Electric Vehicle Technology

Modernizing the Marine Corps' tactical wheeled vehicle fleet

by Mr. Marc Paquette

As of this writing, the United States has over 1.8 million electric vehicles (EVs) registered in the United States. In comparison to the world stage, the United States represents a mere 17 percent of the 10.2 million EVs. The EV's popularity comes with a push from the current administration to grow the capability and pressure from Congress to adopt the technology on Tactical Wheeled Vehicles (TWV).

The payback of acquiring EVs for the military are many and may include such benefits as lower sound and infrared signature, superb mobility, higher reliability, and perhaps—at some point—lower maintenance cost. The technology also offers the ability to inaudibly export onboard power for such mission support as a silent watch, mobile command post, medical support, and much more.

The total life cycle implications of electrified TWVs are not yet fully understood. More specifically, the logistics required to sustain and maintain electrified TWVs are in the early infancy stage, and much remains to be discovered.

This article is not an endorsement to electrify or not electrify the Marine Corps Tactical Wheeled Vehicle fleet or to define what degree of electrification the Corps should pursue. It is instead the author's interpretation of the current state of readiness to proceed and identification of the pitfalls if done hastily as well as gains to be achieved if done methodically.

State of the Technology

Industry has come a long way in making the batteries better, lighter, and last longer. The average battery pack on commercially available e-vehicles lasts ten-fifteen years with minimal loss of capacity. Any casual observer will notice that much growth has occurred to ensure rapid charging stations are operational in many shopping centers located near highways and byways.

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Very little has however been done in terms of supporting a battalion of e-TWVs. How will we recharge our fleet in forward areas? Will it take a larger footprint to transport or place forward charging stations? It is not like we will be performing a combat mission on I-95 with the ability to drive to a Walmart rapid charging station. No one can say for sure what it all means in terms of the Concept of Operations and sustainability.

The time to look at EVs for the Marine Corps is indeed now but a measured and deliberate approach is required.

The first step of an incremental approach is already well underway with our industry partners cementing e-TWV using Independent Research and Development dollars. Billions are being spent on vehicle designs, battery and battery management systems, production facilities for vehicles, as well as production facilities to produce U.S. manufactured batteries. These e-TWVs will no doubt possess superb off and on-road capability, offer reliability and ease of maintenance, long-lasting battery life, provide low detectability, and the potential ability to export high levels of power. These benefits will also undoubtedly come at a cost, and operational trade-offs such as range and payload will have to be made.

For the past decade, Naval Surface Warfare Center Crane has been advancing electrification of the light and ultra-light tactical vehicle space. These endeavors have included extensive modeling and simulation in addition to the development and testing of multiple technology demonstrators ranging from fully electric to diesel-electric vehicles.

MTVR fording. *(Source: https://commons.wikimedia.org/wiki.)*

The results of these efforts reveal that fully electric vehicles are not viable on the tactical edge with present commercial EV technology. This is largely because of the relatively low energy density of automotive lithium batteries with respect to that of kerosene-based fuels. In order to perform the same mission requirements, the dry weight for a fully electric vehicle can be expected to be at least twice that of its internal combustion engine counterpart. This would result in reduced flexibility of employment (e.g. payload capacity degradation, exceeding floor pressure for internal air transportability, etc).

Another area little understood at the moment is fording in fresh and saltwater environments. Development and Operational Testing will yield valuable information on the system and operational suitability and reliability for all of the electrical systems and components when immersed. The data will also provide insight into the engineering required to make the systems suitable for Marines to use in all climes and locations.

Transportation and storage safety procedures and mitigation strategies will also prove to be challenging. Funding will need to be allocated to research and develop safety systems that may require the retrofit of ships, aircraft, and facilities. Navy ships have not been fully evaluated for their ability to support the transportation of e-TWVs. The storage of lithium-ion batteries presents challenges and investigation of what will be required to safely store them aboard Navy ships is in an embryonic stage. Firefighting and HAZMAT capabilities aboard Navy ships are designed to respond to fuel fires that spread across the deck of vehicle storage compartments. Lithium-ion battery fires can create what is referred to as a "three-dimensional fire," which burns within the vehicle obstructed behind vehicular panels with no direct access.

