

ARMY RDT&E BUDGET ITEM JUSTIFICATION (R2 Exhibit)

February 2006

BUDGET ACTIVITY
2 - Applied Research

PE NUMBER AND TITLE
0602705A - ELECTRONICS AND ELECTRONIC DEVICES

COST (In Thousands)	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate
Total Program Element (PE) Cost	101771	91925	42175	41729	41917	43483	43904
EM4 Electric Component Technologies (CA)	22518	9661	0	0	0	0	0
EM6 HEATING AND COOLING TECHNOLOGIES (CA)	3449	3943	0	0	0	0	0
EM7 POWER AND ENERGY COMPONENT TECHNOLOGIES (CA)	35292	39331	0	0	0	0	0
H11 BATTERY/IND POWER TECH	11872	11993	12336	11769	10241	10347	10439
H17 FLEXIBLE DISPLAY CENTER	0	4895	5151	5113	5115	5163	5175
H94 ELEC & ELECTRONIC DEV	28640	22102	24688	24847	26561	27973	28290

A. Mission Description and Budget Item Justification: This program element provides 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 Future Combat System (FCS) and Future Force Warrior applications. Project H11 researches 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 consists of 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 new 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 Strategic Planning Guidance, the Army Science and Technology Master Plan (ASTMP), the Army Modernization Plan, and the Defense Technology Area Plan (DTAP). Work is performed by the Army Research Laboratory and the Army Communications and Electronics Research Development and Engineering Center, Fort Monmouth NJ.

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	FY 2005	FY 2006	FY 2007
<u>B. Program Change Summary</u>			
Previous President's Budget (FY 2006)	102768	39554	41536
Current BES/President's Budget (FY 2007)	101771	91925	42175
Total Adjustments	-997	52371	639
Congressional Program Reductions		-402	
Congressional Rescissions		-927	
Congressional Increases		53700	
Reprogrammings	-997		
SBIR/STTR Transfer			
Adjustments to Budget Years			639

Thirty-three FY06 Congressional adds totaling \$53,700 were added to this PE.

FY06 Congressional adds with no R-2A (appropriated amount is shown):

(\$1000) Advanced Oscillator Technology for Radar and Communications Systems

(\$1000) Advanced Power Component Technologies

(\$1000) Bipolar Wafer-cell Lithium-ion Batteries

(\$1000) Carbon Dioxide Heating and Cooling Technology

(\$1000) Conformal LI-ION Polymer Belt Battery for Urban 1st Responders

(\$1000) Development of Clean Sources of Hydrogen for Fuel Cells

(\$2000) Direct Methanol Fuel Cell Lifetime Improvement Program (DMFC-LIP)

(\$2000) E-Beam Reticle and Lithography Inspection Tool

(\$1000) Field-Ruggedized Mid-Range Direct Methanol Fuel Cells

(\$1000) Flexible Microelectronics in Support of Flexible Display Initiative (FDI)

(\$2600) Flexible Polymer Multilaminate Packaging

(\$1000) Future Soldier Hybrid Power Sources for the Battlefield

(\$1000) Higher Energy Density Rechargeable Batteries Based on Stabilized Lithium Metal Power (SLMP)

(\$3600) Jet/Diesel-Fueled Military Fuel Cell System

(\$1000) Liquid Silicone (Large Format Plate Type) Li Rechargeable Battery for the Future Force Warrior

(\$2200) Lithium Air Metal Battery

(\$2500) Lithium Carbide Monofluoride Military Battery Packs

(\$1800) Manufacturing Technology Development of Advanced Components for High Power Solid-State Lasers

(\$1500) Miniature Tactical Energy Systems Development

(\$1000) Nanofluidic Electronic BioSensor Technologies for Defense Applications

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(\$1400) Novel Zinc Air Power Sources for Military Applications (\$1000) ONAMI Miniature Tactical Energy Systems Development (\$1000) PEM Fuel Cell Tactical Quiet Generators (\$2000) Portable Power Technology and Manufacture (\$1000) Portable Reforming on the Battlefield (\$2000) Portable Solid Oxide Fuel Cell SOFC/JP-8 Demonstrator (\$2700) Revolutionary 1.5V Alkaline (\$1400) Soldier Fuel Cell System (\$1500) Soldier Portable Fuel Cell Power Using Solid Fuel Hydrogen Generator (\$2000) State of Charge Battery Life Indicator (\$2800) Thin Cylindrical Iron Disulfide Primary Battery (\$3000) Transcritical Carbon Dioxide (CO2) Environmental Control Unit (\$1700) Weapons of Mass Destruction Marking Set		

