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

June 2001

BUDGET ACTIVITY
2 - APPLIED RESEARCH

PE NUMBER AND TITLE
0602618A - Ballistics Technology

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	41177	53258	61502	0	0	0	0	0	0	0
H03 ROBOTICS TECHNOLOGY	0	14344	24234	0	0	0	0	0	0	0
H75 ELECTRIC GUN TECHNOLOGY	11012	12833	5019	0	0	0	0	0	0	0
H80 BALLISTICS TECHNOLOGY	30165	26081	32249	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.

This program element (PE) provides ballistic technologies required for armaments and armor to support the Future Combat Systems (FCS) and the Objective Force and to allow US dominance in future conflicts across a full spectrum of threats in a global context. Project H75 focuses on pulsed power technologies for electric armaments which offer the potential to field leap-ahead capability in providing hypervelocity and hyperenergy launch well above the ability of the conventional cannon. It also includes work in hypervelocity penetrator effectiveness and electrothermal chemical (ETC) technology that will greatly increase anti-armor capabilities. Project H80 is focused on applied research in ballistics technology to enhance the lethality and survivability of future weapons. Focus areas included advanced solid propellants, launch and flight dynamics, weapons concepts for light forces, warheads and projectiles, armor and munition/target interactions. Project H03 is a restructure from Project H80 to conduct applied research for advanced autonomous mobility technology for future land combat systems of the Objective Force. Included in H03 is a total $43.4M in funding transferred from OSD to the Army's Robotics Program from FY01 to FY05. Projects AH03 and AH80 will enable lethality and survivability technologies for the Future Combat Systems (FCS). 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.

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B. Program Change Summary	FY 2000	FY 2001	FY 2002	FY 2003
Previous President's Budget (FY2001 PB)	42017	49750	52675	0
Appropriated Value	42287	53750	0	
Adjustments to Appropriated Value	0	0	0	
a. Congressional General Reductions	0	0	0	
b. SBIR / STTR	-710	0	0	
c. Omnibus or Other Above Threshold Reductions	-109	0	0	
d. Below Threshold Reprogramming	-130	0	0	
e. Rescissions	-161	-492	0	
Adjustments to Budget Years Since FY2001 PB	0	0	8827	
Current Budget Submit (FY 2002/2003 PB)	41177	53258	61502	0

Change Summary Explanation: Funding - FY 2001 Congressional add was received for Electric Gun Technology (+4000). FY02 funds (+8000) added to develop underlying sensor/perception and intelligent control technologies for near-autonomous operations.

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June 2001

BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
2 - APPLIED RESEARCH	**0602618A - Ballistics Technology**	**H03**

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
H03 ROBOTICS TECHNOLOGY	0	14344	24234	0	0	0	0	0	0	0

A. Mission Description and Budget Item Justification: This project advances autonomous mobility technology for the Future Combat Systems (FCS) and the Objective Force. It will investigate robotics technology critical to the development of future Army systems, including unmanned elements of the FCS and crew aids for future manned systems. It provides the basis for a tri-service research consortium joining researchers from DOD, other Government agencies, industry, and academia in a concerted, collaborative effort to advance key enabling technologies. Achieving these goals will provide future land combat forces with significant new operational capabilities permitting paradigm shifts in the conduct of ground warfare, providing significantly greater survivability and deployability. Technical efforts will be focused towards advancing perception for autonomous ground mobility, intelligent vehicle control and behaviors, and human supervision of unmanned ground systems. Research will be conducted at the Army Research laboratory, other DOD laboratories and research centers, NIST, NASA and DOE research laboratories, as well as industry and academic institutions. The applied research conducted in this program will be transitioned to technology development, demonstration and materiel acquisition programs being conducted by the OSD Joint Robotics Program and each of the Services. Robotics Technology (Project H03) was previously funded in Project H80 prior to FY2001. This program supports the Objective Force transition path of the Transformation Campaign Plan (TCP).

FY 2000 Accomplishments

Project not funded in FY 2000.

FY 2001 Planned Program

- 2000 - Establish external research consortium involving Industry, Academia and Historically Black Colleges and Universities and Minority Institutions (HBCU/MI's) to conduct applied research on the topics of perception, intelligent control and man/machine interfaces supporting development of the Future Combat Systems.
- 11933 - Design and integrate multi-sensor perception technology required to implement baseline follower operation by unmanned ground vehicles (UGVs).

