

ARMY RDT&E BUDGET ITEM JUSTIFICATION (R2 Exhibit)

February 2008

BUDGET ACTIVITY		PE NUMBER AND TITLE					
2 - Applied Research		0602618A - BALLISTICS TECHNOLOGY					
COST (In Thousands)	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	62516	68899	71550	75526	78694	75831	68118
H03 ROBOTICS TECHNOLOGY	15767	15078	16403	15985	15867	16221	16586
H75 ELECTRIC GUN TECHNOLOGY	4098	3942	4050	4085	4107	4209	4316
H80 BALLISTICS TECHNOLOGY	35872	34640	51097	55456	58720	55401	47216
HB1 SURVIVABILITY AND LETHALITY TECHNOLOGIES (CA)	6779	15239					

A. Mission Description and Budget Item Justification: This program element (PE) provides funding for ballistic technologies required for armaments and armor to support the Future Force and, where feasible, exploits opportunities to enhance Current Force capabilities. Projects within this PE will enable lethality and survivability technologies for the Future Force. These technologies 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 that 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 for the Soldier and vehicles; kinetic energy active protection; crew and component protection from ballistic shock and mine-blast; insensitive propellants/munitions; novel multi-function warhead concepts; affordable precision munitions technologies; and physics-based techniques, methodologies, and models to analyze combat effectiveness of future technologies. Project HB1 funds congressional special interest items. 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).

Work in this project is performed by the Army Research Laboratory (ARL).

The cited work is consistent with the Director, Defense Research and Engineering Strategic Plan, the Army Modernization Strategy, and the Army Science and Technology Master Plan.

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<u>B. Program Change Summary</u>	FY 2007	FY 2008	FY 2009
Previous President's Budget (FY 2008/2009)	58568	55014	55736
Current BES/President's Budget (FY 2009)	62516	68899	71550
Total Adjustments	3948	13885	15814
Congressional Program Reductions		-1455	
Congressional Rescissions			
Congressional Increases		15340	
Reprogrammings	4825		
SBIR/STTR Transfer	-877		
Adjustments to Budget Years			15814

FY09 increased to research and investigate armor solutions for Soldier and ground combat and tactical vehicle against advanced emerging threats.

Eight FY08 congressional adds totaling \$15340 were added to this PE.

- (\$500) Small Unmanned Aerial Vehicles (UAVs) and Sensors
- (\$800) Beneficial Infrastructure for Rotorcraft Risk Reduction Demonstrations (BIRRRD)
- (\$1200) Multi Mission Armored Watercraft (MMAW) Project
- (\$1600) Advanced Composite Materials Research for Air and Ground Vehicles
- (\$1840) Flexible Solar Cell for Man-Portable Power Generator
- (\$3000) Advanced Composite Armor for Force Protection
- (\$3200) Laser Based Explosives and Chem/Bio Standoff and Point Detector
- (\$3200) Super High Accuracy Range Kit - 105mm Artillery Technology

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BUDGET ACTIVITY 2 - Applied Research		PE NUMBER AND TITLE 0602618A - BALLISTICS TECHNOLOGY					PROJECT H03	
COST (In Thousands)	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	
H03 ROBOTICS TECHNOLOGY	15767	15078	16403	15985	15867	16221	16586	

A. Mission Description and Budget Item Justification: Research in this project advances autonomous mobility technology for the Future Force. The research focuses on investigation of robotics technology critical to the maturation of future Army systems, including unmanned elements of the Future Force 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 thereby 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).

Work in this project is performed by the Army Research Laboratory (ARL).

The cited work is consistent with the Department of Defense Research and Engineering Strategic Plan, the Army Science and Technology Master Plan, the Army Modernization Strategy, and the Army Posture Statement.

