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 0602114N *I Power Proj Applied Research*							
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	23.028	27.643	18.546	-	18.546	19.583	23.743	25.048	29.341	Continuing	Continuing
0000: *Power Proj Applied Research*	0.000	13.372	14.643	18.546	-	18.546	19.583	23.743	25.048	29.341	Continuing	Continuing
9999: *Congressional Adds*	0.000	9.656	13.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	22.656

A. Mission Description and Budget Item Justification

The efforts described in this Program Element (PE) are based on investment directions as defined in the Naval Research and Development Framework. This strategy is based on needs and capabilities from Navy and Marine Corps guidance and input from the Naval Research Enterprise (NRE) stakeholders (including the Naval enterprises, the combatant commands, the Chief of Naval Operations (CNO), and Headquarters Marine Corps). It provides the vision and key objectives for the essential science and technology efforts that will enable the continued supremacy of U.S. Naval forces in the 21st century. The Strategy focuses and aligns Naval S&T with Naval missions and future capability needs that address the complex challenges presented by both rising peer competitors and irregular/asymmetric warfare.

This 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, and electro-optic/infrared (EO/IR) sensor technologies.

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	13.553	14.643	14.610	-	14.610
Current President's Budget	23.028	27.643	18.546	-	18.546
Total Adjustments	9.475	13.000	3.936	-	3.936
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	13.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-0.524	0.000			
• Program Adjustments	0.000	0.000	3.936	-	3.936
• Rate/Misc Adjustments	-0.001	0.000	0.000	-	0.000
• Congressional Add Adjustments	10.000	-	-	-	-

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 0602114N *I Power Proj Applied Research*

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2018	FY 2019
Project: 9999: *Congressional Adds*		
Congressional Add: *High Performance Microwave for Counter-IED Research*	4.828	9.000
Congressional Add: *Adaptive Optics*	4.828	0.000
Congressional Add: *Directed Energy*	0.000	4.000
Congressional Add Subtotals for Project: 9999	9.656	13.000
Congressional Add Totals for all Projects	9.656	13.000

Change Summary Explanation

The program increase in FY 2020 is associated with an increased concentration on the applied research of Air Weapons.

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 0602114N / *Power Proj Applied Research*	Project (Number/Name) 0000 / *Power Proj Applied Research*	

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: *Power Proj Applied Research*	0.000	13.372	14.643	18.546	-	18.546	19.583	23.743	25.048	29.341	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project addresses the technology issues involving the Navy's capability to project naval power on the broad seas and in the littoral regions.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Title: DIRECTED ENERGY	4.494	6.463	6.427	0.000	6.427
Description: The goal of this activity is to develop Directed Energy technology for Navy applications. The DE program addresses the requirements of future Navy combatants to provide ship defense against the emerging threats that are proliferating throughout the Navies of the world. The Directed Energy portion of this activity consists of two elements.					
FY 2019 Plans: Directed Energy Research: Continue research and thrusts in component technologies and basic understanding of laser/material interactions to enable higher power, more lethal High Energy Laser, high power Microwave/Radio Frequency, and Ultra Short Pulse Laser weapons capabilities. Some examples of research include the development of novel laser and beam directory architectures, improved sensor and illuminator technologies including materials and coating, improved HEL electrical to optical efficiency, improved laser sources with enhanced spectrum control, reduced system jitter and improved precision aim point maintenance. Other research areas that will be explored are the syntheses of target recognition, pose/trajectory estimation, autonomous aim point selection and maintenance including tracking through intermittent viewing conditions such as waves and clouds, understanding atmospheric characterization and modeling tools, blooming, laser/material/target interactions, novel laser sources in Medium Wavelength Infrared (MWIR) and the Long Wavelength Infrared (LWIR)-(4-12 microns), USPL propagations and effects. Research will continue in Counter Directed Energy Weapons (CDEW), in response to the development of high energy laser (HEL) and high-power microwave (HPM)/high-power radio frequency (HPRF) threats. Complete effort to develop a fiber based high power laser operating in the eye safe regime beyond 2 microns.					

