

MODELING AND SIMULATION

PEO Land Systems Marine Corps has a continuing requirement for the development of an integrated suite of non-proprietary multi-variable modeling and simulation (M&S) tools. These tools must leverage existing ground vehicle simulation tools and enables M&S based acquisition and lifecycle 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.

Computer-based simulation of the actual functions of tactical vehicle systems must be expanded in order to shorten development time and reduce program risk/cost. 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 (LCC) estimates and significantly reduce the total LCC of the system.
- ▶ Save money by reducing design as well as test and evaluations costs.

- ▶ Allow high fidelity requirements trade-offs with accurate predictions of costs, schedule, and performance (CSP).
- ▶ Evaluate potential new technology insertions and their effects on CSP.

6.3.1 PEO LS Future M&S Vision

The Challenge

PEO LS has a need for a universal M&S 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 CSP output that will allow leadership to confidently assess the value of a proposed system or upgrade (See Figure 6.3-1).

The development of a universal M&S aggregation tool will provide:

- ▶ A streamlined and standardized approach for assessing CSP of future GCVs and proposed upgrades/modifications.
- ▶ A single integration tool capable of assessing multiple platforms and multiple configurations.
- ▶ Allows plug and play capability for upgrade or alternative component comparison, as well as future modernization programs.
- ▶ Utilizes requirement's based scenarios to assess total LCC and performance for each platform/configuration and upgrade.
- ▶ Establishes standardized interfaces for

