Section 5.4 Focus Area

MODELING AND SIMULATION

PEO LS has a continuing requirement for the development of an integrated suite of non-proprietary multi-variable M&S tools that leverage existing ground vehicle simulation tools and enables modeling and simulation based acquisition and life cycle management of tactical ground vehicles to include cost data. The ultimate value of a fully integrated M&S toolset will be the ability to maximize the effectiveness of limited resources through Simulation Based Acquisition (SBA) while bringing optimized, focused capabilities to the Warfighter.

To shorten development time and reduce program risk/cost, computer-based simulation of the actual functions of tactical vehicle systems must be expanded. Currently, not enough components are accurately simulated and few are simulated together as a system (co-simulation).

A fully integrated SBA approach that incorporates co-simulation tools will:

- Enable "virtual" vehicle designs to be functionally tested on computers.
- Optimize vehicle prognostics and performance tools.
- Assess candidate vehicles against critical performance parameters.
- Inform the requirements process by identifying system requirements that are realistic and achievable.
- Inform Life Cycle Cost estimates and significantly reduce the total life cycle cost (LCC) of the system.
- Save money by reducing design and T/E costs over the long term.
- Perform high fidelity requirements trade-offs with accurate predictions of costs, schedule, and performance.
- Evaluate potential new technology insertions.

