Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Army											Date: February 2015	
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 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**	**Cost To Complete**	**Total Cost**
Total Program Element	-	68.062	73.422	55.301	-	55.301	57.002	55.296	55.922	57.021	-	-
EM4: *Electric Component Technologies (CA)*	-	10.000	17.000	-	-	-	-	-	-	-	-	-
EM8: *High Power And Energy Component Technology*	-	14.532	13.177	12.143	-	12.143	12.680	12.888	12.937	13.194	-	-
H11: *Tactical And Component Power Technology*	-	11.475	11.766	11.810	-	11.810	11.914	9.641	9.602	9.791	-	-
H17: *Flexible Display Center*	-	2.617	0.571	1.136	-	1.136	1.011	1.024	1.074	1.096	-	-
H94: *Elec & Electronic Dev*	-	29.438	30.908	30.212	-	30.212	31.397	31.743	32.309	32.940	-	-

Note

FY14 reprogramming moved Congressional add for Silicon Carbide research from 0602105A for proper execution.

A. Mission Description and Budget Item Justification

This program element (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, microwave, electronic components and technologies. Project H11 designs, fabricates and evaluates advanced portable power technologies (batteries, fuel cells, hybrids, generators, chargers, and 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 0602709A (Night Vision Technology), PE 0602782A (Command, Control, Communications Technology), PE 0602783A (Computer and Software Technology), PE 0603001A (Warfighter Advanced Technology), and PE 0603772A (Advanced Tactical Computer Science and Sensor Technology).

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

Exhibit R-2, RDT&E Budget Item Justification: PB 2016 Army	Date: February 2015
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*

Work is performed by the Army Research Laboratory, Adelphi, MD. and the Army Communications-Electronics Research, Development, and Engineering Center, Aberdeen Proving Ground, MD.

B. Program Change Summary ($ in Millions)	FY 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total
Previous President's Budget	58.990	56.435	55.672	-	55.672
Current President's Budget	68.062	73.422	55.301	-	55.301
Total Adjustments	9.072	16.987	-0.371	-	-0.371
• Congressional General Reductions	-	-0.013			
• Congressional Directed Reductions	-	-			
• Congressional Rescissions	-	-			
• Congressional Adds	-	17.000			
• Congressional Directed Transfers	-	-			
• Reprogrammings	10.000	-			
• SBIR/STTR Transfer	-0.928	-			
• Adjustments to Budget Years	-	-	-0.371	-	-0.371

Congressional Add Details ($ in Millions, and Includes General Reductions)	FY 2014	FY 2015
Project: EM4: *Electric Component Technologies (CA)*		
Congressional Add: *Silicon Carbide Research*	10.000	12.000
Congressional Add: *Program increase*	-	5.000
Congressional Add Subtotals for Project: EM4	10.000	17.000
Congressional Add Totals for all Projects	10.000	17.000

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army			Date: February 2015
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 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
EM4: *Electric Component Technologies (CA)*	-	10.000	17.000	-	-	-	-	-	-	-	-	-

Note

Not applicable for this item.

A. Mission Description and Budget Item Justification

Congressional Interest Item funding for Electronic Component applied research.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015
Congressional Add: Silicon Carbide Research ***FY 2014 Accomplishments:*** Researched high-voltage high-power density SiC power devices and power components. ***FY 2015 Plans:*** Continue research on SiC power devices and power components.	10.000	12.000
Congressional Add: Program increase ***FY 2015 Plans:*** This is a Congressional interest item.	-	5.000
Congressional Adds Subtotals	10.000	17.000

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 2016 Army											Date: February 2015	
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 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**	**Cost To Complete**	**Total Cost**
EM8: *High Power And Energy Component Technology*	-	14.532	13.177	12.143	-	12.143	12.680	12.888	12.937	13.194	-	-

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); and traditional and non-traditional RF and laser electronic attack. 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 (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 and Soldier portfolios.

The work in this project is coordinated with the U.S. Army Tank and Automotive Research, Development, and Engineering Center (TARDEC); Armaments Research, Development, and Engineering Center (ARDEC); the U.S. Army Aviation and Missile Research, Development, and Engineering Center (AMRDEC); and the U.S. Army Communications-Electronics Research, Development, and Engineering Center (CERDEC).

