Ground & Sea Platform COI Overview 2016

2016 NDIA S&T Conference

Dr. John Pazik
Head, Expeditionary Maneuver Warfare and Combating Terrorism Department, ONR
Chair, Ground and Sea Platforms COI Steering Group

Agenda

- **GSP Overview**
- **Transition Opportunities**
- **Roadmap Process**
- **Roadmap Discussion by Technical Challenge Area**
  - Opportunities
  - Challenges
  - Focus Areas
- **Way Ahead**

COI Portfolio Overview – COI Membership

Steering Group

Dr. John Pazik (USMC)
Dr. Thomas Fu (Navy)
Dr. Jennifer Hitchcock (Army)

Deputies

Mr. Sam Kirby (USMC)
Mr. Bob Lapolice (Army)

Executive AO:
Mr. Troy Hendricks (USMC)

Working Groups

Survivability
Thomas Meitzler (Army)
Roshdy Barsoum (Navy)
Rod Peterson (USMC)

Modularity / Design & Integration
Rob Maline (USMC)
Matt McMahon (Navy)
Chris Mocnik (Army)

Mobility
Dale Martin (Army)
Don Hoffman (Navy)
Al Schumacher (Army)

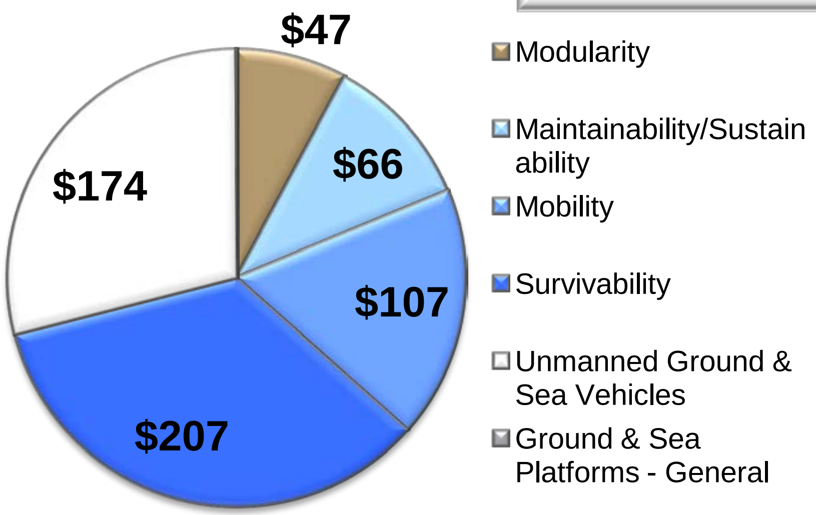
Maintainability / Sustainability
Billy Short (USMC)
John Szafranski (Army)
Airan Perez (Navy)

Unmanned Platform Integration
Greg Hudas (Army)
John Andrews (USMC)
Bob Brizzolara (Navy)

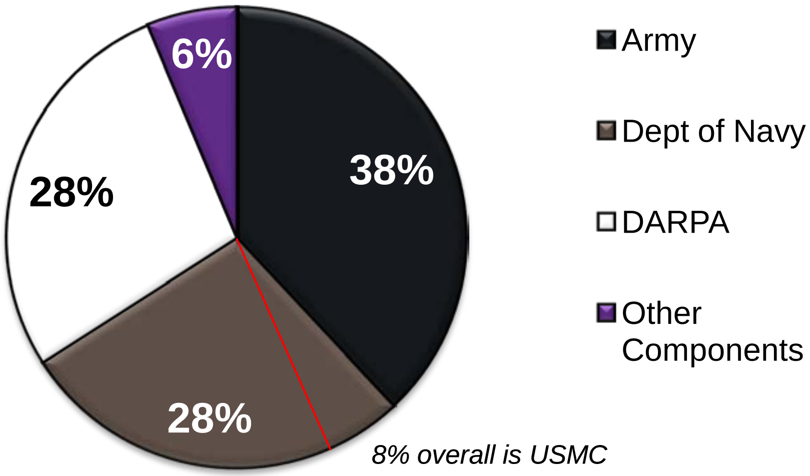
COI Portfolio Overview – Overall G&SP COI Investment Profile

COI Sub-Areas ($M)

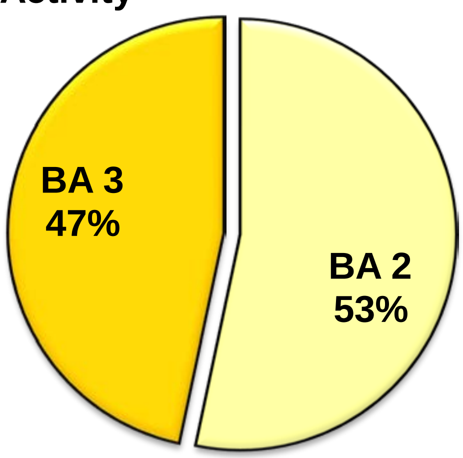
Total = $602M



Component Investment



Budget Activity



Source: DoD PB16 FY 2016

Major Programs:

- Unmanned: LDUUV, ACTUV, Hydra
- Survivability: ORP, Multi-Axis Protection of Ships, Modular Active Protection System
- Modularity: Squad-X
- Mobility: CVP, GXV
- Maintainability: Hybrid Multi-Material Rotor

Commercial-DoD Leverage in Ground & Sea Platform Technologies

TECHNOLOGY LEVERAGE

- Reduce Platform Fuel Demand
- Reduce Weight of Powertrains
- Enhance Propulsion

- Enhance Energy Efficiency
- Advance Corrosion & Wear Resistant Systems

- Condition Based Maintenance
- Protect Cyber Capabilities in Platforms & Embedded Systems

- Improve Internal Occupant Protection,
- Buyback Mobility in Soft Soil

- Reduce Impact of High Sea States
- Improve Design for Higher Speed

- Integrate and Enhance Platform Autonomy
- Optimize Platforms by/for Unmanned Operations

WEIGHT/SIZE (Heavy – Medium – Light)

Ground

- **Tactical Ground:** Abrams, Bradley, LAV, Stryker, JLTV, HMMWV
- **Combat Support:** **Heavy** (e.g., HEMTT, PLS); **Medium** (e.g., FMTV, MRAP)

Sea

- **Surface Ships:** Aircraft Carriers, Cruisers, Destroyers, Littoral Combat, Patrol Coastal
- **Amphibious:** Assault, Transport Dock, Landing Craft, AAV/ACV
- **Military Sealift:** Oilers, Dry Cargo/ Ammunition, RORO

