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 3: *Advanced Technology Development (ATD)*					R-1 Program Element (Number/Name) PE 0603271N *I Electromagnetic Systems Advanced Technology*							
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	32.924	26.421	9.360	-	9.360	8.804	9.556	8.056	8.217	Continuing	Continuing
2913: *Electromagnetic Systems Advanced Technology*	0.000	32.924	26.421	9.360	-	9.360	8.804	9.556	8.056	8.217	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 January 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.

Activities and efforts in this Program Element (PE) address technologies critical to enabling the transformation of discrete functions to network centric warfare capabilities, which simultaneously perform Radar, Electronic Warfare (EW), and Communications and Network functions across platforms through multiple, simultaneous and continuous communications/data links. The Electromagnetic Systems Advanced Technology program addresses Radio Frequency (RF) technology for Surface and Aerospace Surveillance sensors and systems, EW sensors and systems, RF Communication Systems, Multi-Function sensor systems, and Position, Navigation and Timing (PNT) capabilities. Within the Naval Transformational Roadmap, this investment offers affordable options for the transformational capabilities required by the Sea Shield (Theater Air and Missile Defense), Sea Strike (Persistent Intelligence, Surveillance, and Reconnaissance), and ForceNet (Communications and Networking) SeaPower 21 Naval Warfighting Pillars.

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

Exhibit R-2, RDT&E Budget Item Justification: FY 2018 Navy					Date: May 2017
Appropriation/Budget Activity 1319: *Research, Development, Test & Evaluation, Navy I* BA 3: *Advanced Technology Development (ATD)*			R-1 Program Element (Number/Name) PE 0603271N *I Electromagnetic Systems Advanced Technology*		
B. Program Change Summary ($ in Millions)	**FY 2016**	**FY 2017**	**FY 2018 Base**	**FY 2018 OCO**	**FY 2018 Total**
Previous President's Budget	34.856	26.421	26.199	-	26.199
Current President's Budget	32.924	26.421	9.360	-	9.360
Total Adjustments	-1.932	0.000	-16.839	-	-16.839
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-0.974	0.000			
• SBIR/STTR Transfer	-0.958	0.000			
• Program Adjustments	0.000	0.000	-16.839	-	-16.839
• Rate/Misc Adjustments	0.000	0.000	0.000	-	0.000

Change Summary Explanation

The funding decrease from FY 2017 to FY 2018 reflects the realignment of EMC2 and NEMESIS Innovative Naval Prototype (INP) and Leap Ahead Technology (LA-Tech) program investments to the new INP PE 0603801N Innovative Naval Prototypes (INP) Advanced Technology Development.

Technical: Not applicable.

Schedule: Not applicable.

Exhibit R-2A, RDT&E Project Justification: FY 2018 Navy			Date: May 2017
Appropriation/Budget Activity 1319 / 3	R-1 Program Element (Number/Name) PE 0603271N / *Electromagnetic Systems Advanced Technology*	Project (Number/Name) 2913 / *Electromagnetic Systems Advanced Technology*	

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
2913: *Electromagnetic Systems Advanced Technology*	0.000	32.924	26.421	9.360	-	9.360	8.804	9.556	8.056	8.217	Continuing	Continuing

A. Mission Description and Budget Item Justification

Work in this project addresses cost-effective RF technology for Surface and Aerospace Surveillance sensors and systems, EW sensors and systems, RF Communication Systems, Multi-Function sensor systems, and Position, Navigation and Timing (PNT) capabilities.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
Title: ELECTRONIC AND ELECTROMAGNETIC SYSTEMS	11.586	17.260	5.269	0.000	5.269
Description: The overarching objective of this activity is to develop, test, and demonstrate communications, electronic attack (EA), electronic surveillance (ES), electronic warfare (EW), and radar functions. This activity also includes development of affordable wideband, high performance Advanced Multifunction Radio Frequency (AMRF) apertures. A portion of this PE is devoted to mid-term technology development in close concert with acquisition programs of record. The products of these efforts are expected to transition at the end of their schedule into the associated acquisition program of record. a) Advanced EW Enabling Technologies - Develop classified advanced electronic warfare technology in support of current and predicted capability requirements. b) Electromagnetic Maneuver Warfare Command & Control (EMC2) (FY16-FY20) - Enable a battle group to work cooperatively in the EM Spectrum (EMS) to optimize Electronic Warfare (EW), Information Operations (IO), Communications (Comms) and Radar performance. EMC2 will build upon the Resource Allocation Manager (RAM) that was previously developed for single multifunction systems under the InTop program to optimize spectrum and functional use across a platform and an entire battle group. The increase from FY 2016 to FY 2017 reflects an increase in the level of effort for the new Electromagnetic Maneuver Warfare Command & Control (EMC2) Innovative Naval Prototype (INP) Program. The decrease from FY 2017 to FY 2018 reflects the realignment of the EMC2 Innovative Naval Prototype (INP) and Leap Ahead Technology (LA-Tech) designated program to PE 0603801N Innovative Naval Prototypes (INP) Advanced Technology Development where all of the INP/LA-Tech investments are being consolidated.					

