ARMY RDT&E BUDGET ITEM JUSTIFICATION (R2 Exhibit)

February 2005

BUDGET ACTIVITY
2 - Applied Research

PE NUMBER AND TITLE
0602618A - BALLISTICS TECHNOLOGY

COST (In Thousands)		FY 2004 Actual	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate
Total Program Element (PE) Cost		57815	54889	49163	52168	53761	54833	52639	52783
H03	ROBOTICS TECHNOLOGY	17675	17023	15097	17682	18473	18687	16181	16060
H75	ELECTRIC GUN TECHNOLOGY	5114	4946	4802	5050	5278	5368	5414	5454
H80	BALLISTICS TECHNOLOGY	29573	27840	29264	29436	30010	30778	31044	31269
HB1	SURVIVABILITY AND LETHALITY TECHNOLOGIES (CA)	5453	5080	0	0	0	0	0	0

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 Future Force and, where feasible, exploits opportunities to enhance Current Force capabilities to allow US dominance in future conflicts across a full spectrum of threats in a global context. Project H03 focuses on applied research for advanced autonomous mobility technology for future land combat systems of the Future Force. Project H75 focuses on technologies for electric armaments which offer the potential to achieve leap-ahead lethality capability by providing hypervelocity and hyperenergy launch well above the ability of the conventional cannon. It also includes work in hypervelocity penetrator effectiveness that will greatly increase anti-armor capabilities. Project H80 is focused on applied research in ballistics technology to enhance the lethality and survivability of the Future Force. Focus areas include advanced solid propellants, launch and flight dynamics, weapons concepts for light forces, warheads and projectiles, armor and munition/target interactions. 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 0602624 (Weapons and Munitions Technology), PE 0602705 (Electronics and Electronic Devices), PE 0602716 (Human Factors Engineering), PE 0602782 (Command, Control, Communications Technology), PE 0603004 (Weapons and Munitions Advanced Technology), and PE 0603005 (Combat Vehicle Advanced Technology). The cited work is consistent with Strategic Planning Guidance, the Army Science and Technology Master Plan (ASTMP), the Army Modernization Plan, and the Defense Technology Area Plan (DTAP). Work in this project is performed by the Army Research Laboratory (ARL).

B. Program Change Summary	FY 2005	FY 2006	FY 2007
Previous President's Budget (FY 2005)	51301	53700	56100
Current Budget (FY 2006/2007 PB)	54889	49163	52168
Total Adjustments	3588	-4537	-3932
Net of Program/Database Changes			
Congressional Program Reductions	-765		
Congressional Rescissions			
Congressional Increases	5300		
Reprogrammings			
SBIR/STTR Transfer	-947		
Adjustments to Budget Years		-4537	-3932

Change Summary Explanation:

Three FY05 Congressional adds totaling $5300 were added to this PE.

FY05 Congressional adds with no R-2A:
($2110) Advanced Tungsten Penetrators and Ballistic Materials, Project HB1: The purpose of this one year Congressional add is to fund research in alloy tungsten armor piercing ammunition. No additional funds are required to complete this project.

($959) Guardian Angel, Project HB1: The purpose of this one year Congressional add is to fund research in ballistics technology. No additional funds are required to complete this project.

($2013) Structural Reliability of Electronic Components for Munitions and Lightweight Structures, Project HB1: The purpose of this one year Congressional add is to perform research in electronic component structures. No additional funds are required to complete this project.

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February 2005

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

COST (In Thousands)		FY 2004 Actual	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate
H03	ROBOTICS TECHNOLOGY	17675	17023	15097	17682	18473	18687	16181	16060

A. Mission Description and Budget Item Justification: This project advances autonomous mobility technology for the Future Combat Systems (FCS) and the Future Force. It will investigate robotics technology critical to the maturation of future Army systems, including unmanned elements of the FCS, Future Force Warrior (FFW) 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 are focused on 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/Project: 63005/515, and subsequent development of both semi-autonomous and near autonomous unmanned ground vehicles (UGVs). 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. Research supports collaborative efforts with DARPA. The cited work is consistent with Strategic Planning Guidance, the Army Science and Technology Master Plan (ASTMP), the Army Modernization Plan, and the Defense Technology Area Plan (DTAP). Work in this project is performed by the Army Research Laboratory (ARL).

