| Exhibit R-2, RDT&E Budget Item Justification: PB 2015 Navy | | | | | | | | | | | **Date:** March 2014 | |

| **Appropriation/Budget Activity** 1319: *Research, Development, Test & Evaluation, Navy I* BA 2: *Applied Research* | **R-1 Program Element (Number/Name)** PE 0602235N *I Common Picture Applied Research* |

COST ($ in Millions)	Prior Years	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO #	FY 2015 Total	FY 2016	FY 2017	FY 2018	FY 2019	Cost To Complete	Total Cost
Total Program Element	0.000	37.643	34.136	43.541	-	43.541	42.681	42.821	37.482	37.578	Continuing	Continuing
0000: *Common Picture Applied Research*	0.000	37.643	34.136	43.541	-	43.541	42.681	42.821	37.482	37.578	Continuing	Continuing

The FY 2015 OCO Request will be submitted at a later date.

Note

FY 2013 funding and associated Future Naval Capability (FNC) efforts addressed in this Program Element (PE) are transferring to a new PE titled Future Naval Capabilities Applied Research (PE 0602750N). This is to enhance the visibility of the FNC Program by providing an easily navigable and consolidated overview of all 6.2 FNC investments in a single PE.

FY 2014 - R2 Activity Human Factors and Organizational Design requirements and associated funding is transferred to the Warfighter Sustainment Applied research PE (PE 0602236N). Ongoing Human Factors research is more closely aligned to Warfighter Sustainment objectives.

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 (Sep 2011). 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 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; Naval Research Laboratory (NRL) Space; Advanced Tactical Data Link; and Autonomous Tactical Persistent Surveillance. 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).

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

B. Program Change Summary ($ in Millions)	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO	FY 2015 Total
Previous President's Budget	41.696	34.163	35.528	-	35.528
Current President's Budget	37.643	34.136	43.541	-	43.541
Total Adjustments	-4.053	-0.027	8.013	-	8.013
• Congressional General Reductions	-	-0.027			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-0.573	-			
• Program Adjustments	-	-	2.013	-	2.013
• Rate/Misc Adjustments	-	-	6.000	-	6.000
• Congressional General Reductions Adjustments	-3.480	-	-	-	-

Change Summary Explanation

Technical: Not applicable.

Schedule: Not applicable.

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COST ($ in Millions)	Prior Years	FY 2013	FY 2014	FY 2015 Base	FY 2015 OCO #	FY 2015 Total	FY 2016	FY 2017	FY 2018	FY 2019	Cost To Complete	Total Cost
0000: *Common Picture Applied Research*	-	37.643	34.136	43.541	-	43.541	42.681	42.821	37.482	37.578	Continuing	Continuing

The FY 2015 OCO Request will be submitted at a later date.

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 (Sep 2011). 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 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; Naval Research Laboratory (NRL) Space; Advanced Tactical Data Link; and Autonomous Tactical Persistent Surveillance. 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 Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
Title: COMMUNICATION AND NETWORKS	6.617	7.471	7.151
Description: The overarching objective of this activity is to develop high throughput dynamic wireless communications and network 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,			

