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MASTER OF MILITARY STUDIES

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**High Water Speed: An Investment in Our Operational Future**

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

Lynn W. Berendsen

AY 14-15

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## Executive Summary

**Title:** High Water Speed: An Investment in Our Operational Future

**Author:** Major Lynn W. Berendsen, United States Marine Corps

**Thesis:** A complementary operational/strategic surface, amphibious, forcible-entry capability will strengthen the Marine Air Ground Task Force (MAGTF) and ensure the Marine Corps fulfills its Title X responsibilities while retaining both tactical and strategic influence.

**Discussion** In light of the benefits already derived from the MV-22, a complementary operational/strategic surface amphibious forcible entry capability is a necessary and cost-effective investment for the Marine Corps. This recommendation becomes clear from an examination of both improved competitor capabilities and Special Purpose (SP) MAGTF operations in the current operating environment. Such an examination must also address the following areas: defining forcible entry, identifying competitor capabilities, assessing the benefit for SP MAGTF operations, exploring how new amphibious forcible-entry capabilities can be applied to the current operating environment, and determining whether an operational/strategic surface amphibious forcible entry capability is both technically feasible and cost effective. At the same time, however, the MV-22 offers new opportunities. With its range and speed, the MV-22 has proven to be a game changer for the Marine Corps, allowing Navy ships to operate from outside the A2/AD envelope and facilitating operational and strategic actions like land-based SP MAGTFs. This capability contains its own risk: One of the potential costs of relying too much on the air component of the MAGTF is it makes the Marine Corps and the Navy one-dimensional, predictable and in turn vulnerable to the weather and enemy targeting.

**Conclusion:** Having a high speed, amphibious, armored personnel carrier capable of launching from Navy ships or foreign shores and landing on contested beaches to either secure an operational objective or to seize a foothold for follow on forces undoubtedly supports the Marine Corps' warfighting philosophy.

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## *Preface*

I have been working with Amphibious Assault Vehicles for nearly twenty years. For the majority of that time I have looked forward to the leap in capability that the Marine Corps had promised with the AAV, which became the EFV and for a short time some iteration of ACV. In 2011, the cancelation of the EFV program and the decision to move forward with a less water capable wheeled ACV has continued to make me question the rational. I chose this topic in an effort to point out some of the benefits that Marine Corp will be giving up in favor of IED protection and truck like land ward capabilities.

I would like to thank Dr. Anne Louise Antonoff for her guidance and assistance in this project. She helped me organize my thoughts and focus this paper. Her suggestions for refinement and clarification were always spot on. I would also like to thank Col Tracy Tafolla and Mr. Ken Lardie. They provided me with an enormous amount on information and helped me develop my topic as I began writing. Without the guidance and words of encouragement from Dr Antonoff, Col Tafolla, and Mr. Lardie this paper would not have been possible.

In 1950, Lieutenant General Victor Krulak expressed confidence in the abiding importance of the United States Marine Corps as an expeditionary force: “There is little that will sober an enemy more surely than the knowledge that somewhere, just over the horizon, lies a force of well-trained, well-equipped Marines in competently manned ships capable of delivering a stunning amphibious blow at a point and time of their own choosing.”<sup>1</sup> General Krulak’s statement in 1950 still holds true today. However, the Marine Corps is neglecting to equip a portion of the Marine Air Ground Task Force (MAGTF) by not investing in a modern, mobile, surface amphibious, forcible entry capability and potentially relying too much on air and naval forces.

The need for the new vehicle arises from both new risk and new opportunity. On the risk side, the number of Navy amphibious ships has steadily decreased over the past three decades, making it difficult for Marines to stay forward deployed and simultaneously meet the combatant commanders’ demands in conducting security cooperation operations. Even if there were enough amphibious ships, the growing Anti-Access/Area Denial (A2/AD) threat continues to push Navy ships further away from the shore, limiting surface amphibious operations typically responsible for moving two thirds of the Marine Air Ground Task Force (MAGTF) ashore. A new High Water Speed vehicle thus becomes necessary in order to operate under these changed circumstances.

At the same time, however, the MV-22 offers new opportunities. With its range and speed, the MV-22 has proven to be a game changer for the Marine Corps, allowing Navy ships to operate from outside the A2/AD envelope and facilitating operational and strategic actions like land-based Special Purpose (SP) MAGTFs. This capability contains its own risk: One of

the potential costs of relying too much on the air component of the MAGTF is it makes the Marine Corps and the Navy one-dimensional, predictable and in turn vulnerable to the weather and enemy targeting. Having a complementary operational/strategic surface, amphibious, forcible-entry capability will strengthen the MAGTF and ensure the Marine Corps fulfills its Title X responsibilities while retaining both tactical and strategic influence.

In light of the benefits already derived from the MV-22, a complementary operational/strategic surface amphibious forcible entry capability is a necessary and cost-effective investment for the Marine Corps. This recommendation becomes clear from an examination of both improved competitor capabilities and SP MAGTF operations in the current operating environment. Such an examination must also address the following areas: defining forcible entry, identifying competitor capabilities, assessing the benefit for SP MAGTF operations, exploring how new amphibious forcible-entry capabilities can be applied to the current operating environment, and determining whether an operational/strategic surface amphibious forcible entry capability is both technically feasible and cost effective.

### ***Definition of Terms***

Why do we need a surface forcible entry capability? The USMC Capstone Concept, *Expeditionary Force 21 (EF 21)* describes the Marine Corps' vision of how it will train, equip, and fight in the future. In its opening paragraphs it states, "The law requires and our heritage demands that we maintain a force that is naval in character and capable of conducting amphibious operations."<sup>2</sup> It goes on to describe the flexibility forward deployed amphibious forces offer the Combatant Commanders in the way of humanitarian operations,

adversary deterrent, and power projection in the littorals to defeat our enemies. In order to conduct these amphibious operations, the Marine Corps must maintain the capability to conduct operations that range from “security cooperation to forcible entry with a special emphasis on crisis response.”<sup>3</sup> Forcible entry constitutes a key component of the Marine Corps’ capability set that it provides to the Combatant Commander, and as *EF 21* suggests, it will remain so into the indefinite future. Stated more bluntly, the requirement for forcible entry is not going away. A surface amphibious capability is necessary to enable forcible entry operations. The United States’ nearest peer competitor, China, is investing in this capability, while the current US capability is basically the same as at the end of the Vietnam conflict.

