Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Navy										DATE: February 2010	
APPROPRIATION/BUDGET ACTIVITY 1319: *Research, Development, Test & Evaluation, Navy* BA 2: *Applied Research*				R-1 ITEM NOMENCLATURE PE 0602235N: *Common Picture Applied Research*							
COST ($ in Millions)	**FY 2009 Actual**	**FY 2010 Estimate**	**FY 2011 Base Estimate**	**FY 2011 OCO Estimate**	**FY 2011 Total Estimate**	**FY 2012 Estimate**	**FY 2013 Estimate**	**FY 2014 Estimate**	**FY 2015 Estimate**	**Cost To Complete**	**Total Cost**
Total Program Element	89.673	90.440	70.168	0.000	70.168	67.281	63.400	62.980	66.380	Continuing	Continuing
0000: *Common Picture Applied Research*	81.196	82.732	70.168	0.000	70.168	67.281	63.400	62.980	66.380	Continuing	Continuing
9999: *Congressional Adds*	8.477	7.708	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	101.644

A. Mission Description and Budget Item Justification

The efforts described in this Program Element (PE) are based on investment directions as defined in the Naval Science and Technology (S&T) Strategic Plan approved by the S&T Corporate Board (Feb 2009). This strategy is based on needs and capabilities from Navy and Marine Corps guidance and input from the Naval Research Enterprise (NRE) stakeholders (including the Naval enterprises, the combatant commands, the Chief of Naval Operations (CNO), and Headquarters Marine Corps). It provides the vision and key objectives for the essential science and technology efforts that will enable the continued supremacy of U.S. Naval forces in the 21st century. The Strategy focuses and aligns Naval S&T with Naval missions and future capability needs that address the complex challenges presented by both rising peer competitors and irregular/asymmetric warfare.

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 S&T investments. The program focus is on S&llars and contains investments in the following Enabling Capabilities (ECs): Combat Identification (ID) Information Management of Coordinated Electronic Surveillance, Automated Control of Large Sensor Networks, OCO Focused Tactical Persistent Surveillance, Globally Netted Joint/Coalition Force Maritime Component Commander, Dynamic Tactical Communications Networks, Dynamic C2 for Tactical Forces and Maritime Operations Center (MOC), High-bandwidth Free-space Lasercomm, Actionable Intelligence Enabled by Persistent Surveillance, Pro-Active Computer Network Defense and Information Assurance, Fast Magic, and NRL Space. 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 ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Previous President's Budget	85.209	83.163	0.000	0.000	0.000
Current President's Budget	89.673	90.440	70.168	0.000	70.168
Total Adjustments	4.464	7.277	70.168	0.000	70.168
• Congressional General Reductions		-0.377			
• Congressional Directed Reductions		0.000			
• Congressional Rescissions	0.000	-0.086			
• Congressional Adds		7.740			
• Congressional Directed Transfers		0.000			
• Reprogrammings	5.722	0.000			
• SBIR/STTR Transfer	-1.258	0.000			
• Program Adjustments	0.000	0.000	70.168	0.000	70.168

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2009	FY 2010
Project: 9999: *Congressional Adds*		
Congressional Add: *Cognitive Radio Institute*	0.000	0.797
Congressional Add: *Head Attitude Tracking System*	0.000	1.593
Congressional Add: *Intelligent Decision Exploration*	0.000	3.884
Congressional Add: *Sensor Integration Framework*	1.197	1.434
Congressional Add: *All Weather Sense & Avoid Sensors for UAVs*	2.492	0.000
Congressional Add: *Layered Surveillance/Sensing*	1.596	0.000
Congressional Add: *SOF Test Environment for Adv Team Collaboration Missions*	1.995	0.000
Congressional Add: *Unmanned Ground Vehicle (UGV) Mobility & Coordination in Joint Urban/Littoral En*	1.197	0.000
Congressional Add Subtotals for Project: 9999	8.477	7.708
Congressional Add Totals for all Projects	8.477	7.708

Exhibit R-2, RDT&E Budget Item Justification: PB 2011 Navy	DATE: February 2010
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Change Summary Explanation

Technical: Not applicable.

Schedule: Not applicable.

FY11 from previous President's Budget is shown as zero because no FY11-15 data was presented in President's Budget 2010.

Exhibit R-2A, RDT&E Project Justification: PB 2011 Navy			DATE: February 2010
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COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
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A. Mission Description and Budget Item Justification

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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 S&T investments. The program focus is on S&llars and contains investments in the following Enabling Capabilities (ECs): Combat Identification (ID) Information Management of Coordinated Electronic Surveillance, Automated Control of Large Sensor Networks, OCO Focused Tactical Persistent Surveillance, Globally Netted Joint/Coalition Force Maritime Component Commander, Dynamic Tactical Communications Networks, Dynamic C2 for Tactical Forces and Maritime Operations Center (MOC), High-bandwidth Free-space Lasercomm, Actionable Intelligence Enabled by Persistent Surveillance, Pro-Active Computer Network Defense and Information Assurance, Fast Magic, and NRL Space. 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).

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
COMMUNICATION AND NETWORKS	10.161	6.721	8.811	0.000	8.811

