

USN Office of Naval Research (ONR)

May 2017

800 North Quincy Street
Arlington, VA 22217-5000
(703) 696-4917 Office of Public Affairs
<http://www.onr.navy.mil>

Brief

The Office of Naval Research (ONR) was established in 1946 to act as the contracting agency for bringing scientific skills into the service of meeting urgent goals in national security. It was reorganized late in 1992 by consolidating the original ONR, the Office of Naval Technology (ONT), and the Office of Advanced Technology (OAT) into a reconstituted ONR. The new office continues to work with university scientists and engineers conducting research having broad potential application in areas of interest to the Navy, including advanced materials, computers, ocean sciences, electronics, medicine and engineering. Working with the contracting community, ONR demonstrates military and commercial applications of its technology to new ships, aircraft, electronic systems and other naval products.

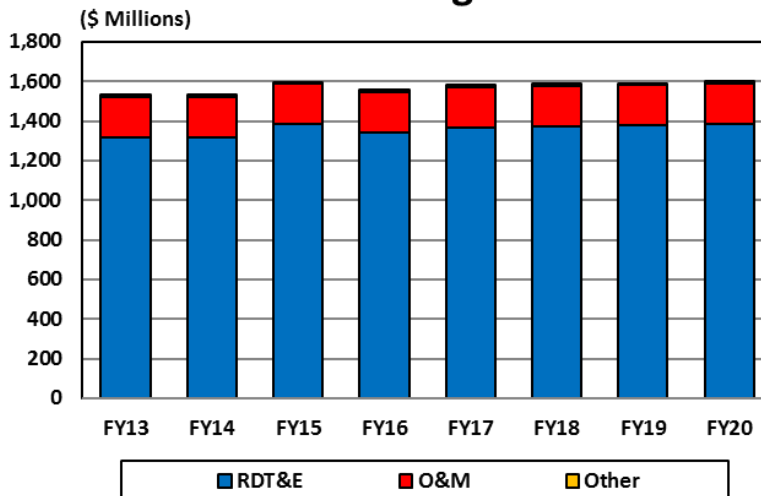
ONR plans, fosters, and encourages scientific research in recognition of its paramount importance as related to the maintenance of future naval power, and the preservation of national security. Its mission is to provide the science and technology (S&T) base that maintains and expands the technological superiority of naval forces and its goal is to respond to naval requirements and lead the international S&T community, to provide both evolutionary technology improvements and revolutionary capabilities. ONR supports basic research, the investigation of fundamental truth concerning the physical world. Proposals are examined from candidate investigators who present ideas for projects that range across a full spectrum of scientific research.

Research funded by ONR is conducted under contract by universities,

nonprofit institutions, industrial establishments, and by Navy laboratories, including ONR elements such as the Naval Research Laboratory (NRL; see report). ONR also sponsors programs that support objectives for insuring adequacy of numbers among scholars who can pursue careers in science and engineering. Central to this plan are programs supporting doctoral or postdoctoral education for selected US citizens, academic appointments to Navy laboratories, and minority and small business opportunities. Separately from basic research, a program of applied research and exploratory development is conducted to adapt and extend the results of the basic research programs. The policy of ONR is to use flexible contract and grant procedures in carrying out its program. Proposals are sought from qualified organizations whose research and/or development efforts help the facility meet its mission objectives.

ONR manages all the Navy's S&T funds, including basic and applied research and advanced development. It develops a strategy for each warfare mission area that describes the potential impact of the planned

ONR Funding Profile



technology program on the warfighting capability of the Navy and Marine Corps and oversees the Navy's technical activities regarding Industrial Independent Research & Development (IR&D).

ONR manages other programs assigned to it, and functions essential to the command. These include comptroller, contracting, and legal services, Navy policy office for patents and intellectual property, administrative contracting services for all Federal agencies at universities, comptroller for the Navy RDT&E appropriation, DoD agency for indirect cost negotiation at educational institutions, and coordination of all Navy programs at Historically Black Colleges and Universities (HBCU). In the non-S&T area, it has responsibility for the SSBN Security Program, Naval Low Observables Program, Naval Science Assistance Program

(NSAP), and Small Business Innovation Research (SBIR) program. It also conducts work for others (DARPA, BMDO, etc.).

ONR initiated an integrated Department of the Navy (DoN) Science

and Technology (S&T) process based on the OSD Science and Technology Investment Strategy thrusts involving Global Surveillance and Communications, Air Superiority and Defense, Precision Strike, Sea

Control and Undersea Superiority, Technology for Affordability, and Synthetic Environments.

Funding Data

The Office of Naval Research has an FY17 budget of \$1.56 billion, which is less than the FY16 number of \$1.6 billion. Within the ONR

budget, RDT&E provides approximately 90 percent of the annual funding, with nearly all of the RDT&E funding coming from the 6.1, 6.2, and 6.3 accounts, which provide the

early thrust of all Navy research. The table below presents ONR’s budget for the FY14-FY21 time frame (dollars in millions).

Program	FY14	FY15	FY16	FY17
RDT&E	1,319.0	1,318.0	1,382.0	1,341.0
O&M	205.0	205.0	206.0	205.0
Other	10.0	10.0	9.0	10.0
Total	1,534.0	1,533.0	1,597.0	1,556.0
Program Forecast	FY18	FY19	FY20	FY21
RDT&E	1,367.0	1,371.0	1,376.0	1,383.0
O&M	206.0	206.0	206.0	207.0
Other	10.0	10.0	10.0	11.0
Total	1,583.0	1,587.0	1,592.0	1,601.0

Teal Group Analysis

The Office of Naval Research budget spiked way back in FY09, largely on the basis on add-ons to the Applied Research (6.2) and Advanced Technology Development (6.3) budget activities. The budgets are stabilizing in the long-term cycle.

Starting in FY18 the trend is expected for an slow increase in R&D funding through FY21.

The Navy’s changing priorities and the need to fund some areas of the service budget that have been shortchanged could cause this slow growth. Also playing a role will be the strong growth the other stages of

Navy research should see, which will take funding from early research. Emphasis in areas pertaining to surface ship and submarine technology, electronics and computer technology, and ocean and atmospheric technology provide a substantial boost to efforts in the near term. There will also see greater funding in unmanned platform research and in programs that will support joint operations.

ONR continues to maintain the research reserve program and will coordinate naval basic and applied research and advanced technology development. It will also continue its

efforts in promoting cooperative research within Navy, other DoD, NASA, DARPA, and other government research groups as R&D funding becomes more focused to meet budget constraints. It will remain as the focal point for world-wide research information and is expected to aggressively search out joint R&D efforts with foreign governments to allay mounting development costs.

As always, ONR’s budget is deeply affected by Congressional add-on funding.

RDT&E Involvement

ONR’s involvement in the Navy RDT&E program includes management of science and technology efforts (basic research; 6.1), the development and evaluation of the feasi-

bility of proposed technological solutions to specific naval problems (applied research; 6.2), and the transition of this early development into fleet systems (advanced development; 6.3). Its elements (primarily

the Naval Research Lab [NRL]—see report) are also responsible for certain of the programs further on in the development cycle. It maintains administration responsibility for the

contract management program at educational institutions, financial management of RDT&E appropriations for ASN (R&S), and has responsibility for representing the Chief of Naval Research and maintaining liaison between the US Navy and all scientific research agencies conducting programs of interest in the UK, Europe and other areas of the world. Some of this effort is financed through the Navy's Defensewide Mission Support budget activity (BA 6).

Separately from basic and applied research, a program is conducted by the office to adapt and extend results of 6.1/6.2 programs to specific naval applications. These commitments to the advancement of science and technology serve the objectives of ONR. They include the support of Technology Base programs and put the facility in touch with many programs contained in other budget activity areas. Recent projects have focused on engine, torpedo, and antenna technology; decoys; acoustics; mines; and

blood research. Three bottleneck areas which are expected to govern the ability to achieve the vision for the "Navy-after Next" and for which the Navy is expected to expand its efforts include software development, microelectronics, and novel materials. Detailed below are the important programs at the present time for ONR. Not included are those programs and projects which are under the direction of or show involvement for NRL. These are included under the NRL report herein.

ONR Program Elements/Projects

0601152N In-House Independent Laboratory Research

ILIR
Science Tech Engineering & Math Efforts

0601153N Defense Research Sciences

Air Ground & Sea Vehicles
Atmosphere & Space Sciences
Hybrid Threats
Human Systems
Math, Computer, & Info Sys
Materials/Processes
Medical/Biology
Ocean Sciences
Science & Engineering Edu
Sensors, Electronics & EW
Weapons
Basic Research Challenge

0602114N Power Projection Applied Research

0602121N Surface Ship Technology

Directed Energy
High Speed Propulsion & AWT
Nav EO/IR & Sensor Tech
Strike & Littoral Combat Tech
Electromagnetic Guns

0602123N Force Protection Applied Research

0602131M Marine Corps Landing Force Technology

Aircraft Technology
Fleet Force Protection & Def
Advanced Energetics
Surface Ship & Sub HM&E
Naval Research Enterprise

0602131M Marine Corps Landing Force Technology

C4
Firepower
Force Protection

Human Perf, Training & Edu
Intel, Surveillance & Recon
Future Naval Capabilities
Logistics
Maneuver
Expeditionary Cyber
Future Concepts

0602235N Common Picture Applied Research

Communication & Networks
Multi-Source Integration
Tactical Space Exploitation
Autonomous Sys & Robotics

0602236N Warfighter Sustainment Applied Research

Adv Naval Materials
Biocentric Technologies
Environmental Quality
Human Factors
Medical Technologies
ONR Global
Training Technologies

0602271N Electromagnetic Systems Applied Research

Electronic Warfare Tech
EO/IR Sensor Technologies
Navigation Technologies
Solid State Electronics
Surveillance Technology
Vacuum Electronics
NEMESIS

0602435N Ocean Warfighting Environment Applied Research

Costal Geosciences/Optics
Marine Mammals and Biology
Marine Meteorology
NOPP
Ocean Acoustics
Physical Oceanography

0602651M Joint Non-Lethal Weapons Applied Research

0602747N Undersea Warfare Applied Research

ASW Distributed Search
ASW Precision Localization
ASW Surveillance
Marine Mammals
Undersea Weaponry

0602750N Future Naval Capabilities Applied Research

Capable Manpower
Enterprise & Platform Enablers
Exped Maneuver Warfare
FNC Management
Force Health Protection
ForceNet
Power & Energy
Sea Basing
Sea Shield
Sea Strike

0602782N Mine & Expeditionary Warfare Applied Research

Mine Technology
Mine/Obstacle Detection
Mine/Obstacle Neutralization
Special Warfare/EOD

0602792N Innovative Naval Prototypes

Cyber
Directed Energy/Electric Weapons
Electro Maneuver Warfare
INP Management
Undersea Warfare
Unmanned & Auto Systems

<p>0602861N Science & Technology Management</p> <p>0603114N Power Projection Advanced Technology Precision Strike Technology</p> <p>0603123N Force Protection Advanced Technology Surface Ship & Sub HM&E Aircraft Technology</p> <p>0603271N Electromagnetic Systems Advanced Technology Electronic & Electro Systems GPS & Navigation Tech INTOP INP NEMESIS</p> <p>0603640M Marine Corps Advanced Technology Demonstration C4 Firepower Force Protection Human Performance ISR Future Naval Capabilities Logistics Maneuver Expeditionary Cyber CSS & Force Protection Fires Targeting & Maneuver MAGTF C4 MAGTF ISR MCWL/FD Support Warfighting Excellence</p> <p>0603651M Joint Non-Lethal Weapons Technology Dev</p> <p>0603673N Future Naval Capabilities Advanced Technology Dev Capable Manpower</p>	<p>Enterprise & Platform Enablers Exp Maneuver Warfare Force Health Protection ForceNet Power & Energy Sea Basing Sea Shield Sea Strike</p> <p>0603680N Manufacturing Technology Program Composites Proc & Fabrication Electronics Proc & Fabrication Metals Proc & Fabrication Manufacturing Enterprise/Other</p> <p>0603729N Warfighter Protection Advanced Technology Naval Noise-Induced Hearing Loss</p> <p>0603747N Undersea Warfare Advanced Technology Naval Forces UUV Dev</p> <p>0603758N Navy Warfighting Experiments & Demonstrations Operations Analysis SwampWorks Tech Solutions Precision Strike Technology</p> <p>0603782N Mine & Expeditionary Warfare Advanced Technology Joint EOD Demos Mine Technology</p> <p>0603801N Innovative Naval Prototypes Advanced Technology Development Cyber Directed Energy/Electric Weap Electro Maneuver Warfare Undersea Warfare Unmanned & Autonomous Sys</p>	<p>0605154N Center For Naval Analyses R0148 CNA, Navy</p> <p>0605155N Fleet Tactical Development & Evaluation Program R0151 Intertype Tactical Development & Evaluation</p> <p>0605853N Management, Technical & International Support R0149 International Cooperative RDT&E R1767 NWC Center for Naval Warfare Studies X2221 Assessment Program X2222 Naval Modeling & Simulation</p> <p>0605861N RDT&E, Laboratory & Facilities Development Support R0135 ONR Science & Technology Management</p> <p>0605862N RDT&E,N Instrumentation & Materiel R0137 ONR Science & Technology Instrumentation Modernization</p> <p>0605863N RDT&E Ship & Aircraft Support S0354 RDT&E Ships Support S0354 RDT&E Aircraft Support</p> <p>0605865N Operational Test & Evaluation Capability R0831 OT&E Force Support</p> <p>0605866N Navy Space & Electronic Warfare Support R0739 Navy C4I Top Level Requirements</p>
--	--	---

Organization of the Research Program

The Science & Technology Program at ONR is conducted under three directorates and six departments:

Directorates

The **Office of Innovation** cultivates innovative science and technology approaches that support the Department of Navy and facilitate rapid and agile responses to our changing national security environment.

The **Office of Research** Discovery and Invention portfolio makes broad investments in basic and ap-

plied research that will increase fundamental knowledge, foster opportunities for breakthroughs and provide technology options for future naval capabilities and systems. Discovery and Invention programs nurture creativity and seek a balance between risk, opportunity and potential naval impact.

Transition of technologies to the fleet and acquisition are top priorities. ONR emphasizes transition centric programs and methodologies under the **Office of Transition** including efforts covering manufacturing methods used to build naval warfare systems, programs that stimulate advantageous government-industry

partnerships, and an investment portfolio focusing on requirements pull by the fleet and acquisition.

Departments

The Departments and their general areas of expertise are as follows:

Expeditionary Maneuver Warfare & Combating Terrorism (Code 30)

Code 30 is composed of three divisions: Expeditionary Maneuver Warfare & Combating Terrorism Research Division (Code 301); Expeditionary Maneuver Warfare & Combating Terrorism Applications Division (Code 302); and Expeditionary Maneuver Warfare & Combating Terrorism Integration & Transition Division (Code 303).

The three divisions consolidate and focus the Thrust Area S&T investment and technology efforts of the Department in accordance with requirements as identified by the Science and Technology Objectives (STOs). In addition, Code 30 manages a Basic Research program working to enhance universities' capabilities to perform basic science and to demonstrate the feasibility and practicability of employing emerging technology. Code 30 is organized around seven "Thrust areas" each of which seeks to develop and leverage advanced technologies:

Command, Control, Computers and Communication (C4): The Office of Naval Research (ONR) Command, Control, Computers and Communication (C4) thrust seeks to improve C4 capabilities for naval warfighters with an emphasis on small units, asymmetric and irregular warfare, information analysis and communication, and distributed operations. Its technology investment areas include network-centric warfare and interoperability, over-the-horizon communications gateways, and small-unit technologies.

