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Overview

National security strategy depends on sustaining access to world markets for American commerce in peacetime and for the Armed Forces to various parts of the globe in times of crisis or war. Potential nation-state adversaries understand the importance of this access and are devising strategies and investing in systems to delay, discredit, or deny U.S. entry to those regions of vital interest where they wish to become the dominant power. Most of these regions are adjacent to international waters where American naval forces freely operate today.

Naval forces provide a valuable degree of sovereign and secure access in a strategic environment in which overseas land bases are becoming increasingly restricted politically and vulnerable militarily. The mobility and layered defensive capabilities of American warships, particularly those operating in carrier battle groups, make them the hardest of all tactical forces for an adversary to find, target, and effectively strike with antiaccess systems, such as cruise or ballistic missiles.

State-of-the-art long-range surveillance systems, such as satellites, are ineffective against moving targets at sea. Mobility also keeps ships from being vulnerable to ballistic missiles and makes accurate, long-range targeting of antiship cruise missiles a great operational challenge. Moreover, the latest generation of weapon systems for defense against submarines and cruise missiles is extremely effective against the current and projected systems of potential adversaries. These defensive systems are fielded on many, but not all, U.S. ships because of budget constraints and past estimates that likely adversaries had minimal naval capabilities. As national strategy changes to one that accounts for more demanding antiaccess threats, the technology and operational skill will become available to sustain assured access for American naval forces.

Military Center of Gravity

The United States expects more from its military than any modern nation ever has. Its potential opponents scout it heavily, know that they cannot beat it head-to-head in a game played by American rules, and are constantly looking for the trick play that will let them score a few points early. This situation creates a uniquely demanding set of requirements for the U.S. military, and it places a premium on the capability of naval forces to operate forward, sustaining worldwide maritime access and delivering decisive and immediately employable combat power when required.

The current balance of power in the world is fundamentally different from the circumstances of most of the 20th century. There is no hostile Germany or communist Soviet Union on the Eurasian landmass seeking continental domination. The North Atlantic Treaty Organization and the European Union have quelled centuries of grand conflict in Europe. No great power navy exists to challenge the United States for control of the open oceans. The military battlespace has shifted to the seas close to foreign shores. Control of these seas is prerequisite to controlling the challenges of conventional

Center for Technology and National Security Policy

The National Defense University established the Center for Technology and National Security Policy in June 2001 to study the implications of technological innovation for U.S. national security policy and military planning. The center combines scientific and technical assessments with analyses of current strategic and defense policy issues. Its major initial areas of focus include: (1) technologies and concepts that encourage and/or enable the transformation of the Armed Forces, (2) developments by defense laboratories, (3) investments in research, development, and acquisition and improvements to their processes, (4) relationships among the Department of Defense, the industrial sector, and academe, and (5) social science techniques that enhance the detection and prevention of conflict. The staff is led by two senior analysts who will hold the Roosevelt Chair of National Security Policy and the Edison Chair of Science and Technology and who can call on the expertise of the university community and colleagues at institutions nationwide. The papers published in the *Defense Horizons* series present key research and analysis conducted by the center and its associate members.

warfare and vital to providing the sovereign capability that is useful in controlling such unconventional challenges as terrorism.

The remaining military threats to U.S. interests are in the Middle East, Southwest Asia, and East Asia. Although these areas are closer to the sea than were many threats of the last century, they are not in a position to deny America's free use of the oceans. They are, however, capable of challenging use of their littoral waters and of impeding the free flow of maritime commerce through nearby geographic chokepoints and superports. Because any such disruption of commerce would greatly affect the globalized economy, a standing worldwide mission of U.S. naval forces is to ensure that disruption does not occur or cannot endure.

political and operational trends are pushing the United States toward a greater reliance on the maritime and long-range aerospace dimensions of access

The Nation finds itself today planning against potential regional threats in Asian theaters of operations and against terrorist threats from these same regions. The response of the Armed Forces generally includes rapidly deploying significant combat power from the United States across 5,000 or more miles of ocean. Many of the potential conventional threats are at least as likely to involve aggression across maritime borders as across land borders, and even the land borders are generally near a coast. The role of maritime forces in such conflicts is different from their role in past European conflicts. They not only must win a maritime campaign to enable the access of land-based forces to the fight, but they also must have access to engage in the fight themselves, directly and from the beginning.

