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HOUSE ARMED SERVICES COMMITTEE
EMERGING THREATS AND CAPABILITIES SUBCOMMITTEE

STATEMENT OF
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BEFORE THE
EMERGING THREATS AND CAPABILITIES SUBCOMMITTEE
OF THE
HOUSE ARMED SERVICES COMMITTEE
ON
THE FISCAL YEAR 2017 BUDGET REQUEST

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INTELLIGENCE, EMERGING THREATS AND CAPABILITIES SUBCOMMITTEE

Introduction

Thank you for the opportunity to talk to you today about the Department of the Navy (DoN) Science and Technology (S&T) Strategy and discuss how the President's FY 2017 Budget for S&T investments supports our Sailors and Marines. The FY 2017 Budget requests $2 billion for Naval S&T. At almost 1.4 percent of the entire DoN Budget, I view S&T as the venture capital of the Navy and Marine Corps. In building a future Fleet and Force to achieve U.S. national security objectives, we balance S&T resources between a range of initiatives to support near-term advances in established operational areas – and to sustain long-term research that will prove disruptive to traditional operational concepts.

Naval Science and Technology Strategy

The Secretary of the Navy has renewed the call for innovation, recognizing its vital role in sustaining our warfighters' decisive edge. While innovation of all types and at all levels is needed, the kind of innovation that wins wars is technology-based. As the Office of Naval Research (ONR) celebrates its 70th anniversary in 2016, the Navy continues to leverage its phenomenal track record in maintaining a decisive capability advantage and the Naval Science & Technology Strategy guides these efforts. The strategy drives ongoing research and provides the foundation for how we invest the DoN's S&T budget. Our strategy is simple*: to discover, develop and deliver decisive naval capabilities, near to long term, by investing in a balanced portfolio of breakthrough scientific research, innovative technology and talented people.*

The Naval S&T Strategy outlines our investment portfolio and identifies nine S&T research focus areas: 1) Assure Access to the Maritime Battlespace, 2) Autonomy and Unmanned Systems, 3) Electromagnetic Maneuver Warfare, 4) Expeditionary and Irregular Warfare, 5) Information Dominance – Cyber, 6) Platform Design and Survivability, 7) Power and Energy, 8) Power Projection and Integrated Defense, and 9) Warfighter Performance. The Naval S&T Strategy charts our course as we navigate between existing systems and concepts of operations toward a warfighting capability to counter predicted and emerging threats in an increasingly complex, uncertain future. Starting with evolution of current systems through incremental improvement and spiral development of known technology, we move toward yet-to-be-

discovered, disruptive, game-changing technologies. The Naval S&T Strategy aligns S&T investments with Naval missions and future capability needs by targeting knowledge gaps to develop new technologies that will address warfighting capability needs.

Executing the Strategy

Naval S&T investment portfolio falls into four broad components – Discovery and Invention (D&I), Leap Ahead Innovations (Innovative Naval Prototypes/INPs), Technology Maturation (Future Naval Capabilities/FNCs), and a Quick Reaction S&T (QRST) capability to respond to emerging requirements.

Discovery and Invention

New technologies emerge from basic research. ONR's Discovery and Invention (D&I) includes basic research (6.1) and early applied research (6.2). D&I develops fundamental knowledge, provides a basis for future Navy/Marine Corps systems, and sustains our Scientist/Engineer workforce. D&I enables future capabilities, with the majority of D&I investments conducted by academic and non-profit performers. The ONR Naval Research Laboratory conducts the majority of the DoN's basic research effort across all nine focus areas. D&I is peer reviewed by outside experts and overseen by ONR program officers and senior leadership. Investment decisions are guided by need, risk, impact, significance, originality, principal investigator, and budget resources.