Unmanned

- **Unmanned Ground:** Combat (e.g., TERRAMAS), Logistics, Counter Mine/ISR (e.g., PACKBOT), Home/ Personal
- **Unmanned Sea:** ACTUV, LDUUV, REMUS AUV, Space Exploration

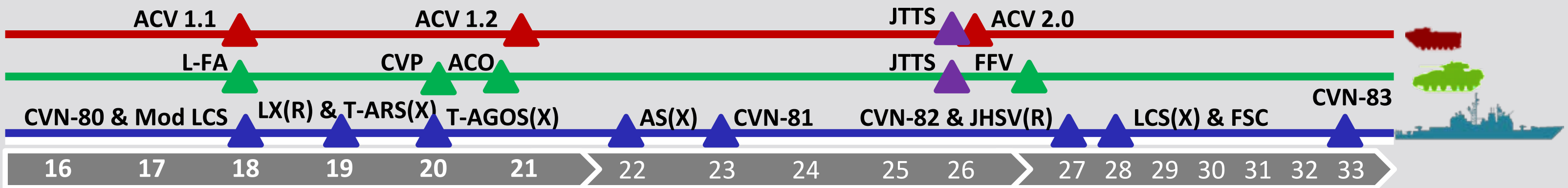
Legend
DoD
Commercial
DHS
NASA

DoD looks for opportunities to leverage commercial technology where applicable

- **Identifying commercial technology suitability to military use/environment is a challenge**
- **It must be carefully evaluated to ensure requirements unique to DoD systems are met**

Transition Targets

Major Programs or POR



Other Navy Opportunities

- Repurpose decommissioning ships (USS PONCE, formerly LPD 15, repurposed as Afloat Forward Staging Base and hosted first deployed tactical laser weapon)
- Upgrade existing ships

Other Army Opportunities

- Modification to existing combat and tactical vehicle programs

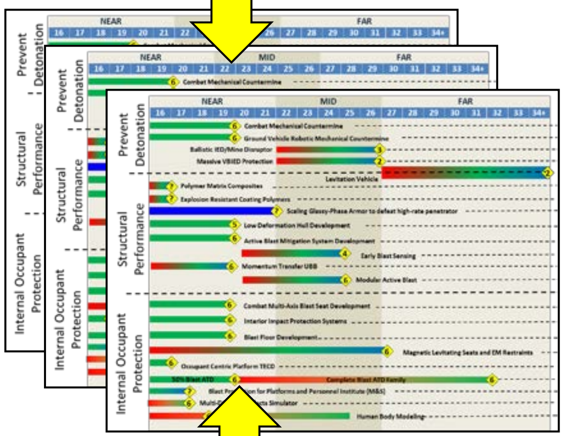
Other USMC Opportunities

- Modification to existing vehicle programs

GSP COI Roadmap Process

Created and defined technical performance and schedule objectives

OBJ 4. Directed Energy Weapon Defeat	Sensor Protection from Lasers	3rd Gen Integrated Detector / Electronics cooler assembly with integral laser protection to defeat current threats	Low reflectivity focal plane arrays and detector / dewars Low optical cross section EO sensor	Advanced materials survivable against high energy CW laser
	Protect system/sub-system from direct fire laser damage	Quantify material interaction with laser weapons	50kw HEL protection	100+kw HEL protection
OBJ 5. Enhanced Ballistic Protection	Passive Armor: Optimizing armor performance for multiple threats. Affordability of new material solutions., development of high performance materials., SWAP C.	5% increase in Light Armor mass efficiency (Em)	10% increase in Light Armor mass efficiency (Em)	15% increase in Light Armor mass efficiency (Em)
	Advanced Armor (Adaptive, Electromagnetic):	Hybrid electric armor use of electrical energy and other passive materials to defeat threats.	Cooperative survivability – multiple systems on one vehicle	Holistic survivability – unit level capability to provide multi-platform coordinated defense

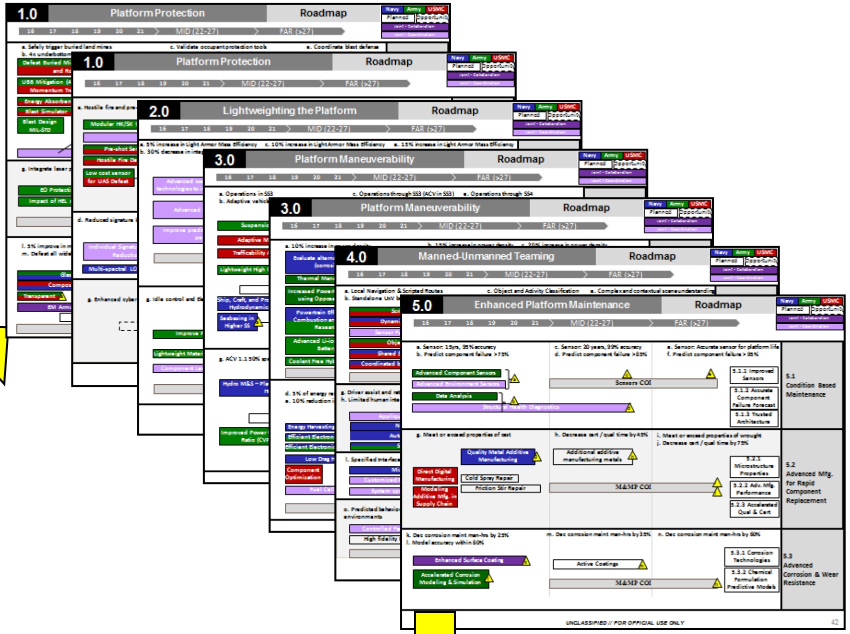


Developed 19 Investment Plans to align all service investments with technical challenges

Project Name	Service	Research Category	Final TRL	Year Complete	Transition Opportunities
Combat Multi-Axis Blast Seat Development	Army	6.3	6	2019	[Army] M2 ECP, Stryker ECP, M1 [USMC] ACV 1.2 [Navy] Small boats
Interior Impact Protection Systems	Army	6.3	6	2019	[Army] M2 ECP, Stryker ECP, M1 [USMC] ACV 1.2 [Navy] Small boats
Blast Floor Development	Army	6.3	6	2019	[Army] M2 ECP, Stryker ECP, M1 [USMC] ACV 1.2 [Navy] Small boats
Occupant Centric Platform TECD	Army	6.3	6	2016	[Army] M2 ECP, Stryker ECP, M1 [USMC] ACV 1.2 [Navy] Small boats
Energy Absorbent Materials for Blast Mitigation	USMC	6.3	6	2016	[Army] M2 ECP, Stryker ECP, M1 [USMC] USCM PMLTV

