Research Report

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Connector Survivability in the Current Operating Environment

The U.S. Navy and U.S. Marine Corps developed its current fleet of connectors for a different era. Current concepts, such as Distributed Maritime Operations (DMO), Expeditionary Advanced Base Operations (EABO), and Stand-In Forces (SiFs), recognize that the Navy and Marine Corps face a new threat environment that will require them to operate differently than they currently do. The naval services must address the survivability of their current fleet of combat craft, which they rely on for maneuver and sustainment of troops and large equipment.

In addition to the recommendations presented in this report, Navy and Marine Corps organizations should consider how to apply the established survivability framework to developing updated requirements. How might susceptibility, vulnerability, and recoverability be considered in a more holistic way throughout the entire capability development process? As an integral part of launching and ferrying connectors into desired areas of operations, how do traditional Marine Air-Ground Task Force (MAGTF) constructs, such as an amphibious task group (ATG) or amphibious task force (ATF), fight as part of a SiF? Wargaming or modeling and simulation could be employed to explore scenarios in which an ATG or ATF operates alongside units from a Marine Littoral Regiment (MLR) conducting EABO and thus ensure that survivability is a key component of the model.

RECOMMENDATIONS

- Develop and formalize an analytic framework for connector survivability and use it to develop requirements for future connectors.
- Invest in the survivability of the current connector fleet to enhance the viability of current platforms.
- Develop tactics, techniques, and procedures and associated training to support the Marine Corps' new operating concepts.
- Elevate the role of operational and tactical intelligence for amphibious forces.

Introduction

Navy and Marine Corps concepts have evolved significantly in the past five years. Such concepts as DMO, EABO, and SiF call for a naval force that can fight within the weapon engagement zone (WEZ) of a peer competitor during a high-end conflict. Such a naval force requires capabilities for maneuver and sustainment, which depend, in large part, on the current and future fleet

Abbreviations

A2/AD	anti-access/area denial
AAV	amphibious assault vehicle
ATF	amphibious task force
ATG	amphibious task group
DMO	Distributed Maritime Operations
EABO	Expeditionary Advanced Base Operations
FARPS	forward arming and refueling points
HADR	humanitarian assistance and disaster relief
LAW	Light Amphibious Warship
LCAC	landing craft air cushion
LCU	landing craft utility
MAGTF	Marine Air-Ground Task Force
MEU	Marine Expeditionary Unit
MLR	Marine Littoral Regiment
OMFTS	Operational Maneuver from the Sea
SiF	Stand-In Force
SME	subject-matter expert
SSC	ship-to-shore connector
STOM	Ship-to-Objective Maneuver
UAS	unmanned aircraft system
WEZ	weapon engagement zone

of both surface and air connectors. Therefore, Navy and Marine Corps analysts are confronted with the challenge of developing the right family of systems to keep SIFs moving in a high-end fight under the anti-access/area denial (A2/AD) threat.

Survivability is a critical consideration for all combat watercraft, including the Navy's current fleet of amphibious connectors. The landing craft utility (LCU) and landing craft air cushion (LCAC), also known as ship-to-shore connectors (SSCs), the key lifting components of that fleet, were not designed with survivability in mind as part of a SiF. The requirements for these craft were developed using past naval concepts for power projection and in a more permissive threat environment. Such concepts as Operational Maneuver from the Sea (OMFTS), which was introduced in 1996, and Ship-to-Objective Maneuver (STOM), which was introduced in 1997, called for capitalizing on intelligence and maneuver to avoid obstacles and defenses en route to the objective.[1] Although the analysis behind the requirements was sound, current operating concepts demand that the Navy and Marine Corps place craft survivability at the center of their analysis for the current and future fleet.

In this report, we take an exploratory look at three research questions:

1. How have past concepts driven Navy and Marine Corps thinking about watercraft survivability?
2. How was survivability factored into the requirements for today's fleet of amphibious connectors?
3. How can the Navy and Marine Corps improve surface connector survivability for the fleet of the future?

For this exploratory research, we relied on documentary research, interviews, and limited structured discussions.

What Is Survivability?

In this report, we take a broad look at survivability in terms of a craft's ability to avoid destruction or loss of mission function.[2] We accept the formal Navy definition that is provided in OPNAV Instruction 9070.1B:

> A measure of both the capability of the ship, mission-critical systems, and crew to perform assigned warfare missions, and of the protection provided to the crew to prevent serious injury or death. This capability is applicable whether the risk is encountered during combat or the result of a non-combat related incident or accident (e.g., grounding, collision, fire). Principal disciplines of survivability include: susceptibility, vulnerability, and recoverability.[3]

Survivability is the ability of a ship, or watercraft, to avoid damage to its structure and systems and harm to its crew, to continue functioning despite damage (if it does occur), and to be reparable to the maximum extent possible. In the formal definition, survivability consists of the following three functions:

- Susceptibility: "A measure of the capability of the ship, mission-critical systems, and crew to avoid and or defeat an attack and is a function of operational tactics, signature reduction, countermeasures, and self-defense system effectiveness."[4]

- Vulnerability: "A measure of the capability of the ship, mission-critical systems, and crew to withstand the initial damage effects from conventional, CBR, or asymmetric threat weapons, or accidents, and to continue to perform assigned primary warfare missions and protect the crew from serious injury or death."[5]
- Recoverability: "A measure of the capability of the ship and crew, after initial damage effects, whatever the cause, to take emergency action to contain and control damage, prevent loss of a damaged ship, minimize personnel casualties, and restore and sustain primary mission capabilities."[6]

