4.3 Survivability and Mobility

"We must be able to disperse and concentrate, conduct full spectrum operations across all dimensions (air, land, sea, cyber and the electromagnetic) and provide protected mobility to both dismounted and mounted Marines."

-Statement before the House Armed Services Committee, Subcommittee on Tactical Air and Land Forces, November 16, 2011, of Brigadier General Daniel J. O'Donohue, Director, Capabilities Development Directorate and Brigadier General Frank L. Kelly, Commander, Marine Corps Systems Command and Mr. William E. Taylor, Program Executive Officer Land Systems

Bottom Line Up Front	
Challenge	
Survivability and Mobility are addressed jointly because they are clearly linked. This challenge is to provide increased protection (survivability) while maintaining (or increasing) mobility.	
Potential Solutions - Survivability	
ONR	Advanced Electromagnetic Armor (AEMA) Advanced Requirements for Crew Safety Combat Science and Technology Vehicle (CSTV) Shock Mitigating Seats Energy Absorbing Structures for Blast Mitigation Expeditionary Light Armor Seeding Development High Strength-High Ductility Nano Composites Survivability Analysis of Alternative Tool Trimodal Aluminum
RDECOM / TARDEC	Advanced Combat Vehicle Armor Development (ACVAD) Electro-Magnetic (EM) Armor KE Active Protection System (APS) Kinetic Energy Armor Integration Techniques Laser and High Energy threat Research Low Risk EM Armor Multi Threat Armor Development Multi-Function Armor Occupant Centric Survivability RPG Active Protection (RAP) Sensor Enhanced Armor Tactical Vehicle Armor Development Transparent Armor Vision Protection from Lasers Warfighter Injury Assessment Manikin (WIAMAN)
SBIRs	Mitigation of Blast Injuries Laser Eye Protection Light Weight High Temp Armor Lightweight Self-Sealing Fuel Tanks with Hydraulic Ram Mitigation Lightweight Armor Study Transparent Armor Delamination Study Software for FOA of Effects of Blast & Ballistic Impacts on Vehicles Innovative Manufacturing Research-Forming of Large Light Armor Alloy Modular Anthropomorphic Test Device Modular Light Weight Armor Composite Armor Structural Monitoring (CASM)

Bottom Line Up Front	
Potential Solutions - Survivability Continued	
SBIRs conitinued	Innovative Cost-Effective Lightweight Transparent Armor for Vehicles Low Cost Manufacturing of the Ballistic Resistant Transparent Spinel Windows Nanoinfusion Technology for Low-Cost, Lightweight, Transparent Armor Optically Transparent, Ballistic Protective HybridSil Armor for Combat Vehicles Real Time Damage Monitoring of Composite Vehicle Armor Structure Integrity Using Embedded Sensors Transparent Armor Delamination Phase A Study North Carolina State University – Metallic Foam Armor MTVR Blast Seat Evaluation
Potential Solutions - Mobility	
ONR	Advanced Suspension System – LAV Advanced Propulsion Technologies Electrical Acceleration Assist & Integrated Starter Generator (ISG) Combat Science and Technology Vehicle (CSTV) Infinitely Variable Transmission (IVT) Modular Vehicle Platform (MVP) Vehicle Stability
RDECOM / TARDEC	Advanced Propulsion w/ISG Research Advanced Running Gear Mobility Combat Engine Research Concept Based Maintenance (CBM) Technologies Continuous High Output Engine Research Elastomer Maturation for Increased Track Durability GVPM High Performance Lightweight Track System Next Generation Engine Research
MCWL	Autonomous Mobility Appliqué System (AMAS) JCTD
SBIRs	An Innovative Ultra Lightweight Runflat Technology Passive Adaptive Run-on-Flat (RoF) Tires High Mobility Suspension Technologies Suspension and Track Noise and Vibration Reduction

Potential Solutions

Survivability

Although fire suppression is a subset of survivability, all fire related projects and programs are addressed in the Fire Suppression section 4.5 of the ATIP.

