Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Office of the Secretary Of Defense	Date: February 2018
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide* / BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0604055D8Z / *Operational Energy Capability Improvement*

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
Total Program Element	224.936	41.459	38.403	40.582	-	40.582	40.652	41.387	42.032	42.803	Continuing	Continuing
455: *Operational Energy Capability Improvement*	206.773	41.459	38.403	40.582	-	40.582	40.652	41.387	42.032	42.803	Continuing	Continuing
456: *Hybrid Energy Storage Module (HESM)*	18.163	0.000	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	-	-

Note

None

A. Mission Description and Budget Item Justification

The basic mission of this program element is to fund innovation to improve the Department of Defense's (DoD) operational effectiveness via targeted operational energy science and technology (S&T) investments. It contains the two projects described below:

P455, the Operational Energy Capability Improvement Fund (OECIF), incentivizes S&T to promote long term change in DoD capabilities so they are better aligned with the Operational Energy Strategy. OECIF generally fosters innovation to improve operational energy performance and has two key mission aspects. First, to develop operational energy technologies and practices that will improve DoD military capabilities and possibly reduce costs. Second, to establish within the military Services institutional momentum to continue those innovations. OECIF funds serve as "seed money" to start or consolidate promising operational energy innovation to be sustained by the Services; accordingly, OECIF generally emphasizes supporting or establishing programs, rather than one-off projects.

P456, the Hybrid Energy Storage Module (HESM), co-sponsored by the Assistant Secretary of Defense for Research and Engineering (ASD(R&E)) and the Assistant Secretary of Defense for Energy, Installations and Environment (ASD(EIE)), develops advanced energy storage technologies to maximize performance and reliability, and enable future high power weapons and sensor systems on legacy and next generation vehicles, aircraft and ships. The goals of HESM are to (1) demonstrate energy storage systems with high power/energy densities, scalable to all power levels, that reduce total logistics demand, (2) increase platform ability to sustain operations during engagement, and (3) reduce maintenance. Once demonstration is complete, this technology will be sustained by the Services and will be used to extend the operational performance and safety for these applications beyond the hybrid storage module baseline design configuration. This program is closely coordinated with the Advanced Management and Protection of Energy-storage Devices (AMPED) program of the Department of Energy's (DOE) Advanced Research Projects Agency - Energy (ARPA-E).

Exhibit R-2, RDT&E Budget Item Justification: PB 2019 Office of the Secretary Of Defense	Date: February 2018
Appropriation/Budget Activity 0400: *Research, Development, Test & Evaluation, Defense-Wide I* BA 3: *Advanced Technology Development (ATD)*	**R-1 Program Element (Number/Name)** PE 0604055D8Z *I Operational Energy Capability Improvement*

B. Program Change Summary ($ in Millions)	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total
Previous President's Budget	37.329	38.403	40.914	-	40.914
Current President's Budget	41.459	38.403	40.582	-	40.582
Total Adjustments	4.130	0.000	-0.332	-	-0.332
• Congressional General Reductions	-	-			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	5.000	-			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-0.823	-			
• FFRDC Transfer	-0.047	-	-	-	-
• Economic Adjustment	-	-	-0.332	-	-0.332

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2017	FY 2018
Project: 455: *Operational Energy Capability Improvement*		
Congressional Add: *OECI*	4.953	0.000
Congressional Add Subtotals for Project: 455	4.953	0.000
Congressional Add Totals for all Projects	4.953	0.000

Change Summary Explanation

Economic adjustment directed for FY19 (EA-008 budget decision).

Exhibit R-2A, RDT&E Project Justification: PB 2019 Office of the Secretary Of Defense			Date: February 2018
Appropriation/Budget Activity 0400 / 3	R-1 Program Element (Number/Name) PE 0604055D8Z / *Operational Energy Capability Improvement*	Project (Number/Name) 455 / *Operational Energy Capability Improvement*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
455: *Operational Energy Capability Improvement*	206.773	41.459	38.403	40.582	-	40.582	40.652	41.387	42.032	42.803	Continuing	Continuing

Note

P455, the Operational Energy Capability Improvement Fund (OECIF), incentivizes S&T to promote long term change in DoD capabilities so they are better aligned with the Operational Energy Strategy. OECIF generally fosters innovation to improve operational energy performance and has two key mission aspects. First, to develop operational energy technologies and practices that will improve DoD military capabilities and possibly reduce costs. Second, to establish within the military Services institutional momentum to continue those innovations. OECIF funds serve as “seed money” to start or consolidate promising operational energy innovation to be sustained by the Services; accordingly, OECIF generally emphasizes supporting or establishing programs, rather than one-off projects.

