Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Defense Advanced Research Projects Agency	Date: March 2019
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603766E / *NETWORK-CENTRIC WARFARE TECHNOLOGY*

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	-	429.691	434.069	512.424	-	512.424	447.162	428.781	401.315	397.315	-	-
NET-01: *JOINT WARFARE SYSTEMS*	-	75.460	99.963	99.487	-	99.487	162.805	179.345	167.590	193.992	-	-
NET-02: *MARITIME SYSTEMS*	-	123.462	110.363	132.484	-	132.484	105.909	160.550	189.725	193.323	-	-
NET-06: *NETWORK-CENTRIC WARFARE TECHNOLOGY*	-	230.769	223.743	280.453	-	280.453	178.448	88.886	44.000	10.000	-	-

A. Mission Description and Budget Item Justification

The Network-Centric Warfare Technology Program Element is budgeted in the Advanced Technology Development budget activity because it addresses high payoff opportunities to develop and rapidly mature advanced technologies and systems required for today's network-centric warfare concepts. It is imperative for the future of the U.S. forces to operate flawlessly with each other, regardless of which services and systems are involved in any particular mission. The overarching goal of this program element is to enable technologies at all levels, regardless of service component, to operate as one system.

The objective of the Joint Warfare Systems project is to create enabling technologies for seamless joint operations, from strategic planning to tactical and urban operations. Joint Warfare Systems leverage current and emerging network, robotic, and information technology and provide next generation U.S. forces with greatly expanded capability, lethality, and rapid responsiveness. Critical issues facing this project are: (1) U.S. opponents utilizing systems that are flexible, robust, and difficult to neutralize; and (2) U.S. doctrine that limits the use of firepower to lessen the impact of operations on noncombatants. These problems are magnified in urban and semi-urban areas where combatants and civilians are often collocated, and in peacekeeping operations where combatants and civilians are often indistinguishable. Meeting these challenges places a heavy burden on joint war planning. Understanding opponent networks is essential so that creative options can be developed to counter their strategies. Synchronization of air and ground operations to apply force only where needed and with specific effects is required.

The Maritime Systems project is identifying, developing and rapidly maturing critical advanced technologies and system concepts for the naval forces' role in today's network centric warfare concept. Improvements in communications between and among submarines, surface ships and naval aircraft have allowed these forces to operate seamlessly with each other and with other Service's network centric systems. Naval forces will play an ever-increasing role in network centric warfare because of their forward deployed nature, their unique capability to operate simultaneously in the air, on the sea and under the sea and their versatile ability to provide both rapid strike and project-sustained force. The technologies developed under this project will capitalize on these attributes, improve them and enable them to operate with other network centric forces.

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Defense Advanced Research Projects Agency	Date: March 2019
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide I* BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0603766E *I NETWORK-CENTRIC WARFARE TECHNOLOGY*

B. Program Change Summary ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Previous President's Budget	439.386	438.569	451.035	-	451.035
Current President's Budget	429.691	434.069	512.424	-	512.424
Total Adjustments	-9.695	-4.500	61.389	-	61.389
• Congressional General Reductions	0.000	-4.500			
• Congressional Directed Reductions	0.000	0.000			
• Congressional Rescissions	0.000	0.000			
• Congressional Adds	0.000	0.000			
• Congressional Directed Transfers	0.000	0.000			
• Reprogrammings	-0.554	0.000			
• SBIR/STTR Transfer	-9.141	0.000			
• TotalOtherAdjustments	-	-	61.389	-	61.389

Change Summary Explanation

FY 2018: Decrease reflects SBIR/STTR transfer and reprogrammings.

FY 2019: Decrease reflects Congressional reduction.

FY 2020: Increase reflects initiation of the Heterogeneous UnderWater Communications (HUWC), Maritime Missileer and Angler programs, and classified program expansion.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Defense Advanced Research Projects Agency			Date: March 2019
Appropriation/Budget Activity 0400 / 3	R-1 Program Element (Number/Name) PE 0603766E / *NETWORK-CENTRIC WARFARE TECHNOLOGY*	Project (Number/Name) NET-01 / *JOINT WARFARE SYSTEMS*	

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
NET-01: *JOINT WARFARE SYSTEMS*	-	75.460	99.963	99.487	-	99.487	162.805	179.345	167.590	193.992	-	-

