Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy	Date: March 2019
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602123N *I Force Protection Applied Res*

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
Total Program Element	0.000	182.614	180.549	119.517	-	119.517	119.535	121.947	124.439	126.937	Continuing	Continuing
0000: *Force Protection Applied Res*	0.000	122.743	124.049	119.517	-	119.517	119.535	121.947	124.439	126.937	Continuing	Continuing
9999: *Congressional Adds*	0.000	59.871	56.500	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	116.371

A. Mission Description and Budget Item Justification

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 stakeholders (including the Naval enterprises, the combatant commands, OPNAV 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.

This PE addresses applied research associated with providing the capability of Platform and Force Protection for the U.S. Navy. It supports the development of technologies associated with all naval platforms (surface, subsurface, terrestrial, and air) and the protection of those platforms. The goal is to provide the ability to win or avoid engagements with other platforms or weapons and, in the event of engagement, to resist and control damage while preserving operational capability. Within the Naval Transformational Roadmap, this investment directly supports the Theater Air and Missile Defense transformational capability required by Sea Shield and the Ship to Objective Maneuver key transformational capability. This is accomplished by improvements in platform offensive performance, stealth, and self-defense.

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

B. Program Change Summary ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Previous President's Budget	125.557	124.049	121.889	-	121.889
Current President's Budget	182.614	180.549	119.517	-	119.517
Total Adjustments	57.057	56.500	-2.372	-	-2.372
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	56.500			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-4.947	0.000			
• Program Adjustments	0.000	0.000	-2.372	-	-2.372
• Rate/Misc Adjustments	0.004	0.000	0.000	-	0.000

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Navy				Date: March 2019
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 2: *Applied Research*		R-1 Program Element (Number/Name) PE 0602123N *I Force Protection Applied Res*		
• Congressional Add Adjustments	62.000	-	-	-

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2018	FY 2019
Project: 9999: *Congressional Adds*		
Congressional Add: *Program Increase*	24.142	0.000
Congressional Add: *Alternative Energy Research*	24.142	28.000
Congressional Add: *Power Generation and Storage Research*	0.000	5.000
Congressional Add: *Battery Storage and Safety*	4.828	0.000
Congressional Add: *Hybrid Composite Structures Research for Enhanced Mobility*	4.828	5.000
Congressional Add: *Standoff Detection of Buried Hazards*	1.931	3.000
Congressional Add: *Advanced Energetics Research*	0.000	7.500
Congressional Add: *Advanced Hull Form Development and Demonstration*	0.000	8.000
Congressional Add Subtotals for Project: 9999	59.871	56.500
Congressional Add Totals for all Projects	59.871	56.500

Change Summary Explanation

The program decrease in FY 2020 is due to the completion of research efforts included in the Applied Research Challenge (ARC) program through FY 2019. These efforts were within Surface Ship & Submarine HM&E subproject.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy			Date: March 2019
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602123N / *Force Protection Applied Res*	Project (Number/Name) 0000 / *Force Protection Applied Res*	

