The Naval Warfare Domain

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The maritime domain, in and through which operations on and under the oceans and seas are conducted, presents unique challenges as well as advantages to maritime nations and military forces. The domain is generally subdivided into two primary categories: littoral (coastal) and open ocean ("blue-water"). The littorals are defined by relatively shallow waters and close proximity to the coasts and include the territorial waters of coastal nations. Open-ocean operations, as the name suggests, are marked by waters beyond the maritime boundaries of nations, with their extreme depths and vast spaces.

While the maritime domain demands some common capabilities and operational concepts for all naval forces, littoral and blue-water environments require very different forces and warfighting strategies. The maritime domain drives some common characteristics for naval vessels: relatively large size and payloads compared to land and air platforms, slow speed, limited organic sensor range, long-range communications requirements, and naval logistics. In addition, the maritime domain shapes naval concepts of operations with tactics such as layered defense, forward presence, and sea control.

Importance of the Maritime Domain

Since prehistoric times, the world's oceans and seas have played a critical part in the development of mankind and many of man's dominant civilizations. Evidence suggests that the earliest man-made boats date back as far as 45,000 years.[1] Initially, these vessels were used for coastal fishing, but as they became larger and more sophisticated, people used them to trade with other coastal civilizations. Once man learned to navigate beyond sight of land and to harness the wind, exploration and trade routes developed across the Mediterranean Sea, the Arabian Sea, the Indian Ocean, and the Pacific Ocean. Maritime exploration also led to human migration between continents and island archipelagos.

The development of larger vessels made it possible to transport greater quantities of commodities both faster and more cheaply than was possible over land routes. These maritime trade routes eliminated the need to transit through the sovereign territory of other nations and pay often exorbitant tolls. However, the movement of large amounts of precious commodities by sea soon led to the rise of piracy. Just as land armies arose to defend national borders and trade routes, armed naval vessels soon arose to help protect these maritime trade routes. From the Ancient Egyptians to the Greeks and on to the rise of the British Empire, dominant maritime trade and naval power were critical to the rise and expansion of these empires.

The oceans and seas still play a vital role in the prosperity and protection of most of the world's population. Of the world's 195 nations, 147 border an ocean or sea, and 40 percent of the world's population lives within 100 kilometers (62 miles) of an oceanic coast.[2] In addition, maritime trade through international shipping lanes comprises over 90 percent of global commerce.[3] In a modern world that appears to be dominated by wireless communications and satellite broadcasts, 99 percent of all international data (phone, texts, and Internet) is transported over approximately 200 undersea fiber optic cables at speeds eight times faster than satellites.[4] While typically very robust, these submarine cables are susceptible to landslides and other seismic events.

Challenges and Advantages of the Maritime Environment

For those whose experience with the oceans is limited to the coasts, the vastness of the world's oceans is difficult to convey. The five recognized oceans (Atlantic, Pacific, Arctic, Indian, and Southern) cover 71 percent of the Earth's surface with an average depth of 13,000 feet.[5] The Atlantic Ocean covers "approximately 41,105,000 square miles," and the Pacific Ocean covers "more than 60 million square miles," or approximately 20 percent and 46 percent, respectively, of the Earth's surface.[6] For comparison, the Pacific Ocean is larger than all of the Earth's land masses combined;[7] the continental United States covers only 3,120,426 square miles (1.58 percent) of the Earth's surface.[8]

The vastness of the world's oceans presents both advantages and challenges. The immense oceanic distances and limited speed of ships (10–15 knots on average for transoceanic travel) create natural barriers of time and space. For example, these barriers prevented transoceanic exploration and colonization for centuries until shipbuilding technology and seafaring techniques became advanced enough to withstand storms, navigate safely, and carry sufficient supplies to survive weeks or months of travel. While land forces can resupply along their route with local fresh water and food, transoceanic vessels must be self-sufficient for extended periods, carrying or making adequate fresh water, food, and fuel.

The limited speed of naval vessels limits their rapid responsiveness or repositioning. For example, the great circle route (the shortest distance between two points on the curved surface of the Earth) between Norfolk, Virginia, and the Strait of Gibraltar at the entrance to the Mediterranean Sea is 3,326 nautical miles. For a ship traveling at an average speed of 12 knots—a common economical speed for commercial shipping—it would take 11.5 days to make this transit, while a modern jet passenger aircraft traveling at 500 knots would take approximately six hours and 40 minutes.

This time and distance effect requires preplanning or prepositioning of naval forces if a nation desires a timely transoceanic response to maritime crises. For the United States, this has meant development of a forward-deployed blue-water Navy. Maintaining a credible deterrent force constantly deployed near potential naval adversaries enables the U.S. to respond rapidly to maritime security crises before they approach America's shores. This could not be accomplished with naval forces that remain predominantly in their home ports or near territorial waters.