<u>Accomplishments/Planned Program:</u>	<u>FY 2007</u>	<u>FY 2008</u>	<u>FY 2009</u>
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 FY07, developed multi-sensor fusion approaches towards improved perception in dynamic and urban environments and permitted meaningful collaboration by autonomous vehicles (including mixed air and ground assets) utilizing the scout reconnaissance mission as the focus for technology development. In FY08, research 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 develop technology for scene understanding and autonomous tactical behavior in the context of reconnaissance mission scenarios.	7310	7000	7495
Develop 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	4460	3939	4921

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BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT		
2 - Applied Research	0602618A - BALLISTICS TECHNOLOGY	H03		
Technology) project 515 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 FY07, conducted research on perception and control technologies that permitted unmanned ground vehicles to safely maneuver in dynamic environments at increasing speeds. In FY08, develop perception and control technology to permit initial implementation of behaviors to enhance the operational effectiveness of robotic vehicles, including safe operations in populated environments. In FY09, will develop 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 show improved capability 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 FY07, evaluated technologies for safe operation of unmanned vehicles in dynamic on- and off-road environments. In FY08, 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.	3997	3750	3987	
Small Business Innovative Research/Small Business Technology Transfer Programs			389	
Total	15767	15078	16403	

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BUDGET ACTIVITY 2 - Applied Research	PE NUMBER AND TITLE 0602618A - BALLISTICS TECHNOLOGY					PROJECT H75	
COST (In Thousands)	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	4098	3942	4050	4085	4107	4209	4316

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 necessary for a long life, field-worthy 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. 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 demonstration system.

Work in this project is performed by ARL.

The cited work is consistent with the Department of Defense Research and Engineering Strategic Plan, the Army Science and Technology Master Plan, the Army Modernization Strategy, and the Army Posture Statement.

<u>Accomplishments/Planned Program:</u>	<u>FY 2007</u>	<u>FY 2008</u>	<u>FY 2009</u>
Pulsed Power: In FY07, established optimal active cooling of high speed pulsed alternator rotors and developed high conductivity materials. In FY08, 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.	1179	1397	1600
Launcher: In FY07, experimentally validated performance of three meter long 500 kilojoule (kJ) composite electromagnetic launcher with long bore life and transitioned technology to ARDEC.	800		
Projectile: In FY07, launched fully-functional NKEP at 2 megajoules (MJ). In FY08, 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.	1032	1300	1300
Full-Scale Hypervelocity Lethality: In FY07, compared reactive material (RM) and high explosive fills at hypervelocity and validated performance of deploying NKEP against realistic targets. In FY08, 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.	800	800	800
Analysis: In FY07, devised techniques to incorporate EM gun-equipped hybrid vehicles into force-on-force models. In FY08, analyze	287	368	350

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BUDGET ACTIVITY 2 - Applied Research	PE NUMBER AND TITLE 0602618A - BALLISTICS TECHNOLOGY	PROJECT H75	
utility of EM guns on the battlefield. In FY09, will define the guidance and control parameters needed to increase hypervelocity hit probability.			
Small Business Innovative Research/Small Business Technology Transfer Programs		77	
Total	4098	3942	4050

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BUDGET ACTIVITY 2 - Applied Research		PE NUMBER AND TITLE 0602618A - BALLISTICS TECHNOLOGY					PROJECT H80	
COST (In Thousands)	FY 2007 Estimate	FY 2008 Estimate	FY 2009 Estimate	FY 2010 Estimate	FY 2011 Estimate	FY 2012 Estimate	FY 2013 Estimate	
H80 BALLISTICS TECHNOLOGY	35872	34640	51097	55456	58720	55401	47216	

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 for 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. Specific technology thrusts include: lightweight armors (Soldier/vehicle) 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/munitions 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; and 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.

Work in this project is performed by ARL.

The cited work is consistent with the Department of Defense Research and Engineering Strategic Plan, the Army Science and Technology Master Plan, the Army Modernization Strategy, and the Army Posture Statement.

<u>Accomplishments/Planned Program:</u>	<u>FY 2007</u>	<u>FY 2008</u>	<u>FY 2009</u>
Optimize advanced lightweight structural, ceramic, and electromagnetic armor technologies for transition to current and Future Force (FF) vehicle designers (e.g. Joint Light Tactical Vehicle (JLTV) and Future Combat Systems (FCS)). In FY07, experimentally validated integrated add-on ballistic protection technologies that made tactical combat vehicles more survivable; designed and validated armor configurations for Future Force Objective threats. In FY08, develop passive armor designs with lower densities that defeat tactical vehicle threats; experimentally validate optimized second generation armor and structure configurations for Future Force threats; explore novel electrical protection system (EPS) mechanisms for full spectrum defeat. In FY09, will prove passive armor designs that defeat future tactical vehicle threats with further density reductions; experimentally show objective threat defeat at goal vehicle weights; couple modeling and simulation with ballistic characterization to validate third generation armor concepts for Future Force threats.	6300	9408	11808
Develop 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 FY07, provided design guidance and proven anti-tank (AT) mine blast protection structure/crew system to vehicle designers for ground tactical vehicles; validated technologies to improve flexibility of protection equipment (torso, extremities, neck) for individual Soldier. Accelerated underbody protection to meet objective threat	8607	3500	3550