In the area of network-centric warfare and interoperability, ONR

seeks nearly ubiquitous communications and availability of information for naval warfighters, particularly in austere environments.

Fires: The Office of Naval Research (ONR) Fires thrust seeks to enable warfighters employed in small, distributed units with tools to locate and decisively destroy larger enemy forces by applying timely, reliable, precise and accurate fires from a myriad of platforms. Products will equip warfighters with integrated, light-weight optics and sensors to see through all battlefield conditions (day, night, low-light, and obscurity) and light-weight, organic, advanced weapons for the rapid, accurate, effective application of firepower. Productions would also equip tactical units frequently operating well beyond conventional parameters of direct fire mutual support. The increased intelligence capabilities delivered by company intelligence cells will generate more potential targets in the future.

Force Protection: The Office of Naval Research (ONR) Force Protection thrust seeks to develop and mature technologies that provide protection from myriad modes of enemy attack throughout the spectrum of warfare, including concepts such as asymmetric and irregular warfare and distributed operations which concentrate on the small unit (battalion and below) and individual warfighter levels. End products will include protective systems expeditionary in nature, light-weight and capable of providing a far greater degree of performance than any comparable system currently available. The functional areas of investigation are explosive hazard defeat through detection, breaching and neutralization of all explosive hazards, counter sniper, counter rocket, artillery, and mortar

(CRAM), counter-bomber and personal protective equipment.

Human Social, Cultural and Behavior: The Office of Naval Research (ONR) Human Performance Training and Education (HPT&E) thrust seeks to develop, evaluate, and deliver scientifically proven methodologies and technologies that enable the cognitive and physical superiority of Marines. The vision for HPT&E is to develop and foster expeditionary warfighters who are ready to deploy anywhere in the world on short notice, to serve within their team, take on leadership roles, and complete their missions under any extremes or circumstances, and return home uninjured. To support this vision HPT&E focuses on two Technology Investment Areas (TIAs): Decision Making & Expertise Development and Warrior Resilience.

ISR: The Office of Naval Research (ONR) Intelligence, Surveillance and Reconnaissance (ISR) thrust seeks to develop and leverage advanced technologies for applications in future intelligence, surveillance and reconnaissance systems. It also seeks to enhance situational awareness to enable real-time tactical decision making for distributed operations and provide proactive and predictive capabilities for asymmetric and irregular warfare.

Logistics: The Office of Naval Research (ONR) Logistics thrust seeks to provide Marines of the future with a precisely tailored level of sustained logistic support from sea-based platforms to rapidly maneuver forces ashore. Logistics delivery systems of the future will be more responsive and flexible, enabling Marines to out-pace rapidly changing operational scenarios. Likewise, delivered logistic commodities will provide more operational value per

unit weight, enhancing combat unit self-sufficiency and maneuverability. Finally, operational units will benefit from technologies that maximize equipment readiness by minimizing both downtime and maintenance requirements.

Maneuver: The Office of Naval Research (ONR) Maneuver thrust explores technologies to increase the warfighting capabilities and effectiveness of the Marine Corps Air Ground Task Force with emphasis on improving survivability and enhancing maneuver and maneuver-enabling systems in both decentralized and asymmetric warfare. Marine forces of the future will be significantly more agile, lethal, mobile and survivable.

Command, Control Communications, Computers, Intelligence, Surveillance & Reconnaissance (Code 31)

This department's three divisions support science and technology programs in Electronics; Mathematical, Computer, and Information Sciences; Surveillance, Communications, Navigation, Precision Time, and Electronic Combat. Sponsored programs focus on experimental and theoretical research and technology in these areas with applications across near-, mid-, and far-term applications. The research programs range from fundamental investigations into mathematical foundations for models, computability, and algorithms; solid-state materials and electronic devices; and image and signal analysis in the far-term to C2 applications and infrastructure, sensor technology, and robust navigation technology in the near-term. The technology programs seek to exploit the results of research opportunities to enhance surveillance capabilities, communications, command and control, new concepts for electronic devices, application of information sciences to complex problems including human-computer interaction, navigation, and electronic warfare.

Contact: 703-696-4212

Ocean Battlespace Sensing (Code 32)

The department consists of two large divisions, Ocean Sensing and Systems Applications and Ocean, Atmosphere, and Space Research, of integrated, multidisciplinary programs in naval environments, undersea warfare, and related subjects.

The department focuses its S & T programs in the areas of:

- **Battlespace Environments (BSE):** Observing, modeling, and predicting both small and large scale processes in the air/ocean/shore environments. It contains the traditional oceanographic and meteorological disciplines and encompasses: Environmental Processes, Sensors/Data, Model Development, Data Assimilation and Information Exploitation, and Validation Studies.
- **Anti-Submarine Warfare (ASW):** Detecting, localizing, and classifying submarines with active and passive acoustics as well as non-acoustic means. These are enhanced by automated data fusion and coupling with environmental understanding and modeling. Encompasses: Cooperative ASW, Wide-Area ASW Surveillance, and Battlegroup ASW Defense. This investment area includes the Littoral ASW Future Naval Capability effort. (For platforms or weapons see Engineering, Materials and Physical Department)
- **Mine Warfare (MIW):** Detecting, localizing, identifying, and neutralizing mines in both the ocean and littoral environment, and improving offensive mining capabilities. Also includes Naval Special Warfare/Explosive Ordnance Disposal. Encompasses: Organic Minehunting (Sensing/Processing), Mine/Obstacle Neutralization, Sweeping/Jamming, Mining, and Advanced Force Operations. This investment area includes the Organic Mine Countermeasures FNC effort.

Contact: 703-696-4125

Sea Warfare and Weapons (Code 33)

This department is focused on: Providing technologically superior warfighting capabilities for surface, subsurface, and marine ground platforms through high survivability, mission flexibility, and low detectability; Providing significant reductions in total lifecycle costs for naval platforms; Providing superior undersea weapons technologies that ensure high probability of kill and low probability of counter-kill within an autonomously delivered package; and Providing the technologies required to improve current and facilitate future sea basing concepts of operations.

The department is composed of three divisions: Ship Systems and Engineering; Naval Materials; and Sea Platforms and Weapons.

The Sea Platforms and Weapons Department invests in basic and applied research, and supports advanced technology development leading to improved capabilities for the Department of the Navy. Frequently the application of technological advances developed within this department has a wider influence, such as the other Department of Defense Services and Agencies, as well as US industries. They are committed to actively pursuing programs that provide cutting-edge science and technology in the areas of ship design, construction, and operations.

The scope of the programs supported by the divisions can be characterized as "from nanostructures to aircraft carriers. These programs are focused on materials sciences, chemistry and ship applied physics as they apply to specific ship engineering challenges. Active investigations are being conducted in areas such as structural materials, functional materials, energetic materials, maintenance reduction, environmental quality control, energy generation, energy storage, hydromechanics, signature reduction and control, computational physics, solid mechanics, electromechanics, advanced electrical power

systems, damage resistant hull & structures, integrated platform systems, and advanced platform concepts & designs.

Contact 703-696-5075

Warfighter Performance

Department (Code 34)

The Warfighter Performance Department supports basic and applied research, and advanced technology development leading to applications for the Departments of Navy and Defense, and US Industry. They are committed to active exploration programs that are at the leading edges of medical science, human performance, biotechnology, training and human factors, neural information processing, and biorobotics.

Programs supported by the divisions range from molecular biology to the development of advanced medical therapies for saving lives and

strategies for preserving a healthy and fit fighting force. Investigations are conducted of neural, perceptual, and cognitive levels of organization, with an emphasis on the reverse engineering of biological systems to develop devices for fleet operations. Additional emphasis is placed on the study and exploitation of biological processes toward protection of the environment.

Three divisions comprise the department: Human & Bioengineered Systems Division; Warfighter Protection & Applications Division; and Research Protections Division.

Contact 703-696-4501

Naval Air Warfare and Weapons (Code 35)

Provides the scientific and technological base that expands the operational superiority to the Navy and

Marine Corps in Air Warfare and Naval Weapons

As S&T lead for the Sea Strike pillar of Sea Power 21, the department is responsible for the fostering, planning, managing and executing of scientific research and technology development in the areas of physics, aerospace materials, energetics, surface and air launched weapons, kinetic and directed energy weapons, robotics and unmanned aerial systems, air vehicle structures and subsystems, vehicle self-protection and survivability and air vehicles design, modeling and simulation.

The two divisions that comprise this department are Aerospace Science Research and Air Warfare and Naval Weapons Applications.

RDT&E Highlights

R&D efforts at ONR span the basic and applied research, and advanced development stages of development in the DoD budget structure for development programs, with this workload the responsibility of the Science and Technology (S&T) Directorate at the office. Basic research, the cornerstone of future Navy and Marine Corps technology, is under the Science segment of the S&T Directorate where support is given to

research proposals from universities, Navy labs and warfare centers, private corporations, and nonprofit institutions. The research conducted provides the base for subsequent applied research (was exploratory development) and advanced development in Defense-related technologies and new and improved military capabilities in areas such as communications, propulsion, materials, training,

and safety. Although particular emphasis is placed on investing in ONR core competencies such as ocean sciences, advanced materials sciences, and information sciences, broad and flexible programs that target all areas of science with potential Navy or Marine Corps relevance are also supported. This basic research effort is found in the Navy Defense Research Sciences program (PE# 0601153N).

Defense Research Sciences (PE# 0601153N)

The Navy Defense Research Sciences provides new technological concepts for the maintenance of naval power and national security, and helps avoid scientific surprise. It is based on investment directions as defined in the Naval Science & Technology Strategy. This strategy is based on needs and capabilities from Navy and Marine Corps guidance and input from the Naval Research Enterprise (NRE) stakeholders (including the Naval enterprises, the combatant commands, the Chief of Naval Operations (CNO), and Headquarters Marine Corps). It exploits

scientific breakthroughs and provides options for new Future Naval Capabilities (FNCs) and Innovative Naval Prototypes (INPs).

This PE addresses basic research efforts including scientific study and experimentation directed toward increasing knowledge and understanding in national security related aspects of physical, engineering, environmental and life sciences. Basic research efforts are developed, managed, and related to more advanced aspects of research on the order of a hundred technology and capability-

related 'thrusters', which are consolidated into about fifteen research areas. These in turn supports the major research areas of the Navy and Marine Corps: Autonomous Systems; Command, Control, Communications and Computers (C4); Marine as a System; Information Analysis and Decision Support; Intelligence, Surveillance and Reconnaissance; Logistics; Materials; Operational Environments; Platforms; Power and Energy Technology; Sensors and Electronics; Warrior Performance and Protection; Weapons and Support (Education and Outreach).

S&T investment in basic research also includes the National Naval Responsibilities (NNRs), fields upon which a wide range of fundamental naval capabilities depend. There are currently five NNRs.

The Defense Research Sciences program budget for FY17/18/19 is \$422.7 million, \$458.3 million, and \$469.9 million. Funding in FY22 will hit \$478 million.

Air Ground and Sea Vehicles

Efforts in the Air, Ground, and Sea Vehicles project include: Surface/subsurface reduced signatures; free-surface, subsurface, and propulsor hydrodynamics; hull life assurance; advanced ship concepts; distributed intelligence for automated survivability; advanced electrical power systems; air vehicles; air platforms propulsion and power; air platforms survivability and signature control; special aviation projects; Unmanned Air Vehicle/Unmanned Combat Air Vehicle (UAV/UCAV); environmental quality; logistics; and power generation, energy conversion, storage and advancements in naval technology innovations.

Funding for FY17/18 is \$52.1 million and \$57.2 million. The funding increase in 2018 is the result of several increased Department Research Initiatives in the areas of Science of Autonomy, Advanced Naval Power Systems, and Advanced Sea Platform Performance.

Atmosphere and Space Sciences

Efforts in the Atmosphere and Space Sciences project include: Efforts include: Marine Meteorology and Prediction, and Space Sciences.

Funding for FY17/18 is \$24.4 million and \$25.5 million.

Science Addressing Hybrid Threats

The Sciences Addressing Hybrid Threats (formerly Counter Improved Explosive Device (IED)

Sciences program provides research for Naval Forces to fight hybrid threats, and adversaries in expeditionary operations. Naval Expeditionary Forces need science advances to address a range of Basic Research challenges that result from physical and operational environmental limitations so harsh that solutions push basic discovery and invention. Naval Forces able to operate amphibiously and in the littoral will have all of their capabilities exposed to degrading sea and land physical effects. Expeditionary forces operating austere must be agile and lethal but will be constrained by size, weight, and power requirements and must be sustained across distributed forces covering large areas. Further complicating the problem context is the nature of hybrid threats, and adversaries. The program seeks to establish and nurture a multidisciplinary Science and Technology community of Government, academic and industry researchers to accelerate the transition of new science and technology into fielded systems.

Funding for FY17/18 is \$17 million and \$23.7 million. The funding increase in 2018 is the result of DON increased basic research to include a complex, hybrid adversary consisting of state and non-state actors in order to better reflect the threat environment that Naval Forces will face in the future.

Human Systems

Efforts in the Human Systems project include: Human factors and organizational design; manpower, personnel, and training; integrated avionics, displays, and advanced cockpit; and pattern recognition. Funding for FY17/18 is \$16.1 million and \$15.5 million.

The funding decrease in FY17 is the result of changing S&T investment priorities within the Department of the Navy, resulting from decreased PE level funding availability resulting in lower investment levels.

Mathematics, Computer & Information Sciences

Efforts in the Mathematics, Computer, & Information Sciences project include: Mathematical foundation and computational theory and tools for design, communication, and control of intelligent autonomous systems; theory, algorithms and tools for decision support; decision theory, algorithms, and tools; heterogeneous information integration, management, and presentation; information assurance, computation and information foundation for cyber defense, secure and reliable information infrastructure for command and control; mathematical optimization for optimal resource allocation and usage; modeling and computation of complex physical phenomena; modeling and computation for electromagnetic and acoustic wave propagation and scattering; seamless, robust connectivity and networking; foundations for novel computing hardware, including nanoscale materials, emerging devices and circuits, emerging computational architecture and nanofabrication. Funding increase in FY16 is the result of Nano-electronics effort moving to this R-2 activity from PE# 0601153N R-2 activity Sensors, Electronics and Electronic Warfare (SEEW). Funding for FY17/18 is \$42.2 million and \$45.4 million. The funding increase in 2018 is the result of increased research initiatives in the area of Extramural Machine Learning, Reasoning and Intelligence.

Materials/Processes

Efforts in the Materials/Processes project include: Structural Materials; functional materials; maintenance reduction; Environmental Sciences; and Manufacturing Science. Accomplishments and plans described below are examples for each effort category. This activity also includes Secretary of Defense directed peer-review basic research to develop innovative solutions and enhance the science and engineering base. Funding for FY17/18 is \$52.9 million and

\$57 million. The funding increase in 2018 is the result of several increased research initiatives in the area of Extramural Structural Materials.

Medical/Biology

Efforts in the Medical/Biology project include: Bioinspired autonomous and surveillance systems, and bio-inspired processes, materials and sensors; synthetic biology for Naval applications; casualty care and management; casualty prevention; undersea medicine/hyperbaric physiology; biorobotics; expeditionary operations training; and stress physiology. These efforts are coordinated with the Army and Air Force through joint program reviews and are complementary, not duplicative. Funding for FY17/18 is \$17.3 million and \$19.1 million. The funding increase in 2018 is the result of increased research initiatives primarily in the area of Naval Biosciences and Synthetic Biology for Sensing & Energy Production.

