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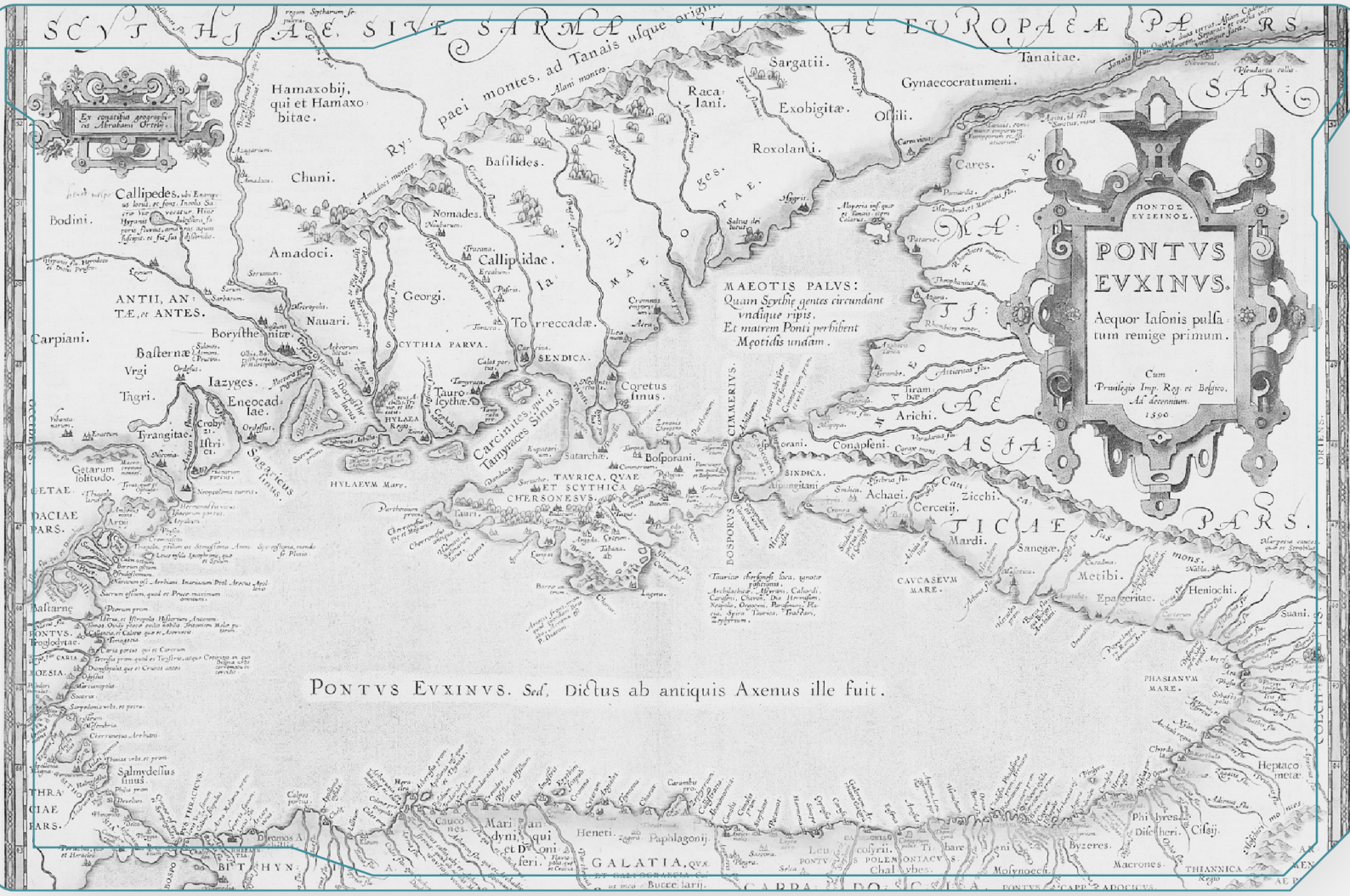

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From Naval Dominance to Sea Denial Zones: Evolving Technologies, Defense Industries, and the New Black Sea Security Order*

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Abstract

This paper examines how the Russian-Ukrainian War has fundamentally restructured the Black Sea maritime security order, shifting the regional balance from traditional Russian naval dominance to contested sea-denial zones. Addressing the core research question of how emerging military technologies and defense-industrial shifts are redefining littoral power hierarchies, the study explores six interrelated capability categories: mines and anti-ship missiles; uncrewed surface and underwater vehicles; uninhabited aerial systems; artificial intelligence; space-derived services; and cyber/information warfare. Finally, the article examines evolving defense-industrial capacities across littoral states and concludes with key findings on the future of maritime security.

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Introduction

The Russian-Ukrainian conflict has upended our understanding of the naval power hierarchy in the Black Sea, which was marked by Russia's unquestionable mastery before February 2022. By relying on a mix of old and new tactics and technologies, Ukraine has turned the situation around in its favor since then. Therefore, this research report aims to provide an early assessment of the impact of the new tactics and technologies Ukraine has employed to shift the Black Sea naval balance of power dramatically. Moreover, it attempts to identify lessons learned in the Black Sea and discuss their applicability in other naval theatres worldwide. To this end, this paper unfolds in four parts. The first part provides a brief overview of the evolution of maritime security in the Black Sea since the end of the Cold War. Then it moves on to a discussion of the six interrelated technology and military capability categories that have come to define the conduct and the character of maritime operations in the Black Sea in recent years. These six categories are: mines and anti-ship missiles; uncrewed sea vehicles (USVs) and uncrewed underwater vehicles (UUVs); uninhabited aerial vehicles (UAVs); artificial intelligence (AI); space-delivered services; and cyber/information warfare. In the third part, the paper's focus shifts to the role of defense industries in sustaining the advantage these technological and capability categories afford to protagonists in warfare. The fourth and final part concludes with a discussion of the impact of the current conflict on non-belligerent states' thinking about the means and ends of maritime security in the Black Sea.

Evolution of Black Sea Naval Power Hierarchy

Since the end of the Cold War, security in the Black Sea littoral has rested on a Russian-Turkish condominium (Çağaptay, 2022), while other regional players—Bulgaria, Romania, Ukraine, Georgia—remained on the sidelines, constrained by more limited naval, defense-industrial, and technological capabilities. The relationship between these two dominant actors has been compartmentalized and transactional, waxing and waning between outright confrontation and reconciliation in the Black Sea (Güvenç, 2024). The first two post-Cold War decades saw a marked deterioration of Russia's military capabilities. This decline coincided with remarkable growth in Türkiye's economic, military, technological, and defense-industrial capacity. As a result, Türkiye gained the upper hand in the naval domain (Coşkun, 2024).

