Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Navy											Date: May 2021	
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 2: *Applied Research*					R-1 Program Element (Number/Name) PE 0602114N *I Power Proj Applied Research*							
COST ($ in Millions)	**Prior Years**	**FY 2020**	**FY 2021**	**FY 2022 Base**	**FY 2022 OCO**	**FY 2022 Total**	**FY 2023**	**FY 2024**	**FY 2025**	**FY 2026**	**Cost To Complete**	**Total Cost**
Total Program Element	0.000	27.859	38.701	23.013	-	23.013	-	-	-	-	-	-
0000: *Power Proj Applied Research*	0.000	18.205	17.701	23.013	-	23.013	-	-	-	-	-	-
9999: *Congressional Adds*	0.000	9.654	21.000	0.000	-	0.000	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

In an Artificial Intelligence (AI)enabled maritime battlespace, the ability to fight at the speed of light will determine the outcome. The effective defense against threats increasingly beyond human speed, will enable U.S. naval forces to outthink, outmaneuver and outfight adversaries. This Program Element (PE) supports both advanced technology research and near to mid-term transition opportunities. The advanced research focus is primarily on directed energy, high speed weapon propulsion, Electro-Optic/Infrared (EO/IR) sensor technologies, and Naval Precision Strike Operations. The goal of this research is to develop technologies and capabilities that enable Directed Energy (DE) weapons as well as defense against adversary DE systems; the development of vehicle and propulsion technology for high-speed weapons operating from Mach 3 to Mach 8 and beyond; investment in the areas of Electro Optic/Infrared devises and advanced sensors; and technologies that provide the navy of the future the ability to quickly locate, target, and strike critical targets ashore.

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.

Exhibit R-2, RDT&E Budget Item Justification: PB 2022 Navy	Date: May 2021
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602114N *I Power Proj Applied Research*

B. Program Change Summary ($ in Millions)	FY 2020	FY 2021	FY 2022 Base	FY 2022 OCO	FY 2022 Total
Previous President's Budget	28.546	17.792	21.918	-	21.918
Current President's Budget	27.859	38.701	23.013	-	23.013
Total Adjustments	-0.687	20.909	1.095	-	1.095
• Congressional General Reductions	-	-0.091			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	21.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-0.687	0.000			
• Program Adjustments	0.000	0.000	1.157	-	1.157
• Rate/Misc Adjustments	0.000	0.000	-0.062	-	-0.062

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2020	FY 2021
Project: 9999: *Congressional Adds*		
Congressional Add: *Microwave systems for counter-UAS defense*	9.654	0.000
Congressional Add: *Miniaturization of Lasers*	0.000	5.000
Congressional Add: *High Power Microwave Systems for Counter-UAS Defense*	0.000	16.000
Congressional Add Subtotals for Project: 9999	9.654	21.000
Congressional Add Totals for all Projects	9.654	21.000

Change Summary Explanation

Funding: No significant change.

Technical: No significant change.

Schedule: No significant change

Exhibit R-2A, RDT&E Project Justification: PB 2022 Navy			Date: May 2021
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602114N / *Power Proj Applied Research*	Project (Number/Name) 0000 / *Power Proj Applied Research*	

COST ($ in Millions)	Prior Years	FY 2020	FY 2021	FY 2022 Base	FY 2022 OCO	FY 2022 Total	FY 2023	FY 2024	FY 2025	FY 2026	Cost To Complete	Total Cost
0000: *Power Proj Applied Research*	0.000	18.205	17.701	23.013	-	23.013	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

