ARMY RDT&E BUDGET ITEM JUSTIFICATION (R-2 Exhibit)

February 2002

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

	COST (In Thousands)	FY 2001 Actual	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate
	Total Program Element (PE) Cost	40144	49965	27448	30167	31664	32618	35831
EM4	ELECTRONIC DISPLAY RESEARCH	0	9000	0	0	0	0	0
H11	BATTERY/IND POWER TECH	20621	17849	4689	4567	4811	4982	5085
H94	ELEC & ELECTRONIC DEV	19523	23116	22759	25600	26853	27636	30746

A. Mission Description and Budget Item Justification: The work under this program element provides enabling capabilities for the Objective Force by researching and investigating 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 to provide electronic components, power components, and low-cost, lightweight, high-energy density power sources for communications, target acquisition, and miniaturized displays, for applications such as the Future Combat Systems (FCS) and soldier systems. This program consists of research in the physical sciences essential to all land combat systems that contain electronics, photonics, magnetic materials, ferroelectrics, microwave and millimeter-wave components, batteries, electromechanical systems (engine generator sets) and fuel cells. Supported systems include FCS, soldier systems, autonomous missile systems, advanced land combat vehicles, smart anti-tank munitions, electric weapons, secure jam-resistant communications, automatic target recognition (ATR), foliage-penetrating radar, combat identification, and digitizing of the battlefield. This program supports the in-house applied research effort at a single Army site, which serves as both the center for display technology and the center for frequency control and timing for the Army, Navy, Air Force, and Ballistic Missile Defense Organization. It supports all of the science and technology thrust areas that employ electronic and portable power-source technology. The cited work is consistent with the Army Science and Technology Master Plan (ASTMP), the Army Modernization Plan and Project Reliance. The program element contains no duplication with any effort within the Military Departments. Work is performed by the Army Research Laboratory and the Army Communications and Electronics Research Development and Engineering Center Fort Monmouth NJ. This PE supports the Objective Force transition path of the Transformation Campaign Plan (TCP).

B. Program Change Summary	FY 2001	FY 2002	FY 2003
Previous President's Budget (FY2002 PB)	40891	27819	27312
Appropriated Value	41269	50319	0
Adjustments to Appropriated Value	0	0	0
a. Congressional General Reductions	0	-354	0
b. SBIR / STTR	-747	0	0
c. Omnibus or Other Above Threshold Adjustments	0	0	0
d. Below Threshold Reprogramming	0	0	0
e. Rescissions	-378	0	0
Adjustments to Budget Years Since FY2001 PB	0	0	136
Current Budget Submit (FY 2003 PB)	40144	49965	27448

Change Summary Explanation:

Significant Changes:
FY02 - Congressional adds totalling $22500 (as noted below) were added to this PE in FY02.

FY02 Congressional Adds:
Cylindrical Zinc-Air Battery for Land Warrior System, Project H11 ($1800); Electronic Display Research, Project EM4, ($9000); Fuel Cell Power Systems, Project H11 ($2500); Improved High Rate Alkaline Cell, Project H11 ($1000); Logistics Fuel Reformer, Project H11 ($1000); Low Cost Reusable Alkaline Manganese-Zinc, Project H11 ($600); Polyme r Extrusion/Multilaminate (Battery Research), Project H11 ($2600); Rechargeable Cylindrical Cell System, Project H11 ($1500); TOW ITAS Cylindrical Battery Replacement, Project H11 ($1500); Heat actuated Coolers for Portable Mil Apps, Project H11 ($1000).

Projects with No R-2A:
Project EM4 ($9000) Electronic Display Research - The objective of this one year Congressional add is to investigate high definition Flat Panel Electronic Displays for military applications. No additional funds are required to complete this project.

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

COST (In Thousands)		FY 2001 Actual	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate
H11	BATTERY/IND POWER TECH	20621	17849	4689	4567	4811	4982	5085

A. Mission Description and Budget Item Justification: This project conducts applied research to improve power generation and management technologies for the Objective Force. Researches advancements in energy conversion, electrochemistry, and signature suppression technologies including battery (primary and rechargeable), fuel cell, thermoelectric, hybrid, and electromechanical power sources. This project investigates small, low-cost, environmentally compatible, high energy density sources of power for communications, target acquisition, miniaturized displays, silent watch and future soldier systems. These technologies support reduced acquisition and operation and support costs. This project supports the Objective Force transition path of the Transformation Campaign Plan (TCP).

