Exhibit R-2, PB 2010 Navy RDT&E Budget Item Justification								DATE: May 2009		
APPROPRIATION/BUDGET ACTIVITY 1319 - Research, Development, Test & Evaluation, Navy/BA 1 - Basic Research					R-1 ITEM NOMENCLATURE PE 0601153N DEFENSE RESEARCH SCIENCES					
COST ($ in Millions)	FY 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
Total Program Element	377.396	419.939	413.743						Continuing	Continuing
0000: DEFENSE RESEARCH SCIENCES	377.396	419.939	413.743						Continuing	Continuing

A. Mission Description and Budget Item Justification

This program element (PE) sustains U.S. Naval Science and Technology (S&T) superiority, 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 approved by the S&T Corporate Board (Jan 2007). This new 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).

The vision of the DON S&T strategy is "to inspire and guide innovation that will provide technology-based options for future Navy and Marine Corps capabilities", where "Innovation is a process that couples Discovery and Invention (D&I) with Exploitation and Delivery". DON basic research is the core of D&I. It includes 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 'thrusts', which are consolidated into about fifteen research areas. These in turn support the major research areas of the Navy and Marine Corps: Autonomous Systems; Command, Control, Communications and Computers (C4); Countermeasures and Counterweapons; 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 four NNRs.

S&T investment in basic research also includes the Basic Research Challenge program which was established to competitively select and fund promising research programs in new areas not addressed by the current basic research program. The Basic Research Challenge Program stimulates new, high-risk basic research projects in multi-disciplinary 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.

Due to the number of efforts in this PE, the programs described herein are representative of the work included in this PE.

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B. Program Change Summary ($ in Millions)

	FY 2008	FY 2009	FY 2010	FY 2011
Previous President's Budget	383.217	407.271	423.633	
Current BES/President's Budget	377.396	419.939	413.743	
Total Adjustments	-5.821	12.668	-9.890	
Congressional Program Reductions		-6.168		
Congressional Rescissions				
Total Congressional Increases		18.900		
Total Reprogrammings	-3.796			
SBIR/STTR Transfer	-2.025			
Program Adjustments			-7.233	
Rate/Misc Adjustments		-0.064	-2.657	

Congressional Increase Details ($ in Millions)	FY 2008	FY 2009
Project: 9999, **BIOCHEMICAL AGENT DETECTION**	0.772	0.798
Project: 9999, **CENTER QUANTUM STUDIES**	0.000	1.197
Project: 9999, **ENERGETICS S&T WORKFORCE DEVELOPMENT**	2.321	4.488
Project: 9999, **EVALUATING ELF SIGNALS IN MARITIME ENVIRONMENTS**	1.543	1.596
Project: 9999, **MOBILE AD HOC DATA COMMUNICATIONS FOR UNMANNED SYSTEMS**	0.772	0.000
Project: 9999, **NAVY SCIENCE AND TECHNOLOGY OUTREACH (N-STAR) MARYLAND**	0.795	0.997
Project: 9999, **ONAMI NANOELECTRONICS AND NANOMETROLOGY INITIATIVE**	1.929	3.989
Project: 9999, **RESEARCH SUPPORT FOR NANOSCALE RESEARCH FACILITY**	0.000	2.792
Project: 9999, **ROTATIONAL MOLDED DOUBLE WALL FOR UN-MANNED PATROL BOAT**	2.913	0.000
Project: 9999, **TEXAS MICROFACTORY**	3.374	2.992

Change Summary Explanation

Technical: As directed by the Secretary of Defense, an increase from FY 2008 to FY 2009 for Basic Research (6.1) to fund peer-reviewed research to develop innovative solutions and enhance the science and engineering base. The increase also includes the Basic Research Challenge which is a competitive investment based on proposed scientific activities.

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Schedule: Not applicable.

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COST ($ in Millions)	FY 2008 Actual	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
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The vision of the DON S&T strategy is "to inspire and guide innovation that will provide technology-based options for future Navy and Marine Corps capabilities", where "Innovation is a process that couples Discovery and Invention (D&I) with Exploitation and Delivery". DON basic research is the core of D&I. It includes 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 'thrusts', which are consolidated into about fifteen research areas. These in turn support the major research areas of the Navy and Marine Corps: Autonomous Systems; Command, Control, Communications and Computers (C4); Countermeasures and Counterweapons; 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 four NNRs.

B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
AIR, GROUND AND SEA VEHICLES	44.133	51.856	54.261	
Efforts include: Surface/subsurface reduced signatures; free-surface, subsurface, and propulsor hydromechanics; 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				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011

Combat Air Vehicle (UAV/UCAV); environmental quality; logistics; and power generation, energy conversion, and storage.

As directed by the Secretary of Defense, this activity reflects an increase from FY 2008 to FY 2009 for Basic Research (6.1) to fund peer-reviewed research to develop innovative solutions and enhance the science and engineering base. The increase also includes the Basic Research Challenge which is a competitive investment based on proposed scientific activities.

FY 2008 Accomplishments:

Air Vehicles

- Continued investigations into controlled initiation and recovery from aggressive non-linear aero-maneuvers conducted by unmanned air vehicles.
- Continued university research in rotorcraft technology areas such as tilt rotor aeromechanics, rotor flow field/ship air wake coupling during shipboard operations, flight simulation of advanced ducted fan air vehicles, active rotor control for enhanced ship board operations, autonomous rotorcraft operations in shipboard environment, and innovative rotor design concepts for naval applications.
- Continued research in computational simulation of rotorcraft operations in shipboard environment.
- Continued investigation of advanced structural concepts providing a high degree of crew protection during crashes.

Ship Concepts and Hydrodynamics

- Continued modeling and optimization techniques for Naval design of multi-hulls, optimal functional arrangements for both ship and submarine design, and optimization for semi-displacement craft.
- Continued implementation of nationwide program to increase interest in naval engineering education.
- Continued the Research Tools Development Consortia Program under the University Research – Engineering Design Consortia.
- Continued further examination of computational mechanics to address prediction of acoustic signatures in complex structures, modeling of structural failures and optimization, sensitivity analysis and error control.

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Continued propeller tip vortex cavitation and sheet-to-cloud cavitation. - Completed experiments for rough-wall boundary layer noise. - Completed modeling of multi-phase flow. - Completed potential-flow modeling of waterjet propeller cavitation. - Completed Reynolds Average Navier Strokes (RANS) predictions of surface ship motion for high speeds. - Completed validation of prediction of ship wave breaking and bubbly flow at full scale. - Initiated computational and experimental investigation into complex three-dimensional flow separation problems. - Initiated measurement and modeling of small wave effects on wave breaking and bubble generation. - Initiated modeling and understanding of full-scale circulation control bow planes design. Ship Signatures, Structures, and Materials - Continued the structural performance of hybrid ship hulls and hybrid joints subject to sea loads and weapons effects for application to high speed, low signature vessels. - Continued modeling of alternating current sources and propagation. - Continued Particle Image Velocimetry (PIV)/Laser Doppler Velocimetry (LDV) studies of multiphase bubble flows and interaction with elastic plates in a small quiet water tunnel. - Continued LDV of scaling effects studies of unsteady elastic duct and propulsor interaction in a wind tunnel. - Continued effort on much higher strain rate loading and constitutive behavior of Explosion Resistant Coating (ERC) for strain rates appropriate to ballistic events. - Continued work on cohesive elements for dynamic fracture under combined mode for application to failure in joints in ship structures under blast loading. - Continued work on hybrid ship (no-magnetic stainless steel/composite) hull concepts. - Continued further examination of computational mechanics in order to address prediction of acoustic signatures in complex structures, modeling of structural failures and optimization, sensitivity analysis, and error control. - Continued concept for photonic band gap waveguide.				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Continued methods to model the mechanisms of interaction between an elastic duct wall and fluid-flow in a duct with a propeller. - Continued development of advanced multispectral InfraRed (IR) materials. - Continued development of computational mechanics to provide predictive capabilities of acoustics, linear and nonlinear dynamic response and failure mechanisms of structures. - Continued development of mmWave material characterization system. - Continued efforts in alternative hull for fast ships and hybrid ship hull structures - Continued efforts in understanding of explosion resistant coating under extreme loads and its interaction with other armor and structural materials. - Completed study to extend near-field acoustic holography measurement techniques to large-scale measurements in cluttered noisy environments. - Completed studies of the structural acoustics of anisotropic propulsion ducts. - Initiated investigation into methods to control airborne noise transmission using active control. - Initiated development of metamaterial concepts for radio frequency (RF) signature control and photonic and acoustic applications. - Initiated experimental facility for sea-slamming loads in fast ships, and considering hydro-elasticity and structural details in composites panels and scale effects. Measurements are used developing new theoretical models. Ship and Air Platform Machinery and Systems - Continued efforts to understand and control the generation and propagation of far-field jet noise. - Continued development of Pulsed Detonation Engine (PDE) Technology. - Continued development and understanding of control capabilities and distributed intelligence strategies for shipboard systems. - Continued propulsion system cost-reduction efforts through reduction of vibration, noise and thermal fluctuation at the source by controlling combustion. - Continued passive and active high speed noise control. - Continued studies of alternate propulsion systems for PDE and generate prediction models. - Continued investigation of thermal management approaches for cooling high power electronic devices. - Continued research on non-vapor compression based refrigeration cycles.				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
Power Generation, Energy Conversion and Storage - Continued evaluation of stability and control of electrical power systems. - Continued analyzing synchronization of 19 diode lasers to produce intense beams. - Continued efforts in nanostructures, novel electrolytes, and electrode materials to enable new 3D power source architectures to improve capacity of rechargeable lithium and lithium-ion batteries. - Continued exploration and development of materials for high energy density passive power electronics (Capacitors). - Continued expanding the fundamental understanding of direct electrochemical oxidation and the use of logistic fuels in solid oxide fuel cells. - Continued research into new functional materials and new concepts to efficiently convert thermal, photonic, or vibrational energy to electric energy from primary or secondary sources. - Continued research tools design efforts in Chemical Dynamics and High Temperature Probes. - Continued development of phase change cooling approaches for high power electronic devices. - Continued development of multi-scale thermal modeling approaches. - Continued efforts developing science base for optimized combustion of alternative fuels. - Continued research on the scientific basis of nanostructure enhancement of semiconductor and functional materials performance for power generation and thermal management. *FY 2009 Plans:* Air Vehicles - Continue all efforts of FY 2008. Ship Concepts and Hydrodynamics - Continue all efforts of FY 2008, less those noted as completed above. - Complete measurement and modeling of small wave effects on wave breaking and bubble generation. - Initiate validation of Unsteady Reynolds Averaged Navier Strokes (URANS) prediction on maneuvering effects on ship motion in waves. - Initiate modeling of hydroacoustics of advanced materials propulsor. - Initiate program to investigate renewable energy technologies for navy applications.				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Initiate computational and experimental investigations of wakes in stratified fluids. - Initiate Large Eddy Simulation (LES) modeling of crashback of underwater vehicle with propulsor. Ship Signatures, Structures, and Materials - Continue all efforts of FY 2008, less those noted as completed above. - Complete methods to model the mechanisms of interaction between and elastic duct wall and fluid flow in a duct with a propeller. - Complete PIV/LDV studies of multiphase bubble flows and interaction with elastic plates in a small quiet water tunnel. - Initiate study of droplet & volume scattering phenomena. - Initiate the development of predictive models for infrared emission and reflection from breaking waves. - Initiate development of computational electromagnetic (CEM) tools for electromagnetic materials design & optimization. - Initiate development of a methodology for highly reliable composite to metallic joints. - Initiate fundamental efforts in multi-scale, time-varying, hull structural reliability models and processes for structural performance analysis. - Initiate basic research challenge on "Elastomeric Polymer-by-Design to Protect the Warfighter Against Traumatic Brain Injury by Diverting the Blast Induced Shock Waves From the Head". Ship and Air Platform Machinery and Systems - Continue all efforts of FY 2008. - Initiate studies of advanced air-breathing propulsion concepts. - Initiate study of advanced materials for Pulsed Detonation Engine (PDE) Applications. - Initiate efforts to expand the model based reasoning control algorithm approach to multiple heterogeneous systems. - Initiate studies of complexity in heterogeneous distributed control systems. - Initiate efforts to investigate a market based control approach to distributed control. - Initiate efforts to perform physics based modeling of fluid actuation systems. Power Generation, Energy Conversion and Storage				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Continue all efforts of FY 2008. - Complete development of multi-scale thermal modeling approaches. - Complete research tools design efforts in Chemical Dynamics and High Temperature Probes. - Initiate the investigation of the long-term durability effects of coating/substrate systems from combustion chemistries and products derived from current petroleum-based fuel and from petroleum-based/synthetic fuel blends that lead to predictive models. - Initiate effort in energy and power management to include understanding and reliability of high power electronics. *FY 2010 Plans:* Air Vehicles - Continue all efforts of FY 2009. - Initiate research into new analytical methods for high-fidelity prediction of rotorcraft performance, loads, and vibration. - Initiate university and Navy Lab research in basic rotorcraft science with emphasis on enabling concepts for variable geometry/variable rotor-speed aircraft. Ship Concepts and Hydrodynamics - Continue all efforts of FY 2009, less those noted as completed above. - Complete the Research Tools Development Consortia Program. - Initiate measurement and modeling of unsteady high-speed craft hydrodynamics. - Initiate high-fidelity fluid-structure interaction program. Ship Signatures, Structures, and Materials - Continue all efforts of FY 2009, less those noted as completed above. - Complete development of photonic crystal waveguide and radiating systems. - Initiate the development and understanding of elastomeric polymers for multi functionality in protection systems/armor and structural acoustics with superior properties against environmental effects and extreme temperature.				