Our potential adversaries know what we have to do in order to defeat them and—courtesy of the example provided by Iraq of what not to do in response—what they must do to achieve their ends. In a conventional conflict, the U.S. military needs timely and sustained theater access, and its adversaries need to deny it, at least for long enough to present the United States with a *fait accompli* whose reversal might cost more than America is willing to pay. Clearly, theater access is the U.S. military center of gravity.

The Issue of Access

Understanding the key issue of access is vital. Access has dimensions of time (when and for how long) and space (where). It may be physical or political. Operationally, access early in a crisis is worth much more than access later, after the fight is on; in fact, optimal access would be continuous in time and space, from peace through war and to any place in a theater of operations. The United States must at least ensure that it has access at any time and place of its choosing.

The threats to U.S. access are both military and political. The military dimensions of access depend on technology and operational art and are relatively straightforward to assess. Political access depends on factors that are far harder to analyze, such as U.S. alliances in a region and the domestic politics and perceptions of risk versus reward in nations that must decide whether to grant this access. Nations will make such decisions (and not necessarily promptly) on the basis of their own self-interest.

Events since the end of the Cold War have shown that political access is difficult to predict and often slow to attain in situations where regional countries do not perceive the threat as immediate. Persian Gulf nations granted access within a few days of the Iraqi invasion of Kuwait during Operation *Desert Shield* (and, in the wake of the September 2001 attacks on New York and Washington, appear supportive of access in operations against certain terrorist threats), but the United States for many years had strict limitations on its access in that region for actions against Iraq in Operation *Southern Watch*. Prompt U.S. access to its extensive base network in Japan is more likely in the case of a North Korean invasion of South Korea than for operations elsewhere in Asia. Without political access, the land-based forces that would flow into overseas bases in wartime cannot be effective. The presence of combat-credible U.S. naval forces in a region has a powerful effect on achieving political access.

Technological trends also are affecting the political dimensions of access. As more potential adversaries acquire ballistic or cruise missiles with chemical, biological, or nuclear warheads, fixed U.S. bases in foreign countries (both permanent sites and temporary expeditionary bases in wartime) become inviting targets. In most potential theaters of U.S. operations, bases on land are vulnerable to such missiles today. This scenario subjects our potential allies to a degree of coercion not feasible 10 years ago and makes our access to bases on their territory increasingly risky for them. U.S. land-based and sea-based theater ballistic missile defenses will mitigate this vulnerability when fielded, but only if they are already deployed in sufficient quantity in a theater before a crisis becomes a war.

When evaluating the capability of U.S. forces to deal with anti-access strategies, three questions must be considered:

- How likely is it that the access in question could be denied by non-military (political) means?
- For what purpose is the access required—what operational mission must be accomplished, and at what point in the U.S. campaign?
- What are the relative effectiveness and the vulnerability to access denial of each of the feasible means of accomplishing that mission at that time?

Many current political and operational trends are pushing the United States toward a greater reliance on the maritime and long-range aerospace dimensions of access. Military capabilities that are at sea on sovereign U.S. warship "bases," or that operate out of bases on U.S. territory, are subject to few of the same political access

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denial issues as those based on foreign soil. Also, both require far more sophisticated enemy military systems to target than are required against a fixed base. A key issue in the U.S. defense debate is how to determine the prudent and cost-effective division of labor between what the forces at sea can be counted upon to do early in a crisis versus what long-range aerospace power can do. This question requires an evaluation of the allocation of missions between the two and of the relative effectiveness of each in the face of enemy efforts to deny access. Both clearly have value and will be required in some amount as part of nearly any U.S. military operation.

What are the respective mission contributions of maritime forces and long-range aerospace forces in an overseas crisis, and how important is it that each have the ability to operate in the face of an access denial strategy?

Under current concepts of operations, nearly one-third of Navy forces are kept forward-deployed in theaters of U.S. vital interests and potential military operations. These forces, organized into self-sustaining multiship carrier battle groups and amphibious ready groups, operate on a daily basis in proximity to potentially hostile military forces in what may become a wartime battlespace. Their role in the early phases of a crisis and conflict is to maintain their access to the theater of operations so they can:

- deter adversaries from taking military action and reassure allies of the credibility of the U.S. commitment to them and to their defense
- watch adversaries closely and constantly, above and below the oceans, to learn their tactics, their weaknesses, and their intent, and to learn the battlespace environment where a fight may occur
- secure and protect the sea and air lines of communication, ports, and airfields that U.S. forces will need for their immediate deployment by airlift, sealift, and maritime prepositioning assets, should theater political access be granted
- project high-volume, persistent, time-critical, tactical reconnaissance and both offensive and defensive firepower against key targets in the initial phase of a wartime campaign.

