Section 5.1 Focus Area

POWER AND ENERGY

PEO LS continues to address the challenge of increasing energy and fuel efficiency of Marine Corps vehicles. As the vehicles today are being equipped with a greater number of electronic devices, there is an increase in the demand for onboard power. Vehicle dependence on a common towable power generator only adds to the logistics burden and increases fuel consumption. The benefits of optimizing energy and fuel efficiency are:

- Lightening the load of the Marine Air- Ground Task Force (MAGTF).
- Reducing the requirement for bulk fuel distribution and storage on the battlefield, thereby reducing the logistics footprint.
- Identifying methods to save fuel and to increase vehicle range.
- Reducing total ownership cost.

There is a two-pronged approach within PEO LS to address the needs and requirements of power and energy: **Fuel Efficiency** projects and **Intelligent Power and Thermal Management projects**.

Fuel Efficiency projects focus on increasing the efficiency of mechanical systems (e.g., engine, drive train, vehicle aerodynamics) to increase the amount of energy extracted from Marine Corps vehicles for every gallon of fuel they use.

Intelligent Power and Thermal Management projects concentrate on solutions that increase the efficient use of electricity and power from other sources once these have been generated. Both focus areas are inherently aligned, and these will continue to maximize the power and energy available for the Marine Corps vehicle fleet.

PEO LS is actively engaged with other agencies and technology partners to address the Marine Corps' current and future power and energy challenges. Working with ONR, MCSC, US Army Research Development and Engineering Command, Tank and Automotive Research, Development and Engineering Center (TARDEC), as well as various industry partners, PEO LS S&T representatives continually seek improvements in the areas of fuel efficiency and alternative solutions for generating on-board (and exportable) vehicle power.

5.1.1 Fuel Efficiency

The Challenge

Marines can expect to fight in austere environments in the future and be more dispersed than in the past. Fighting with more fuel-efficient vehicles enables the MAGTF to travel lighter (and farther) with less fuel. The existing tactical vehicle fleet and associated fossil-fuel-consuming end items will be in the Marine Corps inventory for quite some time. Multiple avenues are being explored to maximize the energy extracted from each gallon of fuel and to minimize losses to heat, friction, and other inefficiencies. When implemented together, these S&T investments, which are not limited to one vehicle or even one component, can minimize fuel use and maximize operational maneuver for each gallon of fuel used.

Potential Solutions

PEO LS Efforts

Fuel Efficient Medium Tactical Vehicle Replacement (MTVR)
This effort (a result of a Future Naval

MTVRs operating in Southwest Asia

Capability) will develop, optimize, integrate, and demonstrate at least a 15% fuel efficiency improvement beyond the existing MTVR and across a set of driving cycles representative of likely operational conditions, while maintaining MTVR affordability, current mobility, transportability, and survivability capabilities.

ONR Efforts

Extreme Power Internal Combustion (EPIC) Engine

This program will conduct feasibility studies, combustion modeling and simulation, and kinematic analyses of a Navy-patented novel rotary internal combustion engine concept that provides high power and torque in a small, lightweight, and fuel-efficient package.

Future Naval Capability (FNC) - ACV 1.X Mobility Enhancements

This FNC project will develop, optimize, integrate, and demonstrate a fuel efficiency improvement beyond the current ACV platform across a set of driving cycles representative of likely operational conditions, while maintaining affordability, mobility, transportability, and survivability capabilities. Additionally, the ACV 1.X Fuel Efficient Technology Suite will decrease the fuel consumption of ACV 1.2/1.3 by at least 10% through addressing engine and drive train losses while moving and at idle.

TARDEC Efforts

Advanced Combat Engine

The intent is to design and develop a novel 1000hp Military engine to meet mobility needs for combat vehicles. To meet the Army's need for enhanced protection and fuel efficiency, high power engines (750 – 1500 hp) are needed to offset increasing combat vehicle weights (armor), increased electrical generation needs (onboard and exportable power), improved fuel

economy (cost & range), enhanced mobility (survivability), and reduced cooling system burden (size, heat rejection) in a smaller package (reduce under armor volumes).