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 0602114N / *Power Proj Applied Research*	**Project (Number/Name)** 0000 / *Power Proj Applied Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Electronics: Continue applied research efforts to apply innovative Science and Technology (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. ***FY 2020 Base Plans:*** Conduct research efforts and thrusts in component technologies and basic understanding of laser/material interactions to enable higher power, more lethal High Energy Laser (HEL), high power Microwave/Radio Frequency, and Ultra Short Pulse Laser (USPL) weapons capabilities. Some examples of research include the development of novel laser and beam directory architectures, improved sensor and illuminator technologies including materials and coating, improved HEL electrical to optical efficiency, improved laser sources with enhanced spectrum control, reduced system jitter and improved precision aim point maintenance. Other research areas that will be explored are the syntheses of target recognition, pose/trajectory estimation, autonomous aim point selection and maintenance including tracking through intermittent viewing conditions such as waves and clouds, understanding atmospheric characterization and modeling tools, blooming, laser/material/ target interactions, novel laser sources in Medium Wavelength Infrared (MWIR) and the Long Wavelength Infrared, USPL propagations and effects. Research will continue in Counter Directed Energy Weapons (CDEW), in response to the development of HEL and high-power microwave (HPM) and high-power radio frequency threats. Complete effort to develop a fiber based high power laser operating in the eye safe regime beyond 2 microns. Electronics: Conduct applied research efforts to apply innovative Science and Technology (S&T) in plasmas, pulsed power, electromagnetic acceleration, particle beams, high-energy & Ultra Short Pulse Lasers, and non-linear optics to support current and future Navy and DoD needs. ***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: HIGH SPEED PROPULSION AND ADVANCED WEAPON TECHNOLOGIES ***Description:*** Applied Research into a wide range of technologies that support high speed weapons work in this activity is focused on demonstrating propulsion and vehicle technologies for Mach 3 to Mach 8 or beyond capable weapons. This work includes technologies associated with high-acceleration projectile structures, high temperature and high strength materials to enable projectiles to survive high-speed launch environment,	4.649	3.878	7.774	0.000	7.774

Exhibit R-2A, RDT&E Project Justification: PB 2020 Navy		Date: March 2019
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
improved thermal prediction methodologies and test techniques, wide dynamic pressure adaptable projectile controls and non-explosively launched lethal mechanisms. The high speed projectile technologies are intended to support long range Naval Surface Fire Support weapons. ***FY 2019 Plans:*** Continue current investments to include topics relevant for development of high speed/hypersonic aerodynamics technologies to support exploratory development to enable very long range hypersonic boost-glide missiles and hypersonic ship-launched projectiles. Specific research and development plans include continued development of very long range hypersonic boost-glide missiles and hypersonic ship-launched projectiles; advanced computational and experimental techniques for hypersonic boundary layer transition; high temperature thermal management research; ultra-high temperature materials research for hypersonic leading edges and nose tips; technology maturation of advanced airframes and controls; high Gforce components and miniaturization of electronics; advanced guidance and control technologies for high speed weapons; insulator and ablative technology investigations; high speed propulsion and integrated airframe technology development to enhance system range, responsiveness, and reliability; and advanced material solutions to high speed airframes and air systems operating in maritime environments. ***FY 2020 Base Plans:*** Investments to include topics relevant for development of high speed propulsion for solid rocket motors and hybrid type propulsion technologies such as solid-fuel ramjets for greatly enhanced projectile range and missiles. High-speed and hypersonic external aerodynamic technologies will be investigated to support future development efforts to enable hypersonic boost-glide missiles and hypersonic ship-launched projectiles. Specific research and development plans include continued development of very long range hypersonic boost-glide missiles and hypersonic ship-launched projectiles; advanced computational and experimental techniques for hypersonic boundary layer transition; high temperature thermal management research; ultra-high temperature materials research for hypersonic leading edges and nose tips; technology maturation of advanced airframes and controls; high G-force components and miniaturization of electronics; advanced guidance and control technologies for high speed weapons; insulator and ablative technology investigations; high speed propulsion and integrated airframe technology development to enhance system range, responsiveness, and					

