ARMY RDT&E BUDGET ITEM JUSTIFICATION (R2 Exhibit)

February 2007

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

	COST (In Thousands)	FY 2006 Actual	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate
	Total Program Element (PE) Cost	50152	58568	55014	55736	55672	55850	56939	58130
H03	ROBOTICS TECHNOLOGY	13130	16237	16177	16498	16083	15964	16315	16674
H75	ELECTRIC GUN TECHNOLOGY	4382	5179	3968	4065	4098	4120	4222	4326
H80	BALLISTICS TECHNOLOGY	29191	30229	34869	35173	35491	35766	36402	37130
HB1	SURVIVABILITY AND LETHALITY TECHNOLOGIES (CA)	3449	6923						

A. Mission Description and Budget Item Justification: This program element (PE) provides ballistic technologies required for armaments and armor to support the Future Force and, where feasible, exploits opportunities to enhance Current Force capabilities. This technology will permit 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. 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 lethality and survivability technologies, including research on lightweight armors and structures; kinetic energy active protection; crew and component protection from ballistic shock and mine-blast; insensitive propellants/munitions; novel multi-function warhead concepts; affordable precision munition technologies; physics-based techniques, methodologies, and models to analyze combat effectiveness of future technologies. Projects H03 and H80 will enable lethality and survivability technologies for the Future Force. Work in this PE is related to and fully coordinated with efforts in PE 0602105A (Materials Technology), PE 0602120A (Sensors and Electronic Survivability), PE 0602601A (Combat Vehicle and Automotive Technology), PE 0602624A (Weapons and Munitions Technology), PE 0602705A (Electronics and Electronic Devices), PE 0602716A (Human Factors Engineering), PE 0602782A (Command, Control, Communications Technology), PE 0603004A (Weapons and Munitions Advanced Technology), and PE 0603005A (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 2006	FY 2007	FY 2008	FY 2009
Previous President's Budget (FY 2007)	52010	52221	51092	52188
Current BES/President's Budget (FY 2008/2009)	50152	58568	55014	55736
Total Adjustments	-1858	6347	3922	3548
Congressional Program Reductions		-224		
Congressional Rescissions				
Congressional Increases		7000		
Reprogrammings	-1858	-429		
SBIR/STTR Transfer				
Adjustments to Budget Years			3922	3548

Four FY07 congressional adds totaling $6709 (after adjustment for Congressional Undistributed Reductions) were added to this PE.

($1390) Adv Tungsten Penetrators and Ballistic Materials
($3115) Laser Bsd Explosive- Chem/Bio Standoff & Point Det
($958) Stand Off Explosives Detector
($1246) TAC-C Robotic Vehicles for SOF

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

COST (In Thousands)	FY 2006 Actual	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate
H03 ROBOTICS TECHNOLOGY	13130	16237	16177	16498	16083	15964	16315	16674

A. Mission Description and Budget Item Justification: Research in this project advances autonomous mobility technology for the Future Force. It will investigate robotics technology critical to the maturation of future Army systems, including unmanned elements of the Future Force, 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 the Department of Defense (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 both semi-autonomous and near autonomous unmanned ground vehicles (UGVs) with products transitioning to advanced development efforts. Research is conducted at the Army Research Laboratory, other DOD laboratories and research centers, National Institute of Standards and Technology, National Aeronautics and Space Administration, and Department of Energy 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 Office of the Secretary of Defense Joint Robotics Program and each of the Services. Research supports collaborative efforts with Defense Advanced Research Projects Agency (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 2006	FY 2007	FY 2008	FY 2009
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 on new sensor and sensor processing algorithms for rapid detection and classification of objects in the environment enabling safe 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 FY06, conducted research enabling safe operation of semi-autonomous vehicles in populated environments, including movement in dynamic environments, a key barrier to the utilization of unmanned systems in future urban military operations, providing the ability to detect and classify moving vehicles and pedestrians from a moving platform. In FY07, focus on multi-sensor fusion approaches towards improved perception in dynamic and urban environments and permit meaningful collaboration by autonomous vehicles (including mixed air and ground assets) utilizing the scout reconnaissance mission as the focus for technology development. In FY08, will focus upon improved object recognition and feature detection to enable tactical behavior and initiate creation and integration of mechanisms to adapt to intelligent adversaries. In FY09, will mature technology for scene understanding and autonomous tactical behavior in the context of reconnaissance mission scenarios.	6115	7109	7334	7508
Mature perception and intelligent control technologies required to meet objective capabilities for the armed robotic vehicles and transition this technology to advanced development programs being conducted under PE 0603005A (Combat Vehicle Advanced Technology)	4599	4805	4865	4958

