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Exhibit R-2, RDT&E Budget Item Justification: PB 2021 Navy **Date:** February 2020

Appropriation/Budget Activity 1319: <i>Research, Development, Test & Evaluation, Navy / BA 4: Advanced Component Development & Prototypes (ACD&P)</i>	R-1 Program Element (Number/Name) PE 0603573N / <i>Advanced Surface Machinery Sys</i>
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COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
Total Program Element	244.154	26.272	87.408	38.449	-	38.449	34.179	26.081	24.233	24.710	Continuing	Continuing
2471: <i>Integrated Power Systems (IPS)</i>	244.154	21.448	25.408	38.449	-	38.449	34.179	26.081	24.233	24.710	Continuing	Continuing
9999: <i>Congressional Adds</i>	0.000	4.824	62.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	66.824

A. Mission Description and Budget Item Justification

The FY 2020 to FY 2021 decrease is due to FY 2020 Congressional Adds for silicon carbide power modules, advanced power electronics integration and surface combatant component-level prototyping. The FY 2020 to FY 2021 increase in PU 2471 funds the design and build of the modular scalable shipboard multi-application Energy Magazine (EM) which enables new pulsed, high power directed energy weapons (lasers) and sensors. FY 2020 competitively awarded contracts to up to two (2) vendors fulfills the need for at least two (2) viable sources of supply for EM with lithium ion batteries, and/or capacitors and or flywheel based energy storage systems and power electronics for shipboard applications. FY 2021 includes resource requirements for characterization and qualification of lithium ion battery based energy storage to safe and reliable shipboard service.

This Program Element (PE) includes the development of advanced surface ship Hull, Mechanical, and Electrical (HM&E) components and systems for all future ships and back-fit ships where appropriate as well as development of Situational Awareness, Boundary Enforcement & Response (SABER) prototype hardware for cybersecurity protections of HM&E systems for applicable surface ships. This PE is managed by PMS 320, the Electric Ships Office, located organizationally within PEO SHIPS, responsible for developing Naval Power and Energy Systems that focus power system integration of Directed Energy (DE) and other high-powered mission systems as well as platform integration and improving energy efficiency of those components and systems. The mission of PMS 320 is to develop and provide smaller, simpler, more affordable and more capable electric power systems for all Navy platforms, focus Navy and industry investments, and reduce total ownership cost. PEO Ships AM manages the SABER hardware development effort.

This PE serves as the bridge between Science and Technology (S&T) and ship platform and mission systems acquisition programs by identifying prospective applications for S&T research, advanced development, and performing additional product development and qualification when necessary to meet platform or mission system requirements.

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B. Program Change Summary (\$ in Millions)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Previous President's Budget	27.109	25.408	42.825	-	42.825
Current President's Budget	26.272	87.408	38.449	-	38.449
Total Adjustments	-0.837	62.000	-4.376	-	-4.376
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	62.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-0.073	0.000			
• SBIR/STTR Transfer	-0.764	0.000			
• Program Adjustments	0.000	0.000	-4.480	-	-4.480
• Rate/Misc Adjustments	0.000	0.000	0.104	-	0.104

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

Project: 9999: *Congressional Adds*

Congressional Add: *Silicon Carbide Power Modules*

Congressional Add: *Advanced power electronics integration*

Congressional Add: *Surface combatant component-level prototyping*

Congressional Add Subtotals for Project: 9999

Congressional Add Totals for all Projects

	FY 2019	FY 2020
	4.824	7.000
	0.000	5.000
	0.000	50.000
Congressional Add Subtotals for Project: 9999	4.824	62.000
Congressional Add Totals for all Projects	4.824	62.000

Change Summary Explanation

FY 2020 increase of \$62.000M for silicon carbide power modules, advanced power electronics integration and surface combatant component-level prototyping Congressional Adds.

FY 2021 decrease of \$4.376M due to -\$4.167M reduction to account for the availability of prior year execution balances.

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Appropriation/Budget Activity 1319 / 4					R-1 Program Element (Number/Name) PE 0603573N / <i>Advanced Surface Machinery Sys</i>				Project (Number/Name) 2471 / <i>Integrated Power Systems (IPS)</i>			
COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
2471: <i>Integrated Power Systems (IPS)</i>	244.154	21.448	25.408	38.449	-	38.449	34.179	26.081	24.233	24.710	Continuing	Continuing
Quantity of RDT&E Articles		-	-	-	-	-	-	-	-	-		

A. Mission Description and Budget Item Justification

This project supports the development and transition of Naval Power and Energy Systems including power generation, power conversion, power distribution, energy storage, power utilization and automation and control functions for fully integrated electric propulsion (such as T-AKE -1 class or DDG 1000 class), hybrid electric propulsion (such as LHD 8 and LHA(R) class), as well as legacy mechanical propulsion ships (such as DDG51 class). This project supports optimized integration of Directed Energy (DE) and other high powered mission systems, appropriate component and system controls, integration of components and systems into future and current ships, and providing power and energy system solution alternatives to new and existing platforms. Existing ships' power systems require optimized integration via energy storage and advanced controls techniques to withstand the effects of DE and other high powered mission systems and avoid negative impacts to power generating equipment (diesel/gas turbine engines and generators).