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2013**	**FY 2014**	**FY 2015**
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 actively scanned 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 sensor 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 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 self-organizing 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 2014 to FY 2015 is the reprioritizing of the Development of optical communications technologies for underwater platforms and research into multi-modal networking across undersea platforms with acoustic, optical, and RF communications.			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
The following are non-inclusive examples of accomplishments and plans for projects funded in this activity. ***FY 2013 Accomplishments:*** Radios and Apertures: - Continued development of low intercept and low probability of Detection (LPD), jam resistant communications/networks for distributed nodes. - Continued blue-green fiber laser technology development for space-based submarine communications. - Continued design and development of low observable, jam resistant waveform, including directionalization, for advanced tactical data links. - Continued design and development of electronic protection for HF communications. - Continued development of structurally integrated HF antennas. - Continued development of integrated metamaterial antennas for ship and ground platforms. - Continued demonstration of high peak power, short pulse operation of fiber lasers in blue-green region. - Continued development of optical wavefront modulation techniques and optical phased array beam steering methods for terrestrial EO/IR Lasercomm. - Continued development of new architecture and modes of operation for advanced tactical data link operation in both contested and anti-access regions. - Continued novel fiber technology that enables tunable, energy-scalable emissions at a user-defined/desired wavelength, particularly in the blue-green spectral range. - Continued use of novel metamaterials and metastructures that enable conformal antenna designs with ultra-wideband performance. - Continued program for a novel blade antenna payload for wideband Ku/UHF communications that is light weight, has lower power consumption, and is very low cost. - Complete development and demonstrate electrically small antennas at Very Low Frequency/High Frequency (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. - Initiated technologies to improve spectrum co-existence of military waveforms with commercial communications (e.g., overlay/underlay techniques, interference cancellation, machine learning and reasoning algorithms for distributed spectral awareness/management, etc.). Tactical Networking and Network Control/Management: - Continued development of topology control, discovery mechanisms and directional networking for free space optical links. - Continued design and development of cognitive netops for tactical communications. - Continued development of social network analysis algorithms for protecting wireless networks.			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Continued development of cognitive networking, cross-layer optimization protocols for light SOA for tactical networks. - Continued development of effort to improve secure voice by developing secure voice technology that can interoperate between tactical and strategic networks. - Continued program that leverages topology discovery, content modeling, and resource scheduling to support content management functions at the Tactical Edge. - Continued managing and controlling functions within a protected routing core at the Tactical Edge. - Continued an investigation of applied wireless communication network science for autonomous, mobile information networks. - Completed effort to improve secure voice by developing secure voice technology that can interoperate between tactical and strategic networks. - Completed development of agent based communications, control and distributed authentication techniques in dynamic MANET networks. - Completed 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. - Initiated dynamic routing mechanisms that focus on robust data delivery -- in near real time -- under harsh networking conditions (i.e., intermittent connectivity, limited throughput, etc.). ***FY 2014 Plans:*** Radios and Apertures: - Continue all efforts of FY 2013 less those noted as complete. - Complete design and development of low observable, jam resistant waveform, including directionalization, for advanced tactical data links. - Complete structurally integrated HF antennas. - Complete new architecture and modes of operation for advanced tactical data link operation in both contested and anti-access regions. - Initiate development of low cost approaches for electronic beam steering and multi-beam RF systems - Initiate development of blue-green receiver and detector technologies with greater sensitivity, while reducing size, weight, power, and/or cost. Tactical Networking and Network Control/Management: - Continue all efforts of FY 2013 less those noted as complete. - Complete development of topology control, discovery mechanisms and directional networking for free space optical links. - Complete social network analysis algorithms for protecting wireless networks. - Complete an investigation of applied wireless communication network science for autonomous, mobile information networks.			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Initiate development of techniques and algorithms to manage resources of tactical networks in a manner consistent with Commander's Intent. ***FY 2015 Plans:*** Radios and Apertures: - Continue all efforts of FY 2014 less those noted as complete. - Complete blue-green fiber laser technology development for space-based submarine communications. - Complete novel fiber technology that enables tunable, energy-scalable emissions at a user-defined/desired wavelength, particularly in the blue-green spectral range. - Complete development of low intercept and low probability of Detection (LPD), jam resistant communications/networks for distributed nodes. - Complete development of optical wavefront modulation techniques and optical phased array beam steering methods for terrestrial EO/IR Lasercomm. - Complete use of novel metamaterials and metastructures that enable conformal antenna designs with ultra-wideband performance. - Complete program for a novel blade antenna payload for wideband Ku/UHF communications that is light weight, has lower power consumption, and is very low cost. - Initiate development of technologies to enable troposcatter communications on the move with reduced size, weight, and power antennas. - Initiate development of blue-green filter technologies with wide field of view, narrow bandwidth, and reduced size, weight, complexity, etc. Tactical Networking and Network Control/Management: - Continue all efforts of FY2014 less those noted as complete. - Complete development of cognitive networking, cross-layer optimization protocols for light SOA for tactical networks. - Complete development of effort to improve secure voice by developing secure voice technology that can interoperate between tactical and strategic networks. - Complete program that leverages topology discovery, content modeling, and resource scheduling to support content management functions at the Tactical Edge. - Complete managing and controlling functions within a protected routing core at the Tactical Edge. - Initiate development of techniques and algorithms to ensure end-to-end delivery of data across undersea networks with large delays and multi-modal communications.			
Title: APPLIED INFORMATION SCIENCES FOR DECISION MAKING	9.777	15.618	23.211

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015

Description: 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 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 Nano Electronics Technology activity is focused on developing ultra-low power, higher performance computing devices and components that are based on novel functionalities of nanometer scale materials and are enabled by improved understanding of nanomaterials, new devices and circuit design concepts, as well as new architectures uniquely suited for nanoscale systems.

