ukrainian grain were destroyed by Russian drone and missile strikes on Ukrainian ports along the Danube and Black Sea coasts in July 2023, following Russia's announcement that it was withdrawing from the grain shipping venture. This development increased tensions in the Black Sea. In retaliation, the Kerch Strait bridge – which links Crimea with the mainland – was attacked on July 17. Two individuals were killed and the highway bridge was damaged during an operation that was attributed to the Security Service of Ukraine (SSU).

The "Sea Baby" maritime drone was made exclusively in Ukraine. This kind of drone was used in the bridge attack, carrying 850 kg of TNT on board. Furthermore, a Ukrainian maritime drone attacked the Russian ship "Olenegorsky Gornyak" on the Novorossiysk base on August 3-4, causing significant damage. The UUV that struck the 113-meter-long Russian Navy landing vessel contained 450 kg of TNT. After being damaged, the vessel could not move and had to be pulled to the coast. Since the "Moscova" was sunk in April 2022, the "Olenegorsky Gornyak" was the largest damaged ship.

The Russian tanker "SIG" sustained damage the day after the incident, causing traffic and ferry services in the vicinity to be suspended. Traffic was temporarily interrupted when the tank, owned by the St. Petersburg-based "Transpetrochart" firm, was struck close to the Kerch Strait.

It has been disclosed that the cost of manufacturing each of these drones is $250,000. Two impact detonators from Russian bombs were used on them. They are 5.5 meters long and feature a camera for simpler use. They are able to be used in a mass attack since they are less expensive than bombs or rockets. They are more difficult to target because of their modest profile (on the outside) (Dimitrov, 2024).

Ukraine announced on August 24, 2023, the formation of Brigade 385, the first specialist maritime drone unit in the world. The first objective was to put together a fleet of one hundred medium- and small-sized maritime drones. These drones will be used for a variety of tasks, such as naval escort operations, protecting ports and the sea territorial, patrolling the coastal area, stopping enemy warships from leaving their military bases, defending commercial ships from potential attacks and other military missions like surveillance and reconnaissance.

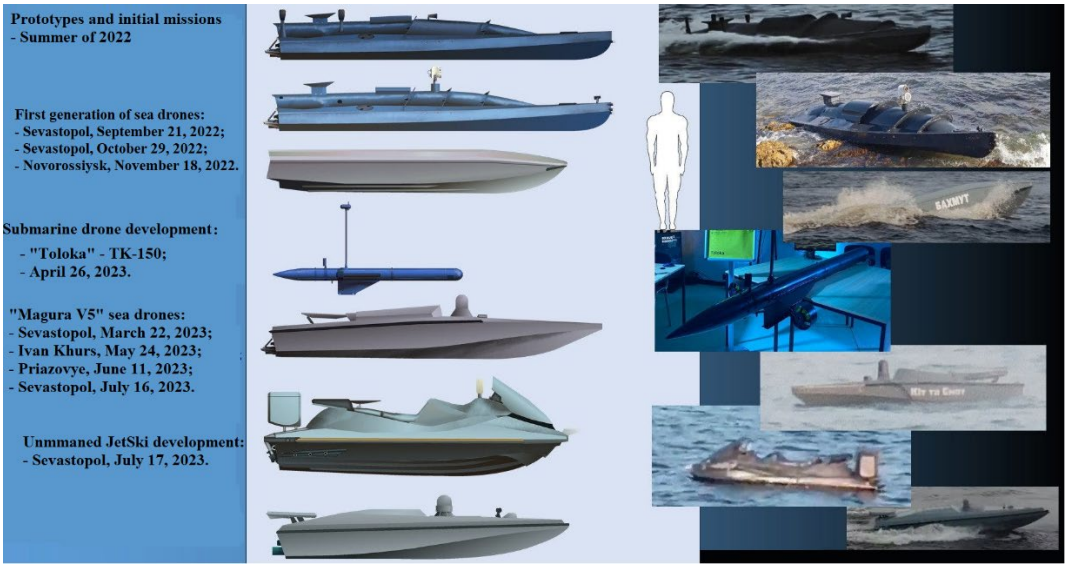


Figure no. 7: *Main sea drones developed and used by Ukraine*
(Source: https://mickryan.substack.com/p/the-state-of-the-ukrainian-2023-campaign)

