FY 2003 RDT&E,N BUDGET ITEM JUSTIFICATION SHEET DATE: February 2002

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

(U) COST: (Dollars in Thousands)

PROJECT NUMBER & TITLE	FY 2001 ACTUAL	FY 2002 ESTIMATE	FY 2003 ESTIMATE	FY 2004 ESTIMATE	FY 2005 ESTIMATE	FY 2006 ESTIMATE	FY 2007 ESTIMATE	TO COMPLETE	TO COMPLETE
0601153N	371,665	388,353	393,557	395,418	404,006	411,991	420,429	CONT.	CONT.

A. (U) 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, while exploiting scientific breakthroughs and providing options for new Future Naval Capabilities. It responds to S&T directions of the Department of the Navy (DON) Integrated Warfare Architecture Requirements for long term Navy and Marine Corps improvements, 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 Joint Chiefs of Staff's Future Joint Warfighting Capabilities. 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, which includes scientific study and experimentation directed toward increasing knowledge and understanding in national-security related aspects of physical, engineering, environmental and life sciences, is the core of Discovery and Invention. Basic research projects are developed, managed, and related to more advanced aspects of research in some hundred-plus technology and capability-related 'thrusts', which are consolidated in 22 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, advanced materials, 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

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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 (started in FY99), Underwater Weapons (started in FY01), Naval Architecture and Hydrodynamics (starts in FY02), with ongoing assessment of Precision Time and Time Transfer.

JUSTIFICATION FOR BUDGET ACTIVITY: This program is funded under BASIC RESEARCH because it encompasses scientific study and experimentation directed towards increasing knowledge and understanding in broad fields directly related to long-term DON needs.

B. (U) PROGRAMS ACCOMPLISHMENTS AND PLANS: Basic research in each ONR thrust includes a continuing core program to advance the state of knowledge and maintain top talent with interest and skill in Naval problems. Core programs are supplemented by initiatives at the ONR/NRL, department, or division level, to explore promising new avenues or take advantage of breakthroughs and potentially disruptive technologies. Initiatives typically last 2 to 5 years. Due to the volume of efforts included in this program element, the programs described in the Accomplishments and Plans sections are representative selections of the work.

1. (U) FY 2001 ACCOMPLISHMENTS:

- (U) ($141,233) Ocean/Space Sciences: Investigated thin ocean layer biological structures and demonstrated that the presence of biologics has strong optical and acoustic consequences impacting acoustic and non-acoustic predictive models. Investigated and showed effects of wave-current-gravity on ocean shelf sediment deposition and dispersal which will lead to improved shelf sediment characterization and more accurate mine burial and detection models and sensors. Studied phenomena of high latitude cloud-ice albedo dynamics and the impacts on rapid polar ice melting and the associated environmental changes. Improved existing ocean and atmospheric models to simulate and forecast the operational environment and provide accurate predictions of optimum sensor and weapon employment. Developed an Acoustic Integration Model to enable planners to synthesize quantitative 4-D information about deep and shallow ocean sound fields and marine mammal movements. Employed the NRL Space Physics Simulation Chamber coupled with theoretical investigations to demonstrate the Earth's magnetospheric boundary layer response to stresses imposed by increased solar activity. Conducted a hyperspectral biological and chemical assessment and the dynamics of Chesapeake Bay outflow plume. Determined effects of microbial

oxidation-reduction of humus substances for improved environmental cleanup techniques. Employed autonomous undersea vehicles based sensors to investigate coastal ocean processes and enable expanded future oceanographic data collection at reduced cost.

- (U) ($66,900) Advanced Material Sciences: Improved 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. Developed an innovative shell casting methodology for reduced maintenance and weight of shipboard watertight doors. Determined the fundamental relationship between the thermal contrast of materials and other physical parameters to allow for a new non-destructive evaluation technique for inspection of metals and composites. Invented two families of methods to compute fluid flow in complex configurations to improve understanding of blast shock mitigation to ships/submarines, ground vehicles, and buildings and other structures. Developed nuclear quadrapole resonance sensors for detection of explosives and contraband. Investigated field emission capabilities of carbon nanotubes leading to new opportunities in x-ray tubes, power amplifiers, and information displays. Developed new thin-film deposition methods to deposit fragile polymers and organic materials for micro-electromechanical devices, micro sensors, and for biological research. Synthesized new functional dendrimeric materials for use in hand held and unmanned air vehicle based chemical weapons sensors. Developed science base for high power millimeter wave beam processing of ceramic materials for piezoelectric actuator assemblies, ceramic heat engine components, thermal barrier coatings, and anti-corrosion coatings.