A. Mission Description and Budget Item Justification

The objective of the Joint Warfare Systems project is to create enabling technologies for seamless joint operations, from strategic planning to tactical and urban operations. Joint Warfare Systems leverage current and emerging network, robotic, and information technology and provide next generation U.S. forces with greatly increased capability, lethality, and rapid responsiveness. Critical issues facing this project are: (1) U.S. opponents using systems that are flexible, robust, and difficult to neutralize; and (2) U.S. doctrine that limits the use of firepower to lessen the impact of operations on noncombatants. These problems are magnified in urban and semi-urban areas where combatants and civilians are often co-located and in peacekeeping operations where combatants and civilians are often indistinguishable. Meeting these challenges places a heavy burden on joint war planning. Understanding opponent networks is essential so that creative options can be developed to counter their strategies. Synchronization of air and ground operations to apply force only where needed and with specific effects is required. This project supports all levels of the force structure including: (1) the strategic/operational level by generating targeting options against opponents' centers of gravity that have complex networked relationships; (2) the tactical/operational level by managing highly automated forces with tight coupling between air and ground platforms; and (3) the focused tactical level by developing platforms and tools, which acquire targets of opportunity and cue network-based analysis of likely enemy operations thus maximizing the effectiveness of ground forces in stability and support operations.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: System of Systems Integration Technology and Experimentation (SoSITE)	29.362	24.594	13.999
Description: The System of Systems Integration Technology and Experimentation (SoSITE) program seeks to implement an architecture framework capable of assessing and demonstrating potential operational benefits of integrating various system capabilities to improve mission success in contested environments. Such assessments would optimize system-level trades of requirements and architectures to leverage an integrated set of system characteristics and capabilities. The demonstration assessment metrics will measure individual and combined system performance to streamline resource allocation to maximize operational impact. In addition, providing a modeling and simulation (M&S) environment to assess complex systems will enable greater utility of emerging system technologies, since they can be assessed in near-real-world simulations without the real-world costs of testing fully integrated systems. The program will also develop system synthesis and integration technologies that enable rapid assimilation of new and off-the-shelf technologies into the system of systems architecture. These technologies will break down current barriers to entry that new technologies face in system of systems using formal methods, compositional reasoning, and automated design space exploration. Technologies from this program will be transitioned to the Services. ***FY 2019 Plans:*** - Secure test articles for flight test experiments of distributed strike and suppression of enemy air defenses using manned and unmanned platforms and experimental mission systems.			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Defense Advanced Research Projects Agency		Date: March 2019
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603766E / *NETWORK-CENTRIC WARFARE TECHNOLOGY*	**Project (Number/Name)** NET-01 / *JOINT WARFARE SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
- Demonstrate the capability of new engineering tools to validate system of systems architecture designs prior to live flight experiments. - Demonstrate the capability of formal verification techniques to validate integration of constituent systems into a system of systems prior to live flight experiments. - Conduct integration events to characterize sub-systems digitally to enable rapid integration into systems of systems. - Conduct live flight experiments of system of systems architectures for networked electronic attack, distributed strike, and suppression of enemy air defense missions. - Apply advanced software integration methods to enable rapid upgrade and improve portability of both new and legacy aircraft platform software. ***FY 2020 Plans:*** - Deploy SoSITE integration technologies, called STITCHES (System of Systems Technology Integration Tool Chain for Heterogeneous Electronic Systems), to a DoD-accredited cloud hosted repository. - Implement upgrades to toolchain required by transition partners, including technology to allow full backwards and forwards compatibility of all versions of the toolchain. - Transition of SoSITE STITCHES toolchain to multiple operational Service partners. - Perform final live flight experiments of system of systems architectures. - Conduct final integration events to enable rapid integration into systems of systems. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The FY 2020 decrease reflects a decrease in flight demonstrations to a focus on toolchain demonstrations.			
Title: Resilient Synchronized Planning and Assessment for the Contested Environment (RSPACE)	20.772	16.869	11.345
Description: Currently, Command and Control (C2) of air platforms is a highly centralized process operating largely independently across planning domains (Intelligence, Surveillance, and Reconnaissance (ISR), strike, and spectrum management) and is optimized for a permissive environment. To address the challenges faced in today's increasingly contested environments, the Resilient Synchronized Planning and Assessment for the Contested Environment (RSPACE) program will develop tools and models to enable distribution of planning functions across the C2 hierarchy for resilience (e.g., loss of communications), while synchronizing strike, ISR, and spectrum planning to maximize the contribution of all assets through increased utilization and exploitation of synergies. The program will develop tools supporting a mixed initiative planning approach, maximizing automation according to operator's choice, and enabling human-in-the-loop intervention and modification. RSPACE will also develop tactical decision aids for maritime commanders and planners to build and assess courses of action (COAs) for fleet and ship movements and the employment of counter-ISR techniques. During execution, the tools will provide lifecycle tracking of targeting and information needs and support assessment of progress towards achieving the commander's intent. The			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Defense Advanced Research Projects Agency		Date: March 2019
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603766E / *NETWORK-CENTRIC WARFARE TECHNOLOGY*	**Project (Number/Name)** NET-01 / *JOINT WARFARE SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
tools will dynamically respond as directed to ad hoc requests and significant plan deviations via a real-time dynamic re-planning capability and easily adapt to technology refreshes. RSPACE tools will transition to the Air Force and the Navy. ***FY 2019 Plans:*** - Conduct one or more live-virtual simulation-based tests in conjunction with a scheduled live Air Force experiment to facilitate transition to the Air Force. - Integrate prototype software with external systems and scale to large, high operational tempo scenarios. - Enhance models and user support interfaces in preparation for transition to operational testing by the Navy. ***FY 2020 Plans:*** - Complete software development in support of transition of select RSPACE software components to Air Force Program of Record. - Complete testing of software with Air Force in support of transition. - Complete integration with external Air Force systems in support of transition. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The FY 2020 decrease reflects decreased scope of software development, integration, and testing due to emphasis on transition to the Air Force.			
Title: Prototype Resilient Operations Testbed for Expeditionary Urban Systems of Systems (PROTEUS)	14.361	17.285	18.480
