# ARMY RDT&E BUDGET ITEM JUSTIFICATION (R2 Exhibit)

**February 2006**

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

| COST (In Thousands) | | FY 2005 Estimate | FY 2006 Estimate | FY 2007 Estimate | FY 2008 Estimate | FY 2009 Estimate | FY 2010 Estimate | FY 2011 Estimate |
|---|---|---|---|---|---|---|---|---|
| Total Program Element (PE) Cost | | 79358 | 90712 | 59439 | 54951 | 43410 | 39310 | 37611 |
| 214 | MISSILE TECHNOLOGY | 33339 | 44185 | 47849 | 54951 | 43410 | 39310 | 37611 |
| 223 | AERO-PROPULSION TECHNOLOGY | 28267 | 11336 | 0 | 0 | 0 | 0 | 0 |
| G02 | Army Hypersonics Applied Research | 8745 | 13012 | 11590 | 0 | 0 | 0 | 0 |
| G04 | AIR DEFENSE TECHNOLOGIES (CA) | 1342 | 4830 | 0 | 0 | 0 | 0 | 0 |
| G05 | MISSILE TECHNOLOGY INITIATIVES (CA) | 958 | 13899 | 0 | 0 | 0 | 0 | 0 |
| G06 | UNMANNED SYSTEMS TECHNOLOGIES (CA) | 6707 | 3450 | 0 | 0 | 0 | 0 | 0 |

**A. Mission Description and Budget Item Justification:** This applied research Program Element (PE) researches and investigates advanced 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 increase the survivability of launch systems; provide greater lethality and effectiveness under adverse battlefield conditions; increase kill probabilities against diverse targets; and provide powerful new simulation and virtual prototyping analysis tools. A major cross-cutting theme is developing missile technology that is 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 research to help solve the insensitive munitions requirements for missiles, hypersonic/hypervelocity missile efforts, and the maturation of a common high-gravitational force (high-g), low cost, Micro Electro-Mechanical System (MEMS) Inertial Measurement Unit (IMU). The goal of the high-g MEMS IMU program is to design and mature affordable, reliable precision guidance components for missiles and guns at a significantly lower unit cost than current systems. In addition, the performance and small packaging goals will enable the components to meet the requirements of 90% of DoD guided munitions and missiles. The performance goal is develop and demonstrate an IMU capable of providing the 1.0 deg/hr gyro bias (drift rate) needed to maintain accurate position reference during a typical tactical missile or gun flight profile without reliance on the Global Positioning System (GPS) and survive the gun-launch environment (20,000g's). A second objective of the high-g, low cost MEMS program is to design a deeply-integrated guidance and navigation unit (DIGNU). The DIGNU effort will develop and demonstrate an IMU or Inertial Sensor Assembly (ISA) with the same requirements of the initial program but with an additional "deeply-integrated" or "deeply-coupled" GPS military receiver. The GPS receiver incorporates a single microprocessor architecture and integrated hardware within a Selective Availability and Anti-Spoofing Module (SAASM) and software anti-jam (AJ) capability. The deliverable DIGNUs will be packaged in a volume of less than four cubic inches and will use a single microprocessor to absorb the mission computer processing functions found in 90% of all DoD guided munitions and missiles. The high-g MEMS IMU program is a joint project between the Armament Research, Development and Engineering Center, and Aviation and Missile Research, Development and Engineering Center. 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 research and investigate small, lightweight force protection technologiesy 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 will investigate and develop the interceptor and fire control technologies necessary to provide the Future Force with an active defense against Rockets, Artillery, and Mortars (RAM).. In addition, the Smaller Lighter, Cheaper (SLC) effort focuses technology to reduce the cost and logistics burden of precision munitions. Through innovative application of technology in concert with more efficient production and integration processes, this program's goal is to reduce the cost per kill of precision guided missiles and munitions. The Army Hypersonics Applied Research program explores and matures 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 Aviation & Missile Research, Development, and Engineering Center, Redstone Arsenal, AL.