COST ($ in Millions)	Prior Years	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total	FY 2021	FY 2022	FY 2023	FY 2024	Cost To Complete	Total Cost
0000: *Force Protection Applied Res*	0.000	122.743	124.049	119.517	-	119.517	119.535	121.947	124.439	126.937	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project addresses applied research associated with providing the capability of Platform and Force Protection for the U.S. Navy. It supports the development of technologies associated with all naval platforms (surface, subsurface, terrestrial, and air) and the protection of those platforms. The goal is to provide the ability to win or avoid engagements with other platforms or weapons and, in the event of engagement, to resist and control damage while preserving operational capability. Within the Naval Transformational Roadmap, this investment directly supports the Theater Air and Missile Defense transformational capability required by Sea Shield and the Ship to Objective Maneuver key transformational capability by virtue of improvements in platform offensive performance, stealth, and self-defense.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Title: AIRCRAFT TECHNOLOGY	38.127	35.419	35.882	0.000	35.882
Description: The Aircraft Technology activity develops technologies for reduced observables technology and enhanced capability of naval aviation aircraft platforms in terms of mission effectiveness, platform range, responsiveness, survivability, observability, readiness, safety and life cycle cost. It also develops new Naval air vehicle concepts and high impact, saleable naval air vehicle technologies, such as - autonomous air vehicle command and control, helicopter and tilt rotor systems, aerodynamics, propulsion systems, materials, structures and flight controls for future and legacy air vehicles. Variable Cycle Advanced Technology (VCAT) will identify and mature critical, relevant variable/adaptive cycle propulsion system technologies for the next generation carrier-based Tactical Aircraft (TACAIR)/Intelligence, Surveillance and Reconnaissance (ISR) systems. The Sea-Based Aviation National Naval Responsibility (SBA NNR) Structures and Materials program will develop the next generation structural capability and material response science for aircraft technology in fixed and rotary wing, manned and unmanned airframe technology to achieve reduced weight, increased durability, strength, streamlined manufacturability, reduced life-cycle cost and maintenance/readiness gaps improvements. Program payoffs include increased availability/readiness, reduced sustainment requirements, fatigue/loads life enhancement, reduced weight and improved range, and advanced prognostics design tools.					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602123N / *Force Protection Applied Res*	**Project (Number/Name)** 0000 / *Force Protection Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
These efforts addresses unique attributes to propulsion and power technologies for Naval Aviation, as well as those having higher importance to Naval Aviation and some that are more pervasive to all of military aviation. Related basic research efforts are addressed under 0601153N Defense Research Sciences. ***FY 2019 Plans:*** Ongoing research related to SBA NNR priorities in Aviation, Propulsion, and Structures and Materials. Ongoing research in Aircraft Technology, examples of research/efforts include Virtual Ship/Aircraft Dynamic Interface, Manned/Unmanned Handling Qualities and Control, Automated Deck Operations, High Lift Aerodynamics and V/STOL Operations, the development of rotorcraft/VTOL systems automated launch and recovery technology and mechanical/environmental failure prediction research. Ongoing research in Propulsion, examples of research/efforts include the VCAT Program. Major engine manufacturers and system contractors will develop/mature the highest priority, long-lead propulsion system technologies, including variable/adaptive cycle engine components, for next generation carrier-based TACAIR/ ISR systems. Ongoing research in Structures and Materials, examples of research/efforts include advanced composite durability technology, new materials development, process-property relationship analysis, improved material selection tools, structural life prediction, multi-functional surfaces, and structural optimization for lightweighting.. Expanding material degradation risk prediction and operational environment-driven materials selection methods. Ongoing research related to Autonomy, examples of research/efforts include high confidence/Safe Autonomous Control in naval environments and on supervisory control of decentralized heterogeneous UAS. Expand efforts on safe-perception based autonomous control in complex naval environments and on autonomy to support combined unmanned and manned air systems/units. ***FY 2020 Base Plans:*** Conduct ongoing research related to Sea Based Aviation National Naval Responsibility (SBA NNR) priorities in Aviation, Propulsion, and Structures and Materials. Ongoing research in Aircraft Technology, examples of research/efforts include Virtual Ship/Aircraft Dynamic Interface, Manned/Unmanned Handling Qualities and Control, Automated Deck Operations, High Lift Aerodynamics and Vertical/Short Take-off and Landing (V/					

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Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602123N / *Force Protection Applied Res*	**Project (Number/Name)** 0000 / *Force Protection Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
STOL) Operations, the development of rotorcraft/Vertical Take-Off and Landing (VTOL) systems automated launch and recovery technology and mechanical/ environmental failure prediction research. Examples of ongoing research in Propulsion include the Variable Cycle Advanced Technology (VCAT) Program. Major engine manufacturers and system contractors will develop/mature the highest priority, long-lead propulsion system technologies, including variable/adaptive cycle engine components, for next generation carrier-based Tactical Aircraft (TACAIR) systems. Ongoing research in Structures and Materials include: advanced composite durability technology; new materials development; process-property relationship analysis; improved material selection tools; structural life prediction; multi-functional surfaces; and structural optimization for reducing structural weight. Methods to expanding material degradation risk prediction and operational environment-driven materials selection methods will be created. Examples of ongoing research related to Autonomy include: high confidence/Safe Autonomous Control in naval environments and on supervisory control of decentralized heterogeneous Unmanned Aircraft Systems (UAS). Expand efforts on safe-perception based autonomous control in complex naval environments and on autonomy to support combined unmanned and manned air systems/units. Specific efforts in FY 2020 include: Efforts to mature Integrated Propulsion, Power and Thermal Management System technologies to an appropriate level to meet the next generation TACAIR Technology Maturation Readiness Review notional plan and schedule. Investigate technologies that could increase engine efficiency, power and aircraft range including engine inlet distortion control, turbomachinery and drive systems optimization, high temperature engine materials and coatings, engine compressor casing treatments and advanced thermal management and transport systems. Flight Dynamics & Control analysis and scaled experiments to demonstrate knowledge fundamental aspects of phenomena associated with multibody control systems with a focus on the ability to demonstrate guaranteed performance relative to a desired end state. Demonstrate algorithms and technology to enable precise ship-relative navigation in GPS-denied environments. Aerodynamics research to demonstrate a new method for in situ measurement if ship airwake dynamics. Demonstrate a leap forward in the capability to run real-time simulations of the coupled aerodynamics involved in					