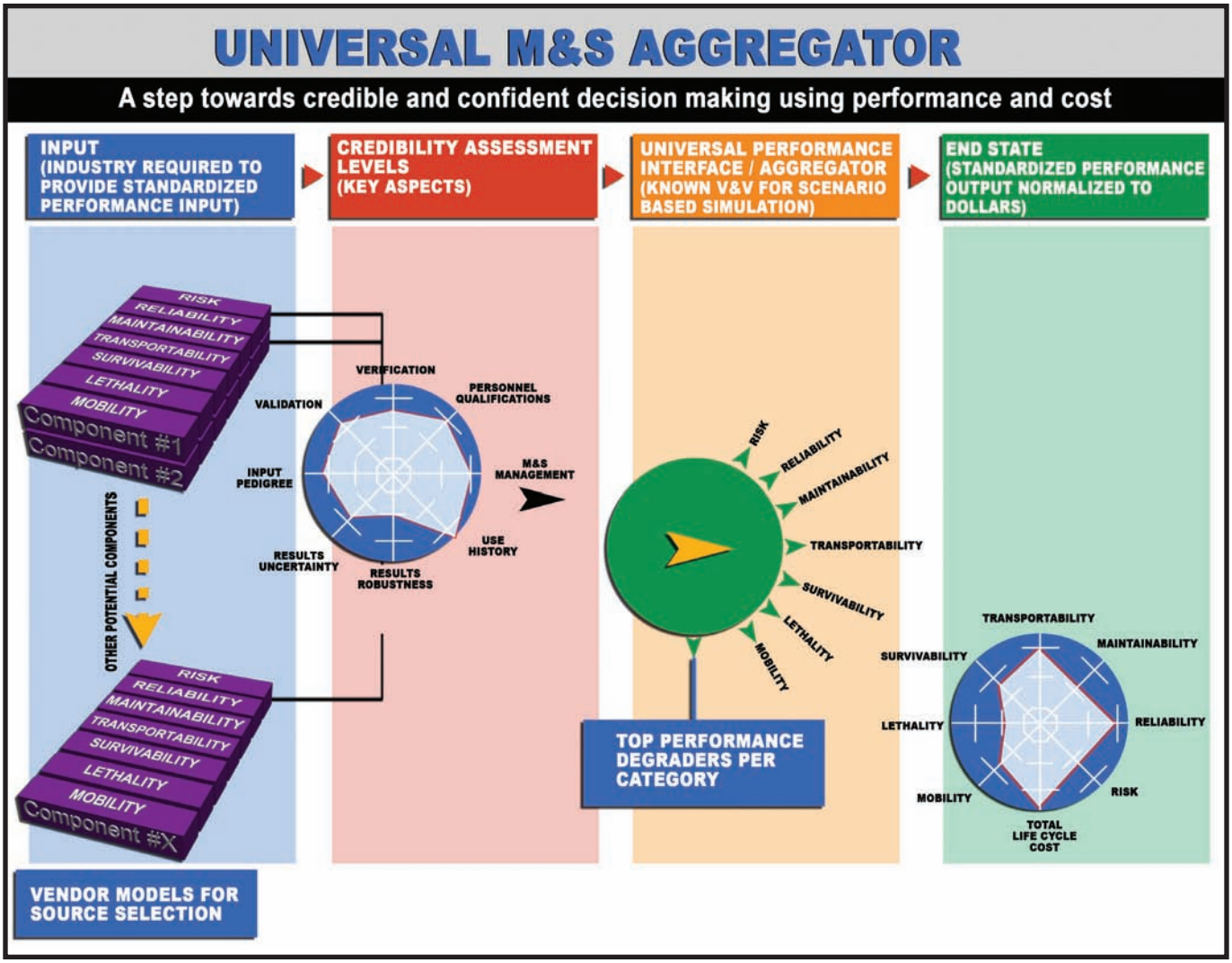
PEO LS Future M&S Vision

The Challenge

PEO LS has a need for a Universal Modeling and Simulation Aggregation tool that is accurate, verified, and validated. This tool will collect and aggregate component and platform data provided by industry for various vehicle systems/platforms, assess the aggregated data through scenario-based simulation, and provide normalized cost, schedule and performance output that will allow leadership to confidently assess the value of a proposed system or upgrade.

The development of a universal modeling and simulation aggregation tool will provide:

- A streamlined and standardized approach for assessing cost, schedule, and performance of future ground combat vehicles.
- A single integration tool capable of assessing multiple platforms and multiple configurations.
- A plug and play capability for upgrade or alternative component comparison as well as for future modernization programs.
- Utilizes requirement's based scenarios to assess Total Life Cycle Cost and performance for each platform and configuration.
- Establishes standardized interfaces for industry to design component models as well as establishing acceptable credibility



Universal M&S Aggregator

assessment levels for key design aspects.

- Provides decision making tools for acquisition leadership with a known confidence level.
- Reduces total ownership costs while maximizing limited S&T resources.

Shaping the Future M&S

Framework Assessing Cost Technology (FACT)

MCSC commissioned the development of the FACT (Figure 5.4-1) as a framework to tie together disparate component and platform modeling efforts. FACT is a modeling and simulation framework that enables real-time collaboration in a web environment; it is primarily geared towards conducting real-time trade space analysis for complex systems-of-systems. FACT uses Systems Modeling Language (SysML) to define complex systems. SysML expands upon the Unified Modeling Language (UML) and goes beyond software-centric design to include hardware components. The specification provides a formal means to describe a system, most notably the decomposition and organization of the system components as well as the parametric relationships between value properties distributed throughout the systems.

