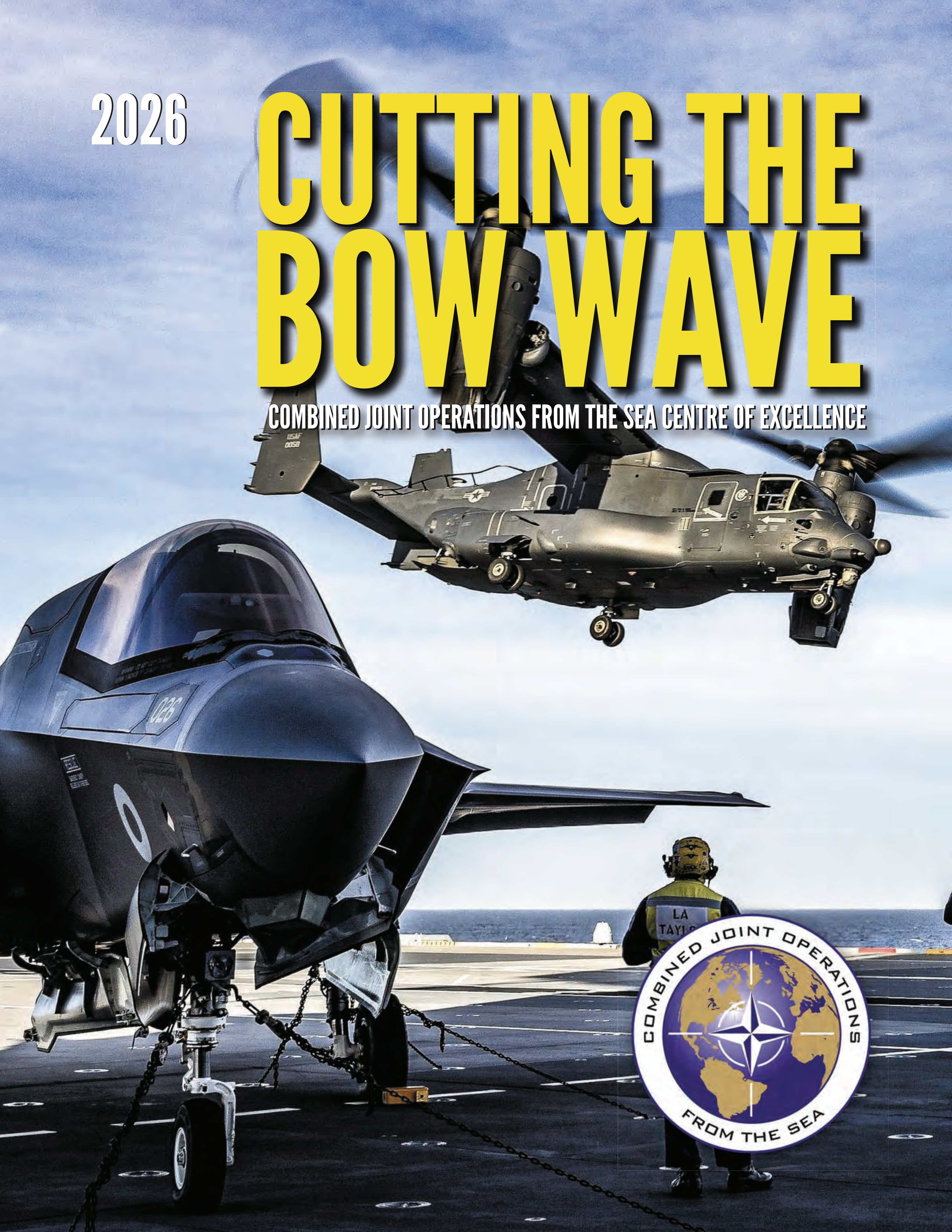
2026

CUTTING THE BOW WAVE

COMBINED JOINT OPERATIONS FROM THE SEA CENTRE OF EXCELLENCE



COMBINED JOINT OPERATIONS FROM THE SEA

A Swedish Air Force JAS 39 Gripen fighter cruises over an Icelandic fjord while deployed as part of NATO's Arctic Sentry activity. Arctic Sentry is a NATO vigilance activity aimed at enhancing security in the north. Courtesy of the Swedish Air Force.

Front Cover: United States Marine Corps V-22 Osprey's and F-35B's operate on the flight deck of HMS prince of Wales in July 2025. Courtesy of the Royal Navy, photo by LPhot Bill Spurr.
Back Cover: A Seahawk medium displacement unmanned surface vessel participates in U.S. Pacific Fleet's Unmanned Systems Integrated Battle Problem , April 21. Courtesy of USN, photo by CMCS Shannon Renfroe.

PUBLISHER'S NOTE

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A Combat Boat 90 (CB90) from the Norwegian Coastal Ranger Command participates in Exercise Arctic Advance in Northern Norway, Nov. 25. Photo by Henrik S. Andersen, Norwegian Armed Forces.

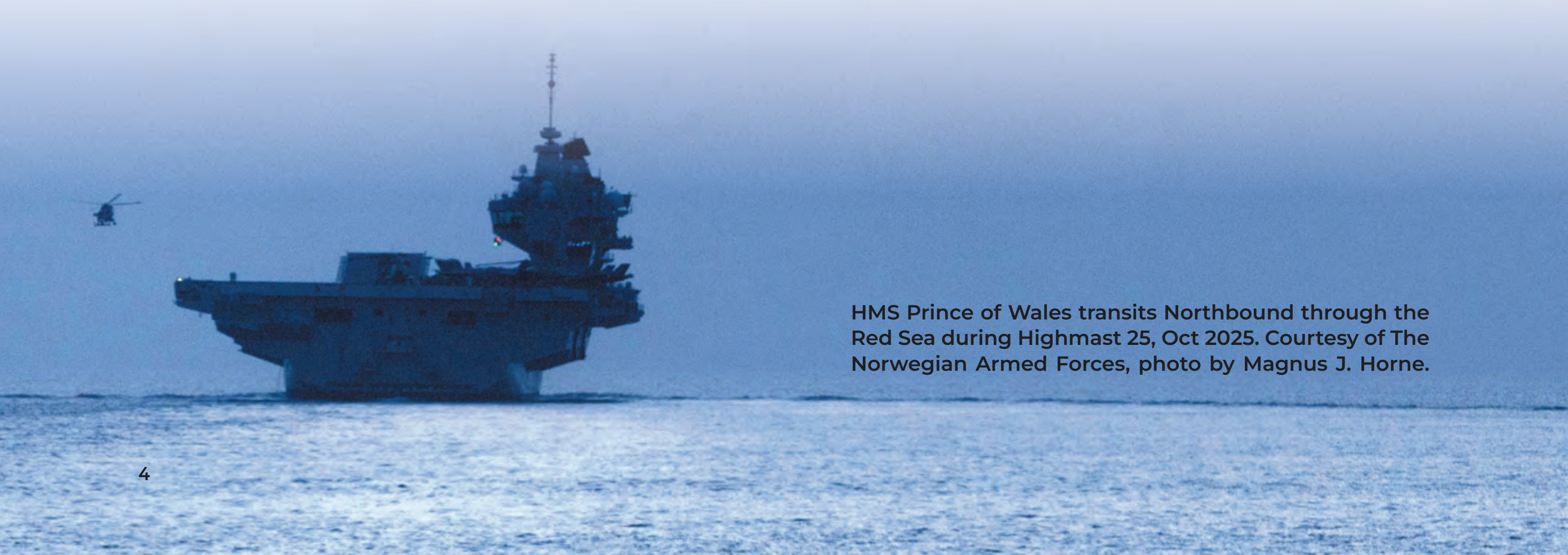
DIRECTOR'S INTRODUCTION

VICE ADMIRAL DOUGLAS G. PERRY
Commander, JFCNF
Commander, U.S. 2nd Fleet
Director, CJOS COE

In my opening comments last year, I referred to the geopolitical landscape surging in unexpected directions. This certainly continued to be the case this year, and from Eastern Europe to the Arctic, to the Middle East, we have seen both ongoing and newly emerging crises, conflicts and challenges. All provide further evidence (if any were needed) of the continued rapid pace of tactical and technological evolution underway across the maritime domain globally. In response, NATO continues to test, experiment, and innovate at the very cutting edge of future military capabilities. This final 'bumper' edition of Cutting the Bow Wave supports this by offering its usual wide range of thought-provoking articles, each penned by a deep expert, and designed to both inform and stimulate on a range of maritime topics and issues of interest. Whether cyber defense; amphibious reconnaissance; the Arctic; uncrewed vehicles; or achieving domain awareness, decision superiority, and command and control in the digital age, all are increasingly focusing minds (and national procurement decisions) across the Alliance today.

But through a more focused lens of NATO's specific Area of Responsibility, this year I would draw your particular attention to the Arctic and High North. As China claims to be a "near-Arctic" state, and Russia re-operationalizes Cold War-era military bases across its Arctic frontier, NATO's gaze shifts ever further northward. NATO operations in the Arctic and High North are increasingly prevalent, and the recently formed Arctic Sentry operation not only consolidates our surveillance activities there but also stands as a clear counter to Russian and Chinese activities in this increasingly vital but contested region. As you explore the articles that follow therefore, I invite you to reflect on their particular application and implications in an Arctic setting.

Lastly, and as with all our previous editions, I invite you to share the articles as widely as possible with your teams, wardrooms, leadership circles, and all those in the profession of arms. While CJOS COE will sadly close this Summer, the work continues elsewhere across the Alliance and in other Centres of Excellence. Equally, the past work of CJOS COE of course endures, and as we bid farewell to the Centre and its dedicated staff, I would observe that both have served as outstanding members of the Norfolk, Virginia higher headquarters family, comprising U.S. Second Fleet; NATO Joint Forces Command Norfolk; and NATO Allied Command Transformation. Reflecting on my two years as Director, I remain incredibly proud of the collaboration and unifying efforts the CJOS team has consistently delivered to our partners and friends in and around the Alliance. CJOS has provided the Alliance with superb analysis, advisory services, exercise support, and operational scholarship for the past 20 years, and on the record here I want to express my personal and professional gratitude to our entire CJOS COE family, past and present, for their outstanding contributions to advancing NATO maritime security and interoperability. Truly, we are stronger together.



HMS Prince of Wales transits Northbound through the Red Sea during Highmast 25, Oct 2025. Courtesy of The Norwegian Armed Forces, photo by Magnus J. Horne.

DEPUTY DIRECTOR'S FOREWORD
CJOS COE – FROM FOUNDATION TO OUR FINAL CHAPTER

COMMODORE DONALD J. MACKINNON OBE PhD RN
Deputy Director, CJOS COE

Welcome to the 2026 edition of Cutting the Bow Wave. Unfortunately, with the news that the Combined Joint Operations from the Sea Centre of Excellence (CJOS COE) will close in 2026, sadly, this will be our final edition. Given this, and before you enjoy this year's edition, I wanted to take the opportunity to offer a brief retrospective on our wider work and achievements over the years from our foundation in 2006 to our final chapter this year.

This year marks CJOS COE's twentieth and final year. Back in 2005, with a perceived reduced threat from Russia, the United States stood down its "Striking Fleet Atlantic" but simultaneously proposed a new Centre for Combined Joint Operations from the Sea be established in Norfolk. A year later, on May 31, 2006, CJOS COE was established, with the outgoing Commander Striking Fleet Atlantic and then Commander U.S. 2nd Fleet, VAdm Mark Fitzgerald USN, stating: "…deactivation of NATO Striking Fleet Atlantic closes one important chapter on how the alliance has made a very real and successful difference in the security and stability of its members. It also serves as a new beginning, with the establishment of a Combined Joint Operations from the Sea Center of Excellence…"[1]

With the United States as Framework Nation, 12 other nations joined CJOS COE, co-located in Norfolk alongside NATO's Allied Command Transformation and several USN Commands. Work in the early years focused on Maritime Security; NATO's Capability roadmap for Maritime Unmanned Vehicles and Systems; the Sea Basing concept in support of the Joint Sea basing initiative; and Joint Expeditionary Operations. Part of this saw CJOS COE chairing the NATO Maritime Operations Working Group, responsible for developing and maintaining doctrine, tactics, tactical instructions, and procedures.

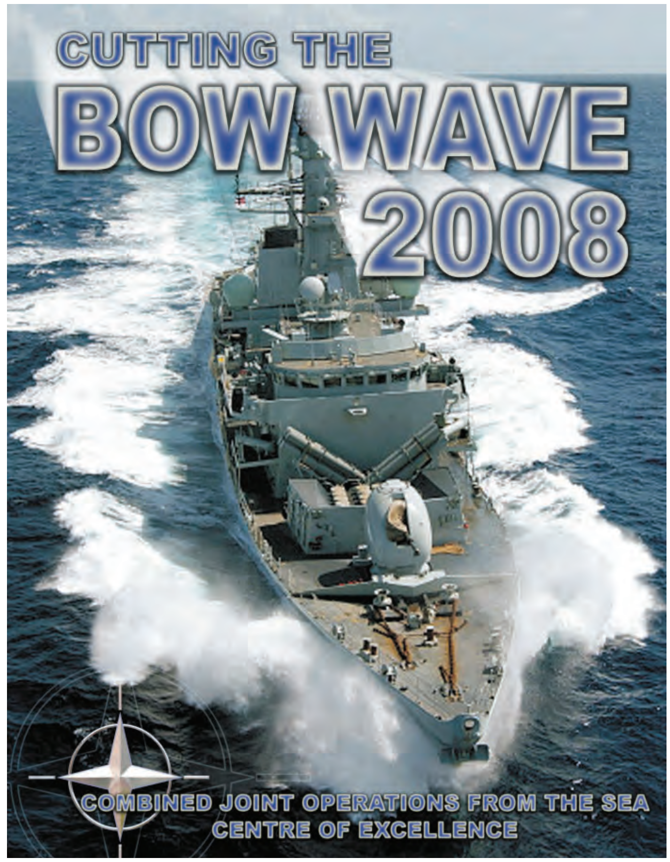
In 2008, we partnered with the Confined and Shallow Water Centre of Excellence in Germany and the NATO Undersea Research Centre in Italy, to host an inaugural Maritime Security Conference with a theme of "Delivering Maritime Security in Global Partnership".[2] This evolved into an annual Maritime Security Regimes Roundtable event and over the years that followed civilian and military professionals have attended from across the globe, representing a wide cross-section of government, non-government, military, academic, and industry experts, coming together to share observations, conclusions and best practice. Also in 2008, CJOS COE published its first Cutting the Bow Wave to showcase some of our projects and activities. Fast forward to today (and nineteen editions later) and Cutting the Bow Wave has delivered a total of 250 articles on a range of topics.

In parallel, CJOS COE has also made significant contributions over the years to Alliance interoperability. In 2010, our first Allied Interoperability Guide was published to provide guidance on integration of Allied units into USN exercises and activities. Over time the guide was revised and reissued based on feedback from users and today remains a key planning text for planners preparing to operate in multi-national settings. With CJOS COE's closure, ownership of the guide will pass to the US Naval Warfare Development Centre.

Looking a little more widely, in 2011, at a time of significant global peacekeeping efforts, CJOS COE supported the UN Department of Peace Keeping Operations by recommending a structure for the maritime component of UN's mission in Lebanon (UNIFIL II). Additionally, we developed the "Supporting L.I.F.E." concept – Logistics, Information, Force Protection, and Expertise, designed to inform both humanitarian and military communities and following extensive consultation with the international humanitarian community. This included stakeholders such as the UN Office for the Coordination of Humanitarian Affairs, the International Committee of the Red Cross, the European Commission Humanitarian Aid and Civil Protection, and the United States Agency for International Development.[3]

Continues on next page.

Beginning in 2014, CJOS COE began to support the planning and execution phases of the annual Bold Alligator exercise, a multi-national amphibious landing exercise off the east coast of the USA. In parallel, our staff have supported the USN's Carrier Strike Group 4 (CSG-4), the principal USN training and certifying organization on the east coast. CJOS COE has helped simulate and incorporate multinational and allied aspects into the pre-deployment planning and certification of multiple USN Carrier and Expeditionary Strike Groups as they prepare for deployment into a coalition environment. To date, this remains the only NATO-centric training deploying USN strike groups receives prior to deployment.



As the threat from Russia grew again, in 2018, NATO decided to adapt the Alliance's command structure with a new Atlantic command, Joint Force Command Norfolk (JFCNF).[4] The USN also re-established its 2nd Fleet.[5] To better align with these changes, in 2020 CJOS COE directorship was transferred from Deputy Commander US Fleet Forces Command, to Commander US 2nd Fleet and Commander JFCNF, then VAdm Andrew Lewis USN, who stated: "By linking C2F, JFC Norfolk, and now CJOS COE, national and NATO commands will further align, catalyzing the development of modern warfighting capabilities in the North Atlantic, and increasing readiness across the joint force."[6]

Whilst we remained focused primarily on maritime and amphibious operations and capabilities, multi-domain and 'cross-domain' thinking was already becoming increasingly important to NATO. By 2022, our then Director VAdm Dwyer USN was offering that: "Purposely situated alongside U.S. Second Fleet and Joint Force Command Norfolk, and adjacent to Allied Command Transformation, CJOS COE is a key enabler that drives interoperability, deepens understanding of the maritime domain, enhances multi-domain integration, and supports the development of innovative technologies."[7] Increasingly, CJOS COE's emphasis was shifting toward interoperability; multi-domain operations; integration of innovative technologies; and deepening our understanding of likely competitors.

Change of Command Ceremony 2020 for the transfer of CJOS COE Director authority from U.S. Fleet Forces to U.S. 2nd Fleet.

This emphasis remained unchanged until 2025 when the United States made the decision to recalibrate its wider commitments to NATO Force Structures and NATO Centres of Excellence. This included US withdrawal as the Framework Nation for CJOS COE, and hence its closure here in Norfolk. Whilst of course disappointing for many, this decision does not, however, diminish the outstanding work CJOS COE has done over the years through its dedicated international staff coupled with the enabling support of the USN. Since its foundation, more than 200 officers from 13 nations have served at CJOS COE and today's current staff are rightly proud of this collective legacy of excellence and delivery.

As for me, I would like to thank all of you who have supported, contributed or engaged with CJOS COE over the years. It has been my great privilege to act as its last Deputy Director, leading and managing on behalf of the Director, a truly exceptional multinational staff. As with previous editions of Cutting the Bow Wave, you can see for yourself in the articles that follow below just a glimpse of their combined talent and knowledge. As such, I commend this final edition of Cutting the Bow Wave to you, and I hope you enjoy reading it as much as the staff enjoyed preparing it. CJOS COE sends....for the final time.

Maritime Security Regime Roundtable 2025

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CJOS COE 2025-2026

BACK ROW: CDR (GRC-N) D. Petrinos, CAPT (USN) K. Tate, CAPT (USN) E. Winn, CPO (USN) A. Patrick-Diekemper, CDR (PRT-M) R. P. da Silva, CDR (RNLN) B. Roelink, CDR (USN) E. W. Herbert, LT (USN) M. Lyons, CDR (TUR-N) E. Yilmaz.
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NOT PRESENT: VADM (USN) D. G. Perry, CDR (USN) A. Steinwand, CDR (USN) J. T. Younts.

TIP OF THE SPEAR

THE EVOLUTION OF ALLIED AMPHIBIOUS RECONNAISSANCE

By

CDR (PRT-M) Ricardo Silva

As NATO adapts to the current geostrategic challenges, the Alliance continues to enhance its ability to project power from the sea and engage threats across the littorals. In this context, the requirement for conventional Amphibious Forces to conduct forcible initial entry operations remains a core component of the Alliance's Maritime Power.[1] Evolved amphibious concepts add to the initial entry role enabling the support of a wider range of maritime activities, including strike warfare, sea control, sea denial, and support to maritime security. Consequently, the utility of NATO's Amphibious Forces can be expected to grow, consolidating their role as a prime instrument of Allied Maritime Power.

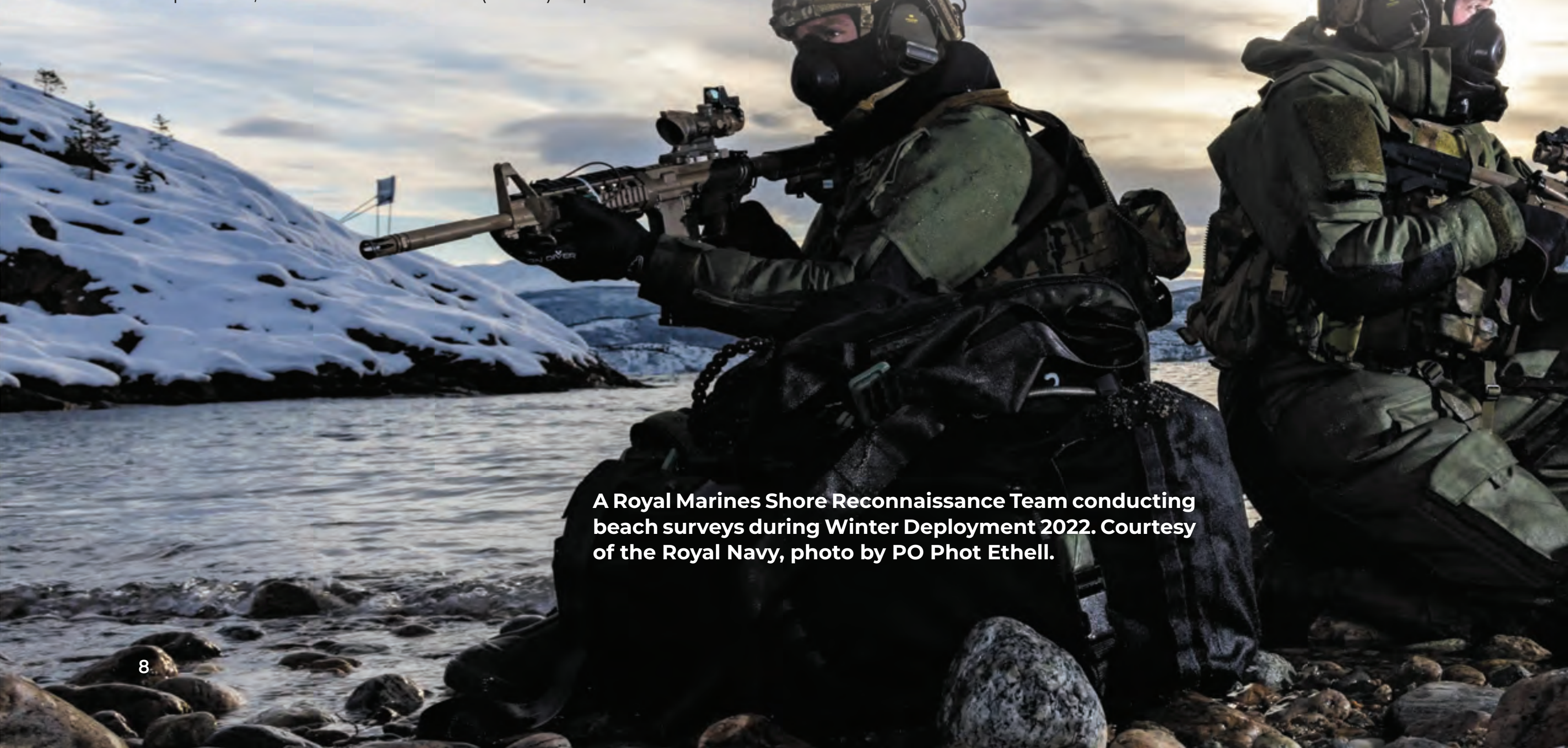
As concepts for the employment of Amphibious Forces mature, the evolution of Amphibious Reconnaissance warrants careful analysis. The central question is: how can Amphibious Reconnaissance leverage the renovated models of Amphibious Forces and better adapt to the future operating environment?

Current trends indicate that maritime power projection will increasingly rely on decentralized, lighter, more lethal Amphibious Forces, capable of operating inside Anti-Access/Area Denial (A2/AD) engagement zones, across the beach and into contested or defended littoral regions.[2,3,4] This approach diverges from traditional approaches and requires the integration of significant technical and tactical innovations. These innovations will enable distributed operations and the performance of an enlarged set of roles across the littorals, supported by enhanced Intelligence, Surveillance, Target Acquisition, and Reconnaissance (ISTAR) capabilities.[5]

THE ROLE OF AMPHIBIOUS RECONNAISSANCE

Amphibious operations are uniquely challenged by the difficulty of gathering intelligence during the planning and initial entry phases.[6] This underscores reconnaissance as a critical function, especially as adversaries deploy capable A2/AD systems that render tactical ISTAR activities increasingly difficult to perform. Amphibious Reconnaissance will thus be required to insert from longer ranges offshore and operate in more dispersed and covert modes to ensure mission success and force survivability, while increasing its ability to collect expanded packages of information, covering the different domains of the operating environment and corresponding threats.[7]

Amphibious Reconnaissance is typically organized into phases and includes the joint application of varied units and assets. External Advance Force Reconnaissance typically operates under the Joint Force Command, mostly to inform strategic and operational decision-making. Internal Advance Force Reconnaissance is part of the amphibious force itself and targets specific information requirements, necessary for detailed amphibious planning. Pre-landing Reconnaissance occurs within the Amphibious Objective Area (AOA) to confirm final environmental and threat conditions before the assault. Following the landing, tactical ground reconnaissance remains critical to support the maneuver of the Landing Force ashore, with specialized reconnaissance units focusing on deep reconnaissance while maneuver units perform short-range reconnaissance.[8]



A Royal Marines Shore Reconnaissance Team conducting beach surveys during Winter Deployment 2022. Courtesy of the Royal Navy, photo by PO Phot Ethell.

The scope of information required to support and enable amphibious operations is diverse, complex, and often time-sensitive, covering hydrographic, meteorological, and geographic information across sea, land, and air domains. Modern reconnaissance must extend into electromagnetic, cyber, and space domains. Therefore, reconnaissance forces must be well-tailored and effectively employed to fit intelligence collection requirements across the entire AOA.[9,10]

As Amphibious Forces expand their scope of operations, reconnaissance must also adapt to address unconventional scenarios and adopt new technologies, supporting faster targeting cycles and the effective employment of advanced weapon systems.[11] In fact, the ability to detect, identify, and track enemy forces may be the exact limiting factor in realizing the full potential of offensive capabilities of naval and Amphibious Forces.[12,13]

In summary, to address the most significant challenges posed to modern Amphibious Reconnaissance, units must be able to:

- Access, operate, and survive in a more lethal battlespace.
- Operate in dispersed formations to enable covert movement, maximize geographic coverage of the Area of Operations, while minimizing risk to Force.
- Perform high-tempo collection of a wide scope of information, particularly in the context of the multi-domain approach to operations.
- Support diverse typologies of Amphibious Forces, including in protracted operations along the coastline and in river basins, as well as contributing to sea denial/ control or maritime strike operations.
- Channel all the collected information into agile and secure frameworks to support the analysis, archival, and sharing of large volumes of actionable intelligence. The discussion of such frameworks falls outside the scope of the present article, although that discussion can be just as relevant as the discussion about collection capabilities.

THE EVOLUTION OF AMPHIBIOUS RECONNAISSANCE

As the operating environment is evolving rapidly, capable and adaptive reconnaissance forces have become essential towards enabling maritime power projection, including amphibious and strike operations inside contested or enemy-controlled areas. These forces operate at the leading edge of naval and joint strike capabilities, enabling the maneuver of friendly forces and the engagement of enemy forces across the littorals.

Modern reconnaissance forces are required to operate inside A2/AD engagement zones and perform sustained information collection activities in denied areas. In this environment, freedom of movement has become progressively more difficult to achieve, and the threat profiles are varied but intense. This reality drives the development of new and sophisticated reconnaissance concepts and force models, reflected in several key trends.

Small, decentralized, and autonomous teams

The emerging proliferation of new technologies and weapons systems, including autonomous and unmanned, and the corresponding growing lethality of the modern battlefield has increased the importance of employing small, dispersed teams capable of operating covertly and independently. These teams are designed to function with minimal external oversight, sustain themselves for extended periods, and rapidly adapt to changing conditions using pre-authorized decision-making frameworks. This decentralized approach improves both survivability and operational flexibility in highly contested environments, while enabling the coverage of wider areas of interest and the establishment of quicker, adaptative targeting cycles.

Integration of unmanned systems

Unmanned platforms are becoming standard tools rather than specialized enablers, extending the reach, speed, and persistence of reconnaissance and surveillance activities. Amphibious Reconnaissance teams are increasingly integrating Unmanned Underwater Vehicles to map underwater terrain, and detect mines and obstacles, Unmanned Surface Vehicles to discreetly scan the surface of coastal waters and deploy sensors or decoys, and Unmanned Aircraft Systems to conduct over-the-horizon surveillance, terrain imaging, threat reconnaissance, and targeting support. All these capabilities significantly reduce personnel exposure to threats while enabling continuous and covert detection and observation of threats and key terrain features in littoral areas.

Stealth insertion and mobility

As adversary surveillance capabilities continue to expand, stealth has become harder to achieve. To preserve operational security, teams are emphasizing greater ship-to-shore projection distances and the use of low-signature platforms, including stealth watercraft, swimmer delivery vehicles, and low-profile or semi-submersible vessels. The deliberate use of deception, strict emissions discipline, and the exploitation of environmental conditions to mask movement are also increasingly important to reduce the risk of detection during insertion and maneuver ashore.

Increased awareness of mine and explosive threats

Mine threats remain a primary concern in the modern battlefield and in amphibious operations. Amphibious Reconnaissance teams must support mine detection and clearance, provide timely reconnaissance and marking of landing routes, and identify any hazards, including conventional or improvised explosive devices. Specifically in the wake of the Ukraine war, the ability to detect, avoid, and report explosive threats has re-emerged as a critical capability for offensive operations.[14,15]

Active electronic signature management

The modern battlefield punishes units that radiate electronic signals. Reconnaissance now demands rigorous control of radio frequency emissions, including the use of burst communications and encrypted, low-probability-of-intercept systems. Maintaining electronic discipline and employing tactics like asynchronous communications is vital for mission survivability against modern electronic warfare capabilities. In addition, visual and Infrared signatures coming from personnel and equipment are also critical vulnerabilities for covert reconnaissance and must be minimized.[16]

Seamless integration between Reconnaissance and Fires

A defining feature of future amphibious capabilities is the seamless integration of reconnaissance with precision fires. Reconnaissance teams are tasked with identifying, locating, and tracking targets for engagement by naval and joint fires. Operating covertly and in proximity to hostile targets, equipped with digital targeting systems, these teams enable sensor-to-shooter networks that reduce kill-chain timeframes and enable dynamic targeting. Under this model, Amphibious Reconnaissance also becomes a direct enabler for strike operations.[17,18,19]

Urban littoral reconnaissance

As global populations concentrate along coastlines, urban terrain has become a key feature of military operations in littoral regions. Reconnaissance in these dense, multi-level environments requires specialized capabilities, training, non-standard tactics, and a culturally attuned intelligence picture. This will enable discrimination between targets, critical infrastructure, key human networks, and the overall ability to distinguish combatants from non-combatants in a cluttered physical and electromagnetic landscape.[20]

CONCLUSION

Amphibious Forces are one of the core military capabilities of the Alliance, and their utility continues to lie in the ability to enable maritime power projection, even in the most demanding scenarios, through the deployment of capable, scalable and agile landing forces. Amphibious Reconnaissance is an indispensable element for ensuring the success of these operations. As such, Amphibious Reconnaissance forces must adapt to emerging requirements imposed by the changing operating environment, evolving to be inserted from greater standoff distances, collecting relevant information across all domains, and operating with increased effectiveness, autonomy, and survivability inside hostile or denied areas.

The modern battlespace, contested in nature, populated by unmanned threats and covered by A2/AD systems, demands the application of new concepts, doctrine, and technology. While technology can be a game-changer, the success of Amphibious Reconnaissance continues to require the application of skill, resilience, and judgment from small, highly trained teams. The complexity of the modern battlefield also requires integrated reconnaissance planning, and effective Command and Control to feed decision-making processes more efficiently than ever before. These factors can and should be incorporated into relevant force development efforts directed at Amphibious Reconnaissance Units.

U.S. Marines launching a RQ-20B Puma small UAS from a rigid-hulled inflatable boat at Camp Pendleton, California, 2021. Courtesy of the USMC, photo by Staff Sgt. C. Hancock.

The effort to modernize doctrine and Tactics, Techniques and Procedures (TTPs) is essential, including the update of Allied amphibious doctrine, with the latest best practices and lessons learned. TTPs for stealth insertion, urban reconnaissance, unmanned systems employment, and reconnaissance-strike integration should be prioritized.

Reconnaissance Forces need to be structured for modularity. This can be translated into the development of modular, task-organized reconnaissance elements capable of operating independently across an entire AOA, in a variety of littoral environments and against differing threat profiles. These scalable force packages should seamlessly integrate with other Intelligence, Surveillance and Reconnaissance (ISR) assets and with Mine Countermeasures and Special Operations Forces (SOF) force elements.

Emerging technologies should be actively tested, incorporated and leveraged into a renewed set of Amphibious Reconnaissance capabilities. A mix of unmanned surface, aerial, and underwater systems should be fielded to enable extended reach and enhance the survivability of reconnaissance teams. Also, Artificial Intelligence applications will be essential for automation, target recognition, data management and analysis.

Multi-Domain and combined operations should be well understood and implemented, codifying the role of Amphibious Reconnaissance. Capabilities, equipment standards and systems need to be aligned for interoperability and effectiveness between different services and Allies, particularly covering joint operations with Maritime SOF, ISR and other joint assets. In the absence of real-world engagements, regular participation in multinational training events and exercises is critical to build and validate combined and joint interoperability.

Human Resources must remain a central piece in the Force Development of reconnaissance units. Selection and training pipelines should be streamlined by investing in high-quality training that covers both basic and advanced skills. Reconnaissance and reporting skills must remain central, but also Survival, Evasion, Resistance, and Escape, and the ability to perform operations in varied natural and urban environments, while employing advanced ISR tools and techniques. Careful attention should also be paid to recruitment, retention and career development of personnel, including the design of clear career pathways to preserve organizational knowledge and expertise.

Training should be performed continuously and with realism. Training scenarios should accurately reflect contested, degraded, and denied littoral operating environments, including urban terrain and electromagnetically contested environments. Virtualized training and simulation can be particularly useful to supplement live exercises.

The redesign and implementation of robust but agile sustainment structures and processes needs to be tailored to any renewed capabilities. New force models require functioning and adaptable support models. Force development and investment must integrate sustainment and life-cycle management to ensure the endurance and availability of new capabilities and assets, particularly during prolonged and/or out-of-area deployments.

In conclusion, Amphibious Reconnaissance is no longer a niche capability but rather a requirement with strategic relevance, necessary for effective power projection operations that leverage superiority in the maritime and air domains, across the littorals, and against land-based opponents. By prioritizing its development through an approach that combines doctrinal evolution with technological innovation and enhanced human performance, Allied Amphibious Forces can ensure that reconnaissance remains and, indeed, grows as a decisive enabler, useful across the full spectrum of conflict and relevant in evermore challenging operating environments.

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PORTS UNDER SIEGE

By CDR (RNLN) Bernd Roelink

HOW MODERN WARFARE IS REWRITING THE RULES OF MARITIME SECURITY

INTRODUCTION

At any given moment, the global economy hums quietly through the world's ports. Containers glide from ship to shore, fuel pipelines pulse beneath the waterline, and digital systems orchestrate the movement of millions of tons of cargo. It's a finely tuned system where ninety percent of global trade travels by sea, and much of it passes through a surprisingly small number of maritime chokepoints and ports.[1]

However, this system was designed for efficiency, not resilience. And in a world where nations' prosperity and well-being depend more than ever on critical infrastructure—like ports and supply chains—that's a harsh reality. While efficiency drives growth, resilience is what ensures survival.

The infrastructure supporting the world's maritime-based supply chain represent some of the most challenging systems to protect due to the size, dynamics and complexity of all the parts involved. Ports, harbours, and ship terminals supporting global trade are often located in areas where large numbers of people live and work. Giant merchant ships, millions of shipping containers, thousands of trucks, rails, and people all come together in confined areas, keeping the global economy moving forward 24 hours a day. Rotterdam, for example, is the largest port in Europe, extending more than 40 km in length, processing more than 23,000 freight containers daily, and employing a workforce of nearly 200,000 people.[2]

As geopolitical competition sharpens and conflict increasingly unfolds below the threshold of open war, ports and maritime supply chains have emerged as some of the most vulnerable—and tempting—targets in modern conflict. What emerges is a stark conclusion: the future of maritime security will be decided not only at sea, but also in ports, harbours, and the digital networks that bind them together.

Rotterdam Port. Photo from Unsplash.

Russia is clearly aware of our dependence on critical infrastructure and the associated vulnerabilities. According to a newly developed database made by the Center for Strategic & International Studies, the Russian Main Intelligence Directorate (GRU) is leading an escalating and violent campaign of sabotage and subversion targeting Western shipping infrastructure in Europe. The number of Russian attacks against maritime infrastructure in Europe nearly tripled between 2023 and 2024, and they appear to have intensified their efforts with multiple drone incursions over Denmark, Poland, Belgium, France and other European countries in the second half of 2025. Russia's primary targets have included critical infrastructure, government institutions, and key industries by employing a range of hybrid tactics designed to sow unrest, disrupt operations, and undermine public trust. These methods encompass both kinetic and non-kinetic actions, including sabotage with explosives, drone activity, electronic warfare (jamming and spoofing), and cyberattacks.

Most of these activities fall into the grey zone: difficult to attribute, calibrated to avoid triggering collective defence, and designed to erode confidence rather than provoke immediate retaliation. This is not preparation for war in the traditional sense, it is war by erosion. In parallel with addressing these hybrid threats, NATO must prepare for overt and direct attacks against the critical port and supply chain infrastructure of its member states. Such hostile acts would aim to cripple the Alliance's ability to mobilize and sustain its forces, while simultaneously targeting economic stability and societal resilience. This necessitates a proactive strategy focused on hardening these vital hubs against a spectrum of threats, from kinetic strikes and physical sabotage to debilitating cyberattacks.

HYBRID THREATS

Hybrid warfare has quietly become one of the defining security challenges of our time. No longer confined to battlefields, it now stretches across political systems, digital networks, and critical infrastructure—including the arteries of global trade: maritime supply chains. NATO describes hybrid warfare as the coordinated use of military and non-military, covert and overt tools, ranging from disinformation and cyberattacks to economic coercion and irregular armed groups.[3]

Modern ports depend on complex digital ecosystems: automated ship-to-shore cranes, interconnected vessel-port networks, legacy software never designed with cybersecurity in mind, and radio-frequency systems operating in congested spectrum environments. These vulnerabilities are not hypothetical. Nearly 80 percent of ship-to-shore cranes at U.S. ports are manufactured in the People's Republic of China, raising concerns over remote access and servicing capabilities.[4] Meanwhile, routine practices such as shared Wi-Fi networks, USB devices, and data exchange between ships and terminals create easy pathways for intrusion.

The consequences of a successful cyberattack can be severe. Disrupted cargo flows, damaged equipment, financial losses, safety risks, and cascading economic effects can follow. In 2017, the NotPetya malware attack on A.P. Moller-Maersk forced the company to rebuild its entire IT infrastructure after operations at 17 major port terminals were crippled—at an estimated cost of up to USD 300 million.[5]

In an era of geopolitical tension, cyber operations against maritime infrastructure have become a preferred instrument of hybrid warfare. They are relatively cost-effective, difficult to attribute, fast to execute without a high risk to people and often fall below the threshold that would trigger a conventional military response. As global trade continues to depend on digital systems, securing the maritime domain is no longer just a commercial concern—it is a strategic imperative.

Ports and merchant shipping have always been vulnerable to direct attacks, but the means have evolved and become cheaper and more accessible. Currently, our adversaries, both state- and non-state actors, can launch coordinated, covert, deniable, and low-cost attacks causing harm, from dragged anchors across seabeds to cyber intrusions and drones loitering over terminals at night.