A *survivable* ship is hard to destroy or damage to the point that it cannot accomplish its mission. The three attributes that define this quality naturally lend themselves to trade-offs in design characteristics. For example, a ship can be designed to minimize its radar cross section, which makes the ship less susceptible to detection and harder for an enemy to identify and target. At the same time, a larger or stronger hull might be less vulnerable to a single strike if engaged or more recoverable because its size would give the crew a greater ability to execute damage control procedures. Similarly, a ship might rely on speed to decrease its susceptibility to attack; however, to maximize speed and maneuverability, the ship needs to be lighter, which could increase its vulnerability. Conversely, vulnerability could be decreased by shock-hardening a ship's hull; however, doing so could decrease speed or create the need for more-powerful engines and a design with greater draft.[7] There is no perfect solution to balancing these trade-offs, but the analysis must be conducted holistically and based on how the ship is supposed to operate. For the Navy's connector fleet, requirements were defined during periods in which the Navy and Marine Corps were designed to fight differently than how they might be needed today. Connectors that were deemed survivable for a different mission in a different threat environment might not be survivable when operating in a contested environment against an evolved adversary.[8]

The Foundation: Global Power Projection

The composition of the contemporary connector fleet took shape during the late–Cold War period. At that time, the Navy and Marine Corps were focused on projecting power in a high-end fight. The design of the LCU was similar to the craft that brought troops ashore during World War II and the Korean War. The LCU 1610 had been in service for around two decades when the initial requirements for the LCAC took shape.[9] The naval services sharply reoriented at the end of the Cold War, not because the potential for a high-end fight had lessened, but because the United States found itself as a lone superpower operating in an environment in which the capabilities designed to fight the Soviet Union appeared sufficient to address future anticipated regional threats. Building up sustainment and logistics ashore first (before launching the attack inland) was no longer the plan. Navy and Marine concepts for regional power projection and new technology were created against this backdrop. The Navy and Marine Corps thought seriously about survivability during this period but envisioned a battlefield in which the sea provided maneuver space to conceal, deceive, and surprise an adversary and in which intelligence, fires, and maneuverability would facilitate direct strikes at key objectives and centers of gravity. Employment of the LCU and LCAC—particularly the LCAC because of its speed and ability to transit to the shoreline—supported these new concepts. Both the LCU and LCAC had the right attributes for both the persistent challenge of crisis response and the distant possibility of a conventional conflict.

Strategy and Concepts: Outmaneuvering Regional Adversaries

In the 1980s, U.S. maritime strategy adopted an aggressive, forward posture toward the Soviet Union. The Navy prioritized sea control, which required neutralizing the Soviet Fleet. Power projection, led by carrier task forces, would take the fight to the enemy, and amphibious forces played a prominent role. Marines would launch assaults and raids to pressure the enemy's flanks and rear, as part of what planners thought would be a global campaign.[10]

The strategic clarity provided by the context of conflict with the Soviet Union quickly evaporated in the early 1990s. During this period, both uniformed and political leaders emphasized power projection in regional crises over a fight for sea control. In a 1992 Navy document, the Secretary of the Navy, Chief of Naval Operations, and Commandant noted that strategy was shifting "from a focus on a global threat to a focus on regional challenges and opportunities" and that the fleet was going to shift focus to complex littoral environments.[11] In such an environment, amphibious operations serve to "build up power rapidly deep in the objective area to disorient, divert, and disrupt the enemy."[12] In that era, the most likely use of the amphibious fleet was for crisis response or to provide humanitarian assistance.

During the 1990s, the most significant naval concept to the amphibious fleet's development was *Operational Maneuver from the Sea* (1996).[13] The concept noted that the firepower and maneuverability of smaller adversary elements was increasing and that the Marine Corps faced additional challenges from precision weapons and the need to reduce its logistical footprint ashore.[14] Serious threats to amphibious operations still existed in the form of "mines, sea-skimming cruise missiles, and tactical ballistic missiles."[15] These threats could be countered by increasing maneuverability, which the flexibility of amphibious ships and a new generation of connectors, such as the MV22, LCAC, and the now-defunct Expeditionary Fighting Vehicle program, could help achieve.[16] Maneuvering from the sea meant no longer following the familiar ship-to-shore movement to seize and establish a beachhead and instead focusing on moving "direct to objectives, treating the littoral as a continuous domain and blurring the lines between seaward and landward operations."[17] That portion of OMFTS was amplified in 1997 in the STOM concept.[18]

Connector Requirements: Maneuverability and Lift Capacity

From the 1980s to the early 2000s, a Navy and Marine Corps designed for power projection assumed they could rely on the LCAC and LCU as the backbone of their connector fleet, which also included rotary wing aviation and amphibious assault vehicles (AAVs). The complementary nature of these platforms allowed landing forces to outmaneuver adversaries and secure the flanks while landward threats were neutralized.[19] The endurance and reliability of the LCU, the agility of the LCAC, the speed of rotary wing aviation, and the offensive firepower of AAVs once ashore all allowed the naval force to effectively build combat power, theoretically even in the face of stiff resistance. In the 1990s, a larger fleet of amphibious shipping also meant that more connectors could be brought into theater to mitigate any losses, which were rarely considered as a limiting factor in wargames.[20] Antitank missile technology at the time did not work well over water and connectors were viewed as too small and low-value to waste expensive antiship missiles on.[21] Threats from indirect fires were to be suppressed by air and naval surface fires. The seapower and airpower provided by a carrier battle group provided an umbrella: Sea control was no object, and even a robust antilanding plan would be quickly degraded by superior firepower in the littorals. "Tactical flexibility, combined with reliable intelligence, will allow it to bypass, render irrelevant, or unhinge and collapse the enemy's defensive measures."[22] The family of systems that the naval force relied on could be reasonably considered survivable.[23]

