ATT P It's All About the Warfighter Advanced Technology Investment Plan 2019 - Volume X



PEO Land Systems Marine Corps



Focusing the Future Faster



PROGRAM EXECUTIVE OFFICER LAND SYSTEMS MARINE CORPS ADVANCED TECHNOLOGY INVESTMENT PLAN 2019



Executive Summary

This 10th edition of the Program Executive Officer Land Systems (PEO LS) Advanced Technology Investment Plan (ATIP) is consistent with previously published ATIPs and continues to emphasize our commitment to "Focusing the Future Faster" by leveraging available Science and Technology (S&T) venues.

The 2019 ATIP provides an update of the Top Technical Issues for PEO LS programs and has been vetted through the program managers to ensure an accurate representation of their highest priority technology needs. The ATIP is designed to inform, influence, and align S&T investments and supports concept aligned, capabilities-focused technology transitions across PEO Land Systems.

This plan is published annually and highlights the importance of collaboration and communication across the S&T Enterprise. The PEO LS ATIP is intended to be used as an informative guide in determining how your proposed solutions or technologies might best provide gap-closing capabilities to our Warfighters.

Program Executive Officer Land Systems Marine Corps



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PROGRAM EXECUTIVE OFFICER LAND SYSTEMS MARINE CORPS ADVANCED TECHNOLOGY INVESTMENT PLAN 2019



Bottom Line Up Front

This year we celebrate the 10th anniversary of the PEO LS ATIP. Over the years we have explored many themes highlighting modernization (modularity) and innovation (autonomy) but our core mission has stayed consistent—to foster collaboration, align S&T investments, and support effective technology insertion within PEO LS programs.

The ATIP identifies and prioritizes Top Technical Issues within PEO LS programs, with the goal of informing, influencing, and aligning S&T investments to resolve program technical issues and support transition of critical capabilities to the Warfighter.

Each technical issue has been thoroughly vetted through the appropriate S&T representative, lead engineer, deputy program manager, and program manager to ensure an accurate representation of each program's highest priority technology needs. The PEO LS ATIP employs a focused, repeatable process, which informs all key stakeholders, industry, and academia of Top Technical Issues within PEO LS programs.

The ATIP can also be accessed via the Office of the Secretary of Defense's Defense Innovation Marketplace website (<u>www.defenseinnovationmarketplace.mil/ATIP.html</u>). This site is a resource for information about Department of Defense (DoD) investment priorities and capability needs.

In an environment of fiscal austerity, changing requirements, and rapid technical innovation, being engaged and knowing with whom to discuss new ideas is vital to fostering opportunities across the S&T enterprise. With your participation, we can maximize these opportunities and help "Focus the Future Faster" for our Warfighters.

As always, we welcome any comments or suggestions to improve the usefulness of this investment plan. Please forward any suggestions or comments to me at <u>michael.d.halloran@usmc.mil</u>.

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Michael D. Halloran Director, Science & Technology Program Executive Officer Land Systems Marine Corps

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PROGRAM EXECUTIVE OFFICER LAND SYSTEMS MARINE CORPS ADVANCED TECHNOLOGY INVESTMENT PLAN 2019



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Section 1.0

"Knowledge is like a garden; if it is not cultivated, it cannot be harvested." -Proverb

In this 10th edition of the PEO LS ATIP, the Top Technical Issues for each PEO LS program are identified. The intent of the ATIP is to inform, influence, and align S&T investments to help resolve these technical issues, transition advanced technology, and deliver capability to the Warfighter. The development of the ATIP is accomplished by utilizing a repeatable, concept aligned, capability-based "Concept to Capability Process" that aligns PEO LS S&T investments with high priority capability gaps and top program technology needs (depicted in figure 2-1). The key to success in 'harvesting' the knowledge contained within the ATIP is stakeholder engagement within the S&T enterprise, industry, and academia. By cultivating an understanding of the 'realm of the possible,' the concepts and requirements developers are able to articulate requirements that become the backbone of program capabilities. These capabilities, clearly and accurately communicated to the materiel developer support the development (and ultimate transition) of critical and affordable capabilities to the Warfighter.

This year's ATIP theme is Focusing the Future Faster and aligns with the United States Marine Corps President's Budget Submission Fiscal Year 2020 Priorities which evolves the Marine Corps to a "2.0" Force "... that has revolutionizing capability for new warfighting concepts... " Published annually, the PEO LS ATIP is a catalyst for opening communication and collaboration between the "3 Circle" partners (combat developer, materiel developer, and the S&T developer) and to other DoD and Non-DoD organizations. The ATIP is developed in collaboration with the Office of Naval Research (ONR), Army Tank Automotive Research, **Development and Engineering Center** (TARDEC), Defense Advanced Research Projects Agency (DARPA), Naval Surface Warfare Centers (NSWC), Naval Undersea Warfare Centers (NUWC), Naval Information Warfare Center (NIWC), and other government agencies. The ATIP is published as an open-source document to increase the probability that it is shared and to allow those outside the DoD to propose solutions that might otherwise be missed.

In today's fiscally austere budget environment, the Marine Corps must continue to find ways to procure the best equipment for the defense of our nation. The publication of the PEO LS ATIP is intended to find ways to enhance our Warfighter's capabilities by:

1. **Identifying and defining the top technical challenges** that must be resolved within each program, some of which remain consistent from year to year. These challenges are vetted and published in the ATIP to alert and assist industry and government regarding the S&T needs of major Acquisition Category (ACAT) programs within PEO LS.

- 2. **Resolving capability gaps and technical issues** by identifying and publishing the technical challenges which require assistance from the S&T enterprise, industry, and academia.
- 3. Informing, influencing, and aligning S&T investments by identifying the S&T needs of PEO LS and supporting the technology insertion and transition into Programs of Record (POR).

Section 1.1 PEO LS ORGANIZATION



Figure 1.1-1. Program Executive Officer Land Systems Organization

The PEO LS , located at Marine Corps Base Quantico, Virginia, is the Corps' only PEO. PEO LS is led by Senior Executive Service John M. Garner, and is tasked with meeting the Warfighter's needs, while partnering with the Marine Corps Systems Command (MCSC), who is responsible for providing support services to include contracting and technical authorities in order to develop, deliver, and provide life-cycle planning for assigned programs. PEO LS reports directly to the Assistant Secretary of the Navy for Research, Development and Acquisition. PEO Land Systems' concentration of effort is on resources to balance Marine Corps modernization and sustainment of assigned programs. The monetary value of these programs across the Future Years Defense Program (FYDP) is approximately \$9.7 billion. THIS PAGE INTENTIONALLY LEFT BLANK

Section 2.0

S&T COLLABORATION AND ENGAGEMENT

Concept to Capability Process

The PEO LS S&T Concept to Capability Process, depicted in figure 2-1, provides the PEO LS with a focused and repeatable process that has proven essential for facilitating effective interaction with S&T stakeholders within the S&T community.

The PEO LS S&T Concept to Capability Process begins with an in-depth understanding of, and alignment to, the overarching concepts identified in **Expeditionary Force 21**, **Marine Corps Service Strategy**, **Marine Corps Service**

Campaign Plan, and the Commandant's

Planning Guidance, the capstone concepts for the future Marine Corps. The next step in the process entails developing an understanding of Warfighter concepts and the core capabilities required to enable those concepts. It is also critical to develop an understanding of the toplevel strategic and operational service issues that rely on materiel solutions for resolution, such as re-honing the expeditionary edge, reducing the sustainment footprint, fuel saving across the Marine Air-Ground Task Force (MAGTF), lightening the MAGTF load, and reducing the MAGTF footprint.



Figure 2-1. PEO LS S&T Concept to Capability Process

Once the operational concepts and capabilities are understood, an analysis is performed by each of the individual programs to identify the Marine Corps' capabilities and technology gaps. These capabilities and gaps are categorized in the Marine Corps Capabilities List (MCCL) and Marine Corps Gap List (MCGL), as well as in the **Marine Corps Solutions Planning Directive** and the **Capability Investment Plan**.

The S&T Objectives (STOs) are matched to the technology issue identified by the program office and the Marine Corps capability gap. This step is performed to ensure the traceability of S&T investments as well as enabling stronger support within the Program Objective Memorandum (POM)/Planning, Programming, Budgeting, and Execution process. Once a matching requirement/S&T initiative capable of lessening the effect on a Marine Corps gap is identified, S&T venues are examined to identify funding for the maturation of the technology.

Before resources are applied, a transition path must be identified. The Program Manager (PM) collaborates with the resource sponsor and the S&T developer to ensure a successful transition. This 'shared commitment' is usually documented in a Technology Transition Agreement (TTA) that is signed by all parties. After the TTA is signed by the appropriate level of 3 Circle leadership (explained further in the following sections), the S&T representative continues to work closely with the PM to ensure funding support is available (within the FYDP). POM funding is essential to integrate and transition the technology to the appropriate POR and to close the associated Warfighter gap. Currently, TTAs are only required for a specific venue, Future Naval Capability (FNC). All other venues and core funding initiatives do not require a TTA, but should have a transition path and an associated service requirement.

By working through the Concept to Capability Process, potential S&T opportunities and solutions are identified, enabling S&T representatives to better inform requirements and to provide the "best value" S&T investment and transition of gap-closing technologies to a POR.

S&T investment is one of the earliest steps in the process of properly equipping the future force. When applied correctly, it will result in a well-balanced Marine Corps, postured for the future with upgrades to their existing legacy systems, as well as new state-of-the-art equipment. This is developed through rigorous analysis, targeted investment, aggressive experimentation, and most importantly, through the active collaboration and engagement of all stakeholders.

S&T Objectives

The most important objective of S&T development is to ensure the Marine Corps always has an overmatching technological advantage. Preserving technological superiority continues to be at the cornerstone of our national military strategy and is critically important as advanced-technology weapons become less expensive and more readily available to traditional and non-traditional adversaries. In addition to preserving our technological advantage, Marine Corps S&T has the following specific goals:

- Inform the Marine Corps Combat Development Process;
- Encourage, promote, plan, initiate, execute, and coordinate research and technology development;
- ► Identify and assess technologies;
- ► Develop and demonstrate technologies;
- ► Reduce technical risks;
- ► Protect against technology surprise;
- ► Conduct warfighting experimentation; and
- Transition mature technology to acquisition PORs.

The Executive Agent for Unites States Marine Corps (USMC) S&T

The Commanding General (CG), Marine Corps Combat Development Command (MCCDC) tasked the Director, Futures Directorate/CG, Marine Corps Warfighting Lab (MCWL) to act as the Executive Agent (EA) for S&T, thereby consolidating responsibility for coordinating all aspects of Marine Corps S&T requirement generation through the Marine Corps EA. Inherent in this transfer of responsibility was the transfer of staff cognizance to the Office of Science and Technology Integration (OSTI) from MCCDC Headquarters to the Warfighting Lab. OSTI is responsible for providing policy, guidance, and strategy in the areas of scientific innovation, to include co-sponsoring annual round tables to identify Marine Corps S&T requirements.

Science and Technology

Within DoD, S&T includes the earliest forms of Research, Development, Test and Evaluation (RDT&E) funding in the federal budget. S&T is composed of three categories: basic research, applied research, and advanced technology development. It is the path by which new ideas are investigated (basic research-phenomenology), further research demonstrates military applicability (applied research-connectivity), and continues through technology demonstration (advanced technology development) to a level of maturity where the technology can be transferred to a program office for the final stages of the Research and Development (R&D) process. Close coordination with the S&T community as well as other services, academia, and industry leaders assist Marine Corps efforts to gain consensus and fund relevant S&T efforts. The ultimate goal is to investigate, develop, demonstrate, and deliver affordable state-ofthe-art technologies to the Warfighter.

Collaboration

Each circle within the 3 Circle S&T community has a unique and pivotal role in the S&T process. Although they have overlapping interests and influences regarding the likelihood of the transition, the collaboration and engagement of these communities are critical for successful transitions (see fig. 2-2).

S&T developers transition their technology to the materiel developers, but the materiel developers must first have a requirement from the combat developer. Therefore, stakeholder involvement is critical to ensure Warfighter priorities are adequately addressed (requirements) and that the technologies being developed are aligned with the POR's resources and schedule.

The S&T Community Stakeholders

The Marine Corps S&T enterprise, which is an integral part of the larger Naval Research Enterprise (NRE), is a collaborative effort led by the Deputy Commandant (DC), Combat Development & Integration (CD&I). However, the USMC S&T enterprise also involves the Futures Directorate, MCWL, ONR, MCSC, PEO LS, and the EA (CG MCWL) for S&T. This 3 Circle relationship is depicted in figure 2-3.

DC, CD&I

The DC, CD&I is the principal agent in the combat developer circle. The combat developer represents the Warfighters who will deploy, operate, and maintain the systems needed for military operations. Combat developers write the requirements that the materiel developers must have to develop and procure materiel. Combat developers also generate new operational concepts, define future capability needs, identify new capability gaps/ shortfalls, and state capability requirements. CD&I receives the Commandant's guidance, develops Marine Corps warfighting concepts, and determines required capabilities to enable



Figure 2-2. A Collaborative, Synergetic Partnership from Concept to Capability



Figure 2-3. The 3 Circle S&T Community

the Marine Corps to field combat-ready and relevant forces.

- ► The Director, Capabilities Development **Directorate** develops warfighting capabilities and requirements. The Director, Capabilities Development Directorate accomplishes this through the Marine Corps Capability Based Assessment (CBA) resulting in the Marine Corps Enterprise Integration Plan (MCEIP). The MCEIP is produced annually, approved by the Marine Requirements Oversight Council (MROC), and signed by the Assistant Commandant of the Marine Corps. This critical document translates strategic guidance into capability development activities, and provides investment recommendations to achieve required capabilities within a fiscally constrained environment. This is done by refining and validating the MCCL, which are prioritized and measured against MROC approved scenarios, guidance, event task, condition, and standards. The gaps in the MCCL are identified and further prioritized to create the MCGL, which feeds into the Marine Corps Solutions Development Directive (MC SDD). MC SDD provides a solutions analysis, which in turn, yields solutions that span the Doctrine, Organization, Training, Material, Leadership and Education, Personnel, Facilities - Policy pillars with identified actions, to include initiatives that implement the solutions. Formulation of the Enterprise Capabilities Management Plan, consolidates CBA analytical results and provides a capability investment strategy to the enterprise to guide future Marine Corps capabilities development.
- ➤ The Director, Futures Directorate/CG, MCWL determines the future Marine Corps strategic landscape by assessing emerging security environments and by developing and evaluating Marine Corps operating concepts by integrating these concepts into Naval and Joint concepts. The Futures Directorate helps to identify potential gaps

and opportunities, which inform the force development process.

► The **Office of S&T Integration** is tasked with implementing the Director, Futures Directorate/CG, MCWL S&T responsibility as the Marine Corps Commandant's EA for S&T. OSTI coordinates S&T within the combat development life cycle from 'requirement to transition.' Through coordination with the 3 Circle S&T community, OSTI develops the vision, policies, and strategies needed to exploit scientific research and technical development. OSTI provides technical oversight of proposals submitted to Office of Secretary of Defense (OSD) and DoD, while managing/monitoring the daily operations of the S&T programs under the OSTI portfolio. Additionally, OSTI develops and coordinates the prioritization of S&T requirements for OSD and the Department of the Navy. OSTI is also tasked with the development of the United States (US) Marine Corps S&T Strategic Plan. Within the US Marine Corps S&T Strategic Plan are STOs, which are products of the MC CBA process and are developed in coordination with the Marine Corps S&T enterprise.

MCSC and PEO LS

MCSC and PEO LS are principal agents in the materiel developer circle. The materiel developer administers and manages the activities of the workforce to meet the modernization requirements and to incorporate enhanced capabilities into PORs efficiently and effectively. The materiel developer community includes the acquisition executives, program executive officers, program managers, project officers, and support staffs. In response to a validated operational requirement from the combat developer, the materiel developer is responsible for assessing alternatives, conducting cost/benefit analysis, establishing R&D requirements, and procuring and fielding the required operational capability.

ONR

The Office of Naval Research is the principal agent in the S&T developer circle. The S&T developer delivers technologies that enable future Warfighters to gain and maintain their technical edge over our adversaries. The community consists of scientists, engineers, and academics who understand the technological frontier and what developments are possible for future systems. This group examines technical possibilities, identifies scientific gaps, develops S&T requirements, and executes scientific efforts. The S&T developer is also responsible for exploring the phenomenology, feasibility, and utility of S&T as it pertains to the improvement of legacy systems, the realization of future capabilities under development, and the advancement of discovery in areas yet to be exploited.

ONR identifies S&T solutions to address Navy and Marine Corps plans and scientific research as it relates to the maintenance of future naval power. ONR also manages the Navy's S&T funds to foster transition from S&T to higher levels of RDT&E. The Director, Futures Directorate/ CG, MCWL also serves as the Vice Chief Naval Research. The below advisors play an integral role in the ONR effort:

➤ ONR Global Science Advisors are civilian scientists, engineers, and technologists selected to participate in a one- to three-year career development tour. Science advisors serve as a Command's senior liaison with S&T organizations in government, academia, and industry. They communicate needs and requirements to the ONR and NRE to help shape S&T investments. They are worldwide in Joint, Navy, and Marine Corps Commands. Specifically, each Marine Expeditionary Force (MEF) has a Science advisor on staff to assist in providing operational ground truth for the S&T community.

Other S&T Stakeholders

► DARPA's singular and enduring mission is to make pivotal investments in breakthrough technologies for national security. The genesis of that mission and of DARPA itself dates to the launch of Sputnik in 1957, and a commitment by the United States that, from that time forward, it would be the initiator and not the victim of strategic technological surprises. Working with innovators inside and outside of government, DARPA has repeatedly delivered on that mission, transforming revolutionary concepts and even seeming impossibilities into practical capabilities. The ultimate results have included not only game-changing military capabilities such as precision weapons and stealth technology, but also such icons of modern civilian society such as the Internet, automated voice recognition and language translation, and Global Positioning System receivers small enough to embed in myriad consumer devices.

