BUDGET ACTIVITY: 02
PROGRAM ELEMENT: 0602235N
PROGRAM ELEMENT TITLE: COMMON PICTURE APPLIED RESEARCH

COST: (Dollars in Thousands)

| Project Number & Title | FY 2004 Actual | FY 2005 Estimate | FY 2006 Estimate | FY 2007 Estimate | FY 2008 Estimate | FY 2009 Estimate | FY 2010 Estimate | FY 2011 Estimate |
|---|---|---|---|---|---|---|---|---|
| COMMON PICTURE APPLIED RESEARCH | 87,928 | 102,107 | 57,693 | 63,141 | 52,154 | 57,442 | 54,536 | 58,050 |

**A. MISSION DESCRIPTION AND BUDGET ITEM JUSTIFICATION:** Work in this Program Element (PE) addresses technologies that enable the transformation to network centric warfare, which relies on information to connect assets and provide timely and accurate understanding of the environment. Technologies of interest provide access to, and automated processing of, information necessary to make decisions that lead to decisive, precise, desired engagement outcomes. The focus is on a high performance network that achieves a common situational awareness that connects geographically distributed forces into a unified Naval Force. Technologies emphasized provide warfighters with a robust, secure, mission responsive network; integrated information leading automated courses of action; and presentation of knowledge to speed understanding. The payoff is access to tailored information in near real time with corresponding increases in speed of command, improved decision-making, and reduction in manpower. The program explores and demonstrates technologies that enable options for Knowledge Superiority and Assurance (KSA), Missile Defense (MD), and Fleet/Force Protection (FFP) Future Naval Capabilities (FNCs). In the context of the Naval Transformation Roadmap construct, this investment will achieve capabilities required by FORCEnet, “Persistent Intelligence, Surveillance, and Reconnaissance,” “Time Sensitive Strike,” “Sea Based Information Operations,” “Sea Strike” Ship-to-Objective Maneuver, and “Sea Shield” Theater Air and Missile Defense. This PE supports the FNC program in KSA, MD, and FFP.

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

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**PROGRAM CHANGE SUMMARY:**

| | FY 2004 | FY 2005 | FY 2006 | FY 2007 |
|---|---|---|---|---|
| FY 2005 President's Budget Submission | 95,432 | 60,134 | 72,612 | 75,504 |
| Cong Rescissions/Adjustments/Undist. Reductions | 0 | -1,006 | 0 | 0 |
| Congressional Action | 0 | 43,000 | 0 | 0 |
| Execution Adjustments | -5,280 | 0 | 0 | 0 |
| FNC Realignment | 0 | 0 | -18,425 | -16,105 |
| Non-Pay Inflation Adjustments | -89 | 0 | 0 | 0 |
| Program Adjustments | 0 | -21 | -54 | -52 |
| Program Realignment | 0 | 0 | 3,451 | 3,299 |
| Rate Adjustments | 0 | 0 | 109 | 495 |
| SBIR Assessment | -2,135 | 0 | 0 | 0 |
| FY 2006/2007 President's Budget Submission | 87,928 | 102,107 | 57,693 | 63,141 |

**PROGRAM CHANGE SUMMARY EXPLANATION:**
Technical: Not applicable.

Schedule: Not applicable.

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**B. ACCOMPLISHMENTS/PLANNED PROGRAM:**

| | FY 2004 | FY 2005 | FY 2006 | FY 2007 |
|---|---|---|---|---|
| **KNOWLEDGE SUPERIORITY AND ASSURANCE** | 18,897 | 17,871 | 4,579 | 4,930 |

Knowledge Superiority and Assurance (KSA) explores fundamental technologies that enhance the Navy’s capability to exploit, manage and integrate complex, heterogeneous, multi-source information for the next generation common picture. Science and Technology (S&T) work is being focused on Navy and Marine Corps Warfighter Capability Gaps identified through analysis of operational and exercise lessons learned, as well as campaign

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analysis of capabilities required in the 2010-2015 time frame. Warfighter Capability Gaps being addressed by FORCEnet S&T include Combat Identification (CID), Ubiquitous Communications (Comm), Computer and Network Defense and Information Assurance (CND&IA). Office of Naval Research (ONR) has established groupings of S&T projects to incrementally provide technology input to eliminate Warfighter Gaps. These groupings are called Enabling Capabilities (EC). Each EC delivers capability-level products to acquisition in a three to five-year effort, and allocates a sufficient investment to ensure a capability is provided. For example, CID EC-1A provides cryptologic management and level one fusion capability in a Global Information Grid-compliant implementation, and transitions to the warfighter in FY05. Ubiquitous Comm provides Dynamically Managed, Interoperable, High-Capacity Connectivity wireless network technology critical to the performance and robustness of naval communications by providing higher data rates, expanded coverage to disadvantaged platforms, and improved bandwidth management. To eliminate redundancy and more accurately describe underlying S&T investments, this activity now includes investments formerly reported under Platform Protection/Electronic Warfare (EW) Systems.

This activity supports the Fleet/Force Protection (FFP) Future Naval Capability (FNC). Currently, small surface, ground and airborne platforms have little to no situation awareness (SA) or self-protection, which jeopardizes their effectiveness and survivability. The Electronic Warfare Integrated System for Small Platforms (EWISSP) program focuses on closing that gap by developing technologies to provide them with a full spectrum threat warning and countermeasures capability. This capability, when integrated with emitter identification and Low Probability of Intercept (LPI) radar detection systems, provides netted targeting information and cueing that enables self-protection. The Battlefield Ordnance Network Centric Employment (BONCE) effort will design and fabricate a compact, low cost, light weight active/passive electro-optic (EO)/infrared (IR) system for ordnance detection. The Tactical Reactive Command and Control (C2W)/Electronic Attack (EA) Network effort will develop and demonstrate a self-adapting, spatially distributed EA network for C2W.
There are several FNC efforts that completed in FY05 and three efforts transitioning to other PEs in FY06.