  - Show robotic follower operation at speeds of up to 20 MPH on-road and 10 MPH off-road.

FY 2001 Planned Program (Continued)

- Devise machine perception technologies to enable rapid classification of a baseline set of terrain types required for high-speed autonomous mobility.
- Devise intelligent control strategies to enable UGVs to execute a basic set of military behaviors.
- Integrate perception and control technologies into a group of UGV testbed platforms. Show semi-autonomous cross-country mobility at speeds of up to 20 MPH (day), corresponding to 50% of the speed of a manned High Mobility Multipurpose Wheeled Vehicle (HMMWV), terrain dependent.
- Conduct Battle Lab Warfighting Experiment employing multiple UGVs to examine the maturity of autonomous mobility technologies.

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

Total 14344

FY 2002 Planned Program

• 8000 - Execute industry/academic consortium for advanced perception, control/behavior and man-machine interface technology required for high-speed mobility (including robotic follower operations) and basic tactical behaviors common to multiple military missions.

• 8234 - Devise simulation based design tools for the development of tactical behaviors for UGVs.

- Devise and integrate mid-range perception technology and control architecture required for development of tactical behaviors.
- Integrate technology on testbed platforms and conduct engineering and troop experimentation to assess performance of perception and intelligent control algorithms.

• 8000 - Adapt and characterize sensors for autonomous navigation and mobility application in the ground combat environment with emphasis on affordability.

- Expand test-bed infrastructure to enable accelerated autonomous mobility technology development through comprehensive field data collection and experiments.
- Expand modeling and simulation infrastructure to enable accelerated autonomous mobility algorithm development and evolution.

Total 24234

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
H75	ELECTRIC GUN TECHNOLOGY	11012	12833	5019	0	0	0	0	0	0	0

A. Mission Description and Budget Item Justification: This project funds applied research for the Army Electromagnetic (EM) armaments technology program. To achieve the objectives of the Army Vision, future armored combat vehicles, including the Future Combat Systems (FCS), will require more lethal, yet compact main armament systems capable of defeating protection levels greatly in excess of currently experienced values. The goal of this project is to evaluate the potential of EM Armaments to field a leap-ahead capability by providing adjustable velocities, including hypervelocity, greatly above the ability of the conventional cannon. EM armaments potentially can be fully integrated with electric propulsion and electromagnetic armor systems to provide the efficient, highly mobile, and deployable armored force required by the nation. This project focuses on addressing technical barriers associated with an EM armament, in particular with pulsed power for electromagnetic (EM) launches. This project funds a new contractual effort to devise and evaluate an efficient pulsed power technology for electromagnetic (EM) launch. The goal is to provide pulsed power technology (rotating machines) with energy density of ten Joules per gram (J/g) and to identify a clear potential for growth required for future combat systems, expected to be greater than fifteen J/g. Efforts in EM pulsed power systems are conducted by Lockheed Martin - Missile and Fire Control - Dallas, TX; CEM - University of Texas - Austin, TX; Kaman Aerospace Corp. - Boston, MA; IAP - Dayton, OH; Maxwell - San Diego, CA; GE - NY; and LMCS - NY. This project funds applied research for the Army Electrothermal Chemical (ETC) gun technology program with contractual efforts by SAIC - San Diego, CA; UDLP - Minneapolis, MN; and Thiokol - Ogden, UT, in close collaboration with the Armaments Research, Development, and Engineering Center, Picatinny NJ, applying ETC technology to potential armament systems for the Future Combat System (FCS) in both medium and large caliber with the FY02 goal of increasing muzzle energy by 25%. This program supports the Objective Force transition path of the Transformation Campaign Plan (TCP).

FY 2000 Accomplishments

- 8512 - Awarded new agreement for the design and evaluation of EM armament system.
  - Conducted trades for EM system including pulsed power machine, launcher, and launch package, for FY2003 demonstration of 5 J/g.
  - Designed switch array for multi-phase, multi-pole control of pulsed power machine - Sub Scale Compulsator.
  - Designed thermal management evaluation approach for rotor.
  - Conducted systems analysis of EM gun integration into future combat vehicles.
- 2500 - In close coordination with ARDEC, designed ETC ignition and propelling charge for FCS armament system.

