RDECOM

TARDEC

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Tank Automotive Research, Development and Engineering Center (TARDEC) Technology Focus

Report Documentation Page

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Agenda

- US Basis For Cooperative R&D
- Technology Integration
- Condition Based Maintenance
- Ground Vehicle Survivability
- Ground Vehicle Power & Mobility
- Intelligent Ground Systems

US Basis for Cooperative R&D

Conditions For Successful Cooperative Programs

TODAY'S FOCUS

- Mutual Understanding Of Plans & Programs
- Equitable Exchange Of Information To Reveal Areas Of Mutual Interest

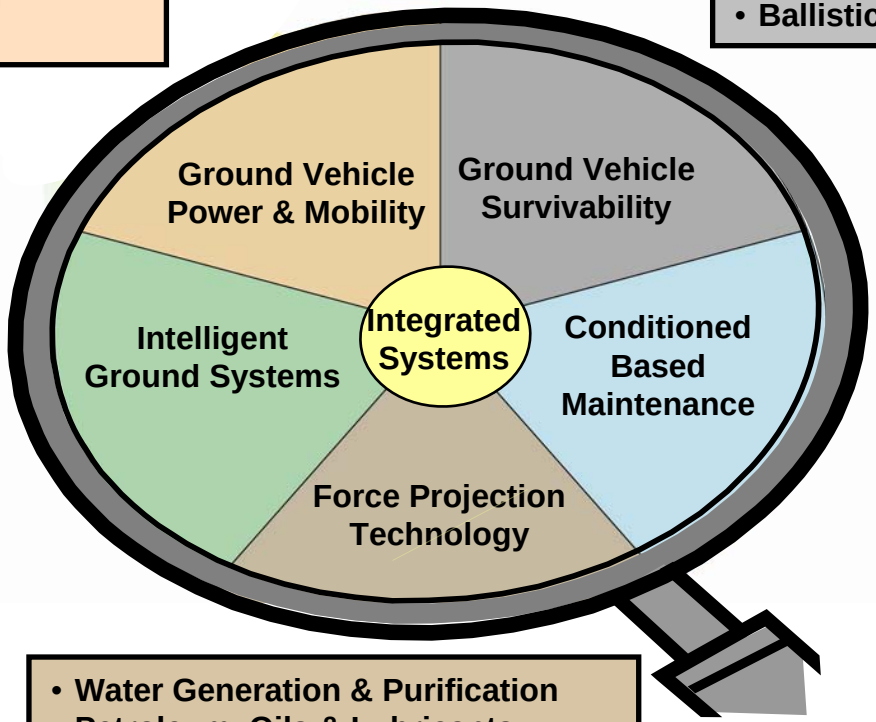
FUTURE FOCUS

- SME Review Of National Programs To Identify Active, Funded, Relevant Programs With Complementary Goals & Schedules As Cooperation Candidates
- TARDEC Decisions Are Based On Program Business Case: Cooperation Must Improve Program Metrics – Cost, Schedule, Performance
- Ultimate Goal Is To Execute Project Agreements To Cooperatively Develop Technology

TARDEC Technology Focus Areas

- Hybrid Electric
- Pulse Power
- Engines
- Fuel Cells
- Suspension
- Tracks

- Active Defense
- Signature Management
- Laser Vision Protection
- Ballistic Protection



- Robotic Systems Technology
- Human-Robot Interaction
- Crew Interface and Automation
- Robotic Follower ATD
- ARV Robotic Technologies Program

- Diagnostics/Prognostics
- Data Analytics
- Sensor Integration
- Network Architectures
- Predictive Maintenance

- Water Generation & Purification
- Petroleum, Oils & Lubricants
- Mechanical Countermine
- Combat Engineering/Bridging
- Gap Crossing
- Future Truck System

TARDEC Integrated Systems

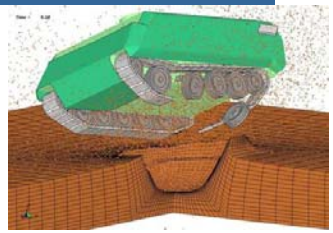
LIGHTWEIGHT TRACK PROGRAM

GROUND VEHICLE POWER & MOBILITY

- Hybrid Electric
- Pulse Power
- Engines
- Fuel Cells
- Suspension
- Tracks

INTEGRATED SURVIVABILITY

- Active Defense
- Signature Management
- Laser Vision Protection
- Ballistic Protection



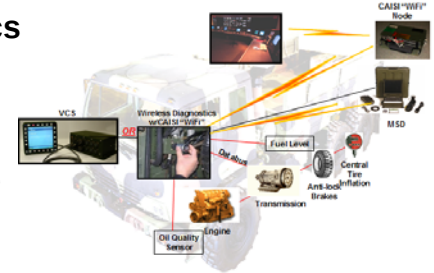
Predictive analysis of blast events – structures & crew

INTELLIGENT GROUND SYSTEMS

- Robotic Systems Technology
- Human-Robot Interaction
- Crew Interface and Automation
- Robotic Follower ATD
- ARV Robotic Technologies Program

CONDITION BASED MAINTENANCE

- Diagnostics/Prognostics
- Data Analytics
- Sensor Integration
- Network Architectures
- Predictive Maintenance



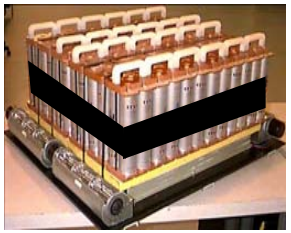
TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

TARDEC Integrated Systems

360 DEGREE SITUATIONAL AWARENESS

GROUND VEHICLE POWER & MOBILITY

- Hybrid Electric
- Pulse Power
- Engines
- Fuel Cells
- Suspension
- Tracks



Battery Pack w/ Integrated Heat Exchanger

INTEGRATED SURVIVABILITY

- Active Defense
- Signature Management
- Laser Vision Protection
- Ballistic Protection

Image Fusion Technology

INTELLIGENT GROUND SYSTEMS

- Robotic Systems Technology
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CONDITION BASED MAINTENANCE

- Diagnostics/Prognostics
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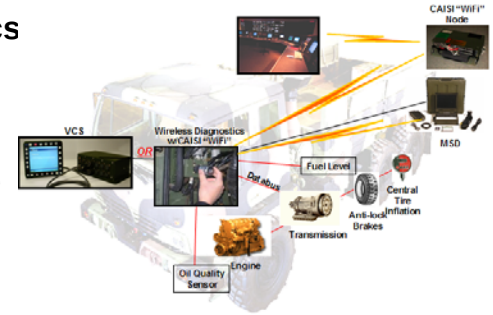

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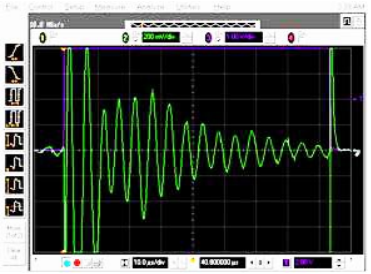
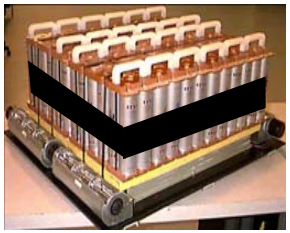
TARDEC Integrated Systems



GROUND VEHICLE POWER & MOBILITY

- Hybrid Electric
- Pulse Power
- Engines
- Fuel Cells
- Suspension
- Tracks



Battery Pack w/ Integrated Heat Exchanger

SMART ARMOR & SMART STRUCTURES

INTEGRATED SURVIVABILITY

- Active Defense
- Signature Management
- Laser Vision Protection
- Ballistic Protection