**FY 2004 Accomplishments:**

• Conducted successful Sea Trial Limited Technology Experiment using Extensible Tactical Communications, Command, Control, Computers, and Intelligence (C4I) Framework (XTCF) with Analytic Support Architecture (ASA), Environmental Visualization (EVIS) and Sea Combat Commander Module (SCCM) for Embarked Staff acting as plug-ins to test applications integrated into a net centric enterprise services system.
• Conducted successful testing of Dynamic Reconfiguration of Link 16 Network Controller and Time Slot

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allocation protocol on USS STENNIS and with F-14/E-2C aircraft. Transition completed to Acquisition Program Manager for Link 16 (PMW-159).
• Completed Transitions of Knowledge Web Technologies (KWT) to PMW-157, Universal Data Exchange Manager (UDEM) to Common Undersea Picture Program Executive Office Integrated Warfare Systems (PEOIWS), Middleware to Submarine Advanced Processor Build-Tactical-03 (PMS-425).
• Completed transition of Human Alerting and Interruption Logistics Surface Ship (HAIL-SS) to AEGIS Open Architecture Baseline (PMS-400).
• Completed transition of Sea Combat Commander Module for Embarked Staff to PMS-411 AN/SQQ-89 Surface Ship Undersea Warfare Combat System and the AN/SSQ-121 Computer –aided Dead Reckoning Tracer (CADRT)
• Completed transition to Knowing What We Know (KWWK) to the Information Warfare Mission Planning and Command and Control (C2) Targeting System (IMPACTS) IW Mission Planner as part of the Cryptologic Unified Build (CUB).
• Completed laboratory performance explorations of a lightweight EO/IR subsystem in preparation for Unmanned Aerial Vehicle (UAV) employment for BONCE.
• Completed development of subsystem software interface algorithms for the 90-degree Shipboard Laser Acquisition System (SBLAS) system and continue exploration and refinement of the subsystem interface software for the EWISSP effort.
• Continued refinement of Cryptologic Management and Analysis Support System (CMASS) with testing in an operational environment.
• Continued refinement of Environmental Visualization (EVIS) to develop forecasting algorithms to provide information less than an hour old for strike operations as well as Meteorology and Oceanography (METOC) forecasting tool for surface, subsurface and Special Operations Forces (SOF).
• Initiated the Automated Digital Networking System (ADNS)/Teleport/Global Information Grid Bandwidth Expansion (GIG-BE) to integrate ADNS III into Department of Defense (DoD) teleports.
• Initiated Dynamic Bandwidth Resource Manager to automate link and network monitoring in ship’s radio room.
• Initiated eXtensible Common Operational Picture (XCOP) to conduct Net Centric Enterprise Services (NCES) work to establish and demonstrate a Common Operational Picture (XCOP) with data management framework that enables more rapid and timely technical and developmental exploitation of emerging, complex, and heterogeneous data sources for the Common Picture in a Service Oriented Architecture.
• Initiated Rapid Maritime Identification and Tracking System (RMITS) to provide bio-metric identification tools for special operations forces and Naval Boarding parties.

**FY 2005 Plans:**

• Complete development of CMASS software to provide a single repository for intercept data, automatic operator

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alerting, and voice analysis; conduct operational test and transition to Cryptologic Unified Build (CUB) PMW-189. Follow-on effort called Processing Tactical Signal Intelligence (SIGINT) will begin in FY06 under PE 0603235N.
• Complete exploration and refinement of the subsystem interface software for the EWISSP effort.
• Continue Environmental Visualization forecasting algorithms to provide information less than an hour old for strike operations as well as Meteorology and Oceanography (METOC) forecasting tool for surface, subsurface and Special Operations Forces (SOF).
• Continue with Net Centric Enterprise Services (NCES) work to establish and demonstrate an Extensible Common Operational Picture (XCOP) with data management framework that enables more rapid and timely technical and developmental exploitation of emerging, complex, and heterogeneous data sources for the Common Picture. Transition to Global Command and Control System - Maritime (GCCS-M) (PMW-157).
• Continue to refine the ASA to improve location accuracy for air defense threats and transition to GCCS-M (PMW-157).
• Continue to refine ADNS/Teleport/GIG-BE to ensure High Assurance Internet Protocol Encryption (HAIPE) Interoperability and transition to ADNS (PMW-179).
• Continue to refine Dynamic Bandwidth Resource Manager and transition to ADNS (PMW-179).
• Continue Rapid Maritime Identification and Tracking System (RMITS) to provide bio-metric identification tools for special operations forces and Naval Boarding parties.
• Initiate effort called High Altitude Relay and Router Package to provide wide-band connectivity to tactical units in theater (moves to PE 0603271N in FY06).

**FY 2006 Plans:**

• Extend Environmental Visualization capabilities to large deck amphibious assault ships to support meteorological products for multiple users in support of strike operations. Complete transition to Naval Integrated Technical Environmental Subsystem (NITES) 2000 (PMW-150).
• Explore rapid course of action development using synthetic semi-automated forces for fast, large-scale, high-fidelity simulations, including models of human cognition and visualization techniques for assessing outcomes and uncertainties.
• Initiate test of the subsystem interface for the EWISSP effort.

**FY 2007 Plans:**

• Initiate level 2 data fusion effort focusing on Asymmetric Warfare to provide automated situation and threat

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assessment for decision support for counter-terrorist operations.
• Complete modification and testing of the subsystem interface software for the EWISSP effort.

| | FY 2004 | FY 2005 | FY 2006 | FY 2007 |
|---|---|---|---|---|
| **NETWORK COMMAND, CONTROL AND COMBAT SYSTEMS** | 13,223 | 17,032 | 10,553 | 11,607 |

This initiative explores development of advanced technologies that contribute to integrated decision-making and mission execution to achieve battlespace superiority. The activity emphasizes activity that leverages the power of networks to exploit information and information technology and maximizes the capability of platforms to use information to accomplish missions. This provides a force multiplier effect and supports Joint/coalition combat operations. Information integration is the primary focus. This focus examines the critical Science and Technology needs of automatic association and merger of information for unified presentation; automated recognition and cueing for significant patterns of information, computer-aided reasoning for task-oriented information dissemination; timely, accurate information and sensor fusion from heterogeneous sources; as well as supporting technologies to provide information assurance. The level of funding in FY06 decreases from FY05 because many projects will be completed and transitioning to the SYSCOMs and other sponsors.

