Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Army											Date: March 2019	
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 2: *Applied Research*					R-1 Program Element (Number/Name) PE 0602705A / *Electronics and Electronic Devices*							
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	-	90.613	96.760	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	187.373
EM4: *Electric Component Technologies (CA)*	-	33.000	38.500	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	71.500
EM8: *High Power And Energy Component Technology*	-	10.416	12.575	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	22.991
H11: *Tactical And Component Power Technology*	-	8.215	7.655	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	15.870
H17: *Flexible Display Center*	-	2.063	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	2.063
H94: *Elec & Electronic Dev*	-	36.919	38.030	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	74.949

Note

In Fiscal Year (FY) 2020 this Program Element (PE) is being realigned, with continuity of effort realigned to the following PEs:
* PE 0602143A Soldier Lethality Technology
* PE 0602144A Ground Technology
* PE 0602145A Next Generation Combat Vehicle Technology
* PE 0602146A Network C3I Technology
* PE 0602148A Future Vertical Lift Technology
* PE 0602150A Air and Missile Defense Technology

A. Mission Description and Budget Item Justification

This PE designs and evaluates power components and power management technologies, frequency control and timing devices, high power microwave devices, display technologies, and electronic components. The applied research on these technologies enable the ability to perform precision deep fires against critical mobile and fixed targets; investigate all-weather, day or night, theater air defense against advanced enemy missiles and aircraft; as well as investigate enhanced communications and target acquisition through support of capabilities such as autonomous missile systems, advanced land combat vehicles, smart anti-tank munitions, electric weapons, secure jam-resistant communications, automatic target recognition, foliage-penetrating radar, and combat identification. Project EM8 designs and evaluates high-power electronic components and technologies. Project H11 designs, investigates and validates advanced power and energy technologies (batteries, alternative energy and hybrids) and power management and distribution techniques (wireless power, intelligent power management). Project H17 designs and evaluates flexible displays in conjunction with the Flexible Display Center. Project H94 researches and evaluates electronic component technologies such as photonics, micro electromechanical systems, imaging laser radar, magnetic materials, ferroelectrics, microwave and millimeter-wave components, and electromechanical systems.

Work in this PE complements and is fully coordinated with efforts in PE 0602120A (Sensors and Electronic Survivability), PE 0602307A (Advanced Weapons Technology), PE 0602709A (Night Vision Technology), PE 0602782A (Command, Control, Communications Technology), PE 0602783A (Computer and Software

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Army	Date: March 2019
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army I* BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602705A *I Electronics and Electronic Devices*

Technology), PE 0603001A (Warfighter Advanced Technology), PE 0603004A (Weapons and Munitions Advanced Technology), and PE 0603772A (Advanced Tactical Computer Science and Sensor Technology).

All FY20 adjustments align program financial structure to Army Modernization Priorities in support of the National Defense Strategy.

The cited work is consistent with the Under Secretary of Defense for Research and Engineering priority focus areas and the Army Modernization Strategy.

Work in this Project is performed by the United States Army Futures Command (AFC).

B. Program Change Summary ($ in Millions)	FY 2018	FY 2019	FY 2020 Base	FY 2020 OCO	FY 2020 Total
Previous President's Budget	58.352	58.283	57.741	-	57.741
Current President's Budget	90.613	96.760	0.000	-	0.000
Total Adjustments	32.261	38.477	-57.741	-	-57.741
• Congressional General Reductions	-0.015	-0.023			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	33.000	38.500			
• Congressional Directed Transfers	-	-			
• Reprogrammings	-	-			
• SBIR/STTR Transfer	-0.724	-			
• Adjustments to Budget Years	-	-	-57.741	-	-57.741

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2018	FY 2019
Project: EM4: *Electric Component Technologies (CA)*		
Congressional Add: *Flexible Hybrid Electronics Tech*	7.000	5.000
Congressional Add: *Protective & Anti-Tamper Tech for Electronic Attack*	10.000	-
Congressional Add: *Silicon Carbide Electronics Research*	16.000	20.000
Congressional Add: *Position Navigation Timing Systems*	-	8.500
Congressional Add: *Tactical Power Generation and Storage Systems*	-	5.000
Congressional Add Subtotals for Project: EM4	33.000	38.500
Congressional Add Totals for all Projects	33.000	38.500

Exhibit R-2, RDT&E Budget Item Justification: PB 2020 Army	Date: March 2019
Appropriation/Budget Activity 2040: *Research, Development, Test & Evaluation, Army* / BA 2: *Applied Research*	**R-1 Program Element (Number/Name)** PE 0602705A / *Electronics and Electronic Devices*

Change Summary Explanation

FY18 increase related to congressional add funding of $33 Million
FY19 increase related to congressional add funding of $38.5 Million
FY20 decrease related to Science and Technology financial restructuring

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army			Date: March 2019
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602705A / *Electronics and Electronic Devices*	Project (Number/Name) EM4 / *Electric Component Technologies (CA)*	

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
EM4: *Electric Component Technologies (CA)*	-	33.000	38.500	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	71.500

