

UNCLASSIFIED

ARMY RDT&E BUDGET ITEM JUSTIFICATION (R-2 Exhibit)								DATE February 2000	
BUDGET ACTIVITY 2 - Applied Research				PE NUMBER AND TITLE 0602618A Ballistics Technology					
COST (In Thousands)	FY1999 Actual	FY 2000 Estimate	FY 2001 Estimate	FY 2002 Estimate	FY 2003 Estimate	FY2004 Estimate	FY2005 Estimate	Cost to Complete	Total Cost
Total Program Element (PE) Cost	26839	42017	49750	52675	57407	56487	62304	Continuing	Continuing
AH03 Robotics Technology	0	0	14476	16164	18859	18863	18856	Continuing	Continuing
AH75 Electric Gun Technology	3736	11305	8952	9335	9922	9915	14753	Continuing	Continuing
AH80 Ballistics Technology	21844	30712	26322	27176	28626	27709	28695	Continuing	Continuing
AH81 Armor/Anti-Armor Technology	1259	0	0	0	0	0	0	0	1259

**A. Mission Description and Justification:** This program element (PE) provides ballistic technologies required for armaments and armor to support the Army Objective Force and to allow US dominance in future conflicts across a full spectrum of threats in a global context. Project AH75 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 AH80 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 AH03 is a restructure from Project AH80 to conduct applied research for advanced autonomous mobility technology for future land combat systems of the Objective Force. There is a total \$43.4 M funding from OSD to the Army's Robotics Program from FY01 to FY05. Project Projects AH03, AH75, and AH80 will enable lethality and survivability technologies for the Future Combat Systems (FCS). Project AH81 ends in FY 1999 because armor technology development has been consolidated in PE 0602601A, Project DC05. Work in this program element has been coordinated with the other military services through the Weapons Technology Area Plan to prevent duplication of effort and to maximize the return on investment. One result of this process is the Army's leveraging of Navy and Defense Threat Reduction Agency investments for ETC technology demonstrations. Work in this program element is consistent with the Army Science and Technology Master Plan (ASTMP), the Army Modernization Plan, and Force XXI.

**UNCLASSIFIED**

<b>ARMY RDT&amp;E BUDGET ITEM JUSTIFICATION (R-2 Exhibit)</b>	DATE <b>February 2000</b>
---	------------------------------

BUDGET ACTIVITY <b>2 - Applied Research</b>	PE NUMBER AND TITLE <b>0602618A Ballistics Technology</b>
--	--

<b>B. Program Change Summary</b>	<u>FY 1999</u>	<u>FY 2000</u>	<u>FY 2001</u>
Previous President's Budget ( <u>FY 2000/2001</u> PB)	27229	36287	37687
Appropriated Value	27475	42287	
Adjustments to Appropriated Value			
a. Congressional General Reductions	-246		
b. SBIR / STTR	-242		
c. Omnibus or Other Above Threshold Reductions		-109	
d. Below Threshold Reprogramming	-40		
e. Rescissions	-108	-161	
Adjustments to Budget Years Since ( <u>FY 2000/2001</u> PB)			+498
New Army Vision/Transformation Adjustment		TBD	+11565
Current Budget Submit ( <u>FY 2001</u> PB)	26839	42017	49750

Change Summary Explanation: Funding – FY 01: Project H03 is a restructuring of efforts previously supported under Project AH80. It was adjusted to increase funding for ground robotics to reflect the new Army Vision/Transformation.

