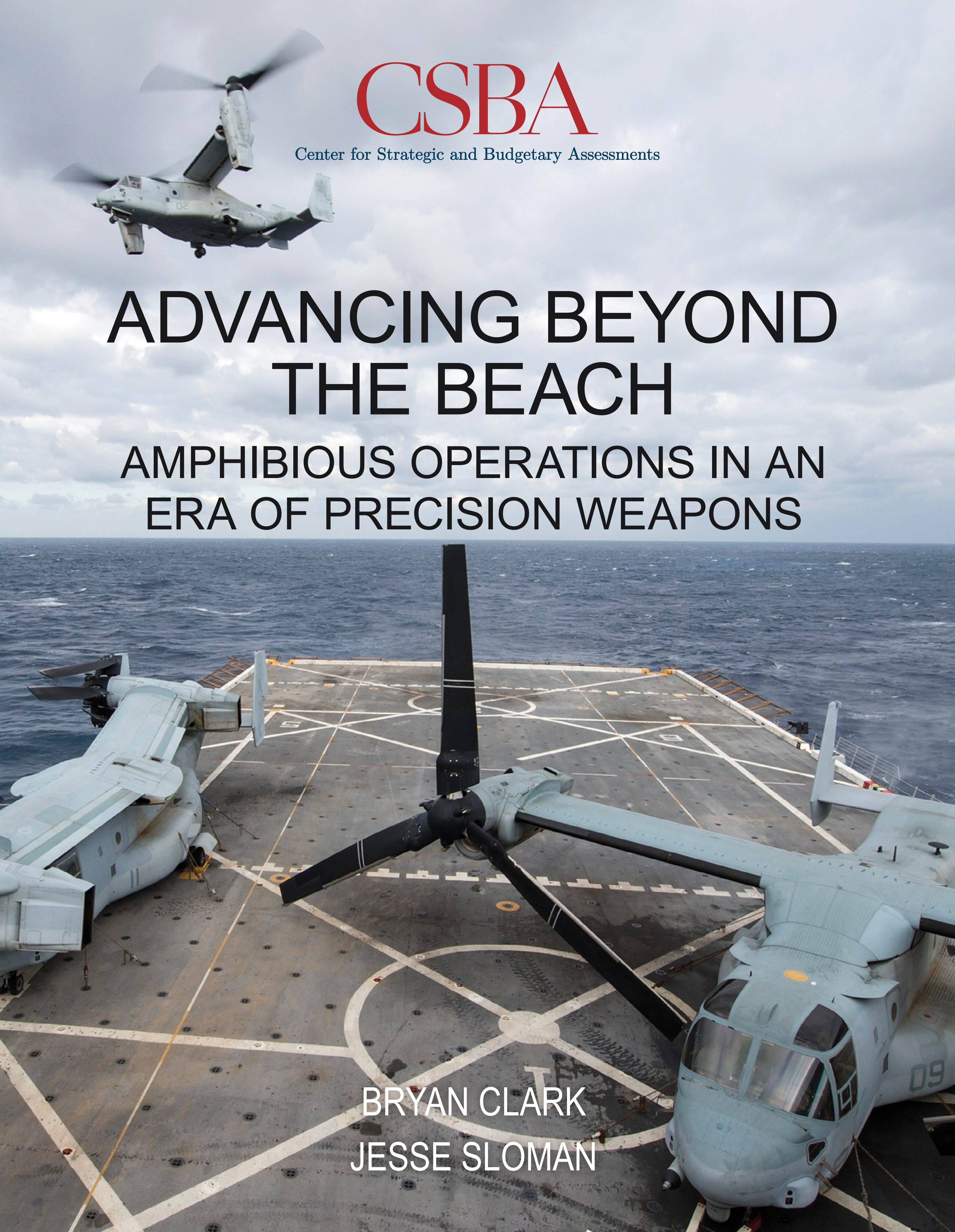

CSBA

Center for Strategic and Budgetary Assessments

ADVANCING BEYOND THE BEACH

AMPHIBIOUS OPERATIONS IN AN ERA OF PRECISION WEAPONS

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The Center for Strategic and Budgetary Assessments is an independent, nonpartisan policy research institute established to promote innovative thinking and debate about national security strategy and investment options. CSBA's analysis focuses on key questions related to existing and emerging threats to U.S. national security, and its goal is to enable policymakers to make informed decisions on matters of strategy, security policy, and resource allocation.

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Executive Summary

Amphibious operations have been an element of naval warfare since ships first went to sea. For more than 2,000 years, naval forces have exploited coastal waters as maneuver space to attack their enemies' weak points, reinforce their own positions, and support littoral sea control. Since World War II, America has maintained the largest and most ready amphibious fleet in the world with an average of more than ten ships and 6,000 Marines on deployment every day since World War II. These forces have conducted more than 100 amphibious operations to cope with disasters, evacuate civilians, destroy coastal targets, and help U.S. allies and partners respond to crises.[1]

Amphibious assaults have always been a competition between attackers at sea and defenders ashore. This competition passes through phases as each new generation of weapons is countered by new methods to get troops ashore. The amphibious warfare competition is now entering a new phase because surface-to-air missiles (SAM) and anti-ship cruise missiles (ASCM) have achieved ranges and lethality that enable them to threaten ships and supporting aircraft 200 nm or more away. This could allow a defender to use a relatively small number of defenses to protect long areas of coastline and significantly constrain the attacker's options for an amphibious assault.

To continue employing amphibious operations in support of American interests, U.S. naval forces require new operating concepts and capabilities that circumvent or defeat increasingly effective coastal defenses. These concepts and capabilities should enable the types of amphibious operations needed in the long term.

These two imperatives are interrelated. Amphibious units will need to disperse, become less detectable, and reduce their time in contested areas to dilute enemy salvos and lower the number of weapons arriving at a target to be within the capacity of its defenses. At the same time, precision-guided weapons (PGW) and new sensor and countermeasure technologies will

1 Carter Malkasian, *Charting the Pathway to OMFTS: A Historical Assessment of Amphibious Operations from 1941 to the Present* (Alexandria, VA: The Center for Naval Analyses, 2002), pp. 28–45.

allow smaller, lighter, and more distributed amphibious forces to achieve similar effects in shorter periods of time than those that fought in previous conflicts.

A New Strategic Approach

Amphibious warfare will be an important element of a new strategic approach to deterring and responding to aggression. Today, the U.S. military's margin of superiority is eroding as potential adversaries develop, acquire, and refine networks of long-range sensors and precision weapons that the Soviets first labeled "reconnaissance-strike complexes."[2] As many powers gain the ability to conduct precision strike operations, it will become will become increasingly difficult and costly for the United States to carry out a forcible entry into a defended region.

Both Russia and China have fielded complete battle networks of sensors, platforms, and weapons to form robust, multi-domain reconnaissance-strike complexes. Smaller powers are also emerging that lack the full spectrum of capabilities available to Russia or China, but whose weapons can offset U.S. strengths and create severe operational challenges for the United States. ASCMs are particularly a cause of concern for maritime forces because they are relatively affordable compared to ballistic missiles and less complex to manage and operate than fighter aircraft.[3] Some eighty countries currently possess ASCMs, and twenty-two build them.[4]

A U.S. campaign to roll back the results of an act of aggression by one of these potential adversaries might eventually be successful. However, the effort could take weeks or months. An adversary might calculate that rapidly attaining a set of limited objectives could achieve a *fait accompli* before U.S. forces are able to complete their rollback campaign. Faced with the prospect of lengthy and demanding preparatory operations to regain theater access, the United States might simply conclude that military intervention is not worth the cost.

America's ability to deter conflict will suffer if its allies and adversaries begin to believe U.S. leaders may be unwilling or unable to reverse the results of adversary aggression. To sustain its alliance commitments, the United States would likely need to move from responding to aggression after the fact to denying the aggressor the ability to reach its objectives and, should that fail, compelling it through punishment to halt. A variation on this approach would be to delay the adversary's aggression sufficiently to render the overall financial and diplomatic costs too high to continue.

Embracing a new denial and punishment approach to deterrence will require three main changes to U.S. naval forces, including amphibious forces:

2 Barry D. Watts, *The Maturing Revolution in Military Affairs* (Washington, DC: Center for Strategic and Budgetary Assessments, 2011), pp. 1–2.

3 Thomas G. Mahnken, *The Cruise Missile Challenge* (Washington, DC: Center for Strategic and Budgetary Assessments, 2005), p. 32.

4 Nolan Fahrenkopf, "Anti-ship missiles: a dangerous gateway," *Bulletin of the Atomic Scientists*, February 9, 2016.

- A new posture that places them close enough to an adversary's forces or objectives to be able to impose costs or interdict the aggression;
- New operating concepts and capabilities that enable them to generate more fires against enemy ships, aircraft, ground targets, and aircraft than today; and
- New operating concepts and capabilities to enable them to persist longer in contested areas so they can expend their offensive weapons or achieve their objectives before withdrawing.[5]

For all the progress the Marine Corps has made towards its vision of amphibious warfare, U.S. naval forces today are unable to execute the full range of amphibious operations in likely contested environments. Amphibious ships and expeditionary troops lack the defensive capacity to protect themselves against the large number of adversary weapons they would face given their need to get close to an enemy's shores before offloading Marines. Amphibious forces will have difficulty reducing their vulnerability by conducting landings from farther away, because almost all Marine equipment is too heavy to be lifted by shipboard aircraft, and current surface connectors cannot safely conduct a transit long enough to grant amphibious ships the standoff they need. Although troops could be moved longer distances by air for small raids, the Marine Expeditionary Unit (MEU) Air Combat Element (ACE) is too small to provide enough long-range fires to degrade ground defenses and provide close air support troops conducting the raid. The Navy will have to address these and other challenges to continue exploiting the sea as a maneuver space for offensive operations ashore.

New Operational Concepts for Amphibious Forces

Operating concepts are the starting point for efforts to improve the range and staying power of amphibious forces. They form the basis for new system and platform requirements, inform strategies for how to prioritize investments, and help guide doctrine and tactics on how to integrate new and existing capabilities. New operating concepts can help solve the Marine Corps' most pressing operational limitations, such as surface connector survivability and long range fires capacity, by using planned or existing capabilities in new ways or enabling new systems to be less sophisticated and costly. Specifically, the Navy and Marine Corps should pursue new operational concepts to:

- **Establish and sustain Expeditionary Advanced Bases (EABs).** EABs in contested areas can support offensive air operations, cross-domain fires, raids, and logistics support at closer ranges and with potentially greater survivability than naval forces at sea or in the air.

5 This approach to deterrence and its implications for fleet architecture are explored in depth in Bryan Clark, Peter Haynes, Bryan McGrath, Craig Hooper, Jesse Sloman, and Tim Walton, *Alternative Future Fleet Architecture Study* (Washington, DC: Center for Strategic and Budgetary Assessments, 2016), pp. 1–6.

- **Execute raids to assure access.** Potential adversaries are using coastal sensors and weapons to contest the surface and airspace around their territory. These systems can be difficult to degrade or destroy with air strikes and may need to be rooted out by Marine raids launched from EABs or outside the contested area.
- **Employ cross-domain fires.** Ground-based air defenses and surface-to-surface weapons can transform islands and archipelagos into barriers against adversary power projection and increase the number and complexity of fires poised at enemy forces.
- **Conduct surface warfare.** Amphibious forces at sea can attack enemy surface combatants with missiles and helicopters to add offensive firepower to U.S. surface forces as well as improve the defense of amphibious ships by challenging enemy surface combatants directly.
- **Impose blockades.** The adoption of a concept of denial and punishment for deterrence increases the importance of blockade. Preventing the flow of goods and commodities to the enemy can impose significant costs as an element of punishment.

Implications for Capabilities and Processes

For amphibious force capabilities to improve, new operating concepts will need to result in changes to systems, platforms, and processes. The Navy and Marine Corps should invest in the following initiatives to implement new concepts:

- **Build lighter vehicles** that can be carried by MV-22s and helicopters to grow the reach of amphibious forces and increase their firepower;
- **Optimize surface connectors** for ocean travel rather than ground movement to increase the range and survivability of amphibious operations;
- **Rebalance amphibious assault ship loadouts** toward aviation to increase the range and amount of fires they can provide;
- **Increase the armament on amphibious ships** to enable them to provide long-range fires and contribute to surface warfare;
- **Acquire more missile launchers** to enable ground troops to provide cross-domain fires and improve their air defense capacity;
- **Grow the Amphibious Readiness Group (ARG)** to sustain lift capacity while increasing the range and amount of long-range fires;
- **Adopt a new readiness model** to achieve greater operational availability and improve the learning and expertise of amphibious forces; and

- **Increase the size of the amphibious fleet** to enable greater tailoring of forces to specific regions, a shift to the four-ship ARG, and sustainable readiness cycles.

Potential adversaries will continue to improve their ability to contest the sea and air around their territory, increasing the range at which amphibious operations must occur and exposing amphibious ships and Marines to greater threats. The United States must adopt new operating concepts and new or modified capabilities for amphibious operations that address these trends and enable the U.S. Navy and Marine Corps team to continue supporting American efforts to deter aggression, respond to crises, and exploit its maritime superiority as an asymmetric military advantage.

CHAPTER 1

Introduction

Amphibious operations[6] have been an element of naval warfare since ships first went to sea. From the Peloponnesian War to Gallipoli to Inchon, naval forces have exploited the maneuver space of coastal waters to achieve the position from which they can attack their enemy's weak points, reinforce their own positions, and support coastal sea control. In World War II, the United States and its allies conducted the largest amphibious operations ever seen to liberate invaded countries in Europe and leapfrog across the Pacific Ocean to eventually reach Japan. America has maintained the largest and most ready amphibious fleet since then, with an average of more than ten ships and 6,000 Marines deployed every day.

The essential nature of the competition between amphibious forces and defenders ashore has remained largely constant over the last two millennia. New platforms would emerge to move troops ashore faster or at lower risk, and defenders would develop new weapons to increase the threat to landings. The character of amphibious operations, however, changed significantly. Oar and sail gave way to steam and diesel propulsion; cruise missiles augmented coastal artillery; and hovercraft and helicopters replaced wooden troop transfer boats.

The competition between amphibious forces and coastal defenses can be seen as proceeding through phases as new technologies and operating concepts enabled one side to gain an advantage, compelling the other to develop new capabilities and approaches to regain the upper hand. Other areas of warfare—such as undersea warfare, electromagnetic spectrum

6 For the purpose of this study, "amphibious operations" are defined as operations launched from the sea to conduct operations ashore within the littorals. They can also include operations launched from shore to influence events at sea within the littorals. The littorals include those land areas (and their adjacent sea and associated airspace) that are predominantly susceptible to engagement and influence from the sea. This definition is based on U.S. Joint Doctrine but adds the element of forces ashore influencing events at sea. See U.S. Department of Defense (DoD), Joint Staff, *Amphibious Operations*, Joint Publication 3-02 (Washington, DC: DoD, 2014), p. 1-1.

(EMS) warfare, and air defense—have experienced similar phases as described in previous CSBA reports.[7]

The last major shift in amphibious warfare started during World War II. The advent of carrier-based aviation enabled naval forces to damage coastal artillery and rapidly degrade defenses from long range. Although forces ashore could employ mines and obstacles to slow down assaults, without air superiority, they could not sustain a defense. The advantage naval aviation gave amphibious forces persisted through the Cold War, although concern about nuclear escalation reduced the frequency and scope of amphibious operations.[8] By the mid-1960s, SAMs such as the SA-2 and SA-5 improved the lethality and altitude of air defenses, dramatically impacting air strike operations and thus their ability to support amphibious assaults. ASCMs followed in the 1970s, threatening amphibious and landing ships. These early missiles, however, were expensive, had relatively short ranges, and could only be in one place at a time. This enabled the invading force to shift their assault to a lower-risk area of coastline.

The amphibious warfare competition is now entering a new phase. In the last 30 years, SAMs and ASCMs increased in range and lethality and became more widely proliferated. They can now threaten assault ships and supporting aircraft 200 nm or more away, enabling a defender to use a relatively small number of defenses to protect long areas of coastline, prevent amphibious ships from using short-range transports to get ashore, and significantly constrain the attacker's options for an amphibious assault.

Despite this difficulty, America's naval forces will still need to be able to conduct amphibious operations. The most likely objectives of America's major rivals, such as the Senkaku Islands or Taiwan for China or the Strait of Hormuz for Iran, lie across or adjacent to littoral seas. In these areas, amphibious operations will be essential to deny an aggressor's ability to gain its objectives, whether by interdicting enemy forces at sea or dislodging them once ashore. Further, adversary SAMs and ASCMs will likely be hidden in coastal emplacements that will be difficult for air strikes to eliminate. Amphibious raids may be necessary to root out these threats.

7 See Bryan Clark and John Stillion, *What it Takes to Win: Succeeding in 21st Century Battle Network Competitions* (Washington, DC: Center for Strategic and Budgetary Assessments, 2015), pp. 93–94; Bryan Clark, *The Emerging Era of Undersea Warfare* (Washington, DC: Center for Strategic and Budgetary Assessments, 2015), p. 2; Bryan Clark and Mark Gunzinger, *Winning the Airwaves: Regaining America's Advantage in the Electromagnetic Spectrum* (Washington, DC: Center for Strategic and Budgetary Assessments, 2015), p. 4; and Mark Gunzinger and Bryan Clark, *Winning the Salvo Competition: Rebalancing America's Air and Missile Defenses* (Washington, DC: Center for Strategic and Budgetary Assessments, 2016), p. 9.

