ARMY RDT&E BUDGET ITEM JUSTIFICATION (R2 Exhibit)

February 2008

BUDGET ACTIVITY	PE NUMBER AND TITLE
2 - Applied Research	**0602705A - ELECTRONICS AND ELECTRONIC DEVICES**

	COST (In Thousands)	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate
	Total Program Element (PE) Cost	80621	105492	45278	46940	46874	47362	48869
EM4	Electric Component Technologies (CA)	14065	21160					
EM6	HEATING AND COOLING TECHNOLOGIES (CA)	2664	3378					
EM7	POWER AND ENERGY COMPONENT TECHNOLOGIES (CA)	27721	37850					
H11	BATTERY/IND POWER TECH	11387	13572	13165	12801	11900	10644	10882
H17	FLEXIBLE DISPLAY CENTER	4653	6026	6562	7114	7126	7242	7360
H94	ELEC & ELECTRONIC DEV	20131	23506	25551	27025	27848	29476	30627

A. Mission Description and Budget Item Justification: This program element (PE) funds enabling capabilities for the Future Force and, where feasible, exploits opportunities to enhance Current Force capabilities by researching and investigating technologies in areas such as electronic components, power components, frequency control and timing devices, and display technologies. The objective of the program is provide technologies to perform precision deep fires against critical mobile and fixed targets; to provide exceptional all-weather, day or night, theater air defense against advanced enemy missiles and aircraft; and enhanced communications and target acquisition for current and future Army systems. Project H11 funds research on advanced portable power technologies (batteries, fuel cells, hybrids, engines, chargers, and power management) that enable: safe, reliable, and cost effective power sources; reduced system power requirements and logistics burden; increased mission duration. Project H94 funds research in the physical sciences essential to all land combat systems that contain any of the following component technologies: electronics, photonics, flexible displays, micro electromechanical systems, imaging laser radar (LADAR), magnetic materials, ferroelectrics, microwave and millimeter-wave components, and electromechanical systems (engine generator sets). Project H17 supports research at the Flexible Display Center to enhance battlefield situational awareness, increased vehicle mobility, survivability, and lethality, while reducing acquisition and support costs. Supported capabilities include autonomous missile systems, advanced land combat vehicles, smart anti-tank munitions, electric weapons, secure jam-resistant communications, automatic target recognition (ATR), foliage-penetrating radar, and combat identification. It supports all of the science and technology thrust areas that employ electronic and portable power-source technology. Projects EM4, EM6, and EM7 fund congressional special interest efforts.

Work in this PE is related to and fully coordinated with efforts in PE 0602120A (Sensors & Electronic Survivability), PE 0602782A (Command, Control, Communications Technology), PE 0602709A (Night Vision Technology), PE 0602783A (Computer and Software Technology), PE 0603008A (Command, Control, Communications Advanced Technology), and PE 0603772A (Advanced Tactical Computer Science and Sensor Technology). The cited work is consistent with the Department of Defense Research and Engineering Strategic Plan, the Army Science and Technology Master Plan, the Army Modernization Strategy, and the Army Posture Statement. Work is performed by the Army Research Laboratory and the Army Communications and Electronics Research Development, and Engineering Center, Fort Monmouth NJ.

B. Program Change Summary	FY 2007	FY 2008	FY 2009
Previous President's Budget (FY 2008/2009)	81773	43391	45365
Current BES/President's Budget (FY 2009)	80621	105492	45278
Total Adjustments	-1152	62101	-87
Congressional Program Reductions		-699	
Congressional Rescissions			
Congressional Increases		62800	
Reprogrammings	614		
SBIR/STTR Transfer	-1766		
Adjustments to Budget Years			-87

Thirty-two FY08 congressional adds totaling $62800 were added to this PE.

