FY 2004/2005 RDT&E,N BUDGET ITEM JUSTIFICATION SHEET DATE: February 2003
Exhibit R-2

BUDGET ACTIVITY: 1 PROGRAM ELEMENT: 0601153N
PROGRAM ELEMENT TITLE: Defense Research Sciences

COST: (Dollars in Thousands)

PROJECT NUMBER/ TITLE	FY 2002 ACTUAL	FY 2003 ESTIMATE	FY 2004 ESTIMATE	FY 2005 ESTIMATE	FY 2006 ESTIMATE	FY 2007 ESTIMATE	FY 2008 ESTIMATE	FY 2009 ESTIMATE
Defense Research Sciences	378,742	396,330	368,517	377,223	390,861	398,708	405,649	412,930

A. MISSION DESCRIPTION AND BUDGET ITEM JUSTIFICATION: This program 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. Additionally, it exploits scientific breakthroughs and provides options for new Future Naval Capabilities (FNCs). It responds to S&T directions of the Department of the Navy (DON) Integrated Warfare Architecture Requirements (IWARs) and Chief of Naval Operations (CNO) N70 Mission Capability Package (MCP) requirements for long term Navy and Marine Corps improvements. Defense Research Sciences is in consonance with future warfighting concepts and doctrine developed at the Naval Warfare Development Command and the Marine Corps Combat Development Command, and enables technologies to significantly improve the JCS's Future Joint Warfighting Capabilities. It also is consistent with the DON Transformational Roadmap as articulated in SEA POWER 21. It is managed by the Office of Naval Research (ONR) through Program Officers at ONR Headquarters, and the base program of the corporate Naval Research Laboratory (NRL).

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 with Exploitation and Delivery". DON Basic Research is the core of Discovery and Invention. 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 in some hundred-plus technology and capability-related 'thrusts', which are consolidated in 12 Research Areas. These in turn support the major motivational research focus areas of the Navy and Marine Corps after Next: maritime and space environments that impact operational capability, information science/knowledge management in network-centric operations, sensors and electronic systems for surveillance and tactical applications, energy/power/propulsion for performance gain and sustainment, advanced air/surface/undersea and multi-environment Naval platforms design/signature reduction, and superior human performance/training/care of Sailors and Marines.

Key aspects of the program are the four ONR Grand Challenges which 'inspire and guide' the direction of research: Naval Battlespace Awareness, Electric Power Sources for the Navy and Marine Corps, Naval Materials by Design, and Multifunctional Electronics for Intelligent Naval Sensors; and the National Naval Responsibilities (NNRs), fields upon which a wide range of fundamental naval capabilities depend, and in which ONR is and likely will remain the principal US research sponsor. NNRs are ratified only after close scrutiny, and currently comprise Ocean Acoustics

(starting FY99), Underwater Weaponry (started FY02), and Naval Engineering (starting in FY03) with an ongoing assessment of Precision Time and Time Transfer.

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

B. PROGRAM CHANGE SUMMARY:

	FY 2002	FY 2003	FY 2004	FY 2005
FY 2003 President's Budget Submission:	388,353	393,557	395,418	404,006
Adjustments from FY 2003 President's Budget:				
SBIR	-7,462			
Congressional Plus-Ups		+12,900		
Congressional Reduction		-1,000		
Cong. Rescissions/Adjustments/Undist. Reductions	-1,906	-4,848		
Execution Adjustments	-243			
NWCF Rate Adjustments			-1,876	-230
Efficiencies at NWCF Activities			-882	-1,007
S&T Program Adjustments			-14,935	-16,324
Pay Raise/Inflation Adjustments		-4,279	-9,208	-9,222
FY 2004/2005 President's Budget Submission:	378,742	396,330	368,517	377,223

PROGRAM CHANGE SUMMARY EXPLANATION:

Schedule: Not applicable
Technical: Not applicable

FY 2004/2005 RDT&E,N BUDGET ITEM JUSTIFICATION SHEET DATE: February 2003
Exhibit R-2a

BUDGET ACTIVITY: 1 PROGRAM ELEMENT: 0601153N Project Title: Defense Research Sciences
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COST: (Dollars in Thousands)

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principal US research sponsor. NNRs are ratified only after close scrutiny, and currently comprise Ocean Acoustics (starting FY99), Underwater Weaponry (started FY02), and Naval Engineering (starting in FY03) with an ongoing assessment of Precision Time and Time Transfer.

B. ACCOMPLISHMENTS/PLANNED PROGRAM:

	FY 02	FY 03	FY 04	FY 05
Information Sciences	51,798	55,582	51,949	54,361

Efforts include: Autonomous systems; information assurance; information management and distribution; information processing, assessment, and presentation; seamless, robust connectivity and networking; modeling and simulation for planning, engineering and acquisition; theater air missile defense; and expeditionary operations Command, Control, Communications, Computers Intelligence Surveillance and Reconnaissance(C4ISR).

FY 2002 ACCOMPLISHMENTS:

- Developed techniques to enable a collaborating team of heterogeneous agents/robots to operate in unknown environments with uncertain sensing.
- Developed a fundamental basis for image recognition and understanding.
- Extended methods for detecting, removing, modifying, decrypting, and creating hidden messages in shared digital media.
- Developed methods to map large three dimensional urban areas with accurate geo-positioning in real time.
- Created science base for intelligent software agents that can reason about physical phenomena and communicate with human collaborators.
- Continued development of novel algorithms for energy-efficient broadcasting and multi-casting on wireless communication networks.
- Continued to investigate methods for employing automated systems as substitutes for human vision for monitoring surveillance and reconnaissance.
- Investigated time-reversal imaging with application to array imaging, secure wireless communications, and nondestructive testing.
- Investigated micro-fluids as detection and analysis of genetic materials used for chemical sensing.
- Continued work on image enhancement and feature extraction techniques for applications to target identification, strike and battle damage assessment.