> ***Lithium-ion battery fires can create what is referred to as a "three dimensional fire ..."***

At a minimum, we will need to explore the following:

- What ship modifications and certifications will be required?
- What will the facilization cost be?
- What facilities will we need in garrison and in the Expeditionary Advanced Bases to charge, maintain, and store the new battery technology?

The issues described above need to be investigated and pursued using an incremental approach totally grounded in experimentation in order to prove or otherwise demonstrate the warfighter's and supporting establishment's ability

JLTV exposed to salt water during recent Marine Corps employment. (Photo by LCpl Drake Nickels.)

to adopt and sustain the new e-technology.

To this end, the Marine Corps should at the onset, identify and designate an infantry battalion to operate using electrified tactical wheeled vehicles and conduct experimentation on scale. This approach would have the added benefit of setting conditions for concept development and would inform requirements. It would perhaps be ideal for this infantry battalion to be based at Twentynine Palms with an added portion of the experimentation in deployed cold weather conditions to assess the cold weather impact on e-TWVs.

Initially, an Integrated Product Team (IPT) should be formed with participants from the chosen infantry battalion, the Office of Naval Research (ONR), Naval Surface Warfare Center Crane, Combat Development Command, and a Marine Corps Systems Command (MCSC) Acquisition Program Manager well versed in experimentation.

The next three to six months should be spent identifying the current state of technology with such excursions and documentation to fully capture the realm of the possible. Such data as weight to range; weight to cube; and vehicle class. A vital portion of the experimentation is forward support and this experiment would examine how e-TWVs are supported both in garrison, as well as in the forward areas with an eye on Expeditionary Advanced Bases of Operations (EABO) and operations in the littorals. The Integrated Product Team would equip itself with desired operational concepts and requirements grounded on the realm of the possible.

Once the requirements are fully vetted with the infantry battalion tasked to perform the experiment, a platoon's worth of prototype e-TWVs would be designed and built over the next 18 to 24 months.

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Once the prototypes are built and delivered, the experimenting infantry battalion would embark on a six-month experiment conducting various mission profiles utilizing a mixed fleet of baseline vehicles and e-TWVs—to include a dedicated period of time in cold weather.

During the above establishment of what is possible and formulation of the requirements, we must keep a solid perspective on acquiring a new system with consideration on the impact to the FMF by considering doctrine, organization, training, materiel, leadership and education, personnel, facilities, and policy. This analysis is the first step in the Functional Solutions Analysis. The Functional Solutions Analysis (FSA). determines/recommends if a non-material approach or a material approach is required to fill a capability gap identified in the Functional Needs Analysis. It includes the entire life cycle, including the sustainment; environment, safety, and occupational health; and all human systems integration domains.

In closing, the possibility of electrification for military TWVs promises many returns and prospectively will provide enhanced capability in terms of exporting power, reduced detectability, increased lethality, amplified persistence, improved performance, reduced fuel cost, greater reliability, and will potentially offer the use of non-organic resupply options such as host nation power grid and fuel scavenging. The unique challenges we are facing with e-TWVs are weight penalty, transportation, forward area of operations support posture, and the high cost of acquisition. However, questions remain that must be examined before the Marine Corps can proceed and an e-TWV experiment at scale offers the proven ability to validate operating and sustainment costs, to develop a concept for operations, and to ultimately inform requirements.

>Author's Note: Contributing editors for the article include Col John T. Gutierrez, Portfolio Manager, Logistics Combat Element Systems, Marine Corps Systems Command, and David Keeler, Lead Technologist, Logistics Combat Element Systems, Marine Corps Systems Command.