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

February 2003

BUDGET ACTIVITY	PE NUMBER AND TITLE
2 - Applied Research	**0602618A - BALLISTICS TECHNOLOGY**

COST (In Thousands)		FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate
Total Program Element (PE) Cost		60646	62458	53478	52392	54843	57366	53913	55240
H03	ROBOTICS TECHNOLOGY	23262	17393	18779	18625	18787	19106	19557	20006
H75	ELECTRIC GUN TECHNOLOGY	4837	4890	5412	5322	5100	5319	5458	5617
H80	BALLISTICS TECHNOLOGY	32547	40175	29287	28445	30956	32941	28898	29617

A. Mission Description and Budget Item Justification: 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 focuses on applied research for advanced autonomous mobility technology for future land combat systems of the Objective Force. Projects H03 and H80 will enable lethality and survivability technologies for the Future Combat Systems (FCS). Work in this PE is related to and fully coordinated with efforts in PE 0602105 (Materials Technology), PE 0602120 (Sensors and Electronic Survivability), PE 0602601 (Combat Vehicle and Automotive Technology), PE 060624 (Weapons and Munitions Technology), PE 0602705 (Electronics and Electronic Devices), PE 0602716 (Human Factors Engineering), PE 602782 (Command, Control, Communications Technology), PE 0603004 (Weapons and Munitions Advanced Technology), and PE 0603005 (Combat Vehicle Advanced 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 (ARL). This program supports the Objective Force transition path of the Transformation Campaign Plan. No Defense Emergency Response Funds have been provided to this program.

B. Program Change Summary	FY 2002	FY 2003	FY 2004	FY 2005
Previous President's Budget (FY 2003)	60948	74094	65408	67445
Current Budget (FY 2004/2005 PB)	60646	62458	53478	52392
Total Adjustments	-302	-11636	-11930	-15053
Congressional program reductions		-6500		
Congressional rescissions		-3613		
Congressional increases				
Reprogrammings	849	-358		
SBIR/STTR Transfer	-1151	-1165		
Adjustments to Budget Years			-11930	-15053

Change Summary Explanation:

Significant Changes:
FY04/05 - Funds realigned to higher priority requirements.

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

February 2003

BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
2 - Applied Research	**0602618A - BALLISTICS TECHNOLOGY**	**H03**

COST (In Thousands)		FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate
H03	ROBOTICS TECHNOLOGY	23262	17393	18779	18625	18787	19106	19557	20006

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, Objective Force Warrior (OFW) and crew aids for future manned systems. It provides the basis for the Collaborative Technology Alliance (CTA) in robotics, which is 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 products will enable rapid implementation of near-term robotic follower technology in support of PE 63005, and subsequent development of both semi-autonomous and near autonomous unmanned ground vehicles. Research is 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. 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 (ARL). This program supports the Objective Force transition path of the Transformation Campaign Plan.

No Defense Emergency Response Funds have been provided to this project.

Accomplishments/Planned Program	FY 2002	FY 2003	FY 2004	FY 2005
- Execute industry/academic consortium (CTA) 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. In FY02, devised approaches that will provide Unmanned Ground Vehicles (UGVs) the ability to classify & understand terrain, and to build the foundation for intelligent tactical behaviors. In FY03, advance technologies in terrain classification and mid-range perception and prove initial tactical behaviors and an improved understanding of human-machine interaction. In FY04, mature initial algorithmic structure to enable adaptive behaviors. In FY05, insert mature technologies onto testbed platforms to promote rapid transition of semi-autonomous capability to Objective Force systems.	7300	5602	7923	7926
- Enhance modeling and simulation infrastructure to enable development of semi-autonomous UGVs; devise and implement tools to enable rapid maturation of tactical behaviors. In FY02, devised One SAF based tools that permitted maturation of basic mapping behavior on a small robot. In FY03, mature common set of modeling tools for creation of tactical behaviors and for improving soldier-machine interfaces. In FY04, employ modeling tools to improve the soldier-machine interface. In FY05, employ modeling tools to implement tactical behaviors.	1296	915	1000	976
- Mature and integrate perception and control technology required for an intelligent robotic follower vehicle capable of achieving 35 MPH on-road and 20 MPH off-road mobility (chassis limited) with a time delay between passage of the manned leader vehicle and unmanned follower of up to 12 hours. In FY02, proved intelligent on and off-road follower capability for single vehicle using GPS generated waypoints. In FY03, transition technology to TACOM for implementation in Robotic Follower ATD.	6000	2744	0	0
- Mature perception, intelligent control, and man-machine interface technology required for a single soldier to manage the operation of multiple unmanned ground vehicles maneuvering near-autonomously through the battlefield. In FY02, devised improved perception capabilities for terrain reasoning and matured associate technology to enable adaptive tactical behaviors. In FY03, mature techniques of object classification. In FY04, implement fusion of multiple sensor modes for improved terrain reasoning. In FY05 mature technology required to show baseline adaptive tactical behaviors by unmanned ground vehicles.	3666	2643	5356	5333