**FY 2004 Accomplishments:**

• Demonstrated multi-modal image registration for multi-resolution and multi-scale image processing effort.
• Demonstrated prioritized real time data replication and dissemination algorithms to prioritize the delivery of real time information from unattended distributed sensors in support of operational missions.
• Demonstrated new techniques for providing improved computer network defense and improved situational awareness.
• Developed high accuracy mobile tracking and registration algorithms used in augmented reality systems for military operations in urban terrain (MOUT).
• Developed advanced algorithms, software tools and decision aids to handle and process large volumes of information.
• Compared alternative architectures for Theater Battlespace Command & Control.
• Designed a Quality of Service (QoS) real-time model that enables the expression of time critical concepts and level of QoS. This will be invaluable in FORCEnet and Network Centric Warfare deployments to predict where, when, and why scheduling and network bottlenecks will occur.
• Conducted laboratory demonstrations of distributed real-time networked data element replication and cross

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database comparisons Real Time Deconfliction effort.
• Completed development of technology for information presentation in Battlefield Augmented Reality Systems. (NRL)
• Continued development of technology to improve fidelity in Marine Infantry combat simulators via virtual locomotion and collision detection. (NRL)
• Initiated development of technology for improving face recognition technology via enhanced image registration software. (NRL)

**FY 2005 Plans:**

• Demonstrate in a FORCEnet limited objective experiment the application of new techniques of discrete optimization, statistical discrimination, and artificial intelligence for the resource allocation of weapons. Compare initial results with high fidelity physics based models for threat and anti-threat weapon systems for continued development of Anti-Air Warfare (AAW) optimization algorithms.
• Develop automated methods for identifying significant changes between temporally separated images (not video) to extend work on automatic target recognition (ATR) and pattern recognition into change detection algorithms.
• Develop and characterize new target detection and recognition algorithms to exploit higher dimensional data (spatial, temporal, and spectral) within the Network Centric Warfare (NCW) framework. Approach will utilize advanced correlation approaches to provide improved target detection and recognition performance by integrating multiple sensor measurements.
• Develop a suitable ontology for exercising large-scale distributed situational threat awareness in Naval battlespace environments.
• Develop a Case-Based Reasoning (CBR) simulation/model for implementing situation/threat awareness fusion solutions and a Bayesian Network (BN) inference engine for manipulating uncertainty and learning from data.
• Develop an initial prototype for an information sharing infrastructure that maintains data integrity and confidentiality for enclaves of networked workstations running commercial off the shelf (COTS) operating systems and applications.
• Demonstrate and conduct image registration error analysis for the multi-resolution and multi-scale image processing effort.
• Evaluate value of three dimensional techniques to enhance visualization technology.
• Conduct worst-case detection and conflict avoidance experimentation for the Real Time Deconfliction effort.
• Augment the real world information with computer-generated information in the Battlefield Augmented Reality System effort. The activity will also design a modular framework to support the system design and enable the

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insertion of custom scheduling and replication solutions. Other efforts will focus on the middleware layer to support emerging network centric sensor-to shooter systems.
• Develop algorithms with Naval/Joint imagery systems to handle video metadata, which includes Global Positioning System (GPS), and time, sensor information.
• Develop recommendations for standardizing the storage and linking of feature descriptions within a common database framework.
• Completed development of technology to improve fidelity in Marine Infantry combat simulators via virtual locomotion and collision detection. (NRL)
• Initiate development of technology for improving voice data interpretation and presentation to cope with audio information overload in Navy Systems. (NRL)
• Initiate development of technology to improve collaborative operational planning for tactical users using Head-Up Displays. (NRL)

**FY 2006 Plans:**

• Develop a set of algorithms and software which implements multiple platforms ATR, as well as performance characterizations and error rates leading to the development of a notional concept of operations.
• Develop sensor management algorithms that reduce the amount of labeled training data required, employing semi-supervised classifier and active learning techniques motivated by asymmetric threat, for which limited training data anticipated.
• Demonstrate predictive surface platform threat behavior algorithms and software employing techniques using pattern recognition on geospatial and attribute data and develop autonomous monitoring and reporting of high interest and anomalous maritime vessels.
• Demonstrate a trusted data store which maintains data pedigree and detects anomalies in a limited objective experiment.
• Develop a feature extraction module that segments the video based on video mosaicking.
• Build the visual thesaurus using texture features. The thesaurus construction is critical to achieving our goal of developing semantic concepts for video databases that are of interest to Navy applications and in general to DoN.
• Continue developing a hybrid CBR-BN system to exploit the mutual strengths of CBR and BN approaches in the development of a best of breed system employing multiple inferencing methods. Continue developing probabilistic graphical models for encoding expert knowledge and performing inference with uncertain and incomplete data for level 1 data fusion.
• Continue development of technology for improving face recognition technology via enhanced image registration

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software. (NRL)
• Continue development of technology for improving voice data interpretation and presentation to cope with audio information overload in Navy Systems. (NRL)
• Continue development of technology to improve collaborative operational planning for tactical users using Head-Up Displays. (NRL)

**FY 2007 Plans:**

• Develop algorithms and demonstrate data reduction through joint classification and feature optimization, realizing transfer of data to information, realizing A/I vis-à-vis Analog/Digital data (reduced bandwidth requirements and reduced burden on analysts and warfighters).
• Demonstrate anomaly detection, feature-based target tracking, track-to-pattern association and scoring, track-to-group clustering, pattern discovery and learning, pattern templates/descriptions and predictive modeling tools in a limited objective experiment.
• Develop an interface between the Level 1 and Level 2/3 data fusion processes.
• Develop ontology for describing a common language for the situation/threat assessment problem including asymmetric threats.
• Develop a CBR system for Level 2/3 fusion.
• Develop a Bayesian Network inference engine to support data mining.
• Extend visual thesaurus with geospatial relationships using a semantic layout model that is a novel combination of two popular statistical models: the Gaussian mixture model and the Markov random field model, to represent spatial distributions of visual features.
• Complete development technology for improving fact recognition technology via enhanced image registration software. (NRL)
• Continue development of technology for improving voice data interpretation and presentation to cope with audio information overload in Navy Systems. (NRL)
• Continue development of technology to improve collaborative operational planning for tactical users using Head-Up Displays. (NRL)

| | FY 2004 | FY 2005 | FY 2006 | FY 2007 |
|---|---|---|---|---|
| **COMMUNICATION AND NETWORKS** | 6,330 | 8,825 | 9,386 | 10,147 |

This initiative develops wireless communications network technologies critical to the performance and robustness of naval communications for air, ship, submarine, and land platforms. Developments include

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bandwidth efficient communication techniques; advanced networking techniques for robust, highly dynamic environments; interoperable wireless networks for secure communications and protocols; bandwidth and network management techniques that can effectively manage and allocate bandwidth across tactical and theater levels in support of wireless network centric operations. The exploration payoffs include increased network data rates, improved coalition interoperability, dynamic bandwidth management, greater mobile network connectivity, and efficient waveforms to improve communications with land forces.