Collected individual service projects and planned efforts

Grouped investments by technical approaches and identified overlaps, investment opportunities, and areas of collaboration



Evaluated Roadmap:

- Identify major efforts and flagship programs
- Conduct self assessment
- Identify and prioritize investment opportunities across the services
- Assess risks and issues

COI

Ground and Sea Platforms
Technical Challenge Breakdown Structure

1.0	2.0	3.0	4.0	5.0
Platform Protection	**Lightweighting the Platform**	**Platform Maneuverability**	**Manned-Unmanned Teaming**	**Enhanced Platform Maintenance**
1.1 Improved Blast Protection	**2.1** Reduced Weight of Armor and Structure	**3.1** Unconstrained Mobility	**4.1** Enhanced Platform Autonomy	**5.1** Condition Based Maintenance
1.2 Directed Energy Threat Mitigation	**2.2** Reduced Weight of Mobility Systems	**3.2** Improved Design for Higher Speed	**4.2** Optimized Platforms by/for Unmanned Operations	**5.2** Advanced Manufacturing for Rapid Component Replacement
1.3 Enhanced Ballistic Protection		**3.3** Enhanced Propulsion	**4.3** Enable Configurable Autonomous & Unmanned Payloads	**5.3** Advanced Corrosion & Wear Resistant Systems
1.4 Hit and Kill Avoidance		**3.4** Enhanced Energy Efficiency	**4.4** Enhanced Assured Trust in Unmanned Systems	
1.5 Detection Avoidance (Signature Management)				
1.6 Enhanced Cyber Defense				

1.0 Platform Protection

Opportunities and Challenges

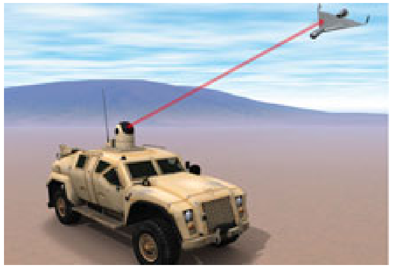
- 1.1 Improved Blast Protection
  - 1.1.1: Prevent Detonation
  - 1.1.2: Structural Performance
  - 1.1.3: Internal Occupant Protection
- 1.2 Directed Energy Threat Mitigation
  - 1.2.1: Sensor Protection
  - 1.2.2: System Protection
- 1.3 Enhanced Ballistic Protection
  - 1.3.1: Passive Armor
  - 1.3.2: Advanced Armor
- 1.4 Hit and Kill Avoidance
  - 1.4.1: Hard Kill and Soft Kill
  - 1.4.2: Sensing
- 1.5 Detection Avoidance
  - 1.5.1: Signature Management
- 1.6 Enhanced Cyber Defense
  - 1.6.1: Enhance Platform Cyber Defense

OPERATIONAL OPPORTUNITIES:

- Negate enemy threat "left of boom"
- Adaptive, modular approach allows platform survivability to outpace threat lethality
- Protect personnel from weapons induced injuries and death
- Operate in complex environment

ENDURING CHALLENGES:

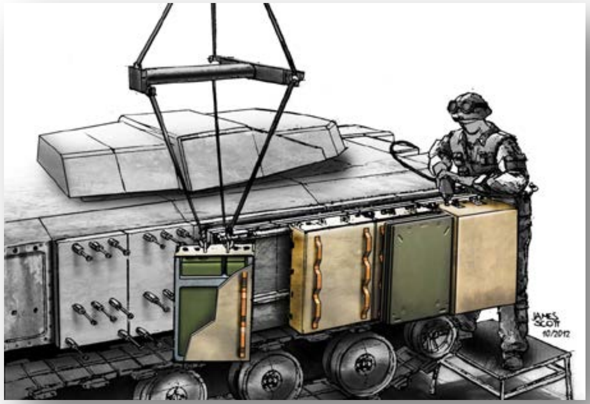
- Smart and lethal/non-lethal threats make armor-only solutions non-sustainable
- Leverage the power of new manufacturing and design processes and material science breakthroughs
- Adapt to an evolving threat attacking across a variety of domains

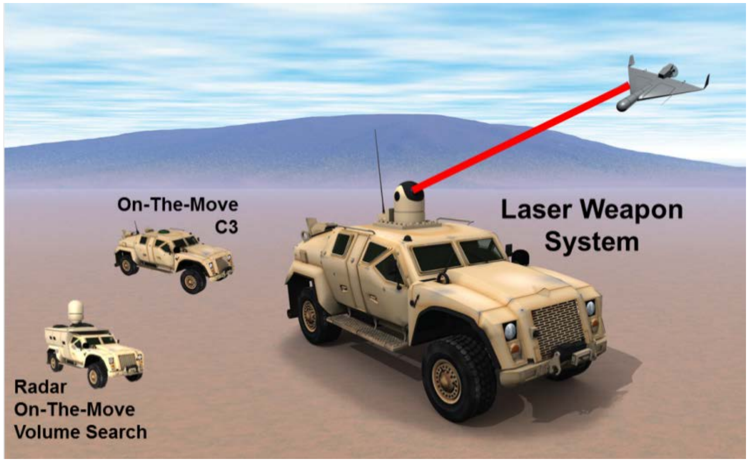


Vision: A system-of-systems that allow the platform to react to and defeat the threat in real time with minimal impact to the occupant and on the mission

Key Focus Areas

- **Cyber Defense of Vehicle Networks**
- **Hard and Soft Kill Options for Counter-UAS**
- **Adaptive Armor**
- **Directed Energy Defeat**
- **Active Protection**