In the geographic areas where our vital interests are most likely to be challenged over the coming decades, U.S. military success will depend on the ability of maritime forces to stand and fight in place and to sustain uninterrupted access for the entire joint force. An opponent who can defeat U.S. maritime forces or raise doubts about their credibility can neutralize capabilities that no other part of the joint force will be able to replace. These capabilities are critical to national political influence and economic survival and to the warfighting success of the joint forces.

Battle for Maritime Access

Many believe that naval surface forces are increasingly vulnerable to rapidly proliferating access denial threats and therefore of questionable utility to the United States in future wars. If this is so, what alternative means of delivering the same required capabilities would be less vulnerable? Moreover, how can the United States project power across the oceans, fight, and win if maritime access is denied? An enemy that can find and hit a heavily defended, rapidly moving ship on the open ocean is even more likely to be capable of hitting any nearby land base that is supporting the operations of U.S. tactical forces. Without the persistent defensive and offensive firepower, surveillance, and battlespace control capabilities of tactical forces (whether land-based or sea-based), the American military response to a crisis is relegated to lobbing in precise long-range conventional strikes against fixed targets. No war has ever been won in this manner. The battle for maritime access is a decisive battle that the United States cannot afford to lose.

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Another widely held belief is that the antiship weapon systems available on the world market represent in some way a new level of asymmetric capability as a result of technological advances. In fact, they are remarkably similar to the systems developed and fielded by the former Soviet Union through the 1980s to contest U.S. control of the North Atlantic. Current antiaccess systems are fewer in quantity and depth and operated by adversaries less competent and far less well financed than the Soviets. The American systems designed to counter them (for example, the Aegis anti-air warfare system and the SQQ–89 antisubmarine warfare system) are now fielded in large numbers.

The Navy did not expect to lose the battle for access to the Atlantic against the Soviets, and today's Navy is better equipped relative to threat capabilities than the Navy of the Cold War. Only if losing the war is defined as losing one ship is there a significant risk of failure; expecting a loss-free war at sea is unrealistic. The proliferation and advance of weapon technology can be expected to increase the sophistication of threats to U.S. access, both by sea and on land. The United States is likely to apply its best technological and training efforts to maintaining the capability to neutralize such threats. It is a race between offense and defense, and at sea today the U.S. defense is ahead and generally is widening the lead. The rate of advance in fielding naval defensive capabilities, however, is limited by funds as a result of a strategy that until recently focused U.S. military resources primarily on two threat nations (Iraq and North Korea) that do not have significant navies.

The process of exercising access denial against a navy has two dimensions: technological and operational. Simple possession of capable weapon systems is the technological dimension, and it requires only cash. Many estimates of antiaccess capability incorrectly assume that those who possess good weapons have complete capability as a result. But something more is needed for most types of antiship weapons (except mines) to deliver their capability. Considerable operational skill is required, and this skill must be developed through time and practice. The access denial also must remain effective in the face of the intense long-range naval strikes that the Navy would bring to bear to neutralize it.

Many of the missions that the Navy must perform to project its offensive and defensive capabilities ashore increasingly can be done from sea because of the long reach of new U.S. sea-based tactical aviation, strike missile, and ballistic missile defense systems. This capability requires the adversary to solve a complex open-ocean targeting problem and use missiles or submarines effectively at long ranges to deny the access required for American missions. Missions in places such as the Persian Gulf that may require clearing a hostile strait for safe passage or landing a marine force, however, continue to require operating in the close-in littoral. When U.S. naval forces do this, an adversary can use lower-technology antiaccess options—such as mines, swarms of small craft, or coastal-launched missiles—that are not available in the open ocean. The adversary's complex task of finding U.S. forces is simplified; to survive, our forces must be capable of destroying significant numbers of well-aimed inbound threats.

