Exhibit R-2, RDT&E Budget Item Justification: FY 2018 Navy											Date: May 2017	
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 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**	**FY 2019**	**FY 2020**	**FY 2021**	**FY 2022**	**Cost To Complete**	**Total Cost**
Total Program Element	0.000	34.583	33.916	32.733	-	32.733	37.919	36.503	30.659	31.272	Continuing	Continuing
0000: *Mine & Exp Warfare Applied Res*	0.000	34.583	33.916	32.733	-	32.733	37.919	36.503	30.659	31.272	Continuing	Continuing

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 S&T Strategic Plan approved by the S&T Corporate Board (20 Jan 2015). 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 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.

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

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B. Program Change Summary ($ in Millions)	**FY 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**
Previous President's Budget	37.418	33.916	34.482	-	34.482
Current President's Budget	34.583	33.916	32.733	-	32.733
Total Adjustments	-2.835	0.000	-1.749	-	-1.749
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-2.116	0.000			
• SBIR/STTR Transfer	-0.719	0.000			
• Program Adjustments	0.000	0.000	-1.749	-	-1.749
• Rate/Misc Adjustments	0.000	0.000	0.000	-	0.000

Change Summary Explanation

Technical: Not applicable.

Schedule: Not applicable.

Exhibit R-2A, RDT&E Project Justification: FY 2018 Navy			Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total	FY 2019	FY 2020	FY 2021	FY 2022	Cost To Complete	Total Cost
0000: *Mine & Exp Warfare Applied Res*	0.000	34.583	33.916	32.733	-	32.733	37.919	36.503	30.659	31.272	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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
Title: MINE TECHNOLOGY	0.812	3.835	3.777	0.000	3.777
Description: This activity assesses advanced sea mine technologies to maintain expertise in this Naval Warfare area. An acoustic sensing capability for the naval mine Target Detection Device (TDD) is being addressed. Future mine and minefield concepts are being addressed. The funding increase from FY 2016 to 2017 reflects the realignment of the Advanced Sea Mines Future Naval Capability (FNC) effort SHD-FY16-OSD Modular UnderSea Effectors (MUSE) program from PE 0602750N Future Naval Capabilities Applied Research. ***FY 2016 Accomplishments:*** - Continued analysis of intermediate and deep water minefield concepts. - Continued assessment of sea mine technologies in order to maintain a level of expertise in naval mines. - Continued development of concepts for semi-autonomous and remote controlled mines and minefields. - Continued development of target discrimination technology for Target Detection Device (TDD). ***FY 2017 Plans:*** - Continue all efforts of FY 2016 less those noted as completed above. - Continue the Modular UnderSea Effectors (MUSE) that transferred from PE 0602750N Future Naval Capabilities Applied Research - Develop of acoustic propagation modeling, algorithms for tracking, and algorithms to exploit the acoustic communications environment.					

Exhibit R-2A, RDT&E Project Justification: FY 2018 Navy		Date: May 2017
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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
- Initiate investigation into advanced mine sensing concepts. ***FY 2018 Base 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 expertise in naval mines. ***FY 2018 OCO Plans:*** N/A					
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 MCM-related FNC ECs. 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 "expert system" are also being developed. Efforts also support development of MCM Mission Modules for Littoral Combat Ships (LCS). Funding decrease from FY 2016 to FY 2017 is due to the completion of the Airborne Laser Mine Detection Systems (ALMDS) Improvement effort that was part of the Speed to Fleet Initiatives that was a 2 year effort that started in FY 2015. ***FY 2016 Accomplishments:*** - Continued effort to double underwater optical imaging range via the use of time-reversed Light Detection and Ranging (LIDAR) pulse propagation. - Continued development of UUV-based, extended range, electro-optic identification sensors and supporting meteorology and oceanography and planning systems.	23.152	18.858	17.754	0.000	17.754

