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

June 2001

BUDGET ACTIVITY
2 - APPLIED RESEARCH

PE NUMBER AND TITLE
0602705A - Electronics and Electronic Devices

COST (In Thousands)	FY 2000 Actual	FY 2001 Estimate	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	Cost to Complete	Total Cost
Total Program Element (PE) Cost	35275	40891	27819	0	0	0	0	0	0	0
H11 BATTERY/IND POWER TECH	12111	21229	4492	0	0	0	0	0	0	0
H94 ELEC & ELECTRONIC DEV	23164	19662	23327	0	0	0	0	0	0	0

A. Mission Description and Budget Item Justification:

PLEASE NOTE: This administration has not addressed FY2003-2007 requirements. All FY 2003-2007 budget estimates included in this book are notional only and subject to change.

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.

B. Program Change Summary	FY 2000	FY 2001	FY 2002	FY 2003
Previous President's Budget (FY2001 PB)	36812	23869	27504	0
Appropriated Value	37096	41269	0	
Adjustments to Appropriated Value	0	0	0	
a. Congressional General Reductions	0	0	0	
b. SBIR / STTR	-537	0	0	
c. Omnibus or Other Above Threshold Adjustments	-83	0	0	
d. Below Threshold Reprogramming	-1000	0	0	
e. Rescissions	-201	-378	0	
Adjustments to Budget Years Since FY2001 PB	0	0	315	
Current Budget Submit (FY 2002/2003 PB)	35275	40891	27819	0

Change Summary Explanation: Funding - FY 2001: Congressional adds were received in: Project H11 for Logistics Fuel Reformer Technology (+2000), AA Zinc Air Battery for Military Applications (+1900), Improved High Rate Alkaline Cell (+1200), Rechargeable Cylindrical Cell Systems (+1600), Low Cost Reusable Alkaline Manganese-Zinc (+500), Phase III of Intell Power Control for Sheltered Systems and Vehicles (+2800), Extrusion of Polymer Electrolytes and Polymer Multilaminate Materials (+2000), Lithium Carbon Monoflouride Coin Cell (+900), AA Zinc Air Battery Production (+2000), Portable Hybrid Electric Power Research (+1500)and Polymer Extrusion (+1000).

FY 2003: Funds were realigned to higher priority activities in support of the Army Transformation.

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

June 2001

BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
2 - APPLIED RESEARCH	**0602705A - Electronics and Electronic Devices**	**H11**

COST (In Thousands)	FY 2000 Actual	FY 2001 Estimate	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	Cost to Complete	Total Cost
H11 BATTERY/IND POWER TECH	12111	21229	4492	0	0	0	0	0	0	0

A. Mission Description and Budget Item Justification: This project provides applied research in the application of the physical sciences of energy conversion, electrochemistry, electronics, power management, and signature suppression as they apply to improving existing systems and enabling newer, more advanced battery (primary and rechargeable), fuel cell, thermoelectric, hybrid, and electromechanical (including engines and permanent magnet alternators) technologies for the Objective Force. This project investigates small, low-cost, environmentally compatible, lightweight, high energy density sources of power for communications, target acquisition, miniaturized displays, silent watch, combat service support applications, and future soldier systems. These technologies support reduced acquisition costs, and reduced operation and support costs. This project supports the Objective Force transition path of the Transformation Campaign Plan (TCP).

FY 2000 Accomplishments

- 935 - Designed lithium-ion polymer electrolyte (dry cell) rechargeable battery that provides higher safety and higher capacity than wet cell batteries for Command, Control, Communication, Computer, Intelligence, Electronic Warfare and Sensors (C4IEWS) training applications; designed and tested universal smart charging cables for charging complete family of military rechargeable batteries used for C4IEWS applications; showed proof-of-concept rechargeable vest battery for the Multiple Integrated Laser Engagement Simulation (MILES) 2000.
- 700 - Completed power electronics design for the next generation family of engine driven generator power systems; installed power on-the-move system in the drive train of a tactical vehicle and performed tests to characterize electrical performance.
- 1319 - Integrated and exhibited battery/battery hybrid; assessed approaches to kinetic active and passive power generation; tested components researched by ARL/DARPA for system design of a thermophotovoltaic (TPV) power source and upgraded design; designed a hybrid fuel cell for soldier systems.
- 1020 - Generated system level design tools for integration to provide a common low power and power management design environment.
- 135 - Established power source and identified power savings technologies for an uncooled infrared (IR) sensor.
- 958 - Achieved objectives of this one-year Congressional add: evaluated low cost, improved rate capable alkaline cells for use in sensor, surveillance, and monitoring applications.

