ARMY RDT&E BUDGET ITEM JUSTIFICATION (R2 Exhibit)

February 2007

BUDGET ACTIVITY	PE NUMBER AND TITLE
2 - Applied Research	**0602303A - MISSILE 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	75149	77276	53038	48324	48310	49211	43384	44284
214	MISSILE TECHNOLOGY	40560	47320	53038	48324	48310	49211	43384	44284
223	AERO-PROPULSION TECHNOLOGY	11022	10977						
G02	Army Hypersonics Applied Research	2000	11462						
G04	AIR DEFENSE TECHNOLOGIES (CA)	4697	1632						
G05	MISSILE TECHNOLOGY INITIATIVES (CA)	13515	4253						
G06	UNMANNED SYSTEMS TECHNOLOGIES (CA)	3355	1632						

A. Mission Description and Budget Item Justification: This applied research program element (PE) investigates, designs, and develops advanced component technologies for missiles, rockets, and launch systems for use in the Future Modular Force and, where feasible, exploits opportunities to enhance Current Force capabilities. The overall objectives of the PE are to investigate and develop technologies which increase the lethality and effectiveness of tactical missiles and guided interceptors under adverse battlefield conditions, enhance the survivability of launch systems, increase kill probabilities against diverse targets, and provide advanced simulation and virtual prototyping analysis tools. A major cross-cutting theme is developing missile technologies that are smaller, lighter weight, and more affordable. Major technology areas include missile guidance systems, multi-spectral seekers, high fidelity simulations, missile aerodynamics and structures, missile propulsion including efforts to help solve the insensitive munitions requirements for missiles, hypersonic/hypervelocity missile efforts, and the development of a common high-gravitational force (high-G), low cost, Micro Electro-Mechanical System (MEMS) Inertial Measurement Unit (IMU). The major efforts inlcude the high-G MEMS IMU program (which is designing and developing affordable, reliable precision guidance components for missiles and guns at a significantly lower unit cost and smaller size than current systems) and integrating a GPS receiver with the IMU in a deeply-integrated guidance and navigation unit (DIGNU). The performance and small packaging goals will enable the components to meet the requirements of 90 percent of Department of Defense guided munitions and missiles. The high-G MEMS IMU program is a collaborative project between the US Army Armament Research, Development, and Engineering Center (ARDEC), and US Army Aviation and Missile Research, Development, and Engineering Center (AMRDEC). The MEMS IMU effort is funded by a combination of applied research funding, in this PE, and manufacturing technology funding, in PE 0708045A (Industrial Preparedness). Another major thrust in the PE is to investigate and develop small, lightweight force protection technologies needed to cost effectively counter the rocket, artillery, and mortar (RAM) threats to the Current and Future Force. The Extended Area Protection and Survivability (EAPS) program investigates and develops the interceptor and fire control technologies necessary to provide the Future Force with an active defense against RAM. In addition, the Smaller, Lighter, Cheaper (SLC) Tactical Missiles effort explores technologies to reduce the cost and logistics burden of precision munitions. This program's goal is to reduce the cost per kill of precision guided missiles and munitions, through the innovative application of technology in concert with more efficient production and integration processes. An important thrust is developing new approaches to ensure future tactical missiles can meet insensitive munition (IM) requirements. This helps insure the safety of Soldiers from unintentional detonation of munitions and missiles. The Army Hypersonics Applied Research program explores and develops the critical technologies required for expendable hypersonic/hypervelocity missiles and hypersonic threats. This PE contains no duplication with any effort within the Military Departments. 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 is performed at the US Army Aviation and Missile Research, Development, and Engineering Center, Redstone Arsenal,

AL.

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BUDGET ACTIVITY	PE NUMBER AND TITLE
2 - Applied Research	**0602303A - MISSILE TECHNOLOGY**

B. Program Change Summary	FY 2006	FY 2007	FY 2008	FY 2009
Previous President's Budget (FY 2007)	90712	59439	54951	43410
Current BES/President's Budget (FY 2008/2009)	75149	77276	53038	48324
Total Adjustments	-15563	17837	-1913	4914
Congressional Program Reductions		-295		
Congressional Rescissions				
Congressional Increases		18700		
Reprogrammings	-15563	-568		
SBIR/STTR Transfer				
Adjustments to Budget Years			-1913	4914

FY06 funds decreased to support higher priority efforts.
FY09 funds increased to support next generation tactical missile technology.
Nine FY07 congressional adds totaling $17924 (after adjustment for Congressional Undistributed Reductions) were added to this PE.