UNCLASSIFIED

ARMY RDT&E BUDGET ITEM JUSTIFICATION (R-2A Exhibit)							DATE February 2000			
BUDGET ACTIVITY 2 - Applied Research				PE NUMBER AND TITLE 0602618A Ballistics Technology				PROJECT AH03		
COST (In Thousands)		FY1999 Actual	FY 2000 Estimate	FY 2001 Estimate	FY 2002 Estimate	FY 2003 Estimate	FY2004 Estimate	FY2005 Estimate	Cost to Complete	Total Cost
AH03	Robotics Technology	0	0	14476	16164	18859	18863	18856	Continuing	Continuing
<p><b>Mission Description and Justification:</b> This project supports the Army Vision by conducting applied research to advance autonomous mobility technology for future land combat systems of the Army Objective Force. It will develop and demonstrate robotics technology critical to the development of future tactical systems for ground combat, including unmanned elements of the Future Combat System (FCS) and crew aids for future manned systems. It will provide the basis for initiating 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 that will permit paradigm shifts in the conduct of ground warfare, including significantly enhanced survivability and deployability. Technical efforts will be focused towards advancing perception for autonomous ground mobility, intelligent vehicle behavior and control, and human supervision of unmanned ground systems. Research will be conducted at the Army Research laboratory, other DOD laboratories and research centers, NIST, NASA and DOE research laboratories, as well as Industry and academic Institutions. The applied research conducted in this program will be transitioned to technology development, demonstration and materiel acquisition programs being conducted by the OSD Joint Robotics Program and each of the Services. Robotics Technology (Project AH03) previously funded in Project AH80 prior to FY2001.</p> <p><b>FY 1999 Accomplishments:</b> Project not funded in FY 1999.</p> <p><b>FY 2000 Planned Program:</b> Project not funded in FY 2000.</p> <p><b>FY 2001 Planned Program:</b></p> <ul style="list-style-type: none"> <li>• 2000 - Establish external research consortium involving Industry, Academia and HBCU/MI's conduct applied research on the topics of perception, intelligent control and man/machine interfaces supporting development of the Future Combat Systems.</li> <li>• 12476 - Develop machine perception technologies to enable rapid classification of a baseline set of terrain types required for high-speed autonomous mobility.             <ul style="list-style-type: none"> <li>- Develop intelligent control strategies to enable Unmanned Ground Vehicles (UGVs) to execute a basic set of tactical behaviors.</li> <li>- Integrate perception and control technologies into a group of UGV testbed platforms.</li> <li>- Conduct Battle Lab Warfighting Experiment employing multiple UGVs to examine the maturity of autonomous mobility technologies.</li> </ul> </li> </ul> <p>Total 14476</p>										
Project AH03		Page 3 of 9 Pages				Exhibit R-2A (PE 0602618A)				

