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

February 2002

BUDGET ACTIVITY
2 - Applied Research

PE NUMBER AND TITLE
0602120A - Sensors and Electronic Survivability

	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	22662	31934	24305	24624	25834	26756	27386
140	HI-POWER MICROWAVE TEC	2655	2746	3111	3248	3866	4062	4154
142	PASSIVE MMW CAMERA	2404	2084	0	0	0	0	0
H15	GROUND COMBAT ID TECH	3346	7996	3648	3878	4056	4185	4268
H16	S3I TECHNOLOGY	14257	16608	17546	17498	17912	18509	18964
SA1	ADVANCED SENSORS AND OBSCURANTS	0	2500	0	0	0	0	0

A. Mission Description and Budget Item Justification: The objective of this program is to enhance the capabilities of the Future Combat Systems (FCS) and the Objective Force by: (1) providing sensor, signal and information processing technology for advanced reconnaissance, surveillance, and target acquisition (RSTA), ground-to-ground and air-to-ground combat identification (ID), and fire control systems, as well as the fuzing and guidance-integrated fuzing functions in future munitions; and (2) significantly improving the survivability, lethality, deployability, and sustainability of FCS by devising high-power electronic components and technologies for compact, light-weight power and energy storage, conversion and conditioning, and radio frequency (RF)/microwave directed energy (RF-DE) weapons. Critical technologies to be addressed to increase the combat effectiveness of tactical Army forces include: (1) high power, solid-state/vacuum, power/RF component technology; (2) combat identification technology; (3) sensors, signatures, signal and information processing (S3I) technology. Work in this program element is consistent with the Army Science and Technology Master Plan (ASTMP), the Army Force Modernization Plan, and Project Reliance. 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 Materiel Command. This program 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)	23008	25797	22011
Appropriated Value	23222	32197	0
Adjustments to Appropriated Value	0	0	0
a. Congressional General Reductions	0	-263	0
b. SBIR / STTR	-346	0	0
c. Omnibus or Other Above Threshold Reductions	0	0	0
d. Below Threshold Reprogramming	0	0	0
e. Rescissions	-214	0	0
Adjustments to Budget Years Since FY2002 PB	0	0	2294
Current Budget Submit (FY 2003 PB)	22662	31934	24305

Change Summary Explanation:

FY03 (+$2294) was added to project H16 to address sensor cueing issues for a distributed sensor network, enhance the ability of an ultra-wideband radar to detect concealed objects, and to establish a baseline hyperspectral target detection algorithm.

FY02 - Congressional adds were received for Passive Millimeter Wave Camera, Project 142 ($2100); S3I Technology Project, Project H16 ($1800); and Advanced Sensors and Obscurants, Project SA1 ($2500).

Projects with no R2-A:
Project 142
- FY02 funding = $2100 Passive Millimeter Wave Camera : This one year Congressional add is for applied research to complete the fabrication and perform field testing of a new and improved version of the camera that will be lightweight, low-cost, and flightworthy. No additional funding is necessary to complete this project.

Project SA1
- FY02 funding = $2500 Advanced Sensors and Obscurants : This one year Congressional add is for applied research into the development of integrated multispectral and advanced designer oobscurants and dissemination methods. No additional funding is necessary to complete this project.

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

February 2002

BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
2 - Applied Research	**0602120A - Sensors and Electronic Survivability**	**140**

COST (In Thousands)	FY 2001 Actual	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate
140 HI-POWER MICROWAVE TEC	2655	2746	3111	3248	3866	4062	4154

A. Mission Description and Budget Item Justification: The objective of this project is to significantly improve the survivability, lethality, deployability, and sustainability of Future Combat Systems (FCS) and the Army's Objective Force by devising high-power electronic components and technologies for compact, lightweight power and energy storage, conversion and conditioning. Current technical barriers result in excessive size and weight requirements for these components and systems. Matching potential FCS radio frequency (RF)/microwave directed energy (RF-DE) and high energy laser (HEL) weapons and other electric power loads such as electromagnetic gun, electromagnetic (EM) armor and electric drive to the FCS electric power sources will be improved with the advances in this project. This program is coordinated and, when appropriate, leveraged with directed energy (both RF and laser) and power programs in the Air Force, Navy, Defense Special Weapons Agency, National Labs, university Consortia and relevant industry and foreign partners. The emphasis of this project is being focused to more effectively support the Army Transformation, by concentrating on the critical path technology of power components common to all Directed Energy Weapons (DEW) and hybrid electric propulsion systems. 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 Materiel Command. This program supports the Objective Force transition path of the Transformation Campaign Plan (TCP).