($800) Improved Energy Density Battery
($800) Large Format Li-Ion Battery
($800) Non-Flammable, High Energy Density, Low temperature Warrior Battery
($800) Soldier Fuel Cell System
($1000) Ceramic Membrane - 10(X) More Energy for Battery Systems
($1000) Enzyme Biofuel Cell (SEBC)
($1000) Miniature Cooling Unit for Electronic Devices
($1200) Bio-Battery
($1500) Renewable Energy for Military Applications
($1600) Advanced Portable Power Institute (APPI)
($1600) Blast Risk Analysis and Mitigation Application (BRAMA)
($1600) Manufacturing Technology Development of Advanced Components for High Power Solid-State Lasers
($1600) Mega-Capacity Hybrid Chemistry Lithium Primary Portable Batteries
($1600) Micromachined Switches in Support of Transformational Communications Architecture
($1600) Portable Hydrogen Generator and Hybrid Power Source
($1600) Revolutionary Self-Seating Plastic Enclosure for Military Batteries
($1600) Roll-to-Roll Microelectronics Manufacturing in Support of the Flexible Display Initiative
($1600) Self-Powered, Lightweight, Flexible Display Unit on a Plastic Substrate
($1600) Silicon Carbide MOSFETs for Electric Power Systems
($2000) Advanced Wearable Microcell Power System Process Development
($2000) Defense Modernization and Sustainment Initiative, Rochester Institute of Technology

($2000) Novel Zinc Air Power Sources for Military Applications
($2400) Cogeneration for Enhanced Cooling and Heating of Advanced Tactical Vehicles
($2400) High-Frequency, High-Power Electronic and Optoelectronic Devices on Aluminum Nitride (AIN)
($2400) Thin Lithium-Iron Disulfide Primary Batteries
($2480) Advanced, Integrated Portable Power Generation and Charging System
($2500) ONAMI Miniature Tactical Energy Systems Development
($2800) Low Signature Portable Fuel Cell Power Systems
($3920) Advanced Lithium-Carbon Monoflouride Combat Portable Batteries
($4000) Lithium Ion Metal Battery
($4000) Soldier Portable Solid Fuel Hydrogen Generator Cartridge
($5000) PEM Fuel Cell Tactical Generators

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February 2008

BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
2 - Applied Research	**0602705A - ELECTRONICS AND ELECTRONIC DEVICES**	**H11**

COST (In Thousands)	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate
H11 BATTERY/IND POWER TECH	11387	13572	13165	12801	11900	10644	10882

A. Mission Description and Budget Item Justification: The focus of this project is on applied research to identify, advance, and enhance emerging power generation, energy storage, and power management technologies for the Future Force and, where feasible, exploits opportunities to enhance Current Force capabilities. This project funds research in electrochemistry, energy conversion, and signature suppression technologies, including those for primary batteries, rechargeable battery hybrids, fuel cells, power management, and components for electromechanical power generation. There is a critical need for ultra-lightweight man portable power, chargers, and power management for the dismounted Soldiers. The Soldier Hybrid Power and Smart Chargers effort investigates high energy and high power density hybrid power source components including rapid recharging methods using smart chargers, fuel cell systems, and smart rechargeable batteries. It also investigates novel power management methods through low power design tools and software operating system dynamic power management. The Silent Mobile power effort funds research in power sources that are smaller and more fuel-efficient and in advanced cooling systems enabling tactical sustainability and survivability. Both efforts will provide future Soldiers and other future force platform applications low weight and volume, safe, reliable, cost-effective power sources, reduced system power requirements, increased mission duration and reduced cost and logistics burdens.

The cited work is consistent with the Department of Defense Research and Engineering Strategic Plan, the Army Science and Technology Master Plan, the Army Modernization Strategy, and the Army Posture Statement. Work in this project is performed by the Army Research, Development and Engineering Command, Communications-Electronics Research, Development, and Engineering Center, Fort Monmouth, NJ.