Because of a ship's constant movement and high speed, time is of the essence in targeting; for example, if more than a few minutes elapse between when the ship's position is located and when a weapon is fired at it, the weapon is likely to find only empty ocean when it arrives. A ship moving at 30 knots can be anywhere within a 700-square-mile area from its starting point in 30 minutes. The sensor-to-shooter process of targeting a ship requires prompt sequential execution of four steps:

1. search the ocean area to detect and locate potential targets
2. identify the desired target and communicate its position to a weapon system
3. position antiship weapon launchers within range of the target
4. launch weapon(s) of sufficient quantity and quality to overcome defensive capabilities.

the time-critical sensor-to-shooter process is one of the most difficult technical tasks facing modern militaries

Search and Locate

Searching an expanse of ocean for a ship on its surface is generally a straightforward application of radar, over-the-horizon radar, and satellites. Other technologies (such as passive electronic direction-finding and underwater acoustic arrays) also can be used, but their operational limitations make them far less effective. In coastal waters, optical targeting is an effective technique under appropriate weather and visibility conditions.

Radar is accurate but limited by the distance to the horizon, which is 30–50 miles for coastal land-based radar or up to 200 miles for airborne radar. Search radars are the first targets for electronic jamming or standoff precision weapons in any U.S. warfighting campaign. They are a concern in peacetime but are likely to be unavailable to an adversary once hostilities become imminent.

Over-the-horizon radar is a sophisticated form of radar available only to a few technologically advanced nations. It works by skipping high-frequency radio waves off the earth's ionosphere. It is vulnerable to decoys and is not accurate enough to use by itself for targeting weapons, but it can make initial detections of ships or aircraft (including stealthy ones) in a range band several hundred miles in width that starts 500 to 1,000 miles away from its mile-long transmitter arrays. These arrays would be a primary target for U.S. cruise missiles at the beginning of hostilities.

Surveillance satellites can locate and identify an object on earth using either radar or optical imaging sensors. They can be military or commercial. Optical surveillance satellites image designated small areas a few miles wide within a band several hundred miles wide underneath their trajectory, but only in daylight and cloudless weather (less than 50 percent of the time). Only a handful of commercial optical satellites (plus a few military satellites) are in orbit today that are capable of distinguishing a warship from a merchant vessel, and they operate in low earth orbits with limited fields of view. Over 100 such satellites, properly positioned, would be needed to provide continuous daytime coverage of even part of an ocean basin. Fewer radar satellites would be required to provide such coverage because they generally have wider fields of view, and radar coverage is usable regardless of time of day or weather, but there is no commercial market for radar satellites with the resolution to identify ships.

The real weakness of commercial optical satellites is not their quantity or quality but their timeliness: commercial images are ordered days to many hours in advance of when they are taken and are returned to the customer well after they are taken, following processing and position mensuration. Compared to the rapidity required to be useful against moving ships, the commercial marketplace has a long way to go and little economic incentive to attain such speeds. Against fixed facilities and the land-based forces operating out of them, however, commercial satellites are a significant and growing targeting threat.

While optical satellites (even military ones) are never likely to be particularly useful against ships at sea, military radar satellites could be useful. The Soviet Union once had a few such satellites; they were immense, nuclear-powered ocean reconnaissance spacecraft with real-time downlink to cruise missile-firing ships. The proposed Air Force/Defense Advanced Research Projects Agency/National Reconnaissance Office *Discoverer II* radar satellite constellation could provide the United States with such a capability worldwide, but not for 10 to 15 years and at a cost of $25 billion. A few other major nations also have sufficient technical skill to build such a system within 20 years, given vast quantities of resources. None has this capability today, and such development efforts would be highly observable.

Identify and Communicate

The real challenge for an adversary in antiaccess operations is sorting out a particular target warship from among all the ships in a crowded ocean and then communicating its position promptly so that a weapon system can be brought to bear before the ship has moved. The time-critical sensor-to-shooter process is one of the most difficult technical tasks facing modern militaries. The United States did poorly at it during Scud-hunting operations in *Desert Storm* and has spent large amounts of time and money since then to improve. No other military in the world has made a similar effort.

Even when a target can be located and identified promptly and precisely, communicating this precise position quickly enough to a shooter to get ordnance on the target before it moves remains a challenge. The communications paths (digital or voice) among sensors that can search widely, identify accurately, and locate precisely are complex and tend to induce error, delay, and confusion in the process of correlating the images that each sensor sees into a coherent tactical picture. This is a particularly troublesome problem when the shooter is a preprogrammed standoff weapon rather than a manned aircraft capable of doing an intelligent search of a wide target area containing many contacts.

