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

COST: (Dollars in Thousands)

Project Number & Title	FY 2006 Actual	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate
COMMON PICTURE APPLIED RESEARCH	105,207	88,929	93,376	54,443	73,158	59,483	57,913	58,578

A. MISSION DESCRIPTION AND BUDGET ITEM JUSTIFICATION: Activities and efforts in this program examine concepts and technologies that enable the transformation to network centric warfare. Network centric capabilities rely on information to connect assets and provide timely and accurate understanding of the environment. The mission area requirements for rapid, accurate decision-making; dynamic, efficient, mission-focused communications and networks; and pervasive and persistent sensing drive network centric Science and Technology (S&T) investments. The program focus is on S&T enabling technologies that provide decision making and mission execution to achieve battlespace superiority. Program activities seek to develop hardware and software technologies that (1) identify and integrate informational content from multi-media sources including images, and intelligence sources; (2) integrate massive amounts of information; and (3) provide automatic correlation, fusion, and insight to support user-cognitive processes. Particular programmatic emphasis will be placed on automating the association of objects and events in the battlespace and automatically transforming this information into actionable knowledge (e.g., indications and warnings of intent). In current and future operational environments such as Global War on Terrorism (GWOT) and Maritime Domain Awareness (MDA), warfighters require technologies evolved to support information needs regardless of location and that are consistent with the user’s level of command or responsibility within varying operational situations. Net-centric operations include communications and information assurance capabilities to enable all-source data access, multi-source processing, and tailored dissemination of information to C2 and Intelligence, Surveillance and Reconnaissance (ISR) users across the network. The operational benefits sought are increased speed of response, accuracy and precision of command; distributed self-synchronization; flexibility and adaptability to an operational situation; and decision superiority. 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.

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This program explores and demonstrates technologies that enable options for the Navy's FORCEnet, Sea Shield, and Sea Strike pillars and contains investments in the following Enabling Capabilities (ECs): Hostile Fire Detection and Response, Next Generation Command, Control and Decision Support, Combat Identification (ID) Information Management of coordinated Electronic Surveillance, Combat ID in the Maritime Domain to Reveal Contact Intent, Automated Control of Large Sensor Networks, and Real-Time Long Range Air Defense Combat ID in Support of Early Engagement. 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; and Sea Based Information Operations), Sea Strike (Ship-to-Objective Maneuver), and Sea Shield (Theater Air and Missile Defense).

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

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B. PROGRAM CHANGE SUMMARY:

	FY 2006	FY 2007	FY 2008	FY 2009
FY 2007 President's Budget Submission	106,391	68,352	72,732	72,115
Congressional Action	0	26,150	0	0
Congressional Reduction	0	-5,211	0	0
Congressional Undistributed Reductions/Rescissions	-664	-362	0	0
Execution Adjustments	1,525	0	0	0
Non-Pay Inflation Adjustments	0	0	-490	316
Program Adjustments	0	0	15,902	-15,700
Program Realignment	0	0	4,989	-2,666
Rate Adjustments	0	0	243	378
SBIR Assessment	-2,045	0	0	0
FY 2008/FY 2009 President's Budget Submission	105,207	88,929	93,376	54,443

PROGRAM CHANGE SUMMARY EXPLANATION:
Technical: Not applicable.

Schedule: Not applicable.

C. OTHER PROGRAM FUNDING SUMMARY:
Not applicable.

D. ACQUISITION STRATEGY:
Not applicable.

E. PERFORMANCE METRICS:
Performance metrics are discussed within the R2a.

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B. ACCOMPLISHMENTS/PLANNED PROGRAM:

	FY 2006	FY 2007	FY 2008	FY 2009
NETWORK COMMAND, CONTROL AND COMBAT SYSTEMS	13,175	15,260	28,491	15,271

This initiative explores development of advanced technologies that contribute to integrated decision-making and mission execution to achieve battlespace superiority. In current and future operational environments, such as the Global War on Terrorism and Maritime Domain Awareness, warfighters require technologies evolved to support information needs regardless of location and consistent with the user’s level of command or operational situation. To achieve this, it must be possible to automate understanding of the battlespace by identifying objects, determining relationships among the objects, assessing intent, and automatically generating courses of action with associated risks and uncertainty. This initiative focuses on information integration, examining the critical S&T 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 the understanding and relationship of different entities shown in the battlespace and their collective intent. This initiative will focus on advanced or novel approaches for processing and fusing information from disparate sources (e.g., images, intelligence sources); optimal decision aids incorporating rigorous decision theory and automated inference and reasoning; and assuring information integrity and availability according to mission objectives.

The increase from FY 2006 to FY 2007 is the result of the realignment of projects, including some previously reported in the FY 2006 President’s Budget Advanced Computing and Sensing activity (eliminated in FY 2007 President’s Budget) into this program. This Activity is focused on and has absorbed projects dealing with

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information fusion efforts – a critical element of network centric warfare and the emerging technologies that enable more automated support to warfighters. While completing earlier projects, this Activity is also initiating a number of efforts that focus on two very critical efforts: Automated Image Understanding (developing the capability to automatically understand image/scenes and assess threats which help the battlefield commander in making efficient and accurate decisions) and Automated Information Integration (leverage emerging technologies to manage and exploit sensors and other sources of data or information to develop approaches and tools for (semi)-automated data integration and reasoning about information from diverse sources in ways that support decision makers with timely, actionable information at operational and tactical levels of command).