The expanse of the oceans and the lack of landmarks once a sailor gets beyond sight of land present unique navigational challenges when traversing thousands of miles of ever-changing ocean surface. The fact that the ocean's surface varies from one second to the next and does not offer any geographical reference points has led to the development of rather sophisticated navigation techniques and technologies. Satellite navigation systems such as the Global Positioning System (GPS) provide a highly accurate real-time ship's position for both military and commercial vessels. GPS and related technologies have afforded military naval vessels the required positioning, navigation, and timing (PNT) accuracy that enables use of precision-guided munitions and coordinated military operations.

With the advent and subsequent proliferation of GPS-denial or degradation technologies, it has become essential for modern military vessels to have backup navigation systems that are resilient and reliable even in the face of enemy actions. Celestial navigation—the determination of one's position on the Earth's surface based on the position of celestial bodies, typically the sun, moon, or specific stars—is one such technique that relies on a clear sky and a highly accurate chronometer. An essential skill for sailors across the centuries, celestial navigation is again being taught to young sailors as navies recognize that they cannot rely solely on GPS. Another critical GPS-denied navigation method is inertial navigation, which provides the speed and position of a ship or other platform by measuring its acceleration in all three dimensions. Once extremely large and expensive, current solid-state inertial navigation units are getting smaller and cheaper, enabling their use on small surface vessels and even on unmanned undersea vehicles (UUVs).

The vast ocean expanses have also provided a measure of stealth for naval vessels, although this is becoming less and less true. For years, most modern naval vessels relied primarily on organic radar and electronic support measures (ESM) systems to locate and target adversary naval vessels at over-the-horizon (OTH) ranges beyond the line of sight. Maritime patrol craft and carrier aviation early-warning aircraft were able to extend the ability of these warships to locate and engage adversaries, but the ocean is a very big place, and even with radar, finding a comparatively small ship was still a challenge.

With the rise of intelligence, surveillance, and reconnaissance (ISR) satellites, this "stealth via vastness" was further reduced. The limited number of ISR satellites, however, precluded continuous coverage of any specific area, affording naval vessels opportunities in specific time and location windows to avoid detection.

The current proliferation of commercial and military electro-optic/infrared, radar, and electronic intelligence (ELINT) satellites is providing greater coverage of and more frequent revisit rates to the world's oceans. In addition, maritime domain awareness technologies such as the Automatic Identification System (AIS) provide the location and identity of commercial shipping, thereby helping to clarify the maritime picture. The proliferation of ISR unmanned aerial vehicles (UAVs) is also changing maritime surveillance by greatly increasing the capacity for real-time OTH ISR and targeting information for naval platforms. Not only can long-range land-based UAVs provide ISR coverage hundreds of miles from shore for 12 hours or more at a time, but smaller UAVs are being fielded that can be launched and recovered from naval platforms, providing naval fleets with organic ISR and cueing.

While these systems still have gaps in coverage and some require complex algorithms to scour the vast amounts of imagery required for open-ocean searches, it is getting harder for a large surface naval vessel such as an aircraft carrier to hide in the open ocean. To this end, many modern navies are regularly practicing electromagnetic emission control (EMCON) operations as well as developing technologies and tactics to deny or degrade ISR satellites and related platforms.

The ocean's depths provide their own condition of stealth for submarines and other undersea platforms such as UUVs, enabling undersea forces to move unseen and relatively undetected by adversary forces. This is because the environment below the ocean's surface is drastically different from the world above it. While light and radio waves can travel thousands of miles through the Earth's atmosphere, they penetrate the ocean's depths only from several inches to a maximum of several hundred feet depending on the frequency of the electromagnetic wave (light or radio waves). For example, only a minuscule fraction of sunlight penetrates the ocean's depths beyond approximately 650 feet, and for much of the ocean's depths, visibility is less than 100 feet in any direction. Radar and other radio transmissions cannot be used to search for objects or to communicate with submerged submarines or other undersea platforms. Although this limits the ability of submarines or other undersea platforms to communicate with ships, aircraft, or land-based headquarters, it also hides them from all but the most advanced search techniques.

While the air is the domain of radio waves and light, the ocean's depths are the domain of sound. Sound is the most effective means to communicate or to detect objects across the vast expanse of the oceans. Compared to light and radio waves, sound can travel from thousands of yards up to thousands of miles in water. For example, the vocalization of blue whales (at frequencies as low as 14 Hz) has been detected thousands of miles away.[9] Sound also travels eight times faster in water than in air, and sound waves travel faster as temperature, water pressure, and salinity increase. The deeper, warmer, and saltier the water, the faster sound travels.