DARPA explicitly reaches for transformational change instead of incremental advances. But it does not perform its engineering alchemy in isolation. It works within an innovation ecosystem that includes academic, corporate and governmental partners, with a constant focus on the nation's military services, which work with DARPA to create new strategic opportunities and novel tactical options. For decades, this vibrant, interlocking ecosystem of diverse collaborators has proven to be a nurturing environment for the intense creativity that DARPA is designed to cultivate.

➤ TARDEC develops, integrates, and sustains the technology solutions for all manned and unmanned DoD ground systems and combat support systems to improve current force effectiveness and provide superior capabilities for the future force. TARDEC leads research in ground systems survivability, power and mobility, intelligent ground systems, force protection, and vehicle electronics architecture. TARDEC is a partner with industry, academia, and other government agencies to harness new technologies for emerging systems, integrate new energy and propulsion alternatives, reduce operating and maintenance costs of fielded systems and ensure that Soldiers have the best performing, most reliable, and easiest to maintain ground vehicles in the world.

➤ Communities of Interest (COI) cover 17 technical areas that span the crosscutting science and technology in the DoD. The scope of each of these COIs and their associated technical sub-groups is available in Reliance 21. The collection of COIs, depicted in figure 2-4, serves as an enduring structure to integrate technology efforts throughout the DoD S&T enterprise. While they cover most of the DoD's S&T investment, some service-specific investments are not included in these groups. COIs were established in 2009 to encourage multi-agency coordination and collaboration in cross-cutting technology

focus areas with broad multiple-component investment. COIs provide a forum for coordinating S&T strategies across the DoD, sharing new ideas, technical directions, technology opportunities, jointly planning programs, measuring technical progress, and reporting on the general state of health of specific technology areas. The COI that PEO LS is most interested in is the Ground & Sea Platforms (G&SP). The G&SP COI provides a forum for discussion of topics associated with a broad range of platform technologies for both ground and sea systems. The portfolio examines concepts in modularity, survivability and mobility as the primary emphasis areas. In addition, examination of required S&T for costeffective maintenance and sustainment efforts for platforms is pursued in the portfolio. These efforts include:

• Maintainability/Sustainability: S&T that reduces life-cycle cost, reduces logistics burden, increases reliability, and provides timely support of ground and sea platforms. Areas of research include structural health monitoring, sustainment analysis tools, networked



Figure 2-4. Communities of Interest

sustainment command and control, and high-reliability structures and components.

- **Modularity:** S&T that standardizes and designs interfaces, subsystems, and components that allow functional elements to be used across or within platforms. Areas of research include flexible designs for multimission adaptability, interoperable components and payloads, and platform infrastructure.
- **Mobility:** S&T focused on improving the mobility/maneuverability of ground and sea platform systems across all operational environments. Areas of research include sea stability during intense maneuvering, land stability in aggressive terrain, high-efficiency powertrain components, fuel economy, technologies enabling increased power generation, and amphibious maneuvering.
- **Survivability:** S&T that provides protection to ground and sea platforms and their occupants, while maintaining and enhancing the ability to accomplish the mission through development, evaluation, integration, maturation, and testing of technologies integrated into the platforms. Areas of research focus on platform-centric approaches to threat defeat, such as active protection (hard and soft kill), ballistic protection, and hazard protection including blast, shock, and fragmentation hazards and directed energy weapons.
- Autonomy: S&T that enables autonomous systems to include the strategic assessment of the challenges, gaps, and opportunities to the development and advancement of autonomous system, and identification of potential investments to advance or initiate critical enabling technology development. The Autonomy COI areas

of research include Machine Perception, Reasoning and Intelligence; Human/ Autonomous Systems Interaction and Collaboration; Scalable Teaming of Autonomous Systems; and Test, Evaluation, Validation, and Verification.

- Unmanned Ground and Sea Vehicles: S&T for maturation and integration of optionally manned competencies into ground and sea platforms to enhance force structure operational capabilities. Areas of research include conversion technologies for manned/unmanned operation and advanced unmanned vehicle development and integration concepts.
- ► Industry: Independent Research and Development (IR&D) is a program designed to allow firms to recover some of their independently funded R&D costs as part of the general and administrative expenses charged to existing contracts. These firms are given the independence to decide which technologies to pursue with these funds, as long as these efforts are of potential interest to DoD. The primary objectives of the DoD IR&D Program are to ensure that: (1) industry is aware of DoD's R&D activities and technological needs; (2) industry provides information to DoD about their IR&D activities; and (3) DoD makes effective use of IR&D accomplishments in defense applications. DoD plays an important role in facilitating the transition of IR&D accomplishments into applications that support the Warfighter. Further, it is DoD's responsibility to review all IR&D projects to identify which new products and services show promise, needing further development, and which technologies, if acquired, can provide immediate impact.
- ➤ Academia: Educational partnerships between academia and the S&T community provide a means for organizations to assist universities in extending their research capabilities in areas relevant to the needs of the Navy/Marine Corps, and they also

provide an opportunity for students to work on degrees in programs of interest to these organizations. The benefits are two-fold: First, the university develops scientific and engineering expertise applicable to future needs. Second, students working on Navy/ Marine Corps sponsored research receive an early exposure to those organizations, which expands the possible talent pool for future recruitment.

► Naval Service Warfare Centers, Naval Undersea Warfare Centers, and Naval Information Warfare Centers are part of the Naval Sea Systems Command (NAVSEA) operated by the United States Navy. The mission of the NSWCs is to cohesively and seamlessly operate the Navy's full-spectrum research, development, test and evaluation, engineering, and fleet support centers for offensive and defensive systems, which are associated with surface warfare and related areas of joint, homeland and national defense systems from the sea. The Warfare Centers are the Navy's principal RDT&E assessment activity and supply the technical operations, people, technology, engineering services and products needed to equip and support the Fleet and meet the Warfighter's needs. They also provide engineering support to ensure that the systems fielded today perform consistently and reliably in the future.

There are a total of twelve Warfare Centers, eight sites or locations are NSWCs, two are NUWCs, and two are NIWCs, formerly known as Space and Naval Warfare Centers. Section 5 provides a detailed description regarding each of the following Warfare Centers:

- Carderock Division of the Naval Surface Warfare Center, Maryland
- Corona Division of the Naval Surface Warfare Center, California
- Crane Division of the Naval Surface Warfare Center, Indiana

- Dahlgren Division of the Naval Surface Warfare Center, Virginia
- Indian Head Explosive Ordnance Disposal Technology Division of the Naval Surface Warfare Center, Maryland
- Philadelphia Division of the Naval Surface Warfare Center, Pennsylvania
- Panama City Division of the Naval Surface Warfare Center, Florida
- Port Hueneme Division of the Naval Surface Warfare Center, California
- Keyport Division of the Naval Undersea Warfare Center, Washington
- Newport Division of the Naval Undersea Warfare Center, Rhode Island
- Naval Information Warfare Center Atlantic, South Carolina
- Naval Information Warfare Center Pacific, California

► Defense Laboratory Enterprise (DLE), which includes the NSWC listed above. is composed of Army, Navy and Air Force laboratories that span 22 states, employing more than 38,000 scientists and engineers and participates in work exceeding \$30B per year. The enterprise provides world leading competencies across a broad R&D portfolio, which includes the development of unique, often multidisciplinary, scientific capabilities beyond the scope of academic and industrial institutions to benefit the nation's researchers and national strategic priorities. The labs also sustain critical scientific/technical capabilities to which the government requires assured access. Additionally, the DLE executes long-term government scientific and technological missions, often with complex security, safety, project management, or other operational challenges.

Defense Innovation Marketplace

CONNECTING INDUSTRY AND THE DEPARTMENT OF DEFENSE



Figure 2-5. The Defense Innovation Marketplace Homepage

► The Joint Non-Lethal Weapons Directorate was established in 1996 with the Commandant of the Marine Corps as the DoD Non-Lethal Weapon (NLW) Executive Agent. Non-lethal weapons provide Warfighters with additional escalation-offorce options while minimizing casualties and collateral damage. The DoD NLW Executive Agent has outlined the DoD NLW Program vision and charged the Joint Non-Lethal Weapons Program (JNLWP) to lead the Joint Force in conducting R&D to enable "an integrated NLW competency." The JNLWP S&T Program contributes to the DoD NLW Program vision by investing in innovative technology and applied research to mitigate non-lethal effects capability gaps and to reduce developmental risk. The JNLWP S&T Program's intent is to "foster the ideation, maturation, and demonstration of innovative and compelling NLW technologies for the Joint Force through focused investment and collaboration internal and external to the DoD Research and Engineering (R&E) Enterprise."

Defense Innovation Marketplace

The Defense Innovation Marketplace (DIM), homepage depicted in figure 2-5, is a webbased forum, located at:

www.defenseinnovativemarketplace.mil, and is designed as a communication resource and linkage between DoD S&T/R&D and Industry/Academia. It provides a centralized resource for DoD's Acquisition/Science and Technology professionals on information regarding industry's independent research and development activities. The DIM's goal is to be a communications resource that provides industry with improved insight into the R&E investment priorities of the DoD. The Marketplace contains DoD R&E strategic documents, solicitations, and news or events to better inform IR&D planning. The IR&D Secure Portal houses project summaries that provide DoD with visibility into the IR&D efforts submitted. As a hub of resources, the DIM enables interested organizations to become involved in the R&D enterprise.

How to Get Involved in the Process

The PEO LS S&T community fosters the cooperative development of requirements, informs and influences S&T budgeting resources, and advances the state of the art for the PEO LS portfolio.

The first step for a business, academic institution, or independent researcher to become involved is a period of investigation and preparation. Having a thorough understanding of the S&T challenges facing PEO LS programs and how your proposed solution can meet those challenges is vital to participating in S&T projects. The subsequent sections of the 2019 ATIP provide an outline of technical challenges facing the PEO LS portfolio. After you have reviewed the challenges and opportunities for the PEO LS S&T Portfolio, the S&T Venue List (Section 8) addresses the methods and venues for your involvement. THIS PAGE INTENTIONALLY LEFT BLANK

Section 3.0 PEO LS TOP TECHNICAL ISSUES

The identification and prioritization of PEO LS programs' Top Technical Issues starts the process of determining which Top Technical Issues will result in the development of an associated capability. These issues are vetted through each program's S&T representative, lead engineer, deputy program manager, and program manager for concurrence and prioritization.

The Top Technical Issues across all PEO LS programs are then rolled up into similar categories that establish key focus areas and informs the prioritization of funding and research efforts. A top-down approach of aligning S&T investment areas with the bottomup prioritized list of Top Technical Issues ensures a consolidated and focused effort to resolve each program's technical issue (see fig. 3-1).

This process allows S&T representatives from all PEO LS programs to work through the Top Technical Issues of their programs and identify capability gaps where S&T could potentially lead to requirement solutions. This collaborative approach has proven extremely valuable not only in identifying individual program technical cross-cutting issues, but also in identifying technology issues that are common among other PEO LS programs. By understanding these common technical challenges, PEO LS can better align and leverage resources across the S&T enterprise. Figure 3-2 identifies the Top Technical Issues of each PEO LS program.



Figure 3-1. PEO LS Top Technical Issue to Capability Roll-Up

PEO LS Programs' Top Technical Issues Roll-Up

Program	Technical Issues
Assault Amphibious Vehicle (AAV)	 Reliability/Sustainment Autonomous Communications Power and Energy
Amphibious Combat Vehicle (ACV)	 Survivability Weight Crew Visibility
Common Aviation Command & Control System (CAC2S)	 Bandwidth Efficient Radar Measurement Data Distribution Bandwidth Efficient Networked Voice Communications Vehicles Cross Domain Security Solutions Small Form Factor CAC2S Contextual Search Engines
Ground Based Air Defense (GBAD)	 Counter Unmanned Aircraft System (UAS) Low-Altitude Air Defense (LAAD) C2 Stinger Night Sight Replacement
Ground/Air Task Oriented Radar (G/ATOR)	 Lowering Manufacturing Costs Increased Dynamic Range Advanced Electronic Protection Diminishing Manufacturing Sources and Material Shortages Improvements in Detecting, Discriminating and Tracking Unmanned Arial Vehicles (UAVs)
Joint Light Tactical Vehicle (JLTV)	 Weight/Protection Vehicle Network Architecture Noise Mitigation Situational Awareness Tires
Logistics Vehicle Systems Replacement (LVSR)	 Fuel Consumption Increased Survivability Sustainability Safety
Medium Tactical Vehicle Replacement (MTVR)	 Increased Survivability Sustainability Safety
Mine-Resistant Ambush Protected (MRAP) Family of Vehicles: Buffalo, Cougar, and M-ATV	 Transparent Armor Sustainability Stress Cracks in Welded Construction and Monolithic Hulls Both Using High Hard Steel
Lightweight 155mm Howitzer (LW 155)	 Navigation in a GPS Denied Environment Safe and Transportable Battery High-Capacity Technology On System Power Generation and Conservation Secure Wireless: Ruggedized/Low Energy Weight Management

Figure 3-2. Pl	O LS Programs'	Top Technical	Issues Roll-Up
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Section 4.0 PEO LS S&T FOCUS AREAS



Figure 4-1. PEO LS S&T Focus Areas

PEO LS S&T focus areas originate from highpriority technology issues identified by each PEO LS program manager. They emphasize areas of focused S&T investment and engagement that are mission essential, crosscutting, operationally relevant, and actionable. These focus areas serve to inform, influence, and align requirements and S&T technology investments while supporting the transition of critical capability to the Warfighter.

S&T Focus Areas

4.1 Power and Energy. This focus area encompasses technologies that expand the

overall capability of the MAGTF by increasing the availability/capability of battlefield power, while decreasing the logistics footprint.

4.1.1 Fuel Efficiency. These technologies enhance vehicle performance, while reducing fuel consumption. Gains in this area also have a significant impact on the logistics footprint of the MAGTF.

4.1.2 Intelligent Power and Thermal

Management. This element centers on the development of an integrated system that manages power utilization on vehicle platforms, heat properties in the cab, and other areas on the platform to maintain equipment and

crew comfort. Ideally, an effective power and thermal management system will improve electrical system efficiency and improve heat rejection by linking power and thermal management strategies into a single on-board architecture. Advanced power and thermal management tools are a critical step in the development of reliable and efficient vehicle platforms.

4.2 Survivability and Mobility.

4.2.1 Survivability consists of autonomy, fuel containment/fire suppression, and safety.

4.2.1.1 Autonomy. These technologies provide full autonomous capabilities and separate the Warfighter from potentially hazardous missions, while providing increased efficiency and economy of force.

4.2.1.2 Fuel Containment/Fire Suppression.

This element includes technologies that safely extinguish internal and external vehicle fires without adversely affecting crews. Preferred solutions will implement a system-of-systems approach that provides fire suppression and/or containment for vehicle cabs, crews, tires, fuel tanks, and engine compartments.

4.2.1.3 Safety. Technologies are needed that increase vehicle stability and mitigate vehicle rollover, while maintaining the ability of vehicles to achieve their off-road and on-road mission profile.

4.2.2 Mobility consists of crew visibility, corrosion, and weight reduction. These technologies improve mobility and increase the survivability of both Marines and vehicles. They include advanced lightweight armor concepts, active protection systems, energy-absorbing structures, floating floors, shock-mitigating seats, and upgraded drive and suspension systems.

4.2.2.1 Crew Visibility. Clear and unobstructed crew visibility is essential for situational awareness. This area addresses technologies that can provide the ability to identify, process, and comprehend critical elements

of information regarding the mission and the operational environment.

4.2.2.2 Corrosion. Damage from corrosion can cause significant maintenance requirements, decrease readiness, and potentially degrade operational capabilities. Marine Corps vehicles are stored and maintained for long durations in pre-positioned stock ashore, at sea, and in other areas that are exposed to salt air, rain, snow, heat, cold, and other corrosive elements. Corrosion resistance technologies will reduce total ownership costs and provide a significant increase in equipment readiness.

4.2.2.3 Weight Reduction. This area develops modular, scalable, lightweight, and affordable components or packages that are tailored to the mission to provide greater flexibility to the Warfighter.

4.3 Modeling and Simulation. This element uses tools that can facilitate a systems engineering approach to platform design by evaluating potential design and technology trade-offs for tactical wheeled vehicles. These trade-offs will address performance, payload, crew protection, life cycle costs, survivability, reliability, availability, and maintainability.

Section 4.1 Focus Area POWER AND ENERGY

PEO LS continues to address the challenge of increasing energy and fuel efficiency of Marine Corps tactical vehicles. With the need of electronic devices in each of the vehicles increasing, there is also a significant increase in the demand for onboard power. Vehicle dependence on a common towable power generator only adds to the logistics burden and boosts fuel consumption. The benefits of optimizing energy and fuel efficiency are:

- ► Lightening the load of the Marine Air-Ground Task Force.
- Reducing the requirement for bulk fuel distribution and storage on the battlefield, thereby reducing the logistics footprint.
- Identifying methods to save fuel and to increase vehicle range.
- ► Reducing total ownership cost.

There is a two-pronged approach within PEO LS to address the needs and requirements of power and energy: **Fuel Efficiency** projects and **Intelligent Power and Thermal Management** projects.

Fuel Efficiency projects focus on increasing the efficiency of mechanical systems (e.g., engine, drive train, vehicle aerodynamics) to increase the amount of energy extracted from Marine Corps vehicles for every gallon of fuel used.

