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

BUDGET ACTIVITY: 2 PROGRAM ELEMENT: 0602236N
PROGRAM ELEMENT TITLE: Warfighter Sustainment Applied Research

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
Warfighter Sustainment Applied Research	107,343	106,745	52,213	59,157	64,832	55,253	56,457	57,703

A. MISSION DESCRIPTION AND BUDGET ITEM JUSTIFICATION: This PE funds applied research supporting FNCs (Capable Manpower, Expeditionary Logistics, Littoral Combat/Power Projection, Total Ownership Cost (TOC) Reduction, and Warfighter Protection) and innovation-based efforts that will provide technology options for future Navy and Marine Corps capabilities. Efforts focus on manpower, personnel, and human factors (HF); naval systems training; expeditionary logistics distribution and command/control; littoral combat and power projection capabilities; energy conversion; advanced naval materials; medical technologies; environmental quality, and biocentric technologies. Within the Naval Transformation Roadmap, this investment supports eight transformational capabilities within the "Sea Strike", "Sea Shield", and "Sea Basing" operational concepts. Additionally, this PE provides technologies to protect the critical "Sea Warrior" component of the overarching "FORCEnet" operating architecture and supports the "Sea Enterprise" transformation process to maximize Naval business efficiencies.

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:	107,842	68,852	68,636	69,226
Adjustments from FY 2003 President’s Budget:				
Congressional Adds		40,310		
Cong, Rescissions/Adjustments/Undist. Reductions	-524	-1,259		
Execution Adjustments	1,629			
NWCF Rate Adjustments			-153	51
Efficiencies at NWCF Activities			-347	-362
S&T Program Adjustments			-14,857	8,483
Pay Raise/Inflation Adjustments		-1,158	-1,066	-1,275
SBIR Reduction	-1,604			
FY 2004/2005 President’s Budget Submission:	107,343	106,745	52,213	59,157

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

BUDGET ACTIVITY: 2 PROGRAM ELEMENT: 0602236N
PROGRAM ELEMENT TITLE: Warfighter Sustainment Applied Research

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: 2 PROGRAM ELEMENT: 0602236N Project Title: Warfighter Sustainment Applied Research
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COST: (Dollars in Thousands)

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B. ACCOMPLISHMENTS/PLANNED PROGRAM:

	FY 02	FY 03	FY 04	FY 05
Manpower, Personnel and Human Factors	6,854	6,605	4,867	3,691

These technologies enhance the Navy's ability to select, assign, and manage its people. Technology developments in these areas respond to a variety of requirements, including: managing the force efficiently and maintaining readiness with fewer people and smaller budgets; providing warfighting capabilities optimized for low-intensity conflict and littoral warfare; and operating and maintaining increasingly sophisticated weapons systems while managing individual workload and supporting optimal manning. This activity supports the Capable Manpower FNC.

FY 2002 ACCOMPLISHMENTS

- **Whole Person Assessment**

Initiated:

- Began the pre-test of all instruments for the person-organization fit effort. This work will develop and test all models and indices for assessing the degree of fit between the person and the organization.
- Commenced the selection of specific predictor measures and objective presentation for the psychometrics of measures program that help "tease out" important non-cognitive individual differences (social judgment/intelligence, emotional intelligence, tendency for negative outlook, coping skills, etc.) useful in making career decisions.
- Initiated the models of aptitude and interest effort to analyze data for job interest inventory. Verified and extended model through correlational and structural techniques to be used in a flexible and valid selection/classification system.
- Started effort that focuses on development of algorithms that optimally assign individuals to jobs. Deliver software version 1.0 from this Usability and Contents research program.

Completed:

- Completed the biopsychological investigation of relationships among performance on spatial abilities (human ability to reason about visual events in space), tests, and performance during stressful training. This could result in significant cost savings in predicting pilot performance.
- Finished the development of new tests of complex cognitive abilities that relate to situational awareness (human perception and information integration of elements in the environment such as other aircraft, terrain, system status and warning lights) during flight.
- Finalized integration of new technologies (non-cognitive and abilities) of whole person assessment for occupational selection and classification.
- Completed development of a methodology to use cluster sampling for valid Navy surveys. This allows researchers to use smaller samplings without biasing the results.
- Demonstrated new psychological assessment methods to predict successful adaptation to military service.

- **Sailor/Marine Career Management System**

Initiated:

- Initiated the job matchmaker program, Sailor/Marine assignment matchmaker that develops intelligent agents to assess desires and qualifications of Sailors/Marines as well as applying/analyzing incentives necessary to influence behavior.
- Began the development of a prototype multi-agent system for sailors in the service member/command intelligent agents program. Demonstrated intelligent software agents with the necessary level of associative intelligence and cognitive capability (human intelligence and aptitude as measured by speed and accuracy of processing verbal, quantitative and spatial information) to gather information pertinent to the service member/command. The objective is for these agents to assist the sailor and the detailer with the complex assignment process.

Completed:
- Completed the (E)-commerce technologies for personnel distribution and assignment program and developed a community-specific database of sailors and jobs to support further testing of the two-sided matching algorithm.
- Developed a robust simulation model capable of incorporating sailor command preferences. Developed experiments to test expected market behavior in the military environment.

- **Personnel Situation Monitoring, Analysis & Response Technologies**

Continued:
- Continued evaluation of alternatives to the Integrated Personnel Simulation Techniques program to validate the simulation algorithm.

Completed:
- Finished the Student Value Model program by transitioning the model to both basic and advanced technical training school planners.
- Demonstrated integration of the web view of statistical reports generated via extensible markup language application with models that exchange information across various platforms and with different communications media.

- **Advanced Interface Design & Training Capability**

Initiated:
- Initiated user profile development in support of new land attack mission.

Continued:
- Continued cognitive task analysis, flow development, task requirements, software requirements, and design of selected tasks and Human-Computer Interaction (HCI) components within the new land attack mission.
- Continued implementation of selected task and HCI designs into a rapid prototype for usability testing.

Completed:
- Completed task and HCI design of land attack tasks: Digital Gun Call for Fire; Tomahawk Land Attack Missile (TLAM) Block III Planning & Engagement Go Path (Preplanned Mission); TLAM Block III with Cell Allocation.
- Completed user profile development in support of new land attack mission.

FY 2003 PLANS

- **Whole Person Assessment**

Initiate:
- Adaptability screening for military service, a battery of non-cognitive metrics to ascertain the probability of attrition as it relates to military culture and environment.

Continue:
- Continue the psychometrics of measures program and begin the transition to the non-cognitive measures advanced technology effort.
- Development continues in the usability and contents effort and delivery of software version 2.0 to the user.

Complete:
- Complete testing a cohort in the Recruit Training Center and A-school and begin data analysis on the cohort for the person-organization fit program. Finalize assessment of the degree of fit between the person and the organization. Transition results to the Attrition Reduction Technologies advanced technology effort.
- Finish the models of aptitude and interest effort and use measures of social judgments and personality to provide an overall structural model of individual and group differences. Deliver a stand-alone version of the interest inventory to an advanced technology effort.

- **Sailor/Marine Career Management System**

Initiate:
- Begin applied research effort, the broker agent program, to demonstrate a series of agents residing within the web-based marketplace that arbitrate between Sailor/Marine and command agents when optimal matches cannot be achieved.

Continue:
- Effort is ongoing to establish a database supporting the Sailor/Marine assignment matchmaker program and to develop a plan to integrate auction theory using intelligent agent technology.
- Continue the service member/command intelligent agents effort and integrate multi-agent system for Sailors into a "personnel mall." These intelligent agents will provide information at appropriate times to adequately advise service members of impending career milestones with recommended choices and provide commands with necessary manpower information to ensure proper personnel planning. The prototype will be an interactive web-based labor market for the labor allocation of military personnel.

- **Personnel Situation Monitoring, Analysis & Response Technologies**

Initiate:

- Begin emerging technology effort of an enterprise management system approach to manpower and personnel management. Optimization, simulation, and statistical forecasts will be developed to capture complexity of factors effecting manpower and personnel management.

Complete:

- Efforts complete to transition algorithm from the Integrated Personnel Simulation Technologies program to user.

- **Advanced Interface Design & Training Capability**

Initiate:

- Initiate workload assessment and allocation for land attack tasks.
- Initiate Training Analysis for Land Attack Human-Computer Interaction (HCI) rapid prototype

Complete:

- Complete cognitive task analysis, flow development, task requirements, software requirements, and design of selected tasks and Human-Computer Interaction (HCI) components within the new land attack mission.
- Complete implementation of selected task and HCI designs into a rapid prototype for usability testing.
- Complete Training Analysis for Land Attack HCI prototype

FY 2004 PLANS

- **Whole Person Assessment**

Initiate:

- Initiate applicant cultures and values program to assess the practicality and predictive validity of socialization measures for selection into the military.

Complete:

- Complete the psychometrics of measures program, a suite of non-cognitive metrics for ascertaining individual differences.
- Development finishes in the usability and contents effort that provides input parameters to the classification and assignment algorithm.
- Complete testing and validation of non-cognitive metrics for adaptability for military service.

- **Sailor/Marine Career Management System**

Continue:

- Continue applied research effort, the broker agent program, to demonstrate a series of agents residing within the web-based marketplace that arbitrate between Sailor/Marine and command agents when optimal matches cannot be achieved.

Complete:

- Effort wraps-up to establish the Sailor/Marine assignment matchmaker algorithm for assignment of Sailors to jobs.
- Complete the service member/command intelligent agents prototype cognitive Sailor agent to be used in web-based detailing.

- **Personnel Situation Monitoring, Analysis and Response Technologies**

Continue:

- Continue applied research effort in developing an integrated optimization, simulation and statistical manpower and personnel suite of decision support tools for manpower and personnel enterprise management system.

- **Advanced Interface Design & Training Capability**

Initiate:

- Initiate Land Attack Training Tool analysis and design

Complete:

- Complete workload assessment and allocation for land attack tasks.
- Complete Land Attack Training Tool analysis and design

FY 2005 PLANS

- **Whole Person Assessment**

Continue:

- Continue applicant cultures and values measures effort to assess the practicality and predictive validity of socialization measures for selection into the military.

- **Sailor/Marine Career Management System**

Complete:

- Finish the cognitive broker agent prototype to be used as the command intelligent agent in web-based detailing.

- **Personnel Situation Monitoring, Analysis and Response Technologies**

Continue:
- Continue validation and testing of out year forecasts, simulations models and optimization algorithms for enterprise management system.

- **Advanced Interface Design & Training Capability**

– No 6.2 effort

	FY 02	FY 03	FY 04	FY 05
Training Technologies	10,928	10,531	9,310	13,465

Training technologies enhance the Navy's ability to train effectively and affordably in classroom settings, in simulated environments, and while deployed, and to operate effectively in the complex, high-stress, information-rich and ambiguous environments of modern warfare. Technology development responds to a variety of requirements, including providing more affordable approaches to training and skill maintenance.

FY 2002 ACCOMPLISHMENTS

- **Training Technologies for Distance Learning**

Initiated:
– Initiated a program on maintenance training support technology.
– Initiated programs on training and performance aiding, Interactive Electronic Technical Manuals, and Condition-Based Maintenance (IETMs/CBM) systems.
– Initiated program on psychometric and statistical issues in 5-vector model.
– Initiated program on role of cognitive style in multimedia training.
Continued:
- Continued program on intelligent agents for objective-based training.
Completed:
– Completed work on instructional authoring tools.
– Completed development of algorithms for generating optimal mentor-prototype pairings.

- **Virtual Technologies and Environments**

Initiated:
- Initiated immersive interaction applications for weapons handling for dismounted combatants in Virtual Environments (VE). Virtual Environments are a cost-effective training venue that can improve training effectiveness and enable improved capabilities in training for dynamic, high-tempo warfighting environments.
- Started Computer Generated Forces (CGF) aimed at improved techniques for human cognitive and behavioral modeling techniques to support realistically behaving simulated teammates and adversaries. This will create more challenging simulated adversaries for application in simulation based naval training. The consequence will be more effective training.
- Began Modeling and Simulation (M&S) studies to determine the appropriate architecture and tools for Close Quarters Battle (CQB) training.