A. Mission Description and Budget Item Justification

Congressional Interest Item funding for Electronics and Electronic Component applied research.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019
Congressional Add: Flexible Hybrid Electronics Tech ***FY 2018 Accomplishments:*** Flexible Hybrid Electronics Tech ***FY 2019 Plans:*** Flexible Hybrid Electronics Tech	7.000	5.000
Congressional Add: Protective & Anti-Tamper Tech for Electronic Attack ***FY 2018 Accomplishments:*** Protective & Anti-Tamper Tech for Electronic Attack	10.000	-
Congressional Add: Silicon Carbide Electronics Research ***FY 2018 Accomplishments:*** Silicon Carbide Electronics Research ***FY 2019 Plans:*** Silicon Carbide Electronics Research	16.000	20.000
Congressional Add: Position Navigation Timing Systems ***FY 2019 Plans:*** Position Navigation Timing Systems	-	8.500
Congressional Add: Tactical Power Generation and Storage Systems ***FY 2019 Plans:*** Tactical Power Generation and Storage Systems	-	5.000
Congressional Adds Subtotals	33.000	38.500

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602705A / *Electronics and Electronic Devices*	**Project (Number/Name)** EM4 / *Electric Component Technologies (CA)*

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army											Date: March 2019	
Appropriation/Budget Activity 2040 / 2					R-1 Program Element (Number/Name) PE 0602705A / *Electronics and Electronic Devices*				Project (Number/Name) EM8 / *High Power And Energy Component 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**
EM8: *High Power And Energy Component Technology*	-	10.416	12.575	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	22.991

Note

In Fiscal Year (FY) 2020 this Project is being realigned to:
Program Element (PE) 0602145A Next Generation Combat Vehicle
* Project BF8 Artificial Intelligence & Machine Learning Tech
* Project BH7 Enhanced VETRONICS Technology
PE 0602146A Network C3I Technology
* Project AO2 Stand-In Advanced RF Effects (STARE)
* Project AP4 CEMA Camouflage Technology
* Project AP5 Electronics Warfare Technology
PE 0602150A Air and Missile Defense Technology
* Project AD2 High Energy Laser (HEL) Enabling and Support Tech

A. Mission Description and Budget Item Justification

This Project provides for the research, development, and evaluation of high-power electronic components, materials, and related technologies. These technologies have application in compact and efficient power conversion, conditioning, and management sub-systems; energy storage and conversion devices; radio frequency (RF)/ microwave and solid-state laser directed energy weapons (DEW); traditional and non-traditional RF and laser electronic attack; and RF photonics. All project elements are coordinated with, and as appropriate leveraged by, DEW and power/energy programs in the Air Force, Navy, High Energy Laser Joint Technology Office, Defense Threat Reduction Agency, national labs, university consortia, and relevant industry and foreign partners. The products of this research are required by developers of Army and Department of Defense (DoD) systems to evolve traditional (mechanical-based) sub-systems such as geared transmissions, plate armor, and kinetic projectiles to electrically-based ones. These products will provide the Soldier enhanced survivability and lethality through increased power management and energy savings as well as new fighting capabilities offered only by electrical power.

This Project sustains Army science and technology efforts supporting the Ground Maneuver, Lethality, Soldier and Command, Control, Communications and Intelligence Portfolios.

The work in this Project is coordinated with the Army Tank and Automotive Research, Development, and Engineering Center (TARDEC); Armaments Research, Development, and Engineering Center (ARDEC); the Army Aviation and Missile Research, Development, and Engineering Center (AMRDEC); and the Army Communications-Electronics Research, Development, and Engineering Center (CERDEC); and the United States Army Space and Missile Defense Command/Army Forces Strategic Command (USASMDC/ARSTRAT).

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602705A / *Electronics and Electronic Devices*	**Project (Number/Name)** EM8 / *High Power And Energy Component Technology*

All FY20 adjustments align program financial structure to Army Modernization Priorities in support of the National Defense Strategy.

The cited work is consistent with the Under Secretary of Defense for Research and Engineering priority focus areas and the Army Modernization Strategy.

