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Naval Combat Systems: Developments and Challenges

edited by Alessandro Marrone and Elio Calcagno

ABSTRACT

Technological innovation has accelerated in the maritime domain, and major navies worldwide must increasingly deal with emerging and disruptive technologies. Some of the most recent advancements in the field of naval combat systems have touched a number of key capabilities, including unmanned systems, quantum technology, hypersonic and conventional missiles, and directed energy weapons. Additionally, new geopolitical competitions are increasingly taking place on the global seas. Russia and China have invested in capabilities aimed at engaging enemy vessels at an increased range and/or disabling its infrastructures. The US Navy, for its part, is attempting to transition to a force with a larger proportion of small manned and unmanned ships, aircraft and underwater vehicles. In Europe, the French Navy has to juggle technological innovation with an overstretched fleet and the running costs of an independent nuclear deterrent, while the UK is seeking to leverage flexibility and lethality against similar constraints. On the other hand, the German Navy may not benefit from the ongoing uplift of its national defence budget. Italy is undergoing an important modernisation process which is increasing its capabilities for high-end naval warfare and power projection.

keywords

Defence | *Naval* | *Technologies* | *Warships* | *US* | *UK* | *France* | *Germany* | *Italy* | *Russia* | *China*

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For the useful and constructive exchange of views during the project, the editors are very grateful to Leonardo Company, CeSMar and the Italian Ministry of Defence, and in particular the Italian Navy. The study also reflects the findings of the seminar "The future naval domain: military capabilities and technological innovation", held in Rome on 14 December 2022. This study has been realised with the support of Leonardo, and it has been completed on 13 January 2023.

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Executive summary

The strategic importance of naval combat systems

The world's seas and oceans are a vital enabler for the functioning of the globalised economy. The sea is also a source of sustenance for around three billion people globally, while its seabed is a deposit of fossil fuels often subject to international disputes. Furthermore, the increasing relevance of seabed pipelines, Liquefied Natural Gas (LNG) shipping and sea-based LNG floating terminals – not to mention fibre optic cables – generates new needs for maritime surveillance and security.

In a context where important state and non-state actors are rejecting the Western-dominated international liberal order, based on the rule of law and including the freedom of navigation, the sea is also a vital arena in which to invest for any hypothetical challenge to US strategic supremacy. Consequently, the development of new and disruptive technologies in the naval domain, for use in both symmetric and asymmetric scenarios, has received considerable attention in the military planning of revisionist powers such as Russia and China as an important foundation for the attainment of regional or wider goals *vis-à-vis* US and/or NATO conventional superiority.

Technological innovation in the defence field is undergoing a radical change of pace. As Emerging and Disruptive Technologies (EDTs) are introduced onto the modern battlefield and make warfighting ever more multi-domain in nature, the naval combat cannot escape this trend. Indeed, given its strategic importance in today's context of geopolitical competition, the maritime domain has become a hotspot for innovation. Naval combat systems encompass de facto all those elements such as sensors, effectors and command, control and communication (C3) that directly contribute to naval offensive and/or defensive operations. These range from missiles, torpedoes, naval guns with guided ammunition, anti-submarine and anti-surface warfare (ASW, ASuW) helicopters and aircraft, to the sensors needed for detection, threat identification, the unmanned systems (UxVs) that extend a warship's reach and, in the not too distant future, Directed Energy Weapons (DEW).

Naval warfare touches perhaps more physical domains than any other kind of warfare, as it extends from space, through the air, sea surface, underwater and down to seabed, plus the littoral areas that are stage to amphibious operations. This uniqueness makes even more important to integrate naval combat systems in a multi-domain approach to military operations.

In recent decades, warships have become increasingly complex platforms, having to account for new and deadlier threats and the necessary counter-measures. As a result, modern warships tend to be fitted with more numerous and more diverse combat systems than their predecessors in order to ensure readiness, effectiveness

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and lethality in case of conflict with peer- or near-peer adversaries. In turn, these systems become increasingly advanced, complex, and expensive, and they account for a larger share of the overall cost of the whole military vessel as a System of Systems (SoS).

While new technologies are mainstreamed into the world's leading militaries, countermeasures are often lagging behind, as is the case for instance with hypersonic missiles and relatively affordable unmanned systems. As a result, warships are starting to become more vulnerable to a wider array of threats spanning from hypersonic and anti-ship ballistic missiles to UxVs, on top of conventional threats.

Thus, the ideal modern warship must be equipped with a great number of cutting-edge sensors, countermeasures and weapons that increase both its offensive and defensive capabilities, while relying on advanced Combat Management System (CMS) able to manage all systems and the incoming data – and to be connected to an integrated network. It therefore follows that the overall cost of modern warships has risen significantly in recent years.

As mentioned before, a large and growing share of this cost is related to the naval combat systems rather than to the hull, propulsion and the navigation systems *per se*. Consequently, navies must find the right balance as they seek to spread high-end capabilities across a greater number of hulls (to increase versatility, survivability and reach) and therefore reduce the potential impact of the loss of one ship to the navy's overall effectiveness.

For larger, manned warships this will likely require ensuring that each vessel has all the capabilities necessary to operate effectively alone or as part of smaller groups when needed. For instance, the US Navy has developed a concept for "Distributed Lethality" as a way to enhance the US fleet's Anti-Access and Anti-Denial (A2/AD) capability and sea control by augmenting the defensive and offensive potential of individual warships.

The war in Ukraine has provided some insight into how much technological innovation, even pertaining to the use of relatively inexpensive unmanned systems, can be effective in the face of an unprepared adversary. Indeed, both the sinking of the Russian Black Sea flagship *Moskva* and the October 2022 Ukrainian attack on the naval base at Sevastopol were carried out with the involvement of UxVs alongside missiles and other assets, sinking or damaging large and much more expensive warships.

The increasing complexity of naval combat systems has also implications on a navy's crew in terms of numbers and of skills required of each sailor, as well as the type of training needed to operate advanced technologies that evolve at a faster pace compared to previous decades. However, while new technologies require a higher degree of specialisation by military personnel in order to operate, maintain and repair current naval combat systems, newer systems generally require less

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crew as they offer a higher degree of automation and increased reliability and availability, thus offering at least a partial solution to the recruitment problems facing most Western navies.

Advancements in terms of space-based earth observation, as well as sensor and UxVs technologies, offer great opportunities to several navies wishing to substantially widen a naval combat system's reach way beyond what was technically possible only a decade ago. These opportunities, however, are contingent on a fleet's ability to adequately integrate a large array of naval combat systems, and the data they generate, into a cohesive SoS architecture. This in turn should be accompanied by a significant doctrinal evolution to keep pace with technological innovation, including with regard to a procurement, maintenance and update cycle for combat systems able to keep up with future changes.

Russia and China approaches to naval combat

China and Russia face very different challenges and opportunities in the adoption of new weapon systems and disruptive technologies in the naval domain. The former operates the largest navy in the world in terms of number of ships (but not tonnage) and can count on a huge, robust and expanding economy, including a growing Defence Technological Industrial Base (DTIB). Meanwhile, the latter has to pursue technological innovation while its shipbuilding industry is stifled by Western sanctions and technical obsolescence, in a weak overall economic context. The war in Ukraine is set to exacerbate existing Russian difficulties. Differences exist also at a doctrinal level: Russia still pursues a platform-centric approach to naval warfighting, while China has been steadfast in adopting a SoS, networked perspective.

Nevertheless, both countries hope that technological innovation will help fill some capability gaps that persist in the respective navies, notably in ASW and Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR). Russia and China consider themselves vulnerable to lightning Western (and specifically US) combined arms attacks. As such, both countries have developed doctrines which emphasise disabling enemy infrastructure and engaging its vessels at increased range, taking full advantage of missile technology and submarines, as well as using unmanned systems as forces multipliers. Be it to maximise the navy's power projection or to guarantee the survivability of its deterrent force, new weapon systems are at the core of both countries' current naval efforts.

The Navy of the Russian Federation (*Voyenno-morskoiflot*, VMF) has a long tradition of putting innovation and technological disruption at the core of its operational concepts. Since the fall of the Soviet Union, and again after the first round of international sanctions in 2014, the VMF has come to regard new naval systems as the key to counterbalance the perceived superiority of its peers in terms of tonnage, number of ships and force projection capabilities. Indeed, the adoption of disruptive technologies (especially UxVs, hypersonic and cruise missiles) has

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become central to its attempt to update an aging fleet. For example, Surrogat-W, presented in Armya-2022 Expo, is imagined as an expendable reconnaissance Unmanned Underwater Vehicle (UUV) tasked to perform duties that would otherwise risk revealing the position of manned submarines. The navy is also working on modernising the fleet's anti-ship missile capabilities through a process known as the "Kalibrisation" drive, i.e. the widespread equipment of 3M14 Kalibr cruise missiles on a variety of vessels. This would play a crucial role for the Russian fleet in the Mediterranean Sea. The next addition to the Navy's missile arsenal would be the 3M22 Zircon hypersonic cruise missile, which is still in development and allegedly capable of Mach 9 speeds with a 1,000 km range.

China's adoption of next generation naval combat systems has been the result of the doctrinal developments accompanying its rise as a global military power. The People's Liberation Army Navy (PLAN) has recently overtaken the US Navy as the largest in the world in terms of number of vessels, though the PLAN displaces around 2 million tons distributed over 335 ships against the USN's 4.5 million over 305, indicating that Beijing still relies largely on a great number of smaller vessels. While smaller vessels can generally be less capable than larger ones, a major naval confrontation between China and the US would likely occur near the Chinese mainland, where smaller PLAN vessels could theoretically operate under an umbrella of land-based A2/AD capabilities. Nevertheless, the PLAN is also proceeding full steam ahead towards becoming a fully-fledged blue water navy. Crucially, the rate at which modern vessels are being commissioned is currently unmatched.

United States: Facing the Chinese challenge at sea

The US Navy and Marine Corps face growing challenges ranging from great powers China and Russia to regional threats such as Iran and North Korea. Supported by commercial and military surveillance networks in every domain, weapons based on adversary territory could threaten US and allied ships, troop formations, and aircraft hundreds of miles away, and slow or prevent intervention by American naval forces. As mentioned before, China fields the most capable of these networks.

Against this backdrop, the US Navy is attempting to transition from a force composed entirely of large, manned platforms to one with a larger proportion of small manned and unmanned ships, aircraft, and underwater vehicles. However, with budgets unlikely to grow substantially during the 2020s, freeing up funds to make this shift will result in the US fleet initially shrinking as numerous surface combatants and submarines built in the waning days of the Cold War retire without immediate one-for-one replacements. By the 2030s Navy leaders intend to begin growing the fleet as new UxVs enter the force, along with hypersonic weapons and lasers to improve the fleet's lethality and survivability, and capabilities developed through Project Overmatch. This project is the navy's top innovation priority and is intended to integrate an increasingly heterogeneous fleet in order to provide decision-making advantages.

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Since 2015, the Navy has fielded and tested prototype Laser Weapon Systems (LaWS) on amphibious ships USS Ponce and Portland capable of countering UAVs surface craft. Longer-term, the Navy's High Energy Laser Counter-ASCM Program (HELCAP) is developing a 300-kW laser. By relying on electrical power instead of surface-to-air missiles, HELCAP would increase the missile defence capacity and survivability of surface vessels.

Command and control is the most important aspect of the US Navy's changing conceptual approach. Commanders of distributed ships and troop formations rely on fleet commanders' Maritime Operations Centres ashore for intelligence, planning, and direction – a dependency that would increase during conflict. However, opponents like China could disrupt long-range communications, requiring the Navy to develop C2 processes and architectures that adapt to different degrees of communications availability.

France: A spread-out fleet

The Marine Nationale is a recovering force: like most navies in the West, its funding largely decreased after the end of the Cold War, with the emphasis for newly built ships being put on affordability and endurance rather than lethality.

Still, the Marine Nationale has maintained capabilities across the board. Operating a nuclear-powered aircraft carrier and a flotilla of capable ballistic missile submarines, however, has placed a significant burden on the navy's finances, with severe consequences over the rest of the force: the average French principal surface combatant lacks defence capabilities – particularly with regards to air defence – and training in the use of complex ammunition is limited. Furthermore, France's main vessels are stretched thin over the second largest economic exclusive zone in the world, which has imposed a severe operational tempo on the fleet, resulting in rising maintenance costs. The French navy remains a capable force, but similarly to its European counterparts it lacks the sheer volume of ammunition stocks required to sustain a prolonged engagement with a peer adversary.

Substantial part of the navy's budget is currently being dedicated to large-scale procurement programmes such as the Suffren-class attack submarines, the Amiral Ronarc'h-class frigates and the development of the next-generation nuclear aircraft carrier. Consequently, relatively little funding is available for other programmes relating innovation in naval combat systems.

In terms of naval aviation, the highest priority is to decide on how to replace its ageing fleet of Béguet Atlantic 2. Another key aspect of France's efforts in the maritime domain rests with the future of its missile selection. The Marine Nationale currently relies on the Aster family of missiles for air defence and is likely to field its latest iteration, the Aster 30 Block 1NT, to boost its ballistic missile defence (BMD) capabilities. It is also rumoured to be considering the purchase and integration of MBDA's MICA VL short range, ground based air defence system aboard its principal surface combatants to gain a cost-effective capability to counter low-level threats.

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This further rationalisation of the French Navy's air defence would also benefit from the introduction of the RAPIDFire close-in weapon system, meant to offer yet another mean to counter unmanned vehicles, light aircrafts and missiles with its future Anti Aerial Airburst (A3B) rounds. With regards to surface warfare, France still heavily relies on the Exocet family of anti-ship missiles (AShM), particularly in its latest iteration, the Exocet Block 3. The renewal of this capability beyond the Exocet life expectancy, however, is part of a larger French-British effort, dubbed Future Cruise and Anti-Ship Weapon (FC/ASW).

Finally, the increasing and mutual interdependence of all domains, and the necessity to operate in the vast Indo-Pacific region vis-à-vis Chinese capabilities, have pushed the Marine Nationale to improve its approach to multi-domain operations by setting up command structures capable of coordinating assets across branches and services.

Germany: A navy's secondary role in the Bundeswehr

The German Navy has shrunk considerably since the end of the Cold War in terms of total hull numbers, with the new crisis response mission profile strongly influencing the design of contemporary units and the decision which older ones to retain. For example, the latest class of frigates is designed to fulfil exactly the types of missions the navy has come to cover since the 1990s: lower intensity, constabulary in nature and far away from domestic supply and maintenance networks.

With high-end warfighting and deterrence of a peer-competitor again high up on the agenda, the German navy designed its next class of frigates and managed the replacements of older units aiming at global deployment ability, much greater tonnage and overall reduction in crew, in a trend that is very much observable also in the submarine field. However, while the German navy has relatively risen in importance in the Bundeswehr over the past thirty years of crisis-response missions, the air force and army will be likely given greater priority in terms of budget vis-à-vis Russian threat on NATO eastern flank.

Concerning its main weapons systems, the navy is procuring a replacement for its ageing Harpoon, Kongsberg's Naval Strike Missile. Aiming to improve stealth and range, the new missile also comes with ship-shore in addition to ship-ship targeting capabilities. As a completely new introduction into the fleet, the F125's 127 mm gun received certification for the use of Leonardo's and Diehl's jointly developed Vulcano long-range ammunition. The navy is also working towards acquiring a submarine-based (anti-helicopter) missile, while the so-called Interactive Defence and Attack System for Submarines (IDAS), has been on the wish-list and under development for a number of years.

Italy: A balanced and evolving force

The war in Ukraine and broader geopolitical confrontation between the West and systemic rivals such as Russia and China, combined with increased threat levels

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in the Mediterranean, have prompted the Italian Navy and the whole MoD to focus more on warfighting capabilities. Such capabilities should be fit for collective defence in the Euro-Atlantic area as well as to keep global SLOC open and safe in case of tensions with peer-competitors. Still, capabilities for crisis management and maritime security operations will be retained within a balanced and evolving force. The geographic focus is on the so-called "wider Mediterranean" region, ranging from the Gulf of Guinea all the way through the Med and the Red Seas until the Persian Gulf and the Gulf of Aden, that encompasses blue waters and not just brown or green ones.

The Navy already operates the Cavour flagship with a carrier wing of F-35B, making it one of only three navies worldwide to have a carrier strike group equipped with 5th generation aircraft – and the only one in the EU. Among the navy's most pressing priorities is to strengthen its ASW capabilities, in view of the underwater environment becoming more congested in the Mediterranean and beyond and the challenges laid bare by the war in Ukraine. This development goes hand in hand with an increasing focus on the underwater environment.

As part of an ongoing modernisation process, the MM is planning to acquire new combat systems that will increase its potential for naval warfare and power projection substantially, starting from long range strike capabilities in the form of cruise missiles fitted onto frigates, destroyers and submarines. The MBDA-made Teseo MK2/E, an evolution of the OTOMAT anti-ship missile, will be equipped on the next generation destroyers and the multi-role offshore patrol corvettes (*Pattugliatori Polivalenti d'Altura* – PPA). Furthermore, the four next generation U212NFS submarines will be fitted with long-range deep strike cruise missiles.

The navy's helicopter fleet, mostly comprised of modern and very capable aircraft, will soon be enhanced by the procurement of embarked rotary-wing UaVs that will specialise in ISR operations. To that end, the acquisition of Leonardo's AW Hero rotary wing UAV is being discussed. Meanwhile, the planned procurement of Vulcano 127 mm ammunition in its unguided Ballistic Extended Range (BER) and Guided Long Range (GLR) versions represents a leap forward in terms of precise artillery strikes for the Italian Navy.

When looking at the navy's fleet composition, a clear trend is observable where warships coming into service in recent years are consistently larger than their predecessors and fitted with more, and more diverse, weapon systems. This trend is likely to continue in the future, in line with the growing focus on high-end naval warfare. For example, the next generation destroyers might reach 10,000 tons at full load versus the 7,050 of Horizon-class destroyers currently in service.

From the Navy's perspective, the ongoing blurring of the domains' boundaries requires a new concept for naval combat, which was outlined in some detail by the Future Combat Naval System 2035 in Multi-domain Operations (FCNS 2035) concept. The FCNS 2035 provides a synthesis of the navy future vision with a specific focus on the development and integration of new technologies in naval

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combat. More generally, the "Defence Approach to Multi-domain Operations" released by the Joint Staff in 2022 outlines the Italian Armed Forces' approach in this regards in line with NATO doctrine.

United Kingdom: Lethality and flexibility vs. fewer hulls

The Royal Navy contends with a series of interrelated shifts in the conduct of war at sea, if it is to meet its aim of being Europe's premier naval contributor. The UK will indeed face new missile and renewed submarine threats with a historically low number of surface vessels, a state of affairs that will continue until the 2030s. The Royal Navy will also need to support the country's Indo-Pacific tilt which, though currently modest in its ambitions and resourcing, could become a more significant pillar of British national security policy driven by factors such as the UK's engagement with strategic partnerships such as AUKUS and longer-term considerations regarding the rise of China as a competitor.

The Royal Navy's current vision for meeting the ambitions set for it by British policy-makers hinges on leveraging flexibility and lethality to get more from a limited number of hulls. Indeed, the UK will not seek to match competitors "hull for hull" but will instead seek to build a lead in disruptive future technologies to offset competitors' quantitative advantages. The realisation of this vision relies on a number of prerequisites, including increased modularity in naval combatants, the adoption of unmanned capabilities and a focus on long range strike, as laid out under the aegis of the Defence Command Paper. Accordingly, the Royal Navy will emphasise modularity in shipbuilding as an offset to limited mass. through the selected hull designs of Type 31 frigate and the upcoming Type 32 frigate. The purpose of these vessels will be to allow mission modules to be swapped to allow a limited surface fleet to perform multiple functions. This design principle will enable the rapid integration of unmanned capabilities, as Type 32 vessels are expected to be interoperable with and capable of hosting, launching and recovering unmanned assets.

Regarding lethality against surface vessels, the Royal Navy will pursue the Norwegian Naval Strike Missile (NSM) as an interim solution, while focusing its longer-term efforts on delivering its Future FC/ASW – an Anglo-French project to which 95 million pounds has been committed. Though pursuing experimentation with and adoption of autonomous capabilities through its NavyX accelerator, the procurement of unmanned capabilities at scale has not yet occurred. This may reflect a desire to procure mature capabilities to meet the goal of distributed operations while preparing platforms capable of hosting them. The Royal Navy is also engaged in efforts to deliver survivability for large platforms in contested environments. It will upgrade its Type 45 to enable it to conduct BMD interceptions – largely as a response to the anti-ship ballistic missile threat. The Royal Navy is also testing the Dragonfire directed energy system, a 50 kw directed energy weapon that can play a role in defending vessels against both missiles and UAS, as the UK MoD plans to spend up to 130 million on the programme. Beyond this, the Navy is committed to enhance the ability of systems, including human operators,

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to respond to fast moving threats. An example of this investment is the AI-enabled Startle system, trialled on the Type 23 frigate during operation Formidable Shield, which is geared towards reducing the operator burden in air defence.

A supporting role for the EU

The European Union is the world's number one exporter and second largest importer, with maritime routes being critical for its trade. Meanwhile, the return of great power competition and the confrontation sought by Russia deeply affect the naval domain. With a renewed focus on high intensity and peer-level competition, the Union can play an important role in encouraging cooperation among its member states as they plan to develop and procure state-of-the-art naval combat systems, including through the financial incentives provided by EU defence initiatives.

The 2022 EU Strategic Compass names the naval domain among the key sectors in which member states intend to invest in order to develop new and enhanced capabilities and innovative technologies, so as to fill existing gaps and reduce dependencies from other countries. In particular, the Union prioritises the achievement of interoperable capabilities able to guarantee superiority at sea and underwater. As a testament to this, the European Defence Agency (EDA)'s capability development priorities include the categories of naval manoeuvrability and underwater control. In order to advance European capability development in these fields, the Union is funding a number of relevant projects – especially under the European Defence Fund (EDF) and its precursor programmes – such as the Modular Multirole Patrol Corvette (MPCC). The MPCC is based on the European Patrol Corvette project led by Italy and participated by France, Greece and Spain within the EU Permanent Structured Cooperation (PESCO). The project is at a critical juncture, whereby decisions have to be take regarding design and commonality of the vessel and its combat systems.

A number of other projects are ongoing within EDF, PESCO or EDA frameworks, focusing among other things on counter-mines measures, harbour protection, and the integration of manned and unmanned assets. Among concluded efforts, OCEAN2020 project – led by Leonardo and involving 43 partners from 15 member states – project proved exactly the integration of UxVs in naval operations, through sea demonstrations in both Mediterranean and Baltic Sea.

Ten key elements for Italy's sea power

In light of the analysis put forward by previous chapters, the following ten elements are particularly important for Italy in the naval domain.

1. A shift towards high-end capabilities within a balanced Navy
2. Multi-domain *cum grano salis*
3. The balancing of fleet numbers and systems
4. A reality check on modularity
5. A renewed approach to naval combat systems

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1. The strategic importance of naval combat systems

by Elio Calcagno

Technological innovation in the defence field is undergoing a radical change of pace. As emerging and disruptive technologies are introduced onto the modern battlefield and make warfighting ever more multi-domain in nature, naval warfare cannot escape this trend. Indeed, given its strategic importance in today's context of geopolitical competition, the maritime domain has become a hotspot for innovation. Naval combat systems encompass all those elements such as sensors, effectors and command, control and communication (C3) that directly contribute to naval offensive and/or defensive operations. These range from missiles, torpedoes, naval guns with guided ammunition, anti-submarine and manned or unmanned anti-surface warfare (ASW and ASuW) helicopters and aircraft, to the sensors needed for detection, threat identification, the unmanned systems that extend a warship's reach and, in the not too distant future, directed-energy weapons (DEW).[1] Naval warfare touches perhaps more physical domains than any other kind of warfare, as it extends from space, through the air, sea surface, underwater and down to seabed, plus the littoral areas that are stage to amphibious operations. This uniqueness makes naval combat an ideal case study when examining how technological innovation affects naval combat systems and how these, in turn, can integrate effectively as part of a system of systems (SoS), multi-domain approach to warfare.

1.1 The sea as a stage for global competition

It goes without saying that the world's seas and oceans are a vital enabler for the functioning of the globalised economy. Indeed, about 90 per cent of global trade volume is transported by sea, while some estimates indicate that maritime trade volumes will triple by 2050.[2] The sea is also a source of sustenance for around three billion people globally, while its seabed is a source of fossil fuels often subject to international disputes.[3] Furthermore, the new relevance seabed pipelines, liquified natural gas (LNG) shipping and sea-based LNG floating terminals (not to mention fibre optic cables) generates new needs for surveillance and security, as demonstrated by recent events involving the Nord Stream 1 and 2 pipelines in the Baltic Sea.[4]

[1] Jonathan Gates, "Combat System", in *Encyclopedia of Maritime and Offshore Engineering*, 2017, DOI 10.1002/9781118476406.emoe308.

[2] Organisation for Economic Co-operation and Development (OECD) website: *Ocean Shipping and Shipbuilding*, https://www.oecd.org/ocean/topics/ocean-shipping.

[3] OECD website: *Ocean Economy and Developing Countries*, https://www.oecd.org/ocean/topics/developing-countries-and-the-ocean-economy.

[4] Christopher Jungstedt, "Explosive Residue Confirms Nord Stream Sabotage in Swedish Probe", in *Bloomberg*, 18 November 2022, https://www.bloomberg.com/news/articles/2022-11-18/nord-stream-explosions-were-caused-by-sabotage-sweden-concludes.

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In a context where numerous state and non-state actors are rejecting the Western-dominated international liberal order, based on the rule of law and including the freedom of navigation, the sea is also a vital arena in which to invest for any hypothetical challenge to US strategic supremacy. Indeed, since the end of the Cold War, the latter was made possible also by Washington's unmatched capacity to project power and forces globally by sea, in the absence of militaries willing and able to significantly disrupt it.[5]

The capacity to exert sea control and effective sea denial are thus prized commodities for major navies in the current context of rising geopolitical competition. Indeed, the ability to secure varying degrees of sea control in a given context is a necessary precondition for any country or alliance wishing to project its military forces, trade and influence by sea, while safeguarding access to the world's key maritime chokepoints. Conversely, the denial of an adversary's capacity for sea control is a crucial goal for any challenger. Last, but by no means least, the sea conceals nuclear-missile-armed submarines – the most resilient of nuclear strike forces and a pillar of strategic deterrence.

Consequently, the development of new and disruptive technologies in the naval domain, for use in both symmetric and asymmetric scenarios, has received considerable attention in the military planning of revisionist powers such as Russia and China[6] as an important foundation for the attainment of regional or wider goals *vis-à-vis* US and/or NATO conventional superiority.[7]

1.2 Technological advancements in naval combat systems

Some of the most recent technological advancements in the field of naval combat systems have touched a number of key capabilities, including unmanned systems, hypersonic and conventional missiles, helicopters, DEWs, and quantum technology. Other emerging and disruptive technologies (EDTs), such as 3D printing, quantum computing and artificial intelligence (AI), have the potential to greatly enhance existing capabilities while also delivering new ones.[8] In addition, effective war-fighting at sea, perhaps more than in any other operational domain, requires a SoS approach and the integration of a multitude of systems and data sources into a common recognised maritime picture. This in turn generates the need for higher degrees of automation as well as improved integration across assets and data communication, as was demonstrated during the Open Cooperation for European mAritime awareNess (OCEAN2020) project led by Leonardo in the context of the

[5] Jonathan Masters, "Sea Power: The U.S. Navy and Foreign Policy", in *CFR Backgrounder*, 19 August 2019, https://www.cfr.org/backgrounder/sea-power-us-navy-and-foreign-policy.

[6] On Russia and China see chapter 2 of this study.

[7] On the US see chapter 3 of this study.

[8] Interview to Lorin Selby, "Chief of Naval Research Talks about Quantum Tech, Lasers, Basic Research and STEM Education", in *U.S. Naval Institute Proceedings*, Vol. 147, No. 5 (May 2021), https://www.usni.org/node/56241.

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EU's Preparatory Action on Defence Research (PADR).[9]

Nowadays, major navies worldwide have no choice but to invest in a timely manner in the means to counter new and upcoming threats such as hypersonic missiles and combined multi-domain drone swarms. Most naval powers currently cannot realistically expect radical budget increases, and are thus forced to find ways to enhance the defensive and offensive capabilities of their fleets through the procurement of advanced and often-expensive technologies rather than increasing hull numbers. Gaining and maintaining a technological edge versus a potential adversary can make the difference between military victory or defeat, as in principle this allows a warship or fleet a useful advantage in terms of detection and/or engagement range as long as the adequate weapon systems and countermeasures are available. Technological superiority, if used adequately, can also serve to strengthen kill chains and optimise logistics management.[10]

1.2.1 Implications for navies

Particularly since the end of the Cold War, warships have become increasingly complex platforms, having to account for new and deadlier threats and the necessary counter-measures.[11] As a result, modern warships tend to be fitted with more numerous and more diverse combat systems than their predecessors in order to ensure readiness in case of conflict with peer- or near-peer adversaries. For example, modern Italian navy destroyers are currently fitted with most types of conventional warship armaments except cruise missiles, including anti-air and anti-ship missiles, naval guns (also acting as close-in weapon systems – CIWS), machine guns, torpedoes and ASW helicopters.[12] Italy's future destroyers, the DDX, will also be fitted with deep land-strike-capable missiles, likely without losing any of the aforementioned capabilities.[13]

While new technologies are mainstreamed into the world's leading navies, countermeasures are often lagging behind, as is the case for instance with hypersonic missiles and relatively affordable unmanned systems.[14] As a result, warships are starting to become more vulnerable to a wider array of threats spanning from hypersonic and anti-ship ballistic missiles to unmanned systems, on top of conventional threats.[15]

[9] On OCEAN2020 and other examples of EU defence cooperation see chapter 8 of this study.