This situation, however, did not last. The 2008 Russia-Georgia War marked a turning point: the poor performance of Russian forces in that conflict convinced Moscow to rebuild and modernize its military, including its naval forces. By the time of Russia's 2014 invasion of Crimea, the world was witnessing a far more modern, professional, and proficient Russian military. The annexation of Crimea further allowed Russia to use the peninsula as an unsinkable aircraft carrier, anchoring a formidable anti-access/area-denial (A2/AD) bubble that extended across the entire Black Sea and reached Türkiye's shores (Egeli, 2017). In the years that followed, Russia's naval construction program gained new momentum, and the Black Sea Fleet tripled—by some accounts quadrupled—in strength (Güvenç, 2024). By 2016, Russian military officials were

publicl y asserting their country's supremacy over Türkiye in the Black Sea (Kucera 2016), even as Ankara sought to preserve the status quo, having diverted priorities and resources toward Syria, Iraq, the Eastern Mediterranean, and Libya during that period.

By February 2022, when Russia launched its invasion of Ukraine, Moscow was already claiming mastery over the Black Sea in its entirety (Güvenç, 2024). Its Black Sea Fleet possessed a formidable array of surface and sub-surface combatants and auxiliary vessels, backed by significant naval air power and by anti-ship, ballistic, and anti-aircraft missile batteries stationed in Crimea. The prevailing assumption, accordingly, was that Russia would effortlessly sweep Ukraine's military presence from the Black Sea and thereby further cement its dominance over the littoral—to the clear detriment of NATO, the EU, Türkiye, and the region's other littoral states (Özberk, 2022).

In its invasion of Ukraine, Moscow sought to use its Black Sea naval power as an integral element of its war effort—launching cruise missiles against land targets, menacing Ukraine's coastline with the threat of amphibious invasion, and seeking to throttle its vital maritime trade (Savitz and Courtney 2023). Yet only weeks into the conflict, events took a turn that surprised analysts: Russia's navy suffered massive losses at the hands of Ukraine, which lacked a proper navy of its own. Ukraine's anti-ship missiles, aerial drones, and eventually uncrewed suicide boats turned the tide against Russia, forcing its fleet into a defensive posture in the easternmost corner of the Black Sea. The ramifications of this unexpected reversal for the region's security landscape and power hierarchy could not have been more dramatic. Meanwhile, Türkiye watched comfortably from the sidelines as the regional maritime balance shifted in its favor (Coşkun, 2024), while other littoral states, alongside NATO and the EU, increasingly aligned with Ankara's policy line to check Russian military adventurism in the Black Sea (Gaber, 2024).

To better understand the implications and longer-term prospects of this new naval, military, and power hierarchy in the Black Sea, it is necessary to take a closer look at the array of new tactics and technologies, along with the defense-industrial and technological enablers needed to field, sustain, and further advance them. With this goal in mind, this paper identifies six closely interrelated technology and military capability categories and examines their employment and impact in the Russo-Ukrainian War. It then turns to recent shifts in the defense-industrial capacities of Black Sea littoral states, before concluding with a summary and key findings.

Mines and Anti-Ship Missiles

Some of the naval weapons Ukraine rushed into service to challenge Russia's naval mastery were not new. Still, they proved effective nonetheless in hindering Russia's naval activity in the Black Sea. Naval mines—which had stymied superior navies since the second half of the 19th century—were used to considerable effect, hampering Russia's ability to mount an amphibious assault on the key port city of Odesa and other coastal areas. Unfortunately, mines drifting south also damaged vessels off the coasts of Romania, Bulgaria, and Türkiye, making them one of the most serious maritime security challenges in the Black Sea today (Güvenç, 2024). In 2024, Türkiye,

Romania, and Bulgaria established the trilateral MCM Black Sea Task Group to counter this threat, a mandate later expanded to include the protection of undersea infrastructure as well (Özberk, 2024).

Likewise, there was nothing revolutionary about the sinking of the Black Sea Fleet's flagship, the *Moskva*, using anti-ship guided missiles that have been employed in other conflicts since the late 1960s (Savitz and Courtney, 2023). The only unprecedented element in Ukraine's sinking of the *Moskva* was the reported employment of a Turkish *TB2 Bayraktar* UAV to distract the crew's attention away from the incoming anti-ship missiles. Ukraine relied on anti-ship missiles supplied by its Western allies and also fielded a domestically produced equivalent—the *Neptune*—effective out to 240 km (Altman, 2025a). Combined with good surveillance and intelligence (part of which came from the U.S. (Harris and Damothe, 2022), timely command and control, and aerial and sea drones—topics examined further in subsequent sections—these capabilities allowed Ukraine to create a sea denial zone near its coast (Mongilio, 2023; The Economist, 2023a). Conversely, because Ukraine lacked a proper navy and sizable naval vessels, Russia could not bring to bear its impressive inventory of land-, sea-, sub-, and air-launched anti-ship missiles. Instead, the Black Sea Fleet diverted these missiles toward land targets. Yet, Russian strikes were marked by strikingly slow targeting and response times, reflecting significant inefficiencies in Russia's command cycle and organization (Smith, 2022)

Besides dedicated naval weapons, Ukraine has also used a wide array of short- and medium-range cruise and ballistic missiles to neutralize and keep constant pressure on the Black Sea Fleet's fixed installations, such as naval bases, shipyards, supply depots, and command headquarters. Foremost among these were the *SCALP-EG* and *Storm Shadow* cruise missiles supplied by France and Britain, later complemented by a land-attack variant of Ukraine's own *Neptune* missile (Altman, 2025a). Flying at nap-of-the-earth altitude to evade Russia's multi-layered mesh of radars and air defense systems, Ukraine's cruise missiles helped cripple the Black Sea Fleet's presence not only in Crimea, but also in Novorossiysk and other naval bases further east, where Russian ships had sought refuge after evacuating Crimea. Russia's use of cruise missiles against Ukraine's naval and coastal targets, by contrast, has remained much more limited (Sutton, 2026).

In addition to cruise missiles, Ukraine has also made full use of its small inventory of Soviet-era *Tochka* short-range ballistic missiles (range: 120 km) to strike Russian ports and sink or damage several naval vessels (Alberque et al., 2023, p.14–15; Sutton, 2026). From spring 2024 onward, the arrival of more accurate, longer-range (300 km) ATACMS missiles from the U.S. enabled Ukraine to broaden the reach and impact of its ballistic missile strikes. Shipyards, piers, berthed naval vessels, naval aviation stations, and the ferries linking Crimea to the Russian mainland via the Kerch Strait have all been repeatedly struck by ATACMS. Still, ATACMS never proved to be a game-changer, given the small quantities Washington provided to Ukraine (Rogoway, 2025; Sutton, 2026). Ukraine's failure to develop ballistic missiles domestically remains the largest material mismatch in the conflict (Méheut, 2026).

