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GEOPOLITICS AND THE NEW UTILITY OF FIGHTING POWER AT AND FROM THE SEA

INTRODUCTION

Geography and the laws of commerce and physics demand that the sea will continue to be the primary medium of access and exchange between continents and countries. As such, the maritime domain remains a critical dimension of warfare that admits and allows the enabling, integration and projection of fighting power, not only at sea, but also contributes to land, air, Space, cyber and electronic dimensions. The future character of warfare at sea, as elsewhere, will be shaped by technological capacity and capabilities, and the resources devoted to it, as well as the physical changes that will be wrought by natural processes and by how Mankind seeks to use and exploit the sea.

At the heart of how force will be threatened, and influence applied, at sea is von Clausewitz's observation that 'everything in war is very simple, but the simplest thing is difficult' will remain the essential reminder about the way in which strategy and its subsequent implementation – dynamically balancing the ends, ways and means within a constantly shifting geopolitical, technological and geo-economic landscape. Other eternal verities hold good. Sea power in the 21st century will continue to reflect the ability of a state, group, company or individual to use the sea for its own benefit (for political, commercial or private reasons) and, if required, to deny or limit its use to others. Hard sea power will continue to confer the ability to threaten or employ violence and coercion as an instrument of policy at a time and place of choice. Soft sea power will be generally associated with the exploitation of the sea's resources (such as with tourism, fishing and resource extraction) and the movement of goods along sea lines of communication. In both its hard and soft forms, sea power will continue to comprise at least four elements: the control and practice of international trade and commerce; the use and control of ocean

resources; the operation of maritime forces in war; and the use of navies and maritime economic power as instruments of diplomacy, deterrence and influence in peacetime. In some cases, as is the case with China, the difference between the state and private sectors, and between hard power and soft power, will be indistinguishable.

GEOPOLITICAL DETERMINANTS

The ghosts of the twentieth-century prophets of geopolitics, Halford Mackinder, Alfred Thayer Mahan, and Nicholas Spykman, would appear to have returned to haunt the twenty-first century. Consequently, global trends and the maritime footprint of major powers are likely to be framed by an international system that will be increasingly characterised by strategic competition between what can loosely be described as a Eurasian authoritarian bloc and a maritime democratic bloc. The Eurasian authoritarian bloc comprises primarily China, Russia, Iran and North Korea while the maritime democratic bloc includes the United States, Canada, the United Kingdom, parts of Europe, Japan, Australia, Taiwan, South Korea and New Zealand, as well as looser affiliates like India, Vietnam, Indonesia and Malaysia, whose geopolitical and commercial interests rely on the protections and provisions of the international rules-based system. Between the two blocs is a range of non-aligned states, whose allegiance to one bloc or the other depends, at any time, on the reliance of their elites on either development or security to maintain their domestic stability and legitimacy.

Strategic competition is already being manifested by attempts by the Eurasian autocratic bloc led by China to 'de-Americanise' Mackinder's World Island of Eurasia and Africa and the waters around it. The bloc looks set to reduce its external energy and economic dependencies, construct and develop mechanisms to extend their cooperation in strategic and economic ways (through enterprises such as the BRICS formula, the Belt and Road Initiative and the Shanghai Cooperation Agreement) and to dominate strategically the hyper-continent of Eurasia and the seas around it. Conversely, the maritime democratic bloc led by the US will seek to preserve as much of the international rules-based system, particularly at sea, that will allow its members to trade and access freely those regions that are needed to preserve and promote their interests, economies and allies.

Despite their evident continental credentials, China and Russia are both projecting significant (and in China's case, increasingly assertive) national state power at sea, whether through the deployment of maritime and air assets or the massively expanding footprint of state-backed energy extraction, fishing, and maritime commercial activity. In addition, both China and Russia are directly challenging the UN Convention of the Law of the Sea (UNCLOS), to gain advantage in their respective spheres of interest; in China's case, to undertake 'land grabs' in the South and East China Seas. Russia, meanwhile, is clumsily and unevenly attempting to neutralise geopolitical competitors and dominate activity in the Baltic and Black Seas, as well as securing primary proprietorial rights in the Arctic. Both seek to control not only their near-abroad, but also to encompass the energy, commercial and geopolitical space across and around the Eurasian continent. Iran, despite recent setbacks, is attempting to restore and extend its power and influence in the greater Middle East.

It is also evident that 'sub-threshold' warfare conducted by the armed forces and agents of the Eurasian autocrats – in the form of cyber, espionage and the physical disruption of infrastructure, with an increased role played by unmanned vehicles and sponsored criminality – is emerging. Space and the deep oceans are becoming more critical areas of strategic competition, with particular emphasis on the opportunities offered by low earth orbit, cislunar Space and the national control of sea space and the resources of the Sea.

This situation would indicate that significant crises, confrontations, and conflicts are likely to occur in the littoral and oceanic regions on the geopolitical tectonic plates between the Eurasian authoritarian states and the maritime democracies (the space obliquely conforming to Spykman's Rimland). This trend will be intensified by a scramble for proxies and partners among a proliferating host of sub-state entities capable of deploying sophisticated systems normally associated with states. These include cruise and ballistic missiles in the hands of paramilitary groups like Hezbollah and the Houthis in Yemen, and the wide availability of precision and saturation opportunities offered by loitering, swarming and unmanned munitions.