Description: The Prototype Resilient Operations Testbed for Expeditionary Urban Systems of Systems (PROTEUS) program will demonstrate that a dynamically composable Mosaic warfare approach provides superior performance and adaptability in the dynamic, uncertain environment imposed on U.S. warfighters by urban combat operations. PROTEUS will provide the tools and automation to enable small tactical units to compose force packages optimized to specific urban combat objectives and challenges. These tools will support planning and force composition for all missions relevant to the urban environment: command & control, fires, maneuver, logistics, intelligence, force protection, and medical. PROTEUS will be adaptive to an inherently dynamic and fluid environment that will account for the environmental influence of non-combatants in urban combat as well as kinetic warfighting. Technologies will be integrated using systems of systems principles developed under the System of Systems Integration Technology and Experimentation (SoSITE) program, budgeted in this PE/Project. To support concept development, testing, and warfighter interaction, the program will also develop a supporting virtual testbed. Technologies from this program will be transitioned to the Services. ***FY 2019 Plans:*** - Develop a multi-resolution scenario within the virtual testbed and compare outcomes against a Marine Corps exercise benchmark.			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Defense Advanced Research Projects Agency		Date: March 2019
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
- Define friendly and opposing force systems for kinetic functions. - Demonstrate integration of the virtual testbed and the composition tool using the benchmarked scenario. - Demonstrate adaptive composition capability with Service participants. - Commence development of mathematical tools to define and score the value of materiel in a logistics flow. ***FY 2020 Plans:*** - Begin development of planning and force composition tools for spectrum and intelligence operations. - Demonstrate integration of the virtual testbed and composition tool using multi-resolution scenarios with increased complexity. - Demonstrate enhanced adaptive composition capability with Service participants. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The FY 2020 increase reflects the shift in focus to testing and extension of previous developed capabilities.			
Title: Systems of Systems-Enhanced Small Units (SESU)	-	11.215	18.385
Description: The System-of-Systems-Enhanced Small Unit (SESU) program will develop and demonstrate adaptive kill-web capabilities based on a system-of-systems architecture that enables a small unit of U.S. forces to prevail against a much larger near-peer adversary force in a contested environment. SESU-developed capabilities will provide the small unit with improved awareness of enemy force composition, disposition, and intent. It will also provide the means to deter escalation of threat, and, if deterrence fails, the ability to degrade, disrupt, and/or destroy enemy anti-access / area denial and combat systems. Technologies to accomplish this include command & control (C2) that operates in a contested environment; distributed sensing, including the ability to leverage indigenous information sources; hybrid effects that include a mix of kinetic, non-kinetic, and information operations capabilities; and autonomous systems to deliver effects and conduct sensing. A Campaign of Learning (CoL) will be conducted in partnership with the Army, and technologies produced by this program will be transitioned to the Services. ***FY 2019 Plans:*** - Complete SESU architecture definition and develop evaluation scenarios. - Demonstrate baseline technologies in a simulated environment. - Initiate design of key technologies (e.g. distributed C2, sensors, and effectors). - Conduct virtual war games that combine modeling and simulation with table top exercises to develop performance metrics, concepts. ***FY 2020 Plans:*** - Integrate modeling and simulation environment and evaluate baseline and advanced architecture performances based on selected scenarios. - Demonstrate impact of advanced technology suites.			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
- Down select from designs based on performance and begin development of prototypes with distributed C2, sensors, and effectors. - Develop plan for live field experimentation for CoL. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The FY 2020 increase reflects the development of prototypes.			
Title: Assault Breaker II (ABII) ***Description:*** Assault Breaker II (ABII) seeks to change the current warfighting paradigm of reliance on Service-specific, platform-centric force executing prescribed kill chains to a highly adaptable, capability-based force operating as a disaggregated kill web able to execute rapidly composable, cross domain kill chains. Building upon technologies developed in the Cross Domain Maritime Surveillance and Targeting (CDMaST) program, budgeted in this PE, Project NET-02, ABII will exploit both existing and emerging technologies across the Services to address known capability gaps, opportunities and threats. ABII will conduct mission-centric, multi-Service and multi-domain analysis, modeling and simulation (M&S), and experimentation to inform research and development and program of record recommendations, and will build an enduring, multi-service M&S environment to support complex, mission level kill web analysis. ABII technologies will transition to the Services. ***FY 2019 Plans:*** - Initiate initial kill web analysis studies and deliver preliminary advanced kill web technologies program recommendation report. - Complete multi-domain, multi-level security environment survey and analysis of alternatives study. - Initiate preliminary design of multi-domain, multi-level security environment. ***FY 2020 Plans:*** - Complete initial kill web analysis studies and deliver updated advanced kill web technologies program recommendation report. - Initiate second round of kill web analysis studies to support kill web architecture refinement. - Complete preliminary design of multi-domain, multi-level security environment. - Initiate detailed design of multi-domain, multi-level security environment. - Complete preliminary experimentation plan. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The FY 2020 increase reflects increased multi-domain, multi-level security environment design efforts.	2.000	10.000	18.000
Title: Glide Breaker ***Description:*** Glide Breaker will develop critical component technologies to support a lightweight vehicle designed for precise engagement of hypersonic threats at very long range. Phase I of the program focuses on a single, critical, long-lead technology with applicability to a variety of interceptor concepts and designs. Phase II will build on the success of Phase I, developing	-	20.000	10.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
additional component technologies and laying needed groundwork for an integrated demonstration which will showcase the system's ability to defeat adversary hypersonic weapons. ***FY 2019 Plans:*** - Conduct Preliminary Design Review (PDR) for technology demonstration. - Execute trade studies to identify key technologies and estimate system performance. - Complete critical design review for technology demonstration. ***FY 2020 Plans:*** - Complete component level bench testing for long lead technology demonstration. - Complete test readiness review for critical, long-lead technology demonstration. - Initiate development of selected key technologies. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The FY20 decrease reflects completion of preliminary and critical design and trade studies and transition to bench testing and development of key technologies.			
Title: Air Combat Evolution (ACE) ***Description:*** As the Services develop new Joint Multi-Domain Battle warfighting concepts, there is a strong demand for innovative ways to perform experimentation in order to assess architectures, advance technology, and support operators developing advanced multi-domain tactics. Current infrastructure and technology do not support experimentation with distributed heterogeneous systems. Based upon technologies developed in the System of Systems Integration Technology and Experimentation (SoSITE) program, budgeted in this PE/Project, the Air Combat Evolution (ACE) program will apply technologies and principles of interoperability, autonomy, and artificial intelligence (AI) to develop an experimentation infrastructure that will allow for the integration of various modeling and simulation (M&S), sub-scale, and ultimately full-scale vehicles in dynamic aerial combat environment. The program will deliver an initial instantiation of a scalable experimentation engine capable of aircraft control at levels ranging from an advanced tactical autopilot to a form of multi-domain mosaic controller. Experiments will explore both augmentation of existing manned platforms and increased capabilities and intelligence of future unmanned systems. ACE will provide an early opportunity to experiment with adaptive human-machine teaming to deliver tools and architectures as the Joint Multi-Domain Battle concept evolves within the Services. Higher-fidelity simulated adversary human behavior will also be developed to ensure blue operators conducting experiments are faced with more realistic dilemmas posed by computer-played adversaries. Technology developed by this program will transition to the Services. ***FY 2020 Plans:*** - Conduct exploratory trade studies to establish feasibility of technical approaches.	-	-	9.278