Effective in FY 2013, this activity title has been changed from Computational Framework and Methods for Rapid Accurate Decision Making to Applied Information Sciences for Decision Making in order to completely capture the work being performed.

The current specific objectives are:
a) Data Understanding (Formerly: 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) Information Integration (Formerly; 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, while inferring relationships and their intentions.

c) Mission Focused Autonomy (MFA): Develop proactive situational awareness and rapid decision making applications and analytics with information PUSH as well as PULL, where joint human controlled and automated analytic processes can collaboratively work together to solve tactical and strategic problems within a multi-level, secure environment. The MFA system contains the following elements: a) access to enterprise level structured and unstructured data repositories and automated search and discovery of evidence collected across these heterogeneous databases; b) analytics that automate the ability to infer the meaning of evidence that is discovered; c) structured process (hypothesis or argument) that provides context in order to

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
constrain and guide the search and analytic techniques toward goals that are focused on proving the hypothesis right or wrong; d) knowledge repository that maintains pedigree and state of hypothesis satisfaction or refutation; e) Collaborative environment wherein all analytic participants can share the state of hypothesis satisfaction and collectively contribute evidence data to solve the common problem. Develop rigorous and efficient methods for building sophisticated situational models, and develop automated reasoning techniques to categorize and recognize situations under a variety of conditions leading to methods that predict situations under different settings. d) Resource Optimization (Formerly: 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, achieving optimal allocations for large complex scenarios, including ones that contain uncertainty, in drastically reduced amounts of time. Develop methods that support decision making in networked sensor management and allocation to ensure sensor assets are deployed in an optimal, or near optimal, manner. e) Trusted Systems & Networks (Formerly: Secure Sensor Networks): Develop tools and methods to securely handle information without exposing intelligence information about the networks or systems to adversaries. f) Nanoscale Electronics: To develop novel nanometer scale (feature size near or below 10nm) logic/memory devices and related circuits and architectures to deliver ultra-low power, light weight and high performance computational capability for autonomous vehicles and individual warfighters. Effective in FY 2014, Nanoscale Electronics has been transferred from Electromagnetic Systems Applied Research to Applied Information Sciences for Decision Making in order to completely capture the work being performed. g) Quantum Information Sciences: Conduct research supporting the efficacy of a free space optical quantum key distribution that would operate in a maritime environment. Understand the implications of imperfect hardware implementations upon the vulnerability of the known protocols. Develop new protocols and encoding schemes that lead to robust performance with high throughput. Conduct research that leads to an understanding of, and develop methods that compensate for atmospheric effects. The increase from FY 2013 to FY 2014 is a result of the expanded investment in Mission Focused Autonomy research and the transfer of requirements and associated funding for Nanoscale Electronics Research from PE 0602271N. The increase of funds from FY2014 to FY2015 is for the development and demonstration of new naval capabilities providing improved cyber situational awareness and cyber toolkit development to assess vulnerabilities in Naval networks. The funds will also explore new technologies to prevent/ isolate intrusions to Naval networks and explore automated approaches to cyber policy implementation management.			

