REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*
04/25/2019

2. REPORT TYPE
Student Research Paper

3. DATES COVERED *(From - To)*
October 2018 - April 2019

4. TITLE AND SUBTITLE
Ensured Access to Contested Beachheads via Autonomous Platforms

5a. CONTRACT NUMBER N/A

5b. GRANT NUMBER N/A

5c. PROGRAM ELEMENT NUMBER N/A

6. AUTHOR(S)
Major Matthew Munroe, United States Marine Corps

5d. PROJECT NUMBER N/A

5e. TASK NUMBER N/A

5f. WORK UNIT NUMBER N/A

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
USMC Command and Staff College
Marine Corps University
2076 South Street, Quantico, VA 22134-5068

8. PERFORMING ORGANIZATION REPORT NUMBER
N/A

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Same at #7

10. SPONSOR/MONITOR'S ACRONYM(S)
Dr. Benjamin Jensen

11. SPONSOR/MONITOR'S REPORT NUMBER(S) N/A

12. DISTRIBUTION/AVAILABILITY STATEMENT
Distribution A: Approved for public release, distribution unlimited.

13. SUPPLEMENTARY NOTES
A future concept paper submitted to USMC Command and Staff College faculty in partial satisfaction of the requirements of an MS in Military Studies and a graduate certificate in Future Concept development as part of the Gray Scholars program.

14. ABSTRACT
The United States Marine Corps is currently underequipped to conduct amphibious landings in an Anti-Access/Area-Denial (A2/AD) environment against contested beachheads with multi-layered, deliberate obstacle belts. The Corps' current model for amphibious raids and assaults assumes a more-than-modest degree of maritime and air superiority. This essay outlines fully, partially, and optionally autonomous capabilities in both surface and air domains which will enable successful amphibious operations against deliberate obstacles employed within a FOCDPIG architecture from shallow offshore through the depth of the beach. It also presents multiple technologies currently in various stages of development and a method of employment which will provide improved likelihood of mission success while minimizing human casualties in the earliest and most dangerous waves of an amphibious operation.

15. SUBJECT TERMS
Amphibious Assault, Raid, Autonomous, Obstacles, EMAV, Coyote, Drone, Swarm, Beachhead, Defense, Breaching, Mines, Hedgehog, Tetrahedron, Ship-to-Shore, Landing Waves, MICLIC, ACV, LCAC, LCU, Data Diver, A2/AD

16. SECURITY CLASSIFICATION OF: a. REPORT	b. ABSTRACT	c. THIS PAGE	17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
UNCLASS	UNCLASS	UNCLASS	UU		USMC Command and Staff College, MCU

19b. TELEPHONE NUMBER *(Include area code)*
(703) 784 3330 (Admin Office)

United States Marine Corps
Command and Staff College
Marine Corps University
2076 South Street
Marine Corps Combat Development Command
Quantico, Virginia 22134-5068

MASTER OF MILITARY STUDIES

Ensured Access to Contested Beachheads via Autonomous Platforms

SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF MILITARY STUDIES

AUTHOR: Major Matthew Munroe

AY 2018-19

Mentor and Oral Defense Committee Member: Dr. Benjamin [illegible]

Approved: [signature]

Date: 4/29/19

Oral Defense Committee Member: Nathan M. Packard

Approved: [signature]

Date: 4/29/2019

DISCLAIMER

Table of Contents

Executive Summary

The United States Marine Corps is currently underequipped to conduct amphibious landings in an Anti-Access/Area-Denial (A2/AD) environment against contested beachheads with multi-layered, deliberate obstacle belts. The Corps' current model for amphibious raids and assaults assumes a more-than-modest degree of maritime and air superiority. While the Corps has maintained the doctrine and force structure to conduct the landings of old, it has not modernized its equipment sufficiently to forcibly enter the shores of a determined resistor. The Corps' ship-to-shore connectors are slow and vulnerable to enemy fires. The Corps' obstacle clearance tools are limited in quantity and capability in the earliest foothold-establishing waves, and the Corps relies heavily on breaching assets which are not organic to any of its afloat expeditionary forces and that are so heavy they can only come ashore via select still more vulnerable connectors and only in later waves when their utility at the beachhead is limited. In short, in its current state, the Marine Corps is not likely to succeed in establishing a beachhead if the enemy defending it employs basic principles of the engineering defense.

The author outlines one potential solution to this problem. The enabling concept herein contains recommendations for inexpensive, autonomous vehicle platforms, employed in swarms (or landing waves) to sense and survey the waters, the beachhead, and relay that information to an afloat Combat Operations Center (COC) for adjudication and planning or to relay, in real-time, this information to queue and direct other autonomous platforms to conduct the earliest, most difficult, and most dangerous stages of an amphibious operation.

The concept leverages autonomous technologies already in the development and fielding pipeline, such as the Data-Diver, the Expeditionary Modular Autonomous Vehicle (EMAV), and the multi-purpose Coyote drone, while calling for as-yet-unsourced technologies which would increase effectiveness, lethality, and survivability during scalable, complex amphibious operations.