Exhibit R-2A, RDT&E Project Justification: FY 2018 Navy		Date: May 2017
Appropriation/Budget Activity 1319 / 3	**R-1 Program Element (Number/Name)** PE 0603271N / *Electromagnetic Systems Advanced Technology*	**Project (Number/Name)** 2913 / *Electromagnetic Systems Advanced Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
The following are non-inclusive examples of accomplishments and plans for projects funded in this activity. ***FY 2016 Accomplishments:*** Advanced EW Enabling Technologies (formerly titled: Electronic Warfare (EW) Roadmap): - Continued development of classified advanced electronic warfare technology in support of current and predicted capability requirement. Electromagnetic Maneuver Warfare Command & Control (EMC2): - Initiated Wideband Airborne Multifunction System design. - Initiated Low-Band RF Intelligent Distribution Resource (LowRIDR) SubSystem build. - Initiated Electromagnetic Warfare Command and Control system design. ***FY 2017 Plans:*** Advanced EW Enabling Technologies: - Continue all efforts of FY 2016 unless noted as complete above. Electromagnetic Maneuver Warfare Command & Control (EMC2): - Continue all efforts of FY 2016 unless noted as complete above. ***FY 2018 Base Plans:*** Continue research in the areas of improved threat warning systems; electronic warfare support (ES); decoys and countermeasures against weapon tracking and guidance systems; electronic attack (EA) against adversary command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR); and electronic protection (EP) of our own weapons and C4ISR from intentional and unintentional interference to control the electromagnetic spectrum (EMS) by exploiting, deceiving, or denying enemy use of the spectrum while ensuring its use by friendly forces. ***FY 2018 OCO Plans:*** N/A					
Title: GLOBAL POSITIONING SYSTEM (GPS) & NAVIGATION TECHNOLOGY	2.338	2.800	4.091	0.000	4.091
Description: The overarching objective of this activity is to develop technologies that enable the development of affordable, effective and robust Position, Navigation and Timing (PNT) capabilities using either GPS systems, non-GPS navigation devices, or atomic clocks. This activity will increase the operational effectiveness of U.S. Naval units. The focus is on the mitigation of GPS electronic threats, the development of atomic clocks that					

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
possess unique long-term stability and precision, and the development of compact, low-cost, Inertial Navigation Systems (INS). The following are non-inclusive examples for projects funded in this activity. As a result of a comprehensive DOD wide assessment of current S&T investments in the area of Position, Navigation and Timing, funding was increased in FY 2018 in the Global Positioning System (GPS) & Navigation Technology thrust for increased investment in Assured Time Dissemination research. ***FY 2016 Accomplishments:*** GPS Anti-Jam Antennas and Receivers: - Continued GPS Antenna System for Enhanced electronic protection (EP), electronic surveillance (ES) and Precise Navigation. - Continued development of Small Antenna Based Anti-spoofing project. - Continued development of Advanced Spoofer Tracking. - Continued development of Next Generation Global Positioning Satellite System - Situational Awareness (XGPSS-SA) Challenged Environment. - Continued Modernized Receiver for RF Challenged Environments. - Continued development of the Simulation of GPS Signals in a Stressed Environment. - Continued development of Self Calibrating GPS Anti-Jam Antennas for Electronic Support. - Continued Cognitive Modernized GPS User Equipment (MGUE) for GPS-Denied Environments project. - Completed Modernized Integrated Spoofer Tracking. Precision Time and Time Transfer: - Continued DoD master clock time transfer via optical fibers. - Continued development of algorithms for distributed time scaling; developed architectures necessary to establish a Navy Global Coordinated Time Scale; tested the algorithms via both simulation and using actual clock data provided by the U.S. Naval Observatory (USNO). - Continued development and Distributing Time-frequency Device. - Continued development of Rb 3-cc Tactical Grade Atomic Clock (TGAC). - Completed Tactical Grade Atomic Clock Non-GPS Navigation Technology:					