FY 2001 Accomplishments:

- 875 - Established the most cost effective, safe, high performance primary battery with greater than 300 watt-hours per kilogram; completed initial applied research of a high energy rechargeable lithium-ion battery with non-flammable electrolyte for C4IEWS applications; completed research and tested manpack metal-air battery powered recharging system with universal smart charging cable for light infantry C4IEWS equipment.
- 730 - Completed integration of power components/subassemblies in a 5 kilowatt engine driven generator system design; implemented tests to ensure proper operation of power electronics subsystems; integrated the power electronics subsystem into a power-on-the-move tactical vehicle.
- 1286 - Characterized battery/battery hybrid for size, weight, and cost; designed and built kinetic energy harvesting system for charging soldier system batteries; designed efficient 500 watt TPV system for soldier support applications; tested and demonstrated hydride fuel cell model for soldier system.
- 840 - Evolved design tools for low power system design; matured power management techniques for reducing power consumption for Land Warrior.
- 144 - Integrated model power source for an uncooled infrared sensor into a 3 pound weapon sight prototype.
- 1444 - Achieved objective of this one-year Congressional add for Portable Hybrid Electric Power Research and Polymer Extrusion: matured a fuel cell/battery hybrid power source.
- 1925 - Achieved objective of this one-year Congressional add for AA Zinc Air Battery Production: matured a low cost primary battery for forward area recharging.

FY 2001 Accomplishments: (Continued)

- 1155 - Achieved objective of this one-year Congressional add for Improved High Rate Alkaline Cell: matured high rate, low cost AA, D cells for night vision devices.
- 866 - Achieved objective of this one-year Congressional add for Lithium Carbon Monoflouride Coin Cell: matured a primary battery for memory backup/extended power.
- 1540 - Achieved objective of this one-year Congressional add for Rechargeable Cylindrical Cell Systems: matured lithium ion cells for soldier systems.
- 481 - Achieved objective of this one-year Congressional add for Low Cost Reusable Alkaline Manganese-Zinc: matured low cost rechargeable batteries for training.
- 1829 - Achieved objective of this one-year Congressional add for AA Zinc Air Battery for Military Applications: matured high speed fabrication techniques for zinc-air batteries.
- 962 - Achieved objective of this one-year Congressional add for Portable Hybrid Electric Power Research and Polymer Extrusion: matured extrusion technologies for polymer electrolytes.
- 1925 - Achieved objective of this one-year Congressional add for Extrusion of Polymer Electrolytes and Polymer Multilaminate Materials: matured extrusion technologies for polymer electrolytes and polymer multilaminate materials.
- 1925 - Achieved objective of this one-year Congressional add for Logistics Fuel Reformer Technology: matured a logistics fuel reformer for portable fuel cells.
- 2694 - Achieved objective of this one-year Congressional add for Phase III of Intelligent Power Control for Sheltered Systems and Vehicles: matured a power management/load leveling system for shelters.

Total 20621

FY 2002 Planned Program

- 1261 - Test, in the field, a forward area battery charging system comprised of a high energy metal-air battery and smart charging cables; provide a prototype battery with energy density greater than 300 watt hours/kilogram, and evaluate a proof-of-concept electrochemical capacitor for hybrid digital pulse C4I applications with 10 times power density and two to four times energy density, integrated into a hybrid power source for field testing in digital pulse C4I and high-power vehicle applications that lasts more than three times the battery alone in the same envelope.