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 0602114N / *Power Proj Applied Research*	**Project (Number/Name)** 0000 / *Power Proj Applied Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
reliability; and advanced material solutions to high speed airframes and air systems operating in maritime environments. ***FY 2020 OCO Plans:*** N/A ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The funding increases from FY 2019 to FY 2020 are associated with an increased concentration on the applied research of Air Weapons such as hypersonic ship launched strike weapons.					
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 2019 Plans:*** Electronics: Efforts to create 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. Electromagnetic Warfare: Conduct multiple efforts to address the necessary technologies to engage Electro Optic/Infrared (EO/IR) threats through both active and passive countermeasures technologies and assuring deployment capabilities are available to achieve the proper disposition of materials for extended durations. Recent results in the application of new material concepts applied to IR concepts have received interest for potential follow on consideration pending successful demonstrations. ***FY 2020 Base Plans:*** Electronics: Create and explore new concepts, components, techniques, and subsystems for the detection of Ultra-violet (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. Electromagnetic Warfare: Multiple efforts will be executed to address the necessary technologies to engage Electro Optic/Infrared threats through both active and passive countermeasures technologies and assuring deployment capabilities are available to achieve the proper disposition of materials for extended durations.	2.521	2.570	2.596	0.000	2.596

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 0602114N / *Power Proj Applied Research*	**Project (Number/Name)** 0000 / *Power Proj Applied Research*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Recent results in the application of new material concepts applied to IR concepts have received interest for potential follow on consideration pending successful demonstrations. ***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: 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 2019 Plans:*** Electromagnetic Warfare: Technology development is ongoing to address capabilities to understand the defeat mechanism for operations of ISR platforms using non-traditional frequencies as well as protecting current capabilities against electronic attack through enhanced concepts. ***FY 2020 Base Plans:*** Electromagnetic Warfare: Technology development is ongoing to address capabilities to understand the defeat mechanism for operations of Intelligence Surveillance and Reconnaissance (ISR) platforms using non-traditional frequencies as well as protecting current capabilities against electronic attack through enhanced concepts. The non-traditional integration of ISR capabilities is being implemented into a major Commercialization Pilot Programs (CPP) funded effort at NRL to validate expectations at minimal cost to this program and expand the capability of a significant testing resource. ***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.	1.708	1.732	1.749	0.000	1.749
Accomplishments/Planned Programs Subtotals	13.372	14.643	18.546	0.000	18.546

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 0602114N / *Power Proj Applied Research*	**Project (Number/Name)** 0000 / *Power Proj Applied Research*

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

This Program Element (PE) develops early component technologies that can be integrated into weapon systems that meet warfighter requirements. 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). The metrics used to evaluate 6.2 programs are necessarily less precise than those used in 6.3 programs.

The metrics for this PE can be divided into two categories: technological and organizational/functional. Technological metrics address the success of the work performed. The primary technological metrics used in this PE involve laboratory experiments/tests demonstrating proof of the concept for the technology. This demonstration is frequently a hand-assembled functioning breadboard of the concept. The organizational/functional metrics applied to this PE include: transition of the technology to advanced development in a 6.3 PE and applicability of the technology to documented warfighter problems or requirements. Successful implementation of these categories would result in the application of a pass/fail metric and further evaluation for possible transition to a 6.3 development/demonstration 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 0602114N / *Power Proj Applied Research*				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	9.656	13.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	22.656

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: High Performance Microwave for Counter-IED Research	4.828	9.000
FY 2018 Accomplishments: Explore the effectiveness of High Power Microwave (HPM) weapons. Perform detailed modeling and simulation of emerging threats to Naval forces, including developing new tools to better predict the effectiveness of HPM weapons. The outputs from the simulation work will be experimentally verified and utilized to inform future technology investments in solid state HPM technologies for improved capabilities. Detailed size, weight and power trade-off studies of candidate solid state technologies performed to enable conceptual design development.		
FY 2019 Plans: Funds will be used towards the isolating/determining high power microwave (HPM) waveform spaces that enable control over desired levels-of-lethality on small unmanned aerial vehicle (sUAV) and similar targets, with the least power density, to drive development of transitionable HPM sources and electronically steerable radiators.		
Congressional Add: Adaptive Optics	4.828	0.000
FY 2018 Accomplishments: The Navy is exploring the potential to defeat anti-ship cruise missiles (ASCM) with laser weapons. It is generally believed that adaptive optics will be critical to compensate for atmospheric effects that would otherwise degrade the effectiveness of a laser for this critical mission. The FY18 appropriation will be used to mature technology and scientific understanding that advances the Navy's ability to use adaptive optics in future laser weapons.		
FY 2019 Plans: N/A		
Congressional Add: Directed Energy	0.000	4.000
FY 2018 Accomplishments: N/A		
FY 2019 Plans: Develop advanced components for use in directed energy applications.		
Congressional Adds Subtotals	9.656	13.000

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C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Congressional Interest Items not included in other Projects.