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Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602123N / *Force Protection Applied Res*	**Project (Number/Name)** 0000 / *Force Protection Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
ship-based recovery of rotary wing aircraft in order to advance the capability of piloted simulations and increase their effectiveness as training tools. High Fidelity Composite Characterization for Rapid Certification of Advanced Structures - application of previously developed advanced characterization methods for current and emerging next generation Composites. This data will feed rapid certification through advanced damage modeling and failure predictions. Advanced Galvanic Compatibly Theory for Operationally Optimized Material Selection - validation and transition of novel compatibility theory to improve material selection and design in vehicle sustainment and life extension. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020.					
Title: FLEET FORCE PROTECTION AND DEFENSE AGAINST UNDERSEA THREATS	3.480	5.775	5.834	0.000	5.834
Description: Fleet Force Protection and Defense against Undersea Threats efforts include applied research for complementary sensor and processing technologies for platform protection. Current small platforms (both surface and airborne) have little to no situational awareness (SA) or self-protection against air, surface, and asymmetric threats. A goal of this activity is to provide these platforms with effective self-protection. The technology areas specific to platform protection will develop individual, multispectral electro-optical (EO), infrared (IR), radio frequency (RF), electro-magnetic (EM), visual and acoustic or chemical sensors/ biosensors and associated processing. To defend platforms from current and advanced threats in at-sea littoral environments and in port, these technologies must improve multispectral detection and distribution of specific threat information. ***FY 2019 Plans:*** Undersea Warfare: Ongoing research in Undersea Warfare, examples of research include conceptualizing and performing laboratory and field studies to: developing acoustics technology and associated signal processing for the detection of small unmanned aerial vehicles (UAVs); continued development of a pressure tolerant, inexpensive hydrogen storage based on hydrogenated graphene to increase undersea storage capacity. Materials and Chemistry:					

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Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602123N / *Force Protection Applied Res*	**Project (Number/Name)** 0000 / *Force Protection Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Ongoing research in Materials and Chemistry, examples of research include design and development, utilizing room temperature ionic liquids, to demonstrate and fabricate inexpensive, miniaturized, low power electrochemical sensors for use in autonomous as well as distributed sensor networks; developing real time, standoff, moving target, laser based detection for explosives and hazardous chemicals with the intent of shifting the paradigm of trace chemical detection through surface contact swabbing to a faster, more flexible wide area, standoff method for significant enhancement of force protection; development and design of a new class of safe high performance rechargeable zinc air batteries to supplant state of lithium-ion batteries; development of chemical vapor sensing strategy for application in a marine environment, significantly different than terrestrial environment; performance demonstrations of highly sensitive electrochemical detection elements incorporated into electronic integrated circuits; and demonstrations of high efficiency of zinc sponge anode in an electrochemical cell.					
FY 2020 Base Plans: Sensors and Associated Processing: Develop a new 3D ISAR capability for moving targets in air, space, ground, and sea to allow better target recognition. Materials and Chemistry: Design and develop, utilizing room temperature ionic liquids, to demonstrate and fabricate inexpensive, miniaturized, low power electrochemical sensors for use in autonomous as well as distributed sensor networks. Develop real time, standoff, moving target, laser based detection for explosives and hazardous chemicals with the intent of shifting the paradigm of trace chemical detection through surface contact swabbing to a faster, more flexible wide area, standoff method for significant enhancement of force protection. Develop and design a new class of safe high performance rechargeable zinc air batteries to supplant state of lithium-ion batteries. Development of chemical vapor sensing strategy for application in marine environment, significantly different than terrestrial environment. Significant accomplishments include performance demonstration of highly sensitive electrochemical detection elements incorporated into electronic integrated circuits. Demonstration of high efficiency of zinc sponge anode in an electrochemical cell. Undersea Warfare: Conceptualize and perform laboratory and field studies to: develop acoustics technology and associated signal processing for the detection of small Unmanned Aerial Vehicles (UAVs); and the development of a pressure tolerant, inexpensive hydrogen storage based on hydrogenated graphene to increase undersea storage capacity.					
FY 2020 OCO Plans:					

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Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602123N / *Force Protection Applied Res*	**Project (Number/Name)** 0000 / *Force Protection Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020.					
Title: ADVANCED ENERGETICS ***Description:*** Advanced Energetics efforts address technology development to provide substantial improvements in energetic material systems and subsystems, primarily in terms of performance, but also addressing safety, reliability, and affordability concerns. Goals include: advanced energetic materials for warheads, propellants, and reactive material based subsystems for both defensive and offensive applications. Efforts include: development of new fuels, oxidizers, explosive ingredients and formulations; and reliable simulation tools and diagnostics to develop and design superior-performance, and/or reduced-vulnerability systems tailored to specific warfighter missions. ***FY 2019 Plans:*** Ongoing research related to Advanced Energetics including development and evaluation of advanced explosive/ propellant/reactive ingredients and formulations for the next generation higher performing systems. Ongoing research in proof of concept efforts to develop insensitive explosives, propellants, and munitions without compromising performance. This work involves development of high quality, small particle energetic ingredients, novel processing techniques, and advanced energy conversion concepts; and involves both theoretical and experimental efforts. Ongoing research focused on chemical processing technologies. Incorporate molecular design and crystal morphology technology into scale-up and process development. New compliant commodity energetic ingredients will be transitioned to the industrial base as appropriate. Continue research in development and diagnostics of novel energy conversion concepts to enhance performance, more efficiently exploit available energy, and more effectively couple energy to target for air, surface, and underwater warhead application. ***FY 2020 Base Plans:*** Conduct research related to Advanced Energetics including development and evaluation of advanced explosive/ propellant/	5.014	5.497	5.380	0.000	5.380