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
The overarching objective of this activity is to develop high throughput dynamic wireless communications and networks technologies critical to the mission performance and robustness of naval communications for widely dispersed mobile air, land, surface and submerged platforms. These platforms are often size, weight and power (SWaP) limited, and will operate under constraints of cluttered RF spectrum, harsh electro-magnetic interference (EMI) and Beyond Line Of Sight (BLOS) conditions. The technical payoff is increased network data rates, interoperability across heterogeneous radios, dynamic bandwidth management, and greater mobile network connectivity. The operational payoff is that warfighters from the operational command to the tactical edge have near real-time access to information, knowledge and decision-making necessary to perform their tasks, including coalition and allied forces. Emphasis is on tactical edge communications and networks to fully realize net-centric warfare, bridging the Global Information Grid (GIG) and the 'disadvantaged user', e.g., small-deck combatants, submarines, unmanned vehicles, distributed sensors and ground units in urban and radio frequency (RF) challenged environments. The current specific objectives are: a) Radios and Apertures: Develop technologies for high band radio, electrically-small and activelyscanned antennas, addressing critical issue of radio spectrum bandwidth efficiency, spectrum contention and clutter, agile frequency communications with dynamic spectrum access, all-digital front-end with wide dynamic range, power amplifier efficiency, multipath effects, saltwater propagation and BLOS communications. Develop algorithms and signal processing for space-time-frequency diversity communications, including measures for electronic protection, such as low-intercept antijam waveforms and modulation. Develop affordable antenna technologies for small size and weight, high radiation efficiency, and wideband operation with rapid beam-steering. Develop alternatives to RF communications in airborne and terrestrial environments as well as high data rate underwater communications for undersea warfare (distributed sensors netting, unmanned underwater vehicle data exfiltration, submarine Communications at Speed and Depth) using electro-optic/infra-red (EO/IR) technologies. Develop secure, high bandwidth communications systems and the exploitation of existing					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
and emerging network protocols that will avail development of new Low Earth Orbit (LEO) based data transport mechanisms. b) Tactical Networking and Network Control/Management: Develop advanced networking techniques for robust, highly dynamic environments; interoperable networks for secure communications and protocols, bandwidth and network management techniques that manage and allocate bandwidth across tactical and theater levels in support of net-centric operations. Develop rapidly auto-configuring and selforganizing networks with efficient and survivable routing, secure authentication, mobility management and Quality-of-Service guarantee while optimizing network resources. Address low bandwidth, synchronization and reliability for Service Oriented Architecture (SOA)/middleware architecture in both mobile ad-hoc networks (MANET) and infrastructure-based Internet Protocol (IP) backbone networks. Develop cognitive network planning and operations engines whose criteria are based directly on mission objectives while self-adapting and managing the spectrum allocation and radio resources in such a way that network operations, SOA community of interest, and computer network defense are integrated to form a single common tactical network picture that requires a minimum of human intervention and skill. Develop technology for improving tactical edge networking and for improving voice communications. The decrease from FY 2009 to FY 2010 is the result of the transfer of resources from this R2 Activity to the Knowledge Superiority and Assurance R2 Activity to support the Overseas Contingency Operations Focused Tactical Persistent Surveillance effort. Additionally, this was due to an increased level of effort on a one time basis during FY 2009 to investigate technology supporting networked electronic warfare efforts executing within this PE. The following are non-inclusive examples of accomplishments and plans for projects funded in this activity.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2009 Accomplishments: Radios and Apertures: - 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. - 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 Broadband Electronically-steerable Array for Mission Security (BEAMS), a low cost analog beam forming and steering technique for unmanned aerial vehicle (UAV) to UAV and UAV to ground station communications. - Continued development of an adaptive rate terminal to maintain laser communications in poor weather conditions. - Continued development of digital beam forming and steering for small UAVs in upper Ka band (38GHz), including Risley prism conformal antennas and lightweight switched beam antennas made of composite materials. - Continued development of submarine to unmanned underwater vehicle (UUV)/unmanned surface vehicle (USV)/sensor comms using underwater Modulating Retroreflector technology. - Continued development of low-cost integrated stub antenna and ferroelectric phased array technology for directional communications. - Continued 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. - Continued development of underwater Extremely Low Frequency (ELF) antenna and RF technology for submarine comms at speed and depth.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Continued development of metamaterial structures and periodic inductive and capacitive loading for submarine High-Frequency Internet Protocol (HF-IP) buoy-cable antennas (BCA). - Continue the development of pattern recognition algorithms to allow detection and identification of intruders into remote or urban areas. - Completed prototyping of the conformal array for digital beam forming and steering on small UAVs in upper Ka band (38 GHz). - Completed development of small foot-print, low-power fly-by optical communications underwater between UUVs/USVs and bottomed sensor field, utilizing direct modulated semiconductor lasers or modulating retro-reflectors (MRR)in the blue-green band. - Completed prototyping of receivers that demonstrate ultra-wide band (UWB) range extension by time reversal methods. - Completed the development of free space hybrid Infrared laser communications links with greater than 10X bandwidth of digital link for same power. - Initiated development of Line of Sight (LOS) high data rate UAV-sensor communications for expeditionary forces. - Initiated development of advanced signal processing, coding and switching amplifier techniques for high power amplification. - Initiated metamaterials based dish antennas development for Ka-Ku band satellite communications (SATCOM). - Initiated development of low intercept and low probability of Detection (LPD), jam resistant communications/networks for distributed nodes. - Initiated blue-green fiber laser technology development for space-based submarine communications. Tactical Networking and Network Control/Management: - Continued 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.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2010 Plans: Radios and Apertures: - Continue all efforts of FY 2009 less those noted as completed above. - Complete ultra wideband time reversal technique improvement, up to a factor of 2 compared to when channel estimation techniques are not used. - Complete demonstrations of pattern recognition algorithms to allow detection and identification of intruders into remote or urban areas. - Complete 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. - Complete the development wireless-ready, reliable data transport technologies suitable for tactical-edge and afloat networks. - Initiate development and demonstrate electrically small antennas at VLF/HF, as well as lightweight beam steering antennas for UAVs using switched (ferrite) multi-horns and Risley prisms with 15-30 dB gain and 1.5 GHz bandwidth in the 38 GHz band. - Initiate design and development of low observable jam resistant waveform, including directionalization, for advanced tactical data links. - Initiate design and development of electronic protection for HF communications. Tactical Networking and Network Control/Management: - Continue all efforts of FY 2009 less those noted as completed above. - Initiate development of a SOA-based secure tactical wide area network for coalition forces, showing independence of coalition tactical communications from satellite backhaul, bandwidth management and service discovery. - Initiate development of topology control, discovery mechanisms and directional networking for free space optical links. - Initiate design and development of cognitive netops for tactical communications.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2011 Base Plans: - Continue all efforts of FY 2010 less those noted as completed above. - Complete demonstrations of ELF/VLF switched antenna with higher radiation efficiency. - Complete development of digital beam forming and steering for small UAVs in upper Ka band (38GHz), including Risley prism conformal antennas and lightweight switched beam antennas made of composite materials. - Initiate development of structurally integrated HF antennas. - Initiate development of integrated metamaterial antennas for ship and ground platforms. - Initiate demonstrations of high peak power short pulse operation of fiber lasers in blue-green region. - Initiate development of optical wavefront modulation techniques and optical phased array beam steering methods for terrestrial EO/IR Lasercomm. - Initiate new architecture and modes of operation, develop prototypes for advanced tactical data link operation in both contested and anti-access regions. Tactical Networking and Network Control/Management: - Continue all efforts of FY 2010 less those noted as completed above. - Initiate the development of social network analysis algorithms for protecting wireless networks. - Initiate development of agent based communications, control and distributed authentication techniques in dynamic MANET networks. - Initiate cognitive networking, cross-layer optimization protocols for light SOA for tactical networks					
COMPUTATIONAL FRAMEWORK AND METHODS FOR RAPID ACCURATE DECISION MAKING The goal of this activity is to support FORCEnet by developing enablers for decision making and mission execution to achieve battlespace superiority. It focuses on the development of algorithms and software technologies that identify and integrate informational content from multiple sources, leading to decision aids that support user-cognitive processes. Because persistent sensors are generating massive amounts of data, the focus is on technologies that not only integrate information from diverse	26.373	24.785	15.516	0.000	15.516