($2875) MARIAH II Hypersonic Wind Tunnel Dev Program
($1534) LENS X Hypervelocity Ground Testing
($6230) Missile Aero-Propulsion Computer System Mod
($1582) Enhanced Area Protection & Survivability
($1247) Jam Resistent Technology for INS/GPS Precision
($958) Materials Applications Research Center (UAB)
($958) Nanotechnology Research with AMRDEC
($958) Novel Lgtwt Armor Material f/Insensitive Munitions
($1582) Unmanned Systems Initiative at AMRDEC

ARMY RDT&E BUDGET ITEM JUSTIFICATION (R2a Exhibit)

February 2007

BUDGET ACTIVITY	PE NUMBER AND TITLE	PROJECT
2 - Applied Research	**0602303A - MISSILE TECHNOLOGY**	**214**

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
214 MISSILE TECHNOLOGY	40560	47320	53038	48324	48310	49211	43384	44284

A. Mission Description and Budget Item Justification: This project focuses on missile and rocket technologies that support lightweight, highly lethal weapons concepts with greatly reduced logistics requirements for Future Modular Force and, where feasible, exploits opportunities to enhance Current Force capabilities. Major technology areas investigated are missile guidance systems; air defense target acquisition systems; multi-spectral seekers; high-fidelity simulations; missile aerodynamics and structures; and missile propulsion including research to help solve the insensitive-munitions requirements. A theme embedded throughout the efforts in this project is developing smaller, lighter, and cheaper (SLC) missile technology to reduce the cost and logistics burden of precision munitions. Program objectives are to enhance the survivability of launch systems, provide greater effectiveness under adverse battlefield conditions, increase kill probabilities against diverse targets, and provide advanced simulation and virtual prototyping analysis tools. A major effort in this project is to design and develop the high-gravitational force (high-G), low cost Micro Electro-Mechanical Systems (MEMS) Inertial Measurement Unit (IMU), and to design, develop, and integrate a GPS receiver with the IMU in a deeply-integrated guidance and navigation unit (DIGNU). The Army is the service lead in the investigation of low-cost MEMS IMUs capable of supporting precision guidance requirements of Department of Defense's missile and gun launched precision munitions programs. The MEMS IMU and DIGNU efforts are funded by a combination of applied research funding, in this PE, and manufacturing technology funding, in PE 0708045A (Industrial Preparedness.) This is a collaborative program with the US Army Armament Research, Development, and Engineering Center at Picatinny Arsenal. The DIGNU effort develops and demonstrates an Inertial Sensor Assembly (ISA) with the same 1.0 deg/hr, and greater than 20,000G survivability requirements of the initial IMU program with an additional "deeply-integrated" or "deeply-coupled" Selective Availability and Anti-Spoofing Module (SAASM)-based GPS military receiver. The DIGNU incorporates a single microprocessor architecture and integrated hardware and software anti-jam (AJ) capability. The Smaller, Lighter, Cheaper (SLC) Tactical Missile effort focuses on technology to reduce the cost and logistics burden of precision munitions. This program's goal is to reduce the cost per kill of precision guided missiles and munitions, through the innovative application of technology in concert with more efficient production and integration processes. The SLC effort includes a partnership with the Defense Advanced Research Projects Agency (DARPA) on the design and proof of principle of the Close Combat Lethal Recon (CCLR) system, a 5 lb, Soldier-launched, loitering munition (two minute duration/two km radius) for use over and around buildings and other obstructions in non-line-of-sight environments. The DARPA portion of the CCLR effort is funded under PE 0603766E. Guidance Electronics Miniaturization and Structronics (GEMS), is working to significantly reduce the size, weight, and cost of guidance electronics. GEMS incorporates commercial electronics miniaturization (die stacking, wafer thinning, etc.) and seeks to develop technologies to use the electronics substrate as the chassis, wiring harness, and printed wiring board for the electronics. Each of these elements are being incorporated into a series of Integrated Guidance Units (IGU) which consist of a guidance computer and an inertial measurement unit. An important thrust is developing new approaches to ensure future tactical missiles can meet insensitive munition (IM) requirements. This helps insure the safety of Soldiers from unintentional detonation of munitions and missiles. Solid propellant formulations along with improved, high performance rocket case materials, and rupture mechanisms are being investigated. Also included in this project is the Extended Area Protection and Survivability (EAPS) program, which develops the technology necessary to provide the Future Force with an active defense capability against rockets, artillery, and mortars (RAM). Major products of this PE generally transition to PE 0603313A (Missile and Rocket Advanced Technology). The cited work is consistent with Strategic Planning Guidance, the Army Science and Technology Master Plan (ASTMP), the Army Modernization Plan. Work is performed at the US Army Aviation and Missile Research, Development, and Engineering Center, Redstone Arsenal, AL.