FY 2001 Accomplishments:

- 2655 - Successfully drove a 15-hp 3-phase induction motor load with the 10-kW class matrix converter. Power levels up to 5 kVA have been achieved, and 10 kVA is anticipated in the near future, demonstrating the feasibility for AC motor drive applications in future Army combat systems.

  - Assembly of a 100kW class matrix converter prototype is nearing completion. Initial laboratory operation is expected before the end of CY01.

  - Characterized power conditioning topologies (modulators) for FCS applications, such as EM armor and DEWs.

  - Determined characteristics of advanced energy storage techniques, such as modeling the Marx-Generator configured, lithium-ion battery.

  - Created initial design parameters for RF-Agile Target Effects System (RF-ATES) breadboard system and surveyed/assessed existing and planned transmitters/antenna technology to determine applicability. RF-ATES will enhance survivability/lethality of FCS and suppressing/defeating close-in threats.

FY 2001 Accomplishments: (Continued)

- Modeled electro-mechanical behavior of the linear diesel alternator with SPICE to allow modeling confirmation with University of West Virginia DEPSCOR program for evaluation hybrid power system design and optimization (includes model of diesel engine and alternator).

Total 2655

FY 2002 Planned Program

• 2746
- Operate the 100-kW matrix converter in a laboratory breadboard environment.
- Evaluate alternatives for solid-state switch-based power conditioning topologies for EM armor.
- Evaluate advanced energy storage techniques - construct Marx-battery breadboard.
- Investigate effectiveness of DEW candidates on ATES targets and finalize RF-ATES requirements.
- Confirm linear diesel alternator model with experiments at University of West Virginia (DEPSCOR program) and use simulation to optimize design and determine suitability for FCS-HEV platforms (first order platform approximation, simple load).

Total 2746

FY 2003 Planned Program

• 3111
- Operate a 100-kW matrix converter in a relevant environment driving an electric drive traction motor such as those needed for FCS applications
- Finalize design of RF-ATES breadboard and research and acquire/develop sub-system.
- Prototype a 100-kW class matrix converter using high temperature/high power silicon carbide switches for traction motor drive applications.
- Evaluate advanced energy storage techniques - construct brass board of Marx-battery system.
- Link linear diesel alternator model to model of matrix converter and mockup of HEV power conditioning system and load to determine suitability of linear diesel alternator for a realistic FCS-HEV platform (complex load approximation).

Total 3111

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

February 2002

BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
2 - Applied Research	**0602120A - Sensors and Electronic Survivability**	**H15**

COST (In Thousands)		FY 2001 Actual	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate
H15	GROUND COMBAT ID TECH	3346	7996	3648	3878	4056	4185	4268

A. Mission Description and Budget Item Justification: The objective is to develop and demonstrate emergent combat identification (CID) systems for air-to-ground and ground-to-ground (mounted, dismounted, forward observer and forward air controller) mission areas for the Objective Force in support of Joint, Allied and Coalition operations (i.e. US, UK, France, Germany, Canada, and Australia). This program provides the technologies necessary for the Coalition Combat Identification Advanced Concept Technology Demonstration. The program provides maturation of the enabling technologies necessary to set the baseline for the objective force to enable fratricide reductions through Combat Identification (CI) concepts for Joint, Allied and Coalition operations. The hardware and software improvements and modeling and simulation (M&S) advances provided by this program are essential for linkage to the Objective Force as we progress to the transformation of the Army. This program expands and builds upon the increased lethality for the Objective Force due to greater capability to identify friend from foe and minimize fratricide incidents across the battlefield. CI must be software functional, portable across a family of platforms, tied to the future tactical internet, over-the-horizon capable and highly resistant to countermeasures. The Objective Force CI capability will fuse situational awareness (SA) and Point-of-Engagement target Identification into a common through sight picture. The future CI architecture will necessitate the integration of a network composed of diverse reconnaissance, surveillance and target acquisition (RSTA) sensors that include non-cooperative capabilities in the sensor suites and a cooperative ID capability that will be realized as part of the future real-time SA. Coordination will be accomplished with other services, allies and coalition partners. MANPRINT will be addressed in all activities. Future CI will operate with the Objective Warrior System providing a seamless boundary with vehicle CI. 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 efforts within the Military Departments. Work is performed by various contractors and the Communications Electronics Command (CECOM). 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. This program supports the Objective Force transition path of the Transformation Campaign Plan (TCP).

