Section 5.1 Focus Area

POWER AND ENERGY

"Marines are innovators and will aggressively pursue new capabilities. Accordingly, we will work to lighten the MAGTF load and reduce the weight and energy demands of our equipment systems."
Marine Corps Installations and Logistics Roadmap 2013

As the MAGTF continues to transition from developed theaters to more expeditionary operations, infrastructure and logistics support will be more sporadic and located at increasing distances between the Sea Base and the tactical edge. This operational shift will require units and vehicles to support themselves organically for longer periods across the range of military operations. The USMC's tactical vehicle fleet must embrace this trend by becoming more efficient as to how it uses and conserves power and energy.

The PEO LS S&T team has created a two-faceted approach to address the needs and requirements of power and energy development: Fuel Efficiency projects and Intelligent Power and Thermal Management projects. Fuel Efficiency projects focus on increasing the efficiency of mechanistic systems (e.g., the engine, drive train, vehicle aerodynamics) to increase the amount of energy that can be extracted from Marine Corps vehicles per every gallon of fuel used. Intelligent Power and Thermal Management projects concentrate on solutions that increase the utility of electricity and other sources of power once it has been generated. These two focus areas are inherently aligned and will continue to maximize the power and energy available for the USMC vehicle fleet.

Photo Below: U.S. Marines, assigned to 2nd Maintenance Battalion, 2nd Marine Logistics Group (Forward), escort more than 35 Afghan trucks to forward operating bases in northern Helmand province.

5.1.1 Fuel Efficiency

The Challenge

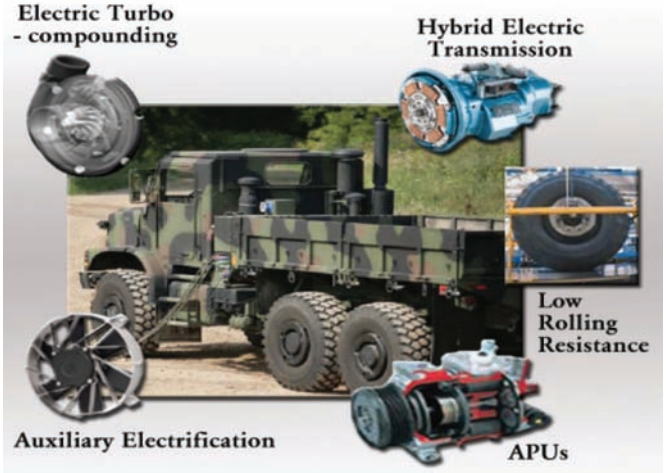
In the near- and mid-term, advances in energy technologies are not expected to progress enough to negate the use of fossil fuels for tactical vehicles in the Marine Corps inventory. However, multiple avenues are being explored to maximize the energy extracted from each gallon of fuel and to minimize losses to heat, friction, and other inefficiencies. These S&T investments, which are not limited to one vehicle or even one component, when implemented together can minimize fuel use and maximize operational maneuver for each gallon of fuel used.

Potential Solutions

ONR Efforts

Fuel Efficient MTVR – Future Naval Capability

The objective of the Fuel Efficient MTVR is to develop, optimize, integrate, and demonstrate a 15% fuel efficiency improvement over the existing MTVR across a set of driving cycles that are representative of likely operational conditions while maintaining MTVR affordability, current mobility, transportability and survivability capabilities. This $87.5 million ONR FNC effort is currently in Phase II and III of development. These phases, researching material solutions and developing technology packages, are on track to be completed by the second quarter of FY 2014. After the three 'technology packages' are developed they will be added to a series of test MTVRs to establish actual fuel savings. The FNC project is expected to transition to the fleet in 2017.



Fuel Efficient MTVR Targeted Areas of Improvement

Additional ONR S&T projects that are of interest to PEO LS include:

- Future Fuel Alternatives
- Advanced Concepts for Fuel Efficiency

RDECOM & TARDEC Efforts

Efficient Powertrain Integration

This five-year project supporting Ker-Train involves developing a next generation transmission based on a planetary gear design with mechanical shifting sequences that is referred to as a binary logic technology. This proposal improves energy productivity and lowers system losses through the vehicle's drive train. If the project's goals are met and TARDEC calculations are correct, the more efficient powertrains can increase vehicle range by 15-20%. The resulting design is expected to be modular and scalable across a range of military vehicles.