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B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
Ship and Air Platform Machinery and Systems - Continue all efforts of FY 2009. Power Generation, Energy Conversion and Storage - Continue all efforts of FY 2009, less those noted as completed above.					
ATMOSPHERE AND SPACE SCIENCES Efforts include: Marine Meteorology and Prediction and Space Sciences. Beginning in FY 2009, this activity includes the Basic Research Challenge which is a competitive investment based on proposed scientific activities. Accomplishments and plans described below are examples for each effort category. The increase in funding in FY 2009 and out reflects an increased emphasis in marine meteorology. *FY 2008 Accomplishments:* Marine Meteorology and Prediction - Continued analysis of results from major field projects on air-sea interaction and transition improvements into applied research to improve the treatment of fluxes in coupled atmosphere-ocean prediction systems. - Continued the development of next-generation ocean-atmosphere coupled models. - Continued effort to investigate and better understand the bulk exchanges, aerosol-cloud interaction, and physical processes that take place at the atmospheric boundary layer interface. - Continued theoretical and observational effort to improve understanding of the fundamental dynamics of mountain waves, including generation, propagation, nonlinear interaction, and wave breaking. - Continued effort to gain a fundamental understanding of the flow-dependent limits of predictability by combining research in data assimilation and atmospheric instability. - Continued investigation into the near-earth environmental effects on electromagnetic propagation. - Continued investigation of sub-grid-scale processes that influence marine boundary layer turbulence, aerosol production and removal, and marine stratocumulus cloud and drizzle formation and dissipation with the goal of improving the predictability of these phenomena in high-resolution mesoscale prediction systems.		22.804	25.247	28.320	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Continued investigation of Western Pacific tropical cyclone dynamics in order to improve the predictability of storm genesis, structure and intensity changes, radii of maximum winds and effects on sea surface waves. - Continued investigation of the effects of radioactively important aerosols on cloud dynamics and thermal structure of the lower atmosphere for the purpose of improving the treatment of these processes in numerical weather prediction models. - Continued effort to assimilate WindSat wind vector, Ozone Mapping and Profiler Suite (OMPS) ozone profiles, and Global Positioning System (GPS) temperature and water vapor profile retrievals into NOGAPS (Navy Operational Prediction System). - Continued effort to derive sea foam coverage from WindSat and to use this information in microphysical aerosol models to derive marine optical properties. - Continued assessment of the status of aerosol observation, prediction, and understanding for use in slant-range visibility and electro-optical performance prediction models. - Continued development of new soil moisture retrieval algorithm that addresses the basic modeling issues pertinent to soil moisture retrieval using passive microwave data from the NRL WindSat instrument. - Continued demonstration and validated a new data assimilation capability in NOGAPS ALPHA to generate the first global atmospheric analysis fields that extend from the ground to the edge of space. Space Sciences - Continued effort to exploit the polarametric aspect of WindSat for non-ocean surface wind vector Meteorological and Oceanographic Command (METOC) retrievals. Effort this year focused on soil moisture and sea ice. - Continued the development of 3D magnetohydrodynamic code for simulations of solar filament eruptions leading to flare and coronal mass ejection (CME) activity. - Continued studies of the major October-November 2003 solar activity events and the associated effects on the near-Earth space environment. - Continued effort to improve understanding of tropospheric and stratospheric bulk exchanges through observations and modeling. Effort this year focused on finding individual thunderstorm cells spawned by forest fires (pyrocumulonimbus clouds) which have injected material into the stratosphere.				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Continued assessment of advanced techniques and algorithms for remote sensing of ocean and atmospheric properties including winds, waves, currents, and surface topography. - Continued program to develop advanced improvements to specification and prediction of the space environment to improve space system performance and their on-call availability. - Continued monitoring of other-agency efforts for 'Naval Harvest' of advanced techniques and algorithms for remote sensing of ocean and atmospheric properties including winds, waves, currents, and surface topography. - Continued a focused program to develop a predictive, operational capability for the onset and evolution of equatorial spread-F that limits space-based communications and navigation capabilities. - Continued a program to use large high frequency/very high frequency (HF/VHF) arrays to investigate fine scale ionospheric phenomena with associated improvements in ionospheric modeling and the performance of current and future DoD capabilities impacted by ionospheric disturbances. - Completed calibration/validation of meteorological satellite wind (WindSat) polarimetric passive microwave data, and developed the version 1 of the WindSat wind vector retrieval algorithm. WindSat wind vectors have been released to the science community for evaluation. - Completed development and evaluation of techniques for remote sensing of upper atmosphere phenomena including neutral density, winds and bulk exchange cycles. - Initiated program to extend magnetohydrodynamic models of solar activity, and related effects on the near-Earth space environment, toward an improved predictive capability on communication and navigation systems, and other related effects on DoD operations. - Initiated effort to develop better physical understanding of small-scale atmospheric wave dynamics in the middle and upper atmosphere. - Initiated effort to develop understanding of how multi-scale interactions impact the predictability of tropical cyclones and their downstream effects. - Initiated effort to develop understanding to forecast the sun’s changing extreme ultraviolet (EUV) radiation and the responses of the upper atmosphere and ionosphere one-to-ten days in advance. - Initiated effort to develop and validate numerical models of high-energy solar energetic particle (SEP) and solar gamma-ray (SGR) emissions.				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Initiated effort to develop a quantitative standard model for solar flares that satisfies UV-X-ray observations; understand the origin, dynamics, and evolution of plasma in active region magnetic flux tubes. *FY 2009 Plans:* Marine Meteorology and Prediction - Continue all efforts of FY 2008, less those noted as completed above. - Initiate effort to derive and test advanced nonlinear atmospheric data assimilation algorithms using variational and ensemble techniques that are firmly based on modern inverse problem theory. - Initiate effort to understand the fundamental physics and dynamics that control cloud and aerosol variability in the marine boundary layer. Space Sciences - Continue all efforts of FY 2008, less those noted as completed above. - Initiate effort to develop the basis for an observational technique potentially enabling the first physics-based prediction of the severity of the largest energetic particle events generated by the Sun. - Initiate investigation in the feasibility of using Thompson scattering to directly and globally image the near-Earth electron density distributions and their variations driven by the solar wind to enable space environment forecasting and comprehensive space domain awareness for the Navy and DoD. - Initiate investigation of the driving mechanisms, mode characteristics, and impact on space plasmas of electromagnetic waves relevant to radiation belt remediation and auroral ionospheric space weather. - Initiate research on advanced EUV/X-ray optics and associated spectral modeling and data analysis, to improve the precision of solar irradiance monitoring and enable accurate irradiance forecasts. *FY 2010 Plans:* Marine Meteorology and Prediction - Continue all efforts of FY 2009. - Complete analysis of results from major field projects on air-sea interaction and transition improvements into applied research to improve the treatment of fluxes in coupled atmosphere-ocean prediction systems.				