ONR Efforts

Advanced Electromagnetic Armor (AEMA). The AEMA program is developing new defeat mechanisms for efficient lightweight protection concepts and exploring novel under vehicle protection concepts and developing improved vehicle mine blast protection. The goal is to increase survivability against Explosively Formed Penetrators (EFPs)/RPGs and Air to Ground Missiles while reducing power requirements and weight burden.

Advanced Requirements for Crew Safety. The objective of this program is to develop validated, quantitative, medically-based and measurable crew survivability requirements for

the JLTV. This program concentrates on the need to focus on the warfighter vice the platform survivability.

Combat Science and Technology Vehicle (CSTV) Shock Mitigating Seats. This ONR project has the goal of developing seating technology and services to protect the crew against current/emerging vehicle IED/Mine threats and rollover. M&S tools for end-to-end threat to occupant characterization will be developed for evaluation of loads and injury assessments. Included in this project is the development of a test-bed for seat concepts, emphasizing lower leg and multi-directional protection.

Energy Absorbing Structures for Blast Mitigation. This project will explore the development of new energy absorbing structures to improve crew survivability against underbody blast events.

Expeditionary Light Armor Seeding Development. By expanding existing ballistic performance design equations, it will be possible to develop properties-based equations for state-of-the-art and emerging ceramic composite armor systems. Possible equation parameters could include ceramic hardness, yield and fracture toughness; and composite yield, elongation, and stiffness.

An up-armored LVSR arrives ashore.

High Strength-High Ductility Nano Composites. The objective is to develop nanoscale reinforcements, in combination with a dispersion strengthened matrix and coarse grained region that has tailorable plasticity to yield a high strength-high ductility multi-scale nano composite aluminum.

Survivability Analysis of Alternative Tool. The objective is to develop an M&S tool to conduct Analysis of Alternatives (AoA) establishing key survivability performance parameter thresholds for crew casualty and help focus investments for survivability.

Trimodal Aluminum. This is a new mass efficient ballistic armor that simultaneously absorbs energy during dynamic loading while maintaining high strength. Trimodal Aluminum has the potential of offering a light appliqué armor system providing equal protection to fielded heavier appliqué systems at 60% less weight. Efforts such as this enable lighter, more survivable, and maneuverable ground combat vehicles.

RDECOM & TARDEC Efforts

Advanced Combat Vehicle Armor Development (ACVAD). The ACVAD program's purpose is to develop and demonstrate EM armor, multifunctional SE and EA armor with an advanced

electro-magnetic defeat mechanism in an integrated armor package. The armor design/ integration lessons learned will be used in the development of EM, SE and EA armors providing a multi-hit armor system without recharging and meet emerging survivability threats.

Electro-Magnetic (EM) Armor. The EM Armor project purpose is to develop and demonstrate an advance electromagnetic defeat mechanism in an integrated armor package. The products developed from the project will be designed to meet ACVAD threats.

KE Active Protection System (APS). KE APS is focused on developing a guided interceptor, warhead and fusing capability that integrate into an Active Protection System providing capability to defeat Tank-Fired Kinetic Energy Long Rod Threats.

Kinetic Energy Armor Integration Techniques. This project focuses on developing and validating improved techniques and capabilities to integrate and test advanced medium and heavy appliqué armors for combat platforms with the goal of providing improved bolted/bonded joints, closeouts, and grilles for medium and heavy armor.

Laser and High Energy threat Research. The purpose of the project is to determine the impact of short-pulse and high energy lasers on vision and sensor technologies and investigate new the technologies for protection.

Low Risk EM Armor. The Low Risk EM Armor will develop and demonstrate electro-magnetic defeat mechanisms in an integrated armor package. It will utilize COTS components to integrate an electro-magnetic armor on a ground combat system platform.

Multi Threat Armor Development. The goal is to develop and mature lightweight advanced multi-threat B-kit and C-kit armor solutions received from ARL and Industry for transition to PEO CS&CSS vehicles and ensure the B-kit and C-kit armor designs can withstand residual projectiles from various APS technologies. The result will be lighter weight armor solutions allowing for greater vehicle payload and performance and reducing the vehicle's overall visual signature.

