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**Exhibit R-2, RDT&E Budget Item Justification:** PB 2025 Navy **Date:** March 2024

<b>Appropriation/Budget Activity</b> 1319: <i>Research, Development, Test &amp; Evaluation, Navy / BA 2: Applied Research</i>	<b>R-1 Program Element (Number/Name)</b> PE 0602235N / <i>Common Picture Applied Research</i>
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COST (\$ in Millions)	Prior Years	FY 2023	FY 2024	FY 2025 Base	FY 2025 OCO	FY 2025 Total	FY 2026	FY 2027	FY 2028	FY 2029	Cost To Complete	Total Cost
Total Program Element	0.000	50.501	52.090	51.202	-	51.202	52.049	55.500	56.896	59.688	Continuing	Continuing
0000: <i>Common Picture Applied Research</i>	0.000	50.501	52.090	51.202	-	51.202	52.049	55.500	56.896	59.688	Continuing	Continuing

**A. Mission Description and Budget Item Justification**

Activities and efforts in this program examine concepts and technologies that enable the transformation to Distributed Maritime Operations (DMO). Network centric capabilities rely on information to connect assets and provide timely and accurate understanding of the environment. The mission area requirements for rapid, accurate decision-making; dynamic, efficient, mission- focused communications and networks; and pervasive and persistent sensing drive network centric Science and Technology (S&T) investments.

Today's Sailors and Marines are enabled by Naval S&T. Since 1946, the Office of Naval Research (ONR) has fostered scientific research related to the maintenance of maritime superiority and national defense. ONR manages the Department of the Navy's (DON) portfolio of naval Basic and Applied research, and Advanced Technology Development investments to ensure naval forces can effectively deter conflict, but when called upon, fight, win and come home safe. Current investments hedge against uncertainty, providing solutions to commanders today, and options for the future. The Naval S&T budget supports higher guidance defined by the National Defense Strategy, and responds to requirements identified by the Secretary of the Navy through research priorities set by the Chief of Naval Research, coordinated across the Naval Research Enterprise (NRE), and outlined in the Naval R&D Framework.

This Program Element (PE) funds Applied Research, which is the systematic study to understand the means to meet a recognized and specific need. Most of the work in this PE can be classified between Technology Readiness Level (TRL) 2 (technology concept and/or application formulation) and TRL 4 (component and/or breadboard validation in laboratory environments).

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

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<b>B. Program Change Summary (\$ in Millions)</b>	<b>FY 2023</b>	<b>FY 2024</b>	<b>FY 2025 Base</b>	<b>FY 2025 OCO</b>	<b>FY 2025 Total</b>
Previous President's Budget	51.911	52.090	53.601	-	53.601
Current President's Budget	50.501	52.090	51.202	-	51.202
Total Adjustments	-1.410	0.000	-2.399	-	-2.399
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-0.269	0.000			
• SBIR/STTR Transfer	-1.141	0.000			
• Program Adjustments	0.000	0.000	-2.399	-	-2.399

**Change Summary Explanation**

Funding: The decrease in FY 2025 is due to S&T reduction in Applied Research.

Technical: No significant change

Schedule: No significant change

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<b>COST (\$ in Millions)</b>	<b>Prior Years</b>	<b>FY 2023</b>	<b>FY 2024</b>	<b>FY 2025 Base</b>	<b>FY 2025 OCO</b>	<b>FY 2025 Total</b>	<b>FY 2026</b>	<b>FY 2027</b>	<b>FY 2028</b>	<b>FY 2029</b>	<b>Cost To Complete</b>	<b>Total Cost</b>
0000: <i>Common Picture Applied Research</i>	0.000	50.501	52.090	51.202	-	51.202	52.049	55.500	56.896	59.688	Continuing	Continuing

**A. Mission Description and Budget Item Justification**

Activities and efforts in this program examine concepts and technologies that enable the transformation to network centric warfare. Network centric capabilities rely on information to connect assets and provide timely and accurate understanding of the environment. The mission area requirements for rapid, accurate decision-making; dynamic, efficient, mission-focused communications and networks; and pervasive and persistent sensing drive network centric Science and Technology S&T investments.

The activities described in this Program Element (PE) address future Navy and Marine Corps capabilities needed to maintain maritime superiority and ensure national security. They are based on input from Naval Research Enterprise (NRE) stakeholders (including the Naval enterprises, the combatant commands, the Office of the Chief of Naval Operations, and Headquarters Marine Corps) and are designed to exploit breakthroughs in science and technology in order to deliver maximum warfighting benefit to our sailors and marines. These efforts are aligned with shared priorities throughout the whole of RDT&E in order to quickly advance new capabilities from discovery to deployment across the warfighting domains.