**FY 2004 Accomplishments:**

• Completed and demonstrated bandwidth efficient line of sight (LOS) technology (BLT) waveform design and simulation, system engineering, software design, code and unit test. Both constant envelope continuous phase modulation (CPM) and non-constant envelope quadrature amplitude modulation (QAM) waveform modes have been integrated with turbo coding and tested.
• Completed tunable optical domain microwave filtering techniques for multifunction antennas.
• Completed the development and integration of the superconducting cross-correlator to technology readiness level (TRL) 4, demonstrating an all-digital RF front end that eliminates analog mixers and synthesizers, thereby reducing cost.
• Completed development of technology for self-organizing distributed sensor networks. (NRL)
• Continued improvements on the Joint Tactical Radio System (JTRS) Maritime Spectrum Awareness and Spectrum Adaptive Polyphase Waveform project. A human-machine interface (HMI) has been developed and digital signal processing (DSP) algorithms have been integrated with the polyphase channelizer. This project provides real-time DSP that enables distributed Navy networks to map and analyze the cluttered Radio Frequency (RF) environment.
• Continued efforts on Next Generation Tactical Internet Protocol (IP) Networks. Established test beds and tools for dual-stacked (coexistent IPv4/IPv6) environments. Developed several novel autoconfiguration and IP multicast approaches for mobile ad hoc network environments. Generated recommended IPv6 transition guidelines for existing Navy Automated Digital Network System (ADNS) networks.
• Conducted a collaborative demonstration of Interoperable Networks for Secure Communications (INSC) internetworking technologies based on IPv6, for allied interoperability. Demonstrated secure coalition IP network capability -- a mixture of IPv6 and IPv4 networks and applications, owned by individual coalition partners that is built as a Virtual Private Network (VPN). An INSC Symposium was organized and held at the North Atlantic Treaty Organization (NATO) Command, Control and Communications (C3) Agency in The Hague, Netherlands.
• Demonstrated high speed laser communications (2.5 gigabits per second) over a 32 mile path in a maritime

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environment; achieved 155 megabits per second in light rain and fog. (NRL)
• Initiated project to improve amplifier efficiency for Orthogonal Frequency Division Multiplexing (OFDM) signaling by reducing Peak-to-Average Power Ratio (PAPR). An OFDM-based constant envelope signal has been developed by embedding the OFDM signal within the phase of a constant envelope signal. Performance bounds have been obtained. A simple suboptimum receiver has been implemented.
• Initiated high efficiency communications transmitter design and development. Simulated and verified that out-of-band energy was eliminated. New delta-sigma circuit concepts have been developed to reduce power loss; silicon carbide switches were investigated for higher power operation.
• Initiated development of an adaptive equalizer for Ultra High Frequency (UHF) submarine communications that minimizes the effects of multipath and narrowband interference. Data from operational tests has been collected and analyzed. Filter structures have been designed, and preliminary designs have been configured for rapid prototyping on DSP.
• Initiated development of a Very High Frequency (VHF)/UHF power amplifier (PA) that provides linear amplification using nonlinear components. Commercial off the shelf (COTS) Class D switching amplifiers are being combined with DSP techniques in an innovative quadrature Linear Amplification Non-linear Components (LINC) PA architecture.
• Initiated development of technology to improve mobile, ad hoc networks via multi-agent programs. (NRL)

**FY 2005 Plans:**

• Complete the JTRS Maritime Spectrum Awareness and Spectrum Adaptive Polyphase Waveform by finalizing development of DSP algorithms and transitioning these algorithms to programmable JTRS platforms.
• Complete the study of Next Generation Tactical IP networks. Prototype and test a number of protocols within the established test beds, update transition papers, and continue Internet standards development and commercial interaction.
• Complete the peak-to-average ratio (PAPR) improvements for orthogonal frequency division multiplexed (OFDM signaling with constant envelope.
• Conduct work on INSC Phase II that will permit transition of INSC technologies into Navy ADNS by FY06. Complete initial research and demonstrate a number of IPv6 and IPv4 mobile networking technologies within the coalition architecture.
• Continue the development of a high efficiency communications transmitter. Enhanced efficiency with commercial filters and switches will be demonstrated.
• Continue development of nonlinear adaptive equalizer for Ultra-High Frequency (UHF) submarine communications. Begin tests to provide a proof of concept that will be tested at sea.

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• Continue the development of a Very High Frequency (VHF)/UHF Power Amplifier (PA). Demonstrate that a significant reduction in size, weight, and waste power can be achieved.
• Continue development of technology to improve mobile, ad hoc networks via multi-agent programs. (NRL)
• Continue the development of a VHF/UHF PA. Demonstrate that a significant reduction in size, weight, and waste power can be achieved
• Conduct demonstration of robotic space rendezvous using real time range imaging and target tracking in the Naval Research Laboratory's Space Robotics Laboratory. (NRL)
• Conduct research to improve tactical networks via the development of models, analysis methodologies, and simulation tools. (NRL)
• Develop the 802.11s standard that will specify a complete Enhanced Service Set (ESS) Mesh architecture, including auto configuration, dynamic broadcast/multicast/unicast routing, end user mobility, security, and integration with other 802 LANs.
• Initiate project to mature the superconducting cross-correlator to technology readiness level (TRL) 6 to enable the development of a multi-function multi-net digital-RF dehopping receiver for Link-16. This will involve the integration of High Temperature Superconductors (HTS) analog and Low Temperature Superconductors (LTS) digital circuits in a COTS two-stage cryocooler.
• Initiate optical receiver design using avalanche photo-diodes (APD) and array-detection techniques for laser communications over the sea in poor weather.
• Initiate research and development into MIMO (multiple-in-multiple-out) antenna technology and OFDM signaling to improve data throughput (500 Mbps) in strong multipath environment.
• Initiate development of a concept for recovering Global Positioning Systems (GPS) signals in a "friendly" jamming environment thus allowing GPS to be used while denying that capability to an adversary. (NRL)
• Initiate development of technologies in support of responsive micro-satellites including high speed W-band communications, compact deployable structures, and small, xenon electric propulsion systems. (NRL)

**FY 2006 Plans:**

• Complete and provide a proof of concept, tested at sea, for the nonlinear adaptive equalizer for UHF submarine communications, mitigating multi-path and narrow band interference. Transition to fleet by DSP software upgrades in submarine UHF receivers.
• Complete the development of an efficient VHF/UHF power amplifier using non-linear components. Transition this effort to the Joint Tactical Radio System (JTRS) program.
• Complete the development of a high efficiency communications transmitter based on delta-sigma modulation. Investigate transition path to deployment, including manufacture.