On September 13, 2023, the biggest offensive against Sevastopol since the start of the conflict was carried out. Ukraine launched a missile and sea drone attack on the Sevastopol base in Crimea. Three maritime drones and ten missiles were employed in the assault. A Russian patrol boat destroyed the marine drones and shot down seven of the missiles (Yonchev, 2023). However, a huge landing craft and a submarine in the port of Sevastopol's ship repair dock were damaged in the raid.

Ukraine's high-speed marine drones can reach Russian military stations and ships operating far from Ukrainian borders, indicating significant technological advancements in the nation. Simultaneously, the Russian Navy showcased its defensive capabilities to counter such threats, if not literally. Russia's readiness to face nontraditional naval threats is demonstrated by its improved recognition, tracking and countering capabilities of these very small and rapid marine drones.

6. SWOT Analysis of Sea Drones

The main objective of SWOT analysis is to identify and qualitatively assess the strengths, weaknesses, opportunities and threats of an organizational and operational system. By identifying these factors new constitutive strategies can be developed based on strengths, by eliminating weaknesses, exploiting opportunities and countering threats. Strategies and weaknesses are identified as internal factors of the system and opportunities and threats are identified as external factors. SWOT is an English acronym from the following words: “S (Strength)”, “W (Weakness)”, “O (Opportunities)”, “T (Threats)”.

More precisely, the SWOT analysis approach allows identifying the state of the systems by classifying internal factors (strengths and weaknesses) and external factors (“opportunities” and “threats”). Therefore, the SWOT analysis method can be applied in order to define the future trends of organizations and systems. The most prominent aspect of the method is the analysis of internal and external factors to obtain systematic approaches and supports for formulating effective strategies.

SWOT analysis for sea drones

STRENGTH		WEAKNESS
– S1 – there is no need for military personnel onboard the sea drones – human life is spared; – S2 – an environment (the military one) in which the delegation of responsibilities is done in an appropriate way in order to develop the best outcomes; – S3 – very good results with prototypes and early models; – S4 – high-quality external reviews, with a high degree of involvement by the AFU; – S5 – a strong leadership from the top management of this military programme; – S6 – a high level of planned control and monitoring of development and production; – S7 – the establishment of a central department that is focused only on this development programme;		– W1 – aspects related to safety, health and the environment are not always put first; – W2 – a certain number of soldiers do not have the will to develop professionally; – W3 – too much emphasis is placed on daily uses and a limited emphasis on the part of planned control and monitoring, but also on the innovation; – W4 – too many priorities are set, which makes it difficult to follow a clear guideline; – W5 – fluctuations in the production process are too great; – W6 – the flow of information; – W7 – a motivation and reward system for soldiers serving these systems; – W8 – battery limitations which have an impact on the sailing duration and the operational range;