FY 2001 Accomplishments:

- 3346 - Characterized Ground Integration Target Identification System technical and operational performance.
  - Completed investigation of Combat Identification (CI) solution for helicopters and execute the design.
  - Completed CI Architecture Study.
  - Completed evaluation of lightweight CI transponder system for helicopters.

FY 2001 Accomplishments: (Continued)

- Evaluated low cost, high efficiency antenna.
- Characterized technical performance of CI for Apache-Longbow.
- Studied CI solution for vehicle-to-soldier application.
- Established program to implement North Atlantic Treaty Organization (NATO) Battlefield Target ID (BTID) Waveform per Standardization Agreement (STANAG) 4579.
- Determined Radio Based Combat D feasibility for Allied radios.

Total 3346

FY 2002 Planned Program

• 7996
- Implement advanced CI concepts for airborne applications as part of the Coalition Combat Id (CCID) ACTD.
- Evaluate several software gateways to establish a coalition SA Network.
- Continue implementation of STANAG 4579 waveform.
- Conduct Radio Frequency (RF) Tags study.
- Support development of STANAG for individual soldier application.
- Perform virtual model development for experiments of all systems participating in CCID ACTD.

Total 7996

FY 2003 Planned Program

• 3648
- Demonstrate advanced CI concepts for airborne applications as part of the CCID ACTD.
- Continue implementation of SA gateway.
- Transition implementation of STANAG 4579 to PM CI.
- Perform platform integration of BTID, RBCI, and Enhanced Position Location Reporting System (EPLRS) systems and characterize system performance.
- Support development of STANAG for RBCI waveform.

FY 2003 Planned Program (Continued)

- Continue development of STANAG for individual soldier application.

Total 3648

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

February 2002

BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
2 - Applied Research	**0602120A - Sensors and Electronic Survivability**	**H16**

COST (In Thousands)	FY 2001 Actual	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate
H16 S3I TECHNOLOGY	14257	16608	17546	17498	17912	18509	18964

A. Mission Description and Budget Item Justification: This project is focused on advanced sensor, signal processing and information technologies to provide the Future Combat Systems (FCS) and the Objective Force with decisive new capabilities to locate, identify, and engage battlefield targets. The ultimate utility of this work will be to protect our soldiers and to increase their lethality and range and speed of engagement. Emphasis is placed on solving critical Army-specific battlefield sensing and information management problems such as dealing with false target situations, complex terrain, movement of sensors on military vehicles, etc. Cost reduction is a key concern. Care is taken to insure that this work is coordinated with outside organizations, particularly the RDEC's and DARPA. Significant areas of research include the following: (1) Low cost sensors designed to be employed in large numbers as unattended ground sensors or sensors for smart munitions. Research into acoustic, seismic, magnetic, and radar sensors is being conducted. Technical barriers include low-power sensors and electronics, small-long-life batteries, autonomous reconfigurable networks, and sensor fusion to maximize the performance of a collection of relatively low performance sensors. (2) Low cost acoustic sensors that can passively detect and track battlefield targets such as tanks, helicopters, etc. and detect and locate gun fire. Technical barriers include algorithms to handle multi-path and reduce false alarm rates. Work to monitor the health of soldiers is also being explored. (3) Sensors and supporting technologies for smart munitions using GPS for guidance or tracking. Technical barriers include high-g electronics. (4) High performance multi-function radio frequency (RF) systems which allow target acquisition, combat identification, active protection, surveillance, and communications systems to consolidated into a single system, reducing system cost and size. Technical barriers include maintaining performance of each function in the combined system. (5) High performance passive and active RF sensors capable of high resolution imaging to detect targets hidden in foliage, smoke and fog. Ultra wideband radar work will enable buried mine detection and target imaging through dense foliage. Technical barriers include real-time signal processing and false alarm rate. (6) Aided/automatic target recognition (ATR) to allow sensors to autonomously or semi-autonomously locate and identify battlefield targets. This research will minimize the workload on the soldier while in combat to find and identify targets using laser radar (LADAR), multi-band infrared cameras, and hyperspectral imagers. Technical barriers include acquisition of large data sets to train and validate ATR algorithms. (7) Optoelectronic (OE) interconnects and processors are being built which will greatly speed the movement of information within and between electronic digital processing units to facilitate smart sensors, adaptive sensors, and sensor fusion for situation awareness, survivability, and lethality. Sensor processing, analysis, and displays will provide soldiers with clearer, higher resolution images from their targeting systems. (8)Advanced battlefield sensor and information processing to conduct a dynamic and real time situation assessment to present a common picture of the battlespace to commanders. Technical barriers include fusion of data from dissimilar sensors, coherent display of complex information, and human factors. (9) Advanced information processing methods to provide automatic information technologies to enable commanders to utilize widely dispersed sensor and legacy information sources. Technical barriers include development of autonomous reconfigurable networks. This work supports the following Army Programs: Future Combat Systems (FCS), Objective Force, Multi-Function Starting Sensors Suite (MFS3), Warrior Extended Battlespace Sensors (WEBS), Smart Sensor Webs, Anti-Personnel Landmine Alternatives (APL-A), Precision Guided Mortar Munition (PGMM), Third Generation forward-looking infrared (FLIR), Full Spectrum Active Protection, and Quicklook.