SURFACE THREATS

Explosive-laden speedboats, hijacked merchant vessels, and deliberate collisions remain effective tactics. The 2000 bombing of USS Cole demonstrated how devastating a small boat attack can be. Today, such methods are cheaper, easier to replicate, and harder to detect amid dense commercial traffic. Since November 2023, Yemen's Houthi rebels have launched numerous attacks on commercial vessels. In July 2025, the Liberian-flagged bulk carrier MV Magic Seas was severely damaged in a coordinated assault off the coast of Yemen. The attack involved small boats and sea drones, forcing the crew to abandon the ship which was reportedly set on fire before it sank.[6]

More troubling is the rise of Unmanned Surface Vehicles (USVs). The emergence of the use of explosive-laden unmanned surface vessels, which Ukraine has used with great effect in its war with Russia, comes as Iran currently threatens to block oil shipments from transiting the key Strait of Hormuz, the chokepoint for one-fifth of the world's oil. As of March 2026, naval drones have been used in at least two attacks on oil tankers in the Gulf region since war erupted between the U.S., Israel and Iran, according to maritime authorities and analysts, demonstrating a dangerous new threat in the key shipping lane.[7]

Ukraine's ability to penetrate Russian port defenses with USVs, demonstrates how quickly both the technology and tactics are evolving.[8] USV tactics evolve with longer-ranged sensors and weapons mounted onboard.

AIRBORNE THREATS

Unmanned Aerial Systems (UAS) have transformed port security calculations. Drone capabilities appear virtually limitless, as they can carry electronic warfare systems capable of jamming or spoofing GPS signals, disrupting navigation systems used by ships and Maritime Traffic Control centres. Drones can even serve as decoys, distracting or exhausting defense systems while more powerful attacks are launched elsewhere, either by conventional forces or other drones.[9]

Drone swarms—coordinated, autonomous, and expendable—represent a particularly dangerous evolution. Traditional air defences are poorly suited to detecting and defeating dozens of small, slow, low-flying targets launched from civilian areas or vessels.

On June 1, 2025, Operation Spider Web, a Ukrainian-led mission, delivered a major blow to Russian military infrastructure by targeting four strategic airbases deep behind enemy lines. The operation highlighted the devastating potential of coordinated drone strikes. Small, high-precision drones were covertly smuggled into Russia and launched from concealed compartments within cargo trucks, allowing Ukrainian forces to strike with unparalleled surprise and accuracy. More than 40 high-value aircraft were destroyed, including the strategic Tu-95MS and Tu-22M3 bombers, as well as A-50 planes critical for coordinating and launching missile attacks on Ukrainian cities. This meticulously planned and executed operation marks a significant milestone in the evolution of asymmetric warfare, showcasing the growing effectiveness of unconventional tactics in a modern conflict.[10]

In 2025 alone, repeated drone sightings over NATO ports heightened fears of escalation and demonstrated how difficult it is to police low-altitude airspace. On Sept 10, 2025, NATO forces shot down Russian drones over Poland, responding to an incursion at a scale unprecedented since the start of Russia's full-scale invasion of Ukraine in February 2022. Twenty-one drones were detected in Polish airspace, flying primarily out of Belarus, according to Polish Prime Minister Donald Tusk.[11]

In September 2025, EU Defence Ministers from eastern and northern Europe met with the EU Commissioner for Defence, Andrius Kubilius, and agreed that Europe urgently requires a "Drone Wall". This is a multilayered system of early warning sensors, airborne counter-drones, ground-based lasers and jammers, ground-based missiles and cannons, air defence frigates deployed to coastal waters and finally fighter jets like F16, F35 and Eurofighters that can be scrambled in extremes to shoot down drones.[12]

Supreme Allied Command Transformation has implemented this ambition in one of their 2026 Beacon Projects: the Layered Counter UAS Initiative, known as LCI-X.[13] Although such an initiative is about safeguarding our borders and will not directly counter Airborne Threats to ports and harbours, it may nevertheless hold interesting ideas in doing so.

Ukrainian soldiers conducting counter UAV-training. Photo from Flickr.

East Coast-based Navy SEALs conduct dive operations off the coast of Key Largo, Florida, 2025. Courtesy of US DoW, photo by NPO 1st Class Katie Cox.

SUBSURFACE SABOTAGE

Drone threats have evolved quickly, but emerging technologies are not hampered by boundaries. Next to large, crewed submarine platforms, the underwater threat today includes autonomous underwater vehicles (AUVs), which bring an entirely new challenge to subsea defence operations.[14]

Ports are acoustic nightmares: shallow waters, constant vessel noise, shifting thermal layers. These conditions throughout the history of maritime warfare have been ideal for concealment, using mini-submarines and divers to place limpet mines and improvised explosives on hulls, piers, pipelines, and cables with minimal risk of detection. However, the introduction of AUVs represents a dramatically higher threat level. The reported Ukrainian AUV attack against a Russian submarine at the Novorossiysk naval base in December 2025 highlights the sophisticated planning, training, and technology required to bypass layered defenses inside protected ports and harbours.[15]

Additionally, the recent attacks on undersea cables in the Baltic and North Sea underscore the strategic importance of this domain. While definitive attribution remains elusive, the message is unmistakable: critical underwater infrastructure is now a frontline.

COUNTERING THE THREAT

Although, as mentioned above, there is an increasing number of both traditional and emerging security threats to ports and supply chains, numerous available efforts and options are available to mitigate vulnerabilities and enhance port and supply chain security.

Maritime Domain Awareness (MDA) is a key component of an active, layered maritime defense in depth. MDA provides the necessary time and space to identify, prevent, disrupt, and overcome adversaries, regardless of whether they are in the planning stages of an operation or on their way to execute an attack or unlawful act. Without a strong understanding of activities within the maritime domain, important opportunities for prevention or early response can be missed, and a layered defense mechanism is ineffective. Procuring unmanned systems, such as USVs and UAVs, for reconnaissance and surveillance will provide real-time intelligence and early warnings, enhancing maritime security.

Maritime fusion centres (MFCs) enhance protection of Critical Underwater Infrastructure (CUI)—such as energy pipelines and data cables—by integrating data from military, private, and governmental sources to detect threats. MFCs gather, analyse and fuse data streams from radar, Automatic Identification System (AIS), satellites, and other sources, into meaningful information, and disseminate actionable intelligence to operational commanders. These centers, including the Maritime Centre for Security of Critical Undersea Infrastructure (MCSCUI) at NATO Allied Maritime Command (MARCOM) in Northwood, analyse "hybrid" dangers and enable coordinated responses against, for instance, hostile surveillance of seabed assets.

Artificial Intelligence (AI) is transforming the security of underwater infrastructure, ports, and harbours by shifting operations from reactive to proactive monitoring. AI systems, including machine learning and computer vision, analyse vast amounts of data in real-time—such as AIS tracking, sonar, and satellite imagery—to detect anomalies, suspicious vessel behaviour, and potential threats to subsea cables, pipelines, and harbour facilities.

Collaboration across the maritime community is crucial for effective maritime security. Allied navies should foster close ties with governmental, non-governmental and trustworthy commercial maritime security agencies, sharing information and best practices, including participating in multinational security initiatives and exercises. Joint training and exercises on securing ports and supply chain infrastructure between military and civilian authorities improve coordination, readiness and response strategies.

Another critical area is strengthening cybersecurity at port and supply chain infrastructure and facilities. Several future measures addressing cyber threats are on the horizon. These include technological advancements like AI and machine learning, policy actions, and strategic initiatives aimed at bolstering resilience and mitigating risks. Advancements in GPS receiver technology are being developed to improve the detection and disability of spoofed signals, along with enhanced alerting systems.[16] Developing comprehensive protocols to protect maritime and port operations from cyber threats is essential. This includes conducting regular vulnerability assessments, providing employee training on cybersecurity best practices, and establishing rapid response teams to address any breaches swiftly.

Investing in these areas should be parallel to developing resilient operational frameworks that include redundant software and sensor systems, and contingency plans that ensure continuity of operations during times of disruption or attack.

Defense against asymmetric threats, such as swarm attacks from small boats or drones, must integrate both offensive counter-tactics and defensive hardening of infrastructure. For naval bases, this means developing and fielding effective counter-swarm capabilities, including directed energy weapons, electronic jamming systems, and rapid response craft for interception (manned/unmanned). Concurrently, the physical security of port infrastructure must be significantly enhanced. This should include the deployment of layered defenses like anti-boat barriers, enhanced vessel entry checkpoints, and biometric access controls to safeguard critical infrastructure.

Numerous lessons from the Russo-Ukraine war have been learned regarding protecting harbours, ports, and supply chains. The war not only underscored the need for Allied navies to incorporate unmanned technologies into their strategies, it also showcased success in safeguarding its ports and critical infrastructure by decentralising key assets to mitigate the impact of targeted strikes. This included moving digital systems to the cloud and shifting towards distributed energy sources. The rapid development of a domestic, decentralised defense industry focused on low-cost drones and other asymmetric technologies further strengthened Ukraine's ability to protect its assets and maintain operational capability against an adversary with more resources and capabilities.[17]

Finally, clearly defining the roles and responsibilities of naval forces and maritime industry during peacetime, conflict, and war is vital. By collaborating with the private sector and governmental and non-governmental organisations, navies can avoid siloed approaches and create integrated frameworks that enhance their ability to respond effectively to maritime threats while fostering cooperation with stakeholders involved in maritime security.

CONCLUSION

Maritime supply chains and port security are increasingly threatened by a multi domain complex array of risks, stemming from state actors and non-state entities employing both kinetic and hybrid tactics. Kinetic threats, such as direct attacks on ports and shipping lanes, pose immediate and tangible dangers to safety, economic stability, and national security. In addition to kinetic threats, hybrid threats complicate the security landscape further.

Countering these multifaceted threats to port and supply chains requires a proactive, novel, and comprehensive approach that integrates advanced technologies, collaborative strategies, and innovative operational tactics.

Situational awareness through improved surveillance and reconnaissance capabilities is essential. This includes investing in technologies such as AI-driven analytics and unmanned systems that can provide real-time intelligence on potential threats. Strengthening cybersecurity for maintaining operational integrity and resilience in the digital age is also crucial.

By fostering a culture of collaboration and preparedness, Allied countries can better deter and respond to the evolving threats posed to maritime security.

The Russo-Ukrainian conflict offers valuable lessons and underscores the importance for Allied Navies to incorporate unmanned technologies into their strategies. It also showcased success of decentralised critical infrastructure.

Ultimately, sustained dominance in this dynamic era will hinge not just on capability, but on the unwavering commitment to out-pace and out-innovate in a complex global maritime security landscape.

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HUMANS AT SEA

UNDERSTANDING SLAVERY, HUMAN TRAFFICKING AND MIGRANT SMUGGLING

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Slavery has existed for thousands of years – roughly as long as humans have existed. Despite the age-old inclination to enslave and subjugate our fellow human beings, slavery and the slave trade are now considered among the great moral stains on human history.[1] Today, and particularly in the west, most of the attention to slavery concerns the transatlantic slave trade, the effects of which remain visible to this day. Between the 16th and 19th centuries, roughly 12.5 million Africans were enslaved and forcibly transported across the Atlantic to Europe and North America.[2] At present, however, it is estimated that as many as 50 million people are currently living in slavery or conditions akin to slavery.[3] And almost every adult alive today was born before Mauritania became the last country in the world to criminalize the enslavement of other human beings. Indeed, it is estimated that between 3 and 20 percent of the Mauritanian population still living in slavery today.[4] This means that there are more people being transported against their will than ever before, and, given the general opacity the maritime domain affords, much of that is happening by sea.

In the maritime domain, there are three primary concerns around humans moving or being transported illegally: 1) Slavery and the Slave Trade; 2) Human Trafficking; and 3) Migrant Smuggling.[5] Unfortunately, the three are often conflated. That is problematic on land, but extremely problematic at sea on account of the differences in enforcement jurisdiction over each offense. Under article 110 of the United Nations Convention on the Law of the Sea (UNCLOS), any vessel can be boarded anywhere for suspicion of being involved in the slave trade.[6] But the ability to stop the other two offenses are much more limited under the UNCLOS regime, only allowing for action against vessels either in the 0-12 nautical mile territorial sea or under immigration enforcement in the 12-24 nautical mile contiguous zone for states that have declared one.[7] The Migrant Smuggling Protocol to the UN Convention against Transnational Organized Crime (UNTOC) provides a permissive regime for enforcement against migrant smuggling beyond national waters. However, this requires the authorization of the flag State for boarding and conducting a search.[8] Theoretically, the same permissive opportunities exist for other offenses, as well, but as explained below, the Migrant Smuggling Protocol at least formalizes it. Ultimately, the challenge for navies and law enforcement in executing Maritime Security Operations is twofold: first, to differentiate between these three distinct maritime crimes, and second, to operate clearly within the specific jurisdictional boundaries that apply to each.


The Italian Frigate Carlo Bergamini conducting an inspection in the Red Sea. Courtesy of Operation Atalanta.

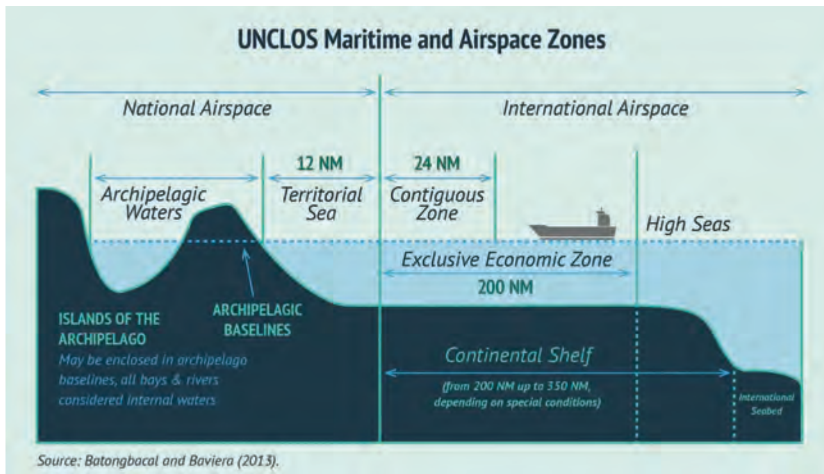
ENFORCEMENT JURISDICTION

According to UNCLOS, which is the primary law governing the oceans and seas, there are strict limitations to the ability of coastal states to enforce the law outside of their immediate jurisdiction. Under article 110, the "right of visit" – in other words, the right of the crew of a warship to get onboard a merchant vessel – is limited to a few circumstances.[9] The easiest is if the warship and the vessel are of the same flag state. Every vessel is required to fly a flag and the flag determines the legal jurisdiction onboard the vessel.[10] It is also possible to board a vessel that is without nationality or that is believed to be stateless in order to confirm its registration. But the majority of at-sea interdiction outside national waters (the territorial sea and, where relevant and applicable, the contiguous zone) either require flag state consent or are not permitted.

There are three offenses that allow for the right of visit – piracy, the slave trade and, somewhat surprisingly to most, unauthorized broadcasting. Piracy is the quintessential maritime crime and pirates have long been considered hostis humani generis (enemies of all mankind).[11] The slave trade, as noted, is universally condemned as one of the most heinous offenses a human can commit against another person. So unauthorized broadcasting seems a bit of an anomaly, but fundamentally, it is about using the maritime domain to violate the sovereignty of the coastal state by broadcasting to their population against the will of the government.[12] Oddities aside, those are the only three offenses for which the right of visit is authorized.

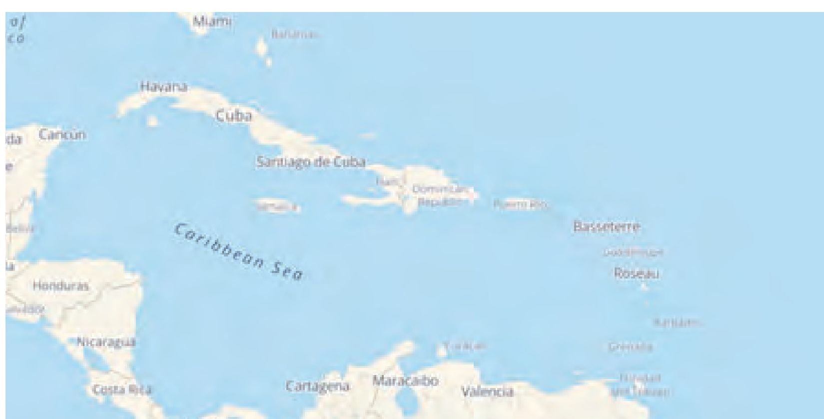
UNCLOS did not create a similar universal right of boarding for drugs, but it did, in article 108, indicate that states would need to work together to counter the flow of narcotics and psychotropic substances.[13] The result was the 1988 United Nations Convention against Illicit Traffic in Narcotic Drugs and Psychotropic Substances, better known as the Vienna Drug Convention, which established a process for drug interdiction outside of national waters.[14] Article 17 is a very specific process by which the interdicting state's competent national authority has to contact the competent national authority of the flag state of the suspect vessel and request permission to board, search, seize and take jurisdiction.[15] That can occur all at once or in sequence, but the interdiction must follow that process to be legal. The reality, though, is that that process may take days, weeks or months, with the two vessels stuck out at sea. So, drug interdiction on the high seas is possible, but not always easy.

Fisheries violations, and violations pertaining to extraction in the exclusive economic zone can be established and enforced out to 200 nautical miles.[16] Everything else – which includes human trafficking, migrant smuggling, arms trafficking and movement of contraband – is limited to either the territorial sea or, for vessel inbound or outbound, the contiguous zone for states that have one. If the flag state consents, these offenses can be dealt with elsewhere, and the Migrant Smuggling Protocol essentially mandates that consent, but as a practical matter, it is almost impossible to interdict these offenses outside national waters. In other words, there is a lot more maritime space in which it is lawful to stop illegal fishing than it is to stop human trafficking.



Graphic of the maritime zones.

Visualizing this problem is helpful for understanding why every maritime operator needs to know the difference between the three offenses and where they can each be addressed. All three maps below are of the Caribbean – a region with numerous states in close proximity, affording a good visualization of the challenge. In the first map, a vessel can be boarded for piracy in the entirety of the blue areas – in other words, in all the waters.



Windward AI map of the Caribbean.

In this second map, the EEZ lines are roughed in. Illegal, unreported and unregulated fishing as well as other extractive violations of living or non-living marine resources can be addressed anywhere inside those lines.

Windward AI map showing the EEZs.

By contrast, this third map shows where human trafficking can lawfully be interdicted – inside the territorial seas of the states.

Windward AI map showing the territorial seas.

These visualizations help indicate why clarity is needed from an operational and legal standpoint, but it remains to explain what the difference is between the three offenses.

DISTINGUISHING THE ISSUES

In migrant smuggling, an individual chooses to put him or herself in the hands of a smuggler, paying that person to help bring them illegally across an international border.[17] The person being smuggled and the smuggler are both criminals. Consequently, the only victim – at least at the outset – is the state.

Whereas migrant smuggling is voluntary on the part of both the smuggled persons and the smuggler, in human trafficking, the person being trafficked is always a victim and cannot volunteer to be trafficked.[18] A deeper dive below will review the elements, but it is important to recognize that migrant smuggling – which starts voluntarily – may turn into human trafficking on account of the smuggler abusing the inherent vulnerability that comes with being smuggled. Unlike migrant smuggling, however, no transportation element is required. Smuggling must be occurring across an international border, whereas trafficking can occur in someone's home.

In slavery, there is no voluntariness on the part of the enslaved, there is no transportation requirement, and the enslaved is always a victim.[19] Legally, it is not possible to volunteer for enslavement.

These differences, however, are at a high level of generality, so it is important to delve into the specifics of these offenses in order to be able to distinguish them more clearly.

MIGRANT SMUGGLING

The internationally recognized definition of migrant smuggling now comes from the Protocol Against the Smuggling of Migrants by Land, Sea and Air, supplementing the 2000 United Nations Convention against Transnational Organized Crime (UNTOC), also known as the Palermo Convention.[20] Under article 3 of the Protocol, "'Smuggling of migrants' shall mean the procurement, in order to obtain, directly or indirectly, a financial or other material benefit, of the illegal entry of a person into a State Party of which the person is not a national or a permanent resident." And for clarification, under that same provision, "'Illegal entry' shall mean crossing borders without complying with the necessary requirements for legal entry into the receiving State."[21] These definitions are consistent with the general discussion above.

While the protocol imposes an obligation on States Party to criminalize this behavior in article 6, there is also an obligation – much like that established by UNCLOS regarding drugs trafficking – to cooperate on the maritime aspects of this offense. Specifically, article 7 says "States Parties shall cooperate to the fullest extent possible to prevent and suppress the smuggling of migrants by sea, in accordance with the international law of the sea."[22] The maritime-specific provisions of the Protocol are most instructive on what that actually means.

Article 8 specifically addresses "Measures against the smuggling of migrants by sea." The first provision provides that when the suspect vessel is flying the flag of a State Party, when it is without nationality, or when it is falsely flying a flag but is actually registered in that State, the State may request assistance from other States Parties to interdict the vessel. None of those situations are unique to smuggling of migrants – boarding can occur under those circumstances for any offense. The second provision is similar in that the interdicting state contacts the flag state of the suspect vessel to share its suspicion, and requests authorization to board, search and take measures to address the situation. If any measures are taken, the third provision requires prompt notification to the flag state.[23] Again, however, this is not unique to migrant smuggling – this sort of cooperative law enforcement dynamic is applicable for any offense over which the flag state would have jurisdiction.

Paragraph 4 obligates States Parties to respond quickly to requests for confirmation of registration. Paragraph 5 allows flag states to set the conditions for interdiction of migrant smuggling on one of its vessels. Paragraph 6 requires that States Party designate national authorities for interaction on the matters of smuggling of migrants at sea. Finally, paragraph 7 allows for States to take measures against vessels without nationality in a manner consistent with the domestic law of the interdicting state.

In many respects, nothing in this Protocol – other than the designation of a specific authority – is new. In other words, this is how law enforcement outside the territorial sea of a state works at any time. The problem is the practical reality that most flag states are not prepared to address these matters and often fail to respond or give permission in a timely fashion – even though technically obligated to do so. And many interdicting states lack long-arm enforcement jurisdiction under their domestic law to take jurisdiction over either a foreign vessel or a vessel without nationality that is suspected of migrant smuggling outside of national waters. This means that many states struggle to find a legal basis for addressing migrant smuggling at sea outside of the territorial sea and, where relevant, contiguous zone.

HUMAN TRAFFICKING

The main international definition of human trafficking also comes from a Protocol to the Palermo convention – the Protocol to Prevent, Suppress and Punish Trafficking in Persons Especially Women and Children.[24] While the language of the Protocol will feature more extensively in the next section, a helpful set of UN graphics have visualized the elements of human trafficking. For an offense to be human trafficking under this Protocol, there must be an Act – recruiting, transporting, transferring, harboring or receiving of a person or people – using one or more Means.[25] Those Means include the threat or use of force, coercion, fraud, deception, abuse of a position of vulnerability, giving of payments or benefits, or abduction. In every case, the purpose must be exploitation.[26]

Before turning to the topic of exploitation, however, it is worth noting that when a person has voluntarily placed themselves in the hands of a smuggler to be taken across an international border, they have put themselves in an extremely vulnerable position. While both the migrants and the smugglers may be perpetrators at the outset, that position of vulnerability may be abused, leaving the smuggled migrant with little recourse. This is how migrant smuggling becomes human trafficking.[27]

Exploitation, however, requires further discussion. There are multiple forms,[28] while the most common are depicted below:

UN graphic depicting types of exploitation under human trafficking.

Nothing in the Protocol, however, addresses human trafficking at sea. Thus, there is even less maritime legal infrastructure for dealing with human trafficking than there is for migrant smuggling. Indeed, as a practical matter, it is extremely difficult to deal with a human trafficking case outside of the territorial sea or, where applicable, the contiguous zone.

SLAVERY

Given that slavery is one of the jus cogens preemptory international norms – in other words, everyone agrees it is a crime – and given that the slave trade is one of the three international crimes under UNCLOS for which a universal right of visit applies, it seems it would be easier to identify and address the maritime aspects of slavery than either migrant smuggling or human trafficking. Indeed, UNCLOS article 99, which is titled "prohibition of the transport of slaves," specifically states, "Every State shall take effective measures to prevent and punish the transport of slaves in ships authorized to fly its flag and to prevent the unlawful use of its flag for that purpose.[29] Any slave taking refuge on board any ship, whatever its flag, shall ipso facto be free." Despite that strong statement, however, the practical reality is much more difficult.

The international legal definition of slavery comes from the 1926 Convention to Suppress the Slave Trade and Slavery. Article 1 of the Convention has two paragraphs providing key definitions:

> *(1) Slavery is the status or condition of a person over whom any or all of the powers attaching to the right of ownership are exercised.*
>
> *(2) The slave trade includes all acts involved in the capture, acquisition or disposal of a person with intent to reduce him to slavery; all acts involved in the acquisition of a slave with a view to selling or exchanging him; all acts of disposal by sale or exchange of a slave acquired with a view to being sold or exchanged, and, in general, every act of trade or transport in slaves.*[30]

So it seems that the right of ownership is the key feature of slavery – an element distinct from migrant smuggling and human trafficking. But from a practical, current context, what that looks like is difficult to determine.

Looking to other legal instruments in the last century, the 1976 International Covenant on Civil and Political Rights provides some guidance. While it does not define slavery, it does distinguish servitude and forced or compulsory labor as separate matters.[31] Article 8 states:

> *1. No one shall be held in slavery; slavery and the slave-trade in all their forms shall be prohibited.*
>
> *2. No one shall be held in servitude.*
>
> *3. (a) No one shall be required to perform forced or compulsory labour;*

No further clarification on what to look for, especially on a vessel at sea, is provided.

While the Trafficking in Persons Protocol to the Palermo Convention of 2000 was discussed above, it is now helpful to return to the specific language. Article 3 of the Protocol defines trafficking in persons as "the recruitment, transportation, transfer, harbouring or receipt of persons, by means of the threat or use of force or other forms of coercion, of abduction, of fraud, of deception, of the abuse of power or of a position of vulnerability or of the giving or receiving of payments or benefits to achieve the consent of a person having control over another person, for the purpose of exploitation.[32] Exploitation shall include, at a minimum, the exploitation of the prostitution of others or other forms of sexual exploitation, forced labour or services, slavery or practices similar to slavery, servitude or the removal of organs." This is hugely problematic from the maritime front. Slavery – a crime with universal right of visit – has become a subordinate element of human trafficking – a crime with extremely limited maritime enforcement jurisdiction.

No instrument since 2000 has helped to clarify this confusion. Even today, the "About" section of the webpage for the UN High Commissioner for Human Rights reads as follows:

> *Slavery, including in its contemporary forms, and trafficking in persons are crimes prohibited under international human rights law. Yet millions of people around the world remain forced into servitude and other contemporary forms of slavery. Millions are also trafficked worldwide for the purpose of exploitation, including sexual and labour exploitation, organ removal, forced marriage or forced criminality. This exploitation persists, even as we approach 100 years since the adoption of the Slavery Convention of 1926, and over 20 years since the Palermo Protocol.*
>
> *Victims of slavery and trafficking often have been subjected to many serious human rights violations. While they have a right to an effective remedy, they are often not able to access justice given limited awareness and multiple structural limitations, including within authorities responsible for supporting or pursuing such claims.*[33]

Ironically, the statement itself betrays some of those reasons why justice is not available. The confusion between not only migrant smuggling, human trafficking and slavery, but related issues like servitude and forced labor are problematic enough on land. But at sea, the blurring of these offenses – even with good intentions – has led to a serious limitation as to what can actually be done. Those good intentions – trying to elevate human trafficking to the same level of seriousness as slavery – has, in the maritime domain had the opposite effect. It has made it so that state practice is to consider everything migrant smuggling, where everyone is a perpetrator, or possibly human trafficking, where enforcement jurisdiction is limited in most cases to national waters.[34]

Irish Naval Service personnel helping migrants at sea in the southern Mediterranean between Italy and Libya. Courtesy of the Irish Navy.

But even if a clear-cut case of slavery was found on the high seas, most states lack domestic legislation to do something about it. UNCLOS provides a mechanism for getting on board, but national law is what would allow a state to take jurisdiction over the matter, bring it back to their home country and prosecute it. Realistically, most states do not have the ability to do that. So, while slavery is a major talking point in the world of human rights, making that human right a reality at sea is incredibly difficult.

CONCLUSION

There are significant and problematic gaps and areas of twilight within international law on slavery, human trafficking, and migrant smuggling, and the practical ability to enforce these prohibitions in the maritime domain, especially on the high seas.

The central issue stems from the differing legal frameworks governing these three distinct offenses. While the slave trade is one of the few crimes granting universal right of visit under UNCLOS, both human trafficking and migrant smuggling have much weaker enforcement regimes, typically limited to a state's national waters or requiring flag state consent on the high seas.

Furthermore, even when there is a legal basis for boarding a vessel on suspicion of illicit activity, most nations lack the domestic legislation required to prosecute the crime, especially when it occurs on the high seas. Ultimately, the confusion between these offenses, coupled with jurisdictional limitations and inadequate domestic laws, has created a maritime environment where it is paradoxically easier to enforce laws against illegal fishing than against human trafficking or slavery.

As navies and law enforcement agencies engage in various Maritime Security Operations, it is paramount to recognize the collective benefit of ensuring that everyone, from the political-strategic to the tactical level possess the necessary understanding to effectively identify and counter the illicit movement of humans at sea.

The German corvette Ludwigshafen am Rhein in the Mediterranean Sea late 2016, participating in the European Union's Operation Sophia, focused on disrupting human smuggling networks. Courtesy of EU.

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NATO'S HIDDEN ADVANTAGE

UNLOCKING THE AMPHIBIOUS FLEET

By CAPT (N) Eric Winn (USN)

The empty well deck on the San Antonio-class amphibious transport dock USS Portland. Courtesy of USMC, photo by Staff Sgt. Donald Holbert.

THE UNDERUTILIZED ASSET IN PLAIN SIGHT

The strategic challenges facing the North Atlantic Treaty Organization (NATO) at sea are well-documented and severe. The 2022 Strategic Concept identifies the fundamental shift in the security environment, emphasizing the systemic challenges posed by strategic competitors and the pervasive threat of advanced anti-access/area denial (A2/AD) capabilities. These threats seek to sever the transatlantic link, contest NATO's freedom of manoeuvre, and undermine the Alliance's capacity for collective defence and crisis response.[1] While the Alliance rightly invests in the next generation of warships, a decisive, immediate, and cost-effective advantage lies dormant within our existing fleets.

For the commander of an amphibious flagship, the greatest fear is the threat you cannot see. As one NATO amphibious commodore put it, "We are effectively deaf to the modern submarine," a stark admission that highlights the reliance on escort ships as these behemoths barrel through the choppy waters of the North Atlantic. A NATO amphibious task force represents a billion-dollar concentration of national will. To an adversary, it also represents high-value targets. This core dilemma, strength that invites vulnerability, threatens the very foundation of Alliance crisis response. Yet the key to mitigating this risk is not a new missile or a new ship, but an expansive, overlooked space hidden in plain sight. The cavernous, protected well decks of NATO's diverse and powerful amphibious ships, from Spain's Juan Carlos I and France's Mistral-class to Italy's Trieste, the Dutch Rotterdam-class, and the American San Antonio-class, are the key to deploying unmanned systems at the scale and speed required by the modern battlespace. By reimagining this common space, we can transform our amphibious forces from vulnerable transports into a distributed and resilient maritime network. This requires a fundamental shift in perspective: the amphibious ship should no longer be defined solely by what it delivers ashore, but by the expanded capabilities it enables at sea. It is an argument for addition, not replacement; for enhancing the platform's core purpose with a new, vital mission.

THE AMPHIBIOUS DILEMMA

The amphibious ship is the cornerstone of Alliance crisis response. It is the platform that delivers our soldiers and marines, our humanitarian aid, and our political resolve to the point of need. This very criticality, however, makes it a high-value target for any adversary. An amphibious task force, by its nature, represents a concentration of force and national will, making it a primary focus for enemy targeting. The core problem is that these highly versatile warships were largely conceived in an era of assumed sea control, a luxury the Alliance can no longer take for granted. This has resulted in a shared vulnerability across the fleet, a legacy design philosophy that, if not urgently addressed, could lead to catastrophic defeat in a peer conflict.

This vulnerability is most acute in the undersea domain. NATO's adversaries' proliferation of quiet, air-independent propulsion (AIP) submarines and long-range, sea-skimming cruise missiles has created a lethal threat environment.[2] According to open-source naval analysis from the International Institute for Strategic Studies (IISS), the active submarine fleet in the Euro-Atlantic area now includes over 60 modern, conventionally-powered submarines capable of operating effectively in the crowded littorals of the Baltic Sea and the Mediterranean.[3] This marks a fundamental increase in capable platforms that can hunt in the very environments where our amphibious forces must operate. The current NATO model for anti-submarine warfare (ASW), which relies on a limited number of specialized frigates and maritime patrol aircraft to protect a large task force, is being stretched to its breaking point by this threat density. Our amphibious flagships, lacking organic, powerful hull-mounted sonars, are effectively deaf to this primary threat.

Furthermore, recent adversary naval exercises have demonstrated the deployment of land- and sea-based anti-ship cruise missiles with stated ranges exceeding 1,500 km (~810 NM).[4] Analysis by the Center for Strategic and International Studies (CSIS) shows this creates an A2/AD "bubble" that can cover the entirety of the Baltic Sea from the Kaliningrad Oblast or hold the critical Greenland-Iceland-UK (GIUK) gap at risk from the Kola Peninsula. An amphibious task force's primary self-defence systems, such as the Evolved Sea Sparrow Missile (ESSM) or Rolling Airframe Missile (RAM), have effective engagement ranges well under 50 km (27 NM).[5] This creates a staggering "Risk Window" of over 1,450 km (~780 NM) where an Alliance force can be detected, tracked, and targeted long before its own organic defensive systems can engage the incoming threat.

Operating our powerful shipboard radars to gain situational awareness only exacerbates this problem, as their emissions can be passively detected at even greater ranges, turning our ships into beacons for enemy targeting.

The Russian exclave of Kaliningrad hosts significant A2/AD capabilities. Courtesy of the Atlantic Council.

This leaves the amphibious commander in an untenable position: forced to operate within range of devastating weaponry, with limited organic ability to sense the undersea threat, and punished for using their own sensors to see the surface and air threat. The well deck, a space critical for the final phase of an amphibious assault, often represents underutilized volume during the long and vulnerable transit phases of a mission. This "available space" is our greatest opportunity to change the equation.

THE WELL DECK ADVANTAGE

Imagine a three-ship NATO Amphibious Ready Group (ARG) transiting the North Atlantic. To an adversary's satellite, it appears as a standard amphibious force. But the reality is different. The flagship, an American San Antonio-class LPD, has its well deck loaded with its traditional complement of landing craft, ready to put Marines ashore. The second ship, a French Mistral-class, carries a similar traditional loadout. But the third, a Spanish Juan Carlos I, is configured for sea control. Its well deck is a hub of activity for a squadron of large unmanned undersea vehicles (UUVs) and armed unmanned surface vehicles (USVs). While the other ships focus on the amphibious mission, this vessel provides a persistent, 24/7 anti-submarine screen for the entire group, actively hunting for threats and extending the ARG's defensive perimeter by hundreds of miles. This is not a choice between missions; it is the simultaneous execution of both; the very essence of a flexible and resilient modern fleet. The solution to this shared dilemma is to re-purpose the well deck, transforming it from a simple boat bay into a dynamic launch and recovery station for a new generation of unmanned maritime systems. Before detailing how this transformation would occur, it's crucial to understand why this approach is a game-changer for the Alliance. The strategic advantage of this concept lies in leveraging an existing, underutilized, and widespread asset. Instead of investing billions and waiting decades to develop and construct new classes of unmanned "motherships," this solution utilizes the dozens of amphibious platforms already in service across NATO fleets. This is not merely an upgrade; it is a fundamental paradigm shift. It converts a logistical asset, traditionally seen as a high-value target requiring heavy protection, into a distributed sensor and effector platform. This approach multiplies the Alliance's sea control and sea denial capabilities at a fraction of the cost of new shipbuilding and on a vastly accelerated timeline. It is the most pragmatic, cost-effective, and immediate solution to the modern anti-access/area denial (A2/AD) challenge.

The unique characteristics of the well deck make it the ideal platform for scaling this capability across the Alliance in a way that no other ship type can match, providing a powerful, asymmetrical counter to the A2/AD threat. This approach offers three distinct and measurable advantages: scale and payload, all-weather operational reliability, and the leveraging of existing Alliance assets.

NATO amphibious ships share a common structural feature, the well deck, across multiple national classes. This commonality allows for Alliance-wide interoperability and standardization without building new vessels.

First, the advantage of scale and payload is undeniable. As Table 1 illustrates, the well deck provides a decisive advantage over a standard NATO frigate, which is typically restricted to launching and recovering small, 5-to-7-meter Rigid Hull Inflatable Boats (RHIBs) with limited range, endurance, and payload capacity. By contrast, the well deck is designed to handle large landing craft and can easily accommodate Unmanned Surface Vehicles (USVs) and Unmanned Undersea Vehicles (UUVs) greater than 15 meters in length. This size increase is not incremental; it is a step-change in capability. Larger unmanned systems, like the Extra-Large Unmanned Undersea Vehicles (XLUUV) platforms, can carry significantly larger fuel loads for extended endurance, more sophisticated sensor suites for better detection, and, crucially, offensive munitions.[6] This allows an amphibious ship to deploy and command and control a family of systems that a frigate or destroyer cannot.

Feature	Standard NATO Frigate	NATO Amphibious Ship	Advance Multiplier
Max Unmanned System Size	< 7 meters	> 15 meters	2x
Max Payload per System	~500 kg	~2.500 kg	5x
System Carried	2	8	4x
24 hr Sortie Rate (Sea State 4)	4 (2 per system)	16 (2 per System)	4x

Table 1 - Illustrative Comparison of Unmanned Launch Capacity

As the analysis shows, the well deck provides a four-fold increase in the ability to generate unmanned sorties in challenging sea states. More importantly, the five-fold increase in payload capacity means these are not just reconnaissance drones; they are platforms capable of carrying mission-defining payloads, from advanced ASW arrays to vertical launch cells, expanding the amphibious ship's contribution to the maritime fight.

Second, the advantage of all-weather operations and maintenance provides a critical degree of operational reliability. Launching and recovering even a small boat from a davit in the high sea states common to the North Atlantic is a dangerous and often impossible evolution. A well deck, by its nature, is a sheltered, controlled environment. By ballasting down and creating a calm basin, the ship can more safely launch and recover large unmanned systems in weather conditions that would leave the conventional surface fleet side-lined. This also enables at-sea maintenance, refuelling, and software updates, dramatically increasing the operational availability of the systems. A standard helicopter detachment provides, at best, 8 hours of airborne ASW coverage in a 24-hour period (a 33% coverage rate), subject to weather and maintenance downtime. A well-deck-deployed squadron of six Large Displacement UUVs (LDUUVs), operating on a "three on-station, three in maintenance" cycle, provides 24 hours of persistent undersea surveillance (a 100% coverage rate), unaffected by surface weather. This represents a 300% increase in operational availability for the critical undersea sensing mission, closing a dangerous gap for the task force commander.

Third, this strategy leverages a common, existing asset, providing a rapid and cost-effective path to modernization. The Alliance has already made a multi-billion Euro investment in its amphibious fleets. This proposal does not require a new class of ship; it maximizes the utility of the capital assets we already possess.

The average procurement cost of a new NATO anti-submarine frigate is over €1 billion.[7] The estimated cost to procure an XLUUV, armed USVs, and supporting UAVs is approximately €200-280 million per ship.[8] By leveraging our existing amphibious hulls, the Alliance can achieve a comparable increase in sea-denial and sea-control capability for less than 25% of the cost of new ship construction. This delivers a vastly superior return on investment and provides a pathway to achieving meaningful capability at the speed and scale the current security environment demands.

