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

June 2001

BUDGET ACTIVITY
2 - APPLIED RESEARCH

PE NUMBER AND TITLE
0602120A - Sensors & Electronic Survivability

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	22978	23008	25797	0	0	0	0	0	0	0
140 HI-POWER MICROWAVE TEC	2465	2687	2771	0	0	0	0	0	0	0
142 PASSIVE MMW CAMERA	1909	2477	0	0	0	0	0	0	0	0
H15 GROUND COMBAT ID TECH	3245	3441	8069	0	0	0	0	0	0	0
H16 S3I TECHNOLOGY	15359	14403	14957	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 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.

B. Program Change Summary	FY 2000	FY 2001	FY 2002	FY 2003
Previous President's Budget (FY2001 PB)	24850	20722	21994	0
Appropriated Value	24978	23222	0	
Adjustments to Appropriated Value	0	0	0	
a. Congressional General Reductions	0	0	0	
b. SBIR / STTR	-372	0	0	
c. Omnibus or Other Above Threshold Reductions	-57	0	0	
d. Below Threshold Reprogramming	-1500	0	0	
e. Rescissions	-71	-214	0	
Adjustments to Budget Years Since FY2001 PB	0	0	3803	
Current Budget Submit (FY 2002/2003 PB)	22978	23008	25797	0

Change Summary Explanation: Funding - FY 2001: A Congressional add was received for Project 142, Passive Millimeter Wave (MMW) Camera (+2500) 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. FY 2002: Increase made in support of the Coalition Combat Identification Advanced Concepts Technology Demonstration (+3803).

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

June 2001

BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
2 - APPLIED RESEARCH	**0602120A - Sensors & Electronic Survivability**	**140**

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
140 HI-POWER MICROWAVE TEC	2465	2687	2771	0	0	0	0	0	0	0

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

FY 2000 Accomplishments

- 2465 - Constructed and operated a 3-phase to 3-phase, 20-kW class matrix converter prototype suitable for application in future electric combat vehicles.

  - Designed initial requirements with TACOM-ARDEC for RF Agile Target Effects System (ATES) for the Battlefield.

  - Provided expertise on Directed Energy Weapon (DEW) threats, effects and hardening to National Intelligence Council, Defense Threat Reduction Agency, Army Research Development and Engineering Centers, Program Managers, and TRADOC.

  - Conducted source/antenna technology survey to address ATES requirements and investigated compact, high power antenna concepts for the FCS.

  - Evaluated alternatives for RF- DEW components/systems for lethal/non-lethal applications for FCS.

  - Transformed the research focus on this project to high power component technology to enable hybrid electric propulsion development supporting Army Transformation.

Total 2465

FY 2001 Planned Program

•	2655	- Show the value of the matrix converter concept to the Army's FCS program by operating a 10-kW class matrix converter in a relevant environment.
		- Achieve initial laboratory operation of a 3-phase to 3-phase 100-kW class matrix converter prototype.
		- Research power conditioning topologies (modulators) for FCS applications, such as EM armor and DEWs.
		- Evaluate advanced energy storage techniques, such as modeling the Marx-Generator configured, lithium-ion battery system.
		- Conduct research into new DEW components/system and perform initial system design for RF-ATES breadboard.
		- Model electro-mechanical behavior of advanced power sources, such as the linear alternator to enable hybrid power system design and optimization.
•	32	- Small Business Innovation Research/Small Business Technology Transfer (SBIR/STTR) Programs.
Total	2687	

FY 2002 Planned Program

•	2771	- 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 for ATES and finalize requirements.
		- Model electro-mechanical to combustion linear alternator with diesel engine driver to enable hybrid power system design and optimization.
Total	2771	

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

June 2001

BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
2 - APPLIED RESEARCH	**0602120A - Sensors & Electronic Survivability**	**142**

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
142 PASSIVE MMW CAMERA	1909	2477	0	0	0	0	0	0	0	0

A. Mission Description and Budget Item Justification: This is a Congressionally funded program; not part of the Army's core mission. This is a development technology program for a passive/active MMW imaging system to demonstrate its performance capabilities as a covert all-weather surveillance and target acquisition system. Funding is provided to perform research on enabling MMW technologies in support of passive/active MMW imaging. These funds have been provided to the Army Research Lab as a result of Congressional interest for the development of a Passive MMW Camera (PMC).