Ocean Sciences

Efforts in the Ocean Sciences project include: Littoral Geosciences, Optics, and Biology; Marine Mammals; Littoral Geosciences and Optics; Marine Mammals and Biology; Physical Oceanography and Prediction; and Ocean Acoustics. Accomplishments and plans described below are examples for each effort category. Funding for FY17/18 is \$70.5 million and \$75.2 million. The funding increase in 2018 is the result of several increased research initiatives in the areas of Ocean Acoustics, Physical Oceanography Processes, Marine Mammals, and Littoral Geoscience and Optics.

Science and Engineering Education, Career Development and Outreach

Science and Engineering Education Career Development and Outreach activities include DON participation in science fairs, summer research interns/fellows at Navy labor-

atories, graduate fellowships for individuals expected to become members of the engineering faculty at Historically Black Colleges and Universities and Minority Institutions (HBCU/MIs), and curricular enrichment programs. Outreach includes the encouragement, promotion, planning, coordination and administration of Naval Science and Technology. Funding also supports ONRG International Science Program whose mission is to search the globe for emerging scientific research and advanced technologies to enable the Office of Naval Research and the Naval Research Enterprise to effectively address current needs of the Fleet/Forces, and investigate and assess revolutionary, high-payoff technologies for future naval missions and capabilities. This is accomplished through PHD-level Associate Director scientists located in Asia, Europe and South America collaborating with international organizations and researchers through grants in innovative basic research, and establishing quality, relevant connections between international science and technology (S&T) centers of excellence and DON, DOD, and other US Government organizations. The direct impact of this investment is to capitalize on international basic research during unprecedented and dynamic global interdependence, increasing the ability to solve DON S&T challenges through shared knowledge and technologies with partners during a time of budget constraints. Additionally, this investment builds global S&T awareness to reduce the risk of potential technological surprise, and supports theater security cooperation goals to sustain cooperative relationships with an expanding set of international partners to enhance global security. Funding for FY17/18 is \$46.1 million and \$49.8 million. The funding increase in 2018 is the result of increased research initiatives in the areas of STEM and International Outreach.

Sensors, Electronics and Electronic Warfare

Efforts in the Sensors, Electronics and Electronic Warfare project include: the basic research portions of: Sensing, diagnostics, and detectors; navigation and timekeeping; nano-electronics; wide band gap power devices; real-time targeting; Electro-Optical/Infra-Red (EO/IR) electronics; EO/IR electronic warfare; EO/IR sensors for surface/aerospace surveillance; Radio Frequency (RF) sensors for surface/aerospace surveillance; solid state electronics; vacuum electronics; and RF electronic warfare. Funding for FY17/18 is \$46.9 million and \$49.8 million. The funding increase in 2018 is the result of increased research initiatives in the areas of Intramural Electromagnetic Warfare and Intramural Electronics.

Weapons

Efforts in the Weapons project include: undersea weaponry; energetic materials and propulsion; expeditionary operations (communications, materials for forensic sensing, landmine detection, human sensory enhancements, lightweight power sources and information efficiency); directed energy (investment curtailed in 2013); counter directed energy and applied electromagnetics. Funding for FY17/18 is \$18.3 million and \$18.9 million.

Basic Research Challenge

The ONR Basic Research Challenge (BRC) program was established in 2008 to competitively select and fund promising research programs in new areas not addressed by the current basic research program. The program stimulates new, high-risk basic research projects in multidisciplinary and departmental collaborative efforts, and funds topics that foster leading edge science and attract new principal investigators and organizations. Basic Research Challenge awards are for a period of four years. Topics are submitted by ONR program officers and are selected for

BRC awards by ONR's director of research. Basic Research Challenge award topics are then issued as a broad agency announcement. Funding for FY17/18 is \$19.1 million and \$21.4 million.

Applied Research (6.2) Programs

In the applied research (6.2) accounts, the Navy sees \$831.5 million and \$886.0 million and \$899.6 million for FY17/18/19. ONR's Science and Technology Directorate develops and evaluates the feasibility of proposed technological solutions to

specific naval problems. Its research is also ensuring the Navy investments in S&T payoff in meeting operational requirements by identifying and demonstrating promising technologies under realistic conditions.

The following table presents a complete listing of the 6.2 Applied Research programs directed by ONR and the funding level for each for the FY17-20 period (dollars in millions).

Navy Applied Research Programs	FY17	FY18	FY19	FY20
0602114N Power Projection Applied Res.	41.4	13.6	17.7	17.7
0602123N Force Protection Applied Res.	158.7	125.6	124.0	121.9
0602131N USMC Landing Force Tech.	51.6	53.9	60.0	57.0
0602235N Common Picture Applied Res.	41.2	36.5	38.4	38.5
0602236N Warfighter Sustainment App Res.	45.5	48.6	48.4	48.4
0602271N Electromagnetic Sys. Appl. Res.	118.9	79.6	81.0	79.0
0602435N Ocean Warfighting Applied Res.	42.6	42.4	45.1	44.8
0602651N Joint Non-Lethal Weapons Res.	6.3	6.4	6.4	6.4
0602747N Undersea Warfare Applied Res	126.3	56.1	58.0	57.3
0602747N Future Naval Capabilities	165.1	156.8	158.2	156.4
0602782N Mine & Exp. Warfare Appl. Res.	33.9	32.7	37.9	36.5
0602792N Innovative Naval Prototypes	—	171.1	160.3	161.9
0602861N Science & Tech Management	—	62.7	64.2	65.9
Total	831.5	886.0	899.6	891.7

Power Projection Applied Research (PE# 0602114N)

This program element addresses the technology issues involving the Navy's capability to project naval power on the broad seas and in the littoral regions.

In particular, the technology developed in this PE will support Navy power projection requirements related to fleet defense and protection of Naval assets in the littoral area, Naval strike operations against critical shore targets, and support for Naval expeditionary forces ashore. This PE supports the Time Critical Strike (TCS) Future Naval Capability (FNC) and the Autonomous Operations (AO) FNC. Within the Naval Transformation Roadmap, this investment will achieve two of four key transformational capabilities required by Sea Strike as well as technically enable the Littoral Sea Control key transformational capability within Sea Shield.

Total PE funding for FY17/18/19 is \$41.4 million, \$13.6 million and \$17.7 million. Funding remain relatively flat through FY22.

Directed Energy

The goal of the Directed Energy is to develop Directed Energy (DE) technology for Navy applications. The DE program addresses the requirements of future Navy combatants to provide ship defense against the emerging threats that are proliferating throughout the Navies of the world. The Directed Energy portion of this activity consists of two elements. The first element involves applied research and development of technologies supporting advanced accelerators with applications to directed energy weapons. This activity also includes the Free Electron Laser (FEL) Innovative Naval Prototype

(INP) which will deliver multimission capability. Funding for FY17/18 is \$27.8 million and \$11 million. Effective in 2018, the SSL-TM funding moves to the new innovative naval prototype (INP) PE# 0602792N Innovative Naval Prototypes.

High Speed Propulsion and Advanced Weapon Technologies

The high-speed weapons work in this activity is focused on demonstrating propulsion and vehicle technologies for Mach3+ to Mach8 capable weapons. This work includes technologies associated with high acceleration capable projectile structures, high temperature and high strength materials to enable projectiles to survive high speed launch environment, improved thermal prediction methodologies and test techniques, wide dynamic pressure

adaptable projectile controls and non-explosively launched lethal mechanisms. The high speed projectile technologies are intended to support long range Naval Surface Fire Support weapons. Funding for FY17/18 is \$3.8 million and \$4.7 million. Previously, there was a significant decline in funding between FY 2014 to FY 2015 due to transition of the Hypervelocity Projectile to an FNC program PE's 0602750N and 0603673N. The increase in FY2018 is due to increased investment in Hypersonic Propulsion.

Navigation, Electro Optic/Infrared and Sensor Technologies

The Navigation, Electro Optic/Infrared and Sensor Technologies activity describes Navy Science and

Technology (S&T) investments in the areas of EO/IR devices and advanced sensors and includes NRL investment/performance in the technology areas of Electronics, Electronic Warfare, and Communications. Funding for FY17/18 is \$5.8 million and \$2.6 million. The FY 2018 decrease is due to the completion of EW Electro Optic/Infrared efforts.

Strike and Littoral Combat Technologies

The focus of the Strike and Littoral Combat Technologies activity is on those technologies that will support Naval Precision Strike Operations and provide the Navy of the future the ability to quickly locate, target, and strike critical targets ashore. Funding for FY17/18 is \$909,000 thousand and \$1.7 million.

Force Protection Applied Research (PE# 0602123N)

This program element addresses applied research associated with providing the capability of Platform and Force Protection for the U.S. Navy. It supports the development of technologies associated with all naval platforms (surface, subsurface, terrestrial, and air) and the protection of those platforms. The goal is to provide the ability to win or avoid engagements with other platforms or weapons and, in the event of engagement, to resist and control damage while preserving operational capability. Within the Naval Transformational Roadmap, this investment directly supports the Theater Air and Missile Defense transformational capability required by Sea Shield and the Ship to Objective Maneuver key transformational capability. This is accomplished by improvements in platform offensive performance, stealth, and self-defense.

Funding for FY17/18/19 is \$158.7 million, \$125.6 million, and \$124 million.

Aircraft Technology

The Aircraft Technology activity develops technologies for reduced

observables technology and enhanced capability of naval aviation aircraft platforms in terms of mission effectiveness, platform range, responsiveness, survivability, observability, readiness, safety and life cycle cost. It also develops new Naval air vehicle concepts and high impact, saleable naval air vehicle technologies, such as - autonomous air vehicle command and control, helicopter and tilt rotorsystems, aerodynamics, propulsion systems, materials, structures and flight controls for future and legacy air vehicles. Funding for FY17/18 is \$65.5 million and \$39.5 million. The funding decrease from FY 2017 to FY 2018 is due to AA-CUS and joint Tern programs moving to new innovative naval prototypes PE 0602792N Innovative Naval Prototypes.

Fleet Force Protection and Defense Against Undersea Threats

Fleet Force Protection and Defense against Undersea Threats efforts include applied research for complementary sensor and processing technologies for platform

Electromagnetic Guns

The Electro Magnetic (EM) railgun program is focused on developing the technology to launch a long range projectile from Navy ships. The EM railgun is being considered for multi-mission applications including USMC Naval Surface Fire Support, anti-surface warfare (ASUW) and ship self defense from missiles and small boat threats.

Funding for FY17 is \$19.9 million. There will be no funding in FY18. The FY 2017 to FY 2018 funding decrease reflects the realignment of the Electro Magnetic (EM) Railgun program to the new innovative naval prototype (INP) PE 0602792N Innovative Naval Prototypes.

protection and shipboard technologies to increase the survivability of surface ship and submarine platforms against torpedo threats and to develop the capability to interdict underwater asymmetric threats to ships and infrastructure in harbors. Current small platforms (both surface and airborne) have little to no situational awareness (SA) or self-protection against air, surface, and asymmetric threats. A goal of this activity is to provide these platforms with effective self-protection. The technology areas specific to platform protection will develop individual, multispectral electro-optical (EO), infrared (IR), radio frequency (RF), electromagnetic (EM), visual and acoustic or chemical sensors/biosensors and associated processing. To defend platforms from current and advanced threats in at-sea littoral environments and in port, these technologies must improve multispectral detection and distribution of specific threat information. Funding for FY17/18 is \$2.5 million and \$5.7 million.

Advanced Energetics

Efforts in the Surface Ship & Submarine Hull Mechanic & Electrical activity include: reduction addresses electromagnetic, infrared, and acoustic signature tailoring, both topside and underwater. Hull life assurance addresses development of new structural system approaches for surface ships and submarines, including the management of weapons effects to control structural damage and the improvement of structural materials. Hydromechanics addresses hydrodynamic technologies, including the signature aspects of the hull-propulsor interaction and maneuvering. Distributed intelligence for automated survivability addresses both the basic technology of automating machinery control systems, as well as, distributed control of systems utilizing autonomy for mission context based reconfiguration. Unmanned Sea Surface Vehicle applied research includes short-term motion forecasting for recovery of USSVs on a host ship in higher sea states and determination of slamming loads on high-speed planing hulls for structural weight reduction. Advanced naval power systems efforts address electrical and auxiliary system and component technology to provide improvement in energy and power density, operating efficiency and recoverability from casualties. Advanced Naval Power efforts include: developing technologies to improve warfighting capability with more energy efficient systems; reducing the time & cost to certify alternative fuels, and mitigate adverse alternative fuel impacts on Naval platforms and equipment; developing sustainable biomass models to support alternative fuel availability to Naval forces; utilizing the Electric Ship Research and Development Consortium (ESRDC) efforts to develop modeling and simulation tools to provide critical design & operational capabilities for the all-electric ship program, accelerate development and demonstration of technologies, reduce risk of new technology insertion and address the

national shortage of electrical power engineers. Efforts for ONR Science Advisors are also funded in this R-2 Activity. Long Endurance UUV technologies will deliver to the Office of Naval Research modular fuel cell systems for UUVs, including practical systems demonstrations, and a path forward for future developments. It will also keep the US Navy at the forefront of advanced electric propulsion technologies. Funding for FY17/18 is \$5.3 million and \$5.3 million.

Surface Ship & Submarine Hull Mechanical & Electrical (HM&E)

The Surface Ship and Submarine Hull Mechanical & Electrical (HM&E) activity efforts include: signature reduction, hull life assurance, hydromechanics, distributed control for automated survivability (includes damage control), and advanced naval power systems. Signature reduction addresses electromagnetic, infrared, and acoustic signature tailoring, both topside and underwater.

Hull life assurance addresses development of new structural system approaches for surface ships and submarines, including the management of weapons effects to control structural damage and the improvement of structural materials.

Hydromechanics addresses hydrodynamic technologies, including the signature aspects of the hull-propulsor interaction and maneuvering.

Distributed intelligence for automated survivability addresses both the basic technology of automating machinery control systems, as well as, distributed control of systems utilizing autonomy for mission context based reconfiguration.

Unmanned Sea Surface Vehicle applied research includes short-term motion forecasting for recovery of USSVs on a host ship in higher sea states and determination of slamming loads on high-speed planing hulls for structural weight reduction.

Advanced naval power systems efforts address electrical and auxiliary system and component technology to provide improvement in energy and power density, operating efficiency and recoverability from casualties.

Advanced Naval Power efforts include: developing technologies to improve warfighting capability with more energy efficient systems; mitigate adverse impacts of alternative fuel on Naval platforms and equipment; and utilizing the Electric Ship Research and Development Consortium (ESRDC) efforts to develop modeling and simulation tools to provide critical design & operational capabilities for the all-electric ship program, accelerate development and demonstration of technologies, reduce risk of new technology insertion and address the national shortage of electrical power engineers.

Long Endurance UUV technologies will deliver to the Office of Naval Research modular fuel cell systems for UUVs, including practical systems demonstrations, and a path forward for future developments. It will also keep the US Navy at the forefront of advanced electric propulsion technologies.

Funding for FY17/18 is \$80.9 million and \$70.4 million. The funding decrease from FY 2017 to FY 2018 is due to the realignment of the Medium Displacement Unmanned Surface Vehicle (MDUSV) Leap Ahead effort to a new PE# 0602792N Innovative Naval Prototypes (INP) Applied Research for consolidation of the Leap Ahead/INP portfolio.

