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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 2013 BUDGET REQUEST

FEBRUARY 29, 2012

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Introduction

It is an honor to appear before you to report on Science and Technology (S&T) efforts within the Department of the Navy (DoN) and discuss how the President's FY 2013 Budget supports the Navy and Marine Corps (USMC). The President's FY 2013 Budget requests approximately $2 billion for Naval S&T.

From the beginning of this nation, the Navy and Marine Corps have leveraged innovation and technology to defend U.S. interests. To ensure continued superiority of U.S. Naval forces after World War II, congress established the Office of Naval Research (ONR) to "plan, foster and encourage scientific research in recognition of its paramount importance to future Naval power and national security." Our Naval S&T objective is to support a Navy and Marine Corps capable of prevailing in any environment. We work directly with the Secretary of the Navy (SECNAV), Chief of Naval Operations (CNO) and Commandant of the Marine Corps (CMC) to achieve this goal by: 1) focusing on S&T areas with big payoffs, 2) encouraging innovative thinking and business processes, and 3) constantly striving to improve transition of S&T into acquisition programs in the most cost-effective means possible. In the spirit of striving for affordability, we must strike the right balance between responsive near-term technology insertion and long-term basic research.

SECNAV priorities include: 1) care of Sailors, Marines, Civilians and families, 2) treating Navy energy requirements as issues of national security, 3) achieving acquisition excellence, and 4) optimizing unmanned systems. We support those priorities by implementing CNO and CMC guidance in the application of S&T resources. In addition, we constantly strive to improve communication and constructive engagement with stakeholders.

Science and Technology Strategic Plan

The Naval Science and Technology Strategic Plan was developed to guide S&T investments and is regularly reviewed by Navy and USMC leadership to affirm the alignment of Naval S&T with current missions and future requirements. It ensures S&T has long-term focus, meets near-term objectives, and makes what we are doing clear to decision makers, S&T partners, customers and performers.

Our focus areas guide investments in corresponding research areas. The recently revised S&T Plan identifies nine focus areas where S&T investments support Navy and USMC requirements: 1) Assure Access to Maritime Battlespace, 2) Autonomy and Unmanned Systems, 3) Expeditionary and Irregular Warfare, 4) Information Dominance, 5) Platform Design and Survivability, 6) Power and Energy, 7) Power Projection and Integrated Defense, 8) Total Ownership Cost, and 9) Warfighter Performance. These nine areas represent an evolving consolidation developed from Naval needs, sized for reasonable scale and magnitude, and linked directly to warfighting functions.

In each area, our goal is to move from existing systems and concepts of operations toward a warfighting capability to counter predicted threats in an increasingly complex and uncertain environment. It is the challenge we face as the proliferation of anti-access, area-denial (A2/AD)

capacity and capabilities among potential adversaries drives the need for technologies that assure access for Naval forces. While the starting point is continued evolution of current systems, we progress toward incremental improvements and spiral development of known technologies – to new development of undiscovered, disruptive technologies. If we are good, and perhaps lucky, this is where today's S&T encounters the unanticipated future.

Implementing the Strategy

We execute Basic Research (6.1) thru Advanced Technology Development (6.3) funds by dividing S&T into four primary areas – Discovery and Invention (D&I), Leap Ahead Innovations (Innovative Naval Prototypes), Acquisition Enablers (Future Naval Capabilities), and a Quick Reaction capability to respond to emerging emergency requirements. As we review and revise plans, the changes reflect our continuing efforts to communicate more effectively, as well as to clarify, streamline and respond more efficiently to Fleet/Force requirements. Our portfolio balances a range of complimentary but competing imperatives, in that we support advances and initiatives in established operational areas – while maintaining a far-reaching complement of long-term research efforts that may prove disruptive to traditional operational concepts.

Discovery and Invention

Discovery and Invention (D&I) includes basic research (6.1) and early applied research (6.2) in areas with unique requirements essential to Naval missions, but also in areas that are undefined but hold promise for future application. D&I develops fundamental knowledge, provides the basis for future Navy/Marine Corps systems, and keeps our Scientist and Engineer workforce relevant. Research areas include autonomous sciences, computational neuroscience, bio-inspired sciences, information technology, cognitive/neural training technologies, advanced quantum computing, materials sciences (acoustic metamaterials, integrated computational material sciences, nano-manufacturing), and counter Improvised Explosive Device (IED) sciences. Work in these areas led to 61 Nobel Prizes for ONR researchers.

Approximately 45 percent of ONR S&T investment is D&I. We assess impact on Navy/Marine Corps missions, as well as potential for innovative performance, in order to invest resources in the best research areas and projects. This develops a broad base of scientific knowledge from which INP, FNC, and quick reaction efforts are generated. Approximately 60 percent of basic research is executed with academic and non-profit performers, with all programs peer reviewed during the second to third year from inception to ensure high quality and integrity. Peer review is conducted by outside scientific and technical experts who provide an independent assessment of the scientific merit of the research being conducted, with results reviewed by ONR program officers, division directors, department heads and senior leadership. Significance and originality, scientific merit and accomplishment, risk and potential impact, the principal investigator, and budget resources are all evaluated, with adjustments made in programs as appropriate.

An important element of D&I is the Defense University Research Instrumentation Program (DURIP), which supports university research essential to Naval research. DURIP complements our D&I programs by supporting purchases of high cost instrumentation necessary to carry out cutting-edge research. ONR awarded 68 DURIP grants in FY 2007, 92 in FY 2008, 82 in FY

2009, 61 in FY 2010, 64 in FY 2011, and plans to award approximately 94 grants in FY 2012. Another D&I program, ONR's Basic Research Challenge, stimulates interdisciplinary research in emerging S&T fields by funding promising research in areas not addressed by the current basic program.

D&I investments develop and invigorate the S&T workforce and support Science, Technology, Engineering and Mathematics (STEM) outreach. Through Independent Laboratory In-house Research (ILIR) and Independent Applied Research (IAR) programs, ONR sponsors critical research, while furthering education of scientists and engineers at Warfare Centers. Education and research opportunities for undergraduate and graduate students, fellows, and future faculty members and researchers are provided through programs such as the Naval Research Enterprise Internship Program (NREIP), which expose participants to work at Naval laboratories and warfare centers.