General

The ability to safely deliver forces to foreign shores in support of the full range of military operations is a fundamental capability of the United States Marine Corps and the Corps derives nearly all of its iconic image from that capability. From the shores of Tripoli to Normandy to Inchon, the Marine Corps has acquitted itself well and shows no signs of abandoning this core competency nor does Congress show signs of amending the Corps' charter. In the 2018 *National Defense Strategy*, then Secretary of Defense Mattis called on the department to be "strategically predictable, but operationally unpredictable… challenge competitors by maneuvering them into unfavorable positions, frustrating their efforts, precluding their options while expanding our own, and forcing them to confront conflict under adverse conditions."[1] Joint Forcible Entry Operations (JFEO), specifically amphibious operations, provide commanders the option to do exactly those things.

The Marine Corps has allowed this capability to atrophy. Despite advances in its aviation capability via the MV-22 Osprey and the F-35 stealth fighter, the Corps has not kept pace with similar investments in its ship-to-shore connectors. The current Assault Amphibious Vehicle (AAV) is a product of the early 1970s and saddled with its Enhanced Applique Armor Kit (EAAK) is even slower and more vulnerable than originally designed.[2] It is sea-worthy only by

---

[1] US Department of Defense, *Summary of the 2018 National Defense Strategy of the United States of America.* (Arlington, VA: Office of the Secretary of Defense, 2018), 5.
[2] Army Recognition, "Army Light Armored Vehicle, AAV-7", accessed March 23, 2019, https://www.armyrecognition.com/united_states_american_army_light_armoured_vehicle/lvtp-7_aavp-7a1_aav-7_amphibious_assault_vehicle_technical_data_sheet_specifications_pictures_video.html.

the most generous of definitions, with a freeboard of less than 11 inches while being barely able to defend itself or reduce obstacles it is likely to encounter at the water line.[3][4]

The Corps continues to employ human reconnaissance as its primary method of interrogating and mapping the beachhead in advance of landing forces and supporting the landing with manned fixed and rotary wing assets. Put simply, against a peer adversary with even reasonably well emplaced obstacles and marginally trained forces the Corps stands little chance of success in a modern-day amphibious assault. This must change or the Marine Corps risks tarnishing its historic lineage of amphibious operational successes.

Purpose

In order to retain ownership of the amphibious domain and dominance therein, the Marine Corps must continue to adapt its approach to amphibious landings, a near universal component of all amphibious operations. The purpose of this paper is to provide an enabling concept of obstacle identification and reduction for future amphibious operations over the next 10-40 years. Additionally, this concept includes both recommended methods of employment for technology already in development as well as capability gaps as yet unaddressed which the Marine Corps must address with commercial technologies or develop from basic research.

Time Horizons, Assumptions, and Risks

This enabling concept is designed to support amphibious operations in accordance with the Marine Operating Concept (MOC) nested within the current National Defense Strategy (NDS) and National Security Strategy (NSS) for a period of no less than 10 years from first

[3] Headquarters US Marine Corps, *Employment of Amphibious Assault Vehicles (AAVs)*, MCTP 3-10C (Washington DC, May 2, 2016), 8-2.
[4] Ibid., A-2.

fielding of all capabilities and extending to 40 years considering the utility of current amphibious assets.

Description of the Problem

Much of the Marine Corps' obstacle construction and breaching doctrine derives from the Army's comprehensive publication, Field Manual 5-34 (FM 5-34) originally published in 1987. The obstacle types, methods of employment, and defensive strategies originate from firsthand knowledge and studies from World War II and Vietnam. The dimensions, spacing, and density of defensive obstacles are designed to counter primarily Soviet armor and troop transport capability. The Corps has failed to modernize its breaching systems to account for advanced enemy techniques of employment and coverage by a variety of fires. As such, the Corps' contested beachhead breaching capability is lacking, if not entirely obsolete and only becoming more so as the corps fields new equipment such as the Amphibious Combat Vehicle (ACV). Despite its centuries-old tradition of amphibious operations and only decades removed from its peak in WWII, the Corps has largely forsaken its forcible entry capability. In order to modernize and maintain operational unpredictability, the Corps must return to its roots in thinking and writing about the amphibious landings of the future, develop novel technologies to overcome all manner of beachhead denial systems, and recognize its enemy's true capabilities, while simultaneously accepting its own limitations.