Yet this asymmetry has not translated into a clear and sustained Russian advantage in the Black Sea. During the conflict's first three years, Russia's use of ballistic missiles against maritime

targets was sporadic and rarely successful. This may now be changing, however: since spring 2025, several merchant ships—including vessels owned by third countries such as Türkiye—have been struck by Russian Iskander ballistic missiles while berthed in Ukrainian ports (Türkiye Today, 2025). Given the devastating impact of ballistic missile strikes on ships, this pattern may deter third-country maritime operators from using Ukrainian ports altogether. Moscow's growing preference for ballistic missiles in the Black Sea may also reflect the country's rising production capacity, which has given it greater latitude to expend these weapons more freely. During the first half of 2026, Russia launched an average of 74 ballistic missiles per month across all sectors of the front—up from 49 per month in 2025, 28 in 2024, and a mere six per month in 2023 (Méheut, 2026).

Uncrewed Sea Vehicles

The battlefields of the Russo-Ukrainian War instantly became a vast laboratory for testing new technologies, hardware, and tactics across a wide range of weapons, including uninhabited systems in air, sea, and land variants. Given their direct impact on the naval balance and threat environment in the Black Sea, remotely controlled and/or autonomous surface vessels and submersibles stand out. Indeed, innovations in uncrewed naval craft have had profound effects not only on the Black Sea but also on the conduct of naval warfare worldwide.

The idea of packing remote-controlled surface and sub-surface vessels with explosives and sending them toward enemy ships and ports has been present in naval warfare since the end of the 19th century. But putting the theory into practice took over a century (Egeli, 2026a). The first successful employment in this regard had already occurred a few years before the Russo-Ukrainian War. From 2017 onwards, Houthi fighters used remotely controlled, explosive-laden speedboats to cripple the Saudi and Emirati navies, ports, and oil terminals in the Red Sea, and later merchant ships of third countries sailing through the Red and Arabian Seas (Conflict Armament Research, 2017; Egeli, 2026a). The Houthis received remote-control kits from Iran, but the boats themselves were converted inside Yemen from leisure craft. The threat to larger naval vessels, merchant ships, and offshore and coastal critical infrastructure was evident. Yet the response, and the corresponding shift in mindset and preparedness among the world's leading navies, has been remarkably slow and, in some cases, altogether absent. On this account, the Russian Navy and its overconfident Black Sea Fleet appear to have missed this new threat category entirely.

Conversely, at the outset of the war, Ukraine lacked a conventional navy and thus found itself exposed to the pressure of the vastly superior and intimidating Russian Black Sea Fleet. Consequently, Ukraine became the side seeking to innovate and find unorthodox, asymmetric ways to neutralize Russia's naval supremacy. In addition to more traditional weapons such as naval mines and antiship missiles, uninhabited aerial vehicles (UAVs) carrying precision-guided weapons, such as the Turkish *TB2*, were pressed into combat with good effect.

Then, in October 2022, roughly eight months into the conflict, Ukraine carried out its first successful raid employing explosive-laden speedboats as suicide drones against Russian naval

vessels anchored at Sevastopol. These were rudimentary forerunners of Ukraine's subsequent family of small, easy-to-build, high-speed craft equipped with Starlink satellite communication antennas for reliable, affordable, hard-to-jam two-way communication with their operators irrespective of range (Sutton, 2025). This adaptation proved a total success. Over the following sixteen months, Ukrainian USVs, in combination with aerial drones and anti-ship and cruise missiles, took out close to a third of Russia's Black Sea Fleet—25 surface vessels and one submarine destroyed, and 15 others damaged. The remainder of the fleet was forced to relocate from its bases in Crimea to Novorossiysk, some 300 km to the east on the Russian mainland (The Economist, 2024). Since then, Russian naval vessels have not ventured more than 40 km from their bases in the eastern Black Sea, leaving the relative safety of their well-protected harbors only to fire cruise missiles before retreating immediately (Gatopoulos, et al. 2025).

One obvious outcome of this retreat has been the lifting of Russia's constant pressure on Ukraine's coastal provinces and maritime trade. Moreover, Russian troops fighting in the northwestern Black Sea can no longer be assisted or replenished from the sea. Equally significant, Russia's coastal infrastructure along the entire Black Sea coastline, as well as Russia-bound maritime traffic, has become hostage to Ukraine's naval and aerial drone raids. No fewer than 20 coastal facilities—among them the Kerch Bridge connecting the Crimean Peninsula to the Russian mainland, along with vital oil terminals and refineries—have been struck multiple times. Russia-bound merchant ships, deprived of Russian navy protection, have fallen victim to drone strikes throughout the Black Sea (Altman, 2025c) and even in the Mediterranean Sea (Lukiv, 2026). In this sense, one of the unforeseen consequences of the Ukraine War has been the demise of Russian naval presence in the Mediterranean Sea (The Maritime Executive 2026), as Ankara closed the Turkish Straits to Russian naval traffic under the provisions of the Montreux Convention (Lund, 2025). As a result, tankers of the Russian 'shadow fleet' now find themselves exposed to the USV threat some 3,000 km from Ukraine.

Notably, thanks to technological innovation and tactical ingenuity, the potential of uncrewed sea vehicles (USVs) to create zones of denial has begun to spill over into the air and land domains as well. Since 2024, several Russian helicopters and combat aircraft have been shot down by USVs modified to launch heat-seeking air-to-air missiles (Newdick, 2024; Altman, 2025b; Sutton, 2026). The result is an evident airspace security challenge for Moscow, whereby Russia's military aviation—and especially its formidable naval air component—can no longer operate over the Black Sea with impunity.

In addition, Ukraine has combined uncrewed boats with maritime drones to attack ground targets in territories adjacent to the Black Sea. In this imaginative teaming of uncrewed systems from two separate domains, uncrewed boats carried, launched, and provided command and guidance to swarms of small aerial drones that struck inland air defense radars and anti-aircraft batteries. The gaps opened in Russia's air defense overlay were subsequently exploited by Ukraine's standoff suicide drones and strike missiles (Altman, 2025d). Ukraine may still be far from retaking Crimea in the foreseeable future. Still, its systematic and innovative use of naval and aerial drones has rendered the entire peninsula uninhabitable for Russian forces and their residents. What was once a prized military asset and trophy for Russia's military posture in the

Black Sea has, in less than a decade, been transformed into a giant logistical mousetrap (Santora et al., 2026).