Accomplishments/Planned Program	FY 2004	FY 2005	FY 2006	FY 2007
- Execute 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. Research focuses upon new sensor and sensor processing algorithms for rapid detection and classification of objects in the environment enabling high-speed mobility and intelligent tactical behavior by future unmanned systems; implementing adaptive control strategies that will enable unmanned systems to display intelligent tactical behavior, and development of human-robot interaction (HRI) scalable, intuitive, multi-modal control interfaces that will minimize the additional cognitive workload for Soldiers controlling unmanned assets. In FY04, matured initial algorithmic structure enabling vehicles to operate in unpredictable environments, validated capability in simulation; instantiated advanced active sensor (LADAR) technology and perception algorithms required for FCS threshold mobility requirements. In FY05, insert mature perception, control, and HRI technologies onto testbed platforms to promote rapid transition of semi-autonomous capability to Future Force systems, including transfer of LADAR sensor technology to FCS program. In FY06, will conduct research enabling safe operation of semi-autonomous vehicles in populated environments, including movement in dynamic environments, e.g., oncoming traffic and pedestrians, a key barrier to the utilization of unmanned systems in future urban military operations. Research supports collaborative efforts with DARPA focused upon both near-term implementation of technologies, and incorporation of DARPA sponsored research in adaptive perception and control technology. In FY07, will conduct research to permit meaningful collaboration by autonomous vehicles (including mixed air and ground assets) utilizing the scout reconnaissance mission as the focus for technology development.	7573	7364	7301	7370
- Enhance modeling and simulation infrastructure to enable maturation of semi-autonomous UGV's; devise and implement tools to enable rapid maturation of tactical behaviors. In FY04, employed modeling tools to improve the Soldier-machine interface and create a portable laboratory environment that can be utilized to develop a scalable family of interface technology for multiple applications and missions. Resultant technology transferred to TARDEC for application in advanced development programs. In FY05, integrate mechanisms for behavioral adapability into test bed vehicles and evaluate approach through field exercises during which a minimum of two vehicles collaboratively conduct maneuver required for a zone reconnaissance mission while adapting their behavior to reflect environmental changes.	928	809	0	0

Accomplishments/Planned Program (continued)	FY 2004	FY 2005	FY 2006	FY 2007
- Mature perception, intelligent control, and man-machine interface technology required for a single Soldier to manage the operation of multiple unmanned ground vehicles maneuvering with high levels of autonomy through the battlefield. In FY04 implemented fusion of multiple sensor modes for improved terrain reasoning, e.g., providing the ability to detect engineered wire obstacles in complex environments and detect water obstacles. In FY05, mature the perception and control technology required to show baseline tactical behaviors by unmanned ground vehicles adapting to dynamic changes in the environment while maneuvering through rolling, vegetated terrain. This will transition into TARDEC's Armed Robotic Vehicle Program.	5026	4877	0	0
- Mature perception and intelligent control technologies required to meet objective capabilities for the Armed Robotic Vehicle program and transition this technology to advanced development programs being conducted under PE 63005 (Combat Vehicle Advanced Technology) Project D515 for integration into test bed systems. Leverage DARPA sponsored research, e.g., Software for Distributed Robotics, for control of collaborating agents to enable mixed teams (manned/unmanned) to conduct military missions. In FY06 will conduct research in perception and control technologies for autonomous mobility that will permit realistic operational speed for FCS with spirals to Current Force. In FY07, will mature perception and control technology to permit implementation of behaviors to enhance the operational effectiveness of robotic vehicles.	0	0	4868	4913

Accomplishments/Planned Program (continued)	FY 2004	FY 2005	FY 2006	FY 2007
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. Leverage algorithms being conducted under DARPA sponsored research, e.g., Learning Applied to Ground Robotics (LAGR). Conduct regular, periodic experimentation at Ft. Indiantown Gap, PA and other military facilities to stress technology in complex environments to further focus CTA sponsored research, assess performance and provide the opportunity for TRADOC to initiate early development of the Tactics, Techniques, and Procedures required for successful utilization of unmanned systems in future conflicts. In FY04, incorporated improved perception and control technology to enable baseline cooperative behaviors in rolling, vegetated environments. The underlying research results have been transition to RDECOM advanced development and FCS SDD programs. In FY05, prove baseline adaptive tactical behaviors through field experimentation designed to demonstrate the ability of unmanned systems to autonomously alter behavior in response to changes in the local environment. In FY06, will incorporate advanced perception and control technology and transition to FCS Autonomous Navigation System prototypes for evaluation in relevant environments. In FY07, will evaluate technologies for collaborative operation of networked air & ground unmanned vehicles managed by a single Soldier.	4148	3973	2928	5399
Totals	17675	17023	15097	17682

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

COST (In Thousands)		FY 2004 Actual	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate
H75	ELECTRIC GUN TECHNOLOGY	5114	4946	4802	5050	5278	5368	5414	5454