Through an extraordinary technical effort based on digital data networks, the United States is finally achieving success in linking airborne sensors (largely in manned aircraft) with manned tactical aircraft to kill mobile targets. These networks are approaching the point at which the critical path in the sensor-to-shooter process is the person who must make the decision on what to fire and when. The fact that the United States can find and strike mobile targets does not mean that adversaries will soon have a similar capability against American naval forces; the capability of U.S fleet air defenses today is such that enemy aircraft within weapons range would be quickly destroyed once hostilities begin. Also, the U.S. capability to jam, deceive, and interdict enemy defensive system networks (so clearly demonstrated in Iraq and Kosovo) will make targeting of U.S. ships at sea difficult for the foreseeable future.

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Antiship Weapons

When and if an adversary resolves the difficult issue of promptly and precisely locating U.S. naval surface forces, the next step is to bring weapons to bear to attack them. These weapons could be antiship cruise missiles (ASCMs), tactical ballistic missiles (TBMs), submarine-launched torpedoes, or swarms of armed small craft. If the enemy goal is simply area denial, the weapons could be mines—in which case locating U.S. forces is not necessary. Each of these antiship weapons has technical and operational limitations and strengths, and the United States has defensive capabilities against each. None is a silver bullet whose simple possession by an adversary makes U.S. naval forces nonviable.

Antiship cruise missiles. Dozens of navies rely on one of the widely proliferated ASCM systems as a principal access-denial capability against surface ships. ASCMs are generally launched from ships or patrol boats or shore batteries; a few nations even have the ability to launch them from aircraft or submarines. Most ASCMs fly at low altitudes, referred to as sea-skimming, to ranges of 15 to over 150 miles. These missiles rely on their low altitude plus speed (generally around 500 miles per hour, with a few such as the Russian-exported SS–N–22 Sunburn capable of up to three times this) and often maneuverability or stealth to evade detection and penetrate defenses. If properly aimed and used against a ship with overmatched defensive systems, the ASCM can be an effective weapon.

Proper aiming is the key operational difficulty with the ASCM. If the target ship is within direct sight or radar range of the shooter (a very short distance if the shooter is a submerged submarine, a longer one if it is an aircraft) and is correctly identified, aiming is not an issue. If the target ship is beyond this range, the shooter must rely on an external network of sensors (with all its attendant operational difficulties and delays) to determine its position and identity. If the target ship position data is provided to the shooter after a time delay, the moving ship will no longer be where the data says it was. In fact, the target is somewhere in an area of uncertainty (AOU) whose radius is the target position data error from the surveillance system plus the product of the time delay (including missile flight time) and ship speed. A sea-skimming ASCM has a small field of view for its ship-homing seeker because of its low altitude, so its ability to search an AOU is limited. The more inaccurate or delayed the target position, the lower the probability that the ASCM will ever see its intended target. Additionally, since more than one ship may be in the AOU, the seeker sensitivity must balance the chance of locking on the wrong target against the chance of not locking on a target at all.

Long range sea-skimming ASCMs (such as the now-retired U.S. Tomahawk antiship variant) that take a long time to reach the target area would be ineffective even if the targeting problem is solved. No navy in the world (including the American Navy) is capable of doing reliable, accurate long-range targeting of ASCMs, except with manned aircraft. Such aircraft are not viable against a Navy carrier battle group with its organic airborne early warning aircraft (E–2C Hawkeye), long-range tactical aircraft, and defensive missiles—systems not available to the Royal Navy in the Falklands War, where it took punishing losses to ASCMs as a result. The operational implication of this is that an adversary will have to fire long-range ASCMs at short operational ranges. Any platform (ship, aircraft, or submarine) that carries an ASCM to short range from its target becomes a vulnerable target itself.

Tactical ballistic missiles. Tactical ballistic missiles are becoming a weapon of choice among nations that wish to deny regional access to U.S. military forces. The accuracy with which these weapons can hit a fixed target is improving, and some nations are trying to equip them with chemical, biological, or nuclear warheads to give them mass destructive power. The United States has limited TBM defensive capability, and although it is developing major improvements, the defense remains well behind the offense. TBMs are capable of doing considerable damage to in-theater ports, airfields, and bases today and are the top challenge to U.S. land-based military operations.

TBMs have zero capability against ships at sea or any other moving target, unless armed with a large nuclear weapon that explodes at high altitude to cover a broad area. TBMs go to the fixed geographic point at which they were aimed. Even if a TBM is fired

from short range, it takes several minutes to get to this point, plus the substantial delay time from when target position was established to when the missile was given this position and fired. Constantly moving targets such as ships will not remain close enough to a TBM time-late aimpoint for it to have even a 1 percent chance of landing within the effective range of a conventional warhead.