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2013**	**FY 2014**	**FY 2015**
The following are non-inclusive examples of accomplishments and plans for projects funded in this activity. ***FY 2013 Accomplishments:*** Data Understanding: - Continued 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. - Continued development of 3D image processing for object recognition and meaningful change detection. - Continued development of modular, interactive, intelligent, video-based surveillance systems. - Continued development of a vision-based system for tactical unmanned aerial vehicle to navigate paths without requiring maps or GPS. - Continued methods for building sophisticated visual knowledge bases, development of methods for visual reasoning and integrating them in image/video understanding, and development of methods for image description. - Completed development and demonstration of revolutionary, hyperspectral imaging spectrometer algorithms and system. Information Integration: - Continued development of algorithms and tools for information representation of unstructured data and structured data in such 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. - Continued 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 of forming a more complete picture of battlespace environment. - Continued development of algorithms and tools for discovering and extracting higher-level features -- objects, events, patterns, intents, relationships, anomalies -- from various data types in support of future asymmetric warfare. Mission Focused Autonomy (MFA): - Continued research in mission-focused autonomy and reasoning methods; expanded autonomy from simple platform kinematics to include all-source information exploitation and surrounding cultural and social influences. Resource Optimization: - Continued 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.			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Continued development of optimization-based decision aids for resource allocation, such as those required for mission planning at the strategic, operational, and tactical level. Trusted Systems & Networks: - Continued 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. - Continued development of automated tools that identify and mitigate potential software vulnerabilities, such as tools that analyze code as it is being written, vulnerability-aware compilers that automatically enhance code security, and techniques for enhancing the client-side security of web applications. - Continued development of theory, methods, and tools for model-driven, component-based construction and automatic verification of software systems. *FY 2014 Plans:* Data Understanding: - Continue all efforts from FY 2013 less those noted as completed above. - Complete effort to develop a vision-based system for tactical unmanned aerial vehicle to navigate paths without requiring maps or GPS. (NRL) - Initiate development of algorithms for extraction of information from Light Detection and Ranging (LIDAR) and Radar. Information Integration: - Continue all efforts from FY 2013 less those noted as completed above. - Initiate development of methods for analysis and integration of text with imagery and video. - Initiate development of methods for analysis of structured and unstructured data. Mission Focused Autonomy (MFA): - Continue all efforts from FY 2013 less those noted as completed above. - Bring capability into a multi-level security environment - Automate current set of time critical reports to ensure timely decision making that is informed by forensics data Resource Optimization: - Continue all efforts from FY 2013 less those noted as completed above. Trusted Systems & Networks:			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Continue all efforts from FY 2013 less those noted as completed above. Nanoscale Electronics: (Beginning in FY 2014, efforts listed below are continued from PE 0602271) - Continue effort to develop a highly linear, low-noise RF amplifier using aligned arrays of single-walled carbon nanotubes. - Continue new research in graphene synthesis and device concepts. - Continue effort to develop the synthesis, fabrication and testing of graphene-based electromechanical structures and devices. - Continue work on graphene-based devices and circuits for low power flexible electronics. - Continue research on graphene-organic hybrid materials interfaces and device structures. ***FY 2015 Plans:*** Data Understanding: - Continue all efforts of FY 2014, less those noted as completed above. - Complete development of electronic protection techniques for long range emitter classification systems. Information Integration: - Continue all efforts of FY 2014, less those noted as completed above. Mission Focused Autonomy (MFA): - Continue FY14 efforts expanding the use cases - Initiate integrating this analytic environment into parallel Navy Tactical Cloud environment Resource Optimization: - Continue all efforts from FY 2014 less those noted as completed above. Trusted Systems & Networks: - Continue all efforts from FY 2014 less those noted as completed above. - Complete development of theory, methods, and tools for model-driven, component-based construction and automatic verification of software systems. Nanoscale Electronics: (Beginning in FY 2014, efforts listed below are continued from PE 0602271) - Continue all efforts of FY 2014, less those noted as completed above. Quantum Information Sciences:			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Initiate free-space Quantum Key Distribution applied research program for secure communication.			
Title: HUMAN FACTORS AND ORGANIZATIONAL DESIGN	5.701	-	-
Description: 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 to revise 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 scenarios. 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 representation and transfer of meaning. c) Organizational Design and Decision Support Systems: Develop quantitative, executable models, task graphs and optimization algorithms for the organizational design of MOC, consistent with the Navy's New Maritime Strategy. Investigate through modeling			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
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 decrease from FY 2013 to FY 2014 is due to the transfer of requirements and associated funding to the Human Factors activities in the Warfighter Sustainment Applied Research PE 0602236N, to provide an easily navigable and consolidated overview of all Human Factors investments in a single PE. The following are non-inclusive examples of accomplishments and plans for projects funded in this activity: *FY 2013 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 development of a testbed for validating cognitive models of operator performance in cross-modal (audio/visual) task environments. - Continued 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. - Continued development of spatialized 3D-audio displays to mitigate cognitive load during the performance of dual-tasks. - Continued investigation of human attentional limitations in understanding sped-up and serialized speech over multiple radio channels. - Continued development of cognitive-model-based predictors of operator error in procedural tasks. - Continued development of cognitive models of the TAO to be utilized within a virtual, Combat Information Center (CIC) simulated environment. - Continued 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.			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Continued development of cognitive models of user interface affordance that could form the basis of usability analysis and evaluation. Collaboration and Knowledge Interoperability: - Completed evaluation of Latent Semantic Analysis (LSA) of operator communications as an effective metric of shared situational awareness in unmanned aerial vehicle control teams. - Completed 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 solving complex problems. - Completed 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. - Completed 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. - Completed 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. - Completed development of metrics to identify and measure the contribution to team performance of the cognitive processes underlying ad-hoc team decision making. - Completed effort to improve the model of ad-hoc team decision making by including collaborative agent-based contribution to team Performance. - Completed test and validation of a cognitive processes model of team collaboration in a Maritime Interdiction Operations domain. - Completed integration of high-level planning and computational cognition with low-level input to enhance situational awareness via swarm-based sensor platforms. - Completed 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. - Completed 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. - Completed development of a performance measurement testbed for assessing the contribution of high level cognitive (macrocognitive) processes to collaboration effectiveness and team performance in special operations intelligence analysis. - Completed validation of computational team collaboration performance metrics for quick response teams, such as maritime interdiction operations and non-combatant evacuation operations. - Completed development of a computational model of teamwork, however, shifted emphasis with issuing of two new grants. CMU will develop and apply novel machine learning algorithms to enable automated discourse analysis in order to identify			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
teamwork processes and corresponding emergent leaders, and OSU will develop proxy agent technology to improve information exchange between emergent leaders and subordinates. - Completed development of metrics to measure team mental model convergence in order to assess teamwork performance in relation to mission success/outcome in submarine Command and Control. Shift emphasis to directly apply metrics to transition into the Capable Manpower Future Naval Capability. - Completed development of the computational aspects of a model of tactical team decision making. - Completed inclusion of the theoretical aspects of group cognition and knowledge building into the model of macrocognition. - Completed development of computational model of teamwork, with increased emphasis on agile management of mission objectives and team tasking. - Completed task management algorithms applicable to agile supervisory control of teams involving human and autonomous agents. Organizational Design and Decision Support Systems: - Completed 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. - Completed jointly with the Air Force applied research on the integration of Information Operations in Air Control Centers. - Completed applied research on command and control adaptive architectures for Expeditionary Strike Groups working with OPNAV and Expeditionary Strike Group ONE, San Diego. - Completed research on quantitative formalisms for developing and assessing the completeness, consistency and accuracy of rules of engagement (ROEs). - Completed 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. - Completed research on models to support the design of scalable, joint and coalition Maritime Operations Centers that allocate responsibilities to elements afloat and ashore. - Completed in cooperation with the Air Force, the capability to examine human competency requirements in offensive and defensive cyber operations, and the effects of courses of action at the tactical and operational level. The research was conducted using DoD and academic laboratories capable of high fidelity mission simulation and precise measurements of independent and dependent measures. - Completed developing cooperatively with the Air Force a series of networked laboratories for hybrid, human-agent experimentation on multi-echelon decision making and adaptive architectures for large maritime operations centers. - Completed model-based simulations and experiments to investigate effectiveness of hierarchical organizational structures in network centric operational environments, with increased emphasis on modeling of tasks and information requirements for rapid mission planning and re-planning.			