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
- Initiated Broadband Navigation Sonar (BBNS) Technology - Continued Mechanical System (MEMS) Inertial Navigation System (INS) Phase II project. - Continued Angle-Only Infra Red Celestial Navigation System. - Continued Optically Transduced MEMS Inertial Navigation System project. - Continued Sub-harmonic Lateral Mode MEMS Inertial Navigation System project. - Continued development of Wavewinds project. - Continued development of Small Unmanned Underwater Vehicle - Sonar Aided Inertial Navigation Technology (UUV-SAINT) project. - Continued development of Portable PCNS project. - Continued development of Alternative Navigation Over Unstructured or Featureless Terrain. - Continued Miniature Ultra-Cold Atom Chip Inertial Sensors. - Completed Two-Axis Gyro-compass Fiber Optic Inertial Navigation System. - Completed development of Superconducting Magnetometer On-Board Navigation (SIMON) System.					
FY 2017 Plans: GPS Anti-Jam Antennas and Receivers: - Continue all efforts of FY 2016 less those noted as complete. - Complete development of Small Antenna Based Anti-spoofing project. - Complete development of Next Generation Global Positioning Satellite System - Situational Awareness (XGPSS-SA) Challenged Environment. - Complete Modernized Receiver for RF Challenged Environments. - Complete development of the Simulation of GPS Signals in a Stressed Environment. - Complete development of Self Calibrating GPS AJ Antennas for Electronic Support. - Complete Cognitive Modernized GPS User Equipment (MGUE) for GPS-Denied Environments project. - Complete GPS Antenna System for Enhanced EP, ES and Precise Navigation. - Initiate advanced receiver design implementing advanced and collective acquisition and tracking techniques. Precision Time and Time Transfer: - Continue all efforts of FY 2016 less those noted as complete. - Complete development of algorithms for distributed time scaling; developed architectures necessary to establish a Navy Global Coordinated Time Scale; tested the algorithms via both simulation and using actual clock data provided by the U.S. Naval Observatory (USNO). - Initiate the development of generalized time transfer modem for terrestrial and shipboard systems.					

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
- Initiate cold atom development efforts for compact, deployable next generation clock technology to surpass current Rubidium and Cesium standards, providing longer accurate time holdover in GPS denied environments. - Initiate RF and Optical time transfer effort for terrestrial, surface, and airborne platforms. Non-GPS Navigation Technology: - Continue all efforts of FY 2016 less those noted as complete. - Complete Optically Transduced MEMS Inertial Navigation System project. - Complete Sub-harmonic Lateral Mode MEMS Inertial Navigation System project. - Complete development of Wavewinds project. - Complete development of Small Unmanned Underwater Vehicle Sonar Aided Inertial Navigation Technology (UUV-SAINT) project. - Complete development of Portable PCNS project. - Complete development of Alternative Navigation Over Unstructured or Featureless Terrain. - Complete Two-Axis Fiber Optic Inertial Navigation System Phase II project. - Complete Mechanical System (MEMS) Inertial Navigation System (INS) Phase II project. - Initiate advanced development of geophysical, RF, and celestial navigation aids for manned and unmanned surface and subsurface platforms. - Initiate cold atom gravimetric measurement system for aids to inertial sensors.					
FY 2018 Base Plans: Continue advanced research and development in position, navigation and timing. This research aims to develop devices and systems that provide assured, cost-effective, and mission relevant PNT to the warfighter. Areas of investment included robust GPS, non-GPS navigation aids, and assured timekeeping. Specifically, research in GPS Anti-Jam Antennas and Receivers for Navy platforms for the purpose of providing precision navigation capabilities in the presence of electronic threats and anti-spoofer/anti-jam processors for the purpose of providing precision navigation capabilities in the presence of emergent threats; Tactical grade atomic clocks that possess unique long-term stability and precision for the purpose of providing GPS-independent precision time and transferring GPS-derived time via radio frequency links for the purpose of providing GPS-independent precision time; and Inertial navigation systems for the purpose of providing an alternative means of providing precision navigation, a correlation navigation technique using earth maps of high precision, for those Naval platforms which may not have GPS navigation capabilities and/or loss of GPS signals.					
FY 2018 OCO Plans:					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
N/A					
Title: INTEGRATED TOPSIDE (INTOP) INNOVATIVE NAVAL PROTOTYPE (INP)	10.000	0.000	0.000	0.000	0.000
Description: The overarching objective of the Integrated Topside (INTOP) INP is to develop and demonstrate a set of prototypes that integrate RF functionality (EW, Radar, Communications, Navigation) into a common set of multi-function apertures electronics and software through an architecture that is modular, scalable across all platforms, and open at the RF as well as computer and software level. The apertures are capable of providing multiple simultaneous, independent beams which can together perform any of the above functions. The major objectives of this activity are: a) Submarine SATCOM Array - Develop wide-band SATCOM array capable of supporting EW for submarines. b) Electronic Warfare (EW)/Information Operations (IO)/Line of Sight (LOS) Communications (Comms) for Surface Combatants - Develop wide-band array to support EW capability and other functions, including but not limited to IO and LOS Comms, for surface combatants with potential application to other platforms. c) Architecture, Standards and Devices - Develop architecture and standards for wide-band multi-beam, multi-band arrays and below deck systems and the technology and electronic devices needed to make integrated array systems affordable. d) Surface Combatant Communication Array - Develop wide-band surface combatant communication array capable of supporting other RF functions. e) Resource Allocation Manager - Develop enterprise common Resource Allocation Manager. f) Digital Radar - Develop an all digital radar to demonstrate advanced concepts for coherent radar networking and control, which will increase radar coverage and provide new levels of electronic protection (EP), while maximizing radar resources and reducing cost. g) Low Band Communications, IO and EW - Develop low band technology development and concept studies leading to development of an Advanced Development Model (ADM).					