Through the University Research Initiative (URI) and Young Investigators Program (YIP), ONR gains access to researchers with a willingness to investigate high priority topics of interest to the Naval services. Through our Multidisciplinary University Research Initiative (MURI), ONR supports multi-disciplinary university teams to speed scientific progress by cross-fertilization of ideas, hasten transition of basic research to practical applications, and train students in cross-disciplinary approaches to science and engineering research of importance to DoD. We also support the Presidential Early Career Award for Scientists and Engineers (PECASE), honoring achievements of young professionals at the outset of independent research careers in S&T. Through demonstration, apprentice, award, and graduate programs, we encourage young people to explore S&T careers in academia, Naval laboratories, and industry.

Nowhere is our support for educational initiative and academic excellence more evident than in ONR's partnership with Historically Black Colleges and Universities and Minority Institutions (HBCU/MI). ONR educational and research partnerships bring together Naval laboratories and warfare centers with dozens of HBCU/MIs, giving hundreds of students an opportunity to have hands-on experience in the Naval research environment. The progression from undergraduate to graduate partnerships, and mentoring by Naval scientists and engineers, resulted, for example, in 33 Tuskegee University graduates being currently employed by Naval Sea Systems Command (NAVSEA) laboratories. Similar examples abound in other Navy labs and warfare centers, with every graduate employed by the Navy representing a success story that we want to duplicate as many times as possible.

ONR is a great place to work, and in the HBCU/MI context, we were recognized as a "2011 Best Diversity Company" by readers of *Diversity/Careers in Engineering & Information Technology* magazine. ONR was selected from over 100 U.S. corporations and government agencies as a leader in workplace diversity, and recognized for its support of minorities and women, attention to work-life balance, and commitment to supplier diversity. In 2011 ONR was also selected as a Top Supporter of HBCU Engineering Schools by *U.S. Black Engineer & Information Technology* magazine. We will not rest on our laurels with respect to earning these honors.

Science, Technology, Engineering and Mathematics (STEM)

Our Navy and Marine Corps ability to support the warfighter depends on our ability to sustain both technology development and a Science, Technology, Engineering and Mathematics (STEM) workforce. We believe the key to achieving this goal lies in supporting STEM education in a continuum of experiences from kindergarten through post-doctoral opportunities. The Department of the Navy is concerned that the number of U.S. STEM graduates will not keep up with our future demand or the increased international competition for that same talent.

China awards nearly three times as many engineering and computer science degrees as the U.S., and surpasses us in the number of STEM-related Ph.D. graduates. Currently, only fifteen percent of bachelor's degrees earned by U.S. students are in STEM fields. Also, if one looks at the breakdown of students receiving STEM degrees, the number of underrepresented minorities and women does not reflect the demographics of our nation. Further, at the K-12 level, our students rank 20th place as compared to STEM students in other industrialized countries. Given that we expect an increased demand for U.S. personnel in STEM fields in the future, these trends threaten not only America's economic security, they directly impact our ability to deliver the most advanced technologies to our warfighters. These negative trends must be addressed now.

The purpose of the Navy's STEM program is to help reverse these negative trends and ensure a strong, STEM-literate Naval workforce in the future. These professionals are a key to innovation and are critical to maintaining the Navy's S&T strength. Because of our previous initiatives and leadership, in 2009 ONR was tasked with coordinating Naval STEM educational and outreach activities. This led to the 2009 launch of STEM2Stern.org, an on-line collaboration resource for information about Naval STEM programs and how to get involved. Managed by ONR, the Naval STEM Coordination Office provides a cohesive approach to STEM education and outreach across the service laboratories and Warfare Centers. This effort helps leverage funding, duplicate successful efforts, broaden the reach and scope of our most impactful STEM programs, and evaluate their impact and return on investment.

Through our strongly coordinated and leveraged STEM program, the Navy is making critical contributions aimed at strengthening America's competitive edge, and ensuring a sufficient talent pool exists to support future Naval technical needs. In an effort to leverage expertise from across the STEM field, ONR hosted a Naval STEM Forum last June that assembled over 750 leaders from the Navy, industry, academia and nonprofits to share best practices and discuss ways to partner with the DoN on STEM initiatives.

Ultimately, the goal of Naval STEM is to increase the talent pool of future Sailors, Marines, Naval scientists and engineers. Our current S&T workforce is aging. Nearly 65% of DoN science and engineering professionals are over the age of 40, and over 50% will be retirement eligible by 2020. Even more alarming, according to a recent study done for NAVSEA, 40 percent of their Naval architects and 30 percent of their Naval engineers will be retirement eligible by 2014. That is just two years from now. Because the Navy's S&E workforce is comprised mostly of engineers, this is where a potential shortfall could lie for the Navy – particularly in Navy-relevant fields such as naval engineering, computer science and ocean engineering. Unfortunately, the U.S. production of engineers has remained flat over the last two

decades at just over 6%, and in these specialty fields it is far less. Further complicating our workforce challenges is the fact that for security reasons, the DoN must rely on U.S. citizens for classified technology work.

ONR/NRL investments total nearly 70% of overall Naval investments in STEM. SECNAV committed to doubling Naval STEM investments by FY 2015. In FY 2010, the Navy's STEM portfolio included education and outreach efforts across 31 commands, reaching over 69,000 participants across the country, leveraging a direct investment of $42 million, and an additional $32 million from OSD and the National Defense Education Program (NDEP). Our investments seek to increase the diversity and numbers of students pursuing STEM degrees though programs, which encourage collaboration among the government and best practice organizations, universities and industry. Our areas of emphasis include: 1) freshman and sophomore STEM retention in college, 2) hands-on STEM learning programs in urban and rural middle schools, 3) teacher training in Naval-relevant fields of study, and 4) mission-critical graduate student and post-doctoral support. Our newest programs incorporate both Naval relevant content and metrics for measuring impact, and will be coordinated with other Federal STEM education programs. Further, these programs were selected based on their potential for rapid growth and geographic expansion, as well as their ability to serve underrepresented student populations.