INTELLIGENT GROUND SYSTEMS

- Robotic Systems Technology
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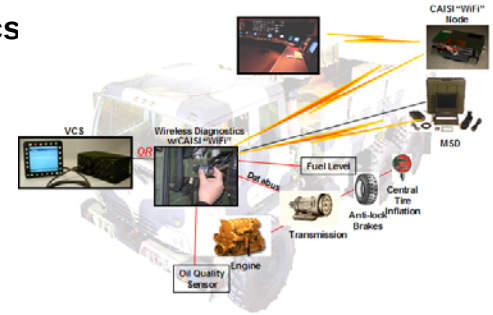
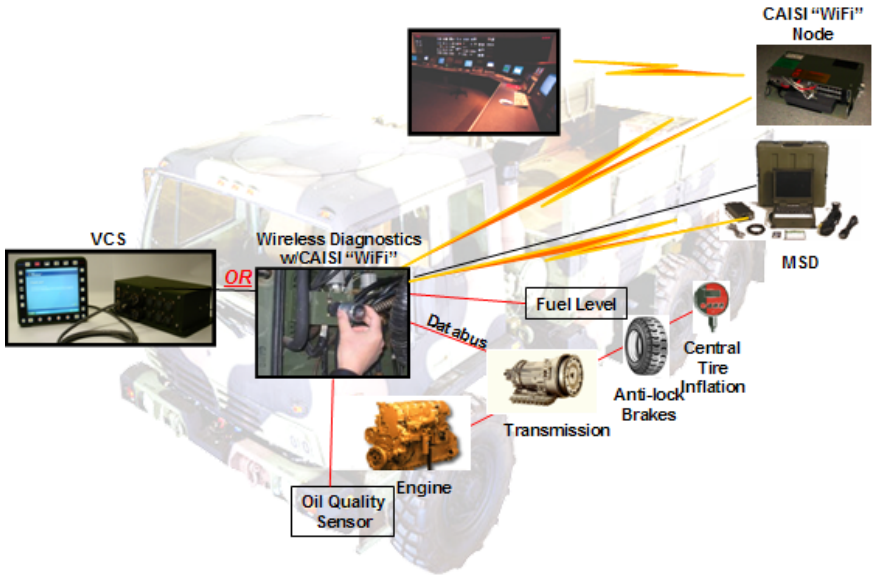


TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Condition Based Maintenance



Current Failure Management Strategies
Common Maintenance Practices

Reactive Maintenance

Run to Failure

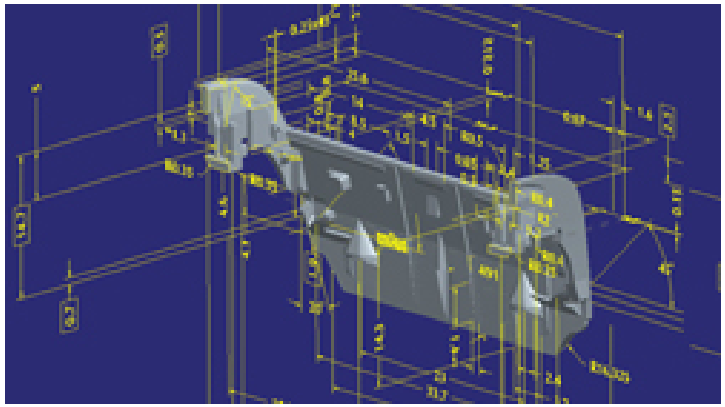
Preventive Maintenance

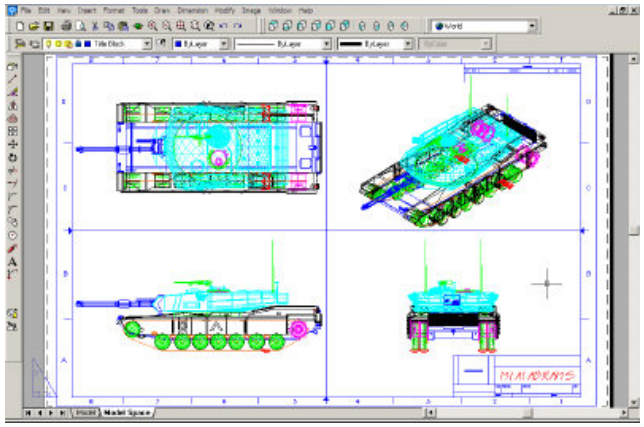
Service

Inspections

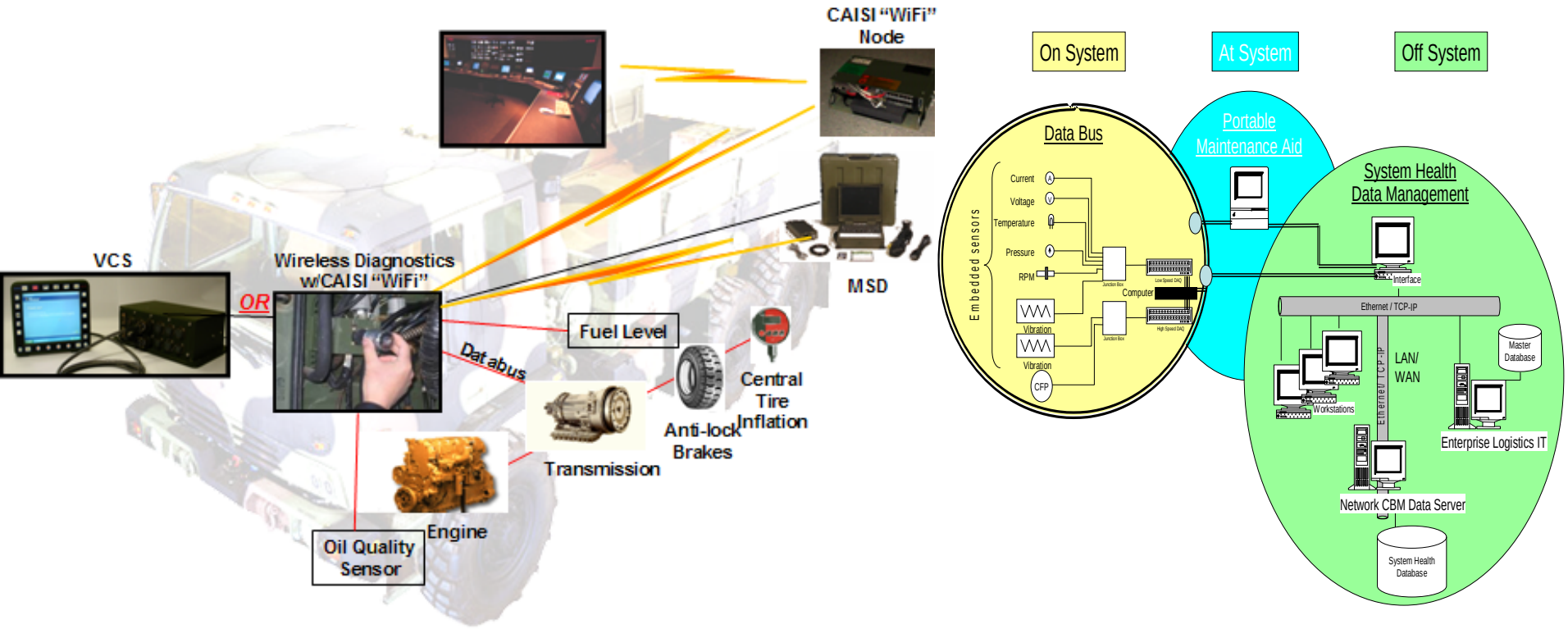
Alterative Maintenance

Redesign





Condition Based Maintenance Concept



Utilize ***onboard sensors, data collection***, networks, and computer resources to better enable the Soldier and the Army to ***Maintain Vehicle Readiness and reduce cost*** by ***proactively pre-empting failures*** through predictive maintenance capabilities.