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), requires more lethal, yet compact main armament systems capable of defeating protection levels significantly greater than current 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 that far exceeds 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 advanced materials for pulsed power and launchers; experimentally validating full-scale hypervelocity utility of novel kinetic energy penetrators against the range of threat armors; and devising and experimentally validating high energy launch packages. In the area of pulse power, it will mature and prove critical materials for compact pulsed power for EM guns. For the launcher, it will establish and mature technologies for efficient, lightweight EM guns and projectile launch packages to enable revolutionary lethality for Future Force platforms. In the area of launch package (projectiles), it will establish technologies for full-scale hypervelocity novel kinetic energy penetrators. This research is conducted at the Army Research Laboratory, Aberdeen Proving Ground, MD. The applied research program receives the output of basic research conducted under H63 by the Institute for Advanced Technology, UT-Austin, and transitions it to the Army environment. In turn, the applied research is moved directly into the ARDEC advanced technology demonstration program where it is incorporated by industry into an EM gun system. The cited work is consistent with Strategic Planning Guidance, the Army Science and Technology Master Plan (ASTMP), the Army Modernization Plan, and the Defense Technology Area Plan (DTAP). Work in this project is performed by the Army Research Laboratory (ARL).

Accomplishments/Planned Program	FY 2004	FY 2005	FY 2006	FY 2007
Pulsed Power - In FY04, devised advanced, high strength composite materials for pulsed alternator rotor and explored rotor thermal management technology. In FY05, prove through laboratory testing the strength of new, thick composite rotor bandings and validate thermal management components. In FY06, prove advanced low density, high strength, low resistivity field coil conductors and efficient switch packaging. In FY07, experimentally validate active cooling of high speed rotor for pulsed power generation.	1953	1877	1898	1920
Launch - In FY04, established processing methodology which was used to fabricate and test an advanced low mass, composite EM launcher; experimentally validated prototype projectile armatures at 2 megajoules (MJ). In FY05, validate integrity of advanced composite EM launchers through actual firing; fire full-up EM projectile at 2 MJ and fire prototype armatures at 8 MJ. In FY06, validate robustness and rail life of composite launcher; and EM launch 8 MJ projectile with monolithic rod. In FY07, EM launch 8 MJ projectile with functioning novel penetrator.	1203	1193	1444	1460
Full-Scale Hypervelocity Lethality - In FY04, established hypervelocity performance of monolithic depleted uranium kinetic energy penetrators and evaluated terminal ballistics of a fixed geometry, novel kinetic energy penetrator (NKEP). In FY05, evaluate flexible geometry NKEP and down-select to most promising hypervelocity penetrator approach. In FY06, mature mechanisms to deploy NKEP in flight. In FY07, validate performance of functional NKEP against realistic targets in full-scale EM gun.	1958	1876	1460	1670
Totals	5114	4946	4802	5050

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February 2005

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

COST (In Thousands)		FY 2004 Actual	FY 2005 Estimate	FY 2006 Estimate	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate
H80	BALLISTICS TECHNOLOGY	29573	27840	29264	29436	30010	30778	31044	31269

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 Future Force and, where feasible, exploits opportunities to enhance Current Force capabilities. The challenge is to ensure 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 (AP) 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 Strategic Planning Guidance, the Army Science and Technology Master Plan (ASTMP), the Army Modernization Plan, and the Defense Technology Area Plan (DTAP). Work in this project is performed by the Army Research Laboratory (ARL).

Accomplishments/Planned Program	FY 2004	FY 2005	FY 2006	FY 2007
- Optimize advanced lightweight structural, ceramic, and electromagnetic armor technologies for transition to FCS vehicle designers, Current and Future Force Platforms, and Ground Tactical Vehicles. In FY04, transitioned advanced lightweight armor designs to FCS Lead System Integrator (LSI) and TARDEC and demonstrated a more than 15% increase in armor performance with an improved ceramic material; and identified an armor technology that could revolutionize shaped charge defeat. In FY05, optimize armor packaging and transition improved hybrid armor technologies to FCS and current vehicle designers; and validate advanced pulse power componentry necessary to enhance FCS survivability. In FY06, will validate the advanced technology for shaped charge defeat and apply the design tools to tactical vehicles to increase their survivability against small arms and improvised explosive devices. In FY07, will experimentally validate integrated and add-on ballistic protection technologies that make tactical combat vehicles more survivable.	5785	5371	6397	7086
- Mature mine blast, ballistic shock mitigation, and crew protection technologies to enable revolutionary survivability of Current and Future Force Platforms, Ground Tactical Vehicles, and the individual Soldier. In FY04, matured advanced blast and vehicle structure models and experimentally validated first-generation Anti-Tank (AT) mine blast appliqué kit for FCS-class vehicles; also applicable to current platforms. In FY05, validate AT mine blast appliqué kit and crew restraint system for FCS; and show capability of ballistic shock mitigation technologies. In FY06, will advance models and mature first-generation designs for integrated AT mine blast protection structure/crew system. In FY07, will provide design guidance and proven AT mine blast protection structure/crew system to vehicle designers for FCS Spirals and Ground Tactical Vehicles; and will validate technologies to improve flexibility of protection equipment (torso, extremities, neck) for individual Soldier.	2489	1950	3004	3589