[10] Interview, 25 October 2022.

[11] Interview, 4 November 2022.

[12] Seaforces: *Andrea Doria Class Guided Missile Destroyer (DDG)*, https://www.seaforces.org/marint/Italian-Navy/Destroyer/Andrea-Doria-class.htm.

[13] On Italy see chapter 6 of this study.

[14] Nick Childs, "Ukraine: Unconventional Impact at Sea?", in *Military Balance Blog*, 11 November 2022, https://www.iiss.org/blogs/military-balance/2022/11/ukraine-unconventional-impact-at-sea.

[15] Interview, 4 November 2022.

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Thus, the ideal modern warship must be equipped with a great number of cutting-edge sensors, countermeasures and weapon systems that increase both its offensive and defensive capabilities, while relying on a modern combat management system (CMS), able manage all systems and the incoming data and connected to an integrated network. It therefore follows that the overall cost of modern warships – including the combat systems they are fitted with – has risen significantly in recent years, even compared to cost increases in other services' platforms.[16] Moreover, a large and growing share of this cost is related to the naval combat systems rather than to the hull, propulsion and the navigation systems *per se*. Amid current trends, navies are faced with a dilemma as they identify their requirements for new warships. Budgets concerns, increasing costs and personnel issues impact negatively on the ability of most navies to increase fleet numbers. Meanwhile, although the increased per-unit cost of combat ships makes the potential loss of each much more damaging, modern warships must be more versatile and capable of operating alone or as part of small groups.[17] Consequently, navies must find the right balance as they seek to spread high-end capabilities across a greater number of hulls (to increase versatility, survivability and reach) and therefore reduce the potential impact of the loss of one ship to the navy's overall effectiveness.

For larger, manned warships this will likely require ensuring that each vessel has all the capabilities necessary to operate effectively alone or as part of smaller groups when needed.[18] For instance, the US Navy has developed a concept for "Distributed Lethality" as a way to enhance the US fleet's Anti-Access and Anti-Denial (A2/AD) capability and sea control by augmenting the defensive and offensive potential of individual warships.[19]

The war in Ukraine has provided some insight into how much technological innovation, even pertaining to the use of relatively inexpensive unmanned systems, can be effective in the face of an unprepared adversary. Indeed, both the sinking of the Russian Black Sea flagship *Moskva* and the 29 October 2022 Ukrainian attack on the naval base at Sevastopol were carried out with the involvement of unmanned vehicles, which played a role in sinking or damaging large and much more expensive warships.[20]

[16] Mark V. Arena et al., "Why Have Navy Ship Costs Risen?", in *RAND Research Briefs*, 2006, https://doi.org/10.7249/RB9182.

[17] Interview, 4 November 2022.

[18] Ibid.

[19] On US see chapter 3 of this study. For an overview of distributed lethality see: Raymond McConoly, "What Is the 'Distributed Lethality' Concept?", in *Naval Post*, 23 June 2021, https://navalpost.com/?p=27049.

[20] Nick Childs, "Ukraine: Unconventional Impact at Sea?", cit.; "Six Months on – Lessons and Impacts from the War in Ukraine", in *Navy Lookout*, 12 August 2022, https://www.navylookout.com/six-months-on-lessons-and-impacts-from-the-war-in-ukraine.

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1.2.2 Adapting to evolving threats

Generally speaking, navies today tend to procure hulls designed to last even longer than the two or three decades that were already the norm until recently. Indeed, the gap between the obsolescence curves of naval platforms and certain combat systems is growing larger. While fitting modern systems onto much older hulls is often difficult and cost-ineffective, modern warship designs must nevertheless take into account future developments in technology and operational requirements in order to lengthen the lifespan of the vessel by delaying obsolescence as much as possible.[21] Such an approach requires the development of open and modular systems that can easily undergo updates and upgrades in order to adapt to new or changing threats and operational requirements with regards to the development and design phase as it is for the contractual framework that underpins a procurement programme. The US Department of Defence (DoD), for example, has been working on mainstreaming a Modular Open Systems Approach (MOSA) in defence acquisition programmes.[22] Also the European Union, through its European Defence Fund (EDF) has identified modularity as a useful approach to the Modular and Multirole Patrol Corvette (MMPC) project, highlighting the ambition to increase "the flexibility of second line vessels in order to conduct a wider range of operations".[23] One way in which a modular approach can also leave an open door to future developments in technology and capabilities is designing larger hulls in order to leave the physical space needed for additions and upgrades. Furthermore, most new systems – while often smaller than their predecessors – may also require more energy to function and thus additional cooling capacity in order to avoid overheating.[24] Other novel systems are larger than previous ones, such as fixed-panel radar systems in comparison with rotating ones.[25]

The increasing complexity of naval combat systems has also implications on a navy's crew in terms of numbers and of skills required of each sailor, as well as the type of training needed to operate advanced technologies that evolve at a faster pace compared to previous decades. New technologies require a higher degree of specialisation by operators in order to operate, maintain and repair current naval combat systems.[26] Many newer systems also generally require less personnel as they offer a higher degree of automation and increased reliability and availability, thus offering at least a partial solution to the personnel problems facing most Western navies. A telling example regarding automation's impact on personnel

[21] Interview, 20 October 2022.

[22] US Department of Defense, *Modular Open System Approach (MOSA) Reference Frameworks in Defense Acquisition Programs*, May 2020, https://ac.cto.mil/wp-content/uploads/2020/06/MOSA-Ref-Frame-May2020.pdf.

[23] European Commission Funding & Tender Opportunities Portal: *Modular and Multirole Patrol Corvette*, https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/edf-2021-naval-d-mmpc.

[24] Interview, 13 December 2022.

[25] Ibid.

[26] Interview, 20 October 2022.

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needs is provided by 127 millimetre guns on US destroyers: while WW2-era US destroyers required between fifteen and twenty sailors to operate these guns, modern *Arleigh Burke*-class destroyers only need six.[27] Similarly, Italy's future DDX is expected to be crewed by more than 300 sailors,[28] while the smaller, now decommissioned Cold War-era *Vittorio Veneto* cruiser was crewed by well over 500.[29] Nevertheless, increased automation, by itself, does not lead to a trajectory of ever-decreasing crew numbers below a certain point: ships will still require a level of human operators that guarantees flexibility and safety.[30]

1.3 The challenges and opportunities of integration

Advancements in terms space-based earth observation as well as sensor and unmanned technologies offer great opportunities to modern navies wishing to substantially widen a naval combat system's reach way beyond what was technically possible only a decade ago. These opportunities, however, are contingent on a fleet's ability to adequately integrate a large array of naval combat systems, and the data they generate, into a cohesive SoS architecture supported by integrated C3.[31] In practice, for instance in the field of combat management systems, navies are increasingly keen on strategic – rather than only tactical-level integration as one way to facilitate interoperability between a greater number of diverse systems, if necessary including unmanned ones and multinational assets.[32] This is particularly important for multi-national operations carried out for instance within a NATO or EU framework, where a flagship from one nation might operate alongside different vessels from other nations. The ability for ships operating jointly to integrate data and information from each other's sensor and weapon systems would greatly enhance the commanders' combined maritime picture, while also allowing each ship to play a specific role within a larger fleet, integrating seamlessly with a larger whole. To this end, in 2021 the European Defence Fund included in its 2021 call for proposals the European Digital Naval Foundation (EDINAF), which aims to create a digital ship reference architecture that will in the future enable the integration of a joint naval operational cloud.[33]

[27] Daniel Vardiman, "Is Cutting-Edge Military Tech Really Cheaper than Manpower?", in *Automating the Fight*, 20 September 2022, https://www.atlanticcouncil.org/?p=563979.

[28] Tom Kington, "Italy Plans New Destroyers for 2028 Delivery", in *Defense News*, 9 November 2020, https://www.defensenews.com/global/europe/2020/11/09/italy-plans-new-destroyers-for-2028-delivery.

[29] Seaforces: *C 550 ITS Vittorio Veneto*, https://www.seaforces.org/marint/Italian-Navy/Helicopter-Cruiser/C-550-ITS-Vittorio-Veneto.htm. Actually *Vittorio Veneto* had to host also the crew for few helicopters, but still the decrease of required personnel is significant.

[30] Interview, 13 December 2022.

[31] Berry Baker, "The Evolving Role of Warships in the 21st-Century Navy", in *Naval Technology*, 23 August 2021, https://www.naval-technology.com/?p=63552.

[32] Interview, 4 November 2022.

[33] See chapter 8 of this study. Also, European Commission website: *European Defence Fund 2021 Calls for Proposals – Results*, https://europa.eu/!MxYPvT.

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One of the main challenges facing navies and the industry as they pursue effective integration is technological: contemporary naval combat systems and sensors produce large quantities of data that requires great bandwidths in order to be shared in real time by data link.[34] Solutions to this requirement include 5G technology,[35] the adoption of "combat clouds" and an "internet of things" architecture in order to manage the huge quantities of data that are generated at the tactical edge of military operations, as is the case for instance for unmanned systems assigned to intelligence, surveillance and reconnaissance (ISR) duties.[36] Furthermore, it is important for future systems to have increased autonomy in order to reduce the bandwidth needed for their control but also to make them less vulnerable to jamming.

Another significant challenge to effective integration of a multitude of systems, ships and unmanned vehicles is that doctrine for this SoS approach to naval combat systems is generally lagging behind what is currently possible from a purely technical standpoint.[37] Interoperability between allies and partner countries, and between manned and manned assets (the so-called manned-unmanned teaming – MUM-T[38]) can also be greatly facilitated by an integrated approach to naval combat systems. However, within NATO, this must be facilitated by shared doctrines and approaches to data processing and communication so that different systems can all communicate efficiently by design. Currently, NATO allies have at their disposal only one STANAG (4586) pertaining to unmanned vehicles, though it was designed for unmanned aerial vehicles (UAV) interoperability, which was also used in the context of OCEAN2020. The Alliance is currently working on STANAG 4817, which will provide common standards for unmanned systems control across domains (air, sea and underwater).[39]

Conclusions

The accelerating pace of technological innovation and increasing competition across the world's seas highlight how important it is for navies to invest today in the wide spectrum of naval combat systems required to attain effectiveness and survivability in scenarios of high-end, large-scale and multi-domain conflicts. However, it is the integration of naval combat systems in a SoS approach that represents the real game changer in naval warfighting, more than individual disruptive technologies or combat systems. This approach is the key to building resilient, versatile and distributed fleets that are truly interoperable, also in a

[34] Interview, 14 November 2022.

[35] NATO Communications and Information Agency, *NATO Tech Agency Explores Potential of 5G for the Alliance*, 28 January 2021, https://www.ncia.nato.int/about-us/newsroom/nato-tech-agency-explores-the-potential-of-5g-for-the-alliance.html.

[36] Cisco, *Internet of Everything Capabilities for the U.S. Navy*, white paper, 2015, https://www.cisco.com/c/dam/en_us/solutions/industries/us_government/resources/navy-ioe-wp1c.pdf.

[37] Interview, 14 November 2022.

[38] Interview, 25 October 2022.

[39] Interview, 14 November 2022.

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multinational context. In order to be successful, and act as a real force multiplier, this level of integration does not only demand cutting-edge technologies to enable data transfer but also, crucially, a clear doctrine pertaining to everything from fleet composition, the levels of versatility required of single hulls, the use of autonomous systems to officer training in a new, more distributed way of war at sea. Finally, navies will have to adapt to a context in which threats evolve constantly by developing a procurement, maintenance and update cycle for combat systems that is more open to eventual frequent shifts in requirements.

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2. Russia and China

by Michelangelo Freyrie*

China and Russia face very different challenges in the adoption of new weapon systems and disruptive technologies in the naval domain. The former operates the largest navy in the world in terms of number of ships (but not tonnage)[1] and can count on a large and expanding economy, including a growing defence technology and industrial base (DTIB). Meanwhile, the latter has to pursue technological innovation while its shipbuilding industry is stifled by sanctions and technical obsolescence, in a weak overall economic context. The war in Ukraine, and the related sanctions, is set to exacerbate existing Russian difficulties. Differences exist also at a doctrinal level: Russia still pursues a platform-centric approach to naval warfighting, while China has been steadfast in adopting a "system of systems", networked perspective.

Nevertheless, both countries hope that technological innovation will help fill some capability gaps that persist in the respective navies, notably in antisubmarine warfare and C4ISR. Both Russia and China consider themselves vulnerable to lightning Western (and specifically US) combined arms attacks. As such, both countries have developed doctrines which emphasise disabling enemy infrastructure and engaging its vessels at increased range, taking full advantage of missile technology and submarines, as well as using unmanned systems as forces multipliers. Be it to maximise the navy's power projection or to guarantee the survivability of its deterrent force, new weapon systems are at the core of both countries' current naval efforts.

2.1 Russian Federation

The Navy of the Russian Federation (*Voyenno-morskoi flot* – VMF) has a long tradition of putting innovation and technological disruption at the core of its operational concepts. Since the fall of the Soviet Union, and again after the first round of international sanctions in 2014, the VMF has come to regard new naval systems as the key to counterbalance the perceived superiority of its peers in terms of tonnage, number of ships and force projection capabilities.[2] Indeed, the adoption of disruptive technologies (especially hypersonic and cruise missiles and unmanned systems) has become central to its attempt to update an aging fleet.

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[1] David Axe, "Yes, China Has More Warships than the USA. That's Because Chinese Ships Are Small", in *Forbes*, 5 November 2021, https://www.forbes.com/sites/davidaxe/2021/11/05/yes-china-has-more-warships-than-the-usa-thats-because-chinese-ships-are-small.

[2] Vadimir Gundarov, "The Navy Is No Help Abroad" [in Russian], in *Nezavisimoye Voyennoye Obozreniye*, 25 August 2022, https://nvo.ng.ru/realty/2022-08-25/9_1203_fleet.html.

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As it is often the case with Russian military technology, research programmes are extremely secretive and open-source information is frequently manipulated for propaganda purposes. Yet, it is clear that disruptive naval systems are regarded as the key element which will allow the VMF to perform an increasingly diverse set of missions.

2.1.1 The VMF's tasks and the role of technology

Current Russian naval strategy is outlined by three official documents: the "Maritime Doctrine of the Russian Federation" (2022), which serves as a threat assessment in this domain; the "Fundamentals of the state policy of the Russian Federation in the field of naval activities for the period until 2030" (2017, henceforth Naval Policy), which describes the development trajectory of the VMF; and finally, the "State Armament Programme 2020-27" (GPV-27) and the "Military Shipbuilding Programme 2050" (PVK-50) which note Moscow's specific procurement priorities.

The primary task of the Russian Navy is to guarantee credible sea-based deterrence, both in the nuclear and non-nuclear realms. The perceived US/NATO capacity to deliver sudden nuclear and conventional blows have pushed Moscow to increase the survivability of its naval assets and to maintain a second-strike capability, as well as the ability to hurt NATO's strategic infrastructure with non-nuclear means.[3]

At the same time, the VMF is clearly tasked with projecting Russian power in its adjacent waters, especially the Arctic and the Black Sea, but also the nearby Mediterranean. The protection of national energy resources, undersea cables and maritime routes (especially in the Arctic)[4] are listed as especially crucial, as is the capability to threaten the enemy's (the incident surrounding the North Stream gas pipeline provides an example of their vulnerability). The development of sea-based precision missile technology also means this mission now goes far beyond classic sea denial and control, leading Russian strategic thinkers to highlight the VMF's potential to disrupt enemy operations from afar and to effectively contribute to ground operations. The latter has become especially evident since the VMF's naval bombing campaign during the Syrian intervention, as well as during the invasion of Ukraine.[5] Conversely, NATO interventions in Libya and during the Gulf wars have made the VMF painstakingly aware of the need to contrast enemy "fleet on shore" missions.

The Naval Policy and its implementation through GPV-27 thus face the tall order of pursuing this set of missions, while knowing that significant fleet expansions will

[3] As of today, the Navy is the only service branch besides the Air Force with the ability to deploy Russia's non-nuclear deterrent, meaning to inflict paralysing strategic strikes without crossing the nuclear threshold.

[4] Prokhor Tebin, "The New Naval Doctrine of Russia", in *Valdai Discussion Club*, 4 August 2022, https://valdaiclub.com/a/highlights/the-new-naval-doctrine-of-russia.

[5] Heather Mongilio, "New Videos Show Russian Navy Firing 8 Naval Cruise Missiles from the Black Sea", in *USNI News*, 22 March 2022, https://news.usni.org/?p=93015.

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be impractical over the next years due to technological and financial limitations. Naval procurement plans made under the GPV-20 have proven impossible to fulfil, with just 33 per cent of the planned frigates and 20 per cent of the corvettes being produced.[6]

As a result, the Naval Policy identifies new naval combat systems to enhance existing assets and allow them to pursue both strike and deterrence missions even with a limited fleet. In fact, with an increased reliance on smaller vessels, the VMF is betting on the possibility to maintain and even expand its strike capabilities against ground-based and naval objectives without incurring in a costly (and unachievable) fleet expansion. The adoption of the 3M14 Kalibr cruise missile by the VMF is exemplary in this regard: with a range between 1,500 and 2,500 km, it has been embarked both on *Buyan*-M-class corvettes, submarines and *Grigorovich*-class frigates and sufficiently enhances their strike capabilities and nuclear potential. Upgrading the fleet's Vertical Launch Systems (VLS) and deploying the Kalibr will be at the core of the naval modernisation drive until 2025.[7]

Overall, this could likely lead to a progressive transformation of the fleet structure. The VMF traditionally divides its force in four ranks of vessels, employed in four equivalent areas of operation: small landing craft and patrol boats operate in the coastal area (*pribrezhnaya*); corvettes, missile boats, and minesweepers are active in the coastal near sea (*blizkaya*); nuclear-powered submarines, carriers, cruisers, destroyers, large landing ships, and larger frigate operate within the far sea zone (*dalnaya*) and "world ocean" (*mirovoi okean*). An increased focus on upgraded smaller ships, capable of performing some of the tasks allotted to higher-rank vessels, would allow for a progressive blending of these zones of operation.[8] This trend towards multi-role ships is not unlike that pursued by other navies.[9]

2.1.2 Unmanned systems

Overall, Russian technological developments broadly seek to upgrade current platforms and counteract the chronic weaknesses of the VMF.

The first area of development pertains anti-submarine warfare and intelligence, surveillance and reconnaissance (ISR) capabilities. Here, robotisation plays a major

[6] Sidharth Kaushal, "The Death of Gorshkov's Navy: The Future of the Russian Surface Fleet", in *RUSI Commentaries*, 1 June 2022, https://www.rusi.org/explore-our-research/publications/commentary/death-gorshkovs-navy-future-russian-surface-fleet.

[7] While the Naval Policy still plays lip service to the need of "re-balancing" the VMF, above all with a new aircraft carrier, this has mostly been done to reassure military professionals critical of overinvestments in the submarine force and sceptical of transforming the VMF in a mosquito fleet serving as a launching platform for K3M-54 Kalibr cruise missiles. The vulnerability of primarily seaborne Kalibr capabilities, compared to ground-based deployments is a recurring theme in naval circles, see Maxim Klimov, "Sea Battle in the Cabinet" [in Russian], in *Voenno-Prosmyshelennyj Kurier*, 8 June 2021, https://vpk-news.ru/articles/62478.

[8] Sidharth Kaushal, "The Death of Gorshkov's Navy", cit.

[9] Interview, 20 October 2022.

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role, as underwater unmanned vehicles (UUVs) and their teaming with existing platforms have been a prominent focus of Russian research effort.[10] Industry has adapted accordingly. For instance, the Rubin design bureau has opened a centre specialised on seaborne unmanned systems in Kronstadt.[11] UUVs are expected to be especially relevant to perform ISR missions in the difficult waters of the Arctic Sea.[12]

An undisclosed company is said to be developing a 14-meter-long autonomous submarine-hunting UUV, with maximum velocity of 35 knots and armed with of two 533 mm multi-purpose electric torpedoes.[13] Other UUVs have been specially designed for anti-sabotage missions and port defence.[14] UUVs are perceived as weapons perfectly suited for ASW, with the implication that they may finally provide an instrument to hunt enemy nuclear powered ballistic missile submarines (SSBNs).[15] They're also perceived as important ISR instruments: Surrogat-W, presented in Armya-2022 Expo, is imagined as an expendable reconnaissance UUV tasked to perform duties that would otherwise risk revealing the position of manned submarines.[16] In 2019 there were also talks about the ongoing development of autonomous sea mines with the capacity to recognise and autonomously select target.[17]

Russia is also developing a new class of seaborne UAVs; the Navy is expected to get a version of the fixed-wing Sirius drone capable of carrying out ASW and ISR missions from 2023 onwards.[18] The current UAV fleet of the Navy (mainly Orlan-10s) operates from onshore positions, and efforts are currently underway to enable information sharing between UAVs and the Navy's Su-30SM2.[19] A deck-based drone is expected to make its maiden flight in 2025.[20] Since 2021, there has also

[10] "Igor Denisov: Sea Robots Can Protect the Russian Border" [in Russian], in *TASS*, 17 January 2018, https://ria.ru/20180117/1512709868.html.

[11] "Centre for Maritime Robotics Starts Work in Kronstadt" [in Russian], in *TASS*, 18 February 2022, https://tass.ru/ekonomika/13753259.

[12] Anna Yudina, "Russian Ministry of Defence Robotics Centre: 'Pocket-sized' Micro-Robots Will Appear in the Arctic" [in Russian], in *TASS*, 24 August 2017, https://tass.ru/interviews/4502372.

[13] "Work Underway on Russia's First-Ever Robotic Torpedo-Carrying Submarine Hunter", in *TASS*, 19 January 2022, https://tass.com/defense/1390151.

[14] "Russian Navy's frogmen Use Submerged Robot to Fight Saboteurs in Black Sea drills", in *TASS*, 9 February 2022, https://tass.com/defense/1400137.

[15] Alexander Yermakov, "Nuclear Future: Underwater and in the Skies", in *RIAC Articles*, 5 July 2022, https://russiancouncil.ru/en/analytics-and-comments/analytics/nuclear-future-underwater-and-in-the-skies.

[16] "ZKB Rubin reveals characteristics of Surrogat-V unmanned system" [in Russian], in *Ria Novosti*, 18 August 2022, https://ria.ru/20220818/nauka-1810347384.html.

[17] Alexey Ramm and Alexey Kozachenko, "Navy Will Get Ammunition with Artificial Intelligence" [in Russian], in *Izvestia*, 5 March 2019, https://iz.ru/841783.

[18] "Russia's Seaborne Strike Drone to Get Rescue/Reconnaissance Capabilities", in *TASS*, 7 February 2022, https://tass.com/defense/1398817.

[19] Anton Lavrov and Alexey Ramm, "Drones in the Navy: Marine Super-Sukhiye Will Lead Drones into Battle [in Russian], in *Izvestia*, 9 February 2022, https://iz.ru/1288567.

[20] "Advanced Deck-based Drone to Make Maiden Flight in 2025 — Source", in *TASS*, 7 June 2022,

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been talks regarding the embarkment of loitering munitions on VMF vessels,[21] another opportunity that could partially counteract the lack of any meaningful naval aviation and ASW capabilities.[22]

2.1.3 Missile and torpedoes technology

The second area of development pertains the seaborne nuclear deterrent. Here, the most prominent UUV project is the Poseidon drone, expected to become a mainstay of Russian seaborne deterrence. The project is essentially a giant nuclear-capable and nuclear-powered torpedo, which will travel at up to 70 knots and is said to be capable of reaching operating depths of 1,000 meters. While not being an independent arms platform, its size and range allows this model to be launched from relative safety, for instance below ice caps.[23] The first Poseidon has been equipped on the Project 09852 nuclear-powered submarine Belgorod, which has just commenced testing.[24]

Finally, the third area of modernisation aims at completing the current "Kalibrisation" drive, i.e. the widespread equipment of 3M14 Kalibr cruise missiles on a variety of vessels.[25] This would play an especially crucial role for the Russian fleet in the Mediterranean.[26]

The next addition to the Navy's missile arsenal would be the 3M22 Zircon hypersonic cruise missile, notably tested at the end of 2021 with a launch from the *Admiral Gorshkov* frigate in the White Sea[27] and from the submarine *Severodvinsk* in the Barents Sea.[28] Exact details of the missile are still unknown, although President Putin has boasted that the Zircon will reach Mach 9 with a range of 1,000 km. This hypersonic missile, which is still in development, should be able to be launched from the 3C14 platforms already used for the Kalibr and Onyx missiles. Most of

https://tass.com/defense/1461445.

[21] Alexey Ramm and Bogdan Stepavoy, "Under a Roof of Drones: The Navy Strengthens Kamikaze UAVs" [in Russian], in *Izvestia*, 29 October 2021, https://iz.ru/1242367.

[22] Viktor Patrushev, "The Fleet Is Not Ready for a Great War" [in Russian], in *Voenno-Prosmyshelennyj Kurier*, 6 July 2021, https://vpk-news.ru/articles/62801.

[23] H.I. Sutton, "Russia's New 'Poseidon' Super-Weapon: What You Need to Know", in *Naval News*, 3 March 2022, https://www.navalnews.com/?p=30954.

[24] "Russian Navy to Receive Special-Purpose Sub with Nuclear-Armed Drones in Summer — Sources", in *TASS*, 26 January 2022, https://tass.com/defense/1393205.

[25] Joshua Menks and Michael Petersen, "The 'Kalibrization' of the Russian Fleet", in *U.S. Naval Institute Proceedings*, Vol. 148, No. 5 (May 2022), https://www.usni.org/node/57880.

[26] Michelangelo Freyrie, "La Russia nel Mediterraneo: una minaccia?", in *AffarInternazionali*, 29 June 2022, https://www.affarinternazionali.it/?p=99059.

[27] Reuters, "Russia Says Zircon Hypersonic Missile Hit Target in Latest Test", in *CNN*, 30 November 2021, https://edition.cnn.com/2021/11/29/europe/russia-hypersonic-missile-hits-target-test-intl/index.html.

[28] "Tests of Hypersonic Missile 'Zirkon' from a Submarine Completed" [in Russian], in *TASS*, 5 October 2021, https://tass.ru/armiya-i-opk/12579789.

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the main Russian ship designs will undergo refits to accommodate the Zircon.[29] The missile could become operational in a relatively short time span as the testing campaign progresses; however, this will also depend on the efficacy of current limitations inflicted to Russia's DTIB by sanctions and the demands of the war in Ukraine, especially when it comes to chips.

Overall, given the effort that the Russian Navy is putting in acquiring new strike capabilities without significant changes to command and control (C2) and operational doctrines, it would seem that Russian naval modernisation mostly remains centred around platforms, rather than moving towards a networked concept of naval power. Most investments revolve around increased lethality of existing vessels via the acquisition of missiles, torpedoes and UAVs. Nevertheless, the new systems and technologies being deployed represent a growing threat to western navies and require appropriate countermeasures, starting with defence capabilities against hypersonic weapons and advanced submarines. Furthermore, Russian naval technologies and vessels continue to be exported to a number of countries, on top of advanced submarines.

Some additional systems need to be mentioned, despite playing less of a role in Russian naval defence innovation. The Rezonans-N radar has recently started to play a major role in the Arctic region, due to its capacity to detect stealth targets and, most notably, hypersonic threats. As with other hypersonic technologies, this is a domain in which NATO navies are currently lagging behind the VMF.[30] The third station in the region was projected to open in mid-2022 and should be able to single out targets at a arrange of 1,000 km flying at Mach 20.[31] In 2022 Russian company Salyut patented a new mobile coastal defence over-the-horizon radar that can stealthily detect targets at a 400 km range.[32]

Directed-energy weapons where first experimented in the Soviet naval context in the 1970s. Despite that, the VMF does not make use of DEWs and it's unknown whether such projects are being pursued. Publicly available information suggests DEWs may be deployed on the future nuclear-powered *Lider* destroyer class (currently in a design phase).[33]

[29] Joseph Trevithick, "Russian Navy's Top Officer Says Shadowy Zircon Hypersonic Missile Has 'Childhood Diseases'", in *The Drive*, 23 January 2020, https://www.thedrive.com/the-war-zone/31908.

[30] Interview, 20 October 2022.

[31] Tong Ong, "Russia's Anti-Hypersonic Missile Radar to Deploy in Arctic by June", in *The Defense Post*, 15 April 2021, https://www.thedefensepost.com/?p=22681.

[32] "Russia Creates Cutting-Edge, Stealth Mobile Coastal Defense Radar", in *TASS*, 6 April 2022, https://tass.com/defense/1433467.