Amphibious operations exist to provide operational options to a commander. Actions on the objective can be ground, air, sea-based or a combination thereof. The historical challenge of sea-based amphibious operations is the aptly named problem of the tadpole. A tadpole is neither particularly adept in the water or survivable on land. It is only when it grows in size and can stretch its legs that it becomes formidable in either domain. An amphibious force is a tadpole and its means to grow is by the rapid establishment of combat power ashore. The amphibious force must have accessible beachfront of sufficient breadth and depth to support this buildup. Obstacles, natural or manmade, limit accessibility, breadth or depth and therefore limit amphibious operations and commander's options. Up to and through WWII, the Marine Corps devoted extensive time, resources, and effort to iteratively overcome beachhead obstacles. During this process, a pattern of enemy response emerged. Initially, coral and rocky shoals provided all the obstacle depth a beach needed to be excluded entirely from amphibious planning.[5] Soon, German and Japanese forces developed and perfected obstacle employment to impede, disrupt, and canalize landing forces. Allies, in turn developed highly specialized equipment (amphibious tractors, waterproof explosives/detonators, etc.) and initiated multi-day sustained naval bombardment of landing beaches to enable opposed beach landings. Today, the Marine Corps' specialized equipment is outdated and atrophying, and the premier platform for sustained naval bombardment, the battleship, is no longer a part of the active Navy inventory.

As the authors noted in the 1946 post-mortem of WWII Amphibious Operations, dozens of types and styles of obstacles, physical, explosive, or both lined the beaches of Normandy, Tarawa, and other prolific battles of the war. Said they of these obstacles, they "…function during the assault to (1) hold or delay attacking forces on vulnerable beach areas, (2) canalize movement…into areas of heavy crossfire, or (3) destroy attacking craft, vehicles, and personnel and to create confusion."[6] Obstacles are not normally delineated as land or sea based, as most, with few exceptions can be employed above and below the water line to elicit different effects.

---

[5] W.P.T. Hill, *The Characteristics of Coral Formations of the Pacific Islands: The Extent to which these Formations Impede Landings from Small Boats and Possible Methods for Reducing Their Effect as Obstacles*, Marine Corps Schools (Quantico, VA, April 20, 1936), 8.
[6] Headquarters US Marine Corps, *Amphibious Operations: Beach and Underwater Obstacles*, NAVMC 4175 (Quantico, VA, March 1946), 1.

Whether they fix, block, turn, or disrupt, they must be addressed, reduced or bypassed. The calculus for the assaulting force is simple; take the time to reduce the obstacle so as to maintain the desired maneuver lanes or surrender the initiative to the enemy by succumbing to the enemy defensive plan? Either choice creates a highly advantageous situation for the enemy while limiting the assaulting force options at the point of maximum vulnerability, as the tadpole attempts to make the difficult transition from water to land. A number of the most common types of obstacles are shown in Figure 1.

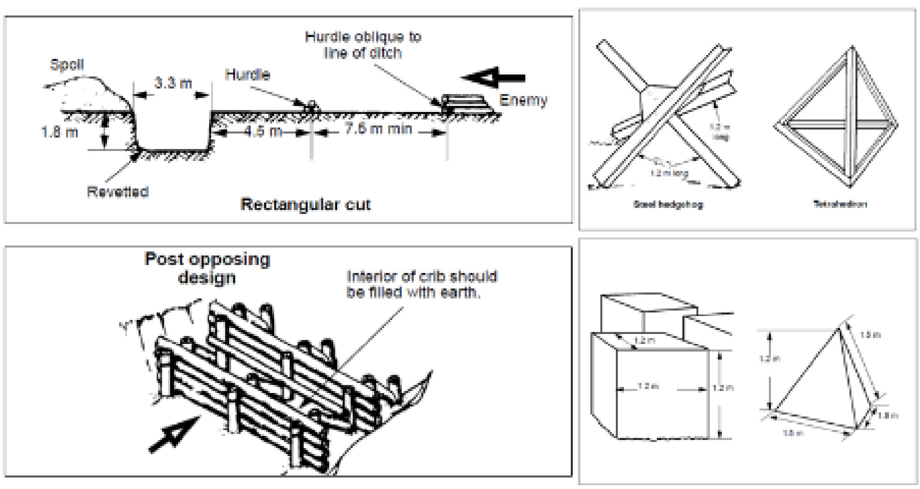

Figure 1: Doctrinal obstacle types, clockwise from top left: antitank ditch, steel hedgehog/tetrahedron, concrete cube/dragon tooth, wood crib. Source: Headquarters Department of the Army, *Engineer Field Data,* FM 5-34 (Washington, DC: Headquarters Department of the Army, April 10, 2003), 203.

The Navy is responsible for all obstacles, normally mines, in the water from the ship to waterline ashore. The area inland of the waterline, ashore, belongs solely to the Marine Corps. The shallow water area on the seaward side of the waterline is the point at which shallow subsurface obstacles begin and continues out to sea roughly to the point of deepest draft of the landing craft. This belt is, doctrinally, the Navy's responsibility, as it owns all of the AOA up to the high-water mark. However, full reduction of obstacles in this area is difficult and, as such, the landing craft are likely to encounter a greater than zero portion of remaining obstacles. From the high-water mark inland, the Marine Corps is responsible for obstacle reduction. The Navy and Marine Corps current obstacle reduction inventories have glaring and easy exploited gaps. The Navy relies almost exclusively on its SEALs to reduce shallow subsurface obstacles explosively. This capability is not organic to any standard MAGTF and is inherently limited in scope due to the highly specialized skillset of the SEALs. The further inland the Marine Corps travels, the more capable it becomes of obstacle detection and reduction. It is the intermediate AOA, beyond the SEALs but before ground-only assets take over, that is lacking. In the Special Landing Equipment training manual, Marine Corps Schools command identified numerous innovative technologies specifically for this area. Of those shown in Figure 2, none were fielded long-term and none exist in kind today.