Accomplishments/Planned Program:	FY 2007	FY 2008	FY 2009
Soldier Hybrid Power and Smart Chargers: Develop and evaluate hybrid power sources, rapid battery chargers, and power management technologies in order to decrease soldier load, increase power capabilities, and decrease battery costs. In FY07, investigated system-level smart chargers integrated with a quiet power source, including Stirling engines and fuel cells, for stand-alone charging; designed and demonstrated ruggedized Soldier hybrid power source for 72 hour mission; investigated micro-reformer components for logistic fueled manportable power source. In FY08, evaluate methanol fueled Soldier hybrid fuel cell power source for 72 hour mission at 700 watt-hours per kilogram; investigate rugged JP-8 burners for solid oxide power sources. In FY09, will demonstrate JP-8 fueled Soldier hybrid solid oxide fuel cell; will demonstrate manportable 160 watt JP-8 linear free piston Stirling engine power source weighing less than 10 kilograms; will evaluate 250 watt reformed JP-8 fuel cell for battery charging.	7402	7383	6694
Silent Mobile Power: Investigate component and system level power technologies that will provide higher energy, reduced weight, quiet, more fuel and cost efficient power generation sources, including silent mobile power sources, cogeneration cooling systems, and tactical power management systems. In FY07, evaluated components for 2 kilowatt (kW) fuel processing system operating on high sulfur fuel (>300 parts per million sulfur); evaluated a preliminary prototype of a 1-2 kW Stirling engine generator system on JP-8. In FY08, demonstrate controlled operational testing in a laboratory environment of 1-2 kW Stirling engine generator on JP-8 fuel; demonstrate controlled operational testing in a laboratory environment of 2 kW fuel cell generator on JP-8 fuel; demonstrate a preliminary prototype cogeneration cooling system using waste heat from a quiet power source. In FY09, will mature system integration and controls in order to demonstrate 2 kW solid oxide fuel cell generator and 1-2 kW Stirling engine generator in relevant field environment; will demonstrate	3985	3886	3471

integrated power/cooling cogeneration system.			
Lithium Air Battery: Develop and investigate advanced materials, material processes, and electrochemical components that will produce a high energy density (>1,000 Watt-hours/kilogram) lithium air power source for soldiers. In FY08, investigate lithium organic and inorganic materials and processes to produce highly conductive electrolytes to achieve greater than 0.5 mill-Amps/square centimeter current densities; demonstrate prototype lithium air cells/batteries having energy densities greater than 800 Watt-hours/kilogram; demonstrate material stability of lithium air cell components to achieve high shelf life (greater than one year). In FY09, will develop material and cell fabrication processes to produce high energy density, stable, safe lithium air battery; will demonstrate prototype lithium air cells/batteries having energy densities greater than 1,000 Watt-hours/kilogram.		2000	3000
Small Business Innovative Research/Small Business Technology Transfer Programs		303	
Total	11387	13572	13165

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February 2008

BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
2 - Applied Research	**0602705A - ELECTRONICS AND ELECTRONIC DEVICES**	**H17**

COST (In Thousands)	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate
H17 FLEXIBLE DISPLAY CENTER	4653	6026	6562	7114	7126	7242	7360

A. Mission Description and Budget Item Justification: This project funds the Army's Flexible Display Center (FDC). The objective of this project is to mature flexible display technologies toward Army applications thereby providing leap-ahead technology to our Soldiers. Flexible displays are inherently rugged (no glass), light weight, conformal, potentially low cost, low power, and hence offer enhanced and new capabilities across a broad spectrum of Army applications. Areas of investigation include: lightweight, low power, and rugged flexible displays.

Work in this project is performed by the Army Research Laboratory (ARL). Note: This project was previously funded in PE 0602705A project H94 and is a restructuring of ongoing research into a distinct project for visibility and management oversight.

The cited work is consistent with the Department of Defense Research and Engineering Strategic Plan, the Army Science and Technology Master Plan, the Army Modernization Strategy, and the Army Posture Statement.