ONR's University Research Initiative (URI) includes the Multidisciplinary University Research Initiative (MURI), the Defense University Research Implementation Program (DURIP), and the Presidential Early Career Award for Scientist and Engineers (PECASE). MURI supports teams of researchers investigating topics that involve multiple technical disciplines. DURIP provides grants for the purchase of instrumentation necessary to perform research essential to the Navy. PECASE recognizes achievements of young scientists/engineers and encourages them to explore professions in academia and Naval laboratories. The Basic Research Challenge funds promising research not addressed by ONR's core program, while the Applied Research Challenge rewards the technical community for specific, measurable progress in new applied research. The Young

Investigator Program supports scientists/engineers with exceptional promise for Naval research. Research opportunities for undergraduate and grad students, fellows, and future faculty members are provided by the Naval Research Enterprise Internship Program (NREIP), where participants work at Naval laboratories and warfare centers. The In-House Laboratory Independent Research (ILIR) and Independent Applied Research (IAR) programs sponsor critical research and further the education of scientists and engineers at warfare centers. ONR also brings Historically Black Colleges and Universities and Minority Institutions (HBCU/MI) together with Naval laboratories and warfare centers to give students hands-on experience in Naval research.

Leap Ahead Innovations (Innovative Naval Prototypes)

ONR's Leap Ahead Innovations portfolio defines the future of naval warfighting. Leap-ahead technology initiatives demonstrate decisive new naval capabilities. Innovative Naval Prototypes (INP) are high-risk/high-payoff disruptive departures from established capabilities and operational concepts that can dramatically change how Naval forces fight, while reducing acquisition risk. The goal is to prove concepts and mature technology in 4-7 years, allowing informed decisions about risk reduction and transition to acquisition programs.

Some INP examples include the Large Displacement UUV technologies deliver game-changing capabilities to naval warfighters. Scientific leadership in autonomy and unmanned systems enabled LDUUV, which complements existing undersea capabilities and platforms. The Autonomous Aerial Cargo/Utility System (AACUS) is developing autonomous capabilities for rapid, affordable rotorcraft supply in permissive, hostile and GPS-denied settings. Electromagnetic Railgun (EMRG) is a revolutionary advancement in naval gun technology, and developmental success has enabled steady progress toward a demonstration. If realized, the capability offered by a multi-mission railgun will provide long-range land-attack, air defense, and anti-surface warfare against ships and small boats.

Technology Maturation (Future Naval Capabilities)

Technology Maturation provides vetted solutions to naval technology requirements and capability needs. It delivers critical component technologies to naval acquisition programs and

many technology transition initiatives are focused on improving affordability. This is the critical component of our transition strategy. It consists of the Future Naval Capabilities (FNC) program, USMC Advanced Technology Development (6.3) funds, Low Observable/Counter Low Observable funds, and Manufacturing Technology (ManTech).

FNCs are near-term (2-4 year), requirements-driven, delivery-oriented projects that deliver mature technologies to acquisition sponsors for incorporation into new or upgraded systems. FNCs use a collaborative process involving requirements, research, acquisition, and Fleet/Force communities to align this part of the S&T portfolio with Naval Capability Gaps identified by the Office of the Chief of Naval Operations (OPNAV) and the Marine Corps Combat Development Command (MCCDC). A gap is any capability required to achieve Naval objectives that are not achievable with current platforms, weapon systems, doctrine, organizational structure, training, materials, leadership, personnel or facilities and requires S&T investment to address. FNCs are based on D&I investments where technology can mature from Technology Readiness Level (TRL) 3 to TRL 6 in 3-5 years. As FNC products transition to Advanced Component Development and Prototypes and Engineering and Manufacturing Development, responsibility for development shifts from ONR to acquisition commands.

Quick Reaction S&T (QRS&T)

QRS&T delivers innovative solutions from ideas submitted by Sailors and Marines via the TechSolutions website. It is responsive to urgent technology needs that solve problems for warfighters, and rapid turnaround delivers a working prototype in less than 2 years. TechSolutions uses quick prototyping to meet specific requirements, with each project structured around definable metrics, and appropriate acquisition/test systems by integrated product teams. While neither a substitute for the acquisition process, nor a replacement for systems commands, TechSolutions prototypes deliver solutions to address immediate needs that can be easily transitioned to the Fleet/Force.

Expeditionary Maneuver Warfare and Combating Terrorism

In this evolving and complex world, the Marine Corps will remain the Nation's Crisis Response Force capable of operating in a forward posture in a joint/coalition environment. The Marine Corps serves as a maritime-based expeditionary force that operates across the range of military operations in a five domain battlespace (sea, air, land, cyber, and space). Projecting power from a variety of naval platforms and land bases, this highly trained and educated force will operate the most modern and technologically advanced equipment.