STRENGTH		WEAKNESS
–S8 – low production costs comparing to real size war ship – around 200.000 $ per unit; –S9 – high degree of manoeuvrability; –S10 – high range (can reach even Russian harbours at the Black Sea).		– W9 – regulation - the legal landscape surrounding sea drone use is constantly evolving, and navigating these regulations can be complex outside de warframe; – W10 – Maintaining the secrecy of production facilities.
SWOT		
OPPORTUNITIES		**THREATS**
– O1 – continuous development of the personnel who operate the systems; – O2 – continuous use of advanced technologies in the military field; – O3 – establishing a long-term relationships with suppliers of parts and materials, but also of innovative technical solutions in the line of monitoring and control; – O4 – creation of an attractive and safe tempting environment for soldiers/sailors who have solid knowledge of advanced drone systems; – O5 – standardization of monitoring sea drones; – O6 – constantly reducing the need of war ships and military sailors; – O7 – development of new methods for monitoring and controlling the naval battlefield; – O8 – development of support software for monitoring and control; – O9 – the development of new striking capabilities; – O10 – the production costs will be lower in the future.		– T1 – the war itself; – T2 – the lack of availability of control and monitoring operators who could carry out exploitation operations, inspections, verifications, etc., but also those who can carry out the related operations for preventive control and monitoring; – T3 – centralization of decisions aimed at programme and major changes in terms of monitoring and control policy; – T4 – ensuring a limited stock of spare parts for the systems, that facilitate the monitoring and control of the entire production; – T5 – ensuring a limited time fund for the development and the production; – T6 – potential decreases in the budget allocated to the programme; – T7 – a lower availability of outsourcing services; – T8 – decrease in the level of motivation and involvement of soldiers; – T9 – high dependence on other services; – T10 – the decrease in the level of quality and the life span of equipment or their essential parts.

7. Conclusions

These days, military actions at sea involve not just surface operations but also activity in other marine dimensions. It should be mentioned that naval forces have operated in three dimensions – above, below and on the surface of the waters – since the turn of the 20th century. These domains actually have unique features that require various approaches from naval forces. Nevertheless, the underwater dimension has a few more special features that set it apart from the surface and above-sea dimensions.

The main objective of the research was to present an accurate picture of how recent underwater technology can be used effectively, given that this equipment will be acquired, developed and used by many more navies, in addition to the states that already use these technologies. In order to

fulfill the main goal of the study a series of challenges had to be overcome. The data available on the topic is not available "at large" and the specialized sources had to be correctly identified, keeping in mind that the largest amount of information had Ukrainian or Russian background. In this order, all data sources had to be verified and validated. The main contribution seems limited on consulting news sources that closely follow the evolution of military actions in the studied area, the profiles of users from specialized platforms in the analysis of events within the conflict. At the same time, the data necessary to carry out this study had to be collected from the official pages of some profile institutions in Ukraine (such as GRU – known today as "HUR MOU", ZSU – known at an international level as "AFU", VMS and others), as well as from a very limited series of scientific articles, which analyze similar topics.

The world below the surface and above the seas are very distinct from each other. An object can be normally viewed, found and identified in the latter two dimensions. Furthermore, the environment won't obstruct or restrict any platform or item movement. In the meantime, physical obstacles including radiation, noise, sights and signals in the submerged environment provide difficulties.

These variations can be categorized into three primary areas: regulatory, cultural and physical (including water temperature, salinity, currents and multi-path reflection from the seabed and top). The lack of underwater traffic management, in contrast to the surface or air realm, is one regulatory characteristic that distinguishes the two domains. Moreover, the cultural component may be interpreted as a command and order paradigm that differs in actual practice. Therefore, in order to operate equipment underwater, the naval forces had to confront and overcome a variety of difficulties. Certain states may view these distinctive characteristics of the underwater domain as both opportunities and difficulties.

Only states with a particular level of advanced capabilities and technology are able to operate, traverse and gain control of this domain, which is undoubtedly a costly and hazardous environment (Yonchev, 2023). The underwater domain has been crucial in forming and deciding the maritime situation and control in general, dating back to the invention of the submarine and the early phases of its military use in the First and Second World Wars. Because they constituted a constant and immediate threat to the Soviet Union up until its dissolution, submarines were a pivotal element in the Cold War.

The intricate maritime battlespace facilitates future tactics development and diversification through the simultaneous use of missile attacks, electronic warfare and stealth tactics, all while using a combination of tiny, fast and unmanned vehicles. Drone deployment in armed situations in the future may have broader effects on maritime security. They have the potential to upend established naval power arrangements and compel modifications to international naval defense plans if they prove to be successful and gain traction.

The potential for combining surface, submarine, air and ground remotely operated devices with their benefits for a given environment or task is vast. They will form the foundation of naval operations tactics in the future when used in a swarm under the appropriate unified command and control of an AI system.

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