Accomplishments/Planned Program:	FY 2007	FY 2008	FY 2009
The objective of this research is to mature flexible display technology for future vehicle and future Soldier applications. The research is being conducted at the Flexible Display Center (FDC) at Arizona State University. Management will be conducted by ARL in collaboration with Natick Soldier Research and Development Center, the FDC, industry, and other university partners. In FY07, designed and fabricated 4" diagonal active matrix reflective and emissive displays with enhanced resolution and functionality and began to qualify the pilot line for displays up to 15" diagonal. In FY08, the FDC develops and delivers reflective displays up to 10" diagonal from the pilot line for the next generation Soldier systems. The FDC begins full color designs. In FY09, the FDC will develop and deliver up to 10" diagonal reflective and emissive displays from the pilot line with increasing performance for next generation platforms.	4653	4860	5062
Flexible display partnerships funded through the U.S. Diplays Consortium (USDC) for tools, process, and materials development that directly support the FDC. In FY08, establish programs through the USDC that support the FDC with existing tool modifications, processes, related material, and device development. The programs directly support the FDC and the Army's mission to develop flexible displays and manufacturing technology for flexible displays. In FY09, will mature the USDC programs that directly support the FDC and the Army's mission to develop flexible displays and manufacturing technology for those displays.		1000	1500
Small Business Innovative Research/Small Business Technology Transfer Programs		166	
Total	4653	6026	6562

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BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
2 - Applied Research	**0602705A - ELECTRONICS AND ELECTRONIC DEVICES**	**H94**

COST (In Thousands)	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate
H94 ELEC & ELECTRONIC DEV	20131	23506	25551	27025	27848	29476	30627

A. Mission Description and Budget Item Justification: The objective of this project is to conduct applied research in electronics and electronic devices including opto-electronics to support advanced power and energy generation and storage; Command, Control, Communications, and Computers (C4); and Intelligence, Surveillance, and Reconnaissance (ISR) technologies for the Future Force. This research supports thrusts aimed at enhanced battlefield situational awareness; increased vehicle mobility, survivability, and lethality; reduced acquisition cost; and reduced operations and support costs. Areas of investigation include: low noise clocks and oscillators; lasers and focal plane arrays for eye-safe laser radar (LADAR) and standoff target acquisition sensors like forward-looking infrared (FLIR); micro-electromechanical systems (MEMS) for multi-function radio frequency (RF) applications as well as smart munitions; advanced RF modules to support radars and communications systems; high-temperature high-power inverter circuits for electric drives; prognostics and diagnostics to reduce logistics demands; micro-power generators and advanced batteries, fuel reformers, and fuel cells for hybrid power sources for individual Soldier and platform applications. The fabrication of novel structures on new electronic materials, such as langasite for oscillators or molecular beam epitaxy (MBE) of semiconductor superlattices and the hybridization of opto-electronic (OE) devices with electronics will be key enablers for more affordable opto-electronic devices with new capabilities. These fabrication techniques require a more complete understanding of fundamental properties, growth techniques, and processing of new materials. These new materials and structures also require the development of new design and layout techniques, more sensitive and flexible test and analysis capabilities, and new means of packaging to protect the devices and promote control of heat and atmosphere while enabling transport of signals and power. These challenges can only be overcome with judicious application of a basic understanding of the physics and chemistry of the electronic and opto-electronic processes. These projects serve to enhance the survivability, lethality, and mobility of future Army platforms by enhancing their survivability electronics suite; increasing ranges while decreasing time lines for target acquisition sensors; and evolving more efficient, controllable power sources, and displays. The cited work is consistent with Strategic Planning Guidance, the Army Science and Technology Master Plan (ASTMP), the Army Modernization Plan, and the Defense Technology Area Plan (DTAP). Work in this project is performed by the Army Research Laboratory (ARL).