FY 2000 Accomplishments (Continued)

- 1341 - Achieved objectives of this one-year Congressional add: delivered, tested, and evaluated prototype reusable alkaline manganese-zinc batteries with improved power capability and cycle life for C4IEWS equipment.
- 575 - Achieved objectives of this one-year Congressional add: designed, matured, fabricated, and delivered prototype rechargeable lithium ion coin cells for safety and performance evaluations.
- 384 - Achieved objectives of this one-year Congressional add: designed, matured, and fabricated initial prototype lithium carbon monofluoride cells to characterize performance, safety, and feasibility for use in batteries.
- 384 - Achieved objectives of this one-year Congressional add: demonstrated improved rate capability, high energy "AA" zinc-air cells for use in Forward Area charger applications.
- 2875 - Achieved objectives of this one-year Congressional add: evolved the micro-channel reactor and engineered catalyst technology required to reform diesel fuel/JP8 into Hydrogen suitable for use in small (soldier portable) and medium sized fuel cell systems; matured, fabricated, and tested laboratory prototypes of critical reformer components.
- 1437 - Achieved objectives of this one-year Congressional add: modeled, matured and fabricated prototype hybrid power sources and components.

Total 12063

FY 2001 Planned Program

- 874 - Establish the most cost effective, safe, high performance primary battery with greater than 300 watt-hours per kilogram; complete applied research of a high energy rechargeable lithium-ion battery with non-flammable electrolyte for C4IEWS applications; complete research and test of manpack metal-air battery powered recharging system with universal smart charging cable for light infantry C4IEWS equipment.
- 730 - Complete integration of power components/subassemblies in a 5 kilowatt engine driven generator system design; implement tests to ensure proper operation of power electronics subsystems; integrate the power electronics subsystem into a power-on-the-move tactical vehicle.
- 1286 - Optimize battery/battery hybrid for size, weight, and cost; design and build kinetic energy harvesting system for charging soldier system batteries; design efficient 500 watt TPV system for a recharger and soldier support applications; test and demonstrate hydride fuel cell model for soldier system.
- 840 - Evolve design tools to support low power/power management, system design and system improvement for Land Warrior.
- 144 - Integrate model power source for an uncooled infrared sensor into a 3 pound weapon sight prototype.

FY 2001 Planned Program (Continued)

- 1444 - The objective of this one-year Congressional add for Portable Hybrid Electric Power Research and Polymer Extrusion is to mature a fuel cell/battery hybrid power source.
- 1925 - The objective of this one-year Congressional add for AA Zinc Air Battery Production is to mature a low cost primary battery for forward area recharging.
- 1155 - The objective of this one-year Congressional add for Improved High Rate Alkaline Cell is to mature high rate, low cost AA, D cells for night vision devices.
- 866 - The objective of this one-year Congressional add for Lithium Carbon Monoflouride Coin Cell is to mature a primary battery for memory backup/extended power.
- 1540 - The objective of this one-year Congressional add for Rechargeable Cylindrical Cell Systems is to mature lithium ion cells for soldier systems.
- 481 - The objective of this one-year Congressional add for Low Cost Reusable Alkaline Manganese-Zinc is to mature low cost rechargeable batteries for training.
- 1829 - The objective of this one-year Congressional add for AA Zinc Air Battery for Military Applications is to mature high speed fabrication techniques for zinc-air batteries.
- 962 - The objective of this one-year Congressional add for Portable Hybrid Electric Power Research and Polymer Extrusion is to mature extrusion technologies for polymer electrolytes.
- 1925 - The objective of this one-year Congressional add for Extrusion of Polymer Electrolytes and Polymer Multilaminate Materials is to mature extrusion technologies for polymer electrolytes and polymer multilaminate materials.
- 1925 - The objective of this one-year Congressional add for Logistics Fuel Reformer Technology is to mature a logistics fuel reformer for portable fuel cells.
- 2694 - The objective of this one-year Congressional add for Phase III of Intelligent Power Control for Sheltered Systems and Vehicles is to mature a power management/load leveling system for shelters.
- 609 - Small Business Innovation Research/Small Business Technology Transfer (SBIR/STTR) Programs.

Total 21229

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.
- 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.
- 1454 - Test, in the field, a battery/battery hybrid; test, in the field, a kinetic energy harvesting system; develop components for a 500 watt TPV prototype.
- 982 - Test and show the initial low power design tool for reduced power consumption in soldier systems.

Total 4492

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

June 2001

BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
2 - APPLIED RESEARCH	**0602705A - Electronics and Electronic Devices**	**H94**

COST (In Thousands)	FY 2000 Actual	FY 2001 Estimate	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	Cost to Complete	Total Cost
H94 ELEC & ELECTRONIC DEV	23164	19662	23327	0	0	0	0	0	0	0

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 2000 Accomplishments

- 1700 - Grew high quality boules of novel piezoelectric crystals, which are superior to quartz, and showed first time thin film growth of langasite for acceleration insensitive clocks.
- 6402 - Investigated high-power 1.5-micron diode laser 600-MHz frequency modulated/continuous wave (FMCW) chirp-modulated source and tested first sample of detector/mixer for scannerless laser radar (ladar).
  - Created and tested acousto-optic tunable filter (AOTF) hyperspectral imagers in the 3- to 5-micron and 8- to 12-micron bands.
  - Achieved growth of mercury cadmium telluride (HgCdTe) for MWIR and LWIR detection on silicon substrates.
- 8280 - Evaluated MEMS, diode and photonic actuated silicon tab array switches to provide multi-beam generation capabilities to enable multiple RF functions such as secure point-to-point communications, combat Identification, etc. through a common aperture to reduce the proliferation of antennas on the battlefield.

