

PE NUMBER: 0602618A

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PE TITLE: Ballistics Technology

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

COST (In Thousands)	FY 1997 Actual	FY 1998 Estimate	FY 1999 Estimate	FY 2000 Estimate	FY 2001 Estimate	FY 2002 Estimate	FY 2003 Estimate	Cost to Complete	Total Cost
Total Program Element (PE) Cost	39248	40042	31115	34900	38352	39263	40592	Continuing	Continuing
AH37 Liquid Propellant Technology	7149	3877	0	0	0	0	0	0	11026
AH75 Electric Gun Technology	7632	11660	7640	9000	9000	9000	7239	Continuing	Continuing
AH80 Ballistics Technology	20173	20350	22167	23067	26169	26957	29957	Continuing	Continuing
AH81 Armor/Anti-Armor Technology	4294	4155	1308	2833	3183	3306	3396	0	Continuing

Mission Description and Budget Item Justification: This program element (PE) provides ballistic technologies required for armaments and armor to allow US dominance in future conflicts across a full spectrum of threats in a global context. Project AH37 is directed toward solving remaining technology challenges identified under previous attempts to weaponize liquid propellant (LP) technology. It capitalizes on the large Army investment in LP technology. 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 AH81 taps the innovation of industry and pursues the most promising and affordable approaches to developing armor/anti-armor technologies. 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 Special Weapons Agency investments for ETC technology demonstrations. These projects include non-system specific development efforts pointed toward specific military needs and therefore are appropriate to Budget Activity 2.

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

PROJECT

AH37

COST (In Thousands)	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	Cost to	Total Cost
	Actual	Estimate	Estimate	Estimate	Estimate	Estimate	Estimate	Complete	
AH37 Liquid Propellant Technology	7149	3877	0	0	0	0	0	0	11026

A. Mission Description and Justification: This project focuses on maturation of liquid propellant (LP) technology with the intent to evaluate LP as a means of achieving increased lethality and/or survivability for future weapons systems applications. Technology challenges including pressure oscillations, material compatibility, and reliability/durability of the propellant in a battlefield environment will be addressed and advantages of an LP weapon will be explored. The LP technology program is managed by the Army Research Laboratory - Aberdeen Proving Ground, MD with contractual efforts at General Dynamics Defense Systems (GDDS) - Pittsfield, MA and Burlington, VT; Wright-Malta Corp. - Malta, NY; Princeton Combustion Research Laboratory - Monmouth Junction, NJ; Institute for Defense Analysis (IDA) - Alexandria, VA; and Penn State University - University Park, PA.

FY 1997 Accomplishments:

- 7149 - Developed techniques for pressure oscillations mitigation and verified experimentally in large caliber LP gun.
- Developed promising additive packages (chelating agents) for hydroxyl ammonium nitrate (HAN)-based LPs to improve material compatibility
- Identified higher energy HAN-based propellant with potential for increasing muzzle energy of an LP gun.
- Completed initial design and testing of a small caliber, high performance LP gun using improved ballistic models.

Total 7149

FY 1998 Planned Program:

- 3779 - Identify and test concepts for reliable ignition of liquid propellant.
- Complete material compatibility testing for specific gun hardware.
- Perform small caliber liquid propellant gun firings to establish design of a high performance, regenerative liquid propellant gun.
- Evaluate Army user needs, technology pay-off for liquid propellant guns, and identify windows of opportunity.
- 98 - Small Business Innovative Research/Small Business Technology Transfer Programs.

Total 3877

FY 1999 Planned Program: Project not funded in FY 1999

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

PROJECT
AH37

B. Project Change Summary

	<u>FY 1997</u>	<u>FY 1998</u>	<u>FY 1999</u>
FY 1998/1999 President's Budget	7343	0	0
Appropriated Value	7343	4000	
Adjustments to Appropriated Value	-194	-123	
FY 1999 President's Budget	7149	3877	0

Change Summary Explanation: Funding: 1998 funds (+4000) added by Congress to complete maturation of liquid propellant technology.

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

PROJECT

AH75

COST (In Thousands)	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	Cost to	Total Cost
	Actual	Estimate	Estimate	Estimate	Estimate	Estimate	Estimate	Complete	
AH75 Electric Gun Technology	7632	11660	7640	9000	9000	9000	7239	Continuing	Continuing