CONTEXTUAL DRIVERS

In practical terms, there are several features of the modern and emerging maritime seascape that will determine how warfare is conducted at sea:

a. The first is that, by the end of the decade, everything on the surface of the planet is likely to be detectable through its physical, electronic and infra-red signature, or through its data exhaust. Maritime forces in future will soon be more detectable, classifiable and targetable, owing to increasingly sophisticated physical, electronic and multi-spectral detection and processing systems, enhanced by Artificial Intelligence (AI), software-enabled devices and quantum technologies. Those platforms neglecting acoustic hygiene and underwater noise suppression and those emitting high levels of broadband and discrete frequencies that allow long-range detection and classification opportunities are likely to be particularly vulnerable. This feature will mean that everything will be similarly targetable. As a result, the undersea and underground dimensions will assume greater importance as 'stealth' environments.

b. As technology develops and proliferates, especially regarding connectivity, miniaturisation and artificial intelligence, the freedom of action of all states will be constrained, in comparison with the past, by the sophisticated maritime denial and offensive capabilities acquired by many countries. The economic convergence between the developed and developing countries in the past two decades has been paralleled by a marked convergence in terms of the technological sophistication and availability of maritime warfare technologies. These include, among others, quiet, high-endurance submarines, powerful anti-ship missiles, modern mines, unmanned vehicles, and access to commercial Space-based intelligence products.

c. Similarly, the rapid proliferation of technologies, weapons and enables irregular groups and individuals to access and exercise military levels of capability, which could be used for both legitimate and illicit purposes. States will not have a monopoly on the instruments of coercion and the use of force. Criminals, terrorists and other sub-state groups will have access to the means to inflict significant damage on civilian populations, armed forces and law enforcement agencies.

d. Technologically advanced or progressively upgraded manned and unmanned attack and surveillance vehicles, will become routinely available at sea, often linked to other integrated surveillance and targeting systems. They will be in the forefront of surveillance and attack and will be staple, indispensable items in the inventories of all maritime powers. Apart from their undoubted operational benefits, their use will encourage states to be more forward-leaning and less cautious in their dealings with their rivals and competitors, especially in situations in which states probe the edges of tolerance in relation to claims and disputes. Unmanned and robotic applications will also enable criminals and terrorists to de-risk a significant proportion of their activities. Narcotics, armaments, and many other forms of contraband can be transported without direct risk to the perpetrator, and so the use of unmanned vehicles by non-state groups is expected to increase rapidly. As such, significant resources and research will be devoted to finding ways to counter unmanned vehicles, notably through physical destruction and manipulation and interruption of their control mechanisms and data links.

e. One issue that looks set to dominate the maritime scene is that of territoriality and the potential confrontation and conflict associated with 'land grabs' at sea, both for jurisdictional control and for resources. The incidence of confrontation and conflict will be determined by the willingness of those states committed to the notion of the freedom of the seas to challenge states, including most evidently China (within its ten-dash line in the Asia-Pacific) and Russia (in the Arctic) that seek to 'own' their EEZs and areas of the high seas in their own interests. As such, the unfamiliar prospect of naval forces 'holding ground' in the form of presence operations is likely to become more prevalent to ensure that others, both state and commercial players,

do not encroach, either on national jurisdictions and entitlements or on the global commons.

f. In tandem, much more attention and investment will be devoted to the seabed, not just in terms of resource exploitation. As states extend their energy, power, communications and data infrastructure and footprint offshore, there will be increased pressure to defend them from potential opponents, leading to extensions of protected zones and jurisdictions, especially to the limits of Exclusive Economic Zones and, in the case of power and communications cables, beyond. Progressively, they will also host a range of sensors and defensive systems designed to detect intruders, but also to deter and deal with potential aggressors. These will include various sensor arrays, mines and unmanned vehicles, as well as installations for power sources and data connections. They might also include stealthy fixed platforms for releasing missiles and other offensive weapons.

g. Finally, maritime warfare is extensively supported by, and will be increasingly reliant on, Space-based services, especially in terms of the ability to locate, track and identify activities taking place at sea, both in peace and conflict. In addition, satellite communications will be significant enablers of data exchange and information networks, control systems for a range of unmanned vehicles and, of course, for providing accurate timing and positional information for precision munitions and other military applications. Those that are not operating in Space are unlikely to prevail at sea.

THE THREAT AND USE OF FORCE AT SEA

It is anticipated that sea power, shaped by the drivers emphasized above, will continue very much as it does today, with warships and auxiliaries going about their familiar business: the maintenance of maritime security, the promotion of a country's interests, the protection of its sovereignty and the projection of national power. Great powers will be defined at sea, in their own eyes and those of potential opponents, by their ability to operate major battle groups, to sustain substantial deterrent forces and to project power beyond their respective

regions. Medium powers are likely to need to be congruent with the bloc to which they are aligned, the demonstrate the ability to balance competing regional rivals and retain just enough capacity to keep under national control sufficient fighting power to sustain deterrence and coercive options in support of their vital national interests. Those countries that can afford, in human and material terms, to acquire and operate advanced technologies, specialist warships and other sophisticated maritime capabilities will do so, although an increasing variety of fire-and-forget and autonomous systems will obviate the need for specialist training and tactical acuity. Warfare will be characterised by weapons and systems that will deny naval forces access to parts of the ocean, which will only be overcome with prohibitive levels of resources, attrition and loss of operational tempo. In addition, a major challenge will be to maintain weapons and sensor effectiveness in the face of increasingly capable and powerful electronic denial and disruption systems.