FY 2003 PLAN:

- Develop theory and algorithms for autonomous systems to recognize a particular scene from different perspectives.
- Continue refinement of techniques for ensuring privacy of information transferred across public networks.
- Develop basis for collaborative mission planning tools to facilitate knowledge sharing and management, regulation of information flow, and work-process monitoring.
- Continue development of turbo-codes and iterative processing techniques to enable high data rates for wireless communication applications.
- Develop adaptive routing protocols to select the links for routing information packets that maximize communication network throughput with minimum energy consumption.
- Initiate development of improved tactical and battlespace decision aids through creation of synthetic natural environments.
- Continue to refine techniques for extracting maximum knowledge from multi-modal imagery, text, and electromagnetic signal data.
- Continue 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.

FY 2004 PLAN:

- Complete theory and algorithms for autonomous systems to recognize a particular scene from different perspectives.
- Continue refinement of techniques for ensuring privacy of information transferred across public networks.
- Develop basis for collaborative mission planning tools to facilitate knowledge sharing and management, regulation of information flow, and work-process monitoring.
- Complete development of turbo-codes and iterative processing techniques to enable high data rates for wireless communication applications.
- Develop adaptive routing protocols to select the links for routing information packets that maximize communication network throughput with minimum energy consumption.
- Continue development of improved tactical and battlespace decision aids through creation of synthetic natural environments.
- Continue to refine techniques for extracting maximum knowledge from multi-modal imagery, text, and electromagnetic signal data.

- Continue 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.
- Continue 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.
- Continue developing framework for dealing with effect of variable latencies in communication within teams of humans and autonomous systems.
- Continue efforts on development of mathematical foundations for image enhancement, feature extraction, feature-based/texture-based compression, denoising, and segmentation; data representation and metrics, content-based indexing and retrieval; reconstruction, interpolation, and registration; and scene analysis and image understanding.
- Continue efforts on quantum computing and cryptography.
- Initiate efforts on general automated theorem prover technologies and biometric technologies for authentication.
- Initiate efforts on modeling chaotic phenomena in network operations.
- Complete efforts in scaleable decision making algorithms for Command and Control.
- Complete efforts in natural language processing.
- Initiate efforts in multi-modal dialog.
- Initiate efforts for integrating domain knowledge into learning methods.
- Initiate computational statistics methods for data streams.
- Initiate efforts for semantic-based information gathering.
- Initiate efforts for multi-sensor 3D digital urban terrain reconstruction.
- Initiate efforts in extended augmented/virtual reality with haptics, sound, and olfactory components.
- Continue efforts in physics-based modeling of natural phenomena for visualization.
- Continue efforts in automatic inference of context from images/video.
- Initiate efforts in detection of caves and underground tunnels.
- Continue efforts in mathematical techniques for inverse problems, including reliable approximate solutions in 3D; adequate representation of the physics of the media and the scatterer; and improved resolution of structural and material properties.

FY 2005 PLAN:

- Complete refinement of techniques for ensuring privacy of information transferred across public networks.

- Complete collaborative mission planning tools to facilitate knowledge sharing and management, regulation of information flow, and work-process monitoring.
- Develop adaptive routing protocols to select the links for routing information packets that maximize communication network throughput with minimum energy consumption.
- Complete development of improved tactical and battlespace decision aids through creation of synthetic natural environments.
- Continue to refine techniques for extracting maximal knowledge from multi-modal imagery, text, and electromagnetic signal data.
- Complete methods to deal with light dispersion on image formation underwater to enable precise navigation, station keeping, and mapping capabilities for unmanned underwater vehicles.
- Continue efforts for enabling teams of autonomous systems to work together, on representations for evolution of cooperative behaviors and in multi-modal interactions with autonomous systems.
- Continue developing framework for dealing with effect of variable latencies in communication within teams of humans and autonomous systems.
- Continue efforts on development of mathematical foundations for image enhancement, feature extraction, feature-based/texture-based compression, denoising, and segmentation; data representation and metrics, content-based indexing and retrieval; reconstruction, interpolation, and registration; and scene analysis and image understanding.
- Continue efforts on quantum computing and cryptography and on biometric technologies for authentication.
- Continue efforts on general automated theorem prover technologies.
- Continue efforts on modeling chaotic phenomena in network operations.
- Continue efforts for multi-modal dialog.
- Continue efforts for integrating domain knowledge into learning methods.
- Continue computational statistics methods for data streams.
- Continue efforts for semantic-based information gathering.
- Continue efforts for multi-sensor 3D digital urban terrain reconstruction and in physics-based modeling of natural phenomena for visualization.
- Continue efforts in extended augmented/virtual reality with haptics, sound, and olfactory components.
- Continue efforts in automatic inference of context from images/video.
- Continue efforts in detection of caves and underground tunnels.
- Continue efforts in mathematical techniques for inverse problems, including reliable approximate solutions in 3D; adequate representation of the physics of the media and the scatterer; and improved resolution of structural and material properties.

	FY 02	FY 03	FY 04	FY 05
Ocean/Space Sciences	142,598	140,949	140,322	143,543

Efforts include: Battlespace environments; environmental processes; environmental model development; environmental sensors and data; data assimilation and information exploitation; validation studies; space platforms; environmental biology/quality; cooperative ASW; wide area ASW surveillance; and battlegroup ASW defense.

FY 2002 ACCOMPLISHMENTS:

- Developed an improved predictive capability of beach characteristics including berm heights and vehicle trafficability to enhance expeditionary force mobility through the surf-zone and across the beach.
- Continued to refine techniques for utilizing autonomous undersea vehicles to investigate coastal and ocean basin processes thereby increasing data collection in areas that are difficult to access.
- Continued study and characterization of solar coronal mass ejections to enable determination of space velocities and predict impacts on critical Naval and national space-based sensors and communication systems.
- Developed improved Earth upper atmospheric neutral density models for more accurate satellite drag prediction and improved estimates of useful satellite life.
- Employed the upgraded Polar Ice Prediction System for improved assessments of the wind-current dynamics of arctic ice movements to reduce the sea ice threat to military and civilian shipping.
- Continued investigation of the marine geology mechanisms for the formation of sedimentary flood deposits on continental shelves and the impacts those mechanisms have on sea mine burial and detection.
- Developed new techniques for extracting useful environmental information from existing observing systems in the most efficient and cost-effective way.

