Building A Better Mousetrap: The Unnecessary Capability of the EFV

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Building A Better Mousetrap: The Unnecessary Capability of the EFV

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The imminent arrival of the expeditionary fighting vehicle (EFV) will revolutionize the future of Marine Corps mechanized operations. With the EFV, Marine maneuver forces will possess a true fighting vehicle for the first time in history. The EFV brings vast improvements in range, mobility, land speed, weapons lethality, NBC protection, communications, and armor protection. However, the layout and construction of the EFV have been optimized for high-speed movement over water. Though this vehicle has many improved land-fighting capabilities over the AAV, they are shoehorned afterthoughts to the prevailing influence on design. In fact, the most touted advancement of the EFV, the capability to travel at twenty-five nautical miles per hour over water is excessively costly and will prove unnecessary and distracting during the EFV's service life.

Background

At some point during the establishment of requirements for the EFV, decision makers determined that this vehicle would require the capability to transit to shore from amphibious ships twenty-five nautical miles from the shoreline. To minimize the duration of ship-to-shore movement, these same decision makers desired the transit to the landing site to be made in one hour. Thus, a water speed of twenty-five knots was required.[1]

[1] United States Marine Corps, Operational Requirements Document: *Advanced Amphibious Assault Vehicle (AAAV)*, loose-leaf, 13 September 2000, p. 28.

This attempt to reduce the duration required for ship-to-shore movement was fueled by the desire to reduce distraction from mission accomplishment. However, this aspect of the EFV has absolutely dominated vehicle development. Ironically, to make the EFV swim fast, concessions in design were made that will adversely affect ground combat capability. In the end, a high-water-speed EFV will detract from mission accomplishment ashore.

Engineering a High-Water-Speed Capability

Once the Marine Corps made the institutional commitment to the high-water-speed EFV, it shifted design focus away from combat performance ashore. The seminal evolutionary leap in vehicle design in moving from the AAV to EFV is the requirement of the vehicle to "plane" on the water.[2] The only possible way to move a high-drag, rectangular, thirty-four-ton metal box on the water at twenty-five knots is to get the vehicle moving fast enough to achieve laminar flow over a relatively sleek and long bottom surface — like a ski boat. Since, as a rule, infantry fighting vehicles look nothing like ski boats, creative engineering was required to achieve the water speed requirements of the EFV program.

[2] Major Patrick J. Darcy, USMC, Armored Vehicle Requirements Officer, Marine Corps Combat Development Command, Quantico, VA, personal interview conducted by the author, 11 January 2005.

The first major design concession of this program was the placement of the engine within the vehicle. The AAV engine is in the front of the vehicle. Forward placement of the engine in the AAV allows for maximum volume of storage space within the cargo area to the rear. In contrast, the EFV engine must be in the center of the vehicle with the center mass of the engine located at the vehicle's center of gravity. This central engine location is an absolute prerequisite to getting the vehicle up on plane. Troop and cargo space within the remainder of the vehicle cavity must be divided into small compartments surrounding the engine.

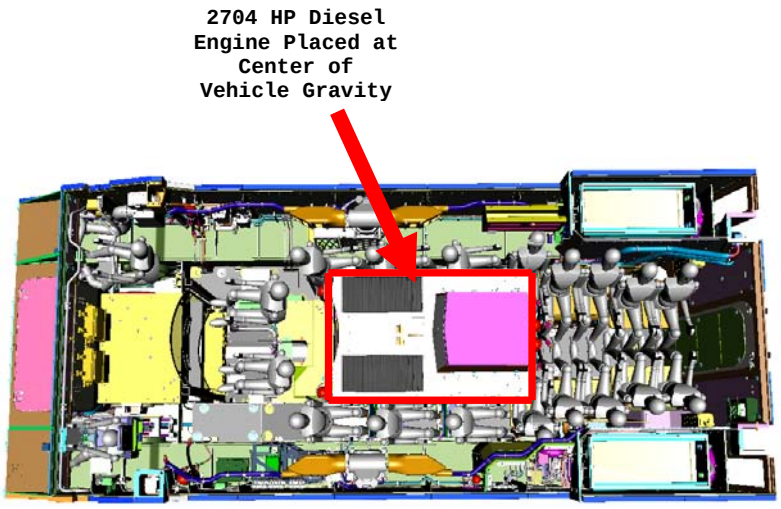

Figure 1: Engine Placement
(From: *EFV Deskbook,* January 2004)