In an Artificial Intelligence (AI)enabled maritime battlespace, the ability to fight at the speed of light will determine the outcome. The effective defense against threats increasingly beyond human speed, will enable U.S. naval forces to outthink, outmaneuver and outfight adversaries. This Project supports both advanced technology research and near to mid-term transition opportunities. The advanced research focus is primarily on directed energy, high speed weapon propulsion, electro-optic/ infrared (EO/IR) sensor technologies, and Naval Precision Strike Operations. The goal of this research is to develop technologies and capabilities that enable Directed Energy (DE) weapons as well as defense against adversary DE systems; the development of vehicle and propulsion technology for high-speed weapons operating from Mach 3 to Mach 8 and beyond; investment in the areas of Electro Optic/Infrared devises and advanced sensors; and technologies that provide the navy of the future the ability to quickly locate, target, and strike critical targets ashore.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022 Base	FY 2022 OCO	FY 2022 Total
Title: Directed Energy	6.309	7.000	7.492	0.000	7.492
Description: The goal of this activity is to develop technologies and capabilities that enable Directed Energy (DE) weapons for naval applications as well as defense against adversary Directed Energy systems.The advanced research focus is primarily for directed energy is in Naval Ship Defense, Naval Air Defense, and Naval Precision Strike Operations. The goal of Directed Energy (DE) research is to develop technologies and capabilities enabling both line of sight and beyond line of sight non-kinetic weapon capabilities, as well as defend against adversary DE systems. This DE Weapons scope includes the associated technologies of optics and material properties, providing Navy future forces the ability to quickly target and strike critical targets, in cost effective means, while minimizing potential collateral damage, as well as the ability to defend against and counter adversarial modes of attack. ***FY 2021 Plans:*** Component Technologies Conduct exploratory research and develop component technologies that enables higher power, more lethal High Energy Laser (HEL), High Power Microwave (HPM) and Ultra Short Pulse Laser (USPL) weapons. Research efforts include: - Development of novel laser and beam-director architectures - Improved sensor and illuminator technologies					

Exhibit R-2A, RDT&E Project Justification: PB 2022 Navy		Date: May 2021
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022 Base	FY 2022 OCO	FY 2022 Total
- Improved HEL electrical-to-optical efficiency - Improved laser sources with enhanced spectrum control - Reduced system jitter and improved precision aim-point maintenance - Improved characterization of atmosphere and associated modeling tools - Improved understanding of blooming and laser/material/target interactions - Development of novel laser sources in MWIR and LWIR - Improved understanding of USPL propagation mechanisms and effects Counter Directed Energy Weapons (CDEW) Conduct exploratory research in response to development of HEL and HPM threats. Research efforts include: - Development of understanding of HPM use in EM Maneuver Warfare and Integrated Defense of US naval forces - Improved understanding of HPM effects and lethality - Improved predictive tools and testing instrumentation Electronics: To develop and apply innovative S&T in plasmas, pulsed power, electromagnetic acceleration, particle beams, high-energy & ultra-short-pulse lasers (USPL), and non-linear optics to support current and future Navy and DoD needs. - Research efforts include: Adaptive Optics for Nonlinear Atmospheric Propagation of High-Power Laser Pulses and on Multiband Tunable High Power Fiber Laser.					
FY 2022 Base Plans: Conduct exploratory research and develop component technologies that enables higher power, more lethal High Energy Laser (HEL), High Power Microwave (HPM) and Ultra Short Pulse Laser (USPL) weapons. Research efforts include: - Development of novel laser and beam-director architectures - Improved sensor and illuminator technologies - Improved HEL electrical-to-optical efficiency - Improved laser sources with enhanced spectrum control - Reduced system jitter and improved precision aim-point maintenance - Improved characterization of atmosphere and associated modeling tools					

Exhibit R-2A, RDT&E Project Justification: PB 2022 Navy		Date: May 2021
Appropriation/Budget Activity 1319 / 2	**R-1 Program Element (Number/Name)** PE 0602114N / *Power Proj Applied Research*	**Project (Number/Name)** 0000 / *Power Proj Applied Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022 Base	FY 2022 OCO	FY 2022 Total
- Improved understanding of blooming and laser/material/target interactions - Development of novel laser sources in Mid Wave Infrared (MWIR) and Long Wave Infrared (LWIR) - Improved understanding of USPL propagation mechanisms and effects Conduct exploratory research in response to development of HEL and HPM threats by potential adversaries. Research efforts include: -Development of Counter-capabilities, including the understanding of HEL Weapons risks to US naval forces -Development of understanding of HPM use in Electromagnetic (EM) Maneuver Warfare and Integrated Defense of US naval forces -Improved understanding of HPM effects and lethality -Improved predictive tools and testing instrumentation Electronics: Develop and apply innovative S&T in plasmas, pulsed power, electromagnetic acceleration, particle beams, high-energy & ultra-short-pulse lasers (USPL), and non-linear optics to support current and future Navy and DoD needs. (- Research efforts include: - Finalize efforts on Adaptive Optics for Nonlinear Atmospheric Propagation of High-Power Laser Pulses. - Continue Multiband Tunable High Power Fiber Laser effort. ***FY 2022 OCO Plans:*** N/A ***FY 2021 to FY 2022 Increase/Decrease Statement:*** There is no significant change from FY21 to FY22.					
Title: High Speed Propulsion and Advanced Weapon Technologies	7.630	8.729	12.787	0.000	12.787
Description: This activity is focused on applied research to support the development of vehicle and propulsion technology for high-speed weapons operating from Mach 3 to Mach 8 and beyond. The goal is to develop computational, experimental and flight testing capabilities along with the workforce needed to support the development of hypersonic weapons. Research includes: Objectives: - Prediction and control of hypersonic boundary-layers and shock-wave boundary-layer interactions - Development of hypersonic ground test facilities, instrumentation and nonintrusive diagnostics - Prediction of interactions between materials and the high-speed flight environment such as flight through weather and oxidation of thermal protection systems					