Intelligent Power and Thermal Management

projects concentrate on solutions that increase the efficient use of electricity and power from other sources once these have been generated. Both focus areas are inherently aligned and these will continue to maximize the power and energy available for the Marine Corps vehicle fleet.



Marines on the move

PEO LS is actively engaged with other agencies and technology partners to address the Marine Corps' ongoing and future power and energy challenges. We continue to work alongside ONR, MCSC, US Army Research Development and Engineering Command, TARDEC, and various industry partners to seek improvements in the areas of fuel efficiency and alternative solutions for generating on-board (and exportable) vehicle power.

4.1.1 Fuel Efficiency

The Challenge

Marines can expect to fight in austere environments in the future and be more dispersed than in the past. Fighting with more fuel-efficient vehicles enables the MAGTF to travel lighter (and farther) while consuming less fuel. The existing tactical vehicle fleet, along with the fossil-fuel-consuming tactical supply items, will continue to be in the Marine Corps inventory for generations to come. Numerous avenues are being explored to maximize the energy extracted from each gallon of fuel and to minimize losses to heat, friction, and other inefficiencies. When implemented together, these S&T investments, which are not limited to one vehicle or even one component, can minimize fuel use and maximize operational maneuver for each gallon of fuel used.

Potential Solutions

RDECOM & TARDEC Efforts

Enabling Components of Fuel Cells and Onboard Hydrogen Systems

This program is focused on enabling components of fuel cells, onboard hydrogen storage system, and hydrogen logistics including generation, storage and refueling systems.

Small Business Innovation Research (SBIR) Efforts

Fuel Efficiency Improvements for Amphibious Vehicles

Composite materials offer weight reduction, corrosion resistance, torsional rigidity, and increased safety over conventional steel components. The primary goal of the project is to achieve Technology Readiness Level (TRL) 6/7 on a composite suspension torsion bar for the Assault Amphibious Vehicle (AAV). Tasks include:

- completion of detail design/analysis of composite torsion bar,
- selection of materials and manufacturing processes that optimize performance and total ownership cost,
- verification of torsion bar design process and analysis modeling via specimen and/or sub-element testing, and
- validation of design via qualification testing.

A secondary effort of the program is to evaluate other potential components, such as the raised crew floor, that would benefit from the use of composite materials.

4.1.2 Intelligent Power and Thermal Management

The Challenge

The management, storage, and efficient use of vehicle power has led to the development of a suite of power control programs that can effectively prioritize and manage between command, control, communications, computers, intelligence, surveillance and reconnaissance, heating, ventilation, and air conditioning systems in an adaptive operational environment. Vehicle thermal management is critical as it can reduce thermal loads, efficiently eliminate heat, reuse waste heat, and integrate systems within the vehicle. This effort can boost operational effectiveness and have a reduced energy load. It can prolong vehicle operations and result in efficient electric generation and consumption. Managing the vehicle's various thermal loads and supplies can also assist with power consumption and resourcefully manage the vehicle's output.

The projects described below address many of the needs associated with this challenge through management of thermal loads and energy consumption on Marine Corps tactical vehicles.

Potential Solutions

RDECOM & TARDEC Efforts

Next Generation Combat Vehicle (NGCV) Platform Electrification & Mobility

This program will develop, test and integrate scaleable electrification technologies necessary to demonstrate a series hybrid-electric powertrain for an unmanned 10-20T platform and for manned 25-35T platform to support emerging capabilities of e-weapons, e-armor, silent mobility, low thermal signature, Vehicleto-vehicle and Vehicle-to-Grid power sharing (import/export), radar, high power jamming, and command and control on the move.

Vehicle Electronics and Architecture (VEA) Mobile Demo

The purpose of this program is to mature the open data and power architecture as well as the system designs to TRL 6 that were implemented as part of the VEA Research System Integration Lab at TRL 5 by integrating those subsystems onto a combat vehicle platform. Validate the power and data capabilities required for the future infantry or combat vehicle modernization efforts while increasing vehicle performance & decreasing size, weight and power (SWaP) over current implementations. Build the TARDEC bench on in-house vehicle integration of these systems.

Power & Energy

	2018	2019	2020	2021	2022	2023	2024
Active & Potential Investment Opportunities D&I B&I E&D FNC SBIRSTTR TARDEC Other	VEA M	bile Demo	Enabling	Components of NGCV Platfo	Fuel Cells, Ont	oon & Mobility	Systems
Funding Profiles (\$M)	FY18	FY19	FY20	FY21	FY22	FY23	FY24
S&T (6.2/6.3)	10.95	11.5	19.71	34.58	37.59	38	34.56
6.1 Clence	e & Technology 🗲		6.3	6.4	◆ System & Devel	lopment	6.7

	2018	2019	2020	2021	2022	2023	2024
Active & Potential Investment Opportunities D&I E&D FNC SBIRSTR TADEC	Amphibious C	y Improvement combat Vehicle	ACV) 1.X Mobil	lity Enhanceme	Store State		
Eunding Profiles (\$M)	FY18	FY19	FY20	FY21	FY22	FY23	FY24
S&T (6.2/6.3)	12.2	15.75	14	7	0	0	0
6.1 Contraction Science	e & Technology 🗲	Î	6.3	6.4	System & Devel	opment	6.7

Fuel Efficiency

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Section 4.2 Focus Area

SURVIVABILITY AND MOBILITY

The Marine Corps' future operating environment will be increasingly complex and marked by the proliferation of conventional and unconventional threats. The solutions to these threats need to be affordable, scalable, and preferably take a system-of-systems approach. In addition to these novel solutions, maintaining and improving legacy vehicles' capabilities is critical to the Marine Corps' overall objectives. As an expeditionary force that is concentrating its efforts on re-honing its amphibious skills, the Marine Corps must ensure that its current and future tactical vehicle fleet is light, fast, easily transportable, and survivable.

The PEO LS continues to collaborate closely with the MCSC, MCWL, MCCDC, ONR, RDECOM, TARDEC, among other agencies in efforts to address the competing challenges of Survivability and Mobility.

The Survivability and Mobility Focus Areas introduce technologies that will enhance mobility and survivability for both the Marines and the vehicles. Survivability and Mobility are addressed together as a combined S&T Focus Area due to their symbiotic relationship.

4.2.1 Survivability consists of:

- ► 4.2.1.1 Autonomy
- ► 4.2.1.2 Fuel Containment/Fire Suppression
- ► 4.2.1.3 Safety

4.2.2 Mobility consists of:

► 4.2.2.1 Crew Visibility

► 4.2.2.2 Corrosion

► 4.2.2.3 Weight Reduction

4.2.1 Survivability

The Challenge

The design, development, production and maintenance of survivable PEO LS vehicles are complex engineering problems because the system-of-systems architecture of the vehicles themselves. Improving and maintaining legacy vehicles remains a substantial challenge within the PEO LS, especially in an environment where affordability is as important as capability. The solutions to these complex engineering problems not only must be cost effective, but it is required that the vehicle must provide the mobility for the Marines to successfully complete the mission.

Potential Solutions

DARPA Efforts

Soldier Protection Systems (SPS)

The DARPA SPS Program is developing and demonstrating lightweight armor material systems to defeat current and potential ballistic and blast threats with performance substantially better than today's protective armor systems. DARPA is focused on materials and material systems that can control the energy absorption and propagation of ballistics or blasts. Guided by mechanicsbased modeling, new materials with superior mechanical properties are being developed and formulated into novel ballistic armor systems. In addition, hierarchical structures that can achieve survivability against highintensity underbody blasts are being developed to provide greatly enhanced protection to the occupants of both tactical and combat vehicles. These approaches aim to enable new lightweight armor that can defeat a broad spectrum of combined threats.

High-Assurance Cyber Military Systems (HACMS)

The goal of the DARPA HACMS program is to create technology for the construction of high-assurance cyber-physical systems, where high-assurance is defined to mean functionally correct and satisfying appropriate safety and security properties. Achieving this goal requires a fundamentally different approach from what the software community has taken to date. Consequently, HACMS will adopt a clean-slate, formal methods-based approach to enable semi-automated code synthesis from executable, formal specifications. In addition to generating code, HACMS seeks a synthesizer capable of producing a machine-checkable proof that the generated code satisfies functional specifications as well as security and safety policies. A key technical challenge is the development of techniques to ensure that such proofs are composable, allowing the construction of high-assurance systems out of high-assurance components.

Ground X-Vehicle Technologies (GXV-T)

The trend of increasingly heavy, less mobile and more expensive combat platforms has limited Soldiers' and Marines' ability to rapidly deploy and maneuver in theater and accomplish their missions in varied and evolving threat environments. Moreover, larger vehicles are limited to roads, require more logistical support and are more expensive to design, develop, field and replace. The US military is now at a point where–considering tactical mobility, strategic mobility, survivability, and cost–innovative and disruptive solutions are necessary to ensure the operational viability of the next generation of armored fighting vehicles. DARPA's GXV-T program seeks to help overcome these challenges and disrupt the current trends in mechanized warfare. GXV-T seeks to investigate revolutionary groundvehicle technologies that would simultaneously improve the mobility and survivability of vehicles through means other than adding more armor, including avoiding detection, engagement and hits by adversaries. This improved mobility and warfighting capability would enable future US ground forces to more efficiently and cost-effectively tackle varied and unpredictable combat situations.



ONR Efforts

Biological Design Features that Retard Visual Detection and Recognition

The purpose of this program is to explore and quantify the design features of animal concealment patterns to defeat human perception with a particular focus on edge design techniques and motion concealment.

Eye tracking with human subjects will explore the effectiveness of different concealment patterns (background matching, mottle, and disruptive coloration) and edge designs.

Cephalopods will be studied in complex and diverse visual habitats focusing primarily on Rapid Adaptive Coloration.

Functionally Gradient Armor Materials (Additive Manufacturing)

This program is using additive manufacturing to fabricate light armor ceramic composite systems with novel geometries and seams.
Hybrid Layered Metal/Composite

The purpose of this program is to explore the response of aluminum-composite structures to underbody blast events.

Injection Molding and Additive Layer Manufacturing of Boron Carbide (B4C)

The purpose of this program is to utilize flowable and highly loaded B4C suspensions with minimum viscosity, maximum loading and tailored rheology using a mix of Polyethylenimine, B4C, HCl, and water as the basis of B4C ceramic armor tiles.

The program will also establish methods of injection molding and 3D printing of B4C greenbodies with subsequent pressureless sintering to produce high density ceramic armor plates.

Injection Molding and Additive Layer Manufacturing of Boron Carbide for Ballistic Testing

Boron carbide possesses a low density and high hardness making it ideal in certain armor applications. However, to achieve these favorable properties, B4C must be sintered to full density. Historically, boron carbide has been sintered using an externally applied pressure, via hot pressing or hot isostatic pressing, due to the challenges associated with densification. Hot pressing approaches limit the geometries of the final pieces to simple shapes such as pellets, plates, disks, and rods and are considered time consuming and costly. Hot isostatic pressing, on the other hand, allows for the sintering of more complex shapes formed through processes such as slip, tape, or gel casting, but is energy intensive and needs high pressure to achieve fully densified samples. There is a need to develop methods that will allow for the cost-effective production of near-net and complex-shaped parts of B4C that could then be sintered without the use of external applied pressure.

LAV Camouflage

The purpose of this program is to develop improved camouflage.

Nanostructured Carbide Armor Composites

The purpose of this program is to use a polymeric method to produce nanostructured ceramics that exhibit high performance as next-generation vehicle armor systems.

Nanostructured Ceramics

This program utilizes the NRL developed polymeric method for the production of nanostructured ceramics in the preparation of test articles for the next-generation armor systems for USMC tactical and amphibious vehicles. This will be accomplished by preparing samples of SiC, B4C and hybrids of SiC and B4C under various processing conditions to determine the optimum composition for integration into Depth of Penetration ballistic testing. The processing parameters including processing temperature, densification factors and ceramic composition as well as physical aspects such as size and depth of ceramic samples and the final volumetric density will be critical for improving overall performance of these ceramics.

The primary objective of this work is to deliver to the USMC vehicle program offices nanostructured ceramics technology for armor applications that will meet threat requirements with decreased system weight and/or cost.

Rapid Innovation Fund Efforts

Deployable Supplemental Buoyancy and Egress Device (DSBED)

This program will design and prototype a Deployable Supplemental Buoyancy and Egress Device kit to facilitate personnel egress from the vehicle while in the water by adding buoyancy and/or increasing the effective freeboard of the vehicle preventing water from spilling into the vehicle during egress. The DSBED kit shall be installed and tested by Navatek, Ltd. on one selected AAV platform.

Long Range Obscurant System

Raytheon's long range obscurant system is designed to disrupt the line-of-sight between an incoming Anti-Tank Guided Missile (ATGM) and the launcher or the missile and the target, effectively eliminating tracking and/or guidance capability of the missile. This two year program (FY18/19) will build and test Controlled Flight Test Vehicles to deliver obscurant at ranges required for defeat of incoming ATGM guidance, to include fly-outs to demo CM guidance, control, and obscurant payload delivery within the extreme environments and time constraints of the Active Protection Systems (APS) mission.

RDECOM & TARDEC Efforts

Combat Vehicle Prototyping (CVP) PMO Survivability STO

The CVP Mission is to execute a five year Ground Vehicle technology development program that delivers a portfolio of leap ahead technologies at TRL 6 by FY19 to the Army and can be integrated and demonstrated on a prototype platform by FY21. The CVP Vision is to develop ground vehicle leap-ahead technologies that ensure the Warfighter maintains its overwhelming ground combat superiority against any enemy worldwide.

Ground Degraded Visual Environment

This program will increase local situational awareness (LSA) in all conditions and environments, to include degraded visual environments, for ground vehicle systems. Utilize scalable LSA sensing & immersive intelligence to improve occupant and vehicle survivability and provide augmented transparent battlefield vision.

Ground System Active Defense

This program will develop active survivability subsystems and effectors which sense, track and respond to neutralize threat prior to terminal effects. The subsystems will leverage the survivability and protection controls architecture to provide threat defeat redundancy and layered survivability to optimize protection with reduced weights.

Modular Active Protection System

This program will demonstrate Soft-kill and Hard-kill APS, that are compliant with a modular approach, to defeat Rocket Propelled Grenades, Recoilless Rifles and Anti-Tank Guided Missiles.

Protection for Autonomous Systems

As unmanned vehicles present unique design considerations from their manned counterparts, this program will undertake a campaign of analysis and experimentation to build an understanding of how to protect individual unmanned platforms. It will explore novel ways that they can provide cooperative and collaborative protection for the other manned and unmanned platforms in a maneuver formation.

Survivability Systems Controls

This program will evolve the active survivability architecture (framework and controller) to host additional sensors and effectors to provide additional capabilities, e.g. Iterative process to integrate survivability system capabilities that are designed for safety, cybersecurity, and compliant with a modular approach to defeat evolving threat environment.

4.2.1.1 Autonomy

Autonomy is a combat multiplier that has the potential to save lives by reducing the Marine's exposure to high-risk tasks. Increasingly, unmanned ground vehicles (UGV) have been developed to work in concert with manned systems; the UGV augments the capability of the Marine and diverts manpower that would otherwise be required for logistics missions toward more tactical roles.

The preeminent value of the UGV is the standoff capability they afford to the Marine. For that reason, they have found their niche in route clearance and counter-improvised explosive device operations, dealing with such threats without putting anyone in the line of fire. In addition, autonomous vehicles can free up manpower from logistics missions, allowing human resources to be taken advantage of more efficiently.

The Challenge

The greatest struggle in the development of UGVs is balancing autonomy with vehicle performance. Current UGV's are not truly autonomous and need a remote human operator to maneuver quickly and navigate difficult terrain. Advancement in artificial intelligence, scene analysis, and similar developments will increasingly lighten the burden placed on the operator. The UGV of the future will be a 'man-in-the-loop' system where a human provides oversight to a vehicle that otherwise acts independently, or completely 'man-out-of-the-loop' system where the vehicle can act in complete absence of human input. This autonomous vehicle will need to capture many of the other S&T Focus areas, making this challenge even more complex.

4.2.1.2 Fuel Containment/ Fire Suppression

The Challenge

Fuel Containment and Fire Suppression technologies remain important to the PEO LS Science and Technology representatives. Addressing fires caused by accelerants and Improvised Explosive Device (IEDs), accidental fires caused by leaks or malfunctions, or battle damage fires all present the same core challenges: to increase the survivability of the vehicle and its occupants.

4.2.1.3 Safety

The Challenge

Safety preserves personnel and equipment, but safety considerations cannot contradict the mission of the Marine Corps' operational objectives. Safety considerations include vehicle stability, safety equipment that include restraint harnesses, fire suppression, clear fields of view, training, policy, procedures, and lines of communication with the Warfighters.

4.2.2 Mobility

The Challenge

The Marine Corps is organized on the concept of Expeditionary Maneuver Warfare and relies on tactical flexibility and agility to project strength against critical targets. The mobility of its fighting force is therefore of utmost importance. The challenge is to find an affordable balance of payload, protection, and performance that maximizes the effectiveness of USMC vehicles.

Potential Solutions

ONR Efforts

Armored Reconnaissance Vehicle (ARV)

The purpose of this program is to plan, initiate, execute, and manage a robust S&T program to research revolutionary technologies and demonstrate the realm of the possible for the next generation ARV.

Electrohydraulic Exoskeletons with Haptic Sensation Powered/Cooled by "Robot Blood"

The purpose of this program is to research a novel energy storage approach where the electrolyte is distributed throughout the exoskeleton components in a human-like circulatory fashion.

Extreme Power Internal Combustion Engine

The purpose of this program is to conduct feasibility studies, combustion modeling and simulation, and kinematic analyses of a Navy patented novel rotary internal combustion engine concept that affords high power and torque in a small, lightweight, and fuel-efficient package.