The second design characteristic dictated by high-water-speed commitment came in engine output. The EFV is heavier than a boat of comparable size. Pushing 76,000 pounds fast enough in the water to achieve planing requires tremendous power. More power generally requires a larger engine. However, the EFV is confined by embarkation requirements and land mobility considerations to roughly the size of the AAV--which is already quite large for a fighting vehicle. This combined requirement

of high power output and limited size demands a one-of-a-kind engine. For the sake of high-speed water movement, the Marine Corps researched, modified, and specifically tailored the most power-dense diesel engine in the world to the EFV.[3] This modification and specialization of technology comes at a high financial price.

In a third major design concession, moving parts were added to transform the underside of the EFV from a high-drag underbelly required for land operations to a low-drag hull required for high-speed water travel. This transforming design required the addition of hydraulically moveable chine flaps to cover the underside of the tracks, a transom flap, and a retractable suspension system (tracks). Without the requirement to plane, this hydraulic system would not be necessary.

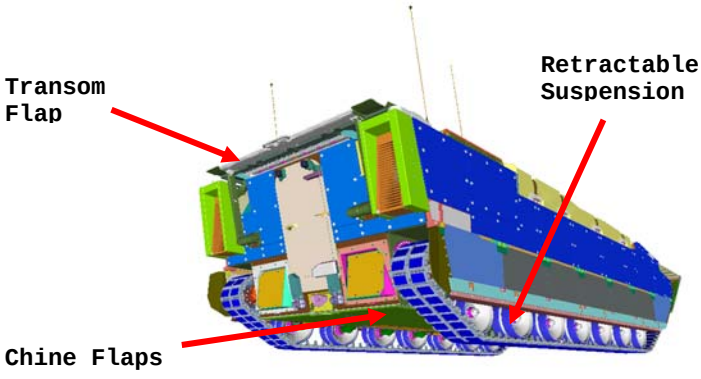

Figure 2: Unnecessary Complexity?
(From: *EFV Deskbook,* January 2004)

Figure 3: Transformed Hull in High-Water-Speed Mode
(From: *EFV Deskbook,* January 2004)

[3] Program engineers sought and found a commercially available base engine for modification. The MTU 883 "Euro engine" was modified for the specific size and power requirements of the EFV. Major William P. Brannen, USMC, Operations Officer, EFV Program Office, email correspondence with the author, 24 January 2005.

When the driver pushes a single button, a combination electric-hydraulic system actually draws the tracks into the belly of the vehicle, covers the rough surface of the treads with smooth chine flaps, and extends and locks a transom flap into place. Prior to coming ashore, the driver reverses the process and the vehicle exits the surf in a land mobility mode. Currently, there is no mechanical back up system.[4]

Hydraulic systems leverage the pressure of a non-compressible liquid. The liquid in the system is contained within hoses and pipes capable of containing the extreme pressures. If a pipe or hose containing hydraulic fluid is ruptured, the system will fail. Since there is no backup system on the EFV, in any hydraulic or mechanical failure in the either the chine flaps, the transom flap, or the retractable suspension system, the EFV has no hope of planing and will travel at its maximum transition speed of 10 knots.[5]

[4] Major Darcy interview.

[5] The likelihood of such a failure is high. The original threshold mean time between operational mission failure (MTBOMF) for the EFV was seventy hours with a target of ninety-five. In 2003, the threshold was reduced to 43.5 operating hours. The 70-hour threshold was simply unattainable. Studies and Analysis Division, Marine Corps Combat Development Command report, *Advanced Amphibious Assault Vehicle (AAAV) Reliability Analysis: Final Report*, published in electronic and loose-leaf formats, 22 August 2003. The actual formal requirement for the threshold MTBOMF to be reduced from 70 to 43.5 hours was signed by General W. L. Nyland on 12 April 2004: *Marine Requirements Oversight Committee Decision Memorandum 35-2004*, loose leaf, provided by Marine Corps Combat Development Command.

Cost

Procurement Costs

The current projected cost, per vehicle, of the EFV personnel variant is around $8.5 million in "then year" dollars.[6] This cost is heavily tied to the design constraints of the ridiculously powerful engine and the hydraulic system required to transition from land mode to high-speed water mode. The Marine Corps will pay heavily to attain the twenty-five knot capability off the showroom floor. The cost of maintaining the engine and the hydraulic system to sustain that capability will continue to add to the economic burden of this program throughout the EFV's service life. Procurement costs for this program would be significantly reduced without the high-water-speed requirement with no impact on land combat capabilities.