Advanced Propulsion with Onboard Power

The goal of this joint TARDEC/ONR funded project is to develop/demonstrate a powertrain-integrated onboard electric power generation system capable of generating at high voltage (600 VDC) 150 kW continuous at all vehicle speeds, with at least 80 kW at a tactical idle speed. Successful completion will allow for an increase in vehicle-supplied power.

Fuel Efficient Gear Lubricants/Energy Efficient Hydraulic Fluids

These two TARDEC projects aim to develop new testing apparatuses and methodologies to assess fuel efficiency improvements of advanced gear lubricants and hydraulic fluids. Both projects are planned to

finish in 2016 and TARDEC expects to produce new specifications for lubricants and hydraulic fluids to formalize their fuel efficiency potential. It is anticipated that the programs will result in at least two new fuel-efficient lubricants and a formulation for a specific energy efficient hydraulic fluid.

Fuel Quality Surveillance

This TARDEC effort, a continuation of an ONR 30 project, involves developing a briefcase-sized portable fuel analyzer kit for expeditionary operations. Maneuvering forces will be able to analyze a sample of battlefield fuel and test for contaminants and performance characteristics in minutes as opposed to days. This R&D effort is anticipated to be complete in 2015 and transition to the Army's PEO-Combat Support and Combat Service Support.

SBIR Efforts

Engine Efficiency Enhancements (Phase II)

This engine efficiency enhancement project consists of researching technologies to modify existing USMC vehicle engines to increase fuel efficiency. The project is endeavoring to reduce fuel use by modifying engines during refits, thus negating the need for new engine development, purchase, and installation and resulting in lower costs. In 2013 updated engine CAD models, optimized heat transfer equations, and worked on developing optimal stroke profiles for USMC diesel engines.

Variable Vehicle Cone Index (VCI) (Phase II)

The objective of this SBIR is to develop a system that will enable on-the-move monitoring of road conditions and automatically adjust tires to their optimal pressure, which will improve tire life, increase fuel efficiency, and maximize mobility on varying terrains. Two companies are developing separate methodologies to achieve VCI goals. Both were awarded Phase II SBIR funding to integrate their technology onto MTVRs.

Adaptive Diesel Engine Control (Phase I)

This SBIR program focuses on developing an innovative approach to modify existing MTVR Caterpillar C12 or similar engines to achieve higher levels of engine efficiency at low load conditions (idle or near idle operation). If program goals are achieved, a 15% decrease in fuel consumption for MTVRs could result.

Variable Ratio Cooling Fan Drive Accessory Drives (Phase II)

The objective of this Phase II research is to develop a variable ratio cooling fan drive for the MTVR. The MTVR currently utilizes 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.

Expeditionary Energy Office (E2O) Efforts

USMC Ground Vehicle Fuel Efficiency Scalability Study

Funded by the E2O office and completed in April 2013, this study investigated the feasibility of Auxiliary Power Units (APU) on USMC vehicles. One of the most intriguing preliminary results was that the integration of a 10 kW APU on LVSRs could result in $156 million in fuel savings with little operational impact. Although there are currently no plans to integrate more APUs on USMC vehicles, studies can inform future investments to increase vehicle fuel efficiency.

MTVR - APU Technology Demonstrator

The MTVR APU Demonstrator is a $600K E2O project designed for E2O's Experimental Forward Operating Base (ExFOB); it is being run through PM-Medium-Heavy and the SIAT Auto Cell. Currently, the project is producing five MTVRs with a series of APU sizes to evaluate the performance of various APU configurations. The goal is to increase static fuel efficiency by 30%.

MTVR Auxillary Power Unit Technology Demonstrator

5.1.2 Intelligent Power and Thermal Management

The Challenge

Inefficient electrical usage and poor thermal management can increase the logistics burden of deployed forces no matter how resourcefully the energy is produced per gallon of fuel. As tactical generators and on-board vehicle power sources produce energy more efficiently, technology must also advance to optimize how the power is used and the thermal variances must be controlled to enhance the overall energy capacity of expeditionary units. The following programs seek to improve the management, storage, and efficient use of energy following production and seek to improve deployed mission effectiveness and maximize utility from all operational energy sources.