The naval services seriously considered the survivability of connectors and amphibious shipping during this period but believed that the attributes of each craft mitigated the risk from increasingly capable regional adversaries. The LCAC provided a fast, maneuverable vessel that could increase the standoff distance of an amphibious task force while quickly bringing combat power ashore at a point that an adversary least expected. The LCU, although it is incapable of maneuvering direct to the objective inland and is not considered a critical part of OMFTS, still offered the required range and lift capacity to bring heavy equipment and troops ashore.[24] The realities of force composition of the time meant that the LCU was necessary for the Marine Corps in ship-to-shore movement. To mitigate additional threats, the naval team also developed tactics to decrease connectors' susceptibility to adversary action. Improvements in intelligence, surveillance, reconnaissance, and precision fires enabled the landing force to either bypass or suppress or destroy adversary defenses. The LCAC's speed was also crucial to exploiting gaps in the antilanding plan and avoiding defensive positions.[25]

However, connectors were well understood to be susceptible to multiple threats and vulnerable if engaged. The rugged LCU traveled relatively slowly toward the beach, and AAVs were both exceptionally slow and had to be launched close to shore.[26] The LCAC offered significant advantages for the landing force in speed and maneuverability, but its profile and structure presented risks. Put simply, LCACs were, and remain, large and loud. The sea spray that they create, the noise of their propulsion systems, and their electronic signatures aid detection by an adversary.[27] In addition to its signature making it susceptible to detection and engagement, the LCAC's structure also made it relatively vulnerable to damage. In the surf zone or on the beach, an LCAC could be engaged by heavy weapons or small arms. According to tactical doctrine, "[c]ritical areas of the craft are lightly armored and capable of withstanding 7.62 mm and smaller projectiles. However, small arms will penetrate the unarmored aluminum skin of the craft at all but the most extreme ranges."[28]

In implementing OMFTS and STOM, planners believed that the advantages provided by the LCAC—speed, maneuverability, lift capacity, and the ability to traverse a wide variety of terrain—outweighed its limitations.[29] Its shortfalls in survivability were mitigated through specialized tactics. Amphibious planners could degrade enemy targeting by thoughtfully planning intervals of landing waves while craft crews varied their formations. Crews used such maneuvers as "zigzags, weaves, and abrupt speed changes to disrupt enemy fire control solutions."[30] Marines and sailors coming ashore could defend themselves with aggressive action, and the craft itself could be equipped with heavy machine guns to counter attacks by ground forces.[31]

The early 2000s was a period of strategic uncertainty for the naval force.

This doctrine was thought to increase connector survivability in an era in which the U.S. Navy was unquestionably the largest and most powerful in the world.[32] Amphibious landings were designed with air supremacy and sea control, if not maritime superiority, in mind. Planners could reasonably assume that surface ships, aircraft, and submarines would provide them with favorable conditions for launch and transit. Because the Navy of the time was largely a power projection force, Marine Corps doctrine identified close air support and naval surface fire support as important enablers of connector survivability.[33]

Adaptations: Evolving Technology and an Uncertain Strategic Environment

The early 2000s was a period of strategic uncertainty for the naval force as it sought to emphasize its maritime identity while fighting the global war on terrorism. Although the services were largely preoccupied with immediate challenges, strategic direction called for global presence to undergird deterrence, counter irregular threats, and build partnerships.[34] New technology forced some adaptations: These adaptations included the initial appearance of A2/AD approaches by potential competitors and the continued need to maneuver and sustain heavier and more–technologically advanced landing forces. It was during this period that the requirements—including any updates in survivability, durability, and reliability—for the SSC (which has been fielded as of 2022) and the future LCU 1700 were formulated.

Evolving Strategy and Concepts: Forward Presence and Irregular Threats

As a result of the invasions of Iraq and Afghanistan in the early 2000s, the Marine Corps was heavily engaged in land wars, conducting counterterrorism, counterinsurgency, and stability operations in both campaigns. The Navy primarily played a supporting role in these fights by providing carrier aviation, stand-off munitions, logistics, special operations forces, and augmentation of joint billets. The naval force of the early 2000s took a capabilities-based approach to strategic planning as opposed to an approach based on specific threats. The Navy framed future maritime capabilities around three thematic groupings: Sea Strike, Sea Basing, and Sea Shield. Sea Strike was the offensive capability to engage threats globally. Sea Basing provided power projection as part of an integrated Navy and Marine Corps team. Sea Shield was a defensive blanket provided by a network of sensors and missiles that contributed to the defense of both forward-deployed joint forces and the U.S. homeland.[35]

Although the immediate challenges of Afghanistan and Iraq dominated defense planning, the naval force did consider provocations by regional adversaries, such as Iran and North Korea, and the alarming military developments of China (although China was not yet discussed as an explicit strategic competitor). As a result, the Marine Corps, Navy, and U.S. Coast Guard developed a Naval Operations Concept using the strategic assessment of the environment. In alignment with that strategy, the concept treated Iraq and Afghanistan as immediate priorities while noting that regional powers were growing in their conventional military capabilities.[36] The concept sought to balance current requirements and potential future requirements by preparing for regional conflicts while deterring major wars and supporting whole-of-government engagement.[37] Additionally, the concept emphasized Sea Basing, noting humanitarian assistance and disaster relief (HADR) as a core capability and discussing the growing importance of irregular warfare.[38] Although the concept as a whole did not prioritize high-end conflict, it did note the need to contend with greater A2/AD capabilities of rising powers, which was then used by the services to frame the operational (and arguably strategic) problems presented by those powers.[39]