Advanced Combat Transmission

This is the development of a high efficient cross-drive transmission for a track vehicle mated to a 1000hp high power dense engine while offering greater fuel economy (↑ 10-15%), improved thermal efficiency (↑ 15%), and lower heat rejection (↓ 20%) for use in future combat vehicles and demonstrated in the CVP platform.

Alternative Fuels Qualification

This project will determine jet fuel specification/purchase requirements needed for approval of alternative jet fuels (ATJ, DSH, CH, AJF) as military ground fuel that enables DLA-Energy to source these fuels when they are commercially available at cost-competitive prices.

Energy Efficient Hydraulic Fluids

This effort will reduce energy (fuel) consumption in CE/MHE equipment by developing an energy efficient hydraulic fluid formulation and hydraulic fluid efficiency models. The EEHF requirements will be documented in a performance specification with qualified products for DLA-Aviation to purchase. Project will verify hydraulic fluid efficiency models developed for CE/MHE to further understand the efficiency gains that can be attributed to hydraulic fluid formulations. Efficiency testing will be conducted via laboratory rig and vehicle level testing.

Fuel Cell In-House

This will maintain and strengthen in-house technical knowledge and competencies through hardware testing, system integrations, collaborations with industry, government and academia and managing technical research efforts that push the state of the art and reduce system cost and complexity.

Fuel Quality Surveillance

The petroleum fuel handlers at all levels (to include Petroleum Groups and Theater and Divisional Sustainment Brigades, and Brigade Support Battalions) lack the ability to rapidly verify the suitability for use of petroleum products prior to issuing. This effort will also develop algorithms and mature technologies that will provide a fuels quality surveillance in minutes. Technologies to be investigated include: Light obscuration, light scattering, and ultrasound for contaminate; and Near Infrared Spectrometry for the portable fuel property monitor.

Small Business Innovation Research (SBIR) Efforts

Fuel Efficiency Improvements for Amphibious Vehicles (Phase I)

The program will develop concepts for fuel efficiency improvements including an estimate of reduced consumption/increased operation time and/or distance for an ACV 1.1 notional vehicle. During the initial phase, the objectives are to demonstrate the feasibility of the concepts in meeting Marine Corps needs and to establish what concepts can be developed into a useful product for the Marine Corps. Feasibility will initially be established by material testing and analytical modeling, as appropriate.

These efforts investigate four possible approaches to improve the fuel efficiency of the ACV system. One approach is energy scavenging technology to maximize the energy obtained from the fuel burned. Second, intelligent mobility technology is being developed to enable the system to self-tune powertrain performance based on the environment in which the system is operating. Third, auxiliary load optimization is being explored to minimize auxiliary component sizing and load on the engine. Finally, weight reduction technologies are being developed to reduce the overall weight and load on the powertrain across the system's operational range.

Variable Speed Accessory Drives (Phase II)
This Phase II research project will develop a variable ratio cooling fan drive for the MTVR. The MTVR currently uses a clutch-style fan drive operated with air pressure. It is believed that the fuel economy of the MTVR can be improved by implementing a variable ratio cooling fan drive and controlling the cooling fan speed as a function of coolant temperature.

RIF Efforts

Amphibious Combat Vehicle Fuel Efficiency Improvement
This effort will address the more than 10% reduction in fuel consumption during the expected ACV driving cycle. The project's major activities are to fabricate retrofit kits for two ACV engine types, conduct dynamometer and durability testing, and to provide the retrofit kits to the Marine Corps for field testing.