During the first three years of the conflict, Ukraine's technological innovation success was due, at least in part, to Russia's slow response and its inability to adapt to the rapidly evolving threat environment. But this is changing, as Russia has also begun fielding USVs of its own to attack Ukrainian ports and the maritime traffic in and out of them (Altman, 2025e; Sutton, 2026). Likewise, Russia is becoming more adept at devising tactics and countermeasures against drones. One path the Ukrainians have chosen to maintain their technological edge against Russian countermeasures is to incorporate more artificial intelligence (AI)-enhanced autonomy into their naval drones. Ukrainian aerial and naval drones already use AI for navigation, but so far, target search and engagement have remained a combined process—part human operator, part AI. Current trends point toward USVs that independently search for targets, distinguish civilian vessels from military ones, and make more of the strike decisions themselves (Gatopoulos et al., 2025).

The third innovative path involved uncrewed underwater vehicles, (UUV) exploiting the obvious advantages of surprise, stealth, and survivability (Sutton, 2024). The result has been the development of explosive-laden UUVs and autonomous underwater vehicles (AUVs). As with uncrewed surface vehicles, Ukraine was not the inventor of this concept. During the 1990s, Iran possibly became the first country to pack underwater vehicles with explosives and transform them into low-end torpedoes (Egeli, 2025). Such weapons were mass-produced but may never have been used in combat, arguably because of the challenges of two-way communication: RF waves do not travel underwater, so submerged vehicles cannot communicate with their operators unless they extend an antenna mast to the surface, compromising their stealth. Ukrainian engineers appear to be overcoming this shortcoming by leveraging rapid advances in AI to transform uncrewed underwater vehicles into fully autonomous weapons capable of navigating, identifying, and attacking targets without a distant human operator. The first successful raid built on this innovation took place at the very end of 2025, when a Ukrainian AUV penetrated the defensive barriers of the naval stronghold of Novorossiysk, navigated the crowded harbor to locate a specific vessel—one of Russia's most modern diesel-electric submarines—and punched a lethal hole in its hull (Altman, 2025f).

Naval warfare in the Black Sea is the first in military history to be decisively shaped by uncrewed platforms (Sutton, 2024). Until 2022, conventional wisdom held that navies could only be defeated by comparable sea, air, or undersea forces—an assumption the Black Sea has since disproved (Ullman, 2023). That said, geography and legal status likely contributed to this success as much as the platforms themselves. The Black Sea is a relatively confined theatre, and uncrewed systems may prove less effective across the vast expanses of open ocean. Ankara's closure of the Turkish Straits to belligerent warships in March 2022 further crippled Russia's ability to reinforce its Black Sea Fleet from other theatres (Lund, 2025), meaning Ukraine's improving capabilities have been tested against a steadily shrinking, rather than a fully representative, adversary. Whether this performance can be replicated across the broader maritime domain remains an open question.

Finally, unlike the Baltic Sea, the Black Sea's critical undersea infrastructure has largely been spared: Ukraine has refrained from targeting Blue Stream or TurkStream with UUVs or AUVs, wary of damaging relations with Türkiye. This restraint is a reminder that political considerations continue to shape and constrain the use of new instruments of warfare.

Uninhabited Aerial Vehicles

USVs and AUVs played a crucial role in slowly dismantling Russia's dominance over the Black Sea. But they were not alone. Uninhabited aerial vehicles (UAVs) fulfilled equally critical, if not more important, tasks. By virtue of their dimensions and the missions they carry out, it is possible to divide UAVs employed by both Ukraine and Russia into three categories: (i) those used for intelligence-surveillance-reconnaissance (ISR) and delivery of precision munitions; (ii) one-way attack (OWA) UAVs undertaking suicide attacks deep into an adversary's territory; and (iii) first-person view (FPV) small drones, available as commercial-off-the-shelf (COTS) items, employed for observation, fire direction, and/or suicide raids at closer ranges.

Starting with UAVs used for ISR, Russia lagged by a wide margin and has to this day failed to field a capability comparable to Ukraine's. Conversely, Ukraine employed its fleet of Bayraktar *TB2* UAVs, acquired from Türkiye, to great effect during the opening phase of the conflict, pounding Russian convoys as well as smaller naval vessels in the Black Sea. *TB2s* also became valuable assets in the information space, with strike footage widely shared on social media (Helou 2023). But as Russia's air defense setup and electronic warfare activity grew more tightly organized, it became increasingly difficult for larger, slow-flying drones to operate safely. According to open sources, at least 26 *TB2*s were shot down within the first few weeks of the war, and actual figures could be significantly higher. This forced Ukraine to withdraw *TB2*s from the front lines and confine them to standoff surveillance from uncontested rear areas (Altman 2025g). It is rather intriguing to observe that, when operating in contested airspace, UAVs suffer very high attrition rates regardless of their size or sophistication. Simple, cheap UAVs costing a few thousand dollars each can absorb such loss rates, because the thousands fielded—the few survivors that evade defenses out of thousands fielded are enough to fulfill the mission. For much more sophisticated and expensive UAVs, however—such as *TB2*s and American *Reapers*, which cost millions of dollars each—attrition at such a pace is unsustainable. Mirroring the Ukrainian *TB2* experience, from late 2024 to mid-2026, the U.S. fleet of *Reaper* UAVs shrank by almost 100 units, to 135 aircraft. Nearly 30 of those are believed to have been lost during Operation Epic Fury against Iran, while dozens more were brought down over Yemen (Trevithick 2026). There is an important lesson here for all militaries, particularly those wagering heavily on fleets of sophisticated UAVs for surveillance and precision strikes: what may be a realistic expectation during the relative calm of peacetime or low-intensity conflict is likely to become untenable in contested airspace. In the context of the Black Sea littoral, this holds a warning for Romania's military posture, especially that of Türkiye, which in recent years has come to rely heavily on its impressive array of comparatively large and sophisticated uninhabited aircraft (Cagaptay and Outzen, 2022).

The second subset of UAVs comprises OWA-UAVs, also known as loitering munitions or suicide/kamikaze drones. Best exemplified by Iran's *Shahed* models, these are simple, easy-to-build airframes akin to model planes but laden with explosives. Costing about US$20,000–30,000 each, they are kept airborne by dirt-cheap, easy-to-find petrol engines and a crude, COTS-based navigation system. They are not sophisticated, but they can be produced quickly by the thousands and used in saturation raids to overwhelm or deplete a rival's air defenses.