The variance in ocean temperature and pressure with depth and geographic location can be exploited to benefit naval operations. Differences in temperature and pressure cause sound waves to bend (or refract) toward the area of slower speed of sound. This bending of sound waves can create "acoustic blind spots" as well as deep-sea sound channels where sound energy is easily transmitted for long distances. Lower-frequency sound travels further in water than higher-frequency sound does. Submarines, surface ships, and aircraft hunting for submarines, as well as land-based command centers communicating with submarines, will use these characteristics to hide from acoustic search or to pulse acoustic energy into the water to affect communications or locate an object.

Background ocean noise can mask quieter noise sources such as submarines. The primary factors contributing to ocean background noise are the sea state (how big the waves are); the amount of local shipping traffic; seismic events such as undersea earthquakes, volcanic eruptions, rock slides, and thermal vents; other noisy maritime evolutions such as fishing and offshore drilling; and even the animal life of the ocean including clicking shrimp, whales, and other marine mammals like porpoises.

Finally, undersea topography can affect the transmission of sound. The ocean's bottom varies from extraordinarily deep trenches to broad plains and undersea mountains, with the floor rising dramatically at times to form walls that stretch upward to the continental shelves. Acoustically, the shallow littoral waters behave differently from the deep oceans as sound waves repeatedly bounce off rocky bottoms and the ocean's surface or are attenuated by muddy sea floors. As on land, these undersea terrain features can affect the transmission of sound and the flow of currents, which in turn can affect temperature gradients as water flows, rises, and falls. The complexity and variability of ocean waters drives undersea naval forces to monitor these changes continuously and alter their tactics and operating profile to exploit any acoustic advantage as effectively as possible.

There are two main types of sound navigation and frequency ranging (SONAR) that provide an acoustic "picture" of the undersea world. The first is passive sonar, which essentially is listening for any noise sources on or below the ocean's surface. Passive sonar provides only the direction from which the sound came.

Active sonar provides a much more complete picture of the undersea environment. Like bats and whales, ships and submarines can transmit sound and then listen for the return echo as the sound wave bounces off an object. Most surface vessels, from small pleasure boats to large commercial transports and naval vessels, use high-frequency active sonar (tens to hundreds of kHz) "depth sounders" to determine the ocean depth beneath them. Active sonars used by submarines and other naval vessels are typically in the 1 kHz to 10 kHz range, with some high-definition sonars in the 100 kHz to 1 GHz or higher range. While the higher frequencies give better resolution of the ocean bottom and other undersea objects, their effective range is less than 100 meters. Conversely, low-frequency active sonars (less than 1,000 Hz) can potentially detect submarines at tens of thousands of yards in proper acoustic conditions.

The disadvantage of active sonar is that the transmitting platform gives away its own presence and position. Since they do not want to surrender their acoustic stealth, U.S. submarines therefore operate their active sonar only in very select tactical situations.

The global maritime commons differ greatly from land, where nations have very visible geographic boundaries, and long-standing protocols—codified in laws, treaties, and recognized practices—govern how countries interact with each other. Whereas almost all of the Earth's land masses are claimed by one nation or another, the vast majority of the 139.7 million square miles of its oceans are international waters and not subject to any one nation's laws or control.[10] This means that ships can sail almost anywhere without needing the permission of or being subject to restrictions or obligations imposed by any one nation.

The 1982 United Nations Convention on the Law of the Sea (UNCLOS) defines a nation's territorial sea as a belt of coastal waters extending at most 12 nautical miles from its coast. The United States has not ratified UNCLOS because of concerns about some of its provisions, but it does recognize the agreement's conventions on territorial limits and freedom of navigation as customary international law and has established similar sovereign rights in U.S. law. While territorial waters are regarded as the nation's sovereign territory, foreign ships (both military and civilian) are allowed innocent passage through them, or transit passage for straits, under specific guidelines. This sovereignty extends to the airspace and seabed.

UNCLOS also establishes an Exclusive Economic Zone (EEZ) in which a coastal state assumes jurisdiction over the exploration and exploitation of marine resources in its adjacent section of the continental shelf, taken to be a band extending 200 miles from the shore. Another important aspect of UNCLOS and international maritime law is freedom of navigation, according to which ships flying the flag of any sovereign state shall not be subject to interference by other states.

Since no one nation's laws apply to these international waters, they are governed by several multilateral treaties. The most important is the 1972 Convention on the International Regulations for Preventing Collisions at Sea, which establishes among other things the "rules of the road" or navigation rules to be followed by ships and other vessels at sea to prevent collisions between vessels. Since there are no marked traffic lanes or stoplights on the open seas, all ships must remain vigilant with respect to the course and speed of other vessels. As the USS *Fitzgerald*'s June 2017 fatal collision with a Philippine container ship demonstrates, even routine at-sea training operations are dangerous and require a minimum safe level of proficiency.[11]

In short, international maritime laws afford the U.S. Navy the ability to project power in response to crises or attempt to deter potential adversaries by sailing U.S. warships anywhere around the globe without having to obtain the permission of any other nation. In similar manner, they also afford maritime competitors the opportunity to sail their naval platforms off the U.S. coast. Visible examples of this are the recent periodic deployments of Russian submarines off the east coast of the U.S. near U.S. naval bases (e.g., Kings Bay, Georgia).