In FY 2008, many of the investments will be approaching demonstration and experimentation phases. The increase from FY 2007 through FY 2008 reflects the cost of field demonstrations, limited objective experiments and sea trials which will be used to validate the utility of the concepts developed along with initiating the development of software and algorithms for integrating the functions of target acquisitions, tracking, data computation, and engagement control across multiple platforms for engaging multiple threats.

In FY 2009, investments in ongoing Common Picture research and the Future Naval Capabilities (FNC) Globally Netted Joint/Coalition Force Maritime Component Commander efforts within the NETWORK COMMAND, CONTROL AND COMBAT SYSTEMS activity are curtailed in response to program reductions.

FY 2006 Accomplishments:

• Continued the development of algorithms and demonstration of data reduction through joint classification and feature optimization, realizing transfer of data to information, realizing automation and integration vis-à-vis Analog/Digital data (reduced bandwidth requirements and reduced burden on analysts and warfighters).
• Continued the development of a feature extraction module that segments the video based on video mosaicing.
• Continued the development of algorithms with Naval/Joint imagery systems to handle video metadata, which includes Global Positioning System, time, and sensor information.
• Continued the development of recommendations for standardizing the storage and linking of feature descriptions within a common database framework.
• Continued the development and characterization of new target detection and recognition algorithms to exploit higher dimensional data (spatial, temporal, and spectral) within the Network Centric Warfare framework. Approach uses advanced correlation approaches to provide improved target detection and recognition performance by integrating multiple sensor measurements.

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• Continued the development of a suitable ontology for exercising large-scale distributed situational threat awareness in Naval battlespace environments.
• Continued the development of a Case-Based Reasoning simulation/model for implementing situation, threat awareness fusion solutions and a Bayesian Network inference engine for manipulating uncertainty and learning from data.
• Continued the development of 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.
• Continued the demonstration and conducted image registration error analysis for the multi-resolution and multi-scale image processing effort.
• Continued the augmentation of the real world information with computer-generated information in the Battlefield Augmented Reality System effort. The activity designed a modular framework to support the system design and enables the insertion of custom scheduling and replication solutions. Other efforts focused on the middleware layer to support emerging network centric sensor-to shooter systems.
• Continued development of automated methods for identifying significant changes between temporally separated images (not video) to extend work on automatic target recognition and pattern recognition into change detection algorithms.
• Continued demonstration of a FORCEnet limited objective experiment involving the application of new techniques of discrete optimization, statistical discrimination, and artificial intelligence for the resource allocation of weapons. Compared initial results with high fidelity physics based models for threat and anti-threat weapon systems for continued development of Anti-Air Warfare optimization algorithms.
• Continued research and demonstrations of modulated near-infrared (IR) optical retroreflector data to develop spacecraft to spacecraft data exchange techniques. (NRL)
• Continued development of "through-the-sensor" exploitation techniques to obtain environmental information from shipboard radars, and use of that information in nowcasting. (NRL)
• Continued development of technology to improve reliability of systems to survive Information Warfare attacks.
• Continued development of technology for improved steganography and watermarking. (NRL)
• Continued development of technology for improving voice data interpretation and presentation to cope with audio information overload in Navy Systems. (NRL)
• Continued development of technology to improve collaborative operational planning for tactical users using Head-Up Displays. (NRL)
• Continued improvement of face recognition technology via enhanced image registration software. (NRL)
• Completed development of new algorithms for hyperspectral target detection in oblique geometries. (NRL)

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• Initiated development of sensor management algorithms that reduce the amount of labeled training data required, employing semi-supervised classifier and active learning techniques motivated by asymmetric threat, which limited training data anticipated.
• Initiated demonstration of predictive surface platform threat behavior algorithms and software employing techniques using pattern recognition on geospatial and attribute data. Also developed autonomous monitoring and reporting of high interest and anomalous maritime vessels.
• Initiated demonstration of a trusted data store which maintains data pedigree and detects anomalies in a limited objective experiment.
• Initiated efforts in ontology-based information fusion for enhanced situational awareness and classification-based knowledge discovery.
• Initiated efforts in Joint Director of Laboratory's Data Fusion Model Level 1/2/3 data fusion using abductive reasoning, Bayesian networks, agent-based techniques, statistical-based methods, and other approaches.
• Initiated efforts in automated image understanding that use active computations and visual pattern recognition for networked target recognition systems in maritime domain awareness.
• Initiated efforts in the automated integration of disparate sources of information that involve data mining methods and game theory.
• Initiated the implementation of a real-time anti-ship missile (ASM) state assessment capability against modern threats by embedding algorithms in a real-time processor. (NRL)

FY 2007 Plans:

• Continue all efforts from FY 2006 less those noted as completed above.
• Complete development of improvements in face recognition technology via enhanced image registration software. (NRL)
• Complete the implementation of a real-time anti-ship missile state assessment capability against modern threats by conducting an empirical performance evaluation and analyze system implications. (NRL)
• Initiate demonstration of 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.
• Initiate development of an interface between the Level 1 and Level 2/3 data fusion processes across federated service oriented architectures.