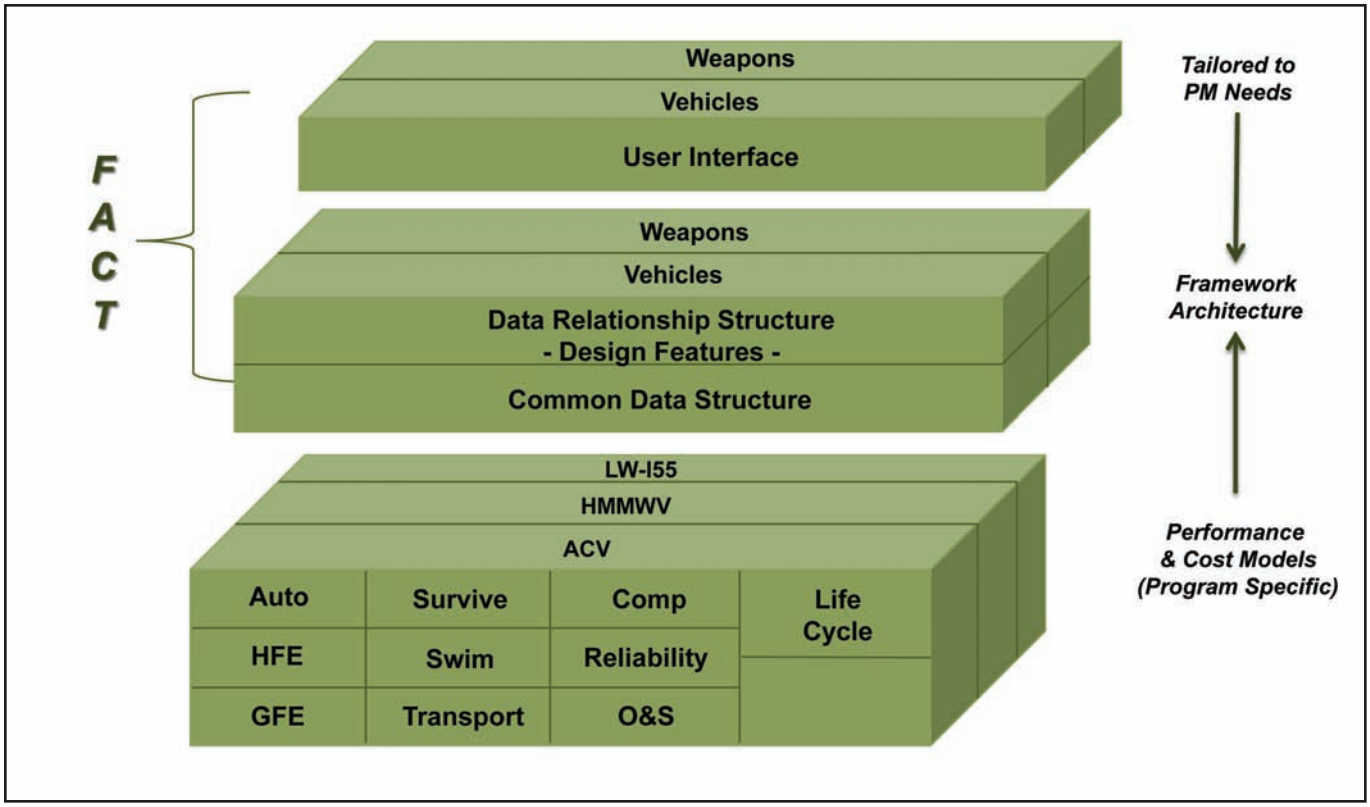


Figure 5.4-1. FACT Architecture

Focusing on the most pressing need and best possible ROI, the first applications of FACT were to the ACV 1.1 and the recapitalization program from the HMMWV, building heavily on prior work in support of the Marine Personnel Carrier (MPC) program.

HMMWV

One of the efforts within the FACT project is the development of a high fidelity HMMWV trade space model that will provide a foundation for a general design tool for light tactical vehicles. The objective of this effort is to provide a framework for integrating numerous models, assess the fidelity of current models and evaluate the available trade space.

ACV 1.1/AAV

Program Manager Advanced Amphibious Assault (PM AAA) received delivery of the FACT toolkit in February 2012 to conduct analysis on thresholds delineated in the Capability Development Document (CDD) for the ACV 1.1 program. The tool provides the Program Manager with an understanding of the possible trade-offs where further investment may result in enhanced capability.

Lightweight 155 Howitzer (LW-155)

The LW-155 FACT initiative is endeavoring to break new ground in trade space modeling. This will be the first time the FACT M&S toolkit is used on a weapons system vice a tactical wheeled vehicle. In addition, it will be venturing beyond the conceptual design efforts already attempted and into the engineering and manufacturing phases of a fielded system. The objectives of this initiative are:

- Increase the strength (reliability) of the re-engineered components and the system as a whole.
- Decrease the Mean Time Between Repair (MTBR).