Accomplishments/Planned Program:	FY 2006	FY 2007	FY 2008	FY 2009

High-G Micro Electro-Mechanical Systems (MEMS) Inertial Measurement Unit (IMU): In FY06, used advanced die packaging techniques to support miniaturization of IMUs to less than four cubic inches volume; incorporated out-of-plane gyros and in-plane accelerometers, and integrated MEMS packaging techniques to get the smallest possible IMU volume; developed die attach methods and a new design process for Application-Specific Integrated Circuits (ASICs); and developed a new internal isolator. Repackaged the gyro, accelerometer, and their respective digital electronics to improve signal isolation. Performed test and evaluation on the preliminary Phase 3 IMUs. In addition, redesigned and evaluated the vibration isolation system for the modified mass and diameter to address the 20,000G. launch environment. In FY07, continue to investigate methods to get tactical grade performance across all environments. In addition, increase built-in-test capabilities, iterate IMU design to get improved performance under vibration, iterate gyro, and accelerometer design to handle canard shock, improve processes to increase sensor yields, and increase automation of test and calibration capabilities. In FY08, perform bench testing and a missile and munition flight test of the final Phase 3 IMUs and analyze and evaluate their performance.	12290	4903	3100	
High-G Micro Electro-Mechanical Systems (MEMS) Deeply Integrated Guidance and Navigation Unit (DIGNU): The DIGNU is being developed in phases with performance being increased and size being decreased for each successive phase. In FY06, tested DIGNU Phase 2s to the following parameters: gyro bias less than 20 deg/hr, volume less than 14 cubic inches, acceleration bias less than four milli-Gs, and gun-hardened to 15,500G. Performed field tests on the DIGNU Phase 2 units to determine GPS/INS/anti-jam capability; refined and further miniaturized internal anti-jam capability; tested G-operational requirements. Evaluated and refined the deep integration algorithms and planned the redesign for DIGNU Phase 3 electronics miniaturization to improve performance and to address performance issues identified during live field tests. In FY07, design and develop a partial system-on-a-chip (SOC) to give DIGNU Phase 3 the smallest volume. Miniaturize GPS receiver and AJ hardware, add frequency excision AJ, miniaturize SAASM, and migrate to an improved microprocessor. Perform test and evaluation on the DIGNU Phase 3s. In FY08, will perform field tests and laboratory characterization on DIGNU Phase 3s including anti-jam capability; will further miniaturize the anti-jam module. The DIGNU Phase 3s will be tested against the following parameters: gyro bias less than one deg/hr, volume less than six cubic inches, acceleration bias less than one milli-G, greater than 90 db J-to-S and gun-hardened to 20,000G. In FY09, test and evaluate anti-jam module with GPS receiver and deep integration (DI) in non-roll and roll environments. Test DI algorithms and anti-jam module with various antenna configurations. Test different platforms, dynamics, and mission envelopes. Test flight scenarios with hardware-in-the-loop. Conduct government test and evaluation on inertial sensor, deep integration algorithms, DIGNU anti-jam capability, GPS receiver, and interaction of all these pieces.	5400	5104	5731	6630
Smaller, Lighter, Cheaper (SLC) Tactical Missiles: SLC reduces precision munition cost per kill and logistics burden via innovative technology application. In FY06, conducted industry surveys of seeker and guidance electronics unit (GEU) components. Completed trade study of system-in-a-package technology to miniaturize seeker electronics by 8 percent (transitioned to improved Precision Attack Missile (iPAM)). Completed feasibility analysis of increasing iPAM range from 2.5 km to 4.0 km. Completed electronics development for TOW Alternate Fuze (TAF) and transitioned to prime. TAF applicable to 2.75 inch rocket and M72. Completed assessment and initial design of multi-purpose warhead (MPW) that defeats armor/fortified structures/ personnel, is IM compliant and scalable for TOW/Javelin/Hellfire/PAM. MPW will transition to PM CCWS. In FY07, will complete MPW design and test against each target type. Initiate design of miniaturized electronics for automated fuze timing to maximize lethality against different target sets without launcher system modifications. Will transition to PM CCWS and other systems with MPW. Complete miniaturized GEU initial design for Close Combat Lethal Recon (CCLR), Javelin Block II GEU, and Command Launch Unit (CLU). Support DARPA development of CCLR system (5 lb Soldier-launched, loitering munition) including initial warhead, safe and arm (S&A) design, trade study on adding uncooled non-gimbaled IR seeker, and assessment of handheld viewer functionality. In FY08, will finalize design, fabricate, and test miniaturized GEU. Will complete design of uncooled non-gimbaled IR seeker, if trades show feasibility. Will finalize design, develop, and fabricate CCLR warhead and S&A. In FY09, will leverage latest in nanotechnology and electronics packaging to achieve small, light, missile form	1500	5900	7000	5500