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Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602123N / *Force Protection Applied Res*	**Project (Number/Name)** 0000 / *Force Protection Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
reactive ingredients and formulations for the next generation higher performing systems. Conduct research in proof of concept efforts to develop insensitive explosives, propellants, and munitions without compromising performance. This work involves development of high quality, small particle energetic ingredients, novel processing techniques, and advanced energy conversion concepts; and involves both theoretical and experimental efforts. Conduct research focused on chemical processing technologies. Incorporate molecular design and crystal morphology technology into scale-up and process development. New compliant commodity energetic ingredients will be transitioned to the industrial base as appropriate. Conduct research in development and diagnostics of novel energy conversion concepts to enhance performance, more efficiently exploit available energy, and more effectively couple energy to target for air, surface, and underwater warhead application. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020.					
Title: SURFACE SHIP & SUBMARINE HULL MECHANICAL & ELECTRICAL (HM&E)	71.587	72.772	67.859	0.000	67.859
Description: Technology programs focused on providing technologically superior warfighting capabilities at reduced total ownership costs for surface and subsurface platforms through investments in applied research and advanced technology development of programs in: a) Advanced Naval Power, b) hydrodynamics, c) structures, d) autonomy for unmanned surface vehicles (USV), and e) platform survivability. This element also includes the National Naval Responsibility in Naval Engineering (NNR-NE). The NNR-NE supports early applied research in the areas of propulsion, platform structures, hydrodynamics, automation control and system engineering,					

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Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602123N / *Force Protection Applied Res*	**Project (Number/Name)** 0000 / *Force Protection Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
design tools, naval power systems and ensuring a strong and healthy academic infrastructure. Specific research themes are: Advanced Naval Power Systems Technology: Efforts address electrical and auxiliary system and component technology to dramatically improve energy and power density, operating efficiency, and recoverability from casualties. A major investment focus is providing the power and energy required for directed energy weapons on current and future surface combatants. Advanced Naval Power efforts include: developing technologies for high-power, cyber-secured energy networks, distribution and control of power, providing warfighting capability with more energy efficient systems; mitigate adverse impacts of alternative fuel on Naval platforms and equipment; and utilizing the Electric Ship Research and Development Consortium (ESRDC) efforts to develop modeling and simulation tools to provide critical design and operational capabilities for the all-electric ship program, accelerate development and demonstration of technologies, reduce risk of new technology insertion, and address the national shortage of electrical power engineers. Develop new machinery integration concepts. Develop simulation based Verification, Validation and Accreditation (VV&A) methods and technologies. Contribute to system reconfiguration. Design a ship electrical system architecture based on a main bus that distributes "rough" Direct Current (DC) power throughout the ship at nominally 10 KV. Development of macro- and atomic-scale multi-physics models is being pursued to enhance understanding of materials processing and performance, energy conversion mechanisms, cyber-physical energy concepts, and power management. System-level studies focus on the scalability and reliability of component technologies. Another thrust is the development of tools to model heat transfer at multiple length scales allowing for simulation of heat flow through the ship in order to evaluate the impact of power conversion electronics, sensors, and weapons on the overall thermal balance of the vessel. Advanced Sea Platform Technology: Hydrodynamics: Critical platform design for surface ships hydrodynamics that is focused on the theory, computation, and lab and at-sea experimentation to develop understanding and prediction capabilities for all hydrodynamic phenomena associated with surface ships and small craft, their effects on vessel performance, and concepts for modification. Propulsor hydrodynamics is focused on understanding the physics of flow around propulsors and their interactions to improve propulsor performance, mobility, efficiency, and affordability, as well as prediction and control of various types of cavitation on propulsors and appendages. This also includes predictive capability of cavitation inception, thrust breakdown, and erosion phenomenon and scaling					