8 Malkasian, *Charting the Pathway to OMFTS*, p. 29.

The Next Phase of Amphibious Warfare

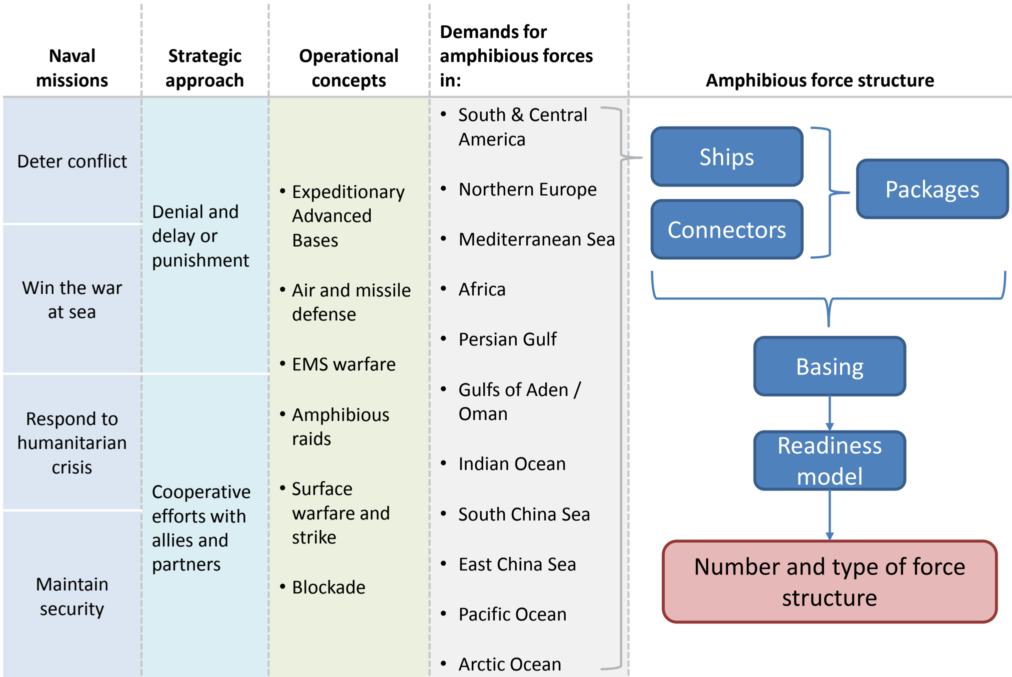
U.S. naval forces require new operating concepts and capabilities that circumvent or defeat improving coastal defenses and permit the types of amphibious operations the United States will need to conduct in the long term. These two imperatives are interrelated. Amphibious units will need to disperse, become less detectable, and reduce their time in contested areas to dilute enemy salvos and lower the number of weapons arriving at a target to be within the capacity of its defenses. At the same time, PGW and new sensor and countermeasure technologies will allow smaller, lighter, and more distributed amphibious forces to achieve similar effects in shorter periods of time than those that fought in previous conflicts.

Changes in the nature of potential targets for future amphibious operations are also making distributed approaches more appropriate. Of note, potential adversaries are fielding land-based SAMs and ASCMs to threaten U.S. freedom of action on or above the water. This includes China's missile batteries on islands in the South China Sea, Iran's coastal defense ASCMs along the Strait of Hormuz, or Russia's long-range SAMs that reach across the Baltic Sea into Finnish airspace. Amphibious units will likely be called upon in wartime to degrade or destroy these installations to deny them to the enemy and help enable U.S. sea and air superiority. In past conflicts, coastal defenses were large and fixed, making them vulnerable to air attack. Today potential adversaries are increasingly turning to small mobile missile batteries and sensors to improve their survivability. These systems are more susceptible to attack by distributed amphibious raids than by air strikes or large-scale amphibious assault.

The need for more distributed and agile amphibious operations has significant implications for the operating concepts, force structure, capabilities, sustainment, and posture of amphibious forces. The U.S. Marine Corps recognized the importance of new warfighting approaches with its recent publication of an updated Marine Corps Operating Concept (MOC). The MOC emphasizes the use of advance bases, a wider range of maritime platforms, cross-domain fires, distributable units, and lighter, more agile forces.[9] This study will build on the MOC to examine the implications of changes in the strategic environment and the conduct of amphibious operations. It uses a similar approach to CSBA's recent study on alternative fleet architectures, as depicted in Figure 1.

9 Robert Neller, *The Marine Corps Operating Concept: How an Expeditionary Force Operates in the 21st Century* (Washington, DC: U.S. Department of the Navy, 2016), pp. 8–10.

FIGURE 1: STUDY METHODOLOGY



This study starts with analyzing the security environment and how it is likely to evolve over the next two decades. It then evaluates the strategic approaches and operational concepts U.S. amphibious forces might pursue to carry out their missions. This evaluation suggests an appropriate posture for amphibious forces overseas in terms of deployed presence and support infrastructure. It concludes by assessing changes needed to amphibious force structure, capabilities, and readiness cycles.

A new approach to amphibious warfare is needed, given trends in naval capabilities, threats, and likely future operations. If U.S. naval forces fail to evolve in anticipation of these trends they will be unable to support future amphibious operations, preventing naval forces from effectively deterring or responding to aggression in the littorals.

CHAPTER 2

A New Strategic Approach

The end of the Cold War left the U.S. military in a position of global pre-eminence. The capabilities, force posture, and doctrine developed for a large-scale conflict with the Soviet Union usually proved sufficient to assure the U.S. military's command of the global commons after the USSR's dissolution.[10] Yet, while the risk of nuclear escalation was diminished, amphibious operations were increasingly challenged by improving SAMs and ASCMs.

Today, the U.S. military's margin of superiority is eroding as potential adversaries develop, acquire, and refine networks of long-range sensors and precision weapons that the Soviets first called "reconnaissance-strike complexes."[11] As more powers gain the ability to conduct precision warfare, it will become increasingly difficult and costly for the United States to carry out a forcible entry into a defended region.

Throughout the 1990s and the 2000s, most armed U.S. interventions, including operations in Iraq, Kosovo, and Afghanistan, followed a similar basic template. After an act of aggression against U.S. allies and partners, U.S. forces would build up theater combat power by deploying personnel and equipment to land bases and waters proximate to the intended area of operations. Tactical aircraft and standoff missile strikes would quickly defeat enemy air defenses and establish air superiority by exploiting U.S. advantages in weapons, electronic warfare (EW), and enablers such as aerial refueling and airborne early warning (AEW).

Once air threats were eliminated, U.S. forces would begin to reverse the adversary's gains. U.S. strike aircraft would carry out attacks against enemy forces to degrade the opposing army. U.S. ground troops would then enter the fight to complete the operation with on-demand air support available.

10 Barry R. Posen, "Command of the Commons: The Military Foundation of U.S. Hegemony," *International Security* 28, no. 1, Summer 2003, p. 8.

11 Watts, *The Maturing Revolution in Military Affairs*, pp. 1–2.

This warfighting model is predicated on *access* to the area of operations. The range constraints of contemporary tactical fighter aircraft require bases and aircraft carriers to be within a few hundred miles of a combat zone. For the past two decades, this degree of standoff has been sufficient to protect U.S. forces from attack because the United States and its allies had a near-monopoly on the sophisticated targeting and weapons technologies necessary to mount successful strikes at longer ranges.

However, over the past few decades, potential adversaries noted the weaknesses inherent in this operational approach. Some states are taking steps to exploit American vulnerabilities by fielding long-range sensors and weapons that can locate and engage U.S. ships and aircraft at ever greater distances from their territory. These capabilities appear poised to delay or stop U.S. forces from interceding in a regional confrontation.

Increasing Challenges to Access

The most capable potential U.S. adversary is China, whose rapid economic growth has fueled an extensive military modernization program during the last 20 years. A centerpiece of these efforts is the development and deployment of new capabilities designed to deny U.S. forces the freedom to operate within striking range of the Chinese homeland. In the maritime domain, radar and electro-optical surveillance satellites and over-the-horizon (OTH) radars provide the People's Liberation Army (PLA) the ability to track and target U.S. surface platforms well beyond the range of American missiles and strike aircraft.[12]

China's sensor network can be used to cue long-range weapons such as bombers and strike fighters equipped with ASCMs or the PLA Rocket Force's road-mobile anti-ship ballistic missiles (ASBMs). The DF-21D ASBM, a derivative of the DF-21 series of medium-range ballistic missiles (MRBM), has reportedly completed testing and is assessed as being capable of reaching targets at ranges in excess of 800 miles.[13] A longer-range version based on the DF-26 MRBM may be able to strike ships more than 1000 nm away.[14] And if naval forces sailed close enough to launch tactical aircraft or missiles at China, the PLA's sophisticated integrated air defense system (IADS) could likely shoot down a large number of them.

Russia's re-emergence as a strategic competitor and regional belligerent also presents a challenge to U.S. freedom of action. The Russian military has modernized many of the weapon systems it fielded during the Soviet era and developed new capabilities that could threaten U.S. power projection forces, such as long-range missiles, submarines, IADS, and electronic warfare systems. U.S. naval platforms operating in the North Sea or the Mediterranean could be

12 Stephen Biddle and Ivan Oelrich, "Future Warfare in the Western Pacific: Chinese Anti access/Area Denial, U.S. AirSea Battle, and Command of the Commons in East Asia," *International Security* 41, no. 1, Summer 2016, p. 23.

13 "DF-21," *Jane's Strategic Weapons Systems*, February 22, 2016.

14 Office of the Secretary of Defense (OSD), *Military and Security Developments Involving the People's Republic of China 2016*, Annual Report to Congress (Washington, DC: DoD, 2016), p. 25.

targeted by ASCMs launched from Russian bombers and strike fighters flying from airfields located relatively deep in Russian territory. Closer in, Russia's ground-based ASCMs could threaten ships steaming in the Baltic and Black Seas.

Both Russia and China have fielded complete battle networks of sensors, platforms, and weapons to form robust, multi-domain reconnaissance-strike complexes. Below these high-end competitors sit a number of powers that lack the full spectrum of capabilities available to Russia or China, but whose weapons can offset U.S. strengths and create severe operational challenges for the United States. ASCMs are a particular cause of concern for maritime forces because they are more affordable compared to ballistic missiles and less complex to manage and operate than fighter aircraft.[15] More than eighty countries currently possess ASCMs, and twenty-two build them.[16] Iran's armed forces, for example, reportedly operate a derivative of the Chinese C-802 ASCM with a range of over 120 miles.[17] The C-802 could cover the entire Persian Gulf from Iranian territory and would be difficult to defeat because of the short resulting time of flight.

The spread of sophisticated anti-ship weapons has extended to non-state actors, creating hybrid adversaries who blend the characteristics of insurgent or guerilla forces with advanced equipment that heretofore was restricted to national militaries. Although it is unlikely that a hybrid opponent would be able to deny the U.S. military access to a given area, such an adversary could make U.S. commanders operate more carefully to avoid exposing their forces to surprise attack. In 2006, Hezbollah severely damaged one of Israel's most modern corvettes, killing four crew members, in an attack off the coast of Lebanon with an ASCM provided by Iran.[18] More recently, in October 2016 Houthi rebels in Yemen destroyed a former U.S. high-speed vessel and on two occasions fired ASCMs at the guided-missile destroyer USS *Mason*, forcing the ship to take defensive measures.[19] U.S. surface vessels operating in the littoral waters of even the most unsophisticated non-state opponents must now be prepared to counter potential attacks from precision weapons.

The U.S. military is responding to efforts by these potential opponents to contest the surface and air around their territory by fielding platforms that can evade detection by enemy sensors. These include stealth bombers and submarines that could attack enemy radars, air defenses, and command and control (C2) facilities and stealth fighters that could defeat enemy aircraft. Once the threat was sufficiently reduced, non-stealthy aircraft carriers, amphibious

15 Mahnken, *The Cruise Missile Challenge*, p. 32.

16 Fahrenkopf, "Anti-ship missiles: a dangerous gateway."

17 "Iran," *Jane's Sentinel Security Assessment: The Gulf States*, October 4, 2016.

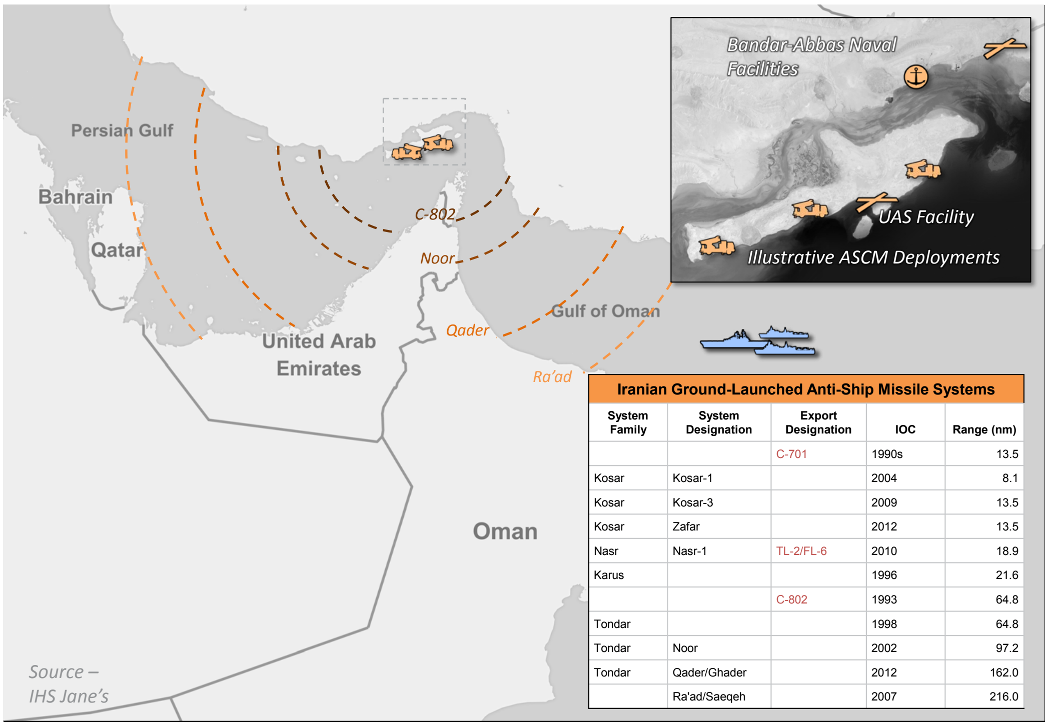
18 "Israel Navy caught out by Hizbullah hit on corvette," *Jane's Defence Weekly*, July 19, 2006.

19 "UAE says Houthi attack on ship in shipping lane was 'act of terrorism'," *Reuters*, October 5, 2016, available at http://www.reuters.com/article/us-emirates-security-idUSKCN1242DB; and Sam LaGrone, "USS Mason Fired 3 Missiles to Defend from Yemen Cruise Missiles Attack," *USNI News*, October 12, 2016.

ships, cargo aircraft, and tactical fighters would move in to conduct large-scale power projection operations.

A rollback campaign employing the full array of U.S. capabilities might eventually be successful against nearly any adversary. However, the effort could take weeks or months. An adversary might calculate that it could achieve a *fait accompli* by rapidly attaining a set of limited objectives before U.S. forces are able to complete their rollback campaign. Faced with the prospect of lengthy and demanding preparatory operations to regain theater access, the United States might simply conclude that military intervention is not worth the cost.

