4.4 Modeling and Simulation

Bottom Line Up Front	
Challenge	
As resources tighten in the Department of Defense but performance demands for tactical vehicles increase, a ground tactical vehicle modeling and simulation "systems engineering" suite of tools that will enable M&S based development, acquisition, and lifecycle management is required. The objective of this focus area is to develop a model to address top priority program technical issues and provide a fully integrated, "turn-key" system that can be operated by Government personnel (without additional support) and eventually be expanded to support all tactical wheeled vehicles within the United States Marine Corps (USMC).	
Potential Solutions	
PEO LS / MCSC	MPC JLTV Systems Engineering Toolkit
ONR	Military Driving Cycle Composite Armor Modeling and Optimization Human Surrogate Development Improved Survivability Modeling and Injury Prediction Correlation to ORCA Modeling and Simulation of Advanced Armor Systems Novel Ceramic Armor Configuration Modeling
SBIR	Mitigation of Blast Injuries through M&S Innovative manufacturing research on forming of large light armor alloy sections resistant to blast and penetration. Linguistic Geometry Based Predictive Technology for Simulation and Training
TARDEC	DADS, Nato Reference Mobility Model GT Power, Star, Multi-Service Electro-Optics Signature Nastran, nCode Fatigue LS-DYNA, Mathmatical Dynmaic Models Cooling System Evaluation Tool Armor Durability Simulation Hit Avoidance SIL Ground Systems Survivability Head Impact Protection SIL Multi-Axis Blast Simulator Threat Oriented Survivability Optimization Model Lightweight Armor Evaluation Process Linear Impact Sled WIAMan Warrior Injury Manikin and Assessment Framework

Potential Solutions

PEO LS is actively engaged with ONR, MCSC, US Army (RDECOM-TARDEC), DARPA and various Industry partners and other agencies to address the Marine Corps' M&S challenges. To date, M&S efforts for Tactical Wheeled Vehicles have not been fully integrated to provide a "total systems" approach. Previous M&S work with a "Systems Engineering" focus includes:

Marine Personnel Carrier (MPC) Vehicle Performance Generation Tool. A suite of interactive systems engineering tools to support decision makers in defining vehicle specifications. The requirements optimization process allows multiple vehicle subsystems to be varied concurrently while assessing differing vehicle performance attributes, such as power train performance, vehicle dynamics, human factors and transportability.

JLTV Systems Engineering Toolkit (Penn State University). Developing common M&S requirements for an acquisition model for JLTV. Developing a Systems Engineering Toolkit for the JLTV program allowed for the exploration of vehicle performance parameters versus vehicle acquisition cost and weight.

FACTS (Flexible AC Transmission Systems) Power network modeling and simulation. These are M&S tools to model this new power transfer, controllability, and stability technology. A new technology based on power electronics -- offers an opportunity to enhance controllability, stability, and power transfer capability of AC transmission systems.

ONR Efforts

Military Driving Cycle. Utilizes a subset of logistics data from the Embedded Platform Logistics System to characterize the terrain and system state of Marine Corps vehicles during high fuel consuming operational scenarios. This effort concluded in FY11 but follow on work will be driven by the Fuel Efficient MTVR FNC.

Composite Armor Modeling and Optimization. This is an ongoing effort with Battelle Institute funded through FY14. The objective of this program is to develop advanced analytical models and designing tools for innovative composite structures for armored vehicles to protect against antitank landmines and Improvised Explosive Devices (IEDs).

Human Surrogate Development. ONR and JHU APL effort to develop state-of-the-art human surrogates to understand how the brain is affected by blast trauma, and to discover novel ways to protect warriors from debilitating Traumatic Brain Injury.

Improved Survivability Modeling and Injury Prediction Correlation to ORCA. This is an FY13 new start designed to review the ORCA blast module in order to determine which changes and additions should be made to improve and expand its capabilities.

Modeling and Simulation of Advanced Armor Systems. This is an FY13 new start program and may align well with the active RDECOM effort to build more accurate predictive modeling and simulation tools focused models (i.e., ceramic crack propagation). This will address the need to define attainable model/simulation goals and would have value to designers/integrators of armor materials systems.

Novel Ceramic Armor Configuration Modeling. This is an FY13 new start that will develop and apply a novel concept to measure penetrator induced shock loads in ceramic armor.