FY 2003 PLAN:

- Develop techniques for utilizing high resolution, motion imagery to predict beach evolution.
- Develop global on-scene, accurate, theater scale, high resolution environmental characterizations and forecasts to improve all weather operations and defense, capabilities of acoustic/electro-optical/Infrared(EO/IR) sensors, and the performance of Naval weapons in the atmosphere and under the sea.

- Initiate investigation of fate and effects of unexploded ordnance in the marine environment to reduce the threat to civilian population and military explosive ordnance disposal personnel.
- Develop improvements to specification and prediction of the space environment to improve space system performance and their on-call availability.
- Develop new techniques and algorithms for remote sensing of ocean and atmospheric properties including winds, waves, currents, and surface topography.
- Continue validation of environmental data and models used by S&T community to ensure reliability and realistic depiction of actual ocean and atmospheric conditions.
- Develop understanding of 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.
- Initiate an integrative ecosystem study to develop environmental predictors of whale presence or absence to reduce impacts of Naval systems to marine mammals.
- Develop new methods for combining "through the sensor" data with other views of the battlespace environment to improve real-time environmental predictions.
- Commence development of major ionospheric interactions research capability at the High Frequency Active Auroral Research Program (HAARP) to identify or improve C3I capabilities for Naval undersea warfare applications.

FY 2004 PLAN:

- Develop programs to validate techniques for utilizing high resolution, motion imagery methods to predict beach evolution.
- Conduct opportunistic validation of global on-scene, accurate, theater scale, high resolution environmental characterizations and forecasts to improve all weather operations and defense, capabilities of acoustic/EO/IR sensors, and the performance of Naval weapon in the atmosphere and under the sea.
- Implement investigation of fate and effects of unexploded ordnance in the marine environment to reduce the threat to civilian population and military explosive ordnance disposal personnel.
- Assess improvements to specification and prediction of the space environment to improve space system performance and their on-call availability.
- Develop and initiate validation of advanced techniques and algorithms for remote sensing of ocean and atmospheric properties including winds, waves, currents, and surface topography.
- Assess validation of environmental data and models used by S&T community to ensure reliability and realistic depiction of actual ocean and atmospheric conditions.

- Initiate 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.
- Implement 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.
- Develop advanced methods for combining "through the sensor" data with other views of the battlespace environment to improve real-time environmental predictions.
- Continue enhancement of ionospheric interactive research capabilities at HAARP and begin program of S&T development leading to improved performance of Naval undersea applications.

FY 2005 PLAN:

- Analyze field programs to validate techniques for utilizing high resolution, motion imagery methods to predict beach evolution.
- Assess validation of global on-scene, accurate, theater scale, high resolution environmental characterizations and forecasts to improve all weather operations and defense, capabilities of acoustic/EO/IR sensors, and the performance of Naval weapon in the atmosphere and under the sea.
- Assess the fate and effects of unexploded ordnance in the marine environment to reduce the threat to civilian population and military explosive ordnance disposal personnel.
- Develop advanced improvements to specification and prediction of the space environment to improve space system performance and their on-call availability.
- Pursue additional validation of advanced techniques and algorithms for remote sensing of ocean and atmospheric properties including winds, waves, currents, and surface topography.
- Assess validation of environmental data and models used by S&T community to ensure reliability and realistic depiction of actual ocean and atmospheric conditions.
- Implement 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.
- Continue and assess 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.
- Implement advanced methods for combining "through the sensor" data with other views of the battlespace environment to improve real-time environmental predictions.
- Complete all enhancements to HAARP interactive research, providing full capability to address all anticipated applications for Naval undersea warfare operations.

	FY 02	FY 03	FY 04	FY 05
Human Performance and Medical Sciences	21,700	21,831	22,540	22,954

Efforts include: Human factors and organizational design; manpower, personnel, and training; integrated avionics, displays, and advanced cockpit; pattern recognition; biosensors, biomaterials, bioprocesses; marine mammals; casualty care and management; fit and healthy force; casualty prevention; biorobotics; expeditionary operations training and education; and chemical-biological defense.

FY 2002 ACCOMPLISHMENTS:

- Developed theories and models that address re-configurable organizational structures to support command decision making and command and control team performance.
- Determined which brain areas are active in performing cognitive tasks and detect likely conflicts among multiple tasks due to loading of same brain areas.
- Advanced the understanding of the basis of stochastic chemical sensing.
- Completed complete genomic sequence of anthrax bacteria. Determined molecular structure of the marine photoprotein obelin at atomic resolution.
- Completed basic physiology research on hemorrhagic shock and trauma resuscitation to improve far-forward, life-saving casualty care.
- Investigated stress physiology to identify the biological bases of individual stress resilience and elucidate biological/cognitive events relevant to Naval operational exposures (e.g., hyperbaric stress, directed energy).
- Investigated genomics and genetic immunization to advance protection against microorganisms. Continued studies on stem cells and signal transduction for advanced transplantation strategies.

FY 2003 PLAN:

- Exploit improved understanding of human cognition and performance to create more realistic simulations and to improve decision algorithms.
- Develop computational linguistic techniques to emulate one-to-one tutoring behavior.
- Conduct research into the efficacy of a group of compounds that mimic or assist endogenous defenses to hearing damage to sailors and marines.
- Develop an understanding of the mechanistic basis of object detection and classification in biologic vision/audition and transform this understanding into robust algorithms for threat and situation assessment decision aids, automatic target recognition in cluttered environments, and detection and classification of buried mines.

- Develop new theoretical treatment of the differences in individual humans. Initiate program to study coiled-coil protein structures. Study self-assembled supramolecular nanoplatforms for molecular medical applications.
- Begin studies on microbial degradation of energetic compounds in marine sediments.
- Continue work on stress physiology, hyperbaric physiology, and biological effects of Naval operational exposures (e.g., directed energy).
- Continue work on genomics, genetic immunization, stem cells, and signal transduction.
- Initiate research effort on the physiological effects of exposure to non-lethal stimuli for a better understanding of human vulnerabilities and enhanced protection.