FIGURE 2: POTENTIAL THREAT ENVIRONMENT AROUND QESHM ISLAND[20]

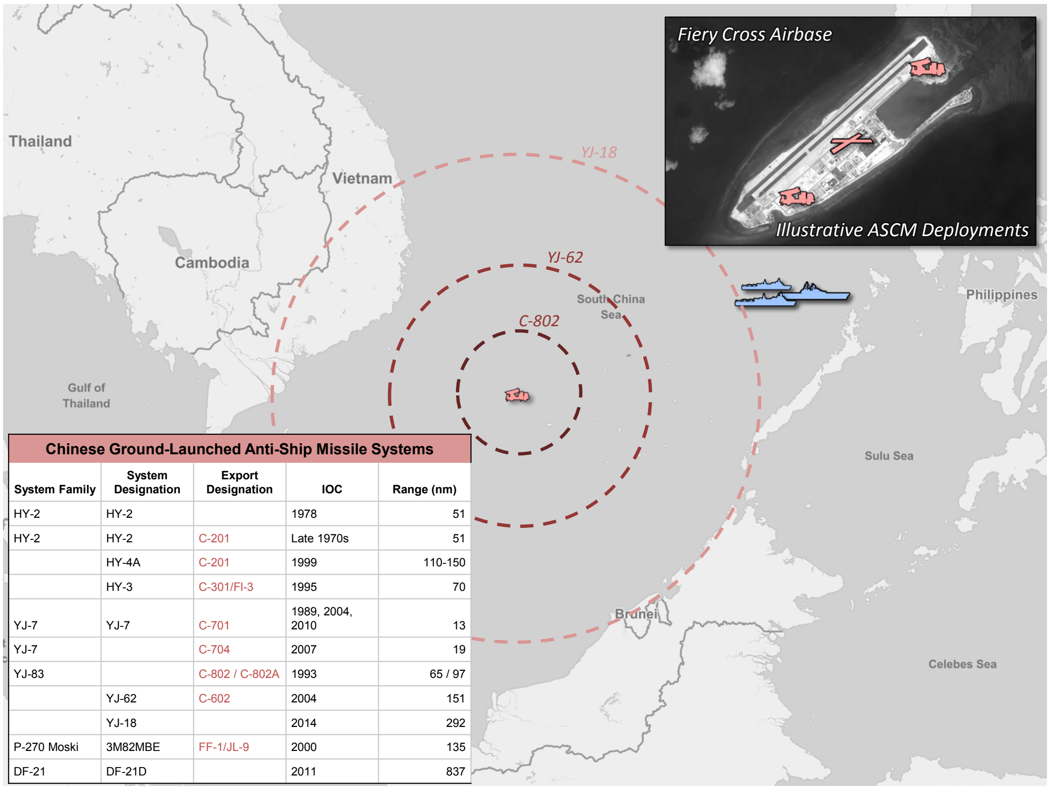


Iranian Ground-Launched Anti-Ship Missile Systems

System Family	System Designation	Export Designation	IOC	Range (nm)
		C-701	1990s	13.5
Kosar	Kosar-1		2004	8.1
Kosar	Kosar-3		2009	13.5
Kosar	Zafar		2012	13.5
Nasr	Nasr-1	TL-2/FL-6	2010	18.9
Karus			1996	21.6
		C-802	1993	64.8
Tondar			1998	64.8
Tondar	Noor		2002	97.2
Tondar	Qader/Ghader		2012	162.0
	Ra'ad/Saeqeh		2007	216.0

20 Figures 2 and 3 were compiled using data from IHS Jane's.

FIGURE 3: POTENTIAL THREAT ENVIRONMENT AROUND FIERY CROSS



Chinese Ground-Launched Anti-Ship Missile Systems

System Family	System Designation	Export Designation	IOC	Range (nm)
HY-2	HY-2		1978	51
HY-2	HY-2	C-201	Late 1970s	51
	HY-4A	C-201	1999	110-150
	HY-3	C-301/FI-3	1995	70
YJ-7	YJ-7	C-701	1989, 2004, 2010	13
YJ-7		C-704	2007	19
YJ-83		C-802 / C-802A	1993	65 / 97
	YJ-62	C-602	2004	151
	YJ-18		2014	292
P-270 Moski	3M82MBE	FF-1/JL-9	2000	135
DF-21	DF-21D		2011	837

Shifting to a Denial and Punishment Approach to Deterrence

America's ability to deter conflict will suffer if America's allies and adversaries begin to believe U.S. forces may not be able to roll back adversary threats and reverse the results of aggression. To sustain its alliance commitments, the United States will likely need to move away from responding to aggression and towards stopping it in real time, whether by denying the aggressor the ability to reach its objectives or punishing the aggressor, compelling it to halt. An example of this approach would be to delay the adversary's aggression and protract the conflict sufficiently to render the overall financial and diplomatic costs too high to continue.

Embracing a new denial and punishment approach to deterrence will require three main changes to U.S. naval forces:

- A new posture that places them close enough to an adversary's forces or objectives to be able to impose costs or interdict the aggression;
- New operating concepts and capabilities that enable them to generate more fires against enemy ships, aircraft, ground targets, and aircraft than today; and

- New operating concepts and capabilities to enable them to persist longer in contested areas so they can expend their offensive weapons or achieve their objectives before withdrawing.[21]

Where naval forces are deployed matters. Unlike air forces that can rapidly redeploy or ground forces that are numerous enough to be widely dispersed, naval forces are constrained by ship numbers and ship speeds. A new denial and punishment approach to deterrence will require changes to the current global distribution of underway Navy and Marine Corps forces to ensure the capabilities present in a given region will be of the right quantity and composition to counter the most likely local threat.

To persist longer in highly contested environments, the Navy will need to increase the capacity of ship defensive systems. U.S. missile defense tactics today focus on engaging incoming air and missile threats with kinetic interceptors as far away as possible, potentially at ranges of more than 100 miles.[22] However, long-range interceptors are costly and physically large, constraining the number that can be carried by a vessel or mobile missile battery. Adversaries know that if they fire a salvo of a sufficient size, U.S. ships or ground units will simply run out of interceptors. Further, non-kinetic capabilities such as lasers, EW systems, or high-power radio frequency (HPRF) weapons only work in the line-of-sight. This limits them to a range of about 10 nm for sea-skimming missiles and, as a result, prevents them from replacing long-range interceptors.

To increase their defensive capacity, naval forces may need to shift from a long-range, layered air defense concept to one using medium- and short-range defenses. This would enable ships and ground units to use smaller interceptors that can be carried in larger numbers, augmented with essentially unlimited magazines of directed energy weapons.[23]

More efficient air defenses can also free up magazine space for more offensive weapons on ships and in expeditionary forces. Unfortunately, today those weapons do not have the range or lethality to enable U.S. naval forces to "fire effectively first."[24] The Navy is addressing this gap in the near term by developing anti-ship variants of weapons such as the SM-6 air defense missile and Tomahawk Land Attack Missile (TLAM),[25] but it will need to increase the volume of fires from naval forces to deny and punish aggression.

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21 This approach to deterrence and its implications for fleet architecture are explored in depth in Clark et al., *Alternative Future Fleet Architecture Study*, pp. 1–6.

22 "Standard Missile 1/2/3/4/5/6," *Jane's Naval Weapons*, August 25, 2016.

23 This approach to air defense is explored in more depth in Gunzinger and Clark, *Winning the Salvo Competition*, pp. 21–27.

24 This is a longstanding principle for success in fleet tactics. See Wayne Hughes, *Fleet Tactics and Coastal Combat* (Annapolis, MD: U.S. Naval Institute Press, 1999), p. 23.

25 Sydney J. Freedberg, Jr., "Anti-Aircraft Missile Sinks Ship: Navy SM-6," *Breaking Defense*, March 7, 2016; and Sam LaGrone, "West: U.S. Navy Anti-Ship Tomahawk Set for Surface Ships, Subs Starting in 2021," *USNI News*, February 18, 2016.

Chapters 3 and 4 will describe new operating concepts and capabilities to improve the posture, defensive capacity, and offensive firepower of naval forces in general and amphibious forces in specific.

Implications of the Environment for Amphibious Forces

An amphibious operation is defined by the U.S. military as "a military operation launched from the sea by an amphibious force to conduct landing force operations within the littorals."[26] Amphibious warfare has always been considered challenging because it places personnel and equipment in positions of vulnerability for extended periods of time.

Throughout history, the steps required to successfully execute a landing remained essentially the same. A large force of surface vessels first approaches a hostile coastline—always a maneuver fraught with hazards such as uncharted shoals and mines—then disgorges a ground force that will be taken ashore by smaller ships or aircraft. Once on land, a landing force must establish fire superiority on a geographically constrained and isolated piece of terrain, then push inland in order to secure the area around the landing zone. Finally, even with a secure beachhead, amphibious ships must remain nearby and continue to disembark equipment and supplies to support follow-on ground operations. For a contemporary MEU, an offload may take 12 hours or more.[27] For a larger force, it could take days or weeks.

Amphibious forces are particularly vulnerable to precision anti-ship weapons. Landing operations need to occur close to shore because most ship-to-shore boats and aircraft can only travel short ranges or are so vulnerable to attack that their time in transit must be minimized.[28] Whereas a carrier battle group can remain hundreds of miles away and still reach targets with its strike aircraft, U.S. ARGs must position themselves within tens of miles of an enemy coastline to launch an assault, well within range of modern, inexpensive ASCMs, SAMs, and shore-based radars or electro-optical and infra-red (EO/IR) sensors.[29]

The challenges of conducting landing operations in the modern era were illustrated during the 1982 Falklands War when the Royal Navy suffered the most ship losses of any fleet since World War II.[30] Two of its six losses came from Exocet ASCMs fired by Argentinian fighter aircraft prior to the landing; the other four ships were sunk by bombs launched by fighters while the vessels were offloading troops in San Carlos Bay and Port Pleasant.[31] These attacks

26 Joint Staff, *Amphibious Operations*, p. xi.

27 Jonathan T. Baker, *New Options for Amphibious Connectors*, Master of Operational Studies Research Paper (Quantico, VA: USMC School of Advanced Warfighting, 2012), p. 3.

28 The boats, helicopters, and tilt-rotor aircraft used to move troops and equipment from amphibious ships ashore are also referred to generally as "connectors."

29 David C. Fuquea, "Amphibious Ops in the 21st Century," *War on the Rocks*, September 17, 2013.

30 Malkasian, *Charting the Pathway to OMFTS*, p. 39.

31 Ibid.

demonstrate how difficult it is to protect ships confined to a narrow patch of ocean against low-flying cruise missiles and aircraft without the support of surface combatants with missile defense systems or airborne early warning aircraft that can detect threats at longer ranges and manage counter-air operations.

During the 1990s, the U.S. Marine Corps recognized the growing challenge posed by ASCMs and other precision weapons and developed a new operational concept, known as operational maneuver from the sea (OMFTS), and an enabling sub-concept, known as ship-to-objective maneuver (STOM). OMFTS seeks to increase the distances and speeds at which amphibious landings are conducted while STOM aims to employ vertical lift as the primary ship-to-shore connector so Marines can bypass the beach altogether.[32] Together, speed and range can enable amphibious groups to avoid a frontal assault on a concentration of enemy forces and instead maneuver to seize undefended or lightly defended rear areas.

OMFTS was linked with another new concept: seabasing. The goal of seabasing is to allow Marines to reduce their footprint ashore by keeping certain equipment, supplies, personnel, and aircraft at sea. This material can then be ferried back and forth to ground forces by air or surface connectors. With fewer people and less gear ashore, Marines can construct smaller bases that will be less vulnerable to enemy attacks. A smaller lodgment also takes less time to establish, allowing Marines to move faster during the conduct of OMFTS operations.

OMFTS was predicated on the acquisition of a trio of enabling technologies: the MV-22 Osprey tilt-rotor aircraft, the F-35B Joint Strike Fighter (JSF), and a replacement for the Amphibious Assault Vehicle (AAV).[33] The MV-22, with a combat radius several times that of the legacy CH-46 Sea Stallion helicopter, would provide a suitable aircraft for the vertical envelopment required to execute STOM.[34] The F-35B would provide Marine Air-to-Ground Task Force (MAGTF) commanders with a low-observable short takeoff and vertical landing (STOVL) fighter that was far more capable than the AV-8B Harrier, and which could support Marine forces from amphibious ships or expeditionary airfields. Finally, the AAV replacement would permit armored landing craft to be launched from over-the-horizon rather than only a few miles away, reducing the risk to amphibious ships.

32 Charles C. Krulak, "Operational Maneuver from the Sea," *Joint Forces Quarterly*, Spring 1999, p. 82.

33 Krulak, "Operational Maneuver from the Sea," pp. 84–85.

34 U.S. Marine Corps, *V-22 Osprey Guidebook* (Washington, DC: DoD, 2012), p. 9.

FIGURE 4: F-35B LIGHTNING II

U.S. Marine Corps Photo

FIGURE 5: MV-22B OSPREY

U.S. Navy Photo

Today, both the MV-22 and F-35B have reached initial operating capability (IOC), while the advanced AAV program has been canceled and replaced by a new vehicle, the Amphibious Combat Vehicle (ACV), which is optimized for land operations and cannot conduct an over-the-horizon amphibious movement. In addition, two Expeditionary Transfer Dock (ESD) ships have been acquired expressly for enabling seabasing operations.

However, for all the progress the Corps has made towards its vision for OMFTS, amphibious forces today are still hamstrung by the same problems they faced several decades ago. Thanks to the Corps' decision to prioritize increased armor over improved portability in new vehicle requirements, the MV-22 can carry just one type of Marine ground vehicle: the Internally Transportable Vehicle (ITV). The ITV was never acquired in great numbers and is no longer in production.[35] Without vehicles, MV-22-delivered ground forces are only able to bring a limited amount of offensive or defensive firepower into a combat zone, and the aircraft has been relegated to raids rather than serving as a critical connector for the sustained amphibious operations envisioned in OMFTS.

The Navy and Marines have made great strides in seabasing, but because of the MV-22's limitations, the concept's Achilles heel remains the surface connectors needed to transport critical capabilities ashore. Only one of them, the Landing Craft Air Cushion (LCAC), can move enough larger systems ashore fast enough to enable a landing force to quickly build up combat power, but its lack of armor and other survivability enhancements make it vulnerable to small arms fire. The Landing Craft Utility (LCU) has a slow top speed, which limits the range it can travel in a non-permissive environment, while the AAV is slow and not stable enough to carry Marines more than 4 miles offshore.[36]

35 Joe Gould, "US Marines Mull Replacement for Osprey-Carried Vehicle," *Marine Corps Times*, September 24, 2015.

36 David C. Fuquea, "An Amphibious Manifesto for the 21st Century," *Marine Corps Gazette* 96, no. 12, December 2012.

FIGURE 6: LANDING CRAFT (UTILITY)

U.S. Navy Photo

FIGURE 7: LANDING CRAFT (AIR CUSHIONED)

U.S. Navy Photo

U.S. amphibious forces today are unable to execute the full range of amphibious operations in a contested environment. Most Marine equipment is too heavy to be lifted by air, and current surface connectors cannot safely conduct a transit long enough to grant amphibious ships the standoff they need against today's threats. For smaller operations such as raids, LCACs or MV-22s can move troops and equipment hundreds of miles from their ship in a matter of hours, but the small MEU ACE will not provide enough long-range fires to degrade ground defenses or close air support to troops fighting the enemy. The Navy must address these and other challenges to continue exploiting the sea as a maneuver space for offensive operations ashore.

CHAPTER 3

New Amphibious Warfare Concepts

Amphibious operations will continue to be an important element of U.S. military strategy. Competitors such as China, Russia, and Iran are increasing their use of islands and littoral areas to host sensor and anti-air and anti-ship weapons. The potential targets of their aggression—including Taiwan, the Senkaku Islands, Baltic NATO allies, and the Strait of Hormuz—mostly lie across littoral seas or are on an adjoining coast. And U.S. naval forces will still be America's first responders during disasters or crises, when the ability to rapidly move people and material ashore is essential.

The advent of new, more capable ways to contest littoral areas and the likely warfighting approaches of opponents will require that U.S. forces adopt new operating concepts and applications for amphibious operations. These approaches will need to be more distributed, survivable, and lethal, and they will need to support littoral sea control and power projection in highly contested forward areas.

Doctrinally, amphibious operations include raids, demonstrations, assaults, withdrawals, and support to crisis response and other operations. These operations are defined as follows:

- An *amphibious raid* is an operation involving a swift incursion into, or the temporary occupation of, an objective to accomplish an assigned mission followed by a planned withdrawal.
- An *amphibious demonstration* is a show of force intended to influence or deter an enemy's decision.
- An *amphibious assault* involves the establishment of a landing force (LF) on a hostile or potentially hostile shore. An amphibious assault requires the swift buildup of combat power ashore, from an initial zero capability to fully coordinated striking power as the attack progresses toward amphibious force (AF) objectives.

- *Amphibious withdrawals* are operations conducted to extract forces in ships or craft from a hostile or potentially hostile shore.
- *Support to crisis response and other operations* focuses on providing a rapid response to crises, deterring war, resolving conflict, promoting peace, and supporting civil authorities in response to domestic crises.[37]

These general categories of operations are unlikely to change, but their objectives and the operating concepts used to conduct them will evolve in response to the changing strategic environment. This chapter will describe some of those new approaches.

The following discussion assumes amphibious ships will consist of amphibious assault ships (LHA/LHD), amphibious transport docks (LPD), and next-generation LX(R) amphibious ships based on the LPD-17 hull form. Marines are assumed to continue to deploy in MEUs of about 2,200 personnel on ARGs consisting of an LHA/LHD and two or more LPDs and LX(R)s.

FIGURE 8: AMPHIBIOUS ASSAULT SHIP (LHA/D)

U.S. Navy Photo

FIGURE 9: AMPHIBIOUS LANDING DOCK (LPD)

Gulf States Shipbuilding Consortium Photo

Expeditionary Advanced Bases

The potential adversaries U.S. forces will be expected to deter or defeat are fielding weapons and targeting capabilities designed to delay and reduce the effectiveness of U.S. or other forces that may attempt to intervene on behalf of allies. These enemy systems are optimized to engage ships and aircraft, which are significant threats to an adversary and have identifiable signatures against relatively plain backgrounds of sea and sky. They are not as effective in attacking ground units, which are composed of smaller, less concentrated capabilities than ships or aircraft and able to blend into the busy background of terrain, trees, and structures. This is a similar problem to what U.S. forces face when attempting to engage relocatable ground-based systems such as transporter-erector-launchers (TEL) employed by Iraq during

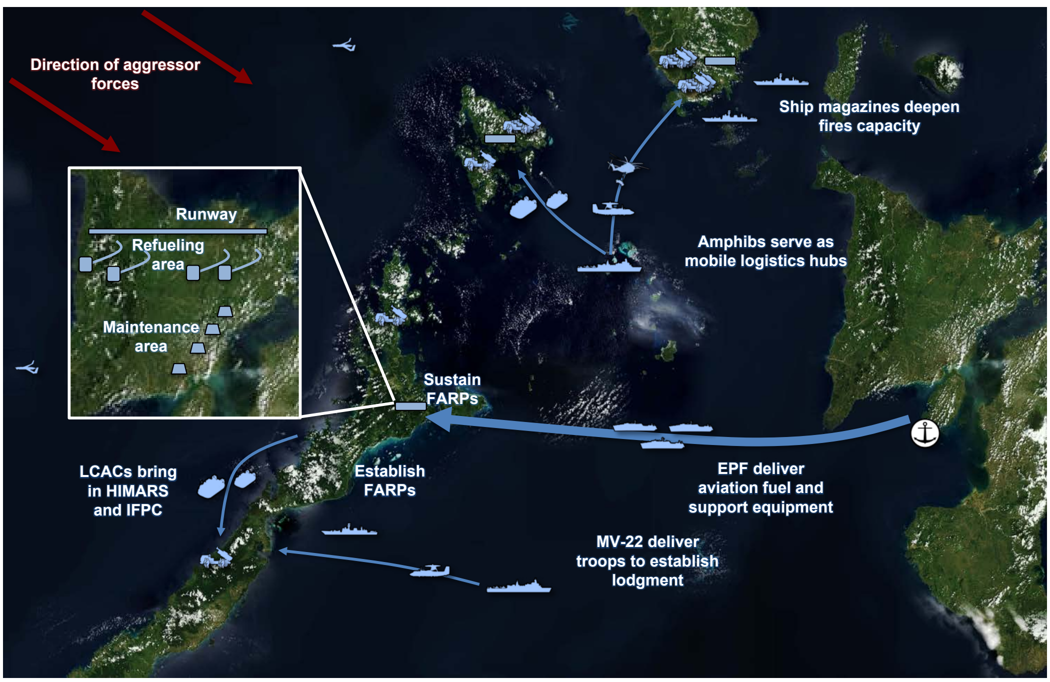
37 Joint Staff, *Amphibious Operations*, pp. 1-2, 1-3.