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• Initiate development of new data schemas and methods to allow more efficient assembly of a common operational picture (COP) integrating informational content from images, track data, intelligence and incomplete track data.
• Initiate development of semi-supervised detection algorithms for multi-sensor imagery, video and human intelligence that will enable self-deploying sensor networks.
• Initiate Level 1 fusion algorithm and architecture design with associated ontology to manage information from automated sensors to provide a more dynamic and accurate battlespace picture through improved object refinement.
• Initiate development of a scalable system design for coordinated Unmanned Aerial Vehicle (UAV) formation control that integrates onboard and offboard sensor data. (NRL)

FY 2008 Plans:

• Continue all efforts from FY 2007 less those noted as completed above.
• Complete the development of algorithms and demonstration of 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).
• Complete the development of a feature extraction module that segments the video based on video mosaicing.
• Complete the development of algorithms with Naval/Joint imagery systems to handle video metadata, which includes Global Positioning System, time, and sensor information.
• Complete the development of recommendations for standardizing the storage and linking of feature descriptions within a common database framework.
• Complete the development and characterization of new target detection and recognition algorithms to exploit higher dimensional data (spatial, temporal, and spectral) within the Network Centric Warfare framework. Approach uses advanced correlation approaches to provide improved target detection and recognition performance by integrating multiple sensor measurements.
• Complete the development of a suitable ontology for exercising large-scale distributed situational threat awareness in Naval battlespace environments.
• Complete the augmentation of the real world information with computer-generated information in the Battlefield Augmented Reality System effort. The activity designed a modular framework to support the system design and enables the insertion of custom scheduling and replication solutions. Other efforts focused on the middleware layer to support emerging network centric sensor-to shooter systems.

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• Complete demonstration of new optimization techniques for resource allocation of submarine missiles.
• Complete development of technology to improve collaborative operational planning for tactical users using Head-Up Displays. (NRL)
• Initiate the development of software and algorithms for integrating the functions of target acquisition, tracking, data computation, and engagement control across multiple platforms for engaging multiple threats.

FY 2009 Plans:

• Continue all efforts from FY 2008 less those noted as completed above.
• Complete the development of a Case-Based Reasoning simulation/model for implementing situation, threat awareness fusion solutions and a Bayesian Network inference engine for manipulating uncertainty and learning from data.
• Complete the development of a 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.
• Complete development of automated methods for identifying significant changes between temporally separated images (not video) to extend work on automatic target recognition and pattern recognition into change detection algorithms.
• Complete sensor management algorithms that reduce the amount of labeled training data.
• Complete ontology-based information fusion for enhanced situational awareness and classification-based knowledge discovery.
• Complete efforts in Joint Director of Laboratory’s Data Fusion Model Level 1/2/3 data fusion using abductive reasoning, Bayesian networks, agent-based techniques, statistical-based methods, and other approaches.
• Complete efforts in automated image understanding that use active computations and visual pattern recognition for networked target recognition systems in maritime domain awareness.
• Complete efforts in the automated integration of disparate sources of information that involve data mining methods and game theory.
• Complete development of technology for improving voice data interpretation and presentation to cope with audio information overload in Navy Systems. (NRL)
• Complete development of technology for improved steganography and watermarking. (NRL)

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• Complete development of a scalable system design for coordinated Unmanned Aerial Vehicle (UAV) formation control that integrates onboard and offboard sensor data. (NRL)

	FY 2006	FY 2007	FY 2008	FY 2009
KNOWLEDGE SUPERIORITY AND ASSURANCE	4,575	5,542	24,586	13,295

This Activity 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 analysis of capabilities required in the 2010-2024 time frame.

Currently, small surface, ground, and airborne platforms have little to no situation awareness 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 Electro-optic/Infrared (EO/IR) technologies to provide them with a full spectrum threat warning and countermeasures capability. This capability, when integrated with future emitter identification and Low Probability of Intercept radar detection systems, will provide netted targeting information and cueing that enables self-protection. (This effort moves to Sea Strike under PE 0603114N in FY 2007.)

The significant increase from FY 2007 through FY 2009 is the result of the following:
• Numerous FNC efforts in this activity completed in FY 2006-2007. Most funding that could have focused on initiations in this activity in FY 2006-2007 was realigned across the PE to accommodate funding requirements for FNC efforts completing in these years in other activities (ex. Multi-Source Integration and Combat Identification).
• There was also a realignment of FNC investments to ECs to provide better coordination and visibility to these high stakes programs. The realignment was completed in FY 2007. As ECs deliver, new ones ramp up, and technology development matures (requiring a rebalancing between Budget Activities 2 and 3), spikes and valleys in EC funding within any PE line become common. This situation is compounded and the spikes and valleys exacerbated by the process of aligning ECs to different R-2 activities within a PE.
• Two ECs, Combat ID Information Management of Coordinated Electronic Surveillance and Automated Control of Large Sensor Networks, are initiated in FY 2007. These ECs have a substantial increase in total investment in FY 2008 to support technology development, limited objective experiments, and sea trials to validate metrics

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and utility in FY 2008. The increase of funding to this PE in FY 2008 and FY 2009 as well as the realignment of funds from the Communications and Networks Activity accommodates the increased investment required.

FY 2006 Accomplishments:

• Continued the EWISSP effort by exploration and refinement of the subsystem interface software that will operate via Versa Module Eurocard (VME)-64 and Recommend Standard (RS)-422 buses.
• Completed Environmental Visualization and transition near real-time meteorological and oceanographic (METOC) forecasting algorithms to the Navy Integrated Tactical and Environmental Systems program.
• Initiated the exploration of rapid course of action development using synthetic semi-automated forces for fast, large-scale, and high-fidelity simulations; including models of human cognition and visualization techniques for assessing outcomes and uncertainties.
• Initiated test of the subsystem interface for the EWISSP effort. This effort moves to Sea Strike under PE 0603114N in FY 2007.