FY 2004 PLAN:

- Learn how to combine cognitive architectures with computational neuroscience to better predict human performance under stress.
- Initiate projects on antimicrobial peptides for inactivation of infectious bacteria.
- Launch efforts to develop next-generation antibiotics.
- Develop novel genetic sequencing tools for marine algae and seaweeds.
- Continue work on stress physiology, hyperbaric physiology, and biological effects of Naval operational exposures (e.g., directed energy).
- Continue work on genomics, genetic immunization, stem cells, and signal transduction.
- Continue non-lethal bioeffects research.

FY 2005 PLAN:

- Develop novel multidisciplinary approaches to human-activity inference from video imagery to enable force protection and counterterrorism.
- Study methods to allow active vision for mobile robotics.
- Use genomics-driven metabolic pathway design for the synthesis of energetic materials.
- Initiate studies in aquatic environmental toxicology for diver protection.
- Continue work on stress physiology, hyperbaric physiology, and biological effects of Naval operational exposures (e.g., directed energy).
- Continue work on genomics, genetic immunization, stem cells, and signal transduction.
- Continue non-lethal bioeffects research.

	FY 02	FY 03	FY 04	FY 05

Advanced Naval Materials Sciences	67,008	72,883	69,120	71,697

Efforts include: Structural materials; functional materials; synthesis, processes, and characterization; prediction and simulation; and maintenance reduction technology.

FY 2002 ACCOMPLISHMENTS:

- Developed improved piezoelectric crystal growth techniques to revolutionize electromechanical transduction for sonar and undersea weapons applications.
- Developed an automated and cost effective process of liquid molding manufacturing of composite components for ship and aerospace applications.
- Continued work to improve understanding techniques for blast shock mitigation to ships/submarines. Developed novel luminescent quantum dot bio-conjugates for chemical and biological weapons sensor applications.
- Developed the science for thermally-stable, long living, highly efficient, light emitting diodes for use in maps and displays.
- Investigated the synthesis and assembly of nanoscale electro-active structures and composites for optical and thermal management applications.
- Continued investigation of engineering nano-structures into functional mesoscopic materials for advanced power sources, low cost technologies for display and transfer of information, and new methods for thermal management.
- Investigated corrosion fatigue cracking and stress corrosion resulting from employing friction stir welding construction techniques on type 2519 aluminum components of amphibious assault vehicles.
- Continued work to improve techniques for high power millimeter wave beam processing of ceramic materials.

FY 2003 PLANS:

- Explore three dimensional nature of solid phases in ferrous alloys for improved high strength steels.
- Design, synthesize and develop advanced polymers including high temperature and flame resistant polymer composites and ceramics for aerospace and ship applications.
- Continue work to improve heat treatments and low alloy compositions for high strength low alloy steels with superior strength and toughness for enhanced shipboard blast protection, reduced weight, and reduced production cost.
- Develop understanding and procedures for growing controlled iron films with adlayer cappings of arsenic and gallium for spin injection structures and devices.
- Perform three dimensional microstructure analysis of high and low carbon steels to provide the scientific basis for fatigue and failure processes.

- Initiate work to develop the scientific basis for revolutionary approaches to discover advanced dielectrics for energy storage for eventual application in electric war ships.
- Establish the scientific basis for advanced materials with improved potential for blast resistance.
- Develop x-ray computed microtomography of composite materials using a synchrotron light source.
- Explore materials and structures capable of limiting optical transmission at variable wavelengths for enhanced eye and sensor protection against agile laser illumination.
- Develop novel magnetic materials for ship board high power applications.

FY 2004 PLANS:

- Develop first principle methods to calculate second and third rank tensor properties of sonar materials such as lead zirconate titanate and lead magnesium niobate.
- Advance the understanding of deformation mechanisms in nanometer scale aluminum and steels to provide new high strength-high toughness alloys for naval platforms.
- Design and explore new processes for diphasic dielectric materials for energy storage for electric warship needs.
- Develop understanding and methodology to predict high deformation rate, blast, processes for engineered topological structures.
- 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.
- Link ab initio calculations of structure to mesoscale simulations of alloy behavior to provide the scientific basis for the design of advanced steels for naval ship applications.
- Explore the scientific basis for highly localized processes such as friction stir welding of steels for low cost ship construction.
- Identify, quantify, and control the atomic scale properties that limit or enhance the performance of magnetic semiconductor materials.
- Develop integrated bio-magneto-electronic structures and devices for experimental evaluation.
- Develop theoretical basis for composite materials behavior based on x-ray computed micrco-tomography.

FY 2005 PLANS:

- Extend 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.

- Explore superplasticity in advanced high strain nanometer scale ceramic composites to provide the basis for the development of such materials in naval applications.
- Explore molecular scale high energy storage dielectrics using solid state reactions to convert oxide layers to conductors for advanced capacitor applications.
- Develop materials and fabrication science for fugitive phase processes for engineered topological structures for ship blast protection.
- Continue to link ab initio calculations of structure to mesoscale simulations of alloy behavior for the design of advanced steels.
- Identify hydrogen embrittlement resistant high strength alloys based on nickel-cobalt-chrome-molybdenum material systems.
- Continue the theoretical development of composite materials behavior based on x-ray computed micro-tomography.
- Continue to explore advanced integrated bio-magneto-electronic materials, structures and devices.

	FY 02	FY 03	FY 04	FY 05
Naval Platform Design Sciences	16,931	17,363	15,508	15,876

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; UAV/UCAV; environmental quality; and logistics.