Work in this Project is performed by the United States Army Futures Command (AFC).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Advanced Solid-State Laser Technology and Integrated Photonic Technologies	1.790	2.000	-
Description: Research novel solid-state laser concepts, architectures, and components with the goal of providing advanced laser technology to Army directed energy weapon and tactical laser developers. Exploit breakthroughs in laser technology, develop and employ innovative laser gain material, and utilize photonics to meet the stringent weight/volume requirements for Army platforms, especially to enhance and improve the generation, transmission, reception, and processing of RF signals. Applied laser research will be conducted in close collaboration with domestic and foreign material vendors, university researchers, and major laser diode manufacturers ***FY 2019 Plans:*** Investigate innovative fully crystalline fiber designs, in particular, the ?crystalline core/crystalline cladding? design (a.k.a. CCCC or C4) developed to enable high energy laser power scaling out of single fiber laser aperture to >10X compared to the current state-of-the-art; explore alternative Raman fiber designs for power scaling of direct diode cladding pumped Raman fiber lasers; and develop structures, devices, and architectures to enable optical phased arrays capable of free space optical communications and ranging, and timing and position synchronization needed for mobile platforms. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This research effort was realigned PE 0602150A (Air and Missile Defense Technology) / Project AD2 (High Energy Laser (HEL) Enabling and Support Tech) in FY20 as part of financial restructuring.			
Title: Electronic Attack Technologies/Spectrum Sensing and Exploitation	2.456	1.788	-
Description: This effort investigates emerging technologies related to electronic warfare (EW) applications, non-kinetic survivability/lethality, and emerging concepts of operation, such as cognitive radar, in the increasingly contested and congested electromagnetic environment, with the goal of enhancing the survivability/lethality of Army platforms through electronic attack (EA), electronic warfare support (ES), and electronic protection (EP). ***FY 2019 Plans:*** Develop neutralization techniques for autonomous vehicles; will investigate remote determination of target susceptibility; and explore next-generation cognitive radar performance in realistic congested and contested spectral environment. Design and			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602705A / *Electronics and Electronic Devices*	**Project (Number/Name)** EM8 / *High Power And Energy Component Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
develop EA, ES, and EP tools, techniques and methodologies for the highest priority Army systems and technologies for which electronic warfare is a critical threat. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This research effort was realigned to PE 0602146A (Network C3I Technology) / Project AP5 (Electronic Warfare Technology) in FY20 as part of the financial restructuring.			
Title: Electronic Components and Materials Research ***Description:*** Investigate compact, high-efficiency, high-temperature, and high-power component technologies (e.g., semiconductor, magnetic, and dielectric devices) for hybrid-electric propulsion, electric power generation and conversion, and smart micro-grid power distribution. Research addresses current and future Army-unique performance and operational requirements. ***FY 2019 Plans:*** Perform measurements on aluminum gallium nitride (AlGaN) high electron mobility transistor (HEMT) devices to demonstrate improved efficiencies and breakdown characteristics based on enhanced ohmic contacts, locally doped p-type regions using ion implantation, and AlGaN films grown on either high quality GaN or aluminum nitride (AlN) substrates; refine high speed motor drive model and utilize model to study wide bandgap (WBG) device performance; characterize WBG device performance using the motor test stand; and investigate WBG devices for high speed high voltage motor drives and tactical power conversion. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This research effort was realigned to PE 0602145A (Next Generation Combat Vehicle) / Project BH7 (Enhanced VETRONICS Technology) in FY20 as part of the financial restructuring.	2.993	3.090	-
Title: Power System Components Integration and Control Research ***Description:*** Research the configuration of electronic components and control strategies required to achieve high-power density and high-efficiency power utilization in current and future platform sub-systems, and vehicle and micro-grid (installation) applications, to include the operation of military-specific power distribution topologies at the circuit and system levels.	3.177	-	-
Title: Advanced Distributed Power for Autonomous Plaforms ***Description:*** The effort investigates power distribution and conversion technologies to provide compact, efficient, and high power capabilities for electrical and electro-mechanical loads supporting both mobile and stationary platforms. High voltage and intelligent control methods will be coupled with the ongoing research in autonomy technologies to provide advanced performance enhancements in mobility and capabilities for these platforms. Research on innovative electric machines covering both electrical generation and motor technologies will focus on providing efficient, power dense, fault tolerant generation and	-	1.405	-

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602705A / *Electronics and Electronic Devices*	**Project (Number/Name)** EM8 / *High Power And Energy Component Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
mobility capabilities. Research addresses current and future Army-unique power delivery challenges in compact autonomous air and ground platforms. ***FY 2019 Plans:*** Investigate power control topologies that provide low speed high torque motor operation; explore power distribution and conversion methods for power generation that enhance fault tolerance and provide graceful degradation; investigate high voltage switching and power packaging for application in conversion and distribution for autonomous platform mobility and power generation; and perform research in compact power switching, conversion and distribution technologies to produce fast, high energy electrical discharge to provide unique mobility enhancements through application of high voltage phenomenology. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This research effort was realigned to PE 0602145A (Next Generation Combat Vehicle) / Project BF8 (Artificial Intelligence & Machine Learning Tech) in FY20 as part of the financial restructuring.			
Title: RF Electronic Attack/Surveillance (Grey C3) ***Description:*** Investigate emerging technologies to enable EW applications in a grey environment. The goal is to develop software and reconfigurable RF hardware in a handheld form factor for distributed electronic attack, distributed EW support, and communications. EW support includes advanced passive and active RF sensing. ***FY 2019 Plans:*** Investigate techniques for distributed EA and ES from handheld platforms; and validate commercial off-the-shelf (COTS) and government off-the-shelf (GOTS) software-defined radios for use as surrogate development hardware. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This research effort was realigned to PE 0602146A (Network C3I Technology) / Project A02 (Stand-In Advanced RF Effects (STARE)) in FY20 as part of the financial restructuring.	-	2.000	-
Title: Vulnerability Analysis Methodology for CEMA threats ***Description:*** Research and investigate the optimum configuration of experimental and analysis methodology for separate and combined cyber and electromagnetic threat attack so as to better support and inform Army system designers, analysts, evaluators, and decision makers. ***FY 2019 Plans:***	-	2.000	-