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Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602123N / *Force Protection Applied Res*	**Project (Number/Name)** 0000 / *Force Protection Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
laws. Technology efforts in the area of Subsurface Hydrodynamics include identifying, understanding, predicting, and controlling flow physics, as well as turbulence and stratified wakes. This is further applied to Subsurface Maneuvering Technologies, and understanding the Dynamics of Interacting Platforms. Additionally hydrodynamic technologies focused on the signature aspects of the hull-propulsor interaction and maneuvering. Platform Structures: Focused on time-varying, structural reliability analysis and prediction for a ship structural system with uncertainty quantification and propagation. Specific topics include novel structural configurations across composite and metallic materials and prediction methods for advanced global hull strength, local panel and component strength, fatigue and fracture strength, and seaway loads and load effects for high-speed/high-performance ships and vessels. Hull life assurance addresses development of new structural system approaches for surface ships and submarines, including the management of weapons effects to control structural damage and the improvement of structural materials. Unmanned Surface Vehicles (USV): Autonomy for USVs and related mission functions aligned with Naval S&T strategic focus on autonomy and unmanned vehicles. Unmanned Sea Surface Vehicle (USSV) applied research includes short-term motion forecasting for recovery of USSVs on a host ship in higher sea states and determination of slamming loads on high-speed planing hulls for structural weight reduction Distributed intelligence for automated survivability addresses both the basic technology of automating machinery control systems, as well as, distributed control of systems utilizing autonomy for mission context based reconfiguration. Sea Platform Survivability Technology: Aligned with survivability S&T strategic focus area, research investigates electromagnetic (EM) sources (including major ferro and non-ferromagnetic sources, eddy currents, and Corrosion Related Magnetic Fields (CRM)) that are associated with naval platforms. Develop understanding of EM field propagation relationships and analysis aids, and technologies to predict the electromagnetic properties of a naval platform. Advance physics based understanding of platform acoustics. Discover and develop algorithms and methods that will enable the development of improved design, analysis, and prediction tools for enhanced acoustic performance. Understand, design and develop optical and acoustic metamaterials to control light and sound propagation over a large frequency range. New architectures to overcome challenges associated with loss, bandwidth, and scalability are being explored. Design and develop models, algorithms, and integrated development environments for simulation and control of complex, interdependent, distributed shipboard machinery systems to enable integrated, autonomous operation and reconfiguration of shipboard machinery systems. Efforts also include: signature reduction, hull life assurance, hydromechanics, distributed control for automated survivability					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
(includes damage control), and advanced naval power systems. Signature reduction addresses electromagnetic, infrared, structural acoustics and acoustic signature tailoring, both topside and underwater. Develop and advance time critical stealth technologies for SSBN and SSN programs. ***FY 2019 Plans:*** Advanced Energy Systems Research: Ongoing applied research related to critical S&T in Power & Energy Technology related to energy systems. This research in energy systems provides innovative energy technologies and system designs to increase mission capability. Areas of research include all scientific and engineering aspects of the production, conversion, delivery, and use of energy for installation critical infrastructure, forward operating and remote bases, humanitarian assistance and disaster relief operations, manned and unmanned platforms, and general energy network applications. Primary objectives are to improve warfighting readiness, effectiveness, and flexibility through research projects focused on enhancing energy cyber-security, resiliency and efficiency. Research programs often include activities that purposely incorporate veterans and other military personnel into projects to enhance military applicability and to provide a sustainable source of military-experienced professionals for the DoN energy workforce. Advanced Naval Power Systems Technology: Ongoing research related to the NGIPS and Distribution/Control of Power Advanced Power Systems with a focus on power and energy requirements for directed energy weapons on current and future surface combatants. Advanced Sea Platform Technology: Ongoing applied research related to critical S&T to investigate platform design efforts related to propulsor and subsurface hydrodynamics; structural reliability science; and structural acoustics. Expand research related to the unmanned sea surface vehicle. Ongoing research related to naval engineering and platform design, including Ohio Replacement Program efforts. Sea Platform Survivability Technology: Ongoing applied research related to critical S&T to investigate efforts related to signature reduction; machinery autonomy; and platform survivability.					