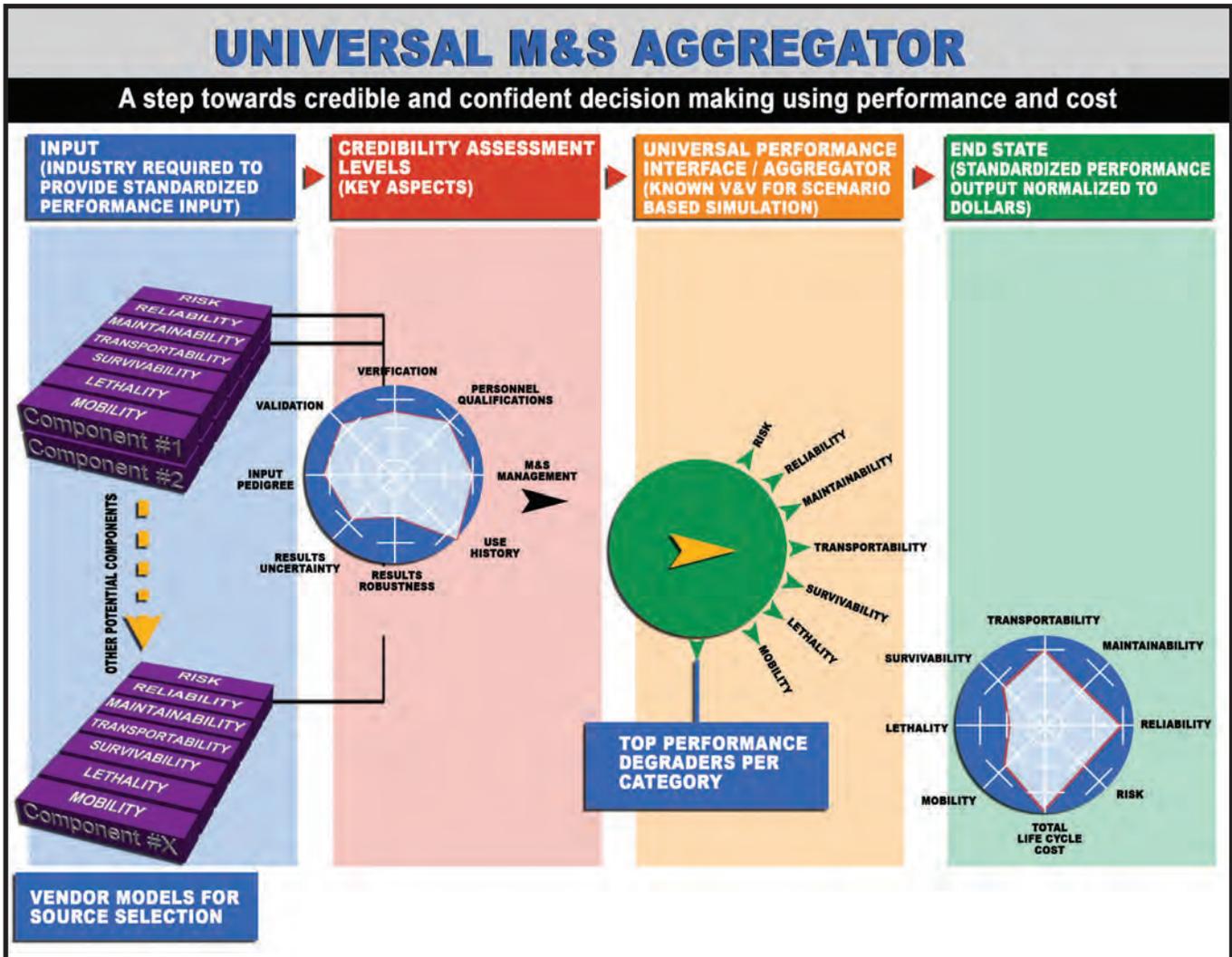


Figure 6.3-1. Universal M&S Aggregator

industry to design component models as well as establishing acceptable credibility 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.

6.3.2 Shaping the Future M&S

Framework Assessing Cost Technology (FACT)

MCSC commissioned the development of FACT (Figure 6.3-2) as a framework to tie together disparate component and platform modeling efforts. FACT is

a M&S framework, enabling real-time collaboration in a web environment, 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 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.

