Application of computational M&S for product development in Systems Engineering Framework

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Application of computational M&S for product development in Systems Engineering Framework

The original document contains color images.
Concepts, Analysis, Systems, Simulations and Integrations (CASSI)

Coordinated approach to virtually describing, and testing new ideas and changes to existing systems.

- Requirements Capture, Concept Development, Program Formulation
- Physics-based Performance Assessments, Mathematical Modeling, Data Analysis
- Physical Validation, Systems-Level Validation
- Integrated System-Level Demonstrations
- High-Performance Computing, Product & Program Data Management

Supported Activities

- Gunners Restraint System
- MRAP Expedient Armor (MEAP)
- Support GCV Blue Ribbon Panel
- MRAP Size, Weight and Power (SWAP) Analysis for Tech Assessment
- Blast Modeling for Lightweight Underbody Protection System

CASSI Support to MRAP Expedient Armor Process

Characterize Vehicle Weight, Axle Loading, Center of Gravity, Suspension
Design Review and Performance Assessments
Final Fabrication
Physical Validation of Performance & Durability Re-Baseline
Endstate: Expedient Armor kit transitioned to depot for kit production
Advanced Concepts Laboratory

- Integrated Concepts Development
- 3D CAD System (Integration) Models
- SWAP Assessments
- Validated Requirements & Specs
- Support Trade Studies
- Technology Program Formulation
- Validated Technology Maturation Studies

Quantify Space and Weight Impacts and Feasibility
CASSI “A” - Analysis

System Level Analysis

- Mobility / Automotive Performance Analysis
- Blast / Crash / Ballistic Analysis
- Thermal / Signature / Aerodynamic Analysis
- Durability / Reliability Analysis

High Performance Computing Infrastructure

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

UNCLASSIFIED: DIST A. Approved for Public Release
Acquisition
- Generate CDD performance targets
- Help with concepts - trade-space sensitivity and SWAP-C studies and evaluation of proposed designs

Current Force
- Field System Support
  - Configuration changes
  - Safe Use Range of operation
- Evaluate Platform Modernization / Tech Insertion
  - HMMWV, FMTV, MRAP…..
  - Stryker, Bradley, Abrams…..

S&T
- Evaluate technologies, vehicle concepts, tech-demonstrators
  - TWVS, CVAD, HEVEA, DCE, FED…..
M&S prediction of M1114 high-speed lateral stability at different payload weights and CG heights generated information for use in providing safety information to soldiers to avoid vehicle rollover.
Crashworthiness Modeling
Computational Fluids (CFD)
- Thermal budgeting/efficiency analysis
- HVAC design/interior cooling
- Underhood cooling
- Fire suppression modeling
- Pressure drops of ballistic grilles

Signatures
- Visual, IR, radar, acoustics
Vehicle Thermal Modeling

<table>
<thead>
<tr>
<th>Description</th>
<th>Thermal Sensation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot</td>
<td>+3</td>
</tr>
<tr>
<td>Warm</td>
<td>+2</td>
</tr>
<tr>
<td>Slightly Warm</td>
<td>+1</td>
</tr>
<tr>
<td>Neutral</td>
<td>0</td>
</tr>
<tr>
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</tr>
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</tr>
<tr>
<td>Cold</td>
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Example: Caiman C2OTM HVAC

Modeling

Model Validation

Validated C2OTM Baseline (idle)

New Duct Design / Optimization

Cooldown HVAC Capacity Study

Cooldown equip in 15 minutes

Physical Simulation – Cell 9

• Surrogate racks / equip
• PVC human “dummies”
Reliability Modeling Example

Multi-body dynamic simulation software used to generate duty cycle loading information for the track pin.

- Dynamic Analysis Design System (DADS)
- Integrated Virtual Reality Environment for Synthesis and Simulation (IVRESS)

Duty cycle loads

FEA model

Fatigue Life Prediction

Material Characteristics

Ncode DesignLife Fatigue Analysis Software
Multi-disciplinary optimization (MDO) is a design approach for meeting multiple discipline-level targets while also achieving top level objectives and satisfying all design constraints.