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602705A / *Electronics and Electronic Devices*	**Project (Number/Name)** EM8 / *High Power And Energy Component Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Design and develop a vulnerability analysis and susceptibility profile methodology based on current simulation and experimental methods for cyber and electromagnetic threats. Investigate and validate methodology to improve Protect, Detect, React, and Restore assessments through automation and advanced analytics. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This research effort was realigned to PE 0602146A (Network C3I Technology) / Project AP4 (CEMA Camouflage Technology) in FY20 as part of the financial restructuring.			
Title: FY 2019 SBIR / STTR Transfer ***Description:*** FY 2019 SBIR / STTR Transfer ***FY 2019 Plans:*** FY 2019 SBIR / STTR Transfer ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2019 SBIR / STTR Transfer	-	0.292	-
Accomplishments/Planned Programs Subtotals	10.416	12.575	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army			Date: March 2019
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602705A / *Electronics and Electronic Devices*	Project (Number/Name) H11 / *Tactical And Component Power 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
H11: *Tactical And Component Power Technology*	-	8.215	7.655	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	15.870

Note

In Fiscal Year (FY) 2020 this Project is being realigned to:
Program Element (PE) 0602143A Soldier Lethality Technology
* Project BD8 Soldier & SM Unit Tactical Energy Tech
PE 0602148A Future Vertical Lift Technology
* Project AM4 Opt Energy Stg & Therm Mgmt for FVL Survivability

A. Mission Description and Budget Item Justification

This Project identifies, advances, and enhances emerging power generation, energy storage, and power management components and software. This Project researches advancements in enabling power management, rapid decision making, expeditionary maneuver, and distributed operations across the battlefield. This Project also researches materials and components to develop lightweight, higher capacity, safer and more efficient power technologies that will enable continuous and energy aware operations while on the move and across battlefield environments.

All FY20 adjustments align program financial structure to Army Modernization Priorities in support of the National Defense Strategy.

The cited work is consistent with the Under Secretary of Defense for Research and Engineering priority focus areas and the Army Modernization Strategy.

Work in this Project is performed by the United States Army Futures Command (AFC).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Tactical Power Generation Technology	3.508	2.906	-
Description: This effort designs, investigates and validates Soldier-borne power generation and energy storage technologies in order to decrease Soldier load and power burden, and increase power capabilities by providing more energy to prolong mission run-time. This effort will investigate energy harvesting devices while on the move which will enable a continuous operations and reduced logistics for the Soldier. This effort will also investigate advanced hybrid battery chemistries for wearable, flexible battery designs.			
FY 2019 Plans: Will complete optimization of electromechanical component technology designs in kinetic energy harvesting devices for maximum power generation and conversion efficiency to enable continuous, distributed operations; continue investigation of power			

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602705A / *Electronics and Electronic Devices*	**Project (Number/Name)** H11 / *Tactical And Component Power Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
generating techniques with significant power densities including ultra-capacitor technology; complete the optimization and integration of high voltage cathode materials into representative battery cells to validate designs and assess energy density advancements; complete the development of Silicon Anode and Lithium Sulfur cell materials for advanced lithium primary and rechargeable battery cell packs that enables a 2x improvement in performance; research novel chemistries and balance of plant materials for smaller, lighter, wearable / portable fueled power sources to enable continuous power generation and platoon battery charging. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This research effort was realigned to PE 0602143A (Soldier Lethality Technology) / Project BD8 (Soldier & SM Unit Tactical Energy Tech) in FY20 as part of the financial restructuring.			
Title: Energy Informed Operations ***Description:*** This effort investigates power management technologies, components and systems to increase the efficiency of energy output, reduce weight and increase reliability, while increasing fuel and cost efficiency across battlefield environments. This effort funds research in control and interface standards for effective power management, novel power distribution techniques, situational awareness, predictive, and prognostic and diagnostics capabilities for tactical power missions. This effort will also investigate scalable brass board designs for power management and distribution in support of missions in the 60 kilowatt (kW) ? 360kW range	4.707	-	-
Title: Optimized Energy for C4ISR Platforms ***Description:*** This effort investigates power and thermal management associated with high power Command, Control, Communications, computers, Intelligence, Surveillance and Reconnaissance (C4ISR) capabilities on ground and air platforms enabling enhanced mobility and mission flexibility. This effort funds research to improve platform efficiency through the use of on-demand hybrid power architectures, while also researching ways to eliminate platform thermal constraints. This effort will also investigate very high density power sources and energy storage for high rate pulsed power, power management and thermal management for dynamic high rate pulsed power. ***FY 2019 Plans:*** Will investigate power requirements for emerging C4ISR capabilities to include directed energy, lasers, high power sensors, and electromagnetic weapons; conduct analysis of size, weight and power requirements necessary to support these capabilities with unique very high density power sources and energy storage for high rate pulsed power; identify interface requirements and constraints for power system; investigate architectures and intelligent controls necessary to manage these loads; investigate and perform high resolution characterization of cyclical, step and high power load profiles likely to result from use of lasers or other high power, short duration burst technology; examine thermal implications and waste heat generated from inefficiencies in power	-	4.647	-