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

Work on this project is performed by the U.S. Army Research Laboratory (ARL), Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: High Power and Energy Technologies	1.098	1.182	1.233
Description: Research and evaluate electronic materials, structures, and components that will enable the realization of higher energy density and efficiency required by future Army systems such as electromagnetic armor, directed energy weapons, power grid protection, and other pulsed-power systems. Special emphasis is on components operating at high voltages - greater than (>) 10 kilovolts (kV).			
FY 2014 Accomplishments:			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
Investigated and developed wide band gap materials and devices, for operation above 20kV to support survivability, lethality systems, and high voltage micro-grid application requirements; evaluated high voltage packaging needs and identified packaging research; and initiated research into wide band-gap semiconductors identified in FY13. ***FY 2015 Plans:*** Investigate and develop advanced wide band gap materials and devices, for operation above 20kV to support survivability, lethality systems, and high voltage microgrid application requirements; research and evaluate high voltage packaging needs; and continue research into wide band-gap semiconductors identified in FY14. ***FY 2016 Plans:*** Will validate a 20kV device and packaging concept; continue to extend the voltage and current capabilities of power switching components through modeling and research of the materials and fabrication processes; and research materials and device technologies required to understand device operation at 40kV for use in advanced Directed Energy systems and other Lethality and Survivability applications.			
Title: High Energy Laser Technology ***Description:*** Research novel solid-state laser concepts, architectures, and components with the goal of providing technology to Army directed energy weapon developers. Exploit breakthroughs in laser technology, material development and photonics basic research to meet the stringent weight/volume requirements for platforms. Applied research will be conducted in close collaboration with domestic and foreign material vendors, university researchers, and major laser diode manufacturers. ***FY 2014 Accomplishments:*** Experimentally validated feasibility of a fiber laser which could provide significantly improved thermal management in order to achieve advanced power scalability (>10X) with good beam quality; and scaled chirped diode laser seed technique to obtain multi-kW power output from a 1060 nm fiber amplifier. ***FY 2015 Plans:*** Investigate techniques for power scaling continuous wave (CW) and pulsed mid-wave infrared (IR) sources for IR countermeasure (IRCM) applications; and explore laser materials with enhanced thermal conductivity that will provide superior ability to meet stringent Army size, weight, and power (SWAP) requirements for counter rocket, artillery, and mortar (C-RAM) applications. ***FY 2016 Plans:*** Will explore novel fiber designs to increase power while preserving high beam quality for enabling laser directed energy weapons; investigate power scaling of continuous wave (CW) and pulsed mid-wave infrared (IR) sources for IR countermeasure (IRCM) applications as well as pulsed eye-safe lasers for scanning LADAR application.	2.477	2.000	2.000
Title: Directed Energy (DE) /Electromagnetic Environments (EME) Technologies	2.322	2.386	2.325

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
Description: Investigate and evaluate emerging technologies related to DE technology, electronic warfare (EW) survivability/ lethality, operations in the EME, and supporting high power components with the goal of enhancing the survivability/lethality of Army platforms. ***FY 2014 Accomplishments:*** Characterized the susceptibility of emerging Improvised Explosive Device (IED) threats to identify their unique susceptibilities/ vulnerabilities; designed neutralization waveforms and techniques based on their vulnerabilities; and developed and evaluated smart radio frequency (RF) waveforms to create countermeasures to affect electronic devices. ***FY 2015 Plans:*** Determine the susceptibility of emerging threat electronics (to include those related to IEDs) to electronic attack; characterize parameters for use in the development of neutralization waveforms and techniques; investigate Digital Radio Frequency Memory (DRFM) technology and its effects on jamming/counter-jamming applications; and develop cognitive RF architecture and baseline hardware and algorithms for sensing and exploiting electromagnetic environment. ***FY 2016 Plans:*** Will develop electronic protection (EP) device technologies for Next Generation Radar requirements by examining the adaptive RF technology threat against Army radar performance.			
Title: Electronic Components and Materials Research ***Description:*** Investigate, and evaluate compact, high-efficiency, high-temperature, 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 2014 Accomplishments:*** Investigated advanced control and diagnostic methods intended for power switches to improve fault tolerance and efficiency; conducted applied research on next-generation materials and fabrication methods for passives and wide band-gap materials and devices and developed switching components to provide power conversion components for micro-grid applications. ***FY 2015 Plans:*** Investigate both gallium nitride (GaN) and silicon carbide (SiC) based electronic components for device reliability and characterize these materials; investigate advanced control and diagnostic methods for power switches to improve fault tolerance and efficiency; conduct applied research on next-generation materials and fabrication methods for compact power switching components that	4.195	3.000	3.234