Operations DESERT STORM and IRAQI FREEDOM, or systems that might be used by China, Russia, or Iran in a future confrontation.

Amphibious forces can exploit this targeting challenge by establishing EABs in littoral areas near enemy forces, targets, or potential objectives. An EAB is a small, expeditionary outpost ranging from company to battalion size.[38] Because they are harder to find and engage, EABs will likely be able to operate closer to the enemy for longer periods than ships or aircraft. Their proximity and persistence could enable EABs to constrain the enemy's freedom of action by threatening anti-air or anti-ship attacks, denying or confusing enemy sensors, or launching unmanned systems that interfere with or interdict enemy forces. EABs would also be targets that could consume large numbers of enemy weapons in an effort to defeat them in detail.

EABs can host a wide range of capabilities forward including missile batteries, forward arming and refueling points (FARP) for tactical aircraft, sensors, logistics hubs, C2 centers, and austere or improvised ports. Figure 10 depicts an illustrative EAB, but the exact configuration and size of an EAB would derive from its purpose and how long it was expected to operate. Some applications of EABs, such as to provide cross-domain fires, launch raids, or support blockades, are described in the descriptions of other new amphibious concepts below.

FIGURE 10: ILLUSTRATIVE EAB CONCEPT



38 A company is about 100 personnel, and a battalion is about 1000 personnel.

In terms of the doctrinal categories described above, establishing an EAB is a type of amphibious assault and may, in fact, become the most likely and common use of amphibious assaults in future conflicts. Large assaults such as those at Inchon during the Korean War and Iwo Jima during World War II would likely result in unacceptable losses today because they provide too many targets to enemy precision weapons for too long a time. For example, U.S. commanders during Operation DESERT STORM used the threat of amphibious assault to pin down six Iraqi infantry divisions on the coast but did not actually send Marines across the beach due to the challenge from Iraq's early Soviet-made SAMs and ASCMs. While these Iraqi units were standing by, U.S. ground forces invaded from other directions ashore.[39]

In contrast, EABs would take less time, require fewer troops, and be further from enemy forces than a large-scale amphibious assault. With their smaller size and scope, EABs could be established and disestablished regularly as demonstrations in peacetime and to habituate adversaries and allies to U.S. ground forces in the region. As opposed to establishing area control after aggression occurs, regular EAB operations would enable advance bases to potentially be in place when a conflict starts.

EABs are only useful if they are forward where they can engage the enemy and disrupt its operations. As such, their most important attribute is survivability. EABs will need to manage their signatures, mount high-capacity air defenses, disperse key capabilities around the base, and be readily relocatable. The objective of these efforts should be to increase the number of weapons, or "salvo size," an enemy would need to use to defeat an EAB or group of EABs. This metric of salvo size allows a disparate array of actions and capabilities to be compared with one another in terms of their impact on the enemy's operations. Moreover, if the required salvo size becomes large enough, an enemy may choose to not attack and save its weapons for other targets.

The Marine Corps emphasizes the importance of managing EMS signatures in its new operating concept.[40] As part of this effort, EABs will need to employ countermeasures including camouflage, decoys, EW systems to jam airborne radars, lasers to "dazzle" EO/IR sensors, and low probability of intercept/low probability of detection (LPI/LPD) communication systems to defeat enemy passive sensors. It is important that these capabilities be employed together as a system of systems so they can achieve an overall beneficial effect even if individual capabilities are not perfect. For example, decoys only need enough fidelity to appear like real targets when they and the real systems are both camouflaged and the sensors looking at them are being jammed or dazzled. This reduces the cost and complexity of signature management operations in the EAB.[41]

39 Thomas M. Huber, "Deception: Deceiving the Enemy in Operation Desert Storm," in Roger J. Spiller, ed., *Combined Arms in Battle Since 1939* (Fort Leavenworth, KS: U.S. Army Command and General Staff College Press, 1992).

40 Neller, *Marine Corps Operating Concept*, p. 17; and Jon Harper, "Marines Prepare to Fight at Sea, on the Ground, From the Air," *National Defense Magazine*, January 2016, p. 12, available at http://www.nationaldefensemagazine.org/archive/2016/january/Pages/MarinesPreparetoFightatSeaOntheGroundFromtheAir.aspx.

41 For a more detailed description of the use of active and passive countermeasures for base defense see Gunzinger and Clark, *Winning the Salvo Competition*, pp. 11–20.

FIGURE 11: VISUAL AND EO/IR DECOY[42]

U.S. Air Force Photo

FIGURE 12: ULTRA-LIGHT CAMOUFLAGE SYSTEM

Photo from Defense Industry Daily

By making decoys and real targets look similar, these countermeasures increase the number of potential targets an enemy would have to engage. Dispersing targets on the EAB would further increase the enemy's needed salvo size.

Amphibious forces will need to complement sensor countermeasures with high-capacity air defenses, both to protect forces from attacks that do occur and to further raise the salvo size needed for a high-confidence attack. Today, Marines only carry man-portable Stinger missiles for air defense, which lack the range, capacity, and lethality to address the large number of bombs, missiles, and other munitions likely to be fired at an EAB. Emerging kinetic capabilities include the truck-mounted Indirect Fires Protection Capability (IFPC) interceptor launcher and hypervelocity projectiles (HVP) that can be shot from existing 155mm artillery to intercept air threats.[43]

FIGURE 13: ARMY IFPC INCREMENT 2-I

U.S. Army Test and Evaluation Command Photo

FIGURE 14: M777 155MM HOWITZER

U.S. Marine Corps Photo

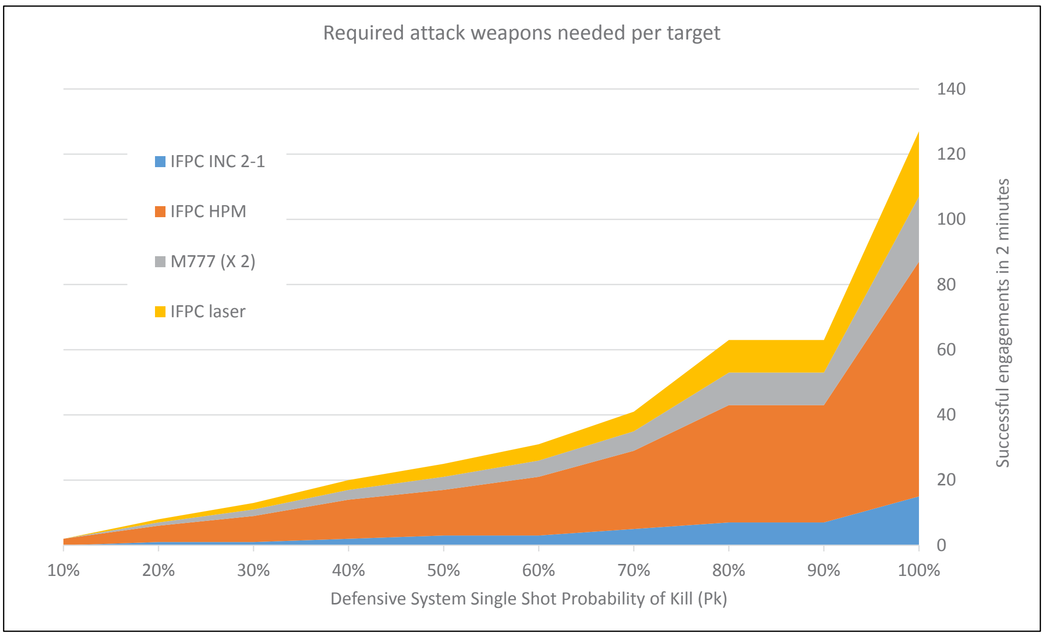
42 USAF Photo was sourced from Alan J. Vick, *Air Base Attacks and Defensive Counters: Historical Lessons and Future Challenges* (Santa Monica, CA: the RAND Corporation, 2015), p. 43. The near plane is a decoy, and the far plane is a real F-16.

43 The IFPC consists of a five-ton medium tactical vehicle carrying the 15-cell multi-mission launcher. IFPC Increment 2-Intercept (2-I) uses the Stinger or AIM-9X missile as the interceptor. The Army plans future IFPC increments to carry laser or HPRF weapons. See Sydney J. Freedberg, Jr., "Lasers vs. Drones: Directed Energy Summit Emphasizes the Achievable," *Breaking Defense*, June 23, 2016, available at http://breakingdefense.com/2016/06/lasers-vs-drones-directed-energy-summit-emphasizes-the-achievable/. The HVP is an artillery round that can achieve hypersonic muzzle velocities (>Mach 5), which would enable it to be shot in front of incoming missiles. The HVP would either directly hit the incoming weapon or (more likely) explode and use shrapnel to damage the missile and send it off course.

Non-kinetic defenses such as lasers or HPRF systems will become an increasingly important component of air defenses for expeditionary forces. These weapons offer high capacity and low cost per engagement but are not effective against all weapons types and in all weather conditions. And like artillery, they would have rate of fire limitations that constrain the number of weapons they can engage in a particular salvo.

Figure 15 illustrates the salvo size needed to overcome the capacity of a relatively small footprint of kinetic and non-kinetic defenses including two M777 howitzers with HVPs, one IFPC with kinetic interceptors, and one IFPC with a laser and HPRF transmitter. These systems could be associated with a company-size landing team that could operate an EAB supporting a FARP or cross-domain fires batteries. If these systems have conservative levels of effectiveness such as a single shot probability of kill (Pk) of 70% for interceptors and 50% for lasers or HPRF weapons and M777s with HVPs, the overall air defense capacity of the EAB would be twenty-seven engagements per two-minute salvo. This may not seem like a large number, but the attacker would not know the exact defensive capacity and would need to exceed this number to ensure the defenses are overcome.

FIGURE 15: ILLUSTRATIVE EAB DEFENSIVE CAPACITY[44]



44 Assumptions: the M777 fires five rounds per minute; HPRF can engage thirty-six weapons per minute; a laser can engage a target every six seconds; and the IFPC can carry fifteen interceptors that would need to be refilled after each salvo.

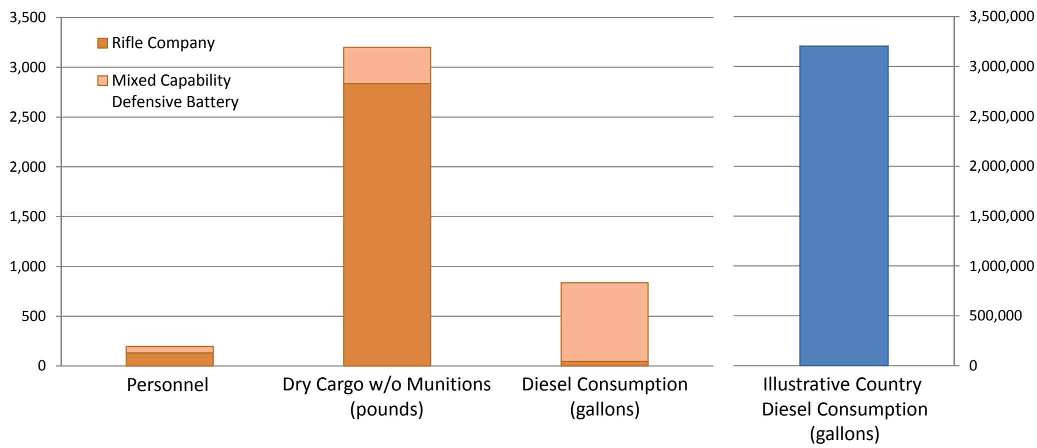
Moreover, since the enemy would not know which of its weapons would be shot down, it would need to launch twenty-seven weapons at each target on the EAB or risk some targets being missed because the defensive systems engaged all the weapons going to the same target. If decoys are mixed in with real systems on the EAB, the number of targets the enemy would have to engage could increase geometrically. The attacker may not be so conservative as to attack each potential target with (in this case) twenty-seven weapons, but ensuring a successful attack on an EAB employing modest defensive systems and some sensor countermeasures could easily require more than 100 weapons. This may be more than the enemy is willing to expend on each advance base.

By establishing EABs inside a contested area, amphibious forces could significantly complicate the enemy's targeting, add multiple axes from which U.S. forces could attack, and enable U.S. air and naval forces to sustain pressure on an enemy. When combined with sensor countermeasures and defenses, EABs can become "hard targets" that are not easily dislodged. Since they are small and require external sustainment, EABs could be suppressed by enemy attacks. This is achieved at a cost, however, draining magazines and taking sensors and platforms away from other missions. Suppression operations could also provide targeting data to U.S. forces for counter attacks.

EABs, particularly on the territory of allies or partners, would be sustainable from amphibious ships or from the host nation. Figure 16 illustrates the logistics requirements for the EAB depicted in Figure 10, which includes two IFPC systems, a company of Marines, air defense radars, and two M777 gun batteries. As the figure indicates, the daily EAB requirements for food, fuel, and water could be met by one to two flights per day by an MV-22 or an unmanned vertical lift aircraft such as K-MAX, which has served with Marine units in Afghanistan.[45] This amount of fuel and other supplies could also be met by the host nation. If the EAB supported air operations as a FARP, required aviation fuel could be provided by a fuel bladder delivered daily by MV-22.

45 The MV-22 has an internal cargo capacity of 20,000 lbs., which would enable one to carry all the dry cargo and food needed in a day. Depending on how the cargo is configured, the EAB's fuel (about 7,000 lbs.) could be carried by the same aircraft, or it would need to be carried by a second MV-22. The K-MAX UAV can carry 6,000 lbs. on an external hook. See Kaman Aerospace, "K-MAX Specifications," available at http://www.kaman.com/aerosystems/solutions/air-vehicles-mro/k-max.

FIGURE 16: DAILY SUSTAINMENT NEEDED FOR AN EAB, COMPARED TO AN ILLUSTRATIVE HOST NATION[46]



Raids to Assure Access

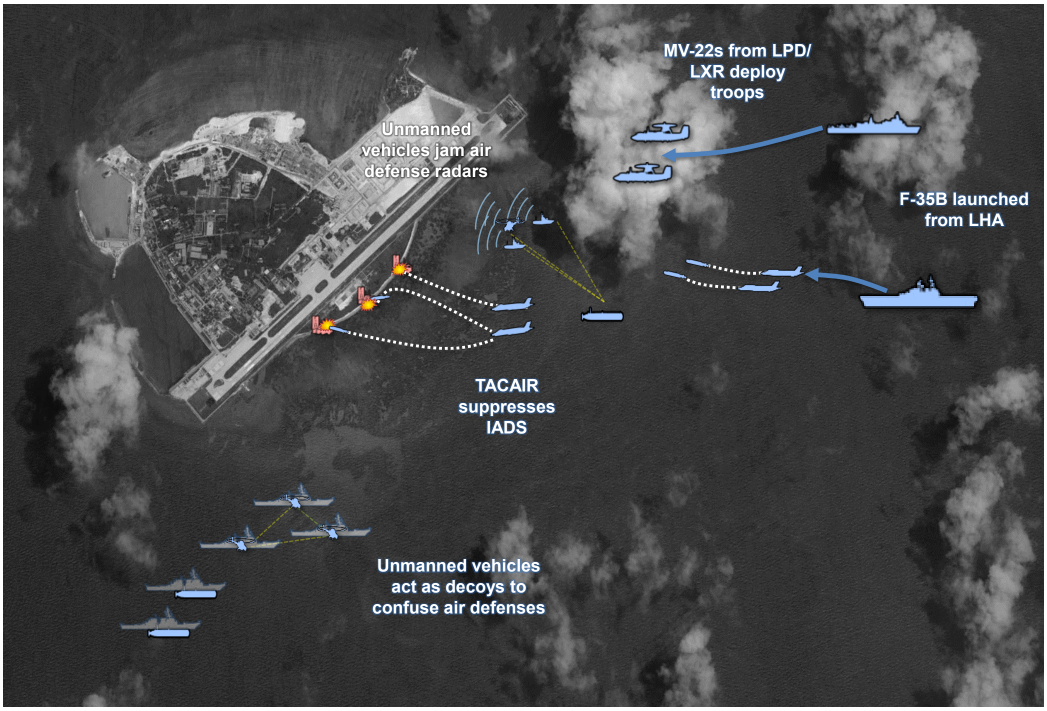
Competitors such as China, Russia, and Iran have the advantage of proximity to important maritime chokepoints and U.S. allies. They can threaten the freedom of the global commons and American alliances with missile batteries based in their home territory or that of friendly client states. As described above for EABs, it is difficult to effectively strike ground-based missile launchers that are hidden in terrain, camouflaged, equipped with decoys, and protected with shelters. Instead, it may be necessary to neutralize them with ground forces.