Crucially, this proposal is an argument for addition, not replacement. It does not advocate for the permanent conversion of amphibious ships into single-mission unmanned tenders. Rather, it is to unlock the latent potential of these platforms, creating a 'swing' capability. The modular nature of the proposed mission packages would allow a commander to configure a vessel for sea control and anti-submarine warfare on one deployment, and for traditional amphibious assault on the next, or even, with the right support, re-role during a single extended deployment. This transforms a specialized asset into a flexible, multi-role power projection platform, maximizing the Alliance's return on its significant investment in these capital ships. The core role of the amphibious ship in projecting power ashore with embarked marine forces remains paramount.

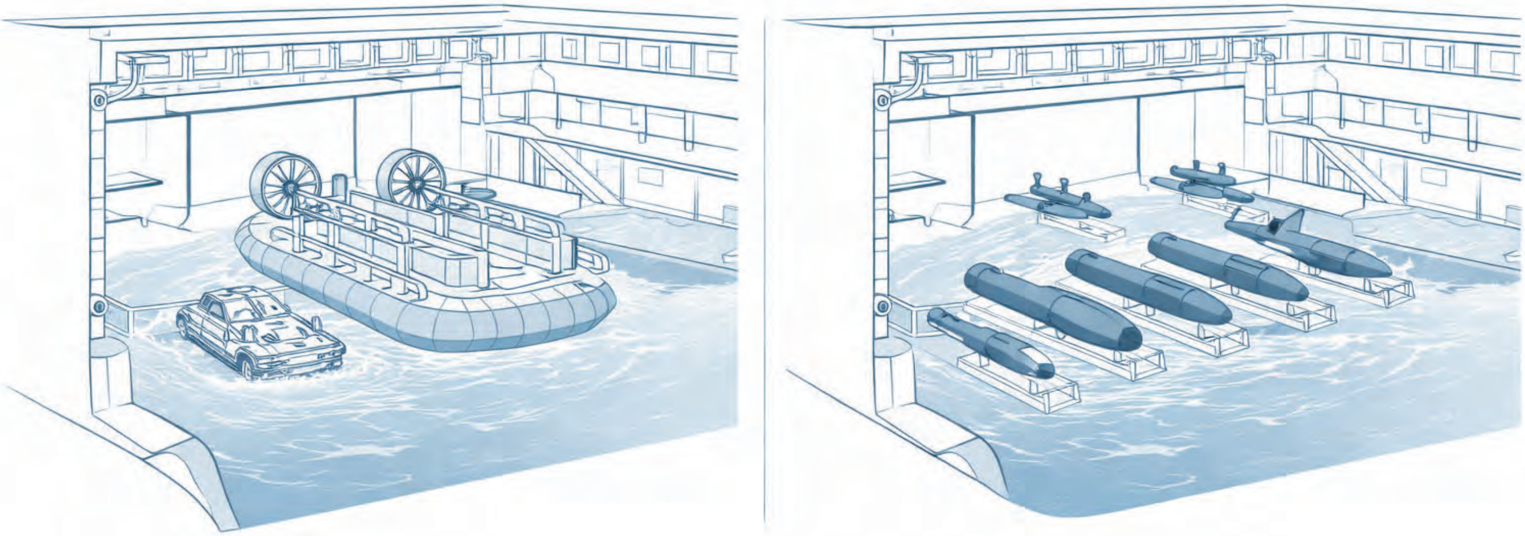
However, not all deployments require an imminent amphibious assault. During missions focused on sea control or denial, deterrence, or maritime security, a well deck configured with a suite of unmanned systems provides a powerful capability that currently does not exist. This concept provides the operational commander with a "swing" asset. For an amphibious assault, the ship would deploy with its traditional complement of ship-to-shore connectors and amphibious vehicles. For a sea control or denial mission, it could deploy with an unmanned systems package. This enhances the platform's overall utility and provides a much needed capability without detracting from its primary mission, ultimately giving commanders more options to address a wider range of contingencies.

IMPLICATIONS FOR ALLIANCE THINKING

If NATO were to view the amphibious well deck not simply as a logistics space but as a latent distributed capability node, several implications emerge for how the Alliance approaches maritime power in contested environments.

First, interoperability would shift from platform commonality to interface commonality. Rather than pursuing new classes of purpose-built unmanned "motherships," the Alliance could instead explore whether a shared set of launch, recovery, power, and data interfaces might allow existing amphibious ships to host multinational unmanned systems. In this framing, the well deck becomes less a national space and more a modular capability environment; one where different nations contribute payloads, systems, or software rather than hulls.

Second, innovation pathways could prioritize integration over invention. NATO has already invested heavily in amphibious platforms across multiple fleets. The question is not whether the Alliance needs new ships to



Conceptual reconfiguration of an amphibious ship's well deck from a traditional transport role to an unmanned systems mothership, supporting different operational functions through changes in integration, not hull design.

support distributed maritime operations, but whether it is fully exploiting the flexibility of those it already possesses. Initiatives such as DIANA and ongoing multinational experimentation efforts suggest a model in which emerging unmanned technologies are evaluated not as standalone programs, but as adaptable mission packages capable of operating from shared physical spaces.[9]

Third, operational experimentation could begin to explore amphibious forces not only as enablers of power projection ashore, but as contributors to both distributed sea control[10] and sea denial. By contributing to sea control, these platforms would ensure friendly forces can operate freely, but they can equally contribute to sea denial by holding an adversary's naval forces at risk and preventing them from using the sea for their own purposes. Major NATO exercises already test multi-domain integration across national lines. Expanding this experimentation to include well-deck-launched unmanned systems would not represent a doctrinal shift so much as an evolution in how amphibious platforms contribute to the broader maritime fight. This work could be spearheaded by NATO's own internal innovation hubs, such as the Centre for Maritime Research and Experimentation (CMRE), leading a multi-national working group to develop the initial TTPs for these integrated operations.[11]

None of these implications require the replacement of traditional amphibious roles. Rather, they suggest a complementary perspective: that during missions focused on deterrence, sea control, or maritime security, the well deck may represent an underappreciated means of expanding sensing, persistence, and reach. In this light, the amphibious ship is no longer defined solely by what it delivers ashore, but also by what it enables at sea.

UNLEASH THE FLEET WE ALREADY HAVE

The security of the Alliance in the 21st century will be defined by our ability to adapt faster and more innovatively than our adversaries. This imperative is at the heart of the new Alliance Maritime Strategy, which explicitly calls on NATO to identify and adopt emerging and disruptive technologies...to maintain a decisive advantage.[12] The threats to our maritime freedom are real, present, and growing. We do not have the luxury of time, nor the limitless budgets required to build a new fleet from scratch. We must find adaptive advantages and leverage the powerful assets we already possess.

The amphibious well deck is that advantage. It is a common capability across our most powerful crisis response platforms. By defining a common standard for its use, we unleash the latent potential of the entire amphibious fleet. We turn a vulnerability into a strength, a transport into a more effective warfighter, one capable of executing its traditional mission and dominating the maritime fight simultaneously. This transforms a collection of national ships into a truly integrated and flexible Alliance force. Let us transform our largest open space into our greatest strategic advantage and, together, build an interchangeable, resilient, and lethal amphibious force. NATO's leaders face a clear choice: continue to operate these critical ships as high-value targets or finally unleash their full potential. The well deck is our common advantage. Our adversaries are counting on us to squander it. Time is not our ally. The data, the strategy, and the shared threat all demand action. Let us unleash the fleet we already have.

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MARITIME ALLIED INTEROPERABILITY & INTEGRATION

FROM NATO STANDING FORCES TO MULTI-CARRIER OPERATIONS

By

CAPT (ITA-N) Marco Bagni

ITS CAVOUR CSG and INS VIKRAMADITYA in the Arabian Sea, October, 2024. Courtesy of the Italian Navy

THE INTEROPERABILITY IMPERATIVE

In today's volatile and complex global security environment, a landscape defined by the resurgence of great power competition and the persistent threat of regional crises, the imperative for true military interoperability has returned to the forefront of strategic thought. For the North Atlantic Treaty Organization (NATO), this is not a new concept but rather a foundational principle that has underpinned its collective defense posture for over seventy years. However, the nature of that interoperability is undergoing a profound evolution. The relative calm of the post-Cold War era, which allowed a focus on out-of-area crisis management and maritime security operations, has given way to a renewed urgency to prepare for high-end, peer-level conflict. In this context, achieving seamless integration among Allied maritime forces is not merely a force multiplier; it is the fundamental enabler of credible deterrence and effective defense across the Euro-Atlantic and beyond.

This journey towards deeper integration is multifaceted. At its most basic level, interoperability is technical, built upon the thousands of Standardization Agreements (STANAGs) that ensure a French missile can be guided by a Spanish radar or a German ship can refuel an Italian helicopter. Yet this is only the starting point. True effectiveness is born from procedural interoperability and shared tactics, techniques, and procedures (TTPs) that allow multinational commanders to orchestrate complex operations with confidence and speed. Interoperability is the "software" that runs on the "hardware" of allied navies. The final, and perhaps most critical, layer is the human dimension: the shared trust, understanding, and professional culture forged through decades of operating, exercising, and training together. It is this human connection that transforms a collection of national assets into a cohesive, fighting force greater than the sum of its parts.

This article analyzes the conceptual and practical evolution of NATO's maritime interoperability through four distinct but interconnected stages. It traces a clear and deliberate path of increasing complexity and integration, beginning with the foundational role of the Alliance's Standing Naval Forces, which have adapted their missions to the modern strategic landscape. It then examines the crucial "Cooperative Deployment" model, which has systematically integrated Allied warships into the heart of U.S. Navy Carrier Strike Group (CSG) operations, fostering a deep and practical level of interchangeability. Building on this, the article explores the coordinated rise of European carrier strike capabilities, particularly within the framework of the European Carrier Group Interoperability Initiative (ECGII), which is synchronizing the power projection of Europe's premier navies. Finally, it assesses the apex of this evolution: the multi-carrier operation, where allied strike groups converge to create an overwhelming concentration of maritime power, demonstrating a level of command, control, and combat capability that is the ultimate expression of Alliance cohesion. This analysis culminates in a series of concrete proposals aimed at consolidating these gains and ensuring NATO maintains its maritime edge for decades to come.

Adapting Standing Naval Forces

The Standing Naval Forces (SNFs) represent the historical bedrock of NATO's maritime interoperability and the most visible, persistent symbol of its collective defense commitment at sea.[1] Their origin dates to 1968 with the establishment of the Standing Naval Force Atlantic (STANAVFORLANT), a multinational squadron created during the height of the Cold War to provide the Alliance with a rapid maritime reaction capability. This revolutionary concept—a permanent, integrated fleet drawn from different nations—was designed to demonstrate political solidarity and ensure that any aggression against the Alliance at sea would be met by a multinational response from day one.

Recent deployments in the Mediterranean underscore an adapted focus on high-end readiness and regional security. When under the command of Italian Rear Admiral Francesco Iavazzo, Standing NATO Maritime Group 2 (SNMG2) provided a clear signal of allied resolve. As RAdm Iavazzo stated, the group's constant activity "demonstrates NATO's capability to operate as one integrated multinational force" and sends "a clear signal of Allied cohesion, determination and readiness."[2] Similarly, the vital mission of keeping sea lanes open was underscored by Standing NATO Mine Countermeasures Group 2 (SNMCMG2), commanded by Italian Navy Captain Fortunato Genovese. He captured the spirit of the mission in his departing remarks, stating, “Over these six months, we have shown what Allied navies can accomplish when we operate as one team… Our success is the result of shared values, professionalism, determination and unwavering commitment.”[3]

This trend toward regional specialization is also evident in the Alliance’s response to the unique challenges of the Black Sea. With access for non-littoral NATO warships restricted by the Montreux Convention, the threat of drifting mines prompted a regional solution. In 2024, Türkiye, Bulgaria, and Romania established the Mine Countermeasures Task Group Black Sea (MCM Black Sea).[4] [5] While technically a trilateral initiative rather than a formal SNF—a structure designed to navigate geopolitical sensitivities—it operates in close alignment with Alliance objectives, ensuring vigilance and strengthening the Alliance’s Eastern flank.[6] The situation highlights the ability of the Alliance to adapt the SNF concept to new threats and avoid wasting resources across additional groups.[7] [8]

The U.S. Navy Cooperative Deployment

A crucial step in the evolutionary ladder has been the systematic, deep integration of allied warships into the most powerful expression of maritime power: the U.S. CSG. This is achieved through the “Cooperative Deployment” model, a framework where NATO and partner navies become fully embedded components of a U.S. CSG during its critical pre-deployment training and certification phase,[9] especially the Task Force Exercises (TFEX), and the Composite Training Unit Exercises (COMPTUEX or C2X). A TFEX is designed to test the strike group’s ability to operate within a larger Task Force structure, often including international partners and/or multiple strike groups, while a COMPTUEX focuses on training and certifying the carrier strike group, internally, as a fully integrated, cohesive fighting force.

Year	Exercise	CSG	NATO/Partnerships
2020	C2X	CSG Dwight D. Eisenhower	HDMS IVER HUITFELDT (F 361) HMCS VILLE DE QUEBEC (F 332) FS NORMANDIE (D 651)
	TFEX 20-2		NRU ASTERIX
2021	C2X	CSG Harry S. Truman	HNoMS FRIDTJOF NANSEN (F 310)
2022	TFEX 22-2		HMS PORTLAND (F 79)
	C2X	CSG George H.W. Bush	ITS CAIO DUILIO (D 554) BNS TIKUNA (S 34)
	TFEX 23-2		ESPS ALVARO DE BAZAN (F 101) FGS HESSEN (F 221) HMCS FREDERICTON (F 337) NRU ASTERIX
2023	C2X	CSG Dwight D. Eisenhower	ITS VIRGINIO FASAN (F 591)
2024	C2X	CSG Harry S. Truman	ITS CARABINIERE (F 593)
2025	C2X	CSG George H.W. Bush	ITS ALPINO (F 594) ESPS BLAS DE LEZO (F 103)

Examples of NATO/Partner Integration in U.S. CSG C2X/TFEX (2020-2025).

This deep integration proved its immense strategic value in the immediate aftermath of Russia’s 2022 invasion of Ukraine. The U.S. Navy responded by placing the USS Harry S. Truman CSG, and later others, under the direct operational command of NATO through Naval Striking and Support Forces NATO (STRIKFORNATO). [10] [11]

European Carrier Strike Groups

The confidence and expertise fostered by the Cooperative Deployment model have been instrumental in fueling the next phase of maritime evolution: the development and coordination of Europe’s own carrier strike capabilities. This cooperative spirit was a central theme at the prestigious Paris Naval Conference in January 2024, where the chiefs of the world’s leading navies gathered and discussed how to better integrate European capabilities into a multinational Carrier Strike Group.[12]

HMS Prince of Wales and ITS Cavour in the Mediterranean Sea, May 2025. Courtesy of the Italian Navy.

This vision is practiced through the ECGII.[13] The ECGII was established in 2008 by a Declaration of Intention agreed by the Defence Ministers of the European carrier nations (France, Italy, Spain, and the UK), alongside five founding non-carrier members (Belgium, Germany, Greece, the Netherlands, and Portugal). Denmark (2018) and Norway (2025) have subsequently joined the Initiative as non-carrier members, while Allied Maritime Command (MARCOM) and STRIKFORNATO contribute with 'observer' status. Aligned with the philosophy of international by design, the ECGII aims to improve the ability of members to integrate ships and aircraft in a CSG centred on a European aircraft carrier and using NATO doctrine, coordinating participation in training activities, and sharing best practice. The ECGII complements other bi- and multi-lateral arrangements, such as the NATO Maritime Strike Forces Forum.

The ECGII played a key role in the high-level coordination of the consecutive deployments of the Italian, French, and British CSGs to the Indo-Pacific in 2024-2025. This was a deliberately planned effort, underpinned by a joint trilateral statement where the navies committed to "coordinate and sequence" their deployments to "maximize our collective strategic impact" and demonstrate the "credibility of the European commitment" to global security.[14]

1. Italian CSG Cavour: During its first-ever Indo-Pacific deployment, the Cavour CSG achieved Initial Operational Capability.[15] Its commander, Rear Admiral Giancarlo Ciappina, articulated the ultimate goal: "We want to be ready, to be plug and play with our Allies and partners… beyond interoperability is interchangeability." The five-month deployment saw the CSG interact with a dozen navies, participating in major exercises like Australia's Pitch Black 24 and conducting dual-carrier operations and multi-large deck events.[16]

2. French CSG Charles de Gaulle: The 'Clemenceau 25' mission marked the French CSG's return to the Pacific, testing innovative AI-driven data hubs and conducting cross-deck operations with U.S. aircraft.[17] [18] French Chief of Naval Staff Admiral Nicolas Vaujour highlighted the CSG's role as a "multiplier of effect in all domains" that can "switch the light on" in its area of operations.[19]

3. British CSG Prince of Wales: The 'Operation Highmast' deployment saw the UK CSG achieve Full Operational Capability while integrating ships from ten nations, including those of the Joint Expeditionary Force.[20] [21] Reflecting on the modern era, Former First Sea Lord Admiral Sir Ben Key has emphasized the challenge of "unleashing the opportunity of digital maritime forces."[22]

Multi-Carrier Operations: The Apex of Integration

The pinnacle of maritime interoperability is the multi-carrier operation, where two or more strike groups are synchronized under a unified command. These events have become a regular feature of NATO's high-end training, providing an unmistakable message of Alliance resolve. Crucially, this model of high-end integration is no longer confined to NATO members. The Alliance and its leading naval powers are actively exporting this expertise, integrating key global partners into their most complex exercises. Nations such as Japan, Australia, India, and New Zealand, which share a commitment to a rules-based international order, are increasingly becoming participants in these sophisticated demonstrations of maritime power. This reflects a shared understanding that crises are not confined to a single area of responsibility and that global security is interconnected. As Admiral Samuel Paparo, Commander of U.S. Indo-Pacific Command, has stated about these large integrated exercises, they "generate readiness, enhance interoperability, and build credible deterrent forces… to ensure a free and open global commons." This perspective underscores that whether in the Atlantic or the Pacific, the strategic goal is the same: to assemble a credible, interchangeable, and overwhelming force that deters potential adversaries and reassures allies and partners alike.[23]

These operations move beyond interoperability to true interchangeability. As former U.S. Chief of Naval Operations Admiral Lisa Franchetti has noted, allied carrier integration sends a "strong deterrence message of allyship," providing political leaders with a powerful "multiplier of options." This is, in her words, the embodiment of "100,000 tons of American diplomacy" working in concert with our closest allies.[24]

The table below catalogs the remarkable frequency and complexity of Multi-Carrier Operations during the last years

Year	Region	Event	NATO/Partner Carriers	Relevance
2021	Med	Sea Guardian	- HMS Queen Elizabeth - ITS Cavour	Cross-decking and integration exercise of IT-UK-US Marine Corps F-35B
2021	Med	Gallic Strike[24]	- FRS Charles De Gaulle - HMS Queen Elizabeth	The first-ever joint training between the French and British carrier strike groups, focusing on dual-carrier operations with 15 ships from US, GR, IT, NL
2021	Philippine Sea	Philippine Sea Operation	- USS Ronald Reagan - USS Carl Vinson - HMS Queen Elizabeth - JS Ise	A massive demonstration of allied naval power in the Indo-Pacific, involving US, UK, JP, CA, NZ, NL
2021	Med	Dual-Carriers Operation[25] [26]	- ITS Cavour - HMS Queen Elizabeth	IT CSG first joint flight activities with Italian Air Force and Navy F-35B STOVL aircraft, alongside the UK CSG with cross deck operations between the two carriers with US Marine Corps F-35B
2022	Med	Tri-Carriers Operation[27] [28] [29]	- ITS Cavour - USS Truman - FRS Charles De Gaulle	Three allied carrier strike groups operating in close coordination
2022	Med	Neptune Shield[30]	- ITS Cavour - USS Truman - ESPS Juan Carlos I	NATO command and control of multiple CSGs, Amphibious Ready Group and Marine Expeditionary Unit , involving the participation of 25 NATO Allied and partner nations
2022	Med	Littoral Response Group	- ITS Cavour - USS George H.W. Bush - FRS Charles De Gaualle	USS Gerald R. Ford and HMS Queen Elizabeth operating at the same time brought five NATO carriers in Europe
2023	Med	Neptune Strike[31] [32]	- USS George H.W. Bush - ESPS Juan Carlos I - ITS Cavour	3 CSGs with 31 ships, 87 aircraft operating in close coordination led by STRIKFORNATO
2023	Med	Noble Shield	- USS Gerald R. Ford - ITS Cavour	
2023	Med	HEMEX ORION 23	- FRS Charles de Gaulle - ESPS Juan Carlos I	Twenty-nine ships and submarines with the CSG Charles de Gaulle and the Expeditionary Strike Group Juan Carlos I
2024	Med	Mare Aperto Polaris[33]	- ITS Cavour - FRS Charles de Gaulle	French Navy major exercise Polaris combined with Italian Navy major exercise Mare Aperto with 2 opposing CSGs
2024	Med	Neptune Strike[34]	- FRS Charles de Gaulle - ESPS Juan Carlos I - ITS Cavour	Successful Transfer of Authority of multiple European naval assets under direct STRIKFORNATO. This created a powerful, tri-carrier European maritime force operating as a single entity under a unified NATO command structure in the Mediterranean.
2024	Philippine Sea	Indo-Pacific operational campaign[35]	- ITS Cavour - USS Abraham Lincoln	
2024	Pacific Ocean	Nobel Raven	- JS Izumo - ITS Cavour	Major multinational exercise with European (GER, FR, IT), Japanese and Australin ships
2024	Pacific Ocean	Indo-Pacific operational campaign	- ITS Cavour - JS Kaga	ITS Cavour CSG achieved Initial Operational Capability August 26, 2024, while anchored in Yokosuka, Japan
2024	Arabic Sea	Indo-Pacific operational campaign[36]	- ITS Cavour - INS Vikramaditya	First Italian Navy dual-carrier operations with the Indian Navy's aircraft carrier
2024	Red Sea	Indo-Pacific operational campaign	- ITS Cavour - USS Dwight D. Eisenhower	
2025	Med	Med - Neptune Strike[37]	- HMS Prince of Wales - ITS Cavour	NATO-led exercise that showcased the alliance's ability to command and control multiple European CSGs with nine NATO ships (CA, FR, IT, POR, NOR, SP, TUR, UK, US). Two non-US, 5th-generation aircraft carriers operated as a single, integrated, and interchangeable force
2025	Philippine Sea	Pacific Steller	- FNS Charles de Gaulle - USS Carl Vinson - JS Kaga	Major tri-carrier exercise
2025	Indian Ocean	Mission Clemenceau	- FNS Charles de Gaulle - INS Vikrant	
2025	Australia	Exercise Talisman Sabre	- HMS Prince of Wales - USS George Washington	Large-scale, US-Australia-led multinational exercise with UK, NOR and CA ships
2025	Pacific	Op Highmast	- HMS Prince of Wales - JS Kaga	First landing of a British F-35B on the Japanese JS Kaga. HMS Prince of Wales CSG achieved Full Operational Capability on November 17, 2025, following an eight-month deployment to the Indo-Pacific

THE HUMAN ELEMENT - THE TRUE CENTER OF GRAVITY

The remarkable progress in allied maritime integration is a story often told through the lens of technology, doctrine, and steel. It is measured in the number of ships, the capabilities of fifth-generation aircraft, and the bandwidth of data links. Yet, to focus solely on these material aspects is to miss the true center of gravity of allied maritime power: the human factor. This sentiment has been best expressed by retired Admiral James G. Foggo III, a leader who spent much of his career strengthening the bonds of the Alliance at sea. He famously stated: “You can’t surge trust.”[25]

This simple, powerful maxim gets to the very heart of interoperability. You can surge forces, you can surge equipment, and you can surge supplies, but the deep, abiding trust required for sailors from different nations to fight and win together under the most immense pressure can only be built painstakingly over time. It is forged in the shared experience of a cold watch on a pitching deck, the successful execution of a complex air defense exercise, and the quiet confidence that comes from knowing the ship sailing alongside you is crewed by professionals who share your values and your commitment. The entire edifice of NATO interoperability rests not on a foundation of STANAGs, but on this bedrock of profound, hard-won trust. The following initiatives, therefore, are not merely technical adjustments; they are direct investments in building that trust.

1. Deepen and Broaden Personnel Exchanges as a Primary Trust-Building Mechanism: The foundation of trust is shared experience. The Alliance must dramatically increase the number of exchanges at all levels. A French radar operator who has stood watch on a Spanish frigate develops a level of innate understanding that no manual can replicate.

2. Invest in Information Sharing as an Act of Trust: The reluctance to share classified information is often a trust problem. Drafting robust Memoranda of Understanding and creating efficient releasing authorities must be seen as a political and cultural act of trust-building, signaling confidence in one another.[26]

3. Integrate National Exercises to Demonstrate Mutual Confidence: Opening a premier national exercise to allied participation is a powerful demonstration of confidence. Formally integrating these events into the MARCOM schedule creates a predictable rhythm of high-end training that normalizes deep integration and builds instinctive trust.

4. Empower Doctrinal Updates to Codify Shared Trust: Doctrine is the written expression of shared professional understanding. An agile update process proves that the Alliance trusts itself enough to learn and adapt together, creating a virtuous cycle where shared experience builds trust, and trust enables the rapid adoption of shared procedures.

5. Standardize Unmanned Systems to Ensure Future Trust: As unmanned systems become central to naval warfare, aggressively pursuing common standards for platforms and C2 interfaces is an investment in future trust, ensuring a commander can confidently integrate an allied drone into their network.

6. Reinforce Global Partner Integration: In an interconnected world, crises are not confined to a single area of responsibility. NATO must formalize and expand initiatives that integrate key global partners like Australia, India, Japan, and New Zeeland into its maritime activities. This “virtual enlargement” of influence reinforces the rules-based order on a global scale and builds a wider network of trusted partners ready to act collectively when shared interests are challenged.

ITS THAON DI REVEL, flagship of SNMCMG2, replenishes with fuel and water three minehunters while adrift in the Mediterranean Sea, 2025. Courtesy of the Italian Navy.

By prioritizing these human-centric initiatives, the Alliance can ensure its strategic advantage endures. The awesome spectacle of a multi-carrier strike group is a projection of power, but its true strength is invisible, captured in Admiral Foggo's wisdom. It is in the shared glances of understanding between bridge teams, the seamless hand-offs between fighter controllers from different nations, and the unwavering confidence of a Task Group Commander in every single ship under their command, regardless of the flag it flies. It is this human element, this profound and tested trust that cannot be surged, that will continue to be NATO's most decisive asset on, above, and below the waves.

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View of Italian and British F-35B Jets embarked onboard the Flight Deck of HMS Prince of Wales in the Mediterranean Sea , Nov. 2025. Courtesy the Royal Navy.

THE BALTIC SEA

EUROPE'S CRITICAL FRONTIER AND SUBSEA BATTLEGROUND

By
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USS Mount Whitney during BALTOPS 2021. Photo taken from the Norwegian corvette HNoMS Gneis. Courtesy of the Norwegian Armed Forces, photo by F. Nydahl.

The Baltic Sea is an important body of water both geopolitically and economically. Accordingly, the Baltic Sea region cannot be ignored or written off as a new "NATO lake," with the admission of Sweden and Finland to the North Atlantic Treaty Organization. It is far from that and will require hard work, coordination, and the willingness to commit resources in order to ensure peace and security in the Baltic Region for the foreseeable future. This article discusses the importance of the region and what neighboring Baltic nations can do to enhance the quality of collective security.

THE ECONOMIC IMPORTANCE OF THE BALTIC

The Baltic Region is comprised of the area bounded by latitude 53°N to 66°N and longitude 10°E to 30°E. The total sea surface area of the Baltic Sea is 420,000 km^2.[1] This land-locked basin is surrounded by nine countries, including Denmark, Sweden, Finland, Estonia, Lithuania, Latvia, Russia, Poland, Germany. The Nordic–Baltic region has some 33 million inhabitants, and a combined GDP of close to $2.0 trillion, which makes it the tenth-largest population and fifth-largest economy in Europe.[2]

About 200 commercial ships transit the Danish Straits every day, notwithstanding the large fishing fleets that live and operate there. The Baltic coastline is an archipelago of islands that challenges even a skilled mariner in fair weather, however the coastline offers almost 1000 ports and harbors to choose from including Szczecin, Gdansk, Gdynia, Copenhagen, Stockholm, Helsinki, St. Petersburg, Tallinn, Riga, Klaipeda, Kaliningrad, Rostock.

The close proximity of Baltic nations across the Baltic Sea has encouraged the development of an infrastructure of cables and pipelines on the floor of the Baltic for transfer of oil, gas, and digital information. Recent incidents have highlighted the need for protection of Critical Undersea Infrastructure (CUI). Clearly, more must be done to protect Baltic CUI.

A REGION ACCLIMATED TO CONFLICT

Vying for access to ports and control of trade routes, for centuries the Baltic Sea has been an area of tension and conflict. From the 13th to 16th centuries, the Hanseatic League represented the most powerful economic consortium in Northern Europe. In the 16th and 17th centuries, nations fought wars for control of the with Sweden emerging as the dominant power. In the eighteenth century, Sweden's defeat in the Battle of Gagnut in 1714, left Russia as the dominant power in the Baltic Sea.[3] After the unification of Germany in 1871 the southern coastline was dominated by Germany. Accordingly, the Baltic Sea was again embroiled in conflict in August 1914 with the outbreak of World War I. Germany began an effective campaign of unrestricted submarine warfare that went unchecked for the first two years of the war. Germany invaded the Baltic States and Poland in 1915 seeking raw materials and food and conscripting forces to fight on the multiple fronts. The British blockade of Germany was impacting the economy and the war effort. The German High Seas Fleet engaged the British Grand Fleet indecisively at the Battle of Jutland in 1916 and remained sequestered for the rest of the war. The entry of the United States in the war in 1917 turned the tide against Germany and led to the armistice in November 1918. Germany's loss was Poland's gain and at the insistence of President Woodrow Wilson in 1919, Poland gained access to the Baltic Sea presenting a new player in an already crowded field.[4]

After two decades and the rise of National Socialism, Germany came back with a vengeance in 1939 with a Blitzkrieg on Poland and a subsequent attack on France in 1940, occupying both countries in the long run. Germany then turned its attention toward Great Britain and occupied strategic ports in Norway. By 1941, Germany seized the Baltic States and the High Seas Fleet remained close in with the mission to prevent allied warships from entering the Baltic Sea: "How well it perfected this defense is evidenced by the fact that no major enemy surface unit penetrated the Baltic Sea during the First or Second World War.”[5]

Once again, German unrestricted submarine warfare manifested itself in the Atlantic while operating from occupied bases in France. By the end of 1942, there was a sea change during the second Battle of the Atlantic as the Allies combined revised training, tactics, and procedures with innovative technology to defeat the German submarine force. Losses were staggering:

> *Germany lost 199 U-boats in World War I. In the recent war she sacrificed 777 undersea boats and over 30,000 men without achieving her objective. The Italian Navy had tried to help out, losing 95 submarines for its trouble.*[6]

During these two bloody conflicts in the 20th century, the Baltic Sea became littered with shipwrecks, downed aircraft, mines, unexploded ordnance, and the dumping of stockpiles of chemical weapons. It remains such a serious problem that some nautical charts warn mariners not to drop anchor due to the presence of unexploded ordnance on the bottom of the Baltic Sea. In fact, it is estimated that 1.6 million tons of unexploded ordnance still remain on the bottom of the Baltic Sea.[7]

Courtesy of GISGeography.

After the defeat of Nazi Germany in 1945, the Soviet Union gained a new foothold in the Kaliningrad Oblast and occupied the Baltic States. A new Cold War quickly developed with the formation of NATO in 1949, and its mirror image known as the Warsaw Pact on the other side of the Iron Curtain. Sovereignty of the Baltic Sea was again in play as western warships and Soviet warships of the Soviet Union or her satellites faced off in the region. My first trip to the Baltic Sea was onboard the nuclear-powered attack submarine, USS Sea Devil (SSN-664) in July 1985. I found navigating these straits was like participating in a ballet on the surface of the sea flanked by the shorelines of Norway, Sweden, and an archipelago of islands, rocks, and shoals starboard and port.

Navigating the Kattegat, Skagerrak, and Store Belt of the Danish Straits was not the only hair-raising part of our journey into the Baltic Sea. This was during the Cold War and neither the Soviet Navy nor the Warsaw Pact were happy about having a U.S. fast attack nuclear submarine in their back yard. We never submerged during the transit, so we were easy to track from the air or on the sea. One morning during the transit, as the sun was coming up, one of our best sonarmen (the likes of “Jonesy” in The Hunt for Red October) was listening to all surrounding traffic and he called the bridge to tell me that there was a Soviet submarine approaching. Incredulous, I scanned the horizon with my binoculars but with low light at the crack of dawn, I couldn’t see anything… then in the mist ahead, outbound in the traffic separation scheme, I observed the silhouette of a Soviet Whiskey-class diesel submarine. I informed the Commanding Officer, and he came immediately to the bridge. The Russians were oblivious to our presence—I guess they didn’t have a Jonesy equivalent—but as the submarine passed abeam of USS Sea Devil, the Russian Officer of the Deck saw our American flag and notified his superiors. So many Russians came to the bridge that it looked unsafe to me. As they proceeded past the beam, the Russian Commanding Officer ordered a U-turn, and the Whiskey pursued us on the surface. We had a 1-2 knot speed advantage at flank speed and quickly opened range until they gave up. Thrilling moment for both crews!

Later in the transit as we approached Kiel on the maneuvering watch, with all hands up and manning additional watch stations for safety, we were met by a welcoming committee of East German Schnellboots, one of which maneuvered close aboard in an attempt to block our transit. Fortunately, despite the East German’s recklessness, nothing transpired and we made it safely into port. The entire crew was exhausted but relieved to finally get some well-deserved liberty.

Our outbound transit from Kiel and back to the North Sea was uneventful and we were once again submerged and undetected and on patrol in the North Atlantic. The mission of an attack submarine is fairly dynamic. Nuclear propulsion gives us the advantage of high speed (hence “fast” attack), stealth while submerged on nuclear power, lethality with the variety of weapons carried onboard, and dwell or the ability to remain submerged and undetected for a very long time. After this short visit to the Baltic region, I wondered what it would be like to fight a war against an adversary in such a congested and constrained environment. I opined that nuclear powered submarines would not be the best platform for such a mission. On the other hand, diesel-electric boats were better suited for unrestricted submarine warfare in such a place. Analogously, it occurred to me that in time of war, whoever controls the Danish Straits controls the Baltic.

Fast forward to the 21st century where I coalesced around a few observations that would guide my thinking about the Baltic for the rest of my career:

- The threat in the region was high, notwithstanding the face-off between two powerful alliances—NATO vs Warsaw Pact. As long as the Soviet Union existed, the West would live in constant fear of an outbreak of WW III. The proliferation of nuclear weapons, both strategic and tactical, made this threat even more real.
- Despite the dark cloud of a potential conflict, the Baltic Sea is a vibrant region that caters to commercial business activity including commercial shipping, fishing, and tourism.
- If war broke out, fighting in the Baltic Sea would constitute a very constrained environment akin to fighting in a bathtub.
- The presence of Kaliningrad in the Baltic, a war prize to Stalin after WWII, is a continuing nuisance to present day. Home of the Baltic Sea Fleet, Kaliningrad represents a threat to NATO and EU members in the Baltic Region. Although small in terms of territory, Kaliningrad is a Russian Oblast with an extremely high density of Russian weapons systems including the Iskander and Bastion missile systems. By employing a combined arms strategy, there is really nowhere in the Baltic that the Russians cannot reach kinetically from Kaliningrad, effectively creating an Anti-Access/Area Denial (A2AD) bubble in the Baltic Sea.
- It would be fairly easy for a nefarious actor to close the Danish straits with a blockade or a carefully placed minefield.
- A disruption of Baltic Sea lines of communication or closure of the Danish Straits would have a catastrophic effect on those nations bordering the Baltic Sea, placing greater strain on landlines of communication and resupply only from ashore.
- Land armies are not capable of maintaining sea lines of communication free and open. Only navies can fulfill this mission. We must never lose track of that.

In my forty-four-year career in uniform, from taking the oath of office as a Midshipman at the U.S. Naval Academy in July 1977 until my retirement as a Four-Star Admiral and Commander of Allied Joint Force Command, Naples (JFC-NP) in September 2020, I saw a lot of change. My career began in the thick of the Cold War and when I deployed on USS Sea Devil for the first time, our mission was to be ready for war.

The fall of the Berlin Wall in 1989 followed by the collapse of the Soviet Union in 1991 did not produce the peace dividend promised, rather we are now back to a Cold War-esque environment whereby Allies and partners feel more threatened today by Russian aggression than they did in the 1980s. Our only hope of deterring the spread of Russian aggression to the rest of Europe is to do so from a position of strength. Regarding the Baltic region in particular, as an Alliance, I believe we need to do the following things to guarantee deterrence.

THE ENDURING VALUE OF BALTOPS

BALTOPS is an annual large-scale exercise sponsored by the U.S. SIXTH Fleet and executed by Striking and Support Forces NATO (STRIKFORNATO) headquartered in Lisbon, Portugal. The unique thing about this paradigm is that the Commander, SIXTH Fleet and the Commander, STRIKFORNATO are one in the same. I commanded BALTOPS in 2015 and 2016. In 2015, for the first time in the history of the exercise, which began in 1972, I commanded BALTOPS under my STRIKFORNATO hat. This was significant because it was the first time a NATO Commander had done so. It was even more significant because the Russian Federation had illegally annexed the Ukrainian territory of Crimea in 2014 and the Baltic nations feared they would be next. Putting a NATO face on the exercise was important.

Although I was satisfied with the outcome of BALTOPS 2015, I was fortunate to have a "re-do" in 2016. Early on in the planning process, I elected to emphasize "amphibiousity"[8] as a centerpiece of BALTOPS 2016. Instead of two amphibious landing exercises, I asked the planners to do more and we really stressed the force with four amphibious landings in 2016, starting with the first shortly after we left Tallin, Estonia on June 6th, 2016. I summarized the conduct of the exercise in 2016 as follows:

> *NATO's inclusion of Finland and Sweden in the BALTOPS 2016 exercise as "Partnership for Peace" nations underscores the fact that their regional security interests in the Baltic are in sync with the 28 members of the Alliance. Just two days ago on 4 June the exercise participants assembled as an entire group for the first time in Tallinn, Estonia, for the Pre-Sail Conference. On 5 June we set sail from Estonia. On 6 June we hit the beach running. . . Literally! The rapid assembly and deployment of forces in the first few days of BALTOPS 2016 is a powerful testament to the strength and agility of the Alliance.*[9]

US Marines executing an amphibious landing in Ustka, Poland, during BALTOPS 2016. Courtesy of US DoW, photo by MCSS A. Sperle.

Admiral James G. Foggo and a Swedish Coastal Ranger during BALTOPS 2016.

I was pleased to support BALTOPS many more times from my position as the Four-Star Commander of Allied JFC-NP from 2017-2020. Many of the lessons I learned as the Commander of BALTOPS in 2015 and 2016 served me well as the Commander of Exercise Trident Juncture in 2018. It remains to this day the largest NATO live exercise since the end of the Cold War with 50,000 Soldiers, Sailors, Airmen, and Marines; 70 ships including the USS Harry S. Truman Carrier Strike Group, USS Iwo Jima Expeditionary Strike Group; 265 NATO aircraft of all Type-Model-Series; and 10,000 tracked or rolling vehicles in an article 5 operation on the territory of Norway. I strongly believe that the lessons learned from BALTOPS and Trident Juncture served the Alliance well in deterring the spread of the Ukraine conflict to the rest of Europe.

REINFORCING FROM THE SEA

While challenging, BALTOPS 2015 comprised of two large amphibious landings during the exercise, and I determined that we had not exercised the force to its full capability or capacity. The first amphibious landing in BALTOPS 2015 took place on the wide sandy beaches of Ravalunda, Sweden. Furthermore, the landing took place on a sunny day with a favorable sea state. It was too easy and defied the American mantra of Murphy's Law, i.e., what can go wrong will go wrong when you least expect it.

