Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Navy	Date: April 2022
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602271N *I Electromagnetic Systems Applied Research*

COST ($ in Millions)	Prior Years	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total	FY 2024	FY 2025	FY 2026	FY 2027	Cost To Complete	Total Cost
Total Program Element	0.000	89.516	91.041	92.444	-	92.444	94.160	96.043	97.964	99.923	Continuing	Continuing
0000: *Electromagnetic Systems Applied Research*	0.000	81.793	85.041	92.444	-	92.444	94.160	96.043	97.964	99.923	Continuing	Continuing
9999: *Congressional Adds*	0.000	7.723	6.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	13.723

A. Mission Description and Budget Item Justification

Freedom of maneuver on a global scale for U.S. naval forces depends upon assured access to the electromagnetic spectrum and the ability to deny adversary exploitation. Electromagnetic technologies must fluidly deliver communication, surveillance electronic warfare and digital integration to understand, shape and defend the battlespace. The Electromagnetic Systems Applied Research Program addresses technology needs associated with Naval platforms for new capabilities in Electro-Optic and Infrared (EO/IR) Sensors, Surveillance, Electronic Warfare, Navigation, Solid State Electronics, Vacuum Electronics Power Amplifiers, and Nanoelectronics. The program supports development of technologies to enable capabilities in Missile Defense, Directed Energy, Platform Protection, Time Critical Strike, and Information Distribution. Activities and efforts within this Program have attributes that focus on enhancing the affordability of warfighting systems.

Today's Sailors and Marines are enabled by Naval Science and Technology (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 PE, the programs described herein are representative of the work included in this PE.

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B. Program Change Summary ($ in Millions)	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total
Previous President's Budget	92.624	85.157	0.000	-	0.000
Current President's Budget	89.516	91.041	92.444	-	92.444
Total Adjustments	-3.108	5.884	92.444	-	92.444
• Congressional General Reductions	-	-0.116			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	6.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-0.891	0.000			
• SBIR/STTR Transfer	-2.217	0.000			
• Rate/Misc Adjustments	0.000	0.000	0.000	-	0.000
• Adjustments to Budget Year	-	-	92.444	-	92.444

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2021	FY 2022
Project: 9999: *Congressional Adds*		
Congressional Add: *Navigation Technology*	2.896	0.000
Congressional Add: *Dark Swarm in Degraded Environments*	4.827	6.000
Congressional Add Subtotals for Project: 9999	7.723	6.000
Congressional Add Totals for all Projects	7.723	6.000

Change Summary Explanation

Financial: No significant change.

Technical: No significant change.

Schedule: No significant change.

FY 2023 funding increase reflects the fact that the FY 2022 President’s Budget request did not include out-year funding.

Exhibit R-2A, RDT&E Project Justification: PB 2023 Navy			Date: April 2022
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602271N / *Electromagnetic Systems Applied Research*	Project (Number/Name) 0000 / *Electromagnetic Systems Applied Research*	

COST ($ in Millions)	Prior Years	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total	FY 2024	FY 2025	FY 2026	FY 2027	Cost To Complete	Total Cost
0000: *Electromagnetic Systems Applied Research*	0.000	81.793	85.041	92.444	-	92.444	94.160	96.043	97.964	99.923	Continuing	Continuing