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
provide high voltage, high current, and/or high frequency operation; and investigate and develop advanced power semiconductor devices and modules, for operation above 20kV and at high currents. ***FY 2016 Plans:*** Will evaluate and develop reliability models of current and next generation wide band-gap electronic components for device enhancements; demonstrate advanced control and diagnostic methods for power switches to improve fault tolerance and efficiency and validate concept for high voltage high performance devices for operations above 20kV.			
Title: Power System Components Integration and Control Research ***Description:*** Research and evaluate 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, vehicle, and micro-grid (installation) applications to include the operation of military-specific power distribution topologies at the system and circuit levels. ***FY 2014 Accomplishments:*** Conducted applied research in intelligent controls and diagnostics for power conversion modules and circuits to provide more efficient, robust, and reliable power delivery and conversion for vehicle and micro-grid power applications; researched intelligent control methodologies for micro-grids and other power distribution systems; and investigated bidirectional power conversion circuits for platform and micro-grids. ***FY 2015 Plans:*** Conduct applied research in power management, intelligent controls, and diagnostics for power conversion modules and circuits to provide more efficient, robust, and reliable power delivery and conversion for vehicle and micro-grid power applications; investigate advanced behavior based Tactical Energy Network control and prediction techniques; and research distributed control strategies to enable more robust and failure resistant grids (e.g. utilize swarm (hive or colony) control, where each member of the swarm represents a specific piece of equipment). ***FY 2016 Plans:*** Research and validate a universal power conversion concept that converts any input power to any output power for vehicle and micro-grid power applications; continue to investigate controls for Tactical Energy Network control and prediction techniques allowing any power input to feed any output power specification; develop distributed control and storage models to demonstrate more reliable and failure tolerant grids; and continue to investigate through modeling and analysis the use of direct current and hybrid grid based technologies for the Army Tactical Energy Network.	3.720	4.609	3.351
Title: Pulsed-Power Components and Systems Research ***Description:*** Investigate, and evaluate emerging technologies such as energy storage capacitors, high voltage converters, high rate-of-current-rise semiconductor switches, and explosive-based pulse generators that improve the reliability and efficiency of	0.720	-	-

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
pulsed-power components for applications such as electromagnetic armor, electronic fuze initiators, and electronic protection systems. ***FY 2014 Accomplishments:*** Analyzed semiconductor switch and component operation under extreme currents and voltages; experimentally characterized and validated improved FY13 SiC switches and other components for electromagnetic armor systems; and developed enhanced power dense power conversion hardware to reduce size and weight for platform survivability efforts through the implementation of novel materials, circuits and module designs.			
Accomplishments/Planned Programs Subtotals	14.532	13.177	12.143

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 2016 Army											Date: February 2015	
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 2014**	**FY 2015**	**FY 2016 Base**	**FY 2016 OCO**	**FY 2016 Total**	**FY 2017**	**FY 2018**	**FY 2019**	**FY 2020**	**Cost To Complete**	**Total Cost**
H11: *Tactical And Component Power Technology*	-	11.475	11.766	11.810	-	11.810	11.914	9.641	9.602	9.791	-	-

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 small unit & Soldier power management, decision making, and distribution. This project also researches power sources that are smaller and more fuel-efficient, advanced cooling systems that enable tactical sustainability and survivability.

This project supports Army science and technology efforts in the Command, Control, Communications and Intelligence, Soldier/Squad and Innovative Enablers portfolios. Work in this Project complements efforts in PE 0603001A (Warfighter Advanced Technology).

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

Work in this project is performed by the Army Research, Development and Engineering Command (RDECOM), Communications-Electronics Research, Development, and Engineering Center (CERDEC), Aberdeen Proving Ground, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Tactical Power Generation Technology (formerly Soldier Power Technologies)	7.579	7.526	4.673
Description: This effort designs, fabricates and validates Soldier-borne hybrid power sources, batteries, rapid battery chargers, and power management software, devices and techniques in order to decrease Soldier load and power burden, increase power capabilities such as extending battery run-time, decrease battery sizes/costs and increase power management and situational awareness.			
FY 2014 Accomplishments: Investigated very high energy density lighter weight Soldier hybrid power sources including wearable conformal Li/Air disposable batteries; increased power density of Li/Air by designing, fabricating and assessing carbon nano-based air electrodes; investigated highly conducting, robust, lower cost lithium ion conducting membranes to further reduce weight and cost of Soldier batteries; investigated renewable multi-fueled Soldier portable power sources and aluminum hydride (high energy density) based fuel cells with extended run time, higher energy density and higher fuel to energy conversion efficiency; assessed Soldier wireless power and energy harvesting concepts to reduce electrical wiring and connectors, achieve greater power transmission efficiencies			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
and reduce energy logistics for extended missions; investigated processes, techniques and hardware for safe wireless power distribution for Soldier borne equipment and wireless charging of Soldier borne batteries. ***FY 2015 Plans:*** Mature very high energy density hybrid power sources as a wearable conformal power source; design a smart Soldier power grid capable of integrating energy storage and power generation devices with smart power management and distribution with little to no user interaction; mature internal components to facilitate a renewable multi-fueled Soldier portable power source; investigate a system to integrate wireless power and energy harvesting technologies into the smart Soldier power grid to reduce cabling and connectors; continue to investigate techniques to increase wireless power transfer efficiency and distance; conduct experiments on novel energy harvesting components to increase efficiency and reduce weight of carried power sources. ***FY 2016 Plans:*** Will mature hybrid power sources to increase power and energy densities and reliability for high energy density devices; optimize electrolyte formulations and cathode materials to improve safety for higher energy and power solutions; research existing and novel energy storage and power generation components to ensure their compatibility within the Soldier power grid; increase efficiency and optimize internal components of multi-fueled generator to facilitate development of a smaller, more portable device; investigate various wireless power transfer technologies and increase efficiencies to enhance power transmission distances; research and design interoperable devices capable of utilizing energy harvesting technologies to charge Soldier wearable hybrid power sources to achieve a net-zero energy posture; investigate wireless solution for net-zero energy approach.			
Title: Energy Informed Operations ***Description:*** This effort investigates power generation materials, components and systems to increase energy output, reduced weight and noise, while increasing fuel and cost efficiency in mobile power generation sources. Products are silent mobile power components and materials, waste-heat recovery components and systems, transitional power sources in the 500 watts (W) to 2 kilowatts (kW) range, towable generator sets up to 100 kW and renewable energy components and power management systems up to 5 kW. ***FY 2014 Accomplishments:*** Investigated monitoring tools for Squad, Platoon and Brigade command post renewable energy power grids (300 W to 10 kW) to provide grid status to the commander; coded intelligent power management protocols to increase reliability and efficiency of renewable energy integrated with fossil fuel generators; designed and assessed high energy density, efficient energy storage modules; investigated advanced harvesting of carbon dioxide (CO_2) from exhaust to provide for autonomous power generation (fuel cells and external/internal combustion) and reduced fuel logistics; designed alternative CO_2 based co-generation capabilities for greater cooling capacity and reduced weight/size of environmental control units. ***FY 2015 Plans:***	3.896	4.240	7.137