Accordingly, during our Hotwash at the end of BALTOPS 2015, our planners concluded that we needed to create more challenging conditions for the amphibious landing force next year. BALTOPS 2016 included our first landing in Hanko, Finland, beginning the day after the fleet pulled out of port in Estonia; a second landing in Uto, Sweden, from June 10 to 13; and a third landing, in Ustka, Poland during the culmination of the exercise.

The bottom line is that you train like you fight and if conflict ever broke out in the Baltic region, NATO nations and their armies would depend on reinforcement from the sea. To plan otherwise would be naïve particularly considering the short distances from the Russian border to the capitals of the Baltic states. This brings me to my next critical point.

VALUE OF NAVAL FORCES IN THE BALTIC

During my time in the Baltic region, I was reminded that defense budgets and orders of battle were biased towards land armies. In the case of the three Baltic nations, this was somewhat understandable based on their history fighting Nazi Germany and the Soviet Union during the second world war. Each of these states shares a border with Russia and the preponderance of force is dedicated to blunting the offensive from the East and defending the capitals of Tallin (Estonia), Riga (Latvia), and Vilnius (Lithuania). As a result, land armies receive the preponderance of funding in Baltic defense budgets. In conflict, this could leave an important flank uncovered—that which exists from the sea.[10] I strongly believe that for NATO to counteract the effects of Russian Forces in Kaliningrad, all Baltic naval forces must be reinforced and modernized.

THE IMPORTANCE OF MINE COUNTERMEASURES

Mines have played an important role in the Baltic Region since World War I. Minemen like to say that "Our wake is the fleet's path…" and when confronted with transit through choke points like the Danish Straits or operation in relatively small geographic areas like the Baltic Sea, mines can be the nemesis of naval operations. Mine warfare is an integral part of the A2AD Strategy currently deployed by nations like Ukraine to deter amphibious assault by the Russian Black Sea Fleet on port cities like Odessa. The same methodology applies in the Baltic Sea Region.

Mine warfare has become more sophisticated and unseen. Today, a minefield can be sewn by surface ships or submarines and autonomous vehicles. It is therefore important that NATO navies maintain a Mine-Countermeasure capability to maintain choke points and seaborne ports of departure open for commercial and military access in peacetime or wartime.

This is not a trivial matter, nor is it inexpensive to maintain a NATO Mine Countermeasures (MCM) capability. The United States Navy is primarily a blue water Navy and has frankly allowed its MCM capability to atrophy over the last two decades. Relief from the modular MCM package on the Littoral Combat Ship is late to need and the limited inventory of American MCM resources has been underscored by the most recent Iranian closure of the Strait of Hormuz and the suspicion that Iran has planted mines.

European navies, and particularly those sailing in the waters of the Baltic Sea, have maintained an MCM capability, but have not recapitalized on this investment to the extent necessary. As I articulated during BALTOPS 2016:

> *Mines protect coastlines and often fit into a country's greater scheme of maritime defense in order to deny access to or control a region. Repeatedly, history has proven that due to their low cost, high availability, and deadly outcomes, mines are effective force multipliers and battle space shapers. Mine warfare has progressed significantly from the simplest contact mines; modern mines use acoustic, magnetic, and pressure sensors and can fire rockets or torpedoes against ships or submarines. Any future naval war will involve maritime mines. Minesweeping goes back to the basic functions of the Navy: keeping the sea lanes of communication open. It is my view that, as an Alliance, we cannot let the skills of mine warfare atrophy or it will be at our own peril.*[11]

CRITICAL UNDERSEA INFRASTRUCTURE

The Baltic Sea region is dependent upon CUI for its economic viability and supply of energy to regions that cannot produce enough natural gas for habitability during the harsh winter months. Attacks on CUI have become a viable weapon in the A2/AD tool kit. More must be done to preserve CUI in the Baltic and other susceptible regions of the globe.

Since the outbreak of hostilities in Ukraine in 2022, the Baltic Region has experienced a number of attacks on Baltic CUI that raise significant concerns. Since September 2022, there have been numerous attacks on Baltic CUI that have made the headlines, temporarily impeding communication grids or undersea energy pipelines and incurring enormous costs on host nations for repair. The magnitude of these incidents demonstrates the fragility of Baltic CUI and the need for a bottom-up review on how to protect western interests in the future.[12]

As a result, NATO Secretary General Jens Stoltenberg created the CUI Cell at NATO Headquarters, headed by LTG Hans Werner Wiermann on 15 February 2023. The purpose of the Center is to examine the vulnerabilities of NATO CUI and form a public-private partnership to share industry best practices and provide greater situational awareness of the threats to CUI and how to mitigate these threats.[13] Likewise, NATO announced the "Digital Ocean Vision" initiative in October 2023 to combine assets in all domains to surveil and report on suspicious activity on or underneath the surface of the sea.[14]

Furthermore, in January 2025, Allied Joint Force Command Brunssum (JFC-BS) stood up Operation Baltic Sentry to quell the incidences of attacks on Allied CUI. The ubiquitous Russian "Shadow Fleet" has been a prime focus of the operation and since its inception, the Baltic Sentry has significantly reduced the number of attacks, but not without significant cost to the Alliance in terms of the deployment of ships, aircraft, and unmanned surveillance vehicles.[15]

Marines from the Finnish Nyland Brigade Amphibious Task Unit, line up Combat Boat 90 craft at Utö, Sweden, during BALTOPS 2016. Courtesy of US DoW, photo by MCSS A. Sperle.

Baltic Sentry is an operation that is ripe for the integration of robotic and autonomous systems to reduce costs over the long term. For now, it's "all hands-on deck" to prevent further attacks on Alliance CUI. Finally, the lessons learned from Baltic Sentry should not be contained in a vacuum. On the road to crisis, it is likely that the Alliance will see the adversary's tactics, techniques, and procedures applied in other geographic areas as well.

THE IMPORTANCE OF JOINT FORCE COMMAND NORFOLK

In an act of solidarity within the Alliance, the United States and NATO have strengthened the Trans-Atlantic Bridge with the establishment of Joint Forces Command Norfolk (JFC-NF) in 2019. Today, JFC-NF has been given co-equal status with JFC-NP, Italy, and JFC-BS, Netherlands. JFC-NF represents a significant force-multiplier for the Alliance. Not only does it add more in terms of a warfighting staff, but in combination with STRIKFORNATO, it more readily integrates American Carrier and Expeditionary Strike Groups into the 4th Battle of the Atlantic thereby enhancing security in the Baltic and High North Regions.

JFC-NF is growing bigger and better every day as it adds both personnel and facilities infrastructure to its headquarters footprint in Norfolk, Virginia. Accordingly, the SACEUR Area-wide Strategic Plans embrace the contribution of JFC-NF to NATO's improved approach to multi-domain operations. From the standpoint of Baltic security, it will be important to watch JFC-NF and its interaction with JFC-BS and JFC-NP in future exercises and real-world operations.

A recent announcement by NATO HQ Brussels indicates that the JFC-NF will soon be commanded by a four-star British officer, who is yet to be determined.[16] This move will put a strong NATO face on JFC-NF and strengthen ties across the trans-Atlantic bridge.

CONCLUSION

While there are many other geographic regions inside the NATO Alliance that we could focus on, I am pleased to highlight the Baltic Region for its strategic and tactical level of importance in this last edition of "Cutting the Bow Wave" magazine. We must continue to reinforce military and economic security in this vital sea that connects so many nations across the Alliance.

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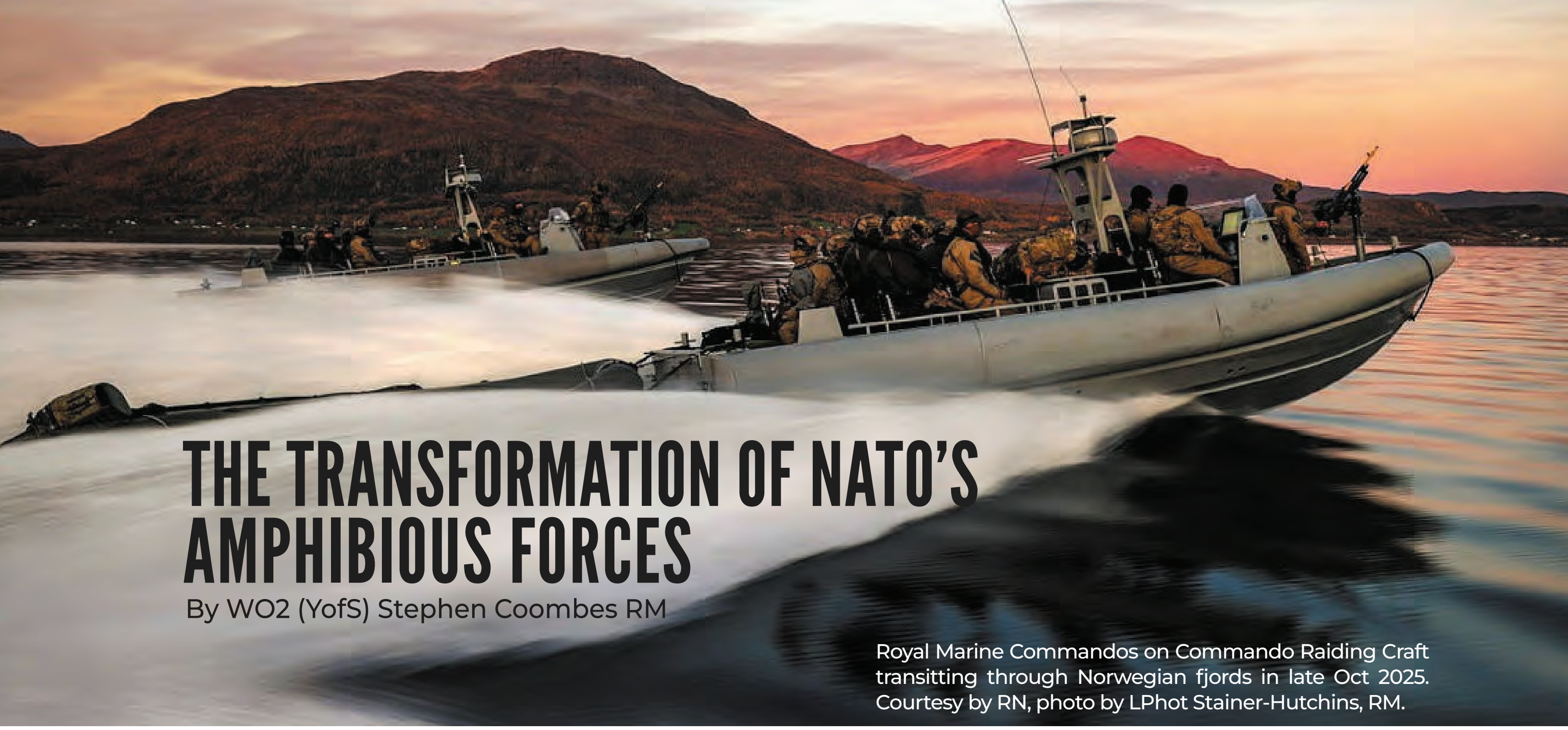
A US Navy Landing Craft Air Cushion conducts ship-to-shore movements in Ventspils, Latvia during BALTOPS 2024. Courtesy of USMC, photo by Cpl. Victoria Hutt.



THE TRANSFORMATION OF NATO'S AMPHIBIOUS FORCES

By WO2 (YofS) Stephen Coombes RM

Royal Marine Commandos on Commando Raiding Craft transitting through Norwegian fjords in late Oct 2025. Courtesy by RN, photo by LPhot Stainer-Hutchins, RM.

Europe is currently facing its most significant strategic shift since the end of the Cold War, primarily due to Russia's invasion of Ukraine in February 2022. Now entering its fourth year, this conflict has brought increased focus on the "NATO 2030"[1] concept, which outlines the Alliance's future capabilities and strategic direction. For NATOs amphibious forces, this evolving situation calls for a thorough reevaluation of their roles, doctrines, and technological readiness. NATO's primary mission is still to deter and counter Russian aggression in the face of complex and technologically advanced warfare. To meet these challenges, littoral forces are being redesigned for better technological integration and stronger multinational cooperation.

THE THREAT

The long-term consequences of the Ukraine conflict pose serious risks to international security, particularly with Russia's growing subversive activities and nuclear threats. Even after suffering considerable losses, Russia continues to be a significant threat, bolstered by alliances with countries like China, Iran, and North Korea. Since 2022, Moscow has viewed the NATO alliance as its "main enemy "and has been rapidly rebuilding its military capabilities in preparation for potential confrontations with the West.

Modern littoral operations are faced with complex challenges due to rapid advancements in military technology and a shifting geopolitical dynamic. Traditional amphibious warfare is increasingly at risk from the widespread availability of Unmanned Vehicles (UxVs), advanced anti-ship cruise missiles, man-portable air defense systems (MANPADS), and long-range air defense systems. The integration of data from various sensors, along with the emergence of supersonic and hypersonic anti-ship missiles, complicates surface vessel operations, making them more vulnerable to detection. The high speed of these missiles means fewer are needed to breach air defenses.[2] Similarly, the improved MANPADS and air defense systems make helicopter insertions significantly more difficult. This was evident early in the conflict when Russian naval infantry faced strong resistance during attempts to land on the Ukrainian coastline.

Establishing and defending a beachhead poses further challenges due to the accuracy and volume of enemy fire. Tactical weapons now include short-range ballistic missiles, and armed drones can provide adversaries with effective tactical air power. The conversion of "dumb bombs" into precision-guided munitions with glide kits allows for a high volume of cheap long-range firepower. In addition, support assets can become overly stretched while defending themselves or critical targets, limiting the availability of counter-air support. Russian forces have shown their ability to concentrate fire efficiently, as observed during the Donbas campaign, where drones facilitated rapid targeting shortly after target identification, resulting in significant Ukrainian losses.[3]

Despite these challenges, utilizing the littoral area as a maneuver space is becoming increasingly vital. This is particularly true in areas like the Baltic Sea and NATO's northern flank, where Russia prefers to operate on narrow, linear fronts. Utilizing the many offshore islands within the region expands the battlefield area, making it more difficult for enemy systems to target. Despite this tactical advantage, NATO's amphibious forces are affected by persistent challenges in Europe's wider military posture. As a lighter, entry-force, they are dependent on follow-on support that is often lacking. For example, a shortfall in heavy maneuver forces means that an amphibious force may struggle to break out or be relieved. Similarly, inadequate airlift and logistics can prevent a landed force from being sustained far from the beachhead, tying it to vulnerable coastal positions. These gaps place a greater emphasis on the self-sufficiency of modern amphibious task groups and drive the transformation towards units that can sustain themselves for longer periods.[4]

An Italian 8x8 amphibious armored vehicle, transits the surf zone during a maritime projection exercise. Courtesy of Iveco Defence Vehicles/Italian Ministry of Defence.

TECHNOLOGICAL TRANSFORMATION

To combat these evolving threats, NATO amphibious forces are undergoing a major technological transformation, focusing on advanced platforms, unmanned systems, precision firepower, and sophisticated sensor networks. The objective is to develop forces that are more agile, resilient, and capable of operating in a distributed manner. A central principle of this transition is a shift away from large-scale, linear amphibious operations in favor of more dispersed and networked operations. This approach makes forces less vulnerable to enemy fire.

The UK's Royal Marines are leading this approach by prioritizing the establishment of agile Littoral Response Groups (LRGs). These units are designed for permanent deployment in key areas, where they are ready to operate within an adversary's Anti-Access/Area Denial (A2/AD) zones. The LRGs operate from Multi-Role Support Ships (MRSS); these groups can execute sea-to-land strikes, enabling the effective deployment of Marines along with their vehicles, boats, and weaponry. The Royal Marines are also reconfiguring their traditional units into 12-man strike teams. These teams are designed to operate within enemy territory, acting as a force multiplier. This shift allows for more tailored strategies and better integration with partner forces.[5]

The design concept of surface maneuver craft is also transforming. The emphasis is shifting from large surface connectors to smaller, more resilient, vessels that prioritize reduced signatures, even if this means sacrificing some carrying capacity. These platforms may also have their own strike capabilities, in the same manner as Iran's Revolutionary Guards Corps arm their speedboats with missiles.

The focus on distributed maneuvers often requires reliance on light vehicles. While this may negatively affect equipment integration with heavier land components, it promotes interoperability with light land reconnaissance units, enabling a comprehensive "whole-of-force effort to win the deep battle." The collaboration between distributed forces and strike focused units is crucial, allowing the distributed force to operate at depths that enable the use of heavier firepower. Furthermore, the firepower from strike focused units enables forward units to generate effects without the need for concentration, thereby eliminating the necessity for vulnerable buildups of capabilities. These small, distributed teams also provide additional advantages. They can deploy intelligence, surveillance, and reconnaissance (ISR) platforms equipped with effective sensor payloads at short ranges, which is crucial given that larger, longer-ranged systems are inherently more susceptible to threats. Additionally, smaller units can take advantage of signature reduction. These approaches are more practical and survivable in the current operating environment, as the larger systems they replace are not only more susceptible to threats but often do not scale well due to their prohibitive cost.

The ability to execute long-range precision strikes from offshore islands and maritime platforms is essential for achieving concentrated effects with distributed forces. NATO forces are increasingly adopting unmanned aerial and ground vehicles, along with Artificial Intelligence (AI), to improve strike capabilities, surveillance, and logistics. For example, Finland is actively exploring the integration of unmanned systems into squad-level operations and utilizing AI for decision-making within its Coastal Brigade.[6] The U.S. Marine Corps' Force Design, which influences the strategic thinking of allied forces, emphasizes unmanned systems for various roles, including surveillance, anti-submarine warfare, and forward attacks.[7] This approach allows personnel to operate from safer stand-off distances. Similarly, the Swedish Armed Forces are prioritizing the development of mobile, modular counter-unmanned aerial system (C-UAS) capabilities to mitigate the significant threat posed by low-cost, agile drones.[8] Additionally, the US Navy is looking to develop unmanned surface and undersea vessels for anti-submarine warfare and other missions.[9]

This shift emphasizes the importance of precision fires in and from coastal areas. Sweden's naval infantry is acquiring seaborne artillery platforms that are equipped with stabilized mortars that can fire while the vessels are moving.

These mortars can theoretically engage targets at greater distances by bypassing an enemy's frontline. Finland is also upgrading its coastal artillery with highly mobile systems that can target both maritime and land forces, utilizing NATO compliant ammunition. These advancements are expanding the battlefield dynamics and further complicating an adversary's surveillance and targeting efforts.

Furthermore, advanced missiles and air power also play a key role. Finland's Hamina-class fast attack craft are being upgraded with new Gabriel anti-ship missiles and enhanced anti-submarine warfare capabilities, including lightweight torpedoes and variable depth sonar.[10] Italy has F-35B short take-off and vertical landing (STOVL) aircraft to enhance its navy's power projection and support amphibious operations, embarking them on carriers like the Cavour and the new Trieste LHD. Forward-deployed F-35 squadrons enhance the capabilities of NATO forces to establish air superiority against robust Russian integrated air defense systems (IADS) and can collect electronic signals to compile a comprehensive picture of forces. The proliferation of various sensor types makes hiding on the surface difficult, so strategies like low observability, decoys, and countermeasures are being explored to make enemy sensor networks less effective against maritime forces.

NEXT-GENERATION AMPHIBIOUS CAPABILITIES

The modernization of NATO's littoral forces encompasses not only technological advancements but also the development of new platforms designed for multi-role operations and improved interoperability. Finland's Squadron 2020 program is introducing the new Pohjanmaa-class corvettes, specifically designed for year-round, multi-role operations in the Baltic Sea, including in ice-covered and shallow waters. These vessels represent a significant enhancement in endurance and capabilities, enabling them to perform a variety of missions such as anti-surface, anti-air, and anti-submarine warfare,[11] along with mine-laying and sea lane protection. They are fully interoperable with NATO systems.

The UK and Netherlands are collaborating on a program to develop the next-generation littoral strike ships to enhance their amphibious operation capabilities.[12] Spain and Italy are also upgrading their amphibious fleets. Spain is replacing its older amphibious assault vehicles with US-designed Amphibious Combat Vehicles (ACVs). Italy is building three new LXD amphibious assault ships to phase out older models by 2030, they will join the larger Trieste LHD. Additionally, Italy's adoption of Iveco SUPERAV vehicles, which are adapted from the US Marines' ACV, highlights a common trend towards modernization of amphibious forces among these countries.[13]

To ensure sustained military operations, NATO's critical support systems are also being strengthened beyond just combat platforms. The US is currently increasing its prepositioned equipment and munitions stocks in Europe, providing a crucial source of material for amphibious forces to draw upon once a port or airfield is secured. The war in Ukraine has shown the importance of having adequate long-range artillery and munitions readily available in the region. For a landed amphibious force, these assets are vital for enabling a breakout from the beachhead. There is also a growing demand for ISR assets. In response, the Department of War (DoW) is modernizing its ISR capabilities and utilizing commercially available satellite imagery, which provides the real-time intelligence needed for beach reconnaissance and identifying threats to the fleet. This approach was effective in identifying Russian military movements before the 2022 invasion.[14] Enhancements to air and missile defense systems are also essential, to protect vulnerable naval assembly areas and the initial beachhead from standoff attacks.

The transformation of NATO's amphibious forces extends beyond the shoreline, demanding deep integration with Europe's broader defense architecture. For amphibious units, once ashore, the ability to maneuver and sustain themselves is critical. Therefore, improving military infrastructure and mobility such as railways, road

Test of the NEMO Naval 120mm Mortar system on Trossbåt in 2018. Courtesy of the Swedish Armed Forces.

networks, and bridges, is crucial for ensuring ease of access for amphibious forces moving from the beachhead, while the installation of fiber-optic cables ensures reliable communication for Command and Control (C2). To that end, NATO has formed an administrative arrangement with the European Defence Agency (EDA) to share information on military mobility and supply chain resilience.[15] both of which are essential for sustaining a force ashore. In the realms of cyber and space, US forces are enhancing the security and stability of their systems and networks while also supporting European partners. US Cyber Command is deploying more "hunt forward" teams to Europe to combat threats from Russia protecting the networks an amphibious task force relies on. Similarly,[16] the US Space Force is defining its role within US European Command (EUCOM) to support forces and maintain satellite communication on which amphibious operations depend for ISR, and over-the-horizon command.

INTEGRATED FORCES AND COLLECTIVE DEFENCE

Multinational interoperability and integration are central to the modernization efforts of NATO's amphibious forces. As a long-established integrated force, it serves as a proven model for multinational cooperation within NATO. The value of the UK/NL Amphibious Force lies not just in its existence as an integrated unit, but in the deep level of interoperability and complementary specialization it has developed over decades.

Finland and Sweden's recent NATO membership has formalised a decade-long trajectory of bilateral defence integration, largely established through the FISE framework.[17] Long before their formal accession, the two nations had already operationalised amphibious forces, such as the Swedish-Finnish Naval Task Group (SFNTG) and the Swedish-Finnish Amphibious Task Unit (SFATU), to secure the complex Baltic and Arctic environments. This pre-existing cooperation which included, shared access to naval bases, joint air surveillance, and the development of a combined brigade framework, served as a "virtual alliance" that enabled an easy transition into NATO's command structure. In 2026, this partnership has evolved further, with Sweden serving as the framework nation for NATO's Forward Land Forces (FLF).[18] Both countries are fully integrating their air and maritime assets into NATO's regional defence plans, transforming their bilateral "specialisation" into a mainstay of collective security on the Alliance's northern flank.

In Southern Europe, Spain and Italy are also pursuing modernization. Spain is working on broader initiatives like Force Design 2030 and Brigada 2035 to create technologically advanced ground forces. This provides a framework for technology and doctrine that will inevitably influence the modernization of its own marine infantry. Italy is exploring the formation of a joint Army-Navy modernization brigade to enhance its expeditionary capabilities and is a key participant in the European Maritime Force (EuroMarFor). This multinational force is capable of crisis management and combat tasks in the Mediterranean and beyond. Both Spain and Italy are investing in advanced amphibious platforms and enhancing their naval and coastal capabilities, underscoring their commitment to interoperability and multilateral cooperation.

NATO's amphibious forces greatly enhance the alliance's collective defense, especially in strategically important areas. They utilize littoral zones as maneuvering space to prevent peer competitors, such as Russia, from engaging in conflicts on narrow fronts.

Royal Marine Commandos transitting through Norwegian fjords in late Oct 2025. Photo by LPhot Stainer-Hutchins, RM.

JOINT EXERCISES AND STANDARDS

Joint training exercises are as crucial as ever. These developing exercises are a response to evolving threats and challenges, aiming to strengthen relationships and ensure continued interoperability among allies. For instance, the annual Baltic Operations (BALTOPS) exercise involves numerous NATO allies and partners, with Finland and Sweden actively participating, underscoring the increased importance of the Baltic Sea region. Similarly, Steadfast Defender is a large-scale exercise that directly tests and validates NATO's new defense strategies in response to the threat posed by Russia.[19]

Another key exercise is Nordic Response, which focuses on enhancing military cooperation in the high-intensity Arctic environment of northern Norway, Finland, and Sweden. These regions are increasingly significant in today's geopolitical dynamic. These collaborative efforts are vital to the NATO 2030 agenda. They strengthen the Alliance's collective defense, help adapt to new threats and reinforce political unity in the face of a common adversary.

NATO membership for countries like Finland and Sweden has enhanced their access to international arms markets, creating opportunities for increased specialization and collaboration across the Alliance. A key example is that new Finnish coastal artillery ammunition will now be compatible with NATO standards.

COMMAND AND CONTROL EVOLUTION

Modernizing Command and Control (C2) structures is essential for the effective deployment of NATO's amphibious forces. To improve interoperability between national amphibious task groups, there is increasing agreement to adopt a centralized Amphibious Task Force (ATF) as the standard C2 structure for NATO amphibious operations. This modernization aligns with the US Joint Warfighting Concept (JWC), specifically its emphasis on integrated command and agile control.[20]

To advance C2 modernization, several key recommendations have been made. These include clearly defining the responsibilities between the combined force maritime component command and the ATF, as well as testing this centralized concept in future exercises. Additionally, it is essential to specify the requirements for sourcing the multinational staff for the Commander, Amphibious Task Force (CATF) and the Commander, Landing Force (CLF).[21] The Alliance also needs to identify tactical interoperability requirements beyond the existing agreements and improve its understanding of modern amphibious battlespace management doctrine. These critical measures are essential for NATO to consolidate its national amphibious capabilities into a single, cohesive, and effective structure that can address current threats.

CONCLUSION

The "NATO 2030" vision heralds a future where NATO amphibious forces are increasingly agile, technologically sophisticated, and deeply integrated through robust multinational cooperation. The shift is driven by the enduring and evolving threat from Russia, requiring a departure from traditional amphibious warfare concepts towards distributed, networked operations. While challenges remain, particularly in the realm of overall European military capabilities and workforce shortages, the commitment to adaptation and collaboration is evident. New technologies, such as unmanned systems, advanced precision fires, and multi-role platforms, are being adopted to enhance lethality and survivability in contested environments. Simultaneously, initiatives like the UK/NL Amphibious Force and the integration of Finnish and Swedish defense capabilities demonstrate the deepening interoperability needed for collective defense. By transforming their structure, equipment, and concepts of employment, European amphibious forces aim to operate in complex coastal environments effectively, contribute strategically to NATO's deterrence, and offer flexibility in an increasingly unpredictable security landscape. This ensures that the utility of maneuver within the littoral remains an important part of the solution to the challenge of Russian combat power in Europe.

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A russian GRK-700 Vizir. Photo from open-source.

Russian Maritime Unmanned Systems

By
CAPT (N) Per Christian Gundersen (RNoN)

> *"You can produce more than 5000 Ukrainian Magura V5 maritime attack drones for the cost of one multi-mission guided-missile Constellation-class frigate."*
>
> Dr. T. X. Hammes

INTRODUCTION

Over the past few years, the Russian Navy has painfully experienced firsthand the impact of Ukrainian Maritime Unmanned Systems (MUS) employed in the Black Sea. Just four months after the Russian invasion in February 2022, Ukraine began striking the Russian-occupied port of Sevastopol with maritime drones, by targeting maritime infrastructure and the Russian naval vessels moored. Since then, more than 20 Russian naval ships have been neutralized by Ukrainian MUS. As a result, the Russian Navy has effectively abandoned its historic homeport of the Russian Black Sea Fleet in Sevastopol, relocating remaining naval forces to the eastern part of the Black Sea at Novorossiysk, rendering them rather useless in the war.[1]

More broadly, the effective use of unmanned systems during the war in Ukraine has been a hard-learned lesson, while also a strategic wake-up call for Russia. It has clearly demonstrated how a military inferior force can mitigate conventional disadvantages and punch above its weight class through innovation and asymmetric capabilities. Over the last two years, Russia has ramped up their production and use of unmanned systems in the war against Ukraine, particularly with the Iranian designed Shahed aerial drones, mainly supported by technology and components from Iran and China.[2] Throughout 2024, the estimated number of Russian Shahed drone attacks in Ukraine averaged just under 1,000 per month. That number has currently increased to a monthly average of 5300 strikes.[3] This sharp increase underscores Russia's ability to scale production, sustain high operational tempo, and adapt to the evolving character of warfare.

In June 2025, during a meeting on the Russian State Rearmament Program, Putin announced that Russia is forming the Unmanned System Forces as a separate military branch.[4] Russia has clearly recognized the importance of unmanned systems in modern warfare and is accelerating its investments and technological development to keep pace with its adversaries.

While there is a wealth of articles and reports focused on Russian Unmanned Aerial Vehicles (UAVs), due to their prominent role in the war in Ukraine, far less attention has been given to the development of Russian Maritime Unmanned Systems (MUS), which in this context include all subsurface, surface, and air unmanned vehicles intended for naval operations. The reasons are at least twofold. First, there is limited publicly available and reliable information on Russian MUS; and second, the Russian Navy appears to be trailing behind its peers and has only recently initiated the development of such capabilities in collaboration with domestic maritime industry and partner nations. Even with a somewhat unclear picture, this article aims to explore how the development of MUS, in general aligns with Russian naval strategies, and more specifically the current state and future development of Russia's MUS programmes and capabilities. Furthermore, the article will broadly assess how these emerging naval capabilities may enhance Russian Maritime Intelligence, Surveillance, Reconnaissance (MISR), strengthening Anti-Access/Area Denial (A2/AD) measures in key regions, and enabling more sophisticated options for hybrid activities below the threshold of armed conflict.

RUSSIAN NAVAL STRATEGY AND AMBITIONS

During a strategic meeting in St. Petersburg in April 2025, while outlining a long-term development strategy for the Navy by 2050, including earmarking $100bn for constructing new naval vessels and capabilities over the coming decade, Putin stated that:

> *"...it is evident that the dynamics of the changing global situation, the emergence of new challenges and threats, including those in maritime domains, as well as the vigorous technological and digital revolution, robotization, and the widespread implementation of unmanned systems – all these necessitate the formation of a new profile for the Navy aiming to enhance its capabilities by 2050."* [5]

The Russian Navy has, during the last one and a half decade, undergone a period of modernization, focusing especially on developing new submarines, and smaller but still potent ships like frigates, and corvettes, fitted with high-precision weapons systems like the well-known Kalibr cruise missile. Despite the frequent delays typical of naval development programmes, Russia has, in less than two decades, managed to commission five Yasen-class nuclear attack submarines,[6] seven Borei-class nuclear ballistic missile submarines,[7] six frigates of the Admiral Grigorovich- and Admiral Gorshkov-class,[8] [9] and twenty corvettes of the Buyan-,[10] Steregushchiy-,[11] and Karakurt-class.[12]

Evidently, as a consequence of the war in Ukraine, Russia is facing significant challenges in maintaining the projected pace of its ambitious naval development programs. As described by the founding director of Russia Maritime Studies Institute at the US Naval War College, Dr. Michael B. Petersen, Russian naval shipbuilders will have to navigate the current debt crisis while simultaneously managing the results of sanctions, fundamental structural neglect, a lack of parts and sub-assemblies, and continued high demand for new and modernized vessels.[13] Nevertheless, several more naval platforms are under construction and expected to arrive by the end of this decade.

Current Russian naval strategy appears to follow two divergent conceptual paths. Influenced by the strategic thinking of Admiral Sergey G. Gorshkov, longtime head of the Soviet Navy (1956–1985), Russia still harbors ambitions to rebuild its navy into a global sea power reminiscent of its Cold War heyday. At the same time, Russia seems to acknowledge the limitations of this path and is complementing it with a naval strategy resembling the French Jeune École.[14] Developed in the late 19th century as a response to British maritime dominance, the Jeune École emphasized asymmetric naval warfare. Rather than relying on large battleships, advocating for numerous small, fast, and inexpensive vessels to disrupt enemy trade and challenge superior fleets. This strategy also emphasized economic warfare, sea denial, coastal defense, and technological innovation as viable methods for weaker navies to counter dominant sea powers. In this context, MUS may play a pivotal role in the Russian implementation of such a strategy, mitigating naval inferiority to its primary adversaries. Arguably, MUS fitted with artificial intelligence (AI) offers a cost-effective means for Russia to challenge the Alliance, particularly the United States, in the maritime domain, enhancing its ability to conduct MISR, sea denial operations, and hybrid activities. As observed by Dr. Katarzyna Zysk, Russia is experimenting with turning AI technology into a battlefield advantage in several fields, including UAVs, unmanned underwater vehicles (UUVs), ground-based robotic systems, unmanned boats and other innovative combat systems.[15] From a NATO perspective, the emerging threat posed by Russian MUS must be taken with the utmost seriousness. The Alliance's Area of Responsibility includes several chokepoints, littorals, congested and strategically vital maritime operations areas where MUS capabilities could have a significant impact in the future, including the Greenland-Iceland-UK-Norway gap, in the Baltic Sea, the Mediterranean, and the Black Sea. As a hypothetical scenario, the price of a single Admiral Grigorovich-class frigate, estimated at half a billion dollars, could instead fund the manufacture of roughly 2,000 maritime drones akin to Ukraine's Magura V5 USV.[16]

In May 2025, Russian media reported that unmanned systems regiments are being formed in all Russian naval fleets and will include air, land and maritime robotic systems. The Kremlin has stated that the key function of these new units will encompass reconnaissance and strike.[17] Before examining the Russian MUS initiatives in more detail, it is important to clarify that 'unmanned' does not equate to 'autonomous.' Simply put, the level of autonomy in MUS depends on the level of human involvement, including integration of Artificial Intelligence (AI) and Machine Learning. At the lowest level, all functions are operator-controlled; at the highest, the system can independently sense, decide, and act, reporting back post-mission. Currently, Russian MUS appear technologically immature and remain mostly at a demonstration-level. They are still heavily reliant on human operators and lag behind peer competitors in terms of autonomous capabilities. Nevertheless, as noted by Samuel Bendett of the Center for a New American Security, enhancing UAV capabilities with artificial intelligence as a core Command, Control, Communications, Computers, Cyber, Intelligence, Surveillance, and Reconnaissance enabler remains a central focus in both academic discourse and ongoing research and development efforts across Russia's defense-industrial complex.[18]

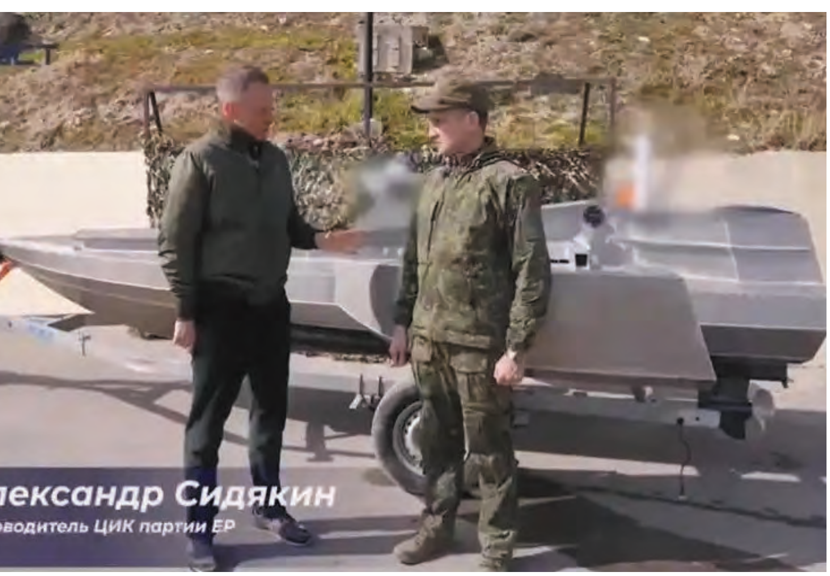
RUSSIAN MARITIME UNMANNED SYSTEMS

Currently, there has only been a handful of reported Russian attacks with the use of MUS in the war against Ukraine. In February 2023, Russian forces reportedly employed a One-Way Attack USV to strike the strategically significant Zatoka road and rail bridge, which connects the Ukrainian port city of Odesa with Moldova. This incident marks the first confirmed instance of Russian USV use in combat operations.[19] In early February 2025, the Russian Ministry of Defense reported that a Ukrainian USV heading toward the Crimean Peninsula was detected and neutralized by a missile-armed Kronstadt Orion UAV on station, suggesting a new tactic to offset Ukrainian MUS capabilities in the Black Sea.[20] Later, during the naval exercise "July Storm", Russia showcased a successful attack by a high payload MUS on a fixed maritime target in the Baltic Sea, completed with a dramatic explosion for the cameras.[21] Furthermore, in late 28 August 2025, the Ukrainian naval Intelligence ship (AGI)[22] Simferopol was attacked and heavily damaged by a Russian USV during nighttime in the delta of the Danube estuary.[23]

Even if there have not been any more confirmed Russian MUS strikes to date, Ukraine is getting increasingly concerned about the Russian ability to catch up with MUS technology. In February last year, at the Defense Tech Innovation Forum in Kyiv, the architect of the very successful Ukrainian naval drone program, Brigadier General Ivan Lukashevych of Ukraine's Security Service, warned that Russia, though with a delay of a couple of years, are replicating Ukraine's success in using sea drones.[24] In July 2025, one of the main developers of maritime drones in Russia, Kingisepp Machine-Building Plant (KMZ) announced that they had opened a centralized production facility for marine drones at their facilities in St. Petersburg.[25] The development of Russian MUS is ongoing, though it is frequently shrouded in secrecy and marked by ambitious claims from companies seeking government funding. Despite this opaque environment, the following offers an overview of some of the major Russian MUS programmes for which information is currently publicly available.

Unmanned Surface Vehicles

The most credible Russian USV to date is the relatively heavy Vizir depicted on the previous page. Developed by KMZ in St. Petersburg, it is fitted with a waterjet engine. According to the company, it is a versatile USV, capable of fulfilling multiple roles such as reconnaissance, cargo transport, or strike missions. It reportedly has a maximum speed of 80 km/h and a range of 500 km at low speed. The Vizir can be configured with heavy machine guns, light missiles, or a payload of up to 600 kg of explosives, effectively making it a One-Way-Attack drone. Additionally, it can be reconfigured for non-kinetic tasks like surveying coastal zones or seabed or used as an electronic warfare platform. In October 2024, KMZ's Managing Director, Mikhail Danilenko, claimed that tests had successfully demonstrated the drone's ability to hunt and destroy Ukrainian kamikaze drones that bypass Russia's coastal defenses. Being already invested in for serial production by Russia, several reports indicate that the maritime drone will be employed as a counter-USV in the Black Sea in the near future.[26,27,28,29]



Frame from a video of the Katran USV. Open-source photo.