A. Mission Description and Budget Item Justification

Freedom of maneuver on a global scale for U.S. naval forces depends upon assured access to the electromagnetic spectrum and the ability to deny adversary exploitation. Electromagnetic technologies must fluidly deliver communication, surveillance electronic warfare and digital integration to understand, shape and defend the battlespace. This project addresses technology opportunities associated with Naval platforms for new capabilities in Electro-Optic and Infrared (EO/IR) Sensors, Surveillance, Electronic Warfare, Navigation, Solid State Electronics, Vacuum Electronics Power Amplifiers, and Nanoelectronics. The project supports development of technologies to enable capabilities in Missile Defense, Directed Energy, Platform Protection, Time Critical Strike, and Information Distribution. This project directly supports the Department of Defense Joint Warfighter Plan and the Defense Technology Area Plans. Activities and efforts within this program have attributes that focus on enhancing the affordability of warfighting systems. The program also provides for technology efforts to maintain proactive connectivity and collaboration between Department Of the Navy (DON) Science and Technology (S&T) and Joint, Navy, and Marine Corps commands worldwide. Due to the number of efforts in this Program Element (PE), the programs described herein are representative of the work included in this PE.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total
Title: Electronic Warfare Technology	40.584	41.770	43.933	0.000	43.933
Description: The overarching objective of this activity is to develop technologies that enable the development of affordable, effective and robust Electronic Warfare (EW) systems across the entire Electromagnetic Spectrum (EMS) that will increase the operational effectiveness and survivability of U.S. Naval units. Technology development is focused on Distributed Electronic Warfare in support of Distributed Maritime Operations. Emphasis is placed on passive sensors and active and passive Countermeasure (CM) systems that exploit and counter a broad range of electromagnetic threats. The focus is on maintaining near perfect, real-time knowledge of the enemy; countering the threat of missiles against deployed Naval forces; precision identification and location of threat emitters; and development of technologies that have broad application across multiple disciplines within the EW mission area. This activity also includes developments to protect these technologies from external interference, and modeling and simulation required to support the development of these technologies. The current objectives are: - Electronic Warfare (EW) Radio Frequency (RF) Technology: Develop and demonstrate technologies in the RF spectrum (covering frequencies from kilohertz to terahertz) that include developments in detection, signal					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total
processing and passive/active techniques for wideband Electronic Attack (EA), Electronic Protection (EP) and the Electronic Support (ES) mission areas. - Electronic Warfare (EW) Electro-Optic/Infrared (EO/IR) Technology: Develop and demonstrate counter EO/IR technologies extending from the ultraviolet to the far infrared spectral bands. This includes advances in multispectral sensors, multiband sources, beam forming/steering, and signal processing and transmission. - EW Integrated and Networked Technology: Develop and demonstrate technologies that will enable an increased situational awareness and response across the Electromagnetic Spectrum (EMS) with broad spatial coverage using all available EW assets to provide coordinated, adaptive and networked EW sensing, protection and attack. - Advanced EW Enabling Technologies: Develop classified advanced electronic warfare technology in support of current and predicted capability requirements emphasizing distributive effects. ***FY 2022 Plans:*** Electronic Warfare (EW): - Continue research in federated, coordinated, and integrated EW systems for the development of distributed Electronic Warfare (EW) technologies for Electronic Surveillance (ES), decoys and countermeasures, and Electronic Attack (EA) against adversary Command, Control, Communications, Computers, Intelligence, Surveillance, Reconnaissance and Targeting (C4ISRT). This Electronic Warfare (EW) research includes Electronic Protection (EP) for our own weapons and Command, Control, Communications, Computers, Cyber Defense, Intelligence, Surveillance and Reconnaissance (C5ISR) systems allowing them to operate in a heavily contested environment. - Continue development and implementation of Artificial Intelligence (AI) algorithms and deep learning techniques for adaptive Electronic Attack (EA) and Electronic Support (ES) applications onto new AI compute processing architectures developed for Electronic Warfare (EW) applications. - Continue research into developing AI-generated tactics against modern and emerging radar sources to improve naval mission effectiveness. - Initiate research and development in the area of hard-kill and soft-kill coordination and planning. - Initiate research into simultaneous multi-spectral (RF and optical) countermeasure development to increase survivability across the entire electromagnetic spectrum and continue development of coordinated EW techniques between RF and EO/IR transmitters and receivers for single and distributed platforms. - Initiate development and implementation of combined EW and cyber effects to increase the reach and effectiveness of each domain in support of distributed maritime operations.					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total
- Initiate the development of a variable-ratio coupler approach to phase demodulation, allowing for the active tuning of a photonics based processor. - Initiate the development of artificial intelligence algorithms to automatically classify tracks for an advanced weapons system and to distinguish anomalous targets, which have not been previously seen by the combat system. - Initiate the development of a quantitative understanding of the relationship between transverse laser fluence profiles and resultant emission, determine to what extent fluctuation in irradiance and fluence profile affects spatial, temporal, and spectral characteristics of generated emission and demonstrate improved quantitative prediction of effects in laboratory and at range based upon deeper understanding. Electromagnetic Warfare: - Continue diverse research spanning multiple projects across a broad spectrum of Radio Frequency (RF) and Electro-Optic/Infrared (EO/IR) technologies that cover the detection of energy in the environment to the formulation of active and passive engagement techniques. - Continue efforts with focus on near-real-time geolocation of stationary (or slowly moving) Radio-Frequency (RF) emitters, and in particular, emerging threat radars employing unusual waveforms resulting in accurate geolocation. - Continue novel real-time signal processing techniques to dramatically increase the useful information content reported in receiver measurements of radar-band signals providing the warfighter with a low-ambiguity warning of detection. - Continue efforts to improve the effectiveness of emitter classification of modern radars for several functions including Automated Identification Systems (AIS) validation increasing Maritime Domain Awareness. - Continue research applying recently developed machine learning methods to the problem of functional classification of radar emissions and demonstrate the ability to perform the functional classification in real time to overcome the inadequacy conventional emitter classification methods. - Continue efforts focused on discovering and defeating unknown and adaptive radios by developing algorithms to observe their behavior, analyze their networking protocols, and optimize engagement techniques to interfere with their objectives. - Continue research to develop and demonstrate high gain distributed aperture technologies compatible with micro-jammer glide vehicles to increase the effective radiated power of a ground-based micro-jammer constellation to provide sufficient power to radars. - Continue development and demonstration of an evolvable Electronic Warfare (EW) transceiver design that optimizes cuing receiver processing to increase situational awareness and enable adaptive electronic attack					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total
response in complex electromagnetic environments to provide effective processing of emergent complex radar modes. ***FY 2023 Base Plans:*** Electronic Warfare (EW): - Complete early development and demonstrate implementation of Artificial Intelligence (AI) algorithms and deep learning techniques for adaptive Electronic Attack (EA) and Electronic Support (ES) applications on new AI compute processing architectures developed for Electronic Warfare (EW) applications. - Continue research in federated, coordinated, and integrated Electronic Warfare (EW) systems for the development of distributed Electronic Warfare (EW) technologies for Electronic Surveillance (ES), decoys and countermeasures, and Electronic Attack (EA) against adversary Command, Control, Communications, Computers, Intelligence, Surveillance, Reconnaissance and Targeting (C4ISRT). This EW research includes Electronic Protection (EP) for our own weapons and Command, Control, Communications, Computers, Cyber Defense, Intelligence, Surveillance and Reconnaissance (C5ISR) systems allowing them to operate in a heavily contested environment. - Continue research into developing AI-generated tactics against modern and emerging radar sources to improve naval mission effectiveness. - Continue research and development in the area of hard-kill and soft-kill coordination and planning. - Continue research into simultaneous multi-spectral (Radio Frequency (RF) and optical) countermeasure development to increase survivability across the entire electromagnetic spectrum and continue development of coordinated EW techniques between RF and Electro-Optic/Infrared (EO/IR) transmitters and receivers for single and distributed platforms. - Continue development and implementation of combined EW and cyber effects to increase the reach and effectiveness of each domain in support of distributed maritime operations. - Continue the development of artificial intelligence algorithms to automatically classify tracks for an advanced weapons system and to distinguish anomalous targets, which have not been previously seen by the combat system. - Continue the development of a quantitative understanding of the relationship between laser fluence profiles and resultant emission, determine to what extent fluctuation in irradiance and fluence profile affects spatial, temporal, and spectral characteristics of generated emission and demonstrate improved quantitative prediction of effects in laboratory and at range based upon deeper understanding. - Continue the development of a variable-ratio coupler approach to phase demodulation, allowing for the active tuning of a photonics based processor.					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total
Electromagnetic Warfare: - Continue diverse research spanning multiple projects across a broad spectrum of RF and EO/IR technologies that cover the detection of energy in the environment to the formulation of active and passive engagement techniques. - Continue efforts with focus on near-real-time geolocation of stationary (or slowly moving) RF emitters, and in particular, emerging threat radars employing unusual waveforms resulting in accurate geolocation. - Continue novel real-time signal processing techniques to dramatically increase the useful information content reported in receiver measurements of radar-band signals providing the warfighter with a low-ambiguity warning of detection. - Continue efforts to improve the effectiveness of emitter classification of modern radars for several functions including Automated Identification Systems (AIS) validation increasing Maritime Domain Awareness. - Continue research applying recently developed machine learning methods to the problem of functional classification of radar emissions and demonstrate the ability to perform the functional classification in real time to overcome the inadequacy conventional emitter classification methods. - Continue efforts focused on discovering and defeating unknown and adaptive radios by developing algorithms to observe their behavior, analyze their networking protocols, and optimize engagement techniques to interfere with their objectives. - Continue research to develop and demonstrate high gain distributed aperture technologies compatible with micro-jammer glide vehicles to increase the effective radiated power of a ground-based micro-jammer constellation to provide sufficient power to radars. - Continue development and demonstration of an evolvable Electronic Warfare (EW) transceiver design that optimizes cuing receiver processing to increase situational awareness and enable adaptive electronic attack response in complex electromagnetic environments to provide effective processing of emergent complex radar modes. - Initiate the development of technology and waveforms to detect the emissions of and deny launch platform targeting radars and/or anti-ship missile seekers the capability to acquire and track ship targets across the electromagnetic spectrum.					