Naval Research Enterprise

The IAR R2 activity was stood up in FY13 as the Naval Research Enterprise (NRE) to consolidate all NRE related IAR investments. Projects funded in this R2 Activity are intended to be approximately 2-3 years in length. Based on historical trends approximately 30% of these projects will turn over each year. The Naval Research Enterprise (NRE)

encompasses the Independent Applied Research (IAR) efforts focused on solving a wide range of Naval Science and Technology (S&T) fleet issues utilizing unique Naval Warfare Center (WC) laboratory capabilities. Efforts under this activity address the full spectrum of the DON S&T Strategic Plan technology using focus areas which engage Naval aviation, sea surface, undersea, space, weapons, communication, information, and human systems. The IAR Program provides participating WCs with in-house funding for applied research to support the execution of their assigned missions by:

- Developing and maintaining a cadre of active researchers who can distill and extend results from worldwide research and apply them to solve Naval problems.
- Promoting the hiring and development of talented new scientists and engineers (S&E) with the insurance of proper mentoring with senior personnel.
- Encouraging collaboration with universities, private industry, and other Navy and Department of Defense laboratories.

Funded projects are chosen through rigorous internal competi-

tion by each WC's selection committee and typically last two to three years. IAR projects are generally designed to promote investment in high-risk/high-payoff research and also allow young S&Es to manage Navy relevant research projects. A limited number of successful efforts developed under the In-House Laboratory Independent Research (ILIR) basic research PE# 0601152N are matured and further developed under the IAR program with the goal of transitioning these technologies to the warfighter.

Funding for FY17/18 is \$4.5 million and \$4.6 million.

Marine Corps Landing Force Technology (PE# 0602131M)

The efforts described in this program element are based on investment directions as defined in the Naval Science and Technology (S&T) Strategic Plan approved by the S&T Corporate Board (March 2010). This strategy is based on needs and capabilities from Navy and Marine Corps guidance and input from the Naval Research Enterprise (NRE) stakeholders (including the naval enterprises, the combatant commands, the Chief of Naval Operations (CNO), and Headquarters Marine Corps). It provides the vision and key objectives for the essential science and technology efforts that will enable the continued supremacy of US Naval forces in the 21st century. The Strategy focuses and aligns Naval S&T with Naval missions and future capability needs that address the complex challenges presented by both rising peer competitors and irregular/asymmetric warfare.

This PE is organized into nine activities which are represented as seven Expeditionary Warfighting Capability Areas, as well as Future Concepts, Technology Assessment and Roadmapping, and the Littoral Combat/Power Projection (LC/PP) FNC. The primary objective of this PE is to develop and demonstrate the technologies needed to meet the Marine Corps' unique responsibility of training and equipping the Marine Air/Ground Task Force (MAGTF) for Expeditionary Maneuver Warfare. This PE provides the knowledge base to support Advanced Technology Development (6.3) and is the technology base for future expeditionary warfare capabilities. This PE supports the Expeditionary Force Development System of the Marine Corps Combat Development Command (MCCDC) and responds directly to the Marine Corps Science and Technology (S&T) process as well as supporting related Littoral

and Expeditionary Maneuver Warfare capabilities developed by the Navy's Mission Capability Program. The Future Naval Capabilities (FNC) process is supported and funds are programmed accordingly. The FNC program explores and demonstrates technologies that enable Sea Strike, Sea Shield, Sea Basing and FORCE-net pillars. The core 6.2 program also supports Discovery and Invention (D&I) and Innovation and Transformation (I&T). Within the Naval Transformation Roadmap, this investment will achieve key transformational capabilities required by the Sea Power 21 Pillars, as well as enable Ship to Objective Maneuver (STOM), Persistent Intelligence, Surveillance and Reconnaissance and Overseas Contingency Operations (OCO).

Funding for FY17/18/19 is \$51.6 million, \$53.9 million, and \$60 million. Past FY19, funding will drop back down to \$52 million by FY22.

Common Picture Applied Research (PE# 0602235N)

Work in this program element is based on investment directions as defined in the Naval Science and Technology (S&T) Strategic Plan approved by the S&T Corporate Board. This strategy is based on needs and capabilities from Navy and Marine

Corps guidance and input from the Naval Research Enterprise (NRE) stakeholders (including the Naval enterprises, the combatant commands, the Chief of Naval Operations (CNO), and Headquarters Marine Corps). It provides the vision and key

objectives for the essential science and technology efforts that will enable the continued supremacy of U.S. Naval forces in the 21st century. The Strategy focuses and aligns Naval S&T with Naval missions and future capability needs that address the

complex challenges presented by both rising peer competitors and irregular/asymmetric warfare.

Total PE funding for FY17/18/19 is \$41.2 million, \$36.5 million and \$38.4 million.

Communication and Networks

The overarching objective of the Communications and Networks activity is to develop high throughput dynamic wireless communications and networks technologies critical to the mission performance and robustness of naval communications for widely dispersed mobile air, land, surface and submerged platforms. These platforms are often size, weight and power (SWaP) limited, and will operate under constraints of cluttered RF spectrum, harsh electromagnetic interference (EMI) and Beyond Line Of Sight (BLOS) conditions. The technical payoff is increased network data rates, interoperability across heterogeneous radios, dynamic bandwidth management, and greater mobile network connectivity. The operational payoff is that warfighters from the operational command to the tactical edge have near real-time access to information, knowledge and decision-making necessary to perform their tasks, including coalition and allied forces. Emphasis is on tactical edge communications and networks to fully realize net-centric warfare, bridging the GIG and the 'disadvantaged user', e.g., small-deck combatants, submarines, unmanned vehicles, distributed sensors and ground units in urban and radio frequency (RF) challenged environments. Funding for FY17/18 is \$7.2 million and \$7.3 million.

Warfighter Sustainment (PE# 0602236N)

This PE supports the Future Naval Capabilities (FNCs) of Expeditionary Logistics, Littoral Combat/Power Projection, and Total Ownership Cost (TOC) Reduction; and innovation-based efforts that will provide

Applied Information Sciences For Decision Making

The goal of the Applied Information Sciences for Decision Making activity is to develop enablers for decision making and mission execution, to achieve battlespace superiority. It focuses on the development of algorithms and software technologies that identify and integrate informational content from multiple sources, leading to decision aids that support user-cognitive processes. Because persistent sensors are generating massive amounts of data, the focus is on technologies that not only integrate information from diverse sources, but also provide indications of information significance in ways that support the user's decision needs, regardless of location and operational situation. To achieve this, it must be possible to automate understanding of the battlespace by identifying objects, determining relationships among the objects, assessing intent, and automatically generating courses of action with associated risks and uncertainty. Effort will also be devoted to developing technology for increasing assurance and security for C3 information systems and technology for improving information discovery and information presentation in such systems. The Nano Electronics Technology activity is focused on developing ultra-low power, higher performance computing devices and components that are based on novel functionalities of nanometer scale materials and are enabled by improved understanding of nanomaterials, new devices and circuit design concepts, as well as new architectures uniquely suited for nanoscale systems. Funding for FY17/18 is \$25.2 million and \$22.5 million.

Multi-Source Integration and Combat Identification

The Multi-Source Integration and Combat Identification activity addresses theater air and missile defense (TAMD), and responds to warfighter needs for rapid, high confidence Combat Identification (CID) of air and missile threats at long range using real time and non-real time threat attributes and intelligence information. Funding for FY17/18 is \$2.9 million and \$1.5 million.

Tactical Space Exploitation

The Tactical Space Exploitation initiative explores the application of new space craft technologies on small, light-weight and low-cost satellites, to enhance naval warfighting capabilities by taking advantage of the global access, revisit and connectivity provided by orbital platforms. Funding for FY17/18 is \$5.9 million and \$5.1 million.

Autonomous Systems and Robotics

The Autonomous Systems and Robotics initiative explores the application of new technologies to advance capabilities in the area of robotics, autonomous systems propulsion and control, and integration of autonomous systems. Efforts will be focused on the Assistant Secretary of Defense (Research and Engineering) (ASD(R&E)) priorities in autonomous systems. Funding for FY16 is \$2 million. There is no funding beyond FY16 reflecting the completion of the efforts for sustainment of Autonomous Systems and Robotics initiative.

technology options for future Navy and Marine Corps capabilities. Efforts focus on manpower and personnel; naval systems training; expeditionary logistics; littoral combat and

power projection capabilities; advanced naval materials; medical technologies; environmental quality; biocentric technologies; high speed sealift; cost reduction technologies; and sea-basing technologies. Within

the Naval Transformation Roadmap, this investment supports eight transformational capabilities within the "Sea Strike", "Sea Shield", and "Sea Basing" operational concepts; the critical human system, "Sea Warrior"; and Naval business efficiencies within "Sea Enterprise."

Total PE funding for FY17/18/19 is \$45.5 million, \$48.6 million and \$48.4 million.

Advanced Naval Materials

Advanced Naval Materials efforts include: developing advanced, high-performance materials; processes to reduce weight and cost; and enhanced sonar transducers. Funding for FY17/18 is \$8.7 million and \$11 million. The funding increase from FY17 to FY18 is due to increased emphasis and investment in structural materials applied research.

Biocentric Technologies

Biocentric technologies provide novel solutions for naval needs based upon the applications of biosensors, biomaterials, and bioprocesses. Topic areas include, but are not limited to development of biologically-based signal processing for medical, surveillance and security applications; bio-inspired robotics; microbial or plant engineering to produce high-value naval materials such as energetic compounds or to develop sentinel organisms, and marine mammal diagnostics to support the Navy's Fleet Marine Mammal Systems. Funding for FY17/18 is \$5.6 million and \$5.7 million.

Environmental Quality

Environmental Quality technologies enable sustained world-wide Navy operations in compliance with all local, state, regional, national and international laws, regulations and agreements, and support the Navy Transformational Roadmap in the areas of Sea Basing, Sea Strike and Sea Warrior. Compliant operations enable training evolutions and exercises

that are critical for maintaining readiness. Funding for FY17/18 is \$2.6 million and \$2.6 million.

Human Factors and Organizational Design

The Human Factors and Organizational Design objective of this activity is the achievement of FORCEnet and Sea Power 21 goals by developing human factors principles and cognitive models for human centric design, decision support systems for collaborative decision making, and adaptive command and control structures. The CNO's new Maritime Strategy and the Commander Fleet Forces Command complementary plan to revise organization of Maritime Operations Centers (MOC) place high priority on the aforementioned FORCEnet and Sea Power 21 goals. Specific objectives focus on improving small team, platform, task force, and battle group operations by developing advanced human factors technologies for incorporation into operational systems. The goals and payoffs are to enhance human performance effectiveness; improve the timeliness and quality of decision making; develop strategies to mitigate high workload and ambiguity; reduce manning; improve situational awareness and speed of command through a deeper understanding of human capabilities and limitations; and improvement of team decision making in ad-hoc, complex problem solving scenarios. Funding for FY17/18 is \$5.1 and \$5.2 million.

Medical Technologies

The Medical Technologies program supports the development of field medical equipment, diagnostic capabilities and treatments; technologies to improve warfighter safety and to enhance personnel performance under adverse conditions; and systems to prevent occupational injury and disease in hazardous, deployment environments. Navy investment in these areas is essential because Navy/USMC mission needs are not adequately addressed by the

civilian sector or other Federal agencies. For example, civilian emergency medicine does not address casualty stabilization during long transit times to definitive care. The National Institutes of Health (NIH) focuses on the basic science of disease processes and not applied research related to development. Funding for FY17/18 is \$6.4 million and \$6.5 million.

The Office of Naval Research Global

ONR has a presence overseas, with an overarching purpose to search the globe for promising, emerging scientific research and development efforts to address the current needs of the Fleet/Forces, and investigate high-payoff technologies for future naval missions and capabilities. To accomplish this task, ONR capitalizes on global innovation and investment to solve U.S. Navy and Marine Corps science and technology (S&T) challenges, builds global S&T awareness to mitigate risk of potential technological surprise, ensures Fleet/Forces capability needs are communicated to the Naval Research Enterprise (NRE), and facilitates delivery of Naval S&T solutions to the Fleet/Forces. Funding for FY17/18 is \$12.2 and \$12.8 million.

Training Technologies

Training technologies enhance the Navy's ability to train effectively and affordably in classroom settings, in simulated environments, while deployed, and to operate effectively in the complex, high-stress, information-rich and ambiguous environments of modern warfare such as asymmetric warfare. Technology development responds to a variety of requirements, including providing more affordable approaches to training and skill maintenance. Improved training efficiency and cost-effectiveness is achieved by applying operations research, modeling and simulation, and instructional, cognitive, and computer sciences to the development, delivery, evaluation, and execution of training. Funding for

FY17/18 is \$4.9 million and \$5 million.

Electromagnetic Systems Applied Research (PE# 0602271N)

The efforts described in this program element are based on investment directions as defined in the Naval S&T Strategic Plan approved by the S&T Corporate Board. This strategy is based on needs and capabilities from Navy and Marine Corps guidance and input from the Naval Research Enterprise (NRE) stakeholders (including the naval enterprises, the combatant commands, the Chief of Naval Operations (CNO), and Headquarters Marine Corps). It provides the vision and key objectives for the essential science and technology efforts that will enable the continued supremacy of US Naval forces in the 21st century. The Strategy focuses and aligns Naval S&T with Naval missions and future capability needs that address the complex challenges presented by both rising peer competitors and irregular/asymmetric warfare.

The Electromagnetic Systems Applied Research Program addresses technology needs associated with Naval platforms for new capabilities in EO/IR Sensors, Surveillance, Electronic Warfare, Navigation, Solid State Electronics, Vacuum Electronics Power Amplifiers, and Nanoelectronics. The program supports development of technologies to enable capabilities in Missile Defense, Directed Energy, Platform Protection, Time Critical Strike, and Information Distribution. This program directly supports the Department of Defense Joint Warfighter Plan and the Defense Technology Area Plans. Activities and efforts within this Program have attributes that focus on enhancing the affordability of warfighting systems. The program also provides for technology efforts to maintain proactive connectivity and collaboration between Department of the Navy (DON) Science and Technology (S&T) and Joint, Navy, and Marine Corps commands worldwide.

Funding for FY17/18/19 is \$118.9 million, \$79.6 million and \$81 million.

Electronic Warfare Technology

The overarching objective of the Electronic Warfare Technology (formerly RF Electronic Warfare Technology) activity is to develop technologies that enable the development of affordable, effective and robust Electronic Warfare (EW) systems across the entire electromagnetic spectrum that will increase the operational effectiveness and survivability of US Naval units. Emphasis is placed on passive sensors and active and passive countermeasure (CM) systems that exploit and counter a broad range of electromagnetic threats. The focus is on maintaining near perfect real-time knowledge of the enemy; countering the threat of missiles against deployed naval forces; precision identification and location of threat emitters; and development of technologies that have broad application across multiple disciplines within the EW mission area. This activity also includes developments to protect these technologies from external interference and modeling and simulation required to support the development of these technologies. Also included is technology development in support of the Integrated Distributed Electronic Warfare System (IDEWS) concept. Funding for FY17/18 is \$70.3 million and \$44 million. The decrease in funding from FY17 to FY18 is due to the completion of exploratory research into advanced technologies to counter emerging threats operating in higher bands of the radio frequency spectrum utilizing extreme spectral and temporal agility.

EO/IR Sensor Technologies

The overarching objective of the EO/IR Sensor Technologies thrust is to develop technologies that enable

the development of affordable, wide area, persistent surveillance optical architectures, day/night/all weather, adaptable, multimission sensor technology composed of optical sources, detectors, and signal processing components for search, detect, track, classify, identify (ID), intent determination, and targeting applications and includes developments to protect these technologies from external interference. Also included are modeling and simulation required to support the development of these technologies. Efforts will also include the development of optical RF components, infrared technologies including lasers and focal plane arrays using narrow bandgap semiconductors. The current specific objectives are: a) Optically Based Terahertz (THz) and Millimeter Wave Distributed Aperture Systems; Wide Area Optical Architectures; Hyperspectral sensors and processing; Coherent Laser Radar (LADAR); and Autonomous and Networked sensing. Funding for FY17/18 is \$5.3 and \$7.1 million.