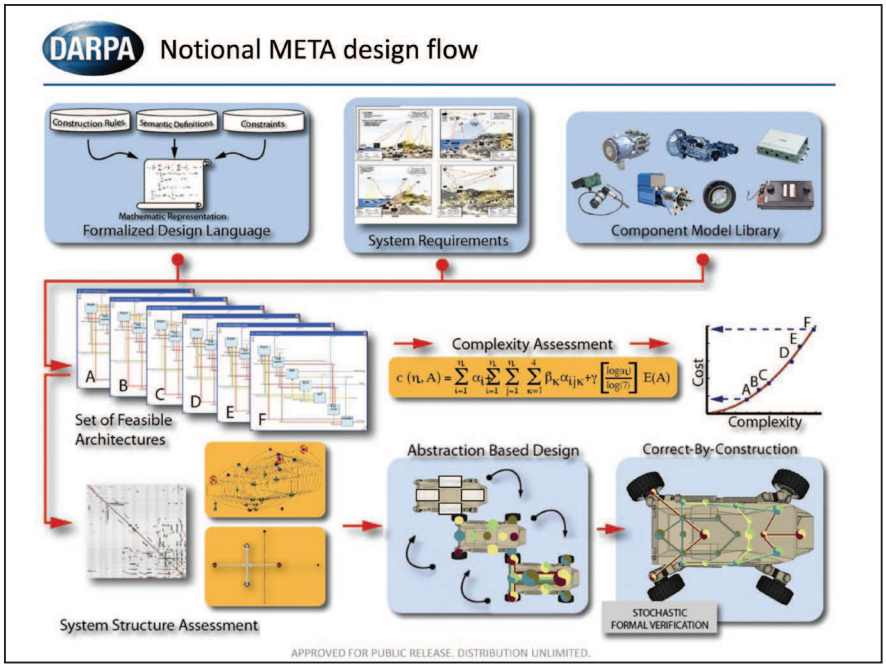
DARPA Efforts

DARPA Advanced Vehicle Make (AVM). The AVM effort is a portfolio of programs addressing revolutionary approaches to the design, verification and manufacturing of complex defense systems and vehicles. The portfolio consists of three primary programs: META, Instant Foundry Adaptive through Bits (IFAB) and Fast Adaptable Next-Generation Ground Vehicle (FANG).

The META program is meant to dramatically improve the existing systems engineering, integration, and testing process for defense systems. META is not predicated on one particular alternative approach, metric, technique or tool. However, in a broad sense, it aims to develop model-based design methods for cyber-physical systems far more complex and heterogeneous than those to which such methods are applied today.

The top-level technical objectives of the META program are as follows:

- Develop a practical, observable metric of complexity for cyber-physical systems to enable cyber-vs-physical implementation trades and to improve parametrization of cost and schedule;
- Develop a quantitative metric of adaptability associated with a given system architecture support trade-offs between adaptability, complexity, performance, cost, schedule, risk, and other system attributes;
- Develop a structured design flow employing hierarchical abstraction and model-based composition of electromechanical and software components;
- Develop a component and manufacturing model library for a given airborne or ground vehicle systems domain through extensive characterization of desirable and spurious interactions, dynamics, and properties of all constituent components down to the numbered part level; develop context models to reflect various operational environments;
- Develop a verification flow that generates probabilistic "certificates of correctness" for the entire cyber-physical system based on stochastic formal methods, scaling linearly with problem size;
- Apply the above framework and toolset to design, manufacture, integrate, and verify a ground vehicle of substantial complexity 5X faster than with a conventional design/build/test approach.