Accomplishments/Planned Program (continued)	FY 2002	FY 2003	FY 2004	FY 2005
- Integrate technology on unmanned ground vehicle testbeds and conduct extensive field exercises for experimentation, technology characterization, and to show capability maturation for near autonomous UGVs. In FY02, proved cross-country autonomous mobility in rolling terrain during field exercises in which a single soldier managed operation of up to 3 unmanned ground vehicles; proved initial baseline tactical behavior by unmanned ground vehicle. In FY03, advance maturity of autonomous mobility technology required to implement FCS Block I Armed Reconnaissance Vehicle. In FY04, incorporate improved perception and control technology to enable baseline cooperative behaviors. In FY05, prove baseline adaptive tactical behaviors.	5000	5489	4500	4390
Totals	23262	17393	18779	18625

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February 2003

BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
2 - Applied Research	**0602618A - BALLISTICS TECHNOLOGY**	**H75**

COST (In Thousands)		FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate
H75	ELECTRIC GUN TECHNOLOGY	4837	4890	5412	5322	5100	5319	5458	5617

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), more lethal, yet compact main armament systems capable of defeating protection levels greatly in excess of current values are required. 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 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. Through FY02, this project funded applied research for the Army Electrothermal Chemical (ETC) gun technology program, 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%. 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 (ARL). This program supports the Objective Force transition path of the Transformation Campaign Plan.
No Defense Emergency Response Funds have been provided to this project.

Accomplishments/Planned Program	FY 2002	FY 2003	FY 2004	FY 2005
- Proved required muzzle kinetic energy with ETC in a surrogate FCS Multi-Role Armament System and identified candidate ETC propellants and validated improved mechanical properties/vulnerability characteristics; transitioned technology to the Armaments Research Development and Engineering Center for further development.	1000	0	0	0

Accomplishments/Planned Program (continued)	FY 2002	FY 2003	FY 2004	FY 2005
- Mature and prove compact pulsed power system for EM guns. In FY02, designed pulsed alternator and conducted component tests to reduce technical risk; produced advanced high power switches for converters for EM pulsed power system; designed and evaluated controller for multi-phase, multi-pole operation of pulsed power machine; and used EM gun component technology models for conducting system level simulations. In FY03, finalize design of EM gun system and begin fabrication of full-scale critical pulsed power components. In FY04, complete fabrication of critical pulsed power components and validate integrity. In FY05, complete fabrication of thermal management, EM shielding, and auxiliary systems.	2437	3950	4833	4912
- Establish and mature technologies for efficient, lightweight EM guns and projectiles to enable revolutionary lethality for Objective Force platforms. In FY02, conducted experiments on laboratory launcher uncovering and solving rail life issues; conducted experiments on field worthy launcher test sections uncovering fabrication challenges; and evaluated launch package designs for integrity and transition resistance. In FY03, solve engineering challenges, build field worthy 60mm launcher, and fire an integrated launch package with a steel, monolithic penetrator. In FY04, conduct firings from field worthy launcher to full design energy and complete maturation of integrated launch package for a KE projectile. In FY05, fire an integrated launch package from field worthy launcher.	1400	940	579	410
Totals	4837	4890	5412	5322

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February 2003

BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
2 - Applied Research	**0602618A - BALLISTICS TECHNOLOGY**	**H80**

COST (In Thousands)		FY 2002 Actual	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate
H80	BALLISTICS TECHNOLOGY	32547	40175	29287	28445	30956	32941	28898	29617

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 challenge is to insure combat overmatch and the survivability of the FCS while achieving rapid deployability in a lighter weight platform (less than 20 tons). Specific technology thrusts include: lightweight armors and structures to defeat existing and emerging ballistic threats; Kinetic Energy (KE) Active Protection (KEAP) 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 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. 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.
No Defense Emergency Response Funds have been provided to this project.

Accomplishments/Planned Program	FY 2002	FY 2003	FY 2004	FY 2005
- Optimize advanced lightweight structural, ceramic, and electromagnetic armor technologies that meet FCS threshold capability for transition to FCS vehicle designers, and mature ballistic shock and mineblast mitigation technologies to enable revolutionary survivability for FCS and Objective Force Platforms. In FY02, designed and evaluated second-generation lightweight frontal and structural armor technologies that were provided as baseline armor configurations in support of FCS vehicle trade studies, and applied modeling and simulation tools for improved performance of FCS armors and survivability concepts. In FY03, transition lightweight armor technologies to TARDEC for integration into FCS. In FY04, evaluate improved objective armor technologies to include electromagnetic and enhanced ceramic armor that improve upon the performance of the transitioned threshold armor and evolve ballistic shock and mineblast mitigation technologies. In FY05, optimize armor packaging and transition improved hybrid armor technologies to FCS vehicle designers and prove capability of ballistic shock and mineblast mitigation technologies.	10640	11592	10295	7469
- Mature multi-role ammunition and lethality technologies. Couple physics-based models describing interior ballistics, launch dynamics, and flight mechanics with system effectiveness models and emerging high-g guidance, navigation, and control (GN&C) technologies to enable dynamic retargeting of precision munitions for revolutionary Objective Force lethality. In FY02, devised and applied physics-based models for missile divert and interior ballistic launch, coupled with weapons effectiveness analyses to evaluate concepts for dynamic retargeting. In FY03, Optimize multi-disciplinary design tools and fully characterize high-g GN&C components. In FY04, Prove validated multidisciplinary models for precision gun-fired munitions, couple with system effectiveness models, and prove gun launch as well as deployment of gun launched dynamic retargeting assets. In FY05, transition fully coupled suite of models and validated dynamic retargeting technology to munitions development community.	4364	4509	4586	4493