A. Mission Description and Justification: This project provides oversight and accountability for the Army electric armaments technology program, which is managed by the Army Research Laboratory at Aberdeen Proving Ground, MD. Future armored combat vehicles will require more lethal, yet compact main armament systems capable of defeating protection levels greatly in excess of currently experienced values. Electric armaments offer the potential to field a leap-ahead capability by providing hypervelocity and/or hyperenergy launch greatly above the ability of the conventional cannon. Electric 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 developing electric armaments primarily for application in direct-fire ground vehicles, in particular with developing pulse power for electromagnetic (EM) launch and advanced propellant performance for electrothermal chemical (ETC) weapon systems. Once these challenges are overcome, electric guns will be considered candidates for main armament systems on future combat vehicles. This project funds a contractual effort to develop an efficient pulsed power system for electromagnetic (EM) launch. The goal is to demonstrate pulse power technology (rotating machines) with energy density of three Joules per gram (J/g) and to identify a clear potential for growth to ten 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 addition, this project supports the development of electrothermal chemical (ETC) technology which is a joint effort with the Defense Special Weapons Agency (DSWA) with contractual efforts by SAIC - San Diego, CA; UDLP - Minneapolis, MN; Thiokol - Northeast, MD; and Olin - St. Marks, FL. The goal of the ETC effort is to demonstrate 140mm lethality from a 120mm cannon.

FY 1997 Accomplishments:

- 7632 - Completed fabrication and assembly of subscale composite rotating machine (compulsator); initiated a series of performance tests to validate fabrication technology and machine design; successfully demonstrated performance as predicted to rotational speeds of 7000 revolutions per minute (rpm) on the way to 12,000 rpm full speed goal, corresponding to an energy density of a 1 Joule/gram (J/g) class pulse power machine.
 - Initiated design concepts for a next generation machine (the Exit Criteria Machine or ECM) which will demonstrate ability to achieve 3 J/g energy density.
 - Completed subscale and full scale testing of several ETC-ignition and propulsion concepts; successfully demonstrated improvements in precision ignition control and repeatability.

Total 7632

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

PROJECT
AH75

FY 1998 Planned Program:

- 11367 - Test subscale compulsator into dynamic load representative of an EM launcher to establish exit criteria machine technology.
 - Test subscale compulsator for EM gun concept at full design limits.
 - Design Exit Criteria Compulsator Machine (ECM) EM launch pulsed power system.
 - Assess the feasibility of multiple ETC concepts and demonstrate 14 megajoule (MJ) muzzle energy from a 120mm, M256 cannon.
 - Design and build EM launcher for Exit Criteria Machine.
 - Design and validate EM launch packages for Exit Criteria Tests.
 - Test prototype advanced switches on subscale machine.
 - 293 - Small Business Innovative Research/Small Business Technology Transfer Programs
- Total 11660

FY 1999 Planned Program:

- 7640 - Begin fabrication of ECM pulsed power system for EM gun concept.
 - Test pulsed power switch system on Subscale Machine (SSM).
 - Prove ETC propelling charge design and begin controlled step-up of muzzle energy toward 16-17 MJ.
- Total 7640

B. Project Change Summary

	<u>FY 1997</u>	<u>FY 1998</u>	<u>FY 1999</u>
FY 1998/1999 President's Budget	7839	8032	10159
Appropriated Value	7839	12032	
Adjustments to Appropriated Value	-207	-372	
FY 1999 President's Budget	7632	11660	7640

Change Summary Explanation: Funding: FY 1998 funds (+4000) added by Congress for electric railgun technology.
 Funding: FY99 funds reprogrammed (-2519) for high priority requirements.

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

PROJECT

AH80

COST (In Thousands)	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	Cost to	Total Cost
	Actual	Estimate	Estimate	Estimate	Estimate	Estimate	Estimate	Complete	
AH80 Ballistics Technology	20173	20350	22167	23067	26169	26957	29957	Continuing	Continuing

A. Mission Description and Justification: This project produces key technologies required for armaments and armor to allow U.S. dominance in future conflicts across a full spectrum of threats. The program focuses on lethality technologies for 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. This project continues to support extensive experimental programs to advance the state-of-the-art in ballistics technologies. 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.

FY 1997 Accomplishments:

- 15195 - Successfully exercised Global Positioning System auto-registration fire control technique to enhance artillery projectile accuracy.
 - Designed long-standoff shaped charge concept for possible use against active protection systems
 - Evaluated advanced armor systems such as sensitized explosive reactive armor and non depleted uranium for protection capability against advanced threats.
 - Completed research module to provide lower cost azimuth determination which when coupled with Global Positioning System will improve battlefield target acquisition and situation awareness.
 - Demonstrated laser igniter for artillery munition propellant which permits high rates of fire while improving safety, reliability and durability.
 - Experimentally validated modeling capability for resin transfer molding of thick composites which reduces costs for retooling and system acquisition time.
 - 3790 - Developed engineering based methods to compute ballistic damage response and performance of combat system components, including main rotor blades, drive trains, and electro-optics to improve survivability/lethality analysis of Army aviation systems.
 - 1188 - Demonstrated integration of the multi-user prototype synthetic environment with computer generated individual combatants. Developed mission planning and rehearsal tools simulating the battlefield to quickly adjust mission plans to changing battlefield situations.
- Total 20173

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

PROJECT
AH80

FY 1998 Planned Program:

- 14182 - Advance technologies such as recoil mitigation and range correction for munitions which will provide enhanced capabilities for light forces in operations across the threat spectrum
 - Apply advanced guidance technology to artillery projectiles, missiles and fire control concepts to provide improved weapon accuracy and associated relief from logistic burden.
 - Enhance direct fire lethality by introducing novel propulsion concepts and advanced warhead designs including multi-stage shaped charge and kinetic energy precursor technology.
 - Investigate advanced basal and appliqué armor technology which will provide new approaches to armoring lighter weight vehicles.
 - 4141 - Implement blast damage algorithm for component damage from small warheads to optimize lethality/survivability of smart indirect fire munitions /ground systems.
 - 2027 - Implement physical models of vulnerability and weapons effects in real time for interactive simulations.
- Total 20350

FY 1999 Planned Program:

- 15884 - Determine the effects of advanced propulsion technology on gun range and accuracy; investigate advances in direct fire propulsion and lethal mechanisms.
 - Optimize guidance and flight technologies to extend range and improve accuracy of indirect fire weaponry.
 - Develop technology which will provide new operational capabilities to soldiers in low intensity conflicts and operations across the threat spectrum.
 - Enhance the armor technology base to address the lethality of advanced threats and increase crew protection in lightweight vehicles.
 Develop enabling technologies for Counter Kinetic Energy (KE) Active Protection System (APS) which extends the engagement envelope for the defeat of tank-fired KE rounds beyond the outer skin of the vehicle. This effort is fully integrated into the Tank-Automotive Research, Development, and Engineering Center (TARDEC) Full Spectrum Active Protection program and is cooperatively managed.
 - 6283 - Implement vulnerability/lethality ballistics methodologies in a server configuration incorporating engineering technologies into higher level models to improve survivability/lethality analysis capability.
 - Provide engineering based predictions of the subsystem capabilities of air and ground combat platforms after multiple impact combinations of direct and/or indirect fire threats.
- Total 22167

B. Project Change Summary

	<u>FY 1997</u>	<u>FY 1998</u>	<u>FY 1999</u>
FY 1998/1999 President's Budget	20328	20998	22642
Appropriated Value	20328	20998	
Adjustments to Appropriated Value	-155	-648	
FY 1999 President's Budget	20173	20350	22167

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

PROJECT

AH81

COST (In Thousands)	FY 1997	FY 1998	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	Cost to	Total Cost
	Actual	Estimate	Estimate	Estimate	Estimate	Estimate	Estimate	Complete	
AH81 Armor/Anti-Armor Technology	4294	4155	1308	2833	3183	3306	3396	0	Continuing

A. Mission Description and Justification: The objective of this project is 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. This project began as a joint program among the U.S. Army, Defense Advanced Research Projects Agency (DARPA), and the U.S. Marine Corps to enhance the national capability in armor/anti-armor (A3) technologies, and has been funded only by the Army since FY 1994. Under the general heading of armor, this project funds development of technologies needed for highly mass efficient ballistic armors and for active protection systems (APS). APS represents a revolutionary combat vehicle protection approach that uses materials projected into the path of a munition to destroy, degrade, disrupt or prematurely initiate it before it hits its intended target. Anti-armor efforts develop technology to supports several initiatives (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. Major contractors include: Dow Chemical Co., Midland, Miland Science Applications International Corp., Albuquerque, NM.

FY 1997 Accomplishments:

- 2585 - Completed KE precursor concept development for ERA defeat and selected final configuration.
 - 1709 - Supported demonstration of integrated survivability approaches to overhead threats.
 - - Completed development of warhead for APS defeat. (1Q97-4Q97)
- Total 4294

FY 1998 Planned Program:

- 2435 - Complete KE precursor final design and transition to PE 0603004A, Proj D232, for cartridge integration.
 - - Conduct exploration of novel penetrator designs to defeat advanced armor systems.
 - 825 - Demonstrate top attack armor concepts employing electromagnetic defeat mechanisms and lightweight materials.
 - 800 - Demonstrate light armor protection panels for scout-class vehicles.
 - 95 - Small Business Innovation Research/Small Business Technology Transfer Programs
- Total 4155

Project AH81

Page 8 of 9 Pages

Exhibit R-2 (PE 0602618A)

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

PROJECT
AH81

FY 1999 Planned Program:

- 1308 - Select and demonstrate novel penetrator designs for full scale testing.
- Design critical componentry for tank extended range munitions.
- Total 1308

B. Project Change Summary

	<u>FY 1997</u>	<u>FY 1998</u>	<u>FY 1999</u>
FY 1998/1999 President's Budget	4403	4287	4797
Appropriated Value	4403	4287	
Adjustments to Appropriated Value	-109	-132	
FY 1999 President's Budget	4294	4155	1308

Change Summary Explanation: Funding: FY 1999: funds reprogrammed (-3489) to other high priority requirements.

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