A. Mission Description and Budget Item Justification

The basic mission of this program element is to fund innovation to improve the Department of Defense’s (DoD) operational effectiveness via targeted operational energy science and technology (S&T) investments.

P455, the Operational Energy Capability Improvement Fund (OECIF), incentivizes S&T to promote long term change in DoD capabilities so they are better aligned with the Operational Energy Strategy. OECIF generally fosters innovation to improve operational energy performance and has two key mission aspects. First, to develop operational energy technologies and practices that will improve DoD military capabilities and possibly reduce costs. Second, to establish within the military Services institutional momentum to continue those innovations. OECIF funds serve as “seed money” to start or consolidate promising operational energy innovation to be sustained by the Services; accordingly, OECIF generally emphasizes supporting or establishing programs, rather than one-off projects.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Operational Energy Capability Improvement Fund	36.506	38.403	40.582
Description: The basic mission of the OECIF is to fund innovation that will improve DoD operational effectiveness via targeted S&T investments. As Defense-Wide funding, it incentivizes S&T to promote long term change in DoD capabilities so they are better aligned with the Operational Energy Strategy. OECIF generally fosters innovation to improve operational energy performance and has two key mission aspects. First, to develop operational energy technologies and practices that will improve DoD military capabilities and possibly reduce costs. Second, to establish within the military Services institutional momentum to continue those innovations. OECIF funds serve as “seed money” to start or consolidate promising operational energy innovations to be sustained by the Services; accordingly, OECIF generally emphasizes supporting or establishing programs, rather than one-off projects.			
FY 2018 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Office of the Secretary Of Defense		Date: February 2018
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0604055D8Z / *Operational Energy Capability Improvement*	**Project (Number/Name)** 455 / *Operational Energy Capability Improvement*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
The TMSC program, which began in FY13, will still be active. TMSC will incorporate DoD and Service comments and publish the final draft for DoD approval. J-DEPLOI, which began in FY14, will still be active. J-DEPLOI plans to complete software development and testing, MBPS integration, and plan transition of the program to MPBS management and PACOM users. The FY15 vehicles program will continue. The Thermally Efficient Cylinders program will test the single-cylinder engine with an optimized coating and piston and will begin laboratory preparations for multi-cylinder testing. The TVEK program will complete the SIL testing with all sub-systems integrated into the vehicle, evaluate the sub-system fuel savings and M&S results from the Matlab Simulink and the Army Joint Operational Energy Initiative (JOEI) model to determine optimal kit architecture, start integration of kits in the HEMTT and LVSR vehicles, initiate electromagnetic interference testing of sub-systems, and develop vehicle test plans and agreements with testing facilities. The Automation/Smart Cruise Control program will complete Phase II by conducting convoy testing, deliver a final report, and provide the developed technology. The M&S for Light-Weighting program will incorporate novel materials for analysis and compare with the baseline system model. The FY16 unmanned vehicles programs will continue. The Reliable, Efficient, Tactical UAS Power System program will test the second generation engine for power output, specific fuel consumption, altitude, and product reliability. The Hybrid Tiger team will begin the flight testing phase validating the performance models and tuning flight controller gains, and refine software to emphasize optimal hybrid mode transitions and increased autonomy for soaring. The HTVE-UE program will continue base tasks related to component fabrication and breadboard assembly and testing, execute at-sea test planning, and perform initial system deployment; and continue studies and analyses related to FDECO interoperability, HTV characterization/ environmental considerations, and CONOPS. The Aluminum Seawater Power program will go through the next round of component development and testing, and begin integration testing. The Small Turboprop Engine Range/Power Enhancement program will begin engine detailed design and acquire long lead materials for engine fabrication. The JP-8 Based Fuel Cell Power program will conduct physical integration of the JP-8 reformer and solid oxide fuel cell and all supporting hardware, and conduct the first two iterations of system level testing to determine weak parts of the system design. The programs begun in FY17 will continue to ramp up during this fiscal year. New programs will start in FY18. The focus of these new programs is likely to reflect input from the Services, various research Communities of Interest within DoD, such as Energy and Power, Ground and Sea Platforms, and Air Platforms, and any developing gaps or opportunities identified by ODASD(OE). ***FY 2019 Plans:***			