[33] Andre Mytrofanov, "Laser Weapons: the Navy. Part 4", in *Voyennoye Obozreniye*, 23 March 2019, https://topwar.ru/155723-lazernoe-oruzhie-voenno-morskoj-flot-chast-4.html.

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2.2 China

China's adoption of next generation naval combat systems has been the result of the doctrinal developments accompanying its rise as a global military power. The People's Liberation Army Navy (PLAN) has recently overtaken the US Navy as the largest in the world in terms of number of vessels, though the PLAN displaces ca. 2 million tons distributed over 335 ships against the USN's 4.5 million over 305, indicating that the former still relies largely on a great number of smaller vessels.[34] While smaller vessels can generally be less capable than larger ones, a major naval confrontation between China and the US would likely occur near the Chinese mainland, where smaller PLAN vessels could theoretically operate under an umbrella of land-based A2/AD capabilities.[35] Nevertheless, the PLAN is also proceeding full steam ahead towards becoming a fully-fledged blue water navy, as conceptualised by the "Near Seas Defence, Far Seas Protection" strategy.[36] Crucially, the rate at which modern vessels are being commissioned is currently unmatched. For instance, 72 *Jiangdao* Type 056 corvettes were built between 2013 and 2021 at a rate of ca. 8 per year, while 30 *Jiangkai* II Type 054A frigates were commissioned between 2008 and 2019.[37] In general, the PLAN is expected to cover an ever-expanding role in the Chinese defence posture, reverting a decade-old trend which put land-based capabilities at the forefront of Beijing's modernisation efforts.[38]

2.2.1 The missions of the PLAN

Chinese naval modernisation is a reflection of both economic and military concerns, which inform the PLA's perspective on the Indo-Pacific (the "Two Oceans", in Chinese strategic parlance[39]). The defence of the country's major sea lines of communication (in particular the *shenging xian* or "lifeline" through the Gulf of Malacca and up to the straits of Hormuz and Bab-el-Mandeb)[40] are deemed

[34] The PLN displaces ca. 2 million tons distributed over 335 ships against the USN's 4.5 million over 305. See: David Axe, "Yes, China Has More Warships than the USA", cit.

[35] Timothy M. Bonds, "What Role Can Land-Based, Multi-Domain Anti-Access/Area Denial Forces Play in Deterring or Defeating Aggression?", in *RAND Research Reports*, 2017, https://doi.org/10.7249/RR1820.

[36] Jennifer Rice and Erik Robb, "The Origins of 'Near Seas Defense and Far Seas Protection'", in *CMSI China Maritime Reports*, No. 13 (February 2021), https://digital-commons.usnwc.edu/cmsi-maritime-reports/13.

[37] Ronald O'Rourke, "China Naval Modernization: Implications for U.S. Navy Capabilities—Background and Issues for Congress", in *CRS Reports*, No. RL33153 (1 December 2022), https://sgp.fas.org/crs/row/RL33153.pdf.

[38] China's State Council Information Office, *China's National Defense in the New Era*, July 2019, https://english.www.gov.cn/archive/whitepaper/201907/24/content_WS5d3941ddc6d08408f502283d.html.

[39] Tom Sun and Alex Payette, "China's Two Ocean Strategy: Controlling Waterways and the New Silk Road", in *Asia Focus*, No. 31 (May 2017), https://www.iris-france.org/wp-content/uploads/2017/05/Asia-Focus-31.pdf.

[40] Conor Kennedy, "Strategic Strong Points and Chinese Naval Strategy", in *China Briefs*, Vol. 19, No. 6 (22 March 2019), https://jamestown.org/program/strategic-strong-points-and-chinese-naval-strategy.

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of strategic importance for the economic resilience of the PRC. At the same time, the PLAN's projection beyond the two island chains is also conceptualised as a way to alleviate the pressure on the littoral operational areas in case of a large-scale conflict. To avoid the PLAN being "boxed in" the first island chain, China has decided to advance Mao's doctrine of active defence and become able to bring the fight outside of its territorial waters.[41] The progressive pivot to "Far seas protection" is central in this regard and is scheduled to be completed in 2049.

The emphasis on disruptive technologies in the naval domain, especially electronic warfare and C4ISR, follows an overall effort to implement netcentric warfare (*xinxiha*), through the pivot from a platform-centric force structure to an integrated, network-enabled system of systems. This effort has been carried out in a gradual manner, such as through the adoption of the ZKJ-4B/6 and ZKJ-5[42] CMS, originally based on the Thompson CSF's Tavitac.[43] Chinese military thinkers have long been concerned by the US concepts of AirSea Battle and Offshore control, which play into the historic weaknesses of the PLAN:[44] long-range targeting, cross-domain coordination and ASW, which is especially difficult to perform in the shallow waters of the South China Sea.[45]

Beijing's response has to strengthen its joint operations capabilities and tighten the reconnaissance-strike cycle of its navy. Overall, the focus of active defence is the ability to perform paralysing blows against enemy C2 nodes, sensors and whole-systems enablers. Additionally, the construction of strongpoints throughout the South China Sea and along the Chinese sea lines of communication (SLOCs) can create both a logistical support network for the PLAN as well as a solid ISR network. The latter task is especially significant as lack of adequate ISR capabilities has long been a significant issue of Chinese anti-ship and ASW capacities.[46]

2.2.2 Ship development and USVs

The platform which most strongly testifies China's changing approach to naval fighting is the Type 054 multi-role frigate. First launched in the early 2000s, the Type 054 was first employed for littoral defence and has since moved progressively towards SLOC patrol and carrier protection roles. Its technological upgrades show the new roles of such vessels in the Chinese strategy: the modernisation of its anti-

[41] Jennifer Rice and Erik Robb, "The Origins of 'Near Seas Defense and Far Seas Protection'", cit., p. 5.

[42] Martin Manaranche, "China Commissioned Its Ninth Type 056 Corvette So Far in 2020", in *Naval News*, 19 June 2020, https://www.navalnews.com/?p=13725.

[43] Gabe Collins, "How Much Do China's Warships Actually Cost?", in *The Diplomat*, 18 June 2015, https://thediplomat.com/2015/06/how-much-do-chinas-warships-actually-cost.

[44] Kimberly Jackson et al., "Command and Control in US Naval Competition with China", in *RAND Research Reports*, 2020, https://doi.org/10.7249/RRA127-1.

[45] Olli Pekka Suorsa, "The Anti-Submarine Warfare Component of China's Sorties in Taiwan's ADIZ", in *The Diplomat*, 4 November 2021, https://thediplomat.com/2021/11/the-anti-submarine-warfare-component-of-chinas-sorties-in-taiwans-adiz.

[46] Kimberly Jackson et al., "Command and Control in US Naval Competition with China", cit., p. 23.

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aircraft and radar systems have bolstered the 054's contribution to area defence. The 054A variant can serve as a "mini-aegis",[47] limited by a reduced number of anti-aircraft missiles it can carry and a curbed radar range of 25 km against sea-skimming missiles.[48] This is an especially dangerous weakness in the vastness of the Pacific Ocean, which limits both the efficacy of the Airborne Warning and Control System (AWACS) fleet of the People's Liberation Army Air Force (PLAAF) and forces China to rely on imprecise land-based over-the-horizon (OTH) radars.[49] More advanced "compact" OTH radars are currently being developed to guarantee long-range detection for the PLAN's carriers.[50]

The need to enhance the surface fleet's ISR capabilities have led to a strong investment in unmanned systems, both in terms of UAVs and USVs. Recent pictures of the *Shandong*'s deck, for example, show that the newest Chinese carrier can operate at least two types of vertical take-off and landing (VTOL) drones.[51] The Japanese navy also had some run-ins with Chinese medium-altitude, long endurance (MALE) UAVs,[52] and it is clear that seaborne UAVs could perfectly enhance the special purpose aircraft of the People's Liberation Army Navy Air Force (PLANAF) tasked with ISR, ASW and electromagnetic warfare (EW) missions. It is not clear whether the PLANAF currently operates Xianglong high-altitude, long endurance (HALE) UAVs. The vastness of the Pacific Ocean and the need for long-endurance aerial assets has also justified investment in "Predator-Class" UAVs, expected to operate primarily from airfields in the South China Sea, both in ISR/ELINT (electronic intelligence) and attack configurations.[53]

Another project aiming at improving the PLAN's ISR complex is reportedly what has been dubbed a one-of-a-kind AI-powered "mothership", the *Zhu Hai Yun*, to deploy UAVs and UUVs in full autonomy.[54] The *Zhu Hai Yun*, while still classified as a civilian vessel, would have obvious military applications. The PLAN has also

[47] The US Aegis system is an integrated combat system built to defend against advanced air and surface threats, combining launching element, the computer programmes, the radar and displays. See Lockheed Martin website: *Aegis*, https://www.lockheedmartin.com/en-us/products/aegis-combat-system.html.

[48] Gabe Collins and Andrew Erickson, "The Type 054/054A Frigate Series: China's Most Produced and Deployed Large Modern Surface Combatant", in *China Signpost*, 2 August 2015, https://www.chinasignpost.com/?p=2308.

[49] Gerry Doyle and Blake Herzinger, *Carrier Killer. China's Anti-Ship Ballistic Missiles and Theater of Operations in the Early 21st Century*, London, Helion & Co., 2022, p. 22-35.

[50] Stephen Chen, "Chinese Navy's New 'Compact' Radar Will Allow It to Keep Watch Over an Area the Size of India", in *South China Morning Post*, 9 January 2019.

[51] Tyler Rogoway, "China's Reported Plan to Deploy Weaponless Stealth Drones on Its Carriers Make Perfect Sense", in *The Drive*, 25 September 2019, https://www.thedrive.com/the-war-zone/30020.

[52] Joseph Trevithick and Tyler Rogoway, "Japanese Fighters Intercept Three Chinese Drones in as Many Days", in *The Drive*, 26 August 2021, https://www.thedrive.com/the-war-zone/42154.

[53] J. Michael Dahm, *Special Mission Aircraft and Unmanned Systems*, Johns Hopkins University Applied Physics Laboratory, October 2020, p. 22-24, https://apps.dtic.mil/sti/citations/AD1128646.

[54] Alia Shoaib, "China Launched the World's First AI-operated 'Mother Ship,' an Unmanned Carrier Capable of Launching Dozens of Drones", in *Business Insider*, 11 June 2022, https://www.businessinsider.com/china-launches-worlds-first-ai-unmanned-drone-aircraft-carrier-2022-6.

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made its first efforts in the field of UUVs[55] for both ISR and strike missions and has even conducted the first trials involving the Jari unmanned surface vessel (USV), which despite the small scale (15 meters long, 4.8 meters wide a displacement of 20 tons) would be heavily armed and be equipped with 4 VLS, two single tube torpedo launchers and a phased-array radar.[56]

2.2.3 Missiles and aircraft killers

The PLAN's expansion has been accompanied by significant leaps in missile technology, both for embarked as well as ground-based launchers. After the Third Taiwan Straits Crisis in 1996 and the demonstrative passage of US carrier task forces, Beijing has sought to adapt existing ballistic missile systems for naval battle purposes, transforming them in unique anti-ship ballistic missiles (ASBMs).[57] Among these, two particularly stick out: the DF-21D (1,500 km range), which has evolved into the quintessential Chinese "carrier-killer", and the DF-26 (5,000 km range), hailed as a "Guam-killer" for its ability to reach the eponymous US naval base on the second island chain.[58] Nevertheless, these weapons have yet to see any combat use despite the former reportedly having reached at least initial operational capability (IOC)[59] and the latter fully operational capability (FOC).[60] The DF-26's estimated circular error probable (CEP) of 140-450m would hardly grant it enough precision to make it truly effective; the relative velocity of US super-carriers would make targeting efforts by the ASBM's re-entry vehicles especially difficult.[61] Despite the lack of details, it has also been announced that China has tested a new type of hypersonic ASBM, launched from a Type 055 destroyer.[62] With a supposed maximum range of 1,500 km, the YJ-21 is designed to strike carrier task forces both from ships and aircraft.[63]

Another area where Beijing has made major strides is the development of anti-ship cruise missiles (ASCMs) and land-based cruise missiles (LACMs). The YJ-18, for instance, is appraised has outranging the US-produced harpoon and may be

[55] David R. Strachan, "China Enters the UUV Fray", in *The Diplomat*, 22 November 2019, https://thediplomat.com/2019/11/china-enters-the-uuv-fray.

[56] "China's JARI-USV Unmanned Ship Has Its First Trial: Detailed Characteristics", in *China Arms*, 25 January 2020, https://www.china-arms.com/?p=1283.

[57] Gerry Doyle and Blake Herzinger, *Carrier Killer*, cit., p. 17.

[58] Ronald O'Rourke, "China Naval Modernization", cit., p. 11-12.

[59] Harry Kazianis, "Behind the China Missile Hype", in *The Diplomat*, 20 January 2012, https://thediplomat.com/2012/01/behind-the-china-missile-hype.

[60] "Meet the DF-26 Missile: China's Prized Anti-Carrier Weapon", in *The Buzz Blog*, 3 October 2019, https://nationalinterest.org/blog/buzz/meet-df-26-missile-chinas-prized-anti-carrier-weapon-85261.

[61] Gerry Doyle and Blake Herzinger, *Carrier Killer*, cit., p. 42.

[62] Minnie Chan, "Chinese Navy Shows Off Hypersonic Anti-Ship Missiles in Public", in *South China Morning Post*, 20 April 2022, https://www.scmp.com/news/china/military/article/3174946/chinese-navy-shows-hypersonic-anti-ship-missiles-public.

[63] Tayfun Ozberk, "China Test-fires New YJ-21 Hypersonic Missile", in *Naval News*, 20 April 2022, https://www.navalnews.com/?p=32654.

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launched from surface vessels as well as Kilo-class submarines. LACMs and ASCMs would play a major role in operations against Taiwan both to eliminate enemy airbases and deny access to US carrier strike groups to the strait.[64]

Information on other technological innovations is more tentative. In 2021 the international press reported on the proposal by a team of researchers at the China Academy of Launch Vehicle Technology in Beijing on the development of a hypersonic missile capable of delivering an electromagnetic pulse (EMP) at a range of 3,000 km, i.e. the distance between China and the island of Guam.[65] The warhead could potentially knock out most communications in the targeted area and be effectively invisible to radar.

Further reporting indicates that according to the Chinese journal *Electronic Information Warfare Technology*, Beijing is looking into the development of an 80Gw EMP weapon and tested such a weapon at an undisclosed location, bringing down UAVs flying 1,500 m above sea level.[66]

Information is also scarce regarding ground-based DEW systems currently possessed by China. Outlets suggest that such weapons may be currently in development with the aim of creating coastal defence batteries and shipborne variants as alternatives to the HHQ-10 short-range surface-to-air missile system.[67]

The only actual recorded use of laser by the PLAN is the employment of targeting systems in an attempt to dazzle pilots flying Australian surveillance aircraft and helicopters. Such incidents have become more and more common from 2017 onwards,[68] despite China being a signatory to the Protocol on Blinding Laser Weapons banning such practices.[69]

[64] Dennis M. Gormley, Andrew S. Erickson and Jingdong Yuan, "A Potent Vector: Assessing Chinese Cruise Missile Developments", in *Joint Force Quarterly*, No. 75 (October 2014), p. 98-105, https://ndupress.ndu.edu/Media/News/News-Article-View/Article/577568.

[65] Michael Peck, "Could China Develop a Hypersonic Electromagnetic Pulse Missile?", in *Forbes*, 30 September 2021, https://www.forbes.com/sites/michaelpeck/2021/09/30/is-china-developing-a-hypersonic-electromagnetic-pulse-missile.

[66] Stephen Chen, "Did Chinese Scientists Just Bring Down an Unmanned Plane with an Electromagnetic Pulse Weapon?", in *South China Morning Post*, 26 August 2021, https://www.scmp.com/news/china/science/article/3146380/did-chinese-scientists-just-bring-down-unmanned-plane.

[67] Andrew Tate, "Chinese Navy Trials Laser Weapon", in *Janes*, 10 April 2019, https://www.janes.com/defence-news/news-detail/chinese-navy-trials-laser-weapon.

[68] Daniel Hurst, "Laser Incident Involving Chinese Warship Most Serious in Growing Trend, ADF Says", in *The Guardian*, 21 February 2022, https://www.theguardian.com/p/kn7b7.

[69] Nic Fildes and Kathrin Hille, "Chinese Naval Vessel Aims Laser at Australian Surveillance Plane", in *Financial Times*, 20 February 2022, https://www.ft.com/content/ab9b6235-762e-494e-a698-0ff510d21cbd.

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3. United States

by Bryan Clarke*

The US Navy is attempting to transition from a force composed entirely of large, manned platforms to one with a larger proportion of small manned and unmanned ships, aircraft, and undersea vehicles. However, with budgets unlikely to grow substantially during the 2020s, freeing up funds to make this shift will result in the US fleet initially shrinking as numerous surface combatants and submarines built in the waning days of the Cold War retire without immediate one-for-one replacements. By the 2030s Navy leaders intend to begin growing the fleet as new unmanned ships and aircraft enter the force, along with hypersonic weapons and lasers to improve the fleet's lethality and survivability, and capabilities developed through Project Overmatch that provide decision-making advantages.

3.1 US Navy strategic and doctrinal thinking

The US Navy and Marine Corps face growing challenges ranging from great powers China and Russia to regional threats such as Iran and North Korea, all of whom seek to undermine their neighbours' stability and revise geopolitical relationships in their favour. Despite the impact of the Covid-19 pandemic and resulting economic downturn, each of these potential adversaries continued to improve its military capabilities, especially the number and reach of precision missiles able to strike US allies and slow or prevent intervention by US naval forces. Supported by commercial and military surveillance networks in every domain, weapons based on adversary territory could threaten US and allied ships, troop formations, and aircraft hundreds of miles away. China fields the most capable of these networks.[1]

Russian and Chinese submarines pose one of the most significant threats to US naval forces in the open ocean, but for different reasons. The Russian Navy's submarine force is relatively small, but its nuclear-powered attack submarines (SSN) are on par with their US counterparts in terms of quieting, sonar, systems, and weapons. Russian SSNs could evade US and allied anti-submarine warfare efforts and threaten attacks targets ashore or at sea.[2] In contrast, the PLA Navy's (PLAN) fleet is comprised predominantly of diesel-electric (SS) and air-independent

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[1] Ian Williams, "Tracking Missile Threats", in *CSIS Commentaries*, 12 August 2021, https://www.csis.org/node/61861; Defense Intelligence Ballistic Missile Analysis Committee, *Ballistic and Cruise Missile Threat*, January 2021, https://media.defense.gov/2021/Jan/11/2002563190/-1/-1/1/2020%20BALLISTIC%20AND%20CRUISE%20MISSILE%20THREAT_FINAL_2OCT_REDUCEDFILE.PDF; US Department of Defense, *Military and Security Developments Involving the People's Republic of China*, November 2021, https://media.defense.gov/2021/Nov/03/2002885874/-1/-1/0/2021-CMPR-FINAL.PDF.

[2] US Office of Naval Intelligence, *The Russian Navy. A Historic Transition*, 2015, p. ix-xi, https://www.oni.navy.mil/ONI-Reports/Foreign-Naval-Capabilities/Russia.

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propulsion (SSP) submarines – but it is rapidly modernising. In a confrontation, the PLAN's growing numbers of quiet conventional submarines could overwhelm ASW capabilities.[3]

The US Navy is responding to the challenge of more contested operating environments with distribution and mobility as described in its Distributed Maritime Operations (DMO) concept, which parallels US Marine Corps concepts for Expeditionary Advanced Base Operations (EABO) and stand-in forces (SIF). These concepts align with the new US Joint Warfighting Concept, which employs "expanded manoeuvre" to disaggregate forces for resilience, aggregates their effects on offense, and relies on decision support and interoperability tools from the DOD's Joint All-Domain Command and Control (JADC2) initiative to build and execute effective force-wide courses of action.[4] Rather than being a concept or programme itself, JADC2 is a coordinated effort among the US military services to improve their ability to connect the best shooter, sensor, and commander for a given task and provide the analytics to gain decision superiority.

Command and control is the most important aspect of the US Navy's changing conceptual approach. Commanders of distributed ships and troop formations rely on fleet commanders' Maritime Operations Centers ashore for intelligence, planning, and direction – a dependency that would increase during conflict.[5] However, opponents like China could disrupt long-range communications, requiring the Navy to develop C2 processes and architectures that adapt to communications availability, rather than trying to build networks that can allow fleet commanders to direct operations under all wartime conditions. The Navy is pursuing agile C3 as part of its JADC2-related experimentation effort, Project Overmatch.

3.2 US Navy technological/innovation priorities

The Navy budget is unlikely to grow substantially. As a result, new concepts such as DMO, EABO, and SIF that require more distributed operations will drive the fleet to become more heterogeneous, incorporating a growing number of lower cost

[3] US Department of Defense, *Military and Security Developments Involving the People's Republic of China*, cit.; and US Office of Naval Intelligence, *The PLA Navy. New Capabilities and Missions for the 21st Century*, 2015, https://www.oni.navy.mil/ONI-Reports/Foreign-Naval-Capabilities/China.

[4] US Marine Corps, *A Concept for Stand-In Forces*, December 2021, https://www.hqmc.marines.mil/Portals/142/Users/183/35/4535/211201_A%20Concept%20for%20Stand-In%20Forces.pdf; David Vergun, "DOD Focuses on Aspirational Challenges in Future Warfighting", in *DOD News*, 26 July 2021, https://www.defense.gov/News/News-Stories/Article/Article/2707633; Christopher H. Popa et al., *Distributed Maritime Operations and Unmanned Systems Tactical Employment*, SEA capstone thesis, 2018, http://hdl.handle.net/10945/59587; Art Corbett, *Expeditionary Advanced Base Operations (EABO) Handbook. Considerations for Force Development and Employment*, US Marine Corps Warfighting Lab, June 2018, https://mca-marines.org/wp-content/uploads/Expeditionary-Advanced-Base-Operations-EABO-handbook-1.1.pdf.

[5] US Joint Staff, *Joint Publication 3-32: Joint Maritime Operations*, updated 20 September 2021, https://irp.fas.org/doddir/dod/jp3_32.pdf.

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and less-multifunctional manned and unmanned vessels and aircraft alongside large traditional multisession platforms.[6]

Project Overmatch is intended to integrate for an increasingly heterogeneous fleet and is the Navy's top innovation priority.[7] Managed by the Navy Information Warfighting Center (NAVWAR), Project Convergence includes actions to connect existing DoD tactical networks such as Cooperative Engagement Capability (CEC), Link-16, and Tactical Targeting Network Technology (TTNT), which were already being integrated through the Navy Integrated Fire Control programme, with newer networks such as the Multifunction Advanced Datalink (MADL) on F-35 aircraft and datalinks used by the Navy's growing family of unmanned vehicles.[8] Project Overmatch also includes C2 and decision support systems needed to manage the complexity associated with more distributed, heterogeneous units and tailored force packages.[9]

Whereas C3 leads the Navy's technical and operational innovation efforts, the service's highest acquisition priority is the *Columbia*-class SSBNs. Built to replace aging *Ohio*-class boats commissioned during the Cold War and now reaching their fourth decade of service, *Columbia* SSBNs will incorporate several new technologies. In addition to adopting sensor and combat system advancements developed for the Virginia attack submarine programme, *Columbia* SSBNs will use electric propulsion and a new system of control planes.[10] In part due to its new technologies, the *Columbia* programme is challenged to remain on schedule, leading the Navy to investigate ways to operate *Ohio*-class submarines beyond their already extended 42-year service lives.[11]

[6] US Marine Corps, *Force Design 2030*, March 2020, https://www.hqmc.marines.mil/Portals/142/Docs/CMC38%20Force%20Design%202030%20Report%20Phase%20I%20and%20II.pdf; US Department of the Navy, *Report to Congress on the Annual Long-Range Plan for Construction of Naval Vessels*, 9 December 2020, https://media.defense.gov/2020/Dec/10/2002549918/-1/-1/1/SHIPBUILDING%20PLAN%20DEC%2020_NAVY_OSD_OMB_FINAL.PDF; Charles, Q. Brown, *Accelerate Change of Lose, US Department of the Air Force*, August 2020, https://www.af.mil/Portals/1/documents/csaf/CSAF_22/CSAF_22_Strategic_Approach_Accelerate_Change_or_Lose_31_Aug_2020.pdf.

[7] Colin Demarest, "Navy to Deploy Carrier Strike Group with Project Overmatch Networking", in *Defense News*, 8 September 2022, https://www.defensenews.com/naval/2022/09/08/navy-to-deploy-carrier-strike-group-with-project-overmatch-networking.

[8] Mallory Shelbourne, "Navy's 'Project Overmatch' Structure Aims to Accelerate Creating Naval Battle Network", in *USNI News*, 29 October 2020, https://news.usni.org/2020/10/29/navys-project-overmatch-structure-aims-to-accelerate-creating-naval-battle-network.

[9] Mallory Shelbourne, "Navy Testing Battle Management Aid on Aircraft Carrier", in *USNI News*, 26 November 2020, https://news.usni.org/?p=81709.

[10] Ronald O'Rourke, "Navy Columbia (SSBN-826) Class Ballistic Missile Submarine Program: Background and Issues for Congress", in *CRS Reports*, No. 41129 (14 December 2022), https://sgp.fas.org/crs/weapons/R41129.pdf.

[11] Megan Eckstein, "Navy May Extend Life of Ohio SSBNs to Provide Cushion for Introduction of Columbia-class", in *USNI News*, 16 November 2020, https://news.usni.org/?p=81493.

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The Navy surface and air warfare communities are also pursuing priority programmes in the DDG(X) destroyer and Next Generation Air Dominance (NGAD) family of manned and unmanned aircraft, respectively. The DDG(X), set to arrive in the mid-2030s, is intended to replace *Ticonderoga*-class cruisers that will retire this decade. DDG(X) would provide naval forces with improved air defence using a larger missile battery and high-energy laser as well as greater offensive reach with hypersonic boost-glide missiles.[12] The Navy is currently pioneering these technologies on existing surface ships. The FA-XX is intended to debut in the mid to late-2030s and replace the Navy's aging fleet of F/A-18 E/F Super Hornets. A sixth-generation fighter, the FA-XX would bring greater range and survivability compared to the F-35 and F/A-18. However, in a tight budget environment, these programmes will likely receive less attention and resources than *Columbia* or JADC2.

3.3 Systems under development in the maritime domain

Although not a national priority like the *Columbia* SSBN, the Navy's *Constellation*-class guided missile frigate (FFG) programme recently began construction, with a plan to build at least 20 of the ships over the next decade. The *Constellation* will focus on ASW and other escort missions to free up *Arleigh Burke*-class guided missile destroyers (DDG) for missile defence and strike warfare. Since it is to be equipped with the CAPTAS-4 towed low-frequency active sonar, the *Constellation* will also likely be the Navy's best platform for tracking quiet enemy submarines.[13]

At about half the cost of a DDG, the Navy intends FFGs to mitigate reductions in the surface fleet's size as Cold War-era cruisers and DDGs retire during the 2020s. And the ability to build more FFGs will gain importance if the Navy follows through on plans to succeed the *Burke*-class DDGs by the end of this decade with a larger and more expensive DDG(X), which will incorporate new hypersonic and laser weapon technologies.

Since 2015, the Navy has fielded and tested prototype laser weapon systems (LaWS) on amphibious ships USS *Ponce* and *Portland* capable of countering UAVs surface craft. The service plans to install the high-energy laser with integrated optical dazzler and surveillance (HELIOS) system on USS *Preble* in 2023, which could be scaled to 120 kW to defeat some missiles or rockets.[14] Longer-term, the Navy's High Energy Laser Counter-ASCM Program (HELCAP) is developing a 300-kW laser.

[12] Sam LaGrone, "Navy Unveils Next-Generation DDG(X) Warship Concept with Hypersonic Missiles, Lasers", in *USNI News*, 12 January 2022, https://news.usni.org/?p=91200.

[13] Ronald O'Rourke, "Navy Constellation (FFG-62) Class Frigate Program: Background and Issues for Congress", in *CRS Reports*, No. 44972 (21 December 2022), https://sgp.fas.org/crs/weapons/R44972.pdf.

[14] Richard Burgess, "Northrop Grumman Laser Weapon System Completes Deployment on USS Portland", in *Seapower*, 6 April 2022, https://seapowermagazine.org/?p=20566; Justin Katz, "Lockheed Delivers High-Energy Laser Four Years in the Making to US Navy", in *Breaking Defense*, 18 August 2022, https://breakingdefense.com/?p=239401.

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By relying on electrical power instead of surface-to-air missiles, HELCAP would increase the missile defence capacity and survivability of surface combatants and is planned for installation on some Flight III *Burke* DDGs.[15]

In concert with the US Army, the Navy is developing a common conventional prompt strike (CPS) hypersonic missile. While the Army version would be deployed from mobile, ground-based launchers, the Navy intends to initially field its CPS weapons on the service's three *Zumwalt*-class DDGs by 2025.[16] CPS missiles would also be introduced Block V *Virginia*-class SSNs that include Virginia Payload Modules starting in 2028.[17] As a boost-glide weapon, CPS uses a ballistic missile to lift its hypersonic glide vehicle warhead into the upper atmosphere, which then drops to the target using gravity to reach speeds of more than Mach 5, using speed and manoeuvrability to evade enemy air defences.

