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Exhibit R-2, RDT&E Budget Item Justification: PB 2023 Navy **Date:** April 2022

Appropriation/Budget Activity 1319: <i>Research, Development, Test & Evaluation, Navy I BA 2: Applied Research</i>	R-1 Program Element (Number/Name) PE 0602782N I <i>Mine and Expeditionary Warfare Applied Research</i>
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COST (\$ in Millions)	Prior Years	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total	FY 2024	FY 2025	FY 2026	FY 2027	Cost To Complete	Total Cost
Total Program Element	0.000	33.228	42.160	31.649	-	31.649	32.285	32.932	33.591	34.263	Continuing	Continuing
0000: <i>Mine and Expeditionary Warfare Applied Research</i>	0.000	30.815	32.160	31.649	-	31.649	32.285	32.932	33.591	34.263	Continuing	Continuing
9999: <i>Congressional Adds</i>	0.000	2.413	10.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	12.413

A. Mission Description and Budget Item Justification

Sea mines remain a significant threat to ships. In fact, fifteen U.S. Navy ships have been sunk or damaged by mines since World War II, almost four times more than any other weapon. The Mine and Expeditionary Warfare Applied Research 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 strongly aligns 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. This investment will enable Ship-to-Objective Maneuver (STOM) and focus 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 and Neutralization efforts include technologies for clandestine and overt minefield reconnaissance, organic ship self-protection, organic mine hunting 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 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, Office of the Chief of Naval Operations (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 align with shared priorities throughout the whole of RDT&E in order to quickly advance new capabilities from discovery to deployment across the warfighting domains.

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.

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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.

B. Program Change Summary (\$ in Millions)	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total
Previous President's Budget	33.081	32.160	0.000	-	0.000
Current President's Budget	33.228	42.160	31.649	-	31.649
Total Adjustments	0.147	10.000	31.649	-	31.649
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	10.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	0.635	0.000			
• SBIR/STTR Transfer	-0.488	0.000			
• Rate/Misc Adjustments	0.000	0.000	0.000	-	0.000
• Adjustments to Budget Year	-	-	31.649	-	31.649

Congressional Add Details (\$ in Millions, and Includes General Reductions)

Project: 9999: *Congressional Adds*

Congressional Add: *Robotics for Mine Neutralization*

Congressional Add: *Human fusion tech for EOD robot applications*

Congressional Add Subtotals for Project: 9999

Congressional Add Totals for all Projects

	FY 2021	FY 2022
	2.413	0.000
	0.000	10.000
Congressional Add Subtotals for Project: 9999	2.413	10.000
Congressional Add Totals for all Projects	2.413	10.000

Change Summary Explanation

Technical: Not applicable

Schedule: Not applicable

Funding: no significant change

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FY 2023 funding increase reflects the fact that the FY 2022 President's Budget request did not include out-year funding.

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Exhibit R-2A, RDT&E Project Justification: PB 2023 Navy										Date: April 2022		
Appropriation/Budget Activity 1319 / 2					R-1 Program Element (Number/Name) PE 0602782N / Mine and Expeditionary Warfare Applied Research				Project (Number/Name) 0000 / Mine and Expeditionary Warfare Applied Research			
COST (\$ in Millions)	Prior Years	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total	FY 2024	FY 2025	FY 2026	FY 2027	Cost To Complete	Total Cost
0000: Mine and Expeditionary Warfare Applied Research	0.000	30.815	32.160	31.649	-	31.649	32.285	32.932	33.591	34.263	Continuing	Continuing

A. Mission Description and Budget Item Justification

This Project focuses on reducing the time involved in conducting Mine Countermeasure (MCM) operations and increasing safe standoff from minefields. It develops and transitions technologies for MCM-related and UAEO-related Future Naval Capabilities (FNC). The MCM effort includes technologies for clandestine and overt minefield reconnaissance, organic ship self-protection, organic mine-hunting, neutralization/breaching and clearance. The Littoral Warfare effort includes critical warfighting functions such as C4ISR, fires, maneuver, sustainment. 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 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total
<p>Title: Mine Technology</p> <p>Description: This activity primarily 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 options for unmanned delivery, detection & classification, and targeting solutions. Mine technology research supports Fleet demand for capability and prototype development for next generation naval mining concepts.</p> <p>FY 2022 Plans:</p> <ul style="list-style-type: none"> - Target Detection Devices (Mine & Expeditionary Warfare): Continue efforts in developments in advanced sensors and algorithmic capabilities that are applicable toward existing target detection devices (TDDs), development of concepts for remote controlled mines, and assessment of sea mine technologies in order to maintain a level of expertise in naval mines. Specific effort will include advanced sensing modalities for improved discrimination. The objective is to achieve a miniaturized, highly capable TDD to advance legacy mine capacity. - Naval Mine Subcomponents (Mine & Expeditionary Warfare): Continue efforts in alternative packaging and miniaturization of naval mine subcomponents. Specific efforts include advanced sensing, remote control and communications, and advanced energetics. The objective is to achieve alternative capability to incrementally advance legacy mine capacity, and find new capability within legacy delivery mechanisms. <p>FY 2023 Base Plans:</p>	2.107	2.110	2.095	0.000	2.095