Following Russia's invasion, it was Ukraine that first resorted to OWA-UAVs, albeit on a limited scale. Then, more than a year into the conflict, Russia followed suit by purchasing 600 disassembled *Shaheds* from Iran, along with the know-how to set up a factory and begin building them domestically. By the second half of 2025, the Russian industry was turning out 5,000 units per month, with up to 1,000 sent toward Ukraine in each raid (Sonne and Barker, 2025). Not to be outpaced, Ukraine has steadily increased its output to launch comparable quantities of long-range kamikaze drones at Russian targets (Korshak, 2026). As a result, these duels of suicide drones have wreaked havoc on both sides' critical infrastructure, including refineries and oil storage sites, power plants, seaports, railroad hubs, and defense industry facilities. Naval and merchant ships, as well as seaports and offshore oil and natural gas rigs, have not been spared. From 2024 onward, Ukraine extended its reach beyond the Black Sea by targeting seaports, ships, and rigs in the Caspian Sea (Newdick, 2025). More recently, Ukraine has further widened the geographic footprint of its drone strikes all the way to the Baltic Sea. In June 2026, a Russian missile corvette was destroyed while in dry dock at St. Petersburg. This episode must have underscored for the Russians the vulnerability of warships even hundreds of kilometers from Ukraine's borders (Newdick, 2026).

On the one hand, OWA-UAVs themselves did not represent a technological breakthrough: they had been developed and used by Iran and its regional proxies over the preceding three decades (Egeli, 2026a). On the other hand, the Russo-Ukrainian War brought their production and employment to an industrial scale, significantly increasing the challenges facing air defense systems. Low- and slow-flying small suicide drones are hard to detect and even trickier to intercept. Not only Russia and Ukraine but also other littoral states—Romania, Bulgaria, Moldova, and Türkiye—have discovered this the hard way: dozens of stray Russian and Ukrainian UAVs have already crashed on their territory, mostly undetected (United Nations, 2026; Nenov, 2023; Yaylalı, 2025; *Türkiye Today*, 2026). Contrary to public expectations, constant, watertight protection of a state's entire airspace against intruding drones is impossible for operational and technical reasons.

To make matters worse, counter-drone defenses are marked by a steep cost asymmetry: intruding drones are very cheap and quick to build, whereas the air defense missiles and aircraft that intercept them are expensive, always in short supply, and slow to build and replace. As a result, established air defense paradigms of the last 80 years are being challenged by rapid technological and tactical evolution—a shift Ukraine, and especially Russia, has experienced firsthand. Paradoxically, several states continue to promote elaborate schemes and projects to erect supposedly impenetrable drone walls or iron, steel, or golden domes over their homelands (Egeli, 2026b).

The third group of UAVs with major influence on the conflict between Russia and Ukraine is the first-person view (FPV) aerial drone: a small, freely sold and traded flying device remotely controlled by a single operator. Originally developed for racing and hobbyist use, FPV drones were rapidly adapted for military purposes, first by terrorist groups in the Middle East (Egeli, 2026a), then by Ukraine and Russia, as expendable reconnaissance and strike weapons. They are dirt cheap, selling for a few hundred dollars each. In the most common usage, they are rigged with explosives and flown by remote control into vehicles, troops, or enemy positions. Detecting them with traditional air defense sensors is impossible, and shooting them down with existing air defense weapons is nearly so. More recent iterations are command-guided toward targets via un-jammable fiber-optic cables or AI-enabled software for semi- or fully autonomous navigation and target detection.

As the numbers in service grew rapidly, the impact of FPV drones has been most immediate and dramatic in land warfare. Ukraine manufactured 3 million FPV drones annually (Zadorozhnyy, 2025). While Ukraine held the lead for a while, by 2025, Russia had caught up and begun fielding even larger quantities (Lovett and Walker, 2025). The impact of so many thousands of lethal FPV drones constantly flying over the battlefront has been stunning: any vehicle or soldier who dares to move is spotted, day or night, and destroyed almost instantly. Since neither side could achieve a breakthrough, the ground battle between Ukraine and Russia settled into a stalemate (O'Grady and Khudov, 2024; The Economist, 2023b). Ukrainian authorities say drones accounted for more than 80 percent of enemy targets destroyed during 2025. There is little doubt that drones have become the defining feature of the land battle, with both sides scaling up production and devising new ways to use them (Ruitenberg, 2026).

Use of FPV drones in naval and littoral warfare has been more limited, yet no less impactful in certain respects. Initially, Ukraine used FPV drones to keep the Russian Navy away from its shores. Russia, in turn, used them to neutralize Ukrainian USVs venturing into its naval bases. During 2025, Ukraine combined FPV drones with uncrewed boats to extend the former's lethal reach beyond coastal waters. Ukrainian USVs were modified to carry six to eight FPV drones in side compartments that opened during an attack (Livingstone 2026a). FPV drones have a limited range, typically 15–30 km; by pairing them with USVs, the Ukrainians extended this to over 1,500 km—the range of the USVs themselves—bringing maritime and inland targets across the Black Sea within striking range. Russia's seaports, naval air bases, offshore rigs, and naval and merchant ships have since been pounded systematically. FPV drones launched from uncrewed boats have also been used to hunt Russian fixed and mobile surface-to-air missile sites and other high-value ground targets inside Crimea (Sutton, 2026).

A summary overview of FPV drones and their impact on modern warfare would be incomplete without examining Ukraine's Operation Spiderweb. In June 2025, the Ukrainians smuggled or assembled hundreds of FPV drones inside Russia. These were then loaded onto civilian trucks whose unsuspecting Russian drivers were instructed to park near five Russian airbases, thousands of kilometers from Ukraine. Next, over 100 explosive-packed FPV drones were flown remotely by drone pilots outside Russia, exploiting Russian mobile phone networks to command them (Lin-Greenberg, 2025; Bondar, 2025). The result was the confirmed ‘kill’ of at least a dozen large bombers—roughly ten percent of Russia's strategic bomber force.

Above all, Operation Spiderweb was a colossal intelligence and internal security failure for Russia. But its phenomenal success also exposed the irrelevance of layered air defenses when pitted against drone threats launched from within the targeted country's own territory. Modern air defense doctrines, developed over the past eight decades, are built to keep aerial threats out; they can do little when threats emerge in the immediate vicinity of the assets they are meant to protect. Consequently, any assumption that military assets and critical infrastructure deep inside a country were protected by strategic depth was shattered (Gady ,2025). Equally significant was the psychological effect, which demonstrated that the depths of the homeland could no longer be viewed as an impregnable sanctuary. What Russia experienced at the hands of a highly innovative rival is a harbinger of the dangers all states will face in the years ahead.

Artificial Intelligence

Artificial intelligence acts as a modern equivalent of electricity, serving as a foundational catalyst that powers and transforms diverse military systems, solutions, and decision-making processes. In modern warfare, this technology fundamentally changes how armed forces operate by rapidly processing vast quantities of data—not only to speed up and automate complex tasks but also to predict patterns and outcomes of battlefield activity. The Russo-Ukrainian War is widely regarded as the first conflict in history to witness the widespread deployment of AI by both parties. Analysts and defense experts frequently label it the world's foremost operational testing ground for militarized machine learning (Takagi, 2022).