**UNCLASSIFIED**

ARMY RDT&E BUDGET ITEM JUSTIFICATION (R-2A Exhibit)							DATE February 2000			
BUDGET ACTIVITY 2 - Applied Research				PE NUMBER AND TITLE 0602618A Ballistics Technology				PROJECT AH75		
COST (In Thousands)	FY1999 Actual	FY 2000 Estimate	FY 2001 Estimate	FY 2002 Estimate	FY 2003 Estimate	FY2004 Estimate	FY2005 Estimate	Cost to Complete	Total Cost	
AH75 Electric Gun Technology	3736	11305	8952	9335	9922	9915	14753	Continuing	Continuing	
<p><b>Mission Description and Justification:</b> This project funds applied research for the Army Electromagnetic (EM) armaments technology program. To achieve the objectives of the Army Vision, future armored combat vehicles, including the Future Combat Systems (FCS), will require more lethal, yet compact main armament systems capable of defeating protection levels greatly in excess of currently experienced values. EM armaments offer the potential 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 challenges associated with an EM armament, in particular with pulsed power for electromagnetic (EM) launches. This project funds a contractual effort to provide an efficient pulsed power technology for electromagnetic (EM) launch. The goal is to provide pulsed power technology (rotating machines) with energy density of ten Joules per gram (J/g) and to identify a clear potential for growth required for future combat systems, expected to be greater than fifteen J/g. Efforts in EM pulsed power systems are conducted by SAIC - Minneapolis, MN; CEM - Austin, TX; CAES - Cumberland, MD; and R-Cubed - Salt Lake City, UT. In the future, a new contractual effort will be started which develops one of the two alternative techniques for pulsed power technology; either a drum topology or a disk topology. This project funds applied research for the Army Electrothermal Chemical (ETC) gun technology program which is a joint effort with the Defense Threat Reduction Agency (DTRA) with contractual efforts by SAIC - San Diego, CA; UDLP - Minneapolis, MN; and Thiokol - Ogden, UT. The goal of the ETC effort is to demonstrate 14MJ from the 120mm, M256 Cannon. ARL, in close collaboration with the Armaments Research, Development, and Engineering Center, Picatinny NJ, will apply ETC technology to medium caliber cannon applications by FY02 with a goal of increasing muzzle energy by 25%</p> <p><b>FY 1999 Accomplishments:</b></p> <ul style="list-style-type: none"> <li>• 1352 - Measured electromagnetic signature of subscale compulsator for application to design of crew and system protection.</li> <li>• 2384 - Achieved the goal of proving 14 MJ muzzle energy from a 120-mm, M256 ETC cannon. This is a significant lethality improvement over conventional gun performance.</li> </ul> <p>Total 3736</p> <p><b>FY 2000 Planned Program:</b></p> <ul style="list-style-type: none"> <li>• 8512 - Design pulsed power machine for FY 2003 demonstration of 5 J/g.</li> <li>• 2500 - In close coordination with ARDEC, design ETC ignition and propelling charge for medium caliber cannon.</li> </ul>										
Project AH75	Page 4 of 9 Pages					Exhibit R-2A (PE 0602618A)				

**UNCLASSIFIED**

<b>ARMY RDT&amp;E BUDGET ITEM JUSTIFICATION (R-2A Exhibit)</b>		DATE <b>February 2000</b>
<b>BUDGET ACTIVITY</b> <b>2 - Applied Research</b>	<b>PE NUMBER AND TITLE</b> <b>0602618A Ballistics Technology</b>	<b>PROJECT</b> <b>AH75</b>
<p><b>FY 2000 Planned Program: (continued)</b></p> <ul style="list-style-type: none"> <li>- Show scalability, ballistic tailorability, and temperature compensation of ETC technology in medium caliber cannon.</li> <li>- Identify ETC tailored propellants with reduced vulnerability.</li> </ul> <ul style="list-style-type: none"> <li>• 293 - Small Business Innovative Research/Small Business Technology Transfer Programs (SBIR/STTR)</li> </ul> <p>Total 11305</p> <p><b>FY 2001 Planned Program:</b></p> <ul style="list-style-type: none"> <li>• 6952 - Conduct pulsed power component tests demonstrating material strength and machine preliminary design.</li> <li>- Devise initial switch array for multi-phase, multi-pole control of pulsed power machine.</li> <li>- Conduct experiments on sub-scale launcher designs demonstrating robust, fieldworthy attributes.</li> <li>- Devise EM Gun technology component models for conducting system level simulations</li> <li>• 2000 - Show controlled step-up toward increased muzzle energy goal in medium caliber ETC cannon using tailored solid propellants.</li> <li>- Prove ETC compatibility with medium caliber conventional and cased telescope cartridges.</li> </ul> <p>Total 8952</p>		
Project AH75	Page 5 of 9 Pages	Exhibit R-2A (PE 0602618A)

