Hybrid-Electric (HE) Drive Knowledge Expanded Through Validation Testing

Chris Williams

A new assessment program developed at the U.S. Army Tank Automotive Research, Development and Engineering Center (TARDEC) expanded an understanding of HE technology for military applications.

Sky's the Limit. An XM 1124 HE High Mobility Multipurpose Wheeled Vehicle (HMMWV) negotiates a 30-percent longitudinal slope at ATC. HEVs experience improved fuel economy in hilly conditions due to frequent braking, which restores kinetic energy and assists in charging the batteries. (U.S. Army TARDEC photo by Johnathon Putrus.)

TARDEC and ATC developed the HEVEA program to assess and evaluate the U.S. Army's HEV fleet. The program incorporates an HEV database, new TOP and a TARDEC-designed VPSET into its processes to ensure HEVs are accurately and efficiently integrated into the Army's future vehicle fleet. (U.S. Army TARDEC photo by Johnathon Putrus.)

California Gov. Arnold Schwarzenegger and TARDEC National Automotive Center Director Paul Skalny discuss an XM1124 HE HMMWV at the Society of Automotive Engineers (SAE) 2009 World Congress held in Detroit, MI, April 20, 2009. This hybrid has a diesel engine and electric motor generator, which combine to create a series hybrid that uses two traction motors to drive the front and rear axles. In addition, this vehicle can export up to 30 kilowatts of power to external sources. This year's SAE event theme was *Racing to Green Mobility*, and TARDEC's display featured alternative energy sources it has been developing. (U.S. Army TARDEC photo by Bill Dowell.)

When HE propulsion systems were first introduced, there were varying opinions about the fuel efficiency improvements that HE vehicles (HEVs) could provide. The HEV Evaluation Assessment (HEVEA) program was developed by TARDEC and the Army's Joint Light Tactical Vehicle (JLTV) program to obtain quantifiable and accurate results on the effects of using HE propulsion systems in Army vehicles. The vehicle testing and data analysis was performed at the Aberdeen Test Center (ATC), MD, where they compiled and analyzed the data and helped develop a test plan.

New Testing Procedures

All military vehicles traditionally conduct fuel economy testing on ATC's Munson Standard fuel economy course, which is comprised primarily of flat, paved surfaces with moderate slopes. HEVs that depend on electric energy to propel the vehicle, however, are heavily dependent on terrain, as braking frequency assists in recovering kinetic energy and charging the batteries. To properly evaluate HEVs' fuel economy, the HEVEA team is developing an accredited Test Operating Procedure (TOP) at ATC, which takes into account the energy gain and loss from the battery and compensates for it in equivalent fuel consumption measurement. To provide a greater understanding of HEVs' fuel economy capabilities, five driving courses — representative of conditions the vehicles will encounter in the field — were selected for the new TOP. "[The Munson Standard Course] doesn't give you the whole bird's-eye view of hybrid, because hybrid is terrain-dependant," remarked Johnathon Putrus, Project Manager for the HEVEA program. "An HE-powered vehicle on hilly terrain is going to have better fuel economy than on flat terrain because you're constantly going to be applying the brakes, which helps charge the battery."

The HEVEA program team also designed an HEV Performance Database, which offers a comparison of nine HEVs and their conventional counterparts and spans all tactical wheeled vehicle classes. A large range of HE-powered demonstrator vehicles were compared against an equivalent conventional counterpart, if one existed, and are currently being evaluated and placed into the database. The database will provide information about HEV capabilities to agencies throughout the military.

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Putrus stated that the HEVEA program team has already identified HE technology benefits. "There's definitely been improvement in a lot of different areas," he explained. "In regard to fuel economy, we've seen an increase in the vehicles that utilize a more robust hybrid architecture. We see improvement in other areas as well, in terms of onboard and export power generation, silent power, and other applications." The vehicles are still being evaluated, and there are still considerable hurdles that HEVs must overcome before being part of the Tactical Wheeled Vehicle fleet. Some of these hurdles include cooling for the power electronics and battery development to address capacity and space constraints. The hybrids' benefits will bring additional capability in the propulsion area and address onboard and export power needs for future weapons and survivability systems.

Testing Without Testing

A key product in the HEVEA program is the Vehicle Propulsion System Evaluation Tool (VPSET) Streamline Acquisition Process developed by TARDEC's Ground Vehicle Power and Mobility technical area's Modeling and Simulation (M&S) team in partnership with private industry. The process's objective is to provide an efficient, flexible and cost-effective method of evaluating conventional and HE propulsion systems without physical testing.

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Previously, propulsion systems were evaluated using various contractor-submitted systems that required the acquisition of expensive licenses, contained variations in coding and required training for employees who were unfamiliar with the programs. There also was no assurance that the simulations handled the technical aspects with the same amount of fidelity, which made comparisons difficult. VPSET's implementation provides users with access to a standardized, government-owned tool that allows for a more accurate comparison between vehicles. Users enter parameters for the various vehicle components. The software generates vehicle system models that are then used to estimate performance, such as acceleration, braking and fuel economy. The government has complete access to the program's source code. The results save time and money by utilizing M&S capabilities as opposed to physical testing.

VPSET can be updated to incorporate new propulsion technologies as they develop and feature safeguards that allow the government to verify contractor model input and results. VPSET also can evaluate performance prediction and risk against technical requirements. VPSET is undergoing a comprehensive evaluation phase by TARDEC engineers and private industry to verify and validate the software predictions. Conventional and HEV test data from the HEVEA is being used for this effort.

Powering Forward

By establishing a new TOP, creating a new database for Army HEVs and utilizing VPSET, TARDEC's HEVEA program is increasing knowledge of HEV capabilities throughout the Army. As TARDEC moves forward in its role as the Nation's military ground vehicle technology integrator, the HEVEA program will play a crucial role in testing and understanding HEVs' capabilities. The program continues to optimize the work being done by TARDEC's Ground Vehicle Power and Mobility team to create and maintain reliable and state-of-the-art ground vehicles for Soldiers.

The XM 1124 HE HMMWV navigates one of five different test courses at ATC. The various courses, which simulate field conditions the vehicles are expected to operate under, provide the Army with an opportunity to evaluate and observe the full capability of HE propulsion systems. (U.S. Army TARDEC photo by Johnathon Putrus.)

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