**B. Accomplishments/Planned Programs (\$ in Millions)**

	<b>FY 2023</b>	<b>FY 2024</b>	<b>FY 2025 Base</b>	<b>FY 2025 OCO</b>	<b>FY 2025 Total</b>
<b>Title:</b> Communication and Networks	6.173	8.124	8.862	0.000	8.862
<b>Description:</b> 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 Radio Frequency (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 RF challenged environments.					
The current specific objectives are:					

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**B. Accomplishments/Planned Programs (\$ in Millions)**

	<b>FY 2023</b>	<b>FY 2024</b>	<b>FY 2025 Base</b>	<b>FY 2025 OCO</b>	<b>FY 2025 Total</b>
<p>Radios and Apertures:</p> <ul style="list-style-type: none"> <li>- 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 Beyond Line Of Sight (BLOS) communications.</li> <li>- Develop algorithms and signal processing for space-time-frequency diversity communications, including measures for electronic protection, such as low-intercept, antijam waveforms and modulation.</li> <li>- Develop affordable antenna technologies for small size and weight, high radiation efficiency, and wideband operation with rapid beam-steering.</li> <li>- Develop alternatives to Radio Frequency (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.</li> <li>- 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.</li> </ul> <p>Tactical Networking and Network Control/Management:</p> <ul style="list-style-type: none"> <li>- 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.</li> <li>- 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.</li> <li>- 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.</li> <li>- 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.</li> </ul> <p><b>FY 2024 Plans:</b> Communication and Networks:</p>					

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**B. Accomplishments/Planned Programs (\$ in Millions)**

	<b>FY 2023</b>	<b>FY 2024</b>	<b>FY 2025 Base</b>	<b>FY 2025 OCO</b>	<b>FY 2025 Total</b>
<ul style="list-style-type: none"> <li>- Complete research on optical beam distortion and phase front corrections with machine learning and neural networks.</li> <li>- Continue research on communications with low probability of detection.</li> <li>- Continue research on novel path computation algorithms and autonomous distributed network control.</li> <li>- Continue research on efficient approaches for wideband, multi-beam, high-power communications.</li> <li>- Continue research on quantum techniques for secure underwater magnetic and optical communications systems.</li> <li>- Continue research on artificial intelligence approaches to establish network policies based on Commander Intent.</li> <li>- Continue research on transmission security enhancements to 5G for tactical operations.</li> <li>- Continue research addressing several known problems in signal processing theory related to synchronization and detection theory specifically for covert communications waveforms.</li> <li>- Continue research on optimization techniques to develop robust data coordination systems for dynamic and denied naval environments.</li> <li>- Initiate research into underwater blue-green optical communications technologies.</li> </ul> <p><b><i>FY 2025 Base Plans:</i></b> Communication and Networks:</p> <ul style="list-style-type: none"> <li>- Continue research on communications with low probability of detection.</li> <li>- Continue research on novel path computation algorithms and autonomous distributed network control.</li> <li>- Continue research on transmission security enhancements to 5G for tactical operations.</li> <li>- Continue research into underwater blue-green optical communications technologies.</li> <li>- Complete research on efficient approaches for wideband, multi-beam, high-power communications.</li> <li>- Complete research on quantum techniques for secure underwater magnetic and optical communications systems.</li> <li>- Complete research on artificial intelligence approaches to establish network policies based on Commander Intent.</li> <li>- Complete research on optimization techniques to develop robust data coordination systems for dynamic and denied naval environments. (NRL)</li> <li>- Initiate research on electrically small antennas at lower frequencies.</li> <li>- Initiate research on interference reduction and cancellation.</li> <li>- Initiate research on using current traffic data to predict future, near-term behavior.</li> </ul>					

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<b>B. Accomplishments/Planned Programs (\$ in Millions)</b>	<b>FY 2023</b>	<b>FY 2024</b>	<b>FY 2025 Base</b>	<b>FY 2025 OCO</b>	<b>FY 2025 Total</b>
<p>- Initiate efforts in Networks and Communications Technology. The overall goal of this effort is devoted to the application of information theory, network and transport layer theory, and applied foundational science in wireless, networked communications, as well as the reference implementation and design of Naval waveforms, heterogeneous communications networks, tactical data links, tactical edge networks, and backhaul communications systems. These efforts include applied science in the technology areas of information system design, protocol engineering, routing, architectures, waveforms, software defined communications systems, tactical data links low probability intercept/detect networks, information operations, C5ISRT/Counter C5ISRT (with focus on Command, Control, Communications, Targeting) and reliable networked communications systems, all of which may be operating in contested and denied environments. These efforts include implementation of applied science in spectrum sharing, spectrum agile communications, dynamic spectrum access radios and networks, as well as heterogeneous networked communications for autonomous vehicles and systems that by the completion of their project work, could be demonstrated in the field or at sea with the Fleet. (NRL)</p> <p><b>FY 2025 OCO Plans:</b> N/A</p> <p><b>FY 2024 to FY 2025 Increase/Decrease Statement:</b> There is no significant funding change from FY 2024 to FY 2025.</p>					
<p><b>Title:</b> Applied Information Sciences for Decision Making</p> <p><b>Description:</b> The goal of this activity is to develop enablers for decision making and mission execution in order 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, recognizing activities, 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 Communication, Command and Control (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</p>	36.853	37.630	37.439	0.000	37.439