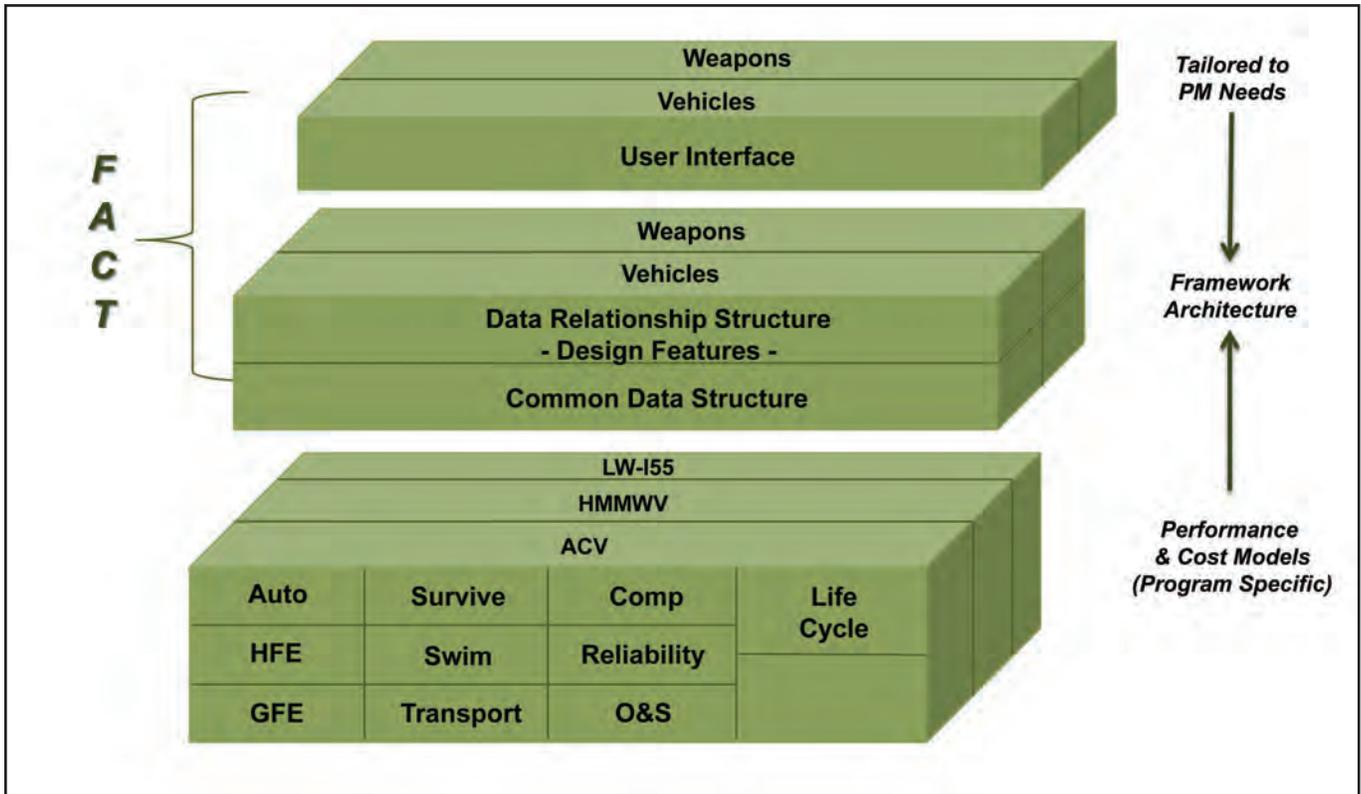


Figure 6.3-2. FACT Architecture

ACV/AAV

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

6.3.3 Ongoing M&S Efforts

AAV Survivability Upgrade M&S

Utilizing high fidelity computational physics-based M&S of blast events; the AAV Survivability Upgrade vendor designs are being evaluated against performance requirements, prior to contract award decisions.

Human Body Model

Current ATDs used to predict human injury risk in live fire blast testing have several limitations,

mainly due to a lack of biofidelity and limited injury assessment capability. The ATD is comprised of metals, rubbers, and plastics, and the majority of injury metrics associated with the ATD were developed under automotive crash loading scenarios.

Development of a human body model is underway; leveraging the recent advances in high fidelity computational physics-based M&S of explosive events against armored vehicles. This major advancement in the ability to accurately predict human injury risk will allow vehicle designers and evaluators to predict risk of injuries across the severity spectrum experienced in the real world, supplement ATD results with prediction of injuries beyond fracture, expand injury risk assessments beyond the 50th% male and support theater event reconstruction and deliver injury causation determination. Beyond the scope of the PEO LS effort focused on injury prediction in IED events, this model could be utilized in the areas of ballistic protection, blast overpressure, burn injuries, and

non-lethal munitions.

Post IED Damage SBIR

Following a vehicle IED event, it is critical to make informed, accurate decisions for damage assessment and repair. Unnecessary repairs lead to vehicle downtime and wasted maintenance manpower. Conversely, the reintroduction into service of a vehicle with significant internal damage, unseen through visual inspection alone, can put warfighters at higher risk for injury or death.

Two companies are currently in Phase II of SBIR contracts to develop the capability to systematically gather and store data from the vehicle and scene post event and then process this data into a format that allows the vehicle Program Management Office (PMO) to assess risk of repair vs redeployment.

SURVICE is developing an integrated, low-cost ruggedized, and portable tablet-based 3D capture tool kit to guide and facilitate the assessment of battle damage to combat vehicle platforms.

Tool to include:

- ▶ Development and integration of ruggedized, low-cost indoor/outdoor 3D scanning technology.
- ▶ Procedural forms and checklists.
- ▶ Photo and video documentation.
- ▶ Expandable framework to incorporate other NDI technologies.

CORVID TECHNOLOGIES is developing Battle Damage Assessment Visualizer (BDAV) software which is run on ultra-portable devices and allows quick time access to a database incorporating hundreds of IED and multi IED-event scenarios. By comparing the damage produced by the incident to a database of simulated vehicle damage, the software determines the closest match and calculates the risk of redeploying vs repairing the vehicle structure.

The tool will also allow for event-reconstruction, identifying the most likely threat scenario that led to the damage. An alternative to visual-only inspection, BDAV provides a more data driven, consistent way to determine vehicle repair levels required, lowering risk to the warfighter while simultaneously reducing unnecessary vehicle downtime. BDAV software relies on robust surface capture and data storage capability being developed under this same SBIR topic.