Military and civilian theorists have been sounding the death knell for amphibious operations since the closing of hostilities after World War II. Famously, Army Chief of Staff General Omar Bradley said, “Large-scale amphibious operations such as those in Sicily and Normandy will never occur again,” only to see General McArthur use a forcible amphibious entry into Inchon, Korea to turn the tide of the Korean War less than a year later.<sup>4</sup> Yet Gen. Bradley was not entirely wrong. Inchon was an important large-scale amphibious operation, yet neither Inchon nor any other amphibious landing since has achieved the scale of those in World War II, whether in the Pacific or at Normandy. When acknowledging General Bradley’s prophecy it is important to point out that amphibious operations have been and continue to remain an important capability in the United States’ arsenal and in particular the Marine Corps’ repertoire, even if they are not on the same scale as many of the World War II operations.

Statements like “We will never do another amphibious landing like Iwo Jima” (or insert any great World War II amphibious landing) can often be heard in the lecture halls and

conference rooms of the Marine Corps University and the Marine Corps Combat Development Command. These statements are often in response to questions about forcible entry operations and amphibious vehicles. The problem is that these statements, often made by senior leaders in the Marine Corps, define forcible entry operations in their most extreme form.

In reality, forcible entry operations reside along a spectrum of conflict, with highly kinetic operations like Normandy on one end of the spectrum and extremely permissive operations like Haiti or Somalia on the other. Both the Normandy and Somalia operation fall under The Joint Publication (JP) 3-18, “Joint Forcible Entry Operations” definition;

Joint forcible entry operations seize and hold lodgments against armed opposition. A lodgment is a designated area in a hostile or potentially hostile operational area that, when seized and held, makes the continuous landing of troops and materiel possible and provides maneuver space for subsequent operations (a lodgment may be an airhead, a beachhead, or a combination thereof).<sup>5</sup>

There is no definition of “armed opposition” in the JP 3-18 or FM 1-02 *Operational Terms and Graphics*, but *Oxford Dictionary* defines armed “as equipped with or carrying a weapon or weapons.”<sup>6</sup> Additionally the Joint Publication 3-18 states, “Although forcible entry is conducted with the expectation and due preparation for armed opposition, prudent commanders have always sought to conduct such operations in a manner that avoids enemy defenses to the greatest extent possible.”<sup>7</sup> The importance is that when Marine Corps leadership makes the argument against investing in a surface forcible entry capability, they need to take care not to sound like Gen. Bradley half a century ago and to understand that amphibious forcible entry operations can take place across a varying range of hostilities.

To remain a credible capability, amphibious forcible entry must not overly rely on any one portion of the (MAGTF). This concept is described in depth in the Marine Corps

operating concept Ship-to-Objective Maneuver (STOM), which was originally penned in 1997 and then updated in 2011. STOM states, “Surface and vertical maneuver elements will be employed to accomplish the mission, producing a cumulative effect greater than the sum of the parts.”<sup>8</sup> Much as in football, if the offense is only capable of running the football then the defense is free to disregard the pass, placing the entire defensive unit near the line of scrimmage and focusing all its energy on stopping the run. Stopping a one-dimensional attack is much easier than stopping an offense capable of both running and passing. The same holds true for amphibious forcible entry. The Marine Corps has done an excellent job in updating and upgrading the air component of the MAGTF, but as LtCol (ret) Hammond points out in his article, “The ACE That Ate the Marine Corps”, these upgrades have come at the expense of the surface options of the MAGTF that enable amphibious forcible entry.

LtCol Hammond goes on to say:

There is significant risk, however, in that the inherent weakness—namely the lack of organic mobility, protection, and significant dependence on air for follow-on movement, fires, and logistical support—of the vertical envelopment forces may be exposed after its initial unexpected insertion. In turn, assault forces transported by surface connectors cannot move ashore with anywhere near the same speed, nor do they have the reach of air-transported forces. The surface assault force, however, balances the air assault force with its superior combined arms combat power that integrates organic tactical mobility, fire power, and protection.<sup>9</sup>

In short, the Marine Corps needs a balanced amphibious force capable of both surface and aerial forcible entry operations.

In 2010, President Obama announced that the United States would “rebalance” to the Asia-Pacific. This shift, also called a “pivot,” portends a reallocation of national power (diplomatic, informational, military, and economic) from the Middle East to East Asia. One purpose for this movement is to deter or respond to possible aggression arising from the

expansion of Chinese influence. The Asia-Pacific region is important to the United States because, according to the Census Bureau, five of the United States' top [eleven] trading partners as of 2014 are in Asia.<sup>10</sup> The US has taken a deep interest in East Asia since Commodore Perry first opened Japanese-American relations in 1854 with the Treaty of Kanagawa. America has committed forces to the region in multiple military conflicts in the past two centuries, including the Pacific War island hopping campaign as well as the wars in Korea and Vietnam. These military actions all utilized surface forcible entry amphibious operations. It is likely the United States will use surface amphibious operations to support its friends during humanitarian operations, to defend disputed islands in the Pacific, and to deter adversaries by projecting power in the littorals.

The workhorse of power projection in the littorals has been the Amphibious Assault Vehicle (AAV) which serves to provide the primary surface lift for the infantry from ship-to-shore during amphibious operations and to provide the mechanized lift for the infantry once ashore. However, its current configuration lacks the speed and firepower necessary to operate in the new threat environment. In January 2011, the Expeditionary Fighting Vehicle (EFV), the proposed replacement for the AAV, was canceled by Secretary of Defense Gates due to cost. This left the Marine Corps without a viable replacement capability for at least the near future.