FY 2023 OCO Plans: N/A					
FY 2022 to FY 2023 Increase/Decrease Statement:					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total
The increase from FY 2022 to FY 2023 is due to increased investments in the development of multi-spectral countermeasure technologies and novel distributed/coordinated cognitive EW techniques that will significantly increase Naval platform survivability by denying networked, multi-spectral threat systems the ability to detect, track, and target our platforms across the electromagnetic spectrum.					
Title: EO/IR Sensor Technologies	7.354	7.207	7.887	0.000	7.887
Description: The overarching objective is to develop technologies that enable affordable, wide area, persistent surveillance optical architectures. Included are modeling and simulation required to support the development of these technologies. Efforts will also include the development of optical Radio-Frequency (RF) components, infrared technologies including lasers and focal plane arrays using narrow bandgap semiconductors. The current specific objectives are: - Optically Based Terahertz (THz) and Millimeter Wave (MMW) Distributed Aperture Systems: Develop Optically Based Terahertz (THz) and Millimeter Wave distributed aperture systems for imaging through clouds, fog, haze and dust on air platforms. - Wide Area Optical Architectures: Develop wide area optical architectures for persistent surveillance for severely size constrained airborne applications. - Hyperspectral sensors and processing: Develop visible, shortwave Infrared (IR), mid-wave IR, and long-wave IR hyperspectral sensors, along with processing algorithms to detect anomalies and targets. - Coherent Laser Radar (LADAR): Develop and improve components for LADAR applications including fiber lasers, coherent focal planes, and advanced processing. - Autonomous and Networked sensing: Develop algorithms and processing that supports autonomous sensing for Unmanned Autonomous Vehicles (UAV) platforms and that supports networked sensing over multiple sensors and/or sensor platforms. ***FY 2022 Plans:*** EO/IR Sensor Technologies: - Complete development and initiate testing of a low Size, Weight, Power and Cost (SWaP-C) prototype room-temperature Mid-Wave Infrared (MWIR) detector array. -Continue to develop novel techniques for Electro-Optic/Infrared (EO/IR) countermeasures to detect, track and/or jam sensors.					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total
- Continue demonstration and test real-time combat Identification (ID) algorithms for detecting and tracking simultaneous targets from networked, high-resolution, wide field of view, and persistent surveillance systems. - Continue work on active imaging laser systems to significantly extend operational range and imaging capabilities in degraded conditions (e.g., dense maritime fog). - Continue efforts to develop and test optical architectures to demonstrate simultaneous wide field of view (FOV) and high-resolution imaging for search, detection, classification, identification and targeting functions. - Initiate demonstration and test performance of previously developed sensitive passive Millimeter Wave (MMW) detectors for detection of targets in degraded visual environments (e.g., clouds, fog, haze and dust) and explore extending capability to sparse apertures to increase resolution. - Initiate research and development of novel ISR and counter-ISR applications with tailored optical beams. Electronics: - Complete research in advanced p-type Gallium-Free Superlattice Long Wave Infrared (LWIR) Sensors. - Complete research efforts associated with Night and Day Maritime Infrared (IR). Electromagnetic Warfare: - Complete efforts towards a new system design and data processing algorithms for small, low-power, high resolution extremely wide FOV IR systems. - Complete efforts to detect, track and defeat an imaging threat sensor over a wide field of view using optical phase conjugation to overcome the existing field of view limitations imposed by current spatial light modulator technology. - Complete efforts towards the improvement in resolution without changing the imaging optics by projecting patterns onto the scene then using knowledge of the patterns computationally recover a higher resolution image resulting in improved resolution enabling better intelligence, surveillance, reconnaissance, and targeting. - Continue development of EO/IR technologies to improve imaging, target identification, threat detection, and engagement capabilities for the war fighter. - Initiate development and demonstration of a low Size Weight and Power (SWaP) transceiver laser system with high accuracy, covert detection, and threat wavelength discrimination using Non-Mechanical Beam Steering technology (NMBS). - Initiate development and optimization of Resonant-Cavity Infrared Detectors (RCIDs) that provide higher sensitivity and reduced optical clutter systems using active imaging.					
FY 2023 Base Plans:					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total
EO/IR Sensor Technologies: - Complete demonstration and test performance of previously developed sensitive passive Millimeter Wave (MMW) detectors for detection of targets in degraded visual environments (e.g., clouds, fog, haze and dust) and explore extending capability to sparse apertures to increase resolution. - Continue to develop novel techniques for Electro-Optic/Infrared (EO/IR) countermeasures to detect, track and/or jam sensors. - Continue demonstration and test real-time combat Identification (ID) algorithms for detecting and tracking simultaneous targets from networked, high-resolution, wide field of view, and persistent surveillance systems. - Continue work on active imaging laser systems to significantly extend operational range and imaging capabilities in degraded conditions (e.g., dense maritime fog). - Continue efforts to develop and test optical architectures to demonstrate simultaneous wide Field Of View (FOV) and high-resolution imaging for search, detection, classification, identification and targeting functions. - Continue research and development of novel ISR and counter-ISR applications with tailored optical beams. - Initiate research into extreme low light imaging cameras built using low-cost Si foundry services as a way to provide all domain imaging for some missions or platforms that can't afford infrared sensors. Electromagnetic Warfare: - Continue development of Electro-Optical/Infra-Red (EO/IR) and Radio Frequency (RF) technologies to improve imaging, target identification, threat detection, and engagement capabilities for the war fighter. - Continue development and demonstration of a low Size Weight and Power (SWaP) transceiver laser system with high accuracy, covert detection, and threat wavelength discrimination using Non-Mechanical Beam Steering technology (NMBS). - Continue development and optimization of Resonant-Cavity Infrared Detectors (RCIDs) that provide higher sensitivity and reduced optical clutter systems using active imaging. - Initiate demonstration of new high performance single band Short-Wave (SW) and dual band SW/Mid-Wave (MW) Infrared (IR) sensors that will substantially improve the Navy's primary night & day maritime MWIR systems, which will show that a broad range of Naval MWIR imagers can be upgraded with a much more capable monolithic SW/MWIR dual band sensor technology, with minimal impact on Size Weight and Power (SWaP) and system cost. ***FY 2023 OCO Plans:*** N/A ***FY 2022 to FY 2023 Increase/Decrease Statement:***					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total
The increase from FY 2022 to FY 2023 is due to increased investments in coherent combination and computational imaging techniques that will increase the resolution and long range imaging capability for Naval systems, thus increasing their survivability, autonomy, and stand-off range.					
Title: Navigation Technology	8.968	11.315	14.366	0.000	14.366
Description: The overarching objective of this activity is to develop technologies that enable the development of affordable, effective and robust Position, Navigation and Timing (PNT) capabilities using non-Global Positioning System (GPS) navigation devices, and atomic clocks. This project will increase the operational effectiveness of U.S. Naval units. Emphasis is placed on GPS Anti-Jam (AJ) Technology; Precision Time and Time Transfer Technology; and Non- GPS Navigation Technology (Inertial aviation system, bathymetry, gravity and magnetic navigation). The focus is on the mitigation of GPS electronic threats, the development of atomic clocks that possess unique long-term stability and precision, and the development of compact, low-cost Inertial Navigation Systems (INS). The following are non-inclusive examples of plans for projects funded in this activity. ***FY 2022 Plans:*** Navigation Technology: -Continue research on automated celestial navigation for submarine platforms to increase operational effectiveness. -Continue research on thermal atomic beam inertial capability to improve non-Global Positioning System (GPS) navigation. -Continue research on next generation atomic clocks to improve long-term stability and precision. -Continue development of earth magnetic anomaly maps for improved magnetic navigation. -Initiate development of navigation capability using very low frequency signals. -Initiate development of a gravity navigation system using a strap down gravimeter. ***FY 2023 Base Plans:*** Navigation Technology: - Complete research on automated celestial navigation for submarine platforms to increase operational effectiveness. - Complete research on thermal atomic beam inertial capability to improve non-Global Positioning System (GPS) navigation. - Complete development of navigation capability using very low frequency signals.					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total
- Continue research on next generation atomic clocks to improve long-term stability and precision. - Continue development of earth magnetic anomaly maps for improved magnetic navigation. - Continue development of a gravity navigation system using a strap down gravimeter. - Initiate development of magnetic anomaly aided navigation systems. ***FY 2023 OCO Plans:*** N/A ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The increase from FY 2022 to FY 2023 is due to additional efforts and investment to enhance platform operability by advancing the development of alternative navigation systems utilizing geophysical features and to support advanced inertial navigation technology. This increased development is partially to support enhanced demand in response to FY21 NDAA Sec. 1601 which directs the DOD to generate and deploy resilient and survivable alternative PNT solutions.					
Title: Solid State Electronics ***Description:*** The overarching objective of this activity is to develop higher performance components and subsystems for all classes of military Radio-Frequency (RF) systems that are based on solid state physics phenomena and are enabled by improved understanding of these phenomena, new circuit design concepts and devices, and improvements in the properties of electronic materials. An important subclass are the Very High Frequency (VHF), Ultra-High Frequency (UHF), Microwave (MW), and Millimeter Wave (MMW) power amplifiers for Navy all-weather radar, surveillance, reconnaissance, electronic attack, communications, and smart weapon systems. Another subclass are the analog and high speed, mixed signal components that connect the electromagnetic signal environment into and out of digitally realized, specific function systems. These improved components are based on both Silicon (Si) and compound semiconductors (especially the wide bandgap materials and narrow bandgap materials), low and high temperature superconductors, novel nanometer scale structures and materials. Components addressed by this activity emphasize the MMW and Submillimeter Wave (SMMW) regions with an increasing emphasis on devices capable of operating in the range from 50 Gigahertz (GHz) to 10 Terahertz (THz). The functionality of the technology developed cannot be obtained through Commercial-Off- The-Shelf (COTS) as a result of the simultaneous requirements placed on power, frequency, linearity, operational and instantaneous bandwidth, weight, and size. Effort will involve understanding the properties of engineered semiconductors as they apply to quantum information science and technology.	9.573	9.539	10.140	0.000	10.140