TARDEC Efforts

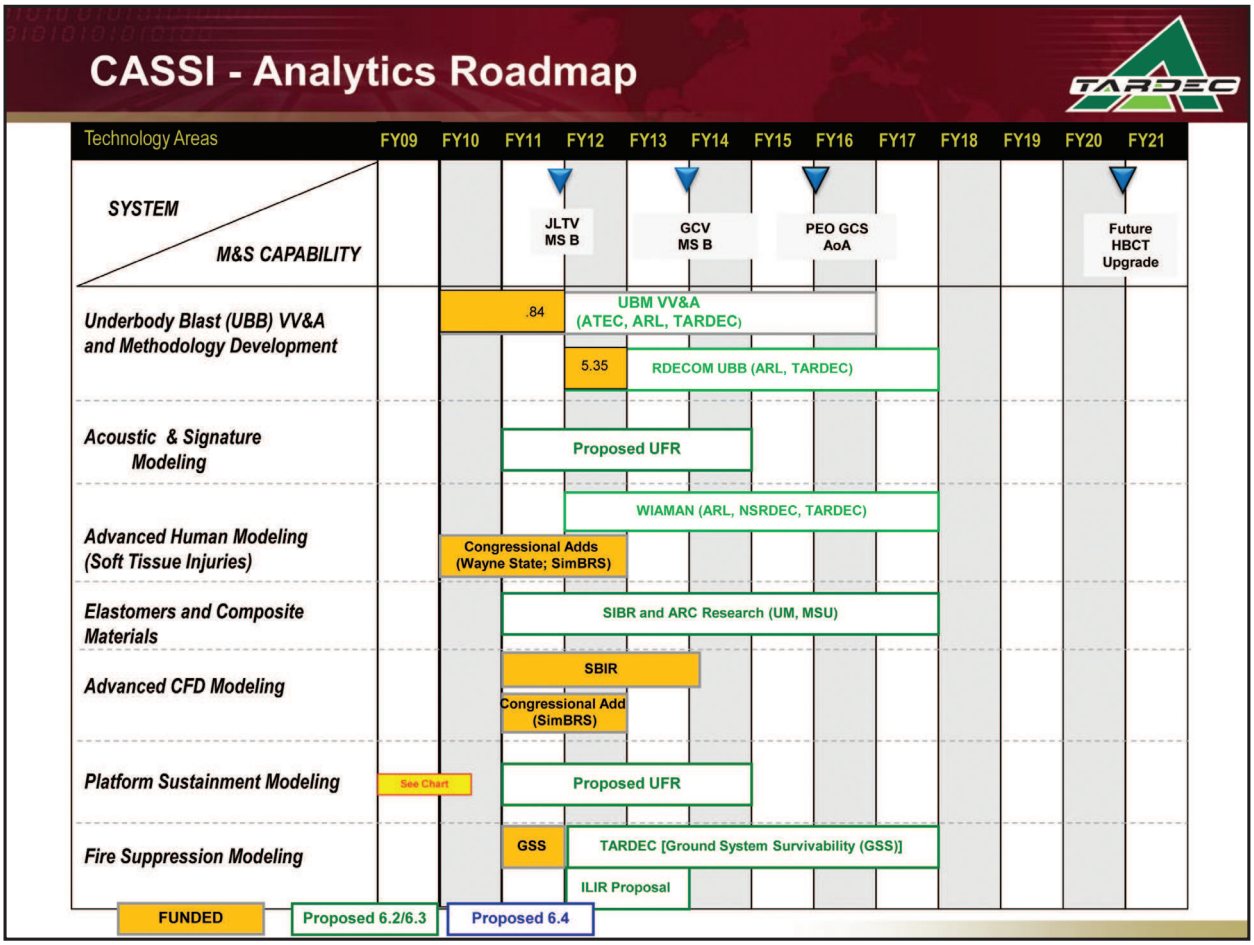


Figure 5-CASSi Analytics Plan

TARDEC has a number of M&S efforts within the Concepts, Analysis, Systems, Simulations, and Integrations (CASSI) program that include:

DADS, Nato Reference Mobility Model - Multi-body Vehicle Dynamics

- Automotive Performance and Mobility Prediction

GT Power, Star, Multi-Service Electro-Optics Signature - Computational Fluid Dynamics

- Thermal and Aerodynamic Analysis

Nastran, nCode Fatigue - Durability, Stress & Fatigue

LS-DYNA, Mathmatical Dynmaic Models - Predictive Analysis of Blast Events

- Finite Element Analysis
- Structural integrity analysis in a blast event

Cooling System Evaluation Tool. M&S and test and evaluation efforts seek to understand the component and system-level impacts of advanced heat-rejecting materials and cooling.

Armor Durability Simulation. Provide the armor technology development community with a computational toolbox for determination of durability and environmental performance of advanced passive/reactive armor designs.

Hit Avoidance SIL. A tool to aid in the development and integration of Hit Avoidance Systems for ground-based combat vehicles.

Ground Systems Survivability Head Impact Protection SIL. Reduce the injuries to head, neck and spine of occupants in a mine/improvised explosive device, crash, and rollover events.

- Head impact protection test rig
- Test methodology and standards
- Finite element models

Multi-Axis Blast Simulator. Intended to reduce the ground system vehicle occupant injuries and develop occupant protection technologies.

- Test rig and laboratory
- Test methodology and standards
- Finite element models

Threat Oriented Survivability Optimization Model. Advanced and innovative capability to perform system level trades using a mathematical assessment of traditional and nontraditional survivability technologies.

- Optimization software
- Survivability metrics
- Streamlining of concept definition

Lightweight Armor Evaluation Process. Support current and future armor needs by providing vendors with a process by which their solutions can be analyzed by the government at the coupon size level. This will also provide the government a common testing reference.

Linear Impact Sled. Creates infrastructure, physical and virtual tools, and other technologies for enhanced occupant protection in ground vehicles.

SBIR Effort

- **Mitigation of Blast Injuries through M&S.** The objective of this topic is to investigate the effect of non-centerline IED/mine blast on crew survivability and to develop a physics-based model that will assist in the design of safety components devised to mitigate injuries sustained by individuals riding in tactical wheeled vehicles.

- **Innovative manufacturing research on forming of large light armor alloy sections resistant to blast and penetration.** Further we will utilize high fidelity modeling and simulation to determine the armor's effectiveness against penetration and blast before testing is required.
- **Linguistic Geometry Based Predictive Technology for Simulation and Training.** This effort will apply Linguistic Geometry technology to enhance predictive technology for tactical training simulations