Naval STEM education and outreach programs include an array of Hands-On programs, Competitions, Internships, Research Fellowships, and Teacher Training. Many students – particularly those from underserved populations (including minorities, females, and students from urban and rural settings) make decisions by the end of middle school to opt out of STEM education. It is therefore critical to engage students no later than middle school by offering them a variety of hands-on learning opportunities and mentoring experiences, building their STEM confidence and encouraging them to pursue the math and science classes needed to make them STEM eligible in college.

In grades K-6, we support programs such as: Iridescent, SeaPerch, and FIRST Robotics. At the high school level, our programs include the National Math & Science Initiative, Science and Engineering Apprentice Programs, Youth Exploring Science (YES), the National Ocean Sciences Bowl, and Naval Science Awards Programs. Our college efforts offer the Naval Research Enterprise Internship Program, Autonomous Underwater Vehicle (AUV) Competition, the Naval Postgraduate School Hartnell Internship Program, and the University Laboratory Initiative (ULI) Program. Post-doctoral opportunities include the Young Investigator Program and University Research Initiative (URI) efforts. Across this spectrum of STEM education, teacher training and education tools are also being developed to strengthen in-classroom and out-of classroom STEM programming. Providing these necessary tools and training to teachers and educators strengthens their expertise, while enabling them to link Naval themes and content to curriculum goals.

Naval STEM ensures continued access to a variety of Navy-unique STEM professionals and locations. In 2010, Naval Sea System Command Warfare Centers supported more than 16,500 students and 800 teachers through in-school and summer camp STEM events. Space and Naval Warfare Systems Command scientists and engineers volunteered more than 10,000 hours in K-12 student communities. Naval Air Systems Command reached 16,000 students and 700

teachers through engineering challenges, speaker bureaus, summer camps, student employment and teacher training.

It is important to point out that this investment can only be justified if we are improving our future workforce. For many of these investments, we may not be able to see that return for many years to come. However, individually and collectively, we are assessing each to best determine how each one contributes to achieving the Navy's goals and how it impacts each stage of the pipeline. Therefore, as we move forward in 2012, we will ensure that a comprehensive evaluation and metrics plan is put in place for all of our STEM programs, one which measures not only the numbers of students and teachers we are reaching but one that also assessing our ability to fulfill our future Naval requirements.

One of our proudest achievements last year was the 49th National Junior Science and Humanities Symposium held in San Diego, California, jointly sponsored by the Air Force, Army, and Navy. Research topics included: acoustics and noise abatement, environmental science (including biodiversity and marine fouling), alternative energy production (including biofuels, solar cells, solar fuel production and aerodynamics of wind turbines), medical and health care (including cancer research and hearing loss), nanotechnology, robotics, rocket motor efficiency, satellite system design, thermodynamic analysis of engine design, design of underwater vehicles, and use of autonomous Unmanned Aerial Vehicles in search and rescue operations. These topics mirror many research topics in which ONR is currently investing.

Scientific papers were presented by, among others, Jonathan Ang, Arjun Balasingam, Mark Becker, Paul Bergin, Connor Berlin, Shyamal Buch, Alexander Chen, Junyoung Choi, Victor Duan, Clara Fannjiang, Margo Fendrich, Katlyn Firkus, Anisha Garg, Andrew Giviansky, Sarah Hardtke, Victoria Huang, Erik Kemp, Swathi Krishnan, Arti Kumar, Vignessh Kumar, Won Lee, Jonathan Li, Wenxi (Sheryl) Li, Yifan Li, Daniel Liss, Anna Maika Manalad, Austen Mance, Sage Mandel, Lisa Michaels, Sophie Miller, Apexa Modi, Hilary Mogul, Paimon Pakzad, Kira Powell, Andrew Raffa, Emma Rose, Himanshu Savardekar, Prem Thottumkara, Haoxuan Wang, Max Wasserman, Zachary Wood, and Jeremy Wortzel.

Every one of these students attended high school in your congressional districts last year. You may not recognize their names today, but our successors in government, in the S&T community and in the Navy will know them because great S&T research achievements lie ahead for them in the future. There is a good a chance that they will lend a competitive edge to this nation, and some may perform research and make new discoveries we simply cannot imagine that save the lives of their fellow graduates who left high school or college to serve in the Navy and Marine Corps. That's what our STEM effort is all about – exploring innovative and exciting ways to attract high quality talent into our labs and warfare centers and raising the general STEM level of achievement throughout our nation.

Leap Ahead Innovations (Innovative Naval Prototypes)

Innovative Naval Prototypes (INP) involve approximately 12 percent of the S&T budget and focus on high-risk/high-payoff opportunities emerging from the D&I portfolio that can significantly impact Naval capabilities if we can mature the technology. INPs are discontinuous,

disruptive, radical departures from established requirements and operational concepts. Approved and overseen by the Naval S&T Corporate Board (Assistant Secretary of the Navy for Research, Development and Acquisition (RD&A), Assistant Commandant of the Marine Corps and Vice Chief of Naval Operations), the goal is to prove concepts and mature technology within 4-8 years, allowing informed decisions about risk reduction and transition into acquisition programs. In order to facilitate transition to acquisition programs, Program Managers are primarily selected from ONR, with Deputy Program Managers typically chosen from the Acquisition community.