For a nonnuclear TBM to become effective as an antiship weapon, it needs a radar or infrared seeker that can search a substantial area and locate a warship, coupled with a maneuverable missile reentry vehicle that can be steered toward that ship. No such antiship-capable TBM seeker has been developed, tested, or fielded. Developing one would be a technical challenge. First, the seeker nose must be both transparent to radar waves or infrared energy and capable of withstanding atmospheric reentry temperatures. Second, the reentry vehicle must have either unusually high aerodynamic maneuverability or a complex exoatmospheric maneuver system to chase down a ship. Finally, the seeker and its power supply must fit in a space-constrained reentry vehicle and continue functioning during and after the high heat of reentry. Although all these challenges could be overcome, doing so would require a time-consuming, technically demanding, expensive research and testing program. By the time this could be accomplished, U.S. sea-based TBM defensive systems would be fully fielded.

Submarine torpedoes. Competently operated submarines are the most challenging threat to operations on the surface of the ocean and have been so since they were first fielded in quantity during World War I. Modern diesel-powered submarines are quiet and therefore hard to find when submerged, and the state-of-the-art submarine torpedo systems available on the world market can be lethal in the hands of skilled submariners. The most daunting challenge that the former Soviet Union posed to Navy maritime supremacy was its submarines, not its surface ships, aircraft, or missiles.

Fortunately for the United States, none of the nations currently skilled at submarine operations are considered potential adversaries. Moreover, those that might be adversaries are not skilled at operating the submarines they have built or acquired. Many of the latter also have poor quality, noisy, and easily detectable submarines. A slow-moving diesel submarine would have to have great operational skill, good equipment, and a courageous crew to locate a fast-moving warship on the open ocean and position itself properly to launch a torpedo at that warship in the face of active efforts by the warship and its supporting aircraft to locate and attack the submarine first. Some of these issues can be resolved if the submarine has long-range target-location support from remote sensors, although this requires a level of operational sophistication beyond the current capability of most potential U.S. adversaries.

Ultimately, the effectiveness of a hostile submarine force will depend on its size and on the rate at which the U.S. military can find and destroy this force in wartime before it can attack American ships. A small adversary force is unlikely to have much impact on the outcome of a war, even if competently operated, as long as the United States has good systems, sufficient forces, and skilled operators in antisubmarine warfare. A larger submarine force will certainly achieve a few hits, even if the force is not operationally proficient. If insufficient U.S. resources or training are dedicated to antisubmarine warfare, however, or if adversaries with numerous submarines become skilled at operation, these losses could grow to the point of significance. Since over 90 percent of the equipment that the U.S. joint force requires in any future war will arrive by sea, and none of this will move to the fight until submarine threats are under control, prompt success at the unique mission of antisubmarine warfare by the Navy is prerequisite to U.S success in almost any war.

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Swarming small craft. In some littoral regions such as the Persian Gulf, threats could include small, fast, stealthy surface craft armed with low-technology small-caliber guns, short-range rockets, or even suicide bombs. Swarming small craft, like any other naval threat, are best dealt with using a layered defense: first, by destruction in port before any attack can be organized; then by tactical jets and armed maritime patrol aircraft at long range; by missile-armed ship-based helicopters at the intermediate ranges; and by shipboard self-defense systems in close. In the wake of the attack on the USS *Cole* and the attacks on Manhattan and Washington, much more attention is being paid to this type of terrorist suicide threat than in the past.

Mines. Underwater mines are the cheapest, most common, and most easily used antiship weapon system. As has been demonstrated often over the last century, they can be effective in delaying or denying the use of a limited area of shallow water to an opposing naval force. Mines are fixed-position defensive weapons that require no trained operator; they simply lie in wait. They cannot be moved, and significant quantities are required to cover an area of any size because their lethal radius is relatively small. They are also ineffective in water deeper than about 1,500 feet, and only the more sophisticated and expensive varieties of self-propelled mines are effective beyond a depth of 300 feet.

When Navy missions call for close approach to a hostile coast in places where the water is shallow, the threat from mines must be taken seriously. The classic method of dealing with them—through use of single-mission, mine-countermeasures ships and helicopters—is effective but slow. It takes time for these specialized systems to be brought to the fight, and then it takes time for them to find and neutralize mines, particularly modern, low-profile types that rest on the ocean bottom in shallow water. The United States keeps these kinds of forces permanently forward-stationed in the Persian Gulf and near Korea (in Japan), permitting them to gain the intimate familiarity with the local undersea environment that is vital

for rapidly discerning in a crisis what has changed and might therefore be a freshly laid mine. This forward-stationing also ensures immediate availability of the first echelon of these forces early in a crisis, when they are most needed.