Exhibit R-2A, **RDT&E Project Justification:** PB 2015 Navy		**Date:** March 2014
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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2013**	**FY 2014**	**FY 2015**
- Completed research on adaptive command and control architectures in support of the Navy's new Maritime strategy, with increased emphasis on dynamic task allocation based on mission phase and emergent mission requirements, and impact to information requirements. - Completed development of Battlespace On Demand Decision Making for Meteorological and Oceanographic Command Decision making, with increased emphasis on development of piracy prediction decision support and uncertainty characterization. - Completed research on development decision support tools for MOC, with increased emphasis on coordination across echelons in support of "Minesweeper to MOC" operations. - Completed research for design of Maritime Headquarters (MHQ) with MOC organizations, with increased emphasis on design of information management tools and algorithm development for information prioritization. Social Network Analysis: - Continued development of new threat scenarios incorporating Joint Force Maritime Component Commander operations, and counterinsurgency 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 an operational command setting at U.S. Pacific Command. - Continued 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 computational models of influence that incorporate the social structure, values and cultural processes of urban, non-western communities for achieving post-conflict stabilization. - Continued 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). - Continued human cultural and social modeling to improve warfighting, civilian military operations and humanitarian operations in non-Western environments. - Continued social complexity modeling for community dynamics (Stabilization, Security, Transition and Reconstruction problems (SSTR) and Humanitarian Assistance/Disaster Relief (HA/DR)), an outgrowth of computational social science/social network analysis in non-Western settings. - Continued new techniques for model development fundamentals. - Continued development of geo-spatial aspects of data presentation, modeling and visualization for improving decision tools in SSTR and HA/DR. - Continued information operations research on non-Western communities. - Continued new methods to analyze, partition and filter massive datasets.. - Initiated new natural language prcessing methods to facilitate massive data collection using social media.			