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
sources, but also provide indications of information significance in ways that support the user's decision needs regardless of location and 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. Effort will also be devoted to developing technology for increasing assurance and security for C3 information systems and technology for improving information discovery and information presentation in such systems. The current specific objectives are: a) Automated Intelligence Tools: Develop automated image and signal intelligence understanding tools based on rigorous mathematical and statistical methods that lead to improved change detection, improve object and activity detection and recognition capabilities, context and scene understanding, and inferring of the threat levels to support decision making and persistent and adaptive surveillance. b) Battlespace Sensor and Intelligence Integration: Develop innovative methods for combining traditional and non-traditional data from sensors and disparate sources to provide the best estimate of objects, events, and conditions in the battlespace, in terms of their identity, associated error or uncertainty, context, impact, and infer relationships and their intentions. c) Automated Reasoning Methods and Models for Situational Analysis: Develop rigorous and efficient methods for building sophisticated situational models, develop automated reasoning techniques to categorize and recognize situations under a variety of conditions leading to methods that predict situations under different settings. d) Automated Decision Tools: Develop automated decision tools based on mathematically rigorous techniques (e.g., mathematical optimization) that support decision-making to ensure the best use of scarce and/or expensive resources to achieve optimal allocations for large complex scenarios, including ones that contain uncertainty, in drastically reduced amounts of time. Develop methods that support					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
decision making in networked sensor management and allocation to ensure sensor assets are deployed in an optimal or near optimal manner. e) Secure Sensor Networks: Develop tools and methods to securely handle information without exposing intelligence information about the networks or systems to adversaries. The decrease between FY 2009 and FY 2010 is the result of the transfer of resources from this R2 Activity to support the Globally Netted Joint/Coalition Force Maritime Component Commander and the Dynamic C2 for Tactical Forces and Maritime Operations Center areas in the Knowledge Superiority and Assurance Activity within this PE. The significant decrease between FY 2010 and FY 2011 is the result of the completion of activities and discontinuation of funding associated with the Joint Integrated Fires Control effort. The following are non-inclusive examples of accomplishments and plans for projects funded in this activity. *FY 2009 Accomplishments:* Automated Intelligence Tools: - Continued the demonstration and conducted image registration error analysis for the multi-resolution and multi-scale image processing effort. - Continued development of semi-supervised detection algorithms for multi-sensor imagery, video and human intelligence that will enable self-deploying sensor networks. - Continued development of interactive image/video-based surveillance systems for perimeter protection, and port protection. - Continued the development of a new radar signature analysis technique based on nonlinear dynamics.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Continued the development of a novel particle filter-based elevation angle tracking algorithm to improve the capability to track low-angle targets over the sea surface under multipath conditions using passive sensors. - Continued the development of the theory and technology for near-field electromagnetic (EM) phenomenology relevant to high resolution, through-the-wall imaging at close ranges in urban operations. - Completed 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. - Completed efforts in automated image understanding that use active computations and visual pattern recognition for networked target recognition systems in maritime domain awareness. - Completed development of a scalable system design for coordinated Unmanned Aerial Vehicle (UAV) formation control that integrates onboard and off-board sensor data. - Complete the development of a new radar signature analysis technique based on nonlinear dynamics. - Initiated development of coordinated multi-platform, multi-component waveforms. - Initiated development of a real-time electronic warfare support deinterleaving capability. - Initiated development of advanced communications emitter identification. Battlespace Sensor and Intelligence Integration: - Continued demonstration of a trusted data store which maintains data pedigree and detects anomalies in a limited objective experiment. - Continued development of an interface between the Level 1 and Level 2/3 data fusion processes across federated service oriented architectures. - Continued 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.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Continued 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. - Continued 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. - Continued the investigation of service oriented methods to automatically retrieve relevant information for a community of interest. - Continued the development and testing of the Joint Integrated Fires Control effort. - Completed 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. - Completed 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. - Completed efforts in the automated integration of disparate sources of information that involve data mining methods and game theory. - Completed development of technology for improving voice data interpretation and presentation to cope with audio information overload in Navy Systems. - Initiated 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, with an emphasis on missions that are related to OCO and force protection. Automated Reasoning Methods and Models for Situational Analysis: - Continued 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.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Continued development of methods for automated generation of courses of action, including techniques for automated planning and reasoning in uncertain environments. - Continued 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. - Completed ontology-based information fusion for enhanced situational awareness and classification based knowledge discovery. Automated Decision Tools: - Continued the development of methods for selecting sensors and platforms for search and surveillance operations in a theater, allocating the selected sensors and platforms to specific missions, operating the allocated sensors during a mission, and fusing the information from the sensors and other sources. - Completed 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 development of algorithms to optimize the selection from disparate and multiple information sources as well as the characterization of related pedigree over multiple user processing requests within extremely large data sets, including checks and balances between assignment, storage, search, quality, reliability, completeness, and latency. Secure Sensor Networks: - Continued development of technology to improve reliability of systems to survive Information Warfare attacks. - Completed 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. - Completed development of technology for improved steganography and watermarking.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Initiated development of improved separation technology for shared-hardware host execution environments to increase information security. Acquisition Workforce Fund: - Funded DoD Acquisition Workforce Fund. *FY 2010 Plans:* Automated Intelligence Tools: - Continue all efforts from FY 2009 less those noted as completed above. - Complete development of interactive image/video-based surveillance systems for perimeter protection, and port protection. - Initiate development techniques for image coding based on shapes and regions and their temporal evolution to facilitate image analysis as well as to enable efficient image transmission and restoration. Develop methods for efficient search of large image and video databases to facilitate automated, realtime image/video registration for surveillance applications, threat detection, and target geo-location. - Initiate development of mathematically rigorous techniques and algorithms for automated understanding of surveillance imagery, including background modeling to assist image context interpretation and multi-sensor characterization of complex scenes. Battlespace Sensor and Intelligence Integration: - Continue all efforts from FY 2009 less those noted as completed above. - Initiate development of tools and processes including higher level statistical methods, game theory, first order logic form, Bayesian networks, and fusion algorithms, to model enemy behavior and provide threat assessment, represent complex data patterns, and model the structure of context to improve the data fusion process.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Initiate demonstrations of ontologies in a maritime environment using an experimental testbed or limited technology experiments to validate new approaches to inference and higher-level fusion capabilities. - Initiate development of algorithms to generalize the characterization of ontologies and to integrate them, including machine processing compatibility to effectively link methods for visualization and human processing (UML methods) with machine and information exchange and processing (XML methods). Automated Reasoning Methods and Models for Situational Analysis: - Continue all efforts from FY 2009 less those noted as completed above. - Initiate development of techniques to uncover trends, links, hidden models, and relationships of behavior/activity that will lead to inferring intent and developing course-of-action (COA) alternatives. - Initiate development of robust reasoning methods supporting automated situational understanding for maritime domain awareness under time-critical constraints and uncertainty. - Initiate development of methods of grouping situations to categorize algorithms for reuse under a variety of conditions, including Naval situation recognition and categorization (used to group similar situational types); situation characterization to define threshold qualifications to "bin" situations within categories (abductive development as a threshold process); situation projection to develop techniques to characterize features necessary to classify a situation - counterfactuals and inductive development. Automated Decision Tools: - Continue all efforts from FY 2009 less those noted as completed above. - Complete the development of methods for selecting sensors and platforms for search and surveillance operations in a theater, allocating the selected sensors and platforms to specific missions, operating the allocated sensors during a mission, and fusing the information from the sensors and other sources. Secure Sensor Networks:					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Continue all efforts from FY 2009 less those noted as completed above. - Initiate development of algorithms, secure protocols, architectures, software tools, languages, certification technologies, standards, guidelines to assure safe, secure, policy-compliant, interoperable systems for information transfer. *FY 2011 Base Plans:* Automated Intelligence Tools: - Continue all efforts from FY 2010 less those noted as completed above. - Complete the demonstration and conducted image registration error analysis for the multi-resolution and multi-scale image processing effort. - Complete development of semi-supervised detection algorithms for multi-sensor imagery, video and human intelligence that will enable self-deploying sensor networks. - Complete development techniques for image coding based on shapes and regions and their temporal evolution to facilitate image analysis as well as to enable efficient image transmission and restoration. Develop methods for efficient search of large image and video databases to facilitate automated, realtime image/video registration for surveillance applications, threat detection, and target geo-location. - Complete development of mathematically rigorous techniques and algorithms for automated understanding of surveillance imagery, including background modeling to assist image context interpretation and multi-sensor characterization of complex scenes. - Initiate development of methods for integration of low-level image processing and high-level knowledge for simultaneous image segmentation and object recognition, and visual reasoning for image understanding. - Initiate 3D image processing for object recognition and meaningful change detection. - Initiate development of modular, interactive, intelligent video-based surveillance systems. Battlespace Sensor and Intelligence Integration: - Continue all efforts from FY 2010.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Complete the development and testing of the Joint Integrated Fires Control effort. - Complete demonstration of a trusted data store which maintains data pedigree and detects anomalies in a limited objective experiment. - Complete development of an interface between the Level 1 and Level 2/3 data fusion processes across federated service oriented architectures. - Complete 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. - Complete 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. - Complete 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. - Complete the investigation of service oriented methods to automatically retrieve relevant information for a community of interest. - Complete 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, with an emphasis on missions that are related to OCO and force protection. - Complete development of tools and processes including higher level statistical methods, game theory, first order logic form, Bayesian networks, and fusion algorithms, to model enemy behavior and provide threat assessment, represent complex data patterns, and model the structure of context to improve the data fusion process. - Complete demonstrations of ontologies in a maritime environment using an experimental testbed or limited technology experiments to validate new approaches to inference and higher-level fusion capabilities.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Complete development of algorithms to generalize the characterization of ontologies and to integrate them, including machine processing compatibility to effectively link methods for visualization and human processing (UML methods) with machine and information exchange and processing (XML methods). - Initiate development of algorithms and tools for information representation of unstructured data and structured data in a way that shared concepts/relationships in disparate data sets can be automatically compared, matched, or associated and in a way that can facilitate and improve information fusion. - Initiate development of algorithms and tools for information fusion of heterogeneous data for classification and reconstruction based on high-level features inherent in each data source with the goal to form a more complete picture of battlespace environment. - Initiate development of algorithms and tools for discovering and extracting higher-level features -- objects, events, patterns, intents, relations, anomalies -- from various data types in support of future asymmetric warfare. Automated Reasoning Methods and Models for Situational Analysis: - Continue all efforts from FY 2010. - Complete 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. - Complete development of methods for automated generation of courses of action, including techniques for automated planning and reasoning in uncertain environments. - Complete 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. - Complete development of techniques to uncover trends, links, hidden models, and relationships of behavior/activity that will lead to inferring intent and developing course-of-action (COA) alternatives. - Complete development of robust reasoning methods supporting automated situational understanding for maritime domain awareness under time-critical constraints and uncertainty.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Complete development of methods of grouping situations to categorize algorithms for reuse under a variety of conditions, including Naval situation recognition and categorization (used to group similar situational types); situation characterization to define threshold qualifications to "bin" situations within categories (abductive development as a threshold process); situation projection to develop techniques to characterize features necessary to classify a situation - counterfactuals and inductive development. Automated Decision Tools: - Continue all efforts from FY 2010 less those noted as completed above. - Complete the development of algorithms to optimize the selection from disparate and multiple information sources as well as the characterization of related pedigree over multiple user processing requests within extremely large data sets, including checks and balances between assignment, storage, search, quality, reliability, completeness, and latency. - Initiate the development of optimization-based decision aids for resource allocation such as those required for mission planning at the strategic, operational, and tactical level. Secure Sensor Networks: - Continue all efforts from FY 2010. - Complete development of technology to improve reliability of systems to survive Information Warfare attacks. - Complete development of improved separation technology for shared-hardware host execution environments to increase information security. - Complete development of algorithms, secure protocols, architectures, software tools, languages, certification technologies, standards, guidelines to assure safe, secure, policy-compliant, interoperable systems for information transfer. - Initiate the development of anti-tamper methods that are capable of lengthy operation in unattended and un- powered environments, have very high probability of tamper detection and very low probability of false alarm, and remain undetected in the host system.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
HUMAN FACTORS AND ORGANIZATIONAL DESIGN	5.261	6.220	6.285	0.000	6.285

