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The autonomous navy: Sea drones and the future of maritime conflict

The autonomous navy

Sea drones and the future of maritime conflict

The game-changing potential of USVs to impact the modern battlefield has sent shockwaves through naval circles around the globe, proving that small, unmanned vessels can pose a serious threat to even the most sophisticated warships. Concepts which had previously existed primarily in theoretical discussions have been validated through Ukrainian operational experiences. USVs have been found to represent more than a mere technological novelty, they are a strategic equaliser that allowed Ukraine to contest maritime spaces previously deemed unassailable.

The Ukrainian conflict has demonstrated that the future of naval warfare will not be defined by the largest or most expensive ships. It has shown that drones can compensate for numerical and economic disadvantages. They are not merely a tactical innovation, but a fundamental reimagining of maritime power. As a result, the entire established global naval hierarchy is challenged. Smaller nations can now develop asymmetric maritime capabilities that meaningfully deter larger, more traditionally equipped naval powers.

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It could be argued that the era of unmanned surface vessels (USVs) in naval combat began in 2016 during the Yemeni Civil War, when Houthis made use of remote-controlled boats full of explosives to attack vessels of the Saudi-led coalition as they operated off the coast of Yemen. This approach was further developed from 2018 to 2020, when Iran employed USVs and unmanned aerial vehicles (UAVs) to harass shipping in the Strait of Hormuz.

Without a doubt, the last decade has seen a growing significance attached to unmanned systems in offensive naval operations. In 2022, the re-commencement of the Russo-Ukrainian conflict saw a series of remarkable advances in drone technology, capabilities, tactics, and strategic applications.

Ukraine has become a crucible for military innovation, particularly in the realm of naval warfare. Their use of unmanned vessels, ranging from explosive-laden surface craft to stealthy underwater vehicles, has revolutionised maritime combat strategies and reshaped the balance of naval power in the region. The result has caught the attention of military planners worldwide.

First generation Ukrainian surface drones

At the onset of war, the Ukrainian military faced the daunting task of countering Russia's naval dominance in the Black Sea. Aided by Western partners, they quickly developed and deployed their first generation of USVs. Initial designs were relatively simple yet effective, built on civilian jet ski or small boat hulls that had been packed with explosives. Their combination of small size and high speed made them difficult to detect and intercept.

Although still fairly basic, these drones differed from those used by the Houthis or Iran in earlier years as they were equipped with cameras, satellite communication systems, and global navigation satellite system (GNSS) navigation, allowing for remote operation or semi-autonomous function. Their simple construction, often utilising commercially available components, facilitated the production of large numbers of vessels at a comparatively low cost, with a single unit costing tens of thousands of dollars. This compares favourably with some of the more well-known anti-ship missiles Harpoon, Maritime Strike Tomahawk (MST), and Exocet costing $1.2 million, $2.3 million and $3.3 million per unit respectively.

Challenging the naval hierarchy

The effectiveness of these first-generation USVs was demonstrated in a series of successful attacks on Russian naval assets. Perhaps the most significant of these occurred on 29 October 2022, when a group of nine Ukrainian UAVs and seven USVs penetrated the defences of Sevastopol Naval Base, the main base of Russia's Black Sea fleet. The Russian defence ministry stated that the *Ivan Golubets*, a Natya-class minesweeper, had suffered minor damage. However, subsequent reports from other Russian sources suggested that the *Admiral Makarov*, an Admiral Grigorovich-class frigate serving as the fleet's flagship, had also suffered damage in the attack. Although the damage inflicted upon these vessels was not severe, the impact of the attack was widely felt.

The success of this operation demonstrated the ability of USVs to penetrate heavily defended areas, strike high-value targets with precision, and inflict damage on much larger and more expensive vessels. Russian naval units became much more cautious. As the greater part of Russia's fleet began to spend much of its time in port, its offensive capabilities and operational flexibility were dramatically reduced.

Technological advances

As the Ukraine conflict progressed, naval drone technology evolved. What began as relatively simple vessels quickly transformed into sophisticated autonomous systems capable of complex mission profiles. Every engagement provided immediate feedback.

Engineers have made significant advances in propulsion systems. In particular, remarkable strides have been made in developing hybrid electric-diesel engines that offer an optimal balance between power, efficiency, and stealth. These propulsion units allow drones to switch between high-speed sprints and low-signature cruising, enhancing their versatility in combat scenarios. Super-cavitating propellers significantly reduce drag and increase efficiency by enveloping the propeller in a bubble of gas. This innovation has allowed some drone models to achieve bursts of speed significantly higher than their cruising speed, something that is crucial for evading enemy fire or closing in on targets rapidly.

The challenge of operating in the complex maritime environment of the Black Sea has also driven substantial improvements in navigation systems. Ukrainian drones now employ a fusion of GNSS, inertial navigation, and terrain recognition algorithms – which use either visual or sonar data to match the seafloor or coastline features for positioning. This multi-layered approach ensures resilience against jamming and spoofing attempts, allowing drones to maintain accurate positioning even in denied environments.