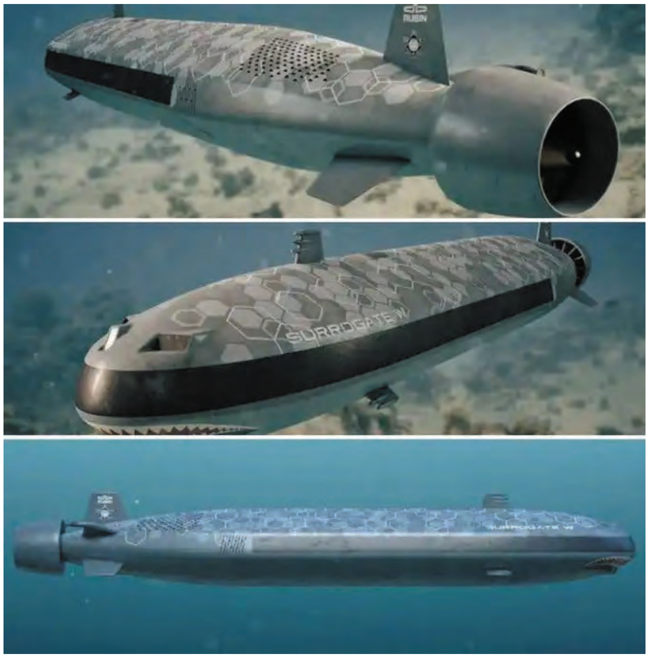
In March 2025, Ukrainian defense analysts reported that Russia's Center for Unmanned Systems and Technologies had delivered the Katran USV to the Black Sea Fleet for testing, configured either with a remotely operated 12.7mm Kord machine gun or Skvorets First-Person View (FPV) UAVs. These FPV UAVs, allegedly capable of recharging while aboard the Katran, have a 5–10 km range, speeds up to 150 km/h, and can carry 1.5 kg warheads. Defense analysts assess that this dual-mode system, integrating USVs and UAVs into a coordinated capability, is intended for low-signature reconnaissance and precision strikes against coastal military and civilian infrastructure. Additionally, it may be employed in a counter-drone role to defend against adversary unmanned systems. However, this project is still considered immature. The Katran lacks satellite communication capabilities, unlike Ukrainian sea drones equipped with systems like Starlink. Instead, it relies on radio channels, limiting its operational range to 100–200 km and making it susceptible to jamming.[30,31,32] Nonetheless, this ambitious project underscores Russia's determination to accelerate the advancement of its maritime unmanned systems capabilities, which are urgently needed in the Black Sea.

Murena 300s USV at the Russian Army 2024 exhibition. Photo from Telegram/Game of Drones

At the Russian Army-2024 defense exhibition, the Murena-300S USV was introduced by the company LLC KB Center for Unmanned Systems. Powered by a Mercury outboard motor, the platform bears a striking resemblance to the Ukrainian Magura V5 and SeaBaby. Several reports suggest that the Murena-300S may have been reverse-engineered, rather poorly, from a captured Ukrainian drone. According to the manufacturer, the multirole Murena-300S can cruise at speeds up to 45 km/h, carry a payload of up to 500 kg, conduct mine-laying, mine clearance, reconnaissance, and fire support, including carrying lightweight torpedoes. It is also stated that the Murena can operate in sea conditions up to Sea State 4. The platform is likely equipped with a thermal camera, an infrared system, and a Light Detection and Ranging (LiDAR) sensor suite. Unconfirmed reports indicate that the maritime drone may be equipped with a Starlink antenna, which, if accurate, could significantly improve its beyond-line-of-sight connectivity.[33,34,35]

Unmanned Underwater Vehicles

Surrogate-V is a heavy duty, 17-meter long UUV introduced by Rubin Central Design Bureau, the leading submarine developer in Russia.[36] According to the company, the UUV is specialized to operate alongside Russian submarines for ISR and target search operations, including mine detection. It may also be used during Anti-submarine Warfare (ASW) as a decoy to divert and deceive warship and aircraft detection systems. It has a maximum range of approximately 1500 km, powered by upgraded lithium-ion battery packs and a fundamentally new power plant based on electrochemical generators.[37]



Artist impression of Surrogate-V UUV from the Russian submarine design bureau Rubin.

In 2015, Russia revealed information through state media about the Poseidon UUV, a nuclear-powered, nuclear-armed unmanned underwater vehicle developed by the Rubin Central Design Bureau.[38] This torpedo-shaped robotic mini-submarine is reportedly capable of reaching speeds up to 100 km/h, with an estimated range of 10,000 kilometers and a maximum operating depth of 1,000 meters, according to its developer. Its primary function is assessed to be a second-strike weapon, designed to generate radioactive tsunamis and/or destroy enemy naval fleets.[39] In January 2023, Russian media reported that the first batch of Poseidon had been produced for deployment aboard the Belgorod special-purpose nuclear submarine,[40] which is assessed to be capable of carrying up to six of these UUVs. Satellite imagery and a subsequent statement from Putin indicate that the UUV was tested in the Kara Sea in October 2025.[41]

Unmanned Aerial Vehicles

The Orion UAV, designed for ISR and strike missions, is developed by the Kronstadt Group, designed for use across Russian service branches. The latest version, known as Sirius, has a wingspan of 30m, is assessed to have a maximum combat load of 450kg, a cruise speed of 295 km/h, a maximum altitude of 12,000m, and an endurance of 40 hours.[42] According to information published by Russian media on March 2, 2025, the Russian Navy has begun utilizing the Orion UAV system to protect its naval bases and anchored warships in the Black Sea, providing early warning and countering threats like Ukrainian USVs.[43] As previously stated, there are indications that it is already being employed with some measurable success.

ENHANCING RUSSIAN NAVAL CAPABILITIES WITH MUS

As previously noted, Russia is compelled to accelerate the development of its MUS to address existing naval capability shortfalls and reduce its inferiority relative to key adversaries, particularly in the areas of ISR and sea denial. Furthermore, given Russia's long-standing engagement in hybrid activities, MUS will clearly serve as an additional instrument in its expanding toolkit for asymmetric operations.

Maritime Intelligence, Surveillance, and Reconnaissance

Russia generally seeks to maintain its advantage over near-peer competitors in terms of geography, domain, and readiness within its spheres of influence. Fitted with AI, a range of sensors, and communication systems, MUS are expected to enhance Russia's ability to maintain persistent presence and situational awareness, particularly in maritime choke points, littoral zones, and other congested areas. As Russian MUS technology continues to mature, maritime ISR drones may be deployed in large numbers, benefiting from low energy consumption and persistent operating profiles. This would enable them to remain on station for extended periods, cover vast areas, and contribute to early warning and threat detection. Furthermore, their low signatures allow them to operate discreetly, or even covertly, forming an outer layer network of sensors in support of MISR.

Taking the Baltic Sea as an example, as capabilities mature, Russia could deploy MUS equipped with passive and active sensors, especially for signal intelligence[44] and imagery intelligence,[45] including satellite communication capable of reaching back to Kaliningrad or St. Petersburg, even from as far as the Norwegian Sea, Skagerrak, and certainly the Danish Straits, to build a comprehensive maritime operational picture. USVs may be equipped with different sensor systems, like thermal cameras, sonars, infrared systems, LiDAR, Antenna Arrays, Radio Receivers and Scanners, Radar Warning Receivers, AI-assisted Signal Processing Units, Data Links, Satellite Communication, and recording and storage modules. This will enable real-time or near-real-time transmission of collected data, enhancing Russia's situational awareness of NATO maritime force presence and activities. Moreover, Russian MUS would most likely be used to map seabed and port infrastructure and monitor the sea lines of communication. MUS offer a degree of passive ISR capability, and their low visual, acoustic, and radar signatures would facilitate covert monitoring of Allied critical national and mission-essential infrastructure in the Baltic Sea region.

Sea Denial

Russia has established layered, multi-domain A2/AD systems across several of its key areas of influence and defense. The introduction of MUS enhances this layered defense architecture, making it more resilient and persistent. A large number of one-way attack MUS, potentially equipped with missiles, torpedoes, mine-laying payloads, or even light-caliber weapons, would pose a significant challenge to any attempt by NATO naval forces, including allied MUS, to penetrate these zones. In congested and strategically vital areas, persistent MUS would provide the Russian Navy with an effective means to constrain Allied naval freedom of action and freedom of navigation. Given Russia's limited number of surface combatants, the low-risk profile of MUS makes them a natural force multiplier for enhancing its sea denial posture. By employing swarming tactics, these systems would saturate enemy sensors and weapon systems, exploit gaps in ship defenses, confuse targeting processes, and carry out kinetic or "suicide" strikes. In addition, when equipped with adequate sensors, these small platforms will contribute directly to target acquisition by detecting, identifying, and locating targets, thereby enabling effective engagement by larger long-range weapons systems in the future. In essence, MUS extend the reach and depth of the maritime battlespace, enabling Russia to establish 'dead zones' areas where the presence or movement of adversary naval forces becomes untenable. This capability could be particularly consequential in contested and confined waters such as the High North, the Baltic Sea, and the Black Sea.

Hybrid Activities

Russia has for decades exploited the gray areas between peace and armed conflict, often referred to as hybrid threats. As described by NATO:

> *Hybrid threats combine military and non-military as well as covert and overt means, including disinformation, cyber attacks, economic pressure, deployment of irregular armed groups and use of regular forces. Hybrid methods are used to blur the lines between war and peace, and attempt to sow doubt in the minds of target populations. They aim to destabilise and undermine societies.*[46]

While Russia's naval power has diminished compared to that of its Soviet predecessor, it is unsurprising that it seeks to augment its military capabilities through measures of influence, deception, and covert action. Arguably, Russia harbors no illusion of becoming a conventional peer competitor to a unified NATO in the maritime domain during an armed conflict, though achieving local or regional superiority remains within reach. In addition, Russia seeks to operate below the threshold of open confrontation, maintaining strategic ambiguity and plausible deniability.[47]

Hybrid activities are closely tied to asymmetric methods, which involve leveraging one's strengths against an adversary's weaknesses to offset conventional disadvantages and pursue strategic objectives. MUS, particularly UUVs, offer a means to do just that, providing covert operational capabilities to exploit vulnerabilities in both critical national and mission essential infrastructure across Allied nations, thereby shaping public perception and influencing strategic decision-making. More specifically, Russian MUS, being attritable and considered risk-worthy, may be employed to obstruct port operations, target offshore oil and gas installations, or sabotage seabed infrastructure such as pipelines and fiber-optic cables. Such actions have the potential to create fear and uncertainty, disrupt Western economies, and serve as a means to probe Allied resilience and cohesion. As experienced with the explosions on the Nord Stream I and II pipelines in the Baltic Sea in September 2022, attributing underwater attacks on civilian and military targets to a responsible party is challenging.

CONCLUSION

Russia harbors no illusion of becoming a conventional peer competitor to a unified NATO in the maritime domain during an armed conflict, though achieving local or regional superiority may still be within reach. Following its recent negative experiences in the Black Sea, Russia is intensifying its efforts to develop MUS. While it obviously still lags in this field, technological support, particularly from China, is accelerating progress. With recent structural initiatives, it is evident that the Kremlin recognizes the importance of unmanned systems as critical to future warfare, including the potential of MUS to enhance ISR, A2/AD, and hybrid operations at sea in congested areas.

Several MUS are currently in development or production, and these systems are likely to play an increasingly vital role in extending the reach, persistence, and complexity of Russian naval operations. MUS can contribute to early warning and situational awareness, strengthen layered sea denial posture in key regions, and provide new, low-attribution tools for hybrid activities. As stated by Rear Admiral Mike Mattis, the current director of Strategic Effects at U.S. Naval Forces Europe and Africa, as well as commander of the Combined Task Forces 166 and 66, "unmanned systems are not the solution to everything. They are a piece of the puzzle, and they are capable, in the right ocean space, of creating a sea denial effect."[48] Clearly, MUS represent a cost-effective way to compensate for Russia's limited number of conventional warships and are poised to become a central component of its future naval capability development and strategy.

The Russian Orion UAV is manufactured by the Russian Kronshtadt company. Photo from Kronshtadt.

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NATO'S DIGITAL TRANSFORMATION

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INTRODUCTION

Over the past several years, unmanned systems have become a popular tool for experimentation and adoption by NATO allies. As a part of its broader Digital Transformation initiative, NATO established Task Force X (TF-X) to further develop strategies in utilizing unmanned systems across tactical environments.[1] While the TF-X initiative successfully proved that military organizations can rapidly acquire and deploy innovative commercial technology to meet military operational requirements,[2] additional actions can and should be taken to build upon that initial success to achieve more holistic digital transformation in the maritime domain. These recommended actions include military organizational change by developing and codifying procedures for tasking and managing unmanned systems, meeting technical standards for integrating national unmanned systems into a NATO task force, and implementing on-the-edge (OTE) technology to ensure rapid and reliable communications and data transfer.

BACKGROUND

In 2025, NATO's TF-X, under Allied Command Transformation (ACT), have been focusing on enhancing maritime dominance through the integration of autonomous systems and artificial intelligence. The initiative emphasizes rapid innovation, leveraging commercial off-the-shelf (COTS) technologies, and enhancing interoperability between NATO allies. By fostering collaboration and adopting advanced technologies, TF-X seeks to maintain security in the maritime domain, ensuring the alliance can effectively respond to emerging threats and safeguard critical undersea infrastructure (CUI) and vital sea lines of communication.[3]

Earlier last year, TF-X Baltic showcased the rapid adoption of autonomous maritime technology in the Baltic Sea, proving its effectiveness for maritime vigilance. Phase I demonstrated that industry can quickly deliver useful, COTS-based solutions. Building on this success, Phase II focuses on national leadership, with Baltic nations adopting uncrewed systems at scale, enhancing capabilities, and integrating them into existing platforms. Countries like Sweden, Latvia, and Denmark have established dedicated institutions and programmes for these systems. While proactively leading initial operating capabilities in Phase I, ACT now acts as a facilitator who can assist with, manage, and ensure coherent regional collaboration. Future efforts involve establishing regional operations centers and exploring joint procurement approaches to accelerate maritime capability delivery.[4]

In addition to nations following TF-X's lead from this past year and taking more proactive steps to acquire COTS unmanned systems that make sense for their national navies, subsequent TF-X phases must also consider additional actions to build upon and further fortify the concept of use, organization, command and control (C2), tasking, and technical improvements of unmanned systems.

INTEGRATING UNMANNED SYSTEMS

In their 2022 study titled, "Military organisations and emerging technologies-How do unmanned systems find a role in future navies," Tarnholm and Liwang stated militaries must make organizational and procedural changes to effectively integrate with unmanned systems.[5] They recommend viewing these systems not just as add-ons but as components of a "system-of-systems" approach.[6] In this approach, the armed forces should be treated as sociotechnical systems that blend technical and social elements, necessitating structural and organizational reforms to optimize technology use.[7]

The study also emphasizes understanding the deployment context for new technology by considering the organization's operational concept and environment.[8] It is critical for the military organization to balance systems engineering, sociotechnical systems engineering, and organizational change processes.[9] Another need is closer collaboration among defense sector stakeholders that moves beyond an acquisition-focused approach.[10] Military operators and engineers must collaboratively develop experimental methods where technological advancements are aligned with organizational needs to address gaps in sociotechnical design approaches.[11] NATO and especially ACT are already practicing some of these insights to more effectively leverage emerging and disruptive technologies (EDT), but doctrine and tasking procedures need to be established to achieve efficient operations and use.

IN THE MARITIME DOMAIN

Standard Operating Procedures

NATO will need to develop a methodology for tasking national maritime unmanned systems (MUS) across different environments (i.e., air, surface, or underwater) based on intended alliance maritime missions when they are transferred to NATO authorities. This will be challenging as nations may not have the same national naval requirements, operational objectives, or even acquire the same or complementary unmanned systems. For example, one nation may only invest in unmanned aerial vehicles (UAVs) that are intended to be deployed from ships conducting blue water operations. Another nation may emphasis procuring unmanned surface vehicles (USVs) and deploy them in littoral or territorial waters. Another still may favor unmanned underwater vehicles (UUVs) to focus on protecting CUI. These complexities, in addition to a challenging maritime environment (e.g., sea state, harsh weather, humidity, wind, salt water, huge operating area), may make unmanned system tasking and tactical deployment more troublesome than originally thought.

In their paper titled, “Manned-Unmanned Teaming Challenges in the Maritime Environment,” Banas, Mehling, and their colleagues explored the integration of Manned-Unmanned Teaming (MUM-T) in maritime operations, highlighting the potential benefits and challenges in using UAVs specifically.[12] The authors conclude that while UAVs can enhance surveillance, reconnaissance, and communication abilities in naval missions, current technology and reliability issues limit their effectiveness within the maritime domain today. Essential improvements include better vehicle autonomy, advanced data links, and task-based control systems to reduce crew workload. Their interviews with German maritime pilots support the need for more robust and adaptable UAV designs to handle maritime environments and mission demands effectively.[13]

The NATO enterprise will need to work together to develop concepts and procedures for employing national unmanned systems when naval units are transferred to a NATO maritime authority for mission tasking. A baseline process must be established but also be simultaneously flexible and adaptable enough to effectively task whatever form of unmanned capabilities come with an allied ship or group.

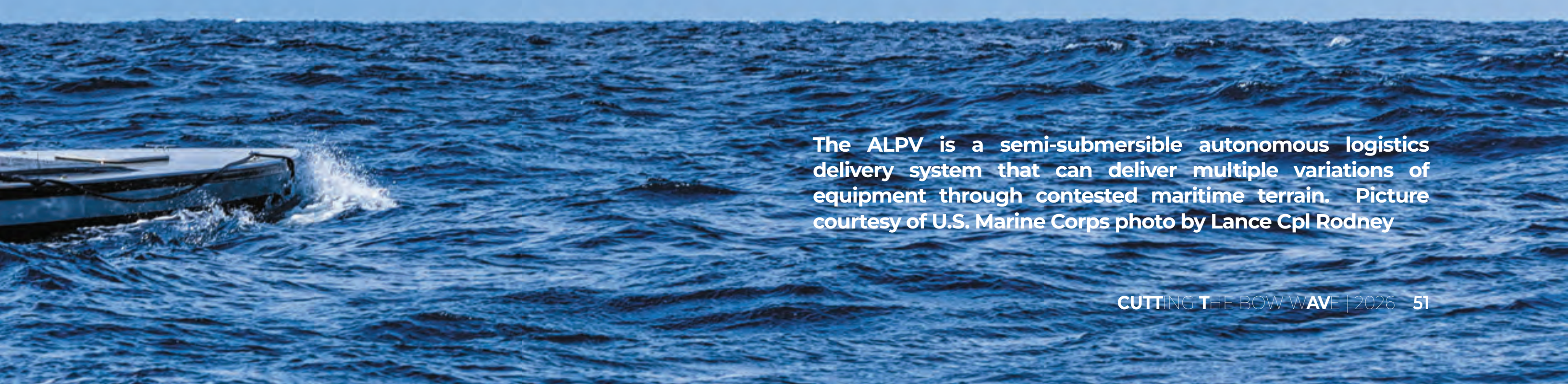
Commercially vs. Government Operated Capabilities

An additional planning consideration for headquarters, warfare development commands, and Maritime Operations Center (MOC) staff is developing procedures that will efficiently enable both commercial and military unmanned system capabilities providers/operators to work in concert with each other to benefit military planning. Though the technical means may be similar, the processes will differ based on who is operating the unmanned system.

One example of a “commercially owned-commercially operated (COCO)” model is Saildrone’s “Voyager” USV, which was exercised as part of NATO’s TF-X Baltic initiative in June 2025.[14] Saildrone’s business model utilizes “data as a service” (DaaS) where the private company maintains and operates the platform, the mission, and the data delivery independently from an official government body and then provides the collected data to the government or military customer. Saildrone successfully executed their USV capability and DaaS model during the Baltic demonstration, providing NATO operators with actionable data in real-time.[15]

While the DaaS methodology has numerous resource-saving benefits for militaries operating in today’s modern, digital age, it is a capability paradigm shift that differs from the traditional “government owned-government operated” (GOGO) model historically used for manned platforms but also unmanned military systems like the United States Navy’s MQ-4C Triton. Unmanned Patrol Squadrons 19 (VUP 19)[16] and 11 (VUP 11)[17] maintain and operate the MQ-4C Triton, a high-altitude, long-endurance unmanned aircraft providing persistent maritime intelligence, surveillance, and reconnaissance (ISR) capabilities with a range of 7,400 nautical miles. The U.S. Navy deploys the Triton alongside its P-8A Poseidon aircraft and its TacMobile ground support system as part of its Maritime Patrol and Reconnaissance Force family of systems that support maritime domain awareness.[18]

Both methods for utilizing unmanned systems provide modern capabilities to meet mission requirements, yet they each have unique procedural characteristics that must be simultaneously met to be effectively used together. Ignoring or failing to codify operating procedures and data/information flow will provide inefficient support to a MOC or other naval units and may introduce confusion or complications that degrade staff effectiveness when unmanned capabilities come with an allied ship or group.



The ALPV is a semi-submersible autonomous logistics delivery system that can deliver multiple variations of equipment through contested maritime terrain. Picture courtesy of U.S. Marine Corps photo by Lance Cpl Rodney

Maritime unmanned systems undergo trials during NATO's DYNAMIC MESSENGER 2025 exercise. Courtesy of NATO.

INTEGRATING NATIONAL ASSETS IN NATO TASK FORCES

The operational capability of a multinational autonomous Task Force (TF) is increasingly dependent on the coordinated deployment of diverse unmanned vehicles (UxV), encompassing air (UAV), underwater (UUV), and surface (USV). While UxVs offer crucial advantages in persistence and data collection, their technical diversity comes from varied national procurement, proprietary control systems, and differing technological maturity. This presents several interoperability challenges. Effective integration requires a unified command, shared situational awareness, and collaborative mission execution across the entire spectrum of unmanned vehicles.[19] To achieve this level of technical fusion, a standardized architectural approach is required. Wilmuth Müller et al. have identified some essential technical standards for merging multiple nations' unmanned systems into a single autonomous task force. These include a Standardized Communication Framework, Translation for Legacy UxVs, Levels of Interoperability (LOI), Standardized Data Formats, and support for Dynamic Mission Planning.[20]

Standardized Communication Framework

The initial requirement for multinational UxV integration is the adoption of a single communication standard that serves as the technical glue binding all vehicles together. This standard must define a common language and structure for how every UxV, regardless of its domain, receives tasking and reports status. The TF should mandate the use of mature standards such as the Joint Architecture for Unmanned Vehicles (JAUS)[21] or relevant NATO Standardization Agreements (STANAGs) such as STANAG 4586 (Standard Interfaces of UAV Control System (UCS) for NATO UAV Interoperability)[22] as the primary communication framework. The lack of a promulgated STANAG for UxV control in an all-domain context is currently a significant gap for NATO.[23]

The JAUS standard serves as a universal communication language for unmanned vehicles but is designed from a land perspective. It achieves this by separating a vehicle's core operating functions, like mobility, payload, and communications, from its specific physical design, allowing different types of unmanned vehicles to operate and be controlled using the same technical framework. This service-oriented approach creates a common operating language, which replaces the need for numerous, complex, and incompatible communication protocols with a single, universally accepted interface. For NATO, this technical uniformity is vital as it minimizes integration time, cuts development costs, and reduces the risk of communication failures when bridging proprietary systems. JAUS is good for helping different unmanned systems communicate. Still, it has two main weaknesses: it's overly focused on technical aspects, and it can't easily handle more practical instructions, such as making a payload perform a specific action when it reaches a particular waypoint.[24]

Translation and Adaptation

While a unified standard is the goal, the reality of a multinational procured TF is the inclusion of existing national/commercial UxVs; many of which use bespoke command and control, communications, computers, and intelligence (C4I) systems or existing middleware like Mission Oriented Operating Suite (MOOS).[25] A complete replacement of these in-service UxVs is impractical. Therefore, the integration architecture must explicitly accommodate existing assets through dedicated translation mechanisms. The architecture must utilize specialized, modular components that act as gateways to interface national vehicles and existing robotic middleware with the TF's common standardized network.

This concept is well-defined within established NATO architectures, such as STANAG 4586, which relies on the functions of two primary translators: the Vehicle Specific Module (VSM) and the C2 Interface Specific Module (CCISM). The VSM is responsible for translating the bespoke protocols of a national UxV platform (e.g., a UUV's unique navigation messages) into the standard message set required by the multinational C2 system. Conversely, the CCISM translates the standard C2 messages back into a format that can be consumed by legacy or national C4I systems. This translator-based support enables vehicles running existing open-source or proprietary middleware to join the standardized network without requiring costly, complex re-engineering of the vehicle's core software. This minimizes technical friction and maximizes the speed at which diverse national vehicles can achieve mission readiness within the joint operating environment.[26]

Define and Apply Levels of Interoperability

The technical landscape of UxV is characterized by significant diversity in size, processing power, and sensor capabilities. Small, resource-limited UxVs, which are often procured quickly for immediate tactical needs, may not possess the processing capacity or bandwidth to fully implement a robust, high-level standard. A successful multinational integration strategy must recognize this reality by defining clear, hierarchical Levels of Interoperability (LOI).

A TF should establish a system of clear LOI tiers, ranging from basic data exchange to full vehicle control, to accommodate the technological diversity and resource constraints of all participating UxVs. LOI provides a range of integration options, ensuring that every participating national asset can contribute at the highest level that its vehicle capabilities and compliance allow and maximize overall utility. The following is the LOI concept ranges from STANAG 4586:

Level 1 (Indirect Interoperability): Simple receipt/transmission of metadata (e.g., position, identification).

Level 2 (Direct Interoperability): Direct receipt and transmission of sensor and health data.

Level 3 (Payload Control): Full control over the sensor or mission package, but not the vehicle's path.

Level 4 (Vehicle Control): Full control of the vehicle's path and status (e.g. UUV route execution).

Level 5 (Launch and Recovery): Control and monitoring of the UxV vehicle including full launch and recovery operations.

By utilizing LOI, a resource-limited national UUV can be integrated at Level 2, effectively providing valuable sonar data to the network, while more advanced vehicles operate at Level 5. This approach prevents the 'lowest common denominator' problem and maximizes operational contribution across the technological spectrum.

Standardize Data Formats

Beyond the C2 message structure, interoperability at the data layer is essential for achieving a Common Operational Picture (COP). If a UxV from one nation reports a contact in a format unreadable by the Command Station of another, collective intelligence fails. The integration architecture must therefore mandate the use of standardized data formats for all sensor and payload output. Strict compliance with established STANAGs for all sensor and payload data would ensure shared situational awareness and effective exploitation across the TFs.

NATO relies on a suite of standards that governs the dissemination of intelligence products, providing a critical foundation for collective ISR.[27] Furthermore, standards like STANAG 4817 are being drafted to ensure a common format and language for C2 messages (including positioning and contacts) used by maritime unmanned systems (MUS).

Dynamic Mission Planning and Adjustable Automation

The complexity of orchestrating multiple UxV types from various nations demands an interoperability standard that supports dynamic tasking, collaborative coordination, and adaptive human-vehicle teaming. The architecture must enable controllers to rapidly define mission goals, assign roles, and dynamically adjust each vehicle's autonomy in response to changing battlefield conditions or communication constraints. The adopted standard must define technical concepts (e.g., roles, responsibilities, and task primitives) and provide the technical means for operators to dynamically command and coordinate UxV teams, including the implementation of adjustable automation capabilities. Effective diverse team management requires the C2 system to process mission goals, account for vehicle capabilities, and allocate tasks based on the standardized service architecture. Adjustable automation is a critical feature, providing the technical means for an operator to dynamically adjust a vehicle's level of independence, seamlessly moving it from fully autonomous route execution to teleoperated, supervised control, and back again. This capability is paramount for two main reasons.

The first reason is safety and workload management. Adjustable automation ensures that human controllers can reduce a vehicle's autonomy when faced with an unexpected hazard or a complex decision, thereby maintaining safety and managing human workload, especially in high-stress, data-rich multi-domain operations.[28]

The second reason is communications resilience. In multinational operations, communications degradation (e.g., latency, link loss) is common. The standard must allow the

The Rattler USV escorts HMS Tyne off the coast of Scotland in Oct. 25. Courtesy of RN, photo by LPhot Daniel Bladen.

operator to pre-define the vehicle's "fail-safe" or contingency automation level. For example, a UUV might be operating at high autonomy (Level 5) but automatically degrade to a lower, fully pre-programmed safe search pattern (Level 3) if communications are temporarily lost.

By enforcing NATO standards that incorporate these concepts, the TF ensures that mission planning remains flexible, coordination is effective, and human operators can safely and efficiently manage large, complex teams of heterogeneous unmanned vehicles.

IMPLEMENTING ON-THE-EDGE TECHNOLOGY

TF-X demonstrated how NATO transforms innovation into operational advantage, turning emerging technology into strategic capabilities[29] that allow NATO navies to conduct maritime domain awareness (MDA) across the North Atlantic and European theaters. John Mustin, a former U.S. Navy Vice Admiral and current president of Saildrone, said, "Maritime domain awareness is the foundation of security in the region, and the Baltic nations must maintain a persistent, comprehensive picture of what takes place on, above, and below the surface."[30] While MDA missions are enhanced by unmanned systems, that advantage is only achievable with real-time data speed via high bandwidth communications. One solution to manage bandwidth utilization on unmanned systems that is already being adopted by militaries is OTE or edge computing.[31]

The Importance of On-the-Edge Technology

Currently, most platforms still rely on over-the-horizon communications and cloud servers to exchange data, which can consume significant bandwidth, degrade data quality, and increase latency. OTE technology, also known as edge computing, involves local processing of data to reduce bandwidth usage and increase response rates as data is passed. OTE devices work by only sending necessary data to a central server or processing unit. By doing so, latency can be significantly reduced and bandwidth costs minimized. Additionally, there is a computing method known as edge-to-edge, in which the necessary data bypasses transmission to the central server and is sent directly to another edge device within an organization's network. This allows for frequent, instant collaboration between edge devices as needed. Microsoft Azure describes edge computing as a distributed model that "reduces latency and strengthens resilience."[32] When it comes to decision-making, the latency and slow transmission of critical data can cause a delay in the ability to make informed decisions.

Ultimately, this can threaten the safety and efficiency of maritime operations.[33] With edge computing removing the reliance on a central system for further processing, decisions can be made quickly in a contested environment by warfighters.[34]

The advantages of implementing edge computing in maritime systems include reduced reliance on internet connectivity through local processing, faster response rates, enhanced efficiency of operations, and reduced bandwidth usage, particularly in denied and degraded environments. According to Scale Computing, "edge computing is a cornerstone in the digital evolution of maritime operations."[35]

Commercial Leadership in Edge Computing

According to Markets and Markets, a management consulting firm, the global edge computing market is rapidly growing with an anticipated projection over $81 billion between 2025 and 2030.[36] Hewlett-Packard Enterprise, Amazon Web Services, Microsoft, and Cisco are leading the U.S. edge technology market[37] while Eurotech S.p.A., ADLINK Technology, and Advantech Europe lead the pack in Europe.[38] Likewise, defense companies are being funded to expand their maritime autonomous system capabilities. In October 2025, Hoverfly Technologies, the current U.S. leader in tethered drone systems, received $20 million in funding, the largest capital raise in company history.[39] Similarly, Lockheed Martin invested $50 million in Saildrone, the U.S. manufacturer of USVs.[40] The NATO Innovation Fund (NIF) is also investing to expand the Alliance's autonomous maritime capabilities, funding an undisclosed amount in Kraken, a United Kingdom-based USV company.[41] This presents an ideal opportunity for TF-X and NATO to merge OTE with maritime unmanned systems.

Saildrone utilizes sensors that collect data-processed OTE, which allows the discovery of threats as they arise.[42] France's SeaOwl Technologies uses the Videosoft FireLight platform in their Beluga USV model, which can support continuous live video streaming with minimal bandwidth. Videosoft Firelight also allows you to retrieve and download high-quality video and data from the edge, regardless of the lack of detail provided by an encoded live stream.[43] In an article written by Joe Macey, a content specialist at Unmanned Systems Technology, he describes Videosoft FireLight as a platform "designed to overcome offshore obstacles like high latency, interference, and bandwidth constraints, the artificial intelligence (AI)-ready FireLight platform ensures uninterrupted, multi-stream video transmission. By providing reliable, low-latency visuals across any network, this breakthrough technology elevates mission-critical USV operations, enabling seamless situational awareness and enhanced decision-making in real time."[44] Hoverfly's NEXUS (Network Extension of Unmanned Systems) works by extending network coverage across

A Saildrone Explorer and Devil Ray T 38 operate together during Exercise Digital shield. Courtesy of US Navy.

multiple unmanned systems. This allows for uninterrupted data exchange between systems. Exchanging data in real time increases awareness and supports rapid adjustment to evolving conditions. Additionally, NEXUS is not a proprietary Hoverfly product; therefore, it can be implemented across various unmanned platforms with the goal of having multiple systems under the management of a single C2 network.[45] Each of these companies have contributed vessels and demonstrated their capabilities during several TF-X events.

CONCLUSION

In summary, NATO's TF-X has significantly advanced the integration of unmanned systems into maritime operations, showcasing the potential of commercial technologies and innovative strategies to enhance tactical and strategic capabilities. The successful adoption of COTS technologies during Phase I demonstrated the feasibility and effectiveness of rapidly integrating unmanned systems for enhanced maritime vigilance and potentially other naval operations. However, for NATO to achieve a more comprehensive digital transformation in the maritime domain, it is essential to focus on several critical areas.

Firstly, developing and codifying procedures for tasking and managing unmanned systems across different environments will ensure streamlined operations and interoperability among NATO allies. Standardizing technical frameworks and communication protocols, such as adopting JAUS and relevant NATO STANAGs, is crucial to overcoming interoperability challenges and enabling effective integration of diverse unmanned vehicles.

Secondly, implementing OTE technology will enhance real-time data processing and ensure reliable communication, reducing latency and bandwidth usage. This technological advancement is vital for maintaining situational awareness and enabling rapid decision-making in contested environments.

Thirdly, fostering collaboration among NATO nations and commercial vendors can accelerate innovation and adoption of edge computing solutions, further enhancing the capabilities of unmanned systems.

By addressing these areas, NATO can build upon the initial successes of TF-X, achieving a holistic digital transformation that ensures strategic superiority and operational readiness in the maritime domain, ultimately fortifying collective security and enhancing the alliance's ability to respond to emerging threats.

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THE POLAR SILK ROAD

CHINA AND ITS DOCTRINE "NEAR-ARCTIC STATE"

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THE ARCTIC GEOPOLITICAL INFLECTION POINT

The Arctic region, long characterized by its geographical isolation and the extreme physical barriers of perennial ice, has entered a period of unprecedented transformation. This shift is not merely an environmental crisis defined by the alarming rate of ice melt; it represents a profound strategic realignment that is redrawing the map of global commerce and security. As the receding sea ice unlocks previously inaccessible maritime corridors and exposes vast, untapped deposits of hydrocarbons and critical minerals, the High North has transitioned from a zone of "exceptionalism" and low tension into a contested theater of multi-domain competition. In this emerging landscape, the People's Republic of China (PRC) has emerged as the most determined and strategically patient non-Arctic actor, formalizing its long-term ambitions through the architecture of the Polar Silk Road.[1]

Historically, the governance of the Arctic was the exclusive domain of the "Arctic Eight" (the littoral and sovereign states that held undisputed authority over the region's development and security). However, the 21st century has seen Beijing systematically challenge this regionalist status quo. The core of this challenge lies in China's "Near-Arctic State" doctrine, a sophisticated legal and political construct introduced to the international stage to justify its expanding footprint in a region where it possesses no territorial sovereignty.[2] This article contends that this doctrine is a calculated instrument of "normative statecraft", designed to erode the traditional exclusivity of Arctic sovereign nations and create a justification for a persistent, dual-use presence that directly threatens the collective security of the NATO Alliance.[3]

For the Alliance, the arrival of the PRC in the High North is not a mere commercial curiosity. It represents a multi-domain strategic challenge where the lines between civilian research, economic investment, and military intelligence are intentionally blurred. China's approach to the Arctic is characterized by "strategic patience" combined with "creeping expansionism", utilizing the veneer of scientific cooperation and infrastructure development to build the capabilities necessary for future naval and aerospace projection.[4] The opening of Arctic sea lanes, such as the Northern Sea Route (NSR), creates a classic "security dilemma": every logistical gain made by a non-aligned, autocratic power in the region potentially subtracts from the situational awareness and defensive depth of the NATO Northern Flank.[5]

DECODING THE "NEAR-ARCTIC STATE" DOCTRINE

The formalization of China's Arctic ambitions reached a critical milestone in January 2018 with the publication of its seminal Arctic White Paper.[6] This document was far more than a policy summary; it was an act of discursive power intended to rewrite the rules of regional participation. By coining the term "Near-Arctic State", Beijing attempted to create a new category in international relations, one that grants political rights based on interests and proximity rather than just territorial sovereignty.[7]

The Construction of a Pseudo-Geographical Identity

Beijing's justification for this doctrine rests on a carefully curated blend of environmental science and political rhetoric. The PRC argues that because the Arctic's climate, specifically its influence on the monsoons and weather patterns of the Northern Hemisphere, directly impacts China's food security and ecological stability, Beijing claims a legitimate interest in the region's governance.[8] However, this is a strategic non-sequitur. While the environmental impacts of the Arctic are global, China's attempt to derive specific political and maritime rights from these impacts is a radical departure from established international norms.[9]

Chinese Icebreakers Xuelong and Xuelong 2 in 2019. Photo: Wu Yue / Xinhua.

The term Near-Arctic itself is geographically suspicious. China's northernmost point is thousands of kilometers from the Arctic Circle, yet the doctrine asserts that this proximity justifies a consultative role in regional affairs. This represents a deliberate attempt to shift from a sovereignty-centric model of governance toward an interest-based framework.[10] By doing so, China aims to bypass the Arctic Council's hierarchy, where non-Arctic states are relegated to observer status with no voting power. Beijing is essentially demanding a seat at the table as a peer to the Arctic Eight, framing itself as a major stakeholder whose voice is essential for the peaceful and sustainable development of the region.[11]

Weaponization of the Global Commons

A central pillar of the Near-Arctic doctrine is the selective and weaponized interpretation of the United Nations Convention on the Law of the Sea (UNCLOS). China meticulously emphasizes the rights of all states to conduct peaceful activities in the high seas, including freedom of navigation, overflight, and scientific research.[12] In its rhetoric, the central Arctic Ocean is frequently referred to as a Global Commons or the common heritage of mankind; terms traditionally reserved for deep-seabed mining under the International Seabed Authority.[13]

This is a direct assault on the regionalism of the Arctic littoral states. By framing the Arctic as an international zone, China seeks to dilute the sovereign rights of countries like Canada, Denmark (Greenland), and the United States over their Exclusive Economic Zones) and continental shelves.[14] The paradox is stark: while China vigorously defends its own expansive (and illegal) territorial claims in the South China Sea, rejecting UNCLOS rulings when they don't suit its interests, it demands a strict, maximalist application of UNCLOS in the Arctic to weaken the boundaries of others . This normative hypocrisy is a hallmark of China's global strategy: leveraging the rules-based order to dismantle regional defense perimeters while building its own fortress in the Indo-Pacific.