Accomplishments/Planned Program (continued)	FY 2004	FY 2005	FY 2006	FY 2007
- Mature advanced 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 Future Force lethality. In FY04, validated multidisciplinary design (MDD) models for precision gun-fired munitions; incorporated dynamic retargeting into system effectiveness models; and proved high G mortar launch as well as deployment of dynamic retargeting assets. In FY05, transition fully coupled suite of models and validated first generation dynamic retargeting technology to munitions development community. In FY06, will experimentally validate new engineering analysis capability which couples interior, exterior, and projectile structures for analysis of smart munitions; and will validate computational fluid dynamics model of advanced actuator divert for medium caliber munitions. In FY07, will experimentally prove dynamic retargeting technologies (in-flight position update) applicable to FCS and Future Force munitions; and will validate closed loop actuator control system technologies required for divert of medium caliber munitions.	4522	4128	4061	3884
- 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/Future Force gun/missile systems and warheads. In FY04, characterized candidate novel insensitive high-energy materials and assessed concepts for exploiting managed energy release for FCS/Future Force gun/missile systems and warheads. In FY05, extend and validate modeling tools used for design of managed energy systems; experimentally assess promising insensitive high-energy materials in notional energy managed configuration; and provide matrix of novel IHEM propellant and explosives candidates for specific Future Force Insensitive Munitions (IM) applications. In FY06, will down-select a weapons system application for validation of novel insensitive energetic material (gun/rocket/ propellant/multi-purpose warhead); and will mature numerical tools for insensitive munitions design. In FY07, will validate selected system using advanced energetic material with tuned energy release (gun/rocket propulsion/ multi-purpose warhead) with increased performance while meeting FCS insensitive munition requirements and will apply emerging numerical tools to novel insensitive munitions.	4623	4505	4132	3734

Accomplishments/Planned Program (continued)	FY 2004	FY 2005	FY 2006	FY 2007
- Mature Active Protection counter-munition and sensor technologies to effectively defeat all anti-armor munitions including kinetic energy (KE) projectiles, which is critical to enable revolutionary survivability of FCS and Future Force platforms. In FY04, proved effectiveness of blast-deflect universal counter-munition warhead and sensor consistent with TARDEC Integrated Survivability Active Defense System requirements. In FY05, prove blast-deflect universal countermeasure design against a variety of KE and CE threats, and transition to TARDEC Integrated Survivability Advanced Technology Demonstration (IS ATD) program. In FY06, will optimize universal counter-munition performance through improved modeling, materials and experimentation. In FY07, will transition optimized universal counter-munition to the IS ATD program.	2000	2000	2000	2000
- Mature advanced 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 Future Force lethality. In FY04, identified penetrator options to reduce energy/mass required to defeat emerging threats and to provide multi-purpose capabilities for revolutionary Future 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 Future Force munitions developers. In FY06, will integrate lethal mechanisms and prove out broad, multi-functional target defeat capabilities. In FY07, will transition Multi-Threat Objective Projectile Technology to ARDEC and AMRDEC and investigate warhead concepts for tailorable and scaleable lethal effects for Military Operations in Urban Terrain.	3594	3456	3248	3044

Accomplishments/Planned Program (continued)	FY 2004	FY 2005	FY 2006	FY 2007
- Devise state-of-the-art survivability/lethality/vulnerability (SLV) methodologies to dynamically model the interaction of conventional ballistic threats versus FCS and Future Force System of Systems. In FY04, enhanced methodology and modeling & simulation capabilities addressing active protection systems, fire, and behind-armor debris; devised and proved capabilities to analyze shock in composite materials, munition lethality versus buildings and bunkers, and penetration against thin laminate armors; demonstrated capability for dynamic ballistic experimentation on tail-rotor blades; conducted ballistic experiments on hybrid-electric propulsion systems. In FY05, incorporate models for various damage mechanisms such as fuel fire, blast and shock, and penetration into complex armors, into production SLV codes; model lethality of structural secondary fragments; develop code architecture and capabilities based metrics to assess survivability in a Systems of Systems context. In FY06, will update SLV modeling framework , as well as methodology for emerging technologies. In FY07, will mature newly emerging technologies; will incorporate models for weapons effects in urban environments, including structural response and structural damage mechanisms; experimentally validate models.	6560	6430	6422	6099
Totals	29573	27840	29264	29436