Exhibit R-2A, RDT&E Project Justification: PB 2015 Navy		Date: March 2014
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Initiated novel data collecting methods for SSTR and HA/DR. *FY 2014 Plans:* All FY 2014 Plans and Accomplishments transferred to PE 0602236N. *FY 2015 Plans:* N/A			
Title: MULTI-SOURCE INTEGRATION AND COMBAT IDENTIFICATION *Description:* 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 decrease from FY 2013 to FY 2014 is due to the completion of Radar and Surveillance supporting Multi-Source Integration and Combat Identification. The following are non-inclusive examples of accomplishments and plans for projects funded in this activity: *FY 2013 Accomplishments:* - Continued development of a new radar signature analysis technique based on nonlinear dynamics. - Continued development of coordinated, multi-platform, multi-component waveforms. - Continued development of a real-time, electronic warfare support, de-interleaving capability. - Continued development of advanced communications emitter identification. - Continued to develop and demonstrate Multiple Input Multiple Output (MIMO) radar concepts and technology using High Frequency (HF) Skywave radar. - Continued development of functional classification techniques of advanced threat emissions. - Continued development of unique tactical feature derivation of modern surveillance systems. - Continued development of electronic protection techniques for long range emitter classification systems. *FY 2014 Plans:* - Continue all efforts of FY 2013. - Complete development of functional classification techniques of advanced threat emissions. *FY 2015 Plans:* - Continue all efforts of FY 2014 unless otherwise noted as complete.	4.437	2.742	2.882

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Complete development of unique tactical feature derivation of modern surveillance systems.			
Title: TACTICAL SPACE EXPLOITATION Description: 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 by taking advantage of the global access, revisit and connectivity provided by orbital platforms. a) Spacecraft Technology: 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. The increase in funding from FY 2014 to FY 2015 reflects initiation of new efforts and planned funding profile of existing efforts within this activity. The following are non-inclusive examples of accomplishments and plans for projects funded in this activity: FY 2013 Accomplishments: Spacecraft Technology: - 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 effort to develop technologies using autonomous, bi-dexterous manipulation for close proximity operations in space. - Continued developing the underlying fluid transfer technologies for steerable radiators that will enable spacecraft thermal radiators to be pointed away from the sun. - Continued developing a proof-of-concept, reliable, touch sensitive skin for robotic arms, with emphasis on space applications, and the associated fault detection and model identification algorithms required to utilize it. - Continued developing the ability to artificially generate and maintain a dust layer in the near-earth plasma environment to induce enhanced drag on space debris, aiming toward debris mitigation. - Continued effort to design, develop and test a novel PicoSat-compatible spacecraft attitude sensor that is based on an existing NRL-designed space weather spectrometer, which will enable PicoSat-class missions requiring continuous day/night operations. - Continued effort to develop a self-contained, space-based plasma impedance probe innovative sensor that will be easy to mount and field on any space platform, which will provide reliable early warning of hazardous spacecraft charging. FY 2014 Plans: - Continue all efforts of FY 2013. Spacecraft Technology:	3.952	4.322	6.265