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BUDGET ACTIVITY 2 - Applied Research			PE NUMBER AND TITLE 0602705A - ELECTRONICS AND ELECTRONIC DEVICES			PROJECT H11	
COST (In Thousands)	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate
H11 BATTERY/IND POWER TECH	11872	11993	12336	11769	10241	10347	10439
<p>A. Mission Description and Budget Item Justification: This project conducts 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 researches advancements 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 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.</p> <p>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, Development and Engineering Command, Communications-Electronics Research, Development, and Engineering Center, Fort Monmouth, NJ.</p>							
Accomplishments/Planned Program				<u>FY 2005</u>	<u>FY 2006</u>	<u>FY 2007</u>	
- 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 FY05, investigated system level stand-alone smart charger technology with 2-hour recharge capability for soldier batteries; investigated power management techniques to reduce operating system power draw for soldier systems by 50%. In FY06, develop and evaluate propane fueled small Stirling engine generator components for silent manportable (<10 kilograms) power 160 watts; design and demonstrate a hybrid fuel cell power source with reformed methanol fuel. In FY07, will investigate system-level smart chargers integrated with a quiet power source for stand-alone charging; will design and demonstrate ruggedized soldier hybrid power source for 72 hour mission; will investigate micro-reformer components for logistic fueled manportable power source.				7613	7817	8168	
- 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, and tactical power management systems. In FY05, developed components for a 2 kilowatt (kW) fuel processing system operating on low-sulfur fuel (<50 parts per million sulfur). In FY06, investigate fuel cell reformer components for 1-2 kW system for scout vehicle silent watch; investigate and mature logistic fueled Stirling engine generator components for silent mobile (for vehicle/trailer platforms) power >1kW; evaluate integrated 2 kW fuel processing system operating on low-sulfur fuel. In FY07, will evaluate components for 2 kW fuel processing system operating on high sulfur fuel (>300 parts per million sulfur); will demonstrate 1-2 kW Stirling engine generator system on logistic fuel.				4259	4176	4168	
Total				11872	11993	12336	

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BUDGET ACTIVITY 2 - Applied Research			PE NUMBER AND TITLE 0602705A - ELECTRONICS AND ELECTRONIC DEVICES				PROJECT H17
COST (In Thousands)	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate
H17 FLEXIBLE DISPLAY CENTER	0	4895	5151	5113	5115	5163	5175
<p>A. Mission Description and Budget Item Justification: This project funds the new Flexible Display Center at Arizona State University. The objective of this project is to conduct applied research in advanced and novel electronic displays. 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: lightweight, low power and rugged flexible 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). 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.</p>							
<u>Accomplishments/Planned Program</u>				<u>FY 2005</u>	<u>FY 2006</u>	<u>FY 2007</u>	
<p>- In FY05, this effort was funded in this PE under Project H94. The Army established a Flexible Display Center at Arizona State University to develop flexible display technology demonstrations for future vehicle and future Soldier applications. In FY06, will design and fabricate larger format reflective and emissive displays (up to 4" diagonal). The research will enable improved integration of display sub-systems. Display drivers will be developed. In FY07, will design and fabricate 4" diagonal Active Matrix reflective and emissive displays with enhanced resolution and functionality. Begin full color design. Display development on the pilot line will begin for improved processes with higher yield. Management and applied research will be conducted by ARL in collaboration with Natick Soldier Center, the Flexible Display Center, industry, and other university partners.</p>				0	4895	5151	
Total				0	4895	5151	