**Inputs:**
- Top-level design objectives and constraints
- Discipline-level design objectives and constraints
- Model of initial design
- Sufficient data to support M&S for each discipline

**Outputs:**
- New design that is optimized to best meet system-level and discipline-level objectives while satisfying all constraints
Ground Vehicle Simulation Laboratory

- Vehicle Characterization
- System Durability Studies
- Performance Validation
- System “Shakedown” Testing
- Man-In-the-Loop Testing
## Technology Readiness Level Description

<table>
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<tr>
<td>1. Basic principles observed and reported.</td>
<td>Lowest level of technology readiness. Scientific research begins to be translated into applied research and development. Examples might include paper studies of a technology’s basic properties.</td>
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<tr>
<td>2. Technology concept and/or application formulated.</td>
<td>Invention begins. Once basic principles are observed, practical applications can be invented. Applications are speculative and there may be no proof or detailed analysis to support the assumptions. Examples are limited to analytic studies.</td>
</tr>
<tr>
<td>3. Analytical and experimental critical function and/or characteristic proof of concept.</td>
<td>Active research and development is initiated. This includes analytical studies and laboratory studies to physically validate analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative.</td>
</tr>
<tr>
<td>4. Component and/or breadboard validation in laboratory environment.</td>
<td>Basic technological components are integrated to establish that they will work together. This is relatively “low fidelity” compared to the eventual system. Examples include integration of “ad hoc” hardware in the laboratory.</td>
</tr>
<tr>
<td>5. Component and/or breadboard validation in relevant environment.</td>
<td>Fidelity of breadboard technology increases significantly. The basic technological components are integrated with reasonably realistic supporting elements so it can be tested in a simulated environment. Examples include “high fidelity” laboratory integration of components.</td>
</tr>
<tr>
<td>6. System/subsystem model or prototype demonstration in a relevant environment.</td>
<td>Representative model or prototype system, which is well beyond that of TRL 5, is tested in a relevant environment. Represents a major step up in a technology’s demonstrated readiness. Examples include testing a prototype in a high-fidelity laboratory environment or in simulated operational environment.</td>
</tr>
<tr>
<td>7. System prototype demonstration in an operational environment.</td>
<td>Prototype near, or at, planned operational system. Represents a major step up from TRL 6, requiring demonstration of an actual system prototype in an operational environment such as an aircraft, vehicle, or space. Examples include testing the prototype in a test bed aircraft.</td>
</tr>
<tr>
<td>8. Actual system completed and qualified through test and demonstration.</td>
<td>Technology has been proven to work in its final form and under expected conditions. In almost all cases, this TRL represents the end of true system development. Examples include developmental test and evaluation of the system in its intended weapon system to determine if it meets design specifications.</td>
</tr>
<tr>
<td>9. Actual system proven through successful mission operations.</td>
<td>Actual application of the technology in its final form and under mission conditions, such as those encountered in operational test and evaluation. Examples include using the system under operational mission conditions.</td>
</tr>
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**Systems Demonstrators** generally will provide the ability for technologies to transition to Readiness Level 6, but may include Operational Environment demonstrations at TRL 7.
Summary

- Concepts, Analysis, System Simulation and Integration (CASSI) capabilities are critical services enabling both Technology Development and System Development Programs.
- With consolidation and improved efficiency, TARDEC is positioning its CASSI services to be a key enabler for Army Programs.
  - Consistent use across Technology and System Programs
  - Single Interface for all Customers
  - Expanded focus on System-of-Systems Perspective
  - Improved Information Management and Sharing
  - Expanded Means for Partner and Customer Collaboration
- CASSI is central to achieving TARDEC’s role as the Army’s Ground Systems Integration Domain Lead.
- Computational modeling and simulation plays a pivotal role in the evaluation of expanded design space to improve product quality and performance and reduce product development costs.
- Current advances in High Performance Computing infrastructure and computational software provide path forward for Multi-Disciplinary Optimization (MDO) for balancing diverse requirements and objectives for various functional areas.

Requirements + Technology + Assessment + Integration

»»»» Improved Alignment and Transition