Exhibit R-2A, RDT&E Project Justification: PB 2019 Office of the Secretary Of Defense		Date: February 2018
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0604055D8Z / *Operational Energy Capability Improvement*	**Project (Number/Name)** 455 / *Operational Energy Capability Improvement*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
The FY 2016 programs will reach their final year of OECIF funding. The IPTE program will complete detailed design, initiate hardware manufacturing for the engine demonstrators, and complete a combustor rig test. The Hybrid Tiger program will integrate energy and software systems to enable 24 hour and max endurance (100+ hour) demonstration flights; document performance, technical details, additional results, and paths forward; establish notional payload integration to determine mission utility and highlight transition path. The Aluminum Seawater Power program will go through breadboard hot-component test readiness review and testing and complete the breadboard full-system test readiness review and testing. The HTVE-UE program will conclude the at-sea testing, retrieve the device and analyze results while completing CONOPS and other studies and analyses as part of planning for transfer to other Navy S&T programs, which can further develop the technology for potential use by programs of record. The JP-8 Based Fuel Cell Power program will conduct the third iteration of the system integration with finalized control strategy and balance plant hardware and begin preparations on the vehicle for installation. The FY 2017 programs will continue. The OSCIPPT team will complete the second major release of the subsystem controls, the interface description document, and coordination control for the physical architecture defined in FY 2017; demonstrate fuel savings improvements on aircraft and ship platforms; and demonstrate improved response times within the power and thermal systems enabling use of future high power sensors and weapons on aircraft. The TEAPPS team will complete testing and modeling the first prototype thermal management system, design a sub-scale diode thermal management device with phase change materials, and identify the interfaces necessary to integrate an advanced thermal management system onto a Naval surface combatant. The PTROL team will further build upon the technology to apply laser power beaming to power remotely a rotary wing unmanned air vehicle at greater range than in previous demonstrations as an interim step towards a broadly-applicable and transition-able final capability to be delivered in FY 2021. The W-Band Power Beaming team will integrate the millimeter wave absorber and heat transfer assembly with the heat pipe and Stirling engine; perform short-range power beaming testing; transfer millimeter wave power from the gyrotron enclosure to the laboratory enclosure via existing waveguide hardware and beamed at the absorber using a short-range horn and mirror array. ***FY 2018 to FY 2019 Increase/Decrease Statement:*** FY18-FY19 Increase in funding ($2.179) Two of the FY17 congressional add programs are able to continue. Space Solar and HD HESM. SSP will fabricate and demonstrate the Rectenna Array (diodes and manifolded antenna) - the goal is to show energy harvesting with a 1 uW per square cm incipient radio frequency. Additionally, teaming with NASA for prior S&T investment capture and work with NREL on space solar cells will continue. HD HESM will execute hardware fabrication and assembly, complete initial factory acceptance testing, initiate HESM Test Program at the Air Force Research Lab, the Army Tank Automotive Research, Development and Engineering Center, and perform Navy platform analysis.			
Accomplishments/Planned Programs Subtotals	36.506	38.403	40.582

Exhibit R-2A, RDT&E Project Justification: PB 2019 Office of the Secretary Of Defense		Date: February 2018
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0604055D8Z / *Operational Energy Capability Improvement*	**Project (Number/Name)** 455 / *Operational Energy Capability Improvement*

	FY 2017	FY 2018
Congressional Add: OECI	4.953	0.000

FY 2017 Accomplishments: The Joint Operational Command and Control effort demonstrated the ability to pass operational energy information around the battlefield. Initial results show the ability to manually capture some limited operational energy information and provided it to decision makers within 24 hours of data capture. The team conducted a design update for the Asset Wireless Network (AWN) Common Communications Module, installed firmware updates and executed a contract with Penn State University for AWN support

Operational Energy Watson was able to demonstrate a minimum viable product centered on AF S&T investment in Hypersonics and specifically in high-temperature materials. OE Watson is developing a cognitive assistant that combines deep learning, quantitative analysis, and analytic wargames. Funding also allowed for adoption of a single knowledge management tool(SEMS2.0) re-purposing from SERDP/ESTCP to OECIF. The tool has been adapted for OECIF and the FY18 call of proposals and selection is utilizing this new capability.