With the Persistent Littoral Undersea Surveillance (PLUS) INP (to develop an autonomous over-the-horizon Anti-Submarine Warfare system) and Sea Base Enablers INP (to evaluate Transformation Craft concepts) completed last year and elements of both transitioning to the Fleet/Force, we have five current INPs:

The Electromagnetic Rail Gun (EMRG) INP continues to develop and test a scalable, more powerful gun, using non-explosive rounds with no gun propellant. The EMRG has more than doubled current state of the art muzzle energy. The program continues to achieve its technical objectives and ONR has initiated Phase Two of the program. EMRG will provide multi-mission capability for long range, persistent, precision fire without unexploded ordnance issues, while increasing magazine capacity, and decreasing total cost. If current research goes as anticipated, projectiles will initially fire at targets up to 100 nautical miles away, and eventually fire at a muzzle velocity of Mach 7.5 and reach targets 200+ nautical miles away in less than six minutes, impacting at a velocity exceeding Mach 5. The Navy is planning to deliver a multi-mission capability to include Naval surface fire support, Anti-Surface Warfare and self defense applications with nearer term capability against cruise missiles and other targets of interest. Ship integration studies for various platforms have been performed including the DDG51. Contractors have built and tested pre-prototype tactical launchers, and the first full scale contractor built prototype was delivered to the Naval Surface Warfare Center at Dahlgren, Virginia in January of this year. I join my predecessors in inviting you to schedule a visit to our facility at Dahlgren and am grateful to your staff members who have already made the visit. Our discussions with your staff during the FY 2012 authorization process led to refinements in the program and planning about which the SECNAV and I will be reporting to you as directed by the FY 2012 National Defense Authorization Act.

The Free Electron Laser (FEL) INP will develop the critical technologies needed for a Megawatt class laser system. The FEL can be designed to be tunable to atmosphere-penetrating wavelengths for use in maritime environments. Focusing on the critical components will allow us to assess the potential of fielding a Megawatt class laser on a surface ship, which will permit additional shipboard sensors and defense that includes tracking, discrimination, countermeasures, and scalable direct fire at the speed of light. Because of its potential to reach Megawatt power levels, the FEL is designed to defend against current and future surface and air threats, anti-ship cruise missiles, small boat swarms, and other asymmetric threats. As concepts of operations, missions and host platforms are refined, so are ONR priorities about laser research investments. Our discussions within the Navy and with your staff during the FY 2012 authorization process led to refinements in the program which we intend to implement this year, including maturation of Solid State Laser Technology. We are determined to put the right laser on the right platform.

The Integrated Topside INP will enable Navy to dominate the electromagnetic spectrum through development of multi-simultaneous function wide-band apertures and Radio Frequency (RF) equipment for all ship classes. We are developing advanced Electronic Warfare, Information Operations, Radar, Satellite and Line of Sight Communication systems using: 1) open architecture for RF equipment, plus computer hardware and software that will enable industry to contribute to development of affordable new systems and upgrades, and 2) modular systems that enable the same technology to be scalable across all Naval platforms to significantly reduce logistics, training, and maintenance costs. FY 2013 will see prototype tests and demonstrations at government and contractor test facilities in Maryland, New Jersey, New York, Rhode Island, Texas, and at the Naval Research Laboratory (NRL).

The Large Displacement Unmanned Undersea Vehicle (LDUUV) INP is developing a reliable, long endurance UUV capable of extended operation in cluttered littoral environments. The program will develop the needed energy, autonomy and core UUV systems to operate in a complex ocean environment near harbors, shore, and high surface traffic locations. Key goals include doubling current UUV energy density, and using open architecture to lower costs, while enabling full autonomy in over the horizon operations. Achieving these goals will reduce Naval platform vulnerability, while enhancing warfighter capability and closing capacity gaps in critical mission areas. During FY 2013 sea trials, we will develop autonomous behaviors and integrate battery and fuel cell power systems. Reliability will be demonstrated by a series of longer endurance tests with goals in excess of three weeks.

The Autonomous Aerial Cargo/Utility System (AACUS) INP is developing intelligent, autonomous capabilities for an aerial cargo/utility system that can provide rapid, affordable, and reliable rotorcraft supply and retrograde. Challenges include dynamic mission management and contingency planning, as well as landing zone location and landing execution under demanding conditions. Potential solutions involve modular capabilities developed in an open system architecture, novel human interfaces (to include optional manning), low impact (size, weight, power, and cost) sensors, and multiple flight demonstration and upgrade cycles.

In addition to INPs, SwampWorks programs, although similarly high-risk and disruptive, are smaller than INPs and intended to produce results in 1 to 3 years. SwampWorks efforts have substantial flexibility in planning and execution, with a streamlined approval process shortening the innovation cycle. Although a formal transition agreement is not required, SwampWorks programs have strong advocacy outside ONR, either from the acquisition community or Fleet. SwampWorks products are frequently inserted into Fleet experimentation and, if successful, can provide impetus for new acquisition requirements.

Acquisition Enablers (Future Naval Capabilities)

Acquisition Enablers (AE) are the most critical component of our transition strategy. Most of the AE portfolio consists of our Future Naval Capabilities (FNC) program, with the remainder including USMC Advanced Technology Development (6.3) funds, Joint Non-Lethal Weapons Directorate 6.3 funds, the Manufacturing Technology (ManTech) program, and the majority of Low Observable, Counter Low Observable funds.

FNCs are near-term projects and represent the requirements-driven, delivery-oriented portion of the Naval S&T portfolio. The FNC process delivers mature technologies to acquisition sponsors for incorporation into systems that provide new capabilities to the warfighter.

FNC investments employ a collaborative process involving requirements, research, acquisition, and Fleet/Force communities to align the requirements-driven portion of the S&T portfolio with Naval Capability Gaps identified by the Office of the Chief of Naval Operations (OPNAV) and Marine Corps Combat Development Command (MCCDC). A gap is any capability required to achieve Naval objectives that is not achievable with current platforms, weapon systems, doctrine, organizational structure, training, materials, leadership, personnel or facilities and requires S&T investment to solve or overcome. Capability Gaps define the requirement but not how to meet it.

FNC projects are selected annually to address specific gaps, with final prioritization approved by a 3-Star Technology Oversight Group (TOG) representing OPNAV, United States Marine Corps (USMC), U.S. Fleet Forces Command (USFF), Assistant Secretary of the Navy (ASN-RDA) and ONR. FNCs are based on D&I investments where technology can be matured from Technology Readiness Level (TRL) 3 to TRL 6 within five years. Selection takes into account related work in the Defense Department (DoD), other government agencies, industry and Naval centers of excellence.

