



# Combat Vehicle Conference 24-26 October 2011



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Chief Scientist**

U.S Army tank Automotive Research, Development and Engineering Center (TARDEC)



# TARDEC Mission





# The Arsenal of Democracy

- Connected to World-Class Automotive Engineering Universities at our Doorstep
- Defense Industry Ground Systems Hub
- Direct Linkage to World-Class Automotive Research and Development Centers
- Strategic Engagement with 1st, 2nd & 3rd Tier Automotive Supplier Network

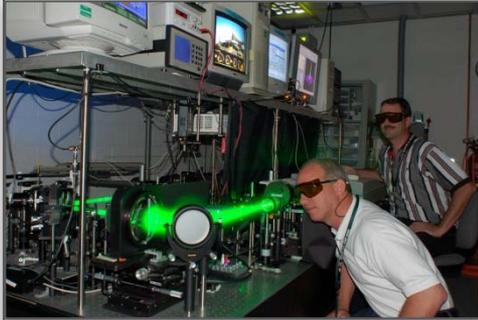


MichiganTech





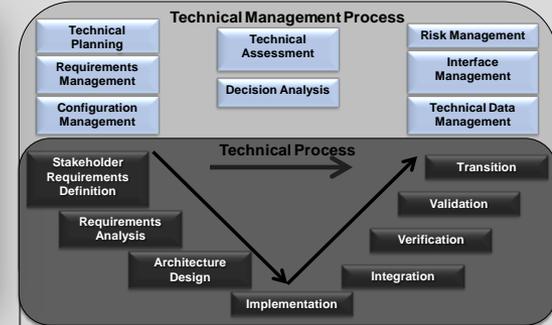
# Capabilities



### Research



### Technology Development



### Systems Engineering

### Integration



### Production Support



### Field Support





## Key Technical Thrust Areas

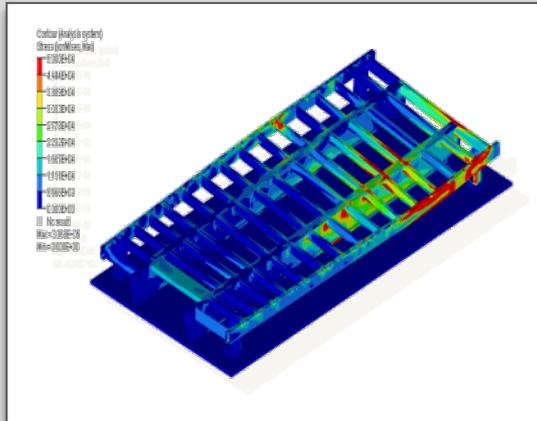
- Ground System Survivability
- Vehicle Electronic Architectures
- Ground Vehicle Robotics and Intelligent Systems
- Ground Systems Power, Energy and Mobility
- Force Projection Technology; Alternative Fuels, Lubricants and Water Purification





## Laboratory Capabilities

- Ground Systems Power and Energy Laboratory (GSPEL)
- Advanced Concepts Laboratory
- Advanced Collaborative Environments (ACE)
- Laser Protection Laboratory
- Armor Nondestructive Testing Laboratory
- Robotics Systems Integration Laboratory
- Ground Vehicle Systems Integration Laboratory
- GVR Robotic Laboratories
- Electronics Integration
- Physical Prototyping
- Design & Digital Mock-up
- Metallurgy Test Laboratory
- Survivable Structures Laboratory
- Ground Vehicle Power & Mobility Elastomer Improvement Laboratory
- Ground Vehicle Power & Mobility Propulsion Laboratory
- Physical Simulation Laboratory
- Analytical Simulation Laboratory
- TARDEC Simulation Labs
- Survivability Armor Ballistic Laboratory (SABL)
- Fuels & Lubricants Laboratories
- Water Purification, oil, fuels and lubricants Laboratory
- Fresh Water Test Facility
- NFESC Seawater Test Facility
- Dynamic Structural Load Simulation Lab