The overarching objective of this activity is the achievement of FORCEnet and Sea Power 21 goals by developing human factors principles and cognitive models for human centric design, decision support systems for collaborative decision making, and adaptive command and control structures. The CNO's new Maritime Strategy and the Commander Fleet Forces Command complementary plan torevise organization of Maritime Operations Centers (MOC) place high priority on the aforementioned FORCEnet and Sea Power 21 goals. Specific objectives focus on improving small team, platform, task force, and battle group operations by developing advanced human factors technologies for incorporation into operational systems. The goals and payoffs are to enhance human performance effectiveness; improve the timeliness and quality of decision making; develop strategies to mitigate high workload and ambiguity; reduce manning; improve situational awareness and speed of command through a deeper understanding of human capabilities and limitations; and improvement of team decision making in ad-hoc, complex problem solving scenarios. The current specific objectives are:

a) Human Computer Interaction/Visualization: Develop an understanding of the limitations of human perceptual and attentional systems in relation to maximizing user performance when interacting with complex Naval displays. A combination of computational cognitive modeling and psychological studies are employed to determine the capacity limitations on human performance that will undoubtedly have impact in reduced manning requirements, including information-rich weapons platforms. Develop technology for improving human interaction with autonomous systems and for improving virtual reality systems for training purposes.