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Complete effort to design, develop and test a novel PicoSat-compatible spacecraft attitude sensor that is based on an existing NRL-designed space weather spectrometer, which will enable PicoSat-class missions requiring continuous day/night operations. *FY 2015 Plans:* - Continue all efforts of FY 2014 unless otherwise noted as complete. Spacecraft Technology - Complete effort develop a self-contained, space-based plasma impedance probe innovative sensor that will be easy to mount and field on any space platform, which will provide reliable early warning of hazardous spacecraft charging.			
Title: INFORMATION SECURITY RESEARCH *Description:* The overarching objective of this activity is to protect the Navy and the Joint information infrastructure from hostile exploitation and attack. This activity transfers from PE 0603235N effective FY 2013 to focus on applied research in information security. The current specific objectives are: a) Network Situation Awareness & Security: Develop tools, techniques and methodologies to improve network resistance to denial of service attacks and improve indications and warnings of suspect activities. b) Network Traffic Analysis and Assessment: Develop methods for conducting network traffic analysis; monitoring and assessing network status and health; identifying new capabilities to analyze network vulnerabilities and attacks; and providing situational awareness of network assets and operations. c) Information Assurance: Develop and measure the effectiveness of Information Assurance (IA) protective solutions and improve the quality and level of certification of information assurance software. The following accomplishments and plans are non-inclusive examples of accomplishments and plans for projects funded in this activity. *FY 2013 Accomplishments:* Network Situation Awareness & Security: - Continued development of algorithms/methods for providing attribution of threat-agents through the network/infrastructure. Emphasis will be placed on addressing translational boundaries, cross-domains, and obfuscation techniques to avoid detection and tagging. - Continued development of new algorithms to link/mine disparate system/network activities in order to identify malicious/threat agent actions against infrastructure components/systems. - Initiated new mobile agent technology that provides network protection, thwarts botnet attacks, and provides for a resilient computational infrastructure and communications environment. Investigate new methods for subverting the control plane of the mobile code attacking the infrastructure.	1.715	2.002	2.060

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B. Accomplishments/Planned Programs ($ in Millions)	**FY 2013**	**FY 2014**	**FY 2015**
Network Traffic Analysis and Assessment: - Continued development of new algorithms focused on detection of nation state sponsored activities through the network infrastructure. - Initiated algorithms to address sophisticated malicious code techniques that exploit network traffic/data that is fragmented, encrypted, and/or obfuscated using polymorphic methods, as well as techniques that transgress security perimeters and exfiltrate data. Information Assurance: - Continued enclave boundary security controller to protect Navy networks from attack and exploitation with emphasis on addressing malware detection, data exfiltration, general attack detection, network reconstitution, exploitable cross-infrastructure dependencies. *FY 2014 Plans:* Network Situation Awareness & Security: - Continue development of algorithms/methods for providing attribution of threat-agents through the network/infrastructure. Building upon previous results, develop network-based techniques to provide pro-active response to attributed threat agents to mitigate attack vector and ensure mission success. - Continue investigating new methods for subverting the control plane of the mobile code attacking the network infrastructure. Initiate the development of new algorithms for taking control of bots once the control plane is compromised. - Complete development of algorithms to link/mine disparate system/network activities in order to identify malicious/threat agent actions against infrastructure components/ systems. Expand algorithms to include threat-agent identification. - Initiate development of new algorithms/techniques to characterize Navy and Marine Corps network assets in order to develop robust security mechanisms and support technologies based on criticality and mission essential operations. Network Traffic Analysis and Assessment: - Continue development of new algorithms focused on detection of nation state sponsored activities through the network infrastructure. Develop algorithms to address sophisticated malicious code techniques. - Initiate development of new algorithms that provide attack prediction and targets of opportunity. Information Assurance: - Complete development of the enclave boundary security controller to protect Navy networks from attack and exploitation with emphasis on addressing malware detection, data exfiltration, general attack detection, network reconstitution, exploitable cross-infrastructure dependencies.			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
- Initiate development of methods and techniques to provide component repurposing/agility to flatten the attack surface from sophisticated nation-state sponsored attacks.			
FY 2015 Plans: N/A			
Title: AUTONOMOUS SYSTEMS AND ROBOTICS **Description:** The Autonomous Systems and Robotics initiative explores the application of new technologies to advance capabilities in the area of robotics, autonomous systems propulsion and control, and integration of autonomous systems. Efforts will be focused on the Assistant Secretary of Defense (Research and Engineering) (ASD(R&E)) priorities in autonomous systems. FY13 funds are for acceleration efforts in Autonomous Systems and Robotics. The decrease from FY 2013 to FY 2014 is due to the completion of initial stand-up activities in FY 2013 for the Autonomous Systems and Robotics initiative. **FY 2013 Accomplishments:** Robotics Platform Research: This addresses development of autonomous robotic systems capability to interact with and service other platforms and autonomous vehicles. Micro-Robotic Servicing - advanced highly dexterous control of extremely lightweight and flexible robotic arms, with specific application to EOD, surveillance and on-orbit servicing robotic communities. This research would extend ongoing research in lightweight robotic arms. Autonomous Refueling - development of hardware, algorithms, and sensors for hybrid rigid-compliant robotic arms in rapidly changing environments, with specific application to autonomous refueling of USVs, UAVs and UGVs while moving in their environments, advancing beyond the DARPA-sponsored "Rapid Autonomous Fuel Transfer Project". Low Power Micro-robotics - development of onboard sensors, control electronics, and actuators requiring very low power, with specific application to robotic missions over long durations. Advanced Manipulators and Tool-Changers - development of innovative robotic manipulators, tool changers, and associated sensors for challenging robotic manipulation tasks, with specific application to EOD and other robotic missions in difficult environments. This research would extend previous research by providing robust end effector technology and tool changing	5.444	1.981	1.972