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**B. Accomplishments/Planned Programs (\$ in Millions)**

	<b>FY 2023</b>	<b>FY 2024</b>	<b>FY 2025 Base</b>	<b>FY 2025 OCO</b>	<b>FY 2025 Total</b>
<p>understanding of nanomaterials, new devices and circuit design concepts, as well as new architectures uniquely suited for nanoscale systems. Applied research in artificial intelligence focuses on the unique challenges of the Naval domain by providing intelligent decision aids while operating in the complex spatio-temporal environments of distributed Naval forces.</p> <p><b>FY 2024 Plans:</b>                      Quantum Information Sciences:                      - Complete research into the application of on-chip optical processing with distributed quantum states of light for suppressing noise for measurement and communication devices.                      - Continue research into efficient protocols to implement quantum information processing with atoms and photons.                      - Continue research into quantum approaches to solve hard decision problems with naval relevance that may outperform classical techniques.                      - Continue research on robust devices compatible with long distance distribution of entanglement.                      - Initiate research on applications of distributed entanglement in a quantum network.</p> <p>Computational Methods for Decision Making:                      - Complete development of methods for continuous learning and expertise assessment.                      - Complete development of mathematical models, theory, and solution methods for effectively allocating scarce resources (funds, information, personnel, equipment) within competitive environments.                      - Complete development of robust reinforcement learning methods for autonomous agents that can learn performing multiple tasks in several different environments.                      - Continue development of methods for large-scale coordination and aggregation of individual preferences.                      - Continue development of methods for adaptive training on individual and group levels.                      - Continue analysis of information flow and dynamics of influence in large networks.                      - Continue development of tools for structured and distributed deliberation and decision-making. - Continue development of secure and privacy-preserving tools for information sharing.                      - Continue development of visual sense making capabilities for distributed Navy teams to successfully run operations in increasingly contested, diverse, multi-expertise, and highly data driven decisional contexts.                      - Continue research into stochastic integer programming models and algorithms to achieve strategic and tactical superiority in a variety of contexts.                      - Continue research into developing practical integer programming approaches to solving binary classification problems.</p>					

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<b>B. Accomplishments/Planned Programs (\$ in Millions)</b>	<b>FY 2023</b>	<b>FY 2024</b>	<b>FY 2025 Base</b>	<b>FY 2025 OCO</b>	<b>FY 2025 Total</b>
<ul style="list-style-type: none"> <li>- Continue development of methods for Unmanned Aerial Vehicle (UAV)-based video surveillance along roads and rivers that are partially occluded by tree canopies using a marsupial system consisting of a large UAV capable of long-duration flight and several small quadcopters.</li> <li>- Continue development of robust computer vision systems inspired by human visual system.</li> <li>- Continue investigation of Radio Frequency (RF) imaging for motion detection and activity recognition behind optically opaque walls.</li> <li>- Continue efforts using Machine Learning (ML) models to recognize and predict what the operator is doing, allowing the system to then facilitate the operator's goals. (NRL)</li> <li>- Continue development of algorithms for unmanned surface vehicles that determine optimal sensor placement for detecting and tracking targets of interest in littoral areas, as well as to develop verification methods and tools to increase the operational assurance of the autonomous vehicles. (NRL)</li> <li>- Initiate development of tools for synthesis of information, intelligence gathering and effective decision making.</li> <li>- Initiate research into logistics planning and scheduling in contested environments.</li> <li>- Initiate research in building reliable classifiers, based on a novel data augmentation approach, for robust object recognition.</li> </ul> <p>Nanoscale Electronics Technology:</p> <ul style="list-style-type: none"> <li>- Complete exploratory research on graphene based vacuum electronics.</li> <li>- Continue research on Two-Dimensional (2D) electronic materials and related device and circuit functions. Specifically, the program will push the limit of 2D semiconductor transistors through van der Waals integration of metallic contacts and gate dielectric stack, requiring exploration of surface and interface engineering of 2D heterostructures.</li> <li>- Continue research on electronic effects of "Moire" textures induced by broken symmetry between 2D atomic layers, for example in twisted bilayer graphene capable of assuming a sequence of correlated phases implementing a physical Hubbard model computation.</li> </ul> <p>Cyber Defense:</p> <ul style="list-style-type: none"> <li>- Complete thrust in cyber decoys and disinformation, exploring how to automatically analyze the artifacts from cyber adversary campaigns for noise generation that could degrade and disrupt those campaigns.</li> <li>- Complete efforts to improve the security of lookup and the security of entrance for Internet sites developing subdomain onion addresses for self-authenticating subdomains of registered domains that will work with ordinary browsers and will appear as alt names in Transport Layer Security (TLS) certificates.</li> </ul>					