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**February 2006**

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

| **B. Program Change Summary** | FY 2005 | FY 2006 | FY 2007 |
|---|---|---|---|
| Previous President's Budget (FY 2006) | 82781 | 62524 | 65801 |
| Current BES/President's Budget (FY 2007) | 79358 | 90712 | 59439 |
| Total Adjustments | -3423 | 28188 | -6362 |
| Congressional Program Reductions | | -4898 | |
| Congressional Rescissions | | -914 | |
| Congressional Increases | | 34000 | |
| Reprogrammings | -3423 | | |
| SBIR/STTR Transfer | | | |
| Adjustments to Budget Years | | | -6362 |

FY 07 decrease of -6.4 million attributed to realignment of funding to higher priority requirements
Nine FY06 Congressional adds totaling $34000 were added to this PE.

FY06 Congressional adds with no R-2A (appropriated amount is shown):
($1400) Cruise Missile Defense Via Passive RF Detection
($3500) Enhanced Area Protection and Survivability (EAPS)
($2500) LENS X Hypervelocity Ground Testing
($9000) MARIAH II Hypersonic Wind Tunnel Development
($2100) Nanoscience Initiative for Next Generation Missiles
($1500) Near Hermetic Packaging and Interconnection Technology
($2100) Red Rain
($8400) Unique Waveform Based Missile Technologies for Horizontal Integration and IED Detection
($3500) Unmanned Systems Initiative at AMRDEC

# ARMY RDT&E BUDGET ITEM JUSTIFICATION (R2a Exhibit)

**February 2006**

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

| COST (In Thousands) | FY 2005 Estimate | FY 2006 Estimate | FY 2007 Estimate | FY 2008 Estimate | FY 2009 Estimate | FY 2010 Estimate | FY 2011 Estimate |
|---|---|---|---|---|---|---|---|
| 214 MISSILE TECHNOLOGY | 33339 | 44185 | 47849 | 54951 | 43410 | 39310 | 37611 |

**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 the Future Combat Systems (FCS) and 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 in the efforts in this project is developing Smaller, Lighter weight, and Cheaper (SLC) missile technology to reduce the cost and logistics burden of precision munitions. Research objectives are to enhance the survivability of launch systems, provide greater effectiveness under adverse battlefield conditions, increase kill probabilities against diverse targets, and provide powerful new simulation and virtual prototyping analysis tools. The major effort in this project is the high-gravitational force (high-g), low cost Micro Electro-Mechanical Systems (MEMS) Inertial Measurement Unit (IMU) program. The Army is the Service lead in the investigation of low-cost MEMS IMUs capable of supporting precision guidance requirements of DoD's missile and gun launched precision munitions programs. 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.) This is a joint program with the Armament Research, Development and Engineering at Picatinny Arsenal. A second objective of the high-g, low cost MEMS program is to develop a deeply-integrated guidance and navigation unit (DIGNU). The DIGNU effort will develop and demonstrate an IMU or Inertial Sensor Assembly (ISA) with the same 1.0 deg/hr, and greater than 20,000 g's survivability requirements of the initial program with an additional "deeply-integrated" or "deeply-coupled" GPS military receiver incorporating a single microprocessor architecture and integrated hardware within a Selective Availability and Anti-Spoofing Module (SAASM) and software anti-jam (AJ) capability. The Smaller Lighter, Cheaper (SLC) effort focuses on technology to reduce the cost and logistics burden of precision munitions. Through innovative application of technology in concert with more efficient production and integration processes, this program's goal is to reduce the cost per kill of precision guided missiles and munitions. 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 apply structronics technologies to the electronics substrate such that the substrate becomes the chassis, wiring harness, and printed wiring board for the electronics. Each of these elements will be incorporated into a series of Integrated Guidance Units (IGU's) which will consist of a guidance computer and an inertial measurement unit. This project 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 three 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. Also included in this project is the Extended Area Protection and Survivability (EAPS) program, which is an effort to develop the technology necessary to provide the Future Force an active defense capability against rockets, artillery, and mortars (RAM). 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 Aviation & Missile Research, Development, and Engineering Center, Redstone Arsenal, AL.

| **Accomplishments/Planned Program** | FY 2005 | FY 2006 | FY 2007 |
|---|---|---|---|
| - High-G Micro-electromechanical Systems (MEMS) Inertial Measurement Unit (IMU) - High-G MEMS IMU - In FY05, performed test and evaluation on the Phase 2 IMUs. The Phase 2 IMUs have been tested to meet the following parameters: gyro bias less than 20 deg/hr, volume less than four cubic inches, acceleration bias less than four milli-g's, and gun-hardened to 20,000 g's. Laboratory characterization tests have been performed on software selectable spin rates: a four Hz roll rate version required for missiles and a 20 Hz roll-rate version | 9235 | 13961 | 5000 |