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2013	FY 2014	FY 2015
capability. The overall research outcomes will enhance DoD capability in the areas of explosive ordnance disposal, autonomous vehicle refueling, and innovative robotic arm control. Research deliverables will include hardware development in the areas of lightweight robotic arms, end effector tools and tool changers, and low power electronics and actuators. Autonomous Vehicles: - This effort will draw from current research and push the technology development to the next level to provide a leap-ahead capability in long endurance, deployable, autonomous, robotic air vehicle using fuel cell electric propulsion systems for high efficiency, even in small vehicles, which can provide robust airborne sensor capabilities for submarines, UUVs, small naval platforms and small dismounted units. Undersea Vehicles: - Funding would be used to acquire a medium sized (12.5 inch diameter) Autonomous Underwater Vehicle as an at sea test platform to advance the state of art of onboard intelligent autonomy. This medium sized UUV is readily amenable to vehicle and sensor testing in the wave pool in the Laboratory for Autonomous Systems Research facility. Subsequently, this would allow at sea testing of State of the art autonomy algorithms (e.g. goal driven autonomy, human cognitive models, Markov decision processes) that allow Navy underwater vehicles to carry out complex mission in denied areas by understanding the environment and adapting mission goals in the context of the commander's intent, with little or no human operator intervention. Autonomous Systems Integration: - To support the Assistant Secretary of Defense (Research and Engineering) (ASD(R&E)) priorities in autonomous systems, and specifically to advance the state of the art in heterogeneous teams of autonomous platforms, (including sensor networks and mobile communication nodes) that can work seamlessly with the warfighter, funding will be applied to small air platforms and militarily relevant unmanned ground vehicles to integrate sensors and advanced power sources, and to develop the autonomy software that allows the individual platforms to work together, as well as to work at a peer-to-peer level with the warfighter. This includes advanced human-robot interaction techniques and information processing and presentation techniques that reduce the warfighter's cognitive load and allows him to work with a team of autonomous systems. ***FY 2014 Plans:*** Continue all FY 2013 efforts and sustainment of Autonomous Systems and Robotics initiative. ***FY 2015 Plans:*** Continue all FY 2014 efforts.			
Accomplishments/Planned Programs Subtotals	37.643	34.136	43.541

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C. Other Program Funding Summary ($ in Millions)

 N/A

Remarks

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:
 - 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 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 in small, light-weight, and low-cost satellites to test new concepts for global ship tracking and two-way data exfiltration.