However, in a contested, but connected world, it seems likely that major maritime powers within the two blocs will cooperate in some areas, in maintaining stability, security and the viability of the international system at sea in general terms, but will compete, either passively or actively, in areas of specific national interest or dispute. A particular area of concern is that states will progressively extend control over their exclusive economic zones (EEZs), while some, like Russia and China, will also claim and assert jurisdictional rights over areas of ocean that are considered the high seas or other jurisdictions under international law. Unless these claims are contested, they are likely to pass into international law on the basis that practice – and the exercise of armed force to reinforce it – tends to result in permanent changes to existing conventions and agreements (in an *ex post facto* legitimisation process).

As such, the first half of the twenty-first century looks set to be an age of strategic brinkmanship at sea, punctuated with periodic episodes of confrontation over disputed claims and unilateral attempts to restrict the freedom of the seas by opportunist powers. The international system of conventions and legal instruments that exists to harmonise competing jurisdictions, contain ambitions and settle disputes will also come under pressure. However, the balance of capabilities in the various regions of the world, including the substantial power of the USA, the existence of nuclear weapons and the considerable

risks of escalation, mean that general war and fleet actions between the major powers are unlikely. No one will be able to deliver the knock-out blow. Nevertheless, more traditional conflict is possible between regional rivals, most immediately in the Asia-Pacific region, but also in relation to unresolved issues in the greater Middle East and Africa.

Strategic competition is therefore likely to be expressed a series of 'encounter' actions that will involve confrontation and armed exchanges between individual units and groups of units engaged in testing the limits of national tolerance regarding assumed rights to resources or sea-space. These will increasingly include altercations between, and losses of, unmanned vehicles in the front line of maritime disputes. One can envisage bloodless confrontations in which the direct combat functions are between machines.

If it comes to further blows, the operational imperative at sea in the future will be on holding potential opponents at risk at the greatest distance possible, using long-range surveillance assets and weapons capable of dealing with hostile platforms and launch systems before they are able to engage. The use of precision munitions will mean that it will be possible to strike vessels and targets at extended ranges, with accurate and increasingly destructive weapons. Traditional forms of force protection and projection will become obsolete in the face of advanced technologies: increasingly lethal ballistic, cruise and hypersonic missiles; more silent, high-endurance nuclear and AIP ocean-going submarines and a range of unmanned, anti-access and sea denial systems. Nor should the threat from chemical, biological and radiological weapons be discounted, especially when linked to synthetic biology, compound materials and nanoscale features.

EMERGING WARFARE TRENDS

MULTI-DOMAIN OPERATIONS

Accelerating computing power, commonly applicable data solutions and advanced communications are the breaking down of divisions between land, sea, subsurface, Space and air environments. As has recently been seen in Ukraine and in the Red Sea, many more military capabilities will be brought to bear at sea, beyond those provided by navies and

sea-based assets. In the future, a range of land-based weapons, systems and aircraft will participate as components of joint (or multi-Domain) approaches to warfare at sea, just as naval forces will increasingly contribute to successful campaigns on the land, in Space and in the air. Capabilities associated with Space, cyberspace and the electromagnetic spectrum will be critical enablers, notably in providing actionable intelligence, communications, precision positioning and timing for weapons systems, but also for attack options and disrupting and disabling the systems and sensors of opponents. Satellite systems and Space imaging, the proliferation of advanced surveillance and data systems and integrated communications technologies are also enabling more agile cueing of an array of responses to situations, as is access to Space-based and other command, control, communications, and surveillance assets.

Meanwhile, near real-time gathering, processing and diffusion of information and decisions will allow the linking up of a broad range of sensors and weapon systems, over considerable distances. Already, this feature is enabling sensors and 'shooters' in different ships, aircraft, unmanned platforms, and land bases to be integrated as a common capability against an opponent's war-fighting assets, with multiple individuals and organisations having direct and simultaneous access to information and to each other. This trend is not only allowing weapons and systems to be used increasingly and routinely across disciplinary boundaries, but is also enabling widely dispersed military units to operate as reconfigurable, mix and match 'communities of operational interest' or as modular components in a cohesive network, allowing closer coordination of engagement and tactical manoeuvre and a degree of redundancy,

This integrated capability will allow sea combat in the future to be conducted at the greatest range possible from an opponent, with reliance on wide-area and unmanned surveillance assets and long-range attack systems. Just as opposing aircraft carriers in the Second World War tended not to be in contact with each other, warships today and tomorrow might never encounter their opponents within visual or even radar ranges. Cooperative and networked systems will mean that an attacking unit will generally be launching its weapons based on cueing and targeting information provided by the sensors in another platform.

All this will result in fewer people being at sea in the future, just as the numbers of personnel required to man a warship in the days of sail were dramatically reduced once the transition to mechanically powered vessels was completed. In the first place, a great many roles currently carried out by sea-based platforms will be conducted from the land, in particular functions such as routine surveillance, traffic control and the control of weapons systems. UAVs will take over many of the functions associated with maritime patrol and remote sensor operation. The application of automation, AI and robotics will further drive down numbers. The effect will be to de-risk a wide variety of functions for human beings, especially in the categories of 'dull, dangerous, deep and dirty' tasks.

Meanwhile, Artificial intelligence (AI) will progressively allow ever more remote identification, classification, and neutralisation of targets, based on rigorously coded criteria and rules of engagement. The techniques would also enable minor warships to confront larger and more powerfully armed opponents by calling in firepower from elsewhere. This aspect implies that many platforms will need significant 'up-arming' if they are not to be overmatched. Indeed, to increase the distribution of lethality, similar 'up-arming' and sensor enhancement could usefully be applied to other platforms, such as the amphibious ships, smaller combatants and a modern version of permanently or periodically earmarked ships taken up from trade (STUFT), if necessary, by 'fitting for, but not always with'. In this way, even if parts of the enabling systems and networks are degraded or destroyed, redundancy can be provided by temporary bearers and proxies in the form of mini- or tactical satellites, unmanned vehicles and other temporary solutions, such as aerostats.