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Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602123N / *Force Protection Applied Res*	**Project (Number/Name)** 0000 / *Force Protection Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Science & Technology to Address Complex Hybrid Warfare Threats: Ongoing projects to counter complex hybrid warfare threats. S&T technologies will address a broad range of multi-faceted threats that employ both conventional and unconventional forces. The S&T technologies will continue to expand and emphasize various compact platforms in multi-environments. Applied Research Challenge (ARC): Ongoing base program efforts, initiated in FY 2017 and FY 2018, including network information sciences, long-range high-resolution imaging, ocean surface scatter in RF propagation, wake measurement technologies, thermal management systems, high power control modules for ship application, decision support/uncertainty analysis for operational environments, and reactive composite materials. In particular, continue research to develop and test autonomy for Unmanned Undersea Vehicle (UUV) missions including understanding of counter-UUV autonomy options; implementations and testing. Materials and Chemistry: Ongoing research for understanding methods for fabricating nickel/graphene/cobalt magnetic tunneling junctions to develop new tunnel barrier materials technology for fast low power radiation hardened memory and magnetic sensors. This continuing effort will be a fundamental shift for magnetic tunnel junction technology, which is significantly different than the use of conventional oxides such as MgO and Al2O3. Favorable accomplishments have been made to show that graphene can be used as a tunnel barrier material. Electronics: Ongoing research to create and explore new high voltage, high efficiency wide bandgap and ultra-wide bandgap power switches for electric propulsion and electric weapons. ***FY 2020 Base Plans:*** Advanced Naval Power and Energy Systems Research and Technology: Advanced energy systems research includes a significant research program with the Hawaii Natural Energy Institute (HNEI) at the University of Hawaii that is focused on the analysis and optimization of resilient electrical grids and microgrids in the Pacific region. Prior and on-going research has demonstrated the ability of advanced batteries and other power management technologies to greatly enhance the stability and reliability of electrical grids possessing high penetrations of variable renewable energy resources. Results from these demonstrations					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
will be used to evaluate and increase the energy resiliency of critically infrastructures on DOD installations in the Pacific. The HNEI program has also initiated a new collaboration with the Alaska Center for Energy and Power (ACEP) at the University of Alaska Fairbanks to explore the use of energy storage technologies and distributed energy resources to enhance the energy resiliency of microgrids at remote locations and at DOD facilities in cold weather environments. To support both new and existing surface ship and submarine programs, specific new and ongoing efforts are aimed at supporting electrical system reliability, as well as advanced power distribution and control and will utilize the Electric Ship Research and Development Consortium (ESRDC) to develop modeling and simulation tools, system analysis tools and models to provide critical design and operational capabilities for the all-electric ship program, accelerate development and demonstration of technologies, and to reduce risk of technology insertion. These efforts also address the national shortage of naval electrical power engineers. Ongoing research related to the Next Generation Integrated Power System (NGIPS) and Distribution/Control of Power Advanced Power Systems with a focus on power and energy requirements for directed energy weapons and advance sensor systems on current and future surface combatants, as well as for unmanned naval platforms. Advanced Sea Platform Technology: New and ongoing applied research related to critical S&T that supports platform design and advanced capability efforts related to propulsor, surface, and subsurface hydrodynamics; platform performance, and platform structural reliability. Specifically, efforts to utilize advanced analytics (machine learning and artificial intelligence), incorporate environmental effects on platform performance, research related to advancing unmanned sea surface vessel technologies and capabilities. Specific naval engineering and platform design efforts to support set-based design for the Next Generation Attack Submarine SSN(X), and efforts to mitigate technology and susceptibility risk for the COLUMBIA class submarine program and the Future Surface Combatant Force. Sea Platform Survivability Technology: New and ongoing applied research related to critical S&T to investigate efforts related to signature reduction; structural and machinery acoustics; machinery autonomy; and platform survivability (detectability and susceptibility); and acoustic and non-acoustic signatures. Specifically, efforts utilizing advanced analytics (machine learning and artificial intelligence) and the integration of environmental effects on platform performance and detectability, Specific naval engineering and platform design efforts to support the Next Generation Attack					

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Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602123N / *Force Protection Applied Res*	**Project (Number/Name)** 0000 / *Force Protection Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Submarine SSN(X), and efforts to mitigate technology and susceptibility risk for the COLUMBIA class submarine program and the Future Surface Combatant Force. Ongoing base program efforts, initiated in FY 2018 and FY 2019, include ocean surface scatter in RF propagation, wake measurement technologies, thermal management systems, high power control modules for ship application, decision support/uncertainty analysis in operational environments, and reactive composite materials. Submarine Security S&T New and ongoing research efforts focused on the science and physics based signal detection technologies that, individually or as a system, can impact the security of the SSBN and submarines in general. Efforts looking at both passive and active detection technologies with near term (0-5 years), mid-term (5-10 years) and far term (10-20 years) implications, as well as improving the understanding of the generation, radiation, propagation, scatter, and detection of a variety of signal types (acoustic, chemical, optical, electromagnetic, hydrodynamic and radiological) associated with a submarine's operation. Autonomy Technology: Ongoing research related to critical multidisciplinary autonomy challenges that cut across areas/domains, including air, sea, undersea and ground. This includes multi-disciplinary research into the science of autonomy focuses on four interrelated areas: scalable and robust distributed collaboration among autonomous systems; human/unmanned system collaboration; autonomous perception and intelligent decision-making; and intelligent architectures for autonomous systems. Continue research to develop and test autonomy for Medium Displacement Unmanned Surface Vehicle (MDUSV) missions including perception and classification. Ongoing efforts, initiated in FY 2018 and FY 2019, include network information sciences, long-range high-resolution imaging, and decision support/uncertainty analysis for operational environments. In particular, continue research to develop and test autonomy for Unmanned Undersea Vehicle (UUV) missions including understanding of counter-UUV autonomy options; implementations and testing. Autonomy development involving a shared world model and sensor feedback will continue. Extensive in-water testing will continue. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:***					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602123N / *Force Protection Applied Res*	**Project (Number/Name)** 0000 / *Force Protection Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
The funding decrease is due to the completion of the Applied Research Challenge (ARC) program which concludes in FY19.					
Title: NAVAL RESEARCH ENTERPRISE	4.535	4.586	4.562	0.000	4.562
Description: The Independent Applied Research (IAR) R2 activity was stood up in FY 2013 as the Naval Research Enterprise (NRE) to consolidate all NRE related IAR investments. Projects funded in this R2 Activity are intended to be approximately 2-3 years in length. Based on historical trends approximately 30% of these projects will turn over each year. The Naval Research Enterprise (NRE) encompasses the IAR efforts focused on solving a wide range of Naval Science and Technology (S&T) fleet issues utilizing unique Naval Warfare Center (WC) laboratory capabilities. Efforts under this activity address the full spectrum of the Naval Research and Development Framework using focus areas which engage Naval aviation, sea surface, undersea, space, weapons, communication, information, and human systems. The IAR Program provides participating WCs with in-house funding for applied research to support the execution of their assigned missions by: -Developing and maintaining a cadre of active researchers who can distill and extend results from worldwide research and apply them to solve Naval problems. -Promoting the hiring and development of talented new scientists and engineers (S&E) with the insurance of proper mentoring with senior personnel. -Encouraging collaboration with universities, private industry, and other Navy and Department of Defense laboratories. Funded projects are chosen through rigorous internal competition by each WC's selection committee and typically last two to three years. IAR projects are generally designed to promote investment in high-risk/high-payoff research and also allow young S&Es to manage Navy relevant research projects. A limited number of successful efforts developed under the In-House Laboratory Independent Research (ILIR) basic research Program Element 0601152N are matured and further developed under the IAR program with the goal of transitioning these technologies to the warfighter. ***FY 2019 Plans:*** Independent Applied Research (IAR) shall align with Naval Research framework priorities (IAR projects which were three years in duration); Augmented Warfighter, Integrated & Distributed Forces; Operational Endurance, Sensing and Sense-Making, and Scalable Lethality. FY19 IAR projects will expand efforts in the areas of physics, chemistry, biotechnology, earth sciences, mathematics, and other hard and soft sciences. Representative projects include; Life Preserver Performance in Waves, Electronic Warfare Activity					

