



**RDECOM**

## Application of Computational M&S for ground vehicles at TARDEC



***TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.***

Workshop on Advanced Computational Methods in Engineering and  
Environmental Sciences, CUNY, NY, 26-28 SEP 2011

Sudhakar Arepally,  
Deputy Associate Director, CASSI-ANALYTICS, RDECOM-TARDEC, U.S. ARMY

# Report Documentation Page

Form Approved  
OMB No. 0704-0188

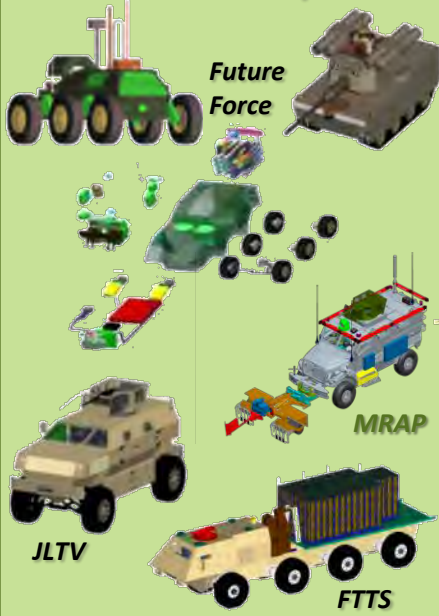
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

1. REPORT DATE <b>23 SEP 2011</b>		2. REPORT TYPE <b>N/A</b>		3. DATES COVERED <b>-</b>	
4. TITLE AND SUBTITLE <b>Application of Computational M&amp;S for ground vehicles at TARDEC</b>				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S) <b>Sudhakar Arepally</b>				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) <b>US Army RDECOM-TARDEC 6501 E 11 Mile Rd Warren, MI 48397-5000, USA</b>				8. PERFORMING ORGANIZATION REPORT NUMBER <b>22310RC</b>	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S) <b>TACOM/TARDEC/RDECOM</b>	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S) <b>22310RC</b>	
12. DISTRIBUTION/AVAILABILITY STATEMENT <b>Approved for public release, distribution unlimited</b>					
13. SUPPLEMENTARY NOTES <b>Presented at the Workshop on Advanced Computational Methods in Engineering and Environmental Sciences, CUNY, NY 26-28 SEP 2011, The original document contains color images.</b>					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT <b>SAR</b>	18. NUMBER OF PAGES <b>8</b>	19a. NAME OF RESPONSIBLE PERSON
a. REPORT <b>unclassified</b>	b. ABSTRACT <b>unclassified</b>	c. THIS PAGE <b>unclassified</b>			

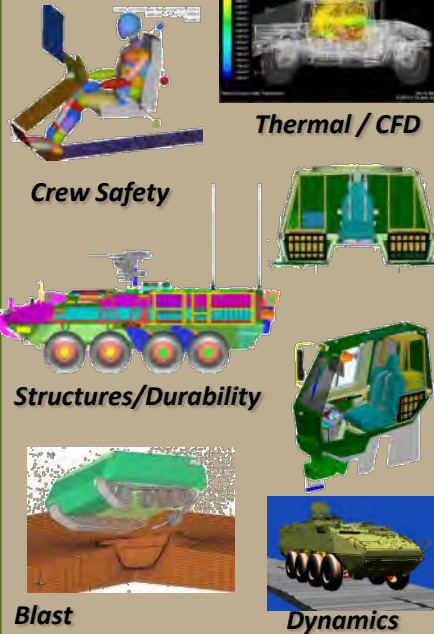
**System-centric, M&S-based Services to integrate and assess  
 the impacts of new concepts/technologies and changes to existing systems.**

**C A S S I**

**Advanced Concepts**



**Analytics**



**Hardware & Man-In-The-Loop Simulation**



**Integration & Demonstrators**



**HPC & Data Management**



Product Data Management

Program Data Management

**Key Partnerships with TARDEC Technology Groups, other Army RDECs/Labs, PM's, TRADOC - MCOE, TACOM Sys & Cost Analysis, ATEC, AEC**