b) Collaboration and Knowledge Interoperability: Develop an understanding of the high-level cognitive processes underlying team knowledge processing, decision making and collaboration in order to improve team performance in the autonomous, agile, quick-response combat team of the future. Develop cognitive science-based tools, models, computational methods, and human-agent interfaces to enhance team collaboration effectiveness and team performance in complex problem solving

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
teams. Specific objectives include application of discourse analysis methods and other process metrics to assess team performance. A conceptual model of team collaboration will be constructed and computational relationships among processes and team performance will be developed. Findings will be validated and demonstrated in operationally oriented testbeds by addressing issues including: rapid team analysis of large volume, uncertain data; knowledge interoperability in coalition ops; measures of team situational awareness; accelerated team synchronization; improved heterogeneous team performance; team collaboration performance metrics; cultural/language/experience-free representationand transfer of meaning. c) Organizational Design and Decision Support Systems: Develop quantitative executable models, task graphs and optimization algorithms for the organizational design of Maritime Operations Centers (MOC) consistent with the Navy's New Maritime Strategy. Investigate through modeling and simulation human competency requirements for staffing MOC. Develop quantitative formalisms for monitoring and assessing the completeness, consistency and accuracy of rules of engagement (ROE). d) Social Network Analysis: Develop computational models and algorithms for the analysis of terrorist threats and counter-measures and strategies against terrorist threats. Develop new computational algorithms for the discovery of missing and hidden nodes in complex graphs applicable to the problem of understanding hidden information in terror networks. Develop new approaches to calculation of network completeness. Develop computational approaches to the study of factionalism in social movements using Islamist movements as exemplar data collectivities. The increase from FY 2009 to FY 2010 reflects new program research to support MOC and additional social and cultural modeling. The following are non-inclusive examples of accomplishments and plans for projects funded in this activity.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
FY 2009 Accomplishments: Human Computer Interaction/Visualization: - Continued application of cognitive architecture modeling to the design of interface analysis tools. - Continued 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. - Continued effort to develop tools for more automated, cost-efficient modeling of human system interaction. - Continued methods to introduce key cognitive abilities to autonomous vehicles that will enable warfighters and vehicles to work together more collaboratively. Collaboration and Knowledge Interoperability: - 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 decisionmaking in a geographically distributed and time-delayed situation. - Continued effort to improve response speed of the LSA tool to a near-interactive level and incorporate into a fleet experiment. Collected and evaluated data to validate improved speed and effectiveness of developing situational awareness. - Continued effort to incorporate the EWALL prototype into a simulation of the Tactical Operations Center of the Special Operations Forces and collected performance data to validate effectiveness.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Continued Sea Basing research on rehearsal for Expeditionary Strike Groups in the conduct of Maritime Interdiction Operations (MIO) and developed reach-back capability for computationally intense analysis for evaluating courses of action. - Continued development of metrics to identify and measure the contribution to team performance of the cognitive processes underlying ad-hoc team decision making. - Continued effort to improve the model of ad-hoc team decision making by including collaborative agent-based contribution to team performance. - Initiated development of a computational model of subjective reasoning for course of action selection activity in distributed, asynchronous teams. - Initiated test and validation of a cognitive processes model of team collaboration in a Maritime Interdiction Operations domain. - Initiated integration of high-level planning and computational cognition with low-level to enhance situational awareness via swarm-based sensor platforms. Organizational Design and Decision Support Systems: - 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 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 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 and Expeditionary Strike Group ONE, San Diego. - Continued research on adaptive command and control architectures in support of the Navy's new Maritime Strategy.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Initiated research on quantitative formalisms for developing and assessing the completeness, consistency and accuracy of rules of engagement (ROEs). - Initiated research on executable models and optimization algorithms for adaptive command structures that are congruent with mission requirements to support the design of Maritime Headquarters with Maritime Operations Centers (MHQ/MOC) organizations. - Initiated research on models to support the design of scalable joint and coalition Maritime Operations Centers that allocate responsibilities to elements afloat and ashore. Social Network Analysis: - 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 the development of advanced computational models capable of analyzing multidimensional networks of thousands of nodes. Current capabilities enable the analysis of networks consisting of hundred of nodes. - Continued 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. - Continued the development of social network models to model the human element in maritime domain awareness. - Continued 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).					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Continued effort to improve social network models to analyze merchant marine traffic. - Initiate human cultural and social modeling to improve warfighting, civilian military operations and humanitarian operations in non-Western environments. *FY 2010 Plans:* Human Computer Interaction/Visualization: - Continue all efforts of FY 2009. - Initiate development of a testbed for validating cognitive models of operator performance in crossmodal (audio/visual) task environments. Collaboration and Knowledge Interoperability: - Continue all efforts of FY 2009. - Initiate research on the use of metaphors and temporal mental models to improve representation and transfer of meaning in ad-hoc, complex team problem solving with the objective of enhancing team collaboration effectiveness and team performance. - Initiate validation of a conceptual model of macrocognition in teams. Scenario-based experimentation will define the presence, persistence and relevance of individual and team cognitive processes and relationships among those processes. Deliverable will be a computational understanding of how teams collaborate to reach consensus. Organizational Design and Decision Support Systems: - Continue all efforts of FY 2009. - Initiate, in cooperation with the Air Force, the capability to examine human competency requirement in offensive and defensive cyber operations and the effects of courses of action at the tactical and operational level. The research would be conducted using DOD and academic laboratories capable of high fidelity mission simulation and precise measurements of independent and dependent measures. Social Network Analysis:					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Continue all efforts of FY 2009. *FY 2011 Base Plans:* Human Computer Interaction/Visualization: - Continue all efforts of FY 2010. - Initiate the development of the multitasking and metacognitive components of the Tactical Action Officer (TAO) model, especially as they apply to dual-tasks involving "chat" style instant-messaging interleaved with other watchstanding duties. - Initiate the development of spatialized 3D-audio displays to mitigate cognitive load during the performance of dual-tasks. - Initiate the investigation of human attentional limitations in understanding sped-up and serialized speech over multiple radio channels. - Initiate the development of cognitive-model-based predictors of operator error in procedural tasks. - Initiate the development of cognitive models of the TAO to be utilized within a virtual Combat Information Center (CIC) simulated environment. - Initiate the investigation of auditory attentional effects on watchstanding activities, especially in the context of monitoring multiple radio channels. Results will be used to provide recommendations for new communications protocols. Collaboration and Knowledge Interoperability: - Continue all efforts of FY 2010. - Initiate development of a performance measurement testbed for assessing the contribution of highlevel cognitive (macrocognitive) processes to collaboration effectiveness and team performance in special operations intelligence analysis. - Initiate validation of computational team collaboration performance metrics for quick response teams such as maritime interdiction operations and non-combatant evacuation operations. Organizational Design and Decision Support Systems:					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Continue all efforts of FY 2010. - Initiate cooperative development with the Air Force of a series of networked laboratories for hybrid human-agent experimentation on multi-echelon decision making and adaptive architectures for large maritime operations centers. - Initiate investigations on Battlespace on Demand Decision Making: Operational Application of Meteorological and Oceanographic Data in Command Decision Making. Social Network Analysis: - Continue all efforts of FY 2010.					
KNOWLEDGE SUPERIORITY AND ASSURANCE This activity is devoted to midterm technology development in close concert with programs of record. The products of these efforts are expected to transition at the end of their schedule into the associated program of record. The Future Naval Enabling Capabilities in this activity span across the Information Infrastructure, Applications/Tools/Decision Aids, Command and Control, Apertures and Radios, Tactical Networks and Network Control/Management, and Computer Network Defense and Information Assurance technology areas. Technologies being developed will integrate sensors, networks, decision aids, weapons and supporting systems into a highly adaptive, human-centric, comprehensive maritime system. This system will operate from the sea bed to space in a Service Oriented Architecture that can be used in a Joint Environment. The current specific objectives are: a) Combat ID Information Management of Coordinated Electronic Surveillance - Develop software algorithms and techniques for the purpose of dynamically re-tasking organic sensors in conjunction with fused intelligence products to support Command Control and Combat Systems. Efforts will include developed capability for automated integration of multi-intelligence surveillance & reconnaissance of	21.745	25.546	34.334	0.000	34.334