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army		Date: March 2019
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602705A / *Electronics and Electronic Devices*	**Project (Number/Name)** H11 / *Tactical And Component Power Technology*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
conversation; explore hybrid energy storage technologies to support cyclical loads such as hybrid batteries or ultra-capacitor technology; determine duel use potential of microwave or laser power transmission technologies with other developmental operational uses; conduct experiments on wireless power transmission capabilities for laser power transmission; explore the use of intelligent control strategies for platform integrated power systems. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** The research effort was realigned to PE 0602148A (Future Vertical Lift Technology) / Project AM4 (Energy Stg & Therm Mgmt for FVL Survivability) in FY20 as part of the financial restructuring.			
Title: FY 2019 SBIR / STTR Transfer ***Description:*** FY 2019 SBIR / STTR Transfer ***FY 2019 Plans:*** FY 2019 SBIR / STTR Transfer ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2019 SBIR / STTR Transfer	-	0.102	-
Accomplishments/Planned Programs Subtotals	8.215	7.655	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army			Date: March 2019
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602705A / *Electronics and Electronic Devices*	Project (Number/Name) H17 / *Flexible Display Center*	

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
H17: *Flexible Display Center*	-	2.063	0.000	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	2.063

Note

This Project concluded in Fiscal Year (FY) 2018.

A. Mission Description and Budget Item Justification

The flexible electronics program conducts applied research on the integration of electronics, power components, and sensors on non-traditional flexible substrates. The program builds upon two-dimensional (2D) flexible electronics to incorporate the integration of electronic components, power systems, and sensors into three-dimensional (3D) flexible architectures. The research includes electronic modeling, design, fabrication, and analysis. The applied research supports the demonstration of Army-relevant sensors on flexible substrates for Army applications such as monitoring of the human state.

This Project supports Army science and technology efforts in the Command, Control, Communications and Intelligence portfolio.

The cited work is consistent with the Under Secretary of Defense for Research and Engineering priority focus areas and the Army Modernization Strategy.

Work in this Project is performed by the United States Army Futures Command (AFC).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Flexible Electronics Development (previously Flexible Display Center (FDC) and Flexible Electronics Development)	2.063	-	-
Description: The flexible electronics program is advancing applied research towards the integration of electronics, power components, and sensors on non-traditional flexible substrates and into 3D architectures.			
Accomplishments/Planned Programs Subtotals	2.063	-	-

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A

Exhibit R-2A, RDT&E Project Justification: PB 2020 Army			Date: March 2019
Appropriation/Budget Activity 2040 / 2	R-1 Program Element (Number/Name) PE 0602705A / *Electronics and Electronic Devices*	Project (Number/Name) H94 / *Elec & Electronic Dev*	

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
H94: *Elec & Electronic Dev*	-	36.919	38.030	0.000	-	0.000	0.000	0.000	0.000	0.000	0.000	74.949

Note

In Fiscal Year (FY) 2020 this Project is realigned to:
Program Element (PE) 0602143A Soldier Lethality Technology
* Project BD8 Soldier & Sm Unit Tactical Energy Tech
PE 0602144A Ground Technology
* Project BL1 Materials and Manufacturing Research Technology
PE 0602145A Next Generation Combat Vehicle
* Project BI2 Sensor Protection Technology
* Project BJ3 Hydrogen Based Combat System Technology
PE 0602146A Network C3I Technology
* Project AO4 Energy Efficient Devices Technology
* Project AV5 Protective Technologies
* Project AV9 Advanced PNT for GPS Independent Environments Tech
PE 0602148A Future Vertical Lift Technology
* Project AK2 Aviation Survivability Technology
* Project AL8 Holistic Situational Awareness and Dec Making Tech
PE 0602150A Air and Missile Defense Technology
* Project AD5 Next Generation Fires Radar Technology

A. Mission Description and Budget Item Justification

This Project designs and characterizes electronics, electronic components, and electronic devices for Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) applications and battlefield power and energy applications. Significant areas of component research relevant to C4ISR include: antennas, millimeter wave components and imaging, micro- and nano-technology, eye-safe laser radar (LADAR), vision and sensor protection, infrared (IR) imaging, photonics, and prognostics and diagnostics. Areas of research relevant to power and energy include power and thermal management, micro-power generators and advanced batteries, fuel reformers, fuel cells for hybrid power sources, and photosynthetic routes to fuel and electricity.

This Project supports Army science and technology efforts in the Command Control and Communications, Soldier, Ground and Air portfolios. Work in this Project is fully coordinated with PE 0602709A (Night Vision Technology), PE 0603001A (Warfighter Advanced Technology), PE 0603004A (Weapons and Munitions Advanced Technology), PE 0603005A (Combat Vehicle and Automotive Advanced Technology), and PE 0603313A (Missile and Rocket Advanced Technology).

All FY20 adjustments align program financial structure to Army Modernization Priorities in support of the National Defense Strategy.

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The cited work is consistent with the Under Secretary of Defense for Research and Engineering priority focus areas and the Army Modernization Strategy.

Work in this Project is performed by the United States Army Futures Command (AFC).