FY 2000 Accomplishments (Continued)

- Proved scalability, ballistic tailorability, and temperature compensation of ETC technology in medium caliber cannon in conjunction with contractual effort with UDLP - Minneapolis, MN.
- Initiated contractual efforts with Thiokol, Ogden UT, to devise ETC tailored propellants to provide high energy with reduced vulnerability.

Total 11012

FY 2001 Planned Program

- 6474 - Complete design of EM armament system.
  - Conduct pulsed power component experiments showing material strength and machine preliminary design.
  - Devise initial switch array for multi-phase, multi-pole control of pulsed power machine.
  - Devise EM Gun technology component models for conducting system level simulations.
- 4000 - Conduct experiments on sub-scale EM launcher designs demonstrating robust, field-worthy attributes.
- 2000 - Show controlled step-up toward increased muzzle energy goal in medium caliber and FCS ETC cannon using tailored solid propellants.
  - Prove ETC compatibility with cased telescope cartridges.
  - In coordination with ARDEC verify reduced recoil forces using ETC and Fire-Out-of-Battery technology.
- 359 - Small Business Innovation Research/Small Business Technology Transfer (SBIR/STTR) Programs.

Total 12833

FY 2002 Planned Program

- 4019 - Generate advanced high power switches for converters for EM pulsed power system.
  - Design and evaluate controller for multi-phase, multi-pole operation of pulsed power machine.
  - Conduct experiments on full-scale medium caliber launcher and launch package designs demonstrating robust, field-worthy attributes.
  - Utilize EM Gun technology component models for conducting system level simulations
- 1000 - Show a 25% increase in muzzle kinetic energy with ETC for an FCS armament system.

FY 2002 Planned Program (Continued)

- Identify fieldable ETC tailored propellant.

Total 5019

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2 - APPLIED RESEARCH	**0602618A - Ballistics Technology**	**H80**

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
H80 BALLISTICS TECHNOLOGY	30165	26081	32249	0	0	0	0	0	0	0

A. Mission Description and Budget Item Justification: The goal of this project is to provide key technologies required for armor and armaments that will enable U.S dominance in future conflicts across a full spectrum of threats. The program supports the Army Vision by focusing on more lethal and more deployable weapons and on survivability technologies to lighten and protect Future Combat Systems (FCS) and the Objective Force. The barrier to this challenge is to insure combat overmatch and the survivability of the FCS in spite of its light weight (less than 20 tons). Specific technology thrusts include: lightweight armors and structures to defeat existing and emerging ballistic threats; Kinetic Energy (KE) Active Protection to defeat/degrade threats before they reach the combat platform; crew and component protection from ballistic shock, mine-blast, and fuel or ammunition fires; insensitive high energy propellants/munitions to increase lethality of compact weapon systems and to reduce propellant/munition vulnerability to attack; novel KE penetrator concepts to maintain/improve lethality while reducing the size/mass of the penetrator; novel multi-function warhead concepts to enable defeat of full-spectrum of targets (anti-armor, bunker, helicopter, troops); smart projectile technologies for launch, flight, and precision strike; physics-based techniques, methodologies, and models to analyze combat effectiveness of future technologies for improved ballistic lethality and survivability. Prior to FY01, this project also provided key technologies for a new class of vehicle control that will enable an unmanned land combat vehicle to intelligently follow a manned combat vehicle (technology is funded and executed in Project H03 beginning in FY01). This new capability will enable a manned crew in a lightly armored vehicle to simultaneously expand its survivability and area of influence, maneuvering and engaging enemy forces without disclosing its own location. The work is conducted at the Army Research Laboratory, Aberdeen Proving Ground, MD and provides required technologies for advanced development programs at the Armaments Research, Development and Engineering Center (ARDEC), Picatinny Arsenal, NJ; the Tank and Automotive Research, Development and Engineering Center (TARDEC), Warren, MI; and the Aviation and Missile Research, Development and Engineering Center (AMRDEC), Huntsville, AL. This program supports the Objective Force transition path of the Transformation Campaign Plan (TCP).

FY 2000 Accomplishments

- 18035 - Investigated an advanced armor system capable of defeating future medium caliber kinetic energy (KE) and shaped charge threats that is compatible with the goals of FCS.