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| required for munitions; performed additional electronics miniaturization to reduce the volume of the IMU to four cubic inches; improved digital IMU electronics design; and performed missile flight tests with the Phase 2 IMUs. Evaluated contractor performance and progress and down-selected from two vendors to one. In FY06, use advanced die packaging techniques to support miniaturization of IMUs to less than four cubic inches volume; incorporate out-of-plane gyros and in-plane accelerometers or other novel sensor packaging strategies to get to smallest possible IMU volume; develop die attach methods, develop a new design process for Application-Specific integrated Circuits (ASICs), design a new internal isolator and integrate the gyro, accelerometer, and microprocessor functions in a single IMU to improve signal isolation. Perform test and evaluation on the early Phase 3 IMUs. In addition, redesign the vibration isolation system for the modified mass and diameter to address the 20,000 g. launch environment. This will require a board stiffness redesign with emphasis on high yield and low cost for the IMU. In FY07, will perform test and evaluation on the final Phase 3 IMU deliverables. 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 | | | |
| - High-G Micro-electromechanical Systems (MEMS) Deeply Integrated Guidance and Navigation Unit (DIGNU). In FY05, performed test and evaluation of the DIGNU1s developed under FY04 Congressional add. The DIGNU1s have been tested to meet the following parameters: gyro bias less than 75 deg/hr, volume less than 28 cubic inches, acceleration bias less than nine milli-g's and gun-hardened to 10,000 g's. Field tested DIGNUs to evaluate performance in actual live-sky GPS conditions. Ensured GPS data input to the DIGNU and measured IMU hardware synchronization with live sky GPS information to evaluate DIGNU Anti-Jam performance. In FY06, mature the deep integration algorithms. Address performance issues identified during live field tests with redesign to improve performance. Support missile flight tests with the development, laboratory test and evaluation of the Phase 2 DIGNUs. Test DIGNU2s to meet the following parameters: gyro bias less than 20 deg/hr, volume less than 12 cubic inches, acceleration bias less than four milli-g's and gun-hardened to 15,500 g's. Perform field tests on the DIGNU2 to determine GPS/INS/anti-jam capability; mature and further miniaturize internal anti-jam capability; test application platform interface software and finalize commonality requirements between the units from the two contractors; test G-operational requirements and expanded temperature range requirements for the DIGNU2 products. In FY07, will perform field tests and laboratory characterization on DIGNU3s including anti-jam capability; will further miniaturize the anti-jam module, modify and retest any issues identified during testing of DIGNU2 and perform test and evaluation on the DIGNU3s. The DIGNU3s will be tested against the following parameters: gyro bias less than one deg/hr, volume less than five cubic inches, acceleration bias less than one milli-g, greater than 90 db J/S and gun-hardened to 20,000 gs. | 4000 | 5400 | 4664 |
| - Smaller, Lighter, Cheaper (SLC) Tactical Missiles. - SLC focuses technology to reduce the cost and logistics burden of precision munitions. Through innovative application of technology, this program's goal is to reduce the cost per kill of precision guided missiles. In FY05, performed assessment of current and future precision guided missile capabilities and gaps. Matched innovative component technology and/or new weapon concepts to both reduce the cost per kill for precision weapons and, where needed, to fill gaps with a new capability. In FY06, initiate efforts with industry to design identified components for reduced cost per kill (e.g. seekers, warheads, guidance electronics). Utilize state-of-the-art System-in-a-Package technology to miniaturize seeker electronics by 80%. Facilitate upgrade of existing seeker to improve range performance from 2.5 km to 4.0 km. Complete trade studies, initial warhead design, effects modeling, and lethality assessment for a multi-purpose warhead that effectively defeats armor, fortified structures and personnel, is insensitive munition compliant, and scalable for TOW, Javelin, Hellfire, PAM, and UAW. This warhead will provide the soldier with a one-round-does-it-all capability while reducing ammunition weight, stowage space, logistics burden and supply chain management. In FY07, will finalize the seeker electronics design, fabricate the electronics first article, and test in a hardware-in-the-loop environment. Will complete the warhead design and perform testing against armor, fortification and simulated personnel targets. Will partner with DARPA to develop and evaluation the Close Combat Lethal Recon (CCLR) system, a three 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. Will | 500 | 1500 | 5900 |
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| establish detailed design of the warhead, safe and arm device, and complete development of the handheld viewer software. | | | |