Continued:
- Continued immersive interaction simulation of human locomotion for use in close quarters battle training.
- Continued effects of ship motion on onboard VE systems. Onboard training using VE systems can prepare students at sea, enhancing mission readiness. Ship motion can interfere and impede these systems, reducing the effectiveness of a valuable training tool.

Completed:
- Finished investigations into alternate visual and aural presentations for individual vehicle simulators. These studies will be used by Demo I researchers in developing simulation systems.

- **Visualization-based Training & Support Systems**

Initiated:
- Initiated exploration of multi-media visualization training techniques.

Completed:
- Completed exploration of multi-media visualization training techniques. Program is not planned to continue beyond FY02.

- **Instructional Strategies and Technologies**

Initiated:
- Began the study of the instructional impact of personified pedagogical agents in computer-based training of problem solving.

- Initiated the use of web-based research and knowledge crystallization tools to aid advanced students (such as Navy Post-Graduate School students in a military intelligence course) to become more independent learners and thinkers.

Continued:
- Continued work on the Physics Tutor. This effort improves instructional effectiveness to aid students in solving problems on their own as well as advancing the state-of-the-art of intelligent tutoring in general by comparing the effectiveness of alternative instructional strategies.
- Continued work on instructional authoring tools designed to improve the efficiency and effectiveness of developing pedagogically sound computer based training tailored to military settings and training needs.

Completed:
- Completed work on artificially intelligent tutoring in dynamic decision-making.
- Completed work on augmenting displays to enhance learning
- Completed work on advancing applied cognitive task analysis.

- **Human Modeling for Simulation-based Training**

Initiated:
- Initiated tasks aimed at improved techniques for human cognitive and behavior modeling to support realistically behaving simulated teammates and adversaries to achieve more challenging and realistic simulation-based training and a reduction in the number of human controllers required as role players in large scale simulations.
- Initiated tasks assessing the capability of Computer Generated Forces (CGFs) to act as instructional agents for scenario generation and provide coaching and feedback, aimed at reducing training personnel costs by at least 25%.
- Started tasks aimed at developing enhanced modeling techniques for representing individual differences such as produced by differing levels of training, aptitude, and experience, making CGF performance less predictable and less gameable.

Continued:
- Continued tasks that created highly realistic simulated teammates to support team training relevant to shipboard combat information center activities.

Completed:
- Finished work on computer generated forces aimed at development of simulated team members to insert into team training and intelligent tutoring systems.

FY 2003 PLANS

- **Training Technologies for Distance Learning**

Initiate:
– Start development of optimized strategies for performance aiding and training.
– Begin development of measures to link shared cognition with team performance.
Continue:
– Continue program on maintenance training support technology.
– Continue programs on training and performance aiding, Interactive Electronic Technical Manuals, and Condition-Based Maintenance (IETMs/CBM) systems.
– Continue program on psychometric and statistical issues in 5-vector model.
– Continue program on intelligent agents for objective-based training.
Complete:
- Complete program on role of cognitive style in multimedia training.

- **Virtual Technologies and Environments**

Initiate:
- Initiate training aid research for Close Quarters Combat (CQB). These devices will assist the trainee to understand the spatial relationships critical to fighting in a close quarter battle.
Continue:
- Continue immersive interaction applications for weapons handling for dismounted combatants in Virtual Environments (VE). Continue Computer Generated Forces (CGF) aimed at improved techniques for human cognitive and behavioral modeling techniques to support realistically behaving simulated teammates and adversaries. Continue modeling and simulation (M&S) to develop the architecture and tools for CQB training.
- Continue immersive interaction simulation of human locomotion for use in CQB training.
- Continue effects of ship motion on onboard VE systems.

- **Instructional Strategies and Technologies**

Continue:
- Continue the study of the instructional impact of personified pedagogical agents in computer-based training of problem solving.
- Continue work on effective feedback in artificially intelligent tutoring for dynamic task environments such as anti-air warfare, instrument flying and other characteristic military tasks.
- Continue development of the physics tutor (electricity and magnetism) as well as associated experimentation to determine the most effective instructional strategies for tutors of this general type.

Complete:
- Develop a class of instructional authoring tools emphasizing simulation and artificially intelligent tutoring of trouble-shooting for maintenance training, including the capability to deliver the resulting instruction over the Internet.

- **Human Modeling for Simulation-based Training**

Initiate:
- Begin task to develop multi-agent based architectures for modeling human behavior with the goal of exploiting the inherent modularity of these architectures to enhance the reusability and therefore, affordability of modeling.
- Initiate task to apply novel architectural strategies that can facilitate the re-use of human behavior models or model components in applications that vary in their resolution requirements and tasks.

Continue:
- Continue task aimed at improved techniques for human cognitive and behavioral modeling to support more realistically behavior simulation teammates and adversaries.
- Continue task to improve the capability of Computer Generated Forces (CGFs) to act as instructional agents for scenario generation and to provide coaching and feedback.
- Continue task to develop enhanced modeling techniques for representing individual differences such as produced by differential levels of training, aptitude, and experience.
- Continue task to create highly realistic simulated teammates to support team training relevant to shipboard combat information center activities.

FY 2004 PLANS

- **Training Technologies for Distance Learning**

Continue:
- Continue program on intelligent agents for objective-based training.
- Continue development of optimized strategies for performance aiding and training.

Complete:
- Complete program on psychometric and statistical issues in 5-vector model.
- Complete development of measures to link shared cognition with team performance.

- **Virtual Technologies and Environments**

Initiate:
- Initiate Virtual Technologies and Environments (VIRTE) Demo III, Full Spectrum Combat. Building upon the foundations of VIRTE Demos I and II, Demo III will research issues associated with integrating many different military domains into a distributed simulation.

Continue:
- Continue immersive interaction applications for weapons handling for dismounted combatants in Virtual Environments (VE). Continue Computer Generated Forces (CGF) aimed at improved techniques for human cognitive and behavioral modeling techniques to support realistically behaving simulated teammates and adversaries. Continue modeling and simulation (M&S) to develop the architecture and tools for Close Quarters Combat (CQB) training.
- Continue immersive interaction simulation of human locomotion for use in CQB training.
- Continue effects of ship motion on onboard VE systems. Continue training aid research for CQB. These devices will assist the trainee understand the spatial relationships critical to fighting in a close quarter battle.

- **Instructional Strategies and Technologies**

Initiate:
- Begin systematic program of research addressing unanswered questions regarding effective instructional strategies in artificially intelligent tutoring.
- Initiate research on instructional strategy issues specific to distance learning applications of computer-based instruction, especially artificially intelligent tutoring.

Continue:
- Continue the study of the instructional impact of personified pedagogical agents in computer-based training of problem solving.
- Continue investigating strategies for artificially intelligent real-time coaching in dynamically evolving environments, such as are characteristic of military tasks and jobs.

Complete:
- Complete physics tutor project.

- **Human Modeling for Simulation-based Training**

Initiate:
- Initiate task to evaluate new algorithms to improve the robustness (capability to react appropriately to unanticipated contingencies) of human behavior models operating in military simulations.

- Initiate task to test in a military context newly developed techniques for automating significant parts of the processes of knowledge acquisition and engineering with the goal of reducing by 50% the costs of these activities.

Continue:
- Continue task aimed at improved techniques for human cognitive and behavioral modeling to support more realistically behavior simulation teammates and adversaries.
- Continue task to develop enhanced modeling techniques for representing individual differences such as produced by differential levels of training, aptitude, and experience.
- Continue task to create highly realistic simulated teammates to support team training relevant to shipboard combat information center activities.
- Continue task to develop multi-agent based architectures for modeling human behavior with the goal of exploiting the inherent modularity of these architectures to enhance the reusability and therefore, affordability of modeling.
- Continue task to apply novel architectural strategies that can facilitate the re-use of human behavior models or model components in applications that vary in their resolution requirements and tasks.

Complete:
- Complete task to improve the capability of computer generated forces to act as instructional agents for scenario generation and to provide coaching and feedback.

FY 2005 PLANS

- **Training Technologies for Distance Learning**

Continue:
– Continue development of optimized strategies for performance aiding and training.

Complete:
– Complete program on intelligent agents for objective-based training

- **Virtual Technologies and Environments**

Continue:
- Continue immersive interaction applications for weapons handling for dismounted combatants in Virtual Environments (VE). Continue Computer Generated Forces (CGF) aimed at improved techniques for human cognitive and behavioral modeling techniques to support realistically behaving simulated teammates and adversaries. Continue modeling and simulation (M&S) to develop the architecture and tools for Close Quarters Battle (CQB) training.
- Continue the immersive interaction simulation of human locomotion for use in Close Quarters Battle training.

- Continue effects of ship motion on onboard VE systems. Continue the Training Aid research for CQB. Continue virtual Technologies and Environments (VIRTE) Demo III, Full Spectrum Combat.

- **Instructional Strategies and Technologies**

Initiate:
- Initiate investigation of instructional strategy issues specific to artificially intelligent training systems designed to train military teams together, working in teams, whether in the same or distributed locations.

Continue:
- Continue the study of the instructional impact of personified pedagogical agents in computer-based training of problem solving.
- Continue investigating strategies for artificially intelligent real-time coaching in dynamically evolving environments, such as are characteristic of military tasks and jobs.
- Continue systematic program of research addressing unanswered questions regarding effective instructional strategies in artificially intelligent tutoring.
- Continue research on instructional strategy issues specific to distance learning applications of computer-based instruction, especially artificially intelligent tutoring.

Complete:
- No completions in FY05.

- **Human Modeling for Simulation-based Training**

Initiate:
- Initiate task to apply in the context of a simulation for Naval training a set of recently developed learning techniques that can be used in a model interacting with its application environment to extend or refine its knowledge base and behavioral competence.

Continue:
- Continue task aimed at improved techniques for human cognitive and behavioral modeling to support more realistically behavior simulation teammates and adversaries.
- Continue task to develop multi-agent based architectures for modeling human behavior with the goal of exploiting the inherent modularity of these architectures to enhance the reusability and therefore, affordability of modeling.
- Continue task to apply novel architectural strategies that can facilitate the re-use of human behavior models or model components in applications that vary in their resolution requirements and tasks.

- Continue task to create highly realistic simulated teammates to support team training relevant to shipboard combat information center activities.
- Continue task to evaluate new algorithms to improve the robustness of human behavior models operating in military simulations.
- Continue task to test in a military context newly developed techniques for automating significant parts of the processes of knowledge acquisition and engineering with the goal of reducing by 50% the costs of these activities.

Complete:
- Complete task to develop enhanced modeling techniques for representing individual differences such as produced by differing levels of training, aptitude, and experience.

	FY 02	FY 03	FY 04	FY 05
Expeditionary Logistics	7,272	7,008	0	0

The Expeditionary Logistics addresses surface distribution considerations and supports efforts in logistics modeling and simulation. Reconstitution and indefinite forward force Sustainment relate to the Seabasing component of Seapower 21, Expeditionary Maneuver Warfare (EMW), and aspects of Sea Strike and Sea Shield. These Naval activities hinge on timely and responsive logistics operations at sea. Investment focus areas encompass surface replenishment of the seabase from Naval and commercial shipping as a force multiplier, and internal Seabase material and cargo handling and conveyance mechanisms for selective off-load. Logistics concepts will also be emphasized through the addition of logistics modeling and simulation activities within the Naval Simulation System and the Joint Wargaming System.

FY 2002 ACCOMPLISHMENTS:

- **Strike Up/Strike Down Systems**

Initiated:
- Initiated development of selective offload system for automated storage and retrieval, suitable for Amphibious and Logistics ships. Considered acceleration to install on a potential sea base demonstration ship. Technical emphasis was on load stabilization, control systems, and component marinization.
- Initiated development of Sensor Based Dynamic Manipulation work to support cargo movement. Performer worked to integrate a control system for robotic arm manipulation and continuous visual sensing via manipulation algorithms. Technical emphasis was on imaging, robotics, and real-time network algorithm manipulation.

- **Seabase to Shore Surface Craft**

Completed:
– Completed a matrix of technology capabilities and short falls to focus efforts and refine execution strategy. Study included review of the Landing Craft Air Cushion (LCAC), the Landing Craft Unit (LCU), and the sea state 3 (SS3) Lighters.