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602123N / *Force Protection Applied Res*	**Project (Number/Name)** 0000 / *Force Protection Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Recognition, Boron-Based Solid Fuel Development for Ramjet Application, Modularization Algorithm for Additive Manufactured Parts, Data Visualization Support for Creation of a Numerical Table: Effects on Training and Performance, Development of a Fully Integrated Ignition System for Multiple Pulse Hybrid Rocket Motor Firings, Active Sonar-based Cooperative UUV Interception, HFA Tactical Oceanography, and Ultra Short Pulse Laser Induced Plasma Filaments for Extended Covert Communications. ***FY 2020 Base Plans:*** Independent Applied Research (IAR) shall align with Naval Research framework priorities (IAR projects which were three years in duration); Augmented Warfighter, Integrated & Distributed Forces; Operational Endurance, Sensing and Sense-Making, and Scalable Lethality. FY20 IAR projects will expand efforts in the areas of physics, chemistry, biotechnology, earth sciences, mathematics, and other hard and soft sciences. Representative projects include; Life Preserver Performance in Waves, Electronic Warfare Activity Recognition, Boron-Based Solid Fuel Development for Ramjet Application, Modularization Algorithm for Additive Manufactured Parts, Data Visualization Support for Creation of a Numerical Table: Effects on Training and Performance, Development of a Fully Integrated Ignition System for Multiple Pulse Hybrid Rocket Motor Firings, Active Sonar-based Cooperative Unmanned Underwater Vehicle Interception, and Ultra Short Pulse Laser Induced Plasma Filaments for Extended Covert Communications. Fund the development of innovative prototypes at Warfare Centers and Naval Laboratories solving key warfighter problems that are identified through the Hacking for Defense innovation process pipeline. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** There is no significant change from FY 2019 to FY 2020.					
Accomplishments/Planned Programs Subtotals	122.743	124.049	119.517	0.000	119.517

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602123N / *Force Protection Applied Res*	**Project (Number/Name)** 0000 / *Force Protection Applied Res*

E. Performance Metrics

This PE supports the development of technologies associated with all naval platforms (surface, subsurface, terrestrial and air) and the protection of those platforms. Each PE Activity has unique goals and metrics, some of which include classified quantitative measurements. Overall metric goals are focused on achieving sufficient improvement in component or system capability such that the 6.2 applied research projects meet the need of or produce a demand for inclusion in advanced technology that may lead to incorporation into acquisition programs or industry products available to acquisition programs. Efforts funded in this PE also include energy programs in support of Navy energy guidance and efforts in support of the Ohio Replacement program.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy											Date: March 2019	
Appropriation/Budget Activity 1319 / 2					R-1 Program Element (Number/Name) PE 0602123N / *Force Protection Applied Res*				Project (Number/Name) 9999 / *Congressional Adds*			
COST ($ in Millions)	**Prior Years**	**FY 2018**	**FY 2019**	**FY 2020 Base**	**FY 2020 OCO**	**FY 2020 Total**	**FY 2021**	**FY 2022**	**FY 2023**	**FY 2024**	**Cost To Complete**	**Total Cost**
9999: *Congressional Adds*	0.000	59.871	56.500	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	116.371