SPACE

As indicated above, it will be necessary to consider the maritime domain as extending from the seabed to Space. The proliferation of anti-ballistic missile technologies will be accompanied by anti-satellite systems, which will hold at risk all existing space platforms and services. In time of conflict, it would have to be assumed that some or all services provided by space-based systems, such as communications, navigational, guidance and

surveillance might be unavailable. Another consideration is that, as the exo-atmosphere becomes more cluttered and disputed – and anti-ballistic missile systems become more effective – it is likely that ballistic (and by extension, hypersonic) missiles will lose some of their vaunted invulnerability. Other forms of strategic deterrence based on the ability to conduct denial of service attacks on integrated, interconnected and fragile infrastructures could emerge, together with space-based systems and other methods of strategic coercion, possibly based around directed energy, electromagnetic pulse, space-based jamming or enhanced cyber options.

The major powers – the USA, Russia and China – already have proven anti-satellite capabilities, and now India is developing its own ability to disable and destroy objects in space. They and other states, as well as sub-state operators, will extend ways of jamming and manipulating the uplink and downlink elements of satellites and compromising the physical, optical and electronic integrity of space systems, with lasers playing a major part, as well as masers, when technology allows. In the future, it is highly likely that there will be 'killer satellites' and high-powered, possibly nuclear-powered jammers stationed in space, in the event of conflict.

In response, states will need to have ways not only of protecting their space assets, but also of mitigating the destruction or disabling of satellites and other space enablers. In some cases, this will be achieved by the launching of replacement mini-satellite chains, perhaps from existing or former ballistic missile submarines, and the substitution of disabled satellites by networks of unmanned or manned aircraft, aerostats or airships to act as communications bearers, re-transmit facilities and network enablers. The loss of positional information for navigation, targeting weapons and other tactical systems would have particularly serious consequences.

CYBER AND ELECTROMAGNETIC WARFARE

Navies currently operate in a generally benign electromagnetic environment, which is largely clear from electronic interference except when in close combat. This is unlikely to continue as both state-based and irregular opponents develop and bring into operation

technologies that disrupt communications, sensors and networks. These devices and systems are likely to degrade or allow manipulation of terrestrial and satellite communications, data exchanges and guidance systems. China, North Korea and Russia already field a substantial number of high-power jamming and disruption systems, ranging from tactical-level electronic countermeasures up to large-area and dedicated systems designed to deal with cruise missiles, GPS-guided munitions and satellite communications. Unmanned systems are likely to have a particularly hard time of it.

In this respect, sensors, communications and weapon systems will need to incorporate the necessary robustness and agility to maintain operational effectiveness in a situation involving heavy electronic suppression. Consequently, more attention will be needed to ensure that existing and emerging systems have sufficient hardening, resilience, and redundancy to survive in an electronic environment characterised by high-intensity and high-power electronic jamming and spectrum denial systems. These will be primarily deployed by military operators, but, given the range of systems available on the open market, the necessary technologies are also likely to be acquired by proxies, criminals, terrorists and other sub-state groups. Mobile and wireless signals will be particularly vulnerable.

Similarly, as computing power increases, as silicon-based circuits give way to graphene and as more of the world's population gains access to Internet and software enabled technologies, through an increasing variety of mobile, wearable, and linked devices, the range and intensity of activity in cyberspace will expand. States and armed forces will constantly probe for vulnerabilities in both peacetime and wartime, to gain critical intelligence, deny opponents the use of, and confidence in, networked products and exploit the medium, for their own benefit and the exclusion of others. Cyberspace will see the development and operationalisation of a vast range of offensive and defensive measures, capabilities that in virtual terms will mirror and complement the hard capabilities available in the real world. At the same time, opponents will target and selectively destroy the physical infrastructure, connections and bearers of fixed and mobile Information and Communications Technologies (ICT), notably masts, servers and routing mechanisms.

Transoceanic fibre-optic communications cables will be subject to either compromise or severance.

Networked systems that are carelessly linked to other networks, with insufficient redundancy, imperfect safeguards, and permeable firewalls, will always be vulnerable to manipulation and degradation. Increasingly, dedicated, stand-alone networks, backed up with sophisticated counter-intrusion mechanisms and voluminous databases, will be created to ensure the integrity of future operations. These will be operated independently of existing servers, cables and telecommunication linkages, to avoid compromise and malware attacks.

SURFACE WARFARE

In most situations, surface vessels will be required to conduct those functions that require visible presence and seamless communications connectivity. For major powers, these will include aircraft carriers and major amphibious units designed to provide deployable air and power projection capabilities, together with other surface vessels, which deal with all those situations requiring direct human engagement, from humanitarian relief to coercive action. Surface vessels will also continue to be needed to transport large quantities of combat material and support the movement of men, equipment and supplies in bulk and over distance. They are also the most suitable types of vessels for a wide range of diplomatic tasks, including forward presence and assurance to allies and friends.