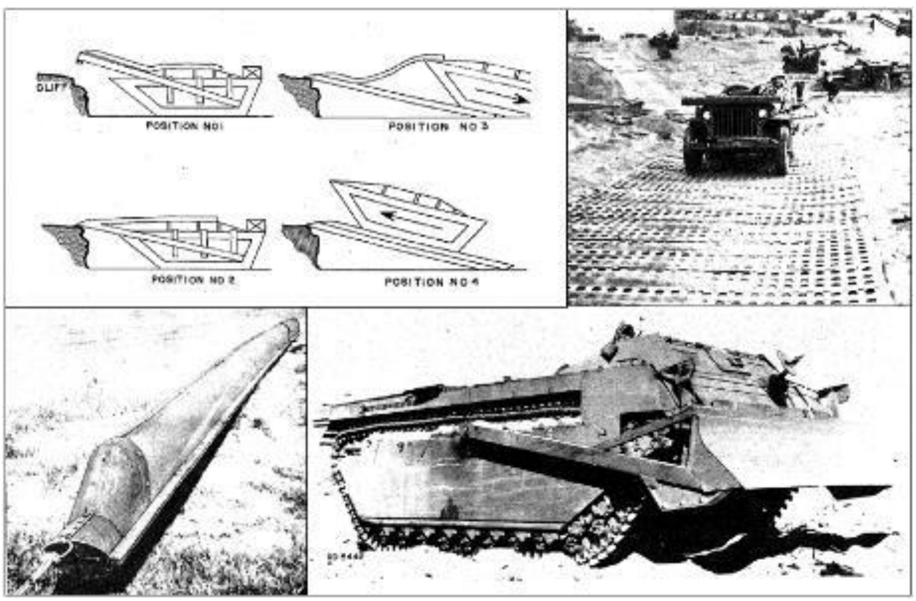

Figure 2: Proposed Special Landing Equipment, clockwise from top left: portable ramp for LVT, beach matting, Reddy Fox charge, LVT dozer. Source: Headquarters US Marine Corps, *Amphibious Operations: Special Landing Equipment*, NAVMC 4221 (Quantico, VA, May 1946), 6.

The current AAV has no portable ramp, its vertical climb capability is only three feet.[7] The Marine Corps does not have, in inventory, an amphibious bulldozing capability. Both the Armored Combat Earthmover (ACE, ford capable, but not amphibious) and the Assault Breacher

[7] Headquarters US Marine Corps, *Employment of Amphibious Assault Vehicles (AAVs)*, MCTP 3-10C (Washington DC, May 2, 2016), 3-5.

Vehicle (ABV) have blades for lane clearance and earthmoving, but must be delivered ashore via separate connectors and neither bladed asset are organic to the afloat MAGTFs. The Marine Corps discontinued beach matting, designed to improve traction in soft sand, for tracked and improved traction wheeled vehicles. The Reddy Fox charge, designed specifically to reduce obstacles in the shallow subsurface zone where landing craft are particularly vulnerable, has no equivalent despite its simple design and high utility value.

The Marine Corps' primary amphibious toolset consists of ship-to-shore connectors such as the Amphibious Assault Vehicle (AAV), Landing Craft Air Cushion (LCAC) and Landing Craft Utility (LCU) as well as breach-specific assets like the Mk154 Mine Clearance Launcher, Armored Vehicle-Launched Bridge (AVLB), Armored Combat Earthmover and Assault Breacher Vehicle (ABV). The Mk154, AVLB and ABV are shown in figure 3.

Figure 3: Current mechanized breaching assets, from left to right: Mk154 Mine Clearance Launcher mounted on AAV, an AVLB, and an ABV. Source: Headquarters Marine Corps.

While the AVLB and ABV provide robust obstacle overbridging and clearance, respectively, they both tip the scales at 59 and 70 Military Load Classification, respectively, and require specialized transport equipment to shore, namely the LCU or LCAC. These are low-survivability transports which require a highly permissive environment in which to operate and are, therefore, normally relegated not to the assault/breaching waves, but the later follow-on and support waves. The Mk154 carries three M59 linear demolition charges that can be launched from more than 60 meters offshore and will clear an 8 x 100-meter lane through surface and buried minefields as well as wire obstacles. Its primary drawbacks are that the additional weight of the kit limits its employment to sea state 1 or lower, the AAV's extremely limited self-defense capability during deployment, and the required proximity to shore for employment (<62.5m).[8] To further exacerbate the issue, the Mk154 AAV capability is headed toward obsolescence as the AAVs replacement, the ACV, is not of sufficient size to carry the Mk154.[9] The likelihood of these goldilocks conditions on contested beachheads in the anticipated A2/AD environment of tomorrow is extremely unlikely. The corps must do more maintain this capability, lest amphibious operations become a shell of what they once were.