A. Mission Description and Budget Item Justification

Congressional Interest Items not included in other Projects.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019
Congressional Add: Program Increase ***FY 2018 Accomplishments:*** Funding used to advance research and facilitate technology adoption for lithium-ion battery safety and electrical grid resiliency, reliability and security. ***FY 2019 Plans:*** N/A	24.142	0.000
Congressional Add: Alternative Energy Research ***FY 2018 Accomplishments:*** Funding used to carryout alternative energy research in several areas including modeling and simulation tools for energy efficient ship design, unmanned vehicle power systems, cyber-secure and resilient micro-grids, marine-derived renewable energy, and a variety of shore-based energy efforts addressing energy challenges in the Asia-Pacific regions, including Hawaii, Alaska, Guam, California, and Australia. ***FY 2019 Plans:*** Funding used to carryout alternative energy research in several areas including modeling and simulation tools for energy efficient ship design, unmanned vehicle power systems, cyber-secure and resilient micro-grids, marine-derived renewable energy, and a variety of shore-based energy efforts addressing energy challenges in the Asia-Pacific regions, including Hawaii, Alaska, Guam, California, and Australia.	24.142	28.000
Congressional Add: Power Generation and Storage Research ***FY 2018 Accomplishments:*** N/A ***FY 2019 Plans:*** Conduct and expand on-going competitively awarded efforts that improve Li-ion battery safety and increase micro-grid resiliency and efficiency	0.000	5.000
Congressional Add: Battery Storage and Safety ***FY 2018 Accomplishments:*** Funding used to conduct effort to develop safer battery technologies, including nonflammable electrolytes and safe cell technology, and to increase micro-grid resiliency and efficiency,	4.828	0.000

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602123N / *Force Protection Applied Res*	**Project (Number/Name)** 9999 / *Congressional Adds*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019
including advancements in battery technologies and utilization. Conduct and expand on-going competitively awarded efforts that improve Li-ion battery safety and increase micro-grid resiliency and efficiency. ***FY 2019 Plans:*** N/A		
Congressional Add: Hybrid Composite Structures Research for Enhanced Mobility ***FY 2018 Accomplishments:*** This effort will develop advanced fiber reinforced plastics for maritime craft and vessel structural components having the strength and weight benefits of traditional composite materials but without the corresponding cost and producibility limitations. In addition, this effort will develop hybrid inflatable structures for high load applications culminating in building and testing a full-scale lightweight ramp structure capable of supporting a 75 ton M1A1 tank. This ramp concept combines a metallic or composite compression member, drop stitch panels, and tension cables to form a lightweight, foldable ramp compatible with smaller vessels such as the Expeditionary Fast Transport and amphibious craft concepts such as the Ultra-Heavy Amphibious Connector. ***FY 2019 Plans:*** This effort will develop advanced fiber reinforced plastics for maritime craft and vessel structural components having the strength and weight benefits of traditional composite materials but without the corresponding cost and producibility limitations. In addition, this effort will develop hybrid inflatable structures for high load applications culminating in building and testing a full-scale lightweight ramp structure capable of supporting a 75 ton M1A1 tank. This ramp concept combines a metallic or composite compression member, drop stitch panels, and tension cables to form a lightweight, foldable ramp compatible with smaller vessels such as the Expeditionary Fast Transport and amphibious craft concepts such as the Ultra-Heavy Amphibious Connector.	4.828	5.000
Congressional Add: Standoff Detection of Buried Hazards ***FY 2018 Accomplishments:*** Detection of Buried Hazards : Develop the basic signal processing requirements for the Laser Multi-Beam Differential Interferometric Sensor system have been analyzed and transformed into system specifications. Draft the necessary test plan to investigate the effectiveness based both acoustic and seismic excitation for buried object detection in outdoor environment ***FY 2019 Plans:*** Detection of Buried Hazards : Develop the basic signal processing requirements for the Laser Multi-Beam Differential Interferometric Sensor system have been analyzed and transformed into system specifications. Draft the necessary test plan to investigate the effectiveness based both acoustic and seismic excitation for buried object detection in outdoor environment	1.931	3.000
Congressional Add: Advanced Energetics Research	0.000	7.500

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602123N / *Force Protection Applied Res*	**Project (Number/Name)** 9999 / *Congressional Adds*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019
FY 2018 Accomplishments: N/A ***FY 2019 Plans:*** These funds will be used towards the advanced demonstration of energetic materials in a variety of weapon system applications to include: high performance solid rocket and air breathing propulsion, reactive materials demonstrations and effects in advanced lethality and effectiveness models, advanced warhead concepts to include novel reactive shaped charge configurations, hybrid reactive material warhead demonstrations, and the development and demonstration of any necessary modeling and simulation capabilities for quantification of damage effects on adversary weapon systems, and other potential energetic technologies.		
Congressional Add: Advanced Hull Form Development and Demonstration ***FY 2018 Accomplishments:*** N/A ***FY 2019 Plans:*** Using computation fluid dynamic modeling, design innovative sea-keeping small-craft with improved performance characteristics utilizing advanced building techniques and materials.	0.000	8.000
Congressional Adds Subtotals	59.871	56.500

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

Not applicable.

E. Performance Metrics

Congressional Interest Items not included in other Projects.