FY 2007 Plans:

• Continue all efforts of FY 2006 less those noted as completed above.
• Continue Actionable Information from Multiple Intel Sources in a Global Information Grid Enterprise Services (GIG-ES) Environment (previously reported in PE 0603235N). Result in: automated integration of multi-INT surveillance & reconnaissance of red, white, and blue force locations for Combat ID by providing software integrated into Navy and Marine Corps Command Control & Combat Systems; order of magnitude less false recognition; and identification of significant military entities consistent with sensor capabilities.
• Continue effort for Improved Maritime Common Operational Tactical Picture in a GIG-ES Environment (previously reported in PE 0603235N). This effort provides software to perform level one fusion of intelligence sources and tactical organic sensors to provide knowledge about battlespace objects including location, track, and Combat Identification.
• Continue design of tools enabling mission-specific tactical sensor fields for at least two separate mission areas (previously reported in PE 0603235N).
• Continue design of tactical distributed data analysis and automated indications and warnings for 50% of tactical data (previously reported in PE 0603235N).
• Continue design of automated tactical platform and sensor planning and management sufficient for one operator to control multiple sensors (previously reported in PE 0603235N).

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• Continue developing and testing airborne and shipboard battle manager platforms for UAVs operating from Littoral Combat Ships. Continue developing and begin testing an open architecture airborne control station that can be used onboard a P-3 type aircraft for the control of multiple UAVs (Previously reported in PE 0602114N).
• Complete development of multi-vehicle cooperation technologies.
• Complete medium-fidelity simulation of multi-vehicle cooperation technologies for multiple classes of Naval unmanned vehicles in littoral Intelligence Surveillance and Reconnaissance (ISR) (Previously reported in PE 0602114N).
• Initiate development of object-level data fusion algorithms to improve maritime common operational picture development in a service oriented architecture environment.
• Initiate Joint Director of Laboratories Data Fusion Model Level 2/3 data fusion research exploring techniques using Bayesian networks, Dempster–Schafer Evidential Reasoning and other techniques for analyzing operational data in establishing routine behaviors & dependencies based on multi-intelligence fusion and anomaly recognition that indicates hostile intent in the maritime/littoral domain.
• Initiate investigation of smart tactical sensors, platforms, and algorithms in an urban/cluttered environment for at least 2 sensing modalities.
• Initiate investigation of human to tactical sensor field interface to enable the user to locate relevant knowledge within 3 minutes.
• Initiate investigation of local tactical net and Distributed Common Ground Station information interfaces to achieve Level 1 integration.
• Initiate the all-source track and identity fusion effort integrating a broad range of intelligence product information including: Kinematic Radar Reports, Organic and UAV imagery, electronic and communications emissions and human spot reports for tactical and organic sensors to be augmented with national sensors.

FY 2008 Plans:

• Continue all efforts of FY 2007 less those noted as completed above.

FY 2009 Plans:

• Continue all efforts of FY 2008 less those noted as completed above.
• Initiate effort to develop and apply emerging technologies that support delivery of Technology Oversight Group approved FNC ECs structured to close operational capability gaps that involve the common picture.

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• Initiate packaging of emerging common picture technologies into deliverable FNC products and ECs that can be integrated into acquisition programs within a five year period.
• Initiate efforts for the mature common picture technologies that support naval requirements identified within the FORCEnet naval capability pillar.

	FY 2006	FY 2007	FY 2008	FY 2009
COMMUNICATION AND NETWORKS	10,777	11,509	9,483	8,117

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 bandwidth efficient communication techniques; advanced networking techniques for robust, highly dynamic environments; interoperable wireless networks for secure communications and protocols; and 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.

Investments in the Communication and Networks activity are primarily aligned to Common Picture requirements associated research sponsored by ONR and the communication and network related efforts funded in the NRL base program. The substantial increase in funding required to properly fund FY 2007 FNC initiation efforts in FY 2008 under the Knowledge Superiority and Assurance (KSA) activity required an offset to other activities in this PE. As such, investment in initiations of non-FNC Communication and Networks efforts were reduced in FY 2008 to accommodate the funding required to meet project requirements for the FNC initiations in the KSA activity. The reduction in funding in this activity in FY 2008 is a direct result of an increase in overall FNC related work in this PE and reduction of non-FNC investments in this activity.

FY 2006 Accomplishments:

• Continued efforts to mature the superconducting cross-correlator to technology readiness level 4 to enable the development of a multi-function multi-net digital-Radio Frequency dehopping receiver for Link-16. This involves the integration of High Temperature Superconductors analog and Low Temperature Superconductors digital circuits in a COTS two-stage cryocooler.