FY 2000 Accomplishments (Continued)

- Assessed radar and communication specifications for new direct digital synthesizer technology to provide waveform diversity to achieve high resolution, reduction of target scintillation and multi-path effects and enhanced electronic countermeasures.
- Assessed advanced Ku band (16-18 GHz), Ka-band (35 GHz) and W-band (95 GHz) devices and modules such as: wide-band 35 GHz low-noise amplifiers; high power gallium arsenide (GaAs) 16-18 GHz amplifiers, and low-noise indium phosphide (InP) 95 GHz amplifiers for multi-function RF applications.
- Advanced the state-of-the-art in temperature insensitive ferroelectric materials for electronically scanned antennas.
- Built inverter circuit for all-electric future ground combat system to provide increased mobility.
- Designed and produced prototype lead zirconium titanate MEMS magnetometer for projectile guidance, counting revolutions and remote sensing for incorporation into 2.75" rocket
- Constructed and evaluated 94 GHz diode based phase shifter monolithic microwave integrated circuit (MMIC) to enable electronic antenna scanning capabilities for multi-function RF systems.

• 3782
- Formulated primary lithium battery for Land Warrior with new cathode material for improved low temperature capacity.
- Formulated capacitors and rechargeable lithium-ion batteries for Future Combat Systems (robotic platforms, vehicles, individual soldier) with high voltage electrolytes and high energy anodes.
- Optimized anodes for methanol fuel cells for individual soldier applications.

• 3000
- Examined a range of physical characteristics of displays, measuring display performance and strategizing for performance enhancements of displays intended for military platforms. Provided documentation on display standards (national/international) and testing procedures/protocols for RDECs, PEOs and PMs to use in performing system level tradeoff analyses for alternative display technologies.

Total 23164

FY 2001 Planned Program

• 2669
- Show factor of 10 improvement in acceleration insensitivity and phase noise in frequency control devices through application of new materials and 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
- Provide ladar with detector/mixer line array.
- Show feasibility of long range scannerless ladar at eye-safe wavelength.

FY 2001 Planned Program (Continued)

- Provide dual color 3-5 microns/8-12 microns HgCdTe infrared (IR) detector array grown on silicon substrate.

• 8436 - Integrate Rotman lens with MEMS switch array for electronic azimuth scanning in order to develop multifunction RF systems for FCS and the Objective Force.

- Design direct digital synthesizer module to support multi-function RF systems.

- Begin design effort for a smaller, lighter weight advanced transmit/receive module to include low noise receiver, high power transmitter, and smart power flow and switch control which has application for electronically scanned phased array antennas.

- Design and prove out X-band ferroelectric module to produce an adaptive multi-tap phase shifter for elevation scanning antenna applications and start the design for a Ka-band ferroelectric phase shifter for electronically scanned antennas.

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

• 2541 - Formulate lithium-ion batteries with new low temperature, low flammability electrolytes for FCS (vehicles, robotic platforms, individual soldier) hybrid power systems.

- Evaluate stability of battery materials for long storage, smart munitions applications.

- Prove out a methanol fuel cell with 5X improvement over batteries for Land Warrior power.

• 139 - Small Business Innovation Research/Small Business Technology Transfer (SBIR/STTR) Programs.

Total 19662

FY 2002 Planned Program

• 2355 - 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.

• 5023 - 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.

• 10220 - Integrate vertically scanned Ka-band array with Rotman lens antenna to form two-dimensional electronically scanned antenna for high performance multi-function RF systems for FCS and the Objective Force.

FY 2002 Planned Program (Continued)

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

- 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 ultra low phase noise millimeter wave optoelectric oscillator for radar and communication.

- 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.

• 2729 - Evaluate additives to stabilize capacity retention at elevated ambient temperatures of lithium-ion batteries for FCS and Objective Force applications.

- Formulate battery chemistries for mini-reserve batteries with assured high-temperature shelf life for smart munitions.

- Explore new catalysts for fuel reformation for FCS (individual soldier, robotic platforms) applications.

• 3000 - Rapidly accelerate promising technologies through the Power and Energy Collaborative Technology Alliance (CTA) to transition to the Objective Force. This technology consists of radio frequency indium phosphide for advanced electronics.

Total 23327