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• Complete the development of the 802.11s standard.
• Continue the design, fabrication, integration and test of superconducting cross-correlators on multi-chip modules (MCM) in the dehopping receiver for Link-16.
• Continue research and development in to MIMO (multiple-in-multiple-out) antenna technology and OFDM (orthogonal frequency division multiplexing) signaling to improve data throughput (500 Mbps) in strong multipath environments. Finish prototyping of lab models.
• Continue the development of the multi-function digital receiver for JTRS-compliant communication, based on the use of cryogenic modules.
• Continue the development of the “friendly” GPS jamming recovery technique. Assess the feasibility of actively canceling current “friendly” GPS jamming techniques (NRL)
• Continue development of micro-satellite technologies including design of W-band system for high bandwidth, low-probability-of-intercept communications. (NRL)
• Continue development of technology to improve mobile, ad hoc networks via multi-agent programs. (NRL)
• Initiate development of technology to improve tactical network SATCOM linkage and multi-user detection. (NRL)
• Develop an adaptive rate terminal to maintain laser communications in poor weather conditions.
• Increase the performance of free space laser communications to include hybrid digital/analog communications links with greater than 10X bandwidth than digital link for same power. (NRL)

**FY 2007 Plans:**

• Complete the cryogenic packaging, test and demonstrate direct digital dehopping of multiple Link-16 waveforms. Establish transition path to JTRS-compliant communications.
• Complete the development of an adaptive rate terminal to maintain laser communications in poor weather conditions. Test the system at NRL’s 32 km maritime Chesapeake Bay test bed. Establish transition path to fleet deployment.
• Complete research and development in MIMO (multiple-in-multiple-out) antenna technology and OFDM (orthogonal frequency division multiplexing) signaling to improve data throughput (500 Mbps) in strong multipath environments. Finish prototyping of lab models. Finish demo in urban environment. Explore possible transition to United States Marine Corps (USMC) and/or JTRS.
• Complete development of technology to improve mobile, ad hoc networks via multi-agent programs. (NRL)
• Continue the development of an adaptive rate terminal to maintain laser communications in poor weather. Test the system at NRL’s 32 km maritime lasercomm test bed.
• Continue the study of “friendly” GPS jamming techniques to include those designed specifically to minimize

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fratricide while maintaining effectiveness of jamming against threat GPS receivers (NRL)
• Continue initiated development technologies in support of responsive micro-satellites including laboratory demonstrations of optimized xenon electric propulsion system and deployable structures. (NRL)
• Continue development of advanced free space communications to include performance tests in marine environments. (NRL)
• Continue development of technology to improve tactical network SATCOM linkage and multi-user detection.(NRL)

| | FY 2004 | FY 2005 | FY 2006 | FY 2007 |
|---|---|---|---|---|
| **MULTI-SOURCE INTEGRATION AND COMBAT IDENTIFICATION** | 6,313 | 7,101 | 8,698 | 11,178 |

Multi-Source Integration (MSI), Advanced Sensor Netting Technology (ASNT) and Composite Combat Identification (CCID) projects address theater air and missile defense (TAMD) needs for rapid, high confidence Combat Identification (CID) of air and missile threats at long range using real time and non-real time threat attributes and intelligence information, and common to all TAMD units in theater; this activity supports the FORCEnet Future Naval Capability (FNC) Enabling Capability (EC) for Joint Combat ID. Provides coordination and engineering support to the Navy live fire demo of the Navy Advanced Area Defense Interceptor (AADI)

**FY 2004 Accomplishments:**

• Continued MSI project development and testing of algorithms to integrate radio frequency (RF) sensor data and correlate satellite communications (SATCOM) data in the E-2C aircraft mission computer. A single contractor was selected to complete MSI effort.
• Continued development of ASNT algorithms for integration of electronic warfare support (ES) data into the Open Architecture Track Manager in future combat systems and transmission of track ID attributes via real time sensor networks. Completed ASNT multi-level network demo in FY04.
• Continued development of CCID algorithms to correlate and fuse real time tracks with intelligence, surveillance and reconnaissance (ISR) data in Ship Signal Exploitation Equipment (SSEE)-equipped surface ships and a common reasoning algorithm CID capability to rapidly build high confidence identification of air tracks using all available ID attributes in theater. Completed CCID STORY MAKER algorithms for ISR data correlation and transitioned to the EP-3E reconnaissance aircraft program. Concurrent CCID risk reduction effort funded under PE 0602123N in FY 2004.

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**FY 2005 Plans:**

• Continue all efforts of FY04, including laboratory demonstrations of ASNT and CCID.
• Continue AADI planning and coordination for FY 2008 Navy Air Directed Surface to Air Missile (ADSAM) live-fire demonstration.

**FY 2006 Plans:**

• Continue all efforts of FY05, including demonstrations of MSI and CCID; ASNT will participate in Joint Task Force Exercise (JTFX).

**FY 2007 Plans:**

• Complete ASNT, CCID, and MSI development.

| | FY 2004 | FY 2005 | FY 2006 | FY 2007 |
|---|---|---|---|---|
| **HUMAN COMPUTER INTERFACE** | 3,775 | 4,763 | 5,416 | 6,020 |

This activity focuses on improving platform, task force and battle group operations by developing decision support technology for incorporation into operational systems. The goals are to enhance human performance effectiveness; improve decision support and decision-making collaboration; improve human-centered design; and accelerate insertion of advanced human factors engineering technology into existing and new weapons systems. The payoff is the creation of decision-action cycles that are faster than an enemy’s, and reduced workload and staffing requirements. Specific objectives include achieving improved situational awareness and speed of command through a deeper understanding of human capabilities and limitations, as well as accomplishing quality performance in complex, dynamic, high-tempo and uncertain threat environments. These objectives are being pursued in three focus areas: Decision Support and Organizational Design; Collaboration and Knowledge Management; and Human-Computer Interaction (HCI)/Visualization.