Potential Solutions

PEO LS Efforts

Advanced Coatings for Non-Hermetic Low Cost G/ATOR T/R Modules (RIF)

This technology development project aims to deploy ceramic coating alternatives to hermetic packaging to achieve a projected 40% reduction in cost of the T/R modules for G/ATOR. An additional benefit will be suppression of 'tin whiskers' and corrosion to provide enhanced reliability and dependability. (Tin whiskers are electrically conductive, crystalline structures of tin that sometimes grow from surfaces where tin is used as a final finish.) This accelerated transition plan will adopt Atomic Layer Deposition (ALD) environmental coatings (ALD-Cap) and deploy production-ready ALD-Cap equipment into the manufacturing line of G/ATOR T/R modules.

Advanced Power Component Integration for Ground-Based, AESA Radar

The purpose of this ONR Rapid Innovation Fund effort is to enhance the power density and power efficiency of the air-cooled G/ATOR Micro Power Supplies (μPS.) By incorporating advanced Gallium Nitride (GaN) assembly and other component advancements, the project will achieve the same form, fit, and function of the line replaceable unit power module, while maintaining or improving unit production cost. The large numbers of μPS's in each G/ATOR will result in a substantial system-level advantage with a few percentage points increase in power efficiency per individual power supply.

ONR Efforts

G/ATOR Micro Power Supply Producibility/ Testability Enhancements & Cost Reductions

The purpose of this ONR effort is to effectively improve the producibility and testability of the Micro Power Supply (μPS) modules that are a key part of the ACAT IC program of record, G/ATOR. By improving the producibility and testability manufacturing process, the effort will facilitate achievable process time reductions and cost reductions. The transition will occur at the successful completion of Performance Qualification Testing of the G/ATOR Transmit/ Receive modules, which are powered by the μPS (4Q FY14.) The TIPS funding will allow savings of over $300 per module, with procurements and fielding of approximately 40,000 units beginning in FY14.

Ground Based Air Defense On the Move (GBAD OTM) – Future Naval Capability

This is a $39 million EC that demonstrates close-in, low altitude surface-to-air laser fire in defense of MAGTF. This EC will demonstrate the capability of a rugged, expeditionary, high energy laser, cued by radar, that is capable of detecting low radar cross section threats and capable of performing soft and hard kills of unmanned aerial systems (UAS).

This future naval capability will require a large power supply that could potentially be provided by a vehicle's APU or OBVP system. GBAD OTM is still in its first year, with proposals submitted against the BAA currently being reviewed, and the project is being staffed. PEO LS will be working closely with the FNC team to determine power requirements needed by the new laser system.

Additional ONR S&T projects that are of interest to PEO LS include:

- Energy Efficient Electronic Devices

SBIR Efforts

Atomic Layer Deposition Technology for Gallium Nitride Microwave Monolithic Integrated Circuits (Phase II)

This Phase II SBIR effort targets the development of a commercially viable silicon-nitride (SiN) ALD process for GaN Monolithic Microwave Integrated Circuit applications. The G/ATOR intends to transition to GaN integrated circuits as a cost reduction measure, and this effort will further reduce cost and increase reliability of the G/ATOR system. The atomic layer deposition process holds the key for affordable, reliable GaN MMICs and the potential for higher performing, higher efficiency, and lower cost military systems.

RDECOM & TARDEC Efforts

Hybrid Vehicle Testing Program

While hybrid military vehicles have been tested in multiple utility studies, this TARDEC program aims to quantify the reliability and durability of tactical vehicles with hybrid power supplies and on-board vehicle power. This study will address program concerns with advanced power technologies, including reliability, maintainability, and availability.

The US Navy shoots down a practice drone with its first ever deployed laser system onboard USS Dewey (DDG 105).