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. This program supports the Objective Force transition path of the Transformation Campaign Plan (TCP).

FY 2001 Accomplishments:

- 3005 - Delivered and evaluated first generation reconfigurable signal processor for unattended ground sensor applications.
  - Conducted field experiment with CECOM-NVESD on acoustic, seismic, magnetic, infrared imager nodes.
  - Evaluated sensor fusion options for unattended ground sensors so enemy threats can be identified before they see our troops.
- 1176 - Showed distributed networked acoustic sensors in support of STO.
  - Designed, built and evaluated optimized physiological monitoring sensors with remote wireless capability in select operating environments so the soldier's health can be monitored remotely.
- 735 - Developed first iteration of a distributed sensor network simulation capable of modeling the detection of moving targets.
  - Provided GPS targeting expertise and support to ARDEC Quicklook program.
- 2434 - Produced simulated synthetic aperture radar images using an imaging geometry consistent with a ground vehicle.
  - Used the ARL HPC to compute the signatures of 2 vehicles at UHF and VHF frequencies.
  - Collected fully polarimetric signatures of an M-60 tank, asphalt runway, grass and a treeline were collected to allow analysis of polarmetric characteristics for improved target detection in clutter.
  - Achieved real-time, high precision tracking of kinetic energy penetrator in range and velocity.
- 1308 - Built and tested a low cost vertically scanned 35 GHz antenna.
  - Completed control hardware and software for vertically scanned antenna.
  - Designed flexible architecture for data acquisition, timing and control, and signal processing for multi-function RF testbed based on field programmable gate array technology.
- 977 - Conducted phenomenological studies of hyperspectral data to assess the minimum number or bands to achieve high discrimination performance at an affordable cost for land warfare systems. In parallel, investigated algorithms that can perform simultaneous compression and detection on hyperspectral data, to reduce bandwidth requirements so the data can be processed on the vehicle or transmitted with minimal bandwidth.

FY 2001 Accomplishments: (Continued)

- Recommended preferred operating wavelengths for broadband imagers, based on experiments using measured phenomena. Delivered preliminary algorithms for processing such data to enhance target detection.
- Conducted studies with stabilization and moving-target indicator (MTI) algorithms using relevant data. Delivered preliminary codes to AMCOM.

• 2113
- Incorporated improved high-data-rate (1GHz) VCSEL/CMOS link into real time optoelectronic transfer of image frames with some CMOS image processing included.
- Conducted joint measurements with AMCOM of improved VCSEL/CMOS processor in missile processor architecture.
- Designed full color electroluminescent devices using single host.
- Characterized engineered limiter materials in best optical designs.

• 1996
- Transitioned an agent-based approach for mediation with legacy software subsystems to improve the commander's ability to synchronize manned and unmanned sensor assets in a lightweight FCS force. This research/technology is on the transition path for CECOM's Agile Commander STO.

- Transitioned enhanced gesture and natural language based control of software components that improve the commander's ability to recognize patterns and trends through the use of intuitive visualization techniques and operate "hands free". This research/technology is on the transition path for CECOM's Agile Commander STO.

• 513
- Next- Generation Autonomous Vehicle Navigation Control System (AUTOVAV) (Partner: Germany): Design of an advanced autonomous vehicle navigation control system. Completed sub-system tests of obstacle detection, classification, and avoidance technologies.