Fundamentals of Radiative Transfer Modeling of Complex Sediments with Variable Saturation Levels

This program is a physics-based approach to retrieving geotechnical parameters from spectra to reduce the amount of empiricism that currently exist in the derivation of surficial sediment strength from hyperspectral imagery. This could lead to the development of fundamental radiative transfer theorybased tools that include models that relate the basic scattering and reflection properties of terrestrial materials as a function of material type, grain-size distribution, moisture content, plasticity limits, porosity, mineralogy, and other factors describing the complex and diverse nature of terrestrial materials.

Predictive/Adaptive Mobility (PAM)

The purpose of this program is to predict upcoming environment and terrain characteristics via on-board databases and remote sensors and intelligently adapt, in nearreal time, platform mobility dynamics systems to optimize mobility, agility, safety, while also providing just-in-time trafficability.

Trafficability and Mobility Analysis from Remote Sensing

The purpose of this program is to use remote sensing focused on terrain and soil characteristics to generate the mobility corridors from the Modified Combined Obstacle Overlay to improve maneuver planning in the littorals. It will demonstrate relevance of unmanned aircraft systems (UAS) and satellite imagery to evaluating soil characteristics, extending database and models to cover broader operational environments, and correlating trafficability products to characteristics of vehicle classes.

Variable Stiffness Materials for Smart Tire Application

The purpose of this program is to develop a novel tire material that can adapt its 'footprint' or stiffness to different terrain conditions via stiffness change of a thermoplastic styrene based polymer around glass transition and phase change of low temperature Bi-alloys encapsulated in an elastomer matrix.

Unmanned Swarming Amphibious Assault Craft (USAAC) CONOPS and Performance Spec. Development

The purpose of this program is to analyze potential mission sets and payload modules while also determining system parameters and desired performance capabilities.

USAAC Conceptual Design and Technology Research

The purpose of this program is to generate concepts and whole system trade analyses.

RDECOM & TARDEC Effort

Advanced Running Gear

The purpose is to develop external suspension and high capacity lightweight track system that will improve the vehicle mobility and survivability. The products will support PM CVP with the potential to support other heavy tracked vehicle customers.

- External Suspension Unit System will provide flexibility for complex hull shaping while buying back internal hull volume. Alleviate effects of increasing gross vehicle weight, such as degraded mobility and reduced ground clearance. Provides for weight growth and height management with adaptive damping.
- ➤ High Capacity Lightweight Track will reduce track system weight and reduce track system rolling resistance through improved track designs. Increase track system durability and fire resistance through advanced elastomer materials.

SBIR Efforts

Lightweight Track Technology

The purpose of this program is to develop a lightweight track product for land and water

mobility by using innovative materials, design, and manufacturing processes to reduce scheduling, manpower and time burden while achieving increased cost efficiencies to translate into lifecycle cost reductions. The Marine Corps seeks a lightweight track product design that provides enhanced water track and land mobility through reduced weight, less ground pressure, better traction and lateral stability; reduced platform vibration, noise, radar/acoustic signatures, weight, and rolling resistance; improved track life and energy efficiency; corrosion and maintenance-free operations; and lower life cycle costs.

Lightweight Roadwheel Technology

Develop lightweight road wheel technologies, for marine and on/off road complex mission profiles, that use innovative materials, design, and manufacturing processes; reduce scheduling, manpower, and time constraints; and achieve increased cost efficiencies to translate into life-cycle cost reductions.

FCT Efforts

Improved Amphibious Tracks

The use of novel materials and designs for IAT are being tested with an objective to improve overall performance of the Assault Amphibious Vehicle Family of Vehicles (AAV FoV). Advances in rubber and composites, including the addition of carbon nano-fiber materials, can allow the IAT to provide a 2,000 lb weight savings, while improving fuel economy (30%), reducing track noise (10 dB), and reducing maintenance (3,000 miles between maintenance actions).

4.2.2.1 Crew Visibility

On the battlefield, any number of factors, both natural and manmade, can obscure the crew's ability to see. Despite the obstruction of darkness, smoke, or weather, the crew must maintain the ability to navigate, identify vehicles, maneuver, and sustain situational awareness. On the future battlefield, the enemy will have increased access to night vision devices, infrared surveillance, and other tools to pierce the fog of war; it will be crucial to maximize crew visibility to combat most potential obstructions.

The Challenge

Paramount importance is given to crew survivability but the cost, weight, and optical limits of transparent armor can burden vehicles with hindered visibility. Optimizing visibility without sacrificing the safety of the crew or imposing a heavy penalty on size, weight, power, and cost presents a significant technological challenge.

4.2.2.2 Corrosion

For the Marines who preserve and maintain thousands of pieces of ground equipment in often harsh saltwater environments, fighting corrosion is uniquely challenging. To face it, the Marine Corps has established an extensive corrosion-prevention program for all tactical ground equipment. The intent is to reduce maintenance requirements and costs through developing corrosion prevention and control products, materials, technologies, and processes.

The Challenge

The Marine Corps will identify and implement anti-corrosion technologies to extend the service-life of its existing fleet as well as reduce required maintenance, and prolong the operational viability of legacy systems.

Potential Solutions

DARPA Efforts

OFFensive Swarm-Enabled Tactics (OFFSET)

DARPA's OFFSET program envisions future small-unit infantry forces using swarms comprising upwards of 250 small UASs and/ or small unmanned ground systems to accomplish diverse missions in complex urban environments. By leveraging and combining emerging technologies in swarm autonomy and human-swarm teaming, the program seeks to enable rapid development and deployment of breakthrough capabilities. OFFSET aims to provide the tools to quickly generate swarm tactics, evaluate those swarm tactics for effectiveness, and integrate the best swarm tactics into field operations. To accomplish these goals, OFFSET will develop an active swarm tactics development ecosystem and supporting open systems architecture.

Squad X Core Technologies (SXCT)

DARPA's SXCT program aims to develop novel technologies that could be integrated into user-friendly systems that would extend squad awareness and engagement capabilities without imposing physical and cognitive burdens. The goal is to speed the development of new, lightweight, integrated systems that provide infantry squads unprecedented awareness, adaptability and flexibility in complex environments, and enable dismounted Soldiers and Marines to more intuitively understand and control their complex mission environments. SXCT plans to explore four key technical areas:

- Precision Engagement: Precisely engage threats while maintaining compatibility with infantry weapon systems and without imposing weight or operational burdens that would negatively affect mission effectiveness. Capabilities of interest include distributed, non-line-of-sight targeting and guided munitions.
- Non-Kinetic Engagement: Disrupt enemy command and control, communications and use of unmanned assets at a squadrelevant operational pace (walking with occasional bursts of speed). Capabilities of interest include disaggregated electronic surveillance and coordinated effects from distributed platforms.

Squad Sensing: Detect potential threats at a squad-relevant operational pace. Capabilities of interest include multisource data fusion and autonomous threat detection. Squad Autonomy: Increase squad members' real-time knowledge of their own and teammates' locations in GPS-denied environments through collaboration with embedded unmanned air and ground systems. Capabilities of interest include robust collaboration between humans and unmanned systems.

ONR Efforts

Cephalopod Inspired Camouflage Skins: Adaptive Color Changing, Pattern Tuning and Texture Morphing

In the context of a study on human-robot interaction, the performer proposes a new cognitive theory that uses mental models to represent the communicated content and their integration.

The approach will identify different types of models, which can then be used by a robot to decide how to respond (e.g., confirm an instruction, request a clarification) and, when an unambiguous model is obtained, what tasks it should perform.

Study supports context of a surveillance mission where the operator and robot perform as a team, and the robot is governed by a goal reasoning decision process.

The environment will be dynamic and multiagent, presenting several challenges for decision making.

Surmounting Arrow's Impossibility Theorem (AIT) + via Revolutionary Logicist AI

AIT roughly says that, without a "dictator" who holds sway, it is impossible to aggregate the individual opinions of a group of agents to yield a decision satisfactory for all. Is there an escape route? The goal of this effort is to develop formal decision & reasoning systems for firstorder logic, modal logic, quantified modal logic with uncertainty values with multiple conflicting chains of reasoning.

Military Swarming: Historical Observations and War Game Experiments

The purpose of this program is to investigate and triangulate the critical elements of swarming at the tactical and operational level.

A summary of historical case studies on the key elements of swarms emphasizing multiple levels of war (i.e., tactical and operational) and a range of military action (i.e., offense, defense, reconnaissance and security) in multiple domains (i.e., air, sea, land, and cyber) and a series of experimental treatments organized as wargames that test concepts derived from historical study on how to employ and defeat swarms in multiple domains will be delivered.

Monterey Phoenix Usability Study

The purpose of this program is to document the architecture for the Monterey Phoenix (MP) software and assess the usability of MP at each of the novice, journeyman, and expert levels of modeling and ensure the MP capability is usable by a wide range of DoD civilian and military personnel with various backgrounds for authoring MP models and using them to answer questions of interest to them.

Modular Autonomous Robotics System (MARS): Collaborative and Adversarial Behavior of Multiple Synthetic Agents

The purpose of this program is to provide systems architect support for the MARS program. Specifically, the contractor shall

- provide necessary program management to ensure successful cost, technical and schedule performance in accordance with the contractor's best practices,
- ► provide systems architecture support, and
- investigate system architecture modeling approaches and associated tool sets and make a recommendation for adoption on MARS program.

MARS: Deliberative Planning, Reactive Control, Low-level Control

The Johns Hopkins University Applied Physics Laboratory shall provide engineering and testing in support of the "Maneuver/ Deliberative Planner," "Reactive Control," and "Low-Level Control" technologies areas for the Forlorn Hope program's Technology Area 1: Autonomy and Manned-Unmanned Teaming.

MARS: Localization and Spatial Orientation Sub-System Development

The purpose of this program is to enable autonomous amphibious mission operations. Charles River Analytics proposes to integrate multiple localization, sensing, and processing capabilities into a Localization and Perception module to support Autonomous Amphibious Robot Optimized Navigation (AARON).

The AARON Localization and Perception module, which fits into the USAAC system architecture will provide state-of-the-art processing techniques to support effective localization in open water, through the seasurf-shore interfaces, and inland in varied operating conditions, including day, night, fog, smoke, and precipitation. AARON will perform localization (both with and without GPS) onboard each vehicle using a variety of sensors fused within a robot operating system framework.

MARS: Perception and World Model Sub-System Development

The objective of this program is to engineer a system that models the environment via sensory input and provides mapping information, which aids in the autonomy of an amphibious vehicle. The final deliverable for this project is the World Model Software Stack that can be distributed across multiple unmanned amphibious vehicle fleets.

MARS: Sensor and Perception Sub-System Development

The Neya Systems led team proposes to develop and demonstrate Swarming Multi-

Modal Amphibious Robotic System leveraging substantial prior and ongoing development in land and maritime autonomy, and advancement of open, modular, and extensible appliqué autonomy solutions. With partners drawn from industry, this effort will develop and deliver perception and wave modeling modules as part of the sensing and computing hardware and autonomy software to transform an amphibious platform into an unmanned asset capable of performing diverse missions in concert with other manned and unmanned assets.

MARS: Panoptes: Seek and We Shall Find

The purpose of this program is to design and implement a portable vision system for autonomous vehicles. This system is designed to take input from stereo cameras and 360 degree cameras and provide pixel-wide segmentation of the entire scene into one of multiple object classes. This system will also provide path-planning for autonomous vehicles to follow the road, avoid obstacles, and detect objects of interest in the scene.

MARS: Supervision Denied Deep Learning

Autonomous vehicles need visual understanding of their environment for navigation and exploration. Military vehicles will encounter rural environments with unpaved roads and surprise obstacles. It is critical that the vehicle be aware of traversable obstacles, can follow unpaved roads, and monitor road conditions to prevent vehicle damage.

Deep Neural Networks excel at learning from large amounts of data, but generalize poorly to new datasets or environments. Even a slight departure from a network's training domain can cause it to make spurious predictions and significantly hurt its performance (Tzeng et al., 2017).

This program develops simultaneous pixel and feature level adaptive learning models which transfer information from the prevalent and annotated urban road scenes to the rural scenes encountered in military operations.

MARS: Systems Integration and Testing

NIWC-Pacific is continuing development of the amphibious autonomy capability utilizing the Gibbs Quadski surrogate platforms.

NIWC-Pacific has demonstrated the baseline ground autonomy functioning properly on the quadski and has demonstrated basic on-water vehicle maneuver capability with the same architecture.

A preliminary perception and inertial sensor data collection has been performed in the surfzone with 2–3' surf and that data is being analyzed.

NIWC-Pacific has drafted an initial strawman autonomy architecture for the USAAC/ MARS program as a starting point when the contractors come on board.

Proteus: Adaptive Camouflage in Organoids

The overall goal of this ONR effort is to generate a material that can change its color and shape (in response to specific stimuli, but with a significant degree of autonomy), is self-healing, and is addressable. The effort also includes components dedicated to interrogating natural examples of such functionality, to understand the algorithms by which living organisms perceive, model, and control their own properties in a changing environment.

MARS: Wave Prediction From a Marsupial Platform

The purpose of this program is to develop a model of wave measurement effects on small vessels in the surf zone and a hardware package to conduct wave measurements from small vessels requiring a small footprint and low sensor height of eye while simultaneously enabling wave observations in extended region around vessel and minimizing sensor cost.

RDECOM & TARDEC Efforts

Autonomous Ground Resupply

This program will develop a baseline open unmanned vehicle architecture and behaviors on the module level. It will also define interfaces and messages for open competition.

Combat Vehicle Robotics

This incremental effort is to spiral increasing autonomous behaviors to the open architecture autonomy framework. It is focused on improving unmanned maneuver, reducing burden on soldier operators, proving the safety case for unmanned systems, and pushing UGVs into combat applications.

Crew Augmentation & Optimization

This program will focus on the utilization of emerging human-interaction technologies, automations, machine intelligence, and the provision of cohesive domain personalization to allow Soldiers to achieve leap-ahead performance beyond today's constrained ground vehicle environment.

The use of vehicle integrated multi-modal hardware, controls & displays, 360 SA, driving aids, and Soldier-Machine Interface will increase crew performance while reducing the physical and cognitive load.

Manned-Unmanned Teaming Platform Enablers

This program will provide additional capability to experimental unmanned platforms (direct fire or scout) to include:

- Platform integration of tethered/ untethered Unmanned Aerial Vehicles (UAVs) to improve communications and intelligence, surveillance, and reconnaissance (ISR) of control platforms.
- Realistic simulation environment for soldier experimentation prior to systems delivery.
- Software improvements to Warfighter machine interface improving unmanned tank operator control.

4.2.2.3 Weight Reduction

Weight reduction extends the reach of the Marine Corps vehicle fleet by improving fuel efficiency, increasing the ability to navigate harsh terrain, and enhancing maneuver from sea. Light-weighting results in a more agile and flexible fighting force.

The Challenge

Marine Corps vehicles are designed to optimize efficiency, therefore there are a limited number of areas where weight can be reduced without losing critical functionality. Weight reduction measures must be affordable and cannot compromise the reliability of the vehicle or the survivability of its crew. Survivability

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Active & Potential							
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Active & Potential Investment	Proteus: Ada	otive Camouflag	le in Organoids				
Opportunities	Surmounting	Arrow's Imposs	sibility Theorem	+ via Revolutior	nary Logistics A	-	
	Military Swarr	ning: Historical	Observations a	ind War Game E	xperiments		
	Monterey Pho	enix Usability S	itudy				
	MARS: Collab	orative and Adv	versarial Behav	ior of Multiple S	ynthetic Agents		
	MARS: Senso	r and Perceptio	n Sub-System I	Development			
D&I	MARS: Percel	ption and World	Model Sub-Sys	stem Developme	ent		
E&D FNC	MARS: Locali	zation and Spat	tial Orientation	Sub-System Dev	velopment		
SBIR/STTR TARDEC Other							
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S&T (6.2/6.3)	3.48	4.09	66.66	60.60	57.17	53.98	54.67
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Autonomy



Mobility

Section 4.3 Focus Area

MODELING AND SIMULATION

As the pace at which technology refreshes continues accelerating, Modeling and Simulation (M&S) becomes increasingly important to industries wanting to gain a complete understanding of how cost, schedule, and performance (CSP) are impacted during a product's lifecycle. The ultimate value of a fully integrated M&S toolset will be the ability to maximize the effectiveness of limited resources through simulation-based acquisition, while bringing optimized, focused capabilities to the Warfighter.

PEO LS has a continuing requirement for the development of an integrated suite of nonproprietary multi-variable M&S aggregation tools that have been validated and have a high degree of fidelity. These tools must collect and aggregate industry component and platform data for various vehicle systems/platforms, analyze the aggregated data through scenariobased simulation, and provide normalized CSP output that will allow leadership to confidently assess the value of a proposed system or upgrade.

Computer-based simulation of the functions of tactical vehicle systems must be expanded to shorten development time and reduce program risk and cost. Currently, not enough components are accurately simulated and few are simulated together as a system. A fully integrated simulation-based acquisition approach incorporating co-simulation tools will:

- Enable comprehensive virtual vehicle designs to be functionally tested on computers.
- Optimize vehicle prognostics and performance tools.

- Assess candidate vehicles against critical performance parameters.
- Inform the requirements process by identifying system requirements that are realistic and achievable.
- Inform life-cycle cost (LCC) estimates and significantly reduce the total LCC of the system.
- Save money by reducing design, testing, and evaluation time.
- Allow high-fidelity requirements trade-offs with accurate predictions of CSP.
- Evaluate potential new technology insertions and their effects on CSP.