Amphibious raids historically have been executed as part of power projection operations such as amphibious assault. In the future, they will likely be done more often to support sea control and freedom of action in littoral areas by degrading or destroying enemy anti-air and anti-ship missile batteries and associated sensors in particular locations.[47] Figure 17 illustrates a raid against radars and ASCM and SAM launchers on a man-made island.

46 This chart is based on information from the Army Logistics Evaluation Worksheet (LEW) and data from published specifications of the applicable systems The illustrative host nation is the Philippines. Philippine energy usage derived from Philippine Department of Energy CY2014 data.

47 Neller, *Marine Corps Operating Concept*, pp. 12–13.

FIGURE 17: AMPHIBIOUS RAID IN SUPPORT OF SEA CONTROL



Because they would occur inside a contested area, raiding forces will need speed, sensor countermeasures, stealth, passive targeting, and mobility to reduce their vulnerability to detection and engagement. Amphibious ships from which raids would originate are large platforms that could be detected and attacked with ASCMs or torpedoes. Self-defense systems and damage control capabilities may prevent these ships from being destroyed outright, but attacks will disrupt and possibly suppress their ability to conduct amphibious operations. Amphibious ships will need to operate at the edges of contested areas to reduce their vulnerability and enable them to support multiple, distributed amphibious operations in a region.

Using the MV-22 tilt-rotor aircraft, amphibious raids could originate from 400 nm away and be completed in a few hours, reducing the vulnerability of amphibious ships and troops.[48] STOVL F-35B Lightning strike-fighters would degrade enemy defenses in advance of the raid. Using their stealth and passive targeting sensors to reduce their risk of counter-detection, they could get close enough to employ short-range weapons such as the Small Diameter Bomb (SDB). In transit, F-35Bs could protect MV-22s from enemy air defenses using their electronic attack and counter-air capabilities.

The long ranges of enemy anti-ship and anti-air weapons would enable them to be widely distributed along a coast or island, similar to how U.S. forces would distribute EABs. This could

48 Boeing Corporation, "V-22 Osprey Technical Specifications," *V-22 Osprey*, available at http://www.boeing.com/defense/v-22-osprey/.

require the same amphibious force to simultaneously support several raids and establish multiple EABs across a region several hundred miles across, such as the South China Sea or the Persian Gulf and the Arabian Sea. This may require more F-35Bs than the six aircraft normally in an ARG ACE.[49]

Cross-Domain Fires

The Navy's new concept of "Distributed Lethality" is designed to attack the enemy from a large number of weapons platforms to grow the amount and complexity of offensive fires and increase the difficulty of defeating U.S. forces.[50] Inside contested areas, submarines, surface combatants, and aircraft would engage enemy ships and targets ashore during the opening phase of conflict with a large volume of missiles and torpedoes. This initial volley of fire would be relatively short due to the finite magazines on ships and aircraft, and American platforms would only need enough defensive capacity to enable them to expend their offensive weapons and withdraw.[51]

The Navy intends Distributed Lethality to enable more effective offensive operations by U.S. naval forces inside contested areas and prevent them from having to cede maritime areas to an enemy because of its anti-air or anti-ship weapons. This should enhance the deterrence afforded by U.S. naval forces because they will be able to remain in the contested area and fight early in a conflict, punishing adversary aggression and possibly denying the enemy its objectives.

Marines and amphibious forces could contribute to Distributed Lethality using ground-based fires in littoral regions near the conflict area, which would further increase the number of targets an enemy must engage as well as the number of axes from which U.S. attacks could originate. For example, Marines in the Philippines could launch strikes against islands and attacks on enemy ships in the South China Sea using missile batteries based on EABs and STOVL aircraft flying from FARPs. Marines today employ M142 High Mobility Artillery Rocket System (HIMARS) launchers, which can fire M31 rockets with a range of about 40 nm, or Army Tactical Missile System (ATACMS) missiles with a range of about 160 nm.[52] These weapons do not have the reach to conduct attacks from outside the likely range of enemy weapons and can

49 U.S. Marine Corps, *Amphibious Ready Group and Marine Expeditionary Unit Overview* (Washington, DC: Headquarters Marine Corps, n.d.), p. 13, available at http://www.hqmc.marines.mil/Portals/61/Docs/Amphibious_Capability.pdf.

50 Thomas Rowden, Peter Gumataotao, and Peter Fanta, "Distributed Lethality," *U.S. Naval Institute Proceedings*, January 2015, available at http://www.usni.org/magazines/proceedings/2015-01/distributed-lethality.

51 For more discussion of the application of Distributed Lethality and its implications for fleet architecture, see Clark et al., *Alternative Future Fleet Architecture Study*, pp. 22–24.

52 U.S. Marine Corps, "High Mobility Artillery Rocket System (HIMARS)," *U.S. Marine Corps Concepts and Programs*, available at https://marinecorpsconceptsandprograms.com/programs/fire-support/high-mobility-artillery-rocket-system-himars; and Lockheed Martin Corporation, "ATACMS Long-Range Precision Tactical Missile System," available at http://www.lockheedmartin.com/content/dam/lockheed/data/mfc/pc/atacms-block-1a-unitary/mfc-atacms-block-1a-unitary-pc.pdf.

only engage fixed targets, but the DoD Strategic Capabilities Office and the Army are developing an anti-ship variant of ATACMS and a new generation of Long-Range Precision Fires missiles that include anti-ship variants.[53] Because they are larger than other MEU equipment, HIMARS launchers would need to be transported to the EAB by C-130 or surface connectors.

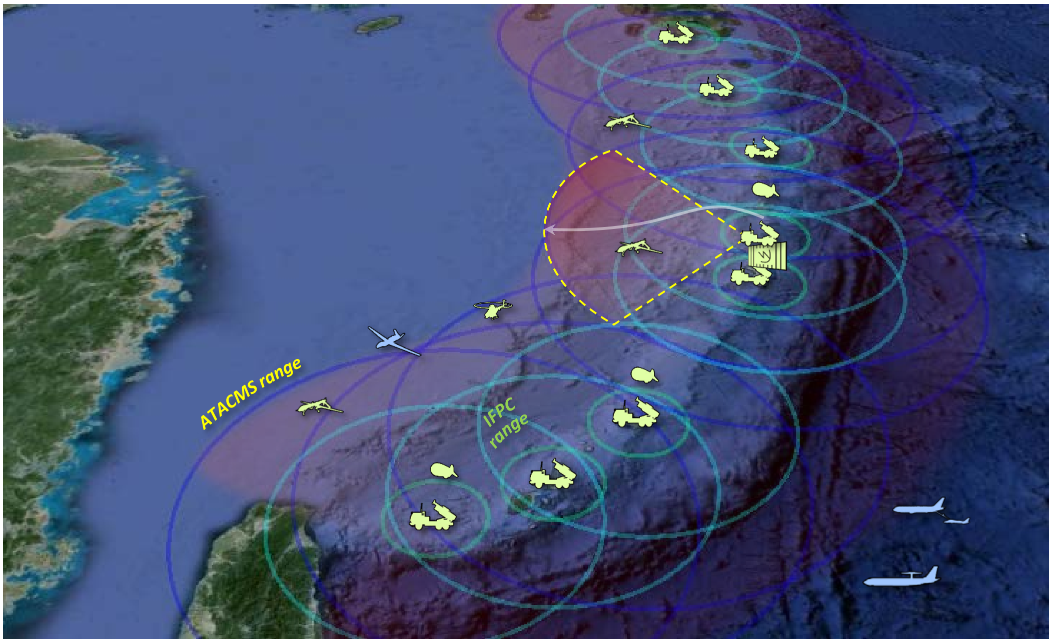
FIGURE 18: HIMARS LAUNCHER

U.S. Marine Corps Photo

Figure 19 depicts the use of EABs for cross-domain fires. In addition to surface-to-surface fires as described above, the EAB can also use its short-range air defense systems to engage nearby enemy aircraft. If several EABs were positioned along a littoral area, as shown in the figure, they can act as a barrier to enemy ships and aircraft attempting to reach open water. Against an adversary such as China, EABs could transform Japan's Southwest Islands and the Philippines into barriers to Chinese power projection and provide a less contested area behind them for more vulnerable aircraft such as airborne early warning and control system (AWACS) and aerial refueling aircraft.

53 The Army's replacement for ATACMS is the Long-Range Precision Fires (LRPF) missile. The Army plans to develop an anti-ship seeker for this missile. See Jason Sherman, "DOD project would add anti-ship capability to Army's premier long-range guided missile," *Inside Defense*, October 28, 2016; and Sydney J. Freedberg, Jr., "New Army Long-Range Missile Might Kill Ships, Too: LRPF," *Breaking Defense*, October 13, 2016, available at http://breakingdefense.com/2016/10/new-army-long-range-missile-might-kill-ships-too-lrpf/.

FIGURE 19: EABS SUPPORTING ANTI-SHIP AND ANTI-AIR OPERATIONS



Surface Warfare (SUW) and Strike

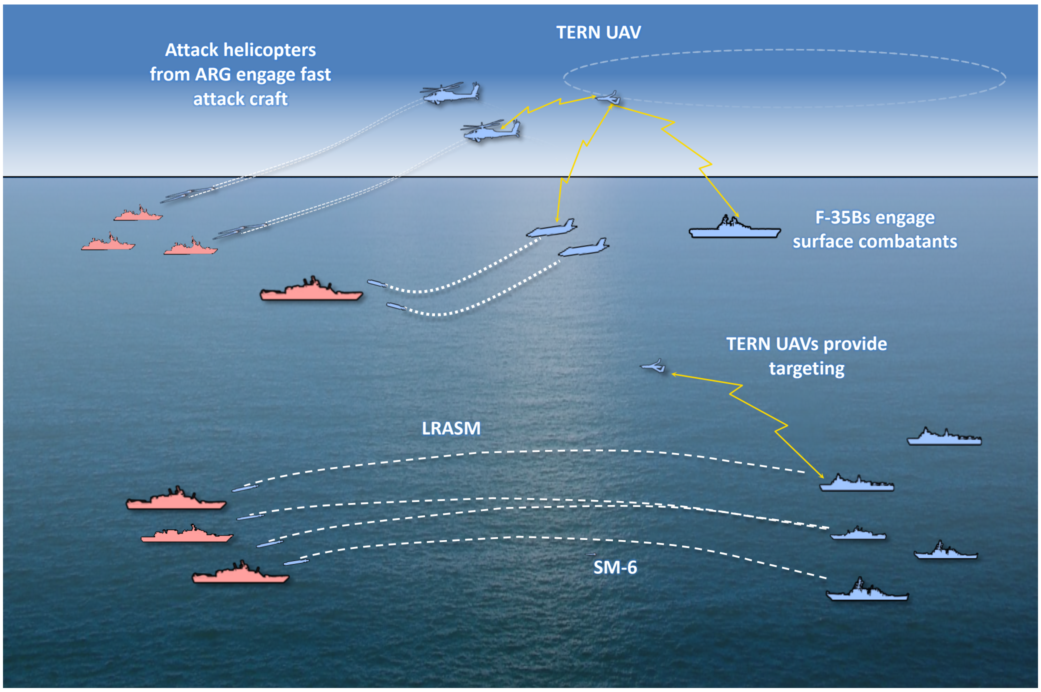
Amphibious forces can augment surface and submarine forces in attacking enemy surface ships and shore targets. A particular challenge for U.S. surface combatants is a lack of capacity for anti-ship and strike weapons in their vertical launch system (VLS) magazines. The majority of VLS magazines are taken up with air defense weapons such as SM-2, SM-6, and Evolved Sea Sparrow Missile (ESSM) interceptors because of the potential density of ASCM salvos and the fact that a ship has to carry all its weapons with it. For example, fifty ASCMs costing $100 million could consume the entire 96-cell VLS magazine of a $1.5 billion DDG-51 Flight IIa destroyer.[54]

As shown in Figure 20, amphibious ships can add to the SUW capacity of Navy surface forces by carrying VLS magazines of their own. Amphibious ships would then be able to employ the Navy's Long-Range Anti-Ship Missile (LRASM) Increment II when it is fielded in the mid to late 2020s, but in the near term they could use the Navy's expanding variety of VLS-launched

54 This calculation assumes SM-2 interceptors and a SS-L-S firing doctrine, resulting in about fifty engagements against modern ASCMs that cost about $2 million each (using the price of a BrahMos ASCM). If the ASCMs are less expensive the cost exchange is worse for U.S. forces. If smaller interceptors such as ESSM are used, then more engagements are possible because ESSM can be carried four to a VLS cell, as compared to one SM-2 interceptor per VLS cell. The need for new Navy air defense doctrine is further addressed in Bryan Clark, *Commanding the Seas: A Plan to Reinvigorate U.S. Navy Surface Warfare* (Washington, DC: Center for Strategic and Budgetary Assessments, 2014), p. 18; and Gunzinger and Clark, *Winning the Salvo Competition*, pp. 21–22.

missiles able to engage surface targets, including SM-6 and Tomahawk.[55] These weapons would have the added benefit of being able to support other missions. For example, the SM-6 can engage enemy aircraft and missiles at long range with cueing from a surface combatant radar, and the Tomahawk can conduct strikes on land targets more than 1000 nm away. Further, amphibious ships equipped with VLS magazines could expand their air defense capacity with VLS-launched ESSM interceptors.

FIGURE 20: AMPHIBIOUS FORCES CONDUCTING SURFACE WARFARE



Today the Navy's primary anti-ship capability resides in fixed-wing tactical aircraft using Harpoon-based AGM-84 Standoff Land Attack Missile-Extended Range (SLAM-ER) missiles, AGM-65 Maverick missiles, and eventually LRASMs. Fixed-wing F-35Bs in the MEU ACE are primarily intended to support ground troops with strikes using SDBs, but could also could engage enemy surface combatants outside enemy weapons range with LRASM.[56] A larger ACE may be required to support anti-ship attacks in addition to air defense, strike, and CAS operations likely to be happening at the same time.

55 Sydney J. Freedberg, Jr., "Anti-Aircraft Missiles Sinks Ship: Navy SM-6," *Breaking Defense*, March 7, 2016, available at http://breakingdefense.com/2016/03/anti-aircraft-missile-sinks-ship-navy-sm-6/; and LaGrone, "West: U.S. Navy Anti-Ship Tomahawk Set for Surface Ships Starting in 2021."

56 The Navy plans to integrate LRASM with the F-35B, but does not yet have plans to integrate other surface-attack weapons.

Over-the-horizon targeting will be needed to engage enemy ships and shore targets from outside enemy weapons range. Target data can come from airborne sensors such as those on the F-35B, the E-2D Hawkeye airborne early warning and control (AEW&C) aircraft, or a medium-altitude long-endurance (MALE) UAV such as DARPA's Tactical Exploited Reconnaissance Node (TERN). These platforms can be networked with each other and with amphibious ships and surface combatants through the Naval Integrated Fire Control-Counter Air (NIFC-CA) concept.[57] NIFC-CA enables sensor and target information to be shared between E-2Ds and surface combatants via the Cooperative Engagement Capability (CEC) datalink, between F-35Bs and some surface combatants via the secure Multifunction Advanced Data Link (MADL), and between other aircraft and ships via Link-16.[58]

NIFC-CA could enable an F-35B flying ahead of an ARG or SAG to detect enemy targets such as warships or missile launchers ashore. It could attack those targets directly using its relatively small magazine of onboard missiles, but could also hand off the target to an amphibious ship or surface combatant to engage with VLS-launched missiles. Alternately, an E-2D flying from shore could detect a threat and pass it to the F-35B via Link-16, allowing the fighter to engage the target without ever acquiring the enemy with its own sensors.

Anti-ship missiles such as LRASM or Tomahawk will not be effective against smaller ships and boats such as patrol vessels and fast attack craft (FAC) that are hard to find with traditional seekers. Large ASCMs are also too expensive to be used against cheap and numerous small craft. For these operations, amphibious forces can use attack helicopters from any amphibious ship to attack small surface combatants with guns or inexpensive missiles such as the AGM-114 Hellfire more effectively and at less cost than an engagement with ASCMs.

Blockade

As described in Chapter 1, an effective strategy to deter aggression would include the ability to immediately deny or delay and punish aggression, as well as the ability to protract a conflict. This would prevent the adversary from achieving a *fait accompli* while showing that simply pressing through the initial U.S. response would not necessarily end the conflict on favorable terms to the aggressor.