Space Solar Power team held the program kickoff, discussed the application for potential users, and defined metrics of success. Initial focus is on current solar cell technology with additional investment in perovskites.

The Ultra High Density Hybrid Energy Storage Module effort (HD HESM) is a follow-on from P456. The team initiated contracting through the Air Force Research Lab for a new High Density System, developed cross service System Requirements (Navy, Army and AF), and initiated platform analysis for HD HESM installation and operation.

OECIF continues to co-sponsor, with SERDP/ESTCP, emerging Waste-to-Energy Technology development.

FY 2018 Plans: TMSC, FY 2013 program, transitions to Project Manager Expeditionary Energy and Sustainment Systems and submits the Standard to the Defense Standardization Program Office.
Two FY 2014 analytical methods and tools programs conclude. STORM-E will finalize EF 21 scenario development and analysis. J-DEPLOI will complete software development into MBPS, provide joint data integration, and complete verification and testing of J-DEPLOI capabilities.
FY 2015 vehicle efforts enter the final year of funding. The Automation/Smart Cruise Control program concludes convoy vehicle testing using smart cruise control. TVEK completes baselining performance data; integration and testing of the anti-idle system (DC/DC, inverter, motor/generator, 6T battery, HVAC, and cabin heating); electromagnetic interference testing on TVEK electrified components; and Functional and Preliminary Design Reviews. The Thermal Barrier Coatings program completes testing multiple iterations of coated pistons and

Exhibit R-2A, RDT&E Project Justification: PB 2019 Office of the Secretary Of Defense		Date: February 2018
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0604055D8Z / *Operational Energy Capability Improvement*	**Project (Number/Name)** 455 / *Operational Energy Capability Improvement*

	FY 2017	FY 2018
will configure the engine test cell for testing a thermocouple instrumented piston. The M&S for Lightweighting program completes M&S for emerging novel materials. The FY 2016 efforts continue. The Small Turboprop Engine Range/Power Enhancement program completes engine testing, and the IPTE completes preliminary engine design while acquiring engine fabrication material. The Reliable, Efficient, Tactical UAS Power System program will have an engine for testing. Hybrid Tiger completes airframe fabrication/energy system integration for first flight; evaluates energy performance; tunes software algorithms; refines benchtop assumptions with real-world flight measurements; updates the simulation to match measurements, and informs the hybrid energy design process. The Aluminum Seawater Power program completes breadboard combustor design review and performs testing; selects product-removal hardware and tests; and selects water replenishment hardware and tests. The HTVE-UE program continues tech development including pool testing and final preparations for 1-year at-sea test, continues studies and analyses related to HTV characterization/environmental considerations and various CONOPS. The JP-8 Based Fuel Cell Power program conducts physical integration of the JP-8 reformer and solid oxide fuel cell and all supporting hardware; and conducts the first two iterations of system level tests to shape system design. The FY 2017 efforts continue. The OSCIPPT team completes first release of the subsystem controls, the interface description document, and the coordination control for FY2017 physical architecture. TEAPPS identifies candidate thermal management system architectures and control schemes using the validated dynamic thermal modeling toolset, tests the thermal performance of a single-diode advanced thermal packaging module with phase change material, and completes fabrication of the first of two prototype thermal management systems for demonstration. PTROL team integrates and test systems for two FY 2018 demonstrations: laser power sent over optical fiber to an Unmanned Underwater Vehicle (UUV), and greater than 500W of power transmitted over 300m to a stationary receiver. The W-Band Power Beaming team completes high power testing of samples of promising ceramic absorber materials developed in the first two years; completes modeling and fabrication of the Sterling engine heat pipe; and models collector antenna, integrated absorber, and heat transfer interface. SSP designs models electromagnetic antennas and manifolding; completes efficiency and sensitivity simulations of discrete rectifier; models rf to dc sensitivity, harvesting beam width, and interaction between rectifier loading and Rectenna. FY 2018 will be 1-year studies that illuminate S&T Gaps for Operational Energy in the near-, mid-, and far-term. These efforts are expected to be complete and shape and influence the next DoD OE Strategy.		
Congressional Adds Subtotals	4.953	0.000