Understand Current Equipment Condition and Respond Proactively

CBM – Technology Gaps

Vehicle

Improved Sensors and Sensor Networks
- Robust/Ruggedized
- Temperature/Impact/Vibration
- Low Cost
- Self-Diagnosing
- Power-Scavenging/Self-powered/Kinetic
- Signal Processing

Batteries, Brakes, Bearings, Belts, Tracks
- Routine Maintenance
- Low Hanging Fruit

New and Innovative Sensing Techniques
- Fusion/Reduction
- Global Sensing

Low Cost Computational Platforms
- Headless Computers
- Diagnostic/Prognostic Framework
- Open Architecture

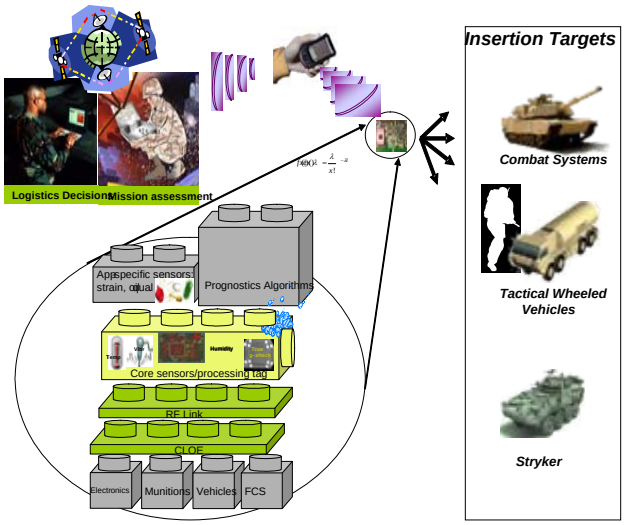
Low Cost Data Acquisition Components
- Multi Channel
- Versatile
  - Multi Bus J1939/1553/J1708

Communication link to transfer information off platform

Short range wireless - CAISI “WiFi”, ZigBee

Long range wireless - SINCGARS, EPLRS, MTS

Walk up, plug in port - Ethernet, USB, RS232
- Bandwidth
- **Security**



CBM – Technology Gaps

Back End

Algorithms to Analyze and Act on Information Rapidly

- Predictive Models
- Self Learning
- Predict the Unknowns

Maintenance Centers, Data Warehouses, Enterprise Resource Planners

- Fleet Level Usage Pattern Detection/Trend Analysis Across the Fleet
- Logistic Footprint Prediction/Preposition Parts
- Tactical Operation Optimization/Situational Awareness
  - Fuel and Ammo

Statistical Analysis and Prognostics

- Data reduction
- Anomaly Detection
- Data Mining

Currently Working with the University of Detroit

Analyzing and Developing Wireless transceivers for sensors.