Drone autonomy has been the leading application of AI technology in the Russo-Ukrainian War. Uninhabited systems—including USVs, AUVs, OWA-UAVs, and FPV drones—have been equipped with software that enables them to navigate and, in some cases, select and engage targets entirely on their own. Normally, precision-strike munitions and uninhabited vehicles retain some degree of man-in-the-loop control, meaning a human manually directs them and selects targets in real time (Rogoway, 2024), or else they sail or fly to a precise target location set in advance by humans. But this is changing fast, and human control is being steadily reduced. One obvious reason is the two-way RF link between the operator and the drone's susceptibility to electronic jamming and terrain- and obstacle-induced interruptions: losing the command signal means mission failure. As a result, there has been ever-increasing pressure to add AI-enhanced autonomy to both the navigation and target-selection phases of drones and munitions. Any munition or uninhabited vehicle capable of navigating to, then finding, identifying, chasing, and striking its target without a command link to a human operator would vastly improve its chances of mission success. The technology already exists, but a moral line remains around removing human oversight from the kill chain (Rogoway, 2024). Most militaries claim they will always keep humans in the loop, as a shorthand for preventing weapons from making homicidal decisions on their own. But in the Russo-Ukrainian War, the line between semi- and fully autonomous has been blurring fast. Equipped with onboard AI software trained on large datasets, FPV drones can already find targets on their own, then wait for a human operator's permission before striking (Chivers, 2025). If communication fails and human control becomes impossible, switching to fully autonomous mode—hunting and hitting targets

independently—is only a line of software code away. In fact, there are already signs of both Ukraine and Russia using lethal drones without human oversight (Sparkes, 2026; Cranny-Evans, 2026). The deployment of fully autonomous OWA-UAVs, uncrewed boats, and the FPV drones they launch, enormously complicates the task facing navies and coastal defenses in confined littorals such as the Black Sea.

Another way AI is already being harnessed to enhance the efficiency of uninhabited vehicles involves swarm tactics. When the enemy appears in large numbers or its drone defenses are intensive, a series of single-drone strikes can feel slow and insufficient. In such cases, drones can be AI-managed to form swarms executing cooperative, tightly sequenced attacks. A single pilot can thus manage dozens of loitering drones awaiting instructions (Chivers, 2025) or acting independently.

Not all military applications of AI involve weapons or uninhabited vehicles. Equally, if not more, decisive are the benefits in command-and-control and battle management functions. Indeed, AI's first trial by fire in the Russo-Ukrainian conflict may have focused primarily on decision-making support, intelligence analysis, target selection, and mission planning. Accordingly, AI has enabled Ukrainian—and, to a lesser extent, Russian—planners to sift through vast amounts of data faster than humans could (Fraser, 2024). In modern warfare, tracking the other side's actions with networked cameras, electronic surveillance, and other sensors generates vast amounts of raw data, whose near-instant processing enables minute-by-minute, near-real-time tracking of enemy movements. This is essential in a war increasingly defined by scale and speed; without it, militaries cannot manage such vast numbers of drones, front lines, and resources (Livingstone, 2026b). Even more exciting, rapid AI-assisted processing and integration of diverse surveillance data reveal patterns—such as recurring times when enemy troops resupply their positions. This insight is then used to synchronize strike-drone flights with anticipated enemy movements, aiming to catch targets in the open (Chivers, 2024).

To conclude, just as with uncrewed air and sea vehicles, AI development has become a constant cat-and-mouse game of technological and tactical innovation. Ukraine has been one step ahead so far, but Russia is following closely behind.

Space-Derived Services

Services derived from satellites in Earth orbit—and the denial of those services—have played an unprecedented role in the war in Ukraine, demonstrating both the value and the vulnerability of space assets and their terrestrial extensions. Paradoxically, Ukraine, the party without its own satellites, managed to make more extensive and effective use of orbital-derived services than Russia. This was mainly due to the assistance of its Western allies, particularly the United States. From the onset of hostilities, the U.S. passed on satellite imagery to Ukraine about the locations and movements of Russian forces in real time. Ukrainian sources claimed the intelligence support they received was of sufficient quality and fidelity to enable strikes on Russian targets (Harris and Damothe, 2022).

The bulk of space-derived intelligence, communication, and positioning-navigation services came from commercial operators whose outputs were purchased by the U.S. government, and possibly other Western governments, and passed on to Kyiv (Horton and O'Grady, 2025). Services of American satellite communication (SATCOM) companies – primarily *Viasat* and *SpaceX* via its *Starlink* constellation – were used to build situational awareness, create a common operating picture among troops, and prepare and disseminate fire-mission plans (Radin 2025). A similar pattern played out with ISR, for which commercial satellite imagery providers such as *Maxar, Planet Labs, Capella, BlackSky*, and *HawkEye 360* supplied photos and RF signals to locate Russian forces. The Finnish company ICEYE's satellites used synthetic aperture radar to locate Russian troops at any time, even in bad weather. Within the first months of using *ICEYE*'s data, Ukraine's Ministry of Defense reported identifying over 7,000 Russian military equipment sites and troop positions (Radin, 2025). U.S. government-owned missile early-warning satellites also detected Russian missile launches from their exhaust plumes, alerting Ukraine's missile defense systems (Adams, 2025).

Arguably, SpaceX's *Starlink* satellite-based internet connectivity was the most impactful. *Starlink* has 150,000 daily users inside Ukraine (Radin 2025). Beyond that, briefcase-sized Starlink terminals installed on Ukraine's naval and aerial drones enabled Ukrainian operators to guide their deadly weapons toward targets. Starlink's impact was reportedly so significant that some Ukrainian commanders believed the war could have been lost without it (Roza, 2025).

By comparison, Russia has lagged seriously in the effective employment of space-derived capabilities. This is rather intriguing, given that Russia is heir to a superpower that deployed a vast array of military satellites throughout the Cold War. Yet most of Russia's existing satellites are now beyond their operational lifespans, and its underinvestment in space capabilities since the fall of the Soviet Union has diminished its ability to leverage space-derived services (Radin, 2025). Astoundingly, after 2024, the Russian military tried to plug its massive communication gap by relying on Starlink terminals smuggled in by the thousands (Altman, 2026). Consequently, Russia's command-and-control, inter-unit communication, fire coordination, and UAV data transmission became tied to America's commercial satellite infrastructure. Not surprisingly, when SpaceX restricted non-registered users' access to Starlink at the beginning of 2026, the Russian military experienced serious command-and-control disruptions and suspended assault operations (Altman, 2026). This may have been one of the contributing factors behind Ukraine's success in turning the tide in its favor during 2026. Russia has since sought workarounds, including exploring whether Chinese satellites could be used, but alternatives will take time to materialize (Altman, 2026).