**UNCLASSIFIED**

ARMY RDT&E BUDGET ITEM JUSTIFICATION (R-2A Exhibit)							DATE February 2000					
BUDGET ACTIVITY <b>2 - Applied Research</b>				PE NUMBER AND TITLE <b>0602618A Ballistics Technology</b>				PROJECT <b>AH80</b>				
COST (In Thousands)				FY1999 Actual	FY 2000 Estimate	FY 2001 Estimate	FY 2002 Estimate	FY 2003 Estimate	FY2004 Estimate	FY2005 Estimate	Cost to Complete	Total Cost
AH80 Ballistics Technology				21844	30712	26322	27176	28626	27709	28695	Continuing	Continuing
<p><b>Mission Description and Justification:</b> This project provides 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 focussing on more lethal and more deployable weapons and on survivability technologies to lighten and protect the force. These ballistic technologies will support advances in vehicle survivability, direct fire armament capabilities, indirect fire support and weapons effectiveness to enable the Future Combat Systems' (FCS) lethality and survivability. This project continues to support extensive experimental programs to advance the state-of-the-art in ballistics technologies. This project also provides key technologies for a new class of vehicle control that will enable an unmanned land combat vehicle to intelligently follow a manned combat vehicle (technology will be funded and executed in Project AH03 beginning in FY01). This new capability will enable a manned crew in a lightly armored vehicle to simultaneously expand its survivability and area of influence, maneuvering and engaging enemy forces without disclosing its own location. The work is conducted at the Army Research Laboratory, Aberdeen Proving Ground, MD and provides required technologies for advanced development programs at the Armaments Research, Development and Engineering Center, Picatinny Arsenal, NJ; the Tank and Automotive Research, Development and Engineering Center, Warren, MI; and the Missile Research, Development and Engineering Center, Huntsville, AL.</p> <p><b>FY 1999 Accomplishments:</b></p> <ul style="list-style-type: none"> <li>• 15682 - Proved out advanced armor capable of defeating all tank gun launched threats at 65% of the weight of current Abrams armor. <ul style="list-style-type: none"> <li>- Elucidated canard and fin flow field and developed CFD characterization for Guided Multiple Launch Rocket System (MLRS) – transitioned technology to MRDEC; Devised structural modeling capability to predict performance of onboard GN&amp;C components-implemented on SADARM</li> <li>- Advanced technologies to provide new operational capabilities to soldiers in low intensity conflicts and operations across the threat spectrum.</li> <li>- Devised burning rate screening criteria and scaled ballistic performance/vulnerability characterization tools to be employed in optimizing future propellants with maximum energy and minimum vulnerability at affordable cost while balancing human factors, life cycle costs, erosivity and propellant performance in gun systems; Implemented Army Solid Propellant Master Plan for energetic materials (ARO, ARL and ARDEC).</li> <li>- Proved ability to track and predict hit-location of KE rod with Passive IR Tracker (PIRT); showed launcher technologies capable of successfully intercepting KE rod; evaluated advanced integrated armor technologies for effectiveness against short l/d fragments like those from a KE rod intercepted by a High Explosive/Electromagnetically-launched intercept device and downselected residual armor technology.</li> <li>- Proved out advanced lethality concepts including the use of novel missile nose cone configurations to initiate reactive armor; devised sheathed penetrator model and determined novel processing techniques; evaluated shaped charge warhead concepts and new tungsten composites for penetrators.</li> </ul> </li> <li>• 6162 - Optimized ammunition response algorithms for rocket motor ignition and explosion to more accurately predict the survivability and lethality of U.S. Army weapon systems such as Crusader, FSCS, MLRS, HIMARS, M74 &amp; M85 bomblets, and BAT P3I. <ul style="list-style-type: none"> <li>- Provided engineering-based predictions of the subsystem capabilities after multiple impact combinations of direct and/or indirect-fire threats.</li> </ul> </li> </ul> <p>Total 21844</p>												
Project AH80				Page 6 of 9 Pages				Exhibit R-2A (PE 0602618A)				