In 2011, the Marine Corps addressed A2/AD with an update of its doctrine for STOM. The concept was intended to contend with the problem of anti-access approaches, although the publication emphasized that it could also apply to other types of operations.[40] The document framed the A2/AD problem as consisting of "integrated air and coastal defense systems which might include anti-ship missiles, mines, and guided munitions, as well as aircraft, submarines, small boats, and mobile reaction forces."[41] Amphibious forces could solve this problem by leaning on Sea Basing for forward presence and sustainment to minimize their footprint ashore.[42] A tenet of STOM was to emphasize maneuver flexibility and avoid established defenses or obstacles to drive planning, course-of-action selection, and method of STOM execution.[43] Rather than face an enemy force head-on, marines would rely on dispersal and avoid strong points.[44] Unlike the amphibious operations of the mid-20th century, which consisted of landing forces seizing a beach and gradually building up combat power in a series of waves, the idea was to move to the objective in a variety of ways, sometimes directly and avoiding the beach altogether or by landing Marines in multiple places with a variety of ship-to-shore profiles.[45] Amphibious forces could defeat A2/AD by

> remaining—at least initially—over the horizon, using the expanded maneuver space offered by the sea to complicate enemy targeting and provide more reaction time to defeat counterstrikes. From this tactically advantageous position, the landing force will be able to initially avoid enemy strength, maneuver to create multiple entry points and disrupt enemy anti-access strategy and then overwhelm adversary defenses to attack or influence its' landward objectives.[46]

Rotary wing and tilt-rotor aircraft were critical to STOM because they could deliver troops directly to key points deep within the adversary's defensive network.[47] The LCU and LCAC were viewed as they had been under the larger concept of OMFTS-complementary tools: "LCACs provide speed, agility, and the ability to negotiate a variety of coastal conditions to rapidly project wheeled vehicles inland. LCUs provide a large carrying capacity, albeit at slower delivery speeds."[48] Although the 2011 version of STOM was forward-looking toward advanced A2/AD threats, it was also informed by success in the early stages of the global war on terrorism. Specifically, in 2002, Task Force-151 launched the longest amphibious raid in history, maneuvering directly to its objective in Afghanistan from the Arabian Gulf and establishing Camp Rhino.[49] In 2003, at the outset of Operation Iraqi Freedom, the 15th Marine Expeditionary Unit (MEU) conducted both overland and amphibious maneuvers as part of a combined force to seize the port of Umm Qasr.

Connector Requirements: Balancing Protection and Mobility

The current fleet of connectors took shape during the time frame of the Afghanistan and Iraq wars, with developmental efforts for two new programs beginning in earnest in 2012.[50] Service life–extension programs, which had been conceived in the mid-1990s and were executed in the early 2000s, were extended for the current connector fleet while the solution to provide future ship-to-shore capabilities was being developed. The requirements for the SSC (a replacement for the LCAC that was introduced to the fleet in 2022) and the forthcoming LCU 1700 (an improved LCU) were both grounded in STOM.[51]

The LCU entered service in the 1960s with an expected service life of 25 years. In 2012, some of the craft in the fleet had been in service for more than 40 years.[52] In Navy analysis, the joint force would have a capability gap if a new solution was not fielded. The LCU was the best way to move personnel and equipment from amphibious ships when speed was not the primary consideration, and its capacity, range, endurance, and durability were higher than that of the LCAC.[53] The LCAC, or a similar capability, needed to remain for its speed, maneuverability, and flexibility in terms of landing areas, but the LCU was best for on-call waves, assault follow-on echelon, or noncombat missions, such as HADR or capacity building.[54]

> The Navy evaluated the characteristics of connector craft through the lens prescribed by its operating concepts

The Navy noted that the MAGTF was in persistent demand for these low-end missions and that the Navy's strategic and conceptual thinking called for an increased emphasis on those missions.[55] Thus, any new landing craft should be largely similar to its predecessor with improvements where possible.[56]

The Navy evaluated the survivability of the craft that would become LCU 1700 in terms of susceptibility, vulnerability, and recoverability.[57] Susceptibility was addressed through crew-served weapons; vulnerability was addressed through seakeeping characteristics and protection from chemical, biological, radiological, and nuclear threats; and recoverability was addressed through damage control systems for firefighting, dewatering, and hull patching.[58] Although survivability was included from the start of the capability development process, there were no requirements to upgrade survivability from that of the craft's predecessor from the 1960s; the standard for each of these anticipated features was explicitly stated to be "equivalent to LCU-1610."[59] This decision does not mean that the Navy did not understand the threat environment. Rather, it means that the Navy considered the characteristics of the craft through the lens prescribed by its operating concepts:

> Proliferation of sophisticated weaponry, coupled with asymmetric threats, could subject the SC (X) R [Surface Connector (X) Replacement] to over matching threats from adversarial ships, submarines, and aircraft and more numerous and diverse short-range systems such as small boats, mines, guided munitions and artillery in littoral waters . . . . Defensive capabilities impose weight, cost and risk trade-