The Challenge

To achieve the PEO LS vision, solutions must be rendered to solve data centric challenges which allow for a more uniform decisionmaking process. The inherent complexities within M&S make it difficult to standardize the situational inputs into a concise and unifying conclusion that leadership could use to make mission-critical decisions. PEO LS M&S efforts have found that holistic modeling of systems on a component by component basis proves difficult due to the number interactions and the data needed to support an entire system. This challenge is compounded by efforts to understand the impact of alternate technology implementation to CSP and a system's lifecycle. To achieve a pragmatic solution, PEO LS requires a solution that can manage large amounts of data while simultaneously standardizing it for easy end-user analysis.



Figure 4.3-1. Universal M&S Aggregator

Potential Solutions

Framework Assessing Cost Technology (FACT)

MCSC sponsored the development of the FACT with Georgia Tech Research Institute to enable investigators to visualize a system's potential costs alongside the systems performance, reliability and other factors deemed important. FACT is a modeling and simulation framework, enabling real-time collaboration in a web environment, primarily geared towards conducting real-time trade space analysis for complex systems-of-systems. FACT uses Systems Modeling Language (SysML) to define complex systems. SysML expands upon the Unified Modeling Language and goes beyond software-centric design to include hardware components. The specification provides a formal means to describe a system, most notably the decomposition and organization of the system components as well as the

parametric relationships between value properties distributed throughout the systems.

Instrumentation Improvements for Ground Vehicle Live Fire Testing and Evaluation (LFT&E)

Improvements will include comparisons of existing commercially available accelerometers and isolators as well as concept gauges using controlled testing for live fire applications. Finally, a user's guide will assist testers in producing valuable and meaningful results from such tests.

Joint Light Tactical Vehicle (JLTV) Blast M&S

The objective of this effort is to develop and execute a physics-based model able to account for both soil/structure interaction and gross vehicle response. Corvid Technologies has prepared high- fidelity models for the Marine Corps JLTV Program Office. The Under-Body Blast M&S efforts will:

- Provide Joint Project Office insight into force protection levels from a structural standpoint and crew-response standpoint
- Support engineering design analyses and modifications
- Provide supplemental information to support key performance parameter analyses for future evaluations of vehicle design modifications and Engineering Change Proposals.

Joint Live Fire Vulnerability Map

This effort is working to create a visual mapping tool to highlight underbody vulnerabilities impacting survivability and augment live fire test data.

Powertrain Modeling

This program will leverage government resources and industry software to develop a library of PEO LS vehicle powertrain models for system development and modification. The models will afford program office engineers the analysis capabilities to consider what effects powertrain modifications and load profiles will have on system performance.

Survivability M&S Efforts for AAV Survivability Upgrade (SU)

Utilize existing vehicle CAD for simulations to aid in shotline selection, instrumentation, preshot predictions of live fire, and tests to identify vulnerable load paths. From analysis improve understanding of vulnerabilities to drive design improvement.

Survivability M&S Efforts for Amphibious Combat Vehicle (ACV)

Develop ACV mesh models, including Energy Attenuating seats, to aid PM shotlines, instrumentation, root cause analysis, and crew casualty assessments. Provide independent assessment of blast survivability of each vendor's vehicle to complement limited test scenarios and drive design improvement.

Survivability M&S Efforts for JLTV

Utilize existing vehicle CAD to provide simulations results to aid in shotline selection, instrumentation, pre-shot predictions of live fire tests identifying the most vulnerable load paths. From analysis improve understanding of vulnerabilities to drive design improvement.

Survivability M&S Efforts for Medium Tactical Vehicle Replacement (MTVR)

Use M&S on existing CAD to identify critical load paths to guide upgrade design effort to improve survivability.

Test & Evaluation Damage Visualizer (TEDV)

TEDV will provide a semi-automated way to view, compare, and search for live fire test data. The tool allows users to view test vs. test, test vs. simulation, and simulation vs. simulation comparisons.

Material Characterization of Energy Absorbers (EA)

The program focuses on material for blast modeling, which is being tested to determine models used to define EA component response. Components to be modeled include seat EAs, cushions and blast mats.

DARPA Efforts

Open Manufacturing

The goal of the DARPA Open Manufacturing program is to lower the cost and speed the delivery of high-quality manufactured goods with predictable performance. It aims to do so by creating a manufacturing framework that captures factory-floor and materials processing variability and integrates probabilistic computational tools, informatics systems and rapid qualification approaches. These newly developed concepts and approaches will be used to characterize and reduce the risk of new manufacturing technologies.

Transformative Design (TRADES)

DARPA's TRADES program aims to advance the foundational mathematics and computational

tools required to generate and better manage the enormous complexity of design. TRADES intends to develop engineering tools to address design representation, analysis, and synthesis. The final TRADES technologies should allow designers to more easily navigate the design space to discover non-intuitive yet realizable designs that fully leverage new materials and advanced manufacturing approaches, ultimately showing a way forward for future design systems and processes.

Prototype Resilient Operations Testbed for Expeditionary Urban Operations (PROTEUS)

The goal of the Prototype Resilient Operations Testbed for Expeditionary Urban Operations program is to create and demonstrate tools to develop and test agile expeditionary urban operations concepts based on dynamically composable force packages. The program seeks to:

- Develop software for simultaneous and dynamic real-time task organization, force package (i.e. platforms & weapons) combination and configuration, and tactics planning suitable for implementation in devices available to Marines in the 2030-2040 timeframe;
- Develop a purpose-built virtual test environment to exercise and demonstrate this capability with an appropriately detailed virtual representation of combined arms operations in a complex urban battlespace; and
- Exercise both capabilities in a series of benchmarking tests involving a participant cohort for both friendly and opposing forces drawn from active duty Marines. These tests will demonstrate that the ability to dynamically compose small unit organization, capabilities and tactics enables superior performance in the battlespace quantified using metrics such as lethality/(area-cost), resilience, and cost imposition.



If successful, the software tools and concepts developed in the PROTEUS program will enable assessment and exploration of new approaches to combined arms operations involving coordination of effects in multiple domains.

ONR Efforts

Velodyne M&S

The purpose of this program is to extend current high fidelity computational models to end-game simulation for active protection systems.

RDECOM & TARDEC Effort

Virtual Prototyping

The purpose of this program is to provide US Army Training and Doctrine Command , NGCV Cross Funtional Team, PEO Ground Combat System and PM NGCV with independent manned and unmanned vehicle concepts, performance analysis, tradespace analysis, and virtual experimentation results. VP results inform NGCV requirements, technology performance, shape demonstrator investments and support NGCV Phase 2 and 3 Test & Evaluation experiments.

Modeling & Simulation



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Section 5.0

WARFARE CENTERS



Naval Sea Systems Command exists to make Naval (Navy and Marine Corps) programs successful. The vision of NAVSEA is to be the Navy's trusted partner for identifying and providing innovative, cost-effective technical solutions to the Warfighter. NAVSEA is responsive to the Naval enterprises, the Joint Force and national requirements, while partnering with industry, other DoD laboratories, and academia. Within NAVSEA, support for the Warfighter is accomplished at the Naval Surface Warfare Center, the Naval Undersea Warfare Center, and the Naval Information Warfare Center.

The mission of the NSWC is to operate the Navy's full-spectrum research, development, test and evaluation, engineering, and fleet support centers for ship systems, surface ship combat, and weapons systems, littoral warfare systems, force warfare systems, as well as other offensive and defensive systems associated with surface warfare and related areas of joint, homeland, and national defense systems from sea and ashore. NSWC also provides the Navy's core technical capability for the integration of weapons, combat, and ship systems into surface ships and vehicles, and for development and integration of energetic materials for joint applications.

The mission of the NUWC is to operate the Navy's full-spectrum research, development, test and evaluation, engineering, and fleet support center for submarines, autonomous underwater systems, and offensive and defensive weapons systems associated with undersea warfare and related areas of homeland security and national defense. NUWC also provides the Navy's core technical capability for the integration of weapons, combat, and ship systems into submarines and undersea vehicles.

The Warfare Centers view the Marine Corps as an important strategic partner. To facilitate a productive relationship with the Marine Corps, the Warfare Center Division Technical Directors chartered the NAVSEA Warfare Center USMC Collaboration Team (CT). The vision for the CT is to work seamlessly across the Warfare Centers Divisions to support and advocate for technically superior and cost-effective solutions for the Marine Corps. In 2018, the CT added the NIWC as partners to jointly support the Marine Corps. The result is a one-team solution for the Marine Corps to access the full technical depth of the NAVSEA Warfare and NIWC. CT members are the readily available resource to facilitate Marine Corps stakeholder engagement with the Warfare and Systems Centers Divisions.

The following NSWC Division Fact Sheets highlight each warfare center's capabilities and focus on capabilities relevant to the Marine Corps.



Warfare and Systems Centers USMC Collaboration Team Stakeholder Engagement

NSWC Carderock Division

Mission

Provide research, development, test and evaluation, analysis, acquisition support, inservice engineering, logistics and integration of surface and undersea vehicles and associated systems. Develop and apply science and technology associated with naval architecture and marine engineering, and provide support to the maritime industry. Execute other responsibilities as assigned by the Commander, Naval Surface Warfare Center.

Description

The Carderock Division consists of approximately 2,000 scientists, engineers and support personnel working in more than 40 disciplines ranging from fundamental science to applied/in-service engineering. We are the Navy's experts for maritime technology. The Division houses world-class facilities and laboratories. Carderock's Headquarters is located in West Bethesda, Maryland. The Division also conducts research and development at several remote sites across the country.

Technical Capabilities

- CD03 Advanced Naval Capability (Marine Corps Vehicles) Concepts and Technology
- CD05 Combatant Craft and Expeditionary Vehicles
- CD07 Hull Forms and Fluid Dynamics
- CD14 Surface, Undersea, and Weapon Vehicle Materials
- CD15 Surface and Undersea Vehicle Structures
- CD16 Alternative Energy and Power Sources R&D

- CD17 Liquid Waste Management, Science and Systems
- CD18 Solid Waste and Hazardous Material Management, Science and Systems, and Ships and Subs Systems Safety
- CD20 Surface, Undersea and Expeditionary Vehicle Vulnerability Reduction and Protection

Facilities

- Acoustic Research Detachment
- Advanced Ceramics Laboratory
- Biotechnology Laboratories
- Center for Innovation in Ship Development
- Circulating Water Channel
- Combatant Craft Department
- David Taylor Model Basin
- Deep Submergence Pressure Tank Facility
- Dosimetry Laboratories
- Electrochemical/Battery Laboratories
- Environmental Protection Laboratories
- Explosives Test Pond
- Fatigue and Fracture Laboratories
- Fire Tolerant Materials Laboratories
- IR Systems
- Large Cavitation Channel
- Large Scale Grillage Test Facility
- Magnetic Fields Laboratory
- Magnetic Materials Laboratory
- Maneuvering and Seakeeping Basin
- Manufacturing Technology Laboratory Marine Coatings Laboratories

- Marine Corrosion Control and Evaluation Laboratories
- Marine Organic Composites Laboratories
- Materials Characterization and Analysis Laboratory
- Metal Spray Forming Laboratory
- Nondestructive Evaluation Laboratories
- Radar Imaging Modeling System
- Rotating Arm Facility
- Ship Materials Technology Center
- Shock Trials Instrumentation
- Signature Materials Laboratory
- Small Gas Turbine Test Facility
- South Florida Testing Facility
- Southeast Alaska Acoustic Measurement Facility
- Structural Dynamics Laboratory
- Structural Evaluation Laboratory
- Subsonic Wind Tunnel
- Survivability Engineering Facility
- Welding Process and Consumable Development Laboratories

Current Marine Corps Support Areas

- USMC Platform/Vehicle Hydrodynamics and Hydromechanics
- USMC Platform/Vehicle Integration and Design
- Survivability
- Structures
- Materials
- Power/Energy

• Environmental Quality and System Safety

Current Marine Corps Programs Supported

PEO Land Systems

ACV

- LFT&E/Survivability
- ACV Interactive Electronic Technical Manual, using MIL-STD-40051-1C and the Interactive Authoring and Display System

AAV Hydrodynamics and Hydrostatic Efforts

- AAV Survivability Upgrade C Variant PDR and CDR
- Remote Weapon Station (RWS) project current manned turret in the AAV SU P variant with an RWS
- Water production qualification testing of the LRIP vehicles
- Ship Launch and Hydrostatic Analysis (GHS) of the LRIP AAV SU P variant design and CDR AAV SU C variant design
- Conduct Time to Sink analysis using existing RAM/RS spreadsheet for the AAV SU P and C variants and provide an assessment of risk associated with reserve buoyancy

ACV Hydrodynamic Support

- Demonstrate the following characteristics for each ACV candidate vehicle (2 vehicles) through testing and/or analysis:
 - Measure static pitch, roll and freeboard at crew-loaded weight (LC1) and Gross Vehicle Weight (LC3) and determine Reserve Buoyancy from provided CAD models. This task includes 2 ACV candidate vehicles.
 - Calculate the Self-Righting characteristics of both vehicles at LC1

and LC3.

- Evaluate the vehicle's ability to survive in a 10-foot PM using a watertight vehicle.

JLTV

• LFT&E/Survivability

Marine Corps Systems Command

- Additive Manufacturing
 - Acquisition and Engineering Support to the MCSC Expeditionary Fabrication Efforts
- Corrosion Prevention and Control and Materials Program
- Expeditionary Power
 - Systems Engineering and Acquisition Logistics (SEAL) and the FCT Office support in the execution of a two-year comparative testing and analysis of both near-term battery systems (Lithium-ion 6T) and advanced cell chemistries
 - Mobile Electric Hybrid Power Sources (MEHPS) user evaluation set to evaluate EMD hybrid power systems in an operational scenario with the intent of informing the MEHPS Performance Spec and CPD
 - Dismounted Warfighter Operational Energy effort sponsored by OSD
 - Identify power and energy gaps and project power demand for the dismounted rifle squad
 - Improved Solar Battery System,
 Worldwide Ruggedized Power Supply,
 Advanced Battery Charger, Medium
 Hybrid Expeditionary Energy System,
 Improved Solar Panels, 600W Power
 Manager and Power Source Technical
 Working Group and Power Source

Technical Working Group performance testing/technical support

- Lithium battery test agent in support of characterizing the improved Bren-Tronics DPD Improved Battery System
- Fabrication and delivery of USMC
 Generator Mounting Rail Kits and provide
 accompanying hardware installation kits

Marine Corps Expeditionary Energy Office

- Power/Energy
- Additive Manufacturing Initiatives

Marine Corps Operational Test and Evaluation Activity

• Integrated JLTV Live Fire Test & Evaluation Activities

<u>Joint Program Executive Office</u> <u>Chemical and Biological Defense -</u> <u>Joint Project Manager Protection</u>

• Joint Service Aircrew Mask Strategic Aircraft Wind Tunnel testing for the XM69 respirator

Marine Corps, Installation and Logistics

Additive Manufacturing Demonstrations

Marine Corps S&T Efforts

- Extended Operational Reach of Expeditionary Forces using Wireless Charging for Battery Operated Unmanned Aircraft
- Quad-Ski Assessment and Familiarity
- Quad-Ski Detection and Signature Evaluation
- Quantifying the Impact of Surf Zone Characteristics on Vessel Dynamics
- Unmanned Swarming Amphibious Assault

Vehicle

- Hybrid Structures for Amphibious Vehicles
- Development Study and Prototyping of All-Solid-State Mediator Supercapacitor
- Advanced Topcoat System Ground Vehicles
- BEYOND LI-ION Hybrid Energy Storage
- Repeatability Study on Additive Manufacturing Systems
- Underwater Wireless Energy Transfer
- Failure Analysis of Lithium Batteries

NSWC Corona Division

Mission

NSWC Corona provides the Navy and Marine Corps independent analysis and assessment with 1400 scientists, engineers, and support staff, and more than 1800 contractors.

The mission of NSWC Corona is to "Serve Warfighters and program managers as the Navy's independent assessment agent throughout systems' lifecycles by gauging the Navy's and Marine Corps' warfighting capability of weapons and integrated combat systems, from unit to force level, through assessment of those systems' performance, readiness, quality, supportability, and the adequacy of training."

Technical Capabilities

- AC01 Warfare Systems Performance Assessment
- AC02 Quality and Mission Assurance Assessment
- AC03 Metrology, Test, and Monitoring Systems Assessment
- AC04 Naval Surface & Air Range Systems Engineering
- AC05 Weapons Systems Interface Assessment
- AC06 Naval Systems Material Readiness Assessment
- AC07 Strategic Systems Testing and Analysis, and Surveillance Assessment
- AC08 Ground Combat Weapons and Ammunition Test, Evaluation, and Assessment

Facilities

NSWC Corona is home to three premier national laboratory and assessment centers: Joint Warfare Assessment Lab (JWAL); Measurement Science and Technology Lab (MSTL); and Daugherty Memorial Assessment Center (DMAC). Along with the "Corona Engineers," these state-of-the-art facilities enable Corona to fulfill its unique mission for the Navy. The JWAL and DMAC are at the core of Corona's integrated approach to warfare assessment, and the MSTL is where Corona researches and establishes the metrology and calibration standards for the procedures for the Navy and Marine Corps. NSWC Corona's Fallbrook Detachment is strategically positioned next to Marine Corps Base Camp Pendleton, providing integrated Test and Evaluation (T&E) support to the fleet.

Using a rigorous, disciplined independent assessment process, Corona provides the fleet, program managers, and acquisition community with the objective assessment needed for the Navy and Marine Corps to gauge warfighting capability of ships, aircraft, and ground systems; assess warfare training; and analyze new defense systems – even those systems in the concept phase.