Project developments are aligned with the Navy's 30 year shipbuilding plan via the Naval Power and Energy Systems Technology Development Roadmap (TDR), which outlines the way ahead for future developments and provides a basis for coordinated planning and investment by the Navy and private industry.

This project develops and transitions products that electrically integrate and provide power to mission systems, integrates those components and systems into ship platforms, increases energy efficiency, and provides cybersecurity capabilities for current in-service Hull, Mechanical and Electrical (HM&E) systems as well as future systems.

The systems developed by this Project are the power and energy foundation of the ships kill chain, and are developed with efficiency requirements as part of total life cycle cost minimization. Efforts within Power and Energy Systems are to design, develop, test and integrate shipboard power systems to incorporate advanced sensors, directed energy and other advanced weapons. Design and testing includes modeling and simulation, as well as land based testing, to reduce risk and demonstrate readiness for shipboard use.

Cybersecurity: This PU will develop and test various SABER prototype hardware that monitors the HM&E network and system communications to detect potential cyber attacks. SABER hardware will transition to appropriate back-fit and forward fit ship installations, as appropriate, once development and testing completes. The Cyber funding also supports using cyber analysis tools to identify potential vulnerabilities in HM&E enclave architectures, hardware components, and software for applicable surface ships.

B. Accomplishments/Planned Programs (\$ in Millions, Article Quantities in Each)

	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Title: Power and Energy Systems	12.787	16.457	30.952	0.000	30.952

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B. Accomplishments/Planned Programs (\$ in Millions, Article Quantities in Each)

	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Articles:	-	-	-	-	-
<p><i>FY 2020 Plans:</i> EM prototype: Continue to execute the Energy Magazine - Prototype Engineering Change Proposal (ECP). Specific FY20 efforts include: order long lead time material(s), complete the design, commence the build of the EM prototype and fabricate artifacts to be used in the redesigned battery modules and commence safety testing. Continue to support PEO IWS and ONR laser testing. Evaluate performance of the EM prototype and, as applicable, incorporate lessons learned into EM procurement</p> <p>Energy Magazine (EM): Following source selection, competitively award EM contracts to up to two (2) vendors to fulfill the need for at least two (2) viable sources of supply for EM with lithium ion batteries, and/or capacitors, and/or flywheel energy storage and power electronics for shipboard applications. In FY 2020, selected vendors will begin design of a modular, scalable, multi-application EM; an energy storage system that serves as the energy resource to enable the introduction of pulsed high power and energy weapons and sensor systems. EM simultaneously supports multiple pulsed loads such as laser, electronic warfare, radars, etc. When fully integrated, EM is expected to also reduce the number of Uninterruptable Power Supply (UPS) on ships which decreases maintenance and costs. This PE will transition ONR Future Naval Capabilities (FNC) products, advanced circuit protection devices and Multi-Functional Energy Storage Module (MFESM). FY 2020 efforts include testing and documentation to transition into EM and Advanced Power Conversion Module (APCM). The EM aligns with PEO IWS plans for development and deployment of shipboard high power directed energy weapons and sensors.</p> <p>Conduct system simulations that focus on EM performance, generate detailed interface requirements, test scenarios and sequences, and incorporate in Power Hardware In the Loop (PHIL) demonstration(s).</p> <p>Continue to conduct feasibility studies, cost based assessments, and develop technical and performance specifications for an Integrated Power & Energy System (IPES) in support of Future Surface Combatant power and energy requirements. Identify shared energy storage and advanced controls requirements enabling an affordable, scalable and flexible power system to meet current and future needs. Refine IPES notional architectures and risk assessments through studies and industry engagement. Draft performance specifications for IPES system, equipment and components.</p>					

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B. Accomplishments/Planned Programs (\$ in Millions, Article Quantities in Each)

	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
<p>Continue to identify requirements for Advanced Controls in order to take full advantage of power and energy resources within the ship's machinery control system and to deliver mission systems the power and energy they require when required. Advanced controls configure the system to operate at max efficiently when appropriate and switch to max performance when necessary through three-way communication and control between the machinery control system, mission planning and pulsed high power and energy weapon systems and sensors. In FY20 this PE will perform advance control optimization based on impact, availability, and resources with a focus on how to use controls to optimize the amount and cost of energy storage in the system taking into consideration stability and pulse-power support for determining energy storage needs.</p> <p>Continue to conduct PHIL demonstrations. In FY 2020 PHIL demonstrations will focus on a modular scalable multi-purpose Energy Magazine and future surface combatants with multiple high pulsed power loads; demonstrating advanced electrical architectures, power conversion equipment, and controls for implementation into an IPES.</p> <p>Execute computer component models and system level modeling and simulation efforts. Plan for land based testing activities.</p> <p>This PE will transition ONR Future Naval Capabilities (FNC) products, advanced circuit protection devices and Multi-Functional Energy Storage Module (MFESM). FY 2020 efforts include testing and documentation to transition into EM and APCM.</p> <p>Advanced Power Generation Modules (APGM): Continue to define performance requirements, explore trade space in next generation compact high power Advanced Power Generation Modules (APGM), continue to develop characterization data used to conduct ship design studies and to establish a benchmark for performance comparison, continue to develop a stand-alone technical description document which describes performance characteristics, continue to evaluate the effect of large pulse loads from future electric weapons on the cycle life of gas turbine engines, and engine capability to respond to such pulse loads without an unacceptable reduction in time between overhaul.</p> <p>Advanced Power Conversion Module (APCM): Continue to conduct feasibility studies, Cost Based Assessments, and development of performance and technical specifications for next generation compact high power APCM incorporating high band gap materials such as silicon carbide. Continue to develop computer component models</p>					