- Decrease the cost of repair parts.
- Increase system availability.
- Open competition for manufacturing repair parts to domestic sources of supply (potentially including government fabrication).

Ongoing M&S Efforts

JLTV Blast M&S

The objective of this effort is to develop and execute a physics-based model able to account for both soil/structure interaction and gross vehicle response. CORVID Technologies will be preparing high fidelity models for the JLTV Program. The under body (UB) blast M&S efforts will:

- Provide the Joint Project Office (JPO) insight into force protection levels (initially from a structural standpoint and evolving to a crew response standpoint);
- Support engineering design analyses and modifications; and
- Provide supplemental information to support key performance parameter (KPP) analyses. The JPO also plans to use M&S for future evaluations of vehicle design modifications and Engineering Change Proposals (ECP).

Potential Solutions

ONR Efforts

ONR has a broad mix of projects, many focused on ground vehicle programs, which adds to the development of a comprehensive suite of M&S tools for the Marine Corps.

Energy Absorbing Structures for Blast Mitigation Light Tactical Vehicles

The objective of this effort is to develop lightweight energy absorbing structures for incorporation into Marine Corps ground systems to enhance occupant survivability. The project includes a review of potential energy absorbing structures for incident angles; computational evaluation of design parameters for selected mechanisms; LS-DYNA simulations of standoff; hull shape, energy absorber characteristics; manufacture and test of selected energy absorbing mechanisms into a prototype; and then blast tests to validate the modeling and utility of the selected design. Focus has been on designing a surrogate V-hull to be compatible with use of Energy Absorbers (EA) for the light tactical vehicle design.

Survivability Analysis of Alternatives Tool

The purpose of this effort is to develop an M&S tool that is capable of supporting Survivability Analysis of Alternatives (AoA) for crew survivability technologies. The goal of this model is to inform early stage vehicle design with outcome-based survivability choices. This will provide useful insight into balancing the allocation of weight between Under Belly Blast (UBB) protection and other protection features and help inform the selection of key performance parameters for crew survivability.

M&S of Advanced Armor Systems

The objective of this effort is to increase the fidelity concerning innovative armor predictive modeling and simulation tools. The ultimate aim is to provide designers and engineers with the ability to accurately model new armor designs and constructions.

Human Surrogate Development

Johns Hopkins University Applied Physics Laboratory is working to develop a human surrogate model of the brain to study the mechanisms that cause traumatic brain injuries and to discover innovative ways to mitigate the blast trauma.

Composite Armor Modeling and Optimization

This modeling effort is designed to determine if sub-component (fiber, resin, and weave) contributions of today's Fiber Reinforced Plastic (FRP) composite armor can be adequately represented through numerical modeling and validate models against physical test data. The final product will accurately

model new FRP armor compositions at reduced development costs.

Novel Ceramic Armor Configuration Modeling
Develop an accurate model to predict measurements of penetrator induced shock loads in ceramic armor.

Incapacitation Prediction for Readiness in Expeditionary Domains: an Integrated Computational Tool (I PREDICT)
The goal of this Enabling Capability (EC) is to provide an integrated, physiologically-relevant human body model and associated software tools that will predict injury outcomes in response to specific stressors (ballistic, blast/acceleration, vibration and blunt traumas). The model will be based on material properties of human tissues and experimentally derived strain rates. This tool will also provide injury mitigation planning capabilities under varying personal protective equipment (PPE) and in response to multiple physical stressors. The preliminary design and testing can be performed using I PREDICT, resulting in cost savings and better products with consideration for engineering trade-offs (e.g., weight vs. mobility) and anthropometry.

Material Characterization of EA Material for Blast Modeling
Testing to determine material models to be used to define EA component response in blast modeling. Components to be modeled include seat EAs, cushions, and blast mats.