Multi-Function Armor. This program will meet the need to develop lower weight, higher performance armor solutions with embedded sensors for real-time health monitoring, signature control and situation awareness. This improved ballistic armor will include embedded health monitoring, antenna and signature control.

Occupant Centric Survivability. The goal is to approach occupant protection from a system level and leverage defense, automotive/race industry & medical community knowledge to integrate IED/mine protection, PPE, crash and rollover protection. Continue development of M&S capability to predict and reconstruct mine/IED/crash events.

RPG Active Protection (RAP). The purpose of RAP is the Active Protection concept developed to current user requirements and matured to TRL 6, with focus on RPGs. The system will be developed to open architecture standards (communication protocols, processors and displays), for the user developed APS requirements.

Sensor Enhanced Armor. This project will implement various ways to assess the health of the armor over the life of the vehicle. The Sensors will provide real-time armor data.

Tactical Vehicle Armor Development. This project will develop opaque armors for the defeat of direct fire, IED, shape charge jet threats and APS residuals.

Transparent Armor. The project purpose is to research and develop technologies and processes to improve the performance and environmental stability of transparent armor laminates, refine ATPD 2352 to improve the quality of transparent armor and the development of products which improve rock-strike and delamination resistance.

Vision Protection from Lasers. The purpose of this project is to develop sensor and vision protection from lasers.

Warfighter Injury Assessment Manikin (WIAMAN). WIAMan is a collaborative effort to create a Warrior-representative test dummy and associated biomedically-validated injury assessment tools for use in live-fire test & evaluation and vehicle development efforts.

DARPA Efforts

DARPA Armor Challenge. Many small companies are developing new armor concepts and products but lack the required resources to initiate full-scale armor development programs. In order to ensure ideas are not overlooked, DARPA has initiated the "Armor Challenge" program to concentrate on inventors and small organizations in efforts to identify revolutionary and promising new armor systems for military vehicles and personnel. While not a full development program, Armor Challenge reimburses qualified participants for the costs of manufacturing initial test articles. The program evaluates participants based on ballistic test results at qualified testing facilities during periodic "shoot-offs" and assesses the cost effectiveness of armor designs. Armor Challenge then considers successful armor designs for follow-on testing or potential armor development programs.

Survivability SBIR Efforts

- **Mitigation of Blast Injuries**
- **Laser Eye Protection**
- **Light Weight High Temp Armor**
- **Lightweight Self-Sealing Fuel Tanks with Hydraulic Ram Mitigation**
- **Lightweight Armor Study**
- **Transparent Armor Delamination Study**
- **Software for FOA of Effects of Blast & Ballistic Impacts on Vehicles**
- **Innovative Manufacturing Research-Forming of Large Light Armor Alloy**
- **Modular Anthropomorphic Test Device**
- **Modular Light Weight Armor**

- **Composite Armor Structural Monitoring (CASM)**
- **Innovative Cost-Effective Lightweight Transparent Armor for Vehicles**
- **Low Cost Manufacturing of the Ballistic Resistant Transparent Spinel Windows**
- **Nanoinfusion Technology for Low-Cost, Lightweight, Transparent Armor**
- **Optically Transparent, Ballistic Protective HybridSil Armor for Combat Vehicles**
- **Real Time Damage Monitoring of Composite Vehicle Armor Structure Integrity Using Embedded Sensors**
- **Transparent Armor Delamination Phase A study**
- **North Carolina State University – Metallic Foam Armor**
- **MTVR Blast Seat Evaluation –** This is an STTR evaluation of energy absorbing seats specifically for the MTVR.

"To move swiftly, strike vigorously, and secure all the fruits of victory is the secret of successful war."

-Lieutenant General Thomas "Stonewall" Jackson, CSA

Mobility

Vehicle Mobility will likely benefit from the Fuel Efficiency, Modeling and Simulation, and Weight Reduction S&T Focus Areas.

ONR Efforts

Advanced Suspension System – LAV. This project will develop a fully operational ride-height adjustable advanced suspension system to be installed and tested on a Light Armored Vehicle replacing the current passive LAV suspension. The goal is to reduce absorbed power at the driver's seat by 30% for all anticipated vehicle weight conditions.