- Wireless Methods Analysis IEEE 802.11, IEEE 802.15.4

Program Expanded into Robotic Sensor Focus

CBM Reps at TARDEC Booth

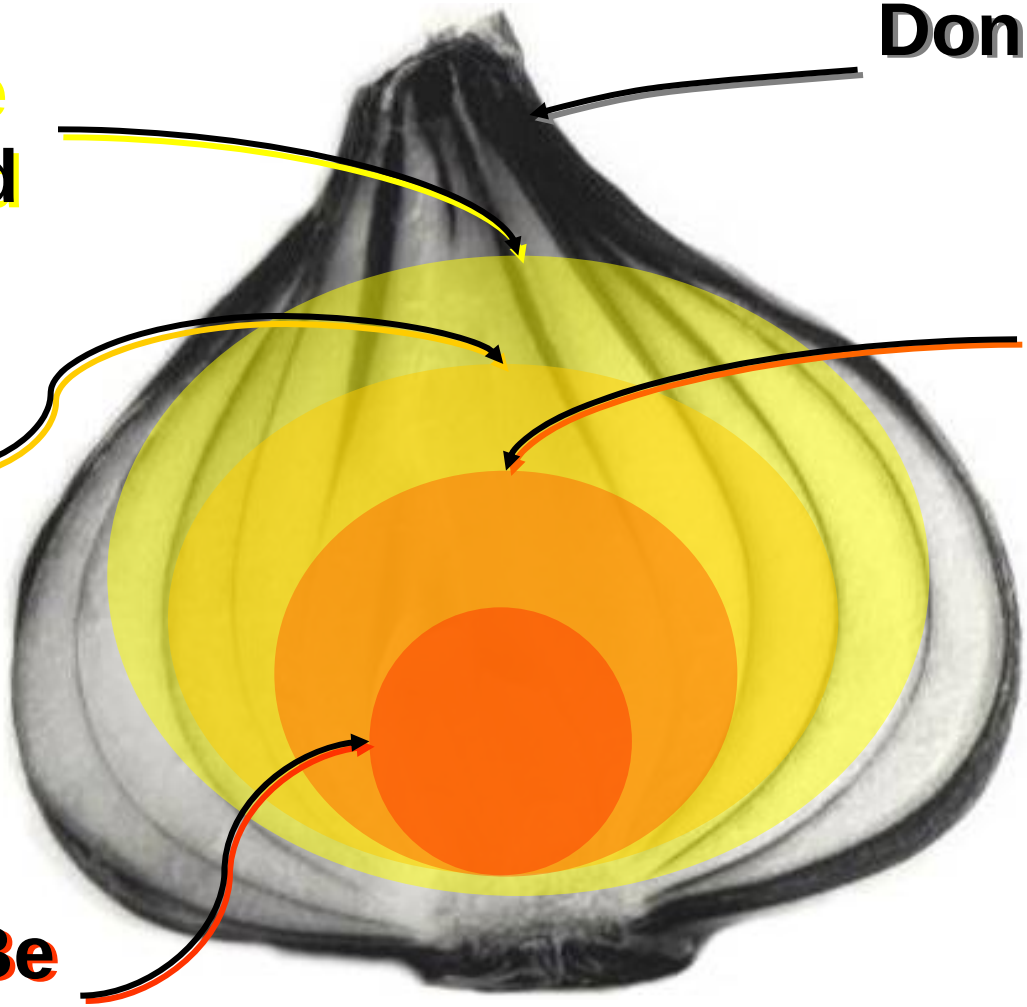
Tuesday, April 15

Tom Udvare

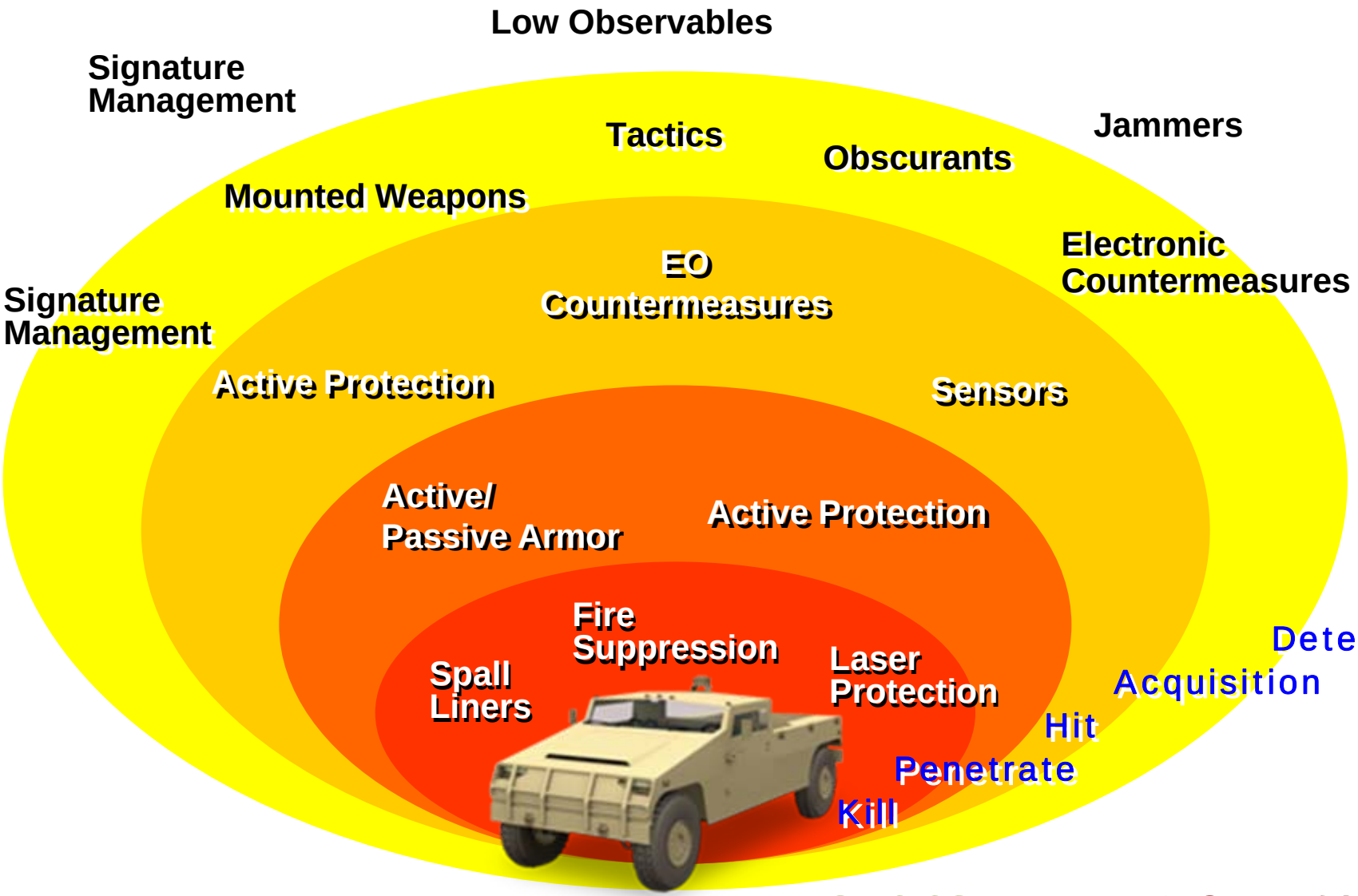
Chris Beck

Ground Vehicle Survivability

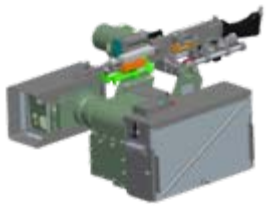
The Integrated Survivability "Onion"



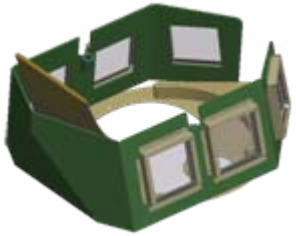
Research Focus Areas



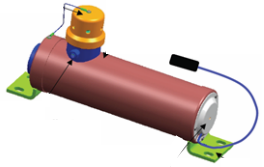
Design for Survivability





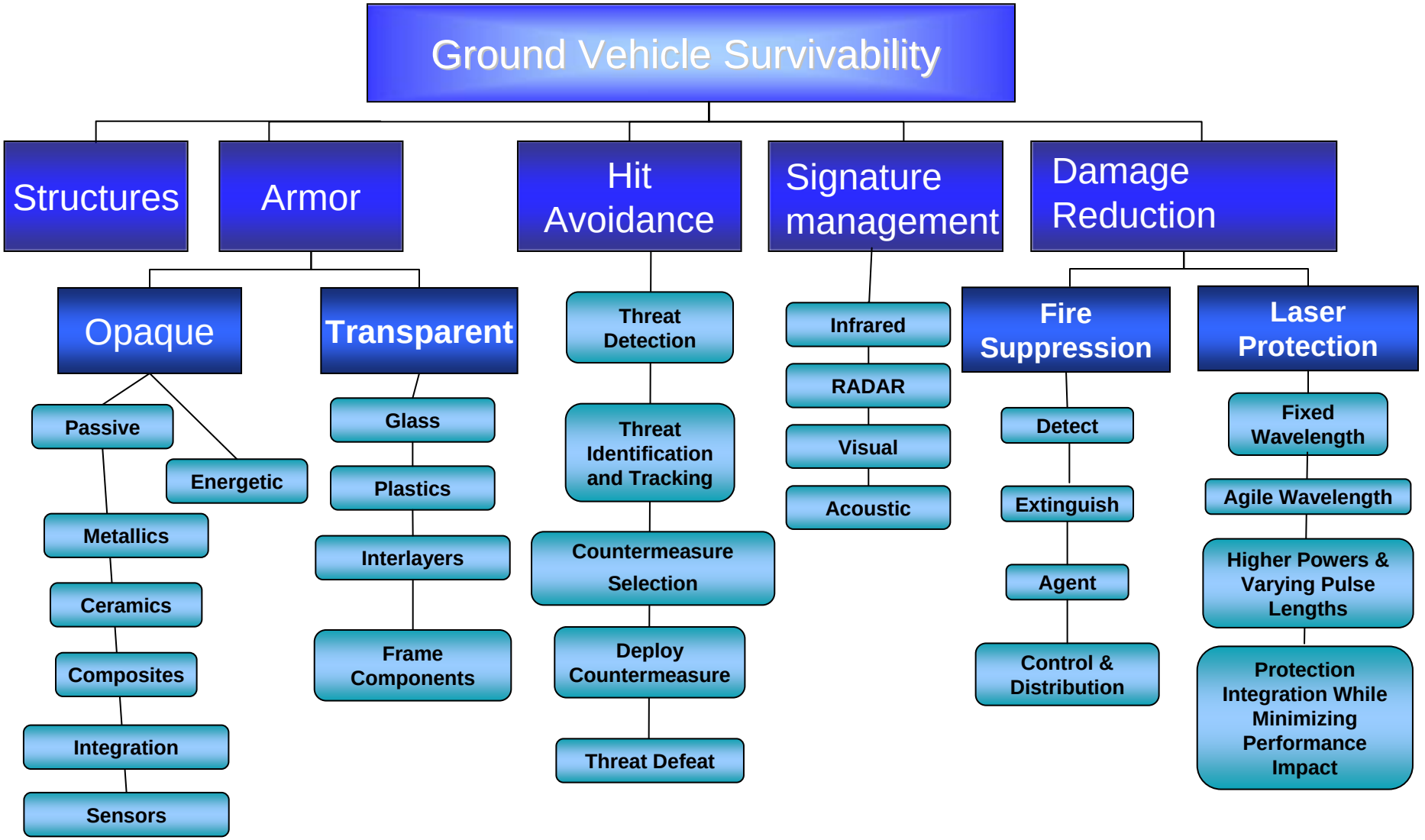




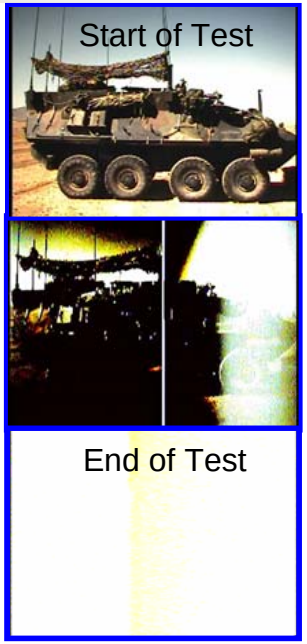

It's about balancing integration, mission, threat & technology

Research Focus Areas Taxonomy

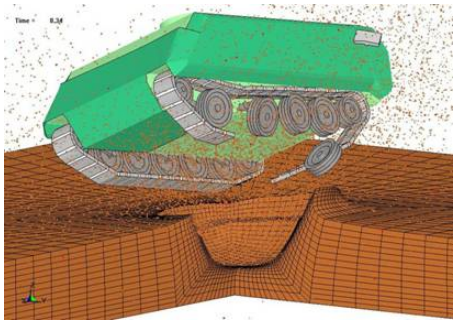


Survivability – Technology Research Gaps

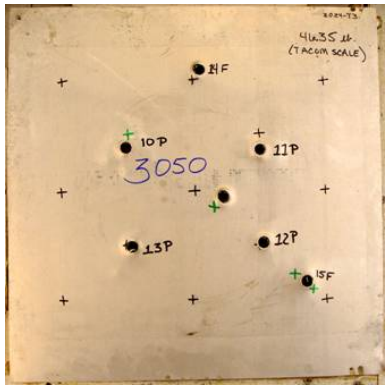
Multifunctional signature materials (visual, thermal RF, acoustic)



Mechanisms that switch high to very low optical transmission in a fraction of a nanosecond, and operate at all visible and near IR wavelengths.