**TARDEC's Warren, MI operations have a resource value of over \$1.1B and occupy 12 facilities on the Detroit Garrison totaling over 936,000 square feet of laboratory space**



# Army Technical Challenge

## More Mobile, Fuel Efficient, Safer Vehicles

### Mobility & Energy Efficiency

### Occupant Centric Survivability



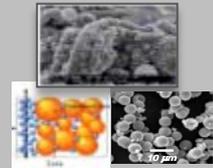
#### Vehicle Dynamics

Newton-Euler Equations of Motion

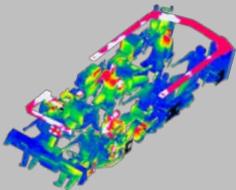
$$\begin{cases} M\ddot{q} + C_q^v \dot{q} = Q \\ C(q, t) = 0 \end{cases}$$

Solve for vehicle mobility and component loads

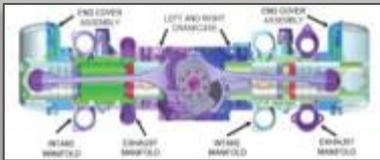
$$\begin{bmatrix} M & C_q^v \\ C_q & 0 \end{bmatrix} \begin{bmatrix} \ddot{q} \\ \lambda \end{bmatrix} = \begin{bmatrix} Q_e + Q_c \\ Q_d \end{bmatrix}$$



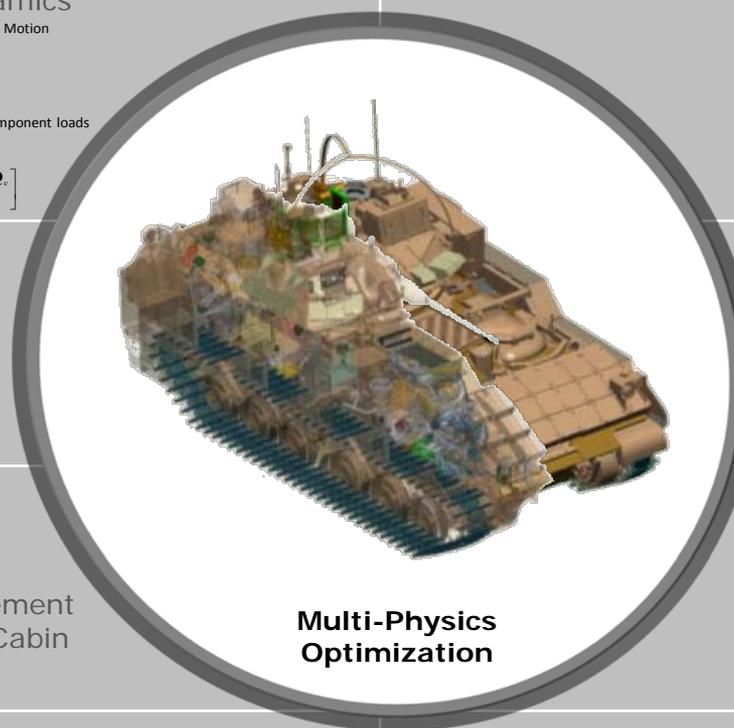
Hi-Energy,  
Hi-Density  
Energy  
Storage



Comprehensive  
Thermal Management  
of Propulsion & Cabin



High Power Density,  
Low Heat Rejection &  
Fuel Efficient Engines



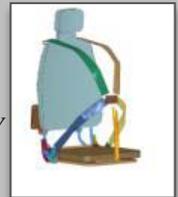
**Multi-Physics  
Optimization**

Active  
Protection  
Systems



Holistic Occupant  
Centric Protection

$$\frac{d}{dt} \int_{V_t} f(x, t) dV = \int_{V_t=V_t} \frac{\partial f(x, t)}{\partial t} dV + \int_{S_t=S_t} f(x, t) \cdot n dS$$