B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
Title: Antennas, Microwave Components, and Millimeter Wave Imaging ***Description:*** This effort designs, characterizes, and validates high performance antennas, microwave components, and software for multifunction radar, radio frequency (RF) sensing, and communication systems. Research areas include scanning techniques, broadbanding, beamforming, polarization, platform integration, and affordability. For microwave components, research areas include software defined radios, analog-to-digital conversion rates, bandwidth resolution, bit accuracy, circuit design and affordability. ***FY 2019 Plans:*** Perform in-situ simulations of low-profile antennas and propagation; integrate and characterize new antenna and RF electronics to improve the performance of the helicopter situational awareness radar and study the fusion of these radars with other hostile fire sensor modalities; enhance efforts for material driven antenna designs to include evolving antenna additive manufacturing through the investigation of higher dielectric feed stock and conductive printed metals; produce novel, complex and conformal multiband array designs that are not cost effective to produce with current commercial materials; design enabling components for transmitter architectures that supports complex digital modulations in the presence of very strong nonlinearities; study enabling devices and integrated circuits at millimeter-wave frequencies at the advent of 5G and newly competed spectrum; develop machine learning techniques/algorithms for RF modulation recognition. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This research effort was realigned to PE 0602148A (Future Vertical Lift Technology) / Project AL8 (Holistic Situational Awareness and Dec Making Tech) and PE 0602150A (Air and Missile Defense Technology) / Project AD5 (Next Generation Fires Radar Technology) in FY20 as part of the financial restructuring.	5.407	5.681	-
Title: Advanced Micro and Nano Devices ***Description:*** This effort designs and characterizes micro- and nano-technology components for multi-functional and integrated RF applications, micro-robotics, integrated energetics, control sensor interfaces, and sensors for improved battlefield situational awareness.	1.947	-	-
Title: Survivability for Wireless Tactical Networks (formerly Security and Survivability for Wireless Tactical Networks) ***Description:*** This effort researches, designs and implements protocols and algorithms for networks of physical devices and autonomous systems operating under severe energy and bandwidth constraints, and which are vulnerable to adversarial	1.567	0.750	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
infiltration. The objective is to enhance the performance and survivability of these tactical wireless networks through improved monitoring and detection of network problems, resulting from both adversarial activity and the operating environment, and through proactive adaption of the computer and network routers to these dynamics. ***FY 2019 Plans:*** Investigate and develop cognitive networking algorithms that optimize media access control scheduling and network routing in resource constrained (e.g. energy, processing), congested and contested environments; implement energy and computationally efficient techniques to determine if resource constrained devices have been infiltrated and corrupted by an adversary; investigate approaches for adapting and optimizing communication modalities in response to adversarial activity; implement techniques for simulating and emulating large scale networks to enable analyzing the behavior of complex systems of networks in complex tactical operating environments. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort concludes after FY19.			
Title: Sensor Protection ***Description:*** This effort develops and characterizes materials for protection of electro-optic (EO) systems from lasers. ***FY 2019 Plans:*** Mature EO materials and supporting electronic components; validate speed and degree of protection of large-area EO shutters; conduct experiments to determine performance of tunable longwave IR filter designs. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This research effort was realigned to PE 0602145A (Next Generation Combat Vehicle) / Project BI2 (Sensor Protection Technology) in FY20 as part of the financial restructuring.	2.914	4.625	-
Title: Applied Photonic and Optoelectronic Devices (formerly Hazardous Material Detection) ***Description:*** This effort models and develops materials and devices for the next generation Army sensor systems. Semiconductor materials and devices from ultraviolet (UV) to IR with active and passive imaging capabilities will be modeled and developed. This will allow the Soldier to maintain situational awareness day and night under cluttered battlefield conditions. Sources and detectors for next generation secure battlefield communication devices will also be developed. For asymmetric threats, chemical sensing devices will also be studied and developed. ***FY 2019 Plans:*** Conduct three dimensional (3D) modeling of the device properties of mercury cadmium telluride semiconductor structures that utilize novel resonant architectures or carrier depletion techniques to reduce dark current and increase operating temperature of	1.957	2.141	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
IR detectors and thereby reduce the need for cryogenic cooling; design and develop near ultraviolet laser sources based upon semi-polar and non-polar III-Nitride semiconductor heterostructures to enable compact and low cost ion-based quantum devices for networking; continue development and characterization of molecularly imprinted polymers as a chemical detection filter / concentrator for studying asymmetric threats. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort concludes after FY19.			
Title: Power and Thermal Management for Small Systems ***Description:*** This effort investigates, designs, and fabricates micro-electromechanical system (MEMS)-based components to improve power generation and micro-cooling technology for both dismounted Soldier and future force applications. ***FY 2019 Plans:*** Demonstrate integrated thermophotovoltaic generator with overall system efficiency improved through an integrated heat recuperator and demonstrate multiple "simple" fuels, including single component hydrocarbons and surrogate fuels for more complex fuels like JP-8; use experimental results to validate models developed as part of this objective for the different fuel and catalyst material combinations. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This research effort was realigned to PE 0602143A (Soldier Lethality Technology) / Project BD8 (Soldier & Sm Unit Tactical Energy Tech) in FY20 as part of the financial restructuring.	0.891	0.903	-
Title: Power and Energy ***Description:*** This research focuses on the design and characterization of chemistries, materials, and components for advanced batteries, fuel reformers, and fuel cells. Potential Army applications include hybrid power sources, smart munitions, hybrid electric vehicles, and Soldier power applications. Additionally, investigate the applicability of photosynthesis to provide fuel and electricity for Soldier power applications, and investigate silicon carbide (SiC) power module components that could enable compact, high efficiency, high temperature, and high power density converters for motor drive and pulse power applications. ***FY 2019 Plans:*** Improve the efficiency of dual intercalation electrodes for inexpensive grid energy storage; investigate additives to limit dendrite formation of lithium metal batteries for high energy density rechargeable batteries; investigate all-solid-state chemistries for safe lithium batteries; analyze and interpret the results of the investigation of new methods for reduced aging improved duration of thermal batteries performed in FY18; determine through modeling or conducting experiments the performance of these methods; investigate nanocomposite non-noble catalysts and acid-alkaline bipolar membrane electrolyte interface and single cell	2.783	1.671	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
performance; integrate semipermeable membrane materials and electrolytes via hybrid bi-cell and bipolar membrane technologies to address costs and balance-of-plant issues. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This research effort was realigned to PE 0602144A (Ground Technology) / Project BL1 (Materials and Manufacturing Research Technology) and PE 0602145A (Next Generation Combat Vehicle / Project BJ3 (Hydrogen Based Combat System Technology) in FY20 as part of the financial restructuring.			
Title: Energy Harvesting ***Description:*** This research develops technologies to substantially reduce the number of batteries required to accomplish dismounted Soldier/Squad mission objectives, thereby significantly reducing Soldier-borne load and logistics requirements. Research will explore technologies to harvest electrical power by converting and storing energy via engineered structures and electronic bandgaps, MEMS-based micro-scale power conversion, and heterogeneous 3D assembly of MEMS with other devices to enable efficient, distributed power conversion. Research explores novel paths to local fuel and energy production, including artificial photosynthesis, to extract hydrogen and electricity directly from water and sunlight. ***FY 2019 Plans:*** Incorporate broad-angle anti-reflection / rear surface light trapping structure matched to response spectrum of optimized hybrid quantum-mechanical based solar cell; investigate novel thermal energy harvesting including elastocalorics and pyroelectrics; develop plasmonically enhanced water and urea splitting device; develop the capability of enhancing catalytic reactions using infrared radiation; develop antimonide-doped gallium nitride water splitting device; demonstrate methanol production from Carbon Dioxide (CO2) through reduction processes in the present of sunlight. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This research effort was realigned to PE 0602143A (Soldier Lethality Technology) / Project BD8 (Soldier & Sm Unit Tactical Energy Tech) in FY20 as part of the financial restructuring.	2.764	3.022	-
Title: Energy Efficient Electronics & Photonics ***Description:*** This effort addresses sustainment operations by unburdening the Soldier and reducing logistics requirements (e.g., fewer batteries) for communications, computing, and sensing. The objective is to improve the underlying energy efficiency of supply and demand for Soldier-portable and unattended sensor electronics to enable the dismounted Soldier to maintain communications, freedom of movement, and increase mission duration. The majority of the electronics power used by the dismounted Soldier and by unattended sensors is attributable to RF communications. In addition, freedom of movement and action during sustained and high tempo operations requires seamless battery recharging. To address these challenges, energy efficient electronics research includes RF circuits, devices, materials and wireless power distribution. Energy efficiency	5.538	5.513	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
improvements will be developed and investigated in support of five key sensor and electronic areas: RF component devices, passively powered components, low-power, long-lived sources, wireless power transfer, and advanced battery chemistries. Additionally, materials and devices used for photonic applications, such as laser diodes and fiber lasers, will be studied and improved with an emphasis on overall size, weight, and power consumption efficiency gains. ***FY 2019 Plans:*** Design and fabricate advanced node silicon and gallium nitride integrated circuits implementing Soldier Radio Waveform with 3X reduction in power draw; characterize carrier transport in semiconductor laser diode structures for the development of large area UV emitters; investigate processes to make 3-D electrode structures and investigate their effect on energy storage chemistry rates and ionic and electronic transports; investigate solid-state chemistries for safe lithium batteries; develop MEMS-based and resonant RF sensors that can passively sense an RF signal while consuming < 10 nW of power for zero-power-consuming sleep mode electronics; determine the efficiency and power transfer limits of laser-to-pyroelectric wireless power transfer; explore acoustic power transfer with the ability to steer the acoustic beam source using arrays of acoustic transducers; design and develop near-ultraviolet laser sources based upon semi-polar and non-polar III-nitride semiconductor heterostructures to enable compact and low cost ion-based quantum devices for networking. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This research effort was realigned to PE 0602146A (Network C3I Technology) / Project AO4 (Energy Efficient Devices Technology) in FY20 as part of the financial restructuring.			
Title: Precision Measurement Technology for Contested Environments (Technologies for Anti Access / Area Denial)	2.941	2.983	-
Description: This research focuses on technologies that will enable precise and assured position, navigation and timing in global positioning system (GPS)-denied environments. The first objective of this research is to improve the size, weight, power, cost, and accuracy of current micro-Inertial Measurement Systems (IMS) through the design, and fabrication of MEMS gyroscopes. The second objective is to develop an opto-electronic device that can be used as an ultra-precise local oscillator with improved stability for precision timing applications. The third objective is to address the ability to transmit jam-resistant precision timing signals by investigating the transmission of precision, synchronized timing signals over optical fibers and free-space using lasers. The fourth objective is to explore new RF antenna concepts to extend the reach of IMS systems through pseudolites (ground-based substitutes for GPS satellites) and Soldier-borne systems, and to integrate multiple sensor modalities with the IMSs using sensor fusion techniques to reduce drift and increase positional accuracy. ***FY 2019 Plans:*** Develop robust object recognition, efficient simultaneous localization and mapping and interactive topological mapping methods and integrate them into low size, weight and power - Cost (SWAP-C) platforms; investigate novel information sources to passively locate humans in a complex and cluttered environment; design, fabricate and characterize an integrated MEMS and			