**FY 2004 Accomplishments:**

• Developed an automated tool to diagnose and correct knowledge sharing deficiencies in collaborative command and control decision making.
• Developed a computational tool for uncertainty resolution and elicitation of unshared information in

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distributed and asynchronous team problem solving.
• Developed an instructional test bed at the Naval Postgraduate School (NPS) for integration of visual information sharing capabilities into Network-Centric Global Information Grid exercises.
• Developed and tested attention management tools for improved resumption after interruptions.
• Modeled and predicted perceptual errors associated with three dimensional (3D) versus two dimensional (2D) visual displays.
• Demonstrated significant performance improvements in detection latency and accuracy and of Combat Information Center (CIC) air defense teams attributed to geo-plot de-cluttering models and algorithms.
• Demonstrated improvements in the performance of CIC teams using the multi-modal watch-station, compared with teams using conventional watch-station consoles in responding to hostile tracks, countering ESM, issuing queries and warnings. Performance improvements are attributable to embedded task management algorithms and integrated display designs.
• Developed and demonstrated HCI design apparatus and software for determining/assessing eye scan and dwell patterns and the efficiency of display designs.
• Developed social network analysis tools for terrorist network analysis and put into real-world tests at the Joint Warfare Analysis Center and National Security Agency.
• Initiated development of cognitive computational models of multi-echelon command decision-making to define critical knowledge components for command and control.

**FY 2005 Plans:**

• Evaluate Latent Semantic Analysis (LSA) of operator communications as an effective metric of shared situational awareness in unmanned aerial vehicle (UAV) control teams.
• Demonstrate Electronic Card Wall (EWALL) (a computational human cognitive processing system) for representation and transfer of meaning among heterogeneous and distributed team members engaged in complex problem solving.
• Develop jointly with the Naval Air Systems Command (NAVAIR), a FORCEnet-based test bed to identify and evaluate the cognitive processes to be employed to optimize collaborative decision-making in a geographically distributed and time-delayed situation.
• Conduct model-based simulations and experiments to investigate the effectiveness of heterarchical organizational structures in network-centric operational environments in order to evaluate the implementation of FORCEnet concepts.
• Develop with the staff of the Naval War College new threat scenarios incorporating Joint Force Maritime Component Commander (JFMCC) operations, countering insurgency and humanitarian operations. These new threat

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scenarios will provide the basis for Limited Objective Experiments in the innovation Laboratory at the Naval War College.
• Develop Dynamic Network (DYNET) analysis (a terrorist network analysis tool) in operational command setting at U.S. Pacific Command.
• Improve terror network analysis decision tools for combatant command use and military planning, including testing of tools, development of metrics and validation.
• Develop a user tool to counteract perceptual errors associated with 3D perspective-view visual displays.
• Evaluate the effectiveness of a change history tool to minimize the effect of interruptions.
• Apply cognitive architecture modeling to the design of interface analysis tools.
• Initiate development of a cognitive model of human performance with 3D audio displays.

**FY 2006 Plans:**

• Incorporate an LSA-based tool into the NPS test bed and evaluate its performance with a Noncombatant Evacuation Operations Scenario.
• Test and validate the EWALL in a Special Operations simulation environment within the NAVAIR FORCEnet test bed.
• Conduct laboratory tests of the cognitive theory of Memory Templates in command and control team decision making using a shared virtual information surface.
• Test and validate DYNET terror network analysis tool, working with U.S. Pacific Command.
• Refine cognitive model of interaction with 3-D audio.
• Develop cognitive architecture based interface analysis tools.
• Develop human error modeling for cognitive architecture tools.
• Initiate jointly with the Air Force applied research on the integration of Information Operations in Air Control Centers.
• Initiate applied research on command and control adaptive architectures for Expeditionary Strike Groups working with OPNAV N-75B and Expeditionary Strike Group ONE, San Diego.

**FY 2007 Plans:**

• Improve response speed of the LSA tool to a near-interactive level and incorporate into a fleet experiment. Collect and evaluate data to validate improved speed and effectiveness of developing situational awareness.
• Incorporate the EWALL prototype into the Tactical Operations Center of a Special Operations Scenario and collect performance data to validate effectiveness.

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• Use Template theory to develop and test cognitive support tools for teams making decisions in tasks characterized by risky outcomes under normal and urgent conditions.
• Conduct jointly with the Air Force, applied research on the integration of Information Operations in Air Control Centers.
• Continue to test and validate terrorist network analysis tools to enable combatant commanders and military planners to probe key flows of resources, information, and personnel, developing what-if scenarios and novel plans of attack against networked forces.
• Incorporate 3D audio interaction model into an existing computational cognitive architecture (ACT-R).
• Apply interface analysis tools to analyzing new interface designs for specific Navy applications.
• Incorporate human error modeling in interface analysis tools.

| | FY 2004 | FY 2005 | FY 2006 | FY 2007 |
|---|---|---|---|---|
| **COMPUTING AND ADVANCED SENSING** | 1,348 | 3,923 | 4,047 | 4,153 |

This program activity includes Naval Research Laboratory (NRL) initiatives which support the general area of computing, advanced sensor integration, biometrics, information assurance and electronic warfare in support of fleet/force protection. This effort supports covert reliable battlespace communications and explores sensor exploitation technologies to communicate between sensors. This effort also supports spacecraft to spacecraft data exchange techniques using modulated optical retroreflectors.

**FY 2004 Accomplishments:**

• Completed laboratory explorations of a lightweight electro-optic/infrared sub-system for employment in an unmanned flight vehicle. (NRL)
• Continued development of signal processing techniques for digital Electronic Support Measures (ESM) receivers to detect and identify advanced radar and communication modulations in the presence of non-Gaussian interference sources. (NRL)
• Continued research in and demonstrations of modulated near-infrared (IR) optical retroreflector data transmission and receipt techniques in field experiments. (NRL)
• Continued independent high-power radar operation using spectrally clean waveforms, CW radar receiver technology (designed 500 MHz X-band Chirp transmitter, X-band canceller, and X-band receiver) and derived mathematical solutions of micro-Doppler modulations when targets have simple rotation and vibration, and conducted initial analyses of measured radar data from ballistic missile defense (BMD) targets and chaff. (NRL)

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• Initiated development of technology for improving reliable system to survive IW attacks. (NRL)
• Initiated collection of highest quality oblique hyperspectral imaging data in the world and are pursuing analysis of this short-wave IR data. (NRL)
• Initiated development of "through-the-sensor" techniques to obtain environmental information from shipboard radars. (NRL)
• Initiated the development of both conventional and unconventional SEI techniques applicable to the communications signal modulations of interest using mathematical models of the signal types and SEI algorithms. (NRL)