- **Ship to Shore/Skin to Skin Material Transfer**

Completed:
- Completed skin to skin material transfer technology feasibility investigations. Independent studies examined the potential to develop new fendering materials, at-sea ship securing systems, future crane technology and surfactants.

- **Logistics Wargame Simulators**

Continued:
– Continued the commander behavior module. Proceeded with the technology insertion into the Naval Simulation System baseline. Transitioned the capability set to the PE0603236N program plan for the Combat Service Support (CSS) Tool Kit supporting Logistics Command and Control.
Completed:
- Finalized the weather module concept development. Proceeded with technology insertion into the Joint Warfare System (JWARS) simulation system.

FY 2003 PLANS:

- **Strike Up/Strike Down Systems**

Continue:
- Continue investigation/development of technologies for selective offload and cargo movement.

Complete:
- Transition technology to the PE0603236N maturation component of the Expeditionary Logistics (ExLog) FNC investment.

- **Seabase to Shore Surface Craft**

Initiate:
- Initiate ship to shore transfer technology development in propulsion, creating 30% greater thrust with the new propulsors, but fitting in the same space as the existing propulsors (to fit in a well deck and keep the drive thru lane on the aft end of the LCAC).
- Initiate work to reduce fan maintenance, including innovative aerodynamic and material technologies to develop a propulsion fan that generates the required thrust efficiently and improves the reliability and maintainability of the propulsion fans.

Complete:
- Transition technologies to the PE0603236N technology demonstration program within the ExLog FNC.

- **Ship to Shore/Skin to Skin Material Transfer**

Initiate:
- Initiate skin to skin material transfer technology development emphasizing fendering materials and alternative crane concepts.

Complete:
- Transition technology development to technology demonstration PE0603236N ExLog FNC program plans.

- **Logistics Wargame Simulators:** N/A

FY 2004 PLANS: NA

FY 2005 PLANS: NA

	FY 02	FY 03	FY 04	FY 05
Littoral Combat / Power Projection	0	0	1,150	3,625

This activity provides technologies which enhance the ability of the Navy-Marine Corps team to achieve assured access and sustained operations in the littorals as the naval portion of a joint campaign. This includes efforts to provide advanced high speed inter theater sealift configurations, in particular projects to mature friction drag reduction concepts. The Littoral Combat/Power Projection FNC considers all the critical functions of warfighting: command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR); fires; maneuver; sustainment; and force protection.

FY 2002 ACCOMPLISHMENTS: NA

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

BUDGET ACTIVITY: 2 PROGRAM ELEMENT: 0602236N Project Title: Warfighter Sustainment Applied Research
PROGRAM ELEMENT TITLE: Warfighter Sustainment Applied Research

FY 2003 PLANS: NA

FY 2004 PLANS:

Initiate:
- Initiate software development for dynamic planning and adaptive execution of Expeditionary Maneuver Warfare via domain interpretation rules, active templates, and intelligent agents.

FY 2005 PLANS:

Continue:
- Continue development of dynamic planning and adaptive execution software by adding functionality and demonstrating during a scheduled training exercise.

	FY 02	FY 03	FY 04	FY 05
Energy Conversion	2,104	0	0	0

Energy conversion efforts address technology development to provide significant improvements in energetic material systems and subsystems in terms of performance, safety, reliability, and affordability, and to transition advanced technology to the Fleet for warfighter sustainment. Goals include: advanced energetic materials for warheads and propellants with superior performance and acceptable insensitivity characteristics to reduce vulnerability to both personnel and platforms; and reliable simulation tools and diagnostics to (1) develop and design superior performance reduced vulnerability systems tailored to specific warfighter missions, (2) improve safety, and (3) reduce cost by enabling simulation aided design and condition-based monitoring capabilities. This work develops technologies for cost-effective design, performance assessment, and vulnerability assessment of enhanced performance, insensitive munitions.

FY 2002 ACCOMPLISHMENTS:

Initiated:
- Evaluation of advanced fuels for enhanced explosive and propellant applications. These are metal based fuels which offer the potential to significantly improve the performance of energetic materials by enhancing ignition times and tailoring rates of energy release. (Effort discontinued due to program priorities).
- Development of a capability to tailor propellant performance to combustion characteristics. This will permit the a-priori optimization of propellant formulation design in order to tailor the safe operating regime of the propellant to the system requirements. (Effort discontinued due to program priorities).

- Development of the capability to predict effects of ballistic modifiers on propellant performance parameters. This capability will permit one to tailor the pressure-combustion rate dependence of next generation propellants using current ballistic modifiers with a-priori design criteria and eliminate many of the empiricisms currently inherent to the development process. (Effort discontinued due to program priorities).
- Development of the capability to predict effects of energetic components on propellant burn rate parameters. This would permit the maximization of performance while simultaneously avoiding catastrophic propellant failure when new designs or design changes are implemented. (effort discontinued due to program priorities).
- Development diagnostics to monitor response of energetic materials to external stimuli. These diagnostics are essential in the understanding of how mechanical energy is absorbed into an energetic material and if it leads to detonation or will quench. (Effort discontinued due to program priorities).
- Calibration of laboratory scale diagnostics to accurately determine underwater explosive performance and validate with large scale test results. This capability would enable laboratory characterization of the small quantities of experimental explosives initially available without the need to invest significant time and resources into material scaleup. (Work transferred in FY03 to PE 0602747N).

Completed: (This work was previously funded in PE 0601153N)

- Completed a 1st generation model to predict effects of ammonium perchlorate size effects on propellant burn rate parameters.

FY 2003 PLANS: *

FY 2004 PLANS: NA

FY 2005 PLANS: NA

	FY 02	FY 03	FY 04	FY 05
Advanced Naval Materials	21,952	21,941	15,296	17,692

Advanced Naval Materials efforts address significant improvements in terms of affordability, reliability and performance to transition advanced technology to the Fleet for warfighter sustainment. Goals include: advanced, lightweight materials and processes to reduce weight and cost; ultrareliable materials and sensors to reduce cost by enabling condition-based and zero maintenance capabilities; environmentally acceptable long-life coatings for aircraft and ships to improve the quality of life for sailors; advanced low cost welding and joining methods, and new low cost sensors. Turbine improvement efforts cover the Navy's share of the turbine engine component development efforts under the Department of Defense (DOD)/National Aeronautics and Space Administration (NASA) Industry Integrated High Performance Turbine Engine Technology (IHPTET) program, ensuring that Navy unique design and operational requirements are met. Also included are aircraft and ship electrical power generation and thermal management technologies. Airframe and ship corrosion efforts address an integrated

approach for the control of the effects of external and internal corrosion. The work develops advanced cost effective prevention and life cycle management technologies. This is particularly significant to life extension for the aging fleet. This activity supports the Total Ownership Cost (TOC) Reduction Future Naval Capability.

FY 2002 ACCOMPLISHMENTS:

- **Structural Materials**

Initiated:
- Initiated development of improved welding consumables for superior strength (greater than 110 ksi)/toughness ship steels. This will provide the Navy with superior performance weld metal with minimized preheat for affordable construction of future ships.
- Began development of higher temperature aluminum alloys. These materials will reduce weight and cost of components, now fabricated from titanium, in the front end of naval gas turbine engines.
- Started investigations of a nondestructive evaluation technique based on the thermographic imaging of structures. Preliminary results indicate it to be very sensitive for the detection of small cracks in naval structures.

Continued:
- Continued stress corrosion tests on friction stir welded advanced amphibious assault vehicle (AAAV) aluminum alloy. This will enable the Marine Corps to select lower cost joining technologies for the AAAV, which yield aluminum alloy microstructures not susceptible to stress-corrosion cracking.
- Continued friction stir welding of steels effort to develop apparatus and processing routes for superior solid state welds in ship structures. This will provide Navy with technique that drastically reduces weld fume and distortion/enhances stealth and affordability in ship construction.
- Continued development of compositions and processing for more affordable, higher performance ship steels such as HSLA-65. This will provide the Navy with ship steels of superior strength/toughness and affordability, and significant weight reduction.
- Continued development and evaluation of weld processing of stainless steel for more affordable superior performance welds. This will provide the Navy with welding technology to fabricate non-magnetic, stealthy ships.
- Continued development of ultra-light heat exchanger for the E-2C aircraft. A planned upgrade in the E-2C radar requires heat dissipation beyond that achievable with standard pin-on-fin heat exchangers. This program will provide that capability and obviate expensive aircraft structural changes.
- Continued development of advanced carbon/carbon materials processes for missile heat shield applications for naval strategic missiles. This work will provide replacements for no-longer available materials and develop better, more affordable new heat shield materials.

- Continued development of advanced composites and polymers with fire resistance for ship structures. Present day composite materials ignite easily generating thick and toxic fumes, therefore are not safe for man rated areas.
- Continued development of mechanics analysis for glass fabric composite structures for future naval topside structures. This will provide the Navy with guidance for the rational selection of material design allowable based on material damage.

Completed:

- Completed pulse thermographic imaging developed for defect characterization in naval structures. This is a portable, wide-area and non-contact inspection technology with significant promise for maintenance cost reduction.
- Finished effort to optimize the damage tolerance response versus the vibration damping characteristics of reinforced polyurethane composites for cost and weight reduction on future Navy ships.
- Completed bismalidie (BMI) composite (patch development) development for high temperature repair applications of present and future naval aircraft. Present epoxy patch technology does not meet the demanding aerospace material requirements.
- Demonstrated superior new MIL-100S welding wire for welding ship steels. This provides the Navy with improved weld metal for welding of HSLA steels with the elimination/minimization of preheat and thus enhanced affordability in ship and submarine construction.
- Concluded pressure/shock testing of cast lattice block material (LBM) water-tight doors. LBM cast steel doors will lead to reduced maintenance (less distortion) and reduced weight.

- **Functional Materials**

Initiated:

- Initiated assessments of applications of high force actuators for naval structures. These actuators will allow active control of structural vibrations reducing acoustic radiation from undersea vehicles, for example, in torpedo acoustic stealth applications.
- Started developments of high strain-high force actuators for sonar source applications. These sonar transducers will allow reduction in device sizes by factors ranging from three to six in applications such as torpedo homing sonar and torpedo countermeasure decoys.

Continued:

- Continued development of frequency agile polymers for application in laser eye protection. These new nonlinear optical limiter materials will protect our sailors and marines from ever changing laser threats.
- Continued development of multi-functional transducer materials. These composite piezoelectric materials can have their properties tailored to meet the requirements of a broad range of sonar systems ranging from submarine

obstacle avoidance sonar through multi-line towed hydrophone arrays to Unmanned Underwater Vehicle (UUV) mounted mine hunting sonar.
- Continued evaluation of advanced transducer single crystal high strain materials. These materials will revolutionize essentially all Navy sonar devices by doubling bandwidths and increasing energy densities more than an order of magnitude.

Completed:
- Completed evaluation of capacitive micromachined ultrasonic transducers for diver-held undersea imagers.

- **Maintenance Reduction Technologies**

Initiated:
- Initiated development of materials and processes for high temperature turbine disks. These materials/processes are needed to provide improved performance, durability and decreased operational cost in future naval gas turbine engines.
- Started development of multi-laser-processing technology for the fabrication of ultra hard materials. This revolutionary new technology will allow us to reclaim old components back into service or produce new components with zero maintenance requirements.
- Initiated work on advanced smart wires for rapid aircraft maintenance. This will provide the Navy and Marine Corps the ability to rapidly diagnose defects in wiring and significantly reduce the time required for maintenance of complex wiring in aircraft and ships.
- Began developing single coat corrosion control coatings for potable water ship tanks. This new coating will replace current five and three coat systems thereby reducing costs.
- Initiated new wash-down processes for United States Marine Corps (USMC) vehicles using recyclable corrosion inhibitors. This will provide the Marine Corps with advanced corrosion control technology and contribute to life extension of vehicles such as the High Mobile Multi-Purpose Wheeled Vehicle (HMMWV).
- Initiated development of standardized road test methodology and coating test metrics for the USMC vehicles that emulate real marine environment.
- Initiated corrosion monitoring sensors to enable early detection of corrosion in hidden/hard-to-reach areas in the aircraft.
- Started developing longer-life, low maintenance Modular Hybrid Pier (MHP).
- Initiated developing longer life, enhanced performance self-priming coating and Corrosion Preventive Compounds (CPC) for the aircraft.
- Initiated spectral imaging/thermography technology for non-destructive evaluation (NDE) of naval materials and structures. This wide area imaging technique will lower the inspection time by 30% while enhancing its reliability of detection.