The requirement for a self-deploying amphibious vehicle has its roots in the inter-war period. The Marine Corps recognized the need to have a vehicle capable delivering troops and supplies from naval ships to the shore with the ability to cross obstacles like sandbars and reefs and to move from the water's edge to a position with some cover and concealment when possible. The first vehicle purchased by the Marine Corps and the Navy for this

purpose was the Roebling Alligator, which featured an open topped steel hull, propelled on land and water by tracks. The vehicles were purchased in 1941 and designated as Landing Vehicle, Tracked 1, (LVT-1), but quickly adopted the nickname AMTRAC (Amphibious Tractor). The LVT-1 saw its first action on Guadalcanal as a troop transport and logistics vehicle. It had no armor and was not equipped with any weapons, but the vehicle showed it was a capable and versatile asset, so much so that it inspired several more generations of AMTRACs .

The LVT-2 was the next production vehicle and featured improvements in powertrain and mobility. The LVT-2 design was the basis for the World War II series of tracked amphibians that included the LVTA1, LVTA2, LVT-4, LVTA4, and LVTA5. The later models featured upgrades that included powered ramps to facilitate on load and offload troops, supplies, and equipment including jeeps and artillery pieces. The “A” in the nomenclature signified that these vehicles were designated as close fire support for the troops conducting landings. These “A” designated vehicles were turreted and could be equipped with 75mm Howitzer, 37mm tank gun, multiple 30mm or .50 Cal machine guns. The LVT(A)5 and the LVT-3 were chosen as the standard LVTs at the close of World War II. In the 1950’s, the Marine Corps enclosed the cargo/troop carrying area to provide protection for fragmentation and breaking waves. The LVT(A)5 and the LVT-3 were the vehicles used during the Inchon Landings and other operations during the Korean War.

The Marine Corps unveiled the next family of amphibious vehicles, the LVT-5, in 1953. This was a completely new design and five different variants, LVT(P)5 Personnel/Cargo, LVT(R)1 Recovery Vehicle, LVT(C)5 Command Vehicle, LVT(E)1 Engineer vehicle, and LVT(H)6 Armored were fielded. The Marines used these vehicles

extensively during the Vietnam War for logistics resupply, riverine patrols, ship-to-shore and shore-to-shore amphibious assaults. Despite being employed extensively, the LVT-5 family of vehicles lacked the water speed and inland mobility the Marines desired. Additionally the location of the ingress/egress ramp at the front of the vehicle exposed Marines to the enemy prematurely in an attack. By the close of the Vietnam War, the next family of amphibious vehicles was in the design phase with an attempt to address these shortcomings.<sup>11</sup>

The Marines began fielding the modern family of LVTs in 1972. This provided improved land mobility, much improved water mobility, and water speed. The Marine Corps purchased three variants, LVTP7 personnel/cargo, LCTC7 command and control, and a LCTR7 recovery variant. The LVTP7, the base vehicle, was capable of carrying 25 Marines or 10,000 lbs of cargo and was armed with a .50 cal heavy machine gun. The Marine Corps re-designated the family of vehicles as Amphibious Assault Vehicles (AAVP7) in the mid 1980's. The re-designation signified a doctrinal shift, where the amphibious vehicle was no longer seen simply as a delivery system for Marines ashore, but was utilized as an armored personnel carrier, designed to support the infantry from ship to the objective. The AAVP7 family of vehicles experienced several modifications over the last forty years of service including an upgraded weapons system, new suspension, engine, transmission, and the addition of a detachable applique armor. The vehicle with the modifications is now designated the AAVP7A1, but these upgrades have not significantly improved the vehicle's basic land and water capabilities.<sup>12</sup>

Even while fielding the LVTP7 family of vehicles, the Marine Corps desired a vehicle with more robust capabilities. In 1973, the Marine Corps published the Landing

Vehicle Assault (LVA) requirement. Maj (Ret) Brunsvold describes the requirement in the article "Will the LVA Ride on Air Cushion or Water Wings?" As he states:

The program is designed to produce an amphibious assault vehicle characterized primarily by high speed over the water and high mobility on land. During the ship-to-shore phase of amphibious operations, the LVA will move assault forces at speeds in excess of twenty-five miles per hour. On land it will exhibit an aggressive combat capability providing speed, troop protection, cross-country mobility, and offensive firepower."<sup>13</sup>

This requirement, expressed in the early 1970s, eventually evolved into the Advanced Amphibious Assault Vehicle (AAAV), initially planned for fielding in the 1990s, and then into the Expeditionary Fighting Vehicle (EFV), which was scheduled for fielding in the 2010s. The EFV program was canceled, in favor of the Amphibious Combat Vehicle (ACV 1.1) program, a wheeled vehicle with a less robust swim requirement than the current AAVP7A1.

A question remains, are the Marines or their funders in Congress taking their eye off the real threat, a peer competitor that continues to build its amphibious capabilities in favor of the more prevalent, but less dangerous HA/DR missions? Alternatively, is the United States accepting risk in a fiscally constrained environment? If one looks at the type of training still conducted in the Marine Corps, like Bold Alligator a large amphibious exercise off the coast of North Carolina, it would appear that amphibious forcible entry is still a valuable capability according to the Marine Corps and possibly even more important to the Navy. Gen Amos stated in *EF 21*, "The law requires and our heritage demands that we maintain a force that is naval in character and capable of conducting amphibious operations."<sup>14</sup> With this focus and efforts, the Marine Corps needs to provide a matching investment in the necessary capabilities to enable amphibious forcible entry operations.