The domain in which Russia has been more effective is disrupting Ukraine's access to space-based services through cyberattacks and electromagnetic jamming. Such interference with satellite operations had been witnessed elsewhere before. Still, the war in Ukraine marked a significant uptick, as counterspace techniques were used for the first time in an all-out war between two state adversaries (Egeli 2026c). Space-based communication systems like *Viasat* and *Starlink* were frequently targeted, but the effects were short-lived, as the commercial operators quickly fixed the problems through software updates (Albon 2022; Mozur and

Satariano 2024). A more persistent and impactful category of Russian counterspace activity involved jamming and spoofing of Positioning-Navigation-Timing (PNT) signals from American GNSS satellites. This service—also known as GPS—is widely used by Ukraine's military for geolocation, navigation, and drone and guided-munition homing. To mitigate the impact, Ukraine's military has shifted toward GPS-free positioning and navigation techniques, such as software that compares surrounding camera footage with onboard 3D terrain maps, and drones and munitions that navigate by celestial navigation (Chivers, 2025).

In retrospect, Russia possessed far greater experience and material capability in space. Yet, Ukraine managed to level the playing field—and even pull one step ahead—by (i) fully leveraging commercial operators, and (ii) adapting, innovating, and diversifying more swiftly and efficiently.

Cyber and Information Warfare

Russia's invasion of Ukraine is “the first full-scale battle in which traditional and cyberweapons have been used side by side, and the race is on to explore the never-before-seen dynamic between the two” (Sanger and Barnes 2022). Russia's cyber campaign was launched a few days before its military invasion and was the most extensive on record (The Economist ,2022). One study reported network intrusions not only in Ukraine but in 42 countries among Kyiv's Western supporters during the first weeks of the war (Microsoft, 2022). In this sense, the contention of cyber warfare proponents that the next major state-on-state conflict would open with cyberattacks was proven accurate. On the other hand, alarmist forecasts of a ‘cyber-Pearl Harbor’ at the outset of future wars did not materialize (Mueller, 2022). Instead, echoing the Russian military's dismal performance on the physical battlefield, most of Moscow's cyberattacks failed. Where they succeeded, their impact was short-lived, and Ukraine and its Western supporters quickly repaired any resulting damage. As a result, Russia's cyber campaign had little if any impact on the course and conduct of tactical operations on the battlefield (Rid, 2022).

Meanwhile, Ukraine and its Western allies did not remain purely on the defensive. Still, they responded in kind (Lyngaas, 2022), distracting Russian cyberattack units and diverting them toward shoring up Russia's own cyber vulnerabilities. From this perspective, an important takeaway from the Russo-Ukrainian War is that persistent, low-intensity cyber conflict is a more likely model for future wars: like submarines and aircraft before it, cyber is—and will remain—a standing component of warfare going forward (Freedberg ,2023).

A frequently overlooked extension of the struggle in the cyber domain is the competition to influence the attitudes of combatants, national populations, their leaders, and international supporters. In the Russo-Ukrainian conflict, too, both sides have invested considerable resources in a wide variety of communication tools. Yet, as exemplified by the successful use of *TB2* UAV footage during the war's initial months, Ukraine has been more successful at producing, releasing, and exploiting those tools. The lesson is that, from traditional to modern social media, the battle of the narrative must now be treated as a key element of modern warfare (Barry, 2023).

Role of Defense Industries

No overview of the impact of evolving technologies and corresponding capability areas would be complete without a closer look at the defense-industrial capabilities that underpin the fielding, sustainment, and effective employment of the resulting military capabilities. Since the outbreak of the war in 2022, the expansion of Türkiye's and Ukraine's defense-industrial and manufacturing capacities has reshaped the security environment, redrawn the region's power dynamics, and steadily eroded Russia's relative weight. Russia's defense-industrial and technological trajectory since the end of the Cold War illustrates the point starkly: decades of underinvestment, brain drain, corruption, international sanctions, and what one observer called 'innovation stagnation' (Boulegue, 2025) have left that former superpower with a defense-industrial and innovation base far diminished from what it once commanded. The war in Ukraine has laid this decline bare: Russia has been reduced to purchasing artillery ammunition and ballistic missiles from North Korea (McCurry, 2025)—a pariah state—and importing badly needed drone technology and components from Iran, itself under heavy international sanctions for over four decades (Ilyushina, 2025). That a state with Russia's historical military-industrial pedigree must now depend on such backwater partners for basic needs underscores how far its indigenous capacity has eroded. Russia's relative decline in Black Sea power standing, measured against other, better-faring littoral states, was all but inevitable.

It is against this backdrop that Ukraine's success in leveling the playing field with Russia should be seen not merely as a consequence of innovative tactics but equally as a direct result of Ukraine's rapidly expanding and dynamic defense industry. In other words, Ukraine's capacity to innovate on the battlefield—rapidly iterating on naval and aerial drone warfare, AI, space-derived capabilities, and long-range strike weapons such as cruise missiles—has been possible precisely because Kyiv has built fast-expanding engineering and manufacturing capabilities able to translate battlefield ideas into fielded products within weeks or months rather than years.

The war has likewise demonstrated the critical importance of deep stockpiles of artillery ammunition, long-range strike missiles and drones, and air defense interceptors of all sorts, whose uninterrupted flow could not be guaranteed unless a state manufactured them itself (Altman, 2025b). During the first two years of the conflict, for instance, both sides experienced chronic shortages of artillery rounds. Russia tried, largely in vain, to cope by purchasing shells from North Korea and digging deep into rusting Cold War stockpiles. In contrast, Ukraine chose to substitute artillery fire with FPV drones assembled from COTS components. In the process, hundreds of startups emerged to meet Kyiv's ever-growing demand for drones, USVs, long-range kamikaze UAVs, and drone-on-drone interceptors. Thanks to these advances, Ukraine's drone industry now ranks among the best in the world, giving Kyiv considerable leverage—not only in its war with Russia but in its relations with other countries. European and Gulf states, and even the United States, now seek Ukraine's expertise and assistance in countering drone threats (Horncastle, 2026). Another area in which Ukraine is at the forefront is AI technology: the country holds the most operationally rich database of real-world combat imagery anywhere. This is an invaluable asset for training AI models that international defense companies and allied governments have already requested access to (Livingstone 2026b). Ukraine's innovative

startups are partnering with European defense manufacturers to co-produce AI and drones (Cohen, 2026). Kyiv's broader bet is a multibillion-euro, European-funded buildup of its arms industry, seen as the country's best chance of keeping Russia at bay and securing its long-term survival, given that formal security guarantees have proven unreliable (Méheut, 2025).