Embedded High Power Maturation

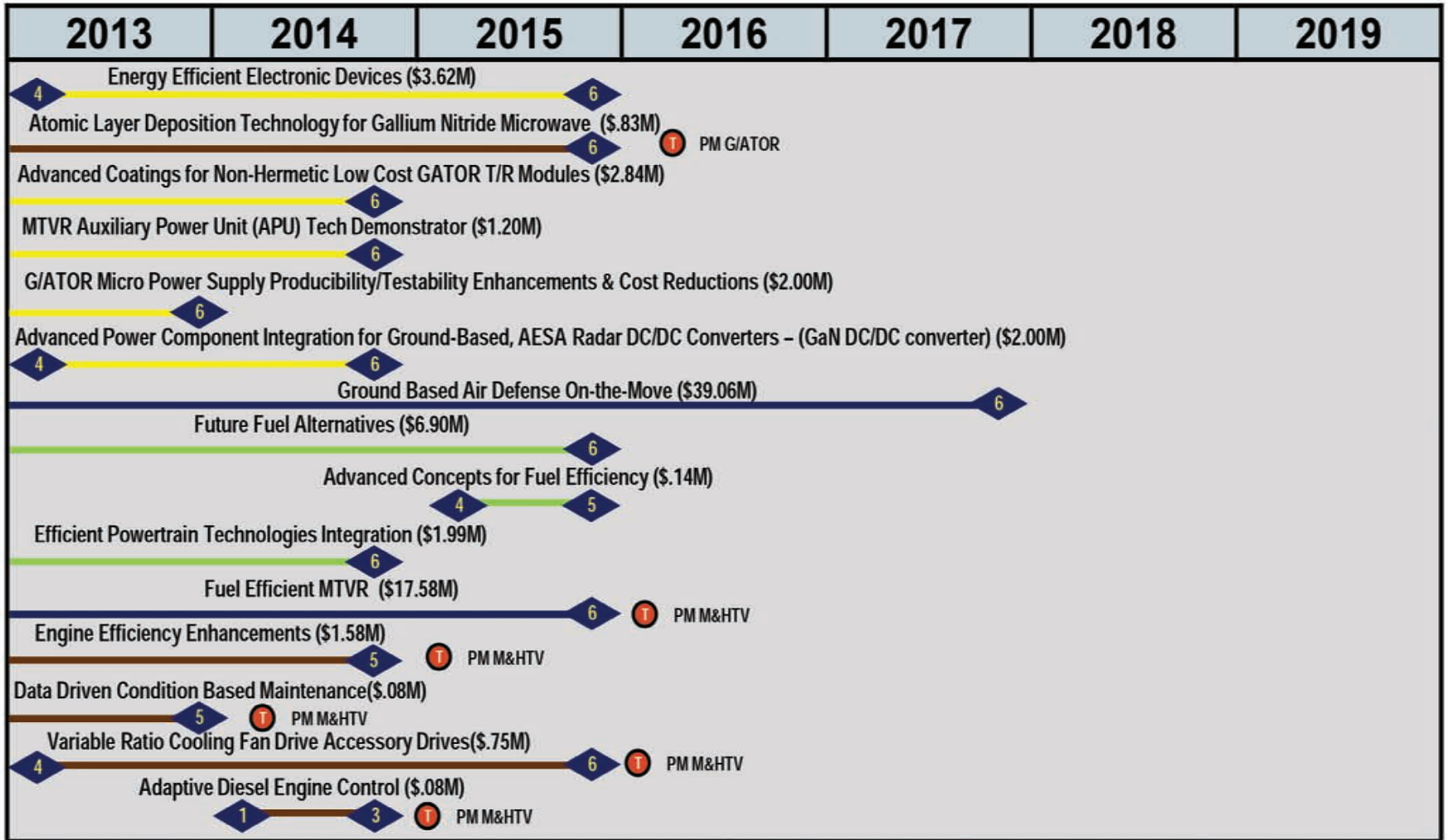
With ongoing advances in pulse power weapons and potential for electro-magnetic armor, TARDEC is developing a compact, modular, high power energy storage system to exploit these applications. The project's goal is to reduce power draw from the vehicle's electrical bus for high power equipment in a product whose volume is <15L and whose thickness is <20cm, and that is able to operate through extreme temperature and vibrations.

Additional RDECOM & TARDEC S&T projects that are of interest to PEO LS include:

- Fuel Cell In-House
- High Efficiency Truck Users Forum

The Power & Energy focus area charts on the following pages highlight critical efforts monitored and supported by the PEO LS S&T Director.