FY 2002 Planned Program (Continued)

- 795 - Test, in the field, a scalable power electronics package in a five kilowatt engine generator set; test, in the laboratory, power on-the-move capabilities.
- 1311 - Test, in the field, a battery/battery hybrid; test, in the field, a kinetic energy harvesting system; integrate components for a stand-alone 500 watt TPV proof-of-concept unit.
- 982 - Enhance the initial low power design tool for additional power consumption reductions in soldier systems; implement and test power management techniques for soldier systems on a distributed test bed.
- 1800 - This one year Congressional add investigates a cylindrical zinc-air battery for Land Warrior applications. No additional funding is required to complete this project.
- 2500 - This one year Congressional add investigates fuel cell power systems. No additional funding is required to complete this project.
- 1000 - This one year Congressional add investigates an improved high rate alkaline cell. No additional funding is required to complete this project.
- 1000 - This one year Congressional add investigates a logistics fuel reformer. No additional funding is required to complete this project.
- 600 - This one year Congressional add investigates low cost reusable alkaline manganese-zinc batteries. No additional funding is required to complete this project.
- 2600 - This one year Congressional add investigates polymer extrusion/multilaminate processes. No additional funding is required to complete this project.
- 1500 - This one year Congressional add investigates a rechargeable cylindrical cell system. No additional funding is required to complete this project.
- 1500 - This one year Congressional add investigates a cylindrical battery replacement for a tube-launched optically-tracked wire-guided missile, improved target acquisition system. No additional funding is required to complete this project.
- 1000 - This one year Congressional add investigates heat actuated coolers for portable military applications. No additional funding is required to complete this project.

Total 17849

FY 2003 Planned Program

- 1048 - Investigate next generation forward area high-rate battery charging mechanisms and improvements in life cycle and energy density of lithiumion rechargeable batteries for use in a platoon level recharging system.
- 2141 - Identify and mature advanced materials (metamaterials) and their application to hybrid excitation machines and combustion enhancement devices (catalytic igniters, electrostatic fuel injectors) to enhance tactical generator set performance, reduce weight and increase survivability.
- 1500 - Identify and evaluate high payoff technologies that can be integrated into a compact fuel cell system capable of meeting the power and high energy (+2000 watt hours/kilogram) threshold of Objective Force Warrior.

Total 4689

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

COST (In Thousands)		FY 2001 Actual	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate
H94	ELEC & ELECTRONIC DEV	19523	23116	22759	25600	26853	27636	30746

A. Mission Description and Budget Item Justification: This project supports applied research in the application of the physical sciences of physics, electrochemistry, biotechnology and electronics for the Future Combat Systems (FCS) and the Objective Force. These technologies support thrusts aimed at enhanced battlefield situational awareness, increased vehicle mobility, reduced acquisition cost, and reduced operations and support costs; they are critical to the realization of the vision of a medium weight force with the capability to detect, target, and engage the enemy of the future. The technical areas addressed under this project are: frequency control; electro-optic sensors to include eye safe laser radar and midwave infrared (MWIR, 3- to 5-micron) and longwave (LWIR, 8- to 12-micron) bands; microelectromechanical systems (MEMS) for multi-function radio frequency (RF) applications as well as smart munitions (e.g., inertial measurements); advanced 16-18, 35, and 95 GHz (Ku, Ka and W-band) modules for RF applications; high temperature high power inverter circuits for all-electric vehicles; rechargeable lithium-ion batteries, and methanol fuel cells for individual soldier applications. Technical barriers include: more stable oscillators for frequency control in communications and location finding, more complete understanding of fundamental properties, growth techniques, and processing of new materials and their exploitation in electronic devices for uncooled infrared detectors, high voltage and high power control electronics; MEMS device design and fabrication techniques; RF microcircuit design; high power and high voltage power materials and device design. This program supports the Objective Force transition path of the Transformation Campaign Plan (TCP).

FY 2001 Accomplishments:

- 2669 - Demonstrated improved (temperature compensated and lower sensitivity to vibration) SAW LGT resonator design, Ka-band low phase noise OEO, and lower sensitivity to vibration (2x10-10/g) quartz resonators and newer materials (LGT) for clock architectures to provide highly stable high data rate communications and Global Positioning Systems (GPS) to meet FCS and Objective Force requirements (e.g., network centric force).
- 5877 - Demonstrated ladar with detector/mixer line array.
  - Proved feasibility of long range scannerless ladar at eye-safe wavelength.
  - Demonstrated growth of 3 - 5 micron and 8 - 12 micron HgCdTe showing feasibility for low cost, large area dual color focal plane array on silicon substrates.
- 8436 - Integrated Rotman lens with PIN diode switch arry and developed MEMS switch for affordable 1-D electronic scanning.
  - Designed direct digital synthesizer module into testbed architecture for the multi-function RF systems.