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• Continued research and development into Navy/Marine Corps multiple-in-multiple-out (MIMO) antenna technology and orthogonal frequency division multiplexed (OFDM) signaling to improve data throughput (500 Mbps) in strong multipath environment.
• Continued project to architect multi-Mega bits per second (Mbps) naval laser communication system for ships. Designed rate-adaptable optical receiver using avalanche photo-diodes and array-detection techniques for improved performance in poor weather conditions.
• Continued development of Specific Emitter Identification (SEI) algorithms for communications signals by conducting lab tests and investigating combinations of precision classical parametric measurements and SEI techniques. (NRL)
• Continued construction and characterization of spectrally clean, out-phased high-power transmitter using X-band monolithic microwave integrated circuit (MMIC) technology, developing Continuous Wave (CW) radar receiver technology implementing wideband 500-MHz linear chirp at the X-band transmitter, and Ballistic Missile Defense (BMD) discrimination by performing experiments to study micro-Doppler signatures from BMD targets that undergo micro-motions. (NRL)
• Continued the design, fabrication and testing of adaptive radio frequency (RF) elements for autonomous systems to increase the RF performance of small stationary autonomous systems. (NRL)
• Continued 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)
• Continued development of technologies in support of responsive micro-satellites including high speed W-band communications, compact deployable structures, and small, xenon electric propulsion systems.
• Continued development of technology to improve mobile, ad hoc networks (MANET) via multi-agent programs. (NRL)
• Continued research and demonstrations of modulated near-infrared (IR) optical retroreflector data to develop spacecraft to spacecraft data exchange techniques. (NRL)
• Completed the development of a high efficiency communications transmitter based on delta-sigma modulation. Investigated transition path to deployment, including manufacture.
• Completed development of nonlinear adaptive equalizer for Ultra-High Frequency (UHF) submarine communications. Provided a proof of concept, tested at sea, mitigating multi-path and narrow band interference. Worked with acquisition partners on potential transition via Digital Signaling Process (DSP) software upgrades in submarine UHF receivers.
• Completed development of a highly linear and power efficient Very High Frequency (VHF)/UHF Power Amplifier (PA) using non-linear components. Demonstrated that a significant reduction in size, weight, and waste power can be achieved. Worked on transitioning this technology to the Joint Tactical Radio Systems (JTRS) program.

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• Completed development of the 802.11s standard that will specify a complete Enhanced Service Set Mesh architecture, including auto configuration, dynamic broadcast/multicast/unicast routing, end user mobility, security, and integration with other 802 Local Area Networks.
• Completed efforts to port Joint Tactical Radio System (JTRS) algorithms developed and tested in FY 2005 to a Digital Mobile Radio (DMR) by upgrading Version II DMR with G4 Altivec processors which hosted the spectrum analysis digital signal processor (DSP).
• Completed efforts on independent high-power radar operation, CW radar receiver technology, and BMD discrimination. (NRL)
• Initiated development of high data rate (HDR) communications (> 1 Gbps data links) for small tactical Unmanned Aerial Vehicles (UAV) in ISR applications, meeting the size, weight and power requirements.
• Initiated development of Robust Airborne Networking Extensions (RANGE) for joint battlespace networking, networking UAVs, and hybrid mobile ad hoc networking (MANET)/satellite operation. Implemented MANET protocols for cross-layer optimized routing, including disruption tolerant networking to sensors and platforms.
• Initiated development of an ultra-wide band (UWB) groundwave communication transceiver for a distributed sensor network and gateway buoys.
• Initiated Broadband Electronically-steerable Array for Mission Security (BEAMS), a low cost analog beam forming and steering technique for UAV to UAV and UAV to ground station communications.
• Initiated development of protocols and algorithms for mobility and security in emerging IPv6 next generation MANET.
• Initiated development of technology to improve tactical network Satellite Communication linkage and multi-user detection. (NRL)
• Initiated development of an adaptive rate terminal to maintain laser communications in poor weather conditions.
• Initiated the development of free space hybrid Infrared laser communications links with greater than 10X bandwidth of digital link for same power. (NRL)

FY 2007 Plans:

• Continue all efforts of FY 2006 less those noted as completed above.
• Complete cryogenic packaging, test, and demonstrate direct digital dehopping of multiple Link-16 waveforms. Establish transition path to JTRS-compliant communications.
• Complete research and development in MIMO antenna technology and OFDM 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 and/or JTRS.

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• 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 BEAMS prototyping and demonstrating Rotman lens beamformer on small UAVs for additional range and mission security.
• Complete development of technology to improve mobile, ad hoc networks via multi-agent programs. (NRL)
• Complete communications SEI by transitioning best approaches into operational Navy electronic support and electronic attack systems. (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 technologies in support of responsive micro-satellites including high speed W-band communications, compact deployable structures, and small, xenon electric propulsion systems. (NRL)
• Initiate development of digital beam forming and steering for small UAVs in upper Ka band (38 GHz), including Risley prism conformal antennas and lightweight switched beam antennas made of composite materials.
• Initiate development of small foot-print, low-power fly-by optical communications underwater between unmanned underwater vehicles (UUV)/unmanned surface vehicles (USV) and bottomed sensor field, utilizing blue-green directly modulated semiconductor lasers.
• Initiate development of submarine to UUV/USV/sensor Comms using underwater Modulating Retroreflector technology.
• Initiate development of advanced topology and medium access control (MAC) for extremely low power consuming sensor networks.
• Initiate techniques for UWB range extension by time reversal and other methods, including receiver prototyping.
• Initiate development of low-cost integrated stub antenna and ferroelectric phased array technology for directional communications.
• Initiate expanded study of "friendly" GPS jamming techniques to include those designed specifically to minimize fratricide while maintaining effectiveness of jamming against threat GPS receivers. (NRL)
• Initiate the development of pattern recognition algorithms to allow detection and identification of intruders into remote or urban areas. (NRL)
• Initiate the development of technical characteristics of a Communications Electronic Attack (EA) system that consists of a master EA platform that operates in concert with a network of simple subordinate platforms. (NRL)
• Initiate investigation of the feasibility of performing emissive hyperspectral imaging for detection and recognition of targets at night with high search rates and high resolution ground samples. (NRL)

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FY 2008 Plans:

• Continue all efforts of FY 2007 less those noted as completed above.
• Complete prototyping of the HDR communications (> 1 Gbps data links) for small tactical Unmanned Aerial Vehicles (UAV) in ISR applications, meeting the size, weight and power requirements.
• Complete development of Robust Airborne Networking Extension (RANGE) protocols and software kit for dynamic inter-UAV networking.
• Complete development of an ultra-wide band (UWB) groundwave communication transceiver and high frequency (HF) antenna for a distributed sensor network and gateway buoys.
• Complete development of protocols and algorithms for mobility and security in emerging IPv6 next generation MANETs.
• Complete 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 underwater Extremely Low Frequency (ELF) antenna and RF technology for submarine comms at speed and depth.
• Initiate development of frequency agile and cognitive communications.
• Initiate development of low probability of intercept/low probability of detect communications, including multipath mitigation of tactical common data link (TCDL).
• Initiate development of protocols and middleware for rapid self-configuration and mobility management (up to hypersonic speeds) in mobile ad-hoc networks.