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
red, white, and blue force locations for Combat Identification by providing software integrated into Navy and Marine Corps Command Control and Combat Systems. b) Automated Control of Large Sensor Networks - Develop smart tactical sensors/platforms and software algorithms for automated and mission specific tactical sensor fields capable of fulfilling specific mission objectives with smart sensors that forward knowledge vice raw data. c) OCO Focused Tactical Persistent Surveillance - Develop agile and enhance tactical sensors for a netted, organically controlled, adaptive sensor field that is capable of detecting and classifying features relevant to other contingency operations to include organic sensors for small tactical expeditionary units, capable of supporting the dynamic character of modern operations from the highly mobile to the long-term. d) Globally Netted Joint/Coalition Force Maritime Component Commander - Develop automated tools and software to capture and share information for 'globally-networked, theater-focused' maritime capabilities that will enhance Joint Task Force (JTF) and COCOMs' ability to execute their intentions. e) Dynamic Tactical Communications Networks - Develop dynamically adaptive automated software algorithms, protocols, and network management techniques that provide a self-organizing networking capability. This capability will adapt to available links of opportunity at lower echelons and assure priority movement of critical data intra-network and through reachback gateway networks that interface with the Global Information Grid (GIG). f) Dynamic C2 for Tactical Forces and Maritime Operations Center (MOC) - Develop software for command control and combat systems that will provide the maritime commander agile and responsive control and management of tactical Antisubmarine Warfare (ASW) and interactions in a net centric					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
enterprise environment. Focus will address classified ASW requirements for command and control at the tactical level. g) High-bandwidth Free-space Lasercomm - Develop, integrate and demonstrate free-space optical terminals and retro-reflector optics that are designed to provide an affordable, reliable and highbandwidth Free-Space Laser Communications (Lasercomm) capability which is adaptive and agile in mitigating a wide range of atmospheric and maritime turbulence, precipitation and obscuration conditions. This capability will enable surface and airborne platforms to exchange very high bandwidth information in Navy Tactical Networks, even with limited SATCOM or RF spectrum access. h) Actionable Intelligence Enabled by Persistent Surveillance - Develop analysis tools and software that will provide accurate threat detection by exposing the enemy's vulnerabilities, unmasking their latent networks, discovering their tactics, techniques, procedures and exploiting in new ways the vast amount of sensor data available today against an irregular threat. Also develop the following: An electrooptical, infrared and laser Intelligence, Surveillance, and Reconnaissance Targeting (ISRT) optics technology, capable of wide Field of View/Field of Range (FOV/FOR) at variable resolution & pointing direction, for installation in mobile platforms without gimbals; a light weight, low cost sensor suite and autonomy algorithms to enable detection and avoidance of all classes of aircraft or Unmanned Aerial Vehicles (UAV). i) Pro-Active Computer Network Defense and Information Assurance - Develop algorithms, protocols, and software that will allow the warfighter to 1)identify and counter real-time threats to the network during mission execution, 2) provide dynamic security management and component management of networked-based assets to support mission execution, and 3) ensure mission essential capabilities and data exist despite malicious cyber actions.				

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
j) Fast Magic - Develop algorithms and computer and information technologies for Naval forces to respond quickly against multiple threats. Details are classified. k) NRL Space - Develop vessel tracking fusion algorithms and software to integrate multiple modalities of informational elements including literal and non-literal information. Develop algorithms and techniques for handling incorrect, out of sequence and intermittent sensor data to provide persistent situational awareness. The increase from FY 2009 to FY 2010 is due to the initiation of new FNC efforts to develop tools and software that will increase the commander's ability to predict threats and support weapons allocation. The increase from FY 2010 to FY 2011 is due to the initiation of new FNC Enabling Capability efforts Pro-Active Computer Network Defense and Information Assurance, Fast Magic, and NRL Space. The following are non-inclusive examples of accomplishments and plans for projects funded in this activity. *FY 2009 Accomplishments:* Combat ID Information Management of Coordinated Electronic Surveillance: - Continued the Electronic Warfare Integrated System for Small Platforms (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. - Continued Actionable Information from Multiple Intel Sources in a Global Information Grid Enterprise Services (GIG-ES) Environment. Provides automated integration of multi-INT surveillance and 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.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Continued developing and testing airborne and shipboard battle manager platforms for UAVs operating from Littoral Combat Ships. Continued developing and began testing an open architecture airborne control station that can be used onboard a P-3 type aircraft for the control of multiple UAVs. - Continued 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. Automated Control of Large Sensor Networks: - Continued design of tools enabling mission-specific tactical sensor fields for at least two separate mission areas. - Continued design of tactical distributed data analysis and automated indications and warnings for 50% of tactical data. - Continued design of automated tactical platform and sensor planning and management sufficient for one operator to control multiple sensors. - Continued investigation of human to tactical sensor field interface to enable the user to locate relevant knowledge within 3 minutes. - Continued development of automated and mission aware large tactical sensor management engines and irregular threat and tactical sensor ontologies. - Continued development of the agents and other analysis applications enabling a fully netted tactical battlespace. Globally Netted Joint/Coalition Force Maritime Component Commander: - Initiated effort to develop and apply emerging technologies that support delivery of Navy-approved FNC enabling capabilities structured to close operational capability gaps that involve the common picture. - Initiated packaging of emerging common picture technologies into deliverable FNC products and ECs that can be integrated into acquisition programs within a five year period.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Initiated efforts for the mature common picture technologies that support naval requirements identified within the FORCEnet naval capability pillar. Dynamic Tactical Communications Networks: - Initiated effort to develop and apply emerging technologies that support self organizing networking and assured communications exchange in tactical communications networks. Dynamic C2 for Tactical Forces and Maritime Operations Center (MOC): - Initiated effort to develop new, and leverage emerging, technologies that support dynamic and response management and control of net-centric enterprise theater and tactical ASW operations. This includes automation support for synchronized planning of resources and multi-mission execution, and access and shared awareness of data activities and status among Maritime Operation Centers and tactical forces in a tactical, netted service-oriented architecture (SOA) environment. *FY 2010 Plans:* Combat ID Information Management of Coordinated Electronic Surveillance: - Continue all efforts of FY 2009. - Initiate demonstrations of the adaptation of fusion and resource management capabilities directly into Distributed Information Operations-Service (DIO-S). Automated Control of Large Sensor Networks: - Continue all efforts of FY 2009. - Initiate demonstrations of mission-aware planning tools that allow large sensor networks to support tactical operations. OCO Focused Tactical Persistent Surveillance: - Initiate development of high information tactical agile sensors, including tactical RF sensors, sensors to sense the state of a person and smart tactical imagers and acoustic sensors.					