The Marine Corps has lost sight of its complete amphibious capability set. It has made too many assumptions that the techniques of yesterday coupled with heavy, slow-moving equipment will facilitate success. This is simply not the case. In the 1930s and 1940s, the Corps invested heavily in thinking through each phase and stage of an amphibious operation. Corners of the Corps, such as the Marine Corps Schools Command devoted time and resources to the problem of the tadpole and methods to overcome it. The Corps looked at everything from coral types and structures to beach sand composition and its effects on vehicle weight displacement. Scholars captured, cataloged, and described the manmade obstacles they'd seen and overcome at Normandy and in the islands of the Pacific; most were wickedly simple but devastatingly effective. And finally, the Corps' young and mid-career officers made recommendations on innovative technologies meant to carry the corps to victory in future conflicts. At some point between the end of WWII with its associated drawdown and today, focus shifted away from robust and well-developed amphibious capability from ship and toward land-based fighting and aviation-centric operations. The technological leaps in those categories are immense in

[8] Ibid., 7-12.
[9] BAE Systems, *Amphibious Combat Vehicle 1.1*, accessed December 20, 2018, https://www.baesystems.com/en-us/product/amphibious-combat-vehicle.

comparison to the surface ship-to-shore capabilities. The Marine Corps must stop assuming away enemy capabilities, overestimating its own, and recognize that the fight at the waterline is still not ours by right, but that it must be taken, by force, from an enemy who will resist, and that those who must take it must be well and fully equipped to do so. Without these improvements, a determined enemy can and will readily stifle an amphibious landing and smother it in the shallow waters of the coastline using technology no more advanced that than last seen in WWII.

Insights from War Games

During the Fall 2018 Gray Scholars Program wargame, the Gray Scholars, in conjunction with the MCWL Ellis Group, explored schemes of maneuver for distributed operations in support of EABO and possible MEU reorganization. The group analyzed and synthesized their findings in a paper titled *Marine Expeditionary Unit Construct.* The group identified challenges in transition from the contact layer to the blunt layer, specifically if the mission required one or more amphibious assaults.

First, the current ship-to-shore connectors are either too slow, lacking in self-defense, highly visible, or all of the above to be employed in a highly contested environment. Next, as EAB persistence and survival is based on the Marines' ability to pack up and move, a smaller, lighter footprint going in and exiting an EAB is required. To be effective and efficient, this lighter footprint needs small, fast transportation. Lastly, EABO requires distributed, highly independent activities without the normal doctrinal complement of large naval surface combatants. Other forms of logistical and fires support are needed.

Additionally, the Gray Scholars identified myriad challenges with deception operations in support of EABO. The need to divert, distribute, and overwhelm the enemy's ISR assets is key to successful EABO. This insight highlights the need for capabilities which look and feel like a real landing in support of EABO while remaining an inert diversionary force. Coupled with EW and IO efforts and risking no human lives in the process, this capability provides robust enabling of future operations and force multiplication, thrusting the enemy deep into the complex problem domain. The enemy must then sense, report, analyze, and respond to all perceived threats, real or engineered. This asymmetric advantage cannot be overstated.

The Opportunity

The United States Marine Corps claims, as a core competency, the ability to conduct forcible entry into hostile territory through amphibious operations. The primary means is via ship-to-shore connectors such as the Amphibious Assault Vehicle (AAV), Landing Craft Air Cushion (LCAC) and Landing Craft Utility (LCU). Aviation ship to shore connectors exist but are limited in both cargo and personnel lift capacity as well as by deck cycles. Additionally, in an A2/AD environment, one the Navy-Marine Corps team would likely encounter in conflict with a peer competitor, low and slow rotary wing assets would be even more severely limited in their ability to support forcible entry. Therefore, surface connectors must reach the beach as only they will maintain the critical operational tempo required for a successful entry. All surface connectors require obstacle free (or obstacle minimized) lanes to access the beach.[10][11] The Marine Corps and Navy share responsibility for these lanes, with the Navy responsible up to the high-water mark, the Marine Corps beyond that point.[12] At this time, neither possesses extensive beach obstacle clearance tools. The Navy relies largely on SEALs to identify and reduce

[10] Kaitlin Kelly, "Marine Corps Systems Command Awards Contract to Produce ACV," United States Marine Corps, last modified June 20, 2018, https://www.marines.mil/News/News-Display/Article/1555187/marine-corps-systems-command-awards-contract-to-produce-acv/.
[11] Glenn W. Goodman, Jr., "Breaching Unseen Bafflers: Offshore Mines Remain the Achilles' Heel of U. S. Naval Expeditionary Forces" Armed Forces Journal International 133, no.4 (November 1995): 41.
[12] US Department of Defense, *Amphibious Operations*, JP 3-02 (Arlington, VA: Office of the Secretary of Defense, 2014), A-5.