Power & Energy

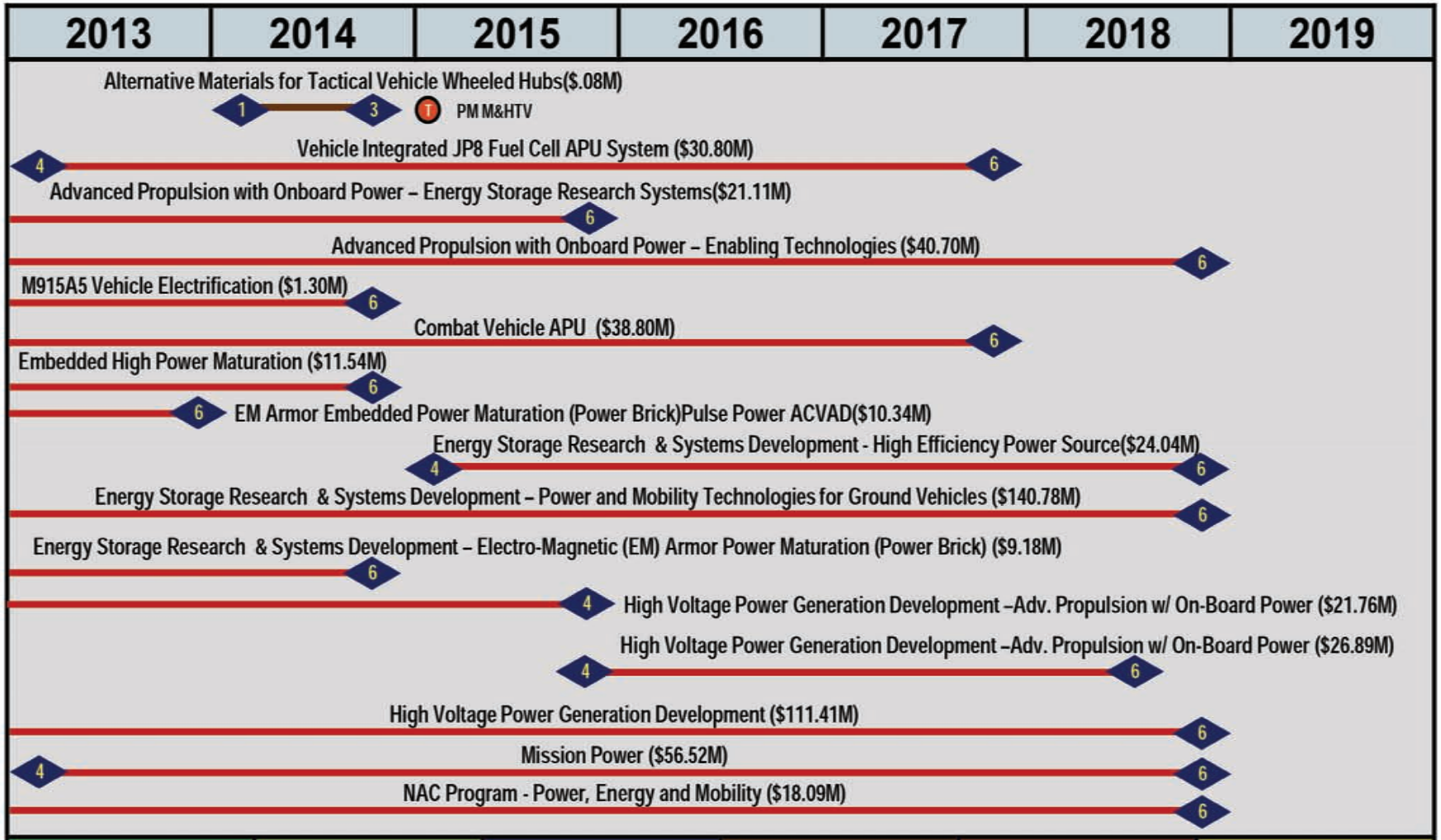


D&I	E&D	FNC	SBIR/STTR	TARDEC	Other

Funding Profiles ($M)	FY13	FY14	FY15	FY16	FY17	FY18	FY19
S&T (6.2 / 6.3)	22.14	21.13	15.14	6.00	5.81		