ONR's science and technology contribution to the Marine Corps mission is executed through the DoN's Expeditionary Maneuver Warfare and Combating Terrorism S&T portfolio. While focused on science and technology to enable new capabilities for the Marine Corps, this S&T portfolio also supports naval special warfare and the Navy Expeditionary Combatant Command. The S&T portfolio provides new technology options to enable capabilities across the areas of Human Performance Training and Education (HPT&E), force protection, logistics, C4 (Command, Control, Communications, and Computers), fires, maneuver, and ISR.

To enable greater performance of our force we demonstrated and delivered to the Marine Corps the Augmented Immersive Team Trainer (AITT), an augmented reality training system that displays virtual indirect fire effects onto actual terrain. We anticipate continued development of augmented reality capabilities ultimately moving from a training perspective into a tactical use which opens the door for different types of scientific advancement and opportunities - e.g., Continuous and Dynamic Geo-Landmark Matching, visualization research, augmented reality metrics and measurement.

The investments we make in intelligence, surveillance and reconnaissance (ISR) have advanced natural language processing and computer vision. These advances enable automated production of increasingly complex ISR products with common semantic representation of different types of data and information. The technology enables intelligence template products to refresh automatically and autonomously, potentially saving many hours of intelligence staff time. This gives Marines more time for deeper analysis and enhanced decision making and increases battlespace tempo that had been limited by the slow intelligence cycle. ISR efforts will continue

the development of deep learning methods to process information. This work has the potential of making big data operationally useful with the construction of signatures that will capture how entities interact with the world and describe relevant behavior and/or activity of those entities.

We have an active program that advances the state of Marine Corps munitions technology. The Enhanced Expeditionary Engagement Capability (E3C) project is an example of a collection of technology advancements that will yield an affordable, precision, guided, extended range, dual-mode GPS and Semi-active Laser (SAL), 81mm mortar munition (Advanced Capability Extended Range Mortar, ACERM). This advanced mortar was designed from the ground up to push the art of the possible with the goal of increased range and increased accuracy. Moving forward we will continue the pursuit of science and technology advances in wide field-of-view visible and infrared frequency band cameras, video analytics implemented on embedded processing, a semi-autonomous system interface, self-correcting fire control, and wireless communications. Advances in these areas will enable the development of weapon system autonomy for application to unmanned ground systems.

Integrated into the Naval and Joint Force with a reinvigoration of maneuver warfare, the Marine Corps will require continued technical approaches to enable high speed mobility from the sea to objective ashore. ONR's S&T continues research in hydrodynamics, propulsion, light-weight materials and human factors to enable maneuver from multiple options for entry. High water speed, reduced signature, enhanced range, and capacity all contribute to flexibility and advancing surface maneuver options, protecting landing forces, reducing risk to shipping and improving combat power build up ashore.

Through our logistics efforts we continue to research areas that reduce maintenance and improve the operations of our ground vehicles. To reduce maintenance associated with corrosion, we supported the advancement of new isocyanate-free polysiloxane-based coatings. Significant progress has been made enhancing the performance of highly hydrophobic, low-gloss, color retaining, flexible, weather resistant, isocyanate-free topcoats that resist chemical agent simulants. The last line of defense in the war on corrosion is the system's topcoat.

ONR continues to identify key S&T opportunities in academia and industry that address unique aspects of information operations, electronic warfare and cyber operations. . Marines working at the "tactical edge" face challenges that require different S&T approaches to provide the small unit, distributed, expeditionary warfighter the information they need when and wherever they need it. Our current and future S&T efforts focus on tactical self-healing networking and the ability to manage a secure mobile network with little supporting infrastructure. We support S&T to develop and apply metrics that provide the most resilient and stable network structure, as well as methods of multilayer device security. We also support technology to provide radio architectures that can quickly change between waveforms, and simultaneously transmit and receive more than one waveform.