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
The following are non-inclusive examples of accomplishments and plans for projects funded in this activity. ***FY 2016 Accomplishments:*** Resource Allocation Manager: - Completed integration and test of Resource Allocation Manager (RAM). Digital Radar: - Completed system build for front-end. - Completed system build for back-end. Low Band Communications, Electronic Warfare (EW) and Information Operations (IO): - Continue and complete development of the initial architecture and requirements. - Completed subsystem designs. ***FY 2017 Plans:*** N/A ***FY 2018 Base Plans:*** N/A ***FY 2018 OCO Plans:*** N/A					
Title: NEMESIS ***Description:*** The objective is to develop a System of Systems (SoS) able to coordinate distribute electronic warfare (EW) resources against many adversary surveillance and targeting sensors simultaneously. It will benefit the warfighter by providing platform protection across the battlespace against many sensors, creating seamless cross-domain countermeasure coordination, and enabling rapid advanced technology/capability insertion to counter emerging threats. a) Develop reconfigurable and modular EW payloads, Distributed Decoy and Jammer Swarms (DDJS), effective multi-spectral countermeasures (CM), and Multiple Input/Multiple Output Sensor/CM (MIMO S/CM) for platform protection across operational domains.	9.000	6.361	0.000	0.000	0.000

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2016	FY 2017	FY 2018 Base	FY 2018 OCO	FY 2018 Total
This R2 activity was initiated in PE 0602271N Electromagnetic Systems Applied Research and expanded in FY 2015 to PE 0603271N Electromagnetic Systems Advanced Technology. The decrease from FY16 to FY17 reflects the transition toward the integration and demonstration of the new technologies. The decrease from FY 2017 to FY 2018 reflects the realignment of the NEMESIS Innovative Naval Prototype (INP) and Leap Ahead Technology (LA-Tech) designated program to PE 0603801N Innovative Naval Prototypes (INP) Advanced Technology Development where all of the 6.3 INP/LA-Tech investments are being consolidated. ***FY 2016 Accomplishments:*** - Continued development and demonstration of the NEMESIS Electronic Warfare (EW) payloads and their integration into platforms. - Continued application of the research supporting distributed control, coordination and networking of NEMESIS payloads and platforms. ***FY 2017 Plans:*** - Continue all efforts of FY 2016. ***FY 2018 Base Plans:*** N/A ***FY 2018 OCO Plans:*** N/A					
Accomplishments/Planned Programs Subtotals	32.924	26.421	9.360	0.000	9.360

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

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E. Performance Metrics

Advanced Electronic Sensor Systems for Missile Defense and Long Range Detection and Tracking ECs are aligned to the Navy's Advanced Cruiser (CG(X)) plans and closely coordinated with Naval Sea Systems Command Integrated Warfare Systems (PEO IWS 2.0). Other performance metrics are discussed within the R-2a. Navigation and timekeeping developments are aligned and coordinated to the OPNAV (N2N6E4) Assured PNT plan for surface and aviation platforms and with the Special Programs office's technology development roadmap.