factors to meet urban and emerging threats. Will conduct trades, build prototype designs. Test small, low cost, ungimbaled seeker/sensor system.				
Missile Guidance Systems and Seeker Technology: In FY06, integrated uncooled infrared (IR) prototype hardware with advanced guidance and control signal processing techniques to provide lower cost IR seekers; demonstrated RF and optical phase shifters for Phased Arrays for Tactical Seekers (PATS) via laboratory tests (PATS will eliminate the moving parts in seekers, increasing affordability). Lab tested damaging laser infrared-counter measure (IRCM) threats to harden optical components. Spiraled stackable substrates and chip-scale packaging into Block 1 Integrated Guidance Unit (IGU). Built, tested, compared to baseline IGU design performance. Stackable IGU substrates miniaturize electronics to enable insertion of guidance packages for missiles that are too small to include guidance. In FY07, evaluate uncooled IR concepts and demonstrate prototype configurations. Fabricate, and test passive phased sub-array from optical phase shifters and initiate transition to provide lower cost IR seekers. Integrate countermeasure algorithms and optics in a seeker and perform hardware-in-the-loop testing. Spiral in die stacking/thinning into Block 2 IGU; build, test, and compare to IGU baseline performance. Transition new vehicle target algorithm to Non-Line-of-Sight Launch System prime for Precision Attack Missile (PAM) target tracker. In FY08, spiral upgrade vehicle target algorithm and initiate Human Tracking Technology (HTT) development for anti-personnel weapon systems. Transition initial HTT to the Close Combat Lethal Recon (CCLR) system. Build and test PATS sub-arrays. In FY09, will transition upgraded HTT to CCLR. Incorporate physics-based versatile/accurate models of threat targets and environments simulation scenes for enhanced algorithm development, tracker, and ATA/R optimization. Fabricate a prototype novel seeker with strap-down electronically stabilized imager. Complete captive flight tests of an imaging radar seeker using low cost hardware.	10545	12984	14155	12411
High Fidelity System Level Simulations and Aerodynamics: The use of advanced simulation and aerodynamics tools promises to reduce size, lighten the weight, and reduce cost in missile systems. In FY06, applied laser radar (LADAR) target signature modeling to specific targets and backgrounds. Completed the design of real-time simulation control software. Extended aerodynamic predictive techniques by validation with detailed measurements to understand the effects and performance of new missile aerodynamic shapes in missile designs. In FY07, complete a hybrid patch approach for clutter statistics in order to progress simulation technology toward a fully predictive scene generation capability to provide accurate and high fidelity simulated scenes for missile seeker simulations. Extend aerodynamic predictive techniques by validation of Navier-Stokes equation solvers with detailed measurements of supersonic, reacting airflows. In FY08, will develop techniques for target modeling applicable to coherent Frequency Modulated Continuous Wave (FMCW) LADARs. PC-based real-time scene generation will be applied to all passive IR simulation capabilities. HWIL simulation control software will be installed and tested in a range of simulation capabilities and will extend aerodynamic prediction techniques for evaluating novel aerodynamic shapes. In FY09, will formalize LADAR target signature modeling techniques into standard procedures. Will extend HWIL simulation control software to improve user capabilities and extend aerodynamic prediction techniques to address fully turbulent, short correlation length, unsteady flows.	2855	2780	3584	3354
Smart, Stealthy, Smokeless Missile Propulsion, Smart Structures and Enhanced Lethality: In FY06, designed, fabricated, and static tested integrated spring assembly actuator and in variable-area-nozzle (VAN) concept in a system configuration for variable thrust rocket motors. Integrated a compact shaped charge warhead with enhanced fragmentation design features into a tandem system concept. Demonstrated the addition of thermobaric explosive to enhanced lethality of warhead sub-system. In FY07, complete testing of VAN and update design concepts and subsystem integration test in order to demonstrate projected increase in performance and decrease in sensitivity of the motor. Demonstrate a compact combined effects warhead which has been integrated into a tandem warhead missile system against a state-of-the-art target set. Investigate and evaluate the integration of warhead concepts into tactical missile systems. In FY08, will investigate new propellant formulations that operate efficiently over extreme temperature ranges. Demonstrate a fully integrated dynamic Hardened Combined Effects Warhead with enhanced blast and fragmentation characteristics against heavy armor and MOUT targets. Design,	4870	6226	8668	7329