Defensive Capabilities

The battle to have or to deny military access is a continuing technological and operational competition. One side develops or deploys a new weapon system or operational tactic to deny access; the other responds with a new way to bypass or defeat the access denial effort. The side with the best weapon system technology, operational proficiency, and (all else being equal) force size generally wins, but victory comes at a cost, and if the cost is estimated to be too high, the potential victor may be deterred from the fight.

The Navy has a dominant technological and operational proficiency advantage over any potential adversary. If it wishes to gain access to virtually any maritime region needed for the defeat of any adversary, the Navy is capable of doing so promptly and decisively. But the political threshold for losses in such a conflict may be quite low. Requirements for defensive system capabilities are accordingly extremely high; America would like to be so capable that it has a good chance of suffering no ship losses at all. Furthermore, the United States needs to maintain its advantage into the future as more advanced antiaccess systems are developed and proliferated.

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The defensive capabilities exist or are in development today to extend U.S. naval access advantage for 15–20 years or more. Because of fiscal constraints, not all of them are funded for full deployment. If the United States finds itself facing rapidly increasing naval threats or a potentially hostile navy of significant size, more funds will be required for deploying *anti*-antiaccess defenses than are currently available for this purpose. Also, more funds will be required in science and technology programs to develop the next generation of systems to extend the access advantage even beyond 20 years. With such investments, and with continued emphasis on recruiting, training, and retaining high-quality personnel, Navy ability to sustain global maritime access for the military and economic interests probably can remain dominant for far longer.

Antiship cruise missile defense (ASMD). Effective ASMD depends on early detection of an inbound missile and engagement of the launch platform (preferably) and missile (if necessary) with multiple layers of defenses. The bedrocks of U.S. capability for ASMD are the carrier-based E–2C Hawkeye airborne early warning aircraft and the Aegis missile weapon system onboard all Navy cruisers and the *Arleigh Burke* (DDG–51) class of destroyers. The E–2C, with the radar modernization program (RMP) capability upgrade that will be fielded in 2007, will be capable of detecting and tracking small cruise missiles at ranges of several hundred miles at low altitudes over water or over land. Working in conjunction with Aegis missile ships, the E–2C RMP will support engaging these inbound threats with ship-launched over-the-horizon anti-air missiles at ranges well beyond 100 miles (by 2010) or at even longer ranges with carrier-based F/A–18 strike-fighter aircraft carrying advanced medium-range air-to-air missiles. The radar pictures held separately by each Aegis and E–2C radar in a battle group will be fused into one highly precise, comprehensive picture by the cooperative engagement capability system starting in 2002, permitting every ship to fire missiles based on the best information available to any of these radars.

The closer-in layers of ship defense against cruise missiles start with highly capable standard missiles fired from Aegis ships in defense of themselves and the carriers, amphibious ships, or logistics ships that they accompany. Each of the four or five Aegis ships in a typical carrier battle group can have over a dozen of these missiles in the air aimed at separate targets simultaneously, a volume of fire that can handle saturation raids of well over 50 cruise missiles inbound at that group.

The final layer is the short-range self-defense systems found on all Navy warships. These range from Sea Sparrow and Rolling Airframe missiles to the Close-In Weapon System (CIWS) radar-directed 20mm Gatling gun, electronic jammers, and passive defenses such as chaff or the Nulka rocket-boosted deception decoy. These systems are present aboard carriers and large amphibious ships; smaller warships possess some subset of these defenses. Each system is regularly modernized to deal with the latest developments in cruise missile capability. The missile and gun systems also are effective against swarming small boats, and the Block 1B upgrade to CIWS is substantially improving this effectiveness, giving it a day/night optical tracking sight and extended range specifically for small boat defense but also improving its already significant lethality against ASCM.

Overall, these layers can provide a cumulative probability of defeating a multiple-ASCM raid of nearly 100 percent. However, not every ship that needs this much capability currently has it because of fiscal constraints. Some older ships have significant vulnerabilities against the small number of latest generation ASCM available in hostile hands and would have to operate in the second echelon of the Armed Forces in early stages of a fight. But the technology is available today to defeat all of the antiship missile threats likely to be in the hands of adversaries. Even if defenses miss one inbound weapon, the sheer size and extensive damage-limiting design features of large U.S. warships (especially aircraft carriers) will normally permit continued mission accomplishment.