FY 2002 ACCOMPLISHMENTS:

- Developed new hull structural acoustic measurement methodologies to enable advanced machinery support systems and improved hull coatings.
- Conducted at-sea experiment on ship wave-breaking, revealing sources of bubble generation and migration.
- Incorporated a model of green water on deck into a motion prediction code for ships.
- Conducted an unprecedented experiment on a large hydrofoil and defined trailing edge hydrodynamics.
- Conducted visualization testing of propulsor tip vortices revealing major potential source of subvisual cavitation.
- Conducted studies of fast sealift configurations which defined technology advances required.
- Placed into operation an experimental apparatus for generating high levels of turbulence.

- Conducted the first quantitative spatial measurements of flow between turbomachinery blades revealing flow dynamics crucial to radiated noise sources.
- Identified unsteady propulsor blade loading due to upstream disturbances that have been found to be inviscid in nature and responsible for tip gap vortex unsteadiness.
- Developed hull structural assessments capabilities for determining the integrity of the ship throughout its service life. Identified and analyzed physics of stratified wakes.
- Identified active control and system stability criteria for very high (greater than 200MW) power systems.
- Identified and quantified bubble sources around surface ships including wave-breaking and turbulence effects.
- Developed new techniques for advanced sensors for emission monitoring, improved membranes for water waste treatment, anti-fouling/foul-release coatings knowledge base for fate/effects of metal and organic materials in the marine environment, and reduction or elimination of Chloro-Fluorocarbon-based cooling.
- Advanced current understanding of high level/nonlinear acoustic propagation and measurement of jet noise to enable passive and active noise reduction techniques. These efforts will result in reduced hearing loss by sailors and marines and reduced jet noise in areas where civilian population is closely adjacent to military facilities.

FY 2003 PLANS:

- Develop reliable sea-keeping prediction methods for advanced surface ship hull forms in heavy seas.
- Develop an integrated acoustics model for complex propulsors.
- Develop infrared ship predictions for low observable ships that include bi-directional reflectance distribution functions.
- Conduct quantitative measurements of bubble concentrations at-sea around a ship to develop prediction methods.
- Incorporate nonlinear incident wave representations in a ship motions prediction method.
- Conduct microbubble drag reduction experiments on a large plate.
- Construct and test a new instrument for spatial measurement of surface waves around models.
- Examine simulations of far wakes in a stratified medium evolution of vertical vortices.
- Measure and analyze high levels of turbulence interacting with blade flow for noise generation.
- Develop a method to infer, for the first time, fluctuating pressure in turbulent flow from Three Dimensional (3-D) Particle Image Velocimetry (PIV) measurements.
- Validate Six Degrees-Of-Freedom (6DOF) Reynolds Average Navier-Stokes (RANS) predictions of surface ship forced roll response.

- Develop a Large-Eddy Simulation (LES) prediction method for unsteady propulsor flow.
- Develop physics-based analysis tools and models for non-linear circuits and loads and highly coupled ship board power systems.
- Develop robust turbulence models in three dimension boundary layers to improve submarine maneuvering predictions.
- Continue work on understanding, predicting, and controlling scattering from discontinuities such as antennas and ship-sea surface radar cross section interactions.
- Develop next-generation infrared scene model to enable optimal infrared reflectance ship surfaces.
- Improve and extend durability of foul-control marine coatings to reduce energy use and adverse environmental impacts, and to extend the time between physical removal of hull and marine structure foulants.
- Investigate the fate and effects of chemical and biological contaminants in marine/estuarine environments.

FY 2004 PLANS:

- Continue development of reliable sea-keeping prediction methods for advanced surface ship hull forms in heavy seas.
- Evaluate electromagnetic signature basic physics including scattering from multi-scaled dielectric materials and evaluation of visual rendering studies into high fidelity infrared modeling.
- Identify and rank bubble sources around surface ships.
- Evaluate a breaking wave prediction method.
- Quantify a 3-D turbomachinery flow using stereo PIV.
- Conduct first measurements of effects of full scale level turbulence on appendage fluctuating surface pressures.
- Conduct detailed measurements of total wave field and resulting ship motions using new instrumentation.
- Continue development of LES method for unsteady propulsor flow predictions.
- Further develop computational mechanics to provide predictive capabilities of acoustics, linear and nonlinear dynamic response and failure mechanisms of structures.
- Develop reliability methodology for hull structures and hybrid joints.
- Develop physics based understanding of composite materials to characterize thermo-mechanical behavior, response to multi-axial loads and improve mechanical properties.
- Develop methods to reduce acoustic modeling requirements and techniques for physical modeling at small scale to better characterize signature phenomenology and control and structure amplified flow noise.
- Develop expanded scaleable simulation capabilities for virtual distributed control.

- Explore and evaluate control system algorithms and strategies in a virtual environment including affordability issues.
- Establish limits for energy-time transients as a function of power system impedance parameters.
- Apply optimal stability criteria to electrical power systems in a simulation environment.
- Determine durability of foul-control marine coatings to reduce energy use and adverse environmental impacts and to extend the time between physical removal of hull and marine structure foulants.
- Initiate assessment of the fate and effects of chemical and biological contaminants in marine/estuarine environments.

FY 2005 PLANS:

- Continue development of reliable sea-keeping prediction methods for advanced surface ship hull forms in heavy seas.
- Evaluate electromagnetic signature basic physics to further understand low observable and infrared technology performance against evolving threats.
- Quantify and model bubble sources around surface ships for prediction methods.
- Validate a breaking wave prediction method against experimental data.
- Examine turbomachinery flow using holographic PIV.
- Validate 6DOF RANS predictions of surface ship motion.
- Validate LES predictions of turbomachinery flow against experimental data.
- Continue development of computational mechanics to provide predictive capabilities of acoustics, linear and nonlinear dynamic response and failure mechanisms of structures.
- Computational mechanics will also address prediction of acoustic signatures in complex structures, modeling of structural failures and optimization, sensitivity analysis and error control.
- Continue to develop methods to reduce acoustic modeling requirements and techniques for physical modeling at small scale to better characterize signature phenomenology and control and structure amplified flow noise.
- Continue development of reliability methodology for hull structures and hybrid joints.
- Continue development of physics based understanding of composite materials to characterize thermo-mechanical behavior, response to multi-axial loads and improve mechanical properties.
- Integrate distributed heterogeneous control simulation capability into the overall control system simulation infrastructure.
- Test and evaluate control system algorithms and strategies in a virtual environment including affordability issues.
- Further evaluate stability and control of electrical power systems in a simulation environment.