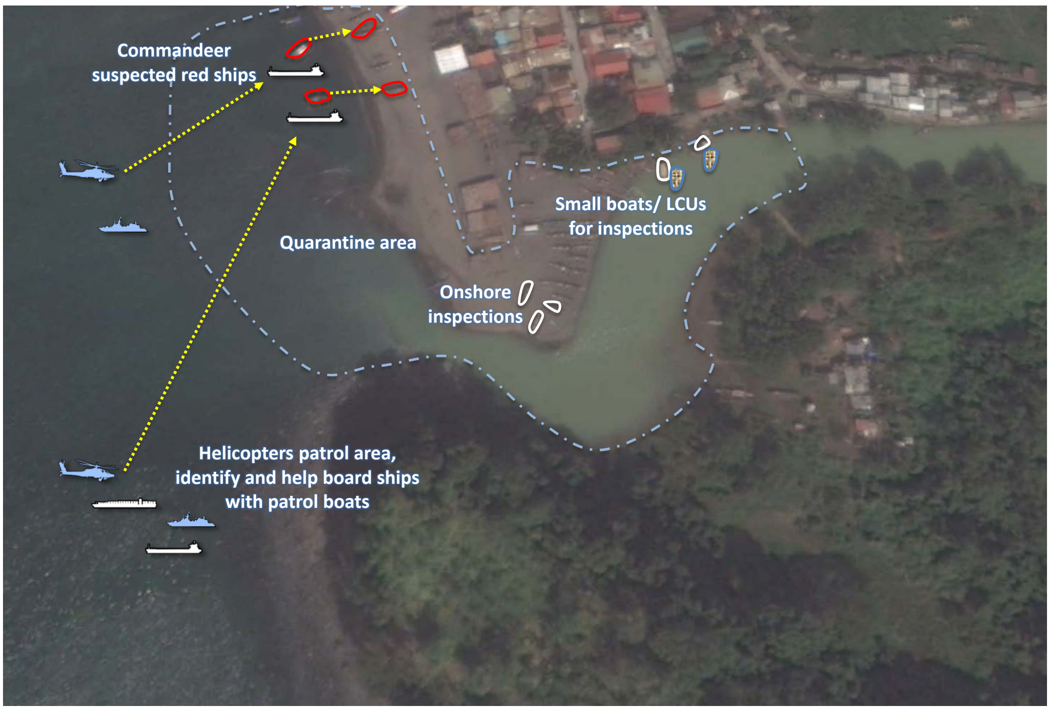
An important element of protracting a conflict would be stopping the flow of vital commodities to the adversary as well as the sale of goods from its businesses and government. The denial of both imports and exports would deny the aggressor money, energy, and material needed to sustain the fight.

57 Sam LaGrone, "Successful F-35, SM-6 Live Fire Test Points to Expansion in Networked Naval Warfare," *USNI News*, September 13, 2016.

58 Scott C. Truver, "Expanding the Distributed Lethality Web," *USNI News*, June 10, 2016.

Mounting a blockade requires more than sea control ships. Surface combatants enable U.S. forces to stop vessel traffic at a chokepoint and attack ships that do not comply. Vessels would then need to be boarded, inspected, and quarantined if they contain banned materials or goods. As shown in Figure 21, amphibious forces would be an essential component of a blockading force. An LPD, for example, carries the small boats, helicopters, and personnel (both Sailors and Marines) to board and seize ships; the landing craft and equipment to establish a secure anchorage such as an EAB to hold seized vessels; and the command and control capabilities to manage the operation. Blockading a high-volume chokepoint such as the Strait of Malacca would involve interdicting dozens of vessels a day and seizing or redirecting most of them if China, for example, is the adversary being blockaded. At those volumes, multiple amphibious ships' worth of boats, helicopters, and personnel would be needed to support the blockade.

FIGURE 21: AMPHIBIOUS FORCES SUPPORTING A BLOCKADE



CHAPTER 4

Implications for Posture, Force Structure, and Capabilities

The emerging strategic environment and new operational approaches imply significant changes for the U.S. amphibious fleet. Some of these implications were raised in the preceding chapters on strategy and concepts. This chapter will synthesize those implications into a set of capability imperatives for amphibious forces and specific modifications needed to the ships, aircraft, weapons, sensors, and networks of the future amphibious fleet.

Imperatives for Amphibious Forces

The importance of deterring aggression by major powers will likely grow over the next two decades due to the improving capabilities and revisionist aspirations of competitors such as China, Russia, and Iran. The long-range weapons and sensors these and other potential opponents are fielding will make a large-scale mobilization and rollback campaign very challenging following an act of aggression. U.S. forces will likely need to rely instead on a deterrence approach focused on denying or delaying adversary aggression, coupled with punishment attacks intended to compel the aggressor to halt.

Implementing this new strategic approach will require the operating concepts described in Chapter 3, which lead to the following implications for the posture, capabilities, and force structure of the amphibious fleet.

A more tailored and relevant posture

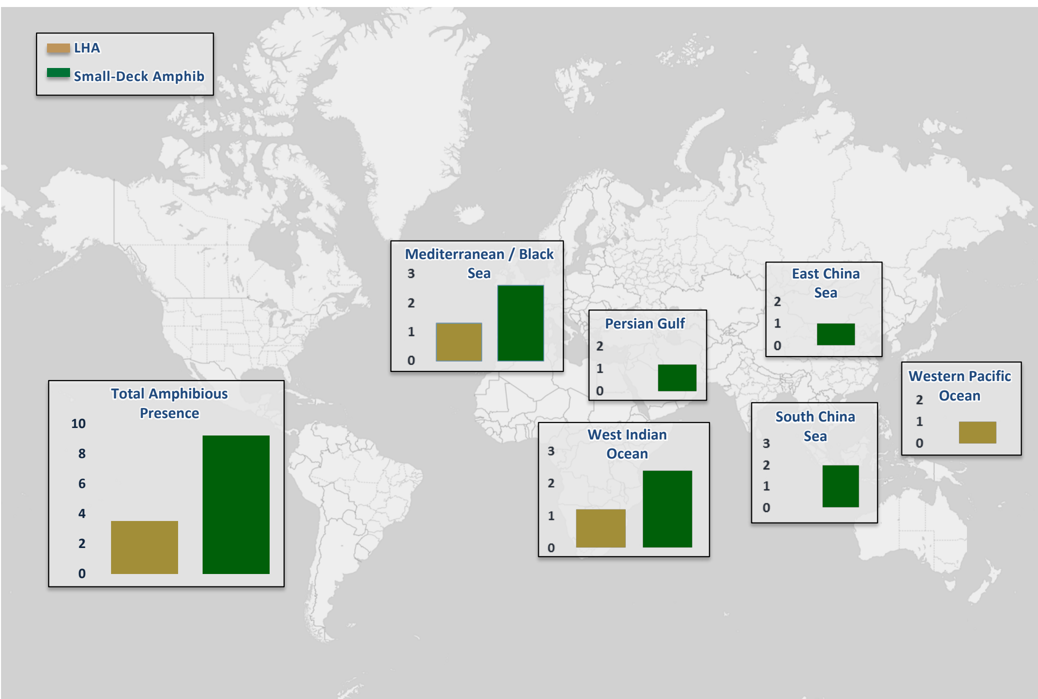
Naval forces will be necessary to promptly deny or punish adversary aggression. Although other elements of the joint force can contribute to denial and punishment operations, land-based air bases close to the adversary may be suppressed by enemy attacks, ground forces may not be in position or be unable to reach the conflict area, and long-range strike aircraft will take time to reach the theater.

Naval forces will need to be postured in proximity to adversary objectives, forces, and territory with the capabilities required to defeat an aggressor's power projection. This differs from today's ARG/MEU presence, which is spread across a Combatant Commander (CCDR) theater and not tailored or ready for the kinds of short, intense conflicts an adversary may seek in pursuit of nearby objectives, such as the Strait of Hormuz for Iran or the Senkaku Islands for China.

Amphibious forces can adjust their posture to help achieve proximity and high readiness by aligning the deployments of ARG/MEUs to specific regions as shown in Figure 22. This will help their Sailors and Marines become familiar with the region's geographic, oceanographic, alliance, threat, and target characteristics, and this in turn will facilitate learning and adaptation by amphibious forces to address the particular challenges and opportunities of their region. A regional focus also enables ARGs to be deliberately configured for the situations they are likely to face, such as having VLS-equipped LPDs in regions where SUW operations will be prominent or being prepared to disaggregate across a theater to support known security cooperation demands.

Amphibious forces will form part of the front-line for U.S. deterrence and crisis response and, in concert with surface and undersea forces, attempt to deny and punish adversary aggression at the onset of conflict. This approach to naval posture will be described in greater detail as part of CSBA's upcoming study of alternative fleet architectures.

FIGURE 22: PROPOSED AMPHIBIOUS FORCE POSTURE



Faster, more survivable lift

Amphibious forces will need to launch raids and assaults from longer distances than today so their ships can remain out of range of as many enemy weapons and sensors as possible. Amphibious operations will also need to be smaller and distributed over wider areas to complicate enemy targeting and increase the number of enemy weapons needed to neutralize U.S. naval forces at sea and ashore.

The longest-range land-based ASBMs will likely be able to reach targets more than 1000 nm away. These weapons, however, will be relatively few in number and may be reserved to attack nuclear aircraft carriers (CVN) or highly defended land bases.[59] The majority of missile threats to amphibious forces will be ASCMs with ranges of 300 nm or less that can be launched from shore as well as by ships and aircraft. To reduce the threat from ASCMs and provide more time to intercept them in flight, amphibious ships will need to be able to move forces and equipment ashore from more than 300 nm away. This would enable the ships to remain outside the range of ASCMs near the objective area of the raid or assault and allow one ship to support operations across a coastline or archipelago 300 nm long, which would be similar in size to the Philippines or the Southwest Islands of Japan.

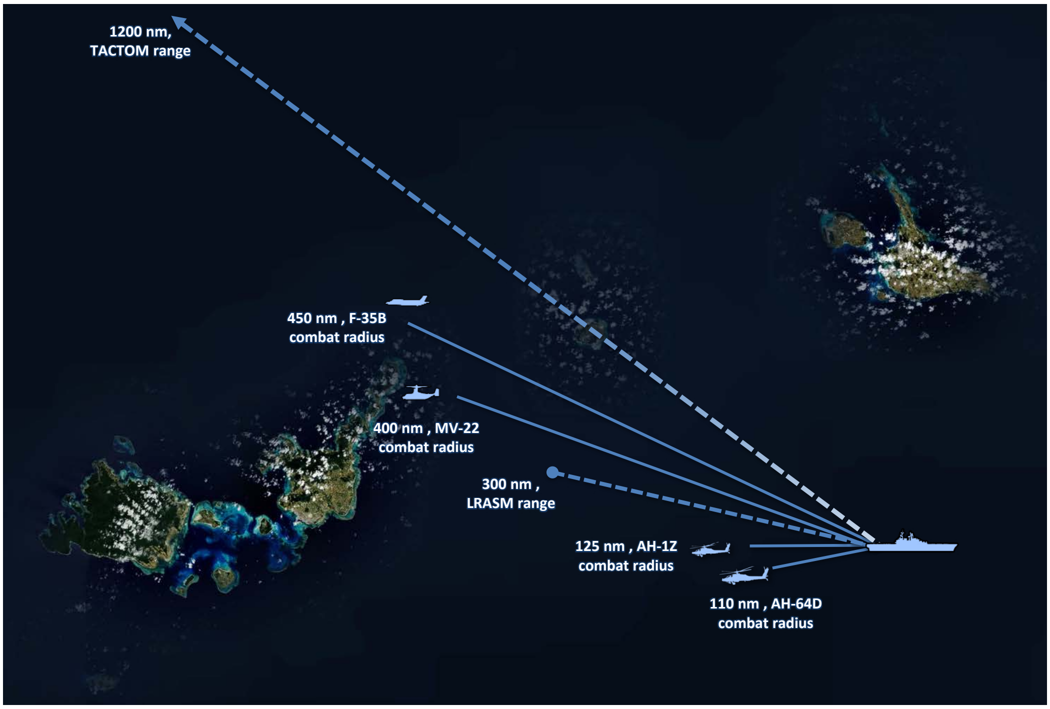
Each of the current Navy and Marine Corps connectors can travel this distance, but may not survive attacks by an adversary's small boats; anti-air weapons; and guided rockets, artillery, mortars, and munitions (G-RAMM). An MV-22 could quickly cover this distance to reduce its vulnerability, but may not be able to carry all the equipment that a landing force needs. New capabilities will be needed to improve connector survivability, or the Navy could develop new connectors that provide the needed combination of range, survivability, and lift capacity.

More long-range fires

Marines rely on fires from aircraft and ships to degrade opposing forces in their planned landing zones and support troops engaging the enemy. Longer-range assaults and raids will stress today's inorganic fires capabilities, as shown in Figure 23.

59 DoD estimates that China has about 200–300 MRBMs, only a fraction of which are DF-21D ASBM. See OSD, Military and Security Developments Involving the People's Republic of China 2016, p. 109. A dozen or more ASBMs would likely need to be launched to ensure one gets through a ship's hard-kill and electronic warfare air defenses. It is unlikely China would choose to attack LPDs or LX(R)s with ASBMs given these constraints. An ASBM may be an attractive option for attacks on land bases because their maneuverability and seekers could enable highly precise attacks that avoid some defensive countermeasures.

FIGURE 23: RANGE OF AMPHIBIOUS FORCE CONNECTORS AND WEAPONS



F-35Bs could provide strikes and close air support but will be constrained by the small number of strike-fighters normally in the ACE. The ACE's six F-35Bs would yield four operational aircraft at any given time, which would only be able to support one or two fires missions. A single ARG/MEU, however, may need to support a half-dozen EABs across a region such as Japan's Southwest Islands or the Philippines. Providing sufficient long-range inorganic fires to Marines distributed over a wide area may require a reconfigured ARG to provide more strike-fighters or modifications to amphibious ships to enable them to provide missile-based fires.

The importance of inorganic fires derives from the inability of current connectors to deliver fires systems safely over long ranges in a contested area. Marines could complement long-range inorganic fires with additional organic fires, provided they could be brought into the landing area without undue risk to the connector platform carrying them.

Higher self-defense capacity

Amphibious forces will likely be operating in contested areas before conflict as an element of U.S. deterrence and security cooperation efforts. They will, therefore, be part of the initial U.S. response to aggression and subject to the enemy's opening salvos. If the adversary wants to pursue a "short, sharp" war, its initial attacks could be very large in an effort to rapidly suppress U.S. forces.

As described in Chapter 3, to achieve the defensive capacity needed to counter the enemy's salvos, amphibious forces at sea and ashore should shift to a medium-range air defense concept that would enable them to employ smaller, less expensive interceptors and directed energy weapons such as lasers and HPRF. New deployable short-range air defenses including IFPC could provide EABs and Marines on the ground the ability to use these defensive capabilities. Amphibious ships could be equipped with VLS magazines and directed energy weapons to enable them to implement a medium-range air defense concept as well.

To decrease the size of enemy salvos, amphibious forces may also need to kill the "archers" instead of their "arrows" by attacking adversary weapon launchers at sea, ashore, and in the air before they can release their weapons. Amphibious ships could carry anti-ship and strike missiles to engage enemy surface combatants and TELs.[60] To engage enemy bombers, amphibious forces could use STOVL strike-fighters since their shipboard medium- and short-range air defense weapons will not reach enemy aircraft before they are in range to launch ASCMs. The need to employ strike-fighters for defensive counter-air operations further reinforces the importance of a larger ACE.

Improved understanding of local conditions

Large amphibious assaults conducted after adversary aggression occurs will involve significant time for mobilization, reconnaissance, and reduction of enemy threats. They will also be much more difficult to carry out against competitors equipped with long-range reconnaissance-strike complexes. In contrast, operations designed to quickly deny or delay adversary aggression and punish the enemy will have to begin immediately after the aggression occurs and will include rapidly establishing EABs and executing small, distributed raids across several islands or coastal areas.

Rapid amphibious operations conducted without significant preparation time require a detailed understanding of the physical conditions, threat environment, and ally and partner contributions. Today's Navy and Marine Corps deployment and readiness models will not enable that level of understanding because amphibious forces such as a deployed MEU have too large a potential area of operations and do not spend enough operational time in any given area to become expert in its human and physical characteristics. New ways of deploying amphibious forces will be needed, as well as new processes for maintenance and training that prepare them for deployment.

60 Iranian, Russian, and Chinese militaries deploy ASCMs with ranges from 50 nm to more than 200 nm and strike missiles with ranges of more than 1000 nm. U.S. ship-launched strike and anti-ship weapons have ranges from 60 nm (Harpoon) to more than 1000 nm (Tomahawk). Depending on the adversary threat, only Tomahawk may be able to reach the enemy ship or TEL before it can launch its weapons.

Capability Implications

Build lighter vehicles to increase range and firepower

The Marine Corps' ability to employ vertical lift to move Marines directly from a ship to an over-the-horizon objective has been hampered by the steadily growing weight of its vehicles. This trend has occurred even as Marine airlift has grown in capability with the introduction of the MV-22 and the impending arrival of the CH-53K. Vehicle weight growth is inhibiting the Corps from taking full advantage of the lift platforms in service today and preventing the Marines from moving beyond their reliance on vulnerable surface connectors to transport nearly all vehicles.

Vehicle weight increases are the result both of survivability enhancements to existing systems and the fact that new vehicles are generally bigger and heavier than the platforms they replace. The IED threat during the wars in Iraq and Afghanistan led to the addition of enhanced armor protection for nearly all the Corps' basic vehicles. For example, a typical up-armored HMMWV weighs over 10,000 pounds, an increase of 2,000 to 5,000 pounds over the baseline model.[61] New vehicles are often designed from the ground-up to be more survivable—and heavier—than their predecessors. The Joint Light Tactical Vehicle (JLTV) weighs almost twice as much as the HMMWV it will be replacing. With its enhanced armor package, the Medium Tactical Vehicle Replacement (MTVR) utility truck weighs nearly 50,000 pounds, more than 36,000 pounds greater than the M35 truck it replaced.[62]

The Marines have also failed to procure vehicles and weapons that are sized to fit aboard their existing airlift assets. The MV-22 offers performance that no helicopter can match, including the ability to carry a 4,000-pound payload over 1,000 nm before executing a vertical landing.[63] Unfortunately, only one type of vehicle can actually fit aboard the Osprey: the Internally Transportable Vehicle.[64] Consequently, the MV-22 is limited to the transport of light infantry and, at most, a 120mm mortar system that is paired with the ITV to create the Expeditionary Fire Support System (EFSS).