obstacles, as does the Corps with its reconnaissance Marines, though to a much lesser extent. Recon Marines are available in limited numbers aboard Marine Expeditionary Units/Brigades (MEU/MEB) and Navy SEALs are not an organic asset thereof. Additionally, the Marine Corps can employ a Mine Clearing Line Charge (MICLIC) from an AAV afloat, but this tool is largely ineffective against submerged surf zone obstacles.[13] The most dangerous course of action the Marine Corps may encounter would be a capable and coordinated enemy who employed obstacles with a FOCDPIG architecture; that is covered by Fire, Observed, Concealed, employed in Depth, Protected by anti-tamper devices, Integrated, and non-Geometric.[14] It is the ability to identify and subsequently reduce these types of obstacles to clear lanes for surface connectors that the author views as an overlooked and assumed away enemy course of action, and as such, a major opportunity and operational necessity in order to maintain the strategic flexibility upon which the Marine Corps prides itself.

Opportunity: Autonomous Obstacle Reduction Drones

A system of autonomous, self-propelled drones capable of mapping the surf zone, identifying obstacles from imagery (self-acquired or externally-sourced), and explosively reducing those obstacles will help enable amphibious forcible entry.

Key Components: Limited Recon/MICLIC assets

According to the RAND Corporation, "Amphibious operations have always assumed the need to overcome an opposing force and to establish a degree of battlespace dominance before attempting operations, but the reach and lethality of modern weapons systems make aspects of

[13] Headquarters US Army, *Mine/Countermine Operations*, FM 20-32 (Washington, DC: Headquarters US Army, February 2, 2004), 10-7.
[14] "Engineering in the Offense and Defense," (course card, The Basic School, Quantico, VA, 2014), 11.

amphibious operations particularly challenging today."[15] Reconnaissance and obstacle breaching are the integral to all amphibious operations. The Marine Corps' current primary tools for obstacle reduction are the SCUBA-trained Reconnaissance Marine carrying a stick of C-4 and the MICLIC, a 350-foot-long flexible sleeve containing 1650 pounds of C-4, capable of clearing a 100m x 8m lane through surface and shallow-subsurface land-based obstacles.[16][17] It is not quantifiably effective against submerged water obstacles such as dragon teeth, tetrahedrons, Czech hedgehogs and mines. Additionally, this capability is limited organically to 1xAAV with three fireable MICLICs with significant employment restrictions. The AAV has limited time remaining in the fleet as the Amphibious Combat Vehicle (ACV) will soon replace it.[18] The ACV is not MICLIC-compatible because it lacks the internal space and the top hatch through which the MICLIC is fired.[19] Even if the MICLIC were compatible with the ACV, it may soon, much like its failed predecessor, the Expeditionary Fighting Vehicle, be obsolete.[20]

The long range, precision weapons systems the MEU-ARG will face en route to the amphibious launch area coupled with the many and varied close-in weapons and complex obstacles necessitate the Corps adopt a fundamentally different approach to amphibious operations.

---

[15] *Amphibious Operations in Contested Environments:* Hearing Before the Committee on Armed Services Subcommittee on Seapower and Projection Forces United States House of Representatives, 115th Cong., (2017) (Testimony of Bradley Martin, The RAND Corporation), 1.
[16] Headquarters US Marine Corps, *Ground Reconnaissance* Operations, MCRP 2-10A.6 (Washington DC: Headquarters US Marine Corps, May 2, 2016), 6-34.
[17] Headquarters US Army, *Mine/Countermine Operations*, FM 20-32 (Washington, DC: Headquarters US Army, February 2, 2004), 10-7.
[18] Shawn Snow, "New in 2019: Corps to Take Delivery of New Amphibious Combat Vehicle," Marine Corps Times, last modified December 29, 2018, https://www.marinecorpstimes.com/news/your-marine-corps/2018/12/30/new-in-2019-corps-to-take-delivery-of-new-amphibious-combat-vehicle-2/.
[19] David Szondy, "BAE awarded US Marine Corps next-gen Amphibious Combat Vehicle contract," New Atlas, last modified June 19, 2018, https://newatlas.com/bae-systems-award-usmc-amphibious-vehicle/55106/.
[20] Bryan Clark and Jesse Sloman, *Advancing Beyond the Beach: Amphibious Operation in an Era of Precision Weapons*, (Washington DC: Center for Strategic and Budgetary Assessments, 2016), 38, https://csbaonline.org/uploads/documents/CSBA6216-AmphibiousWarfare_Final3-web.pdf.