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
- Adapt autonomy and AI technology to modeling and simulation experimentation infrastructure. - Initiate Service outreach to inform and synchronize the experimentation portfolio. - Evaluate commercial, gaming agent-based AI technology to provide higher-fidelity human behavior modelling. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The FY 2020 increase reflects program initiation.			
Title: Retrodirective Arrays for Coherent Transmission (ReACT) ***Description:*** Worldwide advancements in signal processing and electronics have decreased the effectiveness of single-platform, power-based Electronic Warfare (EW) as a viable technique in the future. The goal of the Retrodirective Arrays for Coherent Transmission (ReACT) program was to develop and demonstrate the capability to combine distributed mobile transmitters to direct high-power spatially resolved radio frequency (RF) beams to a single location. ReACT provides this capability by synchronizing multiple distributed transmitters to form a much larger effective array than a single aperture. The key technical challenge was to synchronize distributed and moving transmitters while compensating for platform motion and vibration. The ReACT system sensed the target's emissions and then optimally configured the ReACT transmitters to focus on the area of interest. Technologies from this program transitioned to the Air Force and Navy.	8.965	-	-
Accomplishments/Planned Programs Subtotals	75.460	99.963	99.487

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Specific programmatic performance metrics are listed above in the program accomplishments and plans section.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Defense Advanced Research Projects Agency			Date: March 2019
Appropriation/Budget Activity 0400 / 3	R-1 Program Element (Number/Name) PE 0603766E / *NETWORK-CENTRIC WARFARE TECHNOLOGY*	Project (Number/Name) NET-02 / *MARITIME SYSTEMS*	