In addition, surface combatants (cruisers, destroyers and frigates) are needed to provide sensor platforms, weapons delivery and protective coverage for larger ships and merchant traffic, with systems that enable them to engage in above-water warfare against missiles and aircraft, underwater warfare against submarines and on the surface against other ships. Some can launch cruise missiles against the land, while others are equipped to engage ballistic missiles and satellites. All can host significant communications and data transfer facilities, as well as helicopters and UAVs. Their sensors will be a combination of hull-mounted, towed, streamed and unmanned variants; they will have the ability to remain acoustically and electronically silent, while off-board and cooperative sensors (in other

units) perform warning, targeting and electronic countermeasure tasks. In the light of increasing offensive missile capabilities, the trend will be towards multipurpose platforms that can combine the most utility and firepower with the most stealth characteristics to go in harm's way. As Alfred Thayer Mahan said, 'the back- bone and real power of any navy are the vessels which, by due proportion of defensive and offensive powers, are capable of giving and taking hard knocks'.[1] The guiding principle in the twenty-first century will be that if an asset is not lose-able, in support of strategic and operational objectives, it will not be use-able. It will not be a case of what you have, but what you can use.

Only major navies will retain the capacity and appetite to operate a balanced range of these specialist warships.[2] However, although great powers are likely to continue to invest in high capability, multi-purpose platforms, they will be constrained by the proliferation of both area and tactical denial systems and the cost ratios implied by having to suppress them. For most countries, the force mix is likely to see their defence forces employing, depending on resources, a combination of a few highly capable, multi-purpose warships and a range of other platforms configured for a range of roles.

Consequently, in the future environment, it seems probable that the trend for warship design will be for simple, cheaper hulls with common propulsion and power generation modules, as well as plug-and-play electrical and data highways that could accept a wide range of modular sensors, weapons and applications involving manned and unmanned vehicles. This approach would allow warships to be configured more appropriately and cost-effectively to combine peacetime and wartime roles, allowing mission-tailored system packages and technology insertion to be integrated within standard-sized containers and interchangeable between hulls. Some would large-hulled mother ships, which for leading maritime powers will include carriers and large amphibious ships, capable of deploying a range of well-armed manned and unmanned vehicles. They would be fully integrated within joint structures, enabling them to access – and contribute to – wider capabilities that could

[1] *Naval Strategy* (1911).
[2] A US Navy ARLEIGH BURKE Flight III class destroyer costs $3.7 billion at current (2025) prices.

be brought to bear at sea, through participation with air and land forces and the exploitation of intelligence, surveillance and targeting information.

There will also be consolidation of the trend towards cooperative networks of platforms and systems, incorporating both manned and unmanned technologies, able to absorb damage and reconfigure rapidly and providing redundancy and alternative routeing in the event of failures and disruptions. This will require, and is leading to, as we have seen, an extensive array of surveillance and targeting resources, linked to dispersed weapon platforms that are part of a sophisticated network of sensors and 'shooters'.

ABOVE-WATER WARFARE

As has been indicated, maritime warfare is now characterised by a marked increase in the visibility and vulnerability of surface platforms, notably in littoral waters and choke points, and in enclosed seas, as has recently been seen in the Black Sea and the Red Sea. Visibility and vulnerability are also progressively more evident in oceanic regions and the twenty-first century will be characterised at sea by an intense desire to know where everything is, whether for trade, commercial exploitation, or war. The tracking of one's own and a military opponent's (or commercial competitor's) assets and assessments of his likely intentions will be crucial to success.

Technological advances, particularly in satellite imagery, multi-spectrum sensors, radars and UAVs, as well as area arrays, have enabled much greater coverage of oceanic areas and the location of potential threats. In the future, a wide range of military and commercial satellites will determine the position and identity of individual ships, through optical, radar, signature detection and electronic means. The increasingly sophisticated sensors of space-based platforms, maritime patrol aircraft, wide-area UAVs and land-based systems, coupled to increasingly powerful and capable AI-enabled data analysis, management and exchange networks, will make the task of concealment even harder.

Regarding vulnerability, most notable in this regard is the diversity and numbers of extremely capable cruise and ballistic anti-ship missiles that can be fired from land, sea, or

air, as well as by submarines and sub-state proxies. These will be rapidly joined by hypersonic variants and supplemented by a profusion of unmanned attack applications, operating in the air, on the surface and underwater. Even ships and other vessels alongside are not safe, with extensive provision required for defensive measures, concealment, and the likelihood of a revival of underground docking, maintenance, and storage facilities.[3]

In the immediate future, the balance of advantage in high-end warfare is likely to lie with offensive systems. Their precision, lethality and ability to discriminate between various targets will improve still further, especially when linked to sophisticated surveillance and networked systems. As a result, ships will require increasingly capable and expensive anti-air and anti-missile systems, as well as greatly improved anti-torpedo provision, if they are to perform their operational functions.

New technologies will be needed in the design and operation of surface ships, with increased power generation required to operate a wide range of energy-hungry systems. Greatly increased computing and processing power will enhance the performance and fidelity of sensor systems, such as radars, electro-optical devices and sonars. The introduction of directed-energy weapons (DEWs), electromagnetic rail guns and possibly coil guns is likely to enable the cost-effective engagement of the wide range of high-performance offensive missiles and projectiles. These new technologies will have a transformative effect on the offensive and defensive capabilities of warships in the above-water environment, with the balance of advantage and cost ratios shifting towards defence. The generation and storage of large amounts of electrical power will possibly lead to the development of active force fields, as well as mirrored and other reflective surfaces and coatings that will deflect the impact of DE. There will also be disruptive technologies such as high-endurance, autonomous underwater vehicles (AUVs), anti-satellite options and electromagnetic and cyber penetrators.