Accomplishments/Planned Program:	FY 2007	FY 2008	FY 2009
Design and mature high performance antennas and antenna arrays for RF front-end architectures supporting multifunction radar and communication systems. This work also includes evaluation and validation of these prototype designs. Among the issues addressed in this antenna development are scanning techniques, broadbanding, beamforming, polarization, platform integration, and affordability. In FY07, designed Satellite Communication on the Move (SOTM) and Terrestrial communication antennas and evaluated early prototypes. Evaluated high sensitivity mmW microbolometer detector array. In FY08, validate that these antenna prototypes can be integrated into Army platforms through simulations and laboratory validation. In FY09, will mature these designs based on the measured laboratory data and transition the work to Communications and Electronics Research, Development, and Engineering Center (CERDEC).	2366	2662	2507
Investigate micro and nano technology for small low cost, highly reliable, RF MEMS switches, resonators, and filters for multifunction RF applications; design highly stable low-noise oscillators with low-acceleration sensitivity by integrating photonic resonators and conventional microwave components to improve the capability of radar systems to detect slow moving targets; mature components and software for C4 technology; and perform research in advanced tactical software tools for mobile, ad hoc network access control, intrusion detection, and authentication techniques for the Future Force. In FY07, initiated investigations of 1/f phase noise perturbations and dual-	2320	3420	3702

mode resonators for stabile oscillators; initiated fabrication of wafer-level packaging with a MEMS phase shifter process for multifunction RF applications; conducted characterization of stabilized oscillator dual-mode crystals with low hysteresis temperature effects. In FY08, devise a process for wafer-level packaging with a MEMS phase shifter for multifunction RF applications and complete investigation of 1/f phase noise perturbations and dual-mode resonators for stabile oscillators. In FY09, will investigate approaches for a wafer level antenna. Prepare and integrate passive RF electronics with ARL's RF MEMS switch fabrication process.			
Research, design, and investigate new component materials, structures, devices, and electromagnetic issues of millimeter wave (mmW) components and active devices, such as vacuum electronic (VE) devices and millimeter wave integrated circuits (MMICs), to achieve higher output power, power-added-efficiency, linearity, and dynamic range for increased operation and detection range in future systems, unmanned aerial vehicles (UAVs), Electronic Warfare (EW), radar, and Soldier systems. In FY07, initiated characterization, analysis, and evaluation of high power (80 W) Ka-band MMPM; and initiated design and characterization of GaN power amplifier modules. In FY08, complete efforts on Ka-band MMPM and GaN modules. Design GaN amplifier integrated in mini-package and analyze thermal properties for high power packaged amplifiers. In FY09, will design and fabricate integrated high power package for antenna array.	2415	3497	3205
Investigate eye-safe, scanner-less, 3-D imaging laser radar (LADAR) for both long-range reconnaissance and short-range unmanned ground and air vehicle applications. Investigate optical limiter designs with promising nonlinear materials in order to provide passive protection of Future Force electro-optic (EO) vision systems from damage from laser threat devices. In FY07, used the image tube LADAR to evaluate obscured target detection through 3-D LADAR imagery in simulated UAV and ground-to-ground scenarios; transitioned LADAR architecture to CERDEC for integration into UAV EO payloads; showed large-dynamic-range, broadband optical limiting in a tandem limiter configuration chosen to match that of the Tank and Automotive Research, Development, and Engineering Center (TARDEC) system demonstrator with single Charge Coupled Device (CCD) sensor; transitioned selected broadband nonlinear limiting material to TARDEC for integration into the system demonstrator. In FY08, utilize TARDEC testing results on the system demonstrator to further maximize performance of materials for CCD protection and fabricate an integrated solid-state version of the LADAR architecture for transition to CERDEC and Armaments Research, Development, and Engineering Center (ARDEC). In FY09, will retro-fit the solid-state version of the ladar receiver into the image tube to obtain improved performance required by Aviation and Missile Research, Development, and Engineering Center (AMRDEC).	2728	1835	1132
Investigate multi-color, passive infrared (IR), imaging focal plane arrays (FPAs) for long range target detection and identification. Investigate molecular beam epitaxy (MBE) growth techniques for the growth of mercury cadmium telluride (HgCdTe) on Silicon (Si) substrates for both the mid-wave infrared (MWIR) and long-wave infrared (LWIR) spectral region to significantly decrease the cost and to allow the development of large area arrays. Design and fabricate arrays for higher operating temperature. In FY07, researched MWIR and LWIR FPAs with high operating temperatures of 180 Kelvin for MWIR and 120 Kelvin for LWIR. In FY08, investigate multicolor (Short Wave IR (SWIR)/MWIR/LWIR) FPAs for enhanced range and detection. In FY09, will research polarization sensitive data collection and analysis for improved target classification and identification and explore FPAs with on-chip processing.	2250	2139	2170
Investigate a broad base of extremely quick, accurate, and novel photonic architectures to enable detection of hazardous substances to enhance Soldier survivability. Investigate the hybridization of OE devices with electronics for IR scene projectors and compact 3-D imaging. In FY07, explored possible chip-level technologies (Quantum/Interband Cascade Lasers, MEMS microphones, and MEMS actuators) for incorporation into MEMS photoacoustic chemical sensing system. In FY08, characterize current biomimetic recognition elements using several laboratory analytic methodologies; evaluate olfactory sensor based on integrated MEMS photoacoustic system; characterize efficacy of molecular recognition elements devised using rapid directed evolution methodologies and investigate multi-band IR 2-D arrays for scene generation. In FY09, will assess recognition elements as alternative biologically-inspired methods to produce advanced photonic and electronic structures and investigate hybrid techniques incorporating novel recognition elements and spectroscopic	505	2642	4056