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 conducted research in perception and control technologies for autonomous mobility that will permit realistic operational speed for UGVs that could spiral to Current Force. In FY07, conduct research in perception and control technologies that will permit unmanned ground vehicles to safely maneuver in dynamic environments at increasing speeds. In FY08 will mature perception and control technology to permit implementation of behaviors to enhance the operational effectiveness of robotic vehicles. In FY09, will mature robotics technology that will permit unmanned vehicles to adapt to dynamic situations found in tactical environments.				
Integrate technology on unmanned ground vehicle test beds 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 US Army Training and Doctrine Command to initiate early development of the Tactics, Techniques, and Procedures required for successful utilization of unmanned systems in future conflicts. In FY06, incorporated advanced perception and control technology and transitioned to Future Combat Systems Autonomous Navigation System prototypes for evaluation in relevant environments. In FY07, evaluate technologies for safe operation of unmanned vehicles in dynamic on- and off-road environments. In FY08, will evaluate technologies to enable collaborative operation of near-autonomous unmanned systems, including networked air and ground unmanned vehicles, managed by a single Soldier. In FY09, will evaluate the ability of unmanned ground vehicles to autonomously adapt to dynamic tactical environments.	2416	3897	3978	4032
Small Business Innovative Research/Small Business Technology Transfer Programs		426		
Total	13130	16237	16177	16498

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

COST (In Thousands)	FY 2006 Actual	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate
H75 ELECTRIC GUN TECHNOLOGY	4382	5179	3968	4065	4098	4120	4222	4326

A. Mission Description and Budget Item Justification: This project funds applied research for the Army Electromagnetic (EM) Gun Program. Future combat vehicles will require more lethal yet compact main armament systems with significant enhancements in survivability, reductions in logistics footprint, and decreases in system signature. This project evaluates the potential of EM guns to provide such leap-ahead armaments capabilities that are fully integrated with electric propulsion and electromagnetic armor systems to provide the efficient, highly mobile, and deployable armored force. Focus is placed on addressing EM system technical barriers, in particular advanced materials for pulsed power; robust, compact, and lightweight launchers; full-scale, hypervelocity utility of novel kinetic energy penetrators (NKEPs) against a range of present and future threats; and efficient high energy launch packages. In the area of pulsed power, evolve the high strength composite materials critical for compact pulsed alternators. For the launcher, establish and mature technologies needed to incorporate high strength, low density materials which provide long life, fieldworthy EM cannon. In the area of launch projectiles, develop lethal mechanisms that take advantage of the hypervelocity capability of EM guns and provide the armature and sabot technologies needed for accurate, low parasitic mass launch packages. The research is conducted at the Army Research Laboratory (ARL), Aberdeen Proving Ground, MD, with extensive university and industry support. The resulting developments are moved directly into the Armament Research, Development, and Engineering Center (ARDEC) where they are being 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 ARL.

Accomplishments/Planned Program:	FY 2006	FY 2007	FY 2008	FY 2009
Pulsed Power: In FY06, proved advanced low-density, high-strength composites for field coil support and efficient switch packaging. In FY07, establish optimal active cooling of high speed pulsed alternator rotors and develop high conductivity materials. In FY08, will prove high-strength, low-density, high-conductivity conductor technology and investigate high current switch materials. In FY09, will show capabilities of advanced materials (bandings, conductors, and switches) to reduce pulsed alternator size and mass.	607	1079	1500	1615
Launcher: In FY06, validated robustness of composite launcher and established Cold Spray rail coating technique. In FY07, experimentally validate performance of three meter long 500 kJ composite electromagnetic launcher with long bore life and transition technology to ARDEC.	1100	1200		
Projectile: In FY06, electromagnetically launched a two MJ monolithic rod and established accuracy of prototype projectile. In FY07, launch fully-functional NKEP at two MJ. In FY08, will establish technologies to eliminate arcing at the projectile/launcher interface. In FY09, will demonstrate large-caliber (>5 MJ) kinetic energy and multipurpose projectiles launched from an EM gun.	1275	1300	1300	1300
Full-Scale Hypervelocity Lethality: In FY06, investigated reactive materials (RM) for light target defeat and matured mechanisms to deploy NKEP in flight. In FY07, compare RM and high explosive fills at hypervelocity and validate performance of deploying NKEP against realistic targets. In FY08, will experimentally validate prototype RM multipurpose round at 2 MJ muzzle energy. In FY09, will demonstrate full scale (>5MJ muzzle energy) RM warhead and transition to ARDEC.	1200	1200	800	800
Analysis: In FY06, analyzed performance of hypervelocity projectiles against aerial targets. In FY07, devise techniques to incorporate EM gun-equipped hybrid vehicles into force-on-force models. In FY08, will analyze utility of EM guns on the battlefield. In FY09, will	200	287	368	350