Central Theme

Amphibious operations are complex, unpredictable, and dangerous. Obstacles, well employed, can block, disrupt, fix or turn attackers. Marines themselves are precious, few, and vulnerable to these effects. Robots, well designed, are none of these things. Transitioning from Marine-centric early waves to artificially intelligent robots will save countless lives, create a cost imbalance between the enemy's effort to defend and our risk to land, while simultaneously enhancing combat effectiveness and the likelihood of success of contested amphibious landings.

Application & Integration of Military Functions

The Marine Corps should replace all flesh and blood reconnaissance and initial assault waves with fully autonomous systems. A RAND study found that the average cost per military person-year is about $137,000.[21] This figure was not calculated to, nor is the author attempting to, place a price on the life of a Marine. It is meant, here, to highlight that relatively low-cost robots can act as a force multiplier, performing highly dangerous and specialized tasks and allowing the Navy and Marine Corps to more effectively and efficiently employ their personnel to human-only missions. The multipurpose, low-cost (approximately $15,000 per unit) Coyote drone system can conduct shoreline, beachhead, and inland reconnaissance from the air.[22] For subsurface reconnaissance, Data-Divers (estimated <$1,000 per unit) can assess the water column, map the ocean floor in "touch-down" range for amphibious platforms, and identify bottom-mounted and neutrally buoyant mines and other obstacles.[23] All of this can be done from

[21] Carl J. Dahlman, *The Cost of a Military Person-Year: A Method for Computing Savings from Force Reductions*, (Arlington, VA: RAND Corporation, 2007), 9.
[22] Joseph Trevithick, *Army Buys Small Suicide Drones to Break Up Hostile Swarms and Potentially More*, The Drive, last modified July 17, 2018, https://www.thedrive.com/the-war-zone/22223/army-buys-small-suicide-drones-to-break-up-hostile-swarms-and-potentially-more.
[23] Data Diver Spec Sheet, Apium, 2, https://static1.squarespace.com/static/57bd099220099e411d2add97/t/58991cbe9f74562948e54911/1486429380498/Data+Diver+Spec+Sheet.pdf.

a distance well outside weapons standoff range and at the cost of zero human lives. Each system's low electromagnetic signature and extremely low visual profile, make both platforms ideal for clandestine reconnoitering and survey, all while maintaining security of the force. Additionally, MAGTF commanders can assess multiple potential landing sites for suitability using and reusing many of these assets. With a higher quality battlespace picture, the commander would own maximum maneuver space, enhanced surprise, and the option to mass effectively in both time and space.

Additionally, with expendable autonomous assets, the MAGTF commander can conduct enhanced amphibious deception operations including demonstrations and feints. Dozens of Coyotes can overfly beaches across a wide frontage while data-divers can scan and deliberately emit across broad radio frequencies. Unable to differentiate between legitimate landing beach incursion and a diversionary force, the enemy would be forced to interrogate, analyze and adjudicate all threats. Each action would occupy numerous resources and reduce enemy responsiveness.

Similarly, the Corps should pair its EMAV fleet with autonomous LCUs or other amphibious connector as yet unidentified, perhaps the Ultra Heavy-Lift Amphibious Connector (UHAC) or Expeditionary Fast Transport (EPF).[24] Together, following reconnaissance activities, the pair would proceed forward to identify and reduce obstacles in the shallows and on the beachhead. This initial wave would execute its mission in the most dangerous of circumstances, against the most heavily fortified and ready enemy defenses. Historically it is this wave that receives the greatest number of casualties and must establish the foothold upon

[24] *Advancing Beyond the Beach, 39*.

which all inland ingress hinges. An autonomous set of early assault waves would reduce ground obstacles explosively or, if equipped with a smaller variant of the ABV's full-width mine plough (FMWP) physical clear them. Autonomous forces would draw defensive fires as defenders sought to protect their carefully laid obstacles, designed to deny human landing forces, from robotic ones. Working together, the EMAVs can clear wider lanes, displace larger obstacles, provide smoke obscuration, and provide security for themselves and subsequent assault and on-call waves. Meanwhile, massive follow-on and support waves can prepare in relative security before moving ashore in high-speed craft to a significantly less fortified beachhead. At that time, the surviving EMAVs would transition to autonomous security, equipment transport, and casualty evacuation platforms. All of this economizes the fighting force and increases operational tempo and commander's options during the most complex of military operations.

Necessary Capabilities

According to Joint Publication 3-02, *Amphibious Operations*, there are five standard phases to all amphibious operations, "planning, embarkation, rehearsal, movement, and action."[25] For this concept, planning and embarkation remain largely unchanged. The MAGTF afloat would require a slightly different well deck arrangement to accommodate additional autonomous LCUs or another EMAV transport platform. To transport human troops ashore, the AAV or ACV well deck space would be replaced with smaller, faster craft, perhaps the Maritime Water Craft or similar capability, as seen in Figure 4 below. Rehearsals for autonomous waves would be conducted on a computer screen before uploading the wave plans to the robotic systems themselves. The greatest changes, per this concept, occur in the movement and action phases.