FY 2001 Accomplishments: (Continued)

- Developed design for smaller, lighter weight advanced transmit and receive modules for separate transmit & receive antenna apertures.

- Designed X-band ferroelectric true time delay beamformer and initiated extension to Ka-band for low-cost planar electronic scanning antennas.

- Optimized circuit for all-electric vehicle drive circuit for operation at high temperature (400 degrees C) to provide increased mobility.

• 2541 - Formulated lithium-ion cells with new flame-retardant electrolyte additives and demonstrated low flammability for FCS hybrid power sources.

- Performed initial evaluation of oxyhalide electrolyte stability for reliable battery for self-destruct fuze and other smart munitions.

- Developed improved anodic electrocatalyst for direct methanol fuel cells for power source with 5X greater energy density than batteries for extended Soldier System missions.

Total 19523

FY 2002 Planned Program

• 2334 - Prove out ultra low phase noise millimeter wave optoelectric oscillator for radar and communication.

Construct and show low-insertion-loss narrow-bandwidth anti-jam filter for GPS.

• 4979 - Build and test a breadboard ladar sensor for robotics navigation, collect relevant data and begin analysis.

- Investigate AOTF cells for the 3- to 5-micron and 8- to 12-micron bands with potential for less than 50% diffraction efficiency.

- Integrate laser range finding and target profiling on same detector array.

- Determine optimum growth conditions for superlattice and quantum dot IR detectors.

• 10127 - Integrate vertically scanned Ka-band array with Rotman lens antenna to form 2D electronically scanned antenna for high performance multi-function RF systems for FCS and the Objective Force.

- Integrate silicon germanium (SiGe) direct digital synthesizer module into multi-function RF testbed for rapid flexible waveform generation.

FY 2002 Planned Program (Continued)

- Incorporate multilevel construction using InP & GaAs MMICs and MEMS technologies to design and fabricate a transmit/receive array for a multi-port radar and communication system using an electronically scanned antenna.
- Show improved SAW L-band filter design.
- Design a MEMS based low-loss RF switch with active open/close drive using lead zirconium titanate to enable electronic antenna scanning capabilities for RF systems.
- Design a metamorphic heterojunction bipolar transistor to enable low-cost production of highly linear active devices for use in multi-function RF systems.

• 2704
- Evaluate additives to stabilize capacity retention of lithium-ion batteries for hybrid power FCS and Objective Force missions.
- Develop analytical procedures for predicting long-term storage reliability of batteries for smart munitions.
- Evaluate methanol-tolerant cathodic electorcatalysts for high efficiency direct methanol fuel cell for future Soldier System Applications.

• 2972
- Enhance millimeter wave (MMW) devices for weapon systems through investigations of indium phosiphide and indium phosphide like technologies for higher performance, higher efficiency and lower cost.

Total 23116

FY 2003 Planned Program

• 2828
- Design a compact, fiberless X-band and Ka-band optoelectric oscillator for radar and communication.

• 7978
- Optimize MEMS based low-loss RF switch with active open/close drive using lead zirconium titanate to enable electronic antenna scanning capabilities for multi-function RF systems.
- Design two-layer circuit using heterogeneous integration techniques for multi-function RF applications.
- Integrate high speed CMOS direct digital synthesizer into multi-function RF testbed and quantify performance for rapid flexible waveform generation.

• 9976
- Prove scannerless eye-safe FMCW ladar and AOTF hyperspectral imagers operating in conjunction with two-color, large-area infrared focal plane array sensors for long-range target acquisition and identification.
- Assess large area two-color 3-5 micron/8-12 micron infrared detector array operating at increased operating temperature.

• 1977
- Explore ultra-high energy lithium/air battery formulations for Land Warrior power.

FY 2003 Planned Program (Continued)

- Design direct methanol and reformer-gas fuel cells using new electrocatalysts and catalysts for very compact Land Warrior power.

- Formulate lithium-ion batteries and capacitors with low flammability and good high-temperature capacity retention for FCS and Objective Force hybrid power.

Total 22759