- Initiated fighter/helo arc fault circuit breaker (AFCB) development. This will provide the Navy and Marine Corps the capability to prevent electrical arcing in areas such as fuel tanks greatly enhancing safety of operation.
- Began demonstrating first cooled ceramic (zircon nitride) vane for gas turbine engines. Ceramic components are less susceptible to environmental degradation and will allow several hundred degrees elevation in engine operating temperature.

Continued:

- Continued development of environmental barrier coatings for ceramics/composites to provide higher combustor operational temperatures and extended combustor life times for future naval gas turbine engines. This work is necessary to meet IHPTET Phase III goals and will transition into improved engines for future naval aircraft.
- Continued cadmium replacement technology development for corrosion control. This will provide the Navy with an environmentally acceptable technology for preventing corrosion and hydrogen embrittlement in high strength steel aircraft components such as landing gear and wing boxes.
- Continued development of environmentally acceptable coatings for nonmagnetic ship hulls. This will enable the Navy to select lower cost austenitic stainless steel as a non-magnetic hull material in preference to higher cost titanium alloys.
- Continued evaluation of upgraded seawater valves in land based tests. This will provide the Navy with 40-year valves in seawater systems, thereby eliminating valve replacements currently needed at 10-year intervals.
- Continued development of innovative composites casting technology for ship shafts and seals. This will allow the Navy to fabricate extraordinarily long life seals for propulsion shafts on Navy ships, enhancing combat readiness and affordability/reducing maintenance.
- Continued development of new thermal barrier technology using multiphase coatings for oxidation resistant molybdenum alloys, a likely candidate for the next generation of superalloys. These alloys will provide higher hot section operating temperatures for future naval gas turbine engines resulting in improved performance and decreased specific fuel consumption.
- Continued development of oxidation resistant molybdenum alloys that are leading candidates for the next generation of superalloys. These materials will provide major enhancement in performance and fuel economy for gas turbines by providing higher hot section capability and more thermodynamic efficiency.

Completed:

- Completed corrosion sensor development for condition based maintenance of ballast tanks. This enables the Navy to save maintenance costs by replacing a manual inspection process with an electrochemical monitoring technology for ship tanks.
- Finished ultrasonic imaging camera development for non-destructive evaluation (NDE) of naval materials and structures. This wide area imaging technique will lower the inspection time by 30% while enhancing its reliability of detection.

- Completed advanced applique technologies development for aircraft corrosion control. This will enable the Navy to save maintenance costs by employing easily replaceable stick-on coatings having both corrosion prevention and stealth properties.
- Completed development/evaluation/qualification of the ausform finishing process for aerospace steel gears. This will provide the Navy with superior technology to produce rotorcraft gears with greater load capability and longer service life.
- Finished bristle brush development for paint and corrosion product removal. This will provide the Navy with the ability to spot-repair aircraft paint coatings without having to re-paint the whole aircraft, thereby reducing maintenance costs.

- FY 2003 PLANS:

- **Structural Materials**

Initiate:
- Initiate the development of ultralight, blast resistant structural materials for force protection. These materials will have applications in protecting ship hulls, command and control centers, Marine Corps vehicles, personnel shelter walls, etc.
- Begin the development of low cost Phthalonitrile based organic resin materials with improved fire resistant behavior. These resins will be instrumental for the introduction of composite materials in all man rated areas aboard ships.
- Initiate the development of new process for fabrication of fiber reinforced foam material for structural applications. These materials will have applications in next generation cored composite top side structures.

Continue:
- Continue friction stir welding of steels to drastically reduce weld fume and distortion, enhancing stealth and affordability, in ship construction.
- Continue development of compositions and processing for more affordable, higher performance ship steels such as HSLA 65 for significant weight reduction.
- Continue development and evaluation of weld processing of stainless steel for fabrication of non-magnetic, stealthy ships.
- Continue development of improved welding consumables for superior strength with minimized preheat, for affordable construction of future ships.
- Continue development of advanced carbon composite processes for missile heat shield applications for naval strategic missiles.
- Continue development of advanced composites and polymers with fire resistance for ship structures.

- Continue development of mechanics analysis for glass fabric composite structures for future naval topside structures.
- Continue multi-laser-processing technology for the fabrication of ultra hard materials to produce new components with zero maintenance requirements.

Complete:

- Complete stress corrosion tests on friction stir welded advanced amphibious assault vehicle (AAAV) aluminum alloy. This will enable the Marine Corps to select lower cost joining technologies for the AAAV which do not yield aluminum alloy microstructures susceptible to stress-corrosion cracking.
- Complete investigations of a new nondestructive evaluation technique based on the thermographic imaging of structures excited ultrasonically. Preliminary results indicate it to be very sensitive for the detection of small cracks in naval structures.
- Complete development of ultra-light heat exchanger for the E-2C aircraft. A planned upgrade in the E-2C radar requires heat dissipation beyond that achievable with standard pin-on-fin heat exchangers. This program will provide that capability and obviate expensive aircraft structural changes.
- Complete ultrasonic imaging camera development for non-destructive evaluation (NDE) of naval materials and structures. This wide area imaging technique will lower the inspection time by 30% while enhancing its reliability of detection.

- **Functional Materials**

Initiate:

- Initiate evaluation of single crystal transducer materials' mechanical strength under Naval operating conditions.

Continue:

- Continue to develop multifunctional transducer materials for a broad range of sonar systems.
- Develop high-force high-strain actuators for active control of structural vibrations reducing acoustic radiation from undersea vehicles.
- Continue evaluation of advanced transducer single crystal high-strain materials to revolutionize essentially all Navy sonar devices by doubling bandwidths and increasing energy densities.

Complete:

- Complete frequency agile polymers for application in laser eye protection and transition to the "Warfighter Protection" FNC.

- **Maintenance Reduction Technologies**

Initiate:
- Initiate shipboard testing of upgraded seawater valves to provide the Navy with 40-year valves.
- Begin development of durable new materials for naval gas turbine engine hot sections. This work will provide improved performance, engine life, and reduced operating costs for naval aircraft engines.
- Start development of novel thermal barrier coating technology for gas turbine engine hot section components. Thermal barrier coating reduces hot section metal temperature, thus prolonging engine life and permitting improved operational performance in naval engines.
- Initiate evaluation of joint behavior effects on materials for modular hybrid pier construction.

Continue:
- Continue development of environmental barrier coatings for ceramics/composites to provide higher combustor operational temperatures and extended combustor life times for future naval gas turbine engines.
- Continue cadmium replacement technology development to provide the Navy with an environmentally acceptable technology for high strength steel components.
- Continue multi-laser-processing technology for the fabrication of ultra hard materials to produce new components with zero maintenance requirements.
- Continue development of environmentally acceptable coatings for corrosion protection for nonmagnetic ship hulls.
- Continue development of innovative composites casting technology for ship shafts and seals.
- Continue development of new thermal barrier technology using multiphase coatings for oxidation resistant molybdenum alloys, to provide higher hot section operating temperatures, resulting in improved performance and decreased specific fuel consumption.
- Continue development of oxidation resistant molybdenum alloys to provide major enhancement in performance and fuel economy for gas turbines.
- Continue development of materials and processes for high temperature turbine disks.
- Continue development of higher temperature aluminum alloys to reduce weight and cost of components, now fabricated from titanium, in the front end of naval gas turbine engines.
- Continue development of advanced smart wire for rapid aircraft maintenance.
- Continue to develop single-coat corrosion control coatings for potable water ship tanks to replace current five-coat and three-coat systems thereby reducing coats.
- Continue the development of new wash-down processes for USMC vehicles using recyclable corrosion inhibitors to provide advanced corrosion control technology for life extension of vehicles such as the HMMWV.
- Continue to develop standardized road test methodology and coating test metrics for the USMC vehicles that emulate real marine environment.
- Continue to develop corrosion monitoring sensors to enable early detection of corrosion in hidden/hard-to-reach areas in aircraft.

- Continue to develop longer-life, low-maintenance Modular Hybrid Pier (MHP).
- Continue to develop longer-life, enhanced-performance, self-priming coating and Corrosion Prevention Compounds (CPC) for aircraft.
- Continue to develop spectral imaging/thermography technology for NDE of naval materials and structures to lower the inspection time by 30% while enhancing reliability of detection.
- Continue to develop fighter/helicopter arc fault circuit breaker (AFCB) technology to provide the capability to prevent electrical arcing in areas such as fuel tanks; greatly enhancing safety of operation.

Complete:
- Complete land based tests of upgraded seawater valves. This will provide the Navy with 40-year valves in seawater systems, thereby eliminating valve replacement currently needed at 10-year intervals.

FY 2004 PLANS:

- **Structural Materials**

Initiate:
- Initiate development of integrated structural composites with blast resistance for next generation destroyer applications. Part of this effort will be to develop those manufacturing technologies that will allow the economic integration of functionally diverse materials.

Continue:
- Continue development of ultra light, blast resistant structural materials for force protection and to protect ship hulls, command and control centers, Marine Corps vehicles, personnel shelters, etc.
- Continue development of advanced carbon composite processes for missile heat shield and propulsion applications.
- Continue low cost Phthalonitrile based organic resin material development with improved fire resistance.
- Continue process development for fabrication of fiber reinforced foam material for structural applications. These materials will have applications in next generation cored composite top side structures.
- Begin the development of advanced composites and polymers with fire resistance for ship structures.

- **Functional Materials**

Initiate:
- Develop acceptance testing methodologies for advanced transducer single-crystal high-strain materials. Define standardized materials properties and composition ranges.

Continue:
- Continue to evaluate single crystal transducer materials mechanical strength under Naval operating conditions.

- Continue to develop multifunctional transducer material.
- Continue to develop high-force high-strain actuators for structural applications and sonar transducers.

Complete:

- Complete evaluation of advanced transducer single crystal high strain materials. These materials will revolutionize essentially all Navy sonar devices by doubling bandwidths and increasing energy densities by more than an order of magnitude.

- **Maintenance Reduction Technologies**

Initiate:

- Initiate the development of electrospark deposited coatings and scratch/hole fillers for corrosion and wear applications.
- Initiate portable, real-time, wide area nondestructive inspection (NDI) technology for crack and disbondment detection on substructures on the aircraft.

Continue:

- Continue the development of durable new materials for naval gas turbine engine hot sections.
- Continue the development of novel thermal barrier coating technology for gas turbine engine hot section components to prolong engine life,
- Continue multi-laser-processing technology for the fabrication of ultra hard materials to produce new components with zero maintenance.
- Continue the development of innovative composites casting technology for long life ship shafts and seals.
- Continue the development of environmental barrier coatings for ceramics/composites to provide higher combustor operational temperatures and extended combustor life times for gas turbine engines.
- Continue the development of new thermal barrier technology to provide higher hot section operating temperatures for improved performance.
- Continue the development of materials and processes for high temperature turbine disks.
- Continue the development of higher temperature aluminum alloys to reduce weight and cost of components, now fabricated from titanium.
- Continue shipboard testing of upgraded seawater valves to provide the Navy with 40-year valves.
- Continue cadmium replacement technology development to provide the Navy with an environmentally acceptable technology for high strength steel components.
- Continue the development of environmentally acceptable coatings for corrosion protection for nonmagnetic ship hulls.

- Continue the development of standardized road test methodology and coating test metrics for the USMC vehicles that emulate real marine environment.
- Continue the development of longer-life, enhanced-performance self-priming coating and Corrosion Preventive Compounds (CPC) for aircraft.
- Continue the development of spectral imaging/thermography technology for NDE of naval materials and structures.

Complete:

- Finish development of oxidation resistant molybdenum alloys to provide major enhancement in performance and fuel economy for gas turbines.
- Complete the development of single coat corrosion control coatings for fuel-compensated water ship tanks.
- Complete the development new wash-down processes using recyclable corrosion inhibitors to provide the Marine Corps with advanced corrosion control technology.