Approved technology products are required to have Technology Transition Agreements that document the commitment of the resource sponsor, acquisition program, and ONR to develop, deliver and integrate products into new or upgraded systems to be delivered to the Fleet/Force. Every FNC product is annually measured against technical and financial milestones. All FNC products must meet required transition commitment levels for S&T development to continue. This practice helps make every dollar count. Products that no longer have viable transition paths are terminated with residual funding used to solve problems with existing projects, or start new projects in compliance with Navy priorities, charters, business rules and development guidelines.

The measure of FNC success is whether projects meet technology requirements and exit criteria, and whether acquisition sponsors have transition funds in their programs to accept and integrate FNC products. Products with planned transition funds usually transition after risks are mitigated, a definitive plan finalized, and required funding programmed.

FNC Funding

As has been stated by my predecessors, our investments focus on the most pressing capability gaps, generating year-to-year changes in funding for FNC products based on successful transitions, reprioritization, new starts, and evolving Naval needs and requirements. As FNC products mature, Technology Readiness Levels (TRL) change, moving products from 6.2 to 6.3 PEs. Year one is predominantly 6.2; the final year predominantly 6.3 – with a mix of 6.2/6.3 in-between. When products transition to Advanced Component Development and Prototypes (6.4) and Engineering and Manufacturing Development (6.5) funding, responsibility for continued development shifts from ONR to the acquisition commands. We believe changes in this year's PE structure make realignment of FNC funding more understandable and transparent, and provide a more cost-effective and responsive framework for renewing FNCs. We will work with

you and your staff to ensure that this realignment does not result in any loss of visibility for the FNC program.

Quick Reaction S&T

In addition to Discovery and Invention, Leap Ahead Innovations, and Acquisition Enablers, ONR maintains a capability to initiate quick-reaction projects over a period of 12 to 24 months that respond to immediate needs or compelling innovations identified by Fleet/Force or Naval leadership. TechSolutions provides rapid short-term S&T solutions to immediate operational and tactical requirements. Accessible through Internet and SIPRnet, TechSolutions accepts recommendations from Sailors and Marines working at the tactical level on ways to improve mission effectiveness through the application of technology. TechSolutions uses rapid prototyping of technologies to meet specific requirements. Each project is structured with definable metrics and appropriate acquisition and test systems command elements in an integrated product team concept. While neither a substitute for the acquisition process nor a replacement for systems commands, TechSolutions provides the Fleet/Force with prototypes that deliver solutions to address immediate needs that can be easily transitioned by the acquisition community.

The basic problem we are trying to solve is that the pace of technology development is often faster than the DoD Planning, Programming, Budgeting and Execution (PPBE) process can respond. Our Rapid Technology Transition (RTT) and Technology Insertion for Program Savings (TIPS) programs are structured to provide current-year funding (inside the PPBE process), eliminating the up to 2 year time lag inherent in the PPBE cycle. The general scope of each program is funding up to $2 million for development efforts taking no more than two years to complete, strong Fleet/Force support, and resource sponsor commitment to fund costs to transition the technology into the acquisition Program of Record (POR) or operating system. The RTT program focuses on providing incremental, timely improvements to an acquisition POR. The TIPS program focuses on providing timely improvement which substantially reduces operating and support costs for warfighting systems. Congress has been very supportive of this concept.

In addition, and in partnership with ONR, the Naval Warfare Development Command (NWDC), Naval Postgraduate School, Naval War College and Marine Corps Warfighting Lab (MCWL) explore future warfighting concepts and evaluate emerging technologies. Initiatives and ideas in support of our overall maritime strategy are applied, tested, analyzed and refined through war games, exercises, experiments and operational lessons learned. For example, in support of those efforts, Commander, U.S. Fleet Forces Command, in coordination with Commander, U.S. Pacific Fleet, leads the Fleet-Led Experimentation (FLEX) program, a continuous process of operational and tactical experimentation.

S&T Highlights

The Naval S&T portfolio includes specific projects entering the Fleet/Force or about to enter in a short time, as well as a range of supporting programs. Following are examples of these efforts outlining the impact they will have on Sailors and Marines, today and in the future.

Common Information Environment for Combat Systems (CS); Command and Control (C2) Systems; and Intelligence, Surveillance, and Reconnaissance (ISR) Systems

ONR supports a broad effort to integrate the many disparate, independent CS, C2, and ISR systems into a common information environment architecture that is modular and based on open standards. The goal is to automate analysis of large amounts of data, reduce manpower requirements, and provide technical solutions and direction to related acquisition programs.

Navy and DoD systems are often point solutions with serious data and system interoperability issues. They tend to be proprietary closed systems which are costly to maintain and upgrade. However, ONR, in partnership with Program Executive Office for Command, Control, Communications, Computers and Intelligence (PEO C4I), developed an open source Service Oriented Architecture (SOA) as the foundation for next generation C2 systems. Operational use of this system began in 2006 when a core component was installed aboard CVN-76 (USS Ronald Reagan) to support the Maritime Domain Awareness system.

The SOA provided infrastructure for the C2 Rapid Prototype Continuum (C2RPC) system deployed at Pacific Fleet's request for use in Maritime Operational Center readiness analysis. Readiness analysis formerly required multiple personnel days to accomplish. C2RPC performed this analysis in a matter of hours (over 1400 times faster than manual processes), resulting in it being moved to the watch floor for use in operational planning while still an S&T prototype.

In 2010, the highly adaptable C2RPC SOA enabled additional capabilities and applications which led to installation requests by 5th, 6th, and 7th Fleets. The Air Force's (USAF) Air and Space Operations Center – Weapons System (AOS-WS) is evaluating this system for their use. In turn, USAF information services were directly integrated into the SOA framework, with both Services benefiting from capabilities each developed. This effort also transitioned to Navy's Afloat Core Services (ACS) Program of Record (POR) in Consolidated Afloat Networks and Enterprise Services (CANES).

Another application that resulted in major reductions in manpower and time required to deliver information is a C2RPC application that provides C2 of Intelligence. This prototype application is hosted on networks being evaluated by the Commander, Pacific Fleet, Naval Intelligence (CPF N2) watch team staff for automating theater collection assets as mapped to operational platforms and targets. The premise is to build an all-source collections awareness and decision assessment tool suite for theater intelligence management. The tool suite can be tailored and automated to support intelligence nodes at the theater, operational and tactical levels. As automated software matured, the CPF N2 staff realized they could delegate watch duties from O-3 ranks to the E-3/4 level – and eliminated four watch personnel from the daily rotation structure. C2 intelligence status can be obtained by pressing a print button as opposed to 10 man-hours per day.