6.1 ⟷ Science & Technology ⟷ 6.3 6.4 ⟷ System Development ⟷ 6.7

Power & Energy

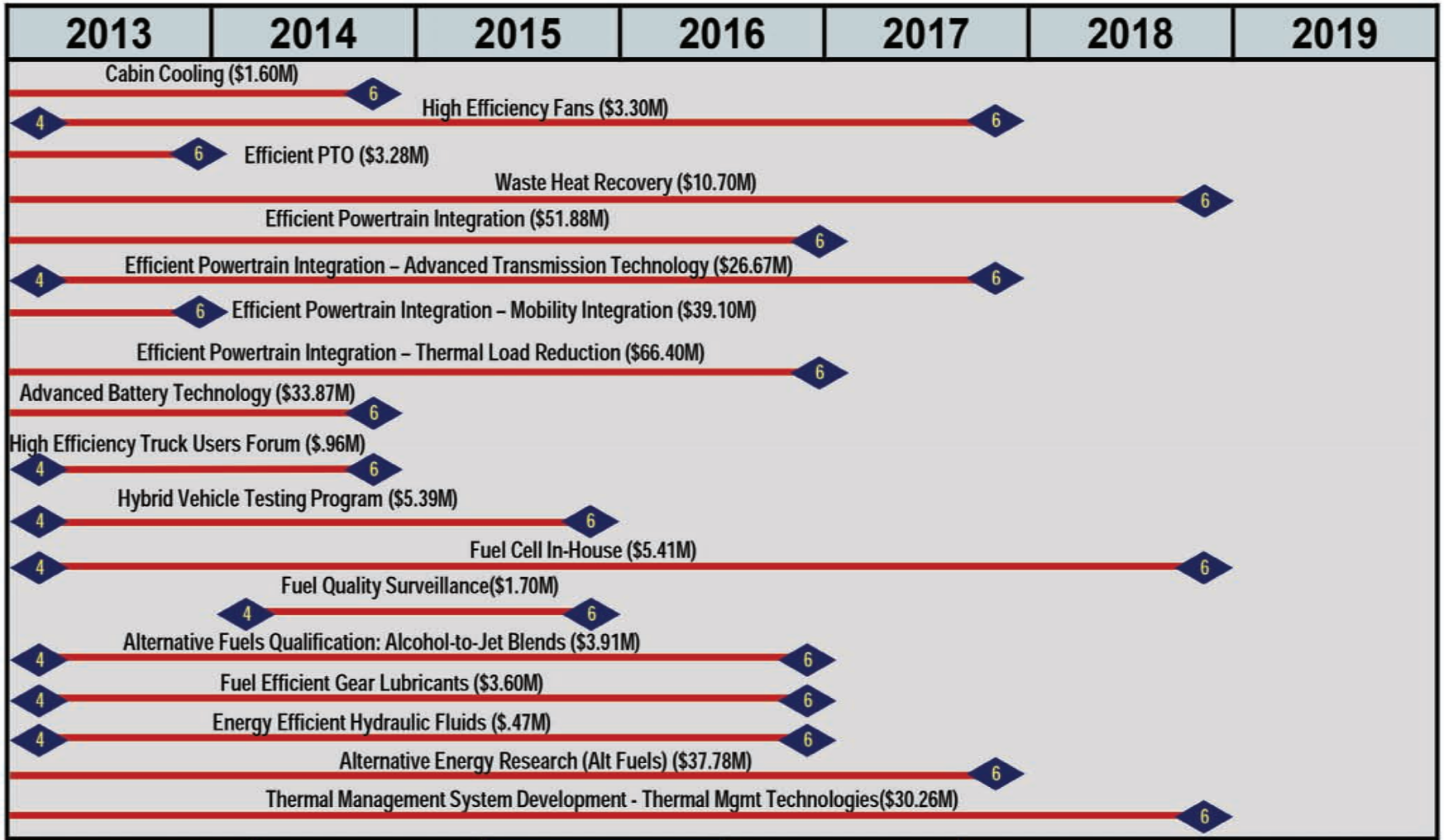


D&I	E&D	FNC	SBIR/STTR	TARDEC	Other

Funding Profiles ($M)	FY13	FY14	FY15	FY16	FY17	FY18	FY19
S&T (6.2 / 6.3)	80.14	75.83	80.97	79.34	85.19	77.07	

6.1 ← → Science & Technology ← → 6.3 6.4 ← → System Development ← → 6.7

Power & Energy



D&I | E&D | FNC | SBIR/STTR | TARDEC | Other

Funding Profiles ($M)	FY13	FY14	FY15	FY16	FY17	FY18	FY19
S&T (6.2 / 6.3)	56.92	38.16	42.53	41.05	25.68	1.50	

6.1 ⟷ Science & Technology ⟷ 6.3 | 6.4 ⟷ System Development ⟷ 6.7