> offs that are today mitigated by the Navy's Sea Shield concept with protection from other U.S. or allied forces. The SC (X) R must have the capacity to deter less sophisticated threats such as terrorist or pirate attach and the CDD [concept development document] should consider added organic defensive systems.[60]

Improved capabilities to the LCU 1700 were all geared toward the Marine Corps structure of the time, most notably by widening the craft by 14 inches to accommodate a track width mine plow on the front of a tank and an increased weight capacity (and additional 30 short tons) to accommodate two combat-loaded M1A1 tanks at once. The propulsion system was also upgraded for increased reliability and better fuel efficiency.[61] However, as of 2021, the Marine Corps no longer has any tanks.[62]

Because the LCAC was faster and more maneuverable, it would serve as the primary surface connector for the assault echelon, and the slower, more powerful LCU would maximize throughput for later waves and sustainment.[63] Although the challenge of A2/AD created a real survivability problem, the Navy understood that less demanding environments, such as those presented by HADR and stability operations, were the most likely employment for the new craft. The Navy was also aware of the design tradeoffs related to enhancements and chose to rely on the umbrella of defense provided by a sophisticated network of sensors and shooters envisioned by the Sea Shield concept to protect the new craft.[64]

The threat assessment for the SSC, the LCAC's replacement, was astute in most aspects. It noted threats from "detection by surface search radars, maritime patrol craft, fixed and rotary-wing aviation, unmanned aerial vehicles, antisurface warfare units, air launched missiles, anti-ship cruise missiles, submarines, torpedoes, [and] mines."[65] In addition, threats from "infantry weapons, such as small arms, crew served weapons, rocket propelled grenades, indirect fires from coastal artillery/multiple launch rocket systems" were identified in the assessment.[66] Notably, antitank missiles were not listed: Although the threat environment had changed since the introduction of the LCAC, the SSC initial capabilities document largely dismissed them as a threat.[67] When pressed on the threat from antitank munitions, SMEs noted that they were not a major consideration. When the LCAC originally came into operation, antitank weapons, such as the tube-launched optically tracked wire-guided missile (TOW), were predominately wire guided and limited in their ability to engage targets on or over water.[68] The threat analysis considered the threats in two categories: overmatching threats, such as antiship missiles, which were most likely to be directed toward the ATF itself or other high-value targets, and those from infantry weapons that were particularly dangerous to the LCAC in the surf zone and ashore.[69] Both could be mitigated by the craft's speed and maneuverability and by the Navy's overwhelming firepower. Prelanding actions, such as shaping fires or advance force operations, were also important mitigation measures.[70]

The survivability analysis for the SSC followed much of the logic of its predecessor. Notes from the initial capabilities document explain that the SSC's survivability will come primarily from its speed and maneuverability.[71] Threats to the craft while in transit would be mitigated by the control of the sea and air space provided by Sea Shield.[72] Crew-served weapons can mitigate landward threats, but more significant armament was out of the question because of the size constraints on the craft (which was employed from the well deck of an amphibious ship) and weight limitations.[73] Additional hardening might decrease vulnerability but increase susceptibility by making the craft slower and less agile.

The demand for surface connectors was minimal during the Iraq and Afghanistan wars of the 2000s. End-of-service life was a more significant driving factor than were new concepts in developing requirements. Alternatives, including hardening and increased self-protection, were considered. In the end, SSC and LCU 1700 were still thought to be survivable in the threat environment of 2012 but in a way that prioritized reducing susceptibility at the expense of increasing vulnerability.

New Concepts: Preparing for a High-End Fight

The Navy and Marine Corps of 2023 are oriented toward strategic competition with China and Russia.[74] This orientation drives a conceptual refocusing within the naval services on sea control and sea denial operations.[75] Naval leaders acknowledge that naval and amphibious warfare has changed, making past approaches to power projection infeasible. As stated by Marine Corps Commandant David Berger, "[v]isions of a massed naval armada nine nautical miles off-shore in the South China Sea preparing to launch the landing force in swarms of amphibious combat vehicles, LCUs, and LCACs are impractical and unreasonable."[76] With a new operational approach and facing an increased threat, the naval force is working to identify the best capabilities to maneuver and sustain itself. The current and future fleet of connectors will likely be an important part of this solution. Because the specifications of these craft were informed by different requirements and in different threat environments, survivability should be central to this analysis.

Strategy and Concepts: Competing for Sea Control

Advantage at Sea, the triservice maritime strategy promulgated by the Navy, Marine Corps, and Coast Guard, prioritizes strategic competition in alignment with the National Defense Strategy. With a focus on peer threats, the naval force developed a series of new operating concepts: DMO, littoral operations in a contested environment, and EABO.[77]

The DMO concept envisions a fleet that deploys in varied force packages, at varied and less predictable times, to disperse its firepower while integrating its effects across domains.[78] The concept of littoral operations in a contested environment, which nests under DMO, was a jointly developed concept for the Navy and Marine Corps to project power in an increasingly denied littoral space.[79] The EABO concept calls for a Marine Corps that fights as part of the fleet distributed in small elements on key maritime terrain in support of sea control and sea denial operations. The advance base is not necessarily a specific

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base but can encompass a tasked geographic operating area. The flexibility and mobility of the marines in the area forms the base. This concept envisions marines deploying across maritime terrain and the littorals to expand the maritime commander's fires across long distances for sea denial and sea control. The marines can also expand aviation logistics networks, setting up forward arming and refueling points (FARPS) for aircraft, such as the F-35 and V-22.[80] Use of connectors will play a key role in distributing those forces along with aviation assets.