China has made some considerable investments in its military capabilities over the past two decades, particularly its Navy. The military advantage the United States once had in the Pacific is slowly diminishing. According to *Jane's International Defense Review*, “[It] is in amphibious power that China is making the biggest stride.”<sup>15</sup> Congress is asking some of the same difficult questions about China’s capability. On 11 March 2015, members of the Committee on the Armed Services received testimony on the Marine Corps Ground Modernization strategy. Many questions were asked about the ACV 1.1, but of particular note, Senator Hirono, when questioning Lieutenant General Glueck asked:

General, I assume you are familiar with the advanced amphibious assault vehicles that China appears to have developed. One version is a tank with a 105 millimeter gun. The other is an infantry fighting vehicle with a 30 millimeter cannon. Both are reported to be high water speed vehicles like the terminated EFV. China is also building its first set of large amphibious ships that compare to the U.S. classes like the LPD-17. What is your assessment of the Chinese amphibious assault vehicles and how do you rate their performance in the water, their fire power, mobility, and protection levels?<sup>16</sup>

The Chinese have fielded up to four Amphibious Transport Dock (LPD) ships capable of carrying up to 800 soldiers, four helicopters, sixteen amphibious armored fighting vehicles, and four hovercraft, demonstrating the emphasis that China is putting on a surface amphibious forcible entry capability.

Of particular note, the Chinese have fielded 1,000 ZBD-05 Tracked Amphibious Infantry Fighting Vehicles (TAIFV).<sup>17</sup> This vehicle has some technological advantages over the current Marine Corps capability of the AAVP7A1 (Table 1<sup>18 19</sup>) and potentially tips the scales for the first time in China’s favor when it comes to projecting power in the Pacific.

**Vehicle Capability Comparison Table**

Capability	AAVP7A1 <sup>20</sup>	ZBD-05 <sup>21</sup>	ACV1.1 <sup>22</sup>
Stabilized Weapon Station	No	Yes	Yes
Primary Weapon	Mk-19	30mm cannon	.50 cal or Mk-19
Secondary Weapon	.50 Cal	Co-Axil 7.62	None
ATGM Launcher	None	HJ-73D	None
Troop Carrying Capacity	21	11	10
Max Land Speed	72 km/h	65 km/h	88 km/h
Max Water Speed	13 km/h	25 km/h	9 km/h
Cruising Range	482 km	500 km	482 km
Trench Crossing	2.4m	2.9m	Unknown
Vertical Wall Climbing	.9m	.6m	Unknown

Table 1

The AAV first put into service in 1972, and has undergone some upgrades over the years, but the basic capabilities described in Table 1 remain the same. The Marine Corps’ solution to the gap created by cancellation of the EFV has been to extend the life of some AAVs with a Service Life Extension Program (SLEP). Additionally, the Marine Corps will procure the Amphibious Combat Vehicle (ACV 1.1), a vehicle optimized for land based, counter Improvised Explosive Device (IED) operations, but reliant on connectors bring the vehicles ashore from naval shipping.

In the absence of the EFV, the Marine Corps is left with a number of inadequate alternative capabilities. The ACV 1.1 is designed as a complementary capability to the current AAV. It is not designed to provide the Marine Corps with a Forcible Entry Capability. The ACV 1.1 Concept of Employment states, “AAVs are intended to remain the primary APC for use in the well-decks of amphibious warfare ships. As a complementary

capability and to fulfill capacity requirements ashore the ACV 1.1 will primarily be transported to the theater of operation via MSC ships.”<sup>23</sup> The ACV 1.1 will either require a port to off load or a floating causeway, which will likely only be available in secure environments already under the control of United States forces.

The alternative is coming ashore via ship-to-shore connectors, namely the Landing Craft Air Cushion (LCAC) and the Landing Craft Utility (LCU). Neither of the Ship-to-Shore Connectors (SSC) is designed to conduct forcible entry operations. The LCU with a speed of approximately 12 kt/hr is not a viable option for conducting Over-the-Horizon (OTH) operations. The LCAC, the only viable OTH delivery method, is extremely vulnerable to small arms and indirect fire threats as described in The Navy Warfighting Publication (NWP) 3-02.12, Employment of the Landing Craft Air Cushion describes. It states that “LCAC vulnerability to direct and indirect fire weapons lies in the susceptibility of propellers and lift fans to FOD (Foreign Object Damage) and the possibility of critical equipment damage and personnel injury due to aluminum skin penetration. . . small arms will penetrate the unarmored aluminum skin of the craft at all but the most extreme ranges.”<sup>24</sup> Additionally the NWP 3-02.12 states the LCAC is vulnerable to beach obstacles like concertina wire and stakes, the types of conditions likely present in any forcible entry scenario whether it is in a permissive or highly kinetic environment. In “Across the Reef,” Victor Croizat says, “Further, although a versatile vehicle, the LCAC remains sensitive to sea conditions and to terrain inland; it also offers a highly lucrative target to enemy guns and missiles.”<sup>25</sup> The ACV 1.1 and other vehicles reliant on current or planned SSCs are not viable options for conducting forcible entry operations.

As described above, the ACV 1.1 is not a replacement for the AAV or its forcible entry, ship-to-objective mission. Although the EFV program was canceled in 2011 mainly due to cost, then Secretary of Defense Robert Gates stated in his termination speech, “The EFV’s aggressive requirements list has resulted in an 80,000 pound armored vehicle that skims the surface of the ocean for long distances at high speeds before transitioning to combat operations on land.”<sup>26</sup> The proven capabilities that Secretary Gates was referring to were outlined Andrew Feickert’s 2011 report, "The Marines' Expeditionary Fighting Vehicle (EFV): Background and Issues for Congress." If fielded, he states,

[The] EFV would be an armored, fully tracked infantry combat vehicle operated by a three-person crew that can carry 17 combat-equipped Marines. It is to be a self-deploying, high-speed amphibious vehicle capable of transporting Marines from ships to objectives inland and aims to have the speed, maneuvering capabilities, fire power, and protection to operate with main battle tanks on land. It is intended to have a 20-knot speed in the water and a 345-mile range ashore with a 45-kilometer-per-hour speed on hard-surfaced roads. The EFV is to be designed to have modular armor and expanded mine blast protection and mount a 30mm high-velocity cannon in a stabilized turret. The EFV is also supposed to be able to communicate in joint networks and operate as part of a joint land force. There are to be two EFV variants. The EFV-P1 would carry a Marine rifle squad and its equipment and provide direct fire support during combat operations. The EFV-C1 variant would provide command and control capabilities for commanders and their staffs.<sup>27</sup>

