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(AR 530-1, Operations Security)

I am aware that there is foreign intelligence interest in open source publications. I have sufficient technical expertise in the subject matter of this paper to make a determination that the net benefit of this public release outweighs any potential damage.

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Reviewer's Determination (check one)

- 1. Unclassified Unlimited.
- 2. Unclassified Limited, Dissemination Restrictions IAW \_\_\_\_\_
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# Hybrid Drive Partnerships Keep the Army on the Right Road

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The drive to security, as well as prosperity, follows the same road. The trucking industry has a vested interest in the alternative propulsion needs of military vehicles. Just as important, the military vehicle community is synchronized with the trucking industry. Only through cooperation can the Army reasonably obtain the drive technology it requires to be successful. By providing that cooperation, commercial interests can develop the technology to meet military requirements while advancing the trucking industry as well.

The mission of the National Automotive Center (NAC), part of the Tank Automotive Research, Development and Engineering Center (TARDEC), located in Warren, MI, is to serve as a catalyst linking industry, academia, and government agencies in the development and exchange of automotive technologies. One focus of the NAC has been to find ways to get more useful work for every gallon of fuel burned. One way is to allow the engine to run as close to its peak operating point as possible, while storing unused, or previously "wasted" energy, to be used for providing the drive during transient stages. This combination of engine power and energy storage is the hybrid concept.

## HYBRID ELECTRIC DRIVE

The hybrid electric concept involves batteries for storing electric power generated by the engine during deceleration and idling. The stored power is then used to accelerate the vehicle until steady-state conditions are reached and the engine takes over. The NAC's Wheel and Track Systems Team is currently involved in several hybrid electric drive programs:

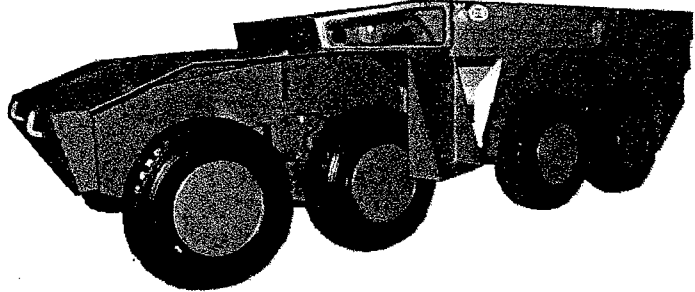
### PROGRAM I – EP-50

The Allison EP-50 Parallel Electric Drive system project involves the NAC and Electricore, Inc., in a Dual Use Science and Technology (DUS&T) contract. Other partners include Allison Transmissions, General Motors Defense, and Mack Truck. The project demonstrates dual-use by integrating the same hybrid electric transmission in both a Light Armored Vehicle (LAV-III) and a refuse hauler. The main technology involved in the

EP-50 system is the EV Drive Unit, which is a patented compound, split parallel hybrid electric drive. The energy storage used in both vehicles consists of six commercial Nickel Metal Hydride (NiMH) battery packs.

**PROGRAM II – AHED 8x8**

The Advanced Hybrid Electric Drive (AHED) 8x8 Demonstrator, by General Dynamics Land Systems (GDLS) and the NAC, is a series hybrid electric drive, eight-wheeled automotive demonstrator designed to meet the most severe military and commercial vehicle requirements in

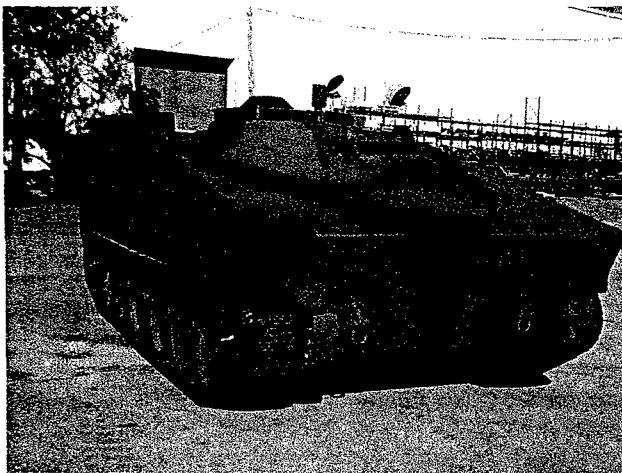


**Figure 1**

the 20-ton weight and power class (see Figure 1). The AHED uses lithium-ion batteries for energy storage. Key technologies include in-hub wheel motors, advanced pneumatic suspension, high-temperature power electronics, and innovative hybrid wheel/track steering.

**PROGRAM III –HE M113**

The NAC and United Defense have designed a Hybrid Electric M113 Transformation Technology Demonstrator



**Figure 2**

(TTD). It is built on a stretch M113 light armored tracked vehicle in a series hybrid configuration (see Figure 2). The drive package consists of a conventional 250 Hp diesel driving a 185 kW AC generator and two 250 Hp AC induction motors with mechanical brakes. The Primary Power Unit consists of the diesel engine, induction generator, and cooling system. Regenerative braking and steer-by-wire are utilized in this system. The TTD energy storage system is comprised of forty commercial, spiral-wound, lead-acid sealed batteries.

## HYBRID HYDRAULIC DRIVE

Like its cousin the hybrid electric, the hybrid hydraulic stores otherwise wasted energy during vehicle operation. The energy storage device in this case is a hydraulic accumulator which is pressurized with fluid while the vehicle is braking. The stored energy is then used to deliver additional torque to the drive shaft during periods of peak acceleration. The storing action has the added benefit of reducing the workload of the braking system.

The Army has teamed up with Permo-Drive Technologies, Ltd. of Australia, the leading innovator of this technology, to verify the concept. Working under a Cooperative Research and Development Agreement (CRADA), the Army, through the NAC, has provided two of its FMTVs (Family of Medium Tactical Vehicles) to Permo-Drive for retrofit and test. One of the vehicles is being used for testing in the US and one is undergoing complete testing in Australia.

Early independent testing has shown a 37% reduction in fuel usage in a simulated urban driving cycle, in addition to noticeable improvements in performance. Preliminary tests have also shown an improvement in the 0-30 acceleration of an FMTV from 14.5 seconds to 8.5 seconds. This could be an important factor in increasing survivability in a wartime environment.

This technology is ideally suited to commercial vehicles used for multiple stops and starts, such as delivery trucks, buses, refuse haulers, etc. The US Postal Service has expressed a profound interest in the program. Permo-Drive also will be working with Mack Truck and Waste Management on a project that will involve the NAC, and expects to have prototype commercial vehicles available for testing before the end of 2003, with possible introduction into commercial fleets by 2005.

**Figure 1 - AHED 8x8 Demonstrator (file photo)**

**Figure 2 - M113 Hybrid Electric Drive System (file photo)**