These maritime concepts are the basis for Commandant Berger's vision of the Corps as a SiF, which was codified in the 2021 *Concept for Stand-in Forces* and structurally supported by the 2020 *Force Design 2030*. A SiF can survive and fight within the WEZ, which provides the joint force with situational awareness during competition and operational advantage during conflict. SiFs extend the *kill web*, a network of sensors and shooters, into areas that would otherwise be denied. They do this by managing their signatures, which makes them hard to locate and target.[81]

The Marine Corps is undertaking an ambitious force design initiative to transform itself into a SiF. This initiative involves jettisoning tanks, trading tube artillery for rocket artillery and long-range missiles (such as antiship missiles), and reshaping a leaner "future infantry battalion" with more firepower at the small-unit level.[82] A new unit type, the MLR, has been stood up in the Pacific. Commandant Berger has made it clear that EABO are just one type of mission that the corps will be able to conduct and that the familiar MAGTF structure will still be employed when appropriate. In particular, this means continuing to deploy as marine expeditionary units. Commandant Berger also envisions a persistent demand for the marine expeditionary brigade, although the need to provide two marine expeditionary brigades at once for joint forcible entry operations is no longer a sizing construct for the service.[83]

Connector Requirements: Surviving in the Weapon Engagement Zone

Risk to connectors becomes a particular challenge to maneuver and sustainment in the current threat environment. EABO and SiF will require connectors to move landing forces ashore and support their maneuver in littoral terrain. Connectors will operate inside the WEZ, where they are highly vulnerable. If the vulnerability of the connector fleet is not analyzed and mitigated, current Navy and Marine Corps concepts and operations might not be executable.

One new component of maneuver and sustainment for the Marine Corps is the planned Light Amphibious Warship (LAW).[84] The LAW is designed to move marines and equipment to and from shore and within the operational theater. Survivability has already become a major variable in deciding the ship's future. Unlike the current fleet of connectors, survivability was specifically written into its design concept.[85] In keeping with the SiF concept, the Marine Corps envisions a ship that can defend itself but that survives primarily by its inability to be targeted.[86] There needs to be enough lift to move and sustain Marines across long distances, so the cost of individual platforms must be kept low. Some reporting suggests that the Navy preference to build a LAW with significant defensive measures could reduce the overall number, which cuts into the SiF's sustainment and maneuver capabilities because of potentially low ship availability. For example, more armor equals more weight, requiring either bigger engines at a great cost or less maneuverability. The Marine Corps might be willing to accept a vessel that is more vulnerable to ensure that enough ships are produced in order to account for losses and an increase in redundancy through a larger inventory. The Navy, on the other hand, reportedly insists on design specifications that reduce the ship's susceptibility at the expense of quantity.[87]

The reported deliberations over LAW survivability are illustrative of the questions facing all ships and combat craft in a competitive environment, especially when it comes to amphibious operations. The Marines are preparing themselves to operate in a WEZ that has been expanding for decades. A 2015 study, for example, found that land-based antiship cruise missiles (ASCM) and surface-to-air missiles could threaten ships and aircraft about 200 nmi from shore.[88] The study concluded that amphibious forces needed "faster, more survivable lift" and that "[n]ew 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."[89] One such add-on capability could be a system similar to the Israeli tank defense system, Trophy. "Trophy is a combined hostile fire detection and active protection system which is available in two main configurations," heavy and light versions.[90] Designed for armored vehicles, it has proven itself against modern antitank munitions. The increased risk to connectors will be present whether they deploy from the well deck of an amphibious ship far from shore or they are in transit between advance bases to move troops and supplies.

SiFs are intended to extend a viable kill web and logistics network while keeping a low signature. The Marine Corps has explicitly identified logistics as its pacing function for force design.[91] Therefore, there must not only be a focus on getting Marines ashore but also on the ability to quickly relocate both Marines and heavy equipment, such as ASCM

> Risk to connectors becomes a particular challenge to maneuver and sustainment in the current threat environment.

launchers, as positions become uncovered or as new battlefield geometry is required.[92] Maintaining FARPs requires the movement of munitions and bulk fuel to the locations, which is a complex task in which surface connectors with greater lift capacity might play a key role. Connectors could thus be required to remain in the WEZ for a long period in a role that is important to the overall operational scheme, while their mother ships (Amphibs) are forced to move to safer waters.[93] Damage to or loss of connectors during a landing could create compounding problems for successive echelons. Limited numbers of connectors combined with minimal options to get replacements into theater makes connectors an increasingly high-value target. When it comes to ATF operations or the sustainment of a SiF, connector survivability is an imperative.

Finally, we note that recent conflicts, such as the war in Ukraine and events on the Black Sea, have demonstrated the increasing vulnerability of combat craft; the operation of connectors in this challenging environment requires even more focus on survivability. According to Commandant Berger, "[w]e must accept the realities created by the proliferation of precision long-range fires, mines, and other smart-weapons, and seek innovative ways to overcome those threat capabilities."[94] The proliferation of various weapon technologies now allows small units—whether part of highly capable nation-state militaries, smaller regional powers, or nonstate groups—to punch well above their weights. Ukraine, thought to have little to no antiship capability, has been able to destroy or damage 12 Russian Navy ships, including sinking two amphibious landing ships and the Black Sea fleet flagship guided missile cruiser, Moskva.[95] Unmanned aircraft systems (UASs), including off-the-shelf models for surveillance, have proved highly effective at both increasing the accuracy of familiar weapon systems and directly engaging targets, as demonstrated in Nagorno-Karabakh and Ukraine.[96] Countering these new threats should be included when considering ship-to-shore movements and intratheater lift.