fabricate, and test distributed thermal ignition concept and grain surface energetic coating schemes in order to improve engagement timeline and accuracy through prompt and repeatable rocket motor ignition with reasonable cost, weight, and volume. This is needed for Active Protection Systems and Area Protection Systems that operate on very short timelines. In FY09, will formulate propellant candidates designed to operate efficiently in extreme temperature ranges. Will evaluate multi-mode warhead characteristics using multi-point initiation concepts to control the energy deposited on the target. Will perform initial investigation and analysis of variable yield warhead/explosive technologies to vary the effects on target and minimize collateral damage.				
Insensitive Munitions (IM) Research: In FY06, conducted solid propellant formulation and characterization efforts in both minimum smoke and high performance propellants (AP/Al) as well as evaluated lightweight barrier concepts. In FY07, will evaluate existing and new energetic ingredients for beneficial insensitive munition characteristics. Will conduct formulations studies for emerging oxidizers, thermal additives, and nitramine replacements. Will apply emerging materials/concepts to canister/case design. In FY08, conduct ballistic/aging evaluation on new formulations. Will develop integrated passive venting designs and characterize performance of lightweight barrier concept to impact and thermal threats. In FY09, demonstrate mitigation of IM response to impact threats of a high performance motor through the use of lightweight barrier. Demonstrate improved IM response of a minimum smoke motor with new propellant formulation and integrated venting to bullet impact, fragment impact, fast cook off, and slow cook off environments. Demonstrate improved IM response to thermal threats of high performance motor with new propellant formulation and integrated venting.	1100	1300	1100	1100
Defense Against Rockets, Artillery and Mortars (RAM) - Interceptor Development: In FY06, began the design and development of critical supporting component interceptor technologies, including lethal mechanisms, propulsion and low cost guidance, and control mechanisms. Conducted a series of lethality tests establishing fragment size, mass, and shape required to defeat the RAM threat. Built and tested prototype forward firing warhead. Developed and began validating lethality assessment models and simulations. Began fabrication of miniature interceptor infrared and radio frequency breadboard sensors. Began fabrication of miniature dual axis canard control system, and began development of physics based digital system level simulations. In FY07, will complete designs and will fabricate and test propulsion subsystem. Will complete fabrication, and begin testing of the interceptor sensors and control systems. Will update system simulations and develop interceptor performance specification. In FY08, will complete testing of sensors and control systems, update system simulations, develop integrated interceptor design, and begin integrating prototype component technologies. In FY09, will fully integrate component technologies into prototype interceptors and perform hardware-in-the-loop testing. Will incorporate the results of all testing into update-error budgets and system level simulations. Will exercise the simulations to evaluate interceptor performance in expected operational scenarios. This project transitions into Defense Against RAM efforts in 0603313A Project 263.	1000	4000	9700	7000
Defense Against Rockets, Artillery and Mortars (RAM) - Fire Control and Systems Architecture: In FY06, defined fire control components, and the required integration of the fire control and interceptor technologies into a robust system architecture. Developed requirements for long range and short range surveillance sensors, developed requirements for the fire control sensors, and developed and evaluated impact point prediction algorithms. In FY07, begin fabrication and bench and field testing of critical short range surveillance and fire control sensor technologies. Transition these technologies to PE 0603313A (Missile and Rocket Advanced Technology) D704.	1000	3263		
Multi-Role Missile Engine and Missile Component Design: In FY09, this effort will gather breakthrough technologies developed in PE 0602303A (Missile Technology) projects in missile propulsion, power, data link, processing, seekers, actuators/controls, navigation, and warheads to develop the next generation of Army missile concepts. This next generation of missiles will be characterized by smaller diameters and shorter lengths building on technologies being developed for use in guided interceptors. Other characteristics will include low-cost multi-mode seekers generally only associated with precision attack munitions, micro electro-mechanical systems inertial measurement units complimentary to both missiles and precision guided munitions, miniaturized deeply-integrated guidance and navigation units, miniaturized electronic units, extreme temperature range insensitive propellants, robust data links, and anti-jamming				5000

capability. Lethality will be maintained while integrating these components into paradigm-shifting missile designs.				
Small Business Innovative Research/Small Business Technology Transfer Programs		860		
Total	40560	47320	53038	48324