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total
FY 2022 Plans: Solid State Electronics: - Continue research of solid-state devices for high frequency analog and digital operation; high efficiency, highly linear amplifiers for microwave, millimeter-wave, low-noise, and power applications; superconducting and other technologies which are prototyped to demonstrate the ability of these components to deliver superior functionality in a system environment. - Continue development and transition of nitrogen-polar based High-Electron-Mobility Transistor (HEMT) technology for advanced linear receivers and efficient transmitters. - Continue development of new materials, devices, components, and circuits that apply quantum phenomena of entanglement, superposition and/or wave function correlation for performance not achievable by classical methods. - Continue integrated circuit technologies in conventional superconductors and Gallium Nitride (GaN) as platforms for quantum-based functional components. - Initiate development of superconducting GaN/niobium nitride heterostructures for Josephson junctions and Millimeter Wave (MMW) resonator circuits. - Initiate Millimeter Wave (MMW) to Terahertz (THz) plasmonic photomixer-based focal plane arrays for imaging systems. - Initiate efforts into Acoustoelectric ScAlN RF Signal Processing Devices (T080-21) and Continuous 3D-Cooled Atom Beam Gyroscope. - Initiate development of chip-scale, acoustic Radio-Frequency (RF) signal processing components, utilizing acoustoelectric effect with high internal gain, in the 1 to 18 Gigahertz (GHz) range using a Scandium Aluminum Nitride (ScAlN) based device architecture with enhanced power handling up to 10 W. - Initiate development of Phase-Change Material (PCM) based couplers with dynamically controllable coupling coefficients to create broadband, low loss, high-tap-count analog canceler filters to provide enhanced TX/RX isolation. - Complete AlN Tunneling Hot Electron Transfer Amplifier for MMW Power. - Complete Phase Change Material RF Components. - Complete Autonomous-Reconfigurable RF and mm-Wave Components. - Complete Memristive Neuromorphic Computing Elements. - Complete Rapid RF IC Prototyping and Manufacture via Micro-assembly. - Complete Neural Red-Out Integrated Circuits.					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total
- Complete ScAlN Based High Power Density MM Wave Transistors.					
FY 2023 Base Plans: Solid State Electronics: - Complete efforts into Acoustoelectric Scandium Aluminum Nitride (ScAlN) Radio-Frequency (RF) Signal Processing Devices (T080-21) and Continuous 3D-Cooled Atom Beam Gyroscope. - Continue research of solid-state devices for high frequency analog and digital operation; high efficiency, highly linear amplifiers for microwave, millimeter-wave, low-noise, and power applications; superconducting and other technologies which are prototyped to demonstrate the ability of these components to deliver superior functionality in a system environment. - Continue development and transition of nitrogen-polar based High-Electron-Mobility Transistor (HEMT) technology for advanced linear receivers and efficient transmitters. - Continue development of new materials, devices, components, and circuits that apply quantum phenomena of entanglement, superposition and/or wave function correlation for performance not achievable by classical methods. - Continue integrated circuit technologies in conventional superconductors and Gallium Nitride (GaN) as platforms for quantum-based functional components. - Continue development of superconducting GaN/niobium nitride heterostructures for Josephson junctions and Millimeter Wave (MMW) resonator circuits. - Continue Millimeter Wave (MMW) to Terahertz (THz) plasmonic photomixer-based focal plane arrays for imaging systems. - Continue development of chip-scale, acoustic RF signal processing components, utilizing acoustoelectric effect with high internal gain, in the 1 to 18 Gigahertz (GHz) range using a ScAlN based device architecture with enhanced power handling up to 10 W. - Continue development of Phase-Change Material (PCM) based couplers with dynamically controllable coupling coefficients to create broadband, low loss, high-tap-count analog canceler filters to provide enhanced TX/RX isolation. - Initiate metal nitride heterostructure mm-wave device investigations. - Initiate relaxed III-nitride channel mm-wave N-polar device development. - Initiate investigations into high throughput, large-area nano-scale lithography for plasmonic devices.					