We are pursuing science and technology that enhance our warfighting capabilities in unmanned aerial systems (UAS) and robotics, artificial intelligence and autonomous technologies that will ultimately provide tactical and operational advantage. Low-Cost UAV Swarming Technology (LOCUST) is an ONR project using the Coyote, a small expendable UAS deployed from an A-size sonobuoy tube or Common Launch Tube (CLT) that performs Intelligence, Surveillance and Reconnaissance (ISR) missions. In order to better understand and define autonomy, ONR is conducting basic research in robotic interaction/human factors; machine reasoning, learning and intelligence; scene/image understanding; bio-robotics; cognitive science, and neuroscience. These fundamentals are the keys to teaching collaboration and teaming among autonomous systems and between human and unmanned systems.

With the accelerated pace of technology development our expeditionary maneuver warfare S&T has to support training events that allow the force to test, fail, and learn. The partnership of S&T with experimentation is a crucial aspect of moving the S&T forward. In these efforts, we work directly with the Futures Directorate and the Marine Corps Warfighting Laboratory (MCWL) at Quantico, whose mission is to use war-games, experimentation, and technology assessment to validate a concept's viability – as well as identify opportunities for future force development.

Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR)

Cyber, space, and spectrum are becoming increasingly contested domains with the proliferation of anti-access, area-denial (A2/AD) capabilities among potential adversaries. We have a requirement to project power despite A2/AD challenges and to maintain maritime superiority in a highly informationalized environment. To achieve that, we are investing in S&T to provide resilient cyber operations, robust communications and networking, rapid accurate decision making, and assured electromagnetic spectrum access for battle space awareness, threat assessment, and agile spectrum maneuver.

In partnership with the Naval Research and Development Establishment (NR&DE) and other Services, ONR developed Naval Tactical Cloud (NTC) to provide the underlying information infrastructure and big data analytics that operate on tactical radio frequency networks to improve warfighting effectiveness while operating inside adversary kill chains. We will transition technologies developed by NTC to the relevant Navy programs, including the Consolidated Afloat Networks and Enterprise Services (CANES), the Agile Core Services (ACS), and the Distributed Common Ground System-Navy (DCGS-N). ONR developed the Dynamic Tactical Communications Network (DTCN) – a GOTS router – that provides enhanced security and priority-aligned routing capabilities for Command and Control (C2) thinline and plans to demonstrate the capabilities of DTCN at Trident Warrior 2016 exercise.

Understanding cyber vulnerabilities in our networks, platforms, computing and information systems, and data is essential to develop technologies that will enable total platform cyber protection for mission assurance. To this end, ONR is investing in S&T foundations and tools for resilient cyber components and systems, including hull, infrastructure, mechanical and electrical systems cyber security; trusted network, data, and computing platforms; and computer network defense. ONR developed Byzantine Fault Tolerance++ (BFT++) to provide cyber-attack fault tolerance of real-time control systems by employing a combination of artificial diversity across the controllers and a known good state recovery mechanism.

The Naval Enterprise is also developing a framework for Electromagnetic Maneuver Warfare (EMW) that will make spectrum an integral part of a strategy to deter, fight and win against near peer adversaries. This framework will bring together multiple functional elements in the domain of electromagnetics: awareness, agility, reasoning and control. This will enable the warfighter to understand, utilize, shape, maneuver, attack and defend the electromagnetic spectrum. ONR is developing S&T building blocks to support the EMW vision, which requires a holistic, coordinated approach for sensing, communications, electronic warfare, information warfare, as well as integration of kinetic and non-kinetic payloads. We developed a multi-platform adaptive sensing technology that networks multiple RF sensors to enhance search sensitivity, electronic protection, and spectral efficiency. ONR will transition the technology to relevant Navy programs of record, including F/A-18 and DDG Flight III.

Ocean Battlespace Sensing

Naval forces must be able to adapt to ocean, air, littoral and riverine environments. Changes in geopolitics, focus on strategic locations, and new detection technologies create an emerging need for more accurate, long range forecasts for DoD and Naval operations. Our basic and applied experimentation to characterize ocean, atmosphere, and arctic processes are building the foundation for the next generation of environmental prediction deployed by Commander, Navy Meteorology and Oceanography Command (CNMOC). ONR's environmental studies are conducted worldwide with international partners to gain specific knowledge of processes in various regions. Currently joint efforts are being conducted with Vietnam, India, Sri Lanka, and Singapore. Ongoing work in the Canadian Basin of the Arctic is studying ocean acoustic propagation and the effects of open water during summer months. S&T will improve understanding of surface wind impact on upper ocean dynamics and energy fluxes across ocean boundary layers and enhance our ability to forecast operational conditions. The payoff is safe and efficient Naval operations in maritime environments through improved immediate, seasonal, and long range forecasts. ONR's research is field-oriented, using oceanographic ships, aircraft, and autonomous air and undersea vehicles – including Navy-owned Research Vessels that ONR schedules and supports in partnership with the National Science Foundation (NSF) as part of the community consortium University National Oceanographic Laboratory System (UNOLS).