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BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT		
2 - Applied Research	0602618A - BALLISTICS TECHNOLOGY	H80		
requirements for future force combat and tactical wheeled vehicles. In FY08, design lightweight, easily installed blast-penetrator protection (to include better seat designs) for occupants of current and Future Force vehicles. In FY09, will devise models for mine protection using Advanced-Electromagnetic Armor (A-EMA) and support experimental validation of A-EMA mine 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 development community.				
Develop advanced technologies to enable a broad spectrum of affordable precision munitions. Develop a multi-disciplinary approach to munitions 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 FY07, modeled and validated extended area active protection system (EAPS) subcomponent technologies by performing integrated critical flight demonstrations of candidate subsystems; developed subcomponent technologies to enable smaller, lighter, cheaper munitions components. In FY08, 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.	4100	4350	4400	
Develop 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 FY07, validated selected system using advanced energetic material with tuned energy release (gun/rocket propulsion/multi-purpose warhead) with increased performance while meeting insensitive munitions requirements and applied emerging numerical tools to novel insensitive munitions. In FY08, 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 munitions 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.	5106	4650	4650	
Develop active protection counter-munitions 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 FY07, transitioned optimized universal counter-munitions to TARDEC, ARDEC, and AMRDEC; provided database of blast warhead technology versus shaped charge threats. In FY08, develop enhanced explosive warhead technology and experimentally validate the warhead technology versus KE and shaped charge threats.	1529	1600		
Develop 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 FY07, conducted full-scale experimental validation of terminal ballistic performance; investigated weapons effects in MOUT environment; experimentally evaluated scalable warhead component technologies and down-selected best technology candidates. In FY08, perform end-to-end validation of Multi-Threat Objective Projectile (M-TOP) warhead; transition M-TOP technologies (including analytic and numerical models for weapons effects) to ARDEC and AMRDEC; develop scalable warhead component technologies and prepare for	4450	4175	3775	

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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 FY07, completed validation of Operational Requirements-Based Casualty Assessment System (ORCA) for blast and bullets; incorporated improved modeling of bullets, structure debris, and personnel injury metrics into ORCA; proved capability to assess blast loading and target effects using Modular UNIX-based Vulnerability Estimation Suite (MUVES); devised methods to assess multi-hit effects on ceramic armor performance; proved automated analysis capability of APS engagement and residual effects on target; enhanced SLV analysis visualization capability. In FY08, develop methodologies to analyze emerging technologies and survivability in a networked, system of systems context and validate for production use. In FY09, will develop novel blast and combined-effects methodologies for non-traditional, emerging synergistic threats; demonstrate an early MUVES 3 analysis capability, and deliver advanced crew-casualty metrics for assessing body armor.	5780	6733	6938	
Armor Materials: In FY09, research and investigate composite ceramic materials to increase body armor performance while reducing weight. For ground combat vehicles, will design and develop reactive armor and electromagnetic armor solutions for defeat of emerging KE and chemical energy threats. Will assess new explosive materials for reactive armors with modeling, simulation, and experiments to characterize performance as well as sensitivity. Will conduct modeling and simulation and experiments of lightweight brass board electromagnetic armor solutions using advanced materials developing in program element (PE) 0602105A to include hybrid armor designs that provide dual threat protection capability. Body armor solutions will utilize material technologies from PE 0602105A, Project H84 and will be assessed and refined in PE 0602786A, Project H98. Reactive armor and electromagnetic armor design solutions will utilize material technologies from PE 0602105A, Project H84 and be assessed and refined in PE 0602601A, Project C05.			15976	
Small Business Innovative Research/Small Business Technology Transfer Programs		224		
Total	35872	34640	51097	