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
- Continued integration of iPUMA and SAS systems in a single vehicle to obtain 100% area coverage. - Continued development of a small ultrasound acoustic underwater camera for UUV-based classification and identification of underwater mines. - Continued development of heat engine for unmanned underwater vehicles powered by thermal gradients in the water column. - Continued development of iPUMA/Synthetic Aperture Sonar system to provide the first non marine mammal based mine detection and classification capability for confined or highly obstructed areas. - Continued development of Small Acoustic Color/Imaging Sonar system to provide the first non marine mammal detection, classification and identification capability for very shallow water (VSW) and reduce the false-alarm rate by x20 for all VSW mine threats. - Completed development of new artificial intelligence technology/techniques required for long duration AUV's. - Completed effort to develop a three-dimensional underwater metamaterial cloaking technology. - Completed effort to provide Navy magnetic silencing ranges with an advanced diagnostic capability to optimize signature reduction techniques. - Initiated applied research into sensor-generic architectures for multi-session minefield mapping with multiple UUVs - Initiated investigation into acoustic radiation forces, or vibro-acoustography to generate new target discrimination feature sets - Initiated applied research in continuous sensing modalities to differentiate between targets and background - Initiated investigation into audition based object formation and attention models for MCM - Initiated applied research in model-based MCM sonar performance estimation - Initiated studies of coastal and riverine environmental characterization to enhance signature reduction for NSW platforms. - Initiated applied research in underwater communications for multiple cooperating minehunting unmanned vehicles. - Completed S2F technology development and demonstration for ALMDS P3I					
FY 2017 Plans:					

Exhibit R-2A, RDT&E Project Justification: FY 2018 Navy		Date: May 2017
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
- Continue all efforts of FY 2016 less those noted as completed above. - Continue effort to double underwater optical imaging range via the use of time-reversed LIDAR pulse propagation. - Complete development of UUV-based, extended range, electro-optic identification sensors and supporting meteorology and oceanography and planning systems. - Complete integration of iPUMA and SAS systems in a single vehicle to obtain 100% area coverage. - Complete development of a small ultrasound acoustic underwater camera for UUV-based classification and identification of underwater mines. - Complete development of heat engine for unmanned underwater vehicles powered by thermal gradients in the water column. -Complete development of iPUMA/Synthetic Aperture Sonar system to provide the first non marine mammal based mine detection and classification capability for confined or highly obstructed areas. - Complete development of Small Acoustic Color/Imaging Sonar system to provide the first non marine mammal detection, classification and identification capability for very shallow water (VSW) and reduce the false-alarm rate by x20 for all VSW mine threats. - Initiate applied research that links observable impacts on acoustic scattering and/or propagation with the underlying phenomenology and/or processes that affect the environment. - Initiate applied research to investigate use of topological spaces for target/clutter features in sonar data. ***FY 2018 Base Plans:*** Conduct Undersea Warfare applied research that investigates and creates new solutions to enable naval forces to conduct more rapid and effective mine detection and classification of moored, proud, and buried mines in high reverberation and man-made clutter environments. The capability to provide effective mine hunting and mine counter-measures from deep water through the beach requires innovative sensor technology, innovative processing techniques, and knowledge and exploitation of the complex operational environments. The advancement of using autonomous underwater vehicles requires investments in underwater acoustic communications, navigation techniques, improved energy densities, hydrodynamics, and vehicle control technologies. Conduct applied research in synthetic aperture sonar (SAS) technologies for longer range detection and classification of mine-like targets, magnetic gradiometer sensing, electro-optic (EO) technology for surface / near-surface mines, buried mine hunting technologies, and sensor integration onto Autonomous Underwater Vehicles (AUVs). Efforts involved in this area include investigations in advanced processing, classification, and					