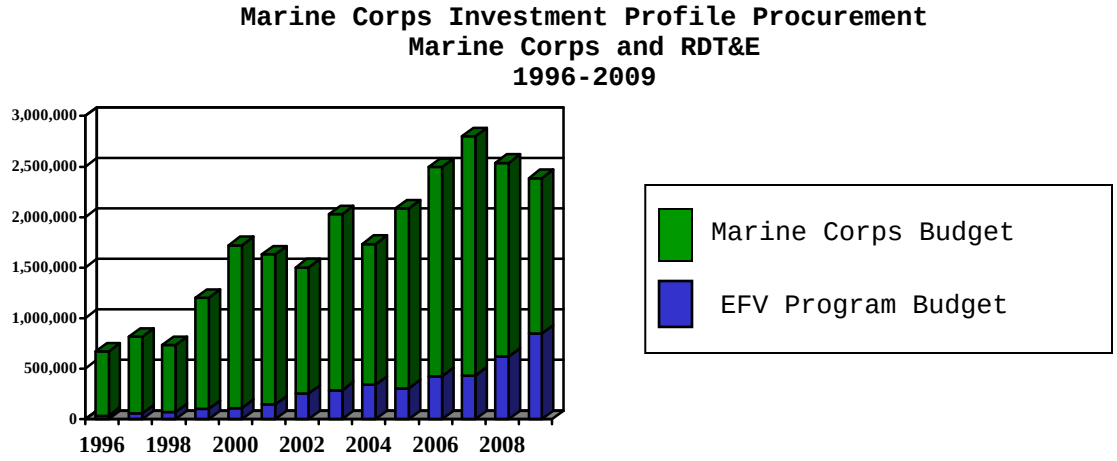

Figure 4: Projected EFV Impact on the Overall Marine Corps Budget
(From: *EFV Deskbook*)

[6] Maj Brannen electronic mail correspondence. According to Maj Brannen, "then year" dollars "are an estimate of the cost (to include inflation, etc.) of the vehicle during the actual (future) years that it will be produced."

Maintenance Costs

The fewer moving parts a mechanical system contains, the more reliable that system. There is a loss of efficiency in a mechanical system at every interface between two moving parts. Friction produces component wear at each point of interface between parts. Mechanical systems become less efficient as they age. Worn components must be replaced over time. If they are not replaced, they will eventually be out of tolerance and cause a mission failure.

As mentioned above, it takes a tremendous amount of horsepower to propel the EFV up on plane. Once the vehicle is on plane, it requires drastically reduced power from the engine to continue skimming the surface. The specialized engine that the Marine Corps paid to research, develop, and adapt specifically for EFV high-speed water travel currently supplies sufficient horsepower to get the vehicle to plane.

However, over time, the engine will become less efficient. As engine output on the EFV degrades, Marine Corps leadership will be cast on the horns of a dilemma of its own making — either spend the large sums of money required to maintain the engines or allow the maximum water speed of the EFV to fall from twenty-five to ten knots. Maintenance costs will be significantly higher over the EFV service live to retain the original high-water-speed capability.

Unnecessary Capabilities

Doctrine states that the Marine Corps anticipates facing many unconventional threats during the projected service life of the EFV.[7] Most sub-national, unconventional threats of the future will not possess the military strength to mount a strong, organized defense of a shoreline. For the foreseeable future, instances of strongly defended littorals will be extremely rare. Individually tailored solutions much less expensive than the high-water-speed EFV will be readily devised for each situation. Marine Corps doctrine also states that the overwhelming trend in future combat is urban.[8] Yet, not one design aspect of the EFV has been optimized for urban combat, *not one*.

In fact, had the EFV been employed in Afghanistan or Iraq, not a single EFV would have conducted a ship-to-objective attack while *every* vehicle would have participated in sustained operations ashore, in an urban environment, against an unconventional, sub-national enemy. While the Marine Corps has designed and developed a vehicle optimized for high-speed water mobility, future conflicts demand a vehicle optimized for ground urban combat against enemies of varying capabilities.