Advanced Propulsion Technologies. The purpose is to investigate and develop advanced propulsion components to achieve improved system efficiency including electric and Hybrid

Electric, and other non-conventional propulsion architectures for manned and unmanned combat vehicles, either wheeled or tracked and other alternative forms of mobility.

Combat Science and Technology Vehicle (CSTV) Infinitely Variable Transmission (IVT). The Objective is to demonstrate an operationally suitable IVT for tactical wheeled military vehicles. The CSTV IVT has the potential of improving fuel economy and reducing gross weight of the vehicle.

Modular Vehicle Platform (MVP). Demonstrate a single self-loading platform (i.e. Medium Tactical Vehicle Replacement) with mobile modular combat capabilities (i.e. weapons, command and control, trauma bay), housed in standard containers (i.e. CONEX shipping container).

Vehicle Stability. Efforts in this area include development of a stability control technology suitable for integration into the tactical vehicle fleet, reducing the tendency of vehicle rollovers. Results of these S&T contributions will include: reduced vehicle rollover tendencies, increased vehicle stability, enhanced vehicle safety, and improved ride quality.

RDECOM / TARDEC Efforts

Advanced Propulsion w/ISG Research. The purpose of this program is to investigate and demonstrate advanced propulsion technologies, develop in-house capability to test, analyze an advance integrated hybrid and mild hybrid systems in vehicle platforms.

Advanced Running Gear Mobility. This project takes a systems approach to research running gear system improvements for legacy and future combat and tactical vehicles to reduce weight, improve durability, survivability, and reliability. An active suspension system will be developed offering energy regeneration based on vehicle movement, real-time prognostic/diagnostic tools, and increased durability. Additional goals include, increased survivability through improved mine blast and fire resistance, reduced track and suspension system life cycle costs through longer lasting materials, greater off road performance, greater roll stability, and lower interior hull shock/vibration.

Combat Engine Research. The purpose of this program is to investigate and validate novel high power density low heat rejection fuel efficient engine design concepts to meet mobility need of future combat engine vehicles.

Concept Based Maintenance (CBM) Technologies. The purpose is to develop, integrate, and demonstrate CBM algorithms, data acquisitions, storage and transfer capabilities, as well as vehicle management agents. This will have the potential for improving operational readiness through platform health status reporting and predictive failures.

Continuous High Output Engine Research. The project's purpose is to continue R&D activity on high speed engines and implement design change improvements identified during exploratory development phases to increase specific output. The best engine candidates will be identified for further advanced development for next generation diesel engines.

Elastomer Maturation for Increased Track Durability. The purpose of this project is to develop improved thermoset components that improve track system durability and reliability and reduce life cycle costs. Track system life improvement goal is 50%.

GVPM High Performance Lightweight Track System. The purpose of this project is deliver a robust, survivable lightweight track system with a 20 to 25% improvement in durability for a 45 ton class vehicle with growth potential for future ground vehicles program.

Next Generation Engine Research. The purpose of this project is to combine high speed combustion, closed loop control, oil cooled, low heat rejection engine research efforts for development of a high power density diesel engine with operating characteristics enabling propulsion system power densities greater than 10 Net Hp/ cu. ft. of system installation volume.

Operating in the harshest of environments, mobility continues to be a challenge for Marine Corps vehicles.

"We are light enough to get there quickly, but heavy enough to carry the day upon arrival."

-General James F. Amos, Commandant of the Marine Corps, February 8, 2011,
Marine Memorial Club, San Francisco, CA

MCWL Efforts

Autonomous Mobility Appliqué System (AMAS) JCTD. This effort provides scalable autonomy in a single material solution, agnostic of tactical platform. The autonomy kit would provide scalable autonomy ranging from Driver Assist functionality through autonomous behaviors. The Vehicle By-wire kit would provide the actuation and interface for the Autonomy kit's capabilities.

Mobility SBIR Efforts

- **An Innovative Ultra Lightweight Runflat Technology**
- **Passive Adaptive Run-on-Flat (RoF) Tires**
- **High Mobility Suspension Technologies**
- **Suspension and Track Noise and Vibration Reduction**