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 0602782N *I Mine & Exp Warfare 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	35.430	38.214	36.074	-	36.074	30.298	30.900	31.533	32.167	Continuing	Continuing
0000: *Mine & Exp Warfare Applied Res*	0.000	31.085	36.214	36.074	-	36.074	30.298	30.900	31.533	32.167	Continuing	Continuing
9999: *Congressional Adds*	0.000	4.345	2.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	6.345

A. Mission Description and Budget Item Justification

This Program Element (PE) provides technologies for Naval Mine Countermeasures (MCM), Expeditionary Warfare, U.S. Naval sea mining, Naval Special Warfare (NSW), and Joint Tri-Service Explosive Ordnance Disposal (EOD) as well as continuing support to research vessels of the U.S. Academic Research Fleet for operations and maintenance that enable applied research at sea. This program is strongly aligned with the Joint Chiefs of Staff Joint Warfighting Capability Objectives through the development of technologies to achieve military objectives with minimal casualties and collateral damage. Within the Naval Transformation Roadmap, this investment will achieve one of three "key transformational capabilities" required by "Sea Shield" as well as technically enable the Ship to Objective Maneuver (STOM) key transformational capability within "Sea Strike" by focusing on technologies that will provide the Naval Force with the capability to dominate the battlespace, project power from the sea, and support forces ashore with particular emphasis on rapid MCM operations. These efforts concentrate on the development and transition of technologies for the MCM-related and Urban Asymmetric/Expeditionary Warfare Operations (UAEO)-related Future Naval Capabilities (FNC) Enabling Capabilities (ECs). The Mine and Obstacle Detection/Neutralization efforts include technologies for clandestine and overt minefield reconnaissance, organic ship self-protection, organic minehunting and neutralization/breaching. The Urban Asymmetric Operation effort includes critical warfighting functions such as Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR), fires, maneuver, sustainment, etc. The Naval Special Warfare and Explosive Ordnance Disposal technology efforts concentrate on the development of technologies for safe near-shore mine detection, diver mobility and survivability, and ordnance disposal operations.

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.

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 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 0602782N *I Mine & Exp Warfare Applied Res*

B. Program Change Summary ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Previous President's Budget	32.733	37.545	36.273	-	36.273
Current President's Budget	35.430	38.214	36.074	-	36.074
Total Adjustments	2.697	0.669	-0.199	-	-0.199
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-1.331			
• Congressional Rescissions	-	-			
• Congressional Adds	-	2.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-1.000	0.000			
• SBIR/STTR Transfer	-0.802	0.000			
• Program Adjustments	0.000	0.000	-0.199	-	-0.199
• Rate/Misc Adjustments	-0.001	0.000	0.000	-	0.000
• Congressional Add Adjustments	4.500	-	-	-	-

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2018	FY 2019
Project: 9999: *Congressional Adds*		
Congressional Add: *Program Increase*	1.931	0.000
Congressional Add: *Submersible Research*	2.414	0.000
Congressional Add: *Unmanned Aerial and Deep Submersible Platforms*	0.000	2.000
Congressional Add Subtotals for Project: 9999	4.345	2.000
Congressional Add Totals for all Projects	4.345	2.000

Change Summary Explanation

Technical: Not applicable.

Schedule: Not applicable.

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 0602782N / *Mine & Exp Warfare Applied Res*	Project (Number/Name) 0000 / *Mine & Exp Warfare 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: *Mine & Exp Warfare Applied Res*	0.000	31.085	36.214	36.074	-	36.074	30.298	30.900	31.533	32.167	Continuing	Continuing