- (U) ($52,033) Information Sciences: Improved embedded learning techniques to enable autonomous vehicles on long duration missions to adapt to unanticipated events. Developed method to process digital terrain elevation data into a model that accurately represents the true geography. Developed principles for producing safe and secure software-intensive systems. Developed ability to characterize a computer network and determine patterns of anomalies to enable network intrusion detection. Developed algorithms to solve very large scale integer combinatorial optimization problems. Developed efficient use of Turbo codes and iterative processing in a wireless communication receiver to increase data rate, increase number of potential users, and provide for higher anti-jam capabilities. Developed intelligent agent software architectures to increase effectiveness of Joint Command and Control Teams. Developed tracking and recognition algorithms for a battlefield augmented reality system. Developed hierarchical level of detail algorithms to enable the visualization of very large ship design data sets.

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- (U) ($44,599) Electronics/Sensor Sciences: Developed instrument for spatial imaging of electron and ion spins to enable study of impurities, defects, and trapped electron in nano-electronic devices. Developed plasma filled diodes for generating high power electron beams for nuclear weapons effects simulation and radiology applications. Developed physics-based target scattering modeling and signal processing algorithms for improved target identification and tracking. Developed a hybrid millimeter wave/infrared lens for improved sensor fusion and day/night imagery. Developed coordinated network-based electronic warfare techniques to achieve battleforce defense. Developed networked radio frequency and infrared offboard countermeasure grid techniques for anti-ship missile terminal defense and radar acquisition denial. Developed and demonstrated techniques to permit the design of a millimeter wave capable ship's decoy. Identified environmentally friendly infrared obscurants and investigated efficient expendable deployment approaches for these materials. Investigated forward radar scatter in the ocean environment and determined the reflection coefficient under a variety of conditions to enable better radar performance predictive models.

- (U) ($29,733) Energy Sciences: Demonstrated jet noise reduction feasibility using passive control techniques thus enabling compliance with increasingly stringent environmental requirements. Developed steady state combustion model to predict missile propellant combustion behavior. Demonstrated a new generation of environmentally preferable and reduced cost green energetic materials. Analyzed the effect of inlet enthalpy on active combustion control effectiveness and demonstrated robust control over a wide range of inlet temperatures and missile flight conditions up to Mach 2.75. Demonstrated the capability for sustained pulse detonation engine operation utilizing standard aircraft fuel. Demonstrated efficiencies of a compact, automated vortex combustor for incineration of solid waste.

- (U) ($22,300) Human Performance Sciences: Developed therapies for treatment of hyperbaric oxygen poisoning to enable safer operations in diving and decompression conditions. Completed a characterization of relationship between brain activity and memory load. Developed basic understanding of hybrid architectures for complex learning with applications in tactical decision making. Developed a novel inner ear treatment approach for noise-induced hearing losses. Exploited improved understanding of human cognition and performance to create more realistic, capable, and cost effective simulated forces to populate training simulations and improve decision aid algorithms. Obtained Food and Drug Administration approval for Algal Hemostatic Dressing which will greatly reduce field combat deaths due to blood loss.

- (U) ($14,867) Naval Platform Design Sciences: Demonstrated feasibility of an integrated full stern/propulsor concept. Implemented radar holography measurement system for both radiation and scattering studies. Developed

numerical models of ferromagnetic signatures that minimize the number of actuators and sensors for closed-loop degaussing. Developed high power density ceramic capacitor material to enable smaller volume power converters for shipboard applications. Developed basic understanding of the phenomenology and control of above water signatures for evolving threat scenarios. Integrate hydrodynamic and electromagnetic models to predict scattering from breaking waves and improve ship hull design.