Exhibit R-2A, RDT&E Project Justification: PB 2011 Navy		DATE: February 2010
APPROPRIATION/BUDGET ACTIVITY 1319: *Research, Development, Test & Evaluation, Navy* BA 2: *Applied Research*	R-1 ITEM NOMENCLATURE PE 0602235N: *Common Picture Applied Research*	PROJECT 0000: *Common Picture Applied Research*

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Globally Netted Joint/Coalition Force Maritime Component Commander: - Continue all efforts of FY 2009. - Initiate development of fusion algorithms and methods that support building and maintaining large distributed databases; implementing GIG-compliant data strategies; mediating and integrating across heterogeneous databases; accessing and discovering authenticated users and brokering agents; and identifying ambiguities or inconsistencies for additional sensing and processing. Dynamic Tactical Communications Networks: - Continue all efforts of FY 2009. - Initiate development of distributed-and dynamic policy based network management, secure mobility management solutions, and network service discovery mechanisms. - Initiate development of robust and bandwidth efficient group communication protocols for the tactical environment, including disruption tolerance and inter-domain (security and routing) protocols for fullyconnected domains. Dynamic C2 for Tactical Forces and Maritime Operations Center (MOC): - Continue all efforts of FY 2009. - Initiate development of tools and algorithms that support automated data access, shared awareness, and automated synchronized planning, coordination and execution of network enterprise resources among tactical units with limited/degraded communications. High-bandwidth Free-space Lasercomm: - Initiate development of mitigation techniques for laser beam propagation through atmospheric turbulence and aerosol obscuration. - Initiate development of and demonstrate technologies that support high bandwidth laser communications, including fast acquisition and fine beam steering/tracking algorithms; wide-area avalanche photo-diode receive array techniques; and high bandwidth wide field-of-view retro-reflector					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
optics. Actionable Intelligence Enabled by Persistent Surveillance: - Initiate development of advanced analysis tools that are relevant to the information needs of tactical warfighters engaged against irregular actors. - Initiate development of a multi-modal tactical wide area surveillance payload and sensors relevant to tier-2 UAVs that can detect other airborne platforms. *FY 2011 Base Plans:* Combat ID Information Management of Coordinated Electronic Surveillance: - Continue all efforts of FY 2010. Automated Control of Large Sensor Networks: - Continue all efforts of FY 2010. - Complete development of automated and mission aware large tactical sensor management engines and irregular threat and tactical sensor ontologies. - Complete development of the agents and other analysis applications enabling a fully netted tactical battlespace. OCO Focused Tactical Persistent Surveillance: - Continue all efforts of FY 2010. Globally Netted Joint/Coalition Force Maritime Component Commander: - Continue all efforts of FY 2010. - Initiate demonstration of the dynamic distributed data layer, role-relevant representation and visualization, and adaptive collaboration assistant in a series of Limited Technology Experiments and Limited Technology Objectives to verify the ability to provide information flow in real time across theaters.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
Dynamic Tactical Communications Networks: - Continue all efforts of FY 2010. - Continue development of, and initiate demonstration of, distributed-and dynamic policy based network management and secure mobility management solutions, network service discovery mechanisms, and robust and bandwidth efficient group communication protocols for the tactical environment, including disruption tolerance. Dynamic C2 for Tactical Forces and Maritime Operations Center (MOC): - Continue all efforts of FY 2010. - Initiate development of automated capabilities for generating multiple alternative course of action (COA) recommendations to the commander including automated development of force plans and allocation of related resources (e.g. sensors, platforms, weapons) and processes; and dynamic management and re-planning of tactical force goals, activities and resources. High-bandwidth Free-space Lasercomm: - Continue all efforts of FY 2010. - Initiate development of and demonstrate error correction methods and adaptive optics techniques for turbulence mitigation; and ultra-fast pulsing for obscuration. Actionable Intelligence Enabled by Persistent Surveillance: - Continue all efforts of FY 2010. Pro-Active Computer Network Defense and Information Assurance: - Initiate development of Next Generation Sensors and Gateways to provide security and control mechanisms to protect networks, data and systems from attacks (e.g., malicious code, data exfiltration).					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Initiate development of Next Generation Security Protocols and Security Management Protocols to provide hardened, highly survivable, stealthy, reconfigurable overlay of protocols onto networks to ensure network-base configuration and control of security components essential to mission operations, as well as provide data provenance to support dynamic resource management and decision support. - Initiate development of Common Operational Security Decision System to aggregate, correlate, fuse and visualize network security posture information to support integrated warfighting decisions. Fast Magic: - Initiate the development of algorithms and computer and information technologies for Naval forces to respond quickly against multiple threats. Details are classified. NRL Space: - Initiate the development of vessel tracking fusion algorithms and software to integrate multiple modalities of informational elements including literal and non-literal information. - Initiate the development of algorithms and techniques for handling incorrect, out of sequence and intermittent sensor data to provide persistent situational awareness.					
MULTI-SOURCE INTEGRATION AND COMBAT IDENTIFICATION This activity addresses theater air and missile defense (TAMD), and responds to warfighter 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. The following are non-inclusive examples of accomplishments and plans for projects funded in this activity. *FY 2009 Accomplishments:* - Continued 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.	0.962	1.087	1.090	0.000	1.090