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B. Accomplishments/Planned Programs (\$ in Millions, Article Quantities in Each)

	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
<p>and system level modeling and simulation efforts. FY 2020 efforts include evaluating the use of silicon carbide high band gap material in EM.</p> <p><i>FY 2021 Base Plans:</i> This PE has pursued an evolutionary energy storage development strategy for surface ships. Prior to FY 2021, this PE has designed, built, and tested at the Center for Advanced Power System at Florida State University (FSU CAPS) the Energy Storage Module (ESM) prototype, the Energy Magazine Bread Board (to test active front end technology to enable peak shaving) and multiple other energy storage devices designed and built outside of this PE. These include the United Kingdom (UK) Flywheel Energy Storage System, the Johns Hopkins University Adaptable Power Supply, and the Northrop Grumman Energy Storage System. This testing has de-risked the Energy Magazine technical specification and increased Navy expertise in the use of advanced energy storage technologies. Energy Storage is a key enabler for high-powered directed energy weapons. The stored energy of the Energy Magazine is required to supplement typical ship service power so that large pulsed loads do not directly tie to the electrical power generator, which potentially damages the shipboard power system. The Energy Magazine consists of power electronics, energy storage media, and controls. The Energy Magazine is a common, modular, scalable intermediate power system that standardizes energy storage across multiple mission systems and ships classes, eliminating wasteful need for mission systems to each develop, build, test and qualify/certify their own unique energy storage systems. The Energy Magazine also provides stable backup power functionality and leads to reduction of uninterruptable power supplies (UPS) aboard ship. Approximately 30-40% of the cabinet components that support weapons and sensing systems are power conditioning; these can be functionally replaced by the Energy Magazine as a more universal power conditioning and energy storage unit that is ship power "reloadable" for multiple directed energy engagements. The Energy Magazine is designed for both new construction and back-fit applications where advanced combat systems loads are being deployed.</p> <p>Energy Magazine-Prototype (EM-P): Continue to execute the Energy Magazine - Prototype (EM-P) Engineering Change Proposal (ECP). Specific FY21 efforts include: order all material, complete build, and conduct Test Readiness Reviews prior to testing the EM-P, conduct first article and factory testing, verify through testing that the EM Prototype performance meets the physical, functional and performance requirements. Continue to support PEO IWS and ONR laser testing. Evaluate performance of the EM prototype and, as applicable, incorporate lessons learned into EM procurement. Commence preparation of test plans and procedures and test site modifications.</p>					

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B. Accomplishments/Planned Programs (\$ in Millions, Article Quantities in Each)

	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
<p>Energy Magazine (EM): Continue executing Energy Magazine (EM) contracts awarded competitively in FY20 to up to two (2) vendors to fulfill the need for at least two (2) viable sources of supply for EM with lithium ion batteries, and/or capacitors, and/or flywheel energy storage and power electronics for shipboard applications. Complete EM preliminary design, commence detailed design, complete S9310-AQ-SAF-010 characterization for Li Batteries / Flywheel Technology Readiness Level (TRL) demonstration, order Long Lead Time Material (LLTM), and prepare to build the prototype units, including strengthening vendor industrial base relationships to ensure receipt of hardware on time to maintain schedule.</p> <p>-- Design activities include: Complete requirements analysis to transition Navy requirements into design, performance and operational environment requirements from which system configuration items (e.g. subsystem and major components) can be designed, integrated and tested; interface management to coordinate interface requirements, assess and document performance in the areas of acoustics, Electromagnetic Interference (EMI); transient stability, load flow, harmonic and system fault analysis; trade-off analyses used to arrive at the design, details of methods used in the design process, the status of the risk management efforts, an assessment of the impact of cost drivers in the design, and a program review of the status of the design to date; and, thermal analysis, mechanical stress analysis, modal analysis, electrical insulation stress analysis, critical charge levels, flame resistance and toxicity of self-extinguishing insulation material, vibration and shock.</p> <p>-- Prepare and deliver a Preliminary Design Report and conduct a Preliminary Design Review (PDR) to review key performance parameters along with preliminary component designs, control philosophy and documentation, system functional requirements, interface requirements, size, weight, electromagnetic fields and interference criteria, thermal management, and performance requirements.</p> <p>-- Fabricate the artifacts to be used in destructive characterization testing for energy storage based on each vendors' designs, conduct characterization testing, and prepare certification data needed for the approval to install the Energy Magazine at Navy land based facilities for testing and for installation aboard ship. Complete appropriate drawings describing the LLTM component usage, prepare LLTM specifications of the LLTM components, and procure LLTM.</p> <p>-- Continue to conduct system simulations that focus on EM performance, generate and validate detailed interface requirements, test scenarios and sequences, and incorporate in Power Hardware In the Loop (PHIL) demonstration(s).</p>					