Exhibit R-2A, RDT&E Project Justification: PB 2023 Navy		Date: April 2022
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602271N / *Electromagnetic Systems Applied Research*	**Project (Number/Name)** 0000 / *Electromagnetic Systems Applied Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total
- Initiate development of new types of quantum based sensors for the measurement of motion and fields, which combine high sensitivity with features that improve the practicality of the technologies, to include continuous, high-bandwidth measurement, and low Size Weight and Power (SWaP). ***FY 2023 OCO Plans:*** N/A ***FY 2022 to FY 2023 Increase/Decrease Statement:*** There is no significant funding change from FY 2022 to FY 2023.					
Title: Surveillance Technology ***Description:*** The overarching objective of this activity is to develop advanced sensor and sensor processing systems for continuous, high volume, theater-wide air and surface surveillance, battle group surveillance, real time reconnaissance and ship defense. Major technology goals include long-range target detection and discrimination, Target Identification (ID) and fire control quality target tracking in adverse weather, background clutter and electronic countermeasure environments, affordable apertures, distributed sensing systems, and includes modeling and simulation required to support the development of these technologies. The current specific objectives are: 1) Radar Architectures, Sensors, and Software which address Ballistic Missile and Littoral Requirement Shortfalls: Develop radar architectures, sensors, and software, which address Ballistic Missile and Littoral requirement shortfalls including: sensitivity; clutter rejection; and flexible energy management. 2) Algorithms, Sensor Hardware, and Signal Processing Techniques for Automated Radar Based Contact Mensuration and Feature Extraction: Develop algorithms, sensor hardware, and signal processing techniques for automated radar based contact mensuration and feature extraction in support of asymmetric threat classification and persistent surveillance to address naval radar performance shortfalls caused by man-made jamming and Electronic Counter Measures (ECM), unfavorable maritime conditions, and atmospheric and ionosphere propagation effects. 3) Software and Hardware for a Multi-Platform, Multi-Sensor Surveillance System: Develop software and hardware for a multi-platform, multi-sensor surveillance system for extended situational awareness of the battlespace. ***FY 2022 Plans:*** Surveillance Technology: - Complete technology development to enable full spectrum battlespace awareness through an ultra-wideband aperture for simultaneously 360-degree beamforming and low profile, ultra-low cross-polarization, ultra-wide-band apertures to provide resilient electronic protection for naval platforms.	13.396	13.413	14.087	0.000	14.087