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B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Complete theoretical and observational effort to improve understanding of the fundamental dynamics of mountain waves, including generation, propagation, nonlinear interaction, and wave breaking. - Complete assessment of the status of aerosol observation, prediction, and understanding for use in slant-range visibility and electro-optical performance prediction models. - Initiate field project to increase understanding of air-sea exchange of enthalpy (heat and moisture) to improve high-resolution coupled atmosphere-wave-ocean TC prediction systems. Space Sciences - Continue all efforts of 2009. - Initiate effort to assemble individual databases and model components of the Sun-Earth System.					
COUNTER IMPROVISED EXPLOSIVE DEVICE (IED) SCIENCES The ONR Basic Research Counter IED program seeks to develop innovative scientific concepts that will form the foundation for future technologies that may be developed and implemented to efficiently and effectively address the IED threat. The effort will emphasize fundamental scientific concepts that can be applied to the detection, neutralization, destruction and mitigation of the effects of these devices and to advance prediction of the occurrence or potential occurrence of IED events. The program also seeks to establish and nurture a multi-disciplinary counter-IED Science and Technology community of Government, academic and industry researchers to accelerate the transition of new science and technology into fielded systems. This activity also includes Secretary of Defense directed peer-review basic research to develop innovative solutions and enhance the science and engineering base. *FY 2008 Accomplishments:* - Continued effort in the area of Prediction to develop theoretical and technical approaches that permit prediction and analysis of IED emplacement as well as the assembly of IEDs. This included recognition of emplacement patterns, human activity recognition from video and other sensing systems, human intelligence and social network analysis of terrorist networks, modeling and simulation of the full spectrum		23.878	23.229	22.323	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
of IED activities, analysis of communications, and knowledge management systems to combine diverse data sources. - Continued effort in the area of Detection to develop concepts that would permit stand-off detection and localization of the explosive, the case materials, the environment in which the device is located, and other components of the IED. - Continued effort in the area of Neutralization to develop scientific concepts that may be applied to remotely render an IED ineffective without necessarily having to detect or destroy it. - Continued effort in the area of Destruction to develop scientific concepts that may be applied to quickly and remotely destroy IEDs without necessarily having to detect them. - Continued effort in the area of Mitigation to develop scientific concepts that may be applied to protect people and/or equipment from the destructive effects of an IED that may be detonated. - Continued computational fluid dynamics (CFD) CT-Analyst technology that provides a sensitive operational-quality capability to backtrack airborne detections of the chemical signatures and taggants of explosives instantly to their source. - Continued reactive flow dynamics study of multiphase reactive flow modeling and simulation that can be applied to investigate mitigation strategies to counter the IED threat. - Continued flame suppression mechanism investigation of additives to fine water mist to provide the scientific basis to guide search for suitable fine water mist based fire suppression strategies for DoD platforms, and to mitigate explosive blast effects. - Continued investigating neutron-sensitive glass materials for remote radiation sensing to develop novel approaches for detection of radiological threats: special nuclear materials, dirty bombs, IEDs. - Continued the study of molecular motions & physical properties under stress to develop better elastomers for applications of flexible materials (blast resistant coatings, sonar domes, appliqués). - Continued investigation and development of nonlinear methods to more effectively describe and analyze hyperspectral and multi-sensor data to improve characterization using nonlinear (manifold) methods. - Continued study of metal nanoparticles for insensitive munitions (IM) with high energy density and low sensitivity to hazardous conditions, operational environment and countermeasures. - Continued development of rapid identification of biological aerosols, a novel method that allows specific biological aerosols to be identified within a background of others and that can fulfill the criteria of continuous sampling, real time performance, use of a small amount of consumables, and portability.				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Continued a systems biology approach for the interrogation of marine microorganisms to describe and predict the functioning of an entire marine bacterial system in response to certain stimuli which will provide the ability to comprehensively model and manipulate microbiological systems for the development of next generation sensors for biological, chemical and explosive agent detection. - Continued synthetic nanopores for single molecule identification to demonstrate a novel synthetic-nanopore-based strategy for real-time, label-free, single molecule detection of chemical and biological threats. - Completed laboratory-on-a-chip studies of molecular dynamics and recognition including complex, integrated separations performed on a rapid timescale for DoD target analytes such as toxic industrial chemicals and chemical warfare agents which may be used in IEDs. - Completed studies of the fundamental issues in processing of quartz-crystal microbalance arrays directed to making micro-arrays of quartz crystals, each working at different frequencies. - Completed the study of radar for active detection of suicide bombers. - Completed activities to devise and demonstrate chemical templates for assembling/positioning nanoclusters and nanowire leads with nanometer precision to better understand the chemical & biochemical assembly of nanocluster-based electronics/sensors. Investigated ultra-fine electroless deposition for forming electrical leads. Explored early applications to single-electron devices and high-sensitivity sensors. - Completed exploration into advanced microarchitectures for bioprocessing and sensing to develop and characterize cellular microarrays expressing G-protein coupled receptors (GPCRs) and other proteins as targets for environmental detection. - Initiated creation of new spectroscopy for sensitive characterization of semiconductor nanostructures, ultra-thin molecular films and chemical/biological threat materials and explosives. - Initiated development of high-power mid-Infrared (IR) lasers for IR countermeasures, explosives detection (ED), biological detection, remote chemical sensing, etc. - Initiated development of product that will provide the warfighter protection against blast pressure wave and complements efforts in ballistic/projectile protection and combat casualty care communities. - Initiated development of a new chemical explosive detection concept based on pump/probe ultrashortpulse lasers.				

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B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Initiated effort to develop a chemically strengthened visible infrared (Vis-IR) composite window made from Spinel ceramic and germanate glass. - Initiated research on characterizing background noise in urban and riverine environments in support of IED signature detection. *FY 2009 Plans:* - Continue all efforts of FY 2008, less those noted as completed above. - Initiate a Counter-IED Grand Challenge effort to pursue innovative device neutralization modalities, augmented by device detection technologies. - Initiate development of nonlinear methods to significantly improve the differentiation of targets from background scenes in multivariate data sets of hyperspectral imagery. - Initiate development of high performance polymer materials for armor applications - Initiate effort to directly observe lattice deformations in explosives under shock impact. *FY 2010 Plans:* - Continue all efforts of FY 2009. - Initiate analytical study to detect an intruder in proximity to an underwater pipeline using structure-guided acoustic waves. - Initiate increased emphasis on sociological and cultural aspects of defeating insurgent networks. - Initiate increased emphasis on standoff wide area neutralization and pre-detonation of IEDs. - Initiate increased emphasis on stronger lightweight armor including nanoparticle designs. - Initiate increased emphasis on detection of physical and temporal device characteristics.					
HUMAN SYSTEMS Efforts include: Human factors and organizational design; manpower, personnel, and training; integrated avionics, displays, and advanced cockpit; and pattern recognition. As directed by the Secretary of Defense, this activity reflects an increase from FY 2008 to FY 2009 for Basic Research (6.1) to fund peer-reviewed research to develop innovative solutions and enhance the science and engineering base. The increase also includes the Basic Research Challenge which is a		7.486	13.966	15.733	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
competitive investment based on proposed scientific activities. The increase in funding in FY 2010 reflects an increased emphasis in immersive sciences for training, cognitive and neural sciences, research in learning and decision models and computational and algorithmic approaches to behavior of individuals, social groups and networks. *FY 2008 Accomplishments:* - Continued research of social networks for counterterrorism. - Continued expansion of the cognitive architectural modeling capability to increase coverage, including spatial reasoning, multi-tasking, and impact of physiological and stress variables, etc. - Continued research of human cognition and performance to create more realistic simulations for training. - Continued program to combine cognitive architectures with computational neuroscience to better predict human performance. - Continued program on implantable electronics for performance enhancement. - Continued research of hierarchical, cellular, and hybrid organization structures for command and control. - Continued schema theory applications to multi-echelon command decision making. - Continued investment in natural language interaction capability for artificially intelligent training systems. - Continued research of neuro-control of high-lift bioinspired Unmanned Underwater Vehicles and active vision and cognitive navigation skills in mobile robots. - Continued computational neuroscience for novel pattern recognition and sensory augmentation. - Continued social-science based computational toolsets for terror network analysis at PACOM'S Joint Intelligence Center and on the USS TARAWA (LHA-1) to support Expeditionary Strike Group One in Overseas Contingency Operations. - Continued investigations to support new missions for Expeditionary Strike Groups in three areas: 1) analysis and diagnosis of Command and Control Organizational structures; 2) effects-based operations and development of reach-back capability for course of actions analysis; and 3) decision support systems for management of Battle Rhythm. - Continued research of human-robot interaction to support team collaboration.				