[3] During the Cold War, several countries built underground facilities for their navies. Sweden, for example, constructed a huge underground complex at Muskö inside a rock face of solid granite, capable of housing submarines and a range of warships up to destroyer size. Today, the Chinese naval base at Yulin on Hainan Island has an underground facility that hides up to twenty nuclear submarines from attack, surveillance and satellites.

In addition, there will be increased investment in reducing the electronic signatures, radar cross-sections, visual profiles and emissions of surface vessels and increasing their 'stealth' characteristics. All these measures will be designed to prevent detection and identification in the first place and, if unsuccessful, reduce to a minimum the chances of a successful engagement by a weapon. As well as reducing radar signatures through design and material measures, they will also extend to employing artificially intelligent decoys and altering received radar and visual images. They will also involve the innovative use of visual disruption, camouflage and composite materials, electronic and physical obscurants and nanotechnology. Meanwhile, unmanned applications will be used for confusing and distracting incoming missiles, alongside novel ways of jamming and manipulating radars and other electronically based sensors, coupled with capabilities to deceive and distract imagery, electronic intercept, and radar satellites. These solutions will be based around offboard and unmanned autonomous and semi-autonomous decoys and emulators, integrated within an agile electronic deception, distraction and denial ecosystem at sea. This approach also needs to be complemented by signature suppression and the means by electronic, multi-spectrum, physical and cyber footprints can be reduced, manipulated and where possible obscured. Nanotechnology could deliver nanobots and micro-flyers that can swarm and generate false signals and images to satellites, surveillance sensors and missile-targeting radars. It would also meet both protective and deceptive requirements, in the form of non-reflective coatings and composite materials.

Alternatively, increasing numbers of warfare functions could be based in submersible or semi-submersible platforms, to reduce the vulnerabilities of surface ships to highly manoeuvrable transonic and hypersonic missiles and to take advantage of the inherent stealth properties of the underwater dimension. Submarines would be the prime beneficiaries, with increased investment applied to make them even more versatile and their size and displacement growing as they incorporated more systems and acquired new roles. These might include functions currently associated with surface combatants, such as land attack and air defence (firing missiles from submerged positions against targets detected by a third party), as a mother ship for a variety of unmanned applications and for assault force insertion.

Semi-submersibles would have the bulk of their structure under the water, with a low freeboard section above the water, comprising light, low-observable composite materials and sensors, which would limit detection opportunities for a wide range of enemy sensors. They would have access ports for both manned and unmanned vehicles, missiles and communications bearers, including aerostats. This arrangement would prevent or limit potential action damage to vital parts of the vessels, with the section above the water being readily replaceable or repairable.

AMPHIBIOUS WARFARE

The freedom of the high seas gives sea-based, especially amphibious forces unrivalled opportunities to influence events and decisions on land, especially when they are positioned in good time and deployed from high readiness. As long ago as 1759, a pundit wrote: 'A military, naval, littoral war, when wisely prepared and discreetly conducted ... comes like Thunder and Lightning to some unprepared part of the world.'[4]

However, even against modest sea denial opponents, the risks involved in approaching hostile or even moderately unfriendly shores, owing to the acquisition of cheap, advanced drones and missiles by potential opponents, means that traditional methods of conducting assaults against the land are likely to be prohibitively risky. With a diminished chance of operational and tactical surprise, amphibious forces would have to stand further out to sea unless an environment is sufficiently shaped and hostile forces suppressed to enable them to come close inshore and ashore to exploit opportunities.

As a result, instead of previous, large-scale amphibious landings, a more dynamic, flexible joint approach will be necessary that capitalises on the surprise and speed generated by maritime forces poising offshore and ranging at will along a coast. The accent would be on generating high levels of operational tempo and achieving the conditions for tactical surprise in many places simultaneously. In this way, operational 'bubbles' of opportunity,

[4] Thomas More Molyneux, *Conjunct Expeditions* (1759).

defined by time and area, would be established, secured and sustained for the minimum time necessary and subsequently collapsed around those objectives to which force was to be applied to achieve the desired effect.

For most of the last century, there was a fixed assumption that 'boots on the ground' were always required to bring conflict to a successful conclusion and that ground had to be occupied to secure military objectives. Mobility, cooperative firepower and high-speed information processing are likely to allow military action to take place from increasingly long-range locations and for shorter times, while reducing the time and 'footprint' on the ground. These 'high-impact, low-footprint operations' would be prioritised towards the achievement of operational objectives with the minimum of effort and risk, with the least exposure of combat forces in time and space to the actions of an opponent or hostile forces.

A commander's calculation should, in the future, centre on how few troops he or she needs to complete a mission, rather than concentrating as much human force as possible. It is likely that 'occupying ground' will in future be seen as a very blunt way of achieving objectives, one that is unlikely to be employed, except by forces that lack the technical sophistication to engage in low-footprint, high-impact operations, in peace support activities and in situations involving total war. In effect, assets will be required to isolate and shape a target area, so that small groups of attackers can achieve their objectives, with the aim of reducing the numbers of humans in direct contact with an opponent. In terms of 'boots on the ground', this approach could be likened to the reduced weight of precision-guided munitions bombs that is needed to destroy a target compared to previous 'dumb' bombs.

This approach would place a premium on special forces and dedicated assault formations, with high levels of mobility, agility and the ability to access firepower, on call from a wide range of other platforms, including ships, aircraft, missiles, drones and land-attack and loitering munitions. This is the concept of a 'fire basket' into which aircraft and a range of time-critical, loitering and fly-through munitions are provided by ships at sea and elsewhere, yet guided to their targets by the troops on the ground, possibly through laser designation or direct steering of the weapons as they arrive over the battlefield. These developments

are likely to reduce the logistical footprint and increase the agility of ground forces and reduce vulnerabilities significantly.