Navigation Technology

The overarching objective of the Navigation Technology activity is to develop technologies that enable the development of affordable, effective and robust Position, Navigation and Timing (PNT) capabilities using the Global Positioning System (GPS), non-GPS navigation devices, and atomic clocks. This project will increase the operational effectiveness of US Naval units. Emphasis is placed on GPS Anti-Jam (AJ) Technology; Precision Time and Time Transfer Technology; and Non-GPS Navigation Technology (Inertial aviation system, bathymetry, gravity and magnetic navigation). The focus is on the mitigation of GPS electronic threats, the development of atomic clocks that possess unique long-term stability and precision, and the development of compact, low-cost Inertial

Navigation Systems (INS). The current specific objectives are: GPS AJ Antennas and Receivers; Precision Time and Time Transfer Technology; and Non-GPS Navigation Technology. Funding for FY17/18 is \$7.3 million and \$6.1 million.

Solid State Electronics

The overarching objective of the Solid State Electronics activity is to develop higher performance components and subsystems for all classes of military RF systems that are based on solid state physics phenomena and are enabled by improved understanding of these phenomena, new circuit design concepts and devices, and improvements in the properties of electronic materials. An important subclass are the very high frequency (VHF), ultra-high frequency (UHF), microwave (MW), and millimeter wave (MMW) power amplifiers for Navy all-weather radar, surveillance, reconnaissance, electronic attack, communications, and smart weapons systems. Another subclass are the analog and high speed, mixed signal components that connect the electromagnetic signal environment into and out of digitally realized, specific function systems. These improved components are based on both silicon (Si) and compound semiconductors (especially the wide bandgap materials and narrow bandgap materials), low and high temperature superconductors, novel nanometer scale structures and materials. Components addressed by this activity emphasize the MMW and submillimeter wave (SMMW) regions with an increasing emphasis on devices capable of operating in the range from 50 gigahertz (GHz) to 10 terahertz (THz). The functionality of the technology developed cannot be obtained through Commercial-Off-the-Shelf (COTS)

Ocean Warfighting Environment Applied Research (PE# 0602435N)

This program element provides the unique, fundamental programmatic instrument by which basic research on the natural environment is

as a result of the simultaneous requirements placed on power, frequency, linearity, operational and instantaneous bandwidth, weight, and size. Effort will involve understanding the properties of engineered semiconductors as they apply to quantum information science and technology. This activity also includes Anti-Tamper development of innovative techniques and technologies to deter the reverse engineering and exploitation of our military's critical technology and critical program information in order to impede technology transfer and alteration of system capability and prevent the development of countermeasures to U.S. systems. Funding for FY17/18 is \$12.9 and \$11 million.

Surveillance Technology

The overarching objective of the Surveillance Technology (formerly RF Surveillance Technology) activity is to develop advanced sensor and sensor processing systems for continuous high volume theater-wide air and surface surveillance, battle group surveillance, real time reconnaissance and ship defense. Major technology goals include long-range target detection and discrimination, target identification (ID) and fire control quality target tracking in adverse weather, background clutter and electronic countermeasure environments and includes modeling and simulation required to support the development of these technologies. Funding for FY17/18 is \$9.7 million and \$9 million.

Vacuum Electronics Power Amplifiers

The overarching objective of the Vacuum electronics Power Amplifiers (formerly RF Vacuum Electronics Power Amplifiers) activity is to

transformed into technological developments that provide new or enhanced warfare capabilities for the Battlespace Environment (BSE). The objectives of this program are met

develop millimeter wave (MMW) and sub-MMW power amplifiers for use in Naval all-weather radar, surveillance, reconnaissance, electronic attack, and communications systems. The technology developed cannot, for the most part, be obtained through commercial off the shelf (COTS) as a result of the simultaneous requirements placed on power, frequency, bandwidth, weight, and size. Responding to strong interests from the various user communities, efforts are focused on the development of technologies for high-data-rate communications, electronic warfare and high-power radar applications at MMW and upper-MMW regime. Funding for FY17/18 is \$2.7 million and \$2.4 million.

NEMESIS INP

The objective of the Netted Emulation of Multi-Element Signatures Against Integrated Sensors (NEMESIS) Innovative Naval Prototype is to develop a System of Systems (SoS) able to artificially create the appearance of a realistic naval force to many adversary surveillance and targeting sensors simultaneously. It will benefit the warfighter by providing battlespace confusion to adversary surveillance and targeting systems, both above and below water, creating seamless cross-domain countermeasure coordination, and enabling rapid advanced technology/capability insertion to counter emerging threats. Starting in FY 2018, all Innovative Naval Prototype (INP) and Leap Ahead Technology (LA-Tech) investments in Electromagnetic Maneuver Warfare will be shown in the new INP PE 0602792N Innovative Naval Prototypes to better convey exactly what the Office of Naval Research is working on in this area.

through measuring, analyzing, modeling and simulating, and applying environmental factors affecting naval material and operations in the BSE.

This program provides for BSE technological developments that contribute to meeting top joint warfare capabilities established by the Joint Chiefs of Staff, with primary emphasis on Joint Littoral Warfare and Joint Strike Warfare.

Funding for FY17/18/19 is \$42.6 million, \$42.4 million and \$45.1 million.

Coastal Geosciences/Optics

The goal of the Coastal Geosciences/Optics activity is to determine the sources, distribution, and natural variability (concentration and properties) of optically important matters in the coastal ocean in support of Naval Mine, Undersea, and Special Warfare. Research investments in this activity support the development and testing of expendable and autonomous bioluminescence sensors, the continued development of extended range underwater imaging technologies, and algorithm development and testing for application to ocean color remote sensing from aircraft and space in order to characterize key features of the coastal battle space such as bathymetry, shallow-water bottom types, and the distribution of ocean water optical properties. Funding for FY17/18 is \$6.6 million and \$7.9 million.

Marine Mammals and Biology

The Marine Mammals and Biology activity consolidates and expands research conducted in previous years in Coastal Geosciences/Optics and the Physical Oceanography Activities and expands these efforts. The sensitivity of Marine Mammals to sound produced by Naval operations and training will continue. This program is to assure that Navy decisions can be based on scientifically defensible positions. Funding for FY17/18 is \$3.4 million and \$3.4 million.

Marine Meteorology

The marine atmosphere affects most aspects of naval operations. This activity develops observing

technologies, models, Numerical Weather Prediction (NWP) systems and Tactical Decision Aids (TDA) that describe the atmospheric environment and its impacts on naval sensors and operations. The Marine Meteorology activity focuses on uniquely marine aspects of atmospheric science such as air-sea interaction, coupled ocean atmosphere modeling, EM and EO propagation, coastal meteorology, Tropical Cyclone (TC) prediction, and the use of remote sensing to obtain quantitative observations of atmospheric properties. Aspects of the atmospheric environment of particular interest include near-surface phenomena that affect refractivity, marine boundary layer dynamics that affect clouds, rain, visibility and fog, and processes that control TC structure, track, and intensity. Objectives of this activity are improved NWP systems and TDAs that provide NOWCAST and forecast skill at global, regional, and tactical scales for operational support, sensor and system development, and performance prediction. Funding for FY17/18 is \$10.8 million and \$9.4 million.

National Oceanographic Partnership Program

The National Oceanographic Partnership Program activity focuses on US Navy investments in the NOPP. NOPP, established by the US Congress (Public Law 104-201) in Fiscal Year 1997, is a unique collaboration among 15 federal agencies involved in conducting, funding, or utilizing results of ocean research. NOPP's value to the Navy derives from the capacity of the partnership to enable and ensure multi-agency efforts where such collaboration enhances efficiency or effectiveness, and/or reduces costs. Major areas of investment by NOPP include: development of an integrated coastal ocean observation system and development of sensors, communications and data acquisition, storage and processing tools required to affect it, moderniza-

tion of ocean research and observation infrastructure, and marine mammal-related research. Funding for FY17/18 is \$8.6 million and \$8.6 million.

Ocean Acoustics

The Ocean Acoustics activity is dedicated to the determination of the impact of the natural ocean environment on acoustic wave phenomena in support of naval undersea warfare and underwater force protection operations. This activity studies underwater acoustic propagation, scattering from ocean boundaries, and ambient noise issues that impact the development and employment of acoustic systems. The Littoral Zone (LZ) has been the ocean environment of greatest interest. Aspects of this environment, that greatly impact underwater acoustic systems, are the shallow water included in the Littoral Zone, the consequent closeness and physical significance of the ocean bottom, and the complexities inherent to rapid changes of the ocean structure. Funding for FY17/18 is \$2.3 million and \$2.1 million.

Physical Oceanography

The goal of the Physical Oceanography activity is to develop naval tactical uses of knowledge of the physics of the ocean within the BSE. This is achieved through the development of predictive models of the water mass structure, waves, currents, and air-sea interactions and developing measurement/observation technology. Other applications utilize knowledge of the interaction of the water column hydrodynamics and the acoustics to predict the undersea transmission characteristics and sources of uncertainty in these statistics. Utilizing knowledge of the ocean surface physics, the physical oceanography program seeks to exploit the combination of remotely sensed data, in-situ data, and adaptively sampled data to optimize predictions of ocean currents and water column structure.

Funding for FY17/18 is \$10.8 million and \$11 million.

Joint Non-Lethal Weapons Applied Research (PE# 0602651M)

The DOD's Joint Non-Lethal Weapons Program (JNLWP) was established by the Secretary of Defense, who assigned centralized responsibility for DoD joint research and development of non-lethal technology to the Commandant of the Marine Corps as the Executive Agent. The Under Secretary of Defense for Acquisition, Technology and Logistics provides direct oversight of the JNLWP. The efforts described in this Program Element (PE) reflect science and technology (S&T) investment decisions provided by the Joint Non-Lethal Weapons (NLW) Integrated Product Team, a multi-service flag level corporate board that executes the JNLWP for the Commandant of the Marine Corps. This direction is based on the needs and capabilities of the Services, the

Special Operations Command, and the Coast Guard, as identified in the DoD's Non-Lethal Weapons Joint Capabilities Based Assessment Document. This coordinated joint S&T development approach addresses mutual capability gaps and assures the best non-lethal technologies and equipment are provided to the operating forces while eliminating duplicative service S&T investment.

This program funds the applied research, study, assessment, and demonstration of technologies that could provide a non-lethal capability or target effect. Investment areas include applied research related to: non-lethal directed energy weapons (lasers, millimeter wave and high power microwave) for counter-personnel and counter materiel missions; non-lethal acoustic and optical

technologies; advanced non-lethal materials (including stopping materials for vehicle/vessel stopping and counter-facility applications); associated human effects and effectiveness for new non-lethal stimuli; injury potential and effectiveness of directed energy, electric stun, ocular, and acoustic based non-lethal technologies; and developing models of crowd behavior and dynamics. This program transitioned from PE 0602114N, Power Projection Applied Research, by order of the Under Secretary of Defense for Acquisition, Technology, and Logistics, to this separate PE for Joint Non-Lethal Weapons Applied Research.

Funding for FY17/18/19 is \$6.3 million, \$6.4 million and \$6.4 million.

Undersea Warfare Applied Research (PE# 0602747N)

This program element funds applied research efforts in undersea target detection, classification, localization, tracking, and neutralization is funded through this PE. Technologies being developed within this PE are aimed at enabling Sea Shield, one of the core operational concepts detailed in the Naval Transformational Roadmap. Associated efforts focus on new Anti-Submarine Warfare (ASW) operational concepts that promise to improve wide-area surveillance, detection, localization, tracking, and attack capabilities against quiet adversary submarines operating in noisy and cluttered shallow water environments. Related efforts are aimed at leveraging technologies that will protect the country's current capital investment in surveillance, submarine, surface ship, and air ASW assets. Research focused on understanding the impacts on marine mammals of manmade underwater sound is also conducted in the Program Element.

Funding for FY17/18/19 is \$126.3 million, \$56.1 million and \$58 million. The funding decrease from FY17 to FY18 reflects the realignment of the Innovative Naval Prototype (INP) Forward Deployed Energy & Communications Outpost (FEDCO), the INP Anti-Submarine Warfare Mission Package (ASW MP), and the INP Large Displacement Unmanned Underwater Vehicle (LDUUV) to the new PE 0602792N Innovative Naval Prototypes Applied Research.

ASW Distributed Search

Anti-Submarine Warfare (ASW) Distributed Search focuses the development of technologies for the non-covert tactical search for undersea targets ranging from hours to weeks using automated sensor systems deployed around operating areas including along key transit routes to protect naval/maritime forces, around temporarily fixed sea base re-

gions and naval force operating areas, or around fixed defensive regions and areas of interest such as key US/Allied ports. "Non-covert" implies availability of airborne assets for sensor deployment (although other means may also be used), and the ability to employ active sonar along with passive and non-acoustic methods. "Search" is conducted in concentrated areas, typically exploiting cues received from surveillance systems. The submarine target must be detected beyond its weapons release range. The objective is to develop rapidly deployable systems employing automated detection and classification capabilities for use in both shallow and deep water operating environments. Distributed Search supports the ASW protected passage Maritime Shield operational constructs. Related efforts include the development of distributed systems employing optimization as well as active acoustic sensing and processing techniques, navy-unique

transduction and underwater networking technology. Efforts also include the development of Unmanned Undersea Vehicle-based and affordable off-board deployable sensing systems employing persistent detection concepts and components. These efforts provide an extended reach of organic platform-based systems through the use of new sensor concepts, improved materials for advanced sensors, optimized deployment, employment, and automated operation of distributed sensor fields. The cornerstone of Distributed Search is the development of rapidly deployable, long-endurance active sensors with automated processing suitable for use in a wide variety of operational environments. Funding for FY17/18 is \$29.9 million and \$15.3 million. The funding decreases from FY17 to FY18 are due to the move of the Forward Deployed Energy & Communications Outpost (FDECO) INP Program to a new innovative naval prototype PE 0602792N Innovative Naval Prototypes Applied Research.

ASW Precision Localization

Precision Localization focuses on the development and demonstration of technologies which use information from surveillance or search systems to determine an area of uncertainty (AOU) relative to target range, bearing, and depth adequate to handoff to an attack system. Precision Localization employs non-acoustic techniques such as magnetic sensing and wake trailing to highly localize submerged threats. The objective is to increase magnetic sensor

Future Naval Capabilities (PE# 0602750N)

The efforts described in this program element address the Applied Research associated with the Future Naval Capabilities (FNC) Program. The FNC Program represents the requirements-driven, delivery-oriented portion of the Navy Science and Technology (S&T) portfolio. FNC investments respond to Naval S&T Gaps that are identified by the Navy

and robustness, enable deployment on Unmanned Air Vehicles (UAVs), and increase wake trailing search rates. Efforts include the development of nontraditional tracking and advanced magnetic and electric field sensors and processing. These technologies will provide a decreased AOU size thus enabling the effective use of smaller, more versatile torpedoes as well as increased performance gain in detection, targeting, tracking/trailing, and homing via wake acquisition and covert prosecution. Funding for FY17/18 is \$3.4 million and \$3.5 million.

ASW Surveillance

ASW Surveillance focuses on dramatically improving detection, classification, and localization capabilities in large ocean areas relative to the capabilities of legacy ASW surveillance systems. The related technologies support the conduct of covert wide-area surveillance ranging from one day to six months. The objectives are to develop and demonstrate technologies that provide clandestine indications and warnings in far forward and contested operating areas and in complex operational environments against all submarine threats including new threats with unknown target signatures and tactics. Funding for FY17/18 is \$77.2 million and \$21.6 million. The FY17 to FY18 funding decreases due to the INP-Large Displacement Unmanned Underwater Vehicle (LDUUV) & INP Anti Submarine Warfare Mission Packages (ASW MP) moving

and Marine Corps after receiving input from Naval Research Enterprise (NRE) stakeholders. The Enabling Capabilities (ECs) and associated technology product investments of the FNC Program are competitively selected by a 3-star Technology Oversight Group (TOG), chartered by the S&T Corporate Board and rep-

resenting the requirements, acquisition, research and fleet/forces communities of the Navy and the Marine Corps.