**FY 2005 Plans:**

• Complete development of signal processing techniques for digital Electronic Support Measures (ESM) receivers to detect and identify advanced radar and communication modulations in the presence of non-Gaussian interference sources. (NRL)
• Continue to develop spacecraft to spacecraft data exchange techniques using modulated optical retroreflectors, and exploit these techniques in the battlespace as well. (NRL)
• Continue development of "through-the-sensor" exploitation techniques to obtain environmental information from shipboard radars, and use of that information in nowcasting. (NRL)
• Continue to evaluate improved method to automatically account for atmospheric effects on hyperspectral data and apply anomaly detectors, matched filters, and new algorithms for hyperspectral target detection. (NRL)
• Continue development of technology for improving reliable system to survive IW attacks. (NRL)
• Continue development of SEI algorithms for communications signals by conducting lab tests and investigating combinations of precision classical parametric measurements and SEI techniques. (NRL)
• Continue construction and characterization of spectrally clean out-phased high-power transmitter using X-band monolithic microwave integrated circuit (MMIC) technology, developing CW radar receiver technology implementing wideband 500-MHz linear chirp at the X-band transmitter and BMD discrimination by performing experiments to study micro-Doppler signatures from BMD targets that undergo micro-motions. (NRL)
• Initiate development of technology to improve voice biometrics via the development of multi-dimensional, adaptive speaker verification technology. (NRL)
• Initiate development of technology for improved steganography and watermarking. (NRL)
• Initiate the design, fabrication and testing of adaptive radio frequency (RF) elements for autonomous systems in order to increase the RF performance of small stationary autonomous systems. (NRL)

**FY 2006 Plans:**

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• Complete development of new algorithms for hyperspectral target detection in oblique geometries. (NRL)
• Complete efforts on independent high-power radar operation, CW radar receiver technology, and BMD discrimination. (NRL)
• Continue to develop spacecraft to spacecraft data exchange techniques using modulated optical retroreflectors, and exploit these techniques in the battlespace as well. (NRL)
• Continue development of "through-the-sensor" exploitation techniques to obtain environmental information from shipboard radars, and use of that information in nowcasting. (NRL)
• Continue the design, fabrication and testing of the phased array RF elements for autonomous systems in order to increase the RF performance of small stationary autonomous systems and incorporate design in an unmanned system. (NRL)
• Continue development of SEI algorithms for communications signals by conducting Tri-Service field tests of the most effective combination of techniques. (NRL)
• Continue the implementation of a real-time anti-ship missile (ASM) state assessment capability against modern treats by embedding algorithms in a real-time processor. (NRL)
• Continue development of technology to improve voice biometrics via the development of multi-dimensional, adaptive speaker verification technology. (NRL)
• Continue development of technology for improved steganography and watermarking. (NRL)
• Continue development of technology for improving reliable system to survive IW attacks. (NRL)

**FY 2007 Plans:**

• Complete communications SEI by transitioning best approaches into operational Navy electronic support and electronic attack systems. (NRL)
• Complete the implementation of a real-time anti-ship missile (ASM) state assessment capability against modern threats by conducting an empirical performance evaluation and analyze system implications. (NRL)
• Complete the design, fabrication and testing of the phased array RF elements for autonomous systems with the fabrication of a prototype unmanned system. (NRL)
• Complete development of technology to improve voice biometrics via the development of multi-dimensional, adaptive speaker verification technology. (NRL)
• Continue to develop spacecraft to spacecraft data exchange techniques using modulated optical retroreflectors, demonstrate skill in using these techniques for covert, reliable battlespace communications. (NRL)
• Continue development of additional "through-the-sensor" exploitation techniques to obtain environmental

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information from shipboard sensors. (NRL)
• Continue development of technology for improved steagongraphy and watermarking. (NRL)
• Continue development of technology for improving reliable system to survive IW attacks. (NRL)
• Conduct testing of the integrated adaptive, unmanned vehicle phased array design. (NRL)

| | FY 2004 | FY 2005 | FY 2006 | FY 2007 |
|---|---|---|---|---|
| **TACTICAL SPACE EXPLOITATION** | 0 | 0 | 15,014 | 15,106 |

The Tactical Space Exploitation initiative explores the application of new technologies on small, light-weight and low-cost satellites to enhance naval warfighting capabilities taking advantage of the global access, revisit and connectivity provided by orbital platforms. Initial efforts will be aimed at developing integrated signals electronics packages to test new concepts for global ship tracking and two-way data exfiltration using next-generation Internet Protocol (IP) technology from an array of sea-based and land-based sensors. Advanced multispectral/hyperspectral electro-optical sensors will be developed to demonstrate new warfighting constructs. This program is funded for the first time in FY 2006.

**FY 2006 Plans:**

• Develop integration plans, algorithms and satellite concept of operations to demonstrate the integrated signals payload as a secondary payload on an FY 2007 small satellite launch.
• Initiate development of small multifunctional integrated signals electronics systems for ship tracking from space and two-way data exfiltration from distributed global sensors.
• Initiate development of a satellite-borne electro-optical sensor system for FY 2008 launch on a small satellite to test new techniques for surveillance of environments and targets of naval interest for anti-submarine warfare and mine warfare.

**FY 2007 Plans:**

• Continue to develop integration plans, algorithms and satellite concept of operations to demonstrate the integrated signals payload as a secondary payload on an FY 2007 small satellite launch.
• Continue development of small multifunctional integrated signals electronics systems for ship tracking from space and two-way data exfiltration from distributed global sensors.
• Continue development of a satellite-borne electro-optical sensor system for FY 2008 launch on a small satellite to test new techniques for surveillance of environments and targets of naval interest for anti-

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submarine warfare and mine warfare.

**CONGRESSIONAL PLUS-UPS:**

| | FY 2004 | FY 2005 |
|---|---|---|
| AIREP, FORMERLY UESA | 10,344 | 11,490 |

This effort completed and installed the Radar Test Bed at Pacific Missile Range Facility (PMRF) for conducting demonstrations and experimentations at the site. This effort will develop the track adaptive processor, an IFF capability for circular arrays and a data collection capability and modify the radar for wideband capability.

| | FY 2004 | FY 2005 |
|---|---|---|
| COMMON SENSOR MODULE (COSM) | 1,735 | 1,784 |

Supported the development of small common sensor modules for ground forces. These sensors were networked to provide total situational awareness for the ground forces and extended the integrated picture to the rest of the forces. Prototype modules were developed and limited demonstrations conducted. Plans are to upgrade capabilities to provide for vehicle classification based on electro-magnetic emissions. Develop algorithms for classification and verify in field testing.