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
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 2014	FY 2015	FY 2016
Develop intelligent power management architecture for mobile power generation grids to enable energy informed operations for integrated command, control, communications, computers, intelligence, surveillance and reconnaissance platforms; design a system of interconnected power grids of various voltages with multiple controllers using a master/slave control scheme capable of supporting ad-hoc connections and configuration; establish standards for renewable power generation and energy storage and incorporate into demonstration grid; establish power management protocols and policies for interfacing with mission systems; develop power planning tools and applications for monitoring and controlling grid status; develop advanced 2kW fuel efficient silent power generation systems with greater than 30% fuel to electric efficiencies. ***FY 2016 Plans:*** Will investigate new software and physical architectures to more efficiently distribute and manage power across the battlefield while reducing size and weight; develop predictive-analysis modeling software to enhance selection and employment of energy sources during the planning and execution mission phases, respectively; continue investigating techniques to reduce the energy demand of Soldier-worn peripherals; assess draft standards for a centralized micro-grid approach and develop standards for a distributed micro-grid; design a micro-grid architecture that distributes control to various power managers between the mission command system and smart power devices allowing for a mesh power network; continue research and design of smart power devices that can be monitored and controlled by the Commander, staff, or autonomously to prioritize loads, reduce fuel consumption, and ensure reliable mission power; design and fabricate improved renewable, alternative fuel, and high fuel-efficiency power sources to supplement base power and further reduce logistic footprint.			
Accomplishments/Planned Programs Subtotals	11.475	11.766	11.810

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 2016 Army			Date: February 2015
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 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
H17: *Flexible Display Center*	-	2.617	0.571	1.136	-	1.136	1.011	1.024	1.074	1.096	-	-

A. Mission Description and Budget Item Justification

This project fabricates and evaluates flexible display and electronic components emerging from the Army's Flexible Display Center (FDC) at the Arizona State University and materials and devices for flexible electronics developed at the Army Research Laboratory. This applied research on flexible display and electronic technologies makes them inherently rugged (no glass), light weight, conformal, potentially low cost, and low power. The resultant technology would enable enhanced and new capabilities across a broad spectrum of Army applications (such as hands-free/wrist mounted situational awareness devices, flexible X-Ray devices, large areas sensor, tagging, tracking, and soldier monitoring.)

This project supports Army science and technology efforts in the Command, Control, Communications and Intelligence and Soldier portfolios.

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

Work in this project is executed by the U.S. Army Research Laboratory (ARL), Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Flexible Display Center (FDC) and Flexible Electronics Development	2.617	0.571	1.136
Description: The Flexible Display Center is developing high resolution flexible reflective (electrophoretic) and emissive (organic light emitting diodes) displays and sensing arrays. The U.S. Army Research Laboratory is developing materials and devices and processes for flexible electronics for Army applications.			
FY 2014 Accomplishments: Developed flexible electronic sensor devices for Army applications to include radiation sensors (visible to x-ray) and particle detection.			
FY 2015 Plans: Develop printable sensor materials and devices that will enable new and enhanced capabilities in areas such as flexible electronic large areas sensors, tagging, tracking, and soldier monitoring.			
FY 2016 Plans:			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602705A / *Electronics and Electronic Devices*	**Project (Number/Name)** H17 / *Flexible Display Center*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Will develop flexible hybrid electronic systems integrating traditional silicon electronics, sensors and power. The applications will include flexible sensing systems for human assessment with situational awareness on 2-dimensional flexible substrates and integrated into 3-dimensional structures for Soldier and small platform applications.			
Accomplishments/Planned Programs Subtotals	2.617	0.571	1.136

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 2016 Army			Date: February 2015
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 2014	FY 2015	FY 2016 Base	FY 2016 OCO	FY 2016 Total	FY 2017	FY 2018	FY 2019	FY 2020	Cost To Complete	Total Cost
H94: *Elec & Electronic Dev*	-	29.438	30.908	30.212	-	30.212	31.397	31.743	32.309	32.940	-	-

Note

Not applicable for this item.