5.1.2 Intelligent Power and Thermal Management

The Challenge

The management, storage, and efficient use of vehicle power has led to the development of a suite of power control programs that can effectively prioritize and manage between command, control, communications, computers, intelligence, surveillance and reconnaissance; hotel services; and heating, ventilation, and air conditioning systems in an adaptive operational environment. Thermal management of electronics is vital to the successful tactical operation of a variety of military electronic systems. Vehicle thermal management is important as it can reduce thermal loads, efficiently remove heat, reuse waste heat, and integrate systems within the vehicle. This effort can improve operational effectiveness and have a reduced energy load. It also can extend vehicle operations and result in efficient electric generation and consumption. Managing the vehicle's various thermal loads and supplies can also assist with power consumption and resourcefully manage the vehicle's output.

The projects described below address many of the needs associated with this challenge through management of thermal loads and energy consumption on Marine Corps tactical vehicles.

Potential Solutions

SBIR Efforts

Lightweight Vehicle Exhaust for Amphibious Vehicles (Phase II)
A major challenge facing designers of exhaust and thermal management systems is the need for increased exhaust transport, heat transfer and dissipation capability, while reducing weight penalties and improving component lifecycle. Currently, the demand for increased exhaust and heat removal in military vehicles is surpassing the performance limits of conventional exhaust and thermal management systems. This is because updated military vehicles include additional armor protection, sensors, firepower, and other advanced capabilities that have added weight and higher performance requirements onto the system components. The Marine Corps experienced exhaust system challenges on the Expeditionary Fighting Vehicle (EFV). The aluminum and composite design developed to meet the exhaust requirements of the 2800 hp diesel engine performed poorly and came at a substantial weight and cost penalty.

As the USMC begins to look at future amphibious assault vehicle (AAV) designs, it is seeking to develop a light-weight, lower-cost vehicle exhaust system that can withstand the repeated heating/cooling cycles under exposure to the aggressive saltwater environment, while minimizing the transfer of heat from engine exhaust to the external surface of the vehicle for improved personnel safety and reduced thermal signature. This program proposes to achieve these objectives

using an exhaust system concept based on a composite wall construction, where each material used in the composite design is selected to perform a specific function. This approach offers the most flexibility with respect to the overall design of the exhaust system, providing multiple ways to address the demanding thermal, structural, and environmental performance requirements.

TARDEC Efforts

Advanced Li-Ion Modular Batteries

This effort will apply recent commercial advances in Lithium-ion based anode, cathode, electrolyte and separator battery materials to electrode, cell, and military specific pack designs to significantly increase energy density vs. lead acid battery baseline from 36Whr/kg to >160Whr/kg while increasing power density by >50% and increase operating temperature range for the Li-ion batteries from (-20°C to +50°C) to (-46°C to +71°C).

Advanced Thermal Management System

The intent is to leverage current investments in combat vehicle cooling technologies to develop, mature and integrate an efficient and effective cooling system for CVP. Also optimize cooling system reducing parasitic power in all modes of vehicle operation for more range & mobility as well as mature advanced technologies into integrated thermal solutions while enhancing performance, decreasing weight, and minimizing cost.