FY 2000 Accomplishments

•	1909	- Investigated components and the design for a Passive Millimeter Wave Camera (PMC) with improved thermal resolution, wider field of view, true video frame rate, and a fully filled antenna aperture.
Total	1909	

FY 2001 Planned Program

•	2404	- Complete the fabrication and perform field testing of the new and improved version of the PMC that will be lightweight, low-cost, and flightworthy for radio-silent navigation and landing, reconnaissance, and search and rescue under conditions of clouds and fog.
•	73	Small Business Innovation Research/Small Business Technology Transfer (SBIR/STTR) Programs.
Total	2477	

FY 2002 Planned Program

- Program not funded in FY02.

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June 2001

BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
2 - APPLIED RESEARCH	**0602120A - Sensors & Electronic Survivability**	**H15**

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
H15	GROUND COMBAT ID TECH	3245	3441	8069	0	0	0	0	0	0	0

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, Australia, and Kuwait). 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). This program supports the Objective Force transition path of the Transformation Campaign Plan (TCP). PM Combat ID manages the FY99 to FY01 program. In FY 02 it will be transitioned to CECOM I2WD in support of the Coalition Combat ID ACTD.

FY 2000 Accomplishments

- 3245 - Evaluated high-fidelity technical and operational performance of Ground Integrated Target Identification System (GITIS) algorithms and simulators for baseline Combat ID for the Future Combat Systems.
  - Conducted, with user participation, technical field and operational trials of the Radio Based Combat ID (RBCI) Fire Support Team (FIST) at the All Service Combat Identification Evaluation Team (ASCIET) 00.
  - Investigated CI solution for Objective Force helicopters.
  - Studied CI Architecture to investigate emerging technologies.

FY 2000 Accomplishments (Continued)

- Conducted RBCI study and analyzed results to migrate to Advanced System Improvement Program (ASIP) radio.
- Evaluated a lightweight CI transponder system for helicopters.

Total 3245

FY 2001 Planned Program

• 3345
- Characterize GITIS technical and operational performance.
- Complete investigation of CI solution for helicopters and execute the design.
- Complete CI Architecture Study to determine and define emerging technologies.
- Complete evaluation of lightweight CI transponder system for helicopters.
- Evaluate low cost, high efficiency antenna.
- Characterize technical performance of CI for Apache-Longbow.
- Study CI solution for vehicle-to-soldier application.
- Implement North Atlantic Treaty Organization (NATO) Battlefield Target ID (BTID) Waveform per Standardization Agreement (STANAG) 4579.
- Determine RBCI feasibility for Allied radios.

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

Total 3441

FY 2002 Planned Program

• 8069
- Implement advanced CI concepts for airborne applications for the Objective Force.
- Evaluate several software gateways to establish a coalition SA Network.
- Continue implementation of STANAG 4579 waveform.
- Conduct Radio Frequency (RF) Tags study for objective force applicability.
- Support development of STANAG for individual soldier application.

FY 2002 Planned Program (Continued)

- Perform virtual model development for experiments of all systems participating in CCID ACTD to include Objective Force applicability.

Total 8069

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

June 2001

BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
2 - APPLIED RESEARCH	**0602120A - Sensors & Electronic Survivability**	**H16**

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
H16 S3I TECHNOLOGY	15359	14403	14957	0	0	0	0	0	0	0

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

FY 2000 Accomplishments

- 3812
  - Created a fully polarimetric, monopulse 35GHz radar and a fully polarimetric 95GHz radiometer. Calibration techniques were used for MMW target and clutter phenomenology to improve our ability to distinguish targets from clutter.
  - Evaluated forward-looking radar imaging techniques for vehicle mounted sensors for FCS robotic vehicle applications.
  - Designed radar for tracking of kinetic energy penetrators for active protection systems (APS) for FCS.
- 1974
  - Investigated and devised visible imaging microsensor and IR imaging microsensor designs for WEBS with CECOM's Night Vision and Electronic Sensors Directorate (NVESD).
  - Evaluated magnetic sensor capabilities for unattended ground sensors and determined unique areas for further research.
- 4001
  - Investigated and devised advanced acoustic target identification algorithms.
  - Showed improved multi- target acoustic tracking for WEBS and MFS3.
  - Investigated a fused 3-5 micron and 8-12 micron ATR algorithm exploiting unique characteristics of each and delivered completed algorithm as part of STO IV.J.12.
- 2787
  - Conducted characterization of optoelectronic image transfer over parallel vertical-cavity surface-emitting (VCSEL) laser array and free-space optical interconnect to standard complementary metal-oxide semiconductor (CMOS) electronics.
  - Replaced electronic interconnects with VCSEL/CMOS interconnects in design of AMCOM missile processor architecture.
  - Surveyed visible and IR hyperspectral data and its applicability to land warfare missions, and experimented with several algorithmic techniques to exploit this data.
  - Built and proved out extended depth of field camera system.
  - Built hybrid thick film electroluminescence structures.
  - Designed optical limiter prototypes that emulate real military optical system designs.
- 2085
  - Researched a software infrastructure for the control, processing, and visualization of unattended ground sensors at Aberdeen Proving Ground, MD.