The next aspect of the effort began in FY 10 with a Limited Technology Experiment to develop the capability to automate generic sharing of information across combat and SOA C2 systems – with emphasis on Anti-Submarine Warfare (ASW). This experiment was conducted with full participation of PEO Integrated Warfare Systems (IWS) and PEO C4I to ensure experimentation

directly addressed critical risks and ensure rapid transition to the Advanced Capability Build (ACB) POR and the CANES POR.

The initial FY 10 experiment demonstrated the transfer of information from the combat system to the Afloat Core Services (ACS) C2 system, with data transfer across platforms accomplished through the Advanced Digital Network System (ADNS) Extremely High Frequency (EHF) Time Division Multiple Access Interface Processor (TIP). The initial experiment met information assurance and latency requirements for the combat system, successfully demonstrated the capability, and helped identify shortfalls that need to be addressed.

In December 2011 we just completed addressing these issues, as well as those required to demonstrate transfer of information from C2 system to combat system. Navy, USAF and Army are conducting joint experimentation involving automated and continuous air, land, and surface battle-space de-confliction utilizing this framework. This will enable rapid Naval fire support and direct machine-to-machine information transfer for joint targeting.

Future plans include:

1) A C2-ISR version of C2RPC will be placed at Joint Interagency Task Force South (JIATF-S) to test and evaluate strategies, algorithms, and hypotheses supportive of planning, execution, and reviewing ISR operations. JIATF-S provides critical opportunities to work with very large, highly disparate data sources, including sensors and soft data, on a continuous basis in a multi-organization environment. This mirrors DoD operations with allies, partners, and non-governmental organizations where similar security issues must be addressed.

2) Experiments will be performed to enable common control of multiple, disparate unmanned ISR vehicles, automated information exchange, and manpower reduction in the management of the overall distributed system. In contrast to the current point solution with costly acquisition, lack of interoperability, and expensive logistics overhead, this effort will include multiple PEOs, ensuring that S&T provides a common approach across multiple acquisition communities.

3) A joint Navy Expeditionary/Marine Corps effort will develop S&T needed to enable riverine forces and Marine squads to significantly reduce Unmanned Aerial Vehicle (UAV) manpower requirements. UAVs utilized by these forces sometimes require so many people to operate and analyze data that combat units don't have sufficient manpower left to exploit emerging tactical opportunities. This effort will address the problem by automating management of a group of unmanned sensor platforms to provide coverage of a 400 square mile area, while simultaneously tracking at least 300 objects and activities of interest.

The overall impact of this broad effort is to develop a highly flexible, open architecture information and decision making capability with applications enabling operational and tactical forces to function with the same distributed information base across all warfare and mission areas. Information gathering and analysis will be largely automated and autonomously controlled so the warfighters can identify valuable time to make decisions and execute plans.

At a fraction of the cost, these efforts succeed where past efforts failed because traditional acquisition approaches issued contracts for proprietary solutions developed by single contractors. However, the SOA approach is unique in using industry and government performers to develop open source, open architecture solutions in an environment where government owns unrestricted licensing rights, and best of breed technologies for various modules individually competed and funded. Equally important, S&T is developed hand-in-hand with acquisition and requirements communities and evaluated by Fleet/Force through numerous Limited Technology Experiments. S&T prototypes are deployed in operational environments for first-hand evaluation, assessment, and Fleet feed-back. This accounts for significant improvement in transition results.

Irregular Warfare, Unmanned Systems, Medical Care

In addition to our dominance of the communications, information and cyber warfare spectrum, ONR's research portfolio reaches into depths of irregular warfare.

Working directly with the Services, the Defense Advanced Research Projects Agency (DARPA), and other DoD components, ONR serves as lead technical agent for the Office of the Secretary of Defense (OSD) Human Social, Cultural, and Behavioral Modeling (HSCB) Program. We are executing the DoD vision for this new domain to provide warfighters and analysts with tools, methods and technologies developed through integration of social and computational sciences. The HSCB program has significantly advanced applied research in this domain, demonstrated operationally focused capabilities with Combatant Command (COCOM) partners, and delivered technology to acquisition Programs of Record that enhance traditional Intelligence, Surveillance, and Reconnaissance (ISR) capabilities by providing insight into the human dynamics of a region.

For example, this year the HSCB Program is delivering a system that provides analytic tools to enhance the analyst's ability to detect trends in events of interest and forecasts to the U.S. Strategic Command (USSTRATCOM) Acquisition Category I (ACAT I) Integrated Strategic Planning and Analysis Network (ISPAN) Program of Record (POR), making this suite of tools available not just to the DoD, but also to interagency and North Atlantic Treaty Organization (NATO) partners as an enterprise solution. Current work in the applied and advanced development pipeline will facilitate the transition of social media sentiment analysis and other open source data to this POR in FY 2013. At the tactical level, HSCB provided USMC Civil Affairs teams participating in the Cobra Gold exercise in Thailand with human dynamics data and analysis to inform the common operating picture, support key leader engagements and humanitarian assistance activities, and provide a baseline for measures of effectiveness.

Our portfolio also emphasizes National Naval Responsibilities (NNR): areas where the other services, the rest of the federal research establishment and the private sector may not have the incentive to investigate – and sole responsibility rests with the Navy. The five NNRs are Ocean Acoustics, Undersea Weapons, Naval Engineering, Undersea Medicine, and Sea Based Aviation. The scope of our research in those areas includes Unmanned Undersea and Aerial Vehicles (UUV/UAV):

One example of research lessons-learned involves the Vertical Take-off and Landing Tactical Unmanned Aerial Vehicle (VTUAV) Airframe. The VTUAV Fire Scout program was initiated

in 2000 as an unmanned system to provide the Navy an intelligence, surveillance, reconnaissance and targeting capability. The Fire Scout airframe was based on a commercial airframe, proposed as a commercial-off-the-shelf (COTS), reliable, powerful, cost-effective solution to the VTAUV requirement. However, deployment in the marine environment led to production refinements in an attempt to address airframe and engine corrosion issues. Based on this experience, we learned that the COTS design of the airframe was not robust enough for daily operating conditions in the harsh marine environment encountered in long-term Navy ship deployments. Like many S&T research investments, we gain knowledge even when we do not succeed in transitioning products to acquisition programs. That hard-earned knowledge earned in failure is precisely what propels us to success in transitioning successful products to acquisition programs down the line. That's why they call it research.