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B. Accomplishments/Planned Programs (\$ in Millions, Article Quantities in Each)

	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
<p>Integrated Power and Energy System (IPES): An IPES is described in the Naval Power and Energy Systems Technology Development Roadmap (NPES TDR) as an advanced power architecture that incorporates multi-use distributed energy storage as well as advanced controls and energy management. An IPES is an evolution of an Integrated Power System (IPS), specifically from that installed on DDG 1000. Changes from IPS on DDG 1000 range from system level improvements such as variable speed prime movers, higher bus voltages, common intra-zone power conversion, improved electrical disconnects, advanced circuit protection, and cybersecurity to component and device improvements such as increased efficiency and performance leveraging industry's advancements in power conversion technology since DDG 1000 was designed. IPES is a system that fully integrates all generated and stored electrical energy in the ship platform so that it is available to all electrical users, including high power weapons, advanced sensors, and electric propulsion, as mission scenarios dictate. IPES removes the need for individual Uninterruptible Power Supplies (UPS) now proliferating on ships. An IPES breaks this paradigm of stove piped energy storage and allows all users to benefit from common, shared sources of energy whether that be for mission systems or providing ride through power for mission critical systems or ship systems. Ship power systems today do not have the capability to share energy resources. In FY21, continue to conduct feasibility studies, cost based assessments, computer real time simulations, and develop technical and performance specifications for an Integrated Power & Energy System (IPES) in support of Future Surface Combatant power and energy requirements. Identify shared energy storage and advanced controls requirements enabling an affordable, scalable and flexible power system to meet current and future needs. Refine IPES notional architectures and risk assessments through studies and industry engagement. Draft performance specifications for IPES system, equipment and components. Continue to engage in robust component-level prototyping of potential new critical systems, including those related to propulsion and electrical distribution in support of future surface combatants to the maximum extent possible. Execute computer component models and system level modeling and simulation efforts. Plan for land based testing activities focused on testing prototypes, validating specifications and standards and interfaces, and functionality of advanced controls.</p> <p>In order to obtain early insight into the effects of high power and energy mission systems on ships electric power systems, evaluate shipboard power and energy systems, and evaluate power system performance at lower cost than full-scale hardware system testing, simulated electrical system integration testing using power and energy system components will be conducted. This lower-cost approach to testing is referred to as Power Hardware In the Loop (PHIL). PHIL includes development of component computer models that simulate and emulate actual operating machinery components and shipboard power and energy systems. PHIL testing replaces component models with hardware once hardware development is complete. PHIL testing costs less than full-</p>					

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B. Accomplishments/Planned Programs (\$ in Millions, Article Quantities in Each)

	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
<p>scale hardware system testing, shortens development time, and affords the opportunity to identify and mitigate risks in a deliberate fashion from specification development to computer model development to hardware development resulting in a more affordable and robust end product. PHIL testing reduces developmental risk, and demonstrates performance potential prior to live hardware integration testing. Continue to conduct PHIL demonstrations. In FY 2021 PHIL demonstrations will focus on available propulsion and electrical distribution component prototypes to support design efforts.</p> <p>Advanced Power Conversion Module (APCM): Continue to conduct feasibility studies, Cost Based Assessments, and developing performance and technical specifications for next generation compact high power Advanced Power Conversion Module (APCM) incorporating high band gap materials such as silicon carbide. Continue to develop computer component models and system level modeling and simulation efforts.</p> <p>Advanced Power Generation Modules (APGM): Continue to define performance requirements, explore trade space in next generation compact high power Advanced Power Generation Modules (APGM), continue to develop characterization data used to conduct ship design studies and to establish a benchmark for performance comparison, continue to develop a standalone technical description document which describes performance characteristics, continue to evaluate the effect of large pulse loads from future electric weapons on the cycle life of gas turbine engines, and engine capability to respond to such pulse loads without an unacceptable reduction in time between overhaul. Continue scale generator physical modeling efforts at Sandia National Labs Small Scale Microgrid to determine the feasibility and operational characteristics of dual wound generators operating through active rectifiers to supply a scale medium voltage DC ships electrical bus with scale pulsed, high power weapons and sensors. Continue industry engagement in early trade and concept studies to determine the cost and feasibility of dual wound, variable speed gas turbine generators. Continue to support maturation and transition of ONR Future Naval Capabilities (FNC) products.</p> <p>FY 2021 OCO Plans: N/A</p> <p>FY 2020 to FY 2021 Increase/Decrease Statement: The increase from FY 2020 to FY 2021 supports FY 2020 competitively awarded contracts of up to two (2) vendors to design and build the modular scalable shipboard multi-application Energy Magazine which enables new pulsed, high power directed energy weapons (lasers) and sensors. Contract awards fulfill the need for at least two (2) viable sources of supply for EM with lithium ion batteries, and/or capacitors and or flywheel based energy storage systems and power electronics for shipboard applications. FY2021 includes resource</p>					