The Navy is pursuing modest improvements to its anti-submarine warfare (ASW) capabilities. To increase inventories, the service restarted production of the venerable Mk-48 submarine-launched heavyweight torpedo, the newest version of which incorporates digital sonar processing and improved guidance and control systems.[18] To help submarines defeat incoming torpedoes and provide ASW aircraft greater weapons capacity, the Navy also developed the Compact Rapid Attack Weapon (CRAW), a torpedo about 1/3 the size of the Mk-54 carried by surface ships, MH-60R *Seahawk* helicopters, and P-8A *Poseidon* fixed-wing aircraft.[19] With the MH-60R and P-8A both finishing production within the last few years, the Navy is not planning to start new maritime patrol aircraft until the mid-2030s.

Due to the procurement and operating costs of its manned surface and undersea platforms, Navy leaders plan for unmanned vehicles to help achieve a more distributed fleet that can conduct operations at a greater scale and tempo compared to today. To that end, the Department of the Navy's 2021 Unmanned Campaign Plan prioritises efforts to develop concepts for manned-unmanned teaming, the digital infrastructure to manage unmanned system operations, and processes for fielding unmanned systems to address important operational problems. However, the Navy has been slow to introduce unmanned systems beyond intelligence, surveillance, and reconnaissance (ISR) systems such as small RQ-21 Blackjack or

[15] Ronald O'Rourke, "Navy Shipboard Lasers: Background and Issues for Congress", in *CRS Reports*, No. 44175 (29 August 2022), https://sgp.fas.org/crs/weapons/R44175.pdf.

[16] Richard Burgess, "Navy Taps BIW, Raytheon for Conventional Prompt Strike Work on Zumwalt DDGs", in *Seapower*, 22 August 2022, https://seapowermagazine.org/?p=21872.

[17] Megan Eckstein, "Navy Looks to Get Back on Schedule for Fielding Hypersonic Missiles on Submarines", in *Defense News*, 18 November 2021, https://www.defensenews.com/naval/2021/11/18/navy-looks-to-get-back-on-schedule-for-fielding-hypersonic-missiles-on-submarines.

[18] Richard Burgess, "SAIC in Full Production for Mk48 Torpedo Propulsion Sections for U.S. Navy", in *Seapower*, 5 November 2020, https://seapowermagazine.org/?p=8373.

[19] "Aerojet Rocketdyne's Lithium Boiler to Power Navy Torpedo", in *C4ISRNet*, 24 October 2022, https://www.c4isrnet.com/battlefield-tech/2022/10/24/aerojet-rocketdynes-sceps-system-to-power-navys-craw-torpedo.

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Scan Eagle shipboard UAVs, Mk-18 mine hunting unmanned undersea vehicles (UUV), oceanographic SHARC wave gliders, and the large MQ-4C *Triton* UAV.[20]

After multiple false starts over the previous decade, the Navy started an unmanned carrier-based aircraft programme in 2018, the MQ-25A *Stingray*.[21] Each *Stingray* refuelling aircraft can extend the reach of two carrier-based strike fighters to about 1,000 nm, relieving F/A-18 E/F *Super Hornets* of this mission and freeing them up for combat operations.[22] However, to refuel all its available strike-fighters each carrier air wing would need to include 15 MQ-25As, rather than the 5-9 described in the most recent Navy plans.[23] Although the Navy's current plans would result in only about 10 percent of each carrier air wing being comprised of unmanned aircraft, Navy aviation leaders intend to increase that fraction to 60 percent by the late 2030s with the NGAD family of systems.[24]

Undersea, the Navy is pursuing a family of systems in four size ranges. At the high-end, the *Orca* extra-large UUV (XLUUV) is intended to be launched from piers or large amphibious ships but has encountered problems in testing that will likely constrain the reach and endurance of its operations. As a result, the Navy is planning to use it mainly for deploying mines and small UUVs (SUUV) rather than longer surveillance missions. Funding for the *Snakehead* large displacement UUV (LDUUV) was truncated by the Navy in its Fiscal Year (FY) 2023 budget proposal but is likely to be restored by the US Congress. The Navy sought to stop work on LDUUV because its deployment concept of being carried in dry-deck shelters on the back of SSNs and guided missile submarines (SSGN) was impractical, competed with the needs of special operations forces, and delayed testing on the programme.[25]

[20] US Department of the Navy, *Unmanned Campaign Framework*, 16 March 2021, https://www.navy.mil/Portals/1/Strategic/20210315%20Unmanned%20Campaign_Final_LowRes.pdf.

[21] US Naval Air Systems Command website: *MQ-25 Stingray*, https://www.navair.navy.mil/node/556; John R. Hoehn and Paul K. Kerr, "Unmanned Aircraft Systems: Current and Potential Programs", in *CRS Reports*, No. R47067 (28 July 2022), https://sgp.fas.org/crs/weapons/R47067.pdf.

[22] The 1:2 ratio applies to F-35Cs with two internal AIM-120 and two internal GBU-31 (or four internal AIM-120s). When armed with two external LRASM and four internal AIM-120s, each F-35C would require 9,500 lbs. of fuel, which would require one MQ-25A to support each F-35C. One MQ-25A can refuel two F/A-18E/Fs to 900 nm, rather than 1,000 nm as with the F-35C. See: Sam LaGrone, "Navy Releases Final MQ-25A Stingray RFP; General Atomics Bid Revealed", in *USNI News*, 10 October 2017.

[23] Of the 44 strike fighters in a squadron, 30 are likely available on any given day and about half will be devoted to air defense missions. See: Rick Burgess, "Navy's Future Carrier Air Wing Configuration Coming into Focus", in *Seapower*, 14 September 2020, https://seapowermagazine.org/?p=7774; this assumes a CVW of 44 strike fighters with an operational availability of 0.7, making 30 aircraft available. "US Navy Doubles Down on Range Requirements for Its MQ-25A Tanker Drone", in *The Drive*, https://www.thedrive.com/the-war-zone/14027.

[24] Paul McLeary, "Navy's Plans Call for New Drones to Shoot, Spy, Jam", in *Breaking Defense*, 30 March 2021, https://breakingdefense.com/?p=147347.

[25] Ronald O'Rourke, "Navy Large Unmanned Surface and Undersea Vehicles: Background and Issues for Congress", in *CRS Reports*, No. R45757 (21 December 2022), https://sgp.fas.org/crs/weapons/R45757.pdf.

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The Navy has had more success with its medium UUV (MUUV) programmes, which are designed to be launched from ships, boats, or torpedo tubes. The Mk-18 Mod 1 and Mod 2 have been in service for more than a decade and will be replaced by the *Knifefish* MUUV. Eventually the *Razorback* MUUV will provide a common MUUV platform for mine-hunting and other missions, including conducting ISR and other missions from submarines using torpedo tube launch and recovery.[26] However, because each MUUV takes up a torpedo stow, the submarine force is unlikely to use it extensively and the MUUV will be operated more often from surface ships or shore.

The *Lionfish* SUUV is the Navy's newest UUV programme. At 10 inches or less in diameter, the *Lionfish* could be small enough to be deployed by submarine countermeasure systems, XLUUVs, and potentially aircraft sonobuoy launchers. SUUV missions would include ISR but could also include acting as sonar decoys or jammers.[27]

Like UUVs, the Navy plans to field several sizes of unmanned surface vessels (USV), also with mixed results. Large USVs (LUSV) are being developed to carry missile magazines to augment manned surface combatants. The Navy has taken delivery of three prototype LUSVs from the Office of the Secretary of Defence's Strategic Capabilities Office (OSD SCO), with one more under construction. Insights from prototype experiments will inform studies of purpose-built LUSVs underway at six design yards.[28]

Medium USVs (MUSV) are intended to conduct reconnaissance and counter-reconnaissance missions by carrying passive radiofrequency and infrared sensors, EW jammers and decoys, or radar illuminators to support multistatic detection by manned platforms carrying radar receivers.[29] The Navy has built three MUSV protypes, which have been used in multiple experiments and exercises. However, Navy leaders suggest the results show MUSV missions could be done more affordably by smaller USVs, which may lead to the programme being cancelled or truncated.[30]

[26] John Keller, "Leidos to Develop Medium-sized Unmanned Underwater Vehicle and Sensors for Maritime Environmental Sensing", in *Military Aerospace*, 12 July 2022, https://www.militaryaerospace.com/unmanned/article/14279432/unmanned-underwater-sensors.

[27] Justin Katz, "Navy Moving Ahead with HII for Small UUV Program", in *Breaking Defense*, 21 March 2022, https://breakingdefense.com/?p=211233; Dan Parsons, "Navy's 85-Foot Orca Unmanned Submarine Will Be a Minelayer First", in *The Drive*, 27 May 2022, https://www.thedrive.com/the-war-zone/navys-85-foot-orca-unmanned-submarine-will-be-a-minelayer-first.

[28] Megan Eckstein, "Navy Christens Third 'Overlord' Robot Ship, with More on Tap", in *Defense News*, 24 August 2022, https://www.defensenews.com/naval/2022/08/24/navy-christens-third-overlord-robot-ship-with-more-on-tap; Rich Abbot, "Navy Continues Six LUSV Study Contracts", in *Defense Daily*, 5 August 2022, https://www.defensedaily.com/?p=1115947.

[29] Ronald O'Rourke, "Navy Large Unmanned Surface and Undersea Vehicles", cit.

[30] Megan Eckstein, "What's New in Navy and Marine Corps Unmanned Boats", in *Defense News*, 19 May 2022, https://www.defensenews.com/naval/2022/05/19/whats-new-in-navy-and-marine-corps-unmanned-boats.

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Nearly all the Navy's small USVs are experimental, such as the Saildrone USVs being used in the Middle East by Task Force 59 (TF-59).[31] Although TF-59's effort may eventually field more than 100 USVs across the Persian Gulf, Arabian Sea, and Red Sea, these commercial systems lack the hardened communications of military vehicles or sensors such as sonar arrays and sophisticated signals intelligence devices. The TF-59 unmanned force may therefore be well-suited, but unique, to the Middle East and not an approach the Navy would replicate elsewhere such as the Atlantic or Western Pacific. The small mine countermeasures (MCM) USV, which reached initial operating capability in 2022, is the Navy only formal USV programme of any size.[32] Although initially designed to tow influence sweep systems, the MCM USV could conduct ISR, EW or other missions in the future.

Despite its challenges in fielding unmanned vehicles, the Navy will likely have by 2030 about a dozen prototype MUSVs and LUSVs. Formal programmes will be established by the mid-2020s for each platform, along with the *Orca* XLUUV, *Razorback* MUUV, and *Lionfish* SUUV that began work in 2022. According to the Navy's most recent shipbuilding plan, the service plans to field between 89 and 149 unmanned vessels by 2045, although the exact mix will depend on technical and operational considerations as the programmes evolve.[33]

3.4 The US Navy's approach to multi-domain and C3

As a multi-domain service, nearly all the Navy's platforms exert effects across domains. For example, SSNs are now deploying EW systems to generate effects in the electromagnetic spectrum, as well as missiles to launch attacks against targets at sea or ashore. Aircraft like the P-8A launch and manage sonobuoys such as the Multistatic Active Coherent (MAC) system that can detect and track even the most capable opposing submarines. And FFGs and DDGs both can conduct ASW, air defence, and strike warfare.

In addition to the hypersonic prompt global strike missile, the Navy surface force is pursuing upgrade to the *Tomahawk* land-attack missile and Standard Missile (SM)-6 air defence interceptors enable them to conduct maritime strike.[34] The submarine force is also planning to leverage the upgraded Maritime Strike *Tomahawk* to enable long-range anti-ship attacks from their vertical launch tubes. Between now and 2030s, the surface force is planning to develop a new Offensive

[31] Sam LaGrone, "Austal USA Inks Deal with Saildrone to Build Wind-powered Drones as USV Work Expands", in *USNI News*, 1 September 2022, https://news.usni.org/?p=97018.

[32] US Navy Office of Information, *Initial Operating Capability Declared for Unmanned Influence Sweep System (UISS)*, 29 July 2022, https://www.navy.mil/Press-Office/News-Stories/Article/3110119.

[33] US Department of the Navy, *Report to Congress on the Annual Long-Range Plan for Construction of Naval Vessels for Fiscal Year 2023*, April 2022, https://go.usa.gov/xJtjj.

[34] Thomas Newdick, "SM-6 Missile Used to Strike Frigate during Massive Sinking Exercise in Pacific", in *The Drive*, 20 June 2022, https://www.thedrive.com/the-war-zone/sm-6-missile-used-to-strike-frigate-during-massive-sinking-exercise-in-pacific.

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Anti-Surface Warfare weapon to replace the Cold War-era *Harpoon* anti-ship missile and complement the *Tomahawk* and SM-6.[35]

With systems operating in the air, on the water, undersea, and ashore, the Navy's C3 architectures and processes are critical to connecting and orchestrating capabilities across domains. The service's efforts under Project Overmatch are extending its C3 capabilities to a growing number and variety of force packages to address fleet commanders' operational challenges. Supporting initiatives, such as the Rapid Autonomy Integration Lab (RAIL) are building the digital infrastructure needed to coordinate unmanned systems across domains, in some cases using common control systems.[36] A combination of C3 capabilities and automation will be essential for Navy leaders to fulfil their vision of a larger, and increasingly unmanned, fleet.

[35] Justin Katz, "Navy's Next-Gen, Ship-Killing Missile Will Be a Hypersonic Weapon Dubbed HALO", in *Breaking Defense*, 27 April 2022, https://breakingdefense.com/?p=219411.

[36] US Navy Public Affairs Office, "Evolving Command, Control and Communications for Unmanned Systems", in *DVIDS News*, 8 January 2021, https://www.dvidshub.net/news/386617.

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4. France

by Hugo Decis

The French Navy, or Marine Nationale (MN) is the largest naval force in the European Union. Operating from three main naval bases in Cherbourg, Brest and Toulon, the MN further benefits from having access to a collection of stations in overseas France, with 6 of its 17 frigates permanently based away from Europe. It is considered a highly modern and capable force, the only navy outside of the US operating a nuclear-powered catapult-assisted take-off but arrested recovery (CATOBAR) aircraft carrier, the *Charles de Gaulle*, and one of the six navies operating a class of SSBNs with its four *Le Triomphant*-class boats.

Despite this apparent strength, the Marine Nationale is a recovering force: like most navies in the western world, its funding largely decreased after the end of the Cold War, with the emphasis for newly built ships being put on affordability and endurance rather than lethality, as exemplified by the *Floréal*-class (1991–1994) and the *La Fayette*-class light frigates (1996–2001). Recent trends in innovation and procurement, however, suggest that France has kept a close watch on naval developments and intends to design and field an increasingly capable and credible force in the future – but with limited ambitions however, with regards to increasing the fleet's hull number.

The war in Ukraine, while mostly fought on land, has had significant implications for the maritime domain. The Black Sea has been the theatres of serious engagements and both parties have effectively used it to carry out sophisticated attacks, relying mostly on guided missiles and unmanned systems. It is unclear how much of it will impact the French Navy's structure and capabilities, but these operations should at the very least act as a reminder of the value of seaborne deep-strike capabilities, as well as the importance of air defence.[1]

Table 1 | Marine Nationale: Selection of assets as of July 2022 and plans for 2030

Classification	2018	2030 (planned)
Nuclear powered attack submarine	6	6
Nuclear powered ballistic missile submarine	4	4
Nuclear powered aircraft carriers	1	1
Landing Helicopter Dock	3	3
Destroyers and Frigates	23	21
Auxiliary oiler replenishment helicopter	3	4

[*] Hugo Decis is a former Research Analyst for Defence and Military Analysis at the International Institute for Strategic Studies (IISS).

[1] French Navy website: *Nos valeurs : Mercator Accélération*, https://www.defense.gouv.fr/node/1400.

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4.1 Strategic and doctrinal thinking

The current posture and format of the Marine Nationale derives from three main documents: the Strategic Review, published in 2017 and updated in 2021,[2] the Military Planning Law[3] (*Loi de Programmation Militaire* – LPM) for the 2019–2025 timeframe, and, last but not least, Plan Mercator, a document setting out the Navy's identity and objectives up to 2030.[4] Together, these clarify what the MN's missions are: to protect France's maritime routes; to maintain the credibility of the country's nuclear posture; to safeguard France's interests and finally, to contribute to the country's ability to collect intelligence. Operationally, this has translated into a renewed interest for SLOCs and maritime chokepoints and the necessity for France to secure partnerships with key maritime powers – including away from Europe.

The LPM in particular indicates the Navy's preferred format: as of 2025, the MN must operate 4 SSBN, 6 SSN, 1 nuclear-powered aircraft-carrier, 15 "first rank frigates" – France's terminology for well-armed destroyers and frigates –, 3 principal amphibious ships, 4 auxiliary oiler replenishment helicopter (AORH), about 134 aircrafts – including 40 fighters, 18 maritime patrol aircraft and 76 helicopters – and 19 patrol ships. These figures do not strongly differ from what the MN's fleet composition as of 2018, which in turns illustrate the Navy's conservative posture and modest planned growth in capabilities, as dictated by its funding.

Very much like the country's land forces, or *Armée de Terre*, the Marine Nationale has maintained capabilities across the board. Operating a nuclear-powered aircraft carrier and a flotilla of capable SSBNs, however, has placed a significant burden on the Navy's finances, with severe consequences over the rest of the force: the average French principal surface combatant lacks defence capabilities – particularly with regards to air defence – and training in the use of complex ammunition is limited. Furthermore, France's main surface assets are stretched thin over the second largest exclusive economic zone (EEZ) in the world, which has imposed a severe operational tempo on the fleet, resulting in rising maintenance costs. The MN remains a capable force nonetheless but similarly to its European counterparts it lacks the sheer volume of ammunition stocks required to sustain a prolonged engagement with a peer adversary.

4.2 Platforms and systems in used and in development

Whether or not the cost of France's nuclear deterrence will prevent the Navy from investing enough resources in much needed programmes remains to be clarified.

[2] French Ministry of the Armed Forces, *Actualisation stratégique et revue stratégique 2017*, 21 January 2021, https://www.defense.gouv.fr/dgris/politique-defense/actualisation-strategique-revue-strategique-2017.

[3] Website of the French Ministry of the Armed Forces: *Le dossier de la Loi de programmation militaire 2019-2025*, https://www.defense.gouv.fr/node/1007.

[4] French Navy website: *Nos valeurs : Mercator Accélération*, cit.

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While the overall defence budget is set to grow by an extra 4 billion euro per year for the next 3 years, as per LPM requirements, the French Navy is currently involved in 4 main procurement programmes, as displayed in the table below, for a total amount of close to 27 billion dollars. In addition to those, France is considering developing a new class of SSBN, commonly referred to as SNLE3G, and has started working on a new nuclear-powered aircraft carrier meant to replace the *Charles de Gaulle* from 2038 onwards, the *Porte-Avions de Nouvelle Génération*, or PANG. Much of the Navy's budget, as a result, is already spoken for, with limited ability to consider new projects without upgrading the current LPM, or adopting a more ambitious one as its successor, in 2025.

Table 2 | Marine Nationale: Main programmes as of July 2022

System	Number of assets	Value (bn US dollars)	Status
Suffren-class (SSN)	1 + 5	10.33	Deliveries in progress
Aquitaine-class (FFGHM)	7 + 1	9.82	Deliveries in progress
Amiral Ronarc'h (FFGHM)	5	5.08	Signed contract
Jacques Chevallier (AORH)	4	1.91	Signed contract

France's naval aviation is also involved in the regeneration of its capabilities: it currently operates 42 Rafale-M fighters, having retired its last Dassault *Super Étendard Modernisé* in July 2016, as well as 22 *Atlantique 2* (ATL2) maritime patrol aircrafts (MPA) – 18 of them in the process of being modernised to remain operational until 2030 – and three E2-C Hawkeye. As an addition to those, it has approved the procurement of seven Falcon 2000LXS – with an option on another five – to replace its ageing fleet of maritime surveillance aircrafts. By far its most pressing need, however, is to decide on how to replace its ageing fleet of ATL2: originally, this was to be part of a joint French-German programme, MAWS, but Germany' decision to procure at least 5 P-8A Poseidon MPAs from the United States has led France to consider purely national options instead, with Dassault's Falcon 10X considered a likely candidate.

Another key aspect of France's efforts in the maritime domain rests with the future of its missiles selection. The Marine Nationale currently relies on the Aster family of missiles for air defence and is likely to field its latest iteration, the Aster 30 Block 1NT, to boost its ballistic missile defence (BMD) capabilities. It is also rumoured to be considering the purchase and integration of MBDA's MICA VL short range, ground based air defence system aboard its principal surface combatants (PSCs) to gain a cost-effective capability to counter low-level threats.[5] This further rationalisation of the French Navy's air defence would also benefit from the introduction of the RAPIDFire close-in weapon system, meant to offer yet another mean to counter

[5] Vincent Groizeleau, "VL Mica NG : alternative à l'Aster 15 ?", in *Mer et Marine*, 27 May 2021, https://www.meretmarine.com/fr/defense/vl-mica-ng-alternative-a-l-aster-15.

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unmanned vehicles, light aircrafts and missiles with its future Anti Aerial Airburst (A3B) rounds.[6] With regards to surface warfare, France still heavily relies on the Exocet family of anti-ship missiles, particularly in its latest iteration, the Exocet Block 3. The renewal of this capability beyond the Exocet life expectancy, however, is part of a larger French-British effort, dubbed Future Cruise and Anti-Ship Weapon (FC/ASW). The systems designed and procured within the framework of this programme would eventually replace France's Exocet anti-ship missiles as well as its MdCN-model naval cruise missiles and help create more commonalities between Europe's two largest naval forces.

4.3 Innovation priorities

France's decision to publish its first Seabed Warfare Strategy[7] in February 2022 has put some increased attention on the country's efforts to procure unmanned and autonomous underwater vehicles (UUVs, AUVs) in the coming years. Albeit backed with limited funding, these efforts would increase France's capabilities on two key and complementary segments of the operational spectrum: hydrographic studies, under the *Capacité Hydrographique et Océanographique Future* (CHOF) programme for the procurement of surface systems capable of deploying UUVs, and mine warfare within the framework of *Système de Lutte Anti-Mines – Futur*, or SLAM-F. Perhaps most importantly, these would allow France to operate assets down to 6,000 m, a significant capability given the limitations on France's current assets, *Ulisse* and *Diomede*, which can only operate at a maximum depth of 1,000 m and 2,000 m respectively.[8]

Table 3 | Marine Nationale: Prospects for UAV integration as of July 2022

Requirement	Programme	Status	Systems
Mini ISR UAV	SMDM	Deliveries in progress	DVF 2000 Aliaca
Medium ISR UAV	SDAM	Deliveries in progress	Camcopter S-100, VSR 700
MALE UAV	AVSIMAR	Under consideration	Patroller, Eurodrone

Another priority for the French Navy is the integration of UAVs across the fleet. Starting with Plan Mercator, the Marine Nationale committed to having one UAV deployed on each of its assets by 2030 and has so far mostly experimented on three systems: Schiebel's Camcopter S-100, Airbus Helicopters' VSR700 and Survey Copter's 2000 DVF Aliaca. These would be tasked with observation and surveillance operations otherwise requiring helicopters and, as such, are considered cost-

[6] Xavier Vavasseur, "RAPIDFire: Thales and Nexter to Equip French Navy Ships with New CIWS System", in *Naval News*, 27 October 2020, https://www.navalnews.com/?p=17236.

[7] French Ministry of the Armed Forces, *Les armées se dotent d'une stratégie ministérielle de maîtrise des fonds marins*, 18 February 2022, https://www.defense.gouv.fr/node/567.

[8] Charlotte Le Breton and Hugo Decis, "France's Deep Dive into seabed warfare", in *Military Balance Blog*, 25 February 2022, https://www.iiss.org/blogs/military-balance/2022/02/frances-deep-dive-into-seabed-warfare.

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effective addition to the fleet's capabilities. The French Navy, however, has so far struggled to identify companies to partner with that would offer tested, affordable and French-made solutions, and could instead elect a European provider for certain segments of its UAV requirements within the framework of the *Système de drone aérien de la Marine* (SDAM) programme. The French Navy is also involved in a similar programme for much lighter, cheaper UAV, under the *Système de mini-drones pour la Marine* (SMDM) programme.

Finally, yet importantly, France is considering adding an unmanned dimension to the renewal of its fleet of maritime surveillance aircrafts by securing an order of MALE UAVs meant to complement the future Falcon 2000 LXS. Among other candidates, the Marine Nationale is said to be considering Safran's Patroller M as well as Airbus' Eurodrone, but delays and over costs in the design and production of the latter are likely to mark it as an unconvincing candidate.

4.4 Multi-domain approach in the naval domain

The increasing and mutual interdependence of all domains have pushed the Marine Nationale to improve its approach to multi-domain operations by setting up command structures capable of coordinated assets across branches and services.

The Indo-Pacific, in that regard, has been a relevant laboratory for multi-domain operations: scarcity in assets, as well as high operational requirements, also played a role in pushing services and branches closer together. The capabilities China is also able to wield across domains may have also forced France to adapt its own thinking accordingly, not only by encouraging cross services and branches coordination, but also by integrating in multinational exercises, operations and exercises alongside allies and partners.

On that note, France traditional emphasis on strategic autonomy and freedom of action has limited its ability to interact with allied forces at a sensitive level, including the prompt sharing of high-value intelligence or the setting up of built-in, dedicated communication lines. This has not prevented US ships from being placed under French command, and vice-versa, but the deeper integration of foreign systems aboard French warships would overall meet more roadblocks than in other qualified services around the world.

Conclusion

Having invested large sums of money into the renewing of its main capabilities, the Marine Nationale stands at a crossroad. In the last decades and ever since the end of the Cold War, it has established itself as a modern, capable force. It has also proven its value and competence throughout various operations as well as frequent deployments – alone, when preferable or necessary, but more often than not alongside partners and allies, placing a welcome emphasis on interoperability and cooperation at sea. The Marine Nationale has the privilege of enjoying the backing of a skilful DTIB. It also benefits from France's decision to team up with a selection

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of European partners, and Italy in particular, as a solution to the mounting cost of modern naval systems. This effort is likely to continue in the future as part of the European Patrol Corvette (EPC) PESCO project[9] that has already brought together a community of countries from Europe as it receives EDF funding.

The French Navy, however, is not without weaknesses: its relatively conservative approach to innovation at sea, partly driven by limited funding, has restricted its capabilities and resulted in delays in integrating unmanned and autonomous systems within the fleet. It has also led the Navy to prioritise the procurement of modern PSCs while its fleet of corvettes and patrol combatants rapidly aged, further damaging its ability to cover the lower end of the operational spectrum, particularly within France's vast overseas maritime domain. Recent developments in naval warfare, including but not limited to the sinking of the Russian cruiser *Moskva*, has had the unexpected consequence of exposing one of the Marine Nationale's main flaws: the fleet's limited antimissile capabilities, as well as lacking training in the use of complex ammunition, as well as sufficient stocks. Fixing both will require either reallocating funding or increasing the Navy's resources – something France will have an opportunity to consider soon, while drafting this year's budget proposal, but even more so while crafting a new LPM, on which work has already started.[10]

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[9] Permanent Structured Cooperation (PESCO) website: *European Patrol Corvette (EPC)*, https://www.pesco.europa.eu/project/european-patrol-corvette-epc.

[10] French Presidency of the Republic, *Discours aux armées à l'Hôtel de Brienne*, 13 July 2022, https://www.elysee.fr/emmanuel-macron/2022/07/13/discours-aux-armees-a-lhotel-de-brienne-1.

5. Germany

by Moritz Brake*

Germany's role in European defence has been less prominent than its otherwise central position in economic, geographic and demographic terms would suggest. This also concerns its role in naval affairs. Even though Germany's gross domestic product is more than double that of Italy's, its navy is closer to half the size to that of its Mediterranean neighbour. This is in part due to the fact that traditionally and in NATO's Cold War strategy, Germany has always been a continental rather than a maritime power. However, since the end of the Cold War and its reunification, Germany has undergone a veritable maritime turn. Especially with the deliberate reforms of Gerhard Schröder's government at the turn of the millennium, Germany reinvented itself as a major international shipping power and an open, globalised economy. Its prosperity is tied to maritime trade much more than any of its allies'. The Navy has proven to be an exceptionally valuable instrument of Germany's foreign policy after 1990, with sea power substantially increasing in national significance. This also finds its expression in the relative increase of the navy's share in personnel and allotted budgetary resources in the traditionally army-dominated Bundeswehr over the past three decades.