Affordable, Multi-  
hit Ceramic Armor

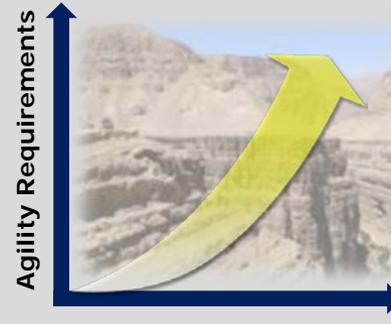


Fire and Toxic  
Fume Resistant  
Materials





# Ground Systems Power, Energy and Mobility



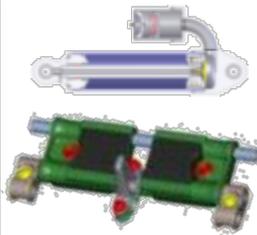
Increasing Demands and Operational Flexibility  
Require Strategic Investments in Key Areas



Powertrain



Thermal Management



Track & Suspension



Non-Primary Power



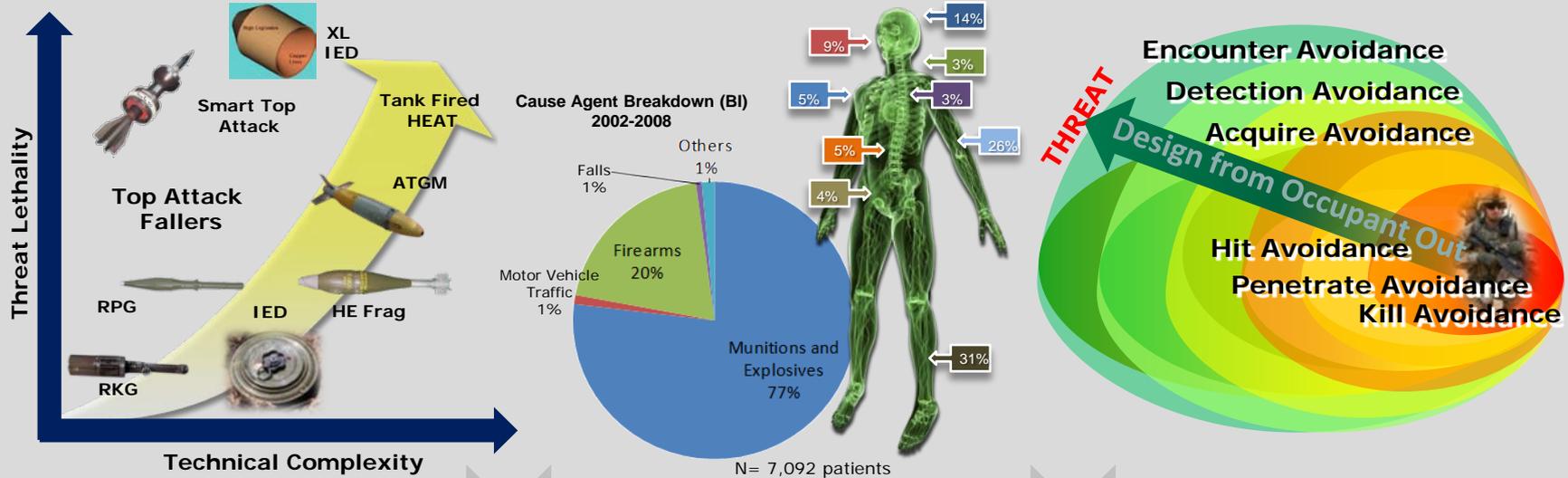
Energy Storage



Advanced Propulsion



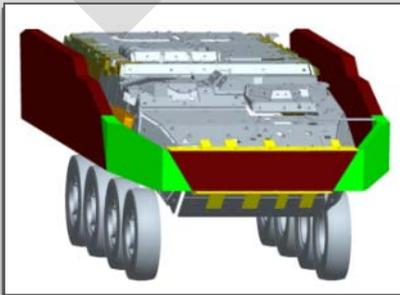
# Occupant Centric Survivability



Increasing Demands and Operational Flexibility Require Strategic Investments in Key Areas