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B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Continued computational and agent-base modeling and experimentation to explore options for Effects-Based Operations. - Continued models of operational decision making for component commanders of an Expeditionary Strike Group with special emphasis on elaboration and planning knowledge. - Continued research of integrated parallel optimization models of adaptive function and responsibility reallocation between commanders/staff and reconfiguration of the command, control, and communication organizational structures. - Completed research on adaptive command and control architectures in support of the Navy's new Maritime Strategy. - Initiated the output human performance usability models with actual human performance results obtained in usability testing on systems under development. These systems include future Naval Combat Systems and Homeland Security Operation Centers. - Initiated investigation of human sensory performance for optimizing video and audio human-electronic device interfaces. *FY 2009 Plans:* - Continue all efforts of FY 2008, less those noted as completed above. - Initiate research to create new social modeling tools for understanding the responses of adversaries, determining the best practices for containing and deterring the adversary, and developing effective course of action in non-Western environments for humanitarian and civilian-military operations. - Initiate research of advanced biometrics such as biodynamic signatures to support spiral 2 and 3 of Navy Identity Dominance System Maritime Domain. - Initiate efforts to extend the representational capabilities of cognitive architectures to accommodate aspects of social cognition and teamwork. - Initiate efforts to develop an empirical understanding and prediction of the behaviors of individuals and social groups and networks, computational approaches to social network theory and the co-evolution of adversarial tactics and strategies, algorithms for exploring scenarios that take into account socio-cultural factors; political and economic factors; local attitudes, values, and social structure. - Initiate research focused towards cognitive and neural sciences, virtual/immersive environment simulators, decision models for improved warfighter performance.					

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
FY 2010 Plans: - Continue all efforts of FY 2009. - Initiate research of human activity and intend recognition and dynamic biometrics for improved human system interfaces and force protection. - Initiate research into probabilistic reasoning in computation cognitive architectures.				
INFORMATION SCIENCES	23.733	32.299	33.583	
Efforts include: Mathematical foundation and computational theory and tools for design, communication, and control of intelligent autonomous systems; decision theory, algorithms, and tools; heterogeneous information integration, management, and presentation; information assurance, 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; and expeditionary operations Command, Control, Communications, Computers Intelligence Surveillance and Reconnaissance (C4ISR). As directed by the Secretary of Defense, this activity reflects an increase in FY 2009 and out for Basic Research (6.1) to fund peer-reviewed research to develop innovative solutions and enhance the science and engineering base. The increase also includes the Basic Research Challenge which is a competitive investment based on proposed scientific activities and an increased level of investment and effort for information technology for software systems. *FY 2008 Accomplishments:* - Continued development of mathematical optimization framework and heuristic algorithms that serve as theoretical and computational basis for network design, resource allocation, and logistics. - Continued development of improved tactical and battlespace decision aids. - Continued to refine techniques for extracting maximum knowledge from multi-modal imagery, text, and multi-source signal data. - Continued to investigate methods to deal with light dispersion on image formation underwater to enable precise navigation, station keeping, and mapping capabilities for unmanned underwater vehicles.				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Continued efforts for enabling teams of autonomous systems to work together and work on representations for evolution of cooperative behaviors, including efforts in multi-modal interactions with autonomous systems. - Continued developing framework for dealing with effect of variable latencies in communication within teams of humans and autonomous systems. - Continued efforts on quantum computing and cryptography. - Continued efforts on model checking and automated theorem prover technologies. - Continued efforts on biometric technologies for authentication. - Continued efforts in physics-based modeling of natural phenomena. - Continued efforts in mathematical techniques for inverse problems, including reliable approximate solutions in 3 dimensions (3D); adequate representation of the physics of the media and the scatterer; and improved resolution of structural and material properties. - Continued development of technology for maximizing information delivery in tactical networks via encoding information under speech. - Continued development of technology to re-engineer legacy code. - Continued development of technology to improve analysis of distributed systems. - Continued focused efforts in development of mathematical foundations for image understanding on a number of key challenges, such as multi-modal imagery representation and metrics, object recognition, scene analysis and understanding. - Continued focused university efforts on statistical data analysis of non-traditional data types, such as text, open source, and streaming data in order to develop a computational statistics framework for integrating information of disparate sources. - Continued efforts on communications and networks. - Completed development of technology for improving behavior of coordinated teams of autonomous systems. - Initiated a study of mathematical functional spaces to represent, compute, and analyze data of diverse and disparate nature in order to develop a robust computational theory for automated information integration of disparate sources of data. - Initiated development of mathematical, statistical, and computational framework leading to robust underlying approaches for automated information integration of disparate sources of data.				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Initiated development of technology for analyzing functionality of executable software code. - Initiated development of technology for assessing effectiveness of automatic translation programs. *FY 2009 Plans:* - Continue all efforts of FY 2008, less those noted as completed above. - Completed efforts on communications and networks. - Initiate research in cognitive radio and networking protocols. - Initiate research on novel switched mode techniques to overcome radiation efficiency limit in electrically small antennas. - Initiate research in cross-layer wireless protocols for delay sensitive network traffic. - Initiate multidisciplinary research efforts to focus on intelligent control systems, cooperative behavior modeling and response, UxV-human interactions and adaptive mission methodologies. - Initiate development of an interaction model of how users characterize visual content and context to improve video surveillance. - Initiate development of improved formal foundations, methods, and tools for compositional verification and construction of high assurance software systems. - Initiate investigation of relational constructive induction, semi-supervised learning, and classifier ensembles to improve Collective Classification technology and operations based automated decision aids. - Initiate multidisciplinary research efforts to focus on intelligent control systems, cooperative behavior modeling and response, UxV-human interactions and adaptive mission methodologies. - Initiate research aiming to develop principled, trustworthy, yet practical and usable approaches to address the issue of software producibility and the development of complex software systems with ensured interoperability. - Initiate research into Anti-Tamper and Information Assurance: research focused on protection techniques, architectures, algorithms, protocols that allow for security and cyber situational awareness. - Initiate research on novel switched mode techniques to overcome radiation efficiency limit in electrically small antennas. - Initiate research to develop mathematical and computational tools for compressive sensing. - Initiate the development of theory and algorithms for quantum communications.				

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B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Increase basic research into the extraction of information from large data sets. *FY 2010 Plans:* - Continue all efforts of FY 2009, less those noted as completed above. - Initiate basic research efforts addressing the representation, computation, and analysis of information from large diverse data sets. - Initiate research efforts to develop tools for proactive information assurance and cyber space security.					
MATERIALS/PROCESSES Efforts 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. *FY 2008 Accomplishments:* Structural Materials - Continued development of first-principles based methodologies for predicting the thermodynamics and kinetics controlling microstructural evolution for the design of advanced weldable, naval steels. - Continued development of models and simulations to understand and predict high deformation rate blast behavior for engineered topological structures. - Continued development of materials and fabrication science for fugitive phase processes for engineered topological structures for ship blast protection. - Continued quantification of the corrosion effects on fatigue to be incorporated into the Unified Damage Model and validate in a few environmental cases on P-3 aircraft real loads data. - Continued developing carbon nanotubes growth and mechanical behavior in advanced composites for next generation ship and aircraft structures.		56.015	58.994	60.111	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Continued development of physics-based models of thermal and materials flow during friction stir welding of steels, including the development of residual stresses that will lead to distortion. - Continued development of progressive damage models for blast effects on composite marine structures. - Continued development of theoretical basis for composite materials behavior based on x-ray computed micro-tomography. - Continued development of understanding and constitutive models of dynamic behavior of naval steels. - Continued evaluating environmental effects on marine composites and sandwich structures. - Continued exploration of composition, processing and microstructural evolution in titanium alloys for marine structures. - Continued exploration of multienergy processes for zero maintenance coatings. - Continued first lubrication-by-design experiments. - Continued high temperature, low frictional sliding coefficient materials for elevated operating temperature gas turbine engine bearings. - Continued investigation of a rapid annealing of surface layers and their effects. - Continued multi-scale (atomic to microscopic) physics/chemistry-modeling of friction, wear, and lubrication for the rational design of high performance bearings, gears, seals, and lubricants. - Continued research tools design efforts in chemical dynamics. - Continued research tools design efforts in dynamic three dimensional control of structures. - Continued the investigation of processing science (single crystals, coatings, thermal barrier coatings (TBC), heat treatment, etc) to materials performance for turbine engine components to develop relevant process protocols to optimize and control quality. - Continued to advance the understanding of processing and deformation mechanisms in nanostructured ceramic composites and metal alloys to provide new high strength-high toughness materials for Naval platforms. - Continued to develop the science of sliding contact and lubrication using physical and chemical first principles. - Continued to investigate the use of photorefractive crystals for the demodulation of a distributed fiber optic Bragg gratings structural health monitoring system. - Completed research into the area of transforming bio-fibrillose material into carbon nanotubes.				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Completed evaluation of new high temperature resin for potential Unmanned Combat Air System (UCAS) high temperature composite applications. - Initiated research on new hybrid composites that integrate polymers, structural fibers, carbon nanotubes, ceramics and metals, with improved blast, ballistic, fire resistance and mechanical characteristics with special emphasis at the interfacial aspects of the new materials. - Initiated efforts to understand and predict salt chemistry effects on high temperature coatings and materials in naval gas turbine environments. - Initiated understanding for development of modeling tools for enhancing dynamic response and projectile resistance for sandwich structures. Functional Materials - Continued research tools design efforts in electromagnetic and acoustic bandgap materials. - Continued study of new transduction mechanisms. - Continued development of the science and technology base for a highly efficient and stable flexible organic solar cell. - Continued effort to fabricate extended 2D left handed materials (LHM) structures. - Continued examination of the effects of acoustic perturbations and interactions in reacting flows and determine how they can be used. - Continued exploration and prediction of new sonar materials based on first principle methods. - Continued extension of first principle calculations of sonar materials tensor piezoelectric and dielectric properties to complex solid solutions to provide the basic understanding and predictive capability for ultra high strain materials. - Continued first principle methods to calculate second and third rank tensor properties of sonar materials such as lead zirconate titanate and lead magnesium niobate. - Continued investigation into the properties and fabrication of novel ceramics which have potential to combine hardness, strength, and high transmission in the long wave infrared (LWIR) spectral region. - Initiated exploration of innovative technologies such as capacitive micro-machined acoustic transducers for naval sonar systems. - Initiated study of standoff detection of explosive materials and devices.				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Initiated development of methods for the intentional, controlled, impurity doping of semiconductor nanocrystal wires. - Initiated effort to synthesize beta-SiC power suitable for subsequent densification into transparent beta-SiC ceramic. - Initiated meta-materials effort to develop negative index materials with dynamic frequency response. - Initiated synthesis and property measurement of new sonar materials predicted by first principle methods. Maintenance Reduction - Continued development of corrosion models. - Continued mechanistic studies of materials deterioration under chemical environment for ship materials and their interfaces. - Continued to identify stress corrosion control methods for friction stir welded high-strength aluminum alloys using advanced thermal treatments, chemical modifications, and surface mechanical processes to tailor compressive stresses. - Continued mechanism-based modeling of H-assisted cracking in ultra high strength steels. - Continued stainless steel carburization study to enhance corrosion performance. - Continued studies on understanding and modeling sea water corrosion effects of thermal cycling of AA 5XXX series. - Initiated the concept study of multiscale corrosion modeling on naval ship materials. - Initiated fundamental theoretical and experimental studies on nanoscale corrosion of metals and alloys. - Initiated corrosion prediction using an integrated deterministic-based model. - Initiated grain boundary engineering to improve corrosion resistance of marine grade aluminum alloys. - Initiated modeling and simulation of corrosion phenomena. Environmental Science - Continued examination of scientific methods for pollution prevention, waste reduction, and hazardous material reduction for Naval Operations. - Continued assessment of the fate and effects of chemical and biological contaminants in marine/ estuarine environments.				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Continued broad based program in anti-fouling and fouling release coatings including investigation of effect of new polymers, materials, processes, and novel testing methodologies for coating efficacy. - Continued effort to determine most promising foul-release approaches based on silicones to meet Navy durability requirements. - Continued research tools design efforts in Sampling and Analytical Methodologies. - Continued effort to develop Reverse Osmosis (RO) pre-treatment strategies to allow water recycling on ships. - Initiated efforts on treatment strategies of oily water containing synthetic lubricants. *FY 2009 Plans:* Structural Materials - Continue all efforts of FY 2008, less those noted as completed above. - Complete development of physics-based models of thermal and materials flow during friction stir welding of steels, including the development of residual stresses that will lead to distortion. - Complete research tools design efforts in dynamic three dimensional control of structures. - Complete research tools design efforts in chemical dynamics. - Complete development of progressive damage models for blast effects on composite marine structures. - Initiate multi-energy processing approaches for the room temperature cure of polymeric materials with high temperature thermoxidative stability and fire resistance. - Initiate the fatigue life prediction model analysis on high temperature engine materials. - Initiate development of new methods for room temperature curing and processing of polymer composites with high temperature oxidative stability and fire resistance. - Initiate assessment of the blast resistance of cellular structures as functions of soil characteristics. - Initiate development of seamless ceramic joining technology for the fabrication of large, complex shape conventional ceramic windows for IR, radar and visible light shipboard systems from small, inexpensive components using electrophoretic deposition of ceramic nanoparticles. - Initiate development of understanding and constitutive models of competing and complementary microstructural factors influencing both dynamic behavior and weldability of high strength steels and naval titanium alloys.				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Initiate expansion of first-principles methods devised to calculate piezoelectric properties of materials for sonar transducers to calculate additional materials properties for other applications. - Initiate materials and fabrication science for fugitive phase processes for engineered topological structures for vehicle blast and fragmentation protection. Functional Materials - Continue all efforts of FY 2008. - Initiate design, processing, and measurements to fashion the new generation of high-strain, high coupling piezoelectric single crystals into high-performance acoustic transducers for naval sonar systems. - Initiate basic research into material technology associated with the development of active and conventional armor. - Initiate effort to characterize regenerative bacterial nanowires. - Initiate effort to synthesize cyclic peptide ring modules and polymerize them into peptide nanotube polymers. - Initiate efforts to utilize chemically modified virus proteins as a scaffold to assemble nanostructured metamaterials with unique optical properties including negative index of refraction. - Initiate effort to develop surface electrons on diamond. Maintenance Reduction - Continue all efforts of FY 2008. - Complete identification of stress corrosion control methods for friction stir welded high-strength aluminum alloys using advanced thermal treatments, chemical modifications, and surface mechanical processes to tailor compressive stresses. - Initiate the investigation of processing science (single crystals, coatings, thermal barrier coatings (TBC), heat treatment, etc) to materials performance to develop relevant process protocols to optimize and control quality. - Initiate studies of surface microstructure optimization to enhance corrosion properties of navy marine alloys - Initiate sensor development for monitoring microstructural changes on alloys under thermal and mechanical stresses.				