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
NET-02: *MARITIME SYSTEMS*	-	123.462	110.363	132.484	-	132.484	105.909	160.550	189.725	193.323	-	-

A. Mission Description and Budget Item Justification

The objective of the Maritime Systems project is identifying, developing, and rapidly maturing critical advanced technologies and system concepts for the naval forces role in today's network centric warfare concept. Improvements in communications between and among submarines, surface ships, and naval aircraft have allowed these forces to operate seamlessly with each other and with other service's network centric systems. Naval forces will play an ever-increasing role in network centric warfare because of their forward deployed nature, their unique capability to operate simultaneously in the air, on the sea and under the sea, and their versatile ability to provide both rapid strike and project sustained force. The technologies developed under this project will capitalize on these attributes, improve them, and enable them to operate with other network centric forces.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Cross Domain Maritime Surveillance and Targeting (CDMaST)	30.841	29.732	24.987

Description: The Cross Domain Maritime Surveillance and Targeting (CDMaST) program seeks to identify and implement architectures consisting of novel combinations of manned and unmanned systems to execute long-range kill chains and develop a robust "kill web" against submarines and ships over large contested maritime areas. By exploiting promising new developments in unmanned platforms, seafloor systems, and emerging long-range weapon systems, the program will develop an advanced, integrated undersea and above sea warfighting capability. The CDMaST program will establish an analytical and experimental environment to explore architecture combinations in terms of operational effectiveness as well as engineering feasibility and robustness. The program will leverage enabling technologies needed for command, control, and communication (C3) between physical domains in order to support the architecture constructs. Through experimentation, the program will not only demonstrate integrated system performance, but also develop new tactics that capitalize on features created by the heterogeneous architecture. The CDMaST program will invest in technologies that will reduce cost, manage complexity, and improve reliability. Technologies from this program will transition to the Navy.

FY 2019 Plans:
- Integrate system of systems assets and perform operational tests leading to at-sea demonstrations of CDMaST capability to facilitate transition to the Navy.
- Continue to refine the CDMaST architecture segments and service layers.
- Continue to conduct elemental, engineering, and operational tests on selected segments of the CDMaST architecture.
- Complete planning for at-sea demonstrations of the CDMaST architecture.

FY 2020 Plans:
- Complete system integration.

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
- Complete software-in-the-loop system testing. - Complete CDMaST testbed. - Conduct at-sea demonstrations of the CDMaST architecture. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The FY 2020 decrease reflects completion of testbed development.			
Title: Positioning System for Deep Ocean Navigation (POSYDON) ***Description:*** The Positioning System for Deep Ocean Navigation (POSYDON) program will provide continuous, Global Positioning System (GPS)-level positioning accuracy to submarines and autonomous undersea vehicles (AUVs) in the ocean over extended periods of time. Undersea navigation cannot use GPS because the water blocks its signals. At shallower depths, masts can be raised to receive GPS signals, but masts present a detection risk. Typically, the alternative to GPS for undersea navigation has been inertial navigation systems (INS), but INS accuracy can degrade unacceptably over time. The POSYDON program will distribute a small number of acoustic sources, analogous to GPS satellites, around an ocean basin at known locations. A submarine or AUV will be equipped with an acoustic receiver and appropriate software in order to obtain and maintain location. By transmitting specific acoustic waveforms and developing accurate acoustic propagation models to predict and interpret the complex arrival structure of the acoustic sources, the submarine or AUV can determine its range from each source and thus calculate its position. Technologies developed under this program will transition to the Navy. ***FY 2019 Plans:*** - Design and test a prototype POSYDON system. - Demonstrate real-time positioning for relevant AUV platforms. - Document results of at-sea testing to support systems integration. ***FY 2020 Plans:*** - Transition POSYDON hardware to Navy undersea test bed. - Demonstrate mission planning tool to guide system employment. - Conduct modeling and simulation to demonstrate concept of operations for deep and littoral mission. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The FY 2020 decrease reflects completion of final analysis after at-sea demonstration.	20.518	19.580	14.719
Title: Hunter ***Description:*** The Hunter program seeks to develop novel concepts for Extra Large Unmanned Undersea Vehicles (XLUUVs) to deliver complex payloads. The program will explore efficient encapsulation and buoyancy control concepts to be implemented with advanced fiber handling capabilities for high bandwidth communications in order to create a highly modular and adaptable	16.979	27.525	23.742