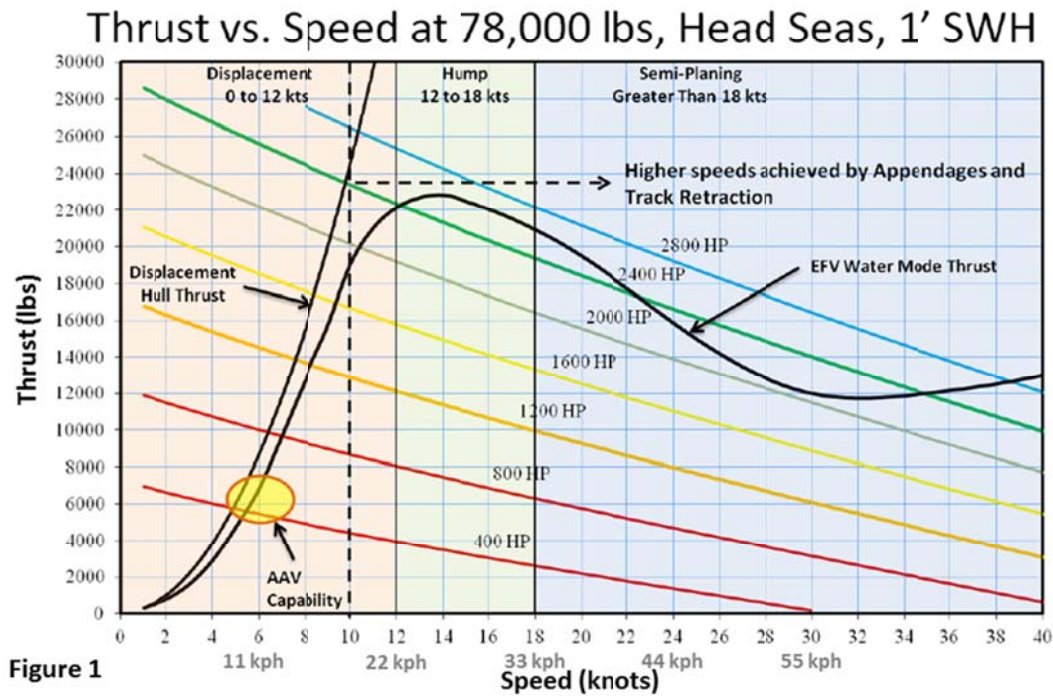
The significant enhancements in firepower and water speed represent the largest leaps in capability from the current AAVP7A1. In the EFV termination speech, Secretary Gates went on to say, “To be sure, the EFV would, if pursued to completion without regard to time or cost, be an enormously capable vehicle.”<sup>28</sup> In the language of the Pentagon and Beltway, this statement means that, in regard to performance, a vehicle with EFV-like capabilities is feasible.

In producing an armored, amphibious vehicle, the number one concern is weight. Weight is significant for two reasons. First, Navy shipping that will likely transport these vehicles to an amphibious launch area or staging area is designed to accommodate a finite

amount of weight and square footage to fit the equipment. Over the past decade, Marine Corps combat equipment has become larger and heavier to counter the IED threat. The increased size and weight of this equipment is a growing concern for the Navy because it threatens the structural integrity, lift capability, and stability of many amphibious ships. Second, amphibious vehicles like the amphibious ships can only carry a certain amount of weight before they become unstable or lose their buoyancy. The margins are much smaller for these armored, amphibious vehicles since they have a much shorter freeboard (distance between the water and the top of the vehicle).<sup>29</sup>

Weight is even more significant for an amphibious vehicle traveling faster than approximately 20 kph on the water. The most energy and power efficient way to move an armored amphibious vehicle in the water is getting the vehicle on a plane. The AAV is a displacement vehicle, meaning it is pushing through the water, creating a great amount of drag. Figure 1 demonstrates this concept; it shows that pushing a displacement vehicle through the water requires a great deal of thrust or horsepower and that there are minimal gains in speed even when increasing the horsepower exponentially.<sup>30</sup> Figure 1 also shows that it takes a considerable amount of thrust to get a vehicle on a plane, but once planing is achieved (getting over the “hump”), horsepower can decrease even while gaining speed. Conceptually this is similar to pushing a rock across a lake or skipping a stone across the top of the lake.

# High Water Speed Physics



**Figure 1 Concept Exploration of the Amphibious Combat Vehicle<sup>31</sup>**

In January 2013, the Assistant Commandant of the Marine Corps and Assistant Secretary of the Navy for Research, Development and Acquisition (ASN RD&A) stood up a working group called the Amphibious Combat Vehicle (ACV) Directorate to examine the technical feasibility and cost of a high water speed capable ACV (HWS ACV). (ACV 1.1 refers to the currently planned wheeled vehicle designed for shore-to-shore operations.) ACV HWS designates a vehicle, capable of traveling 22kph or faster on the water. The ACV working group consisted of government engineers, industry experts, as well as Marines. They determined that five areas largely drive the weight and cost of a HWS ACV: direct fire protection (armor), under vehicle blast protection, lethality (firepower), troop carrying capacity and ability to achieve high water speed. These major cost and weight drivers were referred to as “big-rocks”. As shown in Figure 1, maximum target weight was approximately

78,000 lbs, based on existing high water speed capabilities. The ACV Directorate explored different levels and combinations of big-rocks to give Marine Corps leadership an understanding of the range of capabilities and cost options for a HWS ACV. The capability ranges within each big-rock were established by a government and industry team that examined currently available technologies that when combined could produce a complete HWS ACV, as well as the weight and cost for each configuration. Since the study was directed to determine the feasibility and cost of a HWS ACV, the only trade spaces or capability exchanges examined were direct fire protection (armor), under vehicle blast protection, lethality (firepower), troop carrying capacity.<sup>32</sup>