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B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**

- Initiate research focused on modeling and simulation for platform and system affordability, lifetime materials, shipboard wireless capability, automation to reduce manning.

Environmental Science
- Continue all efforts of FY 2008.
- Complete assessment of the fate and effects of chemical and biological contaminants in marine/ estuarine environments.
- Complete research tools design efforts in Sampling and Analytical Methodologies.

Manufacturing Science
- Initiate a multidisciplinary research task into furthering the sciences associated with advances in manufacturing processes.

FY 2010 Plans:
Structural Materials
- Continue all efforts of FY 2009, less those noted as completed above.
- Initiate exploration of fundamental mechanisms and initiate development of physics-based models of electrophoretic deposition of ceramic nanoparticles and subsequent sintering.
- Initiate physics based models for coupled phenomena in marine composite structures (thermo-mechanical loads, environmental effects, and fluid-structure interactions.)
- Initiate research on innovative concepts for effective radiation barrier coatings and ultra-low thermal conductivity barrier coatings.

Functional Materials
- Continue all efforts of FY 2009.
- Complete first principle methods to calculate second and third rank tensor properties of sonar materials such as lead zirconate titanate and lead magnesium niobate.
- Initiate efforts to develop oxide materials for power management, sensors, and information storage/ processing

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B. Accomplishments/Planned Program ($ in Millions)	**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
Maintenance Reduction - Continue all efforts of FY 2009, less those noted as completed above. - Initiate development of ab initio models of corrosion reactions. - Initiate development of coatings capable of actively responding to environmental stresses. - Initiate study of coating failure mechanism on coating-substrate interface. - Initiate research on innovative concepts for effective radiation barrier coatings and ultra-low thermal conductivity barrier coatings. Environmental Science - Continue all efforts of FY 2009, less those noted as completed above. Manufacturing Science - Continue all efforts of FY 2009.				
MEDICAL/BIOLOGY Efforts include: Biosensors, bioprocesses, and bio-inspired systems; casualty care and management; healthy and fit force; casualty prevention; undersea medicine/hyperbaric physiology; biorobotics; expeditionary operations training; and chemical-biological defense. These efforts are coordinated with the Army and Air Force through joint program reviews and are complementary, not duplicative. This activity also includes Secretary of Defense directed peer-review basic research to develop innovative solutions and enhance the science and engineering base. *FY 2008 Accomplishments:* Medical Sciences - Continued research to understand individual variability in stress response. - Continued non-lethal weapons bioeffects research. - Continued work on stress physiology, hyperbaric physiology, and biological effects of Naval operational exposures (e.g. directed energy).	14.416	16.909	18.230	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Continued work in understanding the mechanisms of decompression illness and hyperbaric oxygen toxicity. - Continued work on genomics/genetics of infectious organisms of military relevance and signal of transduction. - Continued research in casualty care and management and casualty prevention, including investigations of mechanisms of hemorrhagic shock, blast injury, tissue repair, and the biomedical effects of military operational exposures such as directed energy, hazardous chemicals, and sound. - Continued research in Genetic Polymorphisms, the stress response and their Interaction with the Immune System. - Continued research to explore systematic relationships between cognitive and physiological responses to laboratory tasks under operational conditions. - Completed research in healthy and fit force. - Initiated research in the mechanism/effects of underwater thermal stress. - Initiated research in understanding skull bones injury and healing dynamics. - Initiated research to discriminate fatigue and stress performance effects. Biological Sciences - Continued work to power naval ocean instruments with sediment biofuel cells and to elucidate the microbial processes that drive energy harvesting in these systems. - Continued research on biofouling with emphasis on barnacle adhesion studies using molecular biology tools. - Continued work on microbial synthesis of energetic materials. - Continued research of toxicity and enzymatic pathways of biodegradation of Royal Demolition Explosive (RDX), High Melting Point Explosive (HMX) and Dinitrotoluene (DNT) in marine benthos. - Continued efforts focused on microbe-materials interfacial interactions to detect materials defects/ failures. - Continued research on biofouling microbial community succession and invertebrate larval settlement in response to biofilms. - Continued biogeochemical research of Mississippi Sound sediments: Hurricane Katrina effects and recovery.				

Exhibit R-2a, PB 2010 Navy RDT&E Project Justification		DATE: May 2009
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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Continued research to understand physiological effects of sound exposure on marine mammals from Navy sound sources other than sonar. - Continued efforts in “smart cell engineering” to design microbes that can sense and destroy other microbes through antibiotic production, or can “sense” and qualify their surrounding environment and provide information back to the user. - Continued combinatorial chemical screens for bacterial communication pathway inhibitors as potential antibiotics or fouling-control agents. - Continued work to power naval ocean instruments with sediment biofuel cells and to elucidate the microbial processes that drive energy harvesting in these systems. - Completed efforts directed at genomics-enabled anaerobic transformation of polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs) in estuarine sediments. - Completed efforts focused on eelgrass-mediated degradation of PAHs and PCBs. - Completed efforts to develop next-generation and supramolecular antibiotics. - Completed dolphin microarray and gene-based studies to facilitate immunobiology studies of stress response. - Initiated efforts to engineer plants to produce high value naval materials. - Initiated efforts utilizing metagenomic screens to identify novel bacterial activities related to nitration or synthesis of high-N heterocycles. - Initiated efforts to develop ultra-fast methodology for selecting DNA biosensor molecules. - Initiated research to generate label-free assays for biosensing at biointerfaces. - Initiated research to identify inhibitors of lateral DNA transfer in bacteria. - Initiated work to identify plasma biomarkers of domoic acid toxicosis and leptospirosis in California sea lions, and develop a multiplexed assay to measure those plasma biomarkers. *FY 2009 Plans:* Medical Sciences - Continue all efforts of FY 2008, less those noted as completed above. - Initiate research in genetic basis of psychological stress. Biological Sciences				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Continue all efforts of FY 2008, less those noted as completed above. - Complete research on biofouling microbial community succession. - Complete efforts on biomimetic adhesives for underwater use. - Complete biogeochemical research of Mississippi Sound sediments: Hurricane Katrina effects and recovery. - Complete research on toxicity and enzymatic pathways of biodegradation of Royal Demolition Explosive (RDX), High Melting Point Explosive (HMX) and Dinitrotoluene (DNT) in marine benthos. - Initiate increased emphasis in efforts focused on microbe-materials interfacial interactions for detection of materials defects/failures, including corrosion, and for improved energy harvesting. - Initiate increased emphasis in research on invertebrate larval settlement and metamorphosis in response to biofilms and various inhibitors of adhesion. - Initiate efforts to identify molecular biomarkers for battlefield injuries, and high-fidelity biosensors for detection in vivo. - Initiate research into biomolecular 'logic controllers' for in vivo biosensor and in vivo drug delivery systems. - Initiate research on engineered cells for infection detection and treatment in wounds. - Initiate research efforts focused on developing bio-inspired sensors, vehicles and systems for local ISR, WMD detection, personnel protection and affordability. Research elements include advances in microfabrication, biological materials, processing techniques, robustness and efficiency of systems. *FY 2010 Plans:* Medical Sciences - Continue all efforts of FY 2009. - Initiate research on diving in contaminated/polluted water and sediment. - Initiate research on long-term effects of exposure to submarine environments. - Initiate research on physiological and genetic effects of long-term diving. Biological Sciences - Continue all efforts of FY 2009, less those noted as completed above.				