ONR
NAVSEA WARFARE CENTERS DAHLGREN
Directed Energy Warfare Office DEWC

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GBAD

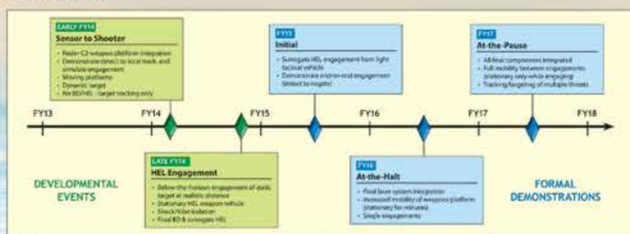
Ground Based Air Defense

Directed Energy On-The-Move

FUTURE NAVAL CAPABILITY

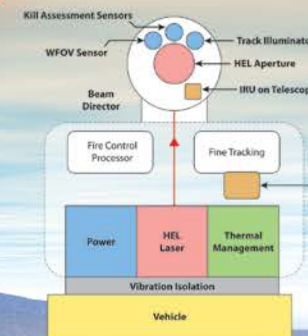
Ground Based Air Defense (GBAD) Directed Energy (DE) Future Naval Capability (FNC) provides an agile, cost effective, deep-magazine On-the-Move (OTM) Detect-to-Engage capability against low altitude Low Observable/Low radar cross section threats to enhance short-range air defense capabilities of the United States Marine Corps (USMC) Marine Air-Ground Task Force Air Combat Element. This effort will tie a High Energy Laser (HEL) integrated onto a USMC light tactical vehicle with a volume surveillance sensor via a command and control interface. This 5-year FNC includes three key milestones demonstrating increased capabilities culminating in an OTM end-to-end engagement of the primary threat in FY17. As depicted in the schedule, initial demonstrations will be on an interim vehicle platform in mid-FY15, followed by demonstration of the final objective system in FY17. Upon successful demonstration, this will transition to the GBAD Program of Record under PEO-Land Systems. Naval Surface Warfare Center Dahlgren Division serves as the Lead System Integrator, and will leverage several S&T development efforts from ONR, the HEL-Joint Technology Office (HEL-JTO), and U.S. Army.

Schedule



Laser Weapon System

Tactical vehicle-mounted mobile/expeditionary/on-the-move system with full-power lasing capability of low altitude, low observable/low radar cross section threats. Objective system weight not to exceed 2,500 lbs, and fully contained within the vehicle's cargo area.



On-The-Move Command, Control, and Communications

Mobile/expeditionary/on-the-move command, control, and communications required to integrate elements of the GBAD FNC product, to include distribution of high-quality stills and/or video imagery, and fire-control quality data (including target position data to permit acquisition of target with local sensors) with ability to minimize latency and support Quality of Service (QoS).

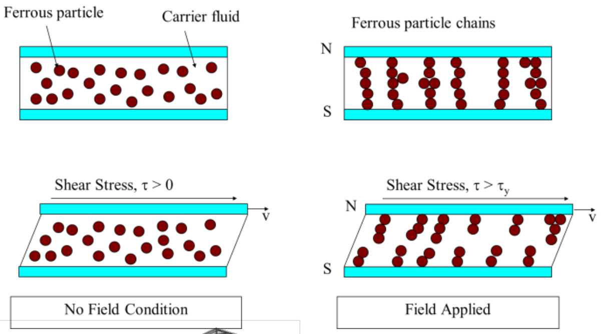
Radar On-The-Move Volume Search

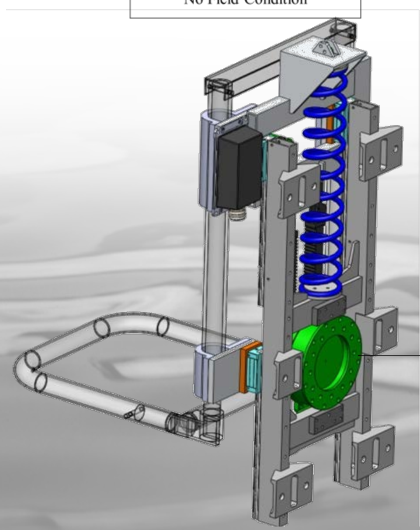
Mobile/expeditionary/on-the-move radar system capable of detecting and tracking targets of interest at operationally relevant ranges with acceptable false alarm rates.

Adaptive Magnetorheological Seat Suspension for Blast Mitigation

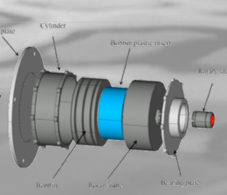
Objective:

Develop and demonstrate an active seat suspension technology that incorporates a magnetorheological (MR) damper for the attenuation of energy from under body blast to protect the crew in military ground vehicles. Secondary objectives are to protect the seated occupant from whole body ground vehicle tactical vibration and adapt to higher energies.





Generation II MR Energy Absorbing (MREA) rotary damper
- Infinite stroke
- 3 stage coil
- 5 inch active diameter
- ~10 lbs



Technology and Key Features:

- Occupant weight adaptation (5th percentile female to 95th percentile male)
- Blast adaptation
- Minimizes occupant loading by maximizing seat stroke
- Senses and calculates 'real time' input velocity and adapts MR output force accordingly
- Mitigates against low frequency chassis vibration to reduce occupant fatigue
- Triggering / timing loops

2.0 Lightweighting the Platform

Opportunities and Challenges

2.1 Reduced Weight of Armor and Structure

2.1.1 Reduced Weight of Armor

2.1.2 Reduced Weight of Structure

2.2 Reduced Weight of Mobility Systems

2.2.1 Reduced Weight of Fuel

2.2.2 Reduced Weight of Powertrains

Operational Opportunities:

- Improve transportability
- Smaller deployment, employment, and sustainment footprints
- Reduce fuel consumption rates and logistical support
- Enhance survivability of small boats and combatants operating in littoral areas
- Improve ship stability

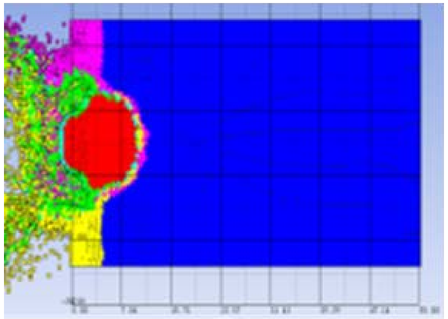
Enduring Challenges:

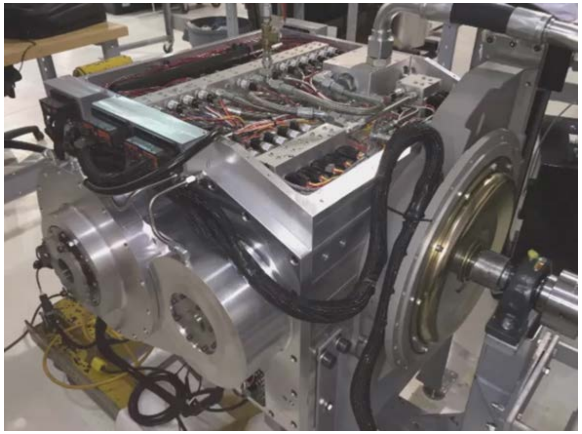
- Reduce logistic burden of storing, transporting, distributing and retrograde of materials
- Achieve operational maneuverability in all environments and at high operational tempo