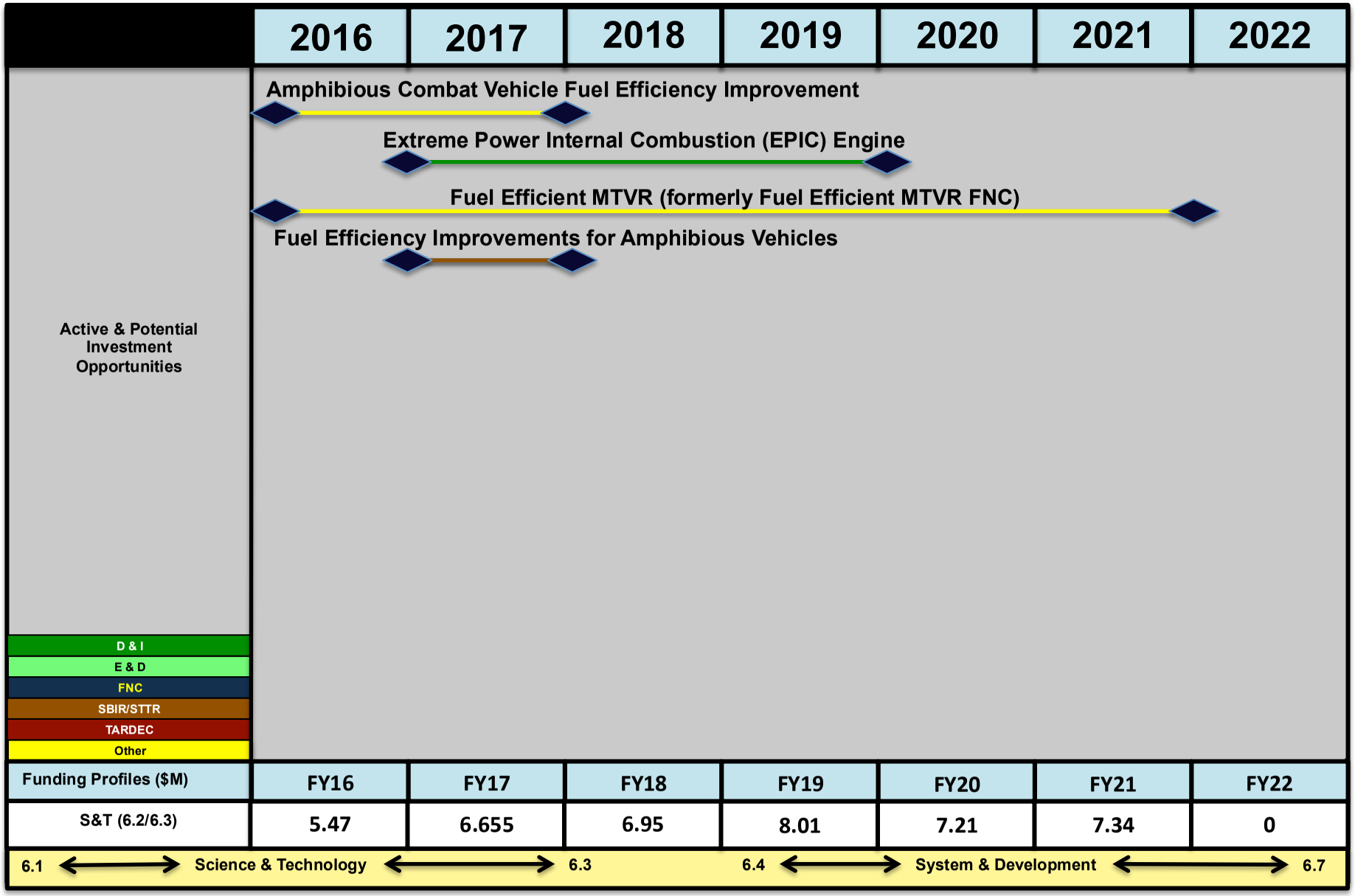
Advanced Vehicle Power Technology Alliance

This will develop advanced technologies that enable military ground vehicles to become significantly more energy efficient. This effort will also collaborate with the U.S. Department of Energy to demonstrate technologies in: advanced combustion engines and transmissions; lightweight structures and materials; energy recovery and thermal management; alternative fuels and lubricants; hybrid propulsion systems; batteries and energy storage; and analytical tools.

Extended Life Coolants

This project will research and evaluate extended life coolants (ELC) to determine their compatibility to military ground systems without degradations in performance and durability (i.e. that thermal efficiency is not compromised and that new additive technologies in ELC do not cause corrosion in legacy ground systems). The use of ELC can reduce operation and maintenance costs by increasing the intervals between drain and refill (potentially three years plus) as compared to the coolants in use today. This project will complement the current work being funded by the Defense Logistics Agency (DLA) on the investigation of the current life of CID-approved coolants and the properties of ELC when mixed with CID-approved coolants to evaluate compatibilities.

Fuel Efficiency



Power & Energy