| - Missile Guidance Systems and Seeker Technology. - In FY05, matured controlled arrays of MEMS sensors to provide full dynamic performance ranges, designed geometry transformations for rapid retraining of automatic target recognition (ATR) systems, evaluated infrared (IR) counter-counter measures (CCM) guidance algorithms in a seeker; matured concepts for advanced uncooled IR seeker and sensor hardware; designed, matured, and tested advanced optics, signal processing, guidance and control techniques and conducted captive carry tests of prototype uncooled seeker. Built a prototype Integrated Guidance Unit (IGU) based on proven design. In FY06, integrate uncooled IR prototype hardware with advanced guidance and control signal processing techniques; demonstrate RF and optical phase shifters for phased arrays for tactical seekers via laboratory tests. Perform lab test of damaging laser infrared-counter measure (IRCM) threats to optical components. Spiral stackable substrates and chip scale packaging into the Block 1 Integrated Guidance Unit (IGU). Build, test and compare to baseline IGU design. In FY07, will evaluate uncooled IR concepts and demonstrate prototype configurations, fabricate and test a passive phased sub-array from optical phase shifters and initiate transition of the technology. Will integrate damaging IRCM algorithms and optics in a seeker and perform hardware-in-the-loop testing. Will spiral in die stacking and die thinning into the Block 2 IGU and build, test and compare to baseline IGU design. | 9640 | 9045 | 13269 |
| - 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 FY05, continued development of techniques for modeling target signatures and backgrounds as perceived by laser radar (LADAR) sensors; completed initial software design and implementation for Phase I of real-time improved control of simulation facilities; applied low frequency radar cross-section (RCS) codes to specific ground targets. Characterized aerodynamics for non-cylindrical and non-typical missile configurations. Implemented new power-on base drag methods in simulation. In FY06, apply LADAR target signature modeling to specific targets and backgrounds; complete the design of real-time simulation control software. Extend aerodynamic predictive techniques by validation with detailed measurements. In FY07, will integrate LADAR, passive IR and visible scene generation techniques on personal computer (PC) hardware; will integrate real-time simulation facility software control to all types of facilities. Will refine and assess aerodynamic prediction methods to maximize benefits from advances in computational power and capabilities. Will investigate novel aerodynamic control methods unique to smaller, lighter, more affordable missiles. | 2710 | 1855 | 4227 |
| - Smart, Stealthy, Smokeless Missile Propulsion, Smart Structures and Enhanced Lethality. - In FY05, completed design, fabrication and demonstration of self-regulating spring assembly and squib actuation in variable-area-nozzle (VAN) brassboard hardware. Performed tandem warhead integration and performance testing of advanced compact shaped charge with fragmenting body design. Tested warhead Insensitive Munitions design features and additional thermobaric fills. Investigated various fragmentation methods, materials and penetration studies against various classes of targets. Developed Lethality Design Tool Set to characterize system effectiveness against various targets. In FY06, design, fabricate and static test integrated spring assembly actuator and VAN concept in a system configuration. Mature integration of compact shaped charge warhead with enhanced fragmentation design features into a tandem system concept. Will demonstrate the addition of thermobaric explosive to enhanced lethality of warhead sub-system. In FY07, will complete testing of VAN and update design concepts. Will complete subsystem integration test in order to demonstrate projected increase in performance and decrease in sensitivity of the motor. Will demonstrate a combined effects compact warhead integrated into a tandem warhead missile system against a target set. Will investigate and evaluate the integration of warhead concepts in missile systems. | 4154 | 4061 | 6226 |
| - Insensitive Munitions Research - In FY05, completed formulation research and identified and evaluated controlled motor case venting techniques and candidate materials for lightweight barriers. In FY06, conduct ballistic/aging studies on new less shock sensitive minimum smoke formulations and new formulations; evaluate lightweight barrier concepts, and demonstrate motor case venting concept. In FY07, will evaluate existing and new energetic ingredients for insensitive munition beneficial characteristics; will conduct formulations studies | 1100 | 1100 | 1300 |
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| for emerging oxidizers, thermal additives, and nitramine replacements; and will apply emerging materials/concepts to canister/case design. | | | |
| - Defense Against Rockets, Artillery and Mortars (RAM) - Interceptor Development. - In FY05, matured interceptor concepts, established interceptor best technical approaches, and developed a draft interceptor specification. In FY06, begin the design and development of critical supporting component interceptor technologies, including lethal mechanism, propulsion and low cost guidance and control mechanisms. In FY07, will begin the component fabrication and bench and field-testing of critical lethality, propulsion, and guidance and control technologies. | 1000 | 4000 | 4500 |
| - Defense Against Rockets, Artillery and Mortars (RAM) - Fire Control and Systems Architecture - Investigates fire control components and the integration of the fire control and interceptor technologies into a robust system architecture. In FY05, matured fire control sensor, acquisition and tracking concepts; established the best technical approaches; developed a draft fire control specification; developed draft system architectures integrating the fire control and interceptor technologies; and demonstrated the operational utility of the system architectures through constructive and force-on-force simulations. In FY06, begin the development and demonstration of critical supporting component fire control technologies, including acquisition and tracking sensors and decision algorithms. In FY07, will begin fabrication and bench and field test critical acquisition and tracking sensor components and decision algorithm technologies. | 1000 | 3263 | 2763 |
| Total | 33339 | 44185 | 47849 |