High Fidelity Computational Physics Blast Modeling Improvements

Utilizing FY2103 Rapid Innovation Funds, further development of high fidelity computational physics-based methods, tools, and models is on-going. The capability to model explosively formed penetrator (EFP), fragmenting IED, and littoral mine threats will be developed under this effort. Additionally, research will be conducted to allow for improvements to the already well-established underbody mine and IED vs armored vehicle simulation capability. Improvements will be seen in material models of soils and a progressive damage model for structural composite materials will be developed. These capabilities will allow improved M&S support to survivability improvement initiatives and aid in the design and evaluation processes required to meet occupant centric protection objectives.

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 has prepared high fidelity models for the JLTV Program. The UBB 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 (ECPs).

Additional M&S projects supporting PEO LS include:

- ▶ Tactical Wheeled Vehicle (TWV) Modernization Study is the development of a plan that synchronizes the strategies and actions involved in lifecycle management of USMC TWV requirements, procurement, integration, sustainment, and management.
- ▶ Material Characterization of Energy Absorbers (EA) material for blast modeling which is 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.
- ▶ Light Tactical Vehicle Technology Advancement Rapid Innovation Fund. Improved design methods and simulation tools will enable optimum performance, reduce expensive “trial and error” tests, and result in lighter, more survivable and cost effective vehicles.

Potential Solutions

ONR Efforts

ONR has a broad mix of projects, many focused on ground vehicle programs, which add 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 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 EA for the light tactical vehicle design. The intent is to develop and demonstrate the use of Energy Absorbing structures mounted between the blast hull and the crew compartment of a general class of tactical vehicles (5 – 15 ton) that substantially mitigates crew injuries.

Detection Avoidance Material and M&S Development

This effort will investigate materials and develop improved M&S for advanced camouflage application.

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 US 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 Department of Energy, Accelerated Strategic Computing Initiative 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, which leverages the best capabilities of each simulation tool. Comparisons will be made between simulations of

the MTRV exposed to a buried threat and live-fire test data for the same configuration.

TARDEC Efforts

Virtual Experiments Capability (VEC)

Will develop a process for modeling innovative TARDEC technologies and inserting them into the Army Capabilities Integration Center (ARCIC) lead Early Synthetic Prototyping (ESP) environment. ESP is an ARCIC led effort to develop a persistent video game environment Soldiers want to play and allows researchers to evaluate emerging military technologies.

Far Term Advanced Capability Development (FAVCAD)

The majority of Army S&T technologists are focused on CVP (near to mid-term). Some are engaged with U.S. Army's Training & Doctrine Command (TRADOC) 2025 but at the individual technology level and not the platform level (mid term). TRADOC is now starting to look into far term operational needs. TARDEC with its Next Gen study is delivering representative Far Term platform concepts integrating RDECOM S&T (technologies and platforms).

Warrior Injury Assessment Manikin (WIAMan)

This project will conduct cadaveric research to establish a scientific and statistical basis for evaluating skeletal injuries to occupants during Under Body Blast events. WIAMan will also develop an improved blast test manikin that incorporates the medical research which provides an increased capability to measure and predict skeletal occupant injury during UBB events.

Modular Active Protection System (MAPS)

MAPS will allow commonality across the vehicle fleet, tailoring of systems to meet PM needs, and platform constraints, provide growth capability to address emerging threats and facilitate transition.

Affordable Lightweight Materials/Structures

This effort will demonstrate best practices in cost-conscious, multi-material design for structures to reduce ground vehicle weight. This effort utilizes and evaluates design tools, advanced materials, manufacturing, and assembly technologies to develop a lightweight structure and enhance core competencies. Support a demonstrator weight savings of ~20-30% over GCV's baseline. Evaluate the current technical capability of the material supply chain.

Combat Vehicle Program PMO

The CVP Mission is to execute a five year Ground Vehicle technology development program that delivers a portfolio of leap ahead technologies at TRL 6 by FY19 to the Army and can be integrated and demonstrated on a prototype platform by FY21. The CVP Vision is to develop ground vehicle leap-ahead technologies that ensure the Warfighter maintains its overwhelming ground combat superiority against any enemy worldwide.

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