**UNCLASSIFIED**

<b>ARMY RDT&amp;E BUDGET ITEM JUSTIFICATION (R-2A Exhibit)</b>		DATE <b>February 2000</b>
<b>BUDGET ACTIVITY</b> <b>2 - Applied Research</b>	<b>PE NUMBER AND TITLE</b> <b>0602618A Ballistics Technology</b>	<b>PROJECT</b> <b>AH80</b>
<p><b>FY 2000 Planned Program:</b></p> <ul style="list-style-type: none"> <li>• 18158 - Investigate an advanced armor system capable of defeating future medium caliber KE and shaped charge threats that is compatible with the goals of Army After 2010. <ul style="list-style-type: none"> <li>- Perform complex numerical simulations of launch disturbances and critical damping of initial free flight motions for future smart munitions to extend range and improve accuracy for both direct and indirect fire weaponry.</li> <li>- Evaluate, in conjunction with Army users, operational concepts employing technologies such as advanced lightweight artillery weapons and systems to enhance positional awareness; employ distributed interactive simulations incorporating these systems to improve training.</li> <li>- Evaluate candidate propellants produced by ARDEC and industry partners; establish comprehensive database for use by ammunition designers to enhance gun lethality at reduced vulnerability.</li> <li>- Evaluate performance of candidate sensor suite and kill mechanism technologies that will enable the development of CKE AP and begin the down-select to those with the best growth potential toward the Full Spectrum Active Protection (FSAP) STO goals. Begin integration of tracker, kill mechanism and residual armor components into a CKE brassboard demonstration. Identify, test and evaluate vehicle integratable sensor technologies and compact, command-fused Kinetic Energy penetrator counter-munition concepts</li> <li>- Exploit emerging technologies in the area of lethal mechanisms for direct fire applications, especially sheathed penetrators, amorphous metals, fragmenting warhead designs for medium caliber ammunition, and extending rods.</li> </ul> </li> <li>• 6737 - Verify and validate select component-level ballistic algorithms to support development and Live Fire Test &amp; Evaluation of over ten U.S. Army weapon systems, including ground, munition, aviation, and lightly armored systems. <ul style="list-style-type: none"> <li>- Optimize physically based models to predict the probability of ignition of sustained diesel and JP-8 fuel fires in U.S. group combat systems with and without fire suppression systems.</li> </ul> </li> <li>• 400 - Prove out the feasibility of future large caliber ETC guns. Evaluate and select ETC technologies, design and fabrication two ETC-gun modules, test, and evaluate modules for feasibility of an ETC-gun weapon system integration info FMVS. (NATO funds: Partner Germany) (Under Project Arrangement A-98-GE-0016)</li> <li>• 5000 - Devise and prove out critical machine perception and intelligent control technologies for an unmanned ground vehicle to autonomously maneuver cross country over vegetated terrain at speeds of up to 20MPH during hours of daylight and 10 MPH during hours of darkness</li> <li>• 417 Small Business Innovative Research/Small Business Technology Transfer Programs (SBIR/STTR)</li> </ul> <p>Total 30712</p> <p><b>FY 2001 Planned Program:</b></p> <ul style="list-style-type: none"> <li>• 19347 - Design and characterize innovative armors, structures, protection mechanisms, and survivability concepts for future lightweight combat vehicle protection. <ul style="list-style-type: none"> <li>- Conduct experimental demonstrations of multi-disciplinary designs for guidance, navigation, and control technologies applied to smart munitions.</li> </ul> </li> </ul>		
Project AH80	Page 7 of 9 Pages	Exhibit R-2A (PE 0602618A)