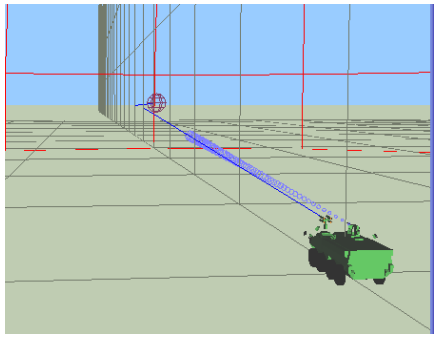


Predictive analysis of blast events – structures & crew

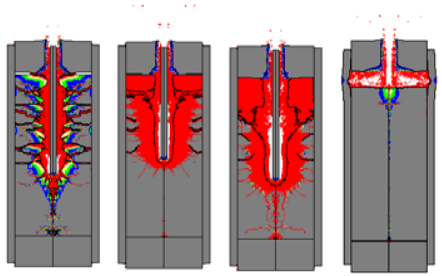


Lightweight multiple-hit armor

Predictive M&S - visual detection model



Predictive analysis for Active Protection systems



M&S for high velocity impact on ceramic/composites

External fire extinguishing systems and agents

Developing countermeasures to defeat full-spectrum threat munitions

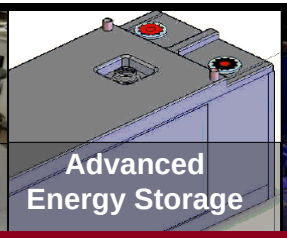
Ground Vehicle Power & Mobility (GVPM)

GVPM - Mission and Vision

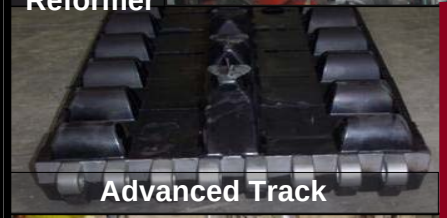

JP-8 Reformer


Engine Testing


Air Cleaner Testing


Advanced Energy Storage


Power and Energy SIL


Advanced Track

MISSION:

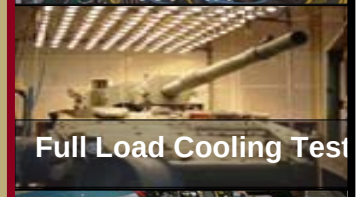
Provide technically sound and timely responses to the soldiers' current and future needs for technology and engineering expertise in ground vehicle power and mobility technologies.

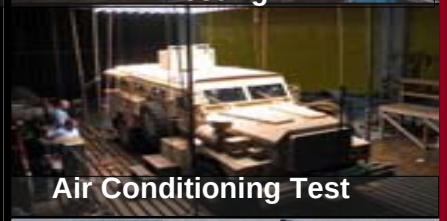
VISION:

Be the Army's "Center of Excellence" for technology and engineering expertise for research, development, testing and engineering of ground vehicle power and mobility technologies – today and tomorrow.


Engine / Generator Test Lab

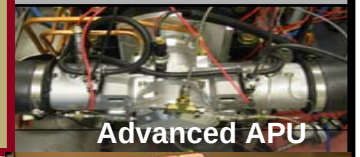

Transmission Testing

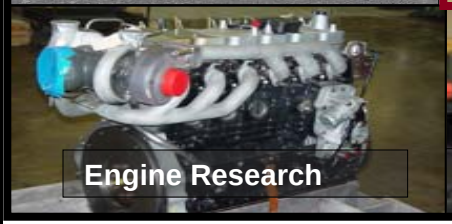

Full Load Cooling Test


Air Conditioning Test


Advanced Power Electronics


Auxiliary Power Units

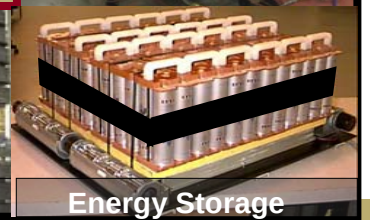

Advanced APU


Engine Research

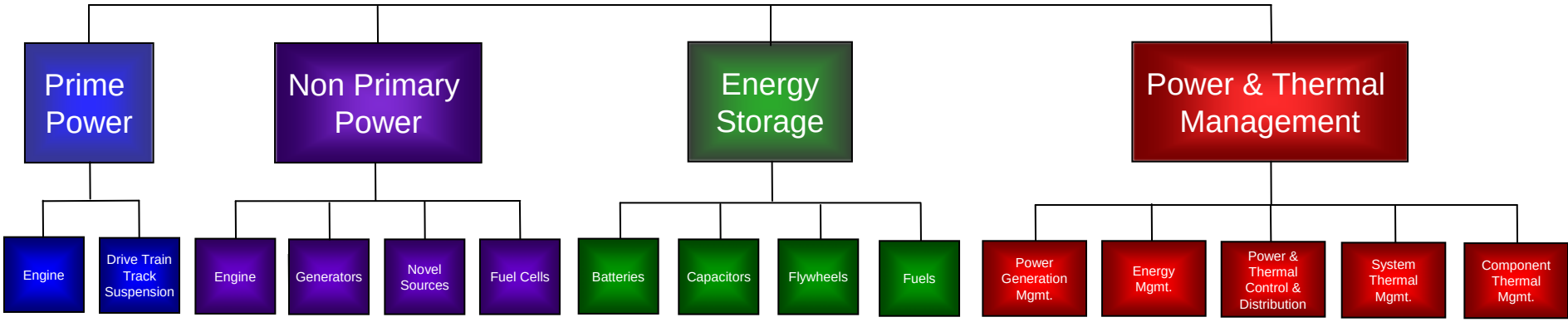

Integrated Power and Thermal Systems

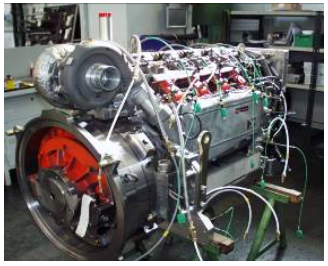

APU Testing & Analysis


Elastomer Research


Energy Storage

GVPM – Organizational Thrust Areas

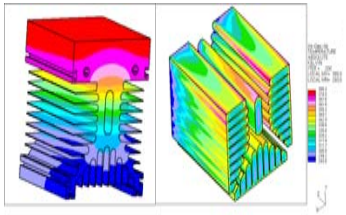




Prime Power

Non Primary Power

Energy Storage



Power & Thermal Management

Prime Power (Engine) Technology

Problem:

Current high power commercial engines are not compact enough for future manned ground combat platforms.

Future ground combat vehicles will require lighter and more efficient engines that occupy less space.

Current state of the art engines require significant development operate on one fuel and meet future vehicle power and mobility needs.

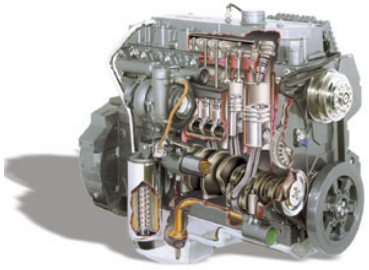
Research Challenges:

Diesel combustion research to increase physical burn time.

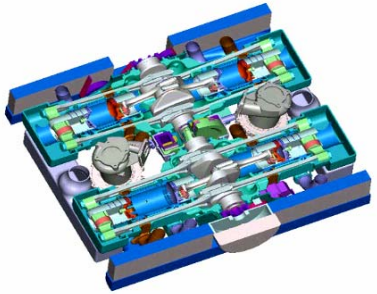
Propulsion system research to increase power density.

Engine thermal management research.

Research combustion optimization strategy for JP-8 military version of an emission compliant commercial engine.



Diesel Engine Research



Advanced Engine Research

Advanced Combustion System Research

Hybrid Electric Technology

Problem:

Hybrid electric systems for combat and tactical vehicles challenged to meet mobility requirements within the specified space and weight constraints.

The State Of the Art power electronics operate at low temperatures resulting in large cooling system which also requires a significant amount of power from the prime mover.