In these circumstances, the specialist amphibious ships could be employed more as dedicated fighting platforms, with marines or troops employed as the weapon systems of those ships. Added emphasis can then be given to making ground precarious and untenable for the enemy rather than occupying it. This means that instead of the traditional amphibious landing, with its heavy footprint and slow build-up, assault forces would undertake a range of lower-footprint, dispersed, but high-impact operations over a wider area supported from the warships offshore and wider joint assets.

Troops could be deployed by high-speed vertical take-off and landing (VTOL) and tilt-rotor aircraft, helicopter, assault craft and air cushion vehicle straight to their objectives to facilitate surprise and permit inshore threats to be bypassed or minimised. Thus, it would be possible to exploit more fully the mobility, protection and infra-structure facilities available afloat and to deploy directly from the ships, with men, equipment and vehicles returning on completion of missions and spending the minimum time ashore. The ships would also provide a 'reverse slope', if it is necessary, to deploy and recover as part of a rolling campaign of continuous assaults, or if it is required to reconfigure or retire in the face of overwhelming force or the use of chemical weapons.

UNDERWATER WARFARE

The future underwater space presents both opportunities and challenges. The arrival of unmanned systems and AI-enabled data processing will make the underwater space marginally less opaque and will allow a range of increasingly effective barrier and dynamic anti-submarine and anti-UUV solutions, while providing additional options for deterrence and sea denial. In particular, the use of intelligent unmanned systems as static, mobile and loitering sensor platforms and mines will both enable the shaping of operating areas and influence the choices and risk assessments of opponents. It hardly needs to be added that these technologies will similarly empower opponents, with attention and investment required to nullify or mitigate their use.

As indicated above, underwater warfare will evolve in response to increasing numbers of functions being stationed in underwater platforms to take advantage of the stealth and secrecy opportunities provided by the sea. Nuclear attack and hunter-killer submarines, and their conventional and advanced diesel-electric cousins, will remain important elements in most war-fighting navies in the early twenty- first century. Nuclear submarines with their flexibility, endurance, high-speed advantage and inherent stealth, survivability and ability to surprise, along with their global reach and sustainability, will persist as formidable opponents. Their presence or mere indication of proximity dramatically shapes the geometry of a tactical situation and the perceptions of opposing commanders. They will continue to host a variety of anti-ship and anti-submarine weapons, as well as both nuclear and conventional land-attack systems, backed up by increasingly sophisticated communications and data transfer systems. Less expensive but having many of the same advantages as nuclear submarines are those equipped with air-independent propulsion (AIP), which enables them to remain submerged without recharging their batteries for anything up to three weeks.

In future, submarines will be more than just ship sinkers (their instinctively preferred role) and will be increasingly employed for other functions, both as multitasked, jacks-of-all-trades (descendants of the current hunter-killer submarines) and as specialist platforms (such as the ballistic missile variants and the modern cruise-missile-firing OHIO class). They will also deploy unmanned vehicles for self-protection, surveillance and attack, as well as manned vehicles for covert operations and insertion. Autonomous and tethered unmanned underwater vehicles (UUVs) will scout out ahead of submarines to detect mines and other submarines, and to conduct covert reconnaissance. The deployment of UAVs while submerged will expand significantly the tactical horizon of submarines, which hitherto has been limited by what could be detected by a submarine's periscopes, sonars and masts and the information provided from external sources. They will also allow more agile response to targeting and guidance information from third-party platforms.

As a result, the hulls and weapon and mission bays of submarines – and their discharge systems – will need to adapt. These are likely to include acoustic cloaks formed of meta-

materials and various autonomous vehicles, pre-programmed with signatures and other deceptive devices. As a result, future submarines are likely to need to change their traditional configuration and shapes, to accommodate new sensors and weapons. They will need alternatives to torpedo tubes, especially for housing and releasing unmanned vehicles that will operate as sensor and weapon platforms and as communications nodes. In addition, there will be increased emphasis on reducing or masking the acoustic, physical and emission signatures of submarines.

However, new technologies mean that submarines are unlikely to have it all their own way in the new environment. Modular solutions already include both active and passive acoustic sensors; deployable (and retrievable) bottom and barrier arrays; and semi-submersible and deep-diving vehicles. Semi-submersibles are already capable of operating multiband and multi-function transducers alone or as part of a networked system. Meanwhile, both manned and unmanned air vehicles are both used for deploying torpedoes and sonobuoys. Likewise, unmanned surface vehicles (USV) have successfully operated dipping sonar, multi-static active sonar and ultra-lightweight towed arrays. It is probable that submarines and underwater craft will find that their ability to remain undetected below the surface will be challenged by the presence of this range of unmanned vehicles, denial systems (predominantly mines and other barrier systems) and wide-area sensor arrays.

Initially, these will be manifested in a range of acoustic sensors and arrays, which will be positioned on the seabed and deployed from aircraft, other submarines and ships. These will include both dormant and active elements, some with the ability to track, classify and engage when necessary. Submarines would find themselves beset, not only by other capable submarines, but also by swarms of dormant or mobile underwater vehicles, both autonomous and manned and linked to networks of sensors, which would only have ears for them. The UUVs will have the luxury of being able to use their active sonars with impunity and will be able to bring more capable helpers to the scene. The presence of unmanned vehicles in these quantities may have the effect of significantly reducing the stealth advantage of submarines. Large, high-endurance UUVs fitted with active sonars that activate when passive sensors indicate an object of interest will patrol wide areas of ocean

on an autonomous basis. They will make the task of ballistic missile-firing submarines, whose prime motivation is to remain undetected, considerably more challenging.