A. Mission Description and Budget Item Justification

This project designs and evaluates electronics and electronic components and 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 nanotechnology, eye-safe laser radar (LADAR), vision and sensor protection, infrared imaging (IR), 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), PE 0603008A (Command, Control, Communications Advanced Technology), PE 0603313A (Missile and Rocket Advanced Technology) and PE 0603772A (Advanced Tactical Computer Science and Sensor Technology).

The cited work is consistent with the Assistant Secretary of Defense, Research and Engineering Science and Technology priority focus areas and the Army Modernization Strategy.

Work in this project is performed by the U.S. Army Research Laboratory (ARL), Adelphi, MD.

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Title: Antennas and Millimeter Wave Imaging	4.574	3.439	3.490
Description: This effort designs evaluates and validates high performance antenna components and software for multifunction radar and communication systems. Research areas include scanning techniques, broadbanding, beamforming, polarization, platform integration, and affordability.			
FY 2014 Accomplishments: Developed new terahertz detector for covert surveillance; continue millimeter wave antenna development; developed and evaluated carbon nanotube based antenna structures for potential integration into soldier uniforms; and designed and developed			

Exhibit R-2A, RDT&E Project Justification: PB 2016 Army		Date: February 2015
Appropriation/Budget Activity 2040 / 2	**R-1 Program Element (Number/Name)** PE 0602705A / *Electronics and Electronic Devices*	**Project (Number/Name)** H94 / *Elec & Electronic Dev*

B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
antenna components to allow interoperability of and reduce interference between electronic warfare and communications functions on a single antenna system; and validated performance of antenna components in laboratory experiments. ***FY 2015 Plans:*** Evaluate the performance of millimeter wave transceivers for covert communications and sensing; extend and modify microwave radar rain scattering models to frequencies above 200 GHz to support transmission of data through rain and dust; and develop and evaluate conformal antennas for non-standard vehicle, covert applications. ***FY 2016 Plans:*** Will devise and evaluate carbon nanotube antennas woven into the fabric of the soldier's uniform; perform in-situ simulation of printed and paint-on antenna designs and low-profile metaferrite antenna designs.			
Title: Advanced Micro and Nano Devices ***Description:*** This effort designs and evaluates micro and nanotechnology components for multifunctional and integrated radio frequency (RF) applications, microrobotics, integrated energetics, control sensor interfaces and sensors for improved battlefield awareness. Work being accomplished under PE 0601102A /project H47 complements this effort. ***FY 2014 Accomplishments:*** Developed, synthesized and evaluated conformal and transparent graphene based electronics, and super-capacitors for high energy and power density; developed MEMS ultra high frequency (UHF) switchable filter module with variable bandwidth, center frequency tuning, and insertion loss <3 dB; investigated integration of MEMS and nano-energetics to enable directionality for jumping microrobots; developed piezoMEMS actuators for tethered flight and millimeter scale robotics; developed a digital interface between the MEMS acceleration switch arrays and the electronics to reduce power consumption; and investigated MEMS-based magnetic permeability sensing hardware for reading and writing non-erasable magnetic memory. ***FY 2015 Plans:*** Develop and prototype MEMS technologies for enabling frequency agile RF systems, mm-scale robotic platforms, and novel MEMS and sensor fusion solutions for enabling position, navigation, and timing in global positioning system (GPS) denied environments; continue investigation of novel stacked two dimensional (2-D) electronic materials (e.g. graphene, molybdenum disulphide, boron nitride) for Army-relevant high performance electronic devices such as flexible and transparent transistors, antennas, oscillators, and amplifiers; develop nanoscale energetic materials for micro-autonomous vehicle propulsion, technology protection, and fuze initiators; optimize magnetic tunnel junction interface with magnetic permeability bits to enhance memory density and read speed; develop MEMS acoustic vector intensity probes for target localization and wind mitigation; and develop intrusion detection algorithm to enhance communication link security. ***FY 2016 Plans:***	2.348	2.318	2.127