The increased sensing and firepower available to small units should inform amphibious operations. The tools and tactics on display in Ukraine could increase the susceptibility of connectors, whether they are moving SiFs as part of sea control operations or happen across a nonstate group during a disaster response. Small enemy units might remain capable of acting despite shaping fires. The maneuverability of an SSC, for example, might not reduce susceptibility to the same extent that it did in 2012 because small units with even a commercial UAS might be able to surveil longer stretches of coastline and more quickly position themselves to threaten a landing zone. Watercraft are now at greater risk from ground-based forces because an anti-armor weapon similar to a javelin can fire over water with greater range and accuracy.

Whether because of advanced A2/AD networks or low-cost sensing and fires, connectors are at far greater risk than they were in 2012. The naval concepts of DMO, EABO, and SiF hinge on the continued ability to bring landing forces ashore, sustain them, and maneuver them in the face of stiff adversary resistance. Given these realities, the survivability of the connector fleet needs to be reexamined.

Conclusion and Recommendations

The Navy and Marine Corps developed their current fleet of connectors for a different era. Current concepts recognize that the Navy and Marine Corps face a new threat environment that will require them to operate differently than they have since the early 2010s. This evolution means that the naval services must address the survivability of their current fleet of combat craft, which they will rely on for maneuver and sustainment of troops and large equipment. The Naval services can do so by ensuring that survivability is systematically addressed in the capability development process for future connectors, enhancing the viability of current platforms, changing tactics for employment of the platforms, and modifying the training and organization of amphibious forces.

Develop and Formalize an Analytic Framework for Connector Survivability

Survivability is a central concern to Navy and Marine Corps force developers. However, from our cursory research, it is unclear whether the codified framework for susceptibility, vulnerability, and recoverability is rigorously applied at all stages of the capability development process. The Navy and Marine Corps should develop and formalize an analytic framework for connector survivability and use it to develop requirements for systems that will support DMO, EABO, and SiF. A standard framework for survivability could be applied throughout the entire requirements process, which consists of wargaming, analysis, initial capability documents, capability development documents, and operational testing and evaluation.

Invest in the Survivability of the Current Connector Fleet

For the foreseeable future, Navy and Marine Corps amphibious forces will be reliant on the LCU and LCAC (or SSC), which are in turn integral to the maneuver and sustainment of the SiF. Although the requirements analysis behind these platforms was sound, these platforms were designed for a different threat environment and employment concept. The SSC and LCU could be the correct platforms for traditional contingency and amphibious operations and might offer some of the right capabilities for the broader SiF. Their survivability, however, will need to be reexamined for these contexts. The first step will be to identify the requirements for connectors in current naval concepts, as the naval services have done for other platforms. Identifying those requirements will likely be an incremental process as the Marine Corps and Navy devise the broader family of systems for the SiF. Once the future roles of the LCU and SSC are clarified, the Navy and Marine Corps can consider ways to enhance their survivability and weigh the costs and benefits of additional investments in the current vessels. Materiel upgrades should account for the complex trade-offs in susceptibility, vulnerability, and recoverability, like the Navy did when it decided to prioritize the speed and maneuverability of the LCU and SSC over hardening them. As the current LAW debate suggests, cost will also be a major factor. Materiel enhancements will raise the cost of individual units, degrading the sustainment and maneuverability of the SiF by reducing the inventory of connectors. Enhancements could also create trade-offs with other Navy and Marine Corps priorities. However, upgrades should be grounded in a holistic analysis of LCU and SSC survivability under the new concepts and taken seriously as a means of reducing increased susceptibility and vulnerability of the LCU and SSC.

Develop Tactics, Techniques, and Procedures and Associated Training to Support New Operating Concepts

The survivability of amphibious forces extends beyond the materiel attributes of combat craft. A platform is just one component of a capability; training and doctrine will also be integral to the survivability of amphibious forces in the future threat environment. Developing tactics, techniques, and procedures and enhancing training are ways of increasing survivability by reducing susceptibility to enemy action. The new naval concepts require the Navy and Marine Corps to operate in new ways and should trigger an examination of the tactical employment of connectors. For example, landing forces and craft crews will likely have to manage their signatures in ways that were not necessary under previous operating concepts. This transition could require changes to standing operating procedures and training.

Although the importance of advance forces was noted in long-standing concepts, such as STOM, the relevance of advance forces might grow further with the SiF. It is possible that Navy SEALs and Force Reconnaissance Marines will establish overwatch positions or aggressively engage small units to disrupt enemy actions. Unmanned systems could be employed by these specialized units to guide connectors, identify threats, and call for fire. Similarly, unmanned systems might be employed landward from amphibious shipping or the connectors themselves. As the naval force explores a new fleet of small craft, these craft, in lieu of additional self-defense systems for the landing craft, could be used as escorts. If this fleet has the capability to counter UASs and is armed with various munitions, such as Trophy, the new small crafts can be used to protect intratheater lift. Forces both landward and seaward will likely act in a mutually supporting approach to outpace an adversary's decision cycle with rapid adjustments and deception.