Figure 4: Necessary Capabilities in Existing Technologic Concepts: clockwise from upper left: Apium Data-Diver, Expeditionary Modular Autonomous Vehicle (EMAV), Maritime Water Craft (MWC), and Coyote Drone. Source: Headquarters Marine Corps

Autonomous reconnaissance will be conducted by a combination of existing technology such as imaging satellites for broad field view and small autonomous systems like the Data-Diver for seafloor and water column mapping along with the Coyote Drone for beach and inland observation. They will communicate and coordinate with other like systems to focus on areas of

[25] US Department of Defense, *Amphibious Operations*, JP 3-02 (Arlington, VA: Office of the Secretary of Defense, 2014), I-6.

deployment, report on areas of interest, and return to their launch locations, queue and await follow-on missions, or self-destruct.

A gap exists in the obstacle reduction mission set. Data-Divers could be equipped with explosive payloads to swarm and destroy mines and other water obstacles as required, however this reduces their range and sensor suite with which to accomplish its primary mission of reconnaissance. On-call waves of explosive Data-Divers (torpedoes for Marines) could follow the reconnaissance waves, equipped with obstacle data, and swarm to in-water-column obstacles to reduce them. Another, larger version of the Data-Diver may be needed to address steel or concrete obstacles in the surf zone, the “touch-down” space for landing craft.

On the beach itself, the EMAVs, work together to clear designated breach lanes and secure the landing beach for on-call and unscheduled waves. They sense, identify, and systematically reduce steel, concrete, surface mines and sub-surface mines. Equipped with FWMPs and simple sand plows, they push aside large obstacles, fill in trenches and could even be equipped with traction matting on their cargo platform to improve trafficability of soft beach areas.

Another gap exists in large-scale, linear explosive breaching. This role has historically been filled by the MICLIC, but its primary amphibious landing platform is retiring (the AAV). The EMAV has sufficient weight capacity to carry and deploy this system either from the LCUs en route to the beach or on the beachhead itself. Adding this capability further diversifies the EMAV’s utility.

Figure 5 below shows a theoretical series of waves for an amphibious landing including full, partial and optionally autonomous designations:

	Primary Purpose	Capability 1	Capability 2	Capability 3	Note
1st Wave	Reconnaissance	ISR Data-Diver	ISR Coyote		Fully Autonomous
2nd Wave	Water Obstacle Reduction	*Kinetic Data-Diver	*Marine Torpedo		Fully Autonomous
3rd Wave	Beach Obstacle Reduction	LCU or *EMAV Transport	*EMAV w/FWMP *EMAV w/Sand Plow *EMAV w/MICLIC *EMAV w/Traction Mat		Fully Autonomous
4th Wave	Beachhead Security	MWC	Marine Platoons	EMAV w/CROWS-2 EMAV w/Equipment Racks *EMAV w/Stretcher Racks	Partially Autonomous
5th+ Waves	Traditional Landing Forces	MWC	LCU	LCAC	Optionally Autonomous

***Denotes technology gap or expansion of existing technology**

Figure 5: A theoretical wave table for an amphibious assault.

Conclusion

As technology advances, so to do the complicating factors of amphibious operations. In order to fulfill its Title 10 responsibilities and its role in JFEO, the Marine Corps must continue to invest heavily in systems which enable distributed, independent, and persistent mission sets.

Enemy coastal defenses have grown in strength compared to historical cases. In addition to shore artillery batteries and anti-aircraft guns, today's enemies have long range anti-ship missiles, ultra-high-resolution radar, and multi-target advanced tracking systems. The attacker fighting to come ashore must be fast, massed, and efficient to survive. Artificially intelligent robots can meet these requirements. As the Corps makes the difficult choices of which technologies best enable its MOC, multiplying the force through unmanned augments is cost effective for us, cost-imposing for the enemy, while dramatically increasing the likelihood of mission success. The need to access enemy shores is not going away and when, not if, the call is made, the entire Department of Defense will turn to the Marine Corps. The Corps must be ready and able to respond.

Clark, Bryan and Jesse Sloman. *Advancing Beyond the Beach: Amphibious Operations in an Era of Precision Weapons.* Washington DC: Center for Strategic and Budgetary Assessments, 2016. https://csbaonline.org/uploads/documents/CSBA6216-AmphibiousWarfare_Final3-web.pdf.

Headquarters US Army. *Mine/Countermine Operations*. FM 20-32. Washington, DC: Headquarters US Army, February 2, 2004.

Headquarters US Marine Corps. *Employment of Amphibious Assault Vehicles*. MCWP 3-13. Washington, DC: Headquarters US Marine Corps, February 17, 2005.

Marine Corps University. *Marine Expeditionary Unit Construct.* Gray Scholars Program. Quantico, VA, 2018.

The White House. *The National Security Strategy of the United States of America.* Washington, DC, 2006. http://www.whitehouse.gov/nsc/nss/2006/.