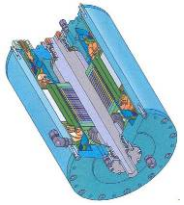
These challenges result in over sizing the engine/generator to gain power lost to the cooling system.

Research Challenges:

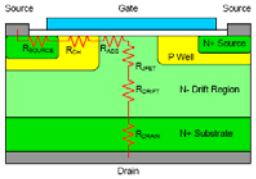
Research high temperature / high frequency compact power electronics.

Research high power / high torque density motor / generators.

Research advanced power electronics and component thermal management.



Traction motor



SiC MOSFET

Power & Energy SIL

Track Technology

Problem:

Future combat vehicles desire lightweight track with no degradation in robustness or field supportability.

Current lightweight track durability challenged at higher GVW vehicles.

Current lightweight track prone to anti personnel mine blast damage.

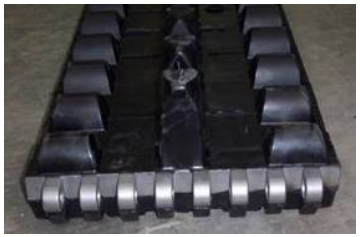
Elastomer components are track system life limiter of legacy track fleet.

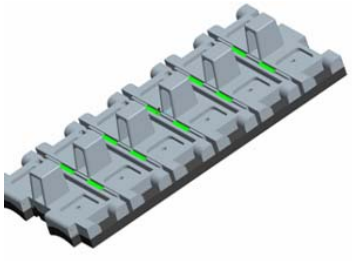
Research Challenges:

Research new lightweight metallic materials for track system application.

Research understanding of mine blast event to improve track survivability.

Research elastomers for improved life spans under high stress / high temperature conditions





Suspension Technology

Problem:

Army Tactical and Combat vehicles require superior performance for battlefield dominance.

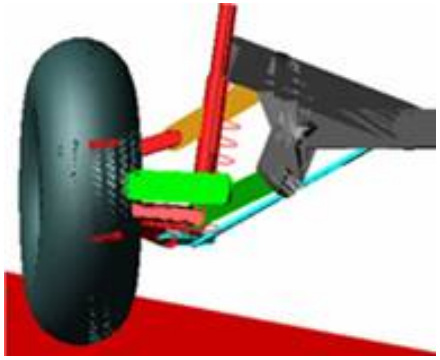
Up-Armoring of existing vehicle fleet challenging stock suspension components.

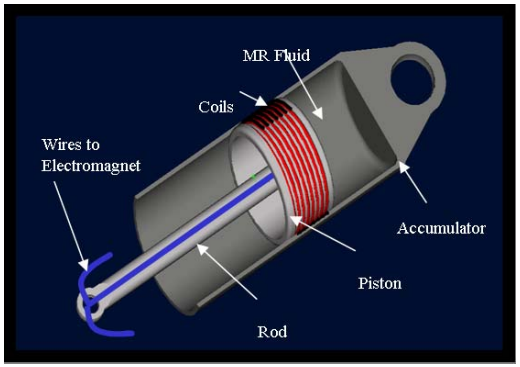
Research Challenges:

Research novel suspension components with adaptive control.

Research suspension components with adjustable weight carrying capacity.

Develop suspension components for robust, passive default, outside armor application.





Non-primary Power System Technology

Problem:

Current non-primary power approach inadequate.

Lead-acid batteries store insufficient energy to meet War Fighter requirements for vehicle silent watch(main engine off). Silent watch requirements vary from several hours to 24 hours. Current approach requires restarting of main engines during silent watch to recharge batteries, causing excessive fuel use, acoustic and thermal signatures.

Research Challenges:

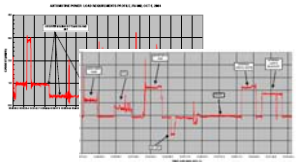
Research engine-generator technologies with high power densities and low acoustic signatures.

Research fuel cell challenges:

- Hydrogen fuel currently not logistically practical.
- JP-8 fuel reforming is developmental.
- Fuel cell power units need maturation for the battlefield.

Rotary Engine APU

OPOC APU



Non-propulsion Load Analysis

SOFC APU

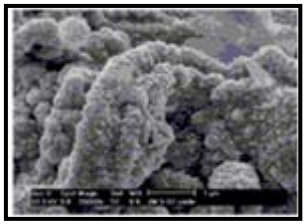
Energy Storage Technology

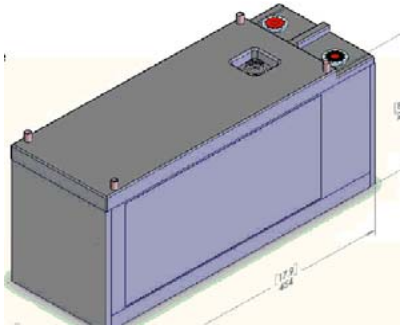
Problem:

High power Li-Ion battery pack sized for combat hybrid electric vehicles is extremely costly.
High power Li-Ion batteries for combat hybrid vehicle application must be safer and more reliable.

Research Challenges:

Research thermal runaway process and its control.
Research power vs. energy trade-off design optimization.
Research manufacturing process development and cost control.
Research thermal management.
Research cell & system, safety & reliability.
Research system control & cell and battery management systems.
Research alternative electrochemical improvements.





Power Management Technology

Problem:

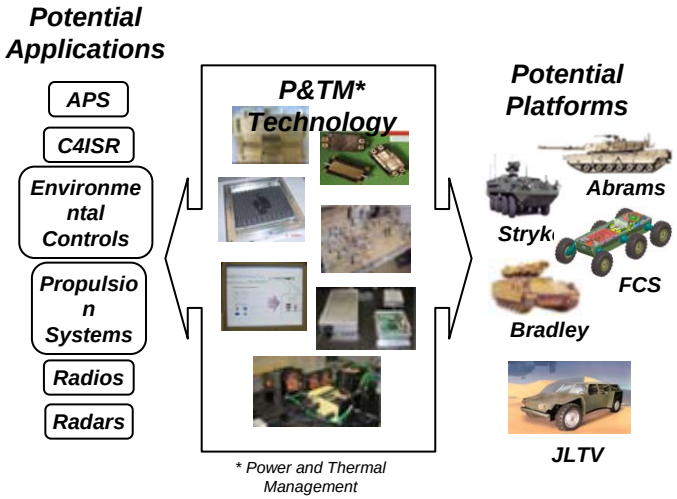
Current and future force electrical power demands exceed power generation and energy storage capabilities.
Advanced power generation systems depend on sophisticated control methodologies for safe operation.
Limited fuel availability in the field.
Increasing number and size of electrical loads on a vehicular platform increases the heat generation.
Presently, no automated way to recover from faults and induced faults (i.e. Sympathetic tripping, chain tripping of loads).
Current vehicular electrical architectures contain vehicle-unique electrical components which increase the logistics burden.

Research Challenges:

Research ability to accurately monitor and control the power distribution to react to fluctuating loads and sources in real time.
Research open architecture for electrical power architecture.
Research power requirements of military equipment and load management strategy.

Software Standard

Flex cable/PCU integration



Thermal Management Technology

Problem:

Cooling systems for hybrid electric combat vehicles challenged for projected requirements.

Increases in electrical power demand proportionately increase cooling system volume and weight requirements.

Thermal degradation inevitably results in reductions of component life and reliability.

Lack of intelligent control strategies for military ground vehicle thermal management systems.

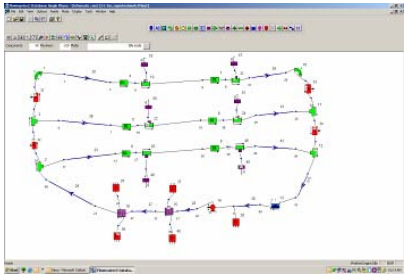
Debris and contamination cause damage to vehicle power train components.