FY 2005 PLANS:

- **Structural Materials**

Initiate:

- Initiate development of vapor-phase corrosion inhibitor emitters for the protection of shipboard electronics and computers.
- Initiate development of new environmentally friendly, affordable and structurally sound Bio-Composite materials for the Navy after next. New genetic manufacturing routes will allow key structural and functional qualities never achieved before while using conventional fabrication methods.

Continue:

- Continue the development of ultralight, blast resistant structural materials for ship hulls, command and control centers, Marine Corps vehicles, personnel shelters, etc.
- Continue the development of advanced carbon composite processes for missile heat shield and propulsion applications.
- Continue the development of integrated structural composites with blast resistance for next generation destroyer applications. Part of this effort will be to develop those manufacturing technologies that will allow the economic integration of functionally diverse materials.
- Continue low-cost Phthalonitrile-based organic resin material development with improved fire resistance.

- **Functional Materials**

Initiate:

- Begin the development of capacitors with ultra-high dielectric constants for increased storage capability and significantly reduced size. Capacitors with increased energy density will provide projected energy storage and conditioning requirements to enable electric force concepts.
- Start development of compositional-tuning, single-crystal, high-strain transducer materials, for specialized Naval system applications.

Continue:

- Continue to evaluate single crystal transducer materials mechanical strength under Naval operating conditions.
- Continue to develop multifunctional transducer materials for a broad range of sonar systems.
- Continue development of high-force high-strain actuators for structural applications and sonar transducers for active control.
- Continue to develop acceptance testing methodologies for advanced transducer single-crystal high-strain materials.

- **Maintenance Reduction Technologies**

Initiate:

- Initiate portable, real-time, wide area nondestructive inspection (NDI) technology for heat damage detection on composite materials.

Continue:

- Continue development of durable new materials for naval gas turbine engine hot sections.
- Continue development of novel thermal barrier coating technology for gas turbine engine components to prolong engine life.
- Continue development of innovative composites casting technology for ship shafts and seals to enhance combat readiness and reduce maintenance.
- Continue multi-laser-processing for the fabrication of ultra hard materials to produce components for zero maintenance requirements.
- Continue development of environmental barrier coatings for ceramics/composites to provide higher combustor operational temperatures and extended combustor life times for future naval gas turbine engines.
- Continue development of new thermal barrier technology using multiphase coatings for oxidation resistant molybdenum alloys to provide higher hot section operating temperatures for future naval gas turbine engines.
- Continue development of materials and processes for high temperature turbine disks.
- Continue development of higher temperature aluminum alloys to reduce weight and cost of components for gas turbine engines.

- Continue development of electrospark deposited coatings and scratch/hole fillers for corrosion and wear applications.
- Continue shipboard testing of upgraded seawater valves to provide 40-year valves in seawater systems.
- Continue cadmium replacement technology development to provide an environmentally acceptable technology for preventing corrosion and hydrogen embrittlement in high strength steel.
- Continue development of environmentally acceptable coatings for corrosion protection for nonmagnetic ship hulls.
- Continue to develop single coat corrosion control coatings for Collection, Holding and Transfer (CHT) water ship tanks. This new coating will replace current five-coat and three-coat systems thereby reducing coats.
- Continue to develop new wash-down processes to provide the Marine Corps with advanced corrosion control technology and contribute to life extension of vehicles such as the High Mobile Multi-Purposed Wheeled Vehicle (HMMWV).
- Continue to develop longer-life, enhanced-performance, self-priming coating.
- Continue to develop spectral imaging/thermography technology for non-destructive investigation (NDE) of naval materials and structures. This wide area imaging technique will lower the inspection time by 30% while enhancing its reliability of detection.

Complete:

- Complete Wide Area spectral imaging/thermography NDI technology.
- Complete development of Corrosion Preventive Compounds.

	FY 02	FY 03	FY 04	FY 05
Medical Technologies	17,371	16,738	17,163	15,524

Medical Technologies improve warfighter safety and enhance personnel performance capabilities under adverse conditions, enhance diagnosis of medical emergencies and treatment of casualties, and prevent costly occupational injury and disease in hazardous environments. Requirements which support technology development in these areas include: improving warfighting capabilities through enhanced supply and long-term storage of pre-positioned medical supplies such as blood; providing better stress endurance/control for key personnel; and providing enhanced casualty care onboard amphibious casualty receiving ships. This activity supports the Warfighter Protection Future Naval Capability.

FY 2002 ACCOMPLISHMENTS

- **Casualty Care and Management**

Initiated:
- Initiated the evaluation of the effects of a hemoglobin red cell substitute on brain injury. These studies will determine if use of a newly developed soluble hemoglobin product will reduce brain damage following blunt trauma.
- Initiated the evaluation of the effects of a colloidal resuscitation fluid on brain injury. These studies will determine if a newly approved colloidal resuscitation fluid reduces brain damage following blunt trauma.
- Initiated studies to assess the energy status of various organs following resuscitation with standard crystalloids. Phosphorus nuclear magnetic resonance (NMR) will be used to determine adenosine triphosphate (ATP) levels in an animal model of hemorrhage following resuscitation, thus determining which fluid provides optimal resuscitation.
- Initiated the evaluation of glycopeptide compounds with regards to efficacy in control of pain, addiction potential, potential for abuse, and sedative properties as a substitute for morphine. These studies are designed to identify a drug or drug formulation that will be as effective as morphine, the current standard of care.
- Initiated the development of a casualty management tool for Operational Maneuver from the Sea (OMFTS) and special operations. This tool will facilitate optimal distribution of medical supplies.

Continued:
- Continued the evaluation of a hemostatic dressing that contains an antimicrobial agent. Incorporation of an antimicrobial, in theory, should decrease the rate of infection and improve morbidity. Studies are designed to test whether this product design is effective.
- Continued the development of freeze-dried red blood cells. Continued evaluation on the impact of high pressures on lyophilization of red cells. By increasing ambient pressure, the movement of water out of red cells may be facilitated, thus improving the efficiency of freeze-drying and quality of the freeze-dried red cell.
- Continued efforts in the development of a hemoglobin substitute. Hemoglobin is the most effective oxygen carrier at present, but it is expensive to isolate and process; these studies will characterize oxygen-binding heme peptides (to be encapsulated in liposome's) that could be manufactured inexpensively.
- Continued applied research on the effects of Food and Drug Administration (FDA)-approved resuscitation fluids on the inflammatory response. Fluids employed in standard of care resuscitation appear to potentiate systemic inflammation; this study will determine which of the currently employed fluids is least likely to promote inflammatory injury.
- Continued applied research on extending the circulation time of the gas diffusion enhancer, trans-sodium crocetinate (TSC). TSC shows promise as an additive to resuscitation fluid, but currently it is excreted too rapidly to sustain tissue oxygenation for more than 20 minutes.

- Continued the evaluation in models of hemorrhage combined with head trauma of arginine supplementation of hypertonic saline resuscitation fluid. By supplying arginine, the substrate for nitric oxide, it is believed that nitric oxide levels will increase and improve perfusion of the brain.
- Continued the evaluation of the control of systemic inflammation by interleukin-II (IL-11). This cytokine, which is approved for human use, has shown promise for preventing intestinal injury following severe hemorrhage.
- Continued the assessment of nasal ketamine to relieve acute pain. This drug may have utility for controlling pain of injury and facilitating self-transport of casualties.
- Continued efforts in the investigation of the chemical properties of a hibernation factor. A factor isolated from hibernating squirrel serum has demonstrated the ability to protect cells from ischemic injury. The factor will be further characterized, cloned and tested in a small animal model of hemorrhage.
- Continued studies in the evaluation of the trauma applications of hand-held ultrasound diagnostic instruments in the field. The relative merits of two systems will be evaluated under field conditions with minimally trained operators to determine if these devices require further development.

Completed:

- Completed studies on evaluation of melatonin in hemorrhagic shock. Melatonin is a readily-available compound that was shown to prevent ischemic injury to the brain, and these studies will determine its full potential for treating head injury.
- Completed studies of the colloidal fluid resuscitation effects on the development of lung injury. Acute respiratory disease (ARD) is the major killer of hemorrhagic shock casualties; these studies evaluated various colloidal fluids that may prevent ARD.
- Completed the evaluation of the effect of hypertonic fluids on head injury (transition). Clinical studies have suggested that hypertonic resuscitation is beneficial in head injury, but the optimal fluid and protocol requires analysis in a head injury model including hemorrhage and resuscitation.
- Completed the evaluation of selected cytokines as predictive indicators of trauma outcome (transition). Data obtained in one clinical center will be replicated in two other clinical centers to determine whether effective markers of multiple organ failure have been identified.
- Completed studies of the effects of mild hypothermia on hemorrhagic shock outcomes. Mild hypothermia was shown to prevent head injury following hemorrhage in rats, but will be further assessed in a swine model for its utility in large species.

- **Casualty Prevention**

Initiated:

- Initiated development of technologies for enhanced body protection against battlefield munitions. In particular, studies will be performed to assess the amount of blunt force trauma damage that is experienced using current and proposed chest protection devices.
- Initiated development of an improved aircrew protection suit for operational aircraft. The suits will be targeted to platforms. High performance aircraft operations will focus on extending g-force tolerance for operators. Helicopter operations will attempt to improve safe operations in extreme heat and cold. Initiated work on a smart ensemble that assesses physiological status and integrates into aircraft control systems, to reduce risk associated with loss of situational awareness or consciousness.

Continued:

- Continued evaluation of malaria DNA vaccine gene sequences for protective efficacy. The optimal combination of oligomers for stimulating protective immunity is being determined based on protection tests in mice and monkeys.

Completed:

- Completed development of a model for the clearance of (insoluble) smoke particles from the lung in order to determine the optimal exposure limits for toxic exposure to smoke in Navy Firefighters.
- Completed examining the short- and long-term effects of acute and chronic exposure to hypobaric (high altitude aircraft and aircraft operations training chambers) oxygen. This work attempted to define the long term risk to personnel and develop new approaches to training and operations that reduce risk of injury from oxygen toxicity.
- Completed exploring effects of motion and acceleration and developing methods to predict and counteract the deleterious effects of low-to-high frequency acceleration (motion) in operational environments. Deleterious motion effects can range from extreme nausea to disorientation and have been identified as contributing factors in numerous fatal mishaps on ships and aircraft. Approaches to be studied include improved control surface and display design, optimal work-rest schedules, and diet and drug-based interventions.

- **Undersea Medicine**

Continued:

- Continued studies to evaluate immunological function during harsh operational conditions. Particular emphasis is placed on characterizing the changes in immunological factors which may predict susceptibility to viral or bacteriological immunological challenges.
- Continued effort to assess the impact of thermal (i.e., heat and cold) stress on operational performance in Navy and Marine Corps personnel. These studies will lead to the formulation of strategies to mitigate the performance decrements induced by exposure to thermal extremes.
- Continued the development of predictive measures for oxygen-induced seizures continued in the hope that a physiologically-based “early warning system” can be engineered to warn divers using hyperbaric oxygen of the impending likelihood of central nervous system seizures.

- Continued efforts to develop prophylactic agents to prevent hyperbaric oxygen toxicity in Navy and Marine Corps divers breathing pure oxygen at depth. These efforts will also identify physiological changes that occur after acute and chronic exposure to hyperbaric oxygen in order to assess if repeated exposure to hyperbaric oxygen increases the probability of seizure activity or brain damage with subsequent exposures.
- Continued the development of novel agents that prevent the neurological damage associated with decompression sickness in Navy divers. Decompression sickness remains a major medical problem in Navy divers.

Completed:

- Completed studies to compare and contrast performance during the 18-hour watchstanding schedules with schedules based upon a 24-hour day. The current submarine watchstanding schedules are based upon an "18-hour day" which may be less than optimal based upon research with shift-workers.

- **Healthy and Fit Force**

Initiated:

- Initiated building on research into the underlying processes for cellular repair, applied research into the regeneration of auditory and vestibular hair cells in the inner ear. This work will attempt to define the chemical changes in the cell during the damage process and develop target drug approaches that improve or imitate upon the body's own damage repair.
- Initiated exploring accident trends aboard reduced-crewed and high performance vessels such as fast boats, smart ships and next generation aircraft carriers to determine new approaches to reduce injury through improved design of workstations, seats, and controls. This effort will include studies of musculo-skeletal injury and how fitness and strength affect injury potential.