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<b>B. Accomplishments/Planned Programs (\$ in Millions)</b>	<b>FY 2023</b>	<b>FY 2024</b>	<b>FY 2025 Base</b>	<b>FY 2025 OCO</b>	<b>FY 2025 Total</b>
<p>- Continue to conduct applied research toward dependable and resilient cyber systems leveraging results from basic research program, and developing and evaluating technical approaches for future naval capabilities. The program investigates technologies addressing root causes of cyber vulnerability and enhancing efficiency, robustness and cyber resiliency for all classes of computing systems in naval enterprise systems.</p> <p>- Continue design and development of tools and techniques for understanding and improving security of cyber-physical systems, which are a critical area of focus for assuring mission success of naval platforms. The systematic extension of techniques in cyber fault tolerance are informing new resilience architectures for information processing systems that ingest data from the physical and spectral environments.</p> <p>- Continue design of approaches to apply techniques from signal processing and machine learning to ingestion of granular system events in context of memory structure for advanced understanding of system state that would be more effective at discovering activity of stealthy adversaries.</p> <p>- Continue development of tools and techniques to model and understand adversary motivation and intent that scale beyond traditional artifact analysis in order to achieve robust, hardened and scalable cyber defense techniques that can be employed throughout Navy networks that address nation state adversary activities. (NRL)</p> <p>- Initiate development of initial prototypes that implement cyber counter proliferation techniques designed to automatically disrupt components necessary for execution of cyber malware campaigns.</p> <p>Data Analytics:</p> <p>- Complete development of disseminating data in a prioritized way and under zero-trust conditions between a shore-based multi-level system cloud environment and an on-premise cloud multi-level system at the tactical edge.</p> <p>- Continue development of methods for large-scale assessment and evaluation of distributed information.</p> <p>- Continue applied research in optimizing coordination, efficient exchange of information and integration of large amounts of data in real time among distributed operations centers.</p> <p>- Continue development of an architecture that supports distributed/resilient Maritime Operations Center operations that supports data in multi-level system with zero trust enforcement.</p> <p>- Continue development of advanced data analytics to enable automated and orchestrated threat detection consistent with the DISA Zero Trust Reference Architecture to refine and extend Agile Enclave to provide secure data access in challenging warfighting environments.</p> <p>- Initiate development of Artificial Intelligence (AI)/Machine Learning (ML) techniques to consistently learn the data analytic environment and apply appropriate analytics to data exchange streams dynamically during challenging operational scenarios.</p>					

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**B. Accomplishments/Planned Programs (\$ in Millions)**

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<p>Science of Artificial Intelligence:</p> <ul style="list-style-type: none"> <li>- Complete AI-based analysis of data from wearable sensors and task performance measures to monitor and optimize human performance. Outcome: a testable AI algorithm that will be used to assess and monitor heat injuries.</li> <li>- Continue applied research on principled computational frameworks for integrating domain knowledge and machine learning for fast robust learning of diverse, complex concepts and tasks with minimal supervision to analyze the sparse, noise and unlabeled data of the Naval domain.</li> <li>- Continue application of new brain-inspired artificial intelligence algorithms and architectures for the development of compact neuromorphic hardware suitable for edge computing and signal processing in Naval platforms.</li> <li>- Continue use of AI for enhanced collaborative complex decision-making and human-machine dialogue to increase the speed and quality of operational decisions.</li> <li>- Continue research on embedding AI in robotic systems to enable human-machine collaboration and robot training for hazardous missions.</li> <li>- Continue to integrate physical models with machine learning to enable predictive maintenance for autonomous Naval platforms and enable long duration autonomous missions.</li> <li>- Continue applied research to design embedded neuromorphic processors into intelligent autonomous systems to permit onboard analysis of target data to enable single-pass mine countermeasures missions.</li> <li>- Continue applied research to validate Artificial Intelligence (AI) algorithms to provide distributed perception in networks of interacting autonomous agents in the presence of varying levels of reliability and trust at both network and individual agent.</li> <li>- Continue applied research on AI tools for multi-level optimization of shipyard maintenance scheduling to accelerate on time delivery of ships out of maintenance and improve ship availability and fleet readiness.</li> <li>- Continue to develop and assess techniques for training AI to extract Naval task procedures from natural language and chat data.</li> <li>- Continue research on the ability to enable a humanoid robot to adapt skills learned in one Naval environment or context, to new situations. Cues of the current context, including the environmental state or goals of the robot or its teammates, will modulate the execution of existing robotic skills, such as adjusting the robot's speed. (NRL)</li> <li>- Initiate research exploring the collaborative relationship between agents and humans, cooperating on common interest goals, with mutual engagement of all participants and coordinated efforts mediated by effective communication.</li> </ul> <p>Electromagnetic Warfare:</p>					