5.1 Strategic thinking behind the use and development of specific systems and technologies

Within the broader discussion about Germany's global role, it matters what Germans think their navy is for. The utility accorded to the Navy in official strategy is comprehensive and consistent with what experienced sea powers expect of their naval force.[1] However, Germany's Bundeswehr has never been a stand-alone national military as its major peer forces are: all of its units have always been fully integrated in NATO's overall defence planning and command structures. There is also no national level "General Staff", the highest level military planning instrument commonly found in other nations. This function has been assumed by NATO's – and also the EU's – military staff, of which Germany is a part. By conscious post-war design, from national defence to expeditionary intervention, Germany has to rely on cooperation with its allies. Any military deployment abroad – apart from immediate self-defence or response to an emergency – needs to be part of a multilateral framework such as NATO, the EU or UN.[2] Accordingly, Germany's navy is not designed to "go it alone" and carry out the entire spectrum of tasks normally

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[1] Moritz Brake, *The Contemporary German Navy as an Instrument of Foreign Policy. The Federal Republic and its Naval Deployments after the Cold War*, PhD Thesis, King's College London, 2022, p. 80, https://kclpure.kcl.ac.uk/portal/en/theses/thecontemporarygermannavyasan-instrumentoffore ignpolicy(171cd138-486d-469e-ac10-f920a2f74bfb).html.

[2] See Federal Constitutional Court, *Urteil des Zweiten Senats vom 12. Juli 1994 (Out-of-area-Einsätze)*, https://www.servat.unibe.ch/dfr/bv090286.html.

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expected of other navies, neither by strategic ambition nor by force composition. This clearly affects procurement plans.

At the same time, due to its post-war strategic culture and specific domestic political configuration, Germany still has far-reaching reservations about the use of military force as an element of state power and a high likelihood of all matters military to become embroiled in difficult inner-coalition and cross-party debate. In this, the anti-interventionist streak in German domestic politics – even if it is not powerful enough to dictate policy – is particularly wary of the Navy's key role in projecting military power abroad. Still, the past thirty years of missions of the Bundeswehr demonstrate that Germany – within certain limits – does deploy its military in concert with its allies and within a multi-lateral framework. An increasingly valuable instrument of Germany's evolving "New Global Role" after reunification, the Navy was the first service to deploy "out-of-area" and since has consistently provided a far-ranging presence in a broad array of missions.

Key strategic documents of Germany, successive iterations of the Defence White Paper (*Weißbuch*) for defence policy, or the defence policy guidelines (*Verteidigungspolitischen Richtlinien*, one level below), demonstrate clearly this shift to an instrument of foreign policy covering comprehensive crisis response and maritime security tasks in contributing to global ocean governance. Following Russia's annexation of Crimea in 2014, the latest White Paper 2016 also translates NATO's reemphasis on national and territorial defence in Europe into German official strategy.[3] It is important to note that even in the light of Russia's further attack on Ukraine in 2022, this reemphasis on territorial defence in Europe has not led to an abandonment of the navy's activities in crisis-response or maritime security activities further afield.

5.2 Systems in use and development in the maritime domain

The German Navy has shrunk considerably since the end of the Cold War in terms of total hull numbers, with the new crisis response mission profile strongly influencing the design of new units and the decision which older ones to retain. For example, the latest class of frigates is designed to fulfil exactly the types of missions the navy has come to cover since the 1990s – lower intensity, constabulary in nature and far away from domestic supply and maintenance networks.

After 2014, with high-end warfighting and deterrence of a peer-competitor again high up on the agenda, the navy designed its next class of frigates, the F126, to be major anti air warfare (AAW), ASuW and ASW units with ship-ship, ship-air, ship-land and anti-submarine-strike capabilities (due to the versatility of the Lockheed

[3] Federal Ministry of Defence, *White Paper 2016 on German Security Policy and the Future of the Bundeswehr*, July 2016, p. 31-32, https://www.bundeswehr.de/resource/blob/4800140/fe103a80d8576b2cd7a135a5a8a86dde/download-white-paper-2016-data.pdf.

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Martin MK 41 VLS).[4] Contracts were signed with Damen Shipyards (Netherlands) in June 2020, with an ambitious schedule for Germany's most expensive-ever shipbuilding project of 5.6 billion euro for four units (with an option for a further two) to arrive in the fleet from 2028 onwards.

Concerning its main weapons systems, the navy is procuring a replacement for its ageing *Harpoon*, Kongsberg's Naval Strike Missile, to be deployed on its F124, F125 and F126 frigates from 2023 onwards.[5] Aiming to improve stealth and range, the new missile also comes with ship-shore – in addition to ship-ship targeting capabilities. Furthermore, starting with the F126 frigates, the navy upgrades its widely used MLG27-*Marineleichtgeschütz* (Rheinmetall's multirole gun system) to the more networked and versatile version "4.0".[6] As a completely new introduction into the fleet, the F125's 127 mm gun is about to receive certification for the use of Leonardo's and Diehl's jointly developed *Vulcano* long-range ammunition (available in guided and ballistic variants; range greater than 70 km depending on the variant). Already in use on Italy's *Fremm*-class frigates, 127 mm *Vulcano* ammunition is also planned for the F126.[7] With regard to its submarines, beyond the established torpedo DM2A4 (Atlas Elektronik; range greater than 50 km) and Leonardo's C303/S counter-torpedo jamming and decoy system,[8] the navy is also working towards acquiring a submarine-based (anti-helicopter) missile. The so-called Interactive Defence and Attack System for Submarines (IDAS), has been on the wish-list and under development for a number of years.[9] While in February, the announced special budget for the Bundeswehr (*Sondervermögen*) initially appeared to allow for the project's realisation, its procurement is now postponed (with research on it continuing).

Regardless of mission focus, the trend towards less but more capable, larger and more expensive units is consistent. This is perfectly illustrated by Germany's submarine force. The replacements of older units came with global deployment ability, much greater tonnage and overall reduction in crew. The aggregate tonnage of the six 212A submarines today is almost equivalent to the aggregate tonnage of twenty-two of the twenty-four much smaller submarines in service in 1990. This evolution will be even more pronounced with the new class 212CD (common

[4] "Fregatten F126 erhalten MK-41-Senkrechtstartsystem von Lockheed Martin", in *Europäische Sicherheit und Technik*, 21 February 2022, https://esut.de/2022/02/meldungen/32490.

[5] Federal Ministry of Defence, *Umfangreiche Beschaffungen für die Deutsche Marine*, 24 June 2021, https://www.bmvg.de/de/aktuelles/umfangreiche-beschaffungen-fuer-die-deutsche-marine-5099106.

[6] "Fregatte 126: Rheinmetall liefert Marine-Leicht-Geschütze", in *Europäische Sicherheit und Technik*, 17 November 2022, https://esut.de/2022/11/meldungen/38061.

[7] Hans Uwe Mergener, "Deutsche Marine: 127-Millimeter Gefechtsmunition Vulcano vor der Einführung", in *Europäische Sicherheit und Technik*, 10 November 2022, https://esut.de/2022/11/meldungen/37913.

[8] Federal Ministry of Defence website: *Die U-Boot-Klasse 212 A*, https://www.bundeswehr.de/de/ausruestung-technik-bundeswehr/seesysteme-bundeswehr/u-boot-klasse-212-a.

[9] Federal Ministry of Defence website: *Lenkflugkörpersystem für U-Boote*, https://www.bundeswehr.de/de/organisation/ausruestung-baainbw/ruestungsprojekte/lfk-sys-see-luft-u212a-idas-.

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design), built by Thyssen-Krupp Marine Systems, contracted together with Norway – two units for Germany, four for Norway. With a prospective ~2,500 tons they are expected to be even larger than the 212A.

5.3 Main technological and innovation priorities

Germany sees its shipbuilding industry generally as a national key technology (*nationale Schlüsseltechnologie*), especially its world-class conventional submarine construction. This makes the consolidation of European naval shipbuilding difficult. The option of relying on OCCAR for achieving economies of scale with common designs at an acceptable level of national allocation in the execution projects has been recognised in Germany – but awaits substantial application in the naval sector. However, the most expensive-ever German shipbuilding contract, the F126, went to a Dutch-led consortium in 2020 – but with all major works carried out in Germany.

Furthermore, naval arms exports are a key element in sustaining Germany's national maritime complex. Without the high margins obtainable in the international naval market, Germany's remaining shipyards would have long gone out of business since the 1990s. While the government controls the permission to export, the navy typically provides the first customer, covering the research and development (R&D) cost necessary to develop a competitive product for customers abroad. The "price" to pay in delays for first-of-a-class units that often require time-consuming fixes before becoming fully operational is perhaps balanced for the navy by a network of an international "user community" for some of its gear, diplomatic advantages abroad and a functioning domestic industrial base.

With what is currently in the order books,[10] the navy is not projected to grow substantially over the coming decade – at least not in quantity. The 100 billion euro *Sondervermögen*, for the Bundeswehr announced by Chancellor Scholz in the wake of Russia's invasion of Ukraine, had initially contained a substantial share for the navy – coming second after the air force and before the army. There was talk about using the option for a further two F126 frigates, further two submarines, another five corvettes and seven additional maritime patrol aircraft. However, from June onwards, it became clear that beyond what had been projected before February 2022, the navy would have to contend itself with only an extra three P8 Poseidon MPAs – thereby replacing the ageing P3 Orions and merely returning the navy's capabilities to the role it vouched to fulfil in NATO.[11]

[10] Federal Ministry of Defence, *15. Bericht des Bundesministeriums der Verteidigung zu Rüstungsangelegenheiten. Teil 1*, 30 April 2022, https://www.bmvg.de/de/themen/ruestung/ruestungsmanagement/ruestungsbericht; Hans Uwe Mergener, "Die Einsatzbereitschaft der Marine – Projekte aus dem Sondervermögen", in *Europäische Sicherheit und Technik*, 13 October 2022, https://esut.de/2022/10/fachbeitraege/36852.

[11] Thomas Wiegold, "Nach Rechnungshof-Kritik: Weniger Projekte im Bundeswehr-Sondervermögen", in *Augen geradeaus!*, 28 October 2022, https://augengeradeaus.net/?p=62218.

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Not only did the navy eventually come out last in priority in the *Sondervermögen* after the latest alterations, the part of the extraordinary budget set aside for R&D, including innovation in AI, translates to less than 1 per cent.[12] This means that with Germany's defence priorities shifting towards army and air force, the navy will numerically more or less remain at its current state, while inflation and the need to stop gaps in existing equipment – especially stacking up on ammunition across the board of the Bundeswehr – there appears to be very little room in Germany's defence budget over the coming years to address future technologies.

5.4 Readiness for a multi-domain approach to the naval domain

The Navy struggles – as do other navies – with the idea that "multi-domain warfare" means more than ASW, ASuW and AAW. The link of these with the dimensions of cyber and space on an operational level at sea is in its infancy but likely to rapidly advance with the pressing needs of the day. Commanders need to be able to fuse awareness about mission-critical space- or cyber-assets with means to detect risks, as well as protect one's own and threaten an enemy's benefits derived from them.

While within the "silos" of the defence bureaucracy a project of the air force, FCAS, the European Future Combat Air System, is also a game-changer for the navy – but not officially linked to its current procurement projects.[13] Warships, helicopters, UAVs or USWs operated by the navy would be fully integrated in what has been called the "combat cloud" of a modern truly multi-dimensional battlespace. In this, the sheer vastness of data generated by a multitude of sensors needs to be made actionable or "digestible" for the human brain and operator. This can only be achieved with the help of AI. The challenge then is not to use or not use AI, but to understand how to use it. Similarly, with certain situations requiring reactions so rapidly – hypersonic weapons or swarms of small UAVs come to mind – it is necessary for the navy to follow the scientists at i.e. the Fraunhofer institute in Bonn, in starting to think about when and within which restrictions it is permissible to resort to fully automatised defence systems.[14]

Conclusion

The navy has relatively risen in importance in the Bundeswehr over the past thirty years of crisis-response missions. However, judging by the latest revisions in the special budget, the air force and army will be given greater priority in the

[12] Federal Government, *100 Billion Euros for a Powerful Federal Armed Forces*, 10 June 2022, https://www.bundesregierung.de/breg-en/news/special-fund-federal-armed-forces-2047910.

[13] FCAS is linked to the army's project "main ground combat system". See Thomas Wiegold, "Bundestags-Haushaltsausschuss billigt Verteidigungsetat und Sondervermögen – Plus eine Milliarde Euro für Munition", in *Augen geradeaus!*, 11 November 2022, https://augengeradeaus.net/?p=62343.

[14] See interview with Wolfgang Koch: "Von HPD & HPE – oder wie eine FCAS-Cloud das Grundgesetz lernen muss", in *Atlantic Talk Podcasts*, 26 May 2022, https://ata-dag.de/podcast/atlantic-talk/koch_wolfgang/16131.

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foreseeable future. This is clearly driven by the perceived needs arising from Russia's invasion of Ukraine and comes despite the acknowledged global role and interests of Germany – an international role and the protection of global interests which critically depend on the maritime dimension. Germany, due to its comprehensive integration in the EU, is no longer "continental" and because of globalisation economically depends on the sea.[15] Accordingly, as is demonstrated by its record of missions since the Cold War, the navy will have to continue to play an important role as an instrument of Germany's foreign policy.

As indicated by the navy's past missions, the current state of the force and the planned units already in the order books, there are persisting restrictions on how and with what type of equipment Germany is likely to contribute to allied and European sea power. To this day, Germany lacks naval strategic or expeditionary transport capabilities. It has not decided to fill this Cold War gap, underscoring its reluctance to overemphasise the deployment of sizeable army detachments overseas. Germany did not acquire or aspires to possess strategic weapons such as submarines with land-strike, let alone nuclear capabilities, or helicopter and aircraft carriers. Only in June 2022, did the navy achieve ship-shore missile strike capability (with respective certification of its corvette-based RBS15 during an exercise in Norway).[16]

Given the average service life of frigates over the past decades in Germany, the fleet even in thirty years will probably still contain F125 frigates and certainly F126-class vessels. But given the tendency to reduce risk to human operators in conflict and at the same time avoid the concentration of more and more mission-critical equipment together with these same valuable humans on few, highly expensive units, it is likely that crewed warships will cover different roles from those navies are currently used to. Human operators, when they do deploy close to "hot" conflict zones rather than in constabulary roles, are probably best situated on submarines that allow for a higher level of stealth and protection than exposed surface units, as they keep on-scene-control over "swarms" of more expendable UAVs and USVs. Still, in addition to the need to maintain reliable control over remotely or (semi-) autonomously operated units, especially democracies like Germany are unlikely to only resort to floating "*robocops*" in their indispensable commitment to global ocean governance.

[15] Federal Government, *Rede von Bundeskanzlerin Merkel bei der 10. Nationalen Maritimen Konferenz am 4. April 2017 in Hamburg*, https://www.bundesregierung.de/breg-de/aktuelles/rede-von-bundeskanzlerin-merkel-bei-der-10-nationalen-maritimen-konferenz-am-4-april-2017-in-hamburg-485752.

[16] "Marine schießt RBS15 gegen Landziel", in *Flugrevue*, 3 June 2022, https://www.flugrevue.de/erster-test-in-norwegen-marine-schiesst-rbs15-gegen-landziel.

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6. Italy

by Elio Calcagno and Alessandro Marrone

6.1 A focus on the wider Mediterranean and on warfighting capabilities

The Italian economy is heavily reliant on imports and exports, much of which are carried by sea. Its geographical position at the centre of the Mediterranean Sea, itself a crucial hub for maritime trade and the blue economy, means that Italy has a marked interest in goods transiting safely through the global commons. Much of Italy's energy supplies come through or from the Mediterranean, which is also an area of instability, illicit trafficking, tensions and conflicts.

Against this backdrop, the Italian Navy (*Marina Militare* – MM) is a vital tool for Rome to safeguard and promote its interests.[1] In geographic terms, the Italian armed forces' principal operational focus is centred around the "wider Mediterranean" (*Mediterraneo allargato*) as a geopolitical macro-region of primary strategic importance for national interests. This area spans from the Gulf of Guinea all the way through the Mediterranean to the Red Sea, the Persian Gulf and the Gulf of Aden, including not only the Med littoral regions, but the whole Middle East and North Africa (MENA), the Sahel and the Horn of Africa.[2] According to the Italian Navy's strategic guidelines, the combination of Italy's geographical position, its strong manufacturing sector and an economy dependent on sea-borne imports and exports makes it crucial for Rome to affirm and defend its interests across the seas and along the world's main SLOCs.[3] Considering the climate change impact on SLOC, Artic region is set to gain growing attention by Italy too.

The wider Mediterranean is now stage to a multitude of destabilising factors, including international maritime disputes[4] as well as unsettled crises and economic stagnation in the MENA region.[5] At a time when the US Navy will increase its presence in the Pacific, Italy needs to play a more prominent role in safeguarding and fostering stability in a volatile wider Mediterranean region, also as part of NATO and the European Union.[6] In this context, the MM identifies Italy's interests

[1] On Italy and the security of the Mediterranean region see, among others, Alessandro Marrone and Michele Nones (eds), *Italy and Security in the Mediterranean*, Rome, Nuova Cultura, 2016, https://www.iai.it/en/node/6851.

[2] Italian Ministry of Defence, *Strategia di sicurezza e difesa per il Mediterraneo. Edizione 2022*, 2022, https://www.difesa.it/Il_Ministro/Documents/Strategia%20Mediterraneo%202022.pdf.

[3] Italian Navy, *Marina Militare - Linee di indirizzo strategico 2019-2034*, Rome, Rivista Marittima, 2019, p. 7, https://www.marina.difesa.it/media-cultura/editoria/marivista/Documents/supplementi/Linee_indirizzo_strategico_2019_2034.pdf.

[4] Galip Dalay, "Turkey, Europe, and the Eastern Mediterranean: Charting a Way Out of the Current Deadlock", in *Brookings Policy Briefings*, January 2021, https://www.brookings.edu/?p=1388353.

[5] Tarik M. Yousef et al., "The Middle East and North Africa over the Next Decade: Key Challenges and Policy Options", in *Brookings Op-eds*, 3 March 2020, https://www.brookings.edu/?p=724684.

[6] Ronald O'Rourke, "China Naval Modernization", cit.

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as spanning the entire globe and thus works to maintain a balanced and flexible navy able to deliver effects in brown, green and blue water scenarios.

Since the end of the Cold War, the MM has put increasing emphasis on an expeditionary-oriented fleet as a way to project force across the wider Mediterranean, protect SLOC, but also as a particular useful capability for a country making significant contributions to crisis management, counter-terrorism,[7] and stability operations across the world.[8] Prolonged maritime security and constabulary operations against non-state actors like pirates in the Gulf of Aden and smugglers in the Mediterranean Sea are prominent examples in this regard.

The war in Ukraine and broader geopolitical confrontation between the West and systemic rivals such as Russia and China, combined with increased threat levels in the Mediterranean, have prompted the Italian Navy and the MoD to focus more on naval warfighting capabilities fit for collective defence in the Euro-Atlantic area as well as to keep global SLOC open and safe in case of tensions with peer-competitors. Indeed, the MoD's latest Multi-year Programming Document (*Documento Programmatico Pluriennale* – DPP) for 2022–2024 dedicates a substantial funding stream toward the replenishment of ammunition for the navy (including missiles, torpedoes and naval gun shells) in order to bring stockpiles up to adequate levels in case of armed conflict.[9]

Nevertheless, despite recent developments, maritime security operations are likely to continue and will also require adequate, cost-effective capabilities. As a result, a certain degree of diversification and specialisation within the MM fleet is on the cards to maintain a balanced, evolving fleet. The combination of the return to a robust defence and deterrence posture, which requires full warfighting capabilities, with the continuing need to provide maritime security, drives a capabilities development that takes into account the full high-low end spectrum.

6.2 The planned fleet evolution

Drafted before the 2022 Russian invasion of Ukraine, the Navy's 2019-2034 Strategic Guidelines drew the minimum assets required at that time to fulfil the MM's mission, envisaging an overall balanced force structure, based on one aircraft carrier, four amphibious landing/assault units, four destroyers with sea-based ballistic missile

[7] For example, in 2001, the Garibaldi carrier strike group deployed in the Indian Ocean operated for months STOVL aircraft running ISR, targeting and strike operations in Afghanistan within the US-led operation Enduring Freedom, while in 2011 the Italian Navy provided a crucial contribution to NATO Operation Unified Protector in Libya. See in this regards Vincenzo Camporini et al., *The Role of Italian Fighter Aircraft in Crisis Management Operations: Trends and Needs*, Rome, Nuova Cultura, 2014, https://www.iai.it/en/node/2155.

[8] For an updated overview of Italian military deployments abroad, see Ottavia Credi and Alessandro Marrone, "Missioni internazionali dell'Italia: poche novità, molte conferme", in *AffarInternazionali*, 4 August 2021, https://www.affarinternazionali.it/archivio-affarinternazionali/?p=89016.

[9] Italian Ministry of Defence, *Documento programmatico pluriennale della Difesa per il triennio 2022-2024. Edizione 2022*, https://www.difesa.it/Il_Ministro/Documents/DPP_2022_2024.pdf.

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defence capability, ten frigates, eight conventional submarines, seven medium and eight light patrol vessels, twelve new generation minehunters, three logistic support ships and three hydro-oceanographic units.[10] At the time, the MM Strategic Guidelines also considered a potential growth of the Navy capabilities given that the envisaged force structure was explicitly defined not as an optimal outcome for the Navy, but as the bare minimum solution allowed by available resources in order to absolve the tasks placed upon the fleet. Such a potential growth should be addressed throughout the standing iteration of the gap analysis, the requirements definition and the descending strategic force planning process.

Currently, a reflection is under way within the Navy on a renewed capability development construct to take into account the Russia-Ukraine war and the related changes in the international security environment. Such a construct is likely to prioritise the aforementioned high-end capabilities, including cutting edge technologies and larger stockpiles of battle-decisive munitions for a more lethal and effective Navy.

The latest MM official documents continue to set as a minimum requirement the ability to generate a Maritime Task Force at Maritime Component Command level (two stars), which would include one Carrier Strike Group (CSG) and an Amphibious Task Group (ATG) able to project power from and on the sea.[11] Indeed, Italy is currently one of two Mediterranean states along with France in possession of an aircraft carrier.[12] Indeed, the *Cavour* makes the Italian navy the only navy in Europe and one of only three worldwide currently operating ship-launched, 5th generation, multi-role, Short Take-off and Vertical Landing (STOVL) combat aircraft as the F-35B (the other two being the UK's Royal navy and the US Navy and Marine Corps).[13]

In the next decade, the MM is set to continue a trend of increasing displacement and warfighting capacity[14] as new naval vessels replace older ones, especially (but not exclusively) in terms of destroyers, frigates, corvettes, logistics support ships (LSS), offshore patrol vessels and amphibious capabilities.[15] For instance, the *Bergamini*-class European Multi-Purpose Frigate (*Fregate Europee Multi-Missione/Frégates Européennes Multi-Missions* – FREMM) frigates have a full-load displacement of 6,700 tons and carry more armaments (including vertical launch systems – VLS) than the previous generations of *Maestrale*-class (3,040 tons at full load) and the

[10] Italian Navy, *Marina Militare - Linee di indirizzo strategico 2019-2034*, cit., p. 62.

[11] Ibid., p. 38.

[12] Spain's Juan Carlos vessel is a LHD and not a fully fledged carrier.

[13] Japan will soon join this small group of countries. See: Mike Yeo, "Japan's Converted Helicopter Ship to Host F-35B Flight Trials", in *Defense News*, 30 September 2021, https://www.defensenews.com/global/asia-pacific/2021/09/30/japans-converted-helicopter-ship-to-host-f-35b-flight-trials.

[14] On the increasing size and complexity of modern naval vessels see chapter 1 of this study.

[15] Interview, 4 November 2022.

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Lupo-class (2,500 tons at full load).[16] Italian destroyers seem to be going down a similar path, as the next generation destroyers might reach 10,000 tons at full load versus the 7,050 of the *Horizon*-class destroyers currently in service.[17]

An increase in capabilities and lethality, as is now arguably under way for the MM, is all the more pressing following the Russia-Ukraine war, at a time when the Italian Navy is observing a growing Russian naval presence in the Mediterranean sea, together with an imminent underwater threat, amid heightened tensions.[18] The Chief of the Defence Staff, Admiral Cavo Dragone, has recently warned of the need to focus on the underwater threat posed by Moscow's navy in the Mediterranean and strengthen the Navy's capabilities accordingly.[19] The MM currently lacks a fixed-wing ASW patrol capability – one which is deemed to be necessary – beyond the P-72A, which was procured as an interim solution for maritime surveillance missions between the retirement of the purpose-built Breguet P-1150 and the procurement of a replacement. Moreover, the Chief of the Navy, Admiral Enrico Credendino, arguing in front of the Parliament's joint defence committee that the fleet also needs more ships specialised in air defence and ASW operations in order to sustain a proper force rotation.[20]

The MM's amphibious capabilities, for years based on the three aging *San Giorgio*-class amphibious transport dock (LPD), are undergoing a process of great renewal which will significantly boost Italy's amphibious operations potential. This process has started with the first of a new generation of amphibious assault ships/landing helicopter docks (LHD), the *Trieste*, which is expected to be delivered to the navy in 2023 as the largest warship ever built in Italy after World War Two.[21] The *Trieste* will not only serve as a platform to operate helicopters but also, when necessary, a complement of F-35B aircraft, making it one of the most versatile LHDs in the world and a huge upgrade from the *San Giorgio* class.[22] The *Trieste*'s procurement confirms the aforementioned trend of increasing size for individual hulls, with displacement ranging from 14,000 and 15,000 tons and a hull length of 165 metres

[16] Data from Seaforces: I*talian Navy - Marina Militare Italiana*, https://www.seaforces.org/marint/Italian-Navy/ships.htm.

[17] Ibid. and Tom Kington, "Italy Plans New Destroyers for 2028 Delivery", in *Defense News*, 9 November 2020, https://www.defensenews.com/global/europe/2020/11/09/italy-plans-new-destroyers-for-2028-delivery.

[18] "The Russian Threat in the Med: Italy's Chief of Defence Speaking", in *Decode39*, 22 August 2022, https://decode39.com/4036.

[19] "Missioni: l'audizione dell'ammiraglio Cavo Dragone alle commissioni Esteri e Difesa", in *Analisi Difesa*, 15 July 2022, https://www.analisidifesa.it/?p=155588.

[20] Italian Parliament, *Audizione del Capo di Stato Maggiore della Marina Militare*, 10 March 2022, http://documenti.camera.it/leg18/resoconti/commissioni/stenografici/html/04c04/audiz2/audizione/2022/03/10/indice_stenografico.0019.html.

[21] Italian Navy, *Iniziano le prove in mare per nave Trieste*, 17 August 2021, https://www.marina.difesa.it/media-cultura/Notiziario-online/Pagine/20210817_Fulge_super_mare_Risplende_sul_mare_la_nave_d_assalto_anfibio_multiruolo_trieste.aspx.

[22] Seaforces: *L 9890 ITS Trieste*, https://www.seaforces.org/marint/Italian-Navy/Amphibious-Ship/L-9890-ITS-Trieste.htm.

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compared to the *San Giorgio* class's ca. 7,700 tons and 133 metres.[23] The MM is also focusing on renewing its minehunter fleet, with the future vessels again larger than their predecessors and expected to be equipped with a wide array of unmanned systems (UxVs).[24]

In the context of fleet modernisation, Italy is the coordinator country for the EPC Permanent Structured Cooperation (PESCO) project, which is now in the development phase thanks to EDF financial support through the twin-project Modular Multirole Patrol Corvette. The MMPC is being carried out by a multi-national industrial consortium under the coordination of Naviris, a Fincantieri-Naval Group joint venture, and it is likely to involve naval combat systems from suppliers like Leonardo. The DPP foresees the acquisition of eight of these vessels to replace a fleet of aging offshore patrol vessels.[25] Once again, the EPC displacement is set to represent an increase over that of its predecessors.[26]

Broadly speaking, the trend to increase the displacement of several classes of ships is meant to satisfy the need to equip more and more advanced combat systems while also leaving room for upgrades and possible additions, as well as to undertake missions in the Wider Mediterranean well beyond green waters. As mentioned before, the MM is going to focus more on the high end of the operational spectrum in terms of naval-warfare capabilities in light of the changed international security environment, as epitomised by its investments on the combat systems to equip the modernised fleet, while maintaining the ability to perform low-end activities such as maritime security operations.

6.3 An overview of naval combat systems

The MMI is planning to acquire new combat systems that will change its potential for naval warfare and power projection substantially, starting from long range strike capabilities in the form of cruise missiles fitted onto frigates, destroyers and submarines.[27] The MBDA-made Teseo MK2/E, an evolution of the OTOMAT anti-ship missile, will be equipped on the next generation destroyers and the multi-role offshore patrol corvettes (*Pattugliatori Polivalenti d'Altura* – PPA), while it may replace OTOMAT missiles on the existing FREMM-class frigates and Horizon-class destroyers. This system represents a significant improvement over its predecessor

[23] Eugenio Po, "Dettagli sulle nuove LPD della MMI", in *Portale Difesa*, 24 May 2022, https://www.rid.it/shownews/4188, Seaforces: *San Giorgio – class Amphibious Transport Dock / LPD*, https://www.seaforces.org/marint/Italian-Navy/Amphibious-Ship/San-Giorgio-class.htm.

[24] "A Intermarine il contratto per il progetto dei cacciamine di nuova generazione", in *Analisi Difesa*, 16 February 2021, https://www.analisidifesa.it/?p=141257.

[25] Italian Ministry of Defence, *Documento programmatico pluriennale della Difesa per il triennio 2022-2024*, cit.