FY 2009 Plans:

• Continue all efforts of FY 2008 less those noted as completed above.
• Complete prototyping of the conformal array for digital beam forming and steering on small UAVs in upper Ka band (38 GHz).
• Complete development of small foot-print, low-power fly-by optical communications underwater between unmanned underwater vehicles (UUV)/unmanned surface vehicles (USV) and bottomed sensor field, utilizing direct modulated semiconductor lasers or modulating retro-reflectors (MRR) in the blue-green band.
• Complete development of advanced topology and medium access control (MAC) for extremely low power consuming sensor networks.
• Complete prototyping of receivers that demonstrate UWB range extension by time reversal methods.

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• Complete the development of free space hybrid Infrared laser communications links with greater than 10X bandwidth of digital link for same power. (NRL)
• Complete the development of pattern recognition algorithms to allow detection and identification of intruders into remote or urban areas. (NRL)
• Initiate TOG approved FNC efforts.
• Initiate development of intelligent autonomous networking algorithms and protocols that combines aspects of cognitive radios with intelligent agents.
• Initiate advanced source coding and compression technologies with underwater RF propagation (using advanced antenna techniques developed concurrently) for high CSD (Comms at Speed and Depth) bandwidth efficiency.

	FY 2006	FY 2007	FY 2008	FY 2009
MULTI-SOURCE INTEGRATION AND COMBAT IDENTIFICATION	8,690	9,994	1,125	822

This activity addresses 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. This activity supports the Sea Shield Pillar Enabling Capability of Real Time Long Range Air Defense CID in Support of Early Engagements and related CID Science & Technology to be worked under the FORCEnet Future Naval Capability (FNC).

The funding decrease from FY 2007 to FY 2008 is due to completion of the technology/algorithm development for Multi-Source Integration (MSI), Composite Combat Identification (CCID), and Advance Sensor Netting Technology (ASNT) in FY 2007.

FY 2006 Accomplishments:

• Continued laboratory demonstrations of ASNT and CCID.
• Continued MSI project development and testing of algorithms to integrate real time and non-real time sensor data and correlate satellite communications (SATCOM) data in the E-2C mission computer.
• 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.

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• Continued development of CCID algorithms to correlate and fuse real time tracks with intelligence, surveillance, and reconnaissance data in Ship Signal Exploitation Equipment (SSEE) equipped surface ships and common reasoning algorithms for CID capability to rapidly build high confidence identification of air tracks using all available ID attributes in theater.
• Initiated development of a robust test environment to elucidate the design principles of human and sensor network interactions. (NRL)

FY 2007 Plans:

• Continue all efforts of FY 2006.
• Complete ASNT, CCID, and MSI development. MSI, ASNT, and CCID will transition to the E-2C/D Program Management Office (PMA-231), Intelligence, Surveillance, Reconnaissance, and Information Operations Program Office (PMW-180), and Program Executive Office-Integrated Warfare Systems (PEO-IWS).
• Initiate effort to improve the resolution of the High Frequency Relocatable Over-the-Horizon Radar (HF-ROTHR) more than two orders of magnitude using time-reversal methods. (NRL)

FY 2008 Plans:

• Continue all efforts of FY 2007 less those noted as completed above.

FY 2009 Plans:

• Continue all efforts of FY 2008.
• Complete development of a robust test environment to elucidate the design principles of human and sensor network interactions. (NRL)

	FY 2006	FY 2007	FY 2008	FY 2009
HUMAN FACTORS AND ORGANIZATIONAL DESIGN	5,410	5,755	6,583	4,720

This activity (formerly Human Computer Interface) 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

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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/Visualization.

Funding profile increases from FY 2007 to FY 2008 are due to additional emphasis and expansion of the exploration of cognitive modeling and exploration of Human and Organizational Interfaces to large complex data sets including the Global War on Terrorism (GWOT).

FY 2006 Accomplishments:

• Continued evaluation of Latent Semantic Analysis (LSA) of operator communications as an effective metric of shared situational awareness in unmanned aerial vehicle control teams.
• Continued demonstration of 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.
• Continued developing jointly with the Naval Air Systems Command, 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.
• Continued model-based simulations and experiments to investigate the effectiveness of hierarchical organizational structures in network-centric operational environments in order to evaluate the implementation of FORCEnet concepts.
• Continued development of new threat scenarios incorporating Joint Force Maritime Component Commander operations, counter-insurgency and humanitarian operations with the staff of the Naval War College. These new threat scenarios will provide the basis for Limited Objective Experiments in the Innovation Laboratory at the Naval War College.
• Continued development of Dynamic Network analysis (a terrorist network analysis tool) in operational command setting at U.S. Pacific Command.
• Continued the improvement of terror network analysis decision tools for combatant command use and military planning, including testing of tools, development of metrics, and validation.
• Continued evaluation of the effectiveness of a change history tool to minimize the effect of interruptions.
• Continued application of cognitive architecture modeling to the design of interface analysis tools.