A. Mission Description and Budget Item Justification

This project focuses on reducing the time involved in conducting MCM operations and increasing safe standoff from minefields. It develops and transitions technologies for MCM-related and UAEO-related Future Naval Capability Enabling Capabilities (FNC ECs). The MCM effort includes technologies for clandestine and overt minefield reconnaissance, organic ship self-protection, organic minehunting, neutralization/breaching and clearance. The Littoral Warfare effort includes critical warfighting functions such as C4ISR, fires, maneuver, sustainment, etc. The sea mining effort emphasizes technologies for future sea mines. The Naval Special Warfare and Explosive Ordnance technology efforts concentrate on the development of technologies to enhance diver capabilities including: safe near-shore mine sensing, mobility and survivability, and ordnance disposal operations.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Title: MINE TECHNOLOGY	3.659	6.962	7.635	0.000	7.635
Description: Mine Technology: This activity primary focuses on developing and demonstrating technologies to support on-demand battlespace shaping through advanced undersea weapons and next generation mining concepts. Efforts include Command & Control to support remote control, advanced sensing technologies, compatibility with unmanned delivery options, detection & classification, and targeting solutions. The program, Modular Undersea Effectors (MUSE), is a critical Science and Technology effort both to support Fleet demand for capability and prototype development for next generation mining concepts, and to develop and investigate flexible, scalable, and asymmetric technologies to deliver next generation mining effects for legacy programs of record. This program provides critical S&T for development and capability in new acquisition programs of record.					
FY 2019 Plans: Conduct applied research in remote control, advanced minefield concepts, minefield planning, and advanced sensors / signal processing. Efforts involved in this area include developments in advanced sensors and algorithmic capabilities that are applicable toward existing target detection devices (TDDs), analysis of intermediate and deep water minefield concepts, development of concepts for semi-autonomous and remote controlled mines and minefields, and assessment of sea mine technologies in order to maintain a level of					

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 0602782N / *Mine & Exp Warfare Applied Res*	**Project (Number/Name)** 0000 / *Mine & Exp Warfare Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
expertise in naval mines. Initiate applied research in modeling and applying novel mine sensing modalities and modeling and development of advanced minefield effects. ***FY 2020 Base Plans:*** Conduct advanced technology development in advanced mining technologies for clandestine, flexible, and scalable minefield deployment, longevity, and endurance, to include remote control, advanced sensing for detection and classification, command & control (C2), and more discriminative targeting solutions. Efforts in this thrust include prototyping and demonstration of advanced sensors and sensor configuration technologies for improved discrimination as well as communications, command, and control technologies. Continue prototyping and demonstration for next-generation target detection devices and mine effects. Joint Service Explosive Ordnance Disposal (EOD): Conduct applied technology development and demonstration in electro-optic & acoustic technologies for buried mine detection, robotic manipulation for ordnance exploitation & neutralization, standoff detection and classification for ordnance, and identification of explosives. Efforts in this thrust include prototype and demonstration of laser interferometric sensor/systems for detection of buried objects, highly dexterous dual manipulator systems (manipulators, controllers) for EOD robots for precision render safe and neutralization missions, technologies for low-observable underwater ordnance neutralization and technologies for the inspection of underwater explosive threats. ***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: MINE/OBSTACLE DETECTION ***Description:*** This activity focuses on applied research to enable longer detection ranges and precise mine location with fewer false alarms in a variety of challenging environments. It supports Discovery and Invention (D&I) and Mine Countermeasures (MCM)-related Future Naval Capabilities (FNCs). Efforts in Synthetic Aperture Sonar (SAS) technologies for longer range detection and classification of mine-like targets and magnetic gradiometer sensing and electro-optic (EO) technology for buried mine identification, and sensor integration onto Autonomous Underwater Vehicles (AUVs) are being addressed. EO sensor research develops algorithms to enable image processing for rapid overt reconnaissance from an Unmanned Aerial Vehicle (UAV). Other processing, classification and data fusion techniques to reduce operator workload, and a mine burial prediction	17.003	17.969	17.329	0.000	17.329

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 0602782N / *Mine & Exp Warfare Applied Res*	**Project (Number/Name)** 0000 / *Mine & Exp Warfare Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
"expert system" are also being developed. Efforts also support development of MCM Mission Modules for Littoral Combat Ships. The program is strongly aligned with the Oceanographer of the Navy (N2/N6E) and the research topics addressed by this sub activity reflects the priorities for improved forecasts of the operational environment and the development and use of autonomous systems for the collection of environmental observations and continuing support to research vessels of the U.S. Academic Research Fleet for operations and maintenance that enable science at sea. This Program requires field research that involves participation in Navy environmental planning efforts including environmental planning documents (Environmental Impact Statements). The use of active acoustic transmissions requires modeling of the acoustic effects of sound on marine life. ***FY 2019 Plans:*** Conduct applied research in novel minehunting technology areas that will ultimately enable unmanned systems to operate flexibly across a wide range of dynamic and unstructured environments and operations. Research thrusts include development of new algorithms, coding schemes, prototype hardware, and problem domain understanding for acoustic communications between unmanned MCM systems in the dynamic environments unique to minehunting; new transduction designs and sensor concepts appropriate for miniaturizing MCM capabilities onto substantially smaller unmanned systems and operating with increased autonomy; algorithmic approaches and new hardware designs that consolidate and optimize sensing, navigation, and communications for smaller autonomous mobile mine hunting and neutralization systems. Conclude development of a high source level projector that can extend the maximum detection range of the Low Frequency Broadband (LFBB) Mine Identification System. Conclude Phase 2 of Advanced Mission Module Technology Development. Conclude development of system concepts for wide area detection of surface and submerged drifting mines. Initiate joint sensing and communication approaches for multi-vehicle mine hunting. Initiate performance estimation for automatic target recognition on non-imaging systems. Continuing support to research vessels of the U.S. Academic Research Fleet for operations and maintenance that enable science at sea. Undersea Warfare: Perform laboratory, field, and theoretical/numerical studies that creates new solutions to enable naval forces to conduct more rapid and effective mine detection and classification such as: the development of unmanned underwater vehicle (UUV) autonomy to interactively sense and exploit the ambient environmental conditions to optimize performance; and to characterize the flow generated by biomimetic					