Ultimately, the Near-Arctic State doctrine serves as a legal Trojan Horse. It provides a veneer of legitimacy to activities that are inherently dual-use. Under the guise of exercising its universal rights to scientific research, China can deploy sensors, map the seabed, and monitor satellite passes, all of which are essential for its goal of becoming a "Polar Great Power" capable of challenging Western hegemony in the High North.[15]

GREENLAND: THE STRATEGIC CENTER OF GRAVITY

To understand the magnitude of China's ambition, it is imperative to focus on Greenland. Within the shifting dynamics of the global strategic landscape, the Arctic has emerged as a critical theater, and Greenland is its most pivotal piece. With its unique geographical position, the island not only dominates the access routes to the North Atlantic but also acts as the sentinel of North America's northern flank. China has identified this critical importance and has deployed a strategy of economic statecraft that seeks to transform financial dependence into permanent geopolitical influence.[16]

The Assault on Critical Infrastructure

The Chinese strategy in Greenland is a case study on how capital can be used as a military vanguard. In 2018, the Chinese state-owned enterprise China Communications Construction Company positioned itself to finance and build three international airports in Greenland (Nuuk, Ilulissat, and Qaqortoq). For the autonomous government of Nuuk, the offer was tempting: a fast track toward modernization and economic independence from Copenhagen. However, for NATO and Washington, the prospect of an entity linked to the Chinese Communist Party controlling the island's most vital transport infrastructure was a strategic nightmare.[17]

The direct intervention of the United States and the Kingdom of Denmark to block this agreement underscores an undeniable reality: any "civilian" port or airport built with Chinese capital in Greenland has the potential to be converted into a logistical support node for the People's Liberation Army Navy (PLAN). If China were to secure a right of access or ownership over these facilities, it would effectively invalidate the strategic depth provided by the North American Aerospace Defense Command.[18]

Rare Earths and Control of the Green Transition

Beyond logistics, Greenland possesses some of the world's largest deposits of rare earth elements, such as the Kvanefjeld project. China, which already controls most of the global supply chain for these materials, has actively sought to monopolize these deposits through stakes in local mining companies.[19]

This control is not only economic; it is a force multiplier. Rare earths are essential for manufacturing fighter jet engines, missile guidance systems, and renewable energy technologies. By securing control of Greenland's resources, Beijing seeks not only financial benefits but the ability to strangle the defense production lines of Western Allies in the event of conflict. The struggle for Greenland's minerals is, in essence, a struggle for NATO's technological autonomy in the 21st century.[20]

DUAL-USE TECHNOLOGY AND SEABED WARFARE

The Polar Silk Road is not just a network of ships and ports; it is a vast data architecture. China is applying its concept of Military-Civil Fusion with precision in the Arctic, using science as a cover for persistent surveillance. This technological dimension represents perhaps the most difficult challenge for the Alliance to counter, as it operates in the gray zone of international law.[21]

The Scientific Trojan Horse and the BeiDou System

China justifies its presence in the Arctic through scientific research, deploying data buoys, research stations like the Yellow River Station in Svalbard, and state-of-the-art icebreakers. However, every hydrographic sensor deployed by Beijing collects critical data that has a dual purpose. Submarine terrain mapping, salinity, and water thermals do not only serve climate change studies; they are essential operational data for Chinese nuclear submarines to navigate silently and safely under the Arctic ice.[22] [23]

A team from China's icebreaker research vessel Xue Long deploying a buoy in the Arctic Ocean. Photo: Wu Yue / Xinhua.

Furthermore, the expansion of ground stations for the BeiDou satellite system in the Nordic region allows China to improve the accuracy of its Positioning, Navigation, and Synchronization systems at high latitudes. This is fundamental for long-range missile guidance and the coordination of Maritime Intelligence, Surveillance, and Reconnaissance (MISR) operations. These stations, often located in the territory of NATO Allies or partners, provide Beijing with a constant window into Western satellite activities and orbital traffic.[24]

The Threat to the Seabed and the Digital Silk Road

The Arctic is a critical node for the undersea fiber-optic cables that connect Europe, Asia, and North America. Under the umbrella of the "Digital Silk Road," China seeks not only to build these cables but also to monitor them. China's capability to conduct seabed warfare has advanced drastically. Using autonomous underwater vehicles (AUVs) deployed from nominally civilian research ships, Beijing can map NATO's critical infrastructure, including data cables and gas pipelines. In a crisis scenario, this persistent presence on the seabed would allow China, or its partner Russia, to sabotage Allied communications with plausible deniability. The Nord Stream sabotage serves as a stark reminder of the vulnerability of these assets. For NATO, protecting the Arctic seabed against Chinese technological intrusion must be as high a priority as defending the airspace.[25 26]

THE SINO-RUSSIAN ARCTIC AXIS

The relationship between the PRC and the Russian Federation in the High North represents one of the most complex and consequential geopolitical dynamics of the 21st century. Historically, Russia has viewed the Arctic as its national fortress, a sanctuary for its second-strike nuclear capability and a critical economic corridor under Moscow's strict sovereign control. However, the geopolitical earthquake of the 2022 invasion of Ukraine and the subsequent imposition of unprecedented Western sanctions have fundamentally altered the power balance in this partnership. Russia's pivot to the east is no longer a strategic choice; it is an existential necessity, and the Arctic has become the primary laboratory for this forced convergence.[27]

From Sovereignty to Dependency: The Post-2022 Reality

Before 2022, the Kremlin was deeply hesitant to allow Chinese investment in its critical Arctic infrastructure, fearing that Beijing's long-term goal was to internationalize the NSR and undermine Russian domestic control. This era of Russian Arctic exclusivism has been forcibly ended by the flight of Western capital and technology. Projects such as Yamal LNG (Liquefied Natural Gas) and Arctic LNG-2, which were originally developed with European and Japanese partners, now rely almost entirely on Chinese financing and engineering. China has filled this vacuum with a predatory pragmatism, providing the funds necessary to keep Russia's energy-driven economy afloat while demanding intimate access to Russian hydrographic data and maritime facilities.[28 29]

This dependency creates a profound sovereignty trap for Moscow. While official rhetoric emphasizes a "no-limits" partnership, the internal reality is one of growing Russian anxiety. China views the NSR as a public maritime highway, a vital component of the Polar Silk Road, whereas Russia continues to claim the route as internal waters. As China increases its icebreaking capacity and naval presence, it will inevitably challenge the Russian requirement for mandatory pilots and fees, leading to a friction point that NATO can exploit. For the Alliance, understanding this latent mistrust is essential: the Sino-Russian axis is not a monolith, but a transactional partnership that remains vulnerable to its own internal contradictions.[30 31]

The Technological Exchange and Naval Interoperability

The cooperation is increasingly extending into the military and technological spheres. In recent years, we have seen the emergence of joint Sino-Russian maritime patrols in the North Pacific and near the Aleutian Islands, signaling a new level of operational coordination. Furthermore, Russia's expertise in nuclear icebreaking and deep-sea technology is being traded for Chinese expertise in microelectronics and satellite-based surveillance. This exchange is critical for China's goal of operating in blue water environments beneath the Arctic ice. By leveraging Russian northern bases, the PLAN can project power into the North Atlantic without having to pass through the traditional chokepoints of the Indo-Pacific, such as the Malacca Strait. This Northern Backdoor strategy is a direct challenge to the defensive depth of the NATO Alliance.[32 33]

NATO'S MULTI-DOMAIN DETERRENCE

The transformation of the Arctic into a contested space requires a fundamental shift in NATO's posture. The era of Arctic exceptionalism, the idea that the High North could remain a zone of low tension regardless of global conflicts, is over. With the accession of Finland and Sweden to NATO, the Alliance now possesses a consolidated northern flank; however, this geographic advantage must be operationalized through the rigorous application of Multi-Domain Operations and persistent deterrence tailored to the unique environmental and strategic demands of the High North.[34]

All-Domain C2 and the Intelligence Gap

The primary challenge for NATO in the Arctic is situational awareness. The vast distances and extreme atmospheric conditions make traditional surveillance difficult. To counter China's MISR capabilities, the Alliance should accelerate the implementation of Joint All-Domain Command and Control (JADC2).[35] This framework is essential for integrating data from undersea sensors, unmanned aerial vehicles, and space-based assets into a single, real-time operating picture.

NATO should also address the vulnerability of its Critical Undersea Infrastructure (CUI). The Polar Silk Road includes a "Digital Silk Road" component, where China aims to build and monitor the subsea fiber-optic cables that connect the global economy. As we have seen in recent sabotage incidents, the seabed is now a front line. NATO's development of Seabed Warfare capabilities, utilizing AI-driven AUVs, is no longer optional; it is a prerequisite for ensuring that the Alliance's communications remain secure against Chinese and Russian hybrid interference.[36 37 38]

THE STRATEGIC REALIGNMENT OF THE ARCTIC

The trajectory of China's "Near-Arctic" doctrine indicates a decisive shift from normative expansion to operational normalization. Over the next decade, China is expected to transition from a "Near-Arctic State" to a "Persistent Arctic Presence". By 2035, China will likely possess a fleet of nuclear-powered icebreakers capable of year-round operations, supported by regular deployments of surface combatants and submarines. This Polar Silk Road will serve as a fully functional logistical alternative to the Suez Canal, granting Beijing significant economic leverage over European markets.

This evolution into a "Polar Great Power" reality is validated by several strategic pillars:

- Normative Erosion: China has systematically weaponized UNCLOS and the global commons concept to challenge the sovereign authority of the Arctic Council and littoral states. By 2030, Beijing is likely to challenge NSR regulations using freedom of navigation rhetoric to justify a persistent naval presence.
- Irreversible Dual Presence: Through strategic investments in Greenland and satellite ground nodes, Beijing has created "facts on the ground" providing surveillance capabilities rivaling traditional military networks. If NATO fails to provide economic alternatives to Greenland, dual-use facilities could serve as permanent Chinese listening posts.
- Strategic Fusion and Hybrid Warfare: The Sino-Russian "Axis of Convenience" will extend the Russian Anti-Access Area Denial (A2/AD) bubble to include Chinese sensor networks, while the rise of undersea hybrid warfare will allow Beijing to map NATO submarine signatures and monitor CUI.[39]

ENHANCING NATO DETERRENCE

The High North is a new front line of 21st-century competition, requiring the Alliance to move beyond a watch-and-wait posture. To ensure the region remains governed by a rules-based order rather than authoritarian expansionism, NATO must adopt a unified strategy prioritizing economic resilience and technological superiority. Implementing this strategy requires, firstly, securing critical logistical nodes and maritime infrastructure to counter foreign economic statecraft, ensuring that Allied freedom of movement is never compromised by predatory investment. Secondly, the Alliance must increase Maritime Domain Awareness by integrating specialized ice-class unmanned systems to close the intelligence gap in extreme conditions. Finally, NATO should counteract hybrid threats by accelerating investments in JADC2 and seabed defense, while modernizing legal frameworks to categorize dual-use scientific research as a potential security threat when it directly compromises collective defense.

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UNMANNED DRONE CARRIERS AND
New Pieces in the Future Warfare Puzzle

By MAJOR (ROU-N) Roxana-Gabriela Damian


AI-generated conceptual depiction of a Drone Carrier executing unmanned aerial and naval operations.

INTRODUCTION

Over the past decades, the proliferation of unmanned systems has generated significant force-design implications and driven substantial adaptation across the DOTMLPFI spectrum – doctrine, organization, training, materiel, leadership, personnel, facilities, and interoperability. These developments have propelled warfare into a rapidly transforming era, driving an agile reassessment of traditional operational concepts and creating a growing demand for specialized platforms capable of supporting the deployment and integration of these emerging capabilities.

This article explores the innovative concepts of unmanned drone carriers and motherships as versatile naval and air platforms designed to deploy, recover, and sustain unmanned systems across multiple domains, thereby facilitating a sophisticated, technology-driven projection of power at the leading edge of contested environments. By analyzing existing platforms alongside cutting-edge conceptual designs, it evaluates the contribution of these systems to operational effectiveness and assesses their implications for future naval strategy.

The strategic urgency of adopting a dynamic posture toward the evolving warfighting landscape lies in remaining competitive through not only the effective integration of these capabilities, but also the ability to counter their employment by potential adversaries, ensuring that blue forces preserve decision and operational advantage in the future battlespace.

To truly appreciate the strategic landscape, the reader is asked to navigate a linguistic minefield where traditional definitions are beginning to fray. The semantics regarding the similarities and distinctions between the terms 'carrier' and 'mothership' reflect the more recent literature reviewed, rather than a fixation on a formal, updated taxonomy that has yet to catch up with the pace of innovation.

For the purpose of this article, an unmanned drone carrier should be viewed as the successor to the legacy carrier ship; it is a mobile launchpad and recovery deck designed for independent strike Unmanned Vehicles (UxV).[1] However, designating a platform as "unmanned" does more than just remove the pilot; it opens the door to a new ship class rather than merely retrofitting existing hulls. In contrast, the term mothership is a concept borrowed from science fiction and wargaming. It describes an aerial platform that is more than just a bus for Unmanned Aerial Vehicles (UAV); it is a literal "host" or "hub," providing the essential command, control,

MOTHERSHIPS

and "life-support" infrastructure—such as mid-air rearming and data processing—that allows its subordinate swarm to function as a unified, persistent extension of the parent craft in a meshed combat action.

HYBRID DRONE CARRIERS: MANNED–UNMANNED

The growing operational relevance of unmanned systems is reshaping how naval forces conduct intelligence, surveillance, reconnaissance, and strike tasks. Unmanned assets aboard warships is progressively evolving toward a more distributed fleet construct where UxV are no longer supporting elements, but rather, central contributors to combat effectiveness and persistence.

This transition reflects a broader shift in maritime power projection logic, moving beyond reliance on large, crewed capital ships toward more flexible and scalable approaches. Within this context, the traditional dominance of the aircraft carrier as the primary instrument of sea-based power projection is being complemented by the emergence of unmanned drone carriers and motherships —platforms specifically designed to deploy, sustain, and coordinate unmanned capabilities. As technological maturity and operational demands converge, the unmanned drone carrier is transitioning from conceptual exploration to an increasingly tangible component of future naval force architecture.

Examining existing initiatives, including operational platforms, systems under development or prototyping, and conceptual or technical proposals provides the necessary context for understanding how unmanned drone carriers and air motherships may shape future operational effectiveness and influence the evolution of warfare strategy.

Manned and Unmanned Drone Carriers

The evolving battlefields of Ukraine and the Middle East have demonstrated that the prevalence of unmanned aerial systems (UAS) is no longer a peripheral tactical advantage but a core strategic necessity. As global navies pivot toward these technologies, the transition from traditional hulls to dedicated unmanned drone carriers or motherships represents a fundamental shift in naval architecture and power projection.

In modern naval discourse, a drone carrier is defined as a maritime platform engineered primarily for the launch, recovery, and command of unmanned vehicles. While most naval UAVs are currently integrated into existing ship classes, the dedicated drone carrier functions as a centralized hub for multi-domain operations.[2]

This emerging class of vessels fundamentally extends the traditional aircraft carrier's role by functioning as a sophisticated command and control node capable of managing complex data links and synchronizing autonomous UxV swarm behaviors in real time. Beyond its role in signaling, the platform serves as a vital logistics hub that provides the specialized maintenance and rapid re-arming capabilities necessary to sustain diverse drone payloads during prolonged engagements. Ultimately, the platform operates as a comprehensive multi-domain carrier, providing a unified launch and recovery environment that supports not only UAVs but also unmanned surface vessels and underwater vehicles within a single integrated battle-space architecture.

The debate regarding the optimal configuration of these systems centers on the trade-off between human intuition and autonomous efficiency. Manned drone carriers, often derived from modified amphibious assault ships, offer a versatile hybrid capability where a human crew can manage complex logistics, perform physical repairs, and provide critical "man-in-the-loop" decision-making during unpredictable electronic warfare scenarios. Conversely, the fully unmanned carrier represents a shift toward a more specialized and potentially expendable asset, where the removal of life-support systems and crew quarters allows the internal volume to be entirely dedicated to maximizing fuel, ordnance, and drone density. While the manned carrier excels in multi-mission flexibility and resilience, the unmanned variant offers a high-attrition solution for projecting power deep within contested anti-access and area-denial zones where the risk to human personnel would be strategically prohibitive. Consequently, the unmanned carrier evolves into a "Swarm Mother," serving as a persistent, floating battery and launchpad capable of maintaining station for months to provide uninterrupted surveillance and precision-strike capabilities.[3]

As of early 2026, the transition from conceptual drone carriers to operational maritime reality has accelerated. While traditional navies continue to integrate unmanned systems into existing multi-mission ships, a specialized class of "flat-top" carriers is emerging, designed specifically to harness the mass and persistence of autonomous swarms. These platforms represent a lower-risk, cost-effective pathway to naval air power, offering a strategic alternative to multi-billion dollar conventional carriers.

The current landscape of drone carrier development is defined by the following national initiatives, presented here in alphabetical order:

Brazil has established its presence in the field by conducting successful trials of the Albatroz Vortex and ScanEagle systems from the deck of the helicopter carrier NAM Atlântico, demonstrating how legacy "large-deck" assets can be repurposed for persistent naval surveillance.[4]

China continues to lead in high-end displacement with the commissioning of the Sichuan, a 50,000-ton Type 076 amphibious assault ship that functions as a specialized Unmanned Combat Aerial Vehicle (UCAV) carrier equipped with electromagnetic catapults to launch stealthy GJ-11 flying-wing drones.[5]

Portugal is set to receive the NRP D. João II in the second half of 2026, a 7,000-ton multifunctional platform that avoids traditional armament to qualify for EU recovery funding while serving as a dedicated "toolbox" for UxV.[6]

Türkiye has achieved a significant milestone with the TCG Anadolu, which made its overseas operational debut during NATO's Steadfast Dart 2026 exercise by autonomously launching and recovering Bayraktar TB3 combat drones to strike maritime targets.[7]

AI-generated visualization of UAVs employed from a C-130 mothership.

United Kingdom defense officials have launched Project Vanquish, an initiative aimed at developing an "Autonomous Collaborative Platform" to augment the Royal Navy's Hybrid Air Wing by integrating jet-powered, AI-driven drones into the existing Queen Elizabeth-class carrier operations.[8]

United States naval strategy is pivoting toward a hybrid fleet, with officials announcing in early 2026 that nearly half of the surface force will be unmanned by 2045, supported by the integration of autonomous "pathfinder" vessels like the Seahawk into active carrier strike groups.[9]

These developments underscore a global trend where "mass" is increasingly prioritized over "platform cost." The drone carrier is not merely an experiment; it is the pioneer of a new class of naval capability manned platforms that will depend on the mission profile and the specific threat environment. However, the integration of dedicated platforms into naval toolboxes is now a prerequisite for maritime dominance in the 21st century. Regardless of

the manning status, drone carriers face a unique set of challenges. As a centralized hub, the carrier is a "single point of failure." An adversary does not need to destroy every drone in a swarm; they only need to disable the carrier's ability to communicate with them. Electronic warfare and cyber-attacks targeted at the "mother-to-swarm" link remain the primary threat to this new class of naval power.[10]

Drone Mothership: Warfare Shift

Historically, certain military innovations have transcended mere technical updates to become harbingers of strategic transformation. Much like the aircraft carrier redefined naval power projection in the 20th century, or stealth technology reshaped air defense paradigms, the emergence of the drone mothership represents a "quantum leap" in modern combat.[11] This platform is not just an incremental improvement in unmanned systems; it is the cornerstone of a new epoch defined by distributed lethality and autonomous swarm tactics.

An aerial drone mothership serves as a centralized transport, deployment, and recovery hub for Unmanned Aerial Systems (UAS). As the scale of drone warfare expands from individual units to swarms of thousands or even millions, the mothership becomes a logistical necessity.[12]

To understand the future of the 21st-century battlefield, it helps to look at a 25th-century classic. For anyone who grew up playing StarCraft, the Protoss Carrier wasn't just a unit; it was a core philosophy. As a massive, dirigible-shaped platform, it did not fight with its own guns. Instead, it "spit out" tiny robot planes—Interceptors—that swarmed over the battlefield in a pixelated cloud of destruction. In the game, building a fleet of ten motherships felt invincible until the moment the enemy bypassed the swarm and targeted the "Mothership" itself. Once the Protoss fell, the entire strategy collapsed.[13]

This fictional scenario illustrates the high-stakes reality both the US Defense Advanced Research Projects Agency (DARPA) and the Chinese People's Liberation Army (PLA) are now navigating: the immense power of a drone swarm is only as resilient as the platform that launches, controls, rearms, and repairs it.

The transition from science fiction to official defense documentation highlights that even a decade ago, the military was internalizing these "Protoss" lessons. Back in 2014, DARPA signaled a paradigm shift in power projection by issuing a formal Request for Information (RFI) to explore converting existing large aircraft into drone motherships.[14] The goal was to prove that massive, legacy platforms—the workhorses of the 20th century—could be adapted into high-tech hubs capable of launching and, crucially, recovering volleys of small UAS while in flight.

The RFI specifically targeted the feasibility of using platforms like the B-52, B-1, and C-130 to deploy swarms of low-cost drones. These "volleys" were designed to carry payloads under 100 pounds, providing a high-volume, low-risk way to penetrate contested airspace. This decade-old initiative highlights a fundamental truth in modern warfare: as rapidly as drone technology evolves, the carriers that deliver them must adapt at an even more aggressive pace to maintain a strategic edge.

A pivotal moment in this evolution occurred in 2021 when DARPA achieved a historic milestone at Dugway Proving Ground: the first successful mid-air recovery of an X-61 Gremlin drone into a C-130 mothership.[15] During this flight test, three Gremlin systems were deployed, proving that the U.S. military's vision of launching and capturing drone swarms in flight was no longer just a theoretical concept, but a demonstrated technical reality.

While public discourse has largely emphasized the use of crewed aircraft as launch platforms, China has advanced a parallel track focused on large UAV platforms capable of functioning as dedicated drone motherships. Among the most notable is the "Jiutian", a massive reconnaissance and strike UAV unveiled at the Zhuhai Airshow in November 2024.[16]

The emergence of such platforms offers two significant implications: firstly in Force Structure, where it reinforces a broader modernization strategy which prioritizes the integration of unmanned systems as a central component of future warfare; and secondly in Operational Flexibility, where the platform's modularity suggests it could be configured for ISR, precision strike, airlift, or serving as a launch and control hub for subordinate drones, expanding the capacity to project power across contested environments.

AI-generated visualization of UAVs employed from a unmanned mothership.

While military focus often oscillates between platform design and payload integration, the evolution of unmanned systems has bypassed the traditional plateau, entering a phase of vertical innovation. Definitive proof of this trajectory lies in DARPA's LongShot (X-68A) program which, by successfully mitigating technical risks and hitting critical integration milestones, is carving a viable path toward extended air combat reach.[17] As ground testing transitions toward a 2026 flight campaign to validate weapon ejection and flight worthiness, it becomes clear that the hardware is only half the battle; the true challenge lies in the operational shift it represents.

This rapid evolution in drone lethality necessitates an equally aggressive adaptation of the host platforms and the defensive countermeasures required to stop them. If the spearhead sharpens this quickly, the shields and delivery systems must evolve at the same breakneck pace. To stay ahead, the military isn't just building better drones; it's reimagining the very vector that bring them to the fight.

In a battlespace where autonomous systems and their control platforms are rapidly moving from concept to reality, the real measure of progress is found in the gap between what is operational today and what innovation makes possible tomorrow. These inherent limitations serve as the strategic compass, dictating the trajectory of future development and the focus of necessary countermeasures. Technically, we stand at the precipice of a massive expansion in drone utility—integrating lethal kinetic effects, increasing velocity, and extending command ranges. We are moving toward a fully realized, AI-driven unmanned scenario, characterized by a seamless and coherent C5-ISR-T (Command, Control, Communications, Computers, Cyber, Intelligence, Surveillance, Reconnaissance, and Targeting) framework that bridges the gap between the carrier/mothership and the edge of the battlefield.

CONCLUSION: RIDING THE WIND OF CHANGE

In the broader context of a multidomain operational landscape—where drones and their hubs have transitioned from conceptual RFIs to tangible operational realities — the true differentiator in the pace of innovation lies in the subtle friction between current capabilities and as-yet-unrealized potential. These inherent limitations serve as a strategic compass, guiding the trajectory of future development and shaping the countermeasures required to sustain operational advantage.

As artificial intelligence and autonomous systems continue to mature toward operational implementation, unmanned carriers and motherships will increasingly serve as linchpins of multidomain operations, orchestrating swarms across air, surface, and underwater domains while enabling rapid adaptation to emerging threats. Rather than signaling the obsolescence of crewed platforms, this transformation opens new avenues for hybrid force architectures in which human and unmanned systems complement one another to multiply effectiveness.

The rise of these platforms therefore constitutes a clear call to action. Militaries—both individually and within allied frameworks—must embrace not only the technological possibilities they offer, but also the doctrinal, organizational, and capability adjustments across the DOTMLPFI spectrum required for their effective integration. Continued experimentation and operational testing—particularly in manned–unmanned teaming, modular payload architectures, and AI-enabled command structures across kinetic and non-kinetic scenarios—will shape the next generation of operational advantage.

Ultimately, unmanned drone carriers and motherships exemplify a "wind of change" sweeping across the battlefield—reshaping multidomain power projection, accelerating the tempo of warfare, and redefining what it means to dominate the battlespace. Those who harness this transformation will not merely keep pace with technological evolution but will shape the strategic contours of future conflict outcomes.

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ALLIES IN THE AGE OF AUTONOMY

FORGING A COLLECTIVE CAPABILITY

By
CAPT (ITA-N) Marco Bagni

UUV REMUS supporting ITS MHV Numana in La Spezia, Italy. Courtesy of the Italian Navy.

NEW THREATS, ALLIED RESPONSES

“Last night, numerous drones from Russia violated Polish airspace… Several Allies were involved alongside Poland. This included Polish F16s, Dutch F35s, an Italian AWACS[1], a NATO Multi Role Tanker Transport, and German Patriots.”[2] With these words, NATO Secretary General Mark Rutte announced that on September 9–10, 2025, approximately 20 Russian drones had violated Polish airspace in an unprecedented, large-scale provocation. Only two months prior, Houthi forces attacked and sank the Liberian-flagged bulk carrier Magic Seas in the Red Sea, a stark reminder of the persistent threat to freedom of navigation since their first attack on November 19, 2023.[3] [4] This threat has since prompted two major international responses: the U.S.-led Operation Prosperity Guardian and the EU-led Operation Aspides.[5] [6]

These events are but two recent examples of the insidious nature of the autonomous threat and the inherent challenges of mounting an effective defence. The core problem is no longer the technology of the threat itself, but the interoperability of the response. This article examines how NATO is pursuing the keystone strategic objective of orchestrating the strength of numerous national autonomous systems into a coherent, dynamic ecosystem by integrating them through experimentation, standardization, and operationalization.

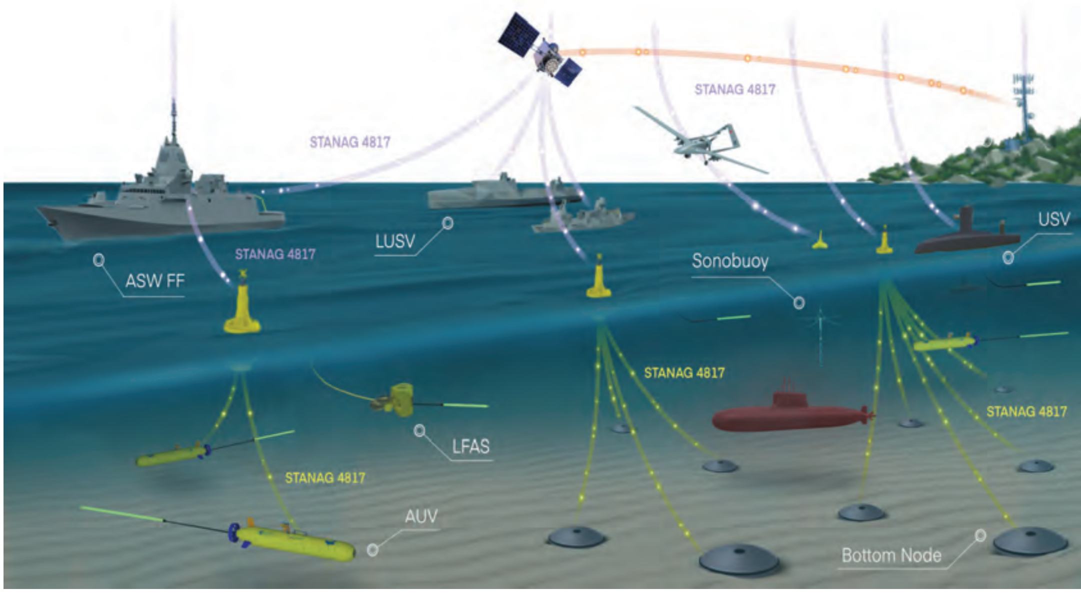
THE EXPERIMENTATION ENGINE

In response to the rising unmanned threat, member nations, regional coalitions, and NATO have all initiated a flurry of studies, operational experiments (OPEX), and acquisitions. While not always synchronized, these efforts have enabled the Alliance to rapidly exploit emerging technologies to counter low-cost, massed drone attacks. Among these initiatives, two examples eloquently describe the synergy between national innovation and NATO’s essential role as an integrator: REPMUS and DYNAMIC MESSENGER.

Hosted at the Portuguese Navy’s Operational Experimentation Centre, Robotic Experimentation and Prototyping using Maritime Unmanned Systems (REPMUS) is an annual exercise that has successfully grown in scope and impact over its 15-year life. REPMUS is a model of the “triple helix” of innovation, bringing together academia, industry, and military end-users.[7] The 2025 edition involved 37 countries, 236 industry partners, and 36 universities, testing 270 uncrewed systems across all domains. A key outcome was the successful implementation of a shore-based Maritime Unmanned Systems (MUS) Task Group, proving a novel Command and Control (C2) concept for delivering maritime effects from land. As Admiral Stuart B. Munsch, Commander, U.S. Naval Forces Europe and Africa, observed: “We continue to advance our robotic and autonomous systems through ongoing testing and combined training with partners… Our collective capability is only getting stronger.”[8]

DYNAMIC MESSENGER (DYMS) marks the evolution of this concept, testing Allied systems in a large-scale NATO operational setting.[9] DYMS 2025 leveraged lessons from REPMUS, involving 3,800 personnel from 22 nations. For the first time, the Ukrainian Navy, alongside Sweden, led the opposing force with over 100 unmanned platforms, adding stark realism. The exercise served as a critical testbed for innovative solutions including cyber defences, federated data sharing via the Allied Data Sharing Ecosystem (ADSE), and AI-driven tools like TALOS for near real-time lessons learned.[10] [11] Vice Admiral Mike Utley, Commander of Allied Maritime Command (MARCOM), captured the exercise’s goal: “The integration of unmanned systems is a critical component of our future warfighting capability, and Dynamic Messenger is a key step in that journey.”[12]

Together, REPMUS and DYMS demonstrate the power of synergy between national innovation and NATO experimentation, producing a hybrid fleet capable of persistent Intelligence Surveillance Reconnaissance (ISR), multi-domain operations, and effective maritime security.



Task Force- X ARCTIC architecture.

FORGING REAL CAPABILITIES

Diving into the capability development process, two specific NATO projects exemplify the Alliance's approach: the Anti-Submarine Warfare (ASW) Barrier project with its Force Lethality Enhancement eXtended (FLEX) Architecture for the maritime domain, and the Layered Counter-UAS Initiative (LCI-X) for land and amphibious operations.

The ASW Barrier concept describes operational scenarios where unmanned systems cooperate to surveil, identify, track, and engage underwater threats to Critical Underwater Infrastructures (CUI) or Allied forces.[13] The FLEX Command Control Communications Computers (C4) ASW Architecture,[14] developed by NATO Centre for Maritime Research and Experimentation (CMRE) is the digital backbone that makes this concept viable. Guided by NATO standards, it focuses on building robust networks, multi-layer data fusion, and AI-enabled mission engineering to create an adaptable and interoperable system.

LCI-X is a recent NATO Allied Command Transformation (ACT) beacon project designed to counter low-cost drone threats with cost-effective "kill boxes" along NATO's eastern flank. Through a series of 'Crucible' events in 2026, LCI-X will test and validate sensor-to-shooter integration in a highly realistic environment, employing a mix of kinetic and non-kinetic effectors. As Admiral Pierre Vandier, Supreme Allied Commander Transformation, stated, "Through LCI-X, ACT is bringing nations, commands, and industry into a single learning environment where we test continuously, learn quickly, and fix integration issues early. This is how we will turn lessons from Ukraine into an interoperable command-and-control framework the Alliance can rely on."[15]

INNOVATION AND CUI PROTECTION ECOSYSTEMS

Navigating the fast-evolving world of autonomous technologies requires both top-down guidance and bottom-up innovation. From a NATO perspective, this is achieved through bodies like the Joint Capability Group for Maritime Unmanned Systems (JCGMUS), which provides strategic direction,[16] and the Defence Innovation Accelerator for the North Atlantic (DIANA), which connects NATO with startups and academia.[17]

This ecosystem has been pivotal in addressing one of the most pressing modern threats: the security of CUI. Following the sabotage of the Nord Stream and Baltic connector pipelines,[18] [19] NATO established the CUI Coordination Cell and the NATO Maritime Centre for the Security of CUI.[20] In response, ACT, MARCOM, and CMRE launched Project MAINSAIL (Maritime AI-enabled Naval Situational Awareness and Intelligence Layer). This AI-driven system is designed to provide a common operational picture around CUI by fusing multi-domain data, from merchant vessel real-time navigational information (AIS, Automatic Information Signal), and satellite radar (SAR, Synthetic-Aperture Radar), to Distributed Acoustic Sensing (DAS), a technology that turns underwater fiber optic cables into sensitive sensors.[21]

The value of such a tool became evident during the series of Baltic cable incidents in late 2024.[22] While national investigators publicly identified suspect vessels like the Yi Peng 3 and Eagle S, a system like MAINSAIL provides the powerful back-end capability for fusing disparate data sources and conducting post-event forensic analysis. By predicting suspicious behavior and enabling rapid decision-making, MAINSAIL is a concrete tool for preventing future attacks on our vital undersea lifelines.

FROM CONCEPT TO DEPLOYMENT: TASK FORCE X

The ultimate proof of operationalization is Task Force X (TF-X), the crucial step where standards, concepts, and architecture converge into a fielded capability.[23] TF-X is NATO's framework for rapidly integrating and employing multi-domain uncrewed systems in contested regions, leveraging successful national initiatives like the U.S. Navy's Task Forces 59[24] and 66[25].

A specific iteration, Task Force X Baltic, has been tailored to the unique challenges of the Baltic Sea, focusing on ISR in chokepoints and opportunistic intercept missions.[26] In a clear demonstration of its impact, a NATO Unmanned Surface Vehicle -X helped detect and track Russian "shadow fleet" vessels in July 2025.[27] However, these deployments are not just operational wins; they are vital learning opportunities. They have highlighted challenges in platform reliability in high sea states, the need for hardened navigation systems against jamming, and the operational limits of certain Unmanned Underwater Vehicles in shallow waters. The lessons from TF-X are fundamental in shaping the design of a resilient and effective future hybrid fleet. As a scalable, regionally agnostic blueprint, the TF-X model can now be applied to other critical regions like the Arctic, Black Sea, and the Mediterranean.

USV Trator do Mar, Sep. 2025. Courtesy of the Portuguese Navy

CONCLUSION

This article has shown how NATO is turning national innovation into collective capability. Through initiatives like FLEX ASW C4 Architecture and LCI-X, frameworks like DIANA and JCGMUS, and fielded capabilities like MAINSAIL and Task Force X, the Alliance is actively integrating autonomous systems into a cohesive multinational force.

The challenges are demanding, requiring firm leadership to navigate this disruptive ecosystem. The approach must be pragmatic, prioritizing early integration testing and rugged, operationally relevant platforms. The Alliance must also modernize its lessons-learned cycle for unmanned systems and, critically, invest in the education and training of our personnel to confidently manage these sophisticated tools.

As we pursue these reforms, we must be guided by a clear-eyed view of the future. The challenges we face are complex, and our adaptation must be relentless. In the words of General Christopher G. Cavoli, at the time the Supreme Allied Commander Europe (SACEUR):

> *"The world we knew is gone, and we are in the world that is being born. The task before us is immense. We must be fast. We must be clear-eyed. And we must be together."*[28]

This sentiment perfectly encapsulates our challenge. By empowering our people with agile standards and living doctrine, we ensure that human ingenuity remains the decisive factor, turning technology into undeniable cognitive and combat superiority.

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MANNED–UNMANNED TEAMING IN MARITIME INTELLIGENCE, SURVEILLANCE AND RECONNAISSANCE OPERATIONS

By

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INTRODUCTION

The current geostrategic environment is increasingly volatile, with attacks on critical maritime infrastructure, disruptions to global sea lines of communication (SLOCs), and rising tensions threatening the stability of global maritime security. Alongside these challenges, illegal migration, illicit fishing, and other unlawful activities continue to undermine security across the world's seas. In this contested maritime environment, maintaining Maritime Situational Awareness (MSA) is essential for operational effectiveness. MSA provides insight into patterns of life, anomalous maritime activity, and critical information for decision-makers planning for, and executing, maritime operations.

Traditional methods for carrying out maritime operations are no longer enough however. With the growing challenges and larger areas to cover, relying on just a few platforms and systems is no longer effective. However, the emerging MUM-T concept between UAVs and manned assets in Intelligence, Surveillance, and Reconnaissance (ISR) operations offers solutions that will enhance the situational awareness of legacy platforms and systems.

Modern naval warfare is already rapidly evolving through the integration of manned and unmanned systems. During NATO's recent Steadfast Dart 26 exercise for example, the Allied Reaction Force demonstrated this with a complex amphibious operation in Northern Germany. A Bayraktar TB-3[1] Unmanned Aerial Vehicle (UAV) launched from TCG Anadolu, the drone carrier-amphibious assault ship of the Turkish Navy, was able to provide real-time intelligence that enabled German Eurofighter Typhoon aircraft to conduct simulated target engagements, together showcasing the power of Manned-Unmanned Teaming (MUM-T).[2]

This article examines how UAVs are transforming ISR operations and naval warfare, focusing on new operational concepts of MUM-T between UAVs and manned assets in Maritime Intelligence, Surveillance, and Reconnaissance (MISR) and their implications for naval operations. [3]

WHY SCOUTING MATTERS

The importance of scouting in naval warfare has long been emphasized in naval strategic thought. In his influential book Fleet Tactics and Naval Operations, Captain Wayne Hughes argued that scouting, not shooting, determines who survives at sea. [4] "Scouting" involves detecting, locating, identifying, and tracking targets across open seas, littoral zones, and ashore. The task force or surface fleet that is the first to detect the enemy, organize an attack, and fire effectively is the one that wins. This perspective highlights the decisive role of early detection in naval engagements.[5] Beyond its theoretical foundations, scouting constitutes the first stage of the naval kill chain, enabling forces to detect, target, and engage adversaries before they can effectively respond.

A Turkish TB3 UAV positioned on the flight deck of TCG Anadolu during Exercise Steadfast Dart 26. Courtesy of NATO.

Hughes' clear reasoning forced naval officers to acknowledge that powerful weapons are ineffective without timely target detection and this has influenced modern thinking on naval reconnaissance and fleet operations. In practice, "scouting" functions as a concise umbrella term for MISR; however, its three components—Intelligence, Surveillance, and Reconnaissance—each have distinct roles despite their close interdependence.[6]

The three elements of MISR are distinct but related: Intelligence, which is the final product from combining various information sources; Surveillance, defined as the persistent monitoring of a target over time; and Reconnaissance, a targeted effort to gather information addressing specific military objectives.[7] These activities are conducted through both direct observation and advanced sensing systems such as satellites and unmanned aerial platforms.[8] The integration of intelligence, surveillance, and reconnaissance ultimately contributes to information dominance, allowing naval commanders to maintain superior maritime situational awareness.

In the era of satellites, UAVs, and long-range missiles, technological advances have dramatically expanded the range and accuracy of naval scouting. Historically, MISR operations posed challenges for naval fleets, making recent technological advancements more impactful in enhancing maritime capabilities.[9] Modern naval forces today therefore rely on a distributed network of scouting platforms, including satellites, maritime patrol aircraft (MPA), unmanned aerial systems, surface sensors, and submarines.

MUM-T IN MISR

While no official NATO definition exists relating to MUM-T, the U.S. Army defines it as the synchronized employment of manned and unmanned platforms, soldiers, and sensors to enhance situational awareness and lethality.[10] Operationally, this cooperation is enabled through distributed advanced data networks linking manned and unmanned platforms. This collaboration acts as a force multiplier, enhancing capabilities while ensuring that manned assets remain safe and in control. Within the MISR cycle, MUM-T expands sensor reach and accelerates the flow of information from detection to decision-making.