FY 2000 Accomplishments (Continued)

- Showed the integration of gesture and natural language multi-modal interface in a 2D / 3D environment during the Army Research Laboratory Federated Laboratory conference.
- Integrated robust speech, natural language, and un-tethered gesture recognition research into multi-modal computer interface modules.

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

Total 15359

FY 2001 Planned Program

• 3006 - Deliver and evaluate first generation reconfigurable signal processor for unattended ground sensor applications.
- Conduct field experiment with CECOM-NVESD on acoustic, seismic, magnetic, infrared imager nodes.
- Evaluate sensor fusion options for unattended ground sensors.

• 1176 - Show distributed networked acoustic sensors in support of STO.
- Research and evaluate optimized physiological monitoring sensors with remote wireless capability in select operating environments.

• 735 - Generate concepts for ammunition suite for FCS program and report to ARDEC.
- Provide GPS targeting expertise and support to ARDEC Quicklook program.

• 2434 - Evolve RF forward imaging concepts consistent with narrow aperture achievable from a ground vehicle to facilitate mobility of robotic vehicles.
- Refine electromagnetic models and use to compute backscatter signatures of one or more tactical vehicles at VHF and UHF frequencies.
- Compare performance and computational-load of clutter adaptive stationary target detection approaches.
- Collect fully polarimetric target and clutter signatures with passive millimeter-wave (MMW) radiometer.
- Achieve real-time, high precision tracking of kinetic energy penetrator in range and velocity.

• 1308 - Build and prove out a low cost vertically scanned 35 GHz antenna array element.
- Complete control and calibration software for vertical electronically scanned (E-Scan) antenna.

FY 2001 Planned Program (Continued)

- 977 - Conduct 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, investigate algorithms that can perform simultaneous compression and detection on hyperspectral data, to reduce bandwidth requirements.

  - Recommend preferred operating wavelengths for broadband imagers, based on experiments using measured phenomena. Deliver preliminary algorithms for processing such data.

  - Conduct studies with stabilization and moving-target indicator (MTI) algorithms using relevant data. Deliver preliminary codes to AMCOM.

- 2113 - Incorporate improved high-data-rate VCSEL/CMOS link into real time optoelectronic transfer of image frames with some CMOS image processing included.

  - Conduct joint measurements with AMCOM of improved VCSEL/CMOS processor in missile processor architecture.

  - Achieve full color electroluminescent devices using single host

  - Characterize engineered limiter materials in best optical designs

- 1996 - Utilize 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.
- 513 - Next- Generation Autonomous Vehicle Navigation Control System (AUTOVAV) (Partner: Germany): Design of an advanced autonomous vehicle navigation control system. Complete sub-system tests of obstacle detection, classification, and avoidance technologies.
- 145 - Small Business Innovation Research/Small Business Technology Transfer (SBIR/STTR) Programs.

Total 14403

FY 2002 Planned Program

- 3190 - 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).

- 1309 - 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.

• 450 - Evaluate concepts for ammunition suite for FCS program and report to ARDEC.

• 2886 - 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 and brief results to DARPA and foliage-penetrating (FOPEN) radar prime contractor.

- Recommend an adaptive stationary target detection approach for real aperture radars.
- Model polarimetric target and clutter signatures for passive and active MMW sensors.
- 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.

• 1319 - Complete building of multi-function RF testbed.

- Generate real-time timing and control hardware and software to implement communications and radar functions.

• 825 - 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 efficacy of dual band features.
- Investigate registration techniques, image differencing, and change detection strategies for target acquisition.

• 2775 - Apply VCSEL/CMOS links to unorthodox digital processing architectures for improved processing of images and other sensor data.

- Build displays on flexible substrates.

• 2203 - 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 14957