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Will develop and verify MEMS components for cognitive RF systems, low power GPS, and sensor technologies for improved Position, Navigation and Timing (PNT); design and develop hardware and algorithms for distributed sensing, micro autonomous system control and chip scale integration of energetic nanoporous silicon for fuze initiation; demonstrate digital circuits on flexible stacked 2-D electronic materials (e.g. graphene, molybdenum disulphide, boron nitride); and explore and optimize the RF performance of stacked 2-D electronic materials.			
Title: Millimeter Wave Components and Architectures for Advanced Electronic Systems ***Description:*** This effort researches, designs and evaluates component materials, structures, devices, and the electromagnetic issues of millimeter wave (mmw) components and active devices. The goal is to develop components that can enable advanced systems that combine multiple RF functionalities. ***FY 2014 Accomplishments:*** Investigated and evaluated RF component integration techniques; built and evaluated test antennas and amplifiers capable of receiving inherently weak wideband threat signatures; and designed and fabricated a circuit that digitizes signals at mmw frequencies to enable architectures for SATCOM with smaller form factors. ***FY 2015 Plans:*** Develop and test multi-function RF components capable of receiving weak signals and threat detection using a combination of advanced processing and hardware architectures; investigate novel thermal management techniques for heat removal in high power amplifiers; and develop and evaluate efficient, wideband, secured communications at mmw/terahertz frequencies. ***FY 2016 Plans:*** Will investigate trade space for device and circuit performance requirements for application to future radar and sensing systems; correlate trade space results with emerging needs from communication systems in order to enable multiple-function hardware as frequency-RF performance requirements converge.	5.570	5.581	5.267
Title: Imaging Laser Radar (Ladar) and Vision Protection ***Description:*** This effort develops and assesses eye-safe three dimensional (3-D) laser radar (ladar) components and phenomenology for long-range reconnaissance and short-range unmanned ground and air vehicle applications. The effort also develops and evaluates materials for passive protection of electro-optic (EO) vision systems from lasers. ***FY 2014 Accomplishments:*** Integrated and evaluated enhanced switching technology with an inorganic crystal-based optical switch for improving laser protection electro-optic shutters; developed and evaluated skin-based spectroscopic and advanced holographic technologies	2.715	2.722	2.659

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
for the identification and verification of uncooperative subjects; and designed and developed miniaturized components for high resolution active imaging systems (ladar and holographic) for higher range and angular resolution. ***FY 2015 Plans:*** Advance the development of fast EO shutters using inorganic crystal-based materials in conjunction with device tiling with the goal of increasing aperture size for non-focal plane vision protection from lasers; research new ladar concepts to reduce hardware cost/complexity and multi-spectral illumination to detect explosive constituents and targets; and conduct field experimentation on novel hostile fire sensing component technology. ***FY 2016 Plans:*** Will study active EO shutter systems that do not need a focal plane to activate and explore their implementation in Army optical systems; explore magneto-optic materials for use in protecting IR systems; investigate ladar concepts for ultra-light or large unattended air vehicle (UAV) navigation; study novel and advanced optical science concepts, such as computational imaging and holography for enhanced imaging and sensing applications.			
Title: Photonics and Opto-Electronic devices ***Description:*** This effort investigates and evaluates novel photonic components and architectures to enable detection of hazardous substances for enhanced Soldier situational awareness and survivability. In addition, this effort develops and assesses the hybridization of opto-electronic (OE) devices with electronics for optical fuze applications. ***FY 2014 Accomplishments:*** Measured the optical spectra of energetic and energetic related materials using ultra fast laser spectroscopy techniques and infrared photo-acoustic spectroscopy to identify explosive materials; and simulate, fabricate, and characterize advanced silicon photonic devices for improved sensing and processing. ***FY 2015 Plans:*** Evaluate ultrafast laser spectroscopy techniques, especially multiplex Coherent Anti-Stokes Raman Scattering (CARS), to enable remote explosives detection; explore infrared photothermal technique used in conjunction with laser Doppler vibrometry for energetic-related material detection; and simulate and characterize advanced optical components in a threat detection device for active protection defeat of both kinetic energy and non-kinetic energy targets. ***FY 2016 Plans:*** Will conduct spectral analysis investigations of candidate spectroscopic detection technologies to include femtosecond Coherent Anti-Stokes Raman Scattering and infrared photothermal spectroscopy; study functional biomaterials in austere environments	2.316	1.287	1.128

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
including the effect of temperature and other degradation pathways; and study and model biological materials designed with specific functionality and stability for their interaction and affinity with non-biological materials such as metals.			
Title: Power and Thermal Management for Small Systems	3.415	3.378	3.374
Description: This effort investigates designs and fabricates MEMS-based components to improve power generation and micro-cooling technology for both dismounted Soldier and future force applications. ***FY 2014 Accomplishments:*** Established models for package-integrated thermal solutions to balance continuous and transient loads in electronic substrates; assessed emerging thermoelectric materials and modules for power generation under the high temperature conditions required for efficient direct power generation or waste heat recovery; characterized catalysts for fuel conversion (JP-8 and alternative fuels) to build reaction models for efficient combustion design; investigated improved interconnects between solar cells with gallium nitride materials with advanced structures and interfaces to lower the resistance and thereby improve efficiency of the modules; and investigated new 3D ultra-high density integration process that enable disparate best-of-breed sensors and electronics to be integrated within a single package with minimal packaging overhead and interconnect losses. ***FY 2015 Plans:*** Investigate heat management techniques for improving engine waste heat recovery; implement techniques for thermal interface measurements to evaluate heat transfer in novel materials; investigate thermoelectric, pyroelectric, and thermophotovoltaic power generation techniques and materials for applicability in direct power generation; characterize advanced materials for improved fuel conversion efficiency and apply them toward developing improved reaction models; investigate improved techniques for wide bandgap material and device design for power supply and conversion systems; and develop improved models and measurement techniques for prediction of silicon carbide device performance and reliability for high power applications. ***FY 2016 Plans:*** Will implement techniques for thermal interface measurements to evaluate heat transfer in novel materials; develop compact 3-dimensional integration techniques for power electronic devices; investigate novel methods of improving condensation heat transfer through acoustic excitation and surface enhancement; investigate integration of phase change materials into electronic packages for temperature spike suppression; investigate improved micro-fabrication techniques for microscale power devices to be used in power supply systems; investigate wireless energy conversion techniques for powering wearable and portable devices; develop fabrication processes for stretchable, wearable, and light-weight power components; investigate thermoelectric, pyroelectric, and thermophotovoltaic power generation techniques and materials for applicability in direct power generation; and characterize advanced materials for improved fuel conversion efficiency and apply them toward developing improved reaction models.			
Title: Emerging Electronic Devices and Circuits	2.080	2.050	1.681