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 0602782N / *Mine & Exp Warfare Applied Res*	**Project (Number/Name)** 0000 / *Mine & Exp Warfare Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
propulsion approaches leading to development of tools to inform the design of future UUVs utilizing such propulsion mechanisms.					
FY 2020 Base Plans: Conduct applied research in novel mine hunting technologies to enable unmanned systems to operate flexibly across a wide range of dynamic and unstructured environments and operations. Research thrusts include the development of new algorithms, innovative processing schemes, prototype hardware, studies of acoustic communications between unmanned MCM systems in dynamic environments; new transducer designs and sensors for miniaturizing MCM capabilities onto smaller unmanned systems and operating with increased autonomy; novel algorithmic approaches and hardware designs that consolidate and optimize sensing, navigation, and communications for smaller autonomous mine hunting and neutralization systems. Conduct investigations of joint sensing and communication approaches for multi-vehicle mine hunting; and, performance estimation for automatic target recognition on non-imaging systems. Laboratory, field, and theoretical/numerical studies will provide new solutions to enable more rapid and effective mine detection and classification. Emphasis will be placed on reducing timelines, or even eliminating, post-mission analysis through enhanced scene understanding derived from acoustic and/or other sensing modalities. Specific research activities include; the development of Unmanned Underwater Vehicle (UUV's) autonomy to exploit the ambient environmental conditions to optimize performance; extend the reach of MCM UUVs to operate at deeper depths; characterization of the flow generated by various propulsion approaches; measurements and modeling of the physics associated with the acoustic interactions with targets and the environment, which can be exploited for detection and classification; investigations that lead to new parameterizations of the ocean seabed applicable to modern mine hunting systems; investigations that link observable impacts on acoustic scattering and/or propagation with the underlying phenomenology that affects the environment, including oceanographic and biologic processes; investigations aimed at linking target scattering physics modalities to specific properties in the feature space domain used for Automatic Target Recognition.					
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 0602782N / *Mine & Exp Warfare Applied Res*	**Project (Number/Name)** 0000 / *Mine & Exp Warfare Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
There is no significant change from FY 2019 to FY 2020.					
Title: MINE/OBSTACLE NEUTRALIZATION	0.415	0.445	0.435	0.000	0.435
Description: Activity includes applied research to support selected Mine Counter-Measures related Future Naval Capabilities (FNC) for rapid mine and obstacle neutralization and sea mine jamming techniques to increase surface ship safe standoff from threat mines. It includes various lethality, vulnerability and dispensing computational tools, models and assessments to support the various far-term Surf Zone and Beach Zone mine and obstacle breaching concepts. ***FY 2019 Plans:*** Conduct applied research in rapid mine and obstacle neutralization and mine sweeping techniques to increase surface ship safe standoff from threat mines. Efforts involved in this area include various lethality, vulnerability, and dispensing models, assessments, and algorithmic approaches to support surf zone and beach zone mine and obstacle breaching concepts; techniques for neutralization of buried mines; techniques for emulation sweep; and investigating the coupling of reacquire & identify capabilities with precision neutralization for buried mines. Conclude development of system concepts for autonomous neutralization of surface and submerged drifting mines. ***FY 2020 Base Plans:*** Conduct applied research to support rapid mine and obstacle neutralization and mine sweeping techniques to enable maneuver of joint forces and increase the safe standoff of various tactical platforms and surface ships from the threat of mines. Research thrusts include development of lethality, vulnerability models, technology concept assessments, and algorithmic approaches to support neutralization of mines and obstacles in all water depths and on the beach, which includes Surf Zone and Beach Zone mine and obstacle breaching concepts; novel approaches for neutralization of buried mines; advanced techniques for emulation sweep; and methods to enable precision neutralization of buried mines. Conclude assessment of preliminary methods for emulation sweep. Conclude investigation of coupling of reacquire and identify capabilities with precision neutralization of buried mines. ***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 0602782N / *Mine & Exp Warfare Applied Res*	**Project (Number/Name)** 0000 / *Mine & Exp Warfare Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
There is no significant change from FY 2019 to FY 2020.					
Title: SPECIAL WARFARE/EOD	10.008	10.838	10.675	0.000	10.675
Description: The goal of this effort is to develop technologies to extend stand-off of special operations and Explosive Ordnance Disposal (EOD) forces in clandestine hydrography, mine clearance and port security missions while increasing the range and effectiveness of divers. Advanced technologies are needed to gain access to areas contaminated by area-denial sensors and/or booby traps. Developed technologies will transition to the Joint Service EOD Program, the Naval EOD Program, or the DOD Technical Response Group. This activity includes applied research in sensor technology for Naval Special warfare (NSW) and EOD autonomous and handheld sonar systems to increase detection range and accuracy in harsh environments. Other efforts include mission support technology improvements for AUVs and human divers - such as communications, navigation and life support. ***FY 2019 Plans:*** Conduct applied research in sensor technology for NSW and EOD autonomous and handheld sonar systems, mission support technology improvements for AUVs and human divers (e.g., communications, navigation, and life support), and threat identification, exploitation, and remediation technologies. Efforts involved in this area include development of technologies to excavate buried IEDs, dual manipulator robots for complex underwater EOD missions, technologies to enhance diver situational awareness and autonomous inspection of ship hulls, support of Joint Service Explosive Ordnance Disposal (JSEOD) applied research, and detection of trace and bulk explosive materials. Conclude investigation of multi-modal signature reduction technologies for wet/dry-submersibles and semisubmersibles. Initiate modeling and development of concepts to increase mobility efficiency for combat divers. ***FY 2020 Base Plans:*** Conduct applied research in sensor, render-safe and neutralization technologies for NSW and EOD autonomous and handheld systems, mission support technology enhancements for manned and unmanned platforms (air, surface or undersea) and new concepts to increase the efficiency and mobility of unmanned platforms and divers (e.g., communications, propulsion, navigation, and life support), and threat identification, exploitation, and remediation technologies. Efforts include development of technologies which will: excavate buried Improvised Explosive Device; use advanced robotic manipulators for complex underwater EOD missions; support Joint Service Explosive Ordnance Disposal (JSEOD) applied research; detect trace and bulk explosive materials at extended standoff distances; detect buried improvised explosive devices, explosive threats and mines using handheld or unmanned platforms; inspect explosive threats from safe standoff, enhance diver situational					