The combination of the ITV, the EFSS, and the V-22 have proven their value in exercises. Small vehicles allow company-size units transported via tilt-rotor to bring more fires, C2

61 Paul G. Sichenzia, *United States Marine Corps' CH-53E Super Stallion Modernization: Necessary or Necessary Victim of Transformation?* (Quantico, VA: USMC Command and Staff College, 2003), p. 32.

62 Robert M. Borka, "Navy/Marine Corp Team's Analysis of Integrating USMC's State-of-the-Art Heavier and Larger Vehicles and Aircraft Onboard USN Ships," *American Society of Naval Engineers*, no. 1, 2010, p. 34.

63 U.S. Marine Corps, *V-22 Osprey Guidebook*, 59.

64 The MV-22 can carry an external payload of up 15,000 pounds with no size limits. However, sling-loading places speed restriction on the Osprey and limits its range to less than half the distance it could cover with an internal load of the same weight.

equipment, and supplies to an operation than a purely foot-mobile element could manage.[65] However, the Corps halted acquisition of the ITV at 411 vehicles (266 individual units and 145 for the EFSS) in 2010.[66] To capitalize on the mobility the MV-22 permits, the Marines must continue to acquire vehicles and fire support systems small enough to fit aboard the Osprey.

The Marine Corps is also challenged by the weight of its armored vehicles, which restricts the number that can be brought ashore by surface connectors or vertical lift platforms. The lightest armored platform in the Marines' inventory is the 14-ton Light Armored Vehicle (LAV). With its 25mm chain gun and two M240 7.62mm machine guns, the LAV provides ground commanders with a powerful set of weapons in a fast and mobile platform.

LAVs may be transported four to an LCAC, allowing four LCACs to assemble an entire company of thirty-two vehicles in just two movements from ship-to-shore.[67] By comparison, the new ACV will weigh more than twice as much, and only half as many can be loaded aboard the LCAC's replacement.[68] The Corps currently plans to keep its existing LAVs in service through the 2030s with modifications and upgrades.[69] These improvements will be vital to ensuring the Marines can continue to field an armored vehicle light enough to be postured ashore rapidly in a contested environment.

New vehicle protection technologies that can increase survivability without the addition of heavy armor offer one option for driving down weight. The U.S. Army and Marine Corps have both lagged behind other nations in their adoption of active protection systems (APS), which make use of kinetic interceptors to destroy incoming rounds before they hit a vehicle. APS can substitute for heavy armor on ground vehicles, driving down their overall weight without sacrificing survivability. Passive camouflage, concealment, and decoys (CCD) improvements will also enhance the survivability of ground vehicles while limiting additional weight and cost.

Looking farther out, a next-generation Marine light armored vehicle may include some of the technologies DARPA is experimenting with in its Ground X-Vehicle Technologies (GXV-T) program. GXV-T aims to use extreme mobility and a comparatively small size to break the existing paradigm of more survivability equaling more armor. Rather than being built to withstand impacts, a vehicle with GXV-T systems would aim to avoid being detected, engaged, and then hit through its sensor countermeasures, active protection systems, agility, and speed.[70]

65 U.S. Marine Corps, *Expeditionary Force 21 Internally Transportable Vehicles in Support of Infantry Operations* (Washington, DC: DoD, 2015), p. 11–12.

66 Joe Gould, "USMC Eyes Options for Light Vehicle," *Defense News*, May 19, 2015.

67 Fuquea, "An Amphibious Manifesto for the 21st Century."

68 Kirk Mullins, "Program Manager: Advanced Amphibious Assault," Presentation to the Expeditionary Warfare Conference," October 12, 2016.

69 "United States Marine Corps," *Jane's World Navies*, June 15, 2016, p. 23.

70 Kevin Massey, "GXV-T," Presentation at Ground X-Vehicle Technologies Program Proposers' Day, Defense Advanced Research Projects Agency, September 5, 2016.

Optimize surface connectors for ocean travel

The Marine Corps has spent decades seeking an amphibious assault vehicle capable of "maneuver[ing] from ship to objective in a single seamless stroke while giving both the ships and landing forces sufficient sea space for maneuver, surprise, and protection."[71] In an attempt to achieve that vision, the Corps spent over a decade in a fruitless quest to develop and procure the Expeditionary Fighting Vehicle (EFV), a platform conceived with the goal of being able to carry seventeen Marines 25 miles to shore at a speed of more than 20 knots.[72]

Today, the niche the EFV was designed to fill—an armored vehicle that can swim ashore from over-the-horizon—has become irrelevant. As threat capabilities have increased, 25 miles is no longer a sufficient standoff distance for an amphibious warship. Modern threats require standoff of 300 miles or more, far too great a distance for an armored vehicle to swim.

Instead of attempting to build a better EFV, the Navy and Marine Corps should optimize their surface connectors for ocean transit. Minimizing on-land requirements for connectors could reduce costs while retaining high water speed and the ability to carry large payloads. Further, by reducing the swimming requirements for ground vehicles, the Marines could purchase a vehicle optimized for land warfare without having to accept tradeoffs to provide amphibious capability.

The ACV represents a step in this direction. The first increment of the ACV, version 1.1, has only a minimal swimming ability and must be moved close to land by another surface connector, such as an LCAC.[73] As the Corps looks to mature the ACV program and seeks a replacement for the LAV, it should continue to focus on ground combat capability at the expense of swim range.

The Marines and the Office of Naval Research (ONR) are currently experimenting with a promising program called the Ultra Heavy-Lift Amphibious Connector (UHAC). UHAC is a vehicle that derives both its flotation and its propulsion from its buoyant air-filled foam tracks. Although the UHAC is in the early stages of development, a full-scale model is predicted to be able to have roughly twice the payload of an LCAC—enough to carry three M1A1 tanks—while retaining the same 200–300 nm swimming range.[74] Additionally, the UHAC offers better survivability than the LCAC because its foam treads provide some organic protection against ground fire, and the UHAC's greater maximum payload creates more trade space for the addition of armor and defensive systems.

71 Krulak, "Operational Maneuver from the Sea," p. 84.

72 U.S. Marine Corps, "Sea Skimmer: Technology breakthroughs lead to dawn of EFV," Marine Corps Systems Command Press Release 01-09, February 11, 2009.

73 U.S. Government Accountability Office (GAO), *Amphibious Combat Vehicle Acquisition: Marine Corps Adopts an Incremental Approach* (Washington, DC: Government Printing Office, 2015), pp. 6–8.

74 Franz Leban, "Innovative Logistical Support Concepts," Presentation to the Center for Strategic and Budgetary Assessments, Washington, DC, June 9, 2016.

The Marines should also continue to experiment with the use of the expeditionary fast transport (EPF) as an interim connector. The EPF was originally conceived of as a high-speed intra-theater cargo ship with a range of 1,200 nm at 35 knots.[75] The EPF's shallow draft and 600-ton cargo capacity also make it an ideal candidate for ferrying amphibious vehicles from a capital ship to land. ONR has worked to develop an improved interface ramp that will permit ship-to-ship or pier-side interfaces in a much wider range of conditions than is allowable today.[76] The new ramp may also permit the EPF to disembark vehicles directly into the sea. An EPF equipped with such a system could shuttle twenty to twenty-one ACVs 100 nm in under 3 hours before offloading them next to their landing point.[77]

As the Corps considers different options for a future surface connector, it should evaluate the utility of increasing the vessel's anti-air defensive capacity. None of the current fleet of surface connectors is armed with anti-air weapons, leaving the platforms vulnerable to even the most rudimentary air attacks. A larger connector, such as the EPF, would have ample room to mount short-range air defenses such as SeaRAM that could provide protection both against aircraft and precision-guided weapons.

Rebalance amphibious ship loadouts toward aviation

During the 2000s, the Marine Corps' desire to take maximum advantage of the F-35B and the MV-22 led to the decision to optimize the new *America*-class LHA for aviation operations by removing the floodable well deck that had previously been considered a standard feature of amphibious ships.

Eliminating the well deck of the *America*-class Flight 0 ships allowed them to better accommodate the Osprey and the JSF, both of which are larger than the aircraft they replace. In addition, the *America*-class Flight 0 LHAs have 40 percent more hangar capacity than the well deck-equipped LHDs, enabling better sustainment of flight operations by increasing the number of spare parts that can be stored aboard and the amount of simultaneous maintenance that can be conducted.[78] The Flight 0 LHAs also have more than double the cargo fuel capacity of the *Wasp*-class LHD.[79]

Two Flight 0 *America*-class LHAs were procured. The Marines then elected to modify the class design by adding a well deck, creating the Flight 1 variant with a more traditional amphibious ship design. The Corps should reverse this decision and continue to acquire Flight 0 LHAs to maximize the aviation capabilities of its new assault ships. With a fighter complement of up to

75 Jessica F. Alexander, "USNS Spearhead: Fast, flexible, first in class," Military Sealift Command, March 2013.

76 U.S. Marine Corps, Combat Development and Integration, Seabasing Integration Division, *Seabasing: Annual Report for POM FY17* (Quantico, VA: U.S. Marine Corps, 2015), p. 23.

77 Daniel Wasserbly, "Bridging the Distance: the US Marine Corps Amphibious Strategy Evolves," *Jane's Defence Weekly*, August 25, 2015.

78 Jeanette Steele, "Q&A on USS America," *The San Diego Union Tribune*, March 21, 2014.

79 U.S. Marine Corps, *Seabasing*, pp. 6–7.

twenty F-35Bs, the Flight 0 *America*-class can provide as much as a fourfold increase in the long-range fires and air defense capacity of the ARG.[80]

Eventually, the Navy and Marine Corps should develop a variant of the LHA equipped with a catapult-assisted takeoff but with arrested recovery (CATOBAR) system that could be classified as a light carrier (CVL). With an overall displacement of between 40,000 and 60,000 tons, these vessels would resemble *Midway*-class carriers in size and capacity. The addition of a catapult would allow non-STOVL carrier aircraft to operate from its deck such as the E-2D and E/A-18G Growler Airborne Electronic Attack aircraft. Moreover, the increase in hangar space and flight deck size would double the size of the air wing that could be embarked aboard.

To provide over-the-horizon targeting capability to ARGs, amphibious ships should embark medium-altitude, long-endurance UAVs such as TERN, and the Navy should consider establishing shore-based detachments of E-2Ds. These airborne passive and active sensor platforms can share targeting information with F-35Bs, ARGs, and SAGs to enable them to contribute to long-range strike and surface warfare.

To support the increased and more frequent lift required by multiple EABs, including FARPs, the ARG ACE should regularly include medium-lift UAVs. Although their lift capacity may be less than MV-22 and often carried externally, UAVs such as K-MAX could augment MV-22s to increase the number of locations that can be sustained simultaneously. As described above, a single medium-lift UAV could provide the cargo lift needed to sustain a non-FARP EAB that is getting its diesel fuel from the host nation or local suppliers. UAVs are also not subject to crew limitations, although they still require maintenance like any other aircraft.

Acquire more missile launchers

The Marine Corps currently fields only two battalions of HIMARS launchers, one active and one reserve, out of eleven artillery battalions total. The Corps has been slow to adopt the HIMARS out of concern for its cost and its limited ability to provide the sort of high-volume, short-range fires at which howitzers excel.

Future amphibious operations will likely be distributed over a much wider area than current doctrine recommends. As a result, meeting the fire support requirements of units that are widely geographically separated will require weapons with ranges well beyond what can be achieved with even an advanced projectile system. The Marines must embrace missile artillery and procure sufficient quantities of launchers and missiles to deploy them throughout the force.

Although ground fires today are mostly limited to a single domain, the Marines should experiment with multi-mode weapons. In an expeditionary environment, ammunition space is at a premium, and a single munition capable of attacking targets in the air, surface,

80 There are typically six AV-8Bs embarked aboard an LHA in the current ARG/MEU construct. Twenty F-35Bs would provide a four-fold increase in available aircraft because they also have higher operational availability.

and land domains will greatly ease logistics challenges. To that end, the Navy's multi-mode SM-6 offers a good template for a versatile weapon that enabled warships to maximize their scarce VLS capacity without worrying that they have selected a loadout optimized for the wrong type of threat.

Long-range ground fires must be supplemented by long-endurance UAVs that can provide detection and cueing information to missile batteries. The Corps should continue to pursue the acquisition of a Group 5 VTOL UAV such as TERN capable of conducting ISR, acting as a communications node, or carrying out limited airstrikes.[81]

Increase the armament of amphibious ships

Amphibious ships today contribute little to the strike capacity of U.S. naval forces beyond what is carried by their aircraft. Without VLS, these large and expensive vessels are handicapped both in their ability to conduct self-defense and in the firepower they can bring to bear against enemy surface vessels or ground targets. The Navy should modify its LPDs and the follow-on LX(R) to include VLS so these platforms can contribute directly to counter-aggression campaigns in addition to launching and recovering Marine amphibious forces.

An LPD-17-class ship has sufficient excess capacity built into its design to accommodate a 16-cell VLS system and, with additional modifications, may be able to hold as many as thirty-two cells. The LX(R) is intended to be a modified version of the LPD-17 and will likely be able to incorporate a VLS of the same size. Adding a 32-cell VLS system to these ship classes would allow each vessel to increase the number of short- and medium-range interceptors it can carry several times over, improving the ship's ability to contend with the large salvos it is likely to face in a contest with a capable adversary. Increasing the organic defensive capacity of amphibious ships also relieves some of the escort burden from other naval vessels, freeing those ships to be used for other assignments.

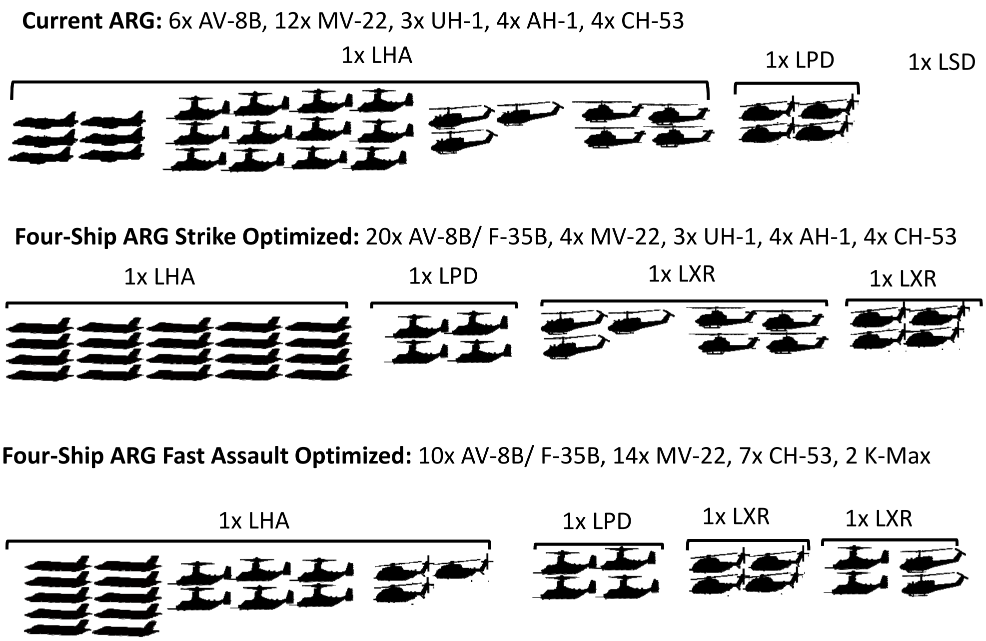
VLS cells can also be loaded with offensive weapons, providing additional fires options to a commander and increasing the number of targets an enemy must engage to eliminate a naval force's strike capability. Land-attack VLS-launched weapons will allow amphibious ships to provide Marine ground commanders with a third option for long-range strikes besides aviation support and ground artillery.

81 Megan Eckstein, "Marines Pursuing Large Ship-Based UAV For Comms, ISR, Fires," *USNI News*, October 24, 2016.

Increase the size of the Amphibious Readiness Group

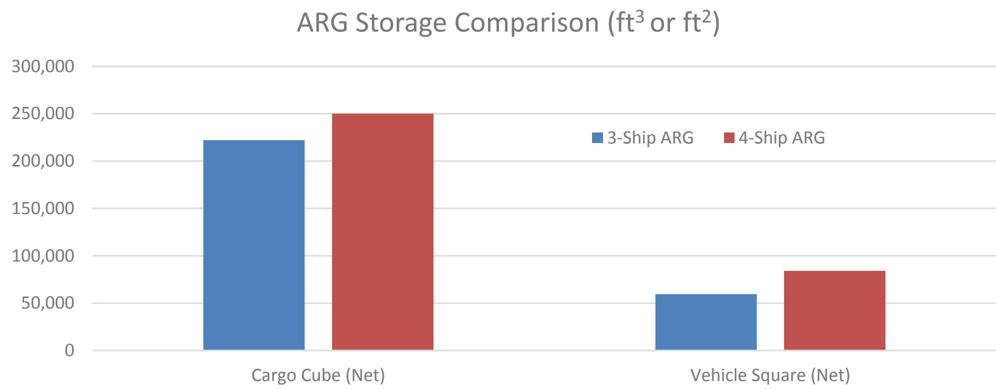
To improve the long-range fires capacity of its ARGs, the Marine Corps should move from its current three-ship formation to a four-ship formation that includes an additional LX(R). A four-ship ARG would enable the Marines to field a force with between 70 and 100 percent more strike aircraft while sacrificing little airlift capacity. Figure 24 depicts the aviation load-out of different ARG configurations.