Kill Avoidance



Penetration Avoidance



Hit Avoidance

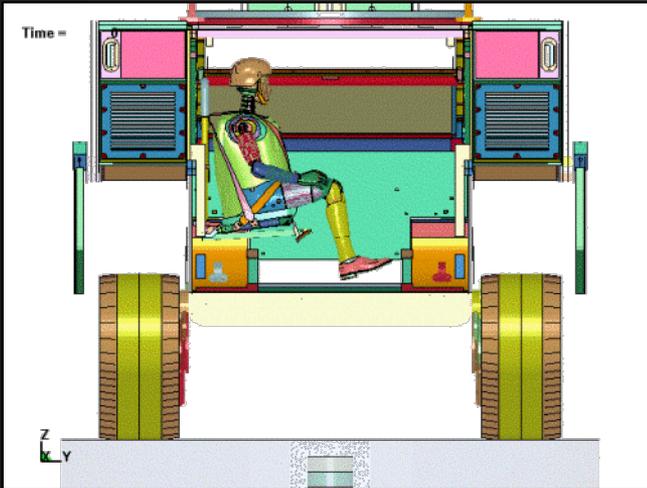


Detection Avoidance



# Underbody Blast

## End-to-End Underbody Blast Simulation



Advanced full vehicle, system level design tools are key enablers to:

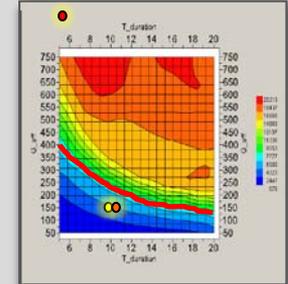
- Assessing Occupant Injury Risk
- Developing new protection technologies
- Improving force vehicles for current threats
- Designing new occupant-centric vehicles



Energetic Event (UB Blast)



Component & Platform Interaction



Occupant Injury Response



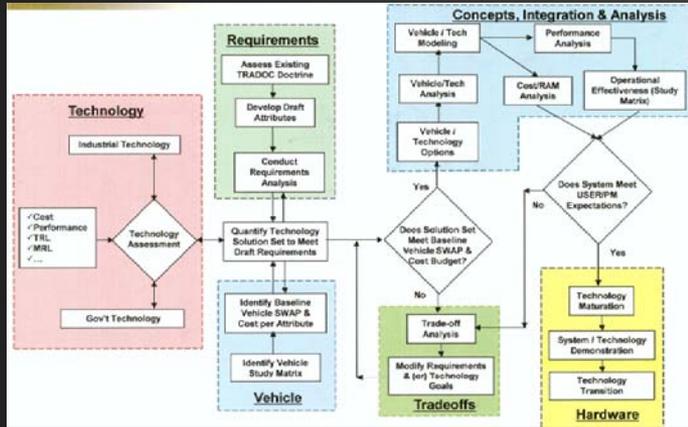
System Evaluation



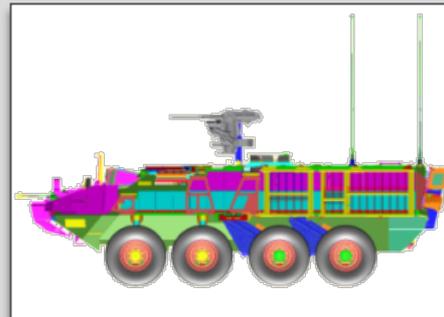
Design Improvement & Optimization



## Integration Services:



- Advanced Concepts Modeling
- Physics Based Analysis
- Statistics based analysis in Man-in-the loop simulation
- Integrated System Level Demonstrators and Prototypes
- High Performance Computing & Data Management