define the guidance and control parameters needed to increase hypervelocity hit probability.				
Small Business Innovative Research/Small Business Technology Transfer Programs		113		
Total	4382	5179	3968	4065

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

COST (In Thousands)	FY 2006 Actual	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate
H80 BALLISTICS TECHNOLOGY	29191	30229	34869	35173	35491	35766	36402	37130

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 US 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 the Future Force and, where feasible, exploits opportunities to enhance Current Force capabilities. The challenge is to ensure combat overmatch and survivability 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; universal 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 kinetic energy (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); affordable precision munitions 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 (ARL), 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 ARL.

Accomplishments/Planned Program:	FY 2006	FY 2007	FY 2008	FY 2009
Optimize advanced lightweight structural, ceramic, and electromagnetic armor technologies for transition to Future Force (FF) vehicle designers, current, and Future Force platforms and tactical vehicles. In FY06, validated the advanced technology for shaped charge defeat and applied design tools to tactical vehicles to increase their survivability against small arms and improvised explosive devices. In FY07, experimentally validate integrated and add-on ballistic protection technologies that make tactical combat vehicles more survivable; design and validate armor configurations for Future Force Objective threats. In FY08, will mature hybrid armor designs with lower densities that defeat tactical vehicle threats; experimentally validate optimized third generation armor and structure configurations for Future Force threats; explore novel electromagnetic armor mechanisms for full spectrum defeat. In FY09, will prove hybrid armor designs that defeat future tactical vehicle threats with further density reductions; experimentally show objective threat defeat at goal vehicle weights; prove explosive threat defeat at lightest weights possible; evaluate novel electromagnetic armor mechanisms to predict performance.	4872	6286	9861	11860
Mature mine blast, ballistic shock mitigation, and crew protection technologies to enable survivability of current and Future Force platforms, ground tactical vehicles, and the individual Soldier. In FY06, advanced models and matured first-generation designs for advanced technology (AT) mine blast protection structure/crew system. In FY07, provide design guidance and proven AT mine blast protection structure/crew system to vehicle designers for ground tactical vehicles; validate technologies to improve flexibility of protection equipment (torso, extremities, neck) for individual Soldier. In FY08, will design lightweight, easily installed blast-penetrator protection (to include better seat designs) for occupants of tactical wheeled vehicles; experimentally prove response of an ammo event minimizing	2650	3364	3500	3550