The overwhelming impetus driving the development of the EFV is operational maneuver from the sea. The vision behind the EFV

[7] United States Marine Corps, *Marine Corps Doctrinal Publication 3: Expeditionary Operations* (Washington, D.C.: Government Printing Office, 1998), 11-18.
[8] *Marine Corps Doctrinal Publication 3: Expeditionary Operations*, 19-20.

is one in which a group of vehicles move from amphibious shipping twenty-five nautical miles from the shoreline and then travel at a high speed to a littoral penetration point to come ashore and seamlessly complete some tactical mission.

The layout and construction of the EFV have been optimized for that high-speed movement over water. But this is not a reasonable focus. The mission profile guidance originally given to the EFV (then the AAAV) team was for 20% operational time in the water and 80% on land. Since then, the mean operational time in the water for all envisioned EFV missions has been revised to 8.2%.[9] Thus, the Marine Corps predicts the EFV to operate eight of every one hundred hours of vehicle operation in the water.

If the Marine Corps had fielded the EFV in January of 2001, the high-water-speed capability would not have been used in either Operation Enduring Freedom or Operation Iraqi Freedom — both expeditionary operations by any standard. In both of these instances, Marine forces transitioned ashore at friendly forward operating bases and have since lingered ashore to this day.

If Marine forces had the EFV in Afghanistan, it would have arrived in an administrative manner either via airlift or over land from a friendly, adjoining nation. The EFV's capabilities

[9] For the original operational mission profile of 20% water and 80% land, see: AAAV ORD Milestone II. For the revised number of 8.2% waterborne operations, see: EFV Operational Mode Summary/Mission Profile of 02 December 2003, page 1-6; Major Darcy interview.

would then have been used in combat and other land operations. In Iraq, EFVs would have landed in Kuwait administratively from amphibious shipping or sealift platforms and been used in combat and other operations ashore. Both Afghanistan and Iraq consist of an initial entry into theater followed by years of sustained operations ashore.

Yet the overwhelming design consideration behind this vehicle is the placement and development of the specialized engine required to sustain the very small sliver of relevant capability required in high-speed water travel. This vehicle is not optimized for sustained, decisive operations ashore. If contemporary history is any guide, sustained operations ashore will still be the primary requirement of Marine Corps forces during the service life of this vehicle.

Distractions and Complications

The EFV requires a minimum water depth of eighteen feet to transition from high-speed water mode to land mode.[10] If the EFV is not in eighteen feet of water, the chine flaps or transom flap may become mired and beach the vehicle trapping the personnel and equipment inside in a vulnerable position.

Nautical charts can and will be inaccurate. They rapidly become outdated near the shoreline due to tidal variations, silt deposits, shifting sand bars, and manmade features. Even the

[10] Major Brannen electronic mail correspondence.

best charts must be confirmed prior to an amphibious landing via active reconnaissance. Consider the negative lesson of Tarawa or the positive example of Inchon. The recent example of the Los Angeles class fast attack submarine, U.S.S. San Francisco, colliding with an uncharted underwater mountain at 35 knots is instructive.

Reconnaissance Marines or Navy personnel currently conduct hydrographic reconnaissance specifically to confirm or update chart data to prevent beaching landing craft. The EFV is optimized to be able to change landing destinations en route to the beach in response to enemy activity. This will increase the landing site options, but also increase the number of sites requiring hydrographic reconnaissance. A failure to conduct such reconnaissance on all potential sites will greatly increase the chances of beaching a vehicle in transition mode or encountering some shallow water obstacle or mine. If at all uncertain about the depth of water, the only prudent course of action for an EFV force is to transition early when the depth is certain to be greater than eighteen feet and proceed in transition mode at ten knots.[11]

[11] Maj Brannen email correspondence. According to the EFV program office, the EFV has consistently achieved ten knot sustained water speeds in transition mode during testing.

Conclusion

The EFV is a phenomenal leap ahead of the current AAV. Upon its arrival, the EFV will immediately provided greatly enhanced battlefield capabilities. The Marine Corps needs this vehicle. However, the institutional commitment to the high-water speed capability of the EFV has dictated engineering constraints that sacrifice overall combat performance. Further, the engineering efforts required to make the EFV swim at high speeds increase the cost and complexity of this vehicle. Few battlefield instances will allow the use of this vehicle's maximum water speed: none will require it. The high-water-speed capability of this vehicle will prove an unnecessary and costly distraction throughout service life of the EFV.

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