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Description: This effort investigates and evaluates emerging electronics such as analog, mixed signal, and millimeter wave. Efforts entail design, fabrication, and analysis of electronic devices and integrated circuits for use in extreme environments necessary for Army applications. ***FY 2014 Accomplishments:*** Designed and developed devices and integrated circuits based upon leading edge group IV and III-V semiconducting materials and nanoelectronic approaches; and developed specialized approaches to accommodate extreme environment operation (built-in self-test, ultra-high power/high thermal stress, etc.). ***FY 2015 Plans:*** Mature the design of devices and integrated circuits including built-in self test of high speed integrated circuits based upon leading edge group IV and III-V semiconducting materials; and investigate emerging electronics and prognostics and diagnostics strategies for microgrid energy and power applications. ***FY 2016 Plans:*** Will explore emerging materials, components, and circuits that enable low energy and power efficient RF devices; design novel integrated circuits that provide improvements in power efficiencies, linearity, and noise; and explore system/chip constraints for ultra-linear performance to enable Soldier-level communication in contested RF environments.			
Title: Advanced Infrared Technology (previously titled Infrared (IR) Imaging) ***Description:*** This effort designs and evaluates materials, components and focal plane arrays (FPA) for the next generation of Army's night vision systems, missile seekers, and general surveillance devices. Technologies investigated include mercury cadmium telluride (HgCdTe) material grown on silicon (Si) substrates, strained layer superlattices (SLS), and corrugated quantum well infrared photodetector (C-QWIP) arrays for both the mid-wave infrared (MWIR) and long-wave infrared (LWIR) spectral regions with goals to increase the operating temperature and decrease the cost of focal plane arrays. Work accomplished under PE 0602709A/ project H95 and PE 0601120A/project 31B complements this effort. ***FY 2014 Accomplishments:*** Model and exploit electromagnetic resonant effects to design and fabricate high quantum efficiency (up to 70%), large format, long wavelength, quantum well infrared photo-detector focal plane arrays with resolution up to 4 megapixel or higher; develop high quality scalable substrates with cadmium (zinc, selenium) telluride buffer layers on silicon substrates; and develop mercury cadmium (telluride, selenide) based infrared sensing materials and devices; and use thermal cycle annealing to reduce dislocations propagating in the active region, which currently limits operability. ***FY 2015 Plans:***	2.410	2.593	2.575

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
Develop high quality scalable substrates with cadmium (zinc, selenium) telluride buffer layers on silicon substrates and develop HgCdTe material in collaboration with industrial partners; further study thermal cycle annealing of HgCdTe IR detecting material to advance the development of low cost, dual-color, high performance night vision detectors; and develop and test high quantum efficiency, high definition resonant quantum well IR photodetector QWIP (R-QWIP) arrays for dualband longwave/midwave infrared (LWIR/MWIR) imaging. ***FY 2016 Plans:*** Will investigate extremely low-doped HgCdTe IR material grown on domestically available lattice matched substrates for different spectral regions, including short wavelength IR (SWIR) and long wavelength IR (LWIR) applications; study effects of thermal cycle annealing on HgCdTe material as it pertains to dopant species and profiles; study the implementation of resonant features on HgCdTe for higher temperature operation; and characterize and analyze R-QWIP material and devices for improved quantum efficiency and operating temperature.			
Title: Power and Energy ***Description:*** This effort designs and evaluates chemistries, materials and components for advanced batteries, fuel reformers, and fuel cells. Potential applications include hybrid power sources, smart munitions, hybrid electric vehicles, and Soldier power applications. Investigate applicability of photosynthesis to provide fuel and electricity for Soldier power applications. Investigate silicon carbide (SiC) power module components to enable compact high efficiency, high temperature, and high power density converters for motor drive and pulse power applications. ***FY 2014 Accomplishments:*** Evaluated thin film thermal batteries; experimentally validated computational models of hydroxyl-ion transport in alkaline membranes for alkaline fuel cells; evaluated lithium/sulfur battery chemistry for grid energy storage, investigated solid electrolyte interphase formation on silicon anodes for lithium ion batteries; demonstrated production of hydrogen gas using photosynthetic methods for alternative energy applications; continued to evaluate and characterize material defects and interface impedances using a diode structure to improve the reliability of electronic power devices; and investigated and characterized high frequency operation of silicon carbide devices for new device material implementation in vehicle motor drives and pulse power applications. ***FY 2015 Plans:*** Transition thin film thermal batteries to U S. Army Armament Research, Development and Engineering Center (ARDEC) for augmented munitions power; determine transport properties of anion exchange polymers for alkaline fuel cells; investigate components for sodium ion batteries, optimize electrolyte composition for silicon anodes for lithium ion batteries, develop three dimensional (3-D) strategies for photosynthetic production of hydrogen for alternative energy applications; and experimentally validate models developed through the multiscale modeling effort for batteries and fuel cells; and investigate gallium nitride	4.010	3.972	3.971