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B. Accomplishments/Planned Programs (\$ in Millions, Article Quantities in Each)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
requirements for characterization and qualification of lithium ion battery based energy storage to safe and reliable shipboard service.					
<p>Title: Naval Power Technology Development / Platform Integration & Transition</p> <p align="right">Articles:</p> <p>FY 2020 Plans: Continue to execute the Advanced Electric Power and Propulsion Systems Development Project (short title is AEP3), Project Arrangement (PA) ref DoD-MOD-N-12-0001 which is an agreement between the US and UK Governments to cooperate on a scope of work associated with characterizing, developing, modeling, and de-risking electrical power and propulsion system architectures and equipment for future surface and submarine platforms to meet the needs of both Navies.</p> <p>Continue to develop power and propulsion system configurations in support of future surface ship acquisition programs. Develop alternative power and propulsion solutions for future surface combatants and amphibious ships. Continue to improve baseline power system performance by performing analysis, modeling and simulation, life cycle cost analysis, producibility studies, module development, and ship integration studies and planning. Continue to analyze alternatives for supplying power to advanced radars, combat systems, and electric weapons power demands and potential interfaces to develop optimum alternative solutions. Continue assessments of Naval Power and Energy System alternate architectures to best meet emerging ship requirements.</p> <p>Commence biennial update of the Naval Power and Energy Systems (NPES) Technology Development Roadmap (TDR).</p> <p>Continue to support maturation and transition of ONR Future Naval Capabilities (FNC) products to meet NPES TDR identified gaps.</p> <p>Support transition from ONR of Silicon Carbon (and other high bandgap semiconductor materials) based power electronic modules. High band gap semiconductor materials operate at high speeds and temperatures as compared with silicon based materials affording more compact, thermally tolerant power conversion equipment making them highly desirable for naval applications.</p> <p>Continue Combat Power and Energy System Overarching Integrated Product Team (OIPT).</p>	1.104	1.104	1.104	0.000	1.104
	-	-	-	-	-

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B. Accomplishments/Planned Programs (\$ in Millions, Article Quantities in Each)

	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
<p>Continue to generate strategy, technology development plan and resource requirements for future surface combatant integrated power and energy system.</p> <p><i>FY 2021 Base Plans:</i> Continue to execute the Advanced Electric Power and Propulsion Systems Development Project (short title is AEP3), Project Arrangement (PA) ref DoD-MOD-N-12-0001 which is an agreement between the US and UK Governments to cooperate on a scope of work associated with characterizing, developing, modeling, and de-risking electrical power and propulsion system architectures and equipment for future surface and submarine platforms to meet the needs of both Navies. Scope of AEP3 PA was modified in FY19 via amendment 2 to include development and testing of advanced cooling methods and distributed thermal management systems, and to jointly develop advanced control methods, technologies, and hardware for management of advanced shipboard power and energy systems. Thermal management of shipboard power and energy systems has lagged behind the rapid development of shipboard electrical power systems. Both nations seek to apply innovative cooling methods derived from academia, industry, and mission systems communities to electric power conversion and distribution. Advanced controls are required to support the rapid power and energy system reconfiguration needed on future surface ships. The benefits to both Participants will be the ability to power revolutionary Directed Energy Weapons on existing ships and field future shipboard electrical architectures with performance thresholds that exceed current thermal management and controls limits.</p> <p>Continue to develop power and propulsion system configurations in support of future surface ship acquisition programs. Develop alternative power and propulsion solutions for future surface combatants and amphibious ships. Continue to improve baseline power system performance by performing analysis, modeling and simulation, life cycle cost analysis, producibility studies, module development, and ship integration studies and planning. Continue to analyze alternatives for supplying power to advanced radars, combat systems, and electric weapons power demands and potential interfaces to develop optimum alternative solutions. Continue assessments of Naval Power and Energy System alternate architectures to best meet emerging ship requirements. Continue Combat Power and Energy System Overarching Integrated Product Team (OIPT) activities. Continue to generate strategy, technology development plan and resource requirements for future surface combatant integrated power and energy system.</p> <p>Issue biennial update of the Naval Power and Energy Systems (NPES) technology development roadmap (TDR)</p>					

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B. Accomplishments/Planned Programs (\$ in Millions, Article Quantities in Each)					
	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Support transition from ONR of Silicon Carbon (and other high bandgap semiconductor materials) based power electronic modules. High band gap semiconductor materials operate at high speeds and temperatures as compared with silicon based materials affording more compact, thermally tolerant power conversion equipment making them highly desirable for naval applications. FY 2021 OCO Plans: N/A					
Title: Situational Awareness, Boundary Enforcement & Response (SABER) - Hardware Development / Prototyping FY 2020 Plans: Continue SABER hardware design, First Article Test (FAT) unit fabrication, and Environmental Qualification Testing (EQT). Continue build of SABER Computing Hardware Lab units for ship integration testing at NSWC Philadelphia Division, Philadelphia PA to support installations. Commence design, FAT fabrication, and EQT of the SABER sensor known as the Copper Tap & Aggregator unit. Commence build of a small Low Rate Initial Production (LRIP) quantity of Copper Tap & Aggregator Units for lab testing at NSWC Philadelphia Division, Philadelphia PA. Develop and test an additional variant of the WeaselBoard (SABER sensor) for shipboard integration. Support the two current Non-Permanent Changes (NPCs) on the host ships. Perform a Cyber Table Top type event on DDG-51 class HM&E Control Systems and a cyber vulnerability analysis of the main DDG-51 class HM&E/Navigation control system network via Model Based Systems Engineering tools. FY 2021 Base Plans: Continue build of SABER Computing Hardware Lab units for NSWC Philadelphia Division, Philadelphia PA for ship integration testing to support installations in FY 2022 and FY 2023. Develop and test additional WeaselBoard variants.	7.557 -	7.847 -	6.393 -	0.000 -	6.393 -
	Articles:				