Continued:

- Continued to evaluate ways to protect hearing and balance through new protective systems. The effort includes studies of new materials that reduce noise levels when applied to personal hearing protection as well as structural insulations. Additional work will continue to develop clinical strategies and interventions such as new drugs to protect and restore hearing and balance progress.

FY 2003 PLANS

- **Casualty Care and Management**

Initiate:

- Initiate a project to evaluate the use of heart rate variability (HRV) as a predictor of survivability of casualties. This effort has direct implications on the assignment of limited resources for evacuation of casualties.
- Initiate a study evaluating the efficacy of a dehydroepiandrosterone (DHEA) analog (Androstenetriol; AET) to decrease mortality and morbidity of battlefield casualties.
- Initiate a study to evaluate the effectiveness of sublingual partial pressure of carbon dioxide (PC02) measurements to predict the onset of shock in patients. This method/device may improve management of casualties in shock due to trauma/hemorrhage.

Continue:

- Continue efforts in the development of a hemoglobin substitute.
- Continue the evaluation of the effects of a colloidal resuscitation fluid on brain injury.
- Continue studies to assess the energy status of various organs following resuscitation with standard crystalloids.
- Continue the evaluation of glycopeptide pain drugs.
- Continue the development of a casualty management tool for Operational Maneuver from the Sea (OMFTS) and special operations.
- Continue the evaluation of the effects of a hemoglobin red cell substitute on brain injury.
- Continue studies on the effects of Food and Drug Administration (FDA)-approved resuscitation fluids on the inflammatory response.
- Continue applied research on extending the circulation time of the gas diffusion enhancer, trans-sodium crocetinate (TSC).
- Continue the evaluation in models of hemorrhage combined with head trauma of arginine supplementation of hypertonic saline resuscitation fluid.
- Continue the evaluation of the control of systemic inflammation by the cytokine, IL-11.
- Continue studies in the evaluation of the trauma applications of hand-held ultrasound diagnostic instruments in the field.

Complete:

- Complete evaluation of a hemostatic dressing that contains an antimicrobial agent.
- Complete the development of freeze-dried red blood cells and evaluation of high pressures on lyophilization of red cells.
- Complete assessment of nasal ketamine to relieve acute pain.
- Complete efforts in the investigation of the chemical properties of a hibernation factor. A factor isolated from hibernating squirrel serum has demonstrated the ability to protect cells from ischemic injury

- **Casualty Prevention**

Initiate:
- Initiate effort to develop salivary tests for disease, toxin, allergen, and agent exposure and to determine immunization status. Particular emphasis is placed on salivary tests to assess immune status to the anthrax vaccine.

Continue:
- Continue development of technologies for enhanced body protection against battlefield munitions.
- Continue development of an improved aircrew protection suit for operational aircraft.
- Continue Rapid Detection and Response for Chem/bio Defense Systems program.

Complete:
- Complete effort to evaluate malaria DNA vaccine gene sequences for protective efficacy.

- **Undersea Medicine**

Initiate:
- Initiate studies to develop methods for the non-invasive detection of bubbles in tissue and blood for improved diagnostics of decompression sickness. Current diagnosis of decompression sickness must rely on the presentation of outward symptoms that may not be manifest for several hours after the dive. The development of technology to detect nitrogen bubbles immediately after a dive will go a long way in identifying likely causes of decompression sickness and thus permitting treatment before major injury occurs.
- Initiate development of a treatment for decompression sickness using perfluorocarbon-based compounds. Artificial blood substitutes which utilize perfluorocarbon molecules to transport oxygen can also increase nitrogen transport in the body and thus may provide a new treatment for preventing decompression sickness after diving.

Continue:
- Continue effort to assess the impact of thermal (i.e., heat and cold) stress on operational performance in Navy and Marine Corps personnel.
- Continue the development of predictive measures for oxygen-induced seizures in the hope that a physiologically-based "early warning system" can be engineered to warn divers using hyperbaric oxygen of the impending likelihood of central nervous system seizures.
- Continue efforts to develop prophylactic agents to prevent hyperbaric oxygen toxicity in Navy and Marine Corps divers breathing pure oxygen at depth.
- Continue the development of novel agents that prevent the neurological damage associated with decompression sickness in Navy divers.

Complete:
- Complete studies to evaluate immunological function during harsh operational conditions.

- **Healthy and Fit Force**

Continue:
- Continue building on research into the underlying processes for cellular repair, applied research into the regeneration of auditory and vestibular hair cells in the inner ear.
- Continue exploring accident trends aboard reduced-crewed and high performance vessels such as fast boats, smart ships and next generation aircraft carriers to determine new approaches to reduce injury through improved design of workstations, seats, and controls.
- Continue to evaluate ways to protect hearing and balance through new protective systems.

FY 2004 PLANS

- **Casualty Care and Management**

Continue:
- Continue efforts in the development of a hemoglobin substitute.
- Continue the evaluation of the effects of a colloidal resuscitation fluid on brain injury.
- Continue studies to assess the energy status of various organs following resuscitation with standard crystalloids.
- Continue the evaluation of glycopeptide pain drugs.
- Continue the development of a casualty management tool for Operational Maneuver from the Sea (OMFTS) and special operations.
- Continue the evaluation of the effects of a hemoglobin red cell substitute on brain injury.
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- Continue applied research on extending the circulation time of the gas diffusion enhancer, trans-sodium crocetinate (TSC).
- Continue the evaluation in models of hemorrhage combined with head trauma of arginine supplementation of hypertonic saline resuscitation fluid.
- Continue the evaluation of the control of systemic inflammation by the cytokine, IL-11.
- Continue studies in the evaluation of the trauma applications of hand-held ultrasound diagnostic instruments in the field.

- Continue a project to evaluate the use of heart rate variability (HRV) as a predictor of survivability of casualties. This effort has direct implications on the assignment of limited resources for evacuation of casualties.
- Continue a study evaluating the efficacy of a DHEA analog (Androstenetriol; AET) to decrease mortality and morbidity of battlefield casualties.
- Continue a study to evaluate the effectiveness of sublingual PC02 measurements to predict the onset of shock in patients. This method/device may improve management of casualties in shock due to trauma/hemorrhage.

Complete:
- Complete applied research on extending the circulation time of the gas diffusion enhancer, trans-sodium crocetinate (TSC).

- **Casualty Prevention**

Initiate:
- Initiate effort to apply novel DNA technologies to protect warfighters with immune system enhancers from environmental agents, endemic and infectious diseases with reduced logistic requirements and enhanced efficacy against multiple pathogens.

Continue:
- Continue effort to develop salivary tests for disease, toxin, allergen, and agent exposure and to determine immunization status.
- Continue development of technologies for enhanced body protection against battlefield munitions.
- Continue development of an improved aircrew protection suit for operational aircraft.
- Continue Rapid Detection and Response for Chem/bio Defense Systems program.

- **Undersea Medicine**

Continue:
- Continue studies to develop methods for the non-invasive detection of bubbles in tissue and blood for improved diagnostics of decompression sickness. Current diagnosis of decompression sickness must rely on the presentation of outward symptoms that may not be manifest for several hours after the dive. The development of technology to detect nitrogen bubbles immediately after a dive will go a long way in identifying likely causes of decompression sickness and thus permitting treatment before major injury occurs.
- Continue development of a treatment for decompression sickness using perfluorocarbon-based compounds. Artificial blood substitutes which utilize perfluorocarbon molecules to transport oxygen can also increase

nitrogen transport in the body and thus may provide a new treatment for preventing decompression sickness after diving.
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- Continue the development of novel agents that prevent the neurological damage associated with decompression sickness in Navy divers.

Complete:
- Complete the development of predictive measures for oxygen-induced seizures in the hope that a physiologically-based "early warning system" can be engineered to warn divers using hyperbaric oxygen of the impending likelihood of central nervous system seizures.

- **Healthy and Fit Force**

Continue:
- Continue building on research into the underlying processes for cellular repair, applied research into the regeneration of auditory and vestibular hair cells in the inner ear.
- Continue exploring accident trends aboard reduced-crewed and high performance vessels such as fast boats, smart ships and next generation aircraft carriers to determine new approaches to reduce injury through improved design of workstations, seats, and controls.
- Continue to evaluate ways to protect hearing and balance through new protective systems.

FY 2005 PLANS

- **Casualty Care and Management**

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- Continue to evaluate ways to protect hearing and balance through new protective systems.

	FY 02	FY 03	FY 04	FY 05
Environmental Quality	2,629	2,534	3,162	3,686

Environmental Quality (EQ) technologies enable sustained world-wide Navy operations, in compliance with all local, state, regional, national and international laws, regulations and agreements. This topic addresses the Navy Transformational Roadmap in the area of Sea Basing, Sea Strike and Sea Warrior. Compliant operations enable training evolutions and exercises that are critical for maintaining readiness. Technology development in this area supports the Chief of Naval Operations (CNO) prioritized Navy Science and Technology (S&T) requirements and leads to systems and processes that provide the Fleet with environmentally compliant forward presence, ashore and afloat. Specifically, this area supports requirements to minimize the curtailment of military operations due to ship, shore and aircraft compulsory compliance with national and international environmental regulations, and to sustain Naval forces anywhere in a timely and environmentally compliant manner.

FY 2002 ACCOMPLISHMENTS

Initiated:

- Initiated air and noise pollutant emissions control and treatment technologies for Navy platforms and assets. Air and noise emissions from existing aircraft do not meet local noise ordnances and air emission requirements and thus limit essential training at shore-based facilities. New technology will reduce or eliminate emissions to meet regulatory levels and ensure continued training and readiness.
- Initiated development of advanced environmentally compliant antifouling (AF) hull coatings for ships and submarines and compliant anticorrosion (AC) coatings for ship and submarine structures. Hydrodynamic performance testing of existing and emerging coatings for durability was initiated. New materials will be non-toxic while preventing hull fouling and vessel structure corrosion.
- Initiated advanced ship and submarine liquid, air, solid emissions control technologies. These will provide compliance with Uniform National Discharge Standards (UNDS) and Marine Pollution Convention/International Maritime Organization (MARPOL/IMO). Pending discharge regulations will limit the ability of Navy ships to sail in any body of water. New control technologies will enable the Fleet with unrestricted access to all water bodies in compliance with all regulations.
- Initiated automated underwater hull paint removal and application technology to eliminate hazardous waste discharges and enable continued in-water hull maintenance and repair operations in compliance with water quality regulations and avoid costly dry-docking.
- Initiated Navy ship ballast water exchange efficacy evaluation for non-indigenous species threat mitigation in order to validate the Navy's current double ballast exchange policy.

Continued:

- Continued and expanded the capabilities of environmentally compliant marine coatings test facilities that support the field-testing of new, improved, non-toxic antifouling coatings and systems for ships and submarine hulls.
- Continued shipboard non-oily wastewater bioreactor treatment system process controller development.

Completed:

- Completed copper sensor technology for Navy IWTP and appliqué technology for ship hulls and structures. This technology will enable the continued use of in-water cleaning of ship hulls while monitoring copper discharges to comply with regulations and will allow Navy Industrial Wastewater Treatment Plants (IWTPs) to cost effectively monitor copper in their regulated discharges; transition to NAVFAC and NAVSEA respectively (PE 0603721N).
- Completed metal hydride battery technology for lighter, more reliable and environmentally acceptable batteries for aircraft and systems; transition to NAVAIR, PMA 251.
- Completed automated dry dock ship paint application, overspray control, collection and treatment technologies to enable adherence to environmental laws and regulations in dry-dock operations, increased productivity and

reduced cost of compliance; transition to NAVSEA 04 (PE 0603721N), Manufacturing Technology (MANTECH) and NAVFAC (CHE).
- Completed identification of Navy air operations pollution control technology initiatives in order to enable continued critical depot maintenance activities while complying with environmental regulations; transition to SYSCOM/CNO Environmental Quality RDT&E Working Group (EQRWG) for prioritization.