TARDEC Efforts

OCP M&S
The Occupant Centric Platform (OCP) TECD seeks to identify, develop, and integrate technologies that will protect occupants of ground vehicle systems from underbody (UB) threats, crashes and rollovers and maintain or improve the mobility of the vehicle system and reduce the weight for that protection. The OCP TECD accomplishes this by addressing gaps in occupant protection standards; tools and techniques to research blast, crash and rollover mitigation capabilities; ground vehicle interior technologies for protection of occupants; and ground vehicle exterior technologies for mitigation effects of underbody blast events. This allows OCP TECD to provide soldiers/Marines and ground vehicle platforms with affordable and relatively easily manufactured survivability solutions against known and anticipated threats within specified programmatic requirements. M&S initiatives include:

- Exterior Protection: Develop protection designs, supplemented by advanced material and manufacturing solutions that provide optimized protection for the occupant to the full spectrum of underbody threats (blast and penetrator).
- Interaction of Sub-Systems: Develop a detailed understanding of the interaction of fidelity of each sub-model of an end-to-end underbody event simulation.
- Threat Loading: A detailed understanding of loading applied to a vehicle (and subsequently to the occupant) from all relevant UB threats.
- Structural/Material Response: Foundation for the development of a Material Specification for Formidable, Weldable Blast Resistant Materials by investigating material and structure processing-property relationships.

Threat Oriented Survivability Optimization Model (TOSOM) Improvements
TOSOM will provide optimized software with quantifiable metrics to assist in the streamlining of the concept definition phase for new programs. This streamlining will be accomplished through advanced and innovative capabilities to perform system level trades using a mathematical assessment of the benefits and burdens of both traditional and non-traditional survivability technologies in the development of survivability options for vehicle platforms. Some of the models being developed include:

- Soldier Vehicle Blast Protection: This component of TOSOM was developed to provide a detailed analysis of the impact of underbody blasts on the military's ground vehicle fleet. The tool takes into account system-wide evaluation of the detonations' effects on ground vehicles, providing a comprehensive view of a range of variables.
- Survivability Analysis and Optimization: A component of TOSOM instrumental in performing rapid turnaround, first order analyses of survivability trade-offs in the design or modernization of military systems.

SBIR Efforts

Mitigation of Blast Injuries through M&S (Reaction Engineering and Protection Engineering)