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B. Accomplishments/Planned Programs (\$ in Millions, Article Quantities in Each)	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total
Conduct Cyber Table Top type events and cyber vulnerability analysis via Model Based Systems Engineering tools of HM&E systems/networks on additional ship classes. FY 2021 OCO Plans: N/A FY 2020 to FY 2021 Increase/Decrease Statement: The decrease from FY 2020 to FY 2021 is to account for the availability of prior year execution balances.					
Accomplishments/Planned Programs Subtotals	21.448	25.408	38.449	0.000	38.449

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

N/A

Remarks

D. Acquisition Strategy

This program develops and transitions higher performance and more affordable electric power and propulsion systems to both new construction and back fit ship applications using an evolutionary acquisition approach. For new contract awards, full and open competition is utilized to the maximum extent possible to provide maximum benefit to the Navy at the lowest possible cost to the taxpayer. When able to meet Navy requirements, commercial technology is leveraged to further minimize cost to the Navy.

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Exhibit R-3, RDT&E Project Cost Analysis: PB 2021 Navy												Date: February 2020			
Appropriation/Budget Activity				R-1 Program Element (Number/Name)				Project (Number/Name)							
1319 / 4				PE 0603573N / <i>Advanced Surface Machinery Sys</i>				2471 / <i>Integrated Power Systems (IPS)</i>							
Product Development (\$ in Millions)				FY 2019		FY 2020		FY 2021 Base		FY 2021 OCO		FY 2021 Total			
Cost Category Item	Contract Method & Type	Performing Activity & Location	Prior Years	Cost	Award Date	Cost	Award Date	Cost	Award Date	Cost	Award Date	Cost	Cost To Complete	Total Cost	Target Value of Contract
Product Development	SS/FFP	Rolls Royce : Walpole, MA	37.903	0.080	Jun 2019	0.100	Nov 2019	0.100	Nov 2020	-		0.100	Continuing	Continuing	Continuing
Product Development	TBD	TBD : TBD	0.000	0.000		2.000	Jun 2020	17.268	Oct 2020	-		17.268	0.000	19.268	-
Product Development	C/FFP	DRS : DRS, Milwaukee WI	48.820	6.053	Mar 2019	6.607	Oct 2019	5.445	Oct 2020	-		5.445	Continuing	Continuing	Continuing
Product Development	C/CPFF	Various : Various	47.500	3.204	Oct 2018	3.900	Oct 2019	4.095	Oct 2020	-		4.095	Continuing	Continuing	Continuing
Product Development	WR	NSWCPD : Phila, PA	60.997	3.303	Oct 2018	3.352	Oct 2019	3.485	Oct 2020	-		3.485	Continuing	Continuing	Continuing
Cybersecurity	WR	NSWCPD : Phila, PA	8.243	3.231	Nov 2018	2.998	Nov 2019	2.835	Nov 2020	-		2.835	Continuing	Continuing	Continuing
Cybersecurity	C/CPIF	Boeing : Huntington Beach, CA	1.000	0.250	Feb 2019	0.250	May 2020	0.250	May 2021	-		0.250	Continuing	Continuing	Continuing
Cybersecurity	C/FP	Various HM&E Equipment Vendors : Various	1.998	0.000		0.250	Jan 2020	0.250	Jan 2021	-		0.250	Continuing	Continuing	Continuing
Cybersecurity	C/CPIF	Various : Various	3.266	0.215	Jan 2019	0.367	Jan 2020	0.024	Jan 2021	-		0.024	Continuing	Continuing	Continuing
Cybersecurity	C/CPFF	TBD Comp HW : TBD	0.000	1.200	Jul 2019	1.500	Nov 2019	1.000	Nov 2020	-		1.000	0.000	3.700	-
Cybersecurity	C/CPFF	JHU APL : Laurel, MD	2.631	1.125	Dec 2018	0.500	Nov 2019	1.000	Nov 2020	-		1.000	0.000	5.256	-
Cybersecurity	C/CPFF	TBD Tap-Agg : TBD	0.000	0.000		1.000	Nov 2019	0.400	Nov 2020	-		0.400	0.000	1.400	-
Cybersecurity	MIPR	Sandia National Labs : Albuquerque, NM	0.750	1.536	Nov 2018	1.000	Nov 2019	0.634	Nov 2020	-		0.634	0.000	3.920	-
Subtotal			213.108	20.197		23.824		36.786		-		36.786	Continuing	Continuing	N/A
Test and Evaluation (\$ in Millions)				FY 2019		FY 2020		FY 2021 Base		FY 2021 OCO		FY 2021 Total			
Cost Category Item	Contract Method & Type	Performing Activity & Location	Prior Years	Cost	Award Date	Cost	Award Date	Cost	Award Date	Cost	Award Date	Cost	Cost To Complete	Total Cost	Target Value of Contract
Test and Evaluation	WR	NSWCCD-SSES : Phila, PA	24.954	0.000		0.000		0.000		-		0.000	Continuing	Continuing	Continuing
Subtotal			24.954	0.000		0.000		0.000		-		0.000	Continuing	Continuing	N/A