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Appropriation/Budget Activity 1319 / 2	R-1 Program Element (Number/Name) PE 0602782N / <i>Mine and Expeditionary Warfare Applied Research</i>	Project (Number/Name) 0000 / <i>Mine and Expeditionary Warfare Applied Research</i>			
B. Accomplishments/Planned Programs (\$ in Millions)					
	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total
<p>- Continue Target Detection Devices (Mine & Expeditionary Warfare): Continue efforts in developments in advanced sensors and algorithmic capabilities that are applicable toward existing target detection devices (TDDs), development of concepts for remote controlled mines, and assessment of sea mine technologies in order to maintain a level of expertise in naval mines. Specific effort will include advanced sensing modalities for improved discrimination. The objective is to achieve a miniaturized, highly capable TDD to advance legacy mine capacity.</p> <p>- Continue Naval Mine Subcomponents (Mine & Expeditionary Warfare): Continue efforts in alternative packaging and miniaturization of naval mine subcomponents. Specific efforts include advanced sensing, remote control and communications, and advanced energetics. The objective is to achieve alternative capability to incrementally advance legacy mine capacity, and find new capability within legacy delivery mechanisms.</p> <p>FY 2023 OCO Plans: N/A</p> <p>FY 2022 to FY 2023 Increase/Decrease Statement: There is no significant change from FY 2022 to FY 2023.</p>					
Title: Mine/Obstacle Detection					
<p>Description: This activity focuses on applied research to enable longer detection ranges and precise detection and mine location with fewer false alarms in a variety of challenging environments. It supports Mine Countermeasures (MCM) related Future Naval Capabilities (FNCs). Efforts include novel sonar technologies for longer range detection and classification of mine-like targets, magnetic gradiometer sensing, electro-optic (EO) technology for buried mine identification, and sensor integration onto Unmanned Underwater Vehicles (UUVs). EO sensor research develops algorithms to enable image processing for rapid overt reconnaissance from an Unmanned Aerial Systems (UAS). Efforts include the development of processing, classification and data fusion techniques to reduce operator workload, and an expert system used to predict mine burial. Efforts also support development of MCM Mission Modules for Littoral Combat Ships.</p> <p>The program is strongly aligned with the Oceanographer of the Navy and the research topics addressed by this activity reflect 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. Field</p>					
	17.990	19.155	18.574	0.000	18.574

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B. Accomplishments/Planned Programs (\$ in Millions)

research within this activity that uses active acoustic transmissions requires modeling of the acoustic effects of sound on marine life in order to meet Navy environmental requirements.

FY 2022 Plans:

- Autonomous Vehicles (Mine & Expeditionary Warfare): Continue efforts to develop approaches for coupling between autonomous vehicles and their sensor payloads. Continue efforts to characterize flow generated by biomimetic propulsion approaches. Initiate development of a learning and planning framework, conducting field experiments that demonstrate simultaneous exploration and navigation in an unknown environments while attempting to execute a complex mission.
- Mine Countermeasures (MCM) Data (Mine & Expeditionary Warfare): Continue efforts to aggregate, curate and interrogate real and simulated data sets for in-situ algorithm adaptation, optimization, and performance assessment. The objective is to enable unmanned systems to operate flexibly across a wide range of dynamic and unstructured environments.
- MCM Sensor (Mine & Expeditionary Warfare): Continue development of next-generation small, highly capable MCM sensors. Specific efforts include sensors, electronics, and computing technology. The objective is to increase deployment options for unmanned systems.
- Mine & Expeditionary Warfare (Target Recognition and Signal Processing): Initiate machine learning algorithm development efforts that yield principled understanding of sensor information content, are robust to challenging operating conditions and produce human-interpretable or traceable predictions.
- Threat Detection/Robotic Techniques (Mine & Expeditionary Warfare): Continue development of robotic technologies to respond to detected threats. Specific effort will include dexterity, haptics and algorithms to achieve human-like behaviors. The objective is to sense and interact with the environment and threats.
- Continue advance underwater optical imager technology focusing on laboratory measurements in various turbidity conditions and environments.
- Continue development and demonstration of adaptive control systems for bio-inspired unmanned underwater vehicles advancing oscillating fin propulsor models, and embedding these models on vehicle hardware.

FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total

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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total
<p>- Continue development of a learning and planning framework, conducting field experiments that demonstrate simultaneous exploration and navigation in an unknown environments while attempting to execute a complex mission.</p> <p>- Continue efforts that will lead to optimized sensing and behaviors by adapting in dynamic and uncertain environments; cooperative vehicle autonomy with increased endurance; data exfiltration and networking to expand reach; next generation sensors (acoustic and non-acoustic); adaptive, autonomous technologies to detect, classify underwater mobile threats.</p> <p>FY 2023 Base Plans:</p> <p>- Continue Autonomous Vehicles (Mine & Expeditionary Warfare) efforts to develop approaches for coupling between autonomous vehicles and their sensor payloads. Continue efforts to characterize flow generated by biomimetic propulsion approaches. Initiate development of a learning and planning framework, conducting field experiments that demonstrate simultaneous exploration and navigation in an unknown environments while attempting to execute a complex mission.(NRL)</p> <p>- Continue Mine Countermeasures (MCM) Data (Mine & Expeditionary Warfare) efforts to aggregate, curate and interrogate real and simulated data sets for in-situ algorithm adaptation, optimization, and performance assessment. The objective is to enable unmanned systems to operate flexibly across a wide range of dynamic and unstructured environments.</p> <p>- Continue MCM Sensor (Mine & Expeditionary Warfare) development of next-generation small, highly capable MCM sensors. Specific efforts include sensors, electronics, and computing technology. The objective is to increase deployment options for unmanned systems.</p> <p>- Continue Mine & Expeditionary Warfare (Target Recognition and Signal Processing) machine learning algorithm development efforts that yield principled understanding of sensor information content, are robust to challenging operating conditions and produce human-interpretable or traceable predictions.</p> <p>- Continue Threat Detection/Robotic Techniques (Mine & Expeditionary Warfare) development of robotic technologies to respond to detected threats. Specific effort will include dexterity, haptics and algorithms to achieve human-like behaviors. The objective is to sense and interact with the environment and threats.</p>					

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B. Accomplishments/Planned Programs (\$ in Millions)					
<ul style="list-style-type: none"> - Continue advance underwater optical imager technology focusing on laboratory measurements in various turbidity conditions and environments. - Continue development and demonstration of adaptive control systems for bio-inspired unmanned underwater vehicles advancing oscillating fin propulsor models, and embedding these models on vehicle hardware. - Continue development of a learning and planning framework, conducting field experiments that demonstrate simultaneous exploration and navigation in an unknown environments while attempting to execute a complex mission. - Continue efforts that will lead to optimized sensing and behaviors by adapting in dynamic and uncertain environments; cooperative vehicle autonomy with increased endurance; data exfiltration and networking to expand reach; next generation sensors (acoustic and non-acoustic); adaptive, autonomous technologies to detect, classify underwater mobile threats. 					
FY 2023 OCO Plans: N/A					
FY 2022 to FY 2023 Increase/Decrease Statement: There is no significant change from FY 2022 to FY 2023.					
Title: Mine/Obstacle Neutralization					
Description: This activity includes applied research to support selected Mine Countermeasures-related Future Naval Capabilities (FNC) for the rapid neutralization of mines and obstacles, and sea mine jamming techniques to increase surface ship safe standoff from threat mines. It includes computational tools and models to assess mine and obstacle vulnerability and lethality of novel approaches for neutralization to support various far-term Surf Zone and Beach Zone mine and obstacle breaching system concepts.					
FY 2022 Plans: -Rapid Neutralization of Mines and Obstacles: Continue effort in rapid neutralization of mines and obstacles including development of lethality and vulnerability models, technology concept assessments, and approaches for neutralization of mines and obstacles in all water depths, the surf zone, beach and inland. The objective is to enable maneuver of joint forces from ship to inland objective.					
	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total
	0.433	0.443	0.449	0.000	0.449