Some of the “big rocks” had several potential configurations, while in other cases only two configurations were identified as technically feasible. Direct fire protection, the level of armor protection from direct and indirect fire threats for HWS ACV, only had two options. Under vehicle blast protection, the protection level provided to the embarked troops and the vehicle systems from improvised explosive devices (IED) and from anti-tank mines only had two levels. There were three options for lethality, all being remotely operated weapons stations, with either a single .50 caliber machinegun, a dual weapon station including a .50 caliber and 40 mm machineguns, or a 30mm cannon with a 7.62 secondary weapon. There were two configurations examined for troop carrying capacity, fourteen or seventeen embarked troops. Table 2 shows the twenty-four possible combination of the “big rock” configurations. Of these, six were determined to be technically feasible with little risk and an additional five were considered technically feasible but were considered high risk due to small margins for weight growth. When the higher level of under vehicle blast protection or the 30mm cannon lethality options were applied to any combination of capabilities, they

made the configurations at a minimum high risk. The risk is in the ability to produce an ACV capable of achieving high water speed due to the weight associated with the increase capabilities.

### HWS ACV Capability Combinations

Capabilities	14 Troops; "A" Direct Fire Protection	14 Troops; "B" Direct Fire Protection	17 Troops; "A" Direct Fire Protection	17 Troops; "B" Direct Fire Protection
"C" Under-Blast Protection; Weapon "X"	Feasible	Feasible	Feasible	High Risk Feasibility
"C" Under-Blast Protection; Weapon "Y"	Feasible	Feasible	Feasible	High Risk Feasibility
"C" Under-Blast Protection; Weapon "Z"	High Risk Feasibility	Not Feasible	Not Feasible	Not Feasible
"D" Under-Blast Protection; Weapon "X"	High Risk Feasibility	Not Feasible	Not Feasible	Not Feasible
"D" Under-Blast Protection; Weapon "Y"	High Risk Feasibility	Not Feasible	Not Feasible	Not Feasible
"D" Under-Blast Protection; Weapon "Z"	Not Feasible	Not Feasible	Not Feasible	Not Feasible

Table 2

Regardless of the configuration, the HWS ACV had to be capable of completing a mission profile that at a minimum included a 12NM ship-to-shore movement at thirty-five or more kph, with an additional 250 miles operating range while on land without refueling. Based on the EFV capabilities (given that HWS ACV models used the same engine and basic water drive systems as the EFV), the operating range in the water for a HWS ACV is 65NM on three hundred gallons of fuel.<sup>33</sup> That equates to approximately four gallons of fuel for every nautical mile traveled in the water. The operating range can be extended by trading seats in the troop compartment for portable fuel bladders. According to Demetri Economos, Len Blasiol, and Mark Richter in the article “Strategic Implications of Combat Overloading,”

“Currently, operators estimate (i.e., "ball park") 250 to 300 lbs per person when Marines board lift assets.”<sup>34</sup> These 250 to 300 lbs, if applied to portable fuel bladders equates to eight to ten additional miles for each Marine not carried in the back of the HWS ACV. (Such calculations are no different from those made by helicopter pilots when they are doing their flight planning.) Leaving four Marines out of the back of a HWS ACV could extend the water operating range to over 100nm (115 miles or 185 kilometers).

One of the significant benefits to extending the water operating range of the ACV to over 100nm is that this distance is outside what is currently considered the anti-access, area denial (A2AD) threat envelope of coastal defense cruise missiles (CDCM). *EF 21* states, “The proliferation of CDCMs and sophisticated target acquisition and guidance systems requires standoff from beyond 65nm until the threat is mitigated.”<sup>35</sup> A HWS ACV with the capability to launching forcible entry, ship-to-objective maneuver from outside the A2/AD threat provides the Navy and Marine Corps with a valuable asset, capable of coming ashore and defeating the threat and seizing a foothold for follow-on forces. The CDCM threat is minimal to the ACV because it provides an extremely small target for missiles. It would be similar to trying to shoot an enemy soldier running across field with a M1A1 main gun round. It would be a very difficult shot because the weapon is designed for large targets and not a prudent use of an expensive round.

A HWS ACV with a range of 100nm supports the concepts of “Operational Maneuver Warfare From the Sea” by using “the sea as a means of gaining advantage, an avenue for friendly movement that is simultaneously a barrier to the enemy and a means of avoiding disadvantageous engagements.”<sup>36</sup> *EF 21* states, “Vehicles, boats, and landing craft require the endurance and speed to operate from 65nm independently or in combination with

other connectors.”<sup>37</sup> *EF 21* also states, “Of particular concern is protection against area denial threats to amphibious ships and connectors transiting the littorals to landing sites. Control of the landing site is essential regardless of means of entry and a critical condition for maneuver inland.”<sup>38</sup> A Marine Corps equipped with HWS ACVs with ranges of 100nm certainly supports the requirements identified in the Marine Corps new operating concept, *EF 21*.

Another significant benefit to extending the water operating range of the ACV to over 100nm is that this distance offers some advantageous shore-to-shore employment options. For instance, there are several strategically important areas where a range of 100nm would allow a land based ACV unit to launch from friendly shores and conduct forcible entry into a contested area. A few potential examples that fall within the 100nm range are: Key West to Cuba, Sicily to Tunisia, Cyprus to Syria, Djibouti to Yemen, United Arab Emirates across the Straits of Hormuz to Iran, Japan to South Korea and South Korea to North Korea. It could even be possible to conduct island hopping in the South China Sea. *EF 21* advocates, “Employ new mobile forward arming and refueling points (FARPs) that are rapidly relocatable and operate as a network to support dispersed F-35B operations.”<sup>39</sup> With coordinated refueling, similar to the F-35 FARPS, a platoon of HWS ACVs could carry 120+ infantry Marines from the Philippines to Taiwan, stopping to refuel on the small islands or atolls along the route and conducting a forcible entry to seize a foothold for follow on forces at their destination. *EF 21* points out the benefit of this capability when it states, “[T]he ability to establish a network of numerous austere advanced bases—by occupation or seizure—as a means of dispersing aircraft, missiles, and intelligence, surveillance, and reconnaissance assets needs to be comprehensively explored.”<sup>40</sup>