[26] Italian Ministry of Defence, *European Patrol Corvette, an International Project in the Naval Sector*, 25 October 2021, https://www.marina.difesa.it/EN/Conosciamoci/notizie/Pagine/20211021_European_Patrol_Corvette.aspx.

[27] Italian Navy, *Marina Militare - Linee di indirizzo strategico 2019-2034*, cit., p. 39.

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in that it can hit ships and land targets from a range in excess of 350 km, greatly enhancing the Italian Navy's capacity to strike deep into enemy territory.[28] Interestingly, the PPAs were designed with a modular approach, but currently the MM aims to have all PPA equipped with the full range of naval combat systems. Furthermore, the Navy aims to equip the fixed-wing air component with capable stand-off weapons and replace the helicopter-launched air-surface missile Marte MK/2S with an extended range version (up to 100 km) capable of engaging ships and shore targets. Such developments are a clear consequence of the changing threat level and the missions required of the service.

In recent years the MoD has planned that the four next generation destroyers and U212NFS submarines (the first of which be delivered in 2027) will be fitted with long-range deep strike cruise missiles – although it is not yet known which system the Navy will procure either MBDA's Scalp Naval or Raytheon's Tomahawk.[29] The Russia-Ukraine war has increased the importance and urgency of that capability. The U212NFS will also be equipped with Leonardo's Black Shark Advanced (BSA) heavyweight torpedoes, an evolution of the Black Shark, destined to gradually replace the older, Cold War-era A184 torpedoes.[30] The MM's ships and aircraft are also currently operating (or phasing in) Eurotorp's light weight ASW MU90 torpedoes.[31]

In late 2022 the MM has reached a total of 100 fixed- and rotary-wing aircraft in service, most of which modern (or being modernised) and very capable.[32] This capability will soon be enhanced by the procurement of embarked fixed- and rotary-wing UAVs that will specialise in ISR operations.[33] Through Leonardo's participation, along Airbus Helicopters and Fokker, in the NH Industries joint venture, the Italian DTIB is involved in the NH90 programme, with the Italian Navy acquiring 46 SH-90 that is the version fitted for naval and ASW warfare.[34] The Navy has also acquired 10 MH-90 helicopters, a tactical transport variant of the NH-90, to be used for tactical transport in amphibious operations and special forces operations. As part of the MM's modernisation process, the SH-90 will eventually replace the older fleet of Agusta AB-212 and will constitute the Navy's

[28] MBDA website: *TESEO MK2/E*, https://www.mbda-systems.com/product/teseo-mk2-e.

[29] Organisation for Joint Armament Co-operation (OCCAR) website: *U212 NFS*, http://www.occar.int/programmes/u212-nfs; Chiara Rossi, "Missili Cruise sulle Fremm, come si armerà la Difesa italiana", in *Startmag*, 27 September 2021, https://www.startmag.it/?p=162370.

[30] OCCAR website: *U212 NFS*, cit.

[31] Eurotorp is a European consortium formed by Italy's Leonardo and France's Naval Group and Thales. Naval Technology website: *EuroTorp. MU90 Advanced Lightweight Torpedo*, https://www.naval-technology.com/?p=1887.

[32] "Cento elicotteri in servizio con la Marina Militare", in *Ares Osservatorio Difesa*, 3 October 2022, https://aresdifesa.it/?p=34446.

[33] Italian Ministry of Defence, *Documento programmatico pluriennale della Difesa per il triennio 2022-2024*, cit., p. 49.

[34] "Consegnato alla Marina il primo elicottero MH-90", in *Analisi Difesa*, 24 January 2017, https://www.analisidifesa.it/?p=104791.

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helicopter-based anti-ship and ASW capacity along with Leonardo's AW101.[35] The Navy's EH101, first entering service in 2001, will soon start a mid-life update, followed by a software and capability upgrade of the NH-90 fleet, which will modernise the Navy's rotary-wing capability and bring these helicopters up to modern standards in terms of the onboard systems.[36] The Navy has also acquired ten MH-90 helicopters, a tactical transport variant of the NH-90, to be used for tactical transport in amphibious and special forces operations.[37] The acquisition of AW HERO rotary UAV is being discussed.[38]

When it comes to Navy fixed-wing aircraft, as mentioned before, Italy is one of the three countries worldwide operating F-35B from an aircraft carrier, a capability that grants the MM a high degree of interoperability with its NATO allies when it comes to carrier operations. As of November 2022, the MoD has authorised the procurement of a total of 30 F-35B STOVL aircraft, to be divided equally among the Navy and the Air Force. The Joint Chief of Staff, Admiral Cavo Dragone has recently stated that while this number is insufficient for the tasks assigned to the Armed Forces, it will be possible for the Navy and Air Force F-35Bs to operate jointly should the necessity arise.[39] Indeed, the two forces have already began carrying out joint exercises and simulations, including from the Cavour, involving these new multi-role aircraft.[40] Italian Navy and Air Force F-35Bs have also landed on the Royal Navy's HMS Queen Elizabeth, while two US Marine Corps F-35Bs embarked on the British carrier landed on the *Cavour*.[41]

Anti-air capabilities aboard MM ships are entrusted to a combination surface-to-air missile (SAM) systems – mainly the Aster 15 (short range) and 30 (medium range) – and naval guns, such as the OTO Melara 76/62 and OTO Melara 127/64 Light Weight deck-mounted guns.[42] The Navy has recently planned the acquisition of a first

[35] Leonardo, *AugustaWestland AW101*, March 2017, https://www.leonardo.com/documents/15646808/16756390/BROCHURE_AW101_Mk517.pdf.

[36] "Cento elicotteri in servizio con la Marina Militare", cit.; Italian Navy website: *Aviazione navale oggi*, https://www.marina.difesa.it/noi-siamo-la-marina/mezzi/forze-aeree/Pagine/aviazionenavaleoggi.aspx.

[37] Italian Navy, *Consegna del primo elicottero MH-90 al 5° Gruppo di Maristaeli Luni*, 24 January 2017, https://www.marina.difesa.it/media-cultura/press-room/comunicati/Pagine/2017_06.aspx; NHIndustries, *NHIndustries Completes Final Delivery of the Italian Navy NH90 MITT Tactical Transport Helicopter Fleet*, 17 September 2021, http://www.nhindustries.com/website/en/press/NHIndustries-completes-final-delivery-of-the-Italian-Navy-NH90-MITT-Tactical-Transport-Helicopter-fleet_173.html.

[38] Interview, 26 November 2022.

[39] "Verso l'integrazione degli F-35B di Marina e Aeronautica", in *Analisi Difesa*, 28 January 2022, https://www.analisidifesa.it/?p=150670.

[40] Marco Battaglia, "Dal cielo e dal mare. Così un F-35 dell'aeronautica su Nave Cavour fa la storia", in *Formiche*, 22 November 2021, https://formiche.net/?p=1434230; Giuseppe Di Feo, "F-35B: ad Alghero esercitazione congiunta dell'Aeronautica Militare e della Marina Militare con il sistema Air Landed Aircraft Refuelling Point", in *Aeronautica Militare*, 31 August 2022, https://www.aeronautica.difesa.it/?p=13129.

[41] Marco Battaglia, "Dal cielo e dal mare", cit.

[42] Seaforces: *Oto-Melara / Oto-Breda 76/62 Compact - 76/62 Super Rapid*, https://www.seaforces.

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batch of Driven Ammunition Reduced Time of flight (DART) guided ammunition for the OTO Melara 76/62, considered a more effective way for these 76 mm-calibre guns to engage manoeuvring missiles.[43]

The planned procurement of Leonardo's Vulcano 127 mm ammunition in its unguided Ballistic Extended Range (BER) and Guided Long Range (GLR) versions represents a leap forward in terms of precise artillery strikes for the Italian Navy. The GLR Vulcano especially will grant the MM unprecedented range and precision in fire support missions against ships or coastal targets.[44]

6.4 The Navy's vision on systems integration in naval combat

The "Defence Approach to Multi-domain Operations" released by the Joint Staff in 2022[45] outlines the Italian Armed Forces' approach in this regards in line with NATO doctrine.[46] This document describes the operational domains as "a single interconnected context" in which the careful coordination and modulation of efforts can help achieve greater results than would be possible assuming a single-domain approach.[47] To a certain extent, MDO operations are not entirely new for the navies like the Italian one, which operate capabilities on sea surface, airspace, underwater – even seabed – and on littoral regions, by relying on space and cyber enablers.[48]

From the Navy's perspective, the ongoing blurring of the domains' boundaries requires a new concept for naval combat, which was outlined in some detail already in 2021 with the release of the "Future Combat Naval System 2035 in Multi-domain Operations" (FCNS 2035) concept.[49]

The FCNS 2035 aims to provide a synthesis of the MM's vision regarding the future of the navy with a specific focus on the development and use of new technologies in naval combat. Among the priority capabilities that should be achieved by 2035 in order to remain relevant in the face of evolving threats and disruptive technologies,

org/wpnsys/SURFACE/Oto-Melara-76mm-compact-super-rapid.htm; and *OtoMelara 127/64 LW Gun*, https://www.seaforces.org/wpnsys/SURFACE/Oto-Melara-127mm-64caliber-gun.htm.

[43] Finmeccanica, *Finmeccanica Onboard of the Cavour Aircraft Carrier*, 2013, https://www.marina.difesa.it/cosa-facciamo/per-la-difesa-sicurezza/operazioni-in-corso/Documents/finmeccanica/Paper%20Finmeccanica%20ENG.pdf.

[44] Italian Ministry of Defence website, *"Vulcano" Ammunitions*, https://www.difesa.it/SGD-DNA/Staff/DT/NAVARM/Vulcano-EN/Pagine/default.aspx.

[45] Finmeccanica, *Finmeccanica Onboard of the Cavour Aircraft Carrier*, cit.

[46] Interview, 26 October 2022.

[47] Italian Defence General Staff, *Approccio della Difesa alle Operazioni Multidominio. Edizione 2022*, https://www.difesa.it/SMD_/Staff/Sottocapo/UGID/Documents/Concetto_Approccio_Difesa_alle_Operazioni_Multidominio_2022.pdf.

[48] Interview, 26 October 2022.

[49] Italian Navy, *Il Future Naval Combat System 2035 nelle operazioni multi-dominio. Edizione 2021*, https://www.marina.difesa.it/media-cultura/Notiziario-online/Documents/Il%20Future%20Combat%20Naval%20System%202035.pdf.

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the FCNS 2035 lists integrated air and missile defence (IAMD), a surveillance capability from sea level to 100 km of altitude and directed energy weapons.

Moreover, in the context of underwater operations, the Navy must be able to operate persistently with no depth limitations (also in the context of critical infrastructures protection) and field a fleet of autonomous vehicles. The 2022 sabotage of North Stream pipeline highlighted the necessity to protect seabed pipelines and cables relevant for Italy, particularly, but not only in the Mediterranean basin. To this end, surface ships, submarines and aircraft need to evolve into "strategic hubs" capable of generating critical mass and significant effects wherever required including by launching and recovering UxVs with a variety of payloads.[50] As the Mediterranean Sea is on average much deeper than the Baltic, developing adequate underwater capabilities will be particularly challenging.

This vision for future capabilities foresees necessarily a high degree of integration[51] among manned and unmanned assets, especially since the FCNS 2035 requires platforms to act as "in-theatre" operational headquarters and decision-making centres, thanks to data fusion capabilities, AI and the ability to manage data at the operational edge.[52]

Against this backdrop, Italy has already been leading a concerted effort – involving both the navy and the industry – aiming to reach higher levels of UxV integration in a multinational operational context, as was demonstrated through Italian leadership of the successful OCEAN2020 project, funded by the EU's Preparatory Action on Defence Research (PADR).[53] OCEAN2020 was the largest PADR project in terms of funding and was coordinated by Leonardo, who led a consortium of over 40 European partners, including industrial actors, navies and research centres, from fifteen EU countries. Its main aim was demonstrating enhanced situational awareness in a maritime environment through the operation and integration of a multitude of unmanned systems during two separate sea demonstrations in the Baltic and Mediterranean seas (the latter hosted in Taranto by the Italian Navy).[54]

At the same time, the Navy is still to procure the next generation of UxVs. Indeed, the FCNS 2035 identifies unmanned systems as a procurement priority for the navy.[55] At time of writing, the Italian Navy is already operating the HUGIN 1000/3000 and REMUS 100/300 autonomous UUVs, equipped with state of the art sensors. In terms future capabilities, given the outcome of the OCEAN2020

[50] Ibid.
[51] Ibid.
[52] For more details on the importance of system integration in naval operations, see chapter 1 of this study.
[53] For more on OCEAN2020, its achievements and Italy's role, see chapter 8 of this study.
[54] See OCEAN2020 website, https://ocean2020.eu.
[55] Italian Navy, *Il Future Naval Combat System 2035 nelle operazioni multi-dominio*, cit.

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sea demonstrations, the MM is currently considering a number of options,[56] such as Leonardo's versatile AWHERO rotary-wings UAS, which took part in the OCEAN2020 sea demonstrations and can carry out a wide array of tasks including Intelligence, Surveillance, Target Acquisition and Reconnaissance (ISTAR).[57]

Broadly speaking, the Italian Navy shows a marked interest in the development and use of more complex unmanned platforms in the maritime domain.[58] Indeed, the Navy sees UxVs as useful assets for specific tasks such as ISTAR, ASW, seabed warfare, mine warfare and logistics, which are set to improve and widen the fleet's performance also in naval combat through a MUM-T approach. Concurrently, investment is ongoing in the automation of a number of systems to improve naval combat capabilities as well as to reduce the workload for the operators, the number of personnel required on board, and thus the spaces and services needed for the crew in current and future vessels. The track record in this regard is encouraging: the *Ardito* class had a displacement of 5,000 tons and a crew of 400, while its successor, the *Doria* class has a displacement of 7,000 tons but is operated by only 200 sailors. Still, the human resource challenges persists, as operational tempo keeps increasing and Italian vessels are more often deployed for longer operations.

6.5 The Italian naval defence industry

Italy's DTIB is traditionally able to satisfy the Italian Navy's needs, thanks to the presence of larger defence industrial actors – Leonardo and Fincantieri – and companies specialised in the electronic warfare, space and missile sectors, as well as innovative small and medium-size enterprises (SMEs). The former is a leading industrial player globally in the defence field, with a total revenue of 14.1 billion euro and 83 per cent of its total sales being carried out in the defence sector.[59] In terms of naval combat systems, the company produces a wide array of relevant products, actually an almost complete one, which is peculiar of the Italian company. In particular, the electronics division focuses on advanced sensors (including radars such as Kronos, optronic and underwater ones), advanced communications, naval gun systems, guided and unguided ammunition, missile systems, torpedoes, and CMS.[60] Its products include deck-mounted cannons, such as the 76/62 Super Rapid, which is the most widely-used in its category with over 60 navies as customers.[61] Leonardo has invested in the development of a new generation of CMS focusing on integrating sensor and combat systems data into

[56] The ongoing procurement process of UaVs for operation aboard Navy ships was confirmed by the MoD's latest multi-year programming document for 2022-2024.

[57] Leonardo website: AWHERO, https://unmanned.leonardo.com/en/products/awhero.

[58] Interview,13 December 2022.

[59] Leonardo, *Integrated Annual Report 2021*, 10 March 2022, https://www.leonardo.com/documents/15646808/16736384/Integrated+annual+report+2021.pdf.

[60] Interview, 4 November 2022; Leonardo website: *Defence Systems*, https://electronics.leonardo.com/en/defense-systems.

[61] Ibid.; Luca Peruzzi, "Leonardo's 72/62 mm Super Rapido: The Full Spectrum Medium Artillery", in *European Defence Review*, 11 July 2020, https://www.edrmagazine.eu/?p=12749.

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an individual "naval cockpit" (*Postazione Integrata di Condotta Nave* – PICN).[62] This effort resulted in the SADOC MK.4 which is now currently equipped on the first Thaon di Revel class multipurpose offshore patrol ships commissioned by the MM.[63] The acquisition of a share of Hensoldt company is set to enhance Leonardo's competences on defence electronics. The company is also a market leader in terms of helicopters specialised in maritime operations with the aforementioned AW101 and the NH90 NFH. When it comes to MM fixed-wings assets, it participates as second-tier partner in the US-led consortium producing F-35B by managing among other things the final assembly and check out (FACO) facility in Cameri where Italian F-35 are assembled.[64]

Fincantieri Marine is among the world's largest shipbuilding groups, with warship-related shipbuilding operations extending also in the US with Fincantieri Marinette Marine. In 2021 the group had a revenue 1.42 billion euro in the defence sector. The company builds almost all of MM's vessels ranging from major surface combatants to submarines, mine-hunters and offshore patrol vessels. It is an important player at European-level in the naval defence sector, also thanks to cooperative projects such as U212, Horizon, FREMM and the EPC.[65] Through its US subsidiary, Fincantieri was awarded the Constellation programme for the US Navy's future guided-missile frigates – which might lead to the construction of a total of 20 units.[66] Furthermore, Seastema, a Fincantieri Group company, is also involved in the construction of the new class of Korean Navy frigates and the design of a new carrier.[67]

Numerous MM capabilities in the realm of electronic warfare and electronic support measures (ESM), some of which are compatible with, or specifically developed for, naval warfare applications, are developed by Elettronica.[68] These include the SEAL family of naval countermeasures, designed for multiple classes of ships. Moreover, the NETTUNO-4100 ECM System is designed to counter incoming missiles and long-range designation radar systems. Other systems developed by Elettronica include Loki, an EW 2C system also used in the naval domain, and the ALR-733 airborne family of ESM systems for maritime patrolling.

[62] Interview, 4 November 2022; Luca Peruzzi, "Italian Navy FoC Thaon di Revel PPA Joins EMASoH", in *Naval News*, 29 August 2022, https://www.navalnews.com/?p=36983.

[63] Ibid.

[64] On Italy participation in F35 see Vincenzo Camporini et al., *The Role of Italian Fighter Aircraft in Crisis Management Operations*, cit., p. 115-127.

[65] Fincantieri, *Annual Report 2021*, https://www.fincantieri.com/globalassets/investor-relations/bilanci-e-relazioni/2021/fincantieri-annual-report-eng-2021.pdf.

[66] Fincantieri, *Fincantieri to Build the Third Constellation-Class Frigate for the US Navy*, 17 June 2022, https://www.fincantieri.com/en/media/press-releases/2022/fincantieri-to-build-the-third-constellation-class-frigate-for-the-us-navy.

[67] Naida Hakirevic Prevljak, "Fincantieri, DSME Team Up on Design of Korea's New Aircraft Carriers", in *Naval Today*, 10 June 2021, https://www.navaltoday.com/?p=55132.

[68] Leonardo holds 33 per cent shares of Elettronica.

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In the space sector, which represents a crucial enabler for naval operations in terms of recognised maritime picture, communications and ISR, Thales Alenia Space, Telespazio and Avio[69] altogether cover both the upstream and downstream sectors and the whole space value chain. Among the programmes of particular relevance to the maritime domain is COSMO-SkyMed, a constellation of small radar observation satellites aimed particularly at the Mediterranean basin.[70]

Finally, MBDA is the European leader[71] in the design and production of missile systems, including the Teseo MK2/E, Marte MK/2S and ER and the ASTER 15 and 30.[72]

When it comes to SMEs, it is worth mentioning GEM, an Italian company specialising in small-size 3D radars for navigation and maritime and coastal surveillance, as well as electro-optical sensors and inertial systems.[73]

[69] Leonardo is a shareholding of Telespazio (67 per cent), Thales Alenia Space (33 per cent) and Avio (29,6 per cent).

[70] Italian Space Agency website: *COSMO-SkyMed*, https://www.asi.it/en/earth-science/cosmo-skymed.

[71] Leonardo holds 27 per cent of MBDA.

[72] MBDA website: *Maritime Superiority*, https://www.mbda-systems.com/solutions-and-services/#maritime_superiority.

[73] Leonardo recently acquired 30 per cent of GEM.

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7. United Kingdom

by Sidharth Kaushal

As it contemplates its role in the future operating environment, the Royal Navy contends with a series of interrelated shifts in the conduct of war at sea if it is to meet its aim of being Europe's premier naval contributor.[1] In the immediate to medium term, the Royal Navy will face two key challenges:

1. The proliferation of long-range precision strike capabilities that will threaten both the freedom of manoeuvre of vessels at sea and the safety of critical infrastructure on the land.
2. A re-emerging subsurface threat to both sea lines of communication and critical national infrastructure.

The navy will meet these challenges with a historically low number of surface vessels, a state of affairs that will continue until the 2030s.[2] To be sure, these are European challenges rather than being exclusive to the Royal Navy. However, if the UK wishes to meet its stated ambition of delivering Europe's premier naval power, then they are central to the Royal Navy's mission. Further afield, the Royal Navy will need to support the Indo-Pacific tilt which, though currently modest in its ambitions and resourcing, could become a more significant pillar of British national security policy driven by factors such as the UK's post Brexit accession to the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP), its engagement with strategic partnerships such as AUKUS and longer term considerations regarding the rise of China as a competitor.[3] If this does come to pass, the UK will operate in a region where the Peoples Liberation Army Navy (PLAN) has surpassed even the US in terms of numbers of hulls fielded and is backed by a formidable ground based missile arsenal.[4]

The Royal Navy's current vision for meeting the ambitions set for it by British policymakers hinges on leveraging flexibility and lethality to get more from a limited number of hulls. As stated by the First Sea Lord, the UK will not seek to match competitors "hull for hull" but will instead seek to build a lead in disruptive

[*] Sidharth Kaushal is Research Fellow for Seapower at the Royal United Services Institute (RUSI).

[1] UK Government, *Global Britain in a Competitive Age. The Integrated Review of Security, Defence, Development and Foreign Policy*, March 2021, https://www.gov.uk/government/publications/global-britain-in-a-competitive-age-the-integrated-review-of-security-defence-development-and-foreign-policy.

[2] UK Ministry of Defence, *Defence in a Competitive Age*, March 2021, https://www.gov.uk/government/publications/defence-in-a-competitive-age.

[3] Currently, the forces allocated to the tilt will be two Offshore Patrol Vessels and a Southern Littoral response group – a force geared more for presence than warfighting see Ibid., p. 31. On the UK's possible accession to the CPTPP see: UK Department for International Trade, *UK Accession to CPTPP: The UK's Strategic Approach*, June 2021, https://www.gov.uk/government/publications/uk-approach-to-joining-the-comprehensive-and-progressive-agreement-for-trans-pacific-partnership-cptpp.

[4] On the Chinese PLAN Navy's developments, see chapter 2 of this study.

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future technologies to offset competitors' quantitative advantages.[5] The realisation of this vision hinges on the following prerequisites:

- Increased modularity in naval combatants to enable mission flexibility and the rapid adoption of capabilities;
- An emphasis on the adoption of unmanned capabilities to make up for a lack of manned mass;
- A focus on long range strike to give the Royal Navy greater reach inland.

This is not dissimilar in certain regards to the visions outlined by the US Navy, albeit at a much smaller scale and with a greater requirement for offsetting the challenge of limited mass.[6]

7.1 The Adversary challenge

In the context of the priorities laid out by the integrated review, the Royal Navy will face two key challenges in the European theatre – upon which this section will focus as it is likely to receive priority over the Indo-Pacific in the immediate to medium term. The first challenge is Russia's anti-access area denial capability. Russia has invested in a range of capable air, sea and ground launched anti-ship missiles which effectively form a layered defence around Russian shores.[7] Secondly, the "Kalibrisation" of the Russian fleet – the incorporation of missiles such as the 3M-14 Kalibr on a range of assets including small vessels such as the *Buyan*-M Corvette means that these vessels can target critical military and civil infrastructure from bastions close to Russian shores. This challenge is compounded by the imminent fielding of hypersonic cruise missiles such as the 3M22 Zircon. Hypersonic missiles substantially reduce the reaction times for air and missile defence capabilities – which raises the risk to critical power projection assets such as aircraft carriers. The relative speed and manoeuvrability of these missiles makes executing traditional "shoot-look-shoot" air defence tactics against them very difficult as warning times are not sufficient to allow this. To be sure, Russia's challenges in areas such as high-tech manufacturing may limit the number of hypersonic missiles it can field, but these missiles will still raise the risk of operating near Russian bastions – allowing the vessels within them to target European critical infrastructure.

The third challenge the Royal Navy will face is a re-emerging subsurface threat from Russia's newest capabilities such as the *Yasen*-M-class submarine, which is smaller than its Soviet predecessors but comparable to western submarines in quietness. Beyond the traditional subsurface threat to naval formations and SLOCs, one might consider the impact of the special purpose submarines operated by Russia's main

[5] Neil Pooran, "First Sea Lord Plans for Navy with More Punch in Coming Years", in *Belfast Telegraph*, 11 February 2022, https://www.belfasttelegraph.co.uk/news/uk/first-sea-lord-plans-royal-navy-with-more-punch-in-coming-years-41338642.html.

[6] On the US Navy see: "U.S. Navy Growth Plan: Retire Unwanted Ships, Add 150 Uncrewed Vessels", in *The Maritime Executive*, 26 July 2022, https://maritime-executive.com/article/u-s-navy-growth-plan-retire-unwanted-ships-add-150-uncrewed-vessels.

[7] On Russian investments on A2/AD capabilities, see chapter 2 of this study.

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directorate of deep sea research (GUGI). The GUGI's submarines include special purpose submarines like the *Losharik* (currently in repair), a titanium hulled submarine built to dive to extreme depths.[8] The likely purpose of these submarines is to tamper with undersea cables upon which large swathes of western economies depend – which could represent both an asymmetrical sub-threshold riposte to economic sanctions and a means of wartime coercion.[9] The need to protect critical undersea infrastructure has driven the planned procurement of two multi-role surveillance vessels. The planned vessels are likely to have relatively light crews and will act as host platforms for UxVs equipped with a variety of sensors.[10] In wartime, the most viable answer to containing a subsurface challenge has, historically, been forward defence. While a reactive posture cedes the initiative to an opponent, a forward posture that imposes dilemmas on an opponent can limit their freedom of manoeuvre.[11] Manning forward positions in areas such as the Barents Sea, and taking the operational initiative in order to contain this threat will be critical. However, this places vessels and aircraft within reach of a variety of anti-access capabilities – making the capabilities needed to secure theatre entry all the more critical.

NATO navies including the Royal Navy face a paradox. On the one hand, Russian anti-access capabilities hold them at arm's length but on the other it is ever more critical that they be able to posture themselves forward in order to both enable joint activity and disable the maritime precision strike threat.

7.2 The Royal Navy's vision for future development

Literature on adaptation tends to subdivide the process into exploration and exploitation.[12] It would be reasonable to say that the Royal Navy is still focused on exploratory phase, and is setting the conditions for future evolution. The vision laid out for the Royal Navy under the aegis of the Defence Command Paper and in subsequent statements by key figures set several core objectives. First, the Royal Navy will emphasise modularity in shipbuilding as an offset to limited mass. The concept underpinning this is that of a protean force – capable of changing its form and function at short notice.[13] Hull designs such as the Type 31 frigate were

[8] H.I. Sutton, *Russia's New Super Submarine Belogorod (K-329)*, 29 June 2021, http://www.hisutton.com/Belgorod-Class-Submarine.html.

[9] Garrett Hinck, "Evaluating the Russian Threat to Undersea Cables", in *Lawfare*, 5 March 2018, https://www.lawfareblog.com/node/14703.

[10] Fatima Bahtić, "UK Sets Sights on Two Survey Ships to Counter Undersea Threats", in *Naval Today*, 6 October 2022, https://www.navaltoday.com/?p=62238.

[11] An example of this principle in action might be the Reagan Administrations naval strategy of the 1980s, see: John B. Hattendorf and Peter M. Swartz (eds), "U.S. Naval Strategy in the 1980s. Selected Documents", in *Naval War College Newport Papers*, No. 33 (2008), https://apps.dtic.mil/sti/citations/ADA522552.

[12] Henrich B. Greve, "Exploration and Exploitation in Product Innovation", in *Industrial and Corporate Change*, Vol. 16, No. 5 (October 2007), p. 945-975, DOI 10.1093/icc/dtm013.

[13] Speech by Rear Admiral James Parkin at the RUSI Sea Power Conference 2022, London, 5 April 2022.

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selected based on this principle. This is also true of the Type 32 frigate, which was announced in the Defence Command Paper. The purpose of these vessels will be to allow mission modules to be swapped to allow a limited surface fleet to perform multiple functions.

There is also a second core function entailed in this design principle – the rapid integration of unmanned capabilities. Vessels such as the Type 32 are expected to be interoperable with and capable of hosting, launching and recovering unmanned assets.[14] This will be critical to delivering the vision of a distributed force capable of operating within hostile anti access bubbles with sufficient mass. Unmanned assets are also envisioned as adding both mass and additional sensors in the subsurface domain, and the potential of distributed networks of sensors on capabilities such as gliders has been noted.[15] Currently, the Royal Navy is experimenting with the MANTA – a 2.4 million pound project to deliver an extra-large unmanned underwater vehicle which will be capable of deploying a range of payloads including, potentially, smaller UUVs and mines.[16] This will be vital given that the navy's manned SSN fleet is unlikely to grow in numbers. High fidelity networks of undersea sensors are viewed as a potential offset to increasingly quiet adversary submarines – and long endurance unmanned capabilities will be a critical component of these networks.[17] The third component of the Royal Navy's vision for delivering future lethality is greater range and speed. The current first sea lord has signposted his ambition to integrate hypersonics on the Royal Navy and the UK is currently pursuing avenues for the collaborative development of these capabilities through the AUKUS partnership.[18] Hypersonics require large launch platforms and could, in principle, be held either on the navy's planned future destroyer the Type 83 or on its future submarine, the SSN(R).