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• Continued deployment of models for Effects-Based Operations (EBO) aboard naval vessels to support Expeditionary Group One to conduct kinetic and non-kinetic tactical operations in a measured manner.
• Continued development of a cognitive model of human performance with 3D audio displays.
• Continued development of technology to improve voice biometrics via the development of multi-dimensional, adaptive speaker verification technology. (NRL)
• Continued jointly with the Air Force applied research on the integration of Information Operations in Air Control Centers.
• Continued applied research on command and control adaptive architectures for Expeditionary Strike Groups working with OPNAV N-75B and Expeditionary Strike Group ONE, San Diego.
• Continued development of a user tool to counteract perceptual errors associated with 3D perspective-view visual displays.

FY 2007 Plans:

• Continue all efforts of FY 2006.
• Complete development of technology to improve voice biometrics via the development of multi-dimensional, adaptive speaker verification technology. (NRL)
• Initiate the development of advanced computational models capable of analyzing multi-dimensional networks of thousands of nodes. Current capabilities enable the analysis of networks consisting of hundred of nodes.
• Initiate the development of computational models of influence that incorporate the social structure, values and cultural processes of urban non-western communities for achieving post-conflict stabilization.
• Initiate the development of social network models to model the human element in maritime domain awareness.
• Initiate effort to 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.
• Initiate effort to incorporate the EWALL prototype into a simulation of the Tactical Operations Center of the Special Operations Forces and collect performance data to validate effectiveness.
• Initiate Sea Basing research on rehearsal for Expeditionary Strike Groups in the conduct of maritime interdiction missions and developing reach-back capability for computationally intense analysis for evaluating courses of action.

FY 2008 Plans:

• Continue all efforts of FY 2007 less those noted as completed above.

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• Complete development of a user tool to counteract perceptual errors associated with 3D perspective-view visual displays.
• Complete research on tools to assist in the management of task interruptions.
• Initiate 3D audio experiments in the context of Common Enterprise Display System (CEDS) to evaluate cognitive models of 3D audio perception.
• Initiate experiments to support the development of computational models of human color perception, for developing tools and systematic guidelines for color displays that are intuitive and compatible with human perceptual capabilities.
• Initiate an effort to develop an integrated data fused system that provides a submarine Commanding Officer with improved tactical situational awareness.
• Initiate an effort to investigate the potential for augmented/enhanced vision inspection systems to aid the war fighter in detecting corrosion on various types of metals under adverse environmental and ambient conditions, e.g. desert.
• Initiate research on advanced computational models to incorporate additional capabilities in the analysis of terror networks and on various types of flow in these networks (such as the flow of expertise, resources).
• Initiate effort to improve social network models to analyze merchant marine traffic.
• Initiate development of metrics to identify and measure the contribution to team performance of the cognitive processes underlying ad-hoc team decision making.
• Initiate effort to improve the model of ad-hoc team decision making by including collaborative agent-based contribution to team performance.
• Initiate research on the application of information architectures (DOD Architectures Framework), executable models (Petri Nets) and cognitive models to the systematic design of Human-Computer Integration.
• Initiate effort to develop tools for more automated, cost-efficient modeling of human system interaction.
• Initiate research on adaptive command and control architectures in support of the Navy’s new Maritime Strategy.

FY 2009 Plans:

• Continue all efforts of FY 2008 less those noted as completed above.

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	FY 2006	FY 2007	FY 2008	FY 2009
TACTICAL SPACE EXPLOITATION	15,012	14,818	23,108	12,218

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 effort began in FY 2006. The significant increase in planned funding in FY 2008 represents resources required to cover costs of hardware, research, and demonstration of technology associated with all programs, with a significant portion of this funding being allocated in support of the Maritime Hyperspectral Payload for satellite based experiments effort.

FY 2006 Accomplishments:

• Initiated development of 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.
• Initiated development of small multifunctional integrated signals electronics systems for ship tracking from space and two-way data exfiltration from distributed global sensors.
• Initiated 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.
• Initiated and complete system designs including configuration of satellite hardware electronics to enable procurement of flight parts.
• Initiated preliminary environmental and flight testing of hardware components.

FY 2007 Plans:

• Continue all efforts of FY 2006.
• Complete preliminary environmental and flight testing of hardware components.

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• Initiate program to use chemical release from satellites launched into selected low-Earth orbits to de-populate intense trapped electrons in radiation belts following a low-altitude nuclear explosion in space. (NRL)

FY 2008 Plans:

• Continue all efforts of FY 2007 less those noted as completed above.

FY 2009 Plans:

• Continue all efforts of FY 2008.
• Complete and launch maritime hyperspectral payload on TacSat or Space Test Program (STP) satellite. Develop improved maritime hyperspectral payload for flight on National Polar-orbiting Operational Environmental Satellite System (NPOESS) through STP. Complete analysis of TacSat 3 data.

CONGRESSIONAL PLUS-UPS:

	FY 2006	FY 2007
ADVANCED PANORAMIC SENSOR SYSTEMS FOR UAVS	0	996

This effort develops advanced visual imaging technologies and related sensor and computing technologies for unmanned aerial vehicles (UAVs).

	FY 2006	FY 2007
AIREP	5,316	0

Continued to expand the Advanced Integrated Radar Electronics and Photonics (AIREP) testbed by installing UHF radar, integrating an open architecture combat system, integrating an automatic identification system for surface ships, completing space time adaptive modeling and demonstrating a simulation of an open architecture radar receiver.