Contributing to our ability to understand and prevail in ocean environments, Navy operates several classes of Unmanned Underwater Vehicles (UUVs). ONR has invested in developing UUVs and autonomy for these systems for several decades, with successful transitions to the acquisition community and Fleet in the areas of Naval Special Warfare, Mine Countermeasures, Explosive Ordnance Disposal, Intelligence, Surveillance and Reconnaissance (ISR), Anti-Submarine Warfare (ASW), and Oceanography. These systems generally fall into three classes: Man-portable, Lightweight, and Large Displacement with corresponding displacement and endurance. The ONR Innovative Naval Prototype Large Displacement UUV (LDUUV INP)ill design and build five LDUUVs: two preliminary designs, two pier-to-pier vehicles, and one submarine compatible vehicle.

The program is developing energy, autonomy and core systems to operate in a complex ocean environment near harbors, shorelines, and other high traffic locations. Goals include doubling air-independent UUV energy density, using open architecture to lower cost, and enabling pier to pier autonomy in over-the-horizon operations. Achieving these goals will reduce platform vulnerability and extend the Navy's reach into denied areas. ONR is developing a long endurance, fuel cell-based power plant to be incorporated into LDUUV prototypes. A long endurance mission demonstration is scheduled in FY 2016.

As Naval S&T has succeeded in developing new capabilities, it has also created successful businesses which arose from academic institutions such as Hydroid, Inc. from Woods Hole Oceanographic Institution and BlueFin Robotics from MIT. Small Business Innovation Research (SBIR) efforts helped nurture these businesses which were bought by larger corporations - - Hydroid was acquired by Kongsberg Marine and BlueFin Robotics was acquired by Battelle. As a result, there is a mature, competitive private sector industrial base for design, development, and maintenance of UUVs and associated sensors and payloads. The exception to this is ONR's technical risk reduction in endurance and autonomy, where there is no analogous commercial need. Our Discovery and Invention, INP and other mission autonomy Future Naval Capability programs in MCM and ASW are providing the research into these critical topics.

Sea Warfare and Weapons

ONR's major focus in Sea Warfare and Weapons is to improve surface and undersea platform, and undersea weapon performance. S&T investments provide options for advanced power and electrical systems and components, and survivable, agile, mobile, sustainable, manned and unmanned, surface and sub-surface sea platforms, and undersea weapons.

Our Electric Ship Research and Development Consortium enlists academic institutions to collaborate with industry and the Naval Warfare Centers to develop electric power architectures and technologies to support high power sensors and weapons, including directed energy weapons. As part of a Department of Defense sponsored joint service initiative, ONR successfully demonstrated a Hybrid Energy Storage Module (HESM) that will lead to systems that enable electric weapons and sensor systems on legacy and next generation naval vessels. Leveraging other government work to maximize the government's return on investment, ONR coordinated this project with the Department of Energy's Advanced Research Projects Agency (ARPA-E) Advanced Management and Protection of Energy-storage Devices program.

ONR's autonomous sea surface vehicle and undersea vehicle S&T includes development of autonomous unmanned sea surface vehicles (USVs) and long-endurance, air-independent power systems for unmanned undersea vehicles (UUVs). We conducted successful tests of USVs demonstrating autonomous navigation capabilities, and multiple autonomous USVs operating jointly toward a common purpose. ONR recently conducted a successful test of a hydrogen powered fuel cell, adapted from an automotive application, in a UUV.

A key enabler of these capabilities is investment in naval materials. Investments focus on performance and affordability of materials for lightweight structures, corrosion and biofouling mitigation, maintenance cost-reduction, undersea acoustic sensors, and energy/power-dense electrical energy conversion and storage. These efforts explore and apply fundamental materials physics to discover and develop materials meeting warfighting platform demands – such as

investment in Integrated Computational Materials Engineering (ICME), a key element of the Lightweight and Modern Metals Manufacturing Initiative.