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B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Initiate efforts to ascertain potential human health and environmental risks of novel nanomaterial-based ammunition primers. - Initiate research on stem cells in marine mammals and their potential clinical role. - Initiate development of a second set of molecular diagnostic tests for recently discovered viral pathogens of marine mammals.					
OCEAN SCIENCES Efforts include: 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. This activity also includes Secretary of Defense directed peer-review basic research to develop innovative solutions and enhance the science and engineering base. *FY 2008 Accomplishments:* Littoral Geosciences and Optics - Continued field programs to understand physical and biological processes responsible for the formation, maintenance, and breakdown of thin oceanographic layers which have a significant impact on undersea warfare sensors and weapons. - Continued field, laboratory, and numerical studies of seafloor sand ripple genesis, evolution, and destruction and their effect on acoustical penetration of the sea floor. - Continued efforts to investigate the effects of oceanic biota on the propagation and inversion of multi-frequency acoustical energy. - Continued investigations of sources and properties of light scatter within the coastal ocean. - Continued to investigate the physical processes that control re-suspension of bottom sediments and the resulting impact on optical and acoustical propagation. - Continued investigations of oceanic processes within the surface boundary layer that control high-frequency variability in image propagation and distortion.		83.737	83.257	83.108	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Continued to investigate and characterize the impact of riverine sources of optically-important matter on underwater visibility, navigation, and surveillance. - Continued field program to infer sea floor characteristics from observations of surface gravity waves. - Continued effort to improve accuracy of the "5-cm gravimetric geoid" and precise geodesy. - Continued effort to understand the extent and intensity of seafloor gas hydrate accumulations and coastal bio-optical response to air-ocean forcing. - Continued programs to estimate optical properties of coastal ocean water from above-surface sensing, using in-situ data for validation. - Continued studies to predict tidal flat evolution in coastal/riverine/estuarine systems. - Continued incorporation of improved understanding of tropospheric and stratospheric bulk exchanges, air-sea interface, boundary layer interface, coastal ocean dynamics, gas hydrate accumulation, and biological responses into atmospheric and ocean prediction models and tactical aids. - Initiated development of prediction models for distributary deltaic coastal environments. Marine Mammals and Biology - Continued field trials of an integrative ecosystem study to provide environmental predictors of whale presence or absence to reduce impacts of Naval systems to marine mammals. - Continued new efforts on tracking of marine mammals using data fusion based on tags and remote sensing. Physical Oceanography and Prediction - Continued field studies/modeling to predict propagation and effect on acoustics of non-linear internal waves in the western Pacific. - Continued development of a ship wave radar driven wave model to allow high resolution studies of near surface ocean processes and to support Sea Basing. - Continued extensive internal wave field program off the New Jersey Shelf; field work coincided with and complemented the Shallow Water Acoustics Program. - Continued an assessment of the role of emerging sub-mesoscale parameterization techniques for improving next generation high resolution/high accuracy environmental models.				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Continued design evaluation for a persistent mobile sampling network based on autonomous undersea vehicle platform and sensor technologies. - Continued extensive 3-year field program on prediction of internal waves. - Continued first field test of the Optimal Deployment DRI (ODDAS) in the South China Sea. - Continued 5-year program on the analysis of coherent structures in rivers and estuaries in support of the prediction and characterization of denied areas. - Continued a field and modeling program to predict mesoscale structures and rapidly-varying currents in the Philippine Archipelago using Synthetic Aperture Radar (SAR), Hyperspectral and other remote data together with new data assimilation methods. - Continued field programs that demonstrate “persistent monitoring and measurement of environmental structures using gliders. - Continued workshops to define science needs for Sea Basing. - Continued a Coupled Oceanographic-Acoustics modeling and field program to demonstrate the use of a fully coupled system in optimizing tactical reduction of uncertainty. - Continued an integrated modeling and field experiment on determining custom self-learning wave databases and forecast systems/ship-movement and engineering systems for Sea Basing. - Continued the pilot test of the novel data (synthetic aperture radar and Hyper-spectral) assimilation forecast system developed under Philippine experiment. - Continued an Estuarine-Littoral Processes Interaction field study in muddy and tidal flat dominated regimes including a data assimilative prediction capability. - Continued studies of complex ocean currents in the Indian Ocean using gliders and remote sensing methods being developed to support tactical oceanography. - Continued studies of internal waves and strait dynamics emphasizing field studies in the Celebes, Philippine, and Sulu Seas. - Continued studies to understand how to sample ocean processes with gliders and other autonomous and remote sensing systems to support tactical oceanography. - Continued the field experiment in Monterey Bay to examine the role of unresolved processes in model parameterizations.				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Continued to develop state of the art numerical model assimilation and initialization techniques, improved physical parameterizations, air-sea interactions, and fidelity for atmospheric and ocean prediction systems. - Initiated development of expert system methods to characterize and predict Riverine/estuarine systems to support Naval Special Warfare, Marine Expeditionary Forces and new Riverine units. - Initiated studies of complex ocean currents in the Indian Ocean using gliders and remote sensing methods being developed to support tactical oceanography. Ocean Acoustics - Continued analysis of deep-water acoustic transmissions made in the North Pacific to understand the scattered sound field due to ocean volume variability and bathymetric features. - Continued field experiments and modeling efforts to examine the performance of Acoustic Vector Sensors. - Continued a field and modeling effort to simultaneously study shallow-water medium fluctuations and develop time-reversal communications using adaptive channel equalizers. - Continued analysis and modeling to understand the physics of buried mine detection through broadband and synthetic aperture sonar. - Continued shallow-water, shelf-break measurements and analysis to characterize the effects of the ocean water column and seabed variability on low- and mid-frequency acoustic propagation and scattering. - Continued a field and modeling effort to establish the capabilities of underwater acoustic communications for FORCEnet and persistent undersea surveillance. - Continued the development and testing of geo-acoustic inversion and extrapolation methods. - Continued investigations into quantifying, predicting and exploiting uncertainty in acoustic prediction models. - Continued to research effect of solitons and internal wave bores on acoustic propagation and buoyancy. - Continued studies of adaptive beam-forming using mobile, autonomous sensors. - Continued research to develop complex analytic equations that couple oceanographic modes, both horizontal and vertical, to their corresponding frequency-dependent acoustic modes to give direct acoustic prediction capability.				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Continued research to quantify uncertainty in acoustic field computations for multi-scale ocean environments using novel approaches involving Bayesian prediction and polynomial chaos expansions to embed environmental uncertainty into multi-scale ocean dynamics and acoustic propagation. - Continued assessment of “time-reversal” propagation techniques for mitigation of environmental variability. - Continued development of algorithms for accurate acoustic predictions in dispersive, turbulent, turbid water. - Continued development of source waveform design for rough littoral seafloors. - Continued effort to develop a methodology for expressing the semantics of physics-based environmental models to support automated computer applications. - Continued effort to understand how mudflat sediments respond to dynamic processes. - Continued effort to understand synoptic scale ocean variability in the strategic Turkish Straits System including water mass exchange between basins and vertical mixing. - Continued field work on adaptive beam-forming using mobile, autonomous sensors. - Continued investigation of acoustically induced magnetic fields using modern experimental equipment and numerical techniques. - Continued research to enhance understanding of the vibrational response of elastic structures to flow-induced excitation while developing a first-principles model for the induced structural acoustic response and reradiated acoustic field. *FY 2009 Plans:* Littoral Geosciences and Optics - Continue all efforts of FY 2008. - Initiate studies of tidal flat evolution in wave dominated environments. Marine Mammals and Biology - Continue all efforts of FY 2008. Physical Oceanography and Prediction - Continue all efforts of FY 2008.				