Current Marine Corps Programs Supported

PEO Land Systems

PM Air Command Control and Sensor Netting (AC2SN)

- MAGTF Common Aviation Command and Control System (CAC2S) Analysis and Assessment
- Composite Tracking Network Analysis and Assessment

PM Ground Based Air Defense (GBAD)

• Counter-Unmanned Aerial Systems Test, Analysis, and Assessment Support

<u>Program Executive Office for</u> <u>Enterprise Information Systems</u>

PM Global Combat Support System-Marine Corps

- Business Intelligence Information Technology support
- Data Analytics and Readiness Assessment
- Information Assurance
- Configuration Management

Marine Corps Systems Command

PfM Logistics Combat Element Systems (LCES), PM Ammunition

- Total Life-Cycle Assessment
- In-Service Engineering Agent
- T&E for Operational Reliability, Service Life, and Surveillance
- Technical Agent for Fleet Malfunction Investigations
- Global Inventory Supply Chain Management and Pre-Positioning
- Knowledge and Information Management
- Joint Services Production Engineering Assessments
- T&E for Javelin and Tube-launched Optically-tracked Wire-guided (TOW) Missiles

PfM LCES, PM Supply/Maintenance Systems

- Test Measurement and Diagnostic Equipment Maintenance
- Automated Test and Equipment Program Calibration
- Metrology and Calibration Engineering
- Infantry Weapons Gage Calibration Program Maintenance

PfM Supporting Establishment Systems

- Emergency Response System Development and Maintenance
- Public Safety Network Engineering
- Secure Operational Network Infrastructure and Communications Analysis

PfM Ground Combat Element Systems (GCES), PM Infantry Weapons

• Test and Evaluation Support

PfM Command Element Systems (CES), PM C2 Systems

- Joint Battle Command Platform T&E
- MAGTF Common Handheld T&E

PM Training Systems (TRASYS)

- Training Assessment Program
 Development
- Tactical Warfare Simulation Certification and Accreditation
- Tactical Training Ranges/Development and Maintenance
- Virtual Battlespace Two Certification & Accreditation

Amphibious Vehicle Test Branch

• Test Instrumentation and Data Collection

SEAL

- GPS Liaison
- ALPS
- Item Unique Identification Engineering

Marine Corps Installations Command

- Logistical Utilities Management and Energy Systems Development
- Advanced Metering Infrastructure C&A

Industrial Control Systems Assessment

Marine Corp Base, Camp Pendleton Environmental Security Division

- Geographic Information Systems
- Knowledge and Information Management and Accreditation
- SharePoint Support

Marine Corps Operational Test and Evaluation Activity

- ACV
- JLTV
- Operational Test and Analysis Division

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NSWC Crane Division

Mission

Provide acquisition engineering, in-service engineering and technical support for sensors, electronics, electronic warfare and special warfare weapons. Apply componentand system- level product and industrial engineering to surface sensors, strategic systems, special warfare devices and electronic warfare/information operations systems. Execute other responsibilities as assigned by the Commander, Naval Surface Warfare Center.

Description

Naval Surface Warfare Center, Crane Division, (NSWC Crane) is a shore command of the US Navy, under the Naval Sea Systems Command headquartered in Washington, DC. It is a business-based enterprise operating under the Navy Working Capital Fund. Sixty-seven percent of the workforce is made up of scientists, engineers, and technicians.

NSWC Crane Headquarters is located in southwestern Indiana and is a tenant on the third largest Navy installation in the world. With nearly 100 square miles of land, no encroachment, strong state and local support, and a cost of living index 22.7 percent below the US national average, Crane is indispensable to the nation as a high-value provider of innovative solutions and services.

Multi-service partnerships with Crane Army Ammunition Activity and Army/Indiana National Guard's Camp Atterbury Joint Maneuver Training Center, Muscatatuck Urban Training Center, and Hawthorne Army Depot in Nevada strengthen Crane's ability to rapidly assess new technologies immersed in an operational-type environment with electronic attack clearance and restricted air space.

In 2013, NSWC Crane realigned our technical capabilities, thus increasing our military value

assessment while integrating our adjacent technology products and narratives. NSWC Crane specializes in sensors, electronics, electronic warfare, and special warfare weapons. Our primary mission focus areas are Special Missions, Strategic Missions, and Electronic Warfare/Information Operations. In support of these Mission Focus Areas, Crane's scientists, engineers, and professional workforce provide stewardship and highmilitary value knowledge, contracts, hardware, and software across the following Technical Capabilities with support from the Business Capabilities.

Technical Capabilities

- CR04 Electronic Warfare Systems RDT&E/ Acquisition/Life Cycle Support
- CR10 Infrared Countermeasures and Pyrotechnic RDT&E and Life Cycle Support
- CR15 Strategic Systems Hardware
- CR16 Special Warfare and Expeditionary Systems Hardware
- CR18 Advanced Electronics & Energy Systems
- CR19 Sensors and Surveillance Systems

Current Marine Corps Programs Supported

PEO Land Systems

PM AC2SN

- CAC2S
- Marine Air Command and Control System (MACCS)
- Composite Tracking Network

PM Ground/Air Task Oriented Radar (G/ATOR)

- Radar Equipment Group
- Parts Task Trainer

PM-Light Tactical Vehicles (LTV - Legacy)

- Joint Light Tactical Vehicle (JLTV)
- Utility Tasked Vehicle (UTV)
- High Mobility Multi-Wheeled Vehicle (HMMWV)

PM Medium & heavy Tactical Vehicles (M&HTV)

- Medium Tactical Vehicle Replacement (MTVR)
- Mine-Resistant Ambush Protected (MRAP) All-Terrain Vehicle (MATV)
- COUGAR Egress

PM GBAD

- Advanced Man-Portable Air Defense
 System
- Counter-Unmanned Aerial Systems

Marine Corps Systems Command

PfM CES, PM-Intelligence Systems (IS)

- Ground Based Operational Surveillance System
- USMC Counter Radio-Controlled Improvised Explosive Device Electronic Warfare
- Topographic Production Capabilities
- Tactical Cyber Innovation Toolkit

PfM CES, PM-Command and Control Systems (C2)

• MAGTF Common Hand Held

PfM CES, PM-Communication Systems (Comm)

- Systems Planning Engineering and Evaluation Device
- Global Broadcast System

- Remote Video Viewing Terminal
- AN/TPS-59 Radar

PfM GCES, PM-Fires (IW)

• Anti Armor Systems (TOW, Javelin, SMAW, SABER)

PfM GCES, PM-Infantry Weapons

- PM-IWS Procurements, Engineering and Testing (M13 Mod7 Sniper Rifle, MK 125 Tripod, .50 Cal Poly Case Ammo, etc.)
- Optics and Non-Lethal Systems (AN/PVS-15, AN-PAS13G, INOD3)

PfM LCES, PM-Engineering Systems

- Automated Test Systems (EMSS, VADS)
- General Purpose Tools and Test Systems
- Combat Support Systems (SSK, ABV, FFME, NBOE)

PfM LCES, PM-Ammunition

• Ammunition (MK323, .50 Cal Poly Case, SOST MK318, M72 LAW FTE, etc)

S&T Working Groups

- Functions are aligned along technical capabilities that support the division's strategic S&T goals. Each technical discipline of interest is linked to a S&T WG that provides cross-cutting coordination of their respective elements of investment within their area of responsibility.
- This cross cutting coordination fosters unity of efforts and begins to morph an S&T culture that encourages collaboration. This type of infrastructure allows the S&T Division to provide a more comprehensive and integrated technology solution.
 - Advanced Electronics and Energy Systems

- Electronic Warfare Systems
- Infrared Countermeasures and Pyrotechnics
- Sensors and Surveillance Systems
- Special Warfare and Expeditionary Systems Hardware
- Strategic Systems hardware
- Disruptive/Transformative Innovation
- Enabling Technologies

FY19 Naval Innovative Science & Engineering (NISE) Projects

- Ceramic Galvanic/Anodic Protection
- USMC Air Combat Element (ACE) Ground Combat Element (GCE) Command and Control (C2) Integration
- Optical Communications for Contested Marine Environments
- Interactive Electromagnetic Warfare Training Guide
- Near Zero Volt Tolerance in Li-ion Cells: Low-cost NMC cathodes, full-scale prototypes, and high concentration electrolytes
- Deployable High Power Transmitter
- AI Aided Radar Detection
- Machine Aided Threat Assessment
- Radiation Effects Modeling and Simulation
- Cu-PEM Analysis
- Monolithic Integrated Photonic Antenna Array
- Naval Operations and Maritime Environment Knowledge Development

- RF Modeling and Simulation Systems Evaluation
- Joint C2 to the Tactical Edge
- MBSE for Advance EA
- Reliable, Efficient, & Dense Power Conversion for EMW Applications
- Controlled Radiation Affects Novel Epitaxy-In Unknown Manners
- NISE SoSITE
- Scalable UAS Systems/Personal Tactical Drone Adaptive
- Reactive Material Synthesis of Gun Barrel
- Machine Learning for Reliability Analysis
- Additive Manufactured Molding Operations for Expeditionary Fab Labs
- Rectenna Array & Multisource Power Control & Management System Integrated into an Electrically Powered UAS
- NextFlex DataCube
- Reverse Engineering and AM Computed Tomography (CT) Advancements
- Quantum Computing
- Surface Treatment Effects
- Upper Spectrum (EO/IR) Threat Exploitation and Advanced Countermeasures Development
- Pilot Curriculum for Electronic Warfare
- RADAR EW HWIL Setup
- Proactive Frequency Agility Analysis
- Passive Defense
- Precision TDOA Analysis
- Smart Phd Research: Wireless Communications and Signal Processing
- Achieving Crash Worthiness Using

Composite Materials in Engineering Design of Structural Components

- Silicon-On-Air Microelectronics
 Technology
- Service Maintenance Augmented Reality Tool
- Enhancing Cranes Recruitment & Retention Strategy
- Automated Cyber Evaluation
- Additive Manufacturing for Reduced Weight, Extended Life Thermal Battery
- Phantom Box Car/RTSO
- COP Analysis
- Establishment and Expansion Of A Warfighter Lab For Testing Weapon Mounted Visual Augmentation And Target Engagement Accessories
- ROOKwerx
- Visible Light Laser Voltage Probe
- ATLAS High-Speed Data Analytics
- Multi-User Visualization

NSWC Dahlgren Division

Mission

Provide research, development, test and evaluation, analysis, systems engineering, integration and certification of complex naval warfare systems related to surface warfare, strategic systems, combat and weapons systems associated with surface warfare. Provide system integration and certification for weapons, combat systems and warfare systems. Execute other responsibilities as assigned by the Commander, Naval Surface Warfare Center.

Description

Through the years, Dahlgren has established itself as the major testing area for naval guns and ammunition. Today, it continues to provide the military with testing and certification using the Potomac River Test Range in Dahlgren, Virginia, and provides Fleet support at the Dam Neck Activity, overlooking the Virginia Capes Fleet Operations Area, Virginia Beach, Virginia.

NSWCDD conducts basic research in all systems-related areas and pursues scientific disciplines including physics, mathematics, laser and computer technology, software, mechanical, electrical and systems engineering, and biotechnology and chemistry.

Technical Departments

- Strategic and Computing Systems (A)
- Electromagnetic & Sensor Systems (B)
- Gun & Electric Weapon Systems (E)
- Weapons Control & Integration (H)
- Training & Readiness Systems (R)
- Warfare Systems Engineering & Integration (V)
- Mission Engineering & Analysis Directorate (ME)

Facilities

NSWCDD occupies four geographic locations, the Naval Observatory in DC and Dahlgren, Wallops Island, and Dam Neck in Virginia. The NSWCDD Headquarters at Dahlgren is near Quantico and the Pentagon while the Dam Neck Activity is near Marine Corps Forces Command in Norfolk. NSWCDD includes several unique national facilities including the Littoral Operational Area Range and the Potomac River Test Range. NSWCDD operates state-of-the-art facilities supporting all assigned technical areas including: sensors, unmanned systems, fire control systems, integrated warfare systems, directed energy, railgun, chemical-biological defense, and electromagnetic environmental effects.

Current Marine Corps Support Areas

- Vehicle Capability Insertions design, integration, fielding and sustainment
- Expeditionary Command and Control design, integration, and testing
- Expeditionary Analysis, Modeling and Simulation
- Human Systems Integration (HSI)
- Electromagnetic Environment Effects (E3)
- Directed Energy Weapons
- Advanced Sensor Development
- Autonomous and Unmanned System Development
- Chemical & Biological Sensors and Defense Development
- Guns and Ammunition T&E
- Life Cycle Cost Estimates

Current Marine Corps Programs Supported

PEO Land Systems

PM AAA

- AAV Remote Weapon Station
- ACV Gun Weapon Station Analysis
- AAV & ACV HSI
- AAV E3 Engineering
- AC2SN
- CAC2S Software Integration and Management
- CAC2S Test & Evaluation

PM M&HTV

- Vehicle Capabilities Insertions
- Logistics Vehicle Systems Replacement (LVSR) Emergency Egress Lighting System E3 Engineering
- G/ATOR
- G/ATOR Software Support Activity
- G/ATOR Engineering and Acquisition
- E3 Engineering
- G/ATOR Special Training System

PM GBAD

- Compact Laser Weapon System (CLaWS)
- Directed Energy Engineering and Directed Energy Weapon Review and Approval Process (DEW RAP)
- E3 Engineering
- HSI
- MORFIUS
- Marine Air Defense Integrated System (MADIS) Trainer

- LTV
- JLTV E3 Engineering
- JLTV HSI
- Mounted Family of Computing Systems (MFoCS) E3 Engineering

Marine Corps Warfighting Lab

- Engineering Support
- E3 Engineering Support

Marine Corps Systems Command

PfM CES – PM C2S

- Combat Operations Center (COC) Engineering
- Joint Battlespace Viewer sustainment
- E3 Engineering
- Composite Tracking Network
- TSOA System Engineering

PfM CES – PM Intelligence Systems

- Communication Technology Engineering
- Ground Based Operational Surveillance System (G-BOSS) T&E support
- Electronic Warfare System (EWS)

PfM LCES, PM-Ammo

- 9mm Blank Cartridge
- 5.56mm Marking Cartridge
- 5.56mm Frangible Cartridge
- .50 Caliber Polymer Case Ammunition
- 40mm Training Ammunition
- Anti-Personnel Obstacle Breaching System (APOBS)
- Shoulder-Launched Multipurpose Assault Weapon (SMAW)
- Light Anti-Tank Weapon (LAW)
- Battlefield Effects Simulators (BES)
- Missiles & Rockets
- Miniature Mission Setter (MMS)
- Javelin Missile E3 Engineering Support

PfM GCES, PM-Infantry Weapons (IW)

- Raids and Recon Depot Support
- Anti-Armor
- M40A5 Rifle Improvement Project
- TOW Missile E3 Engineering Support

PfM GCES, **PM-Fires**

- Target Handoff System
- Ground Counter Fire Sensor
- Next Generation Targeting System
- Survey/Meteorological
- Remotely Operated Ground Unit for Expeditionary Fires (ROGUE-Fires)
- Navy/Marine Expeditionary Ship Interdiction System (NMESIS)
- Common Laser Range Finder –Integrated Capability
- Ground Weapon Radar Support
- High-Mobility Artillery Rocket System (HIMARS)
- Sea-Launched Army Tactical Missile System (ATACMS) from Shipboard HIMARS E3 Engineering Support
- Guided Multiple Launch Rocket System (GMLRS)
- Family of Artillery Munitions (FAM)
- Ship Interdiction and Neutralization Capability (SINC)

PM-Light Armored Vehicle (LAV)

- Light Attack Vehicle E3 Engineering Support
- Family of Artillery Munitions (FAM)

Team EOD

- Ultra-light Robot E3 Engineering
- EOD CORE Visual Inspection Kit E3 Engineering
- KUKRI and SABRE EOD Tools E3 Engineering
- PM Tanks
- Active Protection System E3 Engineering
- PM TRASYS
- E3 Engineering
- SEAL
- Systems Engineering
- CIED Modernization Master Plan (MMP)
- System Security Engineering and Anti-Tamper Support

Other Marine Corps S&T Efforts

- Autonomous Littoral Connectors
- Azimuth and Inertial Measurement
- GBAD Directed Energy On the Move Vehicle Integration
- 81mm Advanced Capability Extended Range Mortar (ACERM)
- 155mm Moving Target Artillery Round (MTAR)
- Autonomous Remote Engagement System (ARES) and Battle Management System (BMS) Integration onto the Common Unmanned Surface Vehicle (CUSV)



Figure 5-1. NSWCDD Capabilities and Programs Supporting the USMC

1. Standard and Custom Environmental Testing 2. Software Development 3. Concept Prototyping

4. JLTV ROGUE Fires 5. HSI 6. Platform Integration 7. GBAD Lasers 8. Mortars and Ammo

NSWC Indian Head Explosive Ordnance Disposal Technology Division

Mission

Research, develop, test, evaluate, manufacture and provide in-service support of energetics and energetic systems. Provide Soldiers, Marines, Sailors and Airmen with information and technology to detect, locate, access, identify, render safe, recover, exploit and dispose of explosive threats.

Description

The NSWC Indian Head Explosive Ordnance **Disposal Technology Division (NSWC** IHEODTD) located in Indian Head, Maryland brings together the largest full-spectrum energetics facility in the DoD with the largest concentration of explosive ordnance disposal technology resources and information in the world. The Division's unique synergy and balanced capabilities address all aspects of the energetics technical discipline, including basic research, applied technology, technology demonstration, prototyping, engineering development, acquisition, low-rate production, in-service engineering, weapons system integration, system safety, mishap & failure investigations, surveillance, EOD technology & information, and demilitarization.