An example of success in the underwater environment is the Mk 18 Mod 1 Swordfish variant of the REMUS 100 UUV, a reliable, deployable, highly portable, multi-vehicle system supporting globally dispersed Underwater Mine Countermeasure capability needs. The Mk 18 Mod 1 Swordfish UUV achieved full operational capability (FOC) in 2008. Follow-on block upgrades will combine two separate UUV programs into the Mk 18 family of systems to deliver improved detection capability against buried mines in high clutter environments and are planned to deliver from FY 2014 through FY 2018.

Unmanned vehicle systems offer many capabilities, including surveillance, reconnaissance, firepower with onboard weapons, and damage assessment. They serve as communications nodes and sensors for signals intelligence, environmental measurements, and identification of nuclear, biological, and chemical threats. Before effective deployment of unmanned vehicles, many technical and operational questions remain to be addressed, such as level of autonomy needed, as well as issues involving reliability, environmental sensitivity, vehicle integration, and operational training. Technical challenges include size, endurance, speed, recoverability, survivability, range and altitude, along with onboard/off-board trade-offs related to communications, intelligence, situational awareness for deconfliction, re-planning capability needed for threat changes, multiple vehicle control, and human interfaces including mixed operations with manned and unmanned aircraft.

Unique to Navy and Marine Corps operations are S&T challenges associated with launch, recovery, and deck operations, especially in proximity to manned aircraft and crew. Damage-tolerance considerations include redundancy in control paths and features to limit propagation of damage, aerodynamic designs allowing continued controlled flight with damage or loss of some airframe elements, and control systems capable of recognizing loss of control surfaces/actuators or changes to aerodynamic configuration of the vehicle and compensating or reconfiguring to allow continued flight. Operations on existing deck configurations with hand signals, visual inspection of data and interfaces, and visual cures for landing and waveoff, pose challenges requiring new technical approaches.

Unmanned Systems will never obviate the need for Sailors and Marines to engage in combat. Our goal is to ensure that they are as safe as they can possibly be in the combat environment. From weaponry to medical care, ONR invests in research about how to better protect personnel. Many of you remember QuikClot, in both the powder and currently utilized Combat Gauze

formulations. Our continuing quest for improved hemostatic products led ONR to support development of an Advanced Trauma Dressing recently approved for external use by the Food and Drug Administration. The Advanced Trauma Dressing is a novel hemostatic bandage with a unique synthetic fibrin carried on a bio-compatible resorbable backing. It was developed to enhance clotting and reduce unwanted adhesion to wounds - while eliminating potential disease transmission found in blood-derived products. Synthetic fibrin dressing is undergoing further development for internal use to stop internal bleeding. The Marines have considerable interest in this product as hemorrhage remains the number one cause of preventable death on the battlefield.

Small Business, Small Business Innovation Research (SBIR), Small Business Technology Transfer (STTR) Programs

ONR small business programs are doing well and can do better. Although we met targets with respect to Small Disadvantaged Businesses, Women-Owned Small Businesses, and Service-Disabled Veteran-Owned Small Businesses, we need to improve our outreach to Historically Underutilized Business Zones and Veteran-Owned Small Business and would like to continue improvements across the board. ONR's FY 2011 achievement of nearly 40% small business awards substantially exceeded the Navy-Marine Corps average, but that is no reason to rest on our laurels.

Our approach continues, for example, to designate all ONR Navy SeaPort(e) support service procurements as 100% small business set-asides, unless it is determined to be in the best interest of the government to proceed with the full and open competitive process. SeaPort(e) is the Navy's electronic platform for acquiring support services in 22 functional areas including engineering, financial management and program management. We emphasized technologies developed by small business in the competitive context of our Navy Rapid Innovation Fund (RIF) Broad Agency Announcement. Finally, we support small business development with ONR's Long Range Acquisition Forecast, a tool being developed on ONR's webpage to assist the small business community in more effectively marketing technologies, goods and services to program components within ONR.

Unique among S&T tools are the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Programs, which apply a combined 2.8% of externally-executed Navy Research, Development, Test and Engineering (RDT&E) funding to high-priority warfighter needs identified by Fleet/Force acquisition programs. Naval SBIR/STTR focuses on delivering quick, cost-effective, and innovative small business technologies to the Fleet/Force. Small business solutions to Fleet/Force requirements play a key role in Navy's R&D transition strategy, and include development and delivery of technological innovations to the *Virginia*-class submarine's command module, Fire Scout's propulsion system, F-35 airframes, and the Military Sealift Command Dry Cargo/Ammunition Ship (T-AKE) cargo storage system.

SBIR/STTR programs also mine small business potential to address Navy-wide priorities such as energy security, with approximately 25% of annual SBIR/STTR topics addressing alternative energy and energy efficiency requirements across commands. Further, SBIR/STTR programs are a portal for small business entry into Navy's emerging open architecture environment, especially for software requirements of Aegis, Next Generation Jammer, and Joint Tactical

Radio Systems. Positive results of these efforts are seen in the $552 million of Phase III (non-SBIR/STTR) funds Naval program recipients received directly from Naval acquisition program sources in FY 2011. Acquisition investment of additional non-set aside dollars in projects initiated through SBIR/STTR programs to meet their requirements is one of our strongest metrics of success.