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
ocean interface. This interface will give XLUUVs significantly increased payload handling ability and allow them to deliver completely new capabilities previously delivered only by manned platforms. Building upon research conducted under the Cross Domain Maritime Surveillance and Targeting (CDMaST) program budgeted in this PE/Project, the Hunter program will establish a new capability for integration into maritime system of systems warfare architectures. Technologies developed under the Hunter program will transition to the Navy. ***FY 2019 Plans:*** - Complete design of Hunter payload delivery carriage. - Build partial carriage payload delivery system to support risk reduction testing. - Commence fabrication of Hunter payload delivery carriage. - Perform stand-alone in-water test of partial Hunter payload delivery carriage. - Apply information assurance measures to Hunter payload delivery carriage. ***FY 2020 Plans:*** - Complete fabrication of carriage system. - Develop full Hunter system and information assurance implementation test plan. - Perform stand-alone in-water test of full Hunter payload delivery carriage. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The FY 2020 decrease reflects completion of system fabrication and entry into the integration and testing phase.			
Title: Ocean of Things ***Description:*** The goal of the Ocean of Things program is to advance oceanographic sensing and battlespace awareness using low-power microelectronics and advanced data analytics. Ocean of Things builds upon advances made in the Cross Domain Maritime Surveillance and Targeting (CDMaST) program, budgeted in this PE/Project. Ocean of Things will develop large numbers of heterogeneous sensing floats to cover large ocean areas, while incorporating environmentally friendly construction materials. These platforms will leverage satellite communications to populate a large data repository with sensor outputs for shared processing. Ocean of Things will apply advanced analysis techniques to the stored data to synthesize and discover new signals and behaviors in the ocean environment. The program will research the spatio-temporal composability of sensors and develop applications for distributed platform behavior using an internet of things (IoT) architecture deployed across the world's oceans. Further research will examine additional platform capabilities and system impacts of communication rate and edge processing. The Ocean of Things program will improve ocean awareness and provide persistent coverage to areas between existing platforms. Technologies developed in Ocean of Things will transition to the Navy. ***FY 2019 Plans:***	-	11.000	25.933

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
- Conduct initial data architecture studies to determine optimal host and service platform. - Conduct initial sensor and payload studies to examine optimal sensor and payload types for platform configurations. - Develop initial hardware design and sensor configurations for test platform delivery. - Demonstrate and test initial sensors through small-scale ocean float deployment. ***FY 2020 Plans:*** - Develop advanced platform design. - Research active sensor behaviors for potential inclusion into advanced system design. - Demonstrate and test advanced sensors through large-scale ocean float deployment. - Develop government data cloud and architecture, model ocean inputs, and apply initial machine learning applications. - Develop visualization of machine learning results for military application. - Evaluate test data to determine performance and coverage in the ocean. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The FY 2020 increase reflects moving from development to a large-scale at-sea float deployment.			
Title: Heterogeneous UnderWater Communications (HUWC) ***Description:*** Integration of undersea elements for joint cross-domain operations is critical for developing the most effective distributed kill webs. The Heterogeneous UnderWater Communications (HUWC) program will create an undersea internet that will span the ocean and bridge to other operating domains. Building upon technologies learned in the Tactical Underwater Network Architecture program, budgeted in this PE/Project, HUWC will provide an adaptive, heterogeneous, highly-connected network capability to link undersea and cross-domain assets together into kill webs and will establish and maintain these networks with minimal operator burden. The program will leverage recent technological developments demonstrating short-range and long-range acoustic communications at higher bandwidth and greater reliability, while minimizing detectability. The program will also leverage recent developments in network interoperability to manage heterogeneous undersea and cross-domain networks. Technology developed by this program will transition to the Navy. ***FY 2020 Plans:*** - Conduct modeling and simulation to determine optimal network configuration. - Begin development of heterogeneous network architectures comprised of acoustic and non-acoustic elements. - Begin development of algorithms to adapt networks to mission and environment. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The FY 2020 increase reflects program initiation.	-	-	11.778
Title: Maritime Missileer	-	-	16.325