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<p>- Continue the development and demonstration of a novel Electronic Attack (EA) capability. It will accomplish this by enhancement of a suite of Radio Frequency (RF) signature-related technologies. The result will provide a new capability to counter advanced threats. (NRL)</p> <p><b><i>FY 2025 Base Plans:</i></b></p> <p>Quantum Information Sciences:</p> <ul style="list-style-type: none"> <li>- Continue research into efficient protocols to implement quantum information processing with atoms and photons.</li> <li>- Continue research into quantum approaches to solve hard decision problems with naval relevance that may outperform classical techniques.</li> <li>- Continue research on robust devices compatible with long distance distribution of entanglement.</li> <li>- Continue research on applications of distributed entanglement in a quantum network.</li> </ul> <p>Computational Methods for Decision Making:</p> <ul style="list-style-type: none"> <li>- Continue development of tools for synthesis of information, intelligence gathering and effective decision making.</li> <li>- Continue research in building reliable classifiers, based on a novel data augmentation approach, for robust object recognition.</li> <li>- Continue development of methods for large-scale coordination and aggregation of individual preferences.</li> <li>- Continue development of methods for adaptive training on individual and group levels.</li> <li>- Continue analysis of information flow and dynamics of influence in large networks.</li> <li>- Continue development of tools for structured and distributed deliberation and decision-making.</li> <li>- Continue development of secure and privacy-preserving tools for information sharing.</li> <li>- Continue development of visual sense making capabilities for distributed Navy teams to successfully run operations in increasingly contested, diverse, multi-expertise, and highly data driven decisional contexts.</li> <li>- Continue research into stochastic integer programming models and algorithms to achieve strategic and tactical superiority in a variety of contexts.</li> <li>- Continue research into developing practical integer programming approaches to solving binary classification problems.</li> <li>- Continue research into logistics planning and scheduling in contested environments.</li> <li>- Continue development of methods for Unmanned Aerial Vehicle (UAV)-based video surveillance along roads and rivers that are partially occluded by tree canopies using a marsupial system consisting of a large UAV capable of long-duration flight and several small quadcopters.</li> </ul>					

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**B. Accomplishments/Planned Programs (\$ in Millions)**

	<b>FY 2023</b>	<b>FY 2024</b>	<b>FY 2025 Base</b>	<b>FY 2025 OCO</b>	<b>FY 2025 Total</b>
<ul style="list-style-type: none"> <li>- Continue development of robust computer vision systems inspired by human visual system.</li> <li>- Continue investigation of Radio Frequency (RF) imaging for motion detection and activity recognition behind optically opaque walls.</li> <li>- Continue work in Artificial Intelligence Technology. The goal of this effort is to develop products in Intelligent Agents, Cognitive Science, Robotics, Autonomy, Machine Learning (ML), and Multi-agent control planes/ protocols intended for future distributed autonomous unmanned systems and swarms. These include reference implementations, integration of S&amp;T products, and sufficiently mature components that, by the completion of their project work, could be demonstrated in the field or at sea with the Fleet. These should include advancements in the fields of Cognitive S&amp;T, Coalition/Alliance compatibility, safe collaboration, multi-agent autonomous systems and control planes, cognitive modeling and machine learning, and all facets of artificial intelligence pertinent to Naval programs of record and S&amp;T projects, to ultimately include deployed Adaptable Artificial Intelligence. This is an expansion on the previously mentioned efforts using Machine Learning (ML) models to recognize and predict what the operator is doing, allowing the system to then facilitate the operator's goals. It also takes into account efforts conducted to enable a humanoid robot to adapt skills learned in one environment or context, to new situations. Cues of the current context, including the environmental state or goals of the robot or its teammates, will modulate the execution of existing robotic skills, such as adjusting the robot's speed. (NRL)</li> <li>- Complete the development of algorithms for unmanned surface vehicles that determine optimal sensor placement for detecting and tracking targets of interest in littoral areas, as well as to develop verification methods and tools to increase the operational assurance of the autonomous vehicles. (NRL)</li> <li>- Initiate development of conversational information retrieval systems.</li> <li>- Initiate research into algorithms that coordinate and optimize the behavior of multiple heterogeneous assets and sensors in a contested environment.</li> <li>- Initiate development of visual analytics for detection, tracking, and recognition of small vessels in the maritime domain from various types of surveillance platforms.</li> </ul> <p>Nanoscale Electronics Technology:</p> <ul style="list-style-type: none"> <li>- Continue integration of contacts and dielectrics on two-dimensional semiconductors.</li> <li>- Complete the investigation of correlated exciton phases in "Moire" superlattices.</li> <li>- Initiate research for designable non-centrosymmetric superconductors.</li> <li>- Initiate research on ultra-fast, non-volatile memory materials and devices.</li> </ul> <p>Cyber Defense:</p>					