Naval SBIR supports delivery of innovative technology, providing incentives to ensure timely engagement by prospective customers and investors. Phase I awards of approximately $150 thousand each (with 570 awards in FY 2011, 25 more than the previous year) include a base-plus-option strategy to ensure business continuity as Proof of Principle is established. Phase II awards of approximately $1 million each to mature project work (with 318 awards in FY 2011, 22 more than the previous year) include a similar funding strategy with technology decision-gates to ensure continuous engagement with acquisition programs to verify "technology pull" from Naval customers. Navy SBIR/STTR supports development and delivery of innovative technology by strengthening small businesses' core competencies through a rigorous 11-month Transition Assistance Program, paired with work with industry prime contractors and integrators to ensure effective partnering on Navy acquisition program requirements. Naval SBIR/STTR participant's dialogue with government and industry culminates in our annual *Navy Opportunity Forum*, where more than a thousand innovators, industry, and government customers learn about small business innovation and explore formal partnership opportunities.

The recent reauthorization of the SBIR/STTR programs includes several changes which should prove beneficial to small business innovation. Among the changes are an increased amount of funds available for technical assistance to small business concerns, increased incentives for prime contractors to utilize SBIR/STTR technologies, and permanent status for a pilot program begun in 2006 to improve commercialization success of Department of Defense projects. These changes along with the many others included in reauthorization should enable Naval SBIR to continue to make a valuable contribution to S&T innovation, Naval RDT&E, acquisition programs, small business development and job creation.

Naval Research Laboratory (NRL)

ONR supports research at the Department of the Navy's corporate lab, the Naval Research Laboratory (NRL). The NRL base program develops S&T to meet needs identified in the Naval S&T Strategic Plan, and sustains world class skills and innovation in our in-house laboratory. The broad-based core scientific research at NRL serves as the foundation that can be focused on any particular area of interest to rapidly develop technology from concept to operation when high-priority, short-term needs arise. NRL has served the Navy, Marine Corps and nation for nearly ninety years with a breadth of the research that facilitates quick assimilation of critical ideas and technologies being developed overseas for exploitation or countermeasures. In addition, NRL remains the lead Navy laboratory for research in space systems, firefighting, tactical electronic warfare, microelectronic devices and artificial intelligence.

Lines of business at NRL include: battlespace environments, electronics and electronic warfare, information systems technology, materials, sensors, space platforms, technology transfer and undersea warfare. For example, NRL research explores Naval environments with wide ranging

investigations that measure parameters of deep oceans, analyze marine atmospheric conditions, monitor solar behavior, and assess survivability of critical Naval space assets. Detection and communication capabilities benefit by research that exploits new portions of the electromagnetic spectrum, extends ranges to outer space, and enables reliable and secure transfer of information. Research in the fields of autonomous systems, bio-molecular science, engineering, firefighting, fuels, lubricants, nanotechnology, shipbuilding materials, sound in the sea, submarine habitability, superconductivity and virtual reality remain steadfast concerns at NRL.

Among our greatest challenges is recapitalizing NRL infrastructure. I invite all of you and your staffs to see this magnificent facility for yourselves, and learn more about the programs, projects, and research undertaken there by some of the greatest scientists and engineers in the world.

ONR Global

The worldwide dimension of S&T is reflected in over 100 percent growth in global S&T investment over the last ten years. When Congress established NRL in 1916 and ONR in 1946, the U.S. was arguably the world leader in S&T. The U.S. monopoly, however, no longer exists, making it imperative to keep our finger on the pulse of S&T in the international environment. Beginning with establishment of our London office in 1946, ONR established offices in Santiago, Prague, Tokyo and Singapore, closely coordinated with the other services and the Assistant Secretary of Defense (Research and Engineering).

The purpose of our effort is to search the globe for emerging scientific research and advanced technologies that enable ONR to address both current Fleet/Force needs, as well as requirements of future Naval missions and capabilities. We work through ONR Global offices to establish new contacts and relationships with international leaders in relevant research fields. This allows us to gain new perspectives and expertise, identify geographically significant trends and advances, and help forecast global trends and threats. It also enables us to recruit the world's best scientists and engineers in partnerships that benefit U.S. forces and allies.

ONR Global programs include the Science Advisor Program which communicates Fleet/Force capability needs to the Naval Research Enterprise (NRE) (consisting primarily of the Navy labs, warfare centers and affiliated universities) and facilitates the development of solutions that can transition back to the Fleet/Force. Program participants are typically senior Navy engineers who coordinate and conduct Naval experimentation, develop prototype solutions, define transition options, and collaborate with Fleet/Force to define S&T investment needs to meet future Naval requirements.

ONR Science Advisors are embedded with the Fleet/Force to ensure that operating requirements are quickly communicated to the Naval S&T community and to facilitate timely delivery of S&T solutions back to the Fleet/Force. They function as the Commanders' link to S&T organizations, assist in prioritizing Command S&T requirements, and help identify transition options. Science Advisor tours are 1-3 years in length, and are highly competitive and sought-after developmental assignments for future NRE civilian leaders, allowing selected scientists and engineers to work directly with operational forces and gain hands-on experience with Command-level engagement, Naval exercises and technology demonstrations both at-sea and in the field.

To increase Naval awareness of global technology, our International Science Program provides scientists from academia, government and industry opportunities to engage leading international scientists and innovators. Our worldwide technical staff helps establish relationships with international leaders in relevant fields, establish direct collaboration between ONR and NRL scientists and their foreign counterparts, and identify significant trends, accomplishments, and centers of excellence for Naval S&T. This strengthens our ability to forecast both trends and threats in global S&T, and avoid technological surprise.

Conclusion

Thank you for the opportunity to discuss Naval S&T. The FY 2013 President's Budget request will enable us to continue moving toward greater integration of capabilities, more effective partnership between research and acquisition, and a clearer vision of how to achieve shared goals among the Army, Air Force, DARPA and other DoD research organizations. At the same time, we also focus considerable energy and investment partnering with performers outside the Naval R&D system in order to tap into the full spectrum of innovative thinking and discovery, and to accelerate transition of appropriate technologies to civilian use.

For these reasons, I believe our S&T investments are sound; represent careful stewardship of taxpayer dollars; and will significantly enhance the safety and performance of our warfighters as they serve in defense of the United States, today and in the future. Thank you for your support.