The ability for a HWS ACV to conduct long-range shore-to-shore movements would be a complementary capability to what the MV-22 offers the SPMAGTFs. It would give the Combatant Commander an additional option for contingency operations. A HWS ACV equipped unit would provide additional offensive capability and maneuverability on an objective with its armor protected mobility and firepower unavailable to a helo-borne unit. An infantry company equipped with HWS ACVs could be a quick reaction force for non-combatant evacuation operations (NEO) where the primary insertion method would be via MV-22s. For example, a HWS ACV equipped infantry company pre staged in Tunisia or aboard Navy ships positioned over the horizon could have assisted in the evacuation of the embassy in Tripoli. A HWS ACV would support a principle described in *EF 21*, “Land-based and sea-based prepositioning must be maintained as a key enabler to access and crisis response.”<sup>41</sup> A HWS ACV used in this capacity is more than just a tactical vehicle used to seize an objective, it becomes a tactical vehicle capable of delivering operational effects.

There is no doubt that an ACV is a tactical vehicle. It is designed to provide the infantry with armor protected mobility and close in fire support. It is possible however, that an ACV with high-water speed capabilities could also provide operational capabilities. The Joint Publication 3-0, “Joint Operations”, states that the operational level of war “links the tactical employment of forces to national and military strategic objectives.”<sup>42</sup> A Combatant Commander could use HWS ACVs to secure objective like the entrance to the Suez Canal. Moreover, a HWS ACV, with its speed, range, fire-power and armor protected mobility, could simply provide a credible threat that prevents an adversary from acting contrary to the United States national interests. The increased range of the HWS ACV allows the commander to employ the operational art “to determine when, where, and for what purpose

major forces will be employed and to influence the adversary disposition before combat.”<sup>43</sup> A HWS ACV acts as a force multiplier by providing a Combatant Commander with an asset capable of influencing tactical, operational, and strategic objectives.

Some senior leaders in the Marine Corps do not see a HWS ACV as a worthy investment. There are a host of arguments against procuring the vehicle in the near term; some are valid while others are unsound. A high-water speed armored amphibious vehicle was supposed to be the third leg of the OMFTS triad including the MV-22 and the LCAC. It has been said, “The difficulty has always come with the third leg: the replacement for the assault amphibious vehicle (AAV).”<sup>44</sup> The EFV is often seen as being more difficult than the MV-22, which cost approximately \$42 billion, was plagued by maintenance management scandals, and killed several Marines in early trials.<sup>45</sup> Yet such a perception makes little sense. Some have pointed to the capability tradeoffs such as- less armor, reduced operational reliability, reduced protection from improvised explosives and less lethality-as being too great. While it is true that capability decisions must be made for a HWS ACV, the ACV 1.1 has also required capability tradeoffs, including reduced troop carrying capacity (likely carrying only ten Marines, requiring rifle squads to be split between two vehicles) and reduced lethality ( M2 machinegun mounted in a remote weapons system). It begs the question, is the capability the Marine Corps values most an IED-proof off-road vehicle? The Marine Corps Gazette article "The Amphibious Combat Vehicle" points out that it “is expected that the cost of a wheeled vehicle will be less than half the cost of an HWS tracked vehicle.”<sup>46</sup> The misconception is that twelve HWS ACVs were expected to support an infantry company while it is expected to take twenty-one ACV 1.1s for the same mission. The result is half the cost per unit, but almost twice the number of vehicles for a land-

optimized mission. There will always be competing interests vying for the limited budget in the Marine Corps; the key is what provides the greatest capability to the Marine Corps and the Combatant Commander.

“*Warfighting, Marine Corps Doctrinal Publication 1*” expresses the Marine Corps’ warfighting philosophy using terms such as: combat power, speed, focus, surprise, boldness. When linked these concepts form the basis for maneuver warfare, the “philosophy that seeks to shatter the enemy’s cohesion through a variety of rapid, focused, and unexpected actions which create a turbulent and rapidly deteriorating situation with which the enemy cannot cope.” Having a high speed, amphibious, armored personnel carrier capable of launching from Navy ships or foreign shores and landing on contested beaches to either secure an operational objective or seize a foothold for follow on forces undoubtedly supports the Marine Corps’ warfighting philosophy. A HWS ACV also supports the Marine Corps’ Title X responsibilities to the Nation. General Dunford, the current Commandant of the Marine Corps, said it best when he stated to Congress, “The need for self-deploying, high-water speed vehicles remains our ultimate objective. The capability to come from the sea and operate in the littorals will be significantly dependent on the speed at which we can maneuver.”<sup>47</sup> This statement demonstrates that General Krulak’s view regarding the necessity of amphibious operations holds as true today as it did sixty years ago.

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<sup>1</sup> Headquarters U.S. Marine Corps, *Marine Corps Vision and Strategy 2025*, June 18, 2007, 9.

<sup>2</sup> Headquarters U.S. Marine Corps, *Expeditionary Force 21 Capstone Concept*, March 4, 2014, 2.

<sup>3</sup> HQUSMC, *EF21*, 7.

<sup>4</sup> Keith Kopets, “Omar Bradley Was Right” *Marine Corps Gazette* (August 2003), 1.

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<sup>5</sup> Joint Chiefs of Staff, *Joint Publication 3-18: Joint Forcible Entry Operations*, 27 November 2012, vii.

<sup>6</sup> *Oxford Dictionary Online*, s.v. "armed," accessed December 18, 2015.  
<http://www.oxforddictionaries.com/definition/english/armed>.

<sup>7</sup> Joint Publication 3-18, *Joint Forcible Entry Operations*, 27 November 2012, I-9.

<sup>8</sup> Department of the Navy, *Ship-To-Objective Maneuver*, May 16, 2011, 9.

<sup>9</sup> James Hammond, W.I.I.I., U.S.M.C. 2014. "The ACE that Ate the Marine Corps." *Marine Corps Gazette* 98 (1): 8.