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**February 2006**

| BUDGET ACTIVITY | PE NUMBER AND TITLE | PROJECT |
|---|---|---|
| **2 - Applied Research** | **0602303A - MISSILE TECHNOLOGY** | **G02** |

| COST (In Thousands) | | FY 2005 Estimate | FY 2006 Estimate | FY 2007 Estimate | FY 2008 Estimate | FY 2009 Estimate | FY 2010 Estimate | FY 2011 Estimate |
|---|---|---|---|---|---|---|---|---|
| G02 | Army Hypersonics Applied Research | 8745 | 13012 | 11590 | 0 | 0 | 0 | 0 |

**A. Mission Description and Budget Item Justification:** This project focuses on the research and investigation of the critical technologies required to mature expendable hypersonic/hypervelocity missiles and to defeat hypersonic threats. Focus areas include: hypersonic/hypervelocity aerodynamic prediction tool development; engine component design; active and passive cooling mechanisms; turbulent mixing enhancement at low Reynolds numbers; computational fluid dynamic code development and validation and high yield, storable fuel grains. Initial efforts will focus on concept maturation of Hypersonic/hypervelocity enabled missiles and guided interceptors to defeat hypersonic threats to enhance Army operational missions. Efforts will be conducted through detailed system and subcomponent simulation, design, maturation and test in laboratory settings. The cited work is consistent with Strategic Planning Guidance, the Army Science and Technology Master Plan (ASTMP) and the Army Modernization Plan, and the Defense Technology Area Plan (DTAP). Work is performed at the Aviation & Missile Research, Development, and Engineering Center, U.S. Army Aviation and Missile Command, Redstone Arsenal, AL.

| **Accomplishments/Planned Program** | FY 2005 | FY 2006 | FY 2007 |
|---|---|---|---|
| In FY05, completed system and component level trade studies to determine missile system technical requirements addressing stated objectives for future Army systems and to assess the operational enhancement expected from a hypersonic/hypervelocity enabled system. Computational fluid dynamic and high fidelity mathematical simulation analysis was utilized in these analyses. Continued constructive simulation efforts based on preliminary design trades to further explore advantages of the proposed systems in new operational scenarios of interest. In FY06, utilize missile system and subsystem trades studies to assess system operational performance as system and subsystem technology matures and clearly identify technological shortcomings that need to be addressed to weaponize the hypersonic/hypervelocity engine technology. In FY07, will continue assessment of system operational performance. Evolving operational scenarios will be explored using constructive and engineering level simulations to assess advantages of hypersonic/hypervelocity enabled systems. | 1450 | 2000 | 2000 |
| - In FY06, further evaluate engine component technology and initiate guided interceptor design effort. Assess operational capability of the component designs and validate computational methods. These efforts consist of experimental model design, instrumentation of experimental models, fabrication of test hardware and extensive ground test investigations of selected missile and guided interceptor components. In FY07, will continue experimental design and evaluation of component technology to optimize the component designs as understanding of component designs improves and technologies mature. Will test and evaluate guided interceptor designs. Component technology will be transitioned during FY07 to PE 0603313 Project G03 and Project 550. | 7295 | 11012 | 9590 |
| Total | 8745 | 13012 | 11590 |