  - Performed complex numerical simulations of launch disturbances and critical damping of initial free flight motions for future smart munitions to extend range and improve accuracy for both direct and indirect fire weaponry.

  - Evaluated, in conjunction with Army users, operational concepts employing technologies such as advanced lightweight artillery weapons and systems to enhance positional awareness; employed distributed interactive simulations incorporating these systems to improve training.

FY 2000 Accomplishments (Continued)

- Evaluated candidate propellants produced by ARDEC and industry partners; established comprehensive database for use by ammunition designers to enhance gun lethality at reduced vulnerability.

- Evaluated performance of candidate sensor suite and kill mechanism technologies that will enable the development of KE Active Protection (KEAP).

- Exploited emerging technologies in the area of lethal mechanisms for direct fire applications, especially sheathed penetrators, amorphous metals, fragmenting warhead designs for medium caliber ammunition, and extending rods.

• 400 - Identified and successfully tested four ETC concepts (2 US and 2 German) in 120 mm during Joint Demonstration Firings conducted in Unterluess, Germany. Downselected two best concepts of the four tested for further evaluation. (NATO funds: Partner Germany) (Under Project Arrangement A-98-GE-0016).

• 5000 - Integrated sensors, perception and control algorithms on small (i.e., 1 ½ Ton class) vehicle testbeds to permit semi-autonomous cross country mobility at speeds of up to 20 MPH during daylight hours.

• 6730 Verified and validated select component-level ballistic algorithms to support development and Live Fire Test & Evaluation of over ten U.S. Army weapon systems, including ground, munition, aviation, and lightly armored systems.

Optimized physically based models to predict the probability of ignition of sustained diesel and JP-8 fuel fires in U.S. group combat systems with and without fire suppression systems.

Total 30165

FY 2001 Planned Program

• 18901 - Design and characterize innovative, lightweight armor technologies and survivability concepts to enable survivable Future Combat Systems (FCS).

- Evaluate multi-disciplinary design tools that couple structural analysis, aerodynamics, and guidance, navigation, and control (GN&C) technologies for precision munitions, missiles, and rockets.

- Implement selected gun propellant formulations (sample sizes) in scaled ballistic studies to show improved performance and propellant integrity with reduced vulnerability.

- Evaluate and characterize selected sensor suites for threat cueing and tracking of KE penetrator in support of TARDEC-ARL-ARDEC Full Spectrum Active Protection Program; perform optimization studies to improve robustness of candidate KE counter-munition concepts.

FY 2001 Planned Program (Continued)

- Devise physics-based models and conduct experimental evaluations of novel KE/Warhead lethal mechanisms to improve FCS lethality while reducing size and mass.

• 410 - Prove out the feasibility of future large caliber ETC guns. Evaluate selected ETC technologies based on FY00 downselect. (NATO funds: Partner Germany) (Under Project Arrangement A-98-GE-0016).

• 6427 - Implement experimentally derived penetration and behind-armor debris algorithms to predict the lethality of U.S. medium caliber munitions against foreign tanks and personnel carriers.

- Implement empirically based combined blast and fragment algorithms to more accurately model the effects of high explosive incendiary projectiles on the survivability of the Objective Force, including ground combat systems and helicopters.

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

Total 26081

FY 2002 Planned Program

• 25384 - Evaluate second-generation lightweight armor technologies and apply modeling and simulation tools for improved performance of FCS armors and survivability concepts.

- Apply multi-disciplinary design tools, coupled with weapons effectiveness analyses, and maturing guidance, navigation and control (GN&C) technologies (DARPA, COTS, etc) to evaluate concepts for FCS precision munitions, missiles, and rockets.

- Characterize performance of high energy/acceptable vulnerability propellant formulation (GEN II) and transition to Armament Research Development & Engineering Center for implementation in advanced multi-role armament for FCS.

- Down-select optimum KE counter-munition defeat and sensor suite configurations for transition to full-scale KEAP breadboard demonstration.

- Improve fidelity of predictive models and perform optimization studies of selected gun and missile KE/Warhead lethal mechanism concepts.

• 6865 - Characterize the ballistic-induced deformation of select composite armors and structural materials to predict the penetration and blast survivability of the FCS.

- Devise engineering-based predictions of crew acceleration and detonation/explosive reactions of stowed ammunition for Objective Force ground vehicles impacted by moderately overmatching ballistic munitions.

Total 32249