While some nations focus their navies on coastal defense against adversaries operating near their coasts and territorial waters, the U.S. Navy has taken a different approach. The Navy's maritime strategy since World War II has focused on maintaining a continuous forward naval presence that strives to deter adversaries and, if necessary, engage them in the open ocean or near their own coasts, keeping the fight and threat far from U.S. shores. At present, no other nation can conduct routine, sustained naval operations far from its home waters as does the U.S. However, some near-peer competitors like Russia could attempt to deploy small numbers of nuclear-powered submarines off the U.S. coast to launch missiles armed with conventional explosives against targets of vital importance to the U.S. In light of this threat, the U.S. Navy and U.S. Northern Command (USNORTHCOM) maintain the ability to find and target adversary undersea forces closer to the U.S. homeland.

Implications of the Maritime Domain for Naval Forces

The ocean and its unique characteristics place demands on and drive the design of a nation's navy. This is most readily apparent in the difference between a littoral or coastal defense navy and a blue-water or global open-ocean navy.

A coastal navy is focused on protecting a country's territorial waters and adjacent international waters. How far a nation's maritime area of concern extends from its coast will depend on the nation's strategic focus and the size of its navy. A coastal navy that operates within several hundred miles from the coast can consist of smaller vessels such as fast attack craft, frigates, and diesel submarines. Since they generally will operate at sea for days to weeks rather than months, they do not require the size and ability to carry large amounts of supplies, fuel, and ammunition.

Coastal waters typically are more protected from severe storms and seas; as a result, coastal naval vessels can be smaller and less robust than open-ocean warships. Also, since they operate closer to shore, these naval vessels will be less dependent on satellite communications and long-range ISR than are their blue-water counterparts, which operate thousands of miles from their military commanders. If necessary, these navies can use line-of-sight UHF or VHF communications with aircraft or other surface vessels to pass urgent communications. Smaller fast attack craft employ shorter-range (tens of miles) OTH anti-ship missiles that can receive targeting information from onboard or, in some cases, even shore-based radars. Larger frigates will operate farther from shore and can support longer-range OTH weapons that can engage adversary surface vessels at ranges in excess of 100 miles, requiring timely and accurate targeting information from other ships, aircraft, or space-based ISR.

Diesel submarines are perfectly suited to the coastal defense mission. Usually operating in a defensive posture off a strategic area of the coast or near a choke point, diesel submarines can operate at very slow speeds (five knots or less) that allow them to conserve their battery energy, which provides propulsion and electrical power while submerged. In areas where the continental shelf extends into diesel submarine patrol areas, modern diesel submarines can even bottom themselves to conserve energy even further.

A modern diesel submarine operating on its battery or Air Independent Propulsion (AIP)[12] is extremely quiet and difficult to detect by passive sonar, especially when operating in or near congested coastal waters. A modern diesel submarine armed with wake-homing torpedoes requires only a moderately proficient crew to attack an adversary's surface ship as it transits through a choke point. A coastal defense approach can be supported by land-based aircraft (fighters, maritime patrol craft, and helicopters); OTH radars; and anti-ship cruise missiles. A coastal navy also does not require a large fleet of logistics ships, because its ships and submarines can return quickly to port for fuel, supplies, and weapons.

Naval mines are extremely well suited to a coastal defense strategy whose primary mission is to keep potential adversaries out of its area of concern or far enough away that they are unable or degraded in their ability to conduct maritime strikes ashore. Naval mines are relatively cheap compared to modern precision-guided munitions, and a littoral minefield can easily be laid by small naval vessels or even by militia vessels (civilian vessels that can be used for some low-end military missions). Just one ship hitting a mine effectively shuts down a choke point or area of concern until it can be confirmed that all mines are cleared. Since the high-frequency sonars required to detect undersea mines have limited range, it can take weeks or months to survey and clear a suspected minefield. This mission gets even harder if the local adversary has surface dominance over the minefield area, thus preventing the use of mine countermeasure ships.

Since the transit time to and from coastal navy's bases to desired operating areas is relatively short (hours to days), a smaller force can maintain a specific defensive posture.

Additionally, coastal navies can surge additional forces quickly if needed and have them on station within hours. Finally, coastal defense navies can use undersea acoustic arrays in or near their territorial waters to provide early warning of adversary submarines or unmanned undersea vehicles approaching their coastlines or critical undersea infrastructure.

