— Press Release —

Issued on behalf of Vehicle Projects LLC by the nonprofit Fuelcell Propulsion Institute

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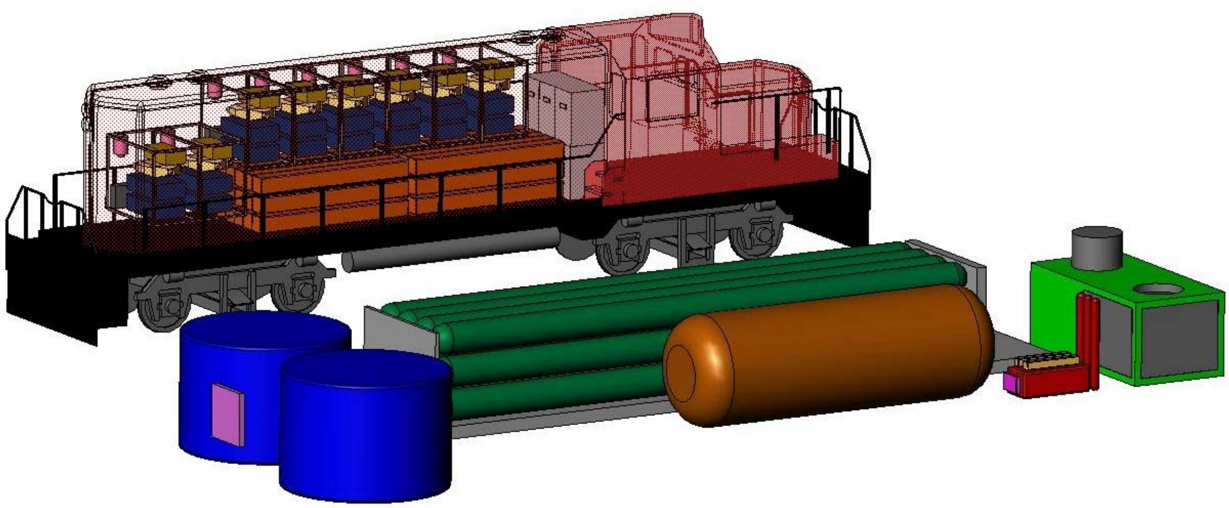
CONCEPTUAL DESIGN OF FUELCELL LOCOMOTIVE

An international consortium is developing the world's largest fuelcell vehicle, a 109 metric-ton, 1.2 MW locomotive for defense and commercial railway applications. Commencing 27 May 2003 with funding of US$1 million for its one-year first phase, the five-year development and demonstration project has completed a major deliverable: conceptual design of the fuelcell locomotive's onboard fuel storage, offboard hydrogen generation plant, refueling system, fuelcell powerplant, and locomotive layout.

The project was conceived, organized, and is led by **Vehicle Projects LLC** of Denver, USA, and is funded and administered by the US Army Research, Development, and Engineering Command's **National Automotive Center (NAC)**, Warren (MI), USA.

Fuelcells are solid-state devices that directly convert the energy of a fuel into electric power. Based on electrochemistry rather than combustion, they are efficient and quiet and give rise to zero emissions.



Conceptual design of the fuelcell locomotive's fuel system: Onboard metal-hydride storage (orange), offboard water-tank heat sink (blue), water-to-air heat exchanger (violet – to left of water tanks), ammonia storage tank (brown-orange), ammonia dissociator and trap (red), hydrogen compressor and nitrogen separator (light green), and compressed-hydrogen holding tank (dark green)

Fuel identity is a major issue impacting eventual commercialization of fuelcell locomotives. Probably no single fuel is practical for all rail applications, which range from subway transit to line-haul freight. Our approach is to examine two promising fuels that can provide hydrogen for locomotive fuelcells: (1) reversible metal hydrides for onboard storage and (2) anhydrous ammonia for offboard hydrogen generation and possible future onboard storage.