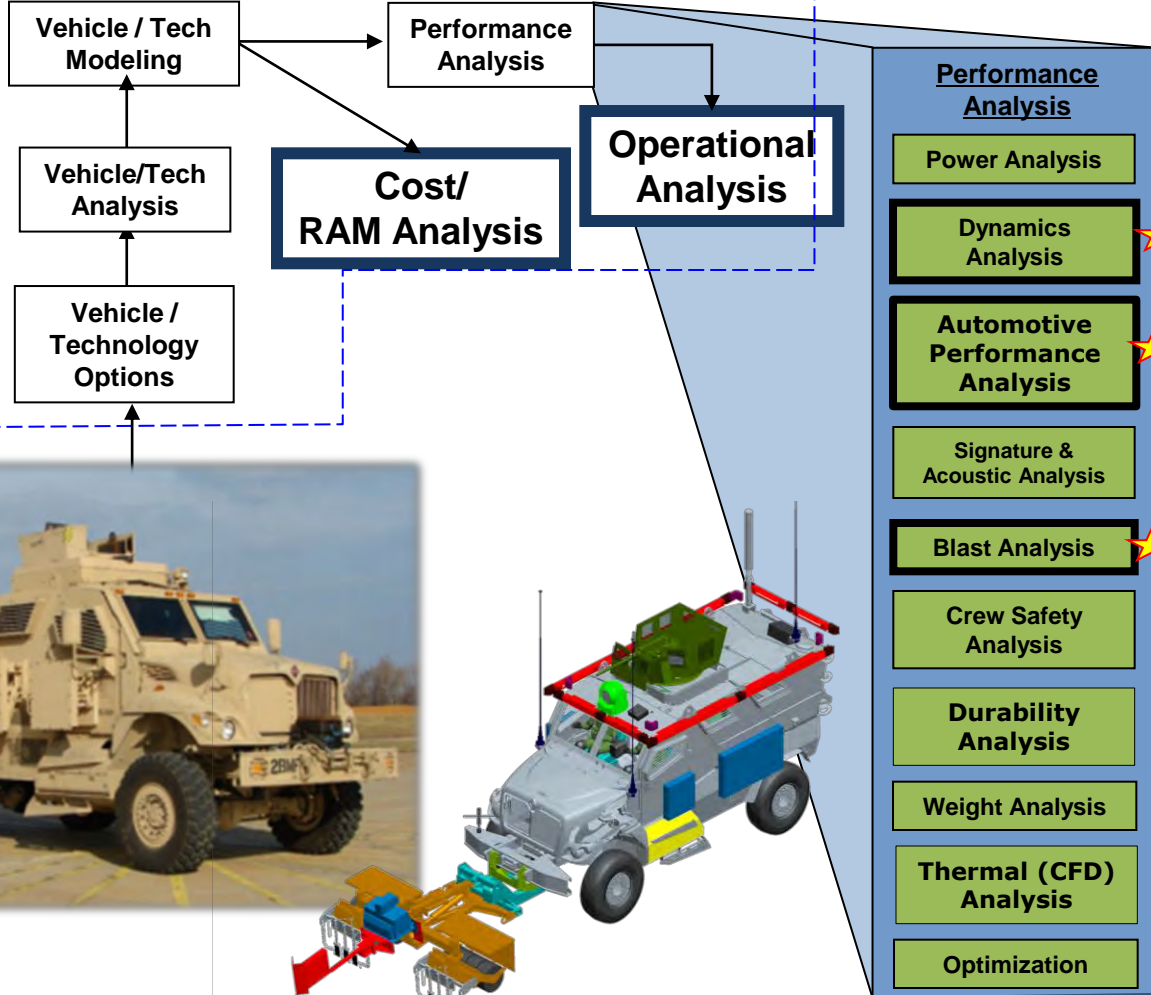
# Mission & Objectives



- Mission:
  - Provide Rapid Assessment and Integration Services to both Technology and System/Platform Development Programs
    - Throughout the Platform Lifecycle
    - Consider Warfighter, System, and System-of-Systems (SoS) Contexts
- Objectives:
  - Provide Systems/SoS Perspective to Combat Developer, PM and Tech Developer on Requirements, Tradeoffs & Integration
  - Provide SWAP, Performance, Operational, Cost, & Sustainment Impacts
  - Provide and Share Configuration Managed Data on Technologies, Systems, M&S and related programs/processes
  - Explore Multiple Options and Trades Rapidly
- Methods:
  - Develop Vehicle Concepts & Perform Concept Analysis and Trade Studies
  - Perform System Assessments using Physics-based, Statistical-based, HW/Man-in-the-Loop, and Distributed Simulation Tools
  - Develop Integrated System Level Demonstrators

# CASSI-Analytics Core Areas

## Concepts, Integration & Analysis



- Reduce Time / Cost to Field
- Reduce Operations & Maintenance Costs (RAM)
- Improve Transportability
- Reduce Inventory
- Save Lives
- Reduce Injuries
- Reduce Failures
- Improve Fuel Economy
- Reduce Weight
- Reduce Risk