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B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Complete studies of internal wave propagation in the South China Sea. - Initiate studies of ocean and wave response to typhoons and monsoons in the Western Pacific. - Initiate studies of how to predict the 'full battle space environmental cube' using networked sensors and multiply coupled ocean/wave/atmosphere/acoustic prediction systems to provide sea base and fleet force protection. Ocean Acoustics - Continue all efforts of FY 2008, less those noted as completed above. - Initiate deep-water acoustic transmission measurements with emphasis on the Northern Philippine Sea. *FY 2010 Plans:* Littoral Geosciences and Optics - Continue all efforts of FY 2009. - Complete field, laboratory, and numerical studies of seafloor sand ripple genesis, evolution, and destruction and their effect on acoustical penetration of the sea floor. - Initiate studies of dissipation of surface gravity waves by muddy seabed sediments. Marine Mammals and Biology - Continue all efforts of FY 2009. - Initiate new efforts to examine physiology of marine mammals in situ and to predict consequences of physiological and auditory stress to populations. Physical Oceanography and Prediction - Continue all efforts of FY 2009, less those noted as completed above. Ocean Acoustics - Continue all efforts of FY 2009, less those noted as completed above. - Initiate data collection and analysis of deep water ambient noise with emphasis on the Philippine Sea.					
SCIENCE AND ENGINEERING EDUCATION, CAREER DEVELOPMENT AND OUTREACH		33.275	33.023	27.414	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
Science and Engineering Education and Career Development activities include DON participation in science fairs, summer research interns/fellows at Navy laboratories, 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. The decrease in FY 2010 represents a decrease in availability of resources. *FY 2008 Accomplishments:* - Continued awarding prizes at 400 regional high school science fairs and three national competitions. - Continued supporting high school summer interns at Navy laboratories. - Continued supporting undergraduate/graduate students as summer research interns at Navy laboratories. - Continued providing graduate fellowship support to HBCU engineering faculty candidates. - Continued funding Young Investigator research grants. - Continued encouraging, promoting, planning, coordinating and administering naval Science and Technology programs. *FY 2009 Plans:* - Continue all efforts of FY 2008. *FY 2010 Plans:* - Continue all efforts of FY 2009.				
SENSORS, ELECTRONICS AND ELECTRONIC WARFARE (EW) Efforts include: 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; Integrated Topside Innovative Naval Prototype (ITS INP); and RF electronic warfare.	40.582	47.137	51.208	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
As directed by the Secretary of Defense, this activity reflects a increase from FY 2009 and out for Basic Research (6.1) to fund peer-reviewed research to develop innovative solutions and enhance the science and engineering base. The increase also includes the Basic Research Challenge which is a competitive investment based on proposed scientific activities. *FY 2008 Accomplishments:* - Continued monolithic integration of multifunctional materials to enable passive devices and sensors into wide bandgap semiconductor circuits. - Continued project to develop linear higher power microwave wide bandgap semiconductor bipolar transistors based on distributed polarization effect (graded composition) base growth and processing technology. - Continued effort to increase power conversion efficiency in an organic plastic solar cell based on Carbon 60 and a transparent hole transporter, and a conducting polymer electrode with achievement of > 4% - Continued investigation of physical basis for improved time and frequency standards using quantum-entangled ions and atoms. - Continued non-cooperative target identification from multiple aspects. - Continued investigation of ultra high speed logic and multiple-quantum-well devices with a goal of >500 giga-hertz (GHz) samplers, in support of mixed signal circuits for receiver analog-to-digital converters (ADC's). - Continued program to extend device performance and architectures to frequencies approaching tera hertz (THz). - Continued program to incorporate Magnesium Diboride (MgB2) tunnel junctions into simple electronic logic structures. - Continued study to determine if the coupling between spins in quantum dots mediated by the virtual excitons is sufficiently strong for use in solid state implementations for quantum information. - Continued program on advanced epitaxial growth for novel Si-based detector applications. - Continued development of a blind adaptive beamforming approach for the High Frequency (HF) radar case and compare with both the conventional and traditional approaches.				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Continued development of approaches for probability of detection for deterministic signals in stationary noise and quantify for non-stationary noise. - Continued development of electromagnetic ultra-near-field holography. - Continued development of sensitive miniature fluxgate magnetometers. - Continued investigation of temporal-spatial noise shaping circuits and architectures for high power digital-to-analog conversion with objectives of doubling spectral bandwidth, reduction of element density (15%), and extension of multidimensional Nyquist limits to both linear and planar arrays. - Continued project to develop linear higher power microwave wide bandgap semiconductor bipolar transistors based on distributed polarization effect (graded composition) base growth and processing technology. - Continued project to lower thermal gradients between active circuit elements and heat sinks. - Continued projects to explore physical behavior of full arrays of nanoscale devices for logic, memory, and imaging. - Continued research to develop electromagnetic ultra-near-field holography. - Continued the demonstration of control of the concentrations of the defects that limit the minority carrier lifetime in SiC. - Continued the evaluation and assessment of hardware-compatible space-time algorithms for Digital Signal Processor (DSP) applications to Transmit/Receive (T/R) arrays. - Continued the growth of semiconductor quantum wires with controlled doping and heterostructure interfaces. - Continued the initial study of the coherent control of wavefunctions in quantum dots. - Continued the study of Reciprocal Quantum Logic (RQL) digital superconducting logic. - Completed the analysis and characterization of micro-motion Doppler modulation. - Completed the evaluation and assessment of hardware-compatible space-time algorithms for Digital Signal Processing (DSP) applications to T/R arrays. - Completed investigation of super-resolution signal processing techniques for closely spaced and unresolved targets in Doppler, range and direction of arrival spaces for a variety of radars. - Completed analyzing effects of maritime and urban aerosols on thermal blooming of high energy laser beams.				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Completed improvements to integrated nanomechanical device arrays to include scaling down resonator architecture and quantifying properties which establish phononic crystal properties. - Completed/transitioned Cellular Nonlinear Network (CNN) fast image processor with multi-spectral focal plane array sensors to 6.2 research. - Completed analyzing effects of maritime and urban aerosols on thermal blooming of high energy laser beams. - Completed development of multi-time and length scale step modeling of heat propagation in bare and packaged wide bandgap power amplifiers, experimental verification of the models, and testing of the role of temperature in observed history effects, non-linearity, and device failure mechanisms. - Completed development of stabilized optical sources and low-noise photodetectors for the fabrication of an ultrastable microwave-frequency source. - Completed exploitation of atom condensates to reach physical limit of frequency precision and control. - Completed improvements to integrated nanomechanical device arrays to include scaling down resonator architecture and quantifying properties which establish phononic crystal properties. - Completed investigation of extension of interference model and adaptive structures to produce waveforms that are transparent to non-users. - Completed research effort to investigate multiple input multiple output (MIMO) signal analysis and characterization with application to wide area surveillance. - Completed research effort to investigate target and signal characteristics based on non-Archimedean geometry. - Completed studies to optimize power and efficiency of compact, high power, electron beam pumped Argon-Xenon (Ar-Xe) laser for Navy directed energy weapons (DEW). - Completed investigations of the modification of metal surfaces by nitriding and other processes to maximize hardness, wear and corrosion resistance for Navy gun barrel applications using the large area plasma processing system (LAPPS). - Initiated research to improve mixed signal III-V device and circuit modeling with objectives of achieving a 30 dB dynamic range improvement for complex circuits containing over 100,000 devices. - Initiated a program to apply innovative mass nanofabrication techniques to previously developed nanodevice arrays. - Initiated a program on the control of deleterious defects in silicon carbide (SiC).				

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Initiated a program on the study of Quantum Dots and their application to coherent wavefunction control and quantum information. - Initiated a program on the tailoring of the optical, structural and electronic properties of semiconductor quantum wires. - Initiated a program to demonstrate non-volatile memory, based on spin-torque Magnetic Random Access Memory (MRAM), with switching speed > 1 GHz and write currents small enough (<1 mA) to be driven by superconducting Rapid Single Flux Quantum (RSFQ) logic. - Initiated a program to determine if the newly invented Reciprocal Flux Quantum Logic in fact delivers 2x higher speeds with 5x fewer Josephson junctions and power, while using the same underlying devices so that single chip hybrid circuits between it and the dominant RSFQ logic are feasible. - Initiated a program to investigate whether pattern dependent RF currents during plasma etching are responsible for observed variability in Josephson junction characteristics in complex circuits and, if so, define design rule changes to avoid the effects. - Initiated demonstrations of tunable analog filters made in a digital Nb device foundry. - Initiated development of a general mathematical framework for developing advanced infrared countermeasures and analyzing/optimizing their effectiveness. - Initiated development of techniques to observe directly the electrical properties of pair states in high temperature superconductors. - Initiated research of a novel extension of the Generalized Radon Transform to establish appropriate wavenumber representations for arbitrarily oriented wave guides, surfaces, and structures. - Initiated work on optical manipulation of ultra-cold atoms. *FY 2009 Plans:* - Continue all efforts of FY 2008, less those noted as completed above. - Complete investigation of extension of interference model and adaptive structures to produce waveforms that are transparent to non-users. - Complete non-cooperative target identification from multiple aspects. - Complete development of a general mathematical framework for developing advanced infrared countermeasures and analyzing/optimizing their effectiveness. - Complete the demonstration of single and two-qubit operations of spins in quantum dots.				

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B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Complete the study of defects involved in limiting the minority carrier lifetime in SiC. - Complete the study of the use of InAs, Ga2O3 quantum wires for optical, structural and electronic applications. - Initiate project to explore graphene based nanoelectronic devices. - Initiate program in chip-scale quantum architectures. - Initiate project to reduce heat transfer through electrical leads in cryogenic packaging. - Initiate project to explore development of devices, sigma delta and time encoder circuits for near THz switching with objectives of enabling analog and digital conversion at millimeter wave frequencies. - Initiate high-sensitivity magnetometry using quantum logic. - Initiate materials studies of low temperature regenerator (high thermal capacity) materials and/or controlled flow microstructures with the goal of improving energy efficiency of cryocoolers. - Initiate research into fundamental concepts and mathematics for digital array architectures. - Initiate research to apply carbon nano-tube technology to acoustic sensing. *FY 2010 Plans:* - Continue all efforts of FY 2009, less those noted as completed above. - Complete research effort to investigate multiple input multiple output (MIMO) signal analysis and characterization with application to wide area surveillance. - Complete research effort to investigate target and signal characteristics based on non-Archimedean geometry. - Complete the study of RQL digital superconducting logic. - Complete determination of the most appropriate tunnel barrier for MgB2 Josephson junctions. - Initiate an effort to grow low defect density, high purity epitaxial 4H-SiC at high growth rates suitable for high power electronic device applications. - Initiate design, construction, and testing of sonic crystals that can be tuned to have specific acoustic properties. - Initiate effort to create a physics-based understanding of epitaxial oxides and insulators for use in applications for advanced electronics. - Initiate investigation into stabilizing in-phase coherent state of coupled systems for coherent power generation.					