Reversible metal-hydride storage is the sole onboard fuel storage in the fuelcell-locomotive conceptual design. Hydride storage offers benefits of efficiency, compactness, and low pressure, and although it is heavy, weight is not an issue for locomotives. Metal-hydride storage previously has been safely and practically demonstrated in an underground mine locomotive by Vehicle Projects LLC. Rate of refueling is determined by the rate of heat removal from the hydride bed. A thermal rate of 2 MW, achieved by use of a large water-tank heat sink, allows a hydrogen refueling rate of 8 kg/min and complete locomotive refueling in approximately 30 minutes.

With the objective of possibly migrating the system onboard a future ammonia-fuelcell locomotive, ammonia is used for offboard hydrogen generation and, concurrently, demonstration of ammonia fuel to the rail industry. Ammonia, as feedstock for catalytic dissociation to hydrogen, is a non-carbon-based, renewable commodity that is typically transported by rail tank car. Ammonia-based hydrogen generation produces a mixture of 75% hydrogen and 25% nitrogen, the predominant component of the Earth's atmosphere. The nitrogen is separated and harmlessly exhausted to the atmosphere, whereas the hydrogen is compressed to 160 bar for storage in an offboard tube-cluster reservoir between refueling operations.

The locomotive is a "road-switcher," a type commonly used for both switching and light line-haul work, to be derived by retrofitting an Army diesel-electric GP-10 locomotive with a fuelcell powerplant. Minor body-shell modifications will update and distinguish the fuelcell version from the original diesel-electric. The proposed 1.2 MW fuelcell powerplant consists of eight identical 150-kW stand-alone modules powered by proton-exchange membrane (PEM) fuelcells. Modules can be swapped in the field like memory boards of a computer. Onboard metal-hydride storage of 250 kg of hydrogen allows operation of the locomotive as a switcher for 30-40 hours under its normal duty cycle.

Conceptual design of fuelcell road-switcher employing 1.2 MW PEM fuelcells (blue) and storage of 250 kg of hydrogen as a reversible metal-hydride (orange)

Four contractors to Vehicle Projects LLC have been selected to provide the major components and integration of the system: **AeroVironment Inc**, Monrovia (CA), USA, will lead the detailed design and integration of the modular powerplant. **HERA Hydrogen Storage Systems Inc**, Longueuil (QC), Canada, and Ringwood (NJ), USA, will design and provide the onboard hydride-storage system. **MesoFuel Inc**, Albuquerque (NM), USA, will design and provide the offboard *MesoChannel*™ ammonia-based hydrogen generation plant. MesoFuel was chosen because of the compactness and efficiency of its hydrogen generation system. **Nuvera Fuel Cells, Inc.**, Cambridge (MA), USA, and Milan, Italy, will provide its *FORZA*™ *Power Modules* to generate 1.2 MW of power for the locomotive. Nuvera's *FORZA*™ will provide the hydrogen-fueled PEM fuelcell stacks for the eight powerplant modules of the locomotive. Nuvera's stacks were chosen because of the ruggedness and compactness of their metal bipolar plates and the simplicity of the proprietary direct-water-injection system of cooling and membrane humidification.

AeroVironment, HERA, and Nuvera have similar roles in another project of Vehicle Projects LLC – development of a 23 metric-ton, 150 kW fuelcell-battery hybrid mine loader supported by the US Department of Energy and Natural Resources Canada.

Other project participants who contributed to conceiving a practical locomotive conceptual design include Burlington Northern and Santa Fe Railway Company, Ft. Worth, USA; Defense NTG & Rail Equipment Center, Hill Air Force Base (UT), USA; Crane Division, Naval Surface Warfare Center, Crane (IN), USA; New York City Transit, New York City, USA; Railway Technical Research Institute, Tokyo, Japan; Regional Transportation District – Denver, Denver, USA; Southwest Research Institute, San Antonio, USA; Transportation Technology Center, Inc (TTCI), Pueblo (CO), USA; US Army CERDEC, Army Power Division, USA; and Volpe National Transportation Systems Center, Research Special Program Administration, US Department of Transportation, Cambridge, USA.

By advancing the commercialization of both military and commercial fuelcell vehicles, major benefits of the project include increased energy efficiency of the transportation sector, increased national energy security by reducing dependency on imported oil, improved environmental quality, and positioning the project partners into leadership roles in advanced rail transportation.

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