C. Other Program Funding Summary ($ in Millions)

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2019 Office of the Secretary Of Defense		Date: February 2018
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0604055D8Z / *Operational Energy Capability Improvement*	**Project (Number/Name)** 455 / *Operational Energy Capability Improvement*

C. Other Program Funding Summary ($ in Millions)

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

None

Exhibit R-2A, RDT&E Project Justification: PB 2019 Office of the Secretary Of Defense			Date: February 2018
Appropriation/Budget Activity 0400 / 3	R-1 Program Element (Number/Name) PE 0604055D8Z / *Operational Energy Capability Improvement*	Project (Number/Name) 456 / *Hybrid Energy Storage Module (HESM)*	

COST ($ in Millions)	Prior Years	FY 2017	FY 2018	FY 2019 Base	FY 2019 OCO	FY 2019 Total	FY 2020	FY 2021	FY 2022	FY 2023	Cost To Complete	Total Cost
456: *Hybrid Energy Storage Module (HESM)*	18.163	0.000	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	-	-

A. Mission Description and Budget Item Justification

P456, the Hybrid Energy Storage Module (HESM), co-sponsored by the Assistant Secretary of Defense for Research and Engineering (ASD(R&E)) and the Assistant Secretary of Defense for Energy, Installations and Environment (ASD(EIE)), develops advanced energy storage technologies to maximize performance and reliability, and enable future high power weapons and sensor systems on legacy and next generation vehicles, aircraft and ships. The goals of HESM are to (1) demonstrate energy storage systems with high power/energy densities, scalable to all power levels, that reduce total logistics demand, (2) increase platform ability to sustain operations during engagement, and (3) reduce maintenance. Once demonstration is complete, this technology will be sustained by the Services and will be used to extend the operational performance and safety for these applications beyond the hybrid storage module baseline design configuration. This program is closely coordinated with the Advanced Management and Protection of Energy-storage Devices (AMPED) program of the Department of Energy's (DOE) Advanced Research Projects Agency - Energy (ARPA-E).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2017	FY 2018	FY 2019
Title: Hybrid Energy Storage Module (HESM)	0.000	0.000	0.000
Description: Co-sponsored by the Assistant Secretary of Defense for Research and Engineering (ASD(R&E)) and the Assistant Secretary of Defense for Energy, Installations and Environment (ASD(EIE)), develops advanced energy storage technologies to maximize performance and reliability, and enable future high power weapons and sensor systems on legacy and next generation vehicles, aircraft and ships. The goals of HESM are to (1) demonstrate energy storage systems with high power/ energy densities, scalable to all power levels, that reduce total logistics demand, (2) increase platform ability to sustain operations during engagement, and (3) reduce maintenance. Once demonstration is complete, this technology will be sustained by the Services and will be used to extend the operational performance and safety for these applications beyond the hybrid storage module baseline design configuration. This program is closely coordinated with the Advanced Management and Protection of Energy-storage Devices (AMPED) program of the Department of Energy's (DOE) Advanced Research Projects Agency - Energy (ARPA-E). ***FY 2018 Plans:*** Additional capability funded with FY17 Congressional Add money in P455 will continue. ***FY 2019 Plans:*** Additional capability funded with FY17 Congressional Add money in P455 will continue.			
Accomplishments/Planned Programs Subtotals	0.000	0.000	0.000

Exhibit R-2A, RDT&E Project Justification: PB 2019 Office of the Secretary Of Defense		Date: February 2018
Appropriation/Budget Activity 0400 / 3	**R-1 Program Element (Number/Name)** PE 0604055D8Z / *Operational Energy Capability Improvement*	**Project (Number/Name)** 456 / *Hybrid Energy Storage Module (HESM)*

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

None