FIGURE 24: AIR COMBAT ELEMENTS ASSOCIATED WITH NEW ARG CONFIGURATIONS



A four-ship ARG also offers an improvement in cargo space and vehicle storage space over the current three-ship organization, as shown in Figure 25. Whereas a three-ship ARG consisting of an LHA-6, an LPD-17, and an LX(R) would have roughly 222,000 ft^3 of cargo space, adding a second LX(R) would increase the cargo capacity to 250,000 ft^3. Similarly, a four-ship ARG will have 84,000 $feet^2$ vehicle storage compared to the 59,500 ft^2 of a three-ship group.

FIGURE 25: STORAGE AVAILABLE IN DIFFERENT ARG CONFIGURATIONS



This storage space may not be fully utilized, however. Although a four-ship ARG will have more square footage of vehicle storage, it is important to note that vehicles embarked on an LHA without a well deck will be solely reliant on vertical lift capabilities for transit ashore. Since most Marine vehicles are currently too heavy to be airlifted, a four-ship ARG may end up with excess vehicle capacity on its LHA/LHD until new vehicles are fielded that can be carried by MV-22s or CH-53Ks.

Adopt a new readiness cycle

Amphibious ships currently operate in a 27-month cycle of deployment, sustainment, maintenance, basic training, and integrated training. This includes a single 7-month deployment which results in an overall operational availability of 26 percent for amphibious ships. Maintaining the presence of a single ship on-station, therefore, requires four ships: one operating forward, one in sustainment after deployment, one in maintenance, and one training for deployment.

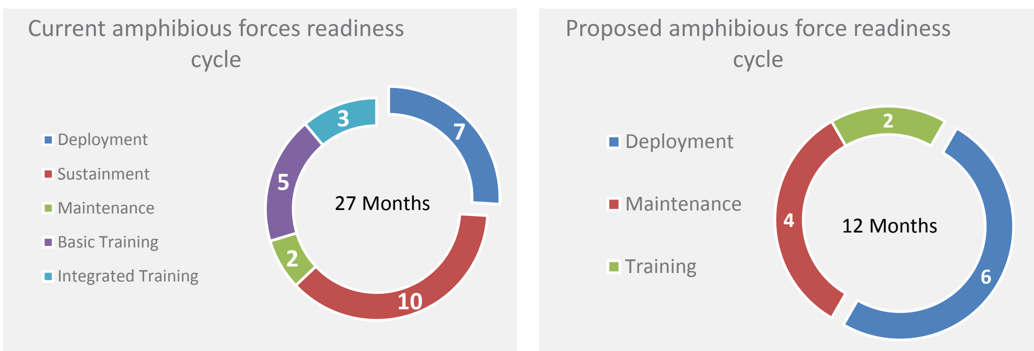
The Navy has found that maintaining the material condition of amphibious ships is difficult even with an operational availability of 26 percent. These challenges stem from funding issues, which prevents maintenance being conducted in a timely manner, and because of the growing age of many vessels.[82] When maintenance is deferred, delayed, or takes longer than expected due to a greater number of discrepancies than anticipated, ships already deployed must stay at sea for longer to accommodate the new schedules of those in maintenance. When the deployed ship finally returns to port, the additional time it spent underway may translate into a longer-than-anticipated maintenance period, propagating delays into the next cycle.

82 Bryan Clark and Jesse Sloman, *Deploying Beyond their Means: The U.S. Navy and Marine Corps at the Tipping Point* (Washington, DC: Center for Strategic and Budgetary Assessments, 2015), p. 12.

The Navy and Marine Corps can reduce the time allotted to training and certification in the deployment cycle by assigning ARG/MEUs to a specific region and tailoring their training to focus on that region's adversaries, potential targets for aggression, and allies and partners. Rather than expecting amphibious groups to be able to carry out the full range of potential missions in all the regions of a CCDR area of responsibility as they do today, region and threat-specific preparation will take less time and may improve the capability of the crews by letting them focus specifically on what they may encounter.

A shift in the focus of amphibious forces to specific regions could enable them to change their readiness cycle to one similar to today's Forward Deployed Naval Forces (FDNF), which yields an operational availability closer to 50 percent, as shown in Figure 26. Even with this higher OPTEMPO, the shorter training time needed for regionally-focused forces could enable them to increase the time they are able to conduct maintenance compared to today's amphibious forces. Additional time at sea will allow the Marines to conduct more high-fidelity amphibious exercises, enabling more experimentation than can occur during today's highly-scripted and infrequent exercises.

FIGURE 26: AMPHIBIOUS FORCE READINESS CYCLES



One risk with this proposed readiness cycle is the possibility that the ARG/MEU may be called upon to carry out a mission for which its Marines and sailors are not trained or equipped. While this may occur, the risk of such a surprise can be mitigated with additional changes to the Navy's deployment model. By separating out a portion of the service to conduct longer training designed to cover a wider array of contingencies, the Navy can create a CONUS-based "maneuver force" that would be on-call to deploy in response to a contingency. A wider discussion of the maneuver force concept is, however, outside the scope of this report.

Increase the size of the amphibious fleet

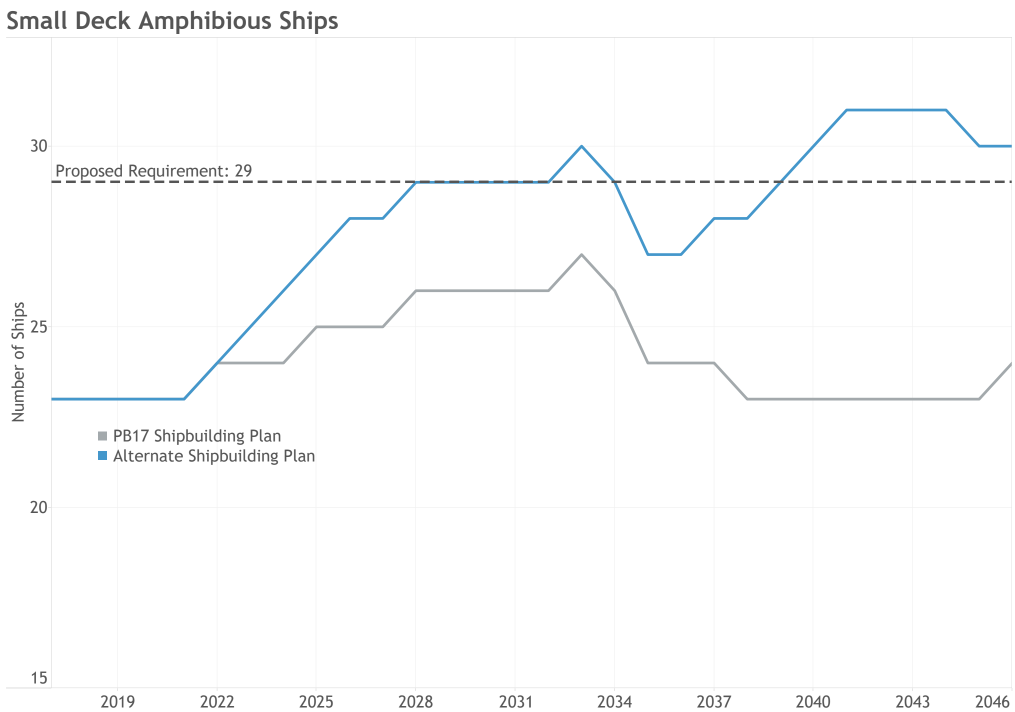
The changes described above for amphibious force posture, capabilities, configuration, and readiness imply a larger amphibious fleet with a different mix of ships is needed. This fleet would refocus LHA/LHDs on aviation and replace them eventually with CVLs over the next several decades.

It would also include more small-deck amphibious ships such as LX(R) to enable a more distributed amphibious force and carry the rotary wing aircraft displaced from LHA/LHDs.

The overall amphibious fleet that results from the changes proposed above includes eleven LHA/LHDs and up to twenty-nine small-deck LPD or LX(R) amphibious ships. This will provide the amphibious force the posture needed to deny and punish aggression and a larger ARG to support widely distributed amphibious operations. It will afford amphibious forces the time needed to conduct maintenance and training between deployments using a higher OPTEMPO readiness cycle.

The alternative 30-year shipbuilding plan to develop this new amphibious fleet includes three LHAs and four CVLs procured at the same rate as the seven LHAs in the current U.S. Navy's plan associated with the President's Budget for fiscal year 2017 (PB 2017). The CVL's lead ship cost of $6 billion is 55 percent greater than the LHA due to the CVL's larger displacement and the addition of two Electromagnetic Aircraft Launch System (EMALS) catapults.

FIGURE 27: SMALL-DECK AMPHIBIOUS SHIP CONSTRUCTION PLAN[83]



83 Cost estimates were derived from Navy budget submissions and Congressional Budget Office reports. For existing platforms, the estimates began with the lead-ship cost of a given class as reported in the Navy's annual budget documentation. For new ship classes, the report uses an analogous current platform to determine a cost per thousand tons (fully loaded) for the lead-ship cost. From there, the analysis factored in learning rate, shipbuilding rate, and shipbuilding inflation to arrive at the cost of future ships of the same class.

The alternative plan raises the total number of smaller amphibious ships procured to twenty-five from sixteen in the PB 2017 plan. As shown in Figure 27, the alternative plan begins procurement of the LX(R) three years earlier and maintains that procurement for an additional five years compared to the PB 2017 plan.[84] The alternative plan delays the initial procurement of the replacement for the LPD-17 until 2042, two years after the PB17 plan.

Adding this amphibious fleet to the existing PB 2017 shipbuilding plan increases the overall cost of the plan by 3.5 percent. If this cost is unaffordable, risk could be taken in regions where a continuous ARG presence may not be needed, and therefore some gaps could be accepted.

84 The alternative plan begins procurement of LX(R) in FY 2017, and continues through 2036.

CHAPTER 5

Conclusion and Recommendations

The U.S. amphibious fleet is at risk of becoming unable to support U.S. deterrence and wartime operations. It cannot conduct amphibious operations effectively at short range in a contested area and lacks the reach to do so from longer ranges where it would be under less of a threat. The U.S. Navy and Marine Corps will need to adopt new operational concepts and field new capabilities to address these shortfalls and for its amphibious forces to regain the ability to exploit the maneuver space of the sea.

Operating concepts are the starting point for efforts to improve the range and staying power of amphibious forces. They form the basis for new system and platform requirements, inform strategies and how to prioritize investments, and help guide doctrine and tactics for how to integrate new and existing capabilities. In some cases, new operating concepts could solve the Marine Corps' most pressing operational limitations, such as surface connector survivability and long range fires capacity, where new operational concepts could enable the use of planned or existing capabilities in innovative ways or allow new systems to be less sophisticated and costly.

DoD will likely have to shift its strategic concept for deterrence to one emphasizing denial and punishment to address the short timelines associated with likely adversary objectives and the ability of adversary weapons and sensors to contest access to their region. Given these conditions a rollback campaign such as that undertaken in Operations ALLIED FORCE and DESERT STORM is unlikely to be completed before the aggressor achieves its objectives.

This new overarching strategic concept will require that amphibious forces be postured inside contested areas to interdict aggression and can safely conduct amphibious operations at longer ranges and over wider areas. Specific operational concepts the Navy and Marine Corps should pursue include:

- **Establish and sustain Expeditionary Advanced Bases.** EABs in contested areas can support offensive air operations, cross-domain fires, raids, and logistics support at closer ranges and with potentially greater survivability than naval forces at sea or in the air.

- **Execute raids to assure access.** Potential adversaries are using coastal sensors and weapons to contest the surface and air around their territory. These systems can be difficult to degrade or destroy with air strikes and may need to be rooted out by raids of amphibious troops launched from defended EABs or from outside the contested area.

- **Employ cross-domain fires.** Ground-based air defenses and surface-to-surface weapons can transform islands and archipelagos into barriers against adversary power projection and increase the number and complexity of fires attacking enemy forces.

- **Conduct surface warfare.** Amphibious forces at sea can attack enemy surface combatants with missiles and helicopters to add offensive firepower to U.S. surface forces as well as improve the defense of amphibious ships by challenging enemy surface combatants directly.

- **Impose blockades.** The adoption of a concept of denial and punishment for deterrence increases the importance of blockade. Preventing the flow of goods and commodities to the enemy can impose significant costs as an element of punishment.

Concepts will need to result in changes to systems, platforms, and processes for amphibious force capabilities to improve. The Navy and Marine Corps should invest in and develop the following new initiatives to implement new concepts for amphibious operations:

- **Build lighter vehicles** that can be carried by MV-22s and helicopters to grow the reach of amphibious forces and increase their firepower;

- **Optimize surface connectors** for ocean travel rather than ground movement to increase the range and survivability of amphibious operations;

- **Rebalance amphibious ship loadouts** toward aviation to increase the range and amount of fires they can provide;

- **Increase the armament on amphibious ships** to enable them to provide long-range fires and contribute to surface warfare;

- **Acquire more missile launchers** to enable ground troops to provide cross-domain fires and improve their air defense capacity;

- **Grow the ARG** to sustain lift capacity while increasing the range and amount of long-range fires;

- **Adopt a new readiness cycle** to achieve greater operational availability and improve the learning and expertise of amphibious forces; and

- **Increase the size of the amphibious fleet** to enable greater tailoring of forces to specific regions, a shift to the four-ship ARG, and sustainable readiness cycles.

Potential adversaries will continue to improve their ability to contest the oceans around their territory. The challenges faced by amphibious forces will grow, increasing the range at which amphibious operations must occur and making amphibious ships more vulnerable unless the United States adopts new operating concepts and new or modified capabilities for amphibious operations. They will help enable the U.S. Navy and Marine Corps team to continue supporting American efforts to deter aggression, respond to crises, and exploit its maritime superiority as an asymmetric military advantage.

LIST OF ACRONYMS

2-I	2-Intercept
AAV	Amphibious Assault Vehicle
ACE	air combat element
ACV	Amphibious Combat Vehicle
AEW	airborne early warning
AEW&C	airborne early warning and control
AF	amphibious force
APS	Active Protection System
ARG	Amphibious Readiness Group
ASBM	anti-ship ballistic missile
ASCM	anti-ship cruise missile
ATACMS	Army Tactical Missile System
AWACS	airborne warning and control system
C2	command and control
CATOBAR	catapult-assisted takeoff but with arrested recovery
CCD	camouflage, concealment, and deception
CCDR	Combatant Commander
CEC	Cooperative Engagement Capability
CSBA	Center for Strategic and Budgetary Assessments
CVL	light aircraft carrier
CVN	nuclear-powered aircraft carrier
DoD	Department of Defense
EAB	Expeditionary Advanced Base
EFSS	Expeditionary Fire Support System
EFV	Expeditionary Fighting Vehicle
EMALS	Electromagnetic Aircraft Launch System
EMS	electromagnetic spectrum
EO	electro-optical
EPF	Expeditionary Fast Transport
ESD	Expeditionary Transfer Dock
ESSM	Evolved Sea Sparrow Missile
EW	electronic warfare
FAC	fast attack craft
FARP	Forward Arming and Refueling Point

LIST OF ACRONYMS

FDNF	Forward Deployed Naval Forces
GAO	Government Accountability Office
G-RAMM	guided rockets, artillery, mortars, and missiles
GXV-T	Ground X-Vehicle Technology
HIMARS	high-mobility artillery rocket system
HPRF	high-power radio frequency
HVP	hypervelocity projectile
IADS	integrated air defense system
IFPC	Indirect Fires Protection Capability
IOC	initial operating capability
IR	Infrared
ITV	Internally Transportable Vehicle
JLTV	Joint Light Tactical Vehicle
JSF	Joint Strike Fighter
LAV	Light Armored Vehicle
LCAC	Landing Craft Air Cushion
LCU	Landing Craft Utility
LEW	Logistics Evaluation Worksheet
LF	landing force
LHA	Landing Helicopter Assault
LHD	Landing Helicopter Deck
LPI/LPD	low probability of intercept/low probability of detection
LPD	Landing Platform Dock
LRASM	Long-Range Anti-Ship Missile
LRPF	Long-Range Precision Fires
MADL	Multifunction Advanced Data Link
MAGTF	Marine Air-to-Ground Task Force
MALE	medium-altitude long-endurance
MEU	Marine Expeditionary Unit
MOC	Marine Corps Operating Concept
MRBM	medium-range ballistic missile
MTVR	Medium Tactical Vehicle Replacement
NIFC-CA	Naval Integrated Fire Control-Counter Air
nm	nautical mile

LIST OF ACRONYMS

OMFTS	operational maneuver from the sea
ONR	Office of Naval Research
OSD	Office of the Secretary of Defense
OTH	over-the-horizon
PGW	precision-guided weapon
Pk	probability of kill
PLA	People's Liberation Army
SAM	surface-to-air missile
SDB	Small Diameter Bomb
SLAM-ER	Standoff Land Attack Missile-Extended Range
STOM	ship-to-objective maneuver
STOVL	short takeoff and vertical landing
SUW	surface warfare
TEL	transporter-erector launcher
TERN	Tactical Exploited Reconnaissance Node
TLAM	Tomahawk Land-Attack Missile
UHAC	Ultra Heavy-lift Amphibious Connector
VLS	Vertical Launch System

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