**UNCLASSIFIED**

<b>ARMY RDT&amp;E BUDGET ITEM JUSTIFICATION (R-2A Exhibit)</b>		DATE <b>February 2000</b>
BUDGET ACTIVITY <b>2 - Applied Research</b>	PE NUMBER AND TITLE <b>0602618A Ballistics Technology</b> PROJECT <b>AH80</b>	
<p align="center">- Transition technologies which will provide new operational capabilities to light forces operating in low intensity conflicts and rapid deployment scenarios to Army Research, Development, Engineering Centers and the user community.</p>		
<p><b>FY 2001 Planned Program: (continued)</b></p>		
<p>- Implement selected gun propellant formulations (sample sizes) in scaled ballistic studies to demonstrate improved performance and propellant integrity with reduced vulnerability.</p>		
<p>- Down select CKE technology options, complete the integration to a brassboard KEAP system and commence testing to optimize performance of the selected system; conduct experimental tests to demonstrate improved compactness and hardening of counter KE technologies with specific focus on the sensor suite/counter-munition integration and optimization.</p>		
<p>- Explore novel lethal penetrator concepts to include explosively-assisted penetrators, hypervelocity penetrator concepts (e.g., segmented rods), and novel shaped charge liner configurations to defeat increasing levels of armor protection.</p>		
<ul style="list-style-type: none"> <li>•</li> </ul>	<p>6565</p>	<p>- Implement advanced armor penetration algorithms in survivability/lethality analysis codes for sophisticated multi-layering schemes for multi-hit protection of U.S. Army ground systems (such as Crusader, FSCS, and FCV).</p>
<ul style="list-style-type: none"> <li>•</li> </ul>	<p>410</p>	<p>- Implement empirically-based combined blast and fragment algorithms to more accurately model the effects of high explosive incendiary projectiles on the survivability of U.S. Army helicopters.</p>
<ul style="list-style-type: none"> <li>•</li> </ul>		<p>- Prove out the feasibility of future large caliber ETC guns. Evaluate selected ETC technologies based on FY00 downselect. (NATO funds: Partner Germany) (Under Project Arrangement A-98-GE-0016)</p>
<p>Total</p>	<p>26322</p>	

**UNCLASSIFIED**

<b>ARMY RDT&amp;E BUDGET ITEM JUSTIFICATION (R-2A Exhibit)</b>							DATE <b>February 2000</b>			
BUDGET ACTIVITY <b>2 - Applied Research</b>				PE NUMBER AND TITLE <b>0602618A Ballistics Technology</b>				PROJECT <b>AH81</b>		
<i>COST (In Thousands)</i>	FY1999 Actual	FY 2000 Estimate	FY 2001 Estimate	FY 2002 Estimate	FY 2003 Estimate	FY2004 Estimate	FY2005 Estimate	Cost to Complete	Total Cost	
AH81 Armor/Anti-Armor Technology	1259	0	0	0	0	0	0	0	1259	
<p><b>Mission Description and Justification:</b> The objective of this project has been to provide significantly increased levels of protection and survivability to existing and future combat systems, and to provide significantly increased lethality and effectiveness to existing and future anti-armor munitions by seeking novel and innovative solutions from industry. All of the funds in this project are used to fund contractual work to tap innovative ideas of industry. Anti-armor efforts develop technology to supports (1) a high priority Army program to enhance U.S. 120mm kinetic energy (KE) tank ammunition, especially against explosive reactive armor (ERA), which is available in the world arms market and is quite effective; (2) novel penetrators to improve munition effectiveness, and (3) an initiative to substantially extend the battlespace of the tank by developing technology needed for an extended range tank munition. Funding for these anti-armor efforts end in FY99. In FY 2000 and beyond, funds have been transferred to PE 0602601A, Project DC05, to consolidate armor technology development in a single project. Major contractors include: Dow Chemical Co., Midland, Miland Science Applications International Corp., Albuquerque, NM.</p> <p><b>FY 1999 Accomplishments:</b></p> <ul style="list-style-type: none"> <li>• 1259 - Showed multi-liner explosively formed penetrator ability to form ultra-long penetrator and provide enhanced armor penetration from a smaller warhead configuration.</li> </ul> <p>Total 1259</p> <p><b>FY 2000 Planned Program:</b> Project not funded in FY 2000</p> <p><b>FY 2001 Planned Program:</b> Project not funded in FY 2001</p>										
Project AH81			<i>Page 9 of 9 Pages</i>			Exhibit R-2A (PE 0602618A)				