2. (U) FY 2002 PLAN:

- (U) ($145,484) Ocean/Space Sciences: Develop 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. Continue 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. Develop 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. Advance 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. Continue 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. Develop improved Earth upper atmospheric neutral density models for more accurate satellite drag prediction and improved estimates of useful satellite life. Employ 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. Continue 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. Develop new techniques for extracting useful environmental information from existing observing systems in the most efficient and cost-effective way.

- (U) ($68,914) Advanced Material Sciences: Develop improved piezoelectric crystal growth techniques to revolutionize electromechanical transduction for sonar and undersea weapons applications. Develop an automated and cost effective process of liquid molding manufacturing of composite components for ship and aerospace

applications. Continue work to improve understanding techniques for blast shock mitigation to ships/submarines. Develop novel luminescent quantum dot bio-conjugates for chemical and biological weapons sensor applications. Develop the science for thermally-stable, long living, highly efficient, light emitting diodes for use in maps and displays. Investigate the synthesis and assembly of nanoscale electro-active structures and composites for optical and thermal management applications. Continue 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. Investigate corrosion fatigue cracking and stress corrosion resulting from employing friction stir welding construction techniques on type 2519 aluminum components of amphibious assault vehicles. Continue work to improve techniques for high power millimeter wave beam processing of ceramic materials.

- (U) ($53,599) Information Sciences: Develop techniques to enable a collaborating team of heterogeneous agents/robots to operate in unknown environments with uncertain sensing. Develop a fundamental basis for image recognition and understanding. Extend methods for detecting, removing, modifying, decrypting, and creating hidden messages in shared digital media. Develop methods to map large three dimensional urban areas with accurate geo-positioning in real time. Create science base for intelligent software agents that can reason about physical phenomena and communicate with human collaborators. Continue development of novel algorithms for energy-efficient broadcasting and multi-casting on wireless communication networks. Continue to investigate methods for employing automated systems as substitutes for human vision for monitoring surveillance and reconnaissance. Initiate investigation of time-reversal imaging with application to array imaging, secure wireless communications, and nondestructive testing. Start investigation on applications to micro-fluids such as detection and analysis of genetic materials used for chemical sensing. Continue work on image enhancement and feature extraction techniques for applications to target identification, strike and battle damage assessment.

- (U) ($45,942) Electronics/Sensor Sciences: Develop methods for utilizing Raleigh waves for detection of land mines in various realistic soil types. Identify basic principles and techniques to allow precise control over atomic motion and enable more precise atomic clocks. Characterize the effects on performance of target echoes and boundary and volume scattering for shallow water active sensors. Quantify electromagnetic characteristics in the littoral environment to support mine countermeasures and surveillance systems. Develop autonomous undersea vehicle compatible sensors that can provide two and three-dimensional images for small target recognition. Develop techniques for extending the average power of solid state lasers by eliminating the heating of the laser medium. Continue to improve radio frequency and electronic warfare emission and reception by using wide bandwidth optical fiber signal processing techniques. Develop a set of advanced digital signal processing

algorithms that support Naval information extraction requirements and throughput capabilities of emerging digital receiver technologies.

- (U) ($30,628) Energy Sciences: Develop dynamic loading/spectroscopic tools for combustion initiation processes. Investigate novel composites for lightweight long life rechargeable batteries. Investigate interactions between oxidizer and fuel in ammonium-per-chlorate based propellants. Continue study on pulse detonation engine dynamics and gaseous and spray detonations. Explore development of fuel cell power sources that can operate on common logistic fuels for Marine combat units. Investigate multi-axis fluidic thrust vectoring to enable elimination of missile fin structure and reduce heat and drag for hypersonic missile applications. Continue work to develop a compact, efficient, and automated vortex combustor for incineration of solid waste. Investigate techniques for developing deformable missile warheads to increase missile lethality by creating an asymmetric blast pattern focussed in the desired direction.

- (U) ($22,971) Human Performance Sciences: Develop theories and models that address re-configurable organizational structures to support command decision making and command and control team performance. Develop techniques for rapid control of arterial bleeding in the far-forward battlespace. Determine which brain areas are active in performing cognitive tasks and detect likely conflicts among multiple tasks due to loading of same brain areas. Characterize the physiologic basis of operational bio-effects on the warfighter such as heat, cold, radiation and g-forces. Initiate a stress physiology program to identify parameters of individual stress resilience and develop novel therapeutics/strategies catering to the individual warfighter.