Warfighter Performance

People are the critical element in complex systems. They provide the ingenuity, collaboration, and determination necessary for operational effectiveness and resilience. Warfighter Performance S&T addresses a broad range of research questions and technology transitions that support Sailors and Marines afloat and ashore. These research areas include manpower, personnel, training and design approaches to enhance performance while reducing costs.

Advances in behavioral sciences, medical technologies, and modeling and simulation techniques are enabling new approaches to mission-critical questions such as: How do we train effectively, efficiently reducing the time and cost of pre-deployment training? How do we design intuitive systems that are easy to use, reducing the requirement for on-the-job training? How do we support decision making in distributed teams of people and autonomous agents? How do we mitigate the risks of putting our warfighters in harm's way, keeping them healthy and ready to fight?

Manpower and personnel simulations can help us design crew complements for new ships across a broad range of missions. Artificially intelligent tutoring systems can help new recruits learn basic skills, while adaptive simulation-based training systems tailor training to the needs of individual Sailors and Marines. Immersive and augmented reality displays provide experiential learning opportunities using simulation to train as we fight. Automated performance assessment techniques enable instructors to evaluate readiness at the individual and team level and to focus their efforts efficiently and effectively on the knowledge and skills gaps of the individual warfighters where it's needed. In FY15/16 the Mission Planning Application (MPA) tool developed through the Office of Naval Research Capable Manpower Future Naval Capability program transitioned to the submarine fleet with installation on 10 SSBN's and two shore trainers as part of combat system upgrades.

Intuitive, decision-centric, and user-friendly interfaces and decision support displays can reduce training requirements and associated costs while enabling more effective operational capability. Human-centered design enhances tactical, operational, and strategic decision making and planning. A deeper understanding of human intelligence, communication, and collaboration will enable better team performance and, ultimately, support peer-to-peer collaboration between human and artificially intelligent machines. Models of human social and cultural behavior will help defeat our adversaries and set the stage for more effective humanitarian assistance and disaster relief.

Synthetic biology and medical technologies are needed to mitigate warfighter risk at sea, in the air, and in austere isolated environments. In FY15, ONR demonstrated reduced noise propagation on a CVN during flight operations and noise reduction in diver helmets, a major source of noise-induced hearing loss in Navy divers. ONR synthetic biology MURIs demonstrated programmable, micro-bio-robots for environmental sensing and computer-aided design capabilities for genetic programming. The Food & Drug Administration selected ONR to provide expertise in the use of closed-loop medical monitoring and therapeutic interventions that will facilitate the use of automated care during sea-based casualty evacuation.

Naval Air Warfare and Weapons

The goal of Naval Air Warfare and Weapons research is to broadly advance the fundamental understanding of the science and technology related to air vehicles and weapons systems for future naval systems and to demonstrate technology for air platforms, missiles, and directed energy weapons in relevant environments. We invest in science and technology for improving and maintaining current aircraft, such as the FA-18 E/F/G, as well as longer term research that will enable greatly enhanced, next-generation air dominance (NGAD) systems. Many of the longer-term, basic research projects are funded at a large number of universities around the country and support fundamental advancements in science as well as supporting workforce development in Aerospace Engineering and related fields. This is critical to ensuring that engineers, particularly those with advanced degrees, are available for the defense industry and DoD laboratories to design and build next generation aircraft and weapons. We also develop,

demonstrate, and transition technologies to increase the speed, range, accuracy, and lethality of Naval weapon systems to enable rapid, precise, assured defeat of land, sea and air targets.

Naval Air Warfare and Weapons research supports the critical National Naval Responsibility (NNR) for Sea Based Aviation. ONR identifies these NNRs as S&T disciplines that are both critical for the Navy and in which other organizations will not provide sufficient investment. While other services and the commercial market invest in aircraft technology, only ONR deals with the unique S&T challenges of Sea Based Aviation. Examples of topics that are funded in the sea-based aviation NNR are materials and structures that can withstand the ultra-demanding marine environment, aircraft technology for ship launch and recovery of fixed and rotary wing aircraft, and propulsion systems that are ultra-compact and responsive to meet demands of wave off and bolter if landings are aborted, while concurrently being ultra-fuel efficient to allow for maximum range. Along with these NNR areas, there is significant investment in energetic materials, single and multiple autonomous vehicle operations, as well as directed energy and counter directed energy systems.