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 0602782N / *Mine & Exp Warfare Applied Res*	**Project (Number/Name)** 0000 / *Mine & Exp Warfare Applied Res*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
awareness and autonomous inspection of structures; conduct vessel interdiction; allow tagging, tracking and locating of targets; conduct characterization, inspection, surveillance and reconnaissance of denied and under canopy areas. Conclude assessment of excavation techniques. ***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	31.085	36.214	36.074	0.000	36.074

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

The overall metrics of this applied research program are the development of technologies which focus on the Expeditionary Warfare challenge of speeding the tactical timeline and increasing safe standoff from minefields. Individual project metrics include the transition of 6.2 technology solutions into 6.3 advanced technology programs.

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 0602782N / *Mine & Exp Warfare 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	4.345	2.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	6.345

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:*** Funds will be used to accelerate development of capabilities to reduce timelines in MCM operations and to study cross-domain hybrid unmanned systems. ***FY 2019 Plans:*** N/A	1.931	0.000
Congressional Add: Submersible Research ***FY 2018 Accomplishments:*** Funds will be used to accelerate development of autonomous vehicle behaviors in cluttered environments. ***FY 2019 Plans:*** N/A	2.414	0.000
Congressional Add: Unmanned Aerial and Deep Submersible Platforms ***FY 2018 Accomplishments:*** N/A ***FY 2019 Plans:*** Funds will be used to further development of autonomous aerial and submersible platforms in cluttered environments.	0.000	2.000
Congressional Adds Subtotals	4.345	2.000

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 0602782N / *Mine & Exp Warfare Applied Res*	**Project (Number/Name)** 9999 / *Congressional Adds*

E. Performance Metrics

Congressional Interest Items not included in other Projects.