Exhibit R-2A, RDT&E Project Justification: PB 2022 Navy		Date: May 2021
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022 Base	FY 2022 OCO	FY 2022 Total
- Development of improved modeling tools to predict the aerothermal and aerodynamic performance of hypersonic weapons over a wide range of velocities and altitudes - Development of ultra-high temperature materials, cooling strategies and thermal protection systems that can survive the launch and flight environment - Development high-speed propulsion technologies such as solid fuel ramjets ***FY 2021 Plans:*** High Speed Propulsion Technologies Current investments relevant to the development of high-speed propulsion technologies such as solid-fuel ramjets to extend the range of projectiles and missiles will continue. High-speed and hypersonic external aerodynamic technologies such as laminar flow control will be investigated to support future developments to enable hypersonic missiles and hypersonic ship-launched projectiles. New research plans include: - Ground experiments and sounding-rocket flight experiments to demonstrate: under relevant conditions, new aeroshell material technology to extend laminar flow - High-fidelity computations, ground test techniques and flow diagnostics to characterize neutral and ionized gas species over the nose-tip region, frustum and wake of ablating hypersonic vehicles - Experimental and computational studies to extend the flight envelope of solid fuel ramjets to higher speeds and altitudes and to improve throttle-ability. ***FY 2022 Base Plans:*** Current investments relevant to the development of high-speed propulsion technologies such as solid-fuel ramjets to extend the range of projectiles and missiles will continue. High-speed and hypersonic external aerodynamic technologies such as laminar flow control will be investigated to support future developments to enable hypersonic missiles and hypersonic ship- launched projectiles. New research plans include: - Assessment of advanced high-fidelity modeling and simulation tools for the prediction of boundary layer transition and turbulent heat transfer on relevant weapons geometries. - Development of physics based computational structural analysis tools for prediction of impact damage in weapon structures due to atmospheric encounters under high-speed flow conditions.					

Exhibit R-2A, RDT&E Project Justification: PB 2022 Navy		Date: May 2021
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022 Base	FY 2022 OCO	FY 2022 Total
- Experimental and numerical investigation on the combustion characteristics of solid fuels in supersonic combustors. ***FY 2022 OCO Plans:*** N/A ***FY 2021 to FY 2022 Increase/Decrease Statement:*** The increase in FY2022 funding is due to investment in assessments of high-fidelity modeling and simulation tools, development of physics based computational structural analysis tools, and experimental and numerical investigation on the combustion characteristics of solid fuels in supersonic combustors					
Title: Navigation, Electro Optic/Infrared (EO/IR), and Sensor Technologies ***Description:*** This activity describes Navy Science and Technology investments in the areas of Electro Optic/ Infrared (EO/IR) devices and advanced sensors and includes investment/performance in the technology areas of EO/IR, Electronic Warfare (EW), Electromagnetic Warfare, and Communications. ***FY 2021 Plans:*** Electronics To develop and explore new concepts, components, techniques, and subsystems for the detection of UV, visible, and infrared radiation to support current and future Navy and DoD needs with attention given to quantum-enabled precise time, and magnetic and gravimetric sensing. Current plans are to focus efforts on: - Solution-Processed Ultra-Sensitive, Room-Temperature Short Wave Infrared/ Mid-Wave Infrared (SWIR/ MWIR) Photodetectors. Electromagnetic Warfare Efforts completing in FY 2021: - Micro-Gas Chromatography with Stationary-Phase Infrared Spectroscopy; Optimize in column planar IR sensor and GC column configuration; Test with range of representative analytes including complex mixture challenges; Include existing IMS or mass spectrometer technology for direct comparison testing; and Demonstrate in	2.548	0.584	0.810	0.000	0.810