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total
- Continue research in sensors, networking and communication connectivity for developing an affordable and fully automated network of collaborative time-coordinated mono-static and Multi-Input Multi-Output (MIMO), surveillance sensors providing real-time tracking, identification, targeting and engagement information with persistent wide area awareness. - Continue efforts to develop affordable and scalable advanced antenna apertures. - Continue efforts to develop electronics and signal processing to enable Radio Frequency (RF) agility and waveform diversity to provide enhanced capability to find, fix, track, target, and assess targets and threats as well as provide automatic target identification. - Continue research in the use of interferometric, polar metric, RF agility, and sophisticated signal processing algorithms to enable the detection, geolocation, tracking, and identification of targets in harsh natural and man-made clutter and interference. - Continue research to enable sensor RF convergence, surveillance allocations, data fusion, multi-hypothesis decision-making, multi-target tracking, and methods for handling and fusing disparate and intermittent data sources. - Continue efforts to develop methods to mitigate Electronic Attack (EA) and Electromagnetic Interference (EMI) to RF sensors and networks. - Continue experimentation with fixed and mobile digital array radars to test and validate MIMO capabilities to provide improved detection, tracking, targeting, electronic protection and survivability. - Initiate development low-cost dielectric lens antennas. - Initiate development of hardware and software for arbitrary waveform generation for agile radar systems. - Initiate development of advanced signal processing and signal data converter. - Initiate development of low-cost components for High Frequency (HF) sensor systems with reduced size, weight, and power needs. - Initiate development of distributed aperture radar systems with improved spatial and waveform agility. Electromagnetic Warfare: - Continue development of radar techniques for detection and identification of small Unmanned Autonomous Vehicles (UAV) and to develop classification and identification techniques for addressing evolving DHS/USMC requirements for assessing this type of threat in tactical environments. - Continue validation of algorithms using innovative concepts from discrete mathematics to accurately predict ship Radar Cross Section (RCS) so as better assess platform vulnerability.					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total
- Continue development of innovative target detection and clutter suppression algorithms for ultra-high frequency SAR that exploits fluctuation and motion within the scene to provide wide-area, automated detection of small targets at long ranges. - Initiate development of the maritime target detection capabilities of a UHF SAR through novel approaches to the fundamental challenge of separating target backscatter from ocean clutter by exploiting both differences in the manner in which the polarimetric signatures of the target and clutter vary as a function of aspect angle and RF frequency, as well as differences between target and clutter motion characteristics. ***FY 2023 Base Plans:*** Surveillance Technology: - Continue efforts to develop affordable and scalable advanced antenna apertures. - Continue efforts to develop electronics and signal processing to enable Radio Frequency (RF) agility and waveform diversity to provide enhanced capability to find, fix, track, target, and assess targets and threats as well as provide automatic target identification. - Continue research in the use of interferometric, polarimetric, RF agility, and sophisticated signal processing algorithms to enable the detection, geolocation, tracking, and identification of targets in harsh natural and man-made clutter and interference. - Continue efforts to develop methods to mitigate Electronic Attack (EA) and Electromagnetic Interference (EMI) to RF sensors and networks. - Continue development low-cost dielectric lens antennas and material resilience in high power transmitters. - Continue development of hardware and software for arbitrary waveform generation for agile radar systems. - Continue development of low-cost components for High Frequency (HF) sensor systems with reduced size, weight, and power needs. - Continue development of distributed aperture radar systems with improved spatial and waveform agility. - Complete research in sensors, networking and communication connectivity for developing an affordable and fully automated network of collaborative time-coordinated mono-static and Multi-Input Multi-Output (MIMO), surveillance sensors providing real-time tracking, identification, targeting and engagement information with persistent wide area awareness. - Complete research to enable sensor Radio Frequency (RF) convergence, surveillance allocations, data fusion, multi-hypothesis decision-making, multi-target tracking, and methods for handling and fusing disparate and intermittent data sources. - Complete development of advanced signal processing and signal data converter.					