lethal effects within crew compartment. In FY09, will devise models for Advanced-Electromagnetic Armor (A-EMA) mine protection and support experimental validation of A-EMA mine armor kits; prove full-scale explosive loading with test apparatus to simulate vehicle borne or roadside blast fragment loading; transition second generation flexible protection equipment for individual Soldier to development community.				
Mature advanced technologies to enable a broad spectrum of affordable precision munitions. Mature a multi-disciplinary approach to munition system design by coupling physics-based models of interior ballistics, launch dynamics, flight mechanics, and high-G guidance, navigation, and control (GN&C) technologies to enable smaller, cheaper, and lighter low-collateral-damage precision munitions for future asymmetric operations in Military Operations on Urban Terrain (MOUT). In FY06, addressed the developing technologies that enable guided medium-caliber munitions for the Extended Area Protection System (EAPS) as well as for infantry operations in MOUT. In FY07, model and validate EAPS subcomponent technologies by performing integrated critical flight demonstrations of candidate subsystems; mature subcomponent technologies to enable smaller, lighter, cheaper munitions components. In FY08, will perform an integrated flight demonstration of a supersonic medium-caliber interceptor; experimentally validate smaller, lighter, cheaper munitions components and transition to development community. In FY09, will address technology that enables precision fires for small unit MOUT operations.	4075	4100	4350	4400
Mature propulsion and energetics technologies. Evaluate, select, and validate novel/nanostructural insensitive energetic materials concepts that exploit managed energy release and are required for improving the effectiveness and reducing the vulnerability of Future Force gun/missile systems and warheads. In FY06, down-selected a weapons system application for validation of novel insensitive energetic material (gun/rocket/propellant/multi-purpose warhead) and matured numerical tools for insensitive munitions design. In FY07, validate selected system using advanced energetic material with tuned energy release (gun/rocket propulsion/multi-purpose warhead) with increased performance while meeting insensitive munition requirements and apply emerging numerical tools to novel insensitive munitions. In FY08, will utilize reactive materials, novel energetics, and nano-structured materials to enhance propellant, igniter, explosive performance, reduce sensitivity, and provide increased multipurpose applications; formulate, evaluate, and characterize propulsion and detonation performance of common low-cost novel insensitive formulations; employ experiments, modeling, and simulation to reduce munition vulnerability and enhance performance and effectiveness. In FY09, will apply ballistic modeling and simulation to evaluate low-vulnerability propulsion charge configurations at reduced caliber for MOUT and gun launched rockets; apply reactive materials and nano-structured materials to enhance energy output with less propellant and explosive material; derive and apply chemical and physical mechanisms to reduced erosion via dynamic nitriding; determine the effects of physical modification and compartment packing design of munitions on the vulnerability of propellants and explosives to fast and slow cook-off, bullet and fragment impact, shaped charge jet impact; evaluate performance of advanced enhanced blast explosive formulations and munitions.	5250	5106	4650	4650
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 survivability of Future Force platforms. In FY06, optimized universal counter-munition performance through improved modeling, materials, and experimentation. In FY07, transition optimized universal counter-munition to TARDEC, ARDEC and AMRDEC; provide database of blast warhead technology versus shaped charge threats. In FY08, will mature enhanced explosive warhead technology and experimentally validate versus KE and shaped charge threats.	2300	1100	1600	
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 addition, investigate technology options for scaling warhead lethality to enhance MOUT war fighting including control of collateral damage. In FY06, conducted terminal ballistic assessment of Multi-Threat Objective Projectile (M-TOP) technology vs. targets of interest; integrated lethal mechanisms and proved broad, multi-functional target defeat capabilities; modeled terminal effects of counter-rockets, artillery and mortar (RAM) engagements. In FY07, conduct full-scale experimental validation of terminal ballistic performance; investigate weapons effects	4410	4450	4175	3775

in MOUT environment; experimentally evaluate scalable warhead component technologies and down select best technology candidates. In FY08, will perform end-to-end validation of M-TOP warhead; transition M-TOP technologies (including analytic and numerical models for weapons effects) to ARDEC and AMRDEC; mature scalable warhead component technologies and prepare for possible technology transitions. In FY09, will prove integrated scalable warhead technology for blast, fragmentation and penetration effects in urban environments.				
Devise state-of-the-art survivability/lethality/vulnerability (SLV) methodologies to dynamically model the interaction of conventional ballistic threats versus Future Force systems. In FY06, validated capability to analyze shock effects using production SLV code Modular Unix-based Vulnerability Estimation Suite (MUVES); incorporated high fidelity personnel modeling capability, Operational Requirement-based Casualty Assessment (ORCA) into MUVES; improved modeling of Active Protection System (APS) interactions; improved damaged helicopter effects models; transitioned geometry engine Ballistic research Laboratory - Computer Aided Design (BRL-CAD) to open source; and devised initial penetration algorithms for MOUT debris fragments against personnel. In FY07, complete validation of ORCA for blast and bullets; incorporate improved modeling of bullets, structure debris, and personnel injury metrics into ORCA; prove capability to assess blast loading and target effects using MUVES; devise methods to asses multi-hit effects on ceramic armor performance; prove automated analysis capability of APS engagement and residual effects on target; enhance SLV analysis visualization capability. In FY08, will mature methodologies to analyze emerging technologies and survivability in a networked, system of systems context and will validate for production use. In FY09 will deliver production version of new SLV modeling framework; will devise modeling capability to analyze newly emerging threats and systems.	5634	5680	6733	6938
Small Business Innovative Research/Small Business Technology Transfer Programs		143		
Total	29191	30229	34869	35173