Evaluate Design Principles and Requirements

*Good Systems Engineering*

# Computational Analysis Areas



**Multi-body Vehicle Dynamics**  
-Automotive Performance and  
Mobility Prediction

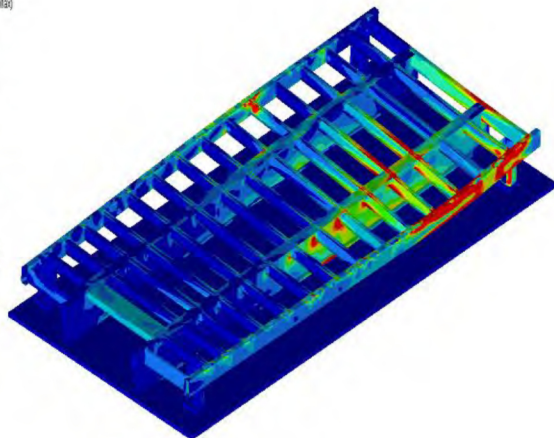


**Crew Safety/  
Biomechanics**

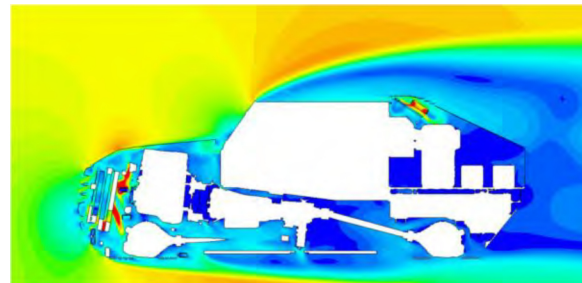


**Multi-body/FE - System Level Durability Degradation**  
-Wheeled and Tracked Vehicles

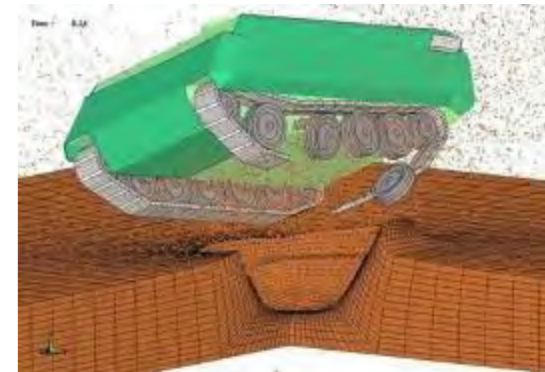
Contour (Analysis system)  
Stress (vonMises, Max)  
5.000E+04  
4.444E+04  
3.888E+04  
3.333E+04  
2.778E+04  
2.222E+04  
1.667E+04  
1.111E+04  
5.556E+03  
0.000E+00  
No result  
Max= 3.388E+05  
Min= 0.000E+00



**Finite Element Analysis**  
-Structural Integrity



**CFD Analysis**  
-Thermal Mgmt

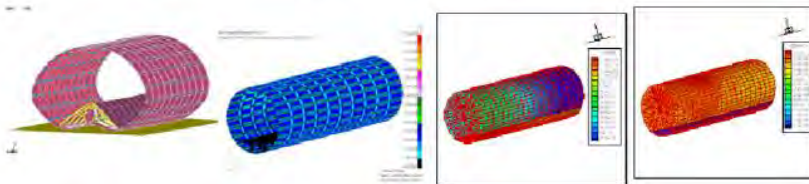
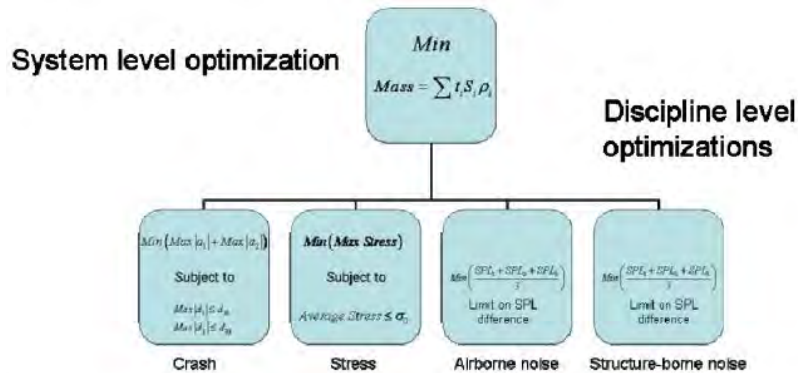


**Non-Linear FE Impact  
Analysis - Blast Effects**

# Multidisciplinary Design Optimization (MDO)

## MDO software tool:

- Runs design optimization process for multiple analysis codes running in parallel
- Employs tailored metamodeling and optimization algorithms to concurrently meet:
  - System-level objectives (e.g., minimize vehicle weight)
  - Multiple discipline-level objectives (e.g., maximize durability and survivability)
- Shepherds discipline-level optimization processes to converge to a single solution
- Ensures that all constraints are satisfied by the final design



### Input:

- Model of initial design
- Design objectives and constraints
- Design parameters (can be shared across disciplines)
- Sufficient data to support M&S

### Output:

- Metamodels from simulations
- Optimal system design



# Summary



- **Analytics is the Army's premier organization for providing fast, accurate System Level ground vehicle system M&S services**
- **In-house engineering analysts perform Soldier-centric vehicle assessments of new systems and modifications to existing systems**
- **Assessments advise customers on impacts to system-level performance and recommend improvements to Army and DoD vehicle designs**



**\*\*Disclaimer:** Reference herein to any specific commercial company, product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or the Department of the Army (DoA). The opinions of the authors expressed herein do not necessarily state or reflect those of the United States Government or the DoA, and shall not be used for advertising or product endorsement purposes. **\*\***