Presently, however, the navy has not committed to immediately fielding systems to deliver lethality and survivability. Regarding lethality against surface vessels, the Royal Navy will pursue the Norwegian Naval Strike Missile (NSM) as an interim solution, while focusing its longer-term efforts on delivering its Future Cruise/Anti-Ship Weapon – an Anglo-French project to which 95 million pounds

[14] Xavier Vavasseur, "Royal Navy Type 32 to Serve as Unmanned Systems Mothership", in *Naval News*, 30 November 2020, https://www.navalnews.com/?p=18096.

[15] Speech by Commander Justin Codd at the RUSI Sea Power Conference 2022, London, 5 April 2022.

[16] "Progress Report: Manta – The Royal Navy's Experimental Autonomous Submarine", in *Navy Lookout*, 1 October 2021, https://www.navylookout.com/progress-report-manta-the-royal-navys-experimental-autonomous-submarine.

[17] This appears to be an alliance wide consensus in NATO as noted by Admiral Rob Bauer at the RUSI Sea Power Conference 2022.

[18] "UK, U.S. Australia Agree to Work on Hypersonics", in *Reuters*, 6 April 2022, https://www.reuters.com/world/uk-us-australia-agree-work-hypersonics-under-defence-pact-2022-04-05; George Allison, "Royal Navy Aiming to Become a Global Leader in Hypersonic Weapon", in *UK Defence Journal*, 12 February 2022, https://ukdefencejournal.org.uk/?p=38887; Navylookout, "Manta - The Royal Navy Gets Its First Autonomous Submarine", in *Navy Lookout*, 31 March 2020, https://www.navylookout.com/manta-the-royal-navy-gets-its-first-extra-large-autonomous-submarine.

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has been committed.[19] The project will likely see delivery in the 2030s. Though pursuing experimentation with and adoption of autonomous capabilities through its NavyX accelerator, the procurement of unmanned capabilities at scale has not yet occurred. This may reflect a desire to procure mature capabilities to meet the goal of distributed operations while preparing platforms capable of hosting them. The first iteration of the Royal Navy's adoption of unmanned capabilities may serve a more modest aim – freeing up personnel from labour intensive tasks rather than ISR or combat functions. Indeed, the navy's first commitment to an unmanned capability has been to replace its mine countermeasures vessels with an unmanned capability.[20] Beyond this, experimentation with the use of unmanned VTOL systems such as Leonardo's Proteus – a project funded at up to 60 million pounds by the Defence Autonomy and Security Accelerator (DASA) – can support a number of ISR functions, including ASW at reach.[21]

Future unmanned capabilities – particularly VTOL UAS – will likely play an important role in both ASW operations and concepts for littoral manoeuvre. They will be part of a capability currently built around the Merlin MK 2/2a in the ASW role and the Mk 4/4a and the Wildcat, held under Commando Helicopter Forces (CHF) supporting littoral manoeuvre. The former was delivered as part of the Merlin Life Extension programme, adapting the Merlin MK3 for a maritime role with features such as new avionics and a folding rotor. The out-of-service date for the Merlin has been extended to 2040 from 2030 – meaning that the Royal Navy will largely be relying on legacy assets for the manned component of vertical lift.[22]

The Royal Navy is also engaged in efforts to deliver survivability for large platforms in contested environments. The Royal Navy will upgrade its Type 45 to enable it to conduct ballistic missile defence interceptions – largely as a response to the anti-ship ballistic missile threat. The Aster 30 Block 1NT will be the BMD solution pursued.[23] The Royal Navy is also testing the Dragonfire directed energy system, a 50 kw directed energy weapon that can play a role in defending vessels against both missiles and UAS.[24] The UK Ministry of Defence (MoD) plans to spend up to 130 million on the programme.[25] Beyond this, the Royal Navy is invested in

[19] UK Ministry of Defence, *Royal Navy Ships to Be Fitted with Advanced New Missile System*, 23 November 2022, https://www.gov.uk/government/news/royal-navy-ships-to-be-fitted-with-advanced-new-missile-system; Tom Dunlop, "Future Cruise/Anti–Ship Missile Project Moves Forward", in *UK Defence Journal*, 17 February 2022, https://ukdefencejournal.org.uk/?p=38961.

[20] UK Ministry of Defence, *Defence in a Competitive Age*, cit., p. 47.

[21] Tony Osborne, "Leonardo Helicopters to Deliver Rotary Wing UAS in the UK", in *Aviation Week*, 21 July 2022, https://aviationweek.com/node/4421351.

[22] Dominic Perry, "UK Extends Merlin Operations until 2040", in *Flight Global*, 11 June 2021, https://www.flightglobal.com/144123.article.

[23] "Royal Navy to Be the First European Force to Field Maritime Ballistic Missile Defence Capability", in *Navy Lookout*, 24 May 2022, https://www.navylookout.com/royal-navy-to-be-the-first-european-force-to-field-maritime-ballistic-missile-defence-capability.

[24] Joe Saballa, "UK Inching Closer to Deploying First 50-Kilowatt Laser Weapon", in *The Defense Post*, 11 November 2022, https://www.thedefensepost.com/?p=45733.

[25] Optics, *UK Armed Forces to Trial Laser Weapon from 2023*, 16 September 2021, https://optics.org/

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enhancing the ability of systems, including human operators, to respond to fast moving threats. An example of this investment is the AI-enabled Startle system, trialled on the Type 23 frigate during operation Formidable Shield, which is geared towards reducing the operator burden in air defence.[26]

In the littoral space, the Royal Marines will likely become a force geared towards raiding functions. Critical to this is the ability to leverage tactical fires such as loitering munitions, as well as connectors to enable insertion at reach. The planned future commando force will be sustained by Multi-Role Support Ships, a multifunctional capability intended to support both sustainment at sea and tasks such as maritime insertion and C2. This will form the backbone of the UK's planned littoral strike groups. The concept of employment would see commandos used to disrupt anti-access bubbles to open the way for operations by a force with more mass such as an American marine expeditionary unit (MEU).[27] Its guiding principle is that, despite declining mass, the commando force can play a critical raiding function by operating as a distributed force within the A2/AD bubble that is present in the early stages of a conflict and can disrupt the points of failure upon which adversary's system of systems depends.

7.3 Conclusions – The early steps towards transition

The Royal Navy as envisioned will be a force capable of adding niche capabilities to an allied coalition. Though not equipped with the manned mass of previous eras, it looks to increase its lethality through a vision that leverages things such as prompt strike, distributed operations and raiding to assure access. It will also attempt to offset its mass through an approach to distributed lethality not unlike that of the US Navy. This vision would entail a heavy emphasis on augmenting manned platforms with large numbers on unmanned capabilities, and being a navy capable of providing specific niche capabilities such as contested theatre entry in littoral spaces, maritime BMD and prompt strike.

Unlike the US Navy, which has now committed to purchasing specific numbers of unmanned capabilities and signposted legacy assets for retirement, the Royal Navy cannot immediately commit to procurement.[28] Currently, its primary emphasis is on setting the conditions for this transition through experimentation, the generation of flexible future capabilities and the creation of an information architecture capable of supporting a distributed force. While this is reasonable given the disutility of adopting technology before the conditions to employ it are set, the key challenge for the navy will be to ensure that it does not delay critical procurement of capabilities at scale too long. As the conflict in Ukraine

news/12/9/26.

[26] UK Ministry of Defence, *Artificial Intelligence Used at Sea for the First Time*, 29 May 2021, https://www.gov.uk/government/news/artificial-intelligence-used-at-sea-for-first-time.

[27] Speech by Brigadier Tony Turner at the RUSI Sea Power Conference 2021, 25 February 2021.

[28] On the US see: "U.S. Navy Growth Plan: Retire Unwanted Ships, Add 150 Uncrewed Vessels", cit.

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has shown, high intensity warfighting involves the mass expenditure of resources – with the two sides already having expended more of certain capabilities than western nations possess in their stockpiles. Building stockpiles of key capabilities, whether on ground or at sea will, then, require time – meaning that the necessary exploration phase of evolution cannot go on for too long.

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8. Relevant EU initiatives

by Ottavia Credi*

8.1 What the naval domain means for the EU

The European Union continues to be the world's first exporter and second largest importer, with maritime routes being critical for its imports and exports. Indeed, the great majority (90 per cent) of EU external freight trade is seaborne, while 833 million tons of goods were handled in the EU's main ports in the first quarter of 2022 alone.[1]

At the same time, the return of great power competition and the confrontation sought by Russia deeply affect the naval domain. With a renewed focus on high intensity and peer-level competition, the Union can play an important role in encouraging cooperation among its member states as they plan to develop and procure state-of-the-art combat systems in the naval domain, including through the financial incentives provided by EU defence initiatives.[2]

The EU considers maritime security as key for its fundamental interests. Indeed, the Strategic Compass names the naval domain among the priority sectors in which member states intend to invest in order to develop new and enhanced capabilities and innovative technologies, so as to fill existing gaps and reduce dependencies from non-EU countries.[3]

The Union is determined to achieve a complete set of capabilities to operate at sea, with full freedom of manoeuvre and the ability to project power and support stability whilst protecting its forces in the maritime domain.[4] In order to do so, the EU prioritises the achievement of interoperable capabilities able to guarantee superiority at sea and underwater. As a testament to this, the European Defence Agency (EDA)'s Capability Development Priorities (CDP) include the categories of naval manoeuvrability and underwater control.[5]

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[1] European Commission website: *Maritime Transport*, https://europa.eu/!P7gTRt; *International Cooperation and Coordination*, https://europa.eu/!9BRdhK; *Maritime*, https://europa.eu/!qfN7Hq; and Eurostat, *Maritime Transport of Goods - Quarterly Data*, October 2022, https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Maritime_transport_of_goods_-_quarterly_data.

[2] Elio Calcagno, Ana E. Juncos and Sophie Vanhoonacker, "Naval Defence Cooperation in the EU: Potential and Hurdles", in *IAI Papers*, No. 22|31 (December 2022), https://www.iai.it/en/node/16335.

[3] Council of the European Union, *A Strategic Compass for Security and Defence*, 21 March 2022, p. 12, https://www.eeas.europa.eu/node/410976.

[4] European Defence Agency (EDA), *The EU Capability Development Priorities*, 2018, p. 13, https://eda.europa.eu/docs/default-source/eda-publications/eda-brochure-cdp.

[5] Ibid.

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8.2 Trends in EU activities in the maritime domain

The EU adopted its first Maritime Security Strategy (and the related Action Plan) in 2014. According to the Strategy, which is currently being updated, progress in the field of surveillance and information-sharing will be instrumental to improve the Union's maritime security awareness, which the EDA's CDP document describes as a key factor for naval warfare and manoeuvrability.[6]

The EU is an active actor in the maritime domain and, throughout the years, it participated in a number of naval operations. A prime example is offered by the EU Naval Force Somalia – Operation ATALANTA, aimed at improving peace and stability in Somalia and the Horn of Africa whilst enhancing the security of the region, also by ensuring the protection of vulnerable vessels within the area of operations. Another relevant EU maritime operation was the European Union Naval Force Mediterranean, better known as Operation Sophia,[7] whose goal was countering human trafficking and smuggling in the Mediterranean Sea. The operation concluded in 2020 and was succeeded by EUNAVFOR MED IRINI.[8]

Beyond EU missions, the European Coordinated Maritime Presences (CMP) tool has been endorsed by the Strategic Compass as a flexible way for willing and able member states to share maritime awareness, analysis and information resulting from national deployments in maritime areas of interest for the EU.[9] Relevant examples include the Gulf of Guinea and in the Western Indian Ocean, where the CMP helps to provide a bridge between Operation Atalanta and European Maritime Awareness – Strait of Hormuz (EMASOH), a national initiative currently under Italian command.[10]

EU maritime activities have a strong focus on situational awareness at sea. This was also the main objective of OCEAN2020 – see paragraph below – which worked on the integration unmanned and autonomous systems also to build a common recognised maritime picture for enhanced maritime situational awareness.[11] On the other hand, the EU is less active when it comes to naval combat. In order to advance its capabilities in these fields, the Union is carrying out projects implemented within different frameworks which will be further discussed in the

[6] Council of the European Union, *A Strategic Compass for Security and Defence*, cit., p. 40; European Commission website: *Maritime Security Strategy*, https://europa.eu/!7kcw9B; EDA, *The EU Capability Development Priorities*, cit.

[7] For further information, see the official website: https://www.operationsophia.eu.

[8] For further information, see the official websit: https://eunavfor.eu.

[9] European External Action Service (EEAS), *Coordinated Maritime Presences*, 3 December 2021, https://www.eeas.europa.eu/node/410805.

[10] EEAS, *Factsheet: Coordinated Maritime Presences*, March 2022, https://www.eeas.europa.eu/node/91927.

[11] Participating countries/organisations: Belgium, Denmark, Estonia, Finland, France, Germany, Italy (coordinator), Lithuania, NATO, Poland, Portugal, Spain, Sweden, The Netherlands, United Kingdom.

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next paragraphs.

8.3 Relevant EU projects

8.3.1 PESCO

The fast-paced advancement of sea mines, combined with their unceasing proliferation, represents a potential threat to EU maritime operations.[12] Such risk is aggravated by the potential employment of sea mines by non-state actors. Meanwhile, attacks by submarines represent another growing threat. Maritime Mine Counter Measures (MMCM) and ASW systems are deemed crucial to enable EU navies and operations to exert appropriate underwater control, contributing to their resilience at sea.[13] To this end, the Union is engaged in several projects to develop and deliver a range of detective, defensive and response systems to be employed at sea or underwater.

Through the framework of PESCO, some EU member states are conducting activities aimed at countering these and other types of threats. Firstly, the Maritime (semi-) Autonomous Systems for Mine Countermeasures (MAS MCM) project is geared towards improving the EU's maritime security by providing its member states with a differentiated set of (semi-) autonomous underwater, surface and aerial technologies able to counter sea mines.[14]

Secondly, the Maritime Unmanned Anti-Submarine System (MUSAS) project intends to create a state-of-the-art C3 service architecture for anti-submarine warfare, allowing EU member states to counter adversary area denial operations.[15]

Project Medium size Semi-Autonomous Surface Vehicle (M-SASV) aims to develop of a medium-sized vehicle with multiple mission modules. Being semi-autonomous, the vehicle intends to allow unmanned operations, whilst ensuring the possibility to resort to manned control when needed.

Confirming its prominent role in the PESCO framework, Italy is currently leading Project Harbour & Maritime Surveillance and Protection (HARMSPRO), working to deliver a new maritime capability which will enable EU member states to ensure appropriate surveillance and protection of maritime traffic and structures, also

[12] EDA website: *CapTech Maritime*, https://eda.europa.eu/what-we-do/all-activities/activities-search/captech-maritime.

[13] EDA, *The EU Capability Development Priorities*, cit., p. 14.

[14] PESCO website: *Maritime (semi-) Autonomous Systems for Mine Countermeasures*, https://www.pesco.europa.eu/project/maritime-semi-autonomous-systems-for-mine-countermeasures. Participating countries: Belgium (coordinator), France, Greece, Ireland, Latvia, The Netherlands, Poland, Portugal, Romania.

[15] PESCO website: *Maritime Unmanned Anti-Submarine System*, https://www.pesco.europa.eu/project/maritime-unmanned-anti-submarine-system-musas. Participating countries: France, Portugal (coordinator), Spain, Sweden.

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through an enhanced C2 function.[16] Rome is also participating in Project Essential Elements of European Escort (4E), whose goal is developing a comprehensive system for surface combat combining combat system, communication and information system, navigation system, platform management system and integration of system of systems.[17]

Last but not least, one of the most important PESCO projects is the European Patrol Corvette which involves Italy, France, Spain and Greece under Italian leadership.[18] In the context of PESCO, the participating countries worked together to define common requirements for this new vessel, initially agreeing on two versions. A long-range patrol version for France and Spain, and a shorter-range version preferred by Greece and Italy, focused more on combat missions.[19]

8.3.2 EDF

The EU is working to boost the joint development of new defence systems and capabilities also through the calls for action financed by the European Defence Fund, including in the maritime domains. The Fund launched its first round of calls in 2021, and awarded 61 winning projects the following year. Among the 924 million euro the EDF will invest for the year 2022, 130 million will be directed towards the naval combat sector, while 55 million will be dedicated to underwater warfare.[20] Among these projects, the Modular Multirole Patrol Corvette is one of the most important testing grounds for the viability of effective cooperation in this field.[21] The project is an offshoot of the EPC. The EDF project is coordinated by Naviris, a Fincantieri-Naval Group joint venture and involves a consortium of over 40 companies. The aim is to design a modern, modular, and multirole vessel able of fulfil a wide range of missions in future contexts of operations, from combat to long-range patrol and constabulary activities.

Being the first naval system developed after the beginning of the war to Ukraine, the MMPC could present some innovative characteristics, including in terms of combat systems integration. The project is based on a modular approach to ship design which should favour integration among systems from different companies

[16] PESCO website: *Harbour & Maritime Surveillance and Protection*, https://www.pesco.europa.eu/project/harbour-and-maritime-surveillance-and-protection. Participating countries: Greece, Italy (coordinator), Poland, Portugal.

[17] PESCO website: *Essential Elements of European Escort*, https://www.pesco.europa.eu/project/essential-elements-of-european-escort-4e. Participating countries: Italy, Portugal, Spain (coordinator).

[18] PESCO website: *European Patrol Corvette*, https://www.pesco.europa.eu/project/european-patrol-corvette-epc. Participating countries: France, Greece, Italy (coordinator), Spain.

[19] Elio Calcagno, Ana E. Juncos and Sophie Vanhoonacker, "Naval Defence Cooperation in the EU", cit.

[20] European Commission, *EDF Calls for Proposals 2022*, 25 May 2022, https://europa.eu/!b8Qnpf.

[21] For the full list of consortium partners, see European Commission, *EPC. Selected Projects European Defence Fund (EDF) 2021*, 22 July 2022, https://defence-industry-space.ec.europa.eu/system/files/2022-07/Factsheet_EDF21_EPC.pdf.

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and countries. Indeed, while this endeavour is certainly a great opportunity for cooperating in fitting the future vessels with common combat systems, its success will ultimately be measured by its ability to achieve a high level of commonality between navigation and combat systems among the national variants.[22] Certain solutions such as missile systems are more likely to be shared thanks to MBDA's position in a largely-consolidated European market. Others, relating for instance to radar and sensors, where multiple of the participating nations (France and Italy *in primis*) boast national industrial champions, will require an approach to cooperation not seen in this field since the Italo-French Horizon destroyers programme.[23] The successful implementation of the project would also entail positive developments in standard harmonisation, thus enhanced interoperability in the field.

Italy's Leonardo and Fincantieri joined forces with other European actors, including academia (e.g., the University of Genoa), to develop a European digital ship reference architecture through Project European Digital Naval Foundation.[24] To this end, consortium partners will work to integrate a joint naval operational cloud into the wider multi-domain operational cloud, ultimately creating the next generation smart vessels.

Some of the EDF projects awarded in 2022 are closely related to the development of UxVs for the naval domain. The Sea/Air Interphasic Wing-in-Ground Effect Autonomous Drones (SEAWINGS) project, for instance, aims at developing a new class of military drones for surveillance purposes.[25] Such drones will constitute a novelty, namely vehicles able to fly above sea surface using ground effect action.[26] They will be able to operate both in the sea and air domain, carry high payloads, and travel long distances. A different project – the Hydrogen Battlefield Reconnaissance and Intelligence Drone (HYBRID) project – aims at developing a Vertical Take-off and Landing unmanned system to be operated in a wide variety of environments and against multiple types of threats.[27]

One of the calls in which the EDF intends to invest aims at studying, designing, prototyping and testing a new medium-size semi-autonomous surface vessel

[22] Elio Calcagno, Ana E. Juncos and Sophie Vanhoonacker, "Naval Defence Cooperation in the EU", cit.

[23] Ibid.

[24] Project leader: Navantia (Spain). For the full list of consortium partners, see European Commission, *EDINAF. Selected Projects EDF 2021*, 22 July 2022, https://defence-industry-space.ec.europa.eu/system/files/2022-07/Factsheet_EDF21_EDINAF.pdf.

[25] Project leader: La Palma Research Centre (Spain). For the full list of consortium partners, see European Commission, *SEAWINGS. Selected Projects EDF 2021*, 16 September 2022, https://defence-industry-space.ec.europa.eu/system/files/2022-09/Factsheet_EDF21_SEAWINGS.pdf.

[26] International Maritime Organization (IMO) website: *Wing-in-Ground (WIG) Craft*, https://www.imo.org/en/OurWork/Safety/Pages/WIG.aspx.

[27] Project leader: Delair (France). For the full list of consortium partners, see European Commission, *HYBRID. Selected Projects EDF 2021*, 22 July 2022, https://defence-industry-space.ec.europa.eu/system/files/2022-07/Factsheet_EDF21_HYBRID.pdf.

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able to host different mission modules.[28] Such modules, which could be operated remotely, would cover ASW, Naval Mine Warfare (NMW), and ASuW capabilities.

8.3.3 The EDF's precursor programmes

Before the inauguration of the EDF, its precursor programmes – namely, the Preparatory Action on Defence Research and the European Defence Industrial Development Programme (EDIDP) – also launched relevant activities in the naval domain.

The aforementioned OCEAN2020 was among the largest projects financed by the PADR: completed in 2021, it brought together over forty partners coordinated by Leonardo. OCEAN2020 succeeded in its goal to integrate different systems – ranging from surface vehicles, to helicopters, to underwater systems – to obtain a common maritime architectural vision. This was achieved through efficient MUM-T and the effective integration of data from different types of systems, also through two sea demonstration in the Mediterranean and Baltic Seas. Besides representing a fruitful example of industrial cooperation among European partners, OCEAN2020 demonstrated the importance of maritime surveillance – not only to integrate separate systems, but also to elaborate concept of operations (CONOPS), communication protocols, and data sharing tools.

Still within the PADR framework, a consortium of four member states worked on a feasibility study on the use of the Electromagnetic Railguns (EMRGs) as long-range artillery systems, in the context of the Projectiles for Increased Long-range effects Using electroMagnetic railgun (PILUM) project.[29] The project also investigates the possibility of integrating the EMRGs into naval platforms.

With respect to the EDIDP, the Mine Risk Clearance for Europe (MIRACLE) project is working to contribute to the improvement of European Mine Countermeasures (MCM) missions through the enhancement of the main components of stand-off mine warfare.[30]

On the underwater warfare front, Project antiSubmarine warfare European Autonomous Networked Innovative and Collaborative Environment (SEANICE) aims to develop the next-generation anti-submarine warfare system based on the teaming of manned and unmanned platforms.[31] By resorting to advanced, state-

[28] European Commission Funding & Tenders Portal: *Medium-size Semi-Autonomous Surface Vessel*, https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/edf-2022-da-naval-msas.

[29] Project leader: Institut Franco-Allemand de Recherches de Saint Louis (France). For the full list of consortium partners, see: European Commission, *PILUM*, 21 June 2021, https://europa.eu/!mxmXb8.

[30] European Commission, *MIRICLE. Selected Projects EDIDP 2020*, 30 June 2021, https://europa.eu/!g7yt9w.

[31] Project leader: Thales (France). For the full list of consortium partners, see: European Commission, *SEANICE. Selected Projects EDIDP 2020*, 30 June 2021, https://europa.eu/!FTVPM8.

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of-the-art technologies, SEANICE intends to enhance EU detection, tracking and classification capabilities.

Project Novel Earth and Maritime Observation Satellite (NEMOS) is geared towards the implementation of a satellite mission which will provide near-real time surveillance for defence operation scenarios involving coastline, sea surface, or maritime critical infrastructures.[32]

Looking towards the future, Project Survivability, Electrification, Automation, Detectability, Enabling Foresight of European Naval Capabilities in Extreme Conditions (SEA DEFENCE) aims to identify innovative solutions the EU is likely to need moving forward, by conducting a feasibility study meant to facilitate the preparation of a technology roadmap for the next-generation naval platform.[33]

8.3.4 The role of the EDA

In line with the EU's effort to counter the risks posed by sea mines and malicious undersea activities, the EDA carries out several projects to enhance the Union's preparedness to face these threats, starting from the European Unmanned Maritime Systems for Mine Counter Measures and other Naval Applications (UMS) programme. Consisting in fifteen coordinated projects made of consortia composed by different industrial actors, research centres and academic institutions, the programme aims at delivering the next generation of technical solutions to be operated at sea.

The UMS programme is directly connected to the Maritime Mine Counter Measures – New Generation (MMCM-NG) project, which ended in 2017.[34] The project developed solutions for ships to counter maritime mines and other underwater improvised explosive devices (IEDs), besides establishing a set of common requirements for EU member states.

The EDA recently inaugurated a new project on swarm of biomimetic underwater vehicles (SABUVIS II), building upon a previous initiative (SABUVIS I) completed in 2019.[35]

[32] Project leader: Damen Holding (The Netherlands). For the full list of consortium partners, see: European Commission, *SEA DEFENCE. Selected Projects EDIDP 2019*, 15 June 2020, https://ec.europa.eu/commission/presscorner/detail/en/fs_20_1092.

[33] Project leader: Satlantis Microsats (Spain). For the full list of consortium partners, see: European Commission, *NEMOS. Selected Projects EDIDP 2020*, 30 June 2021, https://europa.eu/!99J9yF.

[34] EDA, *European Unmanned Maritime Systems (UMS)*, https://eda.europa.eu/docs/documents/factsheet_UMS.pdf. Participating countries: Belgium, Finland, France, Germany, Italy, Norway, Poland, Portugal, Spain, Sweden, The Netherlands.

[35] EDA website: *Maritime Mine Counter Measures - New Generation*, https://eda.europa.eu/what-we-do/all-activities/activities-search/maritime-mine-counter-measures---new-generation. Participating countries: Belgium, Estonia, Germany, Norway, Sweden, The Netherlands.

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In an effort to elaborate a Common Recognised Maritime Picture, several EDA member states and Norway are involved in Project Maritime Surveillance (MARSUR), working to improve the dialogue between maritime information systems.[36]

The EDA also conducts numerous research and technology (R&T) activities, categorised according to their Capability Technology groups – better known as CapTechs.[37] CapTechs aim to identify existing technology gaps in European programmes and find potential areas for cooperation amongst member states.[38]

A specific EDA CapTech is dedicated to the maritime domain. CapTech Maritime is dedicated to supporting European navies as they face the challenges ahead of them, encouraging further streams of research to address critical gaps in capability needs identified through a shared Strategic Research Agenda (SRA). Research on maritime mine counter-measures represents a fitting example.

Also contributing to the naval manoeuvrability and underwater control priorities listed among the EDA's CDP is the CapTech Missiles and Munitions. The CapTech works to conduct research and develop technologies which are bound to strengthen and expand the EU's defence capabilities.[39]

8.3.5 The future of EU collaboration

The EU is currently investing limited resources in the development of naval combat systems. As for all other environments, a successful European cooperation in the naval domain requires a strong collaboration within the Union's industrial sector. The EU can count on an advanced military naval industry, with state-of-the-art systems and cutting-edge technical competences shared among some of its member states. Yet, the Union continues to be affected by fragmentation, duplication of efforts and a lack of interoperability among national navies.[40]

Going forward, further cooperation in the naval domain among member states and their industrial sectors will be crucial not only to achieve higher levels of capabilities and preparedness but also to allow for more effective interoperability also in the field of EU naval operations.

While a project such as the MMPC represents an important testing ground in this regard, meaningful cooperation depends on agreement over the naval combat

[36] EDA website: *Maritime Surveillance (MARSUR)*, https://eda.europa.eu/what-we-do/all-activities/activities-search/maritime-surveillance-(marsur).

[37] For further information, see: EDA website: *Capability Technology Areas (CapTechs)*, https://eda.europa.eu/what-we-do/research-technology/capability-technology-areas-(captechs).

[38] EDA website: *CapTech Maritime*, cit.

[39] For further information, see: EDA website: *CapTech Missiles & Munitions*, https://eda.europa.eu/what-we-do/all-activities/activities-search/captech-ammunition-technologies.

[40] Elio Calcagno, Ana E. Juncos and Sophie Vanhoonacker, "Naval Defence Cooperation in the EU", cit.

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systems that will be fitted on these ships and in all future European ship designs. Given the technological challenges facing European navies, which require a level of investment hardly achievable by single nations, the EU has the potential to play a significant role in encouraging joint investment into future technologies, such as DEWs, AI and quantum computing and hypersonic capabilities to mention but a few. Whether this encouragement will be successful in the long term, as ever, depends not only on how much fund the Union will be able to put on the table, but also by making sure funding leads to the speedy development of shared, key technological solutions.