An unexpected breakthrough came with the integration of biomimetic navigation inspired by marine animals. Some advanced UUVs now utilise artificial lateral lines, mimicking the sensory organs of fish, to detect minute changes in water pressure and flow. This allows for precise navigation in waters thick with sediment or when traditional sensors are compromised.

Artificial intelligence (AI) has become the cornerstone of modern sea drone operations. Machine learning algorithms trained on vast datasets of naval engagements and maritime conditions enable drones to make split-second tactical decisions autonomously. These systems can identify and classify potential threats, adjust mission parameters in real-time, and predict enemy behaviour based on historical patterns. Perhaps most impressively, developers have implemented swarm intelligence protocols that allow groups of drones to operate as a co-ordinated unit. This emergent behaviour significantly enhances their effectiveness in both offensive and defensive operations.

However, the harsh maritime environment continues to pose significant challenges for USV operations. Corrosion from saltwater, extreme temperature variations, and powerful storms have all taken their toll on drone hardware. Engineers have responded with innovative materials and sealed designs, but the need for regular maintenance and replacement remains a logistical challenge.

Countermeasures and counter countermeasures

As Ukrainian sea drones grew more sophisticated, Russian forces intensified their deployment of countermeasures. Advanced electronic jamming systems have been deployed along the Crimean coast, attempting to sever the command links between drones and their operators. This has proven only partially effective. Drones' ability to operate autonomously, with multiple redundant control and navigation systems, mean that even state-of-the art jamming systems can be ineffective. Ukrainian engineers have also developed increasingly resilient communication systems, utilising frequency-hopping techniques and mesh networks to maintain control.

The game of cat-and-mouse extended to GNSS spoofing, with Russia deploying systems to feed false positioning data to incoming drones. Ukraine countered this with enhanced inertial navigation systems and star-tracking cameras, allowing drones to verify their position independently of satellite signals.

The Russian Navy retrofitted many of its vessels with close-in weapon systems optimised for engaging small, fast-moving targets. Laser-based defensive systems, once considered futuristic, have been rushed into service. Russia also began deploying its own defensive drones – of both a naval and aerial nature – designed to intercept and neutralise incoming Ukrainian drones. This has led to the surreal spectacle of drone-versus-drone battles in the skies above the Black Sea.

To regain the upper hand, Ukraine pursued the 'swarm tactics' mentioned above, where multiple drones co-operate as a team to overpower the enemy with weight of numbers. A coordinated swarm can overwhelm defensive technologies and continue the mission, presenting an adaptive threat that conventional military doctrines have so far struggled to counter.

The current state of play

Ukrainian engineers have been adapting their various drones, both aerial and naval, to meet specific operational requirements. One notable example is the Maritime Autonomous Guard Unmanned Robotic Apparatus (Magura) V5, a next-generation, multi-purpose USV that is advertised as being able to perform surveillance, reconnaissance, patrol, search and rescue, mine countermeasures, marine protection, and combat missions. With a length of 5.5 metres, a width of 1.5 metres, and an air draught of 1 metre, the V5's diminutive form in no way reflects its effectiveness. Reported as being able to achieve burst speeds of over 40 knots, it can carry a 320-kilogram explosive payload.

On 1 February 2024, the Magura V5 became the first USV to sink an enemy ship in combat when six of these drones – valued at $250,000 per unit – attacked the *Ivanovets*, a Tarantul-III class missile corvette – valued at $65 million – in Donuzlav Bay, Crimea. Having been adapted to carry air force technology, a Magura V5 also recorded the first confirmed aerial 'kill' by an USV when it successfully downed a Mi-8 in December 2024. By the end of 2024 it was claimed that the Magura V5 had attacked 14 Russian naval vessels since entering service, sinking eight of them, with an estimated total value of $150 million.

Continuing the pattern of innovation, on 6 January 2025 a Ukrainian USV adapted to remotely launch aerial drones became the first USV 'aircraft carrier' (or perhaps 'UAV carrier' is a more accurate term) when the Ukrainian Navy successfully employed it as a mobile launch platform. This significantly extended their operational range, improving their effectiveness against land-based targets. This operation reportedly destroyed two Pantsir-S1 air defence missile systems (valued at $13 million each) and one OSA air defence missile system (valued at $10 million).

Global impact and proliferation

The success of Ukrainian sea drones has prompted a global re-assessment of naval strategies. Many nations and non-state players, particularly those with smaller navies or facing asymmetric threats, are investing heavily in drone technology. This shift is causing a re-evaluation of traditional fleet compositions. Some analysts predict a future where large surface vessels are either complemented or even replaced entirely by swarms of autonomous vessels.