<sup>10</sup> U.S. Department of Commerce., 2014. *United States Census Bureau Top Trading Partners*. September. Accessed November 2014. <https://www.census.gov/foreign-trade/statistics/highlights/topcurmon.html>.

<sup>11</sup> Steven Zaloga., *Amtracs: US Amphibious Assault Vehicles* (Osprey Publishing; 2 edition, 1999) 7-16.

<sup>12</sup> J. H. Alexander., "The LVTP7 and the Surface Assault." *Marine Corps Gazette* (1972) 56 (6): 31-36.

<sup>13</sup> K. T. Brunsvold. "Will the LVA Ride on Air Cushion Or Water Wings?" *Marine Corps Gazette* (1978) 62 (3): 47.

<sup>14</sup> HQUSMC, *EF21*, 2.

<sup>15</sup> Rising STOM: China Expands Amphibious Capabilities 2013. *Jane's International Defense Review* 46 (11). <http://search.proquest.com/docview/1442907356?accountid=14746>.

<sup>16</sup> *Hearing To Receive Testimony On Marine Corps Ground Modernization In Review Of The Defense Authorization Request For Fiscal Year 2016 And The Future Years Defense Program: House Subcommittee on Seapower Committee On Armed Services*, U.S. Congress. House. 11 March 2015.

<sup>17</sup> Rising STOM.

<sup>18</sup> Christopher Foss F.. "China Reveals Amphibious Assault Vehicle Details." *Jane's International Defense Review* (2014) 47 (8).  
<http://search.proquest.com/docview/1547798781?accountid=14746>.

<sup>19</sup> Marine Corps Warfighting Publication 3-13, *Employment of Amphibious Assault Vehicles (AAVs)* 17 February 2005, B2-B7.

<sup>20</sup> MCWP 3-13, B2-B7.

<sup>21</sup> Christopher F. Foss. "China Reveals Amphibious Assault Vehicle Details." 8.

<sup>22</sup> Headquarters U.S. Marine Corps, *Concept of Employment for Amphibious Combat Vehicle 1.1 (Phase 1 Increment 1)*, 2 December 2014, 6-7.

<sup>23</sup> Headquarters U.S. Marine Corps, *Concept of Employment for Amphibious Combat Vehicle 1.1 (Phase 1 Increment 1)*, 2 December 2014, 11.

<sup>24</sup> Navy Warfighting Publication 3-02.12 *Employment of the Landing Craft Air Cushion*, February 1997. pp 52.

[www.combatindex.com/store/MCWP/Sample/TYPE\\_OPERATIONS/MCRP\\_3-31\\_1A.pdf](http://www.combatindex.com/store/MCWP/Sample/TYPE_OPERATIONS/MCRP_3-31_1A.pdf)

<sup>25</sup> Victor Croizat., *Across the Reef* (Marine Corps Association, 1992), 239.

<sup>26</sup> Robert M. Gates, *Secretary of Defense, Delivered at The Pentagon, Thursday, January 06, 2011* <http://www.defense.gov/speeches/speech.aspx?speechid=1527>.

<sup>27</sup> Andrew Feickert,.. "The Marines' Expeditionary Fighting Vehicle (EFV): Background and Issues for Congress." *Congressional Research Service: Report 1-11*. 2011, 1.

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<sup>28</sup> *Delivered by Secretary of Defense Robert M. Gates, The Pentagon, Thursday, January 06, 2011* <http://www.defense.gov/speeches/speech.aspx?speechid=1527>.

<sup>29</sup> Freeboard: The distance between the waterline and the main deck or weather deck of a ship or between the level of the water and the upper edge of the side of a small boat. *Merriam-Webster OnLine - Dictionary and Thesaurus*, [www.merriam-webster.com](http://www.merriam-webster.com).

<sup>30</sup> Dr. John Burrow et al., "Concept Exploration of the Amphibious Combat Vehicle" presentation 2014 <http://doerry.org/norbert/papers/papers.htm>.

<sup>31</sup> Burrow, et al., "Concept Exploration of the Amphibious Combat Vehicle" .

<sup>32</sup> Burrow, et al., "Concept Exploration of the Amphibious Combat Vehicle".

<sup>33</sup> Monty Walker, "United States Marine Corps Operational Maneuver From The Sea" (Presentation 2008).

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<sup>34</sup> Demetri Economos, Len Blasiol, and Mark Richter. "Strategic Implications of Combat Overloading." *Marine Corps Gazette* 92 2008 (12): 31. <http://search.proquest.com/docview/221448895?accountid=14746>.

<sup>35</sup> *EF21*, 32.

<sup>36</sup> "Operational Maneuver from the Sea: A Concept for the Projection of Naval Power Ashore." 1996. *Marine Corps Gazette* 80 (6): A1-A6. <http://search.proquest.com/docview/221467242?accountid=14746>.

<sup>37</sup> HQUSMC, *EF21*, 12.

<sup>38</sup> HQUSMC, *EF21*, 36.

<sup>39</sup> HQUSMC, *EF21*, 42.

<sup>40</sup> HQUSMC, *EF21*, 9.

<sup>41</sup> HQUSMC, *EF21*, 42.

<sup>42</sup> Joint Publication 3-0, *Joint Operations*, 17 September 2006, II-2

<sup>43</sup> JP 3-0, II-2

<sup>44</sup> Kenneth J. Glueck, Jr. 2014. "The Amphibious Combat Vehicle." *Marine Corps Gazette* 98 (9): 24

<sup>45</sup> Hammond, James W, I.I.I. "The ACE that Ate the Marine Corps." *Marine Corps Gazette* 98 (1): 2014, 7. <http://search.proquest.com/docview/1477207273?accountid=14746>.

<sup>46</sup> Glueck, "The Amphibious Combat Vehicle" 27

<sup>47</sup> *General Joseph Dunford Commandant United States Marine Corps Before The House Appropriations Committee Subcommittee On Defense*, 11 March 2015.

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