A blue-water or global open-ocean navy like the U.S. Navy has very different demands that drive the design of its vessels as well as the overall structure of the force. Since these warships operate thousands of miles from their nearest naval base for months at a time, they must be larger than their coastal counterparts for a variety of reasons. First, blue-water naval vessels must be large enough to withstand the worst possible storms and seas; a ship with a maximum speed of 20–30 knots may not be able to outrun a hurricane or other large storm. They must also have larger crews to support sustained 24-hour operations for months on end and perform preventive maintenance to ensure maximum operational readiness.

Since forward-deployed warships cannot count on getting supplies from a port in their forward operating areas during a time of conflict, they must be able to carry sufficient supplies (food, spare parts, etc.) to operate for several months if necessary and must carry sufficient fuel for an operating range of several thousand miles to enable transoceanic crossings without refueling. Blue-water naval vessels also require weapons magazines that are large enough for them to perform their initial warfighting missions.

These warships are usually multimission, since operational commanders must have the flexibility to respond rapidly to numerous military contingencies without waiting weeks for the warship with the "right mission capability" to arrive. While not every ship can perform every mission, having a mix of numerous multimission ships forward deployed enables these naval forces to respond to the vast majority of contingencies. Blue-water navies also require a large logistics fleet to resupply warships with food, fuel, repair parts, and ammunition while underway, thereby enabling them to remain forward deployed and on station for months on end.

The level of training required for blue-water sailors to attain the required proficiency to operate safely and effectively in the harsh open-ocean environment is significantly greater than the level needed for short-duration littoral operations. This training must include at-sea local area operations to simulate the conditions they will face on deployment to ensure that the crew is proficient in all potential missions they could be called on to perform.

An open-ocean global navy requires a much larger force structure than its coastal counterpart. The typical rule of thumb for naval force structure is that it takes a minimum of four ships of a given class to have any one of those ships deployed. This accounts for one vessel in major extended maintenance, one on deployment, one just returned from deployment, and one preparing for deployment. Since it takes weeks for a ship to transit to a forward-deployed area, the geographic combat commanders must maintain a specific minimum number of deployed ships and submarines of various classes so that they can respond immediately to a major combat operation. Even in peacetime, the strategic deterrent provided by a sufficiently large forward naval presence can cause potential adversaries to refrain from taking hostile or other undesirable actions.

Blue-water submarines also have different demands on their designs compared with their coastal counterparts. Nuclear propulsion is more advantageous for a blue-water submarine than diesel electric or an air-independent battery recharge method.

- As noted, it can take weeks to transit an ocean even at an average speed of 12–15 knots. A diesel submarine can transit at that average speed for less than one day before it must slow and come near the surface to recharge its battery. A nuclear submarine, however, can operate at its maximum speed for days or weeks without surfacing if required to transit rapidly across the globe.

- With its greater propulsion power (~40,000 shaft horsepower compared to 4,000 for a diesel boat), a nuclear submarine can be much larger (~7,800 tons submerged) than a diesel submarine (less than 2,000 tons submerged) and therefore carry more weapons and a larger crew.

- A nuclear submarine's greater available power also enables it to have sufficient atmosphere control and fresh water–producing equipment to allow lengthy submerged operations.

The key drawback of a nuclear submarine compared to a diesel submarine is the noise generated by its power plant. The reactor support equipment and steam plant are inherently much louder than a diesel submarine operating an electric motor on the battery. These systems can be made extremely quiet and more closely approach the minimal noise levels of a diesel submarine, but the engineering is much more complicated and expensive. For example, it took the Russian/Soviet Navy and now the Chinese People's Liberation Army Navy (PLAN) decades to develop the expertise to quiet their nuclear submarines so that they could not be heard tens of thousands of yards away.

Similar demands drive the design of open-ocean aircraft carriers. Most immediately noticeable is the size of a modern carrier. For an aircraft carrier to provide sufficient power-projection capability anywhere on the globe, it must be able to store, launch, and maintain a variety and large quantity of aircraft in a carrier air wing. For example, a U.S. Navy carrier air wing typically consists of 68 aircraft of six different types.[13] Steam-driven catapults to launch aircraft and an arrested landing system to enable their recovery aboard ship provide significant decreases over traditional runways, but a minimum distance is still needed for aircraft to take off and land on the carrier's deck (modern U.S. carriers are more than 1,000 feet long). The carrier must also hold sufficient aviation fuel and ordnance to support carrier flight operations for several days without resupply, and the manpower required to operate both the carrier and the carrier air wing is substantial: A typical U.S. carrier deploys with over 5,000 personnel.

All of these requirements result in a vessel that is 60,000 tons to over 100,000 tons for the *Nimitz* class.[14] The large size, need for extended periods of high speed for carrier operations, and power requirements of support equipment (especially the catapult system) make nuclear power attractive for modern carriers.