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BUDGET ACTIVITY 2 - Applied Research			PE NUMBER AND TITLE 0602705A - ELECTRONICS AND ELECTRONIC DEVICES			PROJECT H94	
COST (In Thousands)	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate
H94 ELEC & ELECTRONIC DEV	28640	22102	24688	24847	26561	27973	28290
<p>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, 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.</p> <p>Areas of investigation include: low noise clocks and oscillators; lasers and focal plane arrays for eye safe laser radar 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 ultra-violet (UV)/Infrared (IR) vertical emitters, will be a key enabler for more affordable 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. In FY05, this project also funded the new Flexible Display Center at Arizona State University. As of FY06, the Flexible Display effort will be restructured to Project H17 for increased visibility and management oversight. 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).</p>							
<u>Accomplishments/Planned Program</u>					<u>FY 2005</u>	<u>FY 2006</u>	<u>FY 2007</u>
- Mature high performance antennas and RF front-end architectures to support multifunction radar systems; and design and evaluate electronically scanning antennas for multifunction RF applications. In FY05, prototyped small linear Ka antenna arrays, using ferroelectric and micro electro mechanical system (MEMS) phase shifter technology to assess feasibility of each concept in terms of loss and beam positioning speed. In FY06, will assess Ka-band Electronically Scanned Antenna (ESA) requirements for Army communications. Will design and mature multiple apertures in Joint Service Communications bands integrated into composite armor. Will design high sensitivity single mmW microbolometer detector for radiometry applications. In FY07, will fabricate composite armor antennas consistent with Army directional antenna requirements.					3061	943	1004
- 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					2571	2829	3110

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detection, and authentication techniques for the Future Force. In FY05, assessed the performance of E-Beam lithography in patterning nanoscale RF structures for Future Force and future Soldier communications; designed, fabricated, and evaluated phase-locked cavity based stabilized local oscillator (STALO) for RF front ends; and integrated lead zirconium titanate (PZT) MEMS switches in a phased array in an Electronically Scanned Antenna (ESA) structure. In FY06, will develop a full PZT-MEMS switch based ESA for missile seekers. Investigate 1/f noise physics in resonators, and optimize miniature dual mode resonators with low g sensitivity leading to high g smart munitions. In FY07, will develop wafer-level packaging with a MEMS phase shifter process for multifunction RF applications; and will start characterization of stabilized oscillator dual mode crystals with low hysteresis temperature effects.			
- 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 FY05, integrated and characterized VE tube with semiconductor amplifier and power supply in Millimeter Power Modules (MMPMs); completed transmit/receive (T/R) module incorporating wide bandgap Monolithic Microwave Integrated Chip (MMICs) for synthetic aperture radar/moving target indicator (SAR/MTI) radar to support tactical UAVs. In FY06, will fabricate and evaluate high power (60W) Q-band MMPM amplifier; and will investigate reliability of gallium nitride (GaN) devices under high temperature, fabricate 2nd generation devices, and implement packaging concepts with thermal modeling. In FY07, will characterize, analyze, and evaluate high power (80W) Ka-band MMPM; and will design and characterize GaN T/R and power amplifier modules.	2925	2867	3183
- Investigate eye-safe scannerless 3-D imaging laser radar (ladar) and multi-color passive infrared (IR) imaging focal plane arrays (FPAs) and cameras 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 FY05, implemented and characterized a longer-range improved version of the ladar breadboard, and collected data to show functionality for target acquisition. Using the newly constructed tandem test bed, characterized promising nonlinear optical materials in militarily relevant focusing configurations. In FY06, will analyze passive IR target and background signatures and recommend design criteria to the Communications and Electronics Research, Development and Engineering Center (CERDEC) for advanced IR dual-band passive sensors; will evaluate and select a nonlinear limiting material class with large bandwidth and high optical density for extensive characterization in tandem limiter configuration. In FY07, will design and evaluate obscured target detection through 3-D ladar imagery in simulated UAV and ground-to-ground scenarios and transition to CERDEC Mission Equipment Package for Class II UAV program; will address issues associated with encapsulating the selected nonlinear material in a solid host, leading to development of a robust limiting device, which provides technologies to protect against damage at all laser wavelengths across the operating spectrum of the Future Force electro-optic vision systems.	3309	2982	3210
- 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. Will design and fabricate arrays for higher operating temperature. In FY05, achieved growth of LWIR arrays with less than 2% defective pixels. Fabricated 256x256 LWIR FPA from material grown on Si with high sensitivity. In FY06, will fabricate large area arrays with up to 1000X1000 pixels for both MWIR and LWIR with a goal of less than 1% defective pixels; and will fabricate arrays with new detector design for higher operating temperature. In FY07, will continue the growth of high temperature arrays with the goal of achieving operating temperatures of 180 Kelvin for MWIR and 120 Kelvin for LWIR.	2665	2019	2723
- Investigate a broad base of extremely quick, accurate, and novel photonic architectures to enable detection of hazardous substances to enhance soldier survivability. In FY05, characterized the chemical sensing concept using a photoacoustic system on a Micro-	1884	1404	1492