Research Challenges:

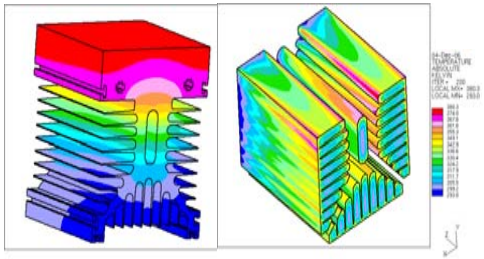
Research heat rejection techniques for the military vehicle application.

Research improvements in capabilities for filtration (liquid and air) without increasing the system physical size.

Research the efficiency benefits of emerging technologies into ground vehicle power electronics.



Analogous flow network model



Computational fluid Dynamics (CFD) model

Intelligent Ground Systems

Intelligent Ground Systems Overview

Furthering Unmanned Systems Autonomy

- Unmanned Ground Vehicle Platforms
- Vehicle Intelligence and Control
- Mission Payload Integration
- Embedded Simulation

Increasing Crew Interface and Control Capabilities

- Human-Robot Interaction
- Advanced Soldier Machine Interfaces
- Embedded Simulation

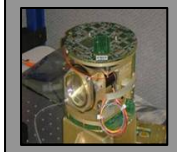
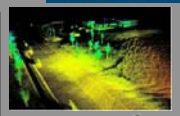
TARDEC Robotics

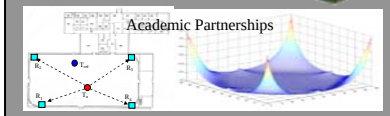
Mission

Integrate, Explore, and Develop Robotics, Network and Control Components with a Focus on Customer Driven Requirements to Provide Full System Solutions to the War Fighter

Technology Components





Integration

Demonstrators

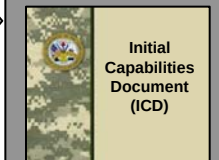

SME Defined Scenarios

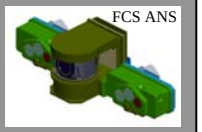
Military Relevant Test & Experimentation



Tech Transfer

Transition and Requirements Development





Integration Technology Development Lessons Learned to Enable Early Technology Insertion

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Enabling Technologies

Making the robots work well with others

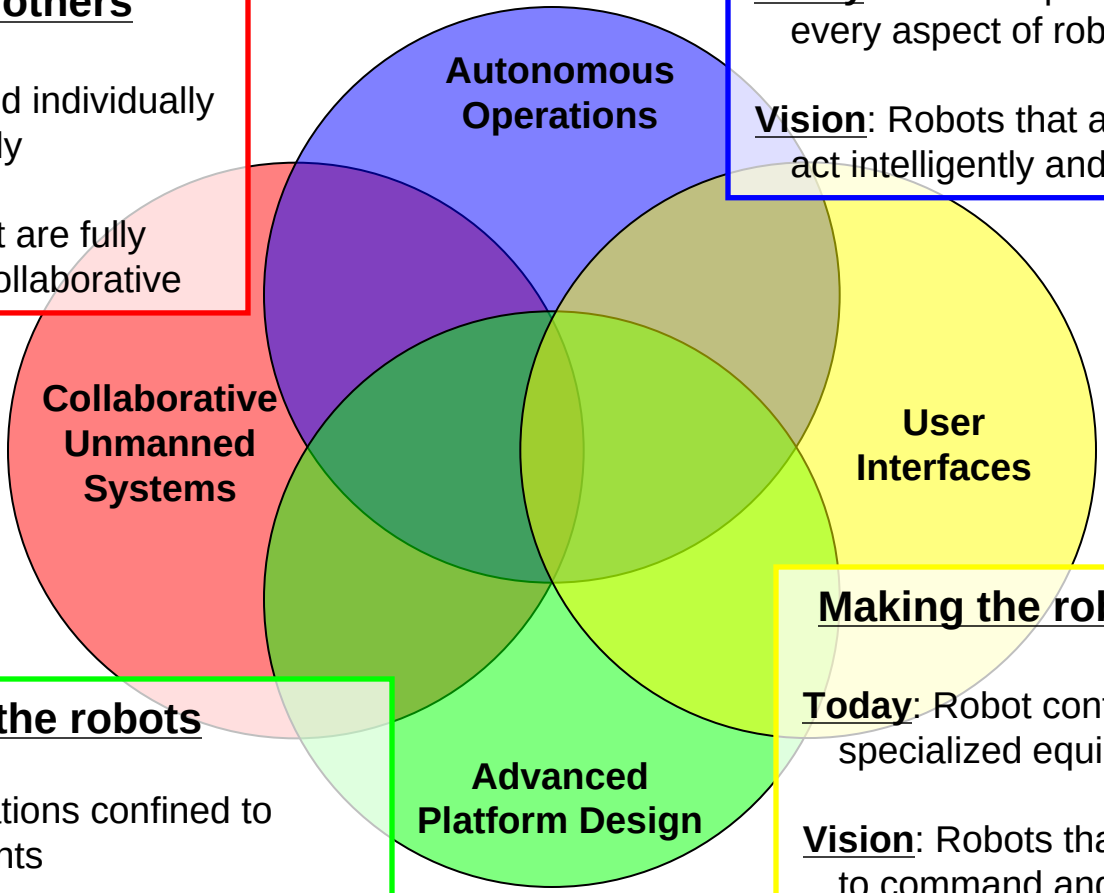
Today: Robots used individually and independently

Vision: Robots that are fully networked and collaborative

Making the robots smarter

Today: Human input required to control every aspect of robot

Vision: Robots that are able to think and act intelligently and independently



Making the robots easier to use

Today: Robot control requires specialized equipment and training

Vision: Robots that are intuitively easy to command and control

Making the robots

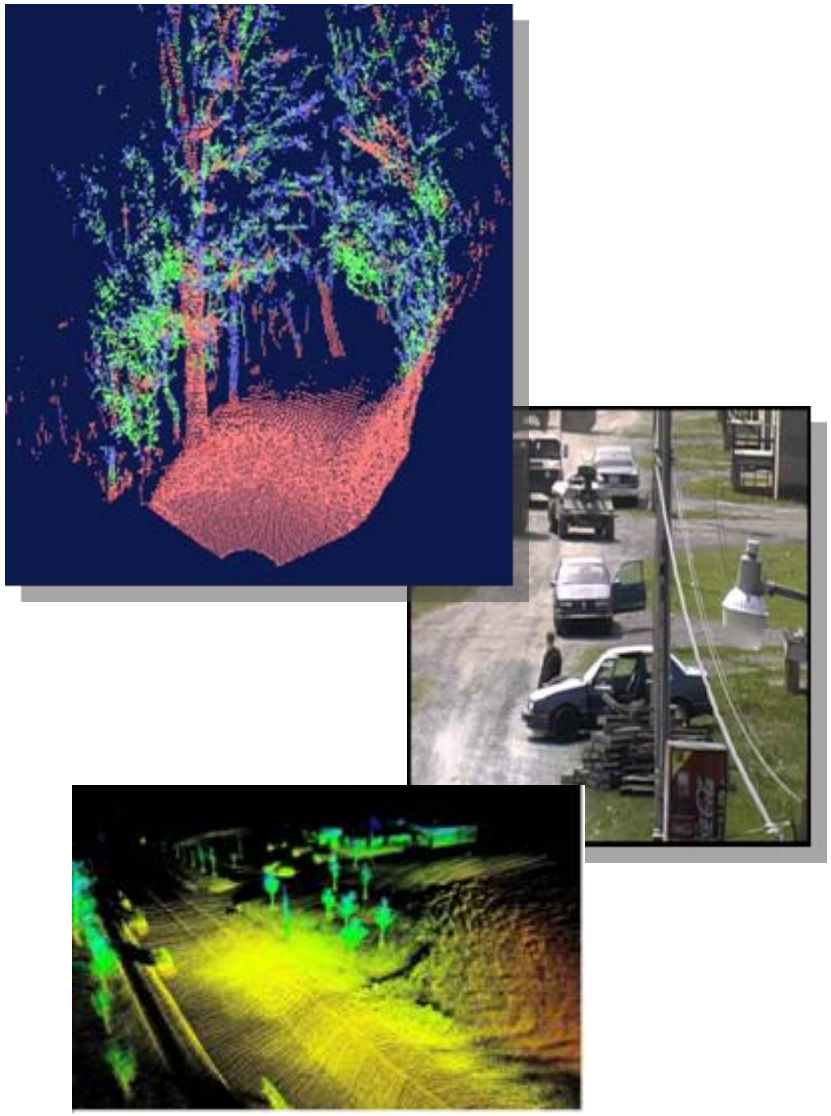
Today: Robot operations confined to limited environments