It has also raised concerns about proliferation. This has led to debates about export controls and the potential for a new type of naval arms race centred around autonomous systems. In fact, the naval drone arms race may have already begun. Yemen's Houthis have been utilising Iranian-supplied weaponry and improved drone technologies to cause ongoing disruption off the coast of Yemen. They have effectively transformed the Red Sea into a high-risk maritime zone. So far, over 185 ships have been targeted by USVs and/or UAVs, with more than 40 of them sustaining damage. In achieving this, the Houthis have become de facto gatekeepers to the Suez Canal. The economic impact has been profound, with cargo volumes through the Bab el-Mandeb Strait decreasing by over two-thirds, resulting in an estimated economic loss of over $200 billion. The ability of a non-state actor to impact international trade routes to this degree using only relatively low-cost drone technology presents a formidable challenge to traditional naval doctrines and maritime security strategies.

In the Philippines, on 30 December 2024, fishermen retrieved a yellow UUV marked 'HY-119' off Masbate Island. The presence of this Chinese-made 'Sea Wing' glider, capable of reaching depths of over 20,000 feet, near the resource-rich Benham Rise demonstrates how UUVs are now critical instruments in the sophisticated reconnaissance strategies that are emerging in maritime geopolitics. Its ability to reach great depths and map communication and power cable routes highlights the current capabilities of autonomous underwater vehicles.

This is a more subtle use of drones than the militaristic deployments seen in the Black Sea and Red Sea. Defence experts have suggested that 'HY-119' may represent part of China's broader 'hybrid and grey zone' strategies. It is a tool to probe and understand potential conflict environments. Strategic reconnaissance used to require expensive aircraft or satellite passes. Now, USVs and UUVs can loiter indefinitely, providing real time observations as they monitor the environment, collecting data on underwater and surface conditions as well as the movement of other nations' military assets.

The USA has also made significant advances in the field of autonomous naval vehicles. In particular, the Manta Ray, extra-large uncrewed underwater vehicle (XLUUV) is designed to be a 'long-duration, long-range, payload-capable' platform. Although the details of its specification are a closely guarded secret it is designed to operate for 'extended durations without the need for on-site human logistics support or maintenance' while at the same time being able to counter 'detection threats'. This highlights the intent of even the world's most powerful military to develop unmanned systems that can operate independently for extended periods in challenging maritime environments.

The rise of naval drones is influencing naval strategies and geopolitical calculations on a global scale. As demonstrated in the South China Sea, the deployment of maritime drones has the potential to escalate tensions in already disputed waters. The ability of smaller nations to challenge larger naval powers through asymmetric drone warfare is causing a re-evaluation of maritime dominance and power projection capabilities. This shift is particularly significant in regions like the Indo-Pacific and the Baltic Sea, where naval drones are becoming a key focus for enhancing maritime capabilities and strategic adaptability. The ongoing 'drone arms race' is likely to exacerbate these geopolitical tensions further, as states compete for technological superiority and strategic advantage in critical maritime zones.

As naval forces worldwide grapple with these evolving threats, the need for effective countermeasures and adaptive strategies becomes increasingly apparent. The proliferation of unmanned systems has sparked a new era in naval warfare, where traditional concepts of maritime dominance are being challenged. Navies are now compelled to develop multi-layered defence systems that can detect, track, and neutralise a wide range of unmanned threats, from aerial drones to underwater vehicles. This includes the integration of advanced technologies such as artificial intelligence, electromagnetic warfare capabilities, and innovative jamming systems.

Future developments

Military strategists envision the development of hybrid drones capable of operating across multiple mediums. Concepts under consideration include aerial drones capable of brief underwater operations for covert approaches. There is growing interest in modular drone designs that can be easily re-configured for different mission profiles. A single platform might be equipped with sensor packages for reconnaissance one day, and offensive weaponry the next, providing operational flexibility. Although energy storage remains a critical limiting factor for drone operations, promising developments in solid-state battery technology could dramatically extend the operational range and endurance of future drones.

Drones are not just weapons but complex systems sitting at the intersection of robotics, AI, communications technology, and strategic thinking. The advances in USVs and UUVs in recent years, but particularly during the Ukraine war, represents a watershed moment in naval warfare. From humble beginnings as improvised explosive delivery systems, they have evolved into sophisticated, AI-driven machines that challenge long-held assumptions about maritime power. Defence departments worldwide are grappling with the economic implications of drone warfare. The ability to field a credible naval deterrent at a fraction of the cost of traditional fleets is particularly attractive to nations with limited resources. However, this also raises questions about the long-term viability of expensive capital ships.

Although it is clear that the era of autonomous naval warfare has only just begun, innovations proven in the crucible of conflict today will shape maritime engagements for decades to come. The nations that adapt to this new paradigm of naval operations will hold a significant advantage in the security landscape of the 21st century.

The sea drone revolution serves as a powerful reminder that technological innovation can radically and quickly alter the balance of power, allowing smaller nations to challenge larger adversaries effectively. As these technologies continue to evolve, debates rage over how existing maritime laws will – or whether they can – be applied to this new technology, the potential for it to lead to unintended escalations, and the appropriate level of human oversight that it should receive. Military planners, law makers and policy developers of the international community face critical questions about their ethical use, legal implications, proliferation, and their long-term impact on global security.