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Exhibit R-3, RDT&E Project Cost Analysis: PB 2021 Navy												Date: February 2020			
Appropriation/Budget Activity 1319 / 4				R-1 Program Element (Number/Name) PE 0603573N / <i>Advanced Surface Machinery Sys</i>					Project (Number/Name) 2471 / <i>Integrated Power Systems (IPS)</i>						
Management Services (\$ in Millions)				FY 2019		FY 2020		FY 2021 Base		FY 2021 OCO		FY 2021 Total			
Cost Category Item	Contract Method & Type	Performing Activity & Location	Prior Years	Cost	Award Date	Cost	Award Date	Cost	Award Date	Cost	Award Date	Cost	Cost To Complete	Total Cost	Target Value of Contract
Management	C/CPFF	Herren Associates : Alexandria, VA	6.092	1.251	Oct 2018	1.584	Oct 2019	1.663	Oct 2020	-		1.663	Continuing	Continuing	Continuing
Subtotal			6.092	1.251		1.584		1.663		-		1.663	Continuing	Continuing	N/A
			Prior Years	FY 2019		FY 2020		FY 2021 Base		FY 2021 OCO		FY 2021 Total	Cost To Complete	Total Cost	Target Value of Contract
Project Cost Totals			244.154	21.448		25.408		38.449		-		38.449	Continuing	Continuing	N/A
Remarks															

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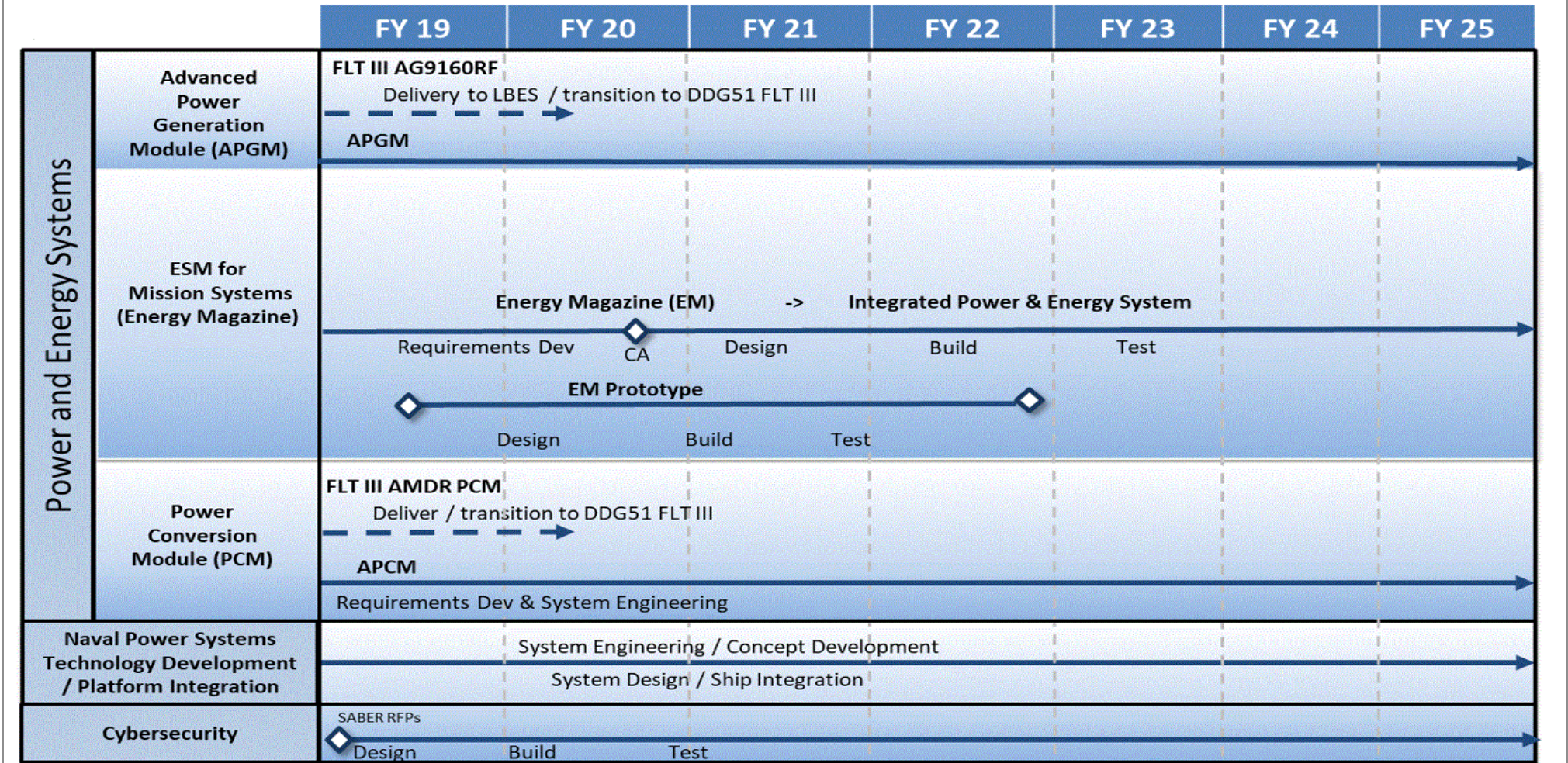
Exhibit R-4, RDT&E Schedule Profile: PB 2021 Navy