Despite these gains, Ukraine's domestic industrial capacity still lags in one domain that has long underpinned Russia's most devastating attacks: ballistic missiles. Besides Ukraine's chronic manpower shortages, this is among the starkest mismatches in the conflict today and a major source of Russian military pressure on Kyiv (Méheut, 2026). Ukraine has pushed hard to build its own ballistic missiles, but such weapons are far more complex and time-consuming to produce than makeshift drones. Just as critically, because Ukraine cannot produce air defense interceptors capable of shooting down ballistic missiles, it is exposed increasingly to Russia's brutal missile salvos (Ogirenko and Smilianets, 2026). Despite local initiatives (Stezhnesky 2025) and a recent American pledge to allow licensed production of Patriot interceptors (Livingstone, 2026c), this gap is likely to persist for some time.

The second littoral state to have made huge progress in advancing its defense-industrial capabilities is Türkiye. The country's defense industry has undergone dramatic growth and diversification over the past 50 years, transforming Türkiye into a significant defense exporter. This transformation has accelerated markedly over the last decade as indigenous systems have matured and exports have surged (Egeli et al., 2024). Particularly relevant to Black Sea security are Ankara's cutting-edge capabilities in naval vessels; naval weapon systems, including antiship missiles; UAVs and USVs; sensors and electronic warfare equipment; indigenous ISR and communications satellites; long-range standoff munitions; and a large array of ballistic and cruise missiles (Egeli and Mevlütoğlu, 2026).

Türkiye's increasingly mature naval, UAV, ISR, munitions, and missile industries have allowed Ankara to project greater power and resilience in the Black Sea independent of outside suppliers. This has further eroded the uncontested regional control that Moscow once enjoyed. Türkiye has also leveraged its rapidly growing defense exports to advance defense cooperation and military interoperability with littoral states (Güvenç, 2024). Ankara exported its renowned *TB2* UAVs to Ukraine, Romania, and Azerbaijan, and set up a factory in Ukraine to co-produce UAVs. Ukraine purchased two *MİLGEM* missile corvettes from Türkiye, and Romania has recently taken delivery of the offshore patrol ship variant of the same (Yaylalı, 2026a). One of Türkiye's leading armored vehicle manufacturers has invested in Romania to produce over 1,000 *Cobra* armored vehicles (Yaylalı, 2026b). This growing list of ties allows Ankara to leverage defense-industry and equipment complementarity to form an *ad hoc* grouping to deter and blunt Russian adventurism (Gaber, 2024). This dynamic has created a particular opportunity for Romania, which has only a limited domestic defense-industrial base. Rather than developing comparable indigenous capacity, Romania has aligned itself with the Turkish-Ukrainian axis through procurement—acquiring drones, naval vessels, and other systems from Ankara and Kyiv. In doing so, Bucharest is effectively buying its way into this *ad hoc* grouping of littoral and near-littoral states whose growing interoperability and combined military capabilities further erode Russia's traditional maritime and military edge in the region.

Conclusion

Since the start of Russia's invasion in 2022, Ukraine has constantly improvised, harnessing innovative technologies and tactics to slowly dismantle Russia's dominance over the Black Sea. What it achieved was an outstanding campaign of sea denial that has forced Russia to stay out of the western half of the Black Sea and confine its naval activity to the vicinity of bases in the east. From this perspective, Bulgaria, Romania, and especially Türkiye have become the major beneficiaries of Russia's astounding strategic blunder in invading Ukraine. Yet the new power hierarchy that has emerged has rendered the Black Sea neither safer nor more stable. For one thing, the war continues unabated in Ukraine, Crimea, and Russia, with mines drifting south, explosive-laden USVs and UAVs going astray, and merchant vessels of littoral states and third countries constantly targeted, damaged, or sunk across the Black Sea, with loss of innocent life.

Even more significant, technologies and tactics pioneered first by Ukraine and then swiftly adapted by Russia have given rise to a new operational reality in the naval domain—one best described as a landscape of denial zones and grey areas, where neither side can move or operate freely enough to exploit its naval superiority. Beyond the two belligerents, the operational and strategic implications should concern other littoral states as well, especially Türkiye, the region's current dominant naval power. The AI-enhanced uncrewed boats, aerial vehicles, and anti-ship missiles—guided by AI-assisted ISR and battle management systems—that have wreaked havoc on Russian and Ukrainian ships, aircraft, and coastal facilities would likely exact a similar, if not greater, toll on other navies. Newcomers to this form of warfare may suffer even more until they learn to adapt, improvise, and innovate. This applies not only to the Black Sea but to other confined, crowded littorals such as the Baltic and Mediterranean—though not necessarily to the open expanses of oceans. Militaries, of course, are typically conservative organizations that resist change. Yet the Ukraine war has made clear that a state's numerical, economic, and industrial superiority may matter far less than its capacity to adapt and improvise against dynamic and innovative adversaries.

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SecureBlackSea

The Black Sea region has long been a focal point of geopolitical competition, shaped by historical rivalries, strategic interests, and evolving security dynamics. In recent years, the region has witnessed growing instability due to escalating tensions, hybrid threats, and the ongoing war between Russia and Ukraine. These developments have not only disrupted regional security but have also posed broader challenges to the European and transatlantic security order. Given NATO's strategic interest in the region, a comprehensive reassessment of security frameworks is necessary to address emerging threats and enhance regional stability.

SecureBlackSea seeks to examine and propose a future security architecture for the wider Black Sea region, aligning with NATO's evolving strategic priorities. Through an in-depth analysis of existing security structures, regional conflicts, and cooperation mechanisms, it aims to provide evidence-based insights into key threats and potential policy responses. A particular focus will be placed on the intersection of conventional military threats, hybrid warfare, economic security, and geopolitical rivalries, recognizing the complex and multi-dimensional nature of regional security challenges.

The project activities include expert workshops, field research, and data-driven assessments. It will evaluate the effectiveness of existing regional security frameworks and NATO's role in shaping stability in the region. In collaboration with policymakers, security experts, and academic institutions, the project team will facilitate policy dialogues and strategic foresight discussions to identify pathways for strengthening regional security cooperation. These efforts will result in the development of comprehensive policy recommendations aimed at enhancing institutional resilience and fostering a more cooperative security environment.

The expected outcomes of this initiative include a thorough assessment of regional security threats, a set of actionable policy recommendations, and strengthened dialogue between NATO and regional stakeholders. By producing analytical reports and policy briefs, the project will contribute to an informed security discourse and provide practical solutions for mitigating risks in the region. By fostering collaboration between academic and policy communities, it will support long-term strategic planning and resilience-building efforts.

SecureBlackSea aspires to provide a timely and in-depth examination of the evolving security landscape in the Black Sea region. It will offer insights that can guide NATO's strategic engagement in the region. Thus, it aims to contribute to a more stable, secure, and cooperative Black Sea security environment in the face of emerging geopolitical complexities.

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