In naval operations, MUM-T integrates ships, submarines, and manned aircraft with unmanned air, surface, and underwater systems to create a networked, adaptive, and resilient force. This approach enhances persistent MSA and distributed warfighting/ combat capability. It also supports the transition from platform-centric to network-centric naval warfare. Recent advances in autonomy and artificial intelligence further enhance MUM-T by enabling unmanned platforms to process sensor data and assist human operators.

Resilient Command, Control, Communications, Computers, Cyber, Intelligence, Surveillance, and Reconnaissance (C5ISR) connectivity and secure tactical data links enable the exchange of MISR data between manned and unmanned systems. Through advanced tactical data links (Link-16/ Link-22), manned platforms can access UAV sensor feeds and intelligence products across different Levels of Interoperability (LOI). NATO has identified five LOIs to adjust operational requirements in Standardisation Agreement (STANAG) 4586.[11] As shown in the table, each level represents a higher degree of control and coordination between manned and unmanned systems from merely receiving data (Level 1) to fully operating and managing the unmanned vehicle (Level 5).

Levels of Interoperability (LOI)	
Level 1	The manned platform indirectly receives data from an unmanned vehicle.
Level 2	The manned platform establishes a direct data link with the unmanned vehicle, receiving information specifically intended for it.
Level 3	The manned platform can both receive data directly and control the unmanned vehicle's sensors (e.g., cameras or radars).
Level 4	The manned platform can control all aspects of the unmanned vehicle's flight, including navigation, launch, and recovery.
Level 5	The manned platform has full control and supervision of the unmanned vehicle, including its launch and recovery operations.

Table 1 - Levels of Interoperability

Maritime MUM-T ISR operations generally follow three operational models: ship-controlled UAVs, manned aircraft-controlled detachments (UAV assets), and networked naval task group integration. These operational models enable naval forces to extend surveillance coverage, reduce risk to high-value platforms, and improve MSA.

Ship-Controlled UAVs

In MISR operations, UAVs are categorized into two types: shipborne (organic) and land-based High/Medium-Altitude Long-Endurance UAVs (HALE/MALE). Shipborne UAVs are smaller, with operational times of up to 12 hours, while land-based UAVs are strategic assets that can operate for up to 36 hours. Shipborne UAVs are fully controlled by surface assets, whereas HALE/MALE UAVs are partially controlled from the ship. Within maritime ISR operations, shipborne UAVs represent the primary organic unmanned assets deployed directly from naval platforms. Ships may host data relay or mission control interfaces from Ground Control Stations (GCS), enabling interaction with HALE/MALE UAVs operating via satellite links.

Ships play a crucial role in MSA and act as key command nodes for ship-controlled UAV operations. Equipped with advanced radar, electronic warfare systems, and robust communications, they support data fusion and intelligence sharing, contributing to the Recognised Maritime Picture (RMP) and Common Operational Picture (COP).

Organic UAVs typically carry Electro Optic//Infrared/ laser sensor suites with limited additional payloads such as surface radar or Synthetic Aperture Radar. Due to their compact size and lower cost, ships can embark multiple units, enhancing local MSA. Directly controlled from the ship and increasingly integrated into the Combat Management System (CMS), organic UAVs extend a naval unit's ISR coverage and allow immediate data processing within the Combat Information Center (CIC). Their low radar, infrared, and acoustic signatures make them suitable for discreet and forward operations, while freeing manned helicopters for more demanding missions.

Despite their advantages, organic UAV operations present operational challenges. Their limited endurance requires multiple UAVs to maintain persistent surveillance, demanding trained personnel, efficient maintenance cycles, and close coordination with helicopter operations or other air support in the operation area. Effective employment also requires unified airspace control under a single authority to avoid conflicts with other air assets. Operational challenges include launch and recovery in adverse weather and ship hangar space integration alongside helicopters. Additionally, there is a need to harmonise procedures between manned and unmanned systems to ensure smooth and safe operations.

Non-organic UAVs (MALE/HALE), considered strategic assets, provide cost-effective, persistent MISR, operating from established airbases and controlled remotely via GCS located far from the Area of Interest (AOI). Equipped with satellite and Radio Frequency communications, UAVs enable long-range command and control (C2) and wide-area coverage.

Ship-controlled or ship-integrated UAVs (MALE/HALE) are equipped with advanced sensors similar to those found in Maritime Patrol Aircraft (MPAs) which allows them to conduct high-risk or prolonged missions, thereby reducing the exposure of manned assets to threats. Additionally, UAVs function as advanced MISR sensors and data relay nodes within the C5ISR architecture, enhancing network integration and operational coordination across the naval task group. Their modular design allows for flexible mission configurations with adaptable payloads, including sensors, electronic warfare systems, and weapons.

One recent example of this concept of operations is the employment of a MQ-9B Sea Guardian UAV, conducting long-range over-the-horizon targeting in support of a US Navy Littoral Combat Ship (LCS). The UAV deployed sonobuoys and employed its onboard ISR sensors to detect maritime contacts. It then relayed the details of contacts through tactical data links to the ship's CIC. This data supported the operational picture of the task unit and enabled timely command decisions.[12] A similar concept is also observed in the Turkish Navy, where Bayraktar TB3 UAVs are being integrated with the Drone carrier TCG Anadolu.[13] Operating as shipborne MISR assets, TB3 UAVs are capable of launching from the vessel and transmitting sensor data to the ship's ADVENT[14] CMS, thereby enhancing the MSA of the naval task group.[15]

A key enabler of effective MUM-T is the installation of full-spectrum C2 and data relay systems that allow UAV data—such as position and sensor feeds—to be shared directly with ships and manned aircraft. Integrating this information into tactical systems or CMS extends MSA and interoperability across the naval task force. Achieving this requires appropriate hardware and software upgrades to ensure seamless connectivity.

In many UAV architectures, sensor data is routed through GCS before dissemination to operational command nodes, which may introduce latency in information sharing. Future advancements are anticipated to enable more direct data sharing and enhanced onboard processing, fostering greater joint operations among UAVs, ships, and manned aircraft. Effective integration of UAV data into CMS requires careful coordination, as GCS operates on a different data network.

The U.S. Navy demonstrating a successful integration of an unmanned maritime surveillance aircraft system with manned capabilities off the coast of San Diego, April 21. Courtesy of USN.

Positioning GCS within the ship's CIC enhances collaboration with key personnel, allowing for a seamless transition from standalone consoles to full integration with CMS.

Developments in launch and recovery technologies will allow UAVs to operate from a variety of platforms, including smaller vessels and aircraft carriers, with Vertical Take-Off and Landing designs eliminating runway requirements. Integrated C2 into existing CMS will enhance mission planning while reducing control system weight.

To maximize the effectiveness and resilience of ship-controlled MUM-T during MISR operations, the UAVs will require improved C5ISR network integration for sensor data dissemination and C2 functionality in degraded environments. Secure communication systems will enable autonomous operations, transmitting critical data as needed. In addition, automated navigation and collaboration with the ship's CMS will reduce operator workload.

Manned Aircraft-Controlled UAV Detachments

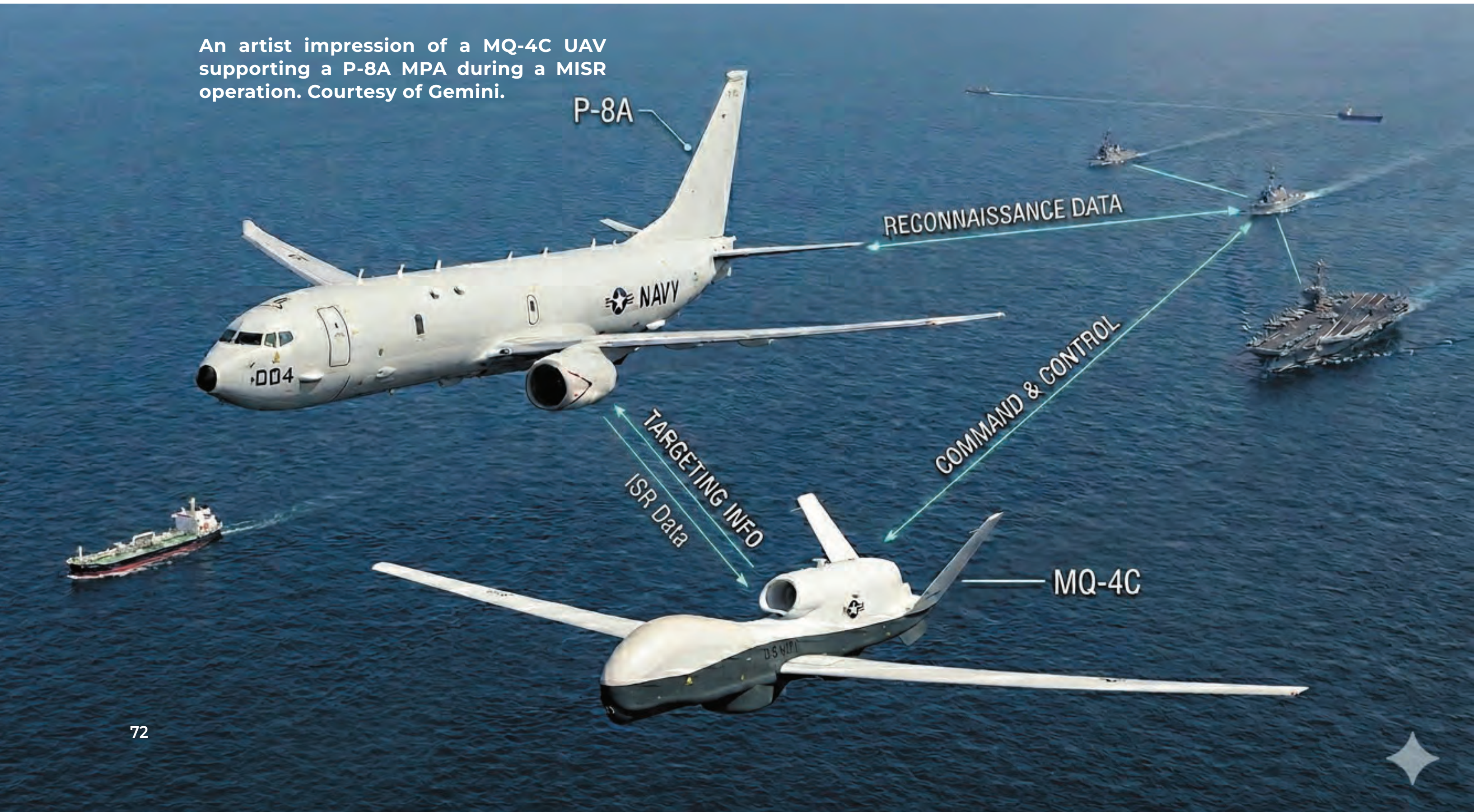
MISR operations are often supported by manned aircraft such as Airborne Early Warning (AEW) platforms, MPA, and shipborne organic helicopters. In recent years, these platforms have increasingly adopted MUM-T concepts, acting as airborne command nodes to coordinate sensors, relay data, and direct MISR UAV assets across the Area of Operations (AOO) or AOI.

The U.S. Navy's E-2D Advanced Hawkeye is a carrier-based airborne early warning and control aircraft that serves as an important command and control node within a Carrier Strike Group. Operating alongside UAVs such as the HALE MQ-4C Triton, it can support persistent MISR coverage by receiving and disseminating near-real-time sensor data to surface ships. This cooperation enhances MSA in contested environments.[16]

In this architecture, the E-2D does not directly control UAVs but can request mission adjustments through the UAV's GCS, where operators modify flight profiles and MISR payload tasking. According to NATO STANAG 4586, this level of interaction corresponds to LOI 2, in which the AEW receives UAV payload data without exercising control over the platform. Achieving direct airborne UAV control would require additional upgrades to the aircraft's mission computer, software, and tactical data links, as well as dedicated UAV control interfaces typically located in ground control stations.[17]

MPAs can integrate UAV sensor feeds to extend MISR coverage across large maritime areas. When operating alongside UAVs in an AOO, MPAs enhance interoperability by receiving data through GCS or networked data links, although they cannot directly control UAVs. Upgrading MPAs for command-and-control capabilities increases mission flexibility. In this architecture, flight control remains with the GCS or UAV's autonomous systems, while the MPA exercises tactical control, directing surveillance priorities, assigning MISR tasks, and integrating UAV sensor data into the operational picture.[18]

A practical example of MUM-T is the cooperation between the P-8A Poseidon and MQ-4C Triton. In this system, MQ-4C Tritons act as a forward sensor, extending the patrol area and persistent surveillance capabilities, while feeding critical data back to the manned P-8A Poseidon crews, who can then manage the overall mission picture, perform data analysis, and deploy kinetic or non-kinetic effects. This cooperation enhances MSA and improves ASW effectiveness across AOO.[19]



An artist impression of a MQ-4C UAV supporting a P-8A MPA during a MISR operation. Courtesy of Gemini.

In addition to fixed-wing aircraft, shipborne helicopters, equipped with essential sensors along with operators for data fusion, may also conduct MUM-T MISR operations. However, helicopter–UAV integration remains limited due to space, crew workload, and equipment constraints. Advancements in automation and the miniaturisation of equipment may enable future data processing without human intervention. These developments could facilitate higher levels of interoperability between helicopters and UAVs in future MUM-T operations.

MUM-T Operational Model	United States	Europe/Türkiye	China
Ship-Controlled UAVs	MQ-8C Fire Scout / Littoral Combat Ship	Bayraktar TB3 – TCG Anadolu VSR700 – French Navy Frigates	AR500 PLAN Destroyers
Manned Aircraft-Controlled UAV Detachments	MQ-4C Triton / P-8A Poseidon	Bayraktar TB2 – ATR-72 MPA Eurodrone – ATL2 MPA	WZ-7 Soaring Dragon KQ-200 MPA
Networked Task Group Integration	MQ-9B SeaGuardian / Littoral Combat Ship	Bayraktar TB2 – ULAQ USV VSR700 – FREMM Frigate	Wing Loong II PLAN Surface Combatants
Attritable UAV Operations	XQ-58A Valkyrie – F-35 / MQ-28 Ghost Bat – Allied Aircraft	KARGU – ALPAGU - Naval Units	FH-97A Manned Combat Aircraft

Table 2 - Examples of MUM-T configurations across different navies

Networked Task Group Integration

In the networked task group model, UAVs operate as shared MISR assets across the entire naval formation rather than being assigned to a single platform. Control authority may shift dynamically between surface units or command centers depending on operational priorities.

This architecture enables UAVs to operate as part of a distributed maritime surveillance network. Such integration aligns with the US Distributed Maritime Operations (DMO) concept, which emphasizes collective situational awareness across dispersed naval forces. This architecture depends on robust C5ISR systems capable of integrating multiple unmanned platforms. UAVs, such as the MQ-4C Triton, share persistent MISR data through resilient networks, enabling real-time mission adjustments across different military assets.[20]

While networked integration improves resilience and operational range, it also creates challenges for C2. Challenges related to data ownership, prioritizing tasks, managing communication spectrum, and ensuring cybersecurity become crucial, and in challenging security environments, clear guidelines, compatible systems, and strong network security are necessary.[21]

Attritable UAVs

A recent advancement in naval warfare and MISR operations is the emergence of “attritable” UAVs—low-cost platforms designed to be expendable in combat. These relatively small UAVs can be launched from various platforms, including ships and larger UAVs, and can operate without traditional airfield support. Attritable UAVs are particularly useful in contested environments where high-value ISR assets face increased operational risk.[22] Within MUM-T architectures, attritable UAVs can function as forward sensors supporting manned platforms and high-end UAV systems.

Examples of MUM-T operational models can be seen across different navies. As shown in Table 2, several countries have begun integrating manned and unmanned platforms into various configurations to enhance MISR capabilities and support networked naval operations.

MUM-T LIMITATIONS

The limitations of MUM-T operations are often tied to the inherent characteristics of UAVs, such as their speed, altitude, and sensor effectiveness. Additionally, UAVs are heavily dependent on operators, especially those with low levels of autonomy. MUM-T operations also face challenges such as C2 complexity, interoperability between different platforms, and spectrum management in congested environments. Moreover, the increasing volume of MISR data generated by multiple unmanned systems risks overwhelming operator workload and exacerbating decision latency.

Aircraft and UAVs face significant communication challenges. UAVs use Line-of-Sight communications and satellite links for Beyond Line-of-Sight (BLOS) operations. This reliance makes them vulnerable to jamming and cyberattacks. Successful MUM-T operations depend on secure and reliable communication systems. Satellite Communications (SATCOM) is crucial for BLOS missions, requiring a multilink approach for secure, low-latency, and high-bandwidth connections.

Future unmanned systems are expected to rely increasingly on higher levels of autonomy. Advances in artificial intelligence and onboard data processing may support automated sensor fusion and reduce operator workload. However, the growing reliance on satellite communications also introduces new vulnerabilities. NATO has increasingly identified both military and commercial SATCOM infrastructure as potential targets in contested environments.[23]

CONCLUSION

Traditional MISR methods are proving inadequate, primarily due to the increasing complexity of maritime threats and the vast expansion of the areas requiring surveillance. The integration of UAVs with manned platforms, such as MPA, AEW, ships, and helicopters, offers a practical solution to extend sensing range, increase persistence, and improve the overall MSA for naval forces. By combining UAV endurance and sensing with the flexibility of manned assets, MUM-T helps naval forces detect, monitor, and respond to threats across maritime domains. As illustrated during NATO's Steadfast Dart 26 exercise, the integration of UAVs with manned platforms demonstrates how MUM-T can enhance MISR and support more effective operational decision-making in complex naval security environments.

The operational models discussed in this article—ship-controlled UAVs, manned aircraft–controlled UAV detachments, and networked task group integration—show how UAVs can be integrated into MISR operations at different levels. When supported by advanced data links, interoperable systems, and effective C2, these concepts improve naval forces' ability to maintain a comprehensive and persistent RMP.

However, the effectiveness of MUM-T depends on addressing several operational and technological challenges, including communication vulnerabilities, interoperability limitations, data management, and the survivability of unmanned systems in contested environments. Continued advances in autonomy, secure communications, and sensor technologies are key to overcoming these limitations.

As naval warfare becomes more distributed and network-centric, integrating manned and unmanned systems will play an increasingly important role in MISR. Effective use of UAV-enabled MUM-T will help naval forces move from platform-based surveillance to more resilient and flexible networked sensing architectures for the future.

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A Turkish TB3 UAV operated from the drone carrier TCG Anadolu during Exercise Steadfast Dart 26. Courtesy of NATO.

GEOMETOC WITHIN NATO OPERATIONS

By

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Courtesy of StockCake.

"GEOMETOC is the collective term for geospatial, meteorological and oceanographic support."

THE EVOLUTION OF ENVIRONMENTAL SUPPORT

The historical significance of environmental conditions in naval warfare is a foundational principle of maritime strategy. Throughout history, the physical environment has often served as an arbiter of military outcomes. A prime example is the 1588 dispersal of the "Invincible Armada," where extraordinary westerly currents and severe weather between June and July forced a massive Spanish fleet to disperse, significantly contributing to the campaign's failure of invading England. A more modern example, is the "Halsey's Typhoon" from WWII in the Philippine Sea, where the lack of integrated meteorological forecasting and oceanographic sea-state analysis contributed to the loss of 790 sailors and three destroyers, proving that environmental information is as vital to fleet survival as tactical prowess.[1]

The modern era of systematic environmental support was solidified during the 20th century, most notably with Operation OVERLORD in 1944. The Allied High Command recognized that the success of the Normandy landings depended on a precise understanding of tides, wave heights, and beach trafficability. A dedicated team of meteorologists and oceanographers, led by Group Captain James Stagg RAF, provided the critical assessment that led General Eisenhower to delay the invasion by 24 hours. This decision avoided a potential catastrophe and proved that environmental information is a vital planning factor to the Commander.[2]

NATO defines GEOMETOC as "the collective term for geospatial, meteorological and oceanographic support". More broadly, we can define it as a multidisciplinary technical

Task Force 99 in the Northern Atlantic, 1941. Courtesy of GEOMETOC USN.

field that obtains, filters, and analyzes environmental information to support the strategic, operational, and tactical decision-making process.[3] As the Alliance transitions toward Multi-Domain Operations (MDO), GEOMETOC has shifted from being a supporting utility to a cornerstone of Decision Superiority. Modern naval forces possess unique characteristics, strategic mobility, high availability, and versatility, that require an equally agile environmental support structure.

This support must be global, as naval forces often operate in remote areas where local data is scarce, requiring organic sensing capabilities and advanced numerical modeling. Furthermore, the information provided must be precise and relevant; for instance, the deployment of unmanned systems (UxVs) is highly sensitive to micro-climatic factors like wind shear, precipitation, and temperature. To maintain coherence across a multinational force, NATO GEOMETOC support is governed by doctrinal principles that necessitate consistency through a centralized 'One Theatre, One Forecast' data model, a focus on decision-making impact to identify environmental advantages and tactical windows, and temporal relevance ensures all information aligns with the operation's 'battle rhythm' for current and future tasks.[4]

The integration of these factors creates a Recognized Environmental Picture (REP), a fusion of static geospatial data and dynamic climate models that allows a Commander to anticipate limitations and exploit the environment as a tactical shield.

NATO COMMAND STRUCTURE AND SUPPORT MODEL

In the complex ecosystem of modern multinational warfare, NATO ensures coordination through a centralized and unified GEOMETOC support model.[5] The ultimate objective is to provide a standardized environmental picture that allows the Strategic Command (SC) and member nations to act in unison.

Centralization and the Multinational METOC Support Group

Currently, the regulatory and management heartbeat of this discipline is the Multinational METOC Support Group (MNMSG), located in Germany. The MNMSG represents the future of resource optimization for the Alliance. It functions as a central node that receives daily operational outputs and data from designated Integrated METOC Lead Nations.[6] This structure relies on a "backup" and "assisting" nation hierarchy to ensure that environmental support remains resilient even if a primary node is compromised.

Doctrinal Governance

To maintain updated procedures and standardized doctrine, NATO utilizes specialized working groups that report to the Military Committee Working Group (MCWG).[7] Within this framework, a technical panel focused on Military Oceanography concentrates on the sub-surface and maritime environment by coordinating procedures for acoustic prediction and underwater surveillance, while a parallel group handles the atmospheric aspects of GEOMETOC to ensure that aerial assets and surface units possess accurate meteorological data. Furthermore, the Geospatial Maritime Working Group integrates essential hydrographic and topographic information directly into the maritime picture.[8]

Centers of Excellence and Strategic Intelligence

Beyond the operational command structure, NATO leverages specialized Centers of Excellence (COE) to provide long-term strategic analysis and technical innovation.The GEOMETOC CoE located in Lisbon, Portugal provides specialized advisory services and hydrographic engineering expertise. It plays a crucial role in integrating national naval capabilities, such as the role of Spanish hydrographic engineers, into the wider Alliance framework. The Climate Change and Security Centre of Excellence (CCAS COE), located in Toronto, Canada focuses on the strategic analysis of environmental shifts and their impact on NATO's strategic objectives.

This integrated model allows NATO to transition from a collection of national agencies to a cohesive "environmental intelligence" network. By speaking a common "GEOMETOC language" through the MNMSG and various technical panels, the Alliance ensures that environmental data is not just a secondary support service but a primary driver of the planning process.

SPACE WEATHER: THE IONOSPHERIC FRONTLINE

In the contemporary operating environment, the definition of GEOMETOC has transcended the terrestrial atmosphere to include the orbital environment. NATO now recognizes Space Weather (Space Wx) as a critical component of environmental support due to the pervasive reliance on satellite-based technology for Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR). As military platforms become more sophisticated, they paradoxically become more susceptible to solar activity and ionospheric disturbances. Space Weather support involves monitoring the variations in solar conditions and predicting their impact on technological systems.[9] For the NATO commander, this is not merely a scientific endeavor but a tactical necessity to ensure the resilience of the force in an increasingly digital battlespace.

Technological Vulnerabilities and Operational Impact

Solar phenomena, including X-rays, Extreme Ultraviolet radiation, radio bursts, and geomagnetic storms, have direct, tangible effects on military hardware and data links. These impacts are categorized by their effect on specific operational domains:

- **Communications and Radar:** Solar radio bursts can cause significant interference with SATCOM links and radar systems, while X-ray emissions may lead to total radio blackouts in the High Frequency spectrum.
- **Positioning, Navigation, and Timing:** Ionospheric "scintillation"[10] causes degradation in Satellite Communications (SATCOM) and introduces severe errors in GPS signals. This affects geolocalization, navigation, and the precise timing required for synchronized data networks.
- **Orbital and Ballistic Assets:** Geomagnetic storms can cause satellite orientation failures and errors in the tracking of ballistic trajectories during launch phases.
- **Personnel Safety:** At high altitudes, energetic particle events pose a radiation risk to aircrews and can cause physical damage to the electronic components within space cabins.[11]

The Allied Space Weather Network

Because no single nation can monitor the entirety of the space environment in isolation, NATO relies on a permanent exchange of information provided by specialized national centers, including the National Oceanic and Atmospheric Administration (NOAA) Space Weather Prediction Center in the United States and the Meteorology Office Space Weather center in the United Kingdom. The integration of these data streams into the Decision-Making process allows NATO forces to anticipate periods of technological degradation. By understanding the "Space Wx" forecast, a commander can choose to delay a precision-strike mission during a period of high GPS error or switch to alternative communication methods when SATCOM is at risk of interference. This level of environmental awareness transforms a potential technical failure into a manageable operational risk.

THE ARCTIC CHALLENGE AND CLIMATE SECURITY

Climate change is officially recognized as a direct threat to NATO's security, defense, and global stability. Beyond its environmental impact, it serves as a "threat multiplier" that affects public safety, critical infrastructure, and political-economic stability. One of the most significant consequences of global warming is the alteration of ice density and extension in the Arctic, which is opening maritime and terrestrial access routes that were previously impassable.[12]

This environmental shift has created a new theater of geopolitical competition. Russia, in particular, has accelerated efforts to extend its military dominance in the High North by establishing new polar bases and securing maritime routes that represent a potential security risk to NATO's northern flank. In response, the Alliance has developed the NATO Climate Change and Security Action Plan to mitigate these risks and adapt military operations to a rapidly changing environment.

To navigate this new reality, NATO relies on advanced research and specialized centers, notably the CCAS-CoE, which acts as a strategic advisor by generating studies that analyze the long-term consequences of climate change for NATO's geostrategic objectives.[13] Concurrently, high-capacity nations like the US, Canada, and Norway are developing specific projects for the Arctic, implementing new climate models based on Intergovernmental Panel on Climate Change projections to identify future technological needs. Effectively navigating this complex and changing Arctic environment requires high-fidelity technical tools, a domain where the Centre for Maritime Research and Experimentation (CMRE) in Italy is at the forefront of the Alliance's effort. These collective research efforts are underscored by other studies highlighting critical vulnerabilities of existing infrastructure, such as the Sewells Point Naval Base in Norfolk, Virginia, where sea-level rise directly threatens operational readiness.

A key development is the SEAWASP software, developed by Australia's Defence Science and Technology Group (DST Group) and utilized by the NATO CMRE. SEAWASP is designed specifically for the prediction and analysis of sonar ranges and submarine detection, integrating real-time oceanographic data with climatic models to determine the probability of detection in specific acoustic conditions.[14] In the Arctic, where melting ice fundamentally alters water temperature and salinity, and thus sound propagation, tools like SEAWASP are essential for maintaining a tactical advantage in Anti-Submarine Warfare (ASW). By mastering these complex variables, NATO can ensure its fleet remains effective in latitudes that were once considered inaccessible.

INTELLIGENCE, AUTONOMY AND THE REP CONCEPT

The Recognized Environmental Picture

As NATO shifts toward MDO, the traditional meteorological forecast has been superseded by the requirement for a REP. The REP is defined as a fusion of static geospatial data and dynamic environmental layers that provides a comprehensive understanding of the battlespace during the planning phase. Unlike standard weather reports, the REP focuses on the "tactical utility" of the environment, characterizing the operational area through procedures, information, and means necessary to reach the most precise

AI generated Rapid Environmental Assessment Staff Meeting.

integration of geospatial, climatic, and bathymetric[15]data. This concept relies heavily on static information, data with slow or zero variation over a 10-year period, such as terrestrial topography, high-resolution bathymetry, and species habitats. By integrating these factors, a commander can identify potential limitations or tactical advantages for specific assets before deployment begins.[16]

The Proliferation of UxVs

The modern naval force is increasingly defined by the use of UxVs), including Unmanned Aerial Vehicles, Surface Vehicles (USVs), and Underwater Vehicles (UUVs). While these platforms are cost-effective and versatile, they are fundamentally more sensitive to environmental conditions than traditional manned platforms, generally due to their smaller size.[17]

- **Meteorological Sensitivity:** Factors such as wind speed or ambient temperature can prevent the effective employment of UxVs or even lead to the loss of the asset.

- **Acoustic and Oceanographic Sensitivity:** For UUVs, sub-surface conditions like salinity, temperature gradients, and currents dictate the success of Intelligence, Surveillance, and Reconnaissance or Mine Countermeasures (MCM) missions.

Rapid Environmental Assessment and Real-Time Feedback

In scenarios where pre-existing data is insufficient or outdated, NATO employs Rapid Environmental Assessment (REA) procedures to obtain precise and updated information through organic sensors, thereby filling critical “gaps” in the environmental picture.[18] This need is driving annual robotic experimentation and prototyping augmented by maritime unmanned systems (REPMUS) exercises, which are specifically designed to identify new requirements in amphibious operations and MCM. During these experimentations, platforms such as the Spanish USV Kaluga or the Spanish Patrol Vessel BAM Tornado demonstrate this capability by utilizing buoys and sensors to acquire and disseminate meteo-oceanographic data in real-time through secure networks, such as 5G. This integration of REA with Big Data and Artificial Intelligence allows for a constant evolution of the environment’s digital twin, ensuring that NATO’s forces are rapidly adapting to the challenges of modern warfare. By mastering the concurrent REP and REA cycles, NATO ensures that its autonomous assets are not just reactive to the climate but are actively optimized to utilize the environment as a tactical enabler.

NATIONAL INTEGRATION AND FUTURE PERSPECTIVES

The effectiveness of NATO’s environmental support depends fundamentally on the quality of the technical contributions from its member nations. While the Alliance provides the doctrinal framework, the development of specialized systems remains a national responsibility. In this context, Spain’s integration of GEOMETOC support serves as a benchmark for how national naval forces can align with NATO standards.[19] The Spanish Navy has evolved its capabilities by mirroring NATO’s organizational structure. A key element in this evolution is the role of the Instituto Hidrográfico de la Marina, which acts as the core for oceanographic and geospatial information. This center ensures that technical advisory services are available not only for national fleet operations, such as the Dédalo [20] deployments, but also for multinational exercises and NATO standing naval forces.

The centerpiece of Spain’s recent technical advancement is the SIAAMETOC (Integrated Automated Meteorological and Oceanographic Support System), a project funded by the Ministry of Defense that represents a critical shift toward the automation and high-resolution modeling required for modern warfare. This system’s operational versatility is realized through specific modules designed to support diverse mission sets, including Amphibious Operations, Mine Countermeasures (MCM), Surface Warfare, and USV operations. Technologically, SIAAMETOC is currently transitioning (2025–2027) toward an ArcGIS Pro-based GIS structure, a move set to significantly enhance its resolution and analytical capabilities. Crucially for NATO, the system is built on a foundation of interoperability, with products designed to be fully exportable to other geographic information systems and usable within WECDIS (Warship Electronic Chart Display and Information System), while strictly adhering to specific NATO formats.[21]

Despite significant technical progress, the future of GEOMETOC within the Alliance relies on the human element and doctrinal integration. There is a recognized need to move beyond regarding GEOMETOC solely as a "scientific service" and instead treat it as an operational advisor present from the earliest phases of planning, capable of supporting decision-making across the strategic, operational, and tactical levels. Effectively bridging the gap between technical data and the Commander's decision-making process necessitates establishing a dedicated "GEOMETOC expert" within fleet staffs. This role depends on continuous innovation, driven by maintaining strong links with R&D centers and universities as they develop the next-generation sensors and algorithms that define environmental support. Furthermore, modern operations also demand a deeper understanding of the ecological environment to incorporate environmental stewardship and minimize the impact of military activities, particularly during training exercises.[22]

As NATO enters an era of multi-domain competition, the ability to exploit the physical environment, through advanced systems like SIAAMETOC and a robust doctrinal framework, will be the defining factor in achieving and maintaining maritime superiority.

GEOMETOC AND ELECTROMAGNETIC WARFARE

In the multi-domain battlespace, the electromagnetic spectrum is as sensitive to environmental conditions as any physical platform. The effectiveness of Electronic Warfare (EW), signals intelligence, and radar performance is dictated by atmospheric and oceanographic variables that create "ducts" or "blind spots" in the spectrum. Understanding these phenomena—such as evaporation ducts over the ocean surface or ionospheric refraction—allows NATO forces to predict the maximum detection range of an adversary's radar or the optimal frequency for secure communications.

GEOMETOC enables the transition from meteorological forecasting to Electromagnetic Battlespace Management. By analyzing temperature gradients and humidity profiles, GEOMETOC officers can advise Commanders on where to position assets to remain "invisible" to enemy sensors or where to deploy jamming assets for maximum effect. This environmental awareness transforms the physical domain into a tactical cloak, providing a significant advantage in denial-of-service operations.

As NATO integrates directed-energy weapons and high-precision laser systems, the role of GEOMETOC becomes even more critical. Atmospheric turbulence, aerosols, and water vapor density can scatter or absorb laser beams, rendering sophisticated weaponry ineffective. Real-time GEOMETOC data enables the calculation of "optical windows" where these systems can achieve maximum lethality. This convergence ensures that the technological superiority of the Alliance is not negated by foreseeable environmental interference.

STRATEGIC RECOMMENDATIONS AND CONCLUSION

Professionalizing the GEOMETOC Officer

A critical takeaway from recent operational experiences is the need for a dedicated GEOMETOC Expert within the staff of a Task Force or Fleet, moving current perceptions from a scientific 'reach-back' service toward a tactical advisory function. Achieving this shift requires NATO to standardize GEOMETOC officer training for dual competency in environmental sciences and naval/joint tactics, ensuring their presence in the earliest planning phases to identify constraints before mission parameters are set; alongside this, Allied nations must prioritize systems interoperability, such as SIAAMETOC natively exporting data into WECDIS and other NATO-standard GIS formats, while forces train to operate in 'GEOMETOC-degraded' environments where Space Weather or jamming compromises primary data links.

Strengthening the R&D-Defense Link

The rapid evolution of GEOMETOC capabilities requires a constant feedback loop between the military, industry, and academia. NATO should increase its investment in centers like the CMRE and specialized CoEs to ensure that the latest advancements in AI and 5G sensing are rapidly weaponized for environmental intelligence.

The Roadmap to Environmental Superiority

In the 21st century, the physical domain is a weaponizable asset. For NATO, mastering GEOMETOC is not merely a matter of safety or logistics; it is a fundamental requirement for Multi-Domain Superiority.

From the silent depths of the Arctic to the radiation-prone ionosphere, environmental intelligence provides the clarity needed to navigate the fog of war. By integrating advanced modeling, autonomous sensing, and specialized doctrine, the Alliance will ensure that it remains the dominant force in an increasingly volatile global security environment.

ENDNOTES

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3 NATO, AJP-3.11: Allied joint doctrine for geospatial, meteorological and oceanographic support (Edition A, Version 1), 2016.
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7 NATO, AJP 3-59: Meteorological and oceanographic operations.
8 Spanish Navy, COPNAV: Naval operations concept, 2015.
9 National Oceanic and Atmospheric Administration. (n.d.). Space Weather Prediction Center.
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15 Bathymetric data refers to the measurement and mapping of the underwater topography of oceans, seas, and other water bodies. Within a NATO operational context, precise, high-resolution bathymetry is critical for optimizing sonar performance, predicting acoustic propagation, navigating subsurface vessels, and identifying mine-like objects or favorable amphibious landing sites.
16 Ortega Felipe, "GEOMETOC support in the Navy and NATO," Revista de Temas Profesionales, 605, 2020.
17 Ortega Felipe, "Present and future of GEOMETOC support," Revista de Temas Profesionales, 1010, 2025.
18 NATO, ATP-32(E): NATO military oceanographic and rapid environmental assessment support procedures.
19 Spanish Navy, COPNAV: Naval operations concept, 2015.
20 The Dédalo deployments refer to complex, high-visibility naval operations of the Spanish Navy, often centered around the amphibious assault ship SPS Juan Carlos I and a complete task force. These deployments demonstrate Spain's strategic projection capability and their integration into NATO's collective security framework. In this context, precise, real-time GEOMETOC support, provided by the Instituto Hidrográfico de la Marina (IHM), is vital for ensuring mission safety and effectiveness.
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USMC FORCE DESIGN
APPLICATIONS TO NATO

By

CAPT (USN) Keith Tate

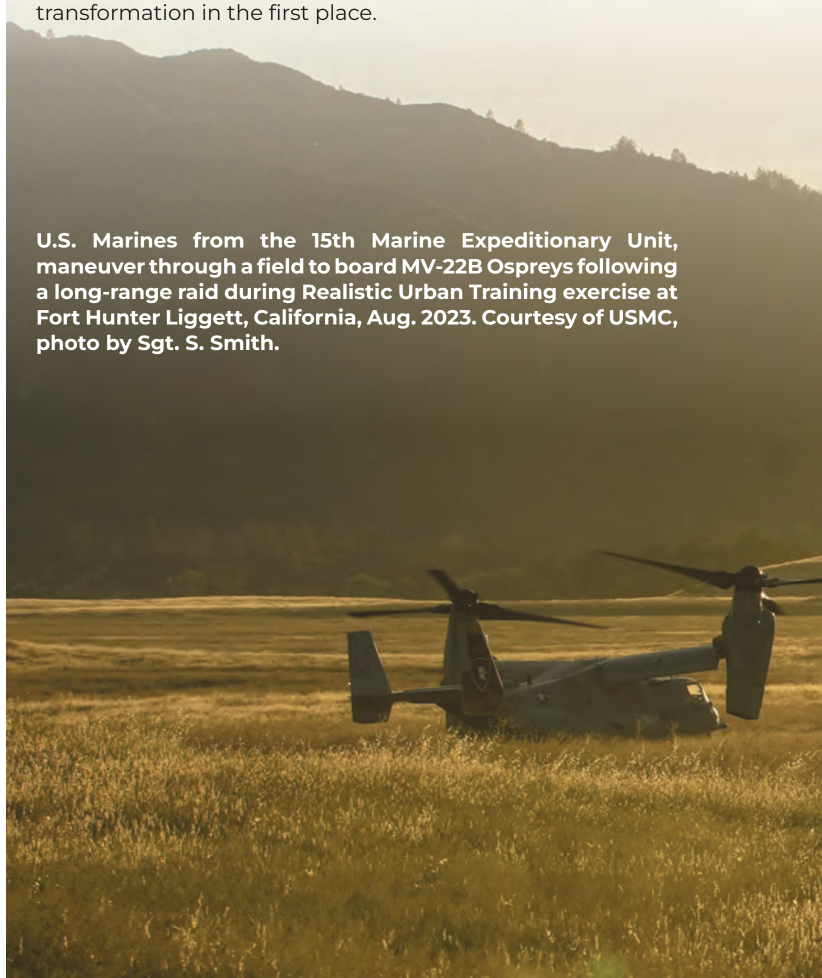
INTRODUCTION

In March 2020, then Commandant of the U.S. Marine Corps, General David Berger unveiled a stunning vision for the Marine Corps. In a sweeping, comprehensive strategy statement, General Berger announced that the fighting expeditionary service would be reorganizing, refocusing, and rebalancing itself in response to the emerging threat in the Indo-Pacific theatre.[1] This organisational makeover was originally titled Force Design 2030 but has officially become known simply as Force Design (FD). FD aims to prepare the Marine Corps not only to fight the next war, but to modernize and adapt one of the world's pre-eminent expeditionary forces into a centrepiece of 21st century joint warfare. FD is characterized by smaller dispersed fighting forces, less tanks and artillery vehicles, new shore-to-sea weapon systems in service of sea denial, and learning to fight and win not as a regiment in a land campaign, but as an agile, low-signature squad or platoon in a contested littoral campaign across a multi-domain spectrum. This article will not only examine the distinctive nature of Force Design, but most importantly, explore whether NATO members should adopt any of the elements of FD for implementation into their respective expeditionary, amphibious, or coastal defence forces as they seek to counter Russian aggression.