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COORDINATED OPERATION OF UNMANNED VEHICLE FOR LITTORAL WATERS	2,509	0

This effort developed: (1) bio-inspired robot platforms for advanced mobility; and (2) methods for coordinated operations involving teams of humans, software agents, and heterogeneous robots.

	FY 2006	FY 2007
CRITICAL AREA PROTECTION SYSTEMS HIGH RESOLUTION SITUATIONAL AWARENESS	1,437	0

This effort continued development and testing of the High Resolution Situational Awareness system for CAPS (Critical Area Protection System): CAPS-HiRSA (High Resolution Situational Awareness). HiRSA is the command and control software within CAPS that provides land-based anti-terrorism/force protection (AT/FP) operators with a persistent surveillance capability and a common operating picture.

	FY 2006	FY 2007
EXPEDITIONARY WARFARE TESTBED GLOBAL INFORMATION GRID ENTERPRISE SERVICES	958	0

This project examined the use of Service Oriented Architecture (SOA) and similar technologies in tactical and low bandwidth environments. The project was used to determine what technology elements could and could not work under specific circumstances.

	FY 2006	FY 2007
Mobile Modular Command and Control (M2C2)	6,224	5,978

FY 2006: Continued the development of command and control subsystems to support on-the-move command and control suitable for future insertion into the Marine Corps to-be-selected transportable vehicle.

FY 2007: This effort supports the M2C2 project.

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	FY 2006	FY 2007
MULTICULTURAL OPERATIONS TRAINING AND TACTICS SYSTEMS (MCOTTS)	0	1,644

This effort supports Multicultural Operations Training and Tactics Systems (MCOTTS).

	FY 2006	FY 2007
Network Applications Integration Facility (NAIF)	4,885	0

Continued to develop interfaces between Tactical Component Network (TCN) and other systems, including examining the extension of Cooperative Engagement Capability (CEC) to disadvantaged platforms thru TCN.

	FY 2006	FY 2007
PACIFIC MISSILE RANGE FACILITY/PEARL HARBOR INTEGRATED NETWORK	0	2,888

This effort improves ability to monitor and display the increasing volume of data collected during tests and exercises at the range.

	FY 2006	FY 2007
PACIFIC THEATER DATA FUSION TESTBED	1,627	0

Developed a Pacific-theater Data Fusion Testbed (PDFT) and provided the U.S. Navy and Missile Defense Agency (MDA) with advanced discrimination and tracking capabilities by developing a framework theater-wide sensor fusion center, multiple discrimination and tracking algorithms, and providing performance verification from development through testing.

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	FY 2006	FY 2007
PACOM AGILE COALITION ENVIRONMENT	0	6,775

The Pacific Agile Coalition Environment (ACE) effort is developing crypto devices agile enough to create virtual private networks (VPNs) to support bilateral and tailored multi-lateral relationships without having to build or lock-down unique networks for each community-of-interest security enclave. ACE enables CENTRIXS to converge from a set of independent networks to a single network that supports multiple security enclaves on an on-demand basis.

	FY 2006	FY 2007
RADIO SENSOR MODULE (RASM)	1,150	2,192

FY 2006: Follow-on to Common Sensor Module (COSM). COSM dealt specifically with near-field magnetic field detection from the charging system of vehicles. RASM examined a phenomenon which could permit longer range detection of metallic objects. The project developed Electro-magnetic remote sensing capabilities to detect armed individuals at distances suitable for taking necessary defensive action.

FY 2007: This effort supports the Radio Sensor Module project.

	FY 2006	FY 2007
SENSORNET	16,758	0

Continued design and development of an information technology infrastructure to provide a national comprehensive incident management system that can provide near-real-time, reliable and secure, collection, processing, management, and dissemination of sensor data (weather, radiological, chemical and video). This data would be relayed to first responders dispatched to an event area while simultaneously alerting centers at the state, regional, and national levels of the incident and response activities.

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	FY 2006	FY 2007
THEATER UNDERSEA WARFARE INITIATIVE	5,746	5,578

FY 2006: This effort developed and enhanced Theater Under Sea Warfare (TUSW) program tools for rehearsal simulations, asset allocation and asset status with an implemented net-centricity approach: a client-server architecture supports the simulation and rehearsal activities to provide a responsive ‘gaming’ environment, while a service oriented architecture supports resources (computational, storage, network) and services (physics, TDAs, dynamic data) integration.

FY 2007: This effort supports theater undersea warfare program research, and transition of an asset allocation tool function point (search effectiveness map) to the USW-DSS Program of Record.

	FY 2006	FY 2007
WEBSTER INTEGRATION	958	0

This effort developed software that collects, fuses and analyses data from multiple web-based information sources to assist naval decision makers.

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

PE 0601153N (Defense Research Sciences)
PE 0602114N (Power Projection Applied Research)
PE 0602123N (Force Protection Applied Research)
PE 0602131M (Marine Corps Landing Force Technology)
PE 0602236N (Warfighter Sustainment Applied Research)
PE 0602271N (RF Systems Applied Research)
PE 0603114N (Power Projection Advanced Technology)
PE 0603123N (Force Protection Advanced Technology)
PE 0603235N (Common Picture Advanced Technology)
PE 0603236N (Warfighter Sustainment Advanced Technology)
PE 0603271N (RF Systems Advanced Technology)
PE 0603609N (Conventional Munitions)

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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)

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.