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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total
<p>-Advanced Minesweeping: Continue effort in advanced minesweeping including development of compact, efficient approaches for sweeping advanced influence mines. The objective is to increase the safe standoff of various tactical platforms and surface ships.</p> <p>-Robotics: Continue development of robotic technologies to respond to detected targets including work on dexterity, haptics and algorithms to achieve human-like behaviors. The objective is to interact with the mine and/or obstacle to achieve neutralization, clearance, render-safe or removal for exploitation.</p> <p>FY 2023 Base Plans:</p> <p>- Continue Rapid Neutralization of Mines and Obstacles effort in rapid neutralization of mines and obstacles including development of lethality and vulnerability models, technology concept assessments, and approaches for neutralization of mines and obstacles in all water depths, the surf zone, beach and inland. The objective is to enable maneuver of joint forces from ship to inland objective.</p> <p>- Continue Advanced Minesweeping effort in advanced minesweeping including development of compact, efficient approaches for sweeping advanced influence mines. The objective is to increase the safe standoff of various tactical platforms and surface ships.</p> <p>- Continue Robotics development of robotic technologies to respond to detected targets including work on dexterity, haptics and algorithms to achieve human-like behaviors. The objective is to interact with the mine and/or obstacle to achieve neutralization, clearance, render-safe or removal for exploitation.</p> <p>FY 2023 OCO Plans: N/A</p> <p>FY 2022 to FY 2023 Increase/Decrease Statement: There is no significant change from FY 2022 to FY 2023.</p>					
<p>Title: Special Warfare/EOD</p> <p>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</p>	10.285	10.452	10.531	0.000	10.531

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B. Accomplishments/Planned Programs (\$ in Millions)

and handheld sonar systems to increase detection range and accuracy in harsh environments. Other efforts include such mission support technology improvements as communications, navigation and life support for UUVs and human divers.

FY 2022 Plans:

- Advanced Robotic Techniques: Continue efforts in advanced robotic technologies including development of human-like manipulators and haptics.
- Platforms: Continue development of air, surface and subsurface platforms to conduct operations in the littorals to improve diver mobility and safety, address drag reduction, diver propulsion, communications, navigation, thermal envelope, life support and contamination protection.
- Ordnance Detection: Continue efforts for sensors to detect buried mines and improvised explosive devices. Specific effort includes technologies for compact, held-hand radar concepts. The objective is to improve the performance of hand-held radar technology to achieve a low false alarm rate.
- Sensor Techniques: Continue effort to develop compact sensor technologies to diagnose explosive threats and unexploded ordnance including the development of hand-held or robot deployable sensor technologies. The objective is to determine the status of explosive threats and unexploded ordnance.
- Neutralization Explosive Threats: Continue effort to develop technologies to enable render-safe or neutralization of explosive threats and unexploded ordnance.
- Unmanned Systems Situational Awareness: Continue onboard processing in unmanned systems to enable environmental situational awareness (SA) in the littorals.
- Continue Rapid Operational Clearance efforts to develop technologies to rapidly clear operational areas of munitions. The objective is to decrease the amount of time needed for services to clear munitions and conduct clearance operations at standoff.

FY 2023 Base Plans:

FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total

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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total
There is no significant change from FY 2022 to FY 2023.					
Accomplishments/Planned Programs Subtotals	30.815	32.160	31.649	0.000	31.649

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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Appropriation/Budget Activity 1319 / 2					R-1 Program Element (Number/Name) PE 0602782N / Mine and Expeditionary Warfare Applied Research				Project (Number/Name) 9999 / Congressional Adds			
COST (\$ in Millions)	Prior Years	FY 2021	FY 2022	FY 2023 Base	FY 2023 OCO	FY 2023 Total	FY 2024	FY 2025	FY 2026	FY 2027	Cost To Complete	Total Cost
9999: Congressional Adds	0.000	2.413	10.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	12.413

A. Mission Description and Budget Item Justification

Congressional Interest Items not included in other Projects.

B. Accomplishments/Planned Programs (\$ in Millions)

	FY 2021	FY 2022
Congressional Add: Robotics for Mine Neutralization	2.413	0.000
FY 2021 Accomplishments: Conducted applied research in Robotics for Mine Neutralization.		
FY 2022 Plans: N/A		
Congressional Add: Human fusion tech for EOD robot applications	0.000	10.000
FY 2021 Accomplishments: N/A		
FY 2022 Plans: Conduct human fusion tech for EOD robot applications applied research		
Congressional Adds Subtotals	2.413	10.000

C. Other Program Funding Summary (\$ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A