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
heterogeneous sensor solution for increased state estimation accuracy; improve positioning, navigation, and timing (PNT) sensor fusion algorithms to include input from a heterogeneous array of aiding sensors in diverse environments; assemble wearable anti-jam GPS test- bed and study performance of body-distributed anti-jam GPS antennas in laboratory environment; design and characterize an asymmetric free-space optical link that uses a retro-reflector to measure the time delay between the transmitter and receiver and uses a modulated laser to develop low SWAP-C free-space optical time transfer techniques; investigate deep learning based approaches for perception, including scene, landmark and skyline recognition on computationally constrained platforms to enable geo-localization without GPS; continue to develop and optimize material fabrication process for construction of environmentally stable Epsilon-Near-Zero oscillator materials and devices. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This effort is complete after FY19.			
Title: Anti-Tamper (AT) Technology Development ***Description:*** This effort develops tools, devices, and techniques to protect acquisition program systems and Critical Program Information (CPI) from adversarial threats. This work is executed by the Army Anti-Tamper Office located at the Aviation and Missile Research, Development and Engineering Center (AMRDEC) at Redstone Arsenal, AL. ***FY 2019 Plans:*** Develop threat-based sensors and secure processor Intellectual Property (IP) to support Rigor technology refresh; manufacture full Rigor 1b engineering models; complete laboratory characterization of Rigor 1b module; continue design and development of Rigor 1a module; and develop Rigor 1a test-modules. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This research effort was realigned to PE 0602146A (Network C3I Technology) / Project AV5 (Protective Technologies) in FY20 as part of the financial restructuring.	5.025	5.900	-
Title: Cognitive Countermeasures Technology Development ***Description:*** This effort investigates and matures novel materials, components, and techniques to counter legacy and emerging threats to Army platforms. Emphasis will be placed on technologies and approaches to enable a robust, holistic countermeasure capability for target defeat, regardless of threat characteristics or guidance mode.	2.010	-	-
Title: Technologies for Alternative Energy ***Description:*** Design and develop novel concepts of energy generation, energy capture materials, and component technologies for efficient conversion of ambient energy to electrical energy for use and storage. Design components to include microscale power devices for multimodal harvesting and efficient distributed power conversion.	1.175	1.191	-