Exhibit R-2A, RDT&E Project Justification: PB 2023 Navy		Date: April 2022
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total
- Complete experimentation with fixed and mobile digital array radars to test and validate Multi-Input Multi-Output (MIMO) capabilities to provide improved detection, tracking, targeting, electronic protection and survivability. - Initiate development of front-end components and phased array architectures that enable concurrent wideband radar and Electronic Support (ES) functions. Electromagnetic Warfare: - Continue development of radar techniques for detection and identification of small Unmanned Autonomous Vehicles (UAV) and to develop classification and identification techniques for addressing evolving DHS/USMC requirements for assessing this type of threat in tactical environments. - Continue validation of algorithms using innovative concepts from discrete mathematics to accurately predict ship Radar Cross Section (RCS) so as better assess platform vulnerability. - Continue the development of innovative target detection and clutter suppression algorithms for Ultra-High Frequency (UHF) SAR that exploits fluctuation and motion within the scene to provide wide-area, automated detection of small targets at long ranges. - Complete the development of the maritime target detection capabilities of a Ultra-High Frequency (UHF) SAR through novel approaches to the fundamental challenge of separating target backscatter from ocean clutter by exploiting both differences in the manner in which the polarimetric signatures of the target and clutter vary as a function of aspect angle and RF frequency, as well as differences between target and clutter motion characteristics. - Initiate applied research into technology base for Radio Frequency (RF) surveillance using active and passive monostatic and distributed sensor concepts. Current efforts seek to contribute to this objective by developing and demonstrating improved planar antennas and cylindrical. ***FY 2023 OCO Plans:*** N/A ***FY 2022 to FY 2023 Increase/Decrease Statement:*** There is no significant funding change from FY 2022 to FY 2023.					
Title: Vacuum Electronics Power Amplifiers ***Description:*** The overarching objective of this activity is to develop Millimeter Wave (MMW) and sub-MMW power amplifiers for use in Naval all-weather radar, surveillance, reconnaissance, electronic attack, and communications systems. The technology developed cannot, for the most part, be obtained through Commercial Off The Shelf (COTS) as a result of the simultaneous requirements placed on power, frequency, bandwidth,	1.918	1.797	2.031	0.000	2.031