But before one can make an informed recommendation on whether an Alliance partner should adopt aspects of FD, one must understand what the aim of FD is, and the current state of expeditionary forces within the Alliance. A strong starting place is the USMC's 2025 annual self-assessment of FD progress, published in October. It opens with this statement from the current Commandant, General Eric Smith:

> *"The Marine Corps is a globally responsive, lethal, and resilient combined-arms naval expeditionary force that projects power from sea-to-land and land-to-sea, fighting as a Marine-Air-Ground Task Force (MAGTF) across all domains in contested environments to deter, deny, and defeat adversaries. Marines conduct sea denial, contribute to sea control, and conduct amphibious operations to deny adversary freedom of action, while extending Joint Force commanders' operational reach. Modernized forward forces, optimized to operate in the littorals, seize and hold key maritime terrain to deliver lethal effects, sense and shape the operating environment, and close kill webs in support of fleet maneuver and joint campaigns."*

Several elements within this statement are striking. First, the statement makes several references to the Marine Corps and its naval connections. One of the concerning assessments by pre-FD era Marine Corps leadership was that the service was becoming an exclusively counterinsurgency (COIN) force and something akin to a smaller version of the US Army. However, by getting back to its naval expeditionary roots, the Marine Corps is making a marked shift away from a post-9/11 mindset and decidedly toward being a more agile and distinctive fighting force alongside its Navy partners. Words like "naval", "maritime", "amphibious", "littorals", "fleet", and "land to sea" are emphasized in the statement and reveal the full extent to which the Marine Corps is embracing its new identity as a fighting partner of the Navy contributing to historically "blue side" objectives. The inclusion of words and phrases typically seen in naval doctrine (power projection, sea denial, sea control, and fleet maneuver) reinforces this notion and communicates to partners and enemies alike that the FD Marine Corps will be heavily contributing to what was before a singular Navy effort. As Alliance partners weigh the benefits of FD adoption, it is important to quickly review what led the Marine Corps to undertake such a transformation in the first place.



U.S. Marines from the 15th Marine Expeditionary Unit, maneuver through a field to board MV-22B Ospreys following a long-range raid during Realistic Urban Training exercise at Fort Hunter Liggett, California, Aug. 2023. Courtesy of USMC, photo by Sgt. S. Smith.

THE RATIONALE

In response to China's rapid defence buildup, and the fact that the Marine Corps was assessed as unprepared and not organized to fight and win against a peer adversary, President Trump's administration released the 2018 National Defence Strategy (NDS). It stated that the US was shifting away from COIN and moving confidently toward near-peer competition in the Pacific. Further, the NDS directed the armed forces to modernize and embrace emerging technology (AI, drones, unmanned systems, etc.).[2] With national guidance in hand, Marine Corps leadership began exploring its history for an operational concept that could be modernized and adapted into something aligned with the new NDS. To do that, the Marines turned to two of their most hallowed moments: the WWII battles of Guadalcanal and Wake Island.

The hard-fought lessons from Guadalcanal and Wake Island revealed an operational concept with 21st century applicability. Guadalcanal demonstrated the importance of capturing and holding forward airfields, including the surrounding approaches, to achieve and sustain air supremacy. Guadalcanal also taught invaluable lessons about the nature of forward logistics and the realities of contested resupply in a littoral environment. Similarly, Wake Island demonstrated how a small island-occupying force could defend an isolated maritime position against a superior force. But to do so, that occupying force requires the appropriate level of Command and Control (C2) to ensure the correct support (logistical and informational) is provided to the forces on the ground throughout the conflict. As Marine Corps strategists studied these examples, a 21st century operational framework emerged: Expeditionary Advanced Base Operations (EABO). The goal of EABO is to use distributed bases to create a more resilient forward force posture that can deny an adversary the ability to execute counter-intervention strategies.[3] EABO provides a doctrinal framework by which Marines can fight, sustain, and win inside a contested littoral environment. But EABO is merely an operational enabler, that is, a means to a greater end. EABO fits within a larger doctrinal framework; a concept known as Littoral Operations in the Contested Environment (LOCE).

LOCE is the broader naval concept for expeditionary forces operating effectively within an adversary's Weapons Engagement Zone (WEZ) in coastal and near-shore areas with the goal of defeating the adversary's Anti-Access/Area Denial (A2/AD) bubble thus enabling follow-on actions from the joint force. Doing so requires a shift in mindset to persistently operate inside the threat range, rather than staying outside of it.[4] EABO enables LOCE to fight on the land within the littoral setting, and moreover, inside the enemy weapon range. Both doctrinal concepts are naval expeditionary frameworks, and as such, the Marine Corps and the Navy will fight in a mutually interdependent relationship not seen in decades. As a result of these emerging doctrinal concepts, the growing China threat, the strategic shift in the NDS, and the state of the Marine Corps in 2018, Force Design was born. But even if an Alliance partner was open to considering changing some aspects of their expeditionary forces to make them more competitive in a 21st century conflict, where to even begin? A survey of some of the doctrinal changes intrinsic to Force Design may reveal some answers.

FORCE DESIGN – DOCTRINE

The concepts of LOCE and EABO have quickly become doctrinal mainstays, but a third concept has emerged within the Corps: Stand-In Forces. The SIF concept aims to employ small, lethal, mobile, and low-signature forces persistently inside an adversary's WEZ during peacetime competition.[5] If EABO and LOCE are strategic objectives, SIF operates at the tactical level. Critics argue that SIF is not only an unproven concept, but that such forces operating inside a WEZ would not receive adequate air support, nor would they be able to mutually support nearby SIF teams in a high-intensity fight. However, in an April 2022 US Naval Institute Proceedings article, USMC Commandant General Eric Smith reminded his readers that the role of the Marine Corps is to deter and defeat that pacing threat when the time comes. To do that, he believes the Marines must adopt a fighting model in which SIF is the edge of the spear. General Smith clarifies the point by stating that SIF is not a rogue band of island-hopping marauders waiting for an enemy to happen upon them. Rather, they are a task-oriented mobile force that can maneuver and sustain independently for days while they support the joint force, providing valuable detect-and-deter capabilities that would not otherwise be possible in that environment. He considers SIF to be a natural and modern extension of naval expeditionary power projection in the 21st century. Lastly, he states with no equivocation that the Marine Corps is

U.S. Marines, alongside NATO allies during a breaching and clearing mission in preparation for Exercise Nordic Response 2024 in Norway. Courtesy of USMC, photo by Lance. Cpl. C. Salazar.

not a Stand-In Force (as a whole), nor is every unit a SIF unit. Rather, the Marine Corps is an expeditionary and amphibious service that is highly capable of conducting SIF operations.[6]

But think-piece articles are not the only way that the Marines are putting FD doctrinal concepts into practice. In his 2025 annual FD assessment, General Smith announced that the latest revisions to EABO and SIF concepts were being implemented and incorporated into the Marine Corps Doctrinal Publication 3 (MCDP 3 "Expeditionary Operations") and the newest Marine Corps Warfighting Publication (MCWP "Littoral Operations"). Beyond the service-specific publications, the Marines have also influenced the latest revisions of Joint and NATO publications. Joint Publication 3-02 (JP 3-02 Amphibious Operations, April 2025) includes the latest Marine Corps doctrine specific to FD, and Allied Joint Doctrine for Maritime Operations (December 2023) has also been updated to reflect FD elements.

As the Marine Corps confidently strides forward to face the China threat in coming years, a new question arises: What elements of Force Design can be adopted by the expeditionary or amphibious forces of Alliance nations? This is not a rhetorical exercise in wishful thinking, but rather a serious consideration of the tangible aspects of Force Design that naturally lend themselves to incorporation by NATO nations. Understandably, the defence programmatic decisions made at the national level will always be driven by fiscal realities and long-term strategic potential. However, a close look at a sample of Alliance members and their amphibious/expeditionary forces reveals opportunity for relevant modernization by drawing from the Force Design blueprint.

NATO APPLICATIONS – SWEDEN

As NATO's newest member, Sweden's comparatively small amphibious force makes her an interesting candidate to adopt facets of Force Design. Sweden's strategic placement in the high North coupled with her archipelagic coastal geography are tailor made for Force Design doctrine. Sweden's expeditionary forces, known as the Swedish Amphibious Corps, for decades have trained in archipelagic warfare, small island defence, mobile coastal battery positioning, and logistics in the high north. Aside from the climate, these qualities align closely with Force Design's leading tenets. The introduction of a long-range coastal weapon like Navy-Marine Expeditionary Ship Interdiction System (NMESIS) into Sweden's armament would greatly enhance the defence in depth capabilities while enabling a heightened ability to deter surface-borne threats at range.

The emergence of the USMC's Stand-In Force model provides a blueprint to which Sweden nearly already operates from. Moreover, the USMC and Sweden's Amphibious Corps already train together in an annual exercise since 2018 called ARCHIPELAGO ENDEAVOR (AE). AE is a bilateral training opportunity in which the USMC and their Swedish counterparts train in Swedish field locations with the training objectives of conducting cold-weather raid missions, arctic operations, and achieving enhanced interoperability. This exercise provides a strong opportunity for both forces to perfect and test various elements of Force Design as it suits their respective needs. To be sure, Sweden does not have the operational reach that the US does, but they do have a vested interest in protecting their coast and being ready to operate in a cold-weather archipelagic environment against a powerful threat.

As of late 2024, Sweden's Amphibious Corps has implemented their own service-wide modernisation program called "Force Design Swedish Marine Battalion 2030". The parallels to the USMC's Force Design are unmistakable, but it does underscore the larger point that Alliance partners have taken notice of FD and have begun examining the readiness of their expeditionary forces to fight and win a 21st century conflict. Force Design offers compelling options to a coastal nation like Sweden that is already aligned to many of its operational concepts. But what about another nation with greater reach and a larger expeditionary force? Does Force Design offer anything to a nation like the United Kingdom?

NATO APPLICATIONS – UNITED KINGDOM

Interestingly, the UK's Royal Marines are conducting an organisational transformation of their own.[7] After many years of operating as a form of light infantry arm of the Royal Navy, the Royal Marines are moving to "commando-ize" their expeditionary forces and focus on littoral operations in support of naval partners at sea. The Royal Marines and Commando Forces have all but adopted the USMC's EABO concept, exemplified by the establishment of Littoral Response Groups (LRG) in 2020, not coincidentally the same year that FD was announced. LRGs are a forward-deployed, highly mobile, amphibious capability designed to perform missions across the spectrum of conflict. Nominally, an LRG consists of a Royal Marines Commando company that is supported by Royal Fleet Auxiliary vessels and landing ships.[8] Further, the LRG is highly interoperable with NATO maritime forces and partner nations. More to the point, the establishment of LRG North, to counter and respond to European/High North crises, and LRG South, which is focused on the Indo-Pacific theatre heavily suggests that the UK is borrowing a page from the Force Design playbook. The UK and the US unsurprisingly possess a shared assessment of the global threat environment and the recent programmatic shifts within the Royal Marines reflect that. Major annual exercises such as TALIMAN SABRE, ATLANTIC ALLIANCE, BOLD ALLIGATOR, and NORDIC RESPONSE have deepened the partnership between the two forces in recent years and serve as a template for other partner nations to emulate.

For years, critics of the UK defence model have argued that it was outdated, too small whilst simultaneously too heavy, and not ready to "fight tonight". Lately however, the UK expeditionary forces are demonstrating commitment to a Force Design-like makeover that not only addresses these criticisms but enhances interoperability as well. In the furtherance of that goal, they should consider formal adoption of EABO and LOCE doctrine in a way that naturally complements the steps they have already taken to modernise their expeditionary forces.

NATO APPLICATIONS – SPAIN

The Spanish Navy's Marine Infantry (Infanteria de Marina) is the world's oldest marine force and is considered Spain's pre-eminent deployable expeditionary force. Most recently, in April 2025, NATO certified the Spanish Navy as the designated Allied Reaction Force (Maritime). The ARF is a new concept for NATO, and it provides multi-domain forces from across the Alliance to produce effects on short notice against conventional, hybrid, or cyber threats.[9] Strategically located at the southwest tip of the European continent with a southern mediterranean coast and west-facing Atlantic shoreline, Spain would undoubtedly benefit from adopting certain elements of Force Design into their own modernisation efforts. By already participating in several Allied and multi-lateral exercises such as UNITAS, DYNAMIC MARINER, and the STEADFAST series, Spain is a professional and highly reliable fighting partner. An examination of their expeditionary forces reveals a consistent willingness to partner alongside the USMC and Alliance nations in an ever-increasing desire to train together and enhance interoperability in any contested environment.

Spain could benefit from modernizing and extending their long-range sea denial capabilities while also exploring high-tech solutions applied to small, agile forces operating in the littorals. The NMESIS program offers this ability. Further, training to a concept like SIF would disperse their forces along their southern coast as opposed to a small number of heavily concentrated areas. And while Spain is actively acquiring the Naval Strike Missile (NSM) for their surface platforms, no official announcement has been made concerning utilizing the NSM in a mobile Spanish coastal battery role. Ultimately, Spain's expeditionary forces are a considerable player. And while not perhaps at the scale of the UK or France, they are unquestionably a regional power, and a key amphibious partner within the Alliance. By strengthening their long-range sea denial capability and exploring SIF concepts in a Mediterranean littoral setting, Spain would develop their expeditionary abilities while simultaneously increasing their coastal defence.

NATO APPLICATIONS - THE NETHERLANDS

The Royal Netherlands Marine Corps (RNLMC) boasts several unique characteristics, chiefly being worldwide deployable within 48 hours, personnel highly specialized in combat training, agnostic to operational climate or environment, deep integration with the UK's Royal Marines and special forces, and a technology-heavy operations model. Some commenters observe that the RNLMC "punches above their weight class" and it is easy to appreciate the metaphor. As a specialized, lean, high tech fighting force, the RNLMC and the USMC train together frequently, both in their respective home countries, but in various global locales such as Scotland and Norway.

Like Spain and the UK, the RNLMC has not formalized any American warfighting doctrine such as EABO or LOCE. However, the RNLMC's fighting model is a solid fit for adopting such doctrine, and doing so would strengthen bi-lateral training events, enhance NATO integration, and deepen ties between the two forces. Such adoption would require the doctrine to be scaled appropriately to the RNLMC as they are a force of 2,500 personnel. However, as the USMC develops agile, low-signature, unmanned systems for logistics support in contested environments, the RNLMC presents itself as an attractive development partner. They do not possess that capability but co-developing an innovative logistics solution would serve both nations in a littoral contest regardless of operational theatre. Similar to other nations already discussed, the recent modernisation efforts undertaken by the RNLMC positively align with Force Design. Continuing to do so, with deliberate emphasis on littoral fighting doctrine and unmanned logistics solutions would increase the RNLMC's standing within the NATO joint structure as a ready fighting force.

NATO APPLICATIONS – FRANCE

Alongside its British and American allies, France is the only other NATO member with sovereign territory in the Indo-Pacific region and is therefore a special case when it comes to the question of Force Design applications. As such, France's expeditionary and amphibious forces are unique players within NATO in terms of Force Design's influence on policy and force modernisation. France's defence priorities in the Indo-Pacific stem from sovereign protection and not merely upholding the rules-based order in the way that other NATO partners might behave. By adopting a national policy of "de-risking, not decoupling" the French economy from China's, France is balancing a cautious, but firm approach to its once very strong economic partner.[10] With that context, analysis reveals that France is currently postured to act as a premier coalition partner in an expeditionary fight, but does not have the mass, depth of manpower, or forward logistical infrastructure to fight unilaterally in a region like the Indo-Pacific in direct conflict with a competitor. However, as evidenced in their recent National Strategic Review, France views itself on an urgent economic war footing. Driven by the strategic dilemma of a "dual-facing" posture, France must simultaneously reinforce NATO's Eastern Flank against Russia and strengthen its presence in the Indo-Pacific. This necessitates a national obligation to equip its forces with lighter, more agile, and robust interoperable systems, vehicles, and equipment.[11]

If those solutions sound familiar, it is because France has identified at the national level what Force Design seeks to address at the service level. Like the authors of Force Design, France recognizes the imminent need to connect shooters with sensors, to revitalize the industrial base with special focus on logistical supply and re-supply, to merge the cyber and expeditionary domains, and to lighten its forces while enhancing lethality in a dispersed fashion. It would be inaccurate to merely state that Force Design influenced France's national defence decisions in recent years, but it is readily apparent that France has arrived at identical strategic conclusions and prescriptive measures as those reached by General Berger and the architects of Force Design.

NATO APPLICATIONS - JEF NATIONS

The ten nations of the Joint Expeditionary Force (JEF) (UK, Sweden, The Netherlands, Finland, Norway, Denmark, Estonia, Latvia, Lithuania, and Iceland) would benefit from adopting certain aspects of Force Design. Because the UK, Sweden, and The Netherlands have already been addressed, this section will cover the remaining nations collectively. First, it is important to understand, especially to readers who may not be familiar with the JEF, that the Joint Expeditionary Force is a UK-led, ten-nation coalition under the NATO umbrella containing deployment-ready forces that are ready to respond to a conflict or crisis. A JEF task force can be led by NATO, the UN, or other security coalitions, and boasts that it is capable of conducting full spectrum operations.[12] Because many of these nations have a strategic interest in the security of the Baltic region, only those elements of FD that serve that goal should be considered; specifically, long range sea denial and force dispersion consistent with EABO doctrine.

Concerning long range sea denial, as has already been discussed, the Baltic Sea is a strategic body of water with thousands of miles of shoreline owned by JEF nations. With a long range, ground based low-cost portable missile battery, JEF nations could hold at-sea high value surface targets at risk from range while complementing their own naval assets and coastal defences. Worth noting is that Sweden, Finland, and others already operate a form of coastal defence batteries, but defence analysts assess that they could integrate a NMESIS-style system which would achieve the objectives stated above.

U.S. Marines and Royal Marine Commandos execute a tactical recovery of aircraft and personnel exercise during Northern Viking 2022. Courtesy of USMC, photo by Cpl. Y. Guyette.

Because most of the JEF nations have comparatively smaller expeditionary forces, many of them are already well trained in small-unit archipelagic operations in multiple climates with diverse geographies. Adoption of EABO frameworks would not only standardize their respective approach to such warfare but would further their ability to exploit northern European geographic features all while presenting a smaller and more challenging target to enemy forces. Additionally, training to a shared, formally adopted standard or doctrine would augment interoperability efforts and provide a unified goal that all participants aspire to attain.

Worth mentioning is the bold step the Marine Corps made when it divested its legacy systems and equipment to more fully focus its efforts (both fiscally and organisationally) on building a future consistent with its new aims. Smaller JEF nations should thoughtfully consider the cost benefit to retaining legacy systems and assets at the expense of incurring a warfighting technological gap that not only risks their strategic interests, but that of their neighbors. In many ways, the UK is already doing this. Previous defence budget constraints have yielded current capability gaps. But the UK, in recognition of this, is prioritizing and developing littoral strike capability over heavy armor. The Scandinavian nations have embraced technology as a critical component of their respective defence strategies and expeditionary operating models, but they would be wise to consider technologies that enhance mobility, stealth, and innovative logistics solutions in contested environments. The truly smaller nations (Latvia, Estonia, etc.) must carefully choose divestiture opportunities in ways that allow them to protect themselves and their larger neighbors on whom they depend. NMESIS is one of several options that would allow a smaller JEF nation to effectively deter a threat from a larger nation.

CONCLUSION

In the final analysis, the Marine Corps' transformation under the banner of Force Design has impacted organisational structure, equipment, technological investment and divestment, doctrine and warfighting. But it is also having an undeniable strategic effect with Alliance partners and their respective expeditionary, amphibious, and coastal defence forces. Force Design is also conditioning the warfighting mindset within the Marine Corps. Gone are the days of heavy armor-centered land campaigns in which the differences between the Marine Corps and the Army were barely distinguishable. Force Design now squarely plants the Marine Corps alongside the Navy in a fight for dominance within the littorals. That fight is characterized by contested logistics, agility, long-range strike and sea denial from the shore, and heavy technological incorporation while presenting a small electronic signature. The accelerated defence growth of China cannot be ignored, and the risk of hybrid warfare on the European continent waged by Russia only continues to increase. Force Design offers a plan with a clear objective at its forefront.

As the nations of NATO with expeditionary forces find themselves in varying degrees of modernisation, a careful examination of Force Design at the national level with its sprawling reach and influence is a worthy endeavor. The Marine Corps has given NATO a blueprint for how to steer a warfighting organisation toward a specific future fight with unique characteristics. While a European NATO nation like Denmark, for example, may not be on a collision course with China in the coming years, it is absolutely concerned with Arctic security, elevating its long-range strike capability, wise defence spending, and force modernisation. Force Design offers solutions and innovative perspectives on these enduring questions.

The NATO nations that have led from the front on military technological advancements should continue to participate in exercises like Robotic Experimentation and Prototyping Augmented by Maritime Unmanned Systems (REPMUS) and DYNAMIC MESSENGER while exploring investment opportunities that support and develop military interoperability within the Alliance. These exercises focus on the employment and testing of unmanned systems in all phases of maritime military operations, to include automated logistics. Force Design requires that logistics in the littorals be agile, resilient, reliable, and low-cost. By partnering with like-minded nations, an innovative solution will get tested, approved, and fielded, greatly diminishing the competitive edge of the adversary.

Perhaps the greatest lesson that the implementation of Force Design continues to teach also serves as the primary reason that the Marines dropped the "2030" from Force Design. As General Smith states, Force Design is not a destination or a date on the calendar. It is a process of learning, improvement, honest self-assessment, and clear-eyed threat recognition.

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HUNTER TO HUNTED

SURVIVING THE DIGITAL DEEP

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INTRODUCTION

Deep beneath the ocean's surface, the submarine has long reigned as the unseen predator of naval warfare, its lethality tied directly and inextricably to its invisibility. For generations, its commanders and crews operated with a serene confidence, secure in the knowledge that the abyssal quiet was their exclusive domain. The ocean's vast, opaque depths were not merely an operating environment but an ally, a three-dimensional battlespace where the submarine was the undisputed apex predator. That historical, hard-won dominance is now facing a reckoning. The threat is no longer a lone hunter-killer submarine or a patient maritime patrol aircraft, but something entirely new: a coordinated, chattering swarm of autonomous systems weaving a digital net that tightens with each passing moment. The hunter is systematically becoming the hunted.

This profound shift is not a distant, theoretical concept; it is the tactical reality of today. The historical advantage of submarine stealth is being fundamentally and systematically challenged by the proliferation of sophisticated, networked autonomous platforms. Fleets of unmanned underwater, surface, and aerial vehicles, all interconnected and orchestrated by artificial intelligence, are striving to create a transparent, "glass ocean." This technological upheaval has ignited a new and rapidly evolving tactical duel, forcing a radical evolution in undersea warfare that will redefine the future of maritime power. This article will trace the arc of this transformation, beginning with the submarine's legacy of dominance and its enduring strategic relevance. It will then dissect the nature of the modern autonomous threat before analysing the adaptive strategies and advanced technologies submarines are now employing to survive and fight back. Finally, it will project the future of this complex, high-stakes competition, a future defined by a permanent duel in a new hybrid, digital deep.

LEGACY-HISTORY: THE RISE OF THE SILENT SERVICE

The submarine's formidable reputation was not granted but earned over a century of conflict, forged on an anvil of stealth and surprise. Its emergence as a weapon of war represented a paradigm shift, proving that true sea control was not merely about ruling the waves, but also about dominating the silent, dark world beneath them. The German U-boats of the First World War forever altered naval combat, demonstrating that a single, unseen assailant could challenge the mightiest surface fleets and hold global trade at risk.[1] These early submersibles established a tactical doctrine built on the ambush, allowing a weaker force to dictate the terms of engagement, strike with lethal precision, and vanish back into the crushing depths before an effective response could be mounted. The submarine thus became the great equalizer in naval strategy, a vessel that does not seek a fair fight but rather engineers an unfair one in its favour by exploiting the unique properties of the undersea environment.[2]

This asymmetric power was cemented during the Battle of the Atlantic in World War II. German U-boats, operating in coordinated "wolfpacks," waged a ruthless and effective campaign against Allied merchant shipping, threatening to sever the vital transatlantic lifelines that were the foundation of the war effort.[3] The psychological impact of this campaign was immense; the enemy was everywhere and nowhere at once, creating a state of constant peril across vast stretches of the ocean. This era perfected the art of the underwater ambush and underscored a critical lesson: naval supremacy required dominance not just on the surface, but also throughout the entire water column.

The rise of the submarine inevitably triggered a desperate scramble to counter it, igniting a technological and tactical "Hide and Seek" game that has continued unabated for generations. Anti-submarine warfare began as a rudimentary affair, relying on static nets, minefields, and the optimistic use of deck guns against briefly surfaced U-boats. The introduction of the depth charge and primitive hydrophones during World War I marked the first true technological shift, giving surface ships a tangible means to fight back against a submerged foe.[4] This duel escalated dramatically in World War II. Pushed to the brink by the U-boat threat, the Allies rapidly innovated, organizing destroyers and frigates into dedicated hunter-killer groups. These groups employed active sonar—known as ASDIC by the British—to actively "ping" the depths, while long-range maritime patrol aircraft like the B-24 Liberator patrolled vast swaths of the ocean, ready to drop depth charges on any contact.[5] The establishment of the convoy system, which grouped vulnerable merchant vessels with armed escorts, was a tactical and organizational masterpiece that transformed the open ocean from a U-boat hunting ground into a lethal trap.

This relentless cycle of innovation reached its zenith during the Cold War, a period that defined the modern submarine. As boats became faster, quieter, and, with the advent of nuclear propulsion, capable of staying submerged for months, ASW technology raced to keep pace. This era saw the deployment of large-scale, fixed surveillance systems

HS MATROZOS (S-122) in Digital Era – AI Synthesized Visual Concept .

like the Sound Surveillance System (SOSUS), a network of hydrophone arrays laid across the seabed of the Greenland-Iceland-United Kingdom gap to listen for the faint acoustic signatures of Soviet submarines.[6] Mobile platforms became more sophisticated, with towed array sensor systems trailing for miles behind surface ships and Magnetic Anomaly Detectors (MAD) on aircraft sniffing for the metallic bulk of a submarine's hull. The high-stakes, and often clandestine, "cat and mouse" games played out by American, British, and Soviet forces—from trailing rival ballistic missile submarines to covertly tapping undersea communications cables—forged a doctrine built on the twin pillars of acoustic superiority and absolute stealth.[7] This enduring, multi-decade competition between the "hider" and the "finder" has directly shaped the complex, technologically dense underwater battlespace of the 21st century.

CONTINUED RELEVANCE IN THE MODERN ERA

In the contemporary strategic landscape, the submarine's importance has not waned; it has simply evolved and, in many respects, intensified. While the prospect of large-scale, fleet-on-fleet naval battles has diminished, the submarine's unique portfolio of capabilities makes it more critical to national security than ever before. It remains the platform of choice for missions requiring persistence, discretion, and a high degree of survivability.

First and foremost, the submarine is the ultimate platform for Intelligence, Surveillance, and Reconnaissance. In an era of anti-access/area denial (A2/AD) environments, where surface ships and aircraft are held at increasing risk, a modern submarine can covertly penetrate contested waters to monitor enemy coastlines, track naval movements, and collect vital signals and acoustic intelligence, all while remaining completely undetected.[8] Its ability to loiter for extended periods provides commanders with unparalleled, persistent situational awareness. This is not passive collection; it is the crucial first step in understanding an adversary's capabilities and intent.

Secondly, the submarine remains a potent and highly flexible instrument of power projection. The integration of long-range land-attack cruise missiles, such as the Tomahawk, allows a submerged and unseen platform to deliver precise, conventional strikes against high-value targets hundreds of miles inland.[9] This capability provides national leaders with a powerful, low-risk, and often deniable option to influence events ashore. Unlike a carrier strike group, which has a massive logistical and political footprint, a submarine's strike can be executed with a degree of strategic ambiguity, sending a clear message of capability and resolve without the escalatory posture of deploying overt surface forces.[10]

Finally, and most fundamentally, the submarine is the most survivable leg of the nuclear triad, representing the ultimate guarantor of national security for nuclear-armed states. Ballistic missile submarines patrol the world's oceans in absolute secrecy, their precise locations unknown at any given moment. This ensures a secure and credible second-strike capability, the bedrock of nuclear deterrence theory.[11] The inherent stealth and mobility of the SSBN platform make it virtually invulnerable to a surprise first strike, guaranteeing that any nuclear aggression would be met with a devastating retaliatory response. This foundational role of strategic deterrence, combined with its unmatched prowess in covert ISR and conventional power projection, ensures that even in an age of ubiquitous sensors and autonomous systems, the "silent service" remains one of the most enduring and vital assets in any modern navy.

CHALLENGES TODAY: THE RISE OF THE DIGITAL HUNT

The submarine's traditional sanctuary is now being systematically penetrated by a new class of hunters, orchestrated into a formidable digital network. This is not a single threat but a multi-domain system of systems, designed to strip away the submarine's cloak of invisibility and render the ocean transparent.

A New Class of Hunter: An Array of Autonomous Threats

- **Unmanned Underwater Vehicles (UUVs):** The deep ocean is no longer the sole domain of crewed submarines. A diverse and growing generation of UUVs is populating the abyss, functioning as tireless sentinels. These platforms range from small, man-portable devices for littoral reconnaissance to large and extra-large UUVs engineered for trans-oceanic persistence, capable of patrolling vast areas for weeks or months on end.[12] Their missions are expanding from mine countermeasures and subsea infrastructure inspection to active ASW. Advanced UUVs are increasingly equipped with sophisticated passive and active sonar suites, allowing them to autonomously detect, track, and classify submerged contacts. Future iterations, operating in coordinated "wolfpacks," could be tasked with deploying countermeasures, launching lightweight torpedoes, or even executing direct-attack missions, transforming them from simple sensor nodes into lethal extensions of naval power.[13]
- **Unmanned Surface Vehicles (USVs):** While UUVs patrol the depths, USVs are revolutionizing the ocean's surface, acting as the critical "connective tissue" in the emerging anti-submarine network. Platforms like the US Navy's Sea Hunter act as mobile, multi-mission platforms that can be deployed independently or from a "mothership" to extend the reach and resilience of naval forces. Their primary role in ASW is to host a vast array of sensors, from high-power active sonars to long towed passive sonar arrays, creating a distributed and persistent sensor web across the battlespace.[14] Crucially, they function as vital communication relays, bridging the formidable gap between undersea, surface, and aerial assets. A USV can receive a trickle of data from a submerged UUV via a low-bandwidth acoustic link and then transmit a comprehensive tactical picture to aircraft or command centres via high-speed satellite communications, creating a cohesive, real-time operational picture that was previously impossible to achieve.[15]
- **Unmanned Aerial Vehicles (UAVs):** Completing this multi-domain threat matrix are UAVs, which provide a critical and persistent "eye in the sky." Deployed from shore, ships, or even submarines themselves, long-endurance drones like the MQ-9B SeaGuardian can patrol for over 30 hours, using high-definition cameras and surface-search radar to scan the ocean. Their most significant contribution to ASW is the ability to rapidly and dynamically deploy and monitor sonobuoy fields. A single UAV can drop and monitor dozens of these acoustic sensors over a wide area, process the data on-board using advanced algorithms, and instantly relay any contacts, transforming the traditionally deliberate process of sonobuoy deployment into a dynamic and responsive hunt.[16] Furthermore, UAVs are now being equipped with advanced sensors previously reserved for manned aircraft, including MAD systems that can pinpoint a submarine's metallic hull.

An AI visualization of a digital Underwater Warfare Barrier Concept.

The Power of the Network and Non-Acoustic Detection

The true disruptive force of these autonomous systems lies not in their individual capabilities, but in their collective power as a networked "system of systems." This "kill web," orchestrated by artificial intelligence, can fuse data from hundreds of disparate sensors to create a comprehensive and undeniable picture of the battlespace.[17] A single human operator can command a "swarm" of autonomous vehicles, with AI algorithms dynamically allocating tasks. A USV may detect a faint acoustic anomaly, automatically cueing a nearby UUV for closer, clandestine inspection while a UAV is retasked to provide overhead surveillance—all happening in seconds, at machine speed.[18] This presents a profound tactical dilemma for a submarine commander, confronting them not with a single, evadable pursuer, but with a distributed, intelligent, and relentless web of sensors and potential effectors.

This digital swarm is complemented by a burgeoning field of emerging non-acoustic detection methods that threaten the very foundation of submarine stealth. These technologies bypass sound altogether, searching for other physical disturbances a submarine inevitably creates as it moves through the water. While traditional MAD has a limited range, new developments in "quantum magnetometry," such as Superconducting Quantum Interference Devices, promise a revolutionary increase in sensitivity, potentially allowing detection from much greater distances.[19] Satellite-based synthetic aperture radar is being refined to detect the subtle surface disturbances caused by a submerged vessel, such as the "Bernoulli hump"[20] or the persistent V-shape of a "Kelvin wake[21]".[22] Advanced blue-green Light Detection and Ranging systems are capable of penetrating the water to directly image a submarine at shallow depths, while other sensors are being developed to detect minute thermal signatures, chemical traces from propulsion systems, or even the faint bioluminescence stirred up by a passing hull in plankton-rich waters.[23] While none of these technologies is a "silver bullet," when layered together and fused by AI, they create a multi-modal, multi-faceted detection net that is incredibly difficult for a submarine to evade.

THE PREDATOR ADAPTS

To survive and fight in this increasingly transparent, hyper-connected environment, the submarine is being forced to undergo a radical evolution. It is adapting its tactics, developing sophisticated countermeasures, and, in a classic case of co-option, embracing the very autonomous technology that threatens it. The predator is learning new tricks.

Counter-Autonomy and the Art of Deception

The first line of defence is to fight back. In response to the growing autonomous threat, navies are aggressively developing sophisticated "drone-killer" torpedoes. These are not the large, heavy weapons designed to sink a capital ship, but smaller, more agile smart munitions engineered to hunt and neutralize the nimble profile of a UUV.[24] They require advanced guidance systems capable of discriminating between targets and executing complex attack profiles in a cluttered environment. Simultaneously, development is surging in non-kinetic solutions, where high-energy lasers or powerful microwave pulses could be used to disable a drone's sensitive electronics without the acoustic transient of an explosion, thus keeping the submarine's own location securely hidden.

Beyond direct attack, the submarine's greatest weapon remains deception. To counter the ever-watchful sensors of autonomous systems, submarines are being outfitted with a revolutionary new class of decoys and jammers. These are not the simple bubble-makers of the past; today's countermeasures are themselves autonomous, intelligent vehicles. Once launched from the submarine, these mobile decoys can mimic a submarine's acoustic, magnetic, and thermal signatures with stunning fidelity, leading hunter-killer drones on a wild goose chase miles away from the actual submarine. The goal is to create a confusing and cluttered underwater battlespace, injecting false targets and ambiguous data to overwhelm the processing power of the enemy's autonomous network.[25]

The Submarine as a Mothership

Perhaps the most significant transformation in a generation is the submarine's evolution from a lone wolf into the pack leader of its own robotic fleet. The concept of the submarine as an underwater "mothership" is now a rapidly emerging reality. Capable of deploying, and in the future recovering, a wide variety of UUVs and UAVs from torpedo tubes or specialized payload modules, the submarine can now project its sensor and effector influence far beyond its own hull.[26] This new capability fundamentally alters naval strategy. A host submarine can dispatch smaller, stealthier UUVs into high-risk littoral zones, contested chokepoints, or heavily monitored enemy harbours—places where a multi-billion-dollar nuclear submarine would never dare to venture. These drones act as the mothership's extended eyes and ears, gathering critical intelligence, mapping the seabed, or silently tracking enemy movements in real-time.

The role of these deployed systems extends well beyond simple reconnaissance. Armed UUVs, operating as a forward-deployed, loyal wing of the mothership, can be tasked to engage targets, deploy mines, or execute electronic warfare missions, all while the parent submarine remains safely at a standoff distance, concealed in deeper water. The U.S. Navy's Virginia-class submarines, with their innovative Virginia Payload Module—a series of large-diameter tubes inserted into the hull—are at the forefront of this evolution, providing cavernous payload bays designed specifically for these new autonomous payloads and next-generation missiles.[27] This strategy co-opts the very technology that poses a threat, turning the submarine into a distributed, networked hunter itself.

The Enduring Quest for Deeper Silence

Finally, in an ocean filling with autonomous sensors, the ultimate countermeasure is to never be detected in the first place. Massive leaps in propulsion and stealth technology are making today's submarines quieter and more elusive than ever. Chief among these innovations is Air-Independent Propulsion (AIP), a revolutionary technology that bridges the critical stealth gap between conventional diesel-electric and nuclear-powered submarines. AIP allows a non-nuclear submarine to operate for weeks without needing to surface or snorkel for air, drastically reducing its vulnerability.

Several competing forms of AIP technology exist, from closed-cycle Stirling engines that burn diesel fuel with liquid oxygen (perfected by Sweden's Gotland-class and Japan's Sōryū-class) to advanced fuel cells that generate electricity through a silent chemical reaction (pioneered in German and South Korean designs).[28] This sustained, silent endurance grants commanders the priceless gift of time—time to wait, listen, and choose the perfect moment to act. This quest for invisibility extends to the very skin of the submarine. Modern hulls are masterpieces of hydrodynamic science, shaped to move through the water with minimal disturbance. These advanced hulls are coated with sophisticated anechoic tiles—specialized rubber or synthetic polymer materials that are designed to absorb active sonar pings and dampen the submarine's own internal machinery noise, effectively making it a black hole for sound in the deep ocean.[29]

THE DUEL IN THE DIGITAL DEEP

The future of undersea warfare is a hybrid domain where the lines between the physical and digital, the human and the machine, are irrevocably blurred. The era of absolute submarine dominance, guaranteed by the single virtue of stealth, is over. It has been replaced by a persistent, dynamic duel between the ever-adapting submarine and the increasingly capable autonomous networks hunting it. This is a high-tech chess match defined not by a single checkmate, but by a continuous, relentless cycle of innovation and counter-innovation, where the tactical advantage will shift with each technological leap.

Victory in this contested domain will not be decided by steel and explosive power alone, but by superior algorithms, high-speed data fusion, and the seamless integration of human crews with their robotic wingmen. The side that can achieve "decision superiority"—the ability to sense, understand, decide, and act faster and more effectively than its adversary—will hold the decisive edge. This places a premium on the development of robust, resilient networks and advanced AI-driven tactical aids that can filter signal from noise and present human commanders with clear, actionable intelligence.

The strategic implications are profound. The proliferation of these technologies challenges the dominance of traditional naval powers and demands a fundamental rethinking of naval force structure, with a greater emphasis on distributed lethality and resilient, networked operations. Ultimately, the success of future undersea operations will depend on the quality of the human-machine team. The submariner's role is evolving from a hands-on operator to a mission commander, orchestrating a fleet of autonomous assets while providing the critical thinking, ethical judgment, and creative problem-solving that machines still lack. The duel in the deep is far from over; it has simply entered a new, more complex, and more intelligent chapter. The nations that master this new form of hybrid warfare will be the ones to secure their interests and shape the maritime balance of power in the 21st century.

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20 YEARS OF SUPPORTING THE ALLIANCE

USNS Wally Schirra, HMS Prince of Wales, and RFA Tidespring conducting a Replenishment at Sea (RAS) during Operation Highmast in August 2025, with HNoMS Roald Amundsen following in formation. Courtesy of Royal Navy, photo by LPhot Bill Spurr.


COMBINED JOINT OPERATIONS
FROM THE SEA