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2018	FY 2019	FY 2020
FY 2019 Plans: Develop improved thermoelectric materials, with a goal of >2X improvement (>10%) conversion efficiency for low temperature differences near 1000 C; assemble and validate battery or pseudo-capacitor packs for both electrochemical and safety. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This research effort was realigned to PE 0602143A (Soldier Lethality Technology) / Project BD8 (Soldier & Sm Unit Tactical Energy Tech) in FY20 as part of the financial restructuring.			
Title: Quantum for Assured PNT in Zero-GPS Environments Acceleration ***Description:*** To develop quantum-based GPS-independent ultra-high precision PNT in a contested/gps denied battlespace for mission durations up to 7 days w/o external timing or position re-synchronization. This effort also enables Camouflage, Concealment, and Decoys (CC&D) in an Electronic Warfare (EW) space and synchronization of disaggregated platforms / fires across the battlefield for distributed sensing, processing, and lethal effect. ***FY 2019 Plans:*** Design integrated triaxial MEMS Internal measurement units (IMUs) with 3 orders of magnitude improvement in accuracy (goal TRL4 in FY21), develop approach/design for integrated photonics and quantum timing circuit that meets PNT timing requirements while meeting on Soldier SWAP-C goals, and to build optical time synchronization demonstration for FY20/TRL3 demonstration. ***FY 2019 to FY 2020 Increase/Decrease Statement:*** This research effort was realigned to PE 0602146A (Network C3I Technology) / Project AV9 (Advanced PNT for GPS Independent Environments Technologies) in FY20 as part of the financial restructuring.	-	3.201	-
Title: FY 2019 SBIR / STTR Transfer ***Description:*** FY 2019 SBIR / STTR Transfer ***FY 2019 Plans:*** FY 2019 SBIR / STTR Transfer ***FY 2019 to FY 2020 Increase/Decrease Statement:*** FY 2019 SBIR / STTR Transfer	-	0.449	-
Accomplishments/Planned Programs Subtotals	36.919	38.030	-

C. Other Program Funding Summary ($ in Millions)

N/A

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C. Other Program Funding Summary ($ in Millions)

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A