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9. Conclusions

by Alessandro Marrone and Michele Nones*

In light of the analysis put forward by the previous chapters, the following ten elements are particularly important for Italy in the naval domain.

1. A shift towards high-end capabilities within a balanced Navy
2. Multi-domain *cum grano salis*
3. The balancing of fleet numbers and systems
4. A reality check on modularity
5. A renewed approach to naval combat systems
6. A smart course to technological innovation
7. The Italian way to automation and unmanned systems
8. A focus on the underwater environment
9. The strategic relevance of a carrier strike group
10. The multiplier effect of international cooperation

9.1 A shift towards high-end capabilities within a balanced navy

The confrontation with the West sought by Russia implies a long-term threat to European security and stability, including across the seas adjacent to Europe. Italy plays a central role in collective deterrence and defence on NATO's southern flank in naval terms too, and contributes to the continental theatre posture of the Alliance from the Baltic to the Black Sea. This situation, particularly the activities carried out by Moscow's vessels and submarines in the Mediterranean Sea,[1] coupled with the risk-prone attitude of the Russian leadership, calls for adequate capabilities in terms of naval warfare. They include ISR, counter-mines, ASW, air and missile defence, as well as deep-strike and amphibious capabilities. It also implies re-investing on niche technologies and know-how like sonar and underwater surveillance and defence, which have somehow lagged behind other investments over the last decades.

At the same time, Italian interests in the wider Mediterranean go well beyond deterrence and defence. Securing SLOCs and seaborne energy supplies, countering illicit traffics, building capacities in partner countries and running naval diplomacy activities all require a proper range of capabilities for maritime security operations. These operations are likely to continue through national, regional or European formats like the Coordinated Maritime Presence (CMP), from the Gulf of Guinea all the way to the Persian Gulf. At the same time, an enhanced NATO deterrence and defence posture will feature Italy at the forefront of the Alliance's naval southern flank vis-à-vis the Russian fleet. This is ever more relevant as several other navies have also built up their naval posture in the wider Mediterranean region. Notably, the Chinese navy's increasing presence along all the SLOCs linking the South

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[1] See section 2.1 of this study.

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China Seas to the Mediterranean basin cannot be overlooked.

As a result, compared to the past three decades, during which Italy allocated a large amount of its naval assets to constabulary operations, the MM (as the other Italian service branches) has to shift its capability development focus towards the higher end of the warfighting spectrum, also by acquiring additional naval combat systems and/or upgrading existing ones. The Italian MoD has traditionally respected the targets of the NATO Defence Planning Process when it comes to naval combat systems, and both the *Cavour* carrier strike group and amphibious group embody the MM's commitment to modern warfighting. Notably, Italy is reviewing the operational concept of the latter to craft a new Littoral Expeditionary Group.[2] Still, a shift towards high-end capabilities is needed and is currently on the cards. This will have to take place within a balanced and sustainable MM posture, which will have to reflect the variety of tasks to be performed by the service.

Accordingly, resources should be devoted to fully equip combat vessels and aeronaval forces with complete warfighting capabilities including missiles, torpedoes, ammunition – preferably of the guided variety – as well as to ensure adequate stocks of weapons to sustain protracted, high intensity combat operations that ceased to be a theoretical eventuality in light of the war in Ukraine.

Such a shift towards peer-to-peer scenarios should be made sustainable also in terms of human resources. High-end capabilities are more complex, expensive and high-tech, and require a greater investment in recruitment, education, training and career of professional military personnel in order to maintain skilful and motivated crews. Personnel numbers should also be adequate to support a demanding operational tempo and ensure persistence both in green and even more so in blue waters, as the Italian navy should better prepare itself for long and prolonged operations.

9.2 Multi-domain cum grano salis

The concept of multi-domain operations gained lots of attention in recent years within the defence policy communities of Western countries. It has become a key concept at the NATO level and will likely influence the EU as well. As other innovative concepts originated in the US, it is deep-rooted in the unique American reality. Single European countries have to take into account diverse levels of ambition, operational theatres, force structures, military doctrines, legacy assets, and a number of well-established practices when it comes to operations, capability development, and defence industrial policy.

Clearly, the current five operational domains are becoming more and more interconnected, and the glue for such connections is increasingly provided

[2] Interview, 12 January 2022.

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by space[3] and cyber technologies, including those for command, control and communication. Moreover, the naval domain is further diversified across the seabed, underwater, surface, air and littoral environments. A carrier strike group embodies the conjunction of air and sea power, while an amphibious assault group inherently bridges sea, air and land domains. Within and around naval vessels a number of diverse systems have to work cooperatively. Thus, the MM has already *de facto* developed an SoS mindset. All these elements concur to a multi-domain approach to naval operations.

The Italian armed forces have already embarked on a long-term process towards joint and combined operations in doctrinal, organisational and practical terms. In particular, in recent years Italy has significantly enhanced its top Joint Operations Command (*Comando Operativo di Vertice Interforze* – COVI), based on fully national technologies, by placing under its authority all branches commands (land, sea and air) as well as the already joint commands for special forces, space[4] and cyber operations.[5] The Italian military has also developed the concept of "supported-supporting", whereby a clear chain of command can be established on a functional basis between the service taking the lead in a joint operation and the other services providing support. However, much still needs to be done in order to fully implement the already planned integrated operational model ("*modello operativo integrato*" in Italian), while maintaining advanced command capabilities such as the MM's *Comando in Capo della Squadra Navale* (Command in Chief of the Naval Fleet – CINCNAV).

Against this backdrop, the concept of multi-domain should serve Italy as further stimulus to pragmatically enhance jointness across service branches, and particularly to develop and implement all the necessary arrangements to make joint operations more effective without introducing unnecessary complications.

In this context, digitalisation and connection should move forward in an effective, secure and resilient way when it comes to data flows and management, artificial intelligence, quantum computing and technological sovereignty over military digital infrastructures.

9.3 The balancing of fleet numbers and systems

Looking to the next decade, trying to draw any general conclusions from trends relating to the fleet numbers of global naval powers can be daunting, as each navy

[3] For a comprehensive analysis of space and its relations with defence, see: Alessandro Marrone and Michele Nones (eds), "The Expanding Nexus between Space and Defence", in *Documenti IAI*, No. 22|01 (February 2022), https://www.iai.it/en/node/14669.

[4] On the Italian space operations command (*Comando Operazioni Spaziali* – COS), see Ibid.

[5] For an in-depth analysis of Italy approach to cyber defence and the cyber operations command (*Comando Operazioni in Rete* – COR), see Alessandro Marrone, Ester Sabatino and Ottavia Credi, "Italy and Cyber Defence", in *Documenti IAI*, No. 21|12 (September 2021), https://www.iai.it/en/node/14125.

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is part of a broader defence apparatus which in turn reflects a unique national reality. However, as discussed in previous chapters, a closer look at the navies of the US, UK, France and Germany shows that most of them are investing in lethality and the integration of a more distributed fleet, bolstered by large numbers of UxVs (all of this is particularly true for the US Navy).

Against this backdrop, Italy's level of ambitions in the naval domain should be matched by adequate resources to effectively perform the tasks assigned to the Navy over both the short and the medium term. In light of the current international security environment, there is an ongoing reflection within the MoD regarding the proper types and numbers of vessels needed, which passes through the current iteration of gap analysis, definition of requirements and the descending strategic force planning process.[6] Clearly, in order to ensure a persistent and effective maritime presence in the wider Mediterranean while supporting NATO´s deterrence and defence tasks, the MM needs more capabilities, including both vessels and combat systems.

Because of the aforementioned shift towards high-end scenarios and the growing importance of naval combat systems, any increase in hull numbers should necessarily be accompanied by proper investments on those systems and ammunition stocks (as well as spare parts) needed to guarantee the effectiveness, lethality and survivability of vessels in high-intensity scenarios of naval warfare. In that context, ASW, counter-mines, missile defence and deep-strike capabilities should be prioritised.

Any evaluation of the balancing of the fleet's numbers and systems should also take into account the effectiveness of aging legacy platforms with respect to state-of-the-art components and technologies, particularly when it comes to naval combat systems. At the same time, innovation in maintenance approaches would contribute to reduce the time lead for MROU activities and increase both readiness and effectiveness of assets.

9.4 A reality check on modularity

Modularity is important for the MM, but should be pursued in a realistic and pragmatic way. Indeed, a vessel could remain about two years in a shipyard to complete changes to a certain naval combat system, unless the ship is designed from the beginning as truly, fully modular and provided that the modules are indeed available and ready to be installed. In other words, modularity concretely works when there are pre-assigned, empty spaces to rapidly install i.e. special forces or medical modules that do not change the predominant, overarching task assigned to the given vessel. Accordingly, each ship should be designed to successfully perform its main task and to carry out a secondary one in a satisfactory way, ensuring a quantum of versatility. For instance, excellent, high-speed mine-hunters can be

[6] See chapter 5 of this study.

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used as good-enough patrol ships in permissive or semi-permissive brown and green waters. This way, the whole fleet would be able to perform the assigned range of missions by ensuring high-level performances. In that perspective, future vessels should incorporate from the beginning all the intended combat capabilities, but also the ability to install over time new, upcoming weapons – such as directed energy ones –without having to re-build the entire ship.

9.5 A renewed approach to naval combat systems

Because of the accelerating pace of technological innovation,[7] the importance, performance, complexity, acquisition and running costs of naval combat systems are set to steadily increase in the near future. Dealing with this challenging reality and exploiting the related opportunities will require a renewed approach to capability development, procurement and innovation policies.

First, the design of future generation vessels should pay even more attention to the availability of free space on board, energy power beyond propulsion, storage and cooling capacities, electromagnetic compatibility, protection against nuclear, biological, chemical and radiological threats, and broadly speaking to all the features needed to accommodate an increasing number of advanced, complex and substantially different naval combat systems, including UxV – some of them still to be developed. Larger hulls help in this regard, as well as in terms of a ship's self-defence, resilience and sailing on blue waters.

Second, while some of these systems will have to be spread out across the fleet, others such as ASW and missile defence will require, to a certain degree, more specialised vessels in line with the basics of naval warfare.

Third, the MM's approach to technological innovation and procurement, in terms of both ships and naval combat systems, should make updates and upgrades more effective, faster, frequent and convenient than current mid-life upgrades throughout the vessel's entire life-cycle.

Fourth, navigation and naval combat systems should be designed following common sets of standards wherever possible, in order to be smoothly and seamlessly integrated as part of a larger system of systems, even when supplied by different companies. Interoperability and open architectures are key elements in this regard. Here, NATO can play an important role through standardisation, and Italy should continue to be proactive in the alliance's framework.

The EPC and DDX programmes will be a key testing ground for the application of a renewed approach to naval combat systems, and will require that the Italian navy and industries closely cooperate from the early stages of the projects in order to wisely steer their development phases. This approach should also avoid the

[7] See chapter 1 of this study.

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EPC's joint procurement to end up with too many and too different class variants, an outcome that would go to the detriment of the project's economies of scale, innovation and effectiveness.

9.6 A smart course for technological innovation

As technological innovation accelerates and some EDTs are developed in the civilian market,[8] European militaries – including the Italian one – face the challenges of facing up to a process they are not entirely driving anymore. Moreover, while hulls-related technologies evolve in a rather incremental way, naval combat system experience an accelerated pace of innovation[9] and features EDTs like hypersonic weapons, AI and autonomous vehicles which are going to deeply influence future naval warfare. Finally, the costs of electronics, sensors, combat management and weapon systems is set to continuously increase compared to hulls, propulsion and alike.

In order to cope with these challenges in the naval domain, Italy has to direct adequate and constant investments in technologies crucial for naval warfare so as to develop, test and mature the vital building blocks for current and next generation classes of vessels. Innovation pertaining certain essential technology bricks has to be supported in a systematic way, also by accepting the risk of failure, in order to lay the foundations for the subsequent procurement of adequate capabilities – taking into account that some key EDTs are being pursued only in the military domain. As a result, a significant adaptation in conceptual, legal and organisational terms for the whole Italian MoD, and in particular for the national armament directorate, should take place to undertake a smart course for technological innovation.

Useful lessons can be derived from the aerospace sector. For instance, technologies for sixth generation combat aircraft will be financed already while the procurement of fifth generation fighters is ongoing, in order to prepare the components and pave the way for a generational leap forward. Obviously, a FCNS is a more complex system of systems that a FCAS. The bottom line is to have an ensemble of coordinated naval programmes, tackling different technologies and systems and acting as catalysts and incubators of technological innovation relevant for the MM. Some of the matured technologies should be implemented on current vessels within the remits of a feasible upgrade, and/or should find their way on the EPC and DDX currently being procured. Systematic cross-fertilisation between military and civilian sectors should be pursued, while making sure that all technology bricks for the MoD capabilities are built according to the secure-by-design principle.[10]

[8] Ibid.

[9] Ibid.

[10] On this principle see and the cyber security challenges of procuring civilian ICT technologies for the armed forces see among others Alessandro Marrone, Ester Sabatino and Ottavia Credi, "Italy and Cyber Defence", cit.

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Such a smart course for technological innovation, as well as the Italian military as a whole, would greatly benefit from a reform of the national military research plan (*Piano Nazionale di Ricerca Militare* – PNRM) to significantly increase its budget and concentrate it on a limited number of priorities. The PNRM should also be better aligned with the EDF, in order to exploit synergies and help the MoD and national DTIB to converge on priority areas relevant to European cooperation and competition, in particular to face up the most demanding challenges that are beyond the grasp of a single nation. It is therefore fundamental to align national, international and EU R&D projects by deciding how to address each technology area at a strategic level. By extension, national funds should also be used to develop qualified technologies that will allow to cooperate with partners in a leading or top-level role.

9.7 The Italian way to automation and unmanned systems

As mentioned in chapter 6, the MM sees automation as a crucial opportunity to simultaneously reduce the crews' workload and the number of sailors and officers required to operate ships, while increasing effectiveness and efficiency of naval operations. In turn, this allows to save precious space onboard and, in some cases, to cope with the long-term recruitment challenges due to a stagnating and aging population – albeit crew numbers cannot diminish under a certain threshold if they are to keep vessels effective, safe and flexible. Italy should continue down this path by exploiting the opportunities provided by big data and artificial intelligence through adequate investments in national, international or EU-level projects, aiming at the next leap forward in terms of automation. At the same time, Italian and NATO armed forces should already seek to define clear boundaries for AI and automation at the operational level.

Important opportunities are also presented by unmanned vehicles within the context and constraints of a European middle power like Italy. Here, the approach outlined by the FCNS 2035, which sees UxVs as valuable assets for various classes of vessels acting as hubs for their management, seems to be a pragmatic way to effectively implement manned-unmanned teaming, including multi-UxV teaming. Minor UxVs are going to be more and more relevant for ISR, movements of divers in special forces operations, mine-hunting under certain circumstances, transports and logistics, and broadly speaking for maritime security operations in a permissive or semi-permissive environment. Above all, UxVs are crucial to ensure a MM persistence (primarily but not only in terms of ISR) in a vast area of operations which cannot be covered only by manned assets.

Building also on the results of OCEAN2020, the integration of UxVs and rotary UAVs should proceed as quickly as possible not only in technological, but also in doctrinal, procedural and organisational terms, while investing in the cyber defence capabilities necessary to operate unmanned vehicles in a warfighting scenario against a peer competitor. Italy has had an important role within the NATO Maritime Unmanned Systems Initiative (MUSI), launched in 2018 and participated by the majority of allies, including during the 2022 REP(MUS) exercise hold in

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Portugal, and this represents an important step in the right direction. Notably, in some areas such as rotary UAVs and manned-unmanned teaming, Italy can boost a significant technological capability and have a leading role in Europe and beyond.

Finally, quantum computing could represent a game-changer also when it comes to UxVs, by ensuring unprecedented levels of encryption for the communication among a variety of manned and unmanned assets, as well as by promising a far larger autonomy to submarines and other vessels from satellites-provided positioning, navigational and timing services.

9.8 A focus on the underwater environment

The underwater environment – including obviously the seabed – represents the next frontier in terms of naval threats. Indeed, the 2022 sabotage of the North Stream pipelines was a stark reminder that critical infrastructures such as internet cables and energy pipelines are becoming increasingly vulnerable to new technologies that are able to operate in this environment. Potential attacks against underwater infrastructure pose a real threat to Italian national security and economic interests in the wider Mediterranean and beyond. As a result, in 2022 the MM has broadened and enhanced the operation *Mediterraneo sicuro* by deploying additional capabilities to protect underwater pipelines crucial, for Italy's energy security.[11]

The Italian navy should frame a new approach to this environment to be fully integrated within the MoD's overall military posture, with a perspective on capabilities needed to adequately operate underwater and on the Mediterranean seabed. An advanced underwater situational awareness should be pursued. Given the characteristics of this environment, the development of unmanned underwater vehicles, sensors and communication is a key element to ensure a persistent military presence in prioritised areas. The plans to build a national centre for the underwater environment in La Spezia (*Polo Nazionale per la Subacquea*), featuring a whole-of-government commitment and public-private partnerships, constitutes an opportunity for technological innovation, the pooling of investments and the development of dual-use capabilities.

9.9 The strategic relevance of a carrier strike group

As discussed in chapter 6, Italy is currently one of the three countries worldwide to operate 5th generation fighter aircraft (F-35B) on its own aircraft carrier *Cavour* – alongside with the US and the UK. This is an extremely valuable asset in political and operational terms, with a view to the aforementioned point on high-intensity scenarios, deterrence and defence, even when in the future few other navies may follow deploying 5th generation aircraft on their vessels. As more F-35Bs

[11] See Michelangelo Freyrie and Riccardo Leoni, "Come la Russia minaccia i gasdotti nel Mediterraneo", in *AffarInternazionali*, 4 January 2023, https://www.affarinternazionali.it/?p=102014.

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enter service in the MM, Italy should develop the necessary strategic approach to employ its carrier strike group, both in terms of operational concepts as well as to raise political awareness of the implications, benefits and potentialities of being able to project power through this unique sea-basing capacity. For instance, as demonstrated by the multi-national nature of the carrier strike groups deployed in the recent years around French and UK carriers, this capability is a valuable tool to increase interoperability while convening allies under the Italian flag, and/or to mark a temporary but meaningful presence in the wider Mediterranean and the Indo-Pacific. Beyond that, it has to be fully understood as a key pillar for deterrence and defence in the naval domain, also in a scenario of high-intensity conflict.

9.10 The multiplier effect of international cooperation

Italy is fully aware of the importance of international cooperation in the maritime domain, as its Strategy for the security and the defence of the Mediterranean (*Strategia di Sicurezza e Difesa per il Mediterraneo*) places operations and cooperation on the same footing as key pillars of the Italian strategy.[12] The MM sees activities carried out by multiple state and non-state actors in the wider Mediterranean and a network of bilateral and regional relations – making the Mediterranean basin itself a rather crowded environment. The importance attached to partnerships and cooperation is well epitomised by the Trans-Regional Sea Power Symposium, regularly organised by the Italian Navy in Venice with the participation of over 50 navies and 100 international organisations.[13] From an Italian perspective, cooperating with allies is crucial to compensate each other's capability gaps, for instance when it comes to the US P-8 maritime patrol aircraft based in Sigonella to enhance NATO's fixed-wings ASW capabilities in the Mediterranean. In particular, the MM has developed strong cooperation with American, British and French navies and keeps regular contacts with Mediterranean littoral states.

The MoD should maintain such a pragmatic approach and develop cooperations with partners and allies concerning maritime security operations, as well as capability development and innovation, by exploiting the advantages provided by bilateral, regional, EU and NATO frameworks. In operational terms, the European coordinated maritime presence and missions like EMASOH, currently under Italian lead, constitute good examples to be replicated in the Mediterranean basin. When it comes to capability development, the EPC is a litmus test for the Italian ability to lead a true cooperation with France, Spain and Greece within the EU framework. Hopefully, this will lead to an asset that is as standardised as possible, although with some national variations, backed by an integrated supply chain and able to compete on worldwide markets. Regarding innovation, within the NATO context the Centre for Maritime Research and Experimentation (CMR&E) located in La

[12] Italian Ministry of Defence, *Strategia di sicurezza e difesa per il Mediterraneo*, cit., p. 2.

[13] Italian Navy, *In Venice the 'XIII Trans-Regional Seapower Symposium' from 5th to 7th October*, 3 October 2022, https://www.marina.difesa.it/EN/Conosciamoci/notizie/Pagine/20221003_in_venice_the_xiii_trans-regional_seapower_symposium_from_5th_to_7th_october.aspx.

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Spezia should be considered as an opportunity to build an innovation pole in the city, connecting the facilities and investments of the MM, Leonardo, Fincantieri, and a number of companies and SMEs operating on naval-related technologies (including the aforementioned underwater national centre).

Broadly speaking, EDF, the EDA Innovation Hub, NATO's CMR&E and DIANA are all international venues to be explored together with partners and allies in order to reach the economies of scale and multiplier effects needed to generate a technological leap forward, with a view not only to interoperability, but also to interchangeability, commonality and integration of naval assets. To achieve this end, Italy has to bring clear ideas and sound plans to the cooperation tables, adequate investments to back them, a strong public-private partnership, and a whole-of-government approach to negotiate win-win solutions on an equal footing with major partners.

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List of acronyms

4E	Project Essential Elements of European Escort
A2/AD	Anti-Access and Anti-Denial
A3B	Anti-Aerial Airburst
AAW	Anti-Air Warfare Systems
AGS	Auxiliary General Ships
AI	Artificial Intelligence
AORH	Auxiliary Oiler Replenishment Helicopter
ASBM	Anti-Ship Ballistic Missiles
ASCM	Anti-Ship Cruise Missiles
ASW	Anti-Submarine Warfare
ASuW	Unmanned Anti-Surface Warfare
ATG	Amphibious Task Group
AUKUS	Pact between Australia, the UK and the US
AUV	Autonomous Underwater Vehicle
AWACS	Airborne Warning and Control System
BER	Ballistic Extended Range
BMD	Ballistic Missile Defence
BSA	Black Shark Advanced
bn	Billion
C2	Command and Control
C3	Command, Control and Communications
CATOBAR	Catapult-Assisted Take-off But Arrested Recovery
CDP	Capability Development Priorities
CEC	Cooperative Engagement Capability
CEP	Circular Error Probable
CHF	UK's Commando Helicopter Forces
CHOF	*Capacité hydrographique et océanographique future*
CIWS	Close-in Weapon Systems
CMP	EU's Coordinated Maritime Presences
CMS	Combat Management System
CONOPS	Concept of operations
COVI	*Comando Vertice Interforze* – Italian Joint Operations Command
CPS	Conventional Prompt Strike
CPTPP	Comprehensive and Progressive Agreement for Trans-Pacific Partnership
CSG	Carrier Strike Group
DART	Driven Ammunition Reduced Time of Flight

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DASA	Defence Autonomy and Security Accelerator
DDG	Guided-Missile Destroyer
DDG(X)	Next-Generation Guided-Missile Destroyer
DDX	Italian Next Generation Destroyers
DEW	Directed-Energy Weapons
DMO	Distributed Maritime Operations
DoD	Department of Defense
DPP	*Documento Programmatico Pluriennale* – Italian Multiannual Planning Document
DTIB	Defence and Technological Industrial Base
EABO	Expeditionary Advanced Base Operations
EDA	European Defence Agency
EDF	European Defence Fund
EDIDP	European Defence Industrial Development Programme
EDINAF	European Digital Naval Foundation
EDT	Emerging and Disruptive Technologies
EEZ	Exclusive Economic Zone
ELINT	Electronic Intelligence
EMASOH	European Maritime Awareness – Strait of Hormuz
EMRG	Electromagnetic Railgun
EMP	Electromagnetic Pulse
EPC	European Patrol Corvette
ESM	Electronic Support Measures
EU	European Union
EW	Electronic Warfare
FACO	Final Assembly and Check Out
FCNS	Future Combat Naval System
FCAS	Future Combat Air System
FC/ASW	Future Cruise and Anti-Ship Weapon
FFG	Guided Missile Frigate
FOC	Fully Operational Capability
FREMM	*Fregate europee multi-missione/ Frégates européennes multi-missions* – European Multi-Purpose Frigate
GLR	Guided Long Range
GPV-27	Russian State Armament Programme 2020-27
GUGI	*Glavnoe Upravlenie Glubokovodnyh Issledovanij* – Main Directorate of Deep Sea Research
Gw	Gigawatt
HALE	High-Altitude, Long Endurance
HARMSPRO	Project Harbour & Maritime Surveillance and Protectio

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HELCAP	High Energy Laser Counter-Anti-Ship Cruise Missiles Program
HELIOS	High-Energy Laser With Integrated Optical Dazzler and Surveillance
HYBRID	Hydrogen Battlefield Reconnaissance and Intelligence Drone
IED	Improvised explosive devices
IOC	Least Initial Operational Capability
ISR	Intelligence, Surveillance and Reconnaissance
ISTAR	Intelligence, Surveillance, Target Acquisition and Reconnaissance
JADC2	Joint All-Domain Command and Control
km	Kilometres
Kw	Kilowatts
LACM	Land-Based Cruise Missiles
LDUUV	Large Displacement Undersea Unmanned Vehicles
LHD	Landing Helicopter Dock
LNG	Liquified Natural Gas
LPD	Amphibious Transport Dock
LPM	*Loi de programmation militaire* – Military Planning Law
LRSS	Long Range Submarine Support Ship
LUSV	Large Unmanned Surface Vessels
MAC	Multistatic Active Coherent
MADL	Multifunction Advanced Datalink
MALE	Medium-Altitude, Long Endurance
MARSUR	Project Maritime Surveillance
MCR&E	Centre for Maritime Research and Experimentation
MCM	European Mines Countermeasuures
MENA	Middle East and North Africa
MIRACLE	Mine Risk Clearance for Europe
MMCM	Maritime Mine Counter Measures
MMCM-NG	Maritime Mine Counter Measures – New Generation Project
MM	*Marina Militare* – Italian Navy
MMPC	Modular and Multirole Patrol Corvette
MN	*Marine Nationale* – French Navy
MoD	Ministry of Defence
MOSA	Modular Open Systems Approach
MPA	Maritime Patrol Aircrafts
MROU	Maintenance, Repair, Overhaul and Upgrade
M-SASV	Medium size Semi-Autonomous Surface Vehicle
MTC/MTF	Lighthouse and Logistic Support Ships
MUM-T	Manned-Unmanned Teaming
MUSAS	Maritime Unmanned Anti-Submarine System

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MUSI	NATO Maritime Unmanned Systems Initiative
MUUV	Medium Underwater Unmanned Vehicle
NAVWAR	US Navy Information Warfighting Center
NEMOS	Novel Earth and Maritime Observation Satellites
NGAD	Next Generation Air Dominance
NMW	Naval Mine Warfare
NSM	Naval Strike Missile
OCEAN2020	Project Open Cooperation for European Maritime Awareness
OSD SCO	Secretary of Defense's Strategic Capabilities
OTH	Over-the-Horizon
PADR	EU's Preparatory Action on Defence Research
PESCO	Permanent Structured Cooperation
PICN	*Postazione integrata di condotta nave* – Integrated Naval Cockpit
PLAAF	People's Liberation Army Air Force
PLAN	People's Liberation Army Navy
PLANAF	People's Liberation Army Navy Air Force
PNRM	*Piano nazionale di ricerca militare* – Italian National Military Research Plan
PNT	Positioning, Navigation and Timing
PPA	*Pattugliatori polivalenti d'altura* – Multipurpose Offshore Ship
PSC	Principal surface combatant
PVK-50	Military Shipbuilding Programme 2050
RAIL	Rapid Autonomy Integration Lab
R&D	Research and Development
R&T	Research and Technology
RS-MCCS	Research Ship – Mine Countermeasures Command and Support Ship
SAM	Surface-to-Air Missile
SDAM	*Système de drone aérien de la Marine*
SEA DEFENCE	Survivability, Electrification, Automation, Detectability, Enabling Foresight of European Naval Capabilities in Extreme Conditions Project
SEANICE	European Autonomous Networked Innovative and Collaborative Environment Project
SEAWINGS	Sea/Air Interphasic Wing-in-Ground Effect Autonomous Drones Project
SIF	Stand-in Forces
SLAM-F	*Système de lutte anti-mines – Futur*
SLOC	Sea Lines of Communication
SMDM	*Système de mini-drones pour la Marine*
SMEs	Small and medium-size enterprises

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SoS	System of Systems
SS	Diesel-Electric Propulsion
SSBN	Nuclear Powered Ballistic Missile Submarine
SSN	Nuclear Powered Attack Submarine
SSP	Air-Independent Propulsion
STANAG	NATO Standardisation Agreements
STOVL	Short Take-Off and Vertical Landing
SUUV	Small Underwater Unmanned Vehicle
TTNT	Tactical Targeting Network Technology
UAV	Unmanned Air Vehicle
UMS	European Unmanned Maritime Systems for Mine Counter Measures and other Naval Applications Project
USV	Unmanned Surface Vessel
UUV	Underwater Unmanned Vehicle
UxV	Unmanned System
VMF	*Voyenno-Morskoi Flot* – Russian Navy
VLS	Vertical Launch Systems
VTOL	Vertical Take-Off and Landing
XLUUV	Extra-Large Underwater Unmanned Vehicle

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