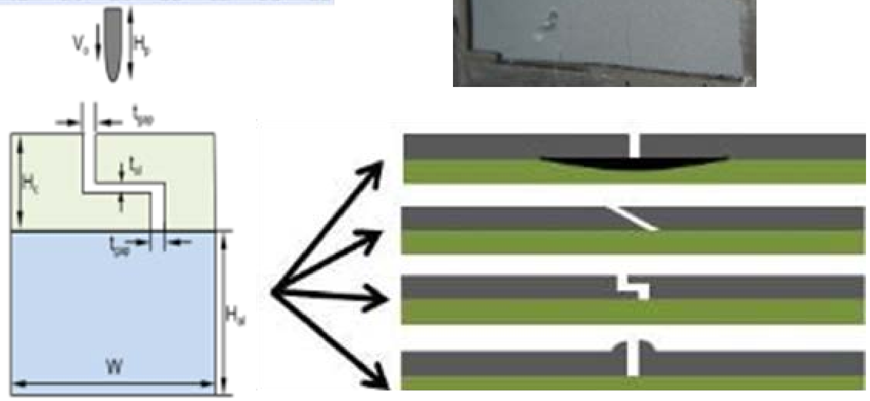
Vision: Provide a lethal and agile force that can be transported and/or deployed across the globe

Key Focus Areas

- **Lightweight track, suspension, powertrain, and other mobility systems**
- **Low cost, high mass efficiency passive armor**







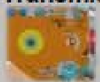
CVP MOVE Prototype Demonstrators

TRL 6 Component Validation

Next Gen Engine

ISG

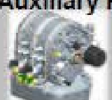
Adv. Transmission



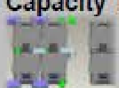
Adv. Thermal Mgmt

Adv. 6T Li-Ion

Adv. Auxiliary Power



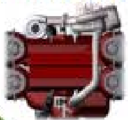
High Capacity Track

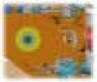
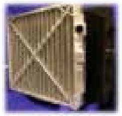


External Suspension

Component Integration to Subsystem

Next Gen Engine + ISG + Adv. Transmission + Adv. Thermal Mgmt + Adv. 6T Li-Ion




Adv. Auxiliary Power + Adv. 6T Li-Ion


High Capacity Track + External Suspension


Validated Design Solutions (TRL 6)

MOVE Adv. Powertrain Demonstrator

Updated Mobility Requirements & Subsystem Data

APU Subsystem Demonstrator

Updated Silent Watch and Electrical Requirements & Subsystem Data

Track and Suspension Subsystem Prototype on Abrams chassis

Updated Track & Suspension Requirements & Vehicle Data

3.0 Platform Maneuverability

Opportunities and Challenges

3.1 Unconstrained Mobility

- 3.1.1: Soft Soil Mobility
- 3.1.2: Operations in High Sea State
- 3.1.3: Operations in Extreme Environments
- 3.1.4: Mobility in Urban Terrain
- 3.1.5: Terrain Transition / Adaptability
- 3.1.6: Operations in Littoral Environments

3.2 Improved Design for Higher Speed

- 3.2.1: Robust M&S Tools
- 3.2.2: Reduce Drag
- 3.2.3: Power to Weight Ratio

3.3 Enhanced Propulsion

- 3.3.1: Power Density
- 3.3.2: Powertrain Efficiency
- 3.3.3: Multi-fuel Capability
- 3.3.4: Thermal Management
- 3.3.5: Operational Availability

3.4 Enhance Energy Efficiency

- 3.4.1: Energy Recovery
- 3.4.2: Fuel Economy
- 3.4.3: Power Density
- 3.4.4: Hybrid / All-Electric Platform
- 3.4.5: Onboard Power Generation

OPERATIONAL OPPORTUNITIES

- Provide access in all operational environments
- Extend platform range/endurance and reduce logistics burden

ENDURING CHALLENGES

- Improve fuel efficiency of platforms with increasing energy demands
- Maneuver a range of challenging terrains and threat environments

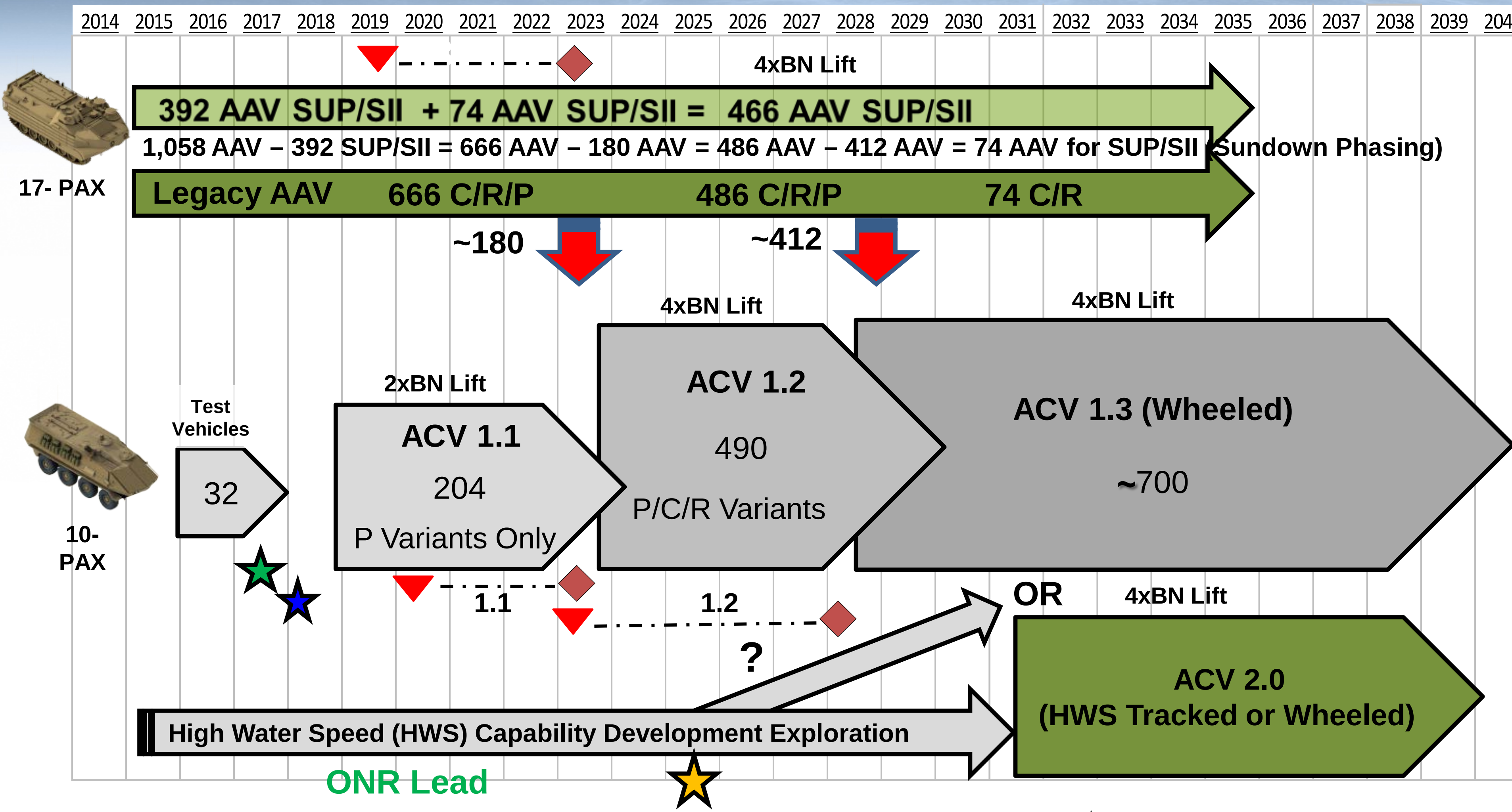
Vision: Provide global operational reach regardless of terrain or sea state at rapid speeds while minimizing the logistics footprint