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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 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
data fusion techniques to reduce operator workload; development of automatic mine detection and classification algorithms for integrated forward-looking iPUMA sonar and side-looking sonars; development of drifting mine detection concepts; high source level, single crystal based projector technologies; thermal engine for unmanned underwater vehicles powered by thermal gradients; modeling of data fusion and mine contact handling; and extension of electro-optical imaging resolution in underwater environments. Complete effort to double underwater optical imaging range via the use of time-reversed LIDAR pulse propagation. ***FY 2018 OCO Plans:*** N/A					
Title: MINE/OBSTACLE NEUTRALIZATION	0.380	0.430	0.428	0.000	0.428
Description: Activity includes applied research to support selected MCM related FNC ECs 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 (SZ) and Beach Zone (BZ) mine and obstacle breaching concepts. ***FY 2016 Accomplishments:*** - Continued development of system concepts for autonomous neutralization of surface and submerged drifting mines - Continued investigation of techniques for neutralization of buried mines. - Continued investigation of techniques for emulation sweep. - Initiated investigation of technigues for neutralization of moored and drifting ocean mines. ***FY 2017 Plans:*** - Continue all efforts of FY 2016 less those noted as completed above. - Continue investigation of techniques for emulation sweep. - Initiate investigation into coupling of reacquire & identify capabilities with precision neutralization for buried mines. ***FY 2018 Base 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 (SZ) and beach zone mine and obstacle breaching concepts; techniques for neutralization of buried mines; techniques for emulation					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
sweep; and investigating the coupling of reacquire & identify capabilities with precision neutralization for buried mines. ***FY 2018 OCO Plans:*** N/A					
Title: SPECIAL WARFARE/EOD ***Description:*** The goal of this effort is to develop technologies to extend stand-off of special operations and 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 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 2016 Accomplishments:*** - Continued development of technologies to neatralize energetic materials from a safe standoff using small EOD robots. - Continued development of technologies to excavate buried IEDs from a small EOD robot. - Continued development of technologies to demonstrate an autonomous dual manipulator robot for complex underwater EOD missions. - Continued development of technologies to enhance diver situational awareness. - Continued development of technologies to reduce platform vulnerability. - Continued investigation of multi-modal signature reduction technologies for wet/dry-submersibles and semi-submersibles. - Continued development of AUV technologies for autonomous inspection of ship hulls. - Continued development of technologies for contaminated water diving. - Continued development of technologies for enhanced navigation and Intelligence, Surveillance and Reconnaissance (ISR) in riverine environments. - Continued development of technologies to detect and locate IEDs. - Continued development of technologies to access IEDs. - Continued development of technologies to diagnose and identify underwater munitions.	10.239	10.793	10.774	0.000	10.774

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
- Continued development of technologies to identify and diagnose components and characteristics of Improvised Explosive Devices. - Continued development of technologies to detect and locate buried munitions. - Continued effort to support Joint Service Explosive Ordnance Disposal (JSEOD) applied research. - Complete development of an air-delivery method of small/tactical UUVs to extend sensor operational range and expedite ingress. - Complete development of technologies to detect trace and bulk explosive materials from a safe position manually. - Complete development of technologies for prospective tele-autonomy features in EOD robotic platforms command and control. - Initiate development of technologies to diagnose buried ordnance in situ from a safe standoff position manually or using small EOD robots. - Completed development of technologies to dispose of ordnance with insensitive munitions from a safe standoff position manually or using small EOD robots. - Initiated development of technologies for ultra light weight, low cost, highly capable autonomous robotic systems for complex dismounted operations. - Initiated applied research into for autonomous ISR and mapping in canopied coastal and riverine environments - Initiated 'through the sensor' in-stride mapping of coastal and riverine land and seascapes using operational EO/IR, radar and acoustic sensors - Initiated investigation of techniques to detect deeply buried explosive threats and ordnance from a safe standoff distance - Initiated investigation of techniques to neutralize or render safe explosive threats that result in low collateral damage to surrounding infrastructure.					
FY 2017 Plans: - Continue all efforts of FY 2016 less those noted as completed above. - Initiate development of technologies to diagnose buried explosive threats using an EOD robotic platform or a hand-held device. - Initiate development of technologies to detect/locate biological WMD using an EOD robotic platform or a hand-held device.					
FY 2018 Base 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					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
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. ***FY 2018 OCO Plans:*** N/A					
Accomplishments/Planned Programs Subtotals	34.583	33.916	32.733	0.000	32.733

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.