A credible blue-water or global open-ocean navy is expensive to build, train, and maintain, but it provides the capability for global power projection and enduring forward presence.

Increasing Maritime Competition and Threats

The world's oceans have never been more critical to its prosperity and security. Global maritime traffic has increased almost fourfold over the past 20 years,[15] with even more dramatic increases in the Indian Ocean and the East and South China Seas. The sea-lanes connecting Asia with North America, the Mediterranean, and Northern Europe flow through the Suez Canal and account for over 15 percent of today's global shipping traffic.[16] These global shipping lanes are extremely congested and subject to increased risk of collisions, terrorism, or piracy as they pass through critical choke points. Each year, for example, 50,000 ships transit the Strait of Malacca, averaging more than 135 per day, and the Suez Canal handles upwards of 75 ships per day.[17] World seaborne trade accounts for 80 percent of global merchandise trade, some 10 billion tons of cargo.[18]

Although global maritime piracy has decreased significantly over the past few years due to the efforts of multinational naval task forces such as Combined Task Force 151 off the east coast of Africa and actions by the commercial shipping industry, piracy remains a prevalent concern. Some areas such as the Gulf of Guinea are seeing increased activity. The threat of maritime piracy affects shipping costs by causing commercial shipping companies to route their ships farther out into the open ocean to avoid these small pirate vessels, thus creating longer and less efficient routes; to deploy armed guards and other self-defense measures; and to transit areas of increased threat at faster speeds that burn more fuel per distance traveled.

The search for oil, gas, and mineral resources has fueled an unprecedented increase in undersea exploration. The commercial use of remotely operated vehicles (ROVs) and UUVs to explore the ocean's bottom and to inspect and maintain deep-sea oil rigs has helped drive the technological maturation and increasing capabilities of small to medium-sized UUVs. Rapidly improving UUV and ROV technology also makes it possible for a growing number of state and non-state actors to find and cut undersea cables clandestinely.

The 2006 magnitude 7.0 Taiwan earthquake severed eight submarine cables in multiple places, resulting in a severe Internet disruption in China. It took 11 special cable-laying ships 49 days to repair the damage.[19] If an adversary or natural disaster cut the majority of cables to the continental United States or even to Hawaii, where U.S. Pacific Command Headquarters is located, it would likely take months to find and repair the damage. Trillions of dollars of international financial transactions would be affected, and secure military communications would be dangerously reduced. It should be noted that of the 56 commercial cable-laying/repair ships in operation worldwide, only one is registered in the U.S., and the U.S. government owns only one cable-repair ship, the USNS *Zeus*.[20] Just how many repair ships the commercial undersea industry would dedicate to such U.S.-focused repairs is therefore uncertain at best.

The search for undersea natural resources has political and legal implications. According to the United States Geological Survey, as much as one-fifth of the planet's undiscovered petroleum reserves may reside in the Arctic: roughly 90 billion barrels of oil and 1,670 trillion cubic feet of natural gas.[21] Under international maritime law, Canada, Denmark, Norway, Russia, and the United States all have a legal claim to this valuable seafloor territory. UNCLOS allows these nations to file claims for additional territory out to 350 nautical miles if they can prove their continental shelves extend into the Arctic seabed. To date, Russia, Denmark, and Norway have submitted claims to an extended continental shelf in the Arctic, providing yet another potential source of maritime conflict.

In the South China Sea, China has staked claims to maritime territory that includes the Spratly Islands, Paracel Islands, and Scarborough Shoal. These claims overlap with the EEZ claims of Brunei, Indonesia, Malaysia, the Philippines, and Vietnam. In addition to fishing rights, potentially lucrative oil and natural gas deposits are at stake. In the past few years, the Chinese have begun island-building projects on the Subi, Mischief, and Fiery Cross reefs to advance their disputed territorial claims. While the Chinese have claimed that these islands are being built for civilian purposes, to increase safety for ships transiting the waterway, analysis of recent construction shows airfields, radars, and hardened shelters that indicate a military focus.

Key Naval Warfare Competitors and Challenges for the U.S. Navy

The rapid maturation and proliferation of certain technologies have affected the maritime environment and security challenges for the U.S. The proliferation of commercial satellites has greatly improved the ability of many nations to conduct open-ocean command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR). Space-based electro-optical and synthetic aperture radar sensors permit wide-area search for surface vessels because, unlike the land with its forests, mountains, and other masking terrain, there is nowhere to hide on the ocean's surface. Commercial satellite communications provide global communications capabilities to nations and navies that do not possess their own, as well as redundant communications for near-peer adversaries.