- Assess durability of foul-control marine coatings to reduce energy use and adverse environmental impacts and to extend the time between physical removal of hull and marine structure foulants.
- Continue assessment of the fate and effects of chemical and biological contaminants in marine/estuarine environments.

	FY 02	FY 03	FY 04	FY 05
Weapon and Energy Sciences	27,974	32,671	26,707	26,098

Efforts include: Undersea weaponry including undersea energetics, undersea guidance and control, and supercavitation physics; expeditionary operations firepower and maneuver; ground mine countermeasures; energy conversion; electrochemical power sources; and novel power sources and energy transfer.

FY 2002 ACCOMPLISHMENTS:

- Developed first generation model to predict propellant burn rate as a function of pressure, fuel to oxidizer ratio, and relative oxidizer particle size.
- Developed computer codes to analyze and predict the two-phase flows around a supercavitating vehicle.
- Conducted water tunnel experiments to study the instability and control of a supercavitating vehicle.
- Conducted 4-inch model tests to quantify the flow noise of a supercavitating vehicle.
- Initiated a University Laboratory Initiative (ULI) program which establishes a strategic alliance between academia, Naval Laboratories and University Affiliated Research Laboratories with the goal of maintaining a constant infusion of educated and career minded scientists and engineers in support of the National Naval Responsibility (NNR) for undersea weapons research. The ULI program is developing a broad based technical personnel base in the disciplines of acoustics, information science, physics, mathematics, chemistry, electrical engineering and mechanical engineering.
- Developed dynamic loading/spectroscopic tools for combustion initiation processes.
- Investigated novel composites for lightweight long life rechargeable batteries.
- Investigated interactions between oxidizer and fuel in ammonium-per-chlorate based propellants.
- Continued study on pulse detonation engine dynamics and gaseous and spray detonations.
- Achieved significant progress in the development of fuel cell power sources that can operate on common logistic fuels for Marine combat units by demonstrating the direct oxidation of synthetic diesel in a solid oxide fuel cell.
- Investigated multi-axis fluidic thrust vectoring to enable elimination of missile fin structure and reduce heat and drag for hypersonic missile applications.
- Continued work to develop a compact, efficient, and automated vortex combustor for incineration of solid waste.
- Investigated techniques for developing deformable missile warheads to increase missile lethality by creating an asymmetric blast pattern focused in the desired direction.
- Developed a nanostructured solid block co-polymer electrolyte with performance comparable to liquid electrolytes at moderate discharge rates using a practical, scalable synthetic route with the goal of improving the safety and energy density of rechargeable lithium and lithium-ion batteries.

- Developed and experimentally validated a new model for solute transport in swollen polymeric gels to provide fundamental insight for polymer electrolyte development.
- Transitioned catalyzed carbon microfiber electrodes for semi-fuel cells to an unmanned undersea vehicle (UUV) demonstration program.
- Identified new class of solid state thermoelectric materials for solid state conversion devices.

FY 2003 PLANS:

- Continue to develop synthesis routes to difluoramino-based and organometallic-based highly energetic ingredients.
- Continue to develop spectroscopic capabilities to accurately determine aluminum combustion temperature in various oxidizing environments.
- Continue to develop fundamental understanding of nitramine and perchlorate decomposition mechanisms for propellant applications.
- Continue to develop fundamental understanding of initiation mechanisms of explosive crystals subjected to shock stimulus.
- Develop improved and new sensor technology that will include (but not be limited to) low-volume and high-directivity acoustic arrays, laser-based passive acoustic arrays, magnetometers for target classification and signal processing algorithms for counter-countermeasure.
- Continue to refine the computer codes for two-phase flows, and investigate supercavitating vehicle dynamics and instability.
- Conduct additional 4-inch model tests to quantify the flow noise of a supercavitating vehicle.
- Expand the University Laboratory program to provide a further infusion of educated and career minded scientists and engineers in support of the NNR for undersea weapons research. This expansion will be conducted by increasing the collaboration with universities and Naval laboratories to broaden the education and technology base thereby seeding future non-traditional capabilities for undersea weapons.
- Develop mechanistic understanding of steady and unsteady combustion characteristics of advanced solid propellants. Develop nanoscale metalized explosives for enhanced lethality.
- Investigate interaction of combustion gases with engine nozzles at high temperatures and pressures to develop techniques for mitigation of nozzle erosion at high pressures.
- Synthesize and characterize new energetic materials with higher energy density and reduced sensitivity.
- Develop materials for enabling rechargeable batteries with an energy density approaching 500 watt-hours per kilogram.
- Continue investigation of combustion control techniques to enable improved thrust vector control, jet noise reduction, more efficient jet engines, and signature reduction.

- Conduct preliminary studies on multivalent ion insertion in nanoscale vanadium pentoxide cathode materials to improve the capacity of rechargeable lithium batteries.
- Continue improvements to catalyzed carbon microfiber electrode development for semi-fuel cells.
- Continue development of nanostructured electrode and polymer electrolyte materials for electrochemical power sources.
- Expand fundamental understanding of direct electrochemical oxidation in solid oxide fuel cells and the use of logistic fuels.
- Expand research into new materials and processes for converting thermal to electric energy.
- Identify new approaches to efficiently transfer thermal, electrical and optical energy from primary sources.
- Develop new energy efficient sources and devices to enable future electric Naval Force.
- Initiate research in materials and processes for energy efficiency.