Exhibit R-2A, RDT&E Project Justification: PB 2020 Defense Advanced Research Projects Agency		Date: March 2019
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0603766E / *NETWORK-CENTRIC WARFARE TECHNOLOGY*	**Project (Number/Name)** NET-02 / *MARITIME SYSTEMS*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Description: The Maritime Missileer program will develop small, low-cost, disaggregated naval platforms to demonstrate the ability to perform persistent power projection and force application combat missions currently conducted from large, high-value capital ships. This network of platforms will project power and provide sea control across the spectrum of conflict, presenting potential adversaries with a dramatically different and rapidly reconfigurable order of battle. Maritime Missileer is envisioned as a family of heterogeneous systems, incorporating advanced autonomy and artificial intelligence to permit stand-in operations in even the mostly heavily contested environments. Effects are delivered with novel approaches to achieving mobility, potentially leveraging innovations in commercial shipbuilding and logistics, and platforms may vary from unmanned, to optionally manned, to manned. Technologies to be developed include advanced propulsion, energy sources for long-term operations, autonomous re-arming and re-fueling, self-maintenance, high-reliability communications, as well as hardware and software approaches to enhance system reliability, adaptability, and autonomous self-defense/anti-tamper. ***FY 2020 Plans:*** - Develop concept of operations. - Identify critical technologies. - Design and develop representative platforms. - Design and develop critical technologies. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The FY 2020 increase reflects program initiation.			
Title: Angler	-	-	15.000
Description: The undersea domain has significant importance to national security and military operations. Yet it is a challenging domain in which to operate due to extreme water pressures, restricted communications, ever changing bottom environments, marine fouling and corrosion. The Angler program seeks to improve U.S. operations in this domain by enabling underwater robotic systems significantly ahead of the state of the art. These robotic systems would be able to search and manipulate objects autonomously, even in dark, turbulent, and semi-opaque sea conditions without the need for human control and without reliance on the Global Positioning System (GPS). Key Angler technical challenges include sensing techniques that provide high-resolution navigation without GPS, perception and manipulation strategies for objects with unknown parameters, long duration autonomy approaches to support mission execution, and autonomy approaches that do not rely on human intervention. This program also has a companion applied research effort budgeted in PE0602702E, Project TT-03. The anticipated transition is to the Navy. ***FY 2020 Plans:*** - Perform subsystem integration and test.			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Defense Advanced Research Projects Agency		Date: March 2019
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
- Demonstrate and test robot system prototypes in a structured maritime environment. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The FY 2020 increase reflects initiation of advanced technology development activities.			
Title: Mobile Offboard Command, Control and Attack (MOCCA) ***Description:*** The Mobile Offboard Command, Control and Attack (MOCCA) program seeks to counter the fourth-generation submarine signature quieting technology that has significantly degraded passive anti-submarine warfare (ASW) sonar detection range and targeting performance. The MOCCA program will nullify submarine signature reduction trends with active sonar projectors deployed from a mobile unmanned undersea vehicle (UUV) and cooperatively processed with onboard submarine acoustic receive sonar systems. The off-board UUV sonar projector will operate under positive control at a significant distance from the cooperative submarine using communication links. The program seeks to achieve breakthrough capability for long-range submarine detection and precision target tracking. The program will develop compact, high-output acoustic transducers and novel low probability of intercept/low probability of detection (LPI/LPD) communication signaling. In addition, the MOCCA system will be integrated into submarine onboard sonar and weapons control systems. Technologies from this program will transition to the Navy. ***FY 2019 Plans:*** - Complete system utility analysis to identify optimal performance specifications for concept of operations under multiple tactical situations. - Integrate MOCCA communications transmission and processing approach onboard a submarine for at-sea feasibility demonstration. - Conduct at-sea feasibility demonstration to evaluate MOCCA communications transmission and processing approach using Navy assets. - Coordinate with the Navy to define concepts of operations. - Transition MOCCA communications and sonar systems to the Navy. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The FY 2020 decrease reflects program completion.	14.366	7.094	-
Title: Tactical Undersea Network Architecture ***Description:*** Systems fighting as a network are vulnerable to a loss of connectivity in a contested environment. This connectivity is important for synchronizing forces, establishing and maintaining situation awareness, and control of remotely operated vehicles and systems. Additionally, undersea systems are challenged to maintain connectivity and must carry their own energy and operate over their design lifetime with little to no maintenance and repair. These factors inhibit their use in collaborative networks	13.430	7.733	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
and prevent the full exploitation of the potential of undersea systems. The Tactical Undersea Network Architectures program will overcome these limitations by developing the technologies necessary for autonomous, reliable, and secure undersea data transfers; true plug, play, and operate standards; and rapid, cost-effective deployment technologies. The program will develop and demonstrate novel technology options and designs to restore connectivity temporarily for existing tactical data networks in contested environments using small-diameter optical fiber and buoy relay nodes. The program will focus on innovative system architecture designs, lightweight optical fiber technologies, and rapidly deployable buoy node designs and component technologies. The Tactical Undersea Network Architecture program will emphasize early risk reduction with scaled at-sea integrated demonstrations of increasing complexity. Program technologies will transition to the Services. ***FY 2019 Plans:*** - Revise and update component and system architectures for final at-sea testing based on results of FY2018 integration and at-sea testing. - Complete integration for updated system and perform at-sea networking demonstration. - Evaluate hardware packaging and radio deployment options in support of potential configuration modifications. - Analyze data collected and finalize reports on Tactical Undersea Network Architecture experimentation and demonstration events. - Transition interface, control, and system architecture documentation to the Services. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The FY 2020 decrease reflects program completion.			
Title: Tactical Exploitation of the Acoustic Channel (TEAC)	12.270	7.699	-
Description: The Tactical Exploitation of the Acoustic Channel (TEAC) program will provide the capability to coherently combine acoustic energy from a distributed network of underwater acoustic sources to improve signal transmission in an undersea environment. The ability to cohere multiple underwater sensors will have a transformative impact on a number of compelling applications including surveillance, communications, and vehicle positioning. For all of these applications, sensor gain is currently achieved by deploying large, costly, and cumbersome cabled arrays. The TEAC program will create the opportunity to deploy groups of low unit-cost sources that work cooperatively to focus energy undersea. This provides an extensible, affordable, and flexible method to harness the rapid development of undersea vehicles and new acoustic source technologies. Technologies developed under this program are intended to transition to the Navy. ***FY 2019 Plans:*** - Demonstrate and test at-sea cohering of acoustic sources. - Analyze sea-test data to identify system performance robustness. - Begin development of command and control for a semi-autonomous distributed system.			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Defense Advanced Research Projects Agency		Date: March 2019
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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
- Develop concept of operations for TEAC system deployment. - Test motion mitigation algorithms and command and control methods and demonstrate results in a limited test. - Develop mobile source network, algorithms, and signal waveforms for at-sea demonstration of semi-autonomous distributed system. - Develop test plan, system architecture, and acoustic propagation modeling for final at-sea demonstration. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The FY 2020 decrease reflects program completion.			
Title: Hydra ***Description:*** The Hydra program developed and demonstrated advanced capabilities for the undersea deployment and employment of unique payloads. Hydra integrated existing and emerging technologies and the ability to be positioned in the littoral undersea battlespace to create a disruptive capability. The system consisted of a modular enclosure with communications, command and control, energy storage, and standard interfaces for payload systems. The modular enclosures were deployed by various means, depending on the need for speed and stealth, and remain deployed until awakened for employment. Hydra developed critical enabling technologies for energy storage and recharging, communications, command and control, deployment, and autonomous operations. Technology developed under this program is transitioned to the Navy.	7.558	-	-
Title: Blue Wolf ***Description:*** Undersea platforms have inherent operational and tactical advantages such as stealth and surprise. Platform drag due to fluid viscosity and platform powering requirements varies with the speed through the water. Platform energy and power density limitations create two distinct operational usage profiles: one for unmanned undersea vehicles (low speed, long endurance) and another for undersea weapons (high speed, short endurance). Designers have historically solved this with hybrid systems such as the Navy's Vertical Launch Anti-Submarine Rocket, or by increasing the size of undersea systems. However, hybrid systems can be vulnerable to air and undersea defensive systems and larger undersea systems can result in significant launch platform modifications. The Blue Wolf program provided a radically different solution to develop and demonstrate an undersea demonstrator vehicle with endurance and speed capabilities beyond conventional undersea systems within the weight and volume envelopes of current Navy undersea systems. Significant technical challenges addressed included, dynamic lift and drag reduction, hybrid energy system development compatible with existing manned platform safety requirements and certification, and system integration and demonstration in at-sea environment. The program leveraged Navy connectivity, autonomy, guidance, navigation, and obstacle avoidance technologies. Under an existing Memorandum of Agreement, following vehicle integration and initial testing, the program is transitioning to the Navy.	4.500	-	-
Title: Hybrid Multi Material Rotor Full Scale Demonstration (HyDem)	3.000	-	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Description: The Hybrid Multi Material Rotor Full Scale Demonstration (HyDem) program applied breakthroughs in materials and material system technologies, and multi-disciplinary design methods to a Virginia Class submarine propulsor, a critical component in submarine performance. This new propulsor enabled the Navy to operate its submarine fleet with improved capability, allowing for the creation of strategic surprise. Submarines can exploit expanded areas previously unattainable for the purpose of submarine warfare, including antisubmarine warfare (ASW), antisurface warfare (ASuW), intelligence, surveillance and reconnaissance (ISR) gathering, strike, Special Forces operations, and strategic deterrence missions. The Navy has evaluated this component in sea trials. It is envisioned that the Navy will integrate this design change into the future development of the Virginia Class and Columbia Class submarines, and could back-fit previously constructed Virginia Class submarines. Technology developed under this program has transitioned to the Navy.			
Accomplishments/Planned Programs Subtotals	123.462	110.363	132.484