Total 14257

FY 2002 Planned Program

• 3537
- Complete and evaluate second generation reconfigurable processor for unattended ground sensors.
- Evaluate multi-sensor nodes systems against real targets along with CECOM-NVESD and transition all WEBS technologies to follow-on advanced technology demonstration (ATD).

• 1457
- Study performance of three-axis seismic sensors for direction finding and fuse data output with acoustic sensors.
- Implement efficient algorithms for target recognition for WEBS low power unattended ground sensor application.

FY 2002 Planned Program (Continued)

- Prove out high-resolution beam forming algorithms for long-range infrasonic detection.

• 500 - Develop sensor error estimates for ammunition suite.

• 3200 - Complete RF forward imaging experiments for robotic vehicle sensors and generate synthetic aperture radar (SAR) images from measured data.

- Generate improved tactical target detection algorithm for foliage-penetrating (FOPEN) radar.
- Model polarimetric target and clutter signatures for passive and active MMW sensors for pilot situation awareness.
- Integrate radar with IR angle tracker and demonstrate real-time engagement of KE penetrator.
- Explore innovative concepts in long-wavelength and high-bandwidth VCSELs for VCSEL/CMOS interconnects and processing.

• 1467 - Complete building of multi-function RF testbed.

- Implement timing and control hardware and software to conduct both communications and radar functions in a programmable configuration.

• 924 - Investigate improvement in material classification/target identification algorithms through the use of adaptable hyperspectral algorithms that adjust to environmental variation in signatures.

- Conduct feature studies of 3-5 micron and 8-12 micron imagery to determine advantages of dual band features.
- Investigate registration techniques, image differencing, and change detection strategies for target acquisition.

• 3056 - Apply VCSEL/CMOS links to unorthodox digital processing architectures for improved processing of images and other sensor data.

• 2467 - Integrate software components from Advanced Battlefield Processing Technology STO to improve information access and operator focus of attention, enabling the warfighter to operate within the enemy's decision cycle.

- Significantly improve tactical knowledge management through intelligent agent based applications and information portals; intelligent systems will acquire and reason on data related to terrain, weather, force distribution, etc. from local and reach back sensors and sources presenting the information from these disparate sources without distorting the spatial and temporal properties of the information.

Total 16608

FY 2003 Planned Program

- 2167 - Complete and evaluate third generation reconfigurable processor for unattended ground sensors which includes communications and sensor functions.

  - Evaluate multi-sensor nodes against real targets along with CECOM-NVESD and Dismounted Battlespace Battle Lab as part of the WEBS STO completion.
- 1825 - Refine integrated acoustic and seismic sensor output and apply advanced algorithms for target recognition and localization in support of DTO.

  - Validate acoustic battlefield decision aid model using signature database and advanced detection and recognition algorithms.
- 498 - Develop capability to address sensor cueing issues in the distributed sensor network simulation.
- 3863 - Show ability of ultra-wideband radar sensor to detect obstacles concealed by foliage for robotic applications.
  - Assess foreign demonstrator radar and address user defined shortcomings.
  - Evaluate fully polarmetric passive MMW imagery to assess helicopter obstacle avoidance in fog and clouds.
  - Integrate Electronically Scanned Antenna with 35 GHz Active Protection Radar.
- 1557 - Perform communications and radar functions on multi-function RF testbed hardware.
  - Show cost vs. performance trade-offs on Multi-Function RF concept.
- 945 - Establish baseline hyperspectral target detection algorithm using joint spatial and spectral information.
  - Establish baseline technique(s) for MTI using relevant imagery data from unattended ground sensor imagers.
  - Create algorithm to simultaneously exploit 3-5 & 8-12 micron dual wavelength FLIR imagery and evaluate the resulting performance improvement.
- 3219 - Transition VCSEL/CMOS digital processor technology to AMCOM.
  - Apply VCSEL/CMOS optoelectronic digital processing approach to the ATR problem.
- 2611 - Significantly improve tactical knowledge management through intelligent agent based applications and information portals. Intelligent systems will acquire and reason on data related to terrain, weather, force distribution, etc. in background and through reach-back to more capable information sources in order to scale and present the information from these disparate sources without distorting the spatial and temporal properties.
- 861 - Funds reprogrammed for ARL lab management support.

Total 17546