FY 2004 PLANS:

- Continue to develop synthesis routes to difluoramino-based and organometallic-based highly energetic ingredients.
- Continue to develop spectroscopic capabilities to accurately determine aluminum combustion temperature in various oxidizing environments.
- Continue to develop fundamental understanding of nitramine and perchlorate decomposition mechanisms for propellant applications.
- Continue to develop fundamental understanding of initiation mechanisms of explosive crystals subjected to shock stimulus.
- Continue to develop improved and new sensor technology that will include (but not be limited to) low-volume and high-directivity acoustic arrays, laser-based passive acoustic arrays, magnetometers for target classification and signal processing algorithms for counter-countermeasure.
- Continue computer code refinements and investigation of supercavitating vehicle dynamics and instability.
- Conduct 4-inch free-running model tests to evaluate control concepts and devices for a supercavitating vehicle.
- Continue the University Laboratory Initiative program to provide an infusion of educated and career minded scientists and engineers in support of the NNR for undersea weapons research.
- Continue research into alternative binder materials for explosives and propellants which are compatible with higher energy ingredients.
- Continue research into the fundamental mechanisms of explosive sensitization/detonation.

- Continue research in man-portable electrical energy storage and conversion.
- Continue improvements to catalyzed carbon microfiber electrode development for semi-fuel cells.
- Continue development of nanostructured electrode and polymer electrolyte materials for electrochemical power sources.
- Develop interaction between the basic research in the direct oxidation and reforming of logistics fuels and the related tri-service programs to improve transition pathways for relevant breakthroughs.
- Continue work in science related to direct energy conversion.
- Enhance research on energy transfer science and research into materials and processes for energy efficiency.
- Enhance activities in nanoscience based approaches to novel power sources.

FY 2005 PLANS:

- Continue to develop synthesis routes to organometallic-based highly energetic ingredients.
- Continue to develop spectroscopic capabilities to accurately determine aluminum combustion temperature in various oxidizing environments.
- Continue to develop fundamental understanding of nitramine and perchlorate decomposition mechanisms for propellant applications.
- Continue to develop fundamental understanding of initiation mechanisms of explosive crystals subjected to shock stimulus.
- Continue to develop improved and new sensor technology that will include (but not be limited to) low-volume and high-directivity acoustic arrays, laser-based passive acoustic arrays, magnetometers for target classification and signal processing algorithms for counter-countermeasure.
- Conduct 4-inch free-running model tests with homing sensors and control devices on a supercavitating vehicle.
- Continue the University Laboratory Initiative program to provide an infusion of educated and career minded scientists and engineers in support of the NNR for undersea weapons research.
- Continue research into alternative binder materials for explosives and propellants which are compatible with higher energy ingredients.
- Continue research into the fundamental mechanisms of explosive sensitization/detonation.
- Continue research in man-portable electrical energy storage and conversion.
- Continue development of nanostructured electrode and polymer electrolyte materials for electrochemical power sources.
- Identify and focus on most promising energy conversion science concepts.
- Continue efforts in novel power source development.

- Initiate studies of integrated science approaches to energy efficient electric Navy.

	FY 02	FY 03	FY 04	FY 05
Electronics/Sensor Sciences	45,448	42,439	42,371	42,694

Efforts include: Sensing, diagnostics, and detectors; navigation and timekeeping; nano-electronics; wide band gap power devices; real-time targeting; 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; advanced multi-function RF system (AMRFS); and RF electronic warfare.

FY 2002 ACCOMPLISHMENTS:

- Developed methods for utilizing Raleigh waves for detection of land mines in various realistic soil types.
- Identified basic principles and techniques to allow precise control over atomic and molecular quantum states and enable more stable and precise atomic clocks for navigation and guidance. Such control also led to designs for more sensitive gyros and gravity gradiometers for inertial navigation and tunnel/bunker detection.
- Characterized the effects on performance of target echoes and boundary and volume scattering for shallow water active sensors.
- Quantified electromagnetic characteristics in the littoral environment to support mine countermeasures and surveillance systems.
- Developed autonomous undersea vehicle compatible sensors that can provide two and three-dimensional images for small target recognition.
- Developed techniques for extending the average power of solid state lasers by eliminating the heating of the laser medium.
- Continued to improve radio frequency and electronic warfare emission and reception by using wide bandwidth optical fiber signal processing techniques.
- Developed a set of advanced digital signal processing algorithms that support Naval information extraction requirements and throughput capabilities of emerging digital receiver technologies.

FY 2003 PLANS:

- Develop high voltage gradient particle linear accelerators by using Wakefield acceleration techniques.
- Explore concepts for new compact tunable short wavelength radiation sources.
- Develop novel large area plasma processing system for high density plasma etching for microelectronics applications.

- Continue development of physics-based, broadband, bi-static active classification algorithms to achieve low false alarm rates.
- Extend development of a hybrid millimeter wave/infrared lens to a 2-color capability for use in advance focal plane arrays.
- Continue development of radio frequency scattering models to more effectively account for composite structures and coated surfaces.
- Establish proof-of-principle of a new aircraft defense capability involving acquisition and laser countermeasure against threat missile seekers prior to their launch.
- Continue to collect and analyze millimeter wave radar time-series data on ships, decoys, and low grazing angle sea clutter and identify potential countermeasure techniques and incorporate millimeter wave phenomena into high fidelity models.
- Continue development of improved clocks, gyros and gravity gradiometers through atom interferometry, quantum information approaches, and optical meteorology. Self- and directed-assembly techniques will be explored as a means to fabricate molecular, nanomagnetic and nanoelectronic components.

FY 2004 PLANS:

- Investigate optical frequency standards and optical clocks based on optical frequency combs to span the frequency scales, and either ion traps, optical lattices, or atom fountains to isolate and interrogate the atoms.
- Investigate further atom-interferometric gyros to seek orders of magnitude gain in sensitivity. Gravity gradiometers will be further explored and improved in sensitivity.
- Explore atom optical devices.
- Develop new sources and detectors of quantum optics in the IR spectrum, and seek to exploit quantum information theoretic concepts to reduce noise.
- Support the Navy/DARPA wide band gap initiatives.
- Research bulk nitride semiconductor substrates (none are currently available), extended and point defect (deep level) identification characterization and elimination, by (amongst others) 'halide-assisted' epitaxy and bulk SiC crystal growth and semi-insulating substrates and epitaxial Nitride and SiC films.
- Research epitaxial multifunction crystal growth on wide gap semiconductors for increased monolithic integration/performance capability (tunable dielectrics, sensors, magnetic materials for Spin devices, superconductors, and non linear optical structures).
- Explore power tunnel junctions/diodes for improved pin-pn stacking and contacts, micro/millimeter wave power bipolar transistor materials and device technology.