Marine Mammals

The goal of the Marine Mammals activity is to support: (1) marine mammal research related to understanding impacts of underwater sound (especially sonar) on marine mammal behavior, hearing, physiology, distributions and ecology; (2) development and testing of new technologies for the detection of marine mammals at sea; (3) research on the bio-acoustic properties, use of sound for detection of, and effects of sound on fish and lesser marine organisms; and (4) research on optically important biota in the coastal ocean in support of Naval Mine, Undersea, and Special Warfare (including oceanic bioluminescence and the development and testing of bioluminescence sensors). Funding for FY17/18 is \$2.6 million and \$2.5 million.

Undersea Weaponry

Undersea Weaponry focuses on the development of enabling technologies to counter threat submarines and surface vessels by increasing Probability of Kill and platform survivability. Weapon technology focus areas include: Explosives and Warheads, Guidance and Control (G&C), Multidisciplinary Systems Design & Optimization (MSDO) (comprising Simulation Based Design, Silencing, and Propulsion), Power Sources, Supercavitation, and Counter Weapons/Counter Measures. Funding for FY17/18 is \$13.2 million and \$13.2 million.

resenting the requirements, acquisition, research and fleet/forces communities of the Navy and the Marine Corps.

Funding for FY17/18/19 is \$165.1 million, \$156.8 million and \$158.2 million. Funding is expected to be just under \$183 million in FY22.

Capable Manpower

The Capable manpower activity contains all Future Naval Capabilities (FNC) Program Enabling Capability (ECs) investments in this PE that are aligned to the Capable Manpower (CMP) FNC pillar. The CMP Pillar develops deliverable technologies that provide new capabilities in manpower and personnel management, training and education, and human-systems integration for more intuitive systems. Funding for FY17/18 is \$9.8 million and \$9.9 million.

Enterprise and Platform Enablers

The Enterprise and Platform Enablers activity contains all Future Naval Capabilities (FNC) Program Enabling Capability (ECs) investments in this PE that are aligned to the Enterprise and Platform Enablers (EPE) FNC pillar. The EPE Pillar develops cross-cutting, deliverable technologies that provide new capabilities for naval service platforms that lower acquisition, operations and maintenance costs, improve system safety and availability, and improve platform survivability. Funding for FY17/18 is \$9.9 million and \$13.7 million.

Expeditionary Maneuver Warfare

The Expeditionary Maneuver Warfare Activity contains all Navy funded Future Naval Capabilities (FNC) Program Enabling Capability (ECs) investments in this PE that are aligned to the Expeditionary Maneuver Warfare (EMW) FNC Pillar. The EMW Pillar develops deliverable technologies that provide new capabilities in expeditionary maneuver warfare, including naval ground forces, with special emphasis on regular and irregular warfare in urban environments and combating terrorism. Funding for FY17 is \$3 million. Funding for this program does not continue into FY18 due to its planned ending.

FNC Management

The FNC Management Activity includes the Science and Technology (S&T) analyses and studies required to take new Future Naval Capabilities (FNC) Program Enabling Capabilities (ECs) approved by the Technology Oversight Group and produce the detailed technology specifications and performance metrics needed to procure the component level technologies that must be developed and tested in order to deliver technology products to the acquisition community. This activity includes development and implementation of innovative and dynamically changing technology management business processes required to manage FNC investments supporting the naval capability pillars. Funding for FY17/18 is \$8.4 million and \$8.1 million.

Force Health Protection

The Force Health Protection Activity contains all Future Naval Capabilities (FNC) Program Enabling Capability (ECs) investments in this PE that are aligned to the Force Health Protection (FHP) FNC pillar. The FHP Pillar develops deliverable technologies that provide new capabilities that provide Sailors and Marines with the best possible protection from operational threats by reducing morbidity and mortality when casualties occur. Funding for FY17/18 is \$5.7 million and \$4.3 million.

FORCENET

The FORCENET Activity contains all Future Naval Capabilities (FNC) Program Enabling Capability (ECs) investments in this PE that are aligned to the Forcenet (FNT) FNC Pillar. The FNT pillar develops deliverable technologies that provide new capabilities in Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR), networking, navigation, sensors, decision support, cyber-space, intelligence, and space technologies that will provide the ar-

chitectural framework for naval warfare in the information age. Funding for FY17/18 is \$42.5 million and \$41.4 million.

Power and Energy

The Power and Energy Activity contains all Future Naval Capabilities (FNC) Program Enabling Capability (ECs) investments in this PE that are aligned to the Power and Energy (P&E) FNC pillar. The P&E Pillar develops deliverable technologies that provide new capabilities in energy security, efficient power and energy systems, high energy and pulse power. Funding for FY17/18 is \$11.8 million and \$11 million.

Sea Basing

The Sea Basing Activity contains all Future Naval Capabilities (FNC) Program Enabling Capability (ECs) investments in this PE that are aligned to the Sea Basing (BAS) FNC pillar. The BAS Pillar develops deliverable logistics, shipping and at-sea transfer technologies that provide new capabilities for projecting expeditionary force from the seabase and providing sea based joint operational independence through improved connector, at-sea transfer and shipboard logistical capabilities. Funding for FY16 was \$.066 million. The program ended at the end of FY16.

Sea Shield

The Sea Shield activity contains all Future Naval Capabilities (FNC) Program Enabling Capability (ECs) investments in this PE that are aligned to the Sea Shield (SHD) FNC pillar. The SHD Pillar develops deliverable technologies that provide new capabilities in theater air and missile defense, anti-submarine warfare, mine countermeasures, defensive surface warfare, global defensive assurance, anti-terrorism, and fleet/force protection. Funding for FY17/18 is \$42.1 million and \$40.1 million.

Sea Strike

The Sea Strike activity contains all Future Naval Capabilities (FNC) Program Enabling Capability (ECs) investments in this PE. The Sea

Strike (STK) FNC pillar develops deliverable technologies that provide new capabilities in power projection and deterrence, precise and persistent offensive power, weapons, aircraft, and expeditionary warfare. Funding

for FY17/18 is \$32 million and \$28.3 million. The FY17 to FY18 funding decrease is primarily do to the completion and planned ramp down of several of its programs.

Mine and Expeditionary Warfare Applied Research (PE# 0602782N)

This PE provides technologies for Naval Mine Countermeasures (MCM), Expeditionary Warfare, US Naval sea mining, Naval Special Warfare (NSW), and Joint Tri-Service Explosive Ordnance Disposal (EOD). This program is strongly aligned with the Joint Chiefs of Staff Joint Warfighting Capability Objectives through the development of technologies to achieve military objectives with minimal casualties and collateral damage.

Funding for FY17/18/19 is \$33.9 million, \$32.7 million and \$37.9 million.

Mine Technology

The Mine Technology activity assesses advanced sea mine technologies to maintain expertise in this Naval Warfare area. An acoustic sensing capability for the naval mine Target Detection Device (TDD) is being addressed. Future mine and mine-field concepts are being addressed. Funding for FY17/18 is \$3.8 million and \$3.8 million.

Mine/Obstacle Detection

The Mine/Obstacle Detection activity focuses on applied research to enable longer detection ranges and precise mine location with fewer false alarms in a variety of challeng-

ing environments. It supports Discovery and Invention (D&I) and MCM-related FNC ECs. Efforts in Synthetic Aperture Sonar (SAS) technologies for longer range detection and classification of mine-like targets and magnetic gradiometer sensing and electro-optic (EO) technology for buried mine identification, and sensor integration onto Autonomous Underwater Vehicles (AUVs) are being addressed. EO sensor research develops algorithms to enable image processing for rapid overt reconnaissance from an Unmanned Aerial Vehicle (UAV). Other processing, classification and data fusion techniques to reduce operator workload, and a mine burial prediction "expert system" are also being developed. Efforts also support development of MCM Mission Modules for Littoral Combat Ships (LCS). Funding for FY17/18 is \$18.9 million and \$17.8 million.

Mine/Obstacle Neutralization

The Mine/Obstacle Neutralization activity includes applied research to support selected MCM related FNC ECs for rapid mine and obstacle neutralization and sea mine jamming techniques to increase surface ship safe standoff from threat mines. It includes various lethality, vulnerability and dispensing computational tools,

models and assessments to support the various far-term Surf Zone (SZ) and Beach Zone (BZ) mine and obstacle breaching concepts. Funding for FY17/18 is \$400,000 million and \$400,000.

Special Warfare/EOD

The goal of the Special Warfare/EOD effort is to develop technologies to extend stand-off of special operations and EOD forces in clandestine hydrography, mine clearance and port security missions while increasing the range and effectiveness of divers. Advanced technologies are needed to gain access to areas contaminated by area-denial sensors and/or booby traps. Developed technologies will transition to the Joint Service EOD Program, the Naval EOD Program, or the DOD Technical Response Group. This activity includes applied research in sensor technology for NSW and EOD autonomous and handheld sonar systems to increase detection range and accuracy in harsh environments. Other efforts include mission support technology improvements for AUVs and human divers -such as communications, navigation and life support. Funding for FY17/18 is \$10.8 million and \$10.8 million.

Innovative Naval Prototypes Applied Research

The Innovative Naval Prototypes (INP) Applied Research Program Element (PE) address the Applied Research associated with the Innovative Naval Prototypes (INP) Program and its associated Leap Ahead Technology (LA-Tech) investments. These investments represent game-changing technologies with the potential to revolutionize operational concepts.

They are disruptive in nature as they would dramatically change the way naval forces fight. INPs push the imagination of our nation's technical talent to deliver transformational warfighting capabilities. The projects in this portfolio are high risk, technically challenging technology development efforts that offer the potential

of high warfighting payoff in the future. The goal of these investments is to develop and demonstrate the viability of new technological capabilities via experimental prototypes that prove the new capability could be implemented if an acquisition program were to be established to further develop the demonstrated capability. These investments are selected by a

process that involves senior leadership in the Department of the Navy, with new INPs approved by the 4-star RDT&E Corporate Board.

Developing INPs and Leap Ahead Technologies requires a systematic expansion and application of knowledge to develop useful materials, devices, and systems oriented toward the design and development of prototypes applicable to specific mission area requirements. The efforts funded within this PE translate promising basic research into solutions for broadly defined military needs. These efforts include developing

breadboard hardware and algorithms that establish the initial feasibility and practicality of proposed solutions to technological challenges, as well as other pre-Milestone B efforts such as concept exploration efforts, studies, investigations, and non-system specific technology efforts.

This is a new Program Element for FY18 that consolidates all Navy 6.2 Applied Research investments funding INPs and their associated LA-Tech investments into a single Navy 6.2 PE. In FY 2017, these investments are spread across four sep-

arate 6.2 PEs: 0602114N Power Projection Applied Research, 0602123N Force Protection Applied Research, 0602271N Electromagnetic Systems Applied Research, and 0602747N Undersea Warfare Applied Research. The consolidation in this PE allows all investments within this portfolio to be viewed in one place. It greatly enhances the visibility of the Program by providing an easily navigable overview of all 6.2 INP and LA-Tech investments in a single place. Its opening funding in FY18 will be \$171.1 million.

Science and Technology Management (PE# 0602861N)

This program supports Office of Naval Research (ONR) leadership, management and direction for the Naval S&T program. This project funds ONR HQ Non-Management Headquarters Activities (Non-MHA) salaries, communications, and other fixed costs. ONR sponsors scientific advances, which lead to Future Naval Capabilities (FNCs), supporting the Fleet's ability to operate from a position of technological superiority. Functions performed include (1) scientific and technical direction of the nationwide 6.1 basic research program with colleges, universities, non-profit organizations and Naval Laboratories and Warfare Centers;

(2) scientific and technical direction of the 6.2 applied research program through the Naval R&D laboratories and Warfare Centers and industry; (3) scientific and technical direction of the Naval 6.3 advanced technology development program through the Navy's R&D laboratories, Warfare Centers and industry; (4) management, resource formulation, program assessment, and contract negotiation/administration of the Navy basic research, applied research and advanced technology development program; and (5) coordination of the Navy's Technology Base program within the context of total DoD/Government (e.g., National Science

Foundation, National Academy of Sciences) R&D initiatives in order to maximize scientific advances. This project also supports ONR Non-MHA management and direction for the following Navy-wide programs: Small Business Innovation Research, Naval Research Advisory Committee, Navy Patent Program, Historically Black Colleges and Universities/Minority Institutions Program, Navy Manufacturing Technology Program and the Ballistic Missile Submarine Nuclear (SSBN) Security Technology Program.

Funding for FY18/19 is \$62.7 million and \$64.2 million.

Advanced Technology Development (6.3) Programs

The Advanced Technology Development stage of research aids in the transition of research and development into fleet systems is often facilitated through advanced technology demonstrations (ATD). ONR's Science and Technology Directorate ensures that Navy investments in S&T pay off in meeting operational requirements by identifying and demonstrating promising technologies under realistic conditions. ONR places an increasing emphasis on technology prototype demonstrations

through programs such as the Advanced Technology Demonstrations (see below). These programs allow functional models to demonstrate technological maturity, productibility, and affordability in operational environments. Although demonstrations typically focus on high-risk technologies, the high payoff for a warfare mission area or platform of successful demonstrations is commensurate with that risk. Technologies developed in an ATD program

are available to update current systems, can be further refined in expanded prototype developments, demonstration and validation (DEM/VAL; 6-4) programs or are sometimes integrated into an engineering and manufacturing development (EMD; 6.5) program.

The Advanced Technology Development (6.3) programs for FY17-20 are listed below along with their respective funding levels (dollars in millions).

Navy Adv. Tech. Dev. Programs	FY17	FY18	FY19	FY20
0603114N Power Projection Adv. Tech	96.4	—	—	—
0603123N Force Protection Adv. Tech.	48.4	26.3	37.0	35.8
0603271N Electromagnetic Sys. Adv. Tech.	26.4	9.4	8.8	9.6
0603640M USMC ATD	140.4	154.4	142.4	143.6
0603651M Joint Non-Lethal Weapons	13.1	13.4	13.4	13.4
0603673N Future Naval Capabilities	249.1	231.8	233.9	231.3
0603747N Manufacturing Technology.	56.7	57.8	58.8	60.7
0603729N Warfighter Protection Adv. Tech.	4.8	4.9	4.9	4.9
0603747N Undersea Warfare Adv. Tech.	25.9	—	—	—
0603785N Navy Warfighting Exp. & Demos	60.6	64.9	68.1	108.7
0603782N Mine & Exp. Warfare Adv. Tech.	15.2	15.2	13.2	13.4
0603801N Innovative Naval Prototypes	—	108.3	86.3	87.2
Total	737.0	686.4	666.8	708.6

Power Projection Advanced Technology (PE# 0603114N)

This program develops and demonstrates advanced technologies, including Directed Energy, for naval weapon systems, and Electric Warship. This Program Element (PE) includes elements of the following Future Naval Capabilities (FNCs); Time Critical Strike (TCS), Autonomous Operations (AO), and Knowledge Superiority Assurance (KSA). Within the Naval Transformation Roadmap, this investment will achieve one of four key transformational capabilities required by Sea

Strike as well as technically enable elements of both Sea Shield and Force Net.