3.0 Platform Maneuverability

Key Focus Areas

- **Fuel efficiency and power enhancements**
- **High water speed for amphibious combat vehicles**
- **Higher power density and onboard power sources**

USMC Amphibious Combat Vehicle (ACV)
Ground Combat Tactical Vehicle Strategy



= Planned Initial Operating Capability

= Planned Full Operating Capability

=Divestiture

= 1.2 CDD Development JROC Staffing

= Assess ACV 1.1 Water Mobility

= HWS Decision

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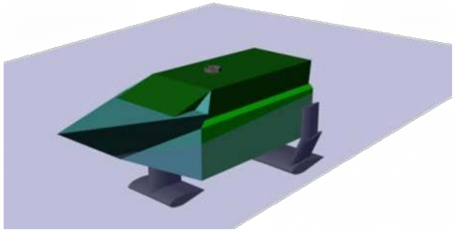
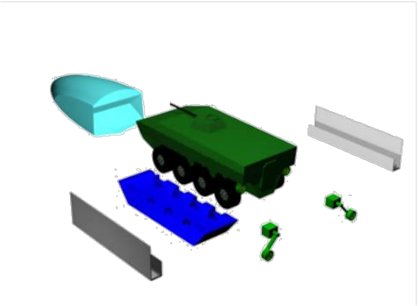
Amphibious High Water Speed S&T Approach

- ONR will lead the HWS Capability Development Exploration phase
- The focus is on a "self-deployed high water speed amphibious vehicle" to enable seamless ship to objective maneuver
  - Explore new and novel "high water speed" technologies and concepts
    - Is a lower cost, more reliable and survivable HWS self-deployable vehicle possible?
    - Our aperture is wide open



  - Other considerations to inform ACV high water speed decisions:
    - Enhance Low Speed Platforms
      - Can we make the ACV 1.X a "higher" water speed vehicle?
    - Research Add-on, Jettisonable Technologies



4.0 Manned-Unmanned Teaming

Opportunities and Challenges

4.1 Enhanced Platform Autonomy
4.1.1: Perception and Control
4.1.2: Human-Machine Interface
4.1.3: Collaborative Tactical Behaviors
4.2 Optimized Platforms for/by Unmanned Operations
4.2.1: Enable New Design Space
4.2.2: Extend Reach
4.2.3: Launch, Recovery, and Sustainment
4.3 Enable Configurable Autonomous Payloads
4.1.1: Autonomous and Integrating Payloads
4.1.2: Backbone (enabling) Architecture
4.1.3: Providing Adequate SA
4.4 Enhanced Assured Trust in Unmanned Systems
4.4.1: TEVV Methodology
4.4.2: Hardware/Software Assurance
4.4.3: Trusted Behavior

OPERATIONAL OPPORTUNITIES:

- Reduce physical and cognitive burden on warfighter
- Provide force multiplier in capability with limited manpower
- Improve ISR and situational awareness

ENDURING CHALLENGES:

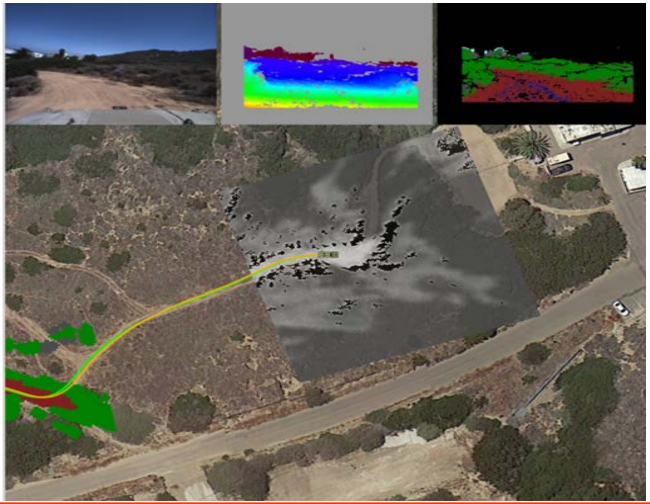
- Sensor and communications to support bandwidth constrained C2 in contested battlespace included GPS denied environment and electronic warfare attacks.
- Platform autonomy to conduct goal based tasking with imperfect information

Vision: An integrated family of unmanned air, ground, and sea vehicles that work collaboratively with the Warfighter to meet mission goals

4.0 Manned-Unmanned Teaming

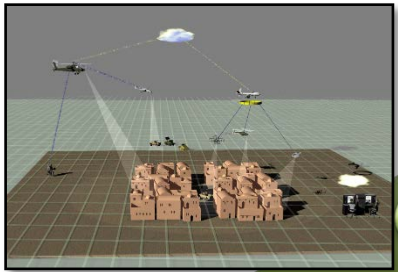
Key Focus Areas

- **Autonomous logistics and convoy operations**
- **Unsupervised unmanned surface operations**
- **Autonomous navigation in GPS denied, degraded visual, and complex terrain**
- **Enhancing trust in unmanned systems**



Autonomous Systems Strategic Capability Progression

Unmanned Air Systems Autonomy (2020)



Synergistic Unmanned-Manned Intelligent Teaming (SUMIT) (2020-2025)

Dynamic Force & Mission Autonomy (2030-2040+)

2035

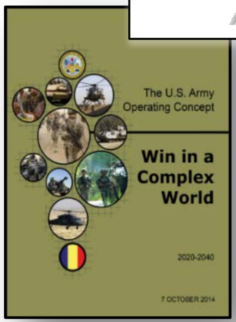
2025

2020

Combined Arms Maneuver (2030-2035)

Extend the Reach of the Warfighter (2020)

Autonomous Convoy Operations (2020-2025)