Vision: Robots that are able to operate in any environment at any time

Unmanned Systems Technology Shortfalls - Perception

Research Topics – Potential Shortfalls

- Sensors – extended range & resolution
- Sensors – all weather sensing/obscurants
- Sensors – reduced size
- Software – Terrain classification, especially at extended range
- Software – Feature classification, especially at extended range
- Software – Detection, classification, tracking of moving vehicles, people, & animals from a moving vehicle (object association/partial obscuration)
- Software – Detection of moving & stationary people, often partially obscured or camouflaged
- Software – Stand-off classification of mud or water – estimate of surface supportability/ trafficability



Research Topics – Potential Shortfalls

Vehicle Intelligence

- Ability to adapt to changing environment & learn from prior experience or act based upon general guidance
- Ability to project future activity or courses of action by others and plan accordingly
- Ability to understand vehicle health and modify plans accordingly

Tactical Behavior

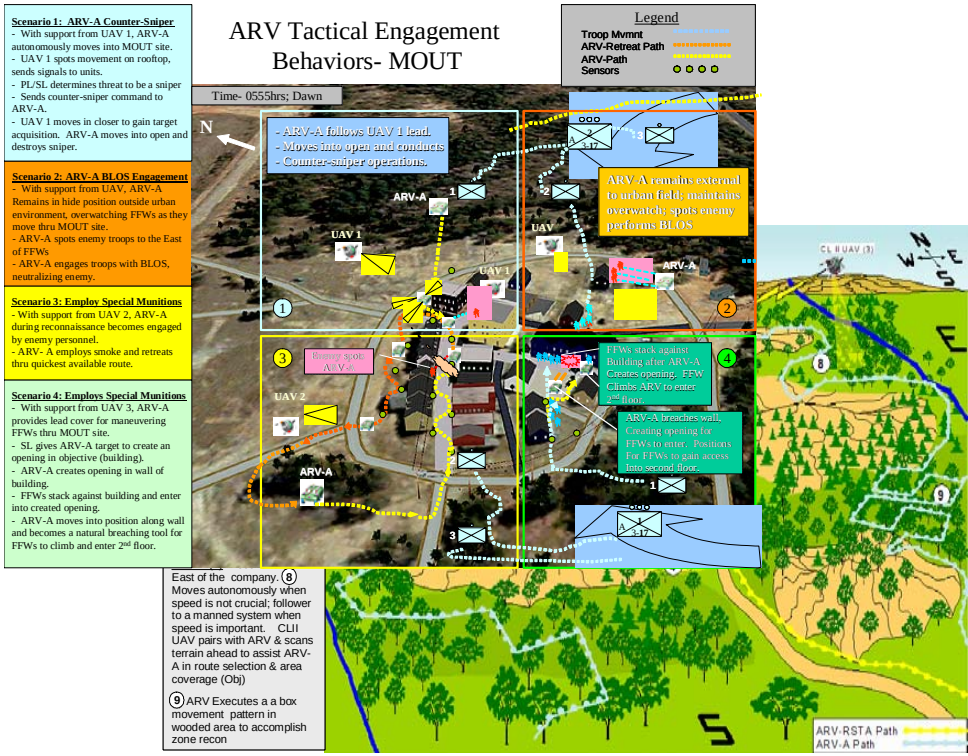
- Mimic the behavior of Soldiers under similar conditions
- Continue autonomous operation during prolonged communications outages
- Self-protection

Collaboration

- Shared situational awareness
- Teaming – robot/robot and robot/Soldier

Mission Specific Behaviors

- RSTA
- Force Protection
- Material handling/delivery



Unmanned Systems Technology Shortfalls - Command and Control

Research Topics – Potential Shortfalls

Operator Control

- Situational awareness of what's going on around the robot/operator intervention
- Scalable interfaces – from MGV to dismount
- Operator workload in realistic tactical environments
- Operator span of control
- Alternative control modes (voice/gesture)
- Hands free, heads up display and control

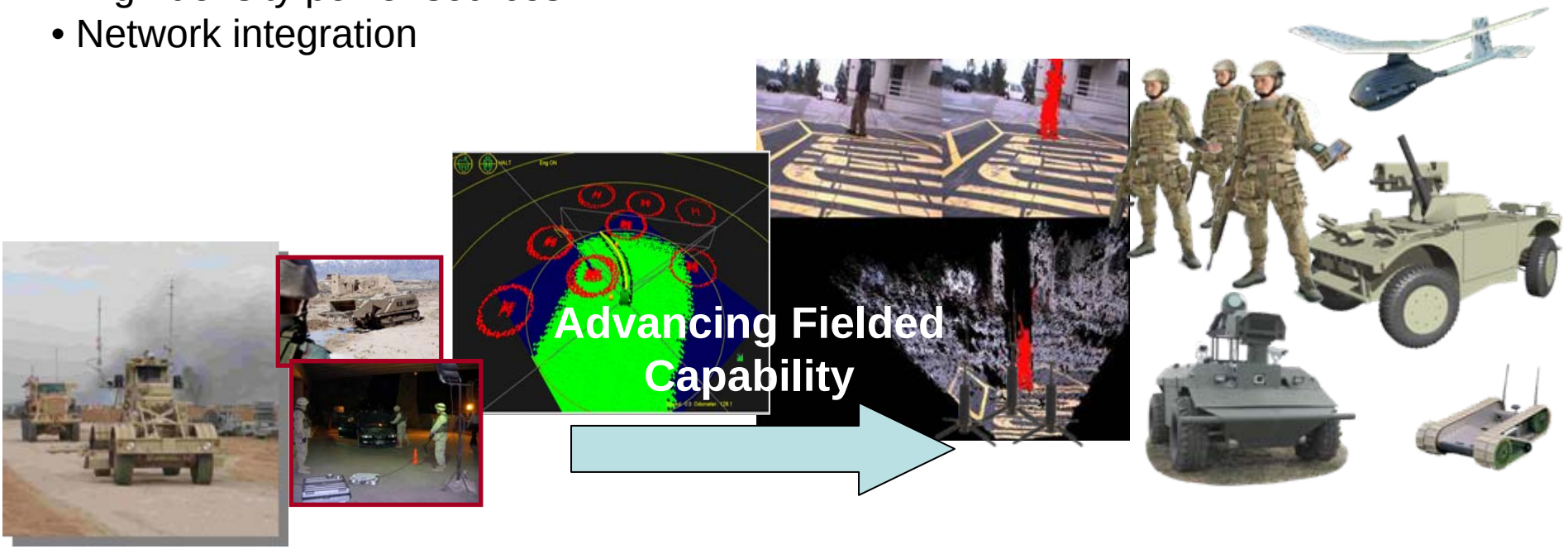
Command Integration

- Fusion of local situation awareness information with the Common Operating Picture

Systems Shortfalls

Research Topics – Potential Shortfalls

- Autonomous Vehicle safety
- Autonomous Weapon safety
- Platform – modularity; shape shifting; micro/miniaturization; bio-mimetic; health maintenance/ prognostics/ self-healing;
- Low SWAP, high bandwidth data links
- High density power sources
- Network integration



Hard On and Off Road Problems

- Very busy environments
- Potholes
- Other vehicles
- Poor lane markings
- Traffic signals
- Pedestrians
- Animals
- Road work

Deep water

Very cluttered environments

Mud, ice, snow, gravel and other traction problems

Sharp rocks, rebar and curbs

Tank traps

Wire, posts and fences

Hidden hazards, e.g. rocks and holes

Fog, dust, smoke, rain

Questions?