Total PE funding for FY17 is \$96.4 million. The funding ends for this Program Element in FY18 reflecting the realignment of the remaining Precision Strike Technology efforts to PE# 0603758N Navy Warfighting Experimentation and Demonstration. Additionally, Innovative Naval Prototypes (INPs) Electromagnetic Railgun (EMRG) and Solid State Laser (SSL) program work will

continue in the new INP PE# 0603801N Innovative Naval Prototypes.

Precision Strike Technology

This Precision Strike Technology activity focuses on the development of high speed (Mach 3 to Mach 4+) strike technologies which significantly decrease the engagement timeline from multiple sea surface and air launched platforms.

Force Protection Advanced Technology (PE# 0603123N)

This program addresses applied research associated with providing the capability of Platform and Force Protection for the US Navy. This program supports the development of technologies associated with all naval platforms (surface, subsurface, terrestrial and air) and the protection of those platforms. This PE supports the Future Naval Capabilities (FNC) in the areas of Fleet/Force Protection, Advanced Capability Electric Systems (ACES), Total Ownership Cost, and Missile Defense. The goal of this program is to provide the ability to win or avoid engagements with other platforms or weapons and, in the event of engagement, to resist and control damage while preserving operational capability.

Total PE funding for FY17/18/19 is \$48.4 million, \$26.3 million and \$37 million.

Surface Ship & Submarine Hull Mechanical & Electrical

The Surface Ship & Submarine Hull Mechanical & Electrical activity includes: Signature Reduction, Hull Life Assurance, and Advanced Capability Electric Systems. Signature Reduction addresses electromagnetic (EM), infrared (IR), and acoustic signature tailoring, both topside and underwater. Hull Life Assurance addresses development of new structural system approaches for surface ships and submarines, including the management of weapon effects to control structural damage and the improvement of structural materials.

Funding for FY17/18 is \$13.5 million and 17.5 million. The funding increase from FY17 to FY18 is due to added Vertical Launch System (VLS) reload at sea effort. The MDUSV and FDECO INP efforts are transferred to the new INP PE 0603801N Innovative Naval Prototypes effective FY18.

Aircraft Technology

The Aircraft Technology activity develops technologies for enhanced capability of naval aviation aircraft platforms in terms of mission effectiveness, platform range, responsiveness, survivability, observability, readiness, safety and life cycle cost. It also develops new Naval air vehicle concepts and high impact, scalable Naval air vehicle technologies,

such as -autonomous air vehicle command and control, helicopter and tiltrotor rotor drive systems, aerodynamics, propulsion systems, materials, structures and flight controls for future and legacy air vehicles. This activity directly supports the Naval Aviation Enterprise Science and

Technology Objectives and the Naval Science and Technology Strategic Plan, principally in the Platform Mobility, Survivability and Self-defense, Affordability/Maintainability/Reliability and Power Projection Focus Areas.

Funding for FY17/18 is \$32.2 million and \$6 million. The funding decrease in FY 18 is due to movement of the AACUS and Tern programs into the new Prototype PE 0603801N Innovative Naval Prototypes.

Electromagnetic Systems Advanced Technology (PE#0603271N)

Work in this program element addresses technologies critical to enabling the transformation of discrete functions to network centric warfare, which utilizes multiple, simultaneous and continuous communications/data links between platforms while simultaneously performing the functions of Electronic Warfare (EW) and radar surveillance. The Radio Frequency (RF) Systems Advanced Technology Program addresses RF technology for Surface and Aerospace Surveillance Sensors and systems, EW sensors and systems, RF Communication Systems, and Multifunction sensor systems. The program emphasizes near to mid-term transition opportunities by developing and demonstrating technologies which enable options for Time Critical Strike, Missile Defense, Fleet Force Protection, and Knowledge Superiority and Assurance Future Naval Capabilities.

Funding for FY17/18/19 is \$26.4 million, \$9.4 million and \$8.8 million.

Electronic & Electromagnetic Systems

The overarching objective of the Electronic and Electromagnetic Systems activity is to develop, test, and

demonstrate communications, electronic attack (EA), electronic surveillance (ES), electronic warfare (EW), and radar functions. This activity also includes development of affordable wideband, high performance Advanced Multifunction Radio Frequency (AMRF) apertures. A portion of this PE is devoted to mid-term technology development in close concert with acquisition programs of record. Funding for FY17/18 is \$17.3 million and \$5.3 million. The decrease from FY17 to FY18 reflects the realignment of the EMC2 Innovative Naval Prototype (INP) and Leap Ahead Technology (LA-Tech) designated program to PE# 0603801N Innovative Naval Prototypes (INP) Advanced Technology Development where all of the INP/LA-Tech investments are being consolidated.

GPS & Navigation Technology

The overarching objective of the GPS and Navigation Technology activity is to develop technologies that enable the development of affordable, effective and robust Position, Navigation and Timing (PNT) capabilities using either GPS systems, non-GPS navigation devices, or atomic clocks. This activity will increase the operational effectiveness of US Naval units. The focus is on the mitigation of GPS electronic

threats, the development of atomic clocks that possess unique long-term stability and precision, and the development of compact, low-cost, Inertial Navigation Systems (INS).

Funding for FY17/18 is \$2.8 million and \$4.1 million.

NEMESIS

The objective of the Netted Emulation ID Multi-Element Signatures Against Untreated Sensors (NEMESIS) is to develop a System of Systems (SoS) able to coordinate distribute EW resources against many adversary surveillance and targeting sensors simultaneously. It will benefit the warfighter by providing platform protection across the battlespace against many sensors, creating seamless cross-domain countermeasure coordination, and enabling rapid advanced technology/capability insertion to counter emerging threats. Funding for FY17 is \$6.4 million. The funding ends in FY18 reflecting the realignment of the NEMESIS Innovative Naval Prototype (INP) and Leap Ahead Technology (LA-Tech) designated program to PE# 0603801N Innovative Naval Prototypes (INP) Advanced Technology Development where all of the 6.3 INP/LA-Tech investments are being consolidated.

USMC ATD (PE# 0603640M)

As the land warfare component of Naval Expeditionary Forces, the Marine Corps has unique and technologically stressing requirements resulting from its amphibious mission, Marine Air-Ground Task Force (MAGTF) organizational structure,

reliance on maneuver, logistic sustainability, and intensive tempo of operations in diverse environments.

Critical Marine Corps requirements addressed in this program element are Command, Control, Com-

munications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR); Maneuver; Logistics; Human Performance, Training and Education; and Firepower. These are ongoing efforts to develop and demonstrate advanced technologies

and system concepts in an operational environment. Multiple transitions into the Sub-system/Component Advanced Development phase are planned, as well as fieldable prototyping to reduce risk in System Concept Development and Demonstration.

Joint service efforts are in line with Defense Technology Objectives (DTOs) and Joint Warfighting Objectives (JWOs). In addition, Marine Corps operational experimentation, warfighting concept experimentation, and conceptual operational assessment of emerging technologies

are funded. Specifically, this PE supports the following capabilities: promptly engaging regional forces in decisive combat on a global basis; responding to all other contingencies and missions in the full spectrum of combat operations (high, mid, and low intensity), in Military Operations in Urban Terrain (MOUT), in Operations Other than War (OOTW), and warfighting experimentation.

This PE supports all of the Marine Corps mission areas. Within the Naval Transformation Roadmap, this investment will achieve one of three

key transformational capabilities required by Sea Shield as well as technically enable the Ship to Objective Maneuver (STOM) and persistent Intelligence, Surveillance and Reconnaissance (ISR) key transformational capabilities within Sea Strike and the enhanced Sea-borne Positioning of Joint Assets within Sea Basing.

Total PE funding for FY17/18/19 is \$140.4 million, \$154.4 million and \$142.4 million.

Joint Non-Lethal Weapons Technology Development (PE# 0603651M)

The DOD's Joint Non-Lethal Weapons Program (JNLWP) was established by the Secretary of Defense, who assigned centralized responsibility for DOD joint research and development of non-lethal technology to the Commandant of the Marine Corps as the Executive Agent. The Under Secretary of Defense for Acquisition, Technology and Logistics provides direct oversight of the JNLWP.

The efforts described in this program element reflect science and technology (S&T) investment decisions provided by the Joint NLW Integrated Product Team, a multi-service flag level corporate board that executes the JNLWP for the Commandant of the Marine Corps. This direction is based on the needs and capabilities of the Services, the Special Operations Command, and the Coast Guard, as identified in the DoD's Non-Lethal Weapons Joint

Capabilities Based Assessment Document.

This coordinated joint S&T development approach addresses mutual capability gaps and assures the best non-lethal technologies and equipment are provided to the operating forces while eliminating duplicative service S&T investment.

Funding for FY17/18/19 is \$13.1 million, \$13.4 million and \$13.4 million.

Future Naval Capabilities Advanced Technologies (PE# 0603673N)

The efforts described in this program element address the Advanced Technology Development associated with the Future Naval Capabilities (FNC) Program. The FNC Program represents the requirements-driven, delivery-oriented portion of the Navy's Science and Technology (S&T) portfolio. FNC investments respond to Naval S&T Gaps that are generated by the Navy and Marine Corps after receiving input from Naval Research Enterprise (NRE) stakeholders. The Enabling Capabilities (ECs) and associated technology product investments of the FNC Program are competitively selected by a 3-star Technology Oversight Group (TOG), chartered by the S&T Corporate Board and representing the requirements, acquisition, research and fleet/forces communities of the Navy and the Marine Corps.

This PE consolidated all Navy 6.3 FNC Program investments into a single Navy 6.3 PE. Marine Corps FNC 6.3 investments are already consolidated in a single Marine Corps 6.3 PE (PE# 0603640M). In FY11 and FY12, the Navy's 6.3 FNC Program investments were spread across 8 separate 6.3 PEs: 0603114N, 0603123N, 0603235N, 0603236N, 0603271N, 0603279N, 0603747N and 0603782N. The consolidation in this PE allows all investments to be viewed by FNC Pillar, Enabling Capability (EC) and Technology Product. It greatly enhances the visibility of the FNC Program by providing an easily navigable overview of all 6.3 FNC investments in a single place.

Funding for FY17/18/19 is \$249.1 million, \$231.8 million and \$233.9 million.

Capable Manpower

The Capable Manpower Activity contains Future Naval Capabilities (FNC) Program Enabling Capability (ECs) investments in this PE that are aligned to the Capable Manpower (CMP) FNC pillar. The CMP Pillar develops deliverable technologies that provide new capabilities in manpower and personnel management, training and education, and human-systems integration for more intuitive systems. Funding for FY17/18 is \$19.2 and \$19.5 million.

Enterprise and Platform Enablers

The Enterprise and Platform Enablers Activity contains all Future Naval Capabilities (FNC) Program Enabling Capability (ECs) investments in this PE that are aligned to the Enterprise and Platform Enablers (EPE)

FNC pillar. The EPE Pillar develops cross-cutting, deliverable technologies that provide new capabilities for naval service platforms that lower acquisition, operations and maintenance costs, improve system safety and availability, and improve platform survivability. Funding for FY17/18 is \$19.2 and \$14.6 million. The FY17 to FY18 decrease was due to the ramp down and completion of some of their programs.

Expeditionary Maneuver

Warfare

The Expeditionary Maneuver Warfare Activity contains the Navy funded Future Naval Capabilities (FNC) Program Enabling Capability (ECs) investments in this PE that are aligned to the Expeditionary Maneuver Warfare (EMW) FNC Pillar. The EMW Pillar develops deliverable technologies that provide new capabilities in expeditionary maneuver warfare, including naval ground forces, with special emphasis on regular and irregular warfare in urban environments and combating terrorism. Funding for FY17 is \$3.1 million. The funding for this program element ends in FY18 due to the completion and transition to acquisition of its projects.

Force Health Protection

The Force Health Protection Activity, new for FY13, contains Future

Naval Capabilities (FNC) Program Enabling Capability (ECs) investments in this PE that are aligned to the Force Health Protection (FHP) FNC pillar. The FHP Pillar develops deliverable technologies that provide new capabilities that provide Sailors and Marines with the best possible protection from operational threats by reducing morbidity and mortality when casualties occur. Funding for FY17/18 is \$15 million and \$10.9 million.

ForceNet

The ForceNet Activity contains all Future Naval Capabilities (FNC) Program Enabling Capability (ECs) investments in this PE that are aligned to the Forcenet (FNT) FNC Pillar. The FNT pillar develops deliverable technologies that provide new capabilities in Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR), networking, navigation, sensors, decision support, cyber-space, intelligence, and space technologies that will provide the architectural framework for naval warfare in the information age. Funding for FY17/18 is \$59.6 and \$61.7 million.

Power and Energy

The Power and Energy Activity contains Future Naval Capabilities (FNC) Program Enabling Capability (ECs) investments in this PE that are

aligned to the Power and Energy (P&E) FNC pillar. The P&E Pillar develops deliverable technologies that provide new capabilities in energy security, efficient power and energy systems, high energy and pulse power. Funding for FY17/18 is \$16.6 and \$15.8 million.

Sea Shield

The Sea Shield Activity, new for FY13, contains Future Naval Capabilities (FNC) Program Enabling Capability (ECs) investments in this PE that are aligned to the Sea Shield (SHD) FNC pillar. The SHD Pillar develops deliverable technologies that provide new capabilities in theater air and missile defense, anti-submarine warfare, mine countermeasures, defensive surface warfare, global defensive assurance, anti-terrorism, and fleet/force protection. Funding for FY17/18 is \$68.9 and \$60 million.

Sea Strike

The Sea Strike Activity contains all Future Naval Capabilities (FNC) Program Enabling Capability (ECs) investments in this PE. The Sea Strike (STK) FNC pillar develops deliverable technologies that provide new capabilities in power projection and deterrence, precise and persistent offensive power, weapons, aircraft, and expeditionary warfare. Funding for FY17/18 is \$47.5 and \$49.3 million.

Manufacturing Technology (PE# 0603680N)

The Manufacturing Technology (ManTech) Program is intended to improve the productivity and responsiveness of the U.S. defense industrial base by funding the development, optimization, and transition of enabling manufacturing technologies to key naval suppliers. In general, investments transition emerging S&T results to acquisition programs; improve industrial capabilities in production, maintenance, repair and industrial base responsiveness; and advance manufacturing technology to reduce cost, improve performance,

and responsiveness. Currently, the ManTech Program is focused on affordability improvements for specific key acquisition platforms as defined in the Navy ManTech Investment Strategy. Key platforms currently targeted include: VIRGINIA Class Submarine (VCS)/OHIO Replacement Program (ORP); DDG 51 Class Destroyer; CVN 78 Class Carrier; Joint Strike Fighter (JSF); and CH-53K Heavy Lift Helicopter. ONR ManTech helps these Navy programs achieve their respective affordability goals by transitioning developed

manufacturing technology which, when implemented, results in needed cost reduction or cost avoidance. This Program Element is the result of the re-alignment of funds from PE Industrial Preparedness (0708011N) and the Manufacturing Science and Technology activity from PE# 0603758N.

Funding for FY 17/18/19 is \$56.7, \$57.8 million and \$58.8 million. Nominal increases will take funding to just under \$62 million by FY21.

Composites Processing & Fabrication

The primary technical goal of the Composites Processing and Fabrication activity is improving weapon systems affordability, enhancing weapon system effectiveness and improving reliability/war-fighter readiness through the increased utilization of composite materials and structures. This is being achieved through the development, maturation, and transition of affordable and robust manufacturing, assembly, and repair processes that fully exploit the benefits of composite materials. Concentration is on affordability for the following: platforms: VIRGINIA Class Submarine (VCS)/OHIO Replacement Program (ORP), DDG-51 Class Destroyer, CVN-78 Class Carrier, Joint Strike Fighter (JSF), and CH-53-K Heavy Lift Helicopter. in medical technology, jet engine physics, personal protective equipment, and mitigation analyses. Funding for FY17/18 is \$7 and \$8 million.