Accomplishments/Planned Program (continued)	FY 2002	FY 2003	FY 2004	FY 2005
- Mature propulsion and energetics technologies. Evaluate, select, and prove novel/nanostructural insensitive high-energy materials (IHEM) concepts, which exploit managed energy release, and are required for improving the lethality and reducing the vulnerability of FCS/Objective Force gun/missile systems and warheads. In FY02, characterized performance of high energy/acceptable vulnerability propellant formulation (GEN II) and transitioned to ARDEC as potential candidate for implementation in advanced multi-role armament for FCS. In FY03, evaluate novel/nanostructural IHEM concepts. In FY04, characterize candidate novel insensitive high-energy materials and assess concepts for exploiting managed energy release for FCS/Objective Force gun/missile systems and warheads. In FY05, provide matrix of novel IHEM propellant and explosives for specific Objective Force applications.	2736	2608	2966	3084
- Mature counter-munition and sensor technologies effective for active protection defeat of kinetic energy (KE) munitions, which is critical to enable revolutionary survivability of FCS and Objective Force platforms. In FY02, down-selected blast-deflect KE counter-munition defeat and sensor suite configurations for transition to full-scale KEAP breadboard experiment. In FY03, combine blast deflect KE counter-munition and sensor suite in breadboard KE active protection experiment and evaluate to optimize performance against KE threat. In FY04, prove effectiveness of blast-deflect KEAP system consistent with Tank Automotive and Armaments Command Full Spectrum Active Protection (FSAP) system requirements. In FY05, optimize blast-deflect countermeasure design against both KE and CE threats, and transition to TARDEC FSAP development program.	4322	3935	1825	1789
- Mature multi-role ammunition and lethality technologies. Identify and model preferred options to reduce energy/mass required to defeat emerging armor threats and to provide multi-purpose capabilities for revolutionary Objective force lethality. In FY02, improved fidelity of predictive models and performed optimization studies of selected gun and missile KE/Warhead lethal mechanism concepts. In FY03, perform breadboard experiment of selected KE/warhead lethal mechanism components and initiate transition to ARDEC and AMRDEC for integration into FCS multi-role munitions. In FY04, identify preferred options to reduce energy/mass required to defeat emerging threats and to provide multi-purpose capabilities for revolutionary Objective force lethality. In FY05, mature and integrate emerging materials and novel lethal mechanism technologies & conduct full-scale experimental validation of integrated solution for transition to Objective Force munitions developers.	3125	3290	3536	3621

Accomplishments/Planned Program (continued)	FY 2002	FY 2003	FY 2004	FY 2005
- Devise state-of-the-art survivability/lethality/vulnerability methodologies to dynamically model the interaction of conventional ballistic threats versus FCS and Objective Force System of Systems. In FY02, characterized the ballistic-induced deformation of select composite armors and structural materials to predict the penetration and blast survivability of the FCS and devised engineering-based predictions of crew acceleration and detonation/explosive reactions of stowed ammunition for Objective Force ground vehicles impacted by moderately overmatching ballistic munitions. In FY03, implement first generation advanced armor penetration algorithms in survivability/lethality analysis codes for sophisticated multi-layering protection schemes employed for multi-hit protection of U.S. Army ground systems and the Objective Force and provide the survivability/lethality analysis code framework to dynamically model the interaction of an incoming conventional ballistic threat versus a ground combat vehicle equipped with an active protection system. In FY04, devise models for various damage mechanisms such as fuel fire and ammunition reaction as well as penetration and blast damage to new/novel materials. In FY05, experimentally validate models.	6100	5543	6079	6200
- Mature and prove advanced pulse power componentry critical to enable implementation of revolutionary electromagnetic armor technology onto FCS platforms. In FY03, optimize logic and control system to minimize space and weight for FCS system. In FY05, prove advanced pulse power componentry necessary to enhance FCS survivability. Program executed by ARL in coordination with TARDEC.	1260	8698	0	1789
Totals	32547	40175	29287	28445