# Reducing the Fuel Logistics Burden



**1 in 46**  
convoys suffered a  
casualty in 2010, leaving  
some 3,000 wounded or  
dead

A **1%** fuel  
savings will lead to

**6444**  
fewer Soldier trips in  
dangerous battlefield  
convoys

*Modeling and Simulation:  
Optimize the System*



*Research and Testing*



*Demonstrate Systems  
and Technologies*



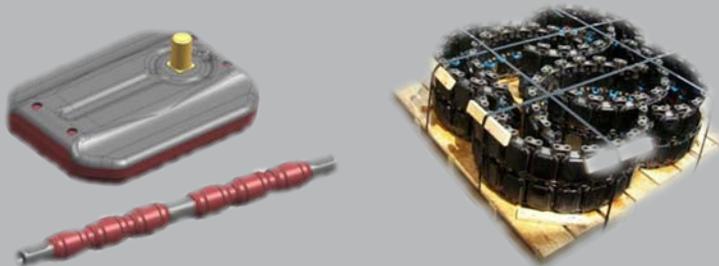


# Reducing the Track Logistics Burden

Abrams T-158LL Track  
Bradley T-157I Track



Track System Research



- Track Systems are the 2<sup>nd</sup> Highest Operation & Sustainment (O&S) Costs
- Abrams T-158LL Track Life is -2,200 miles
- Bradley T-157i Track Life is - 3,000 miles
- Elastomer Components are the primary failure mechanisms for track systems



# Reducing the Battery Logistics Burden

AGM Battery Failures  
2002-2008

~250,000

Incorrect Voltage Output



50%

Damaged - Transport Issues



30%

Improper Electrical Performance



20%

Approximately 80% of incorrect voltage failures were serviceable

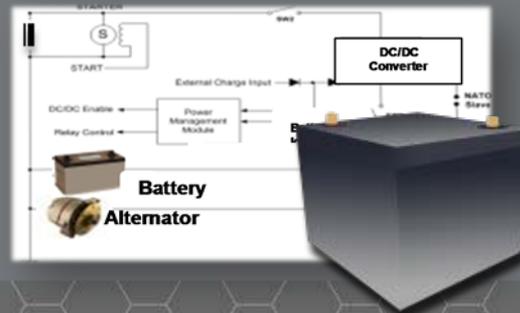
Improved charging techniques can lead to 2X life improvement



## Field Battery Maintenance & Training



## Improved Charging



## Battery Management



- Annual Purchase of Vehicle Batteries: 700,000
- \*\*AGM = Advanced Glass Mat.: "maintenance free"

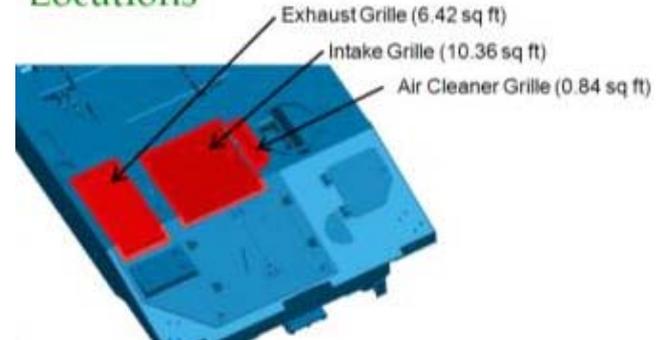


# Current Projects



Light Armored Vehicle-Recovery (LAV-R)

## Locations



Paladin Integrated Management (PIM) Air Grills



Stryker Command and Control on the Move (C2OTM)



RPG Defeat Net



## Doing Business with TARDEC



**TARDEC's Ground Vehicle Gateway  
is YOUR entry point!**

**Submit your technology for review**  
<https://tardec.groundvehiclegateway.com>

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# BACK UP



## The Two Facets of Future Capabilities through the Logistics Lens



Look at  
**Innovative ways to  
Reduce Logistics Burdens**

Unburden the  
Warfighter

Look to  
**Design Good Logistics In  
From Start**

Reduce  
Unintended  
Consequences



# Technology Integration & Engineering

## Integration Services:



- Advanced Concepts Modeling
- Physics Based Analysis
- Statistical-based Hardware & Man-in-the-Loop Simulation
- Integrated System Level Demonstrators and Prototypes
- High Performance Computing & Data Management