Electronics Processing & Fabrication

The primary technical goal of the Electronics Processing and Fabrication activity is improving electronic weapon systems affordability by developing and transitioning affordable, robust manufacturing processes and capabilities for electronics critical to defense applications over their full life-cycle. Efforts create new and improved electronics/electro-optics manufacturing processes for transition to the production floor. Emphasis is on affordability for the following shipbuilding platforms: VIRGINIA Class Submarine (VCS)/OHIO Replacement Program (ORP), DDG-51 Class Destroyer, CVN-78 Class Carrier, Joint Strike Fighter (JSF), and CH-53-K Heavy Lift Helicopter. Funding for FY17/18 is \$12 million and \$12 million.

Metals Processing & Fabrication

The primary technical goal of the Metals Processing and Fabrication activity is to develop affordable, robust manufacturing and repair processes/capabilities for metals and

special materials critical to Navy weapon system applications. Major areas that support this objective include: processing methods, special materials, joining, machining, coating/cladding, assembly, and inspection and compliance resulting in reduced cost of fabrication for components. Funding for FY17/18 is \$12.8 and \$12 million.

Manufacturing Enterprise/Other

The Manufacturing Enterprise/Other activity includes: (1) efforts targeted towards improving, in general, the manufacturing enterprise for the production of key naval platforms (both shipbuilding and aircraft), (2) energetic efforts, (3) naval research enterprise and laboratory support for key projects, and (4) technical program support. Manufacturing Enterprise addresses the development, optimization, and transition of manufacturing enterprise technology to key naval platform suppliers. Funding for FY17/18 is \$24.9 and \$25.8 million.

Warfighter Protection Advanced Technology (PE# 0603729N)

This program supports the development and demonstration of field medical equipment, diagnostic capabilities and treatments; technologies to improve warfighter safety and to enhance personnel performance under adverse conditions; and systems to prevent occupational injury and disease in hazardous, deployment environments. Navy investment in these areas is essential because Navy/USMC mission needs are not adequately addressed by the civilian sector or other federal agencies. For

example, civilian emergency medicine does not address casualty stabilization during long transit times to definitive care, or the logistics of providing self/buddy-carried, life-saving technologies for massive battlefield wounds. The National Institutes of Health (NIH) focuses on disease processes, not product demonstration.

Total PE funding for FY17/18/19 is \$4.8 million, \$4.9 million and \$4.9 million.

Undersea Warfare Advanced Technology (PE# 0603747N)

All Navy advanced technology development in undersea target detection, classification, localization, tracking and neutralization is funded through this PE. The related technologies being developed are aimed at

enabling Sea Shield, one of the three core operational concepts detailed in the Naval Transformational Roadmap. Associated efforts focus on new Anti-Submarine Warfare (ASW) operational concepts that

Naval Noise Induced Hearing Loss

The goal of the Naval Noise-Induced Hearing Loss program is to reduce the incidence of NIHL by nearly 100%. This program employs a total systems engineering approach that includes advancements in medical technology, jet engine physics, personal protective equipment, and mitigation analyses.

promise to improve wide-area surveillance, detection, localization, tracking and attack capabilities against quiet adversary submarines operating in noisy and cluttered shallow water environments. The focus is

on leveraging technologies that will protect the country's current capital investment in surveillance, submarine, surface ship and air ASW assets.

Funding for FY17 is \$25.9 million. In FY18 this PE's projects are moved to the Innovative Naval Pro-

totypes Advanced Technology Development program element and there is no further funding.

Navy Warfighting Experiments and Demonstrations (PE# 0603758N)

This program addresses the development of recent technology breakthroughs to meet current operational needs from a subscale proof-of-principle into a full-scale prototype for warfighter experimentation during laboratory and operational demonstrations, Fleet Battle Experiments (FBE), Limited Objective Experiments (LOEs) and Sea Trial Exercises.

The key aspects of this PE are divided into four areas: (1) SwampWorks develops and demonstrates newly invented or recently discovered technologies that address emergent and enduring operational problems in an accelerated time frame; (2) Naval Warfare Experimentation develops prototypes of recent technology breakthroughs and provides them to the warfighter for experimentation during FBEs, LOEs or Sea Trials; (3) Tech Solutions resolves operational problems submitted by Sailors, Marines and Science Advisors via a collaborative working environment, applies scientific applications to solve these problems, and provides the solution to the sailor for evaluation and use; and (4) Operations Analysis provides the Navy and Marine Corps the means to identify capability needs that can be addressed with science and technology solutions.

Funding for FY17/18/19 is \$60.6 million, \$64.9 million and \$68.1 million.

Naval Warfare Experimentation

The objective of the Naval Warfare Experimentation project is to capitalize on recent technology breakthroughs to develop prototypes quickly and provide them to the warfighter for experimentation during laboratory and operational demonstra-

tions, Sea Trials or LOEs. Current efforts include experimentation with Electronics Warfare (EW) technologies, development of test simulation technology for ship affordability, technology to advance riverine warfare operations, development and demonstration of real time situational awareness technologies, fuel cell power for unmanned air vehicles, and technology investigation studies. Funding for FY17/18 is \$22.4 million and \$18.7 million. The funding decrease from FY17 to FY18 is due to completion of increased products in the areas of Autonomy, Electromagnetic Warfare and the exploitation of unmanned systems.

Operations Analysis

The objective of the Operations Analysis project is to provide operational analysis through studies, analyses, gaming and experimentation to identify Navy and Marine Corps capability needs that can be addressed with Science and Technology (S&T) solutions. The effort includes core analysis of S&T programs, military utility/capability gaps analyses, wargaming and fleet experimentation analysis. Funding for FY17/18 is \$3.1 million and \$2 million.

SwampWorks

SwampWorks seeks to develop and demonstrate technologies that address emergent and enduring operational problems in an accelerated time frame. Some of these technologies may end up in the hands of the warfighter for experimentation, or may culminate in a significant exercise that demonstrates capability then transitions into the Acquisition Program of Record (POR). Examples of recent successes are the half-length torpedo which led to the develop-

ment of the SwampWorks Broadband Sonar and transitioned to the Mk 48 Advanced Capability program and the Aircraft Carrier Situational Awareness System, which will be incorporated into a POR. Examples of current efforts include a high resolution sonar for the new lightweight torpedo, energy storage and reduced energy consumption technologies, coherent stand-in jammer, full ship shock test simulation, effective active acoustics simulation, power and energy for unmanned vehicles, and technology investigation studies. Funding for FY17/18 is \$25.1 million and \$22.6 million.

Tech Solutions

The objective of the Tech Solutions program is to provide deckplate Sailors and Marines in the field with technical solutions to common operational problems and the Office of Naval Research Science Advisors with solutions to current technology gaps. The Sailors, Marines and Science Advisors provide their operational issues and technology gaps throughout the year via a collaborative online working environment. Funding for FY17/18 is \$10 million and \$9.2 million.

Precision Strike Technology

The Precision Strike Technology program is based on investment directions as defined in the Naval S&T Strategic Plan approved by the Science & Technology Corporate Board. This strategy is based on needs and capabilities from Navy and Marine Corps guidance and input from the Naval Research Enterprise (NRE) stakeholders (including the Naval enterprises, the combatant commands, the Chief of Naval Operations (CNO), and Headquarters Marine Corps). It provides the vision

and key objectives for the essential science and technology efforts that will enable the continued supremacy of U.S. Naval forces in the 21st century. The Strategy focuses and aligns

Naval S&T with Naval missions and future capability needs that address the complex challenges presented by both rising peer competitors and irregular/asymmetric warfare. Funding

for this program begins in FY18 and is \$12.4 million.

Mine and Expeditionary Warfare (PE# 0603782N)

This PE primarily develops and demonstrates prototype Mine Countermeasures (MCM), Expeditionary Warfare and Joint EOD system components that support capabilities enabling Naval and Joint EOD Forces to influence operations ashore. Adversarial nations have the capability to procure, stockpile and rapidly deploy all types of naval mines, including new generation mines having sophisticated performance characteristics, throughout the littorals. They also

have the capability to develop or modify explosive devices such as mines and unexploded ordnance to construct Improvised Explosive Devices (IEDs) for the purpose of targeting Joint Forces. Real world operations have demonstrated the requirement to quickly counter the mine threat. Current operations have also demonstrated the requirement to quickly counter the threat from explosive hazards and IEDs during

DoD operations. Advanced technologies must rapidly detect and neutralize all mine types, from deep water to the inland objective. Advanced technologies must enable Joint EOD forces to detect/locate, gain access, diagnose, render safe, neutralize, recover, exploit and dispose of a broad spectrum of explosive hazards including unexploded ordnance and IEDs. Funding for FY17/18/19 is \$15.2 million, \$15.2 million and \$13.2 million.

Innovative Naval Prototypes Advanced Tech Dev (PE# 0603801N)

This is a new program element for FY18 that consolidates all Navy 6.3 Advanced Technology Development investments funding INPs and their associated LA-Tech investments into a single Navy 6.3 PE. In FY 2017, these investments were spread across 5 separate 6.3 PEs: 0603114N Power Projection Advanced Technology, 0603123N Force Protection Advanced Technology, 0603271N Electromagnetic Systems Advanced Technology, 0603747N Undersea Warfare Advanced Technology and 0603758N Navy Warfighting Experiments and Demonstrations. The consolidation in this PE allows all investments within this portfolio to be viewed in one place. It greatly enhances the visibility of the program by providing an easily navigable overview of all 6.3 Advanced Technology Development INP and LA-Tech investments.

Funding for FY18/19 is \$108.3 million and \$86.3 million.

Cyber

This Cyber program contains all Innovative Prototype (INP) and associated Leap Ahead Technology (LA-Tech) investments that are developing new technologies for cyber war-

fare. The Advanced Technology Development effort for the Total Platform Cyber Protection (TPCP) INP was previously funded in PE 0603123N Force Protection Advanced Technology Development. It was selected after the President's Budget for FY17 was delivered to the Congress. The FY 2018 amount reflects the sum total of all Budget Activity (BA) 6.3 Advanced Technology Development efforts in this INP. Funding for FY18 is \$5.2 million

Directed Energy/Electric Weapons

The Directed Energy/Electric Weapons Activity contains all Innovative Prototype (INP) and associated Leap Ahead Technology (LA-Tech) investments that are developing new technologies for directed energy and electric weapons. FY18 reflects the sum total of all such BA 6.3 Advanced Technology Development efforts in the program. Some

of these efforts were previously funded in PE# 0603114N Power Projection Advanced Technology Development and 0603758N Navy Warfighting Experiments and Demonstrations.

Funding for FY18 is \$35.5 million.

Electromagnetic Maneuver Warfare

The Electromagnetic Maneuver Warfare Activity contains all Innovative Prototype (INP) and associated Leap Ahead Technology

(LA-Tech) investments that are developing new technologies for Electromagnetic Maneuver Warfare (EMW). FY 2018 reflects the sum total of all such BA 6.3 Advanced Technology Development efforts in the program. These efforts were previously funded in PE 0603271N Electromagnetic Systems Advanced Technology Development. Funding for FY18 is \$16.8 million.

Undersea Warfare

The Undersea Warfare Activity contains all Innovative Prototype (INP) and associated Leap Ahead Technology (LA-Tech) investments that are developing new technologies for Undersea Maneuver Warfare. FY 2018 reflects the sum total of all such BA 6.3 Advanced Technology Development efforts in the program. These efforts were previously funded in PE# 0603123N Force Protection Advanced Technology Development and PE# 0603747N Undersea War-

fare Advanced Technology Development. Funding for FY18 is \$13.2 million.

Unmanned and Autonomous Systems

The Unmanned and Autonomous Systems Activity contains all Inno-

vative Prototype (INP) and associated Leap Ahead Technology (LA-Tech) investments that are developing new technologies for Unmanned and Autonomous Systems. FY 2018 reflects the sum total of all such BA 6.3 Advanced Technology Development efforts in the program. These efforts were previously funded in PE

0603123N Force Protection Advanced Technology Development and 0603747N Undersea Warfare Advanced Technology Development. Funding for FY18 is \$37.5 million.

Agency Structure

The Office of Naval Research, headquartered in Arlington, VA, is organized around the Science and Technology Directorate, the Naval Research Laboratory and its elements, and various corporate and headquarters staff offices. The S&T Directorate coordinates and jointly plans programs with those of the Army and Air Force through a tri-service reliance initiative. Reliance is a continuously evolving process that enhances the quality and productivity

of DoD S&T programs by reducing overlap and eliminating duplication among the services, while increasing efficiency and productivity through collocation and consolidation of in-house work.

Within the Science and Technology Directorate at ONR are the Departments of Information, Electronics and Surveillance; Ocean, Atmosphere and Space; Engineering, Materials and Physical Science; Human Systems; Weapons, Marine Corps,

and Special Programs; and Industrial Programs. Included as well in the makeup are ONR offices overseas (reports to Special programs). The Navy’s S&T program and its integration into the overall DoD thrust scenario, is the responsibility of the main departments and their various offices and divisions. The most important of the ONR elements reporting to the S&T directorate are listed below.

ONR Directory

Information, Electronics & Surveillance

Director (703) 696-4212
 Mathematical, Computer & Information Sciences (703) 696-4312
 Electronics (703) 696-4216
 Surveillance, Communications & Electronic Combat (703) 696-8033

Ocean, Atmosphere & Space

Director (703) 696-4125
 Sensing & Systems (703) 696-2485
 Processes & Prediction (703) 696-4120

Engineering, Materials & Physical S&T

Director (703) 696-4408
 Physical Sciences Science & Technology (703) 696-4410
 Materials Science & Technology (703) 696-4309
 Mechanics & Energy Conversion Science & Technology (703) 696-5075
 Ship Hull, Mechanical & Electrical (703) 696-4714
 Navy S&T (703) 696-0030

Chemistry & Physics

Materials
 Mechanics & Energy Conversion
 Ship Structures & Systems

Human Systems

Director (703) 696-4501
 Medical Science & Technology

Cognitive & Neural Science & Technology
 Human Systems Technology

Naval Expeditionary Warfare Director (703) 784-4773

Low Observables/Counter-Low Observables (703) 607-1858
 Expeditionary Warfare Operations (703) 588-0701
 ONR European Office-London
 ONR Asian Office-Tokyo
 Special Offices*
 *Includes JMA Integration/Roundtables, Lab IR, TENCAP, BMDO, OST General Engineering Offices, and Analysts (program & Management).

Industrial Programs

Director (703) 696-4448
 Manufacturing Science & Technology
 Industrial Outreach

Others

Advanced Computing Environment Management
 Contracting Activity & Policy Management
 Special Operations
 University/Business Affairs
 ONR Regional Offices
 Contract & Grant Awards
 Financial Management

Navy Science Assistance Program (NSAP)
 Science & Technology Reserve Program
 Automated Information Systems

Naval Research Laboratory, Washington, DC

See report herein for organizational detail

Special Offices

Historically Black Colleges Council (202) 696-4484
 University Research Initiative (703) 696-4111
 Graduate Fellowship Program (703) 696-4108
 Young Investigator Program (703) 696-4111
 Summer Faculty Research Program (703) 451-3176
 ONR High School Apprenticeship Program (703) 696-4111
 University Business Affairs (703) 696-4601

ONR Detachments

Boston, MA (617) 451-3172
 Pasadena, CA (818) 795-5971

Other Offices

USMC Liaison (703) 696-1299
 SOP/Intelligence (703) 696-4275

Public Affairs (703) 696-4917

Acquisition (703) 696-4607