- (U) ($15,364) Naval Platform Design Sciences: Develop new hull structural acoustic measurement methodologies to enable advanced machinery support systems and improved hull coatings. Develop hull structural assessments capabilities for determining the integrity of the ship throughout its service life. Identify and analyze physics of stratified wakes. Identify active control and system stability criteria for very high (greater than 200MW) power systems. Identify and quantify bubble sources around surface ships including wave-breaking and turbulence effects.

3. (U) FY 2002 Congressional Plus-ups:

- (U) ($991) Marine Mammal Low Frequency Sound Research: Conduct Navy research on the possible effects of man-made underwater noise on protected marine life. Includes 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.

- (U) ($495) Quantum Optics Research: Basic research to investigate the feasibility of developing quantum optics technologies for use in Naval applications.

- (U) ($3,965) Southeast Atlantic Coastal Ocean Observing System: Develop 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 will cover the region between the Virginia/North Carolina border to the Dry Tortugas. The effort is conducted under the auspices of the National Ocean Partnership Program.

4. (U) FY 2003 PLAN:

- (U) ($149,552) Ocean/Space Sciences: Develop techniques for utilizing high resolution, motion imagery methods 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/EO/IR sensors, and the performance of Naval weapon in the atmosphere and under the sea. 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. 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. Investigate the fate and effects of chemical and biological contaminants in marine/estuarine environments.

- (U) ($70,840) Advanced Material Sciences: Explore three-dimensional nature of solid phases in opaque ferrous alloys for improved high strength steels. Continue to investigate pulsed laser deposition techniques to deposit thin films of fragile polymers and organic materials for use in micro-sensors and biological research. Design macromolecules composed of photo-active molecules for underwater mine detection applications. Develop an understanding of electron and ion transport at nano-scale dimensions for power sources and micro-electro-mechanical systems. Develop materials and fabrication science for new agile optical limiter materials for eye and sensor protection. Develop novel magnetic materials for ship board high power electronic applications. Design, synthesize and develop advanced polymers including high temperature and flame resistant polymeric 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. Explore materials and structures capable of limiting optical transmission at variable wavelengths for enhanced eye and sensor protection against agile laser illumination.

- (U) ($55,098) Information Sciences: 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 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 maximal 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.

- (U) ($47,227) Electronics/Sensor Sciences: 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.

- (U) ($31,485) Energy Sciences: 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 of 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.

- (U) ($23,613) Human Performance Sciences: Exploit improved understanding of human cognition and performance to create more realistic simulations and to improve decision algorithms. Develop new theoretical treatment of the differences in individual humans. Develop computational linguistic techniques to emulate one-to-one tutoring behavior. Research the efficacy of a group of compounds that mimic or assist endogenous defenses to hearing damage to sailors and marines. Determine dosimetry profiles for exposure to multiple frequency microwaves, evaluate cognitive performance effects, and develop predictions on the most hazardous exposure conditions for humans. 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.

- (U) ($15,742) Naval Platform Design Sciences: 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. 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.

(U) PROGRAM CHANGE SUMMARY:

	FY 2001	FY 2002	FY 2003
FY 2002 President's Budget Submission	377,642	389,829	
Adjustments from FY 2002 President's Budget:			
SBIR	-6,759		
Execution Adjustment	782		
Program Growth Reduction	0	-3,500	
Congressional Plus-ups	0	5,500	
Section 8123 Mgmt Reform Initiative	0	-3,463	
FFRDC Reduction	0	-13	
FY 2003 President's Budget Submission	371,665	388,353	393,557

(U) CHANGE SUMMARY EXPLANATION:

(U) Funding: Not Applicable.
(U) Schedule: Not Applicable.

(U) OTHER PROGRAM FUNDING SUMMARY: Not Applicable

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

(U) NON NAVY RELATED RDT&E:
(U) PE 0601102A Defense Research Sciences (Army)

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(U) PE 0601102F Defense Research Sciences (Air Force)

Activities are coordinated through Defense S&T 6.1 Reliance Scientific Planning Groups

(U) SCHEDULE PROFILE: Not applicable.