Similarly, the drive by states to increase control in their offshore zones, particularly in the EEZs, will lead to the proliferation of networks of underwater detection, recording and response systems. Based around both passive and active acoustic sensors, with integrated analysis and processing facilities, these networks will be linked to anti-intrusion and alerting mechanisms, as well as mines and dormant weapons. Even now, a wide range of civilian applications is unwittingly collecting sensitive acoustic data, including discrete frequencies associated with submarines. These sensors range from academic sampling by fixed and mobile devices and acoustic sensors that sample and test whether marine energy platforms represent an environ- mental and ecosystem risk.

Mines are a simple, cheap way of denying an opponent sea-space and deterring vessels from exercising their rights of innocent or transit passage through waters over which a country wants to exercise jurisdiction. In the future, mines with greater detection ranges and target discrimination (increasingly sophisticated variants will target specific platforms and employ advanced counter-detection and counter-clearance measures) are likely to be made of composite materials that will be difficult to detect by sonar alone. They will incorporate the facility to bury themselves in the seabed. Linked to extensive arrays of sensors, both acoustic and non-acoustic, which will be positioned on the seabed and within the water column, mines will become increasingly mobile, possibly as unmanned underwater vehicles.

They are particularly effective against submarines. They are also attractive as an asymmetric option in the littoral, where even primitive mines pose a significant sea denial capability and a substantial threat to maritime forces, including amphibious forces and inshore submarine operations. Their suppression will require the development of active 3D close-range sonar imaging, lasers and through the more intensive use of UUVs. Mine Warfare (MW) has already moved quickly into the adoption and operation of unmanned applications, using remote and airborne mine-hunting, detection (including lasers) and neutralisation systems.

Finally, as armed forces look to take advantage of the benefits of stationing more of their assets in the stealthy undersea domain, it is feasible in the future that there will be underwater bases, both for protective and operational reasons.[5] Technology, using off-the-shelf petroleum, mining, submarine and nuclear equipment, allows the establishment of permanent manned installations on the sea floor that do not have any air umbilical with the land or water surface, yet maintain a normal one-atmosphere environment.

NUCLEAR WARFARE AT SEA

Substantial number of nuclear weapons are based at sea, most of them fitted to intercontinental ballistic missiles in nuclear submarines, together with those associated with missile, bomb and torpedo delivery systems. Russia and China have explicitly stated that they consider nuclear weapons as warfighting as well as deterrent options. As such, there would appear to be significantly more risk of a nuclear device being used at sea than against land targets. The regime of a power with nuclear weapons that is in future threatened with the overwhelming conventional firepower could resort to nuclear weapons to offset its conventional inferiority. Such might be the case in response to the deployment of carrier battle groups or large concentrations of war materiel in transit to an operational theatre, especially in circumstances (at sea) where the potential perpetrator might believe the effect and subsequent political (and physical) fallout to be containable. All the indications are that tactical nuclear weapon use will resume its Cold War role and profile.

CONCLUSION

History suggests that navies - and armed forces in general - should not rely on the imperfect assumptions that have underpinned recent peacetime-generated strategy and policies while operating in conditions of continuous strategic competition, which might be punctuated by periodic high-impact events or armed action in at sea. In a connected, but contested two-bloc world, the likelihood is that only credible, demonstrated and immediately available

[5] As long ago as 1966, the US Navy recognised that large undersea installations with a 'shirt sleeve environment' could exist on the continental shelf.

combat capability will be sufficient, as in the Cold War, to prevent conflict, limit escalation, protect interests and deter opportunists and potential aggressors at every level of interaction.

Many incidents at sea will not be determined by the aggregate strength of competing naval orders of battle. The key essential in any maritime encounter or engagement will be the ability to achieve local relative superiority through the ability to concentrate and realise decisive effect at a time and place of choice. Again, that does not mean the concentration of forces or activity, but the concentration of impact, possibly through cooperative and distributed deployment of all three components of fighting power (physical, moral and conceptual), that cumulatively realise a successful encounter or engagement. It will specifically draw on Joint Action, the ability to synchronise fires, influence and manoeuvre in the most effective and economical way and the ability to call on all sensors, systems and weapons, not just those deployed at sea, able to determine the outcome of a particular situation.[6]

To compete in future, navies will require agile conceptual thinking, adaptive technologies and responsive supply chains to deploy innovative concepts and effective capabilities, both to sustain the initiative at all levels of maritime engagement and to ensure that ways and means remain sufficient and appropriate to achieve acceptable outcomes, mitigate the risks and cope with the unexpected. They will also require a command culture that maintains tight organisational control of a bewildering array of assets and actionable information, while encouraging mission command and de-centralised operation to deal with the reality on the ground and the unforeseen.

[6] 'You can see that we are going to fight in a system-of-systems way. It's really a joint warfighting ecosystem. … We are going to have capabilities that we deliver through the Navy that enable other services to use their capabilities, and it's this ecosystem of interdependent capabilities that we need to be able to contribute to [sic].' Chief of US Naval Operations, Admiral Lisa Franchetti, presentation at the Stimson Center, 3 Dec 24 (Air and Space Forces Magazine 3 Dec 24).