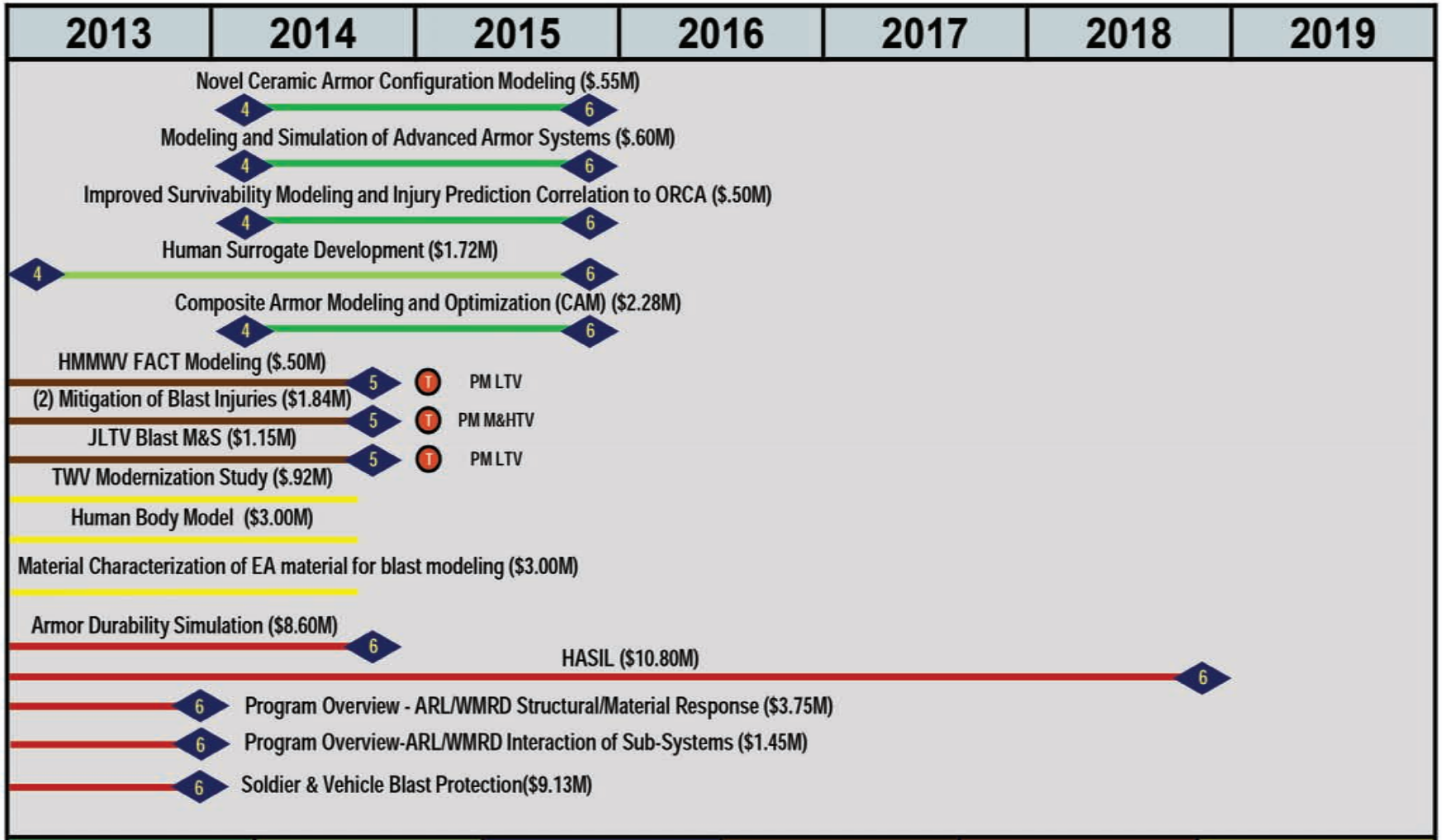
The objective of this SBIR effort is to investigate the effect of non-centerline buried IED/mine explosives used against military vehicles and to develop a physics-based model that will assist in the design of safety components. The proposed effort builds upon previous work performed under a U.S. Army funded program and will develop next-generation simulation capabilities to better predict the effects of buried explosives on ground vehicles and occupants. Blast and soil modeling will be performed using advanced simulation tools developed as part of the DoE ASCI program at the University of Utah, and the vehicles will be modeled with the LS-DYNA FE code. Occupant modeling will be performed using LS-DYNA. The final product of the Phase II will be a micro-coupled MPMICE-LS-DYNA model, that leverages the best capabilities of each simulation tool. Comparisons will be made between simulations of the MTVR exposed to a buried threat and live-fire test data for the same configuration.

Software for First Order Affects (FOA) of Blast & Ballistic Impact on Vehicles

This Phase 1 SBIR effort, in support of PM AAA, is developing a series of fast-running algorithms to improve the time to analyze first order screening of armor based solutions for tactical vehicles. Current trends in vehicle survivability are directed towards a base armor with modular appliqué systems available for increased protection geared towards specific threats. This survivability trend allows for a myriad of configurations, which is a drawback in using the state of the art finite element software. Currently, finite element software requires days to weeks to develop a model and require an hour to complete one basic configuration. This software is to be used as a design tool able to execute multiple iterations i.e. armor configurations on a desktop or laptop computer and should include the acceleration effects to the vehicle in a short time period compared to 6 finite element analyses.