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total
weight, and size. Responding to strong interests from the various user communities, efforts are focused on the development of technologies for high-data-rate communications, electronic warfare and high-power radar applications at Millimeter Wave (MMW) and upper-MMW regime. The emphasis is placed on achieving high power at high frequency in a compact form factor. Technologies include utilization of spatially distributed electron beams in amplifiers, such as sheet electron beams and multiple-beams, and creation of simulation based design methodologies based on physics-based and geometry driven design codes. The current specific objectives are: - High Power Millimeter and Upper Millimeter Wave Amplifiers: Develop science and technology for high power millimeter and upper millimeter wave amplifiers including high current density diamond cathodes, sheet and multiple electron beam formation and mode suppression techniques in overmoded structures. - Lithographic Fabrication Techniques: Develop lithographic fabrication techniques for upper-millimeter wave amplifiers. - Accurate and Computationally Effective Device-Specific Multi-Dimensional Models for Electron Beams: Develop accurate and computationally effective device-specific multi-dimensional models for electron beam generation, large-signal and stability analysis to simulate device performance and improve the device characteristics. ***FY 2022 Plans:*** Electronics: - Complete Monolithic, Microfabricated Traveling Wave Amplifier Arrays. - Complete Electron Focusing Heterostructures for Compact High-Power MM Wave Amplifiers. - Complete Multiple Electron Beam Architecture for Upper-MMW Power Amplifiers. - Initiate development of broadband (3:1) traveling-wave-tube amplifier circuit using hybrid manufacturing techniques. - Initiate development of low-Size, Weight, and Power (SWaP)-C millimeter-wave traveling-wave tube amplifier technology for unmanned platforms, based on Additive Manufacturing (AM) and a high level of Radio Frequency (RF) component integration. ***FY 2023 Base Plans:*** - Complete the development of broadband (3:1) traveling-wave-tube amplifier circuit using hybrid manufacturing techniques.					

Exhibit R-2A, RDT&E Project Justification: PB 2023 Navy		Date: April 2022
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total
- Complete the development of low-Size, Weight, and Power (SWaP)-C millimeter-wave traveling-wave tube amplifier technology for unmanned platforms, based on Additive Manufacturing and a high level of RF component integration. - Initiate the development of Millimeter Wave and sub-MMW power amplifiers for use in Naval all-weather radar, surveillance, reconnaissance, electronic attack, and communications systems. Efforts are focused on the development of technologies for high-data-rate communications, electronic warfare and high-power radar applications at MMW and sub-MMW regimes. ***FY 2023 OCO Plans:*** N/A ***FY 2022 to FY 2023 Increase/Decrease Statement:*** The increase from FY 2022 to FY 2023 is due to increased investments in the development of high-power millimeter-wave (mmW) amplifiers, which either do not exist or are too large to fit on envisioned platforms, to protect Naval platforms from growing threat systems which are becoming more prolific and capable.					
Accomplishments/Planned Programs Subtotals	81.793	85.041	92.444	0.000	92.444

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2023 Navy			Date: April 2022
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COST ($ in Millions)	Prior Years	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total	FY 2024	FY 2025	FY 2026	FY 2027	Cost To Complete	Total Cost
9999: *Congressional Adds*	0.000	7.723	6.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	13.723

A. Mission Description and Budget Item Justification

Congressional Interest Items not included in other Projects.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2021	FY 2022
Congressional Add: Navigation Technology ***FY 2021 Accomplishments:*** Conducted work supporting the Navy Precision Optical Interferometer (NPOI). NPOI has been in operation since 1993 providing a large amount of scientific and other technical data and being used a test-bed for numerous scientific demonstrations. The instrument is in need of long delayed maintenance and modern upgrades to make sure that it is a viable scientific instrument for the 21st century and maintain its world class unique capabilities in the future. ***FY 2022 Plans:*** N/A	2.896	0.000
Congressional Add: Dark Swarm in Degraded Environments ***FY 2021 Accomplishments:*** Conducted applied Dark Swarm in Degraded Environments applied research. ***FY 2022 Plans:*** Conduct applied Dark Swarm in Degraded Environments applied research.	4.827	6.000
Congressional Adds Subtotals	7.723	6.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A