- Research SiC materials and devices for power conditioning technology in the "All Electric Ship". Explore metalization/contact technology for both p- and n-type films as well as Schottky barriers and dry processing (etching, passivation, etc).
- Construct molecular and nanometer-scale electronic and magneto-electronic devices and sensors using assembly-based nanocomponents.

FY 2005 PLANS:

- Continue to investigate and propose designs of optical frequency standards and optical clocks based on optical frequency combs to span the frequency scales, and either ion traps, optical lattices, or atom fountains to isolate and interrogate the atoms.
- Design on-chip atom-interferometric gyros for miniaturization and orders of magnitude gain in sensitivity over designs of that size.
- Further explore and improve in sensitivity gravity gradiometers.
- Take research into atom optical devices into design stages. Quantum optics ideas will enable lower noise sources and detectors.
- Continue supporting the Navy/DARPA wide gap initiatives in the areas of: bulk nitride semiconductor substrates; extended and point defect (deep level) identification characterization and elimination, by (amongst others) 'halide-assisted' epitaxy and bulk SiC crystal growth; semi-insulating substrates and epitaxial nitride and SiC films.
- Continue research in epitaxial multifunction crystal growth on wide gap semiconductors for increased monolithic integration/performance capability (tunable dielectrics, sensors, magnetic materials for Spin devices, superconductors, and non linear optical structures).
- Explore Power tunnel junctions/diodes for improved pin-pn stacking and contacts, micro/millimeter wave power bipolar transistor materials and device technology.
- Research SiC materials and devices for power conditioning technology for the "All Electric Ship".
- Explore metalization/contact technology for both p- and n-type films as well as Schottky barriers and dry processing (etching, passivation, etc), as well as other technologies to support wide band gap initiatives.
- Construct nanoelectronic circuits using assembly techniques in combination with conventional lithography.
- Explore fault-tolerant circuit architectures that can function in spite of imperfect assembly.

Congressional Plus-Ups:

	FY 02	FY 03
Marine Mammal Low Frequency Sound Research	961	N/A

Environmental concerns covering the impact the effects of sonar on underwater mammals have risen to significant levels in recent years.

FY2002 Accomplishments

- Conducted Navy research on the possible effects of man-made underwater noise on protected marine life. Included work associated with the University of Hawaii Marine Mammal Facility and related programs in the state of Hawaii. These programs are unique in providing species of marine mammals (Risso's dolphin, false killer whale) not found elsewhere, and in providing the unique coral reef sheltered, warm, clear waters needed for certain experiments involving open water work with trained research marine mammals.

	FY 02	FY 03
Quantum Optics Research	481	4,791

Basic Research into quantum optics shows promise in the development of novel device configurations for infra-red sources and detectors that have high applicability to Naval sensors and weapons.

FY2002 Accomplishments

- Conducted basic research to investigate the feasibility of developing quantum optics technologies for sources and detectors in Naval applications.

FY2003 Plans:

- Continue designing experimental versions of these devices built based on theoretical advances in areas having to do with quantum interference processes such as lasing without inversion.

	FY 02	FY 03
Southeast Atlantic Coastal Ocean Observing System	3,843	*

- $5,478 (Appropriated in FY03 in 0602435N)

Understanding the impact of the changing environment on the worlds oceans and predicting future trends so that we can better deal with man's affects on the ocean is vital to the future of our country and the world. Setting up an ocean observing systems advances this understanding by collecting, documenting and making available the data to the broader oceanographic community.

FY2002 Accomplishments

- Developed a four-state, inter-institutional partnership that would develop a regional coastal ocean observing system designed to measure conditions in and above the coastal ocean and to report these observations to a broad user base. The system covers the region between the Virginia/North Carolina border to the Dry Tortugas. The effort was conducted under the auspices of the National Ocean Partnership Program.

	FY 02	FY 03
Consortium for Military Personnel Research	N/A	1,368

Manpower is the critical resource to the Naval service. Retention, accession, selection, classification, distribution, assignment, personnel policy and training management are all vital to successfully manning it.

FY2003 Plans

- Efforts in military personnel research that advance the Navy's ongoing efforts in the areas of retention, accession, selection, classification, distribution, assignment, personnel policy and training management.

	FY 02	FY 03
Naval Basic Research	N/A	4,986

The solar radiation spectrum affects militarily critical areas such as communications, navigation, surveillance and guidance systems. Expanded knowledge and understanding of this spectrum will dramatically improve the

fidelity of models of the Earth's upper atmosphere, thus greatly enhancing our ability to mitigate the effects of radiation-induced space weather. Detection of toxic substances is also of critical importance because of the military's need to operate in potentially harmful chemical and biological dangerous environments during wartime.

FY2003 Plans

- Investigate the solar spectrum and its effects on military systems.
- Conduct modeling of cell-based biosensor arrays in an effort to assist in the rapid detection and identification of potentially toxic substances. Pursue research that will lead to the design of complex biomimetics architectures.

	FY 02	FY 03
Robotic Countermine Technologies	N/A	1,467

Mine countermeasures in shallow water and particularly, the surf zone is extremely challenging. Use of robots designed with aquatic characteristics and features have been shown to be particularly promising in this task based on earlier ONR and DARPA research.

FY2003 Plans

- Develop and produce an undersea robotic platform based on biologically derived engineering concepts.

C. OTHER PROGRAM FUNDING SUMMARY:

NAVY RELATED RDT&E:
PE 0601152N In-House Laboratory Independent Research

NON-NAVY RELATED RDT&E:
PE 0601102A Defense Research Sciences (Army)
PE 0601102F Defense Research Sciences (Air Force)

D. ACQUISITION STRATEGY: Not applicable.