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B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Initiate high frequency solid state power devices for active spectral load control. - Initiate high output impedance solid state device technologies and materials. - Initiate effort to fabricate functionalized micro-opto-mechanical systems for the measurement of micromechanical photothermal spectra of adsorbed chemical vapor analytes. - Initiate research effort on chemical synthesis and bandgap tailoring in graphene nanoribbons. - Initiate research on spin dynamics in Group IV semiconductors and related device concepts. - Initiate research efforts on non-conventional nanofabrication that hold promise for sub-10nm resolution. - Initiate studies of the physics origin of noise and behavioral fluctuations in superconducting circuits, especially analog to digital converters, and incorporate the understanding into computer aided circuit simulators. - Initiate studies of the generation and recombination dynamics of non-equilibrium quasiparticles associated with digital switching events in superconducting logic.					
WEAPONS Efforts 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; and Applied Electromagnetics. This activity also includes Secretary of Defense directed peer-review basic research to develop innovative solutions and enhance the science and engineering base. The increase in FY 2010 is due to a larger investment in electromagnetics science. *FY 2008 Accomplishments:* Undersea Weaponry - Continued conducting basic research related to critical S&T (including vehicle control, maneuverability, and stability) associated with the development of high-speed supercavitating vehicles (HSSV). - Continued expansion of the University Laboratory Initiative (ULI) Program to provide a further infusion of educated and career-minded scientists and engineers in support of the National Naval Responsibility (NNR) for Undersea Weapons Research.		12.918	15.173	19.452	

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Continued computer code refinements and investigation of supercavitating vehicle dynamics and instability. - Continued evaluation of viable synthesis methodologies and characterization of candidate explosive ingredients suitable for undersea weapons applications. - Continued development of diagnostic capabilities to accurately determine aluminum combustion characteristics in oxidizing environments. - Continued an Otto Fuel II characterization study for undersea weapons. - Continued assessment of electro-optical technology focused on enhancing undersea warhead fuzing systems. - Continued efforts in nonlinear control laws, gas ventilation, and vehicle stability associated with the development of high-speed supercavitating vehicles (HSSV). - Continued hydroacoustics models and experiments to reduce the self noise on cavitator acoustic array. - Continued isolation and characterization of the tetranitroborate anion as a candidate ingredient suitable for undersea warheads applications. - Continued studies of low probability of intercept sonar, metalized explosives, lattice deformation of crystalline explosives, high thermal conductivity nanocomposites for vehicle arrays, microplasma fuels reforming and biomimetric propulsion mechanisms for underwater vehicles exploiting flutter instability. - Continued analysis of geological false targets for torpedo systems. - Continued fuel cell concept development using hydrogen peroxide reformate as oxidant. - Continued development of an acoustic propagation model for rapid and accurate calculations for undersea weaponry applications. - Continued the novel signal processing approach for detection and classification of countermeasures. - Completed an image compression approach to cooperative processing for swarming autonomous underwater vehicles. - Initiated development of concept for weaponized Unmanned Undersea Vehicles (UUVs) based on game to theoretic approach. Energetic Materials and Propulsion - Continued development of a fundamental understanding of initiation mechanisms of explosive crystals subjected to shock stimulus.				

Exhibit R-2a, PB 2010 Navy RDT&E Project Justification		DATE: May 2009
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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Continued exploring the use of quantum mechanics and molecular dynamics to provide fundamental properties for energetic materials to predict initiation/detonation criteria for insensitive munitions applications. - Continued investigation of JP-10 combustion-based Proton-Exchange-Membrane (PEM) fuel cells. - Continued investigation of multi-tube multi-nozzle Pulse Detonation Engines (PDEs) and multi-tube common nozzle PDEs. - Continued investigation of nanometallic-hydrocarbon hybrid catalytic combustion for increased energy release rates. - Continued investigation of novel initiation techniques, optimize injection parameters, and demonstrate integrated single tube operation for PDEs. - Continued Advanced Energetics research in reactive, explosive, and propulsive energetic materials, including high energy ingredient synthesis & characterization, and fundamentals of initiation and decomposition mechanisms, to tailor energy release processes in order to achieve substantial performance gains and/or enhanced survivability in harsh environments. - Continued to develop fundamental understanding of nitramine and perchlorate decomposition mechanisms for propellant applications. - Continued to develop organometallic-based highly energetic ingredients. - Continued efforts to explore alternative fuel concepts for Naval applications to include hydrogen, synthetic diesel, and biodiesel. - Continued development of multi-parameter sensor for multi-phase combustion flows (UAV and underwater PDEs). - Continued implementation of new & nanostructured materials design concepts for direct energy conversion and waste energy conversion. - Continued investigation of integrated pulse detonation engine-airframe for autonomous vehicles, and pulse detonation for passive weapons (noise, jamming). - Continued studies to determine the best investment of technologies for Unmanned Undersea Vehicle (UUV) Guidance and Control (G&C). - Continued hydroacoustics models and experiments to reduce the self noise on cavitator acoustic array. - Continued acoustic signal processing algorithms for HSSV guidance and control. - Continued development of new concepts for underwater power generation.				

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B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Continued development of non-lethal undersea warheads for Overseas Contingency Operations. - Continued development of PDE for underwater applications. Expeditionary Operations - Continued investigation of catalysts that reduce the pre-processing requirements for using logistic fuels in solid oxide fuel cells. - Completed investigation of modeling and exploiting the nonlinear seismic interactions between buried land mines and their surrounding soil for purposes of landmine detection. - Initiated research in quantum optics, nano-microscale self assembly and molecular recognition for active forensic sensing. Directed Energy - Continued research thrust in directed energy weapons. - Initiated directed energy development in the areas of advanced optical components and coatings for high energy lasers, high power injector and photocathode development, beam control and tracking research, terahertz source development and applications, femtosecond laser application studies, and the modeling and simulation of high power laser operation. *FY 2009 Plans:* Undersea Weaponry - Continue all efforts of FY 2008, less those noted as completed above. - Complete efforts in nonlinear control laws, gas ventilation, and vehicle stability associated with the development of high-speed supercavitating vehicles (HSSV). - Complete hydroacoustics models and experiments to reduce the self noise on cavitator acoustic array. - Complete assessment of electro-optical technology focused on enhancing undersea warhead fuzing systems. - Complete analysis of geological false targets for torpedo systems. - Complete fuel cell concept development using hydrogen peroxide reformate as oxidant. - Initiate validation of hydroacoustic models and test and evaluate acoustic array signal processing algorithms.					

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B. Accomplishments/Planned Program ($ in Millions)	FY 2008	FY 2009	FY 2010	FY 2011
- Initiate study on propulsion and its interaction with supercavitating cavity, and control surfaces. - Initiate acoustic concepts formulation and modeling for low-noise bio-inspired propulsion systems. - Initiate concept development on inversion of swarm dynamics for underwater tactical applications. - Initiate new coating concepts for corrosion and anti-fouling protection of UUVs. Energetic Materials and Propulsion - Continue all efforts of FY 2008. Expeditionary Operations - Continue all efforts of FY 2008, less those noted as completed above. Directed Energy - Continue all efforts of FY 2008. - Initiate multi-disciplinary efforts to include coherent beamforming, beam correction, turbulence effects on propagation, materials for high energy systems and sources. - Initiate basic research into mechanisms and concepts supporting the defeat of and protection against speed of light weapons. Applied Electromagnetics: - Initiate program to conduct basic research and theoretical analysis in electromagnetic phenomena in the spectrum from microwaves to visible light. Areas of research will be in microwave directed energy, optical directed energy (lasers), terahertz sources, and related nanometer-scale electronics and sensors. *FY 2010 Plans:* Undersea Weaponry - Continue all efforts of FY 2009, less those noted as completed above. - Complete a proof-of concept demonstration of a potential electro-optical technology enhancement capability for undersea warhead fuzing systems. - Complete isolation and characterization of the tetranitroborate anion as a candidate ingredient suitable for undersea warheads applications.				

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B. Accomplishments/Planned Program ($ in Millions)		**FY 2008**	**FY 2009**	**FY 2010**	**FY 2011**
- Complete development of an acoustic propagation model for rapid and accurate calculations for undersea weaponry applications. Energetic Materials and Propulsion - Continue all efforts of FY 2009. Expeditionary Operations - Continue all efforts of FY 2009. Directed Energy: - Continue all efforts of FY 2009. - Complete research in turbulence effects on propagation, optical component development, injector and photocathode research, and beam control. - Initiate research into advanced theoretical research and modeling of superconducting laser elements as used in advanced high energy accelerators. Applied Electromagnetics: - Continue all efforts of FY 2009.					

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C. Other Program Funding Summary ($ in Millions)

	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	Cost To Complete	Total Cost
PE 0601101E/Defense Research Sciences									Continuing	Continuing
PE 0601102A/Defense Research Sciences									Continuing	Continuing
PE 0601102F/Defense Research Sciences									Continuing	Continuing
PE 0601103N/University Research Initiatives									Continuing	Continuing
PE 0601152N/In-House Laboratory Independent Research									Continuing	Continuing

D. Acquisition Strategy

Not applicable.

E. Performance Metrics

Defense Basic Research seeks to improve the quality of defense research conducted predominantly through universities and government laboratories. It also supports the education of engineers and scientists in disciplines critical to national defense needs through the development of new knowledge in an academic environment. Initial research focus is generally conducted in an unfettered environment because of the nature of basic research, but as more is learned and applications emerge, individual research projects take on a more applied focus. Individual project metrics then become more tailored to the needs of specific applied research and advanced development programs. Example metrics include a biporous wick structure for thermal management of power electric modules capable of removing 900 watts per square centimeter which was recently developed by an academia/industry team. The National Research Council of the National Academies of Science and Engineering's congressionally directed "Assessment of Department of Defense Basic Research" concluded that the DoD is managing its basic research program effectively.

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