Ballistic missile defense. Ballistic missiles are an antiaccess threat to forces operating ashore, not to naval forces at sea. By 2005, the Navy will field the capability to project theater ballistic missile defense (TBMD) against shorter-range TBM to protect forces ashore and critical ports and airfields, using the Navy Area Defense system on Aegis cruisers and destroyers. This will complement the land-based PAC–3 and theater high-altitude area defense TBMD systems that are to be fielded during the same period. By 2008, naval TBMD

capability could be further expanded with the Navy Theater Wide system to cover much larger geographic areas against longer-range TBMs. These naval TBMD systems would also be fully capable of defending ships at sea against a TBM with an antiship seeker, should one ever be fielded.

Antisubmarine warfare (ASW). Finding and killing submarines is difficult and dangerous; it requires both technology and skill honed by practice. The Navy leads the world in both categories, despite cuts made once the massive Soviet submarine threat vanished. The new generation of ASW sensors being fielded by the United States improves detection ranges of ship, submarine, and airborne acoustic sensors by factors of two to four against quiet diesel submarines, a dramatic increase.

ASW, like ASMD, is fought with layers of defense. The outermost layer is generally a U.S. nuclear submarine, the original stealth fighter. Virtually undetectable because of their extraordinary quietness, these boats operate far forward, close to enemy ports, to interdict submarines before they can threaten American forces. Behind these is a layer of long-range maritime patrol aircraft (the P–3, which will be replaced by 2010), often cued or directed to the position of a submarine by tactical underwater acoustic-detection arrays placed off an enemy port or in a defensive barrier protecting U.S. operating areas, or by the ship-towed surveillance towed array sonar. If a submarine locates and approaches a U.S. naval force, it is challenged by ship or carrier-based SH–60R helicopters with highly effective dipping active sonar and surface combatants with SQQ–89 long-range active and passive sonar. All these are armed with antisubmarine homing torpedoes.

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As a final defense layer, the Navy also has antitorpedo decoy systems on virtually all ships, including carriers. It also has the technology for, but has not been able to fund deployment of, a capability to kill inbound torpedoes with an antitorpedo torpedo. This is one of many capability hedges that the United States could fund to keep pace with antiaccess threats if they develop into a significant concern.

Mine countermeasures (MCM). Placing a mine in international waters is an act of war, and the most efficient MCM technique is to detect and destroy the minelayer before the mines are emplaced. U.S. maritime surveillance and strike systems that are kept forward-deployed routinely in areas of U.S. vital interest provide this proactive capability. Failing this, the United States has significant capability today to locate and neutralize sea mines—far more than was available in *Desert Storm*. However, this capability is all resident on dedicated MCM units and is still technology-limited to operating at slow search speeds. At the beginning of a conflict, the small number of such MCM units kept homeported overseas (assisted by local allied capability) must find and neutralize any mine threat before U.S. naval forces and the sealift bringing in land-based forces and their sustainment can proceed into potentially mined coastal waters. This is a time-consuming task—and a dangerous one in places such as the Strait of Hormuz, where the nearby coast may be hostile.

Starting in 2005, warships within each carrier battle group will begin receiving organic MCM systems, installed on MH–60S helicopters flying from carriers or other surface ships and on unmanned underwater vehicles launched from both DDG–51 destroyers and submarines. This organic MCM capability will let the first-to-fight naval forces detect and avoid bottom-laid mines, destroy near-surface mines, and proceed on their other warfighting duties without having to wait for dedicated MCM forces to arrive.

Since naval warfare began, small navies have pursued strategies, weapons, and tactics to permit them to deny larger navies the ability to access their home waters. Modern technology has improved the capability of small navies to do this, but it has improved the ability of the U.S. Navy to defeat such efforts by an even greater margin. The battle for maritime access, and for the ability to operate in places from which allies can be protected and enemies defeated, is one that is fundamental to the economic security and military strategy of the United States. It is a battle that, with the appropriate level of resources devoted to defensive systems and training, America is likely to win (not without losses) for the next 20 years—especially in waters beyond the horizon from a hostile coast. Moreover, it is a battle that, with the appropriate and significant investments in long-term technology development, the Navy can continue to win well into the 21st century.

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