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Specific programmatic performance metrics are listed above in the program accomplishments and plans section.

Exhibit R-2A, RDT&E Project Justification: PB 2020 Defense Advanced Research Projects Agency			Date: March 2019
Appropriation/Budget Activity 0400 / 3	R-1 Program Element (Number/Name) PE 0603766E / *NETWORK-CENTRIC WARFARE TECHNOLOGY*	Project (Number/Name) NET-06 / *NETWORK-CENTRIC WARFARE TECHNOLOGY*	

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
NET-06: *NETWORK-CENTRIC WARFARE TECHNOLOGY*	-	230.769	223.743	280.453	-	280.453	178.448	88.886	44.000	10.000	-	-

A. Mission Description and Budget Item Justification

This project funds classified DARPA programs that are reported in accordance with Title 10, United States Code, Section 119(a)(1) in the Special Access Program Annual Report to Congress.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Classified DARPA Program	230.769	223.743	280.453
Description: This project funds Classified DARPA Programs. Details of this submission are classified. ***FY 2019 Plans:*** Details will be provided under separate cover. ***FY 2020 Plans:*** Details will be provided under separate cover. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** Details will be provided under separate cover.			
Accomplishments/Planned Programs Subtotals	230.769	223.743	280.453

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

Details will be provided under separate cover.