| | FY 2004 | FY 2005 |
|---|---|---|
| EXPEDITIONARY STRIKE GROUP NETWORK (3RD FLEET) | 4,089 | 0 |

The effort included installation, operator/maintenance training, and sustainment of a Tactical Component Network (TCN) on a selected Expeditionary Strike Group (ESG). ESG funds provided the basic equipment suite, software operating licenses, and technical representative support for the duration of the installation. TCN installation conducted under “temporary alteration” parameters to explore new expeditionary network configurations and collect metrics on network performance.

| | FY 2004 | FY 2005 |
|---|---|---|
| M2C2 | 1,925 | 5,943 |

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This effort developed the operational construct and high-level system design to support Marine Corps Forces Pacific needed for an early-entry mission package for the purposes of: urban operations; halted combat operations; ship-to-shore transition; shore-to-ship transition; medevac assistance; humanitarian assistance; halted video teleconference; host nation support; and non-governmental organizations communications. This effort will develop an early entry command, control, and communications payload, with associated technologies, suitable for future insertion into the Marine Corps' to-be-selected internally transportable (in the MV-22) vehicle. It will provide on-the-move, over-the-horizon connectivity with limited terrestrial communications and command and control capabilities for the local on-site commander.

| | FY 2004 | FY 2005 |
|---|---|---|
| NAIF | 4,812 | 5,943 |

The Network Applications Integration Facility (NAIF) served as a global hub to support Tactical Component Network (TCN) operations, application development and integration, and expansion of TCN instantiation with the Fleet. The NAIF supported component and protocol standardization, global distribution of data, engagement coordination, and test and integration across land, sea, and air platforms. It was manned to accommodate the operating parameters dictated by Fleet needs, and organized to reflect exercise and/or operational contingencies. Contracts for support operations and sustainment emphasized Hawaiian small businesses to the maximum extent practical. Plans are to modify capabilities to integrate into the Navy’s advanced digital networking system. Use the NAIF as an exercise center for upcoming Third and Seventh Fleet demonstrations. Continue Hawaiian tech base development thorough participation of Hawaiian technology firms in Navy program interface development for use in the Tactical Component Network.

| | FY 2004 | FY 2005 |
|---|---|---|
| NATIONAL CENTER FOR ADVANCED SECURE SYSTEMS RESEARCH (NCASSR) | 7,206 | 4,953 |

Developed and demonstrated information assurance research efforts in monitoring, containing and preventing hostile attacks, denial of service and malicious mobile code. Funding addresses continuing advancements in comprehensive vulnerability analysis and the development of tamper-resistant hardware and software.

| | FY 2004 | FY 2005 |
|---|---|---|

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| | FY 2004 | FY 2005 |
|---|---|---|
| NAVAL AUTOMATION AND INFORMATION MANAGEMENT TECHNOLOGY | 961 | 0 |

Developed a formal framework for navigation and coordination of multiple heterogeneous sensor assets operating in real-time; derived a solid foundation for distributed sensing and sensor fusion where information from individual robots was fused and presented to human operators, rather than raw data. Demonstrated improved performance and usability while reducing cognitive demands of the interface, which led to fewer operators needed to control the robot team. It supported the design of a modular hardware and software architecture with platform independent components supporting overall system functionality.

| | FY 2004 | FY 2005 |
|---|---|---|
| SEADEEP | 0 | 2,476 |

Funds support technologies to demonstrate a two-way sensor data link for high data rate, low probability of intercept, communications between airborne platforms and submerged submarines. The plan is to demonstrate the use of a steerable Micro-electro Machine System to steer a laser beam in a small unmanned vehicle.

| | FY 2004 | FY 2005 |
|---|---|---|
| TESTING, EVALUATION AND DEMONSTRATION OF WEBSTER | 0 | 1,485 |

Webster, web-based information fusion system for counter-terrorism operations (CTO), explicitly accounts for uncertainty in data. It uses data from multiple existing INTEL and open source systems (especially the World Wide Web (WWW)) to produce a high-level information system that specifically quantifies data certainty and source reliability. Webster models each step of the normal intelligence analytical process (collect, fuse, analyze, report, and disseminate) and attempts to estimate uncertainty that arises along the way. Plans are to accelerate development and testing of Webster to support operational needs.

| | FY 2004 | FY 2005 |
|---|---|---|
| THEATER UNDERSEA WARFARE INITIATIVE | 5,744 | 7,528 |

This effort demonstrated the ability of various platforms to connect with and use the integrated undersea picture via Web Centric ASW, as well as integrating additional data inputs. This effort will develop Theater

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Under Sea Warfare (TUSW) Program tools with the addition of operations rehearsal simulations, enhancements to the Asset Allocation Tool (AAT), evaluation of TUSW tools in Undersea Warfare exercises and the study of composable FORCENet integration, automated extraction of asset status and Commercial Joint Mapping Tool Kit (CJMTK) cartography benefits.

| | FY 2004 | FY 2005 |
|---|---|---|
| WEB-BASED TECHNOLOGY INSERTION | 1,226 | 990 |

This effort took emerging web based solutions and applied them to an area such as time critical targeting and expeditionary warfare applications, and determined the effectiveness of using enterprise solutions to achieve a prescribed outcome. By use of the web based automated information management tools, this effort incorporated critical Command and Control (C2) legacy systems into the web environment. Experiments were conducted to determine efficiency and effectiveness of the architectures, both from a technical evaluation and Fleet Operator input. Plans are to upgrade capabilities to automate discovery and access functions to lower operator workload. Test to determine suitability of new tools.

**C. OTHER PROGRAM FUNDING SUMMARY:**
NAVY RELATED RDT&E:

PE 0601153N (Defense Research Sciences)
PE 0602123N (Force Protection Applied Research)
PE 0602131M (Marine Corps Landing Force Technology)
PE 0602271N (RF Systems Applied Research)
PE 0603123N (Force Protection Advanced Technology)
PE 0603235N (Common Picture Advanced Technology)
PE 0603271N (RF Systems Advanced Technology)
PE 0603609N (Conventional Munitions)
PE 0603658N (Cooperative Engagement)
PE 0603640M (USMC Advanced Technology Demonstration) (ATD)
PE 0604307N (Surface Combatant Combat System Engineering)
PE 0604518N (Combat Information Center Conversion)
PE 0204152N (E-2 Squadrons)
PE 0205601N (HARM Improvement)
PE 0206313M (Marine Corps Communications Systems)

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NON-NAVY RELATED RDT&E:

PE 0602204F (Aerospace Sensors)
PE 0602702F (Command Control and Communications)
PE 0602782A (Command, Control, Communications Technology)

**D. ACQUISITION STRATEGY:**
Not applicable.