Last year the Solid State Laser Quick Reaction Capability (SSL-QRC) was fielded as a science and technology demonstration aboard the USS PONCE. It was successfully demonstrated as an effective weapon system and was subsequently transitioned to the fleet in the Central Command area of responsibility and is now an operational system. ONR is building on this demonstrated capability with a program to improve component and system performance for directed energy weapons called Solid State Laser - Technology Maturation (SSL-TM). The prime contractor will develop a laser weapon with a beam director system to defend against small boats, unmanned aerial vehicles, and other targets. The Naval Surface Warfare Center, Dahlgren Division will serve as the lead system integrator. The SSL-TM Program is developing a higher powered laser with enhanced capabilities that is planned to be installed and tested at sea in FY18. Technology development efforts will address improvements to laser beam quality, beam director architecture, as well as ship and combat system integration to support extended shipboard demonstrations in the maritime environment.

ONR is developing technology for electromagnetic (EM) railguns, hypervelocity guided projectiles, and the power and cooling systems to integrate these on surface combatants. The railgun is a high-power, kinetic energy weapon capable of launching precision guided hypervelocity projectiles using electricity instead of chemical propellants. Magnetic fields created by high electrical currents accelerate a sliding metal conductor, or armature, between two rails to launch projectiles to velocities greater than Mach 6 at muzzle exit. With its increased velocity and extended range, the EM Railgun will give Sailors a new capability, allowing them to conduct precise naval surface fire support or land strikes; ship defense; and surface warfare to deter enemy vessels. EM Railgun is a true warfighter game changer. Wide-area coverage, exceptionally quick response and very deep magazines will extend the reach and lethality of ships armed with this technology. The Navy partnered with the Office of the Secretary of Defense Strategic Capabilities Office (SCO) to develop closed-loop fire control command guidance for the projectile that will expand the range of future missions for the railgun and HVP.

The Tactically Exploited Reconnaissance Node (TERN) program is a joint ONR-DARPA project to demonstrate technologies enabling unmanned air vehicles to sustain operations at long range from small deck combatants such as the LCS and DDG-51. TERN is intended to improve aviation capabilities from smaller ships substantially beyond the current state-of-the-art. If successful, TERN will provide the flexibility to provide air operations support off existing ships without extensive ship modifications, and would provide the flexibility to carry interchangeable mission packages for both overland and maritime missions. It would be able to operate from multiple ship types and in elevated sea states.

The Autonomous Aerial Cargo/Utility System (AACUS) Program is intended to demonstrate a platform independent autonomous system for landing aircraft without the need for a trained pilot for its operation. Given the approximate location of the desired landing, the system will identify the location for landing by itself and will avoid potential obstacles, such as trees and power lines.

Science, Technology, Engineering and Mathematics (STEM)

A world-class, diverse science, technology, engineering and mathematics (STEM) workforce enables the Department of the Navy to maintain technological superiority across our missions

and to protect our Sailors and Marines at home and abroad. In order to cultivate a talented and well-trained workforce for the Navy and Marine Corps, the Navy has a rich history of providing educational opportunities for students of all ages. These opportunities begin with naval-relevant outreach programs at the pre-kindergarten through high school grade levels, continue through internships and other programs at undergraduate and graduate schools, support student advancement into post-doctoral work and continue through all stages of professional development.

We aim to inspire, engage and educate the next generation of scientists and engineers, and to attract, employ, develop and retain our diverse technical workforce through collaboration across the Navy, the federal government and the broad STEM community. There is no more valuable investment we can make in Naval S&T than in the minds of our workforce, investments that result in greater productivity and innovation throughout Navy laboratories, warfare centers, and in the academic and private sector.