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**B. Accomplishments/Planned Programs (\$ in Millions)**

	<b>FY 2023</b>	<b>FY 2024</b>	<b>FY 2025 Base</b>	<b>FY 2025 OCO</b>	<b>FY 2025 Total</b>
<p>- Continue efforts in High Assurance Systems Technology. This includes but is not limited to a wide range of efforts such as Cyber, Cryptological work, deep neural networks, assured computing, autonomous SDN orchestration, automation for reverse engineering and vulnerability analysis, Game-theoretic Artificial Intelligence (AI) for defenses against cyber-attacks, adversarial threat modeling, privacy-enhancing technologies, covert and encrypted communications, Field Programmable Gate Arrays (FPGA)-based hardware assurance, and automatic generation of Correct-by-Construction code. These endeavors should lead to applied, reference implementations, or sufficient maturity of the basic S&amp;T that are demonstrable in field testing or at sea once the work is completed. Additional areas will apply basic foundational science currently being planned or conducted in areas such as autonomous cyber maneuver, scaling and automation of algorithms for vulnerability discovery, mitigation, weaponization, cyber resilience, programmability, and reconfigurability. This is an expansion of previously mentioned development of tools and techniques to model and understand adversary motivation and intent that scale beyond traditional artifact analysis in order to achieve robust, hardened and scalable cyber defense techniques that can be employed throughout Navy networks that address nation state adversary activities. (NRL)</p> <p>- Continue to conduct applied research toward dependable and resilient cyber systems leveraging results from basic research program and developing and evaluating technical approaches for future naval capabilities. The program investigates technologies addressing root causes of cyber vulnerability in order to enhance efficiency, robustness and cyber resiliency for all classes of computing systems in naval warfighting systems.</p> <p>- Continue design and development of tools and techniques for understanding and improving security of cyber-physical systems, which are a critical area of focus for assuring mission success of naval platforms. The systematic extension of techniques in cyber fault tolerance are informing new resilience architectures for information processing systems that ingest data from the physical and spectral environments.</p> <p>- Continue development of initial prototypes that implement cyber counter proliferation techniques designed to automatically disrupt components necessary for execution of cyber malware campaigns.</p> <p>- Complete design of approaches to apply techniques from signal processing and machine learning to ingestion of granular system events in context of memory structure for advanced understanding of system state that would be more effective at discovering activity of stealthy adversaries.</p> <p>- Initiate design and development of tools and techniques to advance the automation of cyber operations, a critical need as timelines are shrinking and human expertise remains in short supply.</p> <p>- Initiate systematic investigation into transformation and analysis methods toward achieving zero-trust software and hardware supply chains, seeking to proactively disrupt undesirable behavior without having to specifically identify it.</p>					

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**B. Accomplishments/Planned Programs (\$ in Millions)**