Forty of the world's coastal nations currently possess submarines.[22] The capabilities and proficiencies of these submarine fleets vary significantly from nation to nation, but modern export submarines and weapon systems provide even a very small navy with a credible naval threat. The vast majority of these submarines are quiet diesel submarines that operate in coastal defense missions.

Since the passive radiated noise of modern diesel submarines is extremely low when operating on the battery, resulting in exceptionally short passive sonar detection ranges of less than 2,000 yards, active sonar is the most effective means by which to search for and locate diesel submarines. Their limited speed and endurance (most can sprint at speeds in excess of 20 knots only for less than one hour) prevent them from effectively evading a searching platform using active sonar. In addition, efforts by Russia and China to quiet their nuclear submarines have reduced their passive detection ranges, making open-ocean search and localization by U.S. naval forces more difficult and requiring the use of multiple anti-submarine warfare (ASW) assets, such as the Surveillance Towed Array Sensor System (SURTASS), maritime patrol aircraft, and destroyers.

Underwater acoustic arrays have become more prevalent in the littoral areas of most of the world's continents. Although the vast majority of these arrays are for oceanographic research, submarines operating in their vicinity could possibly be detected. Modern air-based and space-based surface search radars also have the ability to detect submarines operating at periscope depth, provided one knows exactly where to look or can apply sophisticated data analysis techniques designed to detect the unique radar signature of an exposed submarine periscope or antenna mast as it interacts with a constantly changing ocean surface.

Some argue that advancing non-acoustic anti-submarine warfare (NAASW) capabilities will soon make the oceans transparent,[23] but the laws of physics and projected technologies do not support this assessment. While the probability of detecting a submarine either acoustically or by means of NAASW increases significantly for a submarine operating in the littorals off near-peer adversaries, especially at periscope depth, a submarine or other undersea platform remains comparatively much harder to detect than even the stealthiest aircraft. The undersea environment continues to provide a significant military advantage to navies that are able to operate in it effectively.

The proliferation of precision-guided munitions, especially land-based and sea-based anti-ship cruise missiles (ASCMs), and other advanced weapons technologies provides an increasing threat to U.S. naval forces, especially when operating in choke points and the littorals. Just as the flat ocean expanses make it easy to see surface ships, they also provide an unobstructed field of fire for adversaries with the ability to field ASCMs. Since ships cannot hide at sea, they must have the capability to defend against these increasingly capable weapons. Although unsuccessful, the October 2016 Houthi missile attack from land-based launchers in Yemen against the USS *Mason* while it was operating in the Red Sea clearly illustrates the reality of this threat.[24] The development of long-range (greater than 1,000-mile) anti-ship ballistic missiles presents a potential threat to carrier strike groups and other surface naval forces.

Rapidly maturing UAV technologies and their proliferation to both state and non-state actors presents another growing maritime threat. Small military and commercial micro-UAVs can easily be "weaponized," allowing them either to drop small explosives on ships or other targets or to serve as "kamikaze" UAVs. These small and slow UAVs are hard to detect with traditional air-search radars, which are focused on larger and fast-moving military aircraft and missiles. While the very small commercial UAVs have a rather limited range of less than five miles, their range and endurance are rapidly increasing, and even today, they could be launched from shore or from a nearby civilian vessel against a naval vessel transiting a choke point.

Key Nations That Affect U.S. Navy Design and Missions

Iran. The Iranian Navy is a regional navy that has been shaped by its maritime operating environment on the Arabian Gulf and the Gulf of Oman. Aided by land-based aircraft and a very capable Russian-built integrated air defense system, the Iranian fleet consists primarily of coastal patrol frigates, fast attack craft, fast inshore attack craft, and submarines. Iranian diesel submarines and mini-submarines armed with torpedoes and anti-ship missiles are ideal platforms with which to lie in wait undersea in Iranian territorial waters and hold the Strait of Hormuz at risk. The Iranian Navy has been observed employing its fast attack craft (FAC) and fast inshore attack craft (FIAC) in swarm tactics meant to overwhelm the capacity of adversary warships to target and engage incoming vessels and their anti-ship cruise missiles.

Although the Iranian Navy possesses only a few dedicated mine-laying vessels, it could employ its FAC/FIAC and other vessels to deploy the over 2,000 naval mines in its inventory.[25] Naval mines would be extremely effective in controlling the relatively narrow Strait of Hormuz, as evidenced by the damage inflicted on the USS *Samuel B. Roberts* when it struck an Iranian floating contact mine in April 1988. Although not a naval capability, Iran's ballistic missile capabilities and their potential threat to Europe have led to a ballistic missile defense (BMD) mission for specified U.S. Navy cruisers and destroyers.