Date: February 2020

Appropriation/Budget Activity
1319 / 4

R-1 Program Element (Number/Name)
PE 0603573N / *Advanced Surface Machinery Sys*

Project (Number/Name)
2471 / *Integrated Power Systems (IPS)*



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Exhibit R-4A, RDT&E Schedule Details: PB 2021 Navy		Date: February 2020
Appropriation/Budget Activity 1319 / 4	R-1 Program Element (Number/Name) PE 0603573N / <i>Advanced Surface Machinery Sys</i>	Project (Number/Name) 2471 / <i>Integrated Power Systems (IPS)</i>

Schedule Details

Events by Sub Project	Start		End	
	Quarter	Year	Quarter	Year
Proj 2471				
Power and Energy Systems	1	2019	4	2025
Naval Power Technology Development / Platforms Integration & transition	1	2019	4	2025
Situational Awareness, Boundary Enforcement & Response (SABER) previously Cybersecurity BDC	1	2019	4	2025

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy **Date:** February 2020

Appropriation/Budget Activity 1319 / 4	R-1 Program Element (Number/Name) PE 0603573N / <i>Advanced Surface Machinery Sys</i>	Project (Number/Name) 9999 / <i>Congressional Adds</i>
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COST (\$ in Millions)	Prior Years	FY 2019	FY 2020	FY 2021 Base	FY 2021 OCO	FY 2021 Total	FY 2022	FY 2023	FY 2024	FY 2025	Cost To Complete	Total Cost
9999: <i>Congressional Adds</i>	0.000	4.824	62.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	66.824
Quantity of RDT&E Articles		-	-	-	-	-	-	-	-	-		

A. Mission Description and Budget Item Justification

Congressional Adds:

Silicon Carbide Power Modules (C447): FY 2019 of \$4.824M and FY 2020 of \$7.000M
 Advanced Power Electronics Integration (C540): FY 2020 of \$5.000M
 Surface Combatant Component-level Prototyping (C541): FY 2020 of \$50.000M

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

	FY 2019	FY 2020
Congressional Add: Silicon Carbide Power Modules FY 2019 Accomplishments: Commenced development of requirements and Silicon Carbide (SiC) Power Converter Simulation, Medium Voltage (MV) SiC Semiconductor Module Refinement and Validation, and MV SiC Semiconductor Module Endurance Test and Prototype Power Converter Development FY 2020 Plans: Continue SiC power module efforts including development, qualification, and systems integration. Specific efforts include SiC semiconductor module refinement and validation, endurance test and prototype power converter development, modeling, prototype power converter testing, etc.	4.824	7.000
Congressional Add: Advanced power electronics integration FY 2019 Accomplishments: N/A FY 2020 Plans: Initiate design integration efforts of Silicon Power Modules into a new 4-6MW advanced power conversion module with integrated energy storage known as the Flexible Bus Node.	0.000	5.000
Congressional Add: Surface combatant component-level prototyping FY 2019 Accomplishments: N/A FY 2020 Plans: Initiate design activities and build initiation of Integrated Power and Energy (IPES) Test Facility known as the "ITF" as a land based test facility by refurbishment and reuse of certain DDG1000 developmental power system components, and other prototype hardware to support advanced controls development and	0.000	50.000

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Exhibit R-2A, RDT&E Project Justification: PB 2021 Navy	Date: February 2020
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Appropriation/Budget Activity 1319 / 4	R-1 Program Element (Number/Name) PE 0603573N / <i>Advanced Surface Machinery Sys</i>	Project (Number/Name) 9999 / <i>Congressional Adds</i>
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B. Accomplishments/Planned Programs (\$ in Millions)	FY 2019	FY 2020
integration of distributed and federated energy storage into ship agnostic Tactical Energy Management for use on future surface ships.		
Congressional Adds Subtotals	4.824	62.000

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

N/A

Remarks

D. Acquisition Strategy

N/A

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Exhibit R-4A, RDT&E Schedule Details: PB 2021 Navy		Date: February 2020
Appropriation/Budget Activity 1319 / 4	R-1 Program Element (Number/Name) PE 0603573N / <i>Advanced Surface Machinery Sys</i>	Project (Number/Name) 9999 / <i>Congressional Adds</i>

Schedule Details

Events by Sub Project	Start		End	
	Quarter	Year	Quarter	Year
Proj 9999				
SiC Power Modules	2	2019	4	2021
Advanced Power Electronics Integration	2	2020	4	2021
Advanced Surface Component Prototyping	2	2020	4	2021