Technical Capabilities

- Threat and Countermeasure Information Development and Dissemination for EOD, IED, and CREW
- Technology Development and Integration for EOD, IED, and CREW
- EOD unmanned systems
- Energetic and Ordnance Component and Ordnance Systems for:

- S&T
- Air Warfare
- Surface Warfare
- Undersea Warfare
- Expeditionary and Ground Warfare
- Emergent & National Requirements.

Major Facilities

- Aircrew Escape Ordnance Devices Development & Prototyping Complex
- Detonation Physics RDT&E and Acquisition
- Bombproofs, blast chambers, selfcontained gun ranges
- Continuous Twin-Screw Processing R&D and Scale-up
- 20-mm, 37-mm, 40-mm and 88-mm extruders
- Novel Materials R&D
- Nano-energetic materials characterization
- Complete suite of analytical capabilities
- Cast Composite Rocket Motor and PBX R&D & Scale-Up Complex
- Ordnance Test Facilities
- Chemical, Physical Property and Metallurgy Labs
- Quality Evaluation (QE)/Surveillance Facility
- Specialty Energetic Chemical Scale-up Facility
- High Pressure Explosives, Physics & Combustion Lab
- Bomb testing; Strand burning; Combustion instability testing

- MEMS Clean Room, Underwater Warheads RDT&E and Modeling & Simulation
- Foreign Ordnance Electronics Exploitation Laboratory
- Magnetic Signature Test Facility
- Ordnance Disassembly Complex
- Hypervelocity Test Facility
- Oxygen Cleaning Laboratory
- EOD Diver Complex

Current Marine Corps Programs Supported

PEO Land Systems

PM AAA

 PdM Amphibious Assault Vehicle (AAV) – Engineering and Sustainment

PM LTV

- PM LTV System Safety Support
- PM JLTV Engineering and Risk Management

PM M&HTV

- PM MTVR System Safety Support
- PM LVSR Logistics Support

PM GBAD

• System Safety Support

PM G/ATOR

• System Safety Support

PM AC2SN

• System Safety and Cyber Security Support

Marine Corps Systems Command

PfM LCES, PM Ammo

- PM AMMO Principal for Safety
- Multi Point Initiator (MPI)
- MK22 Mod 4 Rocket Motor Insensitive Munitions (IM)
 - Insensitive Munitions (IM)
 - MIL-STD 1901 Compliance Redesign
 - Service Life Extension Testing
- MICLIC Arresting Cable Release Mechanism (ACRM)
- ACRM- System Safety Support
- TOW and Javelin Engineering Services
- APOBS IPT Support
- LAW Warhead Production

PfM LCES, PM Engineer Systems

- Explosive Ordnance Disposal (EOD)
- MK154 Electrical Systems:
 - Design Review and Production

PfM GCES, PM Fires

- Cyber Security Support
- Team Tanks Systems Safety Support
- Team Anti-Armor Systems Engineering Services
- Team FSCT Systems Engineering, Technical Support and System Safety Support
- Team FDST System Safety Support
- Team Artillery System Safety Support

PfM-CES, PM C2 Systems

- Cyber Security Support
- COC Test and Evaluation/Software Support

• TSOA - S&T Project Management/ Software Engineering

PfM-CES, PM Intelligence

• Electronic Warfare Systems – System Safety

SEAL

- Experimentation and Demonstration Support
- Command Safety Safety Support
- Automotive Research Team (ART) Engineering Services

Joint Non-Lethal Program Office

- Technical Support
- BAA & Contract Support
- USAF Pre-Emplaced Vehicle Stopper (PEVS) Pilot Program
- NATO Non-Lethal Technology Exercise-2018 Counter-UAS (NNTEX-18C)
- African Lion 2019 Non-Lethal Weapons Integration
- NATO Maritime Interdiction Operations Training Center (NMIOTC) Non-Lethal Weapons Curriculum Integration
- Army Solid State-Active Denial Technology (SS-ADT) Focused Assessment
- NORTHCOM CDO Warfighter Workshop/ Table-Top Exercise
- Viper Radio Frequency Vessel Stopping Warfighter Workshop

Marine Corps Operational Test and Evaluation Activity

Operational Test & Analysis Division (OTAD)
 Math Statistician

Marine Corps Warfighting Lab

- Robotic Targets System Assessment
- Fight the Naval Force Forward (FNFF) Advanced Naval Technology Exercise's (ANTX's)

Office of Naval Research

- High Reliability DPICM Replacement (HRDR)
- Densified Propellant (DP) SMAW
- ACERM
- MTAR
- TechSolutions 60mm Mortar Improvements
- Mine Counter Measures (MCM) Program
- Autonomous Assault Amphibious Vehicle (A-AAV) Program

<u>Marine Corps Combat Development</u> <u>and Integration Fires and</u> <u>Maneuver Integration Division</u>

• Battalion Organic Fires Valuation Workshops

Marine Corps Installations and Logistics

Next Generation Logistics

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NSWC Philadelphia Division

Mission

NSWC Philadelphia Division's Mission is to provide research, development, test and evaluation, acquisition support, engineering, systems integration, in-service engineering and fleet support. NSWC Philadelphia Division is responsible for cyber-security, comprehensive logistics, and life-cycle savings through commonality for surface and undersea vehicle machinery, ship systems, equipment and material, and execute other responsibilities as assigned by Commander, NSWC.

Description

Naval Surface Warfare Center, Philadelphia Division (NSWCPD) provides the Navy's primary technical expertise and facilities for both naval machinery research and development and naval machinery lifecycle engineering. NSWCPD is responsible for the machinery systems core equity of the Ship and Ship Systems Product Area for the United States Navy and serves as a central point for academia and industry to join forces with Navy technical experts to develop solutions to needs in naval machinery. Consistent with its core equity responsibility, NSWCPD fulfills key functions including research, design, development, shipboard and land-based test and evaluation, acquisition support, in-service engineering, Fleet engineering, integrated logistics support and concepts and overall life cycle engineering.

Technical Capabilities

- PD04 Surface and Undersea Vehicle Machinery Systems Integration
- PD09 Surface and Undersea Vehicle Mechanical Power and Propulsion Systems
- PD10 Surface and Undersea Vehicle Electrical Power and Propulsion Systems
- PD11 Surface and Undersea Vehicle Auxiliary Machinery Systems

- PD12 Surface and Undersea Vehicle Hull and Deck Machinery Systems
- PD13 Surface and Undersea Vehicle Machinery Automation, Controls, Sensors and Network Systems
- PD19 Advanced Logistics Concepts and HM&E Life Cycle Logistics Support
- PD21 Ship Recoverability and Damage Control
- PD24 HM&E for Undersea Vehicle Sail Systems and Deployed Systems
- PD27 Shipboard Waste and Hazardous Materials Management Systems
- PD28 Surface Ship and Undersea Vehicle Machinery Systems Integrity
- PD29 Shipboard Habitability Systems
- PD30 SUBSAFE Supervising Authority and Level-I Material Certification

Technical Capabilities leveraged by Marine Corps

- PD11 Surface & Undersea Vehicle Auxiliary Machinery Systems
- PD12 Surface & Undersea Vehicle Hull, Deck, and Habitability Machinery Systems

Facilities

- Auxiliary & Life Support Systems Complex
- Propulsion & Electrical Machinery Systems Complex
- Environmental & Damage Control Systems & Materials Technology Complex
- Machinery Network, Sensors & Data Systems Complex
- Cargo, Weapons Handling & Hull Systems
 Complex
- Environmental & Damage Control Systems & Materials

- Machinery Network, Sensors & Data Systems Complex
- Undersea Vehicle Sail & Deployed Systems Complex

Current Marine Corps Support Areas

- USMC Boiler Inspections
- USMC Ship Alteration

Current Marine Corps Programs Supported

PM TRASYS

- Marksmanship Simulator
 - Install Ship alteration (SA) 85307K (Indoor Simulated Marksmanship Trainer Modifications) aboard USS Mesa Verde

Marine Corps Public Works Camp Lejeune

- Boiler Inspections
 - Inspect and certify 326 shore based boiler systems

Other Marine Corps S&T Efforts

- Armored Reconnaissance Vehicle Advanced Technology Development Future Naval Capability program
- OSD OECIF program
- High Density Hybrid Energy Storage Program
- ONR Multifunction Energy Storage FNC

NSWC Panama City Division

Mission

Conduct research, development, test, evaluation, and in-service support of mine warfare systems, mines, naval special warfare systems, diving and life-support systems, amphibious/expeditionary maneuver warfare systems, and other missions that occur primarily in coastal (littoral) regions. Execute other responsibilities as assigned by Commander, Naval Surface Warfare Center.

Description

NSWC Panama City Division (PCD) performs Research, Development, Test, and Evaluation to include Science and Technology development across the full spectrum of Littoral warfare systems and operations. The warfare center technical expertise in expeditionary warfare encompasses afloat and shore based Command, Control, Communications and Computers (C4); expeditionary systems to ship interfaces; assault breaching systems; land mine and obstacle countermeasures to include technologies to detect and neutralize a broad spectrum of explosive hazards in environments extending from the surf zone to the objective; targeting sensors; seabasing systems; and Shipto-objective maneuver systems.

Technical Capabilities

- PC20 Chemical and Biological Warfare Individual Protection Systems
- PC21 Expeditionary Coastal and Maritime Security System Engineering and Integration
- PC25 Air Cushion Vehicle Systems
- PC26 Expeditionary Maneuver Warfare Systems Engineering and Integration
- PC27 Special Warfare Maritime Mobility Mission Systems and Mission Support Equipment

- PC28 MCM Detect and Engage Systems, Modular Mission Packaging, and Platform Integration and Handling
- PC29 Littoral Mission Systems Integration and Modular Mission Packages Certification
- PC30 Unmanned Systems Engineering and Integration, Autonomous Operations, Joint Interoperability and Common Control
- PC31 Mine Sensor and Target Detection Technology, Mine Delivery Platform Integration, and Minefield Architecture
- PC33 Diving and Life Support Systems
- PC34 Surface Life Support Systems for Extreme Environments

Facilities

Located on 650 acres, NSWC PCD operates state-of-the-art facilities supporting all assigned mission areas such as: LCAC Repair and Maintenance Facility, Air Operations, Sea Fighter (FSF-1), and the Littoral Warfare Systems Facility. The Gulf Coast is an ideal location for Expeditionary Operations and Testing; NSWC PCD manages the water space for the Joint Gulf Test Range (JGTR), which includes Eglin ranges and spans the Gulf of Mexico, bays, estuaries, rivers and harbors. As part of the JGTR, NSWC PCD performs amphibious operations and have developed an Expeditionary Maneuver Test Range for vehicle testing. NSWC PCD also has state of the art acoustic and magnetic test facilities, including a non-magnetic test area to support sensor development efforts that doubles as a laser test range.

Technical Departments

- Littoral & Mine Warfare Systems (A)
- Expeditionary & Maritime Systems (E)
- Science and Technology (X)

Current Marine Corps Support Areas

- Combat Engineer Route Reconnaissance and Clearance (R2C) and Mobility/ Counter-Mobility design, integration, testing, fielding, and sustainment
- Implement OSD Digital Engineering strategy via Vehicle 3-D Modeling and Laser Scanning drawing development, configuration management and sustainment
- Vehicle Capability Insertions design, integration, fielding, and sustainment
- Expeditionary Command and Control design, integration, testing, fielding, and sustainment
- Expeditionary Analysis, Modeling, and Simulation
- S&T development of advanced technologies for explosive hazard detection and defeat, counter tactical surveillance and targeting, and autonomy to support operations across the spectrum of combat environments.

Current Marine Corps Programs Supported

PEO-Land Systems

PM AAA

• AAV Emergency Egress Lighting

PM M&HTV

- LVSR 3-D Modeling
- MTVR 3-D Modeling
- MRAP Cougar Model Based Enterprise (MBE) Configuration Management

Marine Corps Systems Command

PM-Command and Control Systems

- Lead Systems Integrator, Design Agent, In-Service Engineering Agent for
- 74 | 2019 PEO LS Advanced Technology Investment Plan

Expeditionary Command and Control System

• Joint Battlespace Viewer sustainment

PM-Engineer Systems

- NSWC PCD is the Technical Agent (TDA, ISEA, and AEA) for systems of the USMC Engineering Systems Route Reconnaissance and Clearance and Mobility/Counter-Mobility missions.
- Airfield Damage Repair Kit TDP



SEAL

• Expeditionary M&S and FACT Support

CD&I

• FMID - JLTV Transportability Analysis



Office of Naval Research

- Advanced 3-D (A3D) radar for the detection of threat systems
- Pre-shot sniper detection radar
- Low Average Power, High Voltage Energy (LP-HVE)
- Modular Mine Spoofing System (MMSS)

- VSW-SZ EHD Concepts for MEUs
- Advanced Volumetric Processing for Ground Penetrating Synthetic Aperture Radar
- Standoff Interferometric Target Detection and Excitation
- Automatic Target Detection for Interferometrics
- Advanced Land and Anti-Helicopter Mine EHD
- Autonomous Assault Amphibious Vehicle (A-AAV)
- Tactical Vehicle A3D Integration
- LOCUST Integration with Expeditionary Systems
- LOCUST Intermodal Container System
- Sandfly Magnetic Expeditionary Threat Localization (METL)
- ASV/AUV Imaging System (ALIS)
- Unmanned Swarming Amphibious Assault Craft (USAAC) Concept
- VSW-SZ Acoustic Detection
- UUV/UAV Surface Combatant Strike (Super Swarm)
- Super Swarm INP Lead

<u>The Joint Improvised-Threat</u> <u>Defeat Organization</u>

Counter Threat Object Recognition

Marine Corps Warfighting Lab

- Fight the Naval Forces Forward ANTX
- Set-based Design Evaluation Tool (SET)
- Rapid Capabilities Office
- Organic Precision Fires

FY19 NISE Projects

- Mission-ready Autonomous AAV
- Swarm MVP (Minimum Viable Product)
- Expeditionary Seabed Modules/Smart Mining
- Afloat UAS Detection System
- Multi-Warfare Simulation Environment (MWSE)

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NSWC Port Hueneme Division

Mission

Provide test and evaluation, systems engineering, integrated logistics support, inservice engineering and integration of surface ship weapons, combat systems and warfare systems. Provide the leading interface to the surface force for in-service maintenance and engineering support provided by the Warfare Centers. Execute other responsibilities as assigned by the Commander, Naval Surface Warfare Center.

Description

Naval Surface Warfare Center, Port Hueneme Division maintains technical expertise at locations across the United States: Engineering and Logistics at Port Hueneme, California; Search Radar Engineering at Virginia Beach, Virginia; and live fire testing at White Sands, New Mexico.

Port Hueneme Division is recognized as the Navy's Center of Excellence for In- Service Engineering, Test and Evaluation, and Integrated Logistics Support for surface warfare combat and weapon systems. Since its inception in 1963, Port Hueneme Division has been supporting the combat and weapon systems of the Fleet by providing highly skilled personnel and state-of-the-art facilities to lead the development and support of Navy surface ship warfare systems throughout their life cycles.

Port Hueneme Division focuses its technical capabilities on direct connectivity to the Fleet on a global basis and the immediate availability of around-the-clock access to products, services, and Fleet support capabilities. Capabilities will support predictive system failure, remote diagnostics, and corrective action via real-time, networked communications.

Port Hueneme Division capabilities include "Cradle to Grave" lifecycle engineering and sustainment planning to ensure that combat, weapon, radars, air and surface surveillance systems work effectively together to accomplish ship, Strike Group, and Theater Warfare assigned missions throughout their life. Naval Enterprise area assignments include: Surface, Aviation, Expeditionary Combat, NETWAR/FORCEnet, and Undersea for over 50 major acquisition programs. In addition, NSWC PHD provides overland live fire testing of Naval weapons in support of weapons systems acquisition (missiles and laser systems), assembly of weapons for overland and at sea live fire testing, launch of research rockets, and assembly/launch of low- and medium-fidelity theater ballistic targets.

Technical Capabilities

- PH01 Strike Force Interoperability and Theater Warfare Systems
- PH02 Surface and Expeditionary Combat Systems
- PH03 Surface and Expeditionary Weapon Systems
- PH04 Underway Replenishment Systems
- PH07 Surface and Expeditionary Missile Launcher Systems
- PH08 Radar Systems
- PH09 Directed Energy Systems
- PH10 Littoral Mission Module
- PH11 Ballistic Missile Defense T&E Specialized Target Vehicle Development, Integration and Deployment

Marine Corps Support Areas

- Test & Evaluation (T&E), Integrated Logistic Support (ILS), and In-Service Engineering (ISE)
- Enterprise Product Life Cycle Management

Integrated Decision Environment (ePLM IDE), Sustainment and Product Support modeling and analytics/end-to-end product data management

Current Marine Corps Programs Supported

PEO-Land Systems

PM AAA

• AAV Family of Systems (FoS) ePLM IDE product data configuration management implementation

PM AC2SN

• Composite Tracking Network T&E, M&S, ILS & ISE support

PM GBAD-G/ATOR

• G/ATOR T&E, Production Monitoring, Program Management, Contracting Officers Representation, Reliability Maintainability and Availability (RM&A) Engineering, ILS Support

Marine Corps Systems Command

PfM GCES, **PM-Fires**

- AN/TPS-59 and AN/TPS-63 Long Range Radars T&E, Systems Engineering, CM support
- AN/TPQ-49 Lightweight Counter Mortar Radar Sustainability Study, In-Service Review for USMC Primary Inventory Control Activity (PICA), Diminishing Manufacturing Sources and Material Shortages (DMSMS) analysis

SEAL

• In-Service Engineering (ISE), Guidebook Development & Training

NUWC Newport Division

Mission

Provide research, development, test and evaluation, analysis, acquisition support, inservice engineering, logistics and integration of surface and undersea vehicles and associated systems. Develop and apply science and technology associated with naval architecture and marine engineering, and provide support to the maritime industry. Execute other responsibilities as assigned by the Commander, Naval Surface Warfare Center.