Russia. The Russian Navy, like Iran's, has been shaped by its unique maritime operating environment. With much of the Barents Sea covered with ice for part of the year, providing a "bastion" for its nuclear strategic submarines, it is logical that Russia has prioritized its submarine force over a large surface blue-water navy. A resurgent Russian Navy has focused its modernization efforts on submarines and small surface combatants (frigates and corvettes). Its new *Yazen*-class nuclear guided missile submarine is assessed as being extremely quiet and capable of launching conventional or tactical nuclear long-range cruise missiles. The new *Borei*-class nuclear ballistic missile submarine demonstrates Russia's continued prioritization of a submarine strategic nuclear deterrent.

The new Russian Maritime Doctrine illustrates the Russian Navy's focus on the Arctic and Atlantic Oceans with the ultimate goal of restoring its blue-water capabilities.[26] In the Black and Baltic Seas, the Russian Navy would assist any future efforts for Russian influence and territorial expansion in Eastern Europe. The past few years have seen a dramatic increase in provocative and sometimes unsafe engagements between Russian warships and fighter aircraft and U.S. Navy warships and maritime patrol aircraft in the Mediterranean, Baltic, and Black Seas.

China. Over the past two decades, the Chinese military has focused its modernization efforts on developing capabilities to disrupt the U.S. military's power projection forces in the Western Pacific, with a focus on its carrier strike groups and C4ISR enterprise. China's emphasis on denying U.S. access to the South China Sea and East China Sea has concentrated primarily on land-based anti-ship and anti-land ballistic missiles with effective ranges out to over 1,000 miles as well as land-based fighter aircraft best suited for control of the close-in air domain. Long-range land-based OTH radars and airborne early-warning aircraft and satellites provide the necessary detection and targeting data for these long-range weapons.

The development of these long-range, land-based anti-ship capabilities has lessened China's dependence on naval platforms (destroyers, frigates, fast attack craft, and diesel submarines) to disrupt or deny U.S. naval power projection in the South China sea. The Chinese saw the advantages presented by the South China Sea's maritime environment in the context of their strategy and developed new technologies to take advantage of them: the vast capacity advantage that land-based aircraft and anti-ship weapons can provide over a forward-deployed blue-water navy with limited weapons' magazines and extended logistic tail.

Although not critical to support this area denial strategy against the U.S., the PLAN has been slowly developing blue-water naval capabilities: indigenous aircraft carriers, advanced guided missile destroyers, and quiet nuclear attack submarines to supplement its regional naval force structure. These blue-water capabilities help China to protect its growing economic interests in Africa and other maritime areas far beyond the second island chain. It remains to be seen whether China is able to develop the logistics foundation to support a truly forward-deployed naval power—logistics ships, a network of friendly forward bases, and the operational proficiency to project naval power effectively far from its homeland—or whether platforms such as its aircraft carriers are merely symbols of China's economic and military strength.

Implications for U.S. Fleet Design

Given the characteristics of the maritime domain and the evolving challenges affecting the U.S. Navy's ability to protect U.S. national security interests, the Navy must likewise evolve to remain relevant.

The Navy must be able to operate in all subsets of the maritime domain—constricted choke points and archipelagos, the littorals, the Arctic seas, the expansive open ocean, and the complex depths of the undersea world—as well as to defeat potential maritime adversaries with capabilities ranging from swarms of fast attack craft to near-peer competitors' long-range anti-ship missiles. This should drive a force structure comprised of a mix of multimission naval platforms possessing the defensive and offensive capabilities necessary to control the sea when and where necessary and to project power from the sea against any competitor that attempts to deny the U.S. access to regions, markets, and allies.

The fleet must be large enough for forward-deployed naval forces to provide an enduring, credible deterrent to potential adversaries in all critical geographic maritime regions of concern. A sufficiently large, forward-deployed force also enables the Navy to respond rapidly to emerging and unforeseen crises wherever and whenever such response is needed.

Since the U.S. Navy always prefers to play the "away game," keeping enemies as far from the U.S. as possible, there is a pressing requirement for increased magazine size on naval platforms and secure intra-theater weapons replenishment and reload capability. Conflicts in distant theaters typically do not allow time for ships to return to a regionally local port, much less the U.S., for resupply. A robust logistics and airborne tanker fleet and a resilient and secure C4ISR enterprise provide the essential foundation for global maritime operations far from land-based defenses and logistics support.

Fortunately, the Navy's senior leadership has recognized these challenges and is striving to develop new naval strategies and capabilities to maintain America's advantages in this domain. These efforts include Distributed Lethality;[27] Design for Maintaining Maritime Superiority;[28] Undersea Domain Operating Concept (UDOC);[29] and Electromagnetic Maneuver Warfare (EMW).[30]

The key to success in all of these efforts will be a commensurate commitment by the U.S. Congress to provide adequate and stable funding so that the Navy can maintain a healthy, well-trained fleet of sufficient size and capability to secure U.S. interests in the maritime domain.

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