Elevate the Role of Operational and Tactical Intelligence for Amphibious Forces

Our review of naval concepts and the current operating environment suggests that amphibious forces face a set of challenges for which they were not designed, particularly the challenge of surviving in the WEZ. One potential way to enhance the survivability of the force is to enhance the role of intelligence personnel and processes in amphibious units. Fires complexes, ubiquitous surveillance, and loitering munitions represent new and pervasive threats. Maneuver and sustainment in the current littoral environment require exquisite situational understanding that likely exceeds current organic intelligence, surveillance, and reconnaissance capabilities. For example, does an MEU staff have the requisite intelligence personnel with operational expertise to plan a raid against targets defended by robust A2/AD networks? Do units that provide and employ connectors, such as beach groups and their parent expeditionary strike groups, make sufficient use of intelligence throughout the force generation cycle? Allocating additional resources to expeditionary intelligence entails trade-offs with other fleet priorities. Still, a consideration of future fleet capabilities could warrant an examination of how amphibious forces are composed and organized to deal with the evolving threat environment.

Amphibious forces face a set of challenges for which they were not designed.

Areas for Future Research

This initial look at connector survivability as it relates to Navy and Marine Corps operating concepts and an evolving threat environment will require additional research. In addition to our recommendations, Navy and Marine Corps organizations should consider how to apply the established survivability framework to develop updated requirements. How might susceptibility, vulnerability, and recoverability be considered in a more holistic way throughout the entire capability development process? As an integral part of launching and ferrying connectors into desired areas of operations, how do traditional MAGTF constructs, such as an ATG or ATF, fight as part of a SiF? Wargaming or modeling and simulation could be brought to bear on this question to explore scenarios in which an ATG or ATF operates alongside units from an MLR conducting EABO and ensure that survivability is a key component of the model.

Notes

1 U.S. Marine Corps, *Operational Maneuver from the Sea*, p. 13; U.S. Department of the Navy, *Ship-to-Objective Maneuver*, pp. 4–5.

2 For the purpose of this report, a naval connector or craft uses the same criteria for survivability as a naval ship does, although, by definition, a ship is larger and can carry watercraft and connectors.

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8 For a discussion of survivability and its application to Navy fleet design, see Hilger, "Rethinking Survivability."

9 U.S. Navy, "Initial Capabilities Document for Surface Connector (X) Replacement"; U.S. Navy, "Threat Summary."

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22 U.S. Department of the Navy, *Ship-To-Objective Maneuver*, p. 20.

23 Schmitz, *LCAC Versus LCU: Are LCAC Worth the Expenditure?*

24 A new and improved AAV that could maneuver much faster and farther was also part of the strategy but did not come to fruition in the 1990s or early 2000s as planned. Even the current amphibious combat vehicle, replacement for the AAV, does not have the speed in the water envisioned by OMFTS.

25 Schmitz, *LCAC Versus LCU: Are LCAC Worth the Expenditure?*; U.S. Navy and U.S. Marine Corps, *Employment of Landing Craft Air Cushion (LCAC)*.

26 U.S. Navy and U.S. Marine Corps, *Employment of Landing Craft Air Cushion (LCAC)*, p. 1-17.

27 U.S. Navy and U.S. Marine Corps, *Employment of Landing Craft Air Cushion (LCAC)*, pp. 5-1, 5-2.

28 U.S. Navy and U.S. Marine Corps, *Employment of Landing Craft Air Cushion (LCAC)*, p. 5-2.

29 Schmitz, *LCAC Versus LCU: Are LCAC Worth the Expenditure?*; U.S. Navy, "Initial Capabilities Document for Surface Connector (X) Replacement," p. 1; U.S. Navy and U.S. Marine Corps, *Employment of Landing Craft Air Cushion (LCAC)*, p. 1-17.

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[41] U.S. Department of the Navy, *Ship-To-Objective Maneuver*, p. 3.

[42] U.S. Department of the Navy, *Ship-To-Objective Maneuver*, p. 5.

[43] U.S. Department of the Navy, *Ship-To-Objective Maneuver*, p. 6.

[44] U.S. Department of the Navy, *Ship-To-Objective Maneuver*, p. 6.

[45] U.S. Department of the Navy, *Ship-To-Objective Maneuver*, p. 13.

[46] U.S. Department of the Navy, *Ship-To-Objective Maneuver*, pp. 19–20.

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About This Report

U.S. Navy and U.S. Marine Corps concepts have evolved significantly in the past five years. Such concepts as distributed maritime operations, expeditionary advanced base operations, and stand-in forces call for a naval force that can fight within the weapon engagement zone of a peer competitor during a high-end conflict. This capability requires maneuver and sustainment, which depend, in large part, on the current and future fleet of both surface and connectors. Therefore, Navy and Marine Corps analysts are confronted with the challenge of developing the right family of systems to keep a stand-in force moving in a high-end fight under the anti-access/area denial threat.

Survivability is a critical consideration for all combat watercraft, including the Navy's current fleet of amphibious connectors. The landing craft utility and landing craft air cushion, the key lifting components of that fleet, were not designed with survivability in mind as part of a stand-in force. The requirements for these craft were developed using past naval concepts for power projection and in a more permissive threat environment. Although the analysis behind the requirements was sound, current operating concepts demand that the Navy and Marine Corps place craft survivability at the center of their analysis for the current and future fleet.

In this report, we examine how past concepts drove Navy and Marine Corps thinking about watercraft survivability, look at how survivability was factored into the requirements for today's fleet of amphibious connectors, offer recommendations for how the Navy and Marine Corps could improve surface connector survivability for the fleet of the future, and suggest areas for further research. We conducted interviews and discussions with both military and civilian subject-matter experts within the Department of the Navy (Navy and Marine Corps) with oversight and responsibilities for acquisition requirements, doctrine, and operations.

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