	<b>FY 2023</b>	<b>FY 2024</b>	<b>FY 2025 Base</b>	<b>FY 2025 OCO</b>	<b>FY 2025 Total</b>
<p>Data Analytics:</p> <ul style="list-style-type: none"> <li>- Continue development of methods for large-scale assessment and evaluation of distributed information.</li> <li>- Complete development of advanced data analytics to enable automated and orchestrated threat detection consistent with the DISA Zero Trust Reference Architecture to refine and extend Agile Enclave to provide secure data access in challenging warfighting environments.</li> <li>- Complete development of Artificial Intelligence (AI)/Machine Learning (ML) techniques to consistently learn the data analytic environment and apply appropriate analytics to data exchange streams dynamically during challenging operational scenarios.</li> <li>- Complete development of an architecture that supports distributed/resilient Maritime Operations Center operations that supports data in multi-level system with zero trust enforcement.</li> <li>- Complete applied research in optimizing coordination, efficient exchange of information and integration of large amounts of data in real time among distributed operations centers.</li> <li>- Initiate development of Artificial Intelligence/Machine Learning techniques using game theory to model Blue versus Red deliberate planning where decisions made over time with imperfect information inhibits each side of knowing exact state of opposing and own team's condition.</li> <li>- Initiate development of optimization solutions that place Blue forces in optimal search locations due to limited search Blue assets and large search areas against hard to find adversary targets.</li> <li>- Initiate development of multi-commodity optimization solutions for contested environments that satisfy large-scale distribution of classes of supplies while avoiding too-dense consolidation of resources depot, which may serve as an easy target for an adversary to disrupt logistic feasibility.</li> </ul> <p>Science of Artificial Intelligence (AI)</p> <ul style="list-style-type: none"> <li>- Continue applied research on principled computational frameworks for integrating domain knowledge and machine learning for fast robust learning of diverse, complex concepts and tasks with minimal supervision to analyze the sparse, noise and unlabeled data of the Naval domain.</li> <li>- Continue application of new brain-inspired artificial intelligence algorithms and architectures for the development of compact neuromorphic hardware suitable for edge computing and signal processing in Naval platforms.</li> <li>- Continue use of Artificial Intelligence (AI) for enhanced collaborative complex decision-making and human-machine dialogue to increase the speed and quality of operational decisions.</li> <li>- Continue research on embedding AI in robotic systems to enable human-machine collaboration and robot training for hazardous missions.</li> </ul>					

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<b>B. Accomplishments/Planned Programs (\$ in Millions)</b>	<b>FY 2023</b>	<b>FY 2024</b>	<b>FY 2025 Base</b>	<b>FY 2025 OCO</b>	<b>FY 2025 Total</b>
<p>- Continue to integrate physical models with machine learning to enable predictive maintenance for autonomous Naval platforms and enable long duration autonomous missions.</p> <p>- Continue applied research to design embedded neuromorphic processors into intelligent autonomous systems to permit onboard analysis of target data to enable single-pass mine countermeasures missions.</p> <p>- Continue applied research on AI tools for multi-level optimization of shipyard maintenance scheduling to accelerate on time delivery of ships out of maintenance and improve ship availability and fleet readiness.</p> <p>- Continue to develop and assess techniques for training AI to extract Naval task procedures from natural language and chat data.</p> <p>-Continue research exploring the collaborative relationship between agents and humans, cooperating on common interest goals, with mutual engagement of all participants and coordinated efforts mediated by effective communication.</p> <p>-Complete applied research to validate AI algorithms to provide distributed perception in networks of interacting autonomous agents in the presence of varying levels of reliability and trust at both network and individual agent.</p> <p>Electromagnetic Warfare:</p> <p>- Complete the development and demonstration of a novel Electronic Attack (EA) capability. It will accomplish this by enhancement of a suite of Radio Frequency (RF) signature-related technologies. The result will provide a new capability to counter advanced threats.</p> <p><b>FY 2025 OCO Plans:</b> N/A</p> <p><b>FY 2024 to FY 2025 Increase/Decrease Statement:</b> There is no significant funding change from FY 2024 to FY 2025.</p>					
<p><b>Title:</b> Multi-Source Integration and Combat Identification</p> <p><b>Description:</b> 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.</p> <p><b>FY 2024 Plans:</b> Electromagnetic Warfare:</p>	1.726	1.708	0.000	0.000	0.000

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<b>B. Accomplishments/Planned Programs (\$ in Millions)</b>	<b>FY 2023</b>	<b>FY 2024</b>	<b>FY 2025 Base</b>	<b>FY 2025 OCO</b>	<b>FY 2025 Total</b>
<p>- Continue development of sensors and sensor networks to locate and track any target of interest in the Maritime Domain. (NRL)</p> <p><b>FY 2025 Base Plans:</b> N/A</p> <p><b>FY 2025 OCO Plans:</b> N/A</p> <p><b>FY 2024 to FY 2025 Increase/Decrease Statement:</b> The funding decrease from FY 2024 to FY 2025 is due to the completion of efforts in sensors and sensor networks in the Maritime Domain.</p>					
<p><b>Title:</b> Tactical Space Exploitation</p> <p><b>Description:</b> 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.</p> <p>To perform early-applied discovery Research and Development (R&amp;D) to ensure Navy-Marine Corps access to critical space-associated capabilities on the ground, at sea, and in a contested space environment; research thrusts include spacecraft R&amp;D in five strategic cross-cutting areas that lead to the fielding of systems which perform functions critically important to operations. These areas are: (1) Advanced Space Platform Technologies, such as development of new and prototype space systems that are tailored to specific threats, including technologies which reduce cost, mass, power and/ or extend on-orbit lifetimes, and sub-systems that advance propulsion and control capabilities towards precision maneuvering while minimizing fuel; (2) Next-generation Payloads and Sensors, including space robotic capabilities to address on-orbit inspection, servicing, repair, assembly, and mission life extension; (3) Connectivity for disadvantaged users that is rugged, high-bandwidth and space based; (4) Space Weather, and (5) Space Situational Awareness.</p> <p><b>FY 2024 Plans:</b> Space Research and Spacecraft Technology:</p> <p>- Continue early-applied discovery Research and Development (R&amp;D) to ensure Navy-Marine Corps access to critical space-associated capabilities on the ground, at sea, and in a contested space environment. Research thrusts include space related R&amp;D in three strategic cross-cutting areas that lead to the fielding of systems which</p>	5.749	4.628	4.901	0.000	4.901