inspection and investigate highly compact OE transceivers for 3-D imaging.			
Investigate, design, and fabricate MEMS based components to improve power generation and micro-cooling technology for both the dismounted Soldier and Future Force systems. In FY07, designed and fabricated reclaimed energy systems for small engines; investigated methods to integrate MEMS based fuel/air delivery devices into small engines; and designed and fabricated cooling systems that provide 500 W/cm2. In FY08, investigate advanced MEMS cooling systems, demonstrate MEMS components on a small system and l fabricate MEMS valves for high flow applications. In FY09, will fabricate a heteroscopic turbine cooler; and will investigate improved MEMS rotary pumps, MEMS valves, and high flow low power atomizers.	4557	3319	4248
Investigate and evaluate prognostics and diagnostics (P&D) algorithms; design, fabricate, and evaluate MEMS and other sensors; and design, develop code, and evaluate database for the integration into decision systems to extend sensor rationalization and minimize downtime via condition-based maintenance. In FY07, initiated reduction of MEMS switch reset voltage and designed initial package; initiated evaluation of fault identification criteria and determined physics of failure modes. In FY08, fabricate experimental core module applied to specific commodities. Module entails a coded algorithms transceiver, core sensors, processor, and remote sensor interface. Conduct preliminary experimentation on networked RF link and incorporate fault algorithms. In FY09, will implement cross-correlated algorithms in an open architecture P&D system and will conduct fault prognostic tests enhancing algorithms and user interface in an open architecture environment.	2643	2853	2954
Investigate technology for advanced batteries, fuel reformers, and fuel cells to be used in hybrid power sources for future electromagnetic armor and smart munitions. Investigate and mature silicon carbide (SiC) power module technologies to enable compact high temperature (up to 150°C heat sink temperature) and high power density converters for motor drive and pulse power applications for the Future Force. In FY07, provided improved electrolyte for low temperature Li-ion batteries and sulfur-tolerant catalysts for logistic fuel processing for fuel cells. In FY08, explore new technology for reserve batteries and more stable sulfur tolerant catalysts. Investigate and mature high-temperature (90° - 120°C) SiC power modules implemented in voltage-controlled SiC power devices for low power hybrid electric vehicle (HEV) power conversion. In FY09, will explore higher energy reserve battery materials and higher power Li-ion battery materials. Will investigate and mature high-temperature (90° - 120°C) SiC power modules for medium power conversion.	347	1009	1577
Small Business Innovative Research/Small Business Technology Transfer Programs		130	
Total	20131	23506	25551