Description

The Newport Division consists of approximately 3,200 scientists, engineers and support personnel working in more than 40 disciplines ranging from fundamental science to applied/ in-service engineering. NUWC Division Newport provides the technical foundation that enables the conceptualization, research, development, fielding, modernization, and maintenance of systems that ensure our Navy's undersea superiority. NUWC Division Newport is responsible, cradle to grave, for all aspects of systems under its charter, and is engaged in efforts ranging from participation in fundamental research to the support of evolving operational capabilities in the US Navy fleet. The major thrust of NUWC Division Newport's activities is in applied research and system development.

With headquarters in Rhode Island, NUWC Division Newport operates detachments at West Palm Beach, Florida, and Andros Island in the Bahamas. Remote test facilities are located at Seneca Lake and Fisher's Island in New York, and Dodge Pond, Connecticut.

Facilities

- Acoustic Wind Tunnel
- Anechoic Chamber
- Combat Systems Evaluation & Analysis Laboratory
- Launcher Laboratory
- Narragansett Bay Test Facility (NTBF)
- Over-water Arch Facility
- Propulsion Test Facility
- Quiet Water Tunnel
- Submarine Towed and Deployed Systems Research, Development, Test and Evaluation Complex
- Survivability Test Facility
- Undersea Warfare Analysis
- Virginia Payload Tube Facility

Technical Capabilities Leveraged by Marine Corps

- Undersea technologies and SMEs in Underwater Unmanned Vehicles (UUVs)
- Underwater capabilities that support the USMC Reconnaissance – specifically shallow water

Current Marine Corps Support Areas

- ANTX Technical Points of Contact (TPOC) for Mission Areas and Data Processing
 - 2017: S2ME2 Ship to Shore Maneuver Exploration and Experimentation
 - 2018: U5G Urban 5th Generation Marine Exploration and Experimentation Exercise
 - 2019: FNFF Fight the Naval Force Forward

Current Marine Corps Programs Supported

- CY 2017: Autonomous Hydrographic Coastal Survey (AHCS) with the Rapid Capabilities Office
- Rapid Capabilities Office was identifying and assessing technologies that could provide higher fidelity of coastal hydrography while decreasing risk to the warfighter in order to enhance the ability to conduct amphibious operations and inform future investments.
- Assessment areas:
 - Technical: Platform, Sensor, Data Transmission, Planning/Analysis
 - Operational: Size/Weight, Ease of Use, DOTMLPF Impacts

NIWC Atlantic

Mission

Rapidly delivering C4ISR, Cyber and IT systems and engineering services to meet the information warfare needs of the Marine Corps.

Description

NIWC Atlantic, Expeditionary Warfare Department (ExW) delivers information warfare capabilities to the Marine Corps. We provide full spectrum C4ISR systems and services to Marines. We engineer end-to-end C4ISR systems in tactical vehicles. We develop and sustain Enterprise IT system capabilities and solutions.

Technical Growth Areas

NIWC Atlantic, Expeditionary Warfare Department (ExW) is developing knowledge, skills, abilities, and resources in the following Technical Growth Area's through execution and training:

- Cyber Warfare
- Data Science/Analytics
- Assured Communications
- Cloud Computing
- Enterprise Resource Tools
- Collaboration/Social Networks
- Autonomy
- Embedded Systems/Internet of Things
- Mobility
- Model-Based Systems Engineering
- On-Demand Manufacturing

Facilities

A 30,000 square foot Expeditionary Integration Facility is reconfigurable to support multiple concurrent platform systems design and testing. This facility hosts a network of enabling software that enables USMC teams to execute MBSE across all team functions, from mission thread to risk analysis or program management.

A 100,000 square foot Vehicle Integration Facility provides the capability for production scale C4ISR integration. Configured to rapidly customize vehicular platforms with mission equipment.

NIWC Atlantic is partnering with other Warfare Centers to develop a one stop shop capability in Charleston, SC for automotive maintenance and improvement in conjunction with world class C4ISR integration capabilities.

A 40,000 square foot Swing Space Facility is a secure government Test & Evaluation (T&E) laboratory. This space offers the capability to connect to various secure government networks in coordination with other DoD C4ISR projects.

An outdoor Radio Frequency (RF) test and analysis facility with the equipment, personnel, and expertise to ensure RF capable systems are compatible with other subsystems and its host platform.

A Positioning, Navigation, and Timing (PNT) Lab provides, systems development and integration, Navigation Suite Certification, Navigation Suite Modeling and Simulation, and Technology Assessment and Forecasting. This PNT lab provides motion simulation for Sea, Land and Air Applications.

NIWC Atlantic is planning for developing a National Cyber Range node in Charleston, South Carolina.

Current Marine Corps Programs Supported

PEO-Land Systems

PM LTV

• JLTV

PM AAA

- AAV
- ACV

PM M&HTV

- MTVR
- MATV
- COUGAR Egress

PM GBAD

• Marine Air Defense Integrated System (MADIS)

Marine Corps Systems Command

PfM CES, PM-IS

- DCGS-MC (All-Source, GEOINT, SIGINT)
- Communications Emitter Sensing Attacking System (CESAS)
- Technical Control Analysis Center (TCAC)
- Terrestrial Collections
- Tactical SIGINT Collection System (TSCS)
- Identity Operations
- USMC Counter Radio-Controlled Improvised Explosive Device Electronic Warfare (CREW)

PfM CES, PM-C2

- Combat Operations Centers
- Joint Battle Command Platform

- Combat Data Network (CDN)
- Tactical Service Oriented Architecture (TSOA)
- Global Command Control System (GCCS)
- Joint Tactical COP Workstation
- MAGTF Common Hand Held (MCH)

PfM CES, PM-Comm

Tactical Communications Systems

PfM GCES, **PM-Fires**

- Mobile Transport System-Enhanced
- HIMARS Support Kit
- Resupply Vehicle (RSV)

PfM LCES, PM-Engineering Systems

• Route Reconnaissance & Clearance

PfM SES, PM-N&I

- Enterprise Systems, Networks & Infrastructure
- Network Communications Infrastructure
- Enterprise Wireless Systems
- Enterprise Mobility
- Software Defined Networking
- Emergency Response Systems
- Data Center Consolidation
- Data Analytics & Artificial Intelligence
- Marine Corps Enterprise IT Services
- Machine Learning & Automation
- Cyber Security & Information Assurance
- Application Development, Testing and Evaluation (SECDEVOPS)
- Enterprise IT Staging & Delivery

- Science & Technology Rapid Assessment, Prototyping, Integration and Delivery
- Continuous Integration

PfM SES, PM-Applications

- Enterprise Process & Initiatives
- Managed Services Organization (MSO)

Marine Corps Tactical Systems Support Activity

- MCEN PY
- Enterprise Testing & Evaluation
- Enterprise CYBER DT

<u>Marine Corps Warfighting</u> <u>Laboratory Home</u>

Rapid Capabilities Office

• Principal Technology Investigator

DC-I War Room

• Data Manager

Marine Corps Command, Control, Communications and Computers

• Data Center and Cloud Service Strategy

Marine Corps Programs and Resources Department, Installations and Logistics, Manpower and Reserve Affairs

- Business Mission Area (BMA) SECDEVOPS
- Cloud Application Migration
- Cloud Engineering Services Development
- MCIOC (SOCOM)
- Information Operations (IO)
- Military Information Support Operations (MISO)

FY19 NISE Projects

For Fy19, 89 of 126 NISE proposals were selected and 25 have direct benefit to PEO LS/ MCSC. Below are the USMC highlights:

• Vehicle Probability of Detection Utilizing Machine Learning Algorithms



Probability of Detection Application Concept

- TSOA and CAC2S System Integration
- Network Management Made Easy -Develop COC ACT Application into Configuration and Monitoring Application for use in Networking on the Move
- Data Scientists at Tactical Edge w/MEFs
- Enhanced Vehicle NAVWAR
- Enhanced Vehicle Navigational Capability
- LAV Situational Awareness through Augmented Reality
- Programmable Power Management System for Command and Control Mobile Platforms
- 3D Modeling & Simulation CAD LAB
- Babble Analytics
- Heads Up Sensor System



Enhanced Vehicle Navigational Capability

- Secure, Painless, Mobile Credential Provisioning
- RaptorX Special Signals Phase II
- Raptor X PySpeech Integration
- Generalized Recommender Tech Transition
- Digital Thread Additive Manufacturing
- Transfer Learning of Computer Vision Models
- Machine Learning Red Team
- Georgia Tech Electronic Warfare Certification
- Data Scientist at the Tactical Edge
- Naval Enterprise Universal Repository for Analytical Learning (NEURAL)
- Malicious and Fraudulent Hardware Detection
- Tactical Deployable MUOS
- Employ satellite surrogate Software Reconfigurable Payload (SRP) on aerial asset (RQ-21)
- Advanced ANSYS FEA Training



Employ satellite surrogate Software Reconfigurable Payload (SRP) on aerial asset (RQ-21)



Perform complex multi-body simulations across the physics Spectrum - Training

Section 6.0 DARPA EFFORTS

The dynamic nature and trajectory of new technologies have the potential to provide dramatic improvements to the systems within the PEO LS portfolio, as well as providing increased capability to the Warfighter. Therefore, PEO LS strives to enhance its body of technical knowledge by monitoring relevant efforts of cutting edge organizations such as Defense Advanced Research Project's Agency.

For sixty years, DARPA has held to a singular and enduring mission: to make pivotal investments in breakthrough technologies for national security.

The genesis of that mission and of DARPA itself dates to the launch of Sputnik in 1957, and a commitment by the United States that, from that time forward, it would be the initiator and not the victim of strategic technological surprises. Working with innovators inside and outside of government, DARPA has repeatedly delivered on that mission, transforming revolutionary concepts and even seeming impossibilities into practical capabilities. The ultimate results have included not only gamechanging military capabilities such as precision weapons and stealth technology, but also such icons of modern civilian society such as the Internet, automated voice recognition and language translation, and Global Positioning System receivers small enough to embed in myriad consumer devices.

DARPA explicitly reaches for transformational change instead of incremental advances. But it does not perform its engineering alchemy in isolation. It works within an innovation ecosystem that includes academic, corporate and governmental partners, with a constant focus on the nation's military services, which work with DARPA to create new strategic opportunities and novel tactical options. For decades, this vibrant, interlocking ecosystem of diverse collaborators has proven to be a nurturing environment for the intense creativity that DARPA is designed to cultivate.

These efforts expose the S&T director to advanced concepts and emerging technologies with the potential to address current and/or possible future capability gaps.

This section presents many of the technologies that the PEO LS S&T exploration process has identified as possessing potential to address current/future capability gaps. While these programs represent only a fraction of DARPA's overall portfolios, which encompasses a much broader spectrum of military technology development, the identified programs appear to have the greatest applicability to the PEO LS effort.

Communications in Contested Environments (C2E)

The Communications in Contested Environments program seeks to enable the development and deployment of adaptive communication systems through a three-part approach that is motivated by processes in the commercial world, which allow incorporation of third-party technologies that are from neither the hardware developer nor the core software provider. At the base of the C2E approach, a modular hardware architecture provides the flexibility to refresh capabilities and outpace application demands and adversary threats without requiring wholesale system overhauls. In addition, a new waveform-development model leverages re-usable waveform processing elements and formal methods to enable faster development across multiple hardware

platforms. Thirdly, the C2E network vision fully embraces the diversity and multiplicity of radio types across platforms in the airborne battle space, to provide highly reliable, networked and scalable information distribution to every element of the fighting force.

Secure Handhelds on Assured Resilient networks at the tactical Edge (SHARE)



The SHARE program aims to enable the exchange of information at multiple levels of security classification on a single handheld device. SHARE would use a resilient secure network that links handheld devices without needing to route traffic through secure data centers. This capability would operate over existing commercial and military networks while maintaining the security of sensitive information and safety of operations.

XDATA

The goal of the DARPA XDATA program is the development of computational techniques and software tools for processing and analyzing large, imperfect and incomplete data. For scalable analytics, this approach includes researching distributed databases, statistical sampling methods and new algorithmic advances to lower the computational complexity of pattern matching. For information visualization, the approach includes developing human-computer interaction tools that are web-based, factor computation between client and server, and build from an open code base to enable rapid customization to different missions. Warfighters' missions now rely on a virtual

net of sensors and communications systems for battlefield awareness more than at any time in history. At the same time, demands for timely and actionable information have spiked as Warfighters at every level—whether at the planning table or on patrol—are called upon to make well-informed decisions. XDATA seeks to develop software to efficiently fuse, analyze and disseminate the massive volumes of data this network produces.

MEMEX

Memex seeks to develop software that advances online search capabilities far beyond the current state of the art. The goal is to invent better methods for interacting with and sharing information, so users can quickly and thoroughly organize and search subsets of information relevant to their individual interests. The technologies developed in the program would provide the mechanisms for improved content discovery, information extraction, information retrieval, user collaboration and other key search functions.

Aerial Dragnet

DARPA's Aerial Dragnet program aims to achieve the technically difficult goal of detecting and tracking small UAS in urban terrain. The program seeks innovative technologies to provide persistent, wide-area surveillance of all UAS operating below 1,000 feet in a large city. While Aerial Dragnet's focus is on protecting military troops operating in urban settings overseas, the system could ultimately find civilian application to help protect US metropolitan areas from UASenabled terrorist threats.



Mobile Force Protection (MFP)



DARPA's Mobile Force Protection (MFP) program focuses on a challenge of increasing concern to the US military: countering the proliferation of small, unmanned aircraft systems (sUASs). These systems—which include fixed- or rotary-wing aircraft and have numerous advantages such as portability, low cost, commercial availability, and easy upgradeability—pose a fast-evolving array of dangers for US ground and maritime convoys. Countering these threats in real time requires a range of technology advances to enable rapid detection, identification, tracking, and neutralization of adversary sUASs—all while mitigating collateral damage.

Improv 2

The proliferation of low cost, highly sophisticated commercial technology and the global access to knowledge about how to construct and apply these systems has narrowed the divide and placed sophisticated systems and capabilities in the hands of hobbyists across the world. The DARPA Improv program investigated the threat posed by commercial-off-the-shelf (COTS) devices. The Improv 2 program will examine the potential to create small systems comprising COTS components, open source software, and easily fabricated components and examine their current and future potential to provide useful military capability.

Military Imaging and Surveillance Technology (MIST)

The MIST program seeks to develop a fundamentally new optical Intelligence,

Surveillance, and Reconnaissance capability able to provide high-resolution 3-D images to locate and identify a target at much longer ranges than is possible with existing optical systems. Several prototype optical surveillance and observation systems are planned for development, which aim to: (1) demonstrate probabilities of recognition and identification at distances sufficient to allow stand-off engagement; (2) overcome atmospheric turbulence, which now limits the ability of high-resolution optics; and (3) increase target identification confidence to reduce fratricide and/or collateral damage. The program aims to develop and integrate the necessary component technologies including high-energy pulsed lasers, receiver telescopes that have a field of view and depth of field that obviates the need for steering or focusing the optical system, computational imaging algorithms to improve system resolution, and data exploitation and analysis tools.

Advanced Wide FOV Architectures for Image Reconstruction and Exploitation (AWARE)

The DARPA Advanced Wide FOV AWARE program seeks to realize wide FOV, higher resolution, and multi-band imaging capability for increased target discrimination and search in daytime and nighttime conditions. The envisioned imaging systems would be sufficiently lightweight and compact to be fielded on a variety of ground and airborne platforms. The first AWARE systems are expected to be deployed on multiple platforms, providing superior resolution (for better target identification at greater distances), increased operational capability (for the ability to see panoramic scenes with multiple-target tracking), and better day/night visibility (to mitigate brownout conditions for helicopter landings). In addition, AWARE's modular component technologies could have a broad impact on DoD imaging applications, including targeting, persistent surveillance, sensing, and imaging with color fusion. The AWARE program aims to solve the current fundamental scaling limitations in imaging systems and demonstrate a design methodology for building compact systems capable of forming images with an unprecedented combination of high resolution and wide FOV.

Shared Spectrum Access for Radar and Communications (SSPARC)

The SSPARC program seeks to improve radar and communications capabilities through spectrum sharing. Spectrum congestion is a growing problem. It increasingly limits operational capabilities due to the increasing deployment and bandwidth of wireless communications, the use of net-centric and unmanned systems, and the need for increased flexibility in radar and communications spectrum to improve performance and to overcome sophisticated countermeasures. Radar and communications jointly consume most of the highly desirable spectrum below 6 GHz. SSPARC seeks to develop sharing technology that enables sufficient spectrum access within this desirable range for radar and communications systems to accomplish their evolving missions.

Adaptable Navigation System (ANS)

The DARPA ANS program addresses three basic challenges through its Precision Inertial Navigation Systems and All Source Positioning and Navigation efforts:

- Better inertial measurement units that require fewer external position fixes;
- Alternate sources to GPS for those external position fixes; and
- New algorithms and architectures for rapidly reconfiguring a navigation system with new and non-traditional sensors for a particular mission.

Spatial, Temporal, and Orientation Information in Contested Environments (STOIC)

The DARPA STOIC program seeks to develop a backup PNT system that provides GPS-level and better performance without relying on GPS. STOIC comprises three technical areas that when integrated would have the potential to provide global PNT independent of GPS:

- Earth-fixed navigation using very low frequency (VLF) signals;
- Deployable optical clocks based on technology developed under the DARPA QuASAR program; and
- Precision time transfer and ranging over data links.

For additional information concerning any of the DARPA programs highlighted in this document, please contact:

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