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**B. Accomplishments/Planned Programs (\$ in Millions)**

	<b>FY 2023</b>	<b>FY 2024</b>	<b>FY 2025 Base</b>	<b>FY 2025 OCO</b>	<b>FY 2025 Total</b>
<p>perform functions critically important to Naval operations and addressing Navy/Marine Corps current and future needs and requirements. These areas are:</p> <p>1) Advanced space technologies, such as development of new prototype and exploratory space systems that are relevant to maritime navigation, maritime domain awareness, and Distributed Maritime Operations (DMO), including technologies which reduce cost, mass, power.</p> <p>2) Next-generation payloads and sensors, including space-based environmental monitoring instruments and on-orbit autonomous calibration and/or data processing addressing the DON's Electromagnetic Environment (EME) needs.</p> <p>3) Connectivity for disadvantaged maritime and littoral users that is rugged, high-bandwidth and space based.</p> <p>- Continue efforts for the development and demonstration of new measurement and data assimilation capabilities to predict phenomena that influence Over-the-Horizon Radar (OTHR) and communication, which will advance OTHR related capabilities and communication avenues.</p> <p>- Continue research efforts for the development of robust and reliable hypersonic air breathing platforms.</p> <p><b><i>FY 2025 Base Plans:</i></b></p> <p>Space Research and Spacecraft Technology:</p> <p>- Continue efforts into Hypersonic Technologies. Hypersonic technologies are a key enabler for future Naval capabilities. Early applied research on many aspects of this field are expected to have significant impact on future DON capabilities. These include, but are not limited to propulsion, thermal management, materials, airframe design, and in-flight communication. This is an expansion and redefining of efforts aimed at the development of robust and reliable hypersonic air breathing platforms. (NRL)</p> <p>- Continue efforts into Space Environment Awareness and Exploitation. Many Naval capabilities are enabled by or can be disrupted or degraded by the space environment. Research thus is focused on satellite communication, geopositioning, Over the Horizon RADAR, High Frequency (HF) Over the Horizon communication and Intelligence, Surveillance, and Reconnaissance (ISR). Early applied research in sensing, specifying, and forecasting of the space environment is a key enabler for future Naval capabilities in areas including anomaly attribution, domain awareness, operations planning, and tactical decision aids. This is an expansion of previous efforts. Those include efforts for the development and demonstration of new measurement and data assimilation capabilities to predict phenomena that influence Over-the-Horizon Radar (OTHR) and communication, which will advance OTHR related capabilities and communication avenues. It also includes efforts that looked to take early-applied discovery Research and Development (R&amp;D) to ensure Navy-</p>					

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**B. Accomplishments/Planned Programs (\$ in Millions)**

	FY 2023	FY 2024	FY 2025 Base	FY 2025 OCO	FY 2025 Total
Marine Corps access to critical space-associated capabilities on the ground, at sea, and in a contested space environment.(NRL)					
- Initiate efforts into Satellite Technologies. Innovative satellite technologies are a critical enabler for DON-relevant capabilities. The goals of these efforts include robust, responsive, low-cost, resilient space systems, comprehensive maritime domain and space domain awareness systems, protecting assets in all contested theaters, autonomous and robustly reconfigurable architectures and providing connectivity for highly dynamic, dispersed, and disadvantaged Naval users. In addition, novel space technologies have the potential to improve operations in GPS-denied environments using alternative Position, Navigation and Timing (PNT), on-board targeting and payload data edge processing.(NRL)					
<b><i>FY 2025 OCO Plans:</i></b> N/A					
<b><i>FY 2024 to FY 2025 Increase/Decrease Statement:</i></b> There is no significant funding change from FY 2024 to FY 2025.					
<b>Accomplishments/Planned Programs Subtotals</b>	50.501	52.090	51.202	0.000	51.202

**C. Other Program Funding Summary (\$ in Millions)**

N/A

**Remarks**

**D. Acquisition Strategy**

N/A