FY 2003 PLANS:

Initiate:
- Initiate testing of several promising membranes that have been developed in the basic research EQ program. Membranes will be scaled up and optimized using cross flow testing. These membranes are expected to provide higher fluxes and reduced fouling for treatment of both gray water and oily water streams as well as for use as pretreatment microfiltration membranes for reverse osmosis (RO) desalination and water treatment systems.
- Initiate advanced ship wastewater bioreactor technology to optimize non-oily wastewater bioreactor efficiency and thus reduce size and weight, provide the capability for treating other liquid waste streams (oily) and to develop quick bioreactor start-up products (reduce start-up time by 50%).
- Initiate development of improved, "hardened" configuration of copper biosensor for use in underwater hull cleaning and dry-dock operations

Continue:
- Continue environmentally compliant marine coating test facilities support.
- Continue air and noise pollutant emissions control/treatment technologies for Navy platforms and assets.
- Continue advanced development of environmentally compliant antifouling (AF) hull coatings for ships and submarines and compliant anticorrosion (AC) coatings for ship and submarine structures.
- Continue advanced development of ship and submarine liquid, air, solid, emissions control technology.
- Continue automated underwater hull paint removal and application technology development.
- Continue Navy ship ballast water exchange efficacy evaluation for non-indigenous species threat mitigation.

Complete:
- Complete shipboard non-oily wastewater bioreactor treatment system process controller development; transfer to NAVSEA (PE 0603721N).

FY 2004 PLANS:

Initiate:

- Initiate advanced far-term noise and air pollution emissions abatement technology for future Navy platforms to enable unrestricted operations and training while complying with environmental laws and regulations and to reduce costly back-fit scenarios.
- Initiate testing of aqueous film forming foams (AFFF) developed and transitioned from related basic research activities to replace the existing formulations containing PFOS (perfluoro octanyl sulfonates) which have been shown to bioaccumulate and cause adverse environmental and human health effects.

Continue:

- Continue environmentally compliant marine coating test facilities support.
- Continue air and noise pollutant emissions control/treatment technologies for Navy platforms and assets.
- Continue advanced development of environmentally compliant antifouling (AF) hull coatings for ships and submarines and compliant anticorrosion (AC) coatings for ship and submarine structures.
- Continue advanced development of ship and submarine liquid, air, solid, emissions control technology.
- Continue automated underwater hull paint removal and application technology development.

Complete:

- Complete Navy ship ballast water exchange efficacy evaluation for non-indigenous species threat mitigation; transfer results to NAVSEA UNDS program.
- Complete testing and initial evaluation of novel membranes; determine remaining S&T issues and transition to NAVSEA.
- Complete advanced ship wastewater bioreactor technology to optimize non-oily wastewater bioreactor efficiency; Transition technology to NAVSEA 05MR, PE 0603721N.
- Complete development of improved, “hardened” configuration of copper biosensor for use in underwater hull cleaning and drydock operations; transition to NAVFAC (CHE) and to NAVSEA, 05M3, PE 0603721N.

FY 2005 PLANS:

Initiate:

- Initiate advanced environmental protection sensor and system control technology for future Navy platforms to enable more efficient system operation and to decrease manpower requirements for monitoring, diagnostics and repair evolutions.
- Initiate development and evaluation of microwave technologies for an RF plasma torch for use in advanced shipboard waste destruction processes. This will eliminate the use of consumed electrodes currently used in these systems reducing manpower/maintenance requirements.

Continue:

- Continue environmentally compliant marine coating test facility support.
- Continue air and noise pollutant emissions control/treatment technologies for Navy platforms and assets.

- Continue advanced development of environmentally compliant antifouling (AF) hull coatings for ships and submarines and compliant anticorrosion (AC) coatings for ship and submarine structures.
- Continue advanced development of ship and submarine liquid, air, solid, emissions control technology.
- Continue automated underwater hull paint removal and application technology.
- Continue advanced far-term noise and air pollution emissions abatement technology for future Navy platforms.
- Continue testing of aqueous film forming foams (AFFF) developed and transitioned from related basic research activities to replace the existing formulations containing PFOS.

	FY 02	FY 03	FY 04	FY 05
Biocentric Technologies	2,049	1,974	1,265	1,474

Biocentric technologies provide novel solutions for naval needs based upon the applications of biosensors, biomaterials, and bioprocesses. This program brings the power of modern biotechnology methods to bear on naval problems and reduces the technical risk associated with basic research advances by conducting demo-centric technology development programs. Topic areas include advanced sensors for force protection against weapons of mass destruction, novel methods for radar and acoustic signature reduction, chemical sensing in the marine environment for unexploded ordnance detection, green synthesis of energetic materials, and novel energy sources for chemical and biological sensors deployed in the littorals.

FY 2002 ACCOMPLISHMENTS

Initiated:
- Scaled-up and determined yield optimization of green synthesis of energetic materials using enzymes toward an environmentally acceptable production method for energetic materials without the use of hazardous reagents and generation of hazardous by-products.
- Evaluated whether sensors for trinitrotoluene (TNT) and other explosives can be used as autonomous underwater vehicle payloads for detection of unexploded ordnance (UXO).
- Initiated feasibility of energy harvesting benthic fuel cells using bioelectrochemical mechanisms at the water-sediment interface. The goal is to use naturally occurring microbes to harvest low levels of power (~0.1 Watt) on a continuous basis.
- Evaluated applicability of chemical sensing from autonomous underwater vehicles for Special Forces applications.

Continued:
- Continued, within the Chemical Sensing in the Marine Environment Program, efforts for locating the source of chemical plumes in very shallow waters using sensors on autonomous underwater vehicles. This will provide the

Navy with a new capability for the difficult task of remotely identifying unexploded ordnance (UXO) in the littoral zone.

- Continued, within the Chemical Sensing in the Marine Environment Program, efforts to characterize chemical plume structure in the very shallow water regime. Previous research indicates that the plume structure is quite variable and heavily dependent on environmental conditions and interactions. Mapping of plume structure under various environmental scenarios is necessary to guide the development of sensor systems for underwater UXO detection.
- Continued development of novel biosensors for explosives for underwater applications. These novel biosensor systems will provide sensitive, selective, and rapid detection of explosive signatures (such as TNT), a capability that the Navy currently lacks.

Completed:

- Completed and transitioned the metallized lipid tubule materials for radar absorbing and antenna isolation applications. These materials show potential as replacement for the existing systems now used for this purpose, displaying competitive absorption properties but weighing approximately 60% less, a very important advantage on the small decoy vehicles on which they are deployed.
- Completed investigation of bio-molecular barcodes for unique identification and tracing of materials. These barcodes or taggants act as microscopic markers that can be used to trace and identify material of naval interests, e.g., military equipment and personnel, and which have high applicability for counter-terrorism programs.
- Completed, within the Chemical Sensing in the Marine Environment Program, efforts to characterize the source strengths of underwater unexploded ordnance. Distance from source and associated concentration profile data will drive the operational requirements necessary to guide the development of sensor systems for underwater UXO detection.

FY 2003 PLANS:

Initiate:

- Initiate development of stochastic chemical sensors for naval applications to provide single molecule detection.

Continue:

- Continue the development of novel biosensors for detection of explosives underwater
- Continue green synthesis of energetic materials using enzymatic catalyst
- Continue the development and integration of sensors for explosive compounds on Autonomous Underwater Vehicles for underwater applications
- Proceed with energy harvesting benthic fuel cells based on microorganisms

Complete:

- Complete work on locating chemical plume source in very shallow waters using sensors on Autonomous Underwater Vehicles
- Complete the characterization of chemical plume structure in very shallow waters

FY 2004 PLANS:

Initiate:
- Initiate the development of reagentless sensors for Weapons of Mass Destruction.

Continue:
- Continue the development of stochastic chemical sensors for naval applications to provide single molecule detection.

FY 2005 PLANS:

Initiate:
- Initiate the development of novel biomimetic propulsion systems for autonomous underwater vehicles.

Continue:
- Continue the design and development of reagentless sensors for Weapons of Mass Destruction.

Complete:
- Complete the development of stochastic chemical sensors for naval applications to provide single molecule detection.

CONGRESSIONAL PLUS-UPS:

	FY 02	FY 03
3-Dimensional Printing Metalworking Project	*	3,765

The system would incorporate a Three Dimensional Printing (3DP) machine and supporting process equipment. Three Dimensional Printing is a rapid solid freeform process for metal and metal composite parts and tooling. This new technology has been under development at MIT and is an additive manufacturing technology that allows the creation of a component from a computer aided design (CAD) model circumventing the limitations imposed by conventional material removal techniques. The project includes working to define, develop and demonstrate the system and 3DP process on specific DOD and DLA applications. This project will advance the potential use of the 3DP process and its unique capabilities for the manufacture of components in an e-manufacturing environment. (*Appropriated in FY02 in PE 0602123N, $2,401)

Advanced Fouling and Corrosion Control Coatings	FY 02	FY 03
	*	4,793

This project uses combinatorial synthesis to explore advanced development of polymers for use as coatings to prevent corrosion and biofouling of metals such as ship hulls. (*Appropriated FY02 in PE 0602234N, $3,366)

	FY 02	FY 03
Advanced Fuel Additive Pilot	1,644	*

Efforts focus on conducting a pilot demonstration on a Navy diesel platform of alcohol fuel additives blended into diesel fuels. (*Appropriated FY03 in PE 0602234N, $1,662)

	FY 02	FY 03
Advanced Materials and Intelligent Processing	1,452	1,467

Materials applied research is conducted to develop the resin molding process utilizing both sensor and model based approaches. These new materials will provide the Navy the capability to produce battle damage resistant aircraft with improved stealth characteristics.

	FY 02	FY 03
Advanced Safety Tether Operation	965	0

This effort develops tether technology to provide reliable and controlled boost and de-boost of spacecraft. The FY02 tasks are: 1. Establish system requirements for operational and demonstration systems, 2. Conduct tether dynamics simulations, 3. Develop concepts for attaching objects to a tether in deployment, 4. Design and test prototype tether systems.

	FY 02	FY 03
Agile Vaccinology	8,264	3,913

Investigations are conducted on modern vaccine technologies, including DNA-based vaccines. An example is the malaria DNA vaccine where efforts focus on the optimal vaccination strategy in mice and on determining whether the best co-vaccination strategy is a protein antigen delivered by a viral vector or by a replicon system.

	FY 02	FY 03
Automated Diode Array Manufacturing	2,498	2,444

Efforts include applied research to enhance the materials in diode arrays at various steps in the manufacturing process, reduce the heat load, improve the reliability and reduce the cost of large diode arrays used in shipbuilding and other Navy systems

	FY 02	FY 03
Battlespace Information Display Technology (BIDT)	3,266	*

This project established a state-of-the-art battlespace visualization environment to advance Joint Vision 2020 objectives and the United States Navy's "Forward from the Sea" strategy. BIDT integrates commercial technologies with emerging Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) capabilities, specifically for Navy and Marine Corps battlefield commanders and their staffs. In the absence of proven data correlation and information fusion algorithms, BIDT visually represents the positions and tracks of ships, aircraft, and ground-based units, along with threat envelopes - in a whole earth, scalable, multi-resolution virtual display linked to intelligence and operational databases. Therefore, BIDT presents the commander with the battlespace that closely approximates what one sees in their "mind's eye." This realization of the mind's-eye view is expected to result in intuitive actions that transform the 2-D battlespace into a 4-D battlespace so that the warfighter can view events in near-real time and fold in operational aspects associated with time - the 4^{th} dimension. Successful integration and evaluation in this effort will facilitate the production and approval of formal acquisition documentation for the Navy. (*Appropriated in FY03 in PE 0602234N, $2,055)

	FY 02	FY 03
Bio-Detection Surveillance System	0	*

This effort is to develop technologies for rapid detection, identification, and surveillance of a wide range of pathogenic organisms and toxins. The project will support the development of the immunological DNA amplification based detection system with covalent conjugation of the DNA that will allow rapid detection time

appropriate for response to biological weapons and for antiterrorism applications. (*Appropriated FY03 in PE 0602233N, $1,027)

	FY 02	FY 03
Biodegradable Polymers for Naval Applications	0	977

Three approaches are being studied in this program. First, natural polymers based on filled soybean protein/vegetable oil derivatives have been developed for possible use in a chaff cartridge with biodegradation measurements at Natick. In a second project, polylactic acid/cellulose acetate blends are being made with optimal tradeoffs between softening point and biodegradability. Finally, novel exfoliated clay reinforcements are being developed which should provide physical and thermal reinforcement and a mechanism to encourage biodegradation in high salt environments.