2015

Active Safety Driver Assist Appliqué Kits (2015)

"Adapt, Evolve, and Innovate"

Near Term Capabilities:

- *Leader Follower Convoy Technology Employment*
- *Autonomous Mobility Applique System (AMAS)*
- *Lighten the Soldier load*
- *Enhance stand-off from threats and improve situational awareness*

Mid Term Capabilities:

- *Improve the autonomy of unmanned systems*
- *Enable unmanned cargo delivery*
- *Act as a "teammates" rather than tools*
- *Micro autonomous air/ground systems will enhance Platoon, Squad, and Soldier situational awareness.*

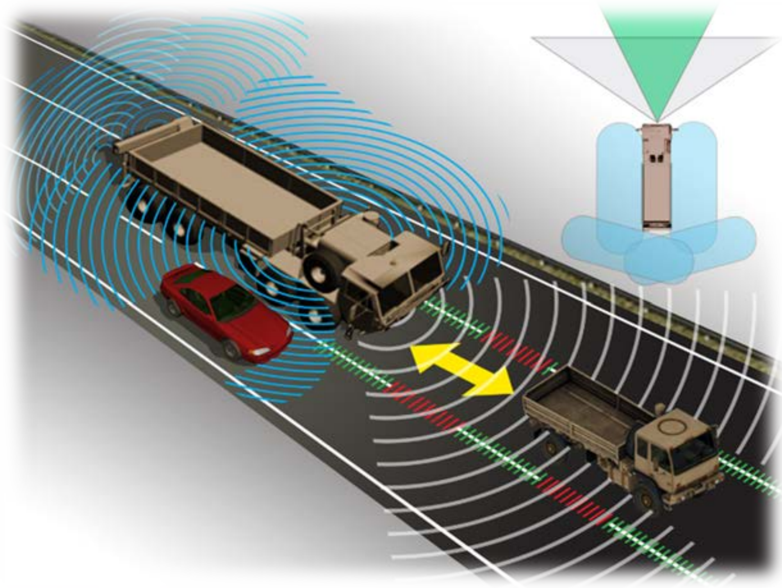
Far Term Capabilities:

- *Enable manned and unmanned teaming in both air and ground maneuver through scalable sensors, scalable teaming, Soldier-robot communication, and shared understanding through advancements in machine learning.*

Security & Resiliency in Autonomous Systems

Background

- A significant increase in trust is required to provide fully functional, self-governing systems that enhance human warrior operational capability.
- Considerations must be made on how to evaluate the autonomous software agents within the context of the larger cyber-physical systems in which they are employed.



Challenges

State-Space Explosion

Because of its size, cyberspace cannot be exhaustively searched, examined or tested; it grows exponentially as all known conditions, factors and interactions expand.

Unpredictable Environments

The power of autonomous agents is the ability to perform in unknown, untested environmental conditions. This performance increase comes with the price of assuring correct behavior in a countless number of environmental conditions.

Emergent Behavior

Interactions between systems and system factor may induce unintended consequences.

Human-Machine Communication

Handoff, communication and interplay between operator and autonomous agents.

Gaps

Verifiable Cyber & Autonomous System Requirements

Modeling, Design and Interface Standards

Autonomy and Cyber Test & Evaluation Capabilities

Human Operator Reliance to Compensate for Brittleness

Run Time V&V during Deployed Autonomy Operations

Evidence Re-use for V&V

Navy Autonomous Swarm Boats

- Allow any unmanned surface vehicle (USV) to not only protect Navy ships, but also, for the first time, autonomously "swarm" offensively on hostile vessels

- Initially demonstrated over two weeks in August 2014 on the James River in Virginia

- Sensors and software enable swarming capability, giving naval warfighters a decisive edge.

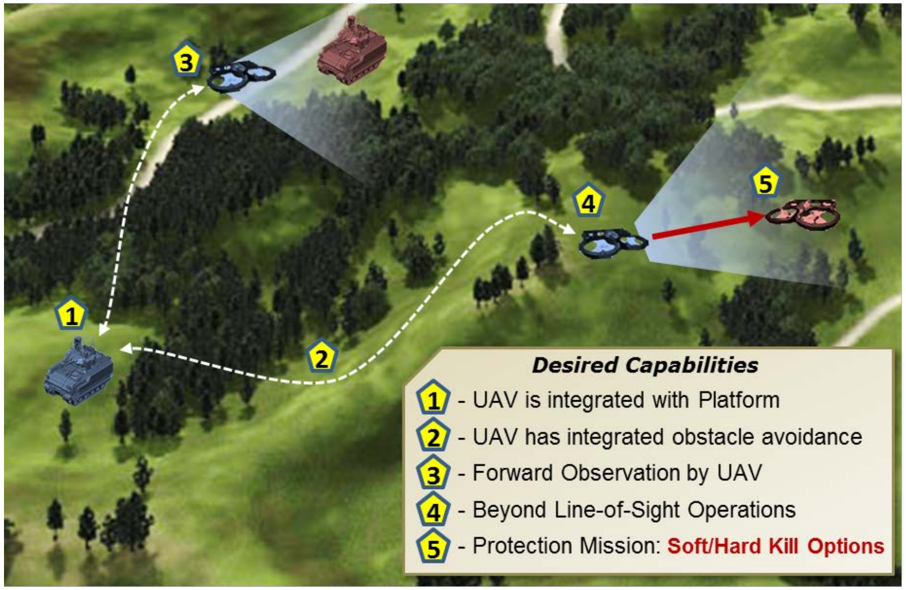
- CARACaS (Control Architecture for Robotic Agent Command and Sensing)—is under development by ONR, and can be put into a transportable kit and installed on almost any boat.

COI: *Ground & Sea Platforms*

UAV Countermeasures Leveraging Unmanned Air & Active Protection Systems

Objectives:

- Address gap identified by the Survivability and Unmanned Platform Integration Taxonomy Areas of the Ground & Sea Platforms COI
- Increase survivability of ground vehicle systems against aerial threats
- Enhance the levels of active and passive protection
- Mitigate the effects of hostile Group 1 Unmanned Aerial Vehicles (UAV) in the vicinity of ground platforms



Operational Opportunities:

- Use of semi-autonomous system leveraging small, platform launched, unmanned air vehicles (e.g., quadrotor) integrated with the platform's situation awareness (SA) and active protection systems (APS)
- Improved 360^{o} SA achieved in a safety hemisphere around ground vehicle in cluttered environments
- Tailored countermeasures to the capabilities and specifications of the Group 1 systems

Technical Challenges:

- Size, weight and Power (SWAP) limitations of Group 1 ground vehicle compatible UAVs
- Installation limitation challenges on ground vehicles - little top side real estate available
- Broad capability range of hostile Group 1 UAVs
- Desire limitation on human supervision requirements
- Obstacle avoidance in complex terrain

5.0 Enhanced Platform Maintenance

Opportunities and Challenges

5.1 Condition Based Maintenance
5.1.1: Improved Sensors
5.1.2: Accurate Component Failure Forecast
5.1.3: Trusted Architecture
5.2 Advanced Manufacturing for Rapid Component Replacement
5.2.1: Control of Microstructure Properties
5.2.2: Advanced Manufacturing Performance
5.2.3: Accelerated Qualification and Certification
5.3 Advance Corrosion & Wear Resistant Systems
5.3.1: Corrosion Technologies
5.3.2: Chemical Formulation Predictive Models

OPERATIONAL OPPORTUNITIES:

- Reduce Total Ownership Cost (TOC) of platforms and improve operational availability of platforms
- Reduce time spent conducting preventive maintenance and repair
- Improve equipment reliability, reduce the size of logistics support elements, and enhance maintenance responsiveness

ENDURING CHALLENGES:

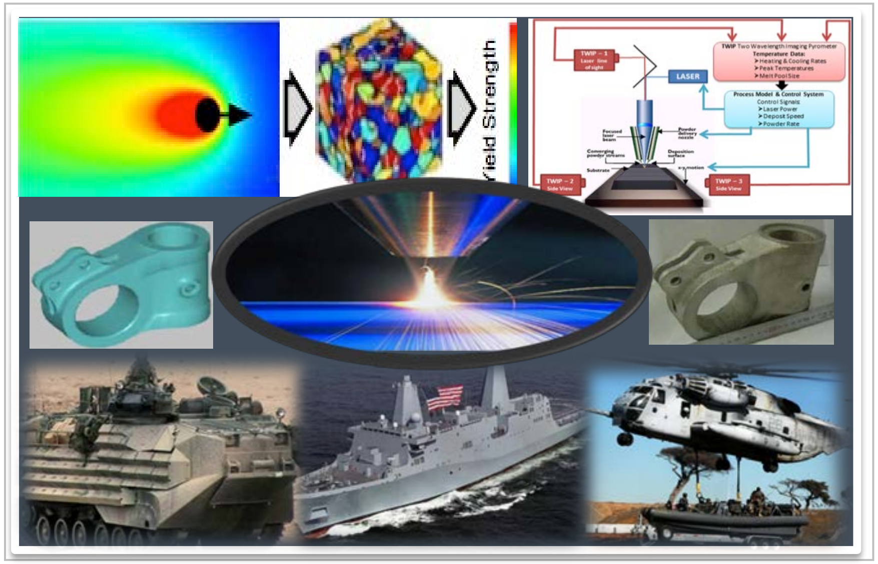
- Harsh and dynamic operating environments
- Repair teams operating independently over extended distances
- Engineer platforms for improved maintainability, rapid repair, nominal tool requirements, redundancy, system bypass capability, and maximum use of plug-and-play modular components

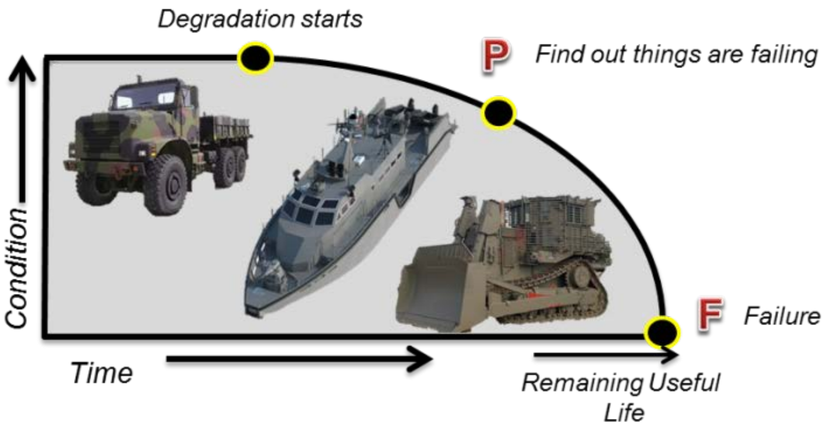
Vision: S&T that enhances the maintainability of current and future combat systems while reducing lifecycle cost & logistics burden and increasing reliability & operational availability for ground and sea platforms.

5.0 Enhanced Platform Maintenance

Key Focus Areas

- **Improved chemical agent and corrosion resistant coating techniques**
- **Condition-based maintenance**
- **Additive manufacturing for replacement parts**





Quality Metal Additive Manufacturing (QUALITY MADE)

FY18-21 Program Goals

- **Enhance quality and reliability of metal additive while addressing key Naval issues**
  - Build confidence in material properties for critical metal parts
  - Improved design and quality control tools & processes
  - Support speedy qual/cert
- **Improved AM design**
  - Enhanced understanding of the correlation of materials properties to AM processes
  - Reduce required redesign iterations
  - Establish an upper and lower control limit for critical AM process parameters
- **In situ sensors and closed loop process controls to ensure a quality build**
  - Control AM process parameters to control microstructure, volume, and geometry
  - Collect build data to support qual/cert

Programmatic Challenges

- **Recruitment and Retention of Scientists and Engineers**
  - Difficult keeping Computer Science / Electrical Engineers to support autonomy and unmanned systems development due to self-driving car initiatives from within and beyond auto industry
- **Military needs continued industry engagement to focus on specialized needs**
  - Particularly advanced engines and transmissions (small volume for overly bureaucratic process)
  - Some industries actively avoid DoD for commercial edge or proprietary advantages
- **Ground and sea vehicles employ technologies optimized for commercial vehicles**
  - Divergence of commercial and tactical technologies: commercial emission requirements reduce fuel efficiency; military vehicles exempted but OEMs focused on meeting commercial standards
  - Different mission profiles for military (off road, significant idle time, time in port)
  - Commercial ships are constantly in motion so bio-fouling is not an issue
- **New technologies must consider interoperability within/amongst services and with allies**
  - Increases cost and time to field and fix systems
- **Push towards open architectures but understand potential vulnerability if security not adequately addressed**

G&SP Way Ahead

- **Completed first GSP COI roadmap**
  - Moving to execution
- **Look for Cross-COI opportunities in focus areas**
  - Cyber (Platform network defense)
  - Materials and Manufacturing (DEW defeat)
  - Autonomy (Trust in Unmanned Systems)
- **Advocate for prototyping and experimentation in key technology areas**
  - Unmanned ground vehicles
  - Cyber-protected, C2, and CBM-enabled Ground Vehicle