Naval Research Laboratory (NRL)

The Naval Research Laboratory (NRL) is the Navy and Marine Corps Corporate Laboratory and reports directly to CNR/ONR. Sponsored by ONR, the NRL base research program develops S&T to meet needs identified in the Naval S&T Strategic Plan. Research at NRL is the foundation that can focus on a broad spectrum of scientific areas to advance scientific understanding for DoN, and develops technology from concept to operation when high-priority, short-term needs arise. NRL is the lead Navy lab for space systems, firefighting, tactical electronic warfare, advanced electronics and artificial intelligence. As the Navy's in-house laboratory, NRL sustains skills and innovation in a world-class workforce. Among our great challenges is the need to modernize aging NRL infrastructure so it can continue to meet the emerging needs of our future Naval forces. This is especially important as the pace of S&T advancement accelerates rapidly across the rest of the world, and near peer competitors begin to arise, challenging our Naval superiority.

ONR Global

ONR Global employs a cadre of technical experts who facilitate international research collaboration, maintain global technology awareness, and provide S&T advice and support to operational fleet/forces. ONR recognizes that R&D spending and technical innovation outside the United States are accelerating and works to improve technology outreach through global partners who assist in our pursuit of innovation and technological superiority. Investment in cooperative research can provide better products for our warfighters at reduced cost. ONR offices in London, Prague, Santiago, Sao Paulo, Singapore, and Tokyo coordinate activities with the other services and Assistant Secretary of Defense (Research and Engineering) in the host country and spanning over 55 countries. We search for emerging S&T to meet current needs, as well as requirements for future capabilities. ONR Global establishes contacts with international S&T leaders, giving us new perspectives and helping identify trends and threats. It enables us to recruit foreign scientists and engineers in partnerships that benefit the U.S. and allies. ONR Global Science Advisors relay Fleet/Force needs to the Naval Research Enterprise (Navy labs, warfare centers, affiliated universities) to facilitate development of solutions to transition back to the Fleet/Force. Science Advisors are Naval engineers who coordinate experimentation, develop prototypes, explore transition options, and collaborate with the Fleet/Force to shape S&T investments. ONR Global Science Advisers support demonstrations of ONR technologies UAVs for tactical ISR from various platforms and prototype laser weapon systems. We continue to see increasing demand for ONR Global activities to keep pace with global technology developments and Navy requirements for innovation.

Small Business Innovation Research

We must increase the return on investment in Small Business Innovation Research (SBIR). ONR's SBIR program has had success helping small businesses make progress in technology development, but we must do a better job of helping small businesses transition from S&T and development to production. Small businesses remain one of Navy's most productive sources of innovation. Active oversight and management of SBIR goals, utilizing marketing, metrics, and improved communications, will ensure that Navy is more aware of small business capabilities – and that small businesses are more aware of Navy requirements. We need to utilize small businesses to the maximum extent possible, and are already doing so in areas as diverse as

development and construction of combat ships and landing vessels, design and manufacture of airframe structural components, marine charter transportation, and non-nuclear ship repair. Small businesses have repeatedly proven their ability to provide lean, agile and innovative solutions to warfighter needs.

70th Anniversary

ONR has been delivering technology innovations to naval forces for 70 years. Established by Public Law 79-588 in August 1946, ONR was our nation's first federal research agency. Although WWII had ended, Congress, the Navy and academia realized the importance of science and technology to meeting the challenges of modern warfare. The technological edge provided by innovations such as radar and the proximity fuze proved key to our warfighters to defeat our adversaries. The Navy had a strong research enterprise in the Naval Research Laboratory and Naval Warfare Centers, but saw the value in expanding the enterprise to academia and industry. Public and private universities, faculty and graduates students could propose naval relevant research. This ongoing Navy investment in civilian research would maintain and build the academic science base and provide a pipeline of science and technology for the future.

By discovering and working with top minds—both here at home and around the world—fostering scientific research to support naval power remains as vital today as it was 70 years ago.

Conclusion

ONR's vision is to "never put a Sailor or Marine in fair fight!" Naval S&T investments represent careful stewardship of taxpayer dollars that lead turns our DoD's toughest challenges that delivers decisive capabilities. The FY 2017 President's Budget request will enable us to move toward enhanced naval capabilities, more effective partnership between research and acquisition, and strengthen partnerships with the Army, Air Force, DARPA and other DoD research organizations – as well as performers outside the Naval R&D system. Thank you for your support of naval science and technology as we discover, develop and deliver decisive naval capabilities for our warfighters.