	FY 02	FY 03
Bioenvironmental Hazards Research Program	961	1,173

This applied research assesses the adverse impacts of Navy operations and training activities on the environment as well as the adverse health effects of contaminated environments on naval personnel.

	FY 02	FY 03
Carbon Foam for Navy Applications	*	439

This effort develops carbon foam materials for Navy use. These advanced materials will have significantly improved mechanical, thermal, and fire resistant properties that will permit their use in man-rated areas aboard ships and submarines. (*Appropriated FY02 in PE 0602234N, $2,509)

	FY 02	FY 03
Ceramic and Carbon Based Materials	0	977

This effort is developing ceramic and carbon based materials to reduce cost of propulsion systems and heat shields. The effort is focused on developing alternate improved refractory ceramic and/or carbon composite fabrication processes which are more robust and less expensive than those currently in use.

	FY 02	FY 03
Characterization of Novel Materials	0	2,738

This effort will support the development and optimization of materials for the electromechanical gun system. Specifically, efforts focus on the characterization of mechanical and thermal properties under shock loading for candidate electromechanical (EM) gun barrel, projectile and target materials. This includes the characterization of the parameters necessary to optimize next generation reactive materials for gun projectiles and electrode materials for enhanced performance, next generation solid-oxide fuel cells. Predictive computer

models will be developed that incorporate these material properties to optimize weapon systems for performance and lethality. These capabilities can additionally be used to evaluate the performance and survivability of on-board microelectronic systems for use in projectile guidance systems or for assessing the mechanical and thermal states of projectiles during the launch-to-target sequence. This capability will guide the development of materials optimized for use in EM gun launchers and hypervelocity projectiles that can be validated with these predictive capabilities. The combined research program in the dynamic response of materials and electromagnetic launching will result in the capability to develop superior bore materials for EM launchers and the evaluation of ballistic projectiles and on-board projectile electronic systems under the extreme acceleration conditions characteristic of these weapons.

	FY 02	FY 03
Combinatorial Materials Synthesis	2,019	0

This work explores combinatorial methods to provide a basis for the development of advanced materials.

	FY 02	FY 03
Fibrous Monolithic Materials Insertion	0	2,200

This effort is developing fibrous monolithic composite materials for application in turbine engines and missiles. The new high temperature materials will replace current metal and composite materials. The applications for these materials are rocket components such as fuel shields and turbine engine components.

	FY 02	FY 03
Formable Aligned Carbon Thermo Sets (FACTS)	1,442	977

This effort advances formable aligned carbon thermosets (FACTS) (fiber stretch breaking) by refining material fabrication processes, developing part-forming processes, and fabricating complex parts. Complex parts are currently formed from materials other than composites resulting in parts that are heavy (weight penalties), expensive, and subject to corrosion. Currently, composite materials (continuous fibers) cannot produce low cost, complex parts, and other attempts to address this problem (resin transfer molding and vacuum assisted resin transfer molding) have produced expensive and sometimes poor quality parts.

	FY 02	FY 03
Human Systems Technology	0	977

Extend the scientific basis of human centered display and interfaces with the goal of enabling non-pilot operators to successfully operate unmanned combat air vehicles (UCAVs); perform psychophysical studies of combining tactile interfaces (based on previous networking research) designed for sensory substitution (e.g. sight) and for sensory augmentation in complex dynamic environments such as aviation; and continue to develop

two classes of advanced Boolean algorithms that support solutions to practical problems (e.g. scheduling, cryptography, network design).

	FY 02	FY 03
Improved Performance Integration Tool (IMPRINT) Modeling	0	1,027

Enhances an Army-developed system called IMPRINT to be used in support of human factors engineering in Navy applications. In its current form, IMPRINT is focused on systems and platforms of Army scale (e.g., tanks, helos), not on a Navy Scale (e.g., ships). A major part of the FY03 effort is to scale up the IMPRINT modeling technique for application in the human factors and manning requirements for the larger Navy platforms.

	FY 02	FY 03
Marine Mammal Research	1,066	977

This work includes applied research related to marine mammals.

	FY02	FY03
Modeling, Simulation and Training Immersion Facility	961	0

Develop the prototyping of faster, less expensive, and more robust virtual and augmented reality systems for the military at this facility. Develop innovative software and hardware components for virtual and augmented reality simulations. Test and evaluate the effectiveness of these new virtual and augmented reality approaches using specific applications. Potential applications include computer graphics and associated display technologies to be used in various military systems; emerging haptic technologies to be used in military tactical training systems or medical trainers; and new systems for locomotion in virtual environments (including computing platforms and networks that facilitate locomotion).

	FY 02	FY 03
National UUV Test and Evaluation Center	0	4,596

This effort supports the development of an integrated Unmanned Underwater Vehicle (UUV) Testbed Environment to meet the broad needs of current and future UUV programs. The test center will serve technology development, multi-mission UUV test and evaluation, fleet training and UUV system support.

	FY 02	FY 03
Printed Wiring Boards	1,633	*

This work will focus on CAD/CAM (computer aided design and manufacturing) of advanced printed wiring boards (PWB). The technologies are (a) laser ablation and metallization, (b) high velocity particle consolidation of metal powders (HVPC), and (c) acoustic microscopy for PWB that will revolutionize PWB manufacturing and reverse engineering for Naval Systems. Special consideration will be given for compatibility with organic semiconductor electronics. (*Appropriated in FY03 in PE 0602234N, $3,325)

Rapid Detection and Response for Chem/Bio Defense Systems	FY 02	FY 03
	0	977

This effort will focus on the development of technologies for rapid detection of, and response to, airborne biological and chemical agents in battlefield and key urban environments. This work will support the development of antibody-based and DNA-based detection systems in a ChemArray Chip (impedance imaging sensing system) as a flow-through reusable sensor. In addition, this work will develop necessary data and models to be used to predict the proper placement of real-time sensors in indoor environments for antiterrorism applications.

	FY 02	FY 03
Rhode Island Disaster Initiative	1,442	1,173

This effort includes technologies and techniques to determine effective solutions for medical disaster response. In particular, this effort focuses on handling mass casualties that would occur from natural disasters, terrorist acts such as the USS Cole, and both military and civilian casualties produced by weapons of mass destruction.

	FY 02	FY 03
Titanium Matrix Composites Program	2,498	2,162

Titanium metal matrix composites are developed to enhance future engine designs (rotating engine parts such as disks and spacers) by permitting greater thrust output to weight ratios than are achievable today with currently available materials. The use of titanium metal matrix composites will also allow high payoff applications in future engine compressor systems where extreme stiffness and strength requirements at elevated temperatures now require the use of significantly heavier superalloys and titanium. The application of titanium metal matrix composites will aid in achieving vertical/short take off and landing (V/STOL) aircraft designs without weight penalties.

	FY 02	FY 03

Virtual Company Distributed Manufacturing	1,057	*

This effort will continue and expand ongoing applied research of the West Virginia High-Technology Consortium Foundation, sponsored by plus-ups in FY 1997 and 2001. The purpose of the work is to establish a network of commercial businesses in the greater West Virginia economic region which are linked by updated, interoperable computer networks and databases, and supported through partnerships with government agencies and private suppliers and buyers of technology. This network will facilitate the flow of new technology among naval, other government, and commercial applications, and thereby foster robust businesses in the region. The Department of the Navy's goal is to reduce the total ownership cost of naval systems by increasing the availability of affordable new technologies through increased commercial activity and use of technologies developed primarily for the commercial marketplace. Work in FY2002 focused on applications of business portals, webcrawling and websearch engines, database access tools, intercompany partnerships, and development of a self-sustaining organization. The program complemented similar efforts in other regions, including for instance the "Hubs" initiative in Delaware, Maryland, New Jersey and Pennsylvania. (*Appropriated in FY03 in PE 0602234N, $1,761)

	FY 02	FY 03
Visualization of Technical Information	1,639	1,662

This effort includes applied research related to enhancing the visualization of technical information. Technology emphasis is on intelligent agent technologies, applied to the understanding and presentation of the readiness status of a shipboard integrated logistics information system. Weapons platforms, shipboard engine health, and other critical sustainment to the battlegroup readiness posture are assessed and disseminated via the intelligent agent community.

	FY 02	FY 03
Wire Chaffing Detection Technology	1,348	*

This effort develops advanced technologies (sensors, electronics, and algorithms) for aircraft wiring diagnostics. The project will provide the Navy a means of rapid detection of faults in wiring and enable rapid, efficient maintenance. (Appropriated in FY03 PE 0603236N, $1,368)

	FY 02	FY 03
Wood Composite Technology	2,029	0

This effort develops advanced-engineered lumber for application in Navy piers and wharves and other shore infrastructure including office space and military housing. These low cost composites will exhibit extreme resistance to environmental degradation thus greatly reducing maintenance costs.

	FY 02	FY 03

ADPICAS	*	0

The ADPICAS (Adaptive Damping and Positioning Using Intelligent Composite Active Structures) effort modifies and refines the designs of active structural components such as composite struts and composite panels. It also explores and tests the integration of these components into systems. (*Appropriated FY02 in PE 0602234N, $1,251)

	FY 02	FY 03
Maritime Fire Training/Barbers Point	*	0

Environmental studies are conducted in preparation for efforts at Barber's Point, HI, to build a firefighting training facility. This research tool will merge the real and virtual worlds to create an environment that can provide cost-effective realism without the dangers created by real fires. In addition, this trainer will enable firefighters to maintain their proficiency while being responsive to increasing environmental constraints related to smoke and water additives released into the atmosphere. (*Appropriated FY02 in PE 0602233N, $2,498)

	FY 02	FY 03
Materials Micronization Technology	*	0

This effort is developing advance grinding processes that can produce ultra fine particles at high production rates and with very little contamination from the grinding media. Such particles will be used as feed materials to manufacture high quality electronic components at a low cost. Other applications will include manufacture of light weight, low cost, structural composites with multifunctional characteristics for future jet fighters. (*Appropriated FY02 in PE 0602234N, $3,379)

C. OTHER PROGRAM FUNDING SUMMARY:

NAVY RELATED RDT&E:

PE 0601152N In-House Laboratory Independent Research
PE 0601153N Defense Research Sciences
PE 0602123N Force Protection Applied Research
PE 0602747N Undersea Warfare Applied Research
PE 0603236N Warfighter Sustainment Advanced Technology
PE 0603512N Carriers Systems Development
PE 0603640M Marine Corps Advanced Technology Demonstration
PE 0603721N Environmental Protection
PE 0603724N Navy Energy Program (Adv)
PE 0604561N SSN-21 Developments

PE 0604703N Personnel, Training, Simulation, and Human Factors
PE 0604771N Medical Development
PE 0604962N Naval Simulation System
PE 0605152N Studies and Analysis Support - Navy
PE 0708011N Industrial Preparedness

NON-NAVY RELATED RDT&E:

PE 0408042N National Defense Sealift Fund
PE 0601102A Defense Research Sciences
PE 0602105A Materials Technology
PE 0602211A Aviation Technology
PE 0602303A Missile Technology
PE 0602601A Combat Vehicle and Automotive Technology
PE 0602705A Electronics and Electronic Devices
PE 0602709A Night Vision Technology
PE 0602716A Human Factors Engineering Technology
PE 0602785A Manpower, Personnel, and Training Technology
PE 0602786A Warfighter Technology
PE 0602787A Medical Technology
PE 0603002A Medical Advanced Technology
PE 0603003A Aviation Advanced Technology
PE 0601102F Defense Research Sciences
PE 0602102F Materials
PE 0602202F Human Effectiveness Applied Research
PE 0602203F Aerospace Propulsion
PE 0602204F Aerospace Sensors
PE 0602702F Command, Control and Communications
PE 0603216F Aerospace Propulsion and Power Technology
PE 0601103D8Z University Research Initiatives
PE 0603716D8Z Strategic Environmental Research Program
PE 0602712E Materials and Electronics Technology
PE 0603851D8Z Environmental Security Technical Certification Program

D. ACQUISITION STRATEGY: Not Applicable