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Completed development of a robust test environment to elucidate the design principles of human and sensor network interactions. *FY 2010 Plans:* - Continue all efforts of FY 2009 less those noted as completed above. - Complete 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. *FY 2011 Base Plans:* - Complete improvements in the resolution of the High Frequency Relocatable Over-the-Horizon Radar (HF-ROTHR) more than two orders of magnitude using time-reversal methods.					
TACTICAL SPACE EXPLOITATION The Tactical Space Exploitation initiative explores the application of new space craft 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 and communications payload technology deployed on satellites to demonstrate augmented mobile satcom capabilities over a theater. Affordably expendable payload and bus technologies will be developed, which will serve as building blocks for future responsive space systems: payloads, bus technologies and significant space robotic technologies that address on-orbit inspection, servicing, repair and assembly, and mission-life extension.	16.694	18.373	4.132	0.000	4.132

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
The decrease between FY 2010 and FY 2011 is the result of investments in this activity being curtailed in response to completion of the efforts associated with the Comm-X payload development and launch aboard TACSAT 4 satellite. The following are non-inclusive examples of accomplishments and plans for projects funded in this activity. *FY 2009 Accomplishments:* - Continued development of integration plans, algorithms, and satellite concept of operations to demonstrate integrated signals payload. - Continued development of small multifunctional integrated signals electronics systems for ship tracking from space and two-way data exfiltration from distributed global sensors. - Continued 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. - Continued the development of a highly capable self-inspection vehicle for spacecraft with large complex deployables. - Continued the development of a preliminary design for electrodynamic propulsion technology demonstration spacecraft. - Completed and launched maritime hyperspectral payload on TacSat or Space Test Program (STP) satellite. Develop improved maritime hyperspectral payload for flight on the International Space Station through STP. Complete analysis of TacSat 3 data. - Initiated effort to develop technologies using autonomous bi-dexterous manipulation for closeproximity operations in space. *FY 2010 Plans:* - Continue all efforts of FY 2009 less those noted as completed above. - Complete Comm-X payload and launch it aboard TACSAT 4 satellite.					

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total
- Complete the development of a highly capable self-inspection vehicle for spacecraft with large complex deployables. - Complete the development of a preliminary design for electrodynamic propulsion technology demonstration spacecraft. *FY 2011 Base Plans:* Base FY 2011 Plans: - Continue all efforts of FY 2010 less that noted as completed above. - Complete the development of a preliminary design for electrodynamic propulsion technology demonstration spacecraft.					
Accomplishments/Planned Programs Subtotals	81.196	82.732	70.168	0.000	70.168

C. Other Program Funding Summary ($ in Millions)

Line Item	FY 2009	FY 2010	FY 2011 Base	FY 2011 OCO	FY 2011 Total	FY 2012	FY 2013	FY 2014	FY 2015	Cost To Complete	Total Cost
• 0603235N: *COMMON PICTURE ADVANCED TECHNOLOGY*	31.136	42.477	44.878	0.000	44.878	49.742	34.581	28.932	12.769	0.000	244.515

D. Acquisition Strategy

N/A

E. Performance Metrics

This PE supports the development of technologies that enable the transformation to network centric warfare. Net-centric operations include communications and information assurance capabilities to enable all-source data access, tailored dissemination of information to Command and Control (C2) and Intelligence, Surveillance and Reconnaissance (ISR) users across the network, and rapid, accurate decision making based on this information. 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.

Specific examples of metrics under this PE include:

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- Increase network data rates and interoperability across heterogeneous radios; improve dynamic bandwidth management and mobile network connectivity.
- Increase the understanding of the battlespace by the development of automated tools for extracting information from images and signals, identifying objects, determining relationships among the objects, assessing intent, and generating courses of action.
- Improve human-factors design principles resulting in enhanced human performance effectiveness, improved timeliness and quality of decision making, reduced manning, and improved team decision making in ad-hoc, complex problem solving scenarios.
- Improve the integration of sensors, networks, decision aids, weapons, and supporting systems into a highly adaptive, human-centric, comprehensive maritime system.
- Improve integrated signals electronics packages small, light-weight, and low-cost satellites to test new concepts for global ship tracking and two-way data exfiltration.

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COST ($ in Millions)	FY 2009 Actual	FY 2010 Estimate	FY 2011 Base Estimate	FY 2011 OCO Estimate	FY 2011 Total Estimate	FY 2012 Estimate	FY 2013 Estimate	FY 2014 Estimate	FY 2015 Estimate	Cost To Complete	Total Cost
9999: *Congressional Adds*	8.477	7.708	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	101.644

A. Mission Description and Budget Item Justification

Congressional Interest Items not included in other Projects.

B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010
Congressional Add: Cognitive Radio Institute *FY 2010 Plans:* This effort supports Cognitive Radio Institute research.	0.000	0.797
Congressional Add: Head Attitude Tracking System *FY 2010 Plans:* This effort supports Head Attitude Tracking System research.	0.000	1.593
Congressional Add: Intelligent Decision Exploration *FY 2010 Plans:* This effort supports Intelligent Decision Exploration research.	0.000	3.884
Congressional Add: Sensor Integration Framework	1.197	1.434

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010
FY 2009 Accomplishments: This effort supported research into an improved common operating picture for the warfighters. *FY 2010 Plans:* Continue this effort to support Sensor Integration Framework research.		
Congressional Add: All Weather Sense & Avoid Sensors for UAVs *FY 2009 Accomplishments:* This effort supported the design, fabrication and testing of a comprehensive all weather sense and avoid system. The system will provide a sensing, decision making and maneuver commands to enable safe separation of aircraft and UAVs.	2.492	0.000
Congressional Add: Layered Surveillance/Sensing *FY 2009 Accomplishments:* This effort supported the development of a layered network of real-time fire control quality data together with on demand situational awareness information distributed across near real-time subnets.	1.596	0.000
Congressional Add: SOF Test Environment for Adv Team Collaboration Missions *FY 2009 Accomplishments:* This effort supported technological advancements within the common operational picture and real time team collaboration - key technology elements of the SOF TEAMS efforts.	1.995	0.000
Congressional Add: Unmanned Ground Vehicle (UGV) Mobility & Coordination in Joint Urban/Littoral En	1.197	0.000

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B. Accomplishments/Planned Program ($ in Millions)

	FY 2009	FY 2010
FY 2009 Accomplishments: This effort supported the development and demonstration of technologies for unmanned ground vehicles (legged robots) with the advanced mobility necessary for negotiating urban terrain to enhance the capabilities of the U.S. Armed Forces and reduce risk for troops.		
Congressional Adds Subtotals	8.477	7.708

C. Other Program Funding Summary ($ in Millions)

N/A

D. Acquisition Strategy

N/A

E. Performance Metrics

Congressional Interest Items not included in other Projects.