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Electromechanical-Systems (MEMS) platform and characterized an antimony-based resonant-cavity vertical-emitting infrared Light Emitting Diode (LED). In FY06, will evaluate MEMS photoacoustic sensor performance for feasibility as a trace-level chemical sensor. In FY07, will explore possible chip-level technologies (Quantum / Interband Cascade Lasers, MEMS microphones and MEMS actuators) for incorporation into MEMS photoacoustic chemical sensing system.			
- 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 FY05, explored designs and fabrication methods for a MEMS based fuel pump, and investigated Aluminum Nitride for a micro-channel cooling system to provide 250 watts / square centimeter (W/cm2) of cooling. In FY06, will fabricate a MEMS based fuel pump and fuel injector devices; design and fabricate reclaimed energy system for small engines, and fabricate micro-cooling systems capable of 250 W/cm2. In FY07, will design and fabricate reclaimed energy systems for small engines; investigate methods to integrate MEMS based fuel/air delivery devices to small engines and fuel cells; and will design and fabricate cooling systems that provide 500 W/cm2.	2500	4435	4564
- Investigate and evaluate prognostics and diagnostics (P&D) algorithms; design, fabricate and evaluate MEMS and other sensors; and design, code, and evaluate database for the integration into decision systems to extend sensor rationalization and minimize downtime via condition-based maintenance. In FY05, fabricated MEMS multi-level acceleration latch/reset switches for no power shock detection and monitoring; and conduct validating experiments on MEMS/nanotechnology sensors. In FY06, will research and evaluate advanced base-sensor suite, processor, and transceiver in distributed multi-node network. In FY07, will evaluate chemical and stress sensors for missile health monitoring.	2815	2780	3442
- Investigate and mature silicon carbide (SiC) power device and packaging technologies to enable high temperature and power density converters for motor drive and pulse power applications for the Future Force (FF). Investigate technology for advanced batteries, fuel reformers and fuel cells to be used in hybrid power sources for FF electromagnetic armor and smart munitions. In FY05, implemented high-temperature controller and DC-DC isolation circuits for high-power converters; investigated high temperature power converters for 10 kilowatt (kW) and 100 kW mobile power applications and implemented high-voltage SiC power rectifier for a survivability application. Provided technology for an advanced high-energy rechargeable battery with enhanced user safety and high temperature charge retention and explored sulfur-removal absorbents for fuel cells. In FY06, will investigate and evaluate high-temperature SiC power converters implemented with current-controlled devices for medium power hybrid-electric vehicle (HEV) power conversion applications; will provide electrode/electrolyte materials technology for enhancing charge/discharge rate of advanced Li-ion batteries and investigate absorbents for removing sulfides in military fuel for fuel cells. In FY07, will mature current controlled SiC power components; investigate/evaluate high-temperature SiC converters implemented with voltage-controlled devices for low power HEV power conversion; and provide improved electrolyte for low temperature Li-ion batteries and sulfur-tolerant catalysts for logistic fuel processing for fuel cells.	1783	1843	1960
- The Army established a Flexible Display Center at Arizona State University to develop flexible display technology demonstrations for future vehicle and future Soldier applications. In FY05, investigated 2.5" diagonal active matrix reflective displays from research line. In FY06, this effort is restructured into PE 0602705A Project H17 for increased visibility and management oversight.	5127	0	0
Total	28640	22102	24688