Exhibit R-2A, RDT&E Project Justification: PB 2022 Navy		Date: May 2021
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022 Base	FY 2022 OCO	FY 2022 Total
column planar IR sensor GC sensor to Government program managers and industry for transitions and commercialization. ***FY 2022 Base Plans:*** Electronics To develop and explore new concepts, components, techniques, and subsystems for the detection of UV, visible, and infrared radiation to support current and future Navy and DoD needs with attention given to quantum-enabled precise time, and magnetic and gravimetric sensing. Current plans are to focus efforts on: - Demonstrating a better way to search for advanced seeker optimal adjustable settings by using machine learning tools. ***FY 2022 OCO Plans:*** N/A ***FY 2021 to FY 2022 Increase/Decrease Statement:*** There is no significant change from FY21 to FY22.					
Title: Strike and Littoral Combat Technologies ***Description:*** The focus of this activity is on those technologies that will support Naval Precision Strike Operations and provide the Navy of the future the ability to quickly locate, target, and strike critical targets ashore. ***FY 2021 Plans:*** Electromagnetic Warfare The projects in this area are developing technology and techniques to provide the Navy of the future the ability to quickly locate, target, and strike critical targets ashore. Current research efforts include: - New high-resolution sensing techniques for emerging USN needs in Maritime ISR to allow 3D imaging through cloud cover - Machine-learning-based resource management for distributed radar system operation to support search and track requirements while minimizing emissions to degrade, defeat, and delay counter targeting.	1.718	1.388	1.924	0.000	1.924

Exhibit R-2A, RDT&E Project Justification: PB 2022 Navy		Date: May 2021
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021	FY 2022 Base	FY 2022 OCO	FY 2022 Total
Ended in FY20: - Developed electronic protection (EP) techniques and algorithms to enable surveillance, imaging, and targeting in EW denied areas. ***FY 2022 Base Plans:*** The projects in this area are developing technology and techniques to provide the Navy of the future the ability to quickly locate, target, and strike critical targets ashore. Current research efforts include: - Conclude research on new high-resolution sensing techniques for emerging USN needs in Maritime ISR to allow 3D imaging through cloud cover. - Continue efforts for machine-learning-based resource management for distributed radar system operation. This will support search and track requirements while minimizing emissions to degrade, defeat, and delay counter targeting. ***FY 2022 OCO Plans:*** N/A ***FY 2021 to FY 2022 Increase/Decrease Statement:*** There is no significant change from FY21 to FY22.					
Accomplishments/Planned Programs Subtotals	18.205	17.701	23.013	0.000	23.013

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2022 Navy			Date: May 2021
Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602114N / *Power Proj Applied Research*	Project (Number/Name) 9999 / *Congressional Adds*	

COST ($ in Millions)	Prior Years	FY 2020	FY 2021	FY 2022 Base	FY 2022 OCO	FY 2022 Total	FY 2023	FY 2024	FY 2025	FY 2026	Cost To Complete	Total Cost
9999: *Congressional Adds*	0.000	9.654	21.000	0.000	-	0.000	-	-	-	-	-	-

A. Mission Description and Budget Item Justification

Congressional Interest Items not included in other Projects.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2020	FY 2021
Congressional Add: Microwave systems for counter-UAS defense ***FY 2020 Accomplishments:*** N/A ***FY 2021 Plans:*** N/A	9.654	0.000
Congressional Add: Miniaturization of Lasers ***FY 2020 Accomplishments:*** N/A ***FY 2021 Plans:*** Conduct applied research in miniaturization of lasers.	0.000	5.000
Congressional Add: High Power Microwave Systems for Counter-UAS Defense ***FY 2020 Accomplishments:*** N/A ***FY 2021 Plans:*** Demonstrate smart directed-energy-based air-to-air layered defense solutions for the afloat and naval covered assets defensive counter air and electronic attack mission.	0.000	16.000
Congressional Adds Subtotals	9.654	21.000

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A