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
material based devices in addition to silicon carbide based Metal Oxide Semiconductor Field Effect Transistors (MOSFETs) for reliability and operability characterization. ***FY 2016 Plans:*** Will evaluate and transition 5-volt lithium ion battery electrodes and electrolytes for development of an sample cell for laboratory testing and evaluation; investigate novel battery chemistries for soldier power; characterize new alkaline membranes for fuel cell applications; develop lower cost catalysts for alkaline fuel cells; develop regenerable sulfur sorbents for desulfurization of JP8 at temperatures of 300-400 degrees C; determine degradation mechanisms and lifetimes of sulfur-tolerant palladium alloys for hydrogen separation from JP8 reformate for use in fuel cells.			
Title: Sensor Protection Technologies ***Description:*** This research will develop technologies to specifically address laser threats at different frequencies (ultraviolet, infrared, etc.) and at a variety of pulse widths (picosecond, femtosecond). This research will develop technologies to protect Army radars by agile spectrum exploitation, reconfigurable high speed switching technology, and novel RF power limiters and switching devices to protect RF front ends in contested environments as well as from self-interference challenges where multiple RF systems are operating in close proximity. ***FY 2015 Plans:*** Investigate non-linear electro-optical materials and devices for use in a broad range of sensors, UV, MWIR, and LWIR against very short pulse (down to femtosecond) laser threats; investigate materials and novel devices to delay the onset of thermal destruction of optics and optical structures from high energy lasers; improve laser protection by exploring fast EO shutters, using inorganic crystal-based materials, in conjunction with device tiling to provide increased protection for large aperture sensors; and investigate novel electronic materials to support fast switching devices and power dissipation techniques to protect RF front ends. ***FY 2016 Plans:*** Will study new materials and devices to counter the laser threat against sensors, particularly the threat of wavelength-agile lasers as threats evolve toward directed high energy weapons and ultrafast femtosecond pulsed lasers, to include short-wave infrared (SWIR) and mid-wave infrared (MWIR) sensor protection; investigate new techniques for protection against continuous wave high energy laser threats; and characterize materials as optical limiters against femtosecond pulsed laser threats across a variety of wavelengths (visible through MWIR).	-	2.000	1.600
Title: Energy Harvesting ***Description:*** This research develops technologies to substantially reduce the number of batteries required to operate electronics needed to accomplish dismounted Soldier/Squad mission objectives, significantly reducing Soldier-borne load and reducing logistics requirements. Research will explore technologies to harvest electrical power by converting and storing energy via	-	1.568	2.340

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B. Accomplishments/Planned Programs ($ in Millions)	FY 2014	FY 2015	FY 2016
engineered structures and electronic bandgaps, MEMS-based microscale 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 2015 Plans:*** Explore novel thermophotovoltage devices to achieve high efficiency conversion considering available microcombustors and wavelength-optimized semiconductor devices; investigate plasmonic and meta-materials for enhanced surface catalysis experiments for enhanced energy harvesting from battlefield-scavenged resources; explore options for reducing parasitic losses for military thermoelectrics; and examine pyroelectric materials and models to determine suitability for energy harvesting. ***FY 2016 Plans:*** Will study the properties of bandgap engineered indium gallium nitride (InGaN) and highly mismatched alloys to develop the capability to split water to produce hydrogen to use for fuel or as intermediates for fuel; evaluate thermoelectric and pyroelectric material properties for energy harvesting; investigate and characterize properties of ultra-energetic (isotopic/isomeric) materials and matched energy conversion structures as a long endurance energy source; and refine growth parameters for novel photoelectric materials for use with non-solar applications.			
Accomplishments/Planned Programs Subtotals	29.438	30.908	30.212

C. Other Program Funding Summary ($ in Millions)

N/A

Remarks

D. Acquisition Strategy

N/A

E. Performance Metrics

N/A