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

Modeling and Simulation

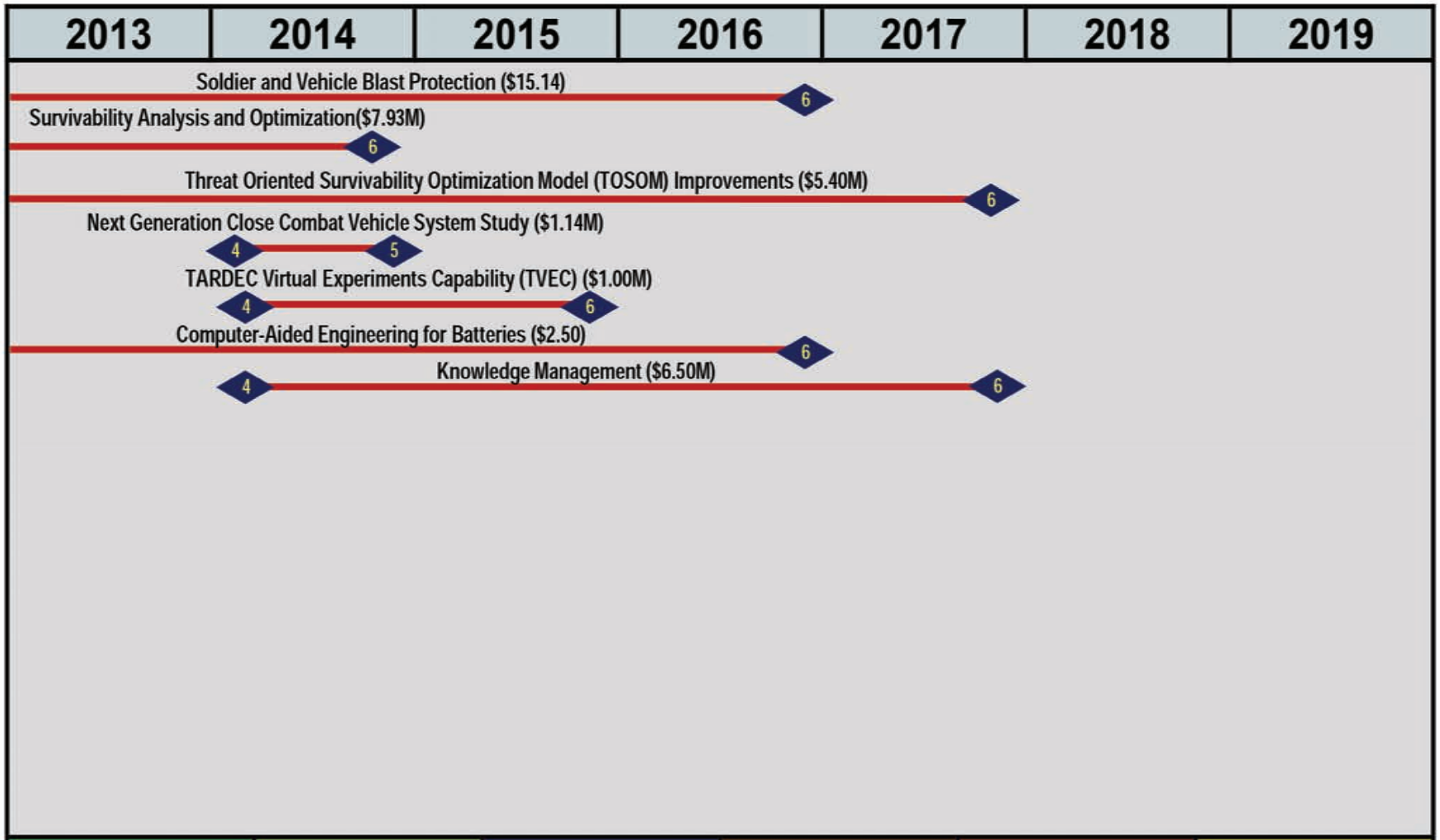


D&I	E&D	FNC	SBIR/STTR	TARDEC	Other

Funding Profiles ($M)	FY13	FY14	FY15	FY16	FY17	FY18	FY19
S&T (6.2 / 6.3